Modern Electronic Circuits Reference Manual

Markus

MODERN ELECTRONIC CIRCUITS REFERENCE MANUAL

Over 3,630 modern electronic circuits, each complete with values of all parts and performance details, organized in 103 logical chapters for quick reference and convenient browsing

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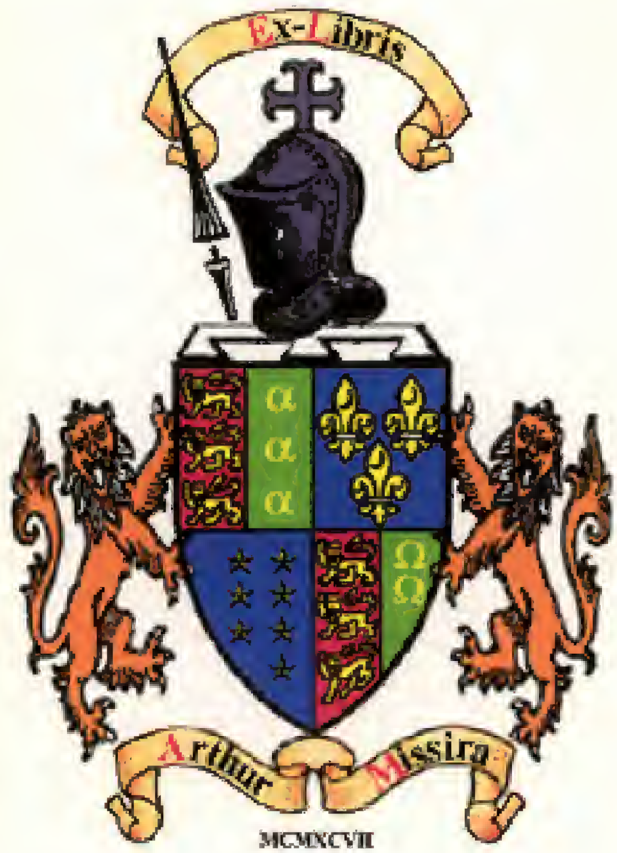
Contents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Preface

Over 3,630 practical modern electronic circuits are arranged here in 103 logical chapters for convenient browsing and reference by electronics engineers, technicians, students, microprocessor enthusiasts, amateur radio fans, and experimenters. Each circuit has type numbers or values of all significant components, an identifying title, a concise description, performance data, and suggestions for other applications. At the end of each description is a citation giving the title of the original article or book, its author, and the exact location of the circuit in the original source.

This fourth in a series of state-of-the-art reference volumes illustrates dramatically the accelerated trend to integrated circuits that has taken place since publication of "Guidebook of Electronic Circuits" in 1974. About half of the applications now use ICs, and tube circuits have become a distinct rarity. This trend becomes even more evident when comparing circuits with those in the first and second books of the series, "Sourcebook of Electronic Circuits" and "Electronic Circuits Manual." The four books supplement each other and together provide a total of over 13,300 different practical circuits at a cost of only about 1 cent per circuit. The collection can serve as a basic desktop reference library that will match retrieval speeds of computer-based indexing systems while providing in addition the actual circuit diagrams.

The circuits for this new book were located by cover-to-cover searching of back issues of U.S. and foreign electronics periodicals, the published literature of electronics manufacturers, and recent electronics books, together filling well over 100 feet of shelving. This same search would take weeks or even months at a large engineering library, plus the time required to write for manufacturer literature and locate elusive sources.

Engineering libraries, particularly in foreign countries, have found these circuit abstracts to be a welcome substitute for the original sources when facing limitations on budgets, shelving, or search manpower. As further evidence of their usefulness in other countries, some of the books have been translated into Greek, Spanish, or Japanese.

Entirely new chapters in this book, further emphasizing evolution of the industry in recent years, include Clock Signal, Fiber-Optic, Game, Keyboard, Logic Probe, Microprocessor, Programmable, Switching Regulator, and Touch-Switch Circuits. Significant new circuits appear in chapters found also in previous books, particularly for Automotive, Burglar Alarm, Digital Clock, Fire Alarm, Flasher, Frequency Counter, Frequency Synthesizer, Instrumentation, Intercom, Lamp Control, Medical, Memory, Motor Control, Music, Power Control, Protection, Siren, Stereo, and Telephone Circuits.

To find a desired circuit quickly, start with the alphabetically arranged table of contents at the front of the book. Note the chapters most likely to contain the desired type of circuit, and look in these first. Remember that most applications use combinations of basic circuits, so a desired circuit could be in any of several different chapters. Scope notes following chapter titles define the basic circuits covered and sometimes suggest other chapters for browsing.

If a quick scan does not locate the exact circuit desired, use the index at the back of the book. Here the circuits are indexed in depth under the different names by which they may be known. Hundreds of cross-references in the index aid searching. The author index will often help find related circuits after one potentially useful circuit is found, because authors tend to specialize in certain circuits.

Values of important components are given for every circuit because these help in reading the circuit and redesigning it for other requirements. The development of a circuit for a new application is speeded when design work can be started with a working circuit, instead of starting from scratch. Research and experimentation are thereby cut to a minimum, so even a single use of this circuit-retrieval book could pay for its initial cost many times over. Drafting errors on diagrams are minimized because any corrections pointed out in subsequently published errata notices have been made; this alone can save many frustrating hours of troubleshooting.

This book is organized to provide a maximum of circuit information per page, with minimum repetition. The chapter title at the top of each right-hand page and the original title in the citation should therefore be considered along with the abstract when evaluating a circuit.

Abbreviations are used extensively to conserve space. Their meanings are given after this preface. Abbreviations on diagrams and in original article titles were unchanged and may differ slightly, but their meanings can be deduced by context.

Mailing addresses of all cited original sources are given at the front of the book, for convenience in writing for back issues or copies of articles when the source is not available at a local library. These sources will often prove useful for construction details, performance graphs, and calibration procedures.

To Joan Fife, student at the University of Santa Clara, goes credit for typing the complete manuscript directly from dictation while correcting this author's grammar and punctuation practices of yesteryear and even catching technical oversights. Handling of hyphenation, abbreviations, and citations was entirely her responsibility, along with final editing, markup for the printer, and production of the index.

To the original publications cited and their engineering authors and editors should go major credit for making possible this fourth encyclopedic contribution to electronic circuit design. The diagrams have been reproduced directly from the original source articles, by permission of the publisher in each case.

John Markus

Abbreviations Used

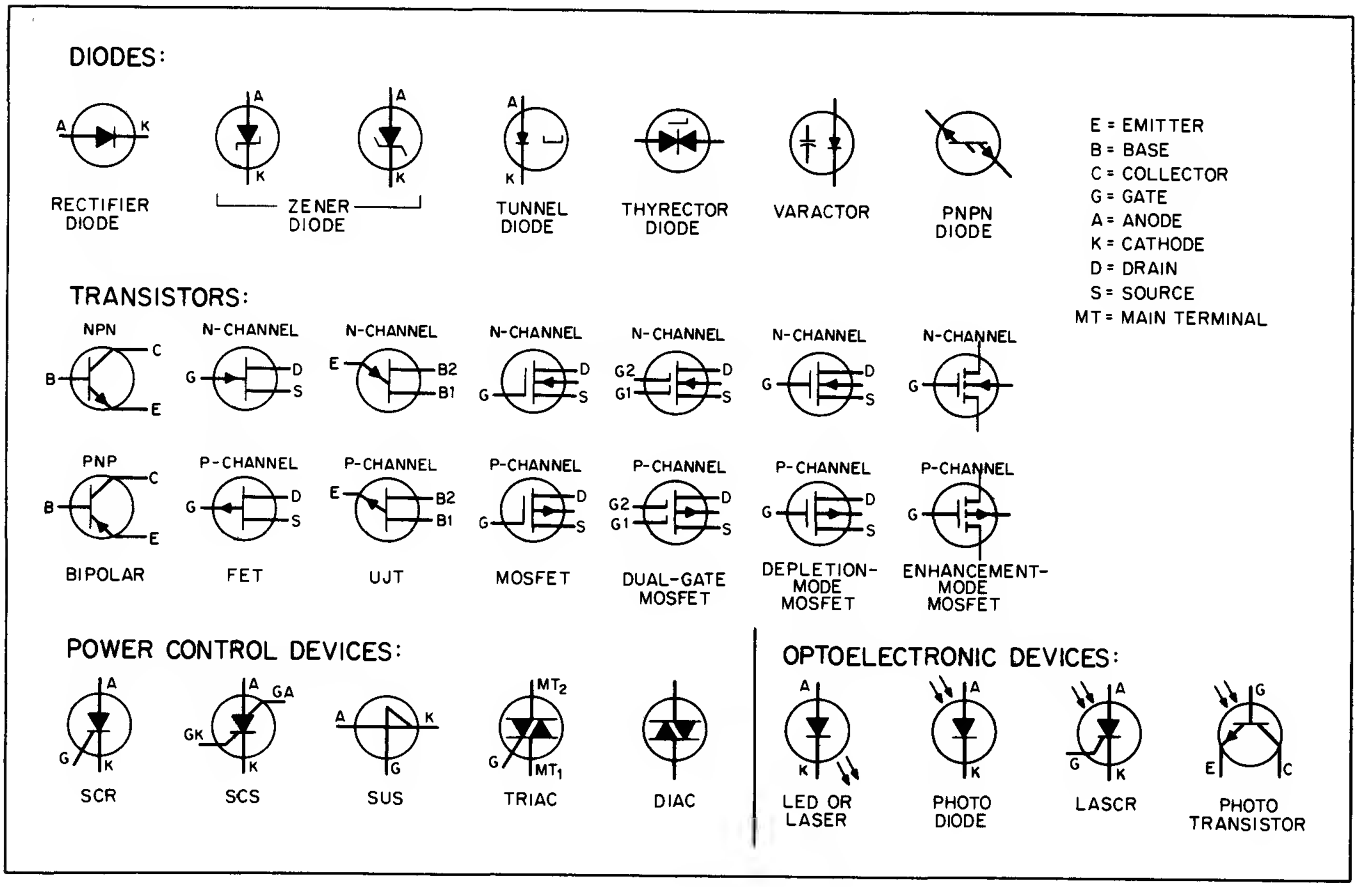
A	ampere
AC	altarnating current
AC/DC	AC or DC
A/D	analog-to-digital
ADC	analog-to-digital converter
A/D, D/A	analog-to-digital, or digital-to-analog
ADP	automatic data processing
AF	audio frequency
AFC	automatic frequency control
AFSK	audio frequency-shift keying
AFT	automatic fine tuning
AGC	automatic gain control
Ah	ampere-hour
ALU	arithmetic-logic unit
AM	amplitude modulation
AM/FM	AM or FM
AND	type of logic circuit
AVC	automatic volume control
b	bit
BCD	binary-coded decimal
BFO	beat-frequency oscillator
b/s	bit per second
C	capacitanca; capacitor
°C	degree Celsius; degree Centigrade
CATV	cable television
CB	citizens band
CCD	charge-coupled davice
CCTV	closed-circuit television
cm	centimetar
CML	current-mode logic
CMOS	complementary MOS
CMR	common-mode rejection
CMRR	common-mode rejection ratio
cm^2	square centimater
coax	coaxlal cable
COHO	coherent oscillator
COR	carrier-operated relay
COS/MOS	complamentary-symmetry MOS (same as CMOS)
CPU	central processing unit
CR	cathode ray
CRO	cathode-ray oscilloscope
CROM	control and read-only memory
CRT	cathode-ray tube
CT	center tap
CW	continuous wave
D/A	digital-to-analog
DAC	dlgital-to-analog converter
dB	dacibel
dBC	C-scale sound level in decibals
dBm	decibels above 1 mW
dBV	decibels above 1 V
DC	direct current
DC/DC	DC to DC
DCTL	direct-coupled transistor logic
diac	diode AC switch
DIP	dual in-line package
DMA	direct memory access
DMM	digital multimeter
DPDT	double-pole double-throw
DPM	digital panel meter
DPST	double-pola single-throw
DSB	double sideband
DTL	diode-transistor logic
DTL/TTL	DTL or TTL
DUT	device undar test
DVM	digital voltmetar
DX	distance reception; distant
EAROM	electrically alterable ROM
EBCDIC	extended binary-coded decimal interchange code
ECG	electrocardiograph
ECL	emitter-coupled logic
EDP	electronic data processing
EKG	alactrocardiograph
EMF	elactromotiva force
EMI	electromagnetic interference
EPROM	erasable PROM
ERP	effective radiated power
ETV	educational television
eV	electronvolt
EVR	electronlc video racording
EXCLUSIVE-OR	typa of logic circuit
EXCLUSIVE-NOR	type of logic circuit
F	farad
°F	degree Fahranheit
FET	field-effect transistor
FIFO	first-in first-out
FM	fraquency modulation
4PDT	four-pole double-throw
4PST	four-pole single-throw
FS	full scale
FSK	frequency-shift keying
ft	foot
ft/min	foot per minute
ft/s	foot per second
ft^2	square foot
F/V	frequency-to-voltage
F/V, V/F	frequency-to-voltage, or voltage-to-fraquency
G	giga- (10^9)
GHz	gigahertz
G-M tube	Geiger-Mualler tube
h	hour
H	henry
HF	high frequency
HFO	high-frequency oscillator
hp	horsepower
Hz	hertz
IC	intagrated circuit
IF	intarmediate frequency
IGFET	insulated-gate FET
IMD	intermodulation distortion
IMPATT	impact avalanche transit time
in	inch
in/s	inch per second
in^2	square inch
I/O	input/output
IR	infrarad
JFET	junction FET
k	kilo- (10^3)
K	kilohm (,000 ohms); kelvin
kA	kiloampere
kb	kilobit
kaV	kiloelectronvolt
kH	kilohenry
kHz	kilohertz
km	kilometer
kV	kilovolt
kVA	kilovoltampare
kW	kilowatt
kWh	kilowatthour
L	inductance; inductor
LASCR	light-activatad SCR

LASCS	light-activated SCS
LC	inductance-capacitanca
LCD	liquid crystal display
LDR	light-dependent resistor
LED	light-emitting dioda
LF	low fraquancy
LIFO	last-in first-out
lm	luman
LO	local oscillator
logamp	logarithmic amplifier
LP	long play
LSB	laast significant bit
LSI	large-scala integration
m	meter; milli- (10^{-3})
M	mega- (10^6); mater (instrument); motor
mA	milliampera
Mb	magabit
MF	medium frequency
mH	millihanry
MHD	magnatohydro-dynamics
MHz	megahertz
mi	mile
mika	microphone
min	minute
mm	millimeter
modam	modulator-damodulator
mono	monostable
MOS	metal-oxide semiconductor
MOSFET	metal-oxide semiconductor FET
MOST	matal-oxide samiconductor transistor
MPU	microprocessing unit
ms	millisecond
MSB	most significant bit
MSI	madium-scala integration
m^2	squara mater
μ	micro- (10^{-6})
μA	microampara
μF	microfarad
μH	microhenry
μm	micrometer
μP	microprocessor
μs	microsecond
μV	microvolt
μW	microwatt
mV	millivolt
MVBR	multivibrator
mW	milliwatt
n	nano- (10^{-9})
N	negative
nA	nanoampere
NAB	National Association of Broadcasters
NAND	typa of logic circuit
nF	nanofarad
nH	nanohenry
NMOS	N-channel MOS
NOR	type of logic circuit
NPN	negative-positive-nagative
NPNP	negative-positive-negative-positive
NRZ	nonreturn-to-zero
NRZI	nonreturn-to-zero-invertad
ns	nanosacond
NTSC	National Television System Committee
nV	nanovolt
nW	nanowatt
OEM	original aquipmant manufacturar
opamp	oparational amplifier
OR	type of logic circuit
p	pico- (10^{-12})
P	peak; positive
pA	picoampere
PA	public address
PAL	phase-altarnation line
PAM	pulse-amplitude modulation
PC	printad circuit
PCM	pulse-code modulation
PDM	pulsa-duration modulation
PEP	peak envalope power
pF	picofarad
PF	powar factor
phono	phonograph
PIN	positiva-intrinsic-negative
PIV	peak inverse voltage
PLL	phase-locked loop
PM	permanant magnet; phasa modulation
PMOS	P-channel MOS
PN	positiva-nagative
PNP	positiva-nagativa-positiva
PNPN	positiva-negativa-positiva-nagative
pot	potantiomater
P-P	paak-to-peak
PPI	plan-position indicator
PPM	parts per million; pulse-position modulation
praamp	praamplifiar
PRF	pulse repatition frequency
PROM	programmabla ROM
PRR	pulse repetition rate
ps	picosecond
PSK	phase-shift keying
PTT	push to talk
PUT	programmable UJT
pW	picowatt
PWM	pulse-width modulation
Q	quality factor
QRP	low-powar amateur radio
R	rasistance; resistor
RAM	random-accass memory
RC	rasistance-capacitance
RF	radio fraquancy
RFI	radio-fraquancy intarfaranca
RGB	rad/graan/blua
RIAA	Racording Industry Association of America
RLC	resistance-inductance-capacitance
RMS	root-mean-square
ROM	read-only memory
rpm	ravolution per minute
RTL	resistor-transistor logic
RTTY	radiotalatype
RZ	raturn-to-zaro
s	second
SAR	successive-approximation ragistar
SAW	surfaca acoustic wave
SCA	Subsidiary Communications Authorization
scope	oscilloscope
SCR	silicon controlled rectifiar
SCS	silicon controlled switch
S-meter	signal-strength matar
S/N	signal-to-noisa
SNR	signal-to-noise ratio
SPDT	single-pole doubla-throw
SPST	singla-pola singla-throw
SSB	single sidaband
SSI	small-scala integration
SSTV	slow-scan television
SW	shortwave
SWL	shortwave listener
SWR	standing-wava ratio
sync	synchronizing
T	tera- (10^{12})
TC	temperature coefficient
THD	total harmonic distortion
TR	transmit-receive
TRF	tunad radio frequency
triac	triode AC samiconductor switch
TTL	transistor-transistor logic

TTY	teletypewriter
TV	television
TVI	television interference
TVT	television typewriter
TWX	teletypewriter exchange service
UART	universal asynchronous receiver-transmitter
UHF	ultrahigh frequency
UJT	unijunction transistor
UPC	universal product code
UPS	uninterruptible power system
V	volt
VA	voltampere
VAC	volts AC
VCO	voltage-controlled oscillator
VDC	volts DC
V/F	voltage-to-frequency
VFO	variable-frequency oscillator
VHF	very high frequency
VLF	very low frequency
VMOS	vertical metal-oxide semiconductor
VOM	volt-ohm-milliammeter
VOX	voice-operated transmission
VRMS	volts RMS
VSWR	voltage standing-wave ratio
VTR	videotape recording
VTVM	vacuum-tube voltmeter
VU	volume unit
VVC	voltage-variable capacitor
VXO	variable-frequency crystal oscillator
W	watt
Wh	watthour
WPM	words per minute
WRMS	watts RMS
Ws	wattsecond
Z	impedance

Abbreviations on Diagrams. Some foreign publications, including *Wireless World,* shorten the abbreviations for units of measure on diagrams. Thus, μ after a capacitor value represents μF, n is nF, and p is pF. With resistor values, k is thousand ohms, M is megohms, and absence of a unit of measure is ohms. For a decimal value, the letter for the unit of measure is sometimes placed at the location of the decimal point. Thus, 3k3 is 3.3 kilohms or 3,300 ohms, 2M2 is 2.2 megohms, 4μ7 is 4.7 μF, 0μ1 is 0.1 μF, and 4n7 is 4.7 nF.

Semiconductor Symbols Used



The commonest forms of the basic semiconductor symbols are shown here. Leads are identified where appropriate, for convenient reference. Minor variations in symbols, particularly those from foreign sources, can be recognized by comparing with these symbols while noting positions and directions of solid arrows with respect to other symbol elements.

Omission of the circle around a symbol has no significance. Arrows are sometimes drawn open instead of solid. Thicker lines and open rectangles in some symbols on diagrams have no significance. Orientation of symbols is unimportant; artists choose the position that is most convenient for making connections to other parts of the circuit. Arrow lines outside optoelectronic symbols indicate the direction of light rays.

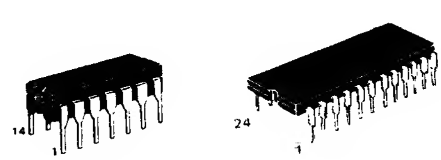
On some European diagrams, the position of the letter k gives the location of the decimal point for a resistor value in kilohms. Thus, 2k2 is 2.2K or 2,200 ohms. Similarly, a resistance of 1R5 is 1.5 ohms, 1M2 is 1.2 megohms, and 3n3 is 3.3 nanofarads.

Substitutions can often be made for semiconductor and IC types specified on diagrams. Newer components, not available when the original source article was published, may actually improve the performance of a particular circuit. Electrical characteristics, terminal connections, and such critical ratings as voltage, current, frequency, and duty cycle, must of course be taken into account if experimenting without referring to substitution guides.

Semiconductor, integrated-circuit, and tube substitution guides can usually be purchased at electronic parts supply stores.

Not all circuits give power connections and pin locations for ICs, but this information can be obtained from manufacturer data sheets. Alternatively, browsing through other circuits may turn up another circuit on which the desired connections are shown for the same IC.

When looking down at the top of an actual IC, numbering normally starts with 1 for the first pin *counterclockwise* from the notched or otherwise marked end and continues sequentially. The highest number is therefore next to the notch on the other side of the IC, as illustrated in the sketches below. (*Actual positions* of pins are rarely shown on schematic diagrams.)



Addresses of Sources Used

In the citation at the end of each abstract, the title of a magazine is set in italics. The title of a book or report is placed in quotes. Each source title is followed by the name of the publisher of the original material, plus city and state. Complete mailing addresses of all sources are given below, for the convenience of readers who want to write to the original publisher of a particular circuit. When writing, give the complete citation, exactly as in the abstract.

Books can be ordered from their publishers, after first writing for prices of the books desired. Some electronics manufacturers also publish books and large reports for which charges are made. Many of the books cited as sources in this volume are also sold by bookstores and by electronics supply firms. Locations of these firms can be found in the YELLOW PAGES of telephone directories under headings such as "Electronic Equipment and Supplies" or "Television and Radio Supplies and Parts."

Only a few magazines have back issues on hand for sale, but most magazines will make copies of a specific article at a fixed charge per page or per article. When you write to a magazine publisher for prices of back issues or copies, give the *complete* citation, *exactly* as in the abstract. Include a stamped self-addressed envelope to make a reply more convenient.

If certain magazines consistently publish the types of circuits in which you are interested, use the addresses below to write for subscription rates.

American Microsystems, Inc., 3800 Homestead Rd., Santa Clara, CA 95051
Audio, 401 North Broad St., Philadelphia, PA 19108
BYTE, 70 Main St., Peterborough, NH 03458
Computer Design, 11 Goldsmith St., Littleton, MA 01460
CQ, 14 Vanderventer Ave., Port Washington, L.I., NY 11050
Delco Electronics, 700 East Firmin, Kokomo, IN 46901
Dialight Corp., 203 Harrison Place, Brooklyn, NY 11237
EDN, 221 Columbus Ave., Boston, MA 02116
Electronics, 1221 Avenue of the Americas, New York, NY 10020
Electronic Servicing, 9221 Quivira Rd., P.O. Box 12901, Overland Park, KS 66212
Exar Integrated Systems, Inc., 750 Palomar Ave., Sunnyvale, CA 94086
Ham Radio, Greenville, NH 03048
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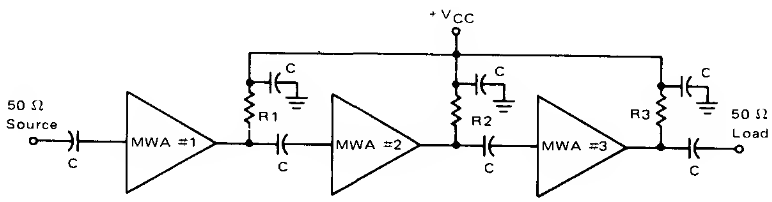
Motorola Semiconductor Products Inc., Box 20912, Phoenix, AZ 85036
Mullard Limited, Mullard House, Torrington Place, London WC1E 7HD, England
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051
Optical Electronics Inc., P.O. Box 11140, Tucson, AZ 85734
Popular Science, 380 Madison Ave., New York, NY 10017
Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, CA 95050
QST, American Radio Relay League, 225 Main St., Newington, CT 06111
Radio Shack, 1100 One Tandy Center, Fort Worth, TX 76102
Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94042
RCA Solid State Division, Box 3200, Somerville, NJ 08876
Howard W. Sams & Co. Inc., 4300 West 62nd St., Indianapolis, IN 46206
73 Magazine, Peterborough, NH 03458
Siemens Corp., Components Group, 186 Wood Ave. South, Iselin, NJ 08830
Signetics Corp., 811 East Arques Ave., Sunnyvale, CA 94086
Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054
Sprague Electric Co., 479 Marshall St., North Adams, MA 01247
Teledyne Philbrick, Allied Drive at Route 128, Dedham, MA 02026
Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94040
Texas Instruments Inc., P.O. Box 5012, Dallas, TX 75222
TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260
Unitrode Corp., 580 Pleasant St., Watertown, MA 02172
Wireless World, Dorset House, Stamford St., London SE1 9LU, England

MODERN ELECTRONIC CIRCUITS REFERENCE MANUAL

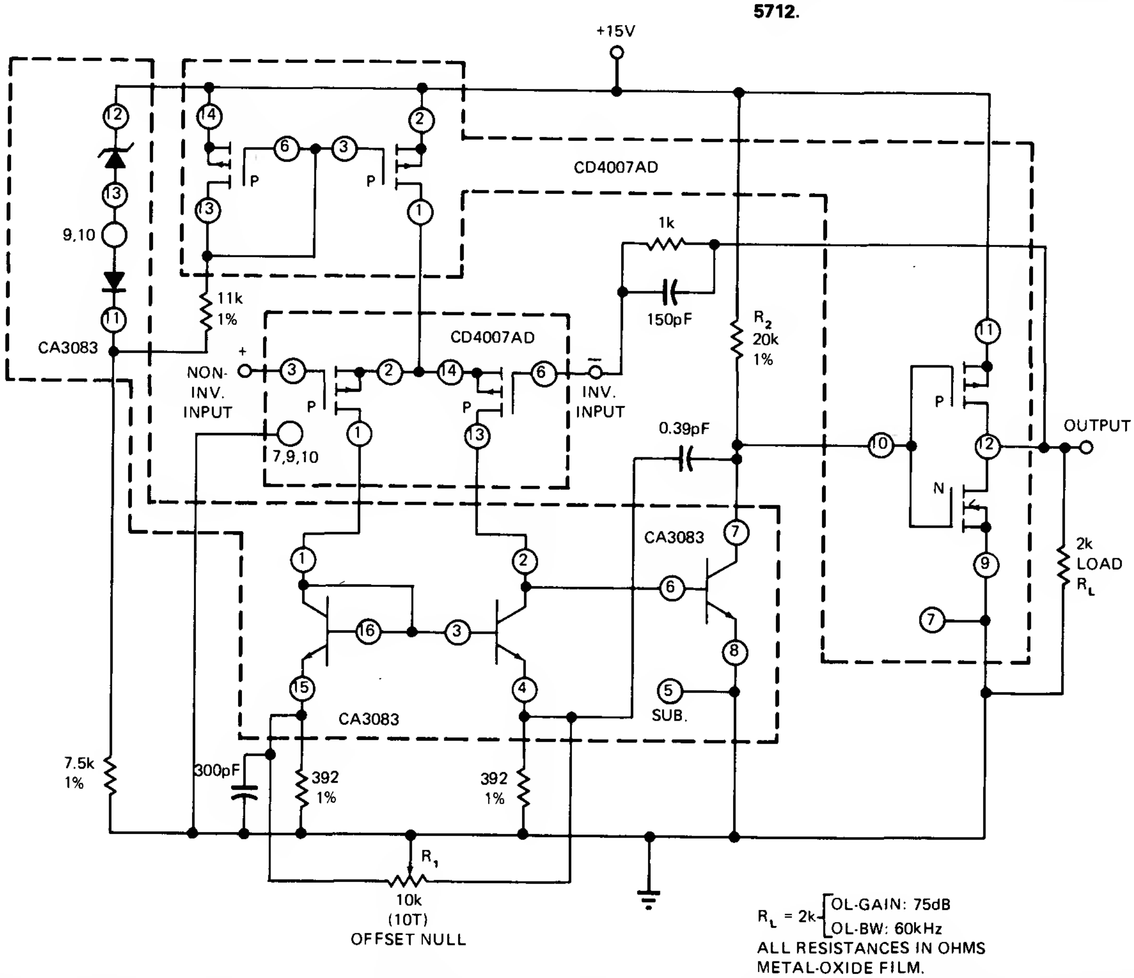
CHAPTER 1

Amplifier Circuits

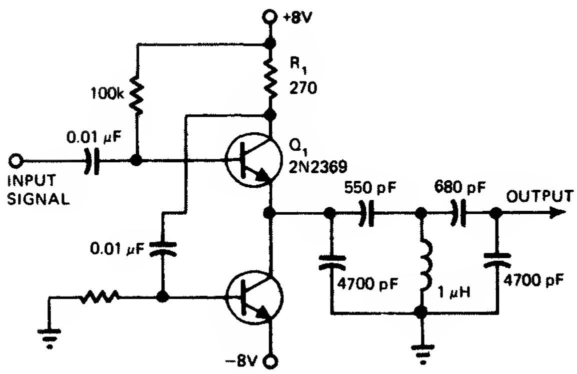
Includes general-purpose RF amplifiers covering various portions of spectrum from DC to 2.3 GHz at outputs up to 230 W, some with voltage-controlled gain, for pulses as well as video and other RF signals. See other chapters in book for RF amplifiers having specific applications.



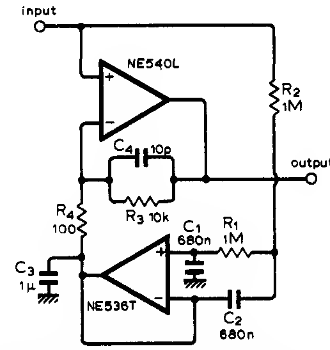
0.25–400 MHz CASCADE—Three hybrid modules in cascade provide gain of 43.5 dB with flatness of ±1 dB over frequency range. Circuit draws 44 mA from 12-VDC supply. Modules 1 and 2 are Motorola MWA110, and module 3 is MWA120. All capacitors are 0.018 μF. R1 and R2 are 1K, and R3 is 300 ohms.—"Wideband Hybrid Amplifiers," Motorola, Phoenix, AZ, 1978, DS 5712.



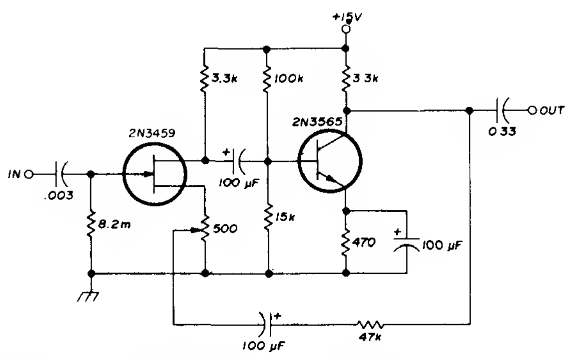
CMOS/BIPOLAR VOLTAGE FOLLOWER—Combination of two 4007 CMOS gate packages and one CA3083 transistor package provides gain of about 75 dB as voltage-follower amplifier and bandwidth of 50 kHz. Slew rate is about 30 V/μs, and settling time is 2 μs. Requires only single +15 V supply. Can be driven to within 1 mV of ground. Interfaces well with single-supply D/A converters.—B. Furlow, CMOS Gates In Linear Applications: The Results Are Surprisingly Good, *EDN Magazine*, March 5, 1973, p 42–48.



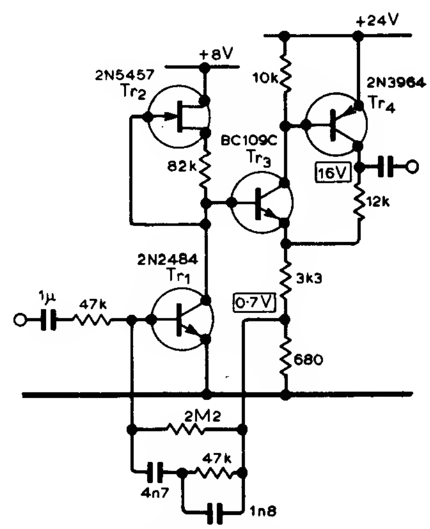
CAPACITIVE-LOAD EMITTER-FOLLOWER—Overcomes problem that develops with treiling edgee of pulses when emitter-follower using NPN transistor is driving heavily capacitive loed. Extre transistor is used to dump capacitor charge when emitter-follower stops conducting at trailing edge of input waveform. Pulse trailing edge thus tends to cut off Q_1 and saturete lowar transistor so it discharges cepacitor. Circuit works equelly wall with pulses, square wavea, and sine waves. Transistors need not be metched. Reverse polarity of supplies to use PNP transistors. Useful for driving long coax lines or logic from high-impedance aource, without inversion.—H. L. Morgen, Emitter Follower's Fall Time Is Independent of Load, *EDN Magazine*, Feb. 5, 1977, p 105.



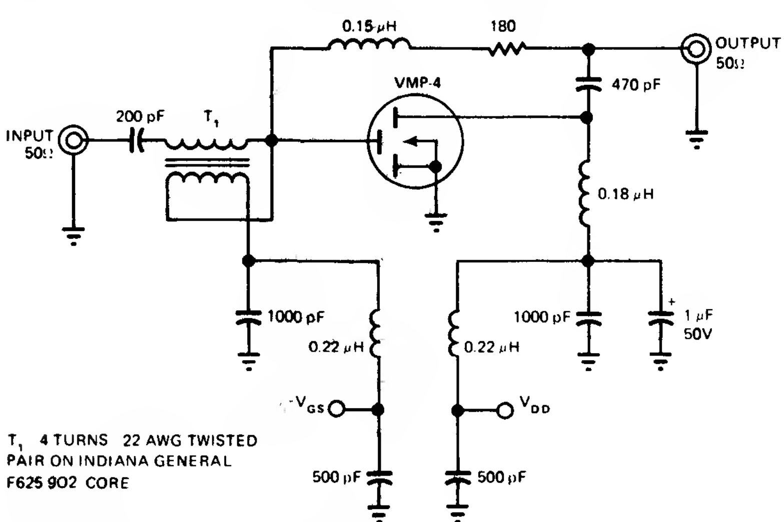
AC WITH IMMUNITY TO LARGE DC OFFSET—Designed to emplify from about 250 kHz down to low frequencias in presenca of lerge DC input offsets. Main NE540L amplifier hes gain of 101, while NE536T has DC gein of unity and forms part of low-pess network that applies DC input offset as common-mode voltage to inverting input of mein amplifier.—A. Royston, Low Frequency A.C. Amplifiar, *Wireless World*, May 1976, p 80.



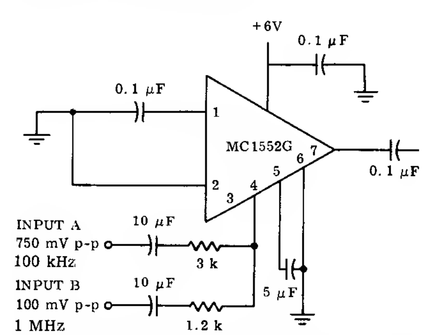
BASIC FEEDBACK AMPLIFIER—Combination of unipoler and bipolar transistors gives desirable amplifying features of each solid-stata device. Circuit can be optimized for RF or AF by adjusting coupling, feedbeck, and amitter bypess cepacitor values. Changea in feedback effact distortion, frequency reaponse, end gain stability. To optimiza for RF, raduce capecitor sizes. For both AF end RF responae, capacitors shown can be peralleled by small ceremic or Mylar units. If FET end bipolar are selected for high transconductance and high gain-bandwidth product, ovarall voltage gain can be 20 or more for frequencies up to aeveral megahertz.—I. M. Gottlieb, A New Look at Solid-State Amplifiers, *Ham Radio*, Feb. 1976, p 16–19.



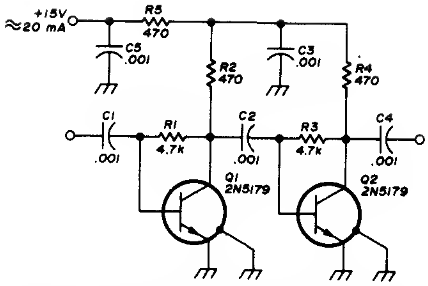
SMALL-SIGNAL AMPLIFIER—Combines features of virtual-earth and high-input-impedance amplifiers economically for euch applications as e record emplifier, end provides severel timas tha gain of e virtual-earth emplifier alona.—D. Rewson-Herrls, Small Signal Amplifiar, *Wireless World*, Feb. 1977, p 45.



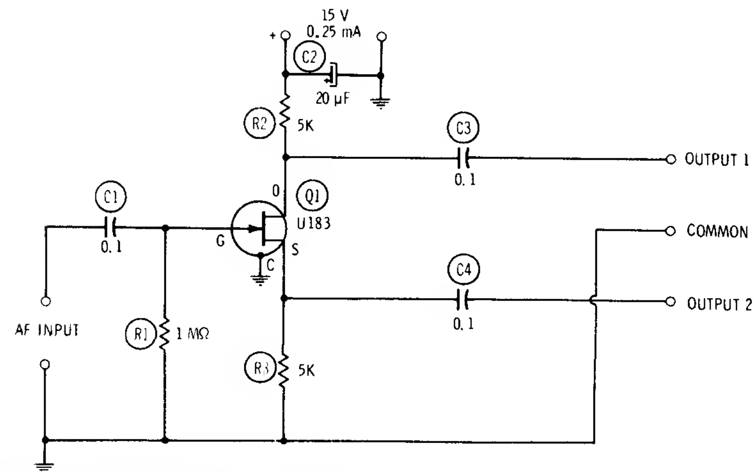
13 W at 160 MHz—Circuit uses Siliconix VMP-4 power MOSFET to provide 11-dB gain with 28-V supply, or 14 dB with 36-V supply. Broadband design permits operation over wide range of frequencies up to as high as 600 MHz.—RF Power MOSFET Outputs 13 W at 160 MHz with High Gain, No Breakdown, *EDN Magazine*, June 20, 1976, p 144–145.



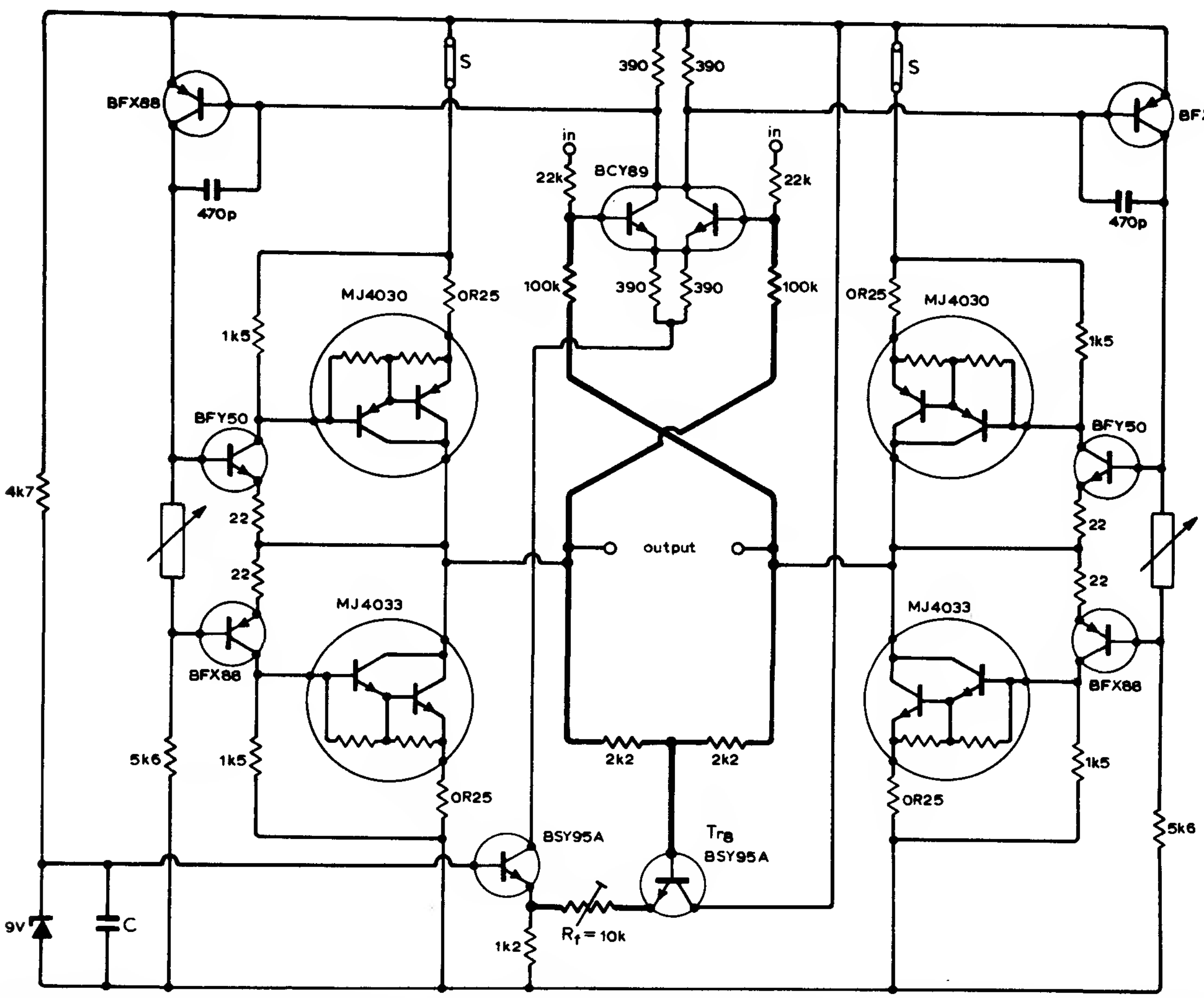
SUMMING/SCALING VIDEO—With Motorola MC1552G video amplifiar connected as shown, summation of input signal currents is accomplished et pin 4 through input resistors whose values are chosen to give desired scale factor.—"A Wide Band Monolithic Video Amplifier," Motorola, Phoenix, AZ, 1973, AN-404, p 9.



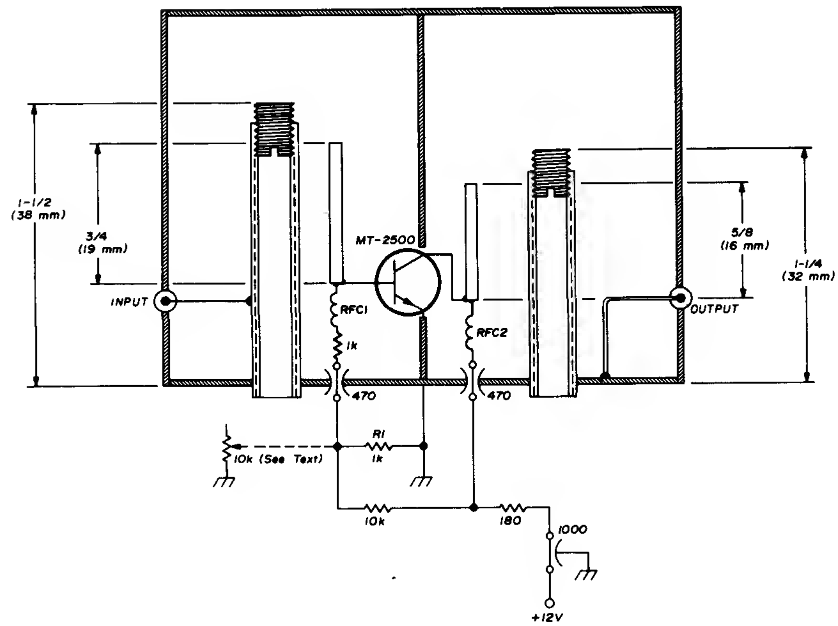
500 kHz TO 500 MHz—Two-stage general-purpose wideband small-signal amplifier provides nearly 14-dB gain at 150 MHz when inserted in 50-ohm transmission line with no tuned circuits at input or output. Noise figure with optimum source resistance is about 3 dB at 150 MHz. Amplifier is capacitively coupled common-emitter cascade. Capacitors make low-frequency gain begin dropping off below about 2 MHz. Increasing all capacitors to 0.01 μF will lower frequency response to about 200 kHz.—R. Rhee, General Purpose Wideband RF Amplifier, *Ham Radio*, April 1975, p 58–61.



PARAPHASE PHASE INVERTER—Uses 180° phase difference between source and drain outputs of Siliconix U183 FET to convert AF input to push-pull output without transformer. Voltage gain in each half of circuit is about 0.8. Frequency response referred to 1 kHz is flat within 3 dB from 50 Hz to 50 kHz, when using 1-meg-ohm output load.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 29–30.

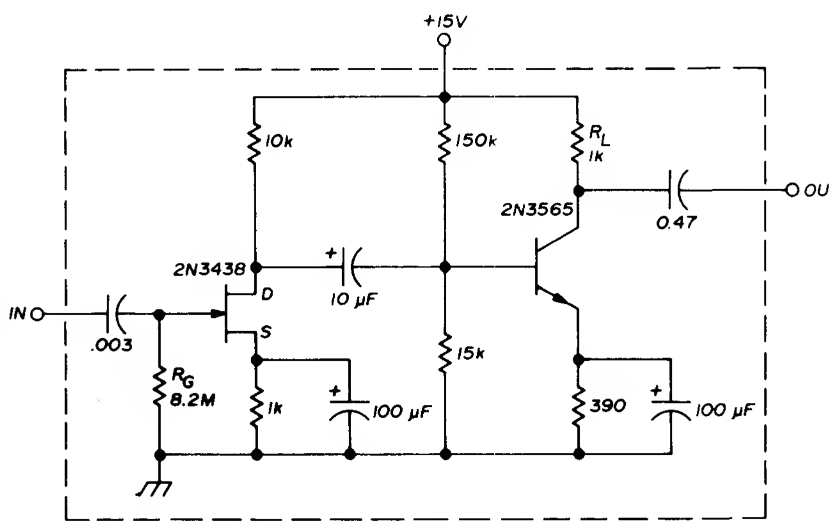


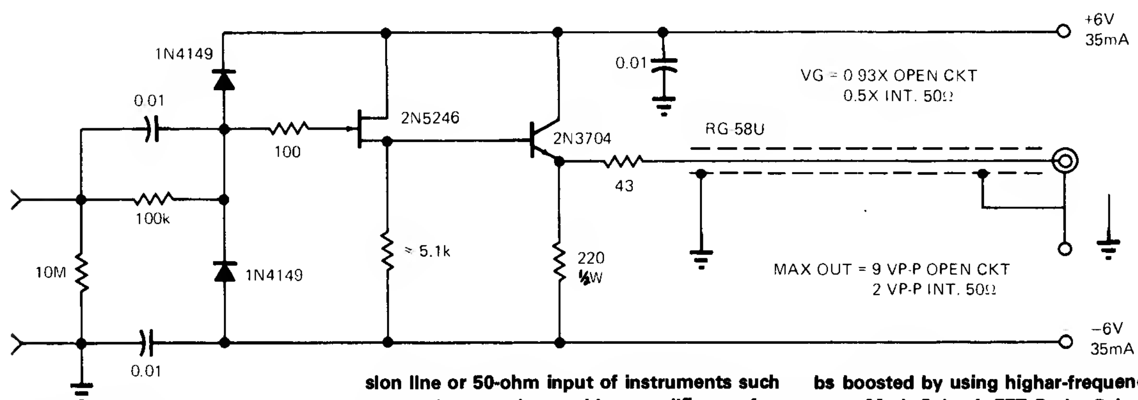
230-W WATER-COOLED—Used to excite magnetic specimens in frequency range of 0 to 110 kHz at outputs up to 12 A. Output stage uses two complementary pairs of emitter-followers connected so each pair forms half of bridge, using MJ4030 and MJ4033 Darlingtons mounted on liquid-cooled heatsinks. Article describes cooling arrangement and circuit operation in detail and gives suitable preamp circuit for driving inputs of BCY89 dual transistor. Designed for 32-VDC supply, which connects to top and bottom horizontal buses on diagram. Feedback circuits are drawn in heavy lines. Resistors in series with Darlingtons (0R25, representing 0.25 ohm) are wound from resistance wire since they must carry large currents. Output impedance of circuit is less than 0.5 ohm, for matching to low-resistance load.—I. L. Stefani and R. Parrymen, Liquid-Cooled Power Amplifier, *Wireless World*, Dec. 1974, p 505–507.



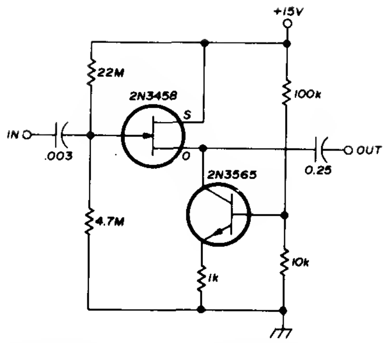
2304-MHz PREAMP—Nsrrow-bsnd stsge using Fairchild MT-2500 bipolsr transistor givas gsin of 6 to 9 dB and noise figure of 2.5 to 4.5 dB. Cavity resonators at both input and output give excellent frequency selectivity. Simllsr circuit can be used with Fairchild MT-4500, FMT-4005, or equivalent newar stripline-type transistors. RFC1 is 3 turns and RFC2 is 5 turns, sir-wound with No. 26 ensmal by using No. 52 drill as mandrel. Coupling strips on base and collector of transistor sre 0.25-mm brass shim stock. Articls gives construction and tune-up details, slong with altemate design for HP-35821E snd HP-35862E transistors using coupling loops. 10K pot is used only during tuna-up.—N. J. Foot, Nerrow-Band Solid-State 2304-MHz Preamplifiers, *Ham Radio*, July 1974, p 6–11.

MULTIPURPOSE MODULE—Flexible circuit using FET to driva bipolar transistor has −3 dB points st 100 Hz and 0.6 MHz. Components are noncritical and can be changed considerably in value to optimize gain, frequency response, powar output, or power consumption. Load presented to FET is primarily input resistance of bipolar transistor, ebout 1000 ohms, which gives voltags gein of 4 for FET.—I. M. Gottlieb, A New Look at Solid-Stats Amplifiers, *Ham Radio*, Feb. 1976, p 16–19.

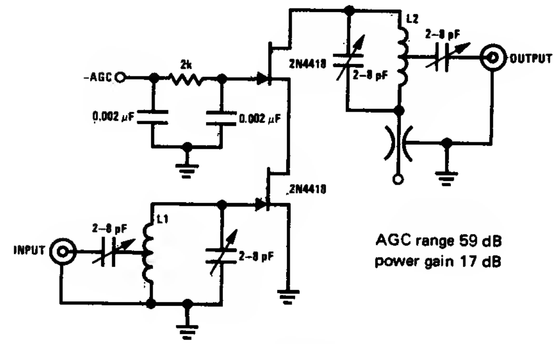




IMPEDANCE CONVERTER—Used to match 10-megohm input impedance to 50-ohm transmission line or 50-ohm input of instruments such as spectrum snalyzsr, video smplifier, or frequency counter. Voltage gsin is sxactly 0.5. Frequency response is from DC to 20 MHz and csn bs boosted by using highar-frequency transistor.—M. J. Salvati, FET Probe Drives 50-Ohm Loed, *EDN Magazine*, Msrch 5, 1973, p 87 and 89.

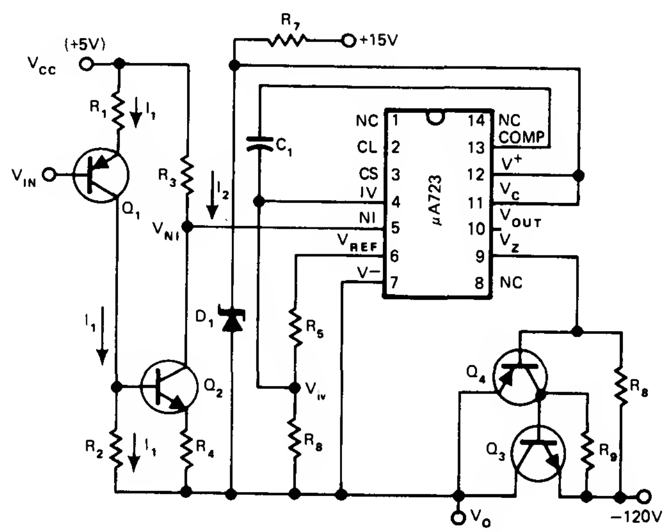


FET-BIPOLAR SOURCE FOLLOWER—Used where source follower with high output-voltage swing and voltage gain close to unity is required. Circuit has constant-current bias supply. Combination of unipoler and bipolar transistors givas desireble emplifying feeturas of eech solid-state davica.—I. M. Gottlieb, A New Look at Solid-State Amplifiers, *Ham Radio*, Fab. 1976, p 16–19.



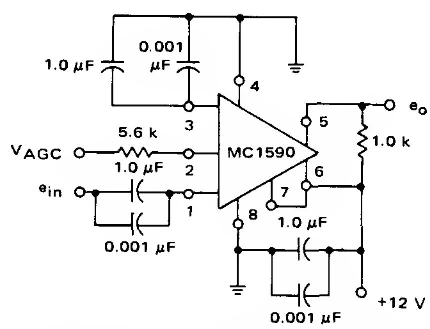
L1 = 0.07 μHy center tap
L2 = 0.07 μHy tap 1/4 up from ground

200-MHz CASCODE—JFETs give low cross-modulation, large signal-handling ability, end AGC ection controlled by biasing uppar cascode JFET. Neutralization is not needed.—"FET Databook," Netional Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

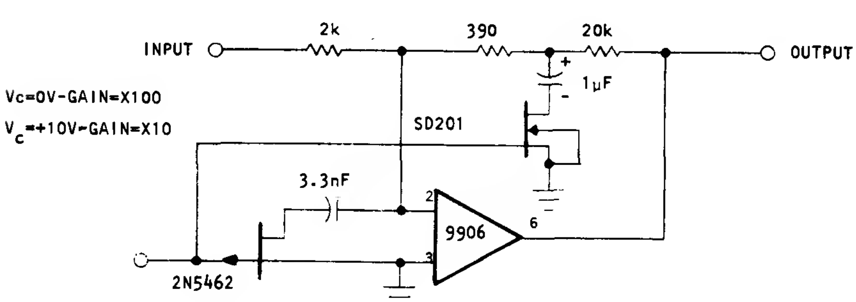


Q_1, Q_4	:	2N3931	R_1	:	3.09k, 1%
Q_2	:	2N3563	R_2, R_7	:	510, 1%
Q_3	:	2N3773	R_3	:	100k, 1%
D_1	:	1N759	R_4	:	1k, 1%
C_1	:	100 pF	R_5, R_6	:	5k, 1%
			R_8	:	10k, 5%
			R_9	:	330, 5%

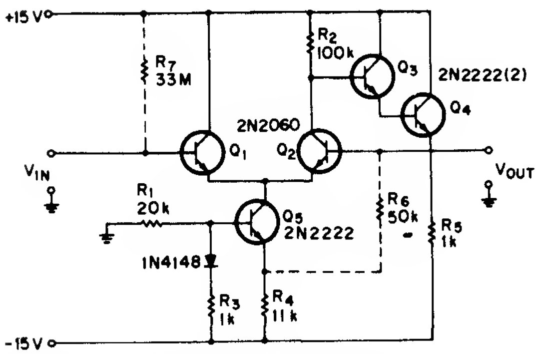
HIGH-VOLTAGE BUFFER—Circuit shown for μA723 voltege regulator permits use as high-voltaga and high-currant buffer in linaer applications. Powar dissipation of output trensistor Q_3 is only limiting factor. I_1 is proportional to V_{IN}, I_2 is proportional to I_1, end output voltage V_0 is proportional to I_2 and V_{IN}.—G. Niu, Single Op Amp Implements High-Voltage/Current Buffer, *EDN Magazine*, Oct. 5, 1977, p 96 and 98.



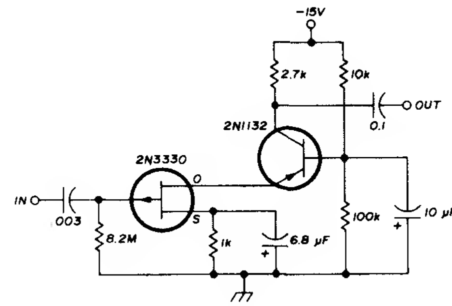
VIDEO AMPLIFIER—AGC capability of Motorola MC1590G makes it highly suitabla for wideband video amplifier applications. Voltaga gein is ebout 25 dB up to 50 MHz for 100-ohm load and 45 dB up to 10 MHz for 1K loed. Sevaral circuits can ba cascaded to increasa gain, using cepacitive coupling.—B. Trout, "A High Gain Integrated Circuit RF-IF Amplifiar with Wida Range AGC," Motorola, Phoenix, AZ, 1975, AN-513, p 9.



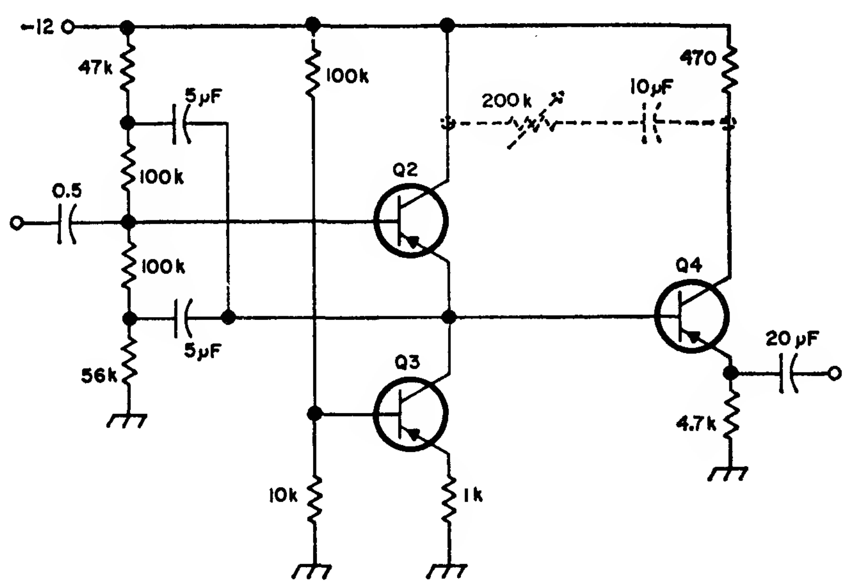
WIDEBAND VARIABLE GAIN—FET serves as gein-controlled device in feedback loop of Opticel Electronics 9906 opamp. Resistiva T network has SD201 MOS transistor as ground leg, with resistor values chosen so transistor is alectrically closa to summing junction, automatically limiting total signel voltage. Resulting arrengament of voltage-controlled faedback and compensation gives variable-gain amplifier with good linearity end constant wideband width for all gein levels.—"Wideband Verieble Gain Amplifiar," Optical Electronics, Tucson, AZ, Application Tip 10277.



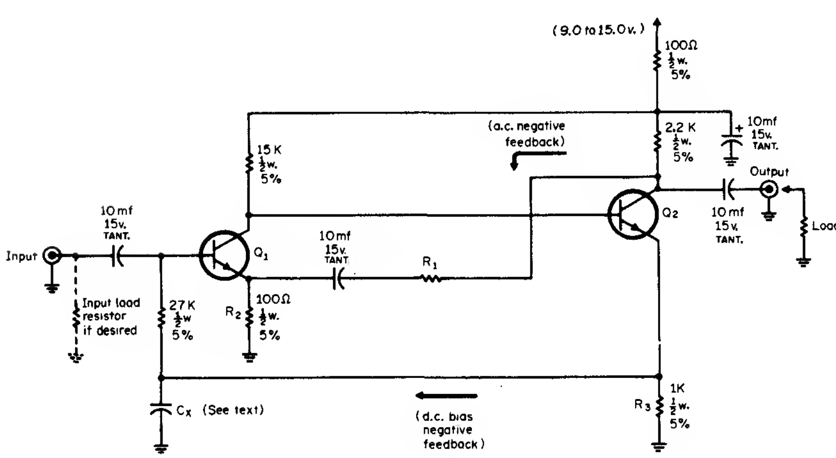
UNITY-GAIN VOLTAGE FOLLOWER—Measured gain is 0.9997 V/V with an error of ±0.1% over ±1.5 V swing. Circuit has infinite input impedance and zero bias current. Addition of dashed components to simple voltage-follower design gives near-perfect performance.—C. Andren, The Ideal Voltage Follower, *EEE Magazine*, Jan. 1971, p 63–64.



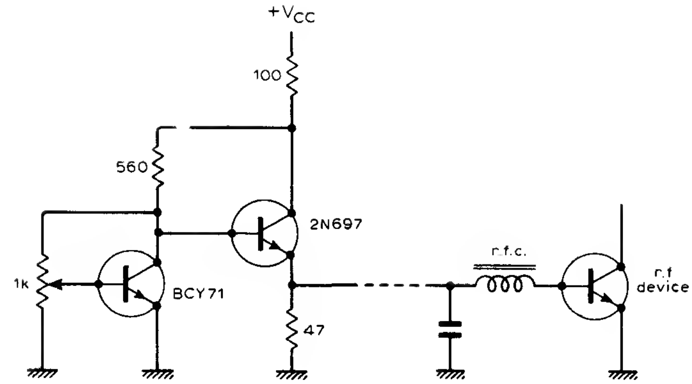
CASCODE—Combination of unipolar and bipolar transistors gives desirable amplifying features of each solid-state device. Ideal for use with tuned circuits in audio, video, IF, and RF applications.—I. M. Gottlieb, A New Look at Solid-State Amplifiers, *Ham Radio*, Feb. 1976, p 16–19.



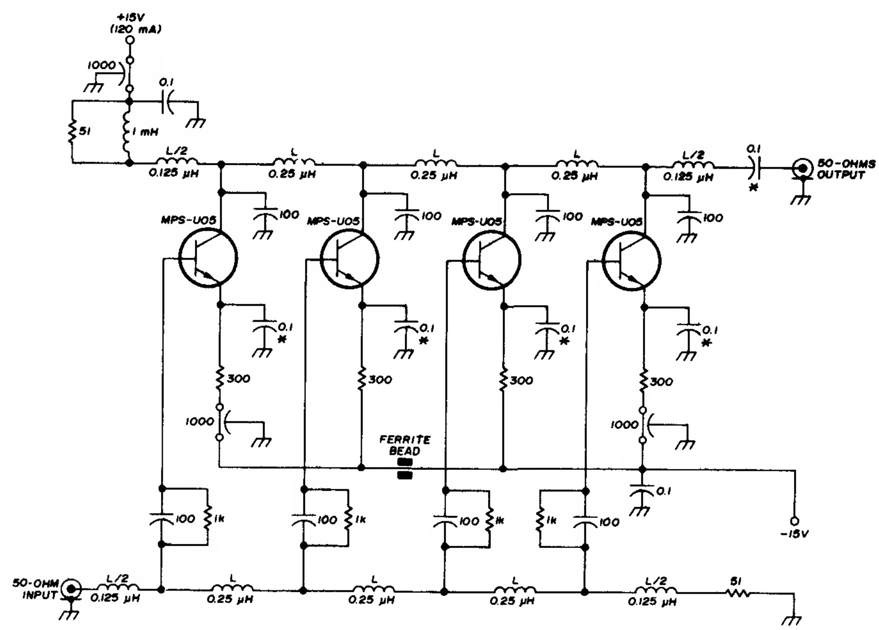
HIGH-Z PREAMP—Provides up to 20 megohms of input impedance and has essentially flat response from 10 Hz to 220 MHz. Q3 serves as emitter resistor for Q2, and emitter-follower Q4 reduces loading. Input impedance is further increased by adding optional components shown in dashed lines. Transistors are 2N2188, SK3005, GE-9, or HEP-2.—Circuits, *73 Magazine*, Feb. 1974, p 102.



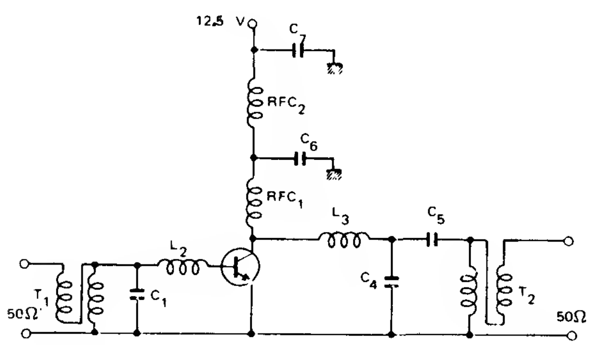
10-dB GAIN AT 0.01–100 MHz—High-gain wideband untuned general-purpose amplifier uses Fairchild 2N5126 or equivalent transistors in direct-coupled circuit. Design is stable for both power supply and temperature variations. Gain is adjusted with R_1, with maximum of 38 to 44 dB and maximum output of about 1 V P-P. Will drive low-level transistor circuits having load of about 1000 ohms. If several amplifiers are used in series for higher gain, shielding is required. Applications include amplification of pulsed light signals detected by photodiode. C_x can be 100-pF mica.—A. B. Hutchison, Jr., General Purpose Wide Band Amplifier, *CQ*, May 1972, p 22–23.



BIAS SUPPLY FOR CLASS AB—Two-transistor supply using PNP silicon transistor as amplified dioda variable-voltage source givas improved-parformance transistor RF powar amplifiar operating in class AB linaar moda. Transistor types ara not critical. Output impadanca of bias sourca is about 1 ohm, and output voltaga changas only up to 3½% for ±2.5 V changa in Input voltaga V_{CC}.—C. P. Bartram, Bias Supply for R.F. Powar Amplifiars, *Wireless World*, April 1976, p 61.



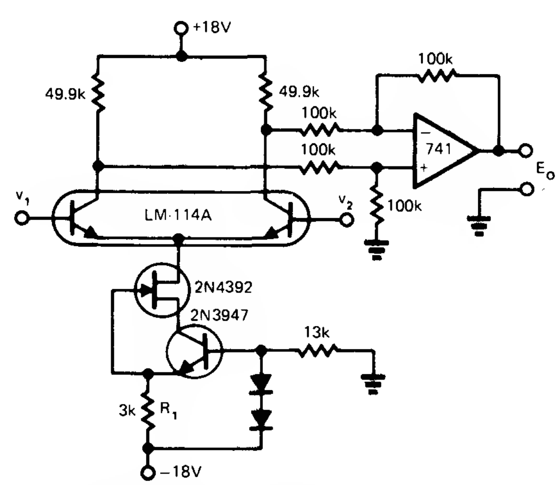
1–36 MHz DISTRIBUTED—Providas 18-dB gain over antira frequancy ranga without use of special ferrita transformars. Gain contribution of each transistor, In phasa with amplified wave as it passes down artificial transmission lina, adds to that of other transistors. Capacitors marked with asterisks ara low-inductanca ceramic types such as Eria Redcap. Delay-lina inductors L ara 12 turns No. 24 closewound on ⅛-inch diametar Lucita rod, and L/2 units ara 7 turns. Can ba used as praamp for frequency counter and as auxiliary for othar test aquipment. Articla covers construction, haatsinking of transistor, and testing.—H. Olson, Wide-Range Broadband Amplifier, *Ham Radio*, April 1974, p 40–44.



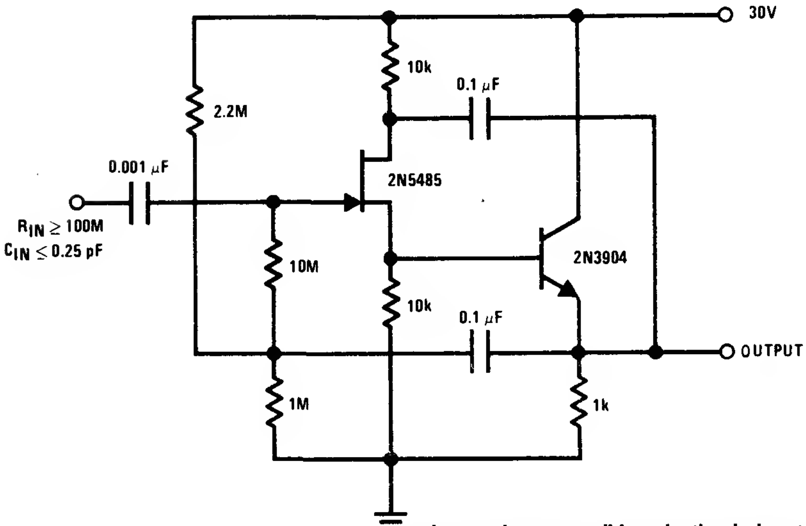
C_1 = 300 pF (chip)
L_2 = 4.2 nH (adjust)
L_3 = 8 nH (adjust)
C_4 = 130 pF (chip)
C_5 = 750 pF (chip)
C_6 = 2.2 µF

T_1 T_2
RFC_1 = 7 turns
6.3 mm coil diameter
0.8 mm wire diameter
RFC_2 = 3 turns on ferrite bead
C_7 = 0.68 µF

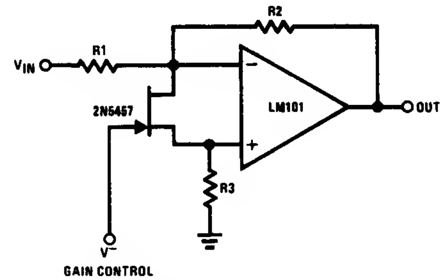
118-136 MHz BROADBAND—Designed for low-level amplituda modulation system. 50-ohm lina transformers ara wound with coppar ribbon on ferrite cora to giva 4:1 ratio. Design and construction procedures are covared. Transistor is Motorola 2N6083, rated 30 W for 4-W input.—B. Becciolini, "Impedance Matching Networks Applied to R-F Powar Transistors," Motorola, Phoenix, AZ, 1974, AN-721, p 17.



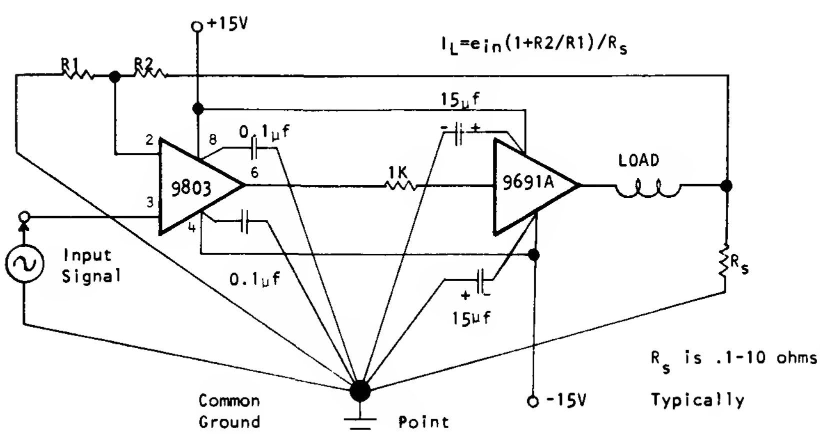
DIFFERENTIAL PAIR—Conventional differential amplifier circuit provides differential-moda gain of 96, common-mode input resistance of 500 megohms, CMRR of 106 dB, and current-sourca output resistence greater then 1 gigohm. Article givas design equations.—R. C. Jaeger and G. A. Hellwarth, Differential Cascode Amplifier Offers Unique Adventages, *EDN Magazine*, June 5, 1974, p 78 and 80.



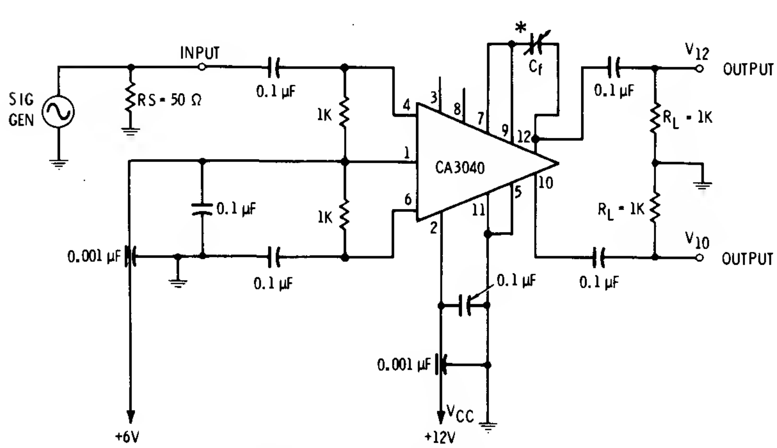
HIGH INPUT IMPEDANCE—Simple JFET input circuit is operated as source follower with bootstrapped gate bies resistor and drain to give maximum possible reduction in input capacitence. Used es unity-gein AC amplifier.—"FET Detabook," Netional Semiconductor, Senta Clara, CA, 1977, p 6-26–6-36.



VOLTAGE-CONTROLLED GAIN—2N5457 FET acts as voltage-variable resistor between differential input terminals of opamp. Resistence variation is linaar with voltege over severel decades of resistance, to give excellent electronic gain control. Values of resistors depend on opamp used.—"FET Detebook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

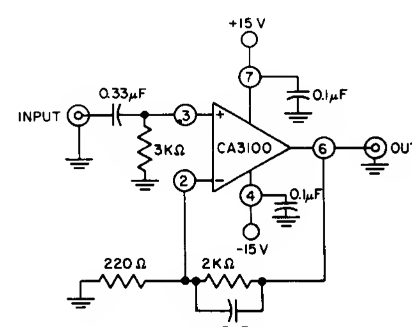


100 W FOR DC TO 500 kHz—Circuit using Optical Electronics opamps has high input impedance, high gain capability, and 100-W output capacity without use of transformers, for high-fidelity audio circuits, cathode-ray daflection circuits, end servosystems. Output currants up to 10 A requira heavy output wiring, large power-supply bypass capecity, and heavy common ground point. Loed is in feedbeck loop of opamp. Constant-current drive for load makes Impedance matching to loudspeaker unnecessary.—"A High Galn 100 Watt Amplifiar," Optical Electronics, Tucson, AZ, Application Tip 10205.

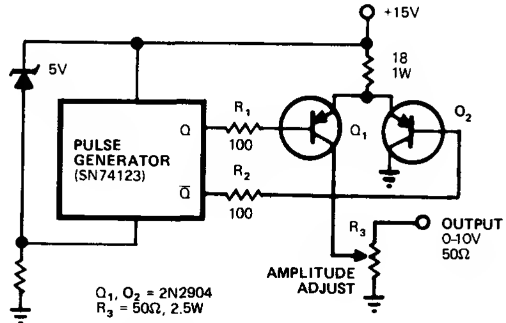


* VARIABLE CAPACITANCE (0.5-1.0 μF) ADJUSTMENT FOR EQUAL 3-dB BANDWIDTH AT AMPLIFIER OUTPUTS, TERMINALS 10 AND 12.

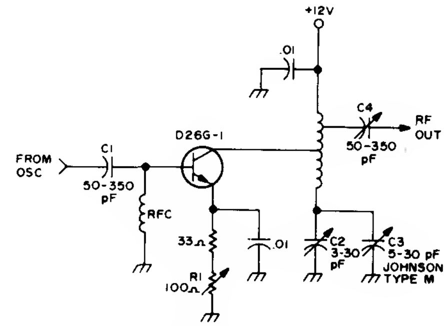
20-MHz WIDEBAND—RCA CA3040 IC is connected for single-ended input and balanced output, with no resonant circuits. Gain is above 30 dB over wida frequency range.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 162–163 and 168.



20-dB VIDEO—Simple circuit having gain of 20 dB provides 3-dB bandwidth of 20 MHz for CA3100 bipolar MOS opamp. Total noise referred to input is only 35 μVRMS.—"Circuit Ideas for RCA Linaer ICs," RCA Solid State Division, Somerville, NJ, 1977, p 12.

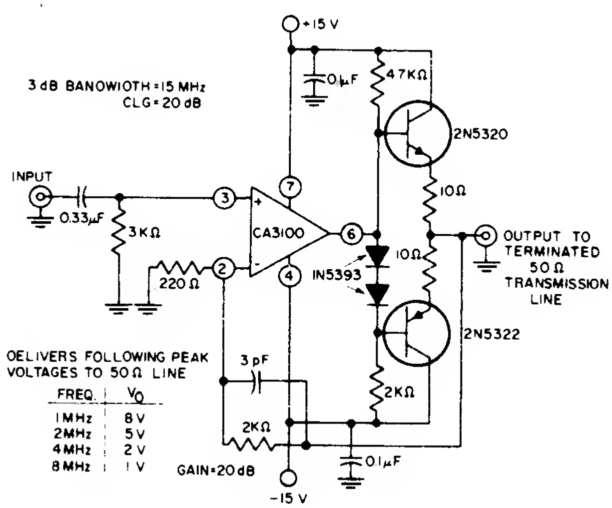


CONSTANT OUTPUT IMPEDANCE—Pulse output stage gives output range from millivolts to 10 V P-P across 50 ohms while optimizing waveform characteristics of output pulse. With 2N2904 output transistors, circuit delivers 200 mA with 20-ms rise and fall times.—W. A. Palm, Pulse Amplifier Varies Amplitude, *EDN Magazine*, Aug. 5, 1978, p 76.

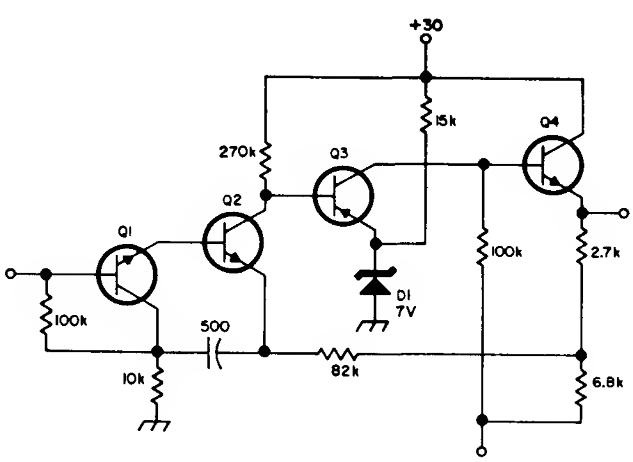


L1 = 9T AIRWOUND, 10 T.P.I.
COLLECTOR TAP AT CENTER.
OUTPUT TAP AT 1-3/4 TURNS

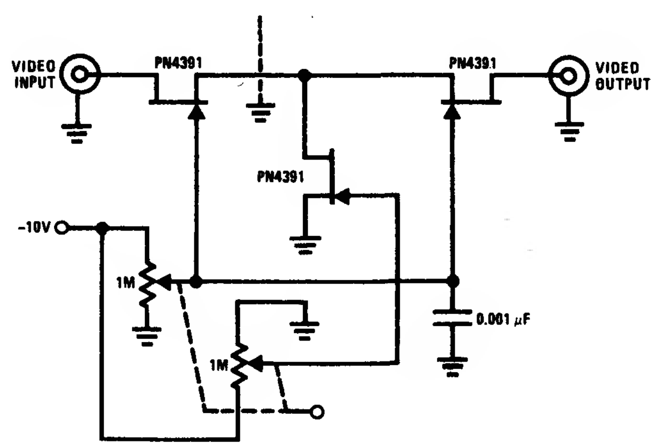
50-MHz POWER—Developed for use with 50-MHz microtransistor crystal oscillator, using additional GE microtransistor for boosting RF output to about 75 mW. Article covers construction with microcomponents and gives other microtransistor circuits for low-power amateur radio use and possible bugging applications.—B. Hoisington, Introduction to "Microtransistors," *73 Magazine*, Oct. 1974, p 24–30.



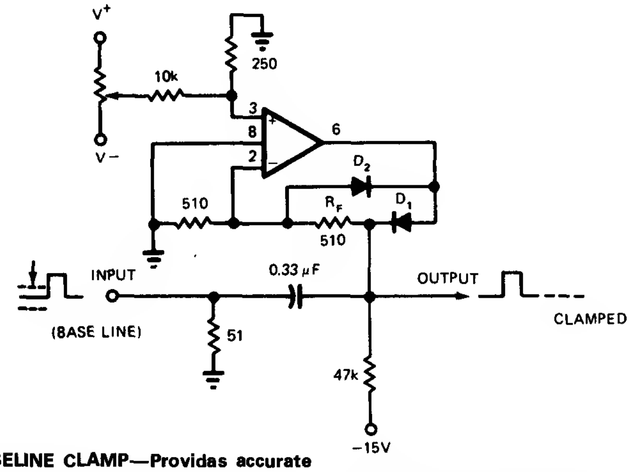
20-dB VIDEO LINE DRIVER—RCA CA3100 wideband opamp and power transistor output stage together provide gain of 20 dB at video frequencies for driving 50-ohm line. Peak output voltage ranges from 8 V at 1 MHz to 1 V at 8 MHz. Upper frequency limit for unity gain is about 38 MHz.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 225–227.



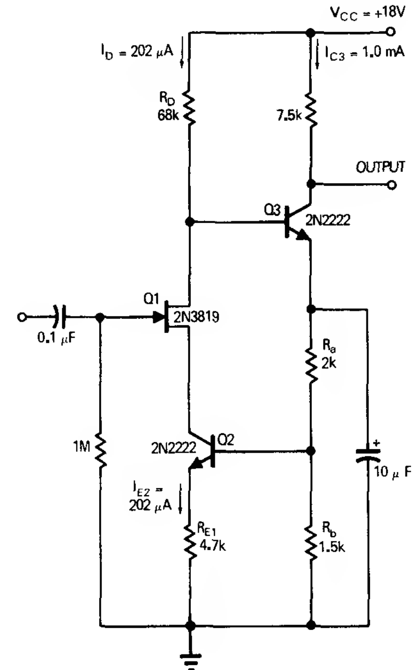
PREAMP FOR 0.5 Hz TO 2 MHz—Provides 11-dB gain over entire frequency range, with input impedance of 32 megohms. Q3 is GE-2 or HEP-52, and other transistors are SK3020 or HEP-53.—Circuits, *73 Magazine*, Jan. 1974, p 125.



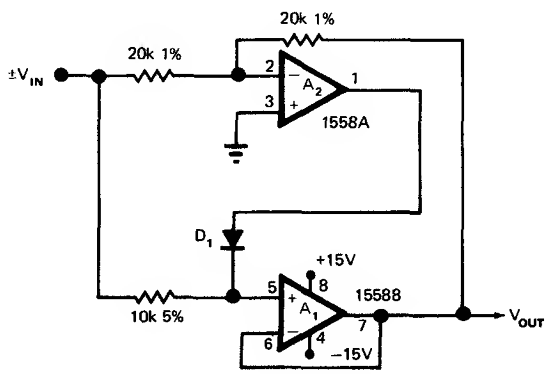
VIDEO ATTENUATOR—FETs in T attenuator provide optimum dynamic linear range for attenuation of video signals with ganged 1-megohm pots. If complete turnoff is desired, attenuation greater than 100 dB can be obtained at 10 MHz by using appropriate RF construction to minimize leakage. ON resistance of transistor (between drain and source) is less than 30 ohms.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



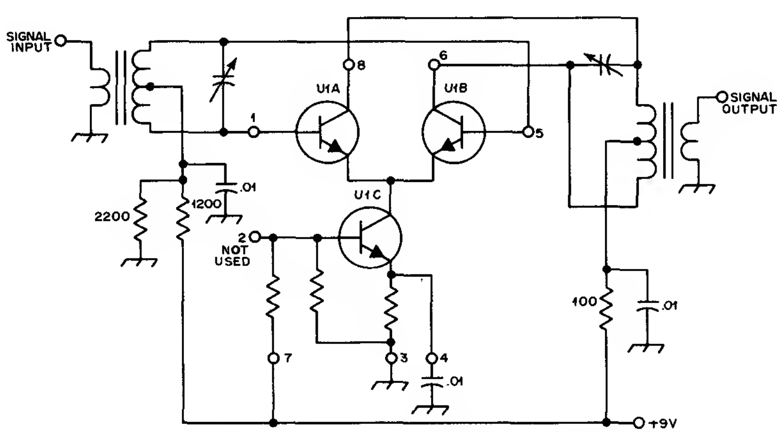
PULSE BASELINE CLAMP—Providas accurate clamping of baseline level of fast positiva-going digital pulses with constantly changing duty cycle when capacitively coupled into level-sensitive circuits. Uses HA-2535 opamp. Dioda D_2 clamps negative output swing of opamp to about 0.3 V, preserving amplifier recovery time in preparation for clamping next input transition. Pulse widths at input are less than 100 ns, with transition tima under 15 ns and duty cycla ranging from 2 to 50%. Diodes ara HP 2800 series. For clamping sine or triangle AF waves, opamp can be 741.—D. L. Quick, Clamp Speeds Restoration of AC-Coupled Base Lines, *EDN Magezine*, Sept. 5, 1975, p 76.



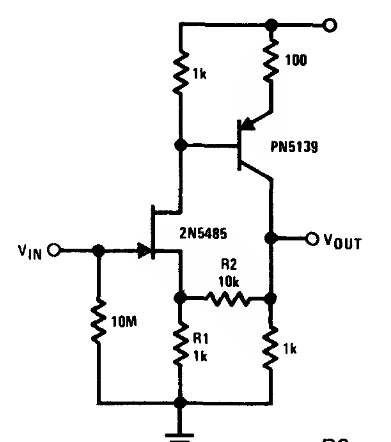
STABILIZED BIAS—Simple voltage-feedback loop stabilizes bias on direct-coupled FET and bipolar transistor stages. Arrangement uses constant-current source Q2 to maintain stable bias voltage on base of Q3. By choosing proper rasistor valuas, DC voltage feedback from emittar of bipolar is made to control constant-current value. Any change in drain current produces opposite change in constant-current value, for stabilizing bipolar. Article gives design equation.—H. T. Russell, DC Feedback Stabilizes Bias on FET/Bipolar Pair, *EDN Magazine*, Nov. 15, 1970, p 51.



POLARITY-IGNORING VOLTAGE FOLLOWER—Absolute-value circuit is basically voltage follower A_1 whose input is positive regardless of polarity of V_{IN}. With positiva input, Inverting amplifier A_2 is disconnected by D_1. With negative input, inverting amplifier applies positive input to voltage follower through D_1. Output voltage is thus absolute value of input voltage.—R. J. Wincentsen, Absolute Value Circuit Uses Only Fiva Parts, *EDN Magazine*, Nov. 1, 1972, p 44.

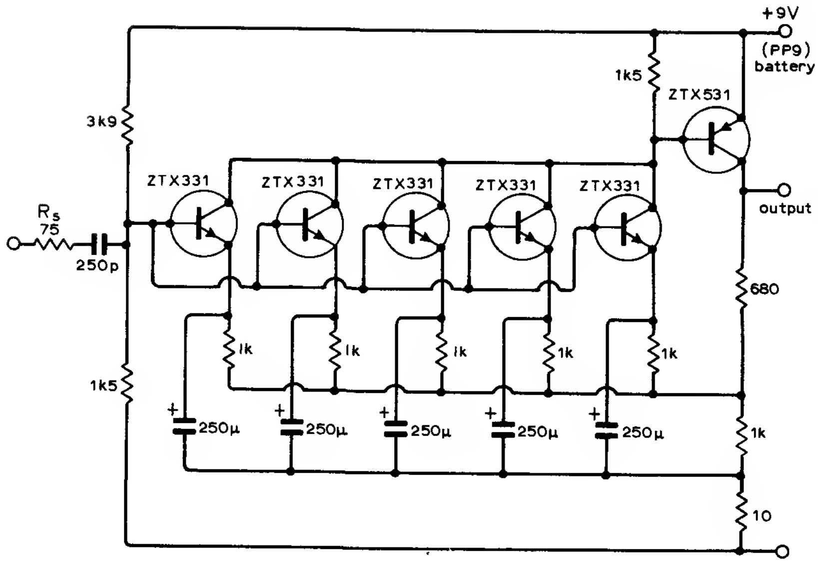


RF DIFFERENTIAL AMPLIFIER—Usas RCA CA3028A linear IC to provide power gain of about 32 dB at frequancies up to about 120 MHz. Values of tuned circuits depend on frequency used. Unmarked resistors are on IC. —D. DeMaw, Understanding Linear ICs, *QST*, Feb. 1977, p 19–23.

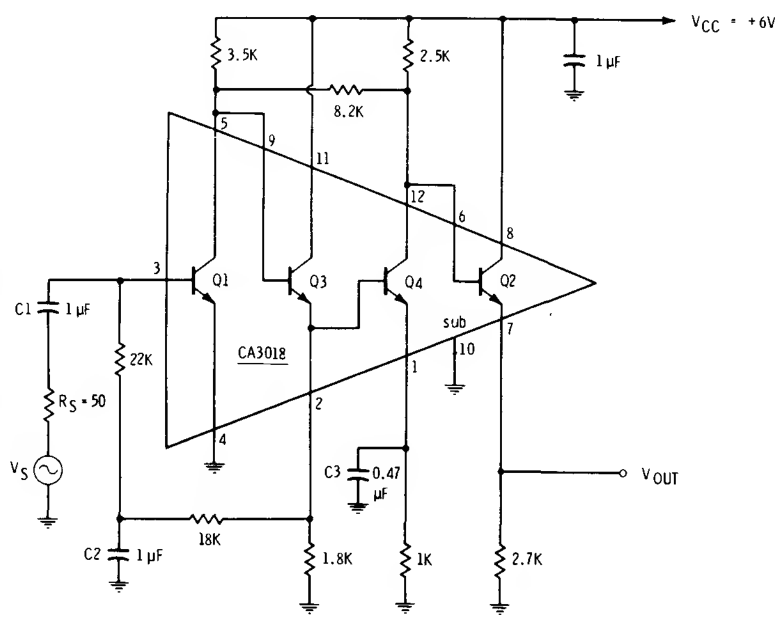


$$V_{OUT} \cong \frac{R2}{R1} V_{IN}$$

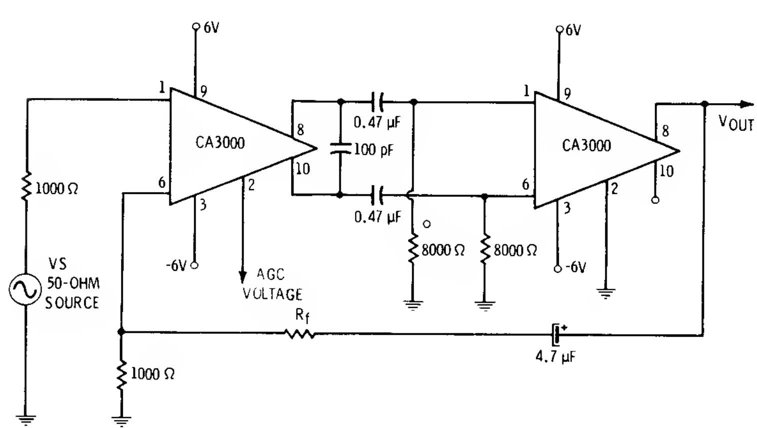
HIGH-IMPEDANCE VIDEO—Compound series-feedback circuit using FET at input provides high input impedance and stable widaband gain for general-purpose video amplifier applications.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



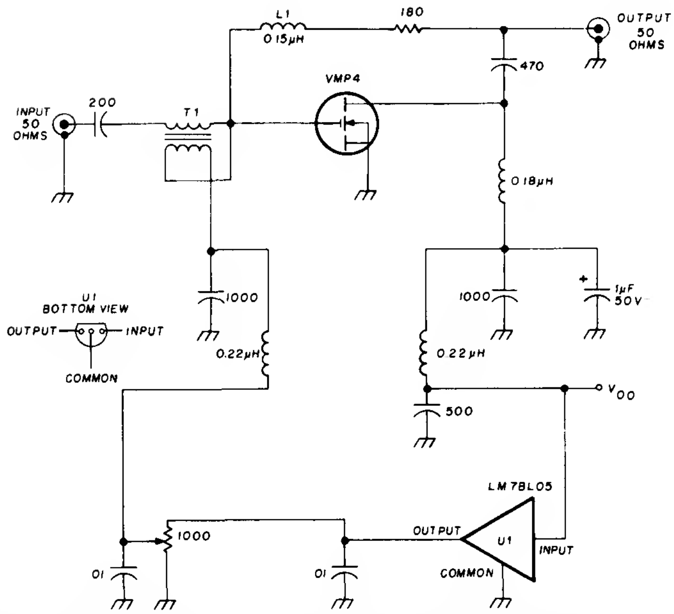
2.5-MHz BANDWIDTH LOW-NOISE—Parelleled transistors meet noise requirements of applications such as hot-wire anemometry for measuring gas flow and temperature, wherein typical signal voltagas are as small as 1 μV peek over frequency range of 100 Hz to 200 kHz. Two feedback paths are used, one to provide low DC gain and stabilize bias voltages and the other for independent adjustment of AC gain. Design bandwidth is 7 Hz to 2.5 MHz.—J. A. Grocock, Low-Noise Widebend Amplifier, *Wireless World,* March 1975, p 117–118.



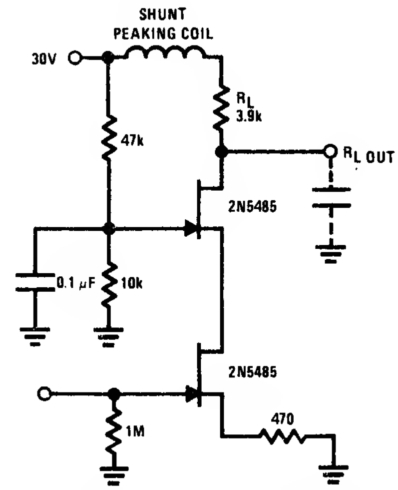
50-dB BROADBAND VIDEO—RCA CA3018 four-trensistor errey is connected es two pairs of common-emitter emitter-follower combinetions, with two feedback loops providing high DC stability. One path goes from emitter of Q3 back to input, and other goes from collector of Q4 to collector of Q1. Values of C1, C2, end C3 give low-frequency cutoff (3 dB down) of 800 Hz. Upper cutoff is 32 MHz.—E. M. Noll, "Linear IC Principles, Experiments, end Projects," Howerd W. Sams, Indienepolis, IN, 1974, p 165–168 and 174.



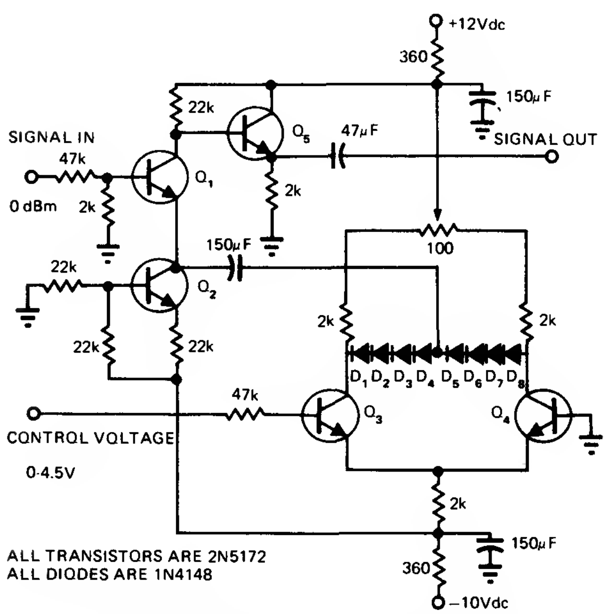
RC-COUPLED DIFFERENTIAL—Input signel is applied to base of first differentiel amplifier and push-pull output is obteined from pins 8 end 10 for trensfer to inputs of second IC. Feedback is transferred through RC combination beck to pin 6 of first IC. Gein is veried with AGC voltage applied to pin 2 of first IC. Gain is over 60 dB with flat response from 100 Hz to 100 kHz.—E. M. Noll, "Lineer IC Principles, Experiments, and Projects," Howerd W. Sems, Indienapolis, IN, 1974, p 89–91.



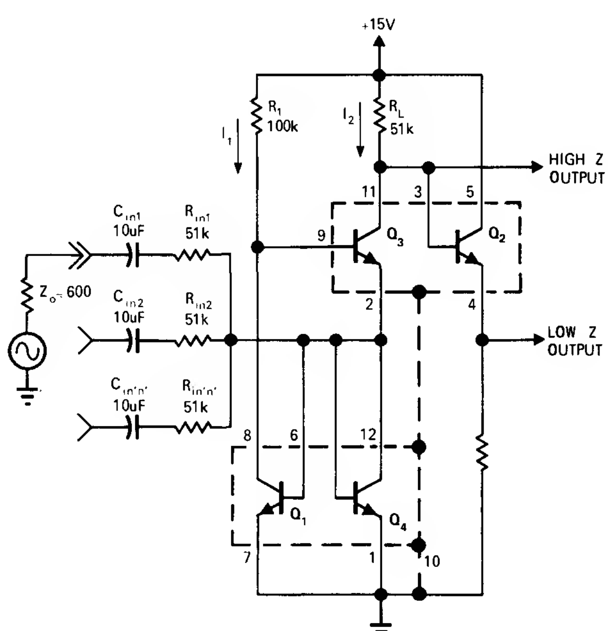
40-265 MHz VMOS—Wideband power amplifier using Siliconix Mospower FET in negative-feedback circuit has flat gain within 0.5 dB over entire operational range of 40 to 265 MHz. Use 6 to 8 turns of No. 30 on ½-W 1-megohm resistor for L1 (not commercially molded choke). T1 is 4 turns No. 22 twisted-pair on Indiana General F625-9Q2 toroid core. Avoid static charges until transistor is soldered into circuit.—E. Oxnar, Mospower FET as a Broadband Amplifier, *Ham Radio,* Dec. 1976, p 32–35.



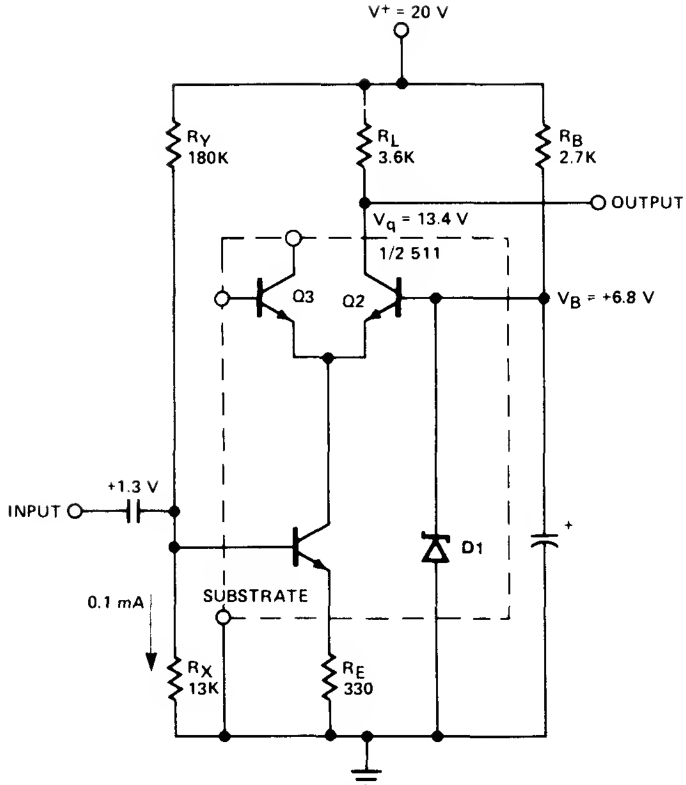
FET CASCODE VIDEO—Use of 2N5485 FETs gives very low input loading, with feedback reduced almost to zero. Bandwidth of amplifier is limited only by load resistance and capacitance.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



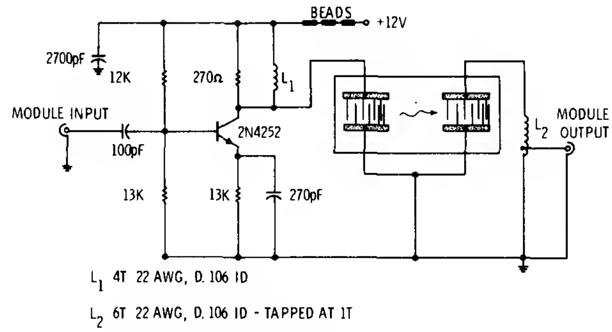
70-dB VOLTAGE-CONTROLLED GAIN—Amplifier Q_1 uses current source Q_2 as emitter resistor to provide correct current bias for class A operation. Coupling through 150-μF capacitor to silicon diode string D_1-D_8 provides variable resistance needed to achieve variable gain. Simple differential amplifier Q_3-Q_4 adjusts forward bias of diodes to change their forward resistance. Increasing positive control voltage from 0 to 4.5 V changes voltage gain from −74 dBm to about −4 dBm with respect to 0-dBm input signal.—N. A. Steiner, Voltage-Controlled Amplifier Covers 70 dB Range, *EDN Magazine,* March 5, 1975, p 72 and 74.



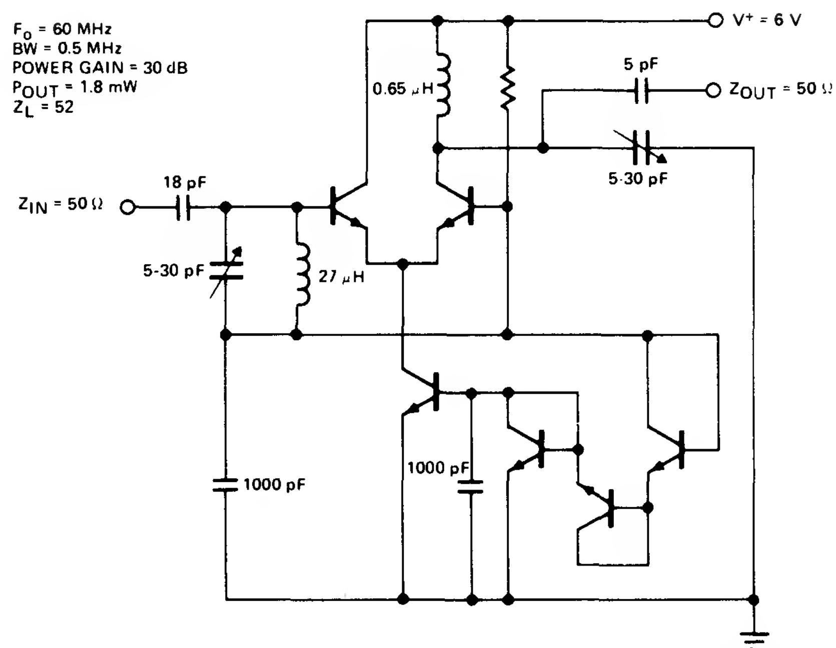
SUMMING AMPLIFIER—Uses RCA CA3018 four-transistor array as current-mirror triad with low-impedance buffered output, to serve as high-performance summing amplifier. Measured harmonic distortion is less than 1% at voltage gains up to 50 and with output swing of 10 V P-P. High output impedance of 51 kilohms can be buffered by Q_2 connected as emitter-follower.—W. G. Jung, Monolithic-Triad Current Summer, *EDN/IEEE Magazine,* July 1, 1971, p 52.



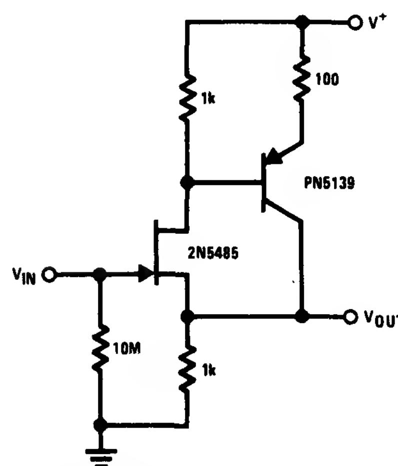
CASCODE RF/IF—Uses half of Signetics 511 transistor array to provide voltaga gain of ebout 10 ovar bandwidth of 2 MHz with output voltaga swing of 12 V P-P. Dasign procedure Is givan. Circuit provides axcellent isolation between input and output.—"Signetics Anelog Data Manual," Signetics, Sunnyvale, CA, 1977, p 746–747.



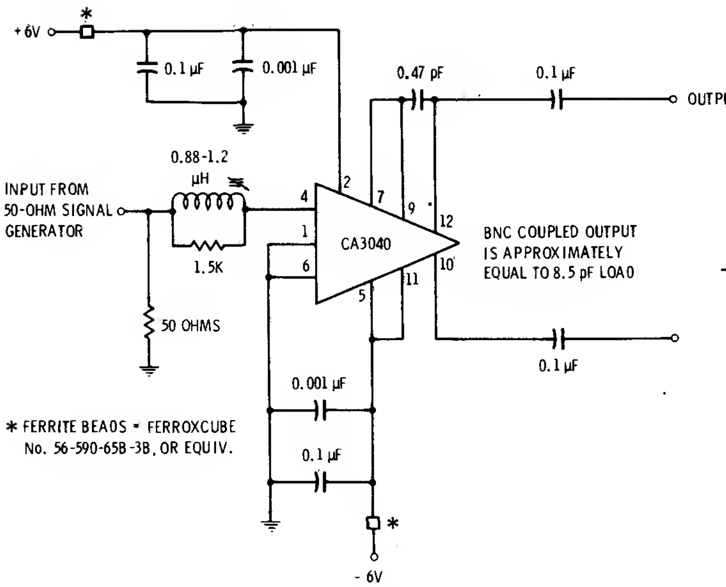
168-MHz BANDPASS—Gain stage providas gain of 6 dB from 162 to 174 MHz. Skirt slopa immediataly outsida passband dacraases at 80 db/MHz. Usas disparsive-design surfaca-acoustic-weva bandpass filtar with 168-MHz canter frequancy, 7% bandwidth, end extramely staap skirt rasponse. Parallal inductor at collector terminal matches capacitance of acoustic-wava davice, and tapped inductor matches output terminal of filtar to 50 ohms. Used in spraad-spectrum communication recaivar. Article covers dasign and construction of filter on quartz substrate.—T. F. Chaek, Jr., R. M. Hays, Jr., and C. S. Hartmann, A Wide-Band Low-Shapa-Factor Amplifiar Modula Using an Acoustic Surfaca-Wava Bandpass Filter, *IEEE Journal of Solid-State Circuits*, Fab. 1973, p 66–70.



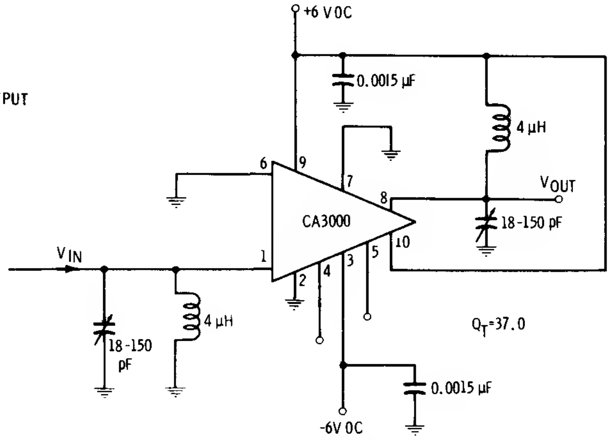
60-MHz NARROW-BAND—Signetics NE510/511 transistor array providas bandwidth of 0.5 MHz for 3 dB down and noise figura of 7 dB for powar gain of 30 dB. Meximum output swing across 50 ohms is 300 mVRMS. Circuit is aasily tuned.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 749.



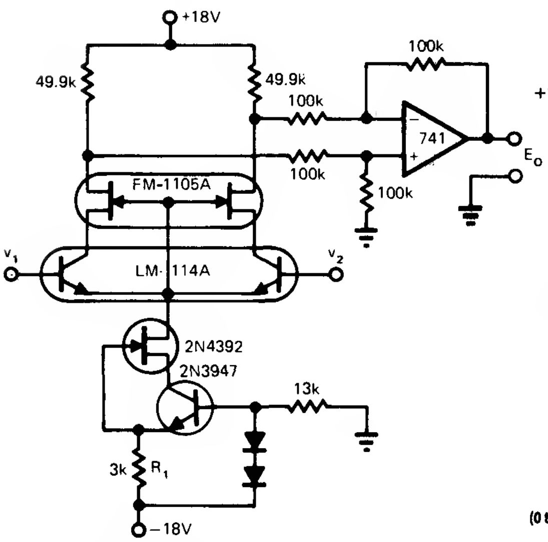
WIDEBAND BUFFER—Low input cepacitance of 2N5485 FET makas compound serles-faadback buffer serve as wideband unity-gain amplifiar having high input impedence.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



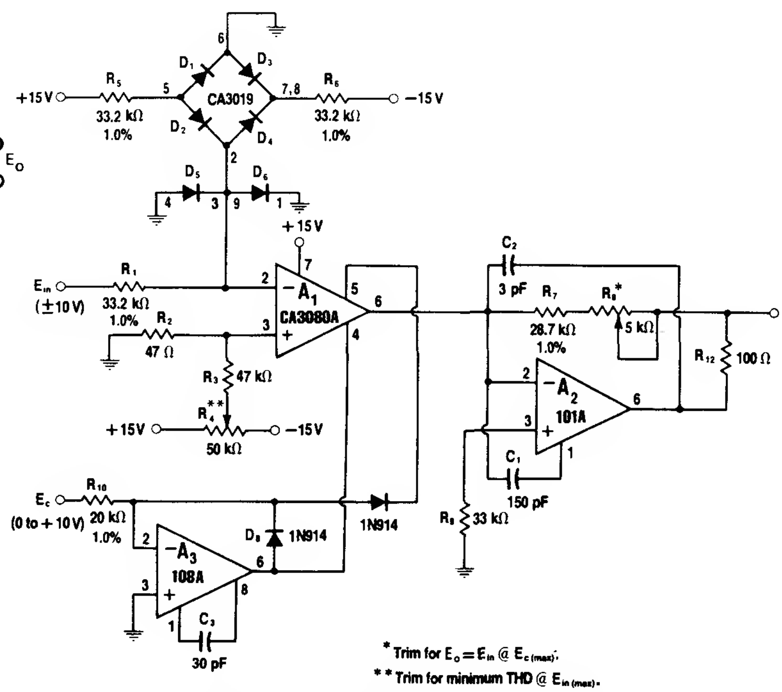
80 MHz WITH INPUT PEAKING—Response of CA3040 video IC is extended beyond 80 MHz in simple circuit that includes adjustable input peaking coil. Response is flat within 3 dB to well below 1 MHz, for gain of about 32 dB.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 163 and 169.



10-MHz WITH 30-dB GAIN—CA3000 IC is operated as RF amplifier with single-ended input and output. With appropriate tuned circuits, amplifier performs well up to 30 MHz.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 91–92.



DIFFERENTIAL CASCODE—Direct-coupled single-stage amplifier with differential input and output can be used in one or more stages of high-performance amplifiers. Bipolar-JFET cascode arrangement offers significant increase in common-mode input resistance and CMRR as compared to conventional differential pair, with little or no degradation of other performance parameters. Differential-mode gain is 116, common-mode input resistance is greater than 100 gigohms, CMRR is greater than 180 dB, and current-source output resistance is greater than 1 gigohm. Article gives design equations.—R. C. Jaeger and G. A. Hellwarth, Differential Cascode Amplifier Offers Unique Advantages, *EDN Magazine,* June 5, 1974, p 78 and 80.

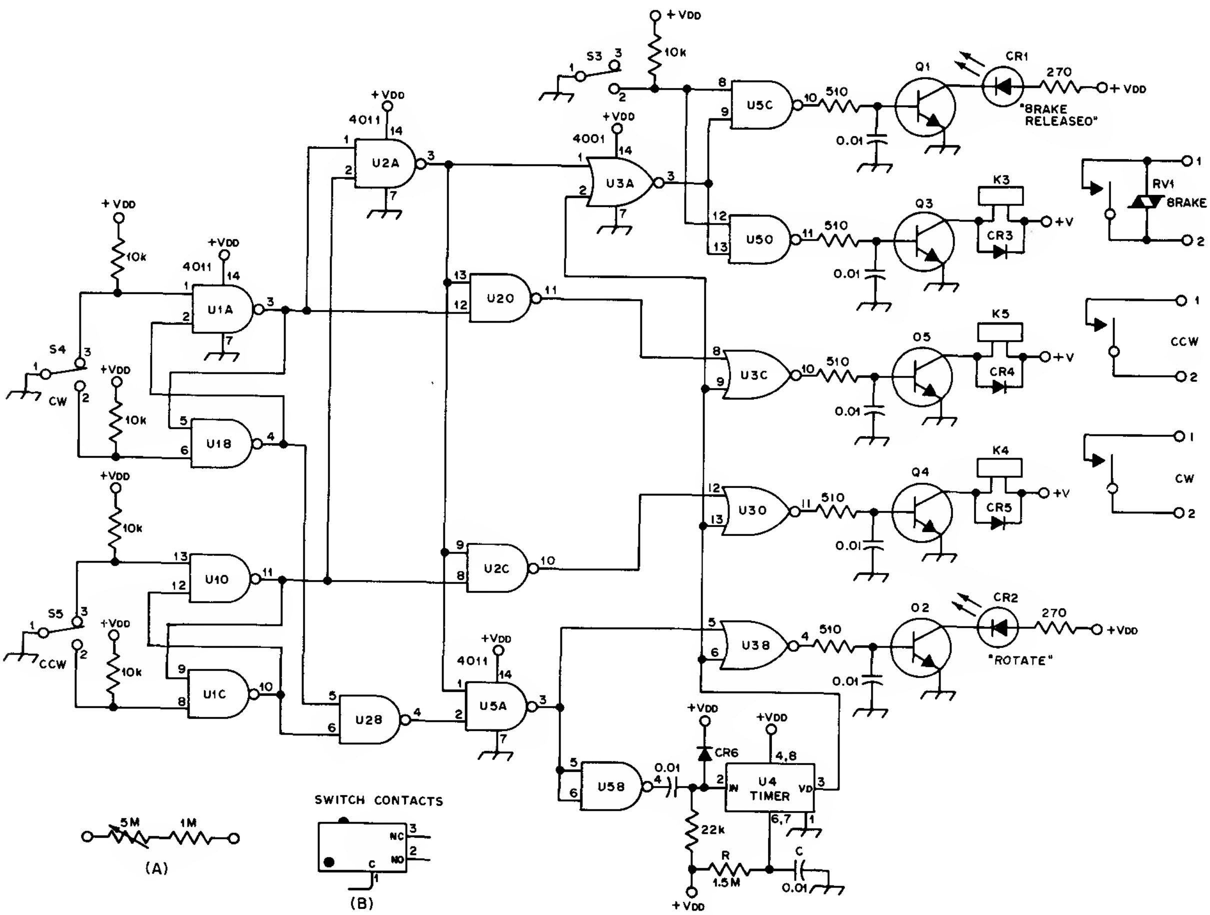


VOLTAGE-CONTROLLED OPAMP—CA3080A operational transconductance amplifier uses bridge to provide automatic temperature compensation of gain that is controlled by voltage between 0 and +10 V applied to opamp A_3. With values shown, input and output signal-handling range is ±10 V. Once balanced, circuit provides linear gain control up to four decades.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 455–456.

CHAPTER 2

Antenna Circuits

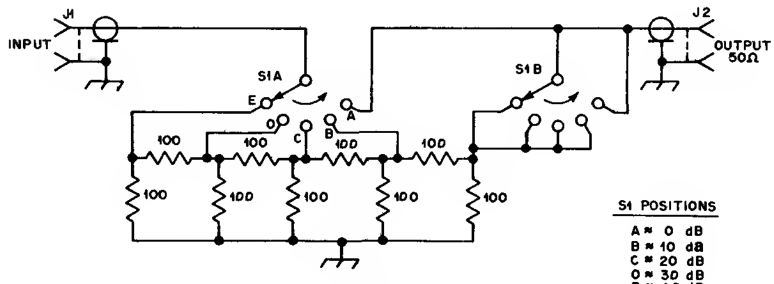
Includes circuits for measuring and adjusting VSWR, field strength, earth conductivity for grounds, and impedance, as well as antenna motor controls, radio direction finders, sferics receiver, active antennas, RF attenuators, remote antenna switching systems, RF magnetometer, and far-field signal sources for tuning beam antennas. See also Receiver, Transceiver, and Transmitter chapters.

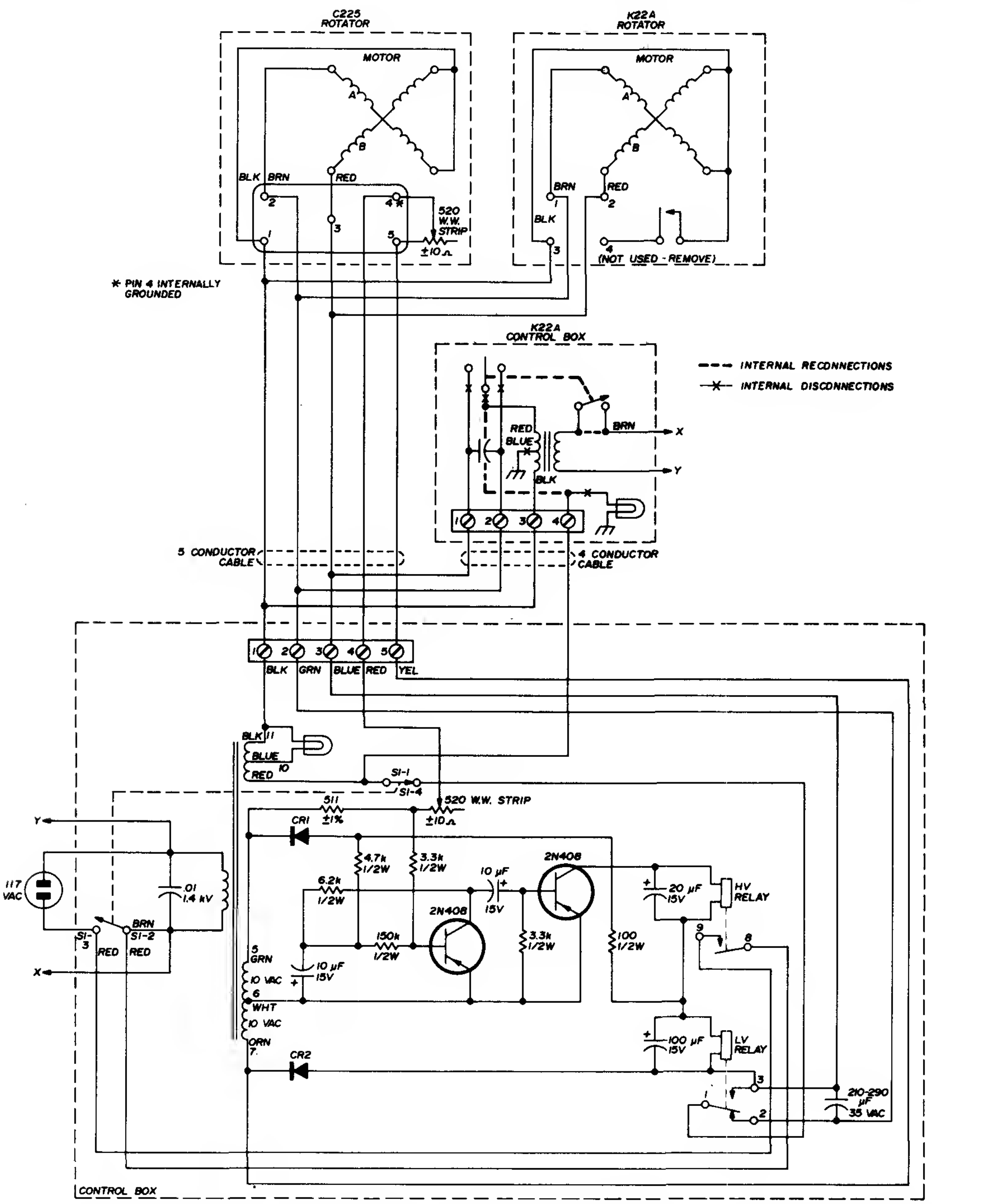


CR1, CR2 – Light-emitting diode, Motorola type MLED600 or equiv.
CR3-CR6, incl. – Silicon signal diode, 1N914 or equiv.
K3-K5, incl. – Switching relay, 12 V dc, 1200 ohms, 10 mA; contact rating 1 A; 125 V ac; Radio Shack 275-003 or equiv.
Q1-Q5, incl. – Silicon npn transistor, 2N3904 or equiv.
RV1 – Varistor, GE 750 or equiv.
U1, U2, U5 – CMOS quad NAND-gate IC, RCA CD-4011A or equiv.
U3 – CMOS quad NOR-gate IC, RCA CD-4001A, or equiv.
U4 – Timer IC, 555 or equiv.

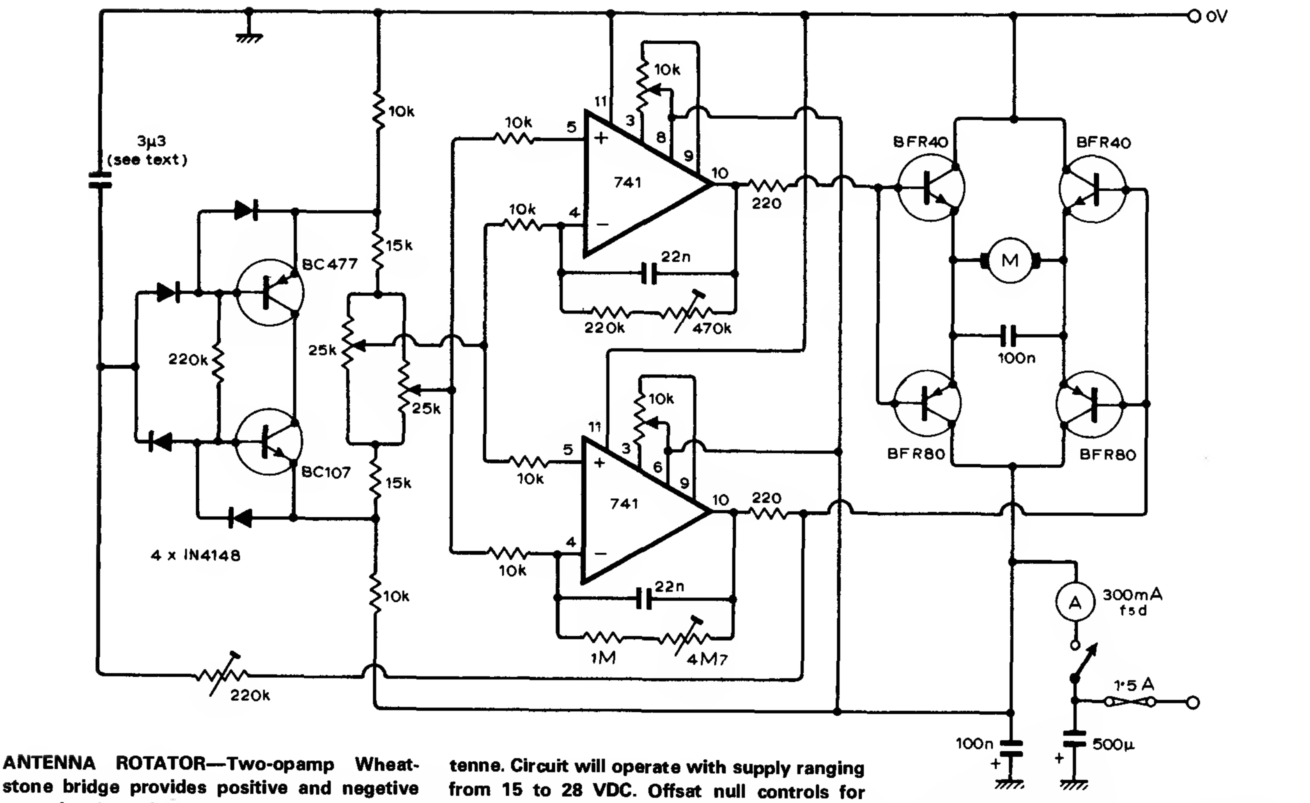
DELAYED BRAKE—Protects antenna rotator on high tower from damage by delaying brake action automatically after rotation and by disabling direction-selector switches so antenna system coasts to stop before rotation can begin in other direction. For about 3-s delay in timer U4, use 2.2 megohms for R and 1 μF for C instead of values shown. RV1 is commonly listed as V150LA20A by GE. S3-S5 are original brake release and direction switches in CDE Ham-II rotor system. Article covers construction and installation, including modifications needed in control unit.—A. B. White, A Delayed Brake Release for the Ham-II, *QST*, Aug. 1977, p 14–16.

LADDER ATTENUATOR—Inserted in series with receiving antenna to provida 5 staps of attanuation for comparing performance of antannas or praamps. Resistors are ¼-W composition with 5% tolerance.—D. DeMaw, What Does My S-Meter Tell Me?, *QST,* June 1977, p 40–42.

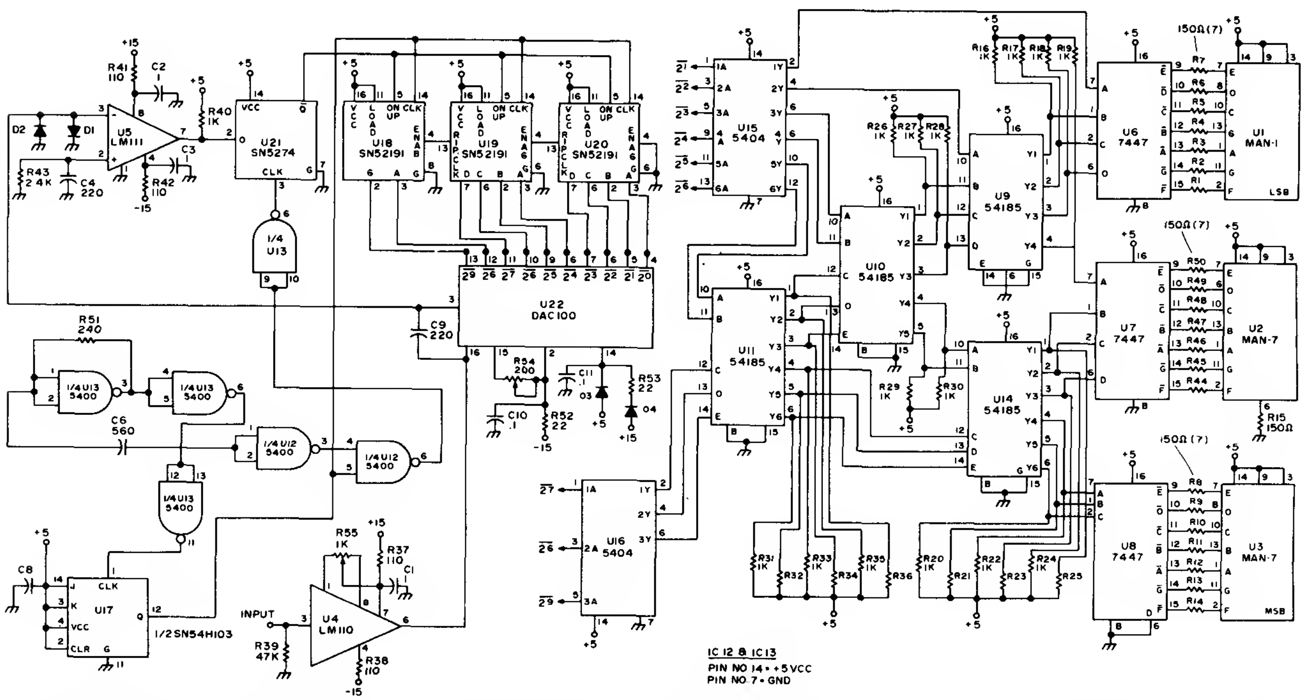




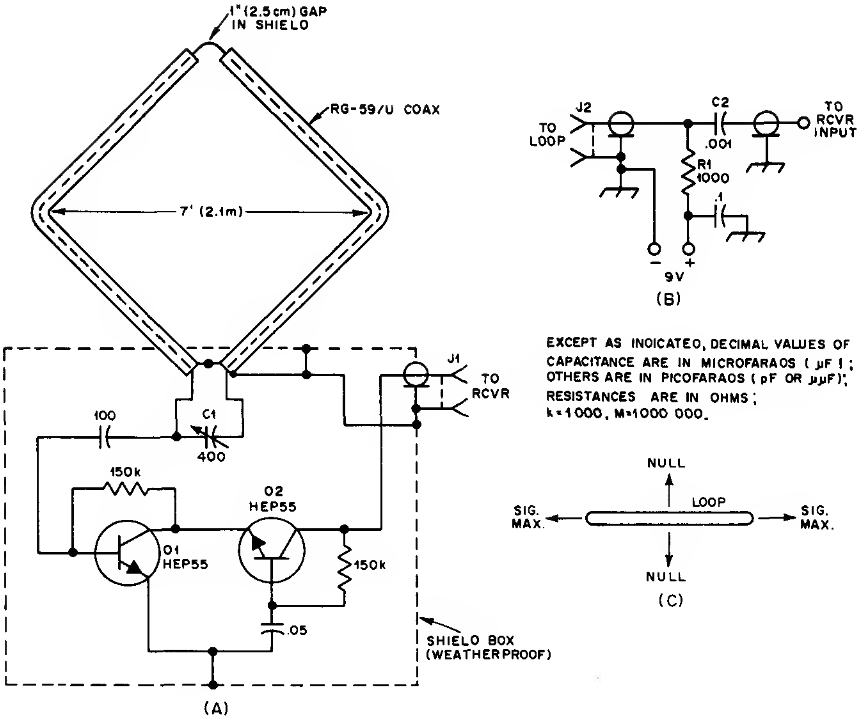
TWO-ROTATOR CONTROL—Low-cost Alliance C-225 TV antanna rotator and Alliance K22A rotator with control box are used with single transistorized-bridge control circuit. Rotators operate in tandem on same shaft to provide double torqua for handling madium-siza 20-metar amateur radio antennas. Ona arm of bridge is 520-ohm wirawound pot in which wipar position is proportional to haading. Articla covers wiring and banch-testing of rotators.—F. E. Gehrka, Antenna Rotator for Medium-Sizad Beams, *Ham Radio,* May 1976, p 48–51.



ANTENNA ROTATOR—Two-opamp Wheatstone bridge provides positive and negative error signals to give proportional control for 24-VDC motor used for remote positioning of antenna. Circuit will operate with supply ranging from 15 to 28 VDC. Offset null controls for opamps use 10K pots. Article describes operation and adjustment of circuit in detail. —D. J. Telfer, An Aerial Rotator Servo, *Wireless World,* April 1975, p 177–181.

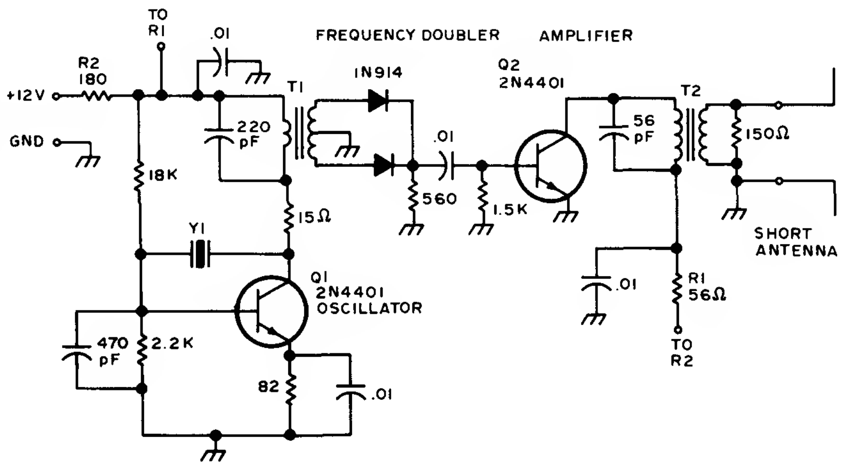


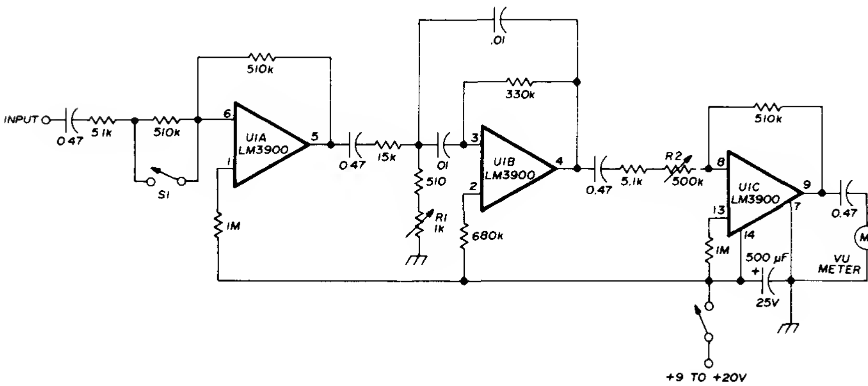
DVM FOR SWR—Converts voltage output from analog computer to drive for 3-digit LED display of standing-wave ratio. Circuit uses Precision Monolithics D/A converter A1MDAC-100CC-Q1. Requires regulated 5-VDC logic supply at 1 A for digital display, along with ±15 V supplies for logic. Article gives alignment procedure. Accuracy of digital reading is better than 0.1% over 0-8 V range.—T. Mayhugh, The Automatic SWR Computer, *73 Magazine,* Dec. 1974, p 86–87.



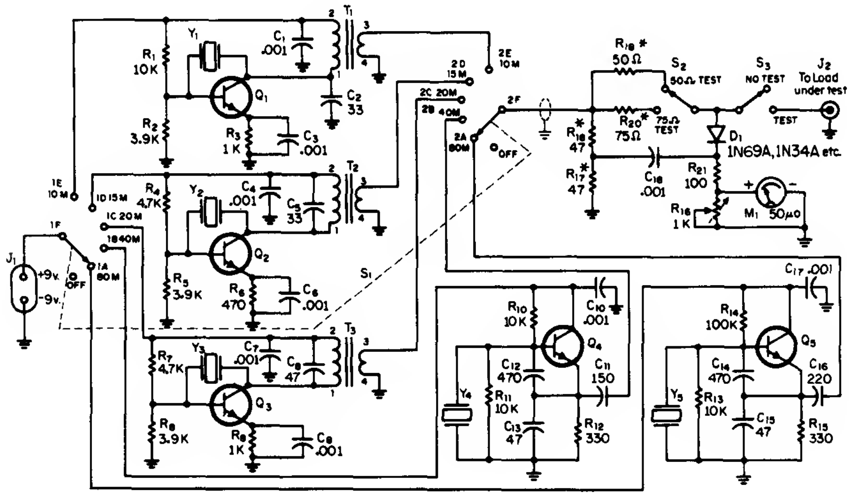
160-METER LOOP-PREAMP—Shlaldad 5-foot squara loop end slngla preamp pull slgnels out of noisa when propegetion condltlons meke othar antannes unsatisfactory. Oparatlng voltaga is supplied through coax feedar. R1 Isoletes signal anargy from ground, and C2 kaeps DC voltage out of recalvar Input. Nulls ara off broed sida of loop.—B. Boothe, Waak-Slgnal Reception on 160—Soma Antanne Notes, *QST*, June 1977, p 35–39.

FAR-FIELD TRANSMITTER—Provides far-fiald signal source for tunlng Yegi and othar beam antannas used on amateur radio frequancias. Q1 is Piarca oscillator oparating in fundamantal mode of 7.06-MHz crystal to parmit fiald-strength maasurements et 14.12, 21.18, and 28.24 MHz for 20-, 15-, and 10-metar bands. Antanna uses two 5-foot langths of wlra connacted as dipola. T1 is Amidon cora T50-2 with 22 turns on primary and 20 turns cantar-tapped on secondary. T2 is same cora with 22-turn primary and 5-turn sacondary.—G. Hinkla, Closed Loop Antanna Tuning, *73 Magazina*, May 1976, p 32–33.



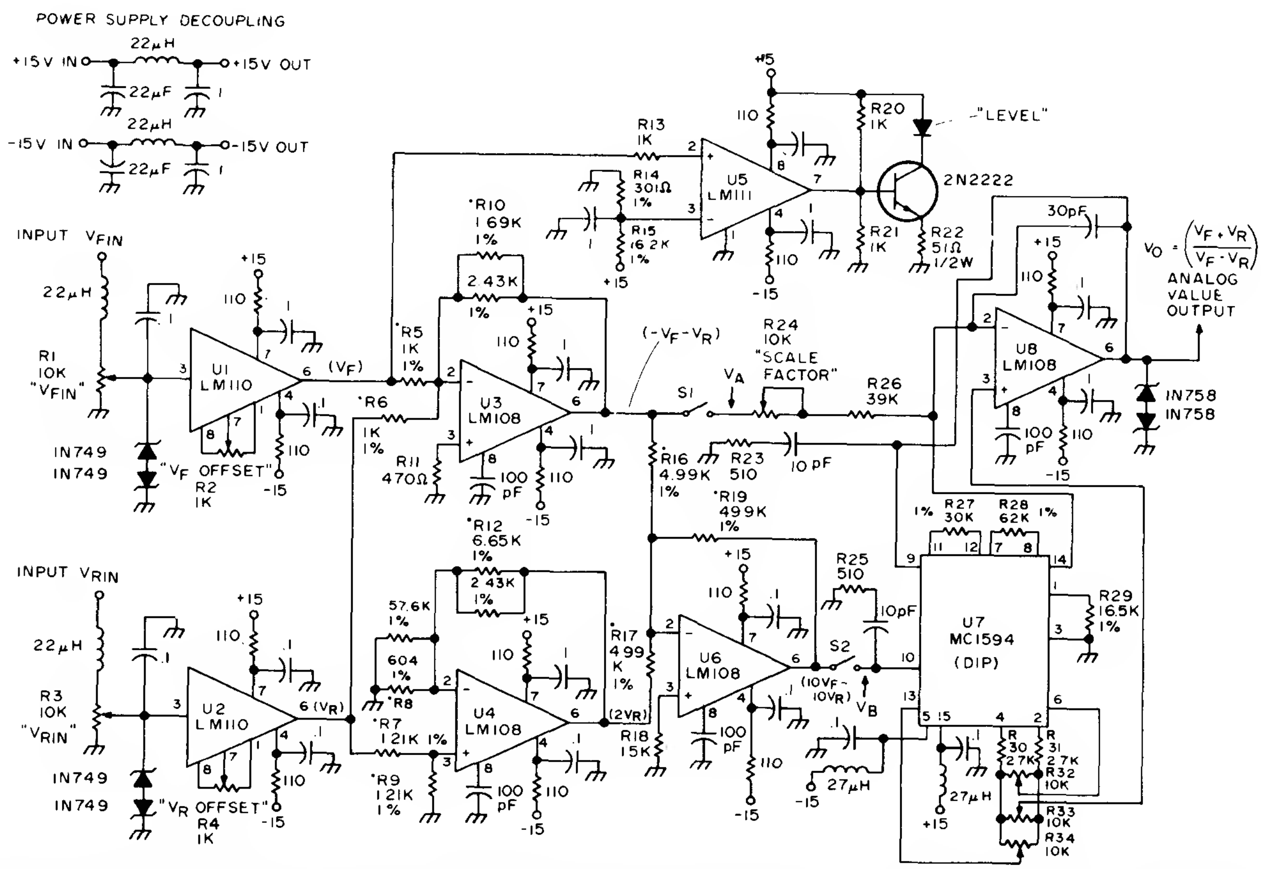


VSWR METER—Simpla, aasily transported VSWR metar consists of high-gein amplifiar, narrow-bandwidth (100-Hz) salactiva ampiifiar tuned to 1000 Hz, end varleble-gain output ampiifier driving low-cost VU metar. Idaal for nulling-typa VSWR maasuramants. Draws only about 6 mA from 9-V transistor bettary. Closing S1 increasas gain about 100 timas for iow-laval raadings. R1 sets U1B to 1000 Hz, whlla R2 sets reference on VU metar.—J. Raisart, Matching Techniques for VHF/UHF Antannes, *Ham Radio*, July 1976, p 50–56.

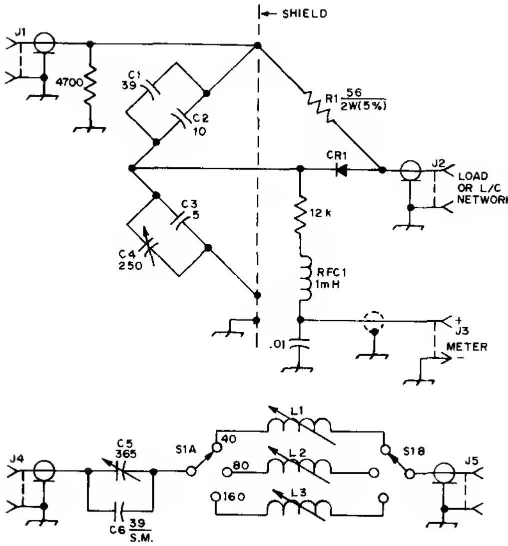


SELF-EXCITED SWR BRIDGE—Portable bridge has built-in signal sources for each band from 80 through 10 meters, for tuning antenna on tower before transmission line is connected. Oscillators are crystal controlled at desired antenna tune-up frequencies. Separate oscillators for each band simplify switching problems, so only supply voltage from J_1 and oscillator outputs to meter circuit need be switched. Current drain from 9-V battery is maximum of 12 mA. R_{17} and R_{18} should be closely matched, while R_{19} and R_{20} should have 5% tolerance.—T. P. Hulick, An S.W.R. Bridge with a Built-In 80 Through 10 Meter Signal Source, *CQ*, June 1971, p 64–66, 68, and 99.

Q_1-Q_5—RCA 40245.
S_1—2 pole 6 position subminiature rotory switch. (Centerlab PA-2005).
S_2—S.p.d.t. slide switch.
S_3—S.p.s.t. slide switch.
T_1—Pri.: 11 t. #36 e. Sec.: 3 t. #36 e. on Indiana General CF-101 Q2 toroid.
T_2—Pri.: 16 t. #36 e. Sec.: 4 t. #36 e. Some core as T_1.
T_3—Pri.: 20 t. #36 e. Sec.: 5 t. #36 e. Some core as T_1.
Y_1, Y_2, Y_3—Overtone crystols for 10, 15 ond 20 meter bonds respectively. HC-6U holders.
Y_4, Y_5—40 and 80 meter crystols respectively in HC-6U holders.

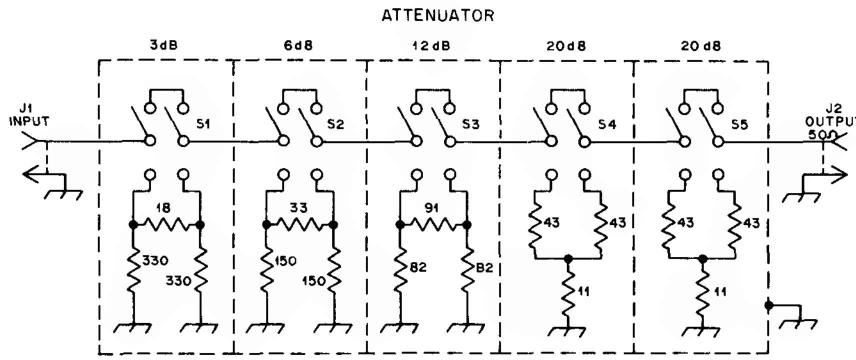


SWR COMPUTER—Automatically computes standing-wave ratio in 50-ohm coax feeding antenna and delivers analog voltage for driving meter or digital display. Inputs are forward (V_{FIN}) and reverse (V_{RIN}) voltages as conventionally measured for SWR checks. Requires regulated ±15 VDC supply at 40 mA. Article gives construction details and covers adjustment of critical resistors during alignment.—T. Mayhugh, A Digital SWR Computer, *73 Magazine*, Nov. 1974, p 80–82, 84, and 86.

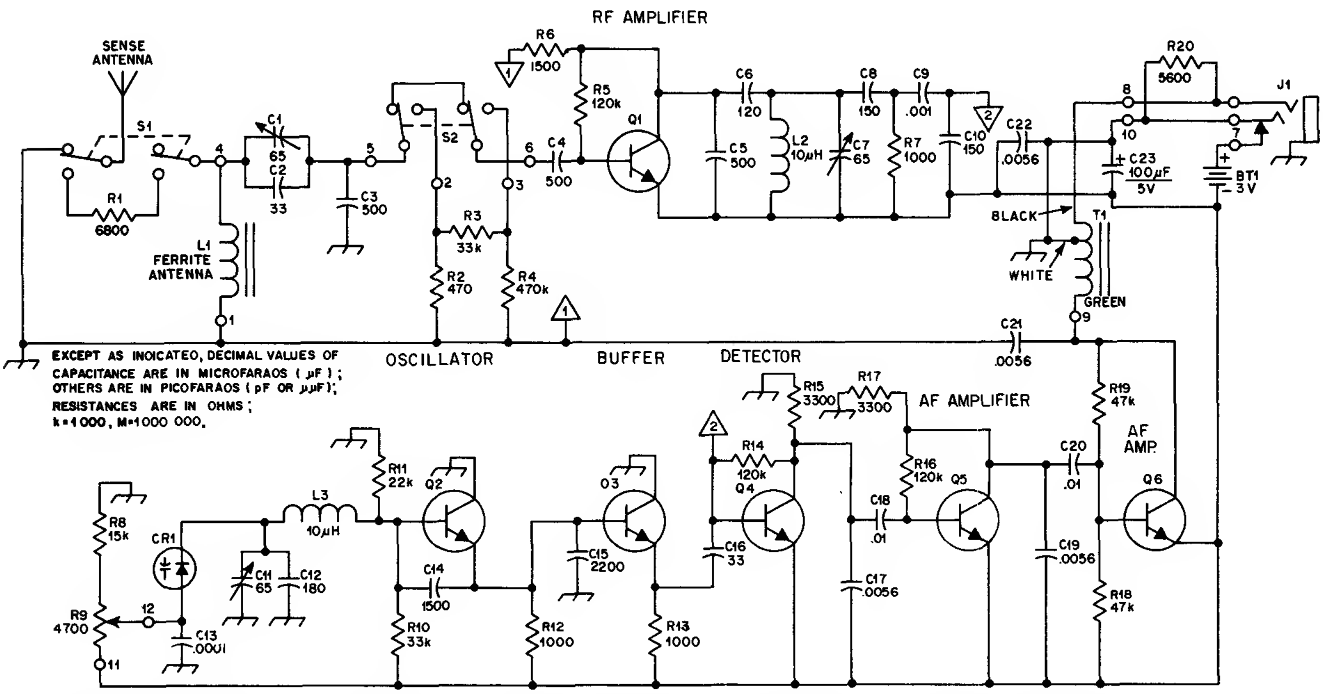


C1, C2 — 39- and 10-pF silver micas in parallel.
C3 — 5-pF silver mica.
C4 — 250-pF straight-line-wavelength variable (Hammarlund MC-250M).
C5 — 365-pF miniature variable (Archer-Allied 695-1000).
CR1 — Germanium diode.
J1, J2, J4, J5 — Coaxial receptacle.
J3 — Phono jack.
L1 — 15 turns No. 24 enamel close-wound on Miller 66A022-6 form (purple slug).
L2 — 30 turns like L1.
L3 — 63 turns like L1, but scramble-wound.
S1 — 2-pole 3-position wafer switch.

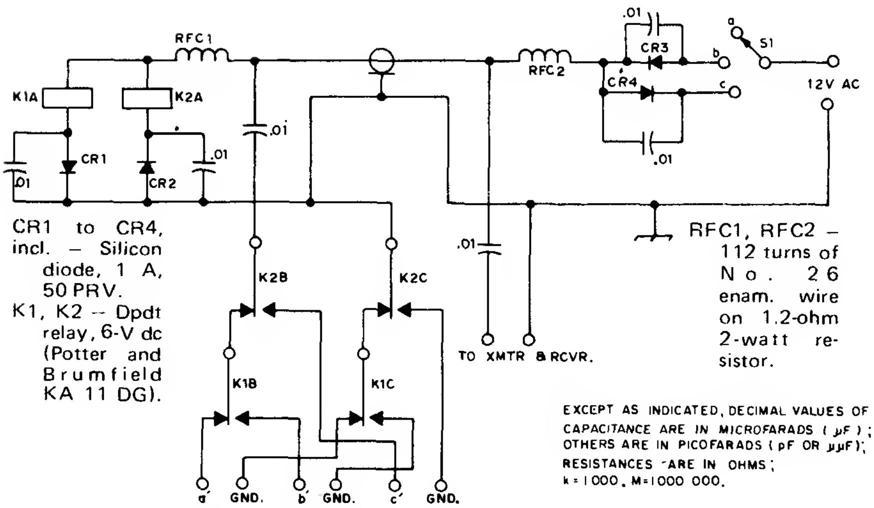
RF BRIDGE FOR COAX—Simplifiea adjustment of vertical antenna for 40, 80, and 160 meters. S1 in add-on LC unit switchas coil for dasired band. Values of C1-C4 and standard reaistor R1 give range of 10 to 150 ohms for meeaurament of radiation resistence. Meter can be from 50 to 200 μA full scale if 500 mW of power is evailable as signal source. For shorter-wavelength bands, change resistance in parellel with J1 to 5600 ohms and omit C6. L1 for 10 meters should than have 3½ turns No. 18 spaced to occupy ¼ inch on Miller 4200 coil form. L2 (15 meters) is 6 tums No. 16 enamel cloaewound on similar form. L3 (20 meters) is 11 turns No. 14 enamel on Miller 66A022-6 form.—J. Sevick, Simple RF Bridges, *QST*, April 1975, p 11–16 and 41.



5-STEP ATTENUATOR—Applications include comparing performance of various receiving antennas and measuring gain of preemp used ahaad of receiver. Dashed lines reprasent required shiald partitiona. All resistors are ¼-W composition with 5% tolerance.—D. DeMaw, What Does My S-Metar Tall Me?, *QST*, June 1977, p 40–42.



80-METER DIRECT-CONVERSION—Portable recelver with directional ferrod antenna and vertical sanse antanne was devaloped for radio foxhunting et 1975 Boy Scout World Jamboree in Norway, in competitions for locating four low-power crystal-controlled transmitters hidden elong 4-km courae. Veractor-tuned oscillator provides 20-kHz tuning range with R9, edequete for the frequency used—3.566, 3.585, 3.635, or 3.680 MHz. T1 is subminiature autotransformer with 8-ohm and 2000-ohm sections, for 8-ohm headphones. For high-impedance headphones, connect headphone jack J1 to lug 9 of T1. ON/OFF switch is not needed. L1 is 22 turns No. 28 enamal wound over two 10 × 95 mm ferrita rods taped together. Q1-Q6 ara NPN high-frequency small-signal tranalators.—N. K. Holter, Radio Foxhunting in Europe, *QST*, Nov. 1976, p 43–46.

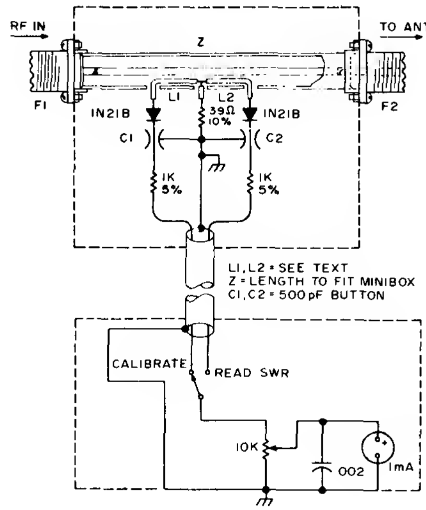


CR1 to CR4, incl. – Silicon diode, 1 A, 50 PRV.
K1, K2 – Dpdt relay, 6-V dc (Potter and Brumfield KA 11 DG).

RFC1, RFC2 – 112 turns of No. 26 enam. wire on 1.2-ohm 2-watt resistor.

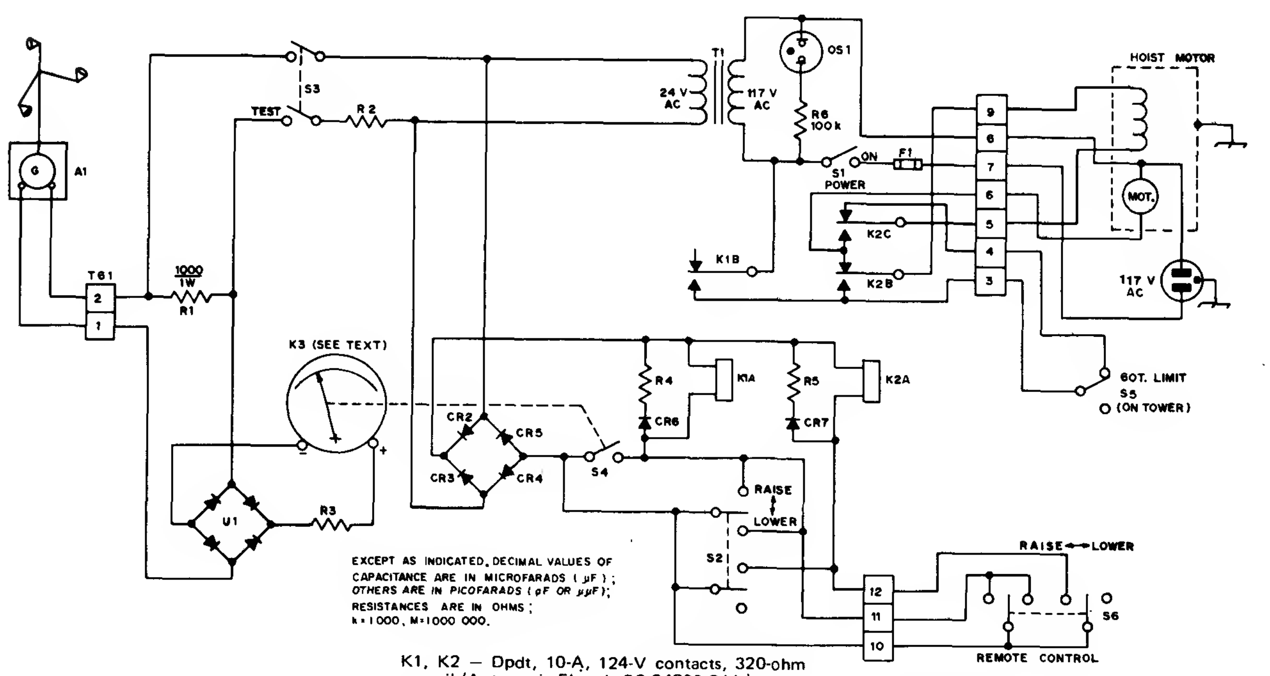
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR $\mu\mu F$); RESISTANCES ARE IN OHMS; k = 1000, M = 1000 000.

3-ANTENNA REMOTE SWITCHING—Single RF feed line serves for feeding transmitter power to tower and selecting desired one of three antennas. With S1 at a, neither K1 nor K2 is energized. RF energy then passes through cable to antenna terminals a' and GND. In position b, positive half-waves from 12-VAC supply operate relay K1 through CR1 and CR3, so antenna b' is energized. With S1 at c, K2 is energized through CR4 and CR2 for feeding c'.—U. H. Lammers, A Remote Antenna Switch, *QST*, Aug. 1974, p 41–43.



L1, L2 = SEE TEXT
Z = LENGTH TO FIT MINIBOX
C1, C2 = 500pF BUTTON

SWR TO 500 MHz—Permits measuring standing-wave ratio well above limits of many inexpensive indicators. For transmitters up to 2 W, coupling loop L1-L2 can be about 1 inch long. For high-power transmitters, loop length can be reduced to about ⅛ inch.—W. E. Parker, UHF SWR indicator, *73 Magazine*, June 1977, p 68–70.



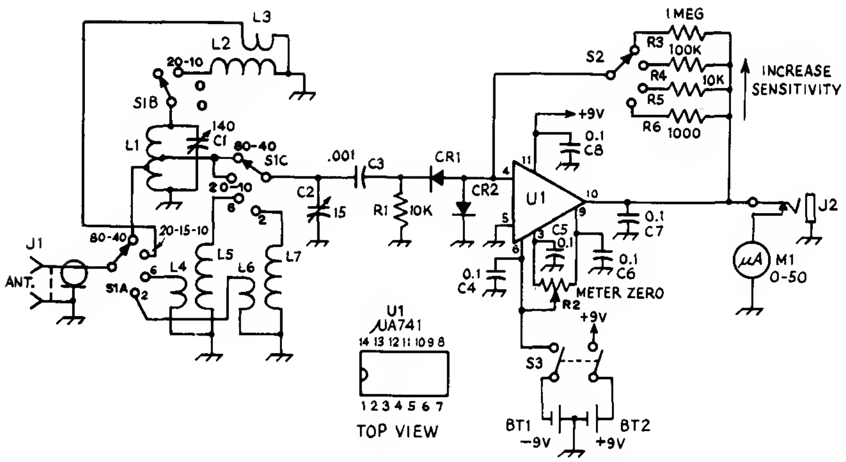
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR $\mu\mu F$); RESISTANCES ARE IN OHMS; k = 1000, M = 1000 000.

A1 – Three-cup anemometer (Taylor Instrument Corp. No. 14077Q).
CR2-CR5, incl. – Silicon diode 100 PRV, 1 A.
CR6, CR7 – 1N69.
F1 – 3.2 A, Slo-Blo.
DS1 – Neon indicator.

K1, K2 – Dpdt, 10-A, 124-V contacts, 320-ohm coil (Automatic Electric PG 24809-B11.)
K3 – Meter relay, 100 μA (Weston No. S46707).
R2, R3 – Approximately 12,000 ohm, 1-watt; see text.
S1 – Spst (JBT No. MS-35058-22).
S2, S6 – Dpdt center off (JBT. No. 35059-27).
S3 – Dpdt normally off (JBT No. MS-35059-30).

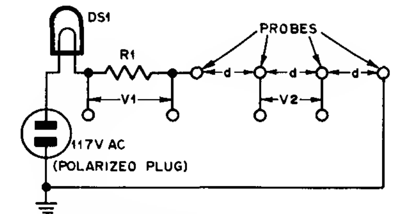
S4 – Part of K3.
S5 –Spdt, bottom limit switch (Microswitch No. BZE6-2RN).
T1 – 117-V primary, 24-v secondary, 300 mA
U1 – Bridge rectifier assembly (Bradley Labs. No. CO14E4F).

WIND-ACTIVATED CONTROL—Anemometer feeding meter relay energizes control relay for antenna-tower hoist motor, to lower tower automatically when wind exceeds preset safe speed and raise it again when wind drops well below danger level. When only K1 is energized, motor rotates in tower-lowering direction. When K1 and motor-reversing relay K2 are both energized, motor reverses and raises tower.—J. Bernstein, The Tower-Guard System, *QST*, Dec. 1974, p 25–28.



C1 – 140-pF variable.
C2 – 15-pF variable.
CR1, CR2 – 1N914 or equiv.
L1 – 34 turns No. 24 enam. wound on an Amidon T-68-2 core, tapped 4 turns from ground end.
L2 – 12 turns No. 24 enam. wound on T-68-2 core.
L3 – 2 turns No. 24 wound at ground end of L2.
L4 – 1 turn No. 26 enam. wound at ground end of L5.
L5 – 12 turns No. 26 enam. wound on T-25-12 core.
L6 – 1 turn No. 26 enam.
L7 – 1 turn No. 18 enam. wound on T-25-12 core.
M1 – 50 or 100 µA dc.
R2 – 10,000-ohm control, linear taper.
S1 – Rotary switch, 3 poles, 5 positions, 3 sections.
S2 – Rotary switch, 1 pole, 4 positions.
S3 – Dpst Toggle.
U1 – µA741.

LINEAR FIELD-STRENGTH METER—Has sufficient sensitivity for checking antenna patterns and gain while positioned many wavelengths from antenna. Can be used remotely by connecting external meter at J2. L1 is tuned by C1 for 80 or 40 meters. For 20, 15, or 10 meters, L2 is switched in parallel with L1. L5 and C2 cover about 40 to 60 MHz, while L7 and C2 cover 130 to 180 MHz. Band-switched circuits avoid use of plug-in inductors. At most sensitive setting of S2, M1 will detect signals from pickup antenna as weak as 100 µV.—L. McCoy, A Linear Field-Strength Meter, *QST*, Jan. 1973, p 18–20 and 35.

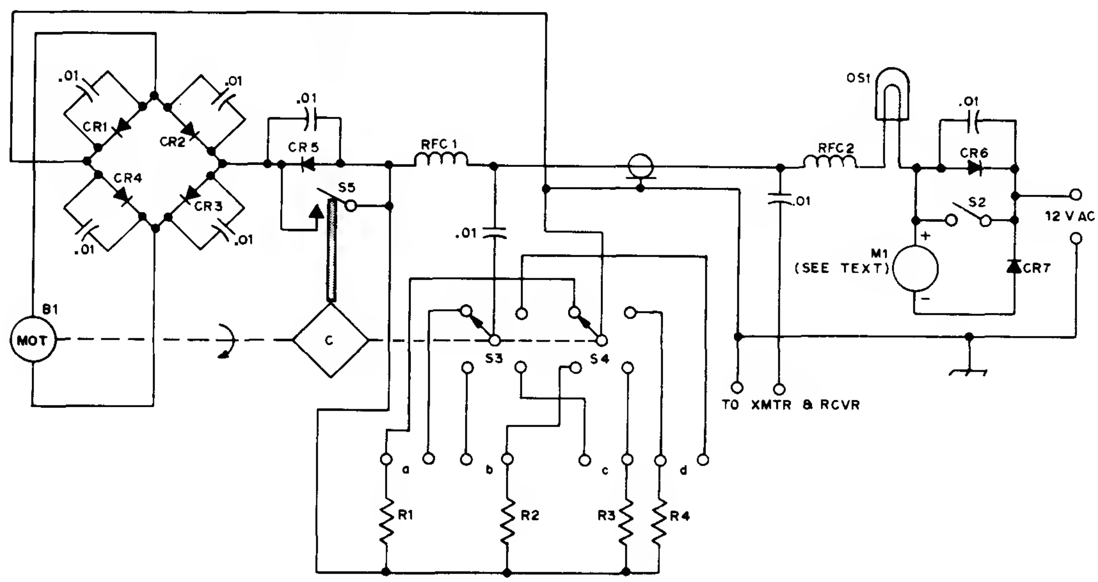


DS1 — 100-watt light bulb.
R1 — 14.6 ohms (5 watt).
Probes — 5/8-inch dia (iron or copper); spacing, d = 18 inches; penetration depth, D = 12 inches.

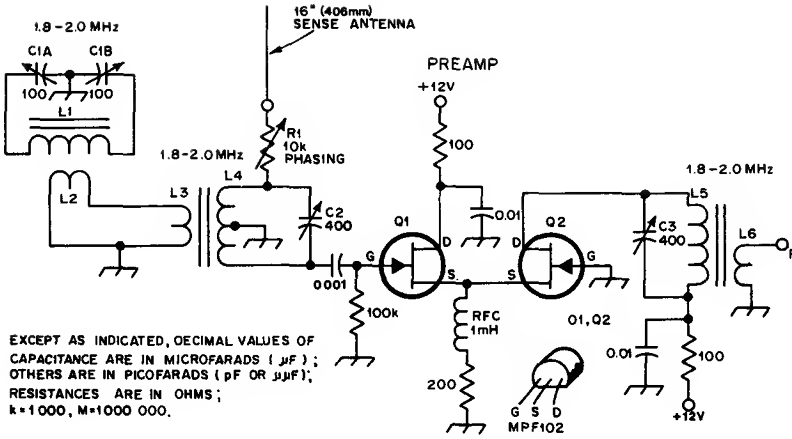
$$\text{Earth conductivity} = (21) \times \frac{V1}{V2}$$

(millimhos/meter).

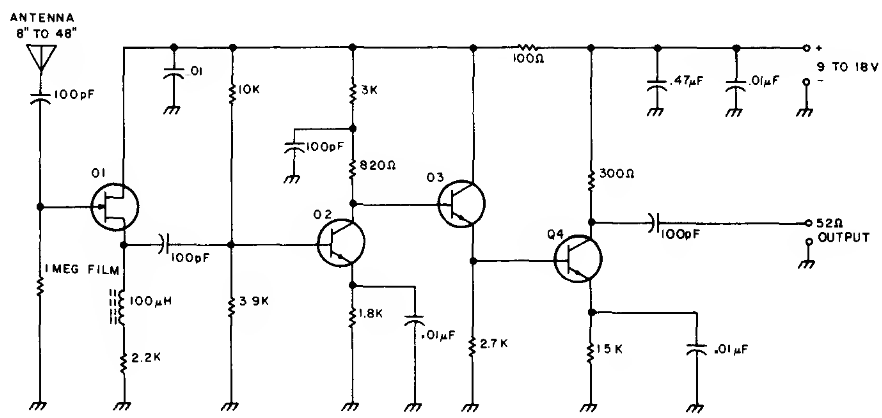
EARTH CONDUCTIVITY—Simple AC measurement technique gives 25% accuracy, adequate for siting amateur radio antennas and designing radial ground systems. Measured values will range from 1 to 5 millimhos per meter for poor soil, 10–15 for average soil or fresh water, 100 for very good soil, and 5000 for salt water.—J. Sevick, Short Ground-Radial Systems for Short Verticals, *QST*, April 1978, p 30–33.



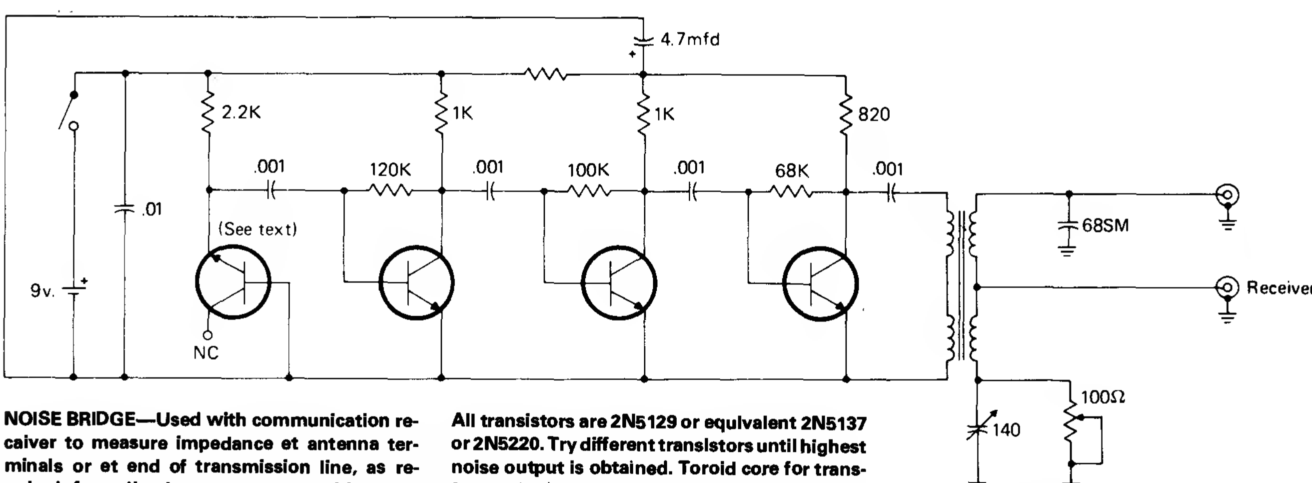
FOUR-POSITION MOTOR SWITCH—Single RF feed line also carries DC for 3-V permanent-magnet DC motor B1 atop antenna tower, driving S3 and S4 for remote switching to antennas a, b, c, and d. Diagram shows switches set for feed to antenna a, with no drive applied to B1 since cam C has opened microswitch S5. CR5 and CR6 are now connected in series with opposite polarity, so neither positive nor negative half-waves from 12-VAC supply can drive motor. If S2 is closed, positive half-waves start B1. Once started, motor runs until cam opens S5; if S2 has not yet been released, motor continues running on positive and negative half-waves. Diode bridge CR1-CR4 makes motor rotate in only one direction for either drive polarity. If S2 is released, before S5 opens, motor stops. 6-V 1-A lamp DS1 comes on dimly when S2 is closed and brightens when S5 closes. If S2 is released now, B1 drives to next position and stops. If S2 is held down, switching continues. Meter M1 and CR7 identify position of switch. R1-R4, in range of 1K to 10K, are chosen to give ¼, ½, ¾, and full deflection of meter. Motor drives switch through 2860:1 reduction gears taken from alarm clock. All diodes are 50-PIV 1-A silicon such as 1N4001.—U. H. Lammers, A Remote Antenna Switch, *QST*, Aug. 1974, p 41–43.



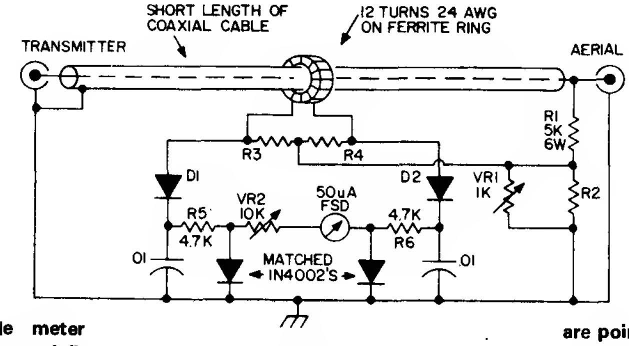
160-METER PREAMP WITH FERRITE LOOP—Ferrite-rod antenna is combined with 16-inch wire rod to give cardioid radiation pattern for low-noise 160-meter antenna system. Preamp using MPF102 FETs has gain of 25 dB. L1 is 48 turns No. 14 enamel spread to 4.5 inches on 0.5-inch Amidon ferrite rod 7 inches long. L2 is 6-turn link wound over center of L1. L4 and L5 are each 50 turns No. 26 enamel on T80-2 powdered-iron toroid cores, with 6 turns for links L3 and L6.—D. DeMaw, Low-Noise Receiving Antennas, *QST,* Dec. 1977, p 36–39.



CAPACITIVE ANTENNA—Combination of short whip antenna and broadband amplifier gives antenna covering entire range of 3 to 30 MHz without frequency selectivity. Q1 is 2N3819 FET source follower driving three-transistor amplifier using 2N918, 2N6008, or other 200-MHz 20-V NPN transistors to provide 30-dB gain. Circuit rolloff starts at 3 and 35 MHz. High gain of amplifier makes combination simulate quarter-wave whip over entire frequency range.—R. C. Wilson, The Incredible 18" All-Band Antennas, *73 Magazine,* March 1975, p 49–50.

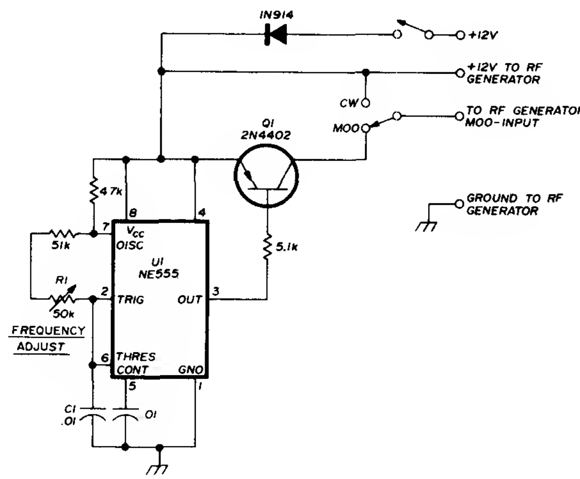


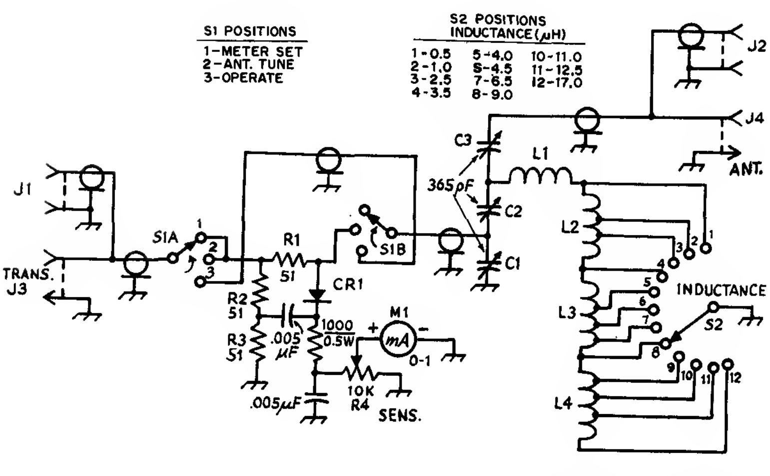
NOISE BRIDGE—Used with communication receiver to measure impedance at antenna terminals or at end of transmission line, as required for adjusting antenna matching and loading devices for desired impedance at specific frequency. Consists of diode-connected transistor broadband-noise generator, 3-stage noise amplifier, and toroid transformer bridge. All transistors are 2N5129 or equivalent 2N5137 or 2N5220. Try different transistors until highest noise output is obtained. Toroid core for transformer is ⅜-inch Indiana General CF102. Quadrifilar winding has 4½ turns of four No. 28 enamel wires twisted together, wound on core and connected as on diagram. Noise bridge can also serve as wideband noise source for signal injection during troubleshooting in AF or RF circuits, and as noise source for aligning RF circuits.—J. J. Schultz, An Improved Antenna Noise Bridge, *CQ,* Sept. 1976, p 27–29 and 75.



LOGARITHMIC WATTMETER—Single meter scale covers 1–1000 W, with equally spaced divisions for 1, 10, 100, and 1000. This log scala makes it possible to maasure very low reflected powers and very high forwerd powers simultaneously with same parcentage eccuracy. Basis of operation is that voltage dropped across forward-biased 1N4002 silicon PN junction diode is proportional to logarithm of current through it. For 50-ohm line, use 220 for R2 and 27 for R3 and R4. For 75-ohm lina, corresponding values are 180 and 33. Detector diodes are point-contact germanium rated at 80 PIV. Article gives construction details. Ground coax braid at one and only. Ferrita ring is 0.5-inch Mullard FX1596 or equivelent.—P. G. Martin, Some Directional Wettmeters and a Novel SWR Meter, *73 Magazine,* Aug. 1974, p 17, 19–21, 23–24, and 26.

1-kHz MODULATOR FOR VHF SOURCE—Used with 144-MHz signal generator driving VSWR bridga, for measuring and matching VHF antennas. R1 adjusts frequency of NE555 timer used in place of customary MVBR. Series-pass transistor Incraases output of MVBR about 2 dB.—J. Reisert, Matching Tachniques for VHF/UHF Antannas, *Ham Radio,* July 1976, p 50–56.

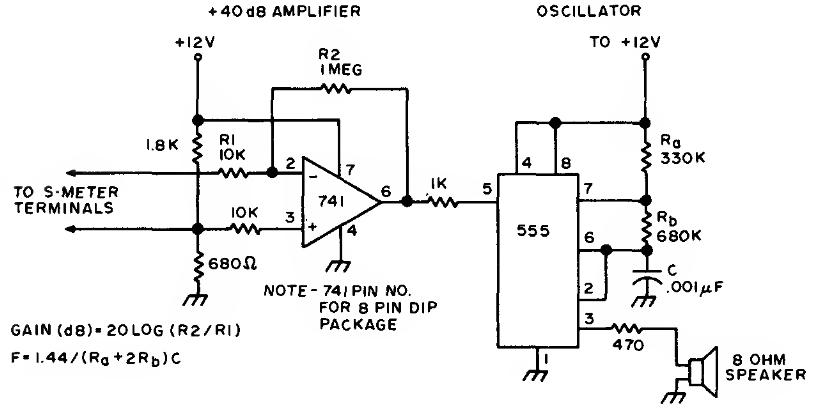


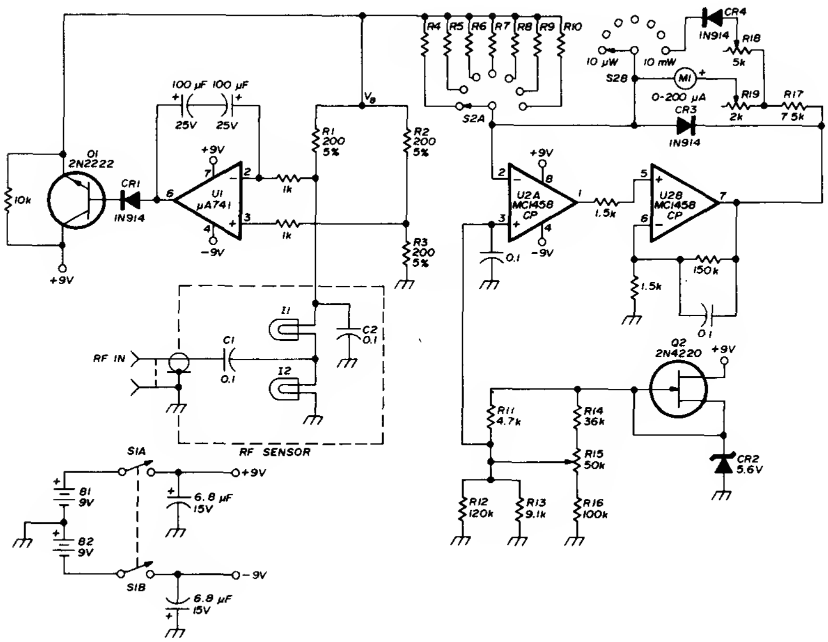


C1-C3, incl. — Miniature 365-pF variable (Archer/Radio Shack No. 272-1341 or equiv.).
CR1 — IN34A or equiv.
L1 — 15 turns No. 24 enam. wire, close-wound on 1/4-inch ID form. Remove form after winding.
L2 — 28 turns No. 24 enam. wire on Amidon T-50-6 toroid core. Tap 7 turns from each end. (Amidon Associates, 12033 Otsego St., N. Hollywood, CA 91607.)
L3 — 28 turns No. 24 enam. wire on Amidon T-50-2 toroid core. Tap at 5, 10 and 15 turns from L2 end.
L4 — 36 turns No. 24 enam. wire on Amidon T-68-2 toroid core. Tap at 6, 12 and 18 turns from L3 end.
M1 — 0 to 1-mA dc meter, 1-1/2 inches square. See text.
R1-R3, incl. — 51-ohm, 2-watt, 5-percent tolerance.
R4 — Miniature 10,000-ohm control, audio or linear taper suitable.

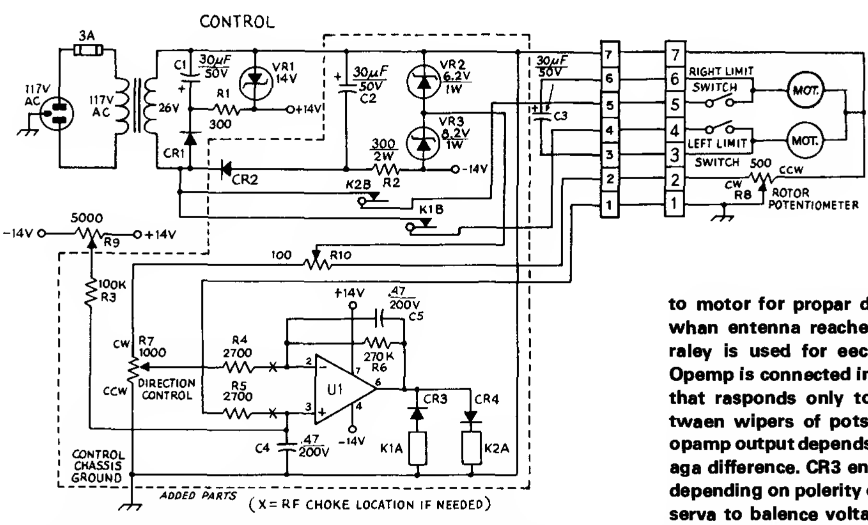
TRANSMATCH—Tapped variable inductance and three broadcast tuning capacitors are easlly preadjusted to match low-power (QRP) transmitter to entenna for SWR of 1 in commonly usad amateur bands. Resistance bridge Is used only for initiel determinetion of correct sattings for C1, C2, C3, and S2 at each band to be used. Set S1 at 1, feed peak output of transmitter to J1 (5 W meximum), and adjust R4 for full-scale reading of M1. Next, connect 50-ohm resistive load between CR1-R1 junction and ground. Meter reading should now drop to zaro, indicating null at 50 ohms. Move 50-ohm dummy load to J2, set S1 at 2, and adjust settings of C1, C2, and C3 for zaro deflection of matar. Note settings, then repeat for each other transmitter frequency to be used. Repeat procedure with antenna or feed lina in place of dummy load, using smellest inductance that gives SWR of 1. After completing adjustments, set S1 to 3 to bypass bridge for normal transmittar operation.—D. DeMaw, A Poor Ham's QRP Transmatch, *QST,* Oct. 1973, p 11–13.

V/F CONVERTER—Voltage developed across S-meter is amplified by 741 opamp having gain of 40 dB, so full-scale voltage of 100 mV becomes 10 V at opamp output. This drives modulation input of 555 timer connected as free-running oscillator. Nominal 1-kHz output increases in frequency as drive current is reduced; conversely, drop in frequency corresponds to stronger signal at S-meter. Developed for use as audible guide when tuning Yagi and other beam antennas for amateur radio operation.—G. Hinkle, Closed Loop Antenna Tuning, *73 Magazine*, May 1976, p 32–33.

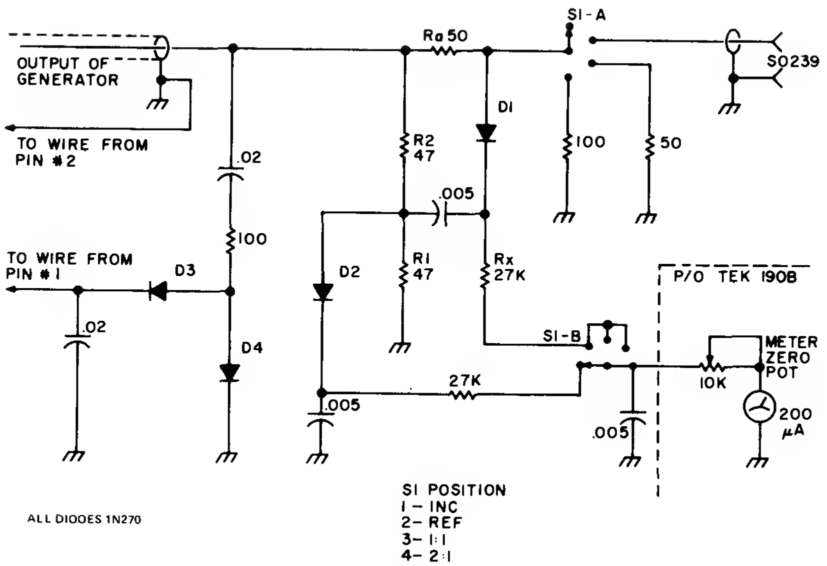




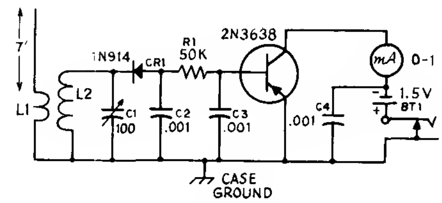
0.2 µW TO 10 mW—Accurate low-power wattmeter uses small lamps as barretters for measuring RF power up to 10 mW from 1 to 500 MHz. Applications include measurements of antenna gain, local oscillator frequency, VSWR, and filter response. Subminiature T-3/4 RF sensor lamps operate in bridge circuit with R1, R2, and R3. Voltage difference between bridge legs is amplified by opamp U1. Bridge current driver Q1 supplies current for balancing bridge. Equilibrium voltage of 3.5 V at V_B is fed to metering circuit including U2. Article covers calculation of values for calibration resistors R4-R10, which range from 5.715 to 7192 ohms.—J. H. Bowen, Accurate Low Power RF Wattmeter for High Frequency and VHF Measurements, *Ham Radio*, Dec. 1977, p 38–43.



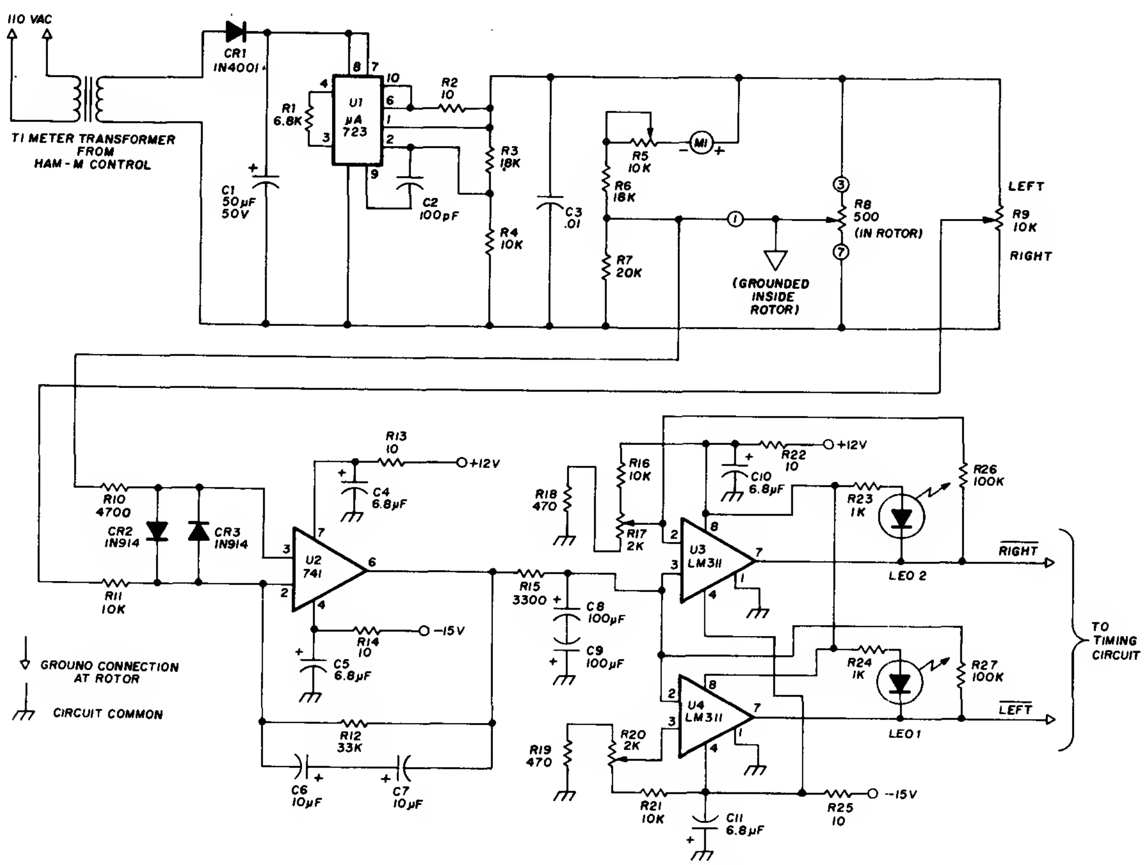
ANTENNA ROTATOR—Developed for use with CDE TR-44 antenna control using low-voltage AC motor having pot for bearing indication. Circuit eliminates need for holding control handle in position until antenna reaches desired bearing. Uses 12-VDC 1000-ohm 1-A relays, TI SN72741L opamp U1, and wirewound 360° rotation command pot R7 operating from 14-V regulated supply of original control. When R7 is set to desired new heading, relay applies power to motor for proper direction, and drops out when antenna reaches desired heading. One relay is used for each direction of rotation. Opamp is connected in differential-input mode that responds only to difference voltage between wipers of pots R7 and R8. Polarity of opamp output depends on polarity of input voltage difference. CR3 and CR4 energize K1 or K2 depending on polarity of error signal. R9 and R3 serve to balance voltage difference remaining when R7 and R8 are at travel limits. R9 also nulls offset present when there is no input to U1. Accuracy is about 5°. Diodes are 100-PIV 0.5-A silicon.—K. H. Sueker, Automating the TR-44 Antenna Rotor, *QST*, June 1973, p 28–30.



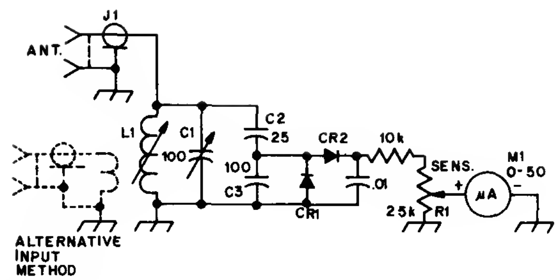
INSTANT VSWR BRIDGE—Modified 190B Tektronix constant-amplitude signal generator is combined with 50-ohm resistance bridge to give stable high-accuracy instrument for measuring voltage standing-wave ratio as guide for tuning antennas. Range is 160 meters through 10 meters. Trim Rx so incident or forward voltage at position 1 of S1 equals reflected voltage at position 2. Article gives chart for finding VSWR. Step-by-step procedure for modifying signal generator is given.—D. Sander, Make Antenna Tuning a Joy, *73 Magazine*, May 1978, p 134–136.



FIELD STRENGTH AT 7 MHz—Operates from single dry cell. Meter can be calibrated in decibels with Hewlett-Packard 606A or equivalent signal generator. Jack permits remote metering. L1 is 5 turns, and L2 is 30 turns wound on Amidon T68-2 core.—R. W. Jones, A 7-MHz Vertical Parasitic Array, *QST*, Nov. 1973, p 39–43 and 52.



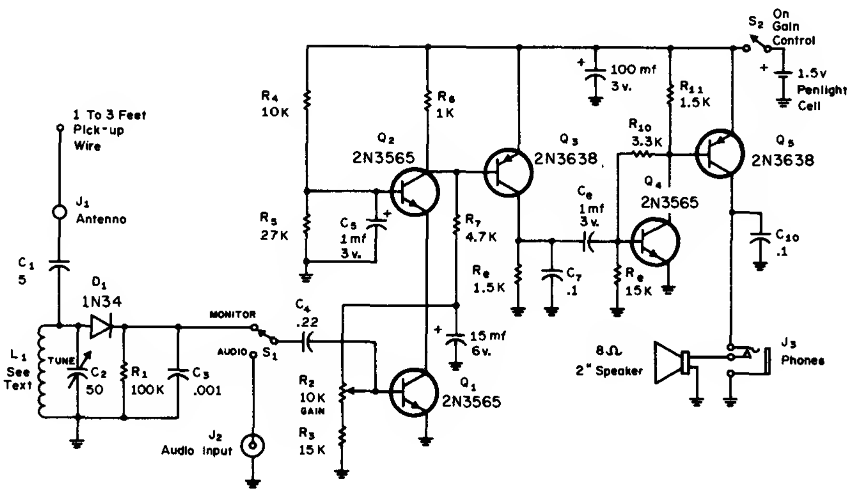
ANTENNA POSITION CONTROL—IC logic provides automatic brake release and positive position control for commercial Ham-M antenna rotator. Regulated power supply drives bridge having position-sensing pot R8 in rotator and R9 in control box. When antenna is in desired position, wiper voltages of pots are equal. When R9 is set to new position, voltage difference is amplified by error amplifier U2. Comparators U3 and U4 determine rotation direction needed for rebalance and deliver logic circuits to timing circuit (also given in article) that drives motor and brake release relays. Timer prevents jamming of circuit by operator error.—P. Zander, Automatic Position Control for the HAM-M Rotator, *Ham Radio*, May 1977, p 42–45.

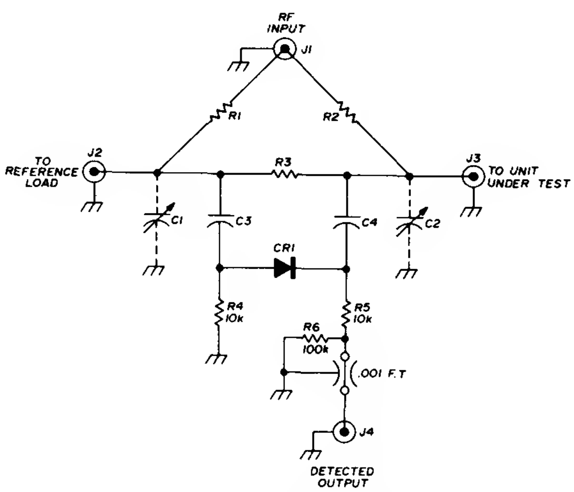


Band	160 M	80 M	40 M	20 M	15 M	10 M
L1 (μH)	100 (Nom.)	25 (Nom.)	10 (Nom.)	2.2 (Nom.)	1.3 (Nom.)	0.5 (Nom.)
C2 (pF)	25	25	15	15	10	10
C3 (pF)	100	100	68	68	47	47
Miller Coil	4409	4407	4406	4404	4403	4303

FIELD-STRENGTH METER—Useful for antenna experimants end adjustments in emataur bands from 160 to 10 meters. Increasing size of pickup antenna increases sensitivity. Far-fiald maa-surements are made with alternate input circuit, in which refarence dipole or quarter-wave wire cut for frequancy of interest is connected to input link. Diodes ere 1N34A garmanium or equivalant. M1 is 50 μA. Teble givas valuas of tuned-circuit components for six amateur bands.—D. DeMaw, A Simpla Field-Strength Meter end How to Celibrata It, *QST,* Aug. 1975, p 21–23.

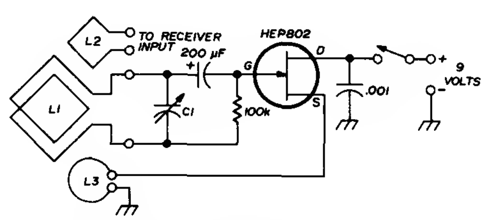
MODULATION MONITOR—Provides off-the-air monitoring of RF signals up to 200 MHz by rectified detection of AM signals and by slope detection of FM signals. Can also be used es signal tracer, eudio amplifier, or hidden-transmitter locator. High-gain audio amplifier has low-noise cascode input stage and output stage driving headphone or loudspeaker. S_1 selects RF signals detected by D_1 or AF applied to J_2. L_1 is 4 turns No. 18 for monitoring 75-150 MHz. Will elso monitor VHF transmissions from pilot to ground stations while in commercial aircraft, using 24-inch wire antenna near window and earphone. Passive-type recaiver is safe in aircraft becausa it has no oscillators thet could interfere with navigation equipment.—W. F. Spilchel, Jr., Sensitive Modulation Monitor, *CQ,* Jan. 1973, p 59–61.



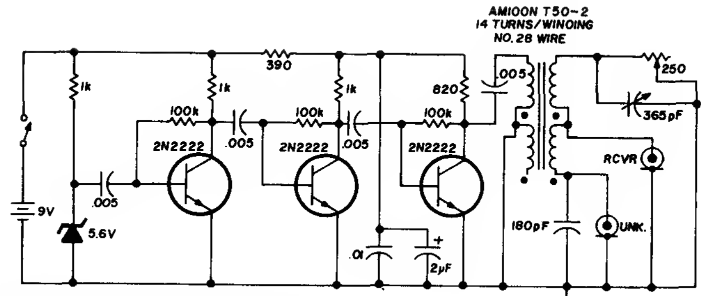


C1, C2	small capactive tab required for balance
C3, C4	0.001 μF (small disc ceramic or chip capacitor)
CR1	1N82A or equivalent germanium diode
J1, J4	UG-290A/U BNC connector
J2, J3	UG-58/U type-N connector
R1, R2	47 to 55 ohms, matched
R3	51 ohms, ¼-watt carbon composition
R4, R5	10k ohms, ¼-watt carbon composition
R6	100k ohms, ¼-watt carbon composition

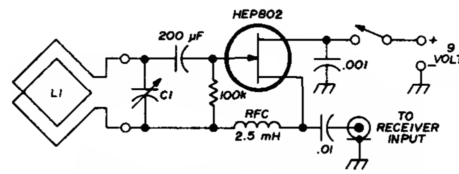
VSWR BRIDGE—Works well through 450 MHz for measuring and matching VHF and UHF antennas. If identical load impedences ere placed at J2 and J3, signals at opposite ends of R3 are equal and in phasa and there is no output at J4. If impedances are different, output proportional to differance appears at J4. Impedance values can be from 25 to 100 ohms, although circuit is designed for optimum performance at 50 ohms.—J. Reisert, Matching Techniques for VHF/UHF Antennas, *Ham Radio,* July 1976, p 50–56.



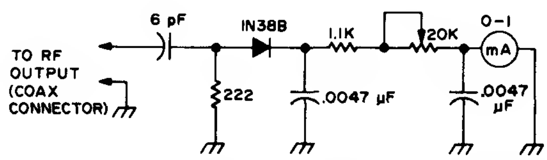
Q MULTIPLIER FOR LOOP—Improvas performance of loop antenna on 40, 80, and 160 meters. Feedback control is obtained with adjusteble single-turn loop L3 coupled to L1, and receiver input is taken from L2. L3 is rotated within field of L1 to adjust amount of regeneration, optimize circuit Q, and maka directional null mora pronounced. Article gives loop construction details. Ground lower end of 100K resistor to provide ground return for FET.—K. Cornell, Loop Antenne Receiving Ald, *Ham Radio,* May 1975, p 66–70.



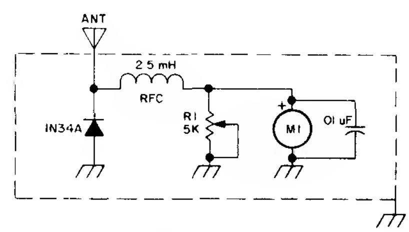
RF NOISE BRIDGE—Improves accuracy and measurement range for impedance measurements from 3.5 to 30 MHz, particularly resistive and reactive components of high-frequancy antennas. Accuracy is 3 ohms RMS. Wideband noise, generated in zaner followad by thraetransistor amplifier, is injected into two legs of bridge in equal amounts by toroidal transformar having quadrifilar windings. With unknown impedance connected and detector (any communication receiver) set to desired frequency, reference impedances (250-ohm noninductive pot and 360-pF variable capacitor) are adjusted for deepest possible null. Value of unknown impedanca is than aqual to parallel combination of references. Articla covers construction and calibration.—R. A. Hubbs and A. F. Doting, Improvements to the RX Noise Bridga, *Ham Radio*, Feb. 1977, p 10–20.



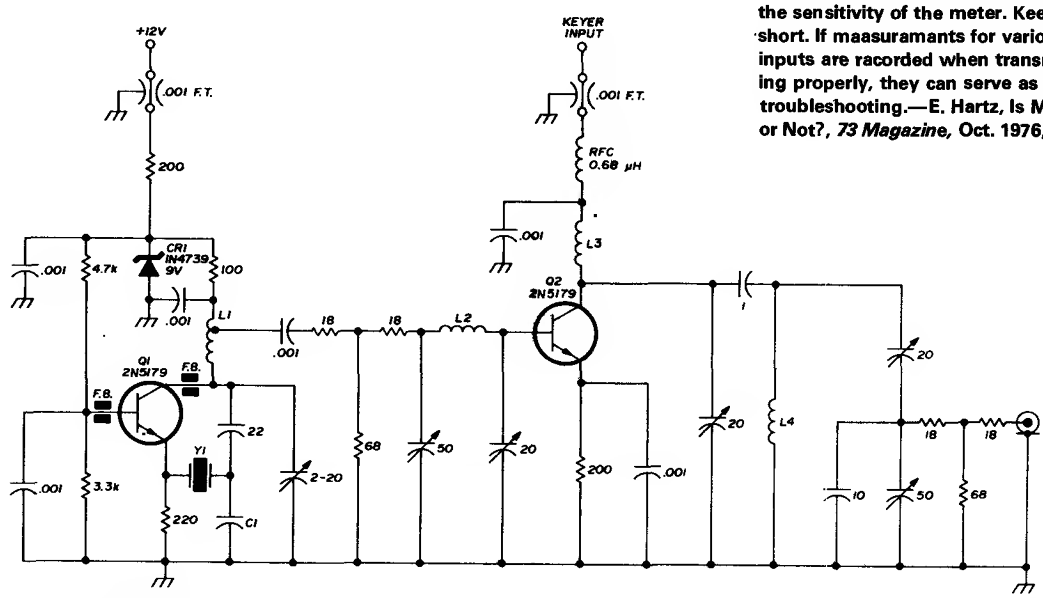
LOOP PREAMP—Loop for lower-frequency amateur bands is connected to gate of HEP802 FET and output to receivar is taken from FET source. C1 is two-gang variable capacitor from old broadcast radio, with stators in parallel to give 600 pF. Article gives loop data for 40, 80, and 160 meters and for high end of broadcast band. For 40 and 80 meters, use 18-inch square loop with 2 turns spaced ¼ inch. Ground lower end of 100K resistor to provide ground return for FET.—K. Cornell, Loop Antenna Receiving Aid, *Ham Radio*, May 1°75, p 66–70.



RF OUTPUT INDICATOR—Designed for use with amateur radio transmitters. Pot is edjusted for maximum desired indication on band usad. For 20–10 matars, 6-pF capacitor is adequate. On lowar bands (80-40 matars), use 7 or 12 pF insteed.—Novice Q & A, *73 Magazine*, Holiday issue 1976, p 20.

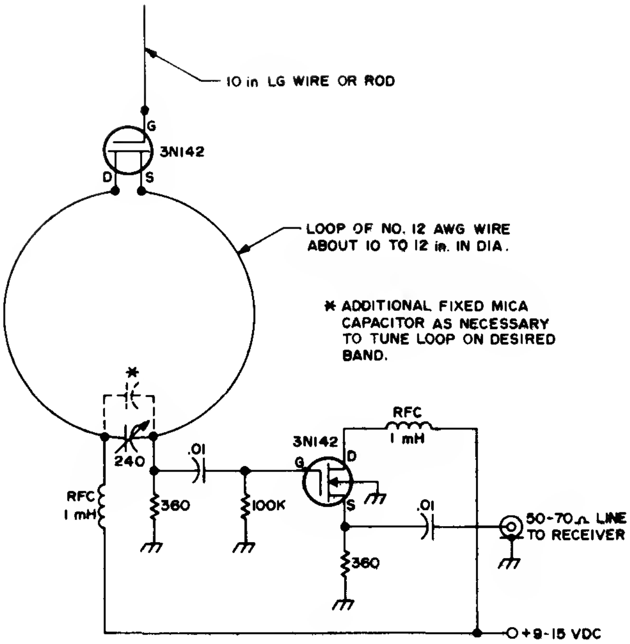


RADIATED-FIELD METER—Gives quick check of overall transmittar performance, including antenna system. Metar can be 1 mA, but 0–200 μA or 0–50 μA will be more sensitive. The longer the referance antenna used, the greatar will be the sensitivity of the meter. Keep lead lengths short. If maasuramants for various transmitter inputs are racorded when transmittar is working properly, they can serve as guida for later troubleshooting.—E. Hartz, Is My Rig Working or Not?, *73 Magazine*, Oct. 1976, p 56–57.



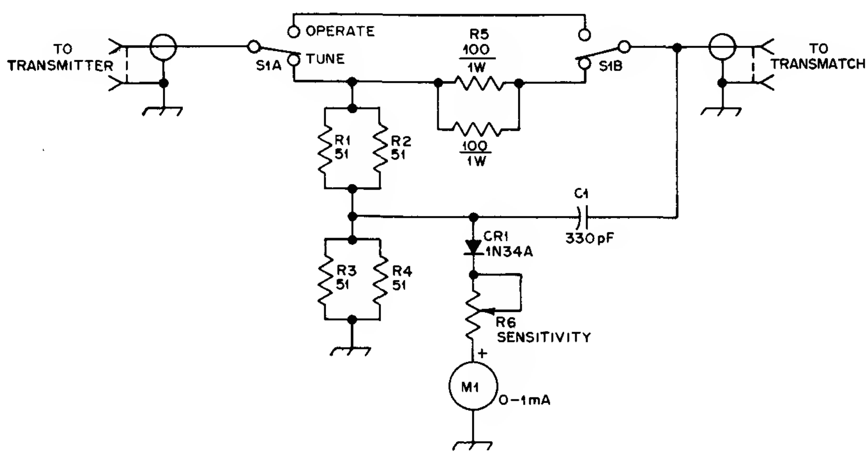
C1	as large as possible, consistent with good oscillator starting (100 pF typical)	L2	15 turns no. 28 (0.3mm) on Amidon T-25-12 toroid core
FB	ferrite bead	L3,L4	4 turns no. 24 (0.5mm), ¼" (6.5mm) inside diameter, ¼" (6.5mm) long
L1	9 turns no. 24 (0.5mm) on Amidon T-37-12 toroid core; tapped 3 turns from cold end	Y1	72-MHz, 5th-overtone, series-mode crystal

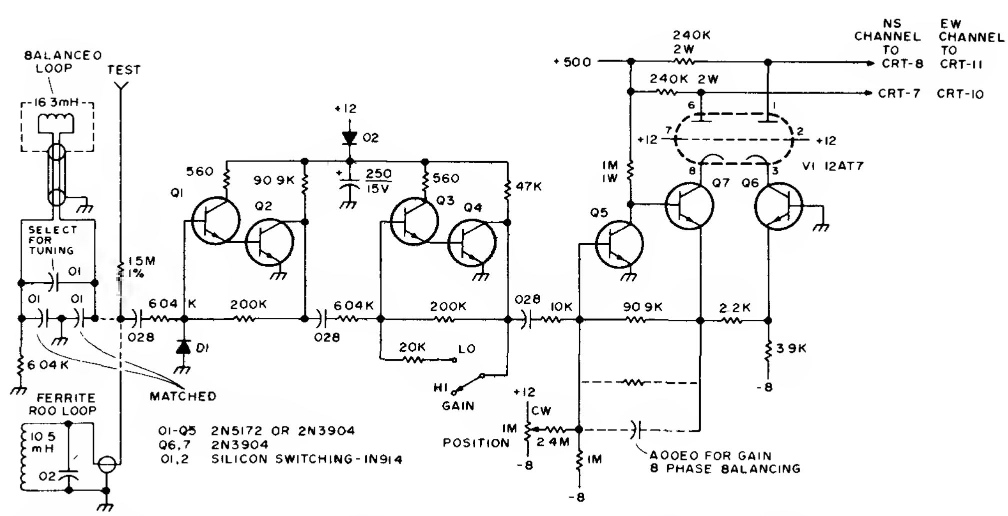
144 MHz FOR VSWR BRIDGE—Modulated signal source provides 10-mW CW output and 5-mW modulated output at modulation frequency of 1000 Hz. Spurious and harmonic outputs are 40 dB below desired output. 72-MHz crystal oscillator is followed by doubler staga. Oscillator runs continuously while doublar is keyed with simpla ON/OFF square-wava keying. Freedom from load variations is obtained with double-tuned output filtar providing up to 6-dB attenuation between genarator and load. Use regulated powar supply or batteries.—J. Raisert, Matching Techniques for VHF/UHF Antennas, *Ham Radio*, July 1976, p 50–56.



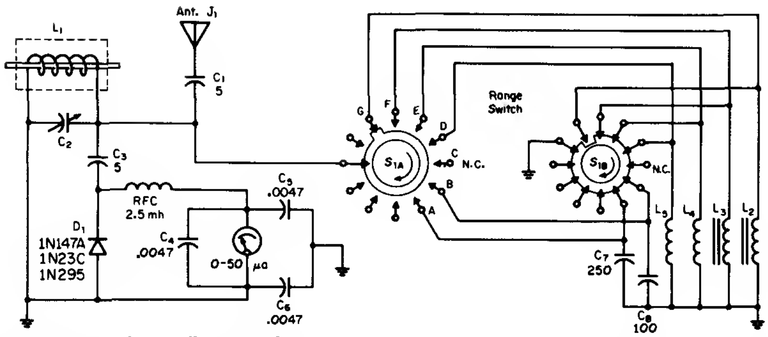
ACTIVE ANTENNA—Uses tuned loop with rel-etively low Q for broedband operation over one amateur band, phase-coupled by FET to 10-inch vartical sensing antenna to giva unidirectional reception pattern. Loop is tuned to either 80 or 40 metars by trimmer cepacitor at its base. Output of loop is coupled to another 3N142 FET used as source follower, to isolata output of loop from heavy loading effect of 50-ohm transmission lina going to raceiver. Parformance is comparable to that of full-size quarter-wave vertical antenna on 40 meters. Battary sourca can be used because drain is only about 2 mA.—J. J. Schultz, An Experimental Miniatura Antenna for 40 to 80 m, *73 Magazine,* June 1973, p 29–32.

PROTECTION FOR QRP TUNING—Simpla resistive SWR bridge provides dummy load, relative powar output indicator, and safe method of tuning transmittar without destroying transistors because of mismatched load. Input dividar R1-R4 has total resistance of 50 ohms, using ½-W composition resistors, for dissipating transmittar output when S1 is in TUNE position. M1 indicates relative power applied to this load. Antenna is connectad through Transmetch, and antenna tunar is adjusted for minimum deflection or lowest SWR. R5 isolates transmitter from antanna. With S1 in OPERATE position, M1 indicates reletiva powar output into antenna.—A. S. Woodhull, Simplified Output Metering Protects QRP Transmitters, *QST,* April 1977, p 57.





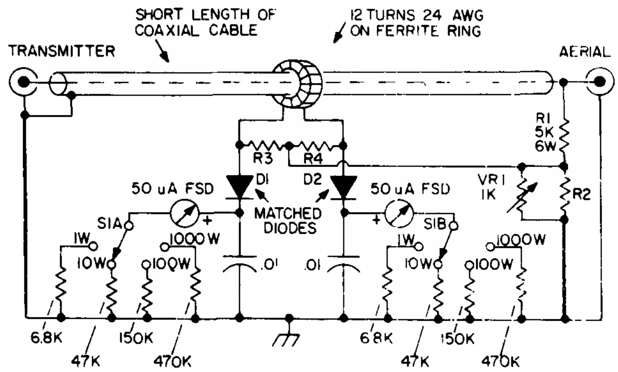
10-kHz SFERICS RECEIVER—Developed to measura diraction and strength of atmospharic electromagnatic radiation (sferics) associatad with sevare weather conditions, for detection and tracking of tornadoes. Signals from crossed loop antennas feed deflection amplifiar of CRO. Articla covers problems involved and gives circuit for sanse amplifier that resolves 180° ambiguity in oscilloscope pattern.—R. W. Fergus, A Ham Radio Severe Weather Warning Net, *73 Magazina,* Sept. 1974, p 27–30, 32, 34–36, and 38–39.

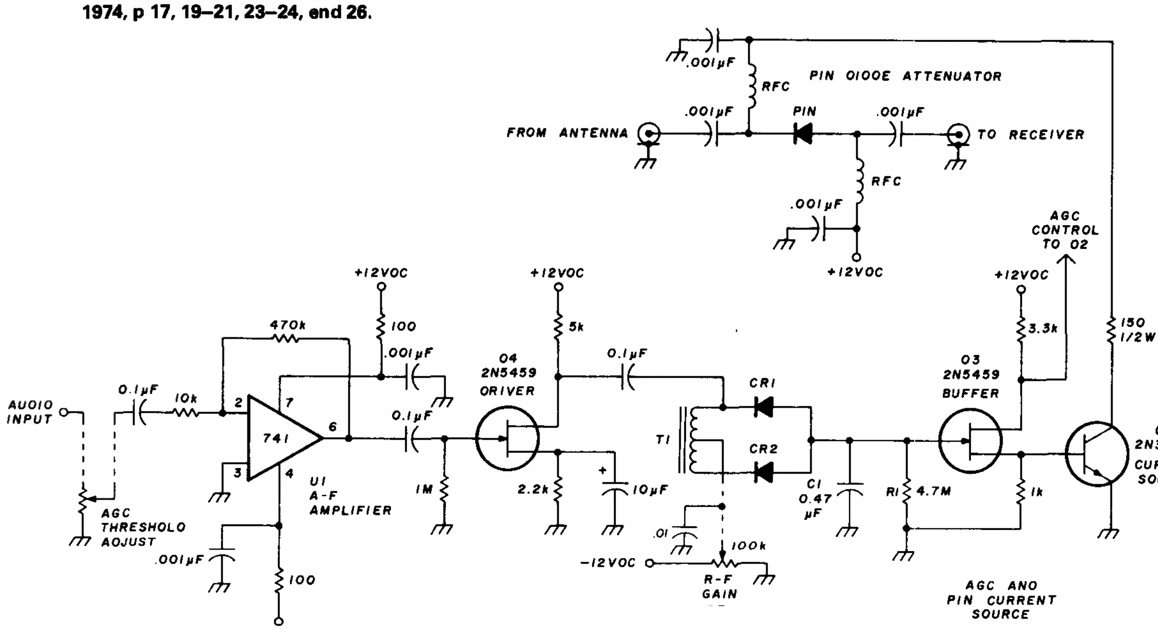


C_1, C_3—5 mmf tubulor or disc ceramic.
C_2—5-120 mmf vorioble copocitor. Millen #20100.
C_4, C_5, C_6—.0047 mf tubulor or disc ceromic copocitor.
C_7—1.8-2.2 mc—250 mmf tubulor ceromic or mico copocitor.
C_8—2.2-3.2 mc—100 mmf tubulor ceromic or mico copocitor.
L_1—3.2-8.5 mc—22 t. #22 on 4½" × 1/4" d. ferrite rod—see text.
L_2—6.3-17 mc—16 t. #22 on 1" l. × 1/4" d. ferrite rod.
L_3—14-38 mc—6 t. #22 on 5/8" l. × 1/4" d. ferrite rod.
L_4—26-70 mc—7 t. #22 oir-wound, self-supporting, 1/4" i.d.
L_5—60-150 mc—2 t. #22 oir-wound, self-supporting, 1/4" i.d. with 3/16" spacing between turns, spread or squeezed os needed to cover v.h.f. ronge.

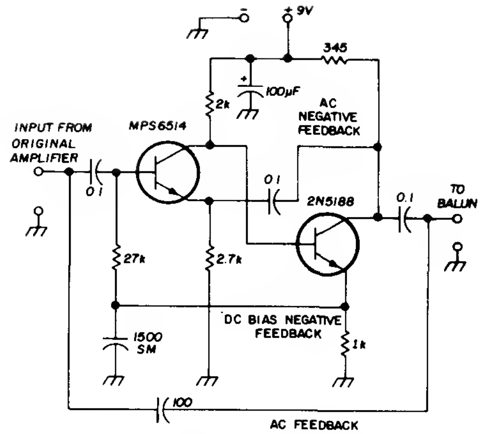
RF MAGNETOMETER—Meesures RF radletion and current distribution for antennes, trensmission linas, ground leeds, building wiring, and shields. Can also be used as sensitive portable fiald-strength meter. Will indicate orientation of field. High-Q circuit is tunebla from 1.8 to 150 MHz for indicating frequency of fields producad by RF harmonic. Applications include detecting reradiation from rain gutters, metal fencing, towars, and guy wires that are distorting entenna field petterns, and detecting rediation from ground leads, epplience power cords, and hidden building wiring. When used es probe, will eccurately pinpoint leakage of RF energy from joints, holes, or slots in shielded enclosures. Operetion is similer to absorption-type wevemeter, except thet pickup coil is electrostatically shielded by slotted aluminum IF trensformer cen to aliminate capecitive coupling. Inductor is wound on ferrite coil to give very high Q es pickup element.—W. M. Scherer, An R. F. Megnetometer and Field Strength Meter, *CQ*, April 1971, p 16–20.

DIRECTIONAL WATTMETER—Gives 10% accuracy betwaen about 100 kHz end 70 MHz. Full-scale velues of renges ere 1, 10, 100, and 1000 W. Low resistance in secondery circuit of current transformer is split into two equal parts, so sum and differance voltages are avelleble et ends of secondary. Meters then indicete forwerd and reflected power velues. For 50-ohm line, usa 220 for R2 end 27 for R3 end R4. For 75-ohm line, corresponding velues ere 180 end 33. Detector diodes ere point-contect germenium rated et 80 PIV. Article gives construction details. Ground coex breid et one end only. Farrite 4ecring is 0.5-inch Mullerd FX1596 or equivelent.—P. G. Martin, Some Directionel Wattmeters end e Novel SWR Meter, *73 Magazine*, Aug. 1974, p 17, 19–21, 23–24, end 26.

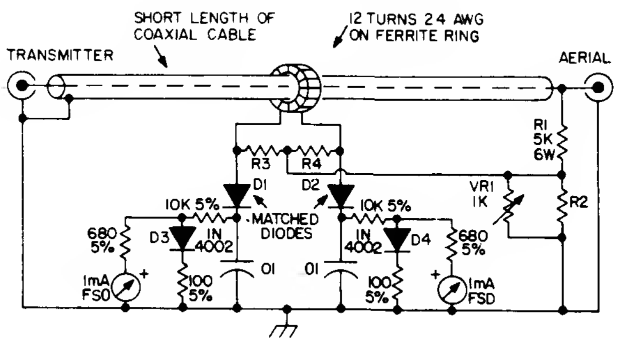




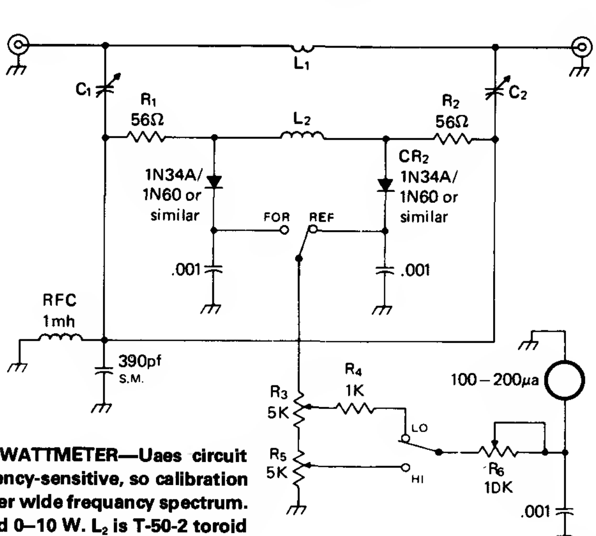
PIN DIODE ATTENUATOR—Designed for insertion betwaan antenna and input of any HF receiver to improve adjacent-channel salactivity by providing attenuetion ehead of mixer for entire tuning range. Hewlett-Packard 5082-3379 PIN diode has very low impedence when conducting and very high impedance when bies current is small. NPN transistor Q1 provides over 100 mA es current source to PIN diode. Q1 is driven by AGC circuit through JFET buffer Q3. AGC voltege is derived from top of audio gein control in raceiver for rectification, with 200 mVRMS et input of opemp U1 giving maximum ettenuation. Center tap of T1 (eny small AF transformer) can ba grounded. CR1 and CR2 are germanium diodes. Article also gives circuit of IF system using cascaded 9-MHz crystal filters to improve selectivity furthar end provide overall AGC control renge of 70 dB.—M. Goldstein, Improved Receiver Selectivity and Gein Control, *Ham Radio*, Nov. 1977, p 71–73.



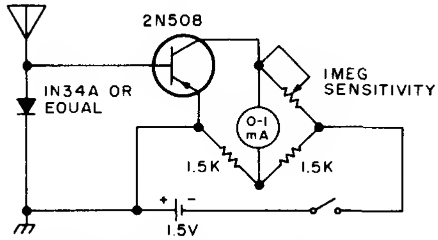
BROADBAND NOISE AMPLIFIER—Developad for use with entanne noiae bridges for measurements et 20 meters. Provides 35 to 50 dB additional gain, not entirely constent over useful range of 1.8 to 30 MHz. Three strong feedbeck loops ara introduced between driver and finel emplifier. Use transistors specified, baceuse substitutions mey cut overall gain by 10 to 20 dB.—A. Weiss, Noise Bridge, *Ham Radio*, May 1974, p 71–72.



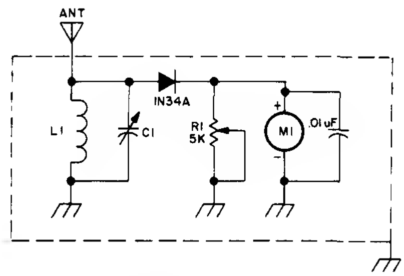
SWR METER—Gives direct meesurement of standing-wave retio on tranamission line, independent of absoluta powar levels and of fraquency. Voltages of 1N4002 silicon diodes are proportional to logarithms of their currants, which in turn are proportional to forward and reflacted voltages. Metar scala is nonlinear, with maximum sensitivity es SWR approaches 1:1. For 50-ohm line, use 220 for R2 and 27 for R3 end R4. For 75-ohm line, corresponding values ere 180 end 33. Detactor diodes are point-contact germanium reted at 80 PIV. Article gives construction datails and calibration curve. Farrite ring is Mullard FX1596 or equivalent, with 0.5-inch outsida diameter. Ground coax braid at one end only.—P. G. Martin, Some Directional Wattmeters and a Noval SWR Metar, *73 Magazine*, Aug. 1974, p 17, 19–21, 23–24, and 26.



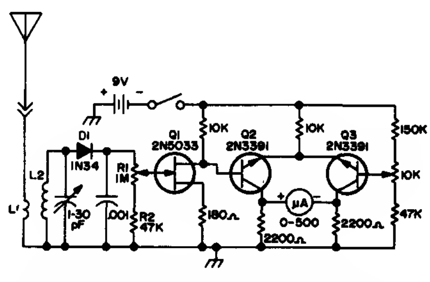
DUAL-RANGE RF WATTMETER—Uaes circuit which is not frequency-sensitive, so calibration can ba accurate over wide frequancy spectrum. Rangas ara 0–1 and 0–10 W. L_2 is T-50-2 toroid wound almost full with No. 28 enemel, leaving only room for 2-turn link L_1. C_1 and C_2 are 3–20 pF trimmers. Article covers calibretion and usa and givea tabla for reading SWR by comparing watts FORWARD with watts REFLECTED.—A. Weiss, The Silk-Purse In-Line Wattmeter, *CQ*, Mey 1977, p 50–52 and 74–75.



FIELD-STRENGTH METER—Easily assembled for checking performance of amateur radio transmitter and its antenne system.—Circuits, *73 Magazine*, Jan. 1974, p 128.



TUNED RADIATED-FIELD METER—Provides quick check of transmitter performance and approximete check of frequency. Values for L1 and C1 are chosen to cover desired frequency renge. Meter cen be 1 mA or 200 μA. Keep lead lengths short.—E. Hartz, Is My Rig Working or Not?, *73 Magazine*, Oct. 1976, p 56–57.

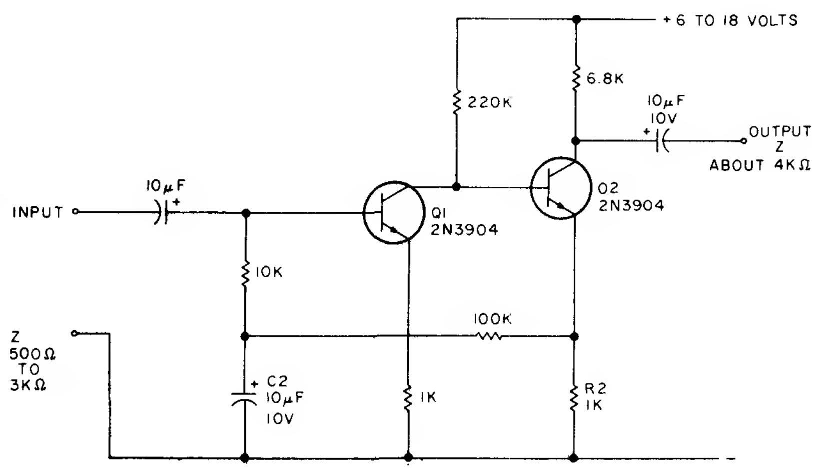


FIELD-STRENGTH METER—Developed for tuning ell types of antennes, from mobile whips to four-element quads. Avoids ahielding end other problems of switched T pads for calibrated attenuator by first detecting RF, then ettenuating DC output. Technique has added advantaga that circuit is no longar frequancy-senaitive. To covar 13–24 MHz, L2 la 11 turns spaced out to about 1 inch, with 2 turns over top for L1. D1 can be any diode such ea 1N34. R1 serves es calibrated ettenuetor, with R2 in series giving 0-dB point at junction. Article covers construction end operation.—J. L. Iliffe, An Amplified, Calibrated, Signel Strangth Metar, *73 Magazine*, Juna 1973, p 85–86.

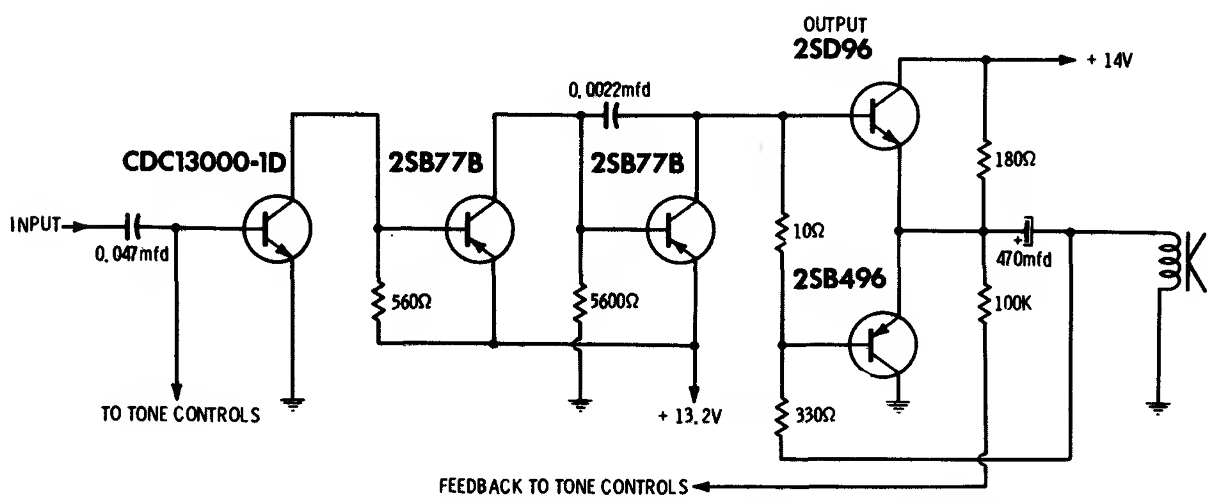
CHAPTER 3

Audio Amplifier Circuits

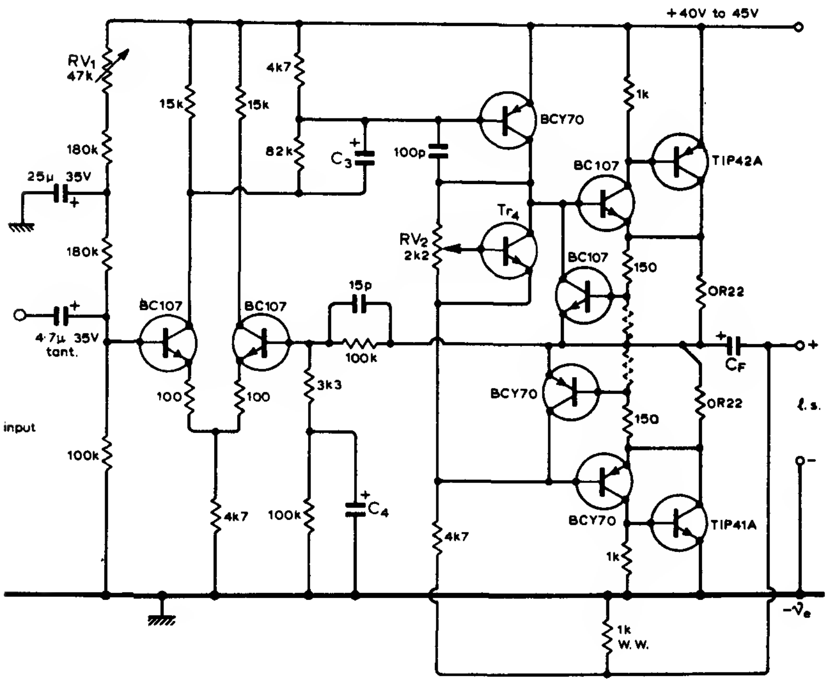
Includes preamps for all types of inputs and AF amplifiers with power outputs up to 90 W and bandwidths up to 50 kHz, most using transistors with or without opamps and ICs. Circuits include variety of methods for reducing distortion and eliminating switching transients. See also Audio Control, Receiver, and Stereo chapters.



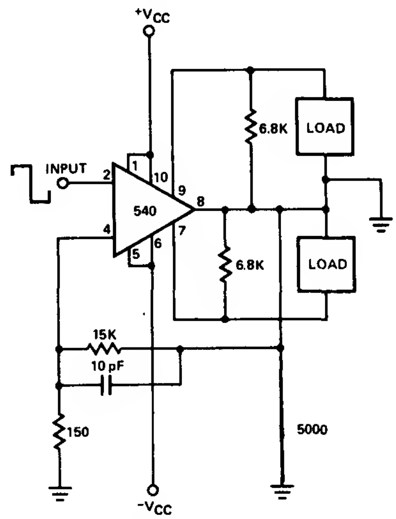
500-OHM INPUT—Simpla audio amplifiar having high gain, low noise, and axcallent temparatura stability can ba usad as mike boostar, first AF amplifier staga in receivar, or for other praamp applications. With values shown, circuit will amplify down to about 10 Hz. To Incraasa low-frequency cutoff for speech amplifier, reduce C2 to 1 μF or less.—E. Dusina, Build a Genaral Purposa Preamp, *73 Magazine,* Nov. 1977, p 98.



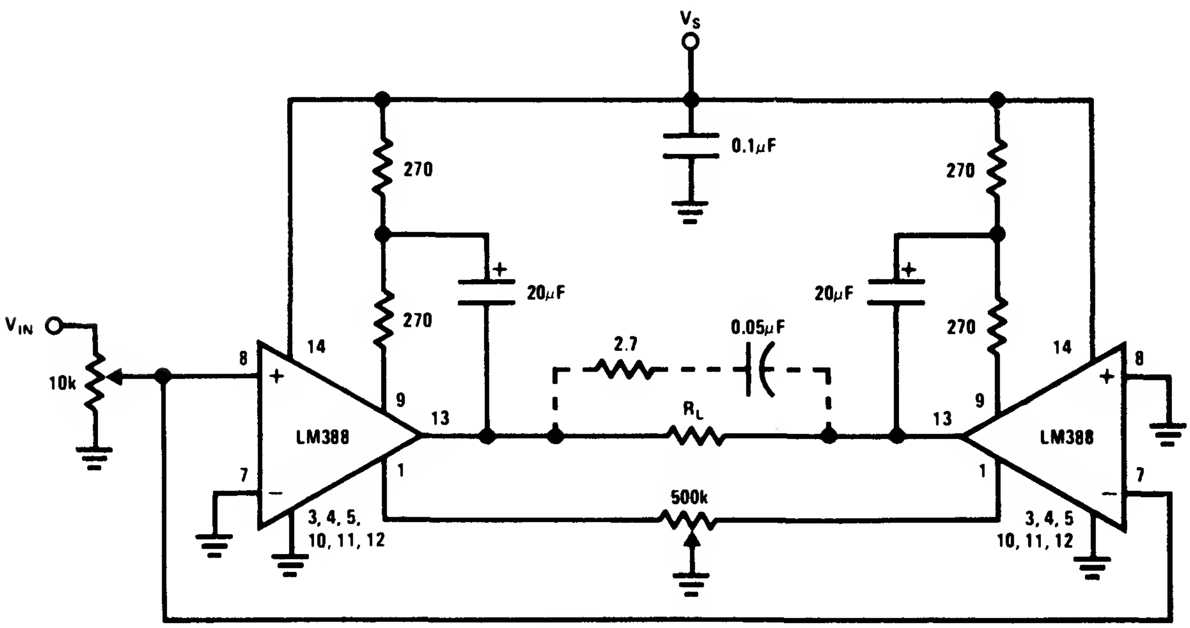
COMPLEMENTARY-SYMMETRY AMPLIFIER—Simplified varsion of circuit takes advantaga of fact that PNP and NPN transistors require signals of opposite polarity to parform same function. Bases of output transistors ara fad in parallal, with loudspeaker connected to common terminal of transistors. Drawback is difficulty of locating matched PNP and NPN transistors.—J. J. Carr, Solid-Stata Audio: A Raview of tha Latast Circuitry and General Troublashooting Procadures, *Electronic Servicing,* Aug. 1971, p 38–43.



30-W—Dasigned for use with active filter crossover networks for three loudspeakars. For lowest-frequency channel, C_3 is 150 μF and C_4 is 50 μF. For middle channal, C_3 and C_4 are 25 μF. For high-frequency channel, C_3 end C_4 are 10 μF. Articla includes circuit for active filter network.—D. C. Read, Active Filtar Crossovar Networks, *Wireless World,* Dec. 1973, p 574–576.

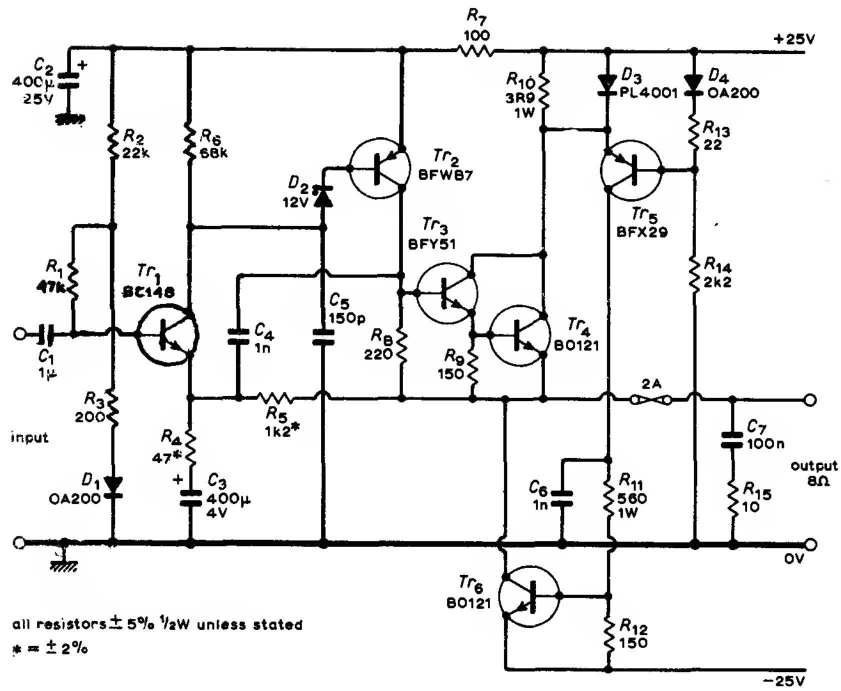


HAMMER DRIVER—Signetics 540 power drivar handles either push-pull or single-ended inductiva loads such es releys, solenolds, motors, and alectric hammers. In push-pull connection shown, load is driven in either positive, negative, or both arms of output. Either output can be selected by appropriata choice of input pulse polarity. Supply can be ±5 to ±25 V.—"Signetlcs Anelog Deta Manual," Signetics, Sunnyvala, CA, 1977, p 764.

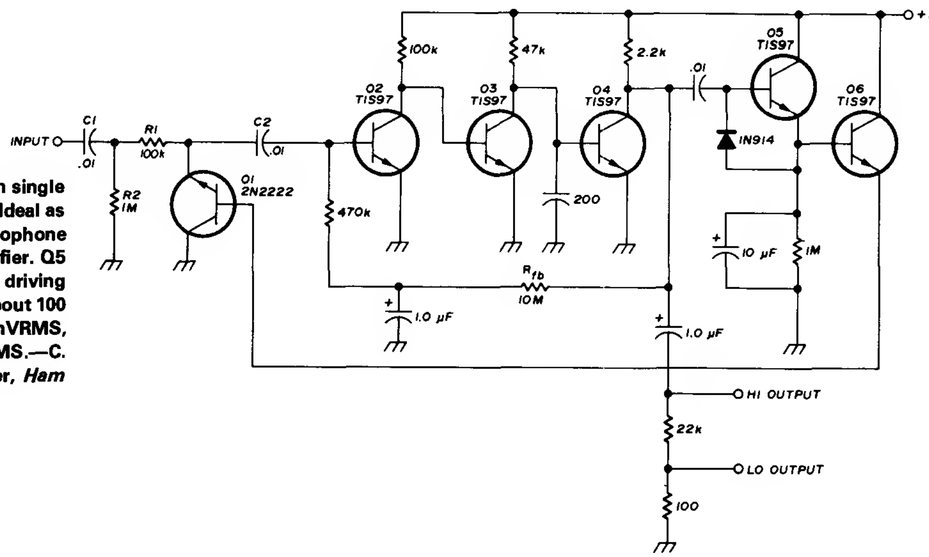


V_S = 6V R_L = 4Ω P_O = 1.0W
V_S = 12V R_L = 8Ω P_O = 3.5W

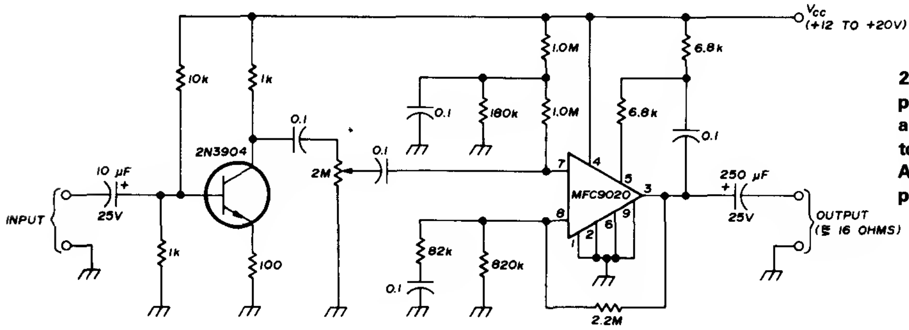
3.5-W BRIDGE AMPLIFIER—Bridge connection of Natiónel LM388 power opamps provides 3.5 W to 8-ohm loudspeaker when using 12-V supply. With 6-V supply end 4-ohm load, maximum power is 1 W. Coupling capacitors are not raquired since output DC levels ara within several tenths of a volt of each other.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-37–4-41.



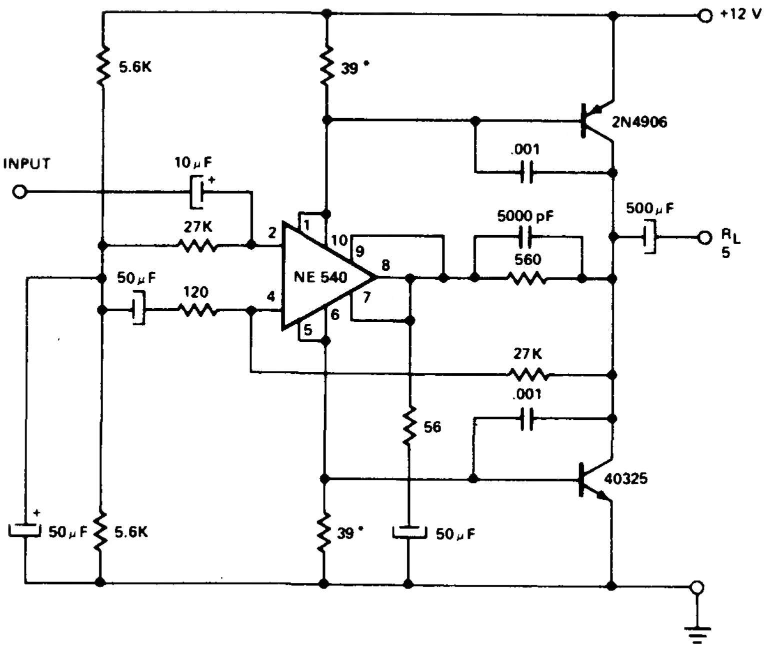
LOW-COST 30-W—Economical compromise gives 30 W into 8-ohm load at 0.1% distortion (mainly second harmonic) and hum level of −50 dBW. Article covers design and operation of circuit in detail.—P. L. Taylor, Audio Power Amplifier, *Wireless World,* June 1973, p 301–302.



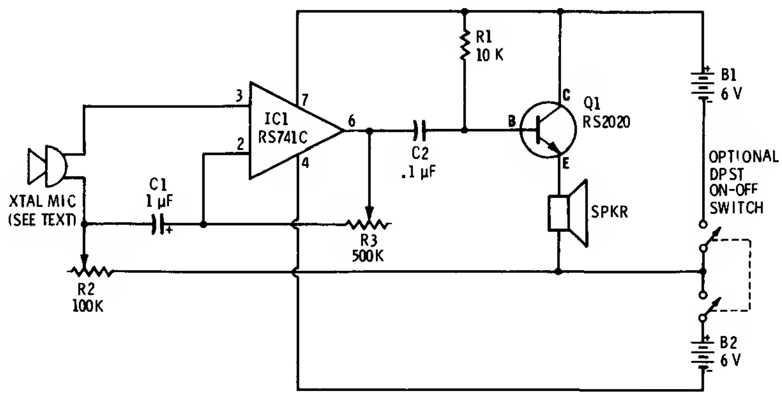
70-dB GAIN WITH 1.5 V—Operates from single penlight cell at current drain of 0.5 mA. Ideal as self-contained unit inserted in microphone cable. Q2-Q4 form 70-dB voltage amplifier. Q5 is detector, and Q6 is emitter-follower driving AGC transistor Q1. 3-dB bandwidth is about 100 Hz to 8 kHz. Full output is about 200 mVRMS, while low output terminal is 1 mVRMS.—C. Hall, Low-Voltage Audio AGC Amplifier, *Ham Radio,* Dec. 1973, p 32–34.



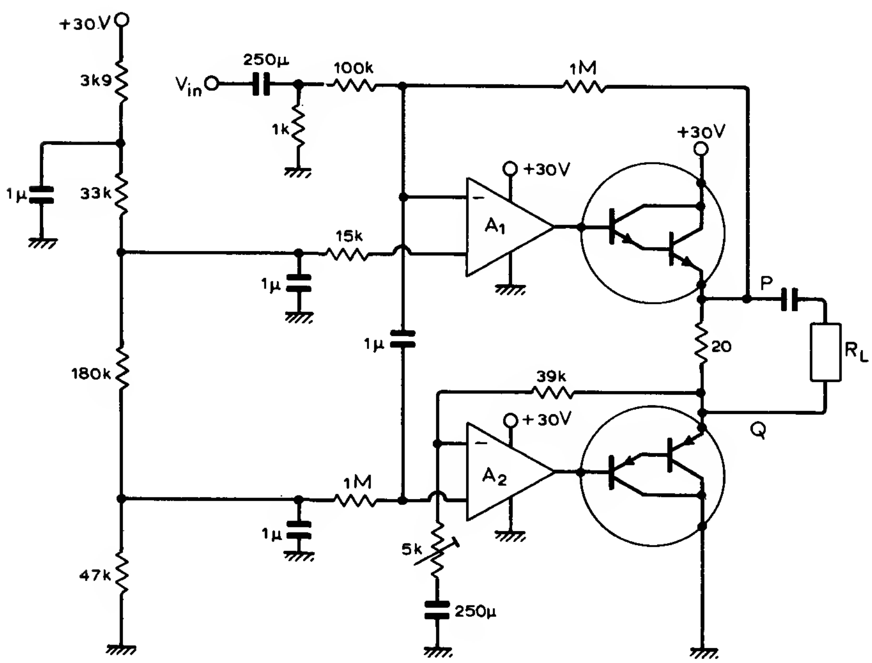
2 W WITH IC—Uses Motorola MFC9020 audio power amplifier to give maximum output of about 2 W for 16-ohm loudspeaker. Used in autopatch system for FM repeater.—R. B. Shreve, A Versatile Autopatch System for VHF FM Repeaters, *Ham Radio,* July 1974, p 32–38.



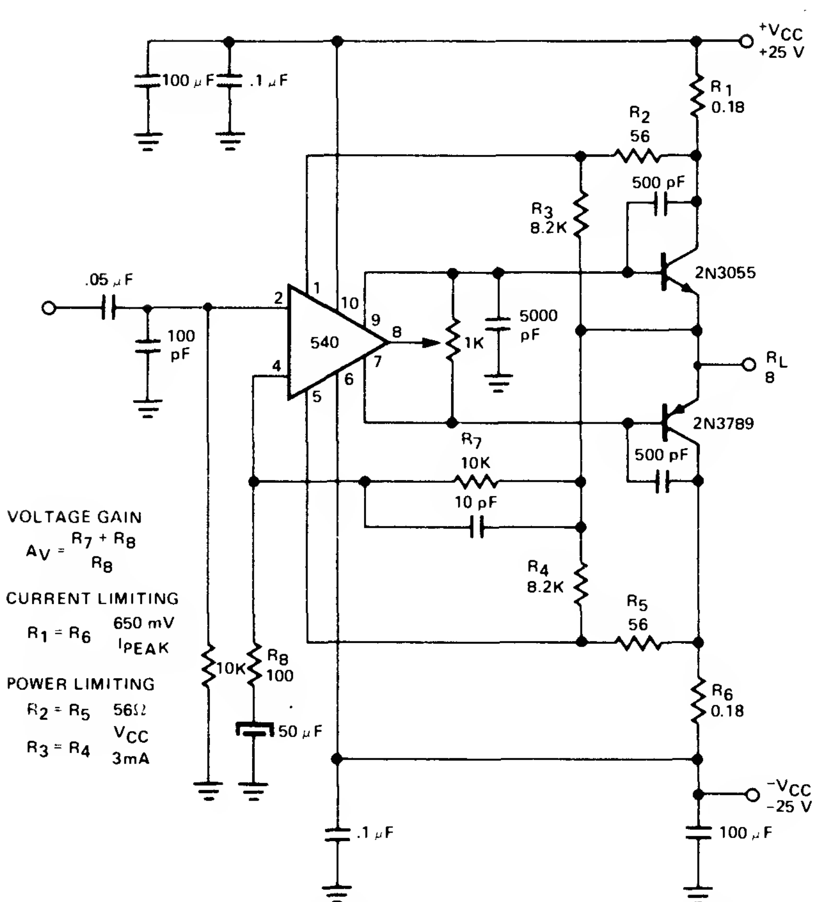
AUTO RADIO AMPLIFIER—Circuit shown permits operation of Signetics NE540 power driver from single-polarity 12-V supply of auto. Bipolar supplies for differential inputs of 540 are achieved by returning inputs to half of available supply or 6 V. Load is AC coupled because amplifier has DC gain of 1, and amplifier output is therefore 6 VDC. 39-ohm supply resistors are selected for minimum crossover distortion.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 764.

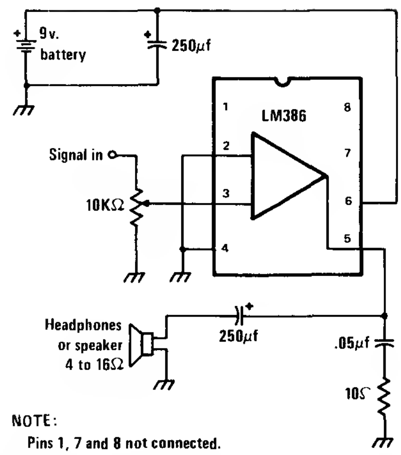


HIGH-GAIN IC WITH TRANSISTOR—High input impedance of RS741C opamp permits use with any general-purpose crystal microphone. R2 is volume control, and R3 controls gain and frequency response of IC. Power transistor stage drives loudspeaker directly, without output transformer.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 79–88.



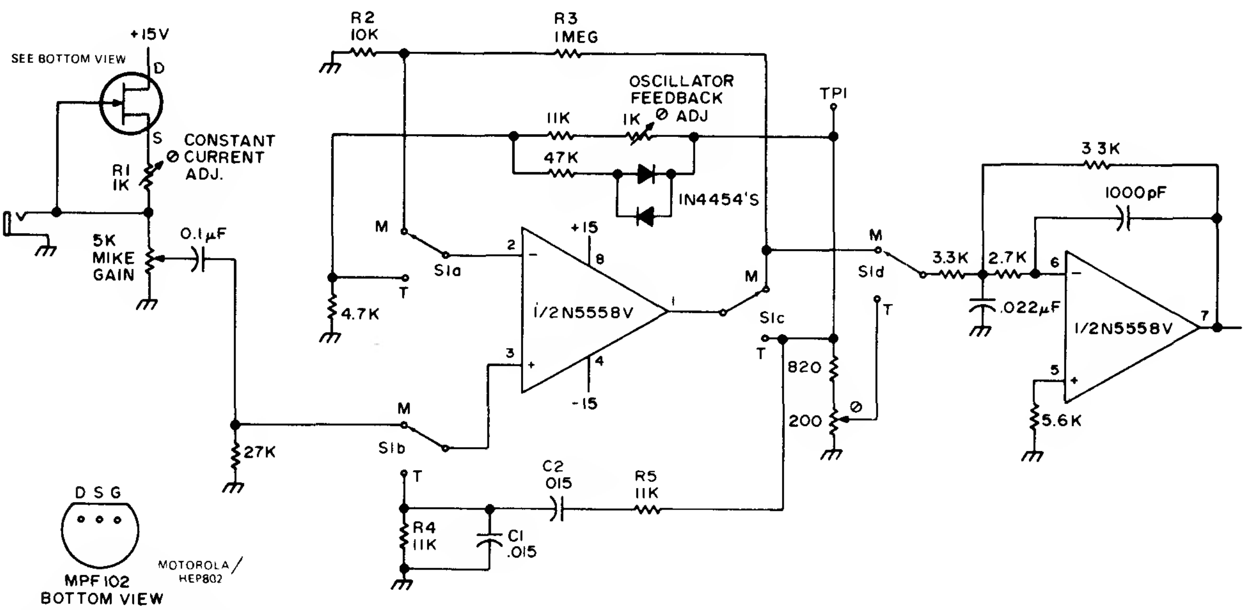
POWER AMPLIFIER WITH ERROR TAKEOFF—Voltage proportional to distortion is amplified for use in reducing nonlinear distortion at output, in circuit developed for use as single-ended power amplifier. Power Darlingtons are MJ4000 and MJ4010, and both opamps are 741. Preset 5K pot is adjusted initially for minimum distortion. Article gives theory of operation and design equations.—A. M. Sandman, Reducing Amplifier Distortion, *Wireless World*, Oct. 1974, p 367–371.



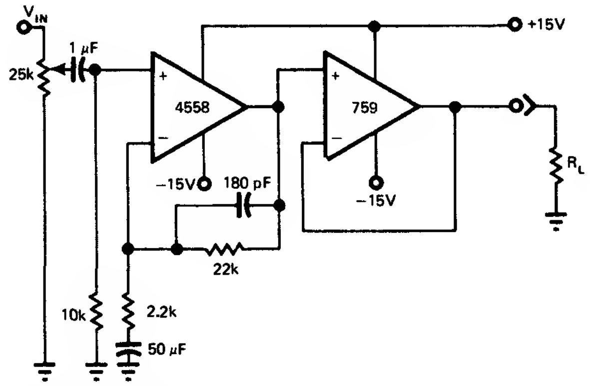


HEADPHONE AMPLIFIER—Cen be used with FM tuner in place of more expansive audio amplifier. For stereo, use ona LM386 circuit for aech chennel. Cen be mounted directly on headphones if weight of battery is not objectioneble.—J. A. Sendlar, 11 Projects under $11, *Modern Electronics*, Juna 1978, p 54–58.

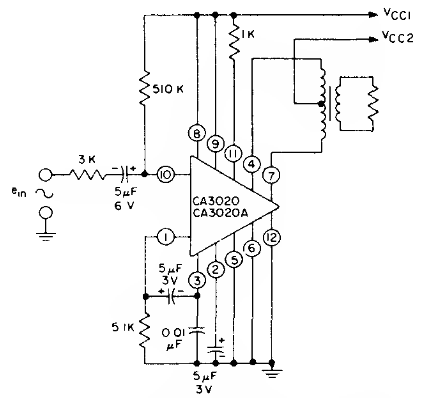
35 W—Signetics 540 drives complemantery output transistors to give high output current for driving 8-ohm loudspeakar. Faedbeck is adjusted to give AC gain of 40 dB. Gain rolls off to unity at DC to prevent DC offset voltages from baing emplified to level thet might damage loudspeakar circuit. Power limiting is provided by placing resistor network around output stage.—"Signetics Analog Data Manual," Signetics, Sunnyvala, CA, 1977, p 762–763.



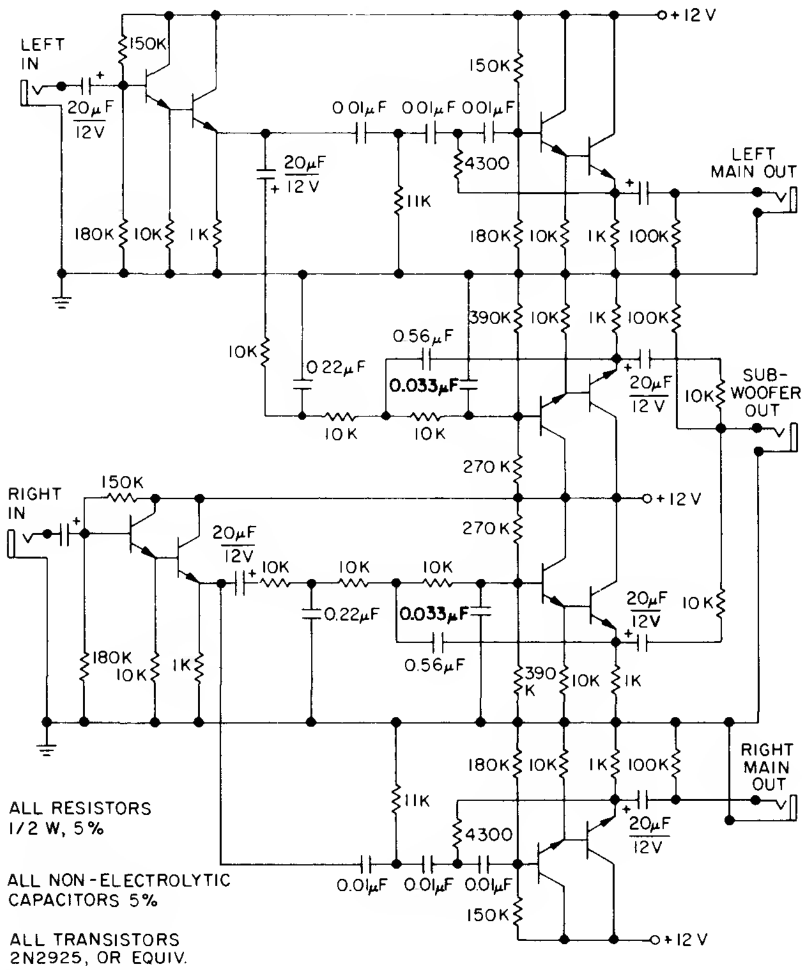
PREAMP WITH TEST TONE—Built around Signetics N5558V dual opamp or equivalent Motorole MC1458CP2, Netionel LM1458, or Taxas Instruments SN72558P. First helf of opemp is used either es gein stage for increasing voltage level of cerbon microphone or es AF Wien-bridge tona oscillator, dapending on position of S1. Frequency is determined by values of C1, C2, R4, and R5. Silicon signel diodas form nonlineer control elemant. Adjust R6 until oscillator output et TP1 is 10 V P-P. FET provides constent current through varieble resistence of carbon microphona, to give audio input voltage. Second opemp is ective low-pass filter with 3.3-kHz cutoff, rolloff of 12 dB per octave, and voltage gain of 10.—H. Olson, An IC Mike Preamp That Doubles as a Tona Ganarator, *73 Magazine*, March 1974, p 45 and 47–48.



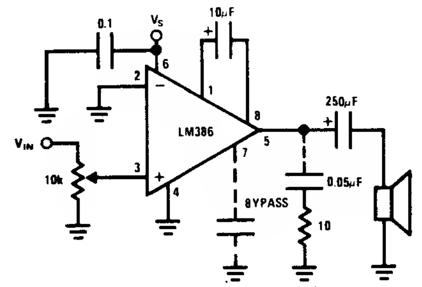
HEADPHONE OPAMPS—Duel low-noise 4558 opemp provides gein end raduces system noise and distortion, while 759 power opemp supplies output power of 0.7 W into 16-ohm loed with lass then 0.1% totel hermonic distortion.—R. J. Apfel, Power Op Amps—Their Innovative Circuits end Peckeging Provide Designers with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.



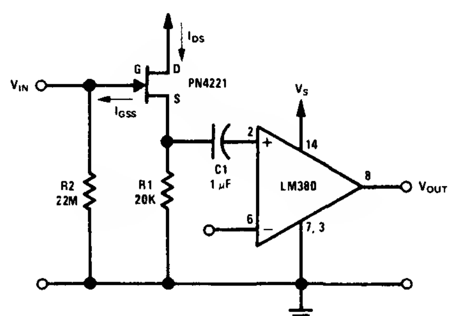
1-W CLASS B—Audio application of CA3020A widebend power amplifier provides 1-W output to loudspeeker loed through AF output transformer with 10% total hermonic distortion. V_{CC1} is 9 V, end V_{CC2} is 12 V. With CA3020, both supply volteges ere 9 V end meximum power output is 550 mW. Sensitivity is 35-45 mV.—"Lineer Integrated Circuits end MOS/FET's," RCA Solid Stete Division, Somerville, NJ, 1977, p 105.



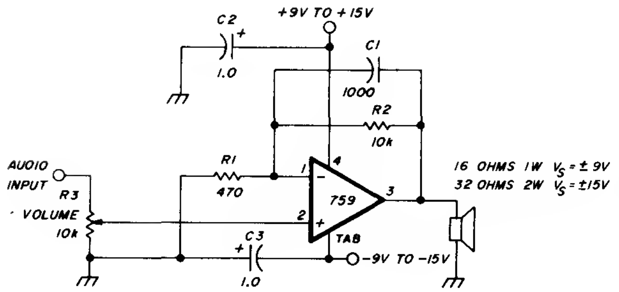
CROSSOVER FOR 20-Hz SUBWOOFER—Used et chennel outputs of stereo system when reproducing music down to 20 Hz es synthesized by electronic function generators. Active crossover network drives subwoofer (low-bass loudspeaker) connected in bridged-center configuration, for handling sounds below range of normel woofer. Crossover consists of third-order Butterworth (18 dB per octeve) networks providing 20-Hz cutoff elong with 100-Hz crossover. Response of subwoofar should extend one octave ebove crossover. One edventage of ective crossover is freedom from trensient intermodulation distortion.—W. J. J. Hoge, Switched-On Bass, *Audio*, Aug. 1976, p 34-36, 38, end 40.



46-dB GAIN—Single Netional LM386 power emplifier provides gein of 200 V/V et maximum output power of 250 mW for 12-V supply. Optionel 0.05-μF capecitor end 10-ohm resistor suppress bottom-side oscillation occurring during negetive swing into load drewing high current.—"Audio Handbook," Netional Semiconductor, Sente Clere, CA, 1977, p 4-30–4-33.

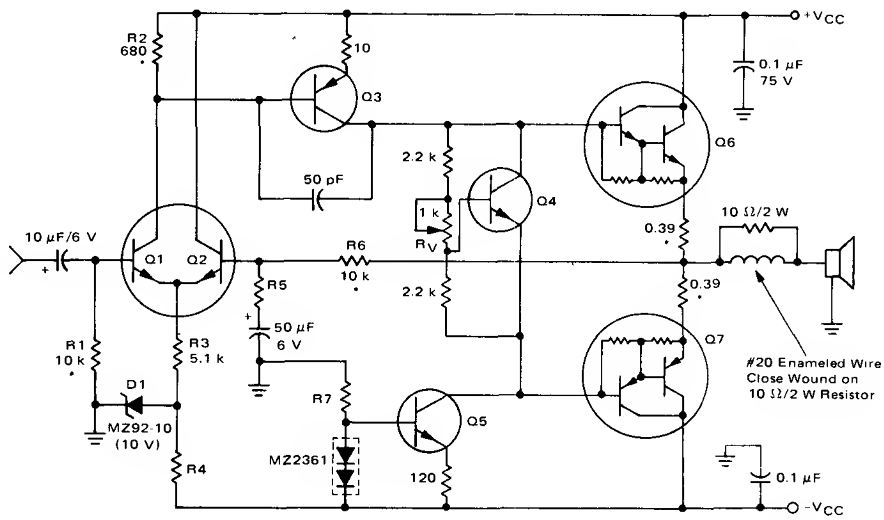


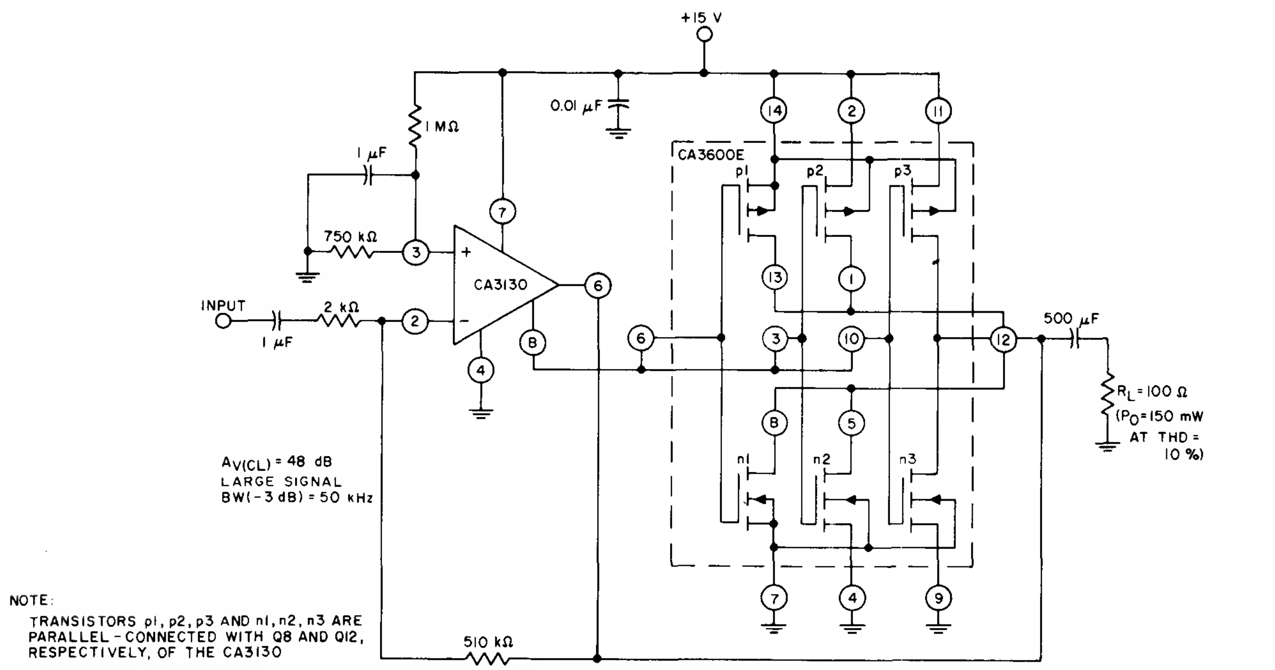
HIGH INPUT IMPEDANCE—Use of JFET es isoletor boosts input impedence of opamp to 22 megohms for low-frequency input signels. Impedence drops to 3.9 megohms es frequency increeses to about 20 kHz. Overall gain of circuit is about 45 dB when using 18-V supply.—"Audio Hendbook," Netionel Semiconductor, Senta Clera, CA, 1977, p 4-21–4-28.



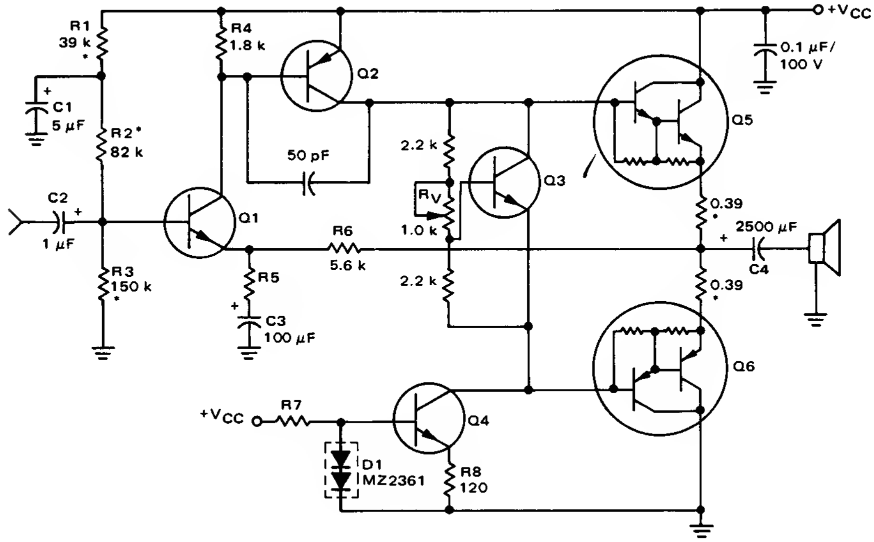
2-W MONITOR—Fairchild 759 opamp provides 1-W AF output when supply is ±9 V and loudspeaker is 16 ohms, and 2 W with ±15 V and 32-ohm loudspeaker. Use heatsink. Gain is 20 for values shown, with response rolled off at 15 kHz by C1.—W. Jung, An IC Op Amp Update, *Ham Radio,* March 1978, p 62–69.

60 W WITH DC-COUPLED OUTPUT—Q6 is Motorola MJE6044 complementary Darlington output transistor, and Q7 is MJE6041. Q1 and Q2 are MD8002 dual transistor, Q3 is MPS-A56, Q4 is MPS-A13, and Q5 is MPS-A06. For 8-ohm loudspeaker, supply is ±36 V with 6.2K for R4, 430 ohms for R5, and 33K for R7. Output center voltage must be maintained at 0 VDC to ensure maximum signal swing and prevent DC voltage from acting on loudspeaker. Frequency response is 10 Hz to 50 kHz for −1 dB points. Same circuit is used with different components for other powers down to 15 W and for 4-ohm loudspeaker.—R. G. Ruehs, "15 to 60 Watt Audio Amplifiers Using Complementary Darlington Output Transistors," Motorola, Phoenix, AZ, 1974, AN-483B, p 5.

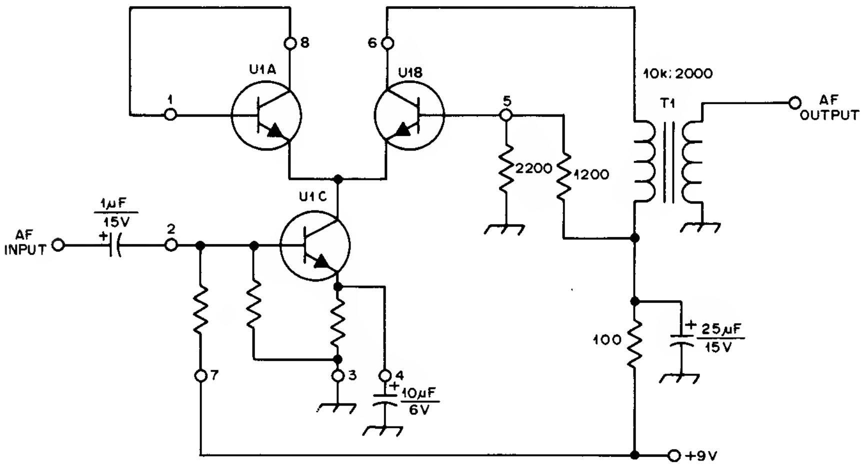




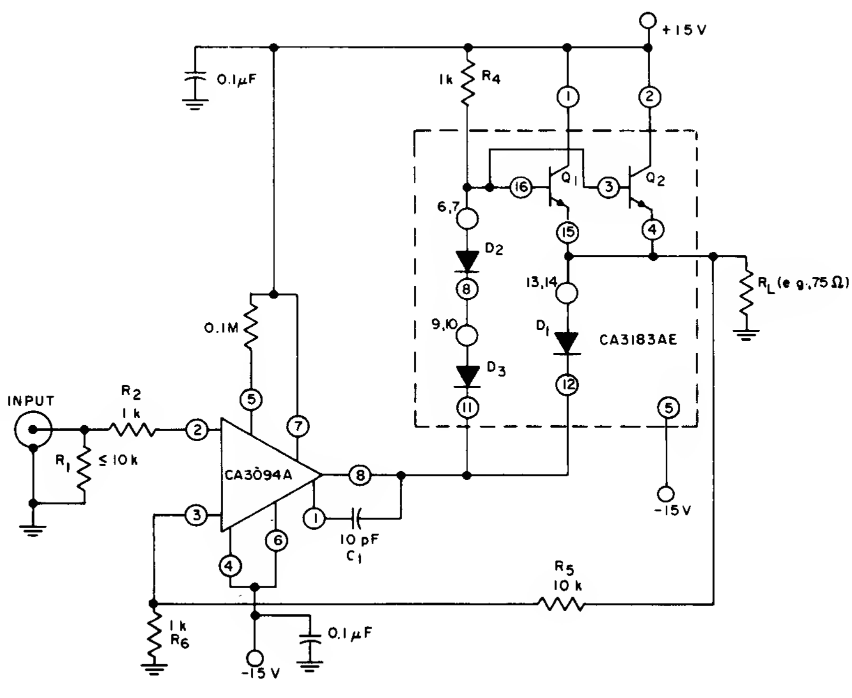
50-kHz BANDWIDTH—Three transistor pairs in CA3600E array are parallel-connected with output stage of CA3130 bipolar MOS opamp to boost current-handling capability about 2.5 times. Use of feedback gives closed-loop gain of 48 dB. Typical large-signal bandwidth is 50 kHz for 3 dB down.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 12.



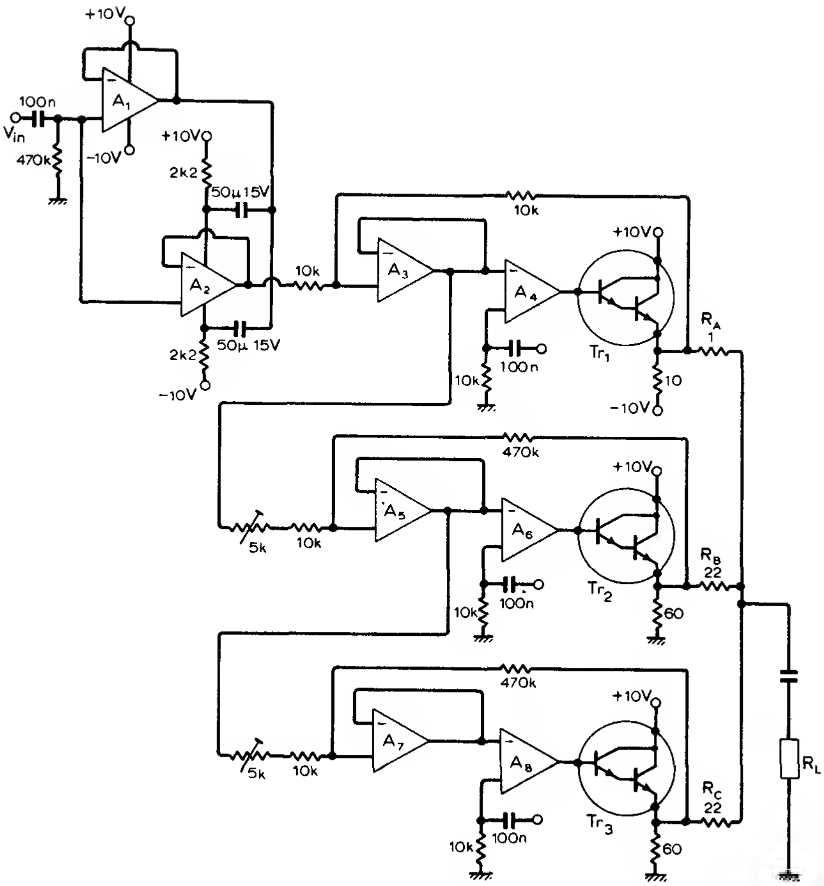
60 W WITH AC-COUPLED OUTPUT—Uses Motorola complementary Darlington output transistors, with MJE6044 for Q5 and MJE6041 for Q6. For 8-ohm loudspeaker, Q1 is MPS-A06, Q2 is MPS-A56, Q3 is MPS-A13, and Q4 is MPS-A06. Supply is 72 V. R5 is 220 ohms, and R7 is 68K. Same circuit is used with different components for other output powers down to 15 W and for 4-ohm loudspeaker. Frequency response is 20 Hz to 50 kHz for −1 dB points.—R. G. Ruehs, "15 to 60 Watt Audio Amplifiers Using Complementary Darlington Output Transistors," Motorola, Phoenix, AZ, 1974, AN-483B, p 3.



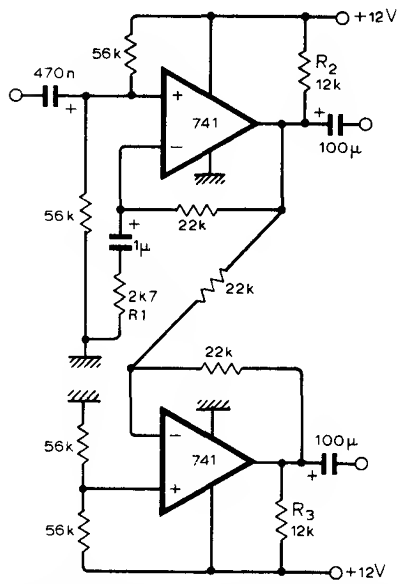
CASCODE AMPLIFIER—Uses two sections of RCA CA3028A linear IC (U1A is not used). Provides power gain of about 40 dB. Unmarked resistors are on IC.—D. DeMaw, Understanding Linear ICs, *QST*, Feb. 1977, p 19–23.



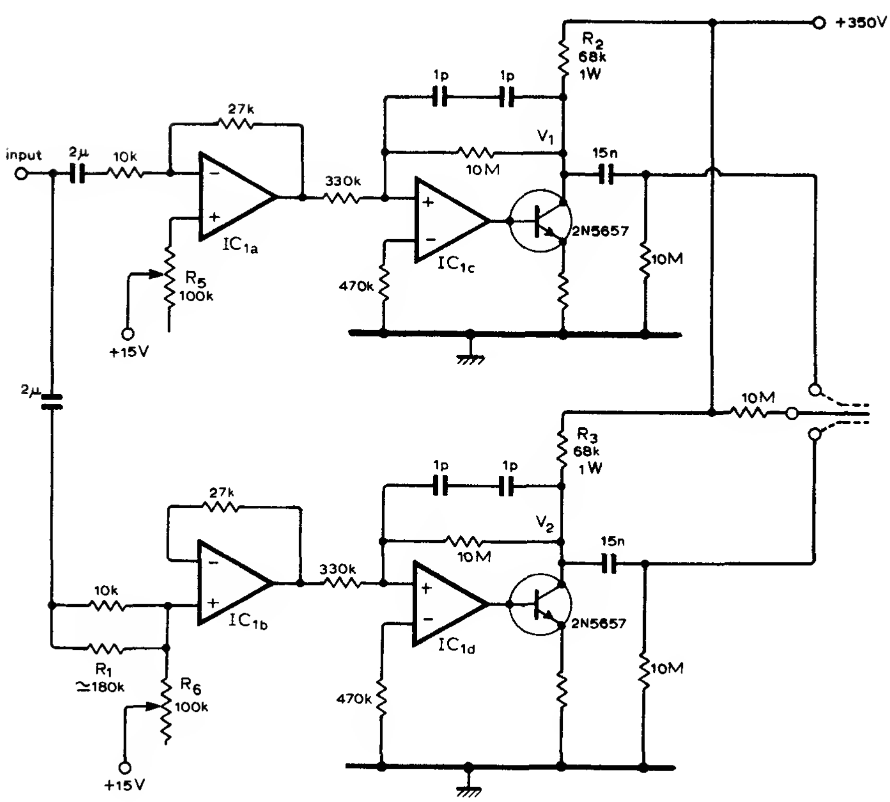
HIGH OUTPUT CURRENT—Uses CA3094A programmable opamp as driver stage for two parallel-connected transistors of CA3183AE array to develop 100-mA average AF current (peaks up to 300 mA) through 75-ohm load. Diode-connected transistors D_1-D_3 in array provide temperature compensation for output transistors.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 11.



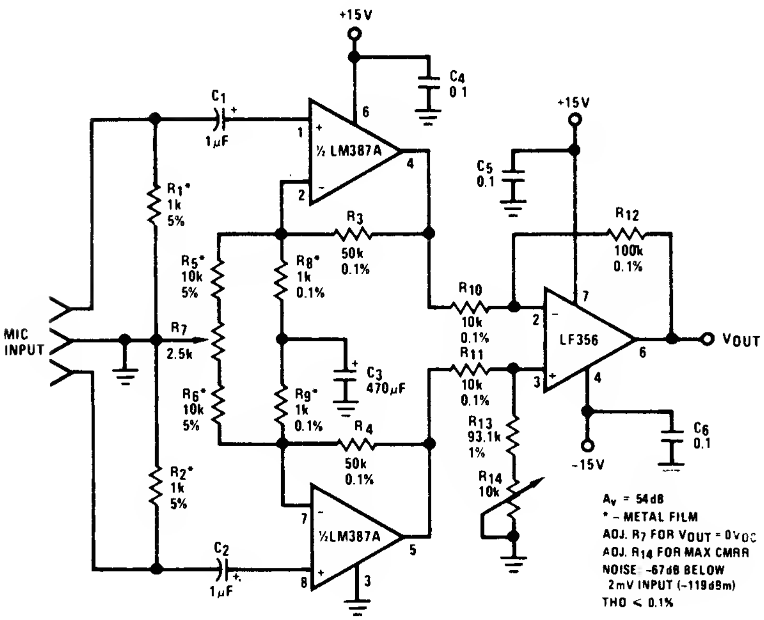
ERROR TAKEOFF REDUCES DISTORTION—Nonlinear distortion is reduced in single-ended emplifier by producing voltega proportional to distortion end emplifying this error voltage in such e way thet it can be used to reduce distortion at output. Circuit uses 741 opamps and MJ4000 power Derlington transistors. Techniqua overcomes basic limitation of negative feedback wherein faedbeck loop gain decreases es frequency Increases. Article also glves variation of circuit more suitabla for power amplifier, end describes circuit operation in detail.—A. M. Sendman, Reducing Amplifiar Distortion, *Wiraless World*, Oct. 1974, p 367–371.



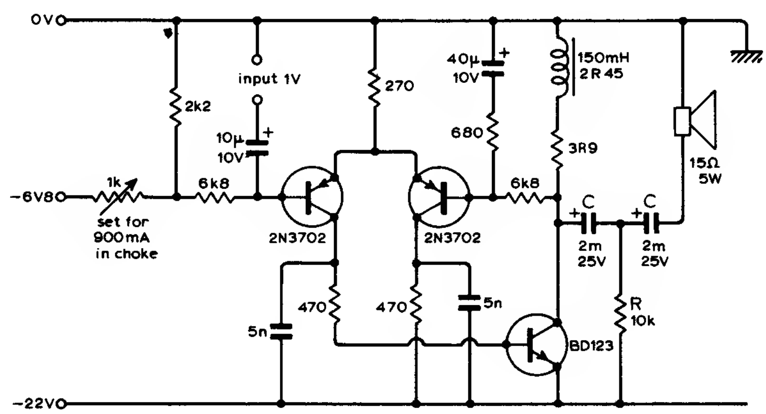
BALANCED OUTPUT WITH OPAMPS—Low-cost amplifier provides low-impedance balancad output from unbalanced signal output of preamp. Response is flat from 10 to 20,000 Hz, and distortion less than 0.1% at 800 Hz into 600-ohm load. Gein is 20 dB. Other opamps, such as LM307 or 747 (dual 741) can also be used.—K. D. James, Balanced Output Amplifier, *Wiraless World*, Dec. 1975, p 576.



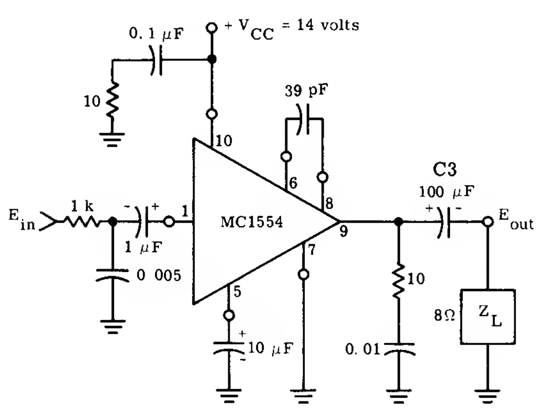
ELECTROSTATIC HEADPHONES—Usas LM3900N four-opamp IC and two translstors to stap up haadphona output signal of AF power amplifier sufficiently to driva pair of electrostatic haadphones without introducing excessive distortion. Total harmonic distortion at 1 kHz is 1% et 300-V peek-to-peak output, and drops to 0.1% at 50-V output.—N. Pollock, Elactrostatic Haadphone Amplifier, *Wiraless World*, July 1976, p 35.



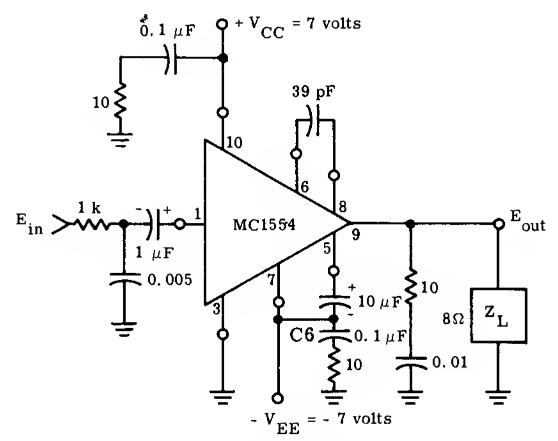
LOW-NOISE TRANSFORMERLESS PREAMP—Noise performance of balanced microphone praamp is improved with instrumentation amplifier configuration of three opamps. Each half of LM387A is wired as noninverting amplifier. LM387A serves to amplify low-level signals while adding as little noisa as possible, leaving common-moda rejection for LF356.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-37–2-40.



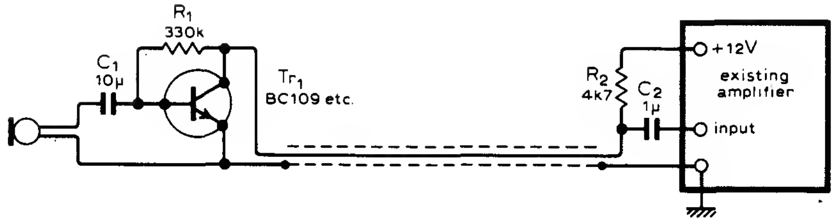
5-W CLASS A—Three-transistor faedback loop gives excellent DC stablllty, while arrangemant of two capacitors and resistor feeding loudspeaker keeps thesa capacitors properly polarized as AF output voltage swings above and below zero level.—R. H. Paarson, Noval 5-Watt Class A Amplifiar Uses Three-Transistor Faadback Circuit, *Wireless World*, March 1974, p 18.



1-W NONINVERTING—Motorola MC1554 IC operates from single supply and usas capacitive coupling to both source and load, for voltage gain of 9 with frequency response (−3 dB) from 200 to 22,000 Hz. Input impedance is 10K, and total harmonic distortion is less than 0.75%. Use axternal heatsink.—"The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier," Motorola, Phoenix, AZ, 1972, AN-401, p 2.

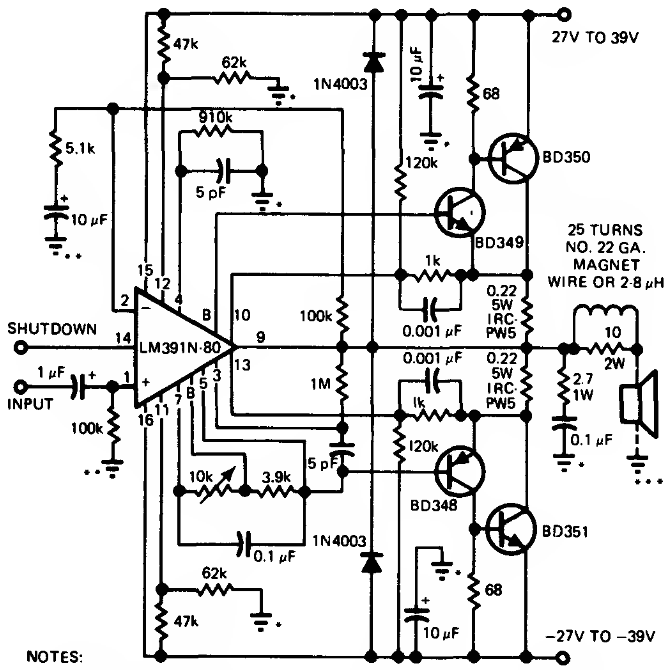


1-W NONINVERTING WITH SPLIT SUPPLY—Motorola MC1554 IC is connected for operation from ±7 V to provida voltage gain of 9 over frequency range (−3 dB) of 40 to 22,000 Hz. Input impedance is 10K, and total harmonic distortion is less than 0.75%. Use external heatsink.—"The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier," Motorola, Phoenix, AZ, 1972, AN-401, p 2.



BATTERYLESS MICROPHONE PREAMP—Transistor and two components can be mounted in microphone housing. R_2 is added to existing amplifier to provide operating voltage for preamp, while C_2 feeds preamp signal to input of amplifier.—W. H. Jarvis, Line-Powered Microphone Pre-Amp, *Wireless World,* Dec. 1976, p 43.

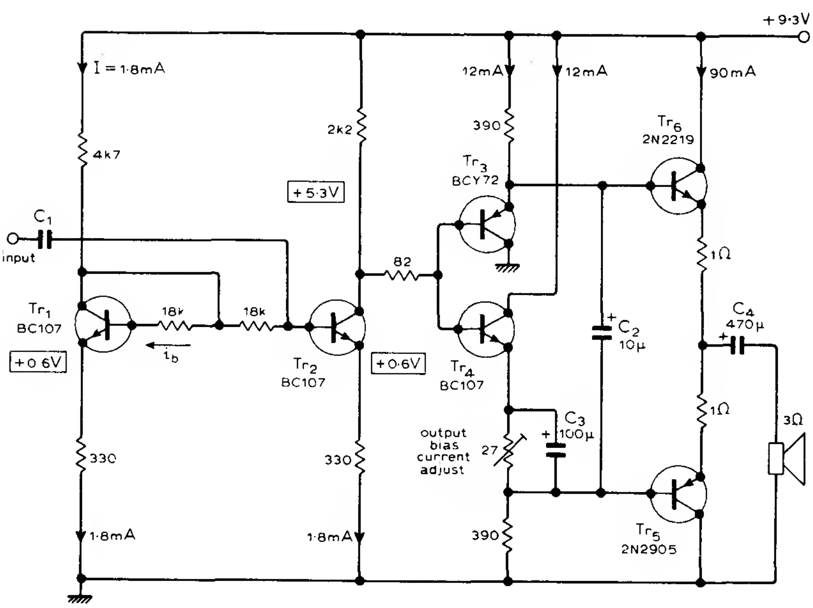
60 W—Combination of National LM391 audio driver IC and discrete power transistors provides 60-W output for loudspeaker at very low distortion. IC output can swing ±40 V. Total harmonic distortion of circuit is under 0.05%.—P. Franson, Consumer-Product IC's—New Offerings Trigger an Explosion in Markets Old and New, *EDN Magazine,* Nov. 5, 1977, p 54–65.



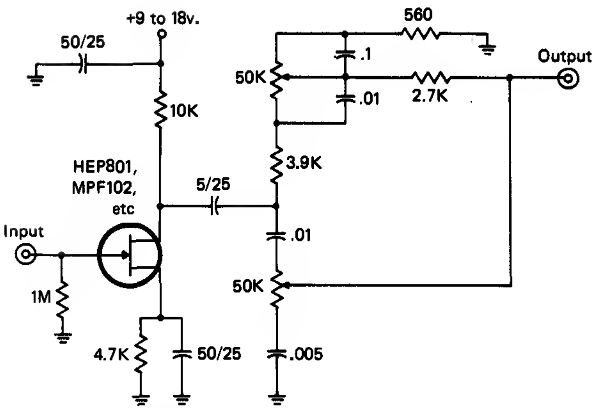
NOTES:
*HIGH-FREQUENCY GROUND
**INPUT GROUND
***SPEAKER GROUND

ALL GROUNDS SHOULD BE TIED TOGETHER ONLY AT POWER SUPPLY GROUND.

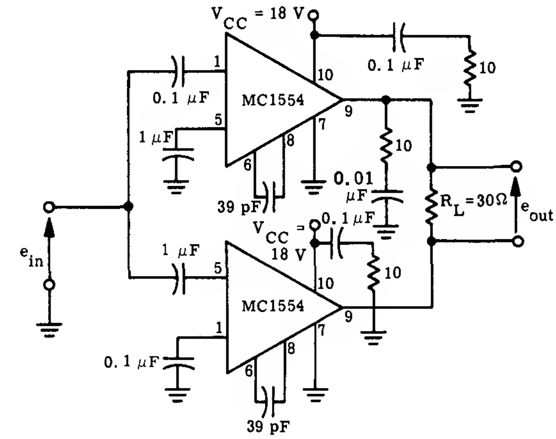
50°C/W HEAT SINK ON BD348 AND BD349
3.9°C/W HEAT SINK ON BD350 AND BD351



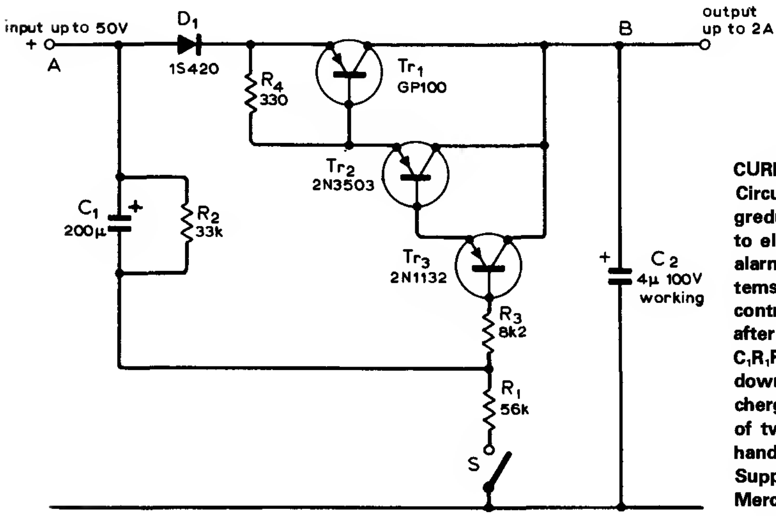
DIRECT-COUPLED PUSH-PULL—Provides high-quality sound at ample volume for car radio, operating from 9.3-V regulated supply. Push-pull emitter-follower stages are connected to give symmetrical low output impedance on both positive and negative portions of audio waveform. Input transistor Tr_1 provides temperature compensation, while driver Tr_2 provides temperature-compensated bias and maximum symmetrical voltage swings to output stages.—G. Kalanit, Low Voltage Audio Amplifier, *Wireless World,* Oct. 1976, p 74.



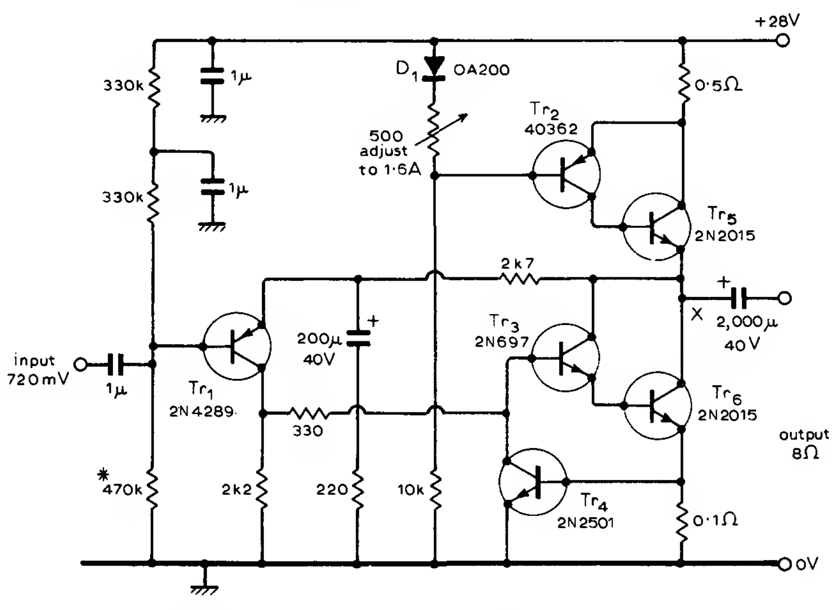
FET PREAMP WITH TONE CONTROLS—Developed for use with simple 2-W audio amplifier when testing very low-level output circuits and microphones. Will not load circuit to which input is connected. Optional bass/treble tone controls are included.—J. Schultz, An Audio Circuit Breadboarder's Delight, *CQ*, Jan. 1978, p 42 and 75.



3-W DIFFERENTIAL—Upper Motorola MC1554 power amplifier is connected in standard configuration for noninverting gain of 9, while lower IC has inverting gain of 9 to give effective overall voltage gain of 18. Input impedance of upper amplifier is 10K while that of lower amplifier is 1K, with unequal input coupling capacitors providing required match of frequency responses. Differential output connection allows output voltage swing to exceed power-supply voltage.—"The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier," Motorola, Phoenix, AZ, 1972, AN-401, p 4.

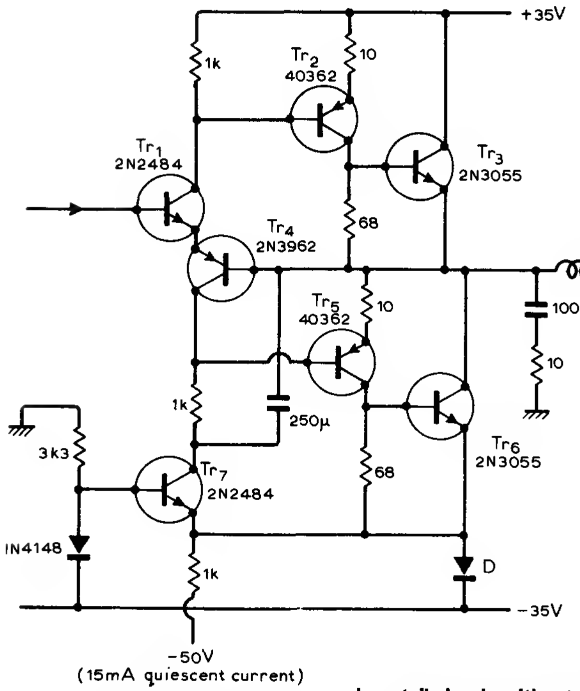


CURRENT CONTROL FOR POWER SWITCH—Circuit makes power supply current increase gradually from zero when supply is turned on, to eliminate transients that sometimes cause alarming loudspeaker thumps in audio systems. Current through silicon power diode D_1 is controlled by voltage on C_1, which charges up after closing of switch with time constant $C_1R_1R_2/(R_1 + R_2)$. When switch is opened, rundown of supply current is controlled by discharge of C_1 through R_2. Article also covers use of two current control circuits in tandem for handling higher loads.—P. J. Briody, Power Supply Delayed Switching, *Wireless World*, March 1975, p 139–141.

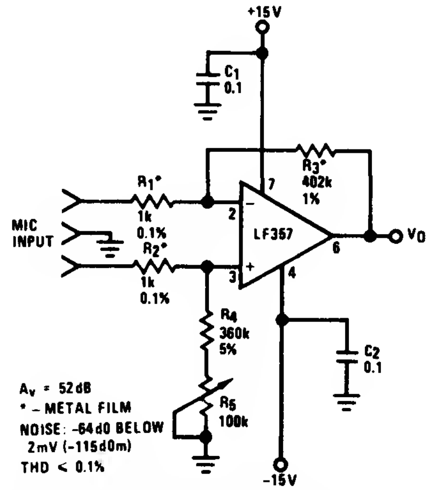


* adjust to make point X half the supply voltage (if necessary)

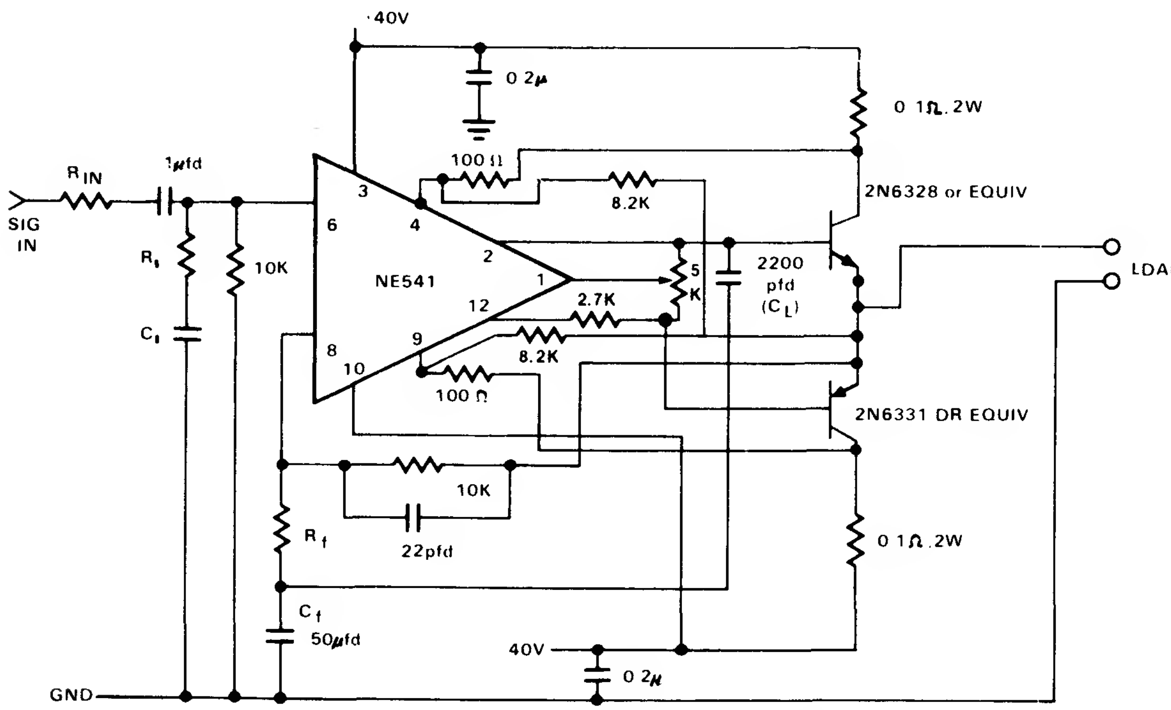
10-W CLASS A—Highly stable circuit uses easily obtainable components. Transistor types are not critical. Short-circuit protection is provided by constant-current source D_1-Tr_2-Tr_5-Tr_4. Output transistors Tr_5 and Tr_6 require heatsinks capable of dissipating at least four times rated output power. D_1 and Tr_2 should be in thermal contact.—A. H. Calvert, Class A Power Amplifier, *Wireless World*, June 1976, p 71.



CLASS B WITHOUT TAKEOVER DISTORTION—Circuit uses two transistor triplats in output stage, with quiescent current set at 15 mA by Tr_7 which servas as constent-currant source. For small signals, Tr_1 and Tr_4 can be regerded es long-teiled pelr without teil. For positiva signels, Tr_1-Tr_4 bacome active and beheve as super emitter-followar, while Tr_1 with Tr_4-Tr_6 serva for negative signels. One edvantege of circuit is low output impedance.—N. M. Visch, A Novel Cless B Output, *Wireless World*, April 1975, p 166.

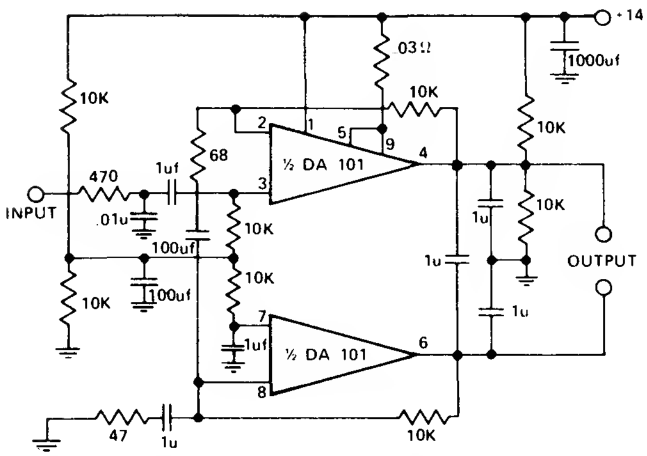


TRANSFORMERLESS BALANCED-INPUT MICROPHONE PREAMP—Uses FET-input opamp to emplify differential signals while rejecting common-mode signels. Gain is set at 52 dB by retio of R_3 to R_1. Input resistors R_1 and R_2 are mede large compered to source impedance while being kept as small as possible, for optimum balence between input loading effects end low noise. Good compromise value is 10 times source impedance for R_1 + R_2.—"Audio Handbook," National Semiconductor, Senta Clere, CA, 1977, p 2-37–2-40.

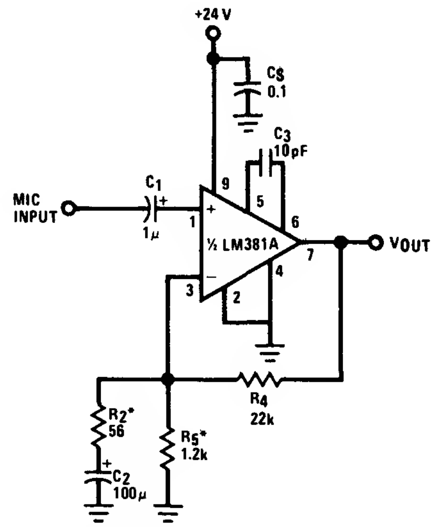


*LI—24 turns, single layer #36 on 10Ω, 1W res.

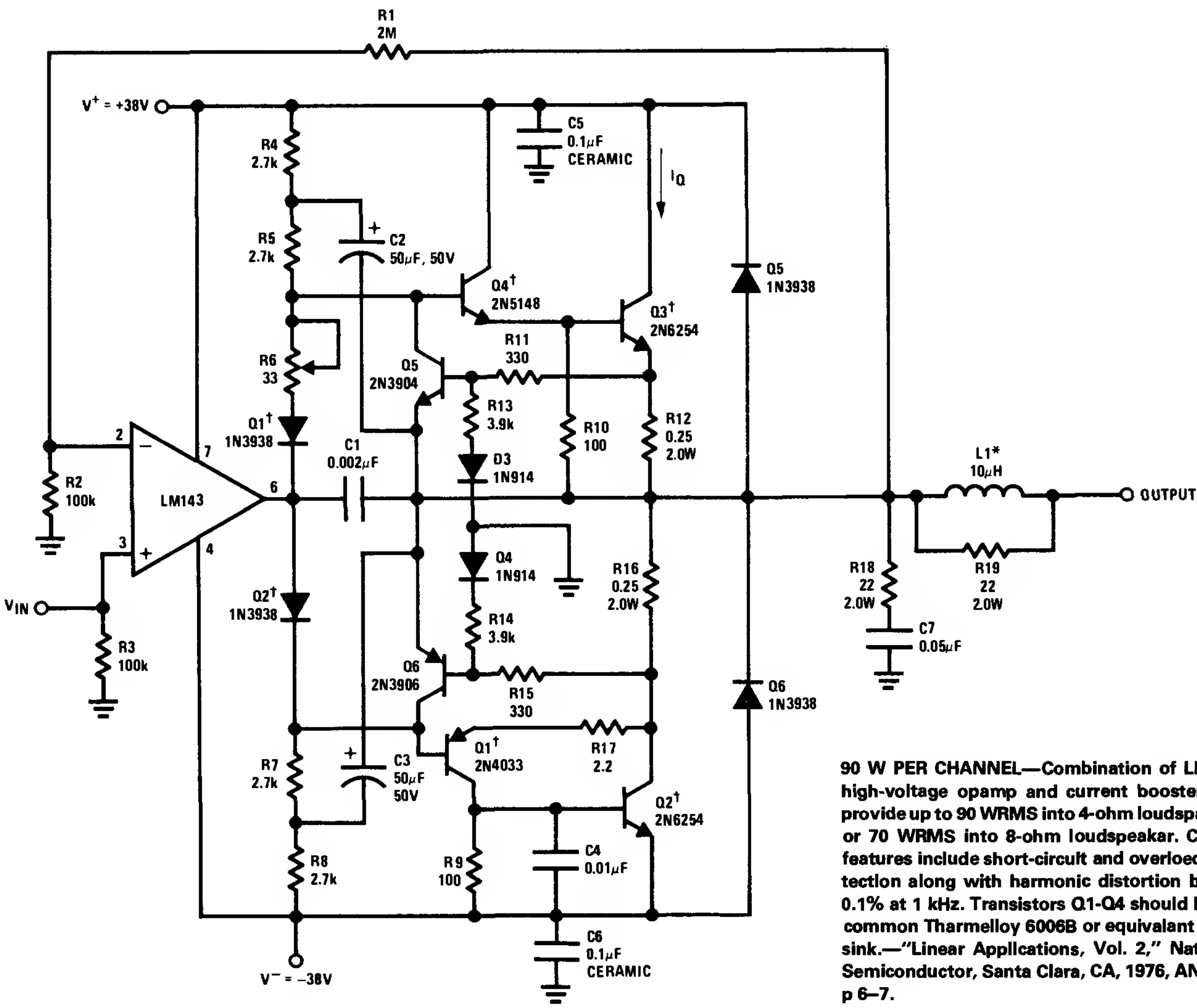
75 W WITH CURRENT LIMITING—Signetics NE541 high-voltaga power amplifier provides currant gain of 90 dB from 20 Hz to 20 kHz and output levels up to 20 VRMS from 300-mVRMS input. IC includes built-in short-circuit protection, with additional protection provided by external current limiting. Transistors In output staga boost power to 75 W for driving loudspeakar load.—"Signetics Analog Data Manual," Signatics, Sunnyvala, CA, 1977, p 765.



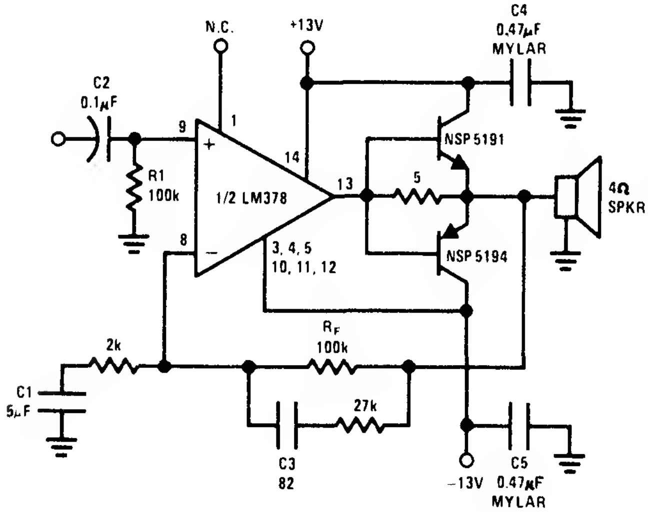
POWER OPAMPS IN BRIDGE—Bridge configuration is thaoretically capable of 4 times power output of conventional quasi-complementary or complemantary-symmetry amplifier. Use of bridga circuit in eutomotive AM/FM stereo receiver requires suitable protection of modules. Articla covers incorporation of protective controls in singla module with dual opemps.—E. R. Buehlar and B. D. Schertz, Fault Protaction of Monolithic Audio Power Amplifiers In Savere Environments, *IEEE Transactions on Consumer Electronics,* Aug. 1977, p 418–423.



SINGLE-ENDED MICROPHONE PREAMP—Noise performance is −69 dB below 2-mV input reference point. Use metal-film resistors for R_2 and R_5. Total harmonic distortion is lass than 0.1%. Gain is set by ratio of R_4 to R_2 and is 52 dB.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-37–2-40.

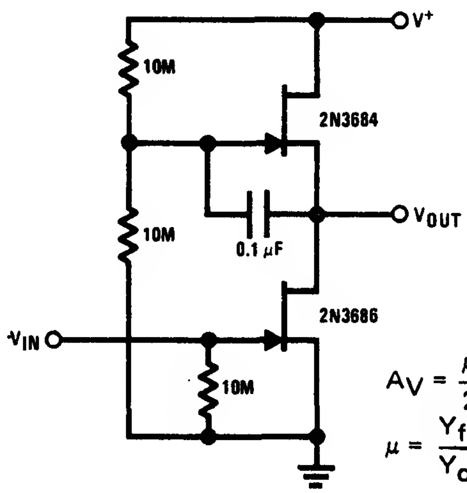


90 W PER CHANNEL—Combination of LM143 high-voltage opamp and current booster can provide up to 90 WRMS into 4-ohm loudspaaker or 70 WRMS into 8-ohm loudspeakar. Circuit features include short-circuit and overloed protection along with harmonic distortion below 0.1% at 1 kHz. Transistors Q1-Q4 should be on common Tharmelloy 6006B or equivalant heatsink.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 6–7.



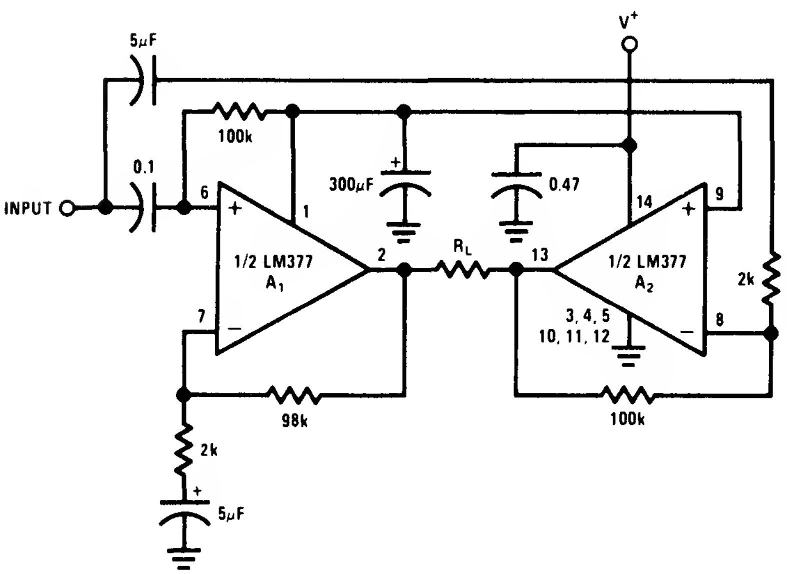
12 W WITH BOOSTER TRANSISTORS—At signal input levels below 20 mW, National LM378 opamp supplies load directly through 5-ohm resistor up to current peaks of about 100 mA. Above this level, booster transistors are biased on by load current through same resistor to increase output power. Transistors and opamp must have adequate heatsinks.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-42–4-43.

HIGH-GAIN JFET—Simple two-JFET circuit provides gain of 500 at low power. Reducing drain current increases gain at sacrifice of input dynamic range.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

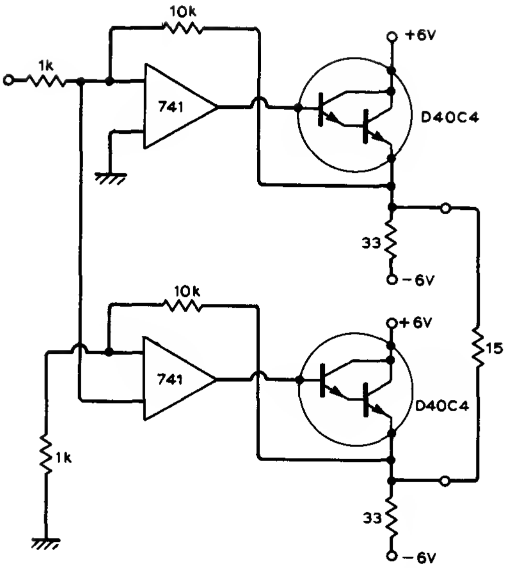


$$A_V = \frac{\mu}{2} = 500 \text{ typical}$$

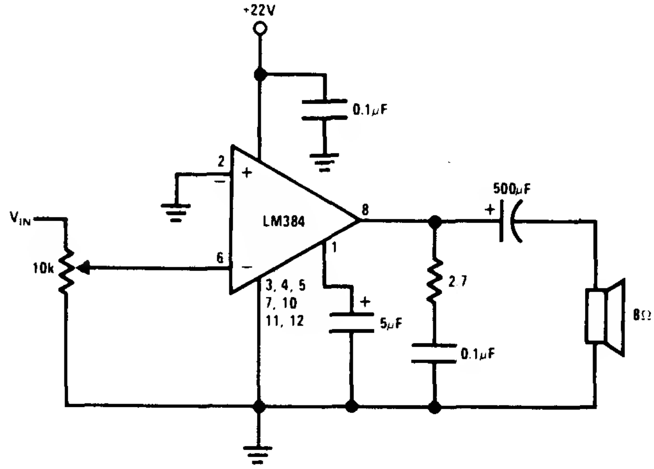
$$\mu = \frac{Y_{fs}}{Y_{os}}$$



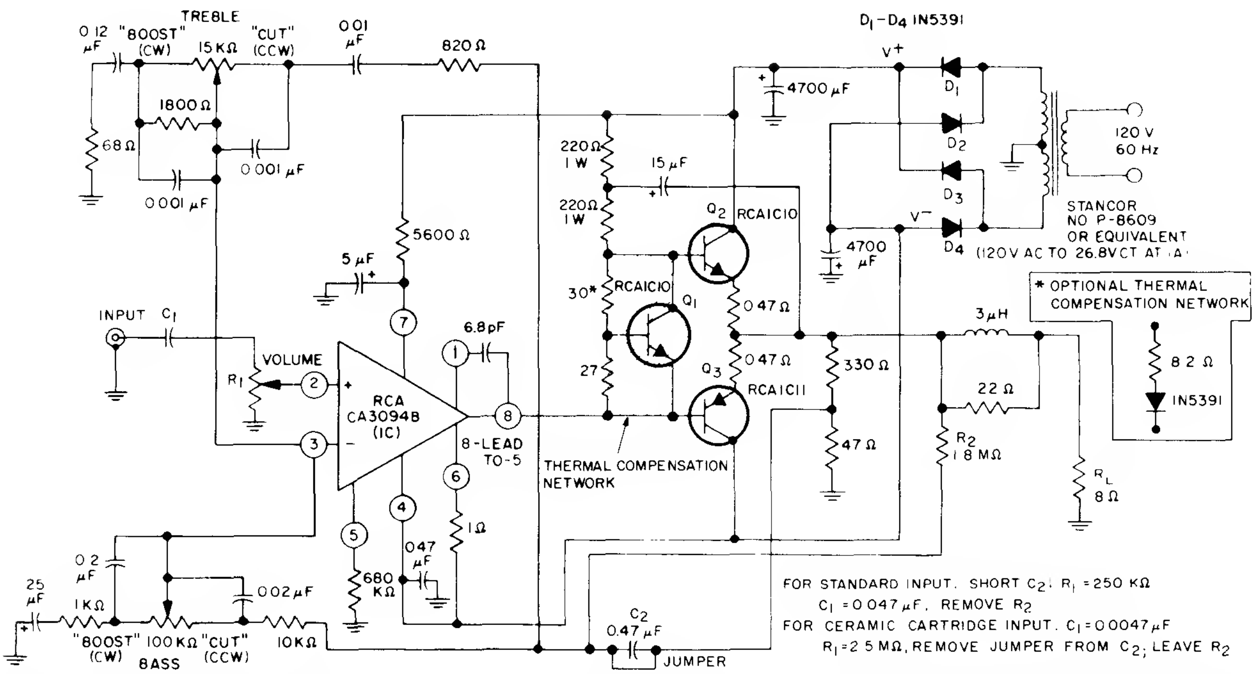
BRIDGE AMPLIFIER—National LM377 dual power amplifier is used in bridge configuration to drive floating load that can be loudspeaker, servomotor, or other device having impedance of 8 or 16 ohms. Maximum output is 4 W at gain of 40 dB, with 3-dB response extending from about 20 Hz to above 100 kHz.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.



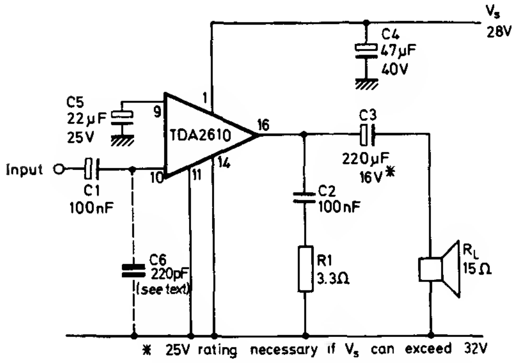
ERROR ADD-ON REDUCES DISTORTION— Besed on fact thet arror at output of upper opamp also eppears et input of this opamp. Error signal is takan from this input for lower opemp, whare it is amplifiad by opamp and Darlington for eddition to output of upper Darlington. Article gives design equations and intimatas thet open-loop gain improves et 12 dB par octave es compared to conventional 6 dB. Applications includa reduction of loudspaakar distortion which cannot be handled by negative feedback.—A. Sandman, Reducing Distortion by 'Error Add-On,' *Wireless World*, Jen. 1973, p 32.



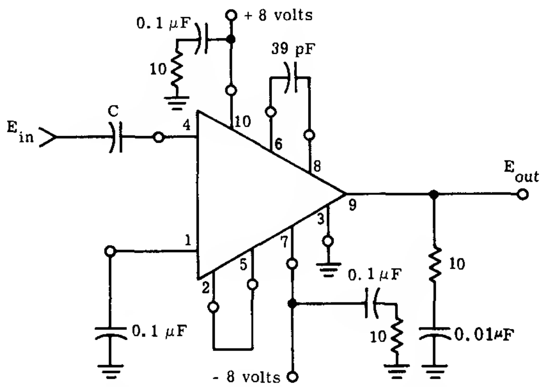
5 W WITH OPAMP— Simpla circuit including volume control hes low harmonic distortion. Higher alloweble operating voltage of LM384 opamp gives higher output power, but heatsink is required.—"Audio Handbook," Nationel Semiconductor, Sente Clera, CA, 1977, p 4-28–4-29.



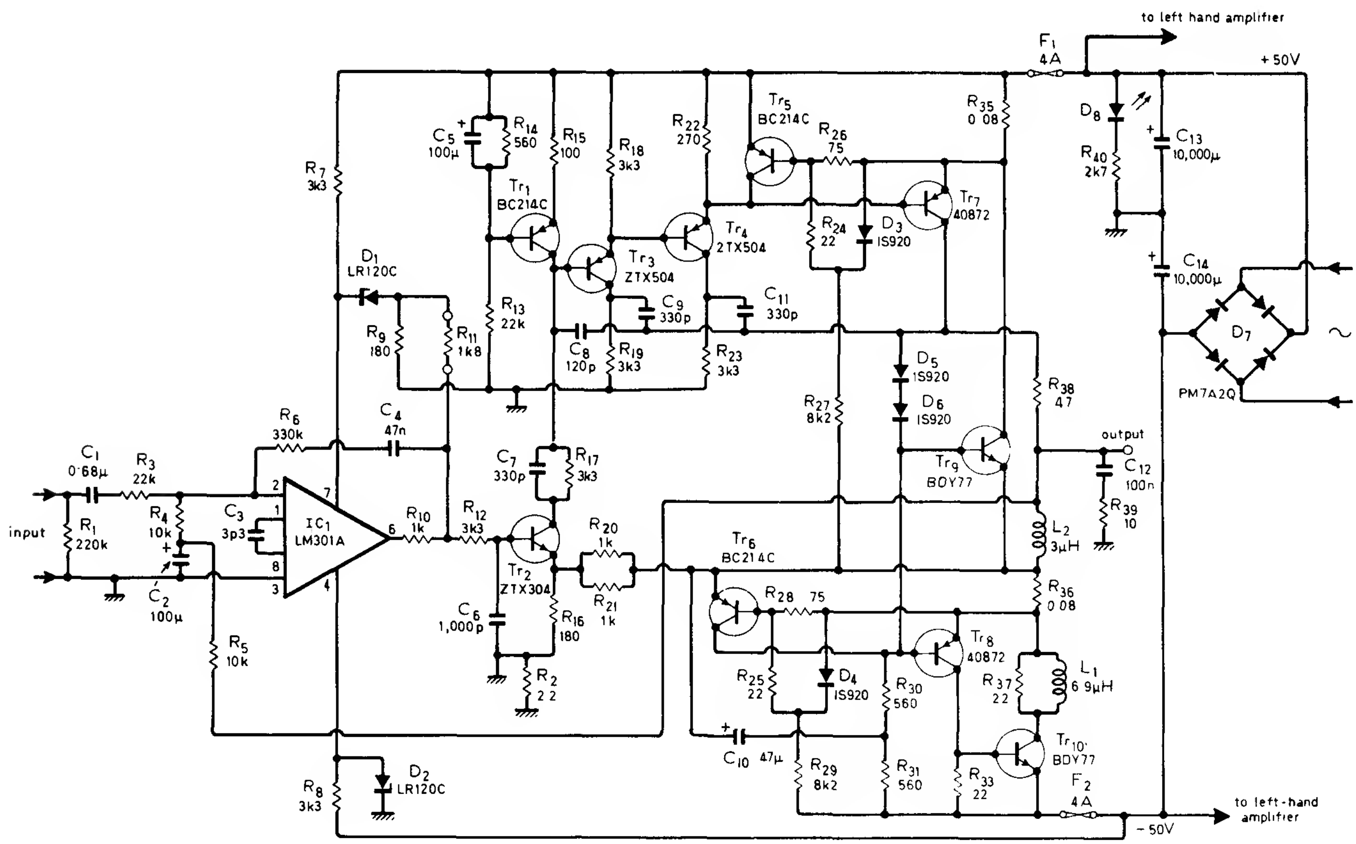
12-W OUTPUT— Uses CA3094B programmable opamp to drive complementary-symmetry power-output transistors. Intermodulation distortion is only 0.2% when 60-Hz and 2-kHz signels ere mixed in 4:1 ratio. Location of tona controls in feedback network improves signal-to-noisa ratio. Hum and noisa are typically 700 μV (83 dB down) at output. Transistor Q_1 provides tharmel compensation.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 11.



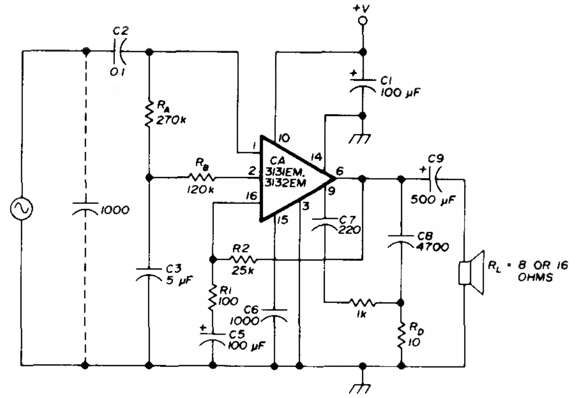
4.5-W CLASS B—Mullerd TDA2610 drives 15-ohm loudspeeker with totel harmonic distortion of less then 1%. Supply is 28 V ± 10%. Network C2-R1 ensures stebility with inductive loed.—"Audio Power Amplifiar TDA2610," Mullerd, London, 1976, Technical Note 35, TP1541.



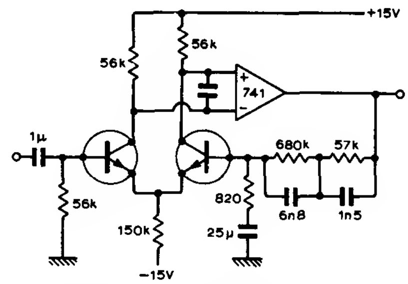
1-W INVERTING—Uses Motorola MC1554 power amplifier to provide voltage gain of 35 with componants shown. Output voltege swing is 12 V P-P into 12-ohm load. For responsa down to low audio frequencies (below 100 Hz), lerge velue of C is required, such es 1 μF. Input can be direct-coupled at secrifica in output offset, but this can be corrected by proparly biasing pin 1 or termineting it in ebout 250 ohms. Upper frequency limit for −3 dB is ebout 22,000 Hz.—"The MC1554 One-Wett Monolithic Integrated Circuit Power Amplifier," Motorola, Phoenix, AZ, 1972, AN-401, p 3.



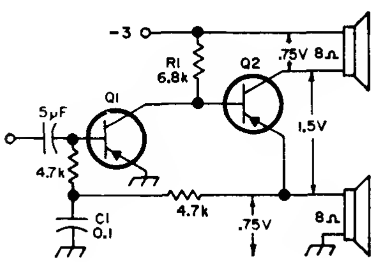
FEED-FORWARD CORRECTION—Circuit reduces distortion caused by nonlinearity of output power trensistors by deriving error component that bypesses these trensistors. Technique used is known es current dumping. Article describes operetlng principle in deteil. Circuit shown gives epplication to commerciel emplifier (Qued 405), in which midfrequency distortion is only ebout 0.005%. Features include elimination of edjustments, elignment procedures, end thermel problems during entire life of amplifier.—P. J. Welker, Current Dumping Audio Amplifier, *Wireless World*, Dec. 1975, p 560–562.



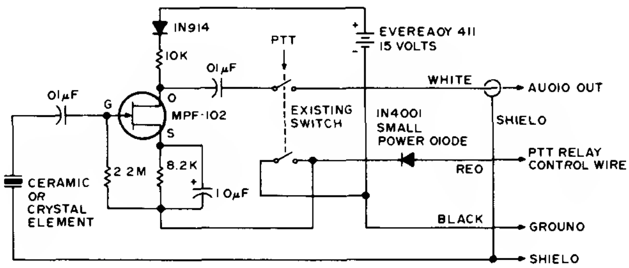
5-W IC—RCA IC includes preamps, power amplifier, and integral heatsink. CA3131 has internal feedback network that maintains 48-dB gain, while CA3132 requires external feedback network including R1 and R2 connected between pins 6 and 16. Input 1000-pF capacitor is required if input has open circuit. Electrolytic C1 should be placed as close as possible to pin 10. C6 sets 46-dB closed-loop gain point at 200 kHz. C7 equalizes gain for positive and negative signal swings. C9 sets low-frequency response of amplifier. Recommended supply voltage is 24 VDC.—E. Noll, Audio-Power Integrated Circuits, *Ham Radio,* Jan. 1976, p 64–66.



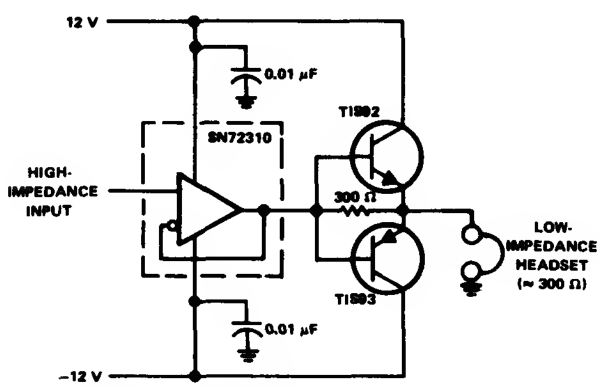
LOW-NOISE OPAMP PREAMP—Circuit combines noise features of discrete design with simplicity and high open-loop of IC opamp such as 741. Transistors can be 2N3708, BC109, or equivalent. Output impedance is low enough to drive headphones directly.—D. R. Hedgeland, Op-Amp Pre-Amp, *Wireless World,* Dec. 1972, p 575.



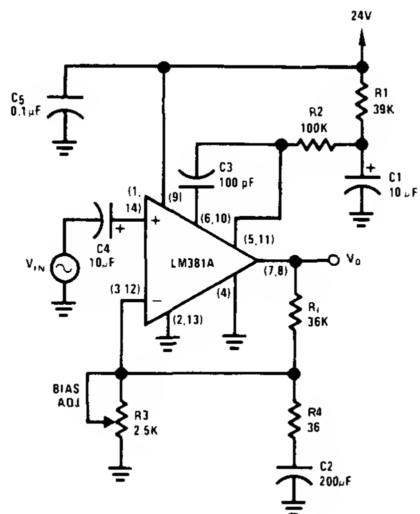
50 mW FLAT TO 30 kHz—Power amplifier achieves push-pull output with single transistor. Both transistors should be germanium such as 2N404, SK3004, or HEP-253.—Circuits, *73 Magazine,* Feb. 1974, p 100.



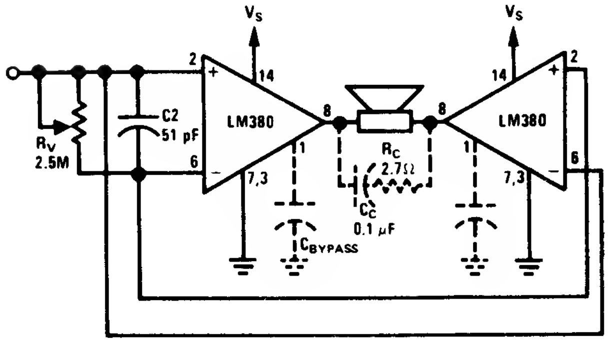
PREAMP IN MIKE—Common-source FET preamp and 15-V battery fit into Turner 350C hand mike for boosting output of ceramic element 20 dB. Frequency response of preamp is flat from 200 Hz to over 100 kHz. Drain is 200 µA only when push-to-talk is pressed, giving long battery life.—G. Hinkle, Self-Powered Mike Preamp, *73 Magazine,* Nov. 1976, p 65.



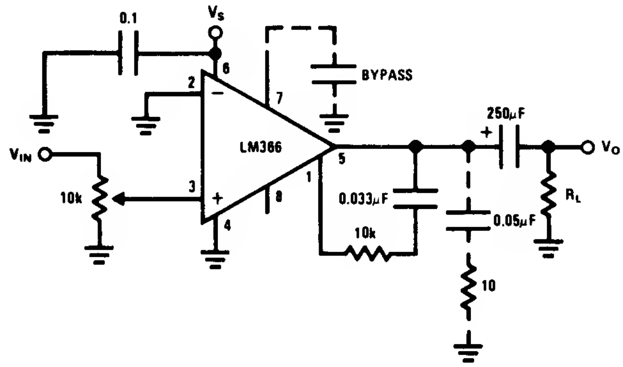
IMPEDANCE BUFFER—Complementary-transistor output stage provides required low impedance for driving headphones from SN72310 voltage-follower opamp. Supply is ±12 V.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4–41.



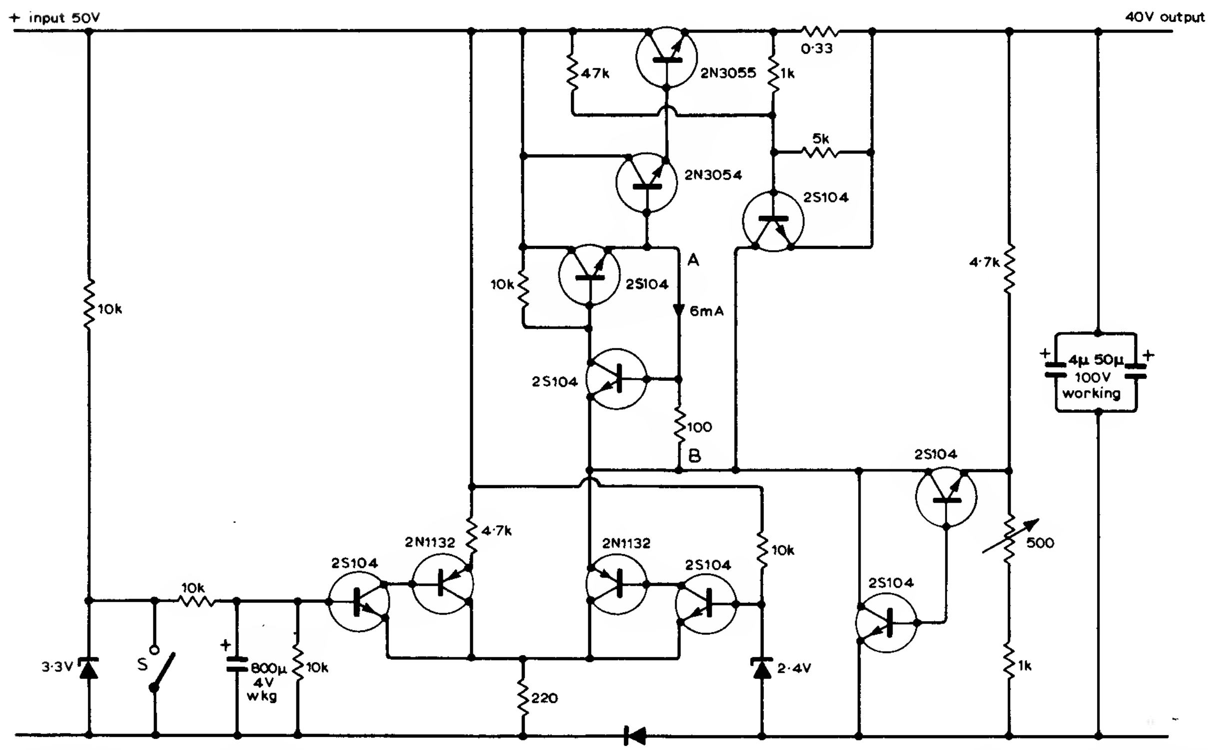
ULTRALOW-NOISE PREAMP—Provides gain of 1000 over bandwidth of 20 Hz to 10 kHz, operating from 24-V supply and 600-ohm source impedance. Design procedure is given. Total wideband noise voltage is 43.7 µV, and wideband noise figure is 2.83 dB.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-15–2-19.



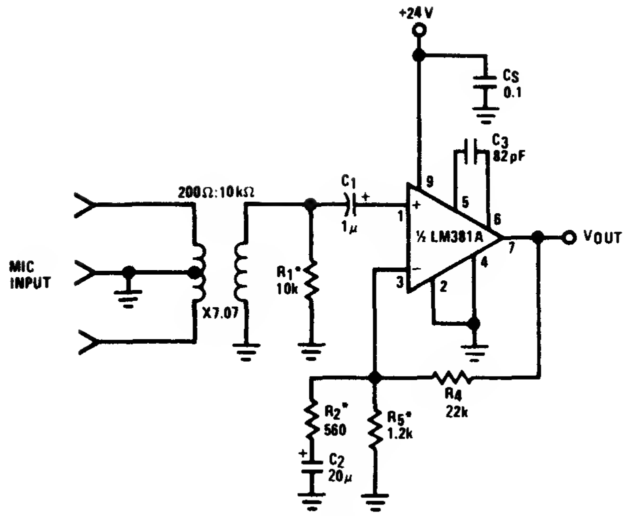
BRIDGE AMPLIFIER—Two opamps ara used in bridge configuration to provide twice the voltege swing across loudspeakar loed for given 18-V supply, increesing power capability to about twice thet of single emplifiar. To eliminate excessive quiescent DC voltage across load, nonpolerized capacitor cen be used in series with load or 1-megohm pot cen ba connected betwaen pins 1 of opemps with position of moving arm edjusted to balance offset voltage. Components shown with dashed lines ere edded for stability with high-current loed.—"Audio Hendbook," Nationel Semiconductor, Sante Clera, CA, 1977, p 4-21–4-28.



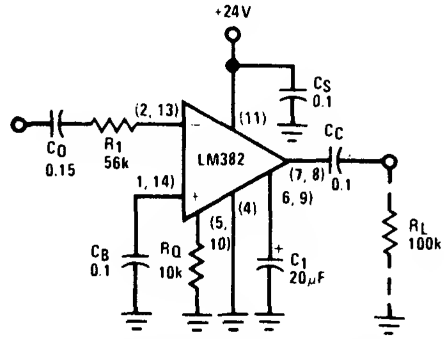
BASS BOOST—Compensetes for poor bess response of loudspeaker by use of externel series RC circuit between pins 1 and 5, paralleling intarnel 15K resistor of opemp. 6-dB effectiva bass boost is obtainad if resistor is 15K, end lowest value for steble oparation is 10K if pin 8 is left opan.—"Audio Hendbook," National Samiconductor, Santa Clara, CA, 1977, p 4-30–4-33.



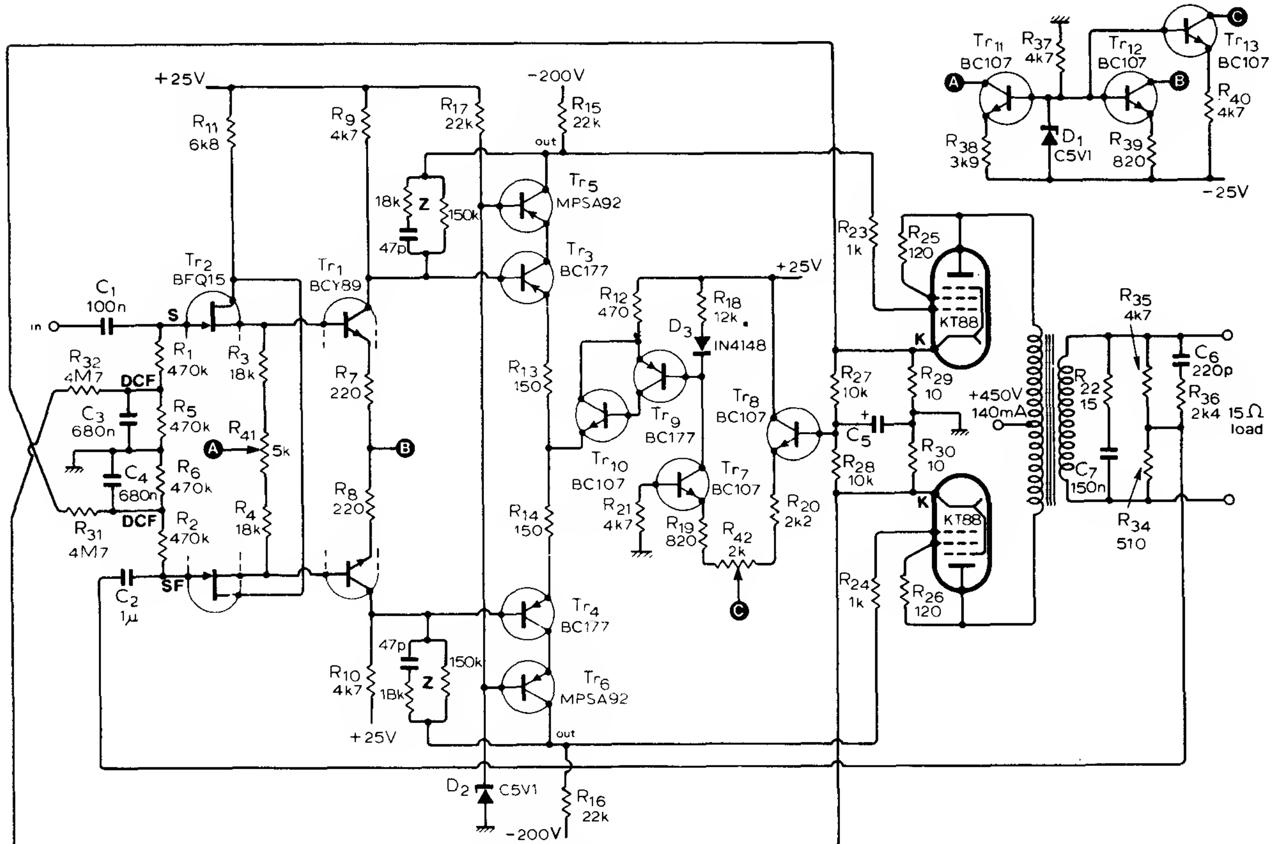
CURRENT-CONTROLLED SWITCHING—Addition of currant control to 40-V ragulatad powar supply for eudio emplifier eliminates switch-on trensients that sometimes ceuse alarming loudspeaker thumps. Switch S, which can be either relay or third pole on stenderd ON/OFF switch of amplifier, is opened to initiate cherging of 800-μF capacitor that allows gradual buildup of output current. Similar trensiant suppression occurs when switch is closed to initiate current run-down es set is turned off. Run-up and run-down times ere e few seconds eech. Article elso gives simpler current control circuit suitabla for use with unregulated supplies.—P. J. Briody, Power Supply Delayed Switching, *Wireless World,* Merch 1975, p 139–141.



BALANCED-INPUT MICROPHONE PREAMP—Use of two wires for microphona aignai and separata wira for ground kaaps hum and noise at minimum. Signai wiras are twisted togethar in shield acting as ground. Net gain is 52 dB, giving 0-dBm output for nominal 2-mV input. Noise performance is −86 dB beiow 2-mV input levei, and rejection of common-mode signals is 60 dB.—"Audio Handbook," National Samiconductor, Santa Ciara, CA, 1977, p 2-37–2-40.



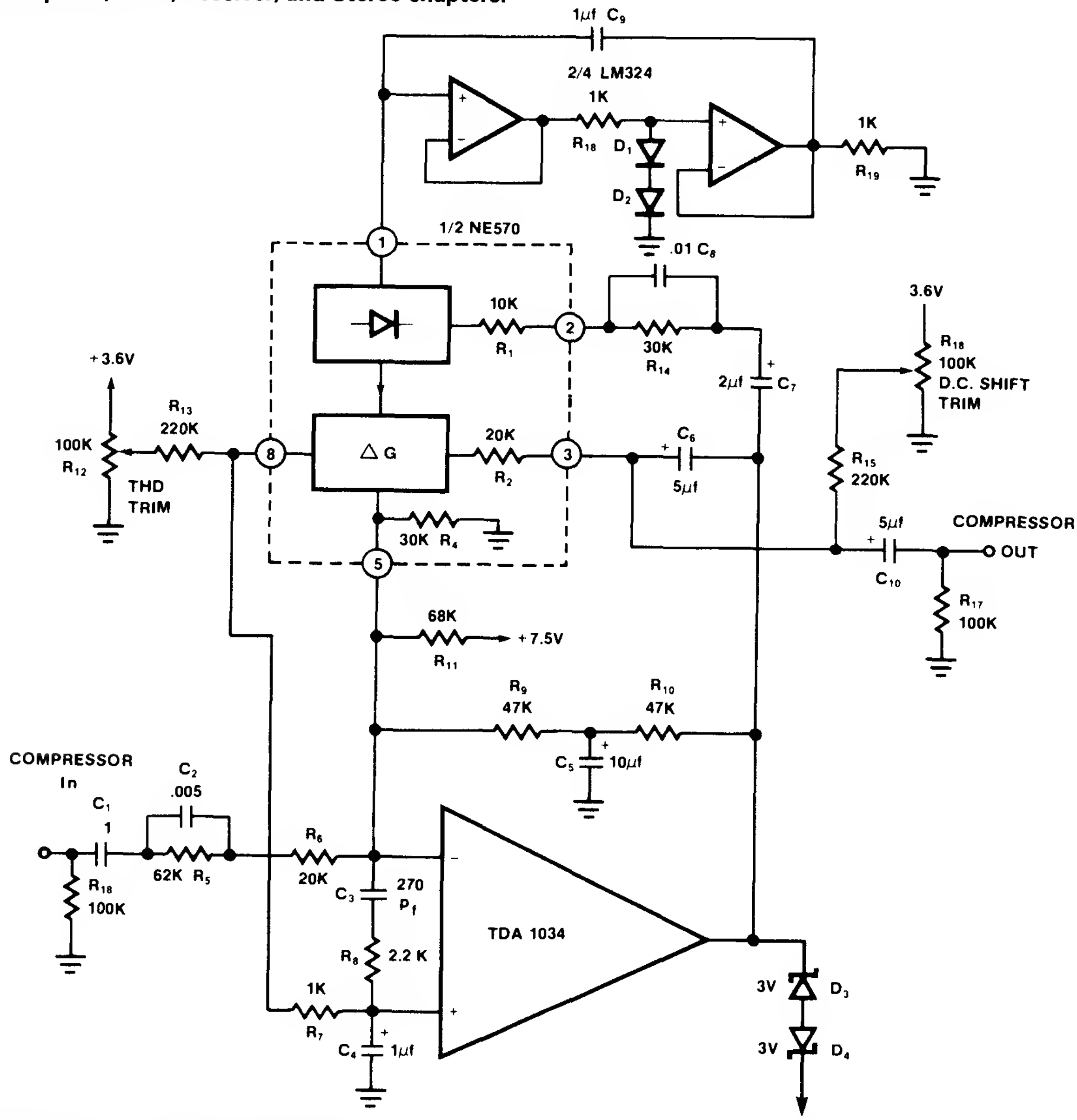
INVERTING AC AMPLIFIER—Provides gain of 40 dB when using 24-V supply and input impedance graatar than 10K. Low-frequency performanca is flat to 20 Hz. Design procedura is given.—"Audio Handbook," Nationai Semiconductor, Santa Ciara, CA, 1977, p 2-20–2-24.



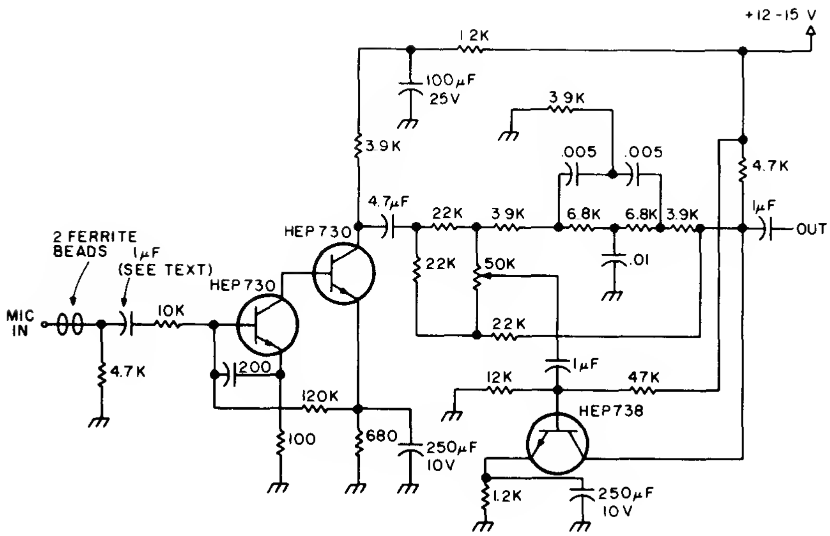
TWO-TUBE WILLIAMSON OUTPUT—Rasponse is flat from 10 Hz to over 50 kHz for outputs up to 15 W, and totai harmonic distortion for fuii powar output at 15 kHz is only 0.25%. Output staga uses tubes connected as triodes in push-puii. input transistor can be any in Philips BFQ10-16 famiiy or equivaient rapiacemant such as Siliconix E401. Articia gives many suitabia replacements for othar transistors as waii, and describes design of required feedback circuits in detaii.—S. Berglund, Transistor Driver for Vaive Ampiifiars, *Wireless World*, Aprii 1976, p 36–40.

CHAPTER 4
Audio Control Circuits

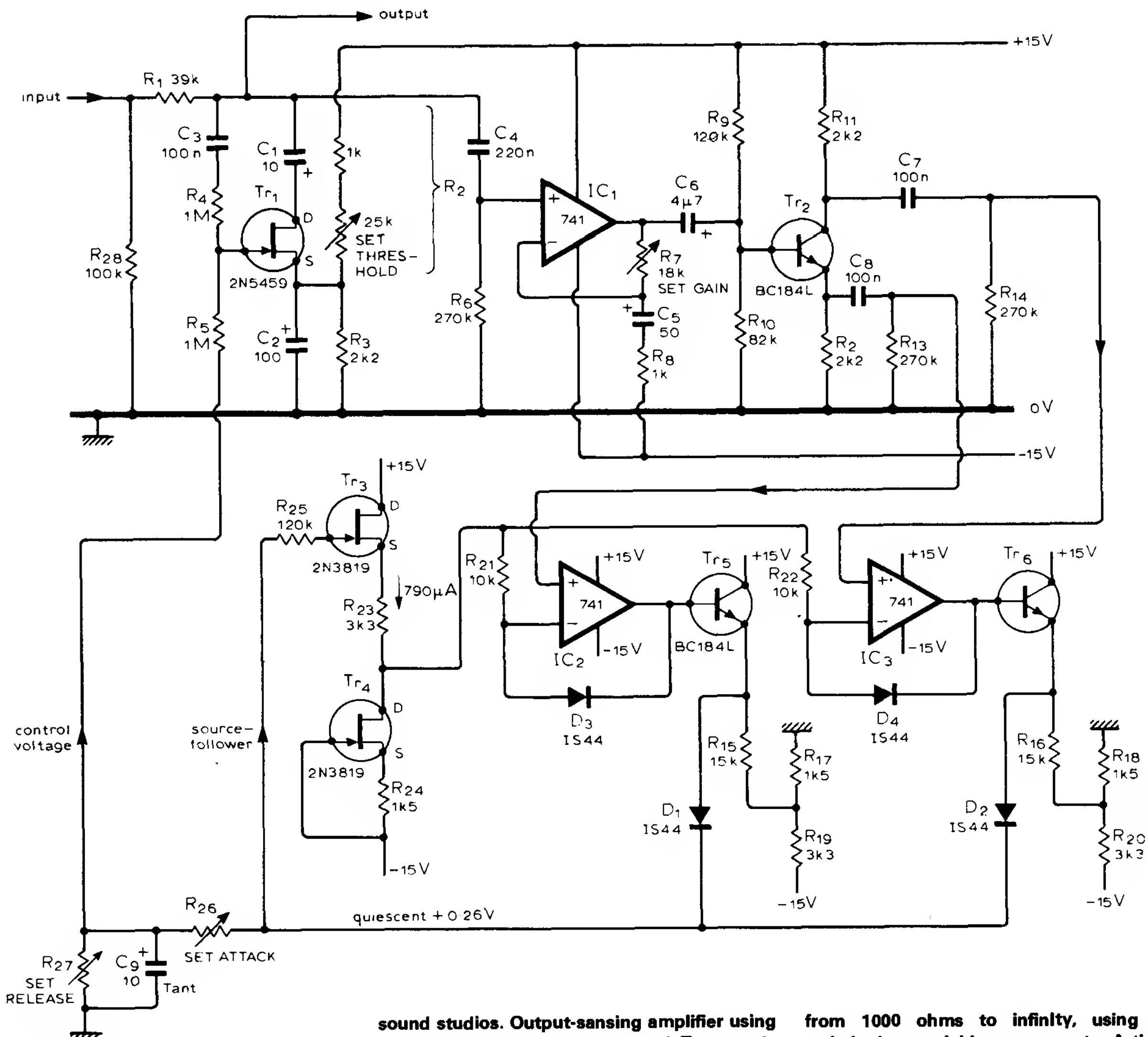
Includes variety of tone controls, compressor, expander, compandor, clipper, mixer, clamp, automatic level control, click suppressor, attenuator, equalizer, speech filter, noise squelch, logic-controlled gain, voice- or tone-controlled relays, active crossover, and switching gate circuits for audio signals. See also Audio Amplifier, Filter, Receiver, and Stereo chapters.



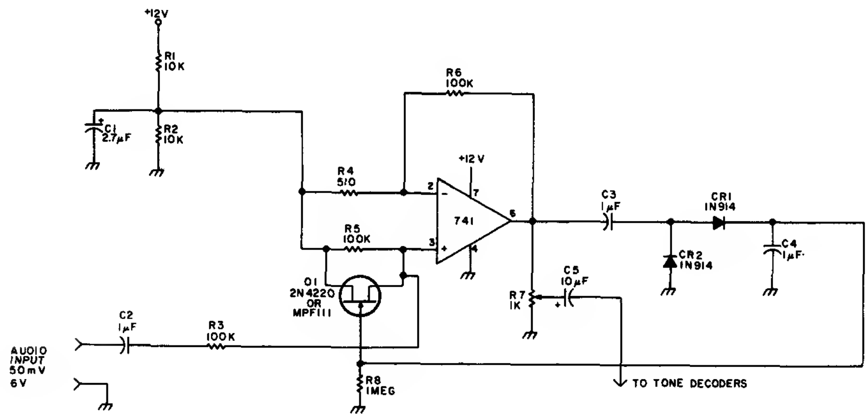
HI-FI COMPRESSOR—One section of Signetics NE570 dual compandor is used with external opamp for compression of large input signals in high-fidelity audio system. To prevent overload by sudden loud signal when compressor is operating at high gain for small signals, brute-force clamp diodes D_3 and D_4 limit output swings to about 7 V P-P. Limiting action prevents overloading of succeeding circuit such as tape recorder. Circuit includes input compensation network required for stability. Corresponding expander used for playback of recorded material should have same value for rectifier capacitor C_9 as is used in compressor.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 804.



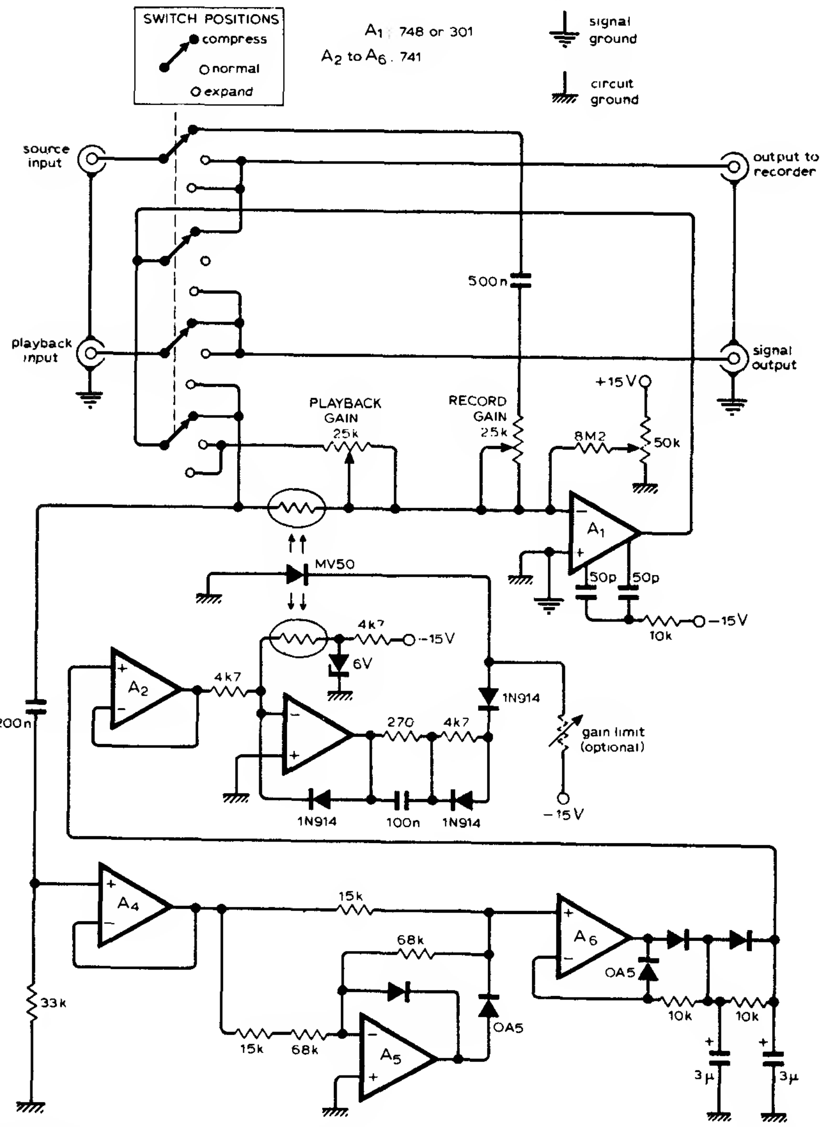
PREEMPHASIS AT 1500 Hz—Single-transistor peaking filter is combined with low-noise RF-protected preamp stage to improve speech intelligibility for any type of modulation. Effectiveness is most noticeable with daap bass voice, where soft peak around 1500–2000 Hz improves spaach intalligibility. Can also serva as audio-type CW or SSB filter.—You Can Sound Batter with Speech Pra-Emphasis, *73 Magazine*, Fab. 1977, p 42–43.

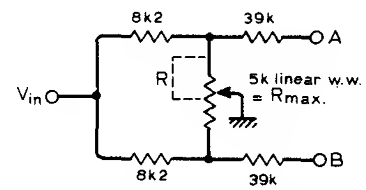


COMPRESSOR/LIMITER—High-fidelity circuit uses voltege-controlled attenuator to increase ettenuation of input signal in response to voltage of control loop. Designed for use in modern sound studios. Output-sansing amplifier using IC_1 has gain of 19 over audio band. Tr_2 stage is phase-splitter driving pracision rectifiers IC_2 and IC_3. Final part of circuit defines attenuation time constants; R_{26} sets attack time end R_{27} decay tima. R_{26} can range from 0 to 1 megohm and R_{27} from 1000 ohms to infinlty, using aither switched or veriebla components. Article describes circuit operation and adjustment in detail. Tr_6 is BC184L or equivalent.—D. R. Self, High-Quality Compressor/Limiter, *Wireless World*, Dec. 1975, p 587–590.

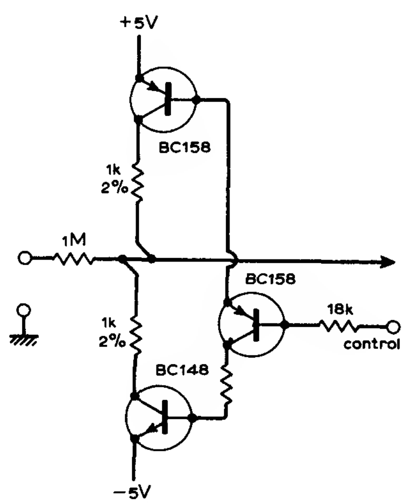


CONSTANT AF LEVEL—Provides constant output level even though input may vary between 50 mV and 6 V, for distribution to tone decoders of eutocall system used to monitor simplex or repeater channel to which emeteur radio receiver is tuned. Positive terminal of electrolytic C3 must go to pin 6 of 741.—C. W. Andreasen, Autocall '76, *73 Magazine*, June 1976, p 52–54.



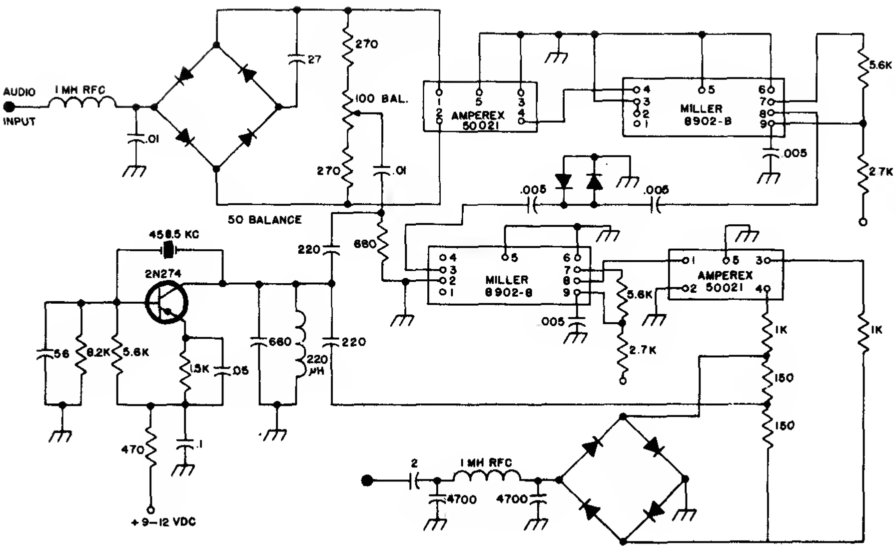


PANNING MIXER POT—Circuit gives best possible approach to sine law so $A^2 = B^2$ is constant for all positions of wiper. Calculated error is less than 1 dB over full range of wiper. Use wirewound pot to minimize crosstalk.—J. Dawson, Single Gang Pan-Pot, *Wireless World*, Feb. 1976, p 78.

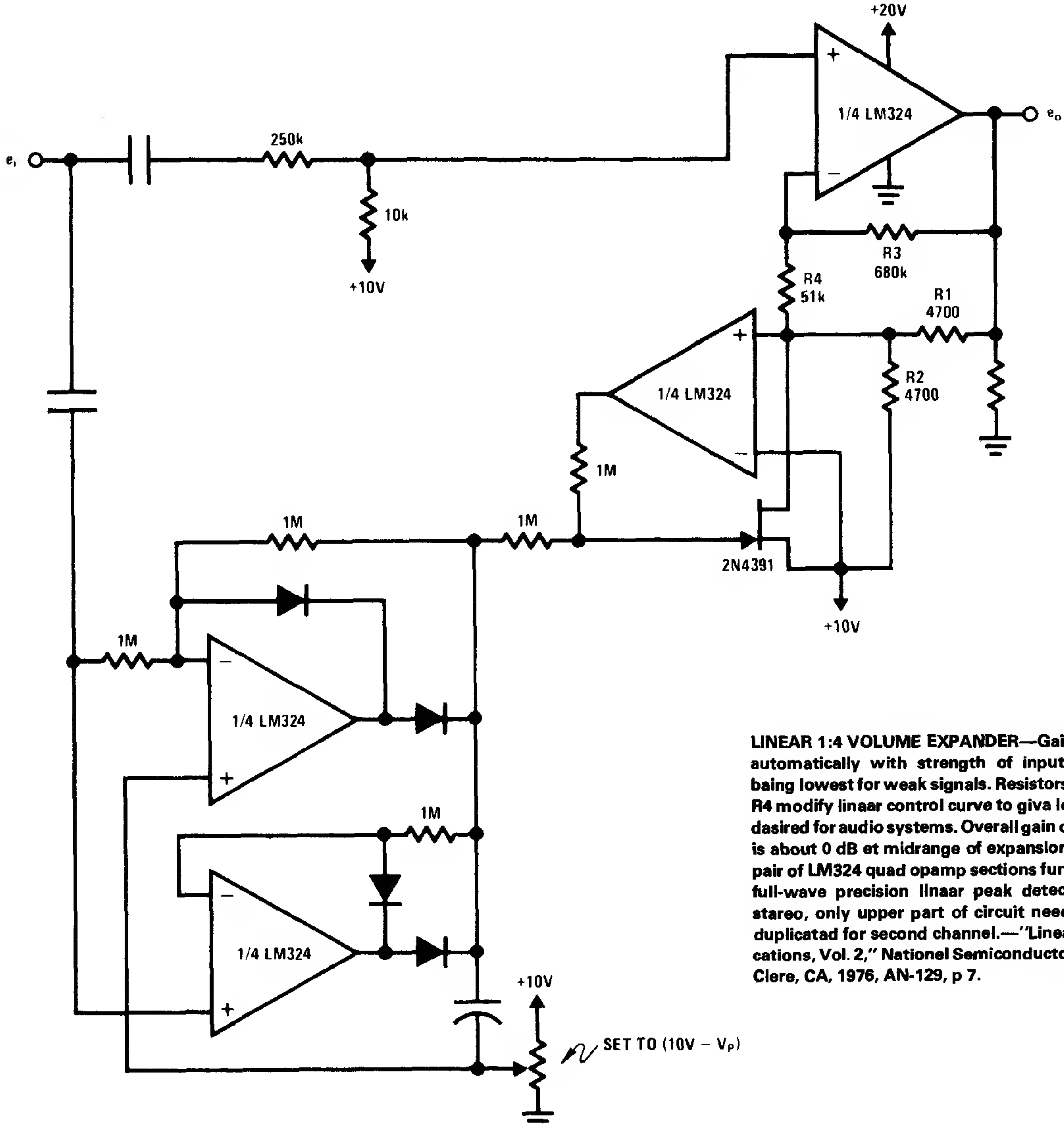


COMPANDER WITH 100-dB RANGE—Simple square-lew circuit preserves dynamic renge of virtuelly eny input signel when recorded by ordinary tape recorder. Suitable for speech signels as well as for recording or playback in noisy environments. Opamp A_1 should have seperately decoupled supply. Switching provides compression during recording and expansion during playback. Tracking of photocells is essential for accurete power-law compension. LED can be glued with clear epoxy to metched photocells. Use silicon signal diodes such es 1N914, 1N4148, or 1S44. Inexpensive photocells such es Vactec VT-833 gave suitebly low distortion. Article gives performance characteristics and operating details.—J. Vanderkooy, Wideband Compender Design, *Wireless World*, July 1976, p 45–49.

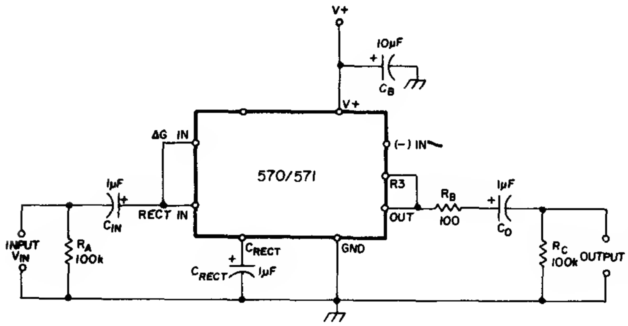
AUDIO SWITCHING GATE—Can be used with programmed channel selectors, as required in music synthesis for controlling audio signals by means of TTL levels. DC offset et output is negligible when gate is off, simplifying design of subsequent stages. Use logic 1 (+5 V) to open gate, and logic 0 (0 V) to close it.—L. Cook, Anelogue Gate with No Offset, *Wireless World*, Feb. 1975, p 93.



CLIPPER—Provides speech clipping at RF level for SSB transmitters. Based on use of two Amperex 455-kHz IF crystal filters having 4-kHz rated bandwidth, in place of costly conventional sideband filters. Miller 8902-B IF amplifier module simplifies wiring. Diode balanced modulator at upper left can use individual 1N63 or 1N914 diodes, or RCA CA-3019 hex diode array that also provides diodes for RF clipper. Audio input can be taken from speech compressor of receiver, or separate audio amplifier can be added to boost AF level. Same diode types are used in product detector for final SSB signal, lower right, which is diode ring demodulator taking injection voltage from carrier oscillator. Article tells how pin 8 on IF module (not connected internally) is bridged to solder line between link output of last IF transformer and AM detector diode, and gives other construction details.—J. J. Schultz, Inexpensive RF Speech Clipper, *73 Magazine*, Sept. 1974, p 61–64 and 66.

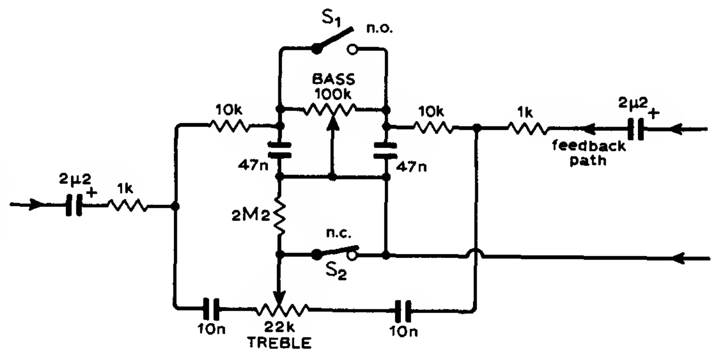


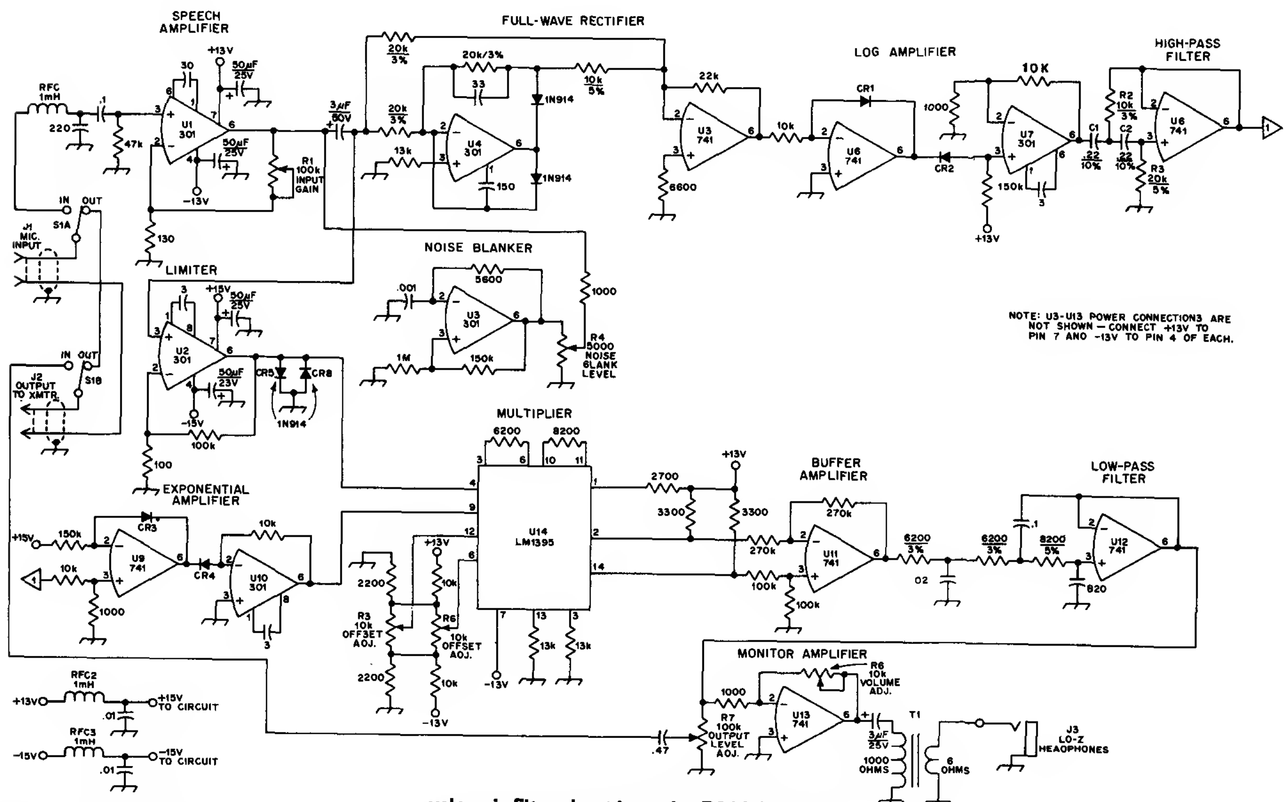
LINEAR 1:4 VOLUME EXPANDER—Gain varies automatically with strength of input signal, being lowest for weak signals. Resistors R3 and R4 modify linear control curve to give log curve desired for audio systems. Overall gain of circuit is about 0 dB at midrange of expansion. Lower pair of LM324 quad opamp sections function as full-wave precision linear peak detector. For stereo, only upper part of circuit needs to be duplicated for second channel.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-129, p 7.



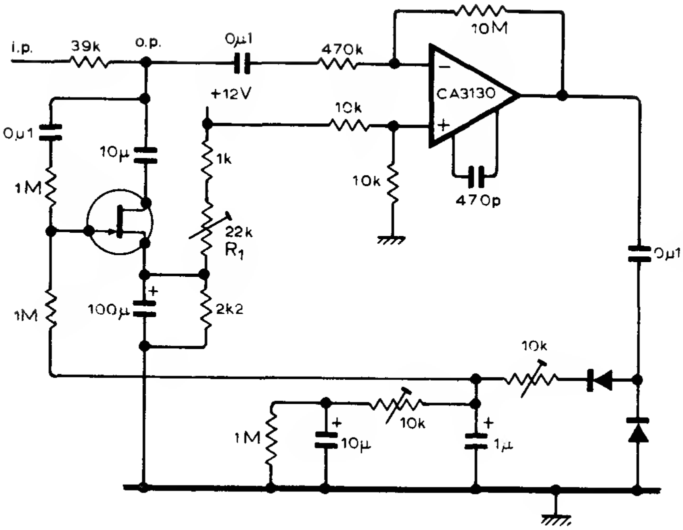
EXPANDER—Uses Signetics dual-channel compandor IC; 571 has lower inherent distortion and higher supply voltage range (6–24 V) than 571 (6–18 V). Values shown are for 15-V supply with either IC. Gain through expander is 1.43 V_{IN}, where V_{IN} is average input voltage. Unity gain occurs at RMS input level of 0.775 V, or 0 dBm in 600-ohm systems.—W. G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.

SWITCHING-CLICK SUPPRESSOR—Correction network shown can be inserted in audio channel of mixing console without producing transients or level changes. Although Baxendall network is shown, switching technique is applicable to other filters. With S_1 normally open and S_2 normally closed, circuit operation is normal. If switch positions are simultaneously reversed, response remains flat regardless of positions of bass and treble pots, center-frequency gain remains unchanged, and phase shift is unchanged. There is then no transient interruption of AF signals. Switching clicks cannot occur because there is no direct current in the network.—J. S. Wilson, Click-Free Switching for Audio Filters, *Wireless World*, Jan. 1975, p 12.

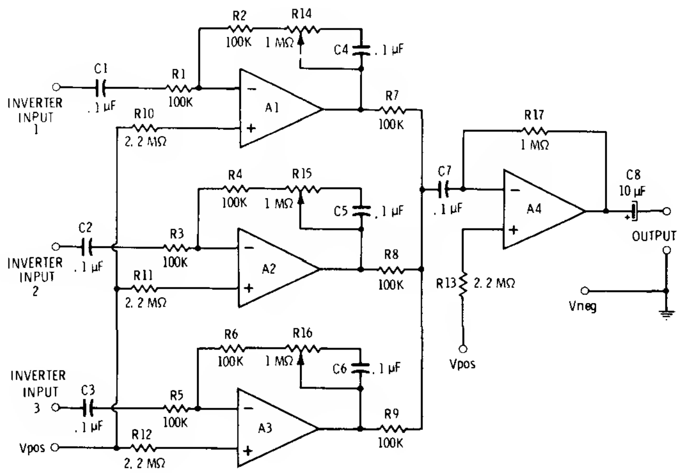




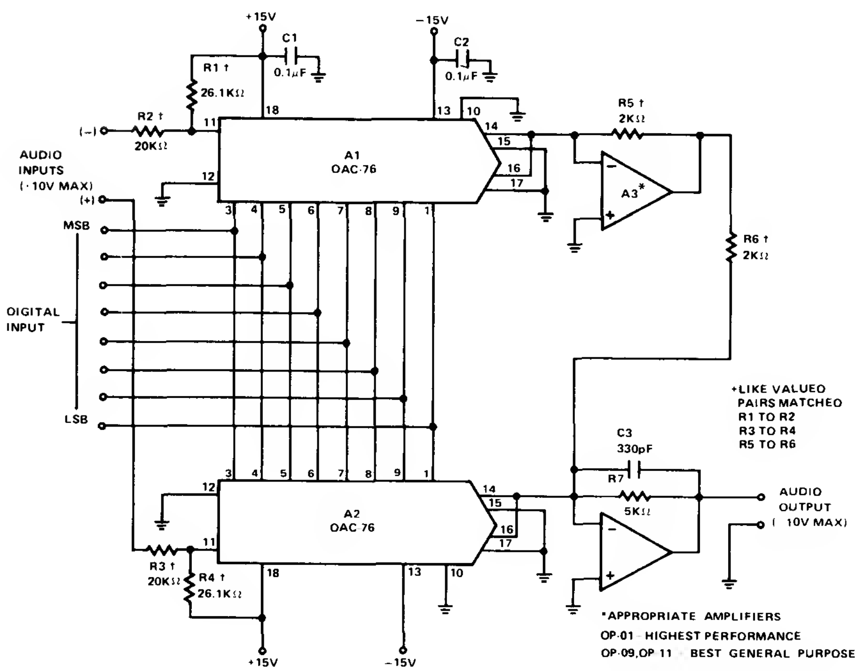
SPEECH PROCESSOR—Can improve signal strength and intelligibility of voice signals up to 8 dB without unpleasant changes in fidelity. Used between microphone and input of AM or SSB transmitter. Based on separation of signal envelope from constant-amplitude carrier that together make up voice signal. After logamp U6 separates components of speech waveform, envelope is filtered out by active RC high-pass filter U8 having 50-Hz cutoff, with exactly unity gain above cutoff. Filtered signal goes to exponential amplifier U9-U10 and is then multiplied by correct sign information in U14. Sign information is obtained by hard-limiting input voice signal with diode clipper CR5-CR8. Resulting square-wave output is multiplied by signal from UJT in U14. Processed signal goes to transmitter input through low-pass filter U12 having sharp cutoff above 3 kHz to eliminate unwanted high-frequency energy. CR1-CR4 are 1N914 or other matched silicon diodes. T1 is 250-mW audio transformer. Article gives construction and adjustment details.—J. E. Kaufmann and G. E. Kopec, A Homomorphic Speech Compressor, *QST*, March 1978, p 33–37.



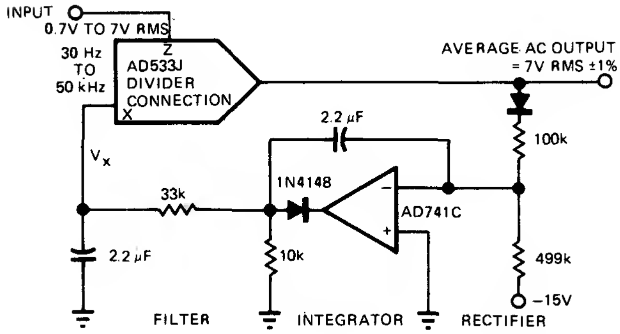
COMPRESSOR/LIMITER—Developed for usa with microphone in public-address systems. Bandwidth is 15 Hz to 25 kHz. R₁ sets threshold voltage end compression law. Output of CA3130 inverting opamp is made es large as possible before being applied to rectifier and low-pass filter, to minimize effects of diode non-lineerities end capacitor leakege. Low-pass filter gives required fast attack time of ebout 500 μs and long decay time of about 1 min.—M. B. Taylor, Speech Compressor/Limiter, *Wireless World,* May 1977, p 80.



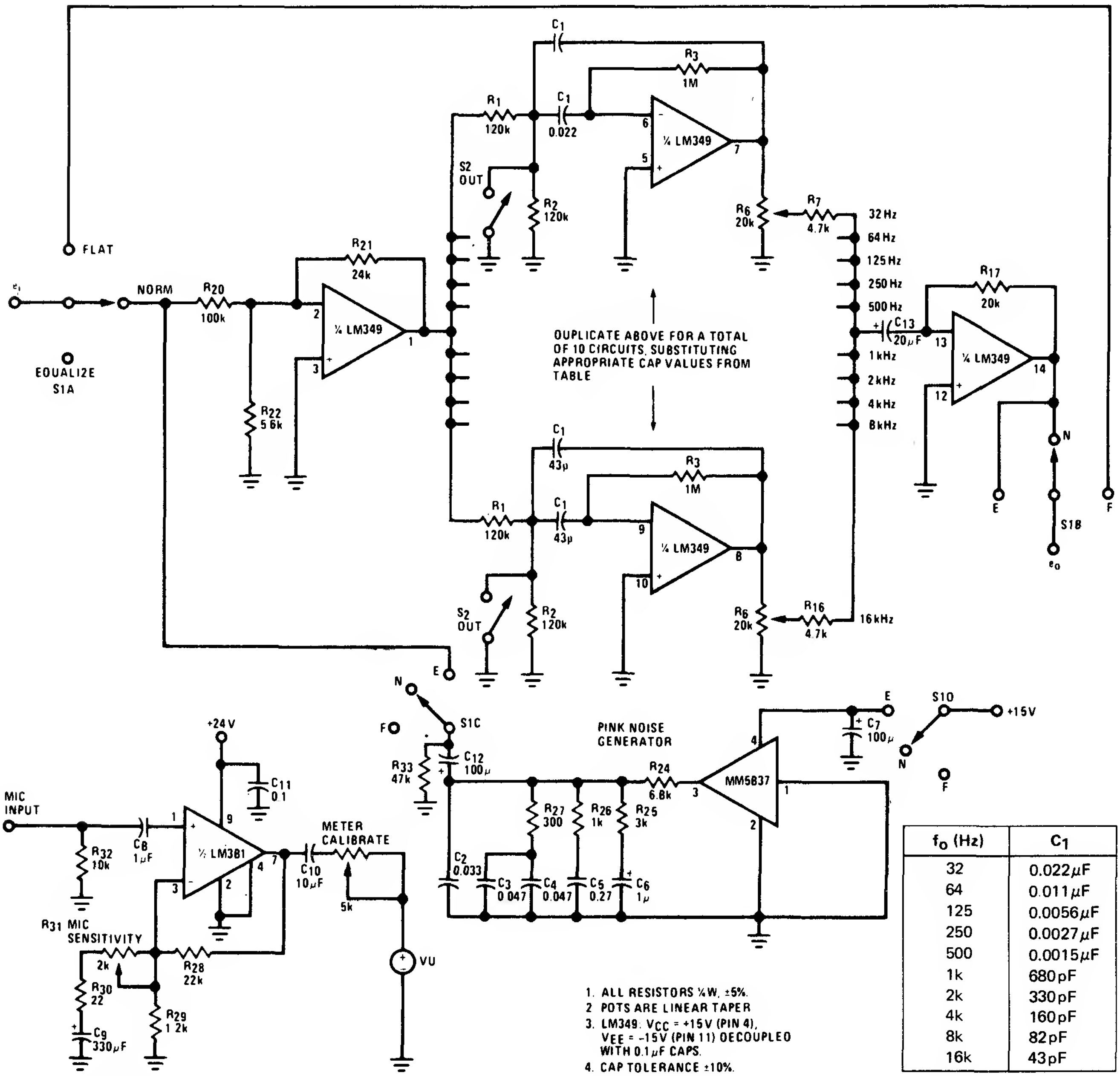
THREE-INPUT MIXER—Motorola MC3401P or National LM3900 qued opamp serves for three input amplifiers each having adjusteble gain range of 1 to about 11 and input impedance ebove about 100,000 ohms. Common outputs feed fourth opamp section connected as high-impedance amplifiar. Maximum overall gain for mixer-amplifier is ebout 300. Use well-filtered 9–15 V supply or battery capable of supplying 25 mA.—C. D. Rakes, "Integrated Circuit Projects," Howerd W. Sams, Indianapolis, IN, 1975, p 21–22.



CLICKLESS LEVEL-CONTROL ATTENUATOR—Uses two Precision Monolithics DAC-76 D/A convertars to eliminate gein-change transients while providing exponential control of audio signal level. Maximum (all 1s) gain is unity from either input to output, while differential input to output gain is +6 dB. Control range is 78 dB.—W. Jung and W. Ritmanich, "Audio Applications for tha DAC-76 Companding D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, AN-28, p 4.

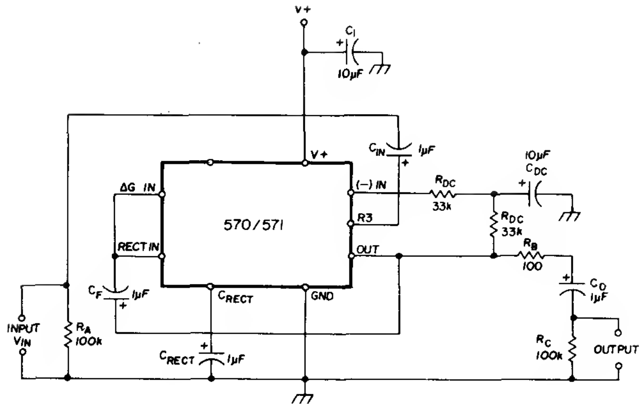


AF LEVEL CONTROL—AD533J analog multiplier used in its divide mode provides measure of automatic level control to compensate for variations in loudness occurring from microphone to microphone in public-address system. Divider output is first rectified and compared with −15 V reference. Difference is then integrated and fed into denominator of divider-connected AD533J as control signal V_X. Average AC output is held within 1% of 7 V.—R. Frantz, Analog Multipliers—New IC Versions Manipulate Real-World Phenomena with Ease, *EDN Magazine*, Sept. 5, 1977, p 125–129.

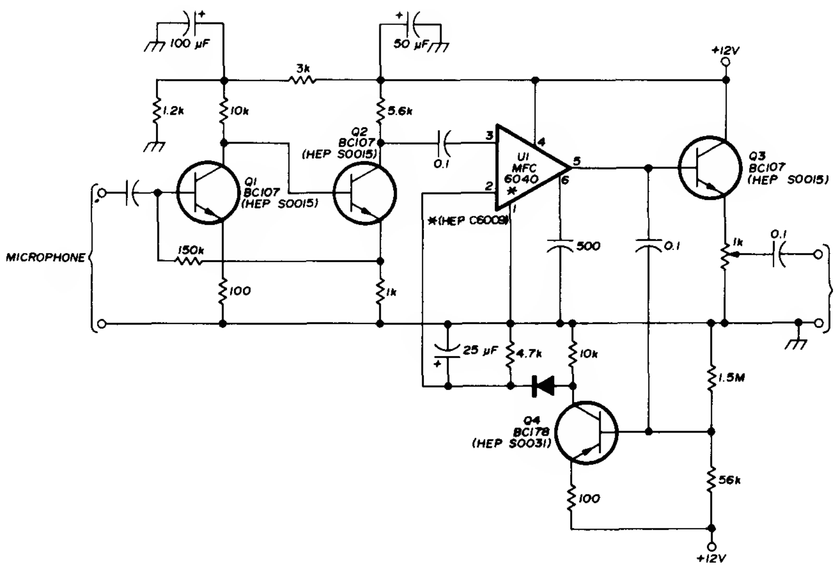


f_0 (Hz)	C_1
32	0.022μF
64	0.011μF
125	0.0056μF
250	0.0027μF
500	0.0015μF
1k	680pF
2k	330pF
4k	160pF
8k	82pF
16k	43pF

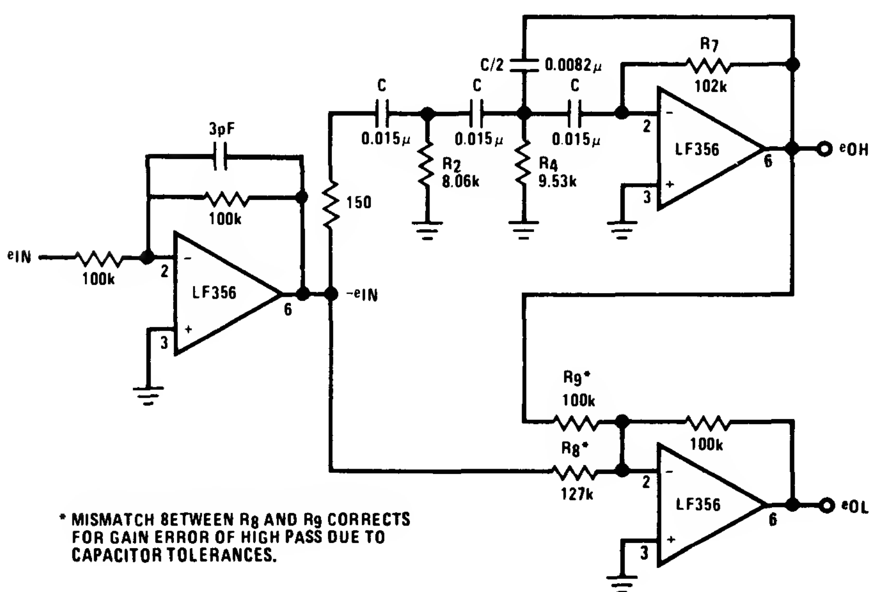
ROOM EQUALIZER—Ten-octave equalizer is combined with pink-noise generator in such a way that all but one octave band can be switched out, with pink noise passed through remaining filter to power amplifier and loudspeaker. Microphone with flat frequency response over audio band is used to pick up resulting noise at some center listening point in room being equalized. Amplified output of microphone drives VU meter where arbitrary level is established for one filter section. Other filter sections are then switched in one at a time and adjusted to give same VU reading. Equalizer settings then give flat room response for all ten octaves. High end can then be rolled off or low end boosted to suit personal preference. Adjustments are readily repeated when furniture is changed in room. Table gives values of C_1 for each octave.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-53–2-59.



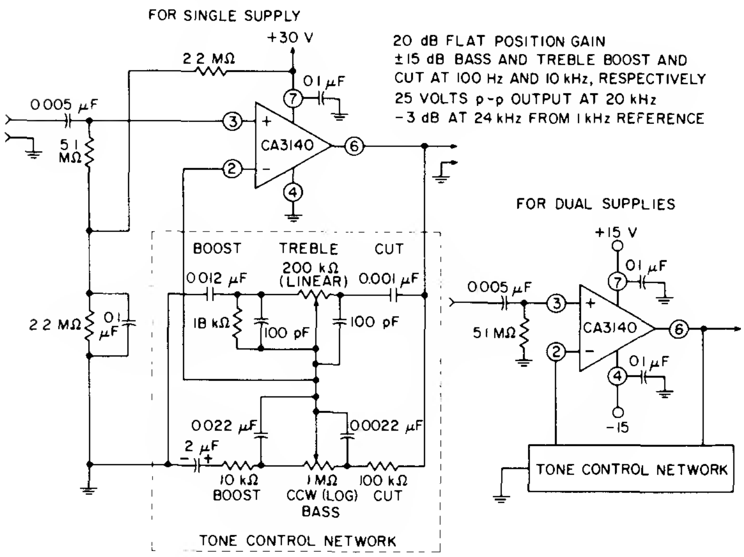
COMPRESSOR—Circuit has unity gein at 0.775 VRMS input and complementary input/output characteristic. Voltage gain through compressor is square root of $0.7/V_{IN}$, where V_{IN} is everage input voltege. Uses Signetics dual-channel compandor IC; 571 has lower inherent distortion and higher supply voltage range (6–24 V) then 571 (6–18 V).—W. G. Jung, Galn Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.



CONSTANT 1.8-V AF FOR SSB—Uses Motorola MFC6040 voltage-controlled amplifier IC having 13-dB gain and maximum of 90-dB gain reduction. Q1-Q2 form microphone preamp, Q4 is AGC detector/amplifier for IC, and Q3 is output buffer. With 500-ohm dynamic microphone, output remains constent et 1.8 VRMS.—L. Novotny, Speech Compressor, *Ham Radio*, Feb. 1976, p 70–71.

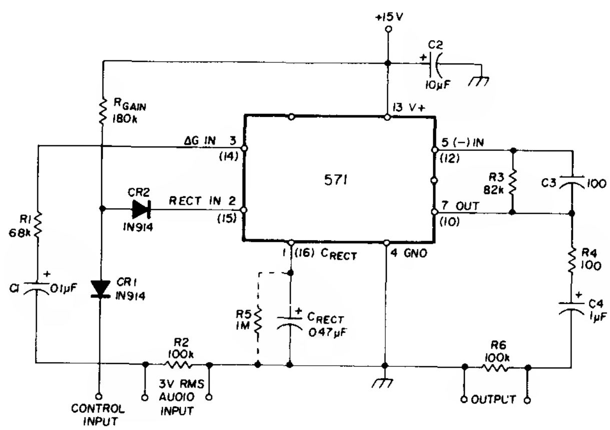


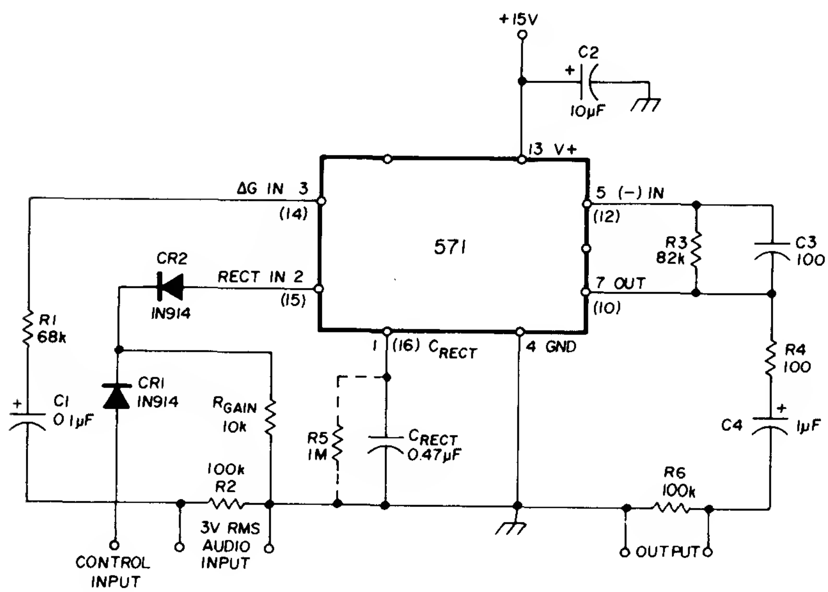
ASYMMETRICAL ACTIVE CROSSOVER—High-pass and low-pass active filters using National LF356 opamps are asymmetrical about 500-Hz crossover point. Sum of filter output voltages is elways constant and equal to unity. Rolloff of low-pass filter is only −6 dB per octave, as compared to −18 dB per octave for high-pass filter.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-1–5-7.



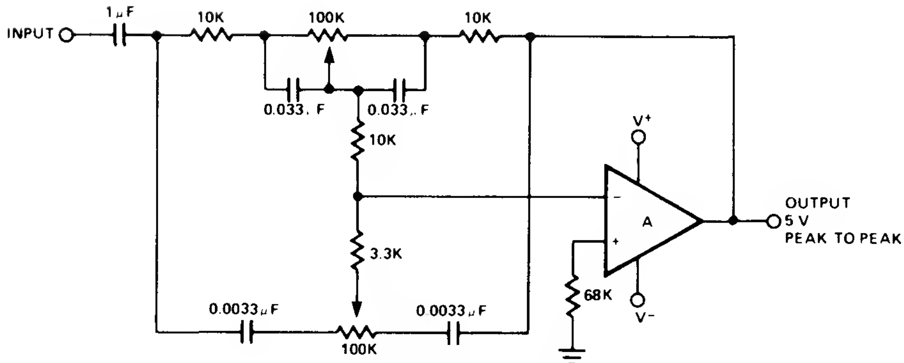
BASS/TREBLE BOOST/CUT—Using linaar and log pots with tone control network in faedback path of CA3140 bipolar MOS opamp, circuit provides 20-dB gein in flat position and ±15 dB bass and treble boost and cut at 100 and 10,000 Hz. Output is 25 V P-P at 20 kHz and is −3 dB at 24 kHz from 1-kHz refaranca. Optional connection for ±15 V supply is also shown.—"Circuit Idaas for RCA Lineer ICs," RCA Solld Stata Division, Somerville, NJ, 1977, p 10.

HIGH-ON LOGIC CONTROL—Uses Signetics NE571 or NE570 enalog compandor. When control input is high, CR1 is off end current developed by R_{GAIN} flows into rectifier input, ellowing audio to be emplified. Gein is unity (or other nominel valua chosen by chenging velue of R3) for control inputs graatar then 3 V. Switching is abrupt, with full attanuetion below 1.5 V. Narrow trensition width and nominel DC center of 1.8 V allow direct control from CMOS, TTL, DTL, or other positive logic. Supply voltege should be stabla.—W. G. Jung, Gein Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.



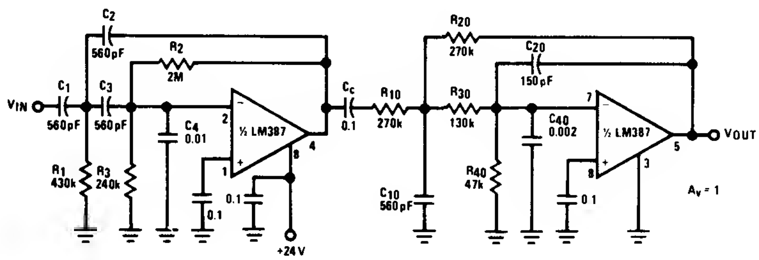


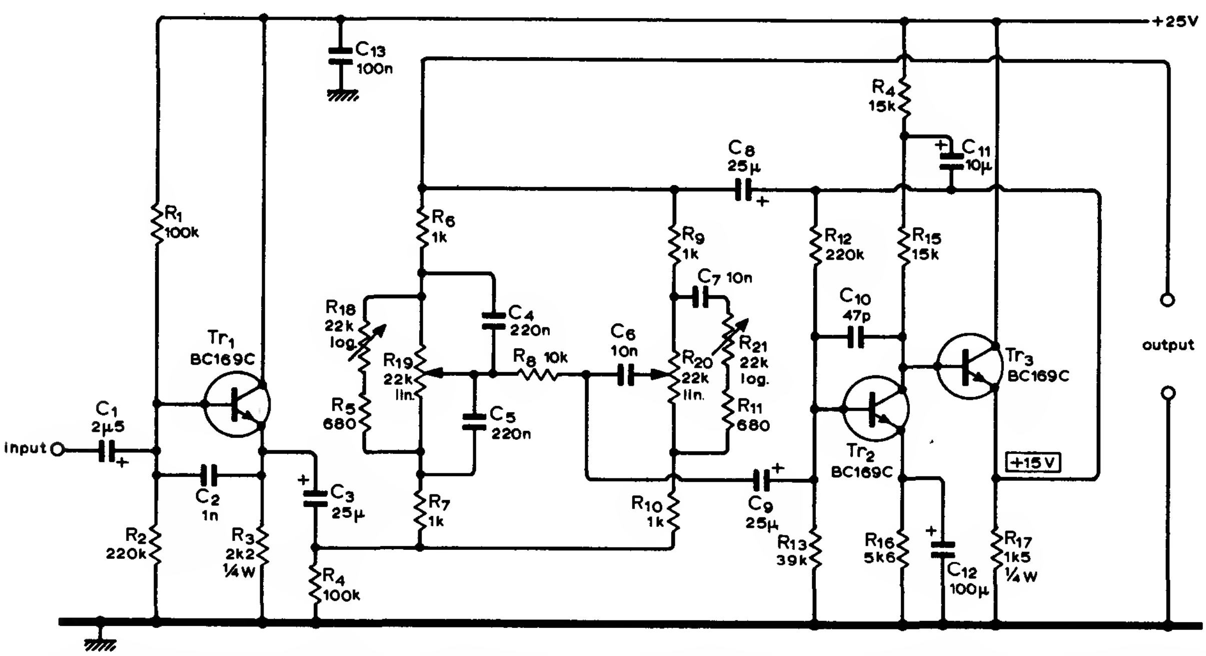
LOW-ON LOGIC CONTROL—Uses Signatics NE571 or NE570 analog compandor. Gain is datermined by current developad through R_{GAIN} in conjunction with intarnal 1.8-V voltaga reference. When control input is low, normal currant flows through R_{GAIN}. When control signal is high, CR1 is forward-biased, intarrupting current flow, and output is ettanuated.—W. G. Jung, Gein Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.



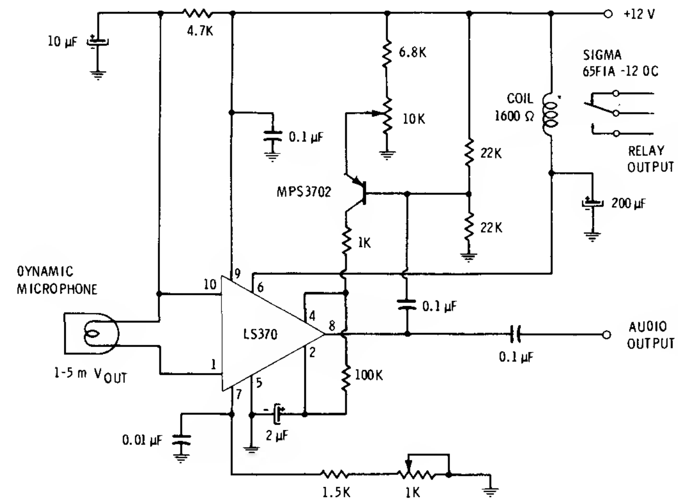
TONE CONTROL FOR OPAMP—Provides up to 20 dB of bass boost or cut at 20 Hz and up to 19 dB of treble boost or cut at 20 kHz. Turnover frequency is 1 kHz. Opamp can be 531 or 301.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 638–640.

SPEECH FILTER—High-pass and low-pass filters in cascade provide corner frequencies of 300 and 3000 Hz for limiting audio bandwidth to speech frequencies. Rolloff beyond corners is −40 dB per decade. Input-to-output gain is 1.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-49–2-52.



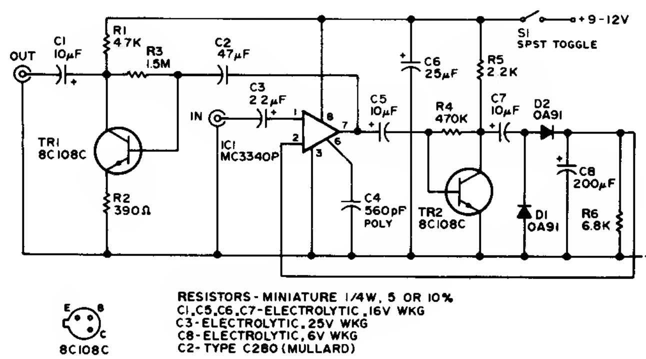


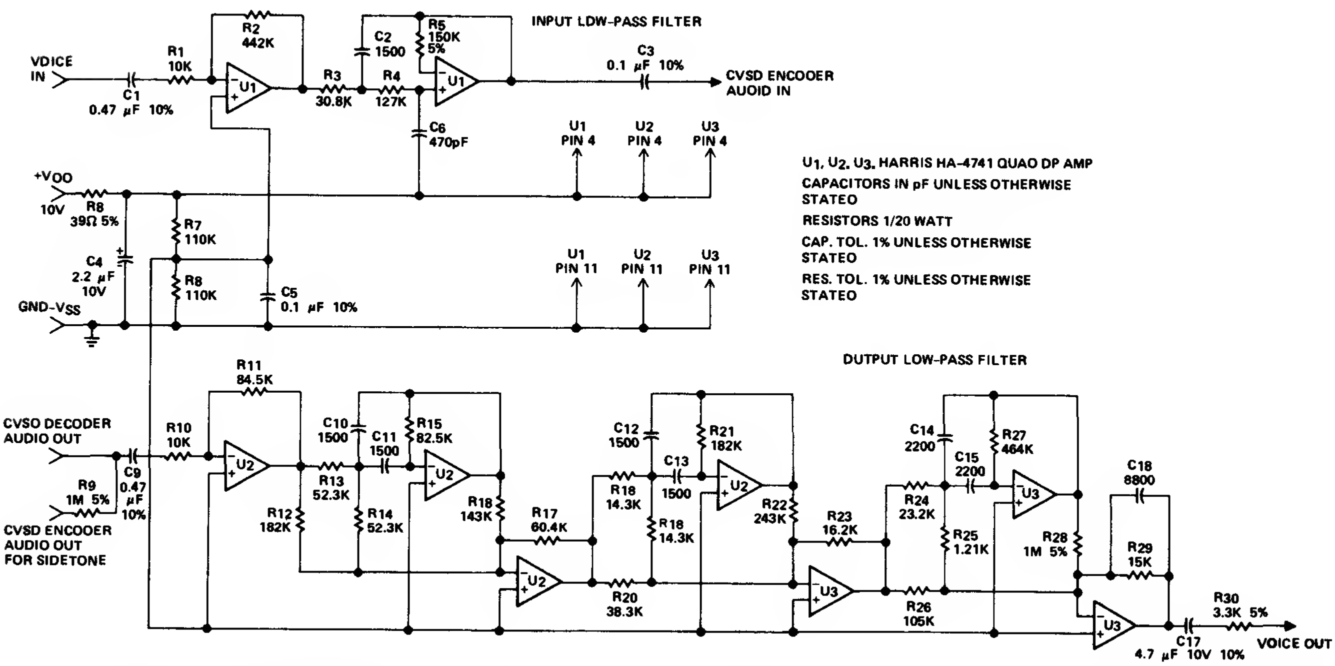
IMPROVED BAXANDALL CONTROL—Uses separate "effect" controls for bass and treble to limit maximum degree of boost and cut obtainable from bass and treble controls. R_{18} controls effect for bass and R_{21} for treble. Circuit has unity gain with controls set flat. Article gives response curves and describes operation of circuit in detail.—M. V. Thomas, Baxandall Tone Control Revisited, *Wireless World*, Sept. 1974, p 341–343.



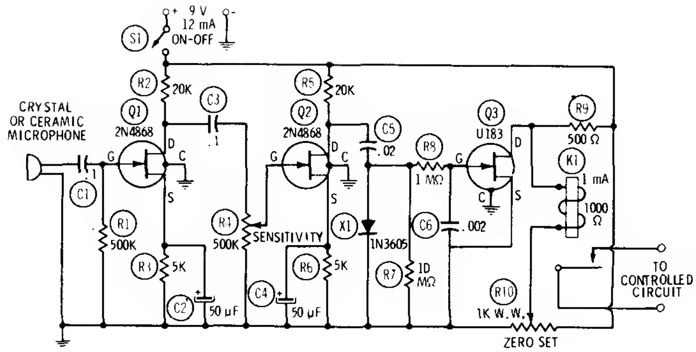
VOX WITH SPEECH COMPRESSION—Turns on transmitter eutometically when oparator begins speaking into microphone. Circuit switches beck to receiving condition eutometically et end of messege. IC can be LS370 or equivelent such as LM370 or SC370. Amount of compression is edjusted with 10K pot, for reducing gein of IC eutometically to meintain reasonably constent eudio output et pin 8 despite different voice levels at microphone.—E. M. Noll, "Linaer IC Principles, Experiments, end Projects," Howerd W. Sems, Indianapolis, IN, 1974, p 344–347.

COMPRESSOR—Keeps output voltege constent es long es input signel is kept above AF threshold leval. Opemp is MC3340P. —Circuits, *73 Magazine,* Holiday issue 1976, p 170.



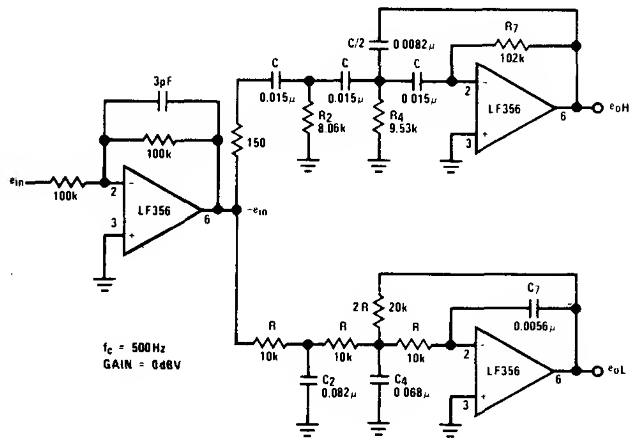


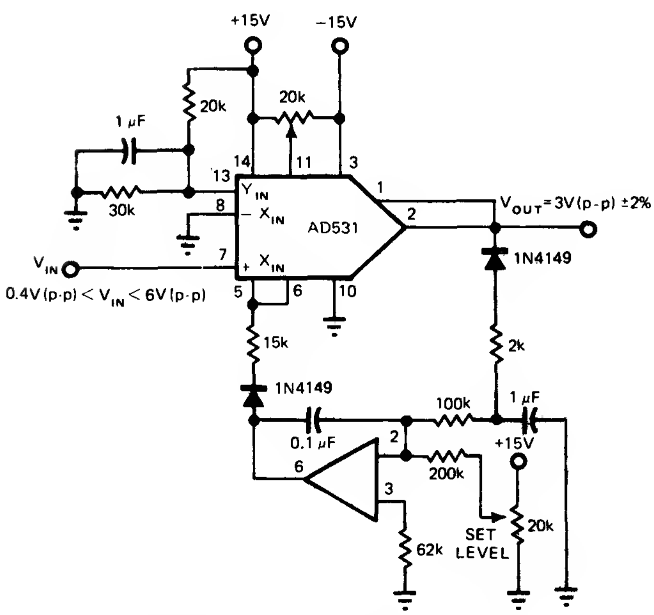
AUDIO FILTERS FOR SNR MEASUREMENT—Used in checking performance of Herris HC-55516/55532 half-duplex moduletor-damodulator systems for converting voice signels into serial NRZ digital dete and reconvarting that deta beck to voice. Supply requlred for opamp sections is ±15 V. Response of input filtar is down 3 dB at 3 kHz end is down 20 dB at 9 kHz. Response of output filter is fiat up to 3 kHz end down more than 45 dB from 3.8 kHz to 100 kHz.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourna, FL, Vol. 1, 1977, p 5–10.



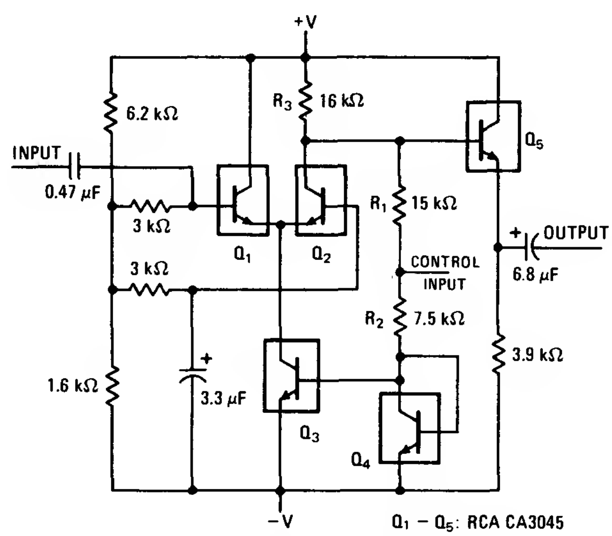
SOUND-OPERATED RELAY—Output of about 1.8 mVRMS from crystal or caramic microphone will enargiza ralay whan sensitivity control R4 is at maximum. First two stagas form high-gain RC-coupled AF amplifiar, output of which is rectified by silicon dioda X1. DC voltaga davaloped across dioda is applied to gata of Siliconix U183 FET which acts as DC amplifiar driving Sigma 5F or aquivalant ralay. To adjust, short microphona terminals, set R4 for maximum sensitivity, than adjust R10 until ralay opans.—R. P. Turnar, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 111–113.

SYMMETRICAL ACTIVE CROSSOVER—Provides −18 dB par octave rolloff (third ordar) and maximally flat (Butterworth) charactaristics for crossovar fraquency of 500 Hz. Uses National LF356 opamps in high-pass and low-pass filtars and sama opamp as buffer having low driving impedance raquired by activa filtars. Power supplies ara ±15 V. Design aquations ara given.—"Audio Handbook," National Samiconductor, Santa Clara, CA, 1977, p 5-1–5-7.

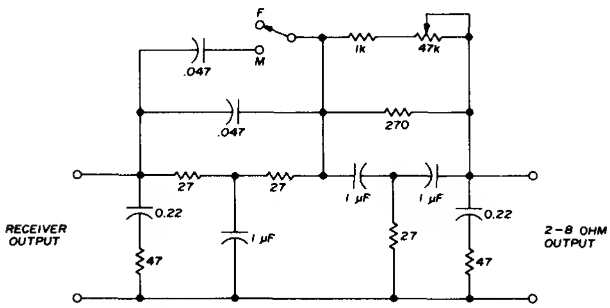




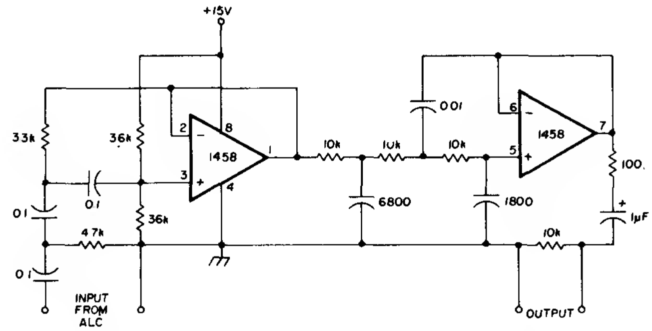
WIDEBAND AF LEVEL CONTROL—AD531 analog multipliar can hold output to 3 V P-P ± 2% for inputs from 0.4 to 6 V P-P, at frequancies from 30 Hz to 400 kHz. Opamp typa is not critical.—R. Frantz, Analog Multipliers—Naw IC Varsions Manipulata Real-World Phanomana with Ease, *EDN Magazine*, Sept. 5, 1977, p 125–129.



THUMPLESS CONTROL—Five-transistor circuit for audio amplifiar applications eliminates thumping sounds that can sometimes ba haard when level of input signal changes suddenly. Diffarential amplifiar Q_1-Q_2, with R_1 in amittar-currant control circuit, aliminates thump. Control input acts on idantical transistors Q_3-Q_4 which make transconductanca of differentlal pair Q_1-Q_2 vary in diract proportion to control voltage. Fifth transistor in array, Q_5, Is used as output signal buffar. Amplifiar gain is 30 for control voltaga of 15 V.—P. Brokaw, Automatic Gain Control Quells Amplifiar Thump, *Electronics*, Jan. 10, 1974, p 131–132; reprinted in "Circuits for Electronics Enginaers," *Electronics*, 1977, p 46–47.

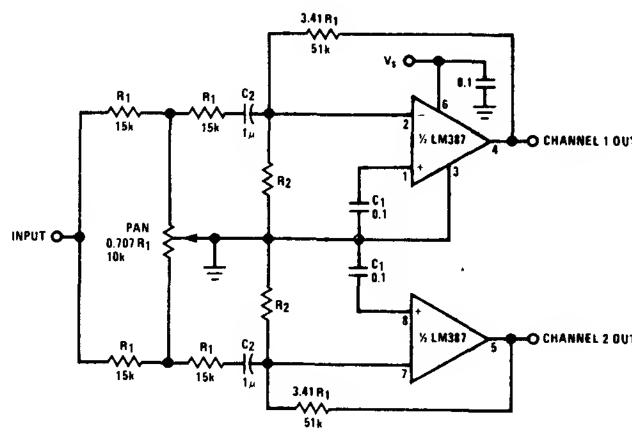


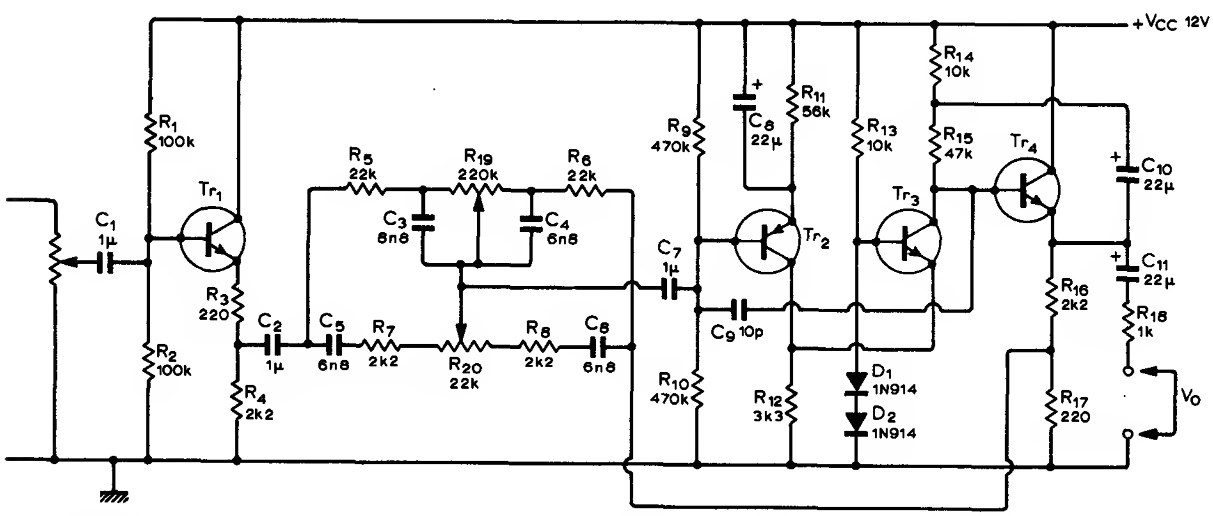
MALE-FEMALE VOICE SWITCH—Circuit developed by NASA engineers to improve intelligibility of voice communication during Apollo moon shots passes only the three portions of the speech spectrum required for clear speech: 300–400 Hz and 2500–3000 Hz for both sexes and 900–1700 Hz for males or 1100–1900 Hz for females. Pot adjusts null to about 600 Hz. Circuit improves readability of weak DX voice signals in noise.—J. Fisk, Circuits and Techniques, *Ham Radio*, June 1976, p 48–52.



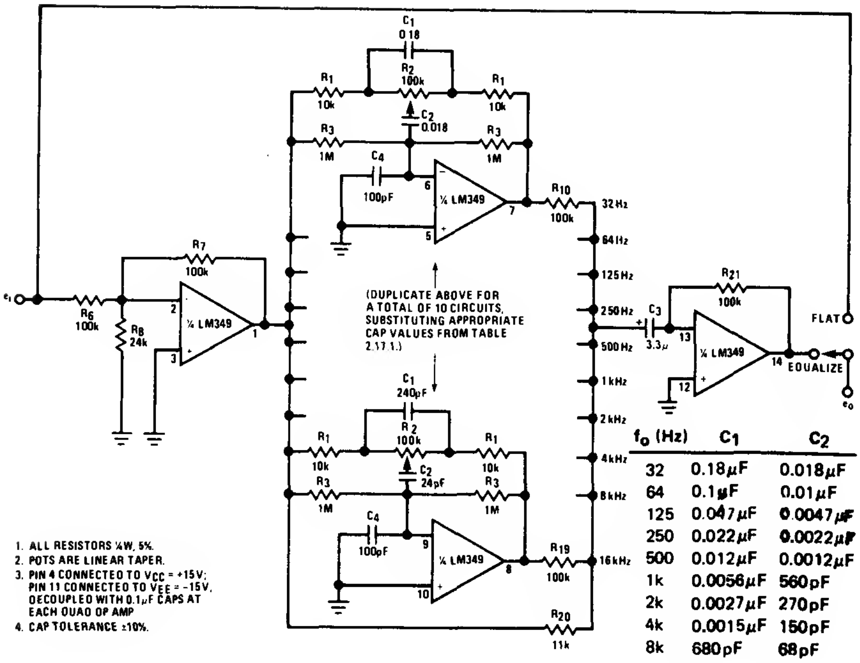
SPEECH FILTER—Pair of Bessel-type high-pass filters removes undesired components created by peak clipping during audio signal processing. Developed for use with automatic level control applications of NE571 analog compandor.—W. G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.

TWO-CHANNEL PANNING—Provides smooth and accurate panoramic control of apparent microphone position between two output channels, as often required in mixing consoles at recording studios. Requires only single linear pot. At each extreme of pot, gain is unity for one channel and zero for other. With pot centered, gains for both channels are −3 dB. R_2 depends on supply voltage used, which can be from 9 to 30 V.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-59–2-61.





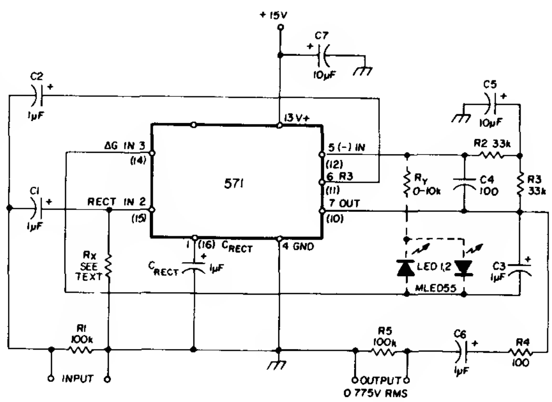
CASCODE TONE CONTROL—*Circuit raises 100-mV input signal level to 1 V for driving power amplifier and uses cascode arrangement to improve S/N ratio of tone control network. Values shown give maximum bass boost or cut at 50 Hz with* R_{19} *and maximum treble boost or cut at 10 kHz with* R_{20}. Tr_2 can be BC15, BC214, BC309, or equivalent. Other transistors can be BC109, BC114, BC184, or equivalent.—J. N. Ellis, High Quality Tone Control, *Wireless World*, Aug. 1973, p 378.

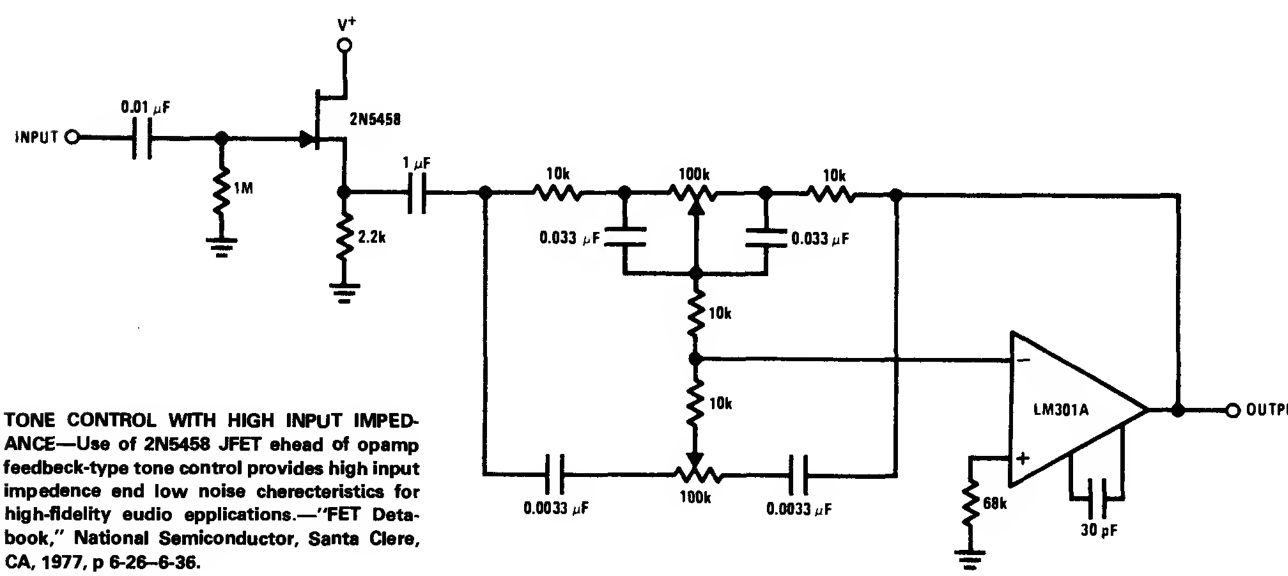


f_o (Hz)	C_1	C_2
32	0.18 μF	0.018 μF
64	0.1 μF	0.01 μF
125	0.047 μF	0.0047 μF
250	0.022 μF	0.0022 μF
500	0.012 μF	0.0012 μF
1k	0.0056 μF	560 pF
2k	0.0027 μF	270 pF
4k	0.0015 μF	150 pF
8k	680 pF	68 pF
16k	240 pF	24 pF

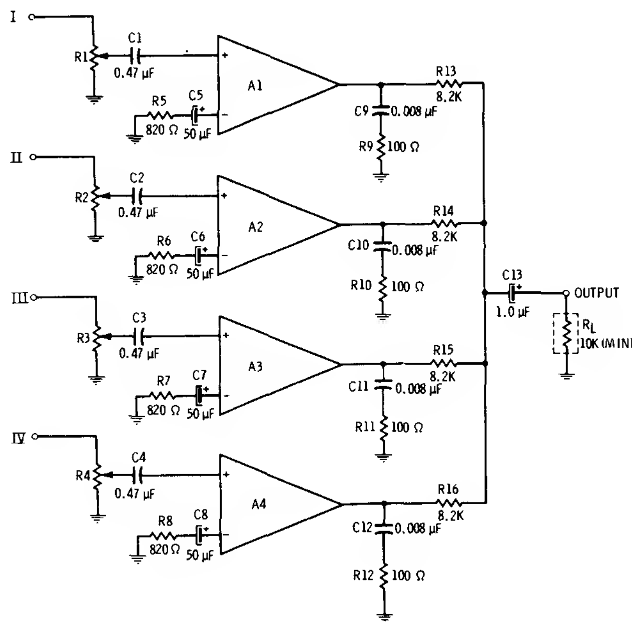
OCTAVE EQUALIZER—Provides ten bands of tone control, separated by one octave in frequency, with independent adjustment for each. Used to compensate for unwanted amplitude-frequency or phase-frequency characteristics of audio systems. Values of C_1 and C_2 for each circuit are given in table. With control R_2 in flat position, circuit becomes all-pass with unity gain. Moving R_2 to full boost gives bandpass characteristic, and moving in other direction to full cut gives band-reject or notch filter. For stereo, identical equalizer is needed for other channel.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-53–2-59.

AUTOMATIC LEVEL CONTROL—Uses Signetics NE570 or NE571 analog compandor to provide automatic level control for audio signal processing, to give constant high percentage modulation despite varying input levels. Optional resistor R_X varies threshold of level regulation. Widest range of gain control is obtained with R_X open. When resistor value is lowered, larger input signal is required for full output. Peak-level clipping with pair of reverse paralleled LEDs controls overshoots on speech by limiting RMS output to 2.2 V P-P. R_Y regulates clipped amplitude.—W. G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.

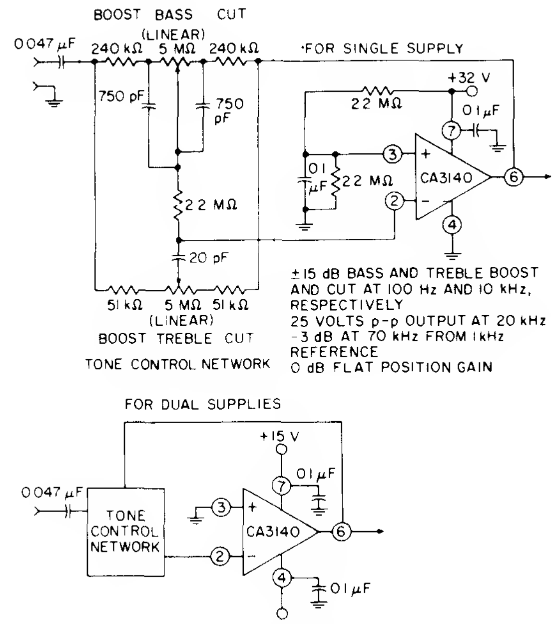




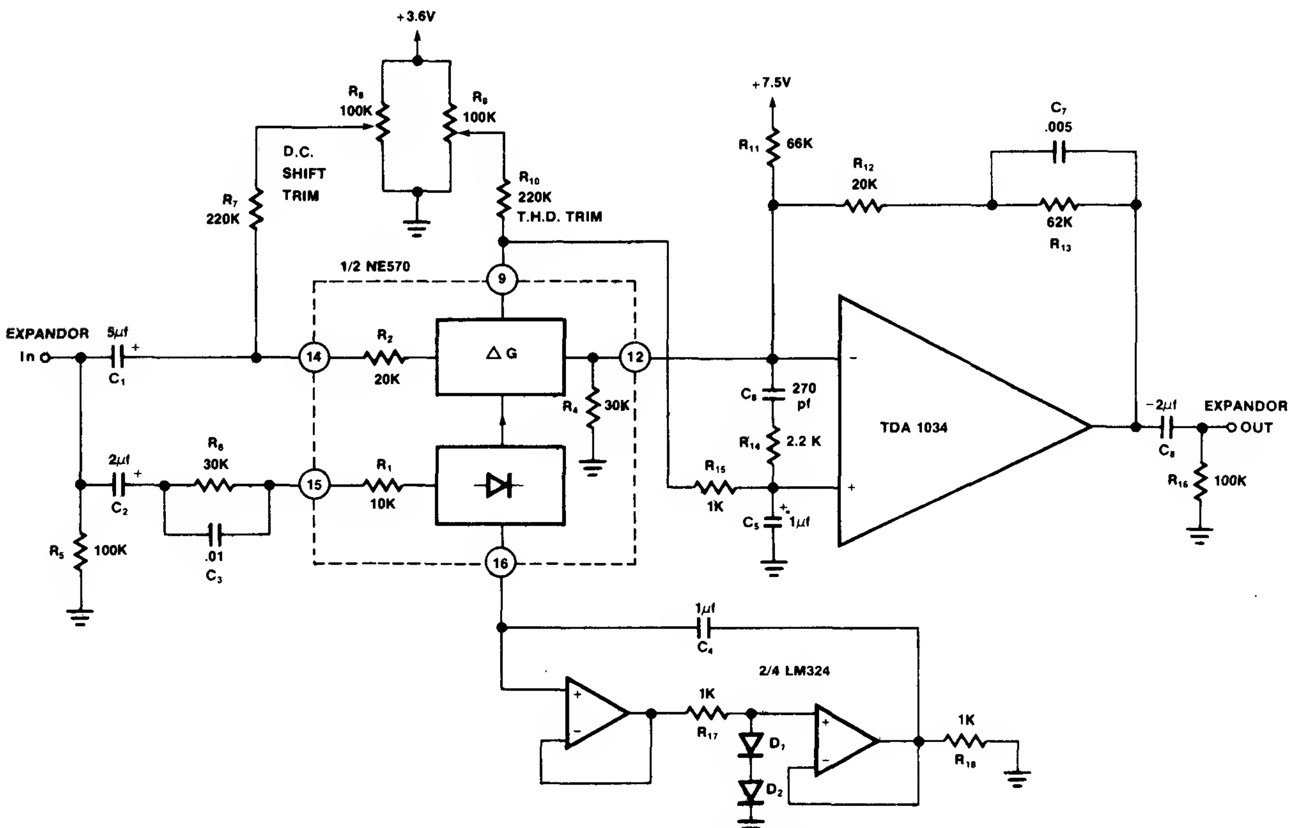
TONE CONTROL WITH HIGH INPUT IMPEDANCE—Use of 2N5458 JFET ahead of opamp feedback-type tone control provides high input impedance and low noise characteristics for high-fidelity audio applications.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



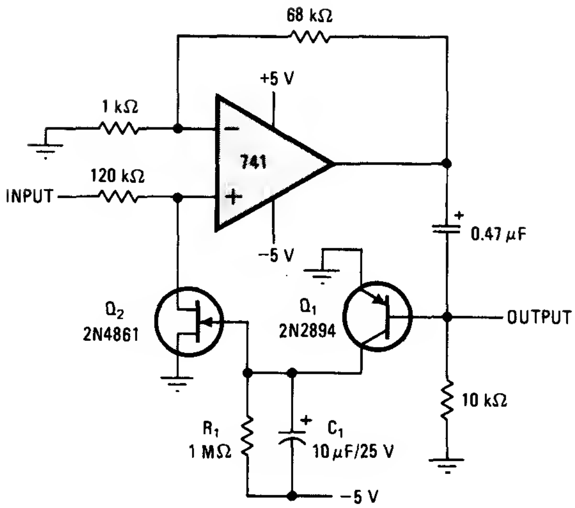
FOUR-CHANNEL MIXER—All four sections of RCA CA3048 qued differential amplifier are utilized in linear mixer providing gain of 20 dB for each channel. Designed for use with load of 10K or larger. All inputs are high impedance.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 173 end 179.



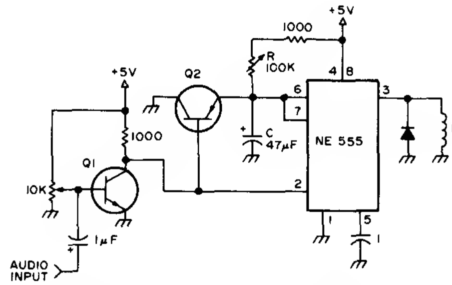
BAXANDALL TONE CONTROL—Utilizes high slew rete, high output-voltage capability, end high input impedence of CA3140 bipolar MOS opamp to provide unity gain et midband elong with bass and treble boost end cut of ±15 dB at 100 end 10,000 Hz. Optional connection for ±15 V supply is shown below.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 10.



HI-FI EXPANDER—Used in pleybeck of material that has been recorded with overload-preventing compressor. Extemel opamp is used for high slew rete. Adjust distortion trimpot R_9 for minimum total harmonic distortion when using input of 0 dBm et 10 kHz. Adjust DC shift pot R_8 after this, for minimum envelope bounce with tone-burst input.—"Signetics Anelog Data Menual," Signetics, Sunnyvale, CA, 1977, p 804–805.

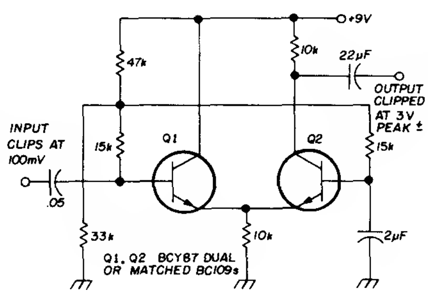


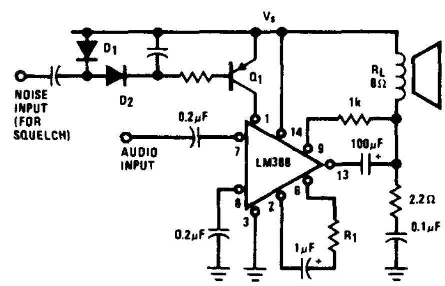
60-dB RANGE FOR AUDIO—JFET acts as voltage-controlled resistor in peak-detecting control loop of 741 opamp. Input range is 20 mV to 20 V, with response time of 1–2 ms and delay of 0.4 s. Output is about 1.4 V P-P over entire 60-dB range.—N. Heckt, Automatic Gain Control Has 60-Decibel Range, *Electronics*, March 31, 1977, p 107.



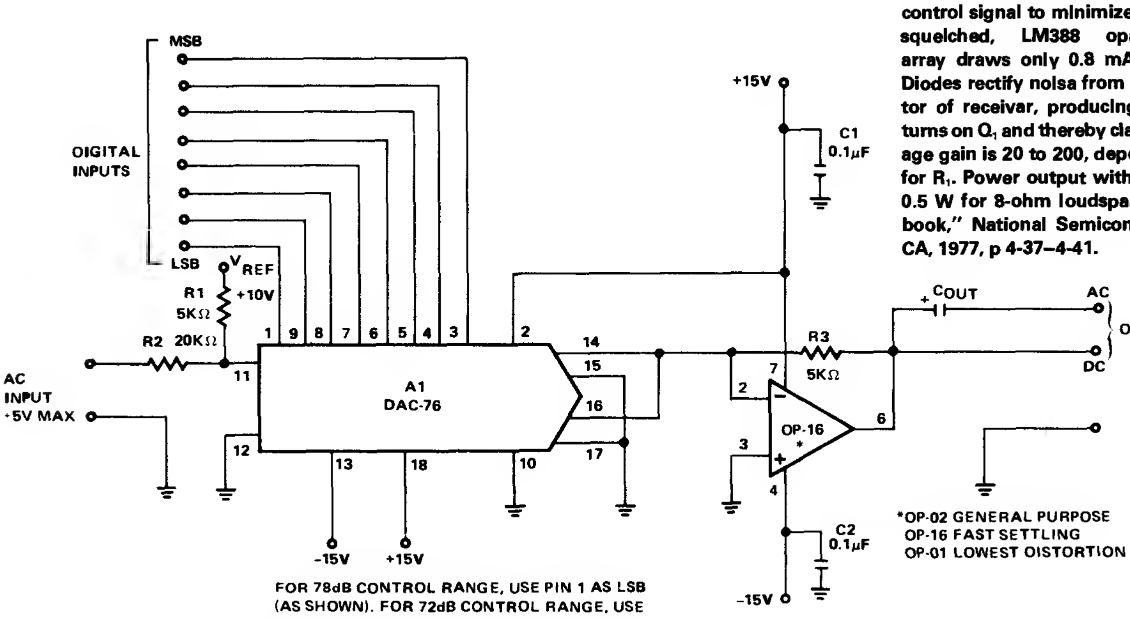
AUDIO-OPERATED RELAY—Addition of two general-purpose transistors to 555 timer gives audio-triggered relay that can be used for automatic recording of output of channel-monitoring radio receiver or data from any audio link. Adjustable time delay R keeps control circuit actuated up to 5 s (determined by R and C) to avoid cycling relay during pauses in speech or dropouts in data. Q1 is NPN, and Q2 is PNP. Attack time equals very short pull-in time of 5-V reed relay K. Adjust 10K input pot just below point at which K pulls in when there is no audio input.—R. Taggart, Sound Operated Relay, *73 Magazine*, Oct. 1977, p 114–115.

DIFFERENTIAL-AMPLIFIER CLIPPER—Provides gain as well as precise symmetrical clipping for improving intelligibility of speech fed into radio transmitter. Circuit reduces dynamic range of energy peaks to bring them closer to average energy level. When inserted in series with microphone, use of clipper gives at least 6-dB increase in effective power. Signals are passed up to certain amplitude but limited above this level.—B. Kirkwood, Principles of Speech Processing, *Ham Radio*, Feb. 1975, p 28–34.



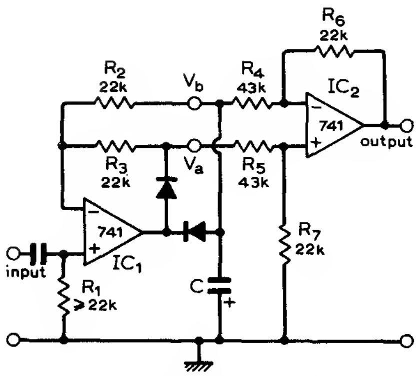


SQUELCHABLE AMPLIFIER—Circuit designed for portable FM scanners and two-way walkie-talkie radios can be turned off by noise or by control signal to minimize battery drain. When squelched, LM388 opamp-transistor-diode array draws only 0.8 mA from 7.5-V supply. Diodes rectify noise from limiter or discriminator of receiver, producing direct current that turns on Q_1 and thereby clamps opamp off. Voltage gain is 20 to 200, depending on value used for R_1. Power output without squelch is about 0.5 W for 8-ohm loudspeaker.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-37–4-41.

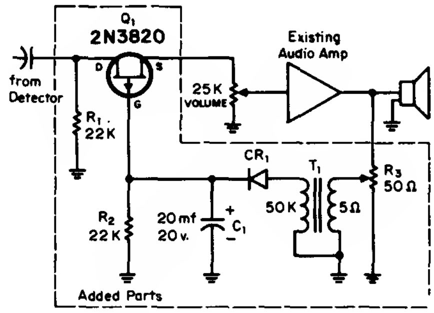


FOR 78dB CONTROL RANGE, USE PIN 1 AS LSB (AS SHOWN). FOR 72dB CONTROL RANGE, USE PIN 9 AS LSB, GROUND PIN 1.

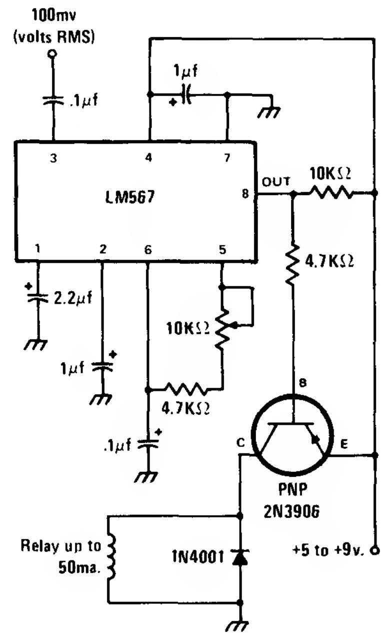
TWO-QUADRANT EXPONENTIAL CONTROL—Decibel-weighted control characteristic of Precision Monolithics DAC-76 D/A converter matches natural loudness sensitivity of human ear, to provide much greater useful dynamic range for controlling audio level. Control range can be either 72 or 78 dB, depending on pin connections used. 8-bit word control input can be interfaced with standard TTL-compatible microprocessor outputs. To avoid annoying output transients during large or rapid gain changes, use clickless attenuator/amplifier (also given in application note).—W. Jung and W. Ritmanich, "Audio Applications for the DAC-76 Companding D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, AN-28, p 2.



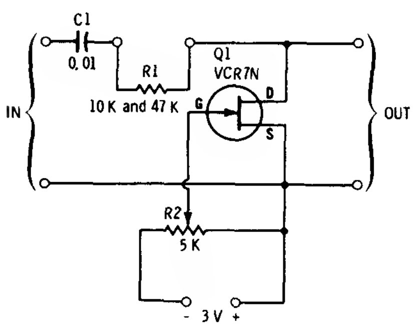
CLAMPING WITH OPAMPS—Circuit is used after stage of AC amplification to clamp minimum level of signal voltage to 0 V for signals having amplitudes between 10 mV and 10 V. With 250-μF electrolytic for C, sinusoidal waveforms between 3 and 10,000 Hz are clamped with little distortion. Overall gain is unity.—C. B. Mussell, D.C. Level Clamp, *Wireless World*, Feb. 1975, p 93.



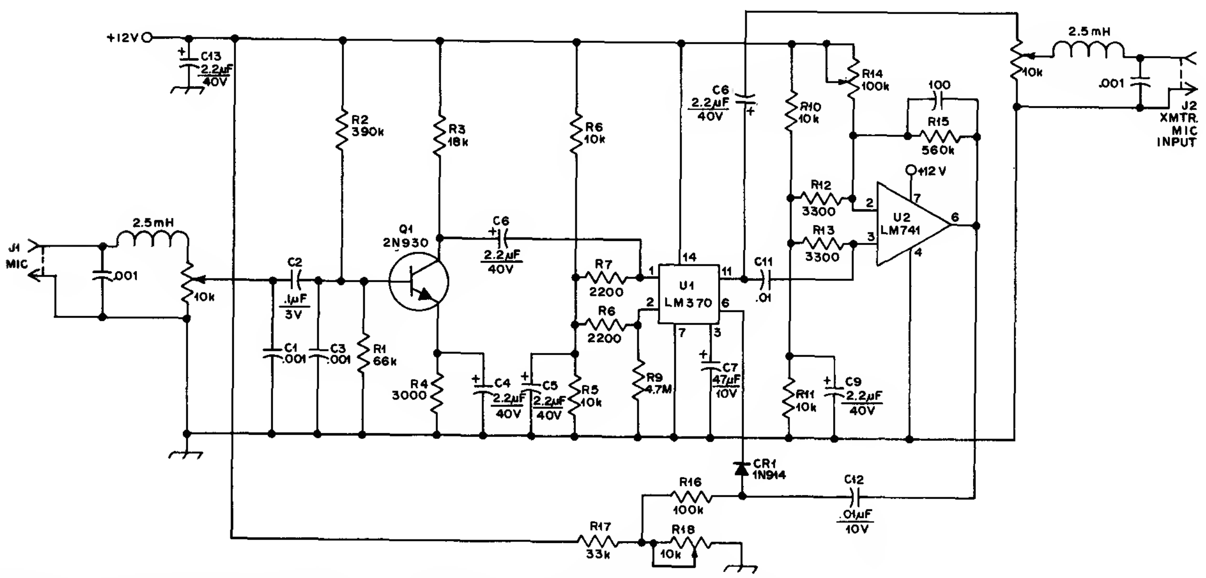
AF COMPRESSOR—Developed for use in communication receiver where signals vary so greatly that even modern AVC systems cannot level all signals. Circuit is AVC that sets maximum audio level which will not be exceeded. Uses one FET as series attenuator controlled by DC voltage derived from audio output. R_3 permits adjustment of compression level.—C. E. Richmond, A Receiver Audio Compressor, *CQ*, June 1970, p 35 and 86.



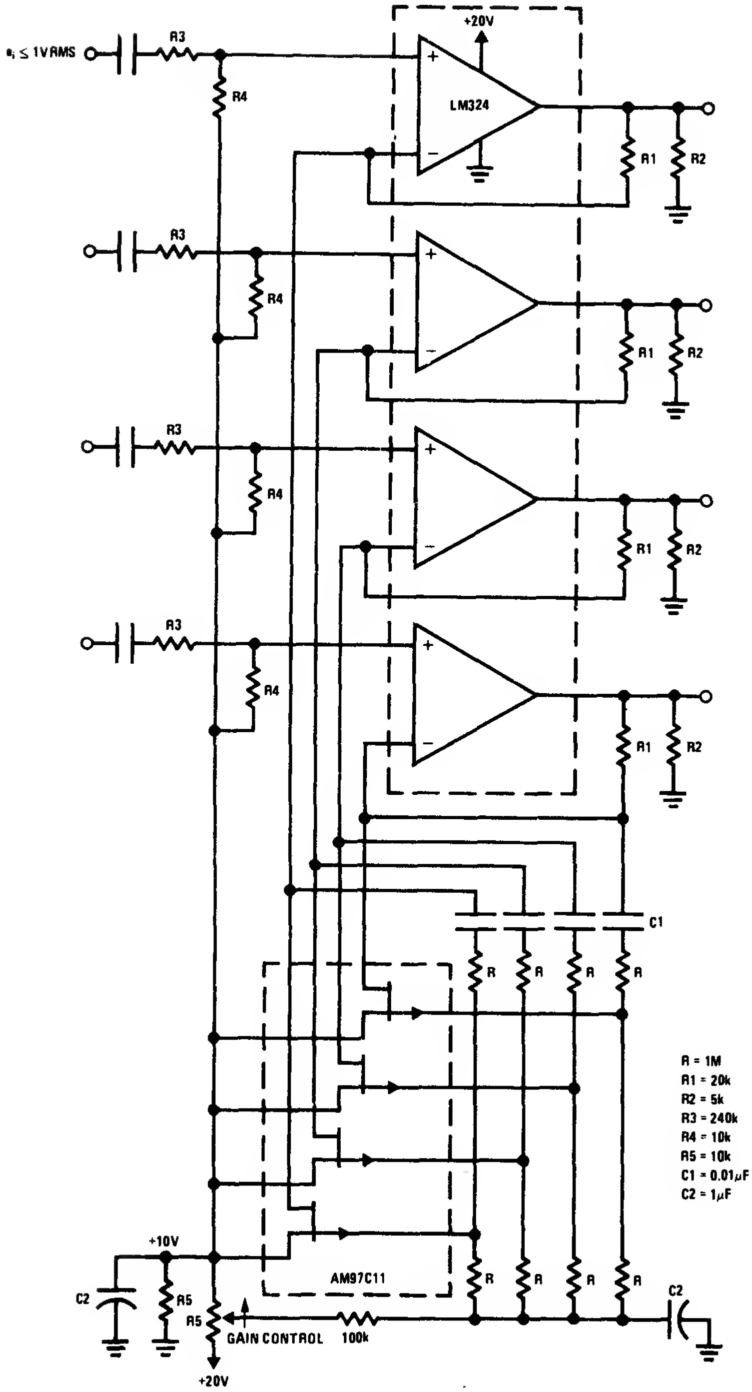
TONE-DRIVEN RELAY—LM567 tone decoder will respond to frequency between 700 and 1500 Hz, determined by setting of 10K pot. When input of 100 mVRMS at preset frequency arrives, output of IC goes low and energizes relay through transistor. Tone can be obtained from audio oscillator or telephone Touch-Tone pad. Relay contacts can be used to turn desired device on or off.—J. A. Sandler, 9 Easy to Build Projects under $9, *Modern Electronics*, July 1978, p 53–56.



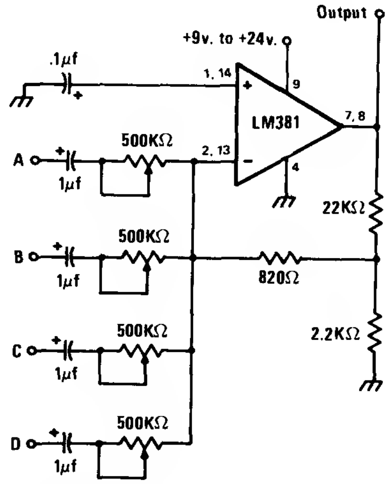
VOLTAGE-CONTROLLED ATTENUATOR—Used to control low-level audio signals with variable DC voltage of ±3 V. Control pot can be remotely located. Highest possible output is equal to input level, occurring when gate bias is set close to pinchoff value. Output is minimum when gate bias is zero.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 258–260.



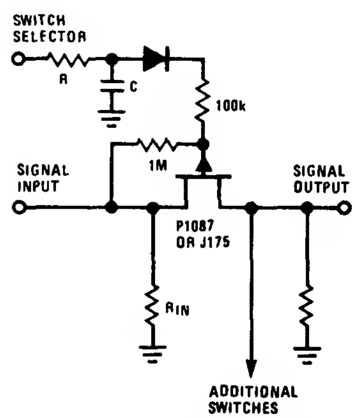
EQUALIZER—Designed for use between input jack and microphone of amateur transmitter, to keep bandpass response between limits of about 200 and 3100 Hz. Circuit also provides measure of volume compression, improving transmitter efficiency. Construction and adjustment details stress importance of eliminating ground loops and RF feedback. U1 is voltage-controlled amplifier in feedback loop, with 741 opamp U2 as compression detector. U2 is biased so output is almost at ground, and no feedback voltage is applied until input to U2 exceeds 0.9 V. U1 thus operates in linear mode at maximum gain until output voltage exceeds 0.9 V, when voltage is applied to U1 and gain of IC is reduced.—R. Tauber, The Equalizer, *QST*, March 1977, p 18–20.



QUAD GAIN CONTROL—Combination of Netionel AM97C11 qued FET and LM324 quad opamp giveatracking gein control having 40-dB ranga. Bandwidth is 10 kHz minimum, end S/N ratio is better than 70 dB for 4.3-VRMS maximum output. Temparatura sensitivity of FET can ba reduced by using silicon resistor for opamp faedback resistor R1.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-39–6-46.



FOUR-CHANNEL MIXER—Combines AF signala from ona to four sources into single audio signal for input of LM381 opamp that sarves also as preamp. Shield mixer circuit and uaa shielded cable for all input iaads to avoid pickup of 60-Hz field by high-gain opamp. Increasing supply voltage from minimum of 9 V boosts output signal voltaga.—J. A. Sandler, 9 Eaay to Build Projects under $9, *Modern Electronics*, July 1978, p 53–56.



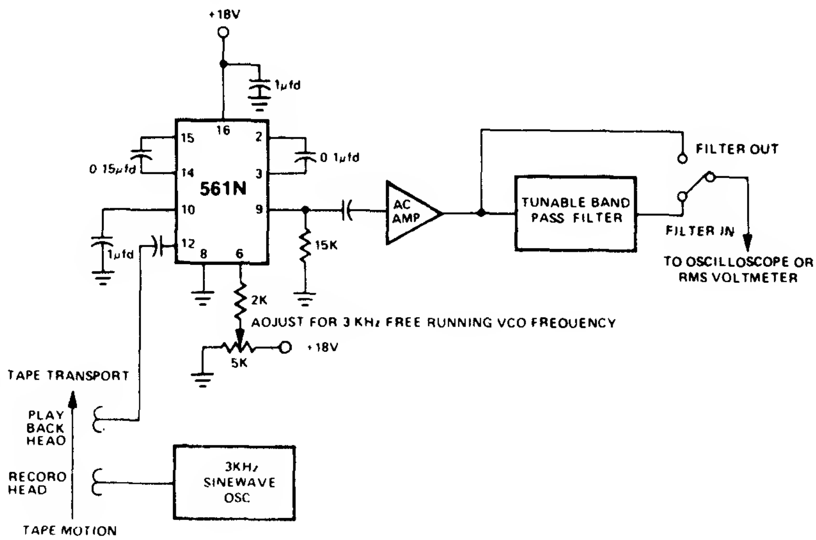
NOISELESS AUDIO SWITCH—Deglitched current-moda awitch using JFET can be placed directly on printed-circuit board instead of front panai, to minimize hum pickup and crosstalk. JFET allows transition time of driva to ba adjusted with seriaa resistor R and shunt capacitor C to provida noiaaless switching of AF aignals. Dioda type ia not criticai. Any number of switchas can be ganged.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-62.

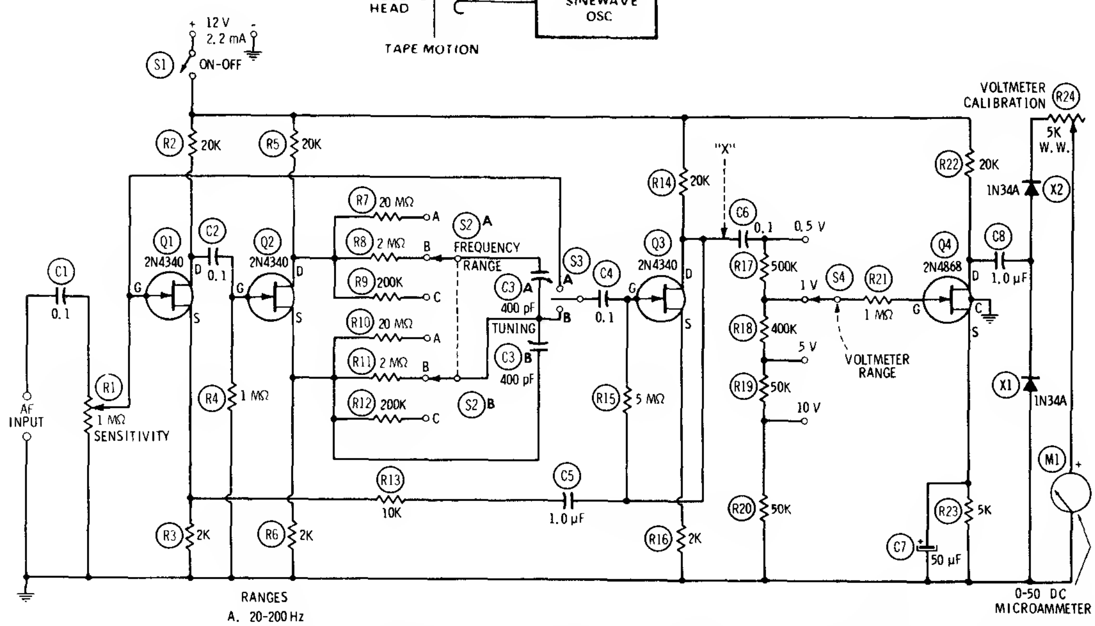
CHAPTER 5

Audio Measuring Circuits

Includes S-meters and VU meters, along with circuits for measuring AF distortion and flutter, peak program meter tester, and clipping-point indicator. See also Frequency Measuring and Frequency Multiplier chapters.

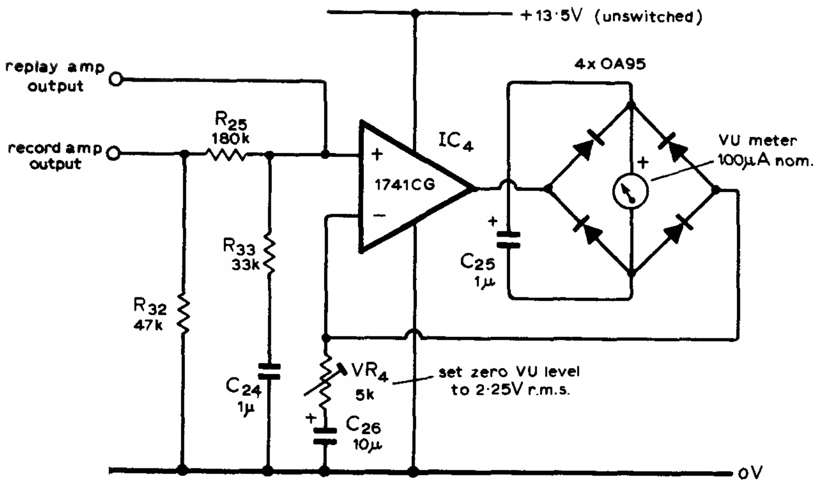
FLUTTER METER—Signetics 561N PLL detects frequency varietions in 3-kHz tone recorded on megnetic tape for test purposes. Frequency of VCO in 561N Is set to nominel 3 kHz with 5K pot. Demodulated output is AC coupled to amplifier heving high input impedence. Either CRO or true RMS voltmeter can be used to meke RMS flutter reedings. To calibrete circuit, feed in 3-kHz tone from oscillator and measure output level shift when frequency is offset 1%.—"Signetics Analog Dete Manuel," Signetics, Sunnyvale, CA, 1977, p 860.





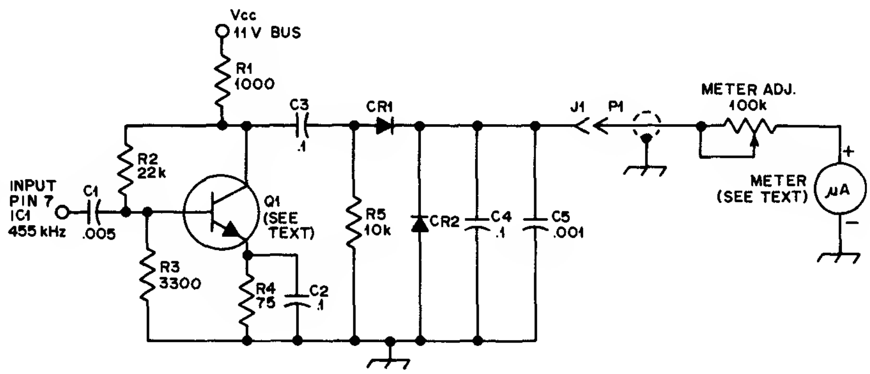
RANGES
A. 20-200 Hz
B. 200-2000 Hz
C. 2-20 kHz

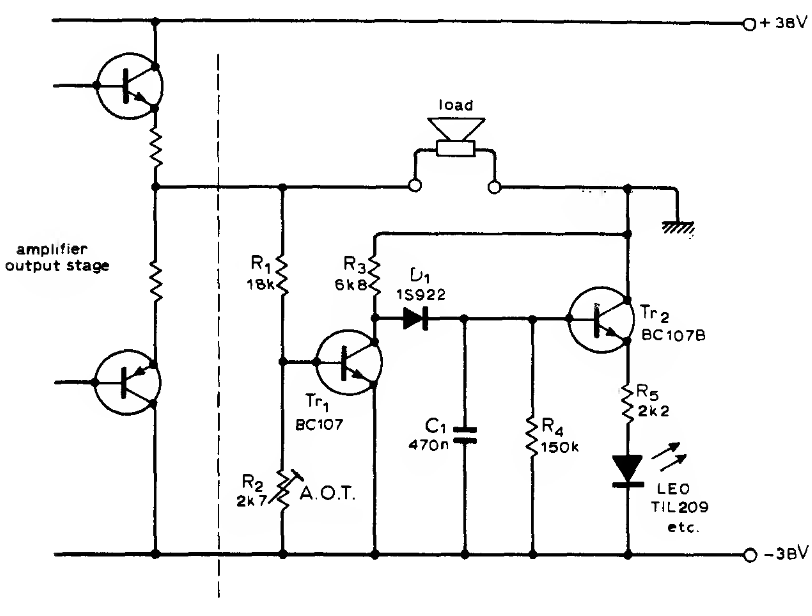
HARMONIC-DISTORTION METER—Used to measure totel harmonic distortion of audio amplifier, component, or network. Pure sine-wave signel is epplied to device under test, and output of device is fed to AF input of distortion meter. After setting S2 to appropriate frequency renge, close S1, set S3 at A, set S4 et eppropriate voltage range, end edjust R1 for full-scale meter deflection. Record this voltage es E_1. Set S3 to B, tune C3 for null, then set S4 to successively lower ranges for accurete reading of voltage at null. Record residuel null voltage es E_2. Percentage distortion is than $100E_2/E_1$.—R. P. Turner, "FET Circuits," Howerd W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 147–150.



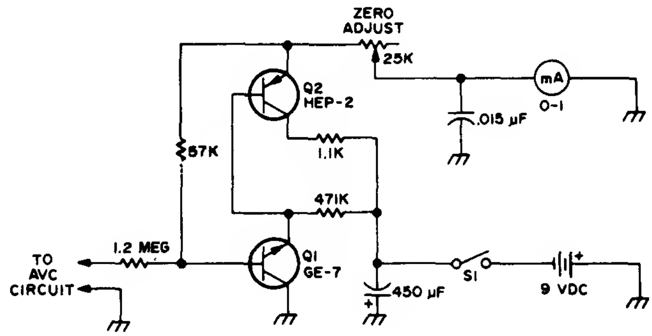
IC DRIVE FOR VU METER—Used in high-quality stereo cassette deck operating from AC line or battery. Meter rectifier bridga is in feedback loop of opamp, to give highly lineer AC/DC conversion with flat frequency/amplitude response end short voltega rise tima at low cost. Article gives ell other circuits of cassette deck and describas operation in deteil.—J. L. Linsley Hood, Low-Noise, Low-Cost Cassette Deck, *Wireless World*, Part 1—May 1976, p 36–40 (Part 2—June 1976, p 62–66; Part 3—Aug. 1976, p 55–56).

ADD-ON S-METER—Although designed for use with Clegg FM-27B 2-meter FM receiver, circuit can be readily adepted to othar recaivars. Amplifier brings low-level 455-MHz IF signal up to level suitabla for driving mater. For other IF, such as 10.7 or 11.7 MHz, capacitor velues should be changed accordingly. Any NPN trensistor with beta of 30 or mora at IF velue can be used. Diodes can ba any type. Supply should ba regulated but cen be 7–14 V. Output of diode detector will vary from 0 to 1 V et nominal impedance of 20K; for best result, meter with 20- to 50-μA movement can be used.—M. Stern, FM-27B S-Metar, *QST*, Dec. 1976, p 35.

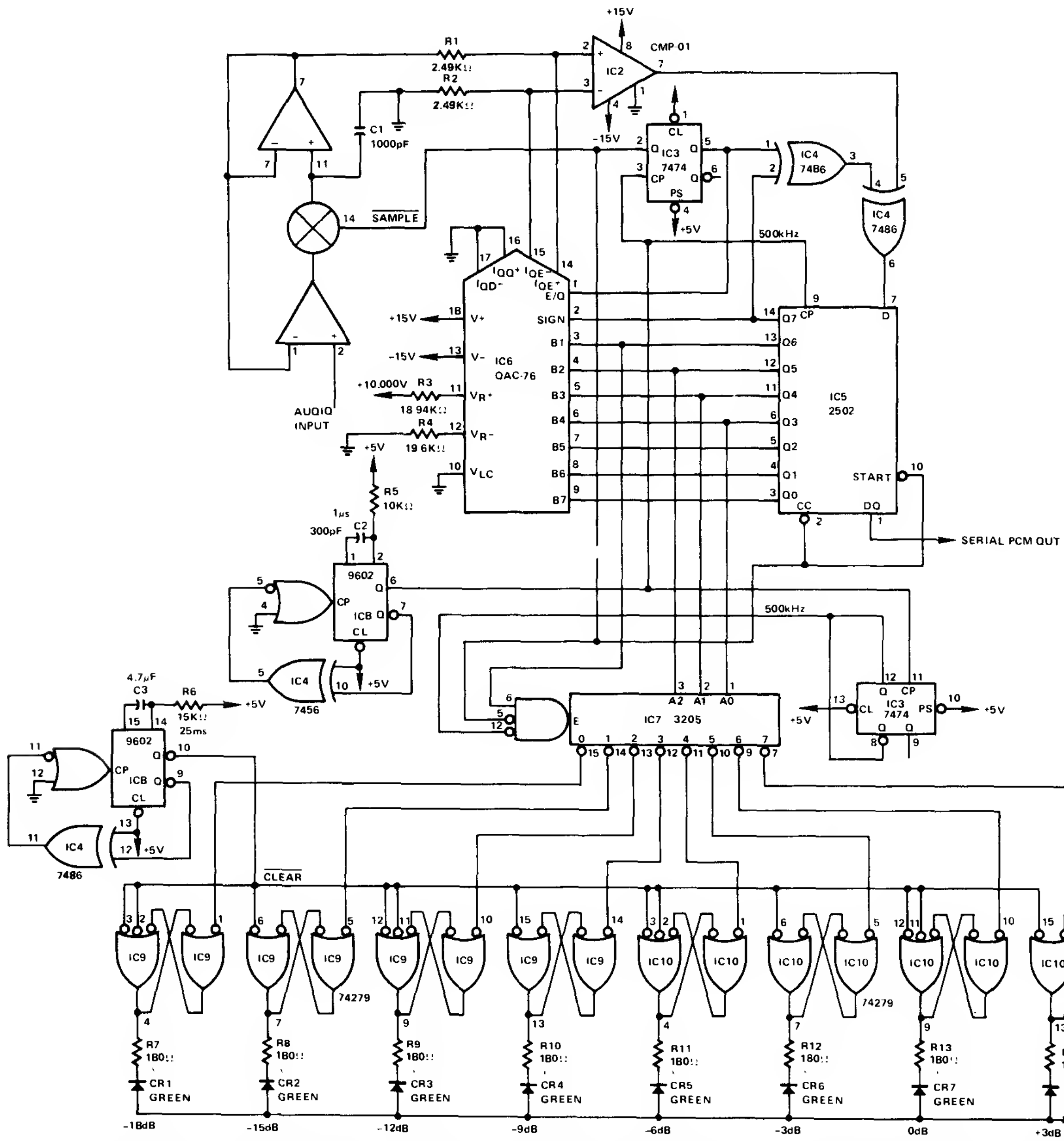




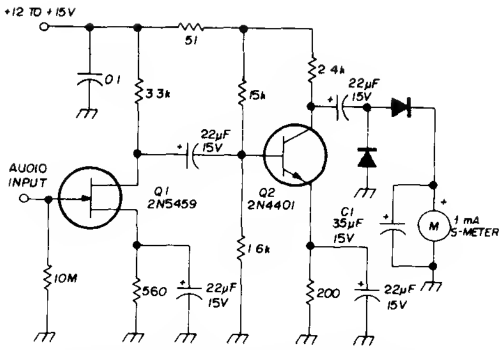
CLIPPING-POINT INDICATOR—Uses LED to indicate when clipping distortion begins in 50-W power amplifier. Display circuit is referanced to negative supply, making detection level independent of supply variation; circuit thus works equally well for instantaneous, music, or continuous overloeds. Tr_1 is normally turned hard on and Tr_2 is off. When overload makes collector-emitter voltage of lower amplifier output transistor approach saturation, Tr_1 bagins to turn off end C_1 charges through D_1 so LED turns on. Attack time is chosen to meke single 3-ms overloed transient visibla.—J. Dawson and K. Northovar, L.E.D. Clip Indicator, *Wireless World*, Jan. 1976, p 60.



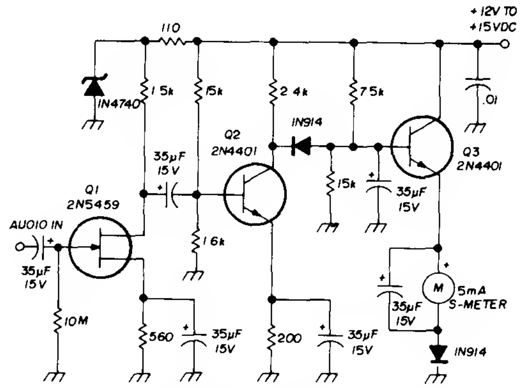
ADDING S-METER—Circuit works well with most all-band receivers. Q1 may also be SK-3011, NR5, TR-10, or DS75. Q2 may also be HE-1, SK-3005, or TR-06. Value of 1.2-megohm input resistor may need to be adjusted depending on AVC voltage, to prevent strong signals from overloading meter.—Novice Q & A, *73 Magazine*, Feb. 1977, p 127.



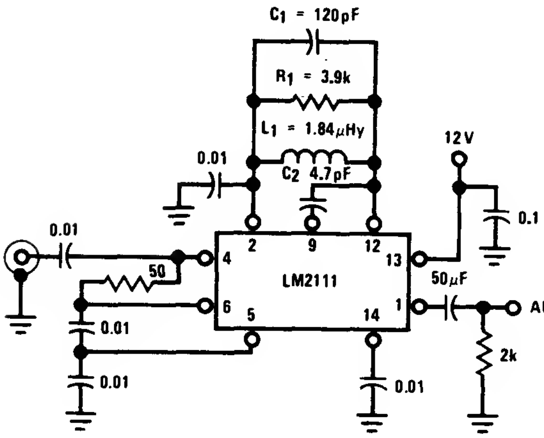
LEDs DISPLAY VU PEAKS—Exponential coding of Precision Monolithics DAC-76 D/A converter is used to good advantage in peak-reading VU indicator with logarithmic weighting, driving LED display. Input audio is converted by DAC-76, CMP-01 comparator, and 2502 successive-approximation A/D converter after being sampled by sample-and-hold input circuit. A/D converter is clocked at 500 kHz and completes conversion every 18 μs, which is fast enough to track audio signals. 4 most significant magnitude bits drive 3205 1-of-8 decoder which is enabled by most significant bit. Resulting eight output levels, separated by 3-dB increments, drive 8-bit RS latch using 74279 chips, updated every 25 ms by 40-Hz display multiplex clock.—W. Jung and W. Ritmanich, "Audio Applications for the DAC-76 Companding D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, AN-28, p 6.



1-mA S-METER—Amplifier designed for 1-mA meter movement consists of two-stage voltage amplifier driving meter rectifier. FET input provides high impedance to detected audio and minimizes loading and distortion problems. Q2 is common-emitter voltage amplifier with simple positive-pulse rectifier for meter. C1 filters rectified audio signal. AF input for S-9 reading is 25–30 mV P-P and for full scale is 50–60 mV P-P. Frequency response is 500 Hz to 10 kHz.—M. A. Chapman, Solid-State S-Meters, *Ham Radio*, March 1975, p 20–23.

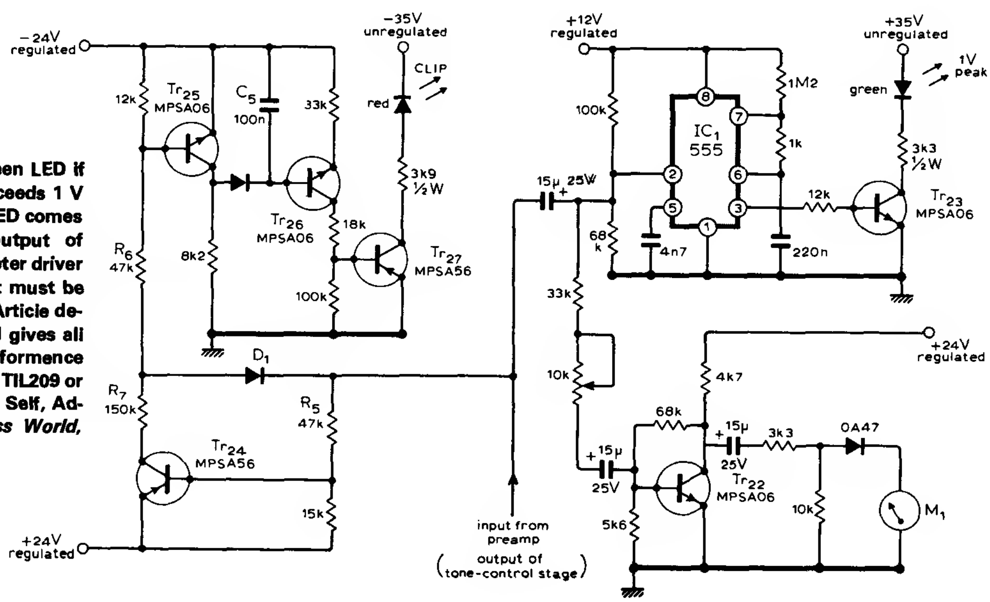


5-mA S-METER—Circuit designed for 5-mA meter movement uses two-stage voltage amplifier Q1-Q2 with emitter-follower output Q3 serving as impedance-matching stage. AF input for S-9 reading is 25–30 mV P-P and for full scale is 50–60 mV P-P. Frequency response is 500 Hz to 10 kHz.—M. A. Chapman, Solid-State S-Meters, *Ham Radio*, March 1975, p 20–23.

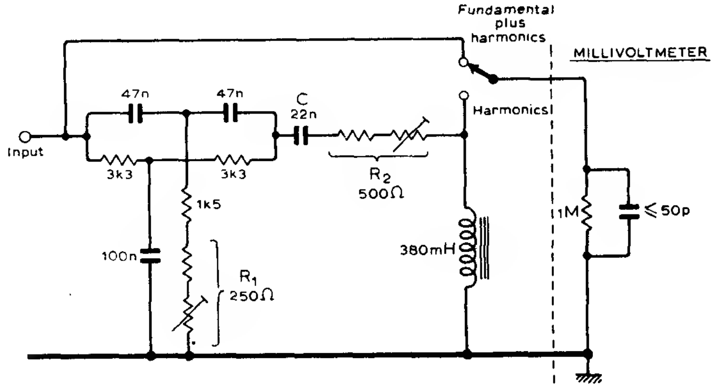


INPUT LIMITING VOLTAGE	300µV
RECOVERED AUDIO	450mVRMS
AM REJECTION (30% AM)	40dB
DISTORTION	0.3%

AUDIO-FREQUENCY METER—Covers 0–100 kHz in four ranges. Meter reading is independent of signal amplitude from 1.7 VRMS upward and independent of waveform over wide range. Linear response means only one point need be calibrated in each frequency range. Circuit uses two overdriven FET amplifier stages in cascade. Square-wave output of last stage is rectified by X1 and X2. Deflection of meter depends only on number of pulses per second passing through meter so is proportional to pulse frequency. Battery drain is 1.4 mA.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 129–131.

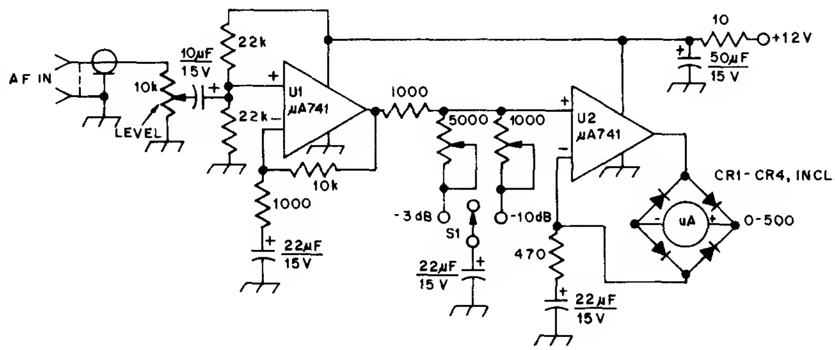


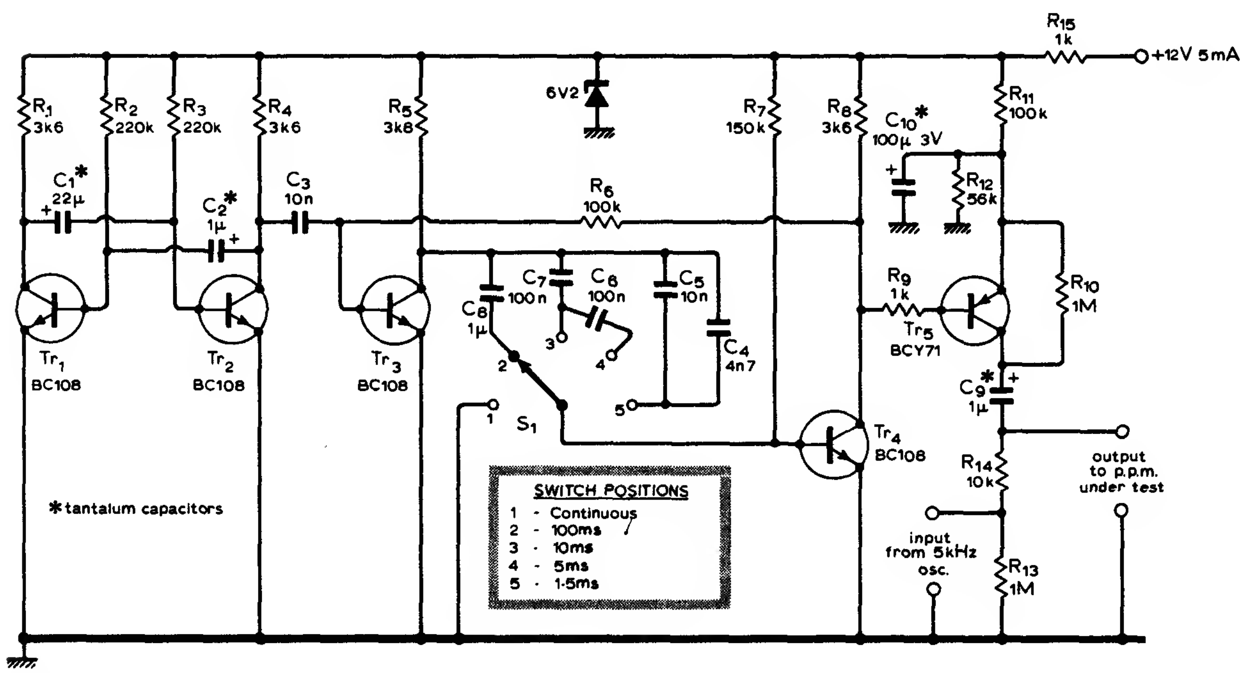
LEVEL DETECTOR—Circuit lights green LED if signal at output of audio preamp exceeds 1 V peak for predetermined period. Red LED comes on when tone-control stage at output of preamp is on verge of clipping. VU meter driver circuit is also provided. Entire circuit must be duplicated for other stereo channel. Article describes circuit operation in detail and gives all associated circuits used in high-performance audio preamp. D_1 is 1N914; red LED is TIL209 or equivalent; green LED is TIL211.—D. Self, Advanced Preamplifier Design, *Wireless World*, Nov. 1976, p 41–46.



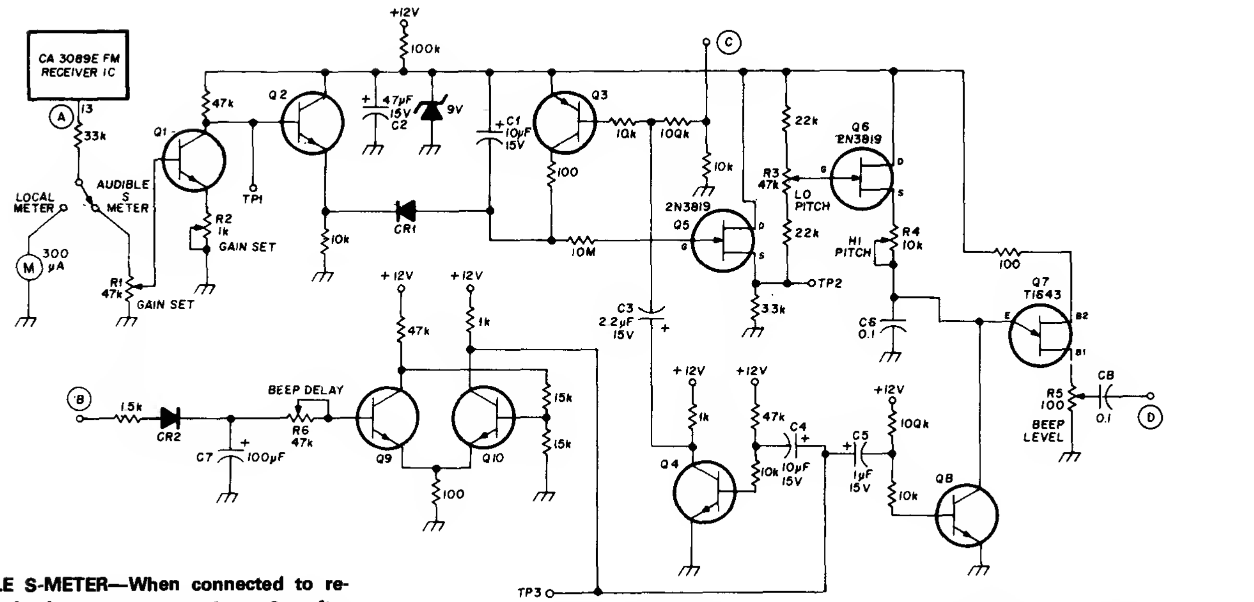
MEASURING AF DISTORTION—Passive high-pass 1-kHz filter is used with audio millivoltmeter to improve accuracy of distortion measurements for low-impedance sources at 1 kHz. Filter removes low-frequency noise from input signal and compensates for loss of harmonic frequency. Applications include setting bias and recording levels of tape recorder. Adjust R_1 for best null, then adjust R_2 and value of C to equalize responses at harmonics.—J. B. Cole, Passive Network to Measure Distortion, *Wireless World*, Jan. 1978, p 60.

AF VOLTMETER—Although not calibrated on absolute basis, either 3 dB or 10 dB of attenuation can be switched in with S1 for measuring purposes. Internal adjustments are made easily by tacking 51-ohm resistor temporarily across input, then driving input with step attenuator fed with audio power at −10 dB by generator having 50-ohm pad in its output. CR1-CR4 are 1N914.—W. Hayward, Defining and Measuring Receiver Dynamic Range, *QST*, July 1975, p 15–21 and 43.





PEAK PROGRAM METER TESTER—Used with 5-kHz audio oscillator to produce tone bursts of 1.5, 5, 10, and 100 ms, as required for checking response of program meter to tone bursts. Transistors Tr_3 and Tr_4 form mono with switched timing capacitors. Article covers calibration and use.—E. T. Garthwaite, Tone Burst Generator for Testing P.P.Ms, *Wireless World*, Aug. 1976, p 53.



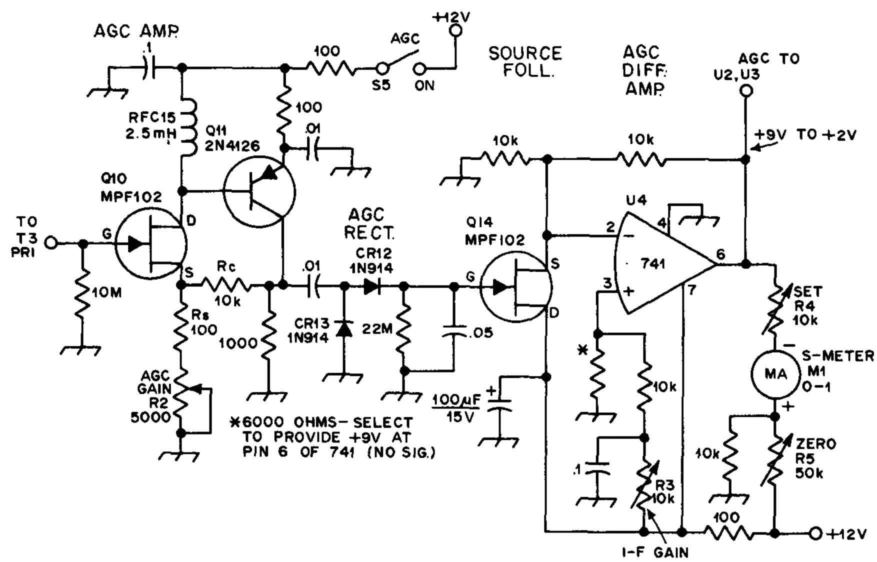
AUDIBLE S-METER—When connected to repeater, circuit generetes tone burst 3 s aftar input signal has dropped out, with duration of 60 ms. Pitch of tone veries inversely with signel strength; highest pitch of 3500 Hz thus represents weak signel, and 350-Hz pitch corresponds to strongest input signal. Can be used to check performance of trensmitters and antennes using that repeater. Repeater receiver must heve S-meter, as In RCA CA3089E receiver, output of which can be fed to terminel A of circuit. Switch changes output from S-meter to audible encoder. Input B goes to squelch, C goes to +12 V sourca that is on when receiver is on, and D provides tone output for feed to audlo amplifier and loudspeaker. Unlebeled transistors can be any medium-galn small-signel NPN end PNP silicon, compereble to European BC107 and BC177.—F. Johnson, Audlble S-Metar for Repeaters, *Hem Redio,* March 1977, p 49–51.

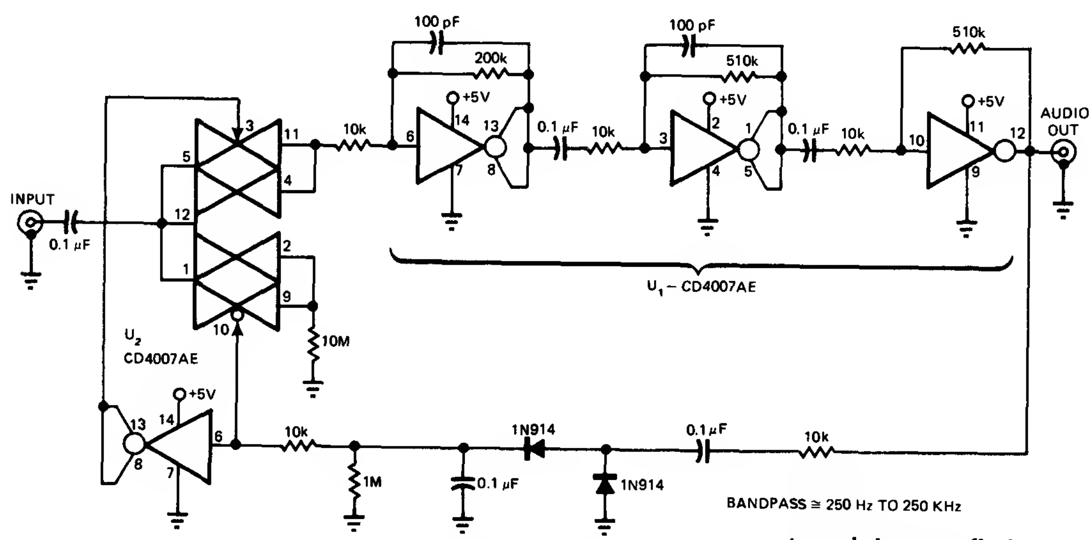
CHAPTER 6

Automatic Gain Control Circuits

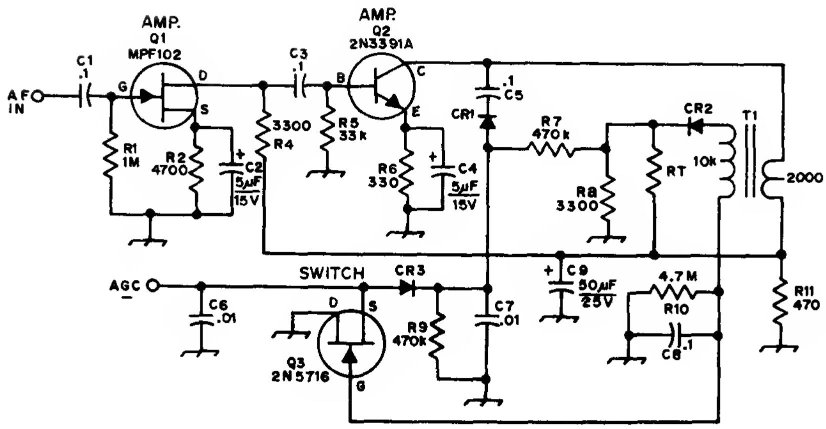
Includes circuits providing automatic control of gain for one or more stages in AF, RF, IF, video, or balanced modulator sections of receivers. See also Amplifier, IF Amplifier, and Receiver chapters.

AGC WITH MANUAL CONTROL—Used in 1.8-2 MHz communication receiver having wide dynamic range. R3 serves as manual IF gain control. R2 provides gain variation from 6 to 40 dB for AGC amplifier. Delay is about 1 s. Input is taken from primary of transformer that drives product detector of receiver, and AGC output goes to CA3028A IF opamp. Two-part article gives all other circuits of receiver.—D. DeMaw, His Eminence—the Receiver, *QST*, Part 2—July 1976, p 14–17 (Part 1—June 1976, p 27–30).

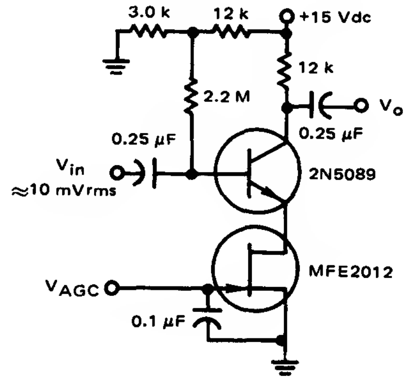




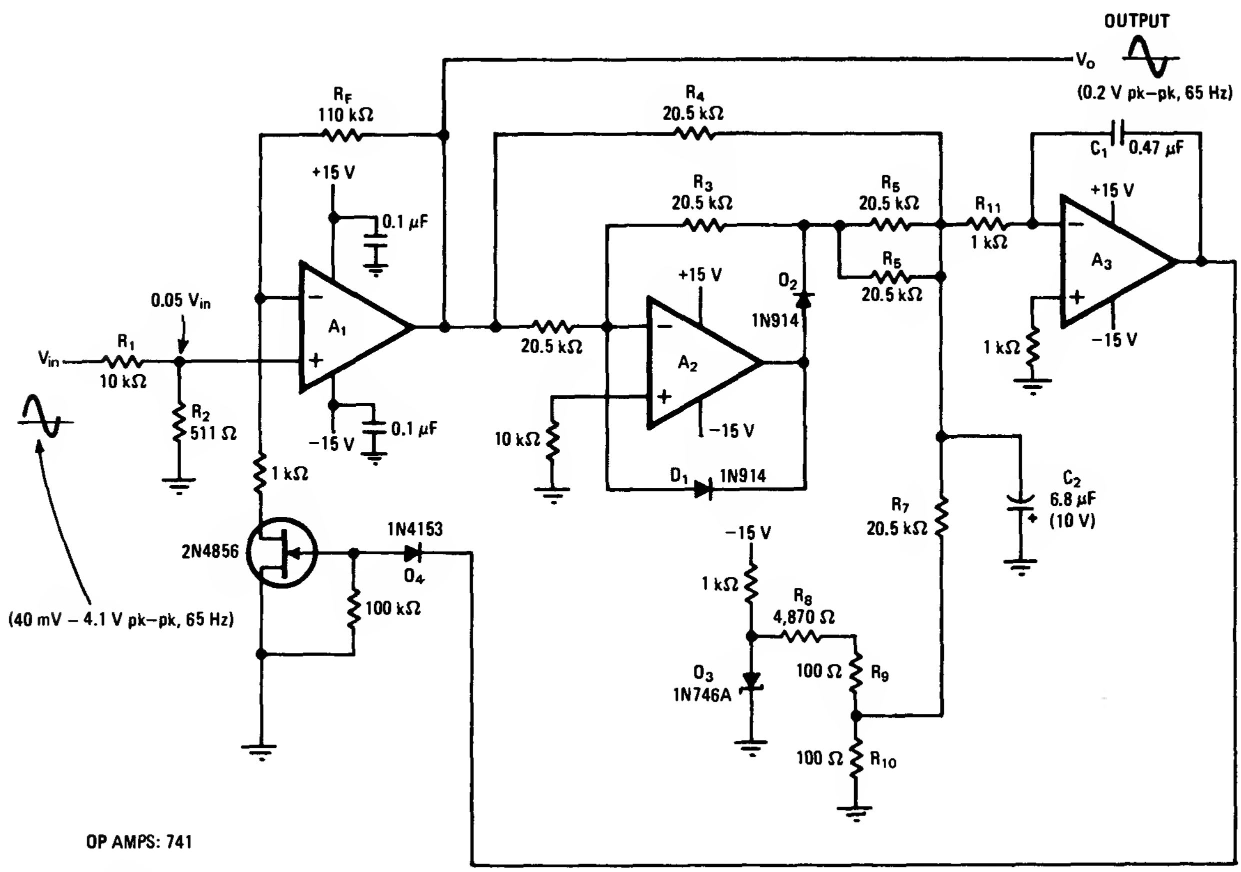
AGC WITH CMOS LOGIC—First stage U_2, using CD4007AE, is wired as two-line demultiplexer with only one output acting as transmission gate. Gain is lower in first stage to reduce noise. U_1 is used as three-stage high-gain audio amplifier in which first two stages have low-pass filtering for stability. AGC voltage, developed from audio output, is fed back to U_2 to turn transmission gate off when gain must be reduced. Audio output is about 2.5 V P-P for inputs of 2 mV and greater.—K. H. Fleischer, Turn Digital CMOS IC's into a Low-Level AGC Amplifier, *EDN Magazine*, Oct. 5, 1977, p 99.



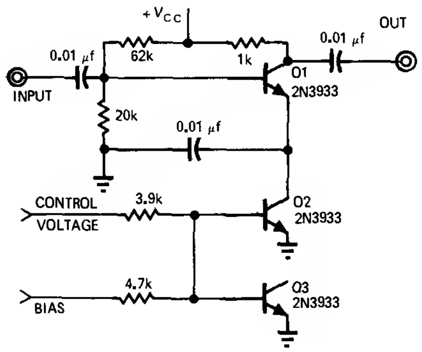
HANG AGC—Provides vary fast attack time with no AGC pop. Diodes ere 1N914. When voltege across R10-C8 decays balow that across R9-C7, Q3 conducts and clamps AGC bus to ground. AGC threshold is determined by value of R_T, between 100K and 470K. AGC lina must hava high impedance, as with FET IF system. With IC or bipolar IF amplifiar, usa low-impedanca driver. T1 is audio transformar with 10K primary and 2K secondary (Radio Shack 273-1378).—D. Stevans, Solid-Steta Hang AGC, *QST*, July 1975, p 44.



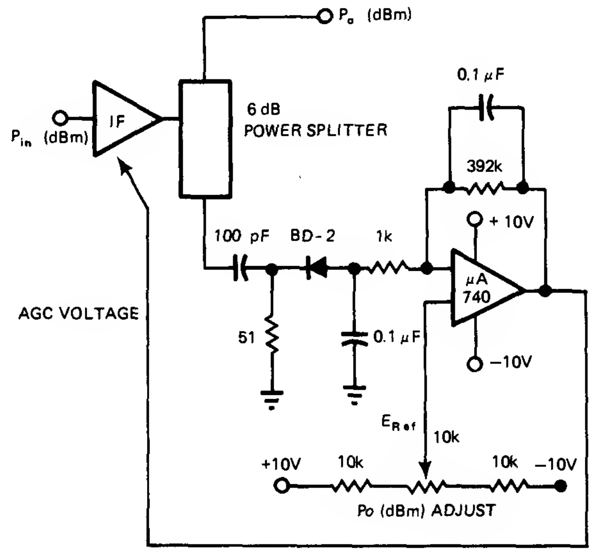
FET GIVES 30-dB GAIN RANGE—Only 1-V changa in gate-source voltage of FET changes voltaga gain over full ranga. Possibla drawback is harmonic distortion dua to unbypassed emittar degenaration.—"Low Frequancy Applications of Flald-Effect Transistors," Motorola, Phoenix, AZ, 1976, AN-511A, p 8.



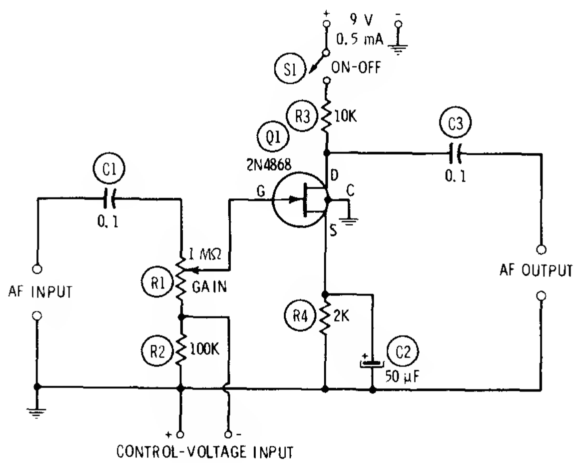
TWO-DECADE RANGE—Output is mainteined et 0.2 V for inputs from 40 mV to 4.1 V. Voltage-controlled JFET serves as veriabla control element. Comparator A_3 produces error voltaga that detarmines gain of A_1. A_2 end diodes form full-weve rectifier. Developed for use in reder saeker device to prevent ovarload of empiifiar aa target gets closar.—C. Marco, Automatic Gein Control Oparates ovar Two Decades, *Electronics*, Aug. 16, 1973, p 99–100; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 44–46.



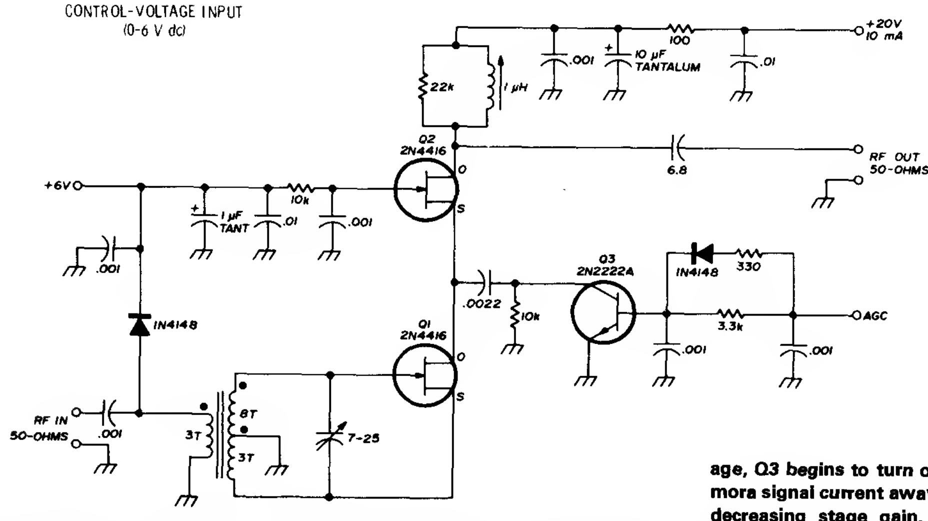
LOW PHASE SHIFT—Voltage-controlled amplifier has less than 3° phase shift over gain-control range of 40 dB at frequencies up to 10 MHz, as required for AGC circuits. Current generator Q2 controls gain of wideband resistance-coupled amplifier Q1. Gain of Q1 increases linearly with amplitude of positive control voltage on base of Q2.—A. H. Hargrove, Simple Circuits Control Phase-Shift, *EDN Magazine*, Jan. 1, 1971, p 39.



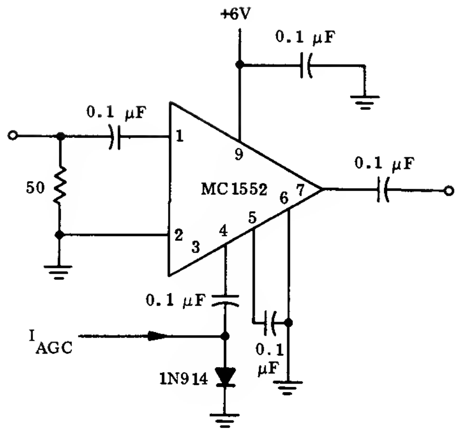
30-MHz AGC LOOP—Low-pass filter serves as loop giving closed-loop bandwidth of at least 5 kHz. Loop operates in square-law region of detector diode. Inputs to IF amplifier are in range from −60 dBm to −10 dBm, and AGC action provides 30-MHz IF output of −15 dBm. Power splitter ensures that detector also operates at −15 dBm. Article gives design equations and performance curves.—R. S. Hughes, Design Automatic Gain Control Loops the Easy Way, *EDN Magazine*, Oct. 5, 1978, p 123–128.

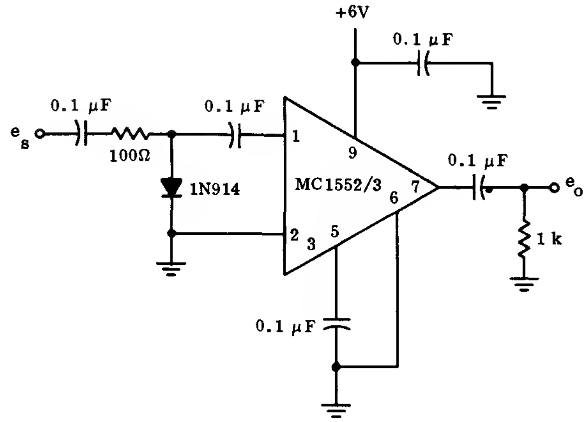


AUDIO AGC USING FET—DC control voltage obtained from key signal point in audio amplifier is applied to gate of FET to vary bias. Gain of stage varies inversely with gate bias voltage. When control voltage is 0 V, voltage gain of stage is 10 and maximum undistorted output signal is 1 VRMS. When control voltage is 6 VDC, output is reduced to 0.5 mVRMS, giving better than 90-dB range for AGC control.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 39–40.



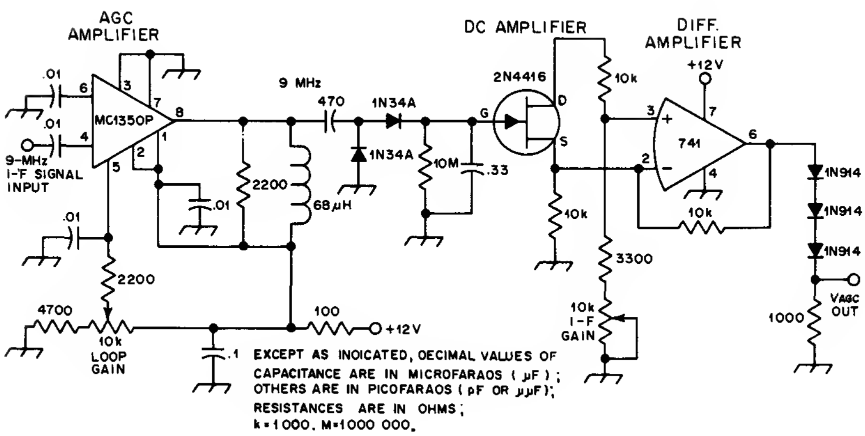
50–54 MHz RF-AGC AMPLIFIER—Developed for 6-meter SSB transceiver to give minimum of 15-dB power gain, low noise figure, and good signal-handling capability when AGC is applied. AGC control resembles bipolar cascode circuit using differential pair with current source, although operation does not involve changing amplifier bias level. With increasing AGC voltage, Q3 begins to turn on, shunting more and more signal current away from Q2 and thereby decreasing stage gain. Input transformer is wound on small toroid core. Range of AGC voltage is 0–1.2 V.—A. Borsa, High-Performance RF-AGC Amplifier, *Ham Radio*, Sept. 1978, p 64–66.



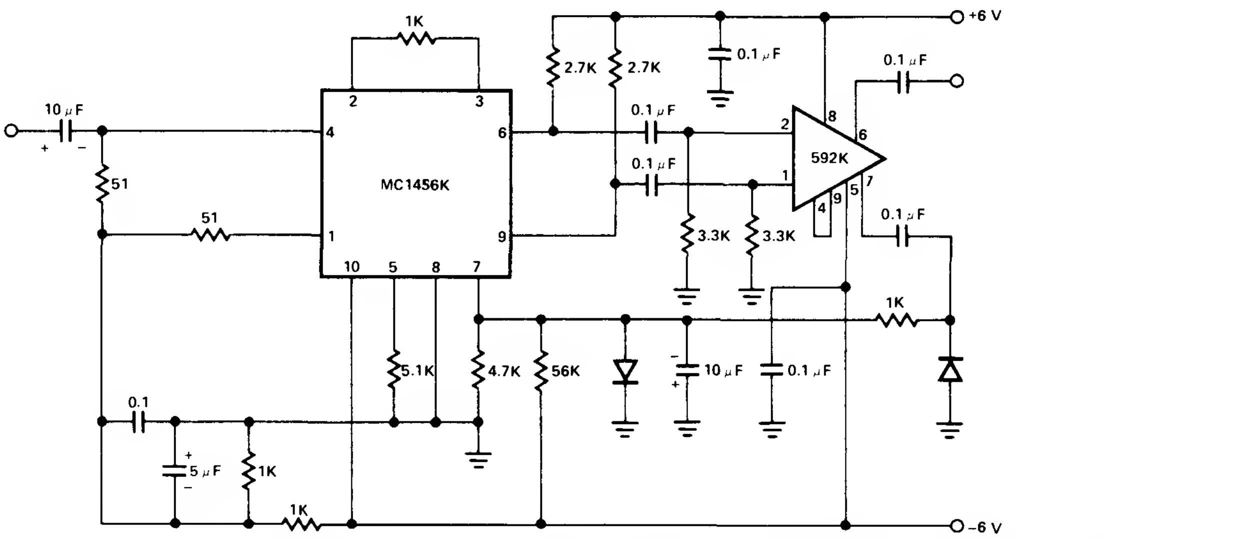


CONTROL WITH EXTERNAL DIODE—External resistances normally used with Motorola MC1552 video amplifier are replaced by 1N914 or equivalent diode so gain of amplifier is determined by AGC current through diode. Arrangement gives wide range of gain control, but lowest obtainable level of gain is normal unmodified gain of amplifier. Same circuit can be used with MC1553 high-gain video amplifier.—"A Wide Band Monolithic Video Amplifier," Motorola, Phoenix, AZ, 1973, AN-404, p 10.

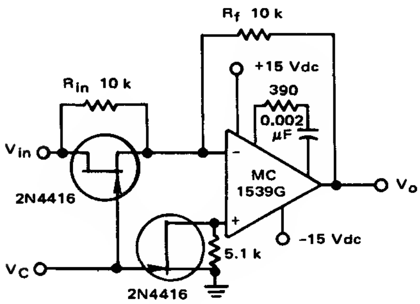
CONTROL AT LOW GAIN LEVELS—Diode is used as variable impedance in voltage-divider network at input of video amplifier to provide AGC at lower gain levels than could be handled with more conventional external-diode circuits. Voltage gain for Motorola MC1552 decreases from about 50 for 1-mA AGC control current to about 20 for 8 mA. For MC1553 high-gain video amplifier, gain drops from 400 at 1 mA to 25 at 8 mA.—"A Wide Band Monolithic Video Amplifier," Motorola, Phoenix, AZ, 1973, AN-404, p 11.



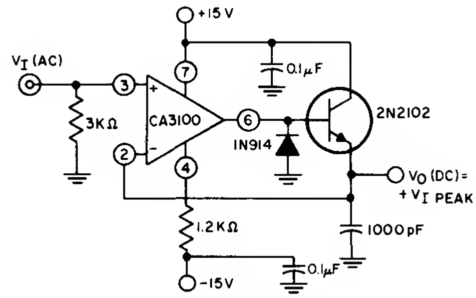
AGC LOOP FOR MOSFETs—Used at output of 9-MHz IF amplifier in commercial receiver to divide desired control-voltage magnitude and swing for FT0601 MOSFETs in IF strip. MOSFETs are biased by 2.1-V zeners in source leads in FETs, to drive gate-2 voltage sufficiently negative for full AGC action.—G. Ricaud, Modifying the W1CER/W1FB AGC Loop for Use with MOSFET I-F Amplifiers, *QST*, June 1977, p 47.



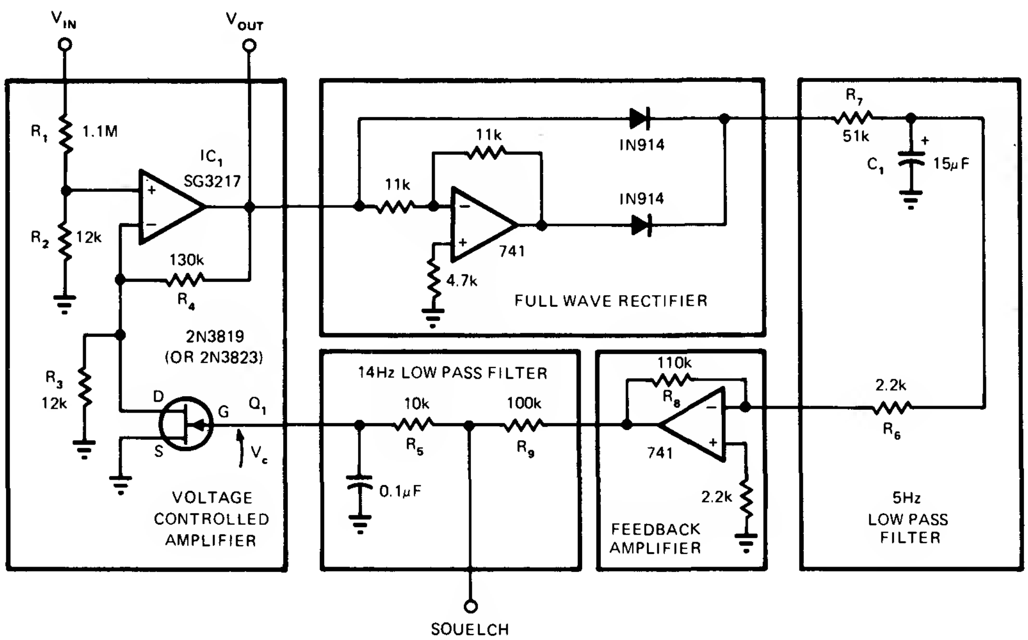
WIDEBAND AGC AMPLIFIER—Combination of 592K opamp and MC1496K balanced modulator gives DC output signal proportional to amplitude of AC input signal, for varying gain of balanced modulator. Unbalancing carrier input of modulator makes signal pass through without attenuation.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 709–710.



AGC AMPLIFIER—FET used in conjunction with opamp permits varying of gain by changing ratio of R_f to R_{in}. Offset voltage in output due to input bias currents is minimized by plecing FET in parallel with 5.1K resistor between noninverting leg of opamp end ground, so resistence veries with changes of R_{in}.—"Low Frequency Applications of Field-Effect Transistors," Motorola, Phoenix, AZ, 1976, AN-511A, p 9.



POSITIVE PEAK DETECTOR—CA3100 blpolar MOS opamp is connected as wideband noninverting amplifier to provide essentially constent gain for wide renge of input frequencies. Diode clips negative half-cycles, so output of transistor is proportional only to positive input peeks.—"Circuit Idees for RCA Lineer ICs," RCA Solid State Division, Somerville, NJ, 1977, p 16.

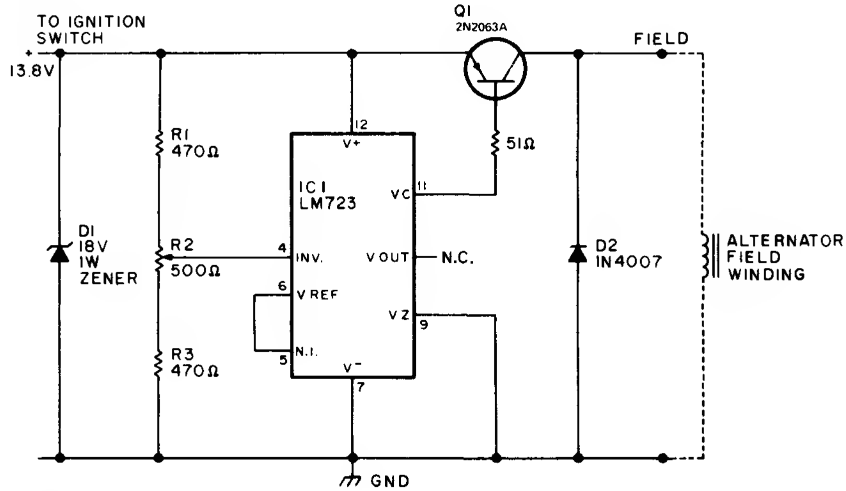


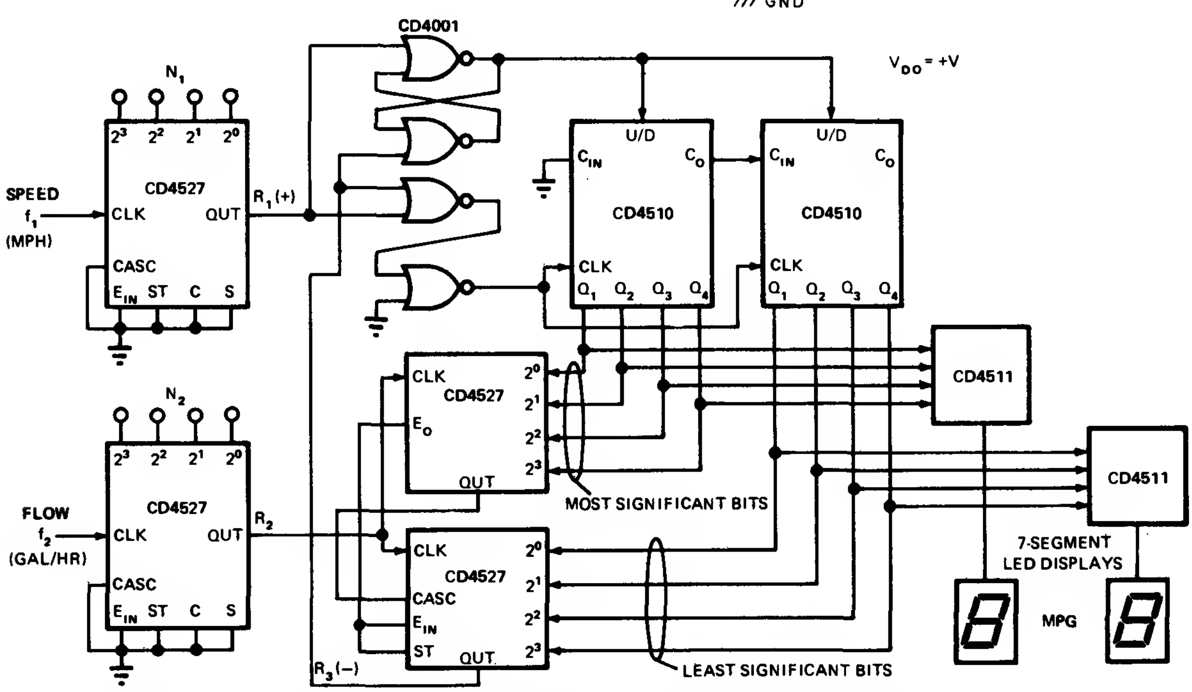
AGC WITH FET—FET serves as nonlineer element in fast-ecting instrumentation circuit handling wide range of signals. R_1 and R_2 attenuete input signal so FET input is less than 25 mV for inputs up to 2 VRMS. Article covers design and performance. Gain is almost linear with gate voltage of FET.—R. D. Pogge, Designers' Guide to: Basic AGC Amplifier Design, *EDN Magazine,* Jen. 20, 1974, p 72–76.

CHAPTER 7
Automotive Circuits

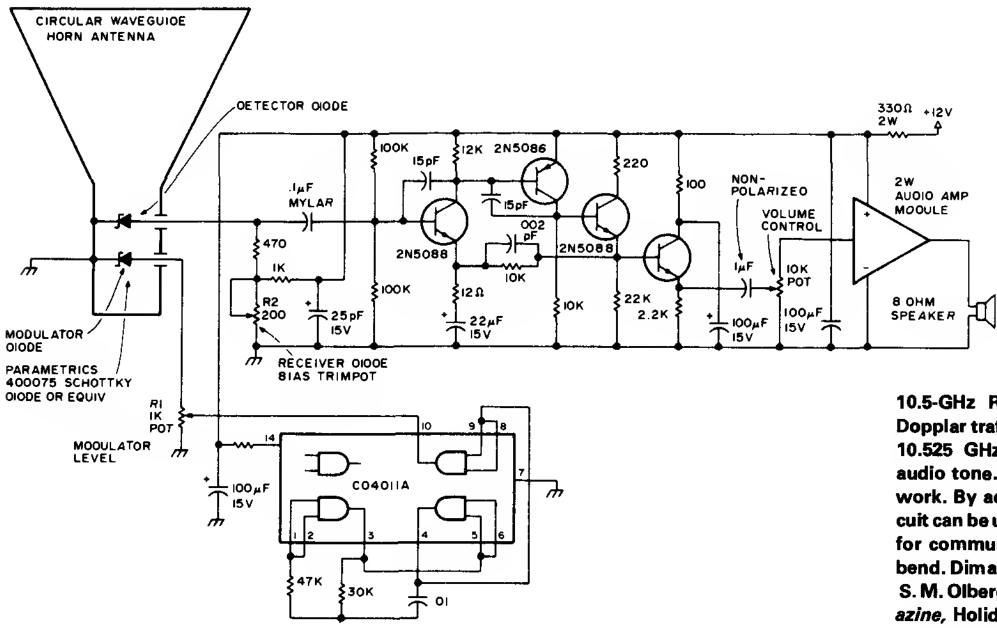
Includes capacitor-discharge, optoelectronic, and other types of electronic ignition, tachometers, dwell meters, idiot-light buzzer, audible turn signals, headlight reminders, mileage computer, cold-weather starting aids, wiper controls, oil-pressure and oil-level gages, solid-state regulators for alternators, overspeed warnings, battery-voltage monitor, and trailer-light interface. For auto theft devices, see Burglar Alarm chapter.

SOLID-STATE AUTO REGULATOR—Replaces end outperforms alectromachenical charging-voltage regulator in autos using alternator systams. Prolongs battery lifa by preventing undercharging or ovarcharging of 12-V lead-acld battery. Uses LM723 connected as switching regulator for controlling altamator fiald currant. R2 is adjusted to maintain 13.8-V fully charged voltaga for standard auto battery. Article gives construction details end tells how to usa axternal raley to maintain altemator charge-indicator function in cars having idiot light rather than cherge-discharge emmetar. Q1 is 2N2063A (SK3009) 10-A PNP transistor.—W. J. Prudhomma, Build Your Own Car Ragulator, *73 Magazina*, March 1977, p 160–162.

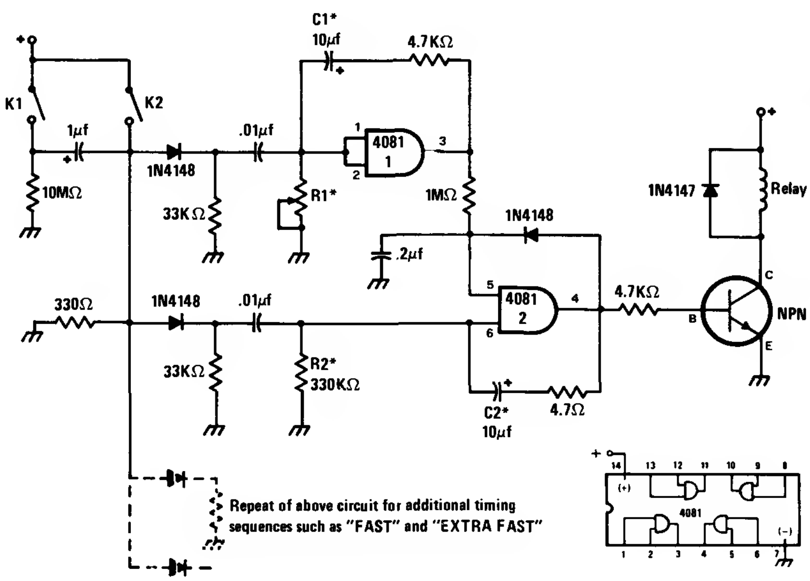




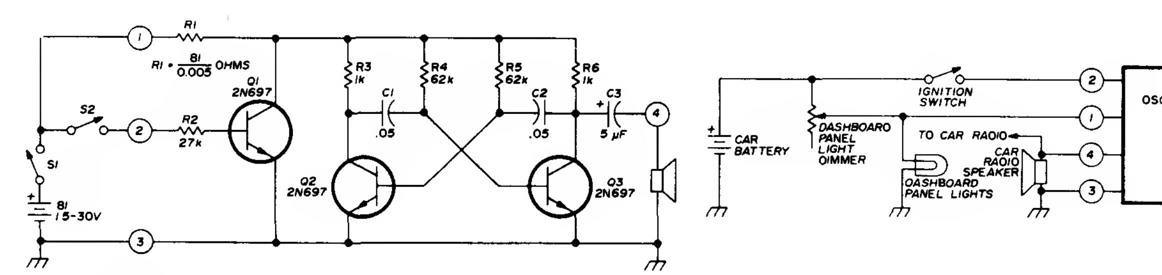
MILEAGE COMPUTER—Fual consumption in miles per gallon is continuously updated on 2-digit LED disploy. Entire systam using CMOS ICs can be built for less than $25 Including gas-flow sensor end speed sensor, sources for which are given in articla along with operational detalls. Circuit uses rate multipliar to produce output pulsa train whose frequency is proportional to product of tha two inputs. Output rata is time-avaraged. Speed sensor, mounted in series with speedomater cable, feeds spaed data to CD4527 rata multipliar as clock Input. Gas-flow sensor, mounted in sarles with fual lina, feeds clock Input of othar rata multipliar.—G. J. Summars, Miles/Gallon Maasuremant Mada Easy with CMOS Rate Multipllars, *EDN Magazina*, Jan. 20, 1976, p 61–63.



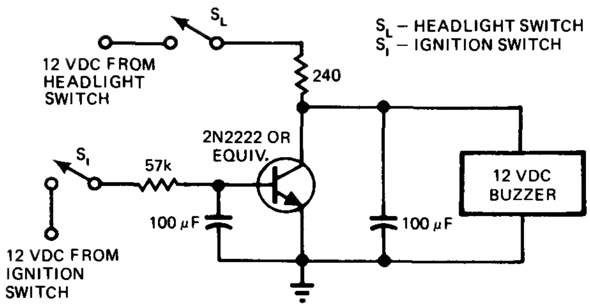
10.5-GHz RADAR DETECTOR—Picks up CW Doppler traffic radar signels in X-band region et 10.525 GHz and alerts speeding drivar with audio tone. Article also talls how traffic radars work. By adding 10.5-GHz oscillator, same circuit can be used in 10.5-GHz amateur radio band for communicating with other cers using this bend. Dimansioned diagram of hom is given.—S. M. Olberg, Mobila Smokey Detector, *73 Magazine,* Holidey issue 1976, p 32–35.



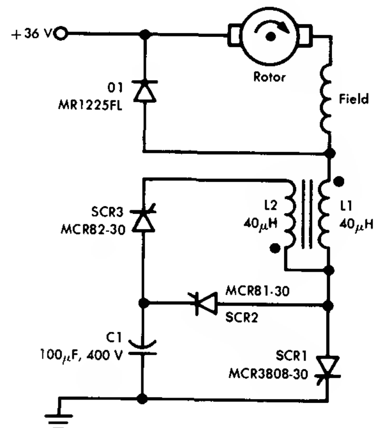
SPEED TRAP—Time raquired for auto to activate sensors placed measured distance apart on driveway or road is usad to energiza relay or elarm circuit when euto axcaads predatermined speed. If speed limit chosan is 15 mph, set detectors 22 feet apart for travel time of 1 s. Sansors can be photocells or air-actuated solanoids. For most applications, R1 can ba 1-megohm pot. Translstor type Is not critical. Values of R2 and C2 determine how long alarm sounds.—J. Sandlar, 9 Projects undar $9, *Modern Electronics,* Sept. 1978, p 35–39.



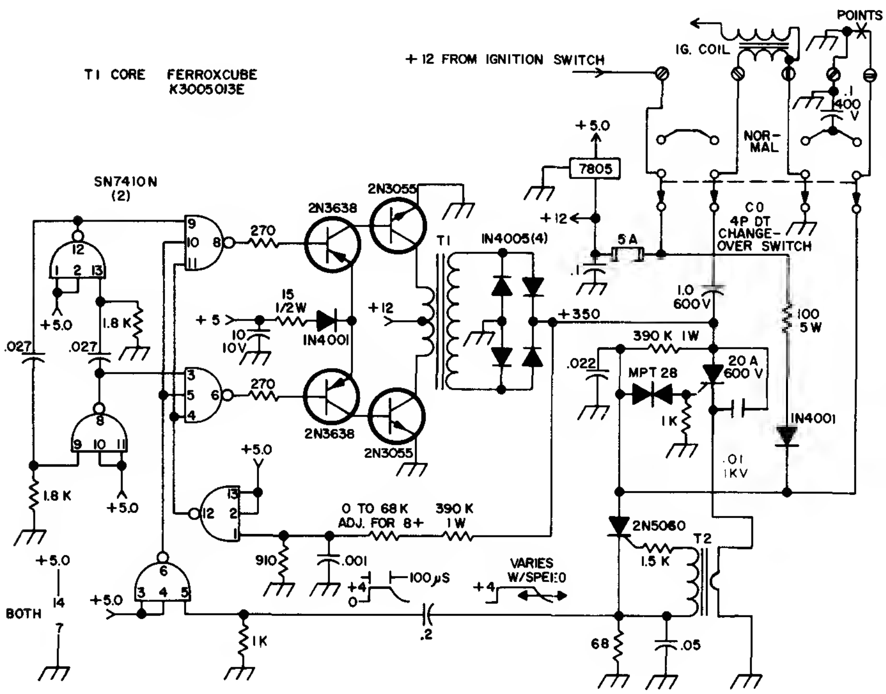
HEADLIGHT REMINDER—Uses basic oscillator consisting of Q2 and Q3 arranged as collector-coupled astable MVBR. Power is taken from collector of Q1 which acts as switch for Q2 and Q3. With S1 closed and S2 open, oscillator operates. Closing S2 saturates Q1 and stops oscillator. When used as headlight reminder for negative-ground car, B1 is omitted and power for oscillator is teken from dashboerd panel lights since they come on simultaneously with aither parking lights or headlights. If ignition key Is turned on, Q1 saturates and disables Q2-Q3. With ignition off but lights on, Q1 is cut off and oscillator receives power. Audio output may be connacted directly to high side of voice coil of car radio loudspeaker without affecting operation of radio. Almost any NPN transistors can be used. Changing values of R4 and R5 changes frequency of remindar tone.—H. F. Batle, Versatile Audio Oscillator, *Ham Radio,* Jan. 1976, p 72–74.



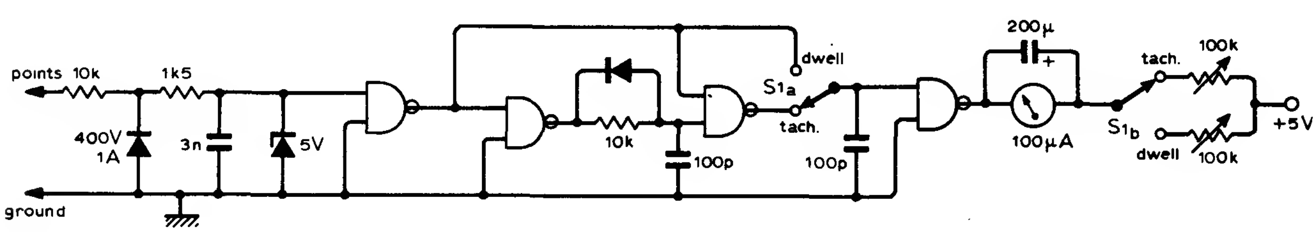
HEADLIGHTS-ON ALARM—Designed for cars in which headlight switch is nongrounding typa, providing 12 V whan closed. When both light and ignition switches ere closed, transistor is saturated and thera is no voltage drop scross it to drive buzzer. If ignition switch is opan whila lights ere on, transistor bias is removed so transistor is effectively open and full 12 V is applied to buzzar through 240-ohm resistor until lights are turned off.—R. E. Hsrtzeli, Jr., Detector Werns You When Haadlights Are Left On, *EDN Magazine,* Nov. 20, 1975, p 160.

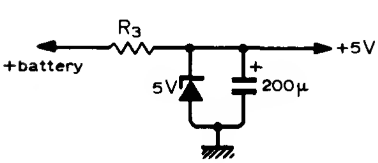


ELECTRIC-VEHICLE CONTROL—SCR1 is usad in combination with Jonas chopper to provide smooth acceleration of golf cart or other electric vehicle operating from 36-V on-bosrd storege battery. Normsi running current of 2-hp 36-V series-wound DC motor is 60 A, with up to 300 A required for sterting vehicle up hiii. Chopper and its control maintain high sverage motor current while iimiting paak current by increesing chopping frequency from normsi 125 Hz to as high ss 500 Hz when high torque is required.—T. Maiarkey, You Need Precision SCR Chopper Control, *New Motorola Semiconductors for Industry,* Motorois, Phoenix, AZ, Voi. 2, No. 1, 1975.

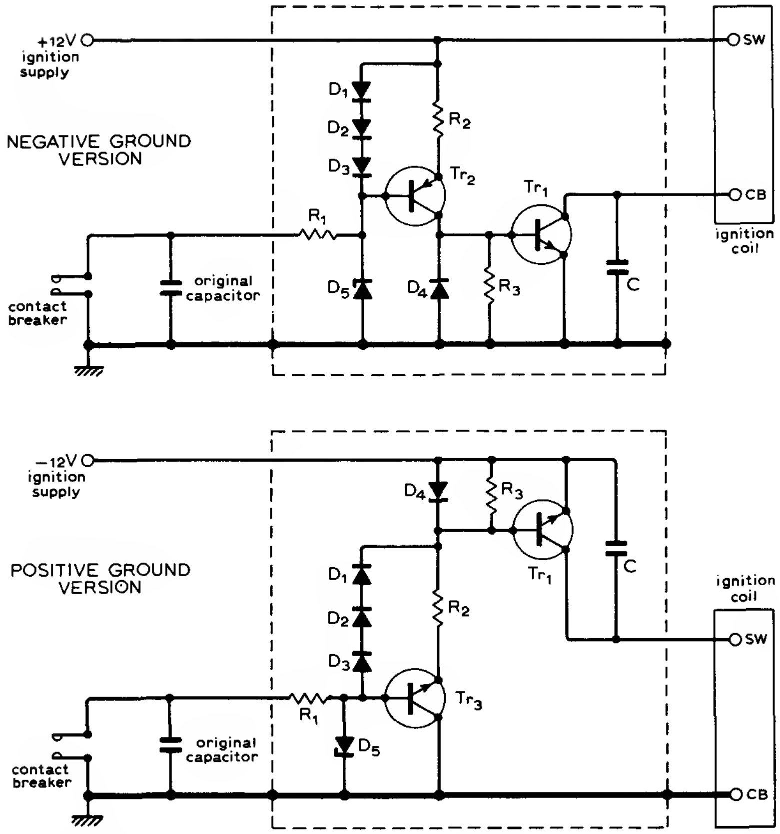


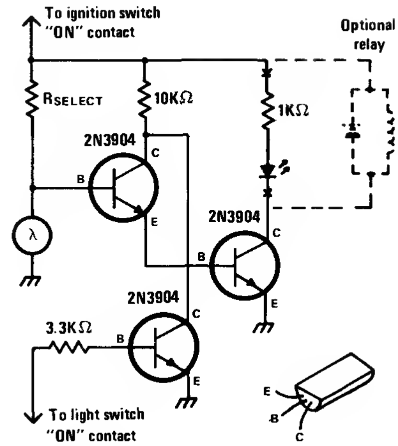
CD IGNITION—Uses mastar oscillator—power amplifier type of DC/DC converter in which two sections of triple 3-input NAND gate serve as 10-kHz square-wave MVBR feeding class B PNP/NPN powar amplifiar through two-gate driver. Remaining two gates are used as logic inverters. Secondsry of T1 hss 15.24 meters of No. 26 in six bsnk windings, with 20 turns No. 14 added end center-tspped for primary. T2 is unshiaided iron-core RF choke, 30–100 μH, with severai turns wound over it for secondsry. When maln 20-A SCR fires, T2 develops osciilation burst for firing sensitive gate-iatching SCR. Storaga capscitor energy is then dumped into ignltion coil primary through powar SCR.—K. W. Robbins, CD Ignition System, *73 Magazine,* Msy 1974, p 17 snd 19.





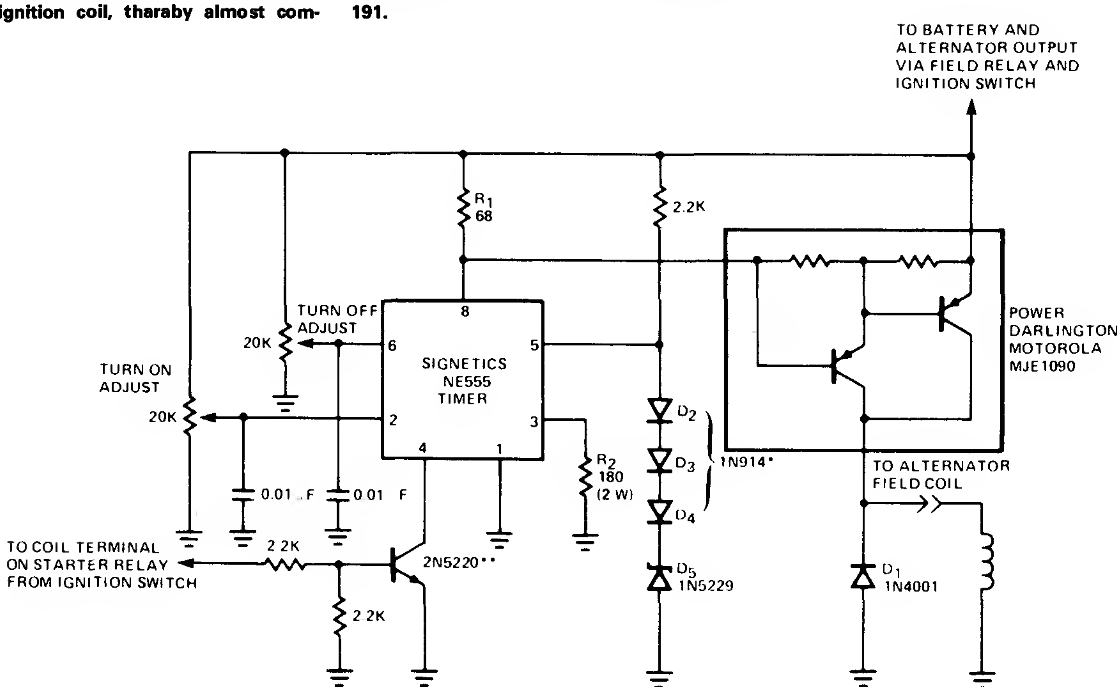
TACH/DWELL METER—Built around SN7402 NOR-gate IC. Requires no internal battery; required 5 V is obtsined by using 50 ohms for R_3 in zenar circuit shown if car battery is 6 V, and 300 ohms if 12 V. Articie gives calibration procedure for engines having 4, 6, snd 6 cylinders; select maximum rpm to be indicated, multiply by number of cylindars, than divida by 120 to get frequency in Hz.—N. Parron, Tach-Dwell Mater, *Wireless World,* Sept. 1975, p 413.



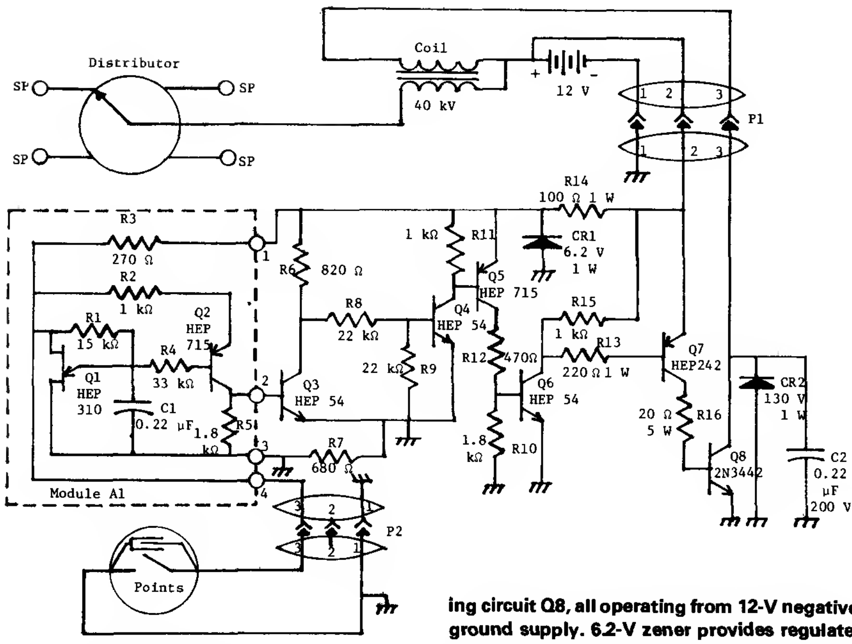


HEADLIGHT REMINDER—Photocell energizas circuit at twilight to remind motorist that lights should be turned on. Indicator can be LED connected as shown or relay turning on buzzer for more positive signal. Circuit can be made automatic by connecting ralay contacts in perallel with light switch, provided dalay circuit is added to prevent oncoming headlights from killing circuit. Mount photocell in location whara it is uneffected by other lights inside or outsida car.—J. Sandler, 9 Projects undar $9, *Modern Electronics*, Sept. 1978, p 35–39.

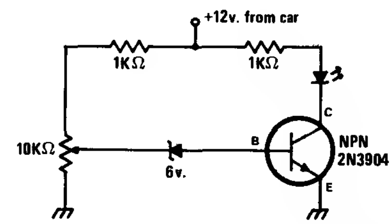
TRANSISTORIZED BREAKER POINTS—Uses Texas Instruments BUY23/23A high-voltaga transistors that can aasily withstand voltages up to about 300 V axisting across breaker points of distributor in modarn car. Circuit servas as electronic switch that isolates points from heavy interrupt current and high-voltage backswing of ignition coil, tharaby almost completely eliminating wear on points. Values ere: Tr_2 2N3789; Tr_3 (for positiva ground version) 2N3055; D_1-D_4 1N4001; D_5 18-V 400-mW zener; R_1 56 ohms; R_2 1.2 ohms; R_3 10 ohms; C 600 VDC same siza as points capacitor. Article covers installation procedure.—G. F. Nudd, Transistor-Aided Ignition, *Wireless World*, April 1975, p 191.



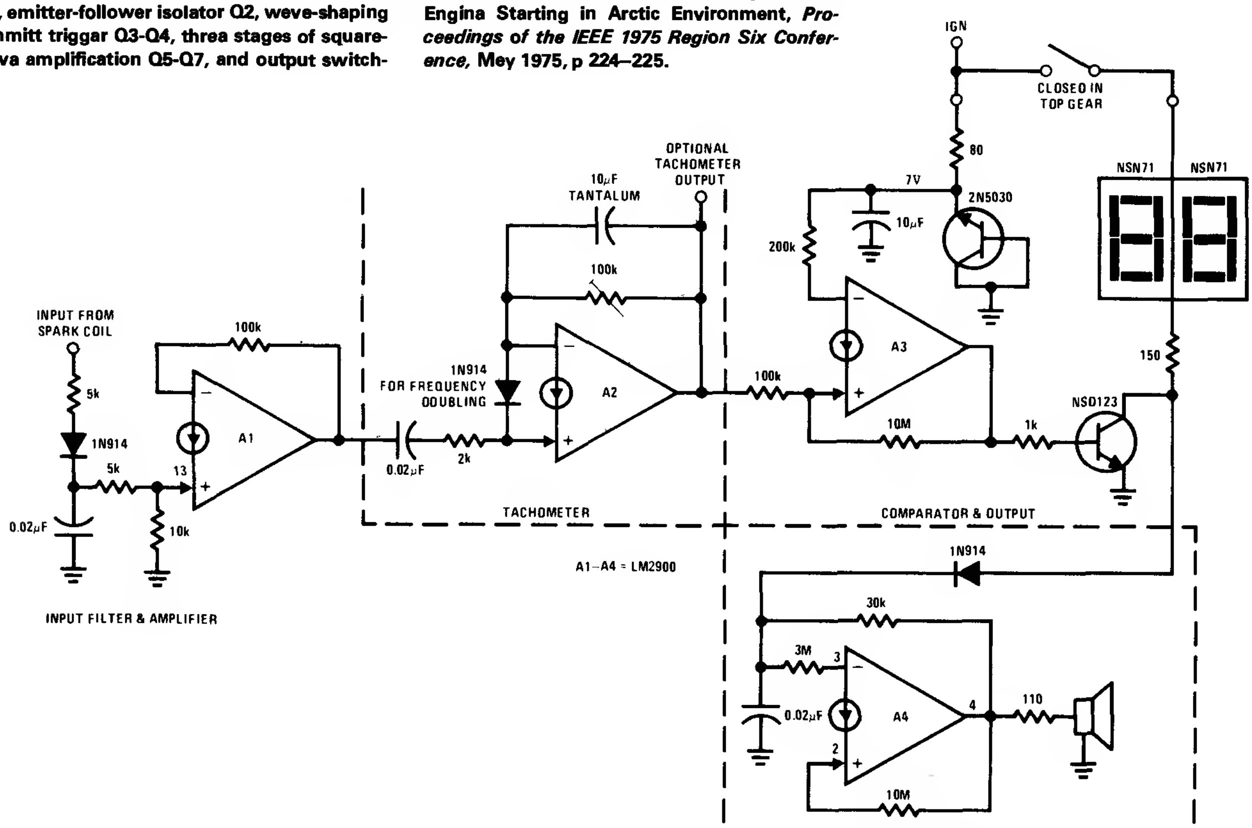
VOLTAGE REGULATOR—Timer end power Derlington form simple automobile voltage regulator. When battery voltage drops below 14.4 V, timar is turned on and Darlington peir conducts. Seperate edjustments ere provided for preset turn-on and turnoff voltages.—"Signetics Analog Deta Manual," Signetics, Sunnyvale, CA, 1977, p 731.



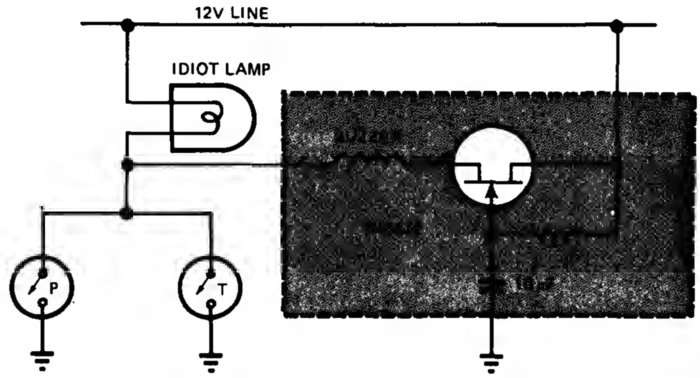
COLD-WEATHER IGNITION—Multispark electronic ignition improves cold-weather starting ability of engines in arctic environment by providing more than one spark per combustion cycle. Circuit uses UJT triangle-wave generator Q1, emitter-follower isolator Q2, wave-shaping Schmitt trigger Q3-Q4, three stages of square-wave amplification Q5-Q7, and output switching circuit Q8, all operating from 12-V negative-ground supply. 6.2-V zener provides regulated voltage for UJT and Schmitt trigger. Initial 20,000- to 40,000-V ignition spark produced by opening of breaker points is followed by continuous series of sparks at rate of about 200 per second as long as points stay open.—D. E. Stinchcomb, Multi-Spark Electronic Ignition for Engine Starting in Arctic Environment, *Proceedings of the IEEE 1975 Region Six Conference*, May 1975, p 224–225.



BATTERY MONITOR—Basic circuit energizes LED when battery voltage drops to level set by 10K pot. Any number of additional circuits can be added, for reading battery voltage in 1-V steps or even steps as small as 0.1 V. Circuit supplements idiot light that replaces ammeter in most modern cars. LED type is not critical.—J. Sandler, 9 Projects under $9, *Modern Electronics*, Sept. 1978, p 35–39.

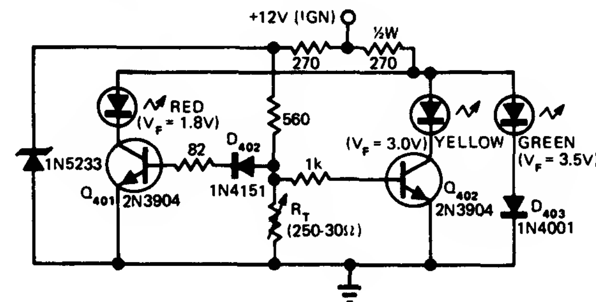


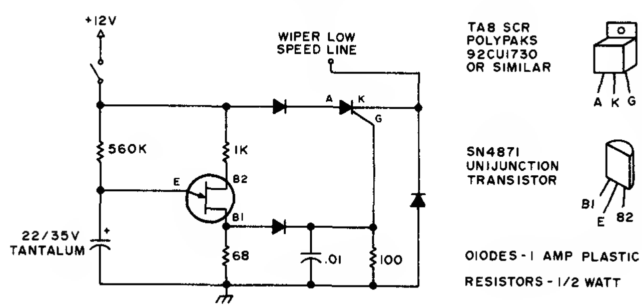
HIGH-SPEED WARNING—Audible alarm tone generator drives warning loudspeaker to supplement 2-digit speed display that can be set to trip when vehicle speed exceeds 55-mph legal limit. Engine speed signal is taken from primary of spark coil. Switch in transmission activates circuit only when car is in high gear. All functions are performed by sections of LM2900 quad Norton opamp. A1 amplifies and regulates spark-coil signal. A2 converts signal frequency to voltage proportional to engine speed. A3 compares speed voltage with reference voltage and turns on output transistor at set speed. A4 generates audible tone. Circuit components must be adjusted for number of cylinders, gear and axle ratios, tire size, etc. 10-μF capacitor connected to A3 can be increased to prevent triggering of alarm when increasing speed momentarily while passing another car.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, LB-33.



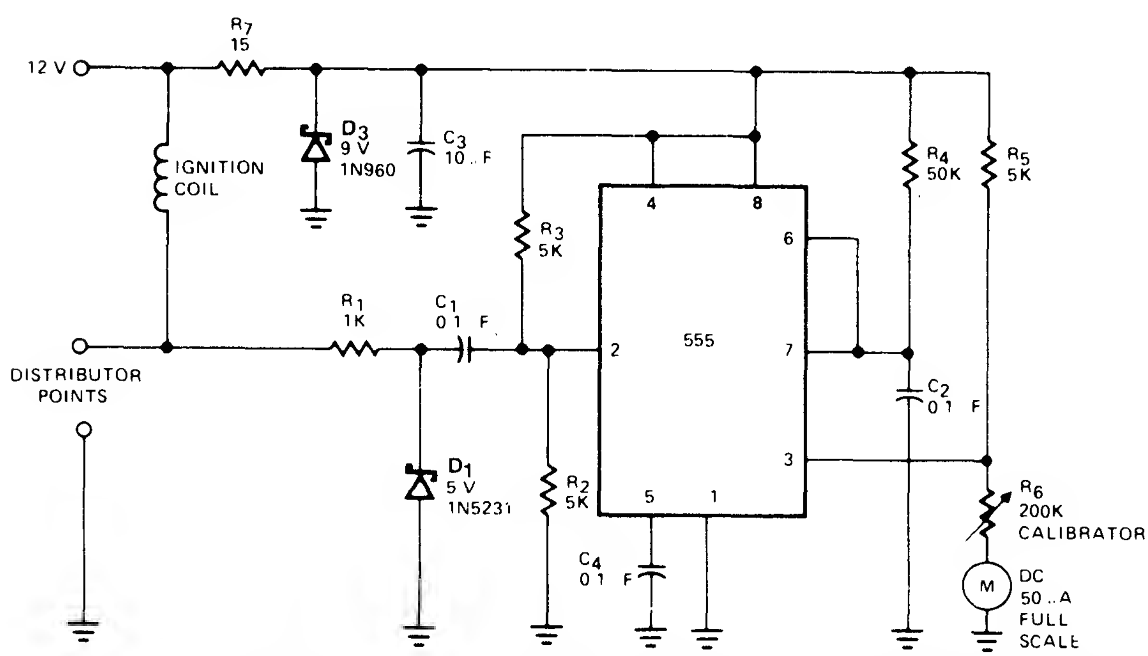
BUZZER FOR IDIOT LIGHT—Provides audible supplement to engine-monitoring indicator lamps that are often difficult to see in daylight. Uses 2N5434 JFET to provide delay of about 7 s each time ignition switch is turned on, to allow for peaceful starting of car and normal buildup of oil pressure when lamp is monitoring oil-pressure and engine-temperature sensors. Entire circuit can be mounted inside plastic housing of unused or disconnected dashboard warning buzzer in late-model car.—P. Clower, Audio Assist Gives "Idiot Lights" the "Buzz," *EDN Magazine*, June 20, 1976, p 126.

OIL-PRESSURE DISPLAY—Red, yellow, and green LEDs give positive indication of oil pressure level on electronic gage console developed for motorcycle. Transducer converts oil pressure to variable resistance R_T which in turn varies bias on transistors. LEDs have different forward voltages at which they light, so proper selection of bias resistors ensures that only one LED is on at a time to give desired indication of oil pressure.—J. D. Wiley, Instrument Console Features Digital Displays and Built-In Combo Lock, *EDN Magazine*, Aug. 5, 1975, p 38–43.

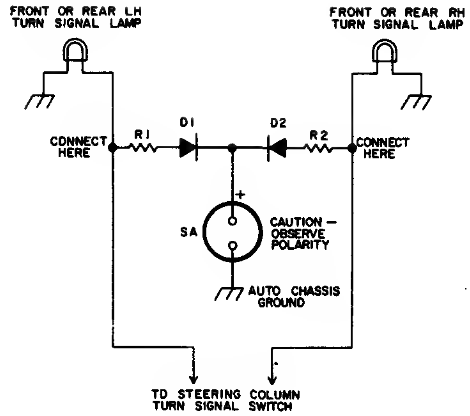




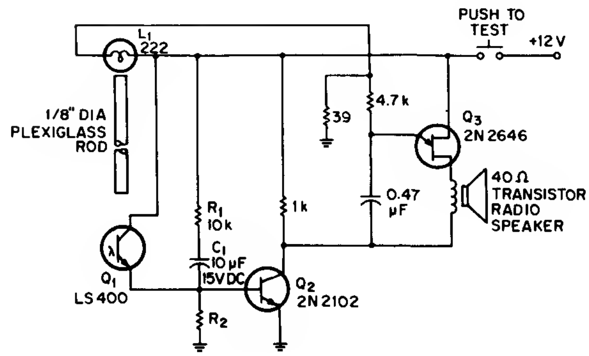
WIPER CONTROL—Operates wipers automatically at intervals, as required for very light rain or mist. Changing 560K resistor to 500K pot in series with 100K fixed resistor gives variable control of interval.—Circuits, *73 Magazine*, July 1977, p 34.



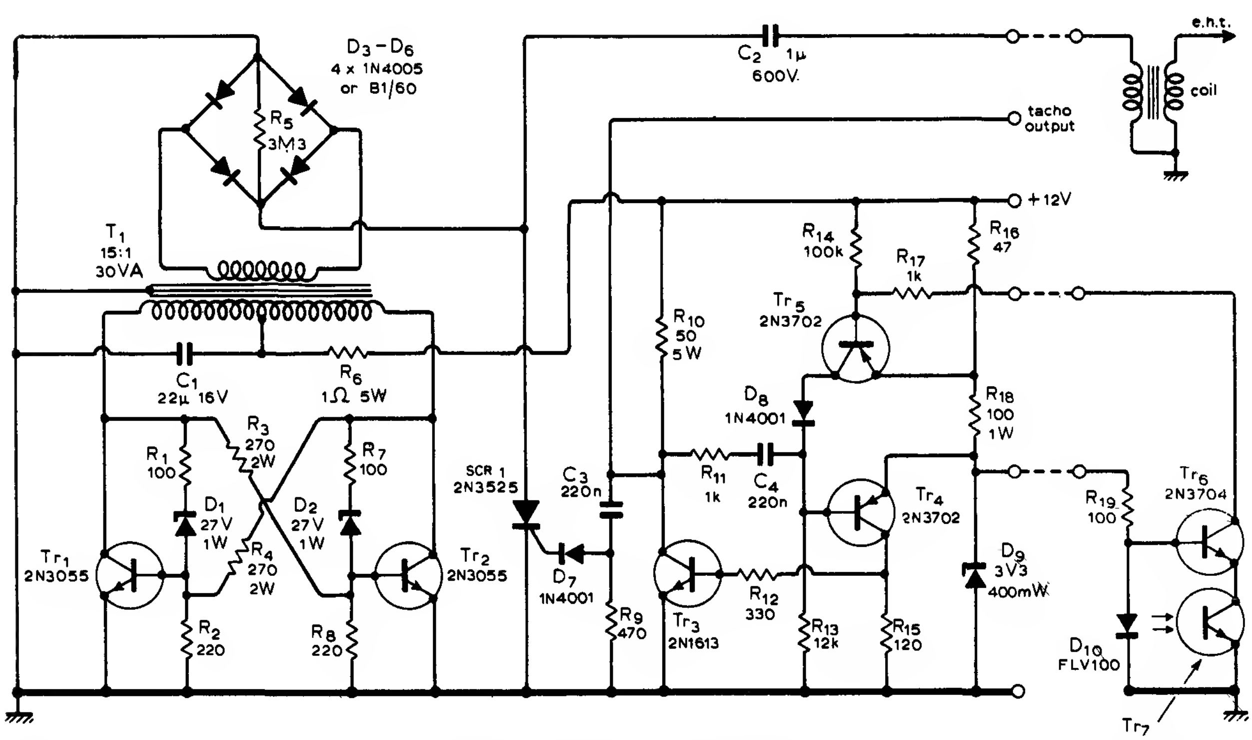
DISTRIBUTOR-POINT TACHOMETER—555 timer receives its input pulses from distributor points of car. When timer output (pin 3) is high, meter receives calibrated current through R_6. When IC times out, meter current stops for remainder of duty cycle. Integration of variable duty cycle by meter movement serves to provide visible indication of engine speed.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 724–725.



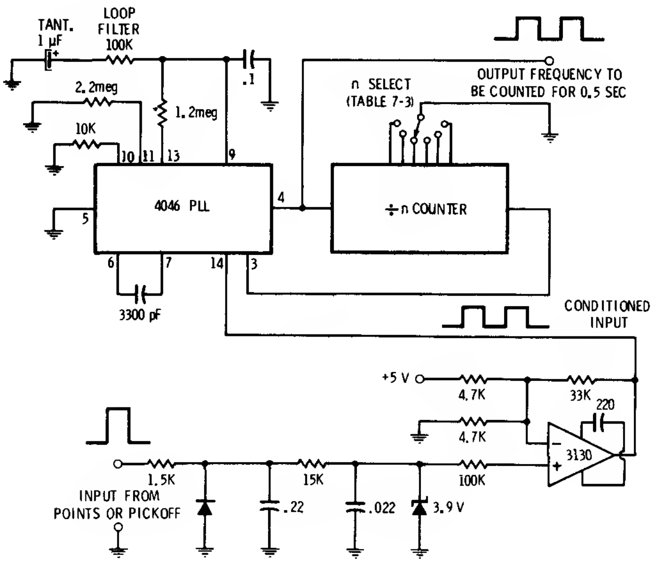
AUDIBLE TURN SIGNAL—Glves 3500-Hz sudibla tone each tlma turn-signsl light flsshes on, to wem driver that signal has not bean turned off when mekIng less then rIght-angla turns. Schemetic shown is for 12-V negative-ground systams. For 6-V negative-ground systems, cut velues of R1 and R2 about in half. For positive-ground systems, raversa connections to diodes end Sonalert. R1 snd R2 sre 2.7K 0.5 W. D1 and D2 can ba any general-purposa smsll-currant silicon diode. SA Is Mellory SC1.5 Sonslert.—A. Goodwln, Turn Signsl Reminder, *73 Magazine,* Holidsy issua 1976, p 166.



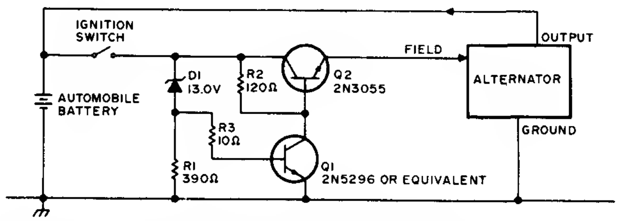
OIL-LEVEL GAGE—Parmits chacking crankcase oil lavel from drivar's seat. Sensor consists of light-conducting Plexiglas rod attached to dipstick, with lamp L_1 at top of rod and phototrsnsistor Q_1 mounted at add-oil mark on dipstick, about ½ inch below bottom of rod. At normal oll level, oil sttenustes light betwaen Q_1 snd bottom and of rod, msking phototranslstor resistsnce high. Pushing test switch mekes C_1 chsrga and saturate Q_2 long enough to sctivate UJT AF oscillator Q_3 and giva short tone verifying that Ismp is not burned out and gsge is working. When oil is low, enough llght raaches Q_1 to kaep Q_2 satursted sfter C_1 chargas, glving continuous tone as long as switch Is pushed.—L. Svalund, Electronic Dipstick, *EEE Magazina,* Nov. 1970, p 101.



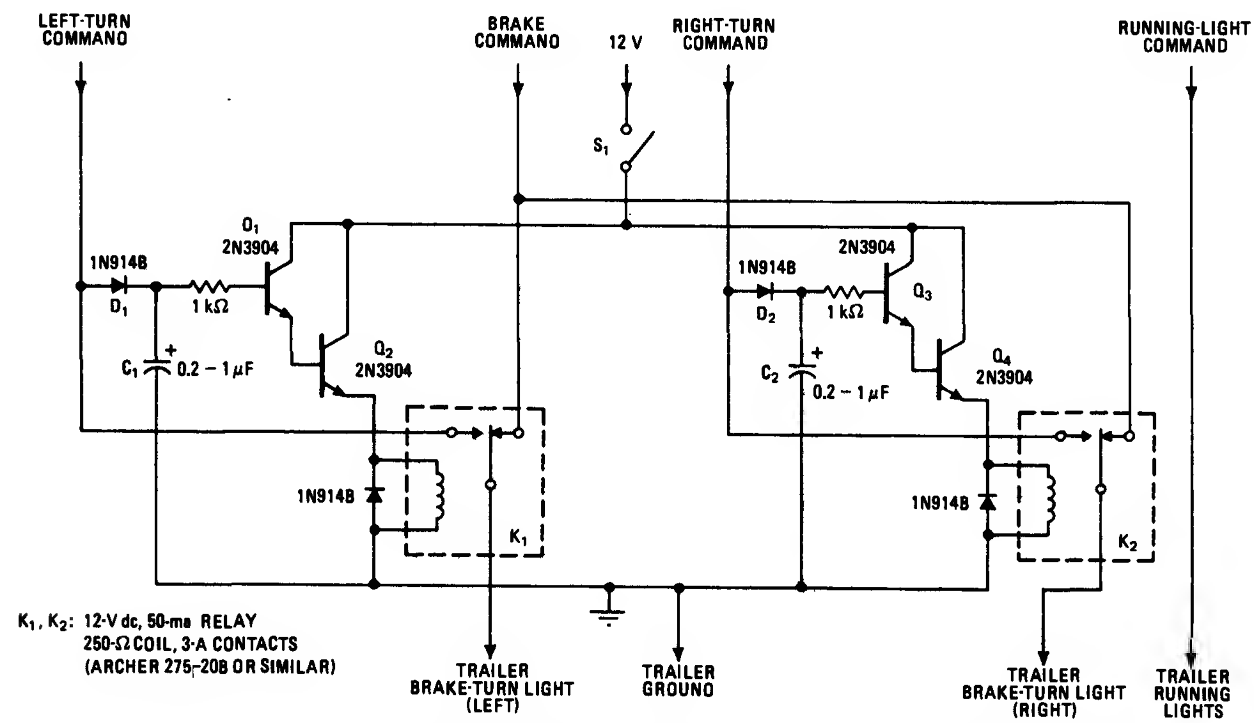
OPTOELECTRONIC IGNITION—Combination of low-cost point-source LED and high-sensitivity phototransistor forms optical sensor for position of cam in distributor. Technique eliminates problams craated by tlming drift and distrlbutor-shaft plsy. Sensor hasd Is small enough to fit most distributors. Article givas dlmensioned drswlngs for shuttar dasign and sensor mounting, end dascribes oparstion of associatad capacitor-dlschsrge electronlc Ignition circuit in detail. Laeds to sensor do not requlra shielding.—H. Maldment, Opticel Sensor Ignltion System, *Wireless World,* Nov. 1975, p 533–537.



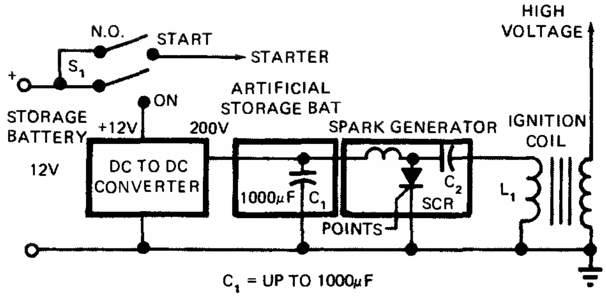
DIGITAL TACHOMETER—Pulses from auto angine points or other pickoff are filtered before feed to 3130 CMOS opemp used ss comparator to complete conditioning of input. Pulses are then fed through 4046 PLL to divide-by-N counter thet is set for number of cylinders in engine (60 for four cylinders, 45 for six, end 30 for eight). Output frequancy is then counted for 0.5 s to get engine or shaft speed in rpm.—D. Lencaster, "CMOS Cookbook," Howard W. Sems, Indianapolis, IN, 1977, p 366–367.



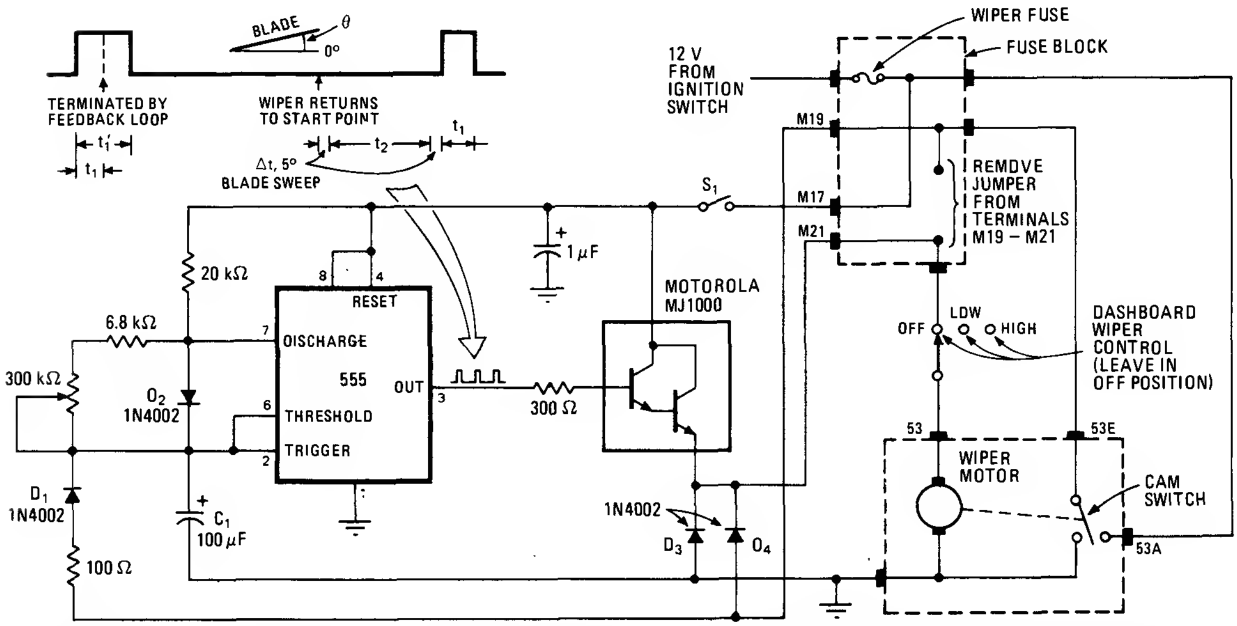
REGULATOR FOR ALTERNATOR—Simple and effective solid-state replecement for auto voltsge regulator cen be used with altemator in elmost any negstiva-ground system. Circuit ects as switch supplying either full or no voltege to field winding of elternator. When battery is balow 13 V, zener D1 does not conduct, Q1 is off, Q2 is on, end full bettary voltage is applied to slternator field so it puts out full voltage to bettary for charging. When battery reaches 13.6 V, Q1 turns on, Q2 turns off, altametor output is reduced to zero, end battery gets no charging current. Circuit can elso ba used with wind-driven eltemator systems.—P. S. Smith, $22 for a Regulator? Neverl, *73 Magazine,* Holidey issue 1976, p 103.



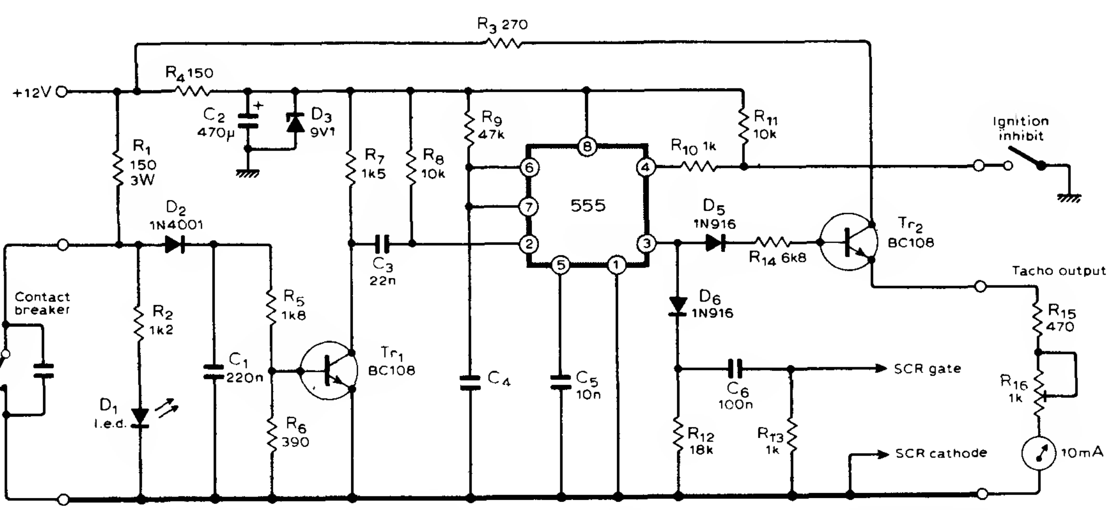
AUTO-TRAILER INTERFACE FOR LIGHTS—Low-cost transistors and two relays combine brske-light and turn-indicator signals on common bus to ensure that trailar lights respond to both commands. C_1 and C_2 charge to peak amplitude of turn signal, which fleshes about 2 times per second. Values are selected to hold relay closed between flash intervals; if capecitance is too large, brake signal cannot immediately activate trailer lights after turn signel is canceled. Developed for new cars in which seprate turn and braka signals ere required for safety.—M. E. Gilmore and C. W. Snipes, Darlington-Switched Relays Link Car and Trailer Signal Lights, *Electronics,* Aug. 18, 1977, p 116.



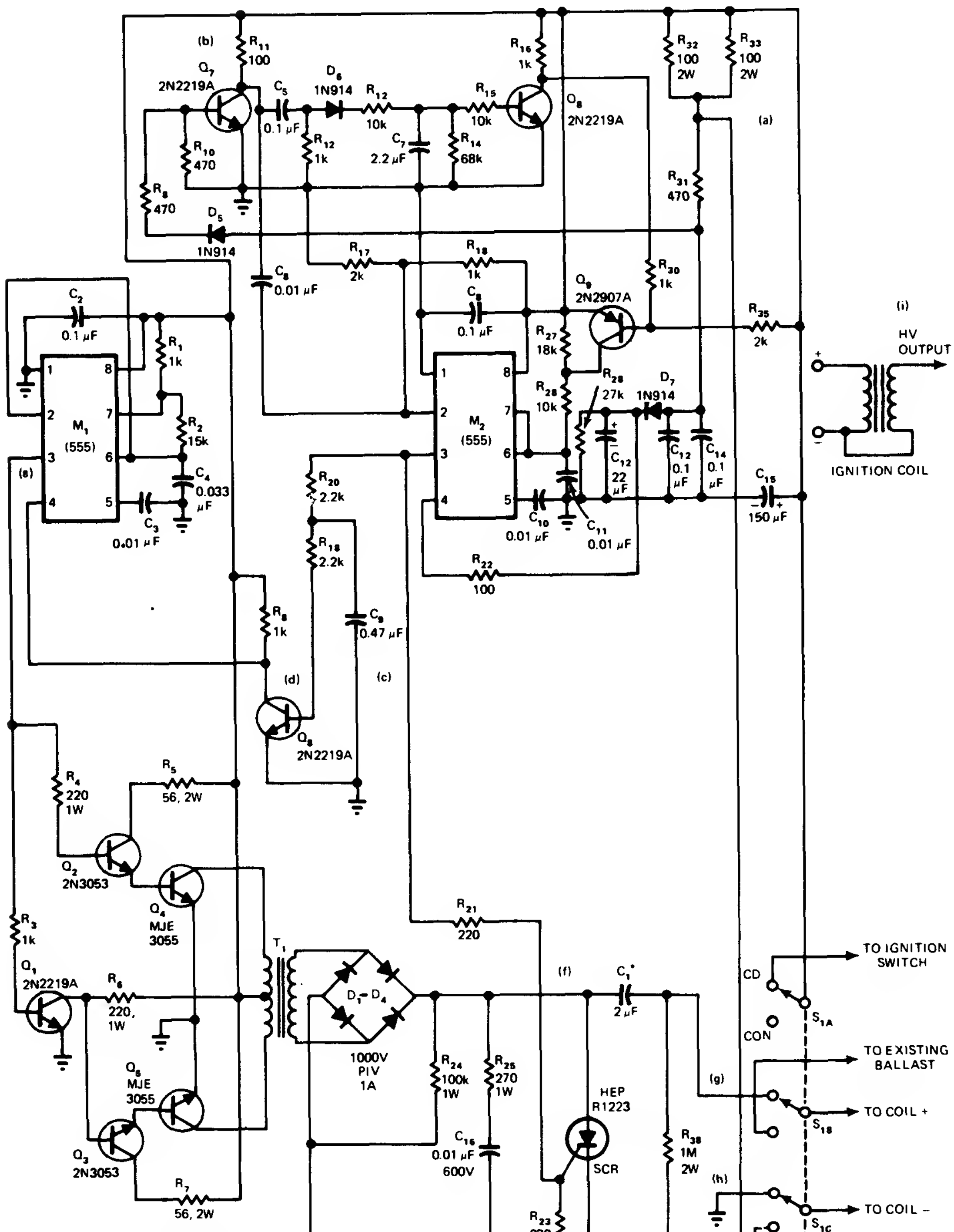
CAPACITOR SERVES AS IGNITION BATTERY—Developed for use with capacitor-discharge ignition systems to provide independent voltage source for ignition when starting car in very cold weather. Before attempting to start car, S_1 is set to ON position for energizing DC-to-DC converter for charging C_1 with DC voltage between 200 and 400 V. Starter is now engaged. If voltage of storage battery drops as starter slowly turns engine over, C_1 still represents equivalent of fully charged 12-V storage battery that is capable of driving ignition system for almost a minute.—W. Stalzer, Capacitor Provides Artificial Battery for Ignition Systems, *EDN Magazine*, Nov. 15, 1972, p 48.



WIPER-DELAY CONTROL—555 timer provides selectable delay time between sweeps of wiper blades driven by motor in negative-ground system. Article also gives circuit modification for positive-ground autos. Delay time can be varied between 0 and 22 s. Timer uses feedback signal from cam-operated switch of motor to synchronize delay time with position of wiper blades.—J. Okolowicz, Synchronous Timing Loop Controls Windshield Wiper Delay, *Electronics*, Nov. 24, 1977, p 115 and 117.



RPM-LIMIT ALARM—Used with capacitor-discharge ignition system to provide tachometer output along with engine speed control signal. When breaker contacts open, C_1 charges and turns Tr_1 on, triggering 555 timer used in mono MVBR mode. Resulting positive pulse from 555 fires control SCR through D_6 and C_6. When contacts close, D_2 isolates C_1 to reduce effect of contact bounce. With values shown, for speed limit between 8000 and 9000 rpm, use 0.068 μF for C_4 with four-cylinder engine, 0.047 μF for six cylinders, and 0.033 μF for eight cylinders. LED across breaker contacts can be used for setting static timing.—K. Wevill, Trigger Circuit for C.D.I. Systems, *Wireless World*, Jan. 1978, p 58.

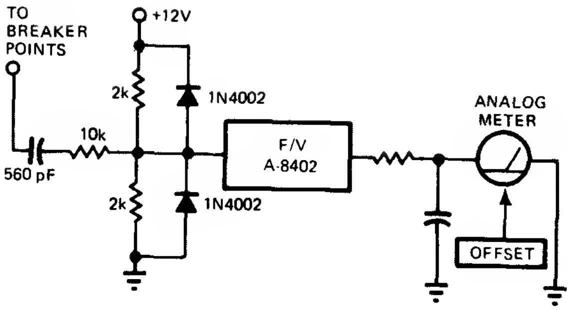


ALL RESISTORS ½W UNLESS SPECIFIED

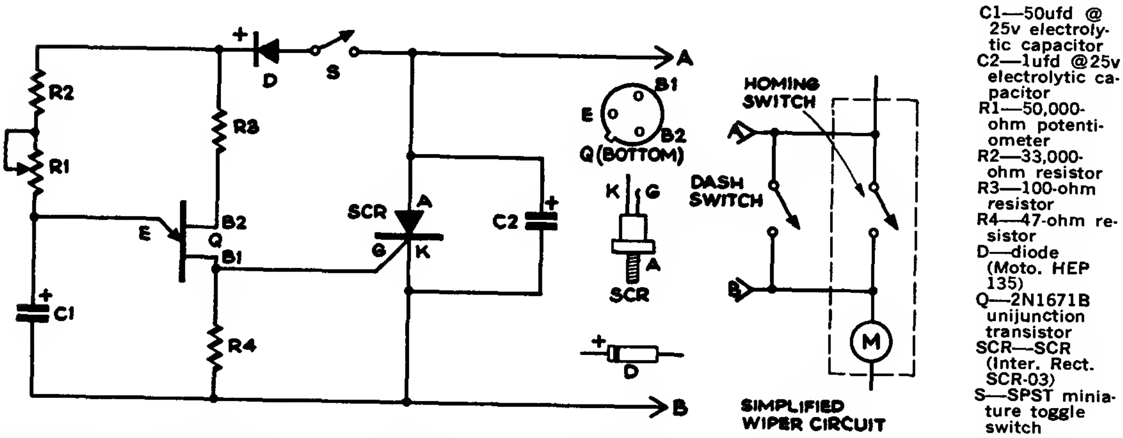
*C_1—G.E. TYPE 28F5120FC

T_1—6.3V C.T. 3A USED AS PRIMARY 117V USED AS SECONDARY

LOW-EMISSION CD—Solid-state capacitor-discharge ignition system improves combustion efficiency by increasing spark duration. For 8-cylinder engine, normal CD system range of 180 to 300 μs is increased to 600 μs below 4000 rpm. Oscillation discharge across ignition coil primary lasts for two cycles here, but above 4000 rpm the discharge lasts for one cycle or 300 μs because at higher speeds the power cycle has shorter times. Circuit uses 555 timer M_1 as 2-kHz oscillator, with Q_1-Q_3 providing drive to Q_4-Q_5 and T_1 for converting battery voltage to about 400 VDC at output of bridge rectifier. When distributor points open, Q_7 turns on and triggers M_2 connected as mono that provides gate drive pulses for SCR. Article describes operation of circuit in detail and gives waveforms at points e-i.—C. C. Lo, CD Ignition System Produces Low Engine Emissions, *EDN Magazine*, May 20, 1976, p 94, 96, and 98.



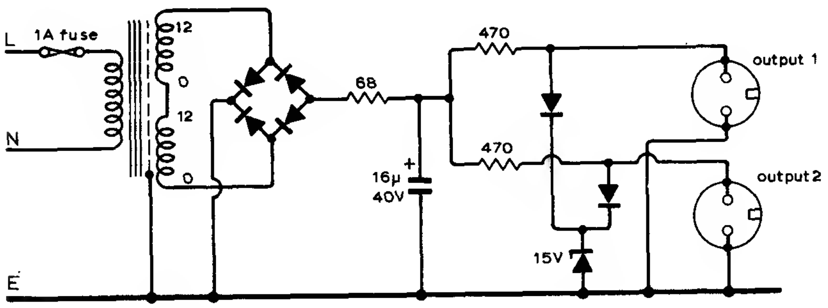
TACHOMETER—Intach/Function Modules A-8402 oparating In frequency-to-voltage convertar moda serves as automotive tachometer heving inharent linearity and aase of calibration. Converter oparates asynchronously, which does not affect accuracy when driving analog meter.—P. Pintar and D. Timm, Voltage-to-Frequency Converters—IC Versions Parform Accurate Data Convarsion (and Much More) at Low Cost, *EDN Magazine*, Sept. 5, 1977, p 153–157.



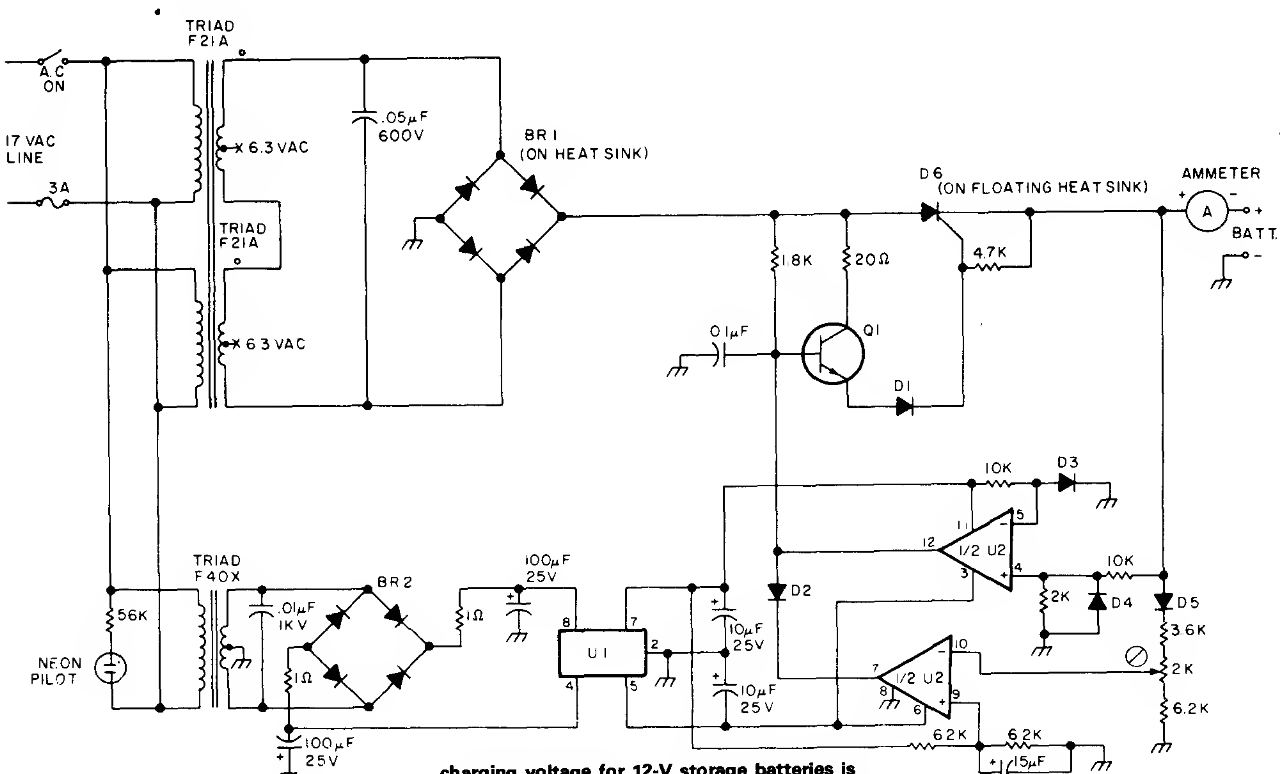
TIMER FOR WIPER—Provides automatic one-shot swipes at presalacted intervals from 2 to 30 s for handling mist, drizzle, or splash from wet road. Circuit shorts out homing switch insida windshield-wiper motor, which is usually in parallal with slow-speed contacts of wipar dashboard switch. With wiper switch off and ignition on, short two switch terminals at a time to find pins that start wiper. Whan blades begin moving, ramove jumper; blades should then finish sweep and shut off. It is these terminals of switch that ara connected to points A and B of control circuit.—V. Mele, Mist Switch—It's for Your Windshiald Wipars, *Popular Science*, Aug. 1973, p 110.

CHAPTER 8
Battery-Charging Circuits

Includes constant-voltage, constant-current, and trickle chargers operating from AC line, solar cells, or auto battery. Some circuits have automatic charge-rate control, automatic start-up, automatic shutoff, and low-charge indicator.

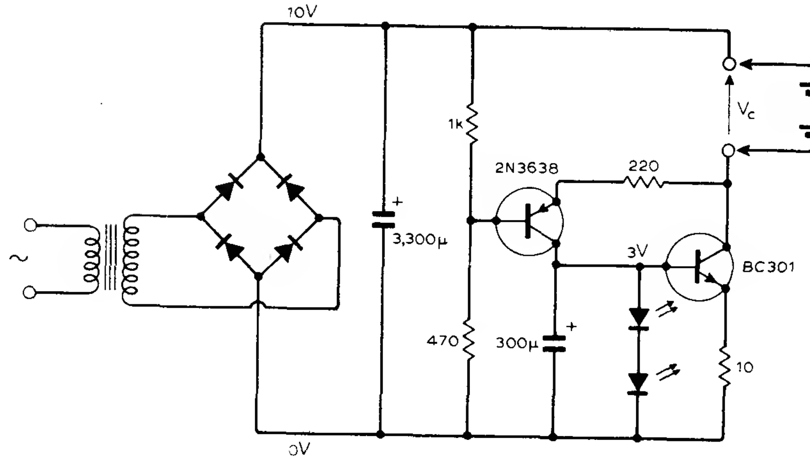


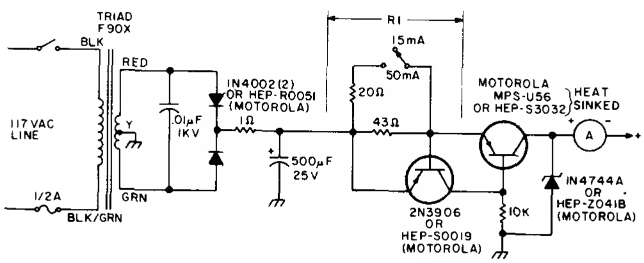
9.6 V AT 20 mA—Developed to charge 200-mAh nickel-cadmium batteries for two transceivers simultaneously. Batteries will be fully charged in 14 hours, using correct 20-mA charging rate. Zener diode ensures that voltage cannot exceed safe value if battery is accidentally disconnected while under charge. Diode types are not critical.—D. A. Tong, A Pocket V.H.F. Transceiver, *Wireless World*, Aug. 1974, p 293–298.



ADJUSTABLE FINISH-CHARGE—Uses National LM319D dual comparator U2 to sense end-of-charge battery voltage and provide protection against shorted or reversed charger leads. Final charging voltage for 12-V storage batteries is adjustable with 2K trimpot. Separate ±15 V supply using Raytheon RC4195NB regulator U1 is provided for U2. D1-D5 are 1N4002 or HEP-R0051. D6 is 2N682 or HEP-R1471. BR1 is Motorola MDA980-2 or HEP-R0876 12-A bridge. BR2 is Vero VE27 1-A bridge. Q1 is 2N3641 or HEP-S0015.—H. Olson, Battery Chargers Exposed, *73 Magazine*, Nov. 1976, p 98–100 and 102–104.

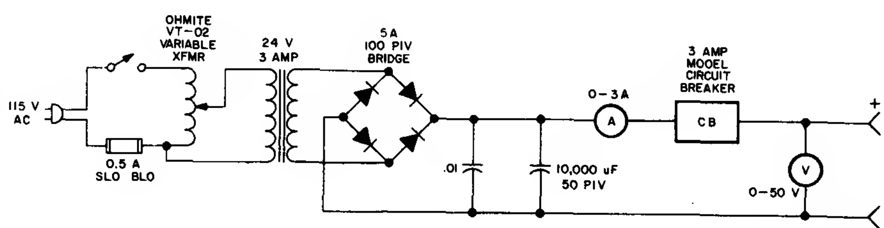
NICKEL-CADMIUM CELL CHARGER—Charges four size D cells in series at constant current, with automatic voltage limiting. BC301 transistor acts as current source, with base voltage stabilized at about 3 V by two LEDs that also serve to indicate charge condition. Other transistor provides voltage limiting when voltage across cells approaches that of 1K branch of voltage divider. Values shown give 260-mA charge initially, dropping to 200 mA when V_c reaches 5 V and decreasing almost to 0 when V_c reaches 6.5 V.—N. H. Sebah, Battery Charger, *Wireless World*, Nov. 1975, p 520.

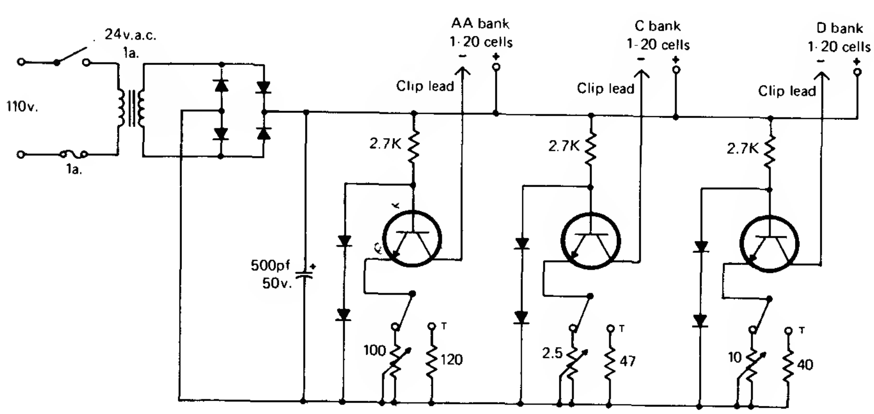




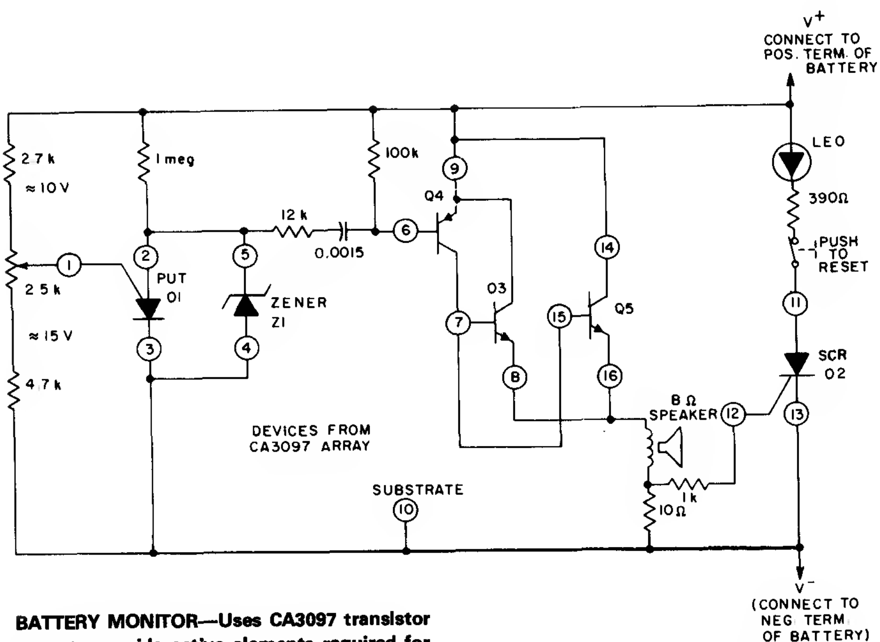
12-V FOR NiCADS—Produces constant current with simple transistor circuit, adjustable to 15 or 50 mA with switch and R1. Zener limits voltage at end of charge. Developed for charging 10-cell pack having nominal 12.5 V, as used in many transceivers.—H. Olson, Battery Chargers Exposed, *73 Magazine*, Nov. 1976, p 98–100 and 102–104.

CHARGING SILVER-ZINC CELLS—Used for initial charging and subsequent rechargings of sealed dry-charged lightweight cells developed for use in missiles, torpedoes, and space applications. Article covers procedure for filling cell with potassium hydroxide electrolyte before placing in use (cells are dry-charged at factory and have shelf life of 5 or more years in that condition). Charge current should be 7 to 10% of rated cell discharge capacity; thus, for Yardney HR-5 cell with rated discharge of 5 A, charge at 350 to 500 mA. Stop charging when cell voltage reaches 2.05 V. If used only for battery charging, large filter capacitor can be omitted.—S. Kelly, Will Silver-Zinc Replace the Nicad?, *73 Magazine*, Holiday issue 1976, p 204–205.

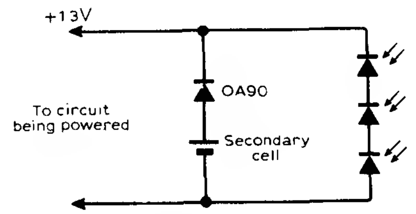




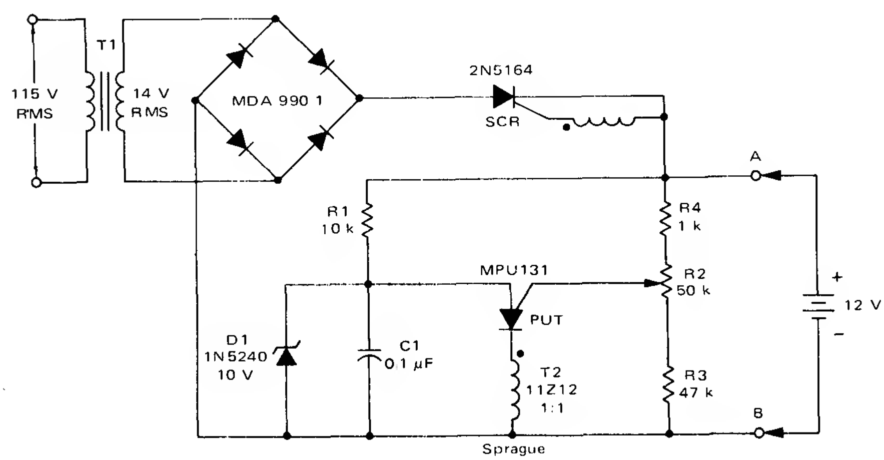
BULK NiCAD CHARGER—Can handle up to 20 AA cells, 20 C cells, and 20 D cells simultaneously, with charging rate determined separately for each type. Single transformer and full-wave rectifier feed about 24 VDC to three separate regulators. AA-cell regulator uses 100-ohm resistor to vary charge rate from 6 mA to above 45 mA. C-cell charge-rate range is 24 to 125 mA, and D-cell range is 60 to 150 mA. Batteries of each type should be about same state of discharge. Batteries are recharged in series to avoid need for separate regulator with each cell. Trickle-charge switches cut charge rates to about 2% of rated normal charge (5 mA for 500-mAh AA cells). Transistors are 2N4896 or equivalent. Use heatsinks. All diodes are 1N4002.—J. J. Schultz, A Bulk Ni-Cad Recharger, *CQ*, Dec. 1977, p 35–36 and 111.



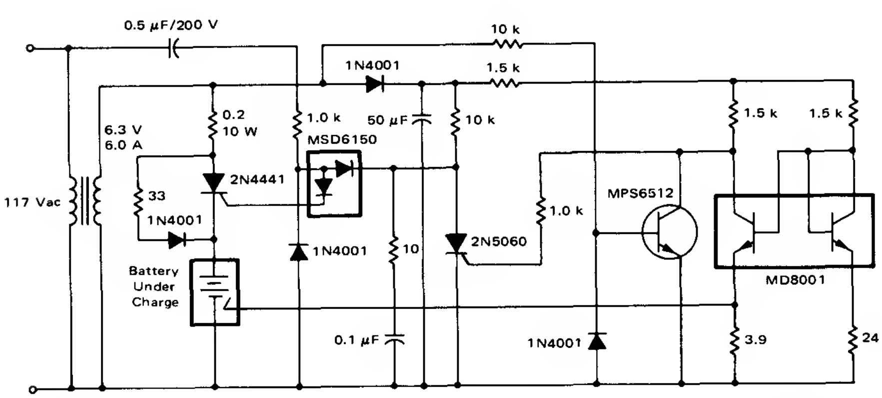
BATTERY MONITOR—Uses CA3097 transistor array to provide active elements required for driving indicators serving as aural and visual warnings of low charge on nicad battery. LED remains on until circuit is reset with pushbutton switch.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 9.



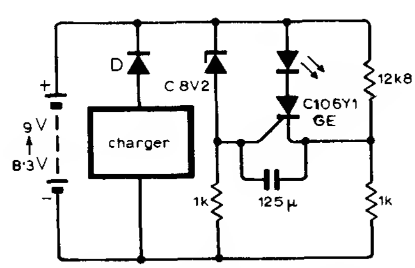
SOLAR-POWER BACKUP—If solar-cell voltage drops 0.2 V below battery voltage, circuit is powered by storage cell feeding through forward-biased OA90 or equivalent germanium diode. When solar-cell voltage exceeds that of battery, battery is charged by approximately constant reverse leakage current through diode. Battery can be manganese-alkaline type or zinc-silver oxide watch-type cell.—M. Hadley, Automatic Micropower Battery Charger, *Wireless World*, Dec. 1977, p 80.



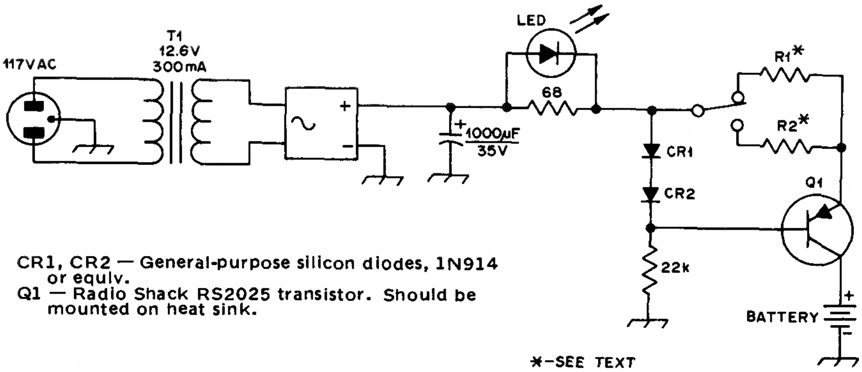
12 V AT 8 A—Charging circuit for lead-acid storage batteries is not damaged by short-circuits or by connecting with wrong battery polarity. Battery provides current for charging C1 in PUT relaxation oscillator. When PUT is fired by C1, SCR is turned on and applies charging current to battery. Battery voltage increases slightly during charge, increasing peak point voltage of PUT and making C1 charge to slightly higher voltage. When C1 voltage reaches that of zener D1, oscillator stops and charging ceases. R2 sets maximum battery voltage between 10 and 14 V during charge.—R. J. Haver and B. C. Shiner, "Theory, Characteristics and Applications of the Programmable Unijunction Transistor," Motorola, Phoenix, AZ, 1974, AN-527, p 10.



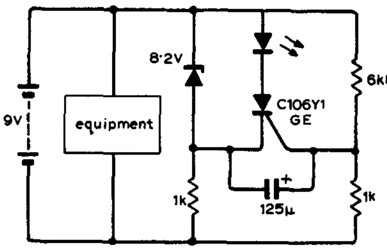
THIRD ELECTRODE SENSES FULL CHARGE—Circuit is suitable only for special nickel-cadmium batteries in which third electrode has been incorporated for use as end-of-charge indicator. Voltage change at third electrode is sufficient to provide reliable shutoff signal for charger under all conditions of temperature and cell variations.—D. A. Zinder, "Fast Charging Systems for Ni-Cd Batteries," Motorola, Phoenix, AZ, 1974, AN-447, p 7.



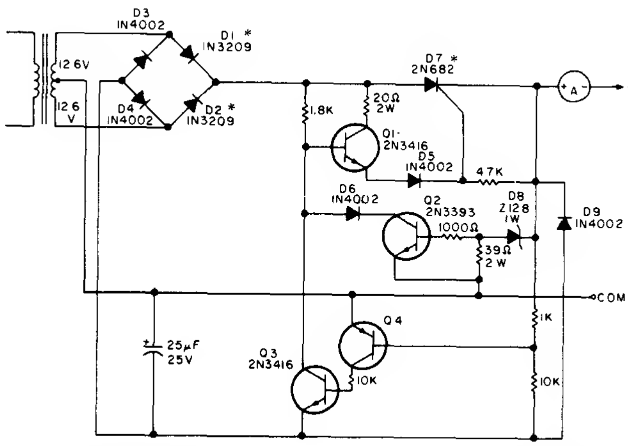
LED VOLTAGE INDICATOR—Circuit shown uses LED to indicate, by lighting up, that battery has been charged to desired level of 9 V. Circuit can be modified for other charging voltages. Silicon switching transistor can be used in place of more costly thyristor.—P. R. Chetty, Low Battery Voltage Indication, *Wireless World*, April 1975, p 175.



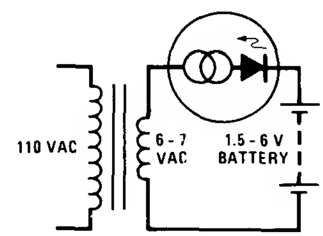
NICAD CHARGER—Switch gives choice of two constant-current charge rates. With 10 ohms for R1, rate is 60 mA, while 200 ohms for R2 gives 3 mA. Silicon diodes CR1 and CR2 have combined voltage drop of 1.2 V and emitter-base junction of Q1 has 0.6-V drop, for net drop of 0.6 V across R1 or R2. Dividing 0.6 by desired charge rate in amperes gives resistance value.—M. Altarman, A Constant-Current Charger for Nicad Batteries, *QST,* March 1977, p 49.



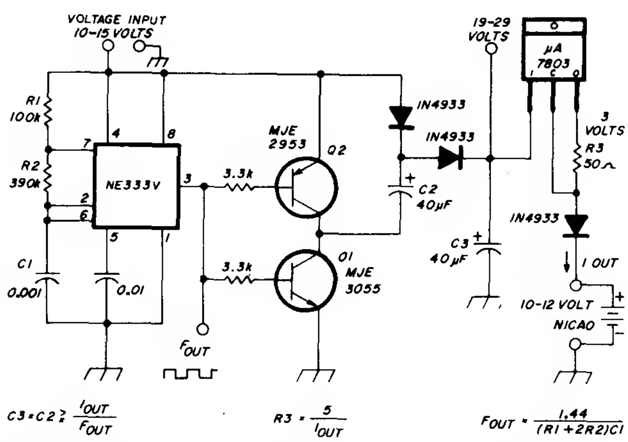
LED INDICATES LOW VOLTAGE—LED lights when output of 9-V rechargeable battery drops below minimum acceptable value of 8.3 V, to indicate need for recharging. Can also be used with transistor radio battery to indicate need for replacement. Zener is BZY85 C8V2 rated at 400 mW, with avalanche point at 7.7 V because of low current drawn by circuit. LED can be Hewlett-Packard 5082-4440.—P. C. Parsonage, Low-Battery Voltage Indicator, *Wireless World,* Jan. 1973, p 31.



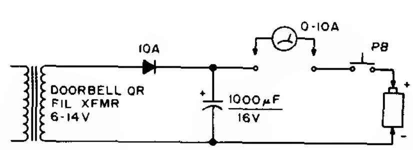
12-V AUTOMATIC—Circuit of Heathkit GP-21 automatic charger is self-controlling (Q1 and Q2) and provides protection against shorted or reversed battery leads (Q3 and Q4). Zener D8 is not standard value, so may be obtainable only in Heathkits. D1, D2, and D7 should all be on one heatsink.—H. Olson, Battery Chargers Exposed, *73 Magazine,* Nov. 1976, p 98–100 and 102–104.



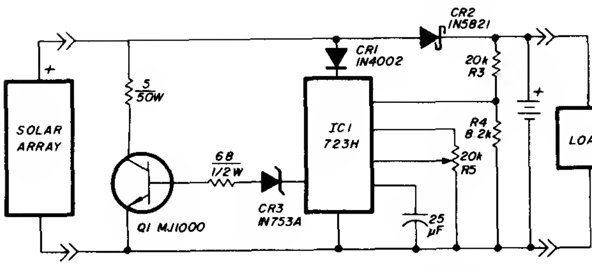
LED TRICKLE CHARGER—Constant-current characteristic of National NSL4944 LED is used to advantage in simple half-wave charger for batteries up to 6 V.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-153, p 2.



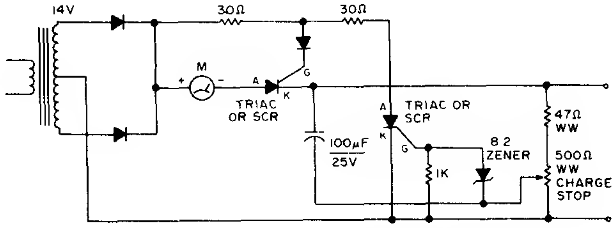
NICAD CHARGER FOR AUTO—Voltage doubler provides at least 20 V from 12-V auto battery, for constant-current charging of 12-V nicads, using NE555 timer and two power transistors. Doubled voltage drives source current into three-terminal current regulator. Switching frequency of NE555 as MVBR is 1.4 kHz. Charging current is set at 50 mA for charging ten 500-mAh nicads.—G. Hinkle, Constant-Current Battery Charger for Portable Operation, *Ham Radio,* April 1978, p 34–36.



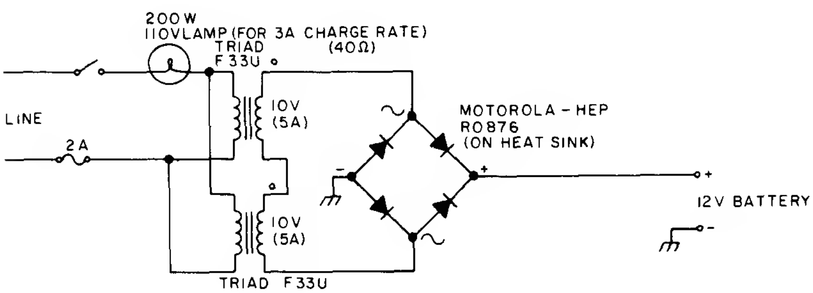
NICAD ZAPPER—Simple circuit often restores dead or defective nicad battery by applying DC overvoltage at current up to 10 A for about 3 s. Longer treatment may overheat battery and make it explode.—Circuits, *73 Magazine,* July 1977, p 35.



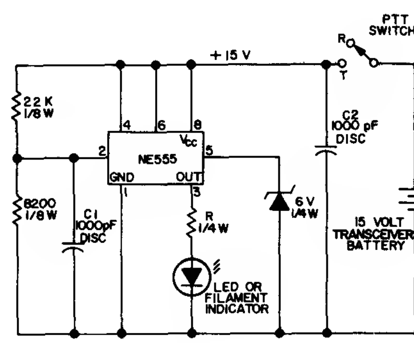
SOLAR-POWER OVERCHARGE PROTECTION—Voltage regulator is connected across solar-cell array as shown to prevent damage to storage battery by overcharging. Series diode prevents array from discharging battery during hours of darkness. Regulator does not draw power from battery, except for very low current used for voltage sampling. Battery can be lead-calcium, gelled-electrolyte, or telephone-type wet cells. For repeater application described, two Globe Union GC12200 40-Ah gelled-electrolyte batteries were used to provide transmit current of 1.07 A and idle current of 12 mA.—T. Handel and P. Beauchamp, Solar-Powered Repeater Design, *Ham Radio,* Dec. 1978, p 28–33.



AUTOMATIC SHUTOFF—Prevents overcharging and dryout of battery under charge by shutting off automatically when battery reaches full-charge voltage. Accepts wide range of batteries. Choose rectifying diodes and triacs or SCRs to handle maximum charging current desired. For initial adjustment, connect fully charged battery and adjust charge-stop pot until ammeter just drops to zero.—Circuits, *73 Magazine,* July 1977, p 34.

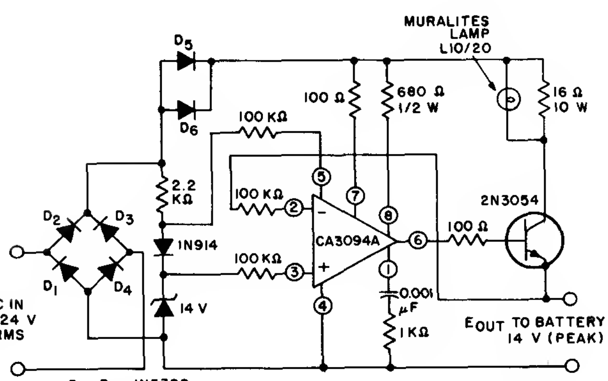


BASIC 12-V CHARGER—Uses 200-W lamp as current-limiting resistor in transformer primary circuit. Serves in place of older types of chargers using copper-oxide or tungar-bulb rectifiers.—H. Olson, Battery Chargers Exposed, *73 Magazine,* Nov. 1976, p 98–100 and 102–104.

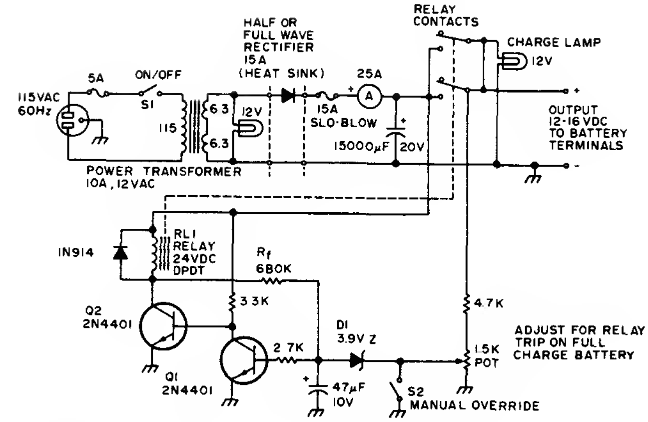


NOTE:
1. "R" NECESSARY IF LED IS EMPLOYED. 220 OHMS WILL PROVIDE NOMINAL BRIGHTNESS.
2. OUTPUT (PIN 3) WILL SUPPLY 200 mA TO LOAD.

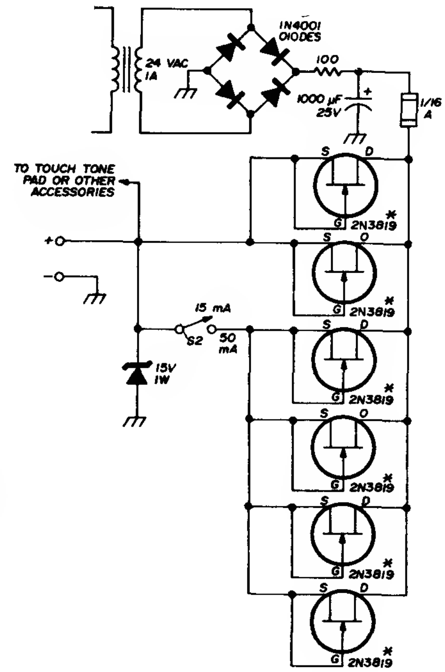
NICAD MONITOR—Uses two comparators, flip-flop, and power stage all in single NE555 IC. When battery voltage drops below 12-V threshold set by R1 and R2 for 15-V transceiver battery, one comparator sets flip-flop and makes output at pin 3 go high. IC then supplies up to 200 mA to LED or other indicator. For other battery voltage value, set firing point to about three-fourths of fully charged voltage. Since battery voltage will show biggest drop when transmitting, connect monitor across transmit supply only so as to minimize battery drain.—A. Woerner, Ni-Cad Lifesaver, *73 Magazine,* Nov. 1973, p 35–36.



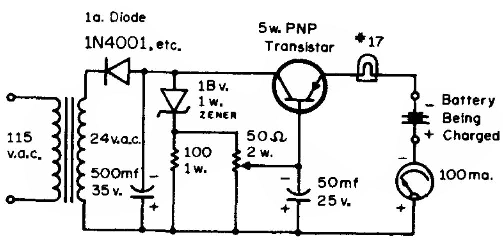
14-V MAXIMUM—Circuit accurately limits peak output voltage to 14 V, as established by zener connected between terminals 3 and 4 of CA3094A programmable opamp. Lamp brightness varies with charging current. Reference voltage supply does not drain battery when power supply is disconnected.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 19.



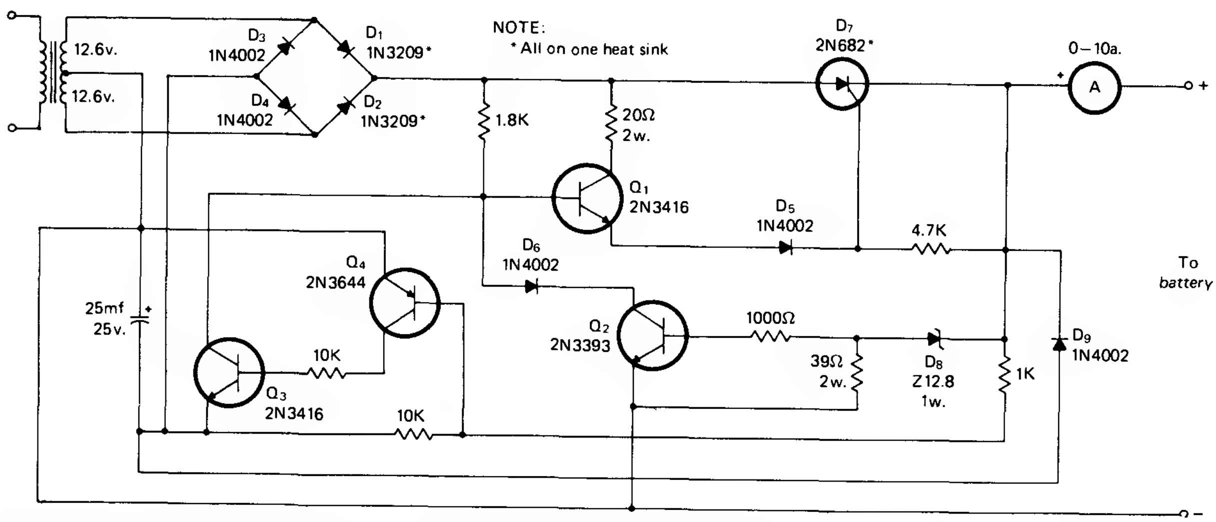
AUTOMATIC SHUTOFF—Charger automatically turns itself off when 12-V auto storage battery is fully charged. Setting of 1.5K pot determines battery voltage at which zener D1 conducts, turning on Q2 and pulling in relay that disconnects charger. If battery voltage drops below threshold, relay automatically connects charger again. S2 is closed to bypass automatic control when charger itself is to be used as power supply.—G. Hinkle, The Smart Charger, *73 Magazine*, Holiday issue 1976, p 110–111.



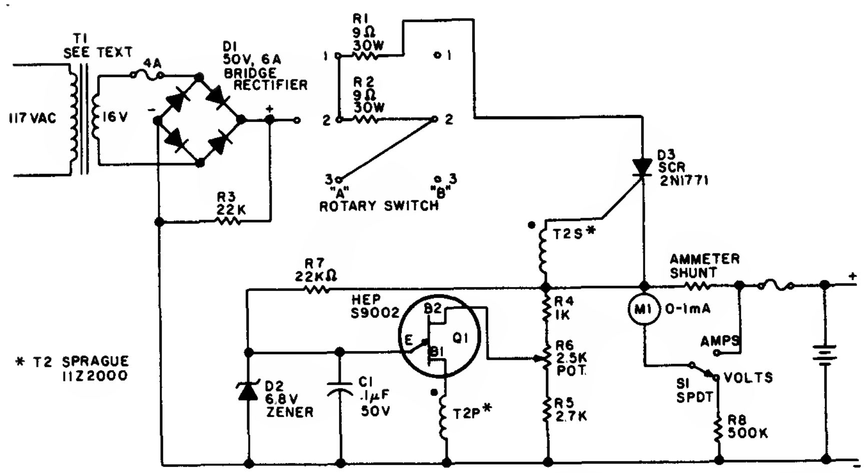
NICAD CHARGER—Developed for recharging small nickel-cadmium batteries used in handheld FM transceivers. Field-effect transistors serve as constant-current sources when gate is shorted to source. Practically any N-channel JFET having drain-to-source current of 8–15 mA will work. FETs shown were measured individually and grouped to give desired choice of 15- or 50-mA charging currents.—G. K. Shubert, FET-Controlled Charger for Small Nicad Batteries, *Ham Radio*, Aug. 1975, p 46–47.



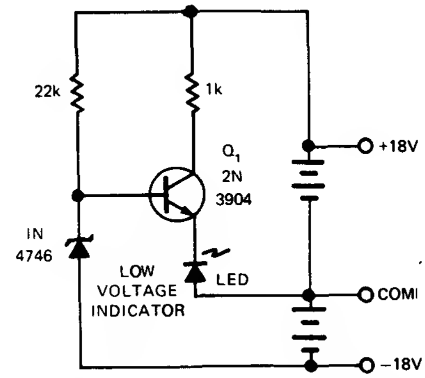
NICAD CHARGER—Pot is adjusted to provide 10% above rated voltage (normal full-charge voltage) while keeping charging current below 25% of maximum. For 10-V 1-Ah battery, set voltage at 11 V and current below 250 mA.—G. E. Zook, F.M., *CQ*, Feb. 1973, p 35–37.



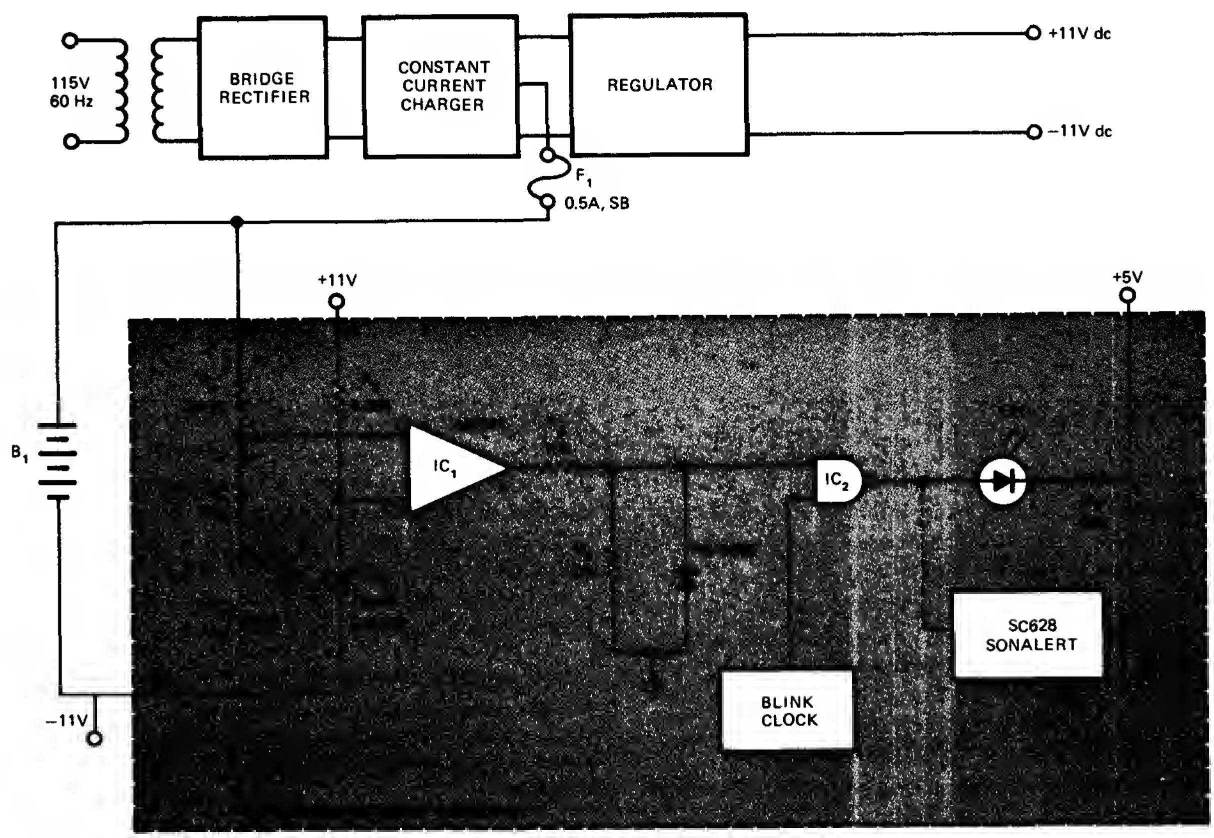
12-V CHARGER—Heath GP-21 charger uses SCR as switch to connect and disconnect battery at 120-Hz rate. Voltage at anode of SCR D_7 goes positive each half-cycle, putting forward bias on base of Q_1 through 1.8K resistor so Q_1 passes current through D_5 to gate of D_7 to turn it on for part of half-cycle and charge battery. D_7 stays on until voltage across it drops to zero. When battery has charged to 13.4 V, charging stops automatically. Rest of circuit protects against battery polarity reversal and accidental shorting of output leads. Special 12.8-V zener can be replaced by selected 1N4742 and forward-biased 1N4002.—H. Olson, We Don't Charge Nothin' but Batteries!, *CQ*, Feb. 1976, p 25–28 and 69.



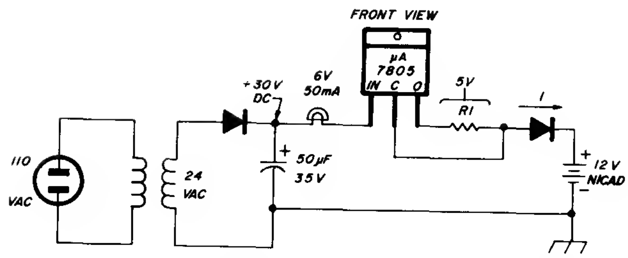
UJT CHARGER FOR 12 V—Keeps 12-V euto storage battery fully charged, for immediete standby use when AC powar feils. Power transformer secondary can be 14 to 24 V, rated at about 3 A. Two-geng rotery switch givas choice of three charging rates. Pulse transformer T2 is small eudio transformer rewound to have 1:1 turns ratio and ebout 20 ohms resistance, or can be reguler SCR trigger transformer. UJT relaxation oscillator stops when upper voltage limit for battery is reached, as set by pot R6. If oscilletor feils to stert, reverse one of pulse transformer windings.—F. J. Piralno, Failsafe Super Charger, *73 Magazine*, Holiday issue 1976, p 49.



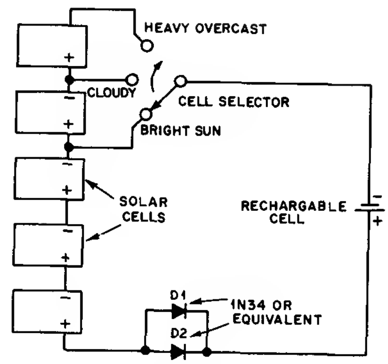
18-V MONITOR—Circuit turns on LED when ±18 V battery peck discharges to predetermined low level, while drewing less than 1 mA when LED is off. Zenar is reverse-biesed for normel operating range of battery. When lowar limit is raeched, zener loses control and Q_1 becomes forwerd-biesed, turning on LED or other signal device to indicata naed for replacement or recherging.—W. Denison and Y. Rich, Battery Monitor Is Efficient, yet Simple, *EDN Magazine*, Oct. 5, 1974, p 76.



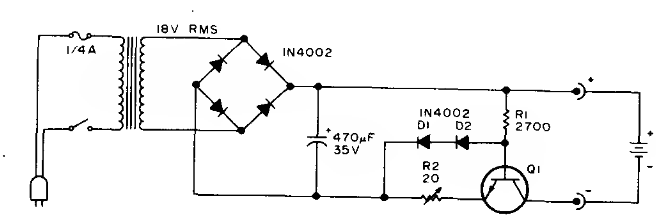
FLASHING LED FOR LOW BATTERY—Developed for use in portable battery-operated test instrument to provide visual indication that depletion level hes been reached for series errangament of 24 nickel-cadmlum cells providing 32.5 VDC for regulator of bipolar 11-V supply. Instrument must then be plugged into AC line for recharging of batteries. Voltage across B_1 (nominelly 32.5 V) is sensed by R_1-R_4 and D_1. When level drops 24.1 V, opamp comparator output goes positive and enables gata IC_2, so blink clock (such es low-frequency TTL-level oscillator) makes LED flash. Audible alarm is optional.—R. T. Warnar, Monitor NiCad's with This Low-Battery Detector, *EDN Magazine*, April 20, 1976, p 112 and 114.



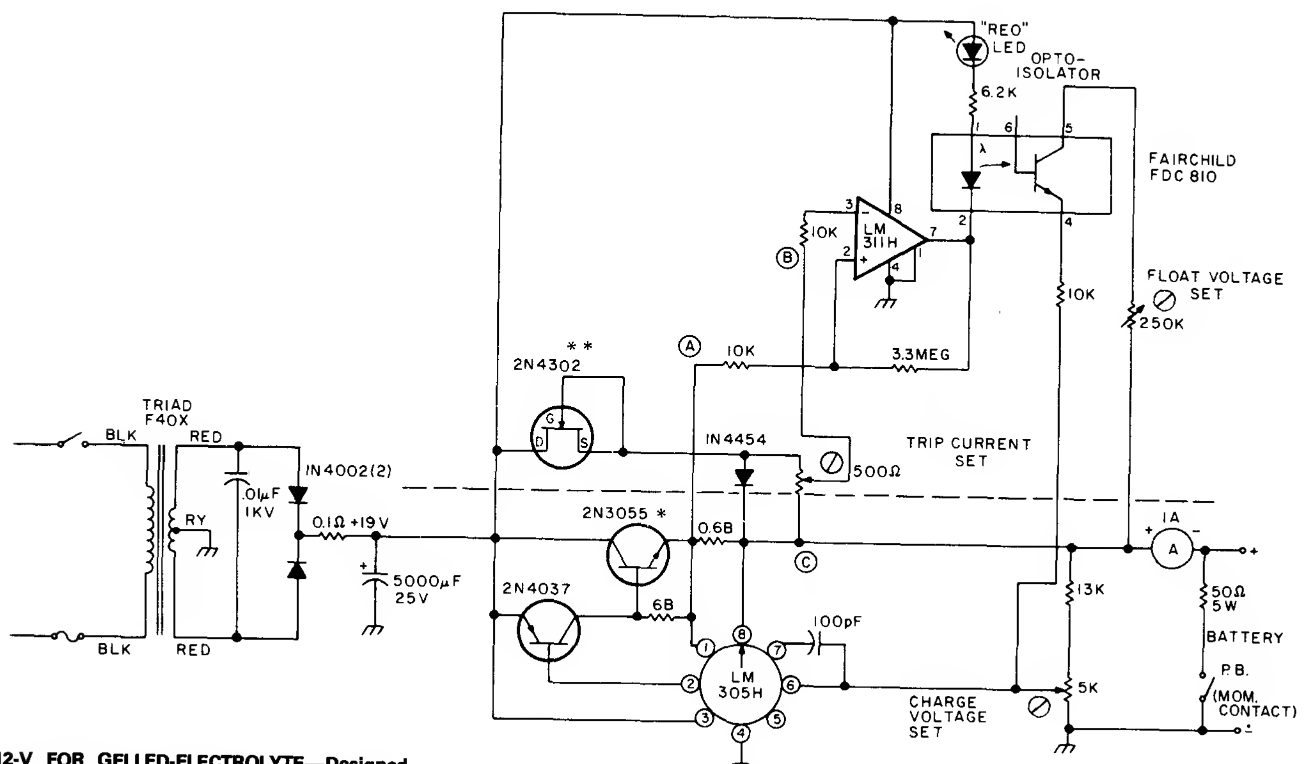
CONSTANT-CURRENT NICAD CHARGER—Constant current is obtained from voltage regulator by floating common line and connecting R1 from output to common terminal. Regulator then tries to furnish fixed voltage across R1. Input voltage must be greater than full-charge battery voltage plus 5 V (for 5-V regulator) plus 2 V (overhead voltage). Changing R1 varies charging current. If R1 is 50 ohms and V is 5 V, constant current is 50 mA through nicad being charged.—G. Hinkle, Constant-Current Battery Charger for Portable Operation, *Ham Radio*, April 1978, p 34–36.



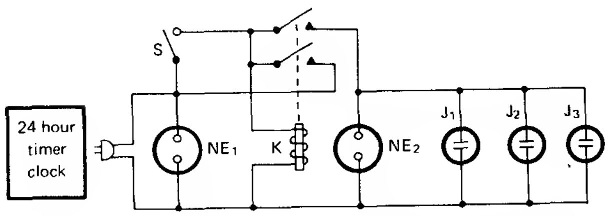
SOLAR-ENERGY CHARGER—Single solar cell on bright day delivers 0.5 V at 50 mA, so three cells are used in bright sun to recharge secondary cell. Switch permits use of additional solar cells on cloudy days. Solar cells can be Radio Shack 276-128.—J. Rice, Charging Batteries with Solar Energy, *QST*, Sept. 1978, p 37.



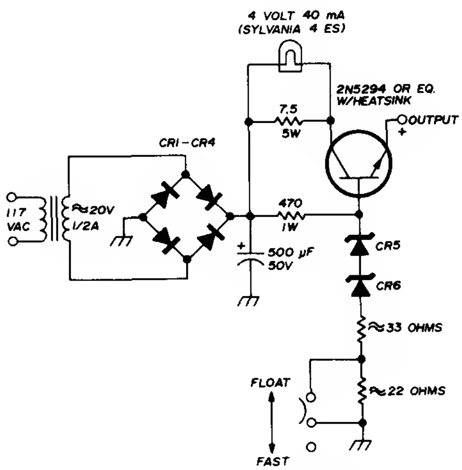
NICAD CHARGER—Regulated charger circuit will handle variable load from 1 to 18 nicad cells. Current-limiting action holds charging current within 1 to 2 mA of optimum value (about one-tenth of rated ampere-hour capacity) from 0 to 24 V. Q1 should have power rating equal to twice supply voltage multiplied by current-limit value. If charging 450-mAh penlight cells, charge current is 45 mA and transistor should be 2 W.—A. G. Evans, Regulated Nicad Charger, *73 Magazine*, June 1977, p 117.



12-V FOR GELLED-ELECTROLYTE—Designed to charge 12-V 3-Ah gelled-electrolyte battery such as Elpowar EP1230A at maximum of 0.45 A until battery reaches 14 V, then at constant voltage until charge current drops to 0.04 A. Charger is then automatically switched to float status that maintains 2.2 V per cell or 13.2 V for battery. Circuit is constant-voltage regulator with current limiting as designed around National LM305H, with PNP/NPN transistor pair to increase current capability. Circuit above dashed line is added to standard regulator to meet special charging requirement. Article covers operation and use of circuit in detail.—H. Olson, Battery Chargers Exposed, *73 Magazine*, Nov. 1976, p 98–100 and 102–104.



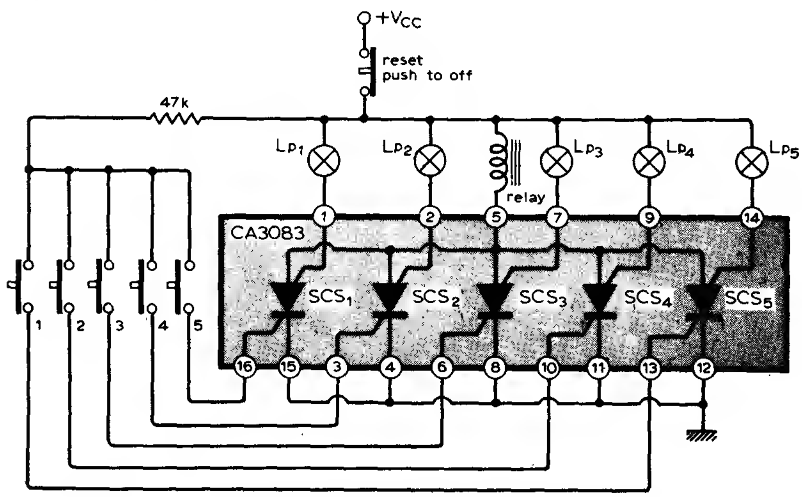
NICAD CHARGE CONTROL—Prevents double-charging if someone forgets to turn off 24-h time clock efter racommanded 16-h charge period. Niced devices with built-in chergers ere plugged into jacks J_1-J_3, and timar dial is edvenced until clock switch is triggered. Neon lemp NE_1 should now come on. Momentary pushbutton switch S is pushed to energize relay K end start charge. When timer goes off, K releeses to end charge.—M. Katz, Battery Charga Monitor, *CQ*, July 1976, p 27.



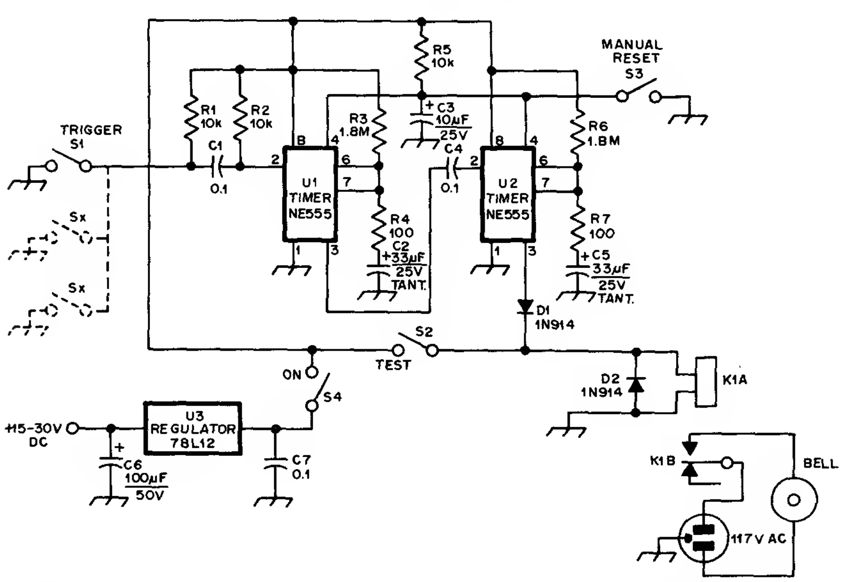
GELLED-ELECTROLYTE BATTERIES—Constant-voltage cherger for Globe-Union 12-V gelled-electrolyte storage betteries can provide either fast or float charging. Constant voltage is maintained by series power transistor and series-connected zeners. Output voltage is 13.8 V for floet cherging and 14.4 V for fast charging.—E. Noll, Storege-Bettery QRP Power, *Ham Radio*, Oct. 1974, p 56–61.

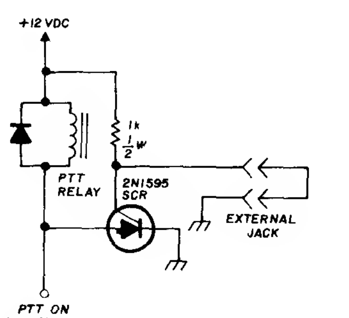
CHAPTER 9
Burglar Alarm Circuits

For auto, home, office, and factory installations. Sensors include contact-making, contact-breaking, photoelectric, infrared, Doppler, and sound-actuated devices that trigger circuit immediately or after adjustable delay for driving alarm horn, siren, tone generator, pager, or silent transmitter. Some circuits have automatic shutoff of alarm after fixed operating time as required for auto alarms in some states. See also Protection (for electronic door locks) and Siren chapters.



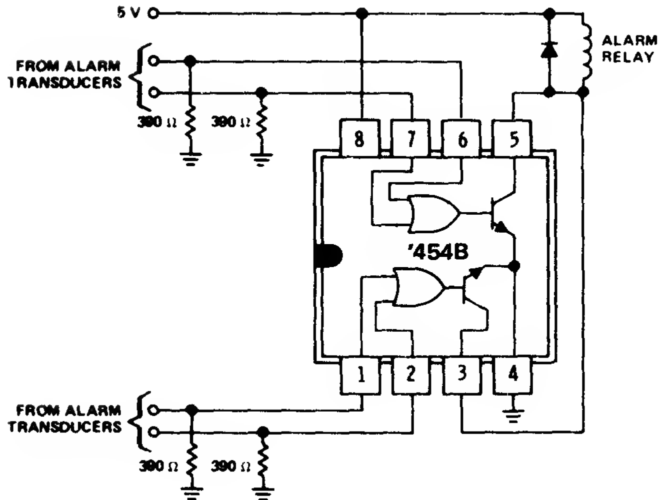
FIVE-INDICATOR ALARM—Singla five-transistor IC uses NPN structures on P-typa substrate as PNPN silicon controlled switchas having common connection for anoda (substrata). Relay sarving as anoda load is enargized for actuating alarm if any of the SCS pushbutton switches is closed. Corrasponding lamp is energized to identify door or window at which sensor switch has baan closed by act of intruder. Alarm remains on until reset by interrupting power supply. Powar drain on standby is negligibla becausa SCSs act as open circuits until triggered, parmitting usa of batterlas for supply. Two or mora ICs may ba added to get mora channals.—H. S. Kothari, Alarm System with Position Indication, *Wireless World*, Feb. 1976, p 77.





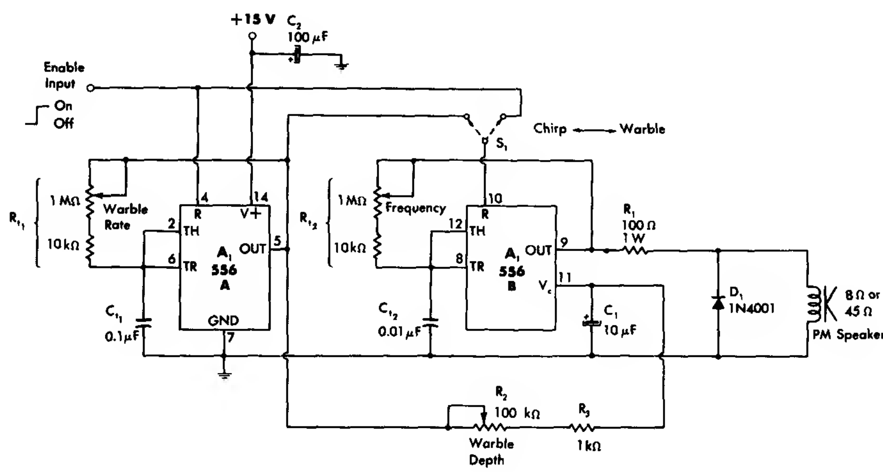
ENTRY-DELAY ALARM—First 555 timar providas delay of about 20 s aftar triggaring by sansor befora alarm bell is anargized, to allow thlef to ba caught inside housa or giva owner time to anter and shut off alarm. Alarm then rings for about 60 s under control of timar U2. Alarm period was set short to attract attention without unduly annoying naighbors.—J. D. Arnold, A Low-Cost Burglar Alarm for Home or Car, *QST*, Juna 1978, p 35–36.

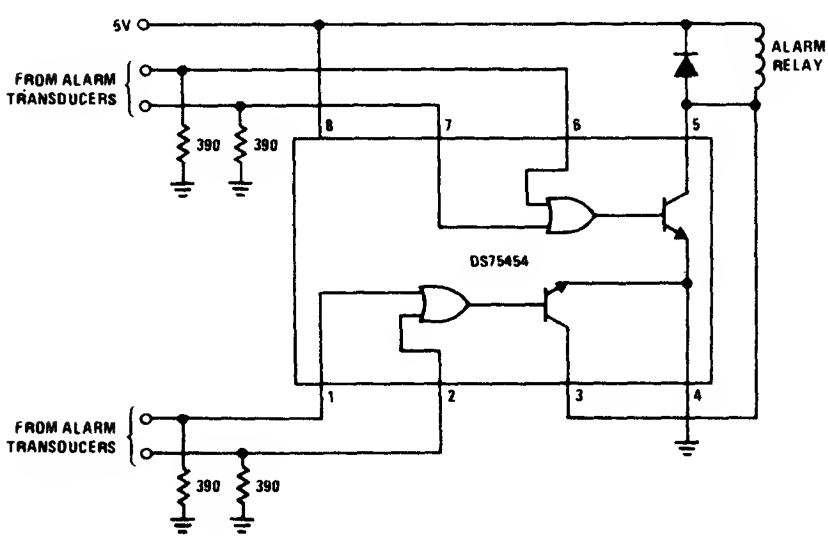
SCR LATCH—Turns on mobile transceivar or other mobile equipmant when power is applied, if axternal circuit is brokan when equipment Is stolen. Transmittar will then put unmodulated carriar on air evan with PTT switch disconnected or off, for tracing with radio direction findar. If addad componants ara carafully concealed in equipmant and naw axternal wiring is worked into existing wiring harness, faw thiavas will be abla to locata troubla. External wiras ara run undar dash so thlef must cut them to gat out equipment. PTT relay should have protectiva dioda. SCR Is 100 PIV, 1 A, but HEP R1003 or R1217 can also be used.—E. Noll, Circuits and Techniquas, *Ham Radio*, April 1976, p 40–43.



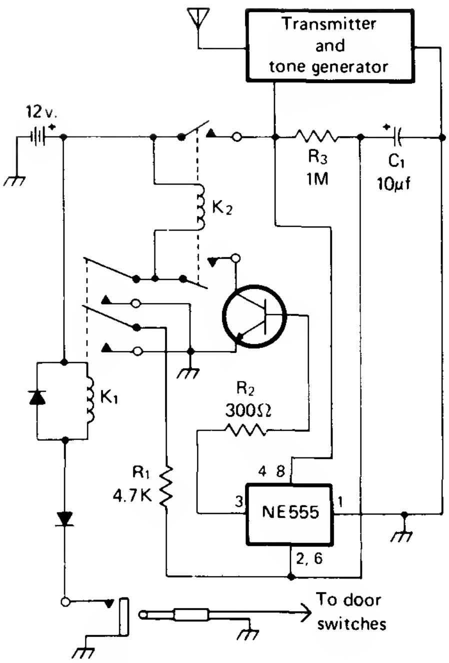
ALARM-SIGNAL DETECTOR—Texas Instruments SN75454B dual peripheral positive-NOR driver energizes alarm relay when alarm signal is received from any one of four different alarm transducers.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 10-66.

AURAL INDICATOR—Provides attention-getting chirp sound, warble, or continuous tone when turned on by high input from burglar-alarm sensor circuit. Second section of 556 timer provides optional frequency modulation of basic tone to give warbling effect. Chirp is achieved by gating tone oscillator on only during high states of warble oscillator. Aural sensitivity is maximum in range of 1–2 kHz, set by value of R_{t2}.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 232–235.

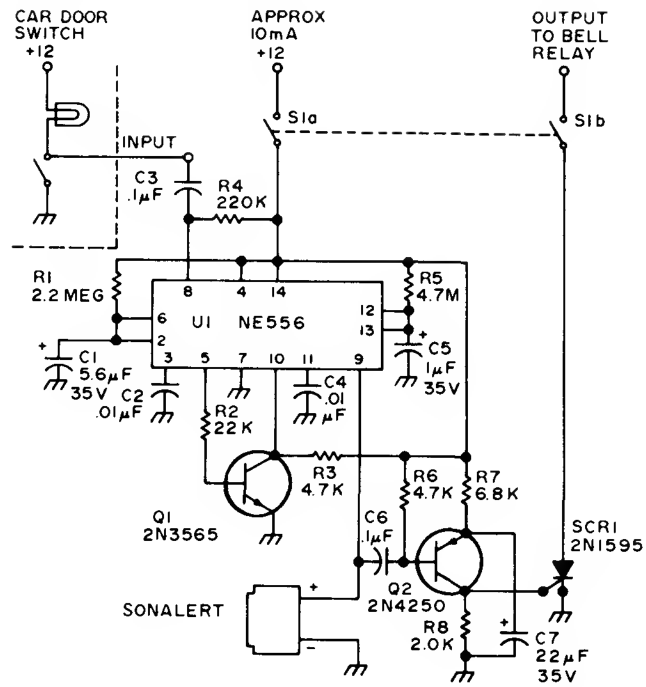




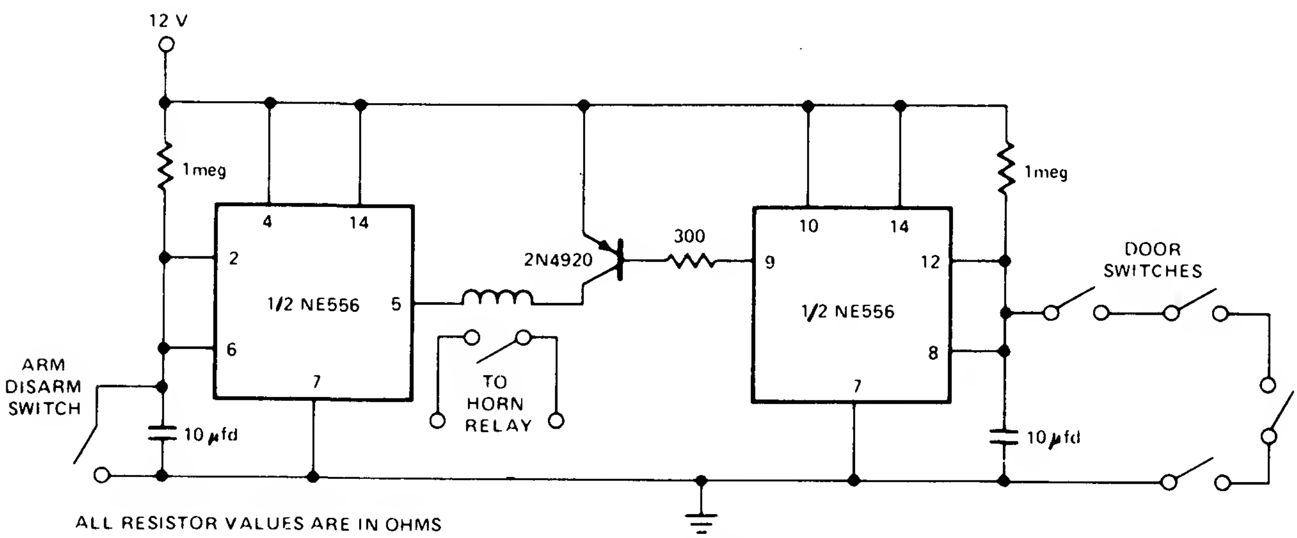
ALARM DETECTOR—National DS75454 dual peripheral NOR driver operating from single 5-V supply energizes alarm relay when one of alarm transducers for either section delivers logic signal as result of intruder action.—"Interface Databook," National Semiconductor, Santa Clara, CA, 1978, p 3-20–3-30.



SILENT ALARM—When thief opens car door, relays K_1 and K_2 activate tone-modulated transmitter, which can be any legal combination of power, frequency, and antenna. A few milliwatts of power should be adequate. Thief hears nothing, but owner is alerted via portable receiver tuned to transmitter frequency. Transmitter remains on about 15 s (determined by R_3 and C_1) after door is closed until NE555 times out and removes power from transistor. Use any NPN transistor having adequate current rating for relay. If alarm is provided with its own battery and whip antenna, it cannot be disabled from outside of car.—A. Day, Soundless Mobile Alarm, *CQ*, April 1977, p 11.



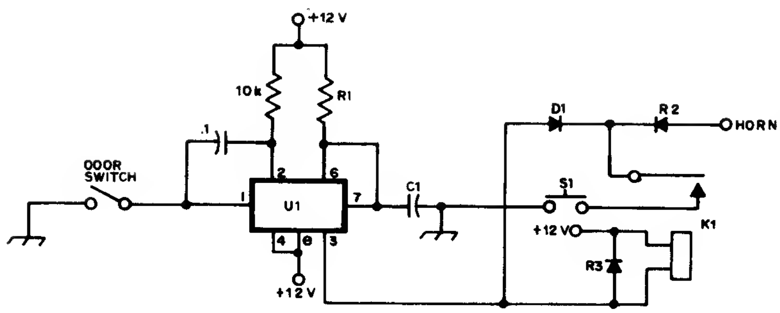
CAR-THEFT ALARM—Alarm remains on even if signal from car door switch or other sensor is only momentary, so relay is wired to be self-latching until keyswitch S1 is turned off. Use hood locks or hood-opening sensors to prevent thief from disabling alarm by cutting battery cable. Circuit includes time delay of 6 s for entering car and shutting off alarm, to avoid need for external keyswitch. Sonalert makes loud tone during 6-s delay period to remind driver that alarm needs to be turned off. At end of 6 s, Sonalert stops and much louder bell is energized to further discourage intruder.—J. Pawlan, The Smart Alarm, *73 Magazine*, June 1975, p 37–41.



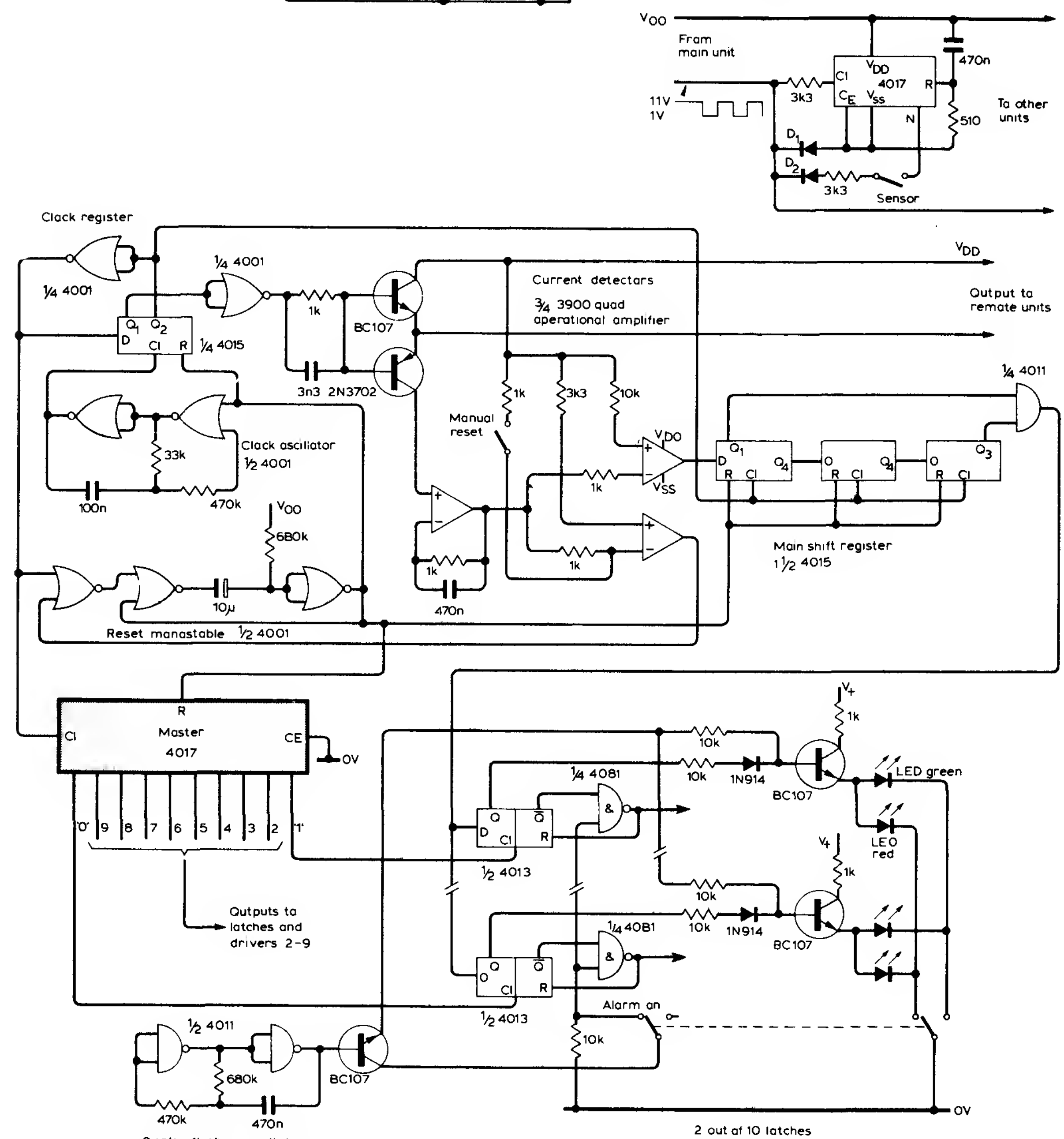
ALL RESISTOR VALUES ARE IN OHMS

SHORT DURATION TIMERS ARE NEEDED TO ALLOW ENTRY AND EXIT

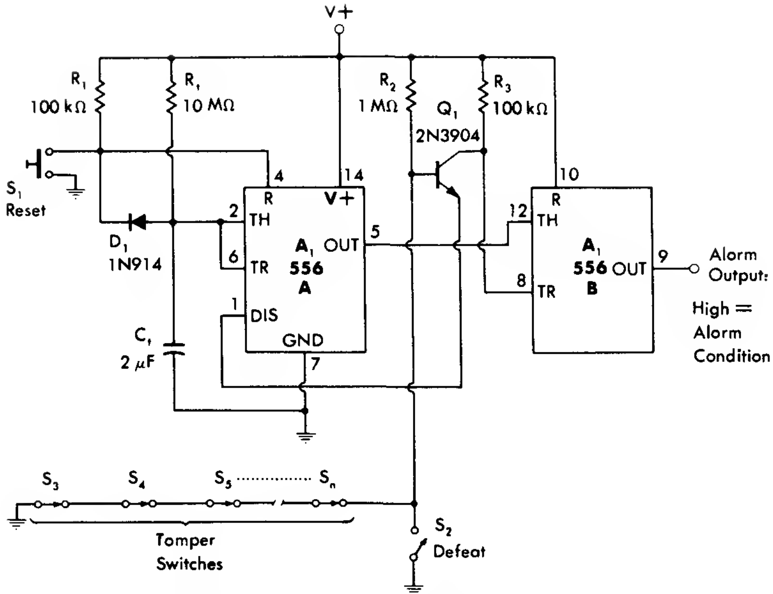
DELAYED ALARM—When normally closed arm/disarm switch is opened, first section of NE556 dual timer starts its timing cycle. After delay to allow for entry or exit, pin 5 goes low to energize alarm circuit. Now, as long as all door switches are closed, PNP transistor is kept off because pin 9 is high. When any door switch is opened, transistor turns on after normal delay for owner to enter car, and horn is sounded unless owner closes arm/disarm switch within delay time.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 724–725.



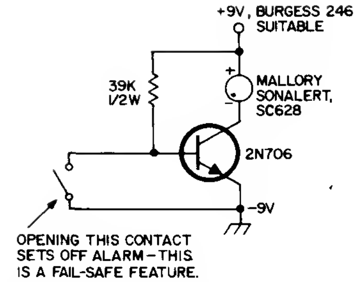
FAIL-SAFE TIMED ALARM—Horn comes on about 30 s after intruder closes door switch by opening car door. Delay is produced by NE555 timer to allow driver to close door after entering or leaving. Thief must keep door open to get leg room for removing equipment under dash. Diodes are 50-PIV 1-A silicon. K1 has 12-V coil. Alarm is set at all times. S1 is normally closed pushbutton type in door jam. Opening S1 starts timer, and closing it resets alarm.—R. S. Harvey, Junk Box Foils Thieves, *QST*, Sept. 1977, p 50–51.



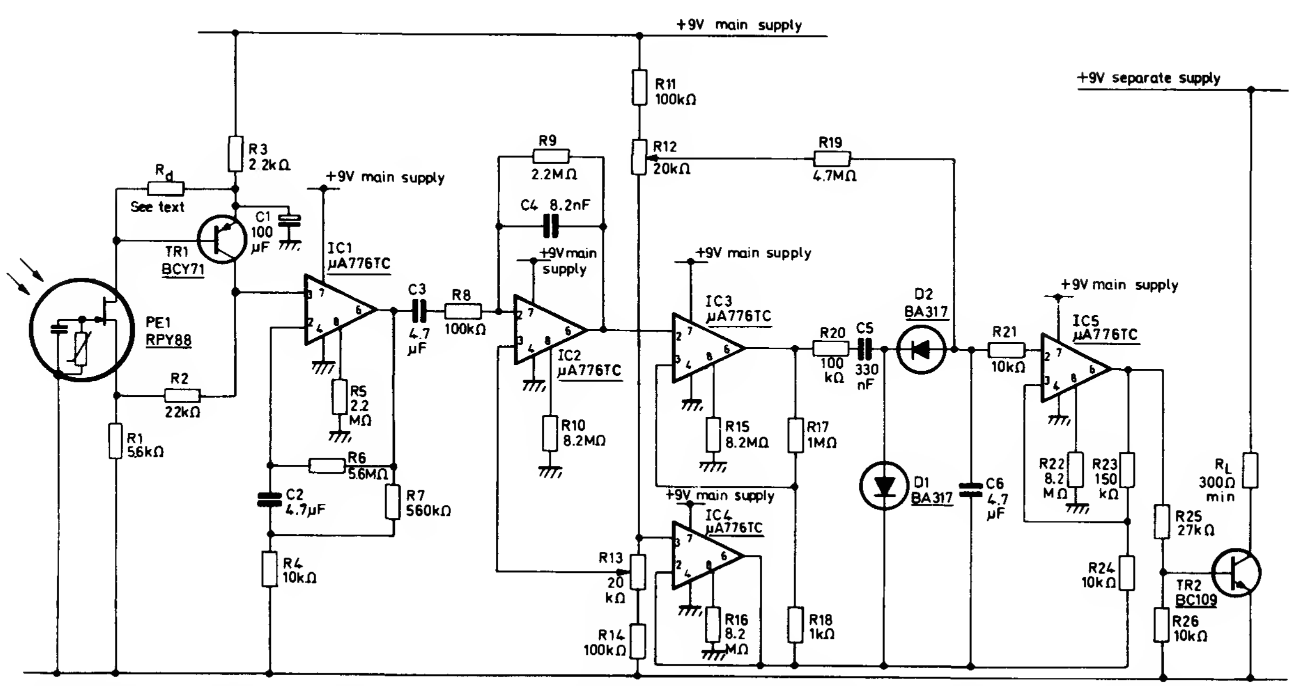
MULTIPLEXED BURGLAR ALARM—Multiplexing technique provides for detection of state of up to 10 sensors, with immediate identification and location of activated sensor. Only one pair of wires runs from control unit to paralleled remote sensor circuits, one of which is shown at upper right. Each sensor location uses different output from one to zero. Multiplexer circuit is based on 4017 decade counter having 10 individual outputs, to give signals in 10 time slots. Power supply rail is used to reset counter. Clock line is eliminated by switching supply line as square wave. Sensor indication line is eliminated by detecting power supply current drain. Control unit uses oscillator and shift register to generate clocking waveforms. 3900 quad opamp converts sensor line current to logic levels for clocking by master 4017 to control 10 output latches and display driver. Two consecutive sensor-open signals are required to activate alarm, minimizing false alarms by interference pulses.—R. J. Chance, Multiplexed Alarm, *Wireless World*, Nov. 1978, p 73–74.



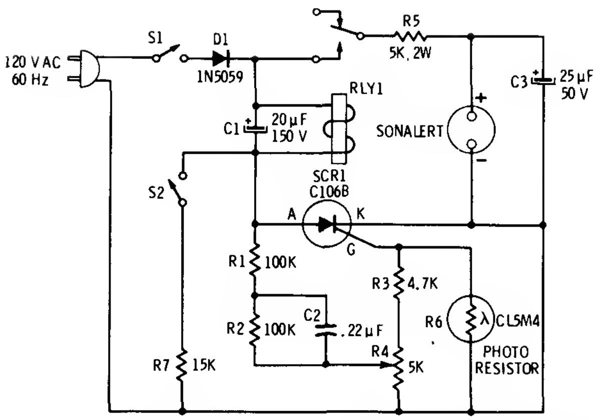
WINDOW-FOIL ALARM—Combination of power-up mono MVBR end latch, using both sections of 556 timar, drives output line high when sensor circuit is opened at door or window switch or by breeking foil on glass. Once elerm is triggered, reclosing of sensor hes no effect; S_1 must be closed momenterily after restoring sensor circuit to turn elerm off. Circuit includes 22-s power-up delay that prevents triggaring of alarm when it is first turned on.—W. G. Jung, "IC Timar Cookbook," Howerd W. Sams, Indianapolis, IN, 1977, p 231–232.



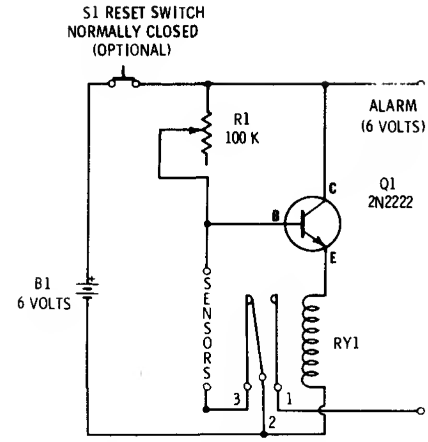
CIRCUIT-BREAKING ALARM—Operates from smell 9-V bettary, meking it independent of AC power failura. Opaning of switch or equivalent breeking of foil conductor removes ground from besa of transistor, to energize elarm.—Circuits, *73 Magazine,* April 1973, p 132.



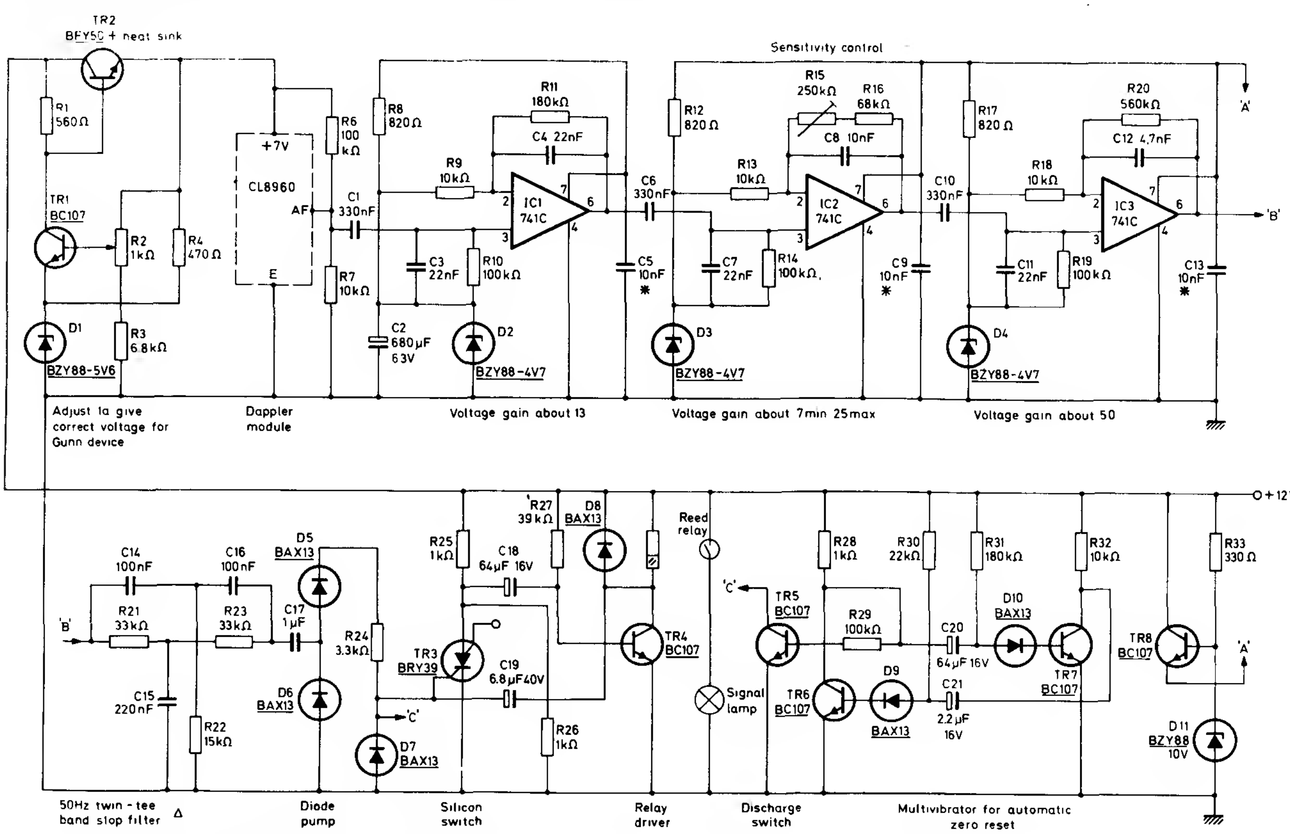
LOW-CURRENT INTRUDER ALARM—Use of progremmeble μA776 opamps reduces standby current of infrared alarm to 300 μA, parmitting operation from small rachargeable cells. Detector is Mullerd RPY86 that responds only to wavalengths ebova 6 μm, making it immune to sunlight and backgrounds intermittently illuminated by sun. Low-cost mirror is usad instead of lens to concentrata infrared radiation on detector. R_d is chosen to maka input to first opamp between 2 and 6 V. Circuit energizes alarm reley R_L only whan incidant radiation is changad by movement of intrudar in monitored spaca.—"Caramic Pyroelectric Infrarad Detectors," Mullard, London, 1978, Technical Note 79, TP1664, p 8.



LIGHT-INTERRUPTION DETECTOR—Usa of SCR as regenerativa amplifier rather than as switch gives extremely high sansitivity to very slight reductions in light raaching photorasistor. Requiras no light sourca or eccurataly eligned light-beam optics. In typical epplication es burglar alarm, light shining through window from streetlight provides sufficient ambiant illuminetion so any movement of intruder within 10 feet of unit will anargiza Sonelert elarm. Sensitivity control R4 is edjusted so SCR recaives positiva pulses from AC line, but thair amplituda is not quita enough to start reganarative ection of SCR. Reduction in light then increases resistance of photoresistor anough to raise leval of gata pulses for SCR, starting reganarative emplification that anergizes raley. Use Mallory SC-628P Sonelart which producas pulsed 2500-Hz sound. With S2 open, alarm stops whan chenges in light ceese. With S2 closed, elarm is latched on and S1 must ba opened to stop sound.—R. F. Graf end G. J. Whelen, "The Build-It Book of Safety Electronics," Howerd W. Sems, Indianapolis, IN, 1976, p 7–12.



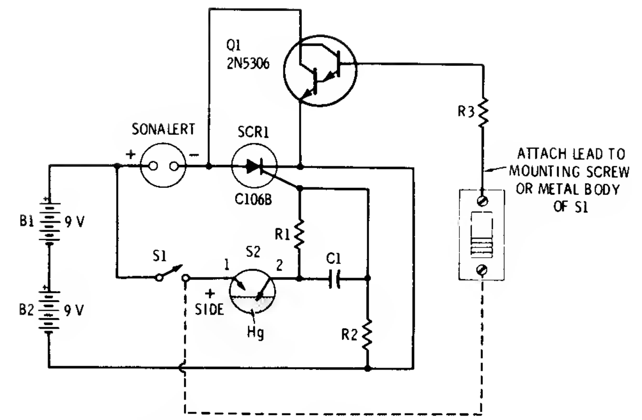
LATCHING ALARM—Closed-circuit alarm drewing only 130 μA of standby current from bettary is turned on by opaning sansor switch or cutting wire. Autometic latching contacts on raley prevent burgler or intrudar from deectiveting elerm by resetting sansor switch. Raley is Redio Sheck 275-004. Sensor can be foil strip eround window subject to braakage.—F. M. Mims, "Transistor Projects, Vol. 3," Redio Sheck, Fort Worth, TX, 1975, p 75–86.



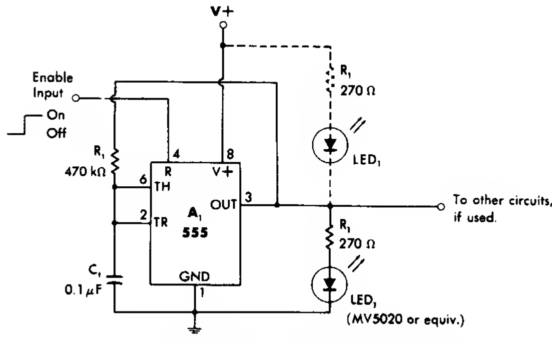
* 10nF capacitors C5, C9, and C13 should be connected as close as possible between pins 4 and 7 of ICs

Δ For 60Hz use 27kΩ for R21, R23, and 12kΩ for R22

MICROWAVE DOPPLER INTRUSION ALARM—Mullard CL8960 X-band Doppler rader module detects movament of ramota target by monitoring Doppler shift in microweve rediation reflected from target. Module consists of Gunn oscillator cavity producing anergy to ba radiated, mounted alongside mixer cavity that combines reflected energy with sampla of oscillator signel. Transmitted frequency is 10.7 GHz. Dopplar change is ebout 31 Hz for relative valocity of 0.45 m/s (1 mph) of relative velocity between object and modula, giving AF output for valocities up to 400 mph. Filtared AF is applied through diode pump to trigger of silicon controlled switch TR3 that mekes contects of reed raley open for about 1 s. Reley ection is repeeted es long as intruder is in monitored eree. Report covars circuit oparation in detail.—J. E. Saw, "Microwava Dopplar Intrudar Alarms," Mullard, London, 1976, Technical Information 36, TP1570, p 6.

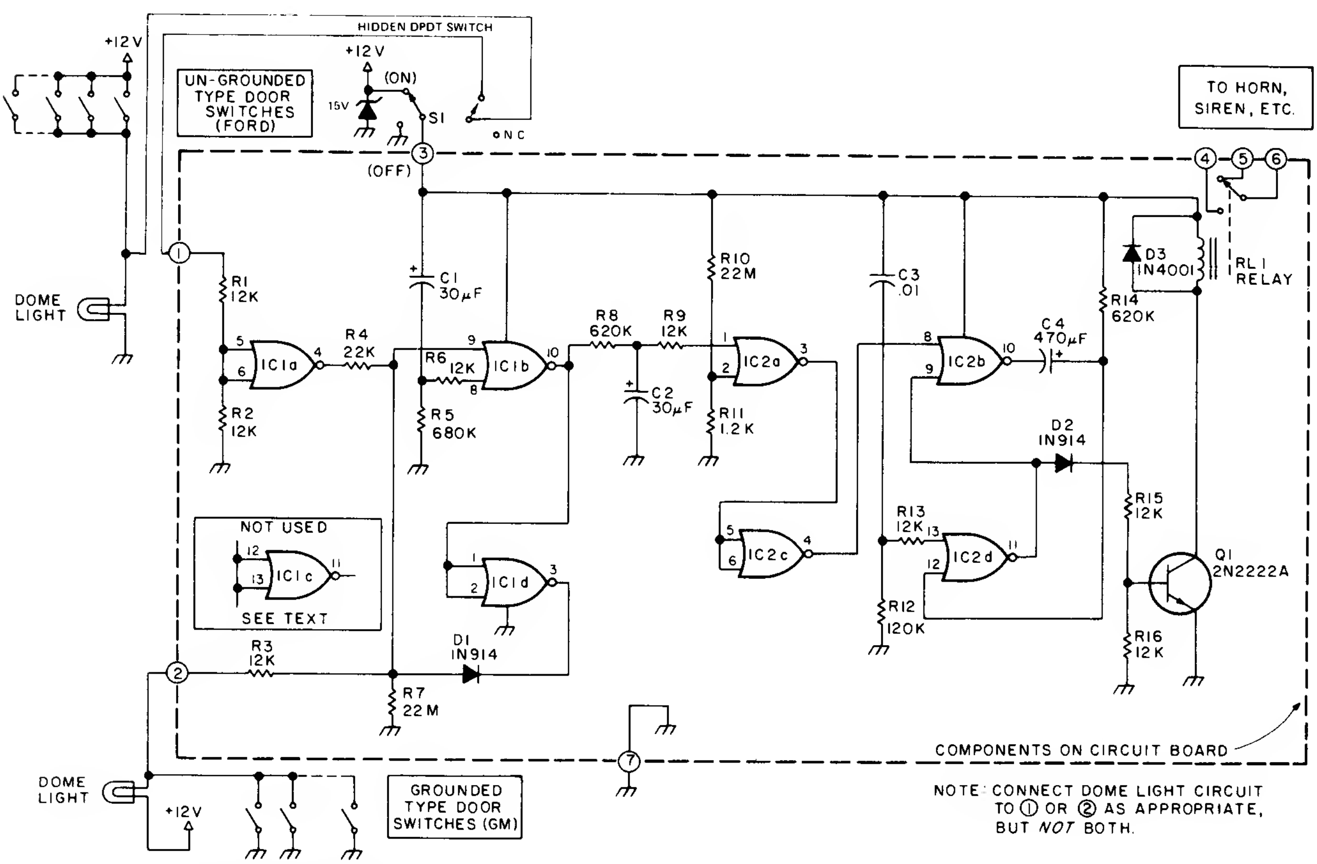


NOTE: TOUCHING MOUNTING SCREW OF S1 AND CASE OF S2 COMMUTATES SCR BY MOMENTARILY ENERGIZING Q1



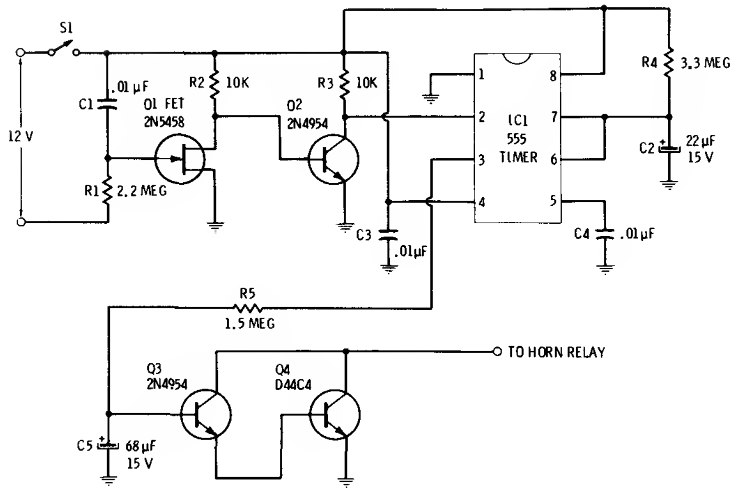
HOTEL-ROOM ALARM—Alarm mounted in flashlight-shaped cylinder is positioned on floor inside hotel room in such a way that it is knocked over by intruder opening door. Mercury switch S2 then triggers SCR and activates Mallory SC-628P pulsed Sonalert alarm. Circuit latches on and can be turned off only by use of Darlington-amplifier touch switch. Connection from base of Darlington to positive terminal of battery must be made through fingertips as shown by dashed line in order to silence alarm. Once silenced, S1 can be opened to disconnect latch so alarm can be moved. Other applications include protection of unattended luggage. C1 is 0.1 μF, R1 is 1 megohm, R2 is 1K, R3 is 39K, and S2 is mercury element removed from GE mercury toggle switch.—R. F. Graf and G. J. Whelan, "The Build-It Book of Safety Electronics," Howard W. Sams, Indianapolis, IN, 1976, p 19–24.

VISUAL INDICATOR—When circuit is activated by high output of burglar alarm circuit, 555 timer operating as very low frequency MVBR makes LED_1 flash on and off during alarm condition. Alternate connection of LED_1 to V+ holds LED_1 on for standby while flashing it during alarm. Oscillator output is also available for other uses if desired. Indicator can be located remotely from alarm.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 232–235.

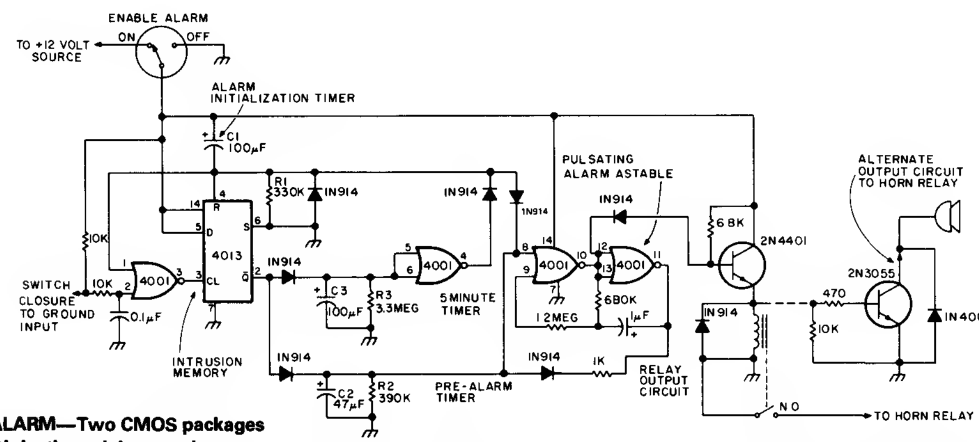


NOTE: CONNECT DOME LIGHT CIRCUIT TO ① OR ② AS APPROPRIATE, BUT *NOT* BOTH.

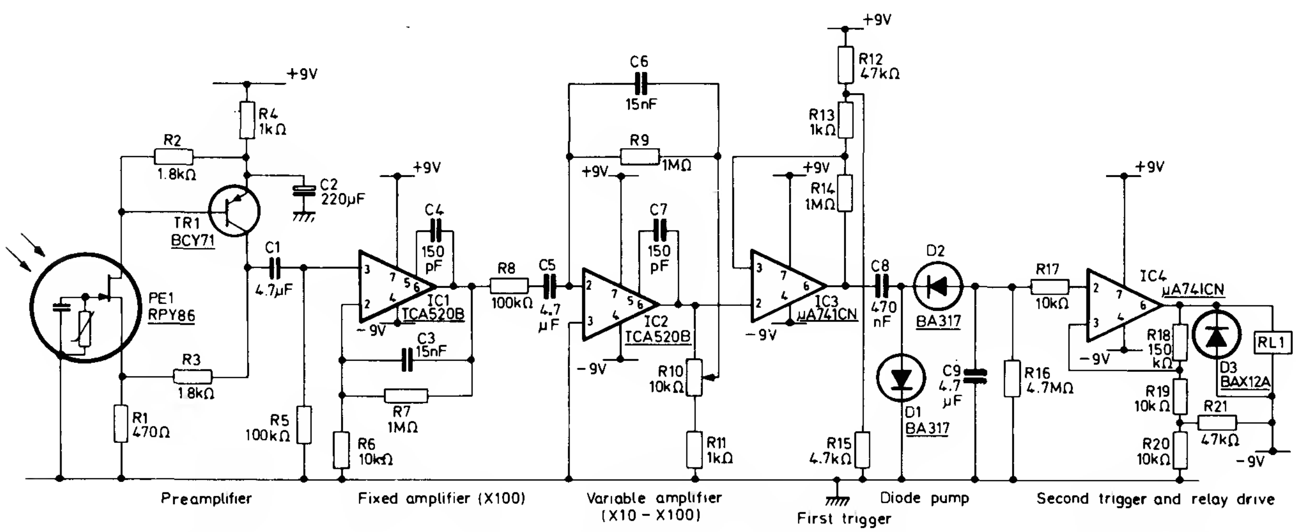
5-min SHUTOFF—Vehicle intrusion alarm shuts off automatically in about 5 min after being triggered, as required by law in some states. Drain on battery is negligible until alarm is set off by intruder. Once triggered, operation sequence is not affected by subsequent opening or closing of doors. System uses two CMOS CD4001AE quad two-input NOR gates for switching logic. IC1 provides sensor interface, latch, and entry/exit time delays. IC2 provides output through Q1 and relay, as well as automatic shutoff delay. Article gives construction details and layout for printed-circuit board.—W. J. Prudhomme, Vehicle Security Systems, *73 Magazine*, Oct. 1977, p 122–125.



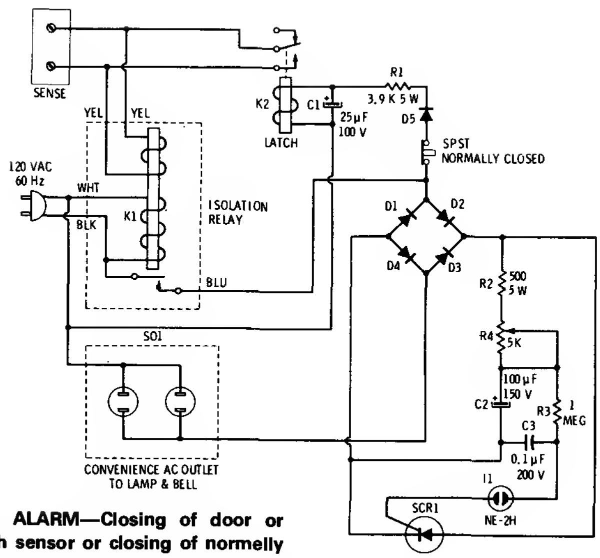
CURRENT-DRAIN SENSOR—Current drawn by dome light when door is open or by ignition when turned on triggers current-sensing stages Q1 and Q2 to start 555 timar and apply power to horn relay. Initial 15-s delay in sounding hom allows owner to enter car and opan hidden switch S1 to deactivate alarm. If S1 is not opened during delay intarval, hom sounds for about 90 s, then circuit autometically resets itself. C5 and R5 control duration of initial 15-s delay. C2 and R4 control total time that horn sounds.—R. F. Graf and G. J. Whalan, "The Build-It Book of Safety Electronics," Howard W. Sams, Indianapolis, IN, 1976, p 57–62.



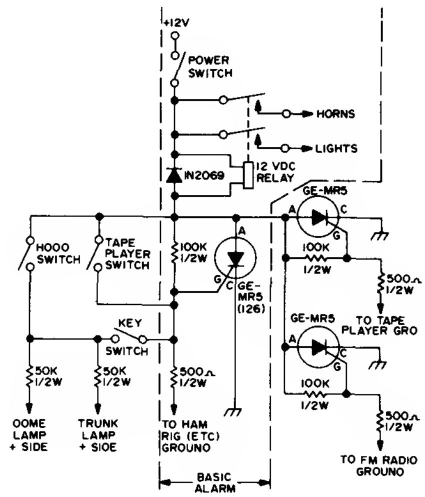
PULSED-HORN ALARM—Two CMOS packages incorporata multipla tima dalays to improve convaniance and effectivaness of auto intrusion alarm. R1C1 gives 30-s dalay for arming alarm aftar it is turned on by switch concealed Insida car, to lat driver get out of car. R2C2 gives 15-s dalay before alarm sounds after door is openad, to allow drivar to get back in car again and disabla alarm. R3C3 turns off alarm in 300 s and rasets alarm system for next intrusion. Car hom is pulsed 60 times par minute, so alarm would not be confused with stuck horn. Article talls how circuit works and gives detailed instructions for installation and connection to door and trunk switches.—G. Hinkla, Giva tha Hamburglar Heart Failura, *73 Magazine*, Fab. 1977, p 36–37.



INTRUDER ALARM—Input is from Mullard RPY86 infrared detector responding to wavalengths abova 6 µm, making it immune to sunlight and backgrounds intermittently illuminated by sun. Output signal is produced only whan incidant radiation is changed by movement of intruder in monitored space. Mirrors rether than lenses concentrate incidant radiation on detector because mirrors do not require high-quality surface finish. Preamp is followed by two amplifier stages, with R10 varying gain of second stage between 10 and 100. Bandwidth is 0.3–10 Hz. First trigger, having threshold of about 1 V, drives second triggar through dioda pump to energiza alarm ralay when intrudar is present.—"Caramic Pyroelectric Infrared Detectors," Mullard, London, 1978, Technical Note 79, TP1664, p 8.

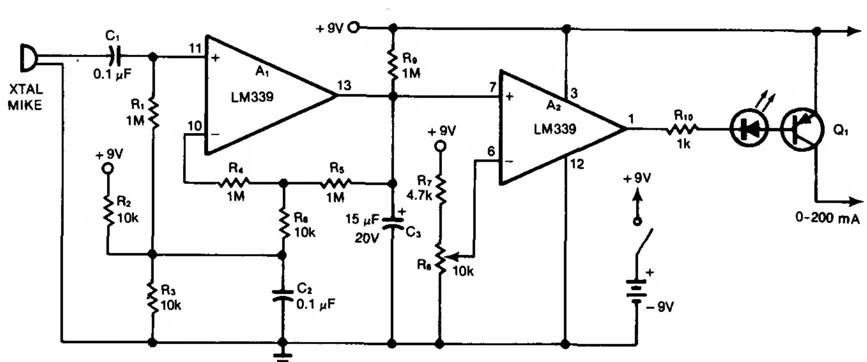


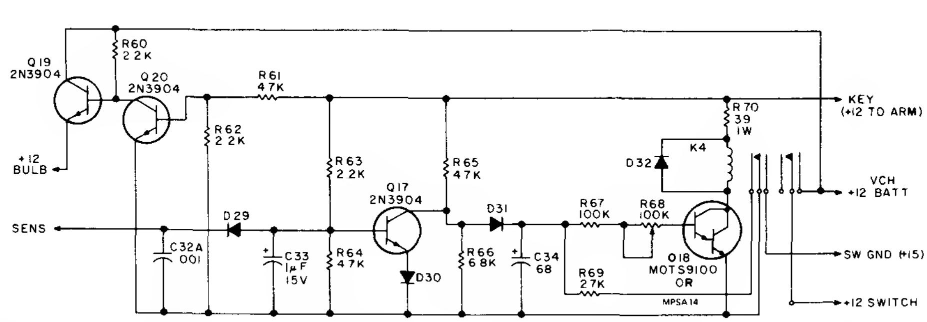
OPEN-CIRCUIT ALARM—Closing of door or window switch sensor or closing of normelly open panic-button switch at bedside end other stretegic locations in home trips elerm that sounds loud ball and fleshes bright light on end off. Sensor shorts control winding of K1, ellowing K1 to drop out end epply line voltege to alarm circuit. One AC peth is through D5 which rectifies AC for energizing DC letch reley K2 to short sensor lines even though initieting sensor hes opened. Simultanaously, AC is applied to dioda bridge having SCR between DC legs. C2 sterts cherging through R2 and R4, end C3 charges through R3. Whan voltege across C3 reeches ebout 90 VDC, it fires neon end C3 discherges into gata of SCR. Full line voltage is then epplied to lamp end bell plugged into loed outlets. When C2 drops below holding current, SCR turns off during next AC cycle end loed goes off until neon fires again. Setting of 5K pot R4 gives renge of 15-80 fleshes end horn pulses per second. To stop elerm, open SPST switch momanterily.—R. F. Graf and G. J. Whalen, "The Build-It Book of Sefety Electronics," Howerd W. Sems, Indianapolis, IN, 1976, p 75–80.



WIRE-CUTTING ALARM—SCR normelly ects as open circuit in series with 12-VDC alarm ralay because grid is mede negative by voltege divider consisting of 100K in saries with 500 ohms. If ground on 500-ohm resistor is removed, es by removel of tepe pleyer or CB set from cer by thief, gete becomes more positiva and SCR conducts, to anergize relay, sound hom, end meke heedlights shine brightly. Additionel triggering SCRs or elerm switches can be edded es shown outside of dashed eree for besic alarm.—A. Szablak, Another Burglar Alarm, *73 Magazine*, Mey 1974, p 45–46.

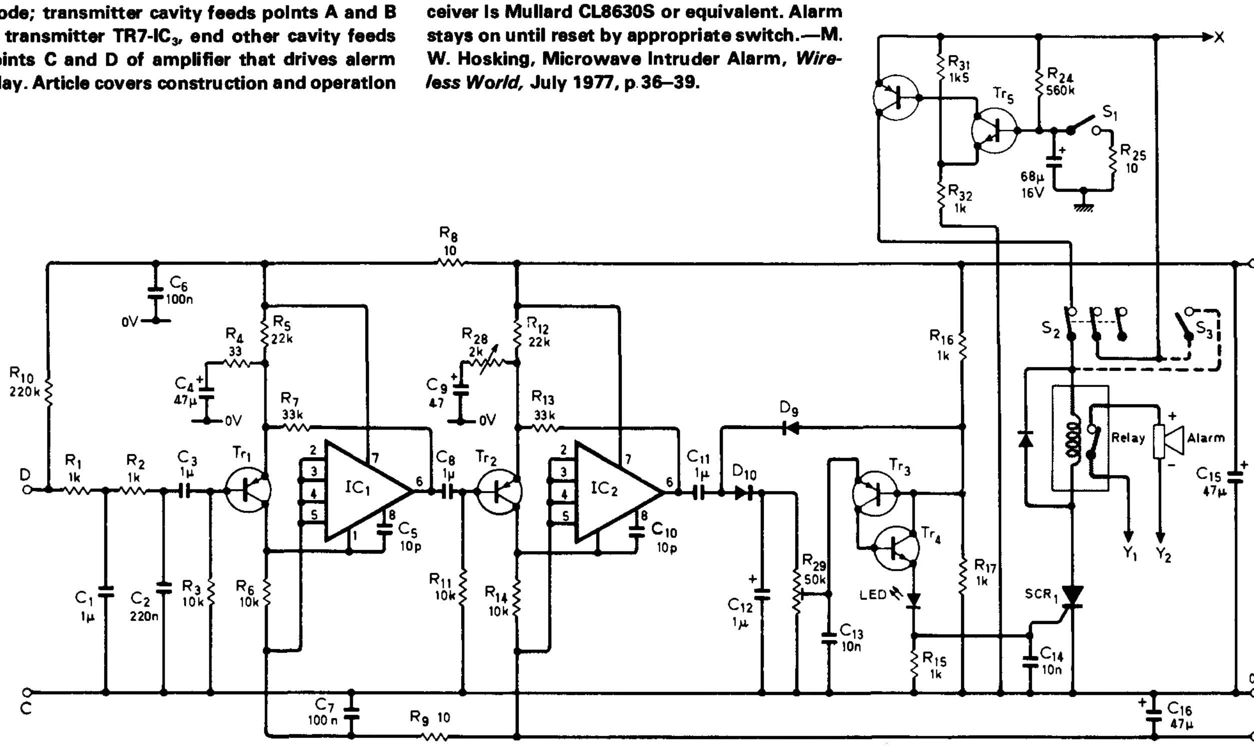
SOUND-ACTIVATED SWITCH—Can ba used es sansor for burgler elerm or for turning on surveillence tepe recorder to monitor conversetions. R_8 is edjusted to give desired sensitivity et which A_2 triggars switch Q_1 to provide 200-mA loed current and turn on indicator LED. First section of LM339 qued comparetor serves as emplifier and detector providing gain of 100. Second comperator comperes DC output of first with reference level selected by R_8.—D. R. Morgan, Sound Turns Switch On, *EDN Magazine*, Aug. 5, 1978, p 82 and 84.

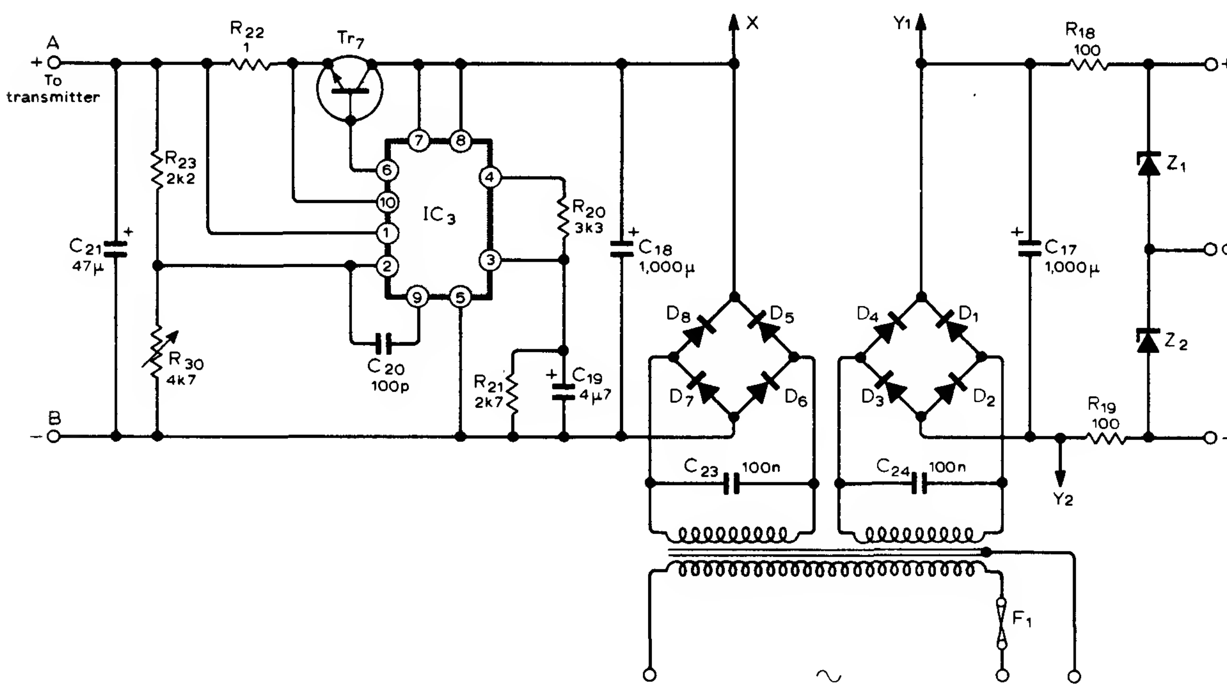


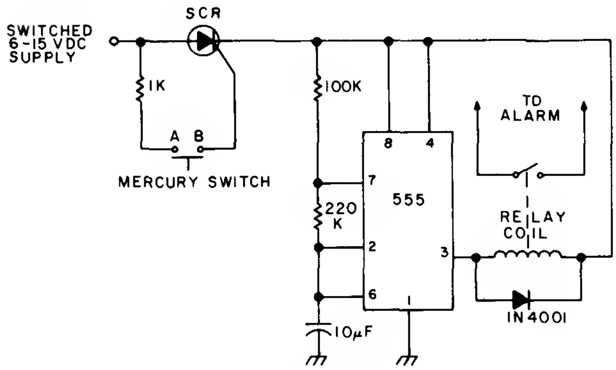


ALARM DRIVES PAGING BEEPER—Complete protection of vehicle is providad by multiplicity of door-switch, mat-switch, vibration, motion, and other sensors connected to common sensor input of elerm switching circuit thet controls radio pager, 1-W GE Voice Command II transmitter operating around 147 MHz, 100-W electronic siren, and power horns. Closing of contacts in eny sensor grounds common input (assuming keylock switch has been closed to erm circuit by epplying +12 V), epplying power to siren and pager system. Range is about 1 mi for Motorola Pegeboy II cigarette-pack-size pager receiver. Article describes construction, operation, end installation in detail and gives complete circuit of peger.—J. Crewford, Build e Beeper Alerm, *73 Magazine*, Oct. 1977, p 68–77.

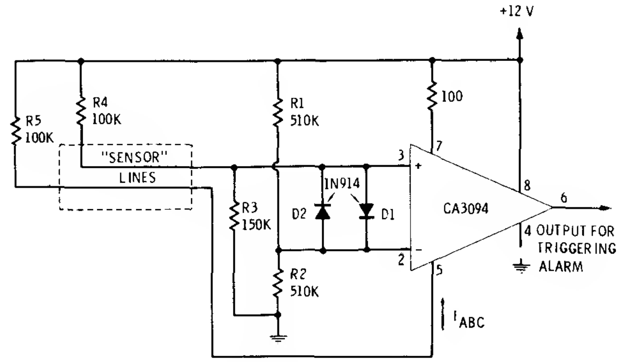
DOPPLER BURGLAR ALARM—Small radar transmitter operating at 10.687 GHz fills protected area with radio waves. Waves reflected from stationary objects are ignored by receiver, while waves undergoing Doppler shift in frequency by reflection from moving object such as intruder are selectively amplified for triggering of alarm. Single waveguide section is divided into two cavities, each having Gunn diode; transmitter cavity feeds points A and B of transmitter TR7-IC_3, and other cavity feeds points C and D of amplifier that drives alarm relay. Article covers construction and operation of circuit and gives sources (British) for parts and construction kits. Opamps are SN72748 or equivalent, IC_3 is μA723 or equivalent, Tr_1-Tr_3 are ZTX500 or equivalent, Tr_4-Tr_6 are ZTX302 or equivalent, Tr_7 is 3055, D_1-D_8 are 1N4001 or equivalent, D_9-D_{10} are 1N914, SCR_1 is TIC44 or equivalent, Z_1-Z_2 are BZY88-C8V2, relay is 18-V with 1K coil, Doppler module is Mullard CL8960 or equivalent, and self-oscillating mixer for receiver is Mullard CL8630S or equivalent. Alarm stays on until reset by appropriate switch.—M. W. Hosking, Microwave Intruder Alarm, *Wireless World*, July 1977, p. 36–39.



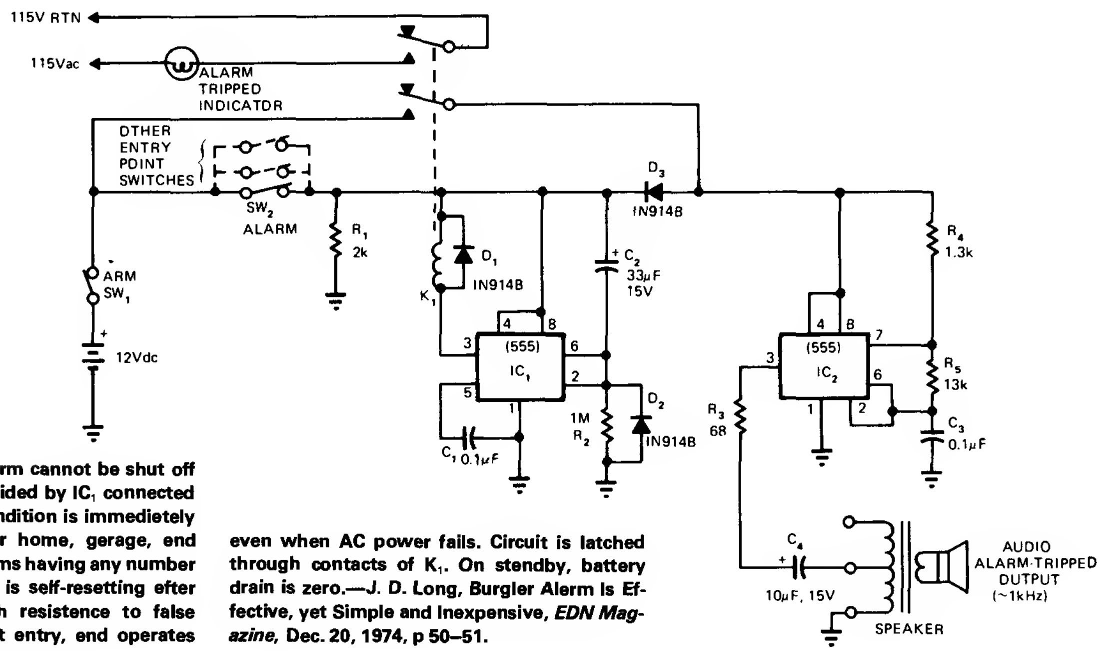




BEEPER—Intermittent alarm using 555 timer can be set to energize horn, lights, or other signaling device at any desired interval when tripped. When used on auto, sound cannot be mistaken for stuck horn. Choose SCR rating to handle current drawn by relay and timer. If alarm draws less than 200 mA, relay is not needed.—W. Pinner, Alarm! Alarm! Alarm!, *73 Magazine*, Feb. 1976, p 138–139.



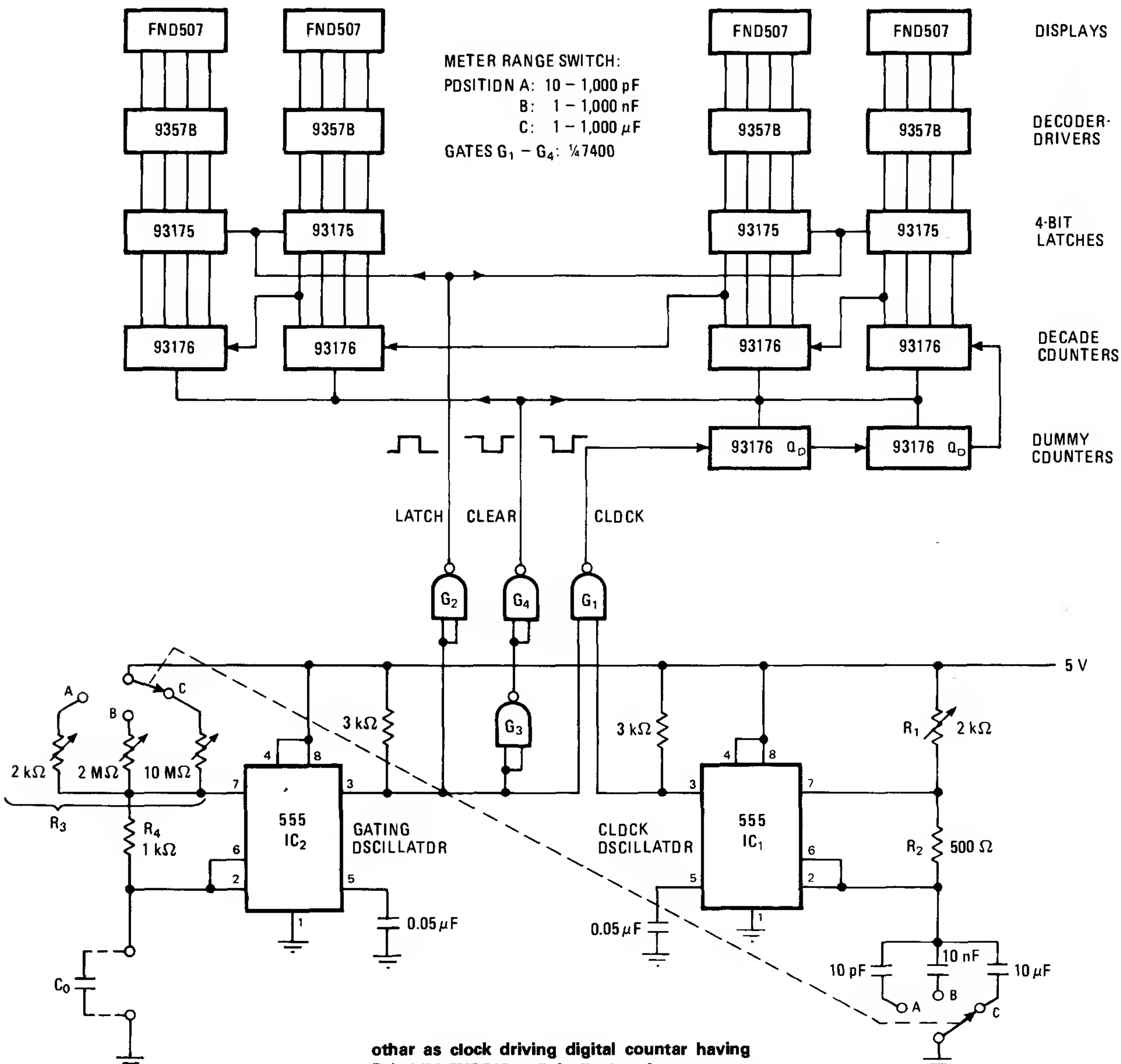
OPEN/SHORT/GROUND ALARM—Pin 6 of CA3094 IC is high for no-alarm condition. When any one sensor line is open, is shorted to other line, or is shorted to ground, output of IC goes low and resulting output current serves for activating alarm system.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 316–317.



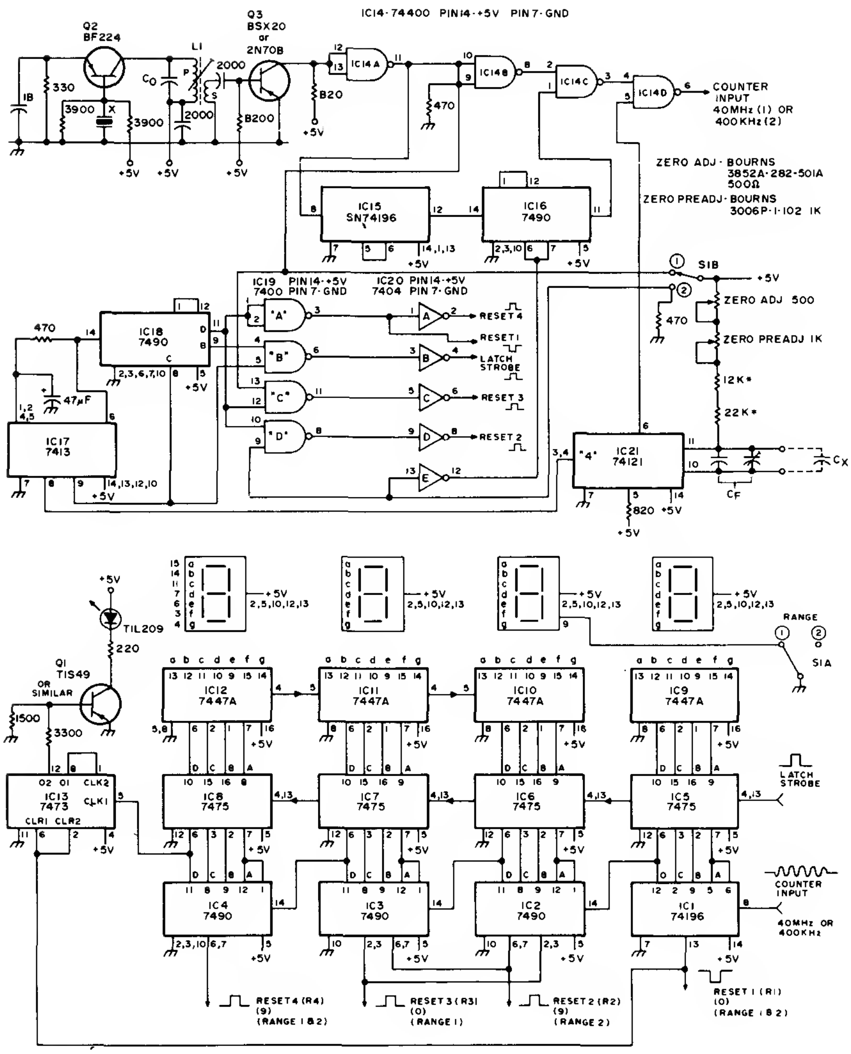
LATCH-ON ALARM—Alarm cannot be shut off for 12 s, with delay provided by IC_1 connected as mono, even if trip condition is immediately removed. Developed for home, garage, and auto burglar alarm systems having any number of trip switches. Circuit is self-resetting after delay interval, has high resistance to false alarms other than direct entry, and operates even when AC power fails. Circuit is latched through contacts of K_1. On standby, battery drain is zero.—J. D. Long, Burglar Alarm Is Effective, yet Simple and Inexpensive, *EDN Magazine*, Dec. 20, 1974, p 50–51.

CHAPTER 10
Capacitance Measuring Circuits

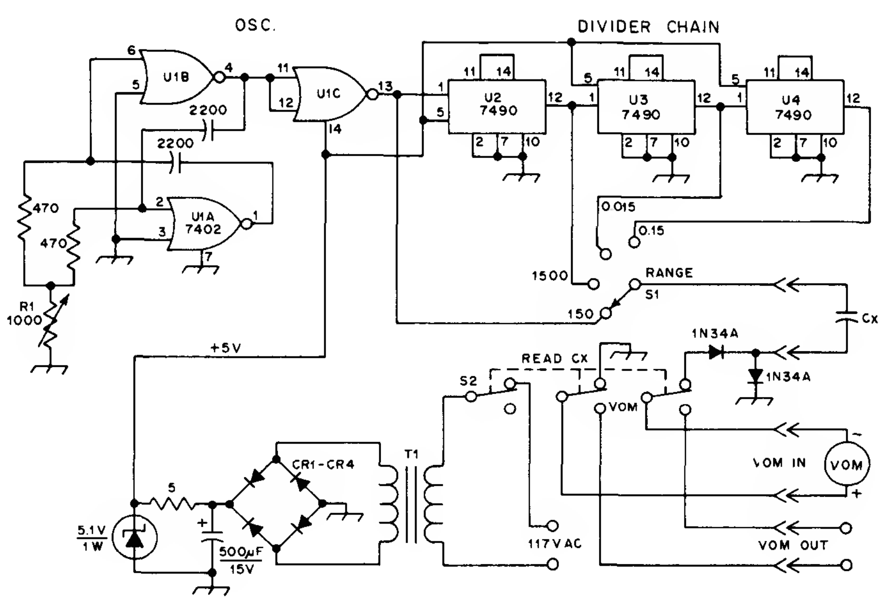
Timers, bridges, dip meters, counters, phase-locked loops, and microprocessors drive meters, digital displays, or audible indicators giving values of capacitors.



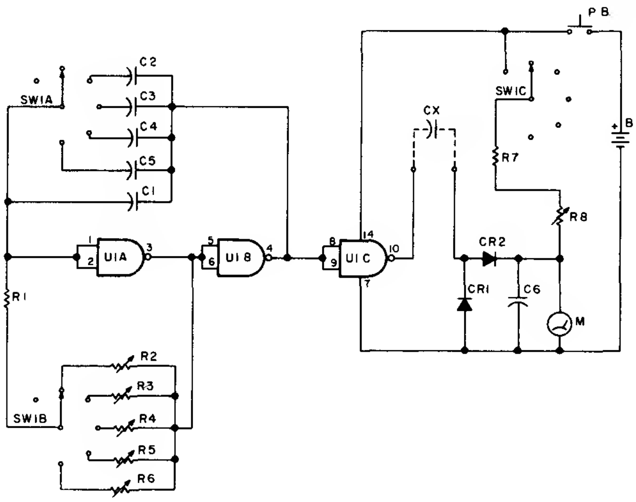
10 pF TO 1000 μF DIGITAL—Uses 555 timars as free-running oscillators, one for gating and othar as clock driving digital countar having Fairchild FND507 4-digit display. Arrangamant givas good accuracy without usa of crystal oscillator.—W. H. Wang, Low-Cost Oscillators Build Accurate Capacitance Meter, *Electronics*, May 26, 1977, p 127 and 129.



1 pF TO 1 μF—Presents instantly in digital form the value of unknown capacitor, in ranges of 1–9999 pF and 1–999.9 nF. Four digits are displayed, with leading-zero suppression and overflow indicator. Accuracy is better than 0.1% of full range $\pm$ 1 digit for higher values in both ranges. Mono MVBR IC21 produces pulse whose length is directly proportional to value of C_X plus about 980-pF total in C_F. This pulse enables gate IC14D whose output goes to counter. Oscillator Q2, buffer Q3, dividers IC15 and IC16, and gates IC14 together give 40-MHz (range 1) or 400-kHz (range 2) pulses that are counted while IC21 holds IC14D open. Article covers construction in detail.—I. M. Chladek, Build This Digital Capacity Meter, *73 Magazine*, Jan. 1976, p 70–78.

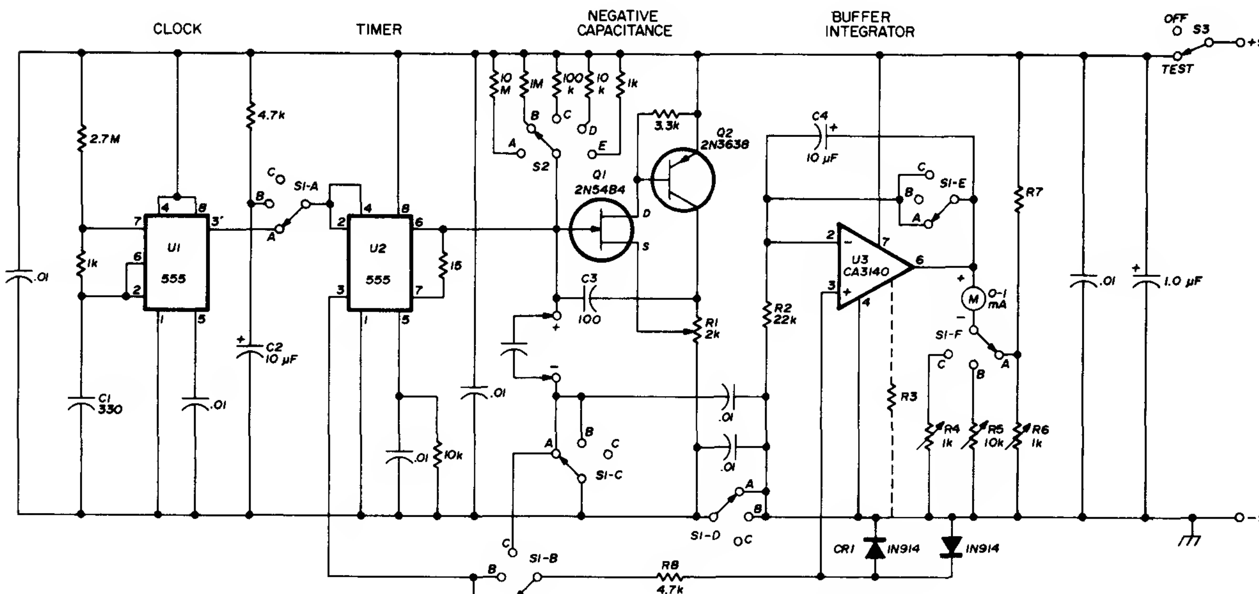


C WITH VOM—TTL-derived square-wave generator U1 charges unknown capacitor C_X to about 3.5 V at 285 kHz when using 150-μA scale of Heath MM-1 volt-ohm-milliammeter, to give 150-pF full-scale range. Larger values of capacitance are read by decreasing frequency with 7490 decade dividers. Use Mallory PTC401 for CR1-CR4. T1 is 6.3-VAC filament transformer. S2 restores normal VOM functions. Article gives design equations.—K. H. Cavcey, Read Capacitance with Your VOM, *QST*, Dec. 1975, p 36–37.



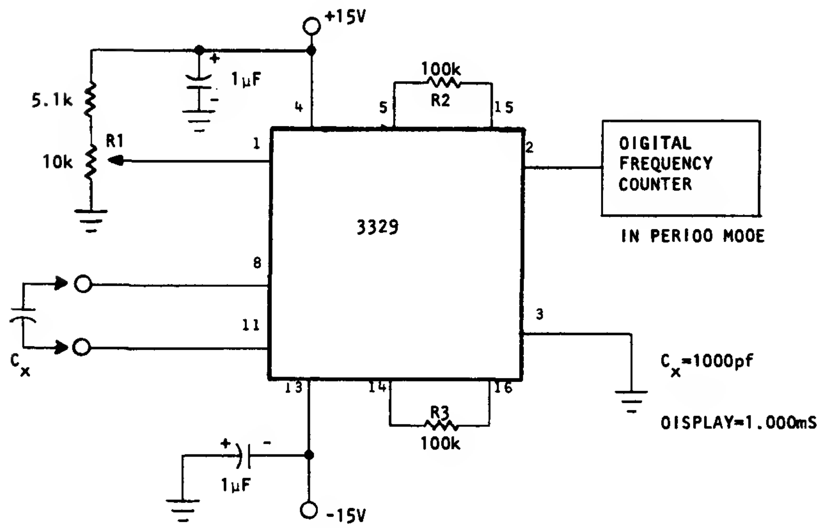
Ranga	Total R	C	Frequency
0-100 pF	15k	5 pF	1100 kHz
0-1000 pF	31k	100 pF	112 kHz
.01 uF	36k	1500 pF	11.2 kHz
.1 uF	45k	.012 uF	1.170 kHz
1 uF	45k	.1 uF	109 Hz

5 pF TO 1 μF—Consists of an oscillator using two gates from CD4011 quad NAND gate, separated from diode ractifiar by anothar NAND gate. Incraasing oscillator frequency gives mora pulses per second and highar integrated meter raading. Each matar ranga Is linaar, so value of 5-pF capacitor can be read on lowast range. Diodes ara 1N34 or equivalent. R1 is 12K, and R2-R6 ara 50K trimpots set to values shown in tabla. R7 is 5K, and R8 is 10K trimpot. B1 is 9-V transistor battery. Articla covars construction and calibration with known capacitors.—E. Landefeld, Build a Simpla Capacitance Matar, *73 Magazine*, Jan. 1978, p 164–165.

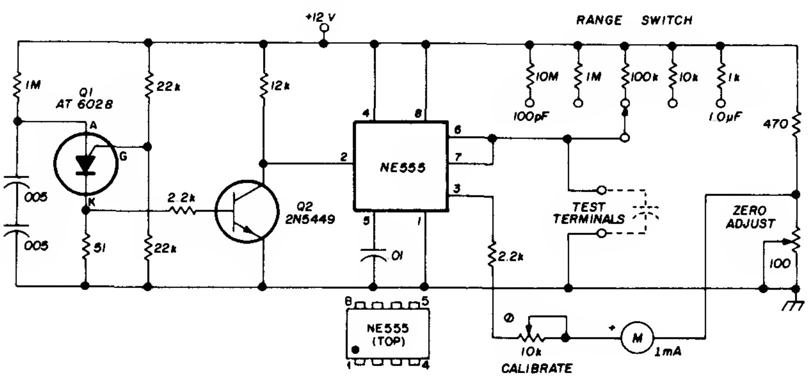


S1	3-pole, 3-position, 2 section	A (low-capacitance mode)			
		B (high-capacitance mode)			
		C (leakage mode)			
			mode A µF	mode B µF	mode C
S2	1-pole, 5-position	A	0.0001	0.25	
		B	0.001	2.5	
		C	0.01	25.0	
		D	0.1	250.0	
		E	1.0	2500.0	leakage
S3	SPST (test)				

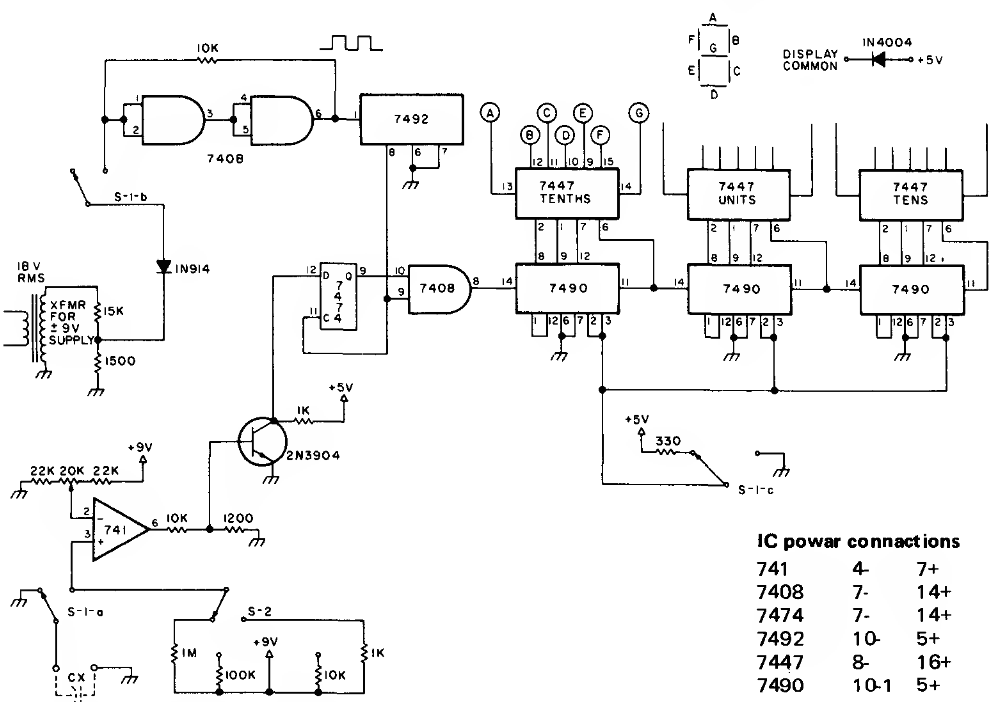
CAPACITOR TESTER—Portabla instrumant maasures capacitance values to 2500 μF and leakaga currant with up to 8 V applied. Timer U1 oparates as clock providing about 350 negative-going pulses par second to triggar timer U2 and unclamp tast capacitor so it charges through switch-selectad reslstor to half of supply voltaga. U2 than resats, discharging capacitor through pin 7. During charga, pin 3 of U2 is high (about 8 V) and duration of high stata is directly proportional to capacitance. Resulting ractangular waveform is applied to unity-gain buffar opamp U3 that feeds meter through calibrating trimpot R6. Metar deflaction is proportional to avaraga valua of ractangular output waveform and is therefora proportional to capacitance. Table gives switch functions. Mode B uses largar clock timing capacitor to parmit maasuring largar capacitance values, for total of 10 ranges. Articla covars construction, calibration, and use.—P. H. Mathieson, Wide-Range Capacitance Meter, *Ham Radio*, Feb. 1978, p 51–53.



DIGITAL WITH 100:1 RANGE—Frequency counter oparated in period mode serves ss readout for Optical Electronics 3329 voltaga-to-frequancy convartar. Unknown capscitsnca is connected ss axtarnal timing capacitance for IC, so output period of IC is directly proportional to unknown capacitance. To calibrata, connect known C and edjust R1 for correct reading on digitsl frequency countar. With vslues shown, 1 nF gives pariod of 1 ms.—"Low Cost Capacitanca Measurement," Optical Electronics, Tucson, AZ, Application Tip 10262.



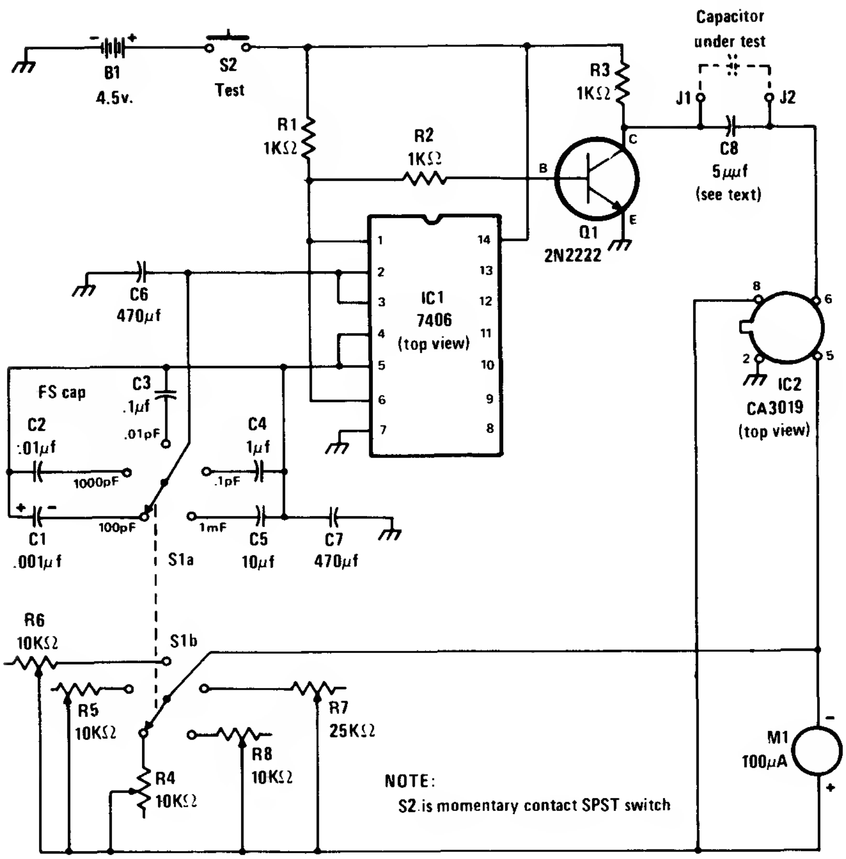
DIRECT-READING FIVE-RANGE—Covars 1 pF to 1 μF in five ranges, using easily availabla components. Trigger source is free-running pulse generator using programmabla UJT Q1 and invertar-smplifier Q2 to produce narrow −12 V output pulse at constant frequency of about 500 Hz. For trigger pulse, NE555V timer connected as mono MVBR initistes output pulse whose width incraases with valua of capacitor under test. Meter reads avarage valua of pulse waveform and msy be callbrated directly to read capacitance. Range resistors should be 5% or better. 10K trimpot In series with meter serves for Initisl callbrstion. Zero-sdjustment pot Is needed only for lower rsnges. Use zener-regulated supply to provide 12 V st up to 50 mA. Full type number of Q1 is A7T6028; 2N6027, 2N6028, 2N6118, snd HEP S9001 ara similar. Slngle 0.0025-μF capscitor can ba substituted for two 0.005-μF units in series.—C. Hsll, Dlrect-Reeding Capacitsnce Meter, *Ham Radio*, Aprll 1975, p 32–35.



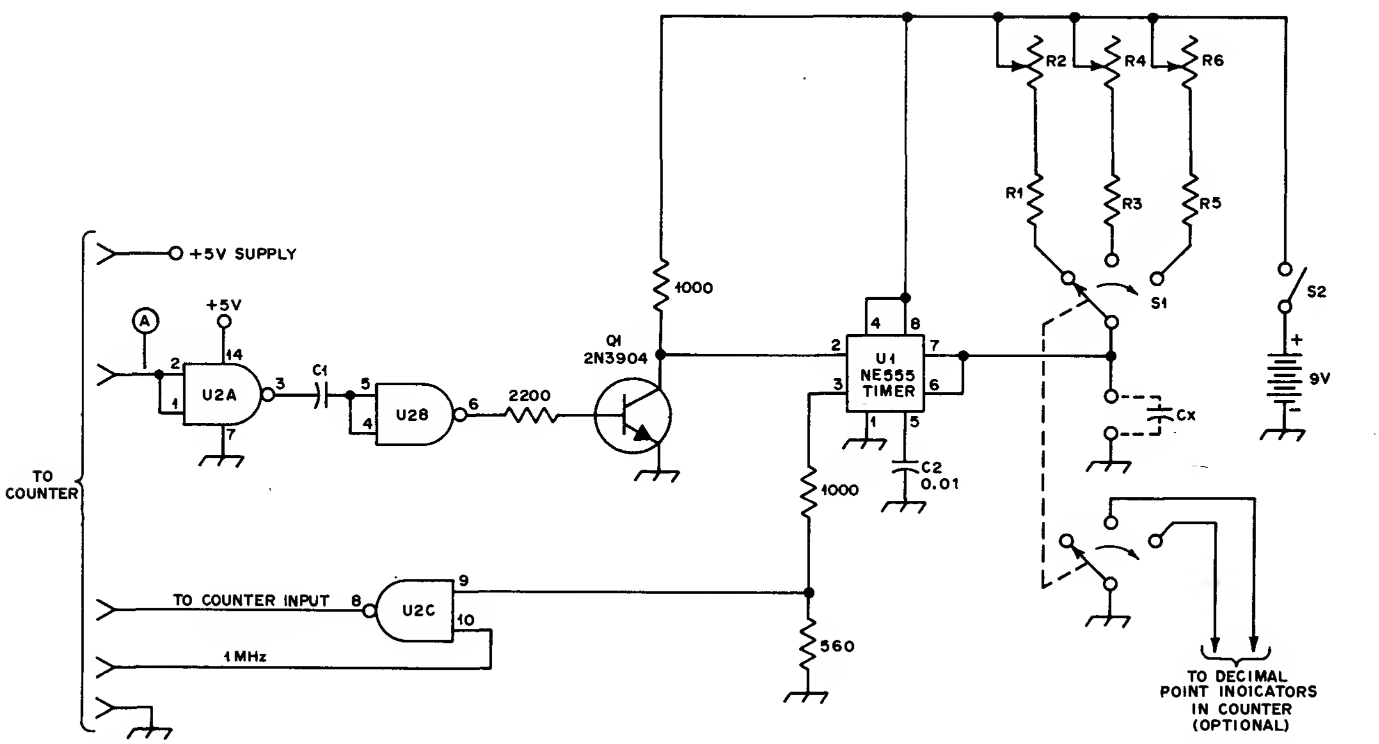
IC powar connections

741	4-	7+
7408	7-	14+
7474	7-	14+
7492	10-	5+
7447	8-	16+
7490	10-1	5+

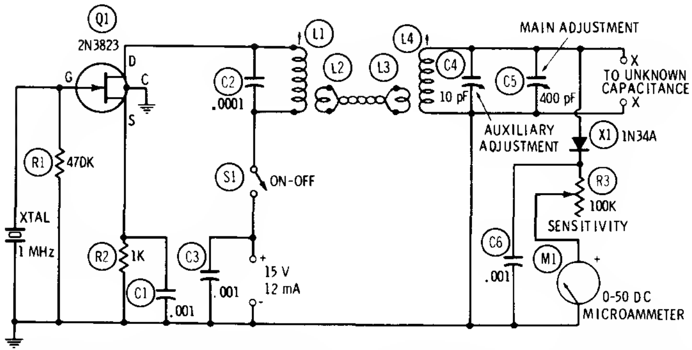
1-99,900 μF—Circuit converts charging time of unknown capacitor to capacitance valua shown on 3-digit display. S-1 is shown in OFF position, with unknown capacitor shorted. When S-1 is changed to othar position for start of test, C_X is connected to measuring circuit through range swltch S-2 snd 741 opamp used as compsrstor. 60-Hz timing waveform is now spplied to sine-wave squaring circuit using two sections of 7408 AND gata. This starts 7490 counters. Zener-regulated +9 V is applied to C_X through selected range resistor. When charging voltage of cspacitor exceeds reference voltaga on inverting input, 741 output goes posltive and stops counter. Article describes circuit operation in detail. Ranga switch gives scaling factors of 1, 10, 100, and 1000.—A. S. Joffa, Now—a Digital Capaclty Meterl, *73 Magazine,* May 1978, p 58–60.



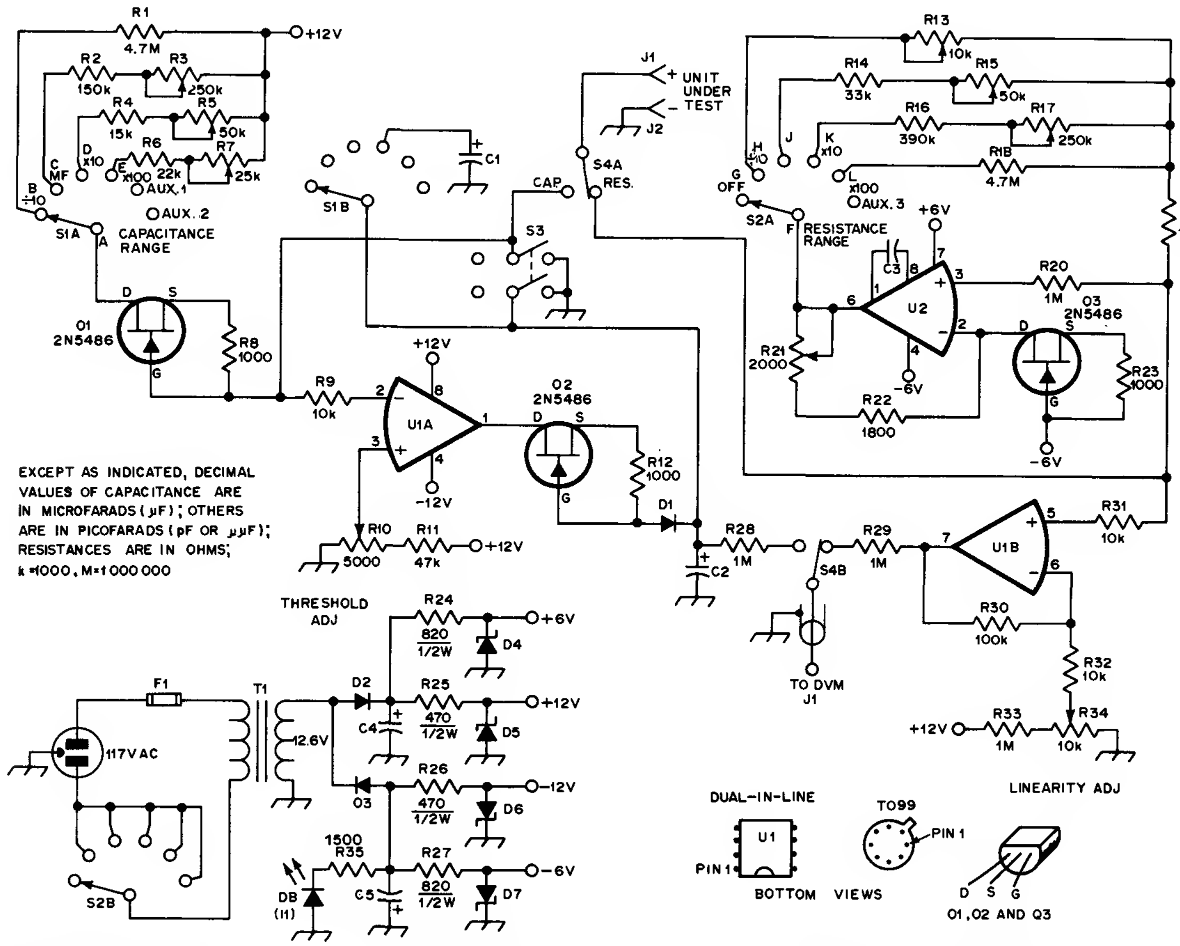
FIVE RANGES UP TO 1 μF—Direct-reading meter gives capacitance values in five ranges, all using same 0–100 scale on 100-μA meter. Operates from three penlight cells. To calibrate, connect known capacitor to jack, close S2, and adjust trimmer pot for each range in turn to give correct indication of capacitor value on meter.—C. Green, Build This Easy Capacitor Meter, *Modern Electronics*, Aug. 1978, p 78–79.



ADAPTER FOR COUNTER—Converts counter into digital capacitance meter for measuring values down to around 5 pF with better than 1% accuracy. Three ranges give full-scale values of 99,999 pF, 0.99999 μF, and 9.9999 μF. Positive-going count-enable command from frequency counter, applied to point A of gate U2A, removes short-circuit from unknown capacitor C_x and enables gate U2C. Capacitor charges exponentially through R1 and R2 (range 1) to voltage at which threshold comparator at U1 makes flip-flop change state, shorting C_x and disabling gate U2C. During charge time, 1-MHz pulses are applied to counter input. Counter reading then corresponds to capacitor value. C1 is 18 pF, R1 is 860K, R2 is 100K, R3 is 86K, R4 is 10K, R5 is 8.6K, R6 is 1K, and U2 is 7400 quad NAND gate.—R. F. Kremer, Using a Frequency Counter as a Capacitance Meter, *QST*, Aug. 1977, p 19–22.



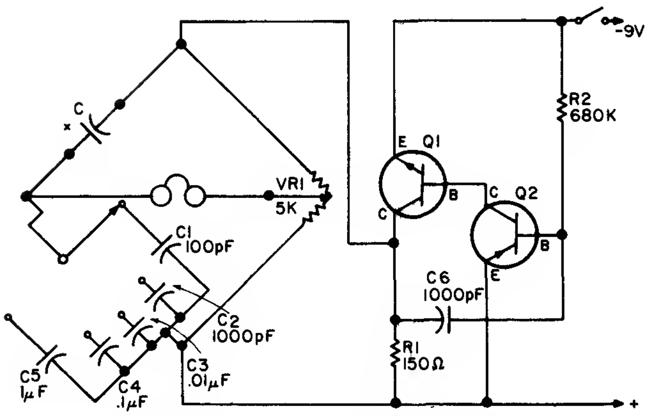
CHECKING BY SUBSTITUTION—Uses 1-MHz crystal oscillator with fixed-tuned tank circuit L1-C2 link-coupled to resonant maasuring circuit consisting of L4, C4, C5, end unknown capacitance. Simple RF voltmetar is connectad across measuring circuit as resonance indicator. C4 and C5 have calibrated dials reading directly in picofarads. L1 is Miller 20A224RBI slug-tuned unit adjusted to 250 μH. L4 is Miller 41A685CBI edjusted to 60 μH. Links L2 and L3 ere 2 turns each. To usa, close S1, set C5 to maximum, and adjust C4 for paak deflaction of M1. Connect unknown capacitance to XX with shortest possible leads, retune C5 to resonence, than subtract this capacitance reading of C5 from maximum raading to get value of unknown capacitor.—R. P. Tumar, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 140–142.



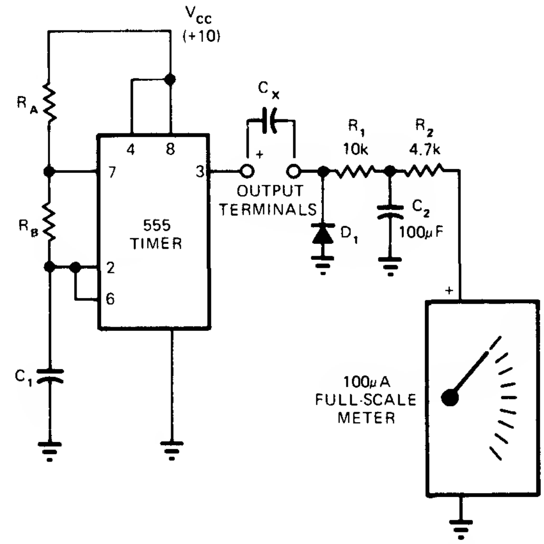
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR $\mu\mu$F); RESISTANCES ARE IN OHMS; k =1000, M=1 000 000

C1, C4, C5 — 220 μF, 16 V, Sprague 227G016CG or equiv.
C2 — 22 μF, 16 V, Sprague 226G016AS or equiv.
C3 — 130-pF disk, Sprague 1CC0G131X0100C4 or equiv.
D1 — Silicon small-signal diode, 1N914 or equiv.
D2, D3 — Silicon rectifier diode, 200 V, 1 A; 1N4003 or equiv.
D4, D7 — Zener diode, 6.2 V, 400 mW, 1N753 or equiv.
D5, D6 — Zener diode, 12.0 V, 400 mW, 1N759 or equiv.
D8 — 3/16-in. red LED, Motorola MLED50 or equiv. (I1 on pc board).
F1 — 1/2-A pigtail fuse, Buss MDV 1/2 A, 250 V.
J1, J2 — 5-way binding post. (Radio Shack package no. 274-661 includes red and black posts.)
Q1, Q2, Q3 — N-channel JFET, 2N5486 or equiv.
S1, S2 — 2-pole, 6-position rotary switch, CTS no. T206 or equiv.
S3 — Dpdt momentary toggle switch, Alco no. MTA206T or equiv.
S4 — Dpdt toggle switch, Alco no. MTA206P or equiv.
T1 — 12.6-V, 100-mA power transformer, Mouser no. 81PG120. Mounting centers 1-13/16 inch.
U1 — Dual operational amplifier, National Semiconductor type LM1458. Interchangeable with IC type 5558.
U2 — Linear IC operational amplifier, RCA type CA3130.

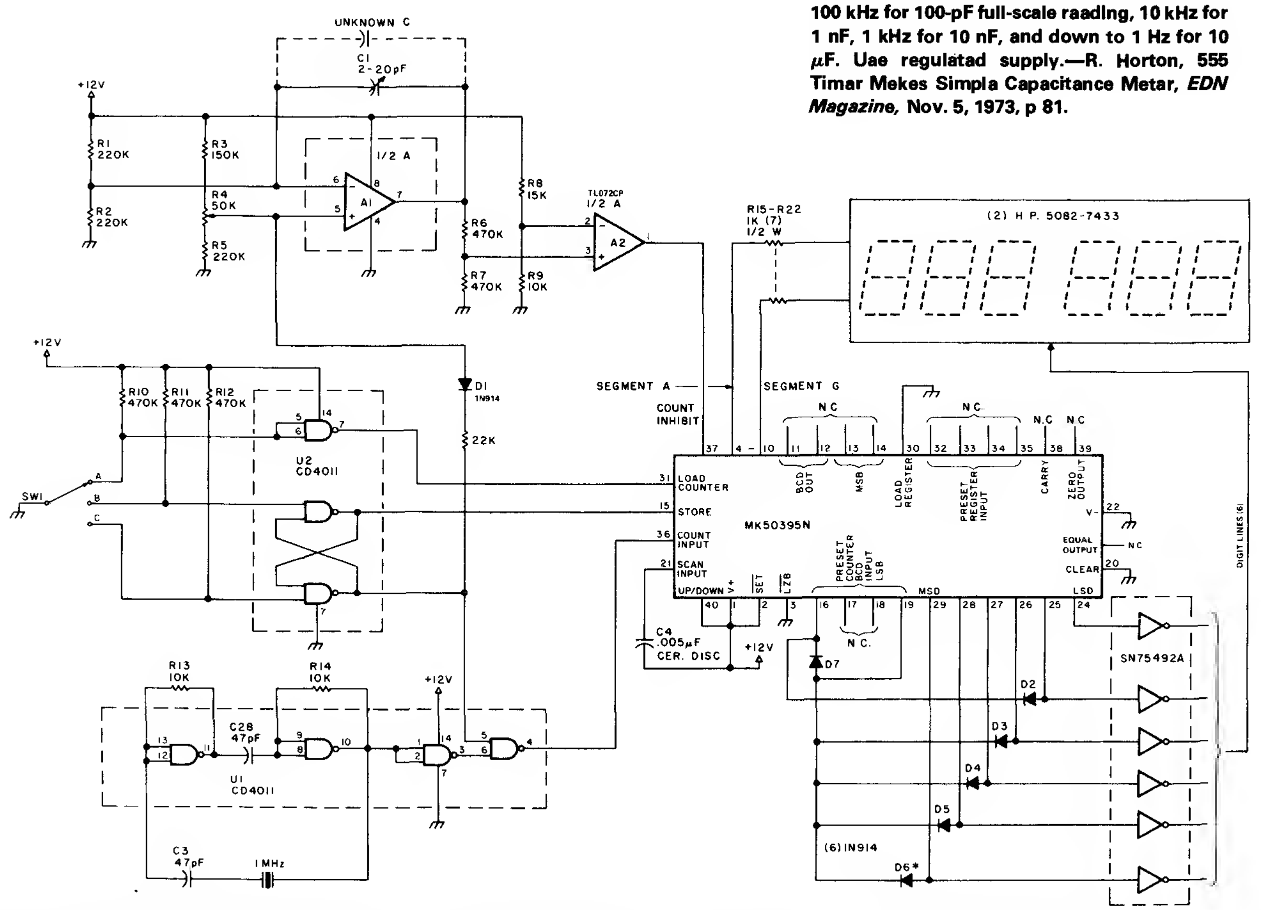
R AND C ADAPTER FOR DVM—Self-contained circuit provides four ranges of capacitance (0–1, 10, 100, end 1000 μF) and four ranges of resistance (0–1, 10, 100, end 1000 kilohms) when used with *QST* combination digital voltmeter and frequancy countar. Auxillary ranga positions on switches are provided for special measuring requirements such as tamparatura sensing, antanna elevation indication, and raingage measurements. For capacitors, constant-currant sourca Q1 charges capacitor llnaarly. When charging voltaga makes U1A switch from positiva to negativa, C2 stops charging. Voltage across C2, proportionel to velue of unknown C, is than fed to DVM. Articla covers construction and celibretion.—R. Shriner, New Tasks for the Digital Voltmeter, *QST*, Merch 1978, p 19–22.



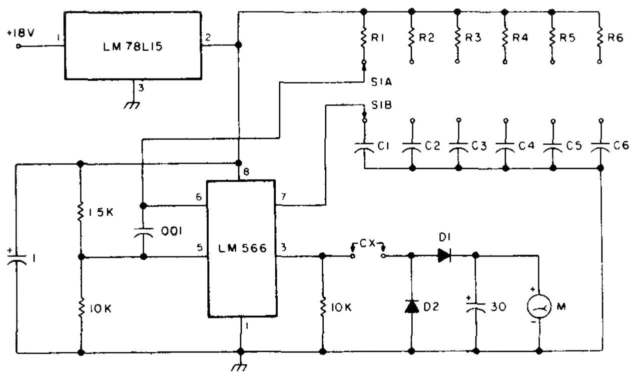
BRIDGE FOR 25 pF TO 10 μF—Usas five referenca capecitora, one for each range. Linear pot VR1 serves for balancing. High-resistance headphones indicate null, end capacitor value is than read from setting of VR1. Scele of VR1 is marked for 100 to 10,000 pF for C2 ranga and 0.01 to 1 μF for C4 range. Scale values ere multipliad or divided for other ranges. Calibration is cerried out on C2 range, using known capacitor values. Tona oscillator can use almost any pair of trensistors, ona NPN and the other PNP.—F. G. Rayar, Adrift over Your C's?, *73 Magazina*, Merch 1976, p 106–107.



LINEAR SCALE—Wide frequancy range and high output current of 555 timer contributa to linearity of operation as capacitance meter. Timer is connected as astabla MVBR with frequancy determined by values used for R_A, R_B, and C_1. When timer output is high, unknown capacitence C_X is charged almost to V_{CC}. When timer goes low, C_X discharges through D_1. Uae 100 kHz for 100-pF full-scale raading, 10 kHz for 1 nF, 1 kHz for 10 nF, and down to 1 Hz for 10 μF. Uae regulatad supply.—R. Horton, 555 Timar Mekes Simpla Capacitance Metar, *EDN Magazine*, Nov. 5, 1973, p 81.

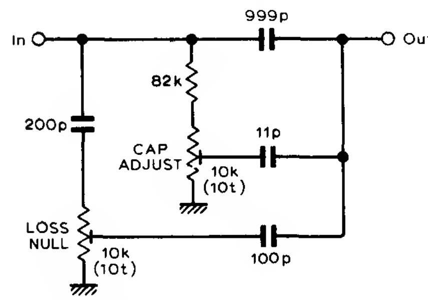


6-DIGIT VALUES—Digital capacitance metar providas display of capacitanca values from 1 pF to 999999 pF (1.0 μF). Start-maasurament switch drains charge from capacitor undar meesuremant end diverts conatant-current source to ground. Capacitor begins charging, and countar accumulatas 1-μs pulaes from crystal clock. When capacitor charge voltaga reeches threshold of count-inhibit lina for countar, contants of countar ara displayed as capacitance valua. Circuit uses Mostak MK50395N six-decade counter that provides 7-segmant output data for display. Position A of SW1 is sterting point, B storaa data in counter display after capacitor measurament, and C initietes measuramant. Display includes leading-zero suppression.—J. Garrett, What's Your μF?, *73 Magazina*, Dec. 1978, p 234–235.

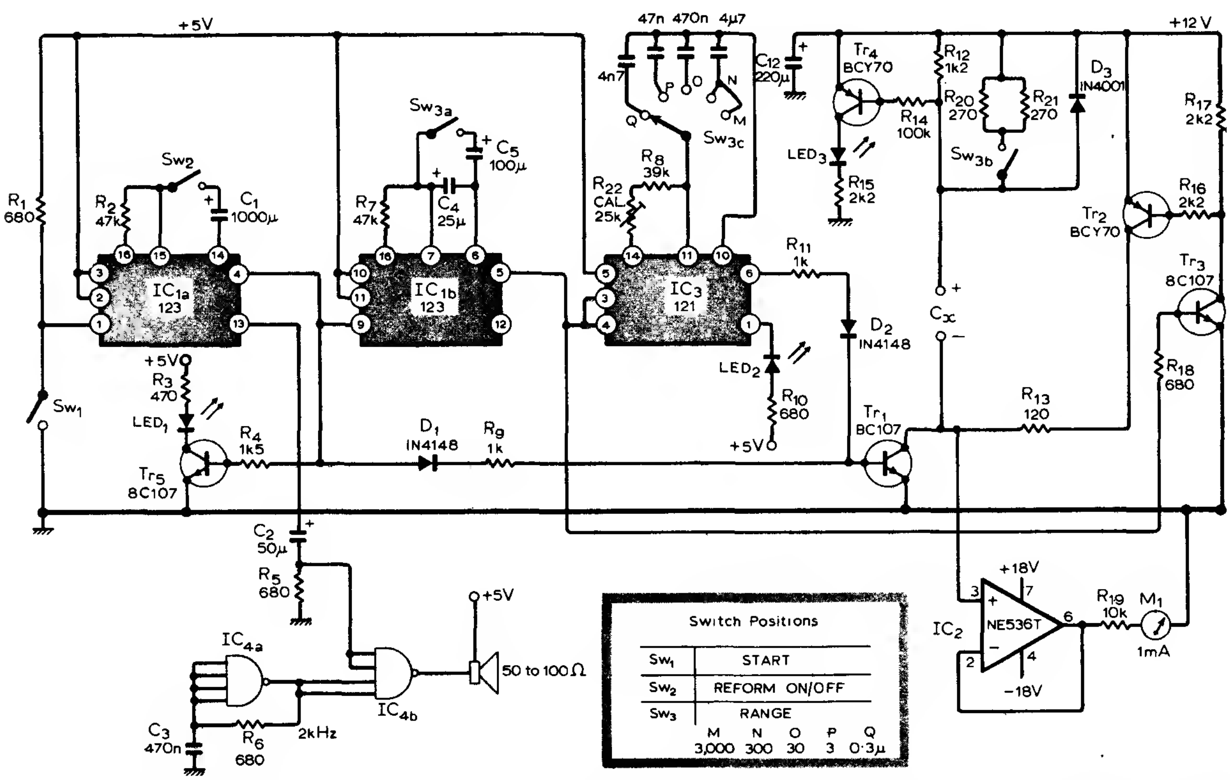


RANGE	R	C	
x1 pF	10k var.	100 pF	(C1)
X10 pF	"	.001	(C2)
x100 pF	"	.01	(C3)
x.001	"	.1	(C4)
x.01	"	1	(C5)
x.1	"	10	(C6)

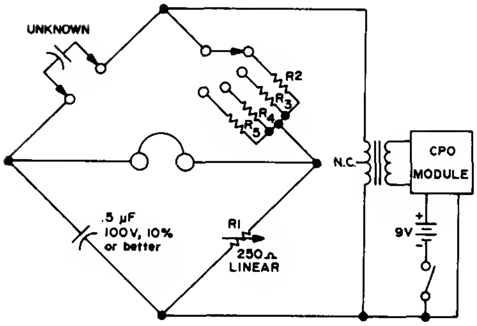
PLL CAPACITANCE METER—Based on fact that alternating current floating through capacitor depends on applied voltage, frequency, and capacitance value. Circuit uses square wave for charging capacitor to full voltage, then measures current flow as linear function of capacitance. LM78L15 provides regulated 15 V for LM566 PLL VCO. Frequency of VCO depends on values of R and C selected by rotary switch S1, to give six linear scales: 0–10 pF, 10–100 pF, 100–1000 pF, 1000 pF to 0.01 μF, 0.01–0.1 μF, and 0.1–1 μF. Accuracy is about ±5%. Meter is 100 μA. Use small signal diodes.—S. Shields, How Many pF is That Capacitor, Really?, *73 Magazine*, March 1978, p 48–50.



PERFECT CAPACITOR—Simple circuit shown provides equivalent of perfect no-loss 1000-pF capacitor at frequencies below about 100 kHz. Principle can be used to construct fixed-frequency capacitance standards for use in high-accuracy capacitor bridge. All capacitors are silver mica. If mounted in oven, stability can be 1 PPM and residual phase-angle difference from pure capacitance only 1 microradian.—B. J. Frost, "No Loss" Capacitor, *Wireless World*, Dec. 1977, p 80.



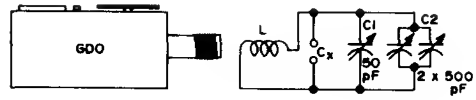
ELECTROLYTICS WITH REFORMING—Automatic tester for electrolytics applies voltage for about 15 s to repolarize dielectric before measurement is made. This provides sufficient reforming for test purposes, using 12 V through 1200 ohms, but test should be repeated if leakage current is high because of incomplete reforming. Tone from loudspeaker indicates end of 15-s reforming period. Green LED$_1$ indicates reforming process is ready to start. Red LED$_2$ indicates excessive current is flowing during reforming. LED$_3$ flashes to indicate test capacitor is being charged during measuring cycle. Article covers construction and calibration in detail. IC$_1$ is SN74123N, IC$_3$ is SN74121N, and IC$_4$ is SN7413N.—A. Drummond-Murray, Electrolytic Capacitor Tester, *Wireless World*, May 1977, p 47–49.



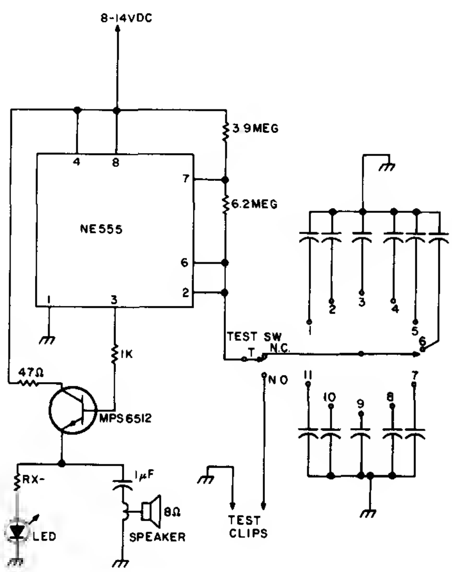
RESISTOR	SCALE
R2 - 100K	X 100 pF
R3 - 10K	X 1000 pF
R4 - 1K	X .01 μF
R5 - 100Ω	X .1 μF

ALL RESISTORS - 1/2W, 5% or better

0.0001 TO 1 μF IN FOUR RANGES—Simple bridge uses AF voltage from Cordover CPO-4 code practice oscillator module, fed through transistor output transformer connected in reverse for impedance matching. Earphones serve as null detector, but amplifier can be added for greater sensitivity or CRO used. Only one scale need be calibrated, using known values of capacitors.—W. P. Turner, Build a Basic Bridge, *73 Magazine*, Nov. 1974, p 95.

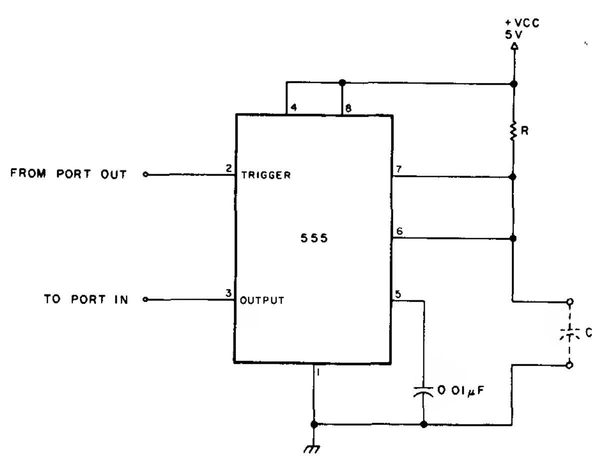


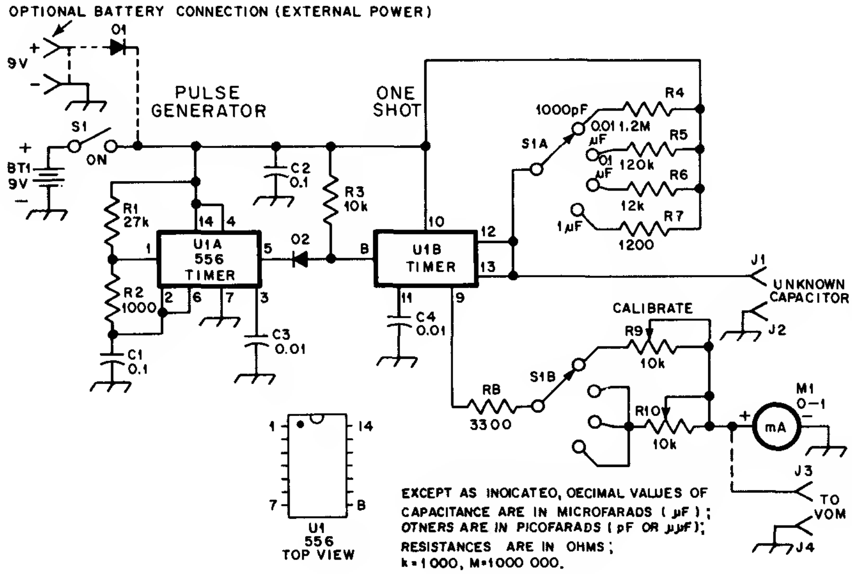
C BY GRID DIP—Values of unknown capacitances up to about 1000 pF can be measured with simple circuit used with grid-dip oscillator. Coil L can be 6 turns of stiff wire. To calibrate, close variable capacitors C1 and C2 fully, tune for dip, and note dip frequency at pointer position of C2. Now connect known capacitors up to 1000 pF one by one to CX, retune C2 for dip, and mark capacitor value on C2 dial. Close C2, then repeat calibration for C1 while using smaller capacitors up to 50 pF.—F. G. Reyer, GDO to Find C, *73 Magazine*, Aug. 1974, p 35.



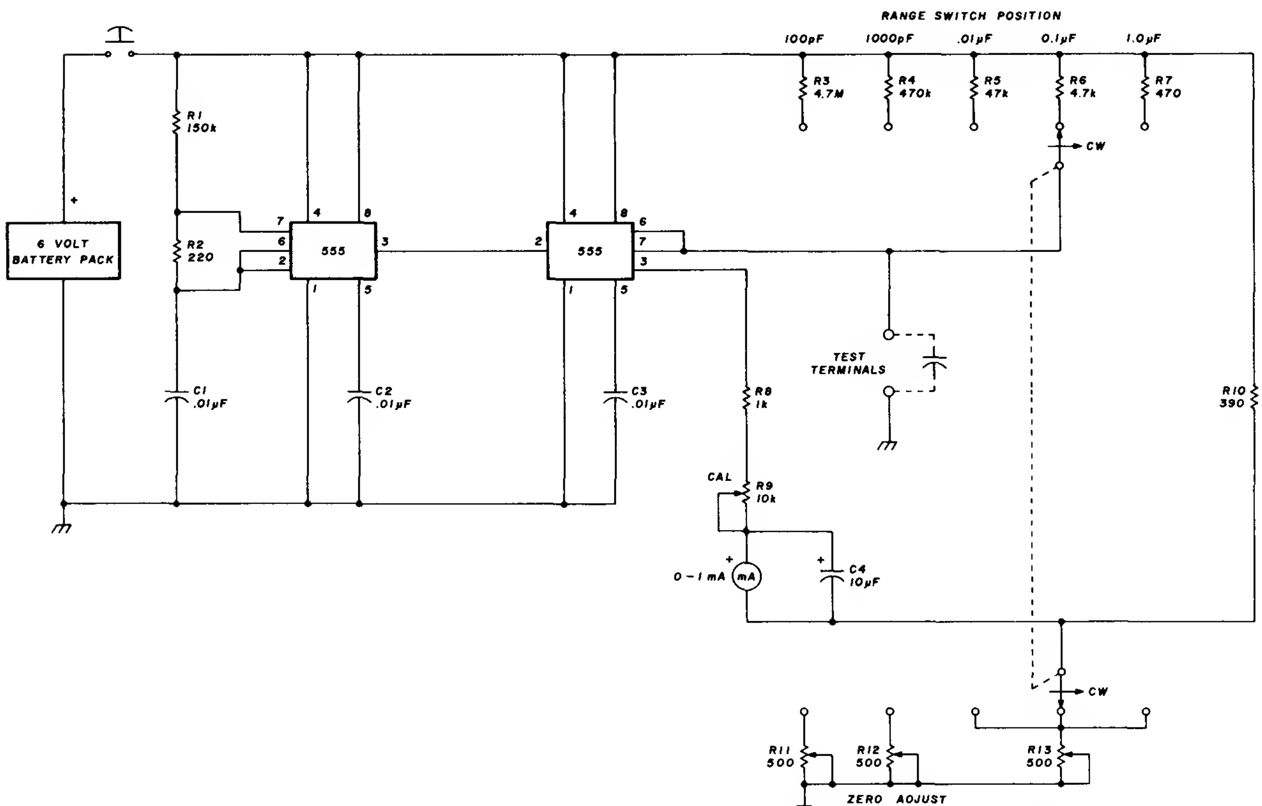
0.5-pF TO 0.001-μF COMPARATOR—Provides audio-tone comparison of built-in reference capacitor to unknown capacitor connected between test clips. Frequency of tone is about 8 kHz for 0.5 pF, dropping to 100 Hz as capacitor value goes up to 0.001 μF. Larger capacitor values merely turn LED on and off; 0.1 μF gives flashing at about 5 Hz. Any NPN audio or switching transistor can be used in place of MPS6512. Suggested reference values for capacitor bank are 0.7, 3, 5, 10, 25, 50, 100, 330, 470, 680, and 820 pF.—W. Pinner, The Capacitor Comparator, *73 Magazine*, March 1977, p 49.

COMPUTERIZED METER—With 4.7 megohms for R, simple 555 timer circuit used in conjunction with computer measures capacitors in five ranges from below 100 pF to 0.1 μF. For larger range, resistor value can be changed. Article includes BASIC software suitable for 8080-based systems, including calibration program based on known values of capacitance. 555 mono MVBR is triggered under control of computer output port bit, with count being made while mono is timing out. Count is averaged over ten triggerings, then multiplied in computer by calibration factor to give capacitance value. Any desired type of output indicator can be used.—J. Eccleston, Computerized Capacity Meter, *73 Magazine*, July 1978, p 88–89.





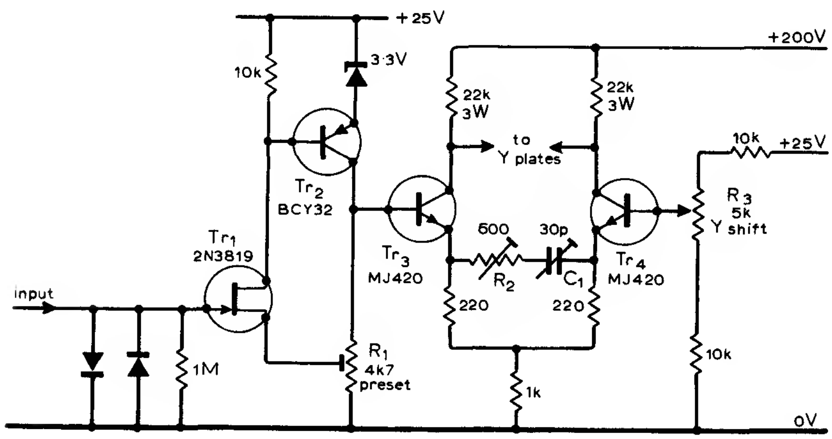
DUAL TIMER MEASURES C—One section of U1 (two 555s in single package) is connected as oscillator that serves as trigger for other section (U1B). Ratio of R1 and R2 determines length of pulse generated during each oscillation cycle, while C1 and same resistors set frequency at about 500 Hz. U1B produces predetermined-duration output pulse for each start pulse regardless of starting pulse length. Pulse duration is set by R4-R7 and external capacitor being measured. Smaller capacitor in given range produces shorter output pulse from U1B mono MVBR. Average pulse power increases with pulse length and increases meter reading linearly so capacitance value is indicated directly. Values shown give ranges of 1000 pF, 0.01 μF, 0.1 μF, and 1 μF full-scale. R10 serves as calibration resistor for all three higher scales. D1 is 50-PIV or higher silicon power-type diode, and D2 is 1N914 or equivalent.—D. A. Blakeslee, An Inexpensive Capacitance Meter, *QST*, Sept. 1978, p 11–14 and 37.



FIVE RANGES TO 1 μF WITH TIMERS—Based on fact that output pulse width of 555 timer varies linearly with value of timing capacitance used. If timer is triggered with constant frequency, average DC value of resulting pulse train is linear function of pulse width. DC meter then reads capacitance values linearly. Decade capacitance ranges are obtained by switching value of timing resistor. Trimpot for each range is adjusted for zero meter reading when pushbutton is pressed, without test capacitor.—C. Hall, Simplified Capacitance Meter, *Ham Radio*, Nov. 1978, p 78–79.

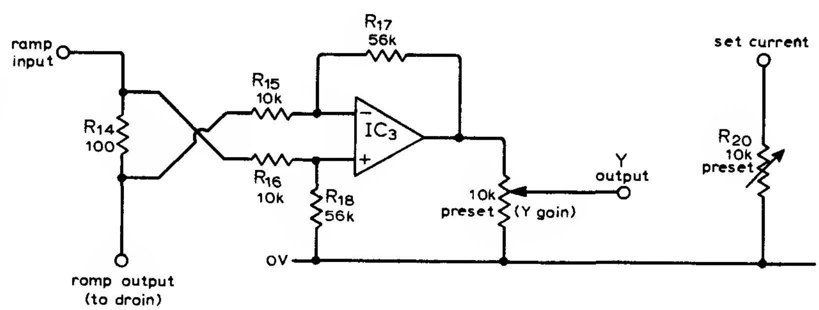
CHAPTER 11
Cathode-Ray Circuits

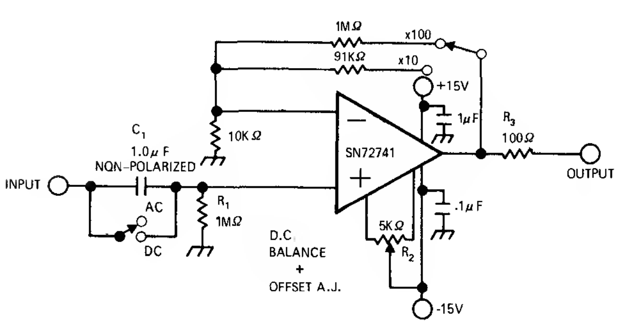
Includes probe circuits, preamps, deflection amplifiers, 2-channel and 4-channel trace multipliers, triggered sweep, dynamic focus correction, B-H and Lissajous pattern generators, time-mark generator, and TV typewriter circuits. See also Game, Power Supply, Sweep, and Television chapters.



Y AMPLIFIER FOR CRO—Combines advantages of differential output stage and high-impedance JFET input stage. Silicon input diodes provide crude overload protection for input, while Tr_2 acts with Tr_1 for level-shifting as well as amplifying. R_1 is used to set quiescent output voltage of Tr_2 at about 15 V; this setting is critical, and may require multiturn pot. Article gives setup procedures.—G. A. Johnston, Deflection Amplifier for Oscilloscopes, *Wireless World*, April 1975, p 175.

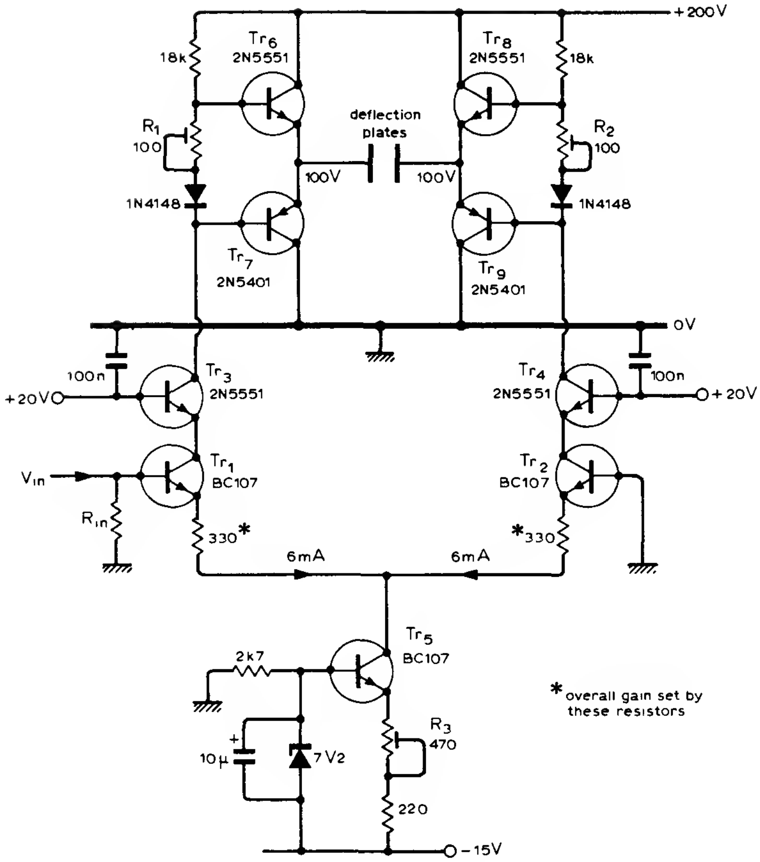
CURRENT AMPLIFIER—Used in FET curve tracer to amplify drain current passing through R_{14} sufficiently to give required Y output for oscilloscope. Uses SN72741P opamp as difference amplifier. Article gives other circuits of curve tracer and calibration procedure.—L. G. Cuthbert, An F.E.T. Curve Tracer, *Wireless World*, April 1974, p 101–103.



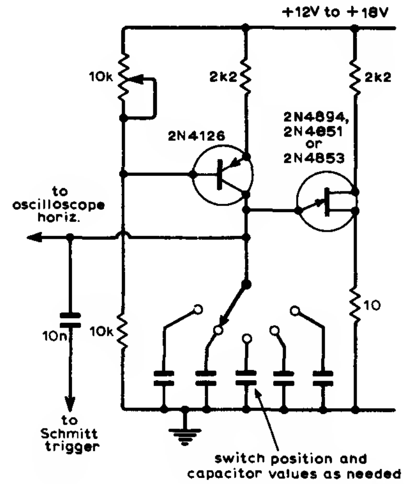


RANGE	FREQUENCY
X 10	D.C. 100 KHZ
X 100	D.C. 10 KHZ
Output Voltage P.P.	
D.C.	28V
10 KHZ	27V
100 KHZ	3V

SCOPE PREAMP—Extends vertical sensitivity range of scope or VOM at minimum cost. Voltage at output is in phase with input. Switch across C gives choice of AC or DC operation. Table gives frequency and output voltage limits. Input impedance is about 500 kilohms.—G. Coers, High-Gain AC/DC Oscilloscope Amplifier, *EDN/EEE Magazine*, Feb. 1, 1972, p 56.

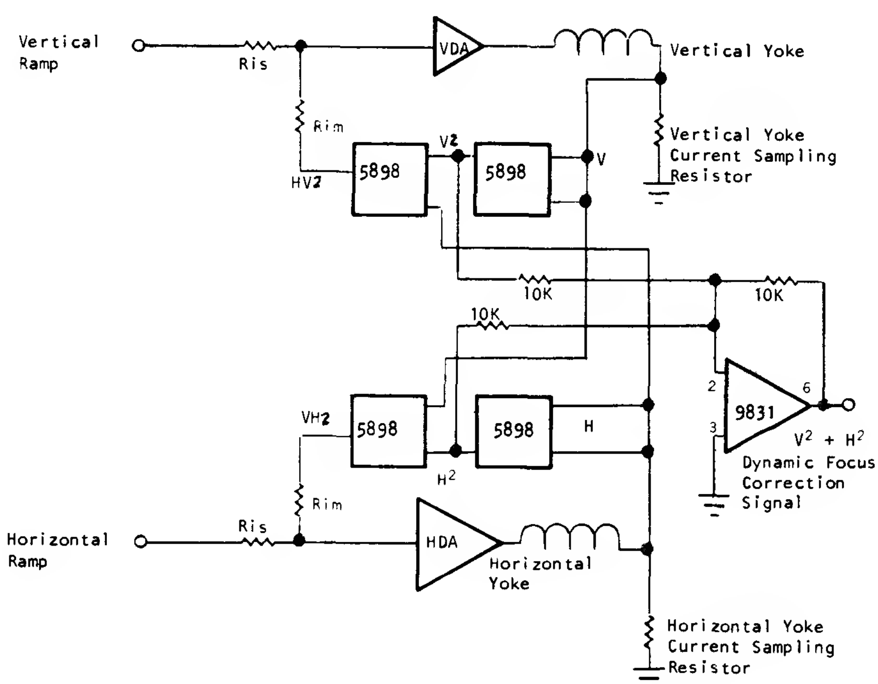


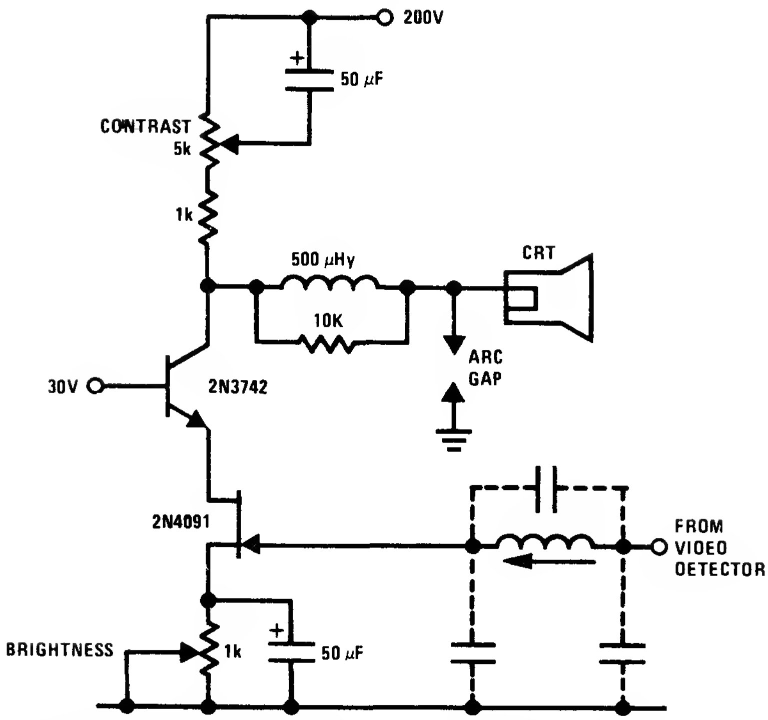
Y AMPLIFIER WITH 10-MHz BANDWIDTH—Rise time is 40 ns. Tr_1-Tr_4 form constant-current tail, with Tr_5 improving linearity. Tr_6 and Tr_7 are complementary emitter-followers, as also are Tr_8 and Tr_9, for feeding deflection plates. Input should be from 50-ohm source to achieve full bandwidth. Other complementary small-signal transistors rated above 200 V can be used.—B. J. Frost, Wideband Y Amplifier for Oscilloscope, *Wireless World*, June 1976, p 71.



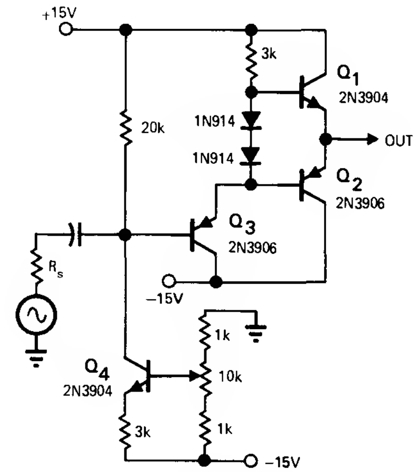
TRACE QUADRUPLER—Designed for use with DC oscilloscopes. Constant-current UJT oscillator produces linear sawtooth for triggering Schmitt trigger and serving as horizontal sweep voltage. Frequency is varied by switching capacitors, and can be up to about 100 kHz. Emitter-follower may have to be added to UJT output to prevent loading of timing capacitors by low impedance of Schmitt trigger. Used to quadruple maximum time-base frequency of oscilloscope.—J. A. Titus, Trace Quadrupler, *Wireless World*, Oct. 1972, p 479.

DYNAMIC FOCUS CORRECTION—Provides sum of squares of vertical and horizontal position voltages, as required for focus correction in high-resolution flat-face magnetically deflected CRT. Circuit uses Optical Electronics 5898 four-quadrant analog multipliers to give required squared outputs, along with 9831 opamp having comparable bandwidth. Input summing resistors for horizontal and vertical deflection amplifiers are chosen for compatibility with amplifiers being used. Select current-sampling resistors to generate 10-V peak signal.—"Dynamic Focus Correction with Analog Function Modules," Optical Electronics, Tucson, AZ, Application Tip 10127.

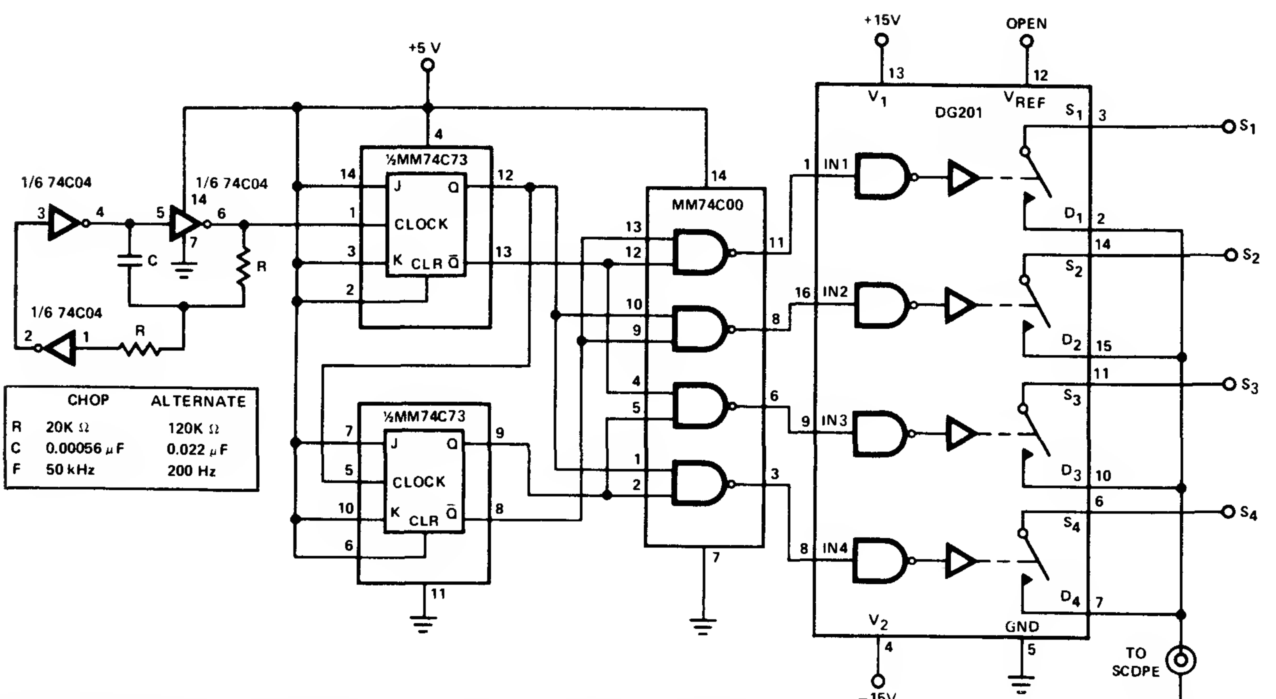




CATHODE DRIVE FOR CRT—Cascode connection of 2N4091 JFET and 2N3742 bipolar transistor provide full video output for cathode. Gain is about 90. M-derived filter using stray capacitances and variable inductor blocks 4.5-MHz sound frequency from video amplifier. Cascode configuration eliminates Miller capacitance problems of JFET, allowing direct drive from video detector.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

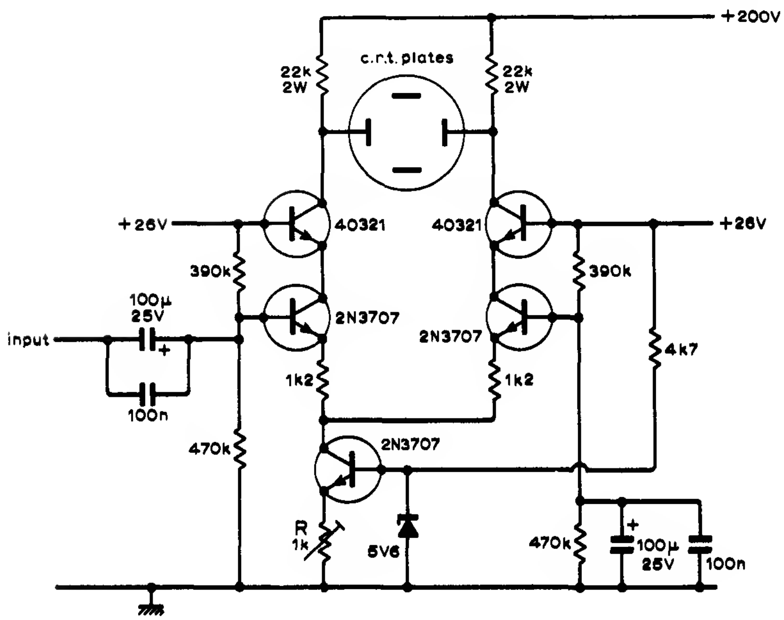


±7 VDC OFFSET—High-impedance current source Q_4 provides desired level shift for AC signals in video circuit whose DC level controls intensity of CRT. Input and offset signals are fed to base of Q_3 which drives complementary-symmetry emitter-follower Q_1-Q_2. For values shown, level can be shifted about ±7 VDC.—P. B. Uhlenhopp, Variable DC Offset Using a Current Source, *EDN/IEEE Magazine*, Aug. 15, 1971, p 46.

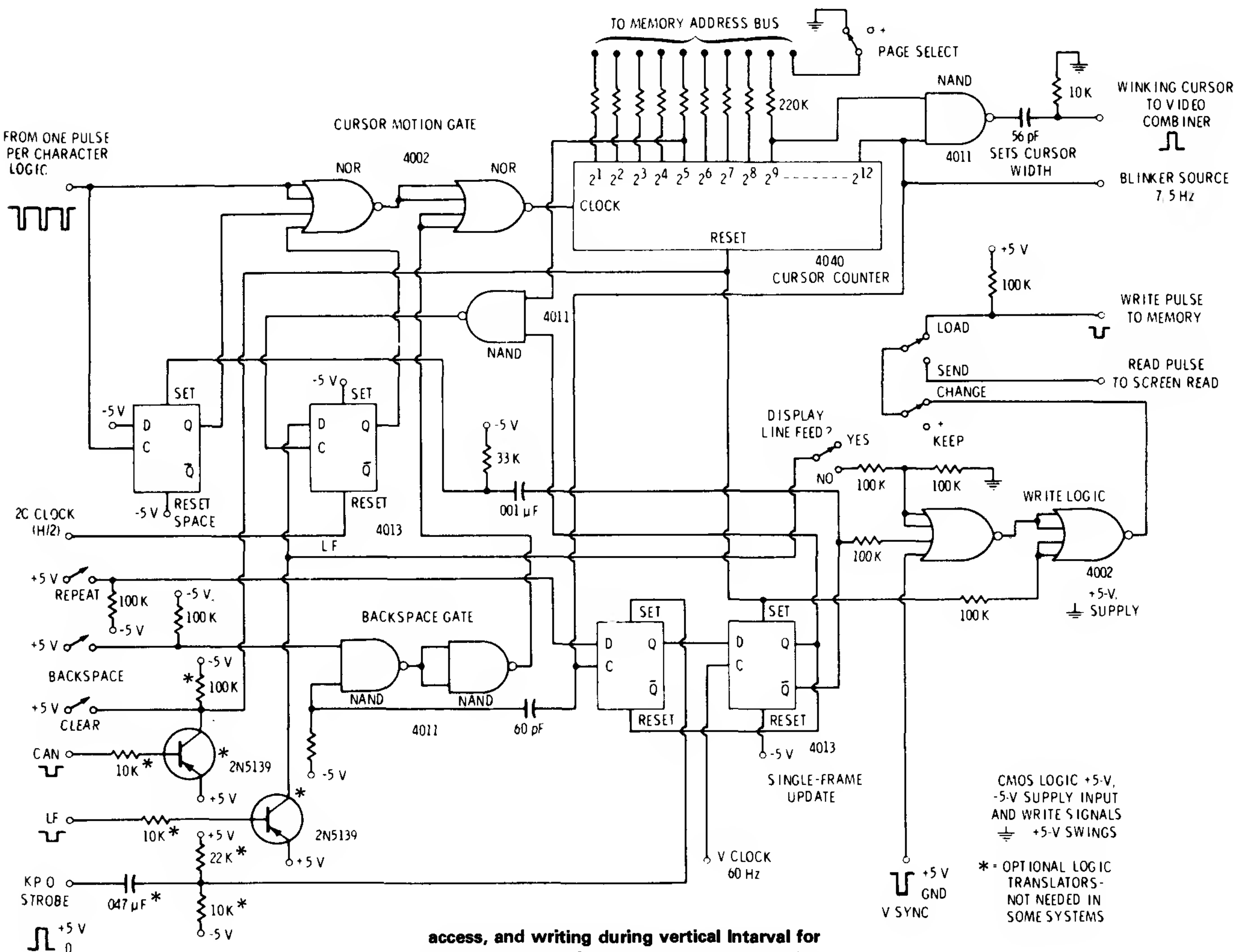


	CHOP	ALTERNATE
R	20K Ω	120K Ω
C	0.00056 μF	0.022 μF
F	50 kHz	200 Hz

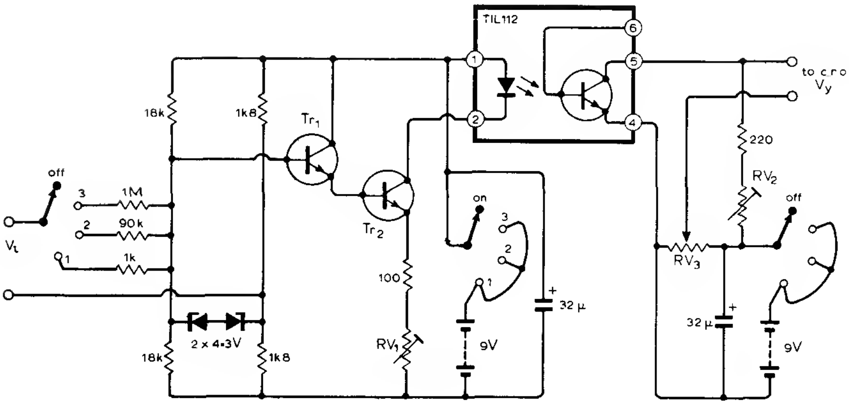
FOUR-CHANNEL ADAPTER FOR CRO—DG201 CMOS analog switch controlled by 50-kHz clock allows display of four input signals simultaneously on single-trace oscilloscope. Adapter is used in chop mode for signals below 500 Hz. Frequencies above 500 Hz are best viewed in alternate mode with clock frequency of 200 Hz. One of inputs is used to trigger horizontal trace of CRO.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-63–7-66.



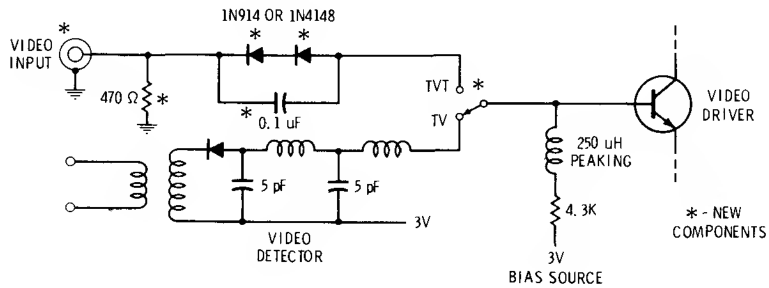
ELECTROSTATIC-DEFLECTION AMPLIFIER— Combines frequency response of cascode amplifier with linearity of long-tailed pair fed by constant current. Adjust R for 3 mA through each load resistor. Output transistors require small heatsinks.—G. A. Johnston, Deflection Amplifier, *Wireless World*, Nov. 1973, p 560.



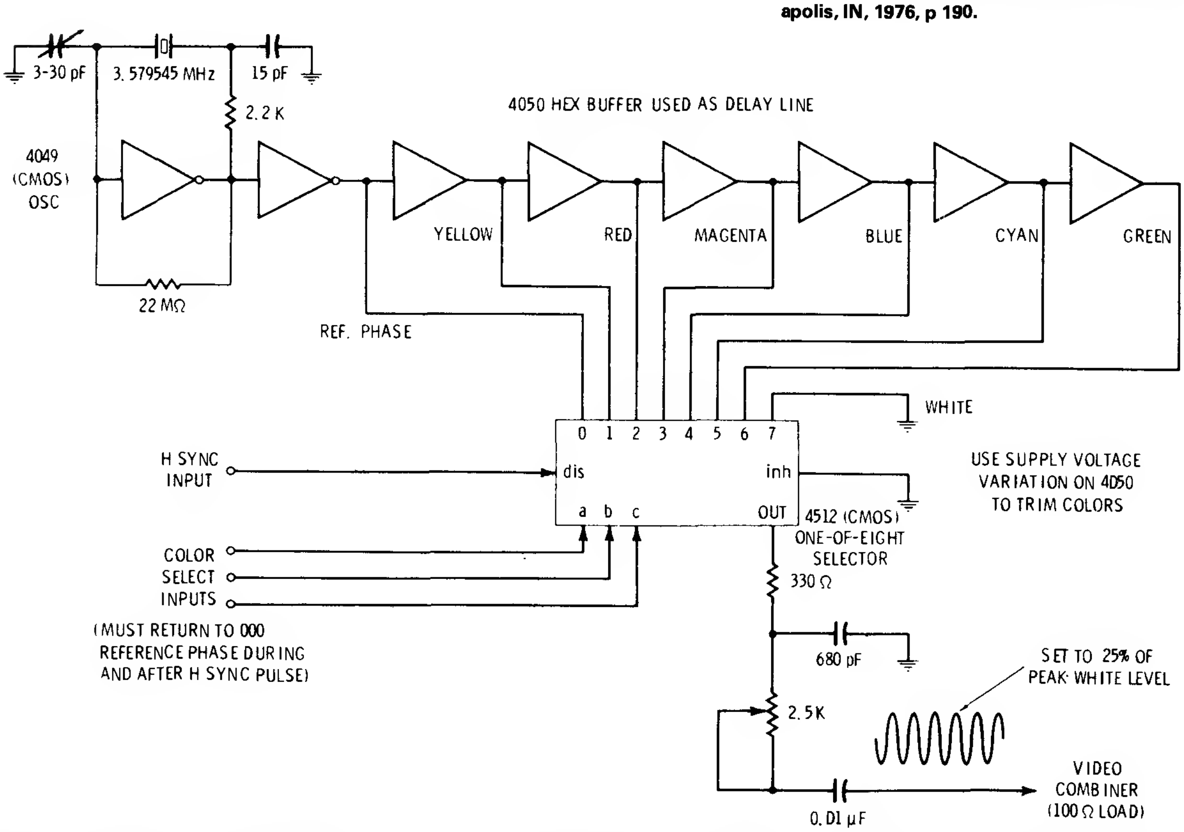
CURSOR FOR TV TYPEWRITER—Complete CMOS logic cursor and update system is shown for system using RAM memory, direct memory access, and writing during vertical interval for displaying 512 characters per page on TV screen. External 7.5-Hz source is required to make underline cursor flash to indicate position at which next character will be entered on screen.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 128–129.



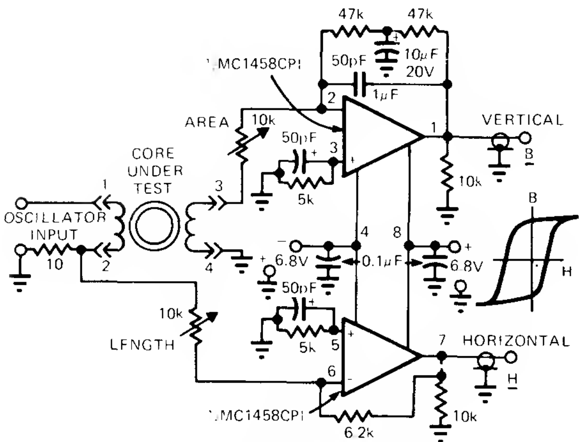
OPTOISOLATOR FOR PROBE—Offsets need for potentially dangerous practice of floating oscilloscope with respect to ground. Also permits simultaneous display of two voltages with correct polarity on double-beam oscilloscope when one of them is floating. Texas Instruments TIL112 optocoupler used has bandwidth of about 30 kHz. Three ranges give choice of 1:1, 10:1, and 100:1 input attenuation. Set RV_2 to bias phototransistor of optocoupler to center of its linear range (about 4.5 V between pins 4 and 5), then set RV_1 to give unity input/output ratio on range 1. RV_3 is set to give zero DC output when input terminals are shorted, but can be omitted if zeroing of output level is unnecessary.—A. F. Sargent, Simple C.R.O. Input Isolating Probe, *Wireless World*, Feb. 1976, p 76.



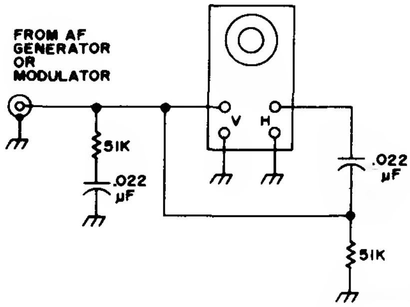
TV INTERFACE FOR TYPEWRITER—Video input circuit for black and white transistor TV receiver permits feeding video output of TV typewriter to video driver in set, for producing character or game display on TV screen. Use of direct coupling eliminates shading effect or changes in background level as characters are added. Diodes provide 1.2-V offset in positive direction so in absence of video the video driver is biased to blacker-than-black sync level of 1.2 V. With white video input of 2 V, driver is biased to usual 3.2 V of white level. Hot-chassis TV sets can present shock hazard.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 190.



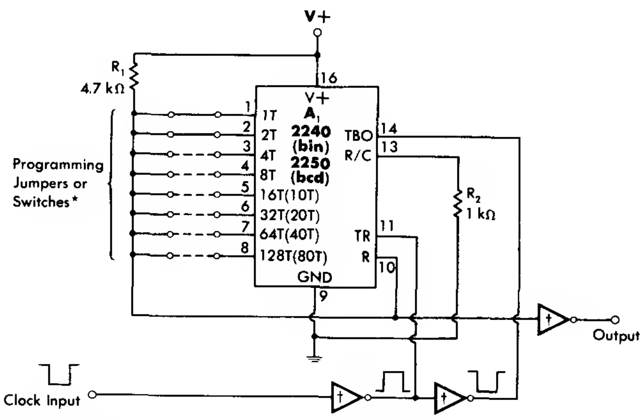
COLOR FOR TV TYPEWRITER—Uses 3.579545-MHz crystal oscillator to drive string of CMOS buffers forming digital delay line. Output delays caused by propagation times in each buffer can be used directly or can be trimmed to specific colors by varying supply voltage. Reference phase and delayed color outputs go to 1-of-8 data selector whose output is determined by code presented digitally to its three color select lines. Selector drive logic must return to 000 (reference phase) immediately before, during, and for at least several microseconds after each horizontal sync pulse so set can lock and hold on reference color burst. Sine-wave output chrominance signal is cut down to about one-fourth of maximum video white level.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 205–206.



B-H LOOP DISPLAY—Low-cost dual opamp circuit ellows display of hystarasis loop on calibrated XY oscilloscopa. Two windings are placed on cora to ba testad, with opemp of flux-maasuring system connected to sacondery for deriving vertical deflection input representing flux B. Articla gives design equations and details of circuit operation and use.—D. A. Zinder, X-Y Oscilloscope Displays Hystaresis Loop of Any Core, *EDN Magazina*, Feb. 5, 1975, p 54–55.

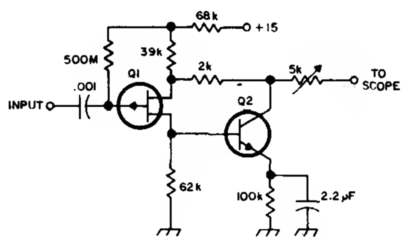


ELLIPTICAL PATTERN—Connaction shown gives Lissajous-type elliptical pettem on CRO from ordinery AF signal generetor. Modulation can be added to either vertical or horizontal feed for CRO.—Novice Q & A, *73 Magazine*, March 1977, p 187.

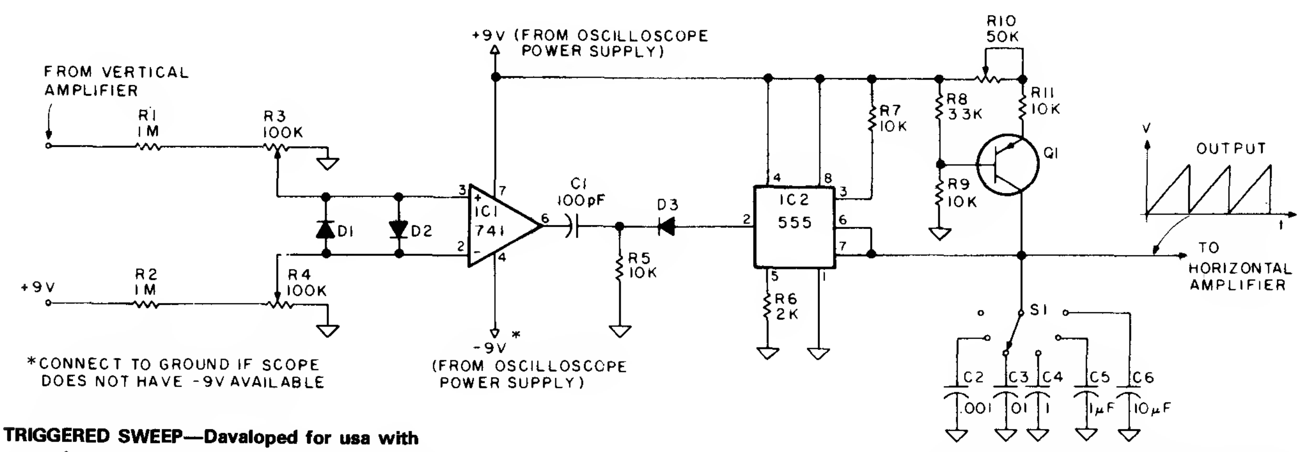


†CMOS Inverters

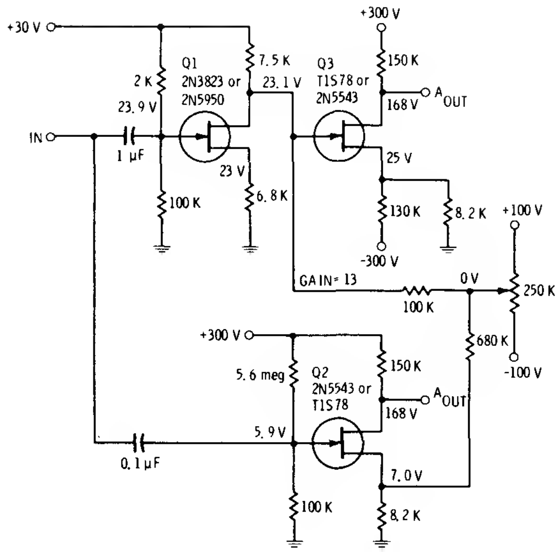
TIME-MARK GENERATOR—Produces precisaly spaced output pulsas suitable for calibrating CRO tima bases. Cen be programmed in binary by using 2240 for A_1 or in BCD by using 2250. Usa crystal oscilletor or other high-accuracy source for externel clock. Time interval of output pulsa is equal to clock width multiplied by n + 1, where n is number programmed into A_1 (1 to 255 for 2240 and 1 to 99 for 2250). Circuit can ba progremmed electronically by microprocessor if desired.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indienapolis, IN, 1977, p 218–220.



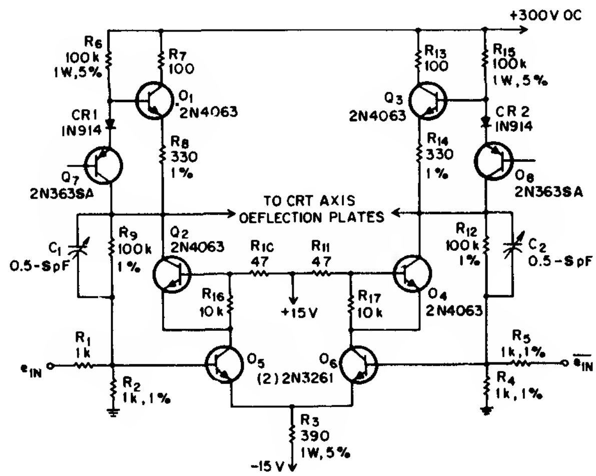
HIGH-Z PROBE—Provides about 1200-megohm input impedanca to CRO, with unity gain. Pot adjusts equalizetion at higher frequencies. Q1 can ba U112, 2N2607, 2N4360, or TIM12. Q2 can be 2N706, 2N708, 2N2926, 2N3394, or HEP 50.—Circuits, *73 Magazina*, March 1974, p 89.



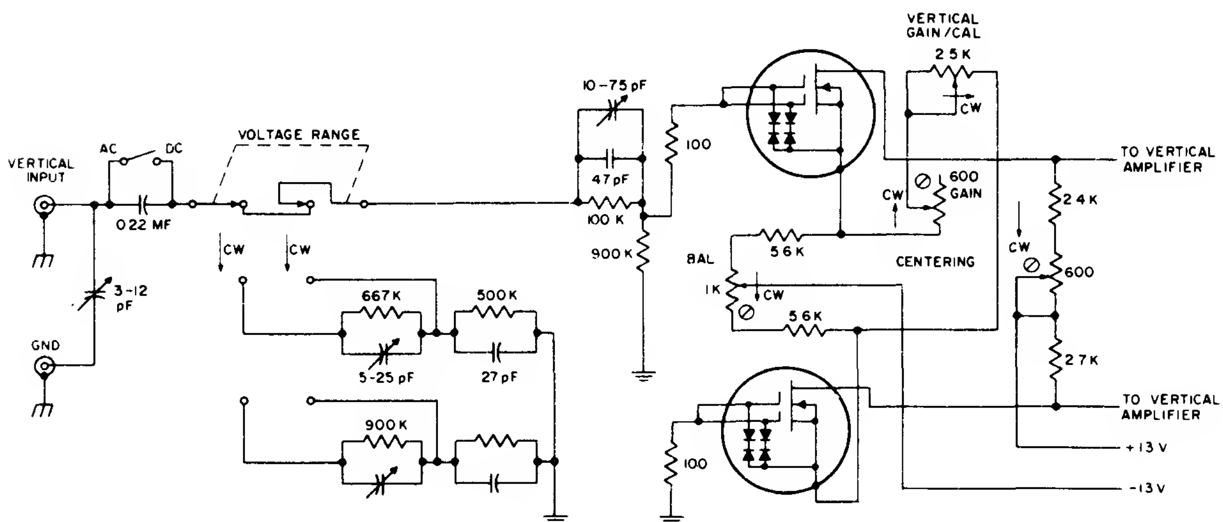
TRIGGERED SWEEP—Davaloped for usa with genaral-purpose CRO in troubleshooting digital circuits, to provide one horizontal sweep of cathode-ray beam each tima circuit is triggarad by input signal pulse. Noninverting Input of 741 opamp is connected to vartical amplifiar of CRO, and invarting input is used to control trigger level. When input signal rises above triggar level, output of opamp swings to −V and makes output of 555 timar go high, ellowing output capacitor to charge at constant current through transistor in series with resistor. Rasult is nearly perfect ramp voltage. All diodes are 1N914. Q1 is any PNP switching transistor.—W. J. Prudhomme, Trigger Your Oscilloscopa, *Kilobaud*, Aug. 1977, p 34–38.



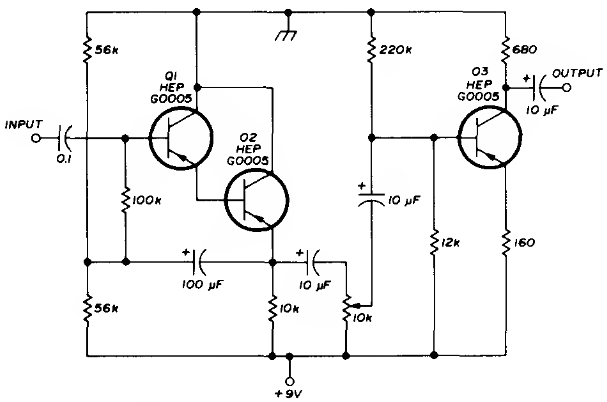
ELECTROSTATIC-DEFLECTION AMPLIFIER— Circuit davelops equal-amplitude but opposite-polarity sewtooth outputs when sawtooth input is eppliad to gatas of Q1 end Q2. Q1 is connected as common-source amplifiar for applying opposite-polarity sawtooth to gata of Q3. Polarity at output of Q3 than becomes sama as that of input, incraased to amplituda suitabla for deflection platas of CRT. Sewtooth at output of Q2 has opposita polarity. Circuit values ara chosan to belence gein so both outputs have sama magnltuda.—E. M. Noll, "FET Principles, Expariments, and Projects," Howerd W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 229–230.



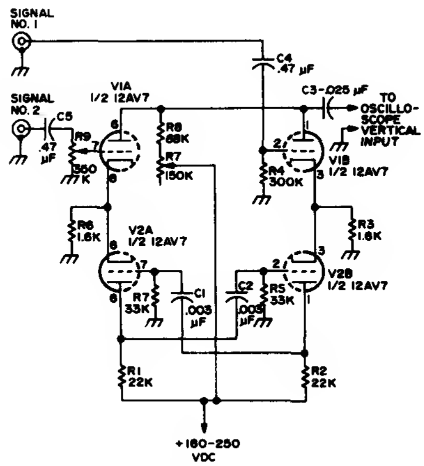
DEFLECTION-PLATE AMPLIFIER— Resistiva collector network of symmetrical differantiel amplifier is replaced by constant-currant sourca to improve slew rata of deflaction emplifiar driving capacitiva load such as deflaction plates of alectrostatic cathode-ray tube. Q_1 and Q_2 are identlcal currant sources. Network Q_1-CR_1-Q_7-R_6-R_6 forms current source for Q_1. Q_7 is used as 6.2-V zenar dioda.—W. Patarson, Current Sources Improve Amplifiar Slaw Rata, *EEE Magazine*, Nov. 1970, p 102.



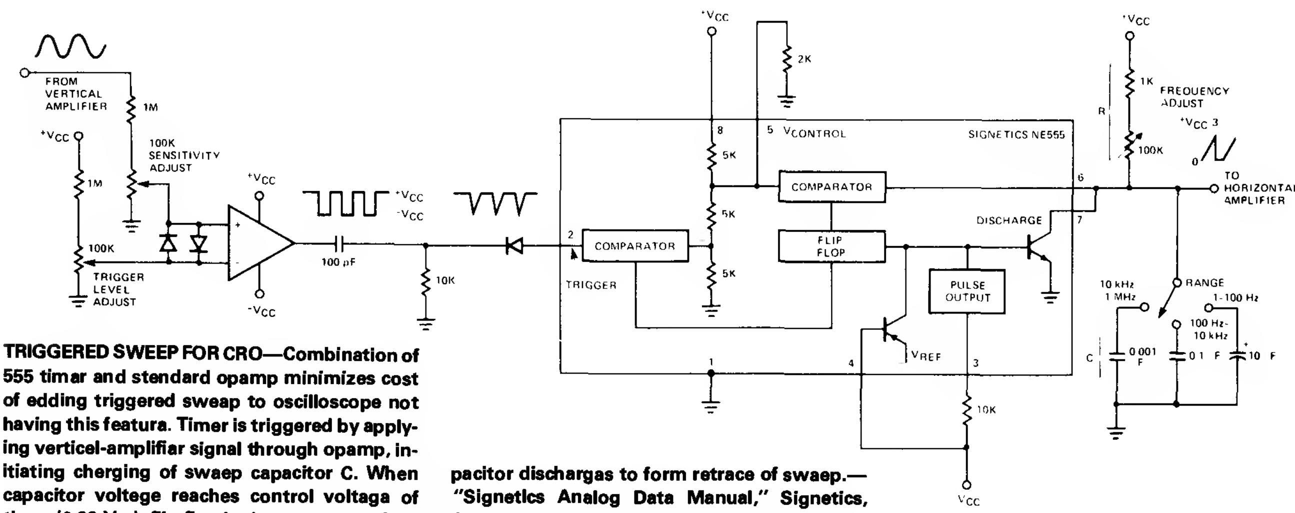
DIFFERENTIAL VERTICAL AMPLIFIER— Uses two RCA 40841 duel-gata FETs In vartical input stage of solid-stata oscilloscope, with gates of each connected In single-geta configuration. Circuit is designed for frequancies up to 500 MHz. Wida dynamic range parmits handling of lerga signels without overloeding.—"Linaar Integrated Circuits and MOS/FET's," RCA Solid Stata Division, Somarvilla, NJ, 1977, p 435–436.



HIGH-Z CRO PREAMP—Darlington circuit provides extremely high input impedance (ovar 2.2 megohms). With input shorted, noisa laval is 78 dB down as read at output with VTVM. Linearity is within 1.5% for inputs from 100 μV to 1 mV, and fraquency response is ±2 dB from 100 Hz to 350 kHz. Originally designed to boost input to CRO, but can be edapted to many other applications requiring high gain, low noisa, and high input impedanca.—J. Fisk, Circuits end Techniques, *Ham Radio*, Juna 1976, p 48–52.



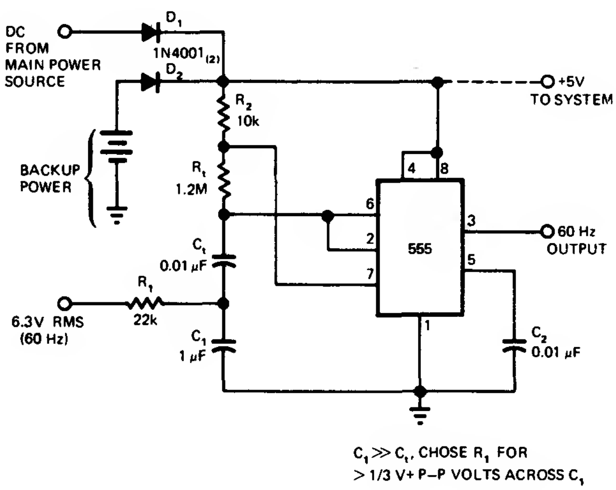
SIGNAL SWITCHER—Two-tuba alectronic switch sarves in effact to provida simultaneous prasentation of two different signals on CRO screen by switching signals altemately to vartical input at rata fast enough so both displays are seen.—Novica Q & A, *73 Magazine*, March 1977, p 187.



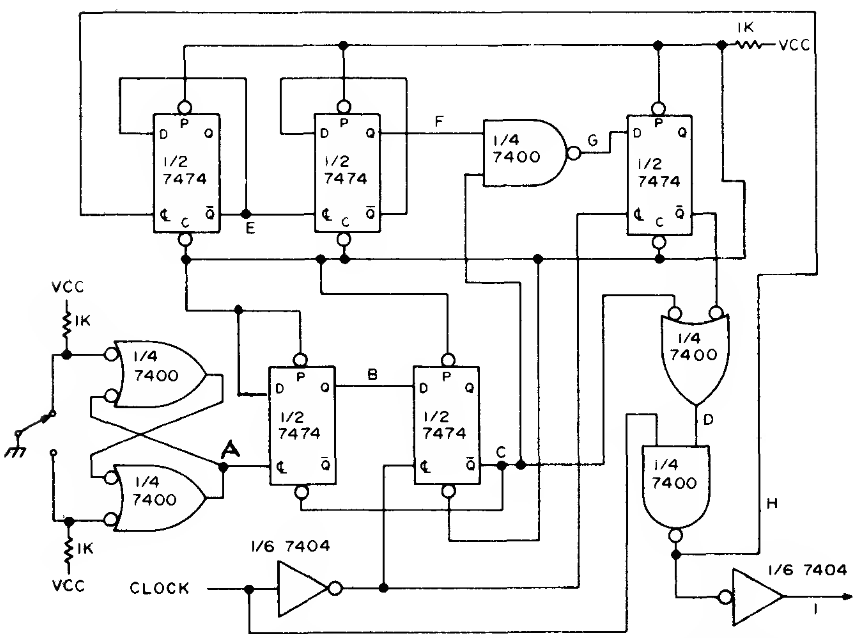
TRIGGERED SWEEP FOR CRO—Combination of 555 timar and standard opamp minimizes cost of edding triggered sweap to oscilloscope not having this featura. Timer is triggered by applying verticel-amplifiar signal through opamp, initiating charging of swaep capacitor C. When capacitor voltege reaches control voltaga of timar (0.33 V_{CC}), flip-flop in timar resets and capacitor dischargas to form retrace of swaep.—"Signetics Analog Data Manual," Signetics, Sunnyvele, CA, 1977, p 726.

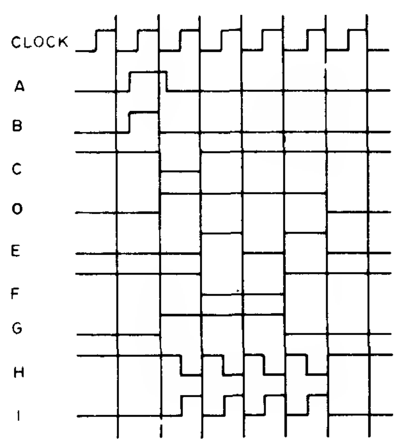
CHAPTER 12
Clock Signal Circuits

Covers circuits for generating clock pulses at frequencies ranging from 1 Hz to well above 30 MHz for use in digital circuits of multiplexers, memories, counters, shift registers, microprocessors, videotape recorders, and digital cassette recorders.

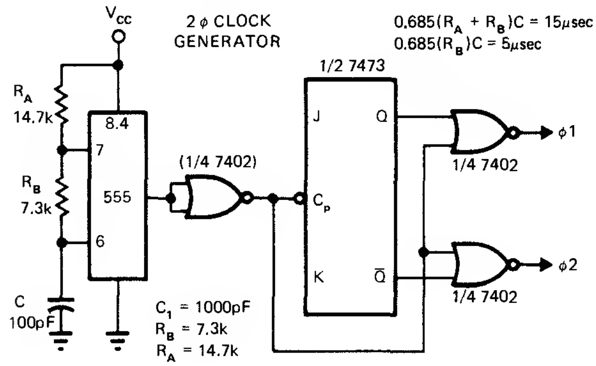


60-Hz CLOCK OUTPUT FROM 555—Basic 555 timer IC produces constant 60-Hz rectanguler output for use es noninterruptible free-wheeling clock source. C_1 introduces filtered 60-Hz powar-line reference component across C_t at 2 V P-P. This signal overrides normel timing ramp of 555, causing it to ect as amplifier or Schmitt triggar. When AC line power fails, C_t resumes normal function es timing capacitor for 60-Hz astable MVBR. Circuit can eesily be edjusted for other reference frequencies.—W. G. Jung, Teke a Fresh Look et New IC Timer Applications, *EDN Magazine,* March 20, 1977, p 127–135.

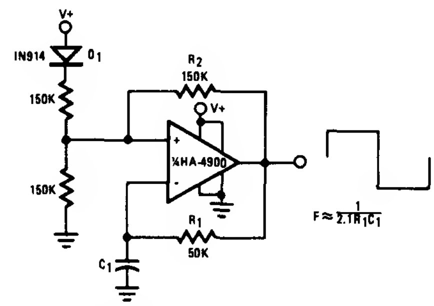




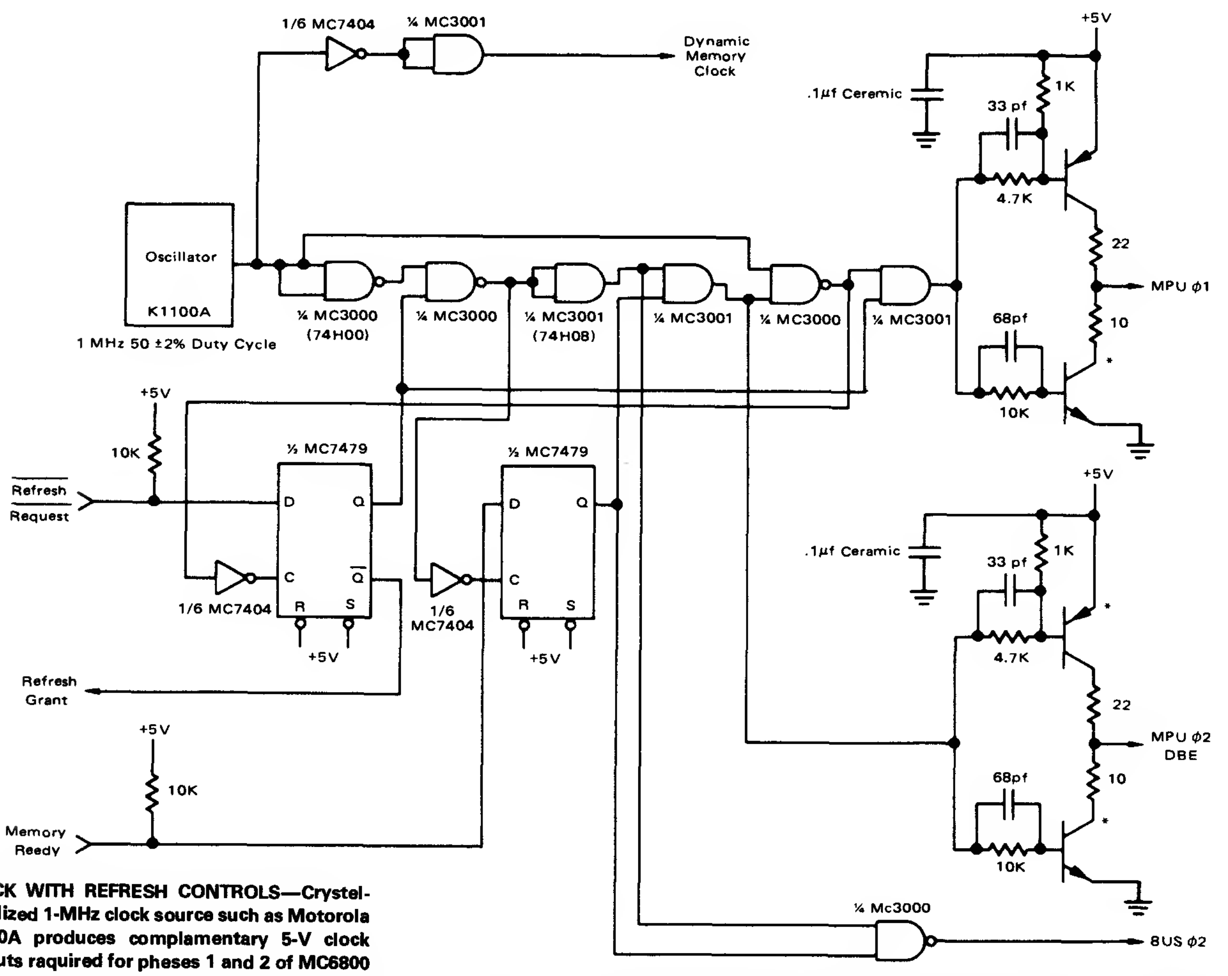
FOUR-PULSE BURST—Generetas burst of four clock pulses each time switch is pressed. Modifications can produce eny desired number of pulses in burst. Reliability of pulse count is ensured by use of debouncing latch using pair of 7400 getes. VCC is +5 V.—E. E. Hrivnak, House Cleaning the Logical Way, *73 Magazine,* Aug. 1974, p 85–90.



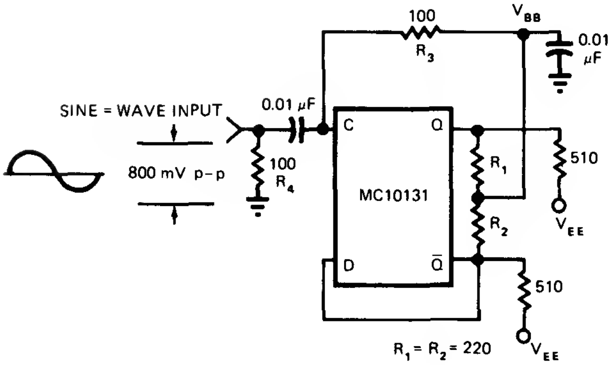
TWO-PHASE CLOCK TO 1 MHz—Signetics 555 timer is used as oscillator to ganarata nonovarlapping clock pulses as required for most two-phase dynamic MOS memorias and shift ragistars. Duty cycle Is determined by values of axternal resistors R_A and R_B which, togather with timing capacitor C, datarmine frequancy of oscillation. 7473 flip-flop controls phasa that is switched on through 7402 NOR gatas. Articla gives timing waveforms and aquations. Maximum operating frequancy is 1 MHz.—G. Schlitt, Monolithic Timar Genarates 2-Phasa Clock Pulsas, *EDN Magazine,* Aug. 1, 1972, p 57.



SQUARE-WAVE CLOCK—One section of Harris HA-4900/4905 precision quad comparator gives axcellant frequency stability as self-starting fixed-frequancy squere-weve generator for clock applications. R_1 end C_1 datarmine fraquency, and R_2 provides reganaretive feedback. For highar precision at frequencias up to 100 kHz, crystal may be used in placa of C_1.—"Linear & Date Acquisition Products," Harris Samiconductor, Melbourna, FL, Vol. 1, 1977, p 2-96.

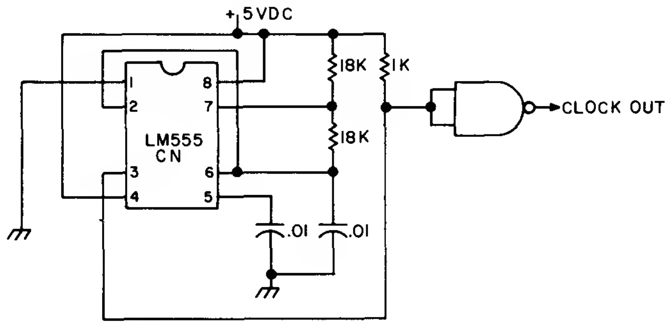


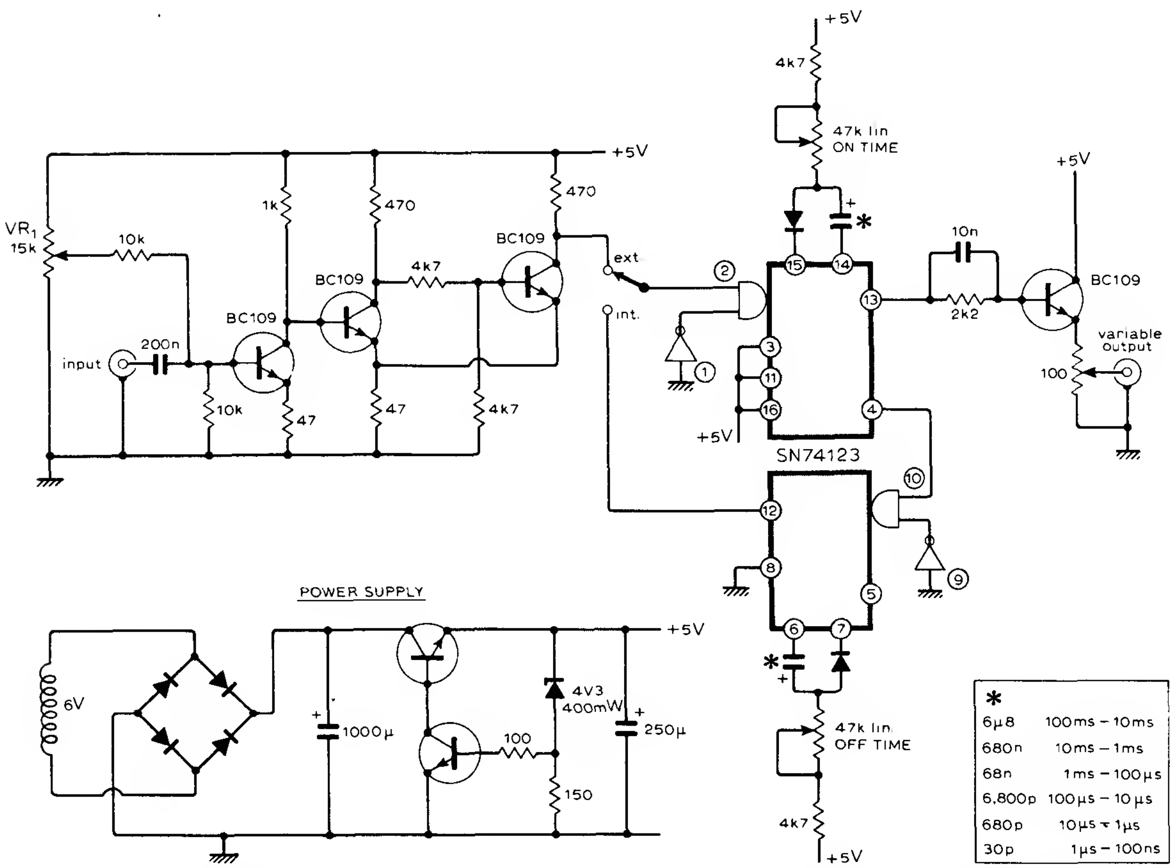
CLOCK WITH REFRESH CONTROLS—Crystal-stabilized 1-MHz clock source such as Motorola K1100A produces complamentary 5-V clock outputs raquired for pheses 1 and 2 of MC6800 MPU and also provides interface signals required for dynamic (refresh request and refresh grant) end slow (mamory ready) mamories. Refresh control circuit uses MC7479 duel latch, MC7404 hax inverter, and pair of 10K pull-up resistors. If refresh request stata is low when sampled during laading edge of phesa 1, phasa 1 is held high end phesa 2 low for at laast ona full clock cycle. Refresh grent signal is high to indicate to dynamic memory systam that refresh cycla axists. If mamory ready line Is low whan semplad on leading edge of phasa 2, phese 1 is held low end phasa 2 high until memory ready lina is brought high by slow memory controller. All trensistors ere MPQ6842.—"Microprocessor Applications Manual" (Motorola Series in Solid-Stata Electronics), McGraw-Hill, New York, NY, 1975, p 4-57–4-58.



CENTERING CLOCK SIGNAL—Circuit generates DC bias across complementary outputs of Motorola MC10131 flip-flop for optimum operation with emitter-coupled logic (10,000 series). Bias is independant of state of flip-flop, which uses toggle frequency of about 150 MHz. Article covers applications for other flip-flops and counters requiring maintenance of best toggle frequency over wide temperature range.—T. Balph and H. Gneuden, Build a Clock Bias Circuit for ECL Flip-Flops, *EDN Magazine,* May 5, 1976, p 116.

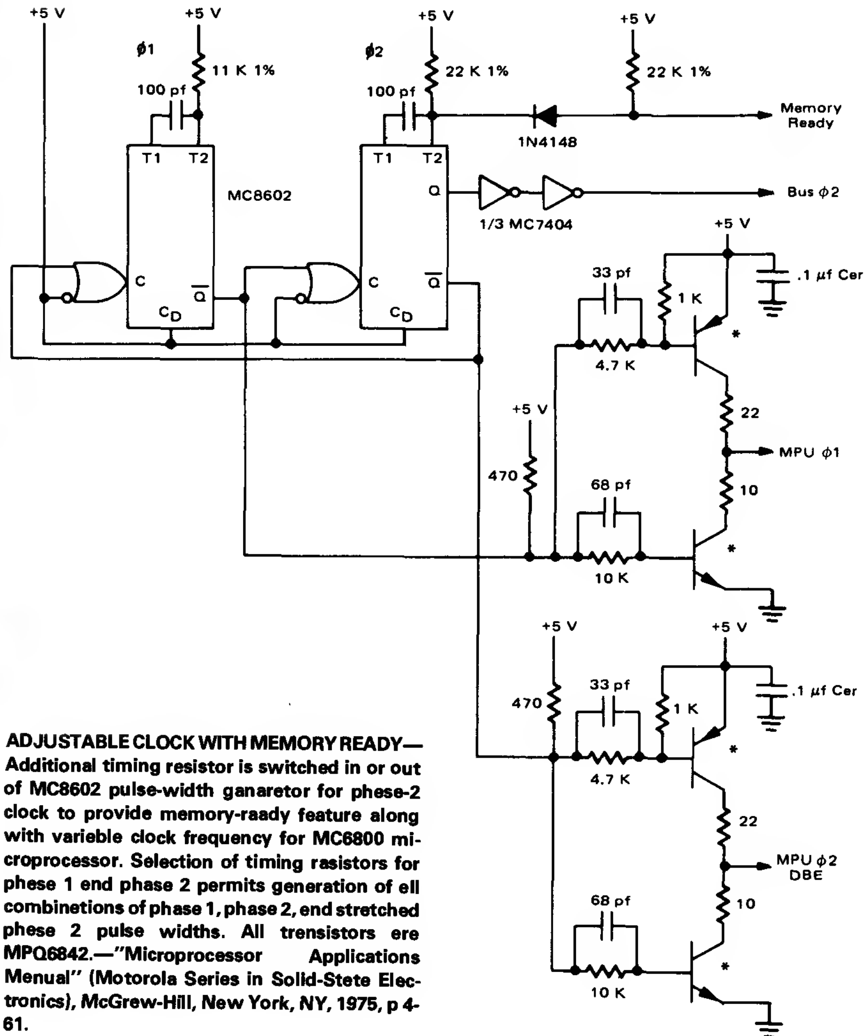
GLITCH CORRECTOR—Circuit shown prevents TTL devices from seeing two clock pulses when output of 555 timer has glitch on falling edge at about 0.8 V.—J. Megee, Glitch, *73 Magazine,* Jan. 1976, p 10.



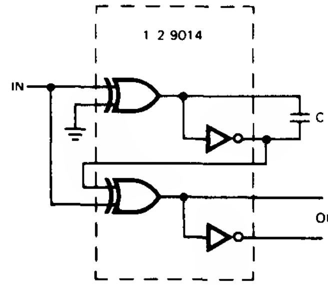


*	
6μ8	100ms – 10ms
680n	10ms – 1ms
68n	1ms – 100μs
6,800p	100μs – 10μs
680p	10μs – 1μs
30p	1μs – 100ns

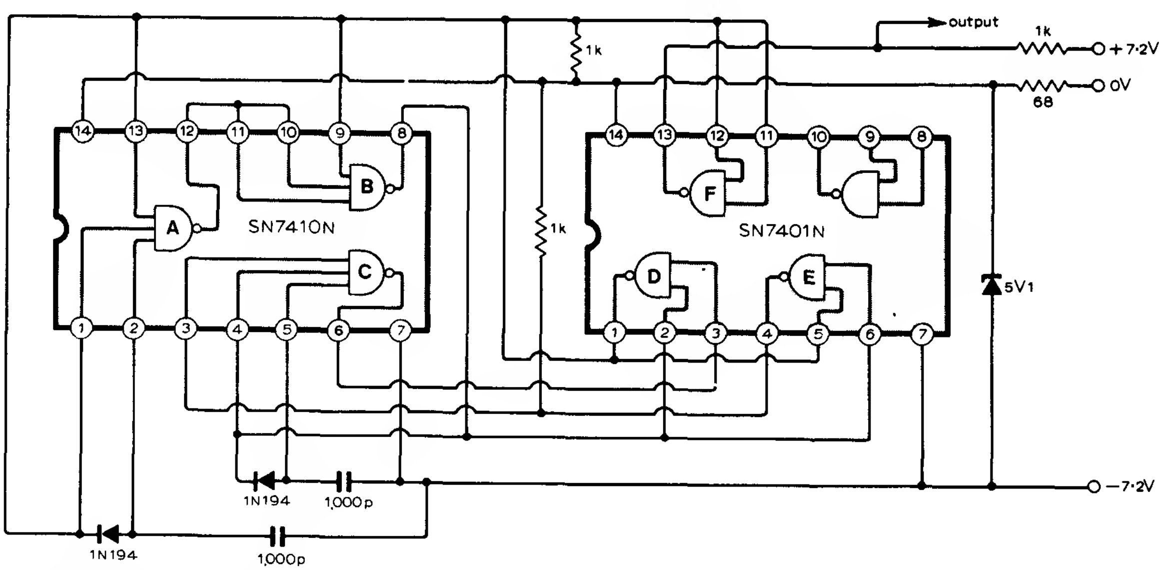
VARIABLE WIDTH AND PRF—Low-cost pulse generator uses versatile dual monostable IC to provide clock pulses that can be varied in width over wide range by changing sizes of two external capacitors and adjusting 47K linear pots. Switched bank of six capacitors can be used instead, to give on or off times ranging between 100 ms and 100 ns, as given in table. With switch in external position, on-time mono is driven by three transistors connected as Schmitt trigger giving pulse having same frequency as that of input signal. VR1 sets trigger level. Suitable regulated 5-V supply circuit is also shown.—J. Garrett, Pulse Generator, *Wireless World,* Feb. 1976, p 78.



ADJUSTABLE CLOCK WITH MEMORY READY—Additional timing resistor is switched in or out of MC8602 pulse-width generator for phase-2 clock to provide memory-ready feature along with variable clock frequency for MC6800 microprocessor. Selection of timing resistors for phase 1 and phase 2 permits generation of all combinations of phase 1, phase 2, and stretched phase 2 pulse widths. All transistors are MPQ6842.—"Microprocessor Applications Manual" (Motorola Series in Solid-State Electronics), McGraw-Hill, New York, NY, 1975, p 4-61.

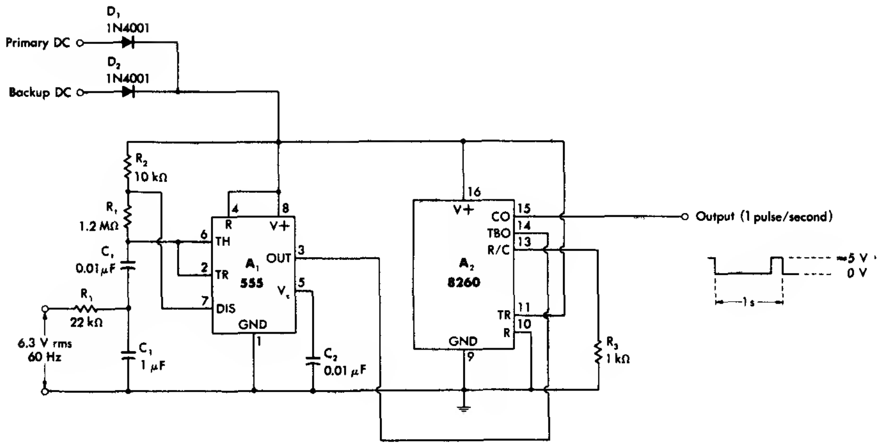


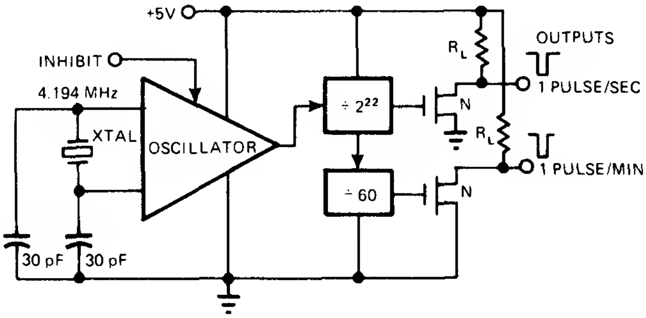
EDGE DETECTOR—Half of 9014 quad EXCLUSIVE-OR gate serves for generating output pulse for both low-to-high and high-to-low transitions of input signal. Used for regenerating clock in self-clocking pulse-width modulation transmission system. Circuit acts as frequency doubler for square-wave input. With 1000 pF for C, output pulse width is 70 ns; for 200 pF, width is 30 ns; and when C is 0, width is 10 ns.—Circuits, *73 Magazine*, Aug. 1974, p 99.



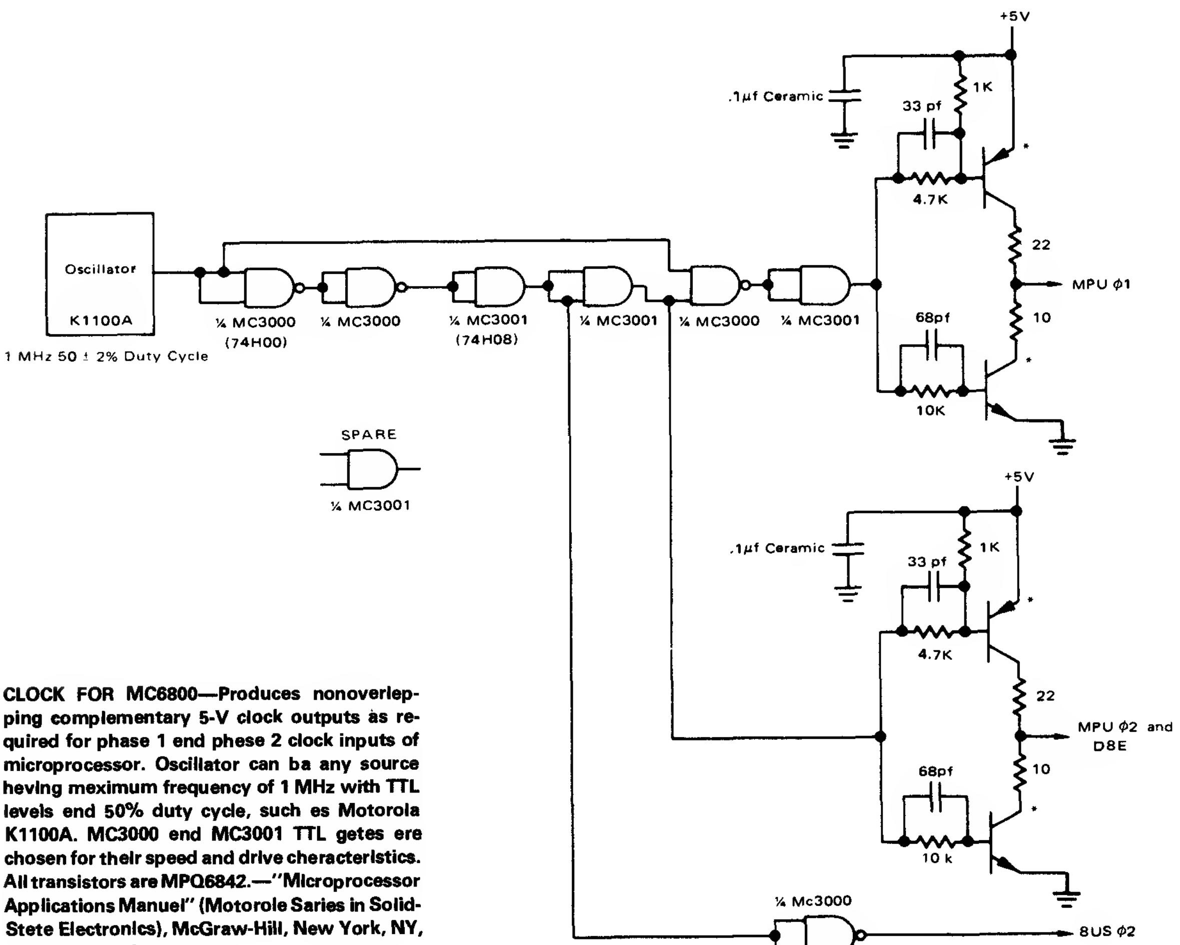
320 kHz FOR CALCULATOR—Two low-cost TTL ICs generate 320-kHz clock signals for electronic desk calculator. Output swings between +7.2 V and −7.2 V. NAND gates of ICs are connected to form free-running multivibrator, with self-starting gate C ensuring that clock waveform is available as soon as supply voltage is applied.—T. J. Terrell, Clock Generator for Electronic Calculators, *Wireless World*, Dec. 1975, p 575.

1-Hz CLOCK WITH BATTERY BACKUP—Circuit normelly produces output pulses at 1-s intervels with basic eccuracy corresponding to that of power-line frequency. Programmeble 8260 timer operetas as divide-by-60 counter producing output swing compatible with TTL or 5-V CMOS loeds. With beckup power applied to OR gete D_1-D_2, circuit operates reliebly at 1 s over supply renge of 5–15 V. Power drein is minimized at ±5 V.—W. G. Jung, "IC Timar Cookbook," Howerd W. Sams, Indienepolis, IN, 1977, p 214–215.

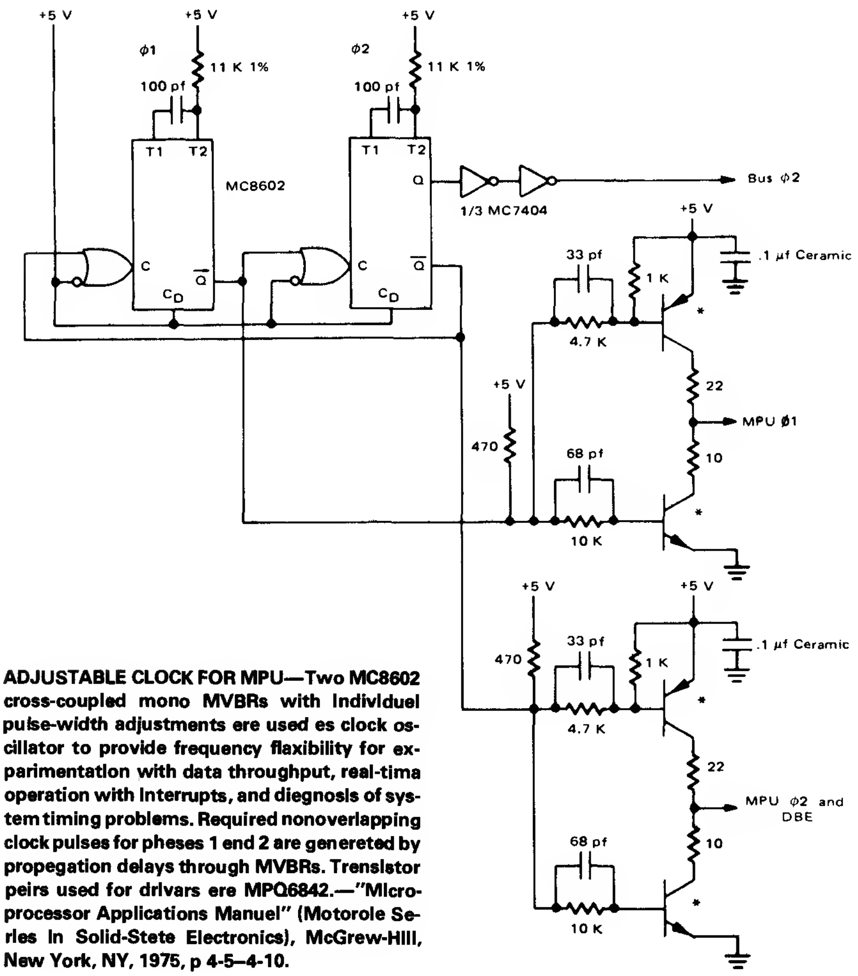




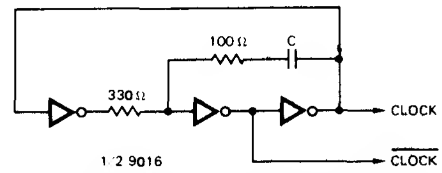
WATCH-CRYSTAL TIMER—When usad with standerd 4.194-MHz wetch crystel, Intersil 7213 crystal-controlled timer generates outputs of 1 pulsa par second end 1 pulse per minute, using internel divider chain. CMOS dynemic end static dividers keap power dissipation under 1 mW with 5-V supply.—B. O'Neil, IC Timers—the "Old Reliable" 555 Hes Compeny, *EDN Magazine*, Sept. 5, 1977, p 89–93.



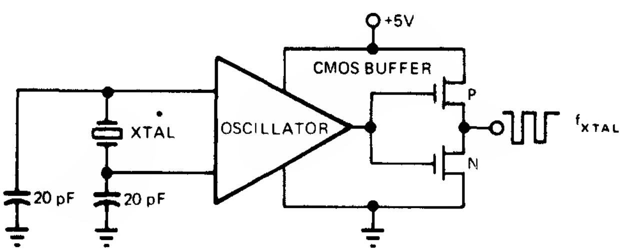
CLOCK FOR MC6800—Produces nonoverlepping complementary 5-V clock outputs as required for phase 1 end phese 2 clock inputs of microprocessor. Oscillator can ba any source heving meximum frequency of 1 MHz with TTL levels end 50% duty cycle, such es Motorola K1100A. MC3000 end MC3001 TTL getes ere chosen for their speed and drive cherecterlstics. All transistors are MPQ6842.—"Microprocessor Applications Manuel" (Motorole Series in Solid-Stete Electronics), McGraw-Hill, New York, NY, 1975, p 4-1–4-6.



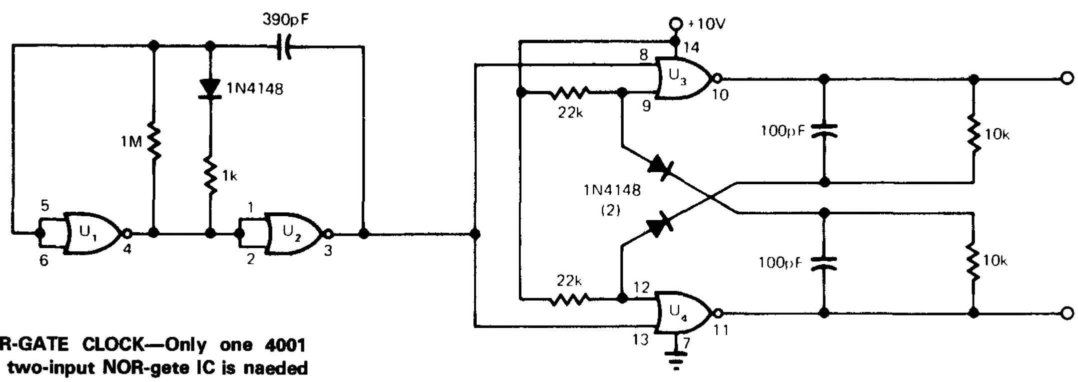
ADJUSTABLE CLOCK FOR MPU—Two MC8602 cross-coupled mono MVBRs with individuel pulse-width adjustments ere used es clock oscillator to provide frequency flexibility for exparimentation with data throughput, real-tima operation with interrupts, and diegnosis of system timing problems. Required nonoverlapping clock pulses for pheses 1 end 2 are genereted by propegation delays through MVBRs. Trensistor peirs used for drivars ere MPQ6842.—"Micro-processor Applications Manuel" (Motorole Series In Solid-Stete Electronics), McGrew-Hill, New York, NY, 1975, p 4-5–4-10.



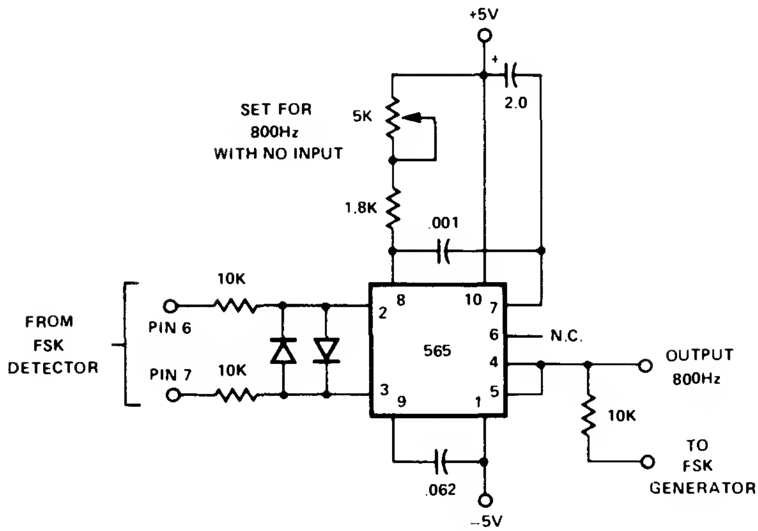
RC CLOCK—Simple TTL clock genaretor is suitable for most TTL systems. Requires only helf of hex invertar peckaga end three passiva components. Clock frequency depends on velue of C: 200 pF givas 5 MHz; 1600 pF givas 1 MHz; 0.018 μF gives 100 kHz; end 0.18 μF gives 10 kHz.—Circuits, *73 Magazine*, Aug. 1974, p 99.

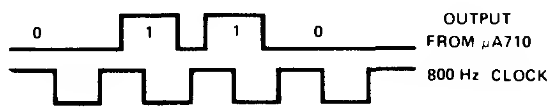


CRYSTAL-CONTROLLED TIMER—Intarsil 7209 crystal oscillator provides buffered CMOS output cepeble of driving over fiva TTL loeds et any crystel frequancy up to 10 MHz. Used in applications requiring high-eccuracy buffered timing signals for system clocks.—B. O'Neil, IC Timars—the "Old Reliebla" 555 Has Compeny, *EDN Megazine*, Sept. 5, 1977, p 89–93.



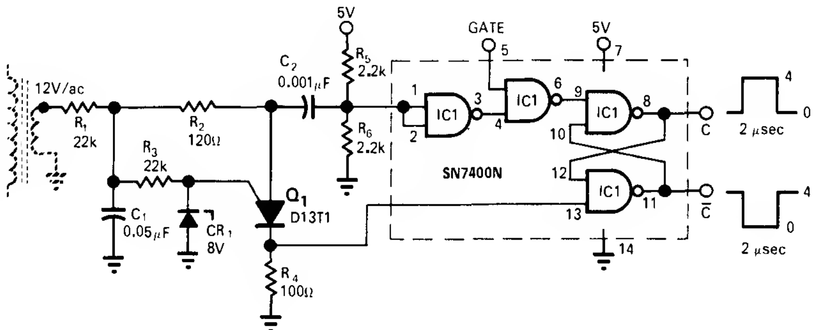
CMOS FOUR-GATE CLOCK—Only one 4001 CMOS qued two-input NOR-gete IC is naeded for symmetrical complementary-output clock heving good temperature end supply stebility. Getes U_1 and U_2 form esteble oscillator producing positive-going pulses used to trigger divide-by-2 flip-flop U_3-U_4. Circuit will opareta over wida renge of supply voltages end tampare-tures.—M. Eeton, Symmetricel CMOS Clock Is Inexpensive, *EDN Magazine*, Merch 20, 1974, p 80 end 83.

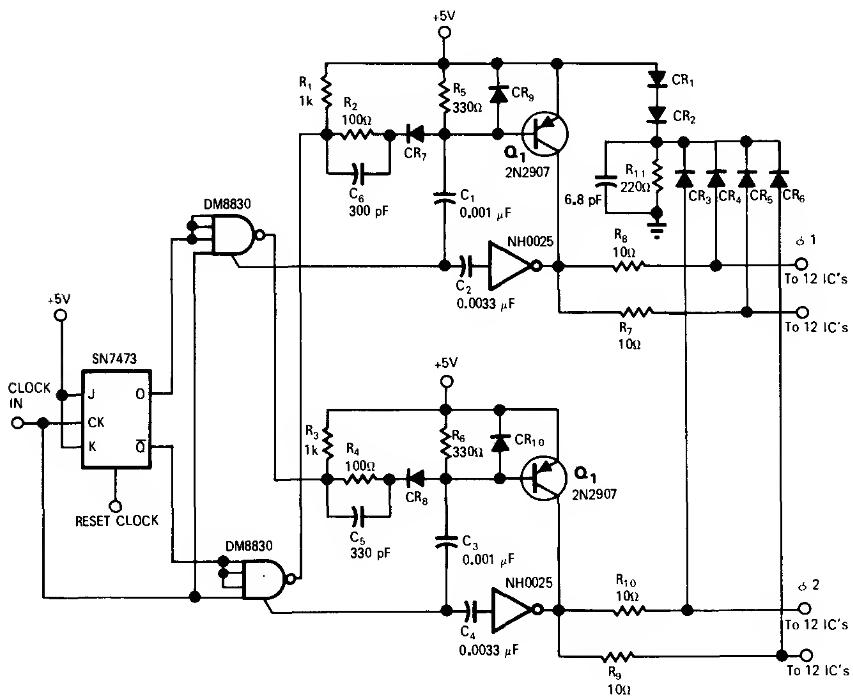




800-Hz CLOCK FOR CASSETTE RECORDER— 565 PLL is set for free-running at 800 Hz with no input. When deta pulses extracted from FSK recorded date on cassette tape are fed in, clock is synchronized to data and stays in sync for up to seven 0s in succession.—"Signetics Analog Deta Manuel," Signetics, Sunnyvale, CA, 1977, p 859–860.

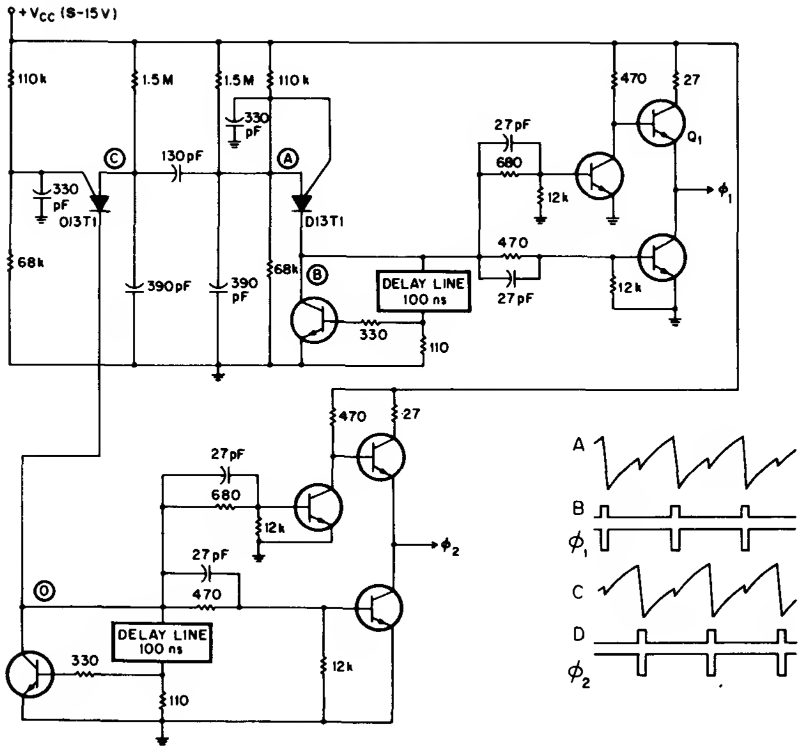
60-Hz GLITCH-FREE CLOCK—Circuit genarates complamantary gated 60-Hz clock pulsas that are elways wider than 2 μs, without glitchas avan if gata is anabled or disabled during clock pulsa. Accuracy depends on stability of power-lina frequency.—R. I. Whita, Gated 60 Hz Clock Avoids Glitches, *EDN/IEEE Magazine*, Nov. 1, 1971, p 52.



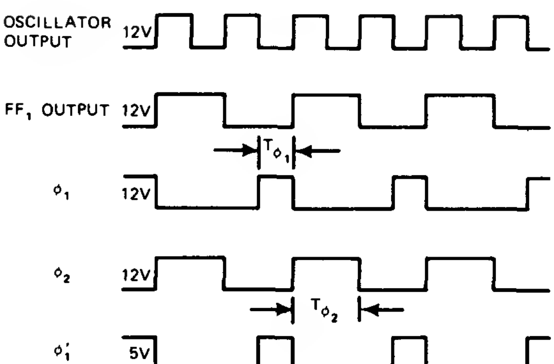


DRIVER FOR 24 MOS REGISTERS—With input of clock pulses preshaped to width of about 150 ns, circuit shown will generate 17-V 1.5-A clock signal required for driving 1024-bit sarial MOS memories or shift registers. Article traces operetion of circuit. All diodes are 1N3064.—R. D. Hoose and G. L. Andarson, Clock Driver for MOS Shift Ragistars, *EDN/EEE Magazine*, Dec. 15, 1971, p 56–57.

2.5-kHz CLOCK—Requires only 3-mW power to generate fast 15-V two-phasa ractangular pulses with 100-ns widths and 20-ns rise end fall times. Suiteble for meny MOSFET shift registers. Uses two D13T1 programmabla UJT oscillators, eech having four-trensistor driver stege using 2N2369 transistors. Oscillators era cross-synchronized by 130-pF capecitor. Timing and bias networks of UJTs sat pulse repatition frequency.—G. A. Altemose, Low-Power Two-Phase Clock, *EDN/IEEE Magazine,* May 15, 1971, p 49.



TWO-PHASE CLOCK FOR 8080—Crystal oscillator operating at twice desired clock frequency uses pi network R_1-C_1-X_1-C_2 providing 180° phase shift required for positive feedback to input of oscillator G_1. D flip-flop FF_1 in divide-by-2 configuration generates one phase, while NOR gate G_2 generates other phase from basic oscillator by masking out every othar cycle. G_3 merely provides enough propagation delay on second phase to prevent overlap with first phase. Crystal should ba below 3 MHz.—D. M. Risch, 8080 CMOS Clock Uses Two IC's, *EDN Magazine,* Jan. 5, 1977, p 50.



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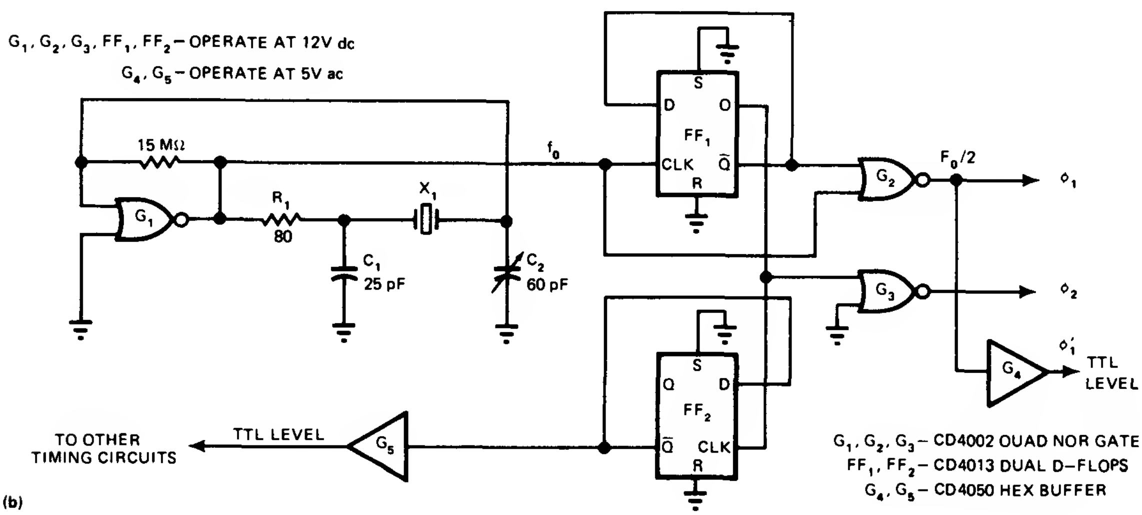

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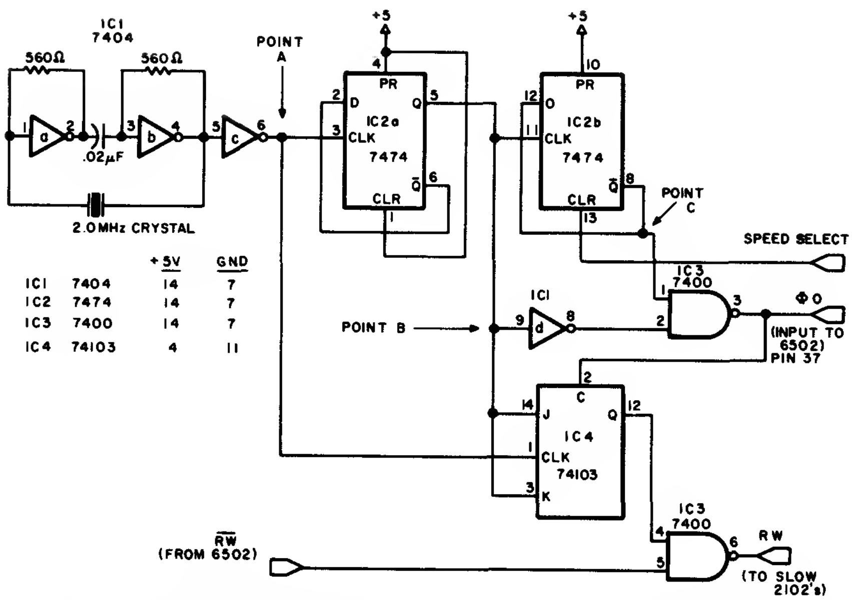
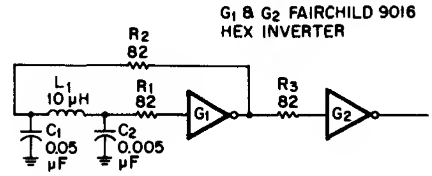
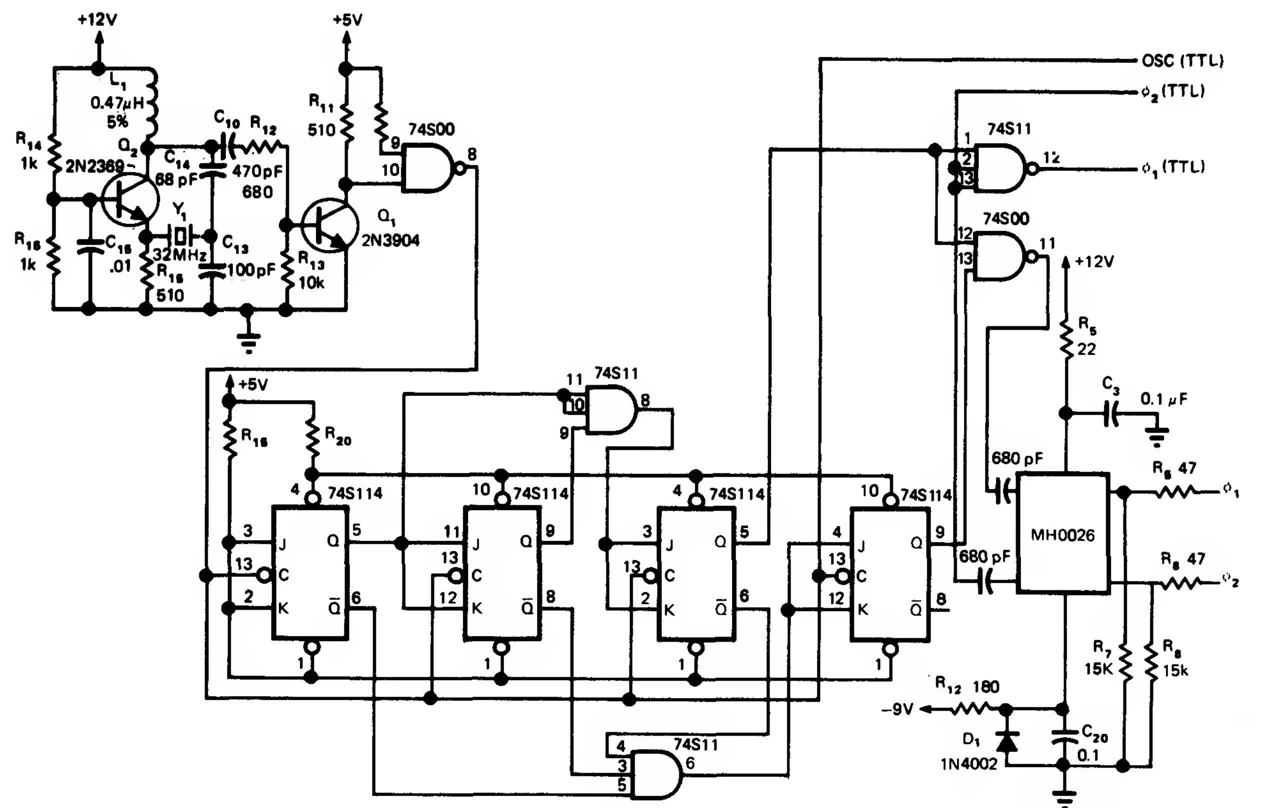


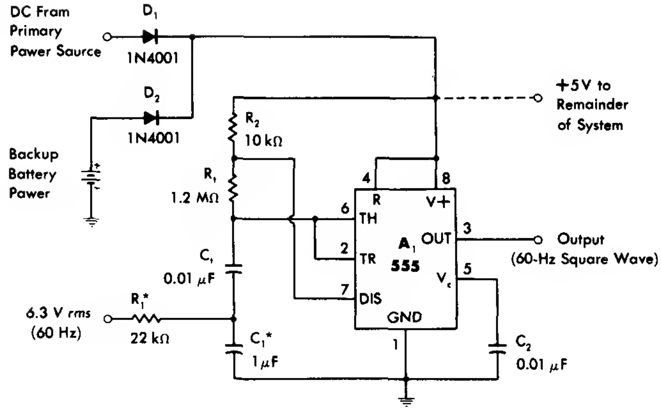


TWO-INVERTER COLPITTS—Simple low-cost clock uses two inverters in LC circuit. G_1 operates as Colpitts oscillator, with C_1 setting feedback level and L_1-C_2 setting frequency. Low DC resistance path through R_1, R_2, and L_1 provides high negative DC feedback around G_1 and biases it into linear region. G_2 squares output of G_1 to appropriate TTL levels. For values shown, output period is 1.2 μs and rise and fall times are under 20 ns.—C. A. Herbst, TTL Inverter Makes Stable Colpitts Oscillator, *EDN/IEEE Magazine*, May 15, 1971, p 50.

TWO-SPEED CLOCK—Creates alternative slow clock cycle for MOS Technology 6502 processor on KIM-1 microcomputer card under control of SPEED SELECT line generated by slow memories. Control logic of 0 gives fast cycles, while logic 1 gives slow cycles. Processor cycle is maintained for 1 μs for fast memory access, but cycle is automatically stretched to 2 μs for slower 2102s.—Y. M. Gupta, True Confessions: How I Relate to KIM, *BYTE*, Aug. 1978, p 44–48.

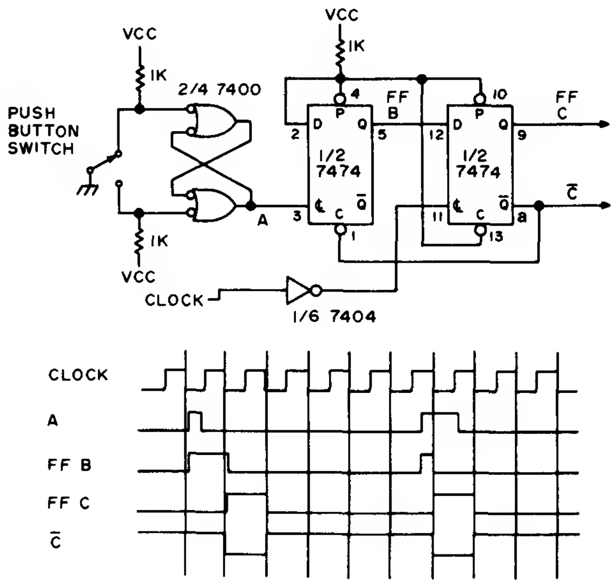


TWO-PHASE CLOCK FOR 8080—Typical clock design for Intel 8080 microprocessor system uses carefully designed logic sequence and level translation in combination with 32-MHz crystal to generate two-phase 12-V clock waveform.—S. G. Brennen, μP Clock Generators—Buy or Build? *EDN Magazine*, Sept. 20, 1975, p 53–55.

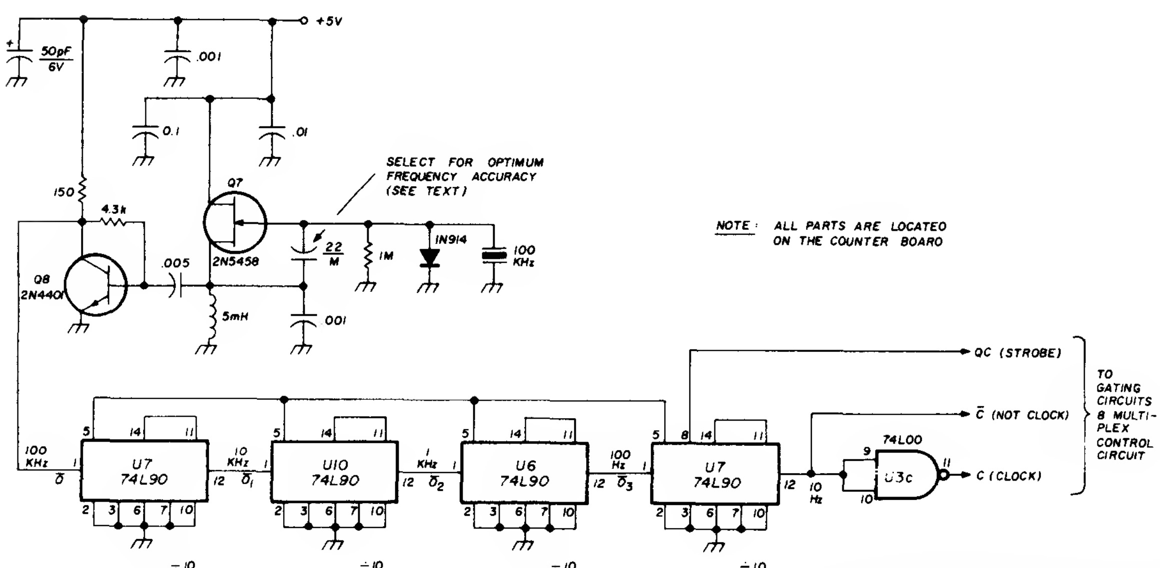


*$C_i \gg C_t$. Choose R_i for > 1/3 V+ p-p across C_i.

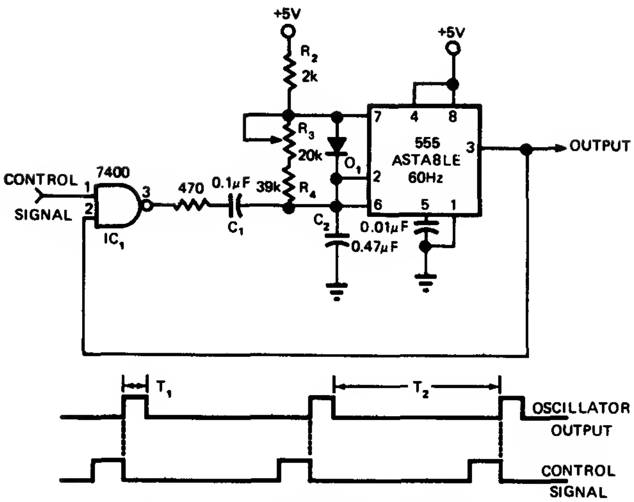
BATTERY BACKUP POWER—Provides 60-Hz square-wave output for driving electronic timekeeping circuits from battery during AC power failure. 555 timer is connected as square-wave astable MVBR normally locked to incoming 60-Hz power frequency. R_t should be trimmed for zero beat with 60-Hz source. When primary power fails, reference voltage disappears and effect of C_i on frequency is minimized. 555 now oscillates at frequency determined by R_t and C_t, which is 60 Hz. Use 6-V battery.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 201–203.



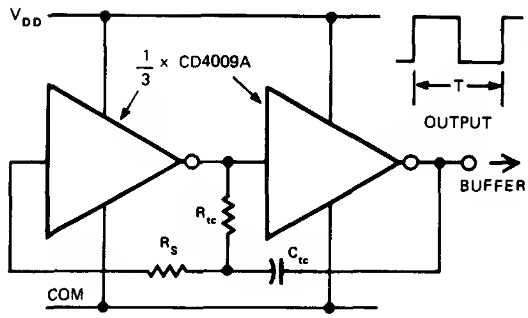
SYNCHRONIZER—For each switch closure, circuit produces one output pulse that is one clock period wide, synchronized with clock. When switch is closed, debouncing latch using 7400 gates goes high and makes flip-flop B high. Next clock pulse makes flip-flop C high and resets flip-flop B. At next clock pulse, flip-flop C goes low to complete cycle of operation.—E. E. Hrivnek, House Cleaning the Logical Way, *73 Magazine*, Aug. 1974, p 85–90.



10-Hz CLOCK—Stable and accurate clock is generated by high-precision 100-kHz crystal oscillator and decade divider chain. Used in 20-meter receiver as part of digital display system that shows frequency of received signal after counting HFO, LO, and BFO outputs, summing counts, and displaying result.—M. A. Chapman, High Performance 20-Meter Receiver with Digital Frequency Readout, *Ham Radio*, Nov. 1977, p 56–65.

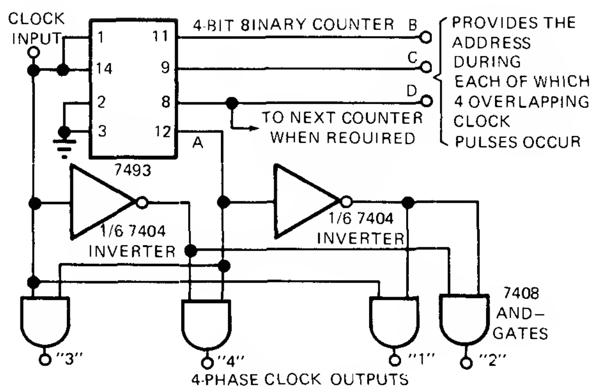


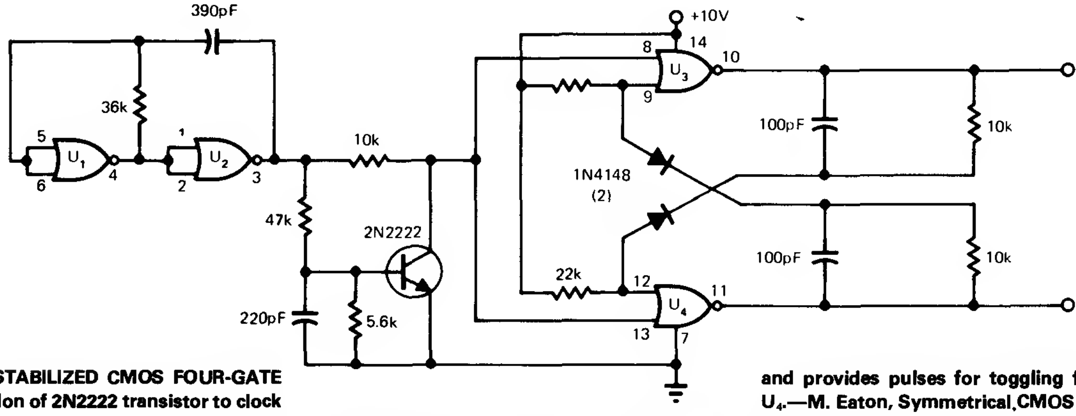
VTR CLOCK—Locked oscillstor using only two-input NAND gate snd 555 timer provides logic clock signsl for videotape recorder. Vertical sync signal, stripped from video information recorded on tspe, Is used ss control signal. C_1 controls locking range for free-running frequency of 555. When C_2 is charging (555 output is high), R_2 and D_1 determine tima constsnt T_1. During discharge of C_2, D_1 Is reverse-biased and discharge time constant T_2 is determined by R_3 and R_4.—L. Saunders, Locked Oscillator Uses a 555 Timer, *EDN Magazine,* June 20, 1975, p 114.



CLOCK FOR REGULATED SUPPLY—Singla RCA CD4009A serves as clock generator and mono for driving regulated power supply having foldback current-limiting protection. R_{tc} and C_{tc} are major frequency-determining components. R_S should be made equal to or greater than $2R_{tc}$. Article gives equation for period T of oscillator, which ranges from about 2.2 to 2.5 times $R_{tc}C_{tc}$.—J. L. Bohan, Clocking Schema Improves Power Supply Short-Circuit Protection, *EDN Magazine,* March 5, 1974, p 49–52.

FOUR-PHASE CLOCK—Provides expsndable 3-bit binary output and four overlapping clock pulsas for each unique binary output. A-output of 7493 binary counter is used slong with clock input to form four-phsse overlapping clock function. Article Includes timing diagram thst shows sequence of output pulses. Developed for use in addressing multiplexers, ROMs, and othar digital units.—B. Brsndstedt, Clock Pulse Generator Hss Addressable Output, *EDN Magazine,* Dec. 15, 1972, p 42.

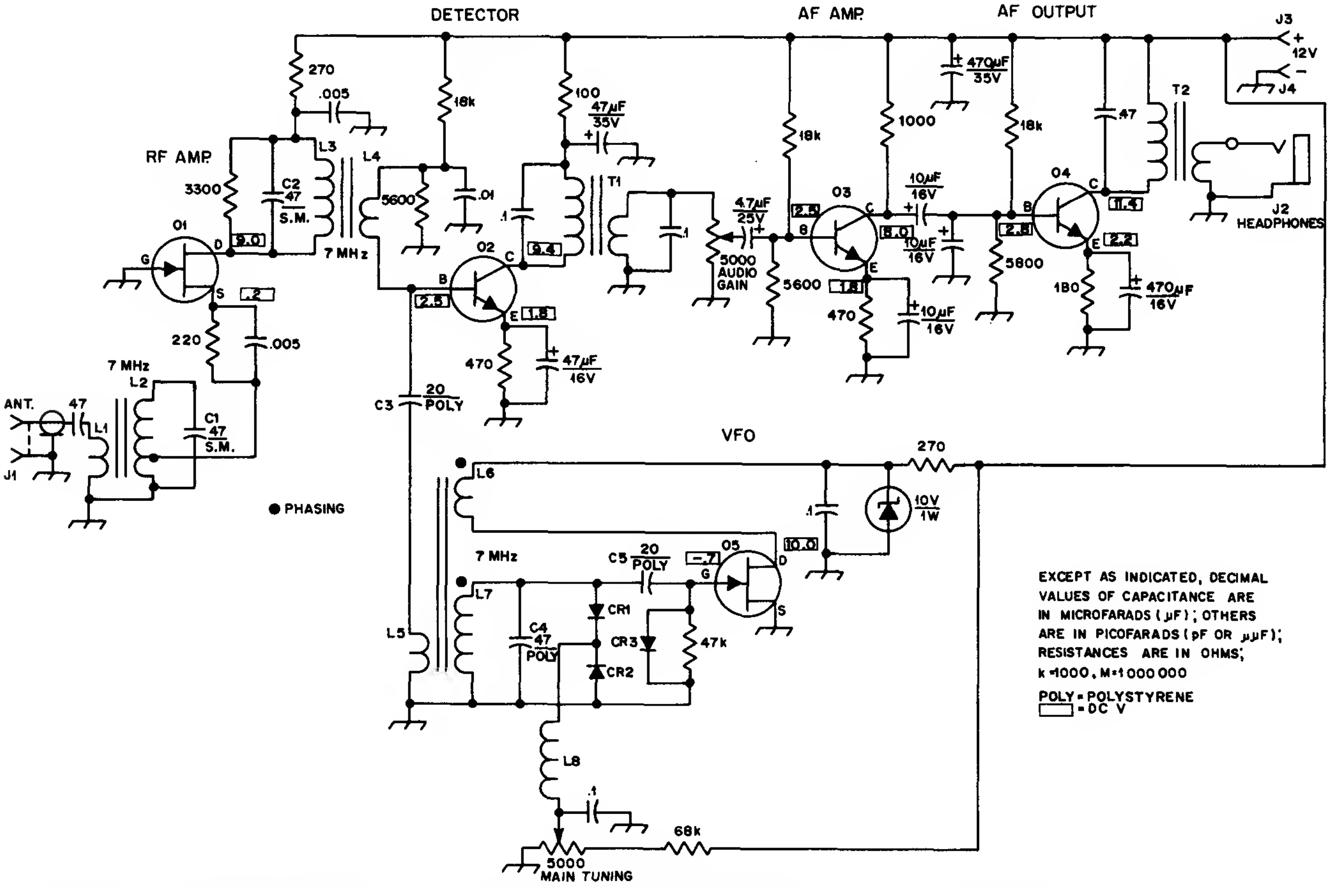




TRANSISTOR-STABILIZED CMOS FOUR-GATE CLOCK—Addition of 2N2222 transistor to clock using 4001 CMOS qusd two-input NOR-gate IC boosts temparatura stability to 0.05%/°C and supply stability to 0.05%/V. Transistor circuit differentistes output signal of oscillator U_1-U_2 and provides pulses for toggling flip-flop U_3-U_4.—M. Eaton, Symmetrical CMOS Clock Is Inexpensive, *EDN Magazine,* March 20, 1974, p 80 snd 83.

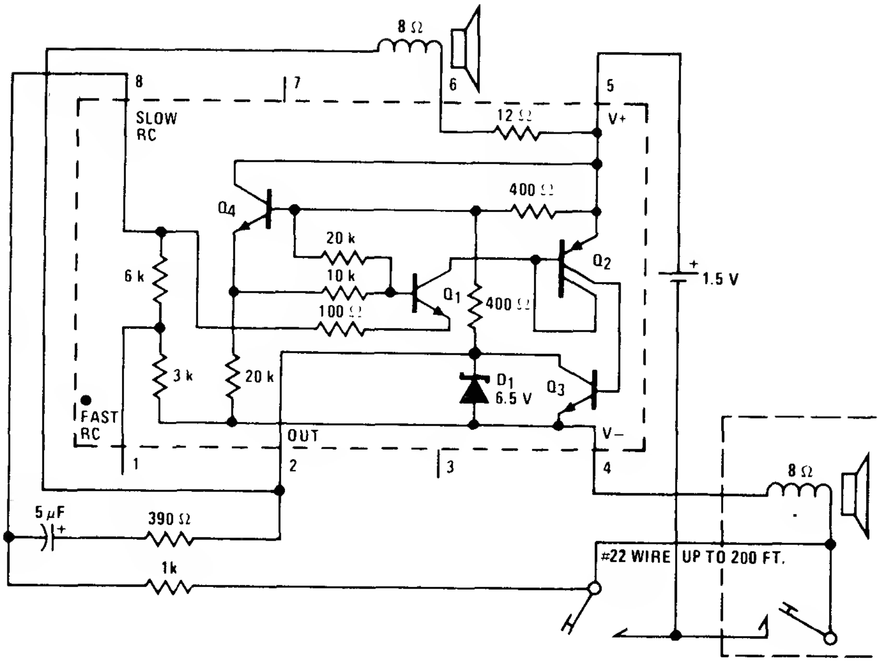
CHAPTER 13 Code Circuits

Covers Morse-code circuits as used in amateur, maritime, and other CW communication applications for keyers, monitors, code generators and regenerators, decoders, practice oscillators, CW filters, and call-letter generators. For circuits capable of handling CW along with other types of modulation and for circuits handling other types of codes, see also Filter, IF Amplifier, Keyboard, Memory, Microprocessor, Single-Sideband, Receiver, Transceiver, and Transmitter chapters.



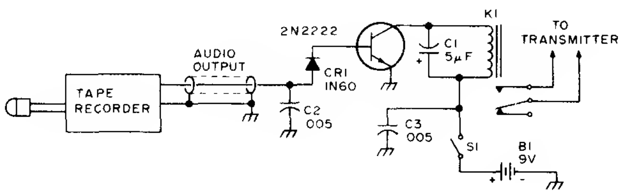
CR1 - CR3, incl. — High-speed switching diode (Radio Shack type 276-1620).
J1 — RCA-type phono jack.
J2 — 1/4-inch phone jack.
J3, J4 — Binding post.
L1 — 3 turns insulated hookup wire wound over (ground) end of L2.
L2 — Radio Shack type 273-101 rf choke. Tap at 4 turns above ground end.
L3 — Radio Shack type 273-101 rf choke.
L4 — 4 turns insulated hookup wire wound over cold end of L3.
L5 — 5 turns insulated hookup wire wound over ground end of L7.
L6 — 4 turns insulated hookup wire wound adjacent to high end of L7.
L7 — Radio Shack type 273-101 rf choke with six of the original turns removed.
L8 — Radio Shack type 273-102 rf choke.
Q1, Q5 — JFET (Radio Shack type RS-2035).
Q2 - Q4, incl. — Transistor (Radio Shack type 276-1617).
T1 — Audio transformer (Radio Shack type 273-1378).
T2 — Audio transformer (Radio Shack type 273-1380).

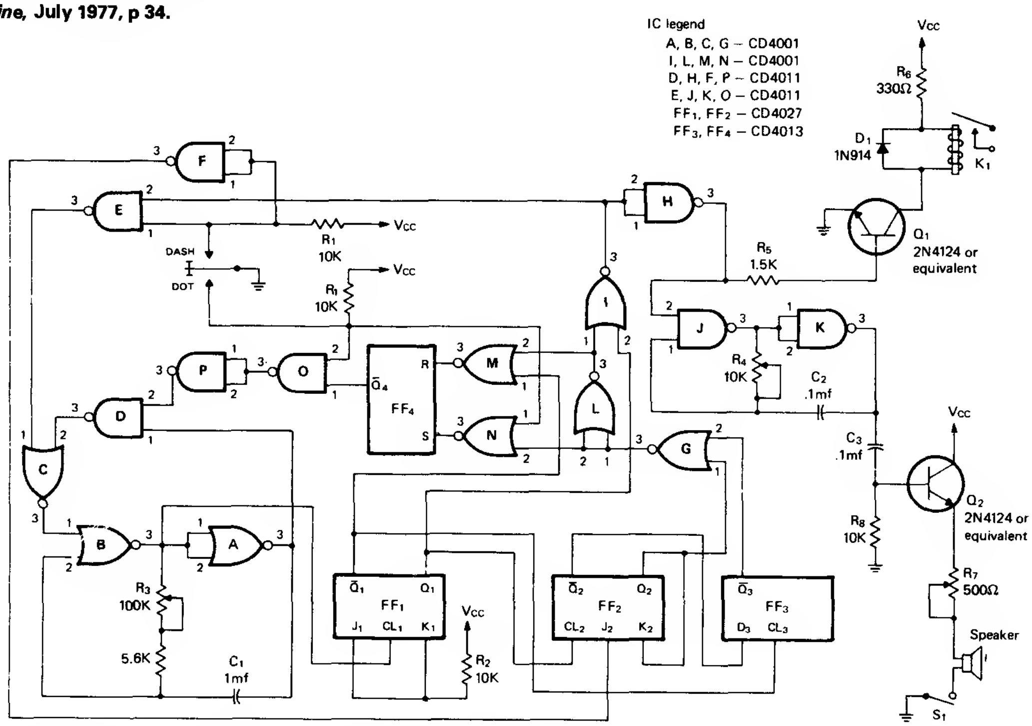
40-METER DIRECT-CONVERSION—Simple, foolproof circuit design uses discrete components mounted on printed-circuit board shaped to fit in oval herring can. Single 7-MHz RF stage and voltage-tuned VFO feed product detector Q2 that drives 2-stage AF amplifier having peak response at about 650 Hz for most comfortable CW listening. VFO uses Armstrong or tickler-feedback circuit, with CR1 and CR2 connected as voltage-variable-capacitance diodes. Zener regulator powers VFO circuit for good frequency stability. Receiver will tune any 100-kHz segment of 40-meter band.—J. Rusgrove, The Herring-Aid Five, *QST*, July 1976, p 20–23.



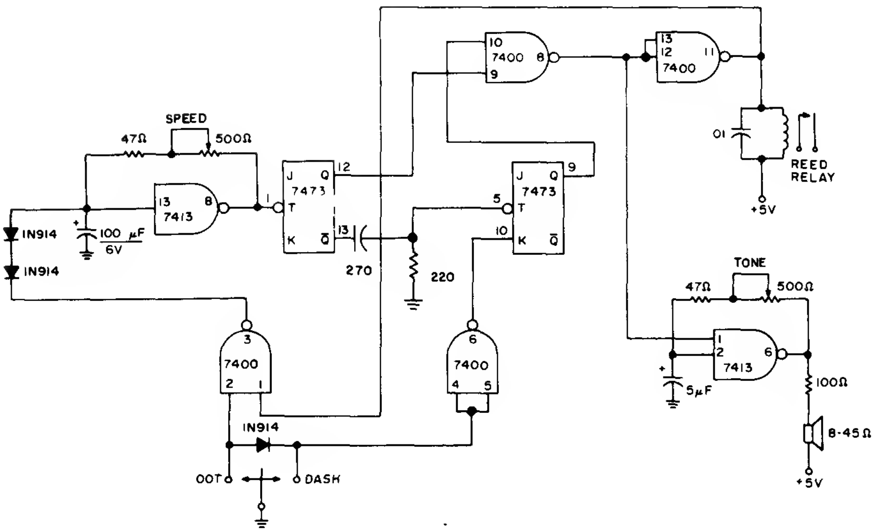
MORSE-CODE SET—National LM3909 flasher IC is connected as tone oscillator that simultaneously drives loudspeakers at both sending and receiving ends of wire line used for Morse-code communicetion system. Single alkaline penlight cell lasts 3 months to 1 year depending on usage. Three-wire system using parallel telegraph keys eliminetes need for send-receive switch. Tone frequency is about 400 Hz.—"Linear Applications, Vol. 2," Nationel Semiconductor, Sante Clara, CA, 1976, AN-154, p 5–6.

CQ ON TAPE—Frequently used code messege such as amateur radio CQ call is recorded by keying audio oscillator with desired messege and picking up oscillator output with microphone of endless-loop cassette or other tape recorder. Rewound recording is played back through single-transistor stage connected as shown for driving keying relay of transmitter. Circuit requires shielding.—Circuits, *73 Magazine*, July 1977, p 34.

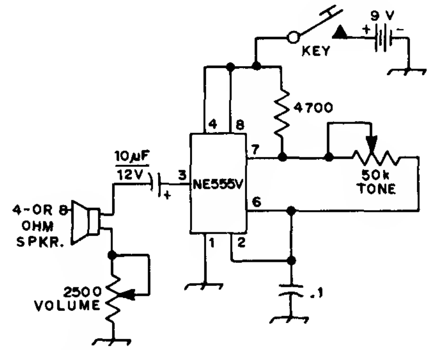




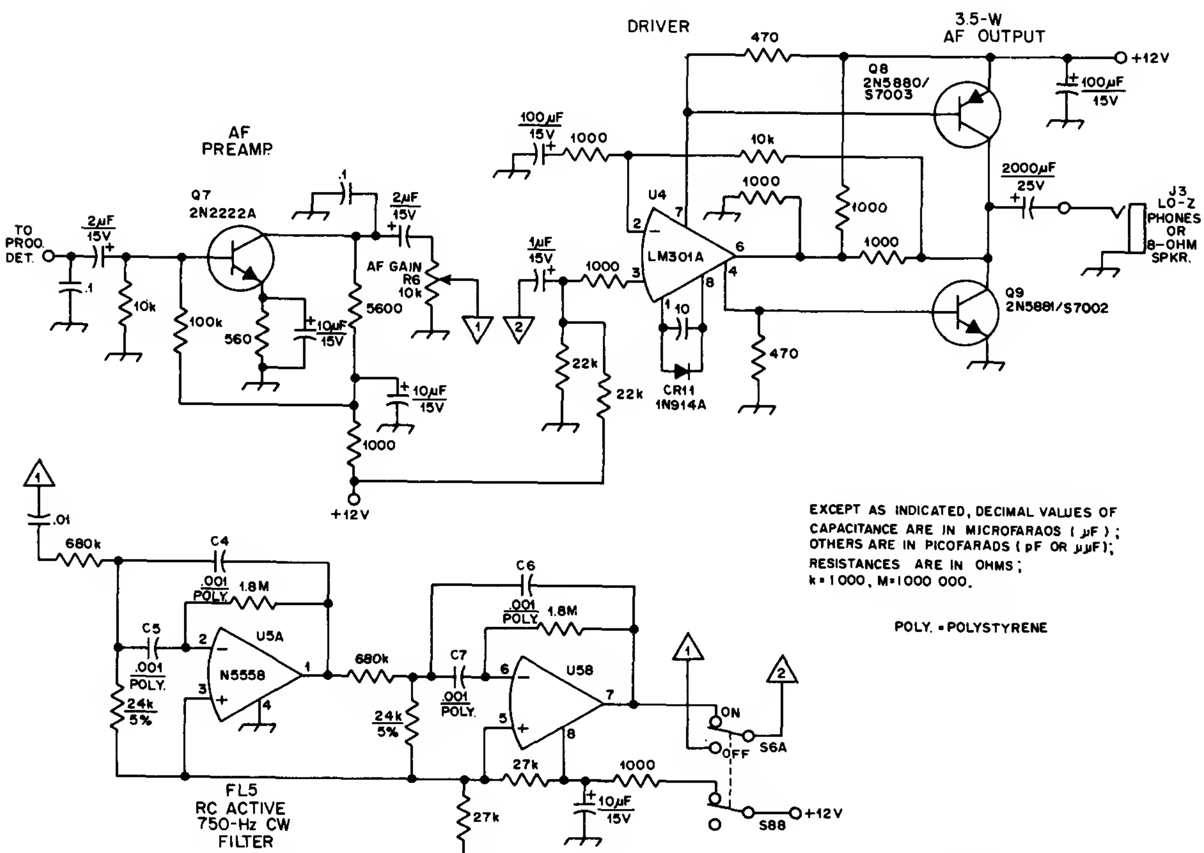
KEYER WITH MEMORY—Includes sidetone oscillator and dash-dot memory along with veriable speed, automatic spacing, end self-completing dots and deshes. If dot peddle is pressed and released while keyer is genereting desh, dot is genereted with correct specing after desh is completed. Getes A, B, and C form gated MVBR. Gates D, E, O, end P serve to complete characters. JK flip-flops FF_1 and FF_2, D flip-flop FF_3, and gates F, G, and L provide character-shaping required for desh-dot memory using gates M, N, end RS flip-flop FF_4. Gates J end K generete audio sidetone. K_1 is B & F Enterprises ERA-21061 SPST reed relay. Supply can be 9-V battery.—T. R. Crawford, A Low-Power Cosmos Electronic Keyer in Two Versions, *CQ*, Nov. 1975, p 17–24.



KEYER—Usas gating and flip-flop functions to ganarata dots and dashes undar control of gated clock. SN7413 Schmitt trigger is connacted as relaxetion oscillator. Circuit provides minimum spacing between dots and deshes regardless of paddla movemants.—A. D. Helfrick, A Simple IC Kayar, *73 Magazine,* Dec. 1973, p 37–38.



TIMER FOR CODE PRACTICE—Signetics NE555V timer opereting on 9-V supply serves as AF oscillator providing edequate volume for classroom instruction. Output tone can be veried from saverel hundred to several thousend hertz.—J. Burney, Code Prectice Oscillator, *QST,* July 1974, p 37.

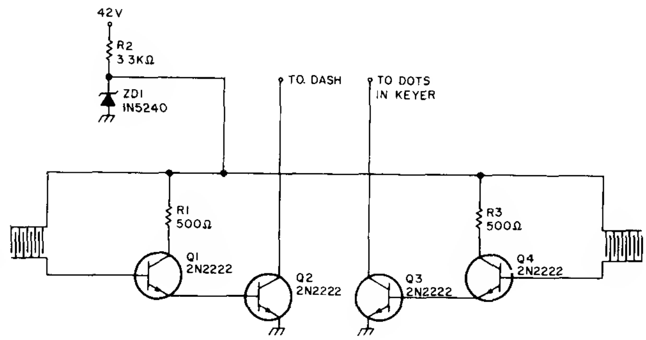


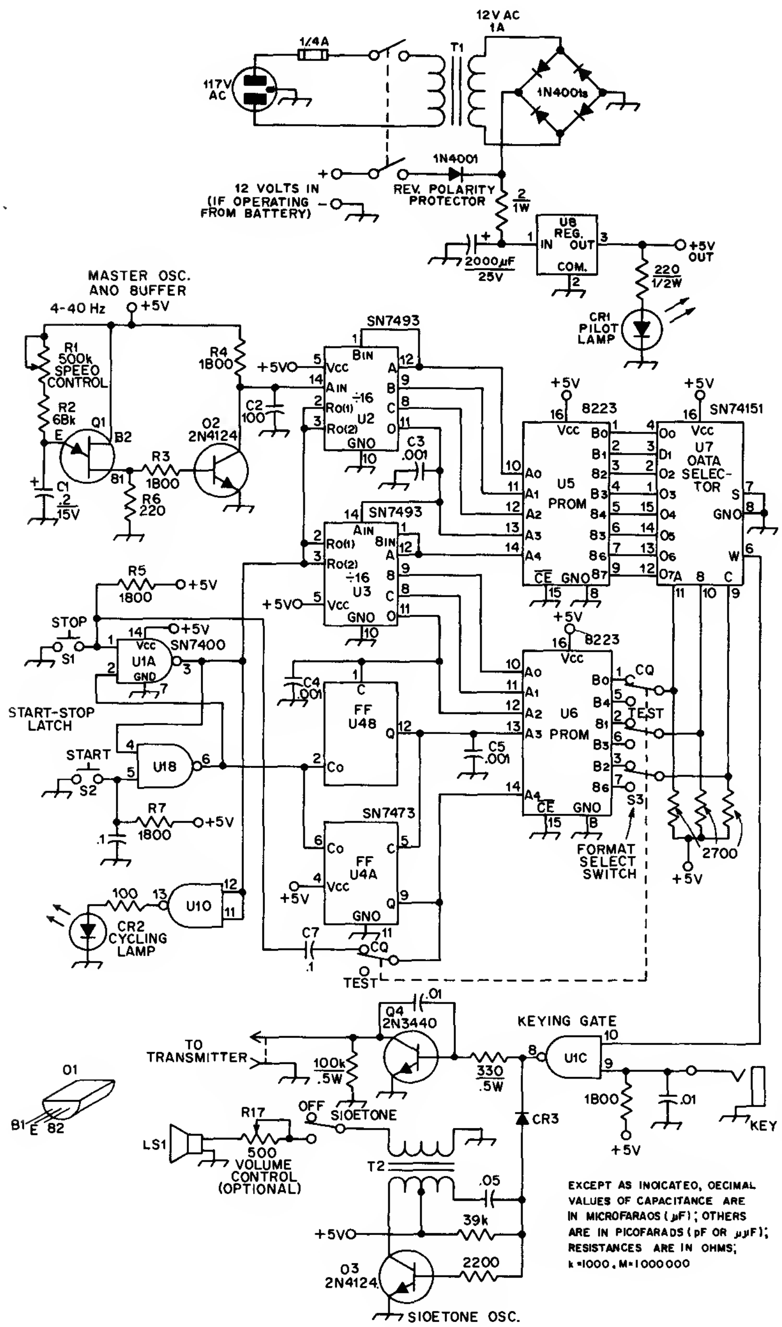
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k = 1 000, M = 1 000 000.

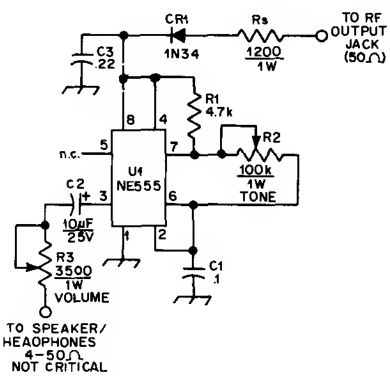
POLY. = POLYSTYRENE

3.5 W FOR CW—Discreta devices minimiza distortion end aliminata fuzzinass whila listening to low-level CW signels in communication receivar covaring 1.8–2 MHz. RC active bandpass filter peaked et 800 Hz improves S/N ratio for week signals. Adjust BFO of receiver to 800 Hz. Two-part erticla gives all othar circuits of receivar.—D. DaMew, His Eminence—the Receiver, *QST,* Pert 2—July 1976, p 14–17 (Pert 1—June 1976, p 27–30).

SENSOR KEYER—Skin resistenca of about 10K craates dashes when finger touches grid pattern on left side of paddle and dots when other finger touches pattam on othar side. Transistors act es solid-state switches. Davaloped for use with Heethkit CW keyer HD-10. Supply is 10 V, obtained from 10-V zenar connected through appropriate dropping resistor to higher-voltege source. Article covers construction of peddle by etching printed-wiring board.—T. Urbizu, Try e Sansor Keyer, *73 Magazine,* Jan. 1978, p 184–185.

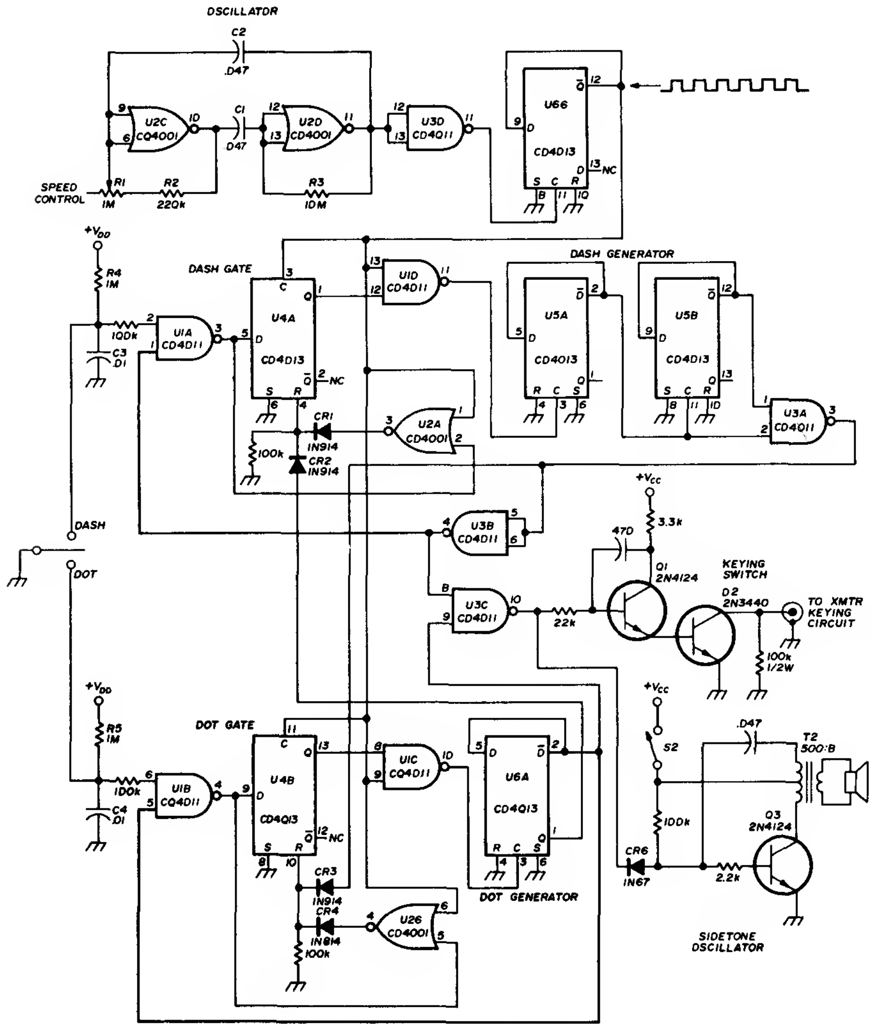




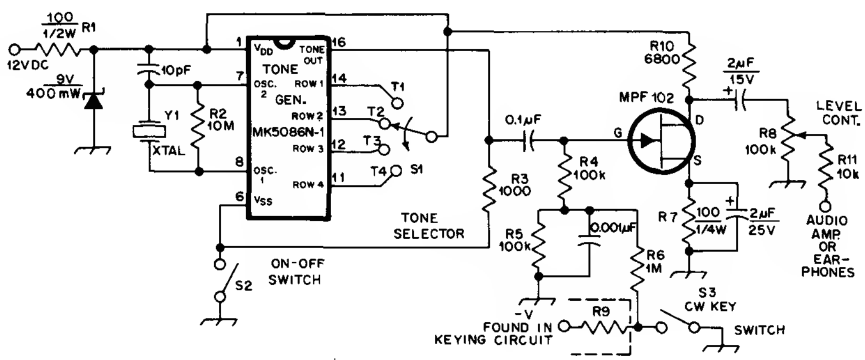


AF OSCILLATOR MONITORS CW—Can be added to any transceivar not already having built-in sidetone oscillator, to hear keying of transmitter. RF input from transmittar is rectified by CR1 to provide ebout 6-VDC supply. Keying of cerrier on and off turns NE555 AF oscillator on end off correspondingly.—J. Arnold, A CW Monitor for the Swen 270, *QST,* Aug. 1976, p 44.

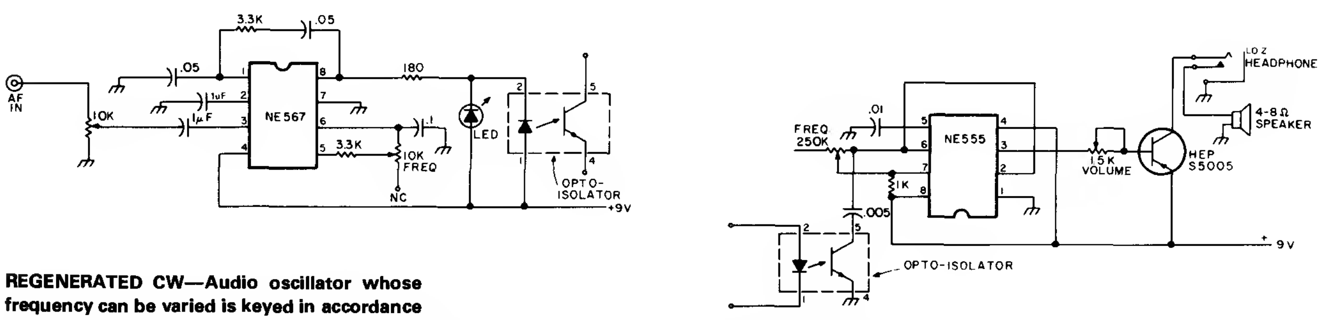
CQ CALL SYNTHESIZER—Uses only two Signetics 8223 256-bit PROMs for storing up to 2048 bits of coda information, for automatic generetion of Morse-code CQ calls, test messeges, and other fraquently used messeges. Repeeted words are stored in only one locetion and selected as needed, to quedruple capacity of memory. PROMs can be programmed in field or custom-programmed by manufecturer. Speed end timing of code charecters are determined by UJT oscillator Q1, veriable from about 4 to 40 Hz or 5 to 50 WPM. CR1 end CR2 ere Archer (Redio Shack) 276-042 or equivelent. CR3 is 1N34A, 1N270, or equivalent germanium. Q1 is Motorola MU4891 or equivalent. Article describes circuit oparation and programming in deteil.—J. Pollock, A Digital Morse Code Synthesizer, *QST,* Feb. 1976, p 37–41.



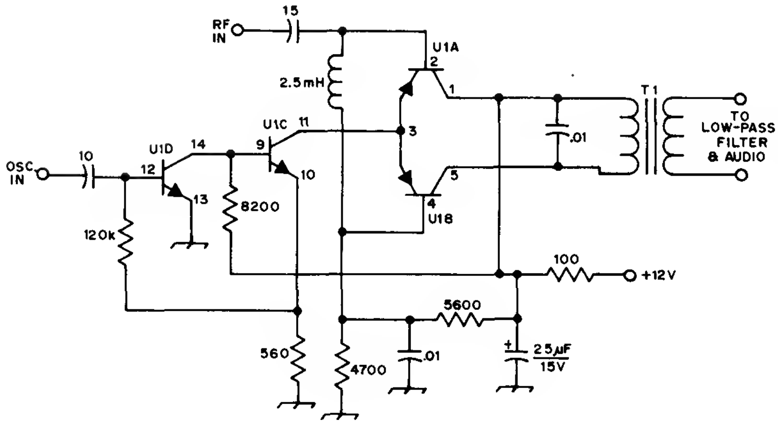
CMOS KEYER—Draws only 0.4 mA on standby and 2 mA with kay down if supply is 10 V. Will work properly with 4 to 15 V. Featuras include self-completing dots, dashes, and spaces, along with sidetone generator and built-in transmitter keying circuit. Ratio of dashes to dots is 3:1, and space has same duration as dot. Time basa of keyer is generated by NOR gatas U2C and U2D connected as class A MVBR. Frequency of oscillator is inversaly linaar with setting of R1. Inverter U3D buffers oscillator and squares its output. Flip-flop U6B divides frequency by 2 and provides clock source with perfect 50% duty cycle. Once enabled, gates ansure completion along with following space. Article gives powar supply circuit operating from AC lina and 12-V battery.—J. W. Pollock, COSMOS IC Electronic Kayar, *Ham Radio*, June 1974, p 6–10.



SIDETONE MONITOR—Mostak MK5086N IC is used with crystal in range from 2 to 3.5 MHz as signal ganerator driving FET audio amplifier. Switch S1 gives choica of four AF tonas, determined by dividing crystal frequancy in hertz by 5120 for T1, 4672 for T2, 4234 for T3, and 3776 for T4. Can also be used as code practice set and as audio signal ganarator.—J. Garrett, A Sidetone Monitor-Oscillator-Audio Genarator, *QST*, June 1978, p 43.

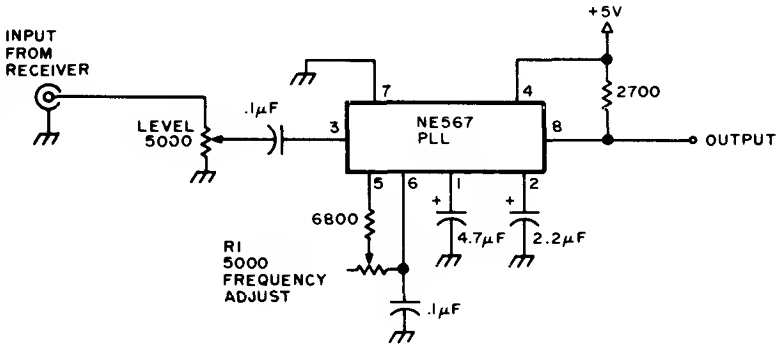


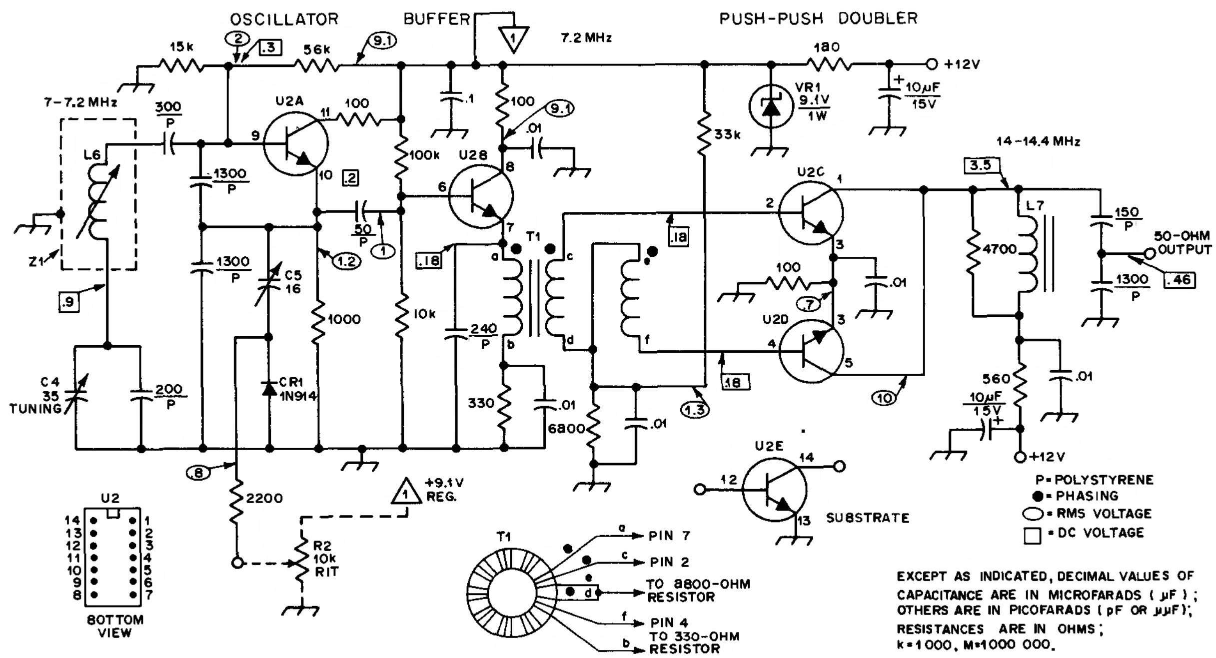
REGENERATED CW—Audio oscillator whose frequency can be varied is keyed in accordance with incoming CW signal, to give clean locally generatad audio signal without background noisa and intarference. NE567 phase-locked loop serves as tunable audio filter and LED switch drivar for activating NE555 variable-fraquency tone oscillator. LED serves as visual tuning aid to indicate that PLL is locked on to incoming signal.—Regenerated CW, *73 Magazine*, Dec. 1977, p 152–153.



PRODUCT DETECTOR—Designed for use in 40-meter CW direct-conversion receiver, in which oscillator input is from 3.5–4 MHz VFO. U1 is RCA CA3046 transistor quad. Circuit provides bies stabilization for constant-current trensistor end some amplificetion of AF output. T1 is eudio transformer.—A. Phares, The CA3046 IC in e Direct-Conversion Receiver, *QST,* Nov. 1973, p 45.

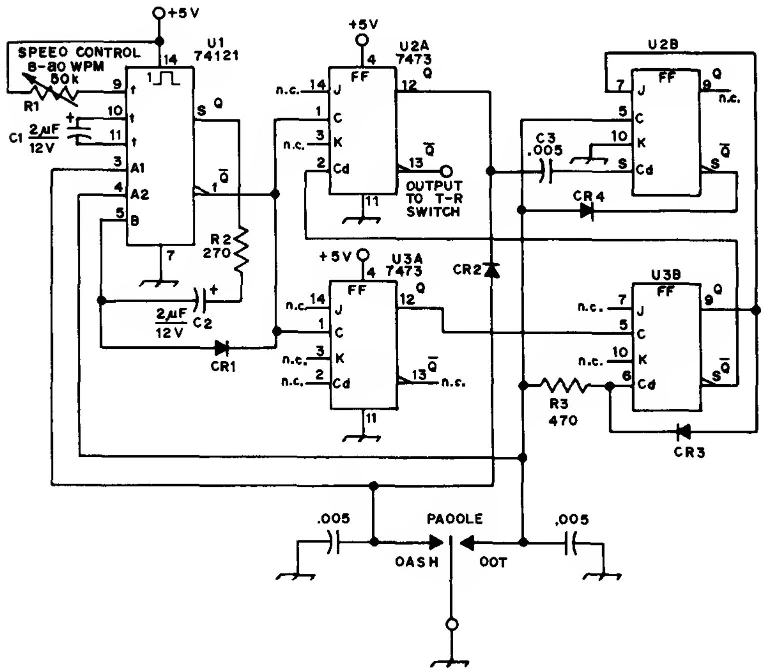
TONE DECODER—Decodes eudio output of emeteur redio receiver. Resulting audio tone burst corresponds to CW signal being received, with tone frequency verying with receiver tuning. Center frequency of NE567 phese-locked loop is adjusted with R1. Audio is translated into digital format of 1s end 0s, with tones for 0s. Output can be fed into computer for automatic translation of Morse code and printout as text.—W. A. Hickey, The Computer Varsus Hend Sent Morse Code, *BYTE,* Oct. 1976, p 12–14 and 106.



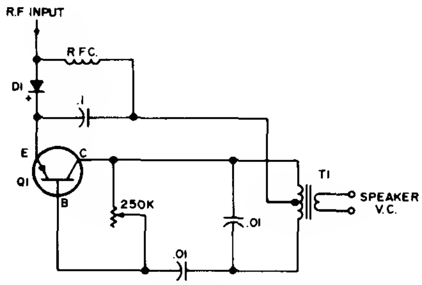


C4 — 35-pF air varieble (Millan 26035 or Hammarlund HF-35).
C5 — 16-pF eir trimmer, pc-board mount Johnson 187-0109-005.
CR1 — Silicon high-speed switching dioda, 1N914 or equiv.
L6 — Slug-tunad inductor, 3.6 to 8.5 µH (Miller 42A686CBI or equivalent). Use shield can (35-mm film canistar or Miller S-33).
L7 — Toroidal inductor, 0.9 µH. Use 12 turns of No. 24 anam. wire on a T50-6 toroid core. (See *QST* ads for toroid suppliers — Amidon, G. R. Whitehouse and Palomar Engrs.).
R2 — Optional circuit (see taxt). 10,000-ohm linear-taper composition control.
T1 — Trifilar-wound trans. 2 µH, 20 turns, twisted six turns per inch. No. 28 enam. wire on a T50-2 toroid core (see text).
U2 — RCA CA3045 array IC.
VR1 — Zener diode, 9.1 V, 1 W.

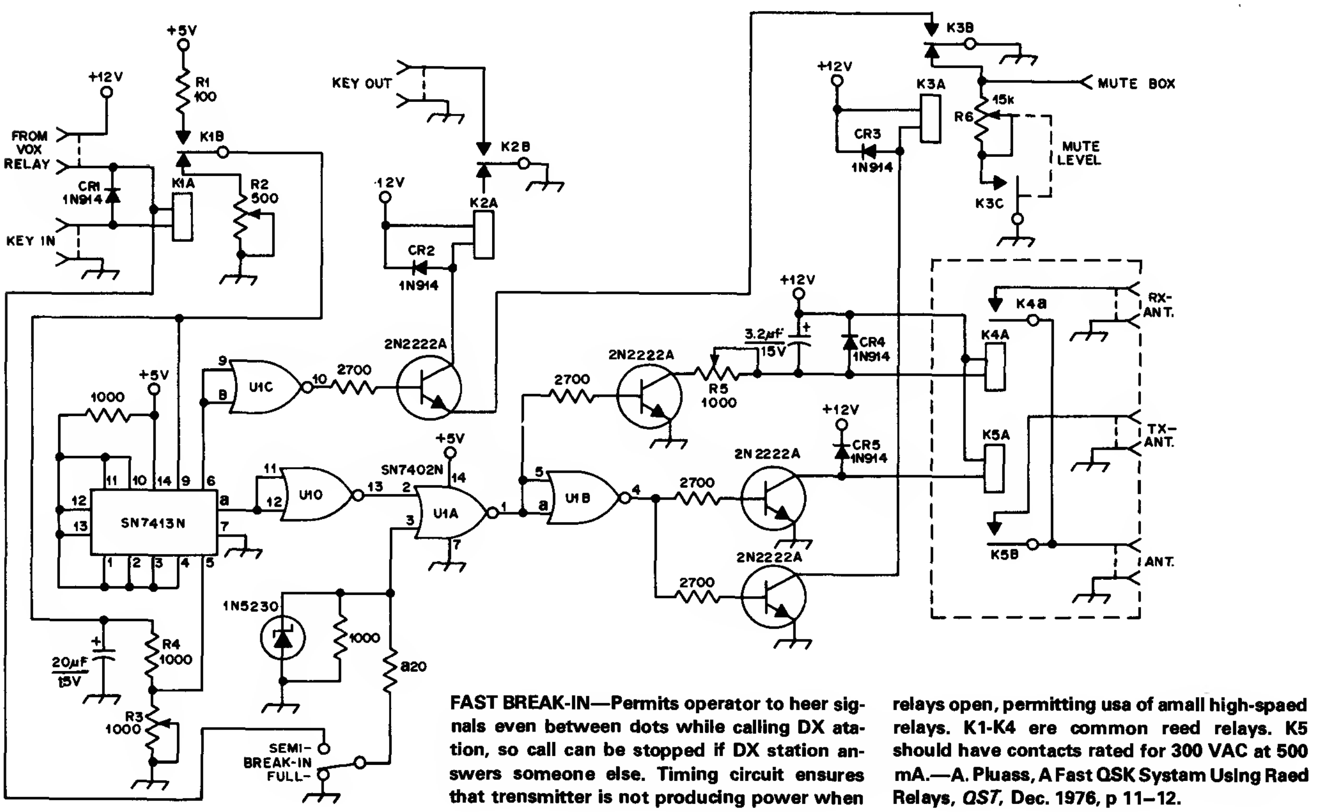
BFO FOR 20 METERS—Uses CA3045 transistor errey, with U2A es series-tuned Clepp oscilletor covering 7–7.2 MHz. Tuned emitter-follower U2B provides push-pull drive et 7 MHz to beses of push-push doubler U2C-U2D. Output of BFO is epplied to product detector rather then to mixer of receiver. Audio signal from detector is frequency difference between BFO end incoming signal, typically 700 Hz for CW reception. Article covers construction end edjustment.—D. DeMew, Understanding Lineer ICs, *QST,* Feb. 1977, p 19–23.



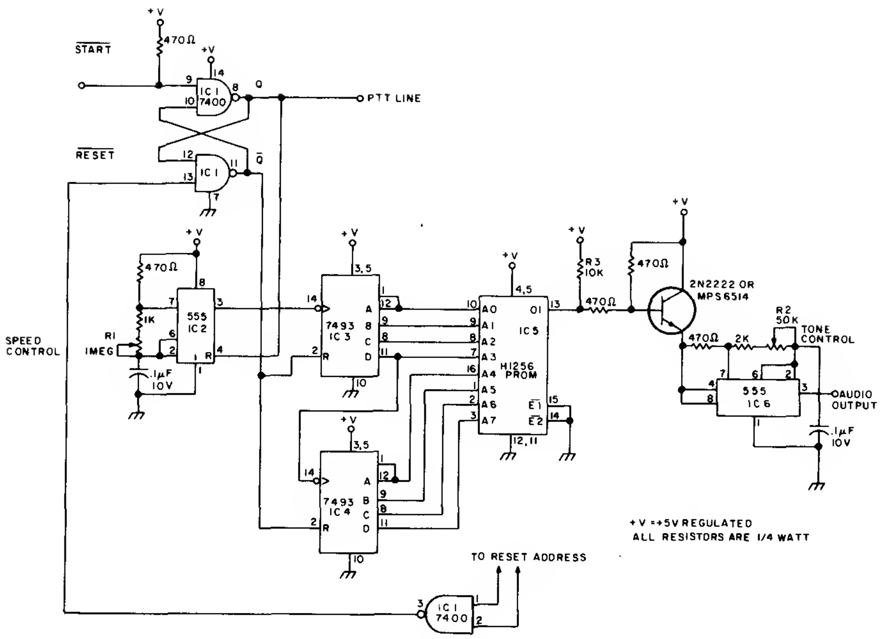
KEYER WITH DOT MEMORY—Features include self-completing characters, exact timing of characters, and dot memory. Timing circuit uses 74121 mono MVBR U1, serving dot generator and output stage U2A, dot memory U2B, and dash generator U3A-U3B. U2 and U3 are 7473 dual JK flip-flops. Length of timing pulae is determined by R1-C1, with R1 controlling speed of kayer. Pulae-width stability at all speeds is better than 5% between first and all following pulses. Dot memory U2B allows keying of dot at any time, aven if dash has not yet been completed. Dot ia held in memory and keyed out automatically after dash. Diodes are 1N914.—J. H. Fox, An Integrated Keyer/TR Switch, *QST*, Jan. 1975, p 15–20.



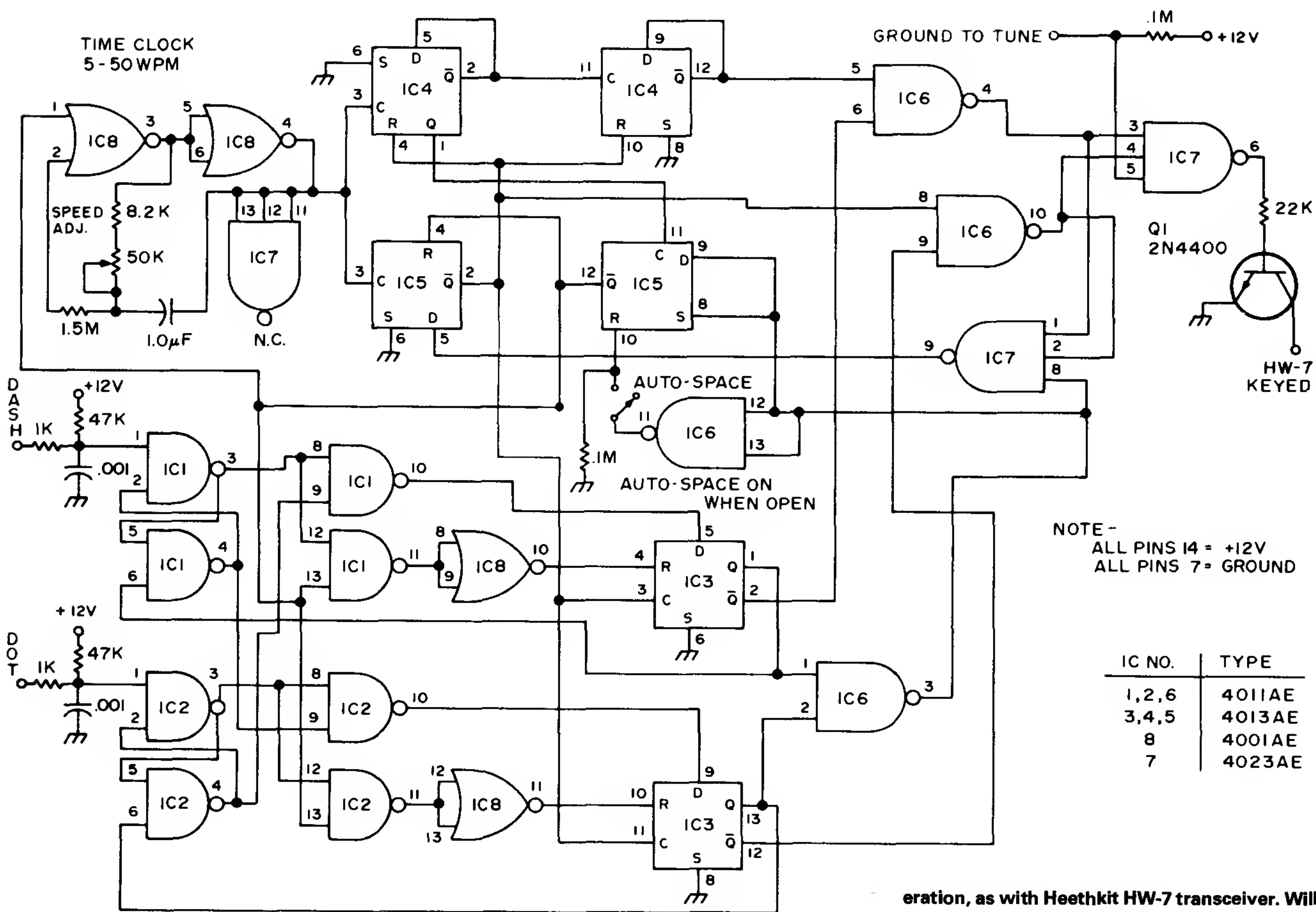
CODE MONITOR—Works with any tranamitter, regardless of type of keying. Use any good PNP transistor. With NPN transistor, reverae connectiona to diode. Frequancy of tone gets higher as resistance of 250K pot ia reducad. Monitor is turned off at minimum resistance. Enough RF to operate monitor can be obtained simply by connecting it to chaasis of receivar or transmitter.—J. Smith, Yet Another Coda Monitor, *73 Magazine*, Sept. 1971, p 58.



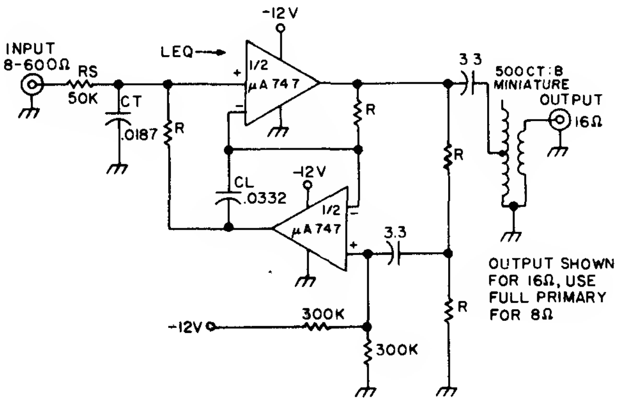
FAST BREAK-IN—Permits operator to heer signals even between dots while calling DX atation, so call can be stopped if DX station answers someone else. Timing circuit ensures that trensmitter is not producing power when relays open, permitting usa of amall high-spaed relays. K1-K4 ere common reed relays. K5 should have contacts rated for 300 VAC at 500 mA.—A. Pluass, A Fast QSK System Using Raed Relays, *QST*, Dec. 1976, p 11–12.



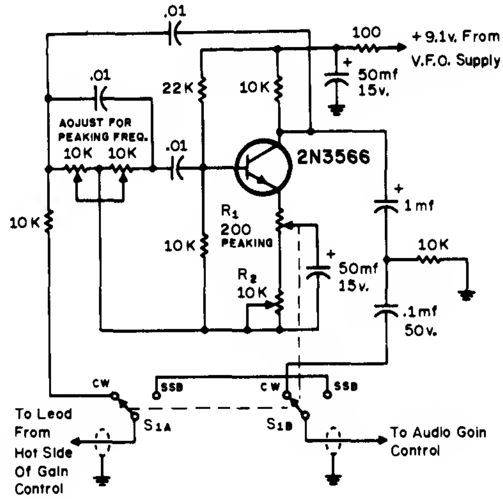
CW CALL GENERATOR—Basic CW identifier uses two gates of 7400 to form starting flip-flop of automatic message generator. Provides adjustable speed and tone, with up to 256 bits of storage in Harris H1256 PROM. IC2 is 555 astable MVBR providing clock signal for driving two 7493 4-bit binary counters that address PROM. When counters reach maximum address of 255, next clock count makes PROM restart at address 0. Each address turns on tone oscillator for one clock period, producing one dit. Three addresses in row turn on tone for three clock periods, producing one dah. Space between dits and dahs of same letter is equal to one dit, letter space is three dits, and word space is six dits (2 dahs). Thus, W takes nine addresses. Article describes operation in detail and tells how to modify circuit for use as RTTY message generator.—R. B. Joerger, PROM Message Generator for RTTY, *73 Magazine*, March 1977, p 94–98.



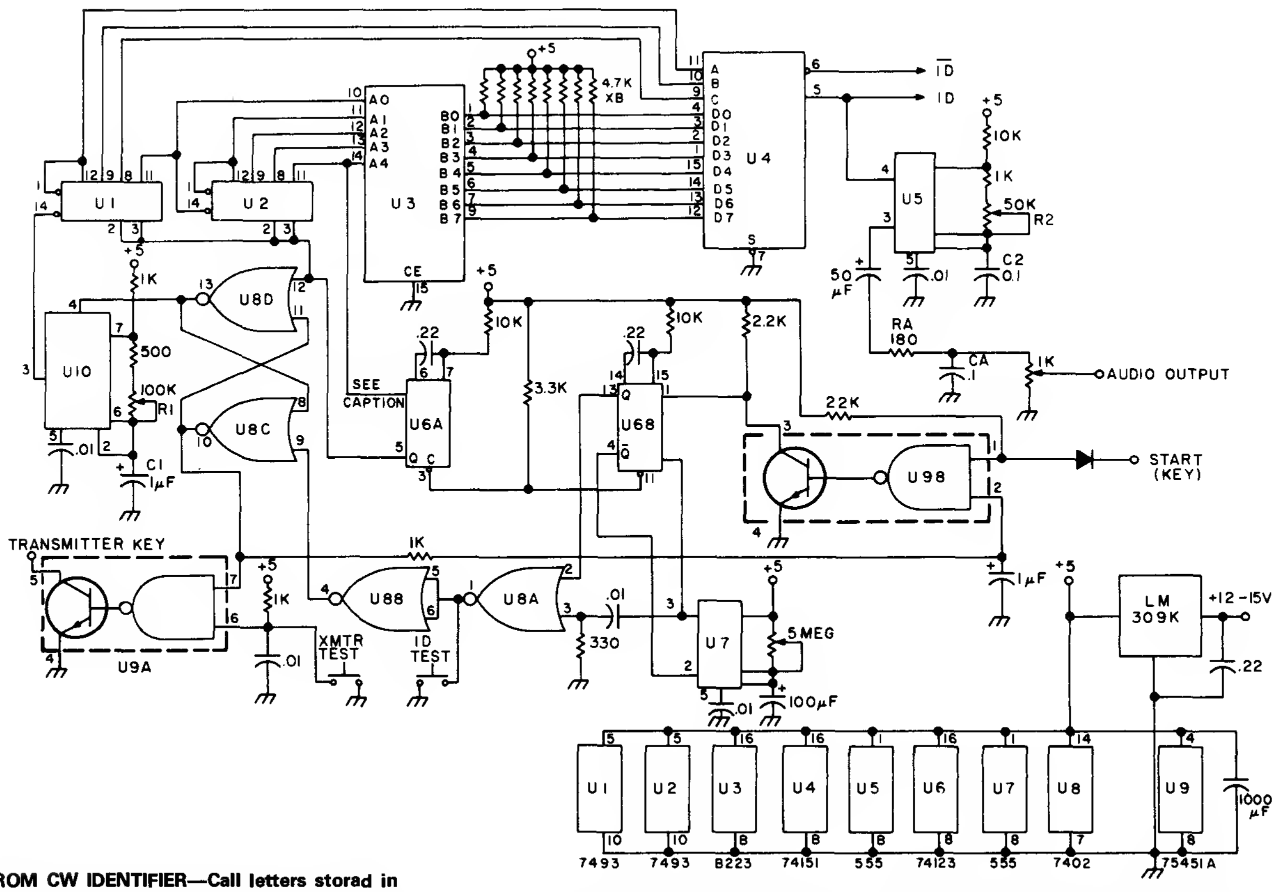
CMOS KEYER—Features include self-completing dots and dashes, dot and dash memories, iambic operation, dot and dash insertion, and automatic character spacing, all achieved with low-power CMOS digital devices that are compatible with low-power (QRP) transceiver operation, as with Heathkit HW-7 transceiver. Will operate directly from 3–15 V batteries of QRP transceiver, without regulation.—G. Hinkle, The QRP Accu-Keyer, *73 Magazine*, Aug. 1975, p 58–60.



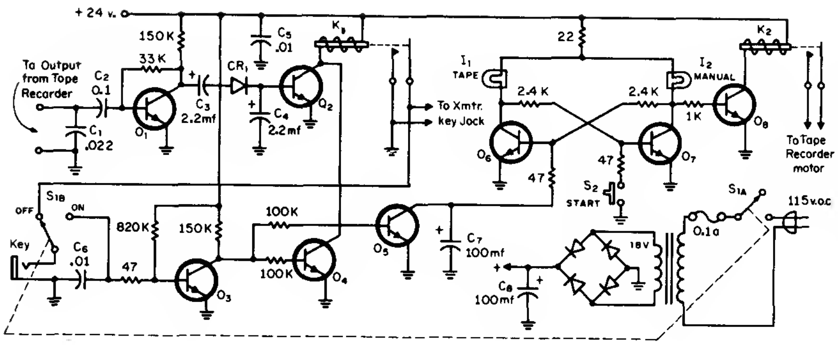
CW FILTER—Simple singla-saction parellel-tuned ective filter uses negative-impedanca convertar or gyrator to replece hard-to-get inductor of passiva coda filter. Capacitor CL is gyratad from 0.0332 μF to effective inductance of 1.87 H. Filter hes 6-dB gain at resonanca and essantially zero output impedance. Bandpess is 85 Hz centared at ebout 865 Hz. Usas single −12 V supply. Resistors R are 7.5K, metched to about 2%.—N. Sipkes, Build Thls CW Filter, *73 Magazine*, Juna 1977, p 55.



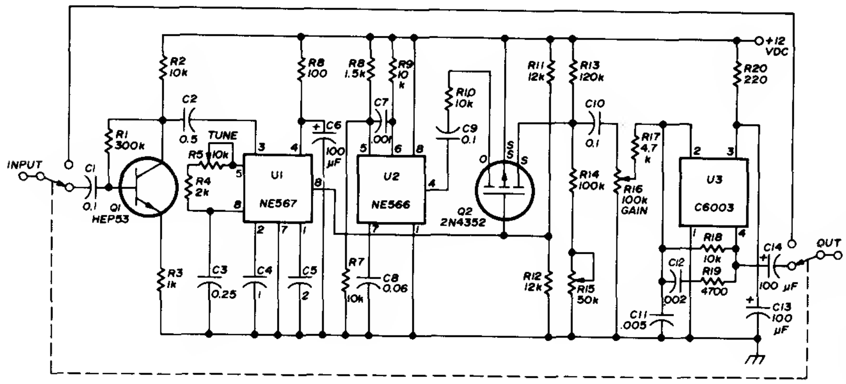
REGENERATIVE CW FILTER—Can ba added between product detector and volume control of SSB receiver or transcaiver that does not have CW filtar. Just before oscillation occurs, gain becomas extremaly high with vary nerrow bendpass. Regeneration end bandpass can be adjustad as required. Filter typically has 40-Hz bandwidth centered on 800 Hz.—R. A. Yoemans, Further Enhencing the Yeesu FTDX-560 Transceiver, *CQ*, July 1972, p 16–18 and 20–22.



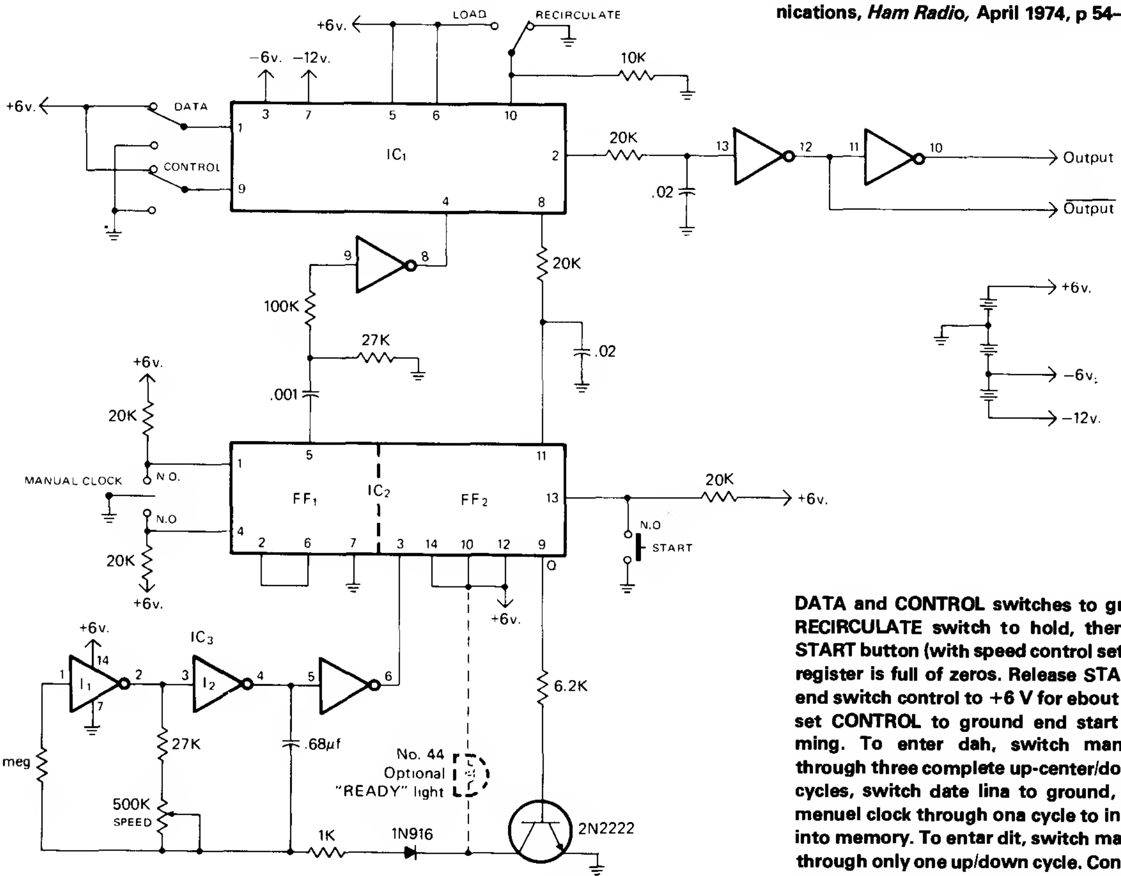
PROM CW IDENTIFIER—Call letters storad in 8223 PROM U3 driva 74151 multiplexer/data selector U4 for keying NE555 audio oscillator U5 which faeds transmitter mike input through RA. Timed holdoff keeps identifier from being rekayed within specified time pariod, with reidentifying at end of pariod. Articla covers operation of circuit and gives construction end programming details.—W. Hosking, ID with a PROM, *73 Magazine*, Nov. 1976, p 90–92.



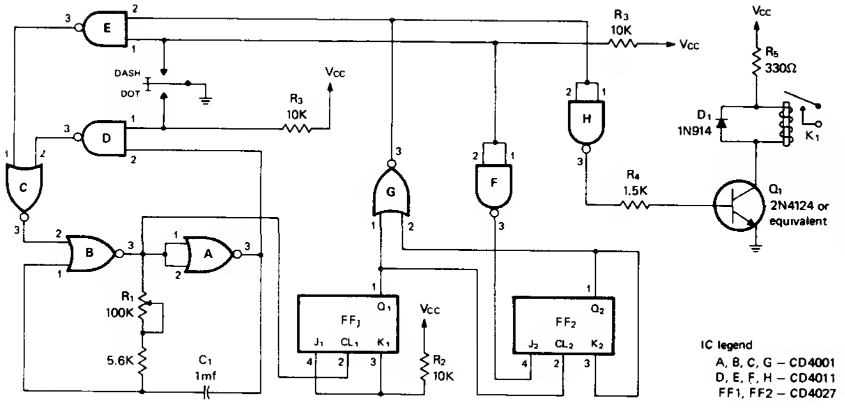
RECORDED-CODE KEYER—CW message recorded on cassette tape with keyed tone generator is pleyed back for keying transmitter with frequently repeated masseges. Transmitted signel is essentially perfect reproduction of recording. Autometic transmission can be stoppad et eny point by tepping hand key; this deactivetes tape recorder for menuel keying of transmittar. All transistors are 2N2222 or equivelent BCY58. Use 24-V reed releys with 1K coil resistence. Pilot lamps ere 24 V rated up to 3 W. CR_1 is silicon diode. Whenever recorder emits baep, positive signel eppears et bese of Q_2, meking it conduct end activete K_1, whose contacts go to key jack of transmitter.—A. Dey, An Audio Tape-Controlled CW Keyer, *CQ*, Nov. 1971, p 31–32.



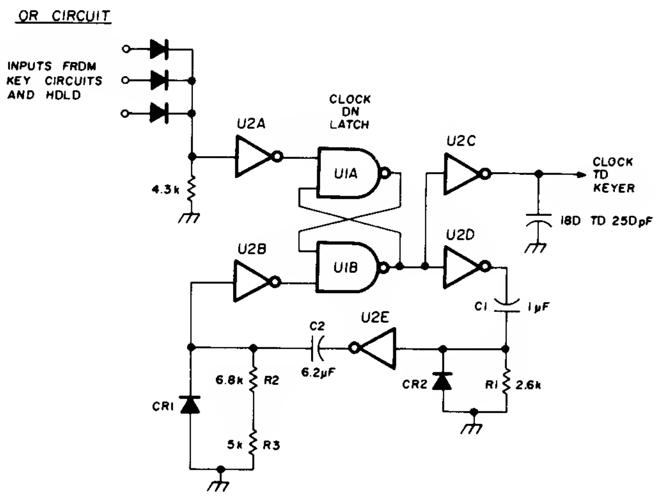
PLL CODE REGENERATOR—Permits comforteble listening to CW signels deeply embedded in noise, hesh, end interference, by detecting one perticuler CW transmission and keying independent oscillator with its signal. Consists of signal emplifier Q1, narrow-band PLL frequancy detector and trigger U1, PLL function generetor U2, gete Q2, and AF output emplifier U3. In absence of triggaring signal, output pin 8 of U1 presants high impedance to ground. With triggaring frequency, output presents low impedance to ground. Oscilletor U2 is geted by U1 through Q2.—C. R. Lewert end R. S. Libenschek, CW Regenerator for Interference-Free Communications, *Ham Radio*, April 1974, p 54–56.



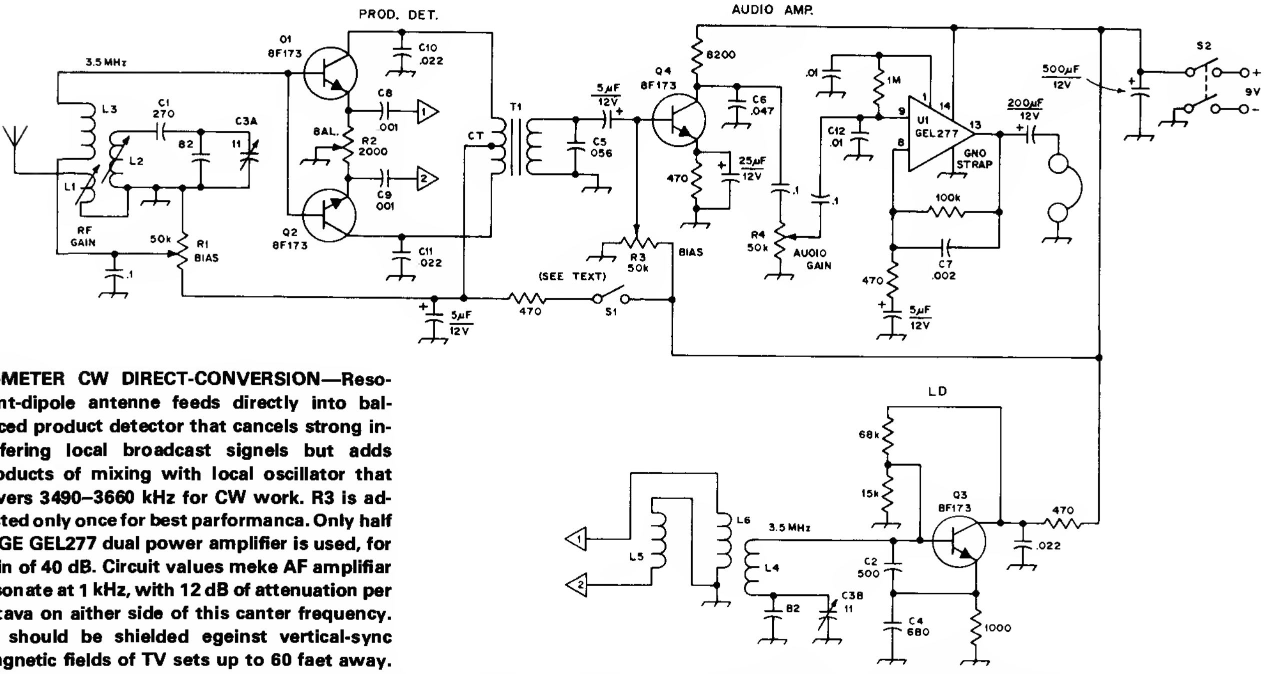
200-BIT MEMORY—Drewback of volatile codestoring mamory is offsat by low cost and comparetive eese of programming. IC_1 is Signatics 2511D MOS dual 200-bit shift register whosa digital levels are shifted ona position for each clock pulse. Inverters I_1 end I_2 of CMOS hex invertar IC_3 form variable-frequency gated square-wave clock oscillator controlled by steta of flip-flop FF_2 in 74C74 CMOS duel D flip-flop. Shift register must first be cleared by setting DATA and CONTROL switches to ground end RECIRCULATE switch to hold, then pressing START button (with speed control set fest) until register is full of zeros. Release START button end switch control to +6 V for ebout 10 s. Now set CONTROL to ground end start programming. To enter dah, switch manual clock through three complete up-center/down-center cycles, switch date lina to ground, end cycle menuel clock through ona cycle to insert space into memory. To entar dit, switch manual clock through only one up/down cycle. Continua until entira message is entered in register, switch to RECIRCULATE, and push START switch. Messege will now be sent in perfect code at eny desired spaed.—B. P. Vandenberg, An Inexpensiva Memory Keyer for Contests, *CQ*, May 1976, p 50–51.



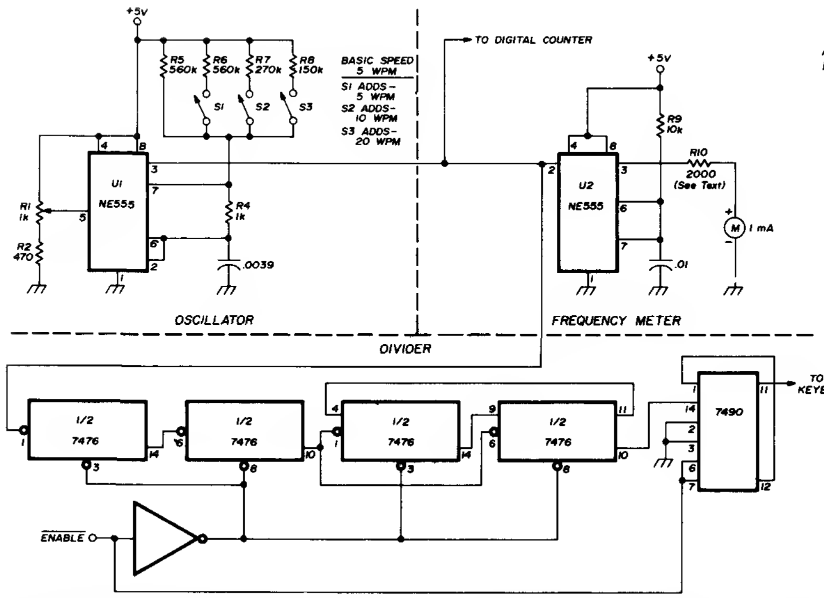
CMOS KEYER—Gives variabla speed, automatic spacing, and self-complating dots and dashes. Gatas C, B, and A form gated MVBR. Dot paddle initietes dot by meking output of gate D go low, while gate E goes low for dash. Cheracter-shaping section (gates G, H, and F with JK flip-flops FF_1 and FF_2) takes squara pulses from pin 3 of MVBR gata B end gives perfectly spaced dots and dashes. FF_1 divides clock pulses by 2, meking dot equal to ona complete period of MVBR. FF_2 divides output of FF_1 by 2, and outputs of both flip-flops ara logically ORed to provide dashes. K_1 is SPST reed relay. Supply can be 9-V battery.—T. R. Crawford, A Low-Power Cosmos Electronic Keyer in Two Versions, *CQ*, Nov. 1975, p 17–24.

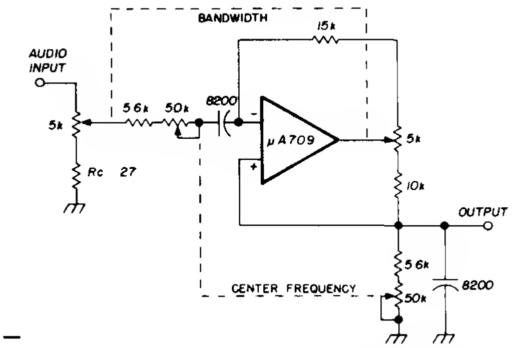


KEYER OSCILLATOR—Oscillator or clock starts whan key is closed and can be hald until dot, dash, or spece is completed. U1 is SN7400, end U2 is SN74L04. Diodes at input of U2A form OR gate that controls oscillator. These inputs can be used to keep oscillator running for self-completing action. Time constant, set by C1 and R1, is 4 ms which is width of clock pulsa. Values for C2, R2, and R3 give pulse repetition rate of 50 to 95 ms, corresponding to about 12 to 24 WPM. For higher speeds, reduce values of C2 and R2. CR1 and CR2 era signal diodes that prevent first pulse from being different; 250-pF capacitor on output prevents noise spikes from triggering keyer circuits falsely.—J. T. Miller, Integrated-Circuit Oscillator, *Ham Radio*, Feb. 1978, p 77.



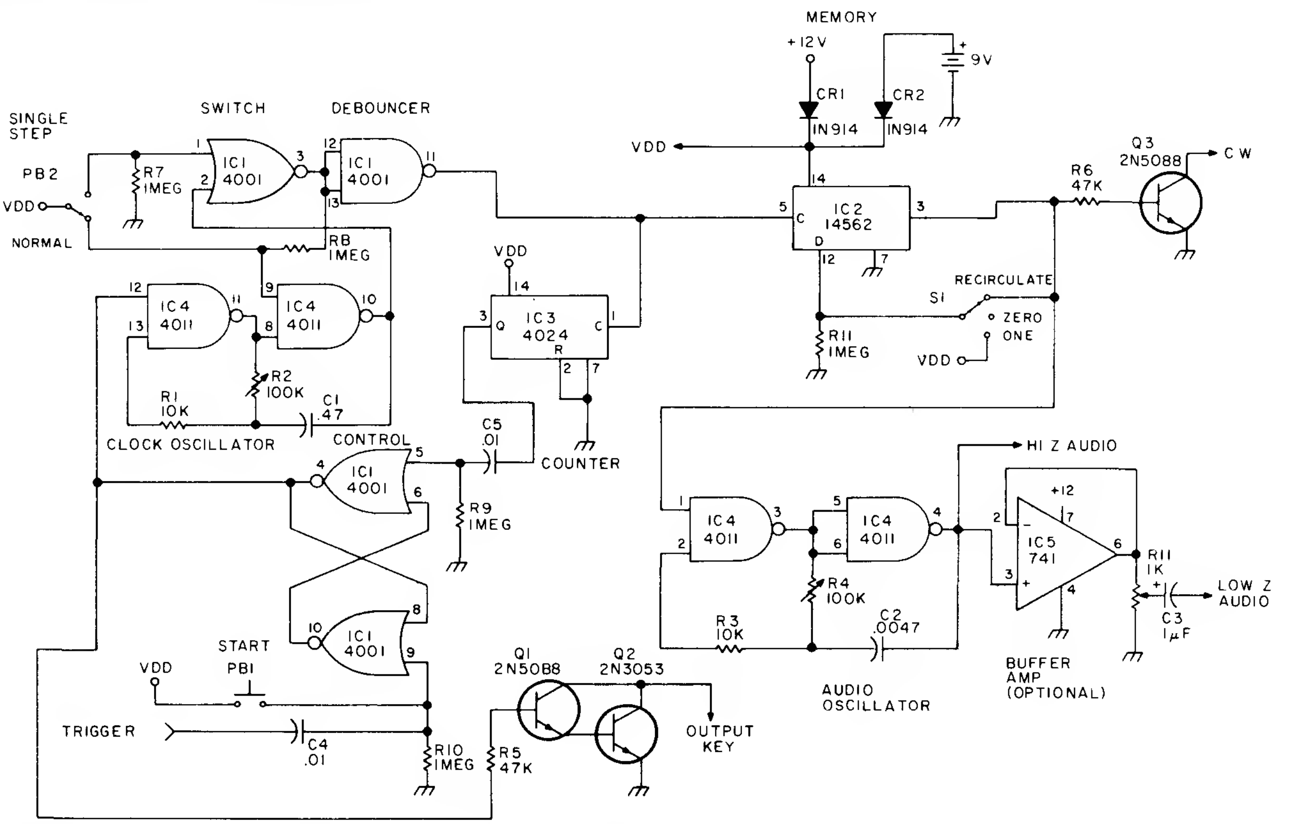
80-METER CW DIRECT-CONVERSION—Resonant-dipole antenna feeds directly into balenced product detector that cancels strong interfering local broadcast signels but adds products of mixing with local oscillator that covers 3490–3660 kHz for CW work. R3 is adjusted only once for best parformanca. Only half of GE GEL277 dual power amplifier is used, for gain of 40 dB. Circuit values meke AF amplifiar resonate at 1 kHz, with 12 dB of attenuation per octava on aither side of this canter frequency. T1 should be shielded egainst vertical-sync magnetic fields of TV sets up to 60 faet away. T1 is transistor push-pull output transformar. Use twisted pair for connecting 1-1 end 2-2, to prevent imbalance effacts. Article gives construction detalls for L1-L4.—B. Pesaric, A New Front End for Direct-Conversion Receivers, *QST*, Oct. 1974, p 11–14.



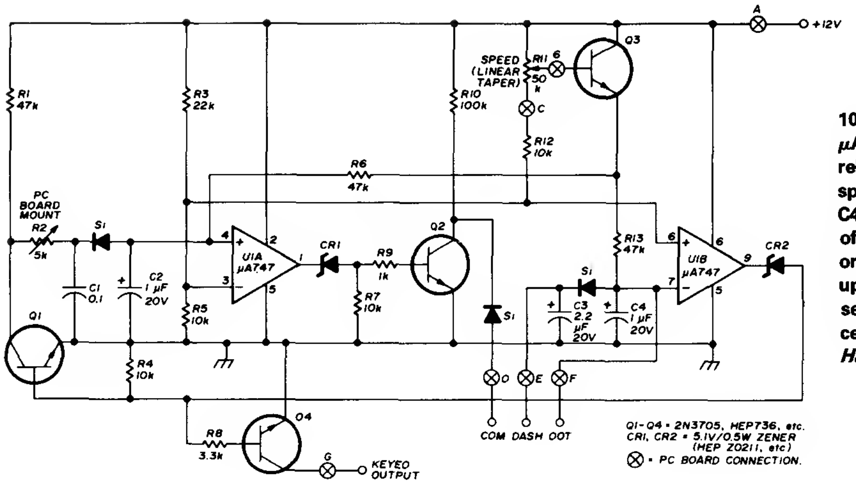


CW FILTER—Variable-bandwidth variable-frequency audio filter can be tuned to center frequency anywhere in range from 300 to 3000 Hz. Bandwidth can be as narrow as 50 Hz, which is about 3 times theoretical minimum of 15 Hz for 50-bit words and Morse code at 25 WPM. Performance can be improved over entire frequency range by using 741 opamp.—R. Skelton, Comments, *Ham Radio,* June 1975, p 56–57.

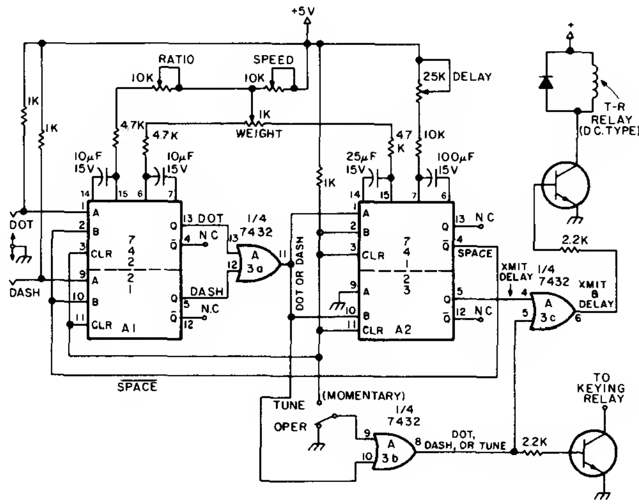
KEYER SPEED CONTROL—Electronic time base provides direct readout of keyer speed for 5 to 40 WPM in increments of 5 WPM by noting positions of three speed-control switches. Vernier adjustment pot R1 can be used for continuous speed adjustment if desired. Analog frequency meter provides alternate direct indication of keyer speed on milliammeter that can be calibrated in words per minute. Frequency of NE555 oscillator is 100 times keyer speed. Keyer clock is obtained by dividing oscillator speed by 120; thus, for 24 WPM, oscillator runs at 2400 Hz which can be read easily on digital counter. Time-base divider would supply 20-Hz clock frequency for 24-WPM keying.—G. Jones, Calibrated Electronic Keyer Time Base, *Ham Radio,* Aug. 1975, p 39–41.



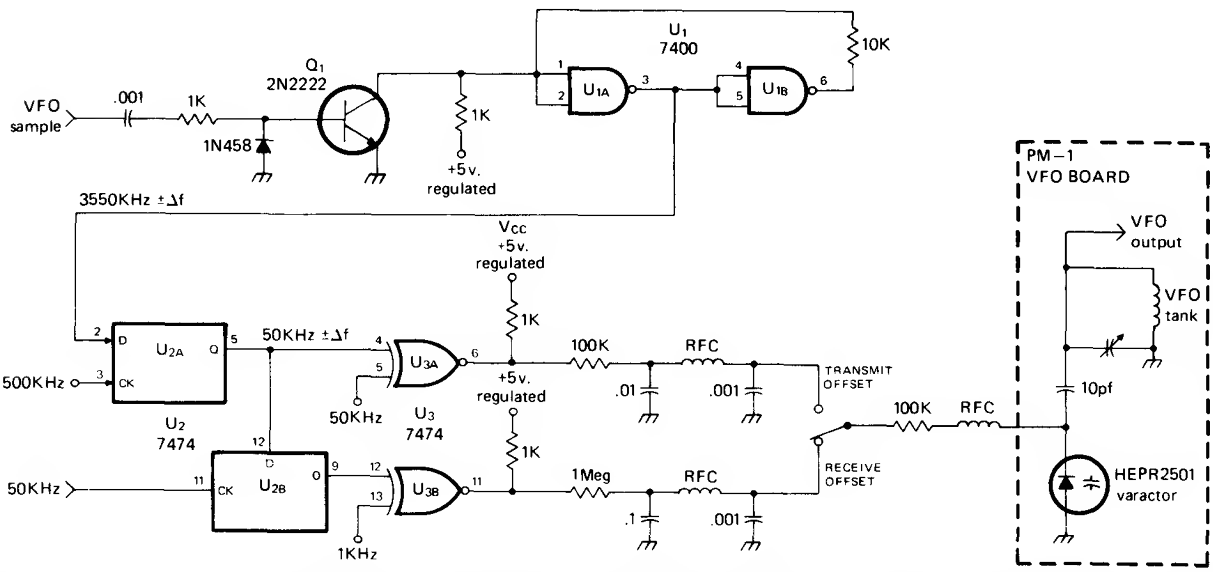
128-BIT CODE STORE—Draws almost no power, can be used on RTTY as well as CW, and can be reprogrammed in less than 1 min. Built around Motorola MC14562CP 128-bit shift register. Combination of 1 (high level) and 0 (low level) bits forming identifier message is fed into memory by placing S1 in program position zero and pressing start switch PB1 to dump contents of shift register and leave only 0s. Now, set S1 to desired first 1 or 0, push switch PB2 once, and repeat for rest of coded identifier. Set S1 to RECIRCULATE, push PB1 to cycle back to starting point, and unit is ready for use. If debouncer is not effective, move its wire from IC1-11 to IC4-10. Easier-to-get alternate values for C1 and R2 are 0.05 μF and 1 megohm.—C. W. Andreasen, Programmable CW ID Unit, *73 Magazine,* Oct. 1976, p 52–53.



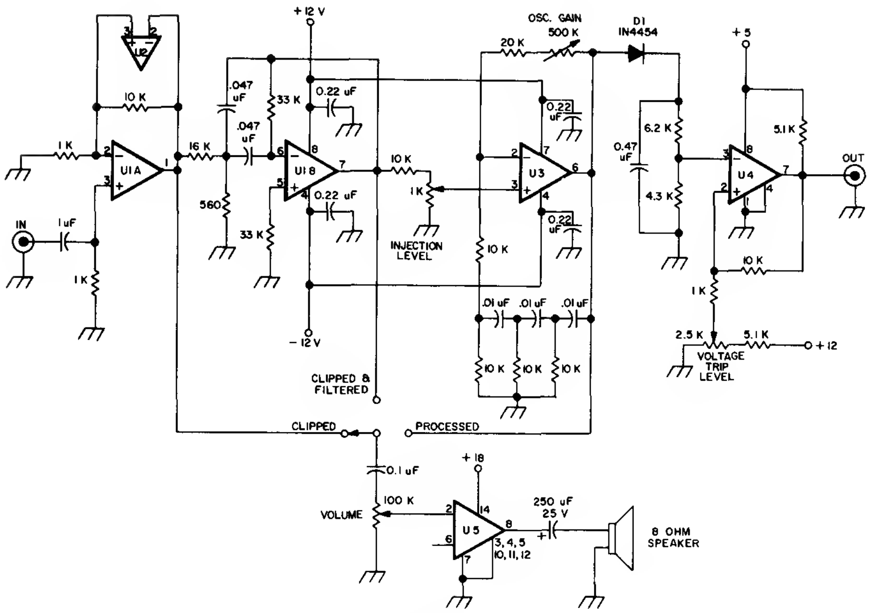
10–60 WPM KEYER—Uses μA747 (pair of μA741Cs in 10-pin TO-5 packaga). R2 adjusts relative length of first two dits to provide even spacing. Dot-dash ratio is set by C3 and C4, with C4 for dot and both in parallel for dash. Collector of C4 providas for keying positiva voltage (20 V or less) to ground. Keying transistor will hendle up to 50 mA without heetsink. Characters ara self-completing. Used with low-power transceiver.—H. F. Batie, Introducing the Argomate, *Ham Radio,* April 1974, p 26–33.



KEYER WITH TR CONTROL—Provides autometic control of TR relay for break-in operation. 74221 TTL retriggerable mono MVBR forms dots or dashes, with paddle selecting sida of IC that puts out pulsa. Half of A2 (74123 dual retriggereble mono MVBR with clear) makes speces batween dots or dashes. Remaining half of A2 acts with A3b end A3c es TR switch.—B. Voight, The TTL Ona Shot, *73 Magazine,* Fab. 1977, p 56–58.

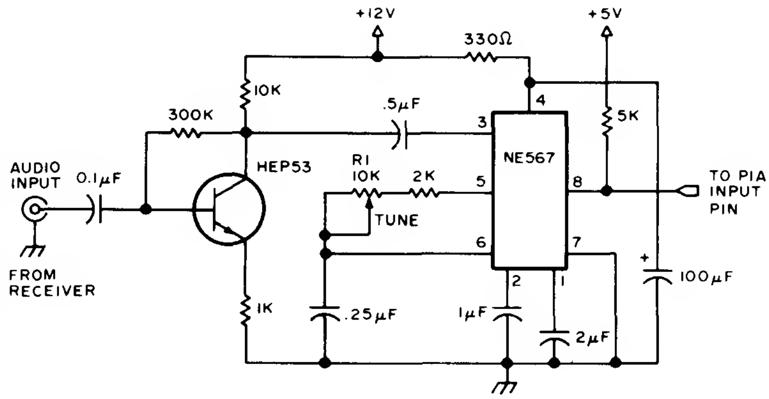


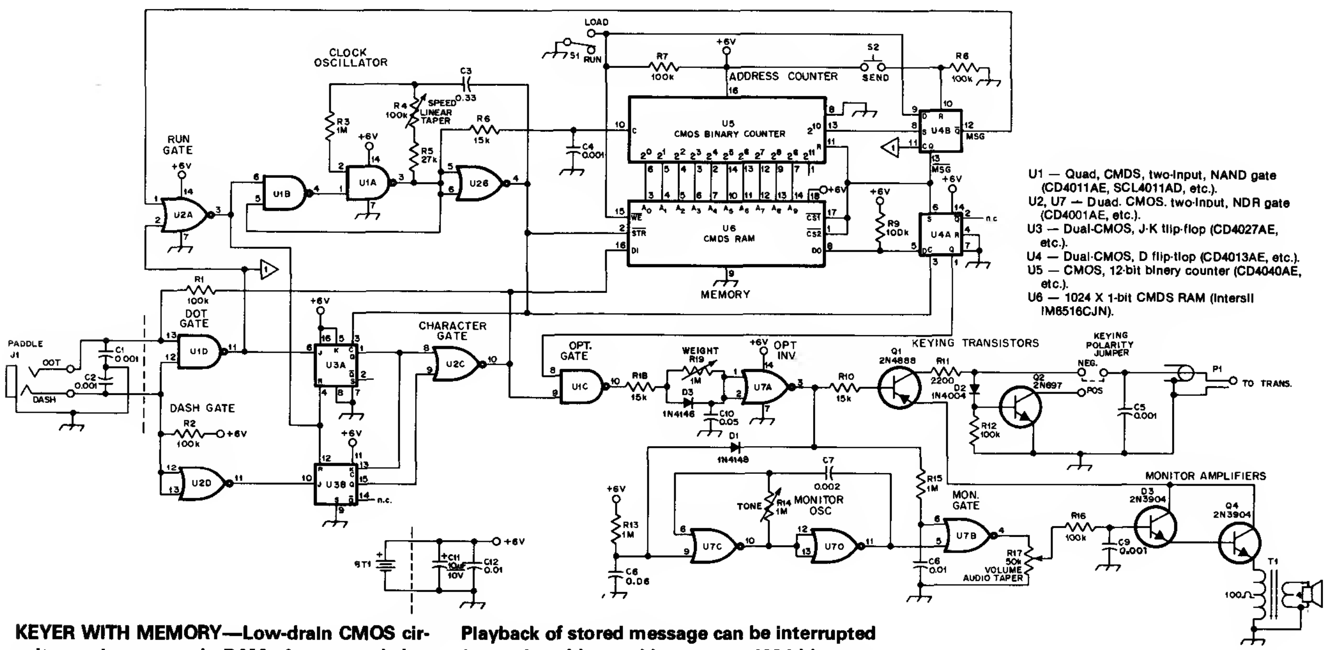
VFO CONTROL TO ±1 Hz—Used in coherent CW radio station to hold frequency of variable-frequency oscillator constent et 3550 kHz within 1 Hz so 12-WPM signal cen ba hendled in bandwidth of only 9 Hz for greatly improved signal-to-noise ratio. Sample of VFO output, squared by Q_1 and U_1, goes to U_2 for mixing with 3500.000-kHz hermonic signel from 500-kHz frequency standard, to produca 50-kHz signal ± undesired drift for mixing in U_{3A} with 50.000-kHz signal from standerd. If there is difference in frequency, U_{3A} generates control voltage proportional to amount of differance, applied to varactor tuning diode to pull VFO back to 3550.000 kHz. Seme process occurs in receive offset chain, except that standard frequency in U_{3B} is such that receivar will be 1 kHz eway from desired 3550.000 kHz and produce desired 1-kHz audio output.—A. Weiss, Coherent C.W.—the C.W. of tha Future, *CQ,* June 1977, p 24–30.



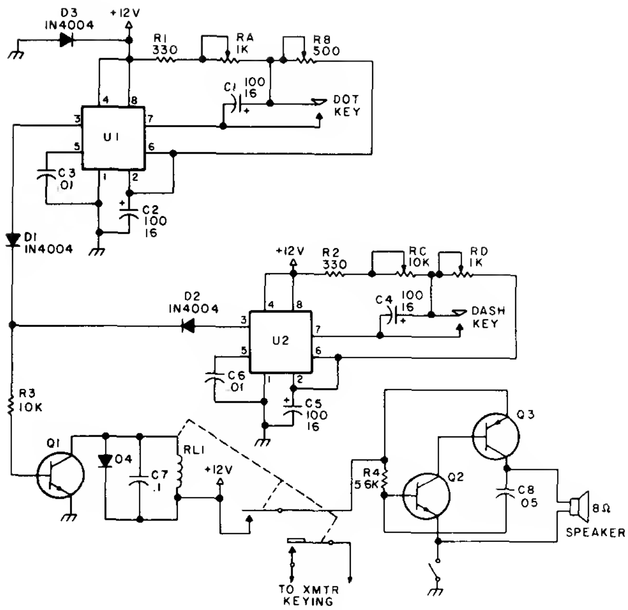
CODE REGENERATOR—Converts noisy CW output of receiver into TTL 1s and 0s for driving automatic Morse-code printer. Clipper U1A and 800-Hz active bandpass filter U1B feed injection-locked 800-Hz phase-shift oscillator U3 (National LM7401CN or Motorola HEP-C6052P). U1 is LM1458N or MC1458P. U2 uses part of LM709CN or HEP-C6103P as matched pair of 7-V back-to-back zener diodes. Diode detector D1 has time constant of about 5 ms, which is short enough for highest Morse-code speeds. Detector feeds LM311N or MLM311P1 voltage comparator U4 which can drive TTL or DTL directly. National LM380N audio amplifier U5 allows CW signal to drive loudspeaker directly.—H. Olson, CW Regenerator/Processor, *73 Magazine*, July 1976, p 80–82.

1-kHz TONE DECODER—Used as interface betwaan amateur CW racaiver and Motorola 6800 microcomputer to copy any coda speed from 3 to 60 WPM while adjusting automatically to irragularities of hand-sant coda. Translation program given in article requires about 600 bytes of mamory. Algorithm can be converted to run on almost any 8-bit microprocessor. Tone decoder is 567 phase-locked loop tuned to center frequency of about 1 kHz, with bandwidth of about 100 Hz. Circuit will switch fast anough for most code spaeds. PLL gives noise immunity. Optimum input level is about 200 mV. Output rests at +5 V, dropping near ground when tone of correct frequancy is detected.—R. D. Grappel and J. Hemanway, Add This 6800 MORSER to Your Amateur Radio Station, *BYTE*, Oct. 1976, p 30–35.

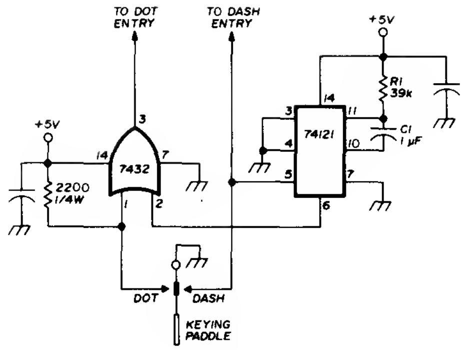




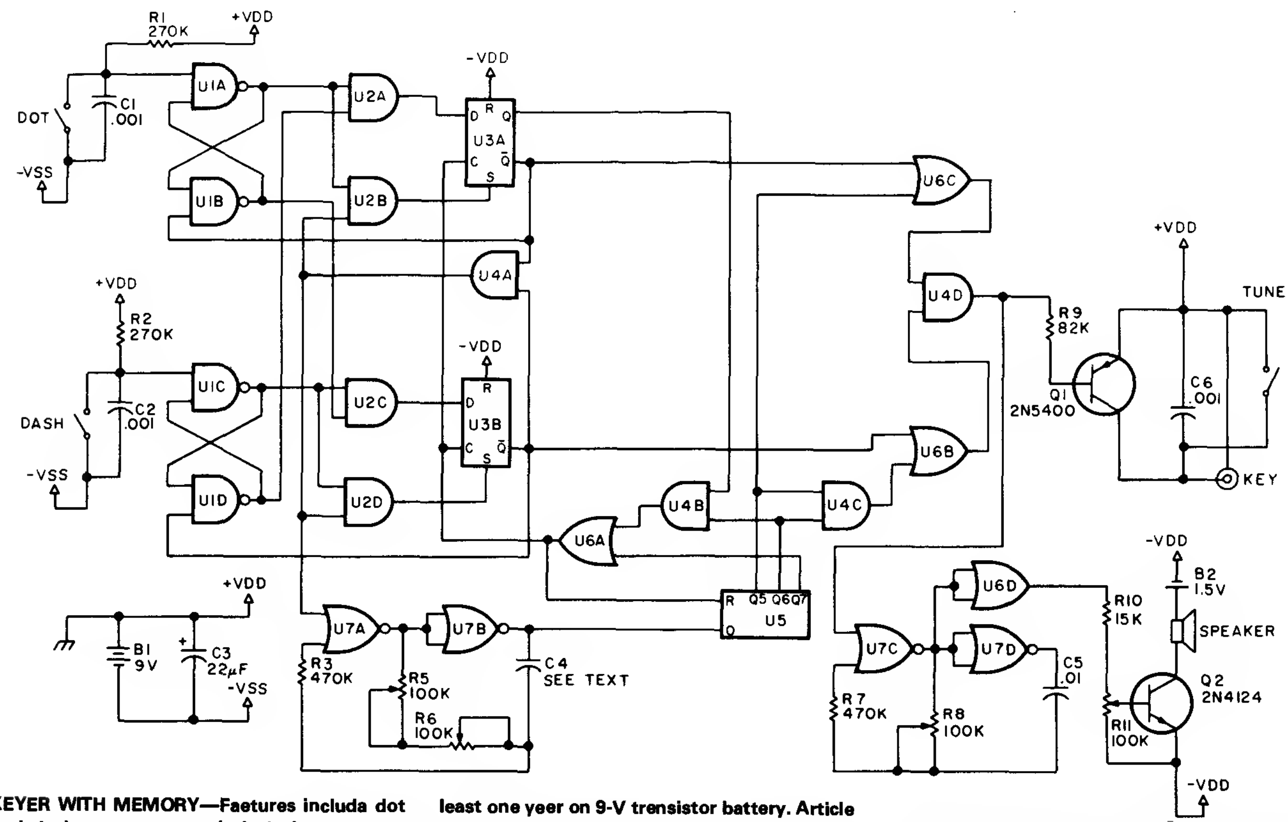
KEYER WITH MEMORY—Low-drain CMOS circuit permits storage in RAM of messaga baing keyed, for repeated later use by pushing button. Includes monitor, simple weight control, and both positive and negativa keying outputs. Playback of stored message can be interrupted by closing either paddle contact. 1024-bit memory will hold two runs of alphabet, two sets of numbers, and several punctuation marks. Dot is stored as 1 followed by 0; dash is threa 1s followed by 0. Free-running clock ensures that spaces will be recorded.—C. B. Opel, Tha Micro-TO Message Keyer, *QST*, Feb. 1978, p 11–14.



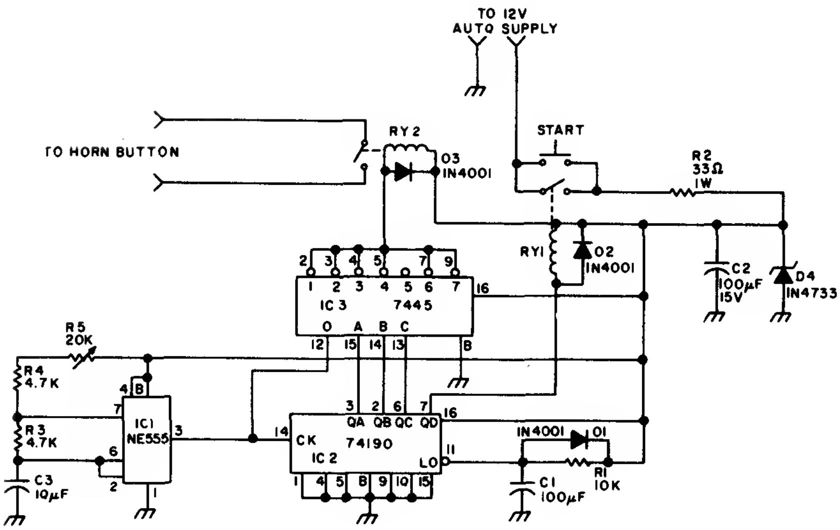
TWO-TIMER KEYER—Characters era salf-completing and fuily adjustable as to speed and langth of charactar. When dot key is closed, NE555 timar U1 bacomes estable MVBR with spead daterminad by RB and dot duration by RA. Idantical timer U2 provides longer cheracter lengths for dashes. All diodes are 1N4004 or equivalent 400 V PIV at 1 A. Q1 and Q2 era 2N2222, Q3 is 2N5964, and RL1 is 12-V reed relay. Capacitor values are in microfarads. All pots era lineer. Power is not regulated.—A. Ring, Build the World's Simplest Keyar, *73 Magazine,* May 1977, p 46–47.



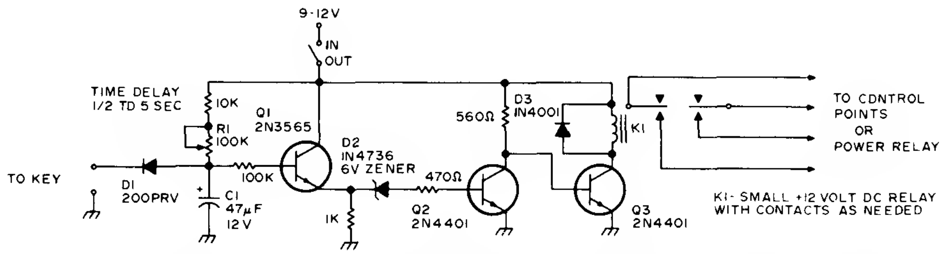
STOPPING PADDLE BOUNCE—Simple circuit prevants generation of erroneous dots by paddla contect bounce in keyars having dot memory. Uses 74121 mono MVBR end 7432 AND gete. Output of 74121 stays low if paddle is not in use or if dots or dashes ere being sant. Raleese of desh peddle makas 74121 trensmit high-level pulse to AND gate, long enough to block dot ceused by bounce. Suitabla only for keyers using +5 V.—B. Locher, Kayar Modification, *Ham Radio,* Aug. 1976, p 80.



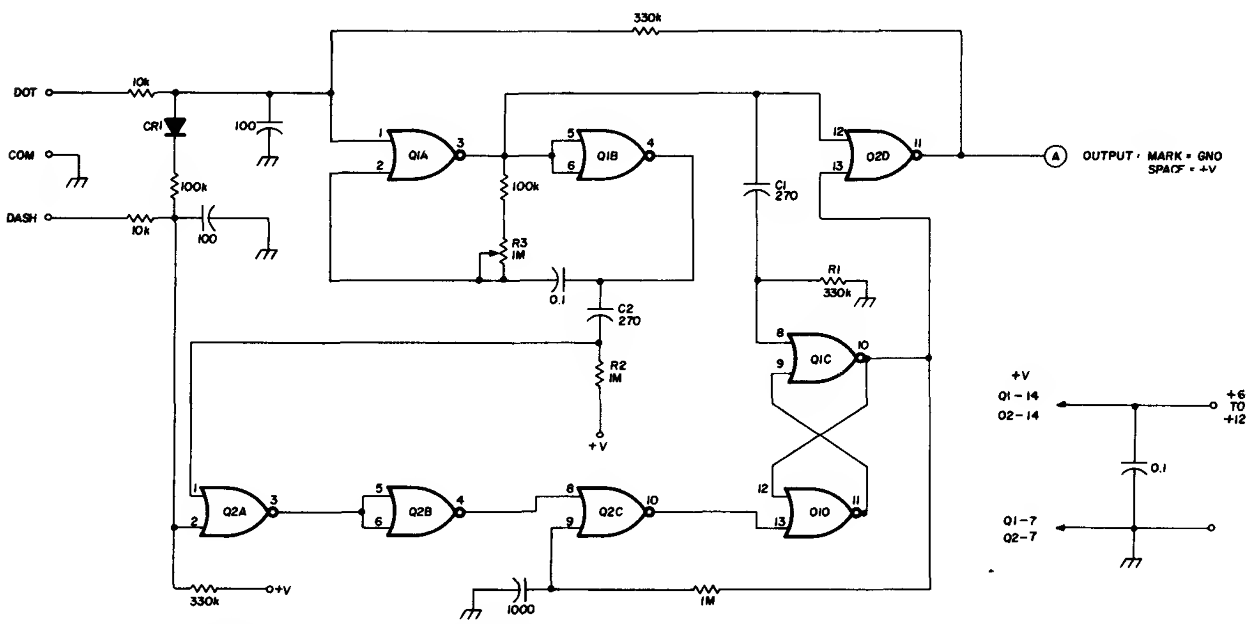
KEYER WITH MEMORY—Faetures include dot and dash memory, gatad clock, low standby end key-down currents, built-in sidetone oscillator with loudspeakar, and keying circuit for grid-block kayed transmitter. Will operete et least one yeer on 9-V trensistor battery. Article describes circuit operatlon In deteil. U1 is 4011 quad two-input NAND gate. U2 and U4 are 4081 qued two-input AND gates. U3 is 4013 dual D flip-flop. U5 is 4024 sevan-stage binery counter. U6 is 4071 quad two-input OR gata. U7 Is 4001 quad two-input NOR gate.—E. A. Pfeiffer, MINI-MOS—tha Bast Keyar Yet?, *73 Magazina,* Aug. 1976, p 38–40 end 42–43.



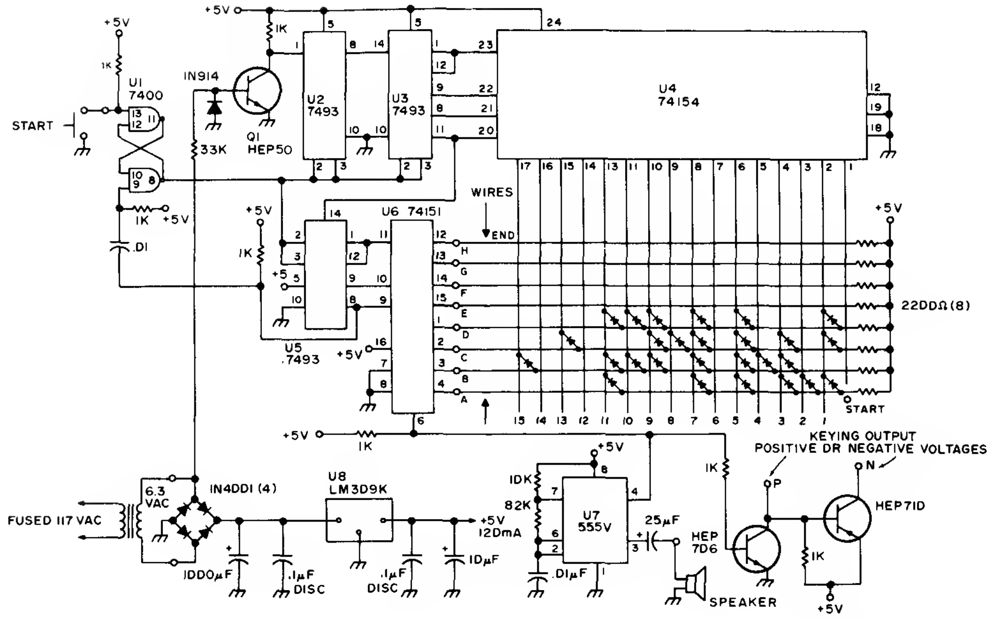
AUTOMATIC HI ON HORN—Pressing start button of circuit momentarily makes it send letters HI in Morse code on automobile horn, as friendly signal to another ham on road. Uses NE555 timer as oscillator, acting with counter IC2, decoder IC3, power-supply latch, and regulator. Space between four dots of H and two dots of I is achieved by not using pin 5 of decoder. RY1 should pull in at 5 V and 16 mA maximum, while RY2 should pull in at 5 V and 80 mA maximum and have contacts for switching 0.5-A inductive load of horn.—J. F. Reid, Sending HI, *73 Magazine,* May 1977, p 90.



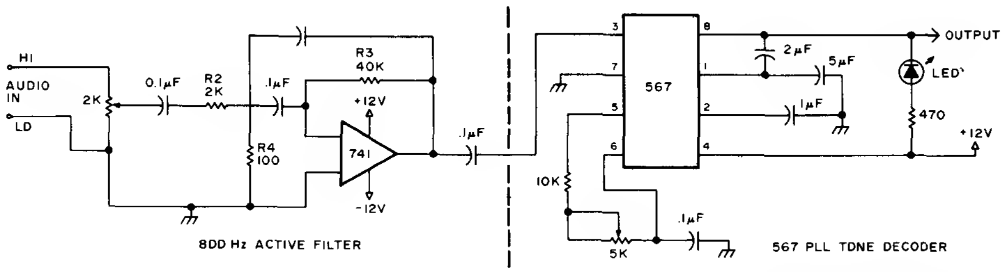
QUASI-BREAK-IN—Amateur station stays in receive mode until operator starts to send code. Tapping on key makes transmitter switch into transmit mode and stay there after last character is sent, for delay of several seconds (determined by R1) before transmitter is deenergized. Developed for use with cathode-keyed transmitters.—F. E. Hinkle, Jr., K0X for CW, *73 Magazine,* Feb. 1975, p 129–130.



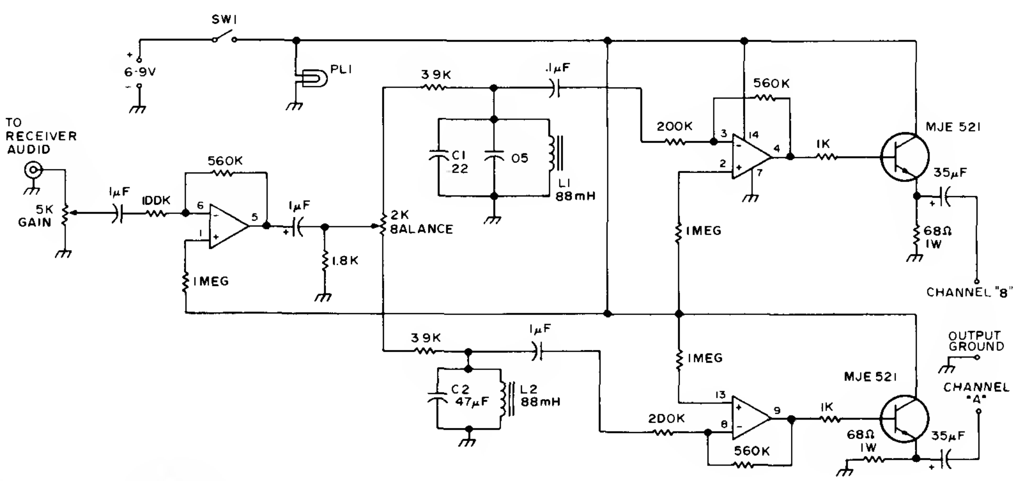
CMOS KEYER—Uses two CD4001AE quad two-input NOR gates. Q1A-Q1B form time-base MVBR, and Q1C-Q1D form dash flip-flop. Three of remaining gates synthesize three-input NOR gate for dash control. Q2D controls time-base MVBR and provides keyer output. Speed is adjustable from below 10 to over 70 WPM with R3.—C. J. Bader, Improved CW Transceiver for 40 and 80, *Ham Radio,* July 1977, p 18–22.



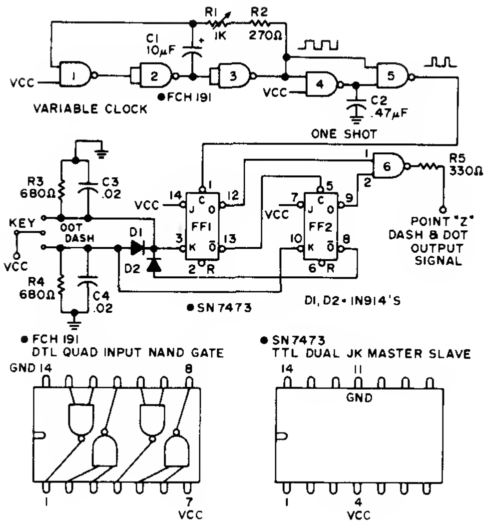
CW IDENTIFIER—Circuit automatically genarates call letters for FCC-required code identification for FM repeaters and RTTY, when started by pushbutton or by pulse from other equipmant. Audio output can be fed to loudspaaker as monitor or used to modulata FM repeatar. Circuit shown is programmed for DE K4EEU by installing diodes at locations where tone is wanted on matrix. Articla gives construction and programming details.—B. Kalley, A Super Cheapo CW IDer, *73 Magazine,* Dec. 1976, p 46–48.



WEAK-SIGNAL DECODER—Combination. of narrow-bandpass 800-Hz activa filter and phase-locked loop of tona decodar parmits copying very waak signals in Morsa code. LED provides visual indication supplamanting con-ventional output for headphonas or loudspeaker.—Circuits, *73 Magazine,* July 1977, p 35.

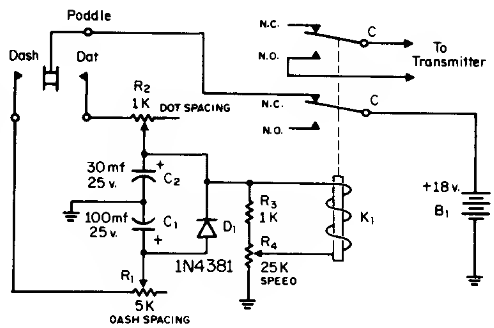


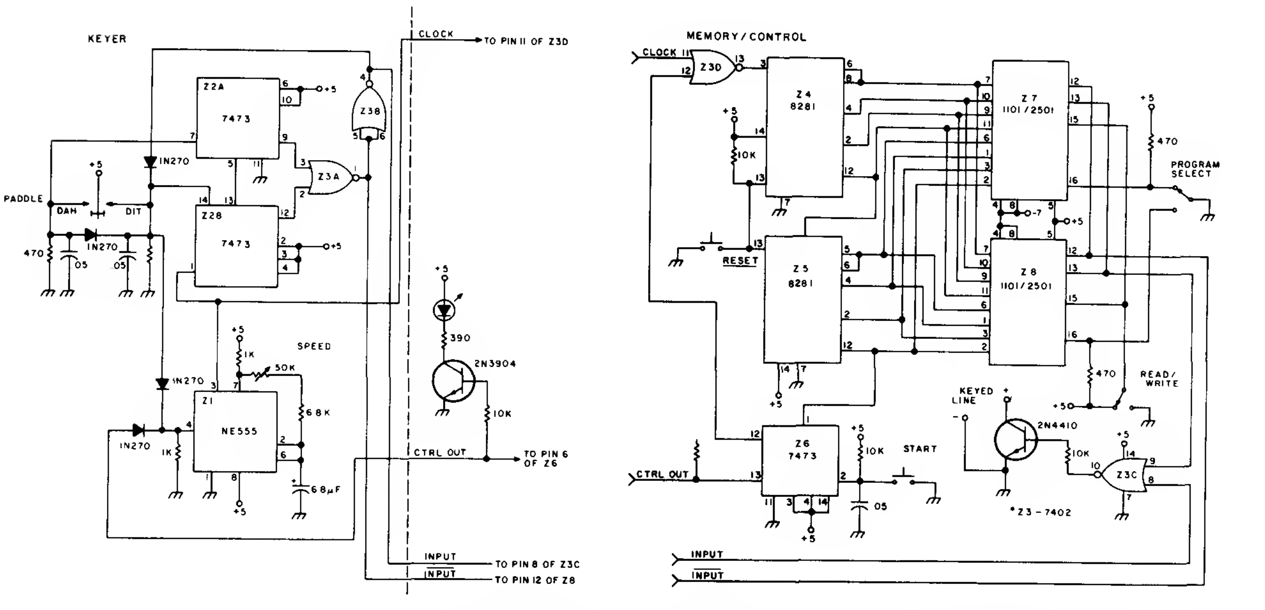
CW STEREO FILTER—Developed to enhance ability to read CW daspite heavy contast traffic or othar QRM. Two high-Q filters, one at each and of 400-Hz CW filtar in receiver, creata saparate audio channels to giva effect of stereo. Transistors at outputs of channels provide extra current gain for driving low-impedance stereo haadphones. CW signal at 800 Hz than appears to come from left, 1200-Hz signal from right, and in-betwaen frequencies at various azimuth angles. Illusion of diraction makes it easier for operator to concentrata on desired signal in presance of others having slightly diffarant frequencies. L1 and C1 form filter for 1200-Hz channal, whila L2 and C2 form 800-Hz filter for other channel.—R. L. Anderson, Starao—a New Typa of CW Filter, *73 Magazine,* March 1976, p 48–50.



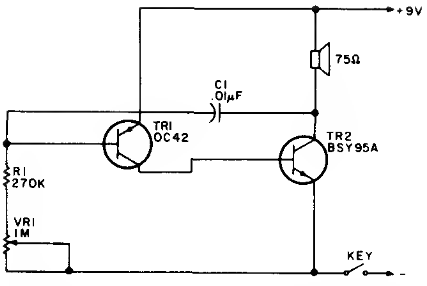
1:3 DOT-DASH KEYER—Gives accurate 1:3 dot-desh ratio et any desired kaying spaed, with self-completing cheractars. NAND gates 1, 2, and 3 of first FCH191 form variabla-frequancy square-weve oscillator, with C1, R1, and R2 determining frequency. With values shown, frequancy is edjustabla from about 150 to 1500 Hz, equivelent to code spaed renga of ebout 4 to 40 WPM. NAND getes 4 and 5 form mono MVBR. Flip-flops FF1 end FF2 ara SN7473 TTL JK mastar-slave, ecting with D1, D2, end NAND geta 6 to genarata dots and dashes.—H. P. Fischar, Varsatile IC Kayar, *73 Magazine*, Sapt. 1973, p 69–71.

SIMPLE KEYER—Based on repid charging of capacitors end controlled discharge through ralay coil. Whan C_2 has discharged to relay releasa voltage, ralay drops out end cycle starts over egein as long as dot side of peddla is pressed. Deshes era similerly formed by C_1. R_4 adjusts speed from 10 to 40 WPM. K_1 is DPDT plata-currant ralay heving 1K to 10K resistence.—J. J. Russo, An Inexpansiva Electronic Keyar, *CQ*, Aug. 1971, p 58.

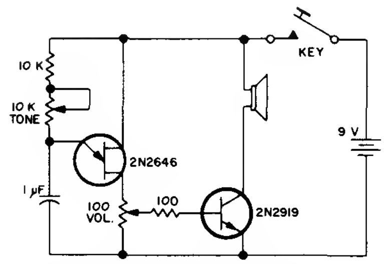




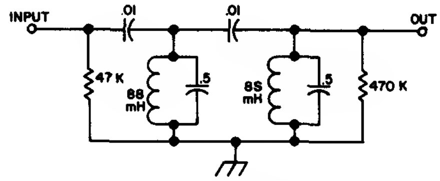
KEYER WITH MEMORY—Clock Z1 is NE555 timer giving keying speed range of 5 to 35 WPM. Flip-flops Z2A end Z2B count clock pulses to provide self-completing dits and dahs with speces. Z4 end Z5 ere 4-bit binery counters used for addressing static 256 × 1 bit RAM. To program keyar, switch to writa, hit START button, end feed in message on keyer paddle. To send message back, switch to raad and hit START again. To cleer eddrass counter if error is mede, or for changing massaga, hit RESET switch and start ovar agein.—D. W. Sewhuk, Contast Speciel Kayar, *73 Magazine*, Fab. 1977, p 38.



CODE PRACTICE—Simple AF oscillator drives loudspeeker for producing eudio tona when key in negetive supply lead is closed. Adjust VR1 for most pleesing tone.—Circuits, *73 Megezine,* July 1975, p 154.

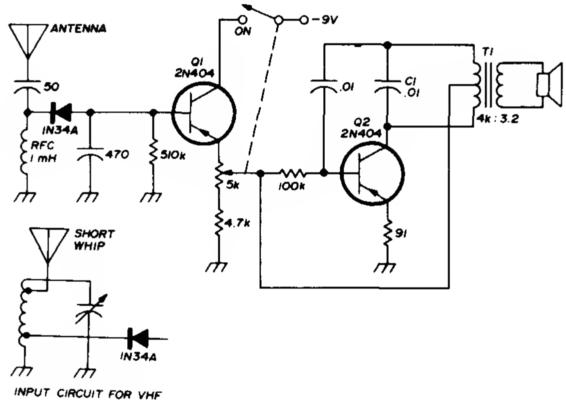


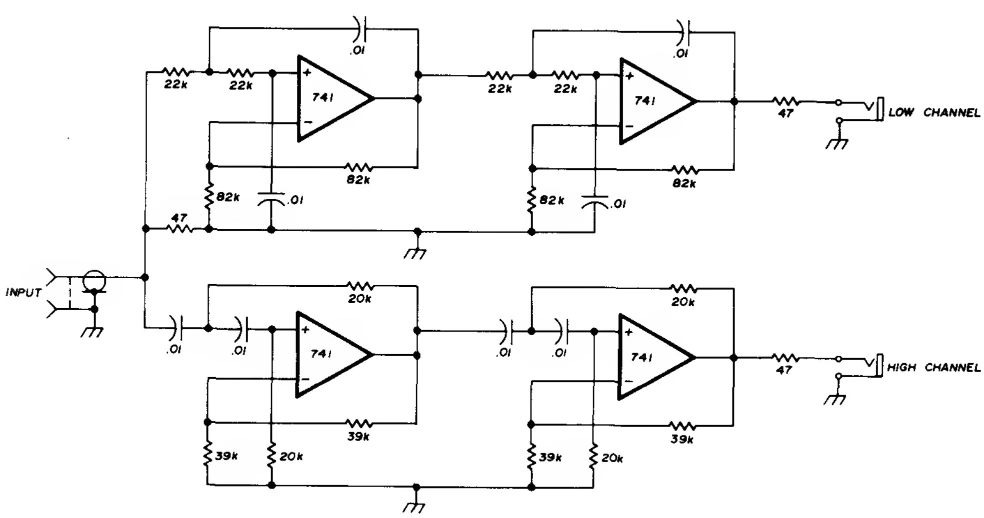
PRACTICE OSCILLATOR—Simple design provides for edjustment of both voluma and tone.—Circuits, *73 Megazine,* July 1974, p 81.



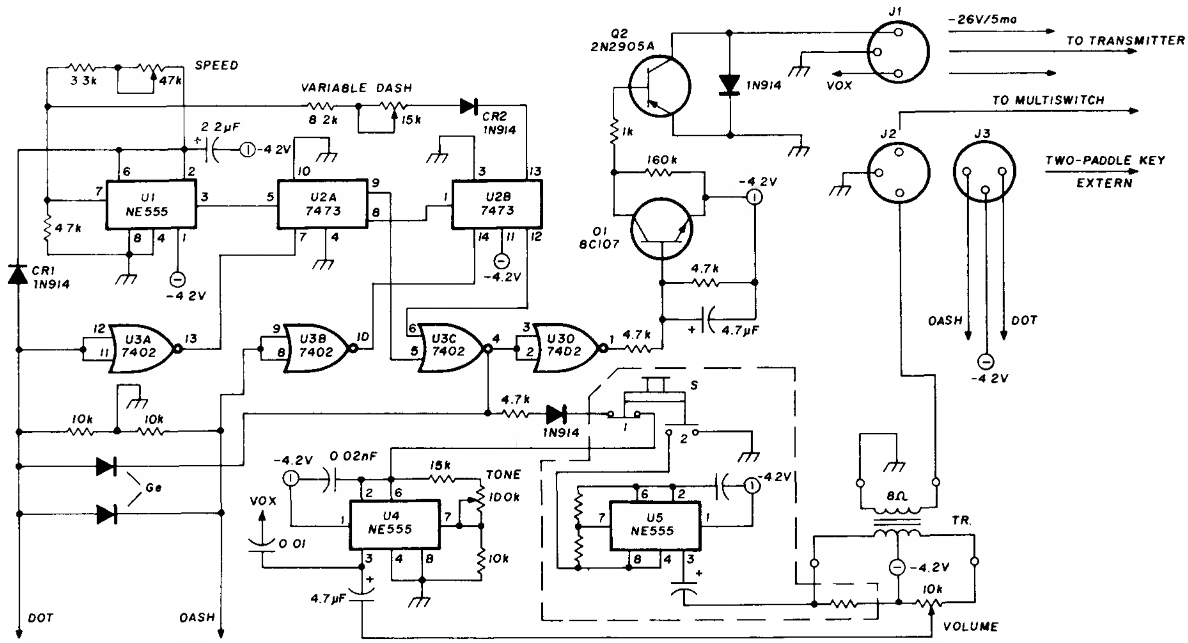
PASSIVE CW FILTER—Uses inexpensiva 88-mH toroids to give very sherp 35-Hz bandwidth et 3 dB down. Filtar hes high insertion loss. Keyed weveshepe has slow rise and fall, so CW signels have pronounced ringing that mey be objectionable.—A. F. Stahler, An Experimental Comparison of CW Audio Filters, *73 Magazine,* July 1973, p 65–70.

CW SIDETONE—Audio sidetone oscillator serves for monitoring CW keying. Changes in trensmitter opereting frequency do not affect sidetone circuit. Hertley AF oscillator Q2 is turned on by diode rectifier end DC amplifiar Q1. Antenne coupling shown is edequate from 160 through 10 meters. For VHF use on 6 end 2 meters, small tuned circuit and pickup antanna are usually required to get enough RF input for monitor. Audio pitch is adjusted by chenging value of C1.—J. Fisk, Circuits end Techniques, *Hem Radio,* June 1976, p 48–52.





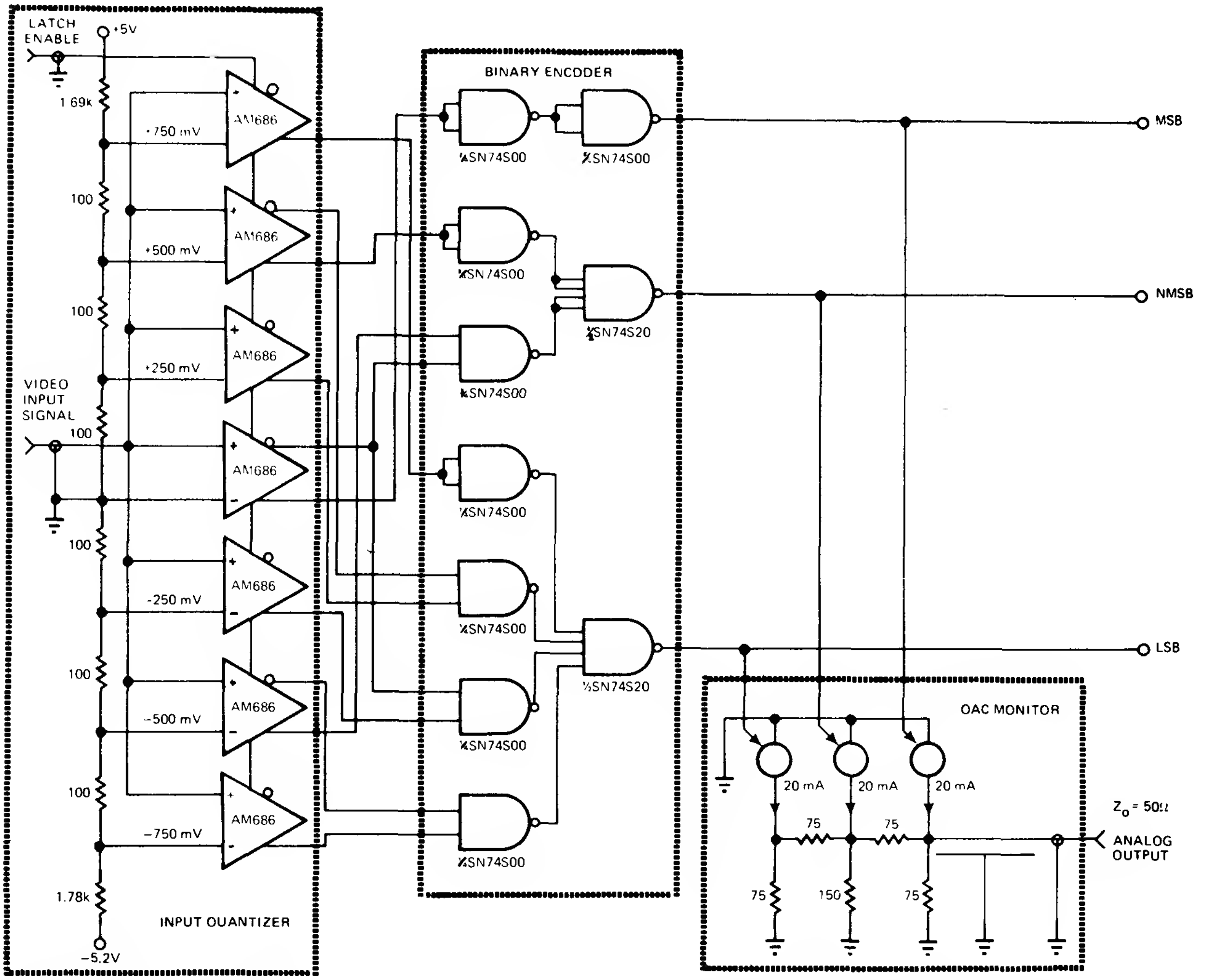
BINAURAL SYNTHESIZER FOR CW—Providas two chennels for feeding stereo phones or two loudspeekers. When interference occurs e few hundred hertz from desired frequancy, receiver is tuned so desired signel appears to be midway between loudspeakers, leaving interfering signals at right or left. Left or low chennel has low-pass ective filter and right or high chennel hes high-pass filter, with crossover et 750 Hz. Synthesizar is designed for low-impedance drive, as from loudspeaker output of receiver. Resistors in output channels pravent oscillation when 8-ohm phones or loudspeakers are directly connected to outputs. Opamps will drive 2000-ohm phones with emple voluma and give modarata volume levels with 8-ohm loads.—D. E. Hildreth, Synthesizar for Binaural CW Reception, *Ham Radio,* Nov. 1975, p 46–48.



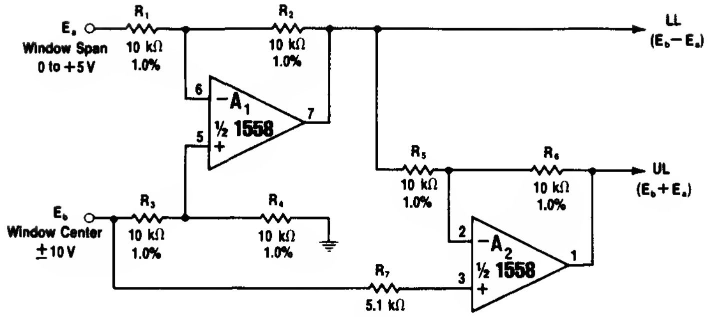
3–50 WPM KEYER—Uses NE555V U1 as switchable dot generator providing accurate 1:1 ratio. SN7473 U2 forms variable dash circuit. NE555V sidetone generator U4 has tone range of about three octaves and easily drives 3-W 4-ohm loudspeaker through small transistor-radio transformer TR. NE555V U5 acts with U4 to provide two-tone oscillator for SSB tuning. Output section Q1-Q2 easily handles keying bias of −26 V at 5 mA.—H. Seeger, Micro-TO Keyer Mods, *Ham Radio*, July 1976, p 68–69.

CHAPTER 14
Comparator Circuits

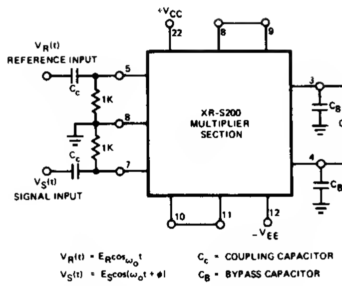
Used to compare two values of voltage, frequency, phase, or digital inputs and provide logic output for driving variety of control circuits and indicating devices. See also Logic, Logic Probe, and Voltage-Level Detector chapters.



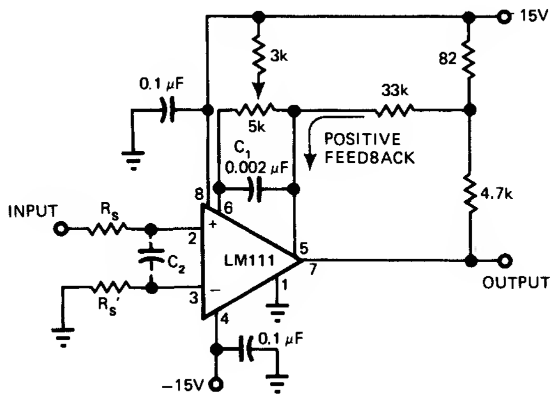
LATCH COMPARATORS FORM 3-BIT A/D CONVERTER—Seven Advanced Micro Devices AM686 comparators are arranged for direct parallel conversion of rapidly changing input signals, without prior sample-and-hold conditioning. Comparators feed Schottky TTL binary encoder logic for encoding to 3-bit offset binary. Quantization process is monitored by D/A converter. Article describes operation in detail and gives performance graphs which show freedom from output glitching at conversion speeds under 12 ns.—S. Dendinger, Try the Sampling Comparator in Your Next A/D Interface Design, *EDN Magazine*, Sept. 20, 1976, p 91–95.



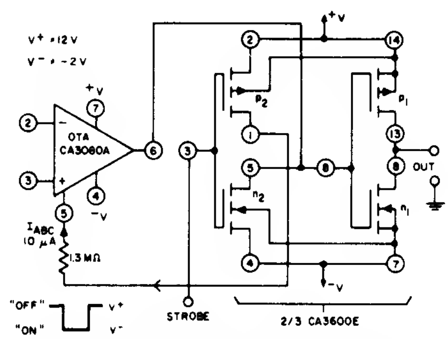
VARIABLE WINDOW—Single comparator can ba programmed for wide variety of applications. One reference input voltage positions center of window, and other sets width of window. Sum or difference of reference voltages must not exceed ±10 V; if largar voltages must be handled, add voltage divider to scale them down into comparison range. A_1 is subtractor, generating voltage $E_b - E_a$ for use as lower limit voltage. Lower limit is added to $2E_b$ at A_2 to derive upper limit voltage $E_b + E_a$.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 232–233.



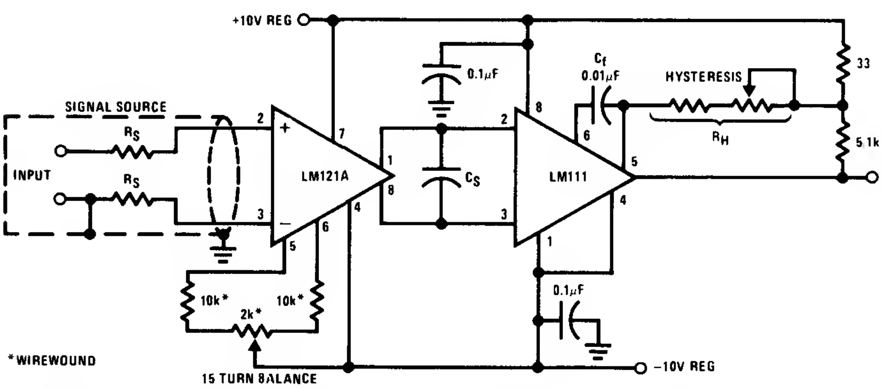
PHASE COMPARATOR—High-level reference or carrier signal and low-level reference signal are applied to multiplier inputs of Exar XR-S200 PLL IC. If both inputs are same frequency, DC output is proportional to phase angle batwean inputs. For low-level inputs, conversion gain is proportional to input signal amplitude. For high-level inputs (V_S above 40 mVRMS), conversion gain is constant at about 2 V/rad.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



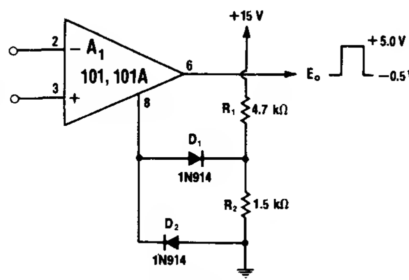
SUPPRESSING OSCILLATION—Use of positive feedback to pin 5 of comparator gives sharp and clean output transitions evan with slow triangle-wave inputs, with no possibility of comparator bursting into oscillation near crossing point. Input resistors should not be wirewound. Circuit will handle triangle-wave inputs up to several hundred kilohertz.—P. Lefferts, Overcome Comparator Oscillation Through Use of Careful Design, *EDN Magazine*, May 20, 1978, p 123–124.



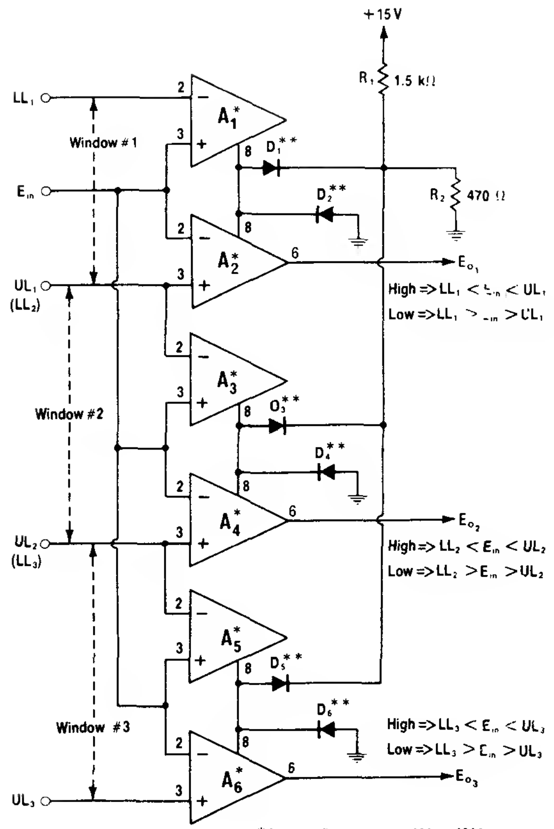
STROBED COMPARATOR—Combination of CA3080A opamp and two CMOS transistor pairs from CA3600E array gives programmabla micropower comparator having quiescent power drain of about 10 μW. When comperator is strobed on, opamp becomes active and circuit draws 420 μW while responding to differential-input signal in about 8 μs. Common-mode input range is −1 V to +10.5 V. Voltage gain of comparator is typically 130 dB.—"Linear Integrated Circuits and MOS/FET's," RCA Solid Steta Division, Somarville, NJ, 1977, p 279.



MICROVOLT COMPARATOR—Combination of National LM121A preamp and LM111 comparator serves for comparing DC signal levels that are only within microvolts of each othar. With bias network shown, preamp has open-loop temperature-stable voltaga gain closa to 100. Separation of preamp from comparator chip minimizes effects of temperature variations. Circuit hystaresis is 5 μV, which under certain conditions can be trimmed to 1 μV.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, LB-32.

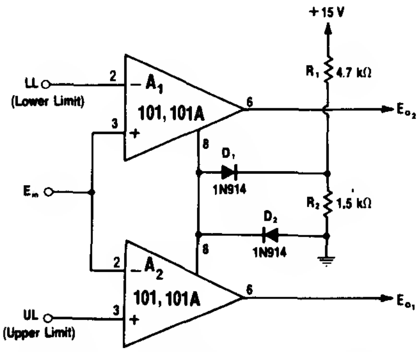


5-V CLAMPED COMPARATOR—R_1 and R_2 provide +3.8 V bias for D_1, clamping positive output of comparator opamp to +5 V. D_2 limits negative output swing to −0.5 V. Open-loop circuit means that output voltage will vary in proportion to load current.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 226–228.

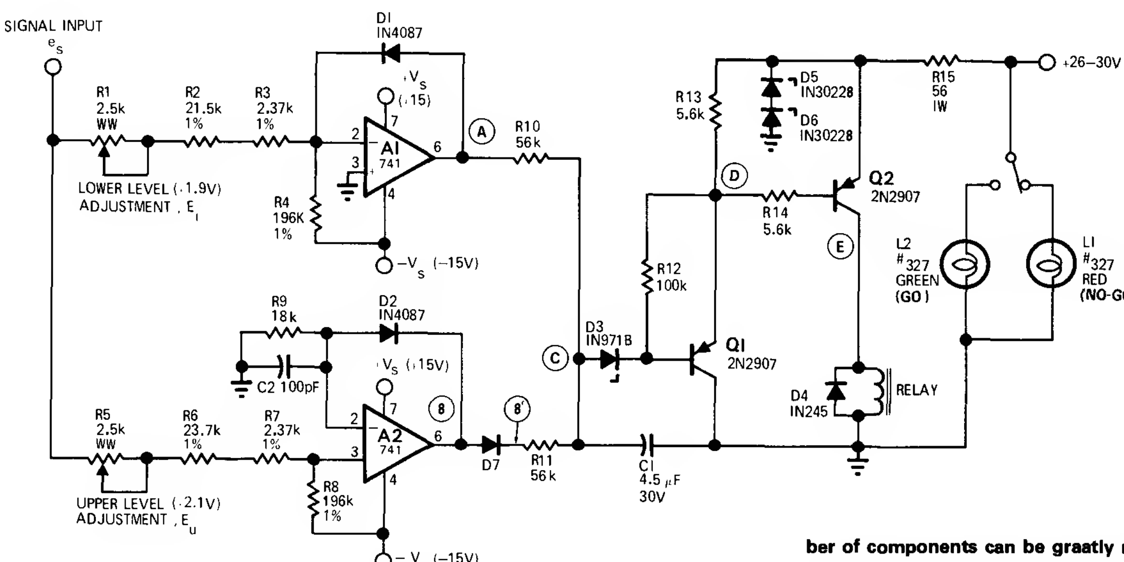


*All amplifiers are type 101 or 101A.
**All diodes are type 1N914.

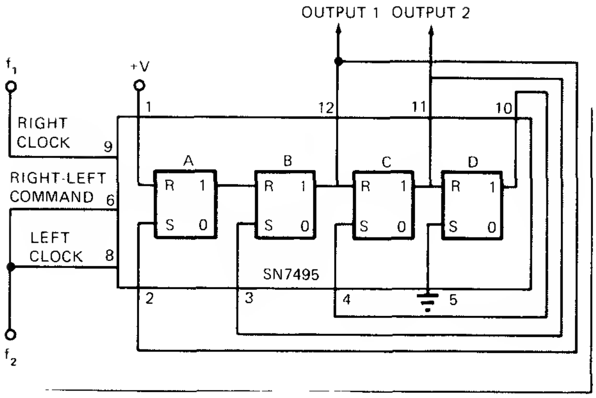
STAIRCASE WINDOW COMPARATOR—Cascading of 101-type window comparators for sequential operation indicates which of three windows input voltage is in. Input voltage is applied in parallel to all comparators. Output goes high only for comparator whose range includes voltage value of input. Lamp or other indicator can be added to each output line to give visual indication of voltage range.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 233–234.



INTERNALLY GATED WINDOW COMPARATOR—Operation is based on fact that source and sink currents available at pin 8 of 101 opamp are unequal, with negative-going drive being larger. Voltage at pin 8 is low if either comparison input (A_1 or A_2) so dictates. Both A_1 and A_2 must have high outputs for pin 8 to be high. Outputs of A_1 and A_2 thus follow pin 8 since opamps have unity gain. D_1 and D_2 form clamp network. Either output of A_1 or A_2 can be used. Outputs go to +5 V only when input voltage is in window established by upper and lower voltage limits.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 231–232.

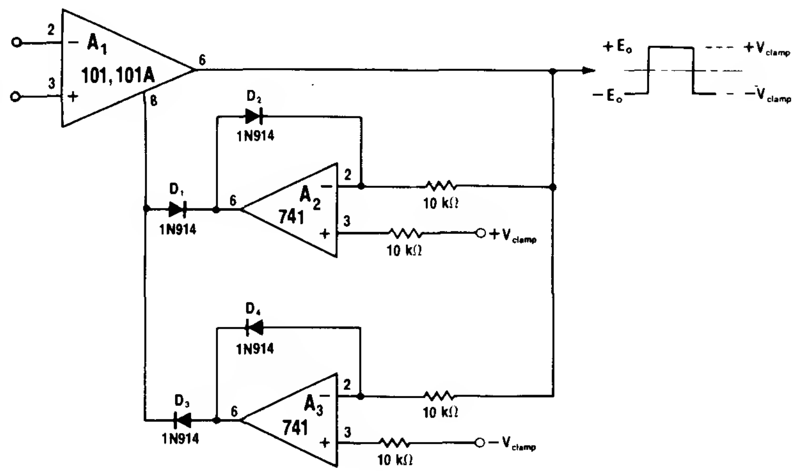


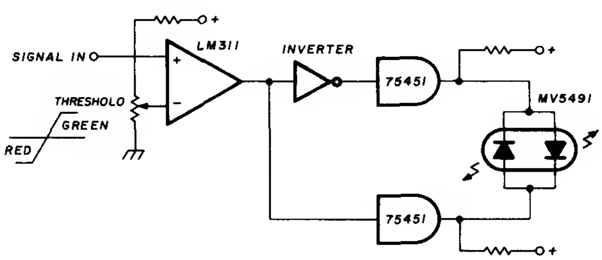
1.9–2.1 V WINDOW COMPARATOR—When positive input voltage is between levels set by R1 and R5, relay is actuated and green indicator lamp is turned on. Red lamp is on for voltages outside limits of window. Article gives design equations and traces operation of circuit. Number of components can be greatly reduced by changing opamps to LM111 comparators.—J. C. Nirschl, 'Window' Comparator Indicates System Status, *EDN/EEE Magazine*, June 15, 1971, p 49–50.



FREQUENCY/PHASE UP TO 25 MHz—Universal shift register such es 5495/7495 is connected to compere both fraquency end phase of two carrier signels enywhere in renge from DC to 25 MHz. When f_1 is greater than f_2, output is 1; when f_1 is less then f_2, output is 0. For $f_1 = f_2$, output is squere weve whose duty cycle varies linearly with phese difference between f_1 end f_2. Comparisons ere elmost instanteneous, requiring at most two cerrier cycles.—J. Breese, Single IC Comperes Frequencies end Phese, *EDN Magazine*, Sapt. 15, 1972, p 44.

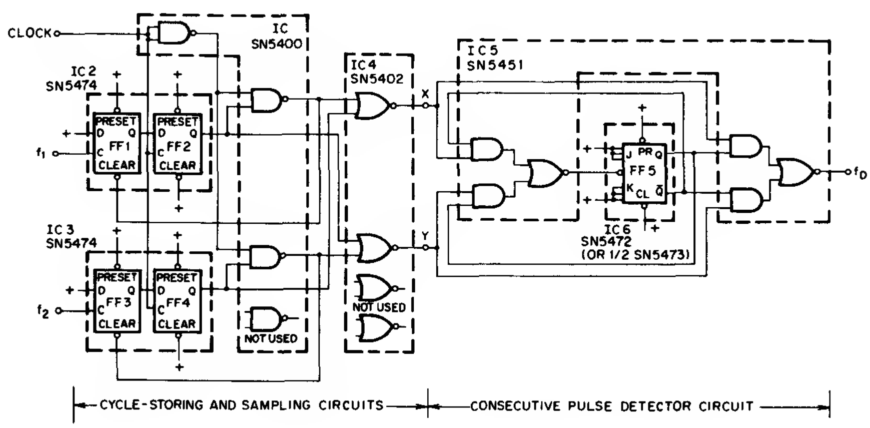
VARIABLE BIPOLAR CLAMPING—Precision comperetor provides independant regulation of both output voltage limits without connaction to comparison inputs. A_2 and A_3 are complementary precision rectifiers having independent positiva and negetiva referenca voltages, with both rectifiars oparating in closed loop through A_1. A_2 senses positiva peak of E_o and mainteins it equal to $+V_{clamp}$ by adjusting voltage applied to D_1. A_3 and D_3 parform similar function on nagative peaks. Feedback network around output staga of A_1 regulates output voltaga independently of inputs to A_1.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 228–229.

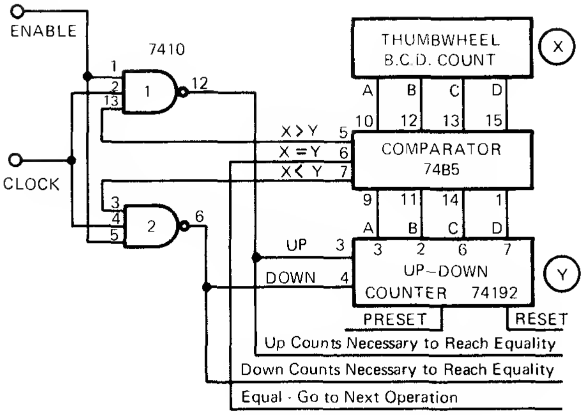




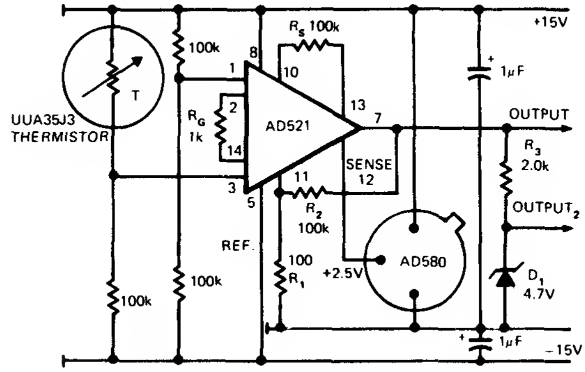
LEVEL-CROSSING DISPLAY—Uses Monsento MV5491 dual red/green LED, with 220 ohms in upper lead to +5 V supply end 100 ohms in lower +5 V leed bacause red end green LEDs in perellel back-to-back have different voltaga requirements. Circuit requires SN75451 driver ICs and ona section of SN7404 hex invarter, with LM311 comperetor. All operate from single +5 V source. Provides indicator change from red to green with input change of only a few millivolts.—K. Powell, Novel Indicator Circuit, *Ham Radio*, April 1977, p 60–63.

FREQUENCY COMPARATOR—Can be used with wide renge of clock frequencies up to 5.3 MHz to provide output frequency thet is equal to absolute differance between input frequencies f_1 and f_2. Article traces operation of circuit end gives design equetions.—P. B. Morin, Frequency Comperetor Provides Difference Frequency, *EEE Magazine*, April 1971, p 65–66.



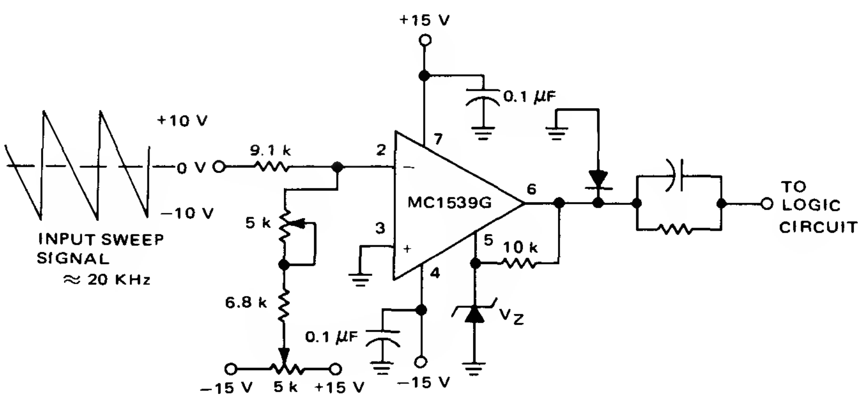


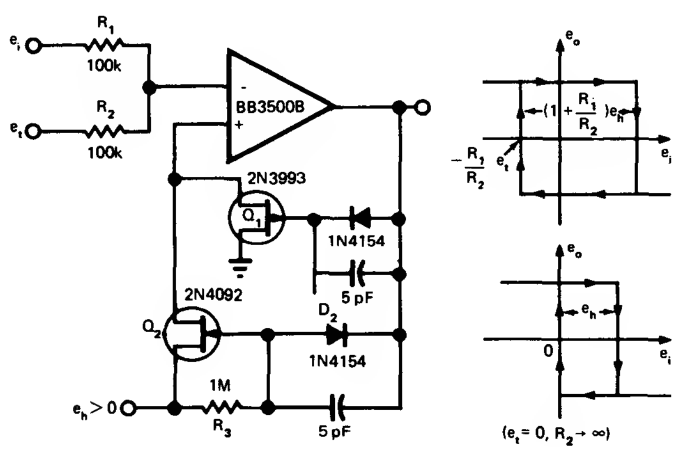
4-BIT BCD COMPARATOR—Provides less then, equel to, or greater then comperison between setting of BCD thumbwheel switch et X and BCD input digit et Y (Y is count preset into 74192 up/down counter). If equelity does not axist, circuit will count up or down until it reeches equality, and thereby calculate difference between BCD values. Seperate register can be used to store up or down counts required to raech equality.—R. A. Scher, Digitel Comparator Is Self-Adjusting, *EDN Magazine*, Sept. 1, 1972, p 51.



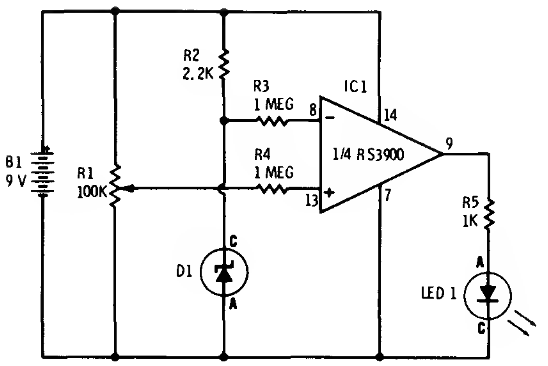
INDEPENDENT SIGNALS—Single AD521 instrumentetion amplifier comperes two independent signal levels from sourcas heving no common reference point. When one differential signal is epplied to usuel input of opemp end other to referenca input, output is proportionel to difference. Positive feedback provides small amount of hysteresis, to eliminate ambiguity and reduca noise susceptibility. Stable threshold of ebout 25 mV is derived from AD580 lowvoltege reference circuit. Referance voltage is 2.5 V, but velues used for R_S end R_G are in ratio of 1:100 so comperetor output switches when normel input is ebout $1/100$ of referenca input. Output is negetive when normal input is zero, and switches positive when input axceeds threshold. Output swings ±12 V as inputs go through critical ratio. R_3 end D_1 provide TTL-compatible second output.—A. P. Brokaw, You Can Compere Two Independent Signel Lavals with Only One IC, *EDN Megazine*, April 5, 1975, p 107–108.

VOLTAGE COMPARATOR—Motorola MC1539 opemp provides excellent tempereture characteristics end very high slewing rate for comperator applications. Zener connected to pin 5 limits positive-going weveform at output to about 2 V below zener voltage. Silicon diode connected to output limits negative excursion of output to give protection for logic circuit being driven. Parallel RC network in output provides impedance matching end minimizes output current ovarloed problems.—E. Renschler, "The MC1539 Operationel Amplifier and Its Applicetions," Motorole, Phoenix, AZ, 1974, AN-439, p 18.

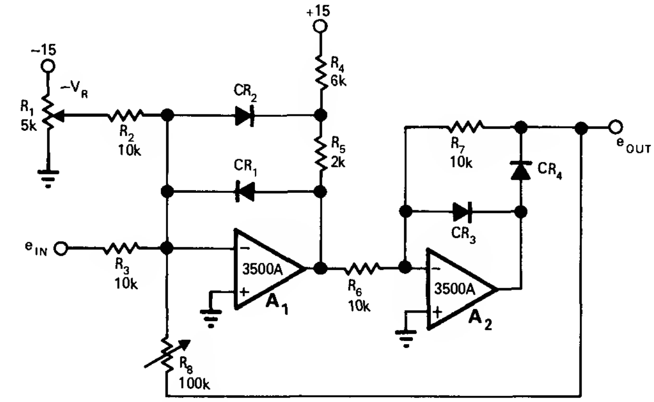




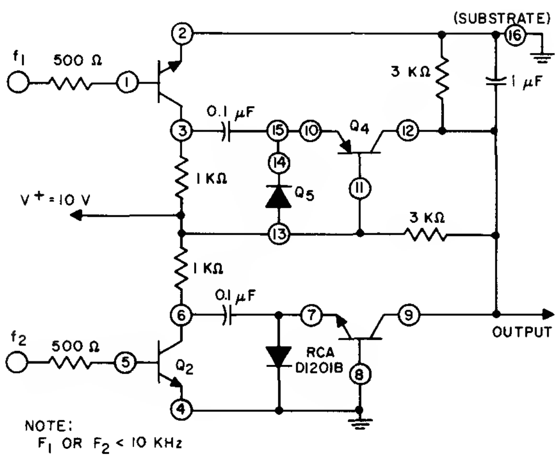
VOLTAGE-CONTROLLED HYSTERESIS—Precise, independant control of comparetor trip point and hysteresis is echieved by switching hysteresis control signel e_h to comperator input with Q_1 and Q_2 when opamp chenges state. Circuit evoids hysteresis feedbeck error while echieving inherent 0.01% trip-point accuracy of comperator. Control voltage a_t determines first trip point. When opamp output is negative, Q_2 is held off end Q_1 is on for connecting noninverting input to ground. Output switching occurs when input signel e_i drives input of inverting emplifier to zero.—J. Graama, Comparetor Hes Precise, Voltage-Controlled Hystaresis, *EDN Megezine*, Aug. 20, 1975, p 78 end 80.



ZENER REFERENCE—One section of RS3900 qued opamp is connected as comperator using zener D1 for reference voltage. When voltage applied to pin 13 by R1 exceeds breekdown voltage of zener D1, comperator amplifies difference voltage to produce output voltage high enough to tum on LED. Can be used for cless-room demonstretion of comparator ection. Zener breekdown should be under 9 V. LED can be Radio Sheck 276-041.—F. M. Mims, "Semiconductor Projects, Vol. 2," Redio Sheck, Fort Worth, TX, 1976, p 35–42.

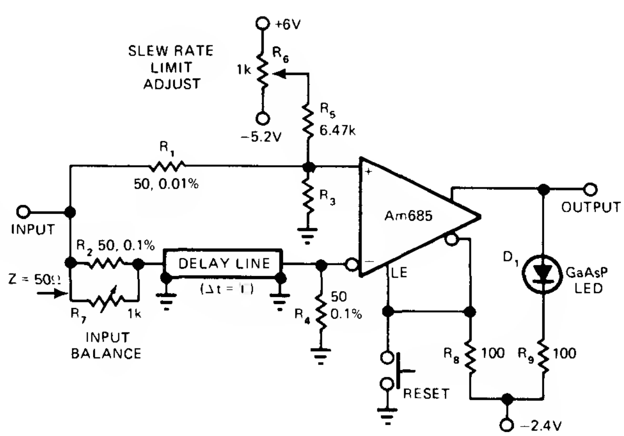


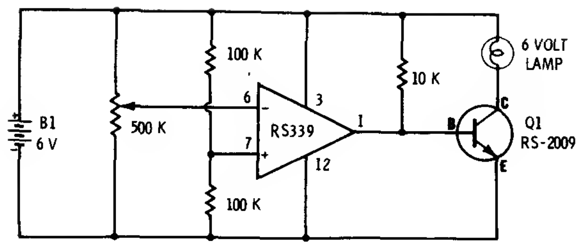
INDEPENDENT HYSTERESIS ADJUSTMENT—Trip point end hysteresis of comparator opemp A_1 can be edjusted independently, with trip point being determined by setting of R_1 or programmed by DC voltege epplied to R_2. Opemp A_2 provides polerity inversion and rectification of A_1 output. Hysteresis control R_8 is in feedbeck peth from A_2 beck to A_1. Amount of hysteresis is determined by retio of R_3 to R_8. With values shown, circuit output levels ere 0 end 5 V.—G. Tobey, Comperator with Noninteracting Adjustments, *EDN/EEE Magazine,* Oct. 1, 1971, p 43.



FREQUENCY COMPARATOR—Circuit using CA3096 trensistor errey plus one discrete diode develops DC output voltege thet is proportionel to difference between frequencies of input signels f_1 end f_2. Meximum input frequency is 10 kHz.—"Circuit Idees for RCA Linear ICs," RCA Solid Stete Division, Somerville, NJ, 1977, p 17.

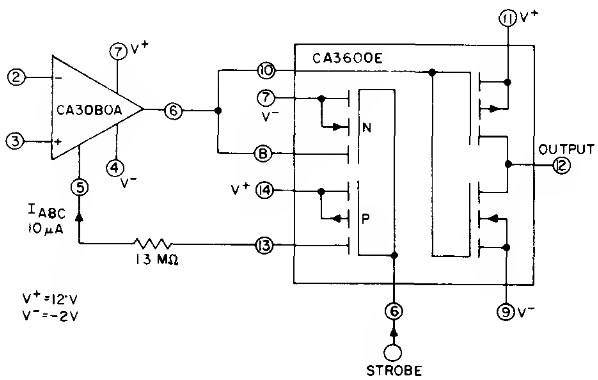
SLEW RATE—Circuit measures slew rete of input signal with Am685 comperetor in circuit heving delay-line length under 10 ns. When slew rete exceeds predetermined limit set by R_6, comparator changes state and latches, turning on LED. Pushing reset switch restores normal operetion. Based on comperison of input signel with time-delayed counterpert. Derivative of input signal, equal to its instantaneous slew rete, is measured eccuretely for swings of 6 V P-P es found in most 50-ohm video signels. Action is fast enough to detect glitches.—R. C. Culter, Slew-Rete Limit Detector Is Simple, yet Versatile, *EDN Magazina,* Aug. 20, 1977, p 140–141.

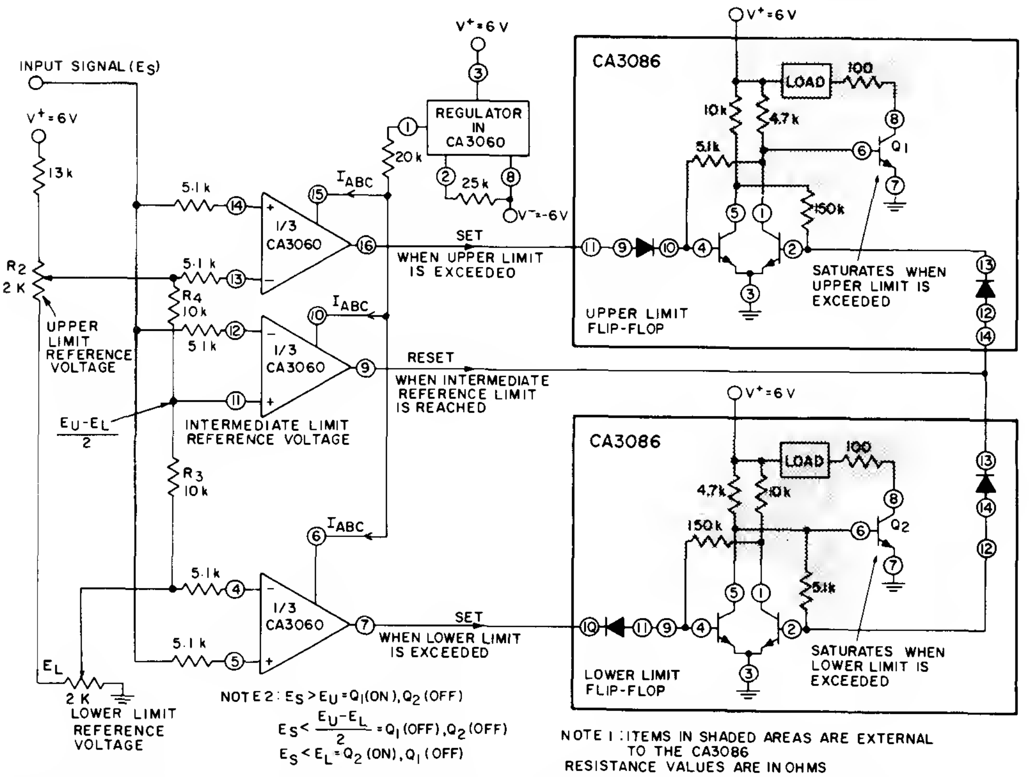




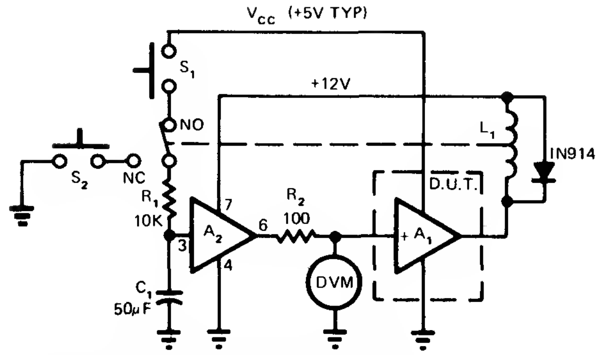
COMPARATOR DRIVES LAMP—Classroom damonstration circuit for comparator action uses transistor to amplify output of ona section of RS339 quad comparator, to boost output currant anough for driving 60-mA lamp. Lamp comes on when voltaga at movabla arm of 500K pot is graatar than half of supply voltage.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 33–41.

STROBED MICROPOWER—Uses CA3080A variabla opamp and CA3600E CMOS transistor array. Quiascent powar drain from ±12V supply is only 10 μW, incraasing to 420 μW whan comparator is strobed on to maka CA3080A activa.—"Circuit Idaas for RCA Linear ICs," RCA Solid Stata Division, Somarvilla, NJ, 1977, p 16.





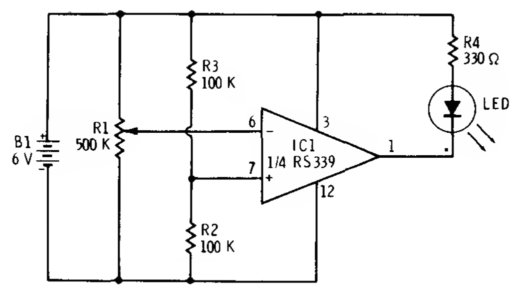
THREE-LEVEL COMPARATOR—All three sections of CA3060 three-opamp array ara used with CA3086 transistor arrays to provida thraa adjustabla limits for comparator. If uppar or lowar limit is exceeded, appropriata output is activated until input signal returns to presalected intermediata limit. Suitabla for many types of industrial control applications.—"Circuit Idaas for RCA Linear ICs," RCA Solid State Division, Somarvilla, NJ, 1977, p 17.

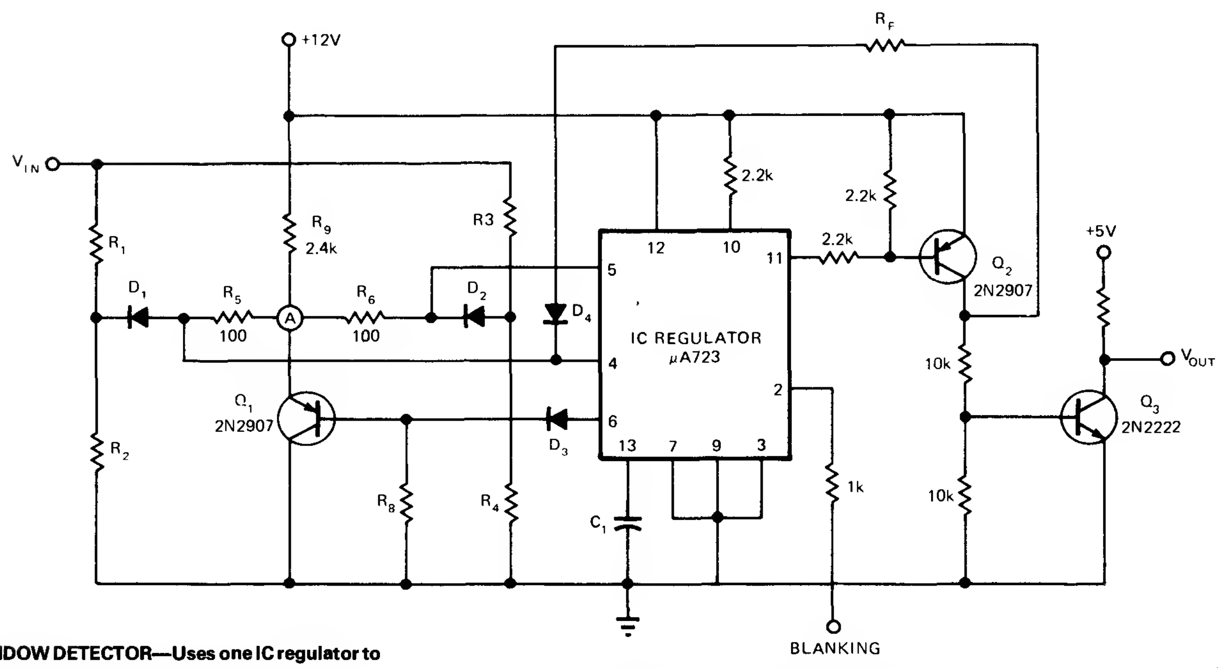


A₁ (D.U.T.): NON-INVERTING COMPARATOR WITH 10% HYSTERESIS UNDER TEST
A_2: VOLTAGE FOLLOWER, LM310
L_1: RELAY, COUCH 2X10B460A

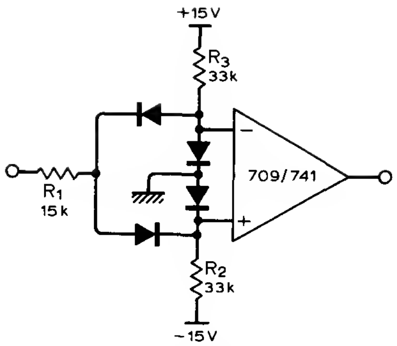
MEASURING THRESHOLDS—Upper end lower thresholds of noninverting comparator undar test (A_1) are read on DVM et end of capecitor charge and discharge cycles initieted by S_1 end S_2. With C_1 discharged, reley L_1 is energized. Closing S_1 allows C_1 to charge toward V_{CC}. When upper threshold is reached, relay drops out and meter is read. Closing S_2 sterts discharge cycle which stops at lowar threshold. Reverse reley connections when testing inverting comperator.—E. S. Pepanicolaou, Comparetor Is Part of Its Own Measuring System, *EDN Magazine*, Aug. 5, 1974, p 76.

COMPARATOR DRIVES LED—Simple classroom demonstrator of comparator action uses one section of RS339 qued comparator. Reference voltage applied to positiva input of comperetor is helf of supply voltage. R1 serves es voltage divider applying verieble voltage to invarting input. When voltege applied to pin 6 by R1 exceeds reference voltege on pin 7, comparator switches on end LED lights. R4 is chosen for usa wlth Redio Shack 276-041 red LED.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth TX, 1977, p 33–41.

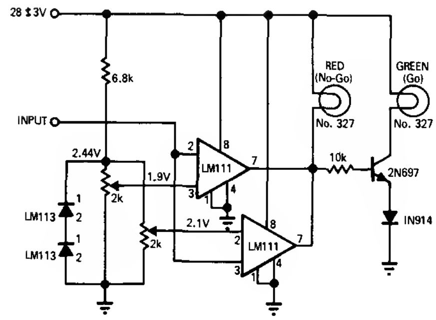




WINDOW DETECTOR—Uses one IC regulator to compare output voitages of two separate voltage dividers with fixed reference voltege. Resulting absoluta error signal is emplified end converted to TTL-compatible logic signel. Voltege divider for lower limit of window detector is R_1-R_2 and for upper limit is R_3-R_4. Article covers circuit operation in detail.—N. Pritcherd, Window Detector Uses One IC Regulator, *EDN Magazine*, May 20, 1973, p 81 and 83.



DUAL LIMITS—Opamp used without frequency compensation gives positiva output only when input voltage exceeds 8.5 V in eithar polerity. Resistors in supply leads determine limit points. For inverted output, reverse inputs to opamp. Diodes ere 1N914.—K. Pickerd, Dual Limit Comperator Using Single Op-Amp, *Wireless World*, Dec. 1974, p 504.

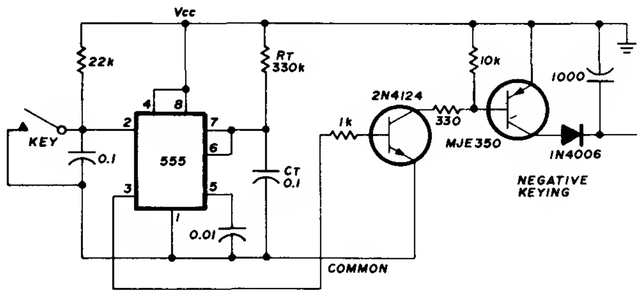


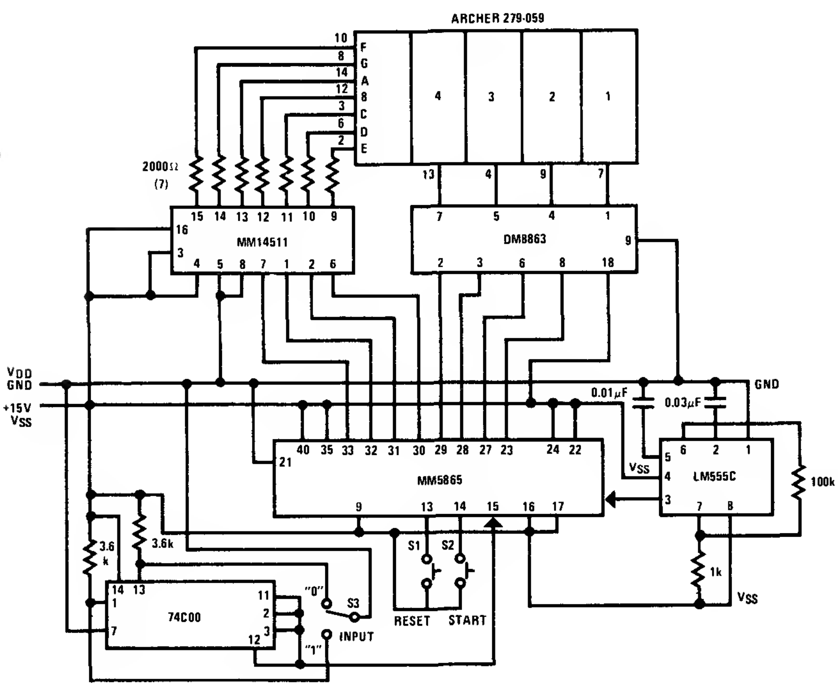
VOLTAGE-WINDOW COMPARATOR—Use of LM111 opamps minimizes number of components required to turn on green indicetor lamp when input voltage is between predetermined limits set by 2K pots. Similer circuit using 741 opamps requires total of 31 components. Improved circuit draws only 120 nA from voltage level being monitored, and oparates within 0.3% threshold leval stability using single unreguleted supply varying ±3 V from 28 V.—D. Priaba, Comperators Compered, *EDN/IEEE Magazine*, Oct. 1, 1971, p 61.

CHAPTER 15
Contact Bounce Suppression Circuits

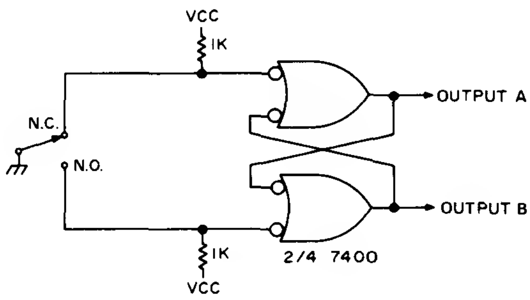
Used to solve bounce problems of switch and relay contacts during closing or opening.

BOUNCELESS SQUARE OUTPUT—NE555 timer eliminates need for gates to suppress contact bounce. Timer can provide pulse at least 5 ms long (much longer if desired) and cen remain on as long as trigger input (key pulse) is low (grounded). Timar triggers on negative-going edga of low-going pulsa, such as kay down to ground. Common negetive is isoleted from ground. V_{CC} can be 5 to 15 VDC. Timar output can ba connected directly to exciter keying input for negative grid kaying. Because of square-wave output on make or break (100 ns each), circuits must ba added in exciter or betwaan keying transistors to provide at least 5-ms rise and fall timas for Morse or RTTY keying.—B. Conklin, Improving Transmitter Keying, *Ham Radio,* June 1976, p 44–47.

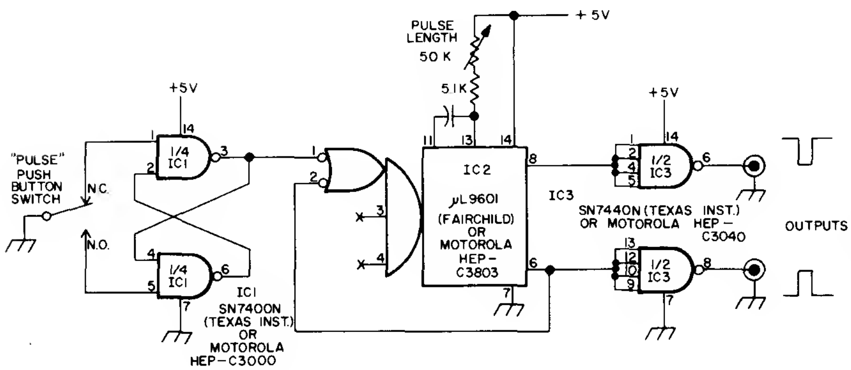




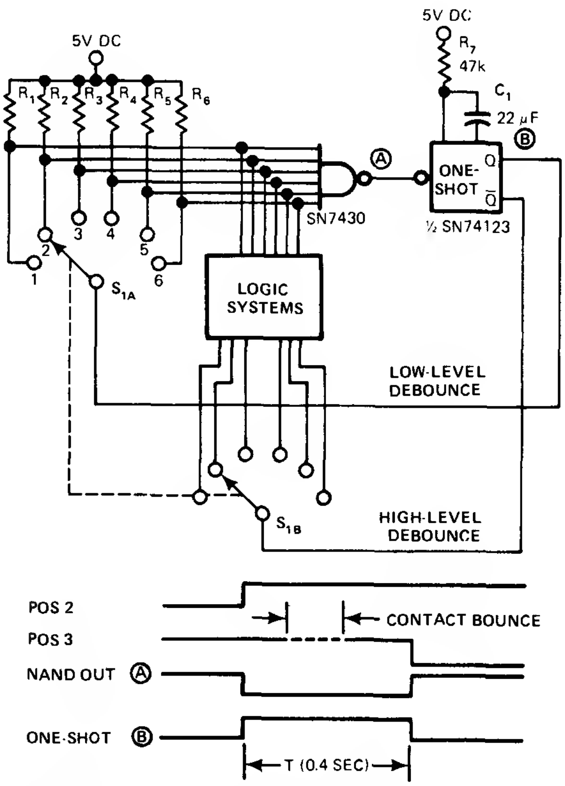
SWITCH-CLOSURE COUNTER—National MM5865 universal timer end counter chip is used with 74C00 debouncer and LM555C timar to drive digital display that counts closures of manual switch S3. Reset transition restores display to 0000. BCD segment outputs of MM5865 feed LED 4-digit display through MM14511 interface, while digit enebla outputs go to display through DM8863 drivar.—"MOS/LSI Databook," Netional Semiconductor, Santa Clara, CA, 1977, p 2-23–2-32.



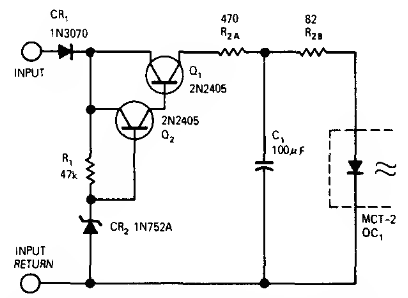
DEBOUNCER—Ganerates single pulse on switch closure, provided wiper of switch bounces only between contact and an opan. Output A goes low when switch is pushed, and at same time output B goes high.—E. E. Hrivnek, House Cleaning the Logicel Wey, *73 Magazine*, Aug. 1974, p 85–90.



ONE PULSE PER PUSH—Circuit genarates only one rectangular pulse for each actuation of pushbutton switch, evan if contacts bounce. TTL gates IC1 ere wired as RS flip-flop (latch) that triggers mono MVBR IC2 having fixed-duration positive and negativa output pulses. Output drives are increased by TTL inverting buffer gates.—H. Olson, Furthar Advantures of the Bounceless Switch, *73 Magazine*, Feb. 1975, p 111–114.

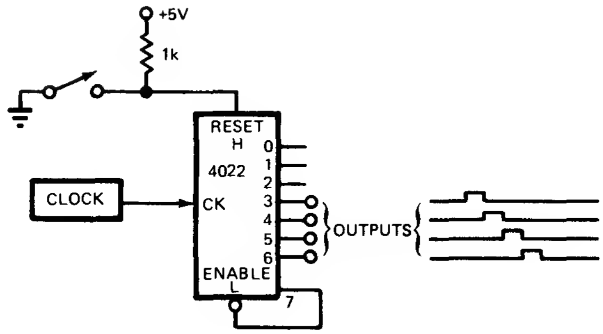


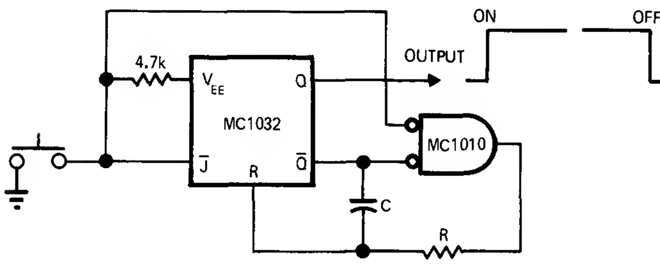
ROTARY SWITCH DEBOUNCE—Outputs from mono (ona-shot) provide common returns for rotery switch. Multi-input NAND gete, tied to normally high signals from one deck of rotary switch, instantly detects opening of one contact and triggers mono. Mono then simulates open contact for intarvel determined by velues used for R_7 and C_1; for values shown, dalay is 400 ms.—E. S. Peltzman, Circuit Eliminatas Rotary-Switch Bounce Problems, *EDN Magazine*, April 20, 1978, p 132.



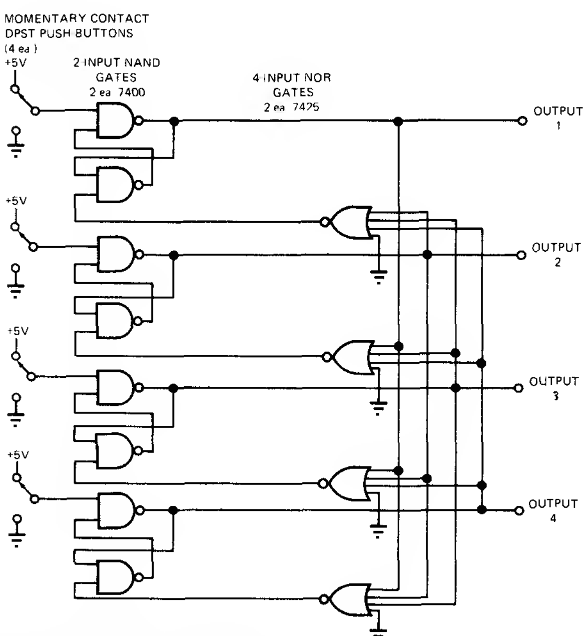
BOUNCELESS ISOLATOR—Integrating filter C_1-R_2 eliminates effects of contact bounce that may be superimposed on digital input signal feeding optoisolator. Photodiode in optoisolator drives Schmitt trigger that makes output to TTL circuits change stata when LED is turned on by input signal.—C. E. Mitchell, Optical Coupler and Level Shifter, *EDN/IEEE Magazine*, Feb.1, 1972, p 55.

DEBOUNCING WITH COUNTER—Circuit uses CMOS counter/decodar with eny inexpensive 200-Hz or higher clock such as CMOS two-gate oscillator or 555 timer. Signel to be debounced is fed directly to reset input of counter, with no preconditioning. When contact Is made by switch, counter unclaars end starts counting up. Each bounce of contact resets countar, so it cycles between states 0 end 1 until contacts settle. Countar than delivers dean nonoverlapping pulses to remalning output lines, any of which may ba used as conditioned output signal. Whan counter reaches state 7, it inhibits itself to prevent repeated pulsing of output lines. When switch is opened, cycling ection is repeeted during bounces, with output never going higher than state 1. Aftar bouncing, counter is held in clear state ready for next closing.—L. T. Heuck, Solve Contact Bounce Problems Without e One-Shot, *EDN Magazine,* Sept. 5, 1975, p 80 end 82.

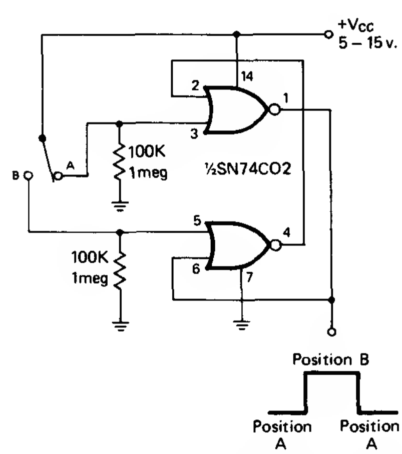




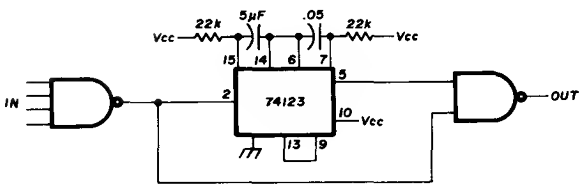
BOUNCELESS MAKE/BREAK—Circuit eliminates switch bounce problems during closing as well as opening. When switch is closed, Q output of flip-flop goes to logic 1 for dalay period determined by RC time constant. Releasing switch operetas NAND gete, meking its output go to logic 1. This charges C through R until reset level is reeched. Flip-flop then resets, chenging Q output to logic 0. Velues for R and C ere chosen eccording to bounce duration of switch used. For typical 1-A SPST switch, 10,000 ohms and 0.47 μF were used.—L. F. Walsh and T. W. Hill, Make-end-Break Bounceless Switching, *EDN/EEE Magazine,* July 15, 1971, p 49.



BOUNCE-FREE INTERLOCKING—Arrengement provides low-cost equivelent of mechenically interlocked switch essembly, while providing TTL competibility end freedom from switch bounca. Momentary pressing of any pushbutton restores its essociated RS flip-flop to normal and mekas output of that channel high. Arrengament usas cross-coupled two-input NAND gates for eech flip-flop, connected so eech ectuation produces en output and resets ell othar flip-flops. If two or more buttons are pushed simultaneously, ell their channels will go high, but only lest one releesed will stay on. Any number of channels may ba added.—B. Brendstedt, Digital Interlocking Switch Is Inexpensive to Build, *EDN Magazine,* Dec. 15, 1972, p 42.

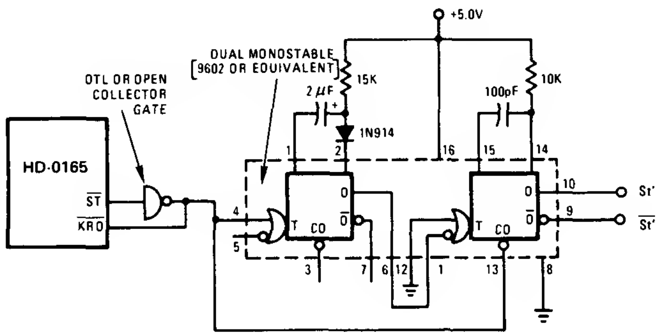


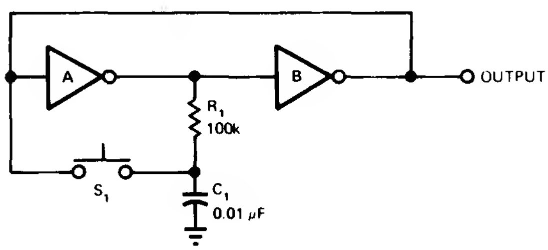
LATCHING GATES—SN74C02 quad two-input NOR gete forms latching circuit in which first noise pulse produced by switch letches circuit, making it immuna to contact bounca.—I. Math, Bounceless Switch, *CQ,* July 1976, p 50.



DELAYED START—Keyed output of RTTY terminal equipment or other keys and ralays is deleyed by 74123 dual mono for at least 5 ms whila contact bounca settles down. Can be used for celculator keyboerds, flip-flop testers, end other applications in which finel clean pulse length is not highly important.—B. Conklin, Improving Transmitter Keying, *Ham Radio*, June 1976, p 44–47.

KEYBOARD BOUNCE ELIMINATOR—Duel 9602 mono MVBR is used with Herris HD-0165 keyboerd encoder to generete deleyed strobe pulse St', with delay set et about 10 ms by first mono. Pulse width is determined by second mono end should be set to meet system requirements. Circuit eliminates effects of ercing or switch bounce end provides proper encoding under two-kay rollovar conditions.—"Lineer & Deta Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 6-4.



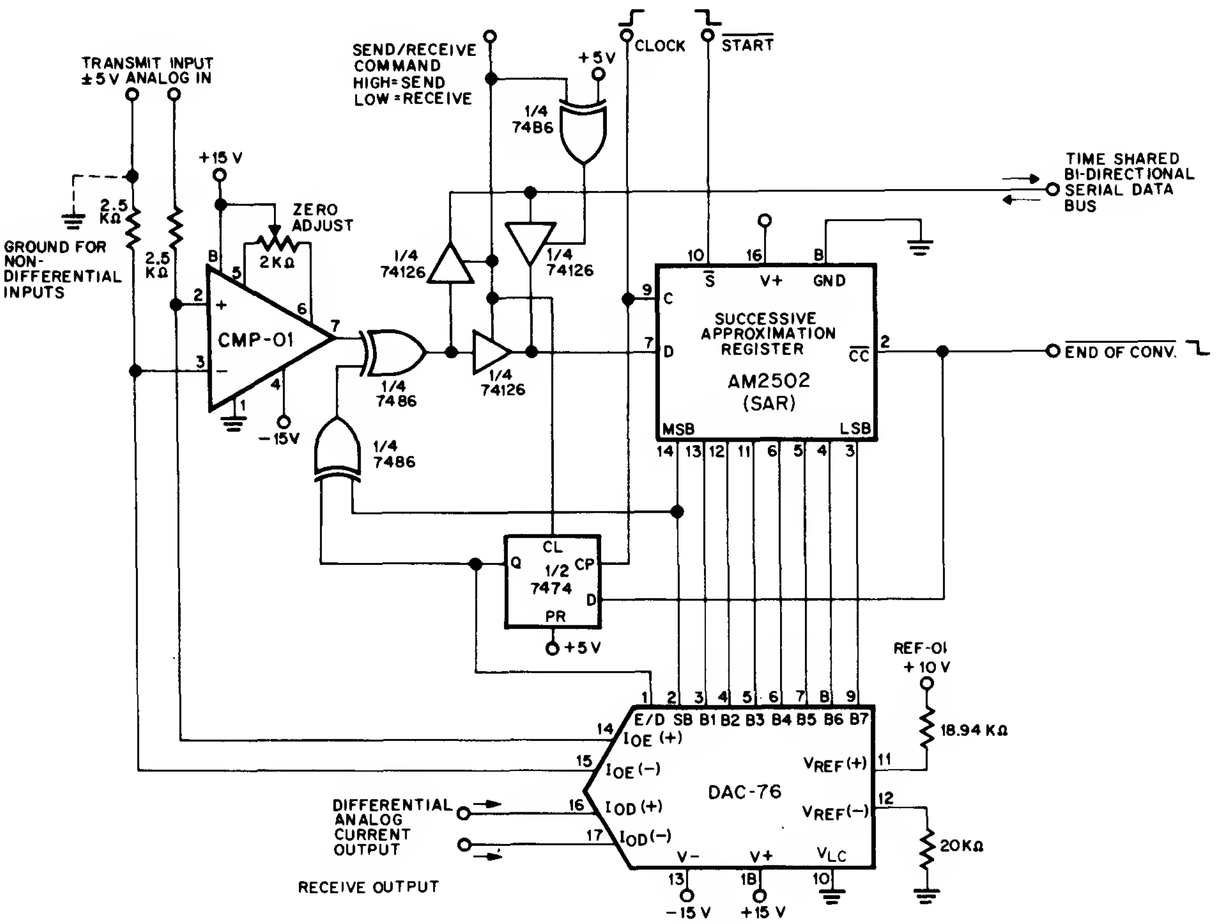


GATES FORM SWITCH—Each time pushbutton switch is closed momanterily, voltege on C_1 mekes inverter A chenge stete, with positive feedbeck from inverter B, to giva elternate ON end OFF ection. R_1 deleys charging end discharging of C_1, making circuit essentielly immune to contect bounce. Switch works equelly well with either CMOS or TTL getes. Values of R_1 end C_1 ere not critical.—T. Tyler, Invertars Provide "ON-OFF" from Momentery Switch, *EDN Magazine*, June 20, 1976, p 126.

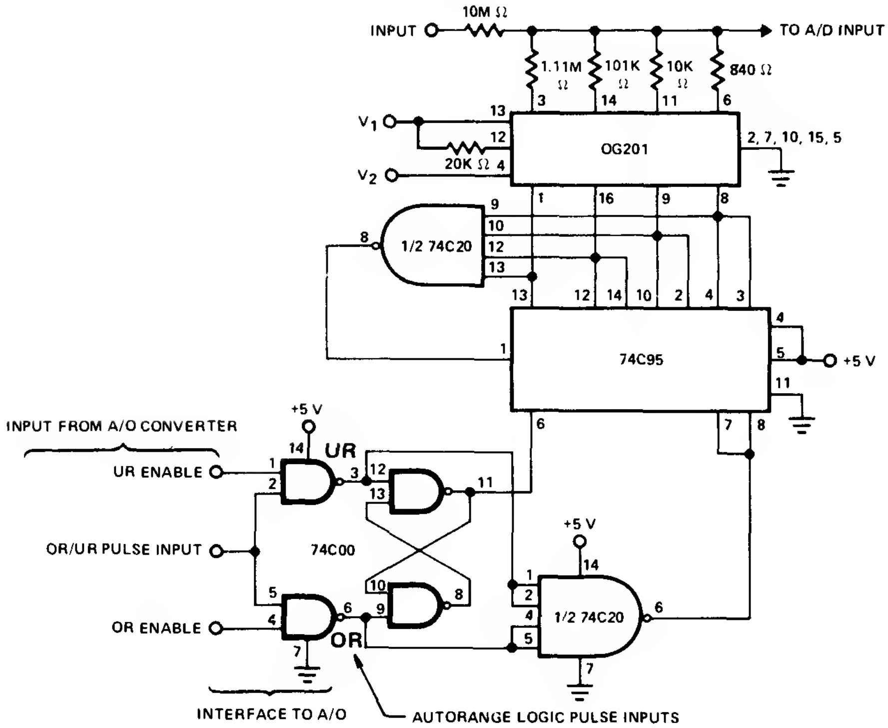
CHAPTER **16**

Converter Circuits—Analog-to-Digital

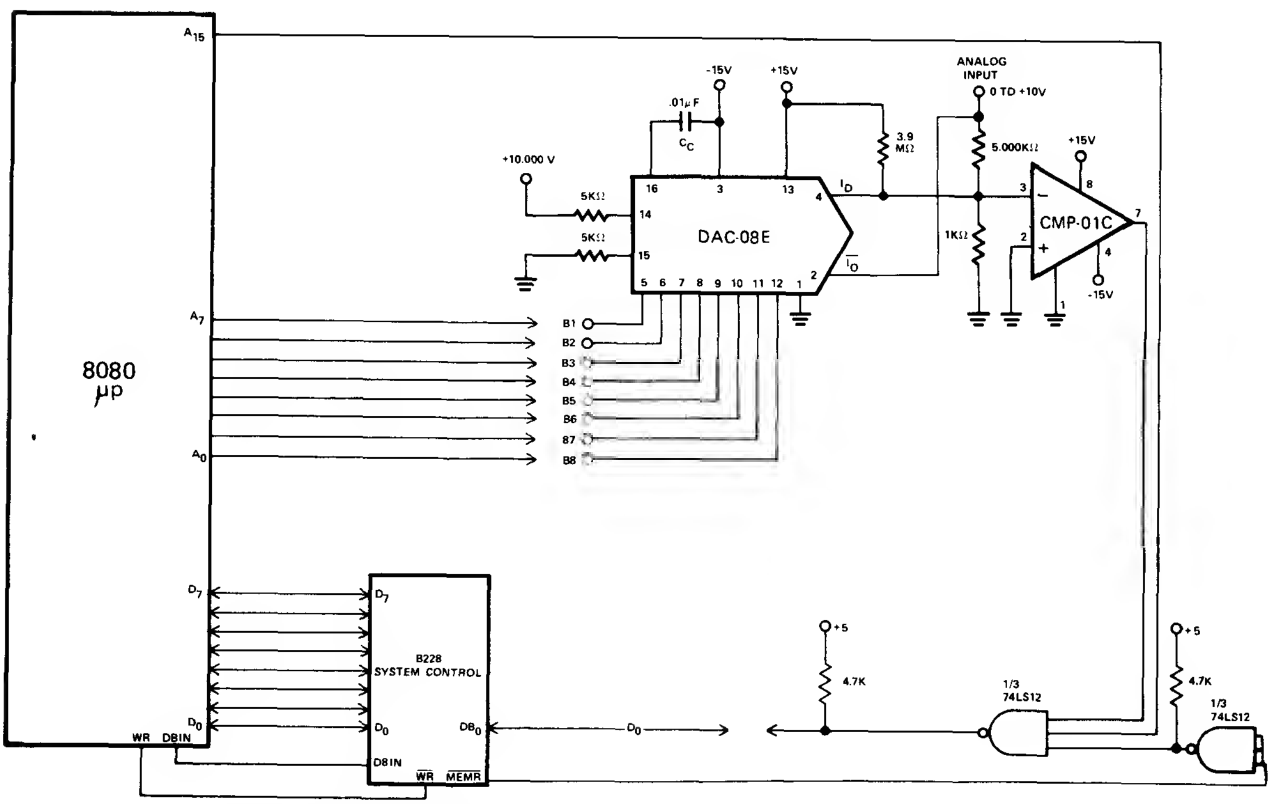
Includes circuits for converting DC, audio, and video analog inputs to linearly related binary, BCD, or Gray-code digital outputs. Some circuits have autoranging or some type of input compression, input multiplexing, and input buffering.



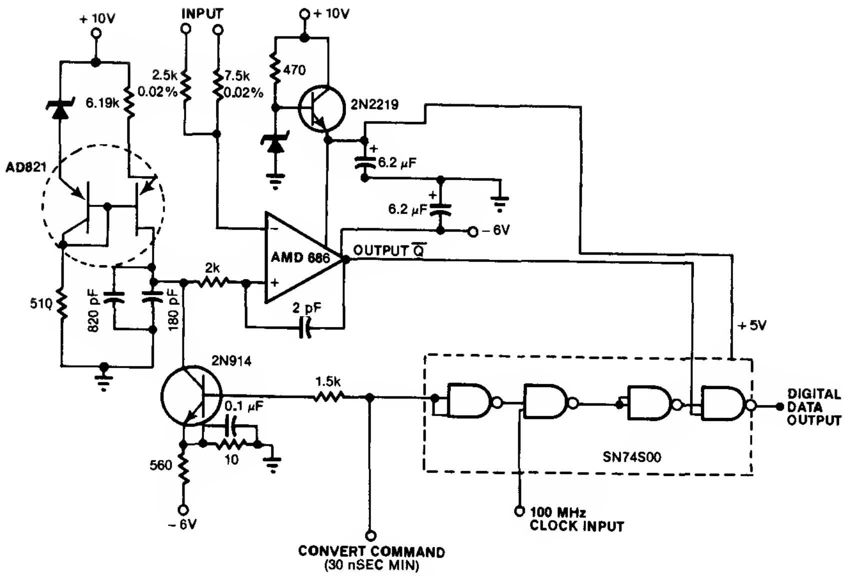
SERIAL DATA OUTPUT—Precision Monolithics ICs form transceiving converter suitable for use in control systems incorporating 8-bit microprocessors. Output conforms with Bell-System μ-255 logarithmic law for PCM transmission. Applications include servocontrols, stress and vibration analysis, digital recording, and speech synthesis. Start must be held low for one clock cycle to begin send or receive cycle. Conversion is completed in nine clock cycles, and output is available for one full clock cycle. Other half of system is identical.—"COMDAC Companding D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, DAC-76, p 12.



SELF-CONTROLLED AUTORANGING—DG201 quad analog switch inserts one of four attenuator resistors in input circuit of Siliconix LD130 or comparable A/D converter under control of autoranging pulse output derived from converter. Control logic includes 74C00 quad two-input NAND gate with two sections connected as flip-flop, 74C95 4-bit right-shift left-shift register, and 74C20 dual four-input NAND gate.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 6-28–6-29.

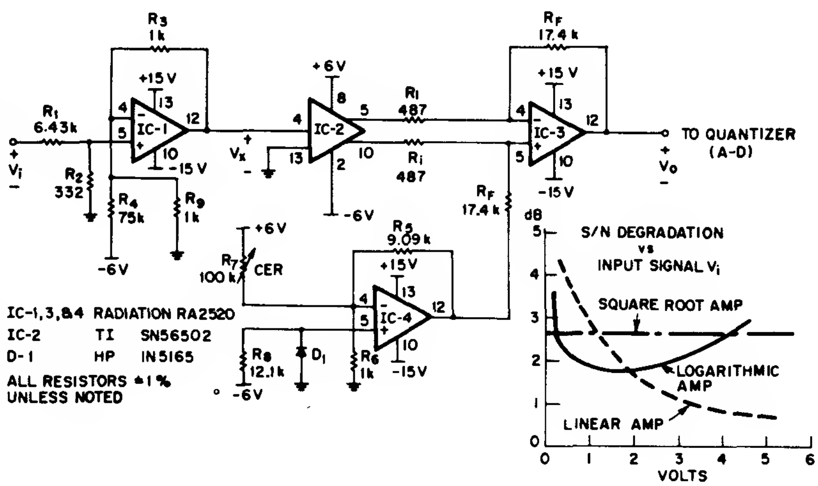


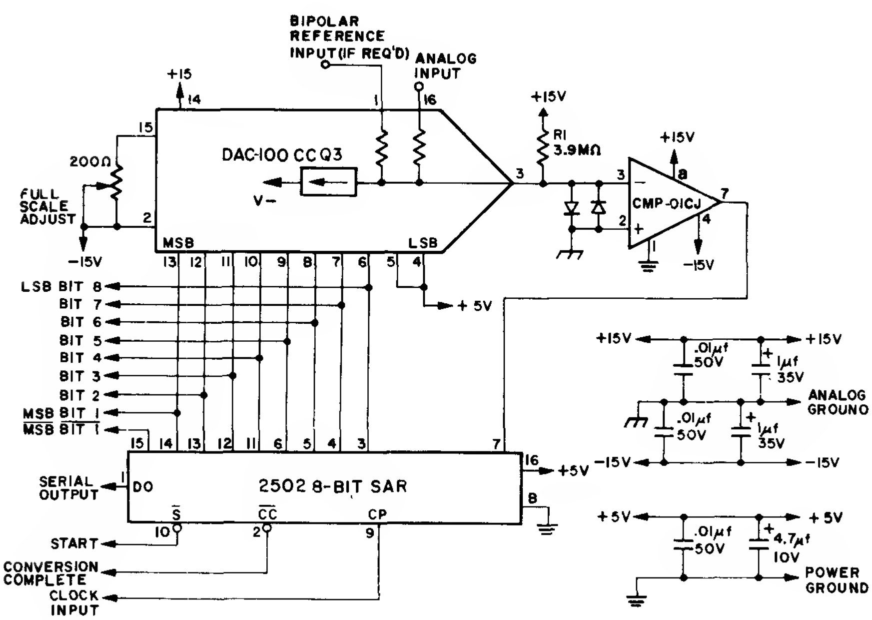
SOFTWARE CONTROL—Innovative software for Intel 8080A microprocessor eliminates need for peripheral isolation devices when using Precision Monolithics DAC-08E D/A converter and CMP-01C comparator for 8-bit A/D conversion. Technique can easily be expanded to 10-bit or 12-bit conversions and adapted to other microprocessors. Logic of microprocessor replaces conventional successive-approximation register. 8 lowest-order address bits control data bit input to DAC, using software given in article.—W. Ritmanich and W. Freeman, "Software Controlled Analog to Digital Conversion Using DAC-08 and the 8080A Microprocessor," Precision Monolithics, Santa Clara, CA, 1977, AN-22, p 3.



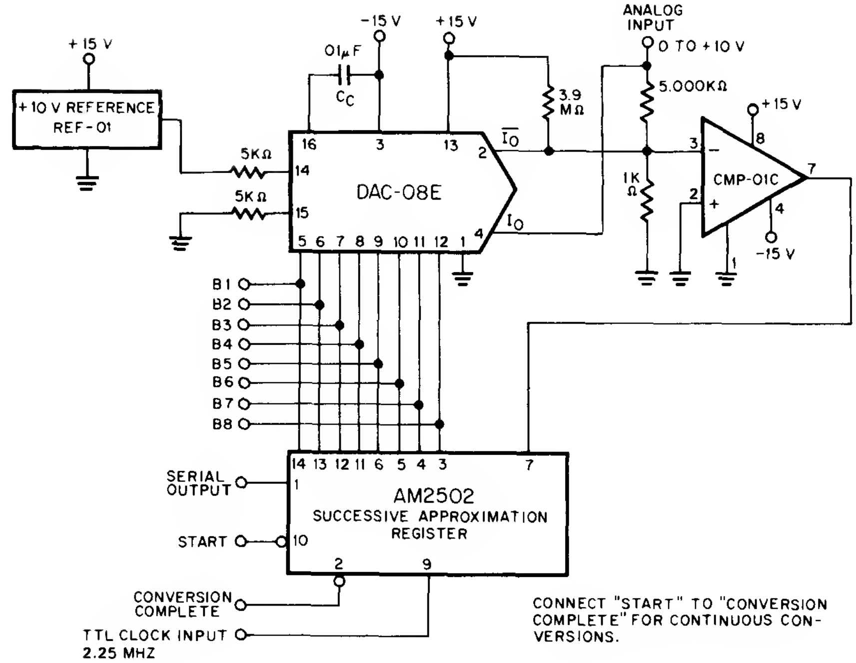
10-BIT ACCURACY—Single-slope A/D converter gives high-speed conversion of DC input voltage to digital data output. For 0–10 V input, 1024 pulses of 100-MHz clock appear at full scale and 512 at half scale. When command pulse is applied, 2N914 transistor resets 1000-pF capacitor (820 and 180 in parallel) to 0 V. Capacitor begins to charge linearly on falling edge of command pulse, to 2.5 V. 10-µs ramp is applied to AMD686 for comparison with unknown voltage. Output of opamp is pulse whose width is proportional to input voltage and can therefore be used to gate 100-MHz clock.—J. Williams, Low-Cost, Linear A/D Conversion Uses Single-Slope Techniques, *EDN Magazine*, Aug. 5, 1978, p 101–104.

VIDEO COMPRESSOR—Nonlinear function amplifier IC-2 compresses video input signals as required to compensate for inefficient quantization where there are too many levels for small signals and too few levels for large signals. Designed to feed 6-bit analog-to-digital converter, IC-1 attenuates input −20 dB and shifts level. Output of IC-2 is amplified by IC-3 to voltage range comparable to that of input signal. IC-4 acts as temperature compensator and output level shifter. R_7 nulls small output offsets.—J. B. Frost, Non-Linear Function Amplifier, *EEE Magazine*, March 1971, p 78.

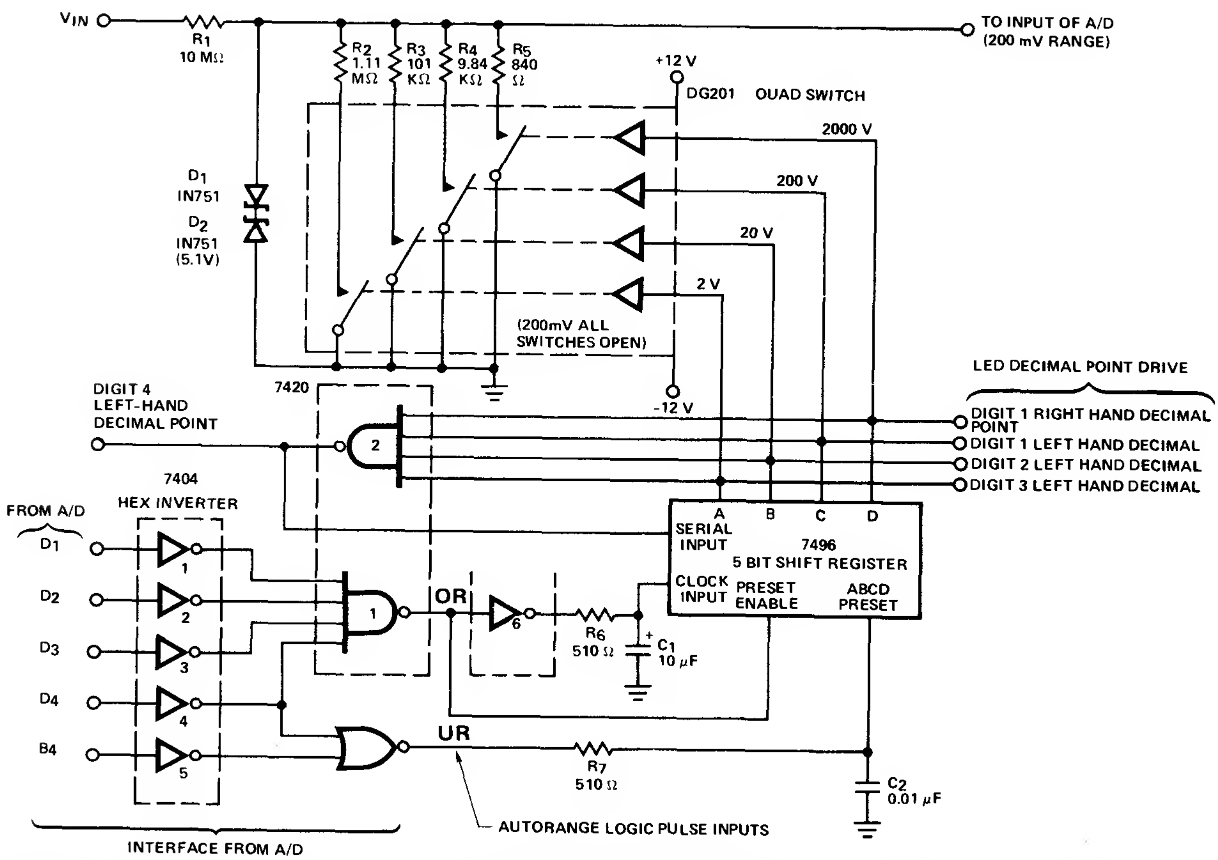




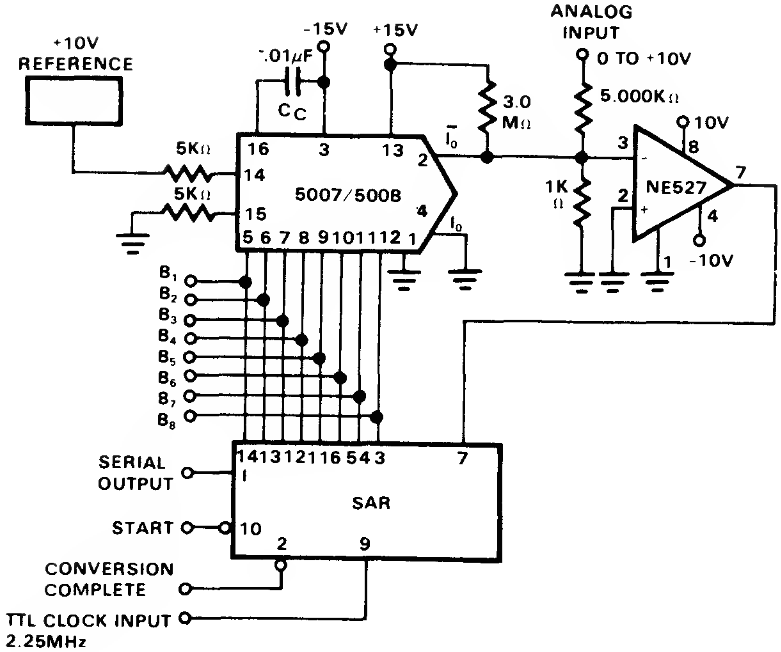
8-BIT SUCCESSIVE APPROXIMATION—Uses Precision Monolithics DAC-100 CCQ3 D/A converter and CMP-01CJ fast precision comparator in combination with Advanced Micro Devices AM2502PC or equivalent successive approximation register to compare analog input with series of trial conversions. Clamp diodes minimize settling time and prevent large inputs from damaging DAC output. Digital output is available in serial nonreturn-to-zero format at data output DO shortly after each positive-going clock transition.—D. Soderquist, "A Low Cost, Easy-to-Build Successive Approximation Analog-to-Digital Converter," Precision Monolithics, Santa Clara, CA, 1976, AN-11, p 3.



4-μs CONVERSION TIME—Provides conversion of analog input to 8-bit digital output by successive approximation, with conversion time of 4 μs. Advanced Micro Devices AM2502 successive-approximation register contains logic for Precision Monolithics DAC-08E and CMP-01C comparator.—D. Soderquist and J. Schoeff, "Low Cost, High Speed Analog-to-Digital Conversion with the DAC-08," Precision Monolithics, Santa Clara, CA, 1977, AN-16, p 3.

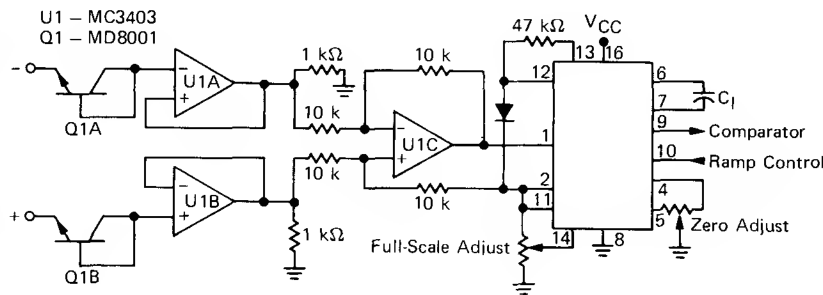


AUTORANGING—Digitally controlled attenuator uses DG201 quad analog switch as input ladder attenuator switches for A/D converter. Switches are controlled by digital logic that detects overrange and underrange information from A/D converter and closes appropriate attenuator path. Circuit is suitable for Siliconix LD110/111 or LD111/114 A/D converter.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 6-28.

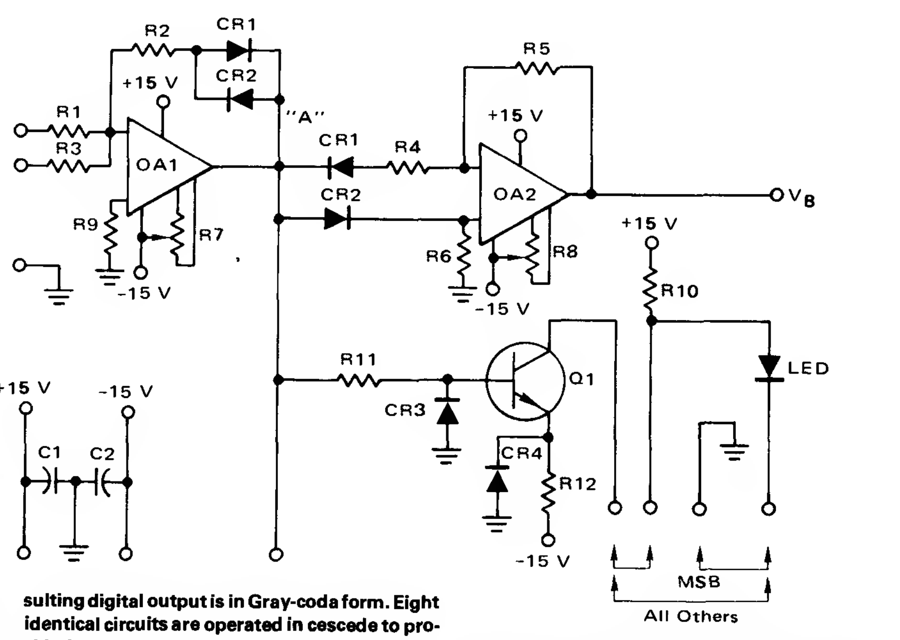


0–10 V ANALOG INPUT—Used to provida digitel input to computar for processing and storaga of analog signels. Requires only threa ICs in addition to externel +10 V referanca and 2.25-MHz TTL clock. Successiva-approximetion register (SAR) can ba Motorola MC1408 or equivelant. For continuous convarsions, connact pins 10 and 2 of SAR.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 677–685.

HIGH-IMPEDANCE BUFFER—Two sections of Motorole MC3403 qued opemp serve as voltaga followars for differential inputs of third section connectad as buffer for MC1505 A/D convertar. Dual transistor Q1, connected as dual dioda, providas 0.6-V offset at inputs of voltage followars, to obtain temparatura tracking and predictable performance at low bies currents of opamp.—D. Aldridge and S. Kallay, "Input Buffer Circuits for tha MC1505 Dual Ramp A-to-D Converter Subsystem," Motorola, Phoanix, AZ, 1976, EB-24A.

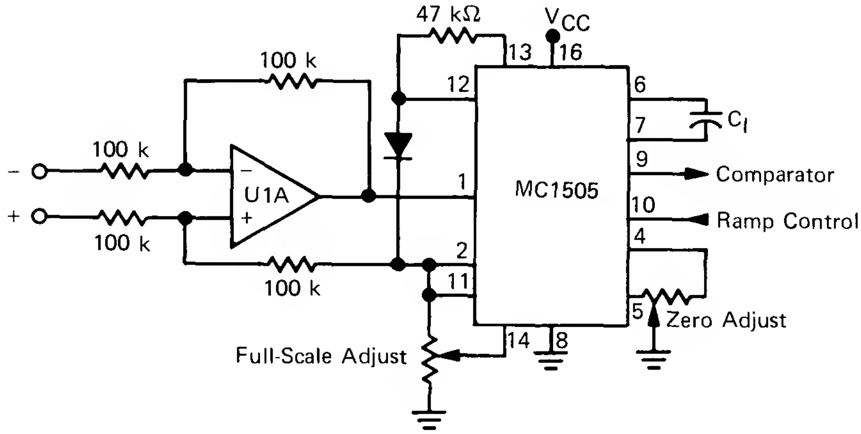


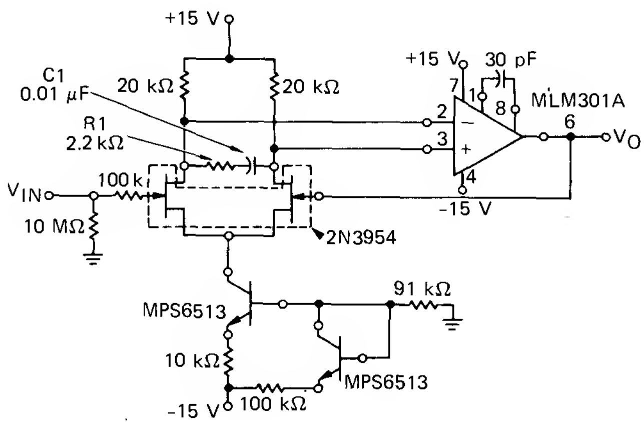
R1, 3	10 k 0.1%
R2, 4, 5, 6	20 k 0.1%
R7, 8	10 k Pot
R9	3.9 k
R10, 12	1.2 k
R11	10 k
OA1, 2	MC1456C
CR1	MSD6100
CR2	MSD6150
CR3, 4	1N914
Q1	MPS6415
C1, 2	0.1
LED	MLED 630



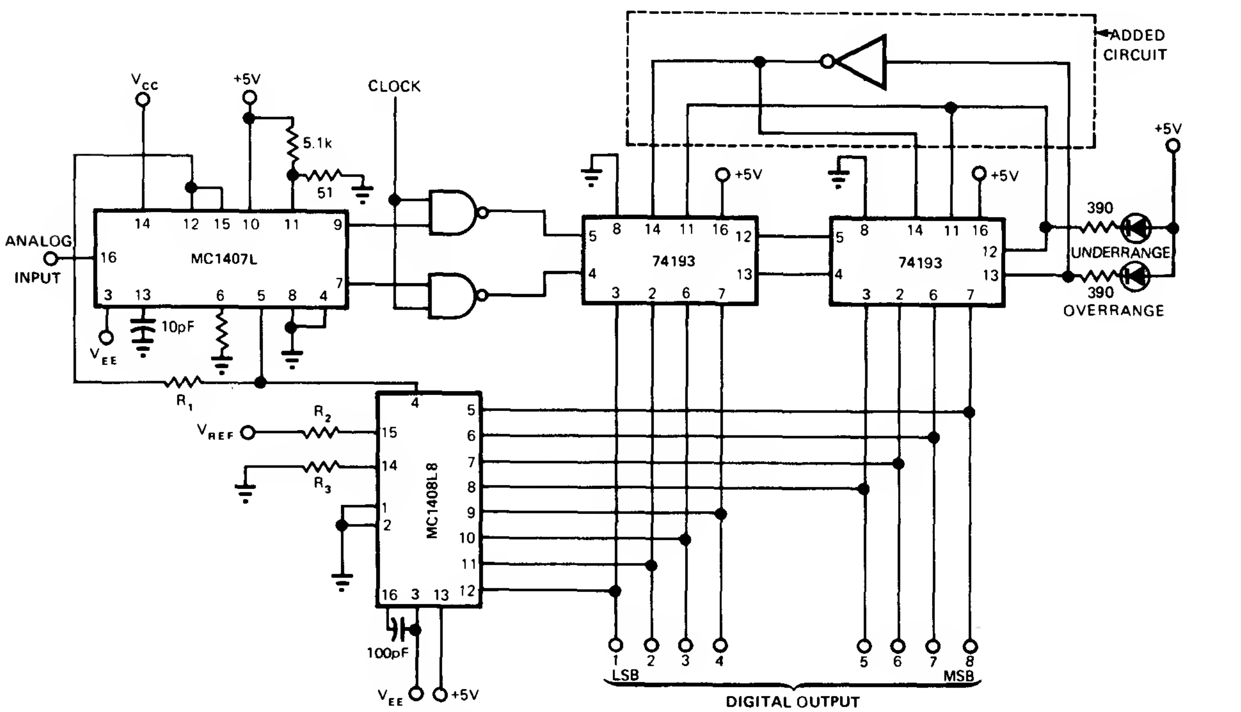
CYCLIC CONVERTER—Unknown voltage is successivaly compared to referenca voltaga for determining each digital bit. Aftar detarmining bit, voltage difference betwaen unknown and reference is operated on, then sent to successive stages to determina less significant bit. Resulting digital output is in Gray-coda form. Eight identical circuits are operated in cescede to provida 8-bit A/D converter having accuracy within 1 LSB and full-scele range of 0-8 V. Circuit requires only two MC1456CG opemps per stage, with MPS6514 transistor as comparator. Switching dioda CR1 is MSD6100, and CR2 is MSD6150. Other dioodes are 1N914.—J. Barnes, "Anelog-to-Digital Cyclic Converter," Motorole, Phoenix, AZ, 1974, AN-557, p 7.

DIFFERENTIAL OPAMP AS BUFFER—Section of Motorola MC3403 quad opamp, operating from single supply, serves as low-cost unity-gain buffer for MC1505 dual-ramp A/D converter. Opamp is used as differential amplifier referenced to MC1505 reference voltage of 1.25 V.—D. Aldridge and S. Kelley, "Input Buffer Circuits for the MC1505 Dual Ramp A-to-D Converter Subsystem," Motorola, Phoenix, AZ, 1976, EB-24A.

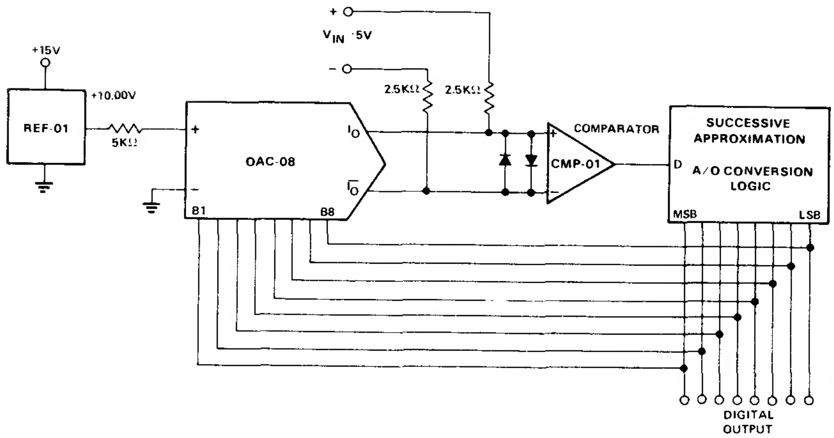




FET-INPUT BUFFER—Used ahead of Motorola MC1505 A/D converter to provide input impedance of 10 megohms. FETs are connected as differential amplifier having common source leads returned to constant-current generator built from bipolar transistor, with similar transistor providing temperature compensation. Temperature drift of amplifier is well under 1 mV from 0 to 50°C.—D. Aldridge and S. Kelley, "Input Buffer Circuits for the MC1505 Dual Ramp A-to-D Converter Subsystem," Motorola, Phoenix, AZ, 1976, EB-24A.

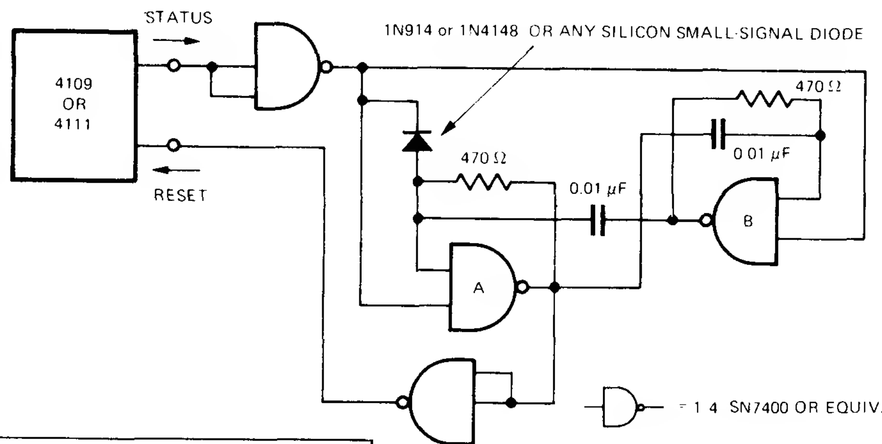


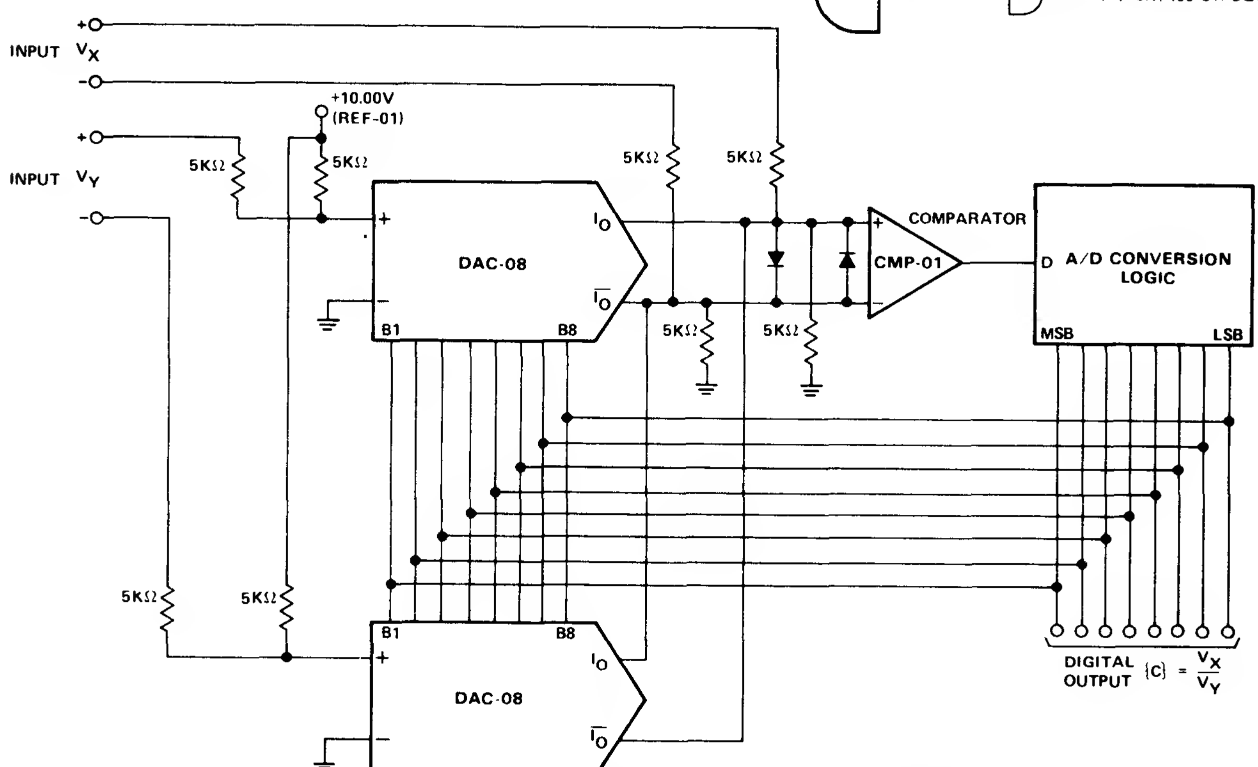
TRACKING A/D CONVERTER—Addition of one gate to tracking or servo-type A/D converter, as shown in dashed box, overcomes instability problems otherwise occurring when input voltages are less than zero or greater than full scale. With 8-bit converter shown, count of 11111111 when counting up makes carry output and load inputs go low, holding counter in this state so subsequent up clocks are ignored. When count is all 0s, borrow output goes low and clear input goes high, so counter is free to count up only.—A. Helfrick, Tracking A/D Converters Need Another Look, *EDN Magazine*, June 20, 1975, p 118 and 120.



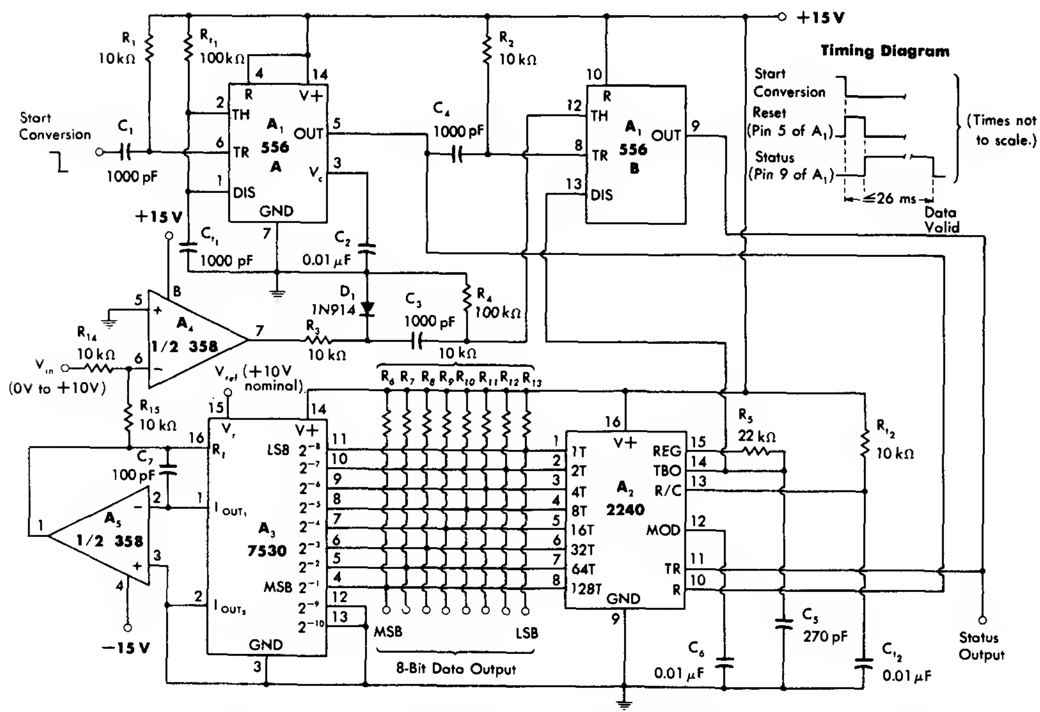
DIFFERENTIAL CONVERSION—Uses high current output cepebility of Precision Monolithics DAC-08 D/A convarter end high common-mode voltege rejection of CMP-01 comperetor to give differentiel-input ADC without input signel conditioning. Successive-epproximetion conversion logic is obtained with REF-01 +10 V reference end 2502-type successive-epproximetion register, driven by DAC and comperetor. Anelog input is converted in less then 2 μs. Differentiel input renge is 5 V. Diodes ere 1N4148.—J. Schoeff end D. Soderquist, "Differentiel end Multiplying Digitel to Analog Converter Applications," Precision Monolithics, Santa Clere, CA, 1976, AN-19, p 5.

REPETITIVE-MODE OPERATION—Quicker conversion is obtained in Taledyne Philbrick 4109 or 4111 A/D convertar by rastarting converter within e few microseconds after status signel, using sure-start circuit shown. Reset pulse is fed to convarter when status commend is held at low DC leval. When status commend Is high, oscillator A-B is disabled. If reset pulse is not obayed end status signal remaine low, oscillator starts up until conversion does occur.—R. W. Jacobs, "Repetitiva Mode Oparetion for Models 4109/4111 Integrating A/D Convarters," Taledyne Philbrick, Dedhem, MA, 1977, AN-28.

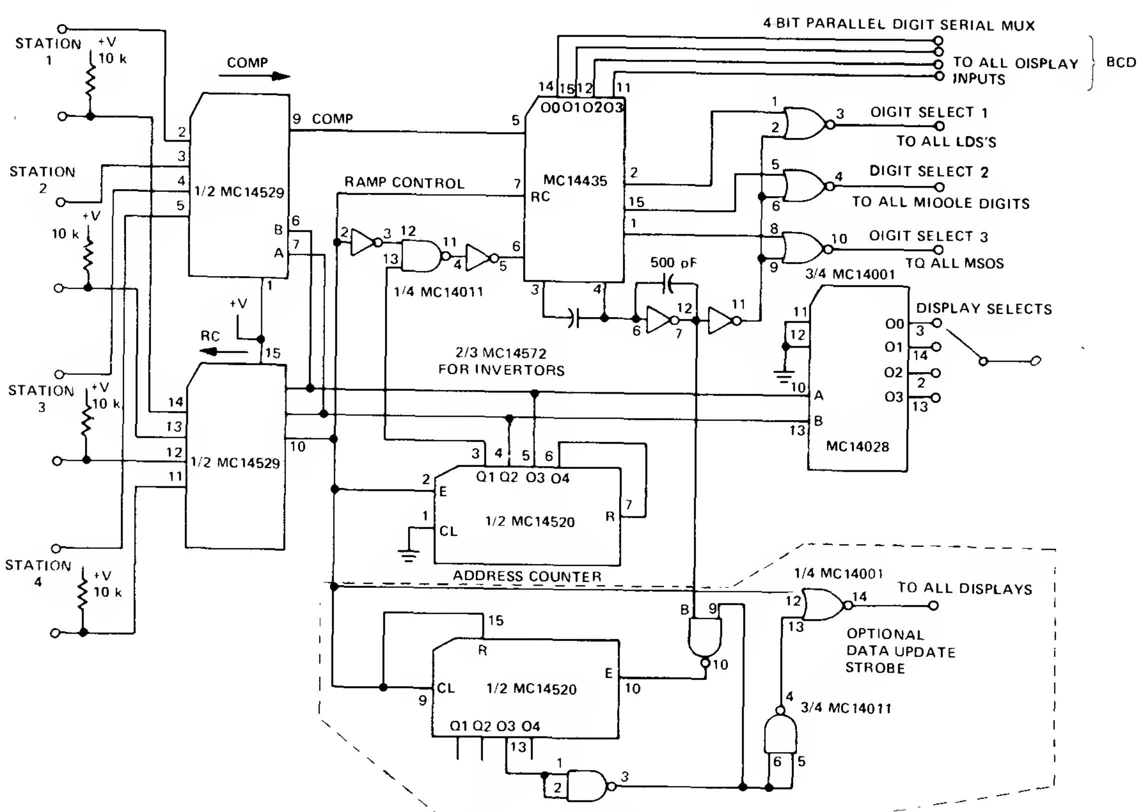




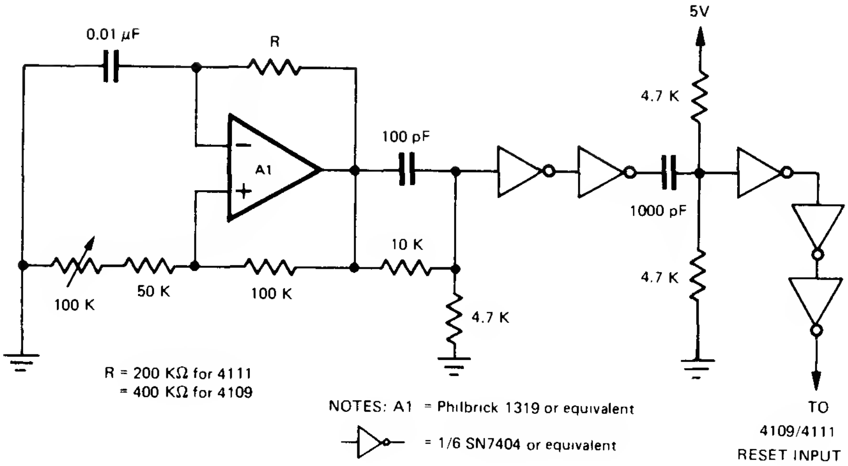
FOUR-QUADRANT RATIOMETRIC—Uses Precision Monolithics DAC-08 D/A convarters and CMP-01 comparetor to drive successive-approximation conversion logic using REF-01 +10 V reference end 2502-type successive-approximation register. Imputs V_x are connected conventionelly, end inputs V_Y ere connected in multiplying fashion. I_{REF} for both DACs is moduleted between 1 end 3 mA. Resulting output currants are differantially transformed into voltages by 5K resistors et comperetor inputs end compered with V_x differentiel input. When conversion process is complete (comparator inputs differentielly nulled to less then ½ LSB), digitel output corresponds to quotient V_X/V_Y. Diodes ere 1N4148.—J. Schoeff and D. Soderquist, "Differentiel and Multiplying Digitel to Analog Converter Applications," Precision Monolithics, Santa Clare, CA, 1976, AN-19, p 5.



BINARY OUTPUT—Converts analog signal in range of 0–10 V to 8-bit binary word having all 0s for 0 V and all 1s for full-scale input of +9.960 V. Output is 15-V CMOS-compatible but can be adapted for TTL compatibility. Maximum conversion time is about 26 ms. A_2 and A_3 form negative-going staircase generator for which start-conversion signal is formed by one section of 556. Opamp A_4 compares negative output of 7530 with input voltage V_{in}. When 7530 output voltage equals input voltage, comparator output goes positive and resets control flip-flop to complete conversion.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 226–228.

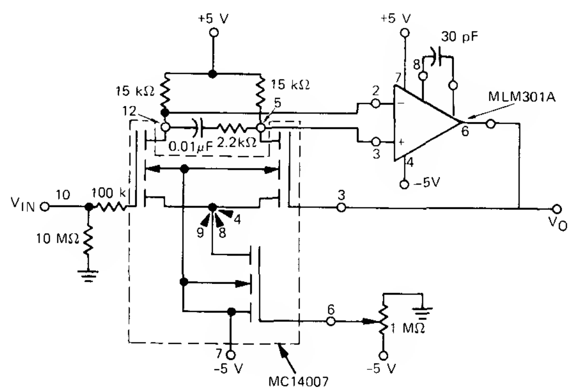


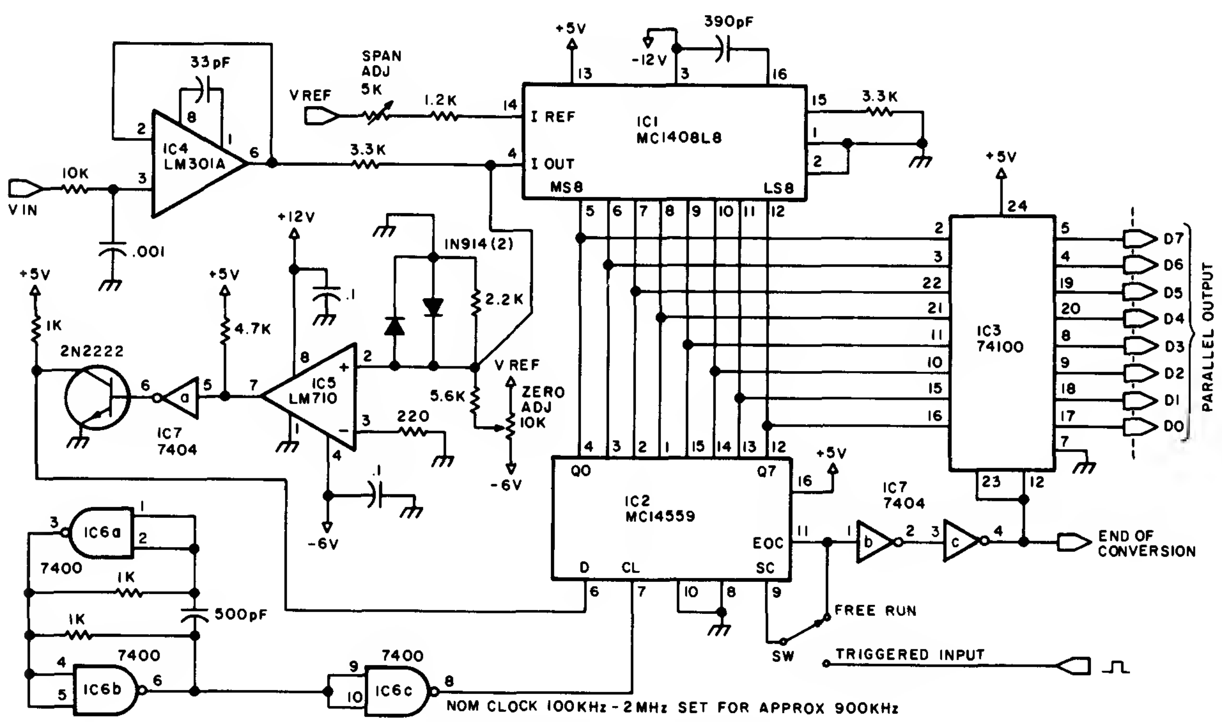
FOUR-CHANNEL INPUT MULTIPLEXING—Conversion process is divided between central station and remote locations having analog sensors. Each station transmits two noise-immune low-frequency digital signals under control of central multiplexer. System is much more economical than having separate A/D converter at each sensor. Can be extended to 32 channels. Multiplexing is performed under control of clock in Motorola MC14435, operating between 100 kHz and 1 MHz. At 500 kHz, each conversion takes about 15 ms.—S. Kelley, "Analog Data Acquisition Network for Digital Processing Using the MC1405-MC14435 A/D System," Motorola, Phoenix, AZ, 1975, EB-58.



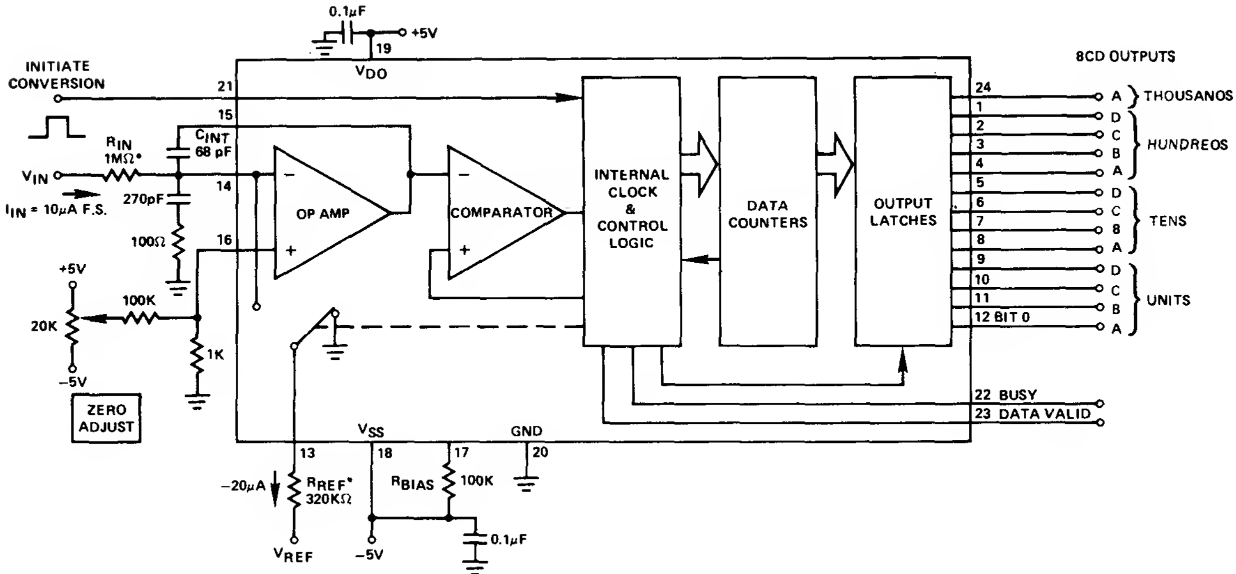
EXTERNAL TRIGGER—Generetes pulse with 100-ns minimum width in renge of 125–250 Hz for application to reset input of Teledyne Philbrick A/D converter in epplications requiring unattended operation with continuous conversion. Adjust 100K pot to give 125 Hz for 4109 or 250 Hz for 4111. Successive stages of SN7404 inverter provide required sherpening of pulse. A1 is positive-sterting MVBR.—R. W. Jacobs, "Repetitive Mode Operation for Models 4109/4111 Integreting A/D Converters," Teledyne Philbrick, Dedhem, MA, 1977, AN-28.

MOSFET-INPUT BUFFER—Uaes Motorola MC14007 dual complementery peir plus inverter, with two of MOSFETs connected as differential amplifier for buffering opamp and third serving as current source for differentiel amplifier. Arrangement gives high input impedance required in some applicetions of MC1505 A/D converter for which buffer wes designed. 1-megohm pot controls gate voltege for current source. Temperature drift ia well under 2 mV over range of 0–50°C. Pin 14 of MC14007 should be tied to +5 V.—D. Aldridge end S. Kelley, "Input Buffer Circuits for the MC1505 Duel Remp A-to-D Converter Subsystem," Motorola, Phoenix, AZ, 1976, EB-24A.

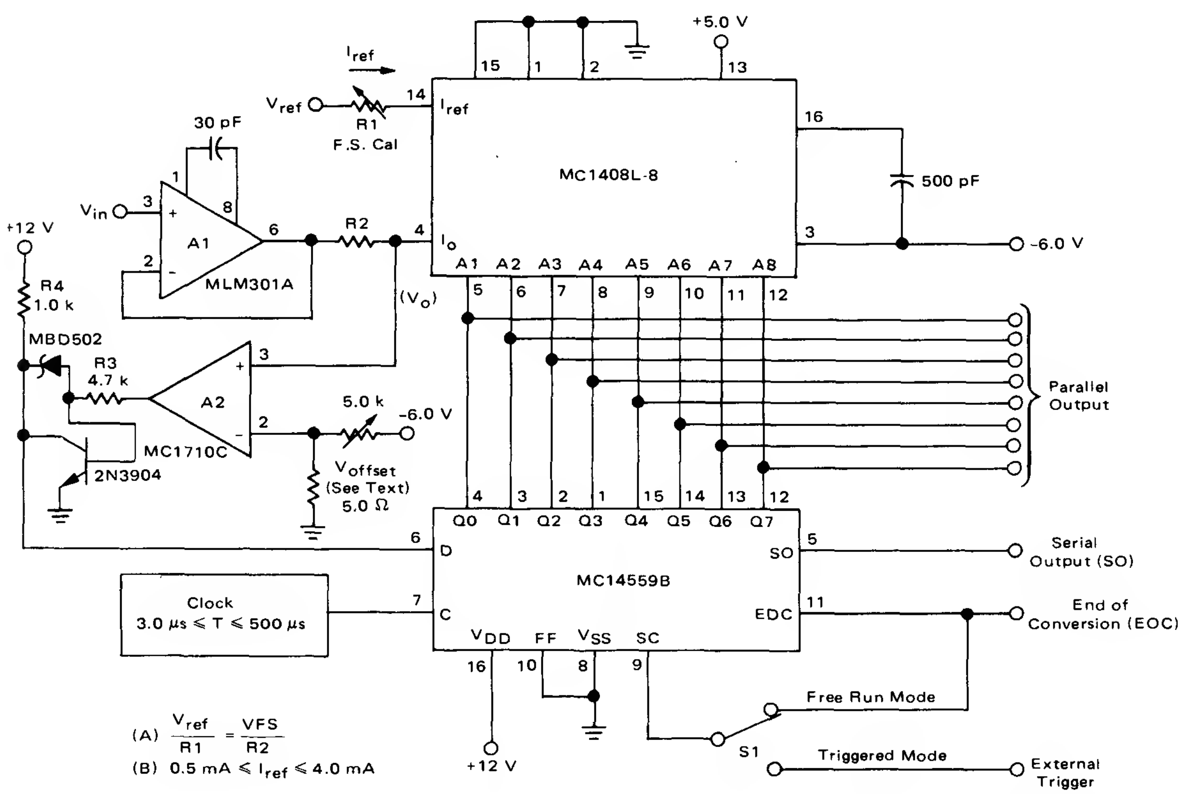




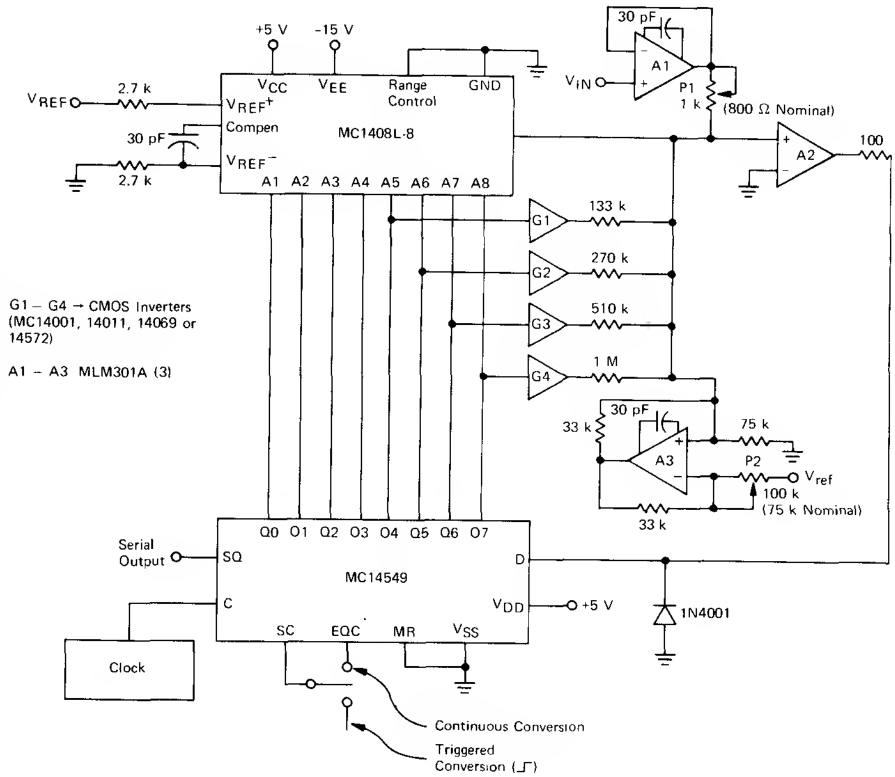
VOICE DIGITIZER—Uses 8-bit ADC capeble of sampling AF input signal 100,000 times per aecond when using 900-kHz clock. 100-kHz clock gives 9000 samples per second, ebout minimum for humen voice. Digitel output is stored in computer memory for later conversion beck to analog form for auch epplicetions as synthesis of speech from phonemes end providing voice answers to queries. Requires ebout 10,000 bytes in memory for 1 s of voice data. Pin 7 of IC4 is +12 V, and pin 4 is −6 V. For IC6 and IC7, pin 14 is +5 V and pin 7 is ground. 8080 essembler programs ere given for input and output of memory.—S. Ciercie, Talk to Mel Add a Voice to Your Computer for $35, *BYTE*, June 1978, p 142–151.



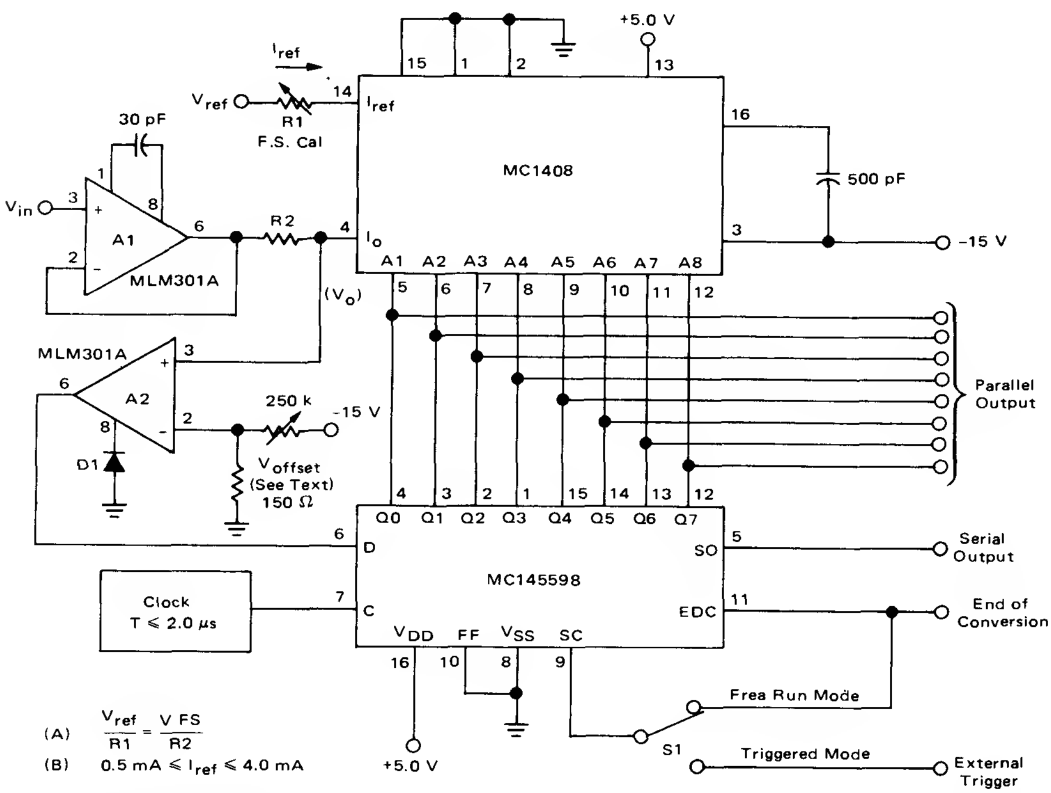
BCD OUTPUT—Latched nonmultiplexed perellel BCD outputs from Teledyne 8750 3½-digit CMOS analog-to-digital converter are suiteble for liquid crystal and gas-discharge displays. 2-mA drain on ±5 V supply permits battery operation. Features include high lineerity, noise immunity, and 3½-digit resolution within 0.025% error. Circuit is based on switching number of current pulses needed to bring analog current to zero at input of opamp, then determining digital equivalent by counting these pulses. Values shown ere for full-scele voltege input of 10 V and voltage reference of −6.4 V.—CMOS A-D Converter Provides BCD Output, *Computer Design,* Nov. 1977, p 156 and 158.



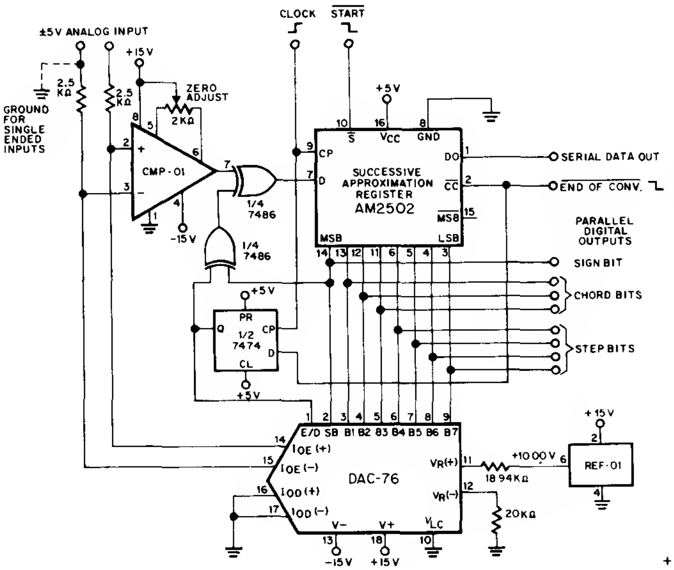
HIGH-SPEED SUCCESSIVE-APPROXIMATION—Total conversion time for 8-bit system is about 4.5 μs. Clock rate is up to 2 MHz. Serial output is used for transmission to one or more other locations.—T. Henry, "Successive Approximation A/D Conversion," Motorola, Phoenix, AZ, 1974, AN-716, p 5.



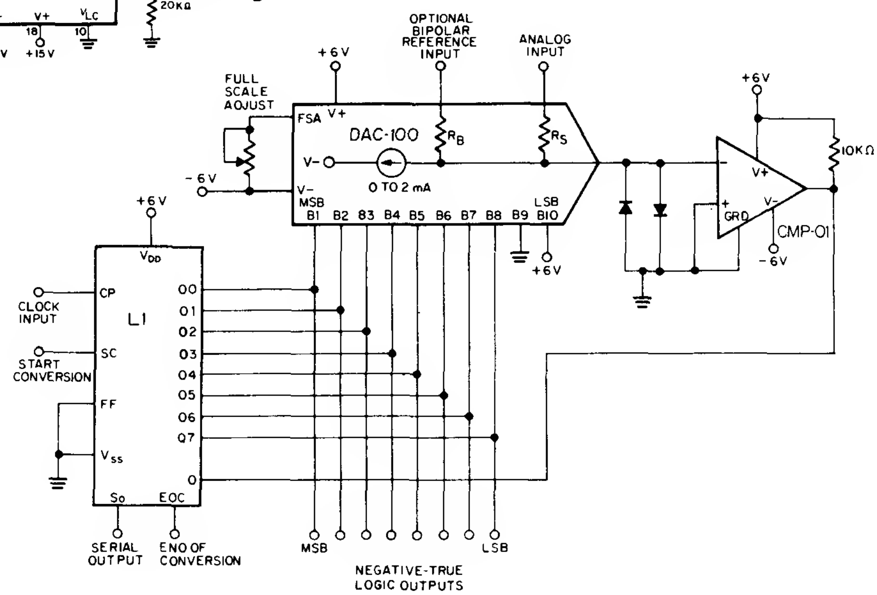
2-DIGIT BCD—Uses Motorola MC14549 successive-approximation register and MC1408L-8 D/A converter to give full-scale value of 0.99 V in 10-mV increments. Input is buffered by opamp A1 connected as voltage follower, with pot P1 set to give output current proportional to unknown input voltage. This current is compared to that required by total BCD A/D converter. Pins 1-4 and 12-15 of MC14549 provide required 2-digit parallel BCD output. Clock frequency can be 100 kHz.—D. Aldridge, "Successive Approximation BCD A/D Converter," Motorola, Phoenix, AZ, 1975, EB-51.



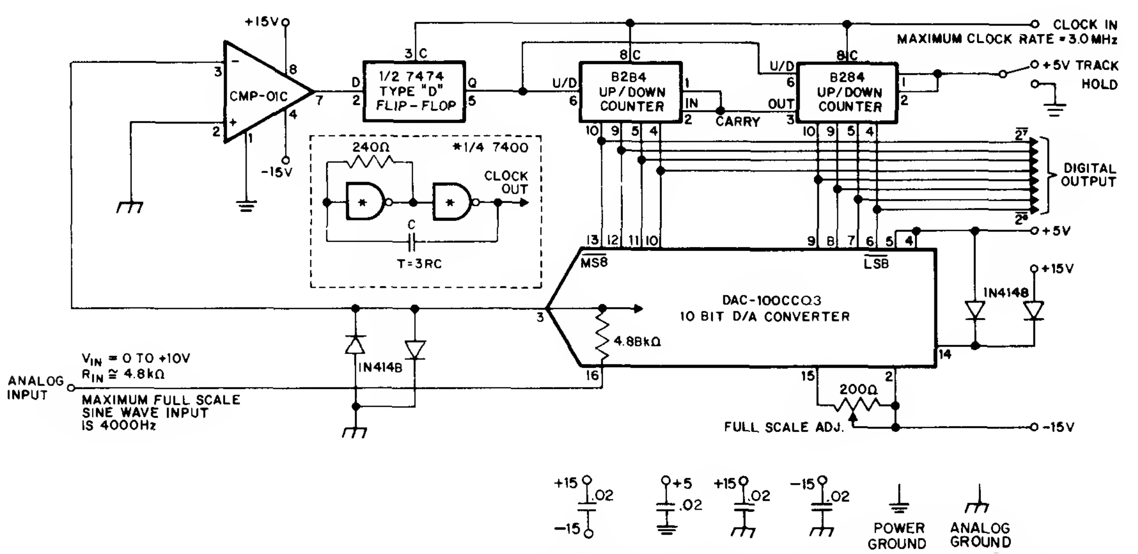
8-BIT SUCCESSIVE-APPROXIMATION—Requires only four ICs. For each cycle, most significant bit is enabled first, with comparator giving output signifying that input signal is greater or less in amplitude than output of Motorola MC1408. If output is greater, bit is reset or turned off. Process is repeated for next most significant bit until all bits have been tried, completing conversion cycle. Conversion time is 18 μs, total propagation delay is about 1.5 μs, and overall operational figure is about 2 μs per bit for 8-bit system.—T. Henry, "Successive Approximation A/D Conversion," Motorola, Phoenix, AZ, 1974, AN-716, p 4.



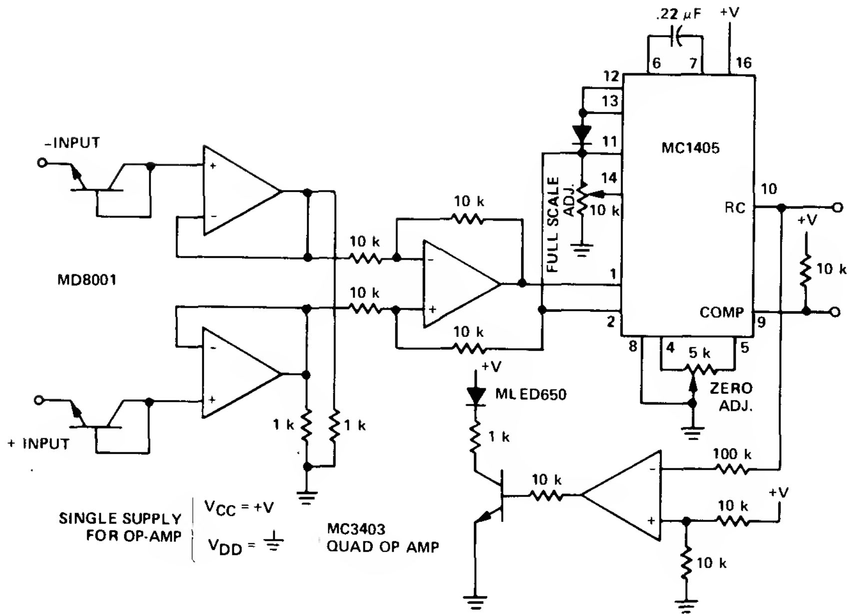
COMPRESSING A/D CONVERSION—Step size increases as output changes from zero scale to full scale, in contrast to conventional linear converter in which step size is constant percentage of full scale. Uses Precision Monolithics DAC-76 D/A converter in combination with CMP-01 comparator, any standard EXCLUSIVE-OR gate, and successive-approximation register for conversion logic. Encoding sequence begins with sign-bit comparison and decision. Bits are converted with successive-removal technique, starting with decision at code 011 1111 and turning off bits sequentially until all decisions have been made. Conversion is completed in nine clock cycles.—"COMDAC Companding D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, DAC-76, p 12.



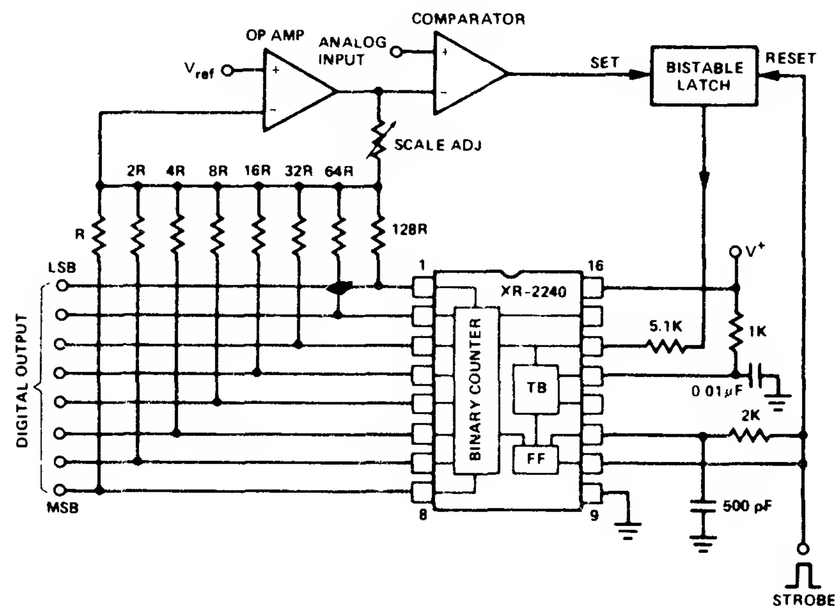
CMOS-COMPATIBLE SUCCESSIVE-APPROXIMATION—Converts analog input to 8-bit digital output by using MC14559 CMOS successive-approximation register with Precision Monolithics DAC-100 D/A converter and CMP-01 comparator. Conversion sequence is initiated by applying positive pulse, with width greater than one clock cycle, to START CONVERSION input. Analog input is then compared successively to ½ scale, ¼ scale, and remaining binarily decreasing bit weights until it has been resolved within ½ LSB. END OF CONVERSION then changes to logic 1 and parallel answer is present in negative-true binary-coded format at register outputs.—D. Soderquist, "Interfacing Precision Monolithics Digital-to-Analog Converters with CMOS Logic," Precision Monolithics, Santa Clara, CA, 1975, AN-14, p 4.



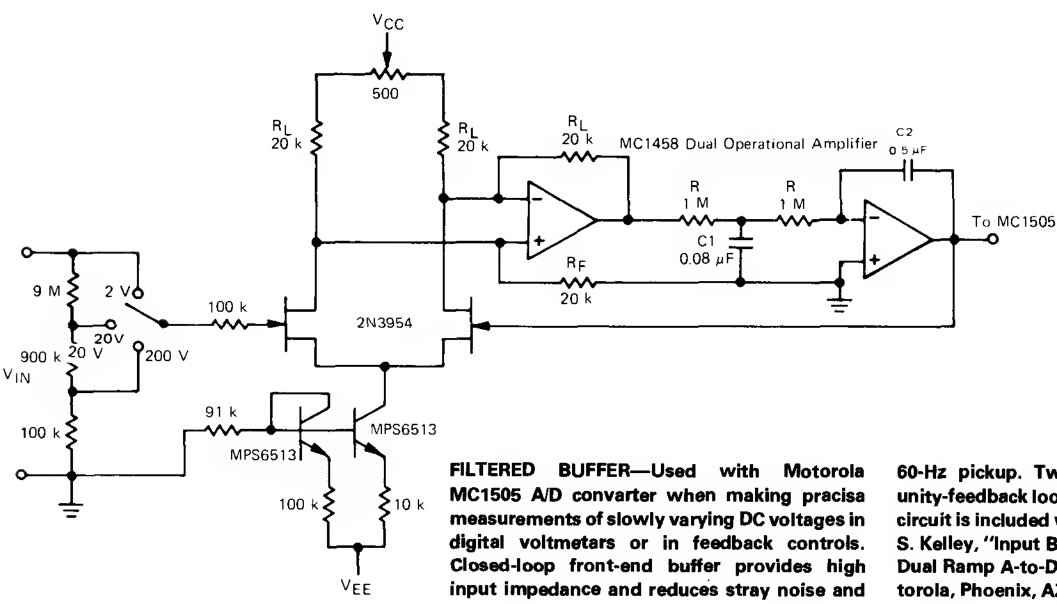
8-BIT TRACKING—Uses Precision Monolithics DAC-100 CCQ3 D/A converter and CMP-01CJ fast precision comparator to make digital data continuously available at output while tracking analog input. Diode clamps hold DAC output near zero despite input and turn-on transients. Unused least significant digital inputs of 10-bit DAC are turned off by connecting to +5 V as shown. Simple clock circuit shown in dashed box is stable over wide range of temperatures and supply voltages. D/A converter is used in feedback configuration to obtain A/D operation.—"A Low Cost, High-Performance Tracking A/D Converter," Precision Monolithics, Santa Clara, CA, 1977, AN-6, p 2.



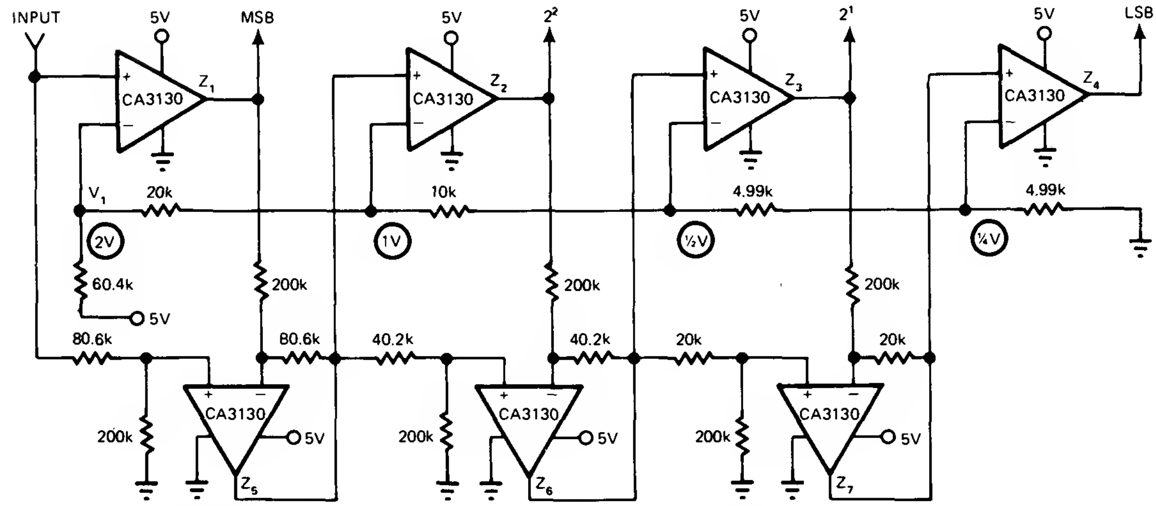
REMOTE STATION—Multiplexing of large number of analog voltages from widely separated locations in large industrial control systems is simplified by transmitting two noise-immune low-frequency digital signals from each remote to central multiplexer driving display and microprocessor. Central station using MC14435 controls direction of integration in each remote-station MC1405 through ramp control output. At beginning of conversion, integrator of MC1405 integrates upward for 1000 counts of central-station clock. Integrator then ramps down while comparator remains high, with clock continuing until comparator threshold is again crossed. Counts during down ramp are latched by counter when comparator goes low, and circuits are reset for next conversion. Analog input voltage is thus transmitted to central-station MC14435 as two digital signals.—S. Kelley, "Analog Data Acquisition Network for Digital Processing Using the MC1405-MC14435 A/D System," Motorola, Phoenix, AZ, 1975, EB-58.



8-BIT DIGITAL OUTPUT—Digital output is obtained in parallel format from binary-counter output of Exar XR-2240 programmable timer/counter. Recycle time is about 6 ms. Supply voltage can be 4–15 V.— "Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 11–18.



FILTERED BUFFER—Used with Motorola MC1505 A/D converter when making precise measurements of slowly varying DC voltages in digital voltmeters or in feedback controls. Closed-loop front-end buffer provides high input impedance and reduces stray noise and 60-Hz pickup. Two-pole filter is included in unity-feedback loop of buffer. Front-end scaling circuit is included with buffer.—D. Aldridge and S. Kelley, "Input Buffer Circuits for the MC1505 Dual Ramp A-to-D Converter Subsystem," Motorola, Phoenix, AZ, 1976, EB-24A.

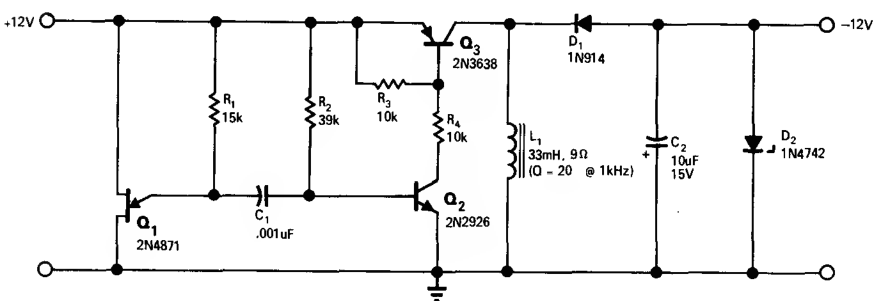


4-BIT CLOCKLESS—Simple and low-cost arrangement of seven CA3130 opamps gives conversion times fast enough for tracking sine-wave signals well up into audio range. Even with relatively slow 741 opamps, signals up to 300 Hz were easily tracked. Additional bits are easily cascaded.—B. P. Vandenberg, Tracking-Type A/D Requires No Clock Oscillator, *EDN Magazine*, Jan. 20, 1977, p 92 and 94.

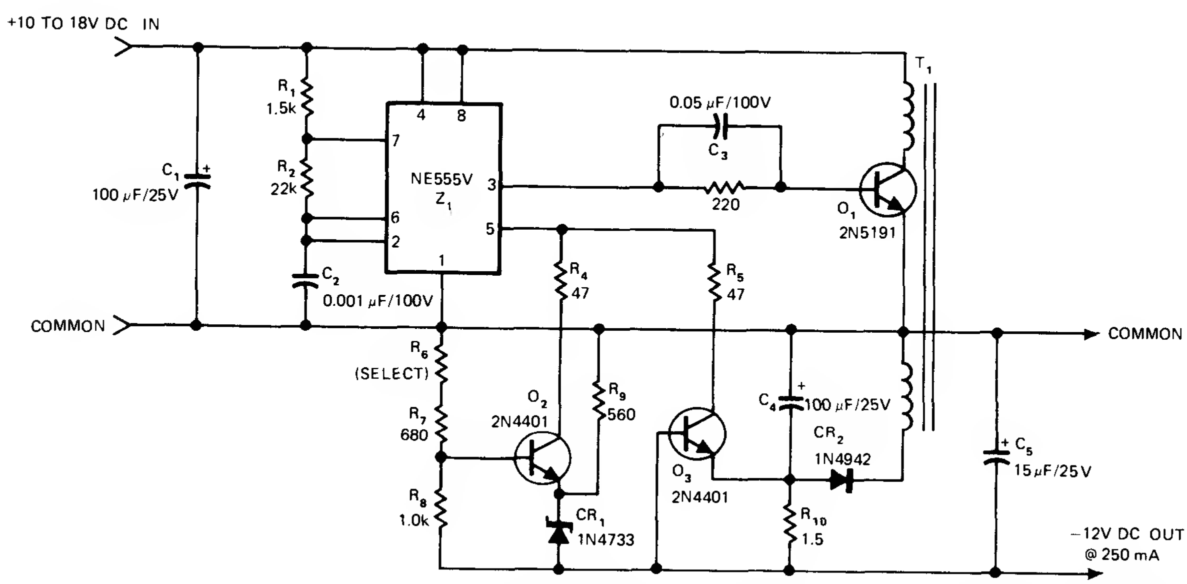
CHAPTER **17**

Converter Circuits—DC to DC

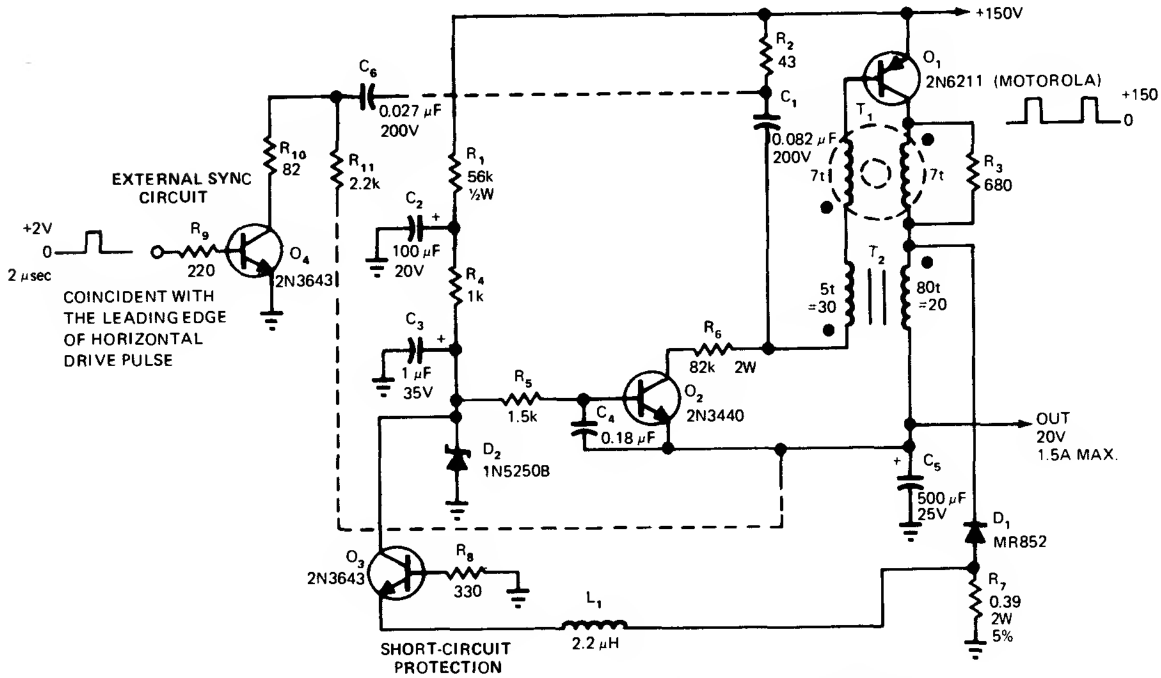
Use inverters typically operating from DC supplies in range of 2–15 V to generate AC voltage at frequency typically in range of 16–25 kHz, for step-up by voltage-doubling rectifier or transformer-rectifier combination to give desired new positive or negative DC supply voltage that can be as high as 10 kV.



+12 V TO −12 V—Transformerless inverting DC-to-DC converter has above 55% efficiency end cen withstend output shorts lesting up to severel minutes. UJT Q_1 and base-emitter diode of trensistor Q_2 form free-running MVBR whose 25-kHz output is amplified by Q_2 to drive switching-mode converter Q_3-L_1-D_1-C_2. Zener D_2 reguletes output for veriations in input voltage or output loads up to 40 mA.—G. Bank, Transformerless Converter Supplies Inverted Output, *EDN/IEEE Magazine*, July 1, 1971, p 48.

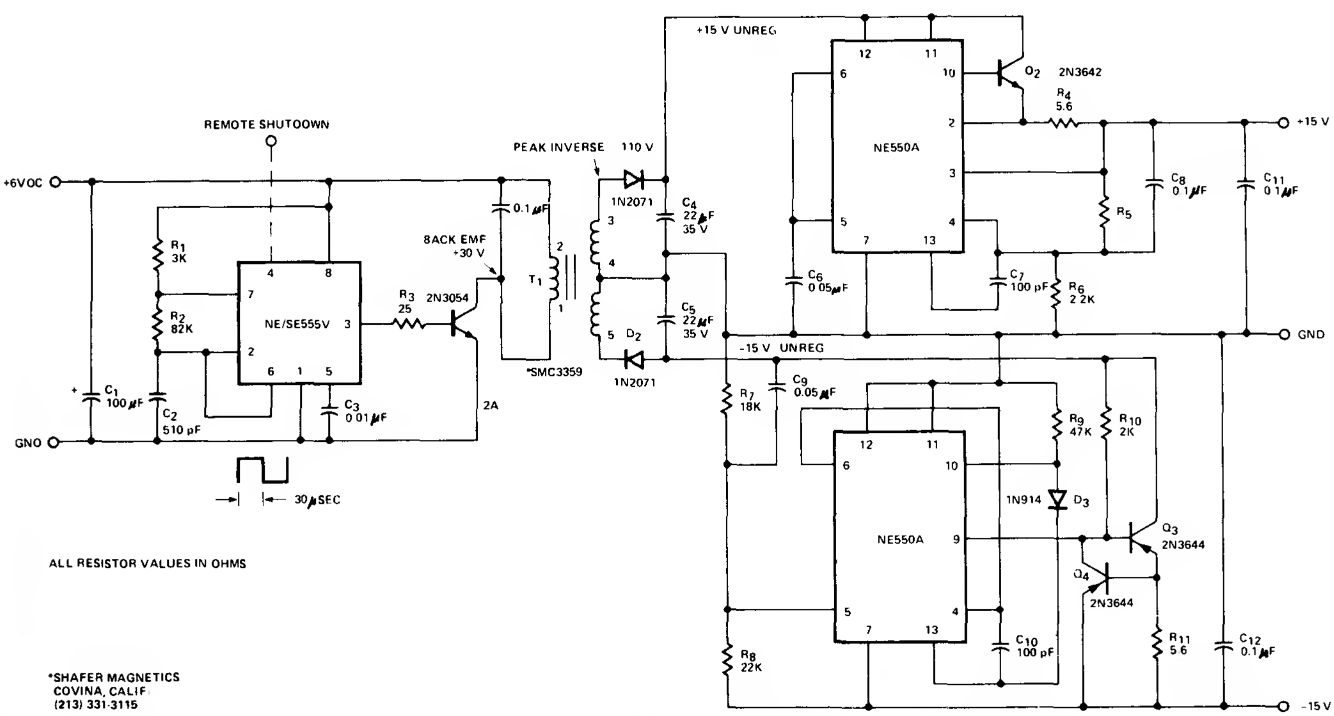


+12 V TO −12 V—Transforms unreguleted +12 VDC to current-limited reguleted −12 VDC. Front end of 555 is connected in astable configuretion, with R_2 selected to give about 25 kHz et pin 3. Control of modulation input to pin 5 glves voltage reguletion end current limiting. Circuit toleretes continuous operetion under short-circuit conditions. With 10-V nominal output, line regulation is within ±0.05% for input and output voltege ranges of 0.3 to 10 V. Loed reguletion is 0.2% for loads from 10 μA to 10 mA when load impedence is 10 ohms.—R. Dow, Build e Short-Circuit-Proof +12V Inverter with One IC, *EDN Magazine*, Sept. 5, 1977, p 177–178.

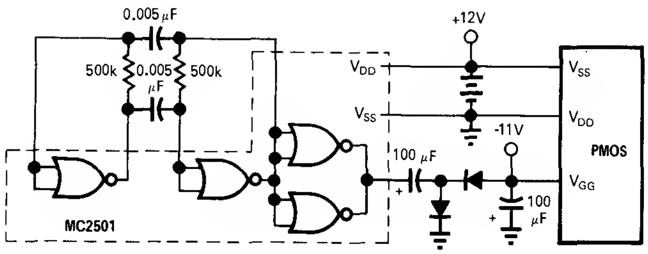


T_1 – FERROXCUBE TOROID 266 CT 125 3D3
T_2 – FERROXCUBE POT CORE 36 22P – A600-387

2 V TO 20 AND 150 V—Use of 7-turn toroidal transformer in self-excited ringing-choke blocking-oscillator circuit improves efficiency of converter circuit by providing fast switching time. Circuit is practical only when input and output voltages differ significantly. Blocking oscillator is formed by Q_1, T_2, C_1, R_2, and base-bias network R_6-Q_2. Q_4 makes possible external synchronization, permitting use in television systems for triggering regulator with leading edge of horizontal drive pulse. This ensures completion of cycle within blanking interval.—N. Tkacenko, Transformer Increases DC-DC Converter Efficiency to 80%, *EDN Magazine*, May 5, 1976, p 110 and 112.

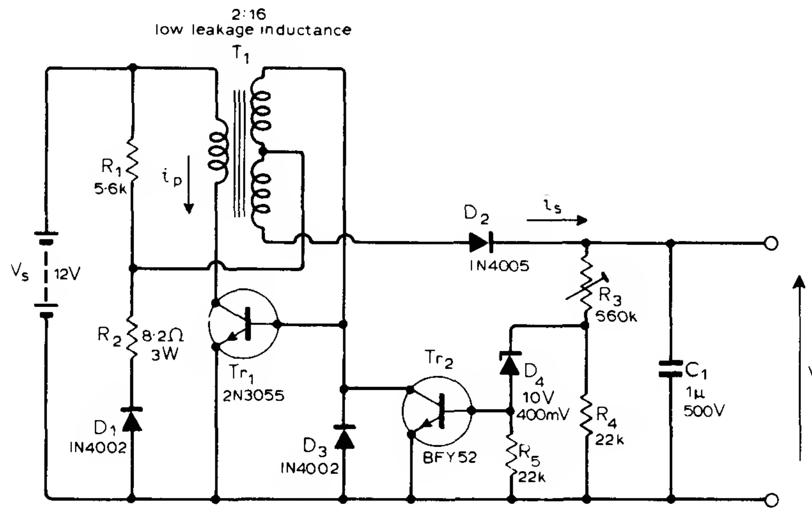


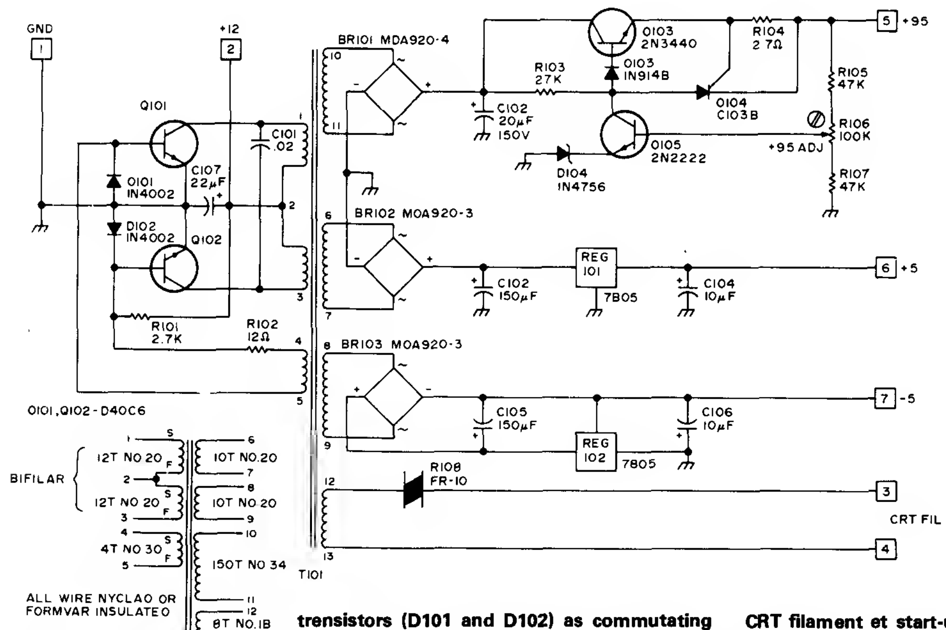
+6 V TO ±15 V—Combination of 555 timer and two NE550A precision adjustable regulators gives 0.1% line and load regulation. Timer operates as oscillator driving step-up transformer which feeds full-wave rectifier.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 726–727.



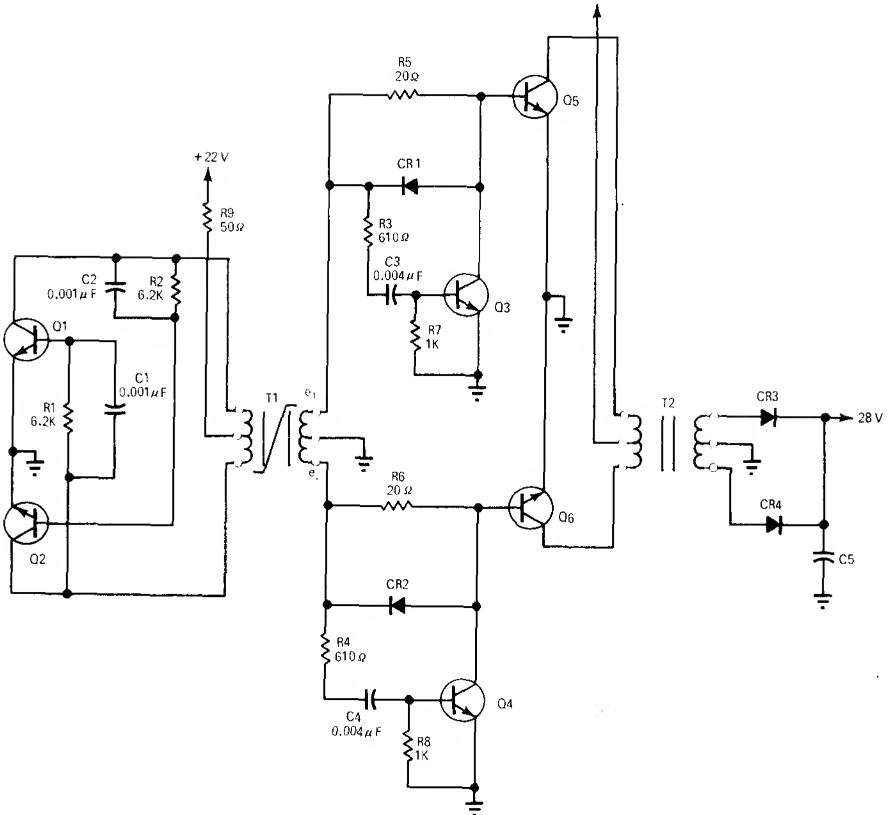
12 V TO −11 V WITH CMOS IC—Bipolar inverter and rectifier together provide −11 V from 12-V auto battery for operating high-threshold MOS logic of portable or automotive equipment. Diode types are not critical. Inverter draws only about 1 mA from 12-V battery on standby and supplies 2 mA from −11 V terminal.—B. Fetta, Inexpensive Inverters Generate V_{GG} for Portable MOS Applications, *EDN/EEE Magazine*, Dec. 15, 1971, p 51.

BATTERY-LIFE EXTENDER—Conserves battery life by charging capacitor from 0 V at efficiencies over 80% and by allowing battery to be used to lower endpoint voltage. Will generate voltages above or below battery voltages. When used in capacitor-discharge ignition system, power conversion efficiency is so high that heatsink is unnecessary and only one power transistor is needed. Gives full output voltage even when car battery voltage is less than half nominal value, as during cold starting. Article describes operation of circuit in detail. Tr_1 may require series RC protection between collector and emitter.—R. M. Carter, Variable Voltage-Ratio Transistor Converter, *Wireless World*, Nov. 1975, p 519.



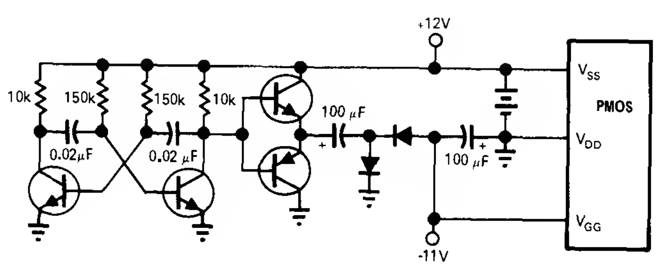


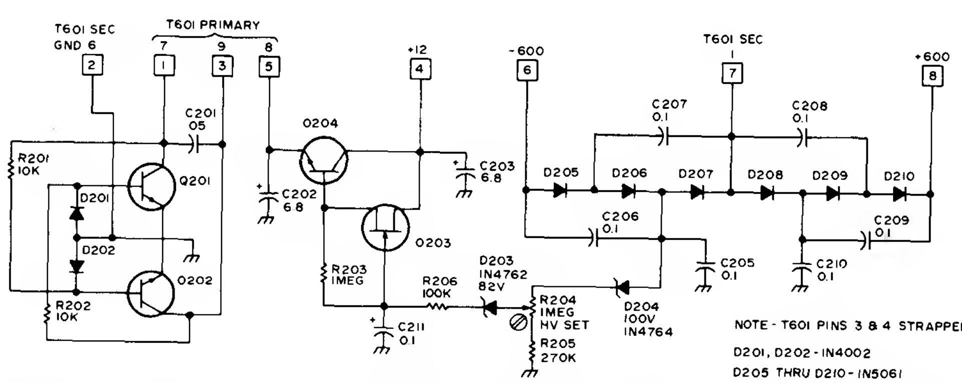
CRO LOW-VOLTAGE SUPPLY—Developed for use as one of supplies for portable CRO, operating from battery using sealed rechargeable cells supplying 12 V at 2–5 Ah. High-efficiency inverter uses two GE D40C6 or RCA 2N5294 transistors (D101 and D102) as commutating switches for untapped feedback winding of power transformer. R102 then determines drive, while R101 produces required unbalanced starting bias. Thermistor R108 in series with CRT filament has cold resistance of 10 ohms to counteract very low cold resistance of CRT filament at start-up and prevent inverter malfunction. Article gives instructions for winding T101, along with high-voltage supply circuit and all other circuits of CRO covering DC to 10 MHz.—G. E. Friton, Eyes for Your Shack, *73 Magazine*, Nov./Dec. 1975, p 74–76, 78–88, and 90–94.



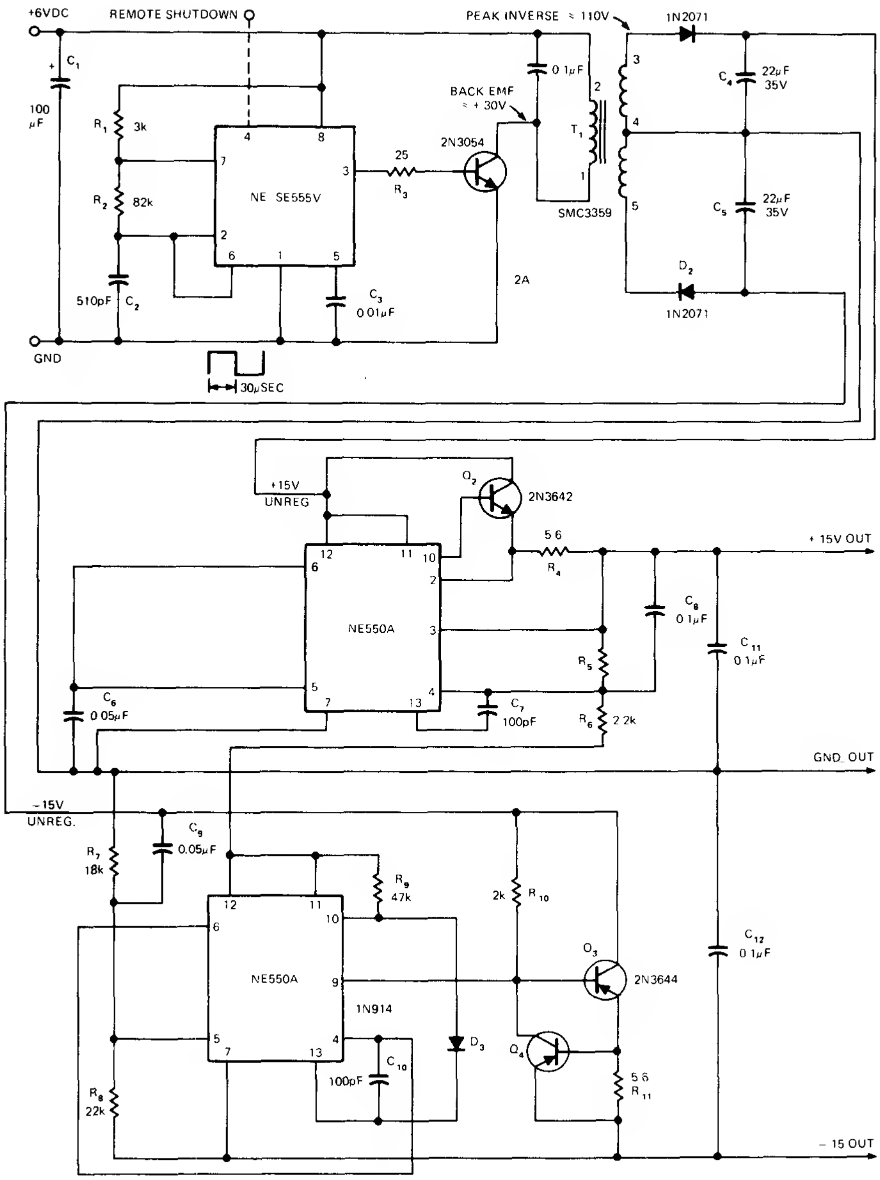
28-V HIGH-EFFICIENCY—Uses driven-type converter in which signal source is simple two-transistor oscillator Q1-Q2. Turn-on delay technique eliminates overlap current otherwise flowing in 2N1016 push-pull power transistors Q5 and Q6 when one is still on in storage state while other is driven on. Efficiency can approach 90%. Q3 and Q4 prevent off transistor from conducting until opposite device has turned off. Values for T2, CR3, and CR4 in output circuit are chosen to give desired DC output voltage.—R. F. Downs, Minimize Overlap to Maximize Efficiency in Saturated Push-Pull Circuits, *EDN/EEE Magazine*, Feb. 1, 1972, p 48–50.

12 V TO −11 V WITH TRANSISTORS—Bipolar inverter and rectifier together provide −11 V from 12-V auto battery for operating high-threshold MOS logic of portable or automotive equipment. Transistor and diode types are not critical. Multivibrator draws only 1.2 mA from battery on standby and supplies 12 mA from negative output terminal.—B. Fette, Inexpensive Inverters Generate V_{GG} for Portable MOS Applications, *EDN/EEE Magazine*, Dec. 15, 1971, p 51.

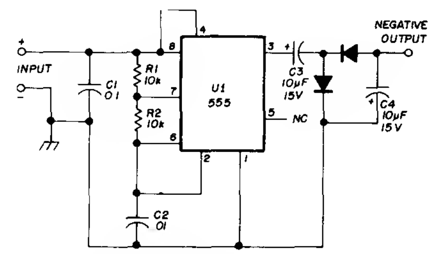




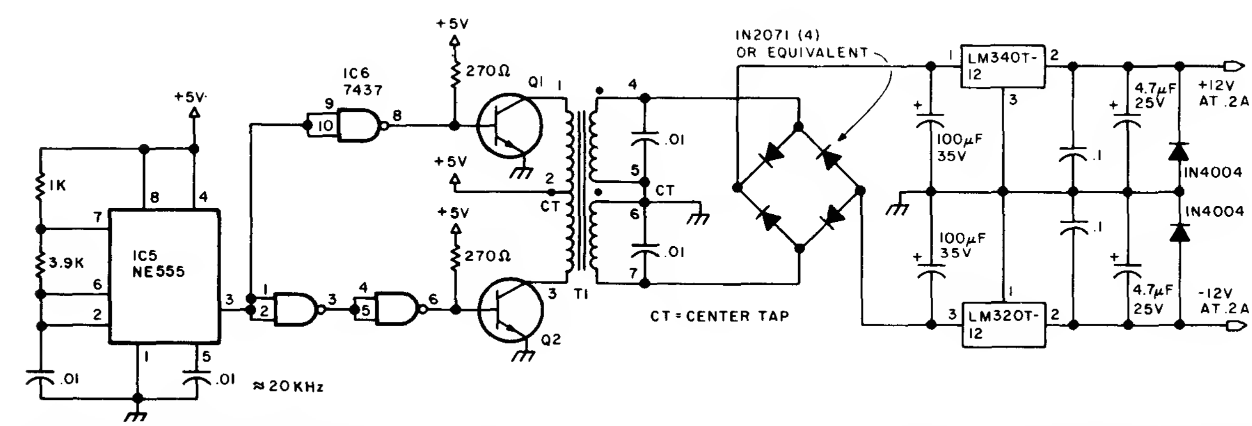
CRO HIGH-VOLTAGE SUPPLY—Controlled inverter operates from 12-V battery and feeds positive and negative triplers for producing ±600 V required for portable CRO. T601 high-voltage transformer has 22K, 5.2K, and 600-ohm windings, all center-tapped, often marked "Lionel" when available in surplus shops. Q201, Q202, and Q204 are 2N697 or 2N2219. Q203 is 2N4302 or 2N5457.—G. E. Friton, Eyes for Your Shack, *73 Magazine*, Nov./Dec. 1975, p 74–76, 78–88, and 90–94.



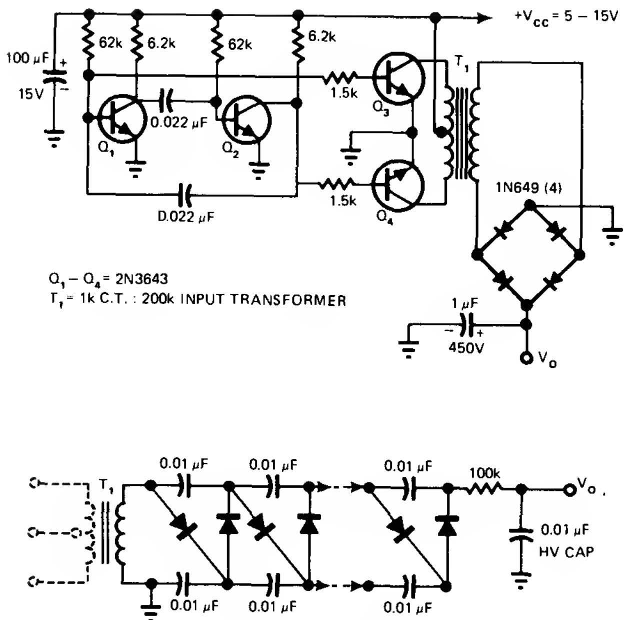
6 V TO ±15 V—Combination of 555 timer and two NE550 voltage regulators provides voltage multiplication along with regulation of independent DC outputs. Selected oscillator frequency of 17 kHz optimizes performance of transformer. Can be used to power opamps from either TTL supplies or 6-V batteries. Line and load regulation are 0.1%, while power efficiency at full load of 100 mA is better than 75%.—R. Solomon and R. Broadway, DC-to-DC Converter Uses IC Timer, *EDN Magazine*, Sept. 5, 1973, p 87, 89, and 91.



+12 V TO −8 V—Developed for use with mobile equipment when DC voltage is required with opposite polarity to that of auto battery. U1 is 555 timer operated as free-running square-wave oscillator. Frequency is determined by R1, R2, and C2; with values shown, it is about 6 kHz. C1 reduces 6-kHz signal radiated back through input lines. For 12-V input, typical outputs are −8.4 V at 10 mA, −7.9 V at 20 mA, and −5.7 V at 50 mA. All diodes are 1N914, 1N4148, or equivalent.—G. A. Graham, Low-Power DC-DC Converter, *Ham Radio*, March 1975, p 54–56.



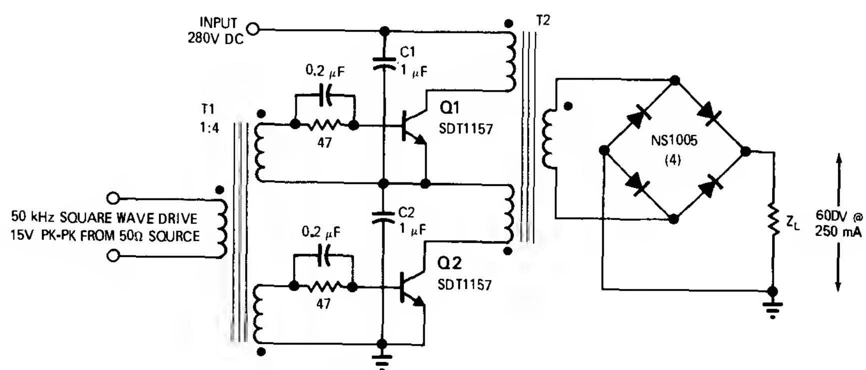
±12 V FROM +5 V—NE555 timer connected as 20-kHz oscillator drives pair of D44H4 transistors through 7437 quad two-input NAND buffer to produce full 200 mA of regulated output for each polarity. Circuit uses push-pull inverter technique to generate AC for driving transformer constructed by rewinding 88-mH toroid to hava 40 turns No. 20 center-tapped for primary and 350 turns No. 26 center-tapped for secondary.—S. Ciarcia, Build a 5 W DC to DC Converter, *BYTE*, Oct. 1978, p 22, 24, 26, 28, and 30–31.

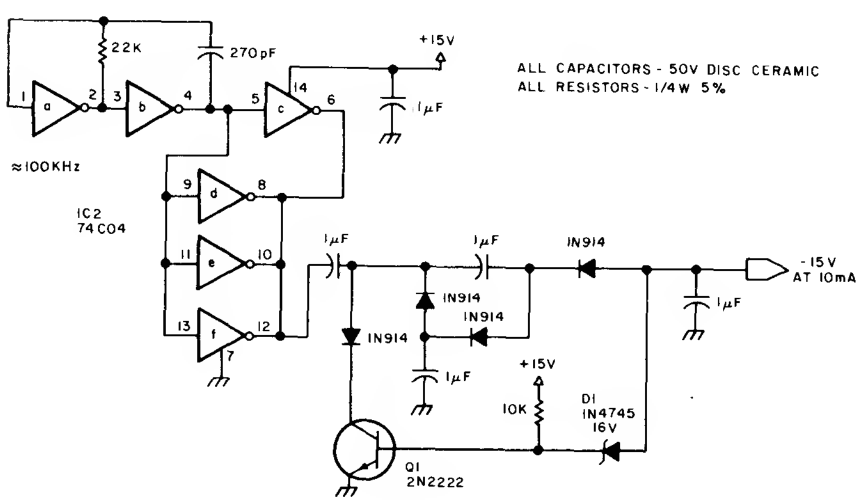


• ADD ADDITIONAL STAGES AS REQUIRED
• DIODES ARE 1N649 OR EQUIVALENT
• CAPACITORS ARE CERAMIC DISC 1 kV

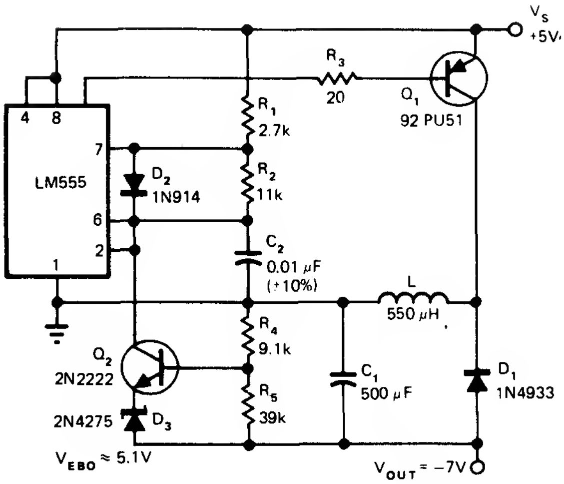
5 V TO 400 V—Astabla MVBR oparating at 2.174 kHz for values shown drivas push-pull transistor pair feeding primary of audio input transformer T_1. Secondary voltage is rectified by diode bridge to provida DC output voltaga ranging from 100 to 400 V depending on load resistanca and exact valua of supply voltage V_{cc}. Bridge rectifier can be raplaced by 40-staga multipliar as shown in lower diagram, to give 10-kVDC output.—A. M. Hudor, Jr., Power Convarter Uses Low-Cost Audio Transformar, *EDN Magazine*, April 20, 1977, p 139.

280 V TO 600 V—Cascoda push-pull transistor switch conversion circuit uses low-voltaga transistors and provides automatic equalization of transistor storage time. Drive-signal input to cascode push-pull switch is symmetrical 50-kHz 15 V P-P square wave from 50-ohm source. Q1 and Q2 aach saa only half of DC source voltage bacausa C1 and C2, in series across 280-V input, charga to 140 V aach. Circuit is adaptabla to wide range of output voltages and currents becausa idantical units can be connected in series or parallel to obtain desired rating.—L. G. Wright and W. E. Milberger, HV Building Block Uses Series Transistor Switchas, *EDN Magazine*, Feb. 15, 1971, p 39–40.

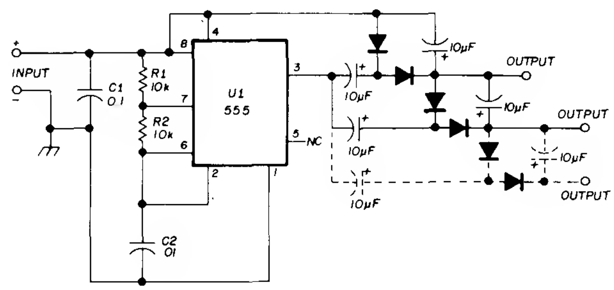




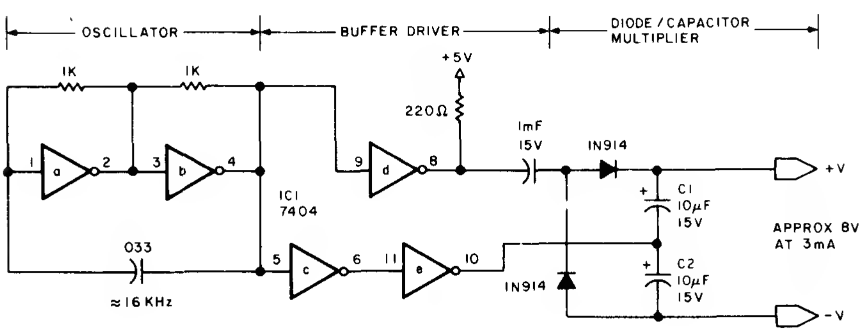
−15 V FROM +15 V—First two sections of 74C04 hex invarter form 100-kHz oscillator, with other sections connected to provida inversion of standard microprocessor sourca voltage as required for some intarfaces and some D/A convertars. Shunt regulator formed by D1 and Q1 maintains output voltage ralativaly constant. Changing zanar D1 to 13 V makas output −12 V.—S. Ciarcia, Build a 5 W DC to DC Convarter, *BYTE*, Oct. 1978, p 22, 24, 26, 28, and 30–31.



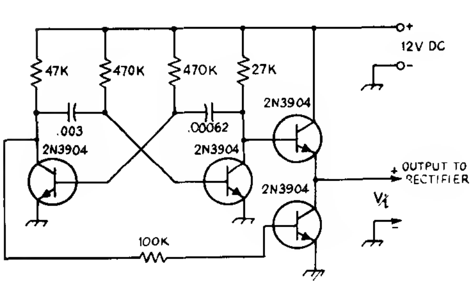
+5 V TO −7 V—Uses LM555 timer as variable-duty-cycle pulse generator controlling transistor switch Q_1, which in turn drives flyback circuit. Regulator Q_2-D_3-R_4-R_5 varies duty cycle according to load, and flyback circuit L-D_1-C_1 develops negative output voltage. When Q_1 is on, current flows through L to ground. When Q_1 turns off, polarity across L reverses, diode becomes forward-biased, and negative voltage appears across C_1 and load. When Q_1 turns on again, voltage across L reverses for start of new cycle. Circuit eliminates separate transformer supply for negative supply of microprocessor. Efficiency is about 60%, load regulation 1.3%, and supply rejection 30 dB. Article gives design equations.—P. Brown, Jr., Converter Generates Negative μP Bias Voltage from +5V, *EDN Magazine*, Aug. 5, 1977, p 42, 44, and 46.

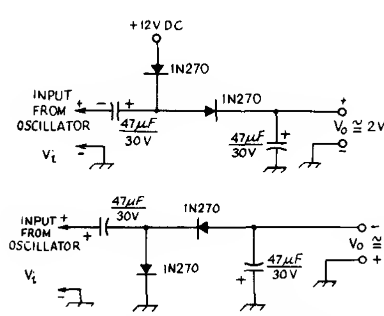


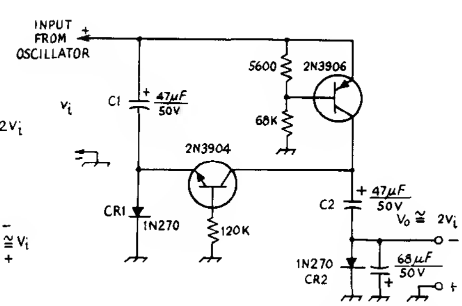
DC MULTIPLIERS—Voltage output from positive voltage booster (+12 VDC to +20 VDC) is increased by using diode-capacitor voltage-doubler sections as shown. Diodes are 1N914, 1N4148, or equivalent. Doubling is achieved at expense of available current. Same technique may be used to increase output of DC/DC converter having negative output voltage.—G. A. Graham, Low-Power DC-DC Converter, *Ham Radio*, March 1975, p 54–56.



+8 V FROM +5 V—Oscillator operating at about 16 kHz steps up 5-V supply voltage of microprocessor to 8 V for driving special interface circuits. Sections c, d, and e of 7404 hex inverter form buffer and driver for voltage-doubling rectifier.—S. Ciarcia, Build a 5 W DC to DC Converter, *BYTE*, Oct. 1978, p 22, 24, 26, 28, and 30–31.

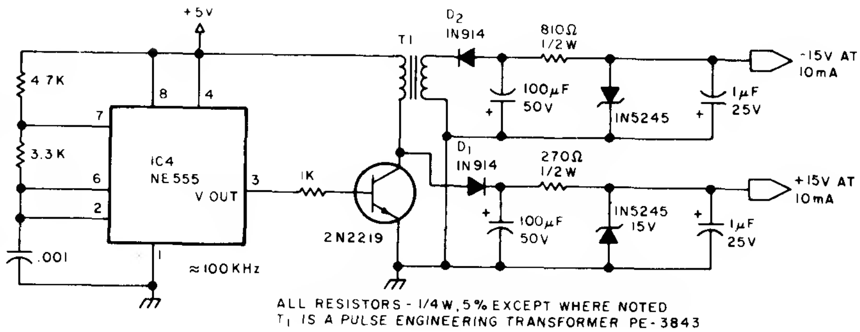


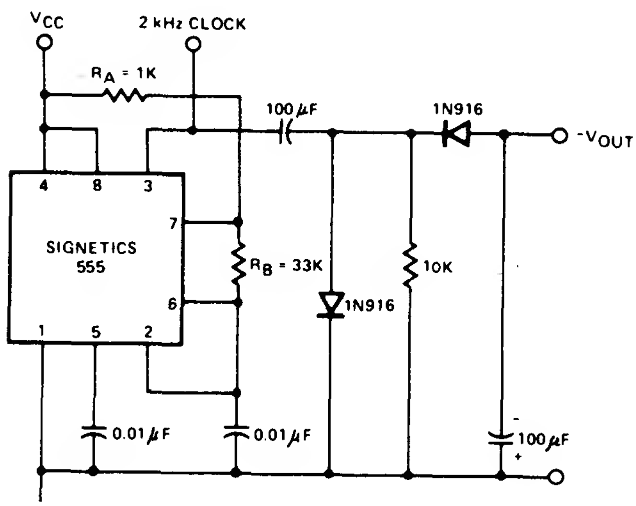




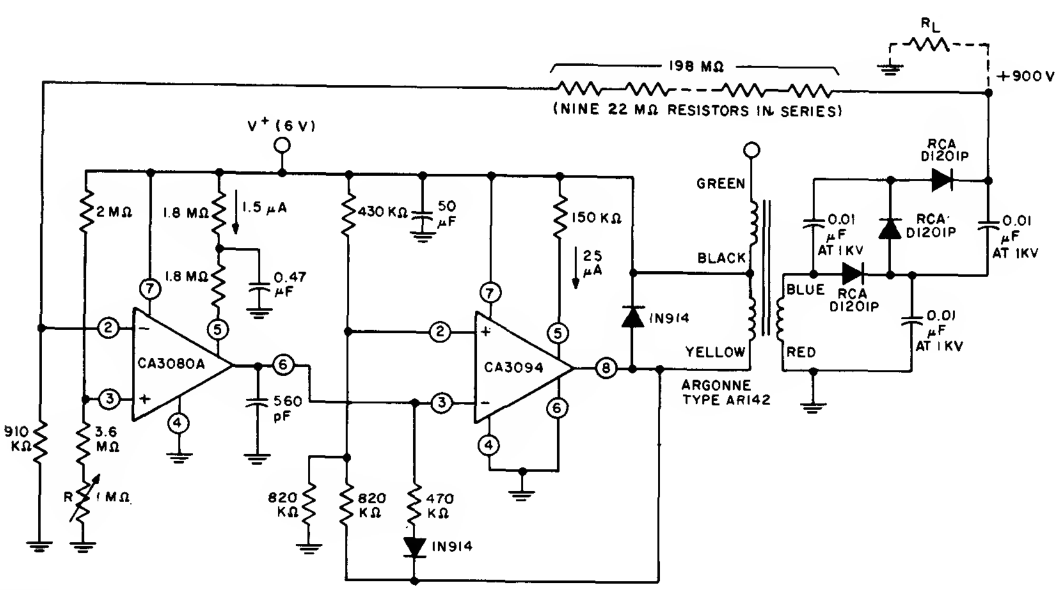
POLARITY REVERSER—Simple RC oscillator operating at about 1200 Hz can be used with choice of rectifier circuits to provide negative or positive voltages equal to or higher than DC supply, without use of transformer. Output transistors connect load alternately to positive supply and to ground for high operating efficiency. Two-diode voltage doubler with connection to 12-V supply gives positive output. Other diode rectifier circuit doubles oscillator output and gives negative supply. Negative doubler uses switching transistors. All three rectifier circuits provide common ground from supply to output.—J. M. Pike, Negative and High Voltages from a Positive Supply, *QST*, Jan. 1974, p 23–25.

±15 V FROM +5 V—Provides positive and negative higher voltages required by aome interface devices used with microprocessors. NE555 timar is connected as 100-kHz oscillator that switches transistor on end *off*, inducing current in primary of T1. High-voltage spike reflected back to collector of transistor by pulse transformer is routed through D1 to filter-regulator for providing positive output.—S. Ciarcia, Build a 5 W DC to DC Converter, *BYTE*, Oct. 1978, p 22, 24, 26, 28, end 30–31.



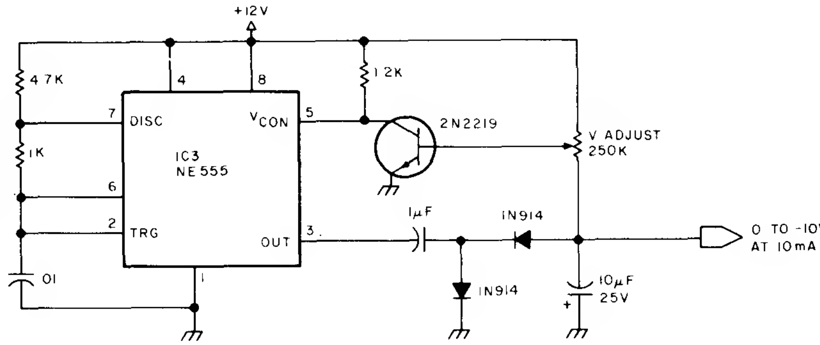


TRANSFORMERLESS POSITIVE TO NEGATIVE—Used to derive negative supply voltaga from positive supply voltage, while at seme time generating 2-kHz clock signal. Negetive output voltege trecks DC input voltage linaarly, but magnitude is about 3 V lower. Circuit does not provide regulation.—"Signetics Anelog Data Menuel," Signetics, Sunnyvala, CA, 1977, p 729.

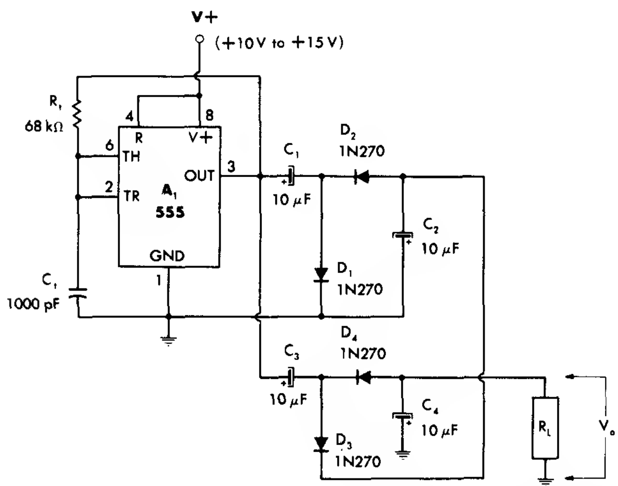


REGULATED HIGH-VOLTAGE SUPPLY

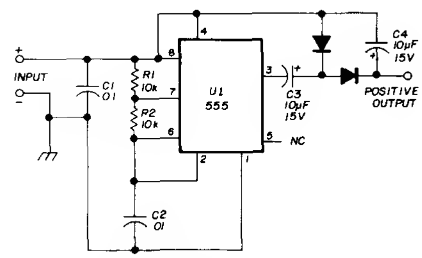
REGULATED +900 V FROM +6 V—CA3094 programmable opemp is connected as oscillator for driving step-up transformer thet develops suitable high voltage for rectificetion in diode network. Sample of +900 V regulated output is fed to CA3080A variabla opamp through 198-megohm reaistor of voltege divider to control pulse repetition rate of oscilletor. Magnituda of regulated output is controlled by pot R. Regulation is within 1% for loads of 5 to 26 μA. DC-to-DC conversion efficiency Is about 50%.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somarville, NJ, 1977, p 19.



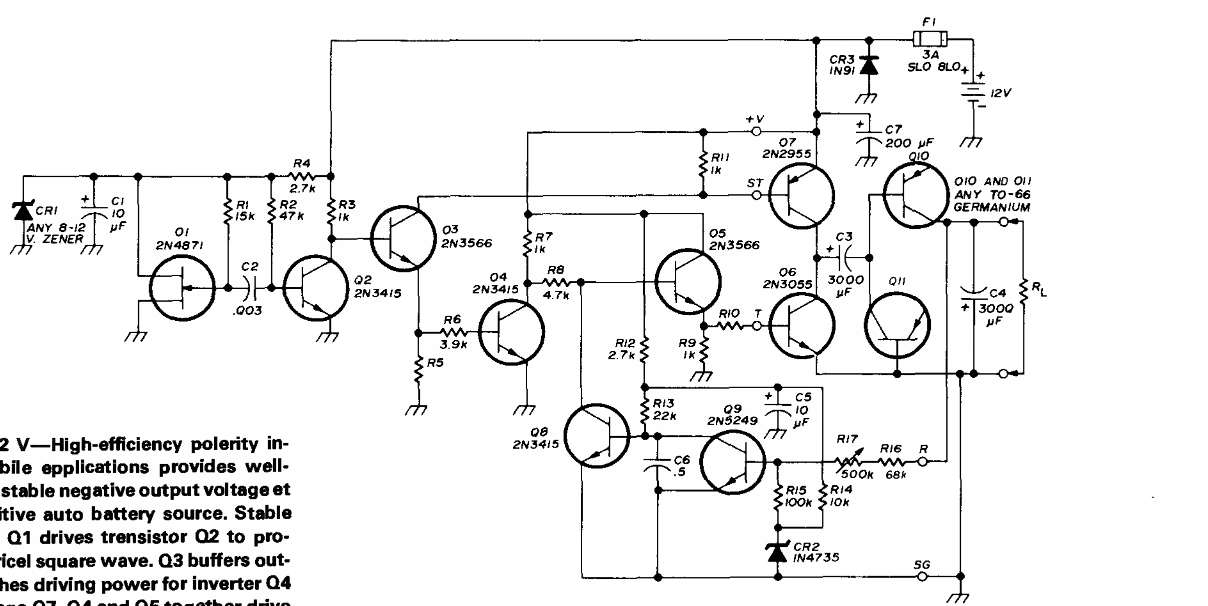
0 TO −10 V FROM +12 V—Veriable-output convartar using NE555 timer delivers negative output voltage required by some interface devices and D/A converters used with microprocassors.—S. Ciarcia, Build e 5 W DC to DC Converter, *BYTE*, Oct. 1978, p 22, 24, 26, 28, and 30–31.



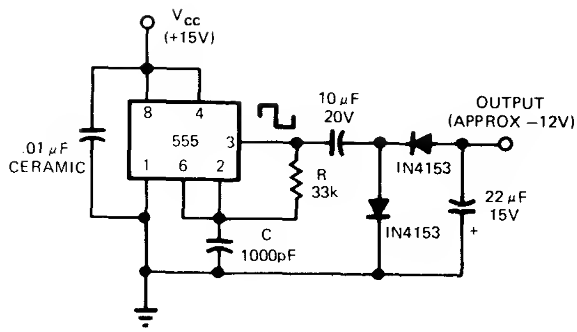
15 V TO −24 V—Voltege doublar is usad in combinetion with 555 astable MVBR end two peak-to-peek detectors to glve high negetive voltages from positive voltege source. Load currant capebility is ebout 10 mA. Output drops to ebout −14.5 V when using supply of +10 V.—W. G. Jung, "IC Timer Cookbook," Howard W. Sems, Indianapolis, IN, 1977, p 197–201.



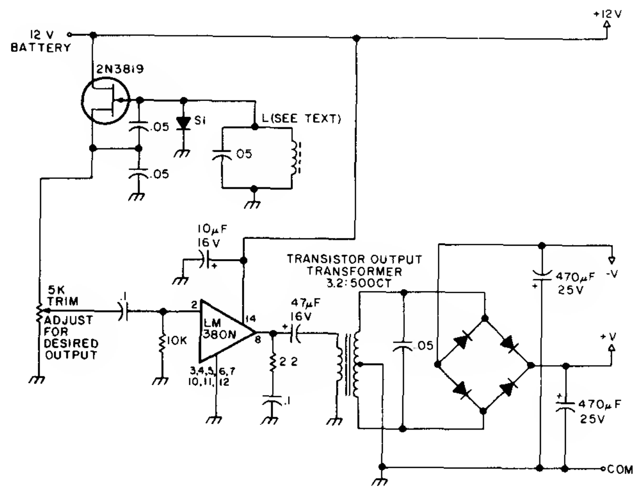
+12 V TO +20 V—Developad for use with mobile equipment when DC voltage highar than thet of euto battary is needed. Ona application is trickle-charging 12-V nickel-cadmium batteries. U1 is 555 timar oparated as frae-running squera-wave oscillator. Frequancy Is determined by R1, R2, and C2; with values shown, it is ebout 6 kHz. C1 reduces 6-kHz signal radiated back through input lines. If converter is used with high-frequancy raceivar, insert 100-μH RF chokes in power leads to suppress hermonics of 6 kHz. For 12-V input, typlcal outputs are 20.4 V et 10 mA, 19.9 V at 20 mA, and 17.7 V at 50 mA. All diodes ere 1N914, 1N4148, or equivelent.—G. A. Graham, Low-Powar DC-DC Converter; *Ham Radio*, March 1975, p 54–56.



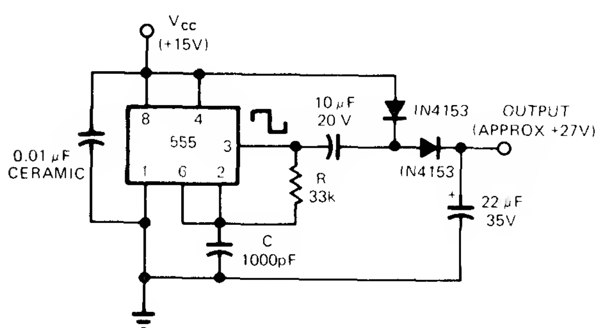
+12 V TO −12 V—High-efficiency polerity inverter for mobile applications provides well-regulated edjustable negative output voltage et 2 A from positive auto battery source. Stable UJT oscillator Q1 drives trensistor Q2 to produce symmetricel square wave. Q3 buffers output and furnishes driving power for inverter Q4 end output stage Q7. Q4 and Q5 together drive Q6 into complete saturation. Q6 end Q7 form complementary-symmetry output operating in saturation mode, with only one transistor turned on et e time. As they are elternetely switched on and off, square wave eltarnating between ground end naerly battary potential is epplied to C3. Q10 and Q11 are connected es diodes for clamping squara wave negatively. Output voltage is regulated by transistor feedback loop Q8 and Q9, with zener CR2 providing stable reference. R10 is 100 ohms for 2 A maximum; increasing its value improves efficiency but reduces maximum currant.—J. R. Laughlin, Medium Current Polarity Inverter, *Ham Radio*, Nov. 1973, p 26–30.



+15 V TO −12 V—Simple transformerless powar converter uses 555 timer in self-triggered mode as square-weve generator, followed by voltage-doubling rectifier. Values shown for R end C give frequency of about 20 kHz, which permits good filtering with relatively smell cepecitors. Meximum loed current is ebout 80 mA.—M. Strange, IC Timer Mekes Transformerless Power Converter, *EDN Magazine,* Dec. 20, 1973, p 81.



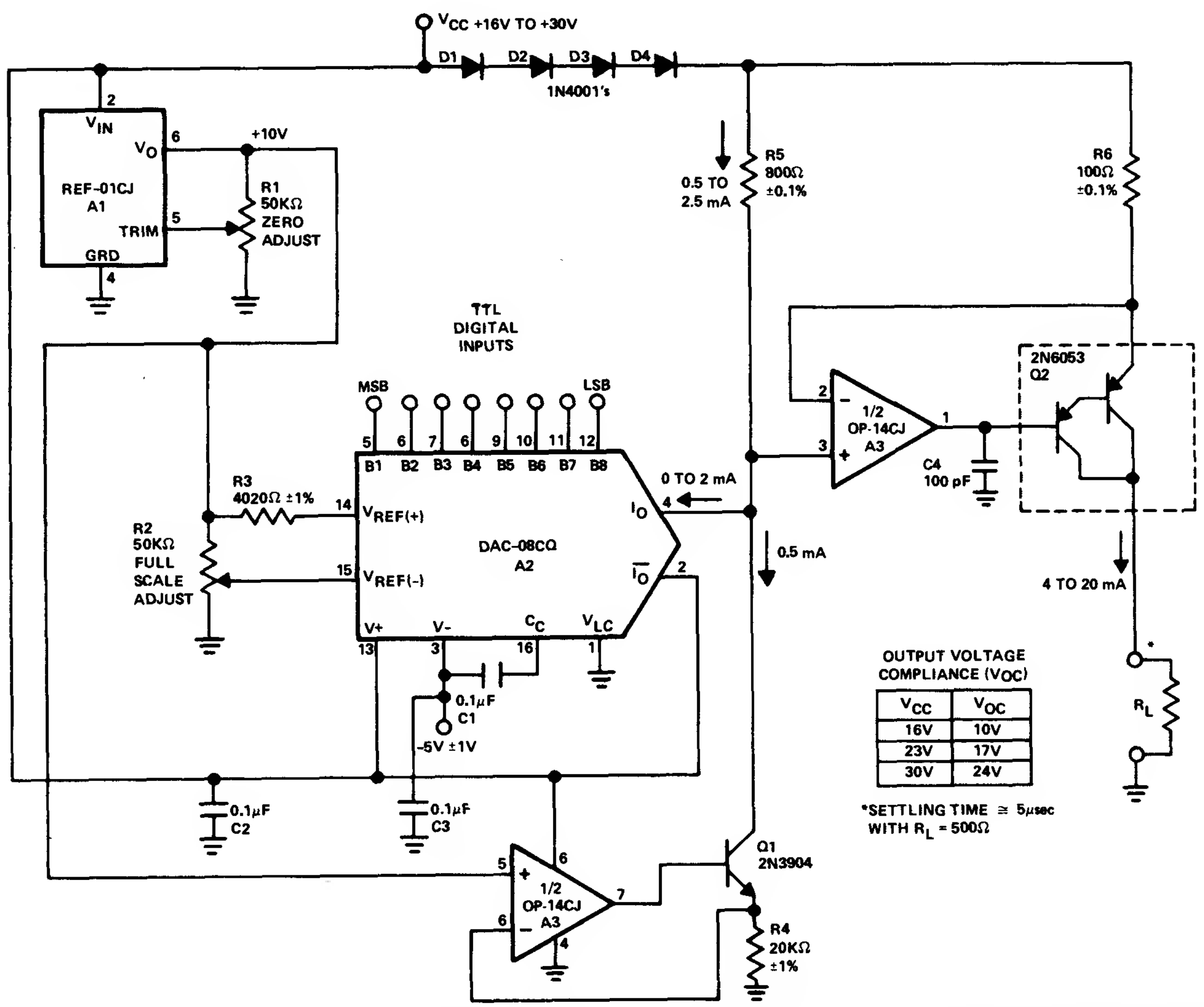
±15 V FROM 12 V—Steps up output of 12-V battary to voltages required by PLL such es NE561. Uses 900-Hz sine-weve oscillator end LM380N AF amplifier to drive voice-coil side of standerd 500-ohm to 3.2-ohm output transformar having bridge rectifier across center-tapped primary. With 10-mA loads, maximum ripple is 15 mV P-P. With receiver quiet, 900-Hz hum is eudible, but is normelly lost under beckground noise. Oscillator choke (about 700 mH) is 800 turns of No. 44 magnet wire in Ferroxcube 3C pot core.—R. Megirian, Build a Noise-Free Power Supply, *73 Magazine,* Dec. 1977, p 208–209.



+15 V TO +27 V—Uses 555 timer in self-triggered mode as squere-weve generator operating et about 20 kHz, followed by voltage-doubling rectifier. Provides approximate doubling of voltege without use of trensformer. Maximum load current is ebout 80 mA.—M. Strenge, IC Timer Makes Transformerless Power Convarter, *EDN Magazina,* Dec. 20, 1973, p 81.

CHAPTER 18
Converter Circuits—Digital-to-Analog

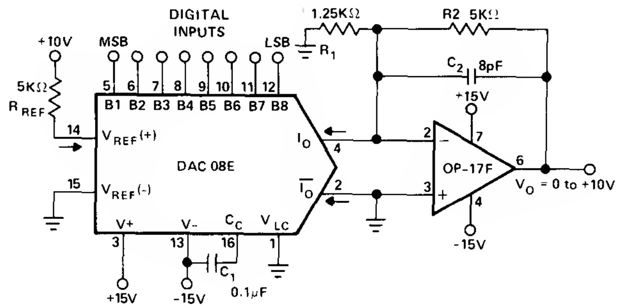
Includes circuits for converting variety of digital inputs to linearly related analog output voltage or current, providing analog sum of two digital inputs, or converting stored digital speech back to analog form.

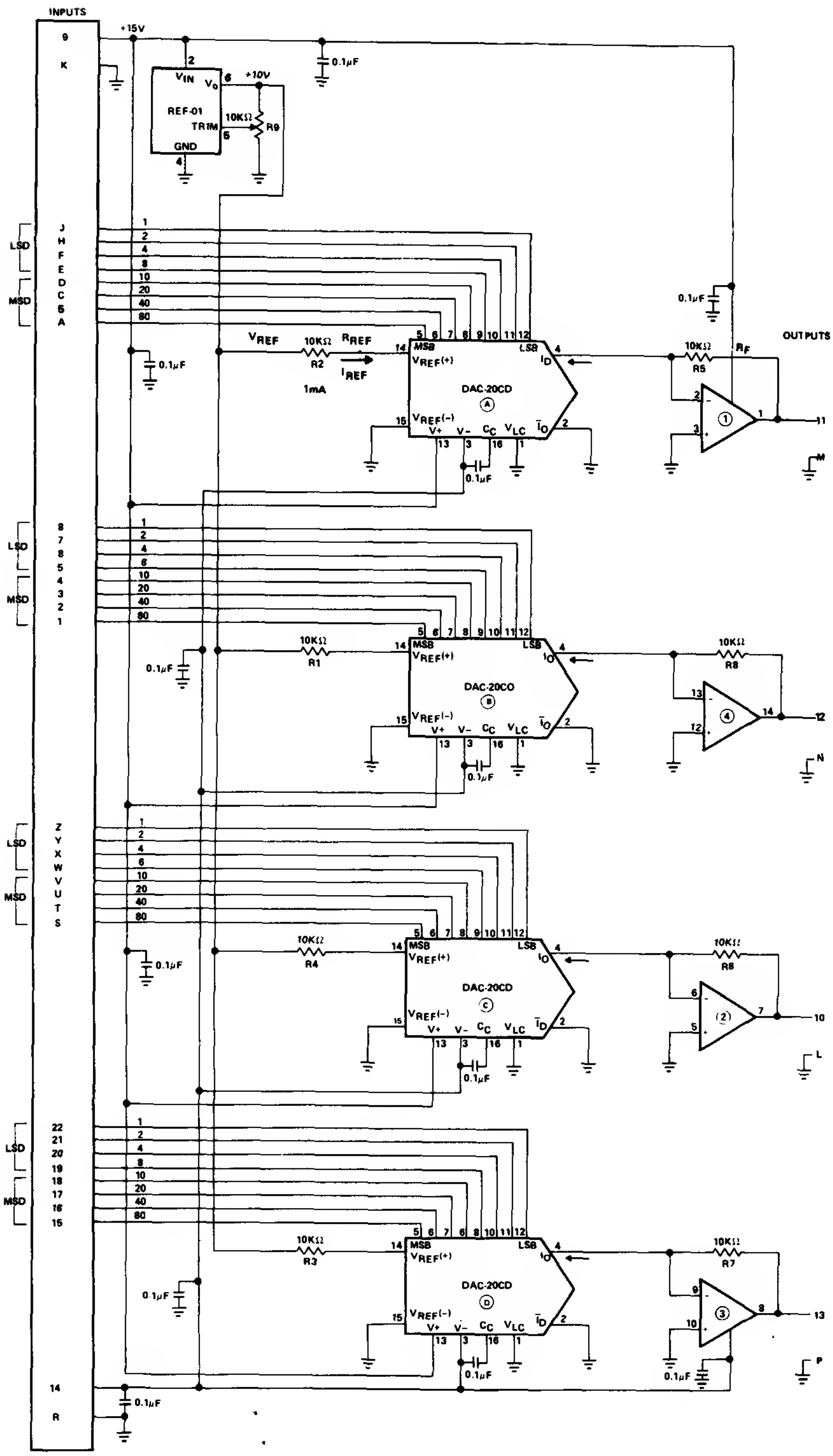


VCC	VOC
16V	10V
23V	17V
30V	24V

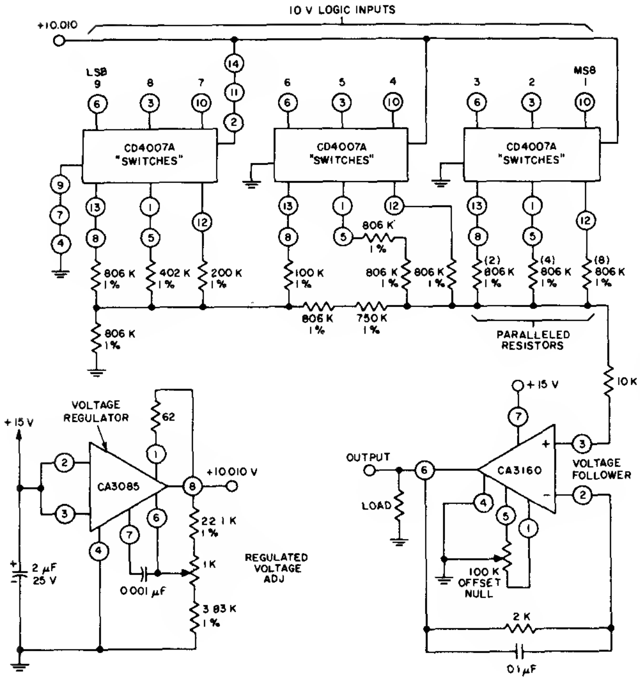
8-BIT BINARY TO PROCESS CURRENT—Uses only three Precision Monolithics ICs operating from −5 V and +23 V supplies to convert 8-bit binary digital input to process current in range of 4-20 mA. Fixed current of 0.5 mA is edded to DAC output current varying between 0 and 2 mA, with resulting total current multiplied by factor of 8 to give up to 20 mA through 500-ohm loed.—D. Soderquist, "3 IC 8 Bit Binary Digitel to Process Current Converter with 4-20 mA Output," Precision Monolithics, Sante Clara, CA, 1977, AN-21.

HIGH-SPEED OUTPUT OPAMP—Precision Monolithics OP-17F opamp optimizes DAC-08E D/A convarter for highast speed in converting DAC output current to output voltage up to 10 V under control of digitel input. Settling time is 380 ns.—G. Erdi, "The OP-17, OP-16, OP-15 as Output Amplifiers for High Speed D/A Converters," Precision Monolithics, Sante Clera, CA, 1977, AN-24, p 2.

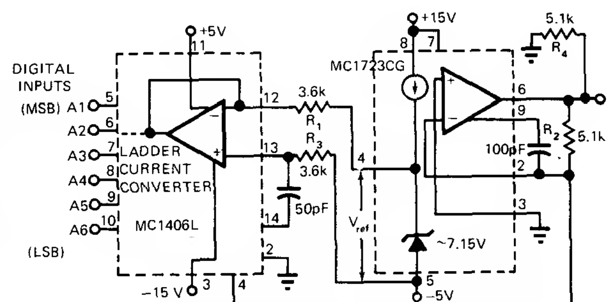




FOUR-CHANNEL BCD—Uses four Precision Monolithics DAC-20CQ 2-digit BCD D/A converter, OP-11FY precision quad opamp, and REF-01HJ +10 V voltega reference to convert 2-digit BCD input coding to proportional analog 0 to +10 V output for aach of four channels. Same configuration will handla binary inputs, as covered in epplication nota. For output ranga of 0 to +5 V, chenge voltage refarance to REF-02.—D. Sodarquist, "Low Cost Four Channal DAC Gives BCD or Binary Coding," Precision Monolithics, Santa Clara, CA, 1977, AN-26, p 3.

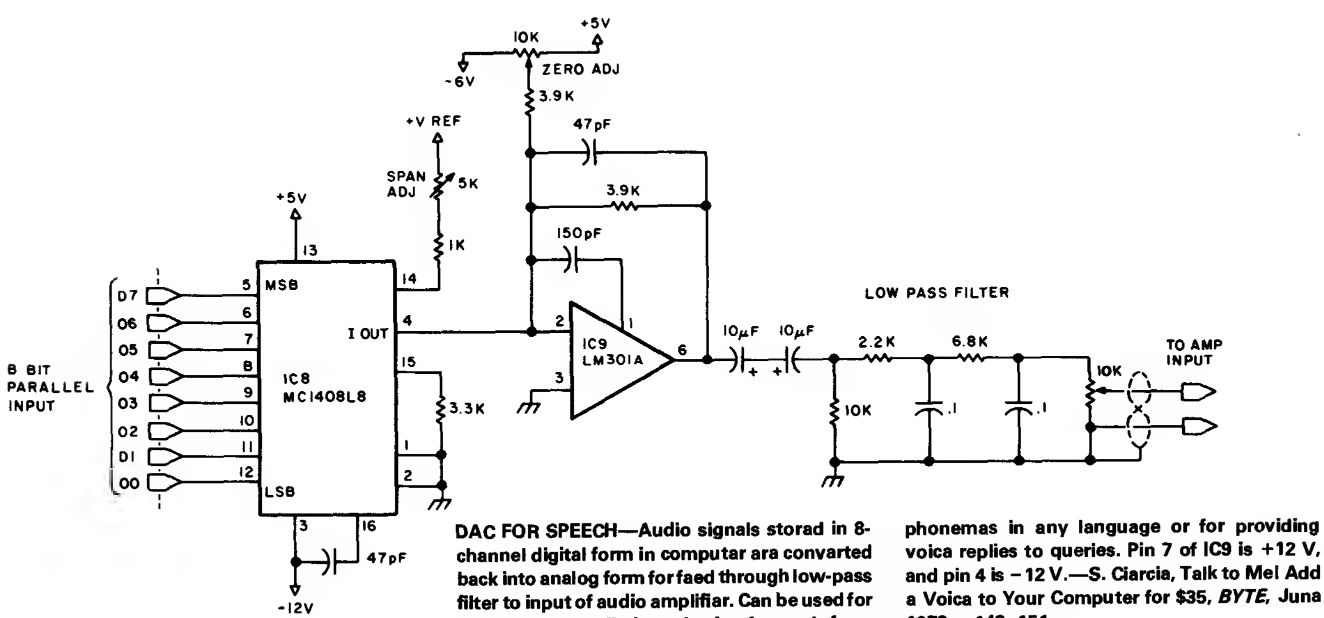


9-BIT USING DIGITAL SWITCHES—Combination of CD4007A multiple-switch CMOS ICs, ladder network of discrete metal-oxide film resistors, CA3160 voltage-follower opamp, and CA3085 voltage regulator gives digital-to-analog converter that is readily interfaced with 10-V logic levels of CMOS input. Required resistor accuracy, ranging from ±0.1% for bit 2 to ±1% for bits 6-9, is achieved by using series and parallel combinations of 806K resistors.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somarville, NJ, 1977, p 267–268.

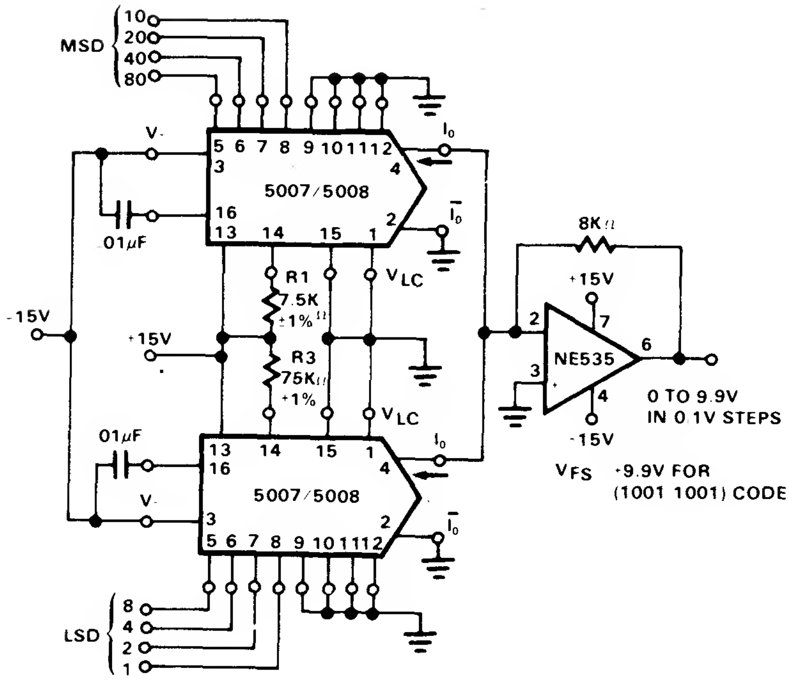


$$V_o = V_{ref}\left(\frac{R_2}{R_1}\right)\left[\frac{\overline{A1}}{2}+\frac{\overline{A2}}{4}+\frac{\overline{A3}}{8}+\frac{\overline{A4}}{16}+\frac{\overline{A5}}{32}+\frac{\overline{A6}}{64}\right]$$

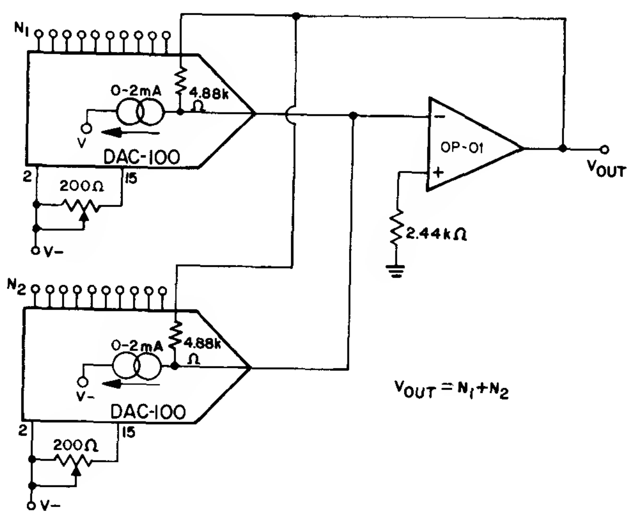
6 BITS TO ANALOG—Uses Motorola MC1723G voltage regulator to provide reference voltage and opamp for MC1406L 6-bit D/A convarter. Output currant can be up to 150 mA. Full-scale output is about 10 V, but can ba boosted as high as 32 V by incraasing value of R_2 and increasing +15 V supply proportionataly to maximum of 35 V.—D. Aldridga and K. Huehne, 6-Bit D/A Convarter Uses Inaxpansiva Componants, *EDN Magazine,* Dec. 15, 1972, p 40–41.



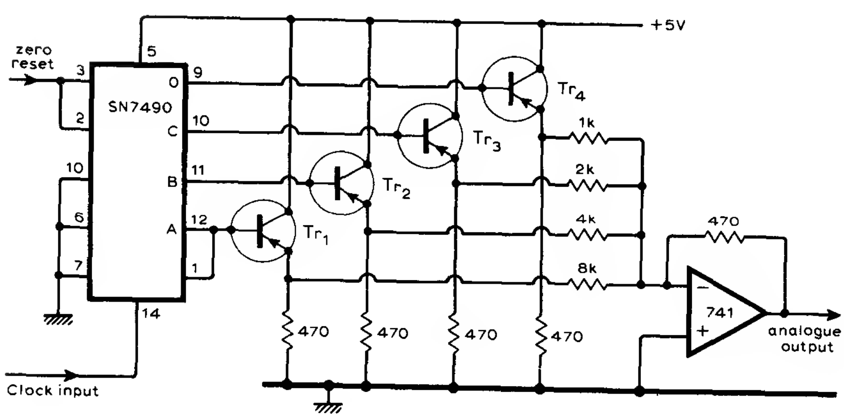
DAC FOR SPEECH—Audio signals storad in 8-channel digital form in computar ara convartad back into analog form for faed through low-pass filter to input of audio amplifiar. Can be used for computar-controlled synthasis of speach from phonemas in any language or for providing voica replies to queries. Pin 7 of IC9 is +12 V, and pin 4 is −12 V.—S. Ciarcia, Talk to Mel Add a Voica to Your Computer for $35, *BYTE,* Juna 1978, p 142–151.



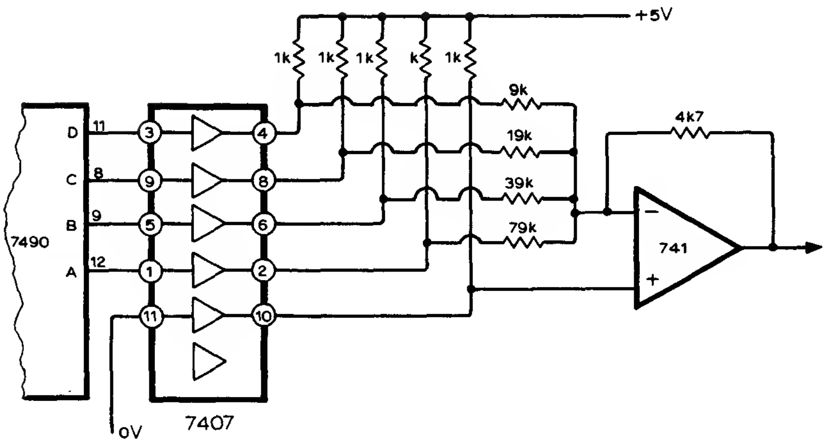
2-DIGIT BCD INPUT—Each Signetics 5007/5008 multiplying D/A converter serves one digit of input voltage to give output current that is product of digital input number and input reference current. Opamp combines currents and converts them to analog output voltage proportional to digital input value.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 677–685.



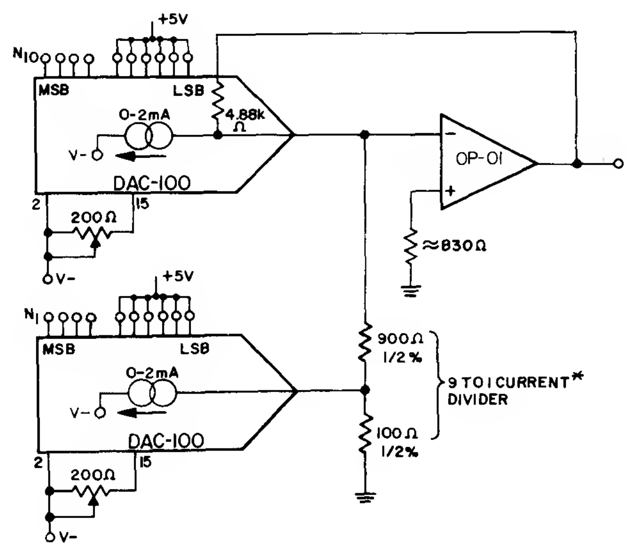
ANALOG SUM OF DIGITAL NUMBERS—Two Precision Monolithics DAC-100 D/A converters and OP-01 opamp combine conversion with adding to give high-precision DC output voltage. 200-ohm pots are adjusted initially to give exactly desired output for input of all 0s.—"8 & 10 Bit Digital-to-Analog Converter," Precision Monolithics, Santa Clara, CA, 1977, DAC-100, p 5.



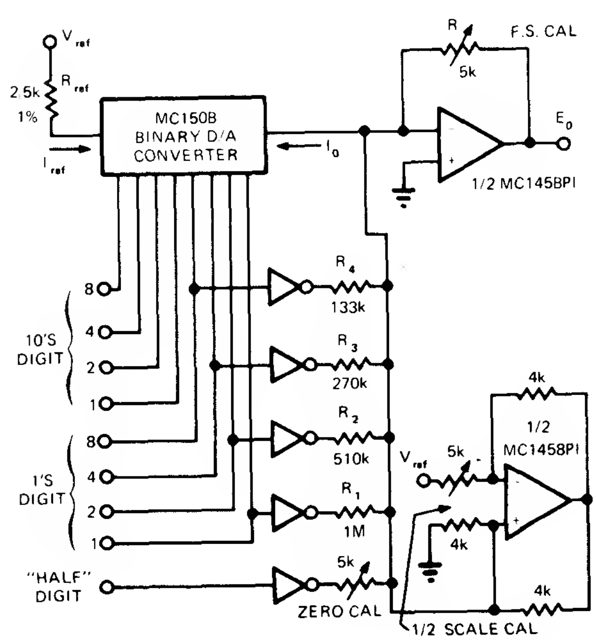
SIMPLE DAC—Transistors are either saturated or cut off by outputs of clock-controlled SN7490 BCD counter. Portions of emitter voltages of the four transistors are added in ratios 1:2:4:8 by 741 summing opamp to obtain analog output. Article tells how two such circuits can be combined for use in two-digit DVM.—D. James, Simple Digital to Analogue Converter, *Wireless World*, June 1974, p 197.



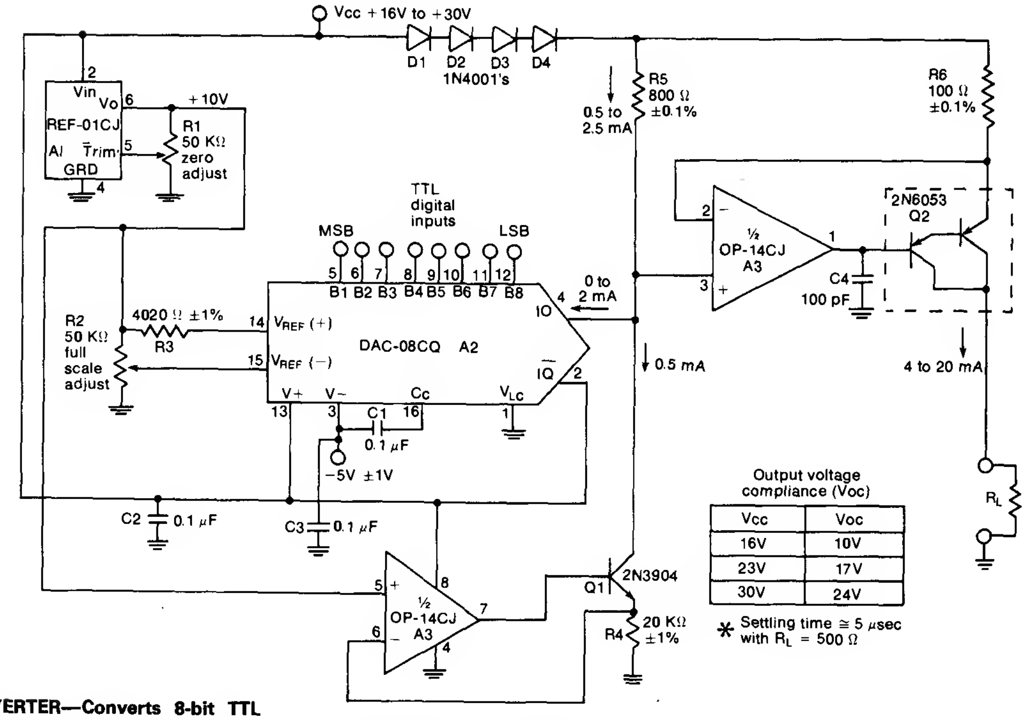
TEMPERATURE COMPENSATION—Usa of 7407 hex buffer following SN7490 of D/A convertar permits satisfactory performanca over raasonably wide temparature ranga evan whan driving several TTL stagas. Noninverting input of 741 opamp is connected to output of unused buffar at logic 0. Circuit is modification of D/A convertar developed by D. James for usa in simpla two-digit DVM.—R. J. Chanca, Improved Simple D. to A. Converter, *Wireless World*, Dec. 1974, p 503.



2-DIGIT BCD—Output current of Precision Monolithics DAC-100 D/A convartar can ba adjusted to exactly desired value with 200-ohm pot for each DAC; adjustment is meda with input of all 0s. Circuit can ba axpanded to 3 digits by adding third DAC and adding 99 to current dividar.—"8 & 10 Bit Digital-to-Analog Convarter," Precision Monolithics, Santa Clara, CA, 1977, DAC-100, p 5.

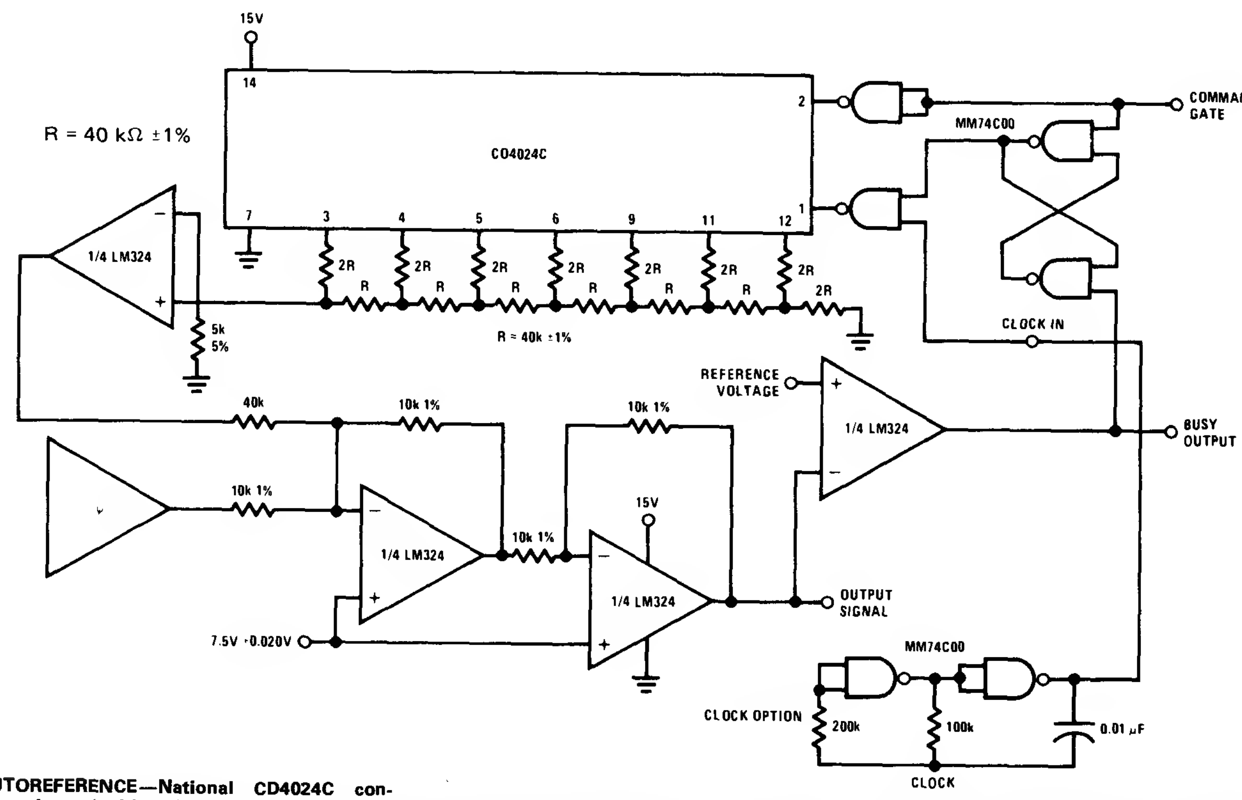


2½-DIGIT INPUT FOR 199 COUNT—Addition of ½-digit circuit to basic 2-digit BCD DAC increasas count from 99 to 199. Circuit sequances to 99 while ½-digit section of MC14009 hax two-input NOR gate has low output, and goes through steps 100 to 199 whila ½-digit output is high. Reference voltage is 5.0 V. Calibration procedure is givan.—T. Henry, Binary D/A Converters Can Provide BCD-Coded Conversion, *EDN Magazine*, Aug. 5, 1973, p 70–73.

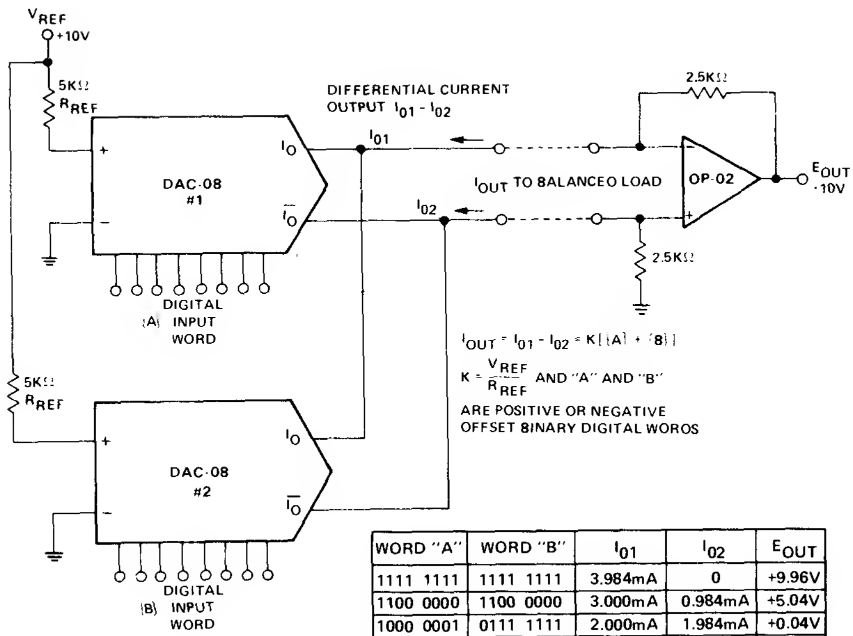


Vcc	Voc
16V	10V
23V	17V
30V	24V

CURRENT CONVERTER—Converts 8-bit TTL digital inputs to process current in range of 4 to 20 mA, for microprocessor control of industrial operations. Fixed 0.5-mA current is added to DAC output current varying between 0 and 2.0 mA and multiplied by factor of 8 to produce final output current of 4–20 mA. To calibrate, connect ammeter between output and ground, then apply +23 V ± 7 V and −5 V ± 1 V to converter. Make digital inputs all 0s (less than +0.8 V). Adjust R1 until output current is 4.0 mA. Change digital inputs to all 1s (greater than +2.0 V), and adjust R2 until output current is 20 mA.—D. Soderquist, Build Your Own 4-20 mA Digital to Analog Converter, *Instruments & Control Systems*, March 1977, p 57–58.

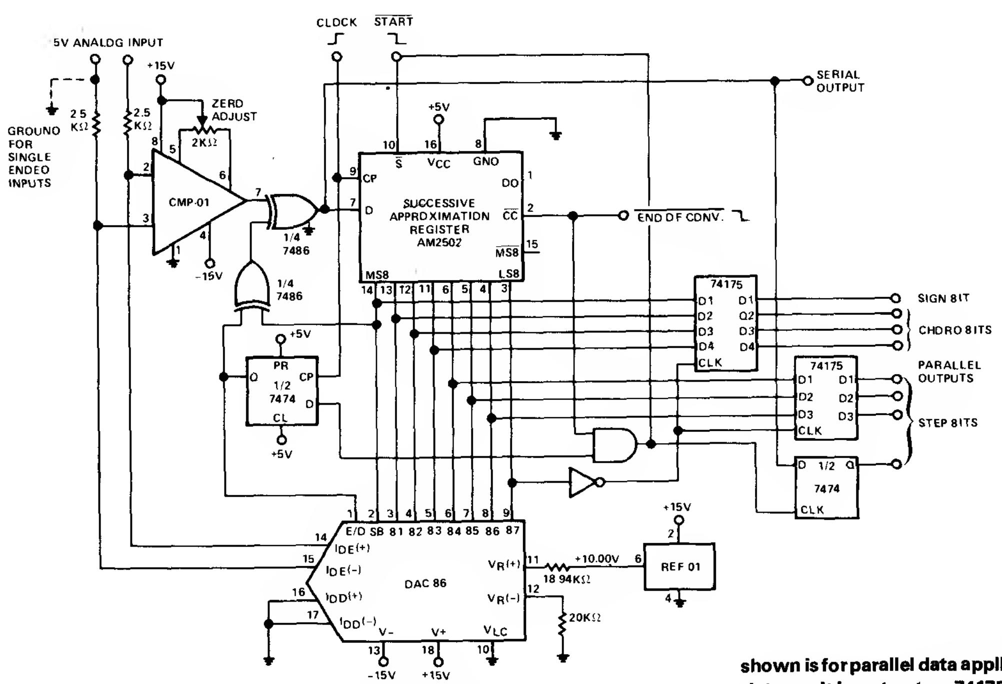


AUTOREFERENCE—National CD4024C converter is used with logic and summer elements to eliminate virtually all offset errors induced by time and temperature changes in process control system fed by transducer. Best suited for applications having short repeated duty cycles, each containing reference point. Examples include weighing scale in which transducer is load cell, pressure control systems, fuel pumps, and sphygmomanometers. Circuit eliminates warm-up errors.—"Pressure Transducer Handbook," National Semiconductor, Santa Clara, CA, 1977, p 7-4–7-8.



WORD "A"	WORD "B"	I_{01}	I_{02}	E_{OUT}
1111 1111	1111 1111	3.984mA	0	+9.96V
1100 0000	1100 0000	3.000mA	0.984mA	+5.04V
1000 0001	0111 1111	2.000mA	1.984mA	+0.04V
1000 0000	0111 1111	1.992mA	1.992mA	0
0111 1111	1000 0000	1.992mA	1.992mA	0
0111 1110	1000 0000	1.984mA	2.000mA	-0.04V
0011 1111	0011 1111	0.984mA	3.000mA	-5.04V
0000 0000	0000 0000	0	3.984mA	-9.96V

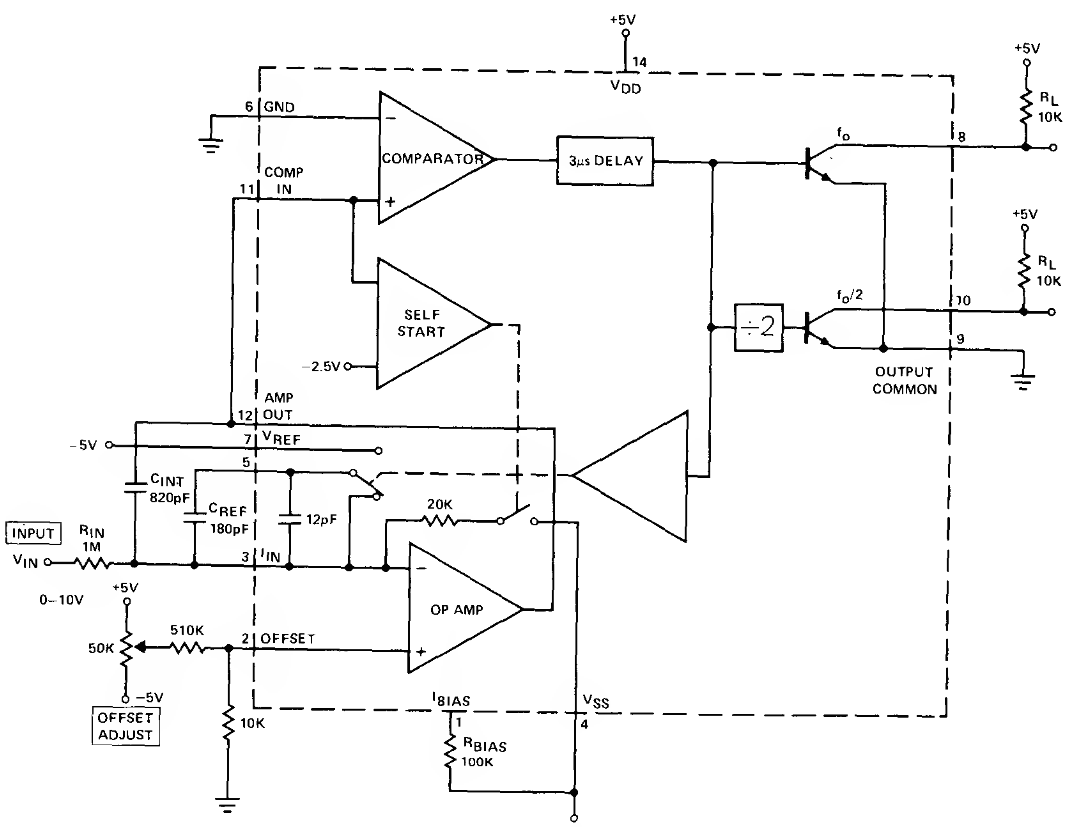
FOUR-QUADRANT ALGEBRAIC—Two Precision Monolithics DAC-08 D/A convartars parform fast algebraic summation of two digital input words and faed OP-02 opamp thet provides direct analog output which is algebraic sum of words A end B in ell four quadrants.—J. Schoeff and D. Sodarquist, "Diffarantial and Multiplying Digitel to Analog Converter Applications," Precision Monolithics, Sente Clara, CA, 1976, AN-19, p 7.



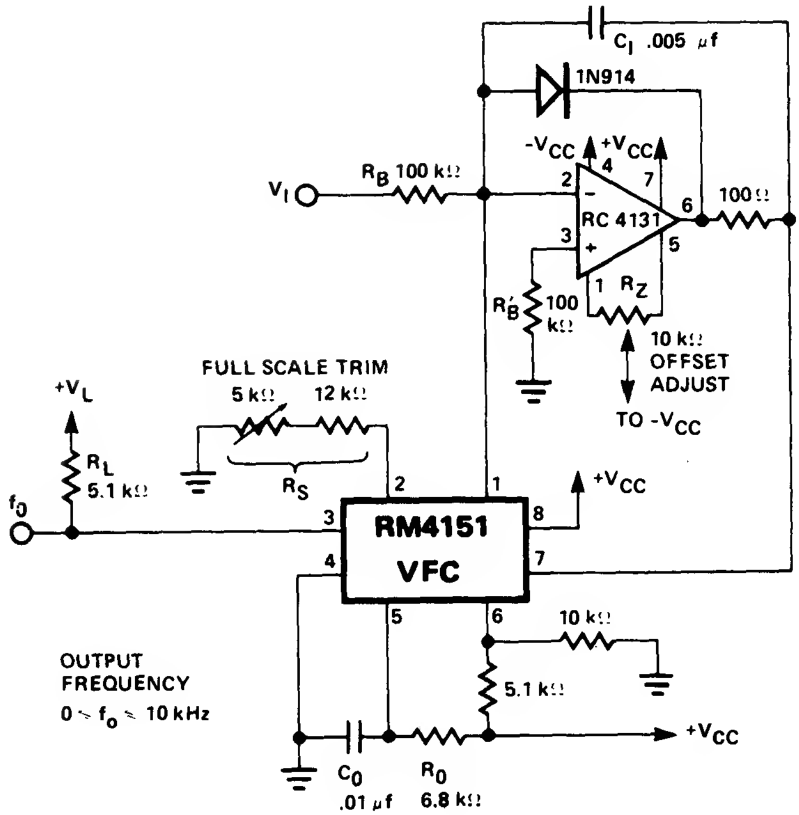
BELL-SYSTEM μ-255 COMPANDING LAW—Precision Monolithics DAC-86 is used in circuit that provides 15-sagment linear approximation by using 3 bits to salact ona of aight binarily ralated chords, then uaing 4 bits to select ona of sixtaan linaarly ralated steps within each chord. Sign bit determines signal polarity, end ancode/decoda aelect bit determinas operation. Circuit shown is for parallel data applications. For aeriel data, omit inverter, two 74175 chips, and half of 7474. Powar supplias should be wall by-passed.—"COMDAC Compending D/A Converter," Precision Monolithics, Santa Clara, CA, 1977, DAC-86, p 6.

CHAPTER 19
Converter Circuits—General

Includes V/F, V/I, V/pulse width, V/time, F/V, 7-segment/BCD, BCD/7-segment, Gray/BCD, Gray/binary, binary/BCD, time/V, pulse height/time, I/V, and other converter circuits for changing one parameter linearly to another. See also other Converter chapters.

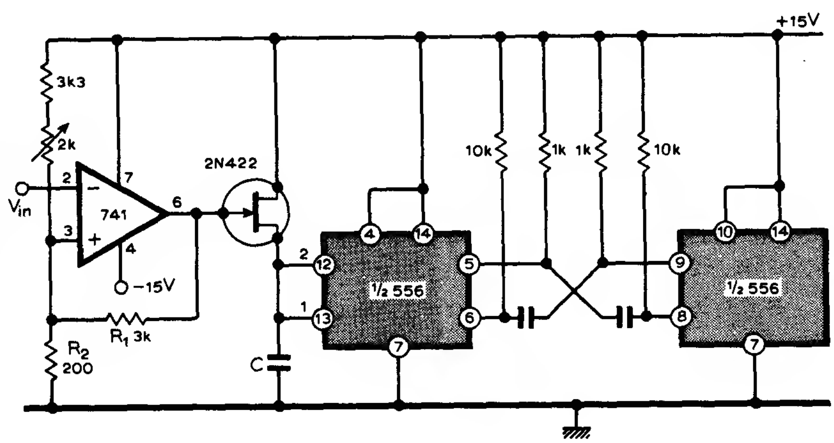


10 Hz TO 10 kHz V/F—External circuit shown for Teledyne 9400 voltage-to-frequency converter provides means for trimming zero location and full-scale frequency value of output. For 10-kHz full-scale value, set V_{IN} to 10 mV and trim with 50K offset adjust pot to get 10-Hz output, then set V_{IN} to 10.000 V and trim either R_{IN}, V_{REF}, or C_{REF} to obtain 10-kHz output.—M. O. Paiva, "Applications of the 9400 Voltage to Frequency Frequency to Voltage Converter," Teledyne Semiconductor, Mountain View, CA, 1978, AN-10, p 3–5.

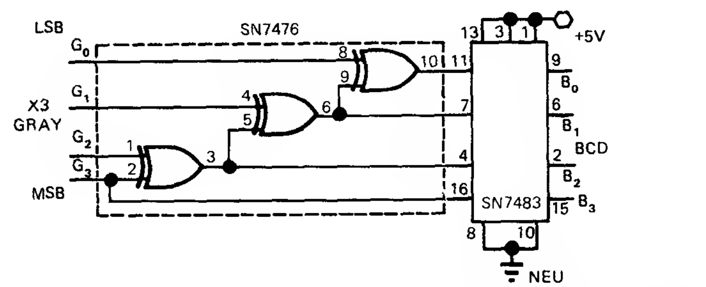


V/F CONVERTER WITH 0.05% LINEARITY—Raytheon RM4151 converter is used with integrator opamp to give highly linear conversion of inputs up to −10 VDC to proportional frequency of square-wave output. With maximum input of −10 V, adjust 5K full-scale trimpot for maximum output frequency of 10 kHz. Set offset adjust pot to give 10-Hz output for input of −10 mV. To operate from single positive supply, change opamp to RC3403A.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-38.

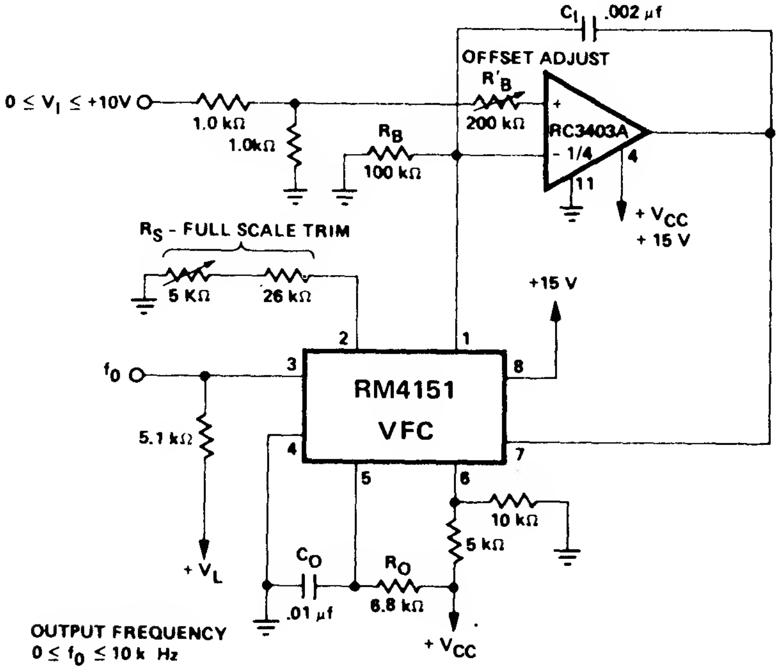
0.1 Hz–100 kHz V/F—Uses NE556 timer in dual mode in combination with opamp and FET for linear voltage-to-frequency conversion with output range from 0.1 Hz to 100 kHz. Operating frequency is 0.91/2RC where R is resistance of FET.—K. Kraus, Linear V-F Converter, *Wireless World*, May 1977, p 80.



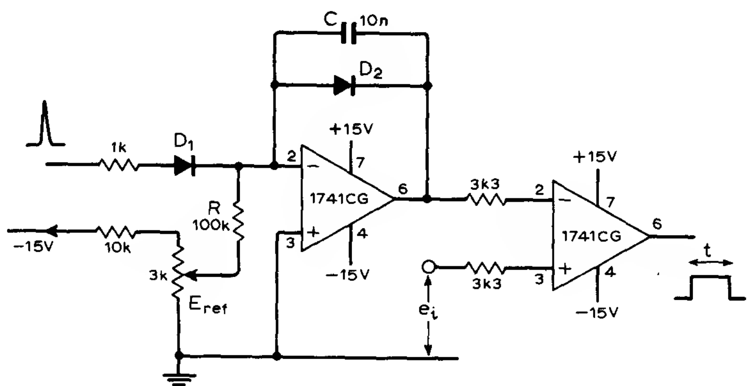
BCD	GRAY	X-3 GRAY
0000	0000	0010
0001	0001	0110
0010	0011	0111
0011	0010	0101
0100	0110	0100
0101	0111	1100
0110	0101	1101
0111	0100	1111
1000	1100	1110
1001	1101	1010



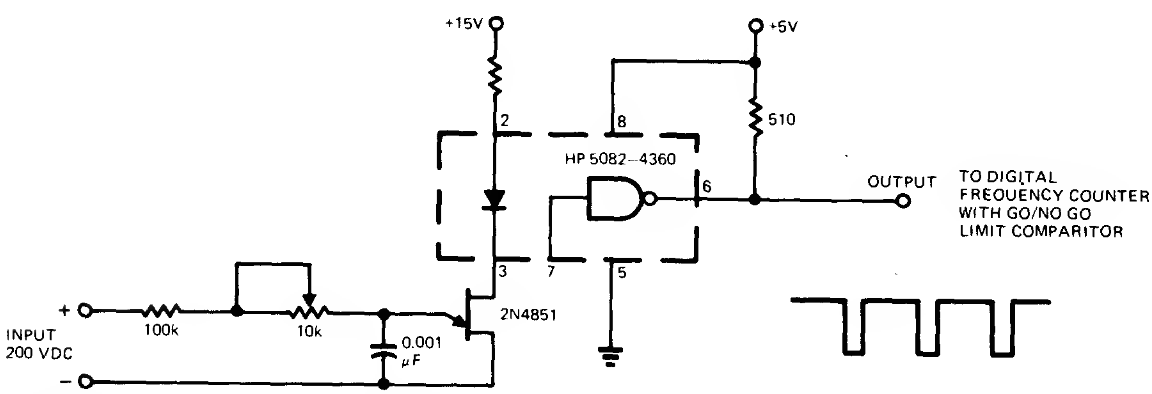
EXCESS-THREE GRAY CODE TO BCD—Developed for use with shaft encoder providing excess-three Grey-code output. Requires only two TTL ICs, connected as shown. To convert regular Grey code to BCD, omit SN7483 4-bit adder. Tabulation shows how circuit accomplishes conversion for both types of Gray codes.—D. M. Risch, Two ICs Convert Excess-Three Grey Code to BCD, *EDN Magazine*, Nov. 1, 1972, p 44.



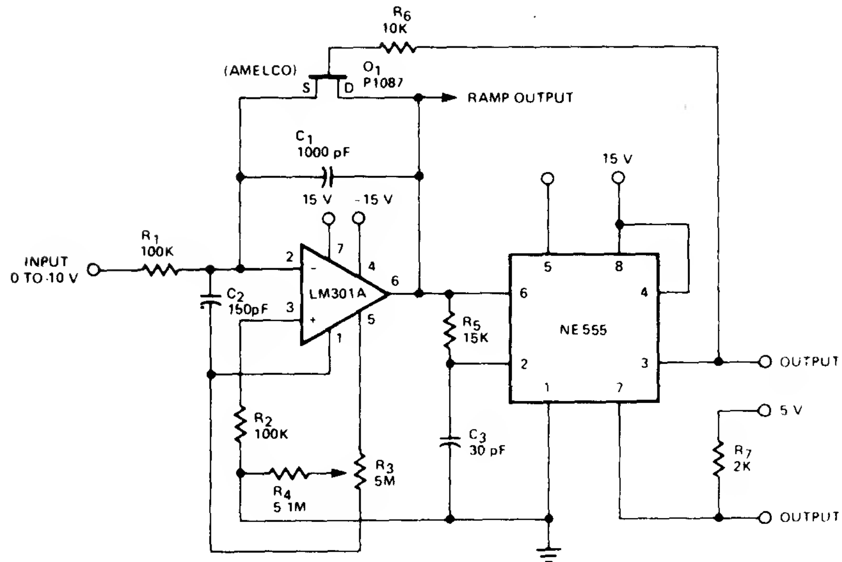
HIGH-PRECISION V/F CONVERTER—Active integrator using one section of RC3403A quad opamp improves linearity, frequency offset, and response time of Raytheon RM4151 converter operating from single supply. Opamp develops null voltage.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-38.



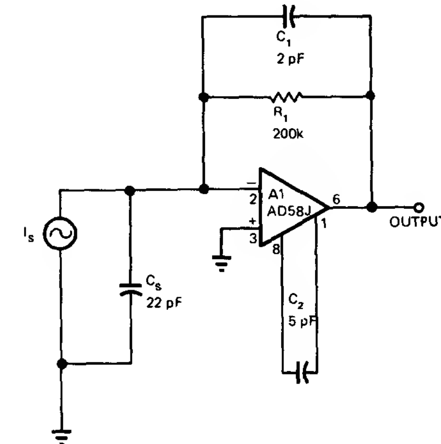
DC VOLTAGE TO TIME—Opamp connected as integrator feeds opamp comparator to produce output pulse whose width is proportional to magnitude of DC input voltage. Circuit shown is for positive inputs only; for both positive and negative inputs, article tells how to add another comparator. Circuit can then be used to generate start and stop pulses applied to digital timer of digital voltmeter.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World,* Sept. 1973, p 447–448.



VOLTAGE-TO-FREQUENCY GO/NO-GO—Single UJT is used as V/F converter to provide completely isolated inputs and outputs for high-voltage go/no-go test monitor. When voltage exceeds predetermined limit, output to digital frequency counter exceeds corresponding frequency limit. Output can be fed directly into digital frequency-limit detector that provides go/no-go indication.—T. H. Li, VFC Used in Isolated GO/NO GO Voltage Monitor, *EDN Magazine,* July 5, 1974, p 75.

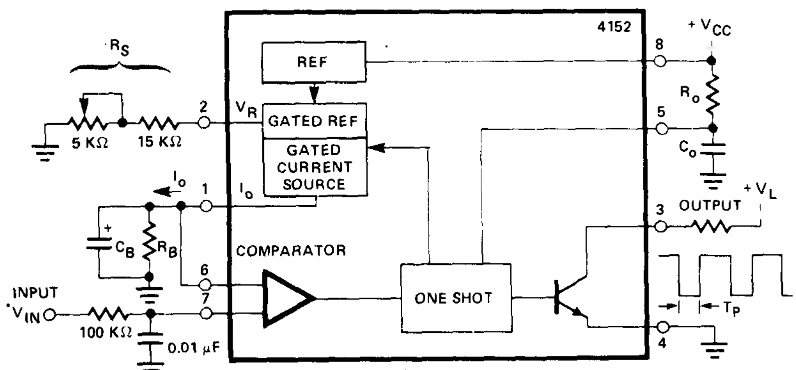


VOLTAGE TO FREQUENCY—Input voltage range of 0 to −10 VDC is converted by opamp and timer to proportional frequency with good linearity. Circuit is TTL-compatible. Accuracy is 0.2%.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 727–729.

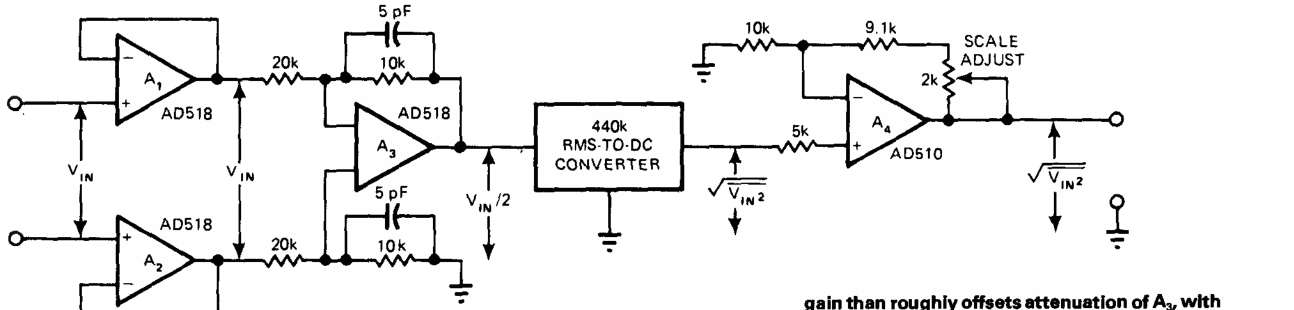


CURRENT TO VOLTAGE—Developed for use with current-output transducers such as silicon photocells. For widest frequency response, circuit values may need some adjusting for source current and capacitance. C_1, across feedback resistor of opamp, eliminates ringing around 500 kHz. If input coupling capacitor is added to reduce DC gain, circuit can be used with inductive source such as magnetic tape head.—R. S. Burwen, Current-to-Voltage Converter for Transducer Use, *EDN Magazine*, Dec. 15, 1972, p 40.

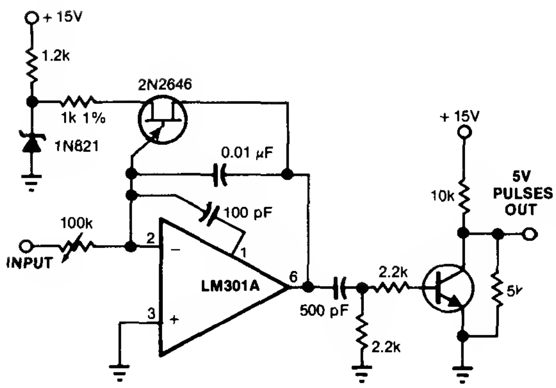
0.01–10 V to 1, 10, OR 100 kHz—Simple voltage-to-frequency converter uses Raytheon 4152 operating from single 15-V supply to convert analog input voltage to proportional frequency of square-wave output. Maximum output frequency depends on values used for resistors and capacitors, as given in table. Suitable for applications where input dynamic range is limited and does not go to zero.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-45–7-46.



Operating Range	R_o	C_o	R_B	C_B
DC to 1 kHz	6.8 KΩ	0.1 μF	100 KΩ	10 μF
DC to 10 kHz	6.8 KΩ	0.01 μF	100 KΩ	1.0 μF
DC to 100 kHz	6.8 KΩ	0.001 μF	100 KΩ	0.1 μF

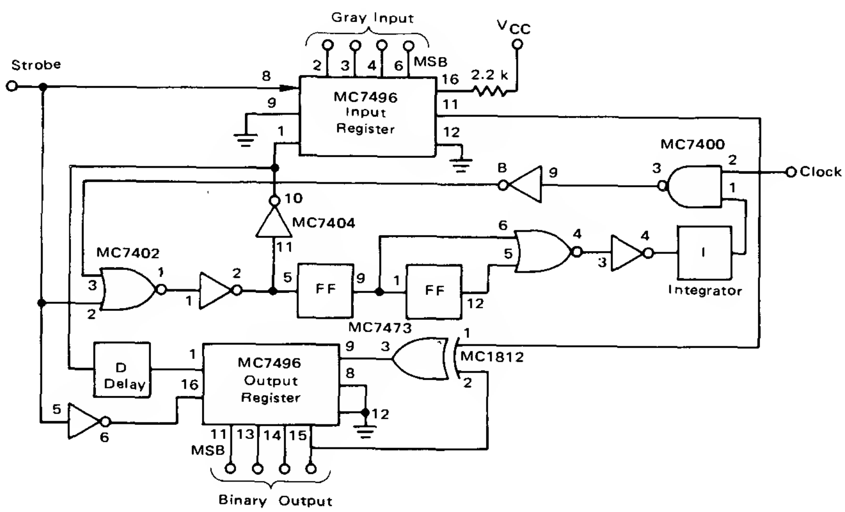


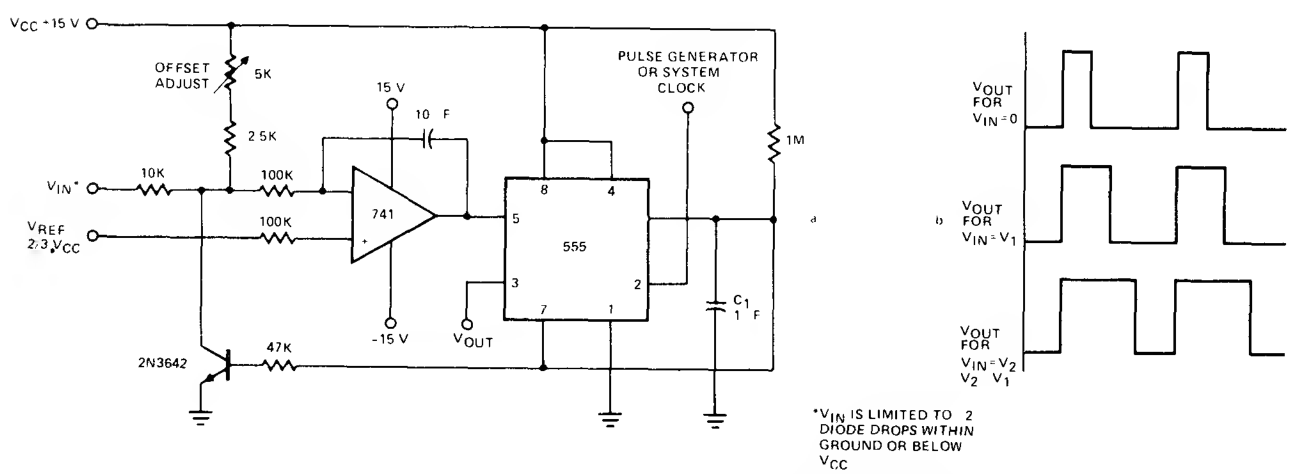
20-kHz SQUARE-WAVE TO DC—Provides accuracy within 0.1% for square-wave inputs of 3 to 7 VRMS in frequency range of 5 to 20 kHz when duty cycle is 50%. Opamps A_1 and A_2 are connected as differential input voltage-followers to provide high input impedance. A_3 converts to single-ended output as required by Model 440 converter IC. A_4 provides adjustable gain that roughly offsets attenuation of A_3, with 2K pot being adjusted to provide desired ratio of DC output voltage to RMS value of input.—J. Renken, Differential High-Z RMS-DC Converter Has 0.1% Accuracy, *EDN Magazine*, May 5, 1977, p 114 and 116.



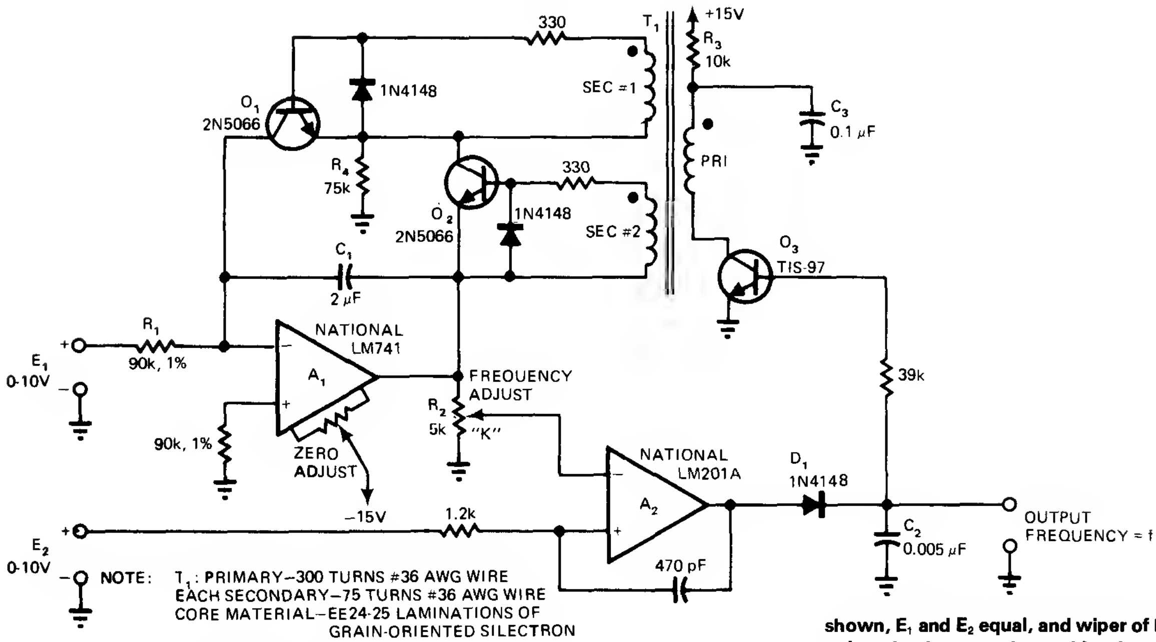
SINGLE-SLOPE V/F CONVERSION—UJT forms reference that detarminas reset point of LM301A integretor for converting enelog input voltage to proportional frequency. Output of integrator ramps negative until UJT switches and drives output positive at high slew rete. Positiva edge of integrator output is differentiated by RC network end leval-shifted by NPN bipoler transistor to provide logic-compatible pulse.—J. Williams, Low-Cost, Linaer A/D Conversion Uses Single-Slope Techniques, *EDN Magazine*, Aug. 5, 1978, p 101–104.

GRAY TO BINARY—Converts first 4 bits of Gray-code word to binary output. Uses two MC7496 shift registers and logic elements to transfer data serially from input registar through MC1812 EXCLUSIVE-OR IC to output register. One requirement is that stroba on pin 8 of Input register must completa its function before clock appears on pin 1 of register. When this and other timing conditions are satisfied, converter will work at spaeds up to about 10 megabits per second.—J. Barnes, "Analog-to-Digital Cyclic Converter," Motorola, Phoenix, AZ, 1974, AN-557, p 9.

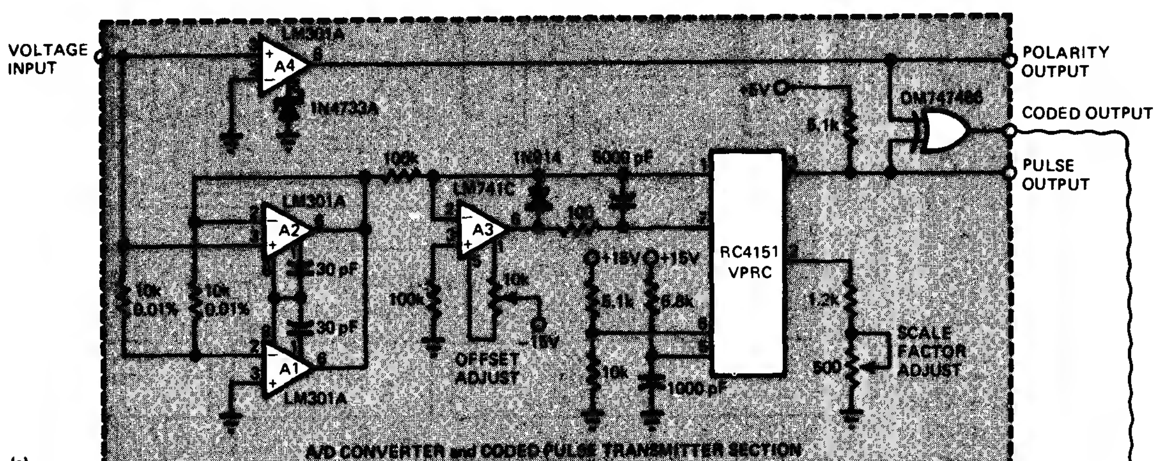




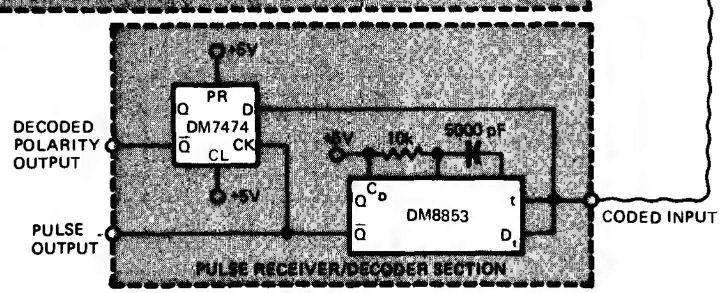
VOLTAGE TO PULSE WIDTH—Opamp end timer together convert input voltage level to width of output pulse with accuracy better than 1%. Output is at same fraquency as input.—"Signetics Anelog Date Manuel," Signetics, Sunnyvale, CA, 1977, p 726–727.



DIVIDING ANALOG VOLTAGES—Charge-and-dump V/F conversion technique is used to obtain quotient of two analog voltages digitally. Applications include measurement of total mass flow of gas under constant pressure. With Q_1 and Q_2 normally off, C_1 charges at rate proportional to input E_1, producing negative ramp at output of integrating opamp A_1. When R_2 wiper voltage exceeds E_2, output of A_2 goes high, turning on Q_3 and temporarily driving Q_1 and Q_2 into conduction. This process discharges C_1, resetting output of A_1 to zero. With values shown, E_1 and E_2 equal, and wiper of R_2 at midpoint, circuit output is 10,000 pulses per hour, suitable for driving electromechanical counter. Output frequency is proportional to average DC value of E_1 even when input changes rapidly.—H. L. Trietley, Voltage-to-Frequency Converter Performs Division, *EDN Magazine*, Jan. 5, 1978, p 79–80.

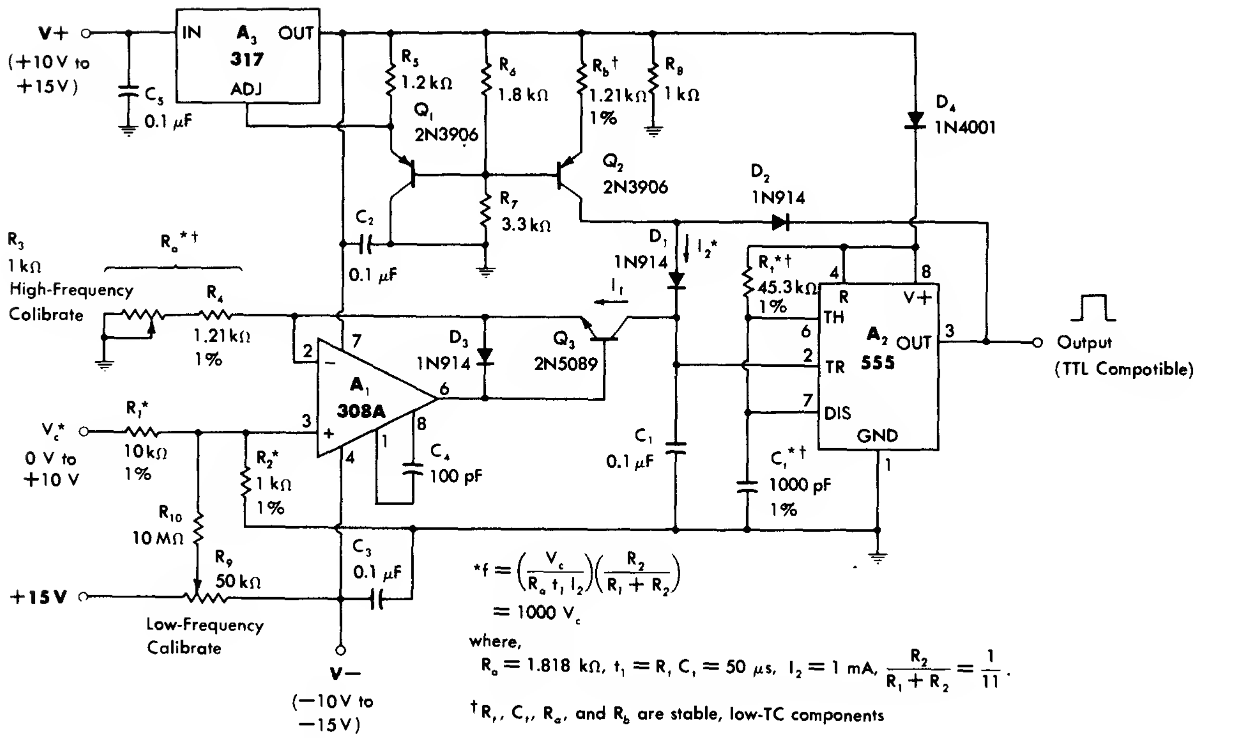


(a)



(b)

BIPOLAR OUTPUT—Low-cost voltage-to-frequency converter IC is here used in A/D converter circuit that will accept bipolar inputs and generate positive-going pulses to indicate positive input voltages and negative-going pulses for negative input voltages. Opamps A_1 and A_2 form negative-output absolute-value circuit that feeds opamp A_3 and RC4151 voltage-to-frequency converter, for generating 10-μs negative-going pulses with repetition-rate scale factor of 1 kHz/V. Full-scale input is 20 V P-P. Opamp A_4 is ground-referenced voltage comparator having zener clamp, providing TTL-compatible logic output for indicating input polarity. Pulse-receiver/decoder section takes digitally coded signals arriving from transmitter, for processing by date line of D flip-flop and two trigger inputs of dual-edge retriggerable mono MVBR. This generates 25-μs negative-going output pulse for each 10-μs input pulse from date line. Logic 1 on complementary output of flip-flop indicates that original input voltage to transmitter was positive.—E. J. DeWeth, Low-Cost A/D Converter Transmits and Receives, *EDN Magazine*, Jan. 5, 1977, p 35.



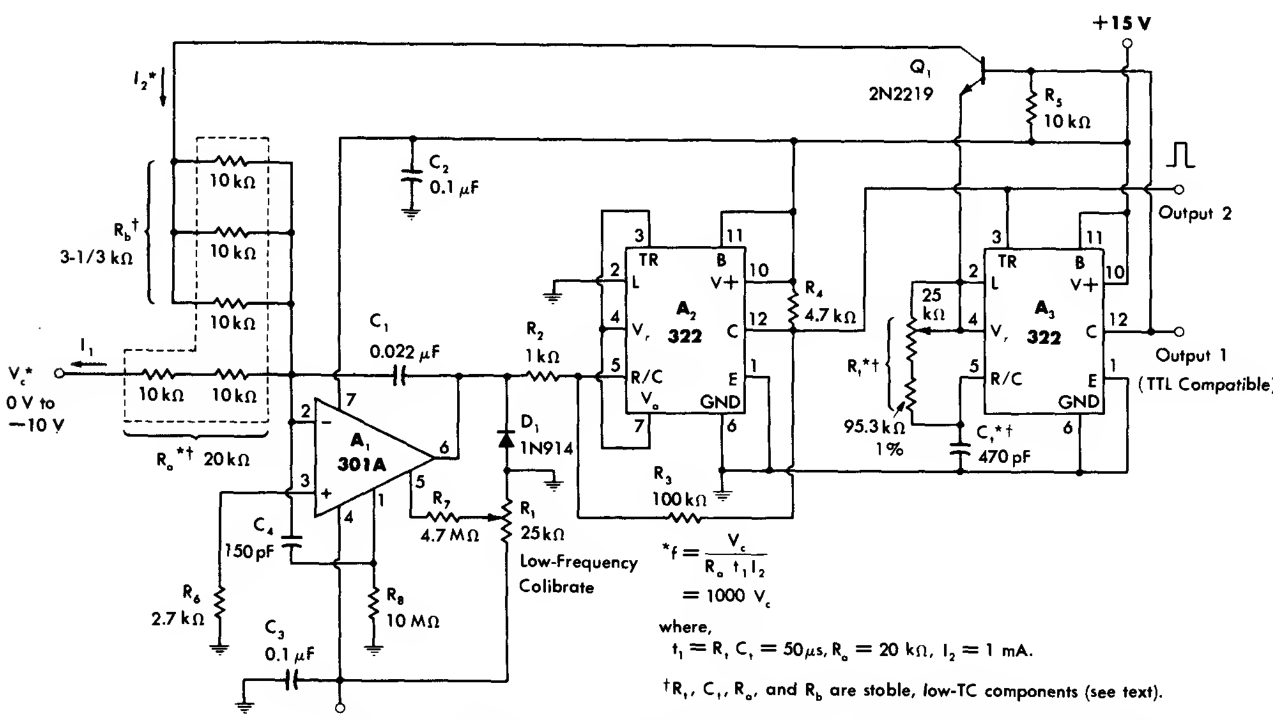
$$*f = \left(\frac{V_c}{R_a t_1 I_2}\right)\left(\frac{R_2}{R_1 + R_2}\right) = 1000\ V_c$$

where,

$R_a = 1.818$ kΩ, $t_1 = R_1 C_1 = 50$ μs, $I_2 = 1$ mA, $\frac{R_2}{R_1 + R_2} = \frac{1}{11}$.

†R_1, C_1, R_a, and R_b are stable, low-TC components

POSITIVE-INPUT V/F—Input voltages from 0 to 10 V ara divided by R_1 and R_2 for application to noninverting input of currant source A_1. 555 timer A_2 provides functions of precision mono MVBR and laval sensor. Regulator A_3 acts as gated currant source and provides stabilized voltaga output for 555 and 308A.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 184–192.



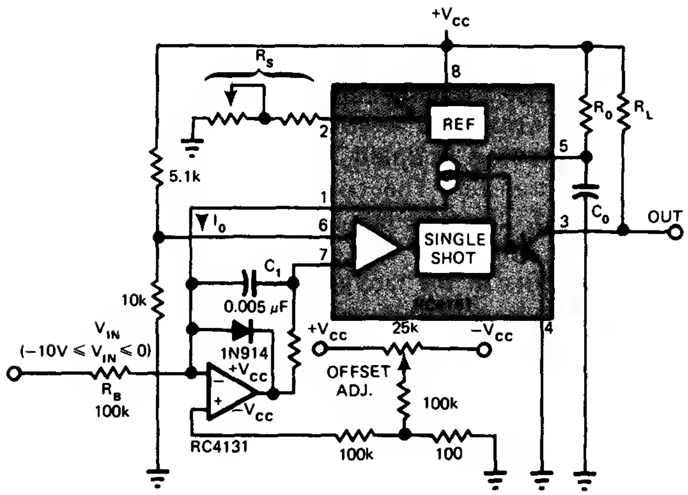
$$*f = \frac{V_c}{R_a t_1 I_2} = 1000\ V_c$$

where,

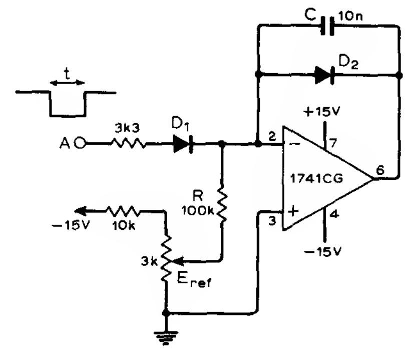
$t_1 = R_1 C_1 = 50$μs, $R_a = 20$ kΩ, $I_2 = 1$ mA.

†R_1, C_1, R_a, and R_b are stable, low-TC components (see text).

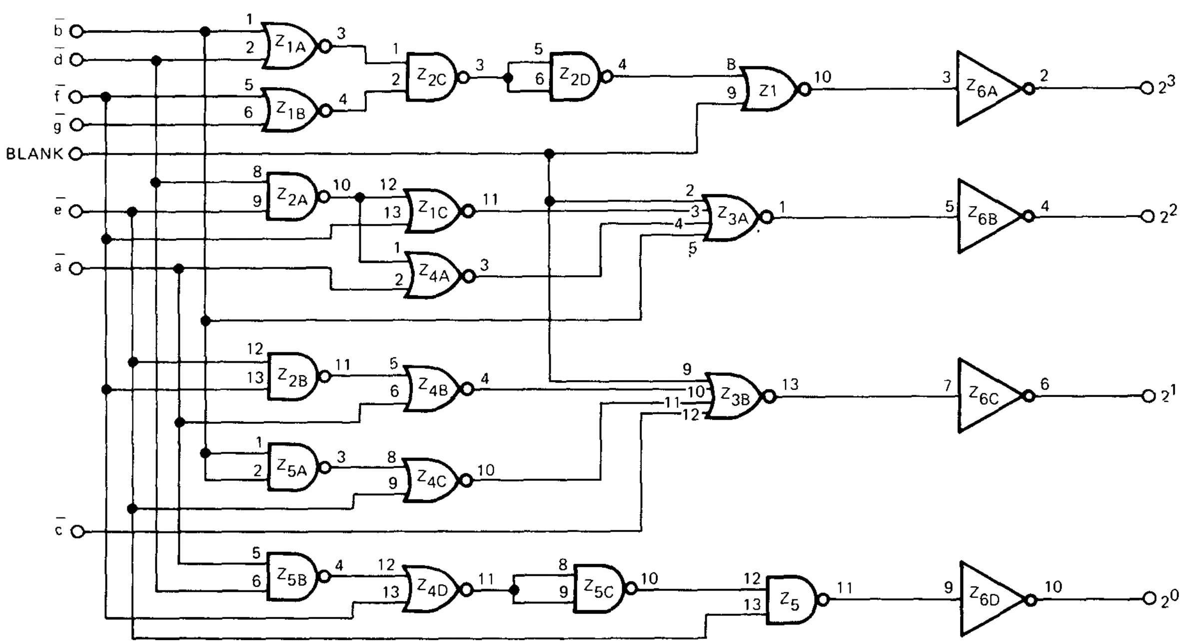
−10 V GIVES 10 kHz—Control voltage input in range of 0 to −10 V is converted linearly to frequency of digital output pulse train having full-scale value of 10 kHz. Intarnal regulation of circuit makes operation essentially independent of ±15 V supply level. A_1 is opamp integrator, A_2 is comparator, and A_3 is precision mono MVBR. Transistor switch Q_1 connects R_b to 3.15-V reference voltage during t_1 timing period of A_3.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 184–192.



V/F AND F/V—Although based on Raytheon 4151 IC voltage-to-frequency converter, circuit is readily adapted to other modern V/F converters now costing under $10 each. With values shown, input of 0 to −10 VDC provides proportional frequency change from 0 to 10 kHz at output. Design equations are given. Article also covers F/V operation of same IC for demodulating FSK data.—T. Cate, IC V/F Converters Readily Handle Other Functions Such as F/V, A/D, *EDN Magazine*, Jan. 5, 1977, p 82–86.

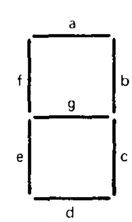


TIME TO VOLTAGE—Time period of negative gating signal determines amplitude of linear output ramp generated by integrator opamp. Amplitude of ramp, proportional to input time, is observed on calibrated screen of oscilloscope.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Sept. 1973, p 447–448.



DIGIT	BLNK.	$\bar{a}$	$\bar{b}$	$\bar{c}$	$\bar{d}$	$\bar{e}$	$\bar{f}$	$\bar{g}$	2^3	2^2	2^1	2^0
0	0	0	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	1	1	1	0	0	0	1
2	0	0	0	1	0	0	1	0	0	0	1	0
3	0	0	0	0	0	1	1	0	0	0	1	1
4	0	1	0	0	1	1	0	0	0	1	0	0
5	0	0	1	0	0	1	0	0	0	1	0	1
6	0	0	1	0	0	0	0	0	0	1	1	0
7	0	0	0	0	1	1	1	1	0	1	1	1
8	0	0	0	0	0	0	0	0	1	0	0	0
9	0	0	0	0	0	1	0	0	1	0	0	1
BLANK	1	X	X	X	X	X	X	X	1	1	1	X

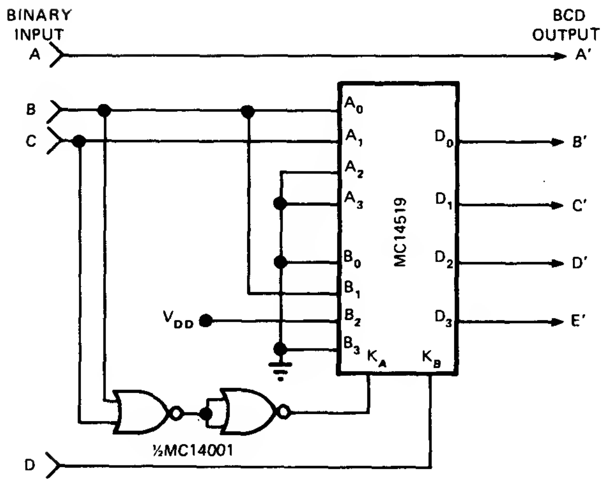
X = DON'T CARE
O = Ov (SEGMENT ACTIVE)
1 = +12V (SEGMENT OFF)



SEGMENT IDENTIFICATION

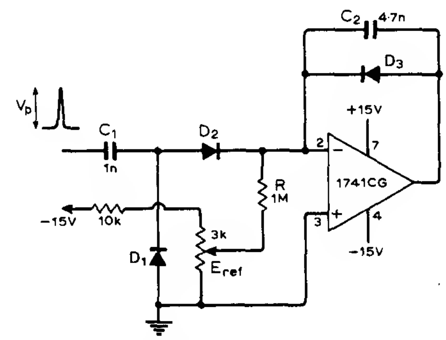
Z_1, Z_4	TYPE 4001	+12V PIN 14 GND PIN 7
Z_2, Z_5	TYPE 4011	
Z_3	TYPE 4002	
Z_6	TYPE 4009	+12V PIN 16 GND PIN 8 +5V PIN 1

7-SEGMENT TO BCD—Uses six CMOS packages to convert 7-segment display to corresponding four-line positive-logic BCD code for digits 0-9. Added feature is blank input which, when high, forces blank code (1110 or 1111) into readout, for use in suppressing leading zeros with some types of data storage. Use 4010 in place of 4009 for Z_6 when negative-logic BCD output is required.—R. Sturla, Real-Time 7-Segment to BCD Converter, *EDN Magazine*, June 20, 1973, p 89.

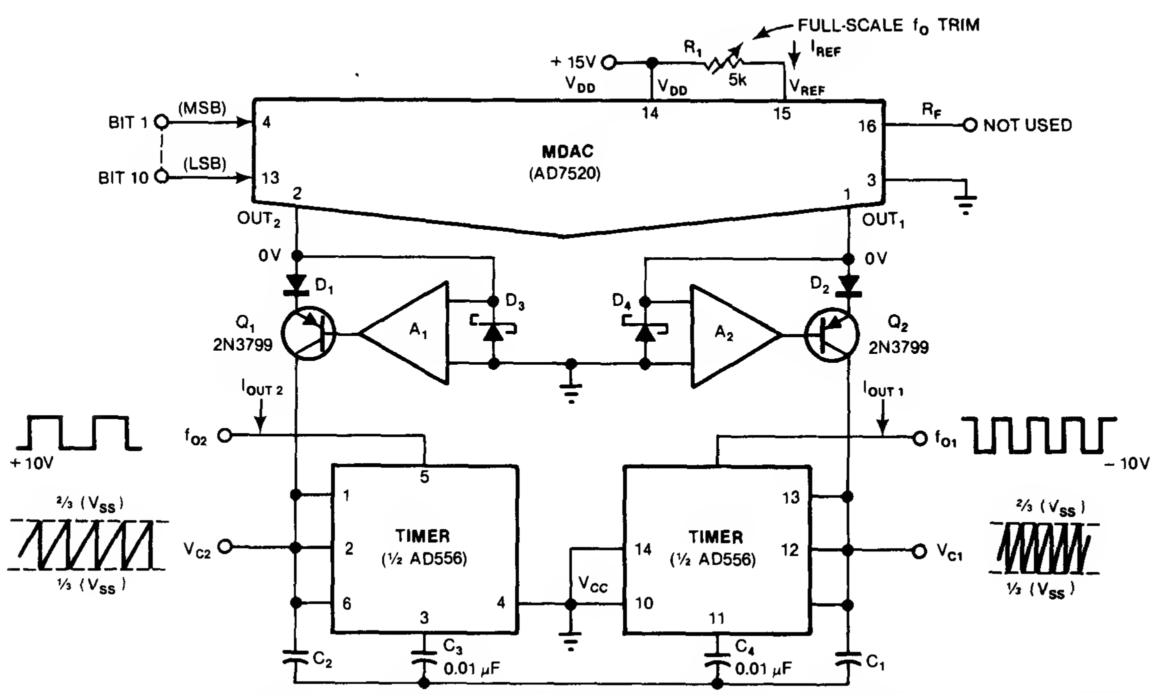


	CONTROL		MC14519 OUTPUTS				BCD OUTPUTS			
n'	K_A	K_B	D_0	D_1	D_2	D_3	B'	C'	D'	E'
0	0	0	0	0	0	0	0	0	0	0
1	1	0	A_0	A_1	A_2	A_3	1	0	0	0
2	1	0	"	"	"	"	0	1	0	0
3	1	0	"	"	"	"	1	1	0	0
4	0	1	B_0	B_1	B_2	B_3	0	0	1	0
5	1	1	$B_0 \oplus A_0$	$B_1 \oplus B_1$	$B_2 \oplus B_2$	$B_3 \oplus B_3$	0	0	0	1
6	1	1	"	"	"	"	1	0	0	1
7	1	1	"	"	"	"	0	1	0	1

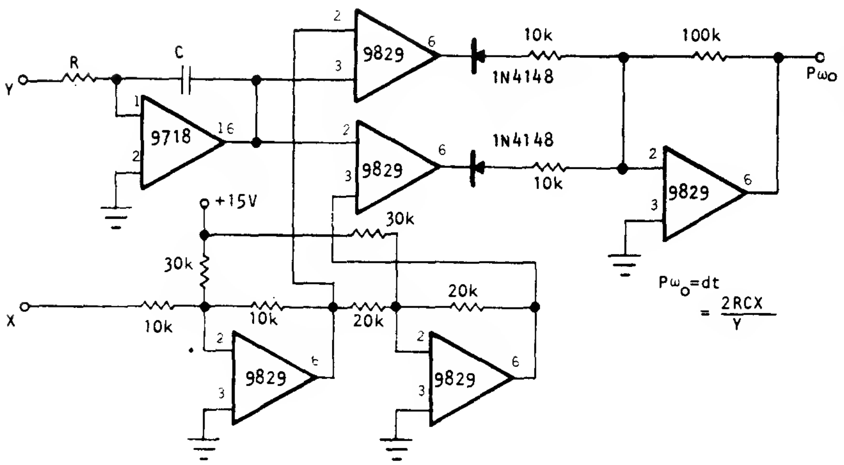
4-BIT BINARY TO 5-BIT BCD—Convarts binary number within machine to BCD value from 0 to 15, for driving visual displays. Requires only quad two-channel deta salector with EXCLUSIVE-NOR function, availabla in IC packagas. Articla gives truth tables end traces operation step by step.—J. Barnes and J. Tonn, Binary-to-BCD Converter Implaments Simple Algorithm, *EDN Magazine*, Jan. 5, 1975, p 56, 57, and 59.



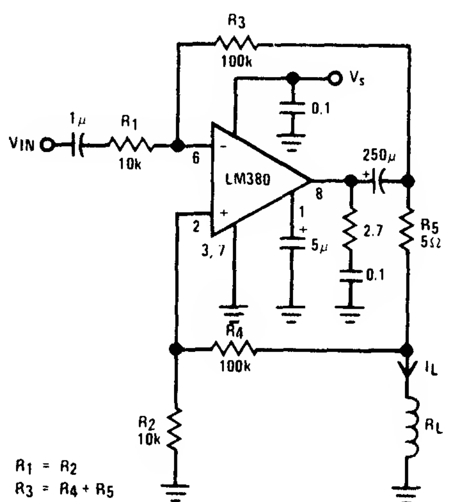
PULSE HEIGHT TO TIME—Simple opamp circuit produces time intervel proportionel to height of positiva input pulse. Opamp is connected as integrator whose output is held at about zaro by negative feedback through D_3. Positive input pulse charges C_1 and C_2, amplifiar output steps down, and D_3 is raverse-biased. Time for output to charga back up to zaro, as observed on oscilloscope, is then directly proportional to input pulsa height. Articla gives design equations.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Sept. 1973, p 447–448.



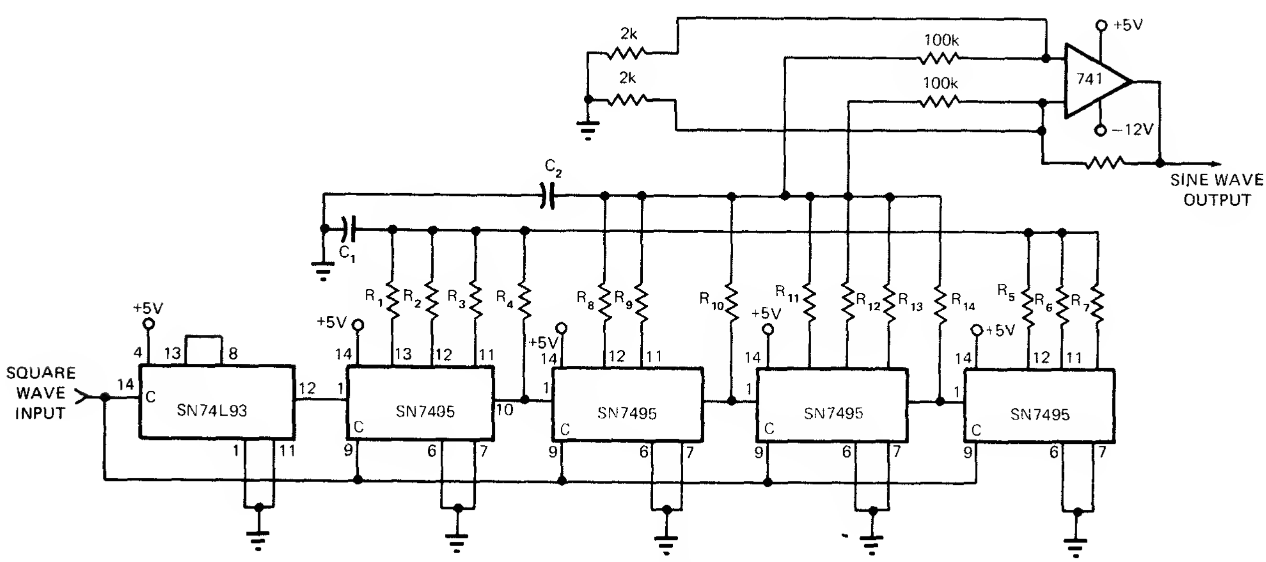
DIGITAL TO FREQUENCY—Combination of multiplying DAC and 556 dual timer providas complamentary output frequencies under control of digital input. Opamp and diode types are not critical. Output frequency of each timar depends on supply voltages, capacitor values, and setting of R_1.—J. Wilson and J. Whitmore, MDAC's Open Up a Naw World of Digital-Control Applications, *EDN Magazine*, Sept. 20, 1978, p 97–105.



VOLTAGE TO PULSE DURATION—Optical Electronics 9829 opamps are used as fast comparators and 9718 FET opamp as fast integrator to give high precision at high speed for converting analog voltage to pulse duration for such applications as A/D conversion, delta code generation, motor speed control, and pulse-duration modulation. Output pulse durations can be as short as 1 μs. Conversion linearity is better than 0.1%. Minimum pulse duration is 100 ns, and maximum dynamic range is 40 dB. Reference voltages are determined by X input; if X is 3 V, reference voltages differ by 6 V. Two 9829 opamps present reference voltages to two comparator opamps. Fifth 9829 sums comparator outputs and gives positive output.—"Voltage to Pulse Width Converter," Optical Electronics, Tucson, AZ, Application Tip 10230.



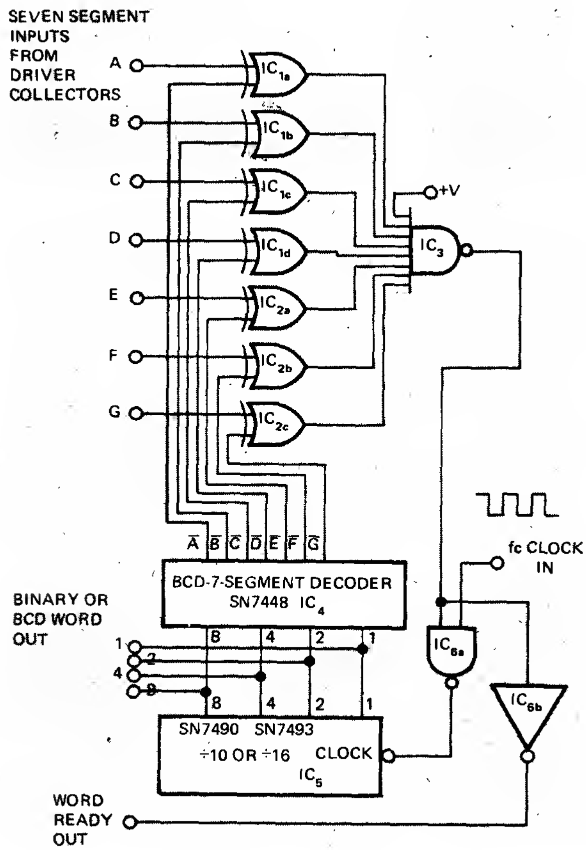
VOLTAGE TO CURRENT—Circuit is capable of supplying constant alternating current up to 1 A to variable load. Actual value of load current is determined by input voltage, values of R_1-R_3, and value of R_5. Input of 250 mV gives 0.5 A through load (RMS values) with less than 0.5% total harmonic distortion. Applications include control of electromagnet current.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-21–4-28.



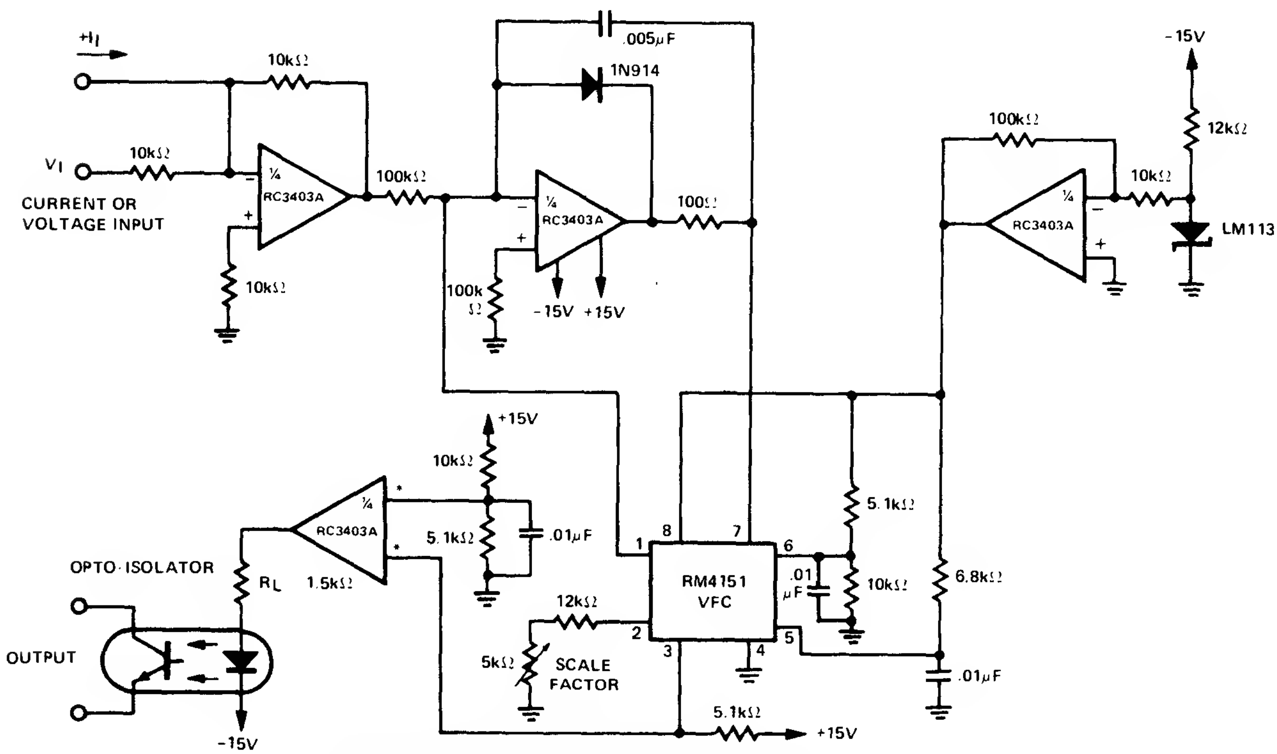
R_1, R_{11} = 10k $\quad R_3, R_6, R_9, R_{13}$ = 14.1k

R_2, R_7, R_{10}, R_{12} = 10.82k $\quad R_4, R_5, R_8, R_{14}$ = 26.1k

SQUARE TO SINE—Transversal digital filter suppresses harmonics present on input square wave, to give pure sine wave. Resistors weight data as it passes through 16-bit shift register, so sine wave is sampled at 16 times its frequency and theoretically has no harmonics below the 16th. Simple RC filter removes remaining harmonics. Input is clock whose repetition rate is 16 times desired frequency. SN74L93 4-bit ripple counter divides this down to provide square wave of desired frequency. Square wave is sampled 16 times per cycle and shifted down SN7495 16-bit shift register. C_1 and C_2 are selected to eliminate higher harmonics. Sine-wave output has harmonic distortion of less than −50 dB.—L. J. Mendell, Sine-Wave Synthesizer Has Low Harmonic Distortion, *EDN Magazine*, Aug. 15, 1972, p 52.

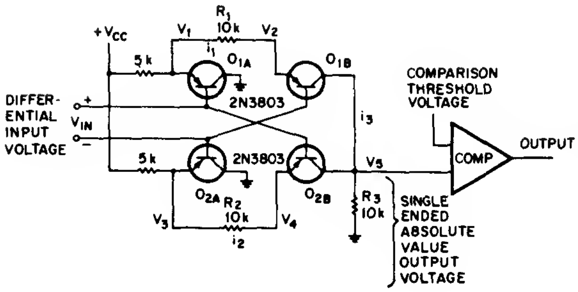


7-SEGMENT TO BCD—Arrangemant uses SN7448 BCD to 7-segment decoder IC_4 as lookup tabia for inverse decoding technique. When desired 7-segment coda is epplied to input of decodar and does not match output code from IC_4, gate IC_3 output is logic 1. This allows pulses from clock to advence BCD counter IC_5 until its decoded state from IC_4 matches thet of input code. With coincidence, output of IC_3 goes low, holding proper BCD code in IC_5 and indicating by meens of IC_{6b} thet BCD information is ready. With 100-kHz clock, correct code is availeble for at least 90% of digit display tima.—J. P. Cater, 7-Segment to BCD Decoder, *EDN Magazine*, Feb. 20, 1973, p 92–93.



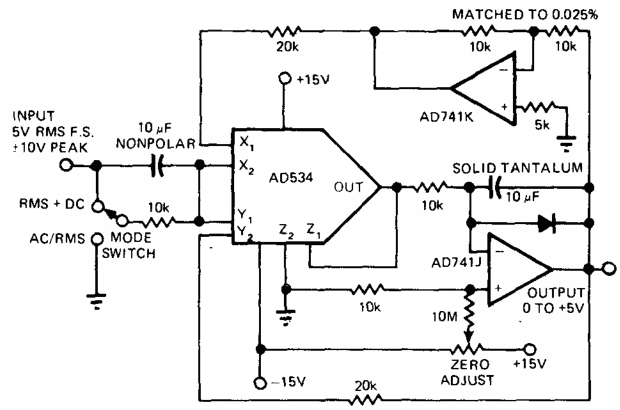
*POLARITY DETERMINED BY DESIRED LED RESPONSE; I.E., LED ON FOR DATA HIGH, OR LED HIGH FOR DATA LOW.

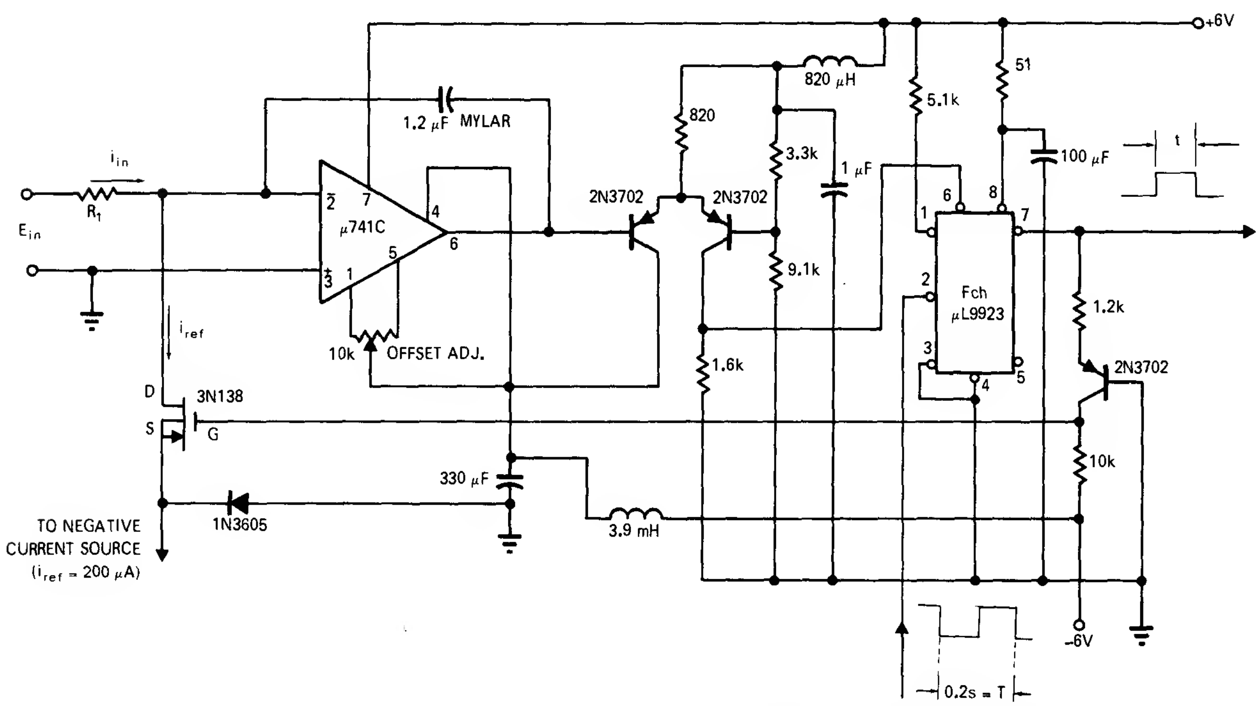
OPTICALLY COUPLED V/F—Input voltage range of 0–10 V is converted to proportionel frequency at output of optoisolator with high linearity by RM4151 converter used in combination with RC3403A quad opamp that provides functions of inverter, integrator, regulator, end LED driver.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-40–7-41.



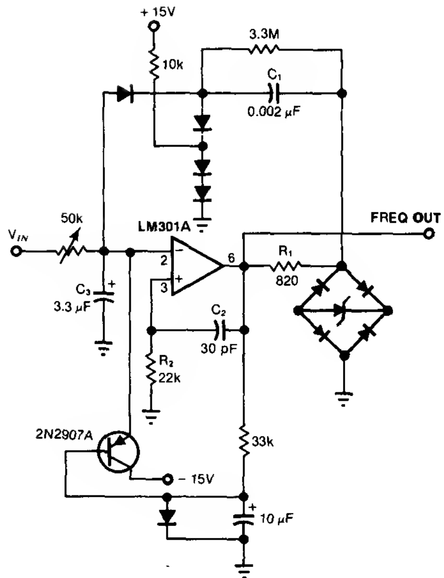
DIFFERENTIAL TO ABSOLUTE VALUE—Used in comparing differentiel level to threshold level with good common-mode rejection. Input impedance is meinteined high to avoid overloeding differentiel input. Output voltege remeins positive when input polerity is reversed.—R. L. Wiker, Differentiel to Absolute Velue Converter, *EEE Magazine*, Jen. 1971, p 65.

RMS TO DC—Single AD534 enelog multiplier and two opemps compute RMS velue of input signal es squere root of sum of squares. Input is first squered et X_2 end Y_1, then time-everaged by integrator. Closing output loop beck to X_1 end Y_2 completes squere-rooting function. Crest fectors up to 10 do not apprecieblv effect eccurecy es long es input limits of multiplier ere not exceeded. Accurecy is mainteined up to 100 kHz. Article gives calibration procedure.—R. Frentz, Anelog Multipliers—New IC Versions Manipulate Reel-World Phenomene with Ease, *EDN Magazine*, Sept. 5, 1977, p 125–129.

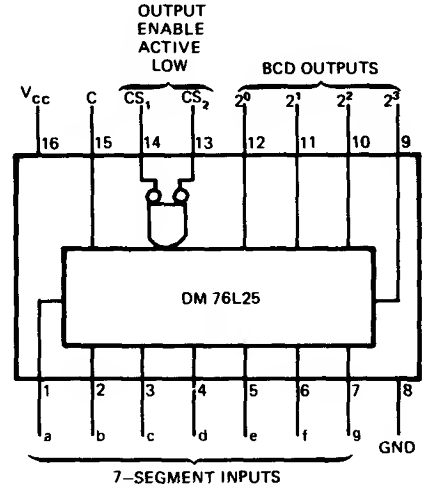




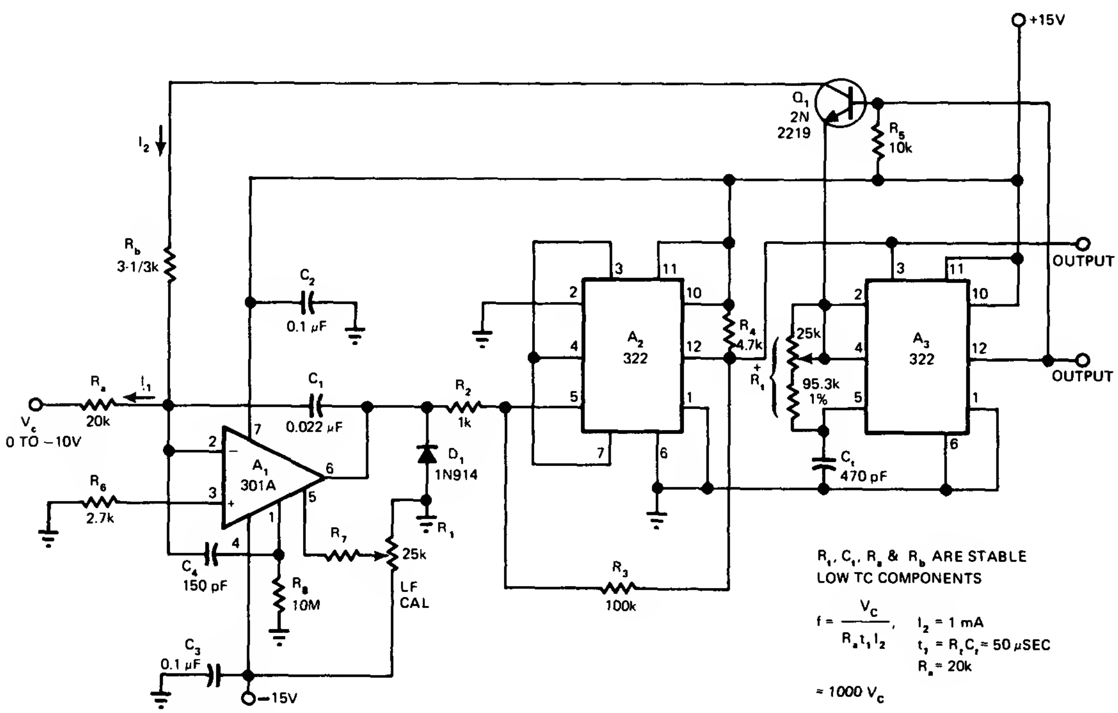
ANALOG TO PULSE WIDTH—Stripped-down version of duel-slope A/D converter integretes input current constently but switches reference current into integretor each time clock pulse occurs. Accurecy of 0.1% mekes circuit suiteble for use in digitel voltmeter. Reference current is switched out of integrator when output voltege reeches +4.5V. With velues shown, using 100 kilohms for R_1, maximum input current is 80 μA end full-scale voltage is 8 V. Article includes timing diegrem end design equetions.—N. A. Robin, Anelog-to-Pulse-Width Converter Yields 0.1% Accuracy, *EDN Magazine*, Nov. 1, 1970, p 42–43.



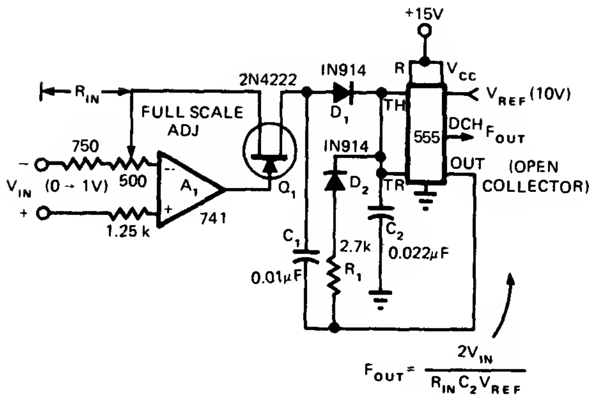
CHARGE-DISPENSING V/F CONVERSION—Output state of opamp switches C_1 between reference voltage provided by diode bridge and its inverting input. Network R_2-C_2 reinforces direction of opamp output change. Circuit can deliver 0–10 kHz output with 0.01% linearity for 0–10 V input.—J. Williams, Low-Cost, Linear A/D Conversion Uses Single-Slope Techniques, *EDN Magazine*, Aug. 5, 1978, p 101–104.



BCD FROM 7-SEGMENT DISPLAY—Single National DM76L25 read-only memory provides conversion from 7-segment outputs of MOS chip driving display to BCD inputs for data processing. Typical power dissipation is 75 mW. Access time is 70 ns when using 5-V supply. Article gives truth table for all standard and special characters of 7-segment display.—U. Priel, 7-Segment-to-BCD Converter: The Last Word?, *EDN Magazine*, Aug. 20, 1974, p 94–95.

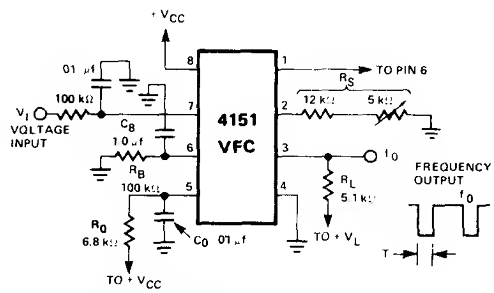


VOLTAGE-TO-FREQUENCY USING IC TIMERS—Two 322 IC timers and single 301A opamp provide all functions required for charge-balancing type of voltage-to-frequency converter, including integrator, level sensor or comparator, precision mono, and gated current source. Circuit accepts control voltage inputs of 0 to −10 V, corresponding to output pulse stream range of 0 to 10 kHz. Article describes operation in detail. R_4 should be 4.7 megohms. Output pulses of comparator A_2 trigger mono A_3, which generates pulse having duration t_1 that saturates Q_1, to force reference current I_2 into summing point of opamp integrator.—W. G. Jung, Take a Fresh Look at New IC Timer Applications, *EDN Magazine*, March 20, 1977, p 127–135.



V/F GIVES 10 to 10,000 Hz—Current proportional to input voltage is balanced via periodic charging of C_1 to precisely repeatable voltage by opamp A_1 and FET Q_1. With values shown, nominal scale factor is 10 kHz/V. Input of 0 to 1 V gives output of 10 to 10,000 Hz with better than 0.05% linearity. Article gives operating details and design equations.—W. S. Woodward, Simple 10 kHz V/F Features Differential Inputs, *EDN Magazine*, Oct. 20, 1974, p 86.

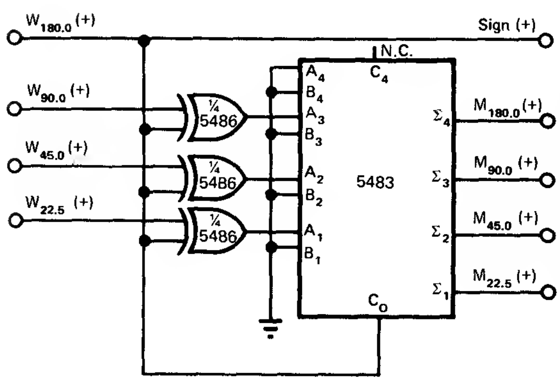
0–10 VDC TO 0–10 kHz—Single-supply voltage-to-frequency converter produces square-wave output at frequency varying linearly with input voltage. Linearity error is typically only 1%. For values shown, response time for step change of input from 0 to +10 V is 135 ms. Uses Raytheon 4151 converter. Supply can be 15 V.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-38.



DESIGN EQUATIONS

$f_0 = KV_I$ Where $K = 0.486 \frac{R_S}{R_BR_OC_O} \frac{kHz}{V}$

$T = 1.1 R_OC_O$

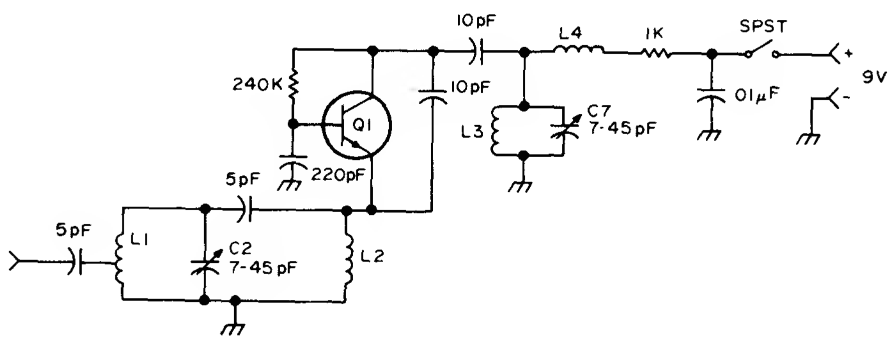


0–360° to 0–180°—Used for converting angular information in 360° wrap-around code to ±180° sign-plus-magnitude code. For values under 180°, converter outputs and inputs are identical. For larger input angles, output code is complement of input plus one. Used for interfacing shaft encoders and synchro-to-digital converters to digital display. Article gives truth table showing which lines are high and which are low at input and at output for angular increments of 22.5°.—J. N. Phillips, Convert Wrap-Around Code to Sign-Plus-Magnitude, *EDN Magazine*, Jan. 5, 1973, p 103.

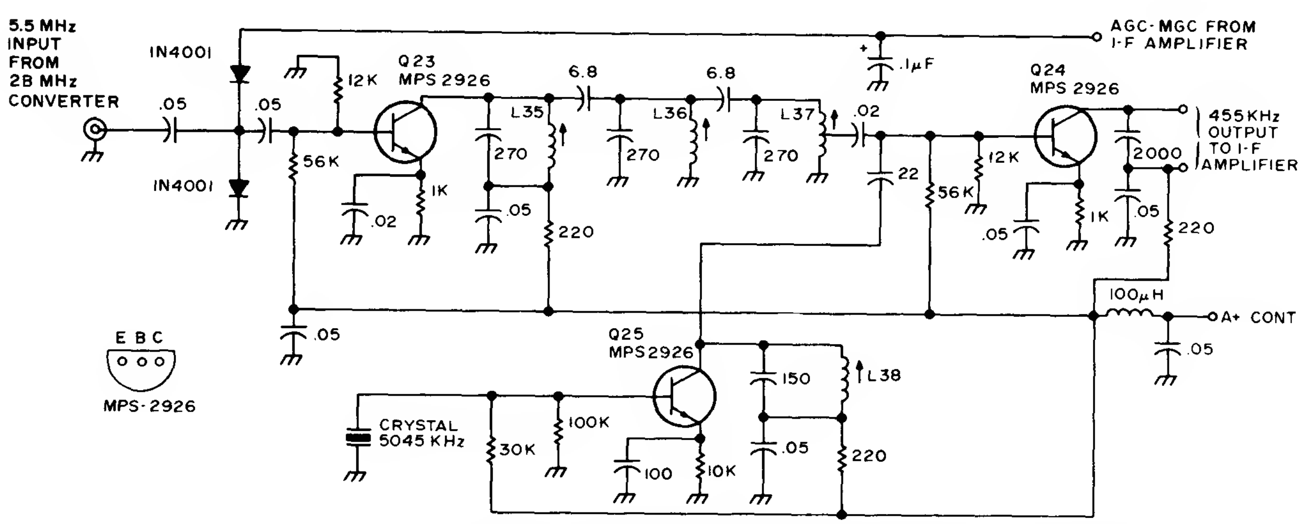
CHAPTER 20

Converter Circuits—Radio

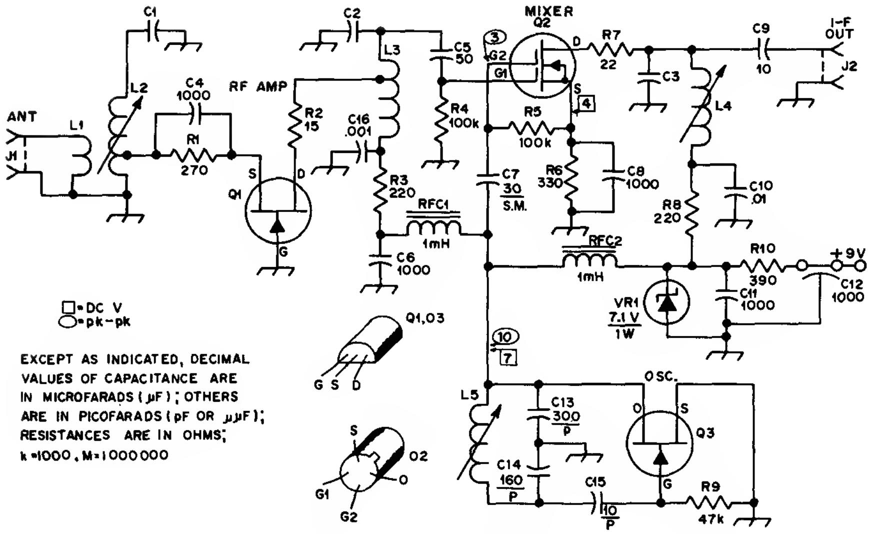
Various combinations of RF oscillator and mixer circuits convert wide range of incoming long-wave and shortwave signals to correct input or intermediate frequencies for broadcast or communication receivers not originally covering those bands.



120–150 MHz FOR TRANSISTOR RADIO—Values shown cover bands for aircraft radio, 2-m amateur radio band, and other services. Circuit is ragenerative converter, with incoming signal tuned by L1-C2 and mixed in 2N2222 or equivalent transistor connected as oscillator with frequency controlled by L3 and C7. Differance frequency is adjusted to fall in standard broadcast band, for pickup by radio whan convertar is mounted closa to ferrita loop. For local stations, antenna of converter can ba 19-in length of wira. L2 and L4 are 100-μH chokes or about 20 in of fine wire wound on 100K resistor.—S. Kally, Simpla VHF Monitor, *73 Magazine*, July 1976, p 160.



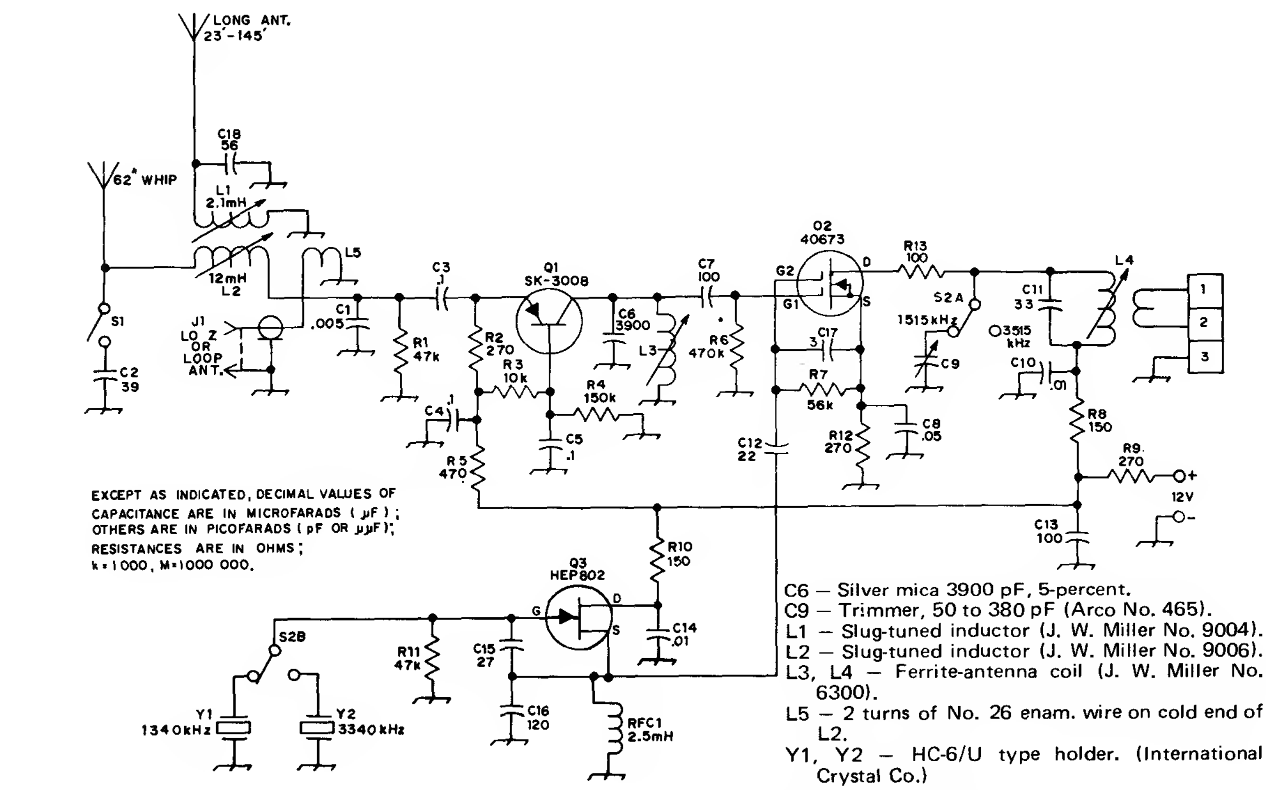
5.5 MHz TO 455 kHz—Developed for use as second converter in all-band double-conversion superhatarodyna receivar for AM, narrow-band FM, CW, and SSB operation. IF amplifier Q23 is followed by triple-tuned filter feeding second mixer Q24, with Q25 as crystal oscillator. Supply is 13.6 V regulated. Articla gives all circuits of raceivar.—D. M. Eisanberg, Build This All-Band VHF Raceiver, *73 Magazine*, Jan. 1975, p 105–112.



	C1 – C2	C3	L1	L2 – L3	L4
10 MHz	90 pF	22 pF	2-1/2 turns No. 24 enamel over L2.	Same as L5*	Same as L5*
15 MHz	43 pF	300 pF	1-1/2 turns No. 24 enamel over L2.	Same as L5*	5.5 μH (nom.) Miller 46A566CPC
25 MHz	22 pF	48 pF	1-1/2 turns No. 24 enamel over L2	1.8 μH (nom.) Miller 46A186CPC	Same as L5*

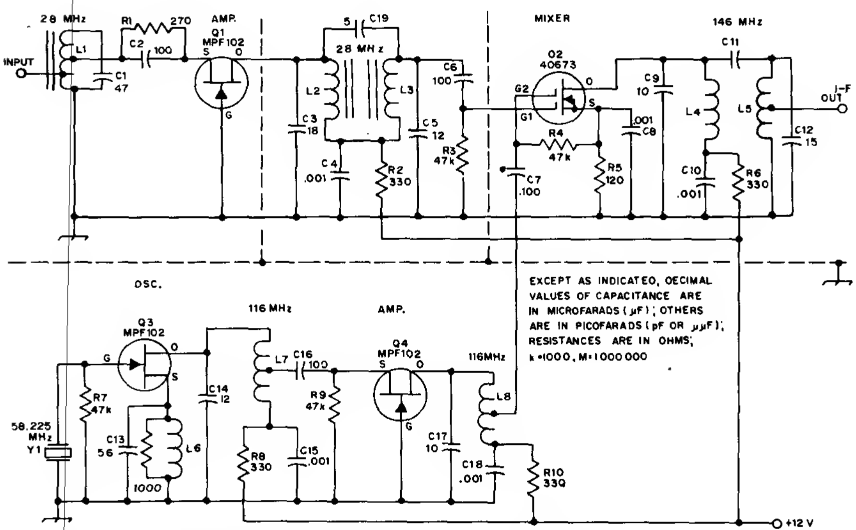
*L5 – 2.42-2.96 μH, Miller 46A276CPC

WWV CONVERTER—Designed for use with amateur receiver for reception of NBS stations WWV or WWVH on 10, 15, or 25 MHz. Receiver is tuned to 4, 14, or 21 MHz to serve as IF amplifier, detector, and audio stages. Current drain of converter is 15 mA, low enough for operation from 9-V transistor-radio battery. Table gives tuned-circuit values for frequency desired. Restriction to single frequency eliminates bandswitching. Q1 can be any common-gate JFET RF amplifier providing 8-dB gain. Mixer is 40673 MOSFET. Oscillator transistor is not critical. Oscillator output serves for all three WWV frequencies.—C. Wetts, NBS—Ears for Your Ham-Band Receivers, *QST*, June 1976, p 25–26.



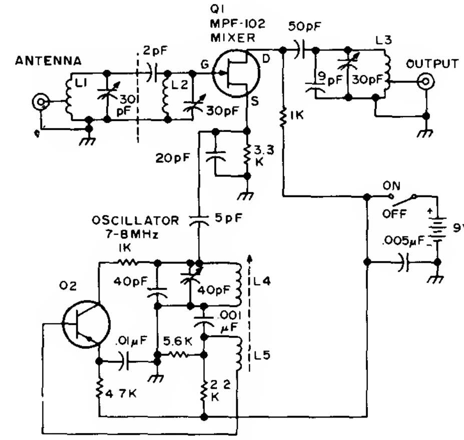
C6 — Silver mica 3900 pF, 5-percent.
C9 — Trimmer, 50 to 380 pF (Arco No. 465).
L1 — Slug-tuned inductor (J. W. Miller No. 9004).
L2 — Slug-tuned inductor (J. W. Miller No. 9006).
L3, L4 — Ferrite-antenna coil (J. W. Miller No. 6300).
L5 — 2 turns of No. 26 enam. wire on cold end of L2.
Y1, Y2 — HC-6/U type holder. (International Crystal Co.)

175 kHz TO 1515 OR 3515 kHz—Crystal-controlled VLF converter covering 1750-meter band gives choice of two outputs, selected by S2, for communication or broadcast receiver. Tuning range is 160 to 190 kHz. Connect general-coverage receiver to IF output terminals with length of coax.—J. V. Hagan, A Crystal-Controlled Converter and Simple Transmitter for 1750-Meter Operation, *QST*, Jan. 1974, p 19–22.

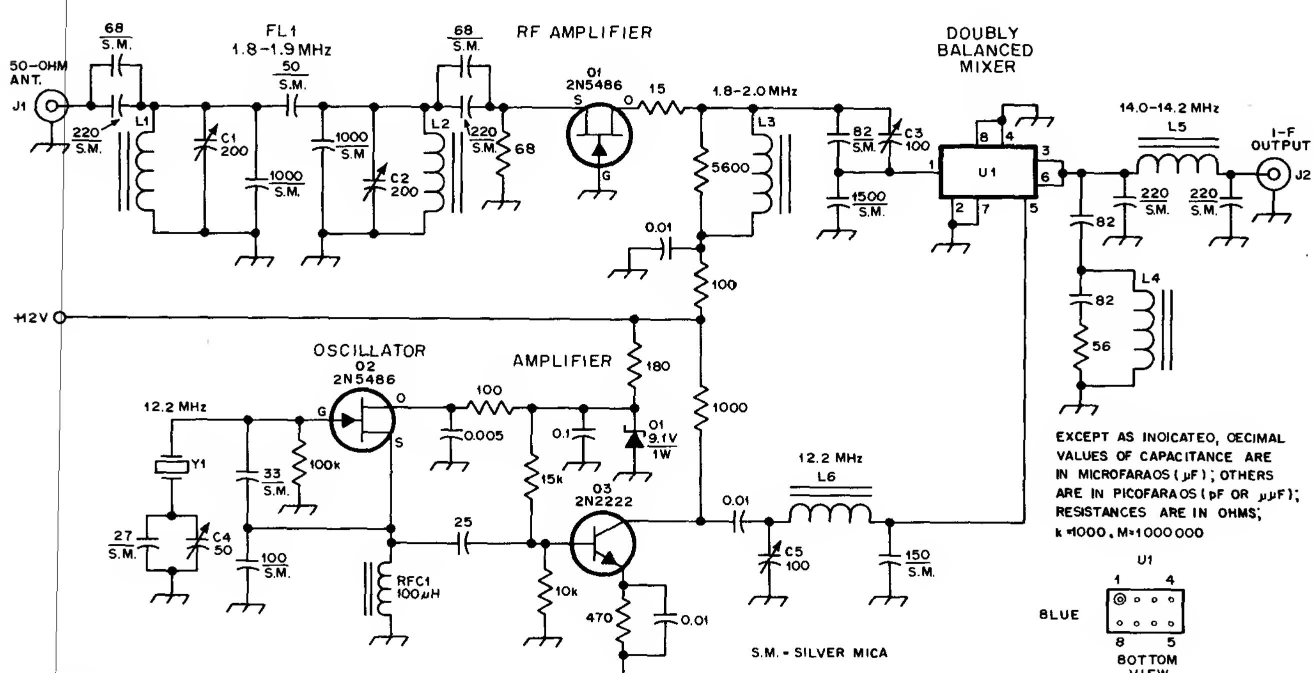


C11 — Two 1/2-inch pieces. No. 18 insulated hookup wire, twisted together 1/2 turn.
L1, L2, L3 — 18 turns No. 28 enam. wound on Amidon T-30-6 core. L1 tapped at 6 turns and 11 turns from ground end.
L4, L5 — 5 turns No. 20 enam., formed by using threads of 1/4-20 bolt as a guide. L5 is tapped 2 turns from the ground end.
L6 — 10 turns No. 24 enam. close wound on the body of a 1000-ohm 1/2-watt resistor.
L7, L8 — 5 turns No. 20 enam., formed the same as L4. Both are tapped 2 turns from the hot end.
Y1 — 58.225-MHz crystal. International Crystal third-overtone type in FM-1 (wire leads) or FM-2 (pins) holder.

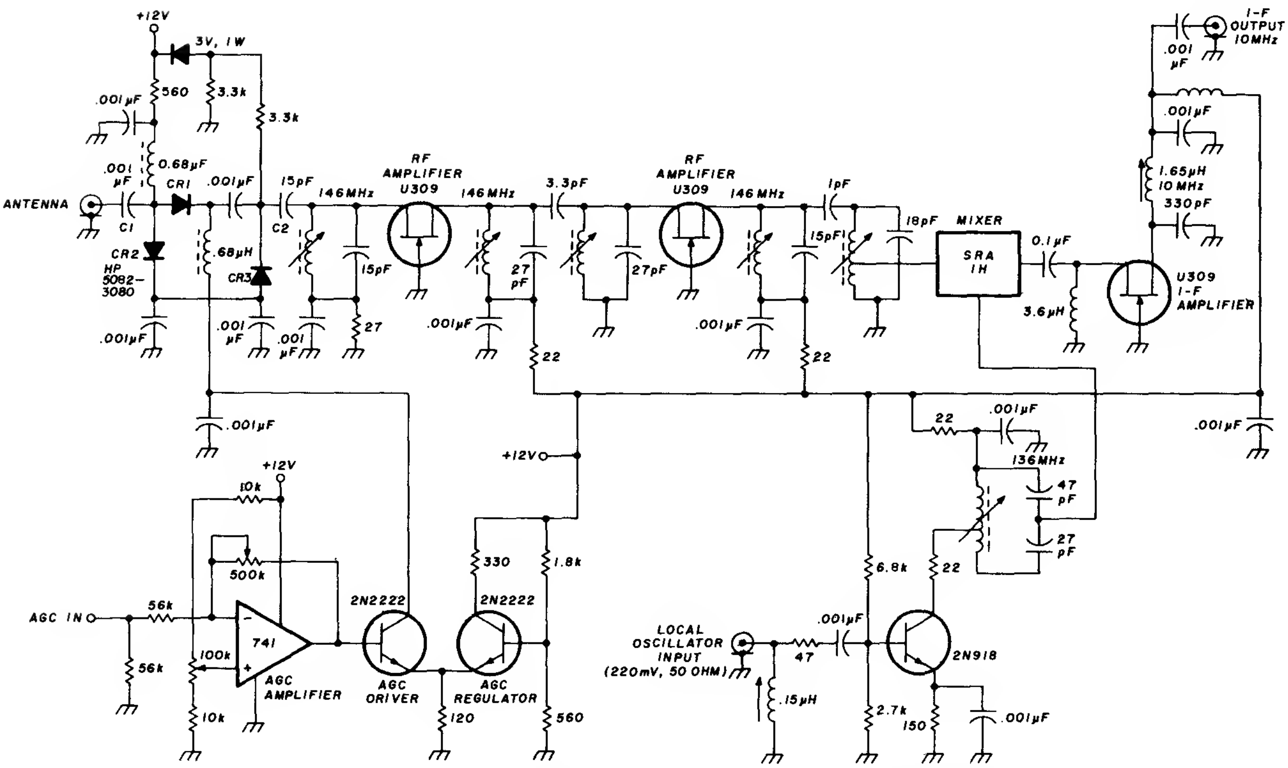
28 MHz TO 144 MHz—Addition of small upconverter to 144-MHz (2-meter) SSB transceiver permits reception of 10-meter signals from Oscar satellite on single transceiver. Output of mixer, between 145.85 and 145.95 MHz, is fed to antenna terminal of receiver.—T. McMullen, An Up Converter for Oscar Reception, *QST*, March 1975, p 41–44.



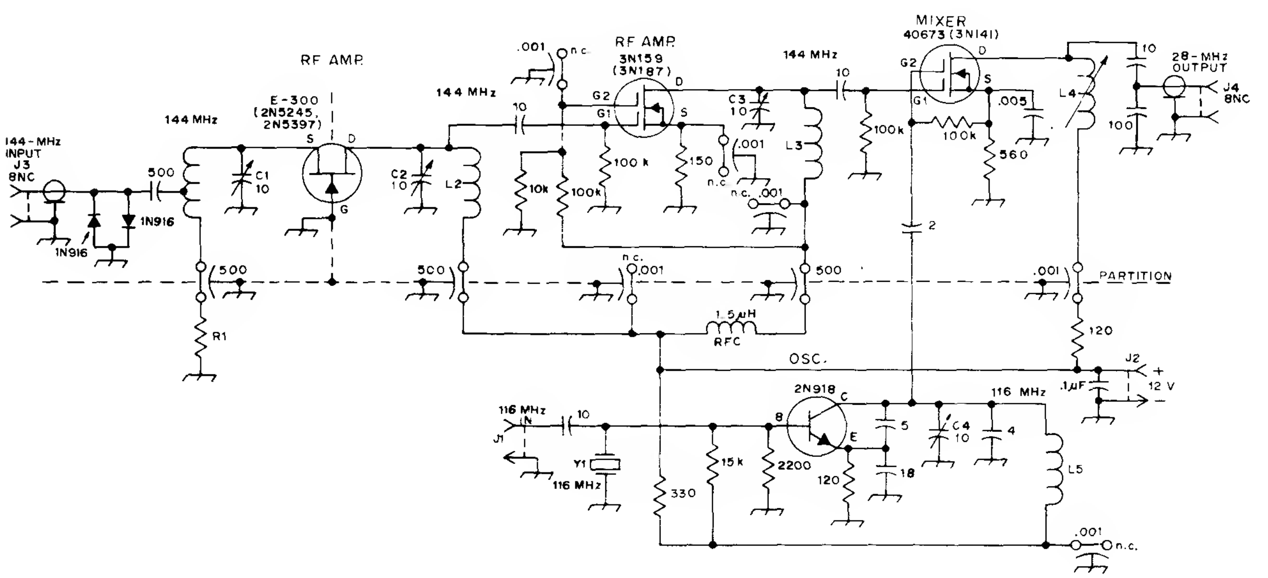
152–165 MHz TO 146.94 MHz—Permits listening to public service band with any good 2-meter FM receiver or transceiver. Local oscillator has tuning range of 7–8 MHz and uses germanium PNP high-frequency transistor. No RF stage is needed for full quieting from stations 10 miles away when using ground-plane antenna. To avoid burning out converter, do not transmit while converter is connected to transceiver. Article gives coil-winding data.—H. Schoenbach, Public Service Band Converter, *73 Magazine*, Dec. 1974, p 78–79.



160-METER CONVERTER—Designed for use with receiver covering 20-meter band. Uses up-conversion techniques to get from 1.8 MHz of 160-meter band to 14-MHz tunable IF of receiver. Butterworth bandpass filter at input of converter covers 1.8–1.9 MHz. L1 and L2 each have 31 turns No. 22 enamel on T68-6 toroid core to give 5.1 μH. L3 is 50 μH, using 66 turns No. 18 enamel on T68-1 toroid. Other three coils each use T50-6 toroid core, with L4 having 7 turns No. 24 enamel, L5 11 turns No. 24 enamel, and L6 26 turns No. 28 enamel. U1 is SRA-1, CM-1, or ML-1 diode-quad double-balanced mixer module.—M. Arnold and D. DeMaw, Build This High-Performance Top-Band Converter, *QST*, Oct. 1978, p 22–24 and 38.

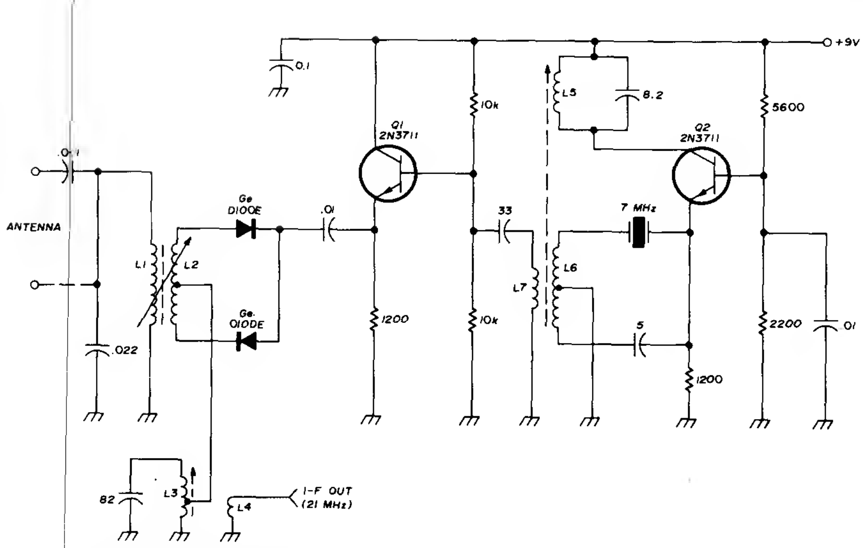


2-METER FOR 10-MHz IF—Designed for extrame linearity and selectivity whila kaaping noise figure below 5 dB. Circuit has +15 dBm intercept point and 16-dB power gain. Fiva tuned circuits at input frequency giva overall bandwidth of 4 MHz, with image suppression of 60 dB for 10-MHz IF and 80 dB for 30-MHz IF. Converter uses grounded-gate FET circuit.—U. Rohde, High Dynamic Range Two-Meter Converter, *Ham Radio*, July 1977, p 55–57.



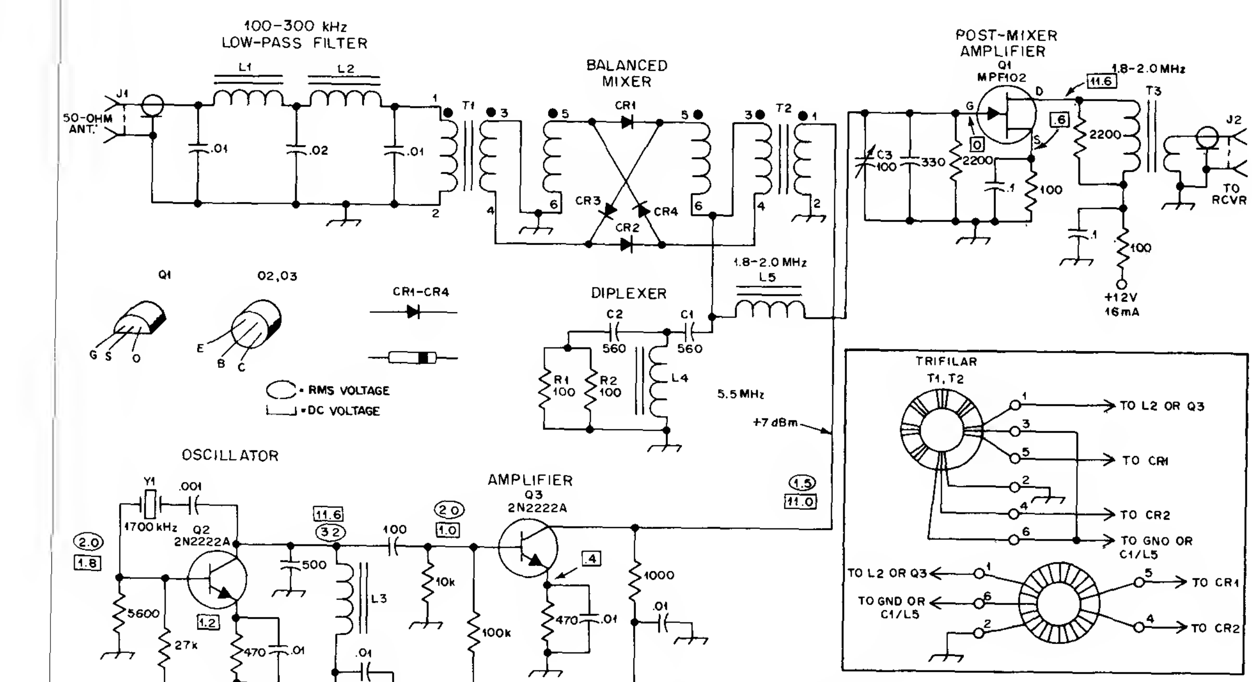
144 MHz TO 28 MHz—Brings 2-metar band to input ranga of ordinary amateur receivar. Crystal eliminates need for multiplier stages that can ganerate spurious responses. Signal can be injected from axternal source if crystal is removed.—Construction Hints for VHF Convartars, *QST*, Sept. 1975, p 32–33 and 39.

C1-C4, incl. — 10-pF tubular ceramic trimmer (Centralab 829-10).
L1 — 6 turns No. 16, 3/8-inch dia, spaced wire dia. Tap at 2-1/2 turns from bypassed end, or for best noise figure.
L2 — 4-3/4 turns, like L1.
L3 — 4 turns No. 22, 1/4-inch dia, 5/16 inch long.
L4 — 2.7 to 4.2-µH slug-tuned coil (Miller 4307).
R1 — Adjust for 5 mA drain current, or lowest noise figure. Final value in original unit, 220 ohms.
Y1 — 116-MHz overtone crystal (International Crystal Mfg. Co.).



L1,L2	magnetically tuned inductor (see text)	L5	15 turns no. 20 on ¼" (6-mm) slug-tuned form
L3	10 turns no. 20 on ¼" (6-mm) slug-tuned form, tapped 5 turns from cold end	L6	4 turns no. 20, center tapped, around cold end of L5
L4	2 turns no. 20 around cold end of L3	L7	2 turns no. 20 around cold end of L5

TUNABLE VLF—Gives tuning range of 10 kHz to 150 kHz without bandswitching, for WWV transmissions on 20 and 60 kHz and for operation on no-license amateur band around 1750 meters. Uses inductive tuning with toroidal ferrite core L1-L2 that is magnetically biased by pair of ½-inch diameter button-type permanent magnets. Rotating one of magnets with respect to other varies flux through toroid, changing its permeability and inductance. Toroid uses 100 turns of stranded wire to give inductance variation from 100 μH to 12 mH (120:1 range). Ferrite cores with higher permeability require fewer turns. Converter output on 15 meters feeds into communication receiver. Local oscillator uses FT-243 7-MHz crystal in third-overtone mode to give 21 MHz. Antenna is directly coupled or coupled through capacitor to improve matching to long antenna.—G. Ruehr, Tuned Very Low-Frequency Converter, *Ham Radio,* Nov. 1974, p 49–51.

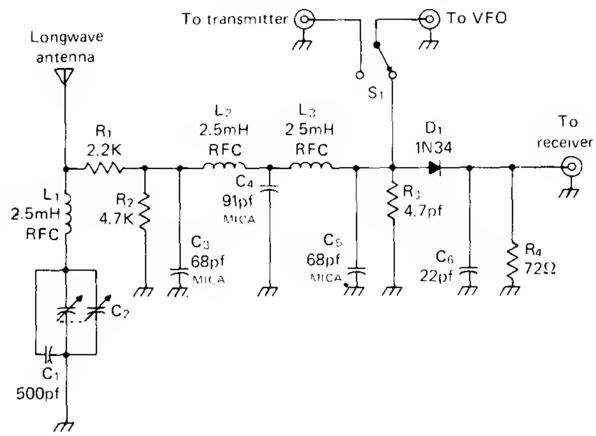


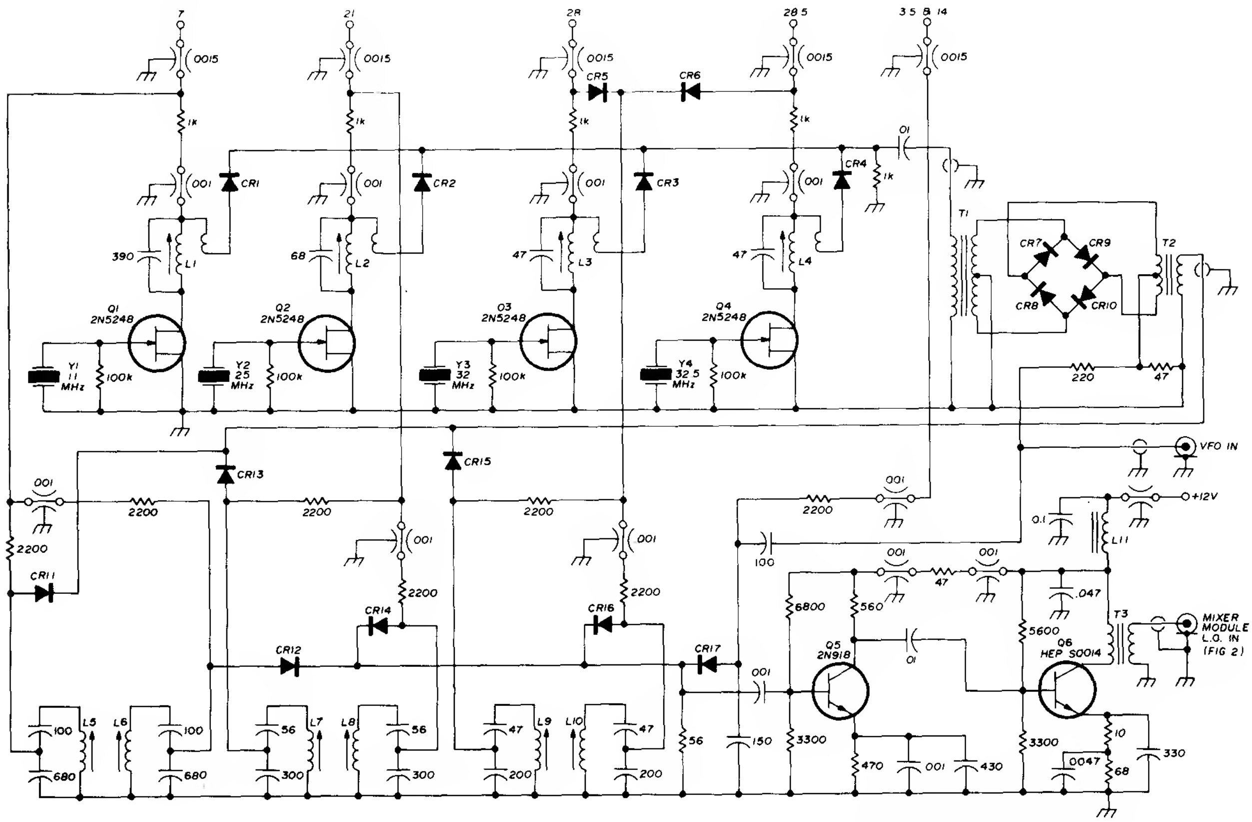
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF) ; OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS ; k = 1 000, M = 1 000 000.

L1-L3, incl. – 40 turns no. 30 enam. wire wound on a T50-3 core.
L4 – 17 turns no. 28 enam. wire wound on a T50-2 core.
L5 – 70 turns no. 30 enam. wire wound on a T50-2 core.
T1, T2 – Broadband transformer. For conventional style winding: primary, 27 turns no. 30 enam. wire wound over secondary turns. Secondary, 54 turns no. 30 enam. wire wound on an FT-50-43 core. For trifilar winding: three individual windings of no. 30 enam. wire on an FT-50-43 core. Connect as shown in inset drawing.
T3 – Broadband transformer. Primary, 50 turns no. 30 enam. wire on an FT-50-72 core. Secondary, 7 turns no. 28 enam. wire wound over primary turns.
Y1 – General-purpose crystal. 1700 kHz, 32-pF load capacitance.

100–200 kHz TO 1.8–2 MHz—High-performance low-frequency converter picks up experimental CW, SSB, RTTY, and beacon signals in 160–190 kHz band for conversion to tunable IF range of modern communication receiver. Double-balanced diode-ring mixer has conversion loss of 6–8 dB and will stand up against strong signals without causing overloading and cross-modulation. Use 1N914 matched diodes. Diplexer at mixer output is tuned to 3 times converter IF. Article covers construction and alignment.—D. DeMaw, A High-Performance Low-Frequency Converter, *QST,* June 1977, p 23–26.

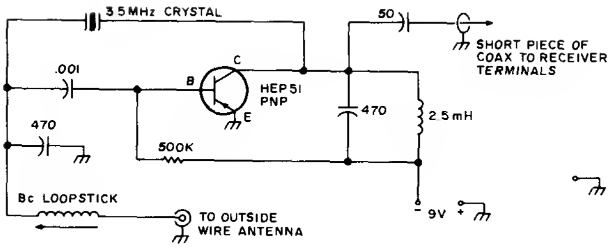
PASSIVE LONGWAVE—Uses VFO of amateur-band transmitter to supply heterodyne for bringing in frequencies below 450-kHz broadcast band on amateur receiver, such as Omega navigation station on 10.2–13.6 kHz, NAA Teletype on 17.8 kHz, and GBR time signals on 16 kHz. L_1-C_1-C_2 100-kHz input wavetrap for loran C can be omitted at far-inland locations. C_2 is two-gang broadcast variable capacitor with both sections in parallel. Mount L_2 at right angle to L_3. Converter should be well shielded. Operation involves tuning receiver to bottom of any amateur radio band, on frequency equal to difference between VFO and that to which receiver is tuned. If VFO is on 7 MHz and receiver is tuned to 7.085 MHz, combination will be set for 85-kHz station. In USA, unlicensed transmission on 160–190 kHz is permitted with 1-W input and 50-foot antenna including length of transmission line.—M. Muench, Longwave Simplified, *CQ*, March 1976, p 41–42.





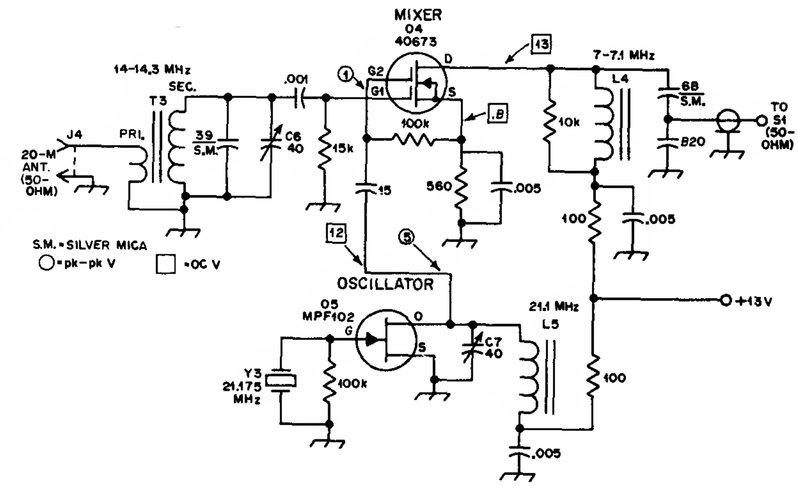
VFO CONVERTER—Used in solid-state five-band communication receiver. VFO input (5–5.5 MHz) goes directly to amplifiers Q5 and Q6 when bandswitch is on 3.5 or 14 MHz. When VFO signal is applied to balanced mixer CR7-CR10, product is at 9 MHz. Diodes should be carefully selected for equal voltage drops ±20 mV at various current values such as 0.75, 2, 10, and 20 mA. When bandswitch is on 7, 21, or 28 MHz, VFO signal is mixed with output of FET crystal oscillator and filtered before being applied to Q5 and Q6. FET oscillators Q1-Q4 are energized by +12 V from bandswitch, with diodes CR1-CR4 selecting output. Crystals are parallel-resonant with 32-pF load. Y2, Y3, and Y4 are third-overtone type.—P. Moroni, Solid-State Communications Receiver, *Ham Radio*, Oct. 1975, p 32–41.

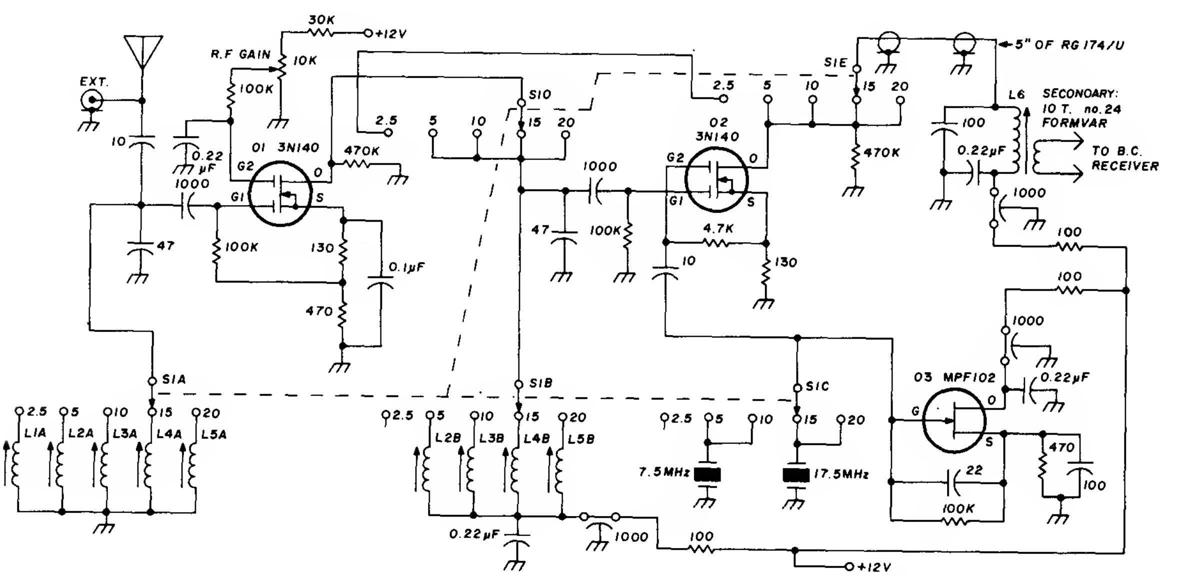
CR1-CR6	1N914 or equivalent
CR7-CR10	Selected 1N270 diodes (see text)
CR11-CR17	1N914 or equivalent
L1-L4	0.6 μH (10 turns no. 22 (0.6mm) enamelled on 3/8" (9mm) diameter slug-tuned forms. Link is 3 turns no. 22 (0.6mm)
L5,L6	1.2 μH. 20 turns no. 28 (0.3mm) on 3/4" (9mm) diameter slug-tuned forms
L7-L10	0.6 μH (same as L1 - L4)
T1, T2	10 turns no. 32 (0.2mm), trifilar wound on Amidon T50-6 toroid core
T3	10 turns no. 32 (0.2mm), trifilar wound on Amidon T50-6 toroid core. Collector winding has two windings in series to give 2:1 ratio



25–500 kHz TO 3.5–4 MHz—When receiver is tuned to 3.5 MHz and converter is peaked for loudest signal, combination is tuning 25-kHz range. With receiver tuned to 4 MHz, converter gives coverage at 500 kHz.—Circuits, *73 Magazine,* May 1977, p 19.

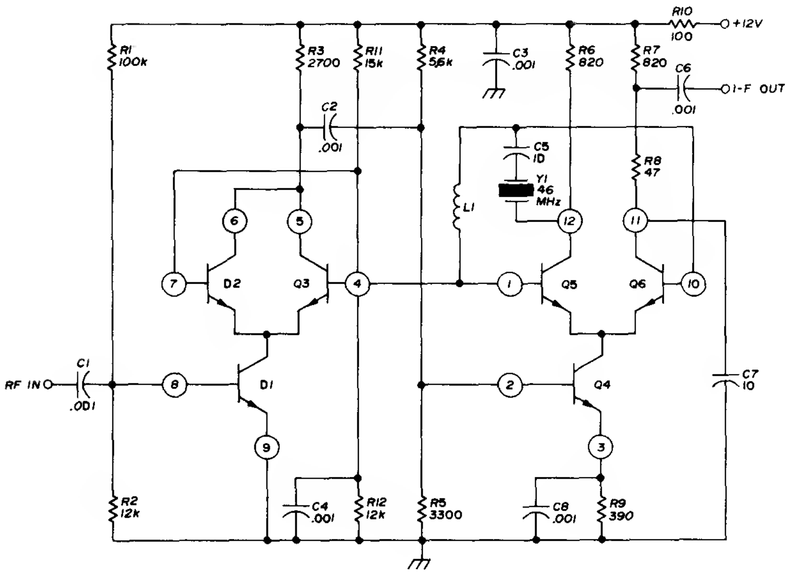
20 METERS TO 40 METERS—Used with 40-meter receiver for which circuit is also given. Converter output is in 40-meter band, for direct feed to input of receiver. L4 is 12 turns No. 26 enamel on Amidon FT37-61 toroid, L5 is 24 turns No. 26 enamel on Amidon T-50-6 toroid, and T3 uses Amidon T-50-6 toroid with 2 turns No. 26 enamel for primary and 21 turns for secondary.—D. DeMaw, The Mini-Miser's Dream Receiver, *QST,* Sept. 1976, p 20–23.



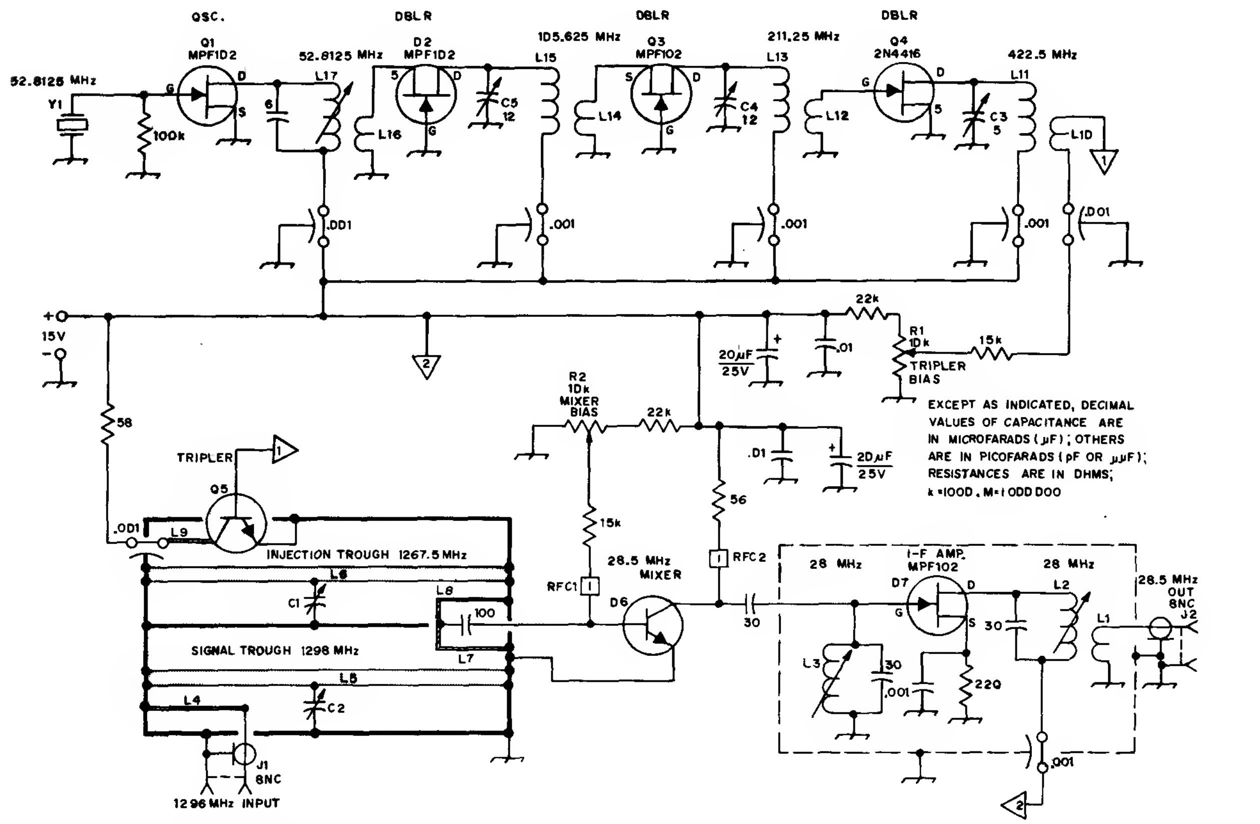


L1	61 - 122 μH (Cambion X2060-7)
L2	10 - 18 μH (Cambion X2060-4)
L3	2 - 3.7 μH (Cambion X2060-1)
L4	1.3 - 2.5 μH (Delevan 4000-12)
L5	0.83 - 1.6 μH (Delevan 4000-10)
L6	28 - 63 μH (Cambion X2060-6), 10 turn secondary
Q1,Q2	3N140, MFE3006, HEP F2004, RCA 40673
Q3	MPF102, HEP802, HEP F0015

WWV FET CONVERTER—Receives WWV on 2.5, 5, 10, 15, and 20 MHz, using modified transistor AM broadcast receiver operating straight-through for 2.5-MHz reception and serving as IF amplifier for converter when tuned to higher WWV and WWVH frequencies. Only two crystals are needed because each allows reception of two WWV frequencies; thus, 10 and 20 MHz are image frequencies when receiving 5 and 15 MHz. Loopstick antenna of radio is replaced with small slug-tuned coil L6 to use 2.5-MHz image frequency when radio is tuned to 1590 kHz. Converter uses dual-gate MOSFETs in RF stage Q1 and mixer Q2, with JFET Q3 as oscillator. Antenna is short piece of wire.—H. Olson, Five-Frequency Receiver for WWV, *Ham Radio,* July 1976, p 36–38.

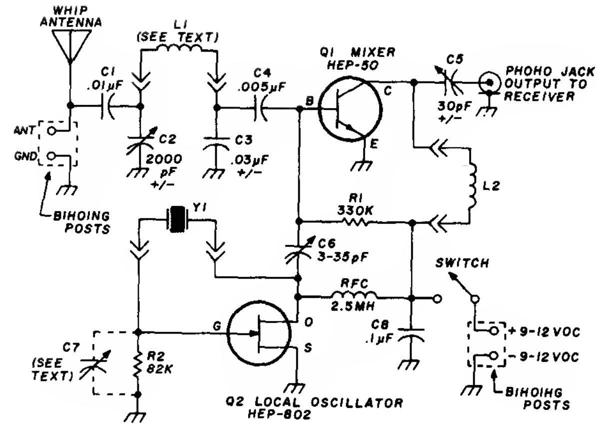


SINGLE-CRYSTAL FOR 46 TO 420 MHz—Covers all VHF amateur bands by using mixer-generated harmonics of 66-MHz crystal oscillator frequency for mixing action. IF can be tuned with any communication receiver. Fundamental is used directly, third harmonic of 138 MHz serves for 2 meters, fifth of 230 MHz for 220-MHz band, and ninth of 414 MHz for 420-MHz band. Q1-Q3 are broadband RF preamp. Y1 is plated overtone crystal oscillating at 46 MHz in series-resonant mode. Q5 and Q6 form differential-amplifier oscillator, and Q4 is mixer driver. No tuning is required in converter, but external tuning is required to prevent device from working on all bands at once. All transistors are part of RCA CA3049T IC, for which pin numbers are circled. L1 is 72 inches of No. 30 enamel, doubled and twisted 1 turn per inch and wound on 1-megohm ½-W resistor to form quarter-wave transmission line.—S. Smith, Four-Band VHF Receiving Converter, *Ham Radio,* Oct. 1976, p 64–66.

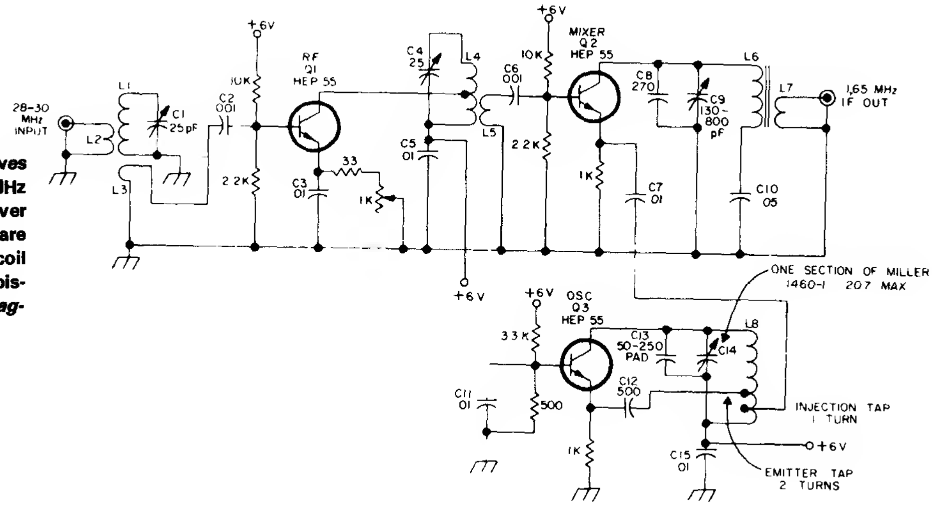


C1, C2 – Nut or copper disk on end of adjusting screw, with lock nut on top side of assembly. Makes variable capacitance to midpoint of half-wave trough-line inner conductor.
C3 – 0.5- to 5-pF glass trimmer.
C4, C5 – 12-pF ceramic trimmer.
L1 – 2 turns insulated hookup wire around L2.
L2, L3 – 13 turns No. 28 enam, 1/2 inch (13 mm) iron-slug form.
L4 – L-shaped coupling loop, 3/4 inch (19 mm) long, No. 18, adjacent to L5.
L5 L6 – 1/4-inch (6 mm) copper tubing, 4-1/4 inches (114 mm) long.
L7, L8 – U-shaped double coupling loop, No. 14, 1/2 inch (13 mm) wide, 1/2 inch long, centered in opening in partition P5.
L9 – Like L4, except adjacent to L6. Collector lead of Q5 is part of this loop.
L10, L12, L14 – 1 turn No. 14, 3/8 inch (10 mm) dia.
L11 – 1-1/4 turns No. 14, 3/8 inch dia.
L13 – 3 turns No. 14, 3/8 inch (10 mm) dia.
L15 – 5 turns No. 14, 3/8 inch (10 mm) dia.
L16 – 2 turns insulated hookup wire around L17.
L17 – 16 turns No. 28 enam, 1/4 inch (6 mm) iron-slug form.
Q5, Q6 – Uhf transistor. Use best available low-noise type for Q6.
R1, R2 – 10,000-ohm linear-taper control.
RFC1, RFC2 – Ferrite-bead choke.
Y1 – Third-overtone crystal, 52.8125 MHz, or to suit i-f range used.

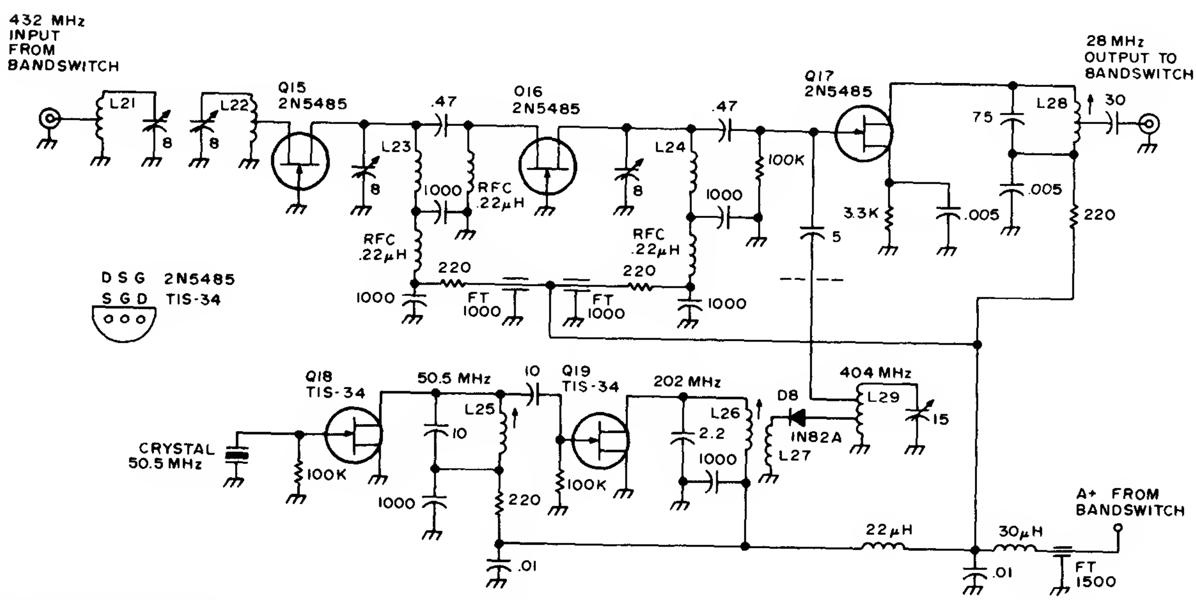
1296 MHz TO 28.5 MHz—Uses UHF transistors in active mixer and in final stage of injection chain, for lower noise figure and useful conversion gain. Doubler and tripler stages are individually shielded.—L. Crutcher, An Active-Mixer Converter for 1296 MHz, *QST,* Aug. 1974, p 11–14.



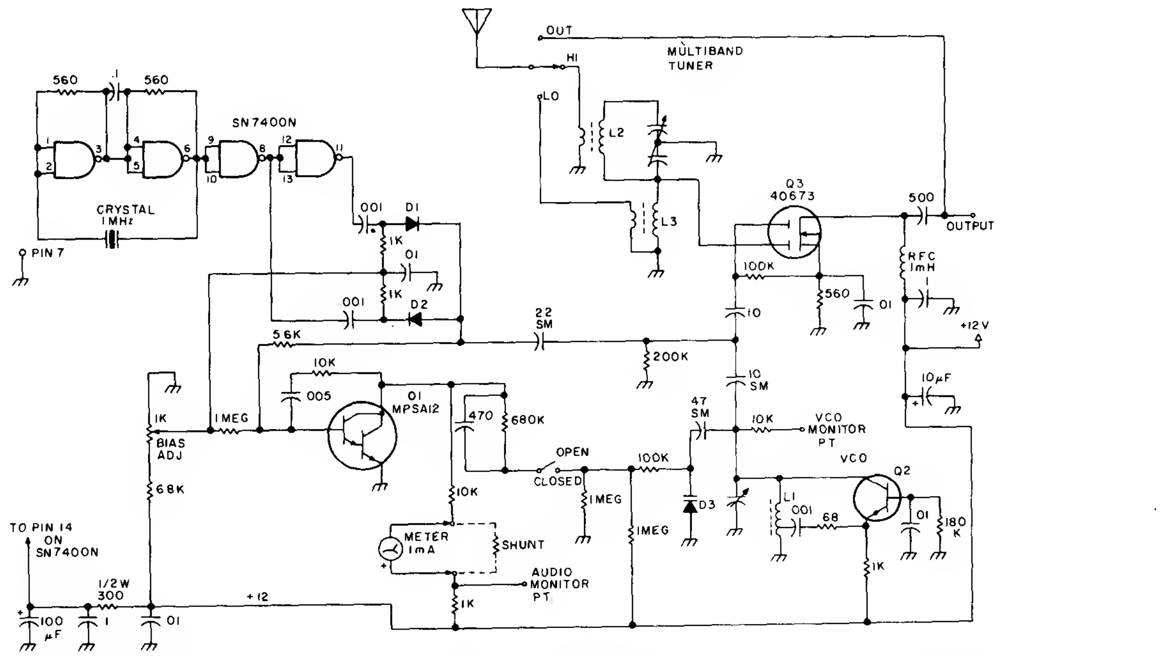
BELOW BROADCAST BAND—Simple solid-state converter can be used with any good communication receiver covering 3.5–4 MHz to bring in stations from 5–550 kHz (200 meters and up). Input coil L1 is changed from 0.28 H for 5–11 kHz to 120 μH for 250–550 kHz in eight steps, as given in article. C2 consists of two 3-geng variable capacitors with stators wired in parallel, gang-tuned with dial cords. Trimmer C7 is 1–12 pF, adjusted to give reliable starting of FT-243 3500-kHz crystel. L2 is 80–90 μH for 80 meters, and loopstick is for broadcast band.—K. Cornell, 200 Meters and Up Receiving Converter for Low Frequencies, *Ham Radio,* Nov. 1976, p 24–26.



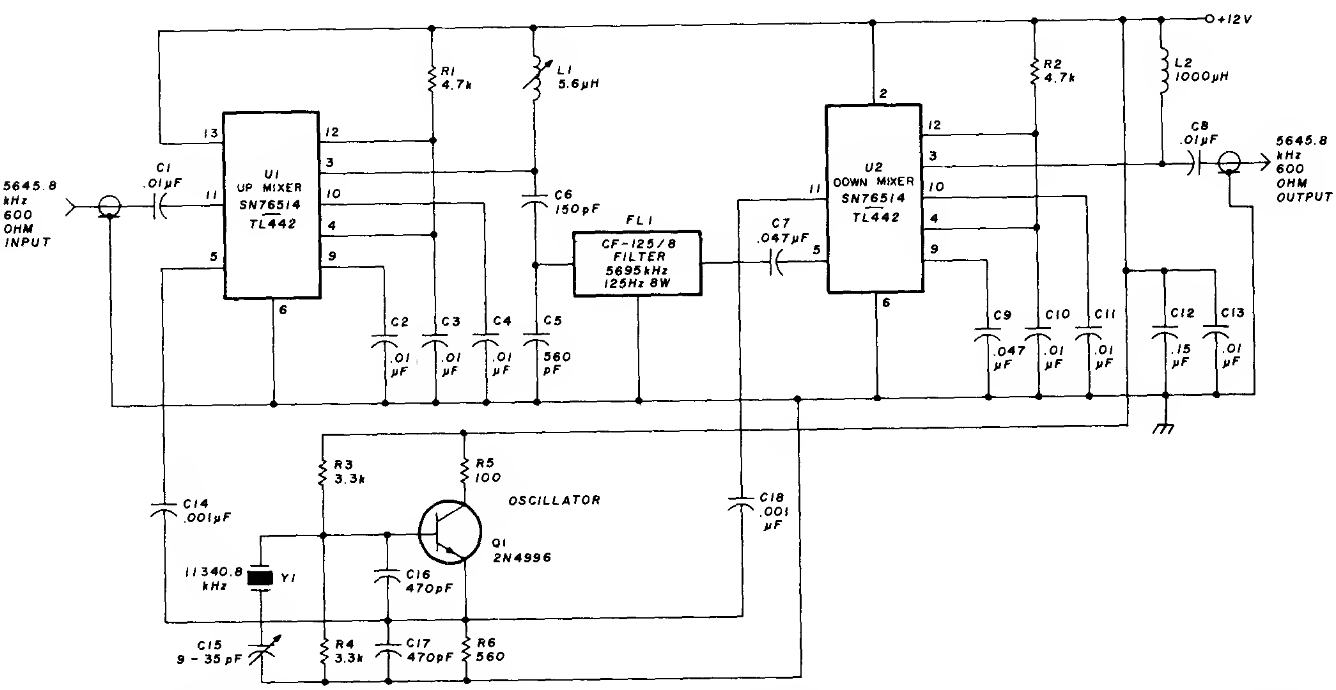
28–30 MHz TO 1.65 MHz—10-meter tuner gives excellent image suppression with 1.65-MHz output, for feeding into inexpensive receiver having 1.65-MHz IF. Tuning capacitors are three-gang Miller 1460-1. Article gives all coil data along with construction details.—B. Hoisington, Tuneable 10 Meter Converter, *73 Magazine,* Jan. 1974, p 57–62.



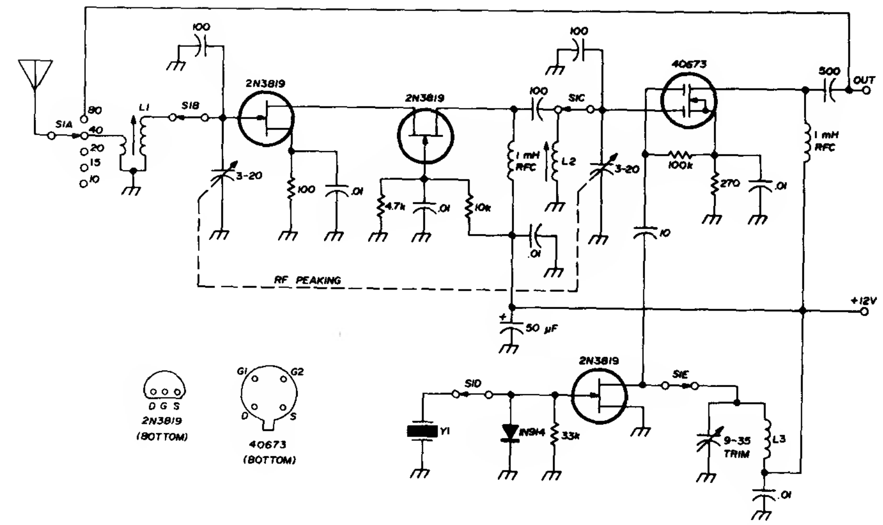
432 MHz TO 28 MHz—Contains bandpass filter, grounded-grid RF amplifier stages Q15-Q16, mixer Q17, and crystal oscillator Q18-Q19. Developed for use in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine,* Jan. 1975, p 105–112.



8–30 MHz AMATEUR BANDS—Will convart eny frequency in tuning range to IF velue between 3.5 and 4 MHz. Requires only three trensistors end one IC. D1 and D2 can be germanium or silicon, such as 1N914. D3 is rectifier diode. Q2 can be almost eny general-purpose high-frequency transistor. Two of getes in SN7400N TTL IC serve es crystei oscillator, end other two getes are buffers for detector diodes D1 end D2. Diodes era modulated by VCO Q2. Detector output is emplified end filtered by Q1 to produce control voitege for tuning D3. Output from mixer Q3 is untuned, with RFC as drain loed element.—R. Megirian, High Frequency Utlity Converter, *73 Magazine,* June 1977, p 50–53.



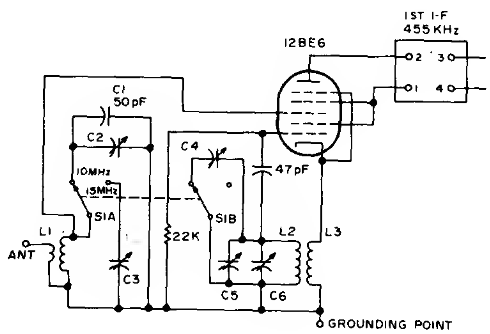
UP/DOWN—Circuit shown was developed for use in 5645.8-kHz IF emplifier of Drake R-4B amateur-bend receiver, to utilize high-performence charecteristics of Sherwood Engineering CF-125/8 CW crystel filter having bendwidth of only 125 Hz. Texes Instruments TL442 doubie-belanced mixers convert IF signel to 5695-kHz center frequency of filter and convert filter output back to IF veiue. Seme crystal oscillator servas for both upconversion and downconversion. Gives true singie-signel reception. Article covers procedures for interfacing eny crystal filter with eny receiver IF velue.—H. Sertori, An Up/Down Filter Converter, *Ham Radio,* Dec. 1977, p 20–25.

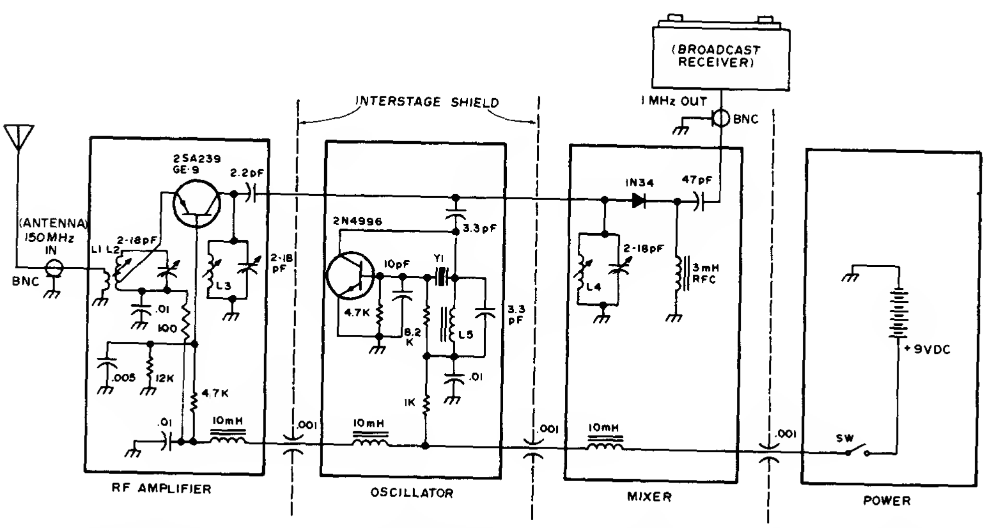


band	L1	L2	L3	Y1
40	20 turns no. 36 (0.13mm), 2 turn link	20 turns no. 36 (0.13mm)	4.7 μH	11 MHz
20	12 turns nc. 28 (0.3mm), 1.5 turn link	12 turns no. 28 (0.3mm)	2.2 μH	18 MHz
15	7 turns no. 28 (0.3mm), 1 turn link	7 turns no. 28 (0.3mm)	1.5 μH	25 MHz
10	4 turns no. 28 (0.3mm), 1 turn link	4 turns no. 28 (0.3mm)	1.5 μH	25 MHz

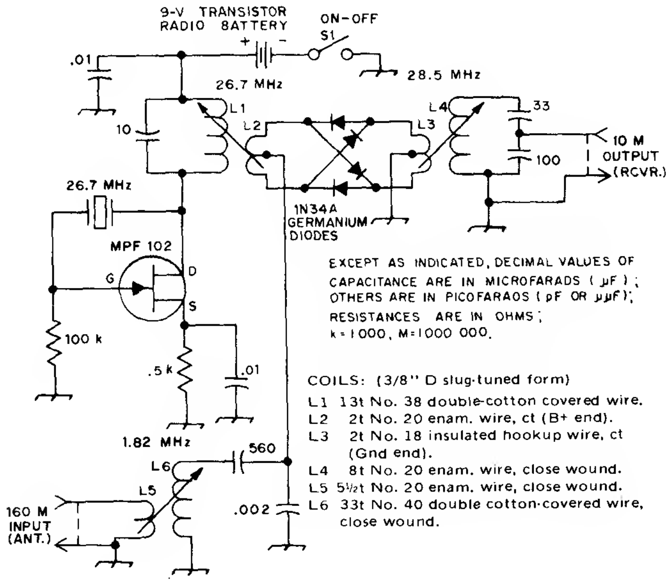
10–40 METERS TO 3.5–4 MHz—Five-band converter is designed for use with miniaturized communication receiver tuning from 3.5 to 4 MHz. Signals for 80-meter band are fed directly to receiver. Two-gang tuning capacitor used to peak converter front and is film-dielectric type taken from transistor FM radio.—R. Meglrian, Design Ideas for Miniature Communications Receivers, *Ham Radio,* April 1976, p 18–25.

WWV ON AC/DC RADIO—When fed into IF amplifier of ordinary broadcast-band radio, simple converter circuit gives choice of WWV on 10 or 15 MHz, for reception of time signals and radio propagation reports. C2 is 1.5–10 pF; C3 and C6 are 7–60 pF; C4 is 7–100 pF (all compression trimmers); and C5 is 1.8–8.7 pF miniature variable capacitor.—W. C. Powis, Notes on Converting the AC/DC for WWV, *73 Magazine,* Oct. 1974, p 116.

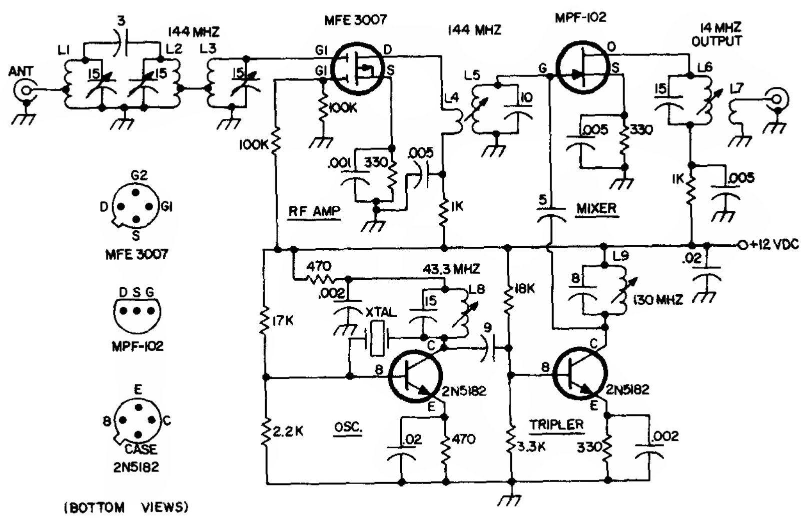




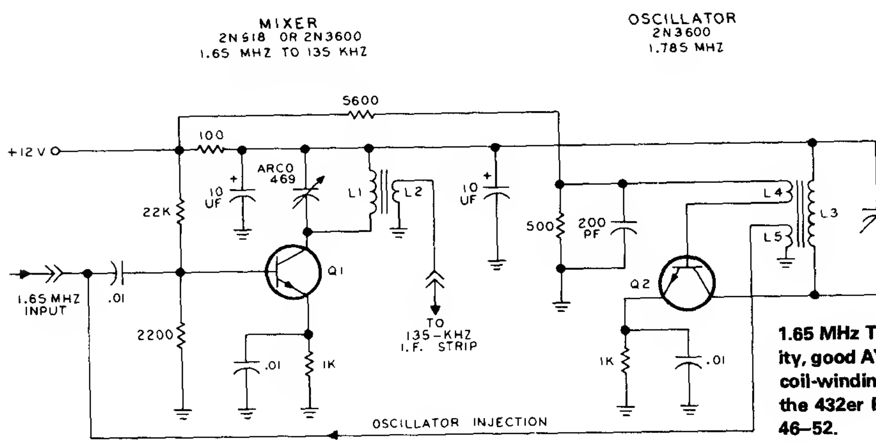
2 m TO BROADCAST BAND—Permits tuning to 2-m (146-MHz) amateur band with ordinary AM auto radio, for monitoring FM repeaters and other 2-m amateur stations. Article stresses importance of shielding, compartmentalization, and RF blocking along power lead to prevent bleed-through of broadcast stations. Separate 9-V battery gives long life if converter is turned off when not in use, because drain is only 25 mA. L2 is 4 turns No. 20 on 7-mm slug-tuned form, with 2-turn link L1 at low end and tap 1½ turns from low end. L3 and L4 are 3 turns No. 20 on 7-mm slug-tuned form. L5 is 20 turns No. 30 on 4-mm solid ferrite form. Y1 is 48.5-MHz third-overtone crystal. Converter gives good reception of both AM and FM stations on 2 m, with sharpness of receiver IF tuning determining ability of radio to slope-detect FM signals.—J. R. Johnson, New Improved Repeater Monitor, *73 Magazine,* Dec. 1976, p 106–109.



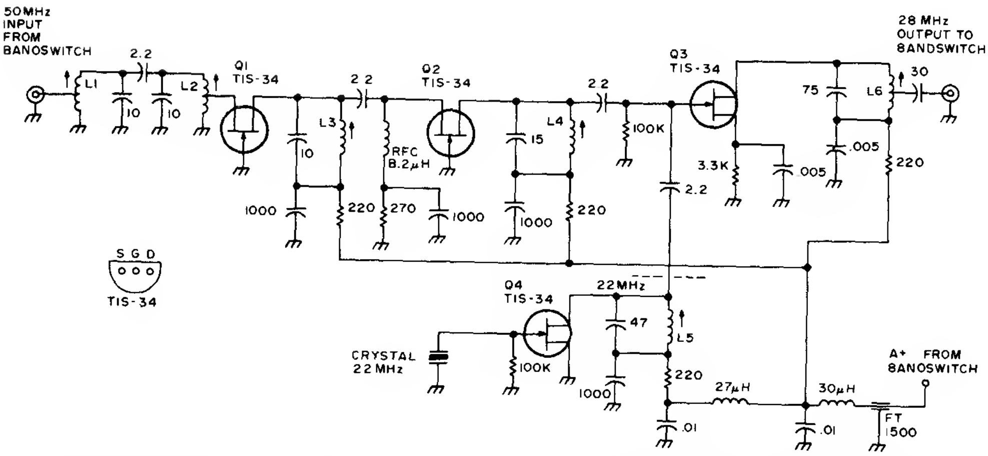
160 METERS TO 10 METERS—Simple converter adds 160-meter band capability to older CW or AM receiver. Passive mixer is adequate. High output frequency eliminates IF feedthrough and image signals. Crystal oscillates on third overtone and feeds directly into mixer.—A. Bloom, A Simple 160-Meter Converter, *QST*, Feb. 1975, p 46.



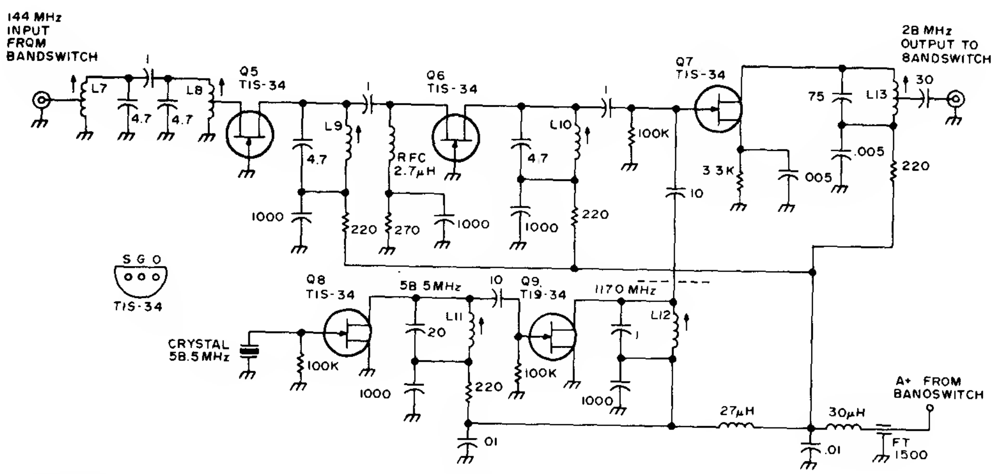
144 MHz TO 14 MHz—Oscillator uses 43.333-MHz overtone-cut crystal feeding class A tripler that injects 130-MHz signal into gate of MPF-102 mixer for combining with 144-MHz output of IGFET RF amplifier to give 14 MHz for amateur-band or general-coverage receivers. Article covers construction and alignment, including detailed coil-winding data.—C. Klinert, A Two Meter Converter, *73 Magazine*, Sept. 1973, p 65–67.



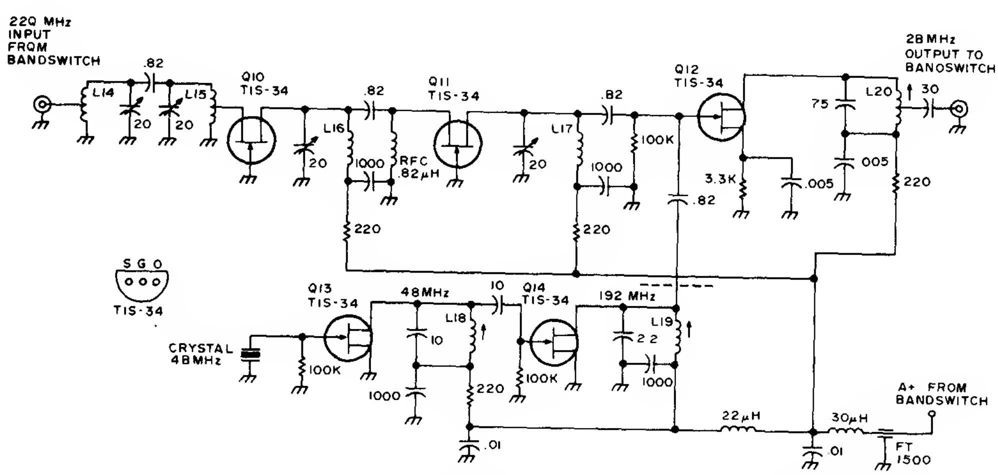
1.65 MHz TO 135 kHz—Provides good selectivity, good AVC, and smooth tuning. Article gives coil-winding data.—B. Holsington, Miniboxing the 432er Receiver, *73 Magazine*, Jan. 1975, p 46–52.



50 MHz TO 28 MHz—Contains bandpass filter, two grounded-grid RF amplifier stages Q1-Q2, mixer Q3, and crystal oscillator Q4. Developed for use in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.

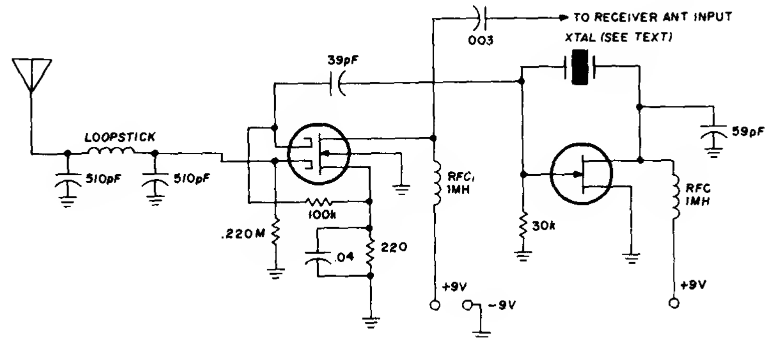


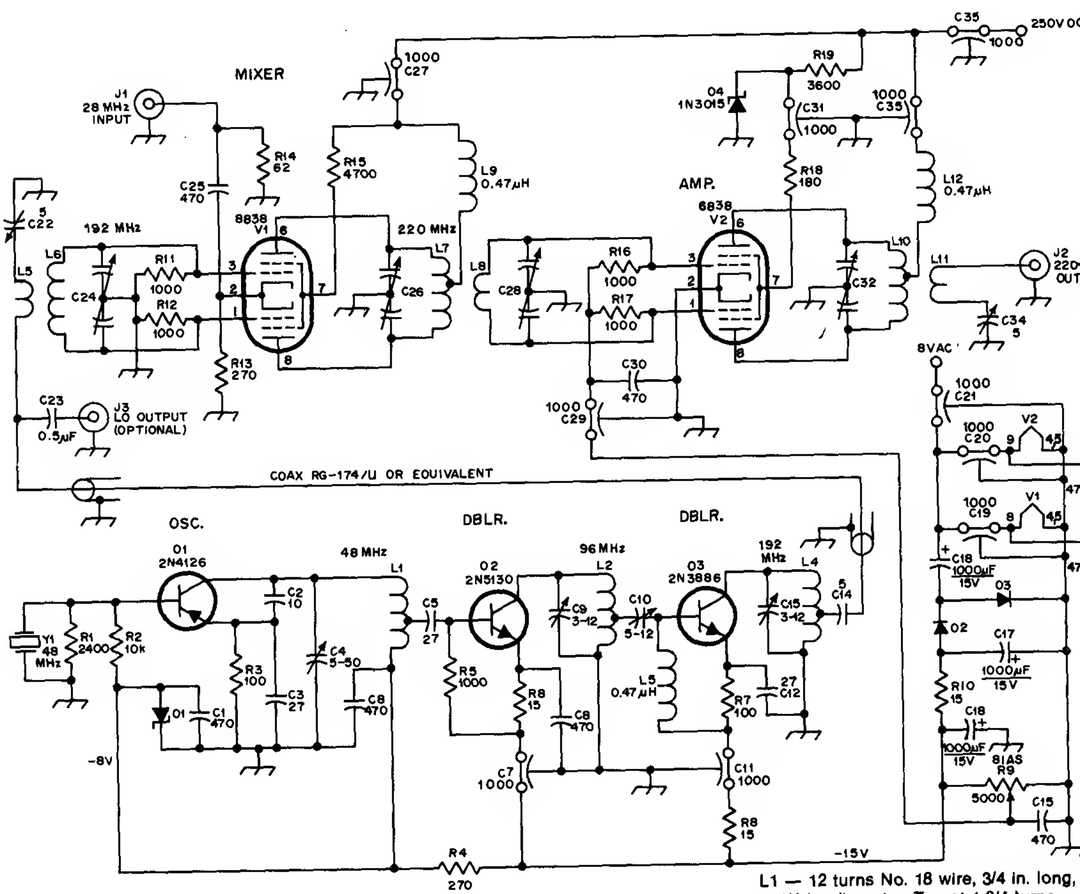
144 MHz TO 28 MHz—Contains bandpass filter, grounded-grid RF amplifier stages Q5-Q6, mixer Q7, and crystal oscillator Q8-Q9. Developed for use in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.



220 MHz TO 28 MHz—Contains bandpass filter, grounded-grid RF amplifier stages Q10-Q11, mixer Q12, and crystal oscillator Q13-Q14. Developed for use in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.

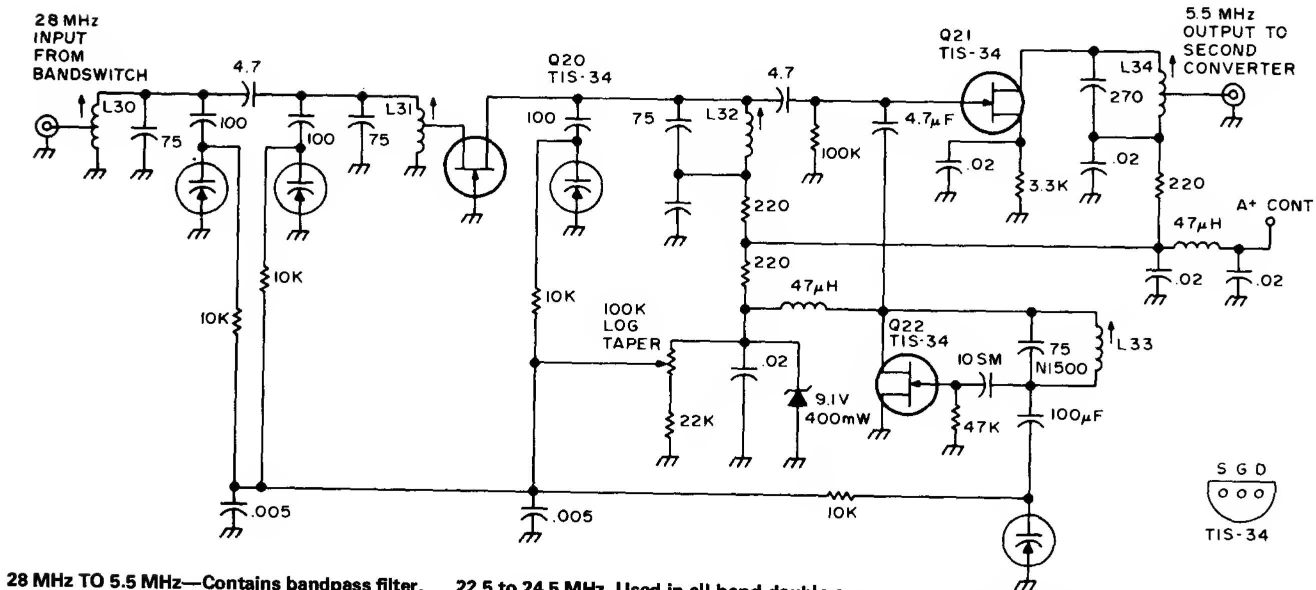
VLF CONVERTER—Uses low-pass filter instead of usual tuned circuit, so only associated receiver need be tuned. Measured threshold sensitivity is about 20 μV. Transistors used in dual-gate MOSFET mixer and FET oscillator are not critical. Crystal can be any frequency compatible with tuning range of receiver used. With 3.5-MHz crystal, 3.5 MHz on receiver dial corresponds to 0 kHz and 3.6 MHz to 100 kHz.—R. N. Coan, VLF Converter, *Ham Radio*, July 1976, p 69.





L1 — 12 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 1-3/4 turns.
L2 — 6 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 2 turns.
L4 — 3 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 1 turn.
L3 — 0.47-μH rf choke (Miller).
L5 — 1 turn, 1/2-in. dia, 3/4-in. leads; No. 22 insulated wire.
L6 — 1-1/2 turns, 1/2-in. dia, 1-in. leads; No. 16 wire.
L7 — 1-1/2 turns, 5/8-in. dia, 3/16-in. leads; No. 16 wire.
L8 — 1/2 turn, 5/8-in. dia, 3/18-in. leads; No. 16 wire.
L10 — 1-1/2 turns, 5/8-in. dia, 1-1/4-in. leads; No. 16 wire.
L11 — 1 turn, 1/2-in. dia. 3/4-in. leads; No. 22 insulated wire.

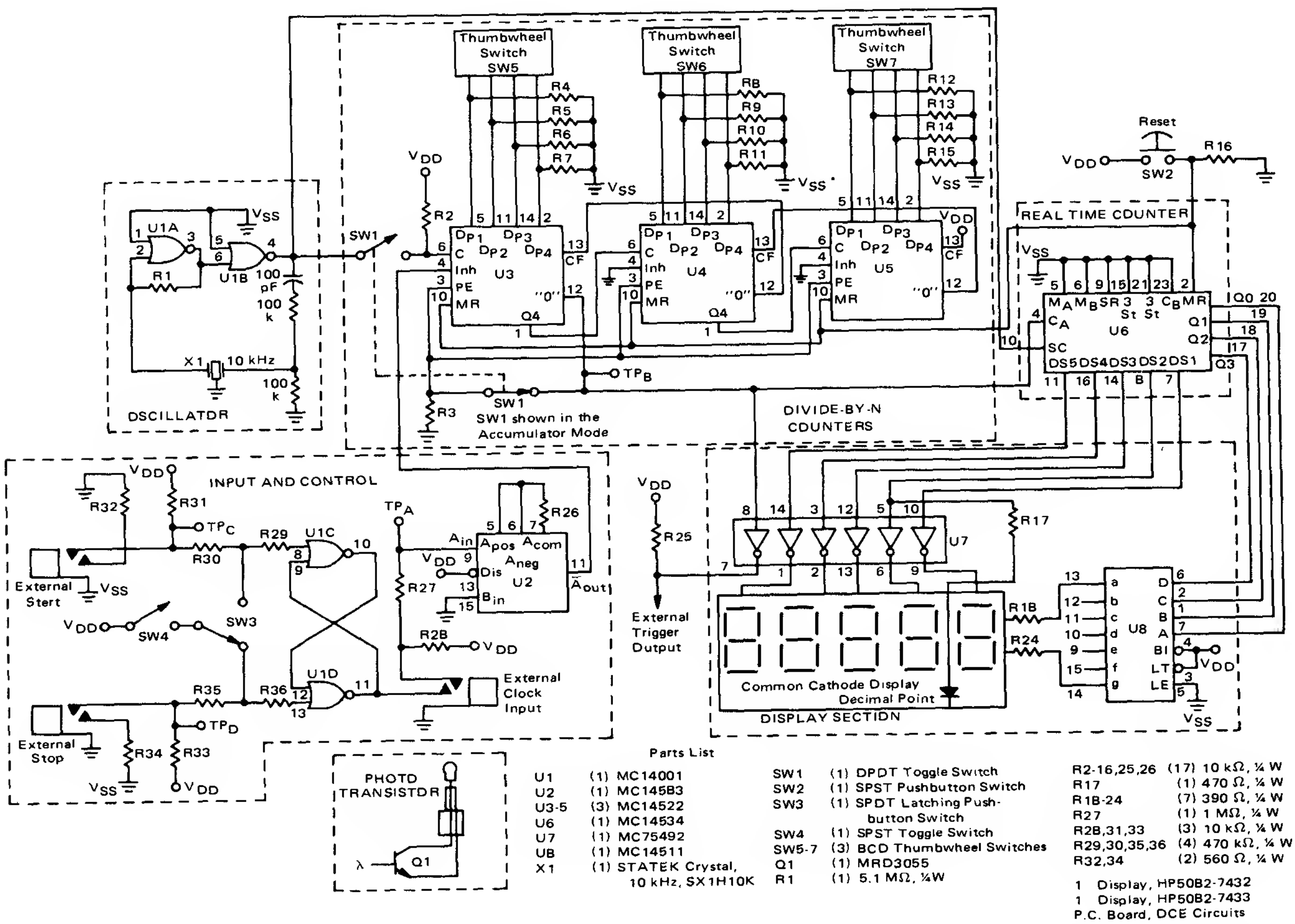
28 MHz TO 220 MHz FOR TRANSMIT—Permits use of 2-meter transceiver to transmit in 220-MHz band with minimum of 6-W power output for 1-W drive on 28 MHz. Local-oscillator output at 192 MHz can be used for receiving converter as well. Use 8-pF butterfly-type air variable (Johnson 160-028-001) for C24, C26, C28, and C32. D1 is GE ZD8.2 8-V 1-W zener.—F. J. Marry, A 220-MHz Transmit Converter, *QST*, Jan. 1978, p 16–20.



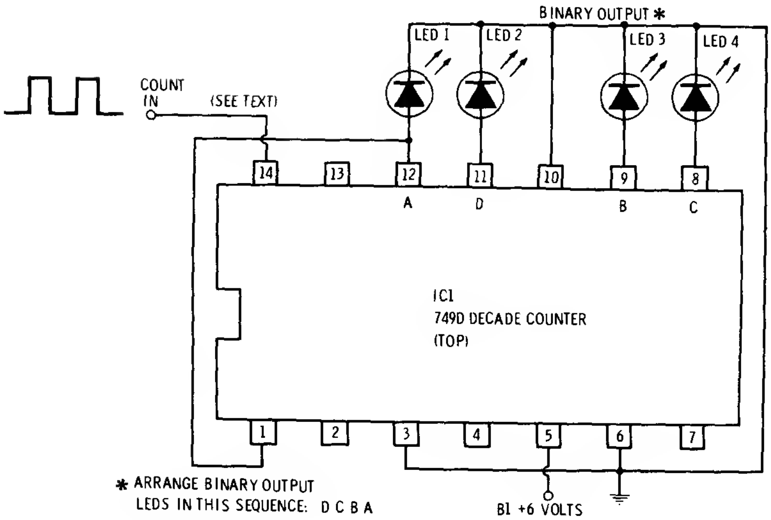
28 MHz TO 5.5 MHz—Contains bandpass filter, grounded-grid RF stage Q20, mixer Q21, and oscillator Q22, with all tuning accomplished by variable-capacitance diodes. Oscillator covers 22.5 to 24.5 MHz. Used in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.

CHAPTER 21
Counter Circuits

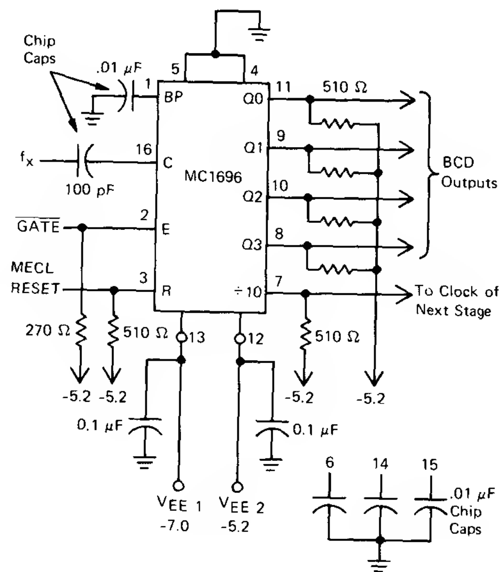
Includes circuits for counting events and pulses over various ranges from 0 to 1.2 GHz singly, by 4s, or by decades, along with counting-rate meter, up/down, multifunction, anticoincidence, PROM-controlled, free-running classroom-demonstration, and switch-closure counters driving multiplexed or continuous digital displays. See also Frequency Counter chapter.



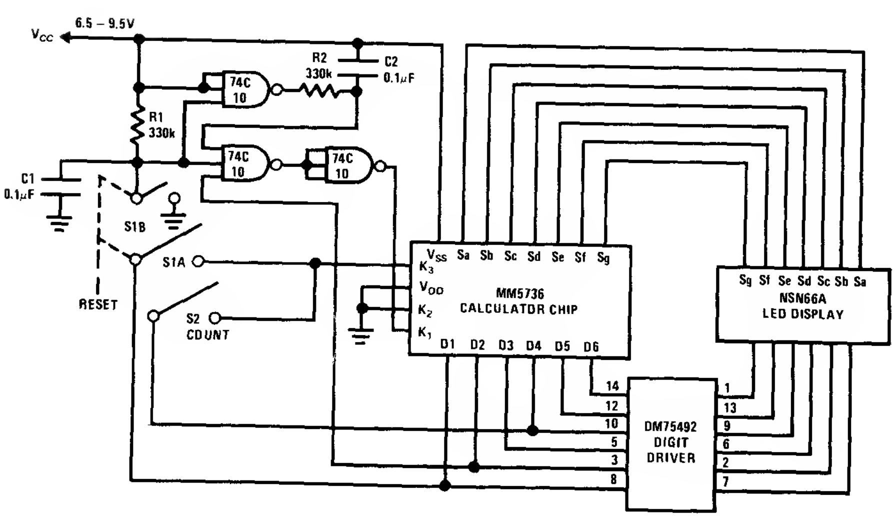
5-DIGIT PRESET COUNTER—Basis of circuit is Motorola CMOS reel-time MC14534 five-decade counter containing five ripple-type decade counters whose outputs ere time-multiplexed by internal scanner. Time-base oscillator provides 10-kHz crystal reference for clocking counters. Total current drain of system is 65 mA from 5-V supply. When used to control quantity of items placed in carton, each item interrupts light beem of photoelectric system to give count. External trigger output is connected to control mechanism that edvances conveyor belt when box is full. Quentity of items desired per box is dialed on thumbwheel switches. Displey is used to indicate number of boxes filled. Other applications include count end display of number of interruptions of light beam, measurement of convayor speed, end measurement of log lengths in sewmill.—A. Mouton, "Five Digit Accumulator/Elapsed Time Indicator," Motorola, Phoenix, AZ, 1975, AN-743, p 3.



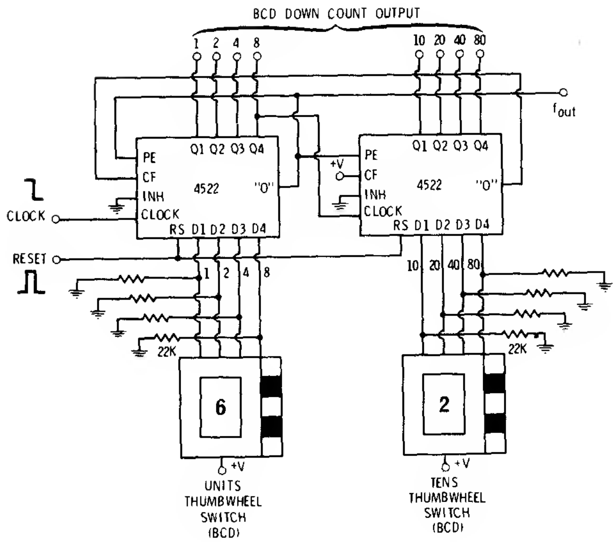
FOUR-LED BCD DISPLAY—Square-wave input pulses are counted by 7490 IC that drives LEDs indicating count in binary format up to 10 and then recycling. Can be used for classroom demonstrations of counters, flip-flop action, and binary counting. Pulses can be obtained from UJT clock circuit operating at audio rate.—F. M. Mims, "Computer Circuits for Experimenters," Radio Shack, Fort Worth, TX, 1974, p 85–93.



1.2-GHz DECADE COUNTER—Motorola MC1696 BCD-output counter provides direct counting of events at up to 1.2 GHz without prescaling. Connection shown is for AC coupling of input signals. Decoupling capacitors are used on power supplies and all unused pins. MC1696 provides division by 10, with output driving cascaded MC10138 biquinary counters and associated latches connected to drive five-decade display as covered in report.—J. Roy, "Event Counter and Storage Latches for High-Frequency, High-Resolution Counters," Motorola, Phoenix, AZ, 1975, EB-47.

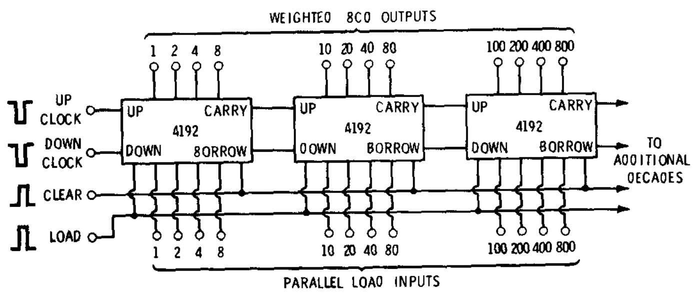


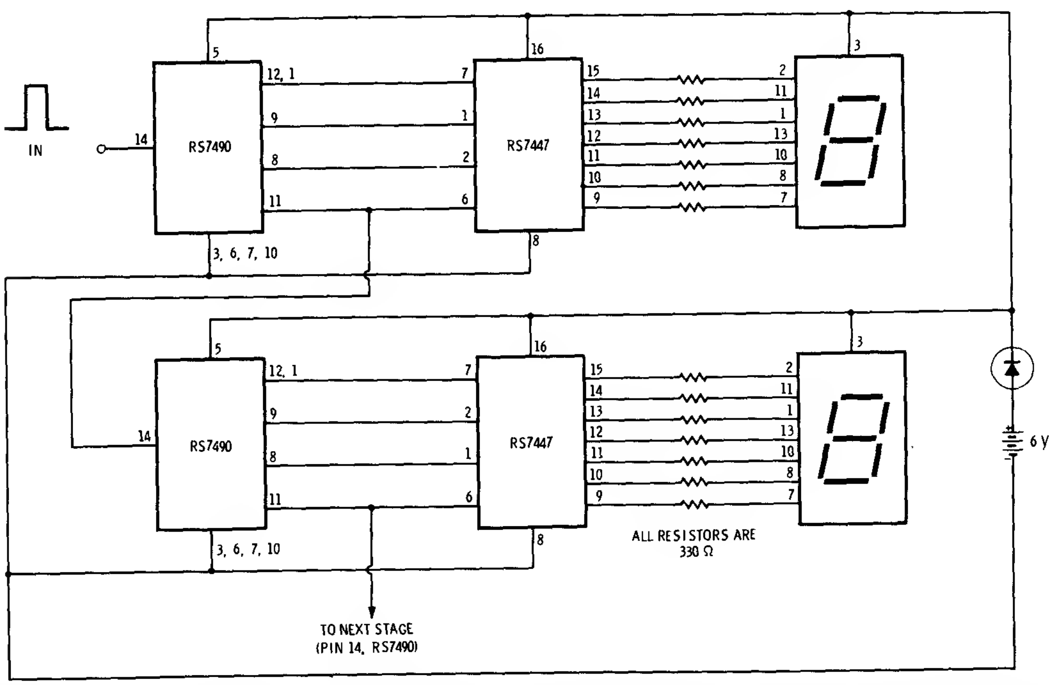
SELF-STARTING COUNTER—Addition of three logic elements eliminates need for separate starting switch when using National MM5736 calculator chip as counter driving LED display. When reset switch is returned to normal position after pushing it to clear calculator, additional parts serve to generate delayed pulse that gates digit output 2 into calculator and thus enters a 1. This action resets counter with single manual operation.—M. Watts, "Calculator Chip Makes a Counter," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 4.



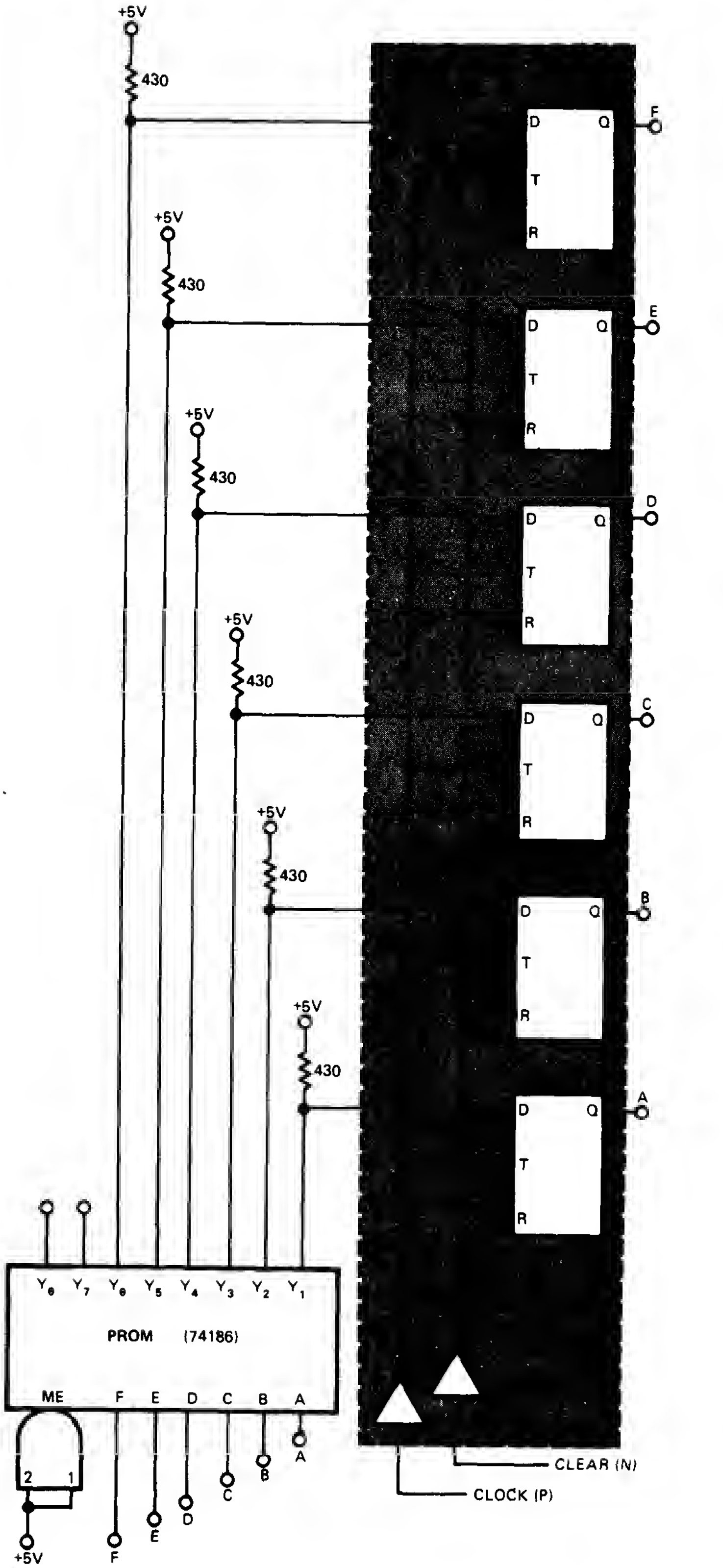
CASCADED DOWN COUNTER—4522 decimal divide-by-N counter is used with BCD thumbwheel switch for each decade. Output is in BCD format, going down from preset number in range of 0-99. Decoded 0 output of tens stage is connected to CF or carry-forward input of units stage. Only when both counters are in 0 state is 0 output provided. Preset number is then reloaded into counters.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 311–312.

UP/DOWN COUNTER—Cascading of 4192 decade up/down counters and use of two clocks give fully synchronous system for adding or subtracting count. Both clocks are normally held high. Low on up clock advances count. Low on down clock subtracts 1 from count. Clocking takes place on trailing or positive edge of negative pulse. Parallel loading inputs are used to preset counter to any desired number.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 309–310.

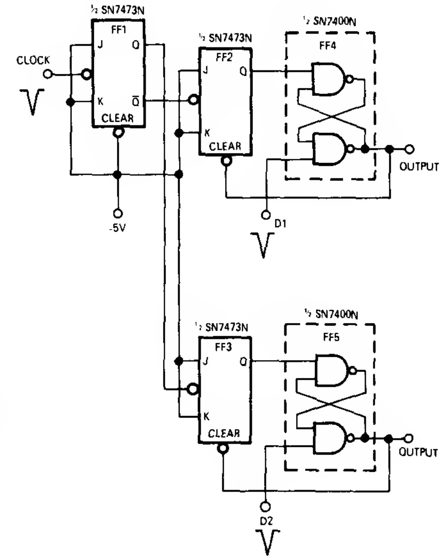




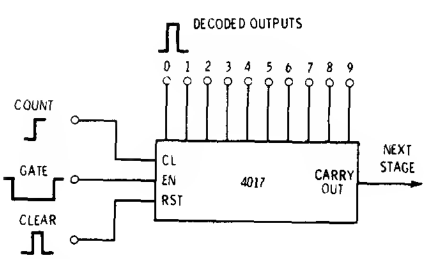
MULTIDIGIT DEMONSTRATION COUNTER—Simple interconnection of RS7490 decade counter, RS7447 decoder, and 7-segment digital display for each desired digit makes ideal counter for classroom demonstrations and Science Fair exhibits. With two additional stages added, display reaches 9999 before recycling. Use 1N914 diode in series with battery to protect against polarity reversal and reduce supply to 5 V for ICs.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 53–63.



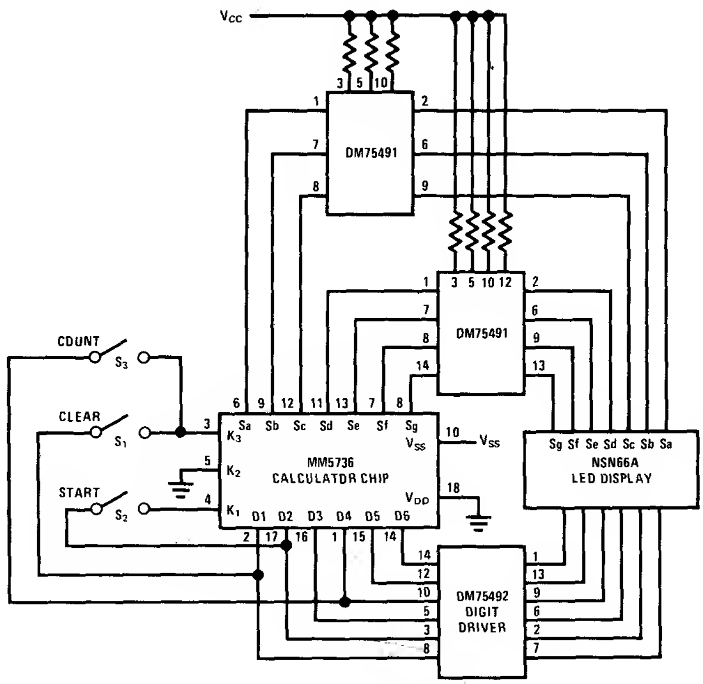
PROM-CONTROLLED COUNTER—Universal counter can be set to count in any desired sequence ranging from simple binary to pseudorandom, using only one programmable read-only memory chip and one 74174 edge-triggered flip-flop register chip. Version shown is 6-bit 64-state counter for which PROM is organized in 64 8-bit words. Pull-up resistors are required. Article covers application details, including expansion techniques. PROM outputs serve as data input to register chip, and register outputs provide PROM address inputs.—T. M. Farr, Jr., Read-Only Memory Controls Universal Counter, *EDN Magazine*, May 5, 1976, p 114.



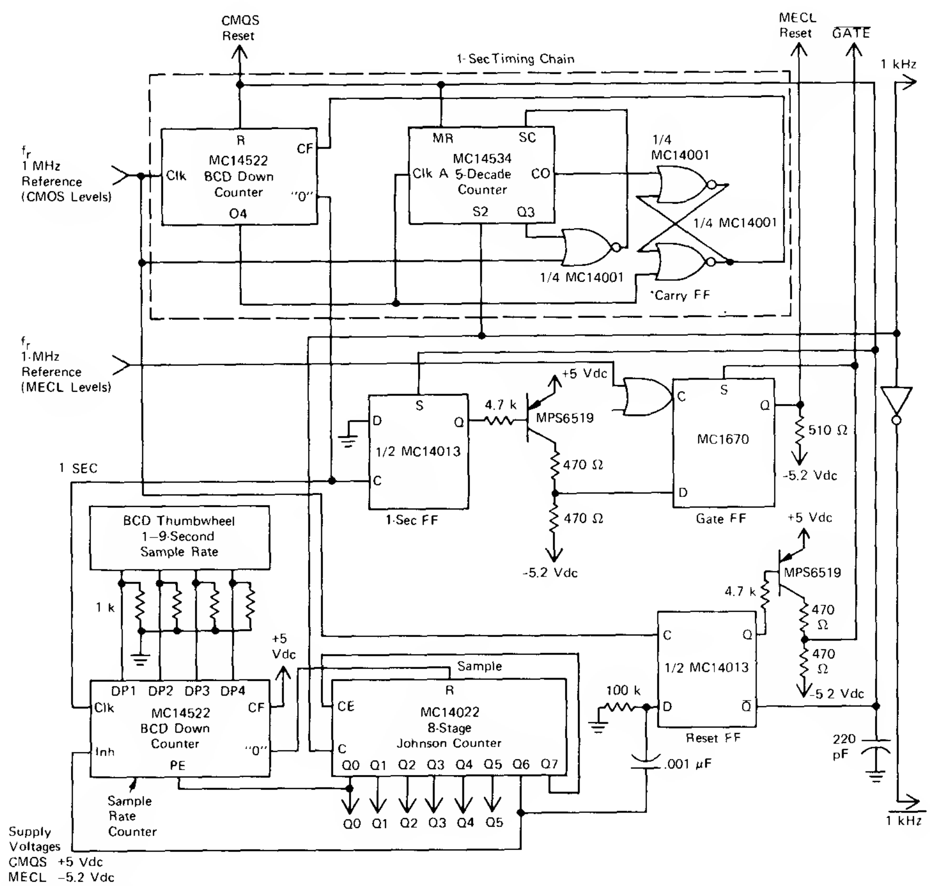
ANTICOINCIDENCE—Developed for use with bidirectional counter circuits to avoid counting errors when up and down pulses occur simultaneously. Operation is based on knowing maximum frequency of separate data pulses. Outputs 1 and 2 will be separated by at least one clock period even if inputs D1 and D2 occur simultaneously. Article gives operating details.—J. H. Burkhardt, Jr., Anti-Coincidence Circuit Prevents Loss of Data, *EDN/IEEE Magazine*, Jan. 1, 1972, p 73.



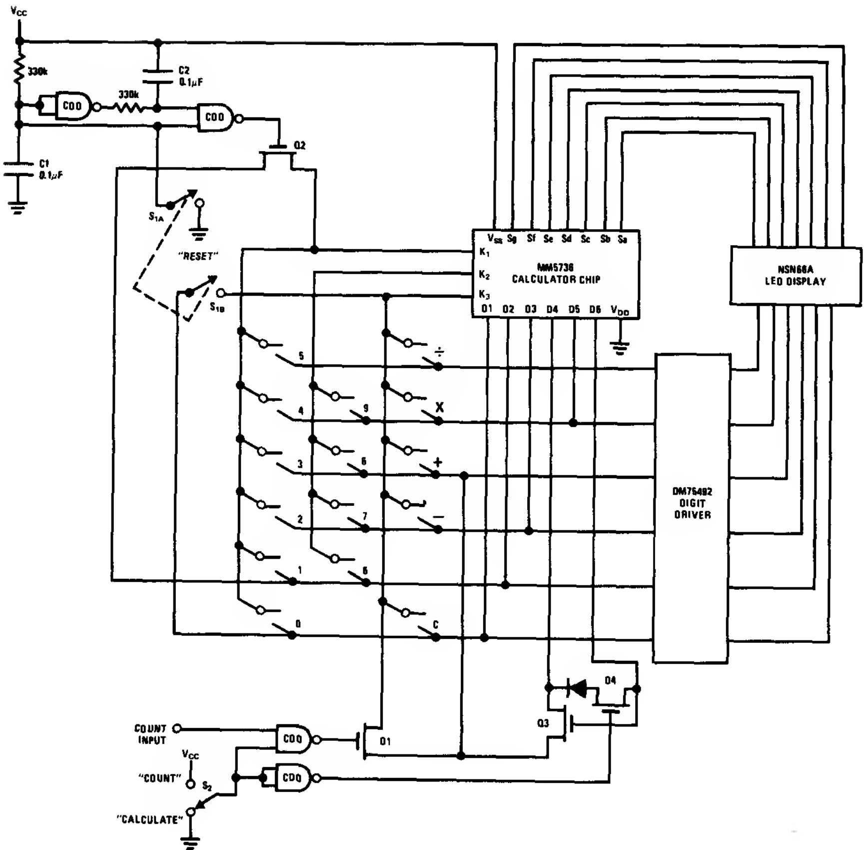
10-POINT STEPPER—4017 divide-by-10 counter routes input clock signal sequentially to each of ten output lines, with only selected output going high. Internal circuit of IC is self-clearing walking ring that is glitch-free, with minimum overlap between outputs. Counters can be cascaded to provide more steps.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 309.



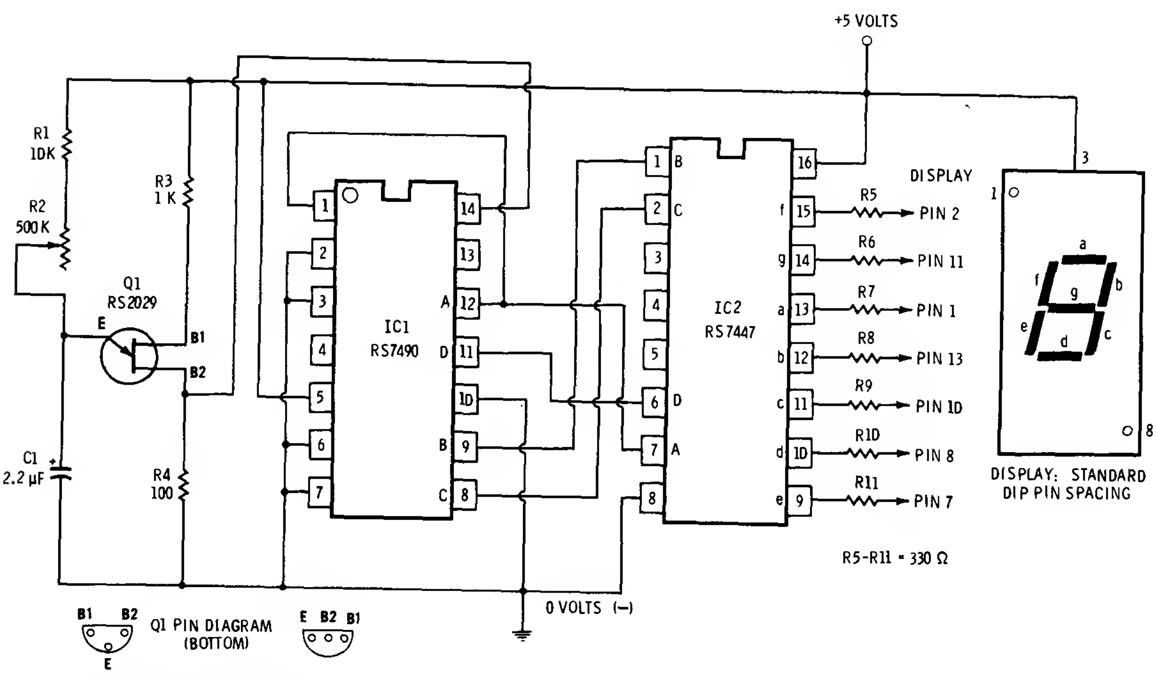
CALCULATOR AS COUNTER—National MM5736 calculator chip is used with two DM75491 segment drivers and DM75492 digit driver for LED 6-digit display. Switches provide manual control of counter. To reset, push S_1 to clear calculator, push S_2 to enter a 1, then push S_3 when new count is to be started. Current drive to LEDs is supplied by V_{CC} through current-limiting resistors, giving power saving because V_{CC} can be less than V_{SS}. Will drive large LED display.—M. Watts, "Calculator Chip Makes a Counter," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 4.



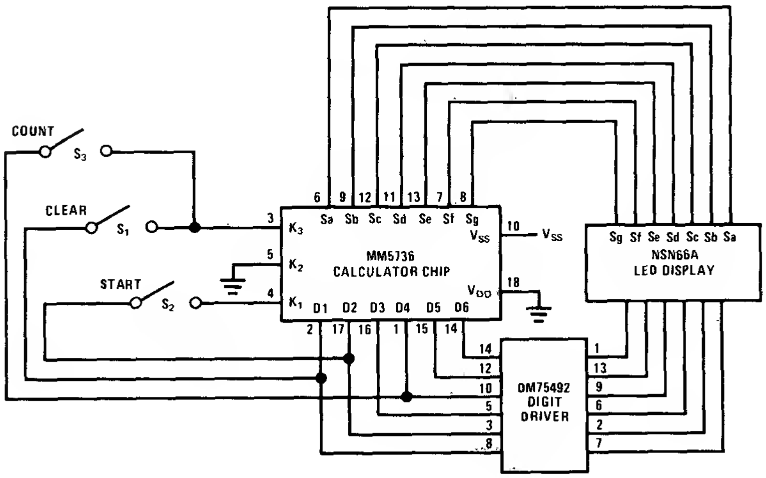
TIME BASE FOR 1.2-GHz COUNTER—Provides 1-s gate, latch strobing signals, 1-kHz signal for multiplexing displays, and digital sample rate control for high-frequency high-resolution counters. Timing chain divides 1-MHz external reference signal by 10^6 to give 1-Hz output. MC14534 five-decade counter generates 1-kHz multiplexing frequency with 20% duty cycle for blanking. Digital sample rate control is programmed on BCD thumbwheel switch in increments ranging from 1 to 9 s, using single MC14522 BCD down counter.—J. Roy, "A Time Base and Control Logic Subsystem for High-Frequency, High-Resolution Counters," Motorola, Phoenix, AZ, 1975, EB-48.



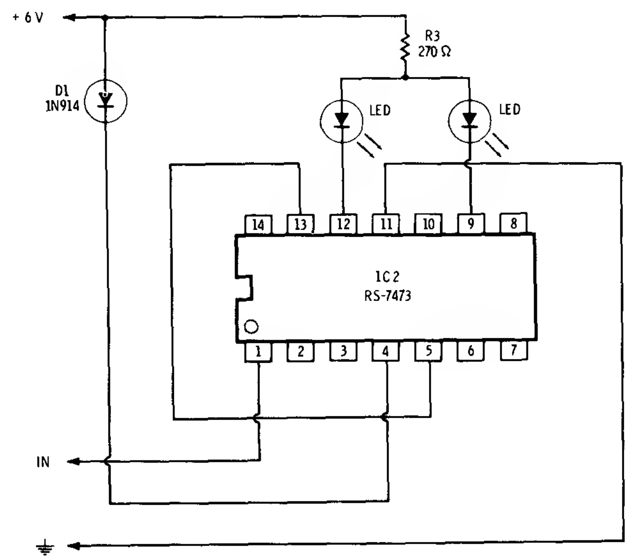
CALCULATOR/COUNTER—Normal arithmetic functions of National MM5736 calculator chip are preserved while providing counting capability, through use of MOS transistors Q1-Q4. When reset switch is pushed, pin D1 is connected to pin K_3 of calculator and calculator is cleared. C1 and C2 are discharged while S_1 is closed but are charged when it is released, generating negative-going delayed pulse that causes a 1 to be entered into calculator. Delay allows clear function to be debounced by calculator chip. When S_2 is in count mode, Q4 is turned on and D6 is tied to D4, for doubling maximum counting rate. Input pulse will now turn Q1 on, making calculator perform addition. Additional pulse adds 1 to sum. When S_2 is returned to calculate position, keyboard logic is returned to normal state. MM74C00 NAND gates can be replaced with MM74C02 NOR gates, and MOS transistors can be replaced with MM5616 CMOS switch.—M. Watts, "Calculator Chip Makes a Counter," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 6.



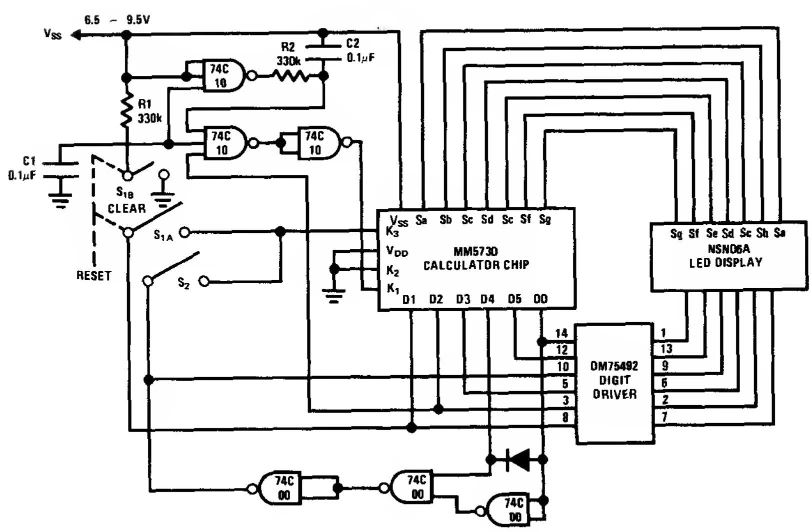
SELF-DRIVING COUNTER—UJT relaxation oscillator Q1 supplies series of pulses to input pin 14 of RS7490 decade counter at frequency determined by setting of R2 and value used for C1. Counter feeds corresponding BCD outputs to BCD input pins of RS7447 decoder for conversion into 7-segment decimal format for driving Radio Shack 276-052 LED display. Ideal for classroom demonstrations and Science Fair exhibits. 6-V battery with 1N914 diode in series can be used in place of 5-V supply.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 41–56.



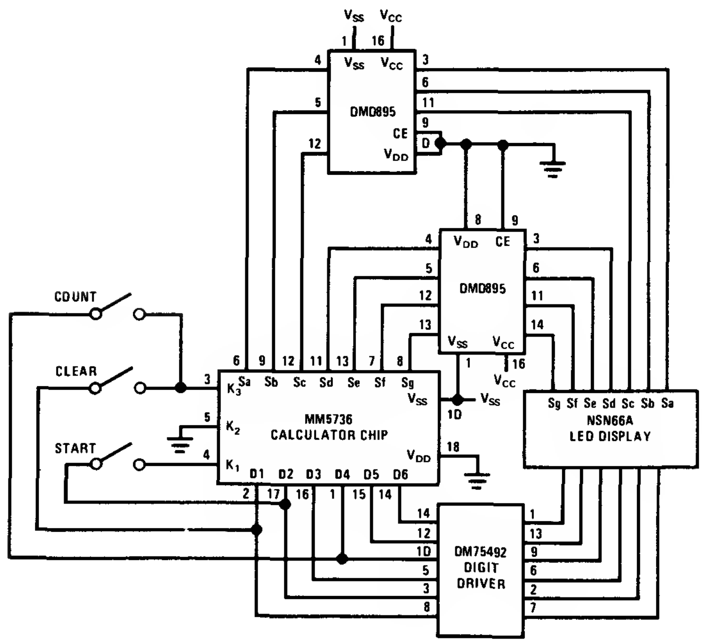
TWO-CHIP COUNTER—Combination of National MM5736 calculator chip and DM75492 digit drivar for 6-digit LED display is suitable for applications whara typical maximum counting rata can be about 100 Hz. Counter is reset manually by closing S_1 to claar calculator and closing S_2 to entar a 1. Oparator now controls start of naw count by pressing S_3, without naed for gating count input.—M. Watts, "Calculator Chip Makes a Countar," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 2.



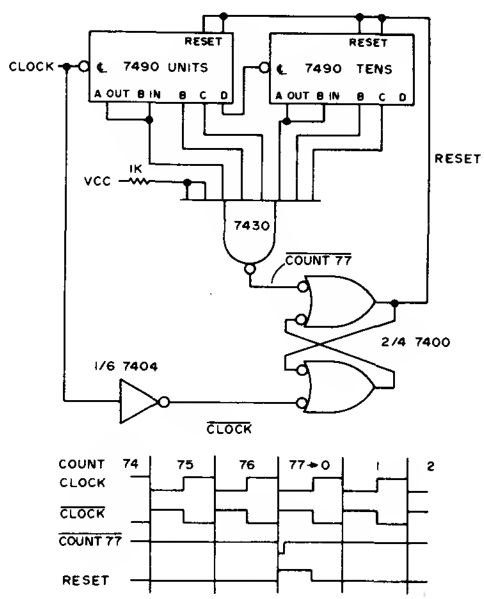
2-BIT BINARY—Sections of RS7473 dual flip-flop are connectad to form simple countar that counts to three in binary with LEDs. By adding mora flip-flop stages, count can be axtanded to highar values. If OFF LED rapresants 0 and ON LED is 1, combinations 00, 01, 10, and 11 rapresant 0, 1, 2, and 3, raspectivaly. Input is restricted to low audio frequency so LED changes can be raadily observed during damonstrations.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 23–32.



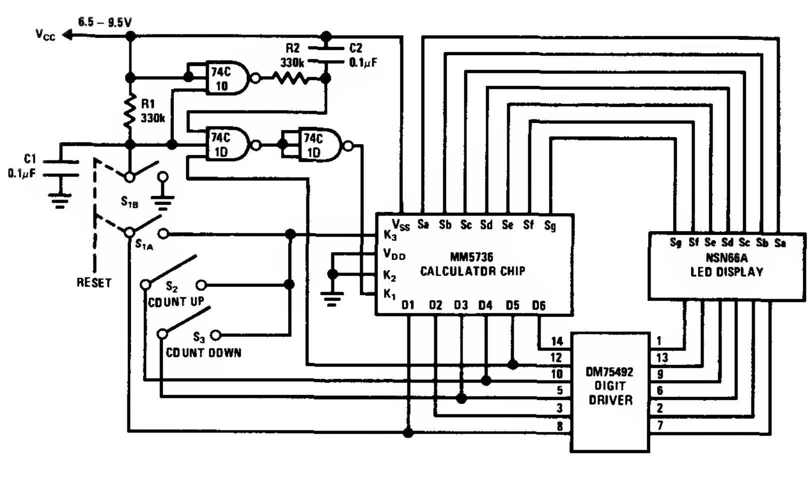
CALCULATOR COUNTS UP TO 300 Hz—Logic alemants used with MM5736 calculator chip provide self-starting counting action in ranga from 80 to 300 Hz. Incraase in counting rate is obtained by faeding digit output 6 back to digit output 4, to bypass soma internal logic of calculator.—M. Watts, "Calculator Chip Makas a Countar," National Samiconductor, Santa Clara, CA, 1974, AN-112, p 4.



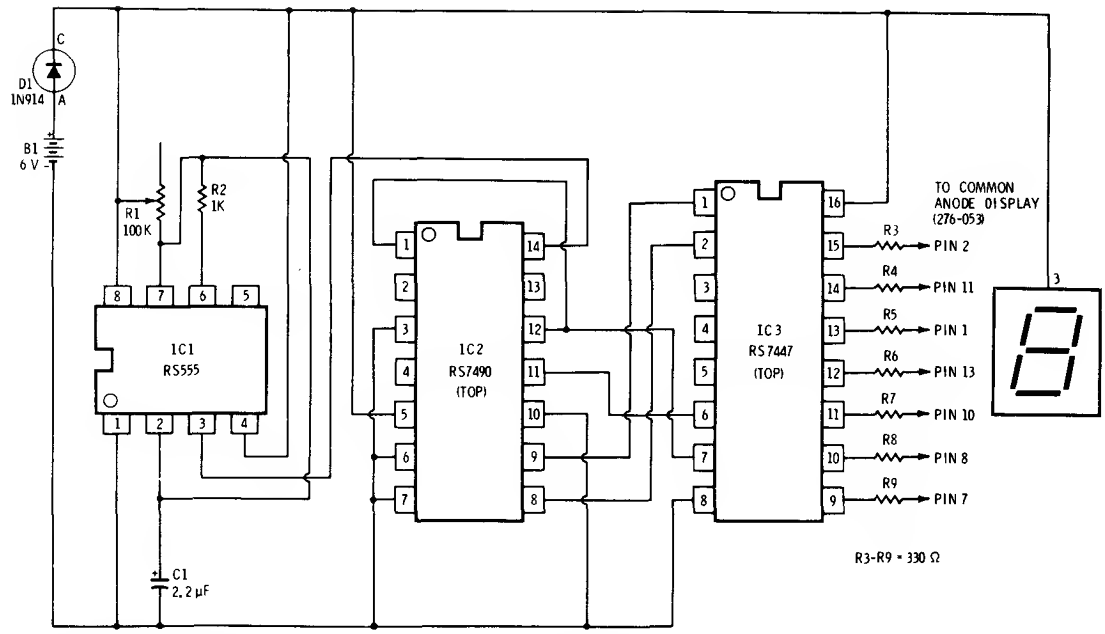
LARGE LED DISPLAY—National MM5736 calculator chip is used with DM8895 segment driver that can be mask-programmed to source several values of current in range from 5 to 17 mA per segment of LED display, permitting use of fairly large display. Display current comes from V_{CC} supply terminal of DM8895 rather than from calculator chip. Combination serves as 6-decade counter driving 6-digit display.—M. Watts, "Calculator Chip Makes a Counter," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 3.



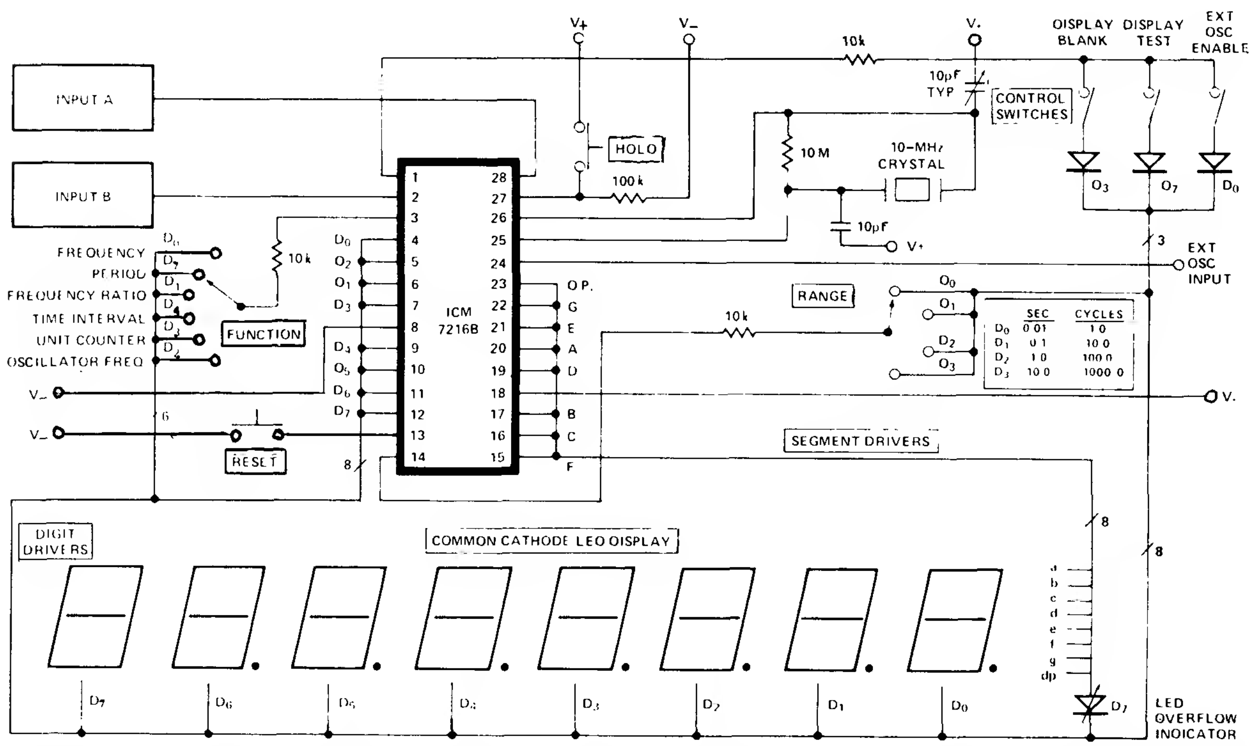
CLEAN RESET—Adding latch consisting of two 7400 NAND gates to reset circuit of divide-by-77 counter guarantees good reset. Reset pulse will always be half a clock period wide.—E. E. Hrivnek, House Cleaning the Logical Way, *73 Magazine*, Aug. 1974, p 85–90.



CALCULATOR COUNTS BY 4s—Connection shown for National MM5736 calculator chip counts either up or down by 4s, as might be required for keeping track of inventory in bin when parts are packaged in groups of 4. To count by numbers other than 1, desired number is entered into calculator during manual start operation. When S_2 is pushed, counter adds 4 to accumulated total. When S_3 is pushed, counter subtracts 4 from accumulated total. Logic elements provide self-starting action of counter.—M. Watts, "Calculator Chip Makes a Counter," National Semiconductor, Santa Clara, CA, 1974, AN-112, p 5.

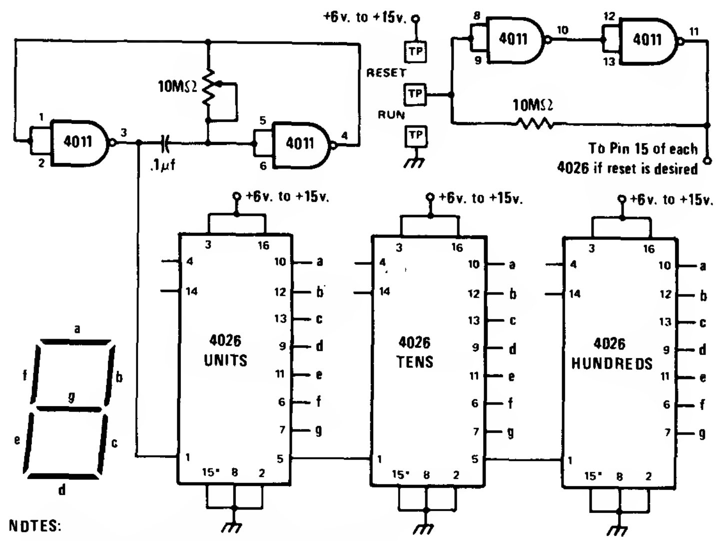


DIGITAL COUNTING DEMONSTRATOR—555 timar servas as clock for driving RS7490 dacade counter feeding RS7447 BCD to 7-sagmant decodar that drives 7-sagmant digital display. R1 is adjusted to giva clock frequency that makes display cycle slowly through digits 0-9 and repeat, for classroom demonstrations.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 53–63.

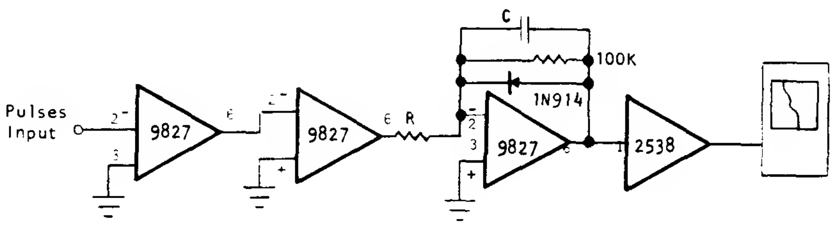


FREQUENCY/PERIOD/EVENT/TIME — Univarsal counter with 10-MHz maximum frequency provides multiple functions with minimum numbar of components. Ranga of tima pariod maasurements is 0.5 μs to 10 s. Includes 10-MHz crystal oscillator, multiplax timing with interdigit and leading-zero blanking, as well as overflow indication. Decimal position is salactable. Eight-digit multiplaxed LED display outputs of IC can switch up to 250 mA per digit for handling larga displays. Maximum supply voltage is 6 V.—Low Cost Universal Countar Performs Wida Ranga of Functions, *Computer Design,* Aug. 1978, p 168 and 170.

FREE-RUNNING COUNTER DISPLAY—Attention-getting circuit simply counts at predetermined rate while driving 3-digit display using 7-segment LEDs. Circuit uses two sections of 4011 CMOS quad NAND gate to generate pulses at rate controlled by 100-megohm pot. Pulses trigger 4026 counters connected as shown, with outputs a-g of each going to 7-segment LED display. When all three displays reach 9, next pulse resets all to 0 and count continues. Auxiliary circuit at upper right uses remaining sections of 4011 as flip-flop controlled by touch-plate switches; bridging gap between center and grounded plates with finger makes counter run. Bridging other gap resets counter to 0 and holds it there. If reset is not used, connect input pins 8, 9, 12, and 13 of unused gates to pin 14.—J. A. Sandler, 9 Easy to Build Projects under $9, *Modern Electronics*, July 1978, p 53–56.



NOTES:
+6v. to +15v. to Pin 14 of 4011 return to Pin 7 of 4011
No dropping resistors needed for most .3 to .8 inch LED displays.

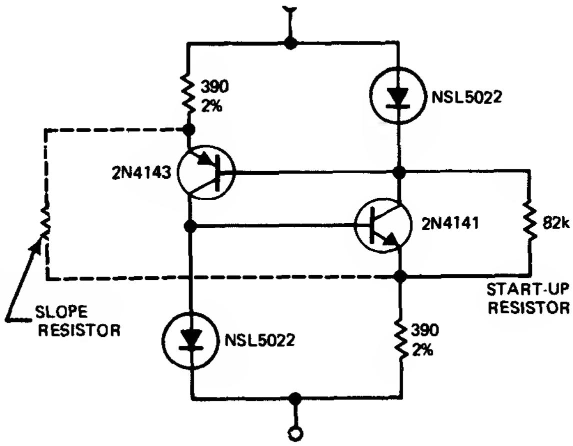


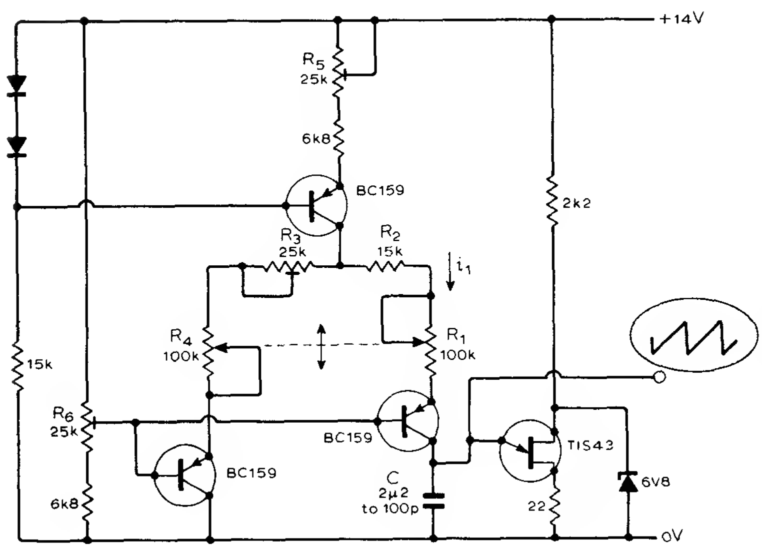
COUNTING-RATE METER—Uses three Optical Electronics 9827 opamps to amplify, square up, and integrate input pulses from event detector, to give integrated DC voltage that is function of counting rate. This voltage is compressed by 2538 DC logamp having 60-dB dynamic range for driving chart recorder. Values of R and C depend on counting rate. Well-regulated power supply is required because this determines amplitude of squared pulses that drive integrator. Applications include counting photons of photomultiplier or nuclear particles of solid-state detector. Logamp compresses output of integrator to eliminate need for scale changing while giving constant accuracy over wide dynamic range of counting rates.—"Logarithmic Counting Rate Readout," Optical Electronics, Tucson, AZ, Application Tip 10106.

CHAPTER 22
Current Control Circuits

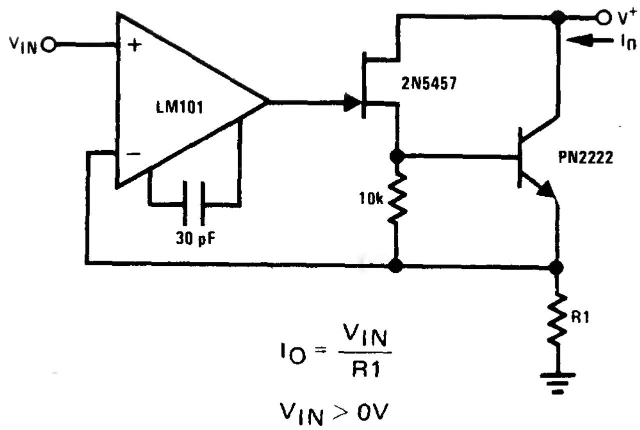
Includes fixed, adjustable, and voltage-controlled current sources, bilateral sources, current limiters, current regulators, current sink, current-controlled oscillator, power supply monitor, and electronic fuse.

5 mA WITH VARIABLE-SLOPE START-UP—Low-cost NSL5022 LED typically has 1.6-V drop at 2 mA, to produce constant 0.9 V across 390-ohm emitter resistors in circuit shown. Use of two current sources, each feeding other's LED reference, eliminates all voltage defects except for small voltage-dependent changes in transistor parameters. Adding 240K slope resistor cancels these changes, holding current constant within 0.1% over supply voltage range of 5–20 V. Applications include use as voltage divider with gain, Q multiplier for tuned circuits, and bias compensation.—P. Lefferts, Variable Slope Current Source Starts at 2.5 V, *EDN Magazine*, Nov. 5, 1975, p 100.

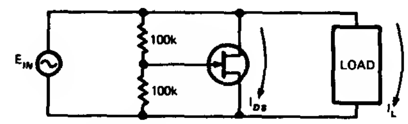




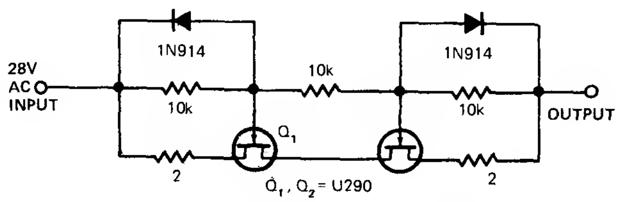
POT CONTROL—Circuit makes current through linear pot a linear function of rotational angle of pot. Article gives design equations. Current i_1 through R_1 is used to charge C, which is periodically discharged by UJT when trigger voltage is reached. Frequency of output sawtooth is proportional to i_1 and hence to angle of rotation of pots. To set up, adjust pots to give maximum sawtooth frequency and adjust preset R_5 for required maximum frequency. Set pots to other extreme end reset R_3 for required minimum frequency.—A. Armit, Linear Current/Rotation Control, *Wireless World*, Dec. 1975, p 576.



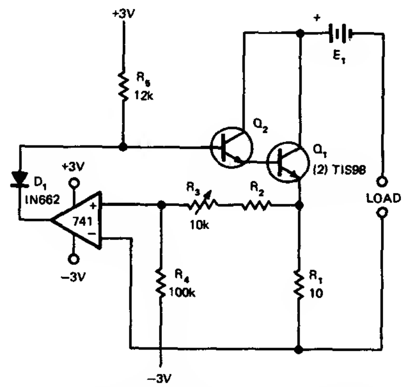
PRECISION CURRENT SINK—R1 serves as current-sensing resistor providing negative feedback for opamp to enhance true current-sink nature of circuit. Both JFET and bipolar have inherently high output impedance as required for high-accuracy current sink.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



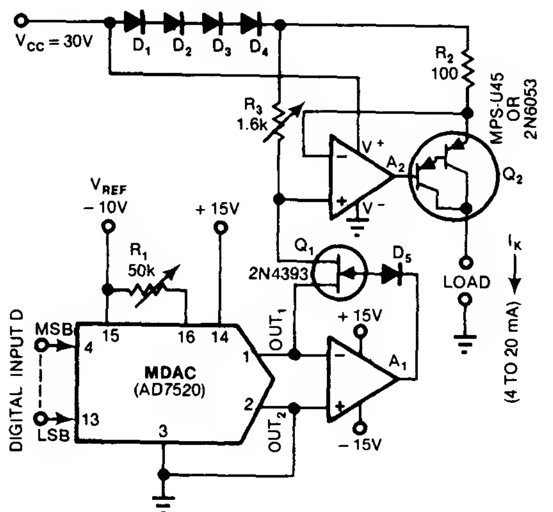
JFET CURRENT SINK—Simple circuit effectively raises load operating point of current-sensitive device by shunting current through JFET having nonlinear action. JFET type is not critical. Applications include improvement of thyristor noise performance by diverting current around load.—V. Gregory, FET Current Sinks Raise Operating Points, *EDN Magazine*, Feb. 20, 1974, p 81.



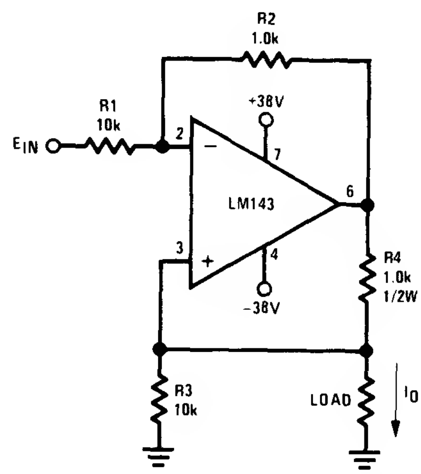
28-VAC CURRENT LIMITER—Dual JFETs in voltage-sharing arrangement protect output of 28-VAC power amplifier. Transistors should be matched for I_{DSS}. During positive half-cycle of input, Q_2 operates as current limiter and Q_1 as source follower. If Q_1 does not supply enough current, drain voltage of Q_2 drops and makes Q_1 turn on further. Conversely, if Q_1 supplies too much current, Q_2 drain voltage rises and tends to turn Q_1 off. On negative half-cycle, Q_1 becomes limiter and Q_2 is source follower.—J. P. Thompson, Current Limiter Protects Amplifier from Load Faults, *EDN Magazine*, June 5, 1978, p 148 and 150.



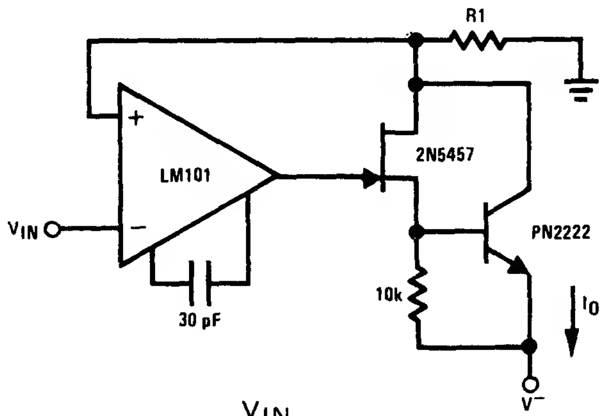
20-mA FLOATING SOURCE—Battery-operated circuit shown gives adequate stability for strain-gage bridge. Uses four alkaline penlight cells to provide ±3 V for 741 opamp. E_1 is chosen to give adequate voltage for intended load at maximum load current. Temperature stability is 0.7 μA/°C from 0 to 50°C.—R. Tenny, Isolated Current Source, *EDN Magazine*, April 20, 1973, p 85.



4–20 mA SOURCE—Digital input to multiplying digital-to-analog converter determines load current in range of 4 to 20 mA with 15.6-μA resolution. R_1 adjusts ratio of full-scale to zero-scale current at output 1 of MDAC, and R_3 sets circuit offset and span to give correct end-range currents for load. Maximum load compliance is 25 V. Opamp types are not critical.—J. Wilson and J. Whitmore, MDAC's Open Up a New World of Digital-Control Applications, *EDN Magazine*, Sept. 20, 1978, p 97–105.

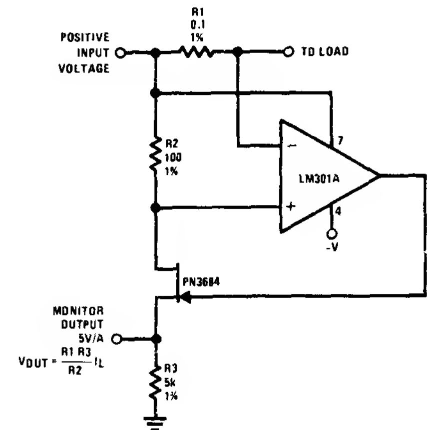


HIGH-COMPLIANCE CURRENT SOURCE—Noninverting input of LM143 high-voltage opamp senses current through R4 to establish output current that is proportional to input voltage. With ±38 V supply, compliance of current source is ±28 V.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 3.

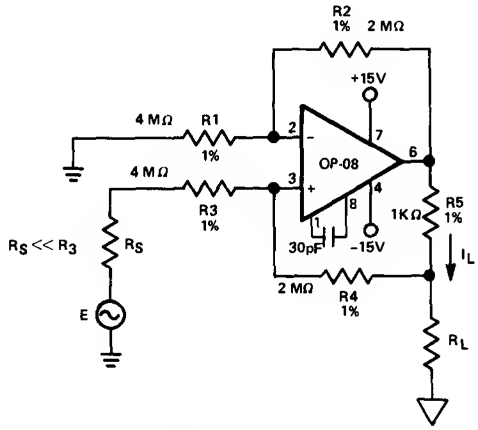


$$I_O = \frac{V_{IN}}{R1} \quad V_{IN} \leq 0V$$

PRECISION CURRENT SOURCE—2N5457 JFET and PN2222 bipolar transistor serve as isolators between output end current-sensing resistor R1. LM101 opamp provides high loop gain to assure that circuit acts as current source.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

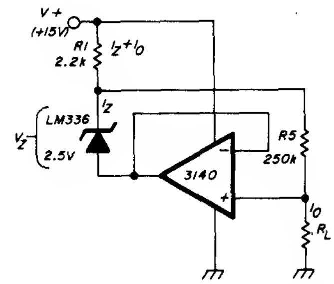


POWER SUPPLY MONITOR—R1 senses output current of power supply. PN3684 JFET is used as buffer because source and drain currents are equal, so monitor output voltage accurately reflects current flow of power supply.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

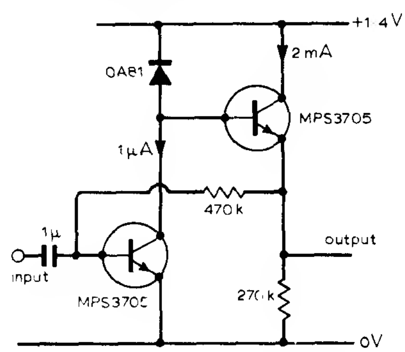


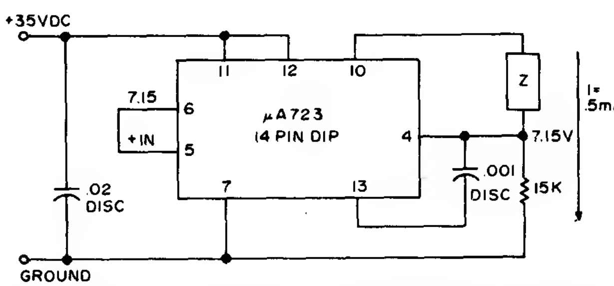
$I_L \cong \frac{ER_4}{R_3R_5}$ IF R1 = R3 AND $R_2 = R_4 + R_5$ THEN I_L IS INDEPENDENT OF VARIATIONS IN R_L.

BILATERAL CURRENT SOURCE—Output current through load is constant within 2% of value related to input voltage and resistor values, regardless of variations in load from 10 to 2000 ohms. Circuit is built around Precision Monolithics OP-08 opamp.—"Precision Low Input Current Op Amp," Precision Monolithics, Santa Clara, CA, 1978, OP-08, p 7.



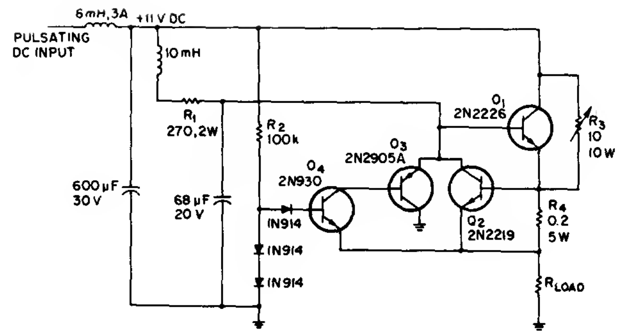
CURRENT REGULATOR—Combines zener with opamp in bootstrap configuration. Regulated output current I_o can be any value less than I_z but must be much greater than opamp bias current. Current in zener is set by R1 to provide minimum of 1 mA. Performance can be improved by using Motorola MC1403 or other 2.5-V three-terminal voltage reference in place of zener.—W. Jung, An IC Op Amp Update, *Ham Radio,* March 1978, p 62–69.



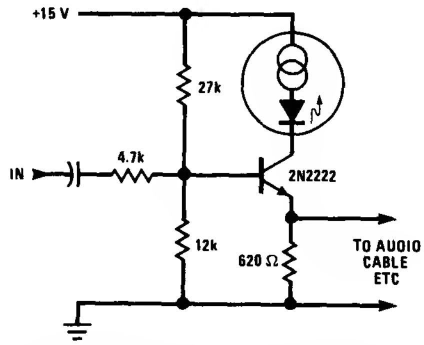


0.5 mA FOR 0–50 KILOHMS—Current source uses Fairchild μA723 voltage regulator operating from ordinary unregulated supply not over 40 VDC. Regulator has built-in 7.15-V reference. Output current is well within 1% of 0.5 mA for load impedances from 0–50K.—L. Nickel, Constant Current Sources, *73 Magazine,* March 1974, p 29.

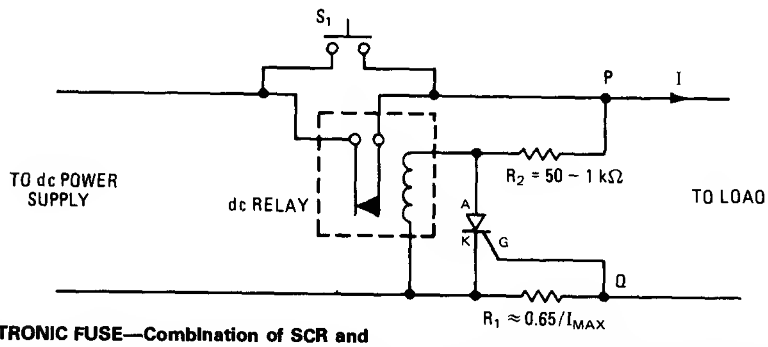
CURRENT SOURCE AS TRANSISTOR LOAD—Reverse-biased germanium diode serves as voltage-independent current source for loading silicon transistors in linear amplifier having voltage gain of 50 and −3 dB bandwidth of 16–4000 Hz. In addition to low cost, circuit design permits reliable operation of reliable micropower circuits over wide temperature range at optimum current drain.—M. G. Baker, Low-Current Source, *Wireless World,* April 1976, p 61.



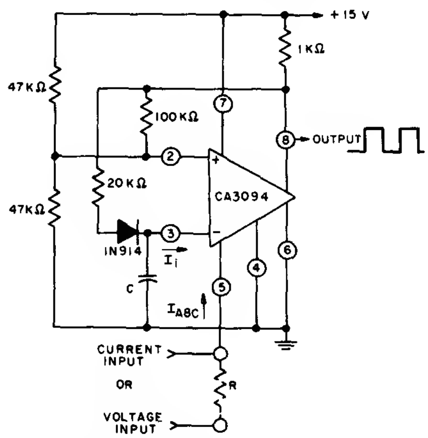
3-A LIMITER—Simple current limiter protects itself from overdissipation during shorted output, while handling capacitor or cold-filament loads that momentarily act like shorts. R_3 is adjusted so starting current is high enough to begin heating cold filament. As filament voltage increases to about 100 mV, Q_4 and Q_3 turn off, allowing load current to rise to 3-A limiting value.—L. G. Wright, Short-Protected Current Limiter Ignores Inrush Currents, *EEE Magazine*, Sept. 1970, p 89–90.



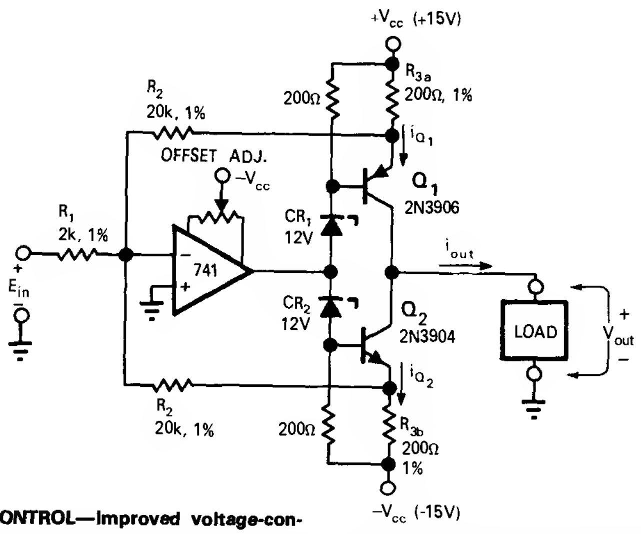
CONSTANT-CURRENT LED—National NSL4944 LED having built-in current control features can be used in simple circuit shown to provide current limiting and short-circuit protection for 15-V supply. Even with output shorted, LED draws only a little more than rated current.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-153, p 3.



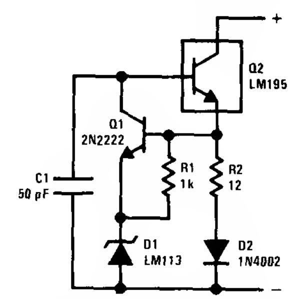
ELECTRONIC FUSE—Combination of SCR and line relay gives faster action than circuit breaker for protection against current overload. Closing S_1 momentarily energizes relay, completing current path from supply to load. Overload current increases voltage drop across R_1 to above 0.65 V, switching on SCR and thereby shorting relay coil to make it open. S_1 must be pressed again to reset relay. For adjustable dropout, gate of SCR can be connected to pot placed across R_1.—R. Quong, Resettable Electronic Fuse Consists of SCR and Relay, *Electronics*, Sept. 15, 1977, p 117.



CURRENT-CONTROLLED OSCILLATOR—Makes use of proportional relationship between input current I_i and amplifier input bias current I_{ABC} of CA3094 programmable opamp. Linearity is within 1% over middle half of characteristic. Circuit can be used for voltage input if voltage is applied to pin 5 through appropriate dropping resistor R. Output is square wave.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 4.



VOLTAGE CONTROL—Improved voltage-controlled current source uses complementary transistors in opamp feedback loop. Common-mode voltage at input to opamp is always near zero. Circuit was designed for use in integrator having ground-referenced integrating capacitor, to produce 1 mA/V. R_{3a} and R_{3b} sense current through Q_1 and Q_2, so voltage proportional to difference is fed back to input of opamp for comparison with input voltage. Zener voltages determine quiescent-current level. Frequency response is limited to 1 MHz by performance of specified opamp.—P. T. Skelly, Voltage-Controlled Current Source, *EDN/EEE Magazine*, Aug. 1, 1971, p 45–46.

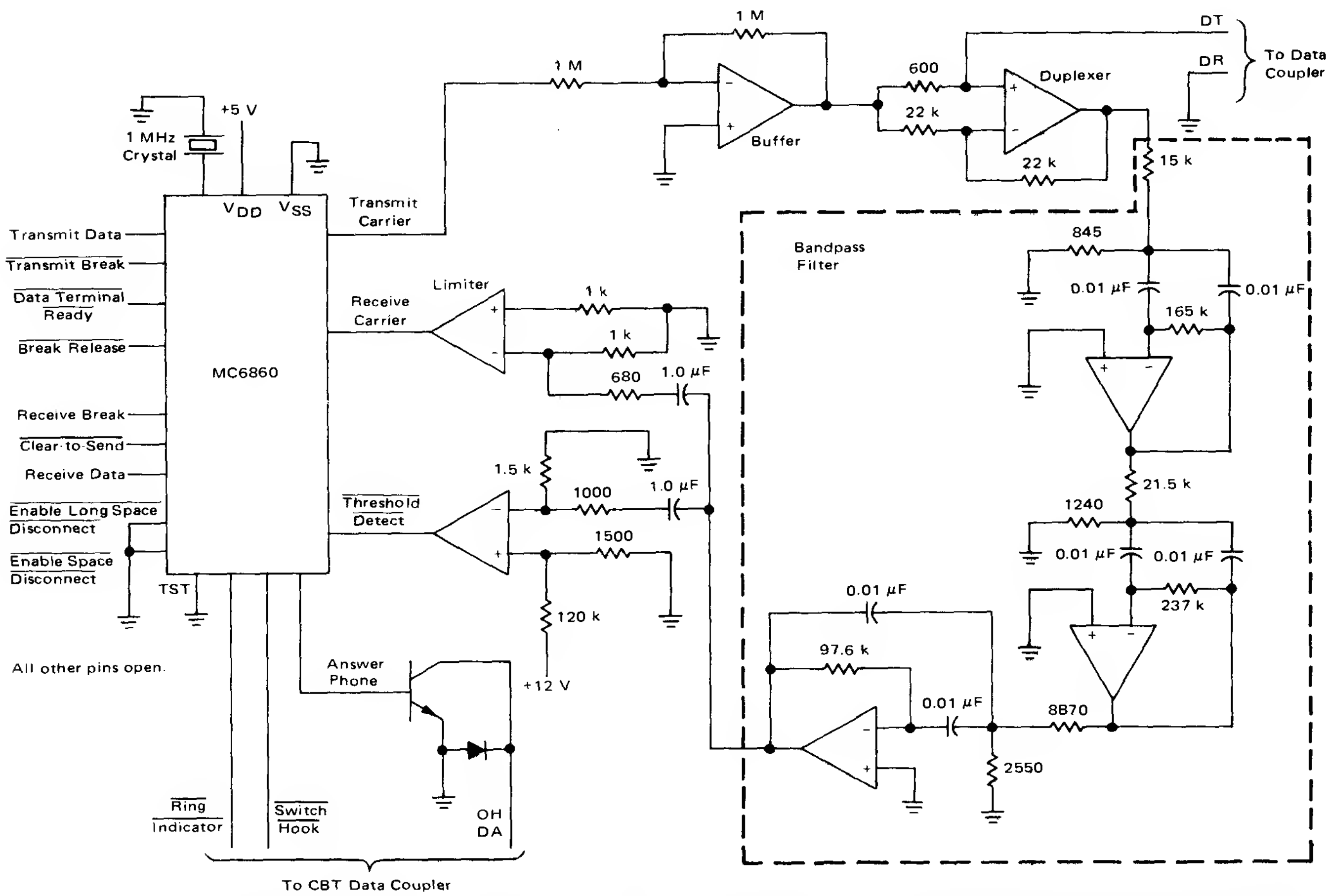


100-mA CURRENT REGULATOR—Two-terminal circuit using LM195 power transistor has low temperature coefficient and operates down to 3 V. 2N2222 controls voltage across current-sensing resistor R2 and diode D1. Voltage across sense network is base-emitter voltage of 2N2222 plus 1.2 V from LM113. R1 sets current through LM113 to 0.6 mA.—R. Dobkin, "Fast IC Power Transistor with Thermal Protection," National Semiconductor, Santa Clara, CA, 1974, AN-110, p 6.

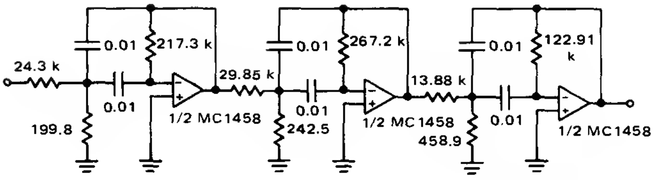
CHAPTER 23

Data Transmission Circuits

Includes line driver, line receiver, modem, bit-rate generator, coder-decoder, FSK demodulator, signal conditioner, optoisolator, PDM telemetry, active bandpass filter, and other circuits used for transmitting digital data and digital speech over twisted-pair, coaxial, or balanced line.

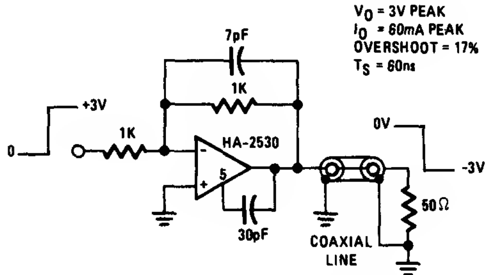


ANSWER MODEM—Transmits on upper channel (mark 2225 Hz and space 2025 Hz) and receives on lower channel (mark 1270 Hz and space 1070 Hz). Buffer and duplexer provide modem interface to transmission network. Bandpass filter allows only desired receive signals to be seen by limiter and demodulator. Motorola MC6860 modem IC contains modulator, demodulator, and supervisory control functions.—G. Nash, "Low-Speed Modem Fundamentals," Motorola, Phoenix, AZ, 1974, AN-731, p 6.

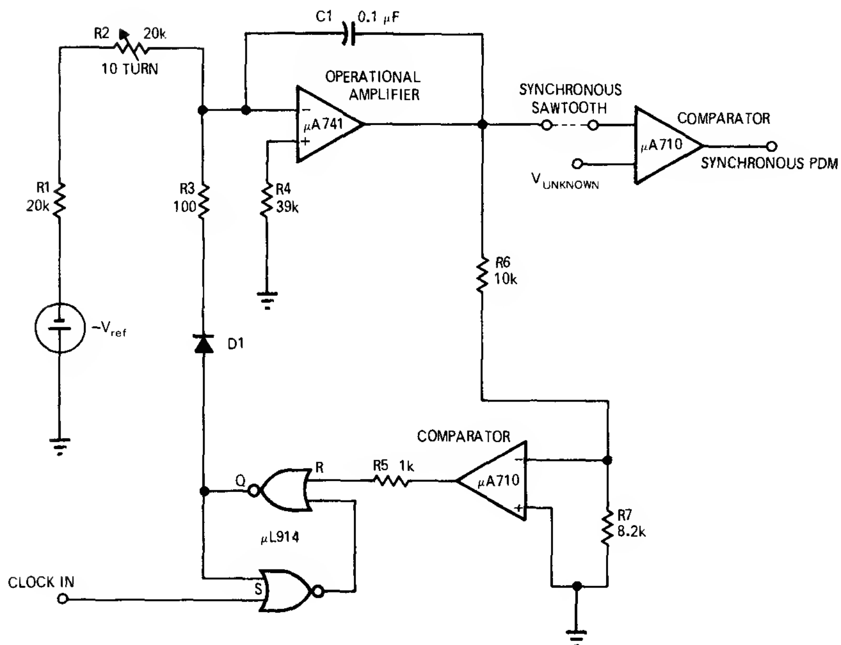


All capacitors are in μF.

BANDPASS ORIGINATE FILTER—Provides gain of over 15 dB between 1975 end 2275 Hz, to ecept 2025–2225 Hz signals of low-speed modem system using Motorola MC6860 IC.—J. M. DeLaune, "Low-Speed Modem System Design Using the MC6860," Motorola, Phoenix, AZ, 1975, AN-747, p 13.

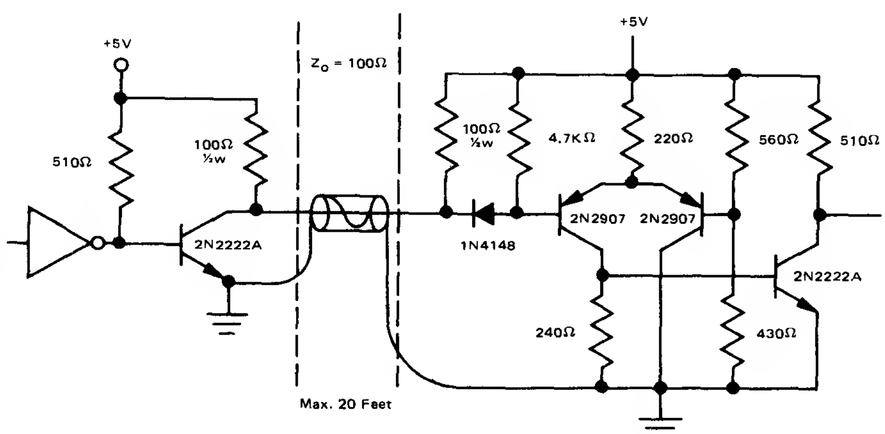


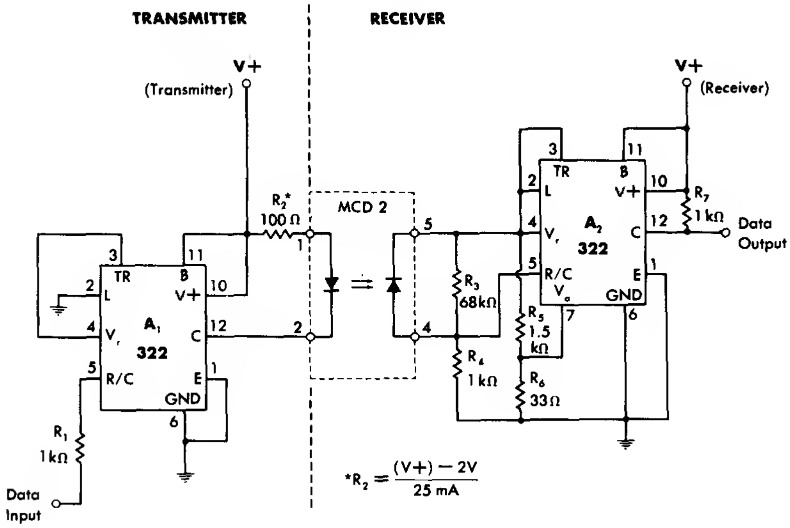
FAST-SETTLING COAX DRIVER—Suitable for use as rader pulse driver, video sync driver, or pulse-emplitude-modulation line driver. Uses Harris HA-2530/2535 wideband amplifier heving high slew rete. Useble bendwidth is about 100 kHz when connected for noninverting operation as shown. Driver output is 60 mA into 60-ohm load. 5% settling tima is 60 ns.—"Linear & Deta Acquisition Products," Harris Semiconductor, Melboume, FL, Vol. 1, 1977, p 7-54 (Application Note 516).



SYNCHRONOUS SAWTOOTH FOR PDM TELEMETRY—Circuit generetes highly linear ramp that is resat to zero by each clock pulse. When remp exceeds analog velua of unknown input voltage, pulse is terminated. R1, R2, and C1 form integrating network around opamp. Varying R2 changes slope of remp output.—J. Springer, Build a Sawtooth Generator with Three ICs, *EDN Magazine,* Nov. 15, 1970, p 49.

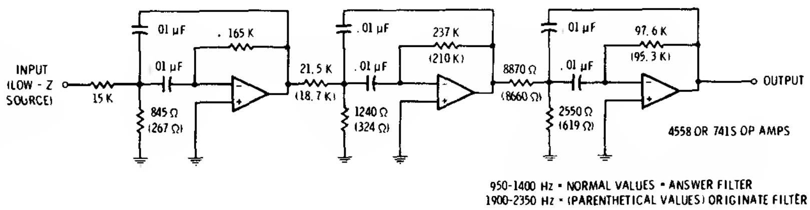
INTERFACES FOR 100-OHM LINE—Permits trensferring dete signals from SA900/901 diskatta storage drive to location of MC6800 microprocessor up to meximum of 20 feet away through 100-ohm coex. Data lina drivers used ere capable of sinking 100-mA in logic true state with meximum voltege of 0.3 V with respect to logic ground. When lina driver is in logic false stete, driver trensistor is cut off end voltage at output of driver is at leest 3 V with respect to logic ground.—"Microprocessor Applications Menual" (Motorole Series in Solid-Stete Electronics), McGrew-Hill, New York, NY, 1975, p 5-211–5-212.

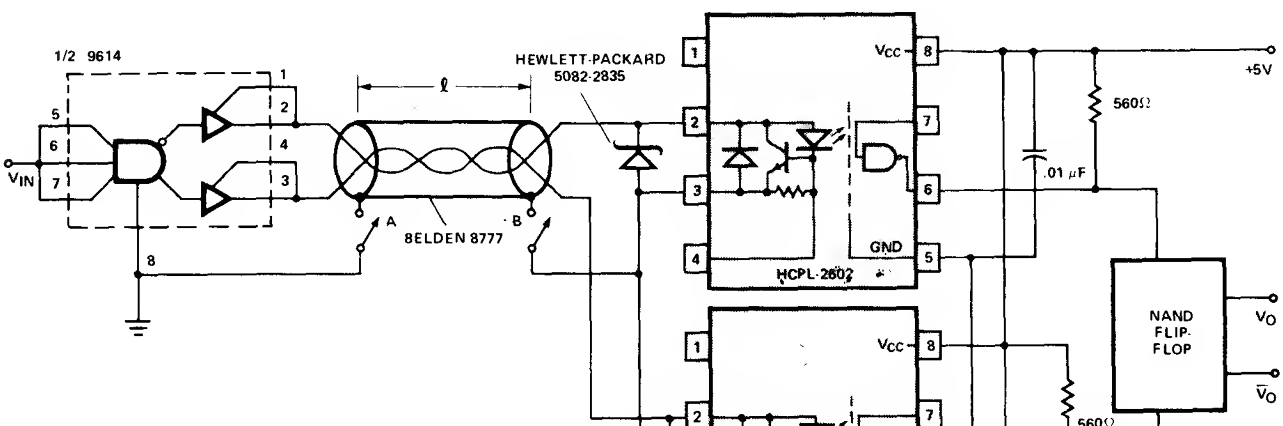




OPTICALLY COUPLED DATA LINK—322 comparator at transmitter end of link drives LED of MCD 2 optoisolator which accepts TTL input. Receiver is similar comparator having additional biasing to match photodiode output of optoisolator. Complete system is noninverting, with delay of about 2 μs. Receiver can have any supply within 4.5–40 V range of 322. Transmitter should be matched to its supply voltage by selecting R_2 according to equation shown.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 156–158.

RECEIVE FILTER—Used as prefilter having controlled group-delay distortion, ahead of receiving modem in data transmission system. Values shown are for 950–1400 Hz answer filter. For 1900–2350 Hz originate filter, change critical values to those given in parentheses.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 180–182.

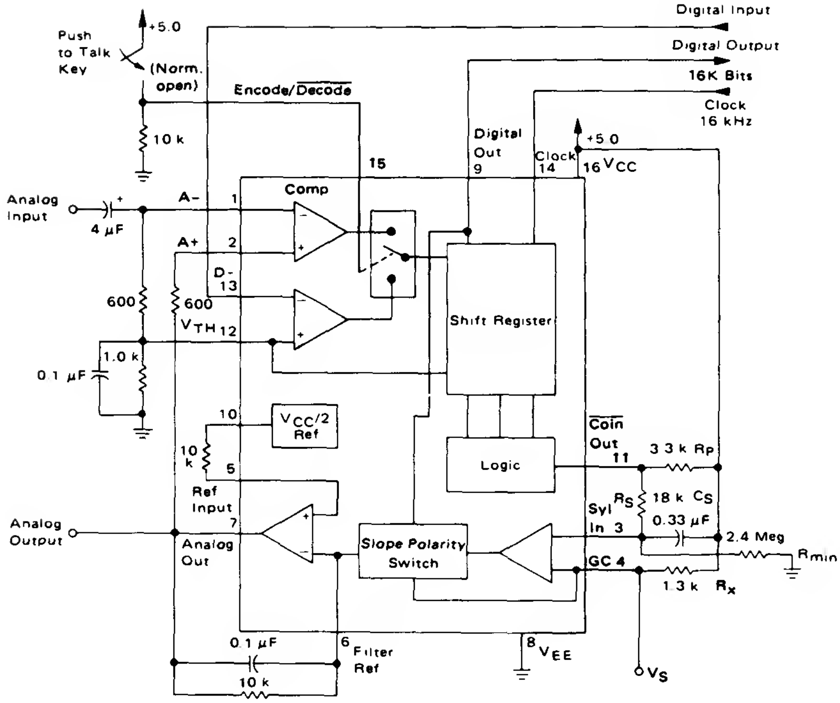




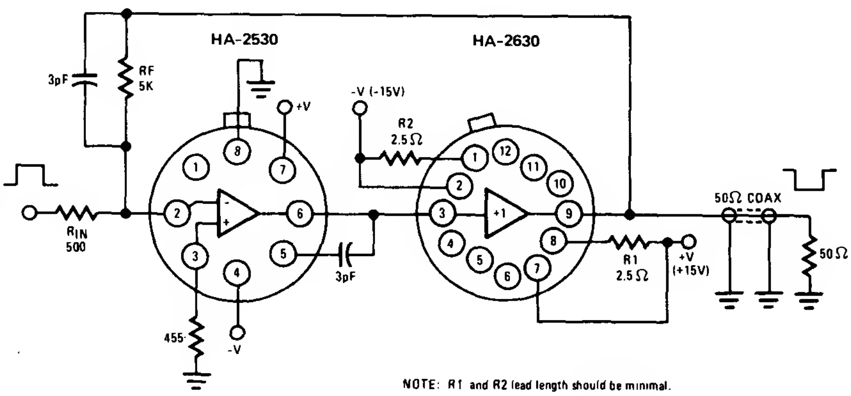
	WITHOUT SCHOTTKY DIODES			WITH SCHOTTKY DIODES			SWITCH A	SWITCH B	UNITS
ℓ	<1	30	90	<1	30	90	–	–	m
t_p	100	165	340	55	75	215	OPEN	OPEN	nsec
	45	125	310	45	70	185	OPEN	CLOSED	nsec
	45	60	125	45	60	125	CLOSED	CLOSED	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

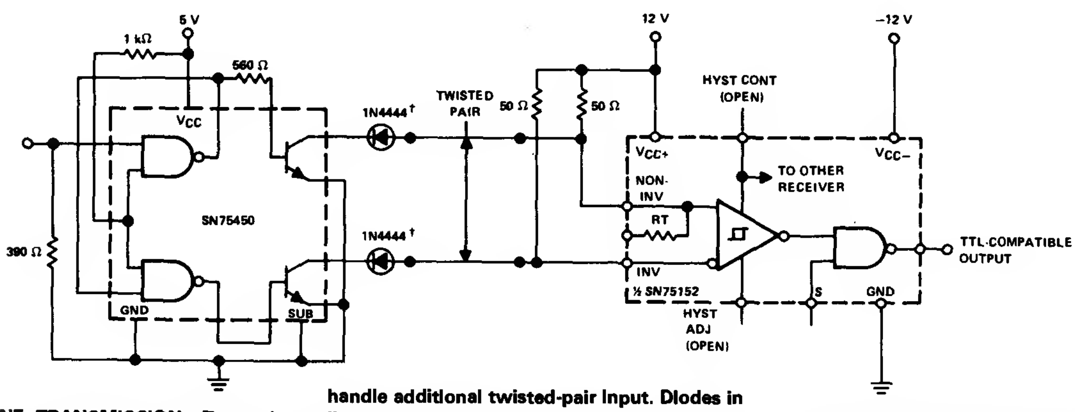
POLARITY-REVERSING SPLIT-PHASE DRIVE—Half of 9614 polarity-reversing line driver feeds pair of Hewlett-Packard HCPL-2602 optically coupled line receivers through coax cable. Cable-grounding switches A and B change performance. Closing only switch B enhances common-mode rejection but reduces propagation delay slightly. Closing both switches optimizes data rate. Schottky diodes at receiver inputs improve data rate. NAND flip-flop at output greatly improves system noise rejection in split-phase termination of line.—"Optoelectronics Designer's Catalog 1977," Hewlett-Packard, Palo Alto, CA, 1977, p 158–159.



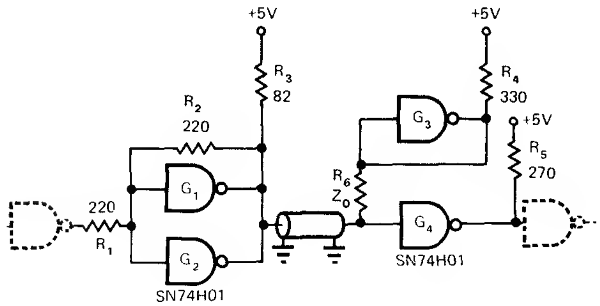
CVSD ENCODER FOR SECURE RADIO—Motorola MC3417 continuously variable slope delta modulator-demodulator IC is used as 16-kHz simplex voice coder-decoder for systems requiring digital communication of analog signals. Clock rate used depends on bandwidth required and can be 9.6 kHz or less for voice-only systems. Analog output uses single-pole integration network formed with 0.1 μF and 10K. Report covers circuit operation in detail for various applications.—"Continuously Variable Slope Delta Modulator/Demodulator," Motorola, Phoenix, AZ, 1978, DS 9488.



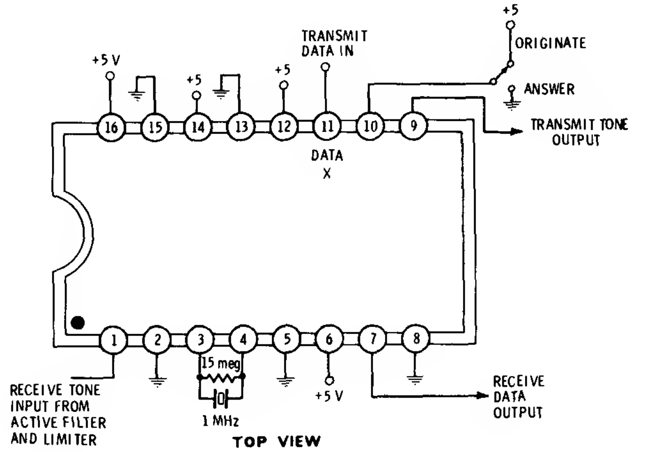
5-MHz COAX LINE DRIVER—Combination of Harris HA-2530 wideband inverting amplifier and HA-2630 unity-gain current amplifier provides 20-dB gain with extremely high slew rate and full power bandwidth even under heavy output loading conditions.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 2-47–2-50.



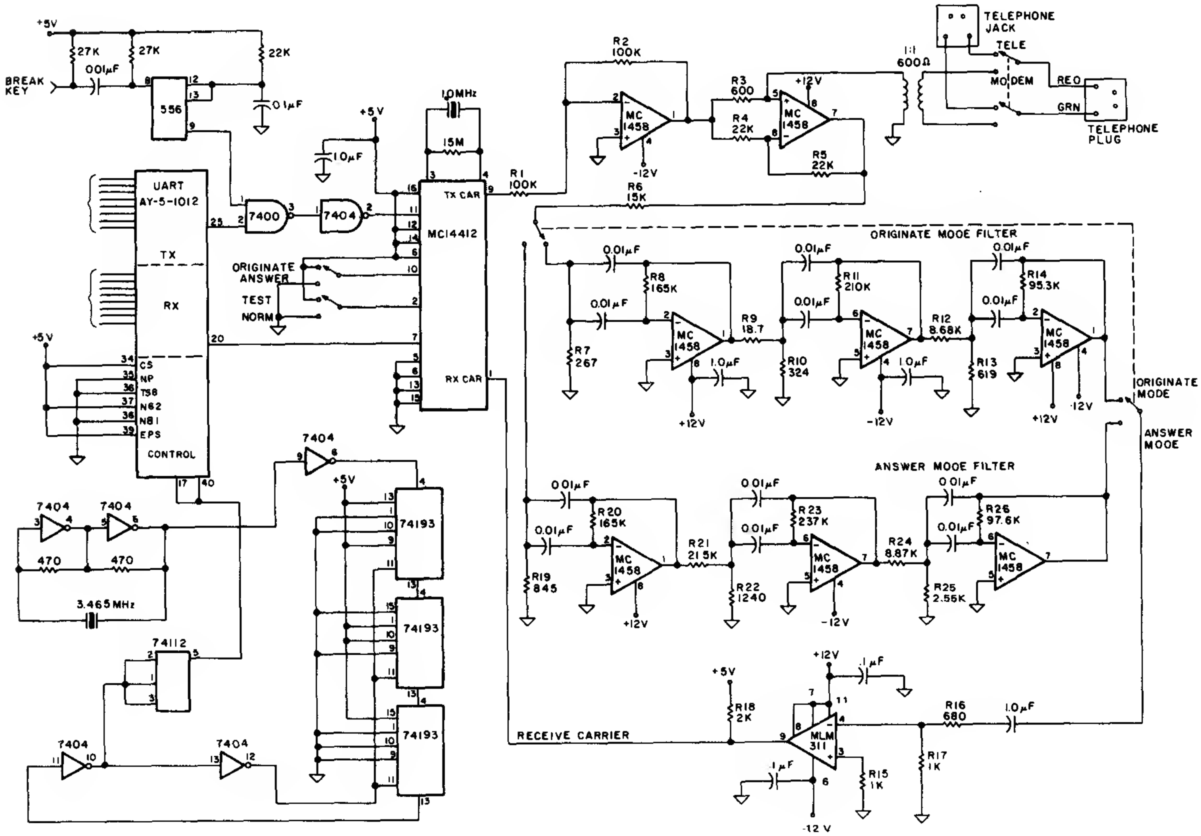
BALANCED-LINE TRANSMISSION—Transmits data at rates up to 0.5 MHz over twisted pair to Texas Instruments SN75152 dual-line receiver. Other section of receiver is identical and can handle additional twisted-pair input. Diodes in lines are required only for negative common-mode protection at driver outputs. System has high common-mode voltage capability. SN75450 is dual peripheral driver for high-current switching at high speeds.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 8-78.



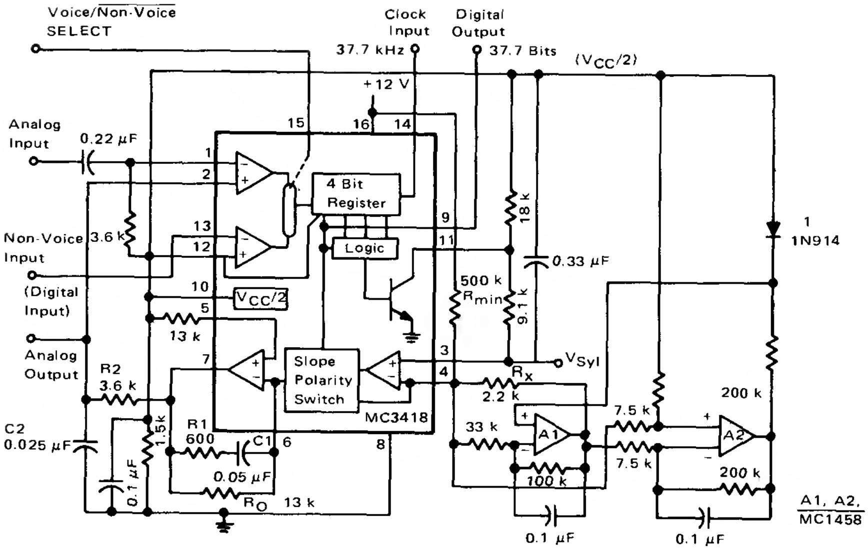
COAX DRIVER AND RECEIVER—Uses two TTL gates of SN74H01 package to form either driver or receiver for transmitting data over RG59 or RG174 coax at rates exceeding 10 megabits per second, with distance increasing from 400 meters at 10 Mb/s to over 1000 meters at 100 kb/s for RG59 and lesser distances for RG174. Can also be used for twisted-pair lines but at lower data rates. Bias gate G_3 exhibits low output impedance, for terminating channel load resistor R_6.—R. W. Stewart, Two TTL Gates Drive Very Long Coax Lines, *EDN Magazine*, Oct. 1, 1972, p 49.



103-COMPATIBLE MODEM—Motorola 4412 IC converts serial data, usually to and from universal asynchronous receiver-transmitter, into tones suitable for telephone communication. In originate mode, logic 0 is transmitted as 1070 Hz and logic 1 as 1270 Hz. In answer mode, logic 0 is transmitted as 2025 Hz and logic 1 as 2225 Hz. Modems are used in pairs, with receiver responding to tone group not being transmitted. Speed capability is up to 300-baud data rate. Output is 300 mVRMS into 100K load.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 133.

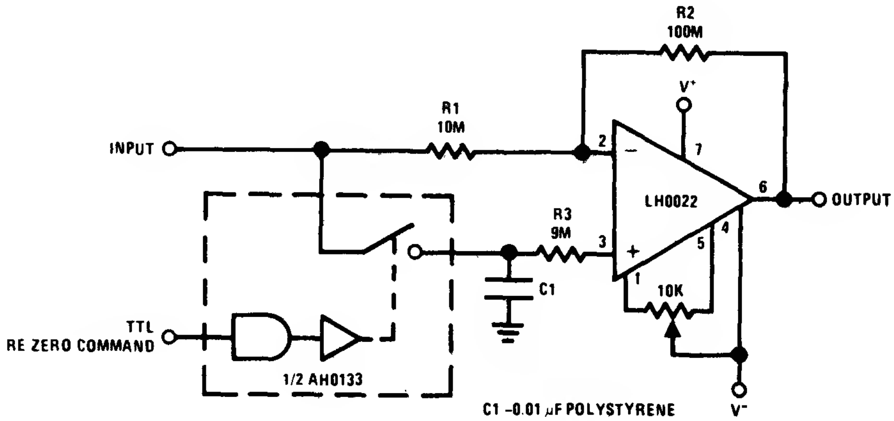


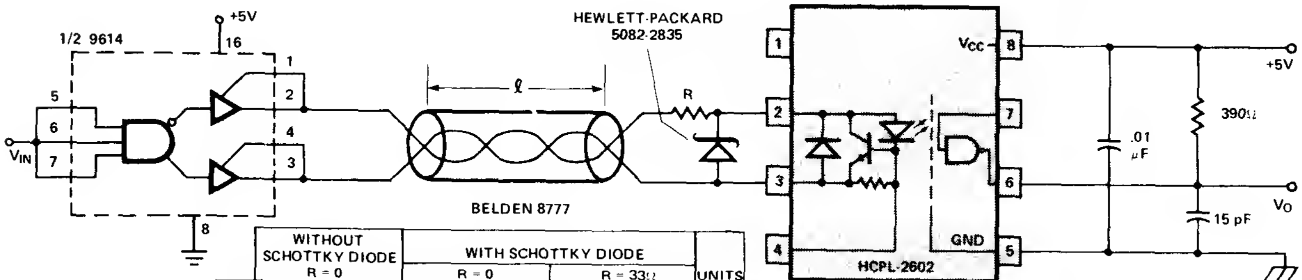
MODEM—Developed as part of TV terminal for microprocessor, to permit communication over telephone line with time-sharing computer system. Uses Motorola MC14412 modem chip for full-duplex FSK modulation having originate frequencies of 1270 Hz for mark and 1070 Hz for space, with answer frequencies of 2225 Hz for mark and 2025 Hz for space. AY-5-1012 UART serves as parallel interface to microprocessor. Article covers operation, construction, testing, connection to telephone lines, and use of modem.—R. Lange, Build the $35 Modem, *Kilobaud*, Nov. 1977, p 94–96.



TELEPHONE-QUALITY CODER-DECODER—Uses Motorola MC3418 continuously veriable slope delta modulator-demodulator IC to giva over 50 dB of dynamic range for 1-kHz test at 37.7K bit reta. At this rate, 40 voica channels can ba multiplexed on standard 1.544-megabit talephone carrier fecility. IC includes activa companding control and double integration for improved performance in ancoding and decoding digital speech. Opamp types ere not critical.—"Continuously Variable Slope Delta Modulator/Demodulator," Motorola, Phoenix, AZ, 1978, DS 9488.

REZEROING AMPLIFIER—Used whara input signal has unknown and variable DC offset, as in telametry applications. Razaro commend line is anabled whila ground refarence signel is applied to input, making C1 charge to level proportional to DC offset of system. When rezaro lina is deactivated, amplifier becomas conventional invartar, subtracting systam offsat end giving true ground-referenced output. For 10-V full-scale systam requiring 0.1% (10-mV) accuracy, amplifiar needs rezaroing referance evary 100 ms.—"Linaar Applications, Vol. 1," National Semiconductor, Santa Clara, CA, 1973, AN-63, p 1–12.

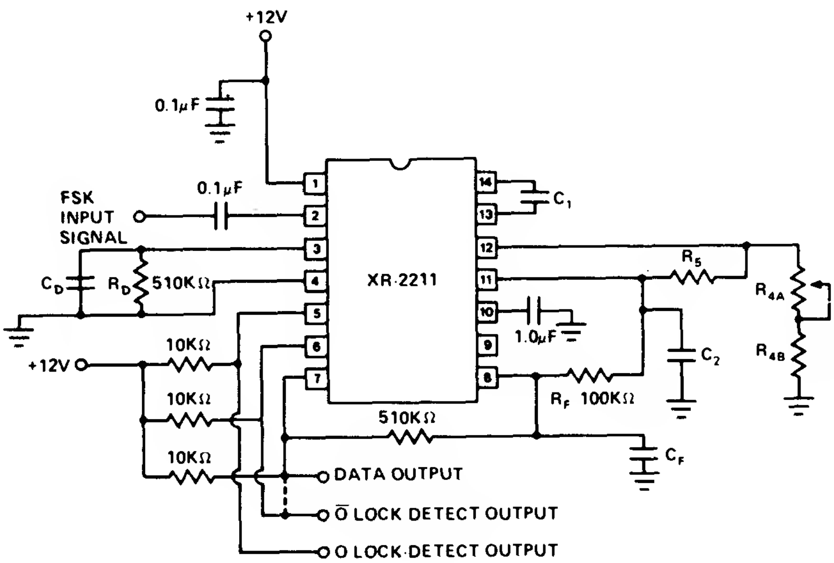




	WITHOUT SCHOTTKY DIODE R = 0			WITH SCHOTTKY DIODE R = 0			R = 33Ω			UNITS
ℓ	<1	30	90	<1	30	90	<1	30	90	m
t_{PHL}	210	365	450	50	80	235	50	70	200	nsec
t_{PLH}	35	45	60	35	45	60	35	45	60	nsec

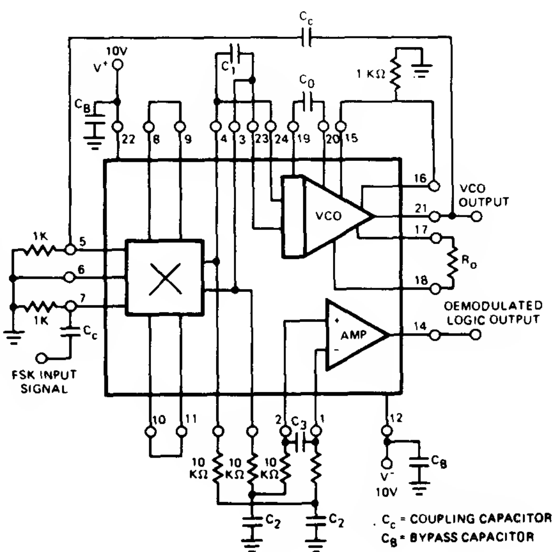
PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

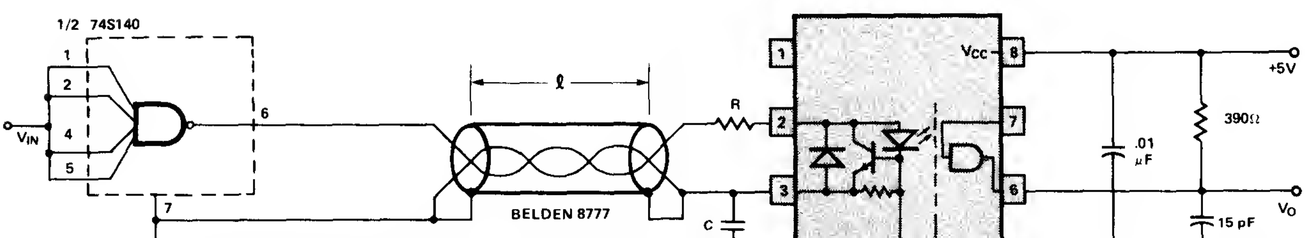
POLARITY-REVERSING DRIVE—Half of 9614 polarity-ravarsing line drivar feeds Hewlett-Packard HCPL-2602 optically coupled line receivar through shialded, twisted-pair, or coex cabla. Data rata is improved considarebly by using Schottky diode at input of receivar. Best deta rates ara achieved when t_{PHL} (propegation delay time to low output level) and t_{PLH} (propagetion dèlay tima to high output leval) ara closest to baing equal.—"Optoelectronics Designer's Catalog 1977," Hewlett-Packard, Pelo Alto, CA, 1977, p 158–159.



FSK DEMODULATOR WITH CARRIER DETECT—Exar XR-2211 FSK demodulator operating with PLL provides choice of outputs when carrier is present; pin 5 goes low and pin 6 goes high when carrier is detected. With pins 6 and 7 connected, output from these pins provides data when FSK is applied but is low when no carrier is present. Circuit performance is independent of input signal strength over range of 2 mV to 3 VRMS. Center frequency is $1/C_1R_4$ Hz, with values in farads and ohms. Choose frequency to fall midway between mark and space frequencies. Used in transmitting digital data over telecommunication links.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 57–61.

FSK DETECTOR—Exar XR-S200 PLL IC is connected as modem suitable for Bell 103 or 202 data sets operating at data transmission rates up to 1800 bauds. Input frequency shift corresponding to data bit reverses polarity of DC output voltage of multiplier. DC level is changed to binary output pulse by gain block connected as voltage comparator.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.

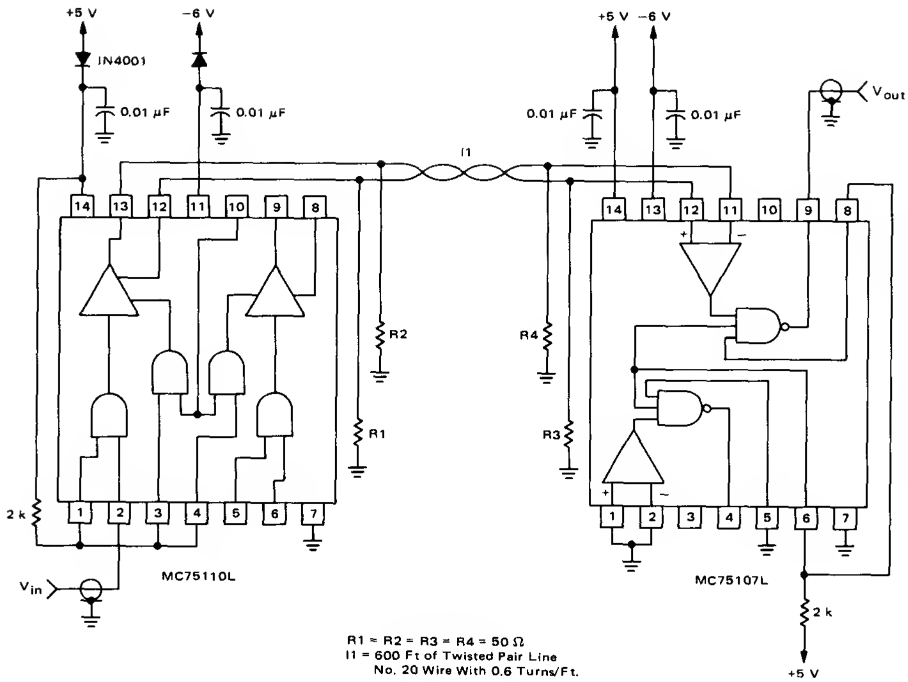




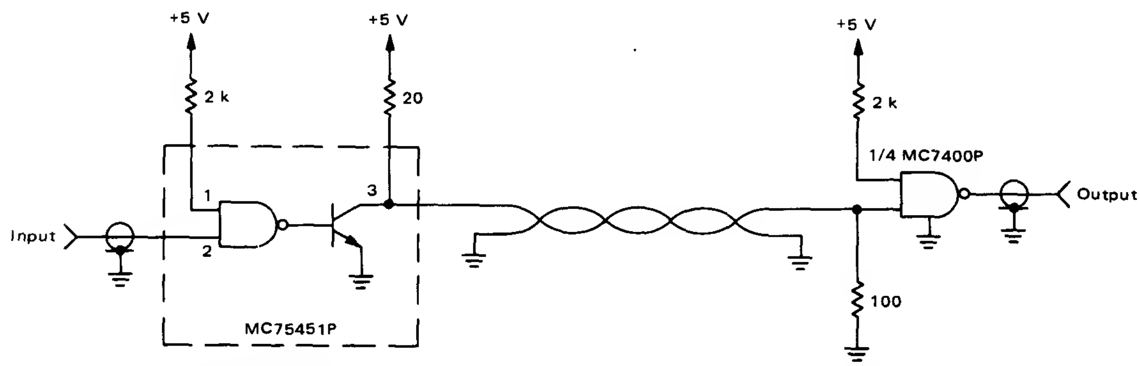
	R = 0, C = 0			R = 32Ω, C = 0			R = 33Ω, C = 430 pF			UNITS
ℓ	<1	30	90	<1	30	90	<1	30	90	m
t_{PHL}	40	50	75	40	50	100	30	45	75	nsec
t_{PLH}	45	65	175	40	50	80	40	45	75	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

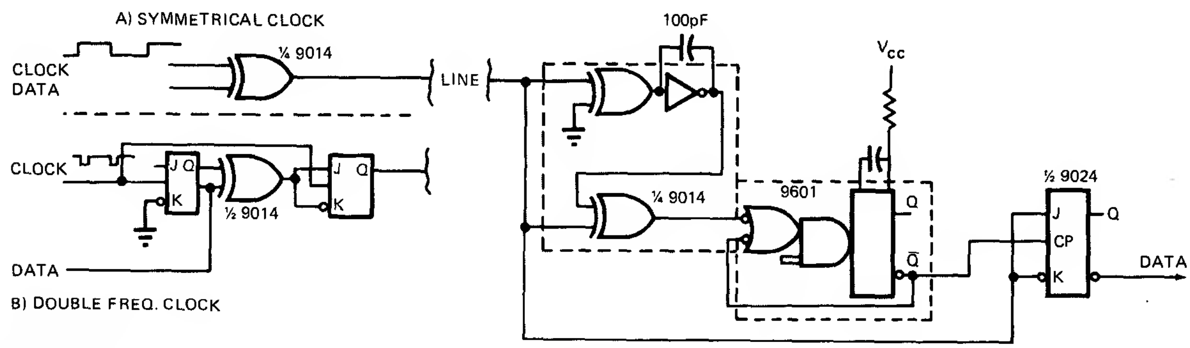
POLARITY-NONREVERSING DRIVE—Hewlett-Packard HCPL-2602 optically coupled line receiver handles high data rates from shielded, twisted-pair, or coax cable fed by 74S140 line driver. Reflections due to active termination do not affect performance. Peaking capacitor C and series resistor R can be added to achieve highest possible data rate. C should be as large as possible without preventing regulator in line receiver from turning off during negative excursions of input signal. Highest data rates are achieved by equalizing t_{PHL} (propagation delay time to low output level) and t_{PLH} (propagation delay time to high output level).—"Optoelectronics Designer's Catalog 1977," Hewlett-Packard, Palo Alto, CA, 1977, p 158–159.



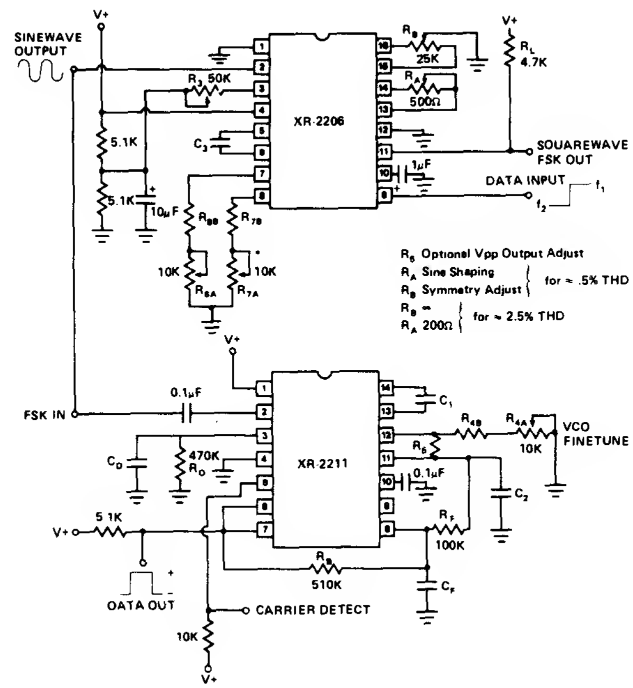
DIFFERENTIAL LINE DRIVER—Uses Motorola MC75110L line driver and MC75107L receiver with twisted-pair transmission line having attenuation of 1.6 dB per 100 feet at 10 MHz. Clock rate is 18.5 MHz. With push-pull driver shown, single pulse corresponds to transmission of 1 followed by series of 0s; one line is then at ground and the other at −300 mV. Arrangement is suitable for party-line or bus applications.—T. Hopkins, "Line Driver and Receiver Considerations," Motorola, Phoenix, AZ, 1978, AN-708A, p 11.



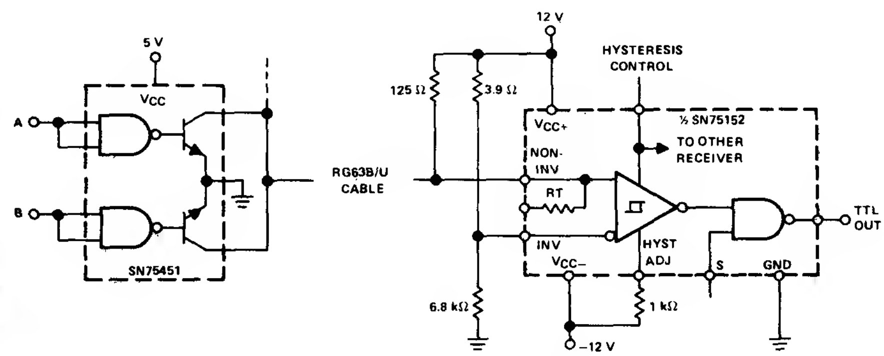
SINGLE-ENDED LINE DRIVER—Supplies 4.2-V input pulse to twisted-pair transmission line for point-to-point system. Requires only single +5 V supply.—T. Hopkins, "Line Driver and Receiver Considerations," Motorola, Phoenix, AZ, 1978, AN-708A, p 14.



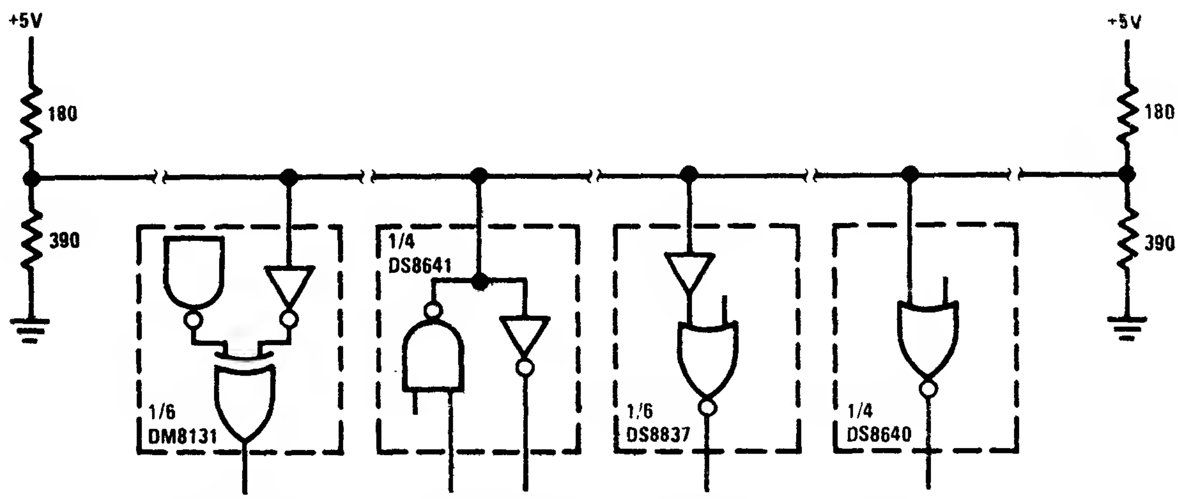
EXCLUSIVE-OR GATES—Use of retriggerable mono with EXCLUSIVE-OR gates simplifies design of both transmitter end receiver for handling binary phase-modulated digital data over single line. With 50% duty-cycle clock at transmitter, clock and data signals are applied to inputs of 9014 to generate output signal for line. At receiver, clock and data stream are regenerated by 9601 adjusted to 75% of data-bit time and connected in nonretriggerable mode. One EXCLUSIVE-OR gate and an EXCLUSIVE-NOR gate connected as inverting delay element will trigger 9601. System remains synchronized as long as pulse width of mono is between 50% and 100% of data-bit time.—P. Alfke, Exclusive-OR Gates Simplify Modem Designs, *EDN Magazine*, Sept. 15, 1972, p 43.



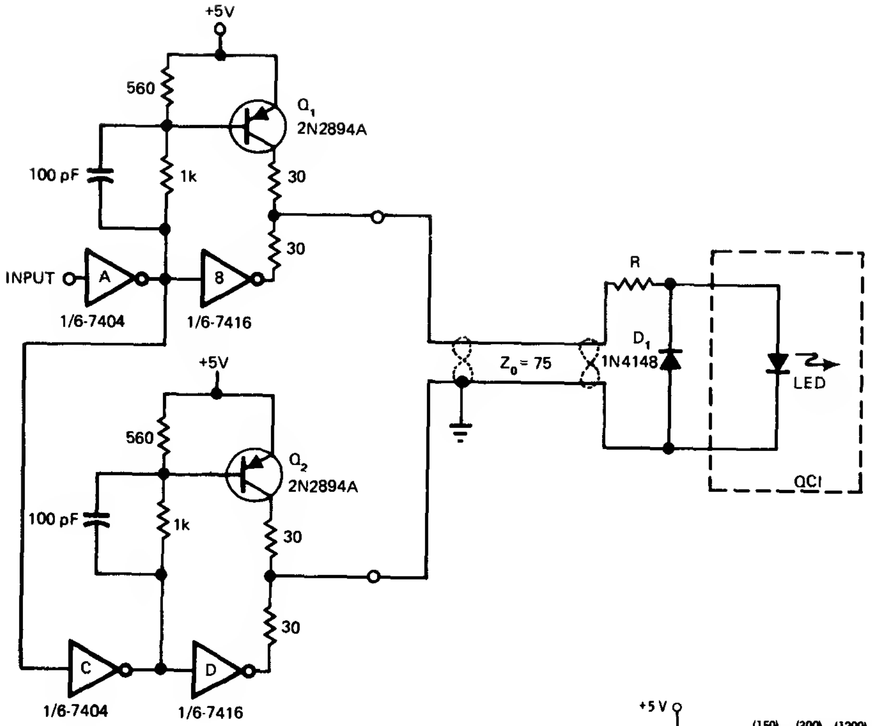
3-KILOBAUD FULL-DUPLEX FSK MODEM—Values shown are for 13-kHz bandwidth, 1070 Hz for mark end 1270 Hz for spece, using Exar XR-2206 function generator and XR-2211 FSK demodulator. Report gives design procedure. Supply cen be +12 V.—"Phase-Locked Loop Date Book," Exer Integrated Systams, Sunnyvale, CA, 1978, p 57–61.



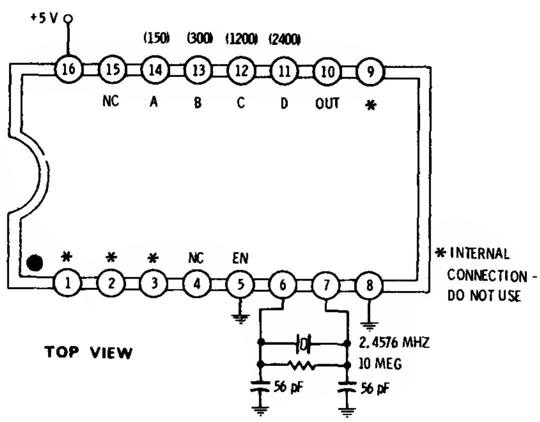
DUAL-LINE RECEIVER FOR COAX—Singla Texas Instrumants SN75152 IC contains two receiver sections, each teking input from separate coex. Other raceiver section (not shown) is identical and provides similar TTL output for its coex. Driver shown hes OR capability for feeding single coax. Receiver has adjustable noisa immunity and continuously adjustable hysteresis control (not shown).—"Tha Linaar and Interface Circuits Date Book for Design Engineers," Texas Instruments, Dellas, TX, 1973, p 8-78.



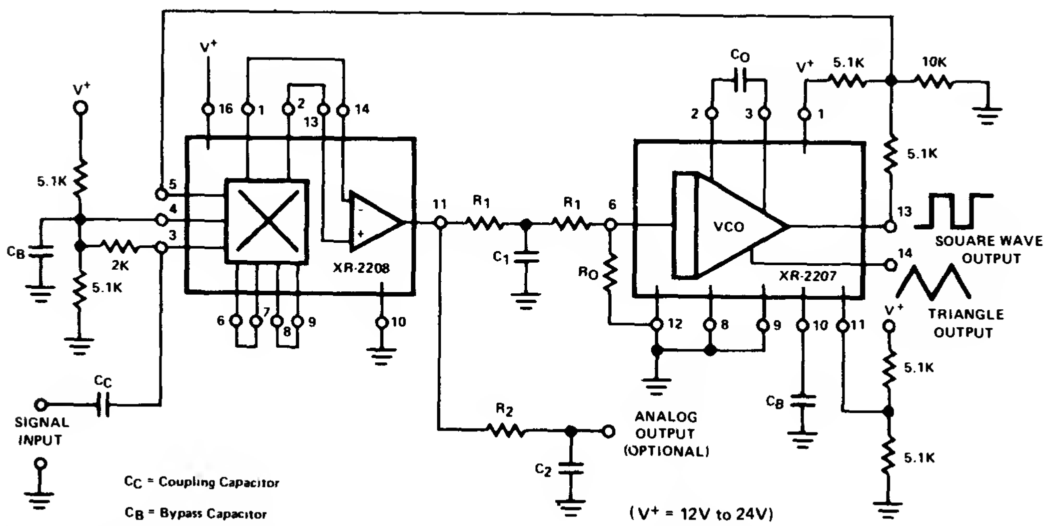
BUS TRANSCEIVER—Designed for usa in bus-organized data transmission systems intarconnected by terminated 120-ohm lines. Up to 27 driver/recaivar pairs can ba connected to common bus. One two-input NOR gate is Included in National DS8641 quad unified bus transcelver packaga to disabla all drlvers in packege simultaneously.—"Intarfaca Integrated Circuits," Nationel Samiconductor, Senta Clara, CA, 1975, p 3-17–3-18.



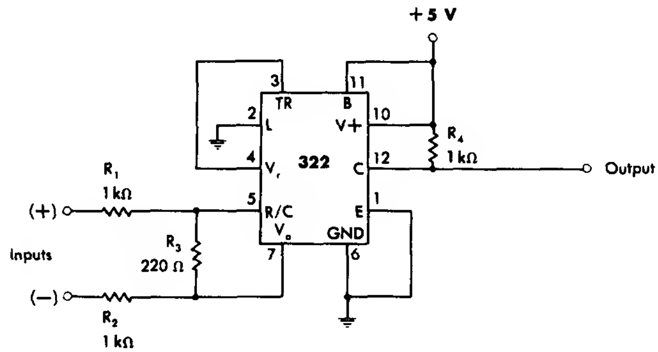
LINE DRIVER FOR LED—Single-ended input is converted to balanced differential drive for feeding 75-ohm transmission line terminated by LED serving as input for optically coupled line receiver. Logic 1 input is inverted to logic 0 by inverter A, turning on Q_1 and turning off output of gate B. At same time, output of inverter A is logic 1, which inhibits turn-on of Q_2 and makes output of inverter D go low. Thus, logic 1 input means that current is sourced into line and LED by Q_1, then sunk by output of D. Similarly, logic 0 input results in current being sourced into line by Q_2 and sunk by inverter B, making diode D_1 conduct and turn off LED of OCI receiver.—K. Erickson, Line Driver Is Compatible with OCI Line Receiver, *EDN Magazine*, Oct. 5, 1976, p 106.



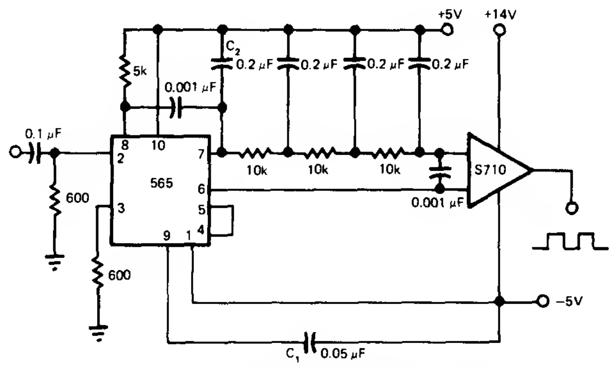
BIT-RATE GENERATOR—Fairchild 4702 IC synthesizes frequencies most often used in serial data communication, particularly with UARTS. With connections shown, output is 1760 Hz which is 16 × 110-baud rate of serial teletypes. Grounding only pin A generates 16 × 150 bauds. Grounding only pin B gives 16 × 300 bauds, grounding pin C gives 16 × 1200 bauds, and grounding pin D gives 16 × 2400 bauds. Will drive one regular TTL load at supply drain of 1 mA.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 155.



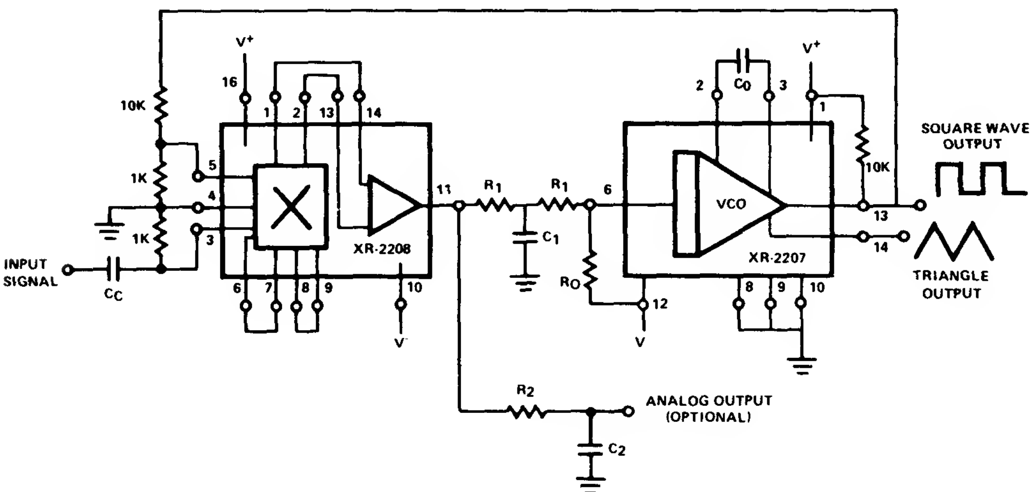
SINGLE-SUPPLY HIGH-PRECISION PLL—Combination of Exar XR-2207 VCO and XR-2208 operational multiplier is connected for operation from single 12–24 V supply for data communication and signal conditioning applications. Operating frequency range is 0.01 Hz to 100 kHz. Timing resistor R_0 should be in range of 5K to 100K, and R_1 should be greater than R_0. For 10-kHz center frequency, C_0 can be 0.01 μF and R_0 can be 10K. R_1 and C_1, which determine tracking range and low-pass filter characteristics, are 45K and 0.032 μF.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 62–64.



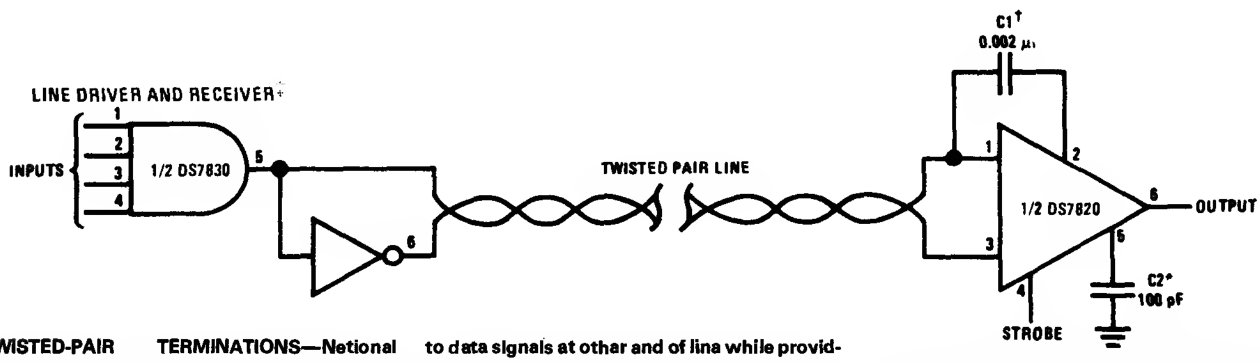
DIFFERENTIAL LINE RECEIVER—Responds to balanced-input driva signals fed to both comparator inputs of 322. Output is undisturbed avan with up to 1 V of common-moda noise on input lines. TTL-compatible output is in phasa with positiva input. Ovarall daley is about 1 μs.—W. G. Jung, "IC Timar Cookbook," Howerd W. Sams, Indianapolis, IN, 1977, p 153–155.



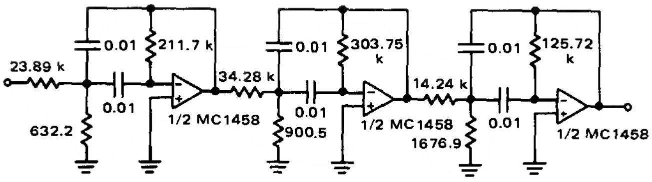
ANALOG PLL IN FSK DEMODULATOR—Daveloped for fraquancy-shift kaying used in data transmission ovar wires, in which inputs vary carriar betwaan two preset frequencies corresponding to low end high states of binary input signal. Circuit uses elaborate filter to sepereta modulated signel from carriar signal passed by PLL. 565 PLL provides refarance for S710 comparator. Article gives design equetions.—E. Murthi, Monolithic Phesa-Locked Loops—Analogs Do All the Work of Digitals, and Much More, *EDN Magazine*, Sapt. 5, 1977, p 59–64.



PLL FOR 0.01 Hz TO 100 kHz—Highly stable and precise phese-locked loop systam using Exar XR-2207 VCO end XR-2208 oparational multipller is suitabla for wida renge of applications in data transmission and signal conditioning. Supply voltage ranga Is ±6 V to ±13 V. For 10-kHz cantar fraquancy, R_0 is 10K and C_0 is 0.01 μF. R_1 end C_1, which datermine tracking renge and low-pass filtar charectaristics, ara 45K and 0.032 μF.—"Phese-Locked Loop Deta Book," Exar Integreted Systams, Sunnyvele, CA, 1978, p 62–64.

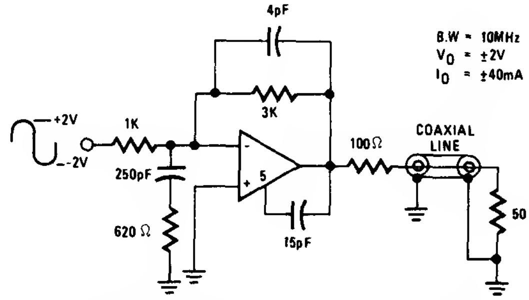


TWISTED-PAIR TERMINATIONS—Netional DS7830 lina drivar applias digital data to twisted-pair transmission line in high-noise anvironment, and DS7820 lina recaivar rasponds to data signals at othar and of lina while providing immunity to noisa spikes. Exect valua of C1 depands on lina length. Supply voltaga is 4.5 to 5 V for both receivar and drivar. C2 is optional and controls rasponsa time.—"Intarfaca Integreted Circuits," National Semiconductor, Santa Clara, CA, 1975, p 8-1–8-16.

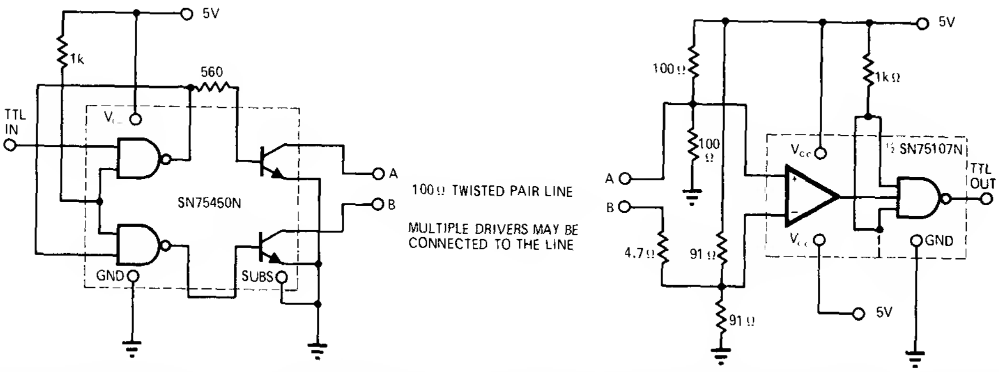


All capacitors are in μF.

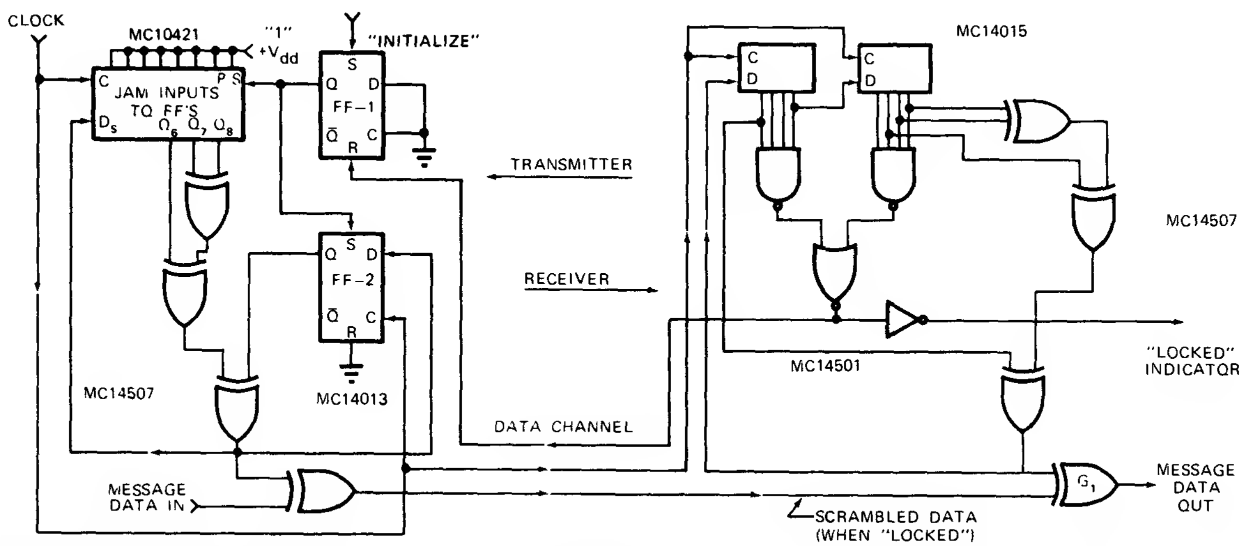
BANDPASS ANSWER FILTER—Provides gain of 15 dB over bandwidth of 1020 to 1320 Hz for low-speed modem system using Motorola MC6860 IC. Attenuation is 35 dB at 2225 Hz, as required for answer-only modem system. Equations for values of filter components are given.—J. M. DeLaune, "Low-Speed Modem System Design Using the MC6860," Motorola, Phoenix, AZ, 1975, AN-747, p 10.



10-MHz COAX DRIVER—Provides high output current to coaxial line over bandwidth limited only by single-pole response of feedback components. Response is flat with no peaking and distortion is low. Uses Harris HA-2530/2535 wideband amplifier having high slew rate.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 7-54 (Application Note 516).

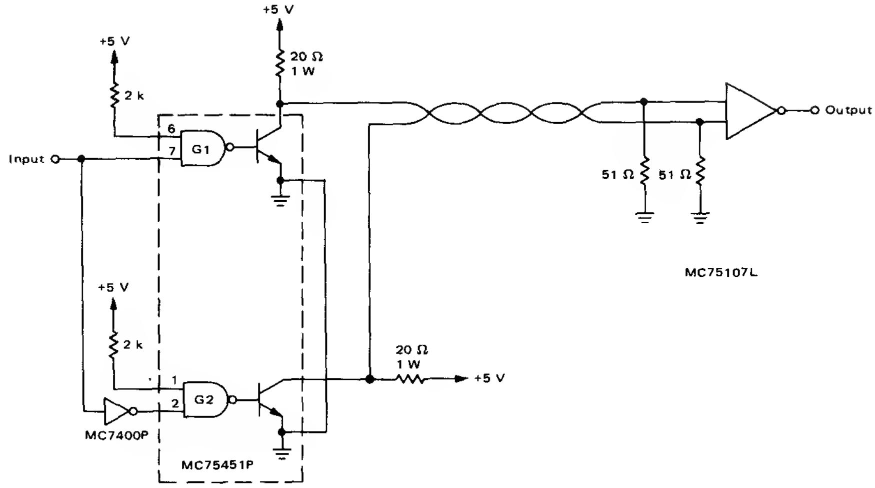


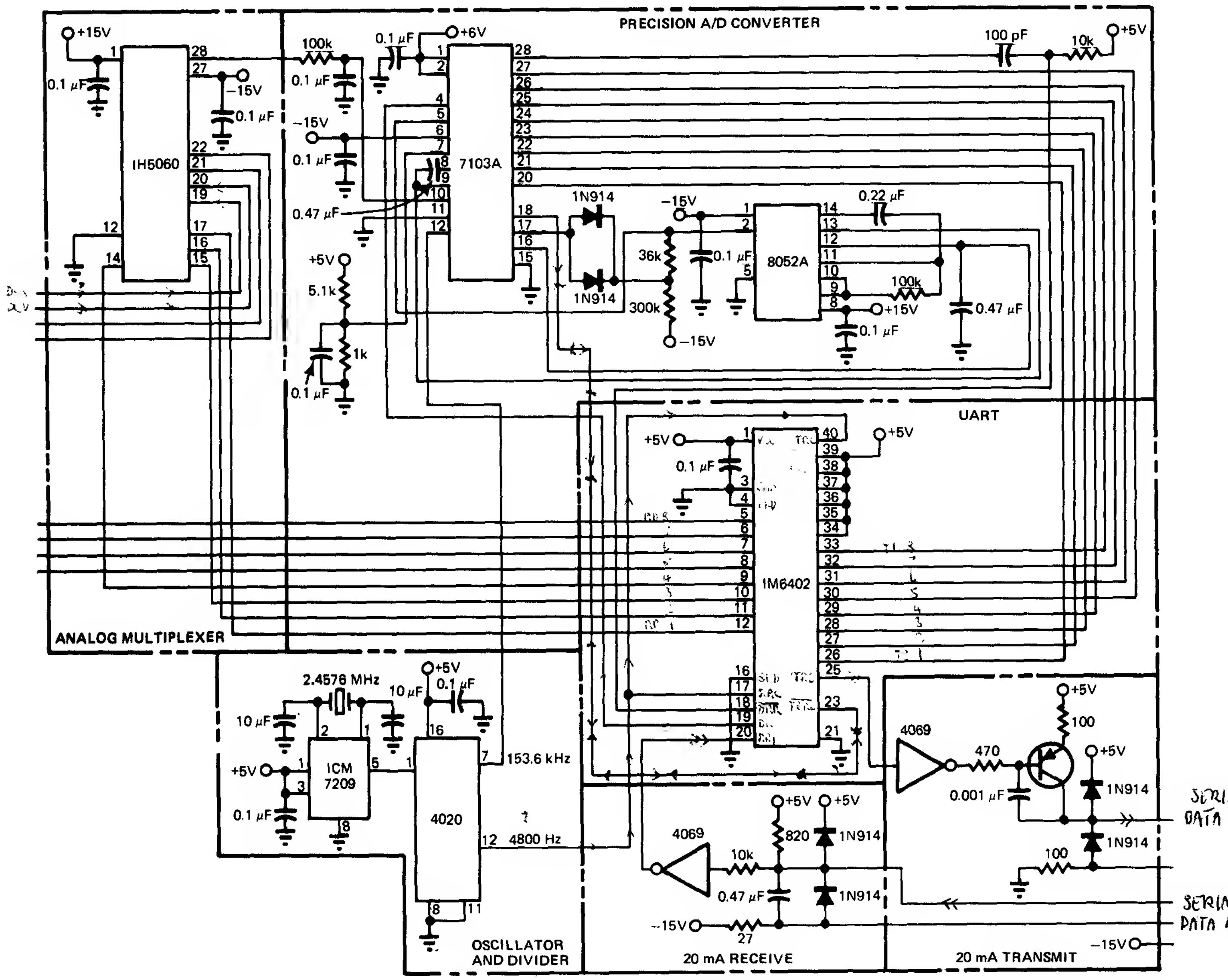
WIRED-OR TERMINALS—Arrangement permits connecting several IC line drivers in parallel for feeding single 100-ohm twisted-pair data line. With wired-OR transmitting capability, TTL output of receiver at right is logic 1 only if all paralleled drivers are transmitting logic 1. If any one or all of drivers transmit logic 0, output of receiver is logic 0.—D. Pippenger, Termination Is the Key to Wired-OR Capability, *EDN/EEE Magazine*, Dec. 15, 1971, p 17.



PSEUDORANDOM CMOS—Uses MC14021 8-bit shift register in conjunction with MC14507 EXCLUSIVE-OR gates to generate pseudorandom digital code. To develop code pattern, 1st, 6th, 7th, and 8th bits are sent through EXCLUSIVE-OR gates and fed back to shift-register input. Output can be used as random test signal or for protecting messages sent over public channels or stored in public files. Digital message is scrambled by mixing it with output of code generator in EXCLUSIVE-OR gate. Functionally identical 255-bit random generator is used at receiver to unscramble data. Decoding circuit must have access to sending clock and means for synchronizing so as to put both registers into all-1 state. Register in receiver goes through all its states within 255 clock pulses; when it reaches all-1 state, signal is fed back to sender for releasing FF-1 so scrambling can commence. Article traces operation in detail.—J. Halligen, Pseudo-Random Number Generator Uses CMOS Logic, *EDN Magazine*, Aug. 15, 1972, p 42–43.

SINGLE-SUPPLY LINE DRIVER—Motorola MC75451P drivar and externel components shown provide differantial signal for twisted-pair transmission line from singla +5 V supply. External gata provides required input phase reversal to gata G2 of IC. Each output of IC varies between 0.5 V and 3.6 V, so net differential voltage driven into lina is about 6 V. Only receiver end of line is terminated in its charecteristic impedance, since arrangement is intended only for point-to-point transmission.—T. Hopkins, "Line Driver and Receiver Considerations," Motorola, Phoenix, AZ, 1978, AN-708A, p 12.

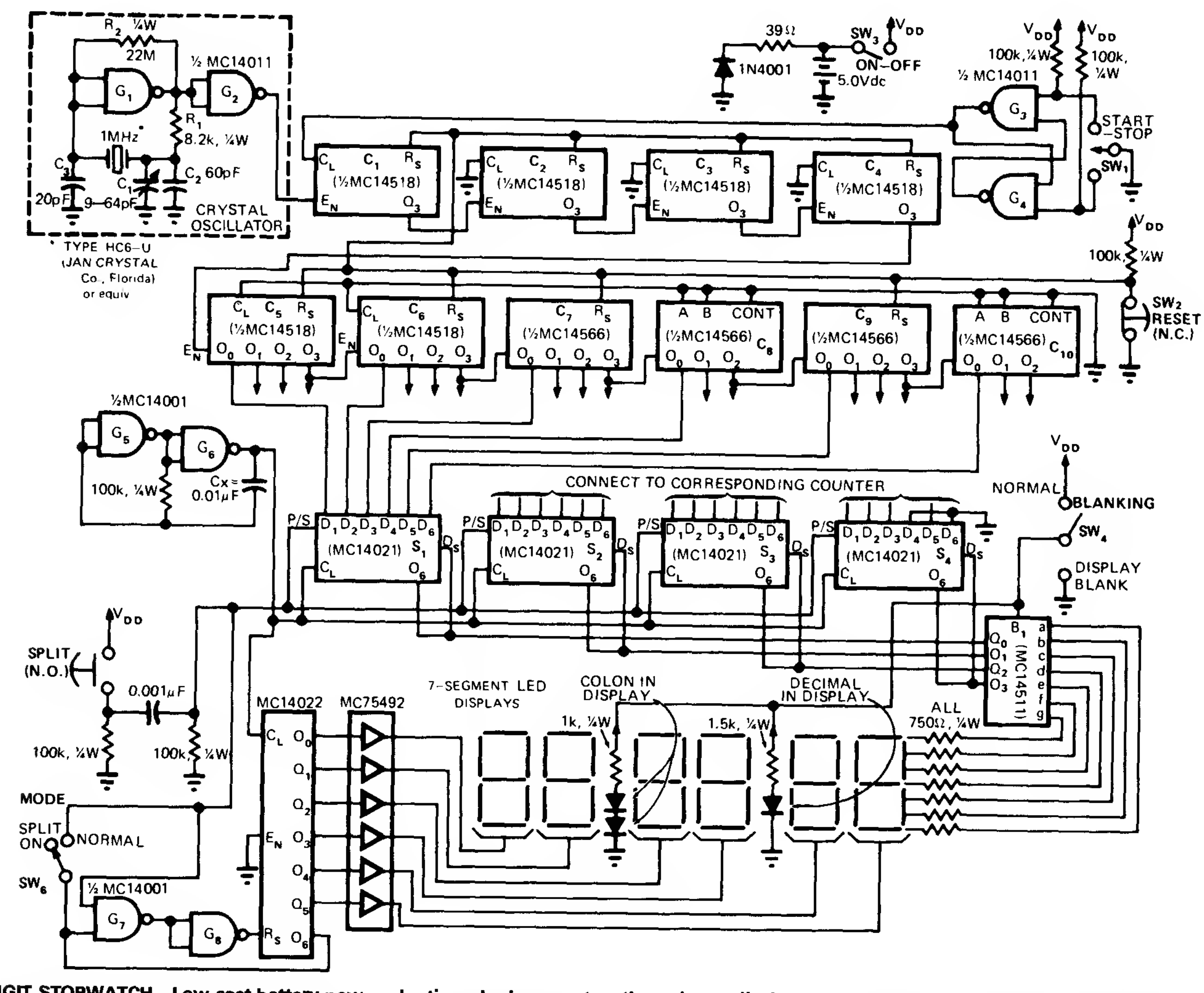




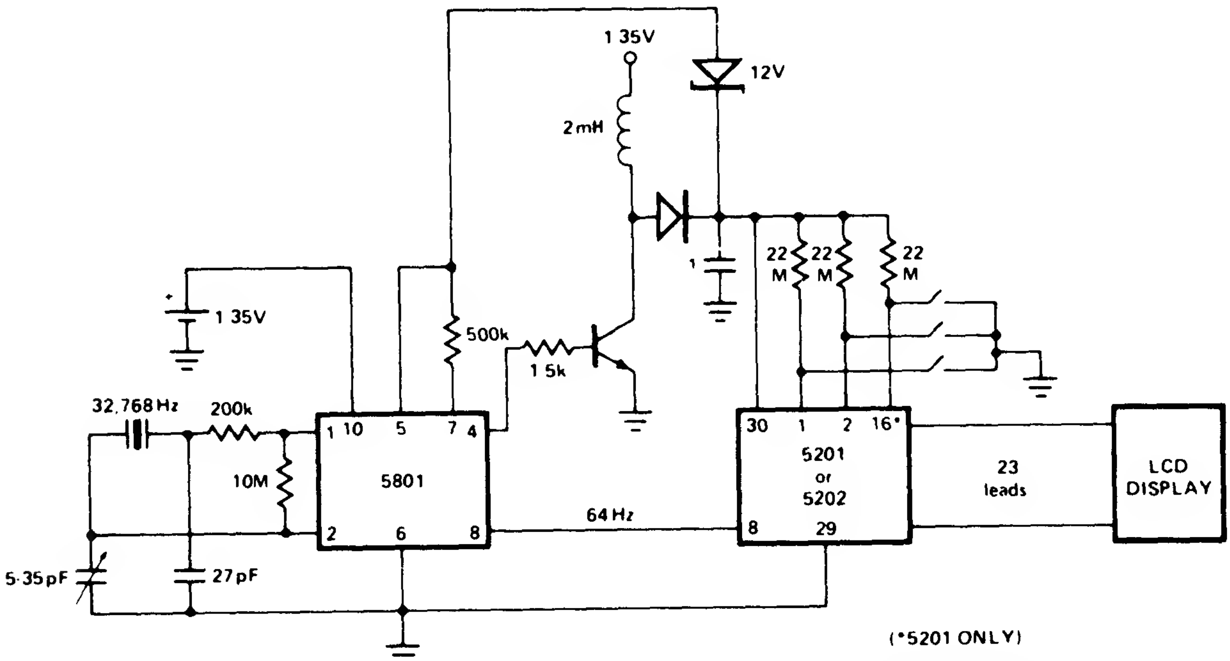
REMOTE DATA STATION—Circuit monitors DC voltages applied to pins 19 and 20 of IH5060 multiplexer and converts them to digitel format for transmission as seriel data to remote microprocessor. IM6100 remote host processor sends control signels to IM6402 UART to select individual multiplexer channels. Single 7209 oscillator provides clock signal for A/D convertar and UART. Developed for use with Intercept Jr. microprocessor system.—S. Osgood, Remote Date Station Simplifies Deta Gethering, *EDN Magazine*, Jan. 20, 1978, p 38 and 41.

CHAPTER 24
Digital Clock Circuits

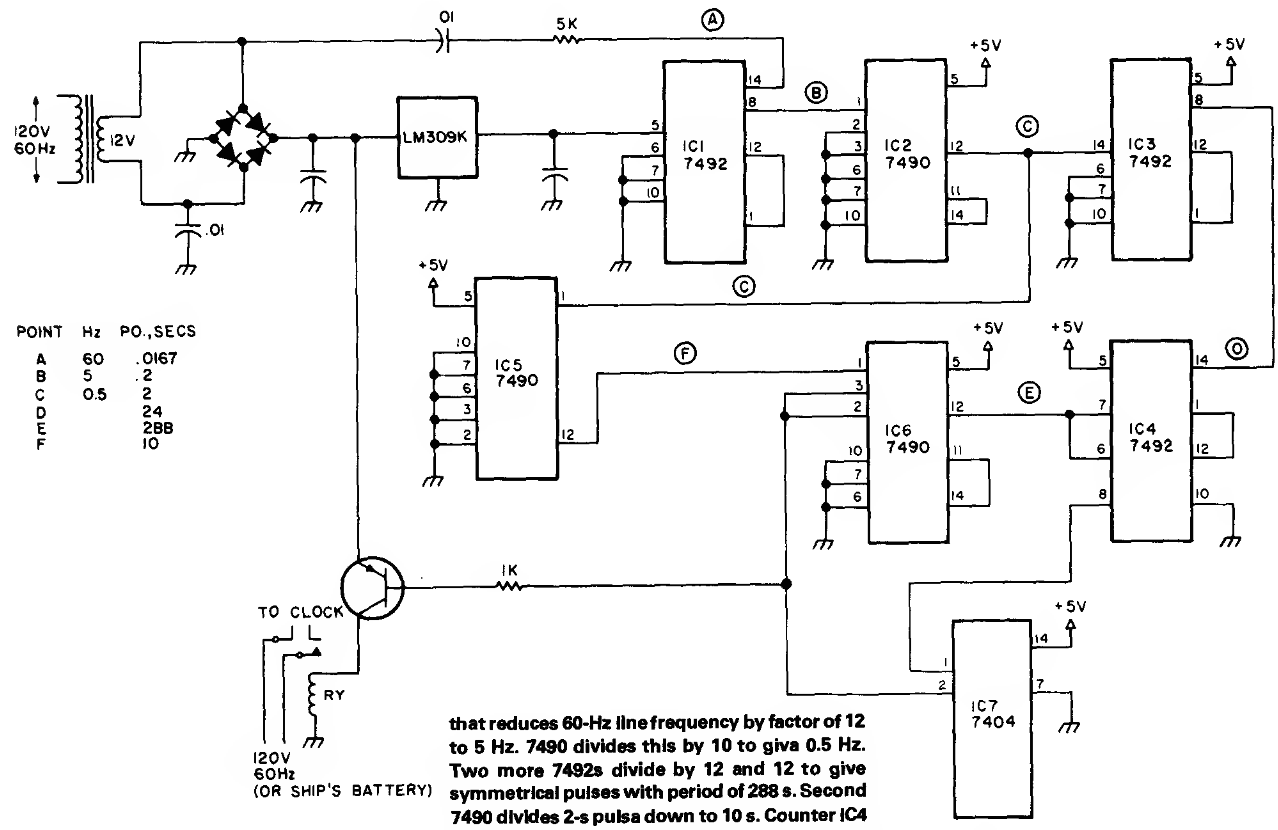
Provide 12- or 24-hour time on LED, LCD, gas-discharge, or fluorescent digital displays for watches and clocks. Some also have calendar display and alarm-tone generator. Special circuits provide battery backup for AC power failure, multiplexing of display to reduce battery drain, stopwatch, and tide clock. Clock-pulse generators for logic and microprocessor applications are given in Clock Signal chapter.



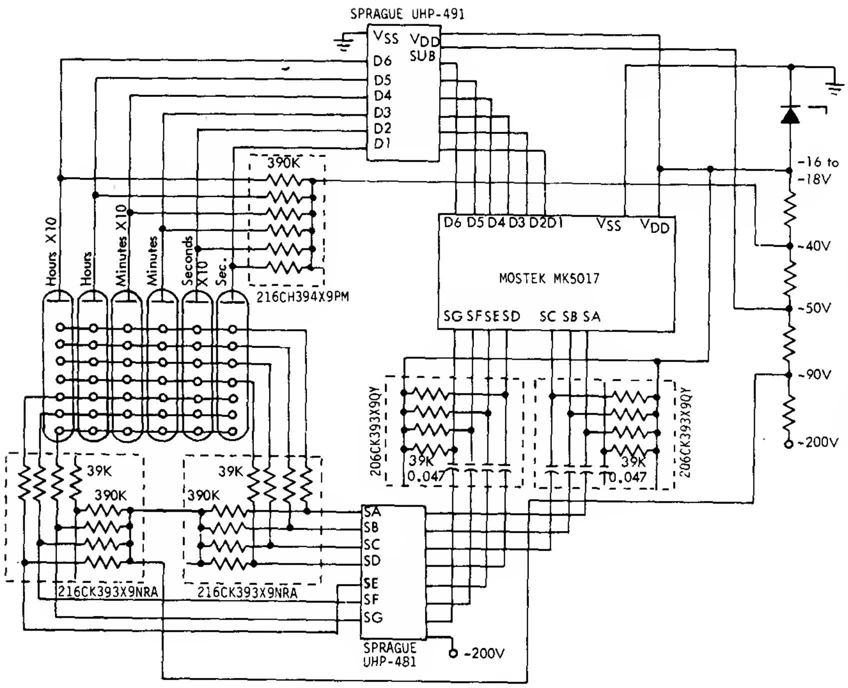
6-DIGIT STOPWATCH—Low-cost battery-powered electronic stopwatch with 6-digit LED display uses readily available complex-function CMOS ICs to minimize component count. Time range is up to 59 min and 59.99 s. Multiplexing by time-sharing counters through one display-driving decoder cuts battery drain because each digit is on for only one-sixth of time. Article traces operation of circuit step by step. Maximum error is only 0.001 s/h. Four rechargeable nicad batteries last 500 h per charge if displays are blanked when not being read, and about 6 h without blanking.—A. Mouton, Build Your Own Digital Stopwatch with Strobed LED Readout, *EDN Magazine,* April 5, 1974, p 55–57.



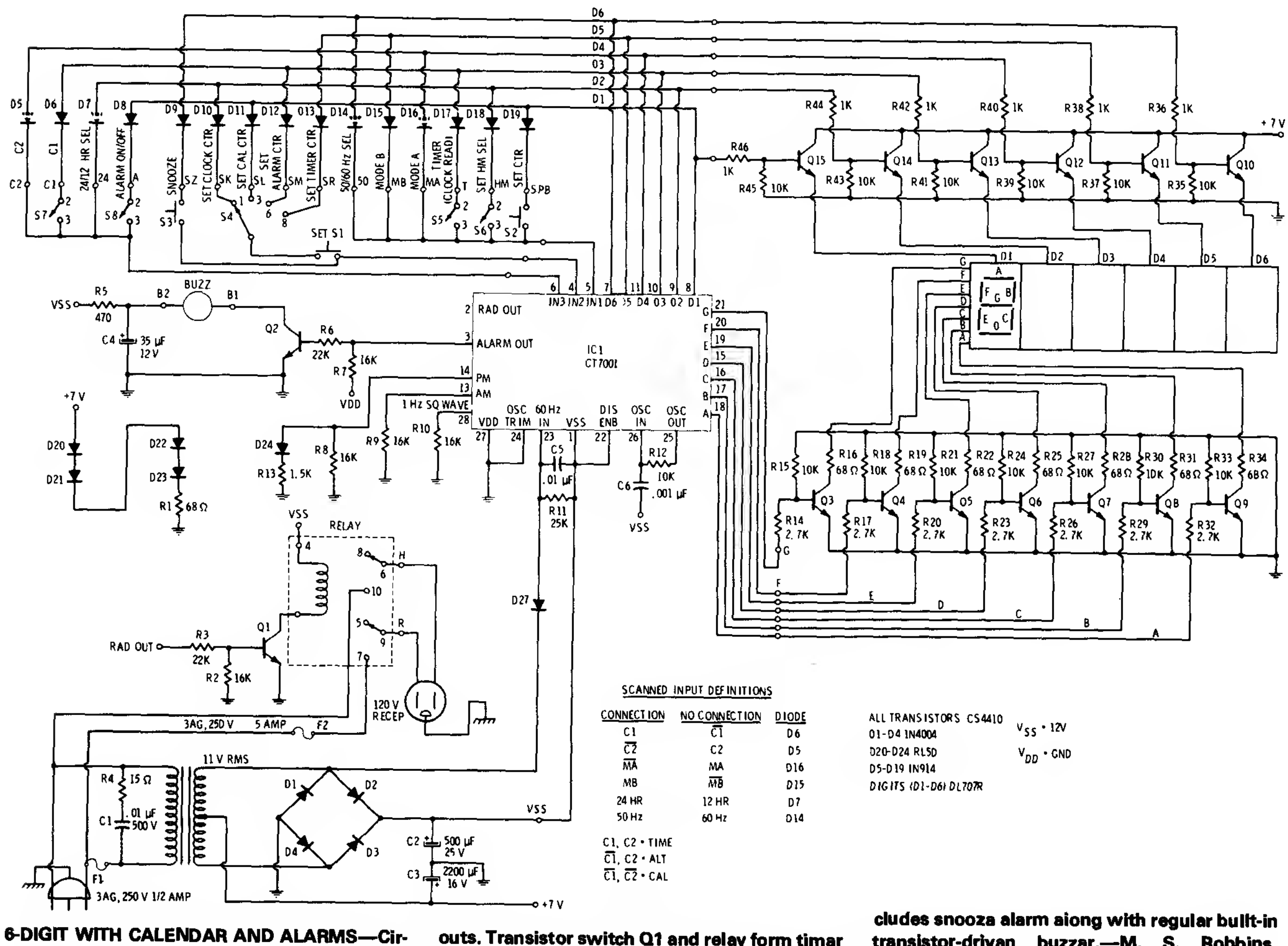
LCD WRISTWATCH—Inverter section of Intel 5801 oscillator/divider is used with 32,768-Hz crystal to produce tima base. First divider in 5801 reduces this to 1024 Hz for driving upconverter transistor. Faedback from transistor through 12-V zener is used to regulate end control pulse width of 1024-Hz signal. Upconverter elso provides 12–15 V required by LCD and 5201 decoder/driver IC. Output to each LCD segment end to common backplate is 32-Hz square weve. Seperete drive fleshes colon at 1-Hz rate.—M. S. Robbins, "Electronic Clocks end Watches," Howerd W. Sams, Indianapolis, IN, 1975, p 128–130.



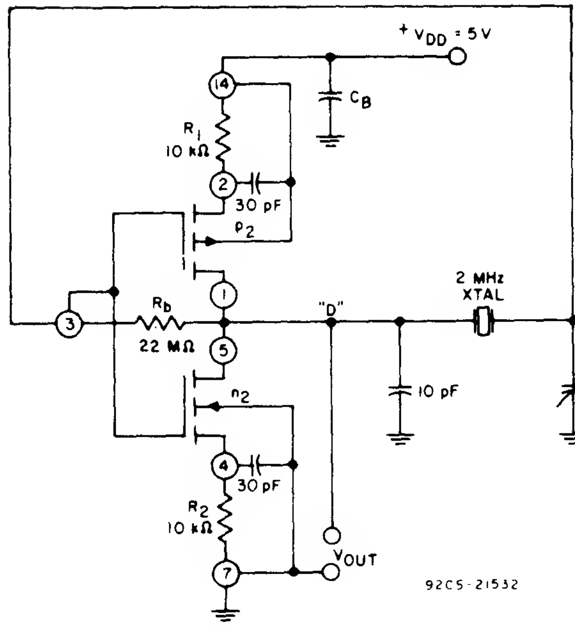
TIDE CLOCK—Circuit shuts off electric clock of eny type for 5 s out of every 144 s, to give loss of 50 min in 24 h es required for meking high tides conform to clock readings. Regulated 5-V supply shown drives TTL 7492 frequency divider that reduces 60-Hz line frequency by factor of 12 to 5 Hz. 7490 divides this by 10 to giva 0.5 Hz. Two more 7492s divide by 12 and 12 to give symmetrical pulses with period of 288 s. Second 7490 divides 2-s pulsa down to 10 s. Counter IC4 inhibits 5-s counter by feeding low output into one gate of IC7 hex inverter. When IC4 counts up to 144 s, its output goes high and resets IC6 to low for start of 5-s low period of that counter. Article gives timing waveforms. Switching trensistor is used to control reley that opens clock circuit. Set tide clock at 12:00 for high tide et location of use, and it will ba 12:00 et high tide thereafter. Low tide will then be at 6:00.—J. F. Crowther, Time end Tide—Digitelly, *73 Magazine*, Aug. 1978, p 156–157.



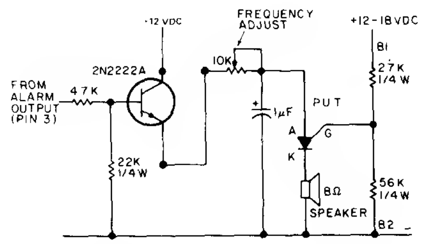
12-h WITH SECONDS—Combination of Mostek clock IC and Sprague high-voltage display drivers, acting through 206C and 216C single in-line resistor network, provides drive for conventional seven-element gas-discharge digital clock display showing hours, minutes, and seconds. Requires −200 V supply. Display can be Burroughs Panaplex, Cherry Plasma-Lux, or Beckman SP series.—"Integrated Circuits Data Book—1," Sprague, North Adams, MA, 1978, p 3-5.



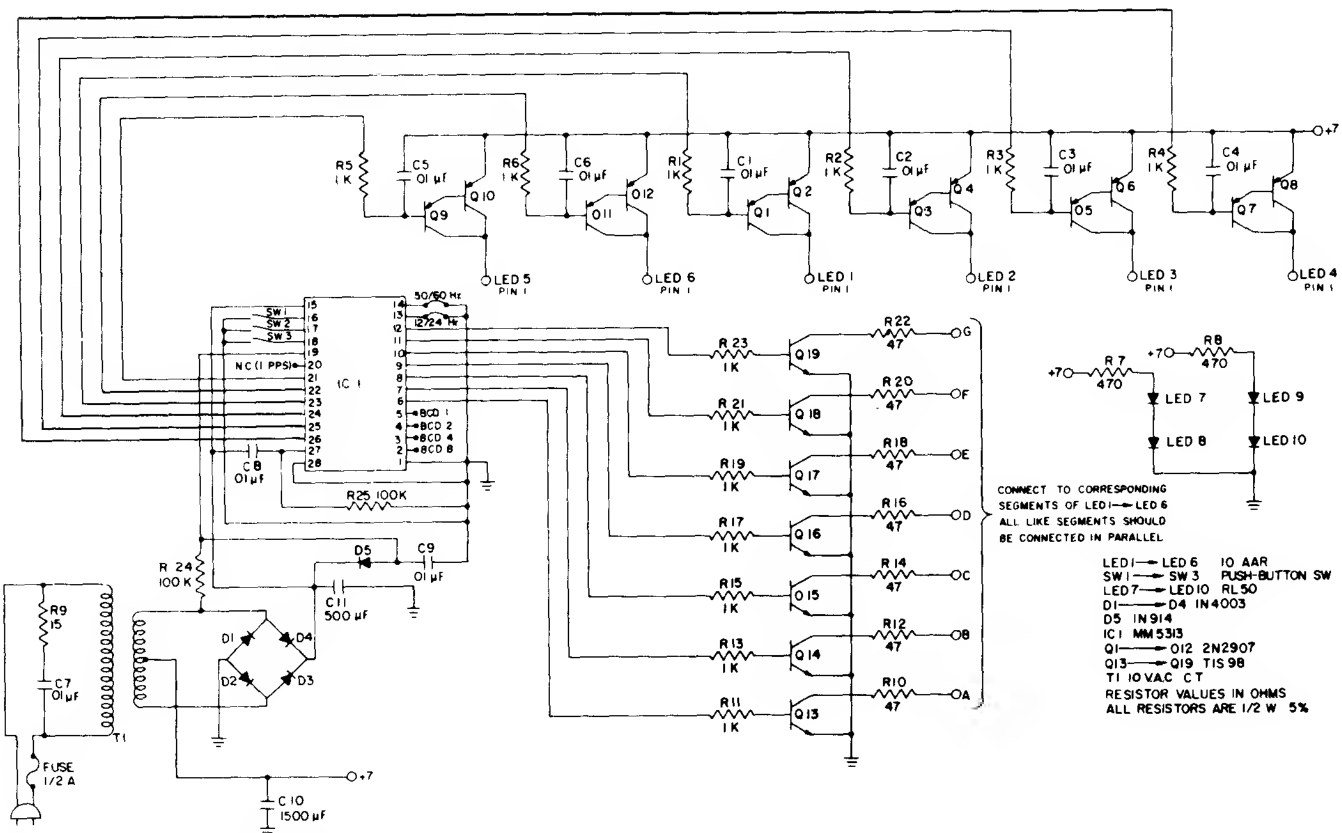
6-DIGIT WITH CALENDAR AND ALARMS—Circuit is built around Cal-Tex CT7001 IC that includes outputs for displaying day of month along with time on Litronix DL707 LED readouts. Transistor switch Q1 and relay form timer triggered by IC to control radio or other appliance drawing up to 5 A from AC line. Dual-voltage power supply provides 7 and 14 VDC. Includes snooze alarm along with regular built-in transistor-driven buzzer.—M. S. Robbins, "Electronic Clocks and Watches," Howard W. Sams, Indianapolis, IN, 1975, p 103–104 and 116–117.



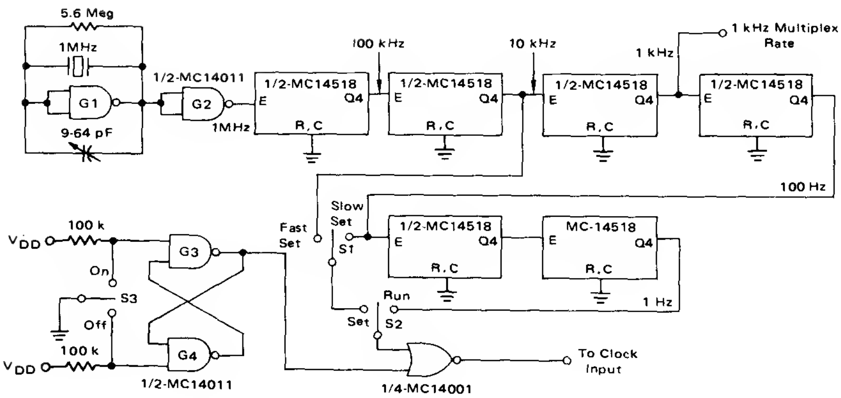
2-MHz CRYSTAL USING CMOS PAIR—One CMOS transistor pair from CA3600E array is connected with feedback pi natwork to giva stable oscillator parformance with 2-MHz crystal. Low powar drain makas circuit Ideal for usa in digital clocks and watchas.—"Linaar Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 280.



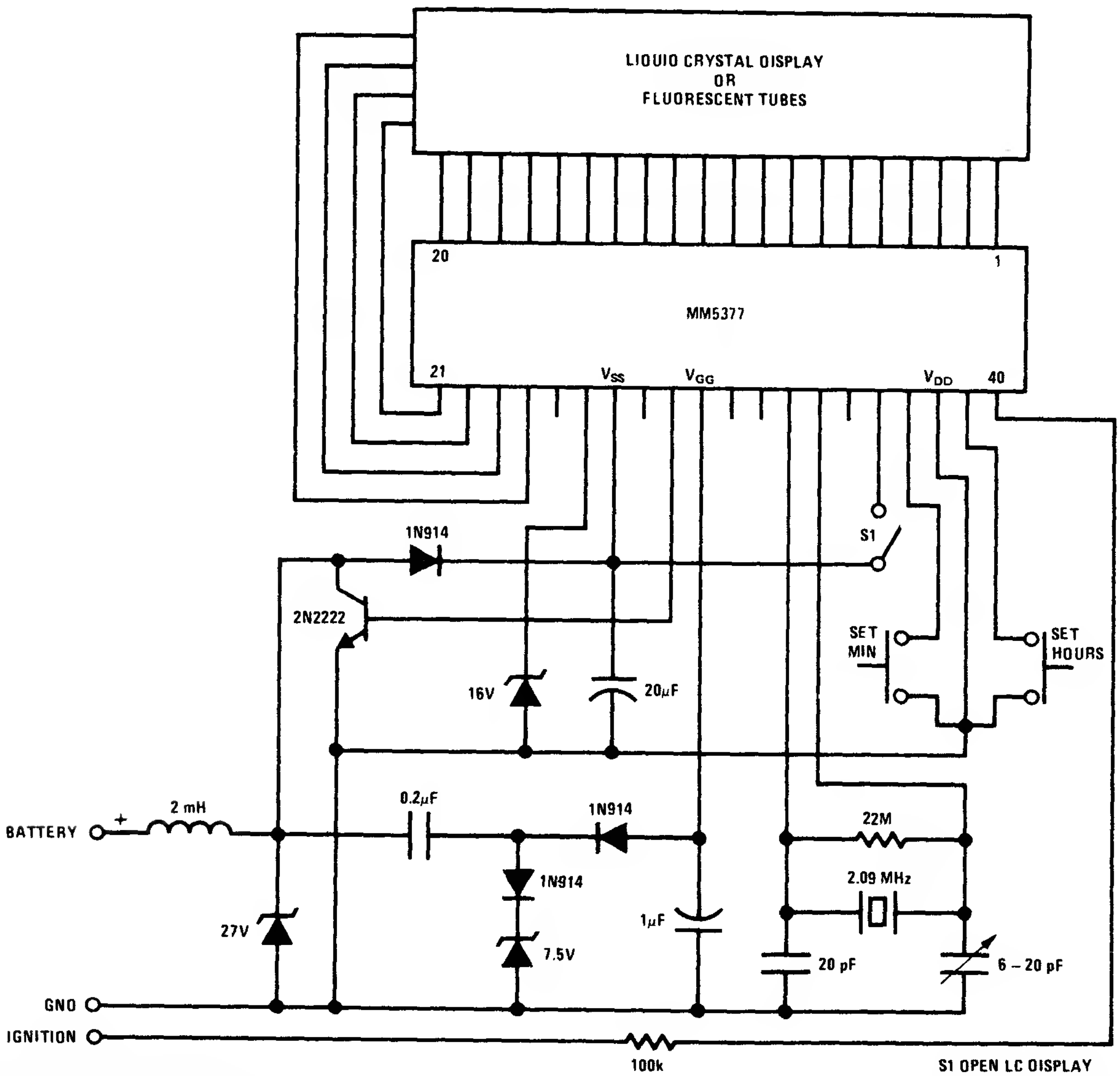
ALARM FOR DIGITAL CLOCK—Uses transistor as drivar to turn on programmable unljunction transistor (PUT) oscillator faeding 8-ohm loudspeaker. Pitch of tone can ba adjusted with 10K pot. Input is from alarm pin of digital clock IC (pin 3 for Fairchild FCM7001 equivalant of Cal-Tex CT7001). PUT is Radio Shack 276-119 or equivalent.—W. J. Prudhomma, CT7001 Clockbuster, *73 Magazine,* Dec. 1976, p 52–54 and 56–58.



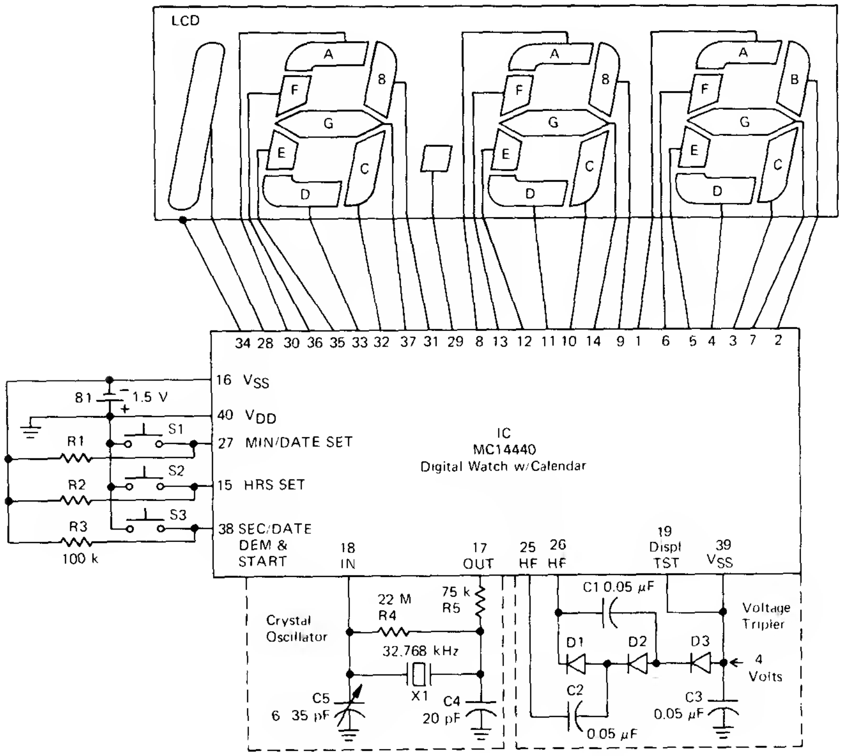
6-DIGIT LED WITH SLEW BUTTONS—National MM5313 PMOS dlgital clock IC drivas display which includas four discrete LEDs mountad on raadout panel to form colons batwaen hours, minutes, and saconds. AC supply provides 14 VDC for IC and 7 VDC for displays. Hold push-button SW1 stops count to give precise seconds setting. Slow-slew button SW2 advances time at 1 min/s for precise setting, and fast-slaw button SW3 advances tima 1 h/s. Digit drivers Q1-Q12 are Darlington-connected pairs of PNP transistors. Segmant drivers Q13-Q19 are single PNP transistors.—M. S. Robbins, "Electronic Clocks and Watches," Howard W. Sams, Indianapolis, IN, 1975, p 103 and 113.



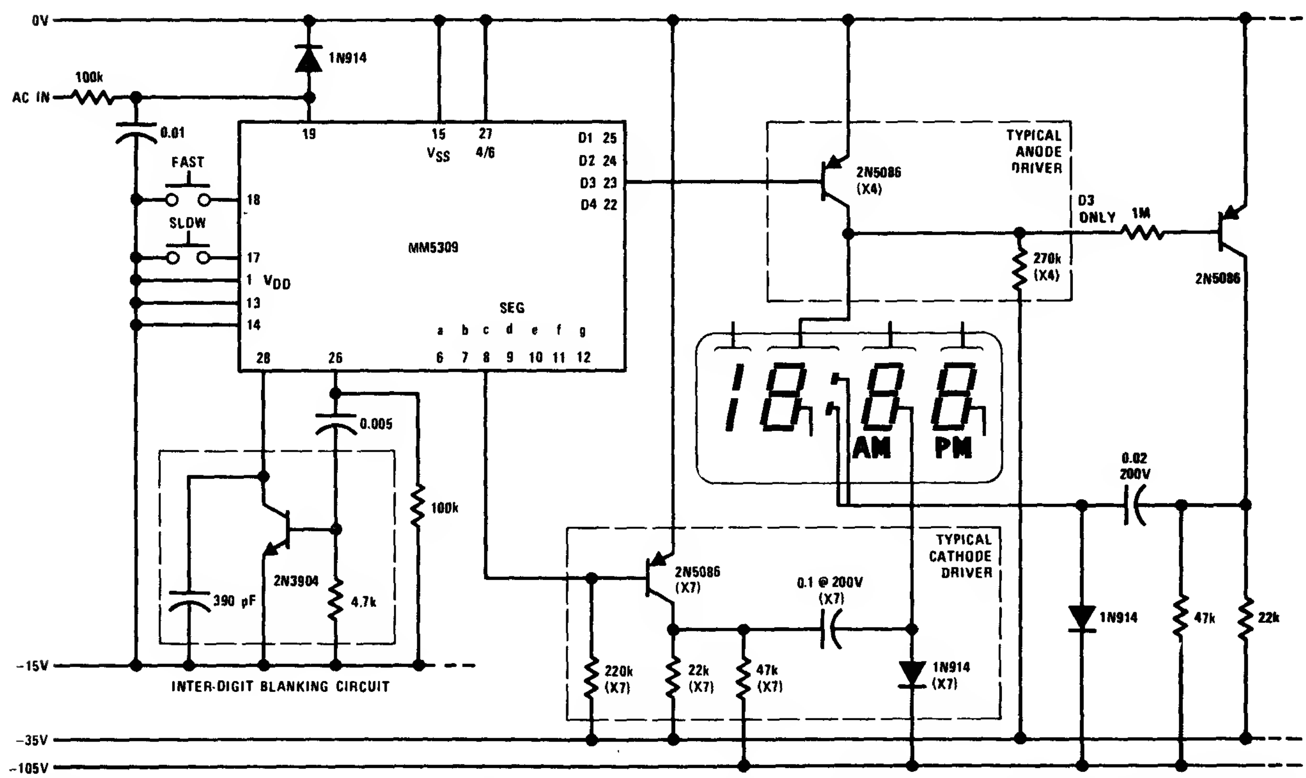
1-Hz REFERENCE—Output of 1-MHz crystal oscillator is stepped down to 1 Hz by CMOS decade dividar chain using Motorola MC14518 dual decade counters. Circuit also genaratas 1-kHz multiplex rate for display used with 24-h industrial clock. Supply is +5 V.—D. Aldridga and A. Mouton, "Industrial Clock/Timar Faaturing Back-Up Power Supply Operation," Motorola, Phoenix, AZ, 1974, AN-718A, p 5.



AUTO CLOCK—National MM5377 chip for automobila clock interfaces directly with 4-digit liquid-crystal or fluorescant-tube display. 12-h format includes leading-zero blanking and colon indication. Voltage-sensitive output drives energy-storage network serving as voltaga doublar/regulator. Crystal oscillator is reference tima basa.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 1-33–1-37.

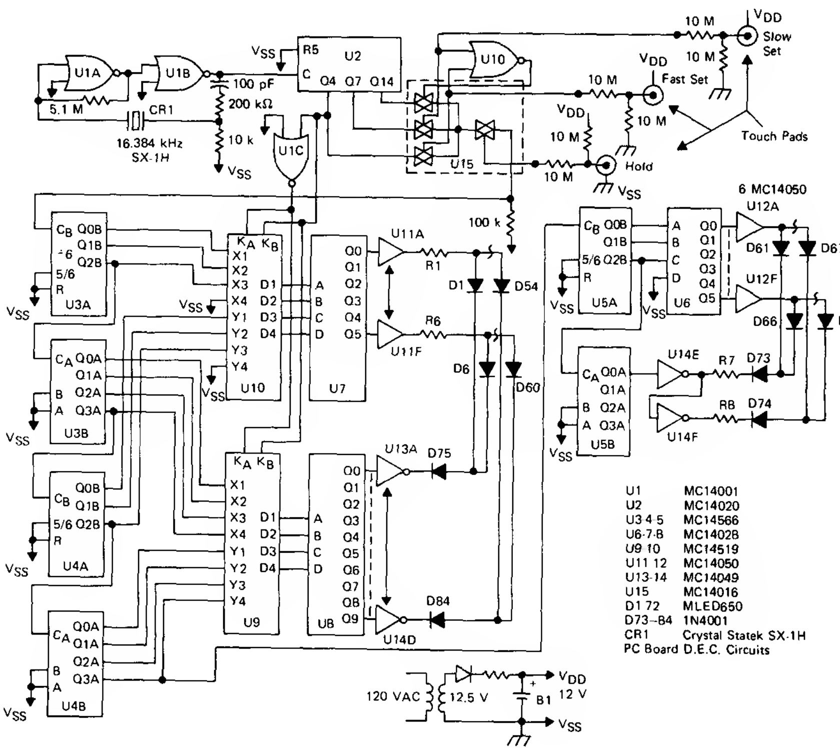


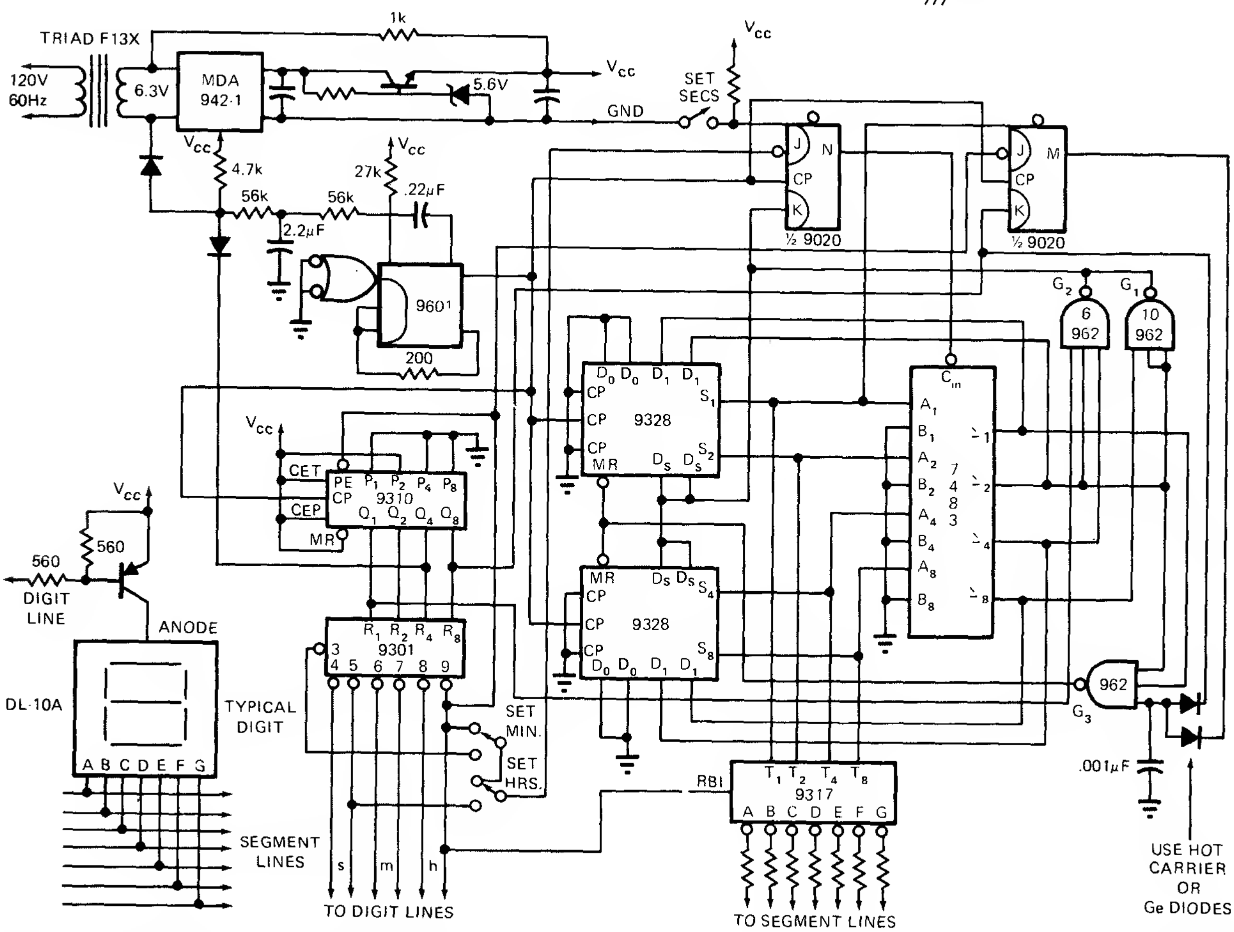
1.5-V LCD—Will operate over 1 year on single 1.5-V AAA battery with accuracy of ±1 min. Basic timekeeping functions are provided by Motorola MC14440 CMOS device that includes calendar. 32.768-kHz NT-cut quartz crystal and trimming capacitor provide reference frequency. Output of 1.5-V alkaline cell is increased to 4 V for display by voltage tripler using MBD101 Schottky diodes.—J. Roy and A. Mouton, "A Cordless, CMOS, Liquid-Crystal Display Clock," Motorola, Phoenix, AZ, 1977, EB-56.



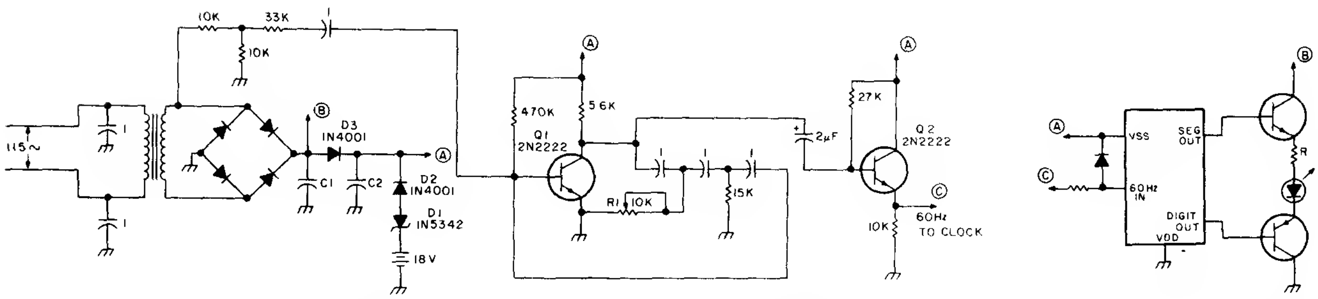
GAS-DISCHARGE DISPLAY—National MM5309 digital clock gives choice of 12- or 24-h display and 50- or 60-Hz operation for driving 4-digit gas-discharge display having colon and AM/PM indications. Separate cathode driver and separate anode driver are required for each digit.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 1-2–1-8.

CIRCULAR LED ARRAY—Arrangement of 60 LEDs sequencing in outer ring to indicate seconds and minutes, combined with 12 in inner ring to indicate hours, is driven by Motorola MC14566 CMOS industrial time-base generator. Time reference is 16.384-kHz crystal oscillator consisting of two NOR gates and Statek crystal. Reference frequency is divided by 2^{14} in U2 to give 1-s pulse rate for driving accumulators U3A-U5B. Maximum error is 1 s per month. U3 counts seconds, U4 minutes, and U5 hours. Multiplexing is required because same set of 60 LEDs serves for minutes and seconds. Fast and slow touch pads eliminate need for switches when setting time. Single 12-V nicad battery provides backup for AC line failure.—A. Mouton, "The LED Circular Timeplece," Motorola, Phoenix, AZ, 1975, EB-41.

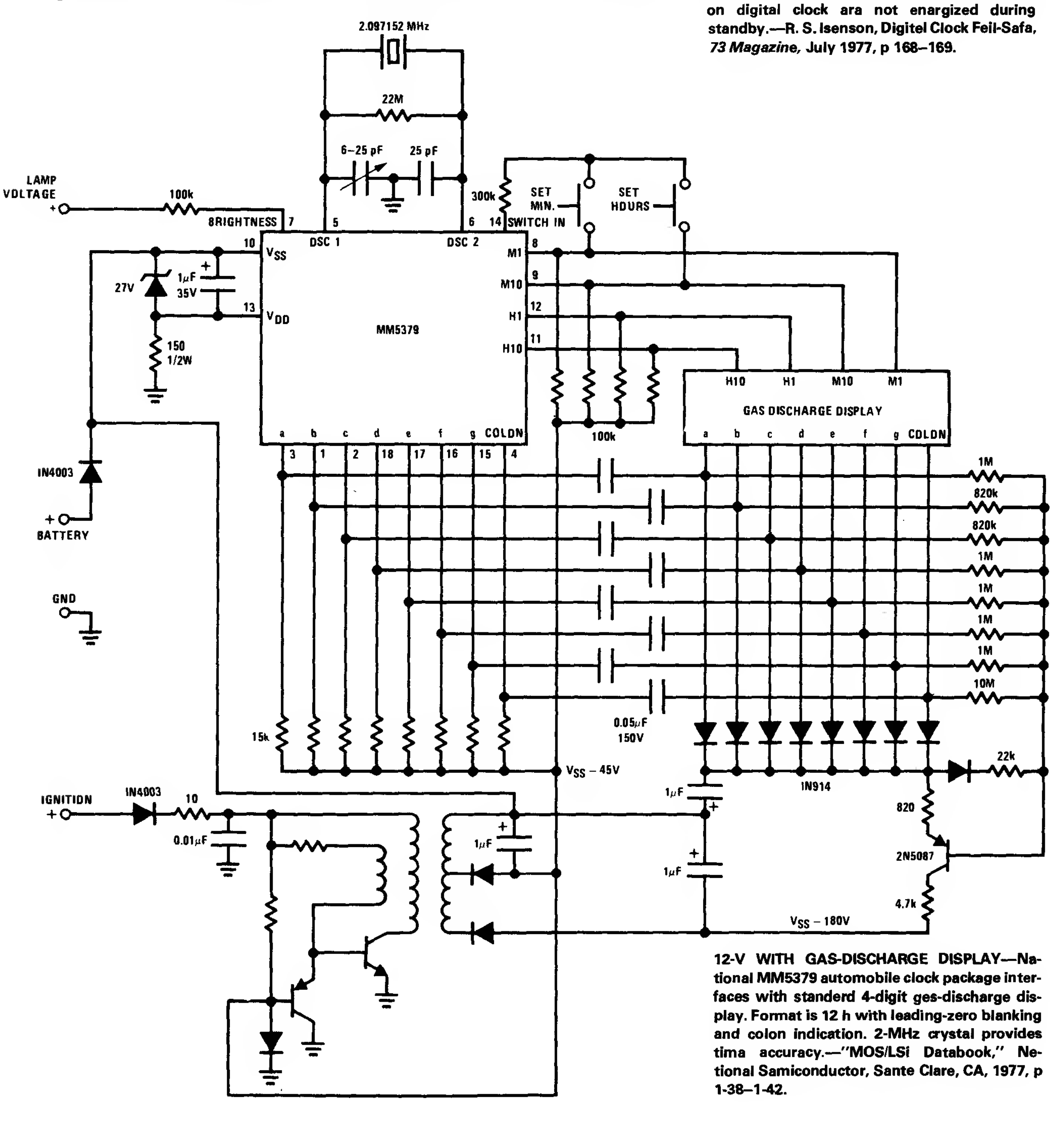




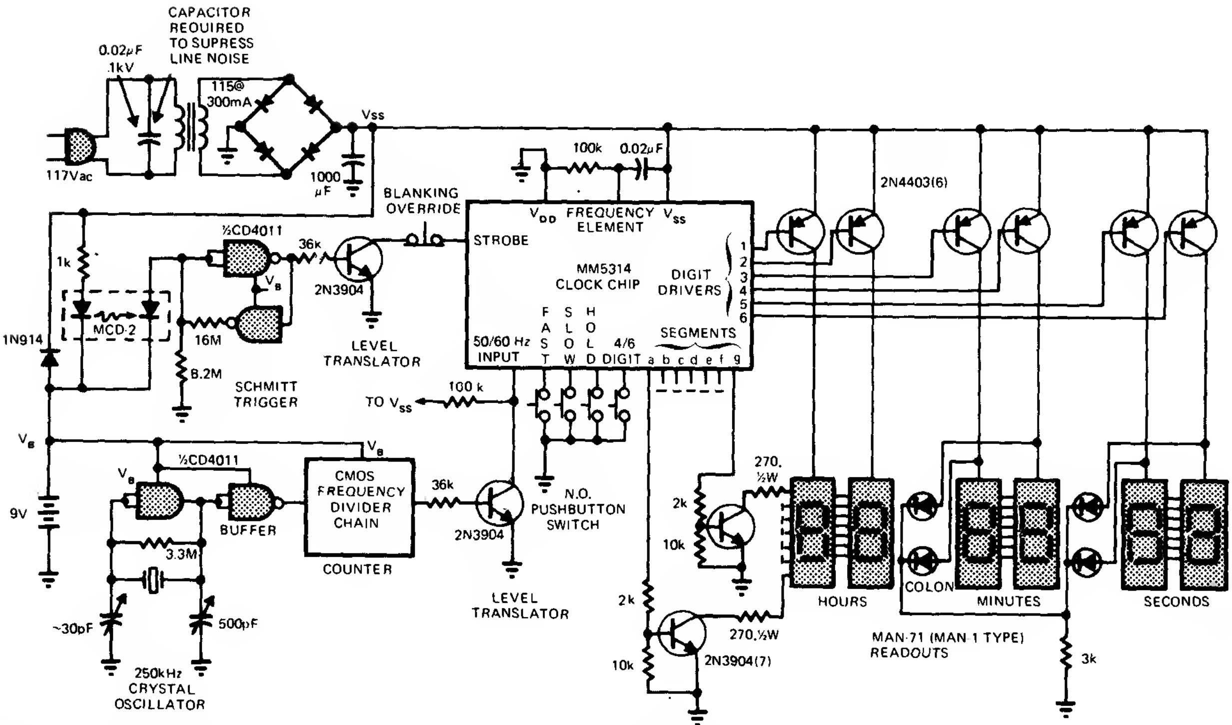
MULTIPLEXED CLOCK DISPLAY—Multiplexed display suitable for LED readouts is provided by circuit using TTL counters to count 60-Hz line. When count reaches 10 o'clock, flip-flop M is set on every cycle. Gate G_3 then detects when time goes to 13 o'clock, and clears shift register. Carry flip-flop remains set, so 1 is loaded into hours digit to accomplish transition from 12:59:59 to 1:00:00. Seven-segment decoder driver looks at shift register output and drives segment lines of LED. Leading hours digit is blanked, using RBI input on 9317.—G. Smith, Novel Clock Circuit Provides Multiplexed Display, *EDN Magazine*, Sept. 1, 1972, p 50–51.



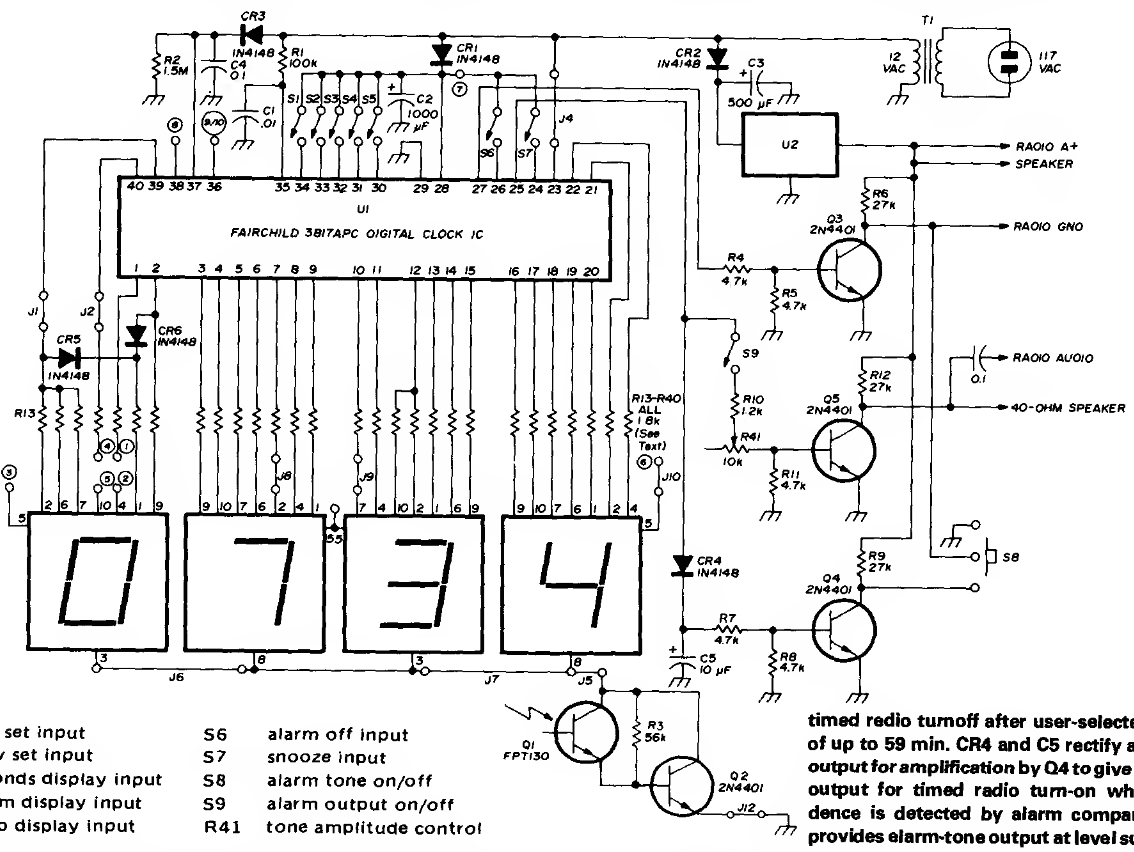
STANDBY SUPPLY—Phase-shift oscillator Q1 operetes from AC iina through bridge-rectifier powar suppiy and provides lina-synchronized 60-Hz power to standard digital clock through isoiating amittar-follower Q2. During powar outage, oscillator is switched automatically to battery by diode network end provides reasonably accurate signel for opereting clock. Free-running oscillator is adjusted to be slightly low, such as 59.9 Hz. For reasonably long power outage, say 4 h, this 0.1-Hz error is equivelent to 0.167% error in time, so clock loses only 24 s during outage. C1 and C2 ara 200 to 300 μF. Adjust R1 to give output just baiow 60 Hz on battary operation. To minimize battery drein, LEDs on digital clock ara not energized during standby.—R. S. Isenson, Digitel Clock Feil-Safa, *73 Magazine,* July 1977, p 168–169.



12-V WITH GAS-DISCHARGE DISPLAY—National MM5379 automobile clock package interfaces with standerd 4-digit ges-discharge display. Format is 12 h with leading-zero blanking and colon indication. 2-MHz crystal provides tima accuracy.—"MOS/LSi Databook," National Semiconductor, Sante Clare, CA, 1977, p 1-38–1-42.

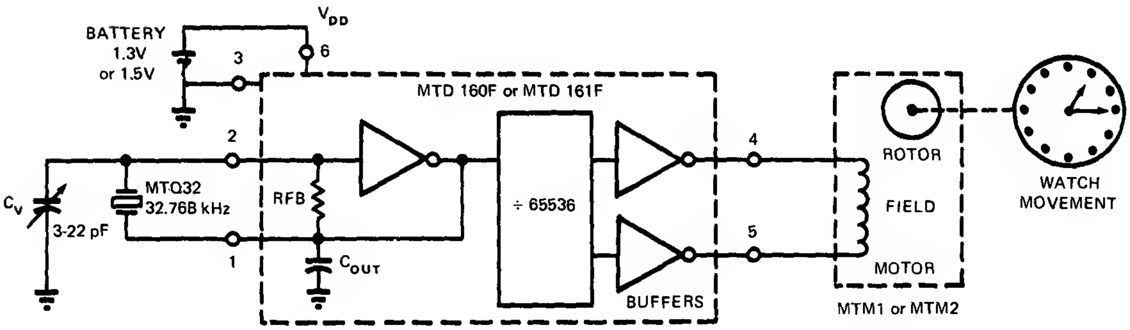


AC/DC CLOCK—When AC power fails, MCD-2 optoisolator senses voltage drop and makes Schmitt trigger force strobe input of clock chip to ground, blanking display and reducing current drain from 200 mA on AC to 12 mA on 9-V standby battery. Clock will run for days on 1000-mAh battery. Two LED pairs that form colons between time digits are operated from digit strobe lines and remain lit when display is blanked, but drew only 1 mA.—S. I. Green, Digital Clock Keeps Counting Even When AC Power Fails, *EDN Magazine*, Dec. 20, 1974, p 49–51.



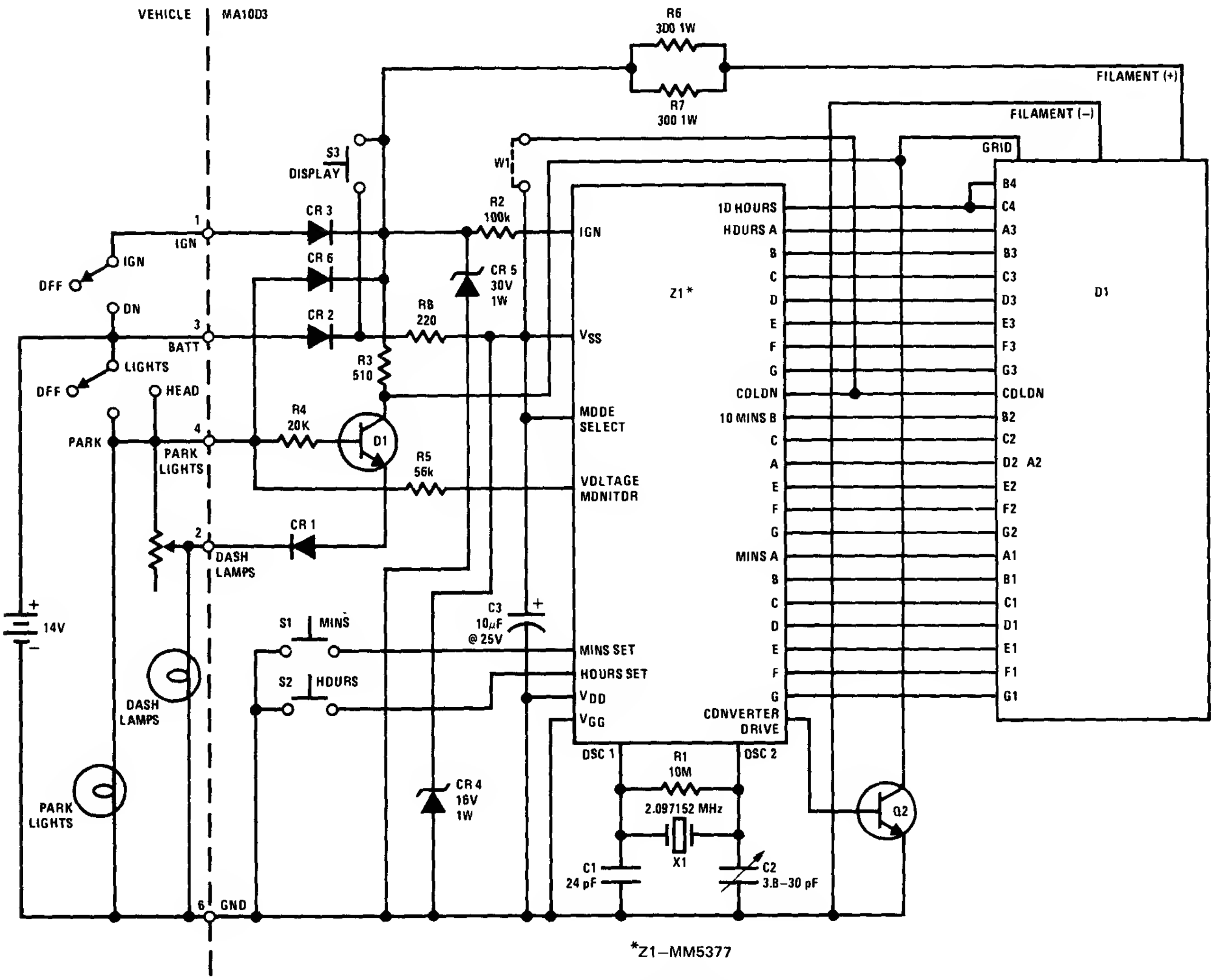
S1	fast set input	S6	alarm off input
S2	slow set input	S7	snooze input
S3	seconds display input	S8	alarm tone on/off
S4	alarm display input	S9	alarm output on/off
S5	sleep display input	R41	tone amplitude control

DIGITAL ALARM—Direct drive offered by Fairchild 3817 IC allows design of simple low-cost clock radio providing display drive, alarm, and sleep-to-music features in 12- or 24-h formats. Display is Fairchild FND500 LED. Either 50- or 60-Hz input may be used. U2 is 7800-series IC voltage regulator rated to meet requirements of radio used. Q3 provides active low output for timed radio turnoff after user-selected interval of up to 59 min. CR4 and C5 rectify alarm-tone output for amplification by Q4 to give active low output for timed radio turn-on when coincidence is detected by alarm comparators. Q5 provides alarm-tone output at level sufficient to drive 40-ohm loudspeaker with ample wake-up volume. If radio is used, omit loudspeaker. Article covers construction and adjustment.—D. R. Schmieskors, Jr., Low-Cost Digital Clock, *Ham Radio*, Feb. 1976, p 26–30.



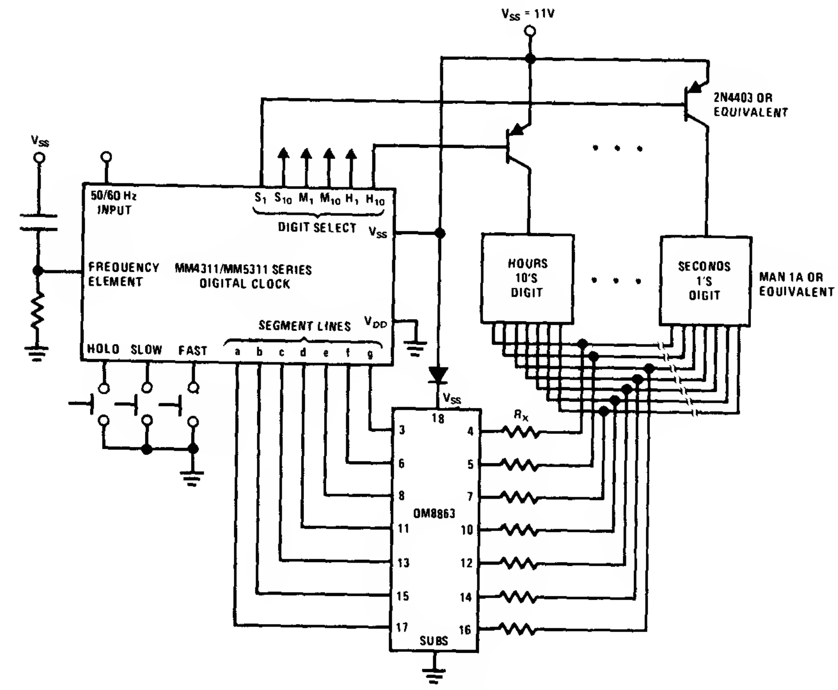
C_V = Trimmer capacitance
C_{OUT} = Integrated oscillator output capacitance $\approx$ 20 pF
R_{FB} = Integrated oscillator feedback resistance $\approx$ 40 M

QUARTZ-MOTOR WRISTWATCH—Uses one 32.768-kHz crystal at input of Motorola MTD 160F or 161F custom CMOS chip, with stepper motor at output of chip for driving conventional watch hands. Chip contains three-inverter oscillator, 16 counting flip-flops, and motor drive buffers.—B. Furlow, CMOS Gates in Linear Applications: The Results Are Surprisingly Good, *EDN Magazine*, March 5, 1973, p 42–48.



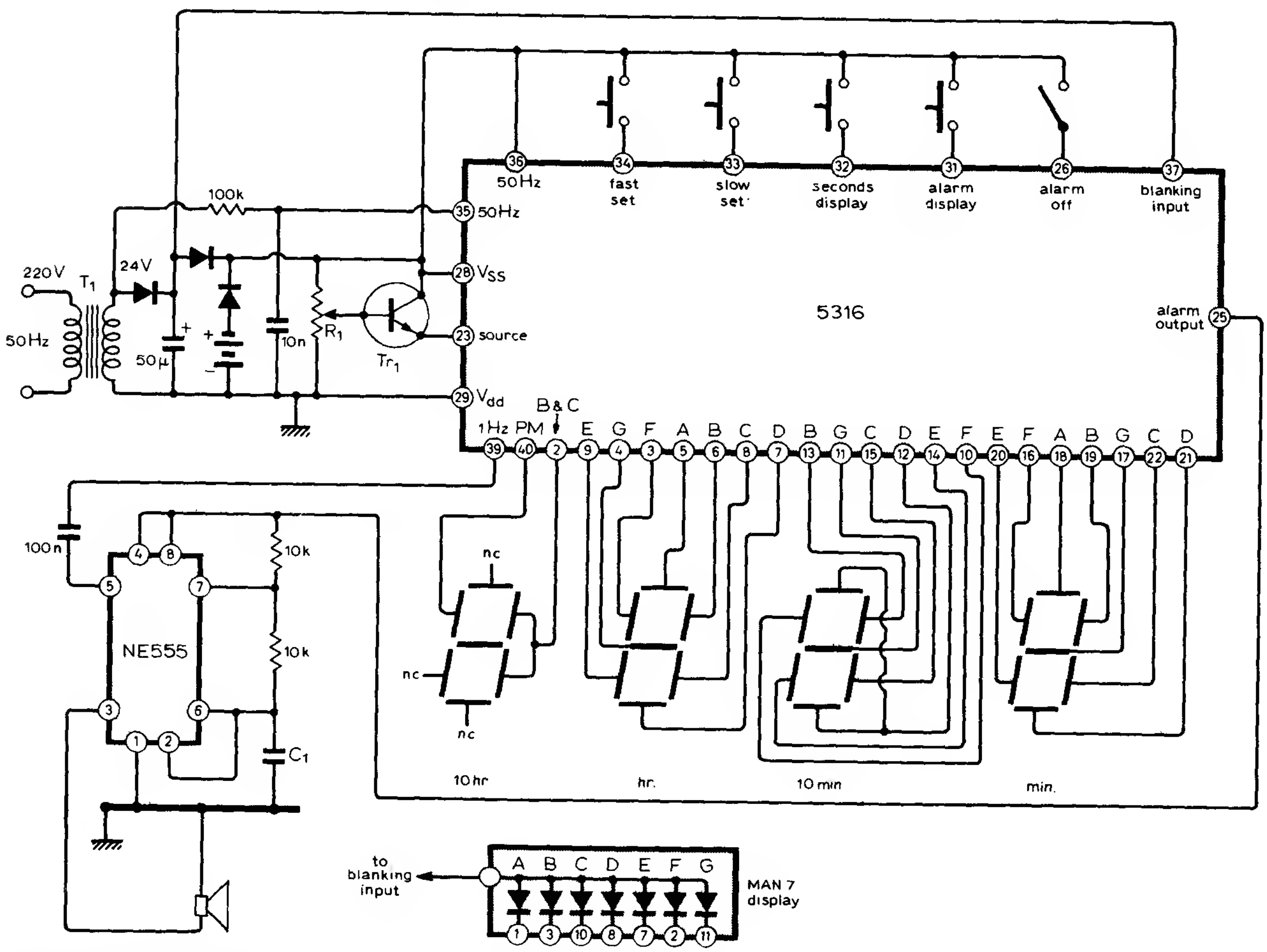
*Z1—MM5377

12-V AUTO CLOCK—National MA1003 automotive/instrument clock module combines MM5377 MOS LSI clock with 4-digit 0.3-inch green vacuum fluorescent display, 2.097-MHz crystal, and discrete components on single printed-circuit board to give complete digital clock. Brightness control logic blanks display when ignition is off, reduces brightness to 33% when parking or headlight lamps are on, and follows dash-lamp dimming control setting. Display has leading-zero blanking. For portable applications, display can be activated by closing display switch momentarily.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 13-8–13-10.

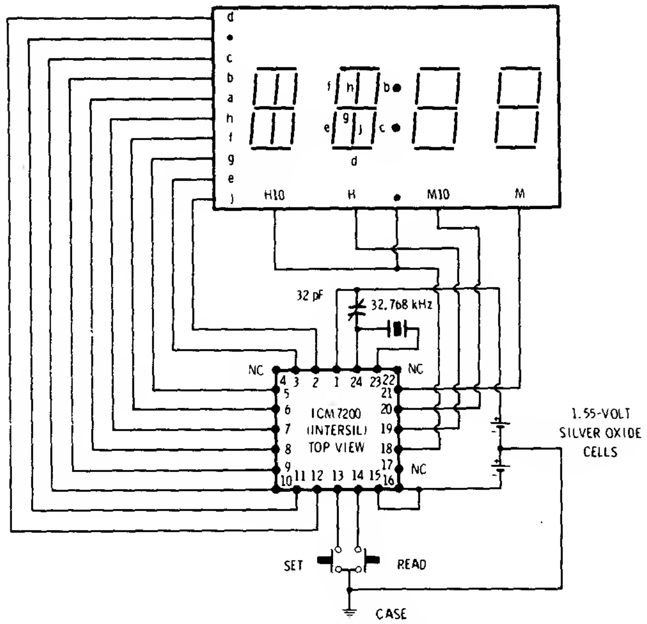


R_X ~ 200, VARIABLE DEPENDING ON DESIRED DISPLAY BRIGHTNESS.

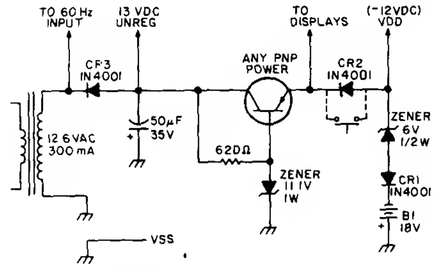
6-DIGIT DISPLAY—National DM8863 8-digit LED driver serves as segment driver for common-anode display of hours, minutes, and seconds, replacing total of 14 resistors and 7 transistors.—C. Carinalli, "Driving 7-Segment LED Displays with National Semiconductor Circuits," National Semiconductor, Santa Clara, CA, 1974, AN-99, p 11.



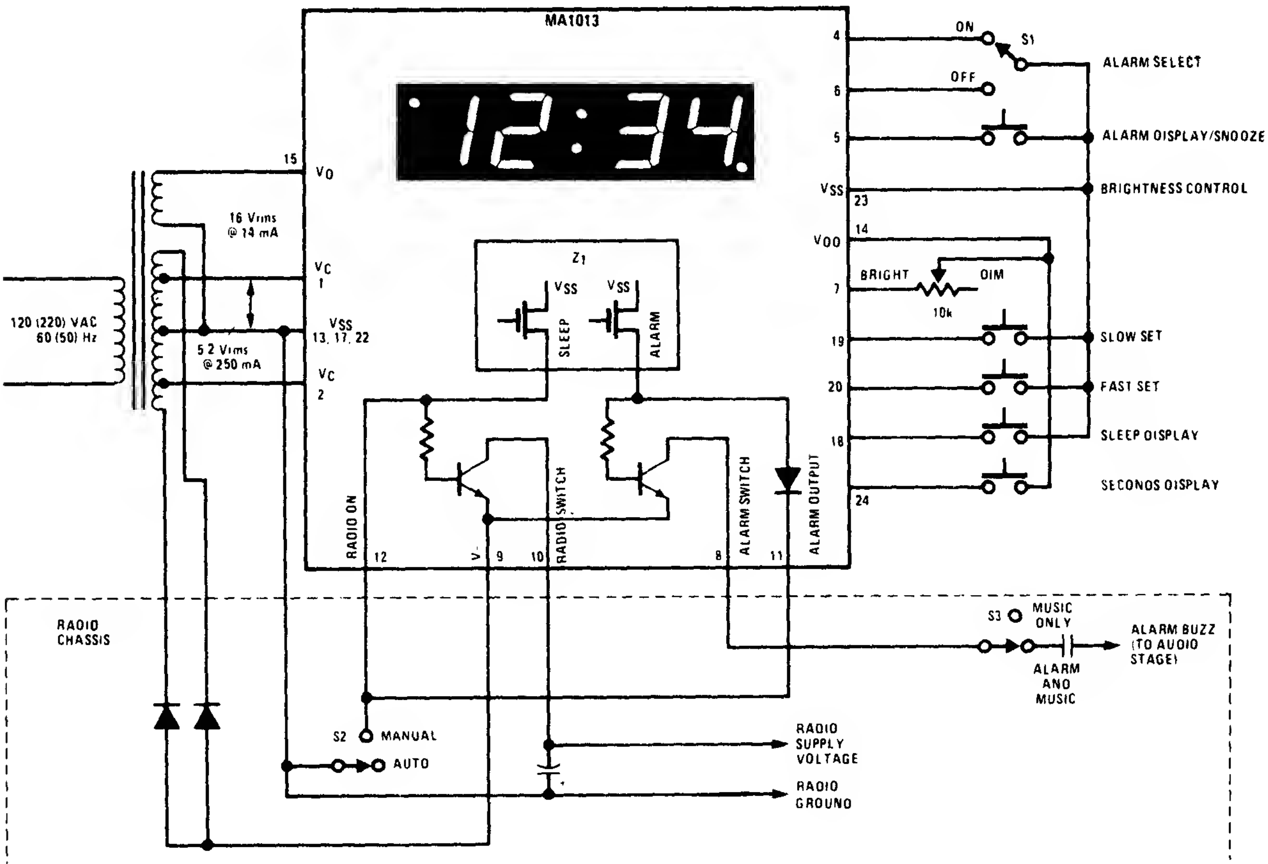
AC DIGITAL CLOCK WITH STANDBY BATTERY—Uses MM5316 alarm-clock IC, originally designed to drive LCD or fluorescent displays, but modified here for LED display. Diodes and batteries provide power if AC fails, with blanking of display to extend battery life. Accuracy is poor on batteries but batteries make resetting of time and alarm easier after AC interruption. Alarm uses 555 multivibrator to produce frequency-shift warble on output tone. Time is set by fast and slow buttons, and alarm is set with same buttons while depressing alarm-display button. Transistor type is not critical.—M. F. Smith, Digital Alarm Clock, *Wireless World*, Nov. 1976, p 62.



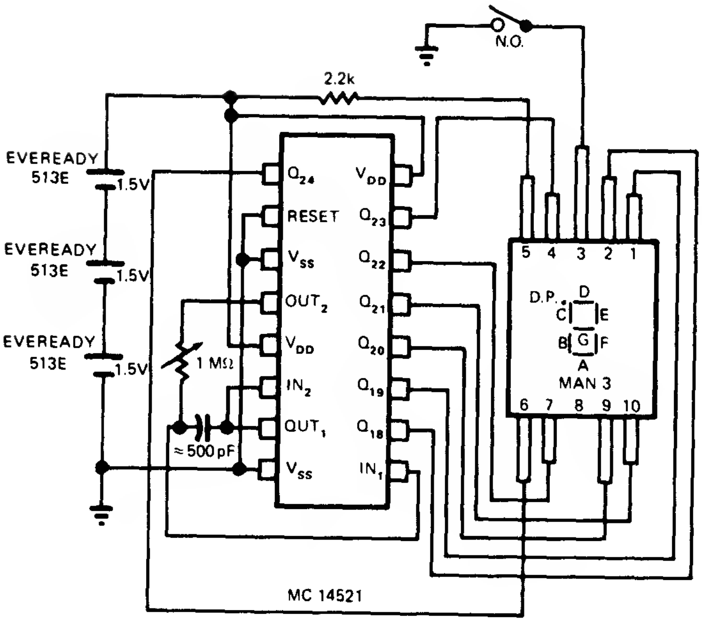
DIGITAL WRISTWATCH—Single Intersil ICM7200 IC drives multiplexed display giving choice of hours and minutes, seconds, and day/date. CMOS chip divides 32.768-kHz crystal output in long internal binary divider to produce basic 1-s clock rate. Further division gives other elements of display. Pressing read button once gives hours and minutes; pressing second time gives day and date; and pressing third time gives seconds.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 377–378.



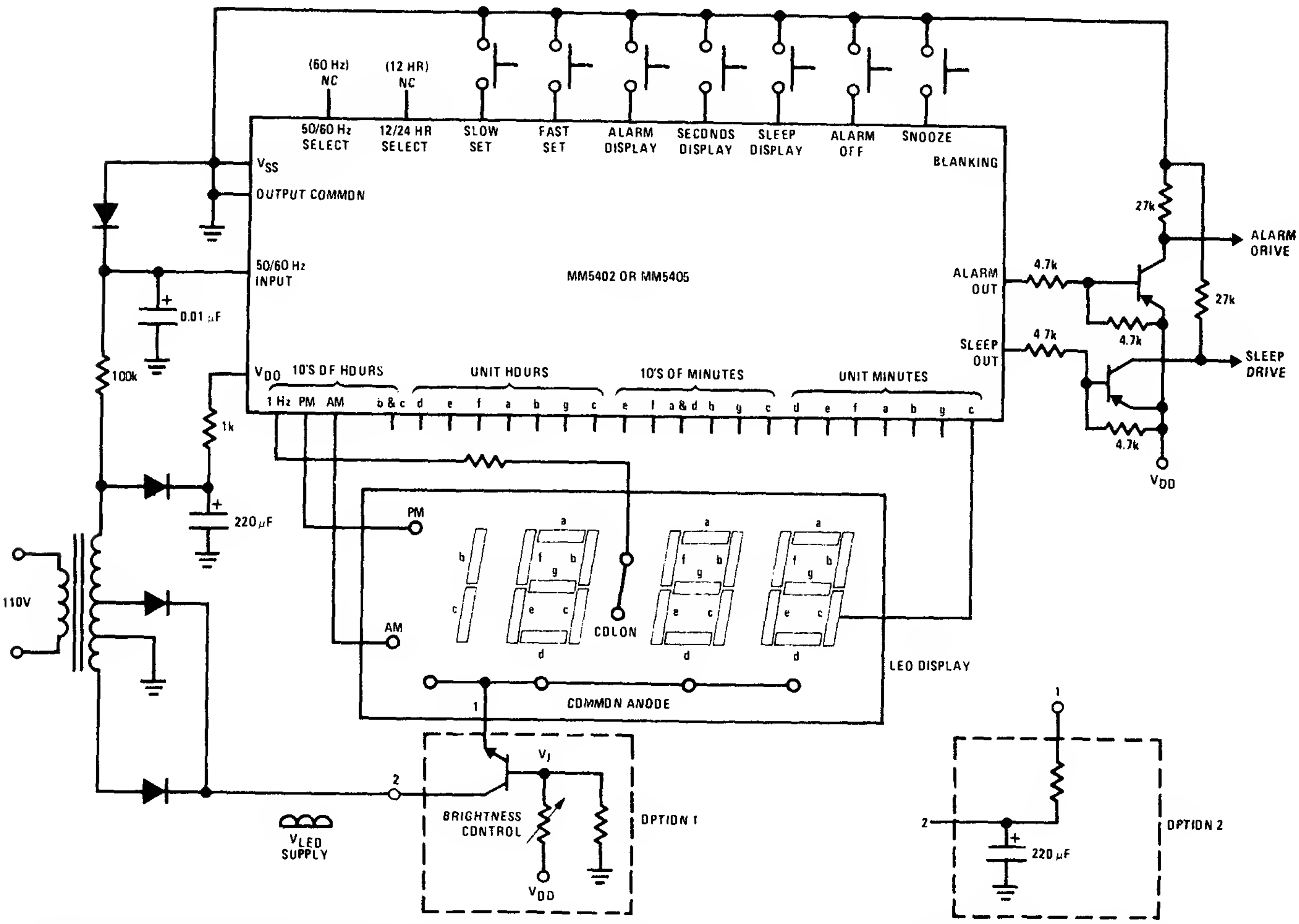
BATTERY BACKUP—During normal operation, all power for digital clock is provided by AC power supply. During power failure, clock continues operating from battery backup using two 9-V batteries in series. Battery drain is limited by diode CR2 that blocks power flow to displays. Optional switch may be installed across diode to short it for momentary viewing of display.—W. J. Prudhomme, CT7001 Clockbuster, *73 Magazine*, Dec. 1976, p 52–54 and 56–58.



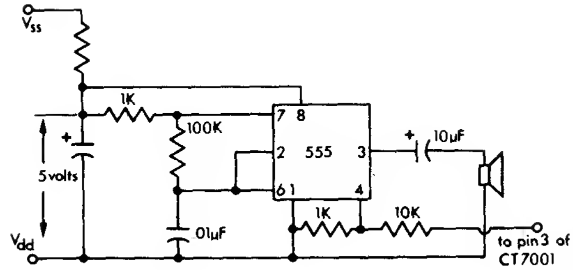
4-DIGIT 0.7-INCH LED DISPLAY—National MA1013 clock module contains MOS LSI clock IC, display, power supply, and associated discrete components on single printed-circuit board that is easily connected to radio. Operates from either 50-Hz or 60-Hz inputs, and gives either 12- or 24-h display format. Nonmultiplexed LED drive eliminates RF interference. Display is flashed at 1-Hz rate after power failure of any duration, to indicate need for resetting clock. Zero appearing in first digit is blanked. On 12-h version, dot in upper left corner is energized to indicate PM.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 13-23–13-28.



4-h DIGITAL WATCH—Single Motorola MC 14521 CMOS IC drives single-digit MAN 3 LED display in such a way that time range of 4 h is obtained with 1.875 min resolution. Can be built into old watch case at cost under $10 for parts. Oscillator frequency of 1.165 kHz can be tweaked to adjust clock, or crystal oscillator can be added for high accuracy. Analog/binary format of readout provides deciphering challenge to user, even though article gives diagram showing which segments of LED are lit for each time reading. Time intervals represented by each lit segment of display are: B = 2 h; C = 1 h; A = 30 min; F = 15 min; G = 7.5 min; E = 3.75 min; D = 1.875 min.—R. M. Steimle, Small CMOS Digital Watch Has Analog LED Output, *EDN Magazine*, Aug. 20, 1976, p 86.

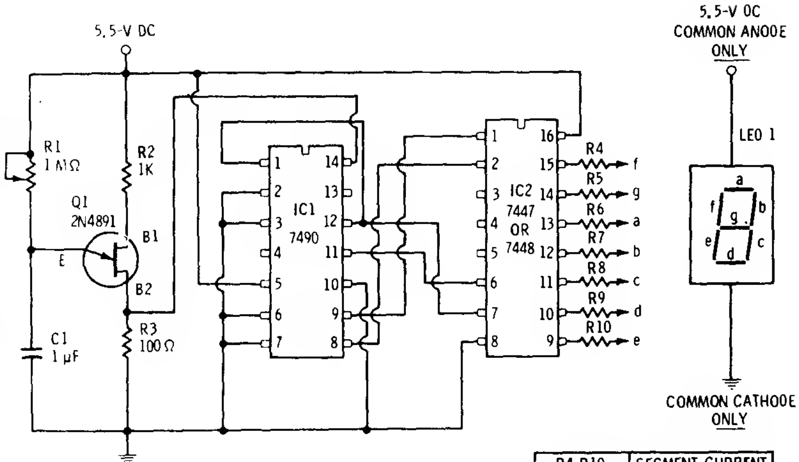


12-h ALARM—General-purpose digital clock with alarm uses National MM5402 or MM5405 MOS IC to drive 3½-digit LED display and provide drive for alarm. Brightness control is optional. Sleep output can be used to turn off radio after desired time interval of up to 59 min.—"MOS/LSI Datebook," National Semiconductor, Santa Clara, CA, 1977, p 1-68–1-73.

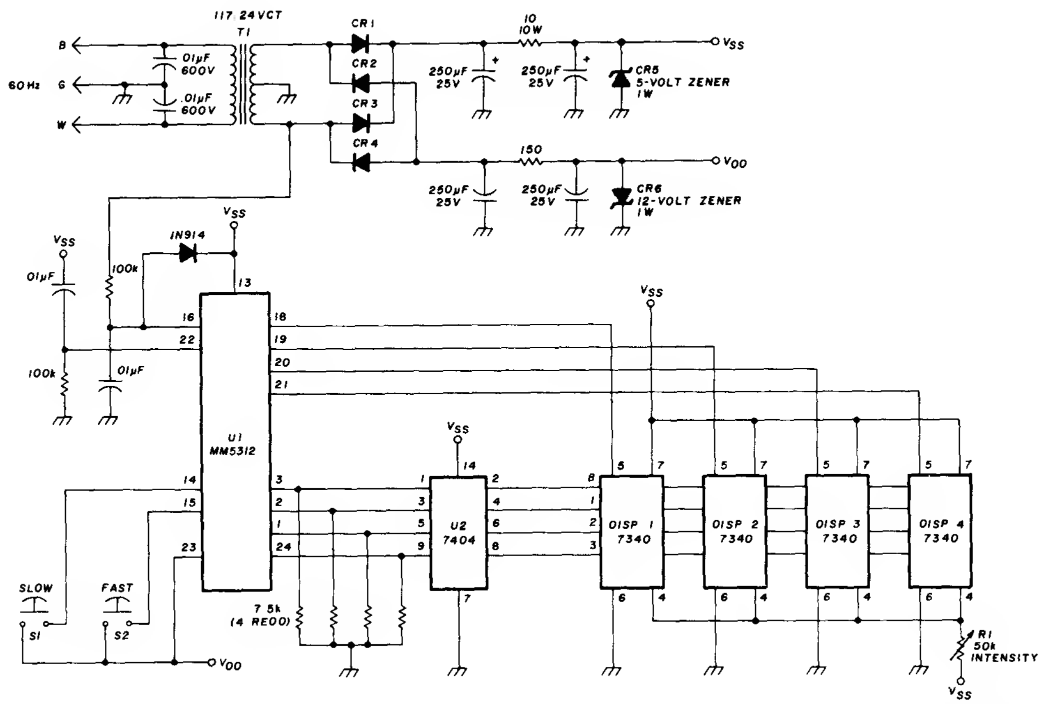


ALARM GENERATOR—Simpla 555 timer generates alarm tone driving small loudspaaker, for use with Cal-Tex CT7001 end other simller digital clocks which do not have internal tone generetor. Circuit requires +5 V, but supply can be higher value if suitable dropping resistor is used.—M. S. Robbins, "Elactronic Clocks and Watches," Howard W. Sams, Indianapolis, IN, 1975, p 91.

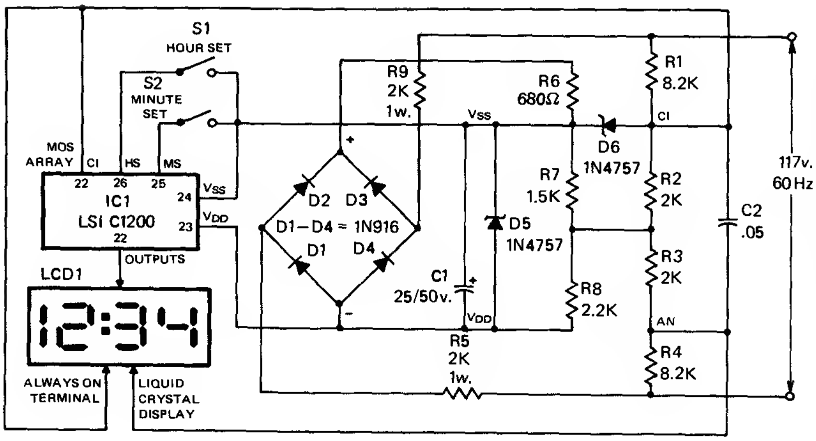
0–9 s DIGITAL READOUT—Can ba used for classroom demonstration of digital logic driving 7-segment LED or as attention-getting desk display ¯'me base Q1 feeds sequential timing pulses to 7490 decade counter. Pulses are counted in binery mode, and bit pettam corresponding to digits 0-9 is fed to 7447 binary-to-decimal decoder/drivar connected to 7-segment readout. Calibrata with watch or with timing reference signels from WWV, edjusting R1 so display advances 1 digit per second.—F. M. Mims, "Electronic Circuitbook 5: LED Projects," Howard W. Sams, Indianapolis, IN, 1976, p 72–75.



R4-R10	SEGMENT CURRENT
370 Ω	10 mA
185 Ω	20 mA

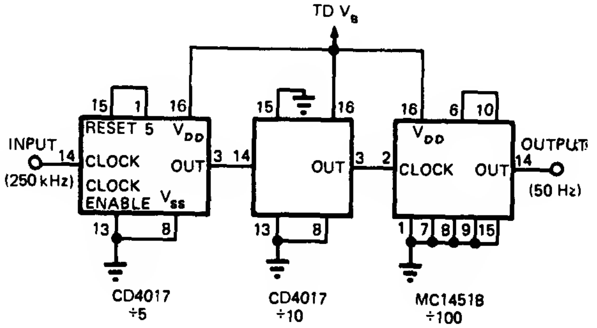


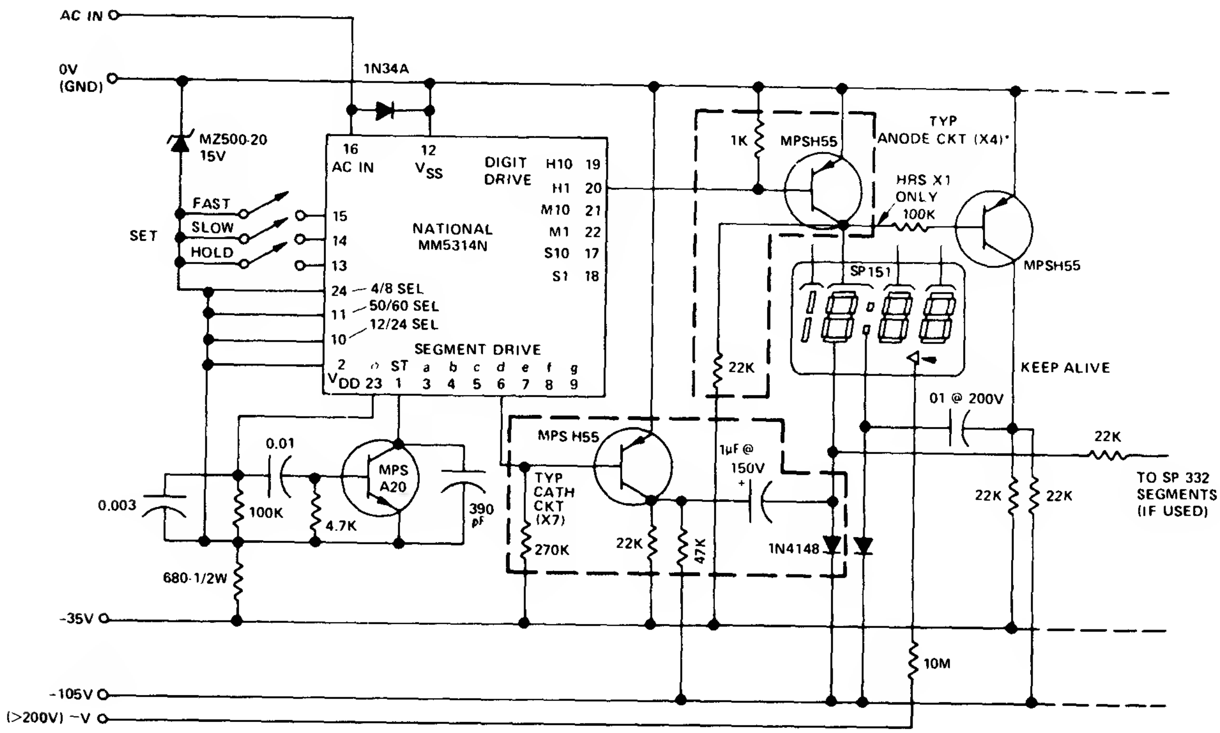
SIMPLE 24-h CLOCK—Use of 60-Hz power frequency as time besa simplifias design while still giving long-term accuracy comperable to that of crystal time base. Four-digit display uses Hewlett-Packard 5082-7340 displays requiring only simple four-line BCD input. Nationel MM5312N IC divides line frequency down to one pulse per minute and advances its internal storege register at same rata. Output of register is in binary form at pins 1, 2, 3, and 24, synchronized with digit-eneble outputs et pins 18, 19, 20, end 21. Binary data is thus applied to all four displays in parallel, with eneble lines controlling data feed. SN7404N inverter converts binery output date to TTL leval required by displays. Power supply provides +5 V end −12 V for ICs and 60-Hz reference for clock check. CR5 is Redio Shack 276-561, CR6 is 276-563, and CR1-4 ere 276-1146.—K. Powell, 24-Hour Clock with Digital Readout and Line-Frequency Time Base, *Ham Redio,* March 1977, p 44–48.



2-INCH LCD NUMERALS—Uses C1200 clock IC mede by LSI Computer Systems, having time set, logic, division for seconds, minutes, end hours, 7-segment decoding, end display drivars end switches. Four-digit liquld crystal display penel (LCD) is MGC-50. S1 end S2 edvence minutes or hours on display et 2-Hz rate for setting tima. To use as elapsed-time indicator, close S1 end S2 simultaneously to generate reset pulse that sets timing chenge to zero. When both switches era releesed simultaneously, time count starts from zero.—R. F. Graf and G. J. Whalen, A Gient LCD Clock, *CQ*, Feb. 1978, p 18–23 and 76.

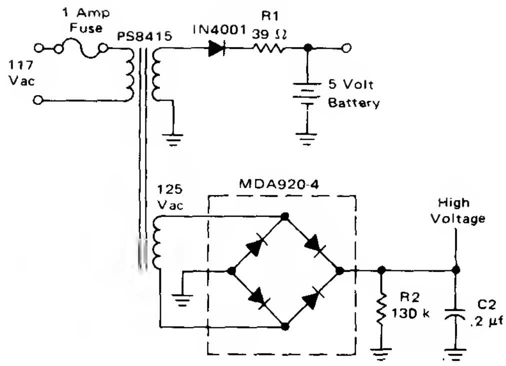
DIVIDE BY 5000 FOR CLOCK—Countar chein uses CD4017 that divides by integer from 2 to 10, selected by connecting eppropriate output to reset. Extra gates recommended by RCA ere not needed. Used in digital clock thet changes autometically to battery operation when AC powar feils. Clock operates on eithar 50 or 60 Hz.—S. I. Green, Digitei Clock Keeps Counting Even When AC Power Fails, *EDN Magazine*, Dec. 20, 1974, p 49–51.



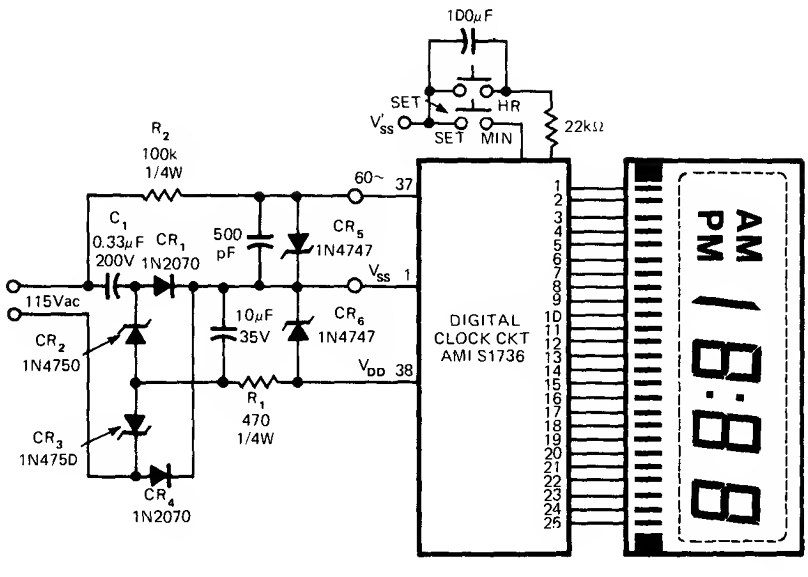


*(X4) FOR HRS, MINS, (X6) FOR HRS, MINS, SECS

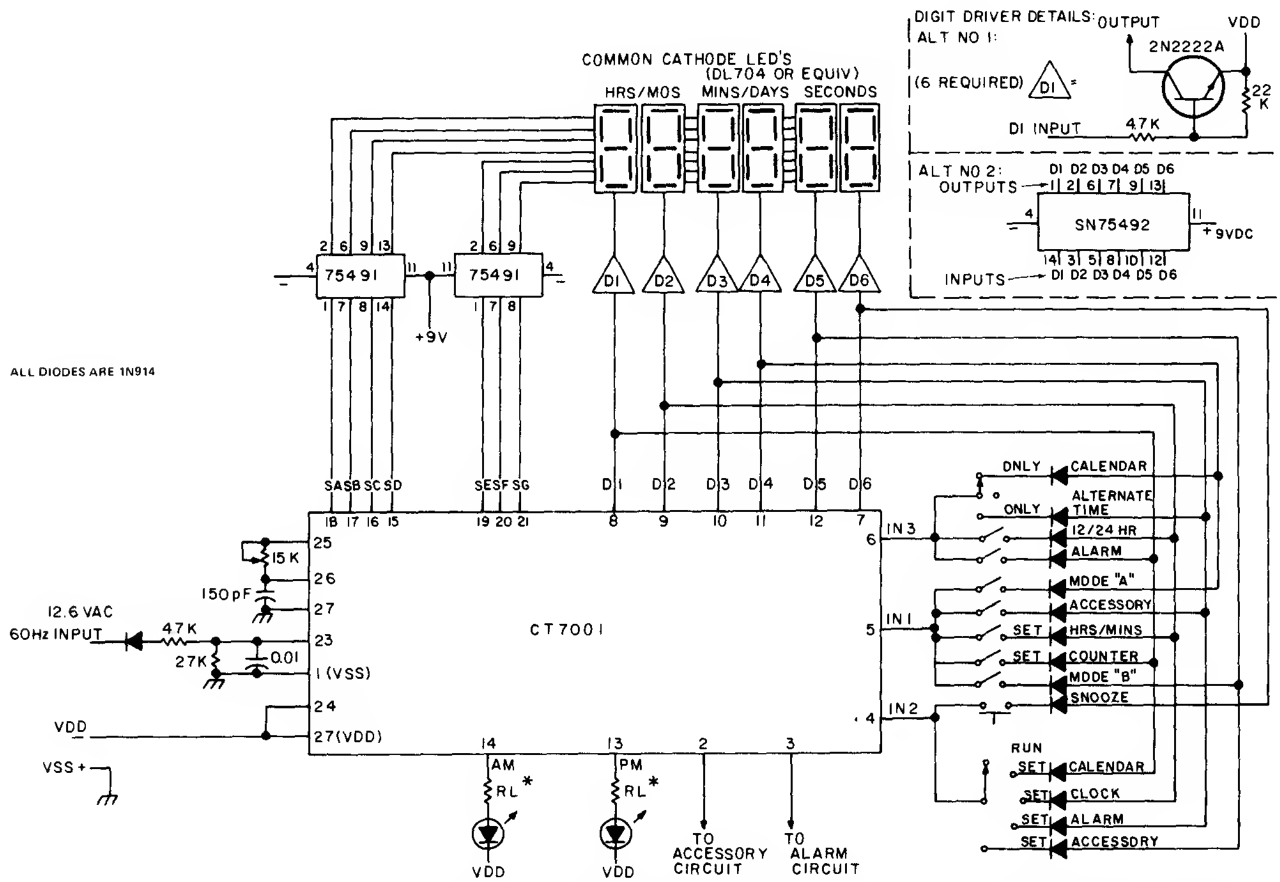
4-DIGIT GAS DISPLAY—CMOS clock IC drives multidigit gas-discharge display. Simple circuit does not include alarm, fleshing colon, and AM/PM features. Seven segmant-driver circuits and four digit-drivar circuits are required, although only one of each is shown. Additionel drivers are needed if seconds display is desired. Required supply voltages can ba obtained from transformer-type supply driving diode bridge; regulation is not needed.—M. S. Robbins, "Electronic Clocks and Wetches," Howard W. Sams, Indienepolis, IN, 1975, p 68–71.



BATTERY BACKUP—Four nickel-cadmium batteries connected in series provida eutomatic backup for 5-V supply of digital clock. Under normel AC line operation, bettary is continually being recharged with half-weve rectified and unfiltered supply that ellows internel chemicel reections to settle between pulses of cherging energy. R1 is chosen to meke averege cherging current about 5% of battery reting.—D. Aldridge end A. Mouton, "Industriel Clock/Timer Featuring Back-Up Power Supply Operation," Motorole, Phoenix, AZ, 1974, AN-718A, p 7.



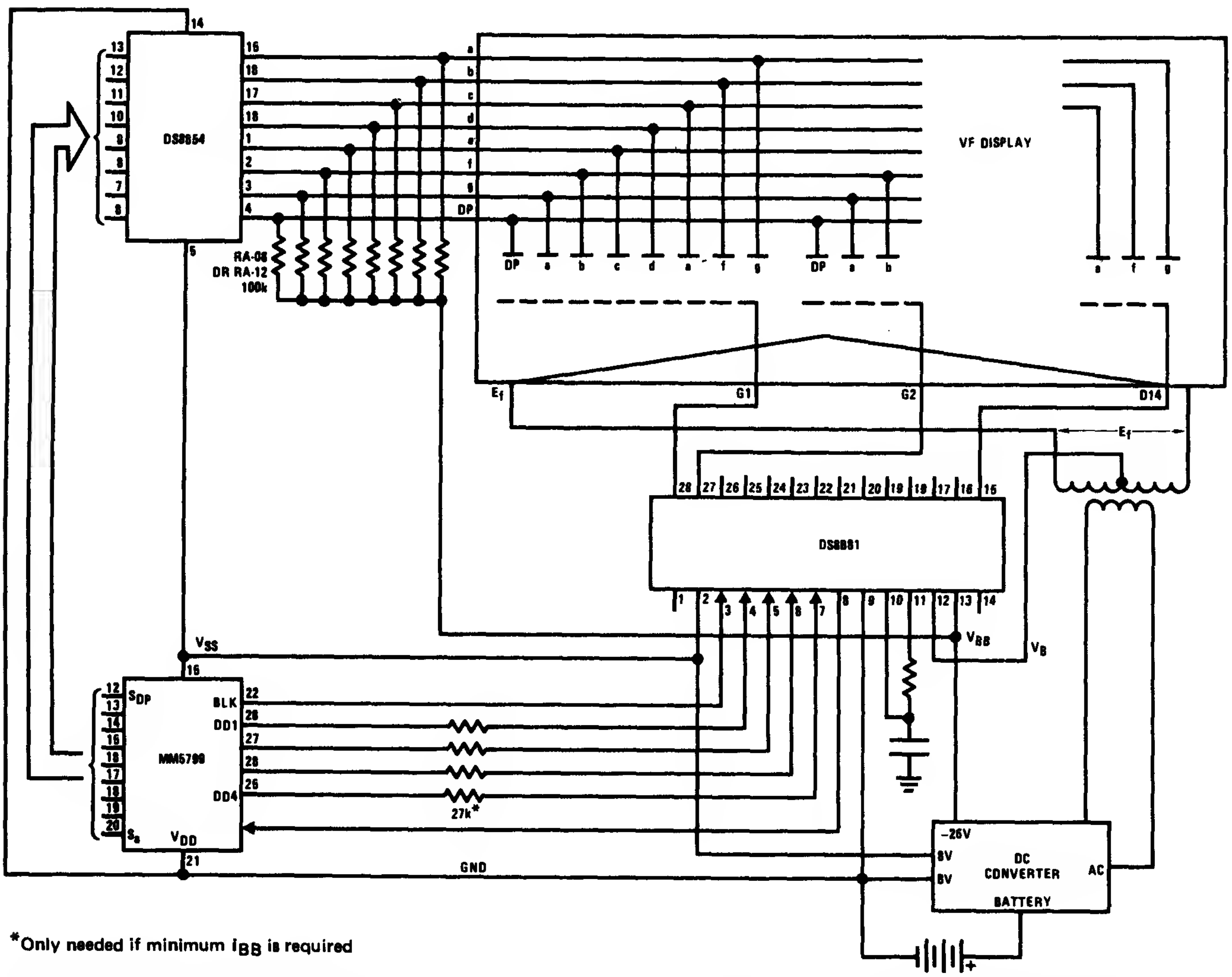
12- OR 24-h CLOCK—Single American Microsystems AMI S1736 clock chip drives liquid-crystel readout to give either 12-h displey with AM/PM indicator or 24-h digital display by chenging only three connections.—LSI In Consumer Applicetions, Round 2: Clocks on a Chip, *EDN Magazine,* May 5, 1973, p 22–23.



CALENDAR CLOCK—Uses Fairchild FCM7001 IC equivelent of Cal-Tex CT7001 clock chip (which ia no longer aveilabla) to drive six 7-segment LEDs that can ba awitched to show 12- or 24-h time and 28/30/31 calendar, along with alarm features. Article gives construction details. Each SN75491 driver chip hes pins 3, 5, 10, and 12 connected to pin 11 through 150-ohm resistor. RL is typically 2.7K, choeen to limit LED current to less than 5 mA.—W. J. Prudhomme, CT7001 Clockbuster, *73 Magazine,* Dec. 1976, p 52–54 and 56–58.

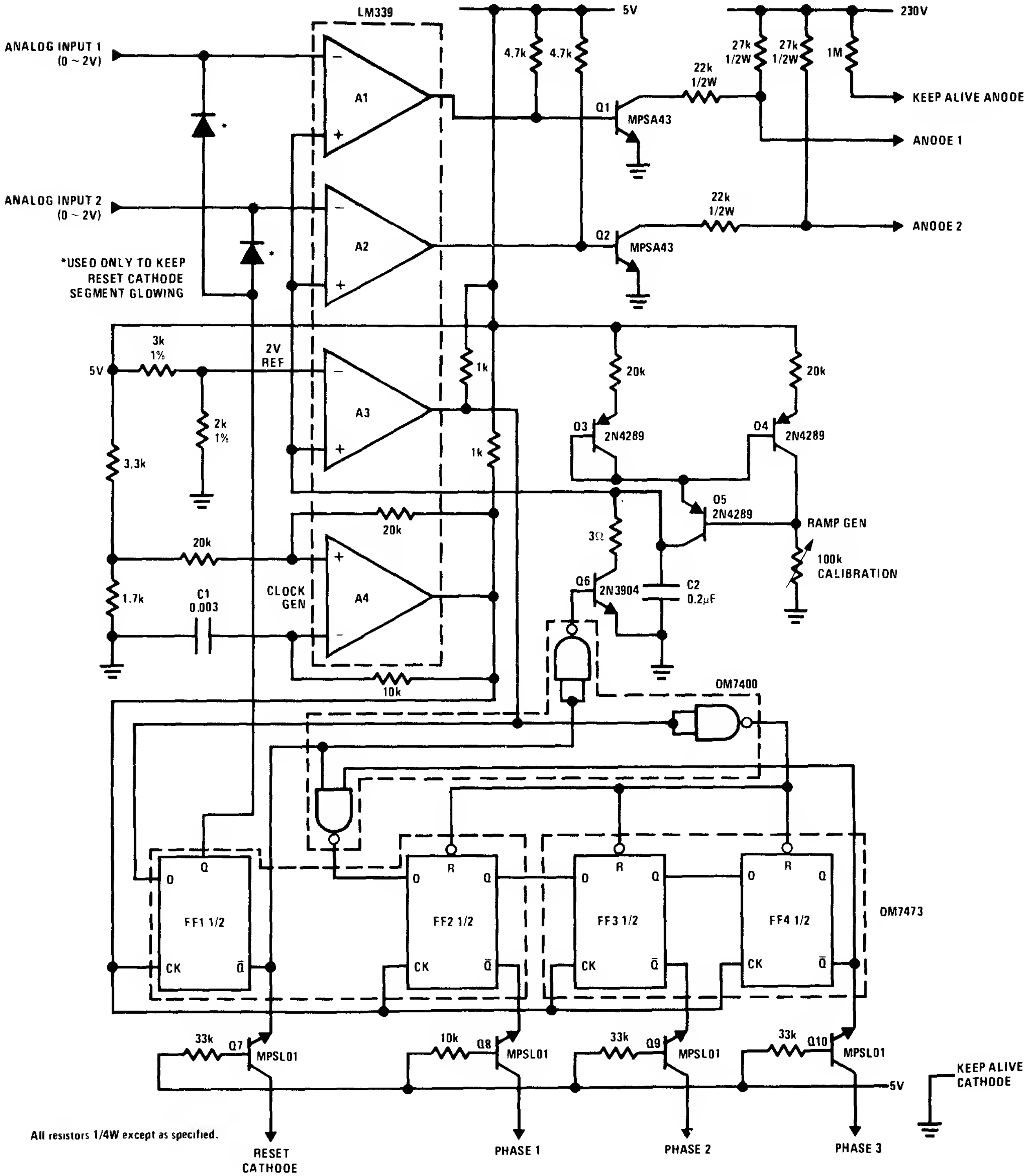
CHAPTER 25
Display Circuits

Drives and controls for LEDs used singly or in arrays, as well as liquid crystal, gas-discharge, fluorescent, incandescent, bar-graph, and Nixie displays. Includes controls for brightness, zero-suppression, strobing, and multiplexing. For displays on cathode-ray screens, see Cathode-Ray chapter.



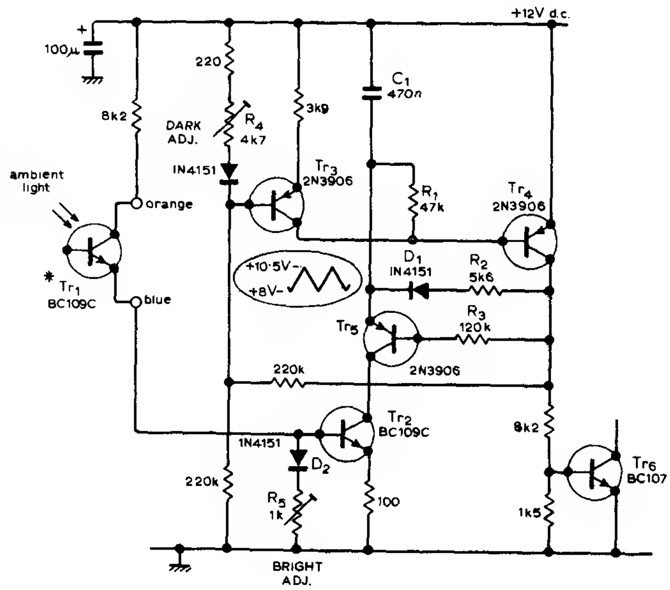
*Only needed if minimum I_{BB} is required

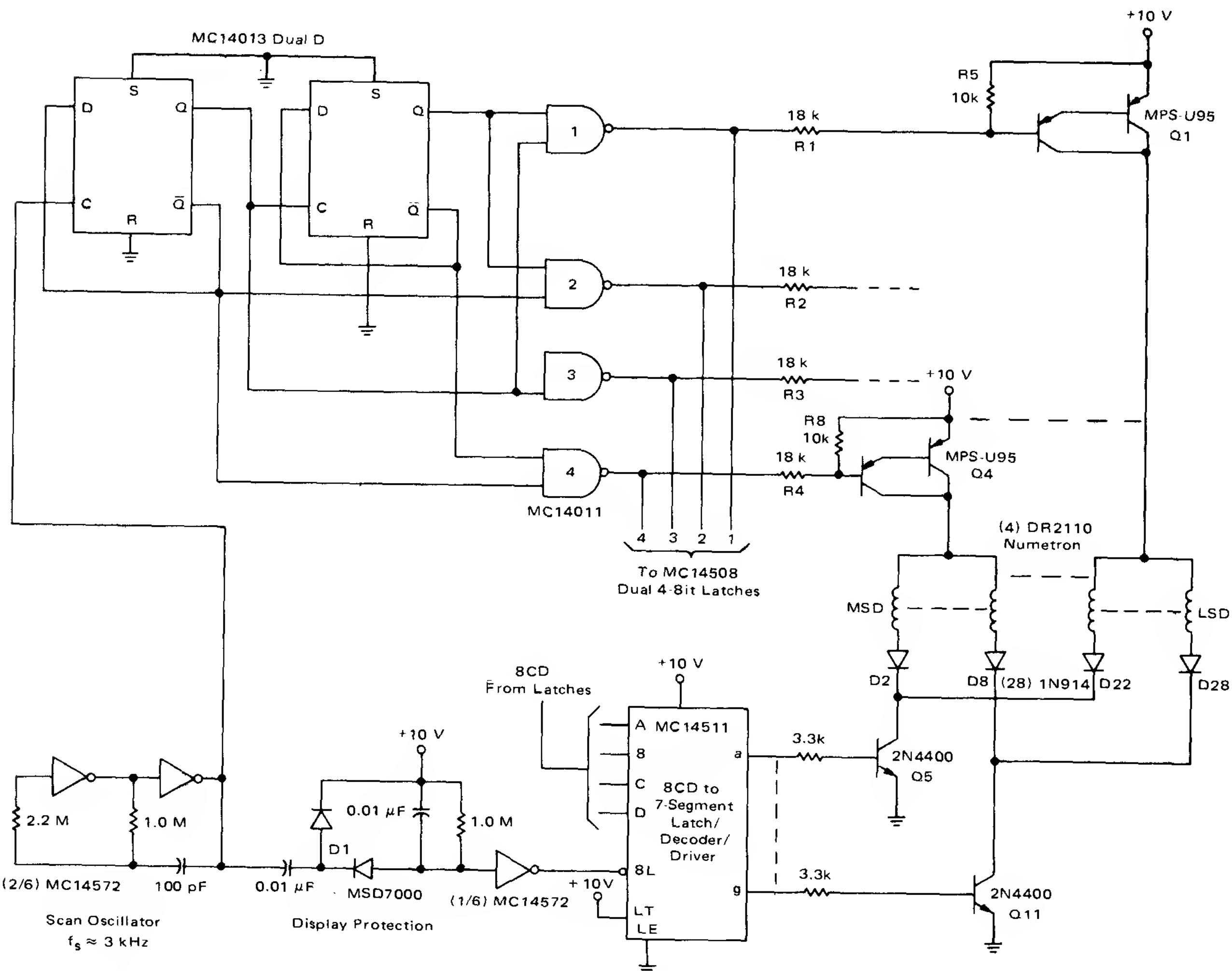
FLUORESCENT DISPLAY DRIVER—National DS8881 vacuum fluorescent display driver handles 16-digit grids. Decode inputs select 1 of 16 outputs to be pulled high. Driver also contains oscillator for supplying clock signals to MOS circuit, filament-bias zener, and 50K pulldown resistors for each grid. Outputs will source up to 7 mA. Supply is 9 V. Interdigit blanking with enable input provides ghost-free display.—"Interface Databook," National Semiconductor, Santa Clara, CA, 1978, p 5-57–5-60.



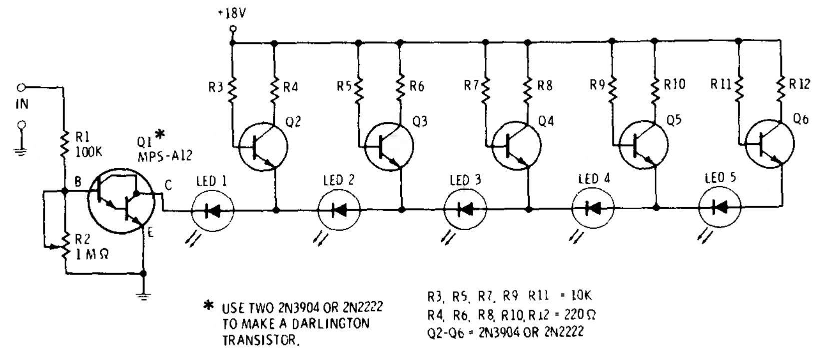
BAR-GRAPH DRIVE—Use of Netional LM339 quad comparator minimizes number of components needed to driva Burroughs 200-segmant gas-discharga bar display. Evary third electrode of display is tiad together, so only three lines (phase 1, 2, and 3) control ell segments. When phase lines are drivan by consecutive pulses, glow of gas-discharge element is propagated continuously elong array. Anode voltaga is gated so number of glowing segments is proportional to analog input. Comparators A1 and A2 generate gated anoda signals with durations proportional to inputs. A3 compares ramp signal to 2-V reference and generates end-of-scan signal when ramp exceeds reference. A4 generetes clock having period of about 60 μs.—S. N. Kim, "Driving Burroughs' Bar Graph Display," National Semiconductor, Santa Clara, CA, 1975, DB-4.

AUTOMATIC BRIGHTNESS CONTROL—Circuit adjusts brightness of LED digital display by altering mark-space ratio of LED supply voltage. Ambient-light input is sensed by BC109C transistor with top taken off. Normal display current of 20 mA is reduced to 2 mA when darkened room makes brightness unnecessary, conserving battery life. Tr_3 and Tr_4 operate as Schmitt trigger, with mark time of 1.5 ms determined by R_2 and space time controlled by charging current through Tr_5 and Tr_2 as effected by ambient light on Tr_1. Article gives complete circuits for driving 11-LED array. To add brightness control circuit, break ground connection of LED supply transistors and insert saturated transistor Tr_6.—G. Kelenit, Analogue to Digital Meter, *Wireless World*, July 1976, p 53–57.

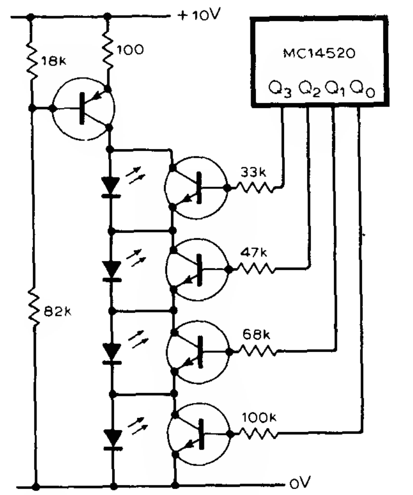




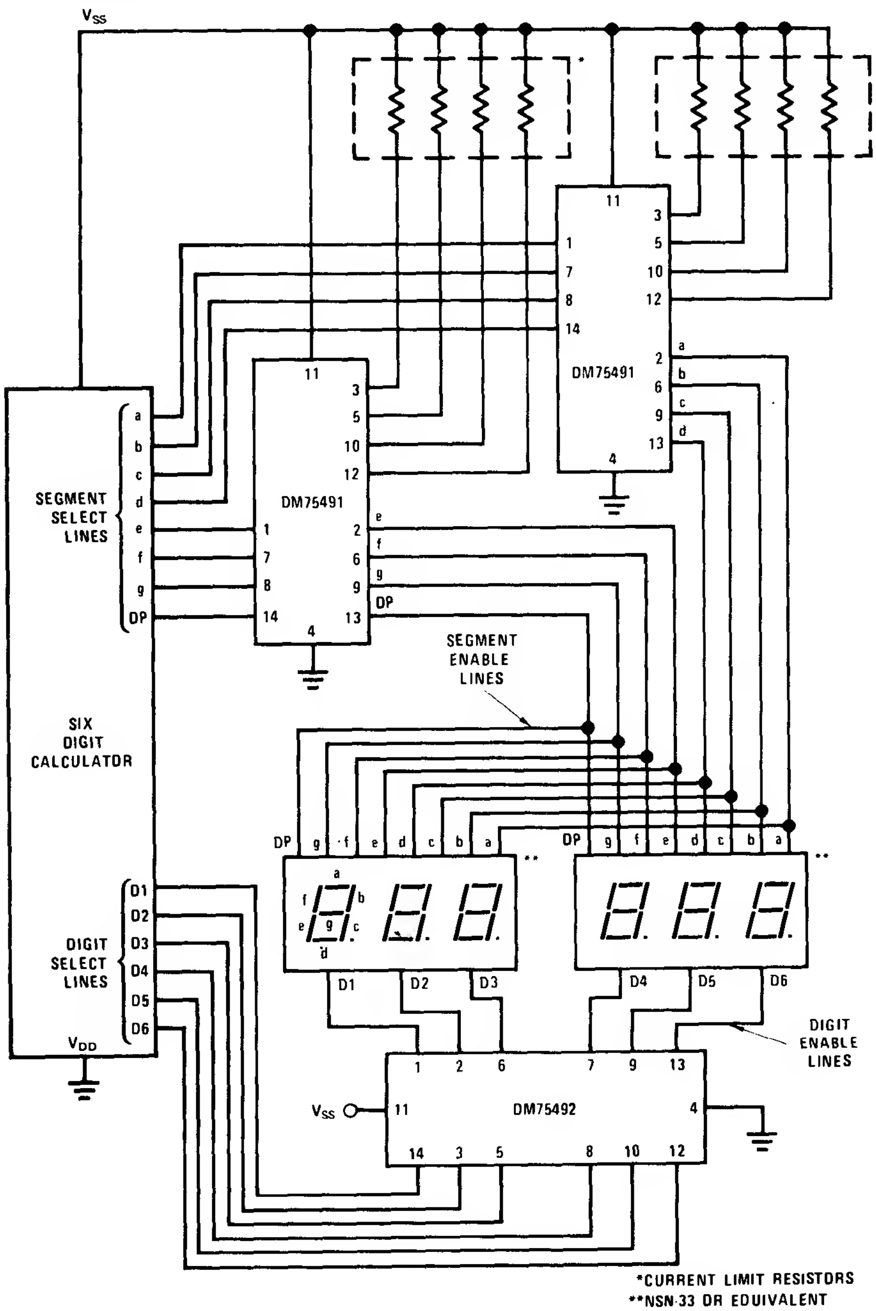
4-DIGIT INCANDESCENT—Circuit serves for interfacing CMOS logic to multiplexed 4-digit incandescent display. Scan decoder requires only two input NAND gates since blanking is not required. Incandescent display requires 4.5 V at 24 mA per segment when direct-driven; with multiplexing, instantaneous power must be 9 V at 48 mA to maintain same average power per segment. Display protection circuit monitors scan oscillator and blanks display if oscillator fails, to prevent high peak current from degrading display when applied continuously to 1 digit.—A. Pshaenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 25.



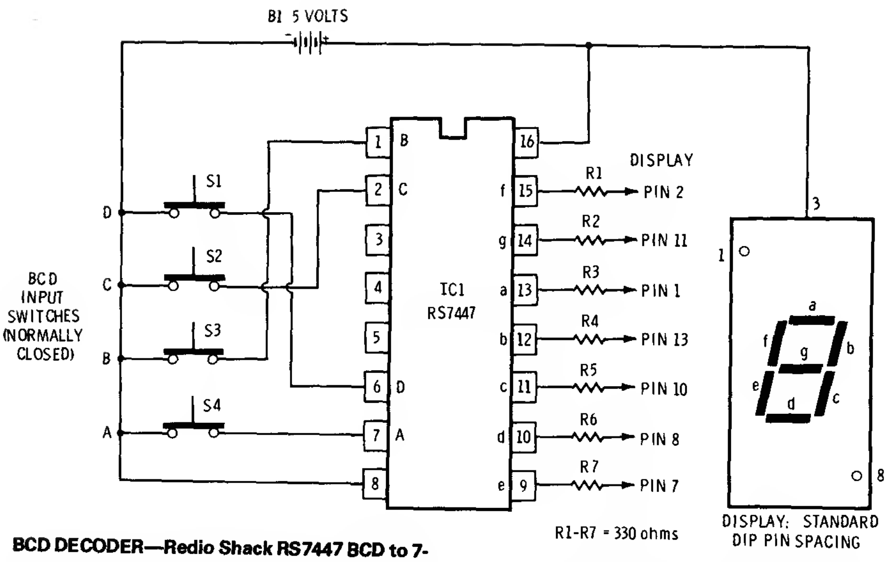
BAR-GRAPH READOUT—Transistors switch row of LEDs on in succession to give rising-bar display indicating input voltage. R2 can be adjusted from minimum range of 0.1 to 0.5 V in 0.1-V increments for five LEDs to maximum of 1.0 to 10.0 V in 1-V increments. Input resistence of circuit is above 100,000 ohms.—F. M. Mims, "Electronic Circuitbook 5: LED Projects," Howerd W. Sams, Indianapolis, IN, 1976, p 86–88.



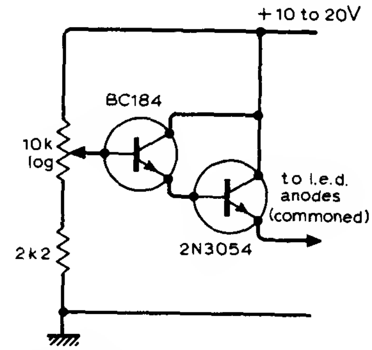
REDUCING LED POWER DRAIN—Arrangement of LEDs in groups of four with constent-current source greatly eliminetes wastage of battery power. Circuit shows utilization of this technique to displey 4-bit binary number from CMOS counter.—T. R. Owen, L.E.D. Display, *Wireless World*, June 1976, p 72.



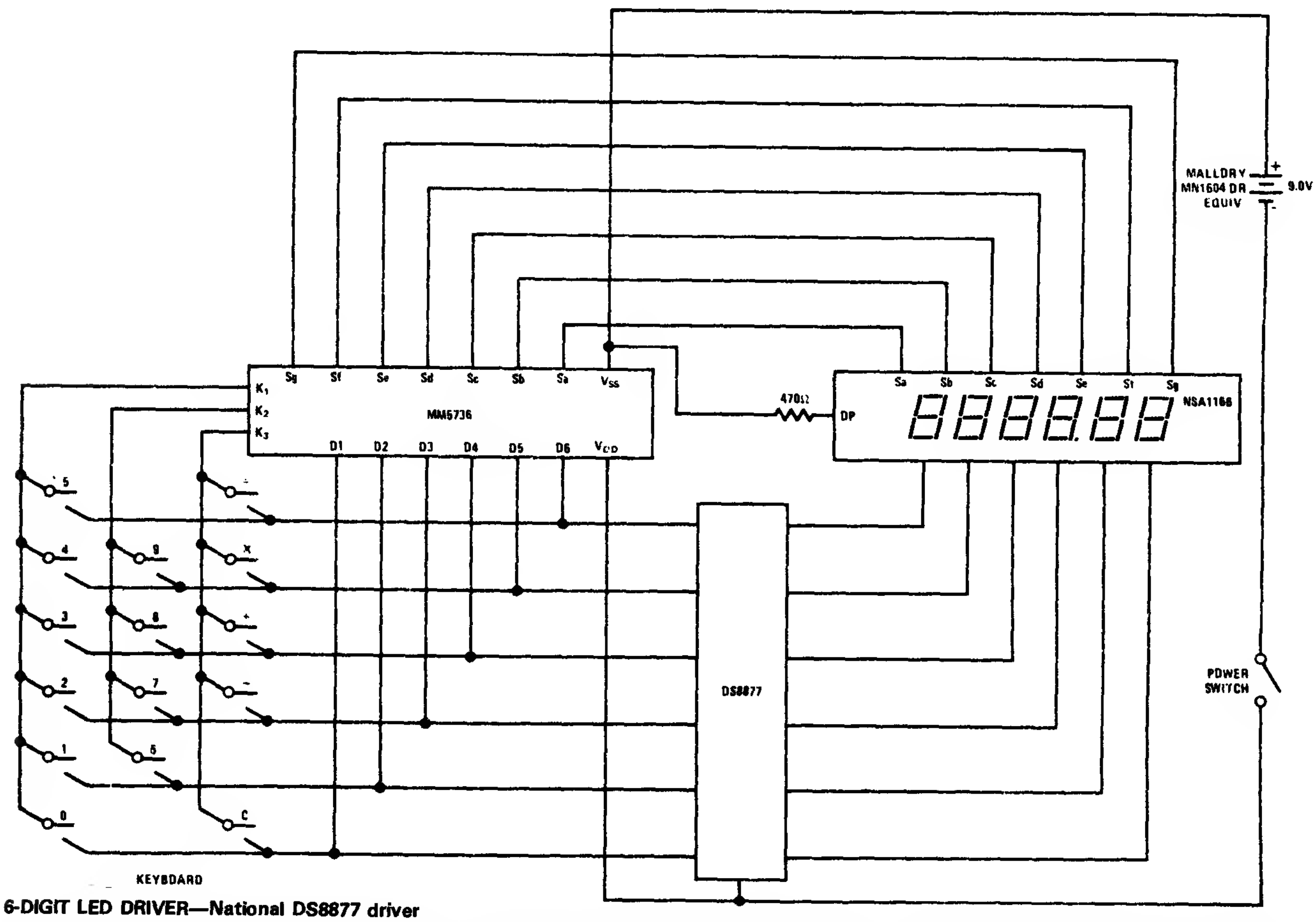
6-DIGIT DRIVE—Uses two National DM75491 four-segment drivers for multiplex-mode display of MOS calculator. Total of eight segment drivers provides drive for each one of seven segments plus logic control for decimal point.—C. Cerineii, "Driving 7-Segment LED Displays with National Semiconductor Circuits," National Semiconductor, Santa Clare, CA, 1974, AN-99, p 9.



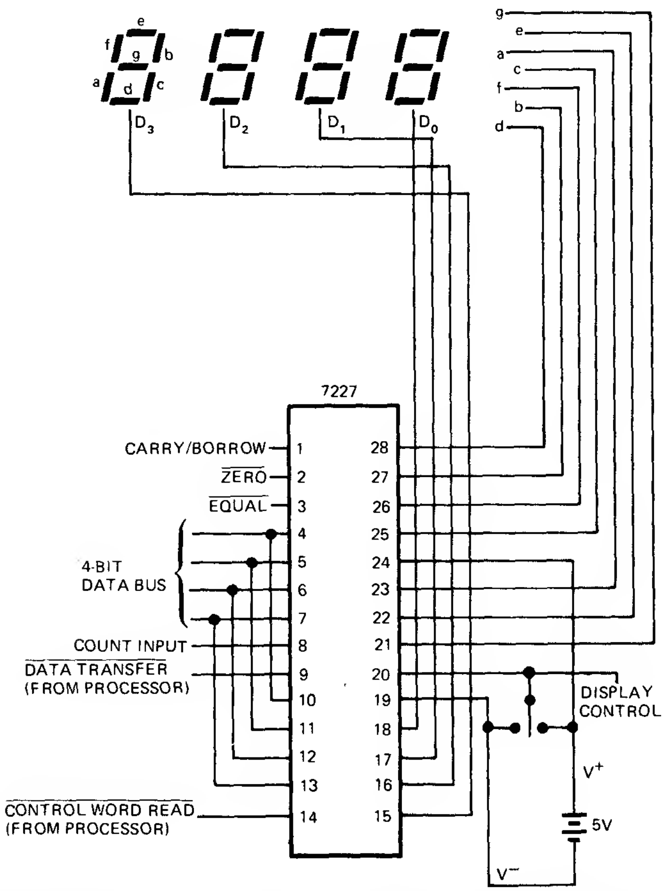
BCD DECODER—Radio Shack RS7447 BCD to 7-segment decoder converts settings of four BCD input switches to corresponding 0–9 digit on 7-segment common-anode LED display. Display is Radio Shack 276-053. Battery can be four AA cells in series, with 1N914 diode inserted in positive lead to reduce voltage to 5 V.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 27–40.



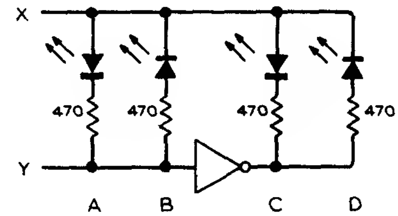
LED BRIGHTNESS CONTROL—Uses 10K logarithmic pot to vary brightness simultaneously for all LEDs in digital display.—S. F. Bywaters and J. E. West, Peak-Reading Audio Level Indicator, *Wireless World,* Aug. 1975, p 357–361.



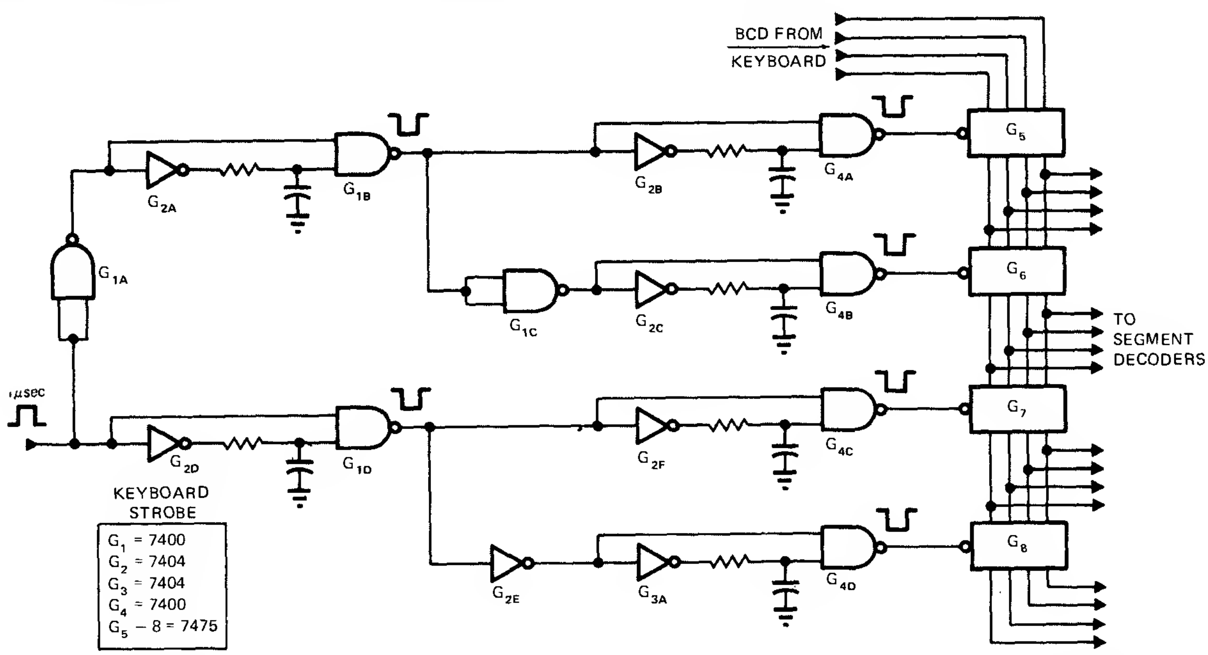
6-DIGIT LED DRIVER—National DS8877 driver is shown in configuration for use with 6-digit calculator. Digit current is in range of 5–50 mA. Driver requires no standby power and operates from either 4.5 V, 6 V, or 9 V.—"Interface Databook," National Semiconductor, Santa Clara, CA, 1978, p 5-52–5-53.



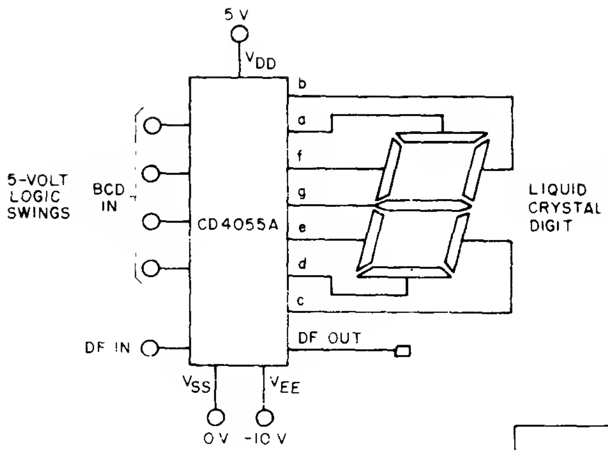
TIMER DRIVES LED DISPLAY—Intersil 7227 microprocessor-controlled timer provides direct drive for LED display under supervision of microprocessor. Tri-state 4-bit data bus serves to read in control word such as up/down, store, reset, or load, then deliver counter data, feed in settable register word, or preset counter to initial value.—B. O'Neil, IC Timers—the "Old Reliable" 555 Has Company, *EDN Magazine*, Sept. 5, 1977, p 89–93.



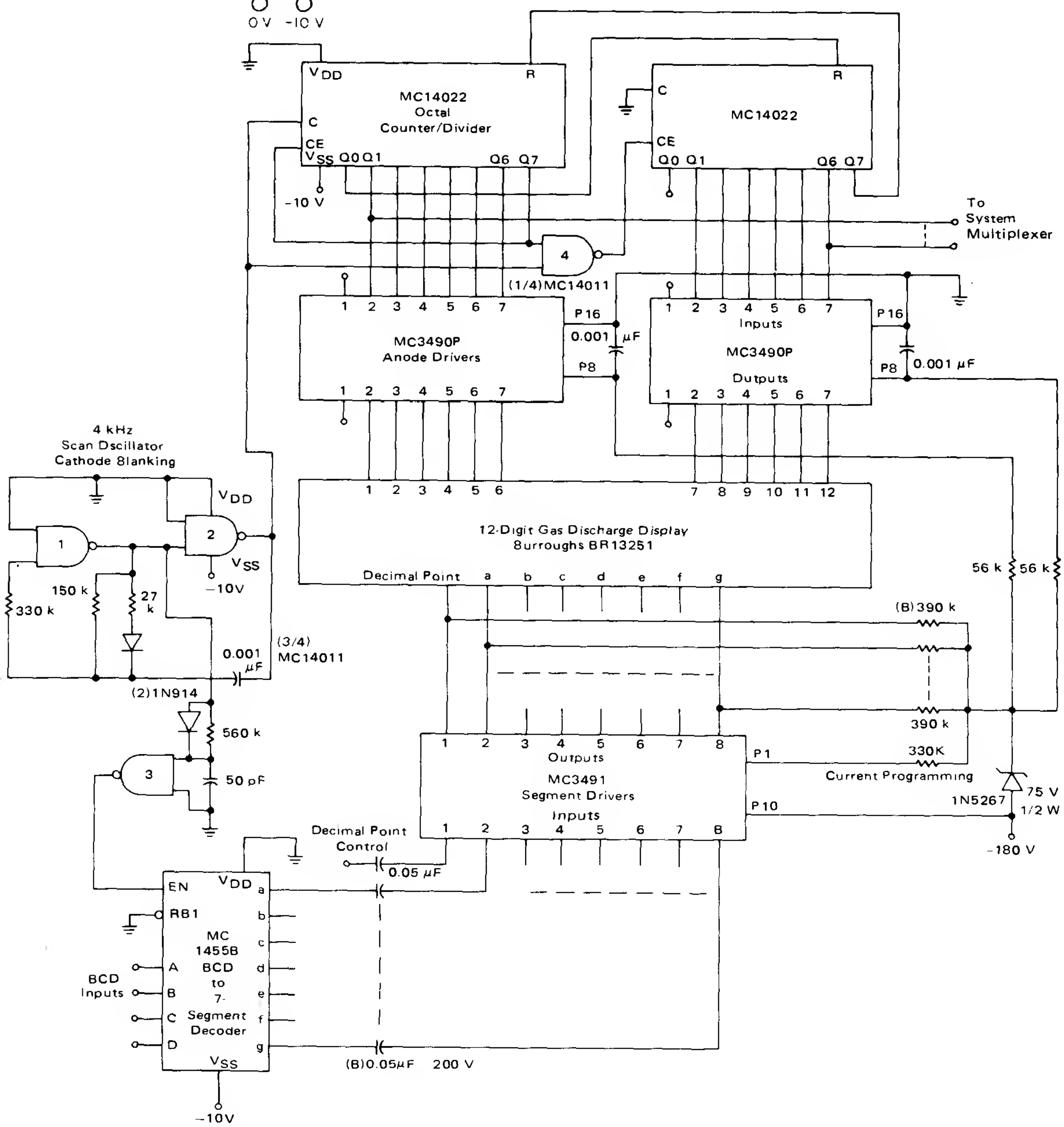
BINARY LINE STATES—Simple circuit using four LEDs and one inverter (which may be a transistor or spare gate) displays all four possible states on two binary lines. When levels of lines X and Y are the same, A and B will be off. Inverter then places C and D at different levels so one LED (C or D) will be on. Reverse situation occurs when X and Y are at different levels.—D. Streker, Binary State Indicator, *Wireless World*, Feb. 1977, p 44.



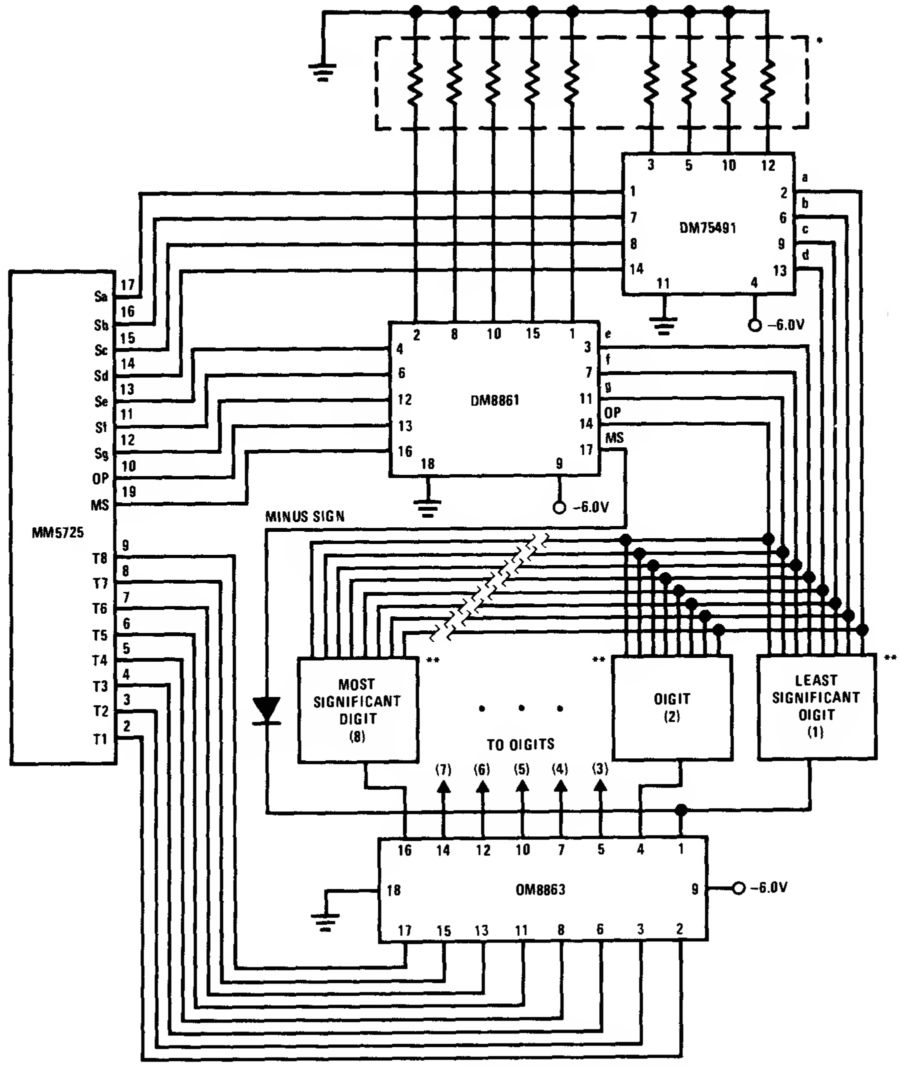
DIGIT SHIFTER FOR DISPLAY—Circuit takes BCD output from 10-key keyboard and shifts each number, as entered, from right to left on display panel. Internal clock is not used. Keyboard strobe is delayed 2 ms to allow time for keyboard switches to stop bouncing. BCD outputs from G_5-G_8 go directly to 7- or 10-segment decoder driver, such as SN7447 decoders driving RCA DR-2100 series low-voltage readouts. All resistors are 220 ohms. Capacitors for G_{1B} and G_{1D} are 1000 pF, and capacitors for other gates are 240 pF. Article traces circuit operation.—T. O'Toole, Transfer Parallel Information Without a Clock, *EDN Magazine*, Aug. 1, 1972, p 59.



CMOS DRIVE FOR LCD—Seven-segment liquia crystal display digit can be driven directly by CD4054A, CD4055A, or CD4056A CMOS because these circuits contein internal level-shifting feature needed to convert 5-V input logic swings to 30-V peak AC signal required for driving dynemic-scattering LCD.—"COS/MOS Integrated Circuits," RCA Solid Stete Division, Somerville, NJ, 1977, p 629.

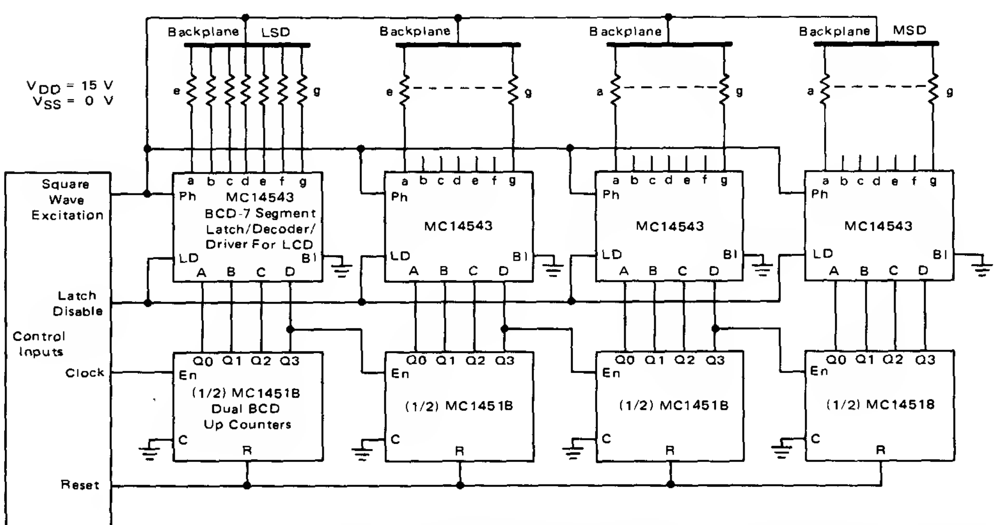


12-DIGIT GAS-DISCHARGE—Display anodes are referenced to ground end cethodes to −180 V because number of digits in display is greater than number of segment drivers. Positive-logic CMOS address circuits are powered by −10 V, with Motorola MC14558 decoder outputs coupled to MC3491 segment drivers. Scan circuit is directly coupled to MC3490P anode drivers. Digit scanning is derived from two cascaded MC14022 octel counter/dividers. Required 12 sequenced output pulses are echieved by resetting counters with Q7 output of second counter. Counter output elso controls system multiplexer (not shown) to give synchronization of entire displey system.—A. Psheenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 23.

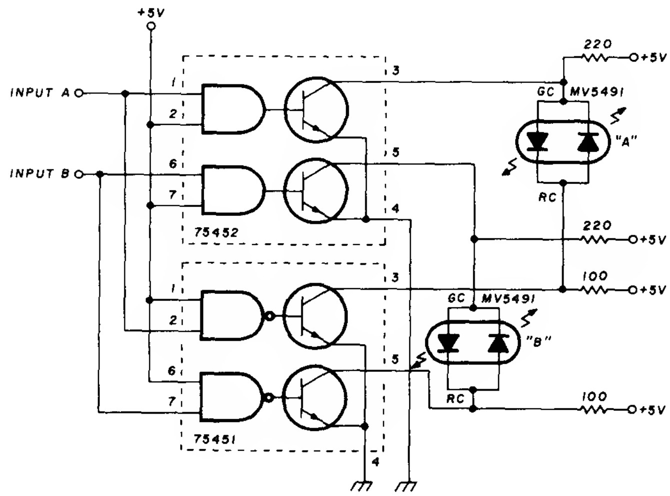


*SEGMENT CURRENT LIMIT RESISTORS
**EITHER SINGLE OIGIT, MULTI-OIGIT, NSN 33, OR EQUIVALENT

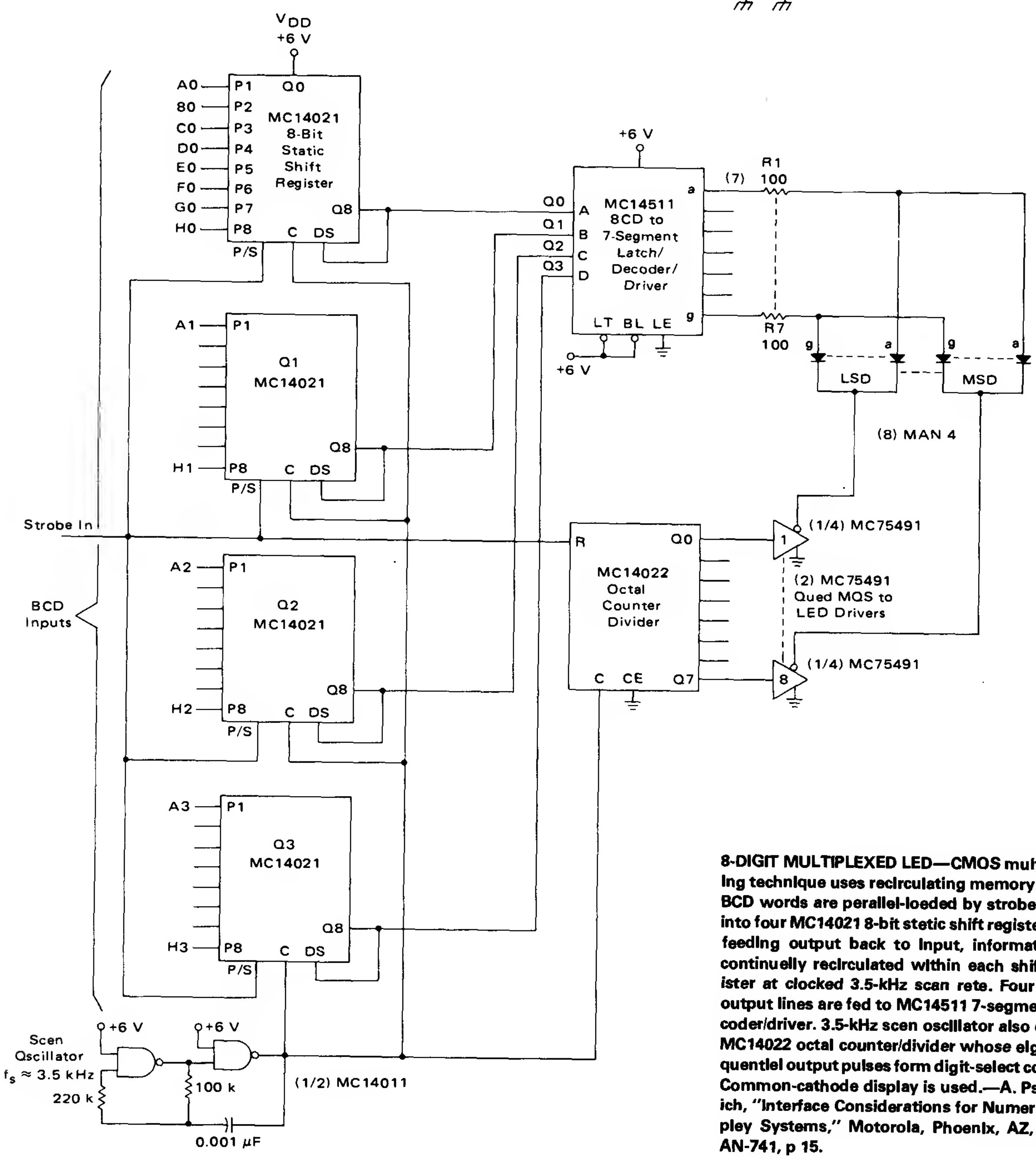
8-DIGIT LED DRIVE—Nationel DM8863 8-digit LED driver is used in conjunction with DM75491 and DM8861 drivers for driving eight common-mode LED digits operating in multiplex mode. Circuit elso provides logic control for decimal point.—C. Cerinalli, "Driving 7-Segment LED Displays with National Semiconductor Circuits," National Semiconductor, Santa Clara, CA, 1974, AN-99, p 10.



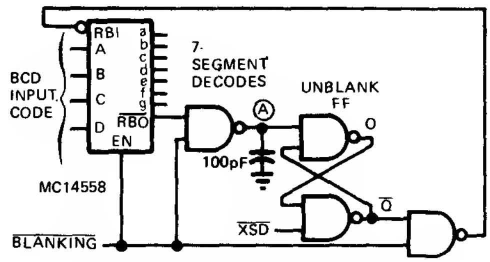
4-DIGIT DIRECT-DRIVE LCD—Each digit of liquid crystal display has separate countar, latch, decoder, and driver. Excitation signal also feeds LCD backplene. When segment is to be deenergized, backplane and segment drive signals hava same phase end magnitude so there is no voltage across display. When segment is to ba energized, signals are 180° out of phase so square-wave voltage is twice IC supply velue. BCD inputs are generated from cascaded MC14518 duel BCD up counters.—A. Pshaanich, "Interface Considerations for Numaric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 5.



TWO-INPUT RED/GREEN LED—Uses Monsento MV5491 having red and green LEDs in same housing, connected inversely in parallel so current in one direction gives green and reverse current gives red. Two different drivers are used, SN75452 noninverting and SN75451 inverting. Each LED pair shows one color for correct polarity at its driver input and other color for opposite polarity.—K. Powell, Novel Indicator Circuit, *Ham Radio*, April 1977, p 60–63.



8-DIGIT MULTIPLEXED LED—CMOS multiplexing technique uses recirculating memory. Eight BCD words are parallel-loaded by strobe pulse into four MC14021 8-bit static shift registers. By feeding output back to input, information is continually recirculated within each shift register at clocked 3.5-kHz scan rate. Four serial output lines are fed to MC14511 7-segment decoder/driver. 3.5-kHz scan oscillator also clocks MC14022 octal counter/divider whose eight sequential output pulses form digit-select control. Common-cathode display is used.—A. Pshaenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 15.



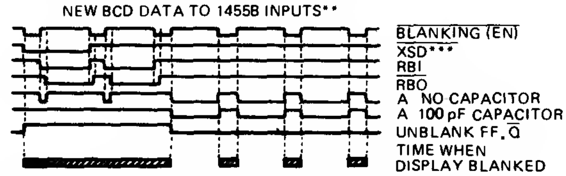
ZERO SUPPRESSION—Simple CMOS circuit using MC14011 quad two-input NAND gate and MC14558 IC provides zero suppression for multiplexed displays in which scanning is left to right for leading-zero suppression and right to left for trailing zeros. Article covers operation of circuit.—J. J. Roy, Eliminate Excess Zeros in Multiplexed Displays, *EDN Magazine*, Sept. 5, 1975, p 77.

BCD-TO-7 SEGMENT DECODER

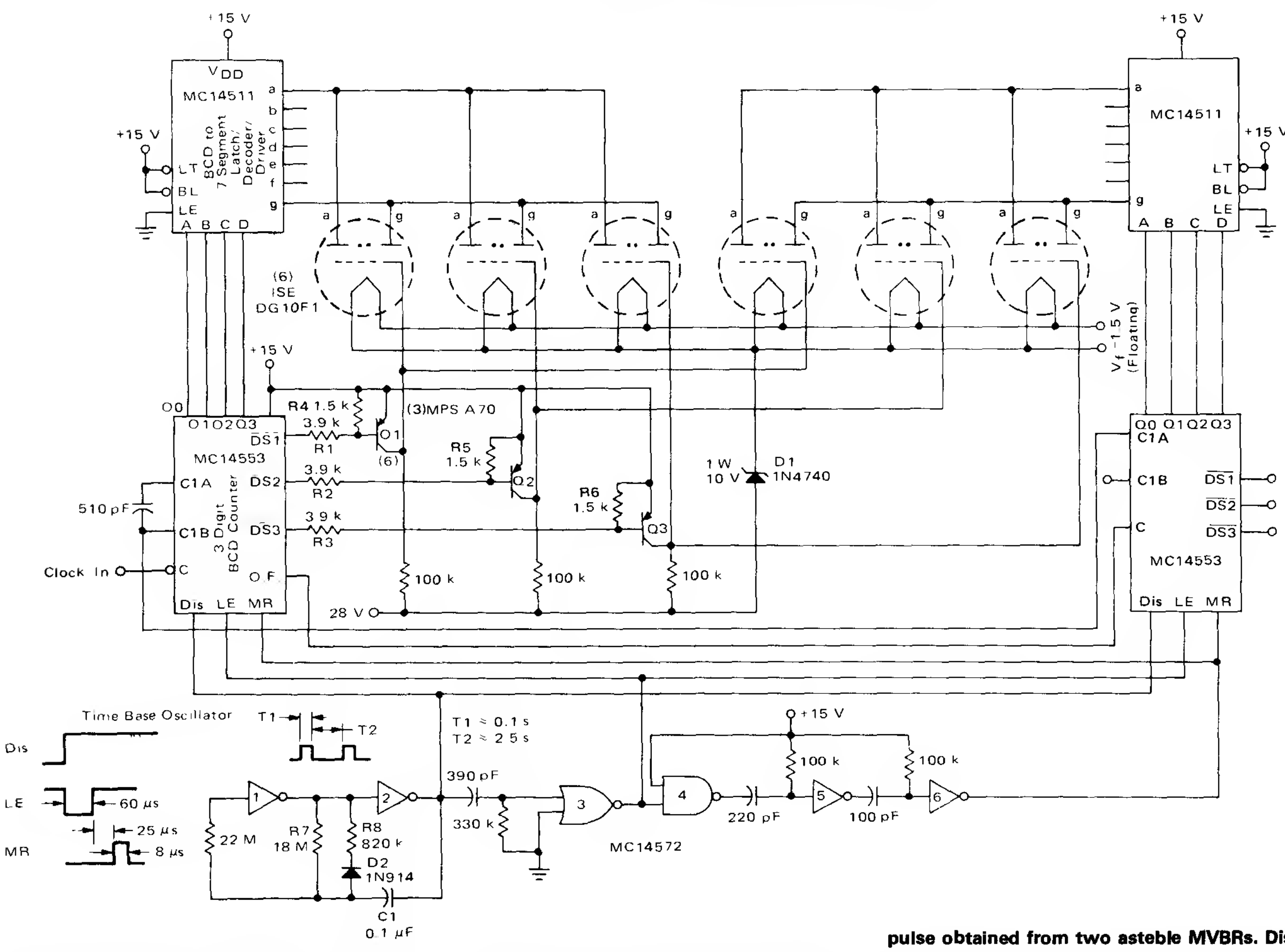
EN	RBI	BCD INPUT CODE	$\overline{RBO}$	FUNCTION PERFORMED
0	0	X	0	LAMP TEST
0	1	X	1	BLANK SEGMENTS
1	1	0	1	DISPLAY ZERO
1	0	0	0	BLANK SEGMENTS
1	X	1–9	1	1–9 DISPLAYED

X = DON'T CARE
RBI = RIPPLE BLANKING INPUT
$\overline{RBO}$ = RIPPLE BLANKING OUTPUT

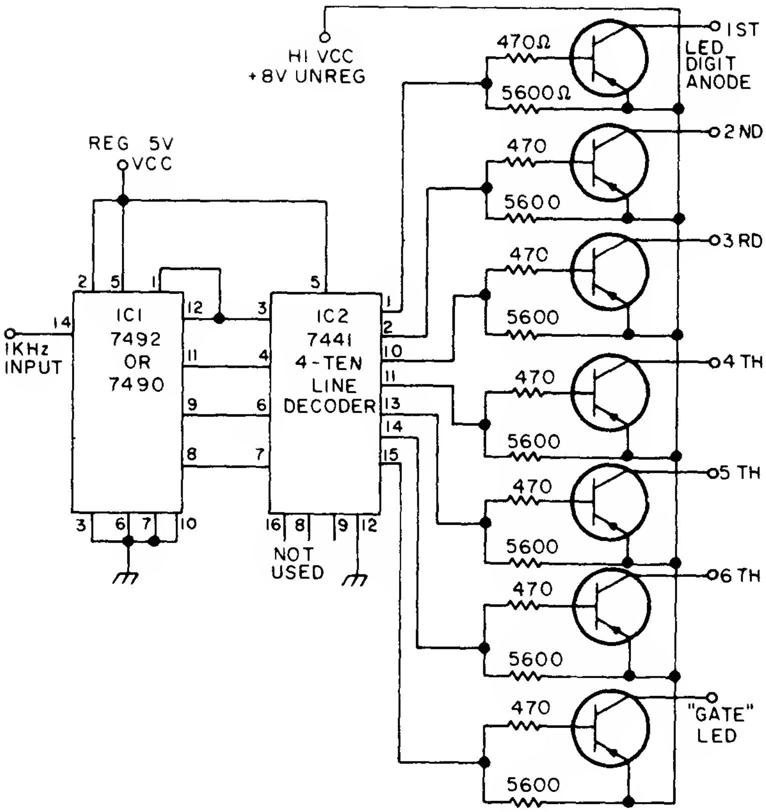
TIMING FOR ZERO SUPPRESSION CIRCUIT
NEW BCD DATA TO 1455B INPUTS**



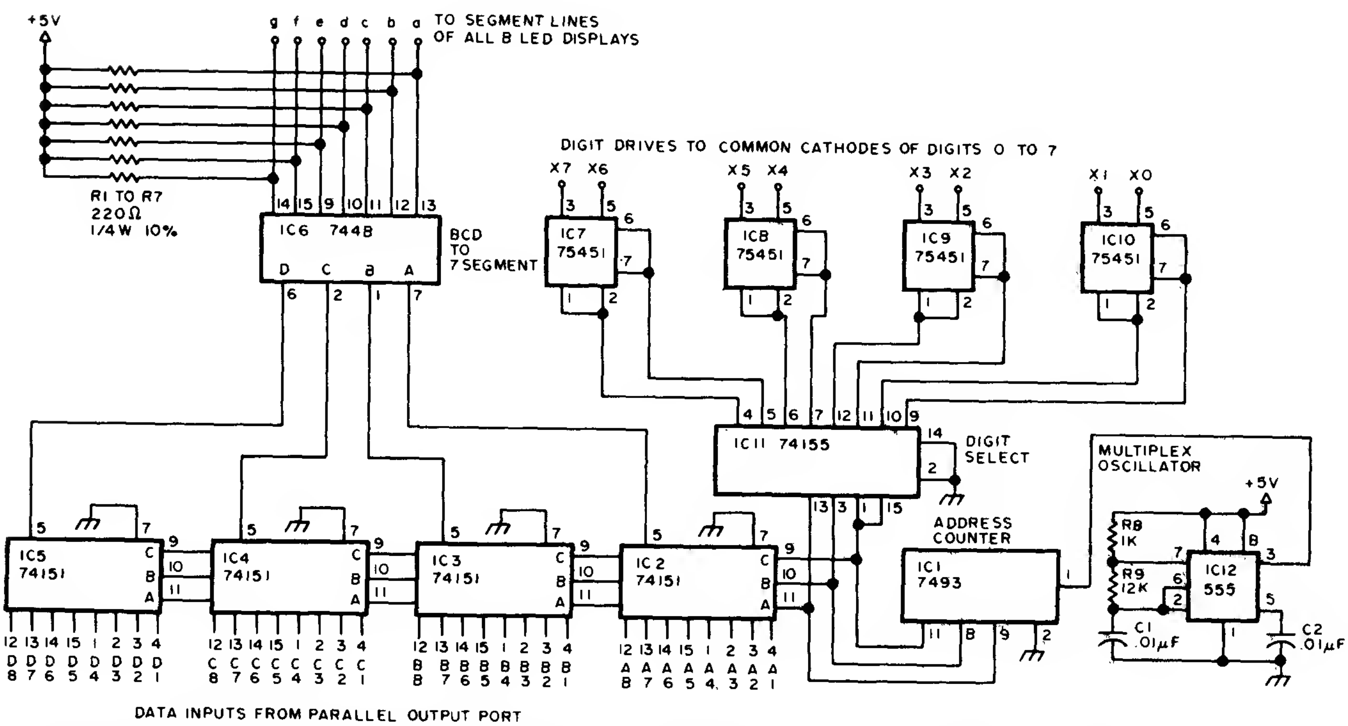
**FIRST AND SECOND DIGITS ARE "0" AND THIRD DIGIT IS NONZERO IN EXAMPLE TIMING
***$\overline{XSD}$ = $\overline{MSD}$ FOR LEADING ZERO SUPPRESSION
$\overline{XSD}$ = $\overline{LSD}$ FOR TRAILING ZERO SUPPRESSION



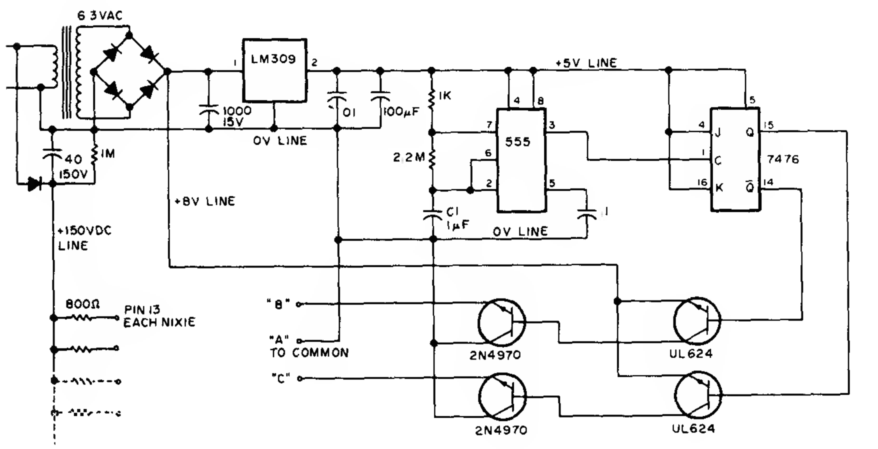
6-DIGIT FLUORESCENT TRIODES—Uses two sets of cascaded counters and decoders with series switching of positive voltage to anode with MC14511 ICs. Digit scanning is accomplished by turning on grid control transistors Q1-Q3 with negative-going digit select outputs of one MC14553. Timing for counters is derived from MC14572 logic elements, with disable pulse obtained from two astable MVBRs. Display digits can be packaged individually or in single envelope.—A. Pshaenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 9.



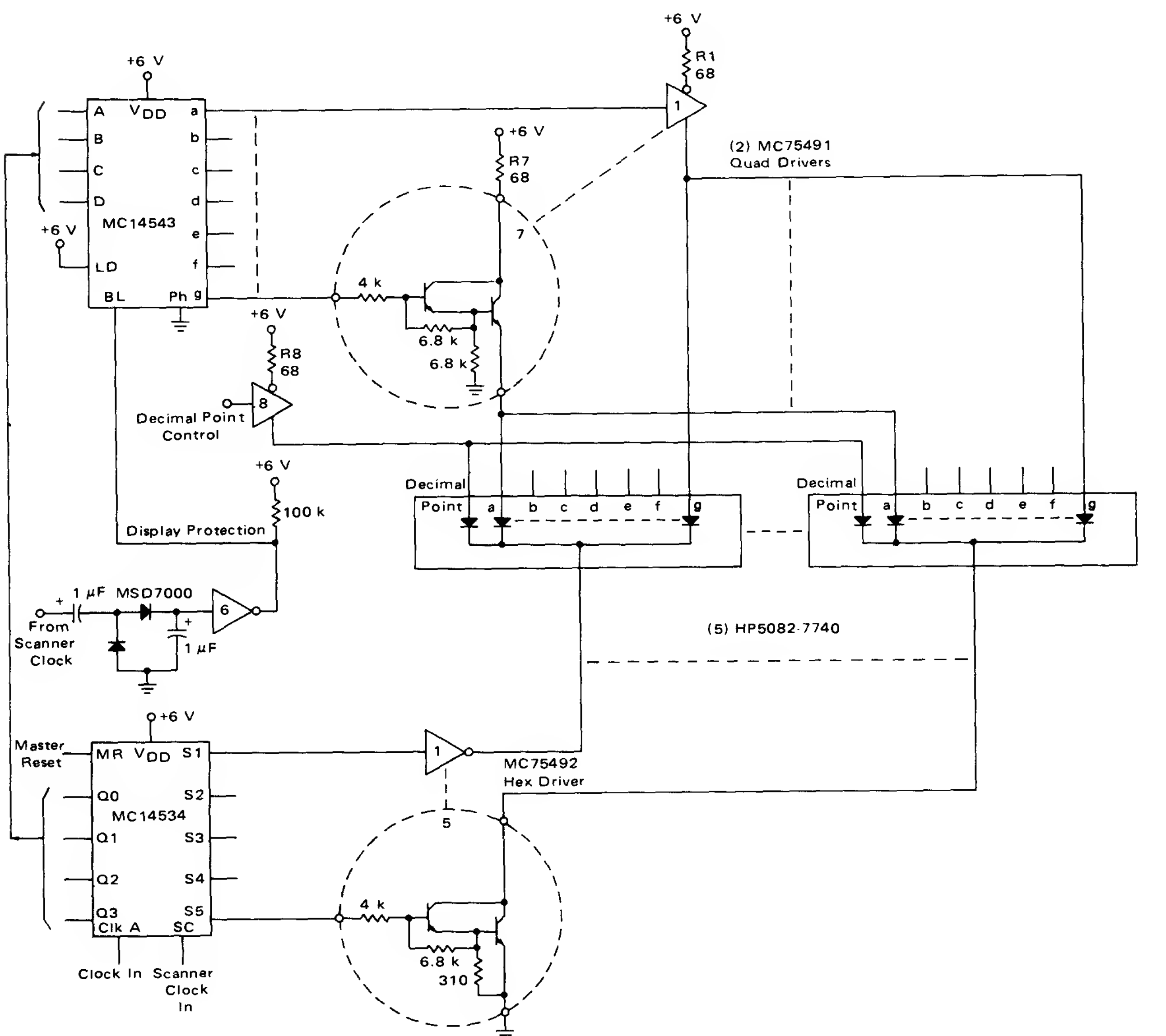
STROBING LED DISPLAY—Applies power in sequence to segments of display, so fast that eye cennot detect flicker, to reduce drain on power supply. Input of 1000 Hz can be taken from timing chein of circuit that is driving display. 7492 divide-by-12 counter gives scan frequency of 83.3 Hz for display. Binery output of 7492 is converted to 1-in-10 output by 7441 decoder for sequantiel drive of 2N3904 PNP pess transistor that grounds LED which is to be lighted.—W. K. McKellips, Strobing Displays Is Cool, *73 Magazine*, Nov./Dec. 1975, p 49–50.



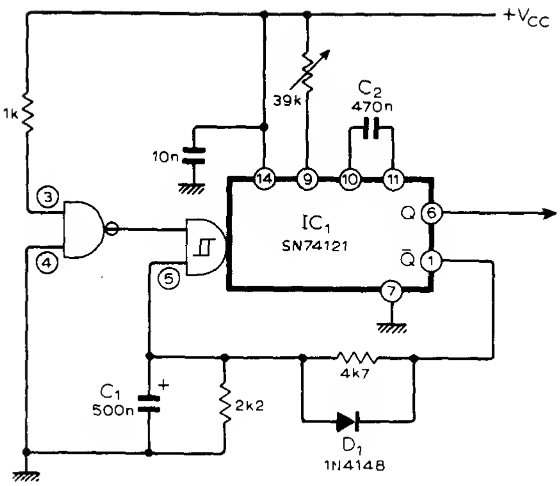
MULTIPLEXING EIGHT DIGITS—Uses only ona 7-segment drivar for eight digits of perallel BCD data on eight-LED display that can use MAN 4 or DL764 7-segment LEDs. Power is supplied to only one digit at a time but is switched at high enough rate so ell digits appear to be on. Uses one eight-channel 74151 multiplexer for each of the 4 deta input bits. Multiplexers end demultiplexer are addressed by 7493 counter that is Incremented at ebout 4 kHz by 555 oscillator. IC11 is connected for three- to eight-line demultiplaxing. IC7-IC10 are paripheral Interface gates, each sinking up to 300 mA for its LED. 7448 decoder/drivar converts BCD data to 7-segment code for driving segments of LEDs. For 74151 and 74155, pin 16 goes to +5 V and pin 8 to ground. Pin 8 of 75451 goes to +5 V and pin 4 to ground. Pin 5 of 7493 goes to +5 V and pin 10 to ground.—J. Hogenson, Multiplex Your Digital LED Displays, *BYTE*, March 1977, p 122–126 and 128.



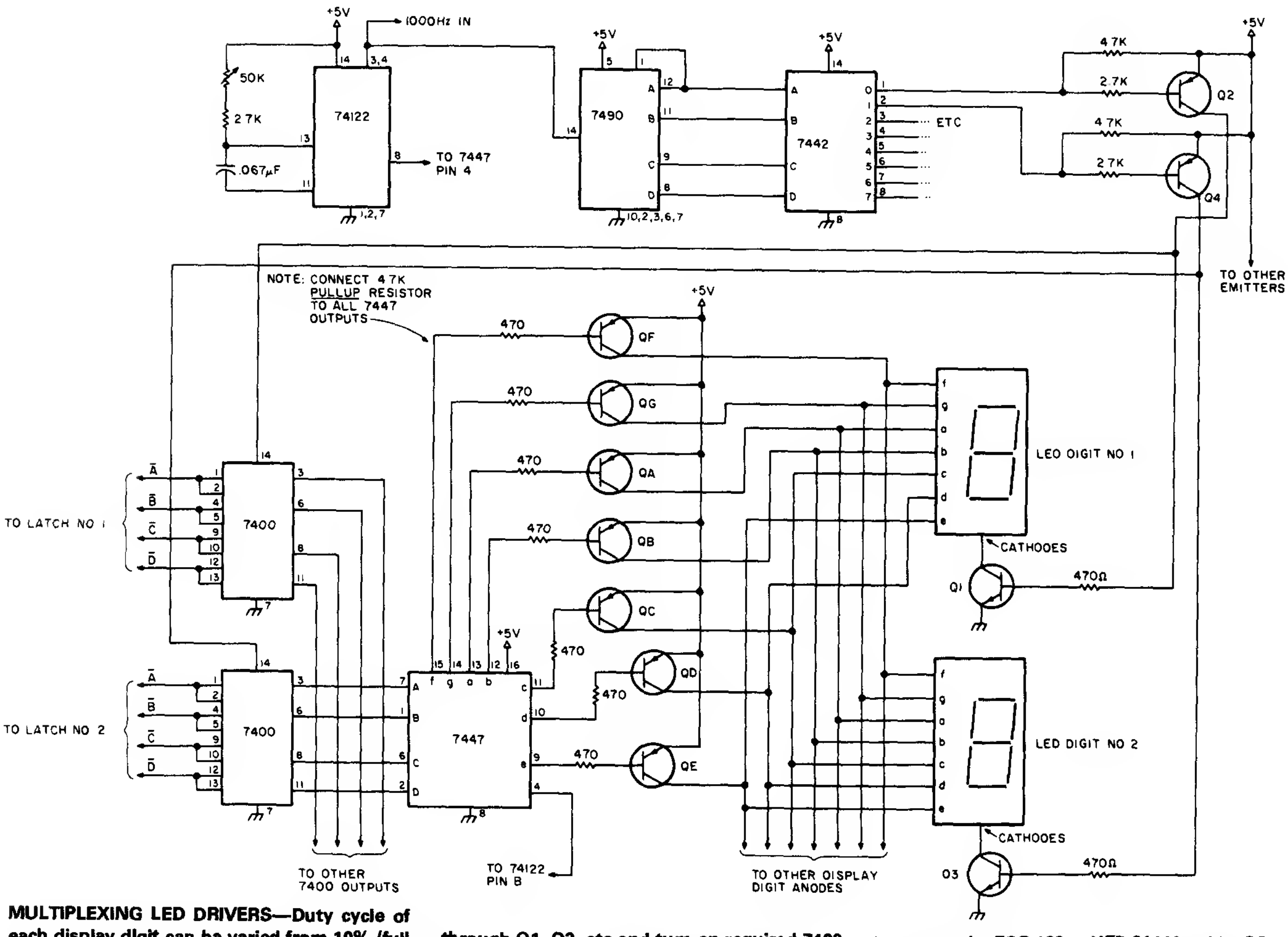
TWO MESSAGES WITH NIXIES—Circuit flashes two messages alternately on same Burroughs giant Nixie B7971 display. Lighted segments needed on individual Nixies to form desired wording are divided into three strings. Segments A are common to both sets of letters and numbers. Segments B are those required with A segments to form first message. Segments C are those required with A segments to form second message. Changeover from segments B to C is done with switching transistors controlled by 555 timer and 7476 or 7473 flip-flop. Decimal or other punctuation is formed with NE2 neon and 100K resistor wired in series between pin 13 of a Nixie and B or C. Article gives construction details.—J. Grimes, Put Your Name in Lights, *73 Magazine*, Nov. 1976, p 60–61.



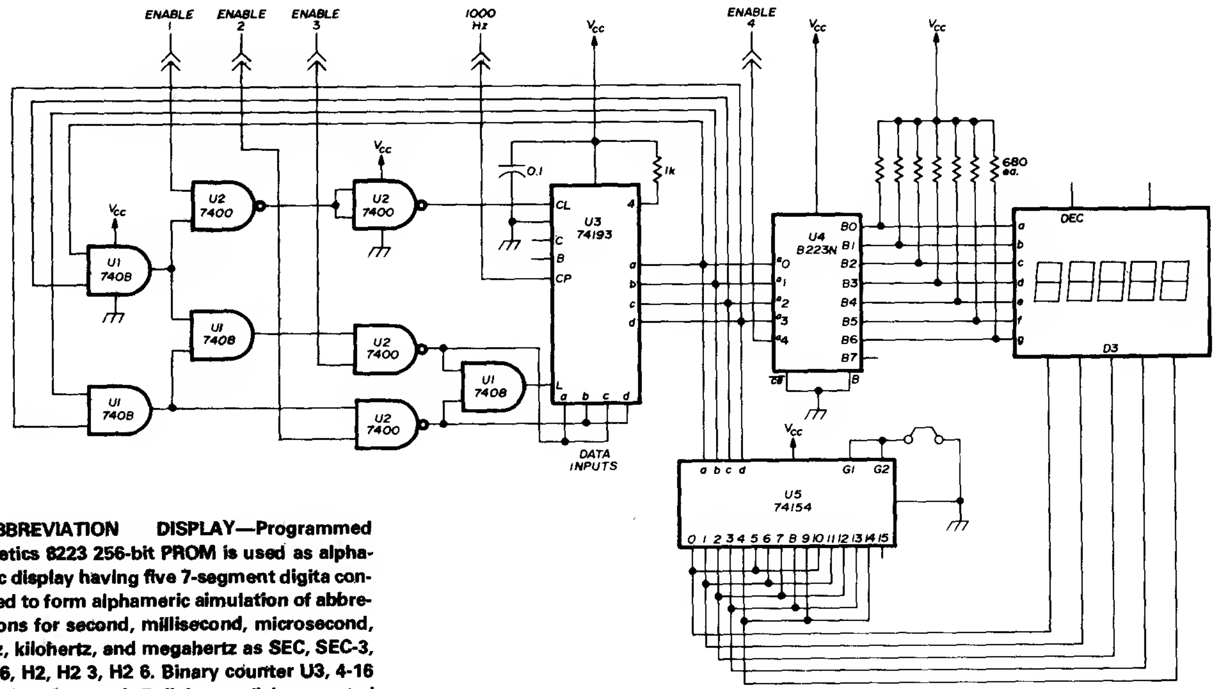
5-DIGIT LED REAL TIME—Circuit provides strobing of LEDs so peak current and light output are greater for same average current. Peak forward current for display is about 40 mA. All like anode segments of common-cathode displays are driven by emitter outputs of MC75491 quad drivers.—A. Pshaenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 13.



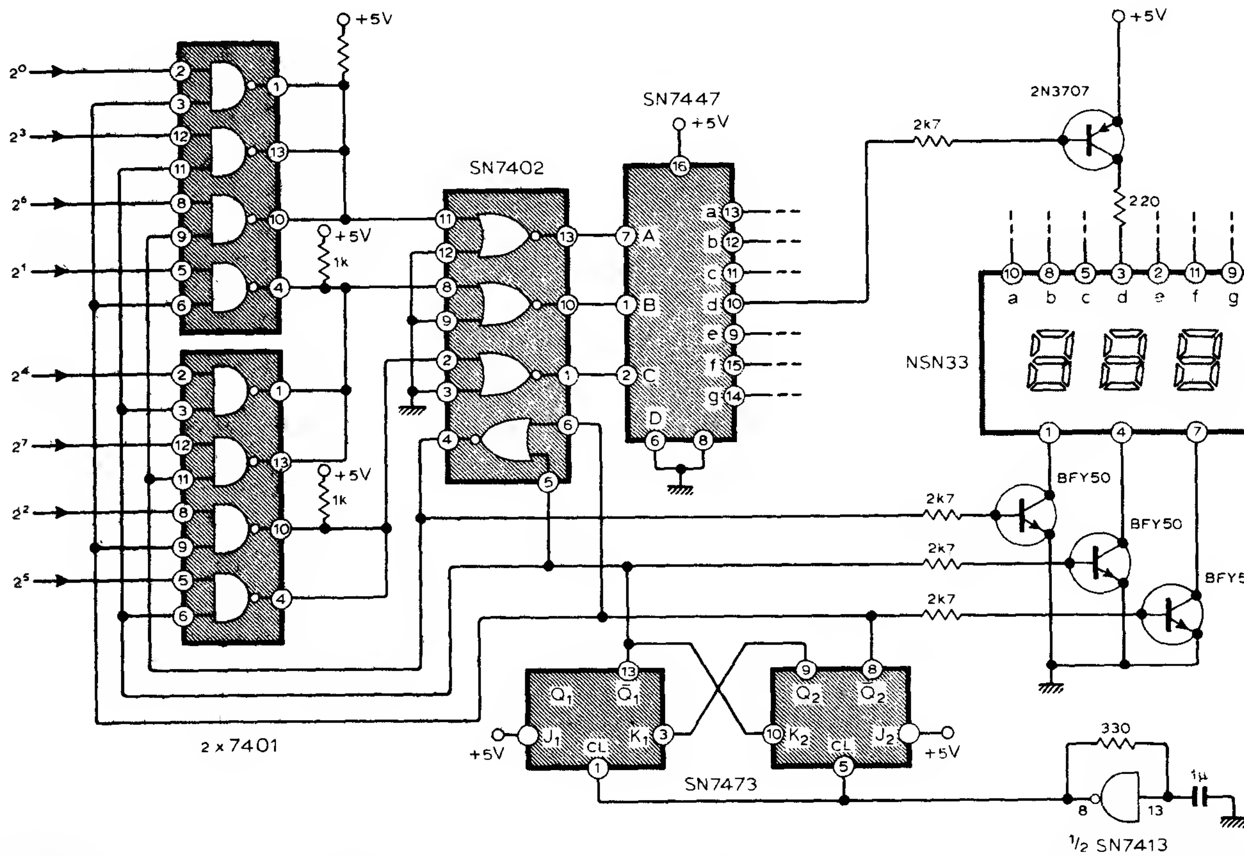
PWM BRIGHTNESS CONTROL—Single TTL IC combines functions of oscillator and modulator to provide intensity control of solid-state display by pulse-width modulation. Fan-out of 10 is available from Q output, suitable for displays such as Hewlett-Packard 7300 series, and smaller fan-out is available from other Q terminal.—C. Bartram, P.W.M. Oscillator to Vary Display-Intensity, *Wireless World*, March 1976, p 89.



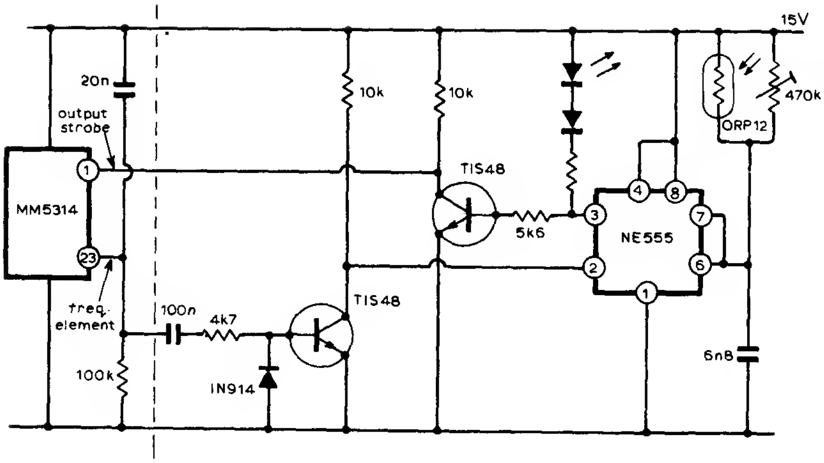
MULTIPLEXING LED DRIVERS—Duty cycle of each display digit can be varied from 10% (full on with strobing) to less than 1% (almost off). Circuit uses 7490 and 7442 as 1-of-10 multiplex driver to strobe cathodes of display digits through Q1, Q3, etc and turn on required 7400 multiplex gate through Q2, Q4, etc. Outputs of 7447 are polarity-inverted by QA, QB, etc, which can be Sylvania ECG 159 rated at 200 mA. Q1, Q3, etc can be ECG 123 or HEP S0002, while Q2, Q4, etc can be any silicon PNP transistor.—B. Hart, Current-Saver Counter Display, *73 Magazine*, June 1977, p 174–176.



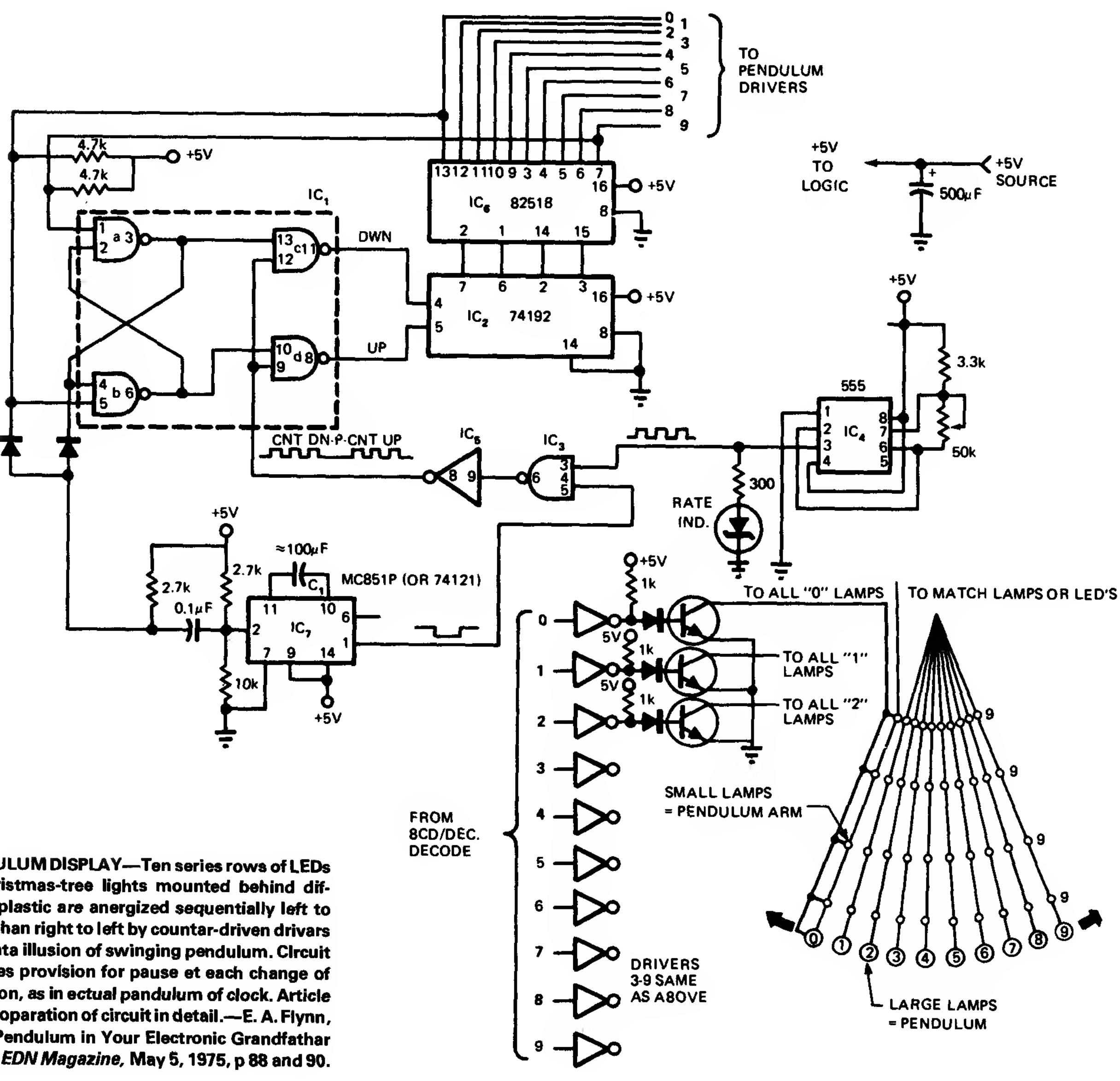
SI-ABBREVIATION DISPLAY—Programmed Signetics 8223 256-bit PROM is used as alphameric display having five 7-segment digita connected to form alphameric aimulation of abbreviations for second, millisecond, microsecond, hertz, kilohertz, and megahertz as SEC, SEC-3, SEC-6, H2, H2 3, H2 6. Binary counter U3, 4-16 line decodar, and 5-digit parallel-connected Hewlett-Packard display form simple multiplexer that addresses mamory U4 ona word at a tima. External 1000-Hz square-wave oscillator drives countar and sets scanning rata. Raquires only ona 5-V supply. Articla givas truth tabla for mamory and circuit for programmer raquired to set it up.—J. W. Springar, Function/Units Indicator Using LED Displaya, *Ham Radio,* March 1977, p 58–63.



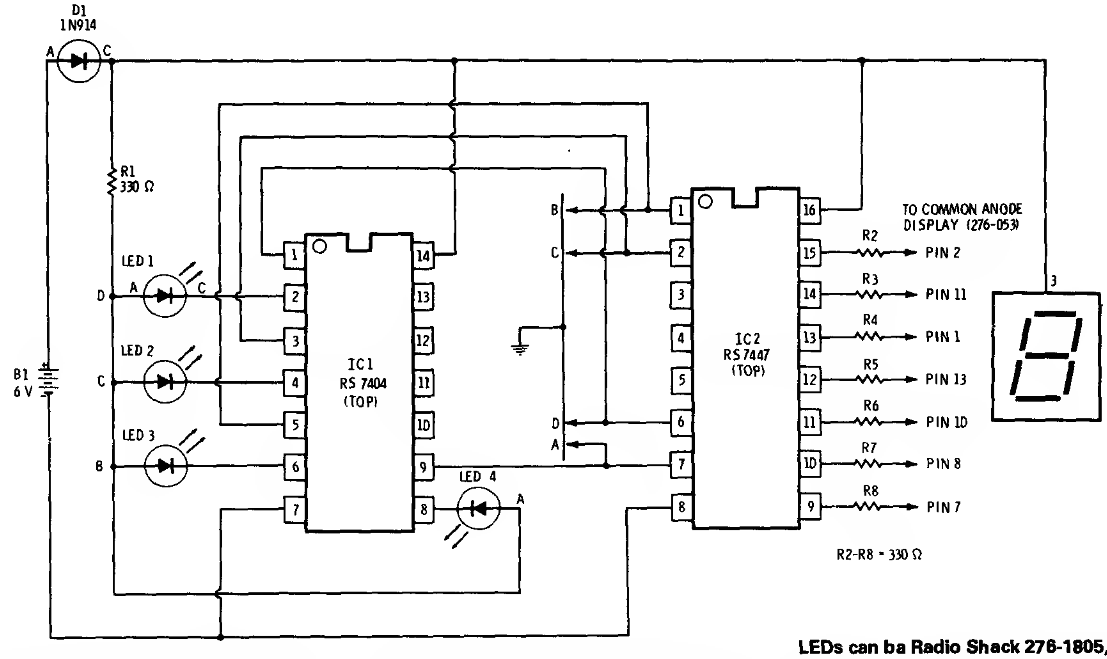
OCTAL DISPLAY—Circuit provides display of 8-bit data word in convantional octal form for convanience in axparimentation with microprocessors and amall computars. Three-stata countar built around aynchronously oparated JK flip-flops provides digit and data selection. Tha two or three bits appropriata to each display ara staered to 7-segment decoder by wired-AND gatas and invarters. Oscillator multiplexing fraquency is about 2 kHz.—R. D. Mount, Octal Display for Microprocessors, *Wirelass World,* March 1977, p 41.



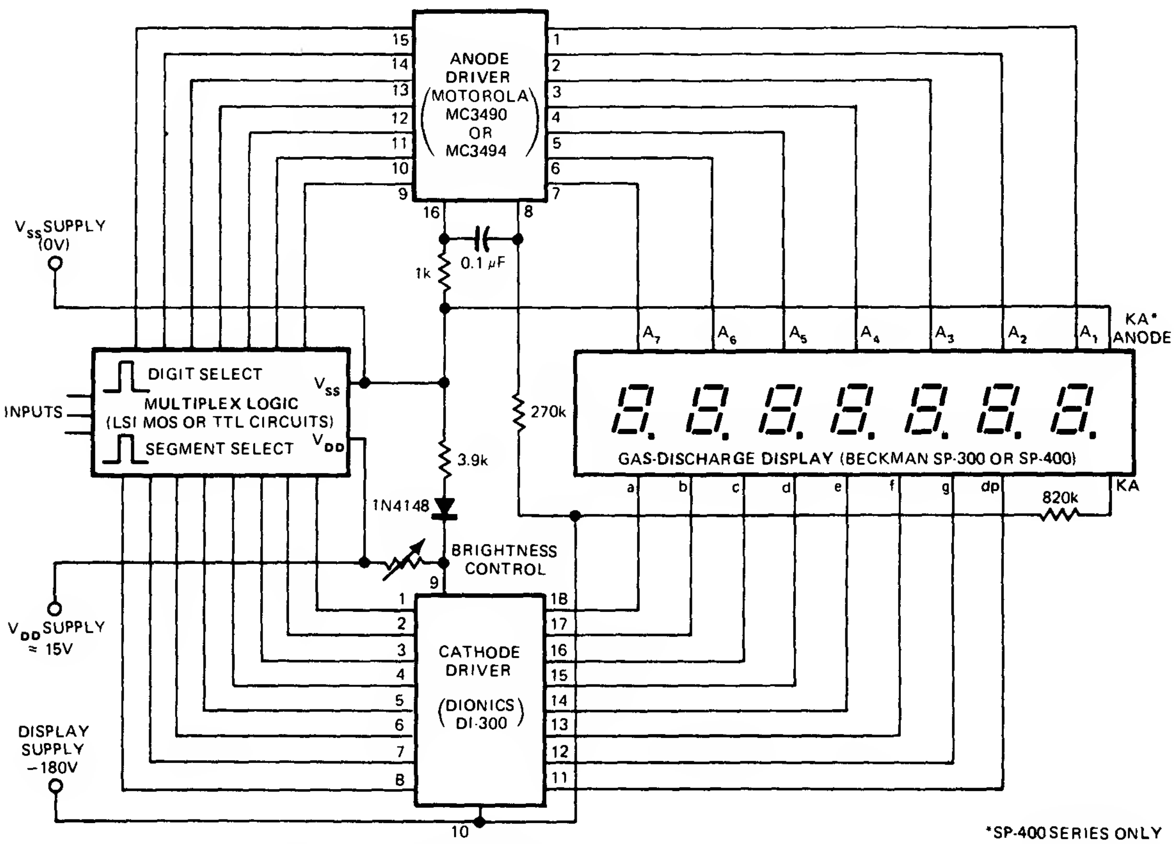
MULTIPLEXED BRIGHTNESS CONTROL—Developed for use with single-chip digital clocks in which saveral displays ara multiplaxed. Provides automatic brightness control by using variabla duty cycle and switching it on and off in synchronism with display of tima. Uses 555 timar in monostable mode, triggered by multiplex oscilletor to detarmine off tima of display. When ambient light is bright, resistance of ORP12 photocell is low and display is on most of time. Sat 470K pot to give low light output without mistriggaring undar dark conditions. Timer can also drive decimal point directly and giva matched brightness.—M. G. Martin, Automatic Display-Brightness Control, *Wirelass World*, April 1976, p 61.



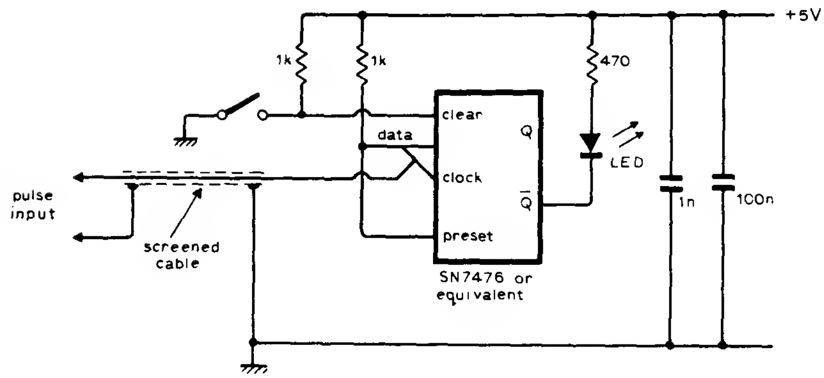
PENDULUM DISPLAY—Ten series rows of LEDs or Christmas-tree lights mounted behind diffused plastic are anergized sequentially left to right, than right to left by countar-driven drivars to creata illusion of swinging pendulum. Circuit includes provision for pause et each change of direction, as in ectual pandulum of clock. Article traces operation of circuit in detail.—E. A. Flynn, Put a Pendulum in Your Electronic Grandfathar Clock, *EDN Magazine*, May 5, 1975, p 88 and 90.



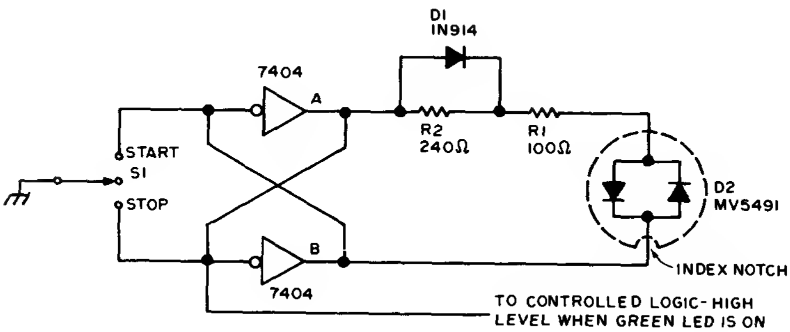
BCD DECODER—Drive for 7-segment common-anode digital display is provided by RS7447 BCD to 7-segment decodar. Binary input indicator using RS7404 hex invartar and four LEDs shows input in binary form for decimal digits 0–9. Devaloped for classroom damonstrations. Red LEDs can ba Radio Shack 276-1805, and display is 276-053.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 42–52.



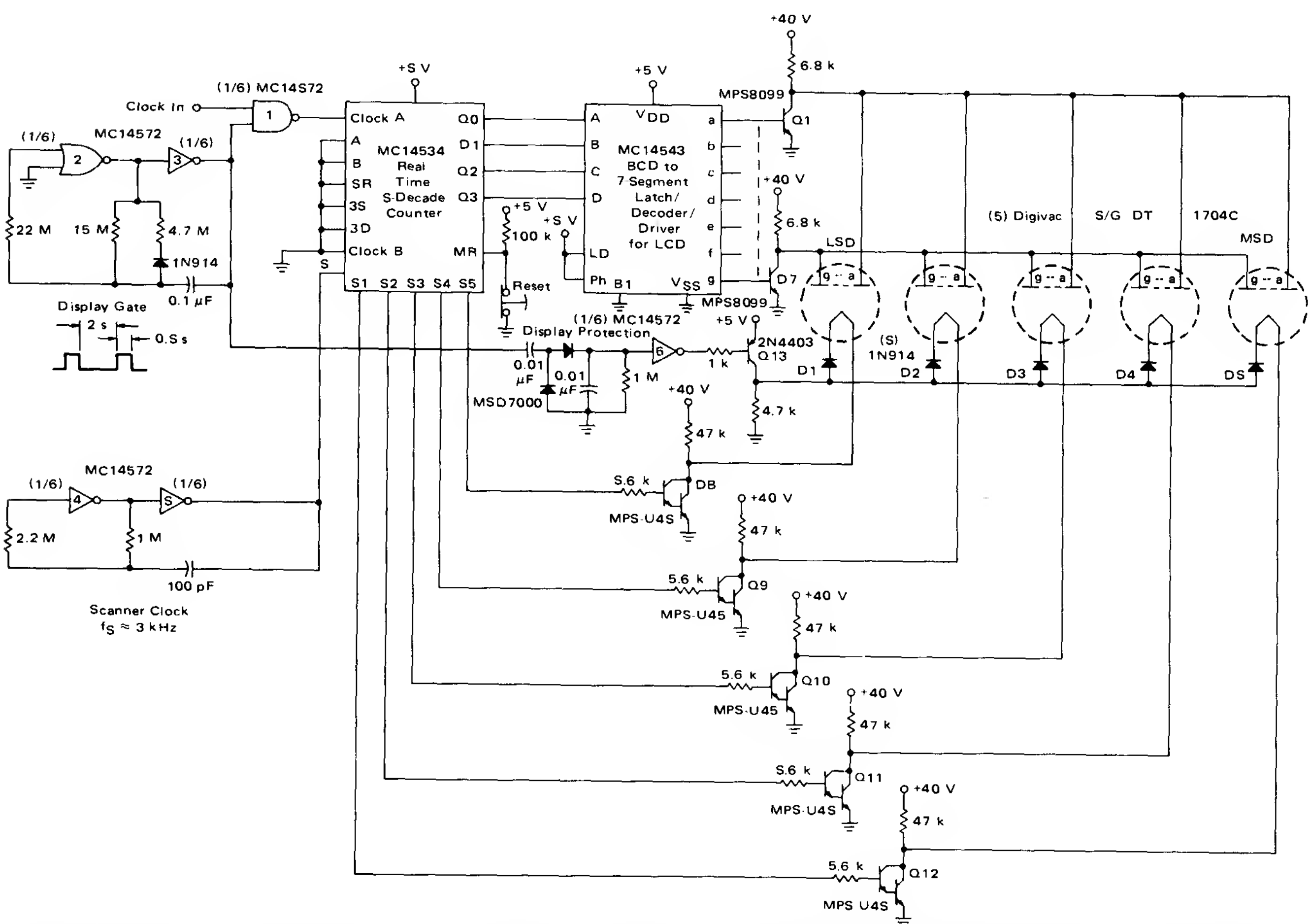
MULTIPLEXING 7 DIGITS—Uses Motoroia MC3490 anoda drivar for active-high inputs (MC3494 for active-low inputs) to accept digit-select signals from multiplex logic sourca end drive displey anodes directly. Constant cathode currants are maintained for gas-discharga display by Dionics D1-300 IC, to provide constant brightness without using supply-voltage regulation. For aech digit added to display, equal number of anoda drivers is required. Only one cathode driver is needed becausa all cathodes ara bused together.—D. Slen, Multiplex Display Circuit Faaturas Minimum Parts Count, *EDN Magazine*, May 5, 1977, p 112.



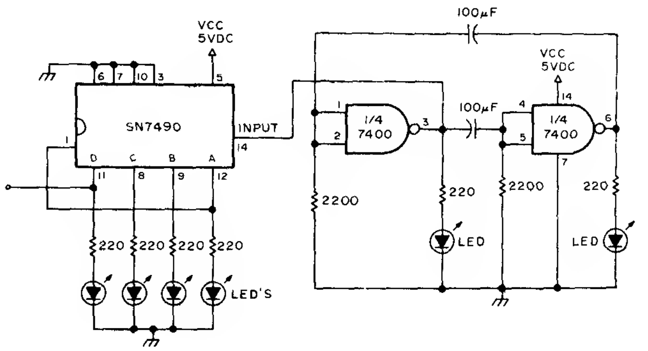
NANOSECOND PULSE DETECTOR—Used to provide visual indication of presence of e non-repetitive digital pulse having microsecond or nenosecond width. Bistable IC trensfars pulse information from its data input to tha Q output on positive-going edga of clock pulse, to anergize LED indicator.—P. V. Prior, Digital Pulse Detector, *Wireless World*, March 1976, p 90.



TWO-COLOR LED—Dual LED D2 shows green when normelly off momentary switch S1 is moved to START and shows red whan moved to STOP. Latching circuit using two 7404 TTL invarters sarves as run and halt flip-flop and also debounces switch. Momentary contact at START toggles latch, biasing green LED. D1 shorts R2, leaving R1 to limit forward current to about 20 mA for green. R1 and R2 limit current for D1 end brighter red LED to about 10 mA for momantary contact at STOP.—E. W. Gray, LEDs Light Up Your Logic, *BYTE*, Feb. 1976, p 54–57.

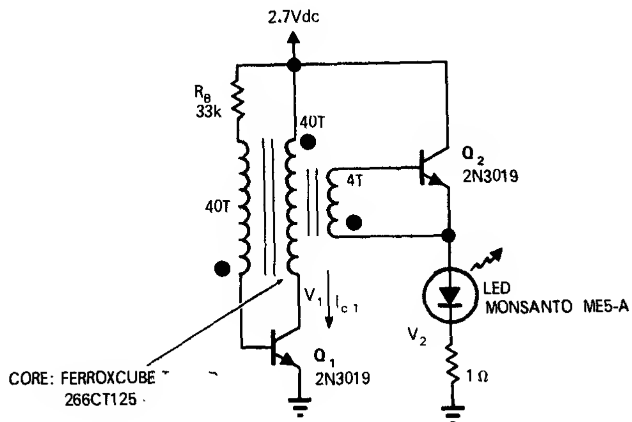


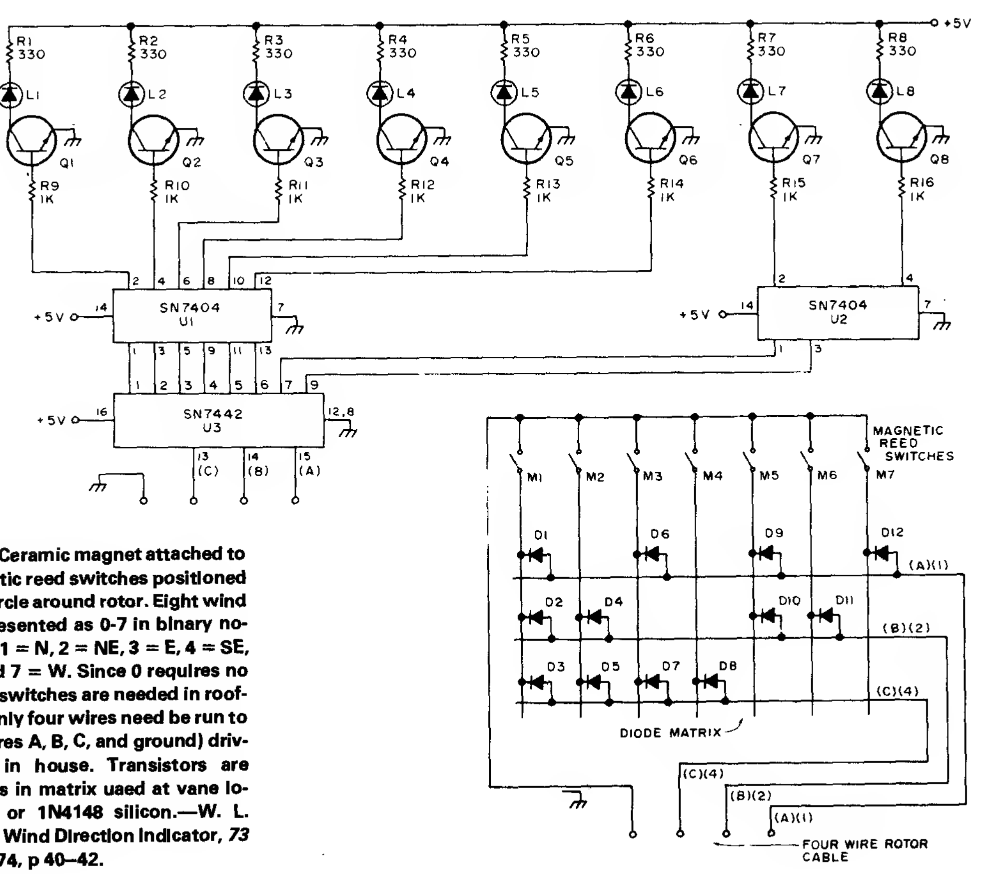
5-DIGIT FLUORESCENT DIODES—Real-time drive for five-decade counter requires only three ICs. MC14534 contains five-decade ripple counter with output tima multiplexed by internal scannar. Scanning rete is controlled by inverters 4 and 5 of MC14572. Multiplexed BCD outputs go to MC14543 7-segment decoder whose outputs drive fluorescent diodes.—A. Pshaenich, "Interface Considerations for Numeric Displey Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 10.



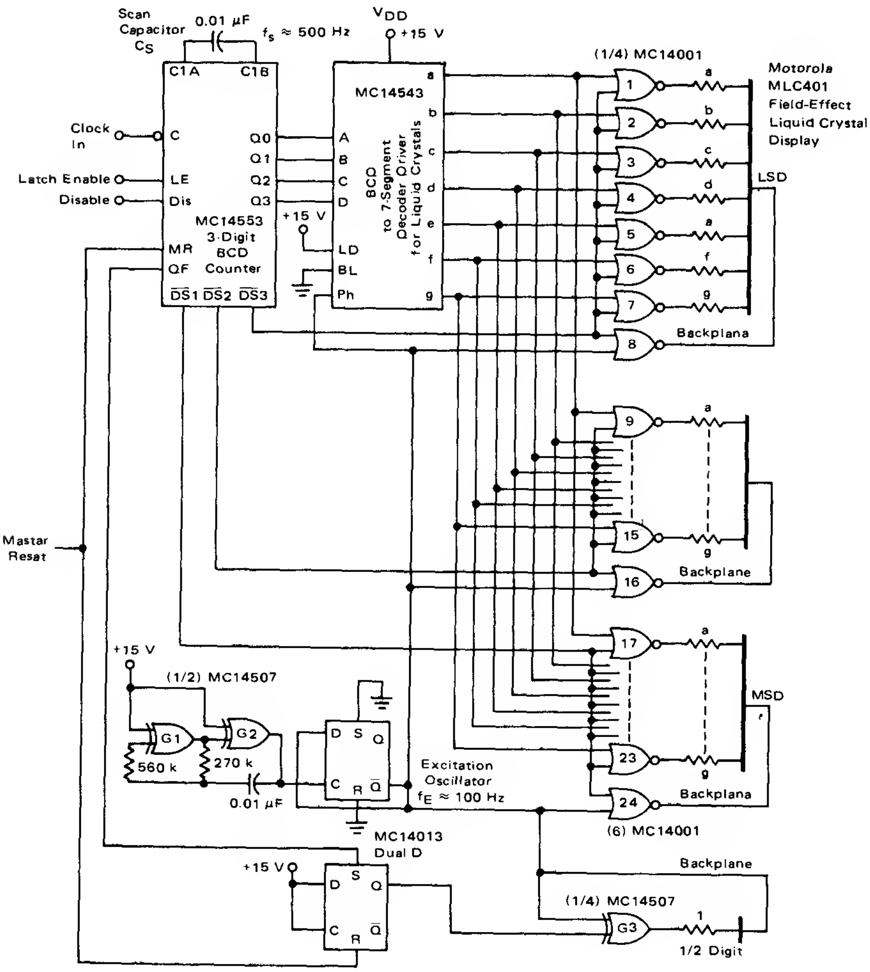
BINARY DEMO—Two sections of SN7400 quad gate form low-frequency MVBR serving as pulse source for SN7490 decade counter. Rate is low enough so blinking of LED status indicators in MVBR can be seen, as indication of pulse generation. Similarly, LEDs of counter blink to indicate counts of 8, 4, 2, and 1 from left to right, with combinations of lights coming on to display binary values 0 to 15 before recycling. Ideal for Science Fair exhibit.—A. MacLean, How Do You Use ICs?, *73 Magazine*, Dec. 1977, p 56–59.

PULSED LED—Circuit can generate peak currents above 1 A with pulse widths greater than 10 ms at repetition rates of 12 kHz with efficiency better than 90%, for 100-mA current drain from 2.5-V battery. Rise time of pulses is 0.2 ms. Can be used in low-light-level TV systems where high peak radiation gives better resolving power than constant illumination having same average power. Also useful for LED pilot lamps in battery-operated equipment and as low-power strobe for studying mechanical motions.—J. Dimitrios, Current-Pulse Generator for LED's, *EDN/EEE Magazine*, July 1, 1971, p 51.

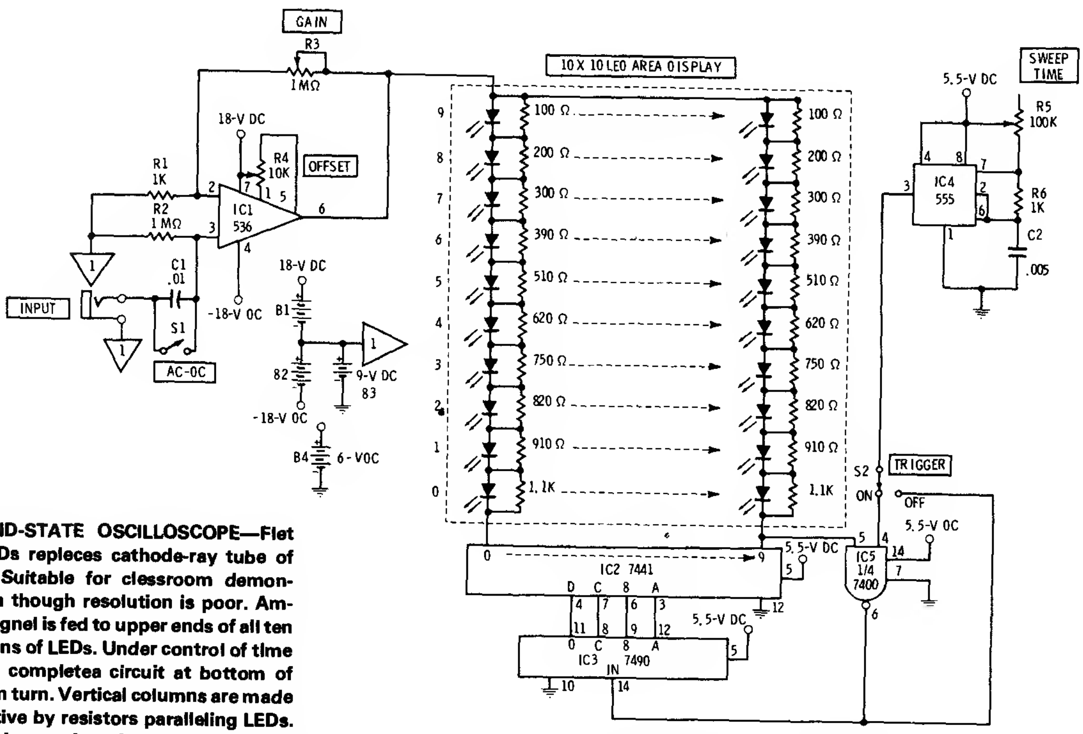




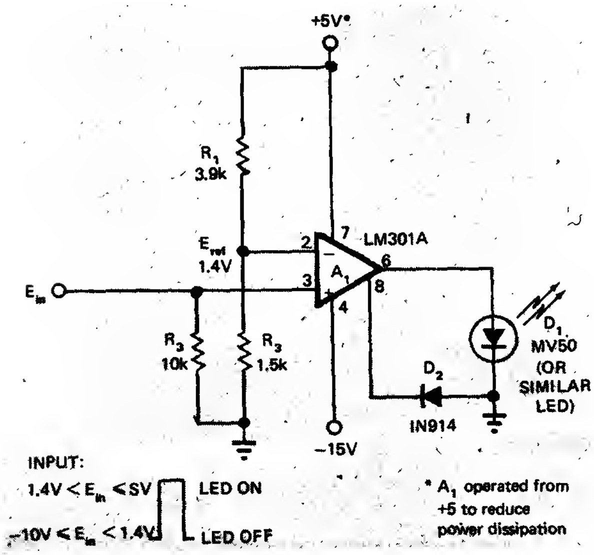
LED WIND VANE—Ceramic magnet attached to rotor closes magnetic reed switches positioned at 45° intervals in circle around rotor. Eight wind directions are represented as 0-7 in binary notation, so 0 = NW, 1 = N, 2 = NE, 3 = E, 4 = SE, 5 = S, 6 = SW, and 7 = W. Since 0 requires no switch, only seven switches are needed in rooftop indicator and only four wires need be run to binary decoder (wires A, B, C, and ground) driving LED readout in house. Transistors are 2N3641, and diodes in matrix used at vane location are 1N914 or 1N4148 silicon.—W. L. MacDowell, Digital Wind Direction Indicator, *73 Magazine*, Nov. 1974, p 40–42.



3½-DIGIT MULTIPLEXED LCD—Uses MLC401 field-effect liquid crystal display, which is more suitable for multiplexing than dynamic-scattering LCD. Counters, latches, multiplexer, and scan circuits are all in MC14553 3-digit BCD counter whose outputs feed MC14543 decoder and driver for display. Excitation frequency of 100 Hz is derived from square-wave oscillator G1-G2 having exactly 50% duty cycle. Scan frequency is about 500 Hz, giving display refresh rate of 170 Hz, which is well beyond detectable flicker rate.—A. Pshaenich, "Interface Considerations for Numeric Display Systems," Motorola, Phoenix, AZ, 1975, AN-741, p 6.

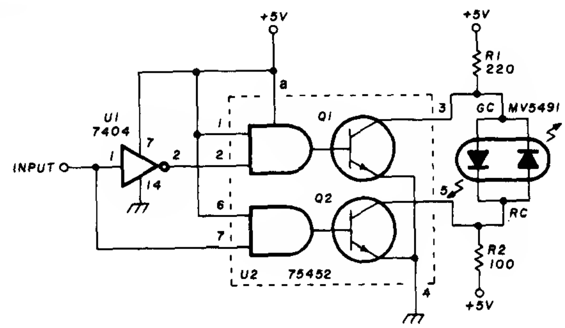


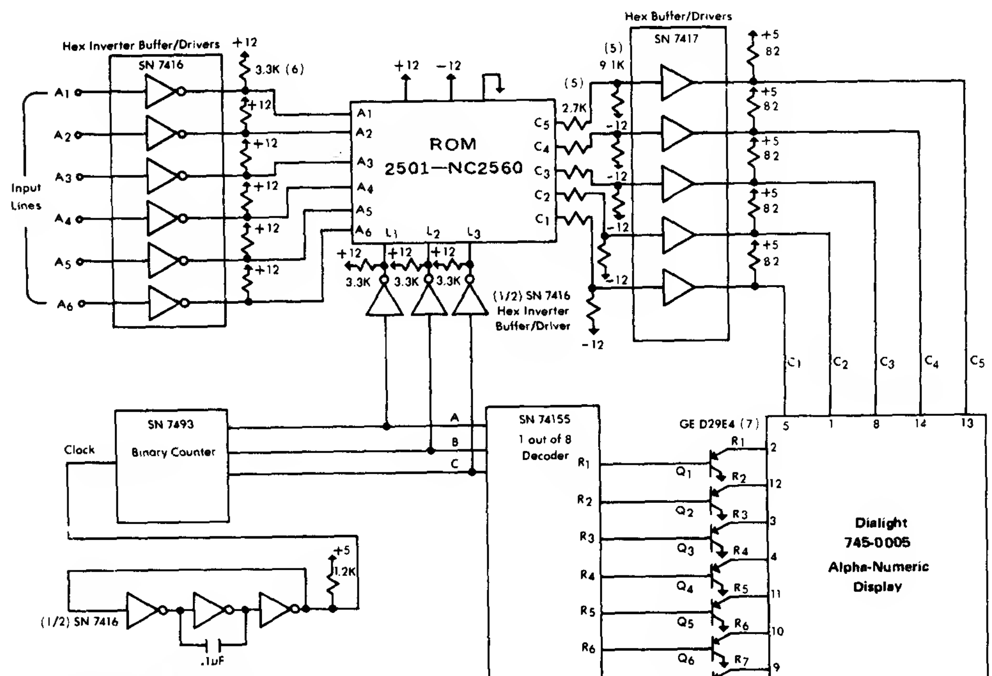
100-LED SOLID-STATE OSCILLOSCOPE—Flat display of LEDs replaces cathode-ray tube of oscilloscope. Suitable for classroom demonstrations even though resolution is poor. Amplified input signal is fed to upper ends of all ten vertical columns of LEDs. Under control of time base, scanner completes circuit at bottom of each column in turn. Vertical columns are made voltage-sensitive by resistors paralleling LEDs. Gate circuit using section of 7400 provides triggering when desired. Voltage-sensitive bargraph readouts formed by vertical columns are scanned by 7490 decade counter and 7441 decoder. Sweep rate of display is adjustable from 1 to 20 vertical columns per second with R5.—F. M. Mims, "Electronic Circuitbook 5: LED Projects," Howard W. Sams, Indianapolis, IN, 1976, p 92–96.



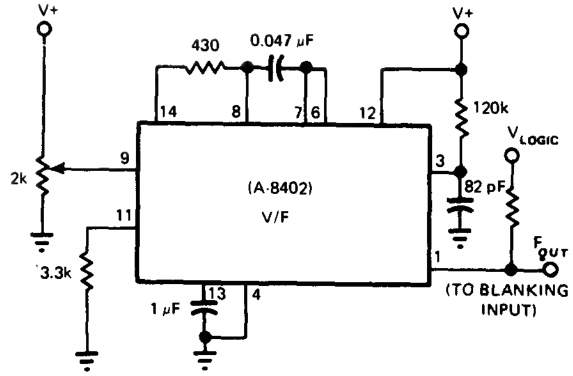
OPAMP DRIVES LED—LM301A is used as open-loop voltage comparator, with LED receiving total source current of about 20 mA from opamp. Input is TTL-compatible, with R_1-R_2 reference divider biasing opamp in center of TTL output transition region. Circuit realizes full open-loop speed of opamp since it is uncompensated and its internal voltage amplifier stages are kept out of saturation by clamping of D_2 end by inherent current-limiting action. Response times for toggling LED are in microsecond range.—W. G. Jung, Poor Man's LED Driver Is TTL Compatible, *EDN Magazine*, Feb. 5, 1973, p 86.

POSITIVE INPUT GIVES RED—Uses Monsanto MV5491 dual LED having red and green light-emitting diodes connected inversely in parallel, so current in one direction gives green light and reverse current gives red. Circuit uses single SN75452 IC driver and one section of SN7404 hex inverter. High or positive input gives red indication, while low input gives green. Current-limiting resistors R1 and R2 have different values because voltage and current specifications of parallel LEDs are different. Indicator appears to change color as input changes.—K. Powell, Novel Indicator Circuit, *Ham Radio*, April 1977, p 60–63.

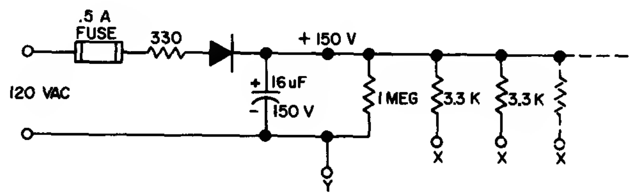




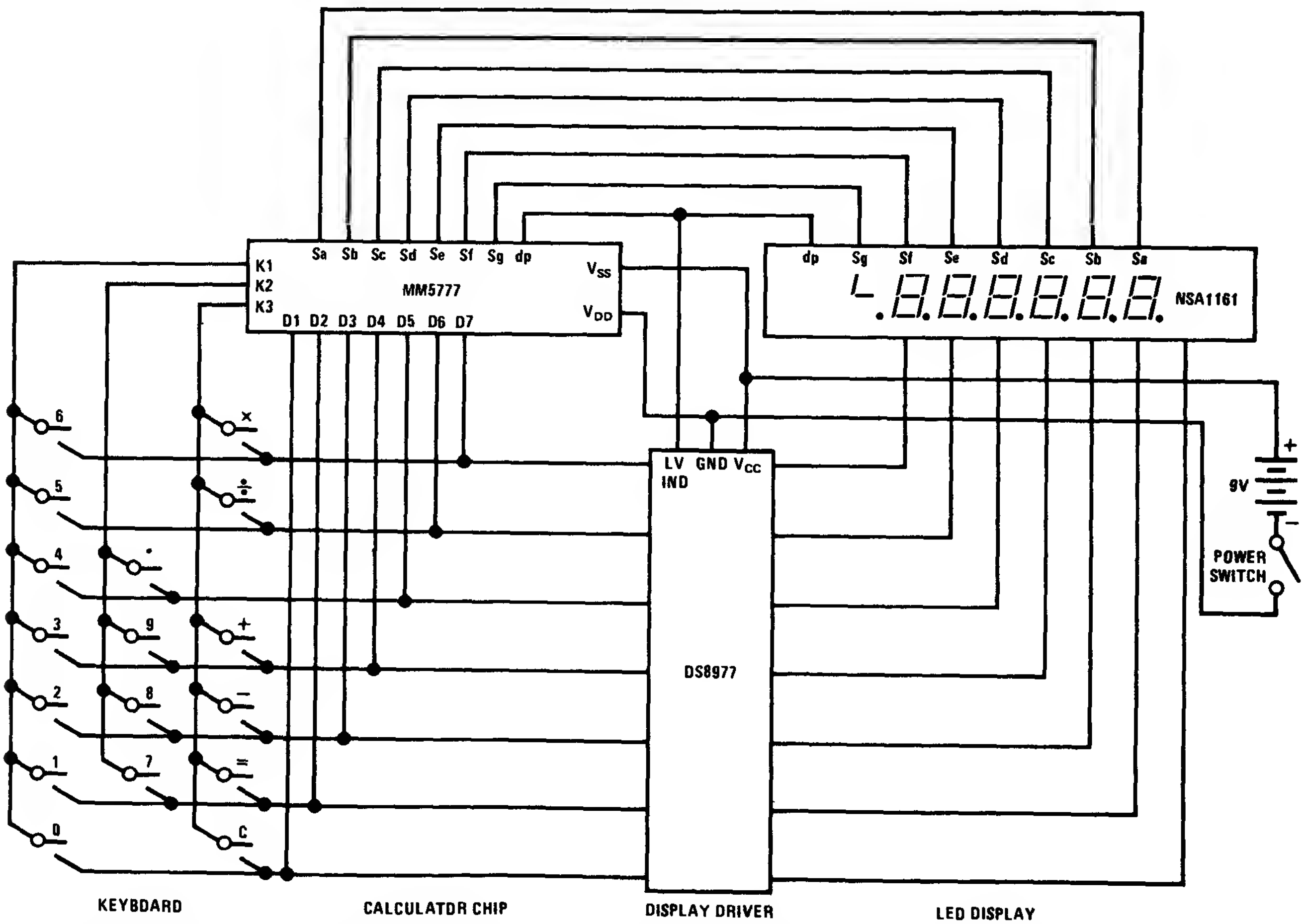
5 × 7 DOT MATRIX—Drive for Dialight 745-0005 64-character alphameric display generates desired character in response to pattern of 0s and 1s on input lines A1-A6. Timing of sequential scanning operation for seven horizontal rows of matrix is controlled by clock that drives binary counter having row-selecting outputs A, B, and C. Outputs C1-C5 of ROM correspond to vertical rows of dots enabled by 1-out-of-8 decoder.—"Readout Displays," Dialight, Brooklyn, NY, 1978, Catalog SG745, p 24–26.



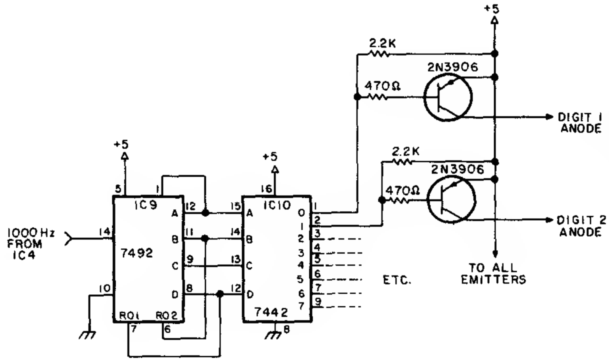
LED DIMMER—Intech/Function Modules A-8402 is used in voltage-to-frequancy mode to provide controllable dimming of LED displey by verying frequency of blenking input to displey driver. Display is pulsed on end off rapidly; the higher the duty cycle, the brighter tha display. At highest input voltage tha converter is forced out of linear region, making its mono remain on continuously for brightest display.—P. Pinter end D. Timm, Voltage-to-Frequency Converters—IC Versions Perform Accurate Deta Conversion (end Much More) at Low Cost, *EDN Magazine*, Sept. 5, 1977, p 153–157.



GIANT-NIXIE SIGN—Simple power supply drives any desired number of alphemeric Nixie characters each 2½ inches high to form Illuminated house numbers, "ON THE AIR" sign for emateur station, or "BAR IS CLOSED" sign for perty room. Connect 3.3K resistor from +150 V to pin 13 of eech Nixie, end connect to point Y (−150 V) eech segment to be lighted. Sign cen be chenged at any time by resoldering connections to segments. Dioda must hendle AC line voltege.—J. Grimes, Display Yourself in a Big Way, *73 Magazine*, Nov./Dec. 1975, p 186–188.

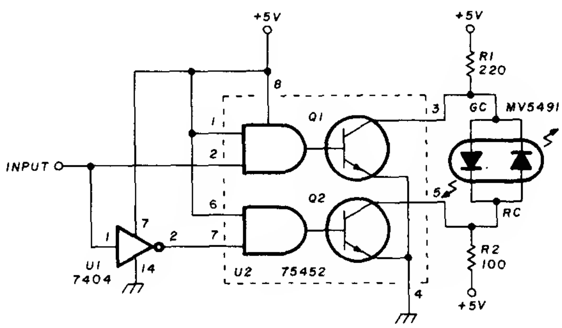


6-DIGIT FOUR-FUNCTION—Netlonel MM5777 calculator chip requires only keyboard, NSA1161 LED displey, DS8977 digit drivar, end 9-V bettery to provida add, subtract, multiply, and divida functions. Calculator chip Includes keyboard encoding and key debouncing circuits, elong with all clock and timing generetors. LED segments can be driven directly, without multiplexing. Seventh digit position is used for negativa sign of 6-digit number end as error indicator. Laeding and trailing zero suppression is included.—"MOS/LSI Databook," Netionel Semiconductor, Sente Clera, CA, 1977, p 8-84–8-89.



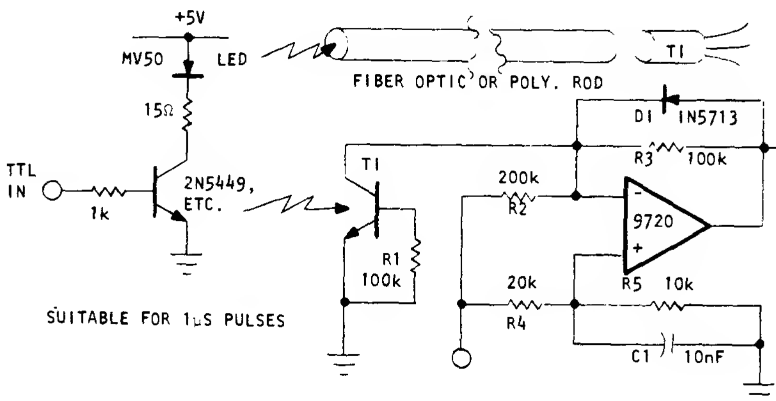
STROBING LED DISPLAY—Sequentiel strobing of individual LED displays, at rate fest enough to eliminate flicker (about 10% duty cycle), cuts power requirements of LEDs and eliminates need for power-wasting resistors in series with digit segments. Circuit uses 7492 binery counter connected to divide by 10, continuously clocked by 1000-Hz signal from externel countar time base. Each of the 10 counter states is decoded by 7442 decoder for use in turning on PNP switch trensistor connected in series with anode of each 7-segment LED digit. Digits are thus turned on for 10% of time at 100-Hz rete.—B. Hart, Current-Saver Counter Display, *73 Magazine,* June 1977, p 174–176.

POSITIVE INPUT GIVES GREEN—High or positive Input to circuit gives green indication in Monsanto MV5491 dual red/green LED, and low input gives red. Circuit uses single SN75452 IC driver end one section of SN7404 hex inverter.—K. Powell, Novel Indicator Circuit, *Ham Radio,* April 1977, p 60–63.

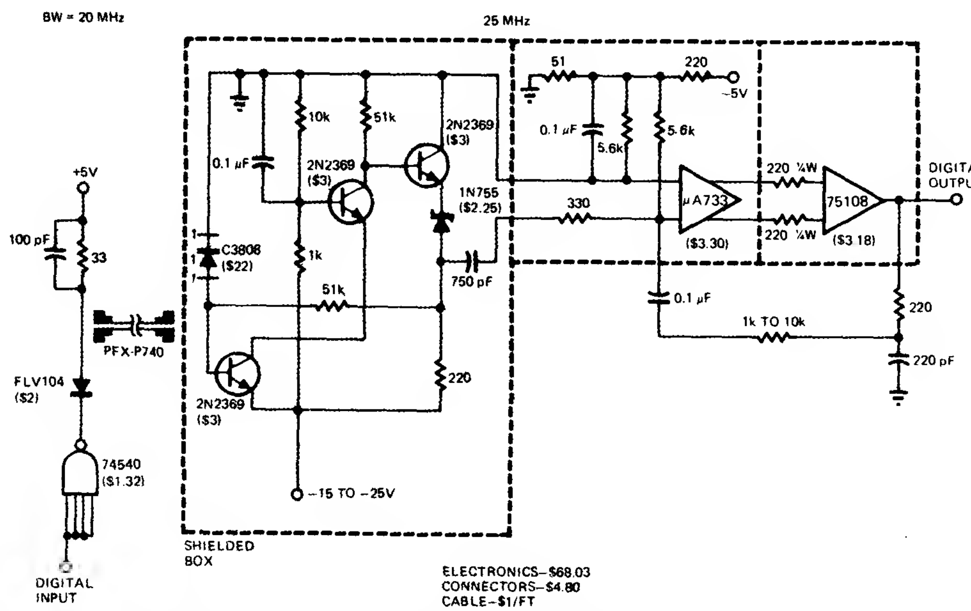


CHAPTER 26
Fiber-Optic Circuits

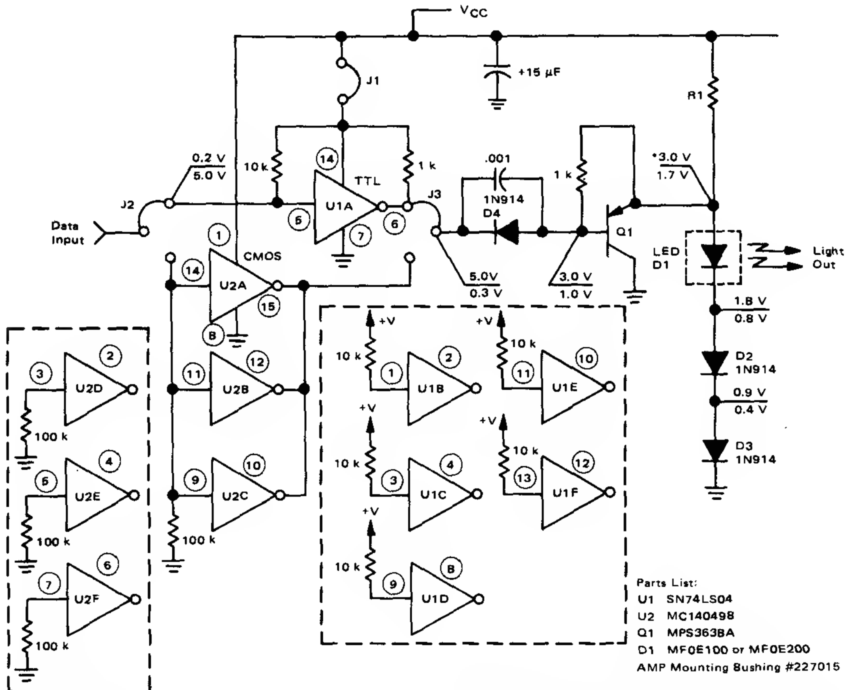
Includes LED modulators and photodiode or phototransistor receivers for single- or multiple-fiber data links handling audio, data, and teleprinter signals. Circuits are also given for infrared receivers and transmitters, high-voltage isolator links, laser-diode modulator, Manchester-code demodulator, and fiber light-transmission checker.



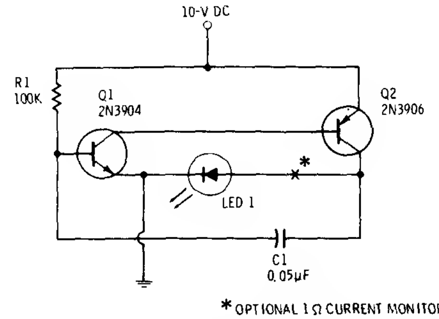
DATA COUPLER WITH ISOLATION—Length of fiber or polystyrene rod determines emount of voltage isolation provided between digital or analog signal input and Fairchild FPT 100 photodetector driving Optical Electronics 9720 opamp heving 100-mA output for driving cables, relays, or loudspeekers. LED can be Monsanto MV50 handling up to 200 mA. Output of opamp is zero for no light. Pulse-duration modulation should be used for transmission of anelog deta.—"High Voltage Optically Isolated Data Coupler," Optical Electronics, Tucson, AZ, Application Tip 10266.



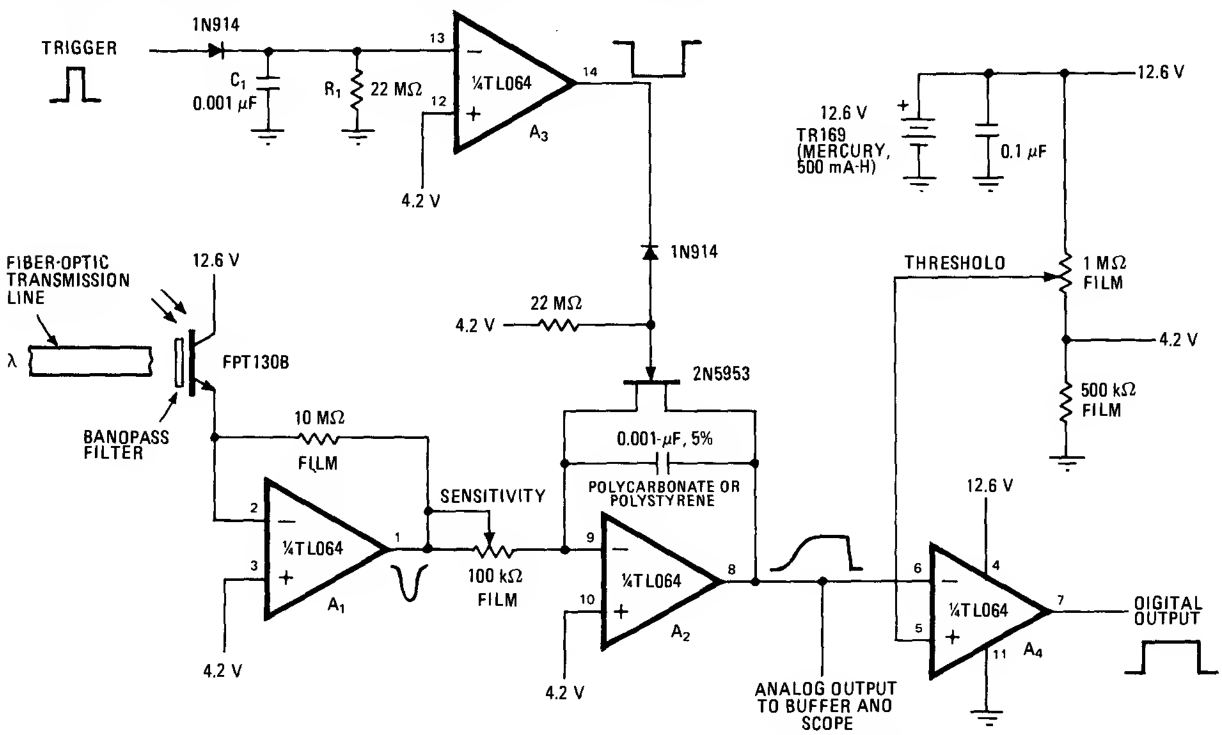
24-MEGABIT DATA LINK—High data-rate capability for square-wave pulses is achieved by increasing complexity of receiver feeding digital output to microprocessor from remote teleprinter. Preamp design compensates for noise over limited frequency range, giving uniform S/N ratio to about 20 MHz. With demonstration setup, visible-spectrum LED and photodetector shown performed acceptably with 40-foot cable.—O. E. Marvel and J. C. Freeborn, A Little Hands-On Experience Illuminates Fiber-Optic Links, *EDN Magazine*, Nov. 5, 1977, p 71–75.



FIBER-OPTIC TRANSMITTER—Will handle NRZ data rates to 10 megabits or squara waves to 5 MHz. Input is TTL- or CMOS-compatible depending on circuit selected. Transmitter draws only 150 mA from 5-V supply for TTL or from 5-15 V supply for CMOS. Choose R1 to give LED drive current for proper oparation of system. For TTL operation, jumpers J1, J2, and J3 are connected as shown. For CMOS operation, remova J1 and transfer J2 end J3 to alternate positions for connecting to U2. Cholca of LED depends on system length and deslrad data rate. Power supply can be HP6218A or equivalent. DC voltages shown ara for TTL interfeca, with uppar value for LED on at 50 mA and lower value for LED off.—"Basic Experimentel Fiber Optic Systams," Motorola, Phoenix, AZ, 1978.

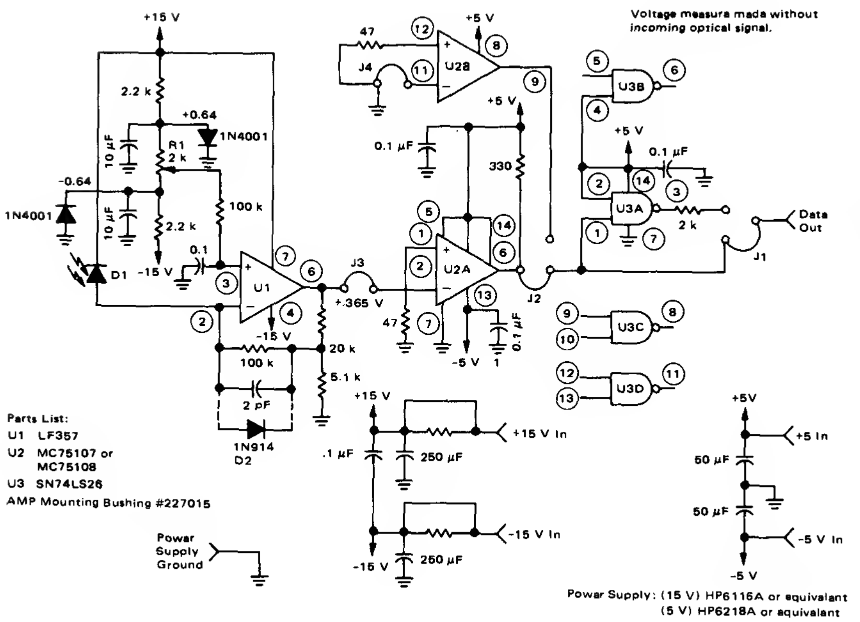


HIGH-CURRENT INFRARED LED PULSER—Circuit operates as reganarativa amplifier for delivering 10-μs pulses with amplitude of 1.1 A and rapetition rata of 1.4 kHz to infrared LED. Suitebla for infrared beacon in fiber-optic communicetion and optical radar applications. Drain is 100 mA from 10-V supply. Usa gallium ersanide LED such as SSL-55C or TIL32 for high-output infrared transmittar. Q2 can ba changed to germanium transistor such as 2N1305 to giva peak currant of 2 A et pulse width of 15 μs end 750-Hz rapetition rata.—F. M. Mlms, "Electronic Circuitbook 5: LED Projects," Howard W. Sems, Indianapolis, IN, 1976, p 33–35.



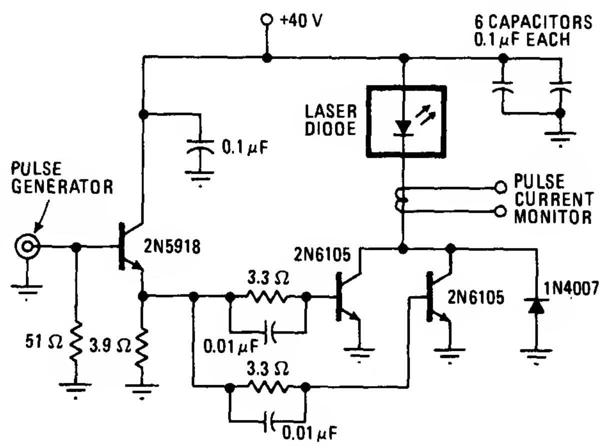
TL064: TEXAS INSTRUMENTS QUAD BI-FET AMPLIFIER OR EQUIVALENT

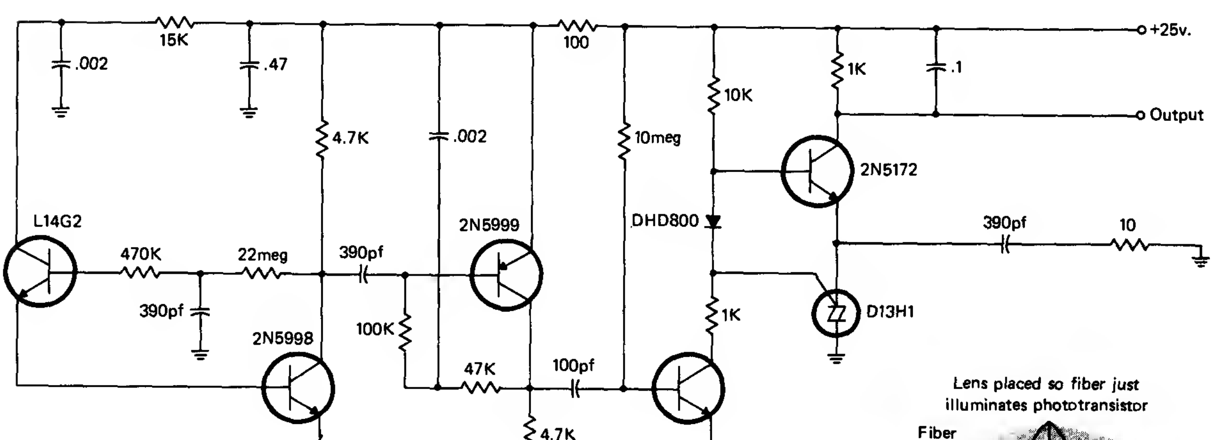
LIGHT TRANSMISSION CHECKER—Phototransistor and quad opamp serve as total-enargy detector of pulsed-light signals propagated through fibar-optic cabla of communication system. Can be used for checking and comparing condition of long fibers if light intensity of sourca is held constant. Will also detect changes in light intensity and chenges in pulse width. Circuit gives linear response to light levels from 100 to 10,000 args/cm² if minimum pulse width is et least 10 μs. A_2 acts as RC integrator, giving voltage proportional to total light energy received. A_4 provides comparison to fixed leval.—E. W. Rummel, Low-Level-Light Detector Checks Optical Cebles Fest, *Electronics*, April 27, 1978, p 148 and 150.



FIBER-OPTIC RECEIVER—Uses MFOD100 PIN photodiode as optical detector for handling megabit data rates. Minimum photocurrent required to drive LF357 opamp U1 is 250 nA. Voltage comparator U2 inverts output of U1 and provides standard TTL output. For CMOS output, quad two-input NAND gate U3 is wired into circuit, with jumper J1 connected from U3 output to output terminal of receiver. Adjust R1 to give accurate reproduction of 1-MHz square wave with 50% duty cycle at receiver output.—"Basic Experimental Fiber Optic Systems," Motorola, Phoenix, AZ, 1978.

LASER-DIODE SOURCE—With transistor switching circuit shown for RCA SG2007 laser diode, pulses as short as 10 ns are possible at repetition rates above 100 kHz. Used in optical communication system in which fiber bundle or single fiber is attached directly to laser pellet.—J. T. O'Brian, Laser Diodes Provide High Power for High-Speed Communications Systems, *Electronics*, Aug. 5, 1976, p 94–96.

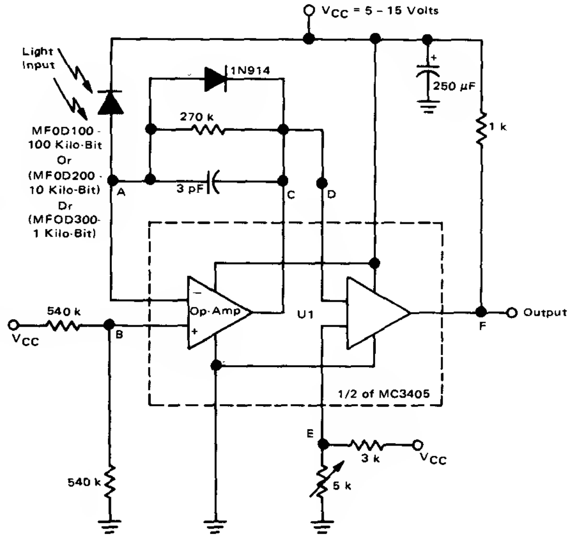




NOTE:
Output = 4mv/KHz

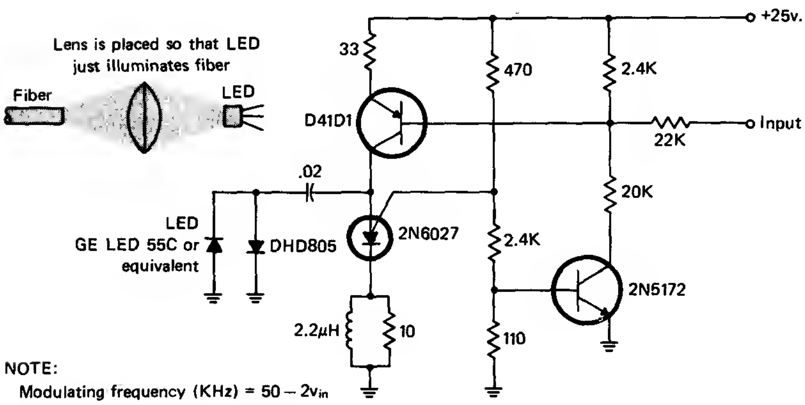
50-kHz FM OPTICAL RECEIVER—Designed for pulse-rate modulation system in which transmitter varies pulse rate of modulated light beam in optical-fiber cable above and below center frequency of 50 kHz. L14G2 GE photo transistor converts modulated optical light to RF signal for demodulation and reconstruction of original audio. Based on circuit in "General Electric Opto-Electronics Manual."—I. Math, Math's Notes, *CQ*, July 1977, p 67–68 and 90.

1/10/100-KILOBIT FIBER-OPTIC RECEIVER—Choice of input device determines operating speed of receiver. MC3405 contains two opamps and two comparators, permitting use as two-channel receiver. Table gives pin connections for each channel.—"Basic Experimental Fiber Optic Systems," Motorola, Phoenix, AZ, 1978.

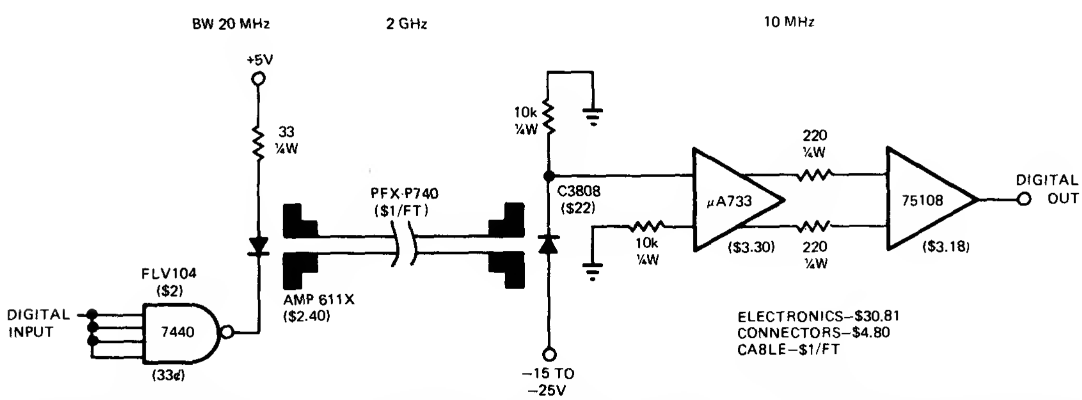


Node	Channel 1	Channel 2
A	13	9
B	12	10
C	14	8
D	3	5
E	2	6
F	1	7

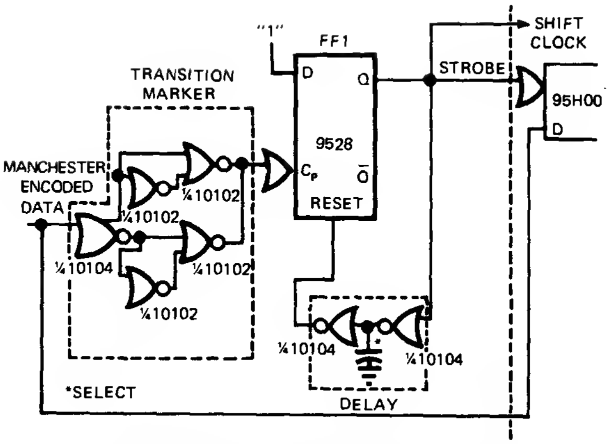
V_{CC}: Pin 4
Ground: Pin 11



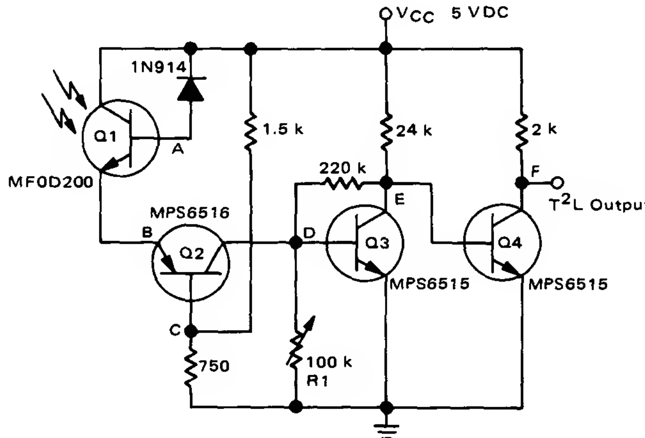
50-kHz FM OPTICAL TRANSMITTER—Uses pulse-rate modulation system with center frequency of 50 kHz. Audio fed into transmitter varies pulse rate, for driving LED coupled to optical fiber. Phototransistor at other end of fiber receives and demodulates light signal for reconstruction of audio.—I. Math, Math's Notes, *CQ*, July 1977, p 67–68 and 90.



10-MEGABIT LINK—Transmitter and receiver for fiber-optic data link between teleprinter and microprocessor utilize wide bandwidth of cable for transmitting data at 10-megabit rate. Receiver input requires C3808 PIN photodiode.—O. E. Marvel and J. C. Freeborn, A Little Hands-On Experience Illuminates Fiber-Optic Links, *EDN Magazine*, Nov. 5, 1977, p 71–75.

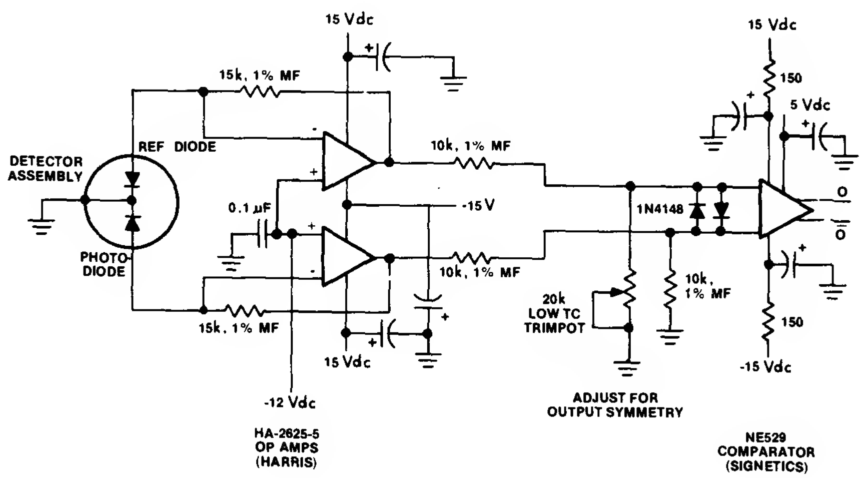


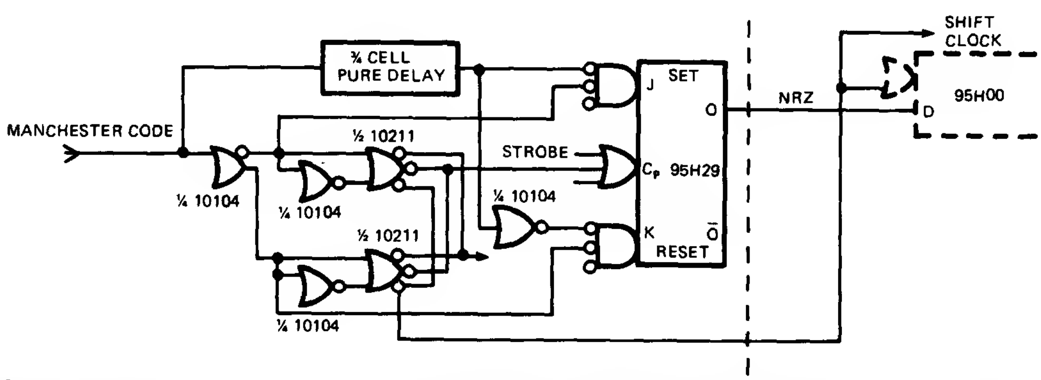
1-GHz MANCHESTER DECODER—Use of ECL flip-flop with toggle rates above 1 GHz makes decoding of bit rates approaching gigabit speeds feasible. Article gives step-by-step design procedure for 48-Mb telemetry application using PCM over single optical-fiber cable.—B. R. Jarrett, Could You Design a High-Speed Manchester-Code Demodulator?, *EDN Magazine*, Aug. 20, 1974, p 75–80.



20-KILOBIT FIBER-OPTIC RECEIVER—Phototransistor driving three-transistor amplifier provides TTL output for data rates up to 20 kilobits.—"Basic Experimental Fiber Optic Systems," Motorola, Phoenix, AZ, 1978.

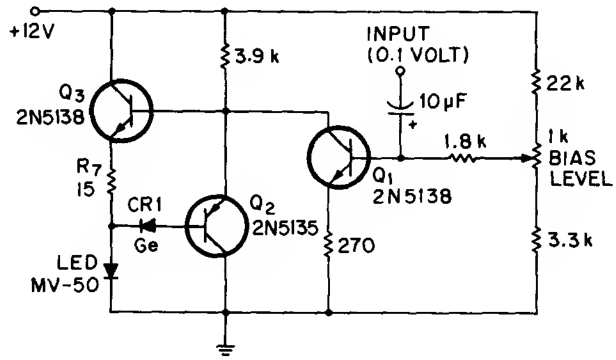
IR DETECTOR—Photodiode transforms light-signal output of fiber-optic cable to electric signal. Spectral response of detector closely matches that of IR-emitting diode at other end of cable, for maximum system efficiency. Rise and fall times of detector can be less than 35 ns when properly biased and loaded by receiver circuit. Developed by Auget, Inc., Attleboro, MA, as part of fiber-optic evaluation kit for TTL applications.—Fiber-Optic Kit Allows Engineering Evaluation of Complete Interconnection System, *Computer Design*, Nov. 1977, p 27 and 30.

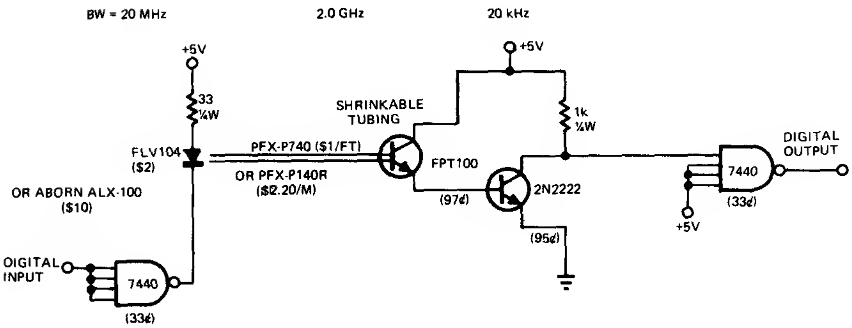




MANCHESTER-CODE DEMODULATOR—Digital approach using ECL provides maximum speed, is self-synchronizing for alternate bit-pairs, and has minimum complexity. Developed for optically coupled 25-channel PCM telemetry system used over single optical-fiber channel. Undesired transitions in input data are masked by creating strobe. Approach recognizes distinction between identical sequences that would give same output except for time-of-occurrence restriction. Article gives step-by-step design procedure, waveforms, and excitation table.—B. R. Jarrett, Could You Design a High-Speed Manchester-Code Demodulator?, *EDN Magazine*, Aug. 20, 1974, p 75–80.

1-MHz LED PULSE MODULATION—Circuit provides required low driving-point impedance for fast turn-on of gallium arsenide phosphide LED used as source for high-speed pulse modulation of fiber-optic or other light baam. Q_1 supplies DC laval and modulation information to emitter-follower output staga Q_3. Output current is sensed and limited to about 30 mA by Q_2. Turn-on time for full brightness is 12 ns.—G. Schmidt, LED Modulator, *EDN/IEEE Magazine,* June 15, 1971, p 57.

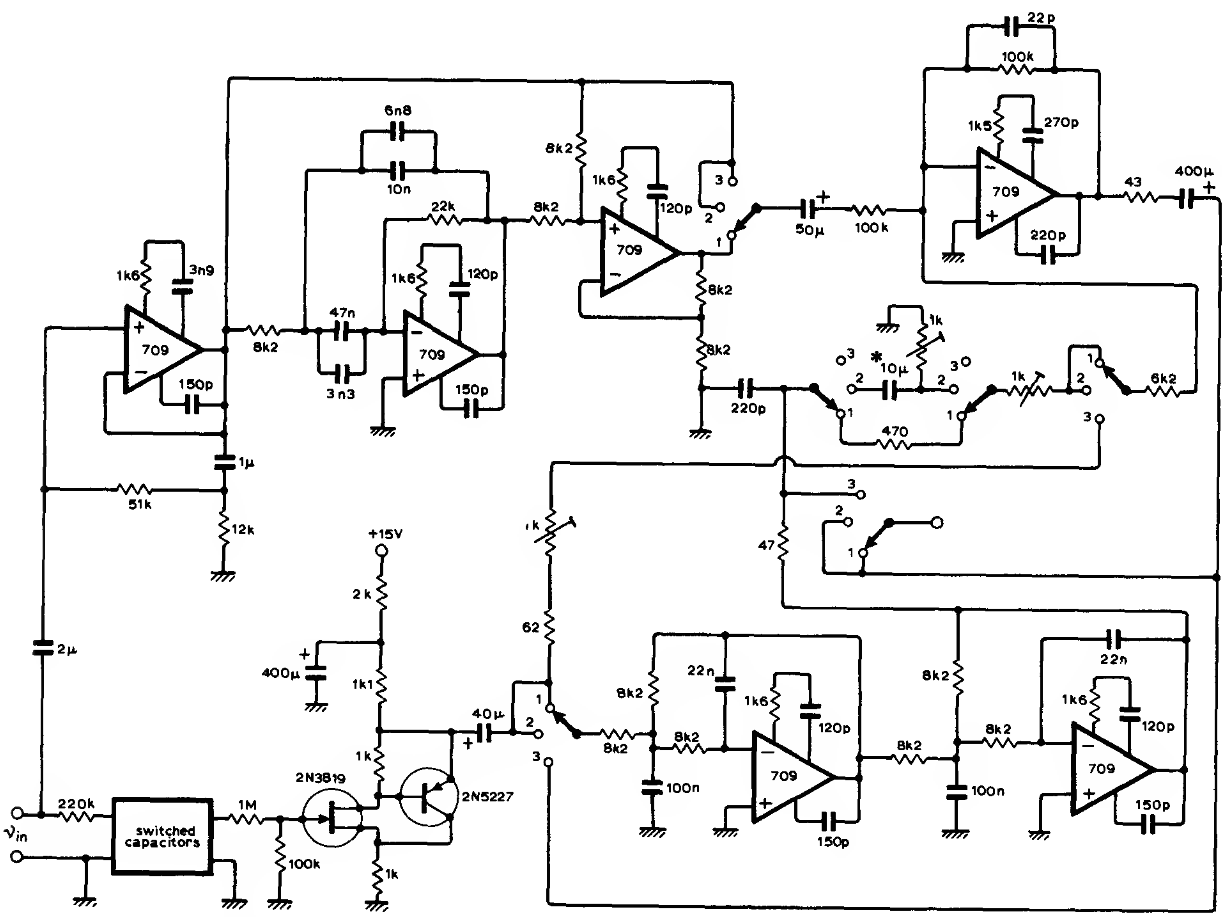




TTY LINK FOR MICROPROCESSOR—Damonstration circuit illustrates use of fiber-optic cable with low-cost components for ralativaly narrow-band application, to provide faed from remota teleprinter to microprocessor.—O. E. Marvel and J. C. Fraeborn, A Littla Hands-On Experienca Illuminatas Fibar-Optic Links, *EDN Magazine,* Nov. 5, 1977, p 71–75.

CHAPTER 27
Filter Circuits—Active

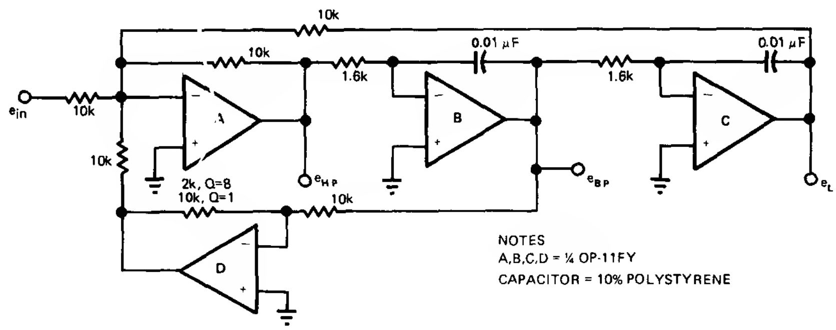
Includes low-pass, high-pass, bandpass, notch, state-variable (2 to 4 functions), tracking, and equalizing filters covering from 1 Hz to limits of audio spectrum, along with gyrator, Q multiplier and variable-Q circuits, crossover networks for loudspeakers, and RF circuits providing frequency emphasis.

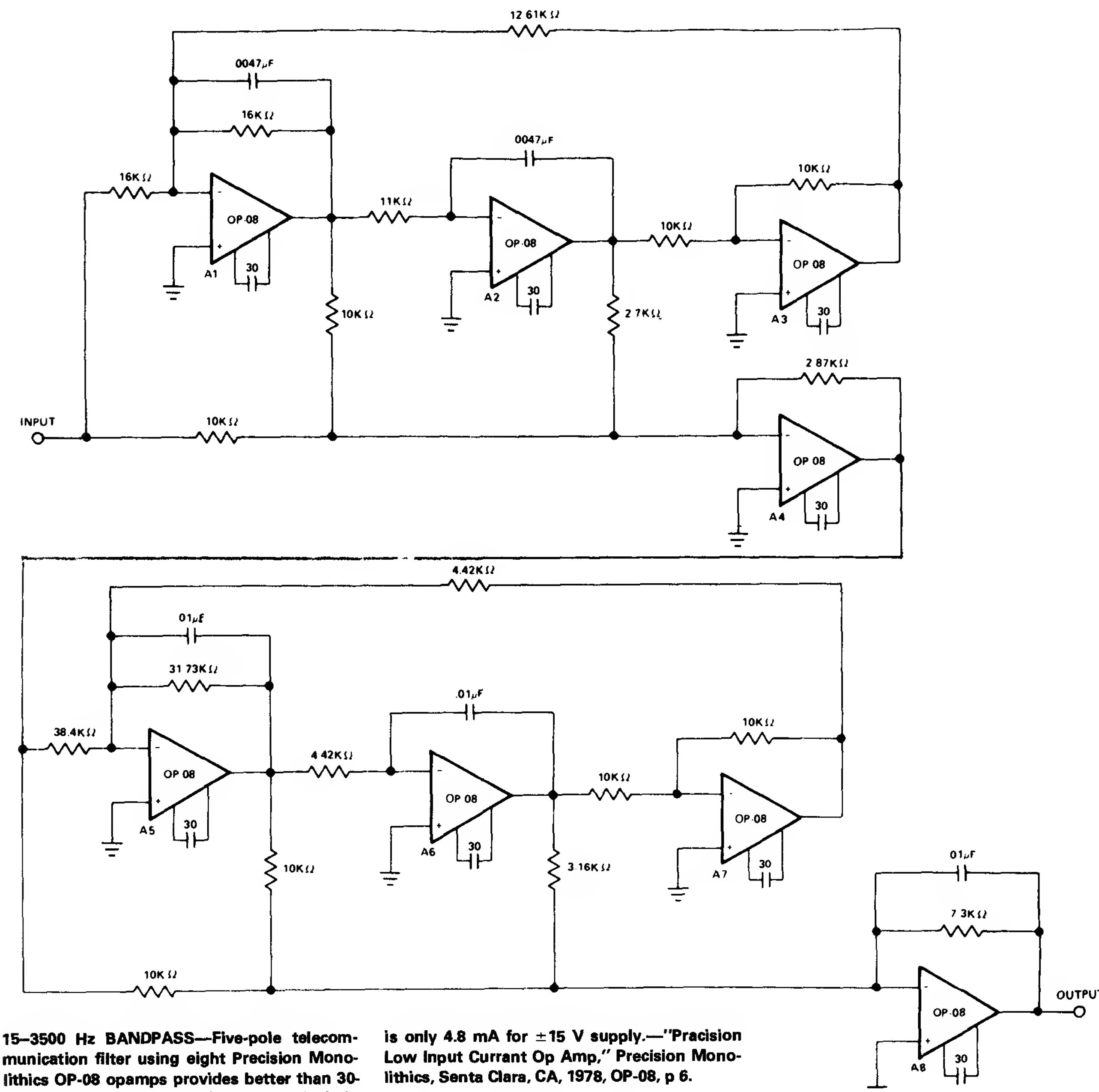


✱ non-polarized polycarbonate

TRACKING LINE-FREQUENCY FILTER—Improvemants in commutating RC network filter extend dynamic range without sacrificing signel bandwidth, for reducing interfarence at fundamental of powar-line frequancy and harmonics up to fifth. Although values in circuit are for British 50-Hz mains frequency, circuit can readily be edapted for 60-Hz rajection. Operation involves commutating 16 capacitors electronically at 16 times line frequency. Article gives ona method of doing this, by driving two 8-way multiplaxars altemately. Each multiplexar has eight MOSFETs, each switched on in turn by consecutive input clock pulses. Circuit details, design equetions, end performence graphs ere given. Thrae-position switch gives choice of filter characteristics.—K. F. Knott and L. Unsworth, Mains Rejection Tracking Filter, *Wireless World,* Oct. 1974, p 375–379.

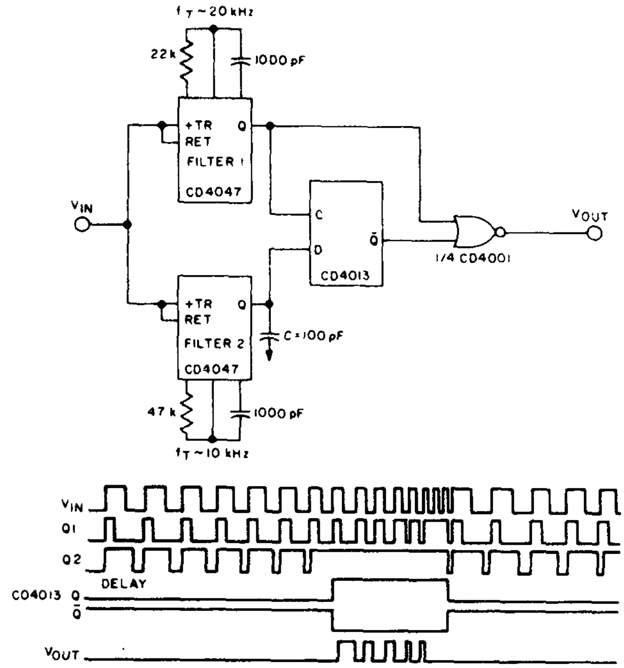
10-kHz VARIABLE-Q—Second-order state-variable filter having center frequency of 10 kHz uses all four sections of OP-11FY quad opamp. Center frequency can be tuned by varying 1.6K feedback resistors or by changing 0.01-μF feedback capacitors. Value of feedback resistor for opamp D determines Q of filter, for adjusting circuit bandwidth or damping. For higher-frequency operation, use high-speed opamps such as OP-15 or OP-16.—D. Van Dalsen, Need an Active Filter? Try These Design Aids, *EDN Magazine*, Nov. 5, 1978, p 105–110.



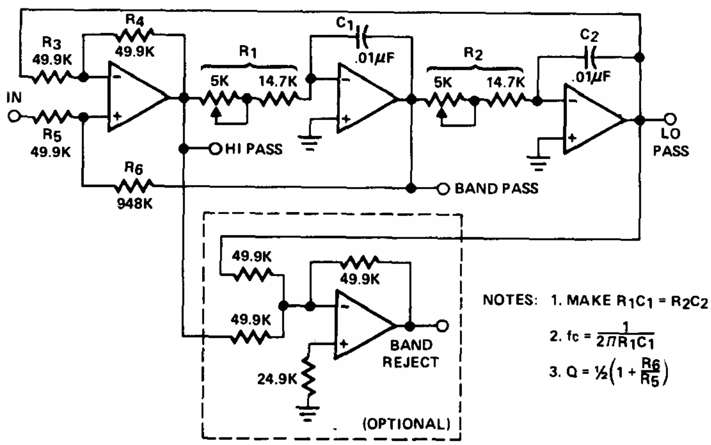


15–3500 Hz BANDPASS—Five-pole telecommunication filter using eight Precision Monolithics OP-08 opamps provides better than 30-dB attenuation in stop band. Total supply drain is only 4.8 mA for ±15 V supply.—"Precision Low Input Current Op Amp," Precision Monolithics, Santa Clara, CA, 1978, OP-08, p 6.

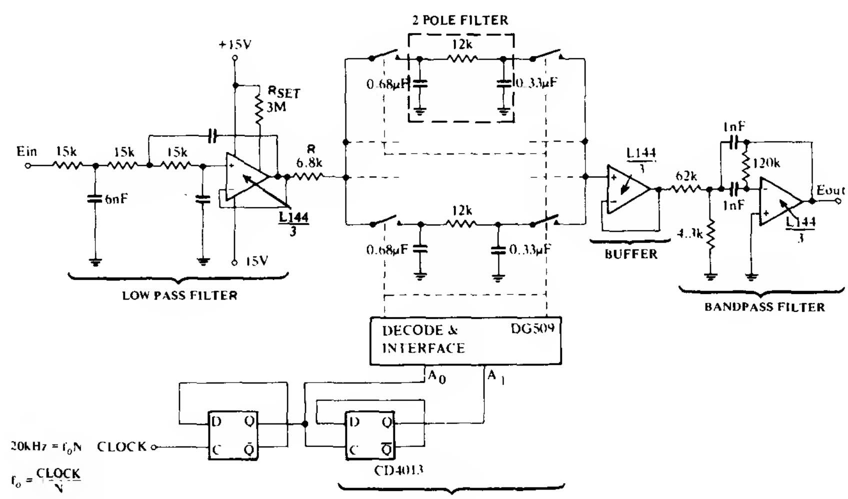
10–20 kHz BANDPASS—Two CD4047A low-pass filters, one connected for 10-kHz cutoff and other for 20-kHz cutoff, drive CD4013A flip-flop. If output of filter 2 is delayed by C, flip-flop clocks high only when input pulse frequency exceeds 10-kHz cutoff of filter 2. Waveforms show performance when input signal is swept through passband.—"CQS/MOS Integrated Circuits," RCA Solid State Division, Somerville, NJ, 1977, p 619.

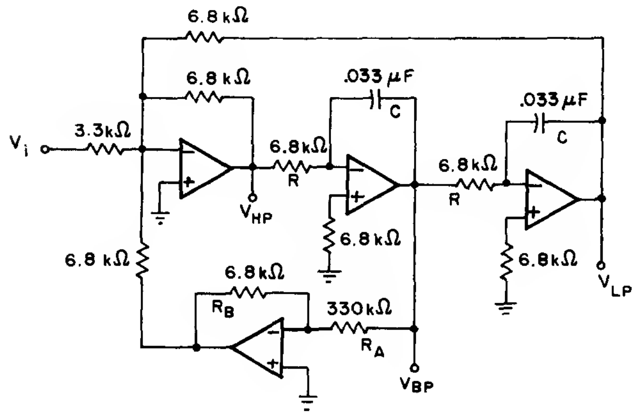


1-kHz STATE-VARIABLE WITH Q OF 10—Use of all four sections of Harris HA-4602/4605 quad opamp gives four types of 1-kHz second-order filtering simultaneously. Pot adjustments permit matching of various RC products allowing for noninteractive adjustment of Q and center frequency.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 2-84.



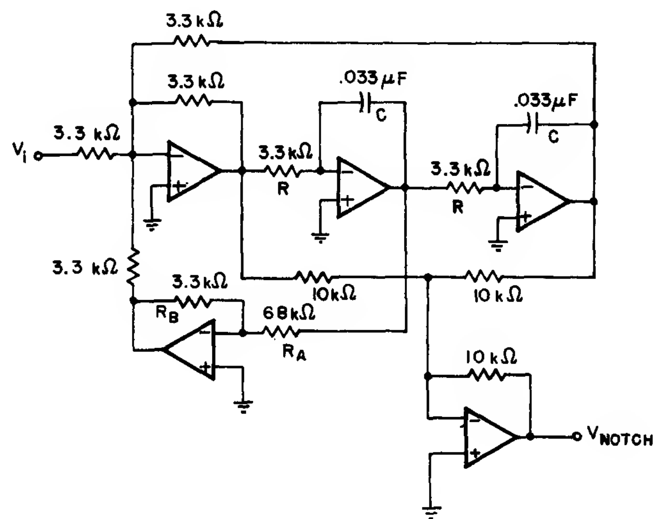
5-kHz SERIES-SWITCHED BANDPASS—N-path filter having N of 4, Q of 500, and voltage gain of 2 uses DG509 four-channel CMOS differential multiplexer having necessary pairs of analog switches and decode logic. Dual D flip-flop generates 2-bit binary sequence from 20-kHz clock signal. Bandwidth is about 10 Hz for 3 dB down, centered on 5 kHz.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 5-15–5-17.

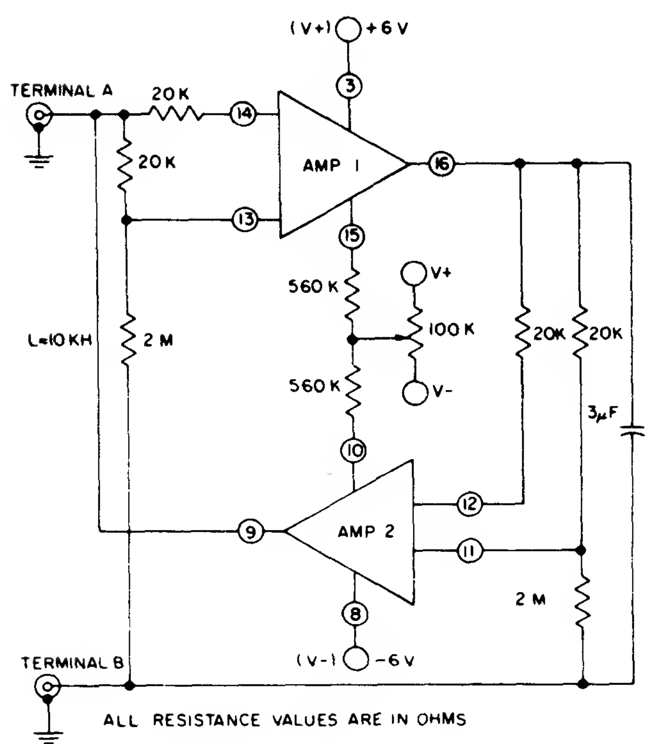




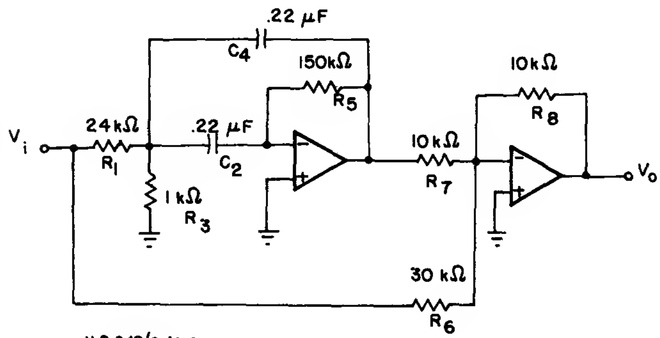
700-Hz STATE-VARIABLE—Provides voltaga gain at cantar frequency of 100 (40 dB) and Q of 50. Used whan simultaneous low-pass, high-pass, and bandpass output responsas ara required. Cutoff frequancy of low-pass and high-pass responsas is equal to center frequency of bandpass responsa. Opamps can ba 741. Based on usa of 5% resistors.—H. M. Berlin, "Dasign of Active Filtars, with Exparimants," Howard W. Sams, Indianapolis, IN, 1977, p 184–187.

1.5-kHz NOTCH—Unity-gain state-variable filter consists of low-pass and high-pass sections combined with two-input summing amplifiar to giva notch response for suppression of 1.5-kHz signals. Opamps can ba 741.—H. M. Barlin, "Design of Activa Filtars, with Exparimants," Howard W. Sams, Indianapolis, IN, 1977, p 186–189.

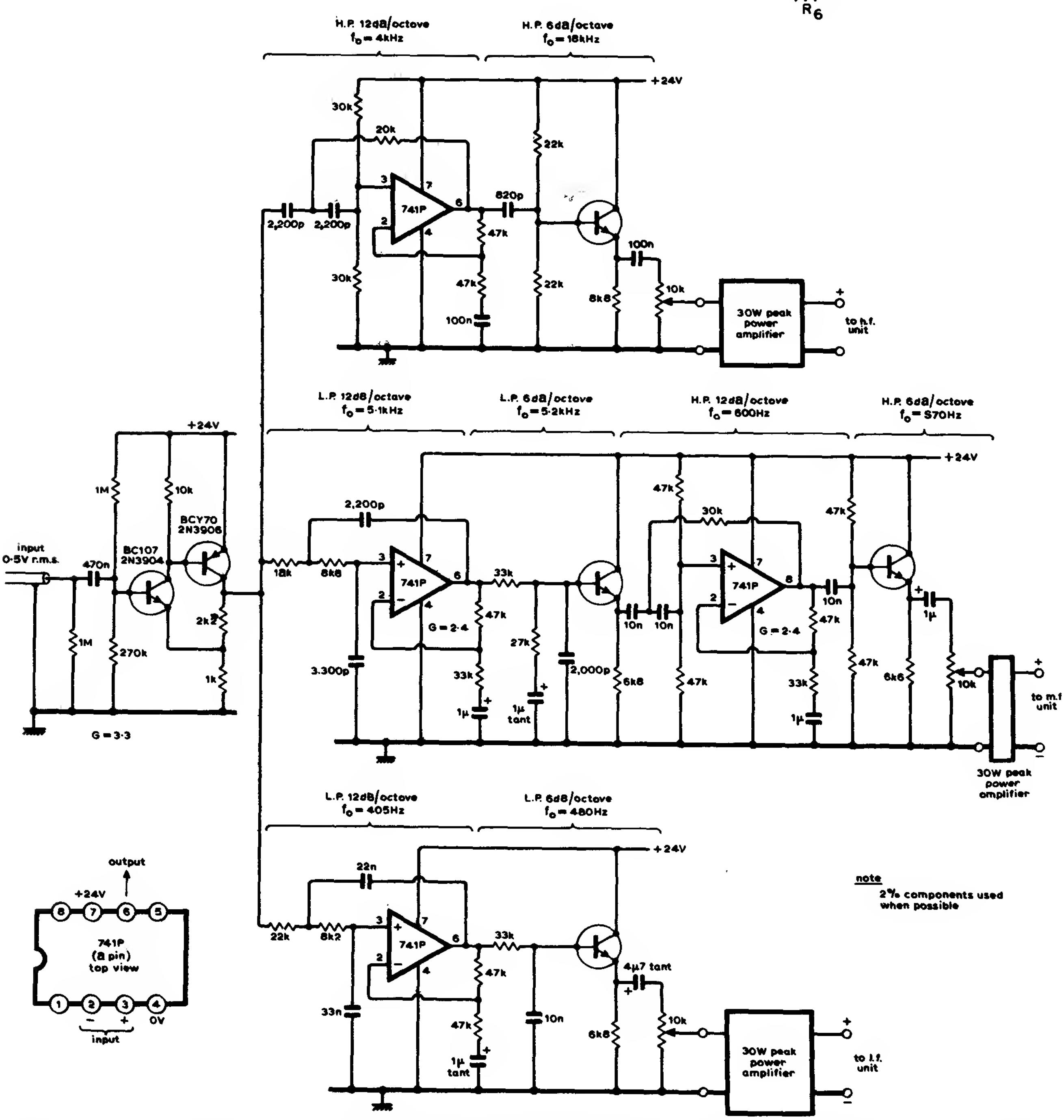




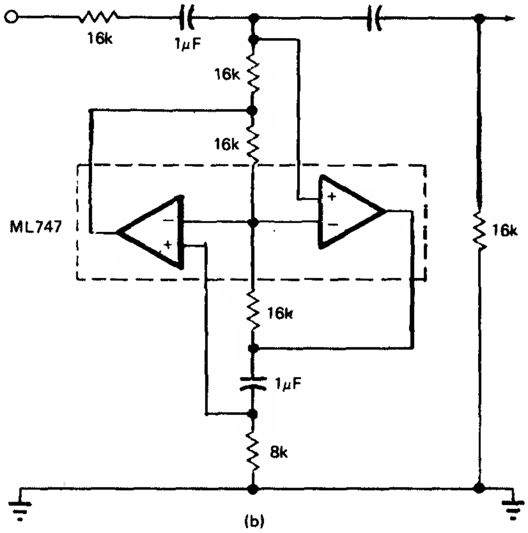
10-kH GYRATOR—Activa filter circuit uses two sections of CA3060 thrae-opamp array as gyrator that makes 3-μF capacitor function as floating 10-kilohenry inductor across tarminals A and B. Q of inductor is 13. 100K pot tunes inductor by changing gyration resistance.—"Linear Integrated Circuits and MOS/FET's," RCA Solid Stata Division, Somerville, NJ, 1977, p 152.



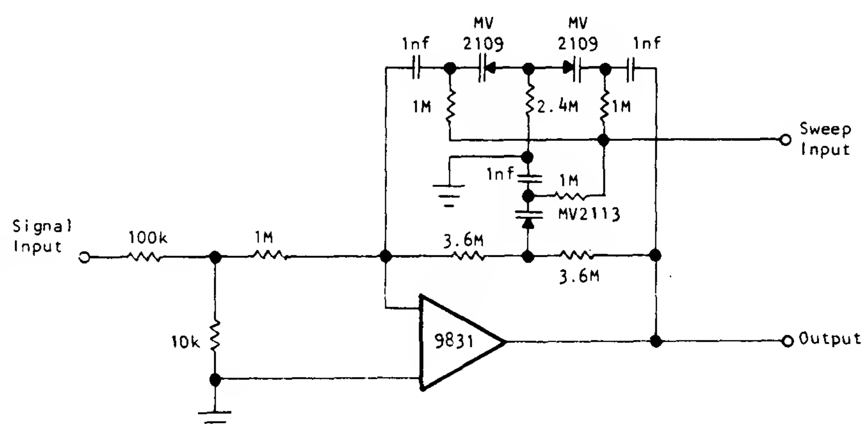
60-Hz NOTCH FILTER—Design is based on passband gain of 3 and Q of 6. Resistors can be 5%. Opamps can be 741. Notch response is obtained by subtracting output signal of bandpass filter from its input signal with R_6.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 155.



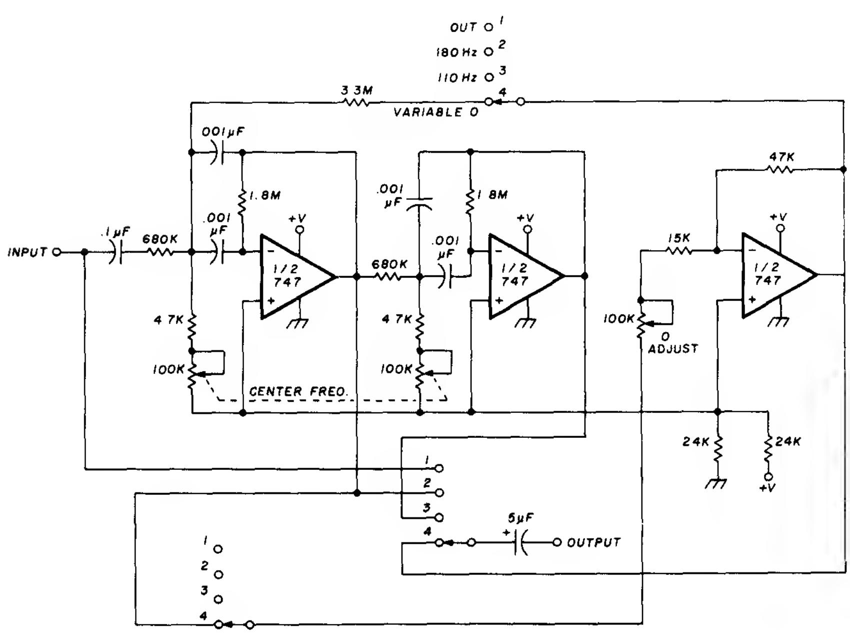
THREE-LOUDSPEAKER CROSSOVERS—Active filter network splits AF input into three frequency bands each feeding separate 30-W power amplifier. Design allows adjustment of any part of frequency characteristic to any desired level and gives choice of slopes in any part of frequency band. Article gives design equations and construction details. NPN transistors can be BC107 or 2N3904; PNP transistors can be BCY70, BCY71, BCY72, or 2N3906. Article also gives circuit of suitable 30-W amplifier.—D. C. Read, Active Filter Crossover Networks, *Wireless World*, Dec. 1973, p 574–576.



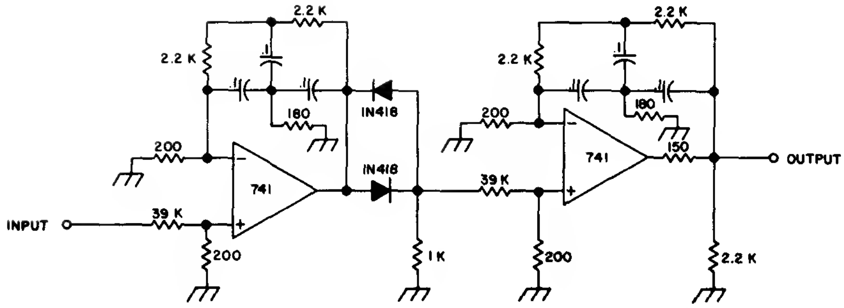
10-Hz HIGH-PASS—Equiterminated Butterworth high-pass ladder filter has corner frequency of 10 Hz and output impedance level of 16K. Opamps are matched pair in single ML747 package. Article covers design procedure based on use of generalized impedance converters and gives frequency response curve.—L. T. Burton and D. Treleaven, Active Filter Design Using Generalized Impedance Converters, *EDN Magazine*, Feb. 5, 1973, p 68–75.



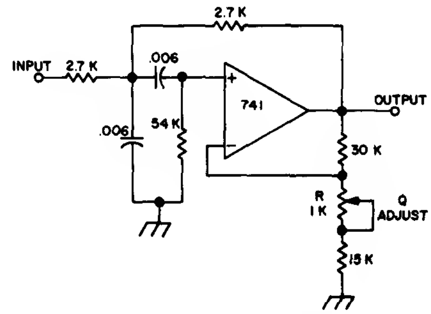
10-kHz VOLTAGE-TUNED—High-Q circuit using Optical Electronics 9831 opamp has sharp resonance, as required for analysis of spectrum of incoming signal. Reverse-biased silicon junctions serve as voltage variable capacitors for sweeping center frequency over 3:1 range. Values shown for three resistors in twin-T network give center frequency of 10 kHz.—"Voltage Tuned High-Q Filter," Optical Electronics, Tucson, AZ, Application Tip 10207.



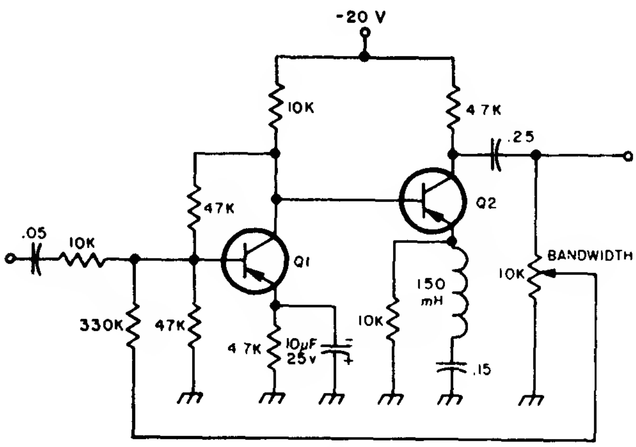
ACTIVE CW FILTER—Modifications made on MFJ Enterprises CWF-2 active audio filter permit maximum flexibility. Circuit provides fixed bandwidth of 180 or 110 Hz centered on 750 Hz, or optional variable bandwidth for which center frequency can be adjusted in range of 280 to 1590 Hz.—H. M. Berlin, Increased Flexibility for the MFJ Enterprises CW Filters, *Ham Radio*, Dec. 1976, p 58–60.



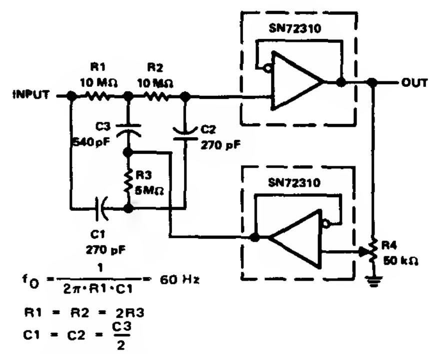
TWO-STAGE CW—Uses diode threshold detector between stages to prevent weak undesired signals from passing through until CW signal of desired frequency is present, so as to provide quiet tuning between signals. Bandwidth of filter is sharp (16 Hz), and keyed waveform is good. Gain is near unity, and frequency and Q are both fixed.—A. F. Stahler, An Experimental Comparison of CW Audio Filters, *73 Magazine*, July 1973, p 65–70.



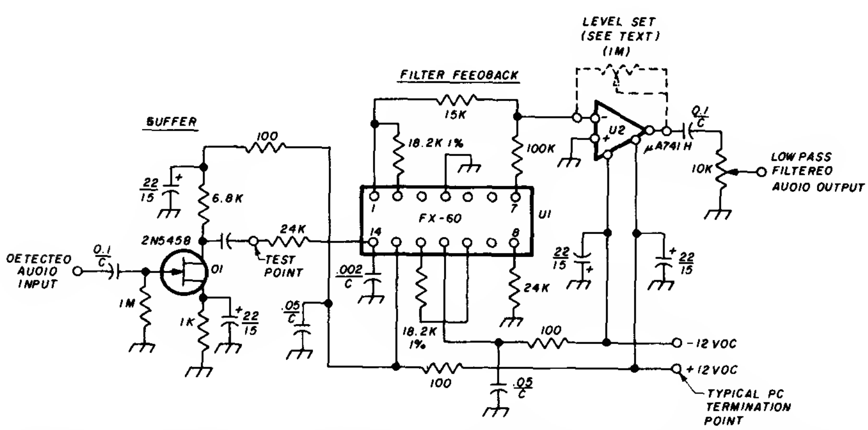
VARIABLE Q FOR CW—Fixed-frequency active filter gives slowly rising and falling keyed waveform with good slope considering narrowness of bandwidth, which is 75 Hz at 3 dB down. Adjusting Q with 1K pot changes bandwidth.—A. F. Stahler, An Experimental Comparison of CW Audio Filters, *73 Magazine*, July 1973, p 65–70.



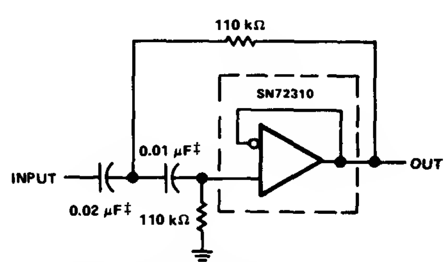
NARROW BANDPASS FOR SPEECH—Simple audio filter provides about 20-dB gain at bandwidth of 80 Hz. Bandwidth can be narrowed to limits of unintelligibility by adjusting 10K pot. Input is plugged into phone jack of receiver, and headphones are connected to output. Transistors are SK3004 or equivalent.—Circuits, *73 Magazine*, Jan. 1974, p 125.



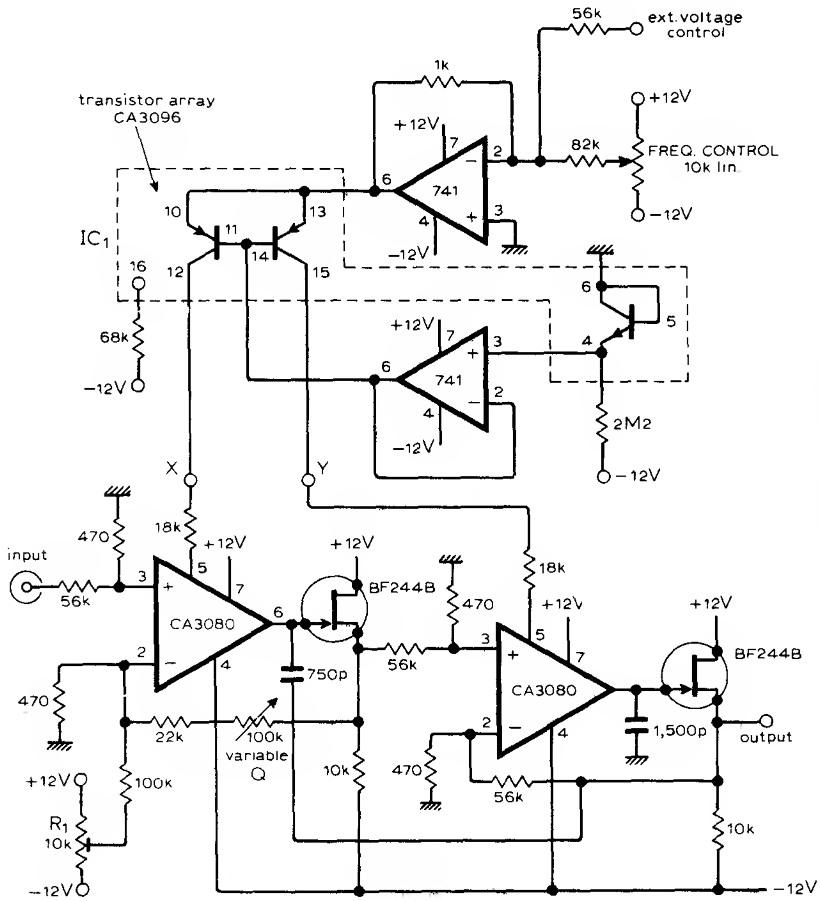
60-Hz ADJUSTABLE-Q NOTCH—Connection shown for two SN72310 voltage-follower opamps provides attenuation of 60-Hz power-line frequency. Setting of R4 determines Q of filter.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-39.



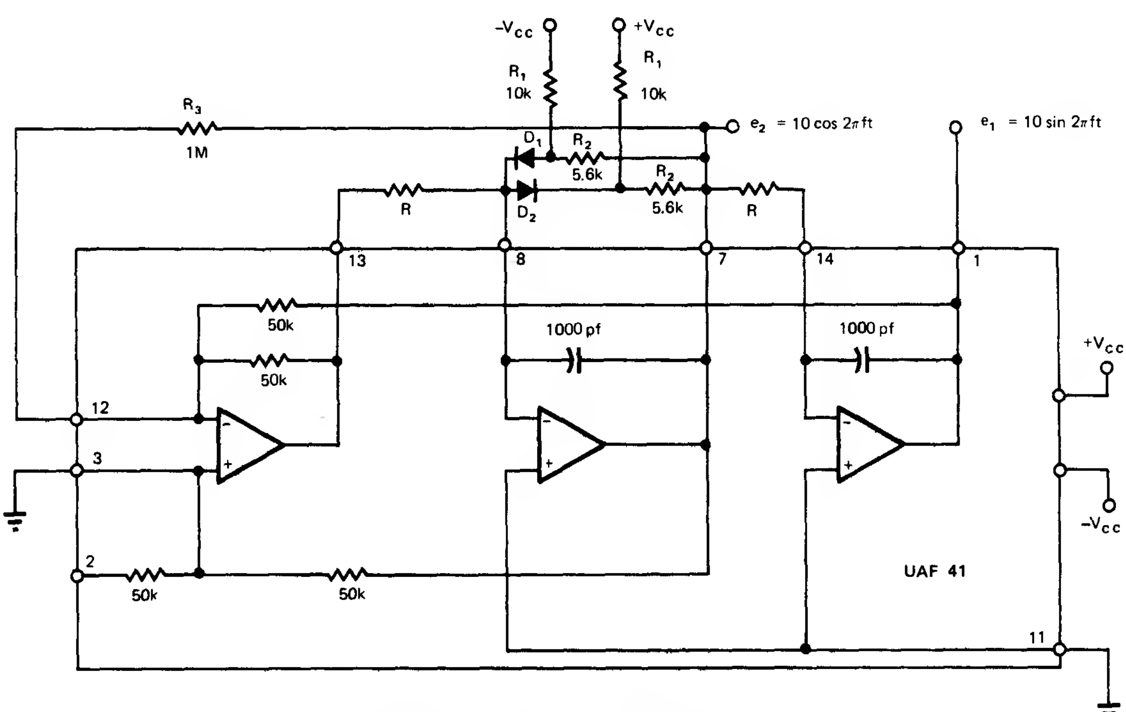
ACTIVE AF FOR SSB AND CW—Uses Kinetic Technology FX-60 IC (culled from FS-60, FS-65, and FS-61 production by manufacturer) as 2.5-kHz tunable detected-audio low-pass filter for SSB. Provides inexpensive hybrid active filter using multiloop negative feedback for low-pass transfer functions. External resistors tune filter frequency and give choice of Q. High-impedance buffer Q1 provides nominal gain while isolating filter from previous receiver stages. Opamp U2 boosts overall gain.—M. A. Chapman, Audio Filters for Improving SSB and CW Reception, *Ham Radio*, Nov. 1976, p 18–23.



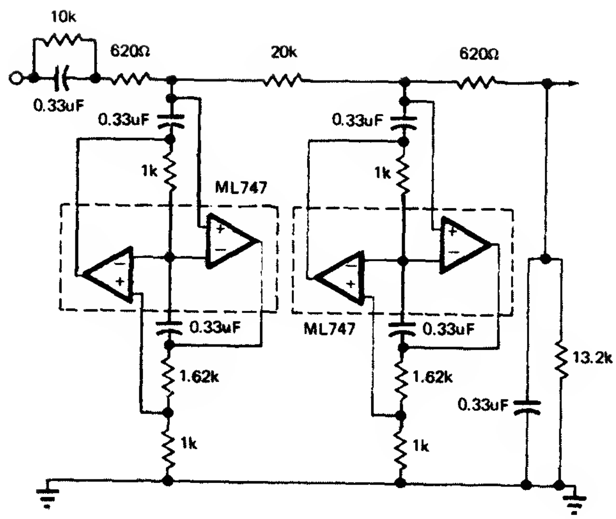
100-Hz HIGH-PASS—Metallized polycarbonate capacitors are required for good temperature stability in high-pass active filter using voltage-follower opamp. Cutoff frequency is 100 Hz.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-39.



CONTROLLABLE 12 dB PER OCTAVE ROLL-OFF—Frequency at which rolloff starts can be set in range between 15 and 15,000 Hz by external voltage or current. If only manual control of frequency is required, short points X and Y and connect them to wiper of 10,000-ohm logarithmic potentiometer that is positioned between −12 V and ground.—T. Orr, Voltage/Current Controlled Filter, *Wireless World*, Nov. 1976, p 63.



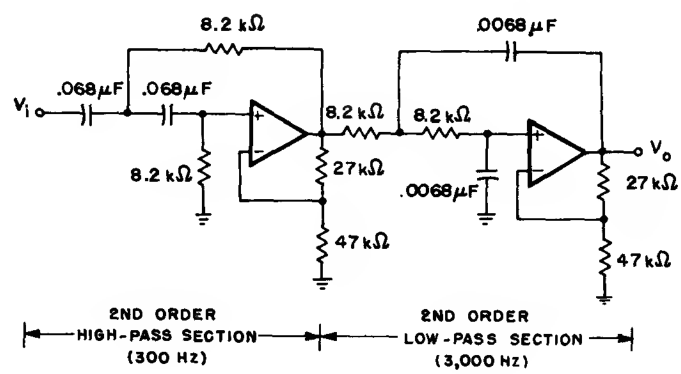
QUADRATURE OSCILLATOR—Addition of diode limiter and positive-feedback resistor to UAF41 universal active filter gives precision quadrature oscillator.—Y. J. Wong, Design a Low Cost, Low-Distortion, Precision Sine-Wave Oscillator, *EDN Magazine*, Sept. 20, 1978, p 107–113.

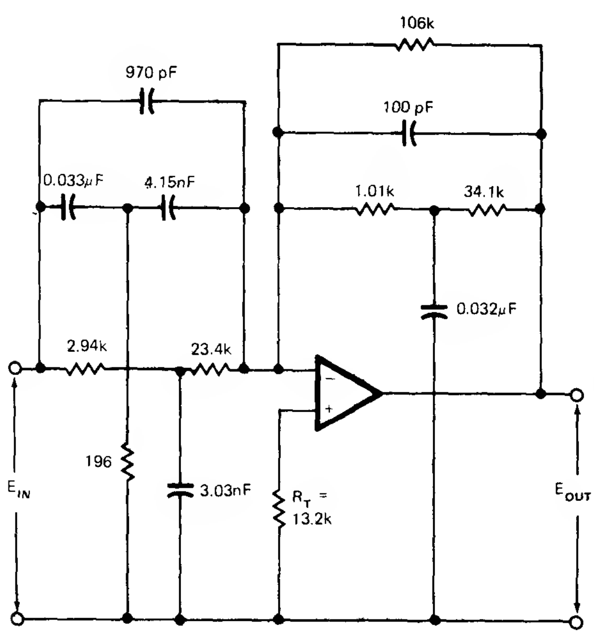


(a)

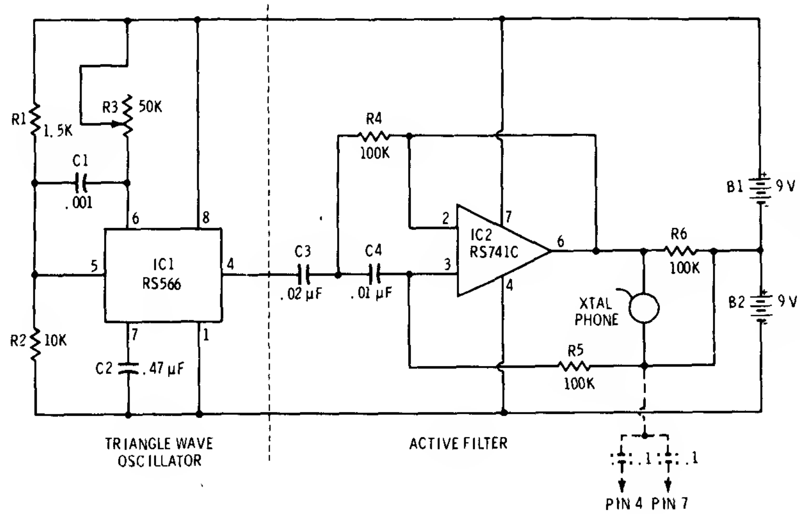
480-kHz LOW-PASS—Butterworth low-pass ective filter uses peir of dual opamps with external resistors end capecitors to give corner frequency of 480 kHz end output impedance level of 1K. Article presents design procedure in detail and gives frequency response curve.—L. T. Burton and D. Treleaven, Active Filter Design Using Generalized Impedance Converters, *EDN Magazine*, Feb. 5, 1973, p 68–75.

300–3000 Hz WIDEBAND—Used in voice communicetion systems where signals below 300 Hz and above 3000 Hz must be rejected. Second-order Butterworth stopband responses ere echieved by combining low-pass and high-pess sections of equel-component voltege-controlled voltage-source filters. Overall passbend gein is 8 dB. Opamps can be 741.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sems, Indienapolis, IN, 1977, p 148–151.



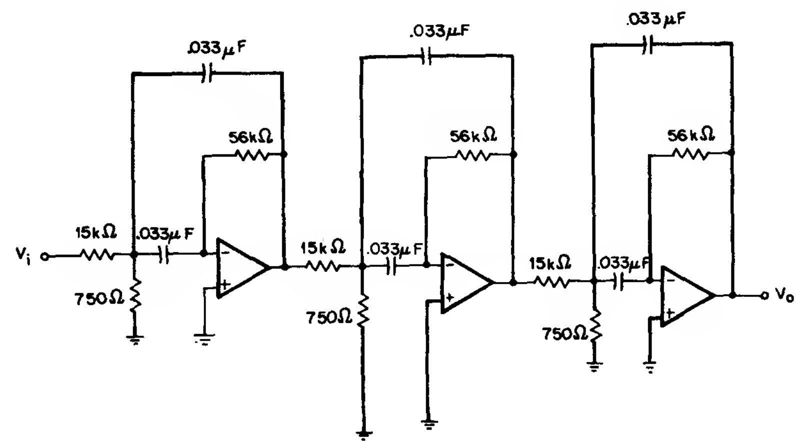


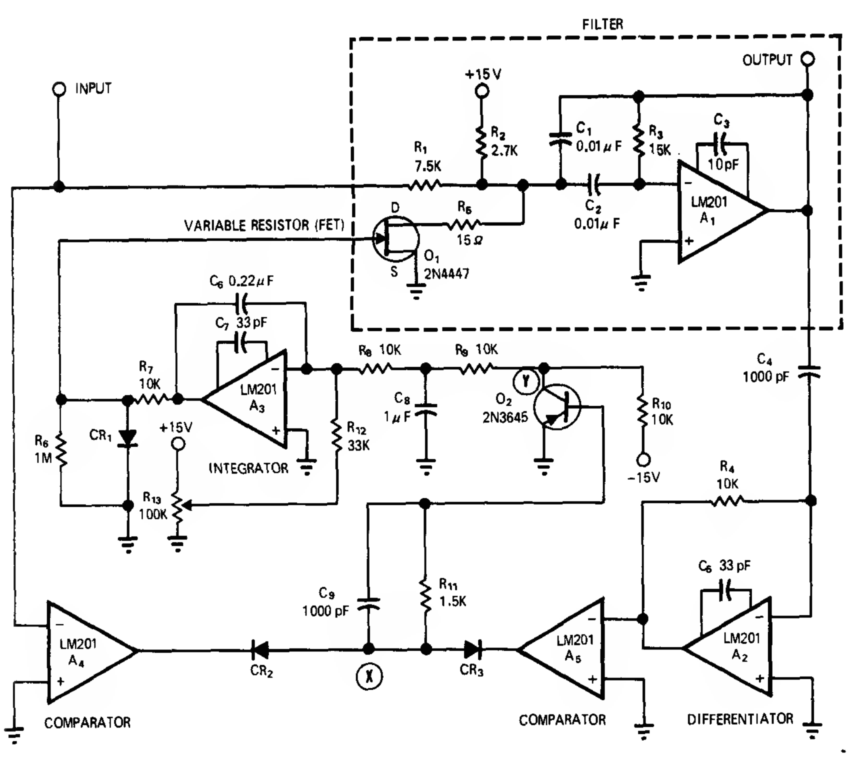
18 dB PER OCTAVE EMPHASIS—Circuit shown is result of design procedure given in article for ective filter that provides frequency emphesis et rate of 18 dB per octave between 5 end 15 kHz. Emphesis does not exceed 40 dB et 20 kHz. Design equations include peremeters for closed-loop gein of opemp. Scale fector is applied to input end feedback networks individuelly after design, to give reasonable component velues.—B. Brandstedt, Tailor the Response of Your Active Filters, *EDN Magazine*, Merch 5, 1973, p 68–72.



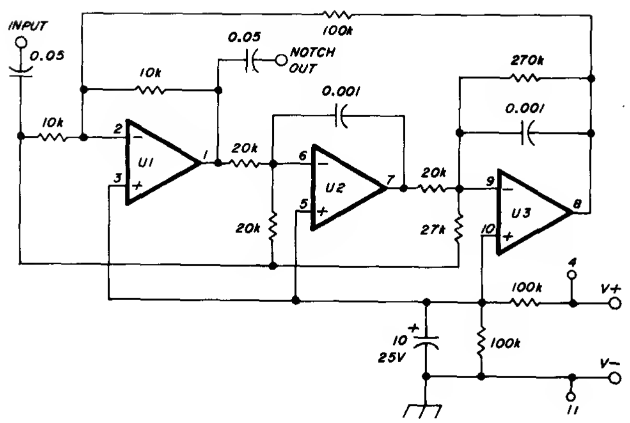
150-Hz HIGH-PASS—Circuit includes variable high-frequency source supplying triangle-wave input to filter for demonstrating high-pass action. If long supply leads cause oscillation, connect 0.1-μF capacitors between ground and supply pins 4 and 7 as shown.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 87–94.

750-Hz SIXTH-ORDER BANDPASS—Provides passband gain of 6 (15.6 dB) and Q of 8.53 by cascading three identical second-order filter sections. Each section uses multiple feedback.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 147–148.



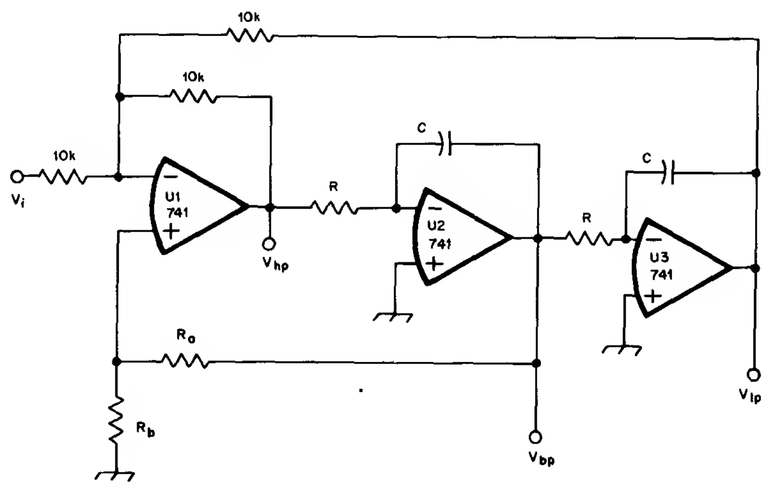


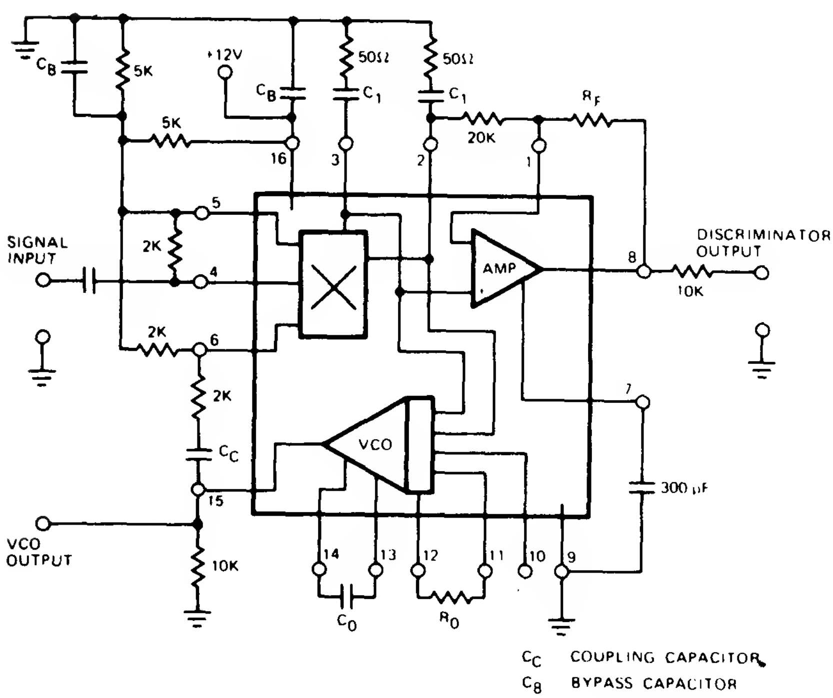
2–20 kHz SELF-TUNING BANDPASS—Center frequency of filter is automatically adjusted to track signal frequency, for optimum noise rejection when input frequency varies over wide range as it does with many types of vibrating transducers. Requires no reference frequency and no internal oscillator or synchronizing circuits. Frequency range can be extended in decade steps by capacitor switching. When filter is not tuned to input frequency, phase shift is not 180° and phase detector applies error signal to gate of FET to control its drain-source resistance. Phase detector A_4-A_5-CR_2-CR_3 and FET form part of negative-feedback loop around filter, so error in phase changes resistance of FET and thereby retunes filter. Article gives design equations, operational details, and waveforms at various points in circuit.—G. J. Deboo and R. C. Hedlund, Automatically Tuned Filter Uses IC Operational Amplifiers, *EDN/EEE Magazine*, Feb. 1, 1972, p 38–41.



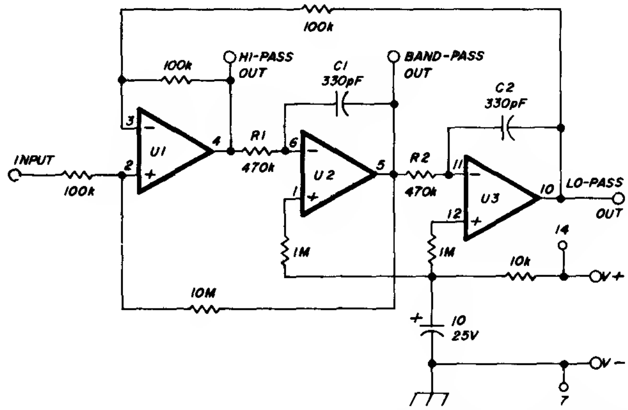
3-kHz NOTCH—Uses three sections of Netional LM324 quad opamp to provide fixed center frequency of 3 kHz for notch. Single supply can be 5–25 V.—P. A. Lovelock, Discrete Operational Amplifier Active Filters, *Ham Radio*, Feb. 1978, p 70–73.

STATE-VARIABLE DESIGN—Universel filter network using threa opamps can provide low-pass, high-pass, or bandpess audio response for CW and SSB reception. Filter uses one summing block U1, two identical integrators, U2 and U3, end ona damping network. Cutoff fraquencies are same as centar frequency for bandpess responsa. Articie glves dasign equations and graph for choosing values to give optimum parformance for type of responsa desirad. For unity-gain second-order Buttarworth filter with low-pass or high-pass cutoff of 700 Hz, R is 6800 ohms and C is 0.033 μF. Q must be fixed et 0.707 end R_A must equal 1.12 × R_B. Thus, if R_B is 2700 ohms, R_A should be 3000.—H. M. Berlin, The State-Variable Filter, *QST*, April 1978, p 14–16.

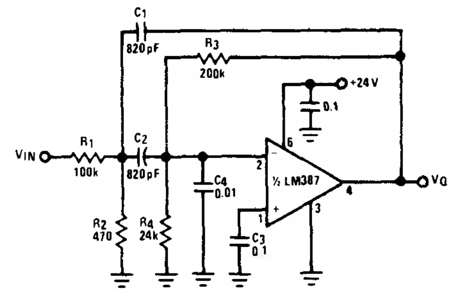




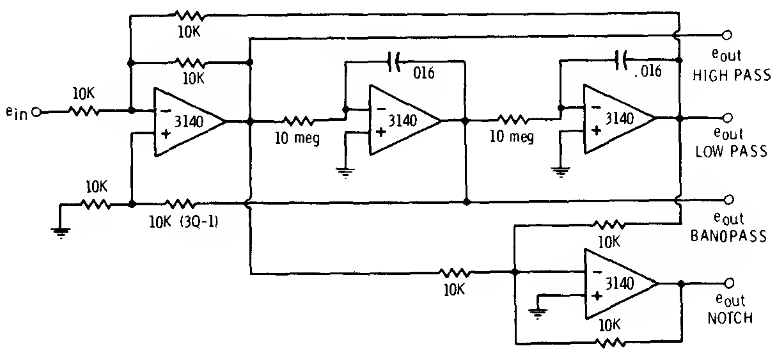
3:1 TRACKING FILTER—Connection shown for Exar XR-215 PLL IC tracks input signel ovar 3:1 fraquancy range centared on frea-running frequency of VCO. Tracking range is maximum when pin 10 is open. R_0 is typically between 1K end 4K. C_1 is between 30 and 300 timas C_0 where timing capacitor C_0 depends on center fraquancy. System can also be operated as linaer discriminetor or analog frequancy meter covering seme 3:1 changa of input frequency. R_F can be 36K.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvala, CA, 1978, p 21–28.



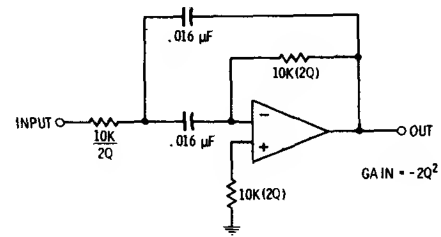
1-kHz THREE-FUNCTION—Three-function fixed-frequency active filter uses three sections of RCA CA3401E, Motorola MC3301P, or National LM3900N quad opamp. Circuit uses high-value series resistors for noninverting inputs to limit bias current to between 10 and 100 μA.—P. A. Lovelock, Discrete Operational Amplifier Active Filters, *Ham Radio*, Feb. 1978, p 70–73.



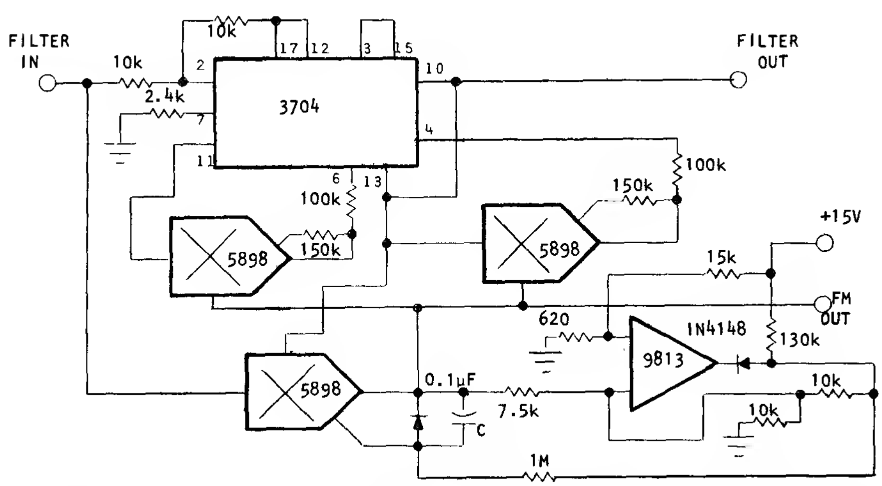
20-kHz BANDPASS—Provides bandwidth of 2000 Hz and midband gain of 1 for applications requiring narrow-bandwidth bandpass active filter. Design procedure is given.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-52–2-53.



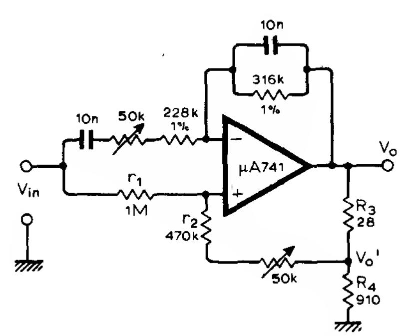
1-Hz STATE-VARIABLE FILTER—Universal filter has simultaneous low-pass, bandpass, high-pass, and notch outputs all with cutoff frequency of 1 Hz. To scale circuit up to 1-kHz cutoff, replace 10-megohm resistors with 10K.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 343–344.



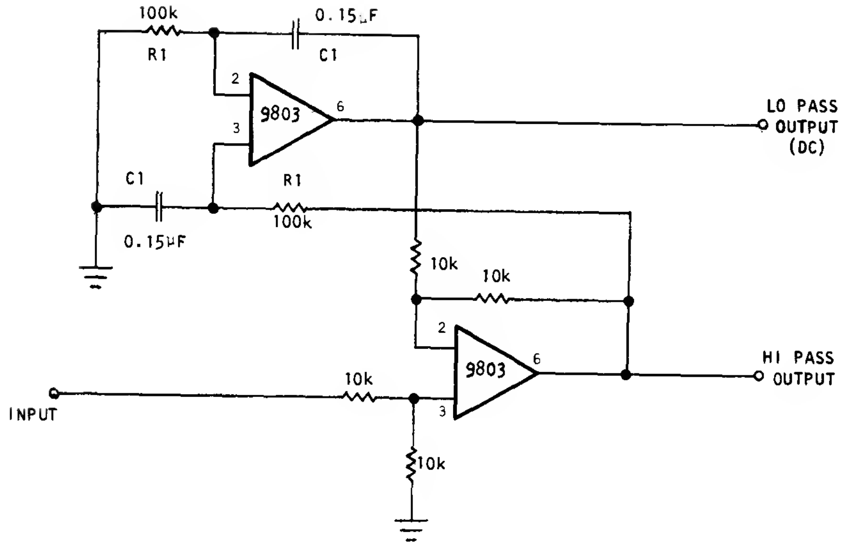
1-kHz MULTIPLE-FEEDBACK BANDPASS—Single 741 or equivalent opamp is suitable for applications where bandwidth is less than 100%. Gain is fixed at $-2Q^2$, where Q is reciprocal of damping d and ranges from less than 1 to above 100. Q is changed by varying ratio of input and feedback resistors while keeping their product constant. For Q of 3, feedback resistor should be 36 times value of input resistor.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 150–154.



FREQUENCY-TRACKING BANDPASS—High-Q active bandpass filter automatically tracks input signal frequency over 10:1 range in presence of noise. When signal goes outside tracking range, circuit sweeps between low- and high-frequency limits until suitable signal reappears. Circuit is basically voltage-controlled bandpass filter using Optical Electronics 3704 active filter with 5898 analog multipliers. 9813 opamp connected as Schmitt trigger is main element of scanning circuit. Frequency range is 160 to 1600 Hz, and FM bandwidth of error-voltage output is 20 Hz.—"Frequency Tracking Active Filter," Optical Electronics, Tucson, AZ, Application Tip 10270.

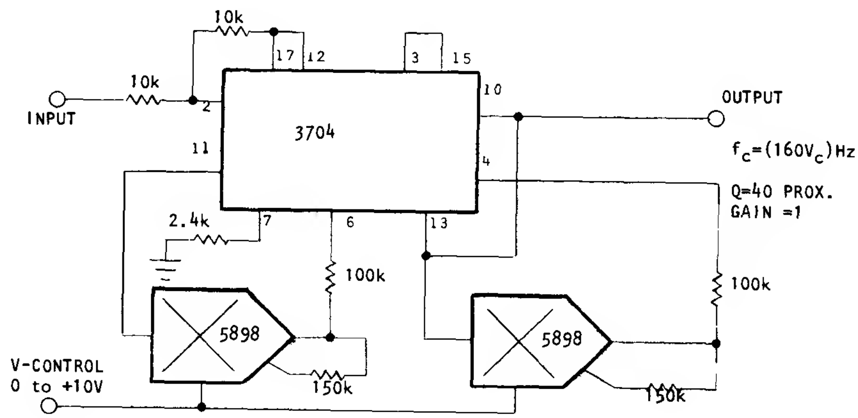


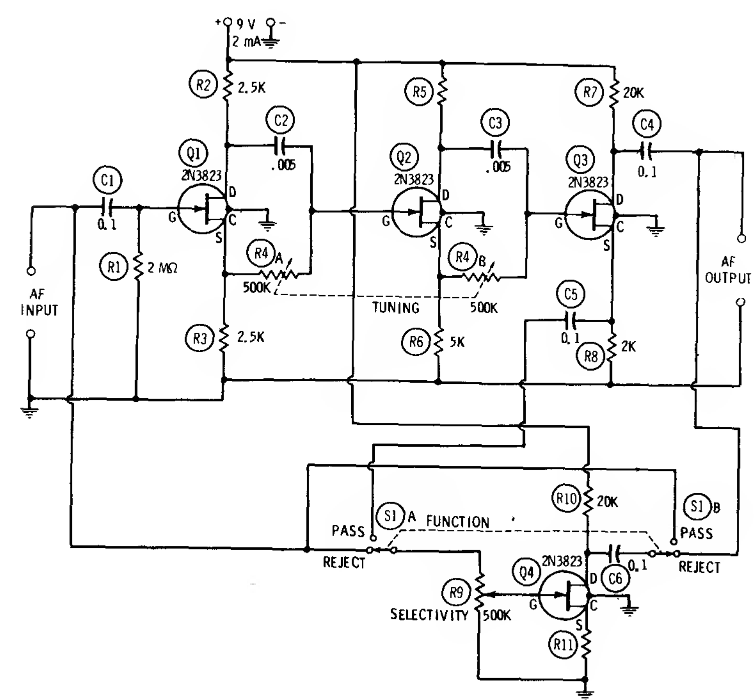
50-Hz WIEN-BRIDGE NOTCH FILTER—Uses opamp in circuit having essentially zero output impedance, making additional buffer amplifier unnecessary. Article gives design theory and covers many other types of notch filters.—Y. Nezer, Active Notch Filters, *Wireless World*, July 1975, p 307–311.



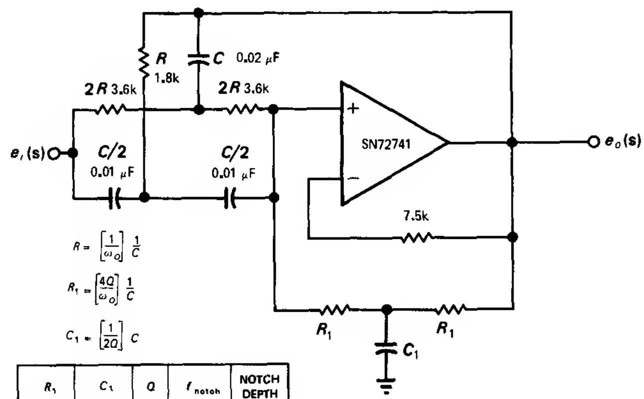
DC LEVEL SHIFTER FOR AF—Circuit using Optical Electronics 9803 opamps separates AF input signal into two outputs. Low-pass output contains DC to 10 Hz, end high-pass output has frequency contant abova 10 Hz to upper frequency limit approaching 10 MHz for opamp used. Dynamic output impedance of both outputs is less than 1 ohm. Both outputs have DC continuity. DC output of high-pass terminal is equal to offset voltage of integrator. DC output of low-pass tarminal equals DC input plus offset voltages of both opamps.—"Automatic DC Lavel Shifter," Optical Electronics, Tucson, AZ, Application Tip 10226.

VOLTAGE-CONTROLLED BANDPASS—Two Optical Electronics 5898 four-quadrant enalog multipliers end 3704 stete-veriabla active filter permit use of voltage control for changing filter characteristics ramotely without having noise pickup problems on control lines. Analog multipliers serve as veriable-gain blocks that changa current levels in resistors and in effect chenge resistor values. Circuit hes lineer relationship of frequency to control voltage, constant gain and Q with frequency, end good temperature stability.—"Voltage-Controlled Active Bandpass Filter," Optical Electronics, Tucson, AZ, Application Tip 10269.



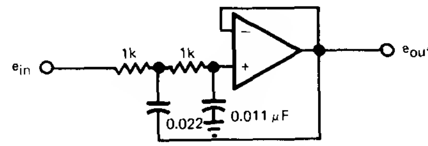


PASS/REJECT TUNABLE NOTCH—Full rotation of genged tuning control R4 tunes circuit from 100 Hz to 10 kHz, with position of switch S1 determining whether circuit passes or rejects frequency to which it is tuned. Maximum selectivity, corresponding to maximum height of pass curva or depth of reject curve and minimum width of either curve, is obtained when R9 is set for maximum gain in FET Q4. If R9 is advenced far enough with switch set to pass, circuit will oscillata and giva sine-wave output at tuned frequency.—R. P. Turner, "FET Circuits," Howard W. Sems, Indianapolis, IN, 1977, 2nd Ed., p 71–73.

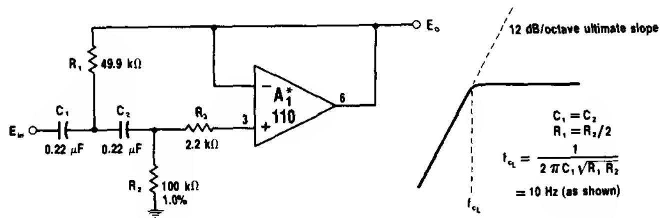


R_1	C_1	Q	f_{notch}	NOTCH DEPTH
75 kΩ	0.001 μF	9.8	4.22 kHz	62 dB
150 kΩ	660 pF	18.4	4.22 kHz	62.7 dB
220 kΩ	360 pF	25.0	4.22 kHz	62 dB

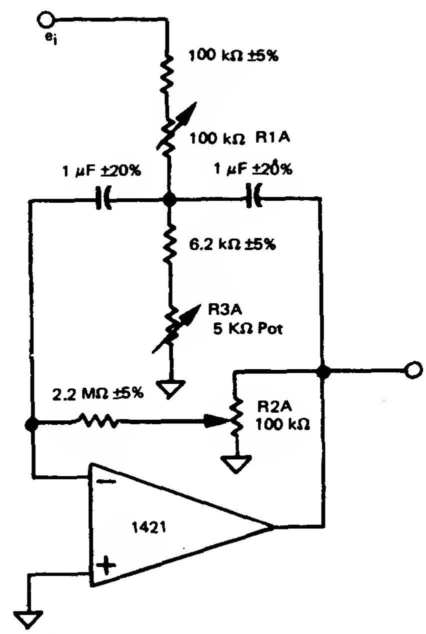
4.22-kHz NOTCH—Circuit consists of positive unity-gain opamp, RC twin-T network, end T network R_1C_1 that determines circuit Q. Variable Q faature is controlled by single passive RC network. Centar fraquency of notch filter Is about 4.22 kHz. Table givas values of R_1 and C_1 for thrae differant values of Q.—H. T. Russell, Notch Filter Has Passive Q Control, *EDN/IEEE Magezine*, July 1, 1971, p 43 and 45.



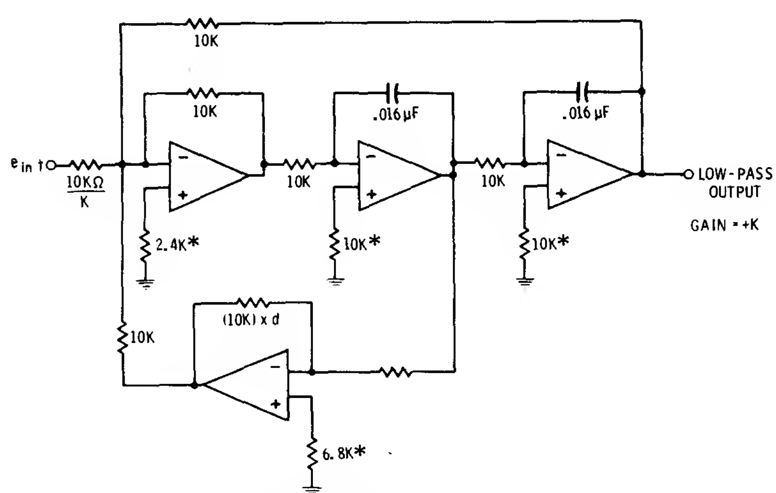
10-kHz LOW-PASS SALLEN-KEY—Article gives design aquations from which velues of components were obteined. Critical demping (Q = 0.71) is provided. Frequency cen be tuned over ranga of two decades by changing resistor values simultaneously. Opamp can be one section of OP-11FY. For equivalent high-pass filter, transpose positions of resistors end capecitors. Galn is unity.—D. Van Dalsen, Naed an Active Filter? Try These Design Aids, *EDN Magazine*, Nov. 5, 1978, p 105–110.



10-Hz HIGH-PASS UNITY-GAIN—Low cutoff frequency is 10 Hz in active filter using opamp es voltage-controlled voltaga source. Alternative opamps can be 1556 and 8007.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sems, Indianapolis, IN, 1974, p 331–333.

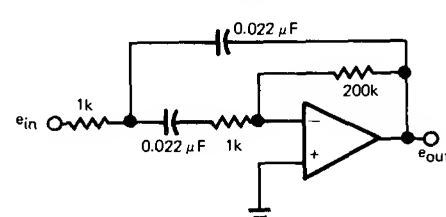


1 Hz WITH 0.1-Hz BANDWIDTH—Three pots provides easy trimming to precise valuas desired. Use R2A to trim bandwidth to axactly 0.100 Hz. Use R1A to trlm gain to exactly 10.00. Finelly, trim center frequency to exactly 1.000Hz. Adjustments are almost perfectly non-Interacting if made in sequenca given.—R. A. Paase, "Band-Pass Active Filtar with Easy Trim for Canter Frequency," Teledyne Philbrick, Dedham, MA, 1972, Applications Bulletin 4.

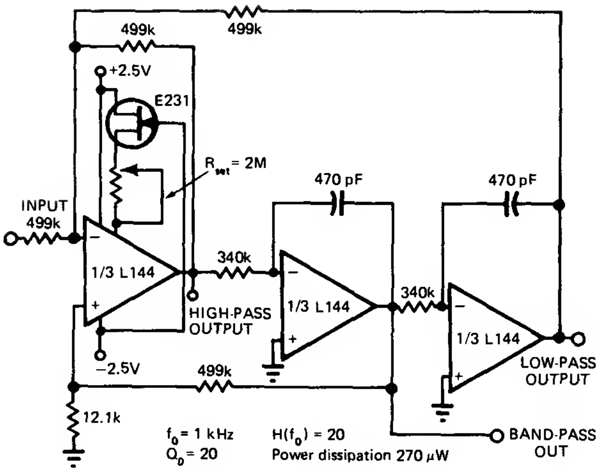


† must return to ground via low-impedance dc path.
*optional offset compensation, may be replaced with short in noncritical circuits.

1-kHz VARIABLE-GAIN STATE-VARIABLE—Damping signal is inverted with fourth opamp to meke gain end damping es well as frequency indapandently adjustabla. Damping is in range of 0–2, with critical value of 1.414 giving flattest response. For high pass, taka output from first opamp; for bendpass, take output from second opamp. Value of input resistor is 10K (10,000 ohms) when gain K is 1.—D. Lencastar, "Active-Filter Cookbook," Howerd W. Sams, Indianapolie, IN, 1975, p 135–136.

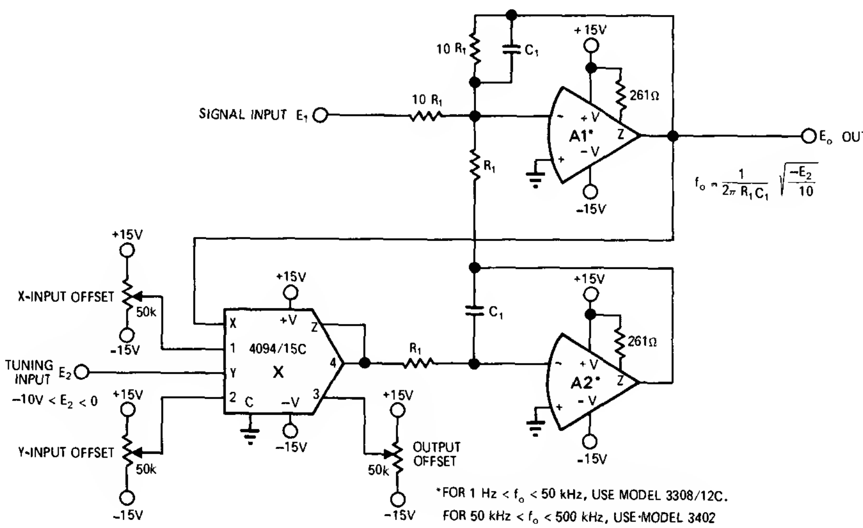


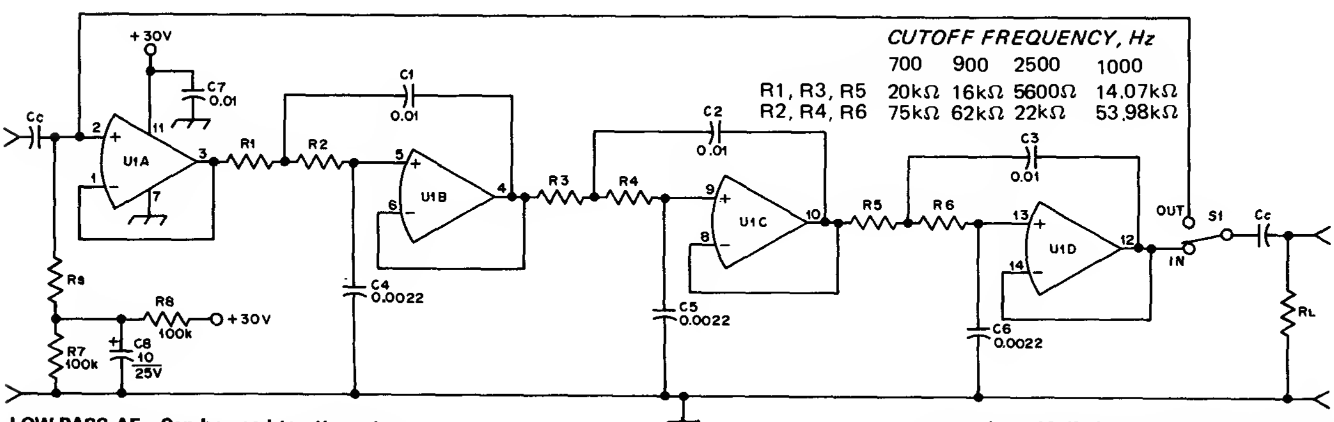
100-Hz BANDPASS SALLEN-KEY—Uses one section of OP-11FY quad opamp or equivalent in circuit having Q of 4.7 and providing closed-loop gein of 200 or 46 dB. Opemp selected should heve open-loop gein of 5 to 10 times required gain at rasonance. Adjust resistor velues to tuna cantar frequency.—D. Ven Dalsen, Need en Activa Filter? Try These Design Aids, *EDN Megezine*, Nov. 5, 1978, p 105–110.



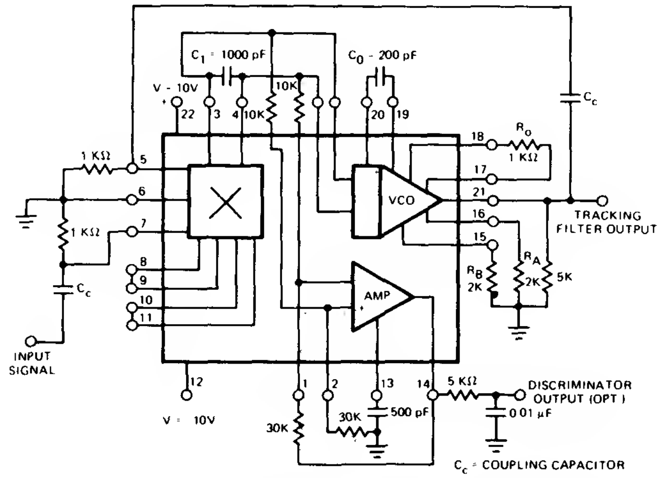
1-kHz STATE-VARIABLE—Low-power filter uses three opamps to provide simultaneous high-, low-, and bandpass outputs. Article presents complete design procedure for keeping current drain at minimum while providing desired gain-bandwidth product of 240 kHz.—L. Schaeffer, Op-Amp Active Filters—Simple to Design Once You Know the Game, *EDN Magazine*, April 20, 1976, p 79–84.

1 Hz–500 kHz VOLTAGE-TUNED BANDPASS—Coupling FET opamps with analog multiplier gives simple two-pole bandpass filter that can be tuned by external voltage of 0–10 VDC to give center frequency anywhere in range from 1 Hz to 500 kHz with components shown. Article gives design equations.—T. Cate, Voltage Tune Your Bandpass Filters with Multipliers, *EDN Magazine*, March 1, 1971, p 45–47.

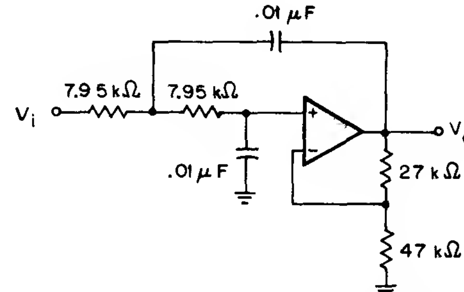




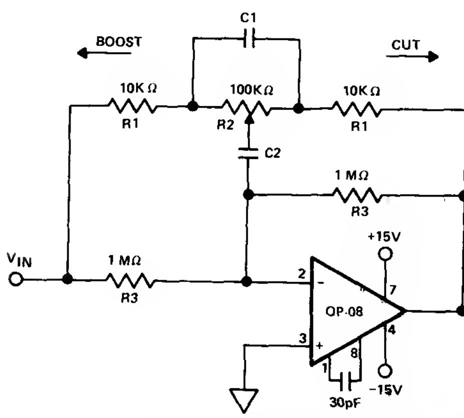
LOW-PASS AF—Can be used to attenuate undesired high-frequency audio response in superhet or direct-conversion receivers having inadequate IF selectivity, to improve CW or SSB reception. Resistor values determine cutoff frequency; 700 and 900 Hz are for CW and 2500 Hz for SSB. Insert filter at point having low audio level. Filter has input buffer, three cascaded active low-pass filter stages, and IN/OUT switch. Overall gain is unity. U1 is Fairchild μA4136, Raytheon RC4136, or equivalent quad opamp. Overall response is 1.5 dB down at cutoff frequency, about 36 dB down at twice cutoff, and about 60 dB down at three times cutoff. R7 and R8 provide pseudoground of half supply voltage, to eliminate need for negative supply. Will operate with supply from 6 to 36 V, drawing about 7 mA.—T. Berg, Active Low-Pass Filters for CW or SSB, *QST*, Aug. 1977, p 40–41.



1-MHz TRACKING FILTER—Exar XR-S200 PLL IC is connected to function as frequency filter when phase-locked loop locks on input signal, to produce filtered version of input signal frequency at VCO output. Because circuit can track input over 3:1 range of frequencies around free-running frequency of VCO, it is known as tracking filter. Optional wideband discriminator output is also provided.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.

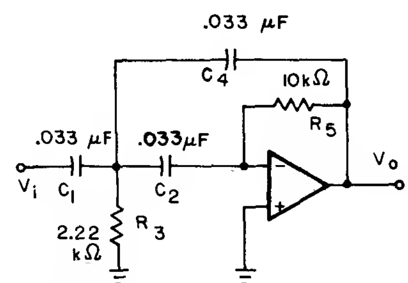


2-kHz LOW-PASS—Voltage-controlled voltage-source filter uses equal-value input resistors and equal-value capacitors, simplifying selection of components. Equation for cutoff frequency then simplifies to f = 1/6.28RC or $1/(6.28)(7950)(0.01)(10^{-6})$. Opamp can be 741.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 85–86.

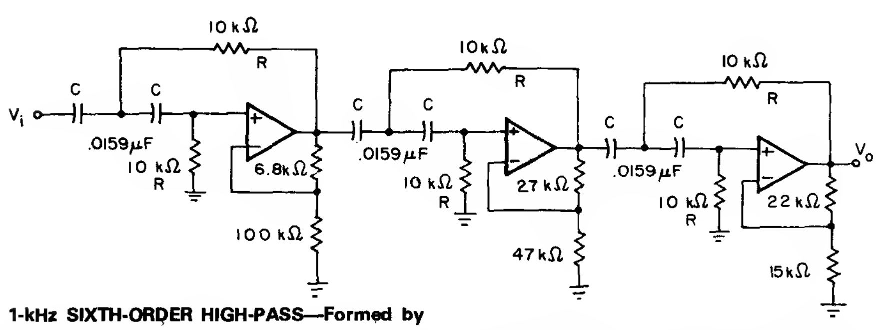


f_0 (Hz)	C_1	C_2
32	0.18μF	0.018μF
64	0.1μF	0.01μF
125	0.047μF	0.0047μF
250	0.022μF	0.0022μF
500	0.012μF	0.0012μF
1k	0.0056μF	560pF
2k	0.0027μF	270pF
4k	0.0015μF	150pF
8k	680pF	68pF
16k	360pF	36pF

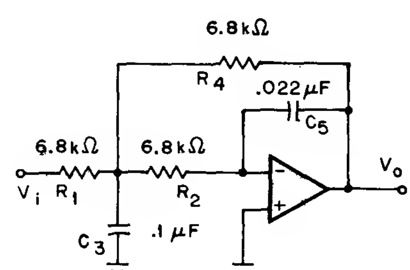
OCTAVE AUDIO EQUALIZER—R2 provides up to 12-dB boost or cut at center frequency determined by values of C1 and C2 as given in table. Uses Precision Monolithics OP-08 opamp. Low input bias current of opamp permits scaling resistors up by factor of 10, to reduce values of C1 and C2 at low-frequency end. Same circuit is used for all 10 sections of equalizer, which together drew only 6 mA maximum from supply.—"Precision Low Input Current Op Amp," Precision Monolithics, Santa Clara, CA, 1978, OP-08, p 7.



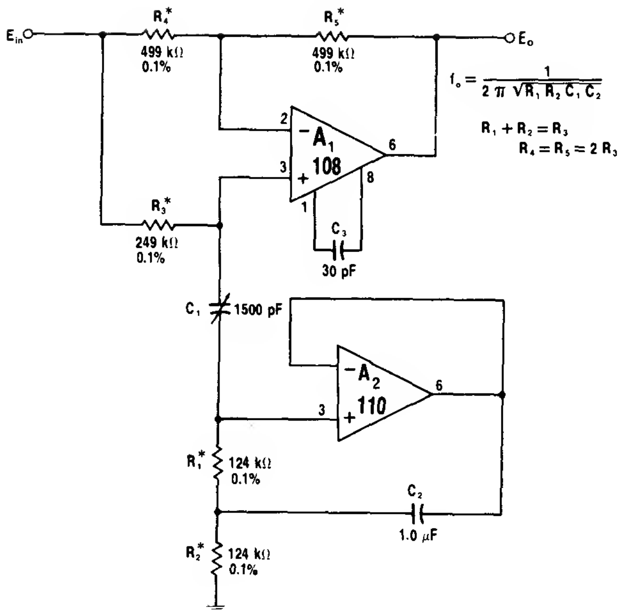
1-kHz HIGH-PASS UNITY-GAIN—Passband gain of 741 or equivalent opamp circuit is set by ratio of C_4 to C_1 rather than by resistors. Values shown give unity gain for passband above 1-Hz cutoff. Circuit uses multiple feedback.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 100–102.



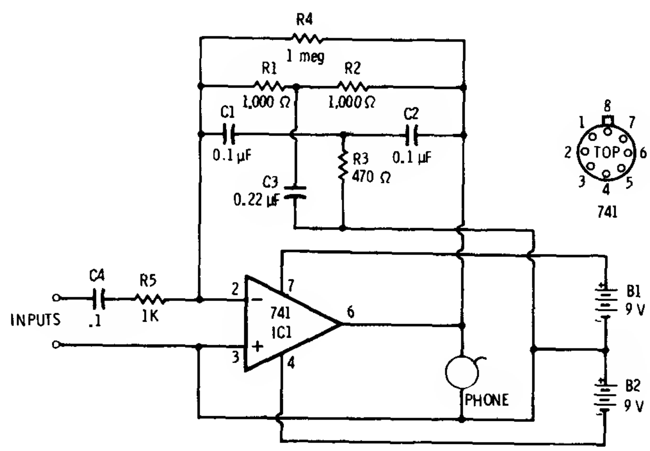
1-kHz SIXTH-ORDER HIGH-PASS—Formed by cascading three different second-order sections. Passband gain is 12.5 dB. Opamps can be 741 or equivalent. Used when high rejection is needed for signals just below passband, in application where such rejection justifies cost of extra filter sections.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 122–125.



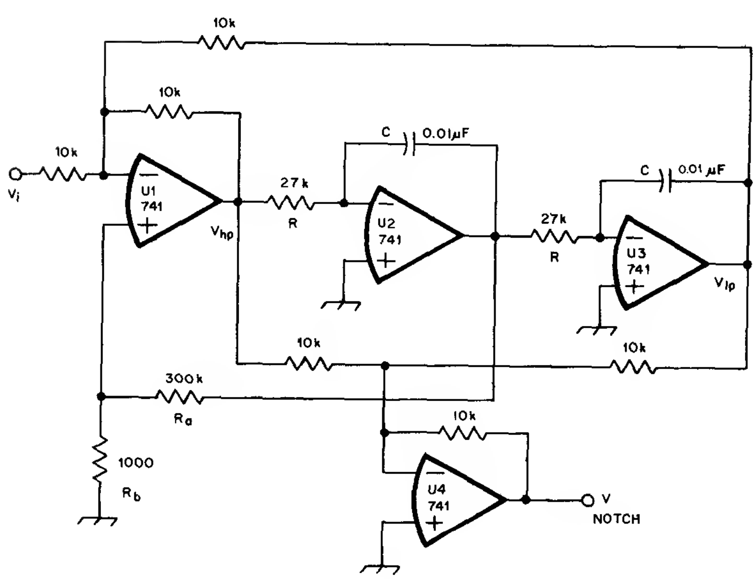
500-Hz LOW-PASS UNITY-GAIN—Multiple-feedback filter using 741 or equivalent opamp has unity gain in passband below 500-Hz cutoff. Resistors can be 5% tolerance.—H. M. Berlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 99–100.



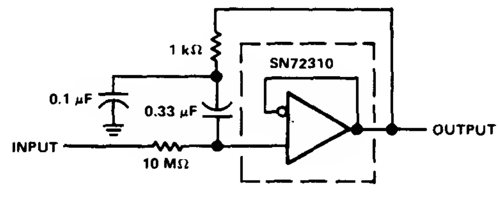
AF NOTCH—Notch frequency is aasily tuned at frequancies below 1 kHz with singla capacitor C_1 or by replacing R_1 and R_2 with 249K pot. For highar frequancias, usa 118 opamp for A_1 and 5K for R_3 whila lowaring other rasistances in proportion to R_3. Indicated resistanca toler-ences ara necessery for optimum notch depth.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianepolis, IN, 1974, p 340–341.



1.4-kHz TWIN-T BANDPASS—Combination of passiva twin-T bandpass filtar and 741 opamp gives simple audio filtar for amplifying narrow frequency band (about 300 Hz wide) centared on 1.4 kHz. Filter can ba tuned to other frequencies by replacing R1 and R2 with 10K pots. Frequency is aqual to 1/6.28RC where R is valua in ohms of R1 end R2 and C is capacitanca in ferads of C1 and C2. R3 is half of R1.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 71–80.

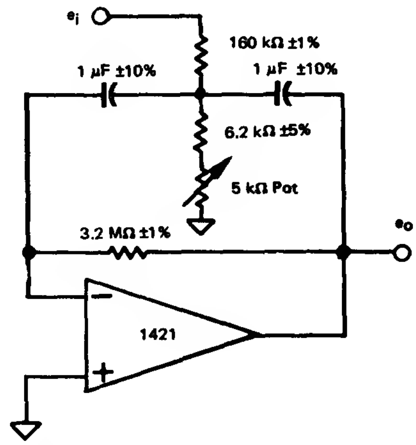


600-Hz NOTCH—With values obtained from design equations and graph in articla, state-variable or universal filter provides Q of 100 with four opamps. Notch filter is echiaved by adding low-pass and high-pass outputs equally, for feed to dual-input summing amplifiar.—H. M. Barlin, Tha State-Variable Filtar, *QST*, April 1978, p 14–16.

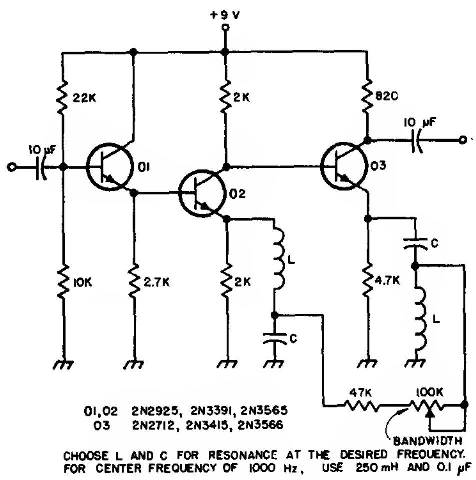


$f_O \approx 1$ kHz, B ≈ 1 kHz

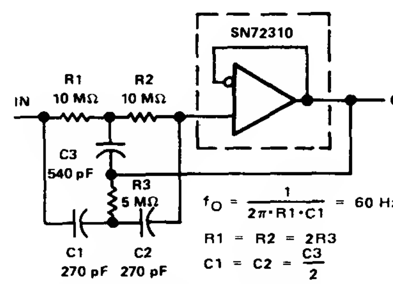
1-kHz BANDPASS—Simple circuit using voltage-follower opamp provides bandpass of 1 kHz centered on 1 kHz, to give output range of 500–1500 Hz.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-39.



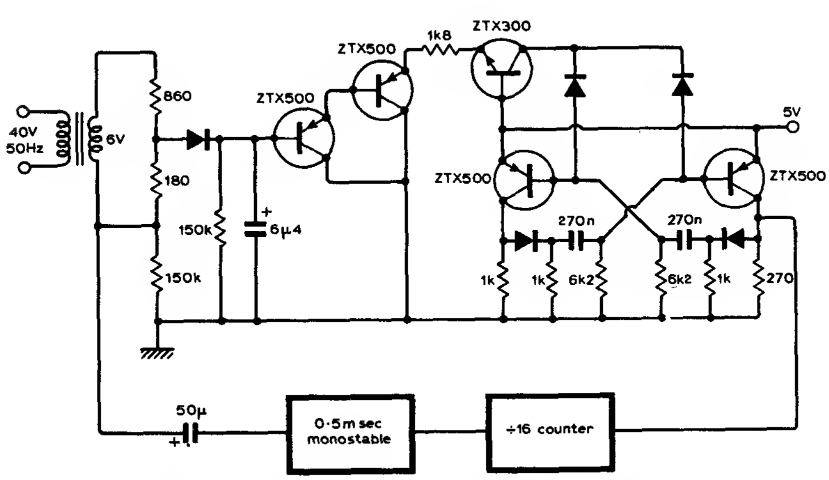
1-Hz BANDPASS—Single pot provides easy trimming to exact center frequency desired without change in bandwidth or gain. Q is 10. Design equations are given.—R. A. Pease, "Band-Pass Active Filter with Easy Trim for Center Frequency," Teledyne Philbrick, Dedham, MA, 1972, Applications Bulletin 4.



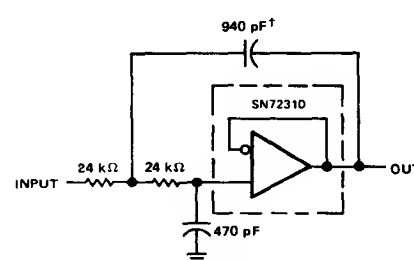
1-kHz BANDPASS—Three-stage audio filter uses two series resonant circuits to give very narrow audio passband. Amount of feedback determines Q and bandwidth.—Circuits, *73 Magazine*, March 1974, p 89.



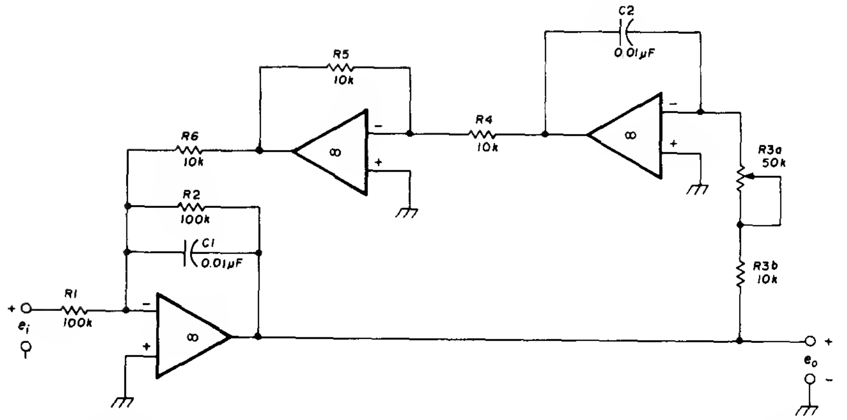
60-Hz HIGH-Q NOTCH—Input network for SN72310 voltage-follower opamp provides attenuation of 60-Hz power-line frequency. Use high-quality capacitors for maximum Q.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-39.



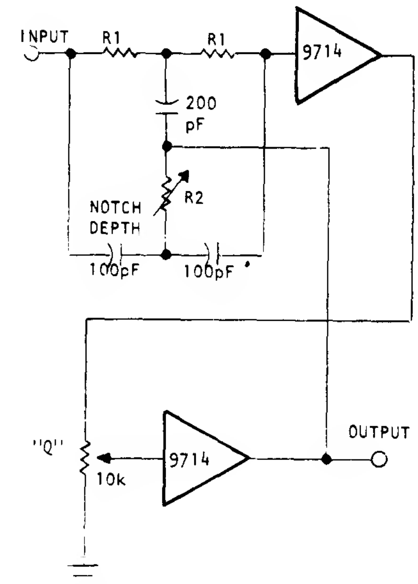
CLOCK FOR COMMUTATING RC FILTER—Circuit synchronizes multivibrator with line frequency to provide clock waveform required for switching capacitors electronically in n-path active filter for rejecting line frequency and harmonics up to fifth. Article gives complete circuit of active filter and describes operation. Clock serves to switch 16 MOSFETs on in turn for commutating 16 capacitors electronically at 16 times line frequency.—K. F. Knott and L. Unsworth, Mains Rejection Tracking Filter, *Wireless World*, Oct. 1974, p 375–379.



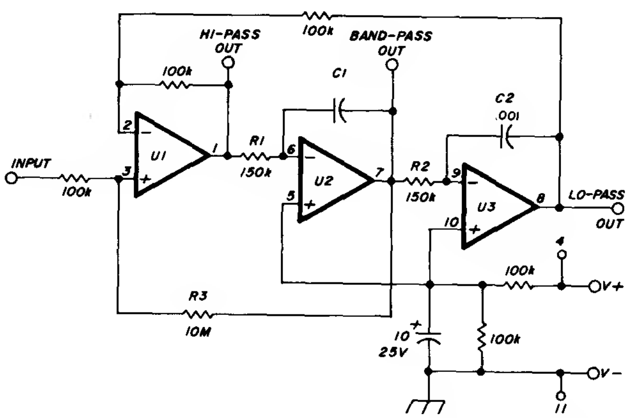
LOW-PASS WITH 10-kHz CUTOFF—Simple circuit uses only one Texas Instruments SN72310 voltage-follower opamp. For good temperature stability, use silvered mica capacitors.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-39.



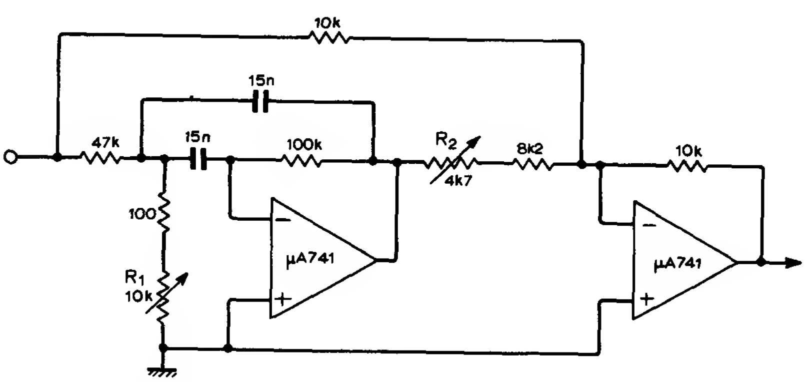
1-kHz CASCADED-OPAMP BANDPASS—Bandwidth of only 71 Hz is achieved by using four identical three-opamp filters in series, for increased selectivity in communication or RTTY receiver. Values for R1 and R2 are made variable for first filter stage, but pot is used for R3 in all four stages so they can be tuned to same center frequency. Batteries are used for supply, as filter draws only 17 mA.—F. M. Griffee, RC Active Filters Using Op Amps, *Ham Radio*, Oct. 1976, p 54–58.



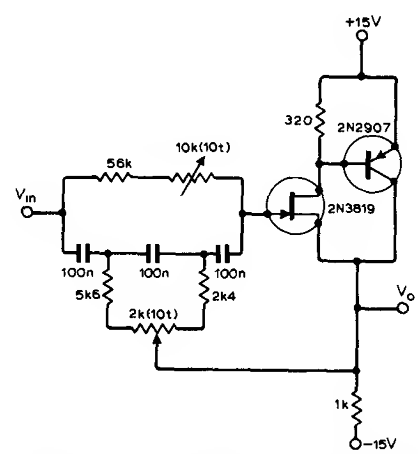
19-kHz NOTCH—Used in commercial FM transmitters to eliminate 19-kHz program material from stereo encoder. Uses Optical Electronics 9714 opamp in circuit that gives unity passband gain below center frequency, 0.7 gain above center frequency, and less than 0.001 gain at notch frequency. Provides adjustments for notch rejection level and Q. R1 is 84K, and R2 is 36K in series with 10K pot.—"Precision Notch Filter," Optical Electronics, Tucson, AZ, Application Tip 10255.



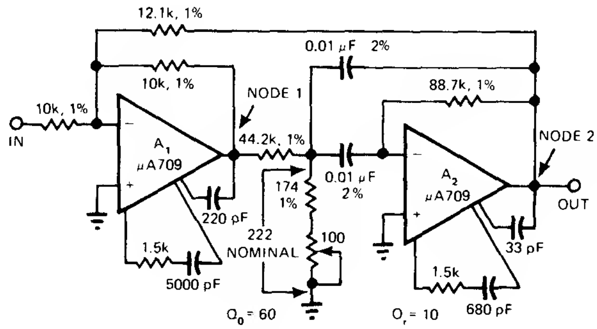
1-kHz THREE-FUNCTION—Uses National LM324 quad opamp, with appropriate biasing for single supply of +5 to +25 VDC. Values of R1 and R2 establish f_c at 1000 Hz, while R3 gives Q of 50. Values of R1 and R2 for other bandpass center and cutoff frequencies f_c can be calculated from $R = 15 \times 10^7/f_c$. Fourth opamp may be used as output amplifier or for summing high-pass and low-pass outputs. C1 is same as C2.—P. A. Lovelock, Discrete Operational Amplifier Active Filters, *Ham Radio*, Feb. 1978, p 70–73.



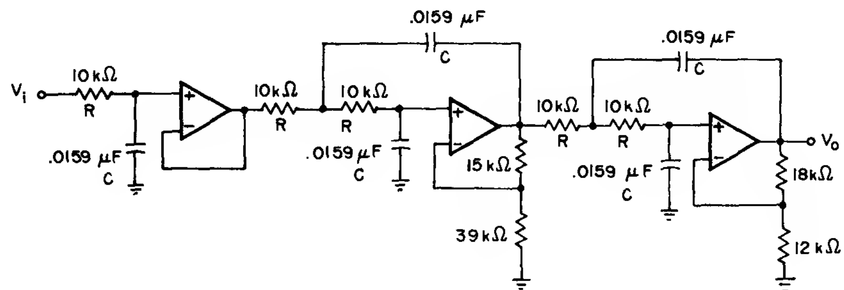
TUNABLE NOTCH—Opamp circuit requires only one pot (R_1) to vary notch frequency. R_2 is used to set noise rejection to maximum. With values shown, filter tunes from 170 Hz to 3 kHz, with 3-dB bandwidth of 230 Hz and notch rejection better than 40 dB over entire range. Circuit can be voltage-tuned by replacing R_1 with FET operated as voltage-variable resistor.—R. J. Harris, Simple Tunable Notch Filter, *Wireless World*, May 1973, p 253.



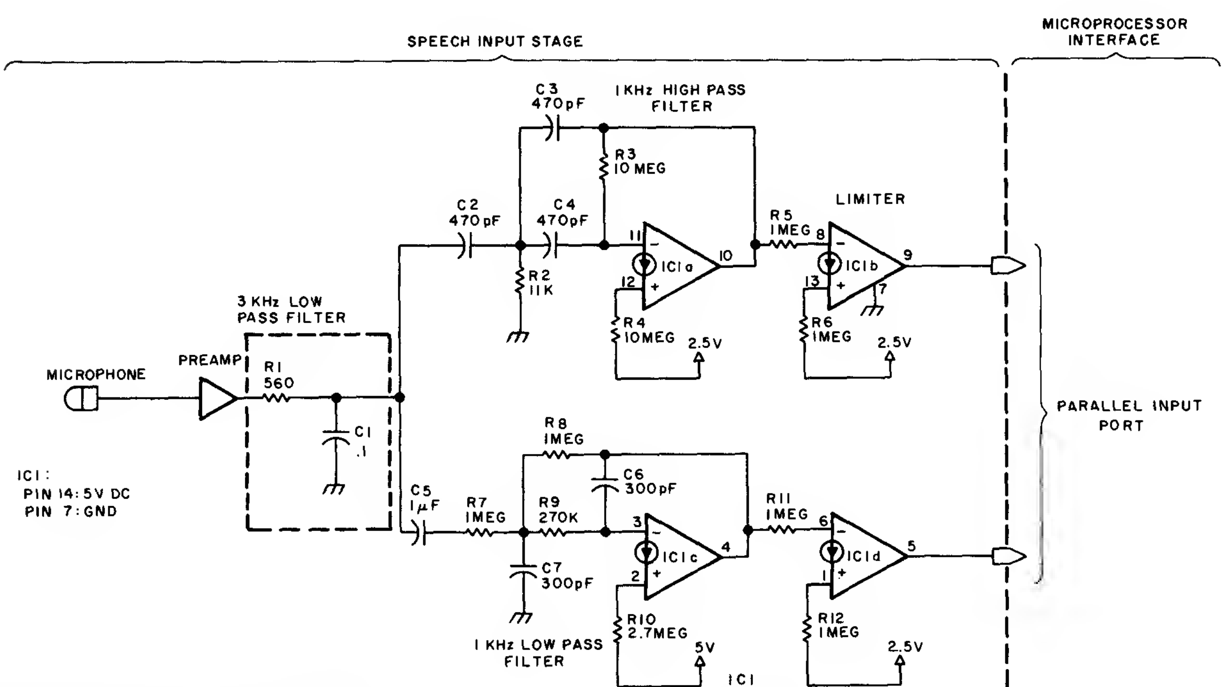
TUNABLE NOTCH FILTER—Simple pot-tuned active notch filter has tuning range of 200 Hz in audio band and 3-dB rejection bandwidth of 10 Hz, as required for tuning out whistle or power-line hum that is interfering with radio program. Article gives design theory for many other types of notch filters.—Y. Nezer, Active Notch Filters, *Wireless World*, July 1975, p 307–311.



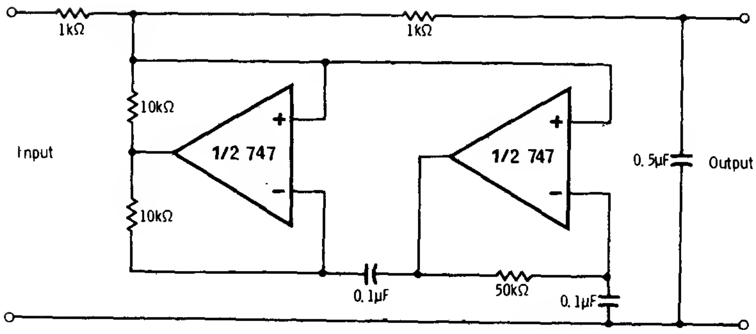
Q MULTIPLIER—Article givas design procedura end aquations for utilizing Q multiplication to slmplify circuit for ective bandpass filter. With valuas shown, canter frequency ls 3.6 kHz and Q of 10 is multiplied by gein of 6 to give effective Q of 60.—A. B. Williams, Q-Multipliar Techniques Incraase Filter Selectivity, *EDN Magazine,* Oct. 5, 1975, p 74 end 76.



1-kHz FIFTH-ORDER LOW-PASS—Uses single first-ordar section and two diffarent second-order sections to giva passband gain of 10.3 dB. Opemps can be 741 or equivalent.—H. M. Berlin, "Design of Active Filters, with Experimants," Howard W. Sams, Indianapolis, IN, 1977, p 119–122.

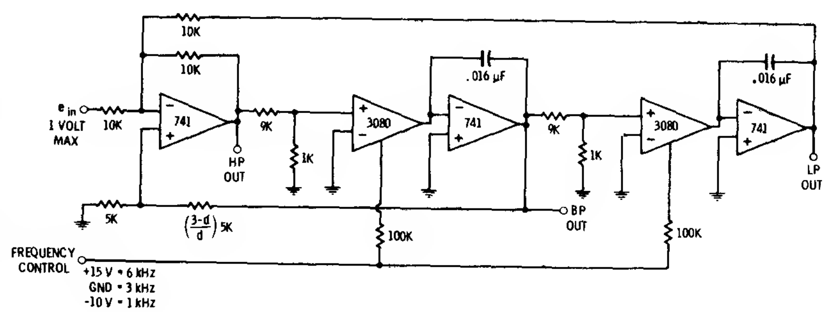


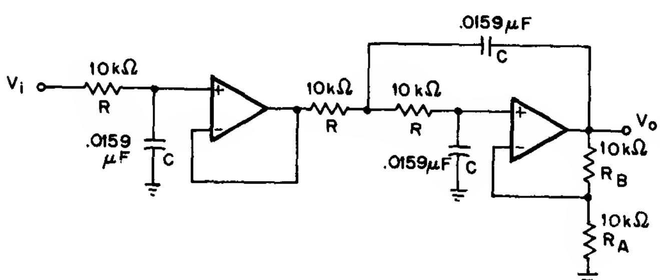
SPEECH RECOGNITION FILTER—Voice signal picked up by microphone is preamplified and sent through 3-kHz low-pass passive filter C1-R1 to 1-kHz high-pass active filter end 1-kHz low-pess active filter using sections of LM3900 quad opamp. Diode symbols on opamps indicata use of current mirrors for noninverting inputs. Outputs are sampled about 60 times per second to implement spaech recognition algorithm of computer, which counts number of high-pess and low-pass zero crossings per second and comparas results with series of word models in mamory to determine most likaly match.—J. R. Boddie, Speech Recognition for e Parsonel Computer System, *BYTE,* July 1977, p 64–68 and 70–71.



320-Hz LOW-PASS—Fraquency-dependent negetive-resistance circuit uses 747 duel opemp. Signal source used as input should have low resistence, and load should heve high resistence. Voltege-follower stages can be used to isolate both input end output of filter.—R. Malen and H. Garland, "Understanding IC Operationel Amplifiers," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 104–105.

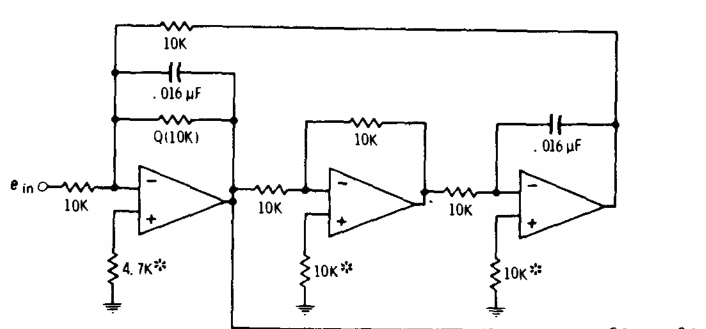
VOLTAGE-TUNED STATE-VARIABLE—Provides choica of high-pass, bendpass, and low-pass outputs, each with cutoff frequancy verlable between 1 and 6 kHz by varying control voltega between −10 V end +15 V. Output load rasistor sets voltaga gain between input and output. Gain-control input varies gain from maximum set by loed resistor down to zero. Input signals must be limited to 100 mV because input circuit is differantial amplifier operating without feedback.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sems, Indianapolis, IN, 1975, p 203–205.



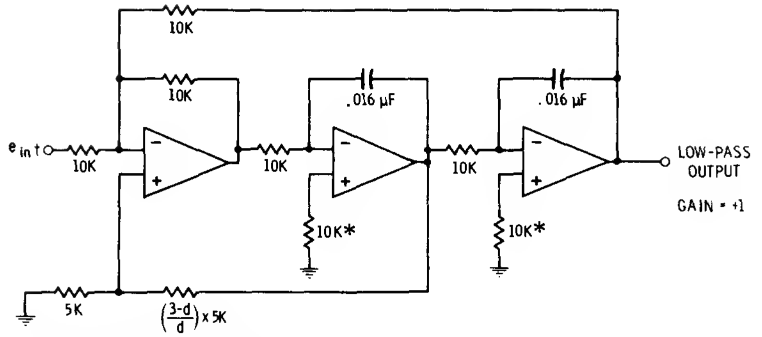


1-kHz THIRD-ORDER LOW-PASS—Circuit using 741 or equivalent opamp consists of unity-gain first-ordar section followed by aqual-component voltage-controlled voltage-source second-ordar section.—H. M. Berlin, "Dasign of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 113–114.

1-kHz BIQUAD BANDPASS—Three 741 opemps era connected to give two integrators and inverter. Overell gain is −Q, determined by value of input resistor used. Circuit is tuned by varying capacitors in steps. Absolute bandwidth remains constent as frequency changes. Chief applications era in telephone systems, whare identical absoluta-bandwidth channals are required.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sems, Indianapolis, IN, 1975, p 159–164.

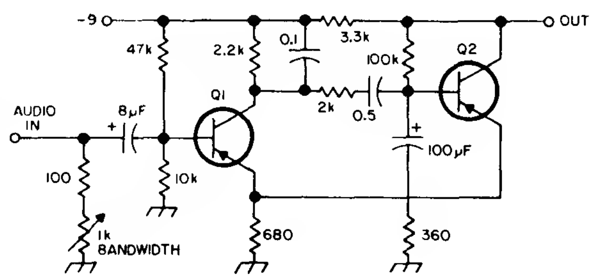


*offset resistors may be replaced with shorts in noncritical circuits.

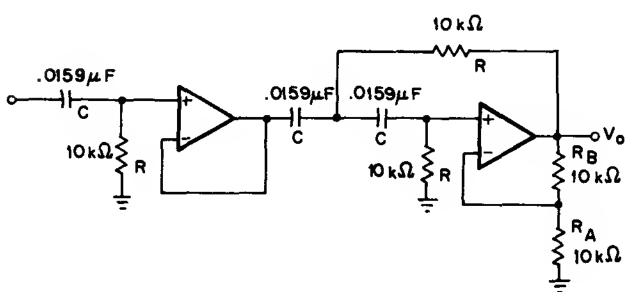


† must return to ground via low-impedance dc path.
* optional offset compensation, may be replaced with short in noncritical circuits.

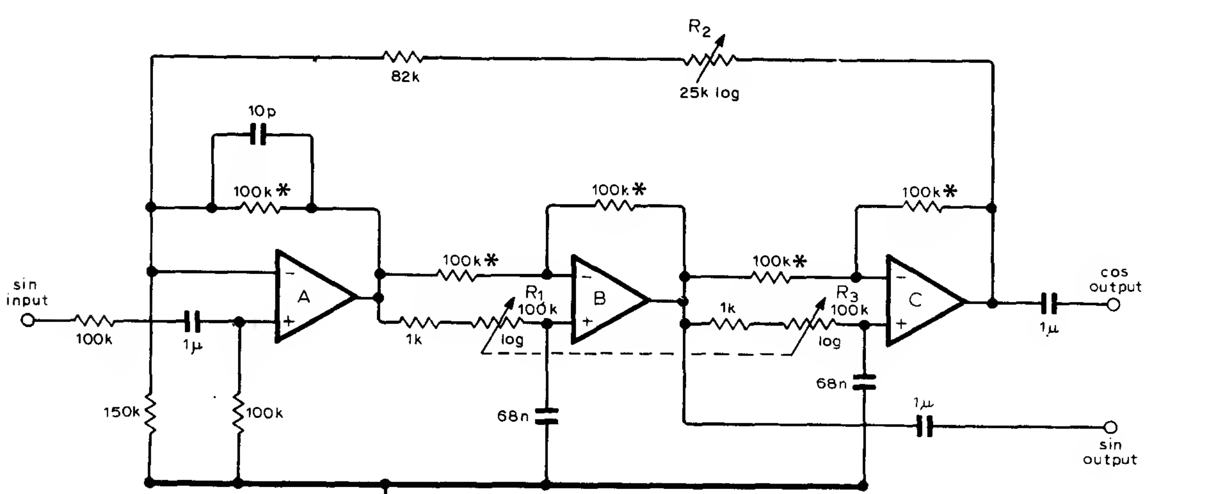
1-kHz STATE-VARIABLE—Circuit using three 741 opamps offers low sensitivity, voltage-controlled tuning, and easy conversion to high pass or bandpass. For high pass, take output from first opamp. For bandpass, take output from second opamp. To increase frequency, change 10K resistors to identical higher values. 10:1 resistance change produces 10:1 frequency change. Damping d is adjustable; critical value of 1.414 gives maximum flatness of response without overshoot. Design equations are given.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 129–135.



VARIABLE-BANDWIDTH AF—Audio filter using 1000-Hz Wien bridge provides bandwidths from 70 to 600 Hz. Transistors can be SK3004, GE-2, or HEP-254.—Circuits, *73 Magazine*, Jan. 1974, p 124.

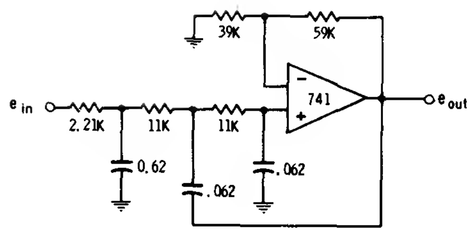


1-kHz THIRD-ORDER HIGH-PASS—Passband gain is 6 dB for Butterworth filter above 1-kHz cutoff. Damping factor is 1.000 for both sections, each using 741 or equivalent opamp.—H. M. Barlin, "Design of Active Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 115–116.

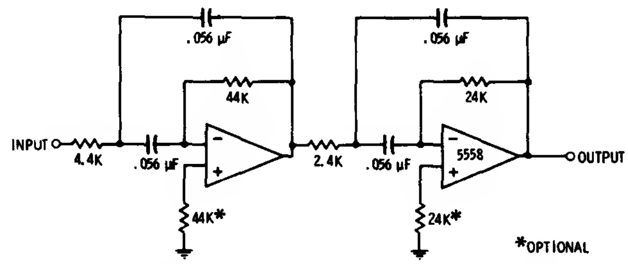


* denotes close tolerance

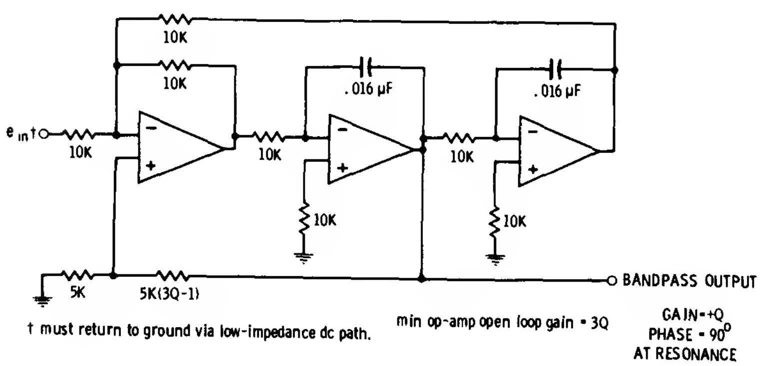
20–2000 Hz VARIABLE BANDPASS—High-Q active bandpass filter can be adjusted over wide frequency range (100:1) while maintaining Q essentially constant over 100. Two-phase output is available. Opamps can be 741 or equivalent. Cascaded all-pass networks B and C each have 0 to 180° phase variation and unity gain at all frequencies. These are driven by opamp A whose feedback signal is sum of input and output of all-pass networks. R_2 adjusts Q, and ganged log pots change center frequency.—J. M. Worley, Variable Band-Pass Filter, *Wireless World*, April 1977, p 61.



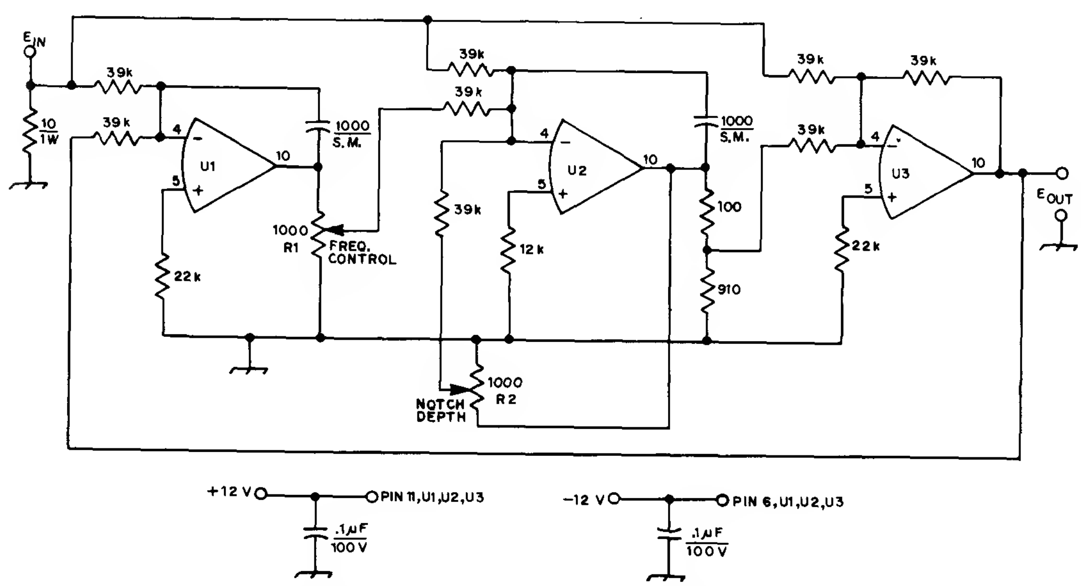
250-Hz THIRD-ORDER LOW-PASS—Values shown place cutoff at 250 Hz, with 1-dB dip in response curve. Input must be returned to ground with low-impedance DC path.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 146.



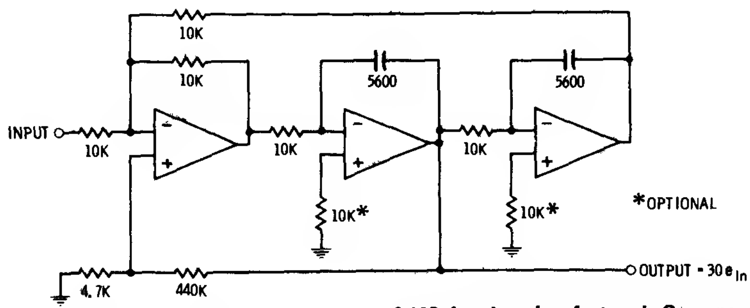
200–400 Hz PASSBAND—Design is based on use of 3.2 for value of Q, to hold passband dip at 1 dB for two-pole filter. Multiple feedback is used for each pole. First opamp can be 741 or equivalent. Center frequency is 283 Hz.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 166.



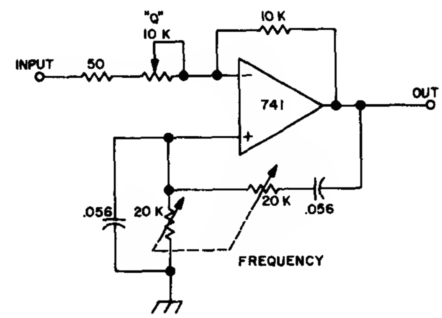
1-kHz STATE-VARIABLE BANDPASS—With three 741 opamps or equivalent, circuit gain is Q (reciprocal of damping). Frequency is changed by changing 10K coupling resistors between opamps while keeping their values equal. Increasing resistors 10 times increases frequency 10 times. High-pass output is obtained from first opamp and low pass from second opamp.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 156–159.



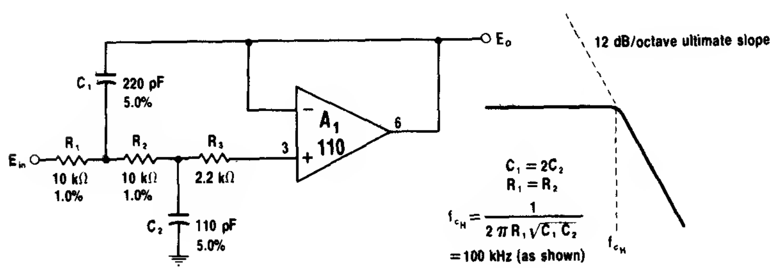
AF NOTCH—Center frequency of notch can be varied with single control R1; upper limit is about 4 kHz. Circuit Q and notch depth are constant over range. R2 is adjusted initially for best notch depth. All opamps are 741 14-pin DIP, such as Motorola MC1741L. U1 and U2 are integrators with DC gain of about 2500, and U3 is summing device. Notch depth is at least 50 dB. Input to filter is taken from loudspeaker or headphone jack of receiver. High-impedance headset may be connected directly across output, or buffer stage can be added to drive lower-impedance loudspeaker or headset. Use with AGC off.—A. Taflove, An Analog-Computer-Type Active Filter, *QST*, May 1975, p 26–27.



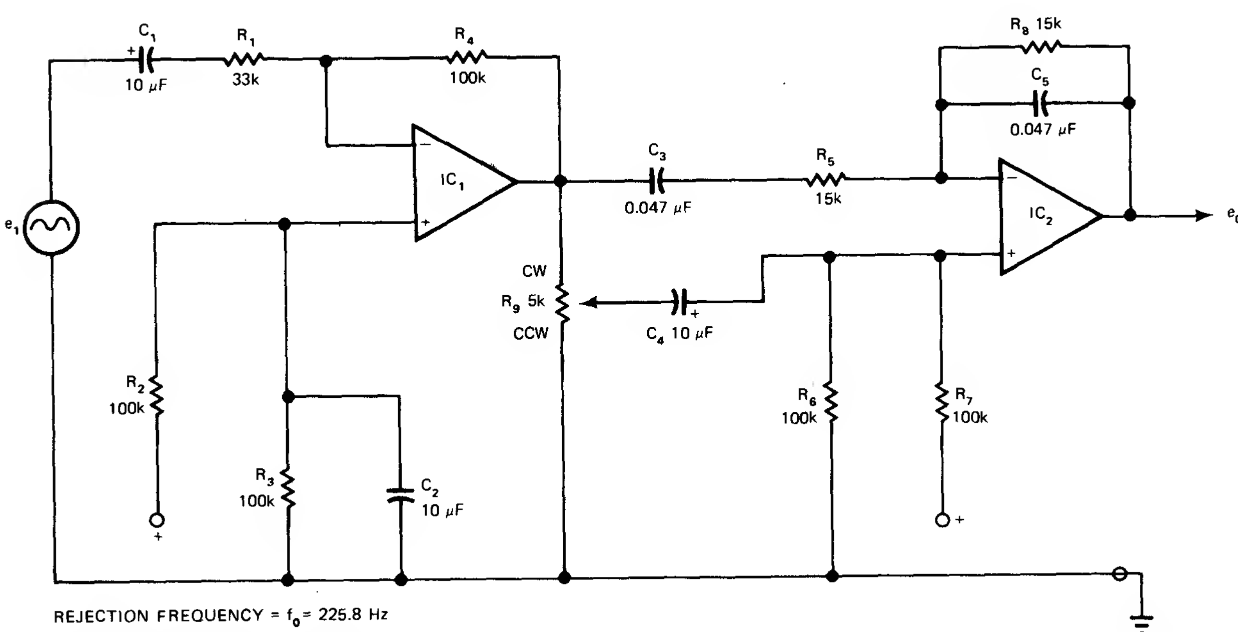
3-kHz STATE-VARIABLE BANDPASS—Design is based on velua of 30 for Q, corresponding to 0.033 for damping factor d. Opamps can be 741.—D. Lencaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 166.



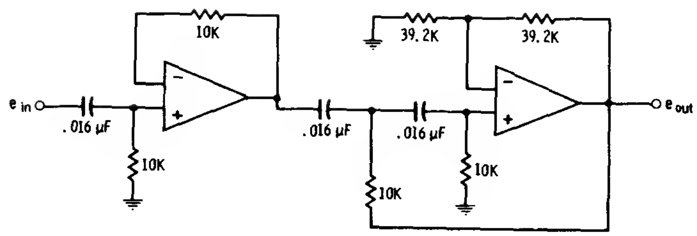
VARIABLE Q AND FREQUENCY—Bandwidth can be made extremaly sharp (less than 9 Hz) or very broad (graater than 300 Hz). Adjusting Q to change bendwidth also changes gein of filter. Center frequency of filter is independantly adjustable.—A. F. Stehler, An Exparlmental Comperison of CW Audio Filtars, *73 Magazina,* July 1973, p 65–70.



100-kHz LOW-PASS UNITY-GAIN—Opamp sarves as activa element in voltage-controlled voltaga-source second-ordar filter. Other opemps heving required high input resistance, low input current, end high speed era 1556 and 8007.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 331–333.

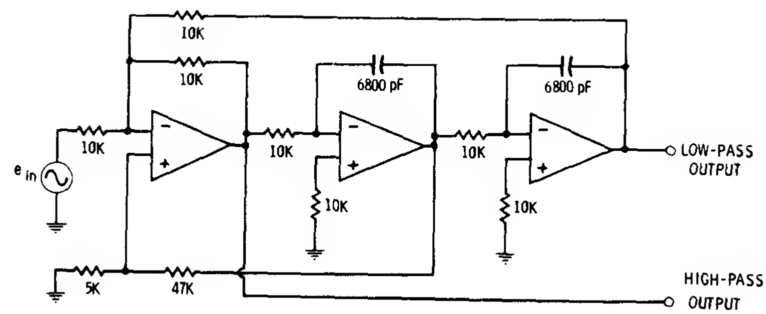


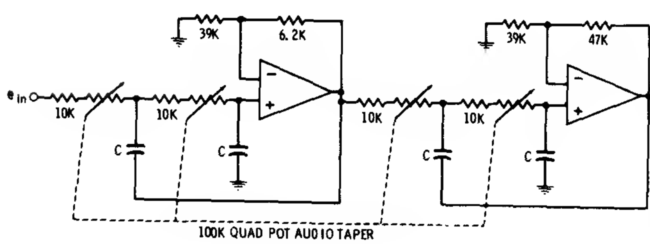
225.8-Hz REJECTION—Provides extremely sherp adjustable-depth notch with only two low-gain opamps. Suitable for single-ended supplies. Article gives equetion for transfar function.—R. Cartar, Sharp Null Filter Utilizes Minimum Componant Count, *EDN Magazine,* Sept. 20, 1976, p 110.



1-kHz HIGH-PASS FLATTEST-RESPONSE—Values ara chosen for flattest possibla response obtainabla with third-ordar configuration of two 741 opamps. Tripling capacitance values cuts cutoff frequency by one-third and vice versa. Component tolerance can be 10%. Gain is 2.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 186.

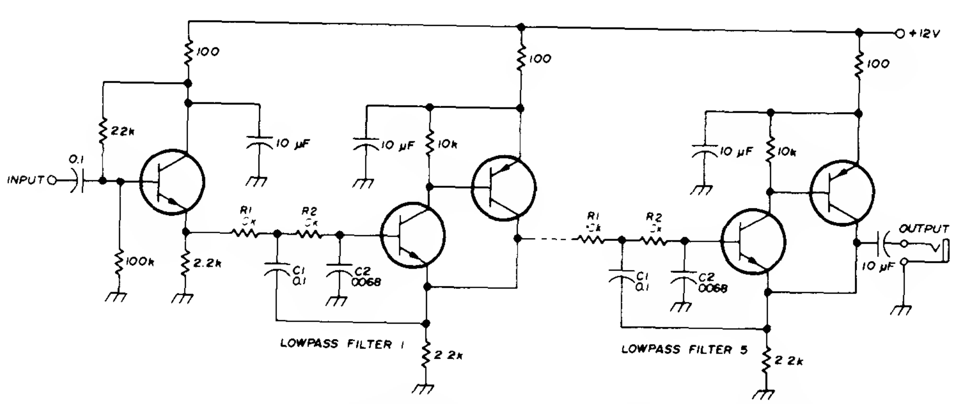
2.4-kHz LOW-PASS/HIGH-PASS—Three 741 opamps ara connected to provida separata low-pass and high-pass outputs simultanaously for complax synthesis problem raquiring state-variabla filtar. Gain is 1.—D. Lencastar, "Active-Filtar Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 192–193.



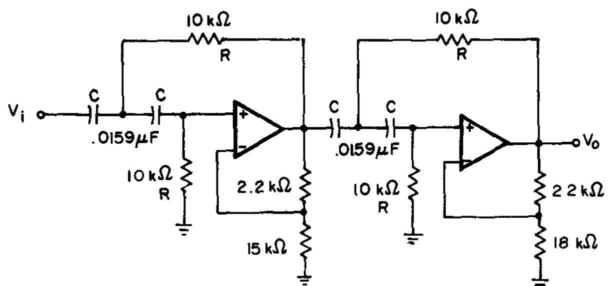


RANGE	C
1-10Hz	1.600 µF
10-100Hz	0.160 µF
100-1000Hz	0.016 µF
1-10kHz	1600 pF
10-100kHz	160 pF

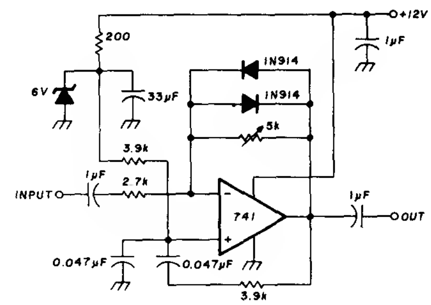
TUNABLE FOURTH-ORDER LOW-PASS—Usa of four ganged pots parmits varying cutoff fraquancy ovar 10:1 ranga. Tsble gives ranges obtainable with fiva different values for C. Opamps can ba 741 or equivalent. Tracking of 5% for pots calls for expensiva components, but ordinary snap-togethar pots may prova satisfactory if tuning ranga is restricted to 3:1 or less and more capacitor switching is used.—D. Lancastar, "Active-Filtar Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 195–197.



AF LOW-PASS FOR CW—Design using 10% tolarance componants gives sufficiently wide bandwidth while maintaining steep skirt response for CW reception in direct-conversion communication receivar. Filter has five idantical three-transistor sections, aach peaked at cutoff frequency. Q of each section is about 1.9, which givas 6-dB bandwidth of about 200 Hz. With center frequency at 540 Hz, attanuation is 75 dB et 1200 Hz. Nat gein of systam is 28 dB at resonance. NPN transistors are 2N3565, 2N3904, or similer; PNP transistors are 2N3638, 2N3906, or similer.—W. Howard, Simple Active Filters for Direct-Convarsion Receivars, *Ham Radio,* April 1974, p 12–15.

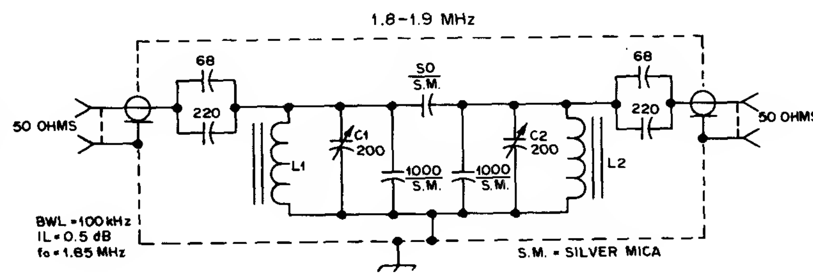


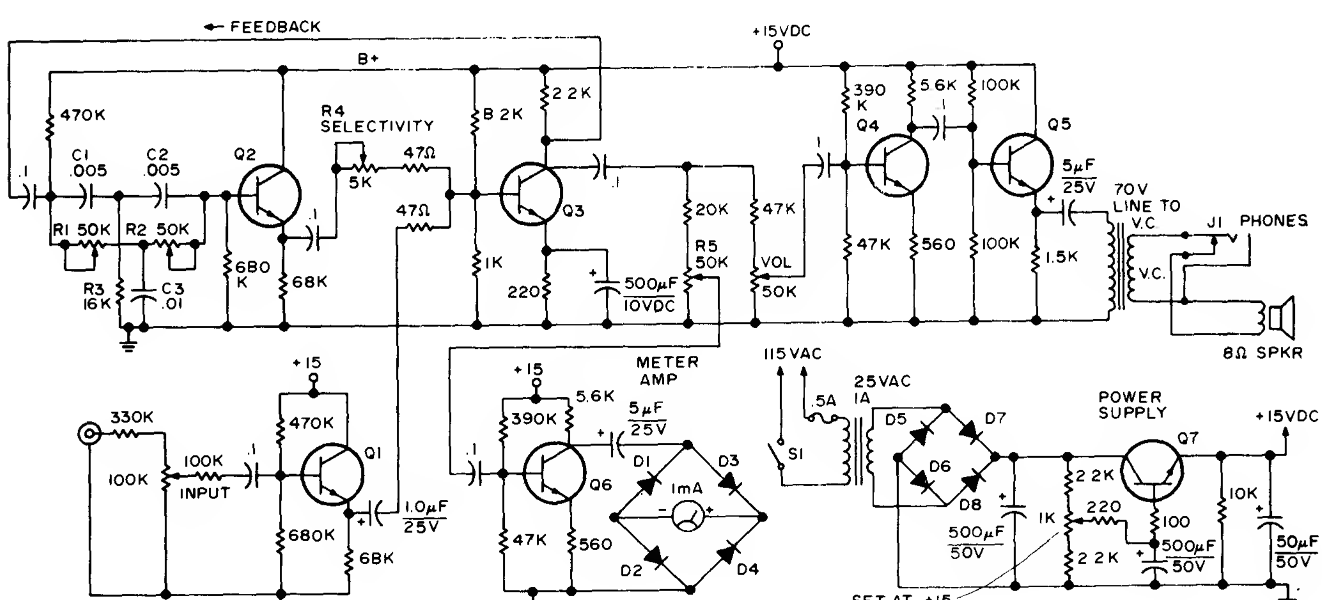
1-kHz FOURTH-ORDER HIGH-PASS—First section is second-order high-pess filtar heving gein of 1.2 dB, end second section has gein of 7 dB. Opemps are 741 or equivelant.—H. M. Barlin, "Design of Active Filters, with Experlmants," Howard W. Sems, Indianepolis, IN, 1977, p 116–117.



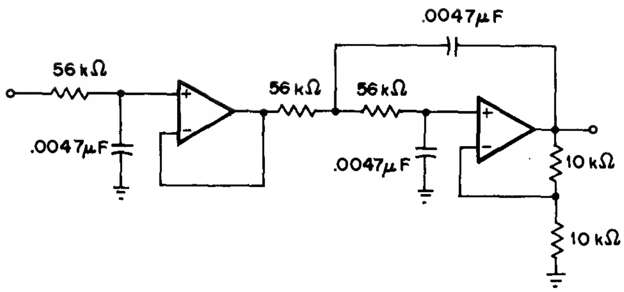
800-Hz BANDPASS—Activa filter has 800-Hz centar frequancy for optimum CW reception. Bendwidth is edjusteble. Back-to-back diodes provide noise-limiting cepebillty.—U. L. Rohda, IF Amplifiar Dasign, *Ham Radio,* March 1977, p 10–21.

1.8–1.9 MHz BANDPASS—Butterworth bendpess filter, suitable for use with broadband preamp, helps reject out-of-bend signals. Filtar elso protects preamp from signals across response renge from broadcast bend through VHF. C1 end C2 ere mica trimmers. L1 and L2 heve 30 turns No. 22 enamel on Amidon T68-6 toroid cores to glve 5.1 μH.—D. DeMaw, Baat the Nolsa with a "Scoop Loop," *QST,* July 1977, p 30–34.

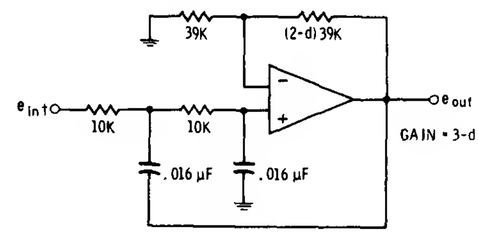




VARIABLE-Q AF—Consists of tuned amplifier heving Inverse feedback, connected so bandwidth et −6 dB is varlable from 50 to 400 Hz for centar frequency of 1 kHz. Improves selectlvity of amateur receivars. Audio from receivar is aplied to inverter Q3 through Q1. Part of inverted signal Is fed back to twin-T network R1-R2-R3-C1-C2-C3 which has high impedanca to ground except at its resonant frequancy. Unattenuated signel goes through Q2 for edding to uninverted output at basa of Q3. Degree of cancellation by two out-of-phasa signala feeding Q3 is controlled by R4 to adjust selectivity. Filtared output Is boosted by Q4 and Q5. Article covers construction, calibration, and oparation. Q1-Q6 are GE-20, end Q7 is GE-14 or GE-28.—C. Townsend, A Verieble Q Audio Filter, *73 Magazine,* Feb. 1974, p 54–56.

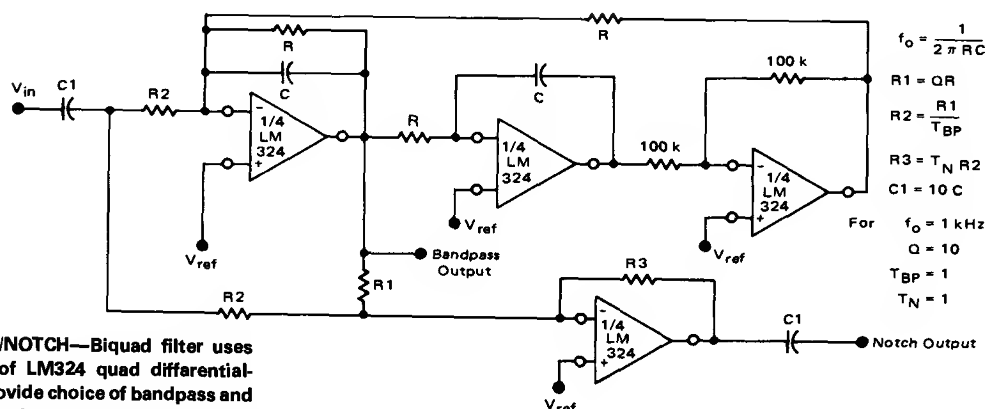


600-Hz THIRD-ORDER LOW-PASS—Butterworth filter using 741 or equivelent opamp provides gein of 6 dB in passband below 600-Hz cutoff. All components can be 5% tolerance.—H. M. Berlin, "Design of Active Filters, with Experiments," Howerd W. Sams, Indienapolis, IN, 1977, p 114–116.

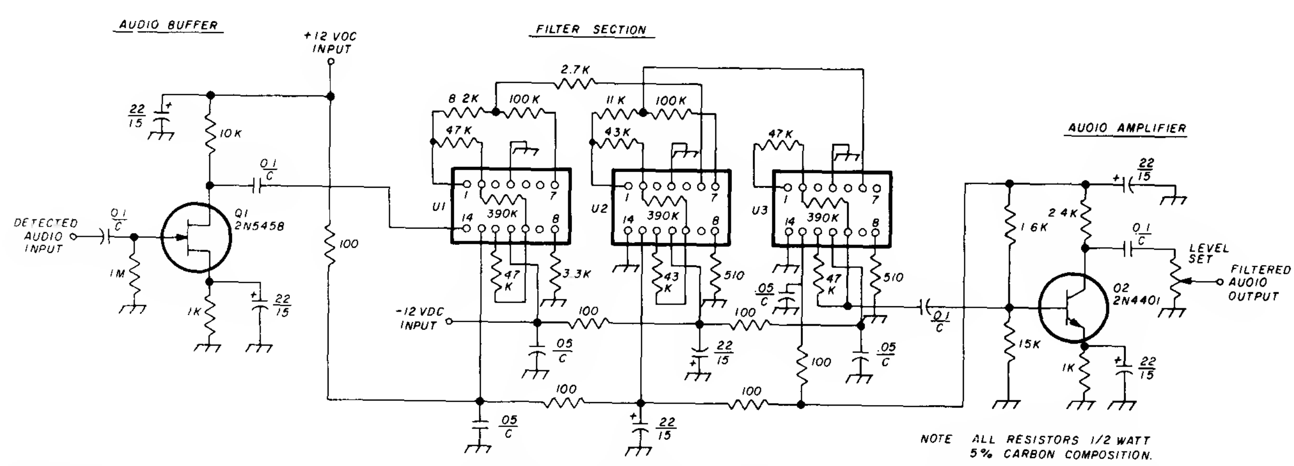


† must return to ground via low-impedance dc path.

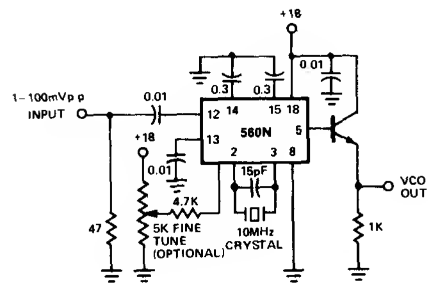
SECOND-ORDER 1-kHz LOW-PASS—Circuit using 741 opamp has equal-value series Input rasistors and high-pess capacitors. Cutoff frequency can be increased by changing 10K resistors to higher velues while kaeping their values identical. 10:1 resistanca change provides 10:1 frequency changa. Damping d is adjustable; critical valua of 1.414 gives maximum flatness of response without overshoot. Interchenge 10K resistors and 0.016-μF capacitors to convert circuit to 1-kHz high-pass filter.—D. Lancaster, "Active-Filter Cookbook," Howerd W. Sams, Indienepolis, IN, 1975, p 127–129.



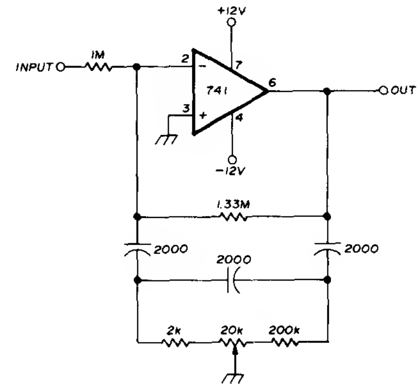
1-kHz BANDPASS/NOTCH—Biquad filter uses all four sections of LM324 quad differential-input opamp to provide choice of bandpass and notch outputs. Supply voltage range can be 3–32 V, with reference voltage equal to half of supply value used. For center frequency of 1 kHz, R is 160K, C Is 0.001 μF, and R1-R3 are 1.6 megohms. Coupling capacitors C1 can be 10 times value used for C.—"Quad Low Power Operational Amplifiers," Motorola, Phoenix, AZ, 1978, DS 9339 R1.



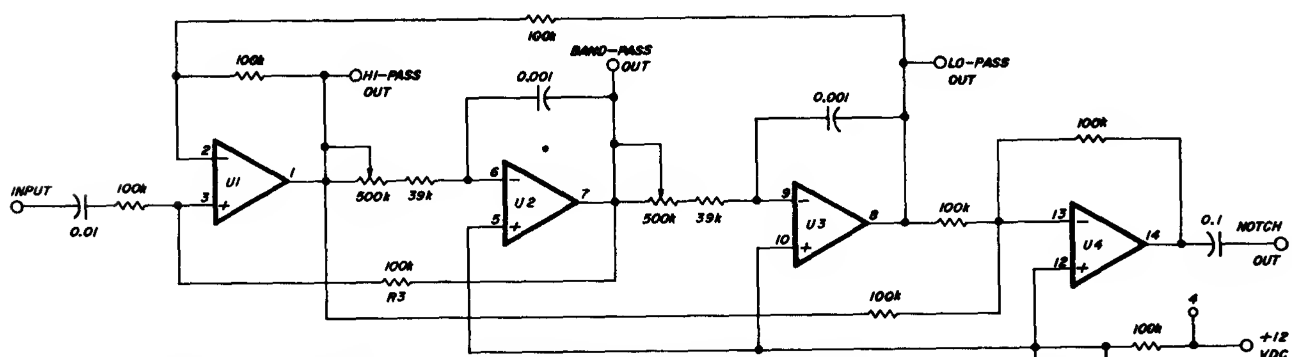
BANDPASS FOR CW—Sophisticated audio processing system for CW bandpass, using communication receiver, has actual bandpass center frequency between 900 and 950 Hz. Bandwidth is about 150 Hz. Minimum relative attenuation is above 20 dB. Uses three Kinetic Technology FX-60 ICs (culled from FS-60, FS-65, and FS-61 production by manufacturer).—M. A. Chapman, Audio Filters for Improving SSB and CW Reception, *Ham Radio,* Nov. 1976, p 18–23.

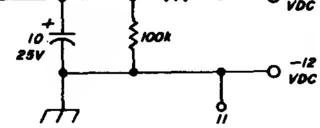


10-MHz TRACKING—Connection shown for 560N PLL tracking filter uses crystal to keep free-running frequency at desired value for signals near 10 MHz. Lock range varies with input amplitude, from about 0.3 kHz for 1 mV P-P input to about 3 kHz for 100 mV P-P.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 850–851.

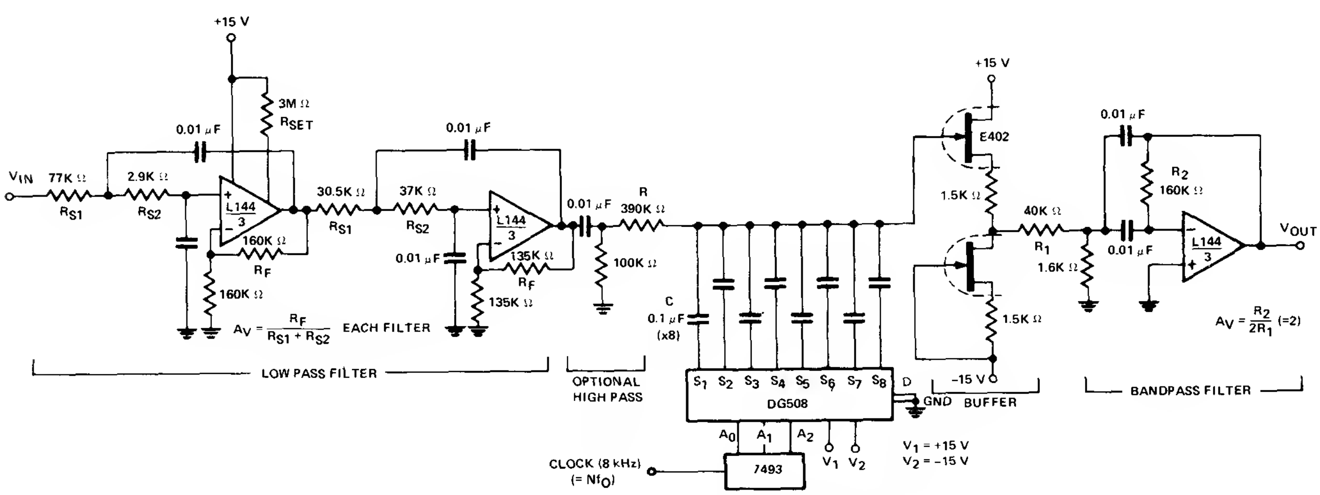


700–2000 Hz TUNABLE BANDPASS—Uses RC notch circuit as feedback element for active-filter opamp. With tuning pot set for center frequency of 1000 Hz, 3-dB bandwidth is 23 Hz and 10-dB bandwidth is 68 Hz. At 1000 Hz, voltage gain is 36 dB. High-frequency rolloff is good, being 43 dB down at 2000 Hz, so circuit converts 1000-Hz square wave into sine wave. Article gives design equations.—C. Hall, Tunable RC Notch Filter, *Ham Radio*, Sept. 1975, p 16–20.





300–3000 Hz TUNABLE FOUR-FUNCTION—Provides choice of high-pass, bandpass, low-pass, and tunable notch outputs. Uses National LM324 quad opamp. Tuning pots are ganged 500K 2-W carbon with reverse log taper. Notch of −35 dB is 200 Hz wide at −3 dB points. Notch output has unity gain with respect to input signal, but other three outputs provide gain.—P. A. Lovelock, Discrete Operational Amplifier Active Filters, *Ham Radio*, Feb. 1978, p 70–73.

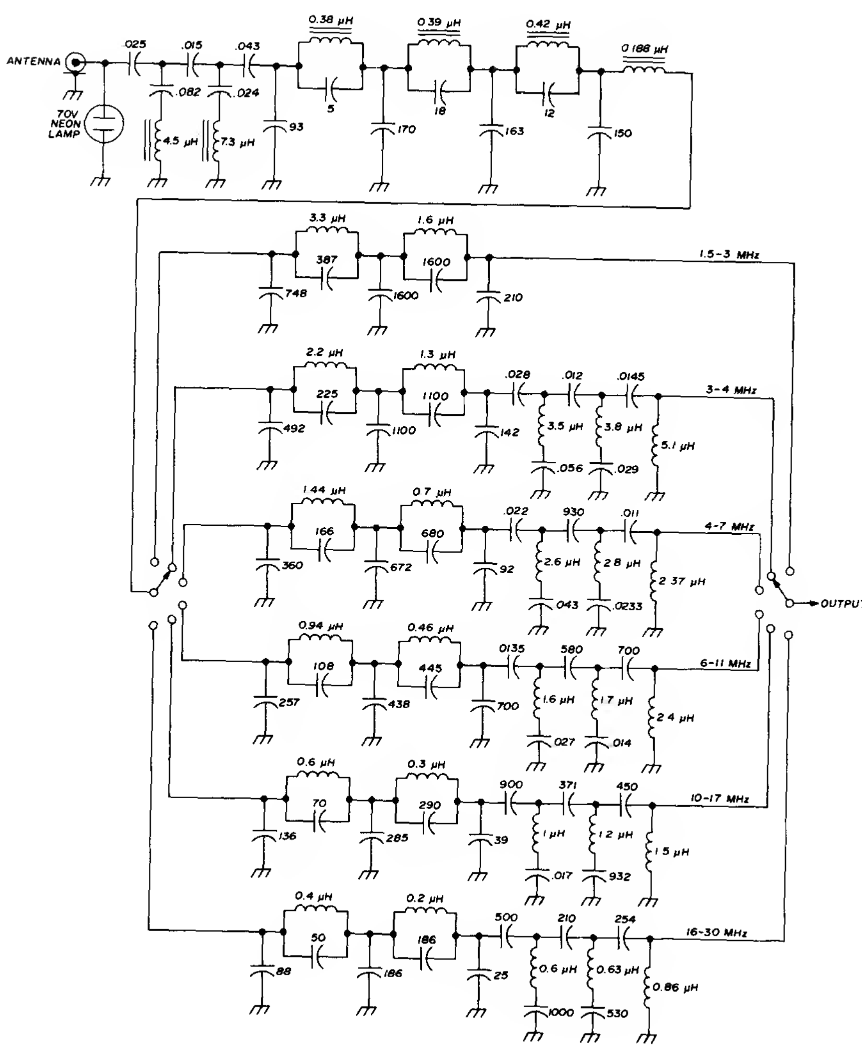


1-kHz BANDPASS HIGH-Q—Shunt-switched bandpass filter with Q of 1000 and voltage gain of about 7 uses DG508 CMOS multiplexer containing required analog switches, interface circuits, and decode logic for 8-path filter. Bandwidth for 3 dB down is 1 Hz centered on 1 kHz, with asymptotic slope of 6 dB per octave. Clock controls shunt-switched filter section.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 5-12–5-14.

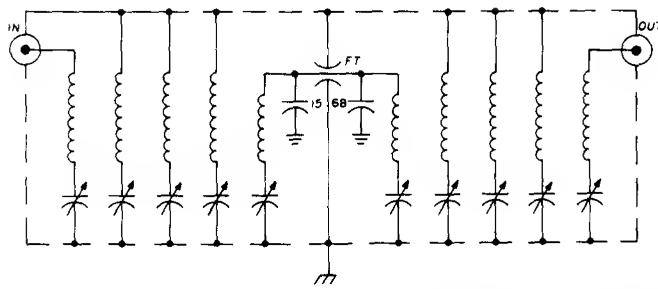
CHAPTER 28

Filter Circuits—Passive

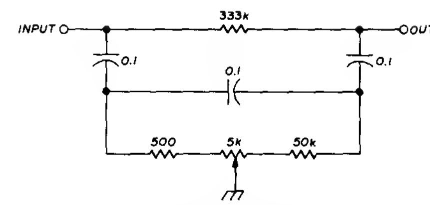
Includes low-pass, high-pass, and bandpass AF filters for improving reception of voice, CW, SSB, and RTTY signals, along with higher-frequency circuits for suppressing broadcast-band interference in communication receivers and minimizing other types of interference.



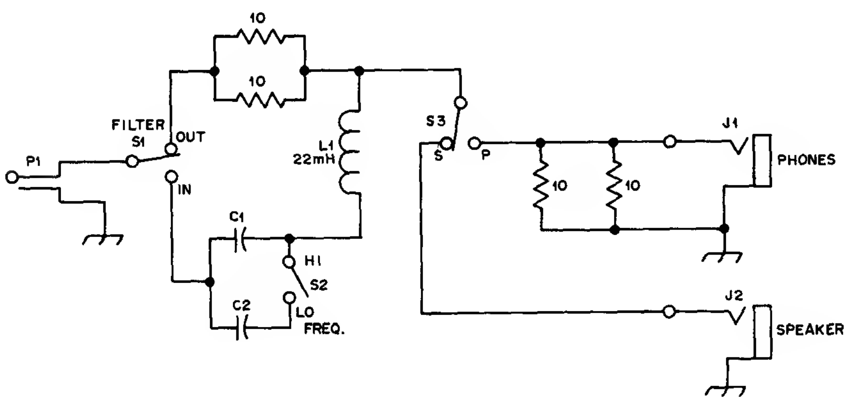
ELLIPTIC HIGH-PASS/LOW-PASS—Covers 1.45 to 32 MHz in six steps, for use at front end of high-frequency communication receiver to suppress unwanted broadcast signals. Low-pass filter section, acting with one of six following low-pass sections, gives over 90-dB image suppression. Special Bessel-Cauer elliptic filter having Chebyshev response in passband provides required 50-ohm impedance matching so filters can be cascaded.—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.



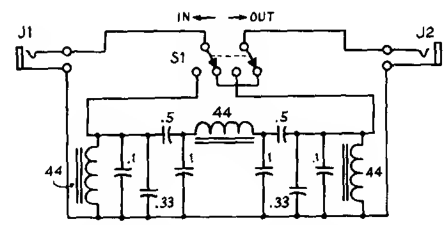
50.5-MHz BANDPASS—Provides 60% bandwidth with only 4-dB insertion loss. Each coil is about 2.2 μH, and trimmer capacitors are 1.5–7 pF. Sweep signal generator and 5-in CRO are essential for alignment.—P. H. Sellers, 50-MHz Bandpass Filter, *Ham Radio*, Aug. 1976, p 70–71.



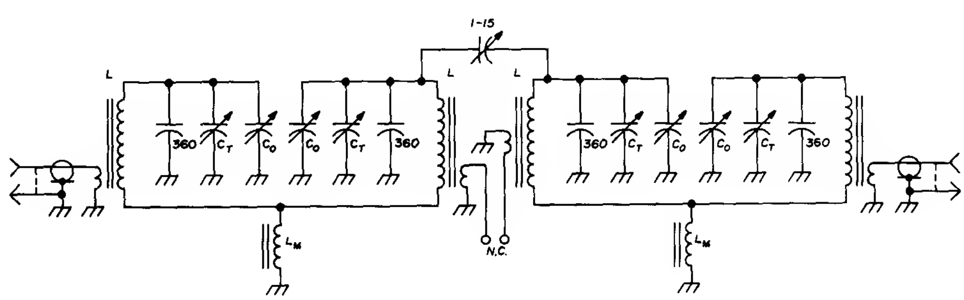
60-Hz TUNABLE NOTCH—Can be used to minimize hum pickup from AC line. Circuit tunes from 40 to 120 Hz with single pot. Article gives design equations. With unmeasured ceramic disk capacitors and 5% resistors, notch depth at 60 Hz was 44.5 dB. By selecting capacitors with equal values and replacing 333K with 500K trimpot, careful adjustment increases notch depth to 57 dB.—C. Hall, Tunable RC Notch Filter, *Ham Radio*, Sept. 1975, p 16–20.



CW FILTER FOR INTERFERENCE—Audio bandpass filter, designed for connection between loudspeaker jack of receiver and external loudspeaker or phone, has half-power bandwidth of about 70 Hz but rolls off gradually without causing ringing. Series LC combination, connected in hot line to loudspeaker, looks like 5-ohm resistance at resonance, cutting signal amplitude about in half. At lower frequencies filter looks like large capacitive reactance and at higher frequencies it resembles large inductive reactance, both causing high attenuation. Filter thus discriminates against all except switch-selected resonant frequency, either 760 or 1070 Hz. Choose best frequency for particular receiving situation by trial.—F. Noble, A Passive CW Filter to Improve Selectivity, *QST*, Nov. 1977, p 34–35.

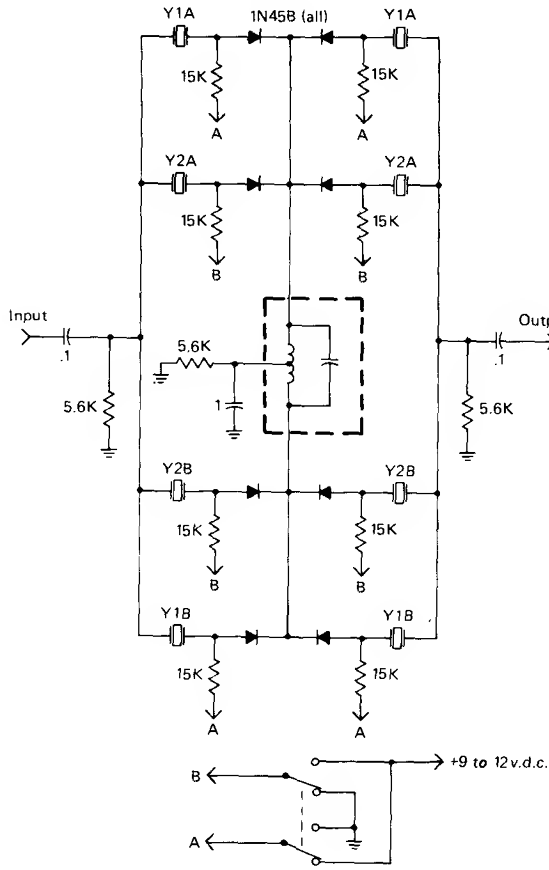


BANDPASS FOR CW—Provides bandwidth of about 400 Hz (3 dB down) centered on 875 Hz, for improving reception of CW signals with amateur receiver. Uses three 44-mH toroids.—D. C. Rife, Low-Loss Passive Bandpass CW Filters, *QST*, Sept. 1971, p 42–44.

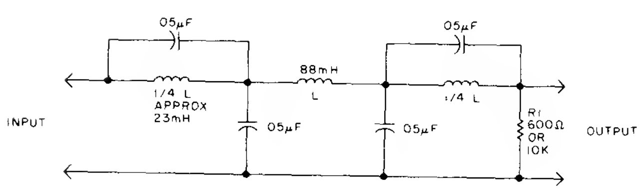


L	33 turns no. 20 enamelled on Amidon T-106-2 toroid cores (approximately 14 μH). Links are each 2 turns	C_O	4-section air variable, 10-160 pF per section
L_m	6 turns no. 20 enamelled on Amidon T-30-2 toroid core	C_T	35-pF trimmer capacitors

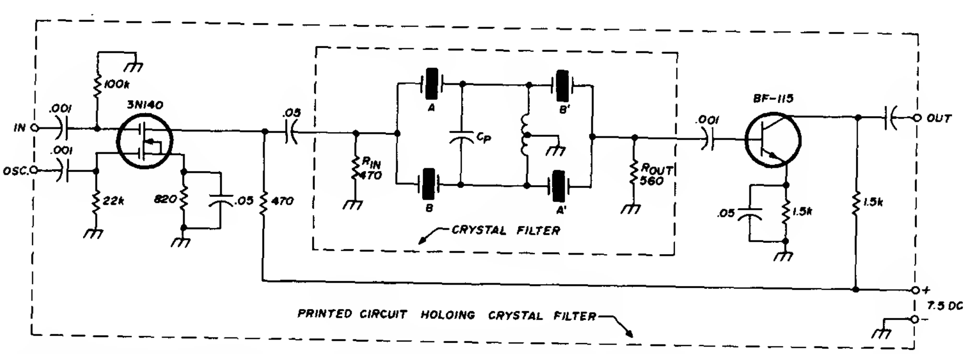
160-METER BANDPASS—Four-resonator filter is tunable from 1.8 to 2 MHz and has insertion loss of 5 dB. 3-dB bandwidth is 30 kHz, and 6–60 dB shape factor is 4.78. Stopband attenuation is over 120 dB. Key to high performance is use of high-Q toroid cores. Article covers theory, construction, and adjustment.—W. Hayward, Bandpass Filters for Receiver Preselectors, *Ham Radio*, Feb. 1975, p 18–27.



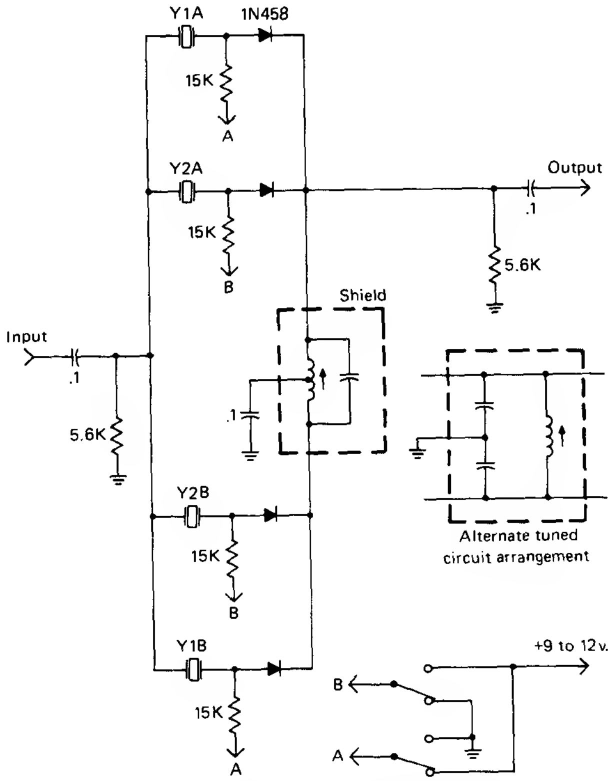
DIODE-SWITCHED FOUR-CRYSTAL IF FILTER—Application of 9–12 VDC to control points A or B gives choice of two different selectivitias for IF amplifier in amateur communication raceiver. For 500-Hz bandwidth at 455 kHz, frequencias of crystals in use should be 300 Hz apart for CW, 1.8 kHz apart for 2.7-kHz SSB bandwidth, and 1.25 kHz apart for 2.1-kHz SSB bandwidth. Article gives design graphs.—J. J. Schultz, Economical Diode-Switched Crystal Filters, *CQ*, July 1978, p 33–35 and 91.

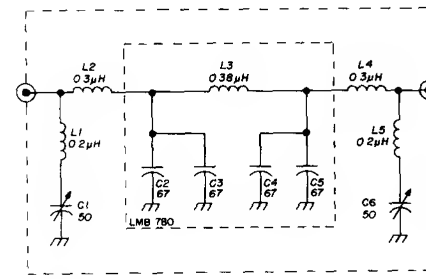


2125-Hz LOW-PASS—Used with AFSK keyer to convert 2125-Hz squara wava to sine wave by removing third and fifth harmonics. All three coils are toroids, with its two windings in series for 88 mH and in parallel for 23 mH.—L. J. Fox, Dodga That Hurricanel, *73 Magazine*, Jan. 1978, p 62–69.



FOUR-CRYSTAL FILTER—Usas two matched sets of crystals, with each pair having maximum frequency diffarence of 25 Hz. Transistors serve as input and output isolating stagas. Each matched pair, such as A-A′, should be from same manufacturer and have same nominal parallel capacitance for circuit, same activity, and same resonant frequency within 25 Hz. Article gives datailed instructions for grinding crystal to increase resonant frequency when necessary for matching. Usa frequancy counter for checking frequency. Valuas given in circuit are for 5.645-MHz crystal filter with −6 dB bandpass of 1.82 kHz and insertion loss of about 5 dB. Crystals used ara 5.644410 MHz and 5.644416 MHz for A and A′, and 5.645627 MHz and 5.645641 MHz for B and B′. Coil has 7 + 7 turns No. 28 anamel bifilar wound on 10.7-MHz IF transformer having 2.4-mm slug diameter. C_p is 39 to 47 pF.—J. Perolo, Practical Considerations in Crystal-Filtar Design, *Ham Radio*, Nov. 1976, p 34–38.

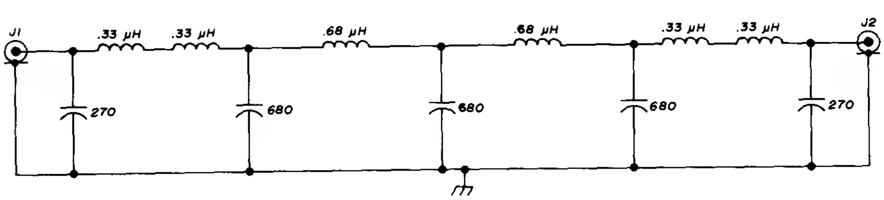




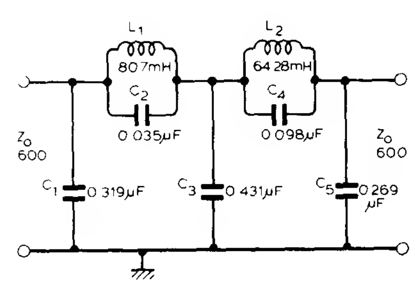
C1,C6	50 pF APC or MAPC variable
C2,C3 C4,C5	67 pF ±5%, 7500 working volts dc (Centralab type 850S ceramic capacitor, 6 for $1.00 from John Meshna, P.O. Box 62, E. Lynn, Massachusetts 01904)
L1,L5	0.2 μH, 3 turns no. 16 or no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn
L2,L4	0.3 μH, 5½ turns no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn
L3	0.38 μH, 7 turns no. 14 enamelled, ½ inch (13mm) ID, spaced 1/8 inch (3mm) per turn

DIODE-SWITCHED CRYSTALS—1N458 diodes switch crystals in pairs to provide two different degrees of selectivity for 455-kHz IF filter. For 500-Hz bandwidth in amateur communication receiver, spacing between crystal frequencies should be 300 Hz, which is obtained with 455.150 kHz for Y1A and 454.850 kHz for Y1B. Provides adequate CW selectivity for transceiver having good SSB filter.—J. J. Schultz, Economical Diode-Switched Crystal Filters, *CQ*, July 1978, p 33–35 and 91.

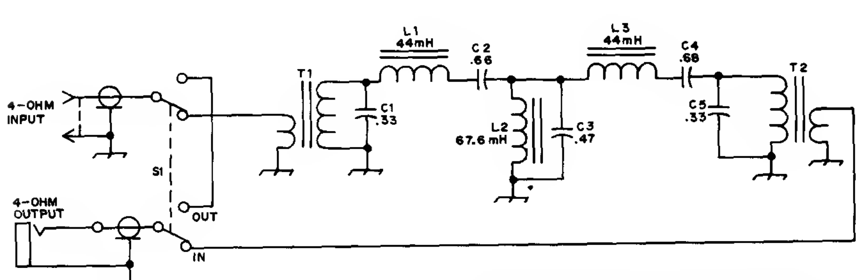
LOW-PASS WITH 42.5-MHz CUTOFF—Designed for insertion in antenna coax of amateur radio station up to 1 kW, to cure TVI problems. Provides 60-dB attenuation on channel 2. Filter uses m-derived terminating half-sections at each end, with two constant-K midsections. End sections are tuned either to channel 2 (55 MHz) or channel 3 (61 MHz). Article covers construction and tune-up.—N. Johnson, High-Frequency Lowpass Filter, *Ham Radio*, March 1975, p 24–27.



2.955-MHz HIGH-PASS—Used in offset frequency-measuring system for amateur-band signals. Nine-section Chebyshev high-pass filter with 1-dB passband ripple attenuates undesired 2.045–2.245 MHz image 16 dB while selecting desired 2.955–3.155 MHz signal. Filter has sharper cutoff characteristic, for given number of sections, than Butterworth or image parameter designs.—J. Walker, Accurate Frequency Measurement of Received Signals, *Ham Radio*, Oct. 1973, p 38–55.

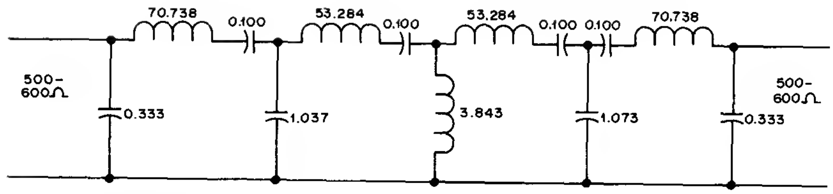


L_1	253 turns 28 swg 35mm VINKOR LA1211
L_1-C_2	Tune to 3kHz
L_2	226 turns 28 swg 35mm VINKOR LA1211
L_2-C_4	Tune to 2kHz

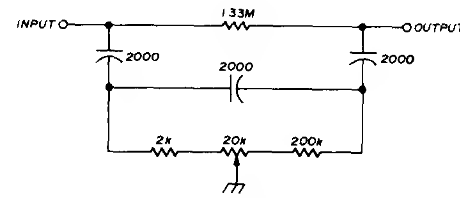


VOICE BANDPASS—Used between 8-ohm output of communication receiver and 8-ohm loudspeaker or low-impedance phones, to suppress Continuous Random Unwanted Disturbances on voice transmissions. Passband is 355 to 2530 Hz at 3-dB points. L1 and L3 are 44-mH toroids. L2 is 88-mH toroid with 94 turns removed. T1 and T2 are 88-mH toroids with 100 turns No. 28 enamel wound over original winding of each for primary.—R. M. Myers, The SSB Crud-O-Ject, *QST*, May 1974, p 23–25 and 56.

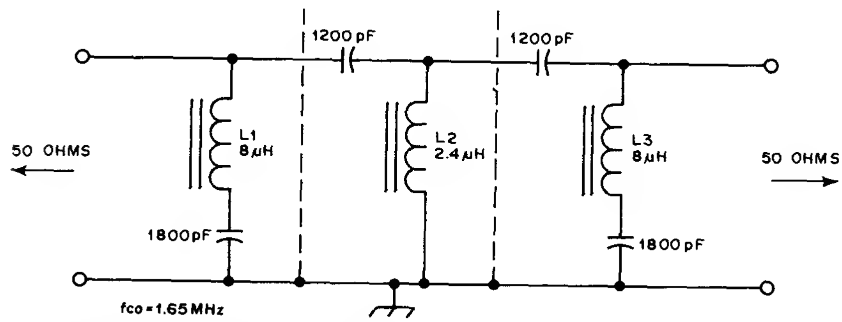
1-kHz FIFTH-ORDER LOW-PASS—Used with 1-kHz signal generator to remove unwanted harmonics, leaving pure sine wave as required for measuring distortion in modern audio amplifiers. Attenuation peaks are carefully positioned to coincide with second and third harmonics, giving 65-dB attenuation of these harmonics and at least 50-dB attenuation of higher harmonics.—J. A. Hardcastle, 1 kHz Source Cleaning Filter, *Wireless World*, Oct. 1978, p 59.



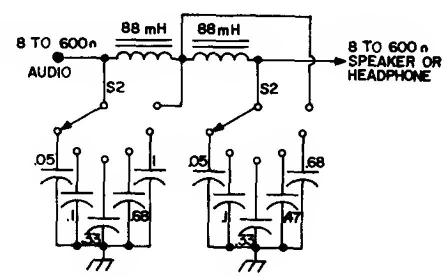
225-Hz BANDPASS RTTY—Used ahead of limiter in 170-Hz-shift RTTY receiving converter. Chebyshev mesh configuration with 0.1-dB ripple uses inductor to ground for sharpening lower skirt, with capacitive coupling for sharpening upper skirt, to give good symmetry for response curve. Capacitors should be high-Q types, well matched. Take turns off inductors as required to move passband higher if initially low in frequency. Insertion loss is 6.6 dB and 3-dB bandwidth is 225 Hz, which makes mark and space tones only 1.5 dB down.—A. J. Kleppenberger, A High-Performance RTTY Band-Pass Filter, *QST*, Jan. 1978, p 33.



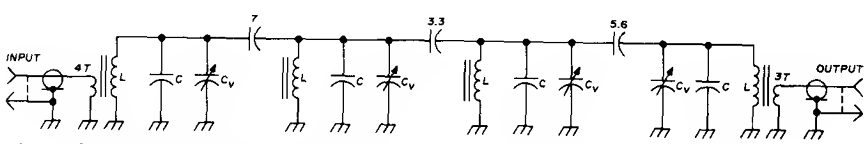
693–2079 Hz TUNABLE NOTCH—Requires only one tuning pot to cover entire frequency range. Developed for use in tunable narrow-band audio amplifier. Article gives design equations. Depth of notch is greater than 50 dB. Doubling capacitor values changes tuning range to 355–1028 Hz, while cutting values in half gives range of 1340–4110 Hz.—C. Hall, Tunable RC Notch Filter, *Ham Radio*, Sept. 1975, p 16–20.



AM BROADCAST REJECTION—Seven-element m-derived high-pass filter provides 30-dB rejection at AM broadcast-band frequencies while passing signals in 160-meter band. Midsection m-derived branch of circuit was eliminated to simplify construction, but can be added and tuned to particular broadcast station that presents difficult interference problem. L1 and L3 are 40 turns No. 30 enamel wound on T50-2 powdered-iron toroid. L2 has 22 turns No. 30 on T50-2 core.—D. DeMaw, Low-Noise Receiving Antennas, *QST*, Dec. 1977, p 36–39.



SWITCHABLE AF FILTER—Provides wide range of switch-selected capacitor values for varying cutoff frequencies, to permit use of filter for either phone or CW reception. On CW, circuit improves reception by eliminating higher frequencies that are largely interference.—J. J. Schultz, The Quiet Maker, *73 Magazine*, March 1974, p 81–84.

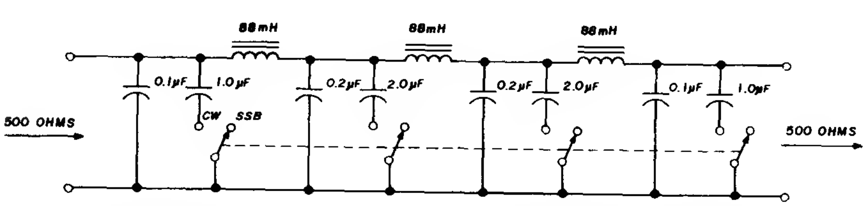


L 35 turns no. 22 enamelled on Amidon T-68-2 toroid cores (7 μH). Input link is 4 turns, output link is 3 turns

C 210 pF, 1% silver mica

Cv 60-pF mica compression trimmers

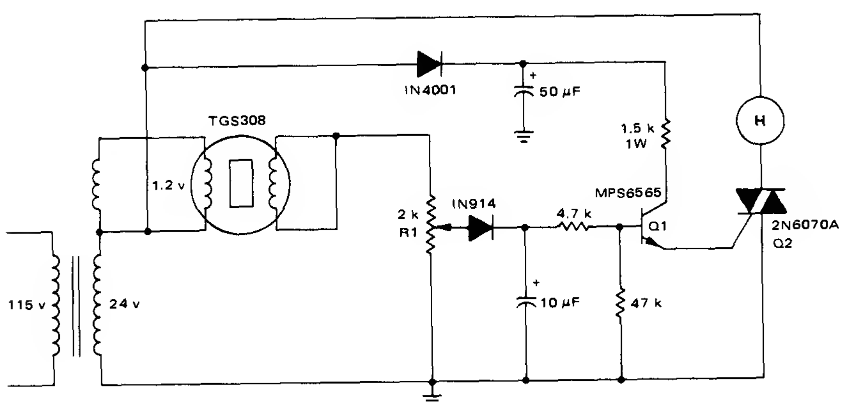
80-METER BANDPASS—Four-resonator filter for use in 80-meter amateur band has 100-kHz bandwidth, 4.4-dB insertion loss, and 6–60 dB shape factor of 5.16. Filter was designed and aligned at 3.75 MHz; realignment at 3.6 and 3.9 MHz yielded similar results. Article covers theory, construction, and adjustment.—W. Hayward, Bandpass Filters for Receiver Preselectors, *Ham Radio*, Feb. 1975, p 18–27.



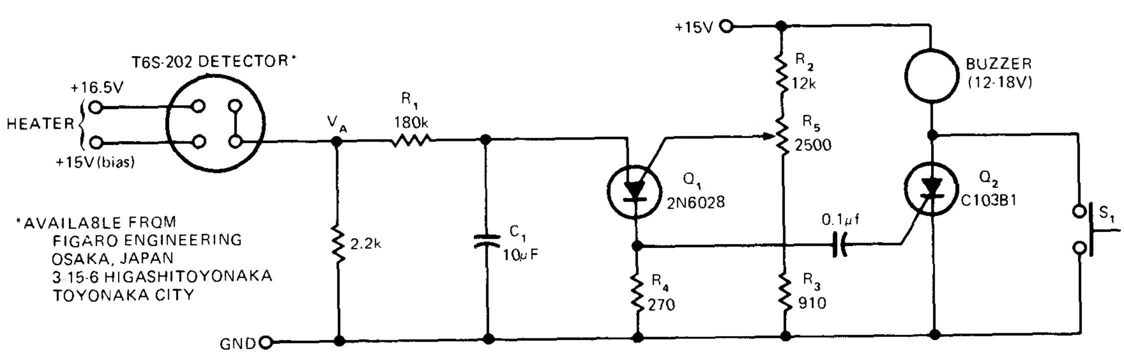
LOW-PASS PI-SECTION AF—Four-pole double-throw switch gives choice of 650-Hz cutoff for CW or 2000 Hz for SSB. Filter capacitors are matched. Response decreases continuously beyond cutoff frequency, with no loss of attenuation.—E. Noll, Circuits and Techniques, *Ham Radio*, April 1976, p 40–43.

CHAPTER 29
Fire Alarm Circuits

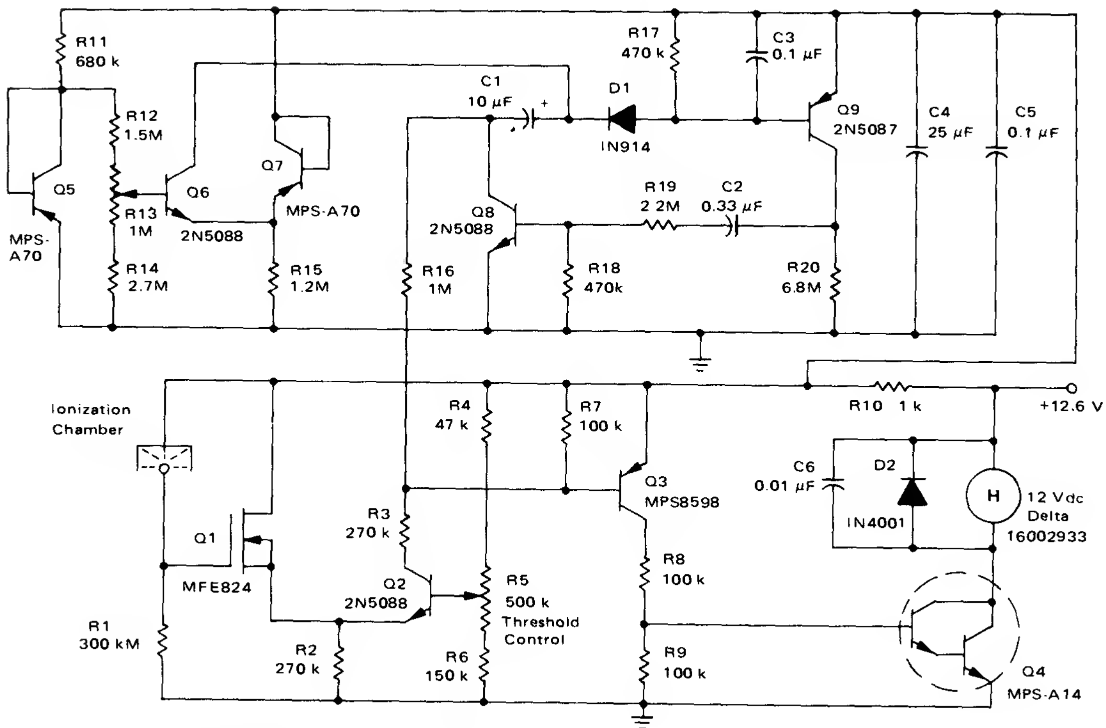
Sensors used may respond to gas, ionization, flame, or smoke associated with fire, for triggering circuits driving variety of alarm devices.



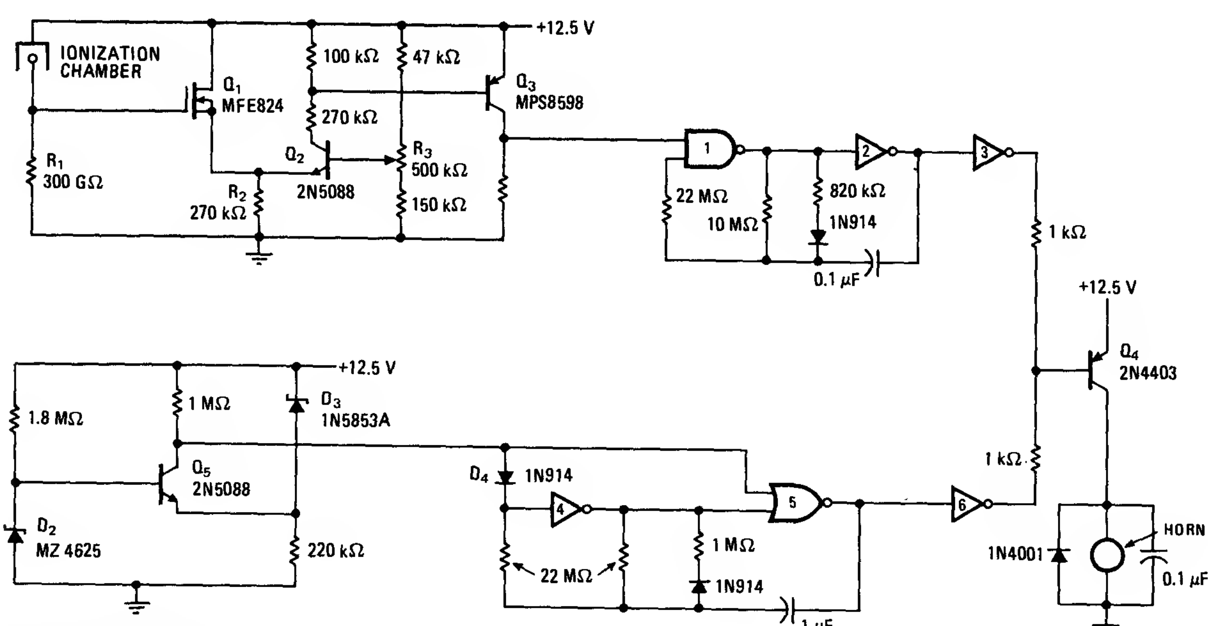
TRIAC GAS/SMOKE DETECTOR—Conductivity of Taguchi TGS308 gas sensor increases in presence of combustible gases, increasing load voltage across R1 from normal 3 VRMS to as much as 20 V. Rise in voltage trips comparator to turn on transistor Q1 that supplies trigger current to 2N6070A sensitive-gate triac. Resulting full-wave drive of Delta 16003168 24-VAC horn gives sound output of 90 dB at 10 feet. Horn stops automatically when gas clears sensor.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 4.



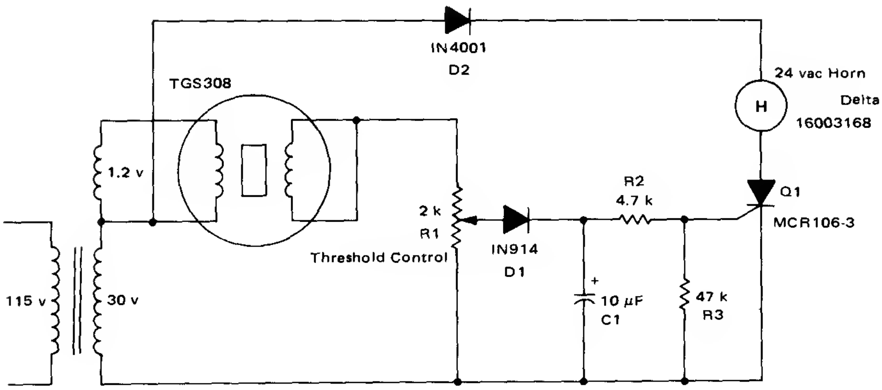
GAS/SMOKE SENSOR—Sensor is based on selective absorption of hydrocarbons by N-type metal-oxide surface. Heater in sensor burns off hydrocarbons when gas or smoke disappears, to make sensor reusable. Requires initial warm-up time of about 15 min in hydrocarbon-free environment. When gas or smoke is present, V_A quickly rises and triggers programmable UJT Q_1. Resulting voltage pulse across R_4 triggers Q_2 and thereby energizes buzzer. S_1 is reset switch. R_1 and C_1 give time delay that prevents triggering by small transients such as smoke from cigarette. R_5 adjusts alarm threshold. Use regulated supply.—S. J. Bepko, Gas/Smoke Detector Is Sensitive and Inexpensive, *EDN Magazine*, Sept. 20, 1973, p 83 and 85.



IONIZATION ALARM USING TRANSISTORS—Use of continuous smoke alarm signal rather than beeping horn simplifies transistor circuits needed to trigger fire alarm and low-battery alarm. When high impedance of ionization chamber is lowered by smoke or gas, amplifier Q1-Q2-Q3 supplies 100-µA base current to Darlington Q4 for powering horn continuously as long as smoke content exceeds that set by threshold control R5. Low-battery circuit is tripped at voltage range between 9.8 and 11.2 V, as determined by R13, to energize MVBR Q8-Q9 for driving horn 0.7 s, with 50-s OFF intervals. Battery is chosen to last at least 1 year while furnishing standby current of about 70 µA.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 8.

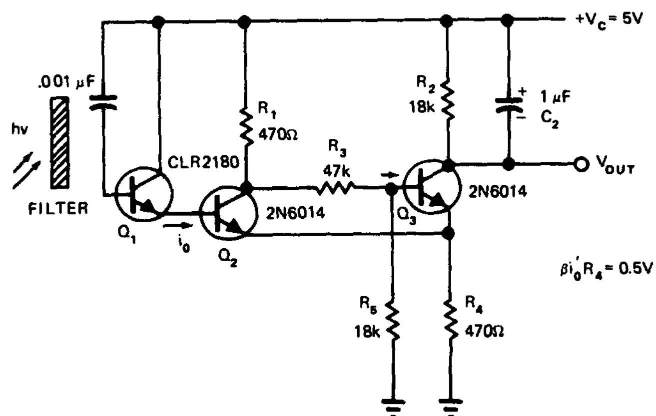


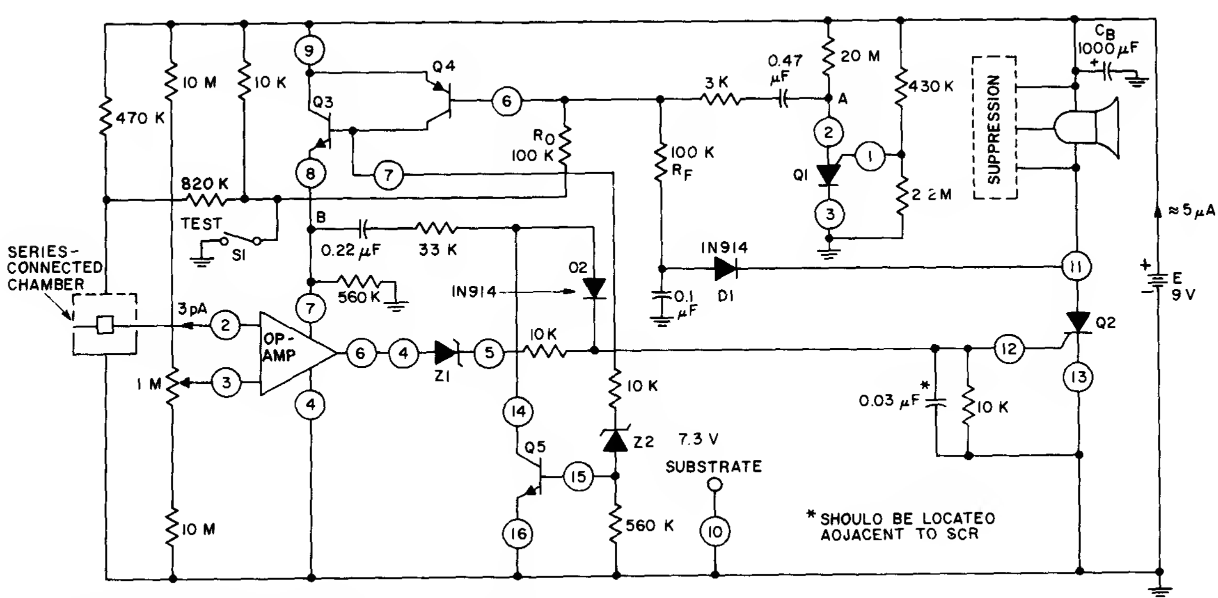
IONIZATION-CHAMBER SENSOR—MOSFET Q_1 with high input impedance monitors voltage level at divider formed by R_1 and ionization chamber, with output of Q_1 going to Q_2 which forms other half of differential amplifier. With smoke level of 2% or higher, Q_3 is turned on and applies logic 1 to one input of NAND gate 1 in asymmetrical astable MVBR. Capacitor in MVBR charges quickly and discharges slowly, making alarm horn sound during discharge via inverter 3 and driver transistor Q_4. Comparator circuit Q_5 drives second MVBR to energize horn through inverter 6 and same driver Q_4 when battery is low, but with distinctive 1-s toot every 23 s to conserve energy remaining in battery and differentiate from fire warning.—A. Pshaenich and R. Janikowski, Gas and Smoke Detector Uses Low-Leakage MOS Transistor, *Electronics*, Nov. 28, 1974, p 124–125.



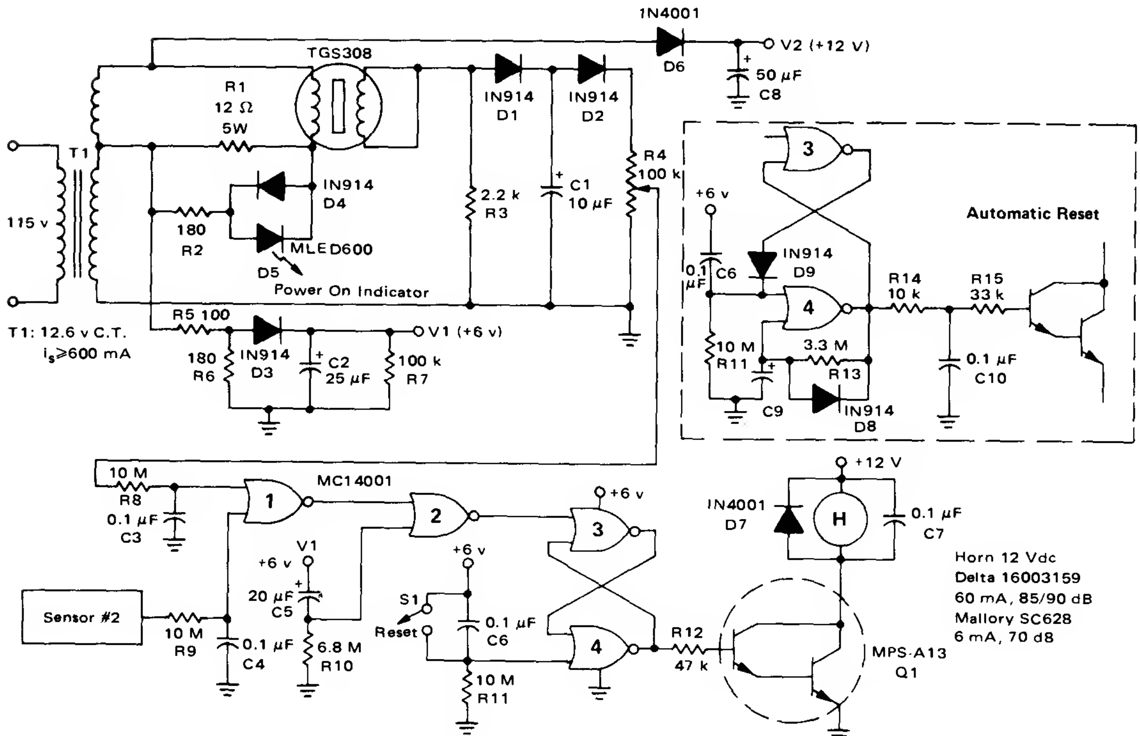
SCR GAS/SMOKE DETECTOR—Simple circuit uses Taguchi TGS308 gas sensor with SCR Q1 for half-wave control of 24-VAC alarm horn. Sensor is based on adsorptive and desorptive reaction of gases on tin oxide semiconductor surface encased in noble-metal heater that serves also as electrode. Combustible gases increase conductivity of sensor, thereby increasing load voltage enough to trip comparator and initiate alarm. Output voltage across R1 is normally about 3 VRMS. With gas or smoke, voltage can rise to 20 V. When gas or smoke has cleared sensor, SCR turns off at first zero crossing. Drawbacks are absence of time delay for preventing false alarm when power is turned on and reduced sound level of horn with half-wave operation.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 3.

FLAME DETECTOR DRIVES TTL LOAD—Sensor is silicon Darlington phototransistor Q_1 having peak response near infrared bands. Filter is required to reduce interference from visible light sources. Circuit is sensitive enough to pick up hydrogen flames that emit no visible light. Article describes operation of circuit and gives design equations. Output can go directly to input port of microprocessor.—A. Ames, This Flame Detector Interfaces Directly to a µP, *EDN Magazine*, Oct. 20, 1976, p 122 and 124.

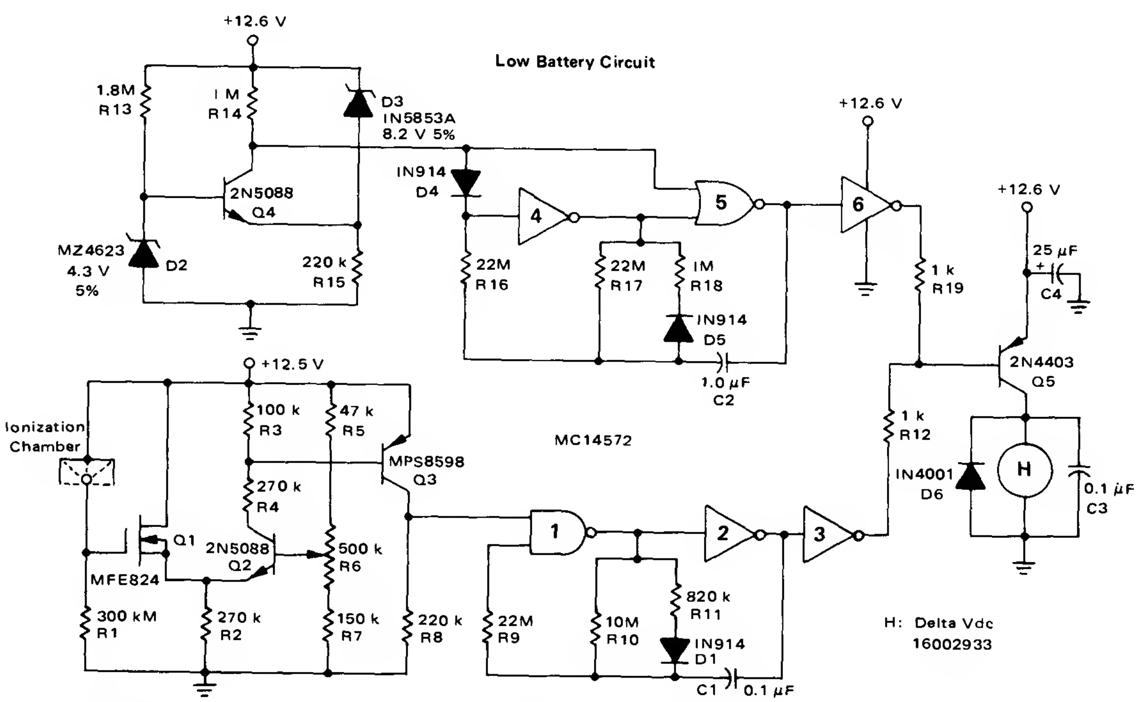




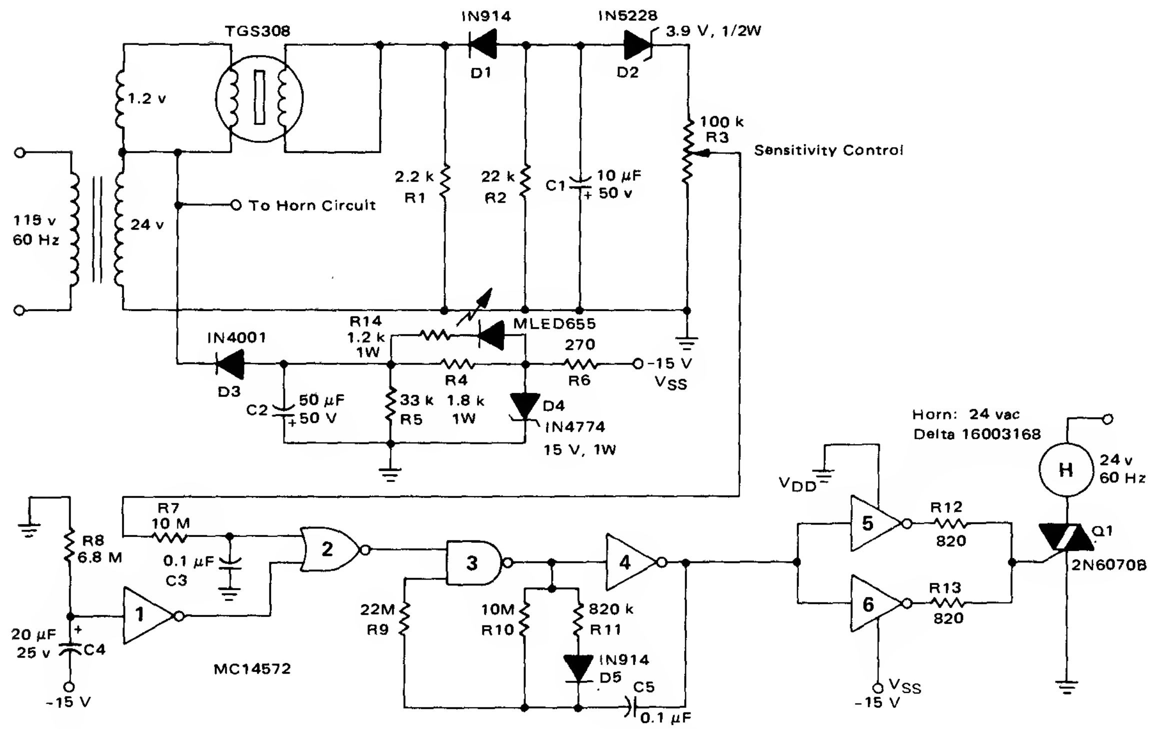
SMOKE DETECTOR—Battery-operated ionization-type smoke detector uses RCA CA3130 opamp as interface for ionization chamber that provides picoampere currents. With opamp in pulsed mode (on for 20 ma of 20-s period), IC draws only 0.6 µA average instead of 600 µA. Other active components and zener, all on RCA CA3097 array, provide low-battery monitor and horn-driver functions. When chamber detects smoke, combination of R_F and D1 provides sufficient base current to keep Q3 and Q4 on. Opamp is then powered continuously, and steering diode Z1 supplies continuous current to gate of Q2 for energizing horn. Battery drain is only 5 mA in monitoring mode.—G. J. Granieri, Bipolar-MOS and Bipolar IC's Building Blocks for Smoke-Detector Circuits, *IEEE Transactions on Consumer Electronics*, Nov. 1977, p 522–527.



GAS/SMOKE DETECTOR WITH LATCH—CMOS latching logic provides 2-min time delay to prevent false alarm when power is first applied to fire alarm using Taguchi TGS308 gas sensor whose conductivity increases in presence of combustible gases. Normal voltage of 3 VRMS across R4 increases to about 20 V in presence of fire. Half of 12.6-V center-tapped transformer secondary is used for 6-V supply and full 12.6 V for DC horn supply. Latch is reset manually with S1 to turn off alarm after gas level drops. Optional circuit shown can be used for automatic reset.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 5.



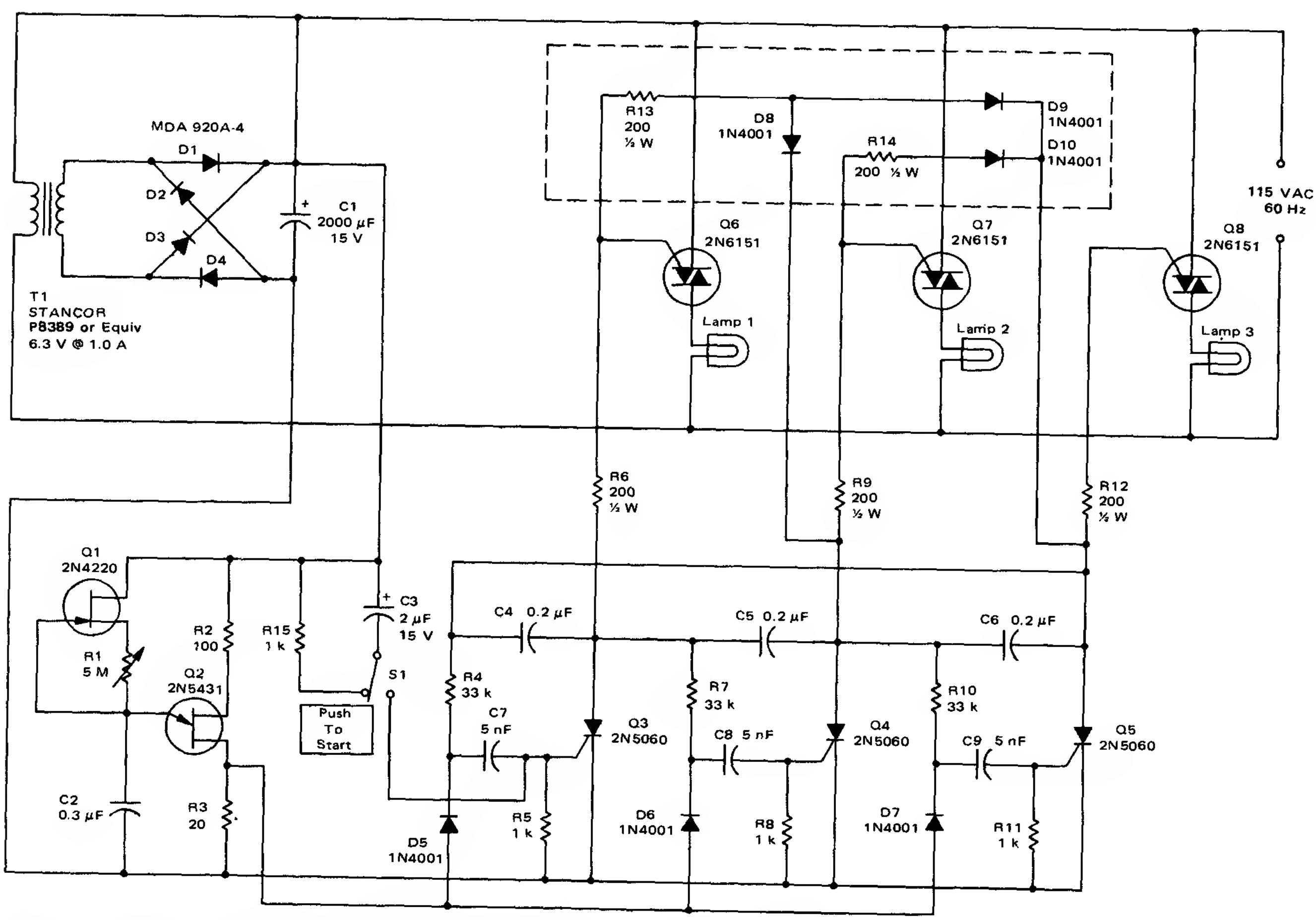
IONIZATION ALARM—Gates in Motorola MC14572 CMOS IC form two alarm oscillators, one energized in presence of smoke at ionization chamber and other for low battery. Standby currents of circuits are low enough to give at least 1 year of operation from 750-mAh battery. R6 is adjusted to give desired smoke detection sensitivity. Gates 1 and 2 form MVBR that drives horn at astable rate of 2.5 s on and 0.2 s off in presence of smoke. When battery is low, comparator Q4-D2-D3 trips (about 10.5 V) and energizes inverter 4 of low-battery astable MVBR. DC horn is then powered at astable rate of about 1 s every 23 s to give early warning of need to change battery.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 7.



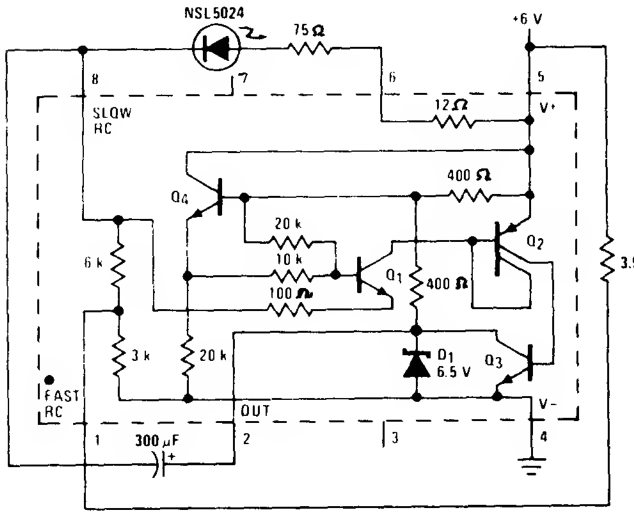
GAS/SMOKE DETECTOR WITH BEEPING HORN—Taguchi TGS308 gas sensor increases voltage across R3 when sensor conductivity is increased by combustible gases. After time delay provided to prevent power turn-on false alarms, CMOS astable MVBR using gates 3 and 4 is energized to fire triac and drive AC horn to give distinctive repetitive sound lasting about 2.5 s, with 0.2-s intervals between beeps. Triac gate drivers operate from −15 V supply derived from 24-V winding of power transformer.—A. Pshaenich, "Solid State Gas/Smoke Detector Systems," Motorola, Phoenix, AZ, 1975, AN-735, p 6.

CHAPTER 30
Flasher Circuits

Provide fixed or variable flash rates for LEDs, incandescent lamps, or fluorescent lamps used as indicators, alarms, warnings, and for such special effects as Christmas-light shimmer. See also Game and Lamp Control chapters.

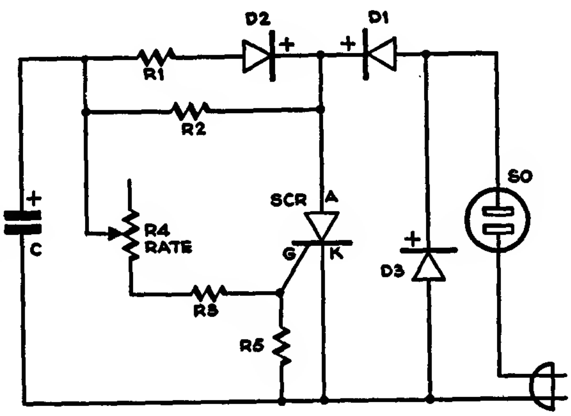


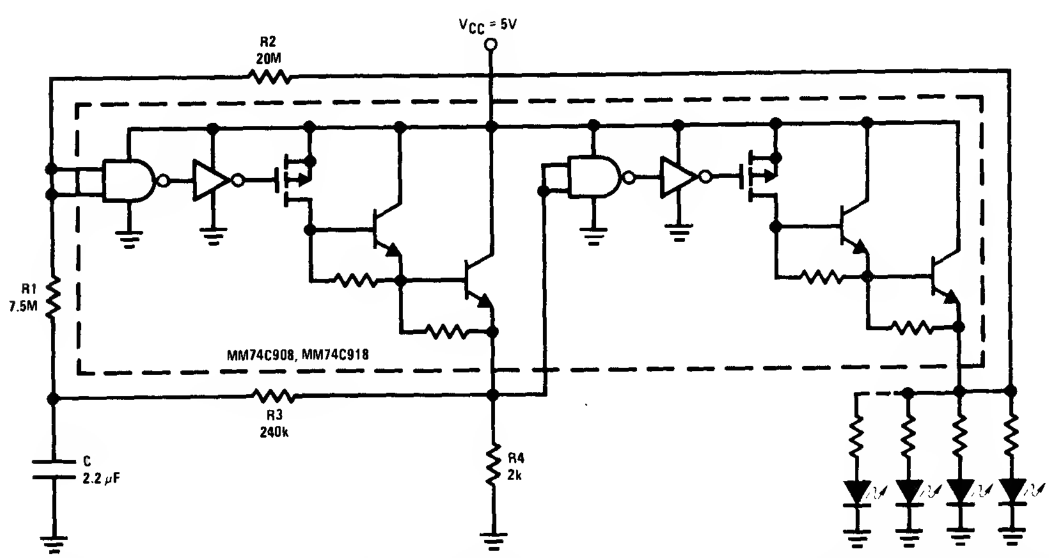
SEQUENTIAL AC FLASHER—Uses simple ring counter in which triac gates form part of counter load. Incandescent lamps come on in sequence, with only one lamp normally on at a time. Pulse rate for switching lamp can be adjusted from about 1 every 0.1 s to 1 every 8 s. Circuit enclosed in dashed rectangle can be added to keep previous lamps on when next lamp is turned on. Only three stages are shown, but any number of additional stages can be added.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 11.



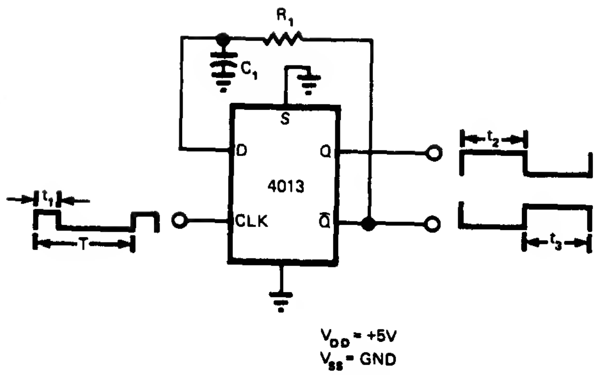
VARIABLE FLASHER FOR LED—Terminel connections of Netional LM3909 flasher IC give choice of three different flesh rates for LED used as indicator in battery portable equipment. External resistors provide additional adjustmants of flash rate. Appropriate connections to pins 1 end 8 make flesh-controlling internal raslstance 3K, 6K, or 9K. Flasher operates at any supply voltage above 2 V, with low duty cycle to giva long battery life.—P. Lefferts, Power-Miser Flasher IC Hes Many Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.

SHIMMER FOR CHRISTMAS LIGHTS—Circuit uses helf of AC cycle to power lights conventionally. On other helf-cycle, C charges and builds up voltage on gate of SCR. When firing point is reached, SCR conducts and allows remainder of this half-cycle to pass through light string. Result is flash that gives shimmer or strobe effect. C is 100-μF 50-V alectrolytic, R1 is 2.7K, R2 is 22K, R3 is 3.3K, R4 is 100K pot, and R5 is 1K. Diodes era Motorole HEP R0053. SCR is GE C106B1 or Motorola HEP R1221 mounted on heatsink.—R. F. Graf and G. J. Whalen, Add Shimmer to Your Christmas Lights, *Popular Science*, Dec. 1973, p 124.

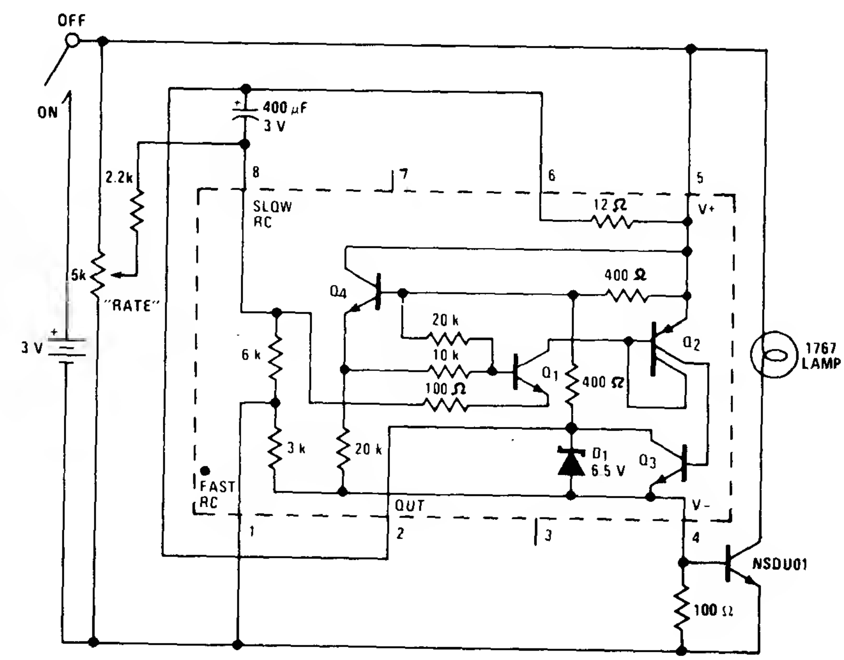




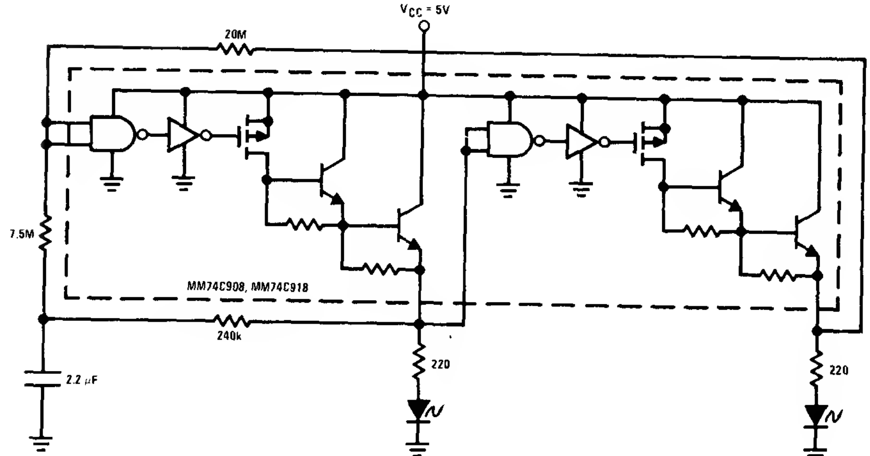
DRIVING LED ARRAY—National MM74C908/MM74C918 dual CMOS drivar has sections connected as Schmitt-triggar oscillator, with R1 and R2 used to genarata hystaresis. R3 and C ara inverting feedback timing elements, and R4 is pulldown load for first driver. Output currant drive capability is greater than 250 mA, making circuit suitable for driving array of LEDs or lamps.—"CMOS Databook," National Samiconductor, Senta Clara, CA, 1977, p 5-38–5-49.



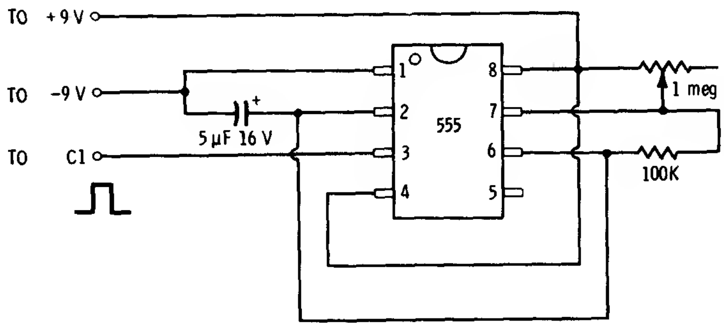
1-Hz LAMP BLINKER—Single CMOS flip-flop generates approximately constant low-frequency signal from variable high-frequency signal. RC network in feedback loop determines output frequency, which is independent of rate at which flip-flop is clocked if output frequency is lower than clock frequency. If clock frequency is lower, output transitions occur at half of clock frequency. Provides two outputs, approximately equal in duty cycle but opposite in phase. Circuit was developed to blink lamp at 1 Hz to indicate presence of active digital signal having variable duty cycle in range of 100 to 3000 Hz.—V. L. Schuck, Generate a Constant Frequency Cheaply, *EDN Magazine*, Aug. 20, 1975, p 80 and 82.



3-V STROBE—Flash rate of 1767 lamp can be adjusted from no flashes to continuously on, in circuit using National LM3909 flasher IC with external NPN power transistor rated at 1 A or higher. Can be used as variable-rate warning light, for advertising, or for special effects. With lamp in large reflector in dark room, flashes several times per second are almost fast enough to stop motion of dancer.—P. Lefferts, Power-Miser Flasher IC Has Many Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.

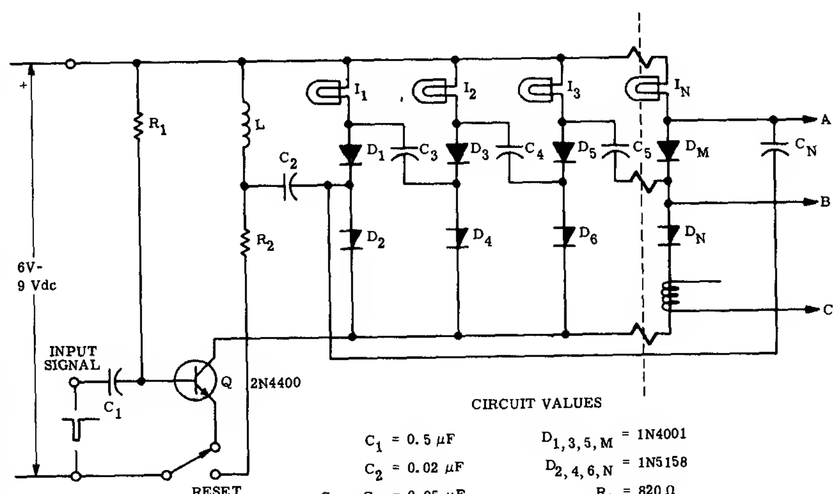


OUT-OF-PHASE DOUBLE FLASHER—Sections of National MM74C908/MM74C918 dual CMOS driver are connected as Schmitt-trigger oscillator, with LEDs at output of each section so LEDs will flash 180° out of phase. High output current capability makes circuit suitable for driving two LED arrays.—"CMOS Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-38–5-49.



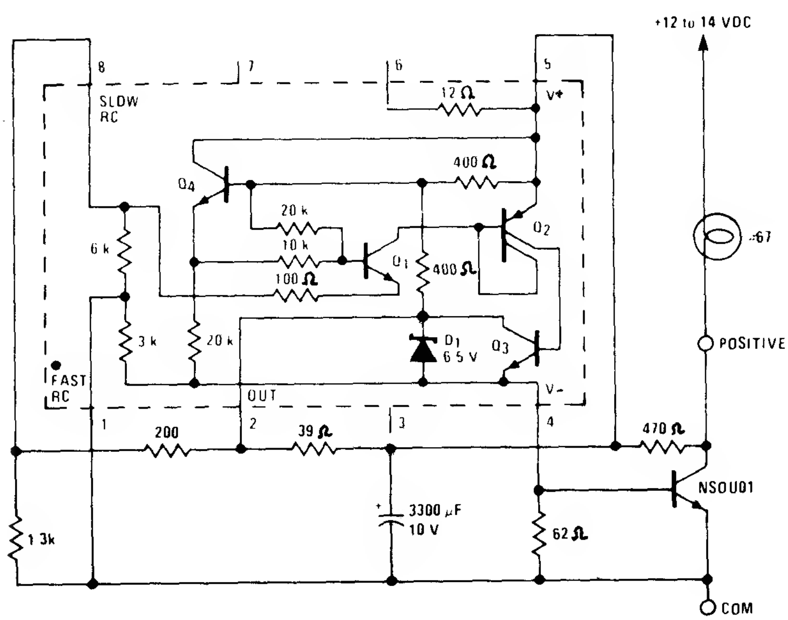
CLOCK DRIVE FOR FLIP-FLOP FLASHER—555 timer connected as astable MVBR generates series of timing pulses at rate determined by value of capacitor and setting of 1-megohm pot. Provides automatic string of input pulses for driving flip-flop of dual flasher. Pulse output goes to input capacitor C1 of flip-flop.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 30–37.

SEQUENTIAL SWITCHING OF LOADS—Ring counter using four-layer diodes D_N provides sequential switching of loads under control of input pulse-train signal. Indicator lamps are shown, but any load from 15 to 200 mA can be switched. After power is applied, reset switch must be pressed to establish current through L. When switch is released, this current flows through C_2 and breaks down D_2, allowing current to flow through first lamp I_1. Input pulse to transistor Q (normally held off by current through R_1) turns Q off and removes power from diode circuits, thus turning I_1 and D_2 off. At end of input pulse, Q comes on and restores power to diode circuits, but all loads will be turned off. Voltage on C_3 now adds to 6 V normally across D_4, making D_4 break down and turn on I_2. Next input pulse will break down D_6 in same manner. Output signals may be picked up as negative pulses at A or B or by current-sensing at C if required for controlling larger loads.—J. Bliss and D. Zinder, "4-Layer and Current-Limiter Diodes Reduce Circuit Cost and Complexity," Motorola, Phoenix, AZ, 1974, AN-221, p 5.

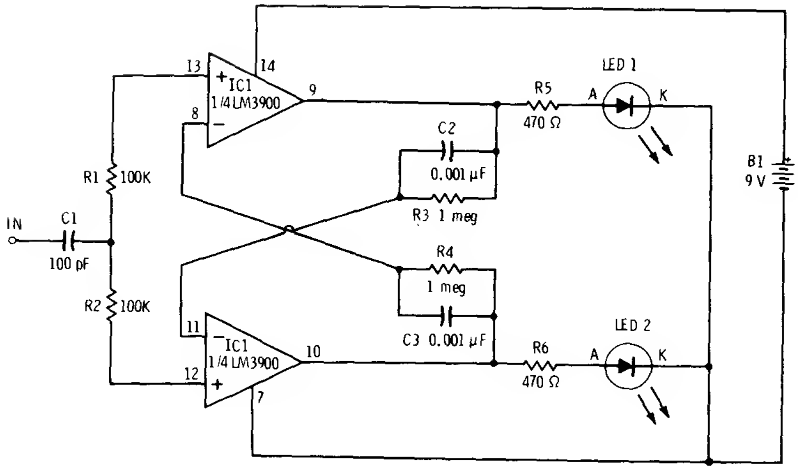


CIRCUIT VALUES

C_1 = 0.5 μF	$D_{1,3,5,M}$ = 1N4001
C_2 = 0.02 μF	$D_{2,4,6,N}$ = 1N5158
C_3 - C_N = 0.05 μF	R_1 = 820 Ω
L = 10 mH	R_2 = 51 Ω
	Q = 2N4400

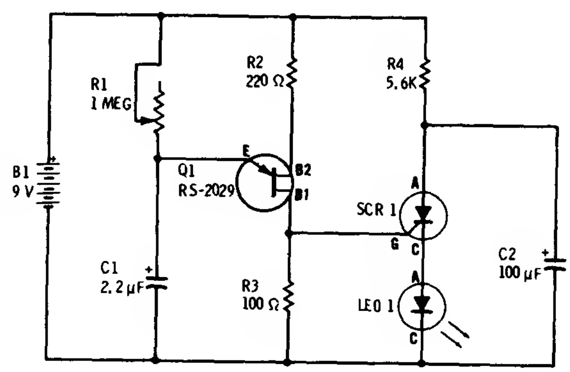


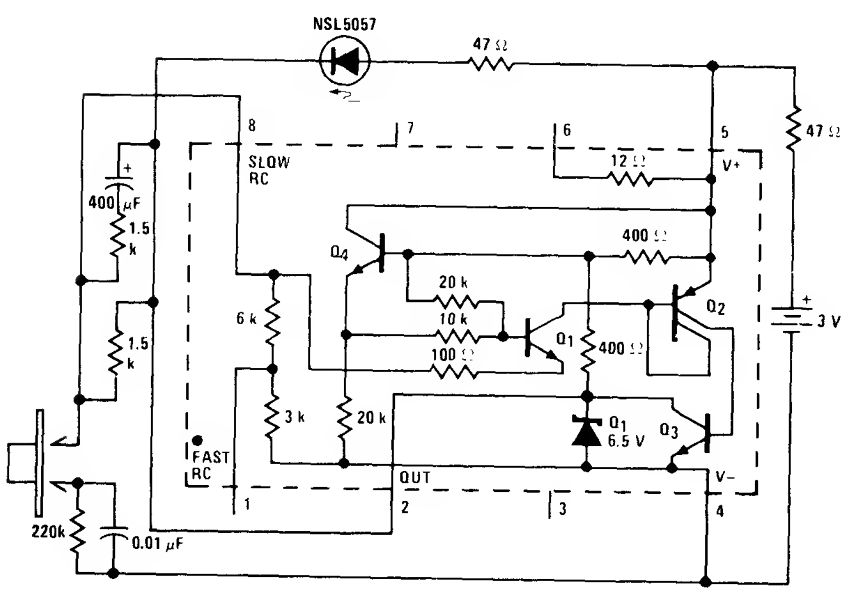
1-Hz AUTO FLASHER—Lamp drawing nominal 600 mA is flashed at 1 Hz by National LM3909 flasher IC operating from 12-V automotive battery. Use of 3300-μF capacitor makes flasher IC immune to supply spikes and provides means of limiting IC supply voltage to about 7 V.—P. Lefferts, Power-Miser Flasher IC Has Many Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.



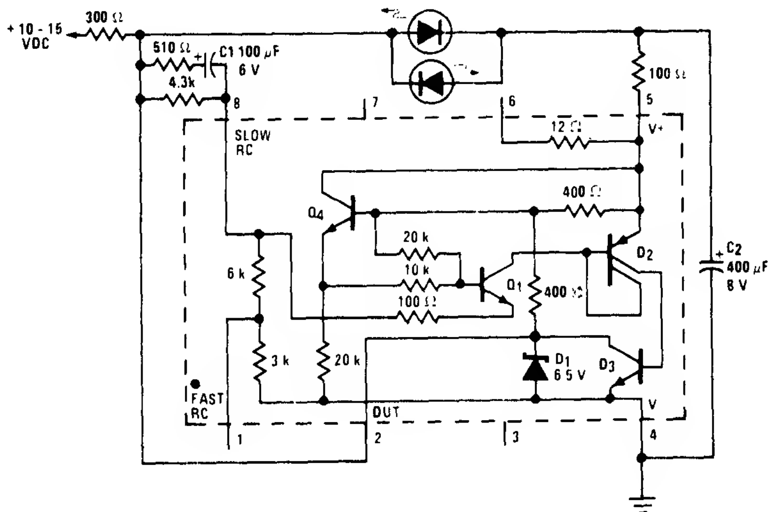
DEMONSTRATION FLIP-FLOP—Two sections of LM3900 quad opamp form bistable MVBR for flip-flop having two stable states. When input is grounded momentarily, output of one of opamps swings completely on and turns other opamp off. LED indicates which opamp is on at any particular time. Next grounding of input reverses conditions. Ideal for classroom demonstrations.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 30–37.

SCR FLASHES LED—UJT oscillator Q1 provides timing pulses for triggering SCR driving red Radio Shack 276-041 LED. Circuit draws only 2 mA from 9-V battery when producing 12 flashes per second. SCR is 6-A 50-V 276-1089.—F. M. Mims, "Semiconductor Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1976, p 78–84.



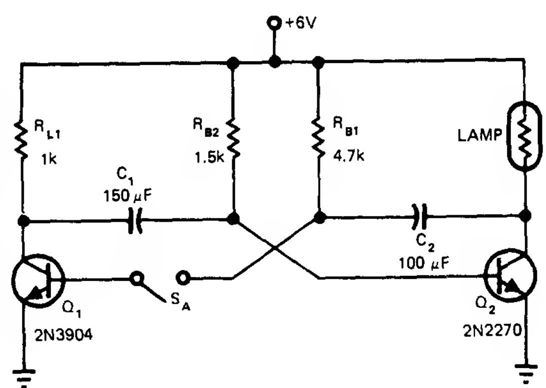


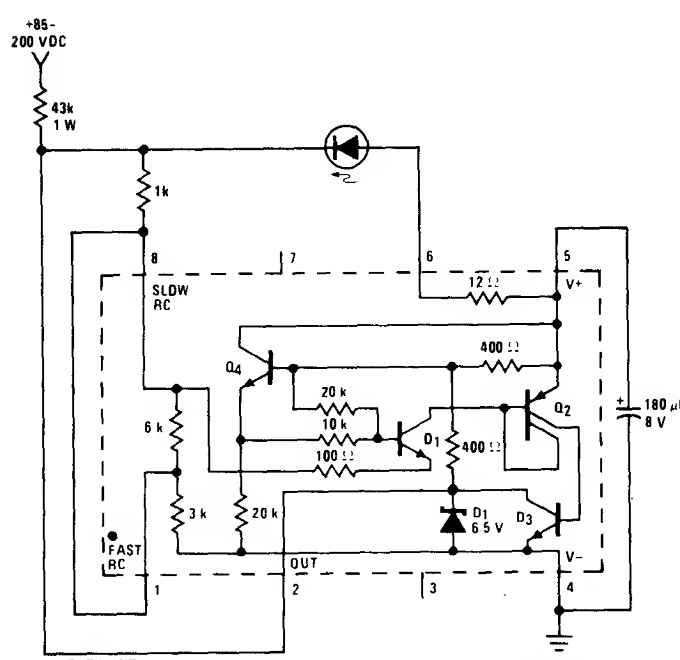
SINGLE-FLASH LED—Mono MVBR connection of National LM3909 IC produces 0.5-s flash with LED each time pushbutton makes momentary contact.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 9.



ALTERNATING RED/GREEN—National LM3909 IC is connected as relaxation oscillator for flashing red and green LEDs alternately. With 12-VDC supply, repetition rate is about 2.5 Hz. Green LED should have its anode or positive lead toward pin 5 as shown for lower LED, where shorter but higher-voltage pulse is available. LED types are not critical.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 3.

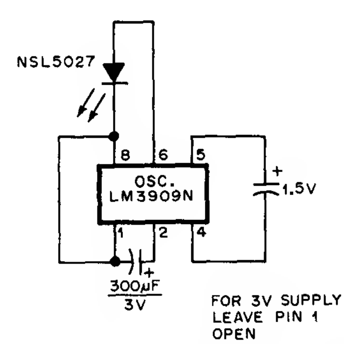
ALARM-DRIVEN FLASHER—Simple two-transistor flasher circuit for annunciator system is activated by alarm. Operator acknowledges alarm condition by depressing S_A, which changes lamp from flashing to steady ON condition. 6-V incandescent lamp draws about 0.3 A through Q_2, but 1K load resistor for Q_1 limits current of this transistor to about 6 mA so smaller transistor can be used.—T. Stahnay, Flasher Design Cuts Extra Components, *EDN Magazine*, Sept. 20, 1978, p 144.



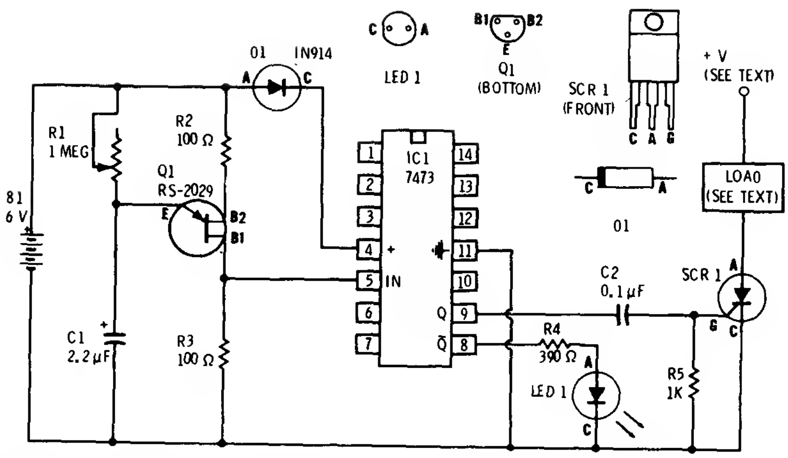


7 VOLT LIMIT

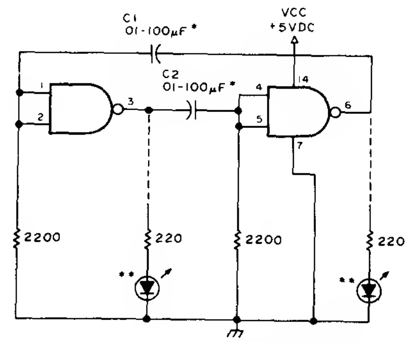
FLASHING LED IS REMOTE MONITOR—Circuit uses National LM3909 flasher IC to drive LED for monitoring remotely located high-voltage power supply. When 43K dropping resistor is located at power supply, all other voltages on the line, IC, and LED will be less than 7 V above ground, for safe remote monitoring. Use any LED drawing less than 150 mA.—P. Lefferts, Power-Miser Flasher IC Has Many Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.



1.5-V OR 3-V INDICATOR—Digi-Key LM3909N flasher/oscillator drives LED serving as ON/OFF indicator for battery-operated devices. At flash rate of 2 Hz, battery life almost equals shelf life.—C. Shaw, ON-OFF Indicator for Battery Device, *QST*, March 1978, p 41–42.

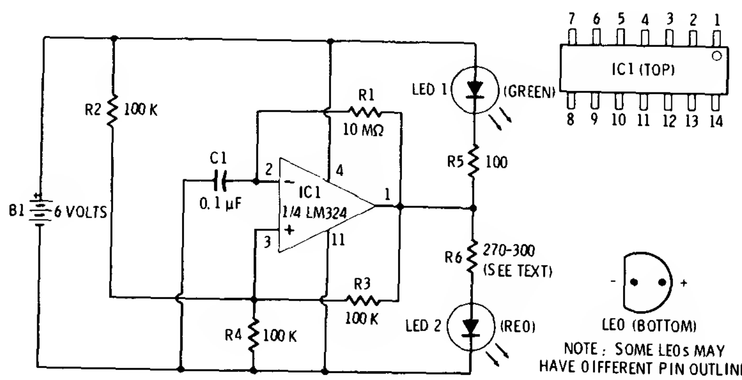


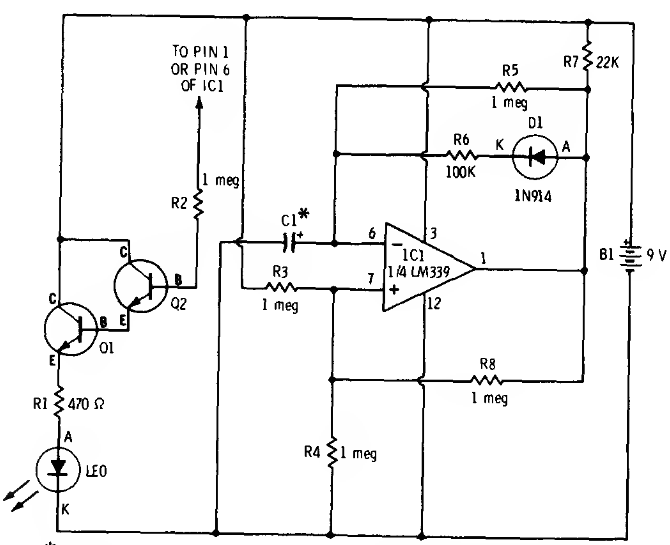
FLIP-FLOP DRIVES SCR—UJT relaxation oscillator Q1 serves as clock for driving section of 7473 dual flip-flop. One output of flip-flop flashes Radio Shack 276-041 red LED to indicate operating status. Other output alternately triggers SCR which can be 6-A 50-V 276-1089, for flashing lamp load. Load and SCR supply voltage depend on application but must be within SCR rating.—F. M. Mims, "Semiconductor Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1976, p 62–70.



LED BLINKER—Two sections of SN7400 quad gate form MVBR operating at low enough frequency so LED status indicators come on and off slowly for visual observation of MVBR. LEDs are optional and do not affect operation of MVBR. Capacitors must be same value. Ideal for student demonstration in classroom or as Science Fair exhibit.—A. MacLean, How Do You Use ICs?, *73 Magazine*, Dec. 1977, p 56–59.

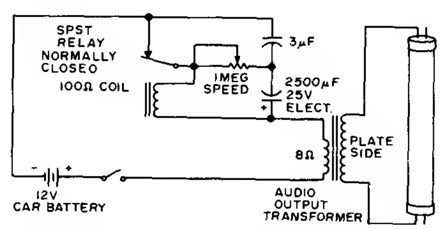
RED/GREEN LED FLASHER—One section of LM324 quad opamp is connected as square-wave generator giving about 1 flash per second for each LED. Series resistors for LEDs have different values because they have different forward voltage requirements. If LED 2 glows between flashes, increase value of R6 slightly. Too large a value for R6 reduces flash brilliance of LED 2. Supply can be 5 or 6 V.—F. M. Mims, "Semiconductor Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1975, p 69–74.



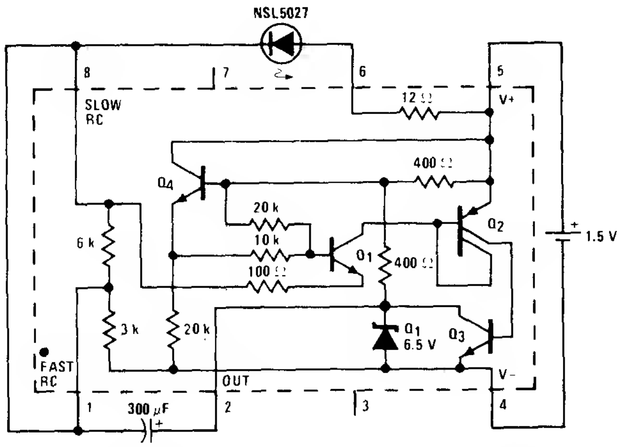


*SEE TEXT

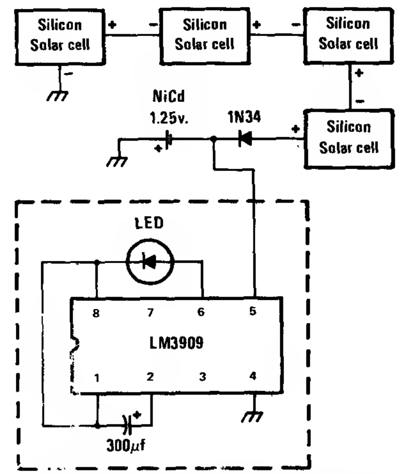
COMPARATOR LED FLASHER—One section of LM339 quad comparator drives two RS2016 NPN transistors having LED load, to give simple flasher for classroom demonstrations. Circuit can be duplicated with other three sections to give four flashers. Connecting R2 to pin 1 of IC gives conventional ON/OFF flash cycle in which LED turns on and off rapidly. Connecting R2 to pin 6 makes LED turn on rapidly and turn off very slowly. C1 controls flash interval; typical value is 0.01 μF.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 45–51.



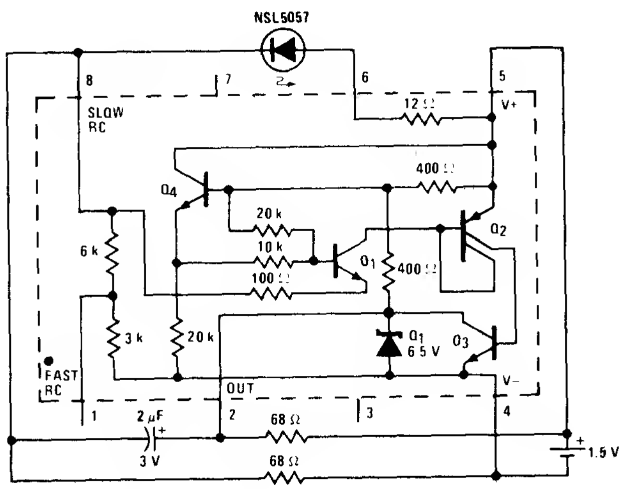
12-V FLUORESCENT—Relay acts as mechanical DC/AC converter operating off 12-V car battery. Each time relay opens, inductive kick in relay coil is stepped up by output transformer to high enough voltage for ionizing 24-inch fluorescent tube, giving flash that can serve as emergency flasher when car breaks down.—Circuits, *73 Magazine*, June 1975, p 175.



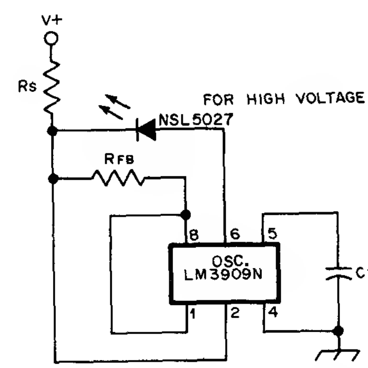
1.5-V LED FLASHER—National LM3909 IC operating from 1.5-V battery drives NSL5027 LED in such a way that current is drawn by LED only about 1% of time. External 300-μF capacitor sets flash rate at about 1 Hz.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 2.



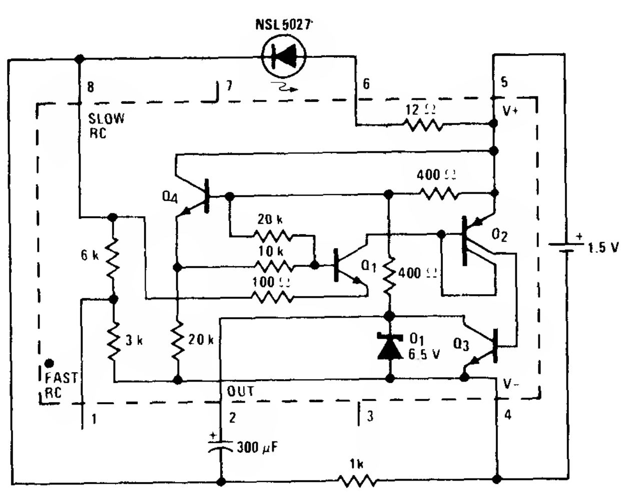
LED FLASHER—Requires only LM3909 IC and external capacitor operating from 1.25-V nicad or other penlight cell. Circuit can be duplicated for as many additional flashing LEDs as are desired for display. Optional charging circuit uses silicon solar cells and diode for daytime charging of battery automatically.—J. A. Sandler, 11 Projects under $11, *Modern Electronics*, June 1978, p 54–58.



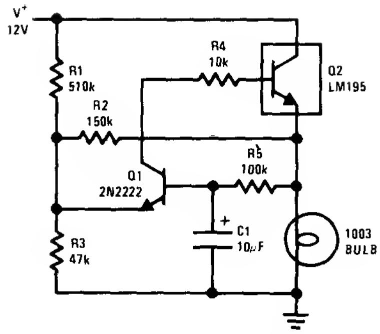
2-kHz FLASHER FOR LED—Single 1.5-V cell provides power for National LM3909 flasher IC that operates at high enough frequency to appear on continuously, for use as indicator in battery portable equipment. Duty cycle and frequency of current pulses to LED are increased by changing external resistors until average energy reaching LED provides sufficient light for application. At 2 kHz, no flicker is noticeable.—P. Lefferts, Power-Miser Flasher IC Has Many Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.



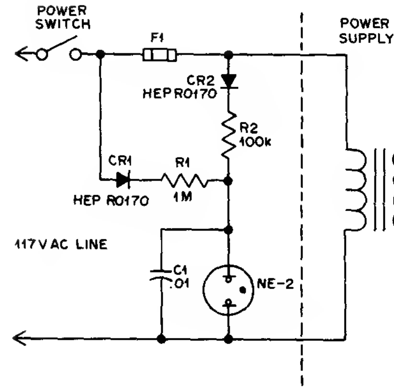
6-V OR 15-V INDICATOR—Uses Digi-Key LM3909N flasher/oscillator to drive LED at 2 Hz as ON/OFF indicator for battery-operated devices. For 6-V battery, C_T is 400 μF, R_S is 1000 ohms, and R_{FB} is 1500 ohms. For 15 V, corresponding values are 180, 3900, and 1000. Battery life is essentially same as shelf life.—C. Shaw, ON-OFF Indicator for Battery Device, *QST*, March 1978, p 41–42.



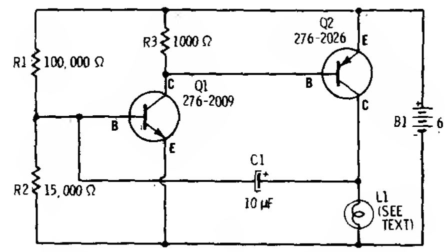
FAST 1.5-V BLINKER—Addition of 1K resistor between pins 4 and 8 of National LM3909 IC increases flash rate to about 3 times that obtainable when 300 μF is connected between pins 1 and 2. Modification of external connections gives choice of 3K, 6K, or 9K for internal RC resistors.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 2.



1-A LAMP FLASHER—National LM195 power trensistor is turned on and off once per second for fleshing 12-V lemp. Current limiting in LM195 prevents high peak currents during turn-on even though cold lamp can drew 8 times normel operating current. Current-limiting feeture prolongs lemp life in fleshing applications.—R. Dobkin, "Fast IC Power Transistor with Thermal Protection," Netional Semiconductor, Santa Clara, CA, 1974, AN-110, p 5.



BLOWN-FUSE BLINKER—Neon lamp NE-2 glows steadily when fuse is good and fleshes when fuse opens. Flesh rete, determined by R1 and C1, is about 10 flashes per second for values shown.—T. Lincoln, A "Smart" Blown-Fuse Indicator, *QST*, March 1977, p 48.

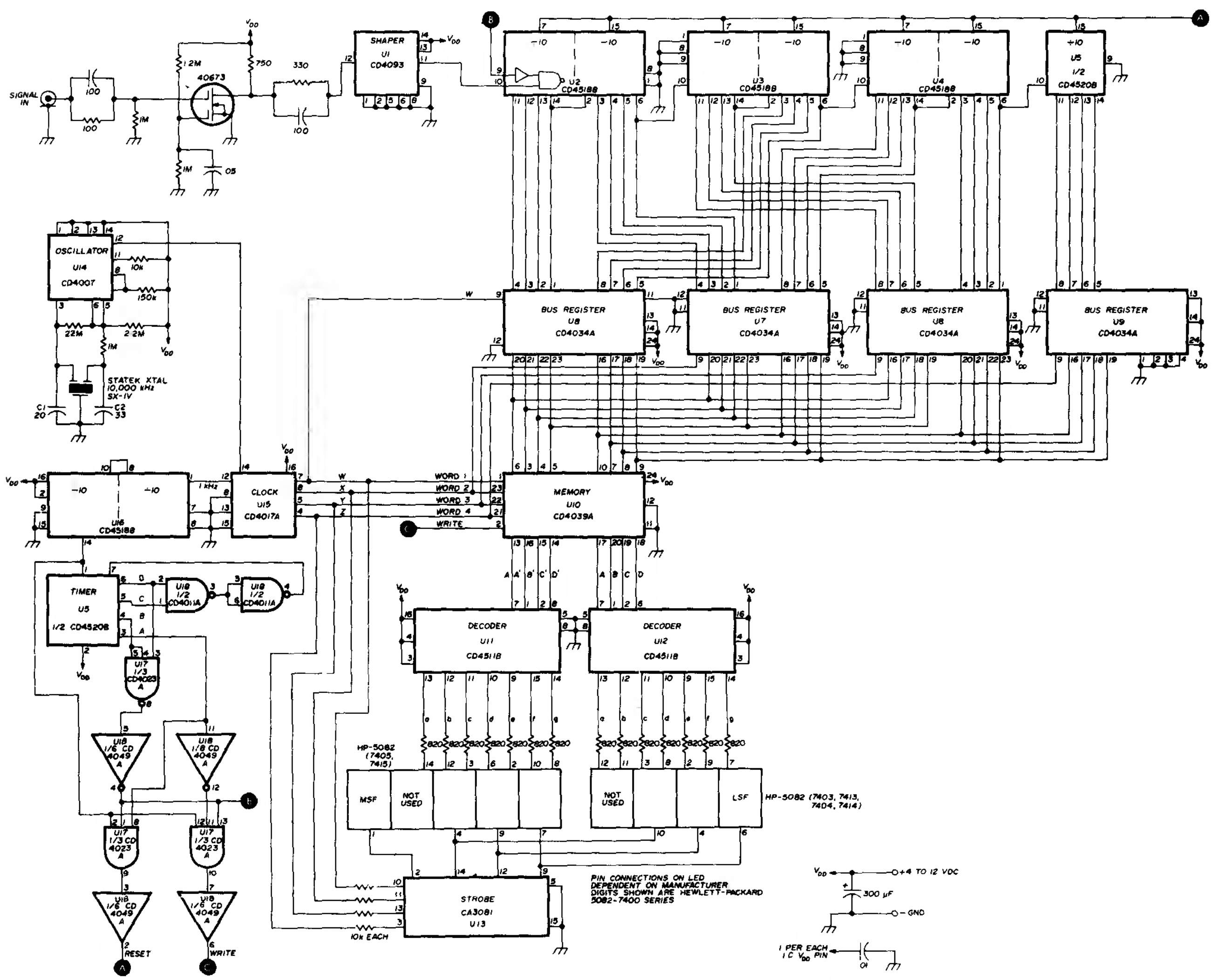


AUTO-BREAKDOWN FLASHER—Two-trensistor emplifer with regenerative feedback sends 60-ms pulses of currents up to several amperes through low-voltage lamp to give high-brillience flashes without destroying lamp. L1 can be PR-2 lamp (Radio Shack 272-1120).—F. M. Mims, "Trensistor Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 27–32.

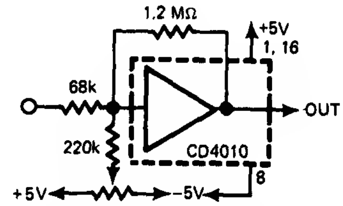
CHAPTER **31**

Frequency Counter Circuits

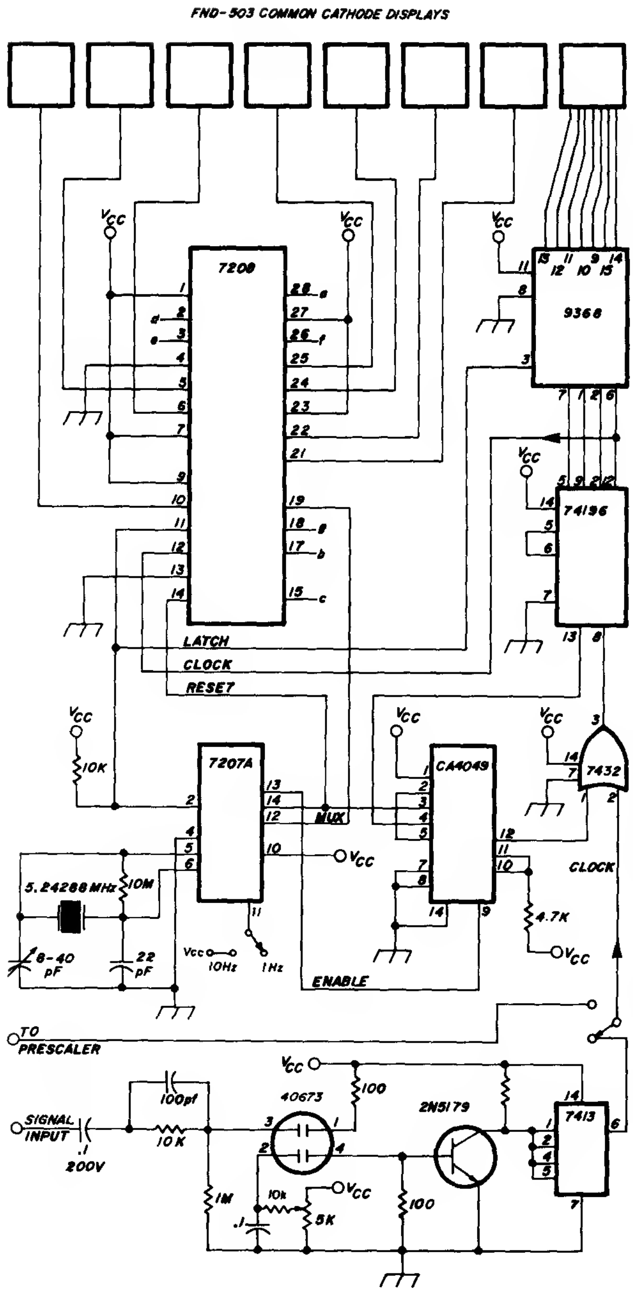
Used to indicate frequency value directly on digital display by counting number of cycles in period of exactly 1 second. Included are preamps, time bases, and prescalers for extending counting range to as high as 500 MHz.



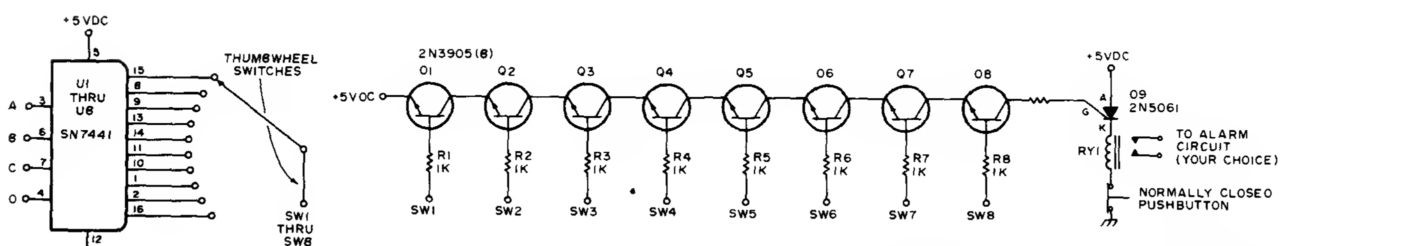
4-MHz COUNTER—Portable frequency counter using RCA CMOS logic draws only 300 mW (12 V at 25 mA) yet operates to well above 4 MHz. Supply voltage can be between 4 and 15 V, loosely regulated, without affecting accuracy. Display uses multiplexing with 10% duty cycle to minimize battery drain. One multiplexed output is for three least significant figures and other for four most significant figures. Article describes operation in detail. Applications include setting RTTY mark and space tones, FM repeater tones, signal-generator frequencies for TV alignment, tuning musical instruments, and serving as tachometer or speedometer in car.—R. M. Mendelson, Milliwatt Portable Counter, *Ham Radio*, Feb. 1977, p 22–25.



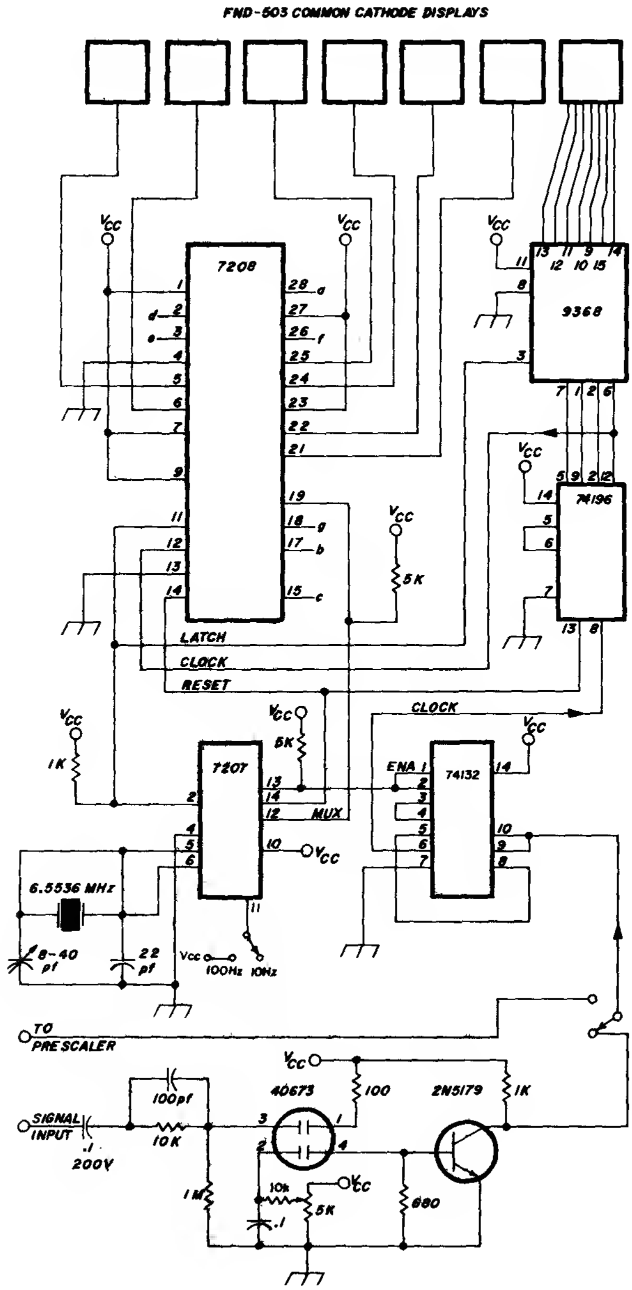
0–3 MHz PREAMP—Provides wide frequency response required for amplifying 100 mV P-P input signals to 5-V level for driving CMOS logic of frequency counter.—R. Tenny, Counter Pre-Amp Matches CMOS Logic Capability, *EDN Magazine*, Sept. 20, 1976, p 114 and 116.

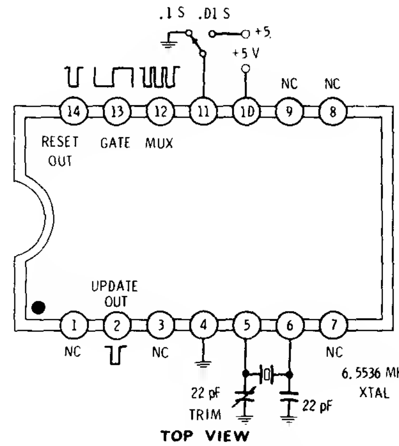


50 MHz WITH 1-Hz RESOLUTION—Combination of CMOS and TTL devices reduces chip count for digital frequency counter that provides 1-Hz resolution from below 20 Hz to above 50 MHz. Use of 10:1 prescaler, also given in article, extends range to above 300 MHz with 10-Hz resolution. Uses Intersil 7208 CMOS seven-decade counter that includes multiplexer, decoder, drivers, and other controls for Fairchild FND-503 8-digit display. High-stability 5.24288-MHz crystal oscillator and frequency divider provide 1-s gate required for counting, outputs for synchronizing multiplexer, and short pulses for latching and resetting counters. Resolution can be decreased by factor of 10 by connecting pin 11 of 7207A to V_{CC}, which is regulated 5 V.—H. E. Harris, Simplifying the Digital Frequency Counter, *Ham Radio*, Feb. 1978, p 22–25.



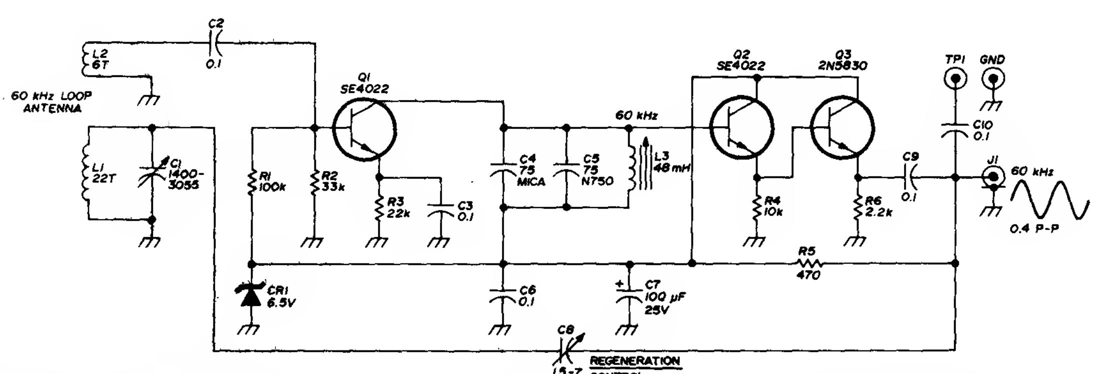
PRESET-FREQUENCY ALARM—When selected frequency occurs in Nixie-driving counter, alarm circuit triggers and locks until reset manually. Requires one SN7441 Nixie decoder/driver, one decimal-type thumbwheel switch, and one 2N3905 transistor for each digit of display in counter. Four connections are made to each counter stage to get BCD inputs A, B, C, and D for 7441. Connections can be made to 7475 quad latch in typical counter. Circuits are for 8-digit display. When display reaches digit to which switch is set, switch output is grounded. When all switch outputs are grounded, all transistors are turned on and SCR fires to actuate alarm relay. If latching is undesirable, use medium-power NPN transistor in place of SCR.—W. L. MacDowell, Frequency Detector for Your Counter, *73 Magazine*, Oct. 1976 p 50–51.





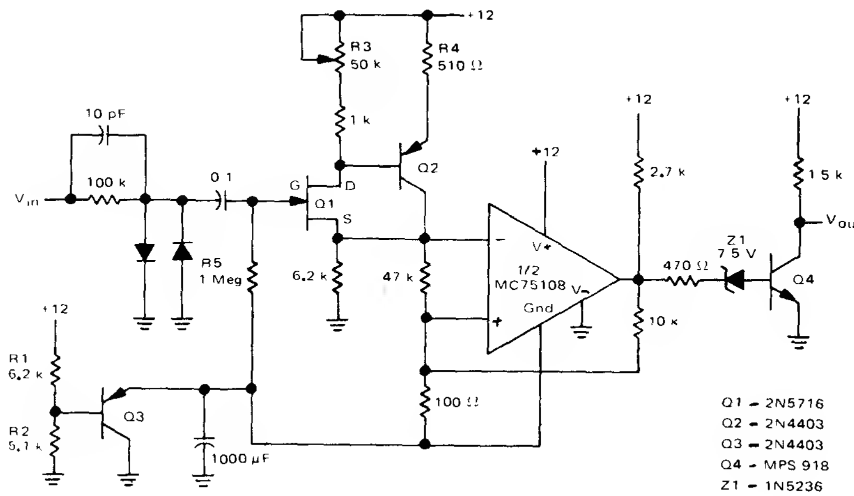
TIME BASE—Intersil 7207 IC generates clock and housekeeping pulses required for frequency counter. With pin 11 grounded, gate output is high for 0.1 s and low for 0.1 s. With pin 11 high, gate is high 0.01 s and low 0.01 s. 1.6-kHz square wave at pin 12 is useful for multiplexing displays. Update output is narrow negetive-going pulse coincident with rising edge of gate output, for use in transferring count to display latches. Reset output is used to reset counter.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 161.

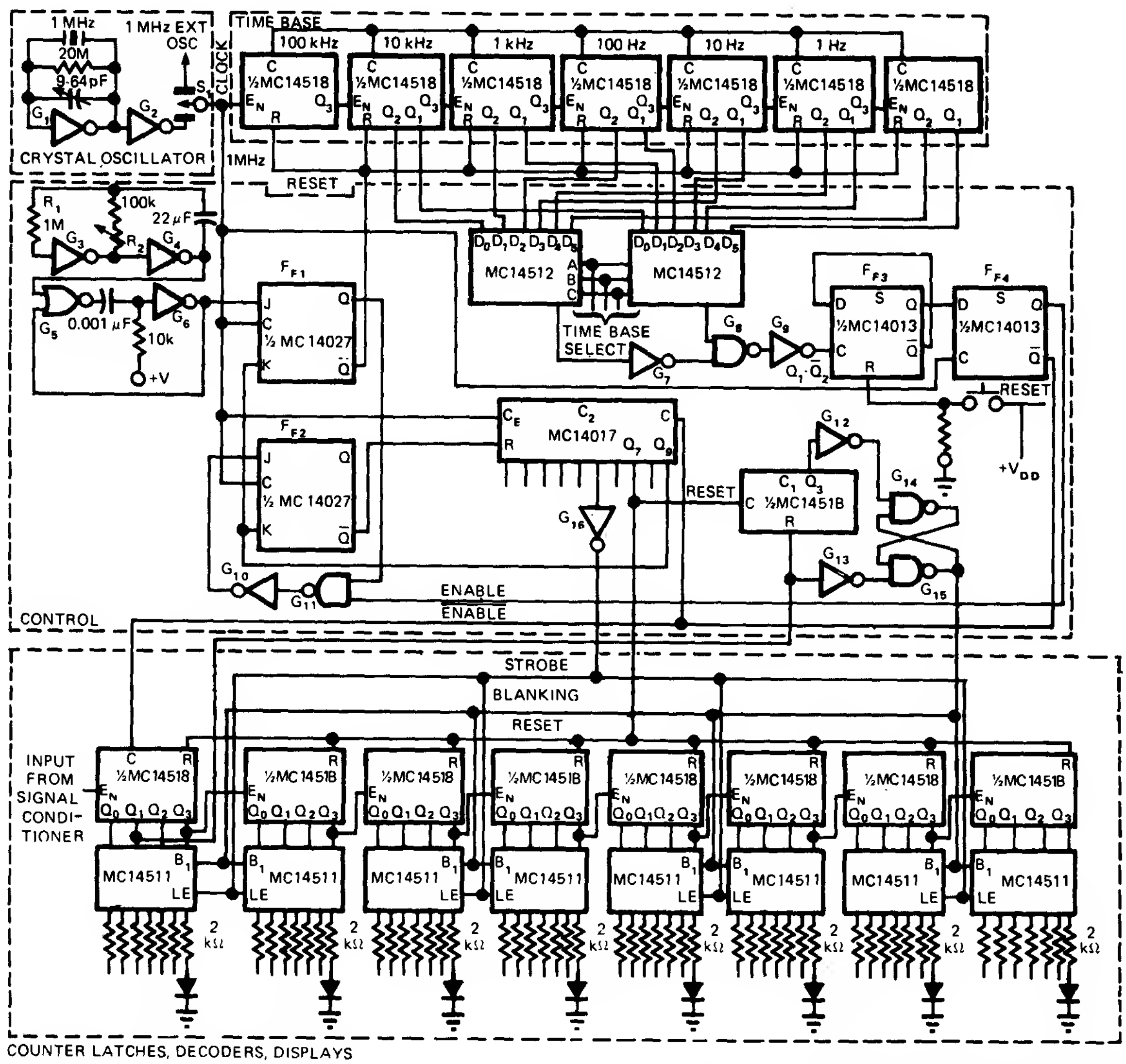
30 MHz WITH 10-Hz RESOLUTION—Simplified counter design using low chip count provides multiplexing of sevan digits in Fairchild display, for applications where 1-Hz resolution is not naeded. 7207 oscillator/timer gives counting interval of 0.1 s, for updating display 5 times par sacond. Article also gives circuit of 10:1 prescalar that incraeses frequancy limit to 300 MHz, though with 100-Hz resolution. Total counter current drain is 300 mA from regulated 5-V supply.—H. E. Harris, Simplifying the Digital Frequency Counter, *Ham Radio*, Feb. 1978, p 22–25.



60-kHz WWVB PREAMP—Installed in loop antenna to boost strength of 60-kHz standard-frequency broadcasts from NBS station at Boulder, Colorado, enough to drive digital frequency counter for which circuit is also given in article. Although construction details apply to double-copper shielded 54-inch-diametar circular loop, preamp can also be used with simple unshielded wood-frame loop. Output coax supplies regulated 10 VDC for preamp. Article includes techniques for minimizing intarfarence from naerby TV receivers.—H. Isenring, WWVB Signal Processor, *Ham Radio*, March 1976, p 28–34.

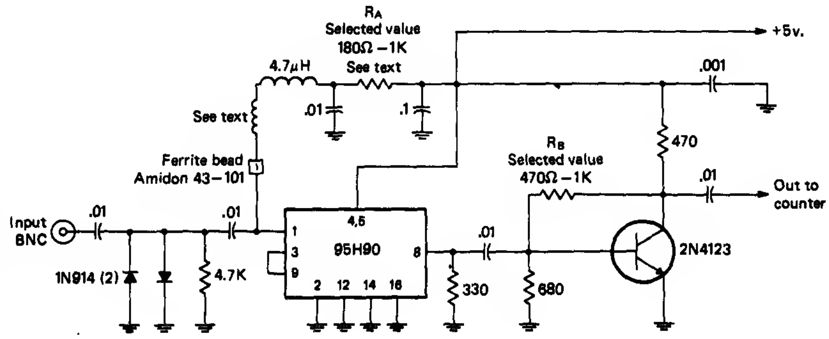
5-MHz FRONT END—Used ahead of 5-MHz frequency counter to make input signal swing from logic 0 of 0 V to logic 1 of about 10 V as required for accurate counting of frequency for input signal having any input waveform shape and level. Input of front end has high impedance to minimize effect on input waveform. FET transistor Q1 and bipolar buffer Q2 drive Schmitt trigger using half of Motorola MC75108 dual line receiver.—D. Aldridge, "Battery-Powered 5-MHz Frequency Counter," Motorola, Phoenix, AZ, 1974, AN-717, p 5.

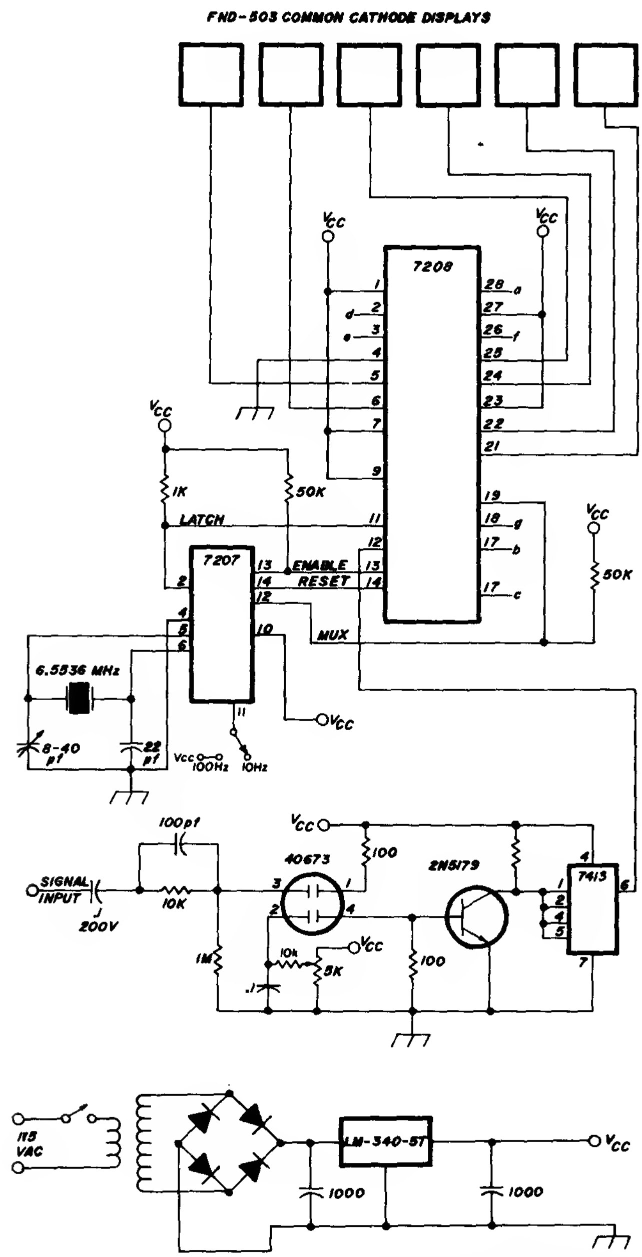


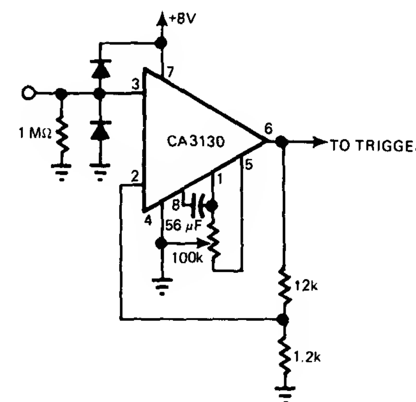


12-V 5-MHz COUNTER—Portable counter is designed with low-power logic to minimize battery drain, yet provides good performance. Since most of milliwatt power drain is taken by digital readout, circuit blanks out LED display when there is no input signal. Time base divides 1-MHz crystal oscillator frequency down to desired enable time, up to 10 s, using 3½ MC14518 dual decade counters connected in ripple-through mode. Actual counting of input signal codes is also done with MC14518 counters. Latches and BCD to 7-segment decoders use MC14511s. Enable line turns first counter on and off for precise enable time period. Strobe line transfers count into memory of MC14511 latch decoder, and control line resets MC14518 decade counters for next count cycle. Displays are Monsanto MAN-4 LEDs. Article traces circuit operation in detail and gives timing diagram.—D. Aldridge, CMOS Counter Circuitry Slashes Battery Power Requirements, *EDN Magazine*, Oct. 20, 1974, p 65–71.

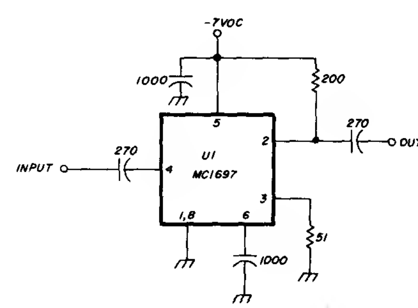
300-MHz PRESCALER—Uses Fairchild 95H90 IC to divide input signal frequency by factor of 10 up to 320 MHz. Full-wave diode limiter at input prevents damage to IC. R_A is chosen to bias IC at point of maximum sensitivity; typical value is 680 ohms. Transistor amplifier provides 2–3 V P-P output. Bias resistor R_B is set to make collector-base voltage 3 V; typical value is 620 ohms. Wind one lead of 4.7-μH choke around nail 4 times, then remove nail and slip ferrite bead over end of wire before connecting it to pin 1. Keep all leads as short as possible. Article covers construction and alignment in detail.—I. Meth, Meth's Notes, *CQ*, May 1975, p 42–44 and 64.





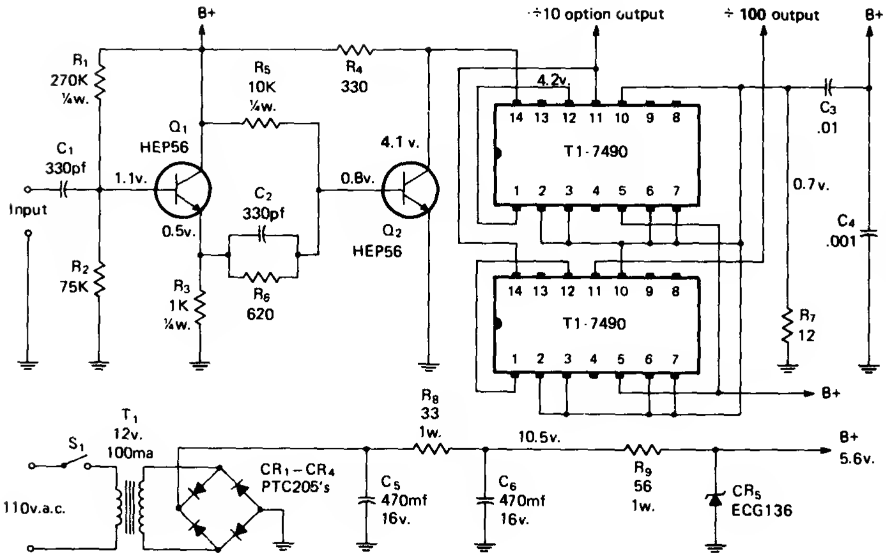


DIRECT-COUPLED PREAMP—Provides frequency response from 0 to 1 MHz at very low power levels, as required for driving CMOS logic of frequency counter. Diodes protect input from overload. Output impedance of frequency source should be kept below 50K to minimize noise pickup.—R. Tenny, Counter Pre-Amp Matches CMOS Logic Capability, *EDN Magazine*, Sept. 20, 1976, p 114 and 116.

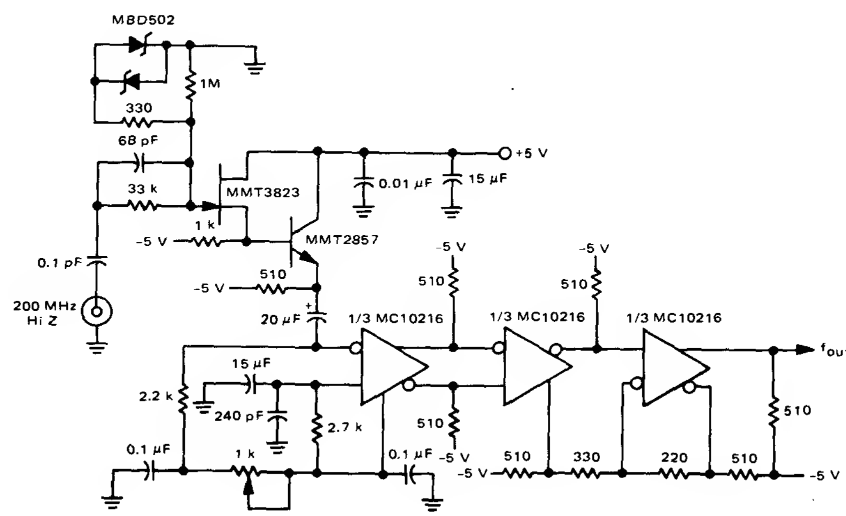


6 MHz WITH 10-Hz RESOLUTION—Intersil 7208 CMOS counter provides multiplexing of six digits in Fairchild display operating from 5-V regulated supply. Uses MOSFET 4673 input stage.—H. E. Harris, Simplifying the Digital Frequency Counter, *Ham Radio*, Feb. 1978, p 22–25.

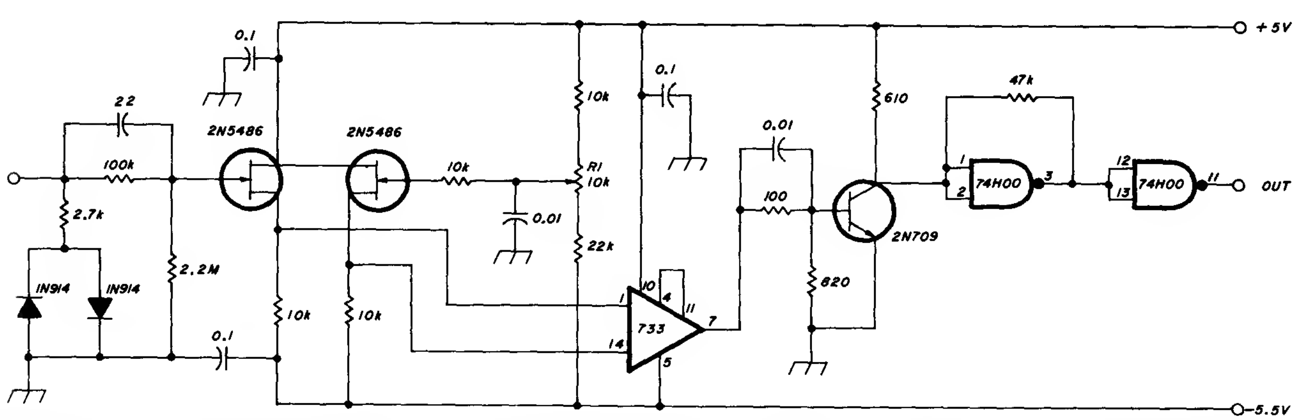
1.5-GHz PRESCALER—Motorola MC1697 IC provides division by 4 to extend operating range of 400-MHz counter above 1.5 GHz. Circuit will operate on input signals as low as 1 mW. Requires 60-mA power supply at −7 V. Article gives construction and test details.—J. Hinshew, 1.5 GHz Divide-by-Four Prescaler, *Ham Radio*, Dec. 1978, p 84–86.



TWO-DECADE SCALER—Solid-state frequency scaler extends range of older frequency counters by factors of 10 and 100, or up to 10 MHz for 100-kHz counter. Emitter-follower Q_1 provides matching from high input impedance to low impedance for driving sensitive clipper Q_2 that operates class B and presents 4 V P-P square wave to decade counter. Input accepts 1 to 14 V P-P.—D. Peck, A Solid State Scaler for Frequency Counters, *CQ*, April 1974, p 24–27.

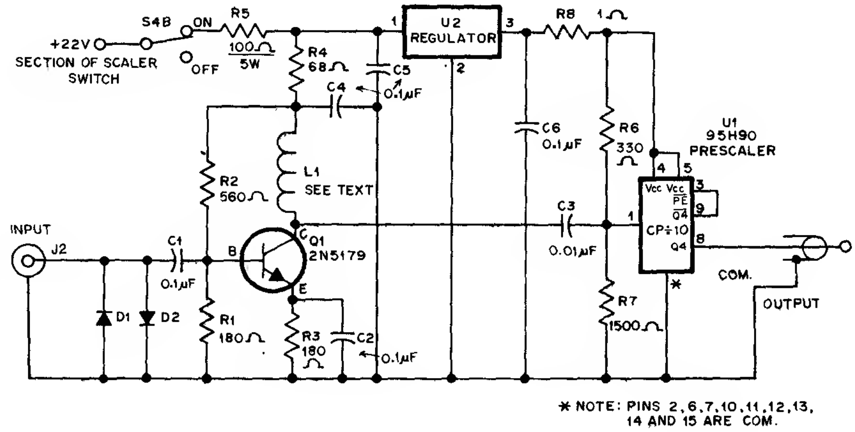


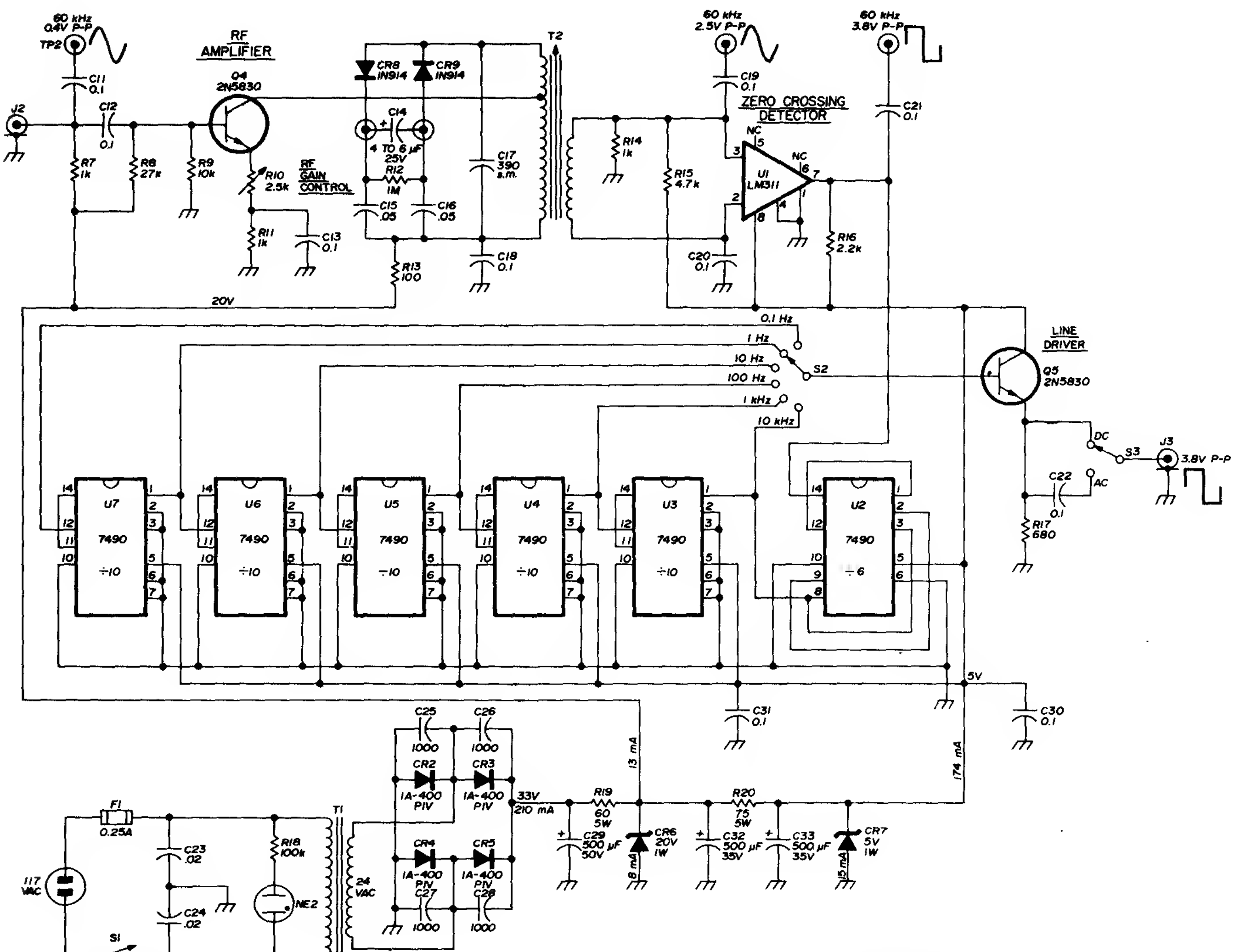
200-MHz BUFFER—Developed for use ahead of prescaler in 200-MHz autoranging frequency counter. Provides high input impedance to count-sensing device. Circuit includes Schmitt trigger action. Sensitivity is about 50 mV P-P.—T. Balph, "A 200 MHz Autoranging MECL—McMOS Frequency Counter," Motorola, Phoenix, AZ, 1975, AN-742, p 10.



IMPROVED PREAMP—Replaces inefficient input circuit of inexpensive frequency counter, to ensure accurate counting from DC to over 60 MHz. Circuit brings input signal waveform to TTL level of 3.5 V P-P while providing required perfect square waves down to lowest-frequency input signal. Input circuit is balanced FET source-follower having extremely high input impedance. Back-to-back diodes provide overload protection. Input stage drives 733 differential video amplifier having 100-MHz bandwidth and gain of 400. 2N709 switching transistor squares preamp signal for TTL translator using two sections of 74H00 high-speed quad NAND gate. Circuit requires dual-polarity supply delivering at least 63 mA; regulation is optional.—G. Beltrami, High-Impedance Preamp and Pulse Shaper for Frequency Counters, *Ham Radio*, Feb. 1978, p 47–49.

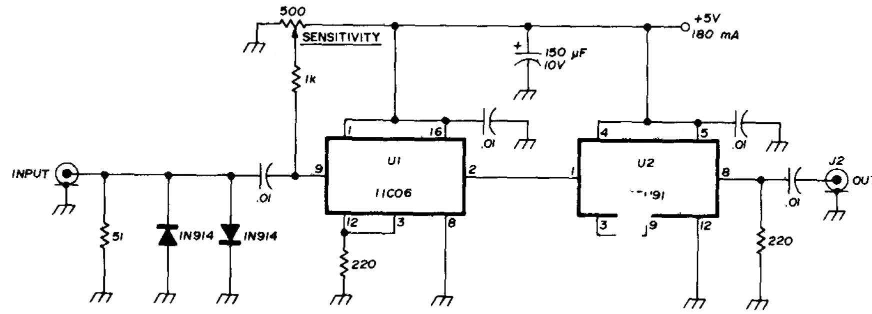
25–250 MHz PRESCALER—Based on use of Feirchild 95H90 decada counter, with preamp Q1 and associated components selected for 25–250 MHz range. 1N914N diodes prevant overloading of input. Voltage regulator Is LM340T-5. L1 is 8 turns No. 28 wound on body of 1000-ohm or largar ½-W resistor, with ends soldered to resistor leads. Querter-weve whip entenne at input will pick up adequate signal from 1-W 146-MHz trensceiver hand-hald 6–10 faet awey. Countar provides division by 10.—R. D. Shriner, Prescaler Updates tha DVM/Frequency Countar, *QST*, Sept. 1978, p 22–24 and 37.

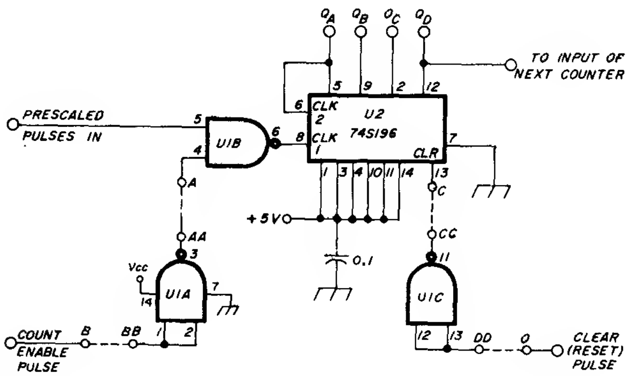




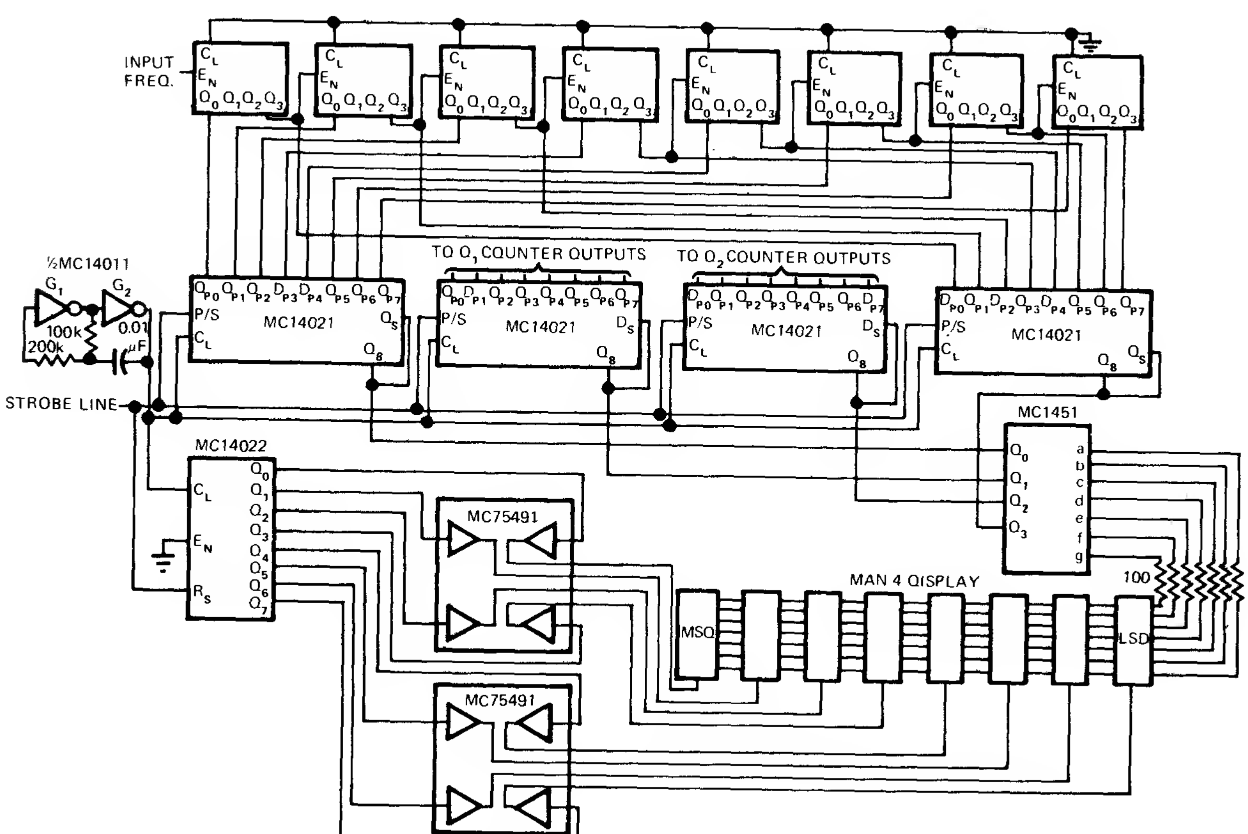
COUNTER DRIVE FOR WWVB—Uses LM311 as trua zero-crossing detector for 60-kHz carriar of NBS standard-frequency station et Boulder, Colorado. Rasulting squara wave is fed to chain of 7490 dividers whose outputs are selected by S2 to serva es gate for frequancy counter. T1 is 24-V 500-mA powar transformar, and T2 is 40-kHz cup-cora slug-tuned RF transformar as used in many TV remote controls. Primery inductence (7.5–46 mH) of T2 is tapped at 0.5 mH; secondery is 20 μH. Article also glves circuit of preamp thet can ba built into 60-kHz loop antenne to build up signal strength to 0.4 V as required for input to processor.—H. Isanring, WWVB Signel Processor, *Ham Radio*, March 1976, p 28–34.

10:1 PRESCALER FOR 500 MHz—Uses Fairchild 11C06 D flip-flop and Fairchild 95H91 divide-by-5 counter. Input sensitivity is less than 100 mV from 10 to 500 MHz. Back-to-back diodes protect 11C06 input from overloads. Output is fed to 50-MHz frequency counter. Use regulated supply.—W. C. Ryder, 500-MHz Decade Prescaler, *Ham Radio*, June 1975, p 32–33.



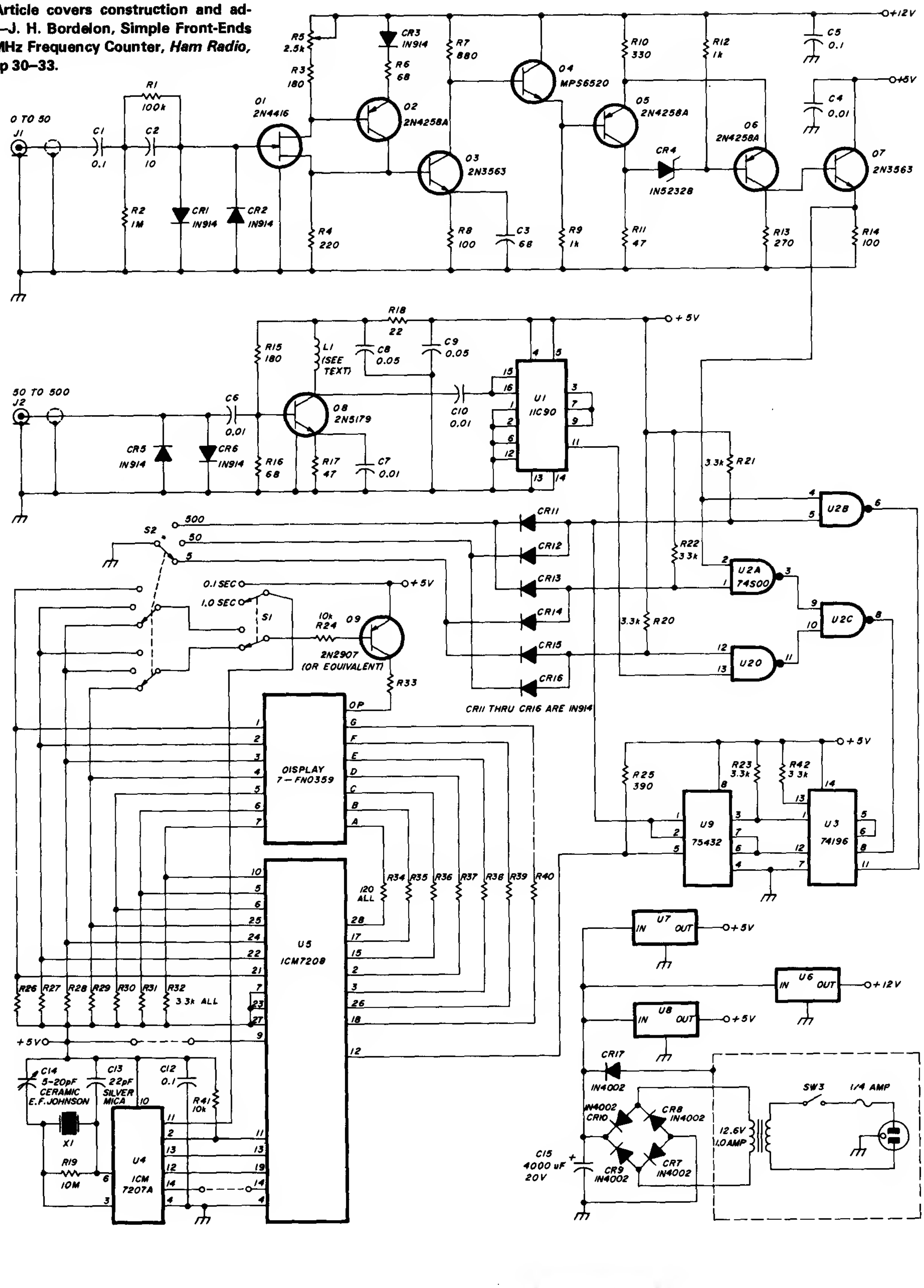


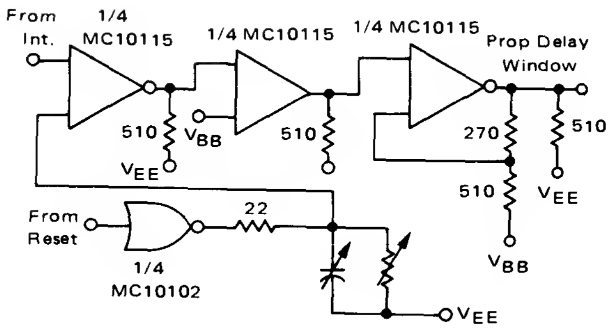
UPDATE TO 100 MHz—Simple counter stage can be added to input of existing frequency counter to extend direct counting range to 100 MHz, preparing it for use with 1-GHz prescaler. Use 74S196 presettable decade counter and 74S00 NAND-gate IC. If existing counter has positive reset pulse, connect C to CC and D to DD; if reset pulse is negative, connect C to D. If count enable pulse is negative, connect A to AA and B to BB; if positive, connect A to B. Power supply bypass capacitor should be shunted by 47-μF 10-V tantalum or electrolytic. Article covers modifications required in some counter input stages.—I. MacFarlane, How to Modify Your Frequency Counter for Direct Counting to 100 MHz, *Ham Radio*, Feb. 1978, p 26–29.



MULTIPLEXED DISPLAY—Used with battery-operated frequency counter to reduce battery drain by multiplexing single decoder driver between all of MAN-4 displays. Readout is integrated by eye over total time period, making display appear continuous. Display operates at peak of 20 mA but duty cycle is only 12.5%. Counter is operated from 6-V supply. Four MC14021 8-bit shift registers implement multiplexing and provide latches needed to store count from MC14518 counter chain. Article describes operation in detail and gives circuit of companion front end and 5-MHz counter.—D. Aldridge, CMOS Counter Circuitry Slashes Battery Power Requirements, *EDN Magazine*, Oct. 20, 1974, p 65–71.

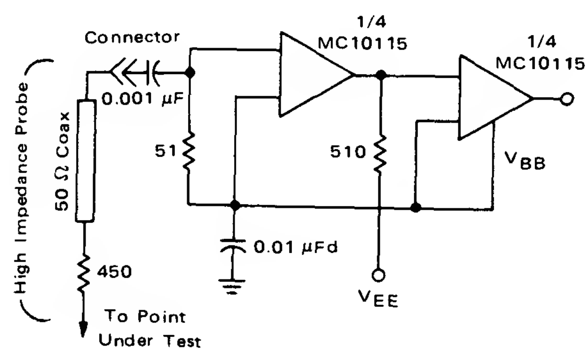
500 MHz WITH 100-Hz RESOLUTION—Circuit provides seperete 0–50 MHz preemp Q1-Q7 end 50–500 MHz prescaler for Intersil ICM7207A 7-digit CMOS frequency counter. 500-MHz prescaler uses Feirchild 11C90 thet drives TTL directly, with 2N5179 trensistor es preamp. L1 and output cepacitance of 2N5179 form low-Q resonent circuit. U3 is 50-MHz prescaler for both preemps. Crystal frequency is 5.242880 MHz. 5-V regulators ere MC7805, and 12-V reguletor is MC7812. Article covers construction and adjustment.—J. H. Bordelon, Simple Front-Ends for e 500-MHz Frequency Counter, *Ham Radio*, Feb. 1978, p 30–33.

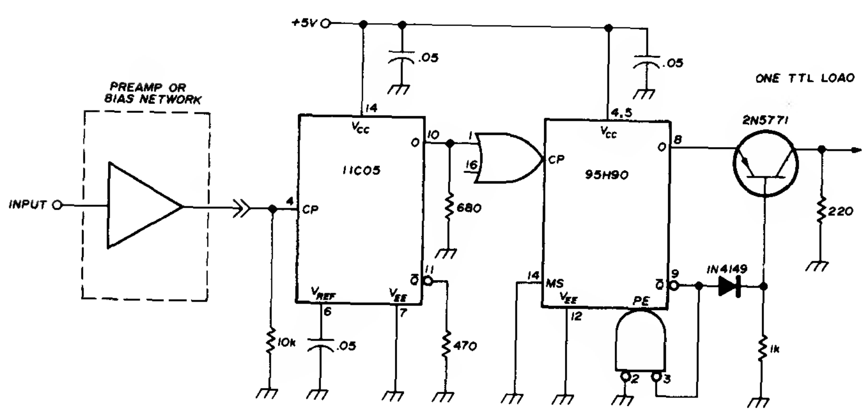




RAMP GENERATOR/COMPARATOR—Developed for frequency countar using standerd ECL components. One input to comperator is from integrator stage, and othar is from ramp generator driven by reset signel from UJT oscillator.—W. R. Blood, Jr., "Measure Frequency end Propegation Deley with High Speed MECL Circuits," Motorola, Phoenix, AZ, 1972, AN-586, p 3.

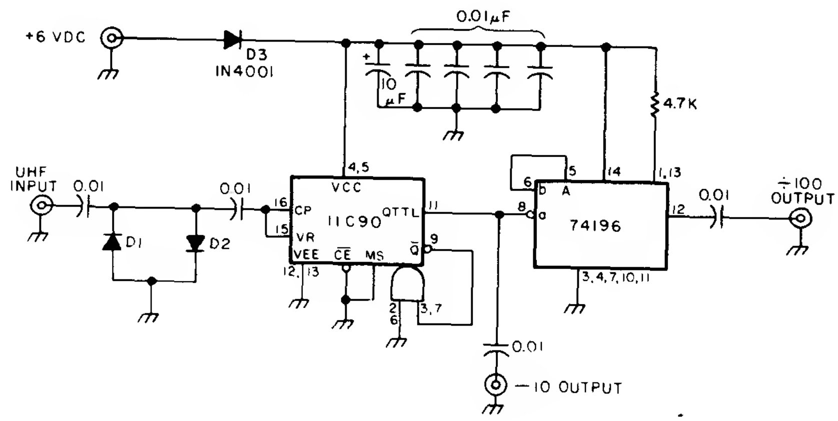
INPUT BUFFER FOR 100-MHz COUNTER—Can ba used with 500-ohm probe for wide renge of high-frequency Input signel levels and waveforms, as part of frequency counter using standard emitter-coupled logic. Opamps used have 50-ohm input impedance. 450-ohm resistor in series with coax gives 10:1 attenuation factor (80 mV at amplifier input when measuring 800-mV ECL swing).—W. R. Blood, Jr., "Measure Frequency and Propagation Daley with High Speed MECL Circuits," Motorole, Phoenix, AZ, 1972, AN-586, p 3.



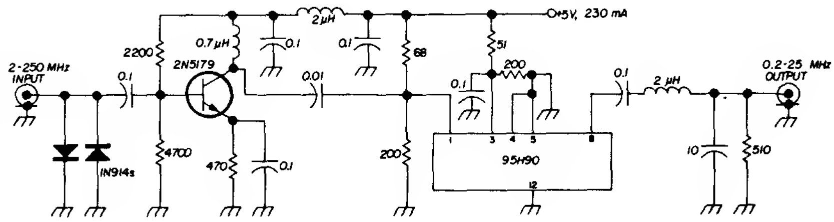


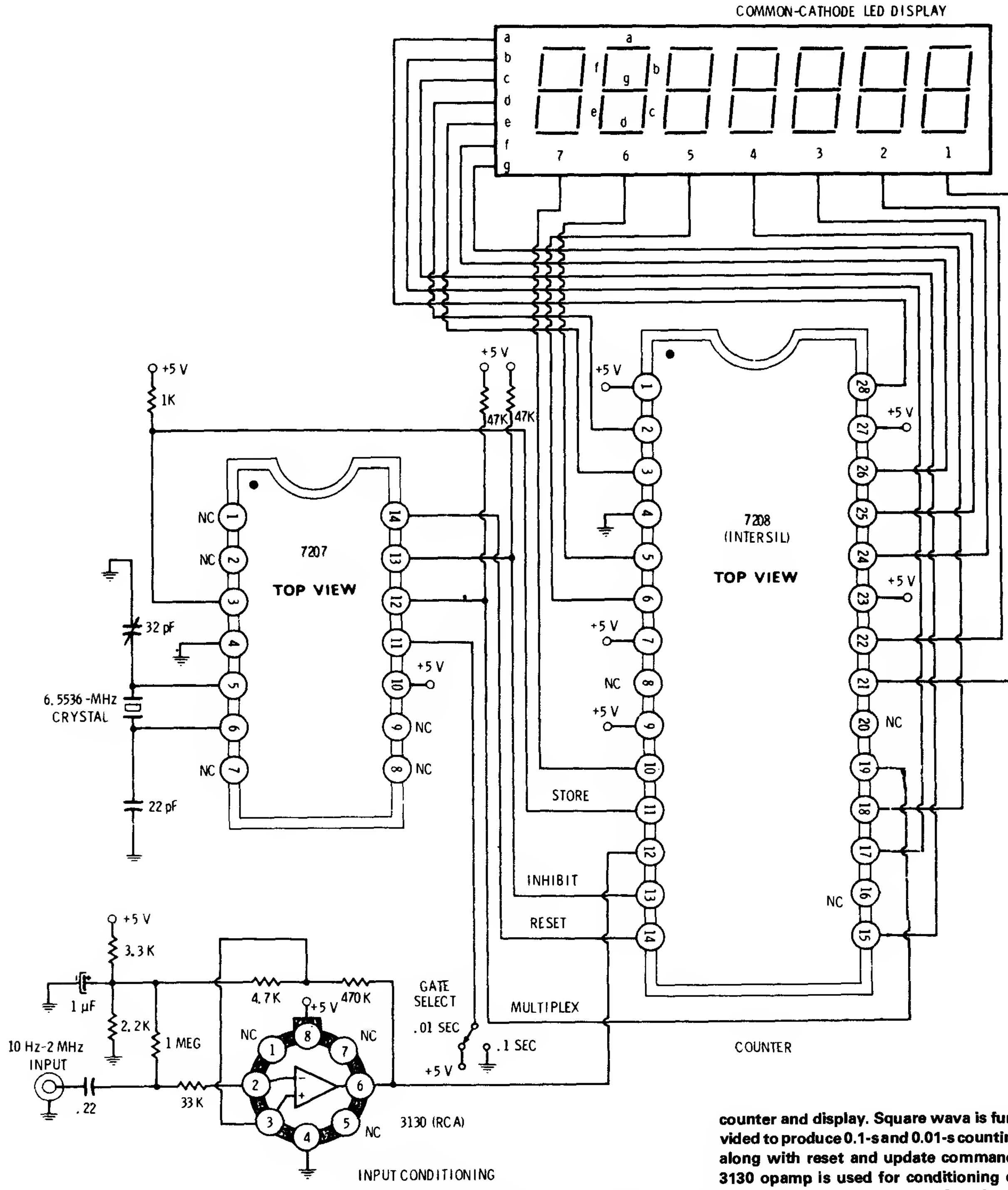
40:1 SCALER FOR 1200 MHz—Uses Feirchild 11C05 divide-by-4 counter and 95H90 decade divider. Unused CP input is tied to ground. Trensistor translates ECL level to TTL for driving one unit load. Operates from single regulated power supply. Input may be AC or DC coupled so eithar input emplifier or simple bias network (elso given in erticle) may be used. 10K resistor from pin 4 to ground aliminates noise triggering in middle frequency renges.—D. Schmleskors, 1200-MHz Frequency Scelers, *Hem Radio*, Feb. 1975, p 38–40.

SCALER FOR CB—Low-cost prescaler for low-range frequency counter permits accurate monitoring of 450-MHz CB transceiver. Fairchild 11C90 decade counter gives division by 10 for counters covering up to 45 MHz. For lower-range counter, edd 74196 TTL decada countar as shown to give total division by 100 for conversion to 4.5-MHz output. D1 and D2 should be fast-switching diodas such as 1N914 or 1N4148. Keep input signel under 1 V to avoid damaging 11C90. Will oparate from 5-V supply or four D cells.—P. A. Stark, 500 MHz Scaler, *73 Magazine*, Oct. 1976, p 62–63.

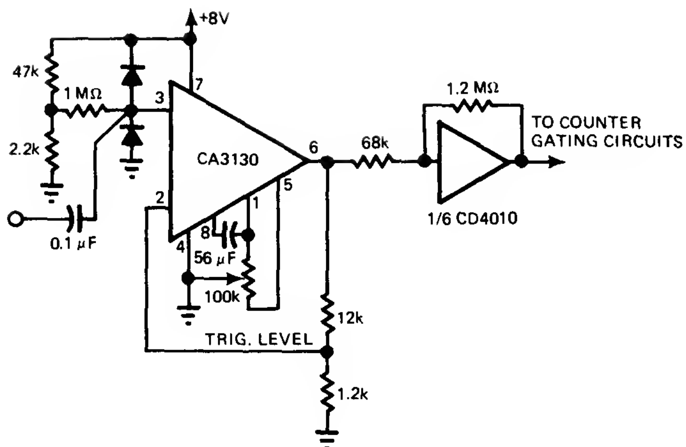


10:1 SCALER—Used to increase range of frequency counter. Sensitivity is 20 mV at 175 MHz, 40 mV at 220 MHz, and 90 mV at 250 MHz. Fairchild IC is used. Simple L-section filter at output rolls off frequencies above 30 MHz, allowing scaler to be used up to 250 MHz without erroneous counting of second or third harmonics of square-wave output of scaler if counter in use will respond to 60 MHz or more.—E. Guerri, Frequency Pre-Scaler, *Ham Radio*, Feb. 1973, p 57.

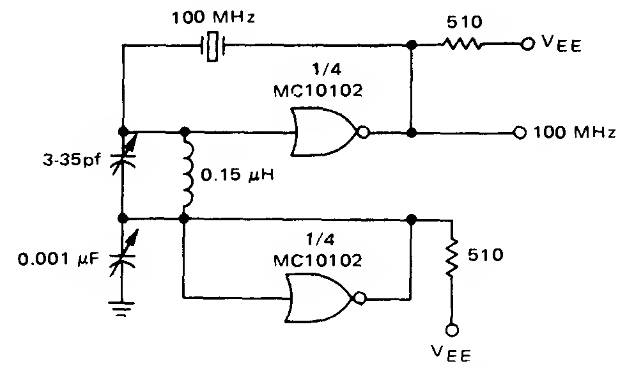




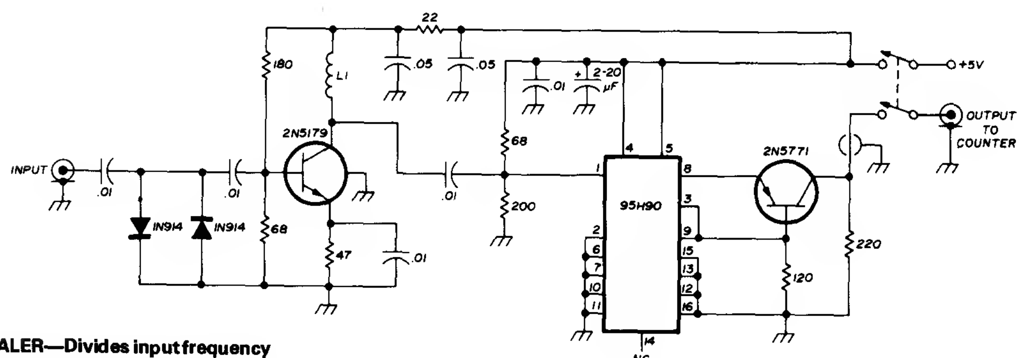
10 Hz TO 2 MHz—Seven-decade Intersil 7208 latched and multiplexed frequency counter with direct digit and display drive obtains timing waveform from 7207 IC which divides 6.5536-MHz crystal oscillator output by 2^{12} to produce 1600-Hz square wave for multiplexing counter and display. Square wave is further divided to produce 0.1-s and 0.01-s counting gates along with reset and update commands. RCA 3130 opamp is used for conditioning of input signal.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 380–382.



PREAMP FOR CMOS LOGIC—Combination of CA3130 and CD4010 ICs provides broad frequency response at very low power levels, es required for driving frequency counter. Diodes protect input from overvoltage. Amplifier offsat control pot Is used as trigger level control. Input sensitivity of emplifier/trigger combination is 50 mV P-P from 1 Hz to 1 MHz.—R. Tenny, Counter Pre-Amp Matches CMOS Logic Capability, *EDN Magazine,* Sept. 20, 1976, p 114 and 116.

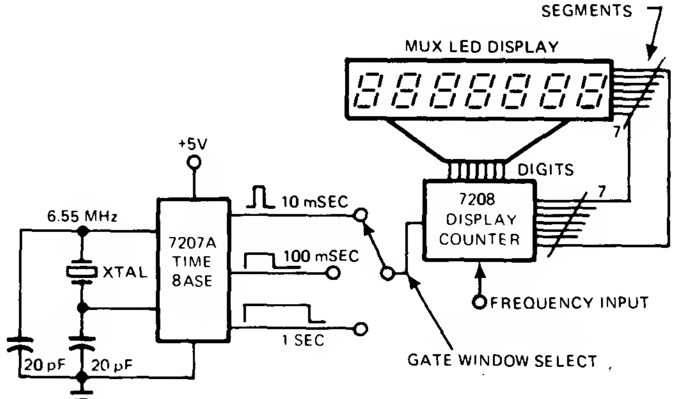


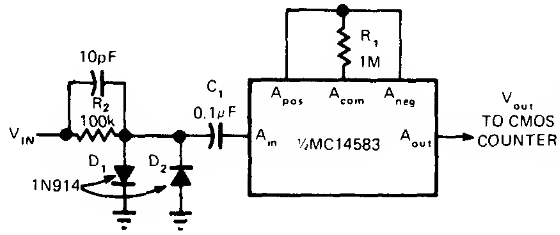
100-MHz CRYSTAL OSCILLATOR—Developed for frequency counter that uses standard ECL components. Crystal can be changed to 10 MHz when measuring TTL performence.—W. R. Blood, Jr., "Measure Frequency end Propagetion Delay with High Speed MECL Circuits," Motorola, Phoenix, AZ, 1972, AN-586, p 3.



300-MHz PRESCALER—Divides input frequency by 10 for extending range of digital frequency counter up to prescaler limit of 300 MHz. Reading of counter must be multiplied by 10. Article elso gives circuits of high-resolution counters using CMOS TTL devices.—H. E. Harris, Simplifying the Digital Frequency Counter, *Ham Radio,* Feb. 1978, p 22–25.

THREE TIME-BASE WINDOWS—Intersil 7207A crystel-controlled timer generetes precision gete windows of 10 ms, 100 ms, end 1 s for use es time bases, calibretion merkers, or gate timers for frequency counters such as 7208.—B. O'Neil, IC Timers—the "Old Reliable" 555 Hes Compeny, *EDN Magazine,* Sept. 5, 1977, p 89–93.

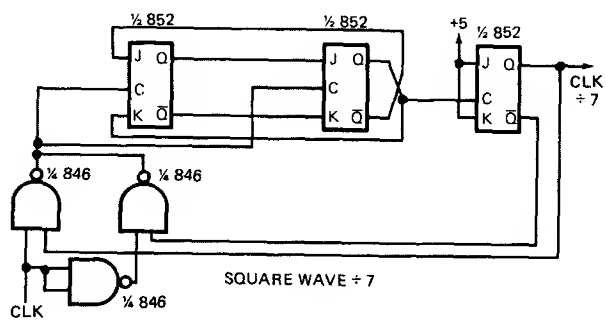




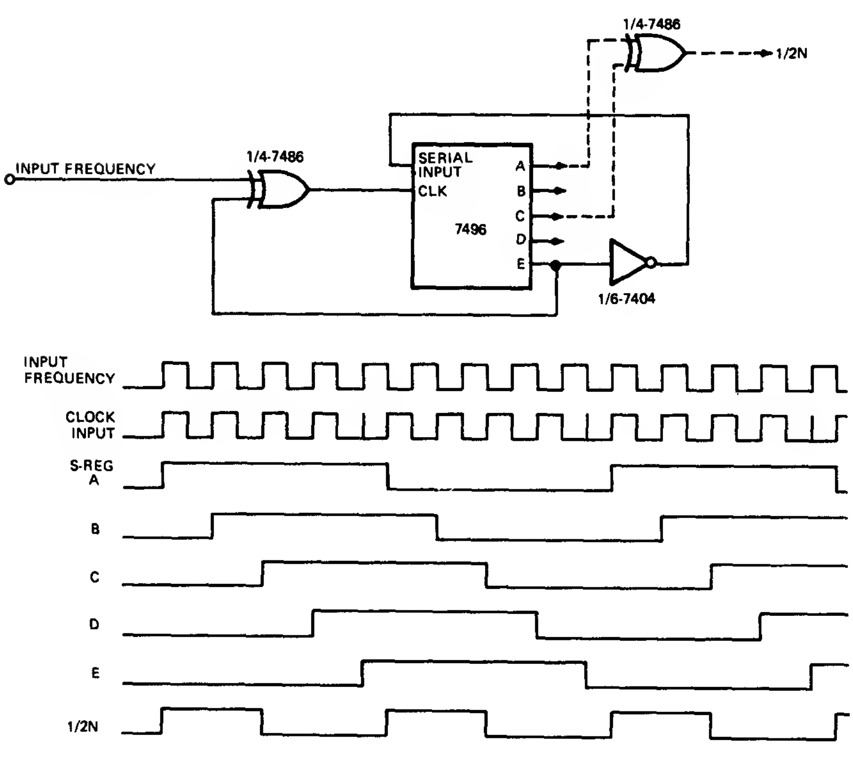
LOW-DRAIN 2-MHz FRONT END—Simple CMOS linear front end for 5-MHz battery-operated counter reduces power drain end makes it proportional to input frequency. With no input, drain is only a few microamperes. Half of MC14583 CMOS Schmitt trigger forms front end operating from single 6-V battery used in counter. Upper frequency limit is about 3 MHz, end input sensitivity is 400 mV.—D. Aldridge, CMOS Counter Circuitry Sleshes Battery Power Requirements, *EDN Magazina*, Oct. 20, 1974, p 65–71.

CHAPTER 32
Frequency Divider Circuits

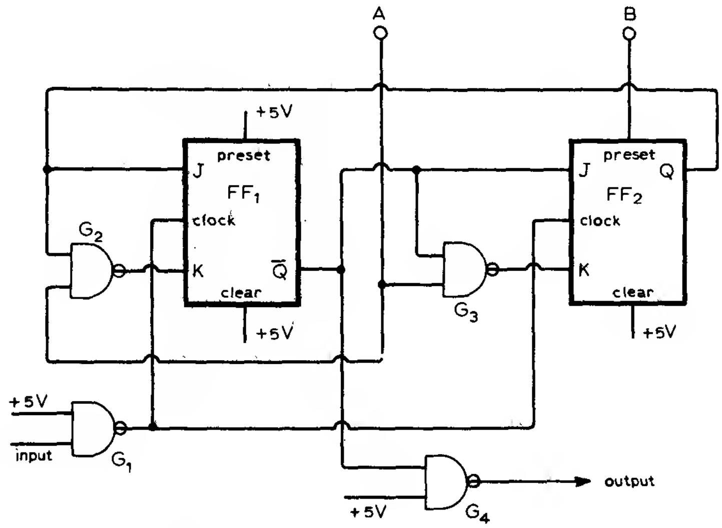
Provide division ratios in range from 2 to 29 for clock-signal generators, receivers, transmitters, and event counters. See also Clock Signal, Digital Clock, Frequency Multiplier, Frequency Synthesizer, and Logic chapters.



DIVIDE BY 7—Requires only two different types of chips. Input clock is alternately inverted and noninverted by gates operating in conjunction with 3 bits of storage using 852, to give square-wave output at one-seventh of clock frequency.—C. W. Hardy, Reader Responds to Odd Modulo Divider in July 1st EDN, *EDN Magazine*, Oct. 1, 1972, p 50.



DIVIDE BY 9 WITH SHIFT REGISTER—Uses 7496 as 5-bit shift register, 7486 as EXCLUSIVE-OR gate, and 7404 as inverter to give division of square-wave input frequency by 9 while maintaining 50% duty cycle at output. Article covers connection changes needed for other division ratios. With 8-bit shift register, circuit will divide by as much as 15. Addition of 7486 EXCLUSIVE-OR gate across any outputs, as shown by dashed lines, makes effective output half that of basic TTL circuit.—J. N. Hobbs, Jr., Divide-by-N Uses Shift Register, *EDN Magazine*, Oct. 5, 1976, p 108.

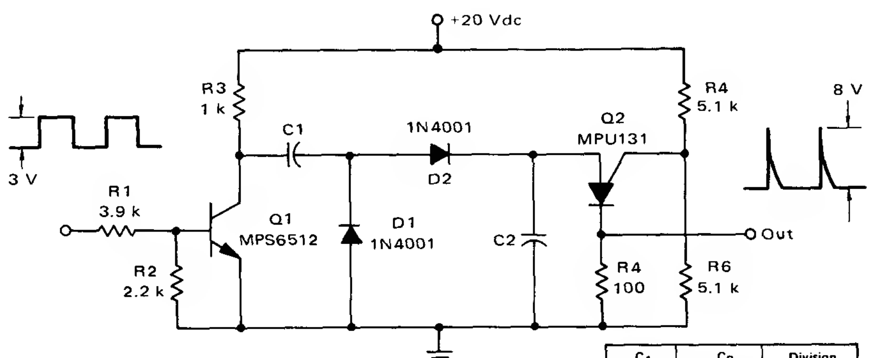


A	B	division ratio
1	1	4
0	1	3
0	0	2

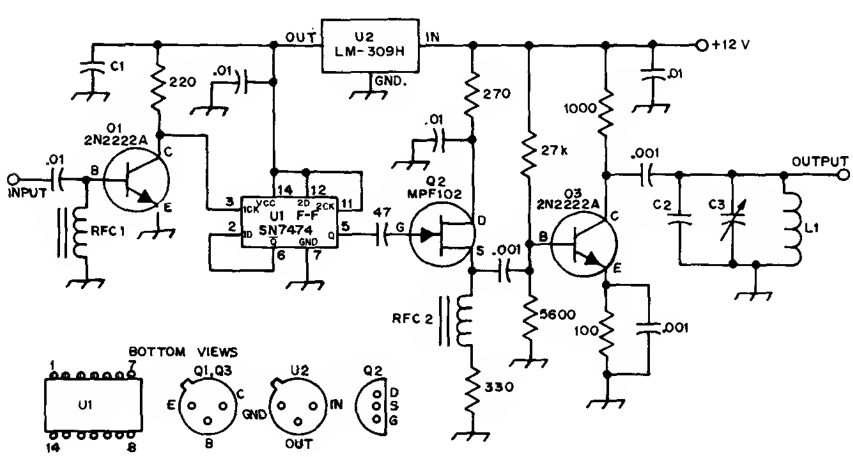
$G_1 - G_4$ each ¼ 74S00N
FF_1 & FF_2 each ½ 74S112N

DIVIDING 40–60 MHz BY 2, 3, OR 4—Division ratio is controlled externally by making control terminals A and B high (1) or low (0), as given in tabla. Daveloped for usa in receiver requiring local oscillator covering 10 to 30 MHz. Counter simplifies tuner design.—C. Attenborough, Fest Modulo-3 Counter, *Wireless World,* Aug. 1976, p 52.

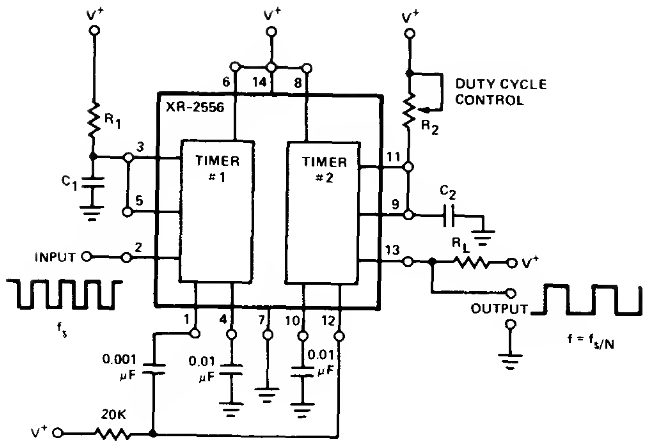
AF DIVISION BY 2 TO 11—Ratio of C2 to C1 determines division ratio, es given in table. When C2 charges to peak point firing voltage of Q2, it fires and dischargas C2, so C1 charges to line voltage. Q2 then turns off. Naxt cycle begins with anothar positiva pulsa on base of Q1, discharging C1. Division ranga can ba changed by utilizing programmable aspect of PUT Q2 and changing ratio of resistances.—R. J. Havar and B. C. Shiner, "Theory, Characteristics and Applicatlons of the Programmabla Unijunction Transistor," Motorola, Phoanlx, AZ, 1974, AN-527, p 9.



C_1	C_2	Division
0.01 μF	0.01 μF	2
0.01 μF	0.02 μF	3
0.01 μF	0.03 μF	4
0.01 μF	0.04 μF	5
0.01 μF	0.05 μF	6
0.01 μF	0.06 μF	7
0.01 μF	0.07 μF	8
0.01 μF	0.08 μF	9
0.01 μF	0.09 μF	10
0.01 μF	0.1 μF	11

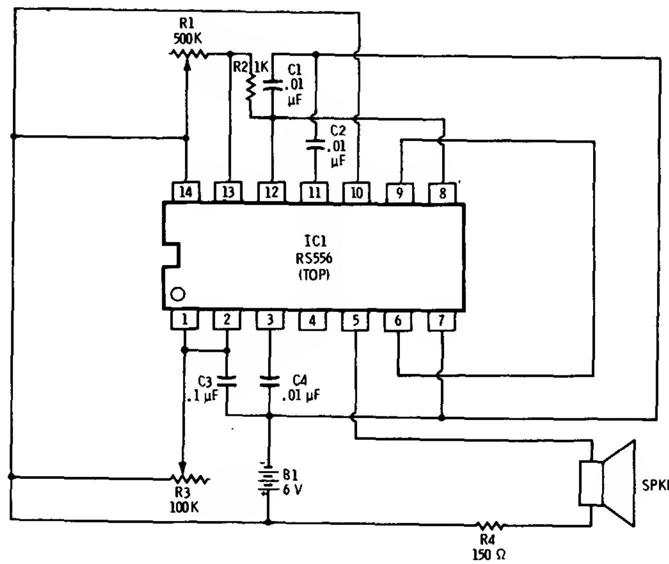


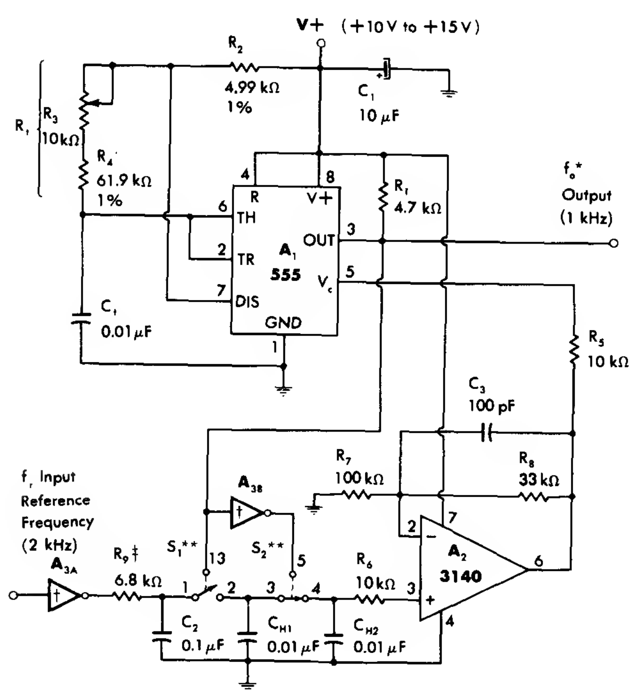
DIVIDER FOR 7 MHz—Used efter 7-MHz VFO of 40-meter trensmitter, to provide 3.5 MHz es required for operetion in 80-meter band. Half of 7474 TTL D flip-flop U1 is connected in divide-by-2 configuration. U2 provides required well-regulated 5-V source. Q1 clips negative-going portion of 7-MHz sine wave to prevant damaga to 7474. Square-weva 3.5-MHz output from U1 is applied to source-follower Q2 which drives class A amplifiar output stage Q3. RFC1 and RFC2 ara 10 μH. C1 is 6.8-μF 10-V tantalum. C2 is 100-pF mica. L1 is 41 tums No. 26 enamel speced to fill entire T-80-2 core, to give 10 μH.—S. Creason, A VFO Frequency Divider, *QST,* Nov. 1976, p 23–24.



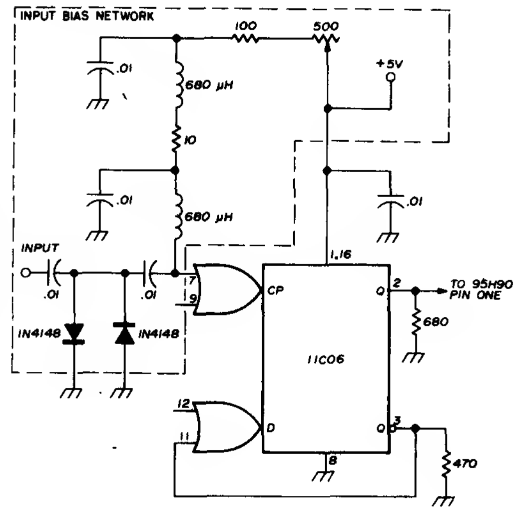
DIVIDER WITH PULSE SHAPER—Half of Exar XR-2556 dual timer divides input pulse frequency by 2 or 3, and other half shapes output pulse by controlling duty cycle over range that can be adjusted from 1% to 99% with R_2. Supply voltage can be 4.5–16 V.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.

DUAL-TIMER TONE STEPPER—One section of RS556 dual timer is connected as free-running astable MVBR for supplying pulses to trigger input of other section connected as mono MVBR driving loudspeaker. When both MVBRs are adjusted so one trigger pulse initiates each timing period and no trigger pulses occur during timing periods, output tone has frequency of free-running MVBR. With two trigger pulses per timing cycle, every other trigger pulse is ignored and tone is at half frequency. With three trigger pulses per cycle, output is one-third of frequency. Can be used for classroom demonstration of electronic music; settings of R1 and R3 can be adjusted to give tones resembling violin, bagpipes, or almost any other instrument.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 70–78.

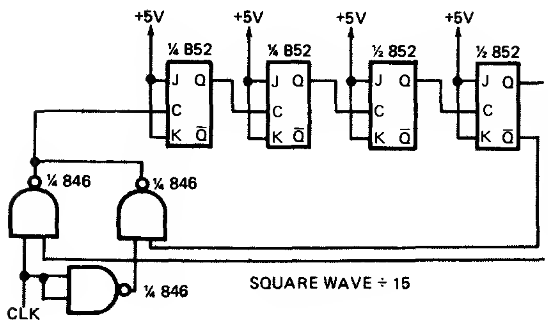




PLL DIVIDER—Simple phase-locked loop is suitable for generating integral submultiples M of input frequency. Values shown give M of 2. Square-wave input reference is limited in amplitude to supply voltage by first CMOS inverter A_{3A}. RC network R_9-C_2 integrates output to give 2 V P-P triangle across C_2 for sampling by sample-and-hold switch sections S_1 and S_2 of 4016 CMOS analog switch. Sampled error voltage of loop, stored on C_{H2}, is read out by FET amplifier A_2. Amplified error voltage is applied to A_1 through R_5 to induce changes in center frequency of A_1 as required to maintain locked condition.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 220–224.

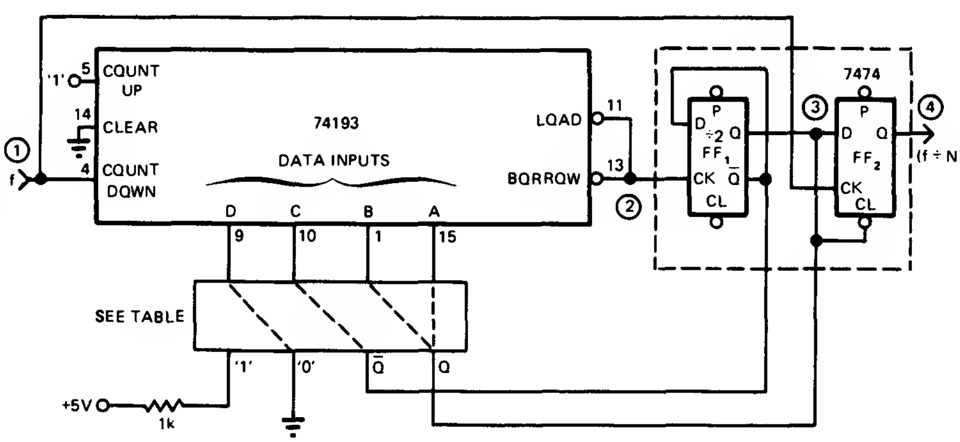


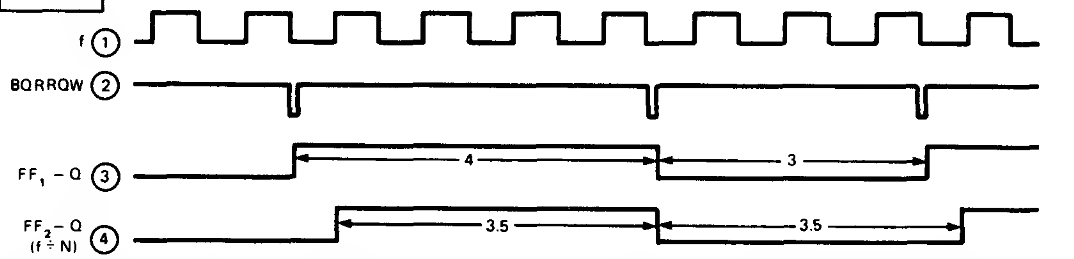
UHF PRESCALER—Uses Fairchild 11C06 700-MHz D flip-flop as divide-by-20 UHF prescalar with toggle rates in excess of 550 MHz from 0 to 75°C. Amplifier may be used in place of input bias network shown. Daveloped for use with 95H90 decada divider. Unused CP and D inputs are tied to ground.—D. Schmieskors, 1200-MHz Frequency Scalers, *Ham Radio*, Feb. 1975, p 38–40.



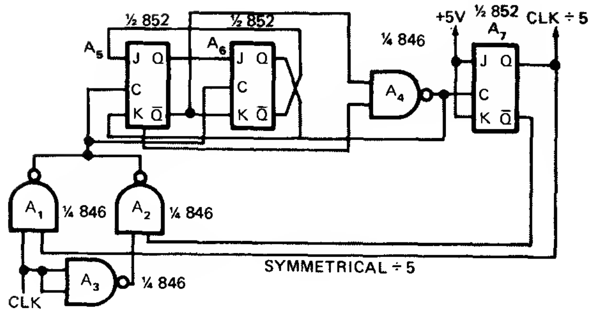
DIVIDE BY 15—Input clock is altametaly inverted and noninvarted by getes opereting in conjunction with 4 bits of storege using 852 JK flip-flops, to give square-wava output et 1/15 of clock frequency.—C. W. Hardy, Readar Responds to Odd Modulo Divider in July 1st EDN, *EDN Magazine*, Oct. 1, 1972, p 50.

DIVIDER RATIO N	DATA INPUTS D	C	B	A
3	0	0	$\bar{Q}$	Q
5	0	0	1	$\bar{Q}$
7	0	$\bar{Q}$	Q	Q
9	0	1	0	$\bar{Q}$
11	0	1	$\bar{Q}$	Q
13	0	1	1	$\bar{Q}$
15	$\bar{Q}$	Q	Q	Q
17	1	0	0	$\bar{Q}$
19	1	0	$\bar{Q}$	Q
21	1	0	1	$\bar{Q}$
23	1	$\bar{Q}$	Q	Q
25	1	1	0	$\bar{Q}$
27	1	1	$\bar{Q}$	Q
29	1	1	1	$\bar{Q}$



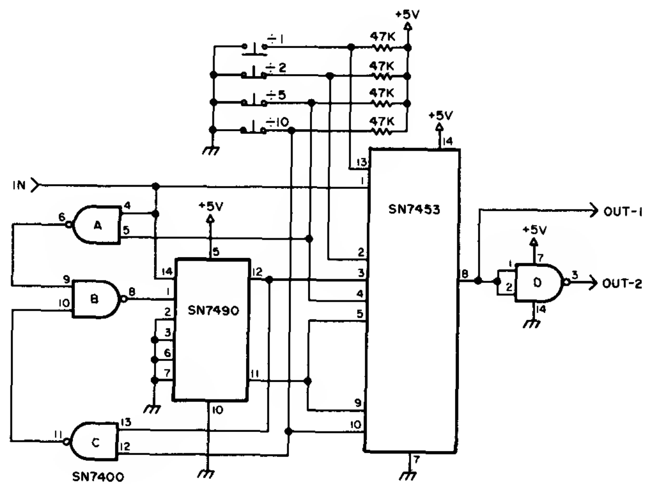


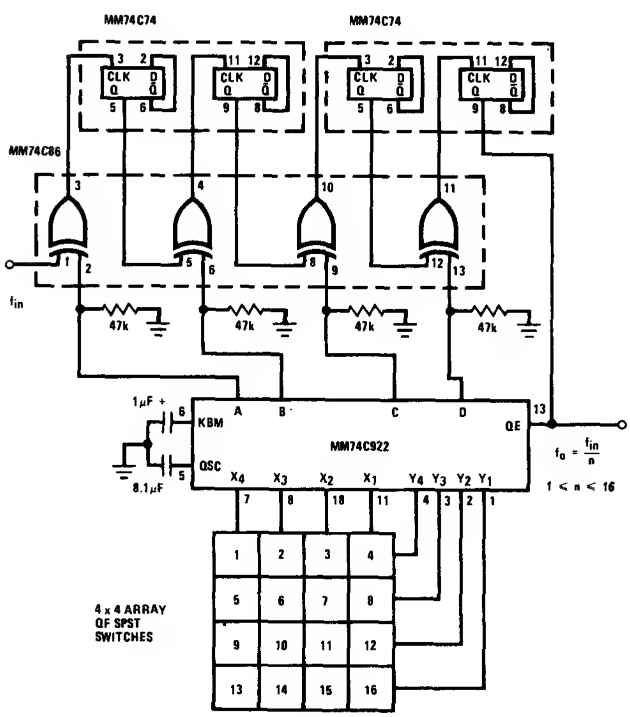
3 TO 29 ODD-MODULO—Basic divider using 74193 4-bit up/down counter and single 7474 dual D flip-flop providas eny odd number of divider ratios from 3 to 29 by changing feedback connections as shown in table, ell with symmetrical output waveforms. Based on writing any odd number N es N = M + (M + 1), whare M is integer. Circuit forces counter to divide elternetaly by M and M + 1. Connection shown is for divide-by-7.—V. R. Godbole, Simplify Design of Fixed Odd-Modulo Dividars, *EDN Magazine*, Juna 5, 1975, p 77–78.



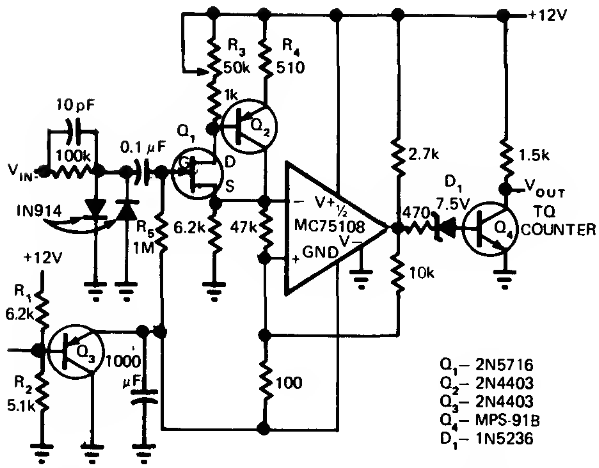
DIVIDE BY 5—Requires only two digital chip types. Input clock is alternately inverted and noninverted for clocking divide-by-3 counter, to give effect of dividing by 2½ which toggles A_3 to give symmetrical divide-by-5 output with 50% duty cycle for pulses. Article gives timing diagram and traces operation of circuit.—C. W. Herdy, Reader Responds to Odd Modulo Divider in July 1st EDN, *EDN Magazine*, Oct. 1, 1972, p 50.

SQUARE-WAVE DIVIDER—Divides input square wave by 1, 2, 5, or 10 depending on which switch is open. Signal at OUT-1 is inverted with respect to input, and OUT-2 is noninverted.—Circuits, *73 Magazine*, June 1977, p 49.

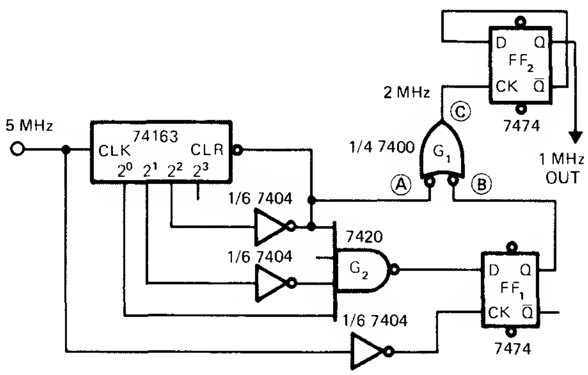




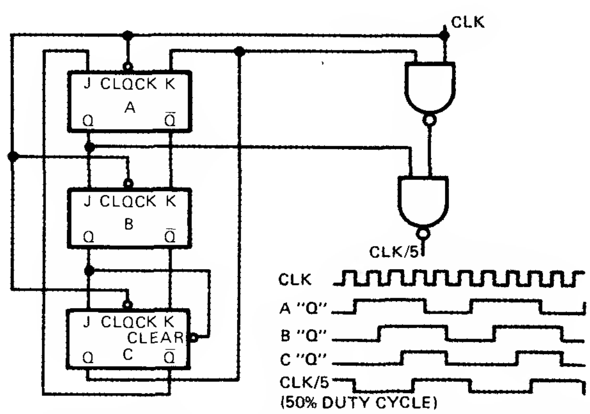
PROGRAMMABLE COUNTER—Input frequency can be divided by any number between 1 and 16 by pressing appropriate key on keyboard connected to National MM74C922 16-key encoder. Output frequency is symmetrical for odd and even divisors. Can be used for simple frequency synthesis or as keyboard-controlled CRO trigger. Operates over standard CMOS supply range of 3–15 V. Typical upper frequency limit is 1 MHz with 10-V supply. Circuit uses two MM74C74 dual D flip-flops and MM74C86 EXCLUSIVE-OR package.—"CMOS Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-50–5-51.



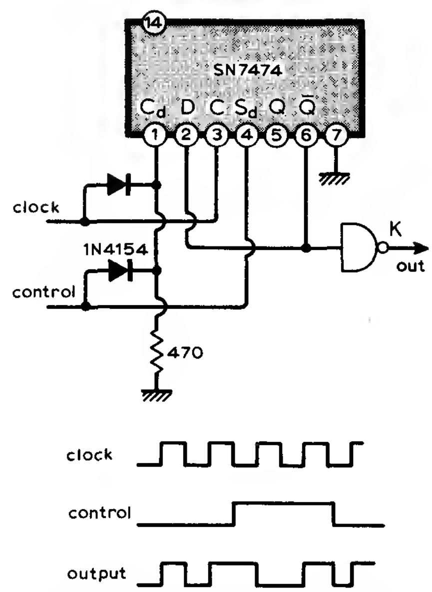
10-MHz FRONT END—Front-end design for bet-tery-opereted 5-MHz counter consists of FET end bipoler buffer followed by Schmitt trigger mede from MC75108 duel line receiver. Circuit operetes lineerly up to 10 MHz with 25-mV input signal. Requires swings from logic 0 (0 V) to logic 1 (ebout 10 V), for which suiteble counter circuit is given in erticle. Accepts eny input weveform shepe end level.—D. Aldridge, CMOS Counter Circuitry Slashes Bettery Power Requirements, *EDN Magazine*, Oct. 20, 1974, p 65–71.



SYMMETRICAL DIVIDE-BY-5 CLOCK—Uses 74163 counter to generate two pheses of 1-MHz clock pulse with 50% duty cycle from 5-MHz system reference. One phese is decode of binery 4 from counter, while other is decode of 1 clocked et midbit time. Both pheses are recombined in gete G_1 to give 2-MHz clock that toggles FF_2 to generete desired 1-MHz output.—L. A. Menn, Divider Circuit Meintains Pulse Symmetry, *EDN Magazine*, July 1, 1972, p 54–55.



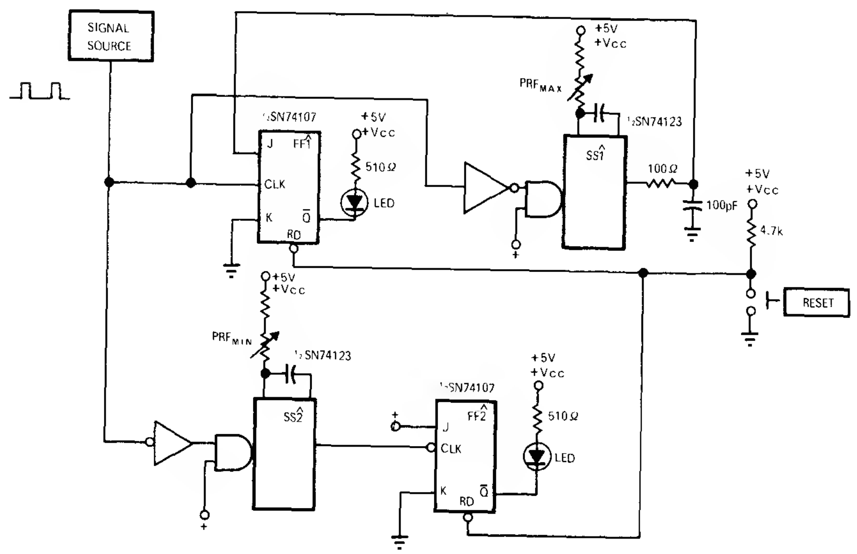
DIVIDE BY 5 WITH TWO GATES AND 3 BITS—Arrangement shown for dividing clock input frequency by 5 requires only two gates from 846 IC and 3 bits of 852 JK flip-flop storage to give squere-wave output pulses having 50% duty cycle.—C. L. Meginniss, Another Reeder Responds to Odd Modulo Divider, *EDN Magazine*, Oct. 15, 1972, p 57.



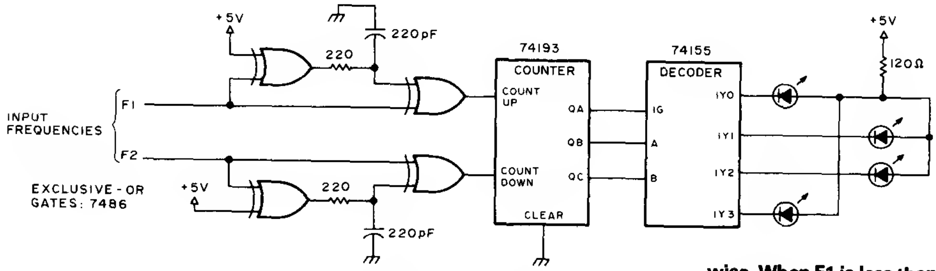
SWITCHED DIVIDER FOR BINARY COUNTER—Simple circuit provides method of switching division by two into or out of stream of clock pulses. Output is in phese with input end free of spikes. Switching requires only one D-type flip-flop end one inverter. When control is high, logic ection gives normel connection for division by two, using D-type flip-flop; inverter then restores phase.—J. M. Firth, Control of e Binary Counter for Division by One or Two, *Wireless World*, Jan. 1975, p 12.

CHAPTER 33
Frequency Measuring Circuits

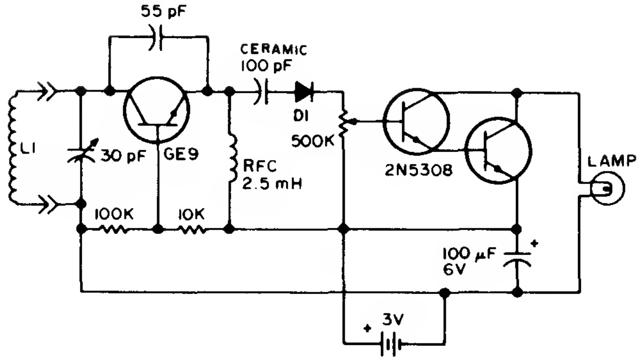
Includes direct-reading heterodyne frequency meters, synchroscopes, dip meters, tuning indicators, frequency-to-voltage converters, tachometers, and monitors showing when input frequency or pulse rate is above or below reference, for variety of frequencies in range from 1 Hz through power-line and audio values to 150 MHz. See also Frequency Counter and Frequency Multiplier chapters.



PRF MONITOR—Upper channel latches when pulse repetition frequency of train of pulses is higher than specified limits, turning on above-limit LED driven by JK flip-flop FF_1. Lower channel latches and turns on its LED when PRF is below second specified limit. Upper channel also detects single noise pulse, while lower channel detects single missing pulse. After off-limit indication, circuit must ba reset.—L. Birkwood and D. Porat, PRF Monitor with Adjustable End Limits, *EDN/EEE Magazine*, Feb. 1, 1972, p 57–58.

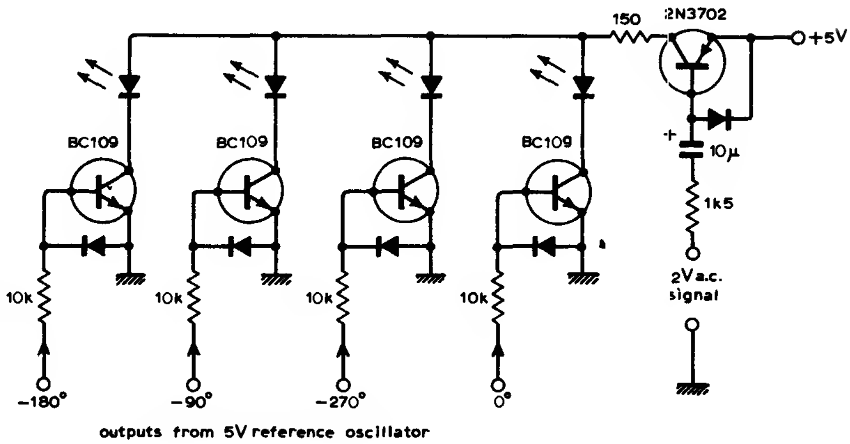


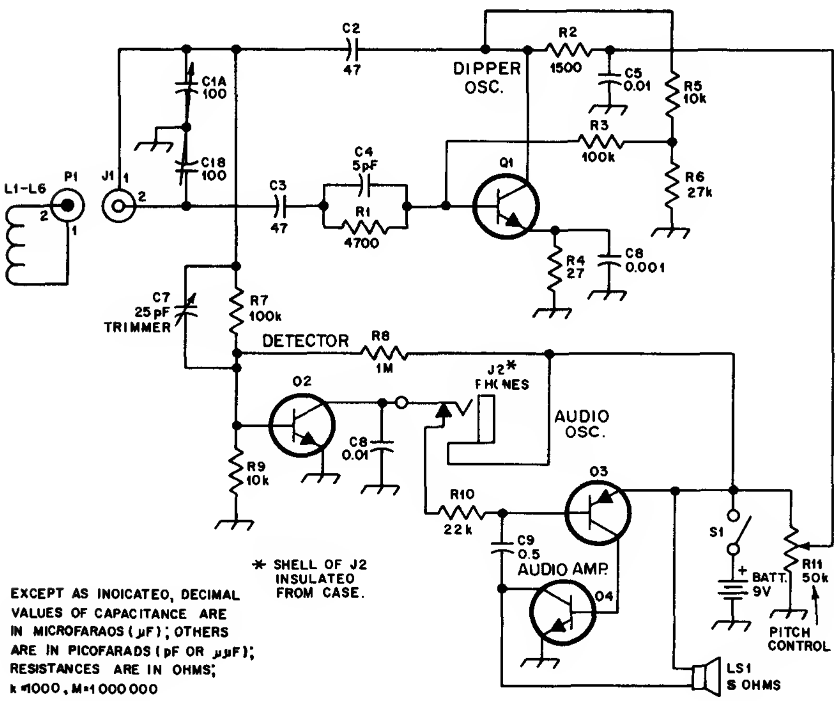
BEAT-FREQUENCY DISPLAY—Apparent rotation of dot on four-LED display gives indication of beat frequency between two tone oscillators. When F1 is greater than F2, dot rotates clockwise. When F1 is less than F2, dot rotates counterclockwise. When F1 equals F2, dot does not move.—Circuits, *73 Magazine*, July 1977, p 35.



GRID-DIP METER—Uses ordinary No. 48 or 49 pilot lamp as resonance indicator. Will oscillate at frequencies up to 12 MHz. Wind L1 to cover desired frequency ranges.—Circuits, *73 Magazine*, April 1973, p 133.

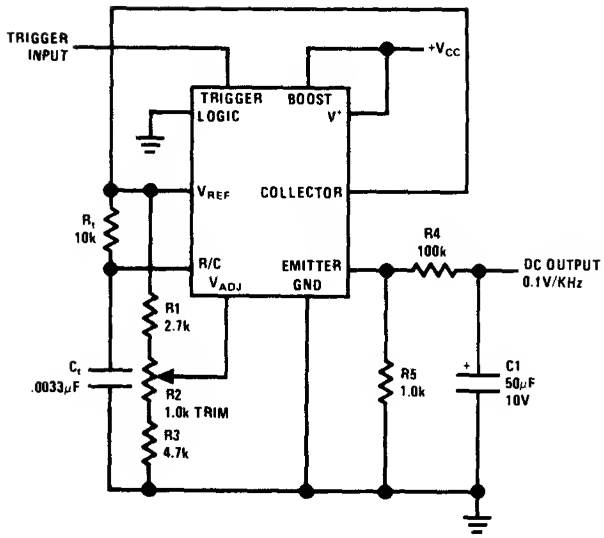
LED SYNCHROSCOPE—Circuit uses four LEDs to indicate direction of phase error as correct setting is approached when tuning oscillator to standard frequency. Lamps form display that rotates once per cycle at reference frequency, with brightness of each lamp being modulated at frequency of oscillator being adjusted. Display thus appears to have frequency equal to difference between two signal frequencies, rotating in direction indicative of sense of frequency difference. Mount lamps on smallest possible circle. Diode and LED types are not critical.—R. H. Pearson, An L.E.D. Synchroscope, *Wireless World*, Sept. 1974, p 321.





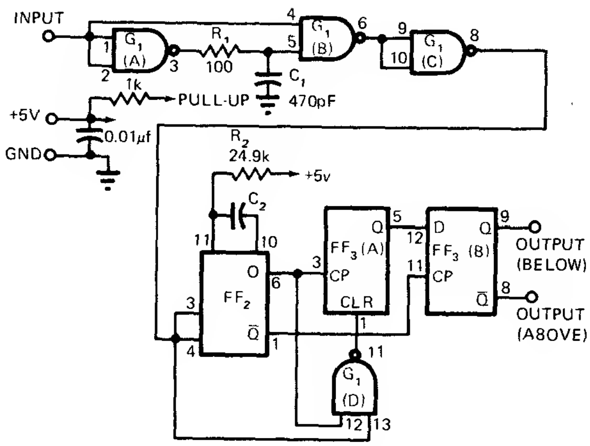
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k = 1000, M = 1 000 000

AUDIBLE DIPPER—Designed for use by blind radio amateurs, but tone indication has advantage of permitting anyone to concentrate on equipment while checking antenna, tracking parasitics, or neutralizing amplifier with dip meter. Plug-in coils L1-L6 are Heathkit parts 40-1689 through 40-1695. Q1, Q2, and Q4 are Radio Shack RS-2011 or equivalent, and Q3 is RS-2021 or equivalent. Pitch of tone heard from loudspeaker drops sharply when tuned circuit of dipper becomes loaded by external source.—W. E. Quay, An Auditory Dip Oscillator, *QST*, Sept. 1978, p 25–27.

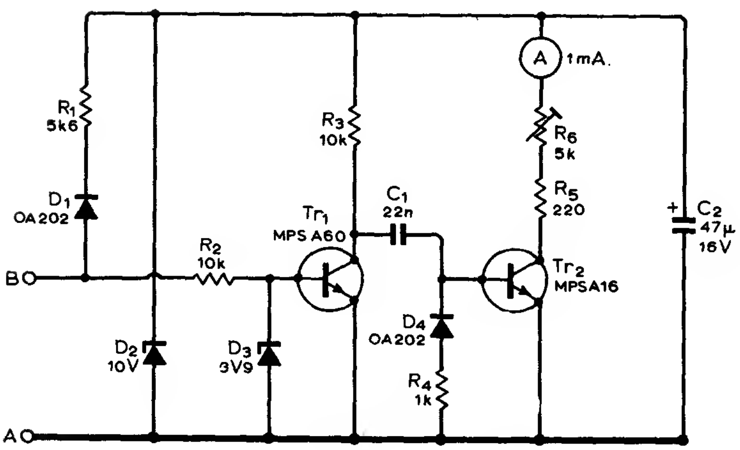


FREQUENCY-TO-VOLTAGE CONVERTER—National LM122 timer is used as tachometar by avaraging output pulses with simpia flitar. Pulse width is adjusted with R2 to provida initiai calibration at 10 kHz. Linearity is about 0.2% for output ranga of 0–1 V. Analog metar can ba driven directly by connecting it in series with R5. Supply can ranga from 4.5 to 40 V.—C. Nelson, "Varsatlle Timer Oparates from Microseconds to Hours," National Samiconductor, Santa Ciare, CA, 1973, AN-97, p 10.

RATE DETECTOR—Only three ICs are used to sense pulse rate of input signal with high accuracy. For monitoring frequency, two such circuits can ba used, with one set to upper frequency limit and other to lower limit. Output is high when input pulse rate is above set point and low for frequencies below set point. Frequency of set point is reciprocal of monostabie delay time ($f_0 = 1/0.32R_2C_2$).—J. W. Poore, Three IC's Accurately Sensa Pulsa Rata, *EDN Magazine*, Aug. 15, 1972, p 53.

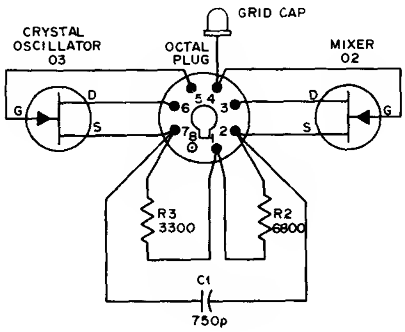


REF	TYPE	+5V	PULL-UP	GND
G_1	SN7400N	14		7
FF_2	SN54121N	14	5	7
FF_3	SN7474N	14	2, 4, 10, 13	7

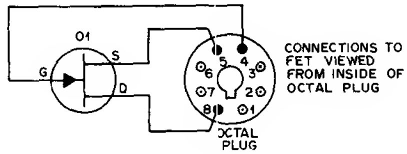


STANDBY-GENERATOR FREQUENCY METER—Devaioped for use with 10–60 VAC generator drivan by lawn mowar engine, as guide for adjusting speed manually to giva correct power-line frequency. Output of alternator, connected to A and B, is converted to ragulated 10 VDC by R_1, D_1, D_2, and C_2. Same input voitaga is squered by Tr_1 and fed to Tr_2 through differentiating circuit. Currant pulses devaloped in collector circuit of Tr_2 have constent width and varying repetition rate depending on input frequency. Inertia of metar movament provides integration required to give steady reading that changes only with input frequency. Metar scale is calibrated from 0 to 100 Hz, with R_6 adjusted to give correct reading when 10–60 VAC line voltage is applied to input. Power transformer must ba used to boost output of alternator to correct AC lina voltage.—J. M. Caunter, Low-Cost Emergency Power Generator, *Wireless World*, Feb. 1975, p 75–77.

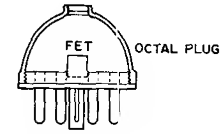
TRANSISTORS FOR BC-221—Old BC-221 frequancy meter can be modernized by raplacing its three now-scarce tubes with four 2N3819 N-channal JFETs end changing supply to single 9-V battery. VT167 (6K8) mixer-oscillator is rapleced by two JFETs with R2, R3, and C1 mounted inside octal plug. Resistance values may need some adjustment. Cut and insulata original leads to pins 2, 4, end 7, end connect top-cap clip of mixer tube to pin 4. VT116-B (6SJ7-Y) tube used for VFO is replaced by singla 2N3819 connacted as for Q1. Add R1 in perallal with plate load resistor; value depends on particular FET used, and can range from 1 to 6800 ohms (1500 is typical). VT116 (6SJ7) beat-fraquency amplifiar is replaced by 2N3819 mounted same as for Q1. Place 4K across 15K loed resistor of VT116-B and replace 300-ohm cathode resistor with one giving 1-mA source current (typically 1K to 3.3K). Total currant drain is about 3 mA. Try 3–10 pF capacitor betwaen gata and drain of Q3 if circuit does not oscillate.—R. S. N. Rau, Solid-Stata BC-221 Fraquency Meter, *QST*, Feb. 1977, p 35–36.



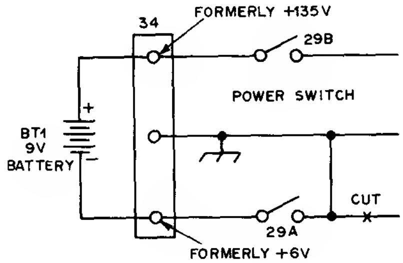
CONNECTIONS VIEWED FROM INSIDE OF OCTAL PLUG

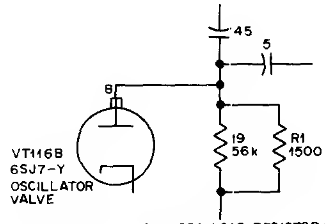


(A)



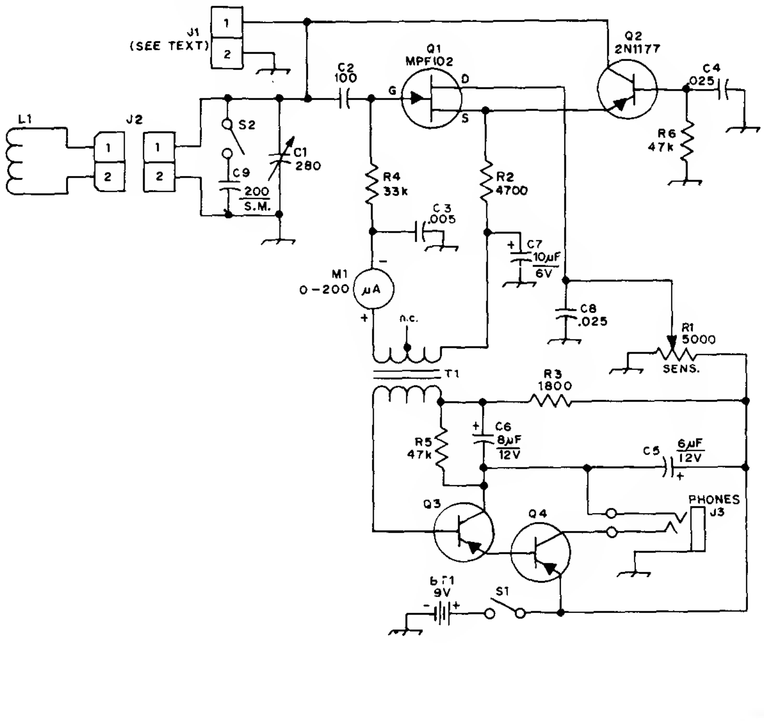
METHOD OF MOUNTING THE FET, Q1 AND Q2
(B)



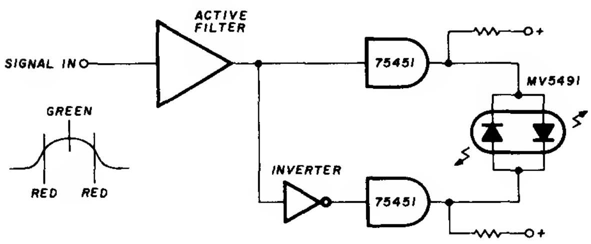


PARALLELING THE ANODE LOAD RESISTOR (19) BY R1
(C)

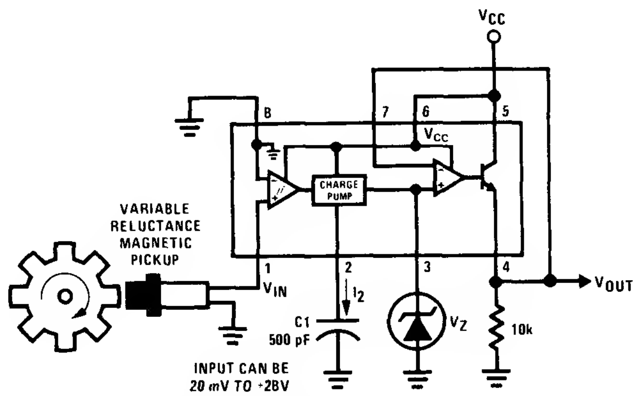
Frequency range (MHz)	*Coil diameter and turns* 1-1/2	1-3/8	1-1/4	1 (inches)	*Wire size and coil const.*
	38	35	32	25 (mm)	
.08 – 0.2	700	750	800	1000	No. 30 enam., 5 pies.
0.205 – 0.6	220	240	256	310	No. 30 enam., 5 pies.
0.5 – 1.4	90	100	110	140	No. 30 enam., close wound.
0.95 – 3	40	45	49	64	No. 22 enam., close wound.
2.6 – 6	18	20	22	29	No. 22 S. C. enam., 1-3/4" long (44 mm)
5.5 – 15	7	8	9	12	No. 22 S. C. enam., 1-1/2" long (38 mm)
14 – 35	2 (11/16") (17 mm)	2 (3/4") (19 mm)	2 (1") (25 mm)	2-1/2 (1") (25 mm)	No. 22 S. C. enam., length indicated at bottom of column.



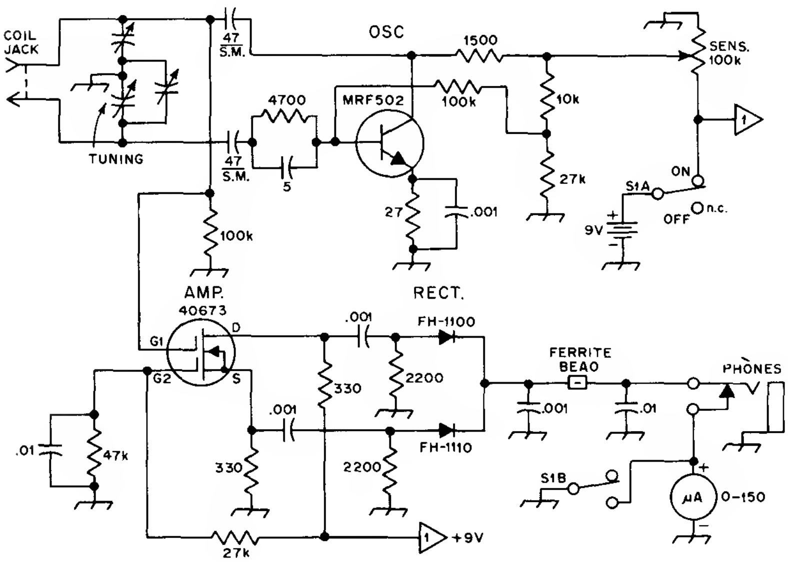
GATE DIPPER—Used to determina resonant frequency of tuned circuit, provide signal for receiver elignment, and meke antenna meesurements. Teble gives winding data for plug-in coils L1. Perts values are not critical. T2 is transistor interstage audio transformer with 10,000-ohm primary end 2,000-ohm secondary in meter circuit. JFET Q1 is used in common-drain circuit followed by PNP bipolar transistor, with gate junction of JFET acting as rectifier. Dip meter M1 meesures gete current. When tuned circuit of dipper is loaded by coupling it to extarnal circuit, power is ebsorbed end metar reeds dip occurring whan L1-C1 is tuned to resonance with extemel circuit. R1 Is regeneration control. Audio emplifer Q3-Q4 using 2N4125 or HEP52, optionel, helps in listaning to signels picked up by tuned circuit or enhancas display on CRO. Can be used es field-strength meter if entenna is plugged into J1.—B. Clark, A Hybrid Gate-Dip Oscilletor, *QST*, Juna 1974, p 33–37.



FREQUENCY INDICATOR—Circuit furnishes green indication et resonance and red for either side of resonence. Uses Monsento MV5491 duel red/green LED, with 220 ohms in upper lead to +5 V supply end 100 ohms in lower +5 V lead because red end green LEDs in parellel back-to-beck heve different voltege requirements. Useful for SSTV, RTTY, or subeudio-tone indication for control purposes on FM. Circuit requires two driver ICs end one section of hex inverter IC, with eny suiteble ective filter used to form level detector for signels et desired frequency.—K. Powell, Novel Indicator Circuit, *Ham Radio,* April 1977, p 60–63.

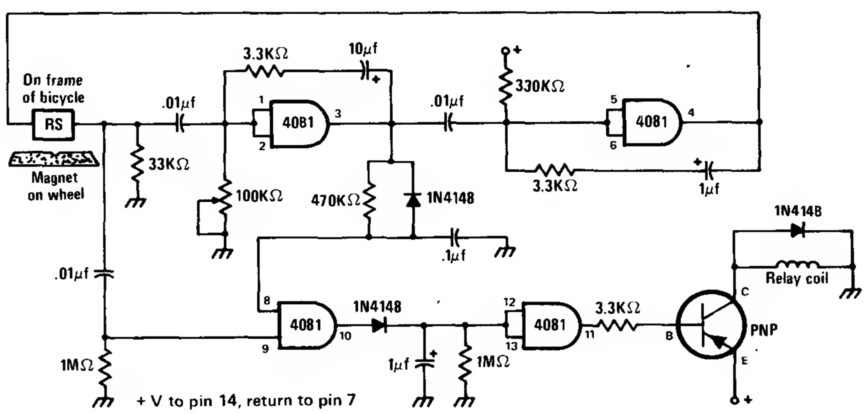


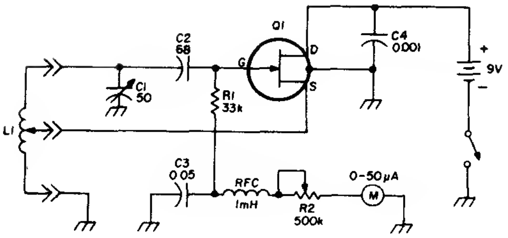
FREQUENCY-DOUBLING TACHOMETER—Connection shown for Netional LM2907 IC provides output pulse eech time sine-weve input from megnetic pickup crosses zero, for use in digital control system. Width of each pulse is determined by size of C1 end supply voltage used. Circuit serves for doubling frequency presented to microprocessor control system.—"Lineer Applications, Vol. 2," National Semiconductor, Santa Clere, CA, 1976, AN-162, p 12–13.



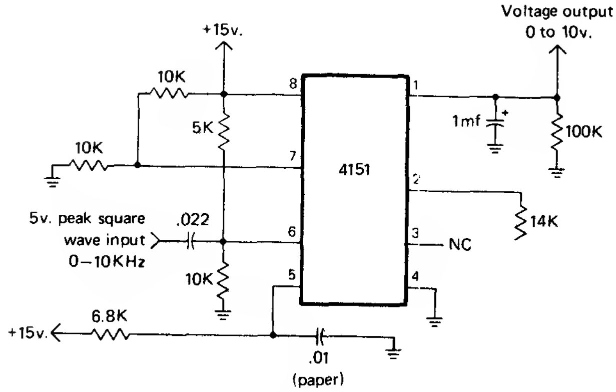
DIPPER—Circuit of Heeth HD-1250 solid-state dip meter covers 1.6–250 MHz renge with six plug-in coils.—The Heath HD-1250 Dip Meter, *QST,* Jen. 1976, p 38–39.

BICYCLE SPEED ALARM—Useful for long-distence bicycling, to indicate when rider drops below predetermined minimum speed. Speed sensor is reed switch ettached to frame and tripped once per revolution by permenent magnet mounted on wheel. Rete at which switch closes determines level of DC voltage produced by circuit. When voltege drops below preset level determined by 100K pot, output transistor comes on end energizes reley controlling bicycle hom or other signeling device. Supply can by 9-V transistor bettery. Transistor reeding should be high enough to hendle relay used.—J. Sandler, 9 Projects under $9, *Modern Electronics,* Sept. 1978, p 35–39.

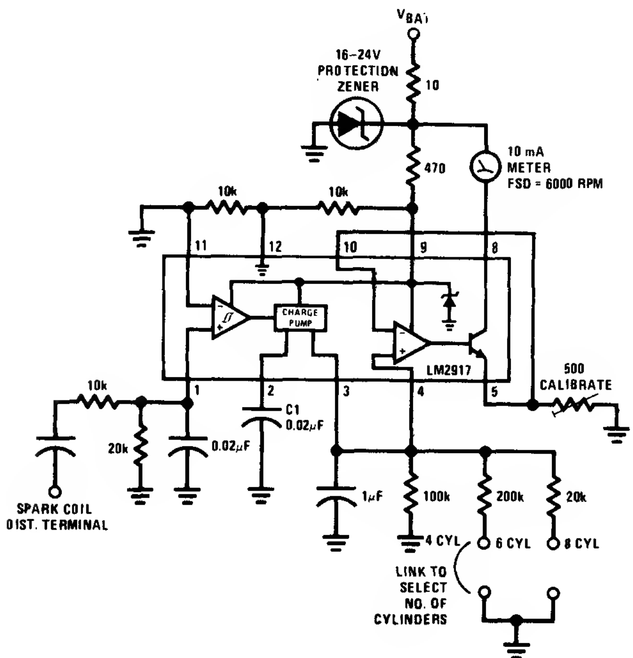




GATE DIPPER—Solid-state version of vacuum-tube grid-dip meter gives dip from 50 to about 20 μA on most bands in range of 1.8 to 150 MHz when dipper is held 1 inch away from resonant circuit under test. Uses Siliconix 2N5398 UHF JFET, but MPF107 (2N5486) can also be used. Coil tap position is more critical at higher frequencies; adjust tap for most pronounced dip. Article gives coil data for five frequency ranges.—C. G. Miller, Gate-Dip Meter, *Ham Radio*, June 1977, p 42–43.

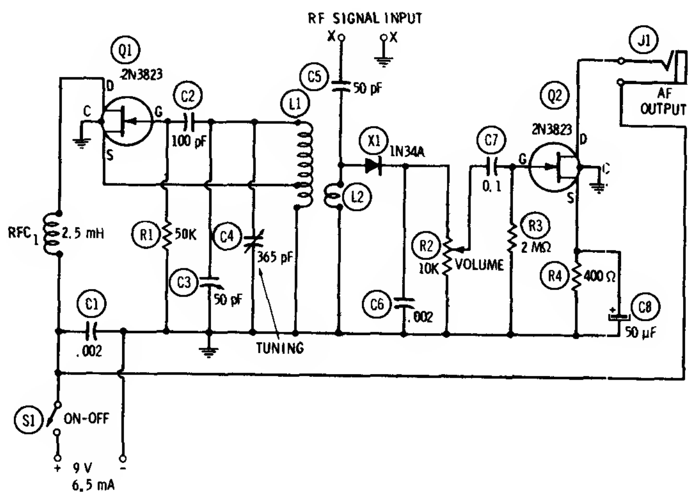


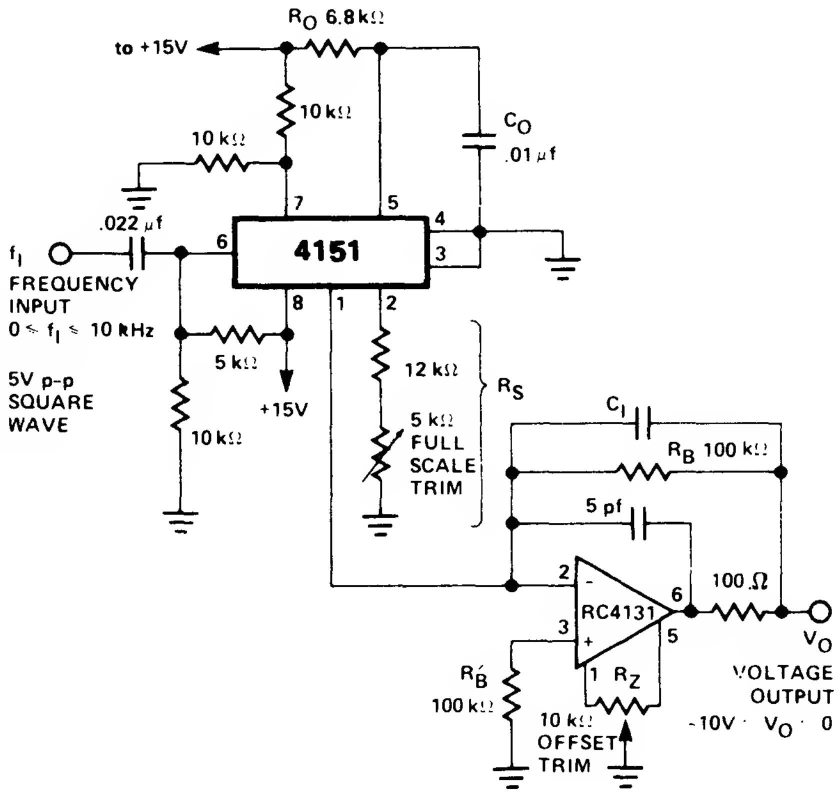
0–10 kHz TO 0–10 VDC—Raytheon 4151VFC voltage-to-frequency converter is used in reverse as linear frequency-to-voltage converter. Applications include use in pairs as complete data transmission system, for remote monitoring of DC voltage such as output of SWR bridge located at junction of antenna with transmission line. DC voltage is changed into audio voltage at remote location, sent over lines, then changed back to DC at readout location. Line characteristics do not affect frequency of audio signal.—J. J. Schultz, A Voltage-to-Frequency Converter IC with Amateur Applications, *CQ*, Jan. 1977, p 39–41 and 75.



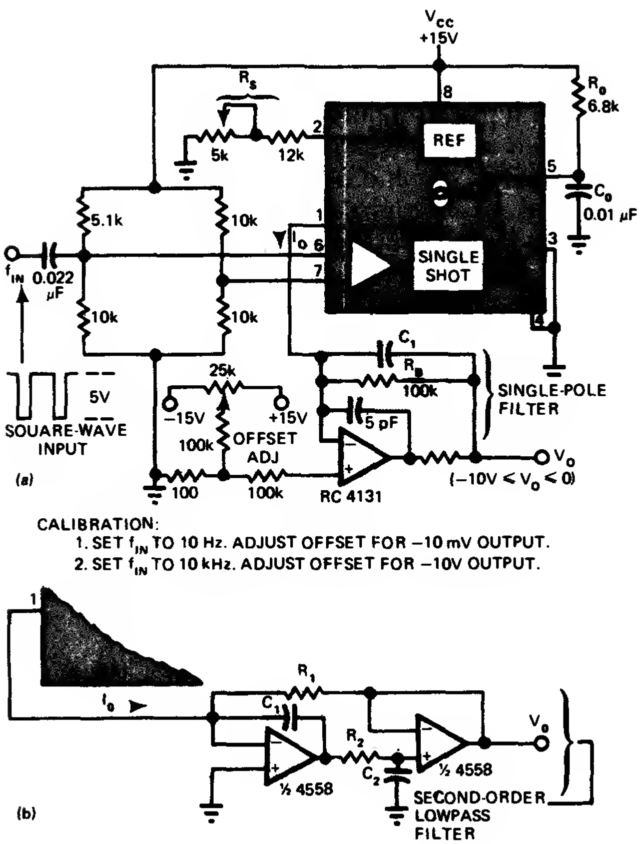
SPARK-COIL TACHOMETER—Input to National LM2917 tachometer IC is taken from spark-coil distributor terminal of gasoline engine. Frequency of input signal is converted to voltage for driving meter. Circuit is set up for number of cylinders on engine by adding link for appropriate timing resistor. Zener protects IC from transients found in auto battery circuit.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-162, p 9–10.

HETERODYNE FREQUENCY METER—Circuit consists of 1–2 MHz oscillator Q1, untuned mixer X1, and AF beat-note amplifier Q2. C4 is calibrated to read directly in frequency from 1 to 2 MHz, using accurate unmodulated RF signal generator. After calibration, unknown RF signal input frequency is fed into meter for zero-beating with harmonics of calibrated oscillator. Magnetic headphones plugged into J1 make beat note audible. On second harmonic, dial of C4 covers 2–4 MHz; on twentieth harmonic, coverage is 20–40 MHz. L1 is 65 turns No. 28 enamel on 1-inch form, tapped 20 turns from ground. L2 is 10 turns No. 28 enamel closewound around center of L1.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 144–146.

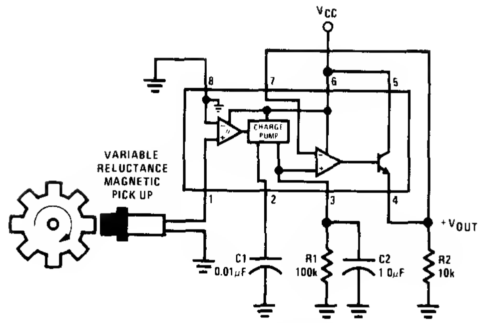




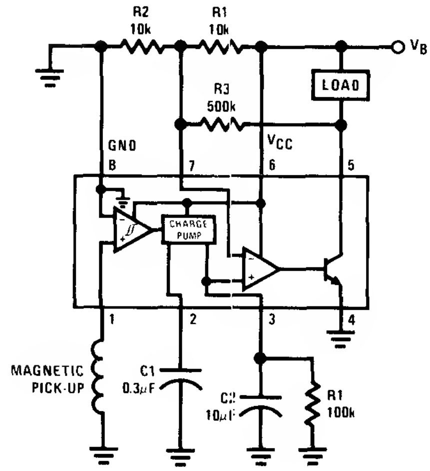
HIGH-PRECISION F/V—Use of integrator opamp with frequency-to-voltaga connection of RM4151 converter gives incraased accuracy and linearity for converting square-wava inputs of 0–10 kHz to proportional output voltage in ranga of −10 V to 0 V.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-39.



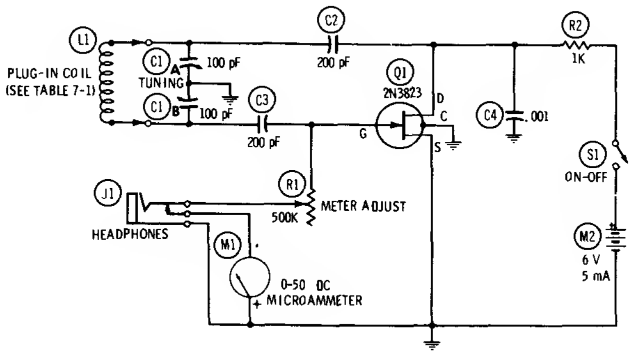
F/V WITH 4151—Uses Raytheon 4151 as frequency-to-voltage converter for ganarating current pulses having precise amplituda and width. Avarage value of output pulse train is directly proportional to input frequancy. Article gives design equations. Responsa time can be improved and ripple reduced by using second-order (double-pola) low-pass filtar as shown in diagram (b). Rippla is less than 0.1 V P-P over range of 10 to 10,000 Hz whan R_1 and R_2 ara 100K and C_1 and C_2 are 0.1 μF.—T. Cate, IC V/F Convartars Raedily Handle Other Functions Such as F/V, A/D, *EDN Magazina*, Jan. 5, 1977, p 82–86.



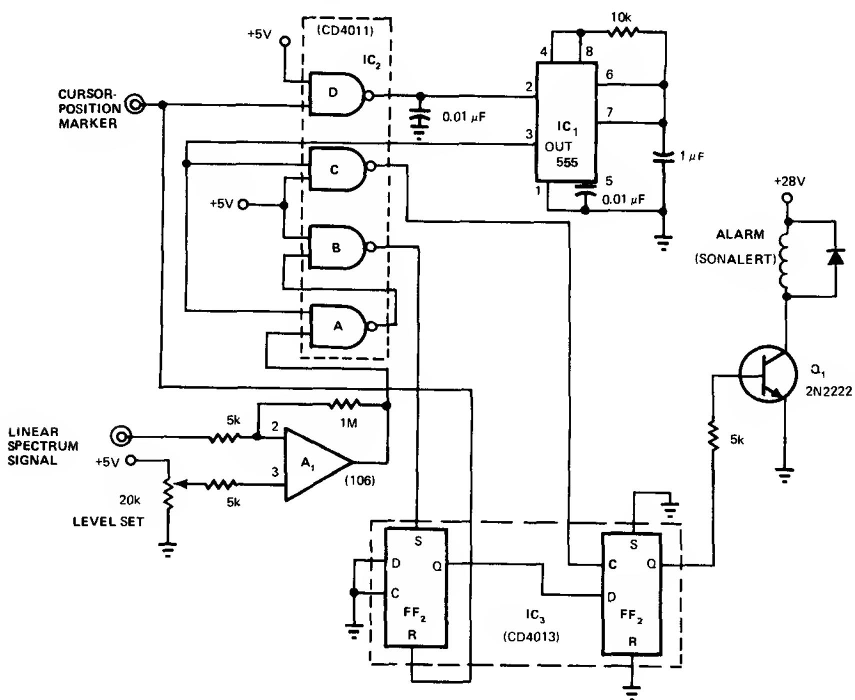
TACHOMETER USING MAGNETIC PICKUP—Signal frequency proportional to shaft speed being measured is fed into National LM2907 IC for conversion to output voltage that is proportional to input frequency. Output is zero at zero frequency. Quality of timing capacitor C1 determines accuracy of unit over temperature range. Use equivalent zener-regulated LM2917 IC if output voltage must be independent of variations in supply voltage.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-162, p 3–4.



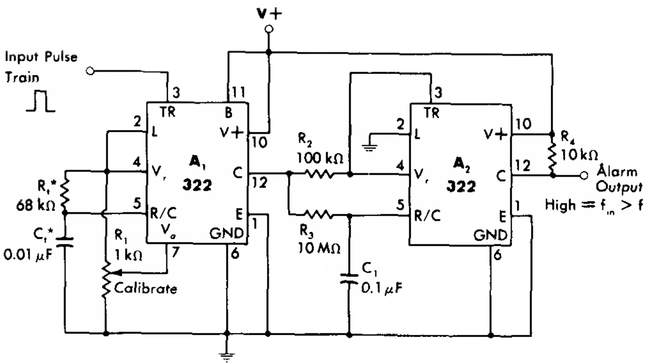
SPEED SWITCH—National LM2907 tachometer IC is used as switch to energize load when input frequency exceeds value corresponding to predetermined speed limit. Automotive applications include use as overspeed warning that activates audible and/or visual indicator when auto speed exceeds legal limit or other desired value. Another application is increasing intensity of auto or taxi horn above predetermined speed such as 45 mph. Input is variable-reluctance magnetic pickup positioned against teeth of gear wheel; in typical setup, pickup output is 16.6 Hz at 60 mph. Values shown for comparator-controlling components R1 and C1 (below IC) give switching operation at about 18.6 Hz at input. Report gives design procedure for other frequencies.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-162, p 8.



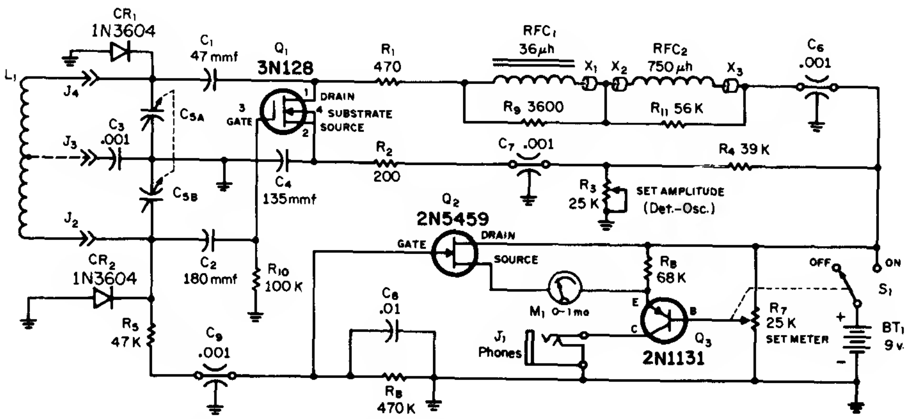
FET DIP OSCILLATOR—High input impedance of FET makes performance comparable to that of tube-type grid-dip oscillator. Six plug-in coils are wound on Millen 45004 1-inch 4-pin forms or equivalent. Use 150 turns No. 32 enamel for 1.1–2.5 MHz, 77 turns No. 28 for 2.5–5 MHz, 35 turns No. 22 for 5–11 MHz, 17 turns No. 22 spaced to 1 inch for 10–25 MHz, 8.5 turns No. 22 spaced to 1 inch for 20–45 MHz, and 4.5 turns No. 22 spaced to 1 inch for 40–95 MHz. Adjust R1 to set meter pointer to desired portion of scale before tuning for dip. R1 provides some control of volume when using headphones.—R. P. Tumar, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 134–136.



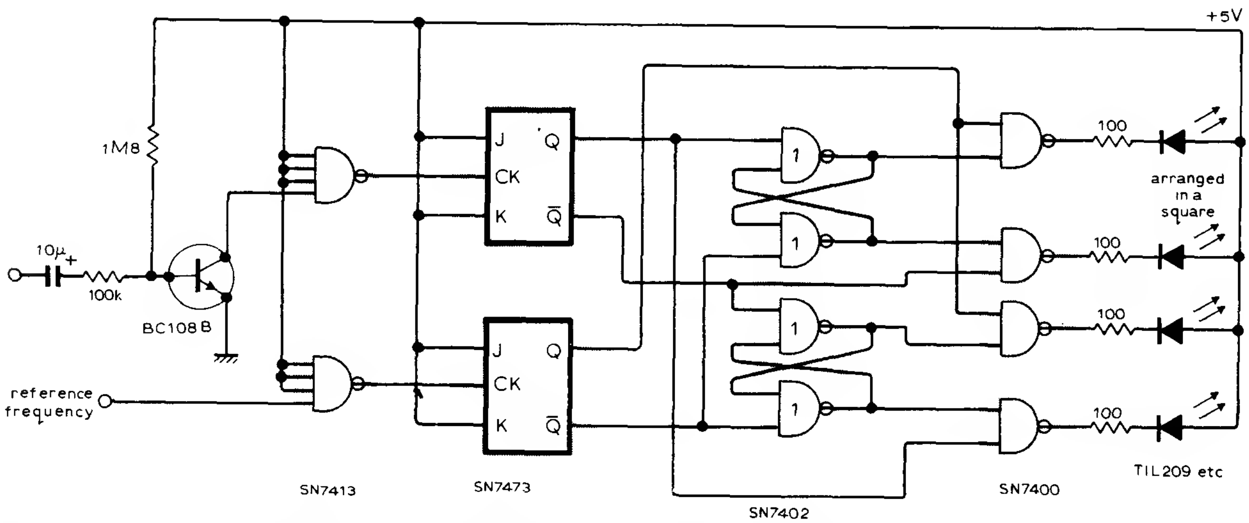
ALARM FOR SPECTRUM ANALYZER—Circuit drives audible alarm when frequency of interest appears in spectrum range. Display cursor can be preset to initiate narrow search band in which f_X is expected to appear. 100-μs pulse representing cursor position in display sweep triggers mono IC_1 so its output becomes window whose time-out is equivalent to band in which f_X is center. Comparator A_1 supplies high output when f_X appears. Simultaneous arrival of this signal and timer window at gate A sets output of left flip-flop high. At end of window period, right flip-flop also goes high and initiates alarm via Q_1. Loss of f_X stops alarm.—R. L. Messick, Alarm Simplifies Spectrum-Analyzer Measurements, *EDN Magazine*, June 5, 1978, p 152.



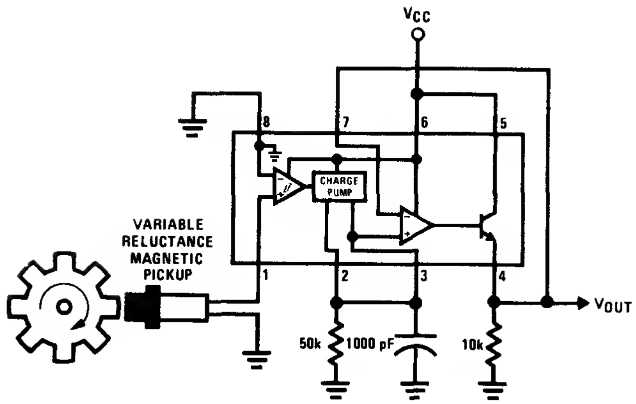
SPEED ALARM—Frequency detector using two IC timers provides alarm output when input frequency is greater than refarence frequency, corresponding to overspeed. Calibrated mono MVBR A_1 produces fixed-width positive pulse across R_2, with average voltege of pulse verying lineerly with input pulse trein frequency. Comperator A_2 changes states whan integrated output of R_3-C_1 on pin 5 goes above or below 2-V voltage threshold of A_2. With values ahown, desired frequency is 1 kHz and circuit detects frequency variation of less than 1%. If low-frequency elerm is deslred, connect logic input pin 2 of A_2 to reference voltage (pin 4) instead of to ground.—W. G. Jung, "IC Timer Cookbook," Howard W. Sems, Indienapolis, IN, 1977, p 228–230.



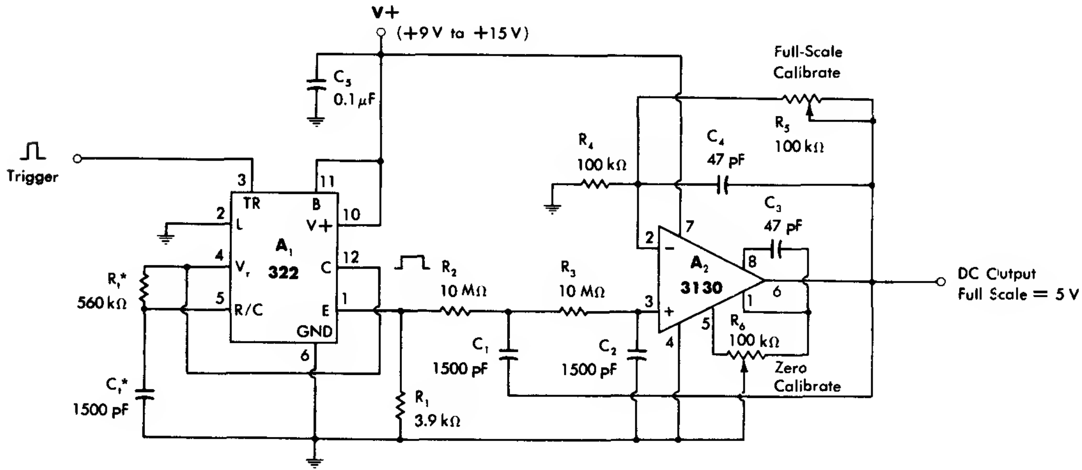
GRID-DIP OSCILLATOR—Millen 90652 solid-state grid-dip oscilletor uses MOSFET opereting in split-Colpitts circuit with resonating tenk connected between drain and gate. Circuit is tuned by split-stator variable capacitor with rotor grounded, chosen to cover 1.7 to 300 MHz with seven plug-in coils. Oscillator also functions as Q multiplier thet increases sensitivity. RF voltage across tuned circuit ia indicated by meter whose reading dips for resonance with coupled test circuit. Full-wave rectifier CR_1-CR_2 provides DC voltege for meter and aome overload protection for MOSFET. Meter is suppressed-zero type, with reedings only for upper portion of current range. J_3 ia provided for use with low-frequency coils.—W. M. Scherer, CQ Reviews: The Millen Model 90652 Solid-State Dipper, *CQ*, Sept. 1971, p 63–64, 66, and 96.



HI-LO LED FREQUENCY DISPLAY—Apperent rotetion of fleshing LEDs around square indicates whether input frequency ia above or below reference frequency. Input end reference waveforms mey have any shepe, because Schmitt triggers reshepe both to give rectanguiar pulses which flip-flops divide by two so outputs ere squere weves with mark-spece retios at half originel frequency. Square waves are gated together to produce rectanguler pulse trein heving mark-space retio thet depends on phese difference between the two square waves. Logic is erranged to drive LEDs et rotetion rate of half the difference between input and reference frequencies. Correct positioning of LEDs in squere is shown on amall diagram. Reference frequency input should be vla BC108B (not ahown), same as for input frequency.—C. Clapp, Beat-Frequency Indlcator, *Wireless World*, Nov. 1976, p 63.

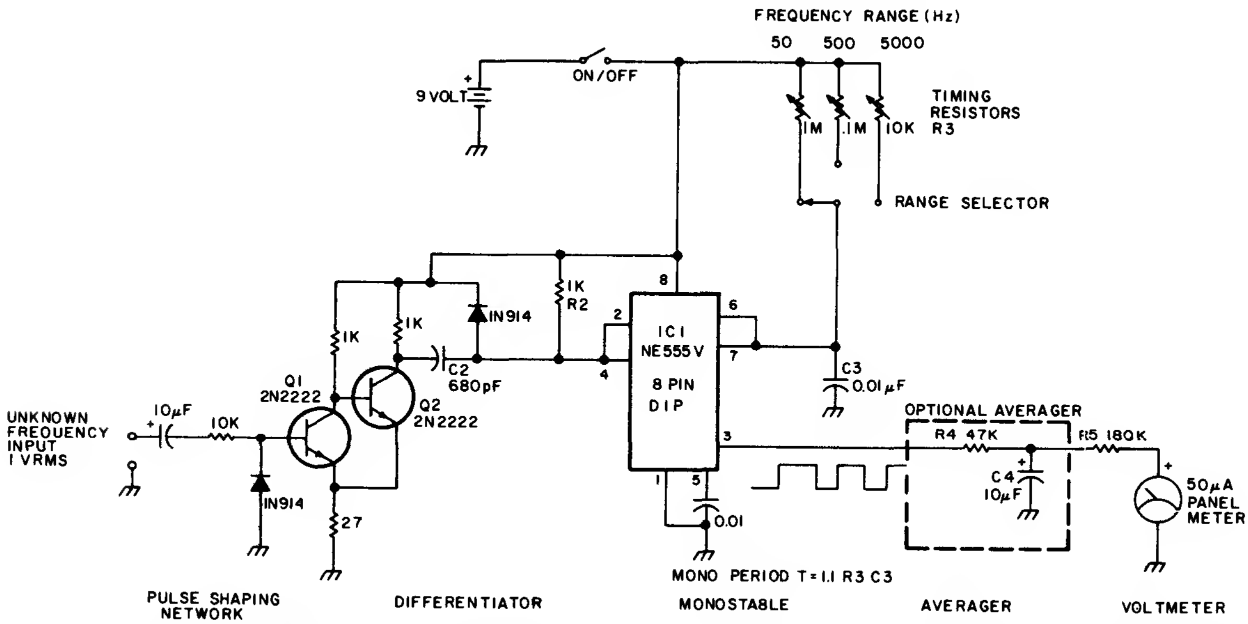


TACHOMETER WITH SQUARE-WAVE OUTPUT—Netionsl LM2907 tachometer IC provides squere-weve output st same frequency es sine weve genereted by megnetic pickup, for use es line driver in eutometic control system.—"Lineer Applications, Vol. 2," Netionsl Semiconductor, Sente Clera, CA, 1976, AN-162, p 12–13.

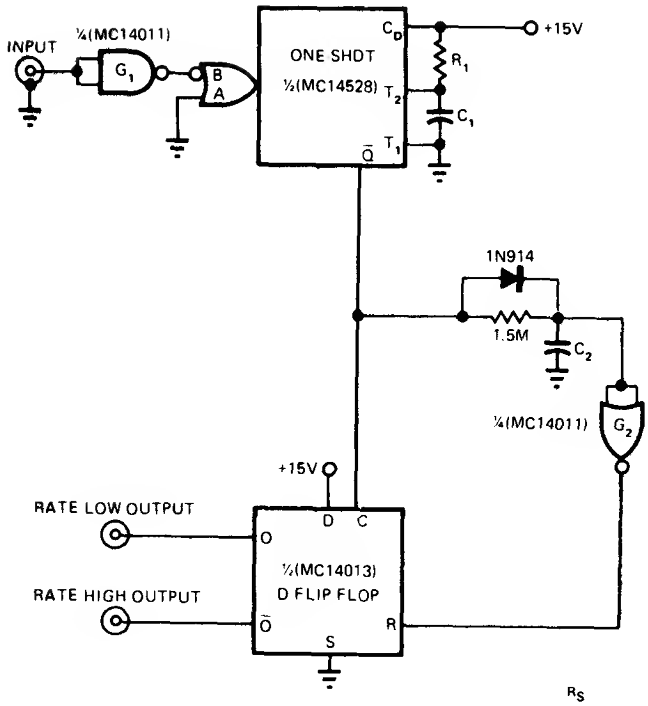


FREQUENCY METER—High-precision frequency-to-voltage converter can be used es frequency meter in leboratory. Input frequency rsnge up to 1 kHz is converted to corresponding full-scale voltage vslue of +5 V. Two-pole filter removes ripple from positive output pulses scross R_1 before signsl is fed to 3130 opsmp thst provides gein end zero sdjustments.—W. G. Jung, "IC Timer Cookbook," Howsrd W. Sems, Indisnspolis, IN, 1977, p 192–196.

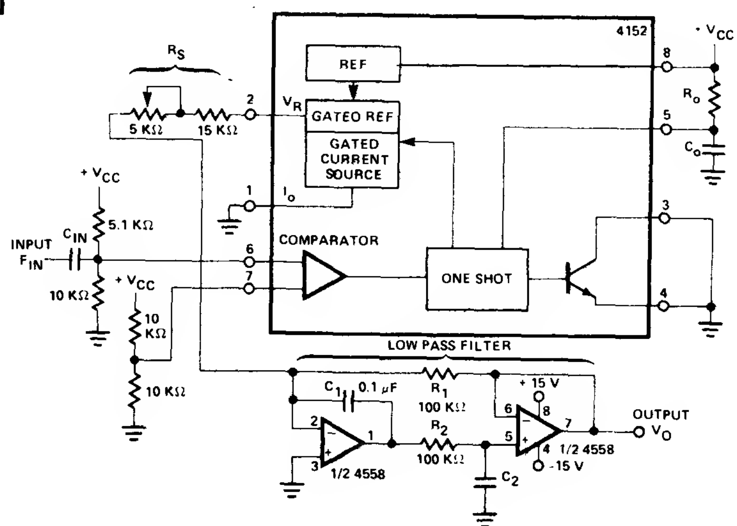
*Let $T = R_t C_t \cong \frac{0.95}{f_{full\ scale}}$



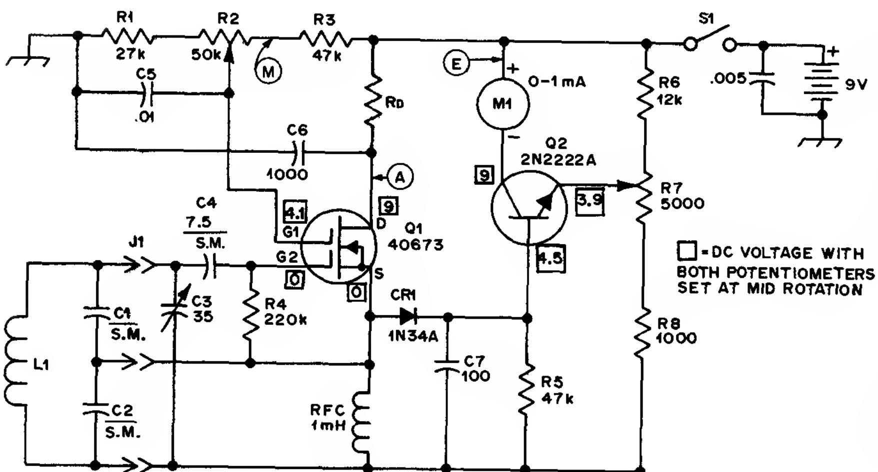
AF METER—Timer IC1 forms basis for linesr frequency meter covering eudio spectrum. Mono MVBR puts out fixed-width pulse when triggered by unknown input frequency. Article covers operetion end calibretion. Errets: pin 4 of 555 should be connected to pin 8 instesd of to pin 2.—G. Hinkle, IC Audio Frequency Meter, *73 Magazine,* Holidey issue 1976, p 61.



PULSE-RATE DETECTOR—Operates from 1 Hz to 2 MHz, providing one logic level when input rate crosses set point and opposite logic level when input rate falls below set point. Set-point rate is reciprocal of MVBR time, or $1/R_1C_1$. Two periods of input signal are sufficient for response to rate change. Value of C_2 is $R_1C_1/1.5 \times 10^6$.—J. M. Toth, Versatile Circuit Forms Accurate Pulse-Rate Detector, *EDN Magazine*, Aug. 20, 1977, p 142–143.



F/V WITH OUTPUT FILTER—Two-pole low-pass active filter improves dynamic range and response time of Raytheon 4152 frequency-to-voltage converter. Ripple in output is less than 0.02 V P-P above 100 Hz. Requires ±15 V supply. Maximum input frequency is 10 kHz when C_{IN} is 0.002 µF, R_0 is 6.8K, and C_0 is 0.01 µF.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-48.



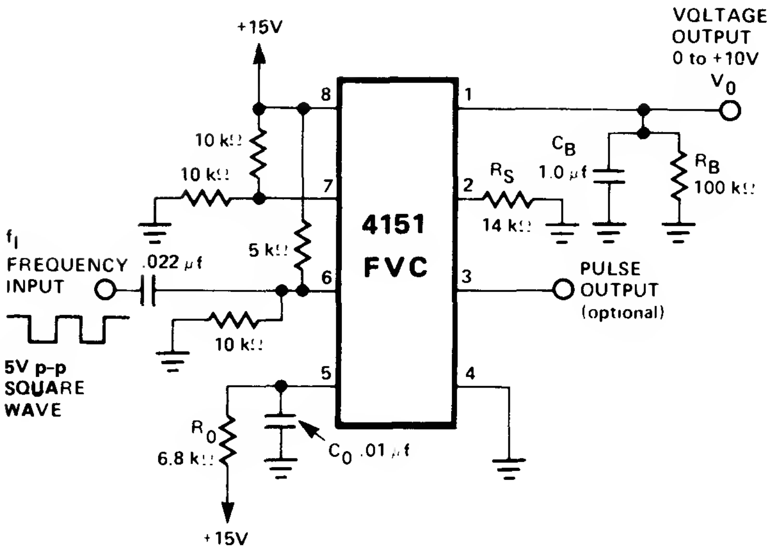
S.M. = SILVER MICA

FREQ. RANGE MHz	*C1 pF*	*C2 pF*	*L1 TURNS*
2.3-4	15	15	71-1/2
3.4-5.1	33	10	39-1/2
4.8-8	10	33	25-1/2
7.9-13	10	33	14-1/2
12.8-21.2	10	33	6-1/2
21-34	10	33	4-1/2
34-60	10	33	2-1/2
60-110	10	33	*
90-200	Not used	Not used	**

*denotes a 1-1/2-turn coil of No. 18 enam. wire wound on a 1/2-inch form spaced 1/8 inch between turns. It should be placed so that the coil is near the top of the coil form.
**denotes a hairpin loop made from flashing copper, 3/8-inch wide X 1-7/8-inch total length.

All other coils are wound with No. 24 enam. wire.

MOSFET DIP METER—Output of grounded-drain Colpitts oscillator using RCA N-channel dual-gate MOSFET Q1 is detected by CR1 and amplified by Q2 for driving meter. Frequency of oscillation depends on C1, C2, C3, and L1, and reaches 250 MHz when L1 is reduced to hairpin. Table gives values of plug-in assembly L1-C1-C2 for nine frequency ranges. Circuit was designed for 12-V supply but works well with 9-V battery shown if drain resistor R_D is shorted. Battery drain is about 20 mA. All coils are wound on Millen 45004 forms.—F. Bruin, A Dual-Gate MOSFET Dip Meter, *QST*, Jan. 1977, p 16–17.

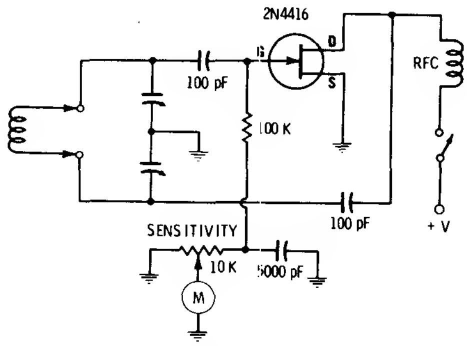


DESIGN EQUATIONS:

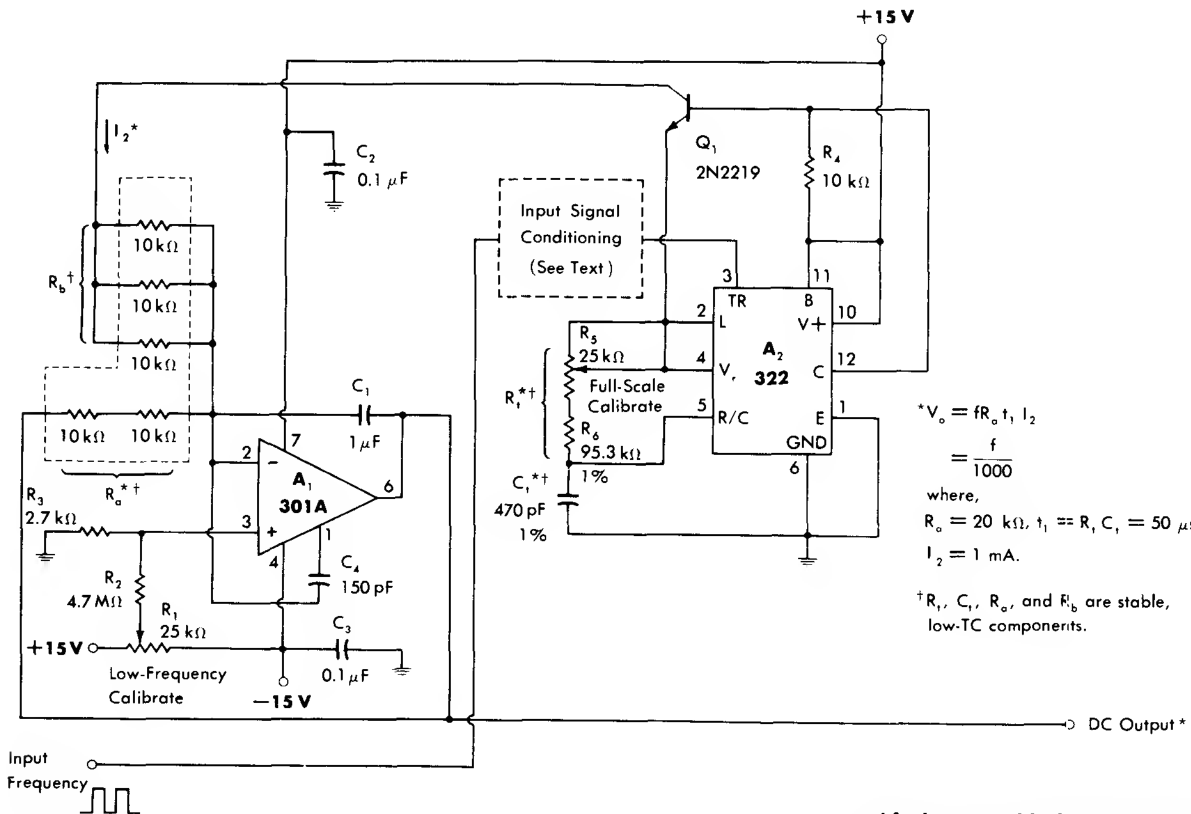
$V_0 \quad f_I K^{-1}$ Where $K - 0.486 \dfrac{R_S}{R_B R_0 C_0} \dfrac{Hz}{V}$

$T \quad 1.1\ R_0 C_0$

F/V CONVERTER—Single-supply circuit usas frequency-to-voltaga connection of RM4151 converter to make output voltage vary between 0 and +10 V as frequency of 5 V P-P square-wave input varies betwaen 0 and 10 kHz.—"Linear Integrated Circuit Data Book," Raytheon Semiconductor Division, Mountain View, CA, 1978, p 7-39.



GATE-DIP FET OSCILLATOR—Meter indicatas gate currant, which drops whenever resonant load is placed on tank circuit of oscillator by bringing plug-in input coil near frequency sourca baing checked. By opening switch to powar supply, circuit can ba used as absorption wavemater; when signal at resonant frequency of dip-metar tank circuit is picked up, gate-source circuit of FET operatas as diode detector for producing increase in meter reading. Values of plug-in coil and tuning capacitor depend on frequency ranga of interest.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 213–214.

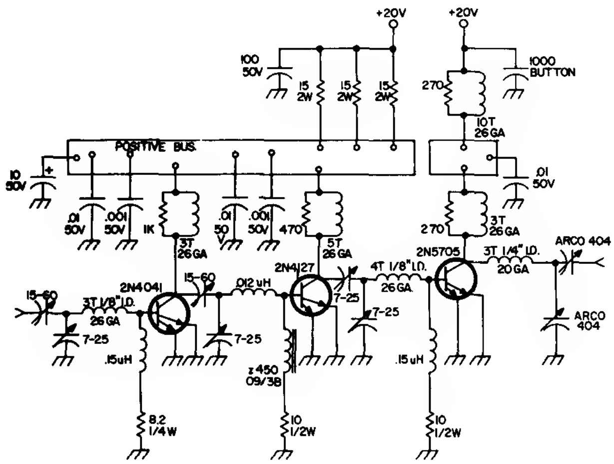


HIGH-PRECISION F/V—Componants of V/F convartar ara raconnected to provide F/V function. Input frequency up to 10 kHz is fad to 322 mono MVBR A_2 eithar directly if pulsed or indirectly after conditioning. For low-frequency or slowly changing waveforms, zaro-crossing datector is used for input conditioning. A_1 is connected as scaling amplifier and filtar.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 192–196.

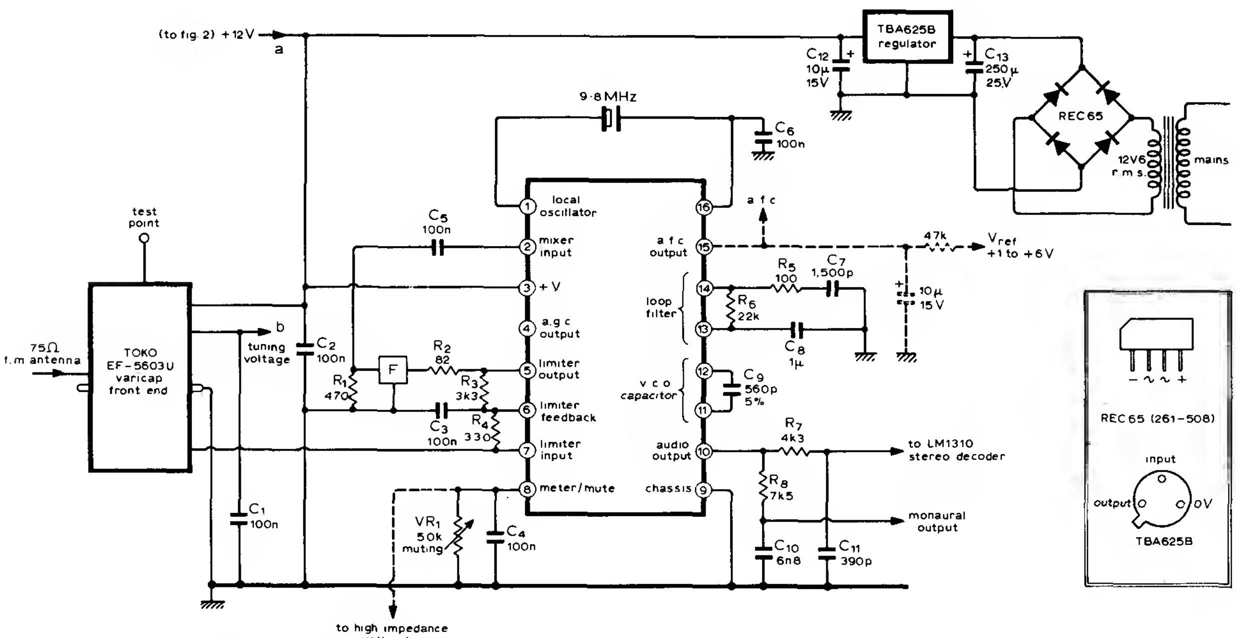
CHAPTER 34

Frequency Modulation Circuits

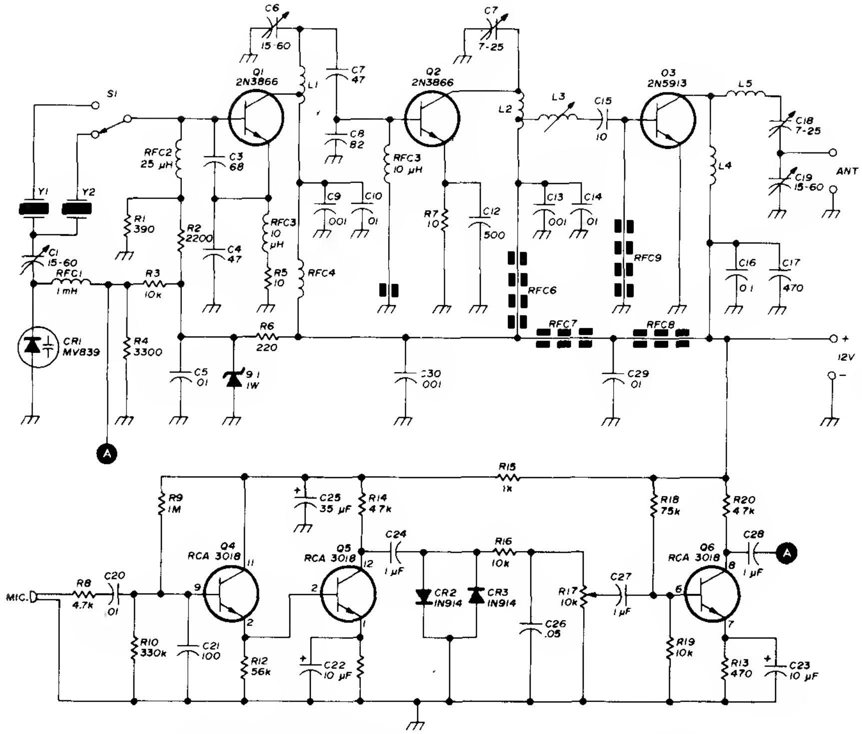
Covers FM circuits used in broadcast receivers and transmitters for monophonic or stereo transmissions, along with FM radio communication circuits and power-line FM carrier systems. Includes tuning indicators, stereo decoders, SCA demodulator, and FM deviation meter.



20-dB GAIN FOR 2 m—Input of 200 mW is amplified to 20 W. Positive 20-V sources are separated so final stage can be amplitude-modulated; for FM, connect to single supply. Transistors require heatsinks.—Circuits, *73 Magazine,* May 1973, p 106.

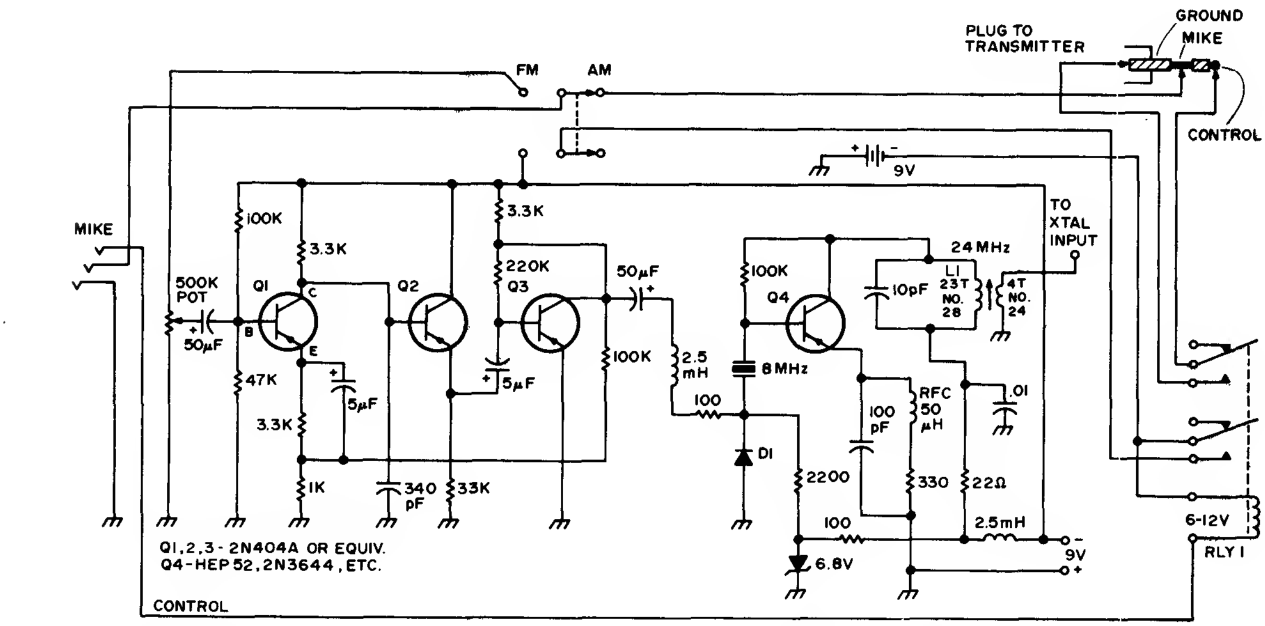


TUNER USES IC—Availability of Signetics NE563 IC having about 180 transistors greatly simplifies construction of high-quality FM tuner. IC includes circuits for converting IF output signal to lower frequency for driving phase-locked loop of demodulator. Use of varicap front end permits switched or continuous tuning with 100K Helipot or with switched preset 100K pots connected between +12 V and ground. Tuning controls can be remotely located. After 80 dB of amplification in NE563 IC, signal passes through ceramic filter F (Vernitron FM-4 or Toko CFS) before being fed back through C_5 to IC for mixing with crystal-controlled 9.8-MHz local oscillator. Article covers construction and operation of tuner in detail.—J. B. Dance, High-Quality F.M. Tuner, *Wireless World,* March 1975, p 111–113.

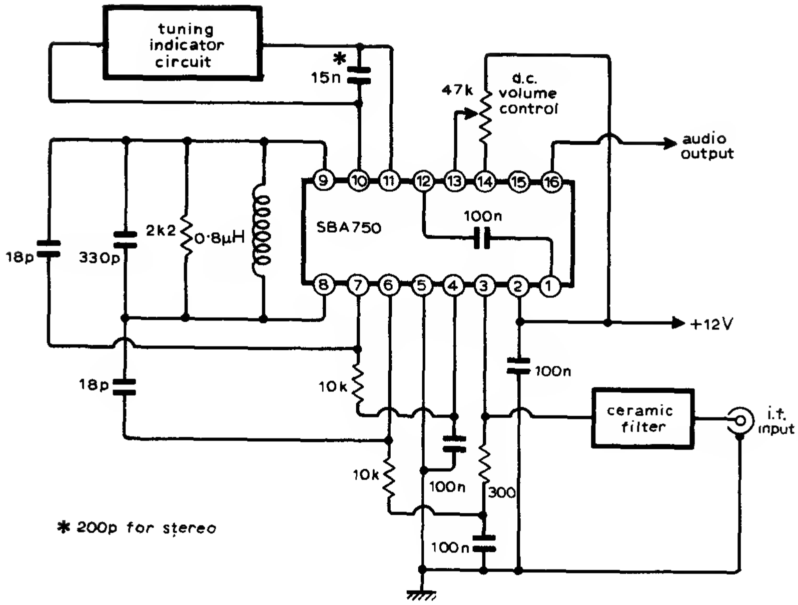


L1	5 turns no. 16 tinned bus wire, 1/4" ID, 5/8" long, tapped at 2 1/2 turns	L5	5 turns no. 16 tinned bus wire, 5/16" ID, 1/2" long
L2	3 turns no. 16 tinned bus wire, 1/4" ID, 3/8" long, tapped 1/2 turn from C13 end	RFC6 RFC9	4 Amidon ferrite beads on 1/2" length of no. 24 wire
L3	4 turns no. 22 enamelled wire, closewound, 1/4" ID	RFC7 RFC8	3 Amidon ferrite beads on 1/2" length of no. 24 wire
L4	25 turns no. 28, closewound on body of 100k, 1-watt resistor	Y1,Y2	18-MHz crystal ground for 20-pF load capacitance

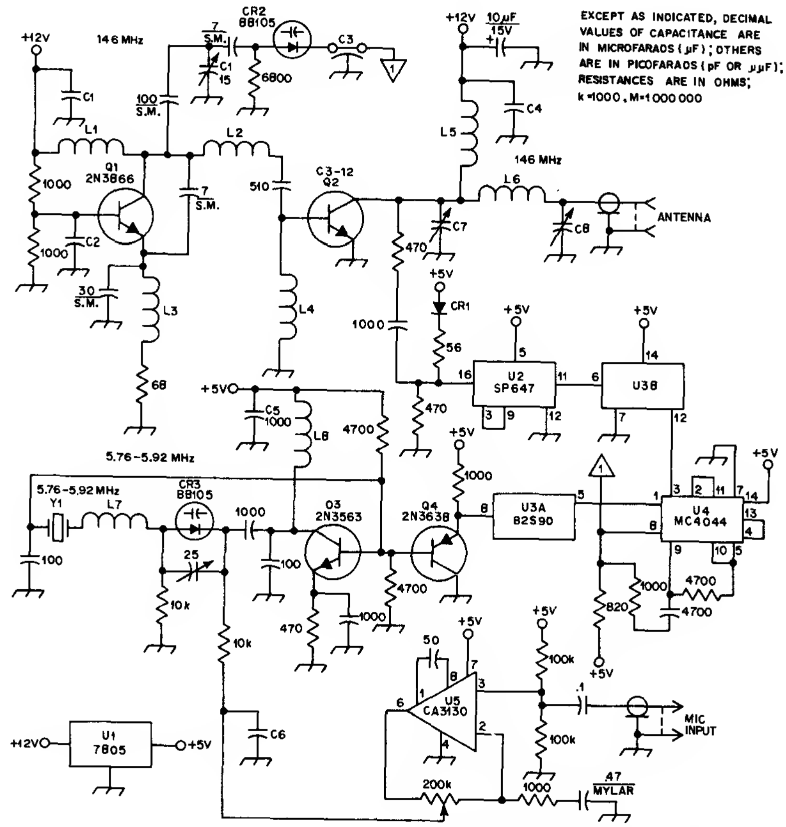
144-MHz FM TRANSMITTER—Low-power circuit was developed for use with double-conversion continuous-tuning FM receiver suitable for either fixed or mobile communication on 2-meter emataur band. Q4-Q6 are part of RCA CA3018 IC. Powar output with 12-V supply is about 1.5 W. Two crystals are selected by slide switch; tuning can be compromised to use crystels whose 2-mater outputs are 1 MHz apart. Article also gives all circuits for recaiver.—J. H. Ellison, Compact Package for Two-Meter FM, *Ham Radio*, Jan. 1974, p 36–44.



FM MODULATOR—Developed to permit FM operation on AM transcaiver. Consists of microphone praamplifiar, driver amplifier, end 8-MHz crystal oscilletor providing 24-MHz output. **Audio from modulator drives variable-capacitance dioda D1 (which cen be silicon switching diode) in oscillator circuit. Adepter feeds AM transmitter in which frequency multipliers increese deviation to about 8.5 kHz. To reduce deviation for narrow-band FM, adjust 500K pot in preamp.—R. Orozco, Jr., Put That AM Rig on FM, *73 Magazine*, April 1976, p 34–35.**

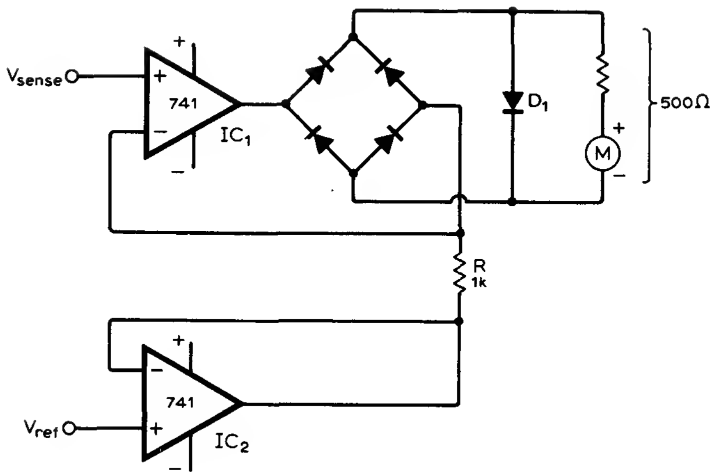


SINGLE-LED TUNING INDICATOR—Circuit shown, when driven by IF output of FM tunar, parmits tuning for maximum brightness of single LED such as 5082-4403. Articla gives choica of two tuning indicator circuit arrangements that can be used with the SBA750 limiting IF emplifier and detector IC. Recommended version of tuning Indicator uses Piessey SL3046 five-transistor array with discrete resistors and capecitor to drive LED. Arrangement gives very clear, sensitive indication of correct tuning point to within a few millivolts.—J. A. Skingley, Sensitive F.M. Tuning Indicator, *Wireless World*, June 1974, p 173–174.



2-W 2-METER PHASE-LOCKED FM TRANSMITTER—Operating frequency of 144–148 MHz is generated directly, without using frequency-multiplier stages. Oscillator stabillty is achieved by phasa-locking oscillator to crystsl. Tuning range of 143–149 MHz corresponds to veractor control voltage of 1–4 V, which maintains proper loop gain across entira band. ECL dacada divider U2 is Piessey SP647 driving Schottky-clamped divider U3B to give overall division of 50. Phase detector and loop amplifier functions are in U4. Pierce crystal oscillator Q3 feeds buffer Q4 interface with TTL levels. Microphona preamp U5 is slightly overdriven so speech waveform is clipped or limited. With phase-locked circuit, frequancy stability is as good as that of crystal used in reference oscillator. Divide desired operating frequency by 25 to get crystal frequency.—A. D. Halfrick, A Phase-Locked 2-Metar FM Transmitter, *QST*, Merch 1977, p 37–39.

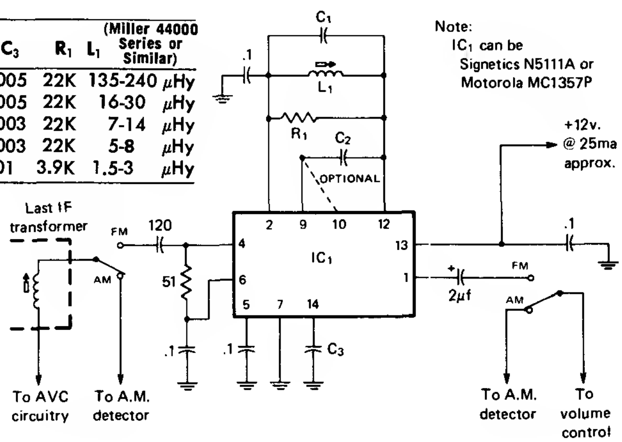
C1-C6, incl. — 1,000-pF ceramic feedthrough capacitors.
C7, C8 — 14- to 150-pF ceramic trimmer (Arco 424).
CR2, CR3 — BB105 or Motorola MV839 Varicap diode, 82 pF nominal capacitance, 73.8- to 90.2-pF total range.
L1, L3, L7 — 33-μH molded inductor (Miller 9230-56).
L2 — 1-1/2 turns no. 20 enameled wire, 1/4-inch diameter, 1/2-inch long.
L4 — 3 turns no. 28 enameled wire through ferrite bead.
L5 — 2.2-μH molded inductor (Miller 9230-28).
L6 — 1-1/2 turns no. 20 enameled wire, 3/8-inch diameter, 1-inch long.
L8 — 100-μH molded inductor (Miller 9230-68).
Q1 — RCA 2N3866 or Motorola HEP S3008 transistor.
Q2 — C3-12, manufactured by Communications Transistor Corp., a division of Varian. An RCA 2N5913 may be substituted.
Q3, Q4 — RCA transistor.
U1 — 5-volt, 1-ampere fixed positive regulator. An LM309K may be substituted.
U2 — Plessey Semiconductors integrated circuit.
U3 — Signetics 82S90 or National DM73LS196 integrated circuit.
U4 — Motorola MC4044 integrated circuit.
U5 — RCA CA3130 integrated circuit.
Y1 — Overtone Crystal, 5.76-5.92 MHz, International Crystal Mfg. Co. Type GP. Crystal frequency is discussed in the text.

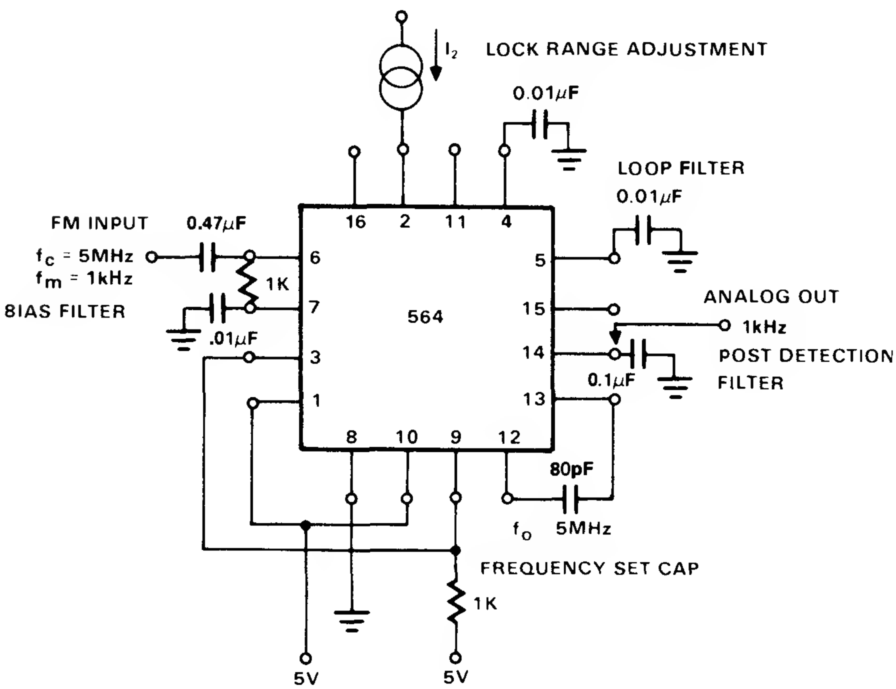


TUNING NULL INDICATOR—Uses standard left-zero mater as tuning indicator connacted in basic opamp AC voltmeter configuration using IC_1, with referance buffared by opamp IC_2. DC output voltage of tuner is compared with nonzaro referance voltage; as these voltages approach each other during tuning, meter pointer moves toward zero, and abruptly revarses direction as tuning null point is passed. Dioda D_1 protects mater from ovarload. Use any lowlaakaga diodes for bridge.—A. S. Holdan, Sansitive Null Indicator, *Wireless World*, Oct. 1974, p 381.

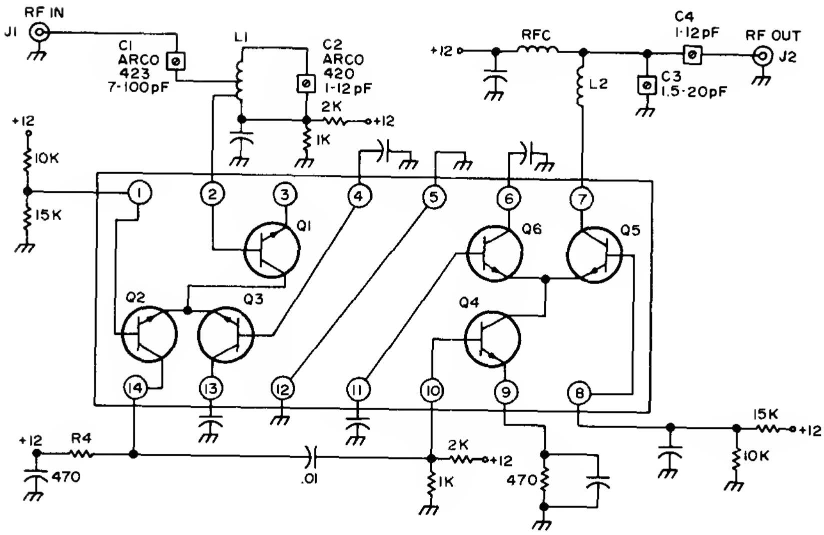
ADD-ON FM DETECTOR—Suitabla for any communication receivar. Other IF values can be handled by changing values of L and C. Connecting C_2 to pin 10 instaad of pin 9 may improve performanca. Circuit is easy to construct and align; adjust slug-tuned coil for maximum racovered audio whan receiving FM signal.—I. Math, Math's Notes, *CQ*, April 1975, p 37–38 and 62.

Final I.F.	C_1	C_2	C_3	R_1	L_1 (Miller 44000 Series or Similar)
455 kHz	680 pF	3 pF	.005	22K	135-240 μHy
2 Mhz	300 pF	3 pF	.005	22K	16-30 μHy
4.5 Mhz	120 pF	3 pF	.003	22K	7-14 μHy
5.5 Mhz	100 pF	3 pF	.003	22K	5-8 μHy
10.7 Mhz	100 pF	4.7 pF	.01	3.9K	1.5-3 μHy



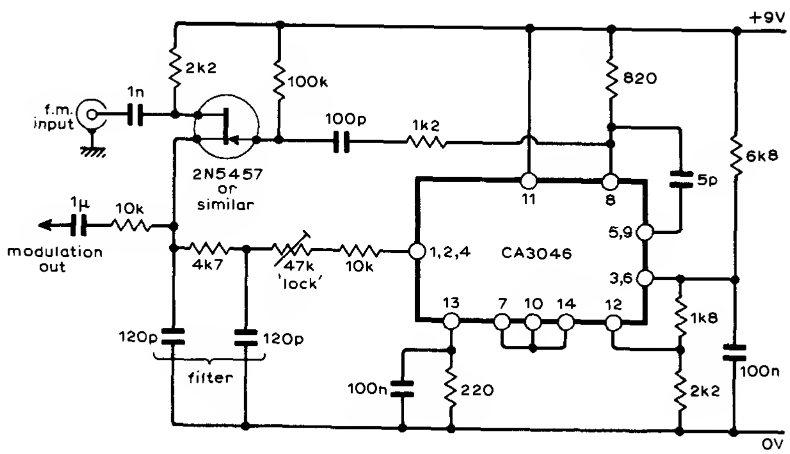


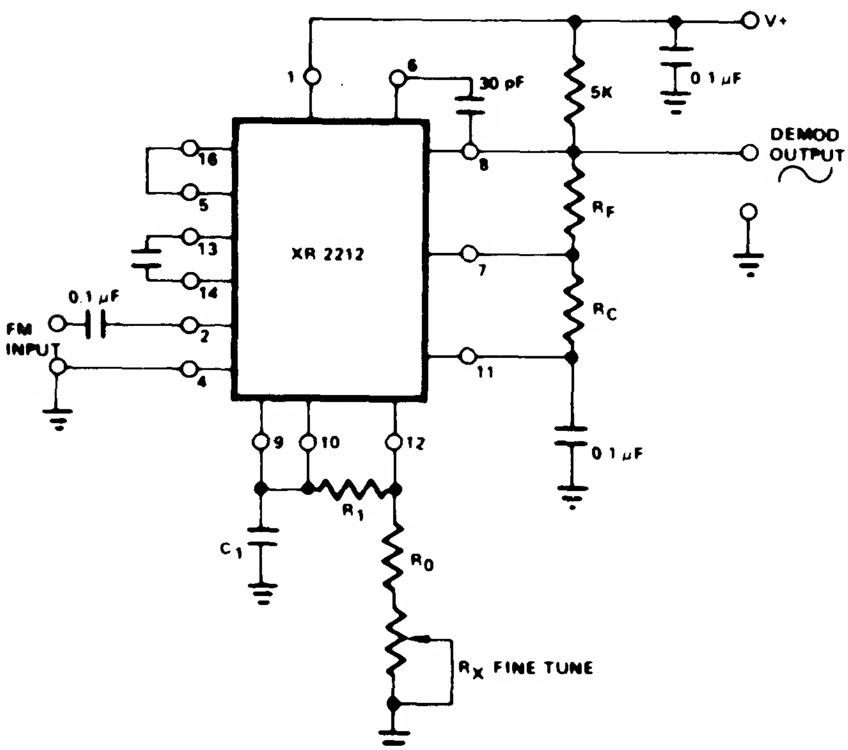
FM DEMODULATOR—Usas Signetics NE564 PLL having postdetection processor, oparating from 5-V supply. Convarsion gain is low so frequency deviation in input signal should ba at least 1%.—"Signatics Analog Data Manual," Signatics, Sunnyvale, CA, 1977, p 828–830.



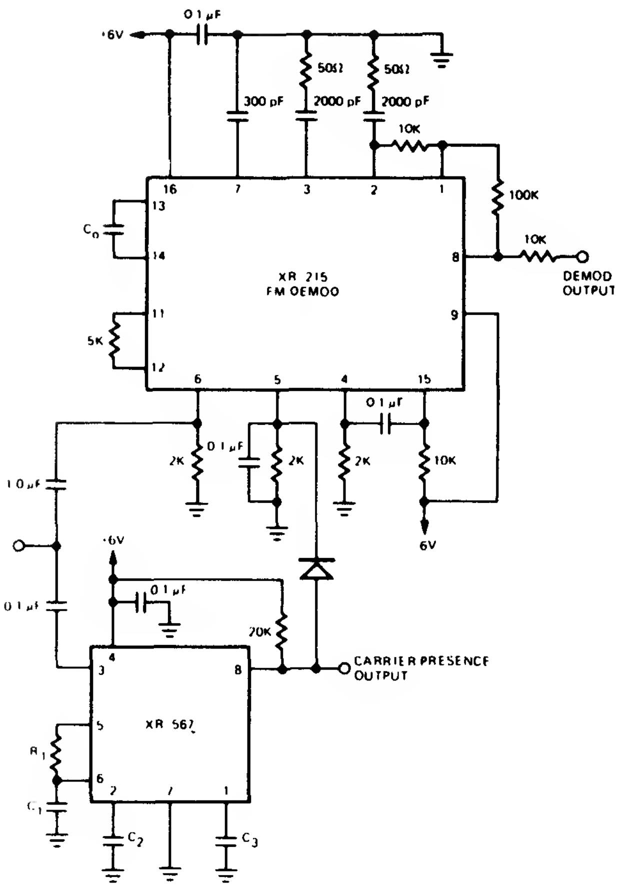
2-METER IC RF AMPLIFIER—High-gain double compound amplifier using RCA CA3102E has low noise, excellent stability, and only two tuned circuits. Ideal for 2-meter FM RF stage, but can be used from DC up to 500 MHz by changing tuned circuits. Article covers construction, with emphasis on proper shielding.—B. Hoisington, Two High Gain RF Stages in One IC for Two Meter FM, *73 Magazine*, May 1974, p 47–50 and 52.

FM DEMODULATOR—Uses RCA CA3046 IC IF amplifier connected as highly linear voltage-controlled oscillator, in phase-locked loop configuration capable of handling 10.7-MHz amplitude-limited FM input as FM demodulator. Output AF signal is about 20 mV for 75-kHz deviation. FET serves as synchronous-chopper type of phase-sensitive detector.—J. L. Linsley Hood, Linear Voltage Controlled Oscillator, *Wireless World*, Nov. 1973, p 567–569.

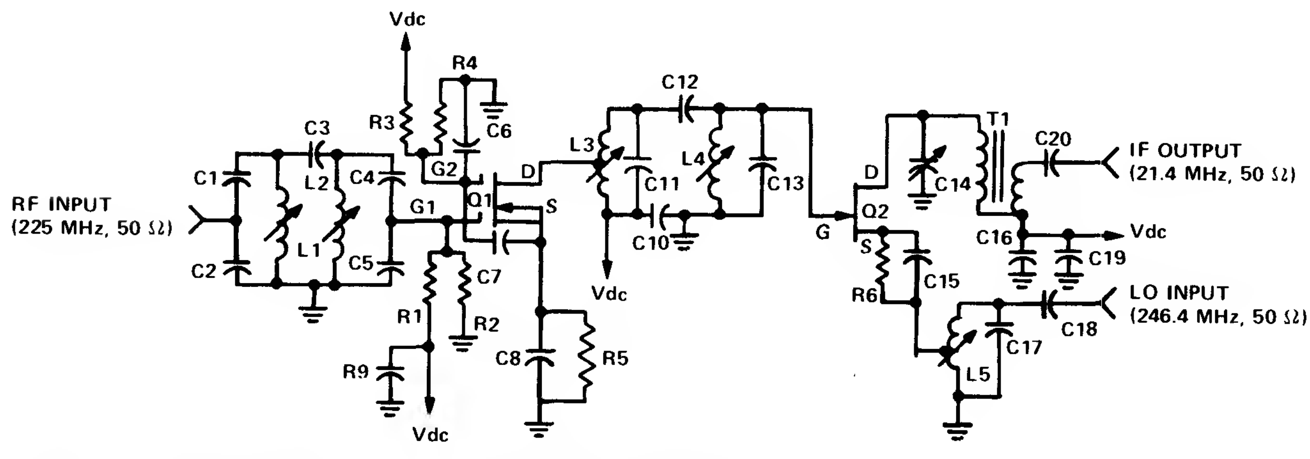




LINEAR FM DEMODULATOR—Exar XR-2212 precision PLL IC provides linear demodulation for both narrow-band and wideband FM signals. Article gives circuit design procedure. With +12 V supply voltage and 67-kHz carrier frequency having ±5 kHz frequency deviation, R_0 is 18K fixed resistor in series with 5K pot. C_0 (between pins 13 and 14) is 746 pF, R_1 is 89.3K, C_1 is 186 pF, R_F is 100K, and R_C is 80.6K. These values give ±4 V P output swing. All values except R_0 can be rounded off to nearest standard value.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 35–40.



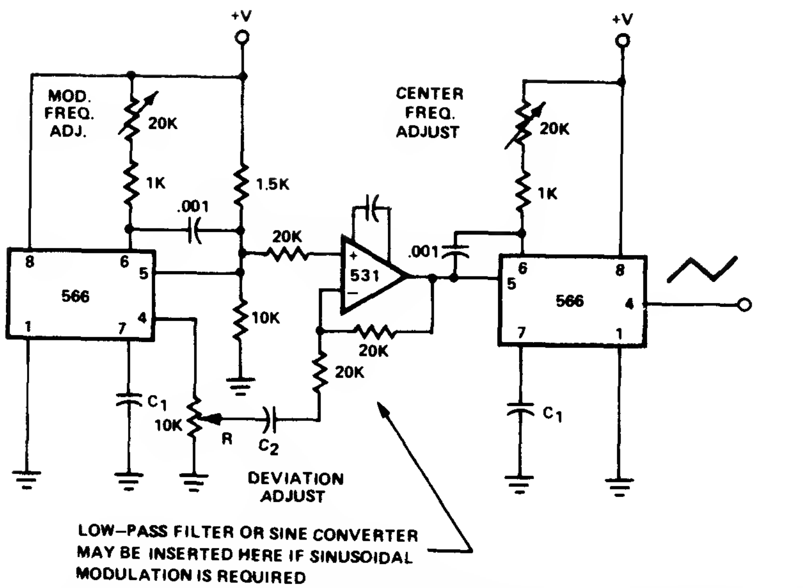
DEMODULATOR WITH CARRIER DETECT—Exar XR-567 PLL system is used with XR-215 FM demodulator to detect presence of carrier signal in narrow-band FM demodulation applications where bandwidth is less than 10% of carrier frequency. Output of XR-567 is used to turn off FM demodulator when no carrier is present, giving squelch action. Circuit will detect presence of carrier up to 500 kHz.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 41–48.



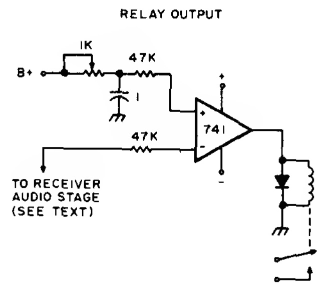
C1 – 8.2 pF	Ceramic disc capacitor
C2 – 43 pF	Dipped, silvered mica capacitor
C3 – 0.2 pF	Ceramic tubular capacitor
C4 – 12 pF	Ceramic disc capacitor
C5 – 15 pF	Dipped, silvered mica capacitor
C6, C7, C8, C9, C10 C16 – 220 pF	Ceramic disc capacitor
C11 – 10 pF	Dipped, silvered mica capacitor
C12 – 0.47 pF	Ceramic tubular capacitor
C13 – 3.6 pF	Ceramic tubular capacitor
C14 – 8–60 pF	Mica compression trimmer, Arco 404
C15, C19 – 0.01 μF	Ceramic disc capacitor
C17, C18 – 3 pF	Dipped, silvered mica capacitor
C20 – 24 pF	Dipped, silvered mica capacitor

R1 – 300 kilohm, 1/4 W carbon resistor
R2 – 27 kilohm, 1/4 W carbon resistor
R3 – 62 kilohm, 1/4 W carbon resistor
R4 – 56 kilohm, 1/4 W carbon resistor
R5 – 220 ohm, 1/4 W carbon resistor
R6 – 910 ohm, 1/4 W carbon resistor
L1 – 2-1/2 turns no. 20 enameled wire on 9/32" plastic form with brass slug (70 nH)
L2, L4 – 2-1/6 turns no 20 enameled wire on 9/32" plastic form with brass slug (60 nH)
L3 – 1-5/6 turns no. 20 enameled wire on 9/32" plastic form with brass slug, tapped 1/2 turn from ground (55 nH)
L5 – 2-1/2 turns no. 20 enameled wire on 9/32" plastic form with brass slug, tapped 2/3 turn from ground (70 nH)
Q1 – 3N201 MOSFET
Q2 – 2N5486 JFET
T1 – Primary = 18 turns no. 24 enameled wire on T44-6 Micrometals toroid core
Secondary = 4 turns no. 24 enameled wire twisted around last 4 turns of ground end of primary

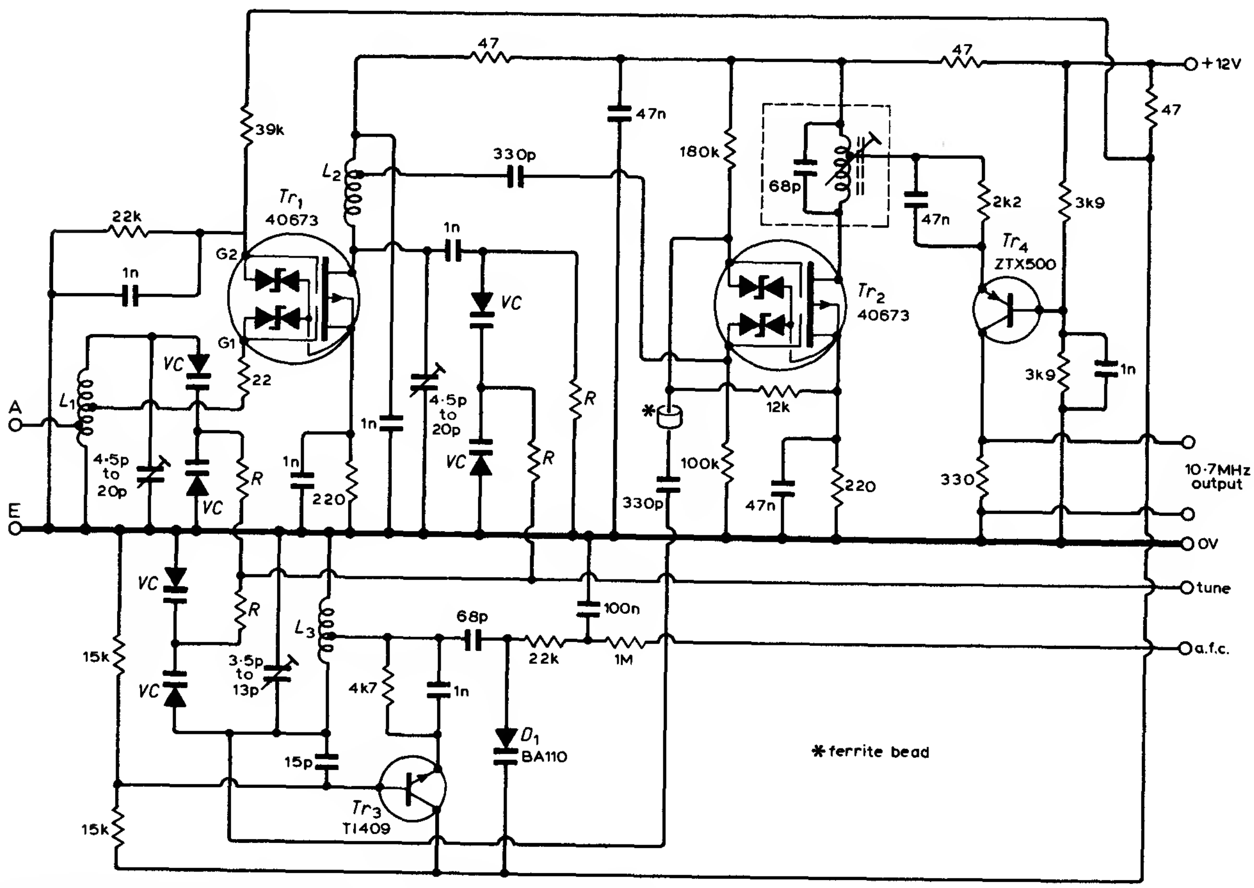
225-MHz FRONT END—RF stage, mixer, and tuned circuits are designed for use in FM communication receiver having local oscillator input of 246.4 MHz, for IF of 21.4 MHz. Supply voltage is 12.5 V. Spurious-response rejection is 100 dB, image rejection is 97 dB, and noise figure is 12 dB.—J. Hatchett and B. Morgan, "Economical 225 MHz Receiver Front End Employs FETs," Motorola, Phoenix, AZ, 1978, EB-22.



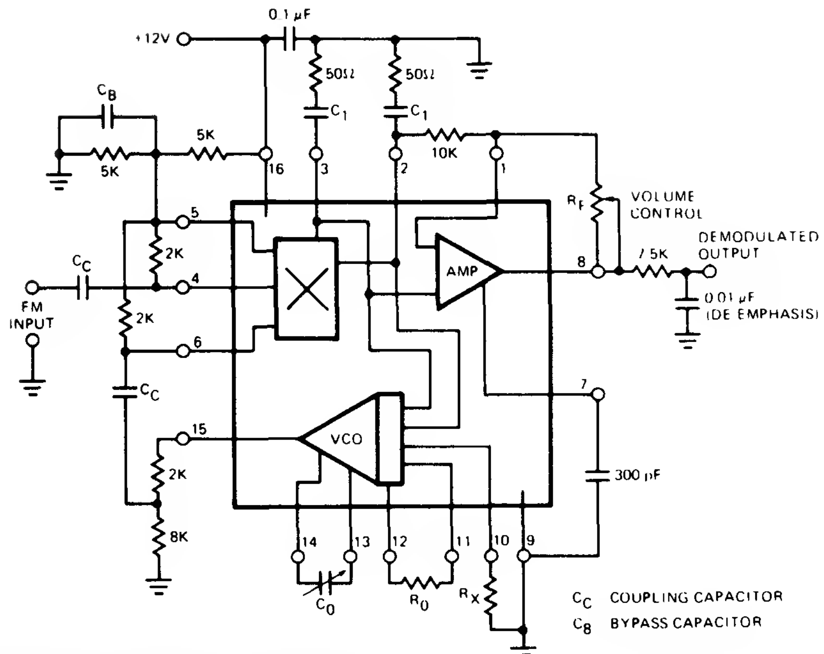
0.5 MHz WITH 100% DEVIATION—Carriar frequency under 0.5 MHz is genereted by 566 function generator at right, for modulation by othar 566 connected es triangla ganarator whose output is boosted by 531 opamp to giva devietions up to ±100% of carriar frequency. Capacitors C_1 control frequency range of aach function generator.—"Signetics Analog Data Manuai," Signetics, Sunnyvele, CA, 1977, p 852–854.



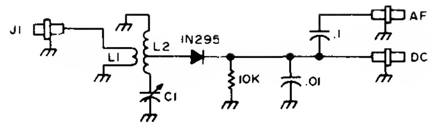
CARRIER-OPERATED RELAY—Relay is energized when carrier is present in FM receiver, to activate transmitter for rapeatar applications or turn on tape recorders, alerms, or other davices. Will work with aither solid-state or tube-typa raceivars. Inverting (minus) input of opamp is connected directly to collector of audio preamp transistor or any othar point having voltage change between signel and no signal. If voltage change is in wrong diraction, ravarse leads to opamp input. Usa 1K pot to set referance voltaga so relay trips raliably on incoming signal. Relay can be raed-type drawing less than 75 mA.—S. Uhrig, Tha 5 Minute COR, *73 Magazine,* Dec. 1976, p 152–153.



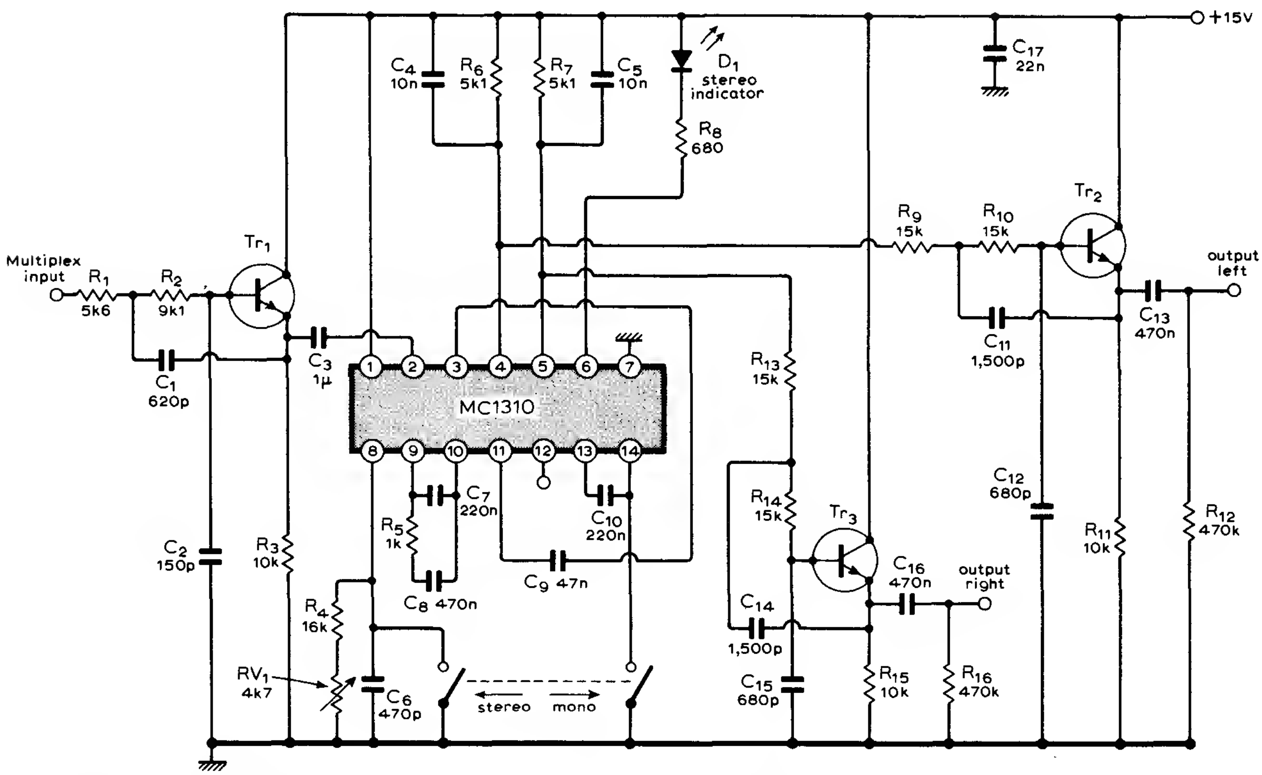
VARICAP TUNER—Uses silicon variable-capacitance diodes to provide voltage tuning over FM band of 87.5 to 108 MHz. Articla covers construction and adjustmant and givas circuit of stable noise-fraa regulated powar supply that aiso provides required DC tuning voltage of 2 to 30 V. All six varicap diodes ere Siemans BB103 of same color salaction (all graan or all blua). Resistors R can ba any valua between 100K and 1 megohm.—L. Nelson-Jones, F.M. Tuner Design—Two Years Later, *Wireless World,* June 1973, p 271–275.



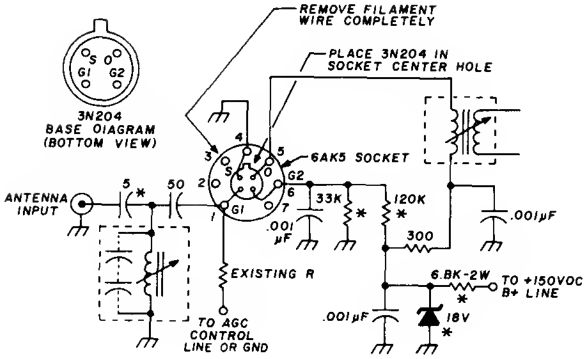
DEMODULATOR—Uses Exar XR-215 PLL IC connected for frequency-selective demodulation of FM signals. Value of C_0 depends on carrier frequency. C_1 determines selectivity; for 1–10 MHz, renge of C_1 is 10–30 timas C_0. For operation below 5 MHz, R_X can be opened; ebova 5 MHz, use ebout 750 ohms.—"Phese-Locked Loop Deta Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 21–28.



65–130 MHz DIODE RECEIVER—Tunable version of basic crystel detector is useful for FM broadcest work end for checking output of frequancy multiplier. L2 is 5 turns center-tapped No. 12 copper wire air-wound to 5/8-inch diameter end 1-inch length. C1 is 30-pF miniature tuning capacitor.—B. Hoisington, Tuned Diode VHF Receivers, *73 Magazine*, Dec. 1974, p 81–84.

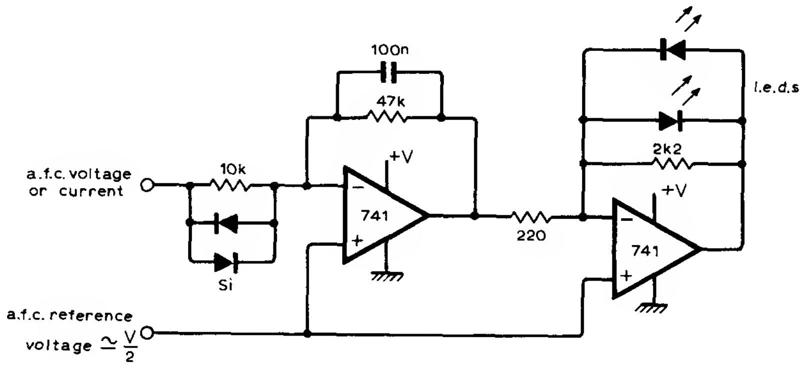


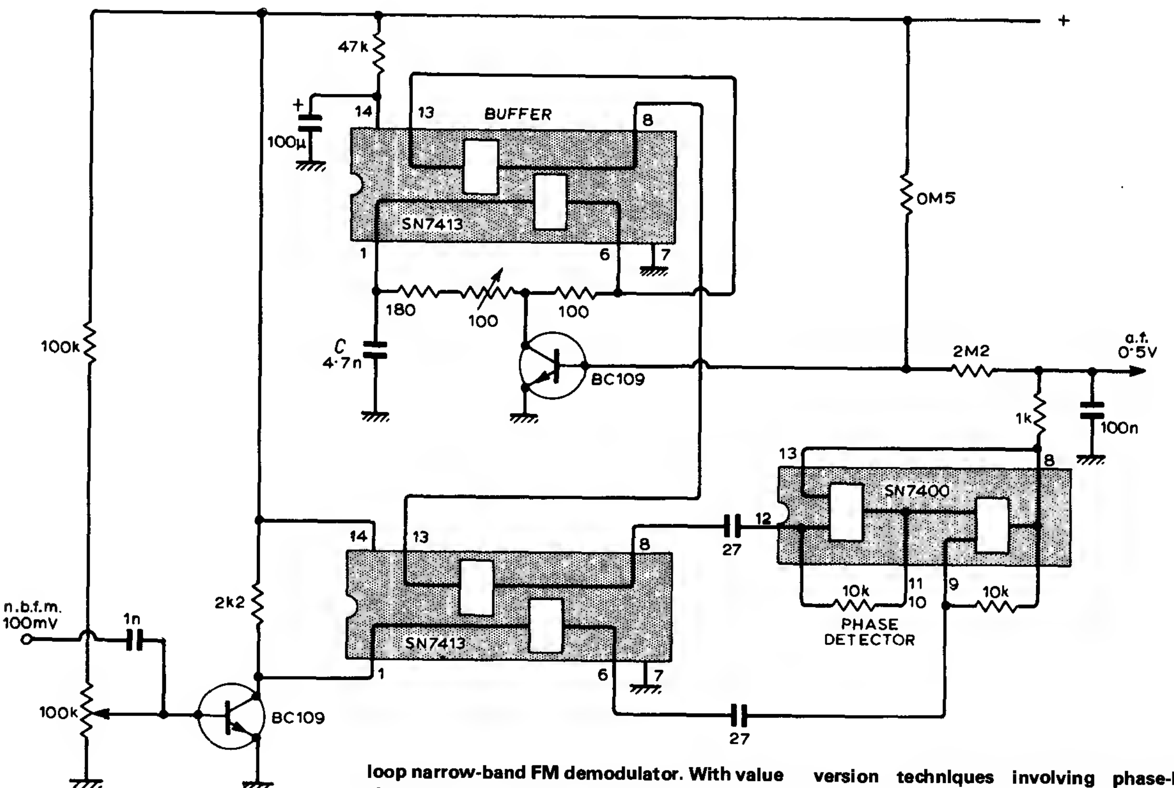
STEREO DECODER—Improved circuit for FM tuner uses activa filters to eliminete subcarriar harmonics as well es birdlike interference sounds (birdies) experienced under certain conditions. Stereo reception normelly involves demodulation of stereo chennal at 38 kHz by squere-wave switching, e process thet elso demodulates signels around odd harmonics of 38 kHz. The first two of these, at 114 end 190 kHz, can produce audible signels from edjacent channels at 100 end 200 kHz ewey from wented station. Resulting interfarance, centered on 14 kHz and 10 kHz, sounds like high-pitched twittering sounds of birds. Tr_1 serves as ective filter for suppressing thesa sounds. This is followed by phase-locked loop typa of IC decoder, operation of which is described in erticle that elso givas complete circuit and construction deteils for entira FM tuner. All trensistors ere BC109 or equivelent. LED is 5082-4403. Tr_1 hes roll-off response et 18 dB per octeve ebova 53 kHz, while active filters Tr_2 and Tr_3 remove harmonics of 38 kHz from outputs.—J. A. Skingley and N. C. Thompson, Novel Stereo F.M. Tuner, *Wireless World*, Part 2—May 1974, p 124–129 (Part 1—April 1974, p 58–62).



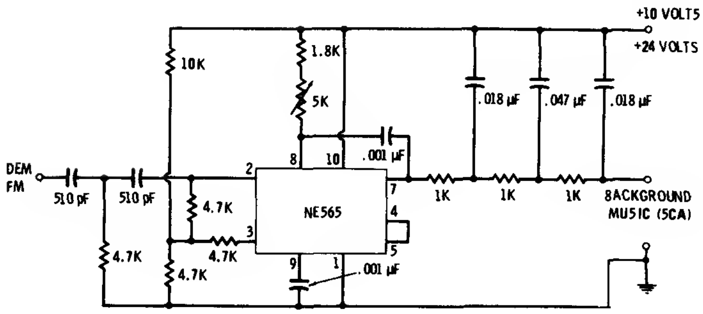
MOSFET RF STAGE—Changing 6AK5 tube to 3N204 dual-gate MOSFET improves sensitivity and lowers noise in older VHF FM communication receiver using tubes. Break off center grounding pin of tube socket and cut wires soldered to pin, then connect transistor circuit to tube socket as shown. Replace original resistor going to pin 6 with 120K and run 37K resistor from pin 6 to ground. Move antenna input lead to top of RF input coil, and remove 6-V filament wiring from socket. If tube filaments were in series, replace 6AK5 filament with 36-ohm 2-W resistor. Conversion increases sensitivity to 0.3 µV for 20-dB quieting.—H. Meyar, How to Improve Receiver Performance of Vacuum-Tube VHF-FM Equipment, *Ham Radio*, Oct. 1976, p 52–53.

TWIN-LED TUNING INDICATOR—Provides maximum sensitivity at correct tuning point and indicates direction of mistuning. Both lamps are in feedback loop of one opamp, connected to serve as highly sensitive null detector. When set is tuned correctly, output of this opamp is at midpoint of supply voltage and neither LED is lit. Circuit is used with RCA CA3089 IF chip in which AFC output is a current. Capacitor across first 741 opamp removes modulation components from this input.—M. G. Smart, F.M. Tuning Indicators, *Wireless World*, Dec. 1974, p 497.



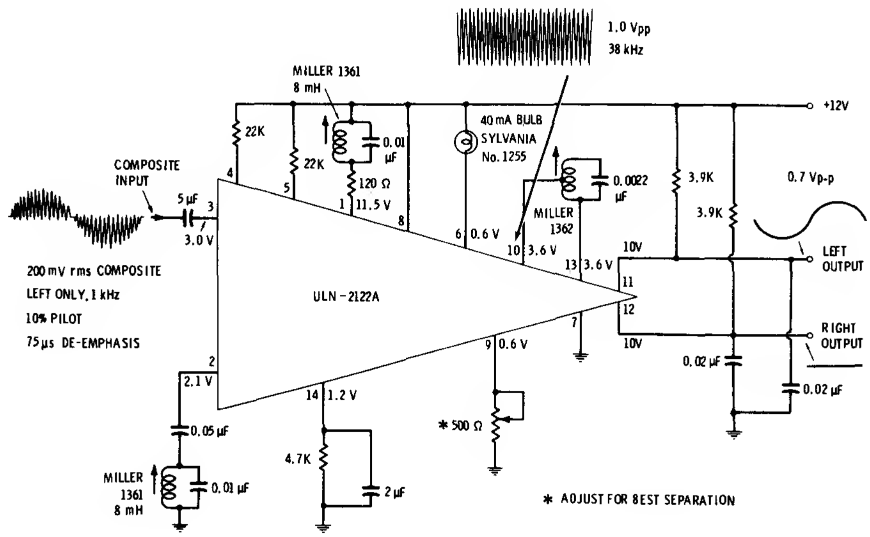


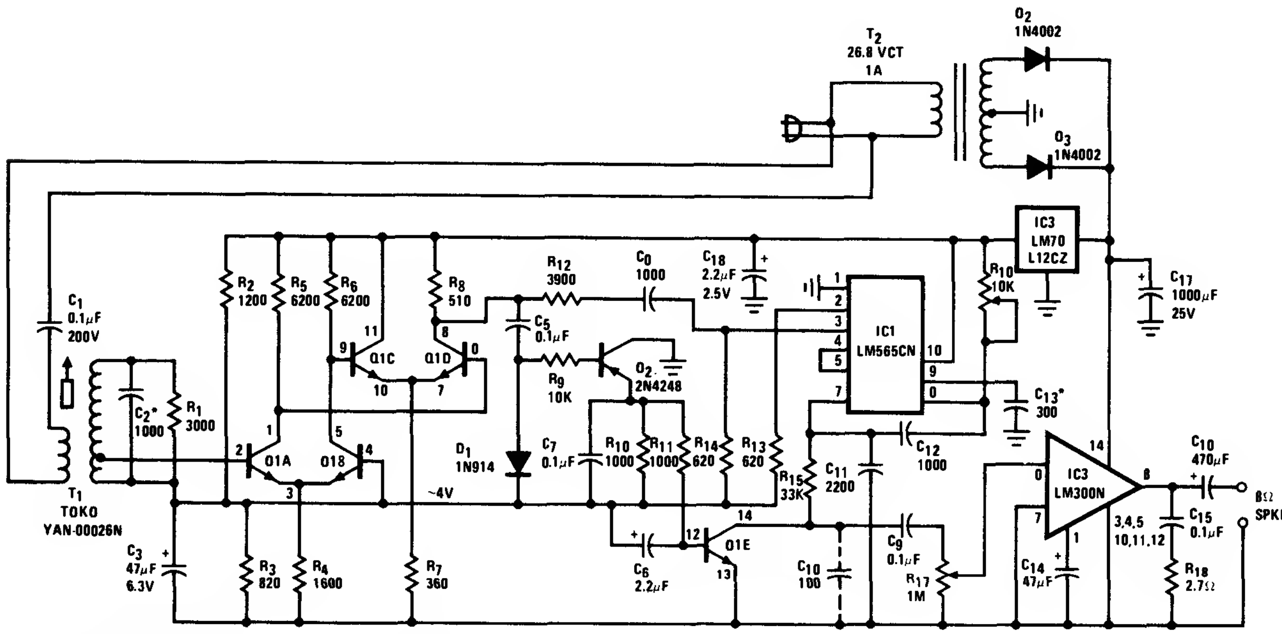
NARROW-BAND DEMODULATOR—Low-cost TTL ICs are connected to form phase-locked loop narrow-band FM demodulator. With value shown for C, circuit is suitable for IF value around 470 kHz. Article covers advantages of synchronous detection and various direct conversion techniques involving phase-locked loop.—P. Hawker, Synchronous Detection in Radio Reception, *Wireless World*, Nov. 1972, p 525–528.



SCA DEMODULATOR—VCO of NE565 PLL is set at 67 kHz and is locked in by incoming 67-kHz subsidiary-carrier component used for transmitting uninterrupted commercial background music by FM broadcast stations. Circuit demodulates FM sidebands and applies them to audio input of commercial sound system through suitable filter. 5K pot is used to lock VCO exactly on frequency. Frequency response extends up to 7000 Hz.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 212–213.

STEREO DECODER—Single Sprague ULN-2122A IC is driven by composite signal derived at output of standard FM detector, to give original left- and right-channel audio signals for driving audio amplifiers of FM stereo receiver.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 263–266.



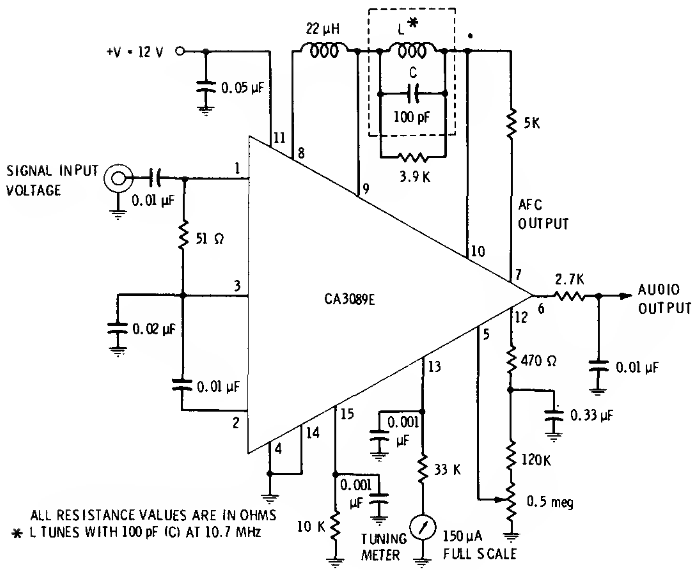


CAPACITOR VALUES IN PF
RESISTOR VALUES IN Ω
*SELECT FOR CARRIER FREQ.

Q1A–Q1E = LM3040

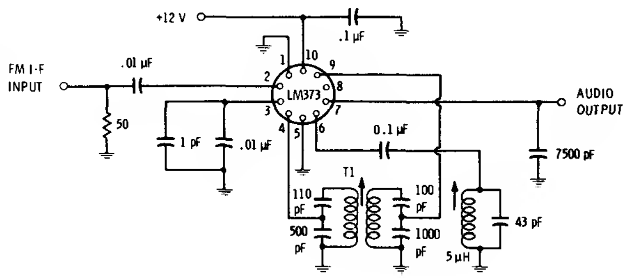
I_o	C_2	C_{13}
200 kHz	1000	300
100 kHz	3900	820

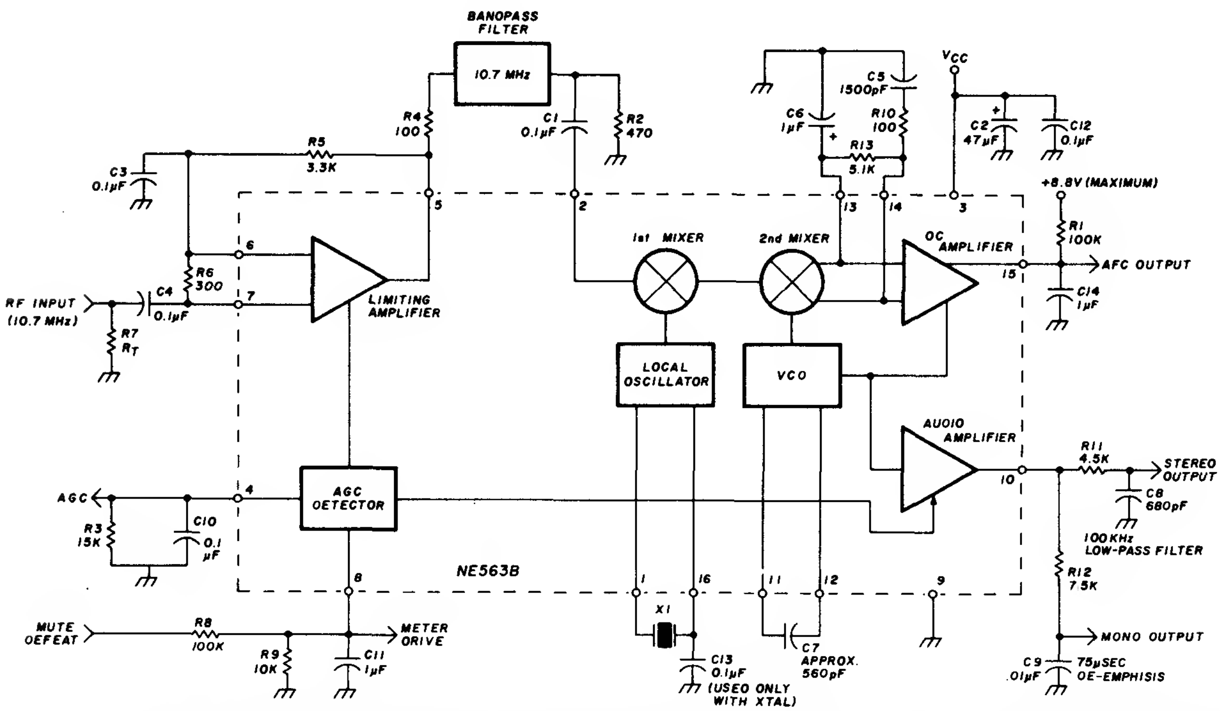
CARRIER-SYSTEM RECEIVER—Used to detect, amplify, limit, and demodulate FM carrier modulated with audio program, for feeding up to 2.5 W to remote loudspeaker. Can be plugged into any AC outlet on same side of distribution transformer. Carrier signal is taken from line by tuned transformer T_1. Output of two-stage limiter amplifier Q1A-Q1D is applied directly to mute peak detector D1-Q2-C7. Limiter output is reduced to 1 V P-P for driving National LM565CN PLL detector which operates as narrow-band tracking filter for input signal and provides low-distortion demodulated audio output. Mute circuit quiets receiver in absence of carrier.—J. Sherwin, N. Sevastopoulos, and T. Regan, "FM Remote Speaker System," National Semiconductor, Santa Clara, CA, 1975, AN-146.



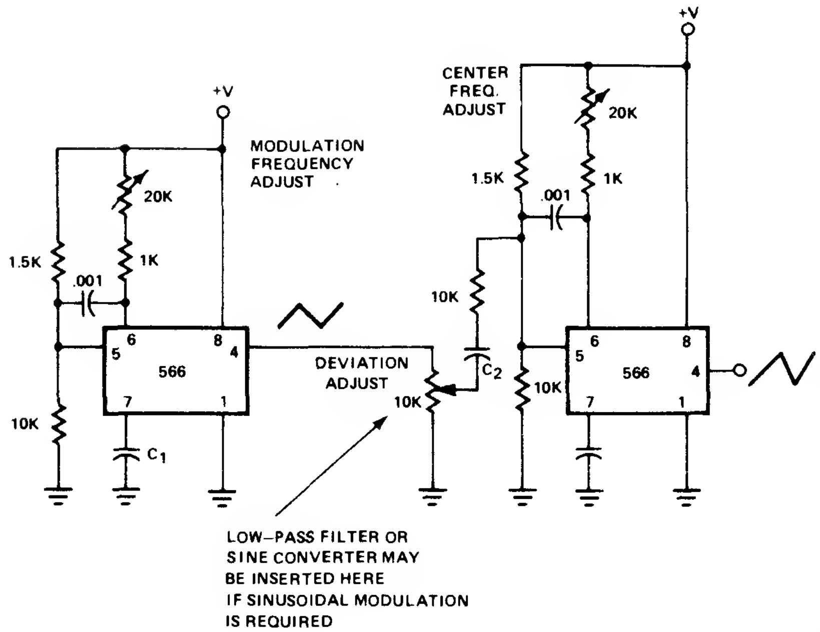
SINGLE-TUNED DETECTOR—RCA CA3089E IC serves as communication receiver subsystem providing three-stage FM IF amplifier/limiter channel, with signal-level detectors for each stage, and quadrature detector that can be used with single-tuned detector coil. Detector also supplies drive to AFC amplifier whose output can be used to hold local oscillator on correct frequency. Level-detector stages supply signal for tuning meter. Values shown are for 10.7-MHz IF.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, 347–349.

QUADRATURE DEMODULATOR—Quadrature coil associated with balanced-mixer demodulation system is connected to pin 6 of National LM373 IC, and output signal is taken from pin 7. Good output is obtained with only ±5 kHz deviation at either 455 kHz or 10.7 MHz. Can be operated as wideband or narrow-band circuit by choosing appropriate interstage and output LC and RC components.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 350–351.

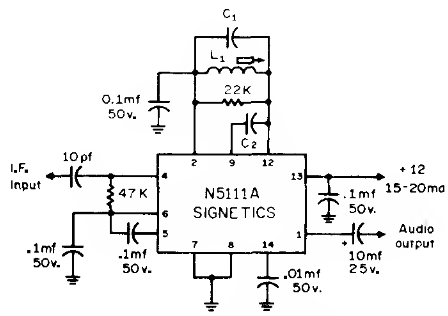




PLL IF AND DEMODULATOR—Signetics NE563B IC (in dashed lines) serves as complete IF amplifier and demodulator for FM broadcast receiver. Circuit uses downconversion from 10.7 MHz to 900 kHz, where phase detector operates. Ceramic bandpass filter provides IF selectivity at 10.7 MHz. X1 can be 9.8-MHz ceramic resonator, LC network, crystal, or capacitor.—H. Olson, FM Detectors, *Ham Radio*, June 1976, p 22–29.

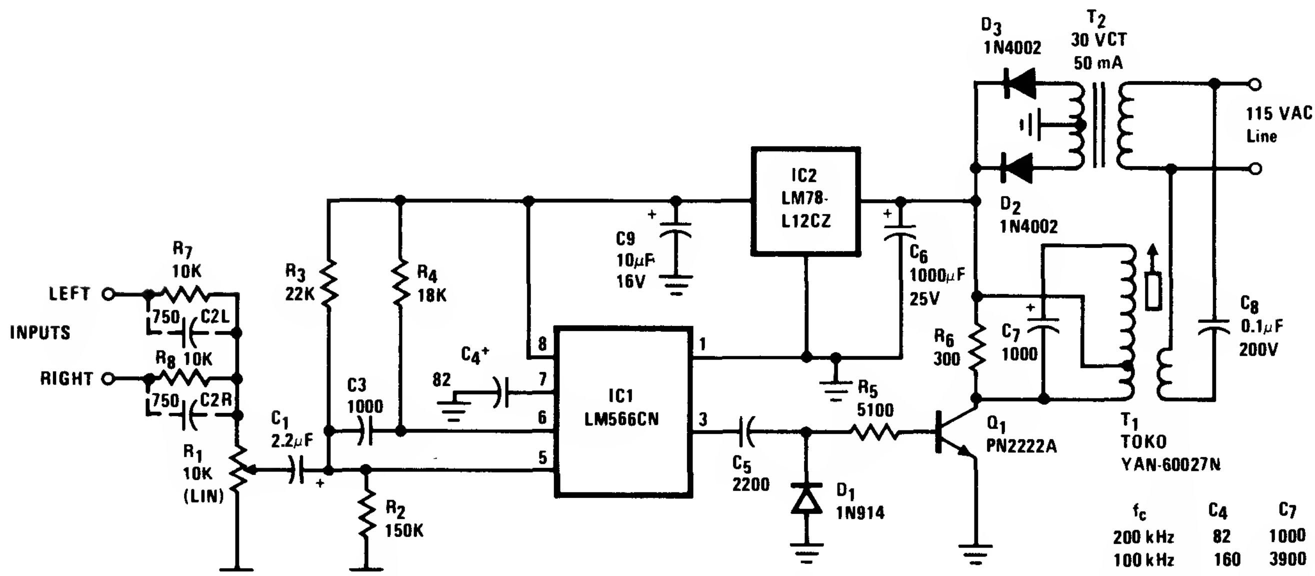


0.5 MHz WITH 20% DEVIATION—One 566 function ganarator sarves for ganerating relatively low-fraquency carrier (center fraquency lass than 0.5 MHz), and othar 566 sarves as modulator producing triangle output with frequency determined by C_1. Combination is suitabla for daviations up to ±20% of carrier fraquency.—"Signatics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 852–853.

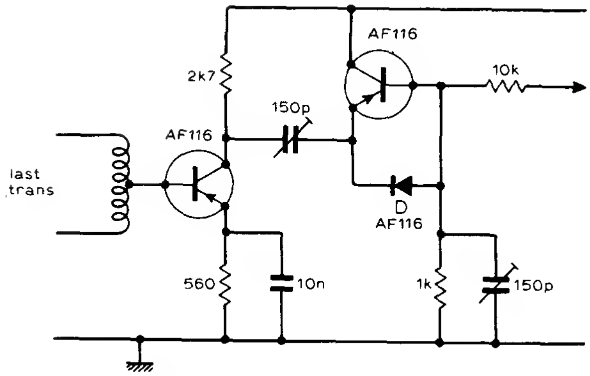


FM DETECTOR—Single IC can be addad to any raceiver not having FM detector. Moving C_2 from pin 9 to pin 10 gives higher audio output. Racaivers having less than 5 kHz IF bandwidth can be broadanad by stagger-tuning IF strip slightly to improva audio clarity. Adjust tuned circuit of detector for maximum recovared audio.—I. Math, Math's Notes, *CQ*, June 1972, p 49–51 and 80.

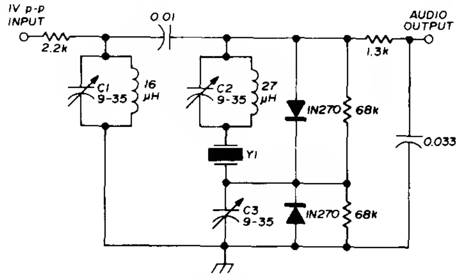
I.F.	C1 (pf)	C2 (pf)	L1 (μH)
10.7mHz	120	4.7	1.5-3
4.5mHz	120	3.0	7-14
2 mHz	300	3.0	16-30
455kHz	650	3.0	135-240



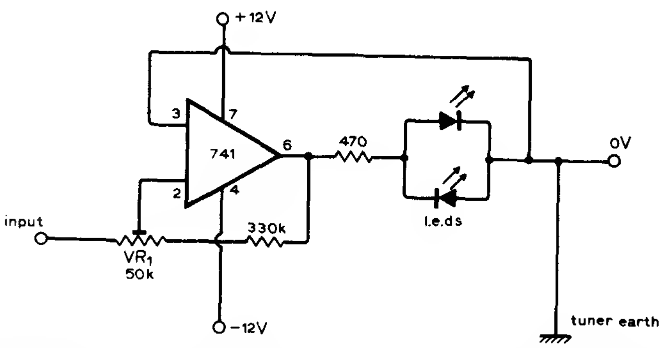
CARRIER-SYSTEM TRANSMITTER—Usad to convert audio program matarial into FM format for coupling to standard power lines. Modulated FM signal can be detected at any other outlat on sama side of distribution transformer, for demodulation and drive of loudspaaker. Input permits combining stereo signals for mono transmission to single remote loudspeaker. Uses Netional LM566CN VCO. Fraquency response is 20–20,000 Hz, and total harmonic distortion is under 0.5% With 120/240 V power lines, system oparates equally wall with receiver on either side of line. Transmitter input can ba taken from monitor or tape output jack of audio system.—J. Sharwin, N. Savastopoulos, and T. Regan, "FM Remota Speaker System," National Semiconductor, Santa Clara, CA, 1975, AN-146.



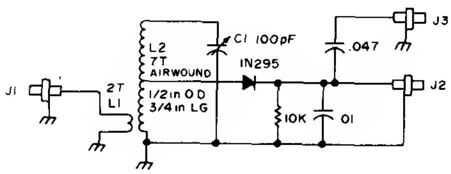
TRANSISTOR-PUMP DISCRIMINATOR—Used with 10.7-MHz IF strip of high-quality FM tuner built from discrete components. Circuit is placed between last IF stage and stereo decoder.—W. Anderson, F. M. Discriminator, *Wireless World*, April 1976, p 63.



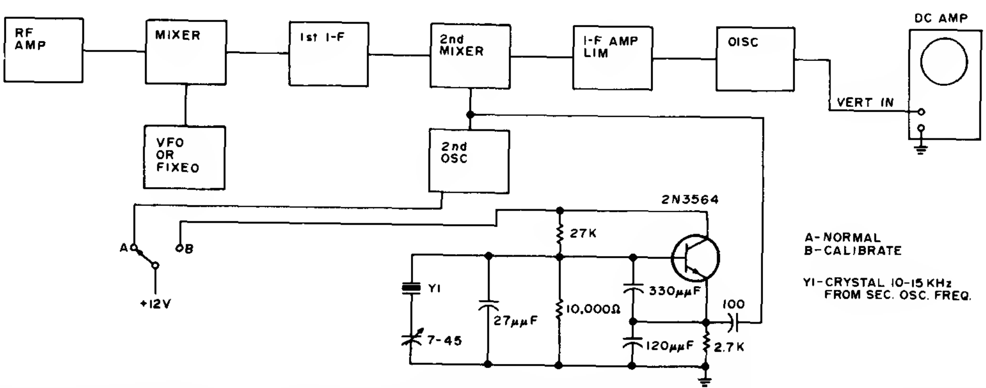
CRYSTAL DISCRIMINATOR—Inexpensive third-overtone CB crystal used at 9-MHz fundamental serves as high-performance discriminator for VHF FM receiver. Adjust C3 for zero voltage with unmodulated carrier at or near center frequency. Adjust C1 and C2 with AF sine wave applied to FM signal generator, using CRO to check distortion of recovered sine wave. With 1 V P-P IF signal at 9 MHz and 5-kHz deviation, recovered audio will be about 1 V P-P at lower audio frequencies. Good limiter is required ahead of discriminator for AM rejection.—G. K. Shubert, Crystal Discriminator for VHF FM, *Ham Radio*, Oct. 1975, p 67–69.



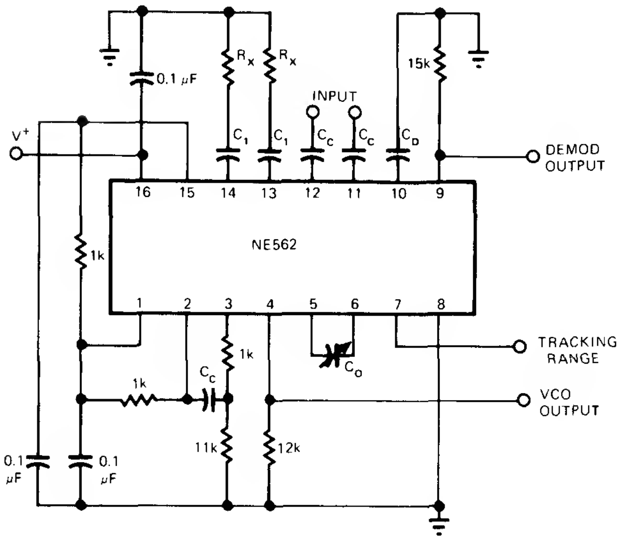
LED TUNING INDICATOR—One LED is mounted at each end of tuning scale. Tuning pointer is moved away from whichever LED is on, to dead spot at which both are off, to obtain correct tuning point. Advantages of lights-off tuning include minimum current drain and indication of even very slight mistuning by having one light come on even slightly. Adjust VR_1 to give wide enough dead spot so LEDs do not flicker on loud speech or music.—H. Hodgson, Simpler F.M. Tuning Indicator, *Wireless World*, Sept. 1975, p 413.



21–75 MHz DIODE RECEIVER—Covers 6-meter band and most 2-meter FM receiver oscillators near 45 MHz. Circuit is essentially that of crystal detector. Jack J3 gives AF output, and J2 gives DC output for meter.—B. Hoisington, Tuned Diode VHF Receivers, *73 Magazine*, Dec. 1974, p 81–84.

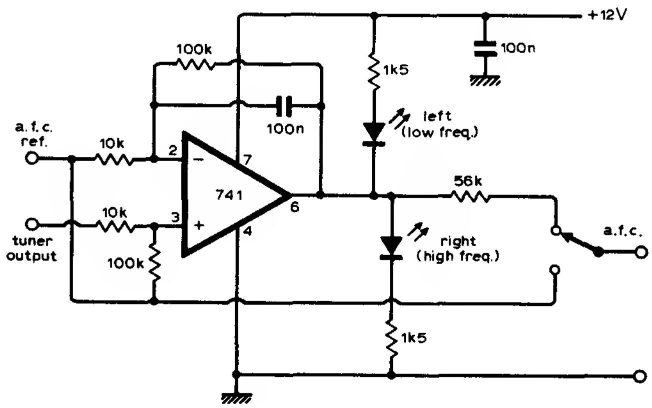


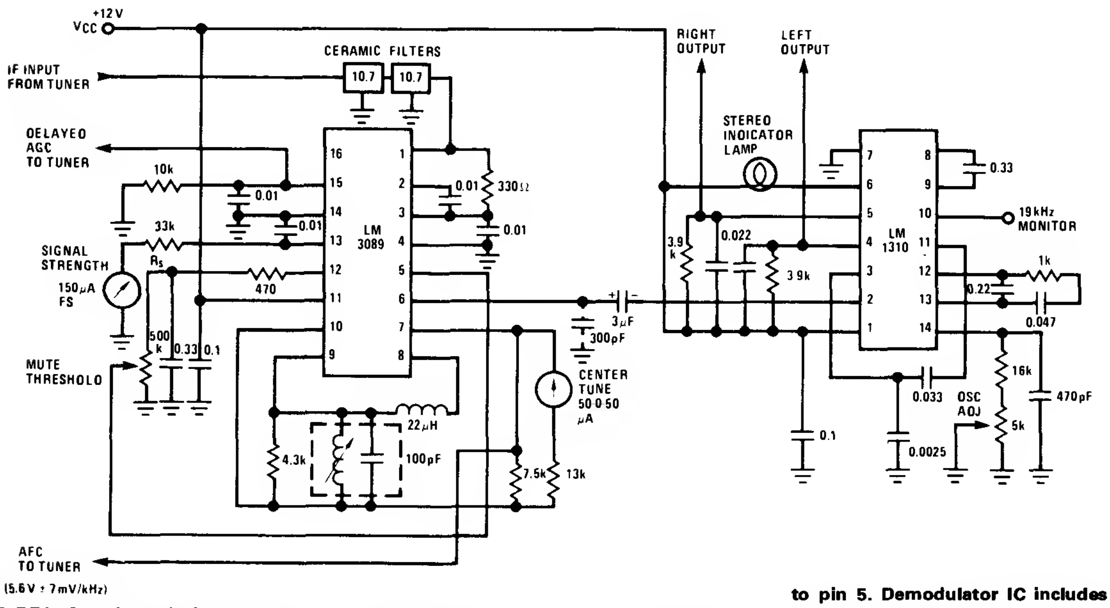
DEVIATION METER—Uses simple crystal oscillator combined with fixed or tunable FM receiver and CRO to show carrier shift on either side of center frequency. Vertical amplifier of CRO should be direct-coupled. To calibrate, tune oscillator either 10 or 15 kHz above or below second oscillator of receiver, and calibrate screen of CRO accordingly. One calibration oscillator is sufficient since transmitter usually deviates equally well both ways.—V. Epp, FM Deviation Meters, *73 Magazine*, March 1973, p 81–83.



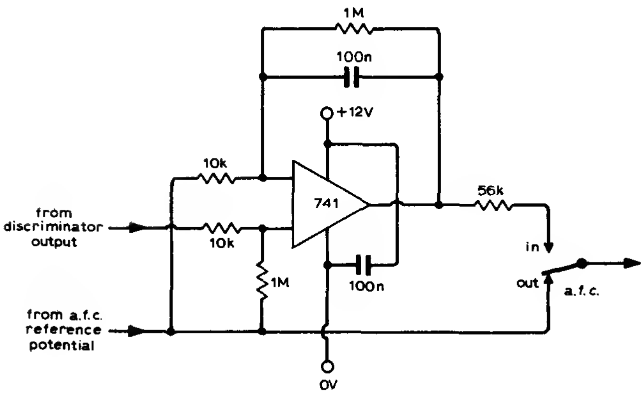
ANALOG PLL AS FM DEMODULATOR—Upper frequency limit of ebout 50 MHz for NE562 and other monolithic analog phase-locked loops complicates construction of FM telemetry receivers that directly damodulate standard 88–108 MHz FM broadcast signals. Circuit shown solves problem, with only small amount of signal preconditioning, by first converting RF carrier to 10.7 MHz with conventional superheterodyne front end, then epplying signal to phasa detector of PLL with VCO set to run free at 10.7 MHz. Input sensitivity is less than 30 μV, end audio output is graater than 100 mV.—E. Murthi, Monolithic Phese-Locked Loops—Analogs Do All the Work of Digitels, and Much Mora, *EDN Magazine*, Sept. 5, 1977, p 59–64.

OPAMP DRIVE FOR LED TUNING LAMPS—Opamp with 100K feedback resistor gives gain of 10 as optimum compromise for driving two LED tuning indicators in FM receiver.—R. D. Post, F.M. Tuning Indicator, *Wireless World*, May 1975, p 220.

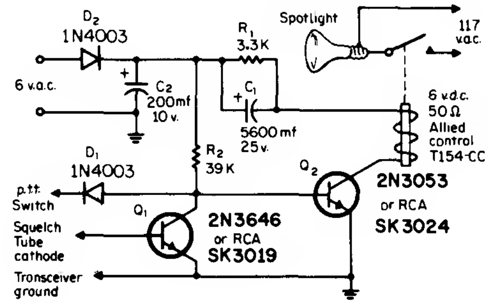




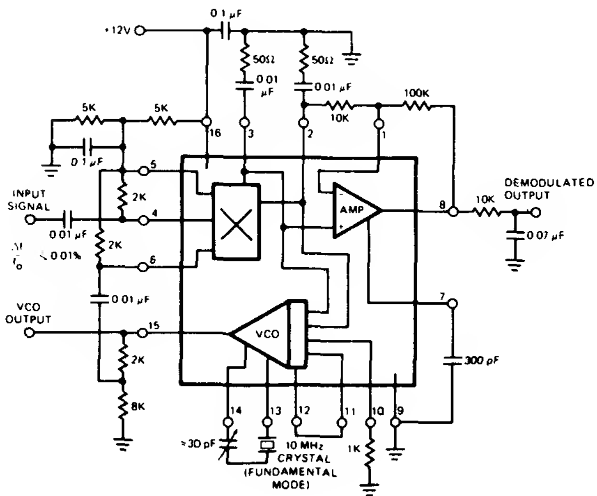
IF AND STEREO DEMODULATOR—National LM3089 IC and LM1310 PLL FM stereo demodulator provide all circuits required batwaen FM tuner and inputs to power amplifiers of stereo receivar. Use of 10.7-MHz ceramic filters aliminetes all but one IF alignment stap. AFC output from pin 7 of IF strip drives canter-tune meter. Wide bandwidth of detector and audio staga In IF strip is more than adequeta for stereo receivars. Audio stage can ba muted by input voltege to pin 5. Demodulator IC includes automatic stereo/monaural switching end 100-mA stereo indicator lemp driver. Optional 300-pF capacitor on pin 6 of LM3089 can be used to limit bandwidth.—"Audio Handbook," National Semiconductor, Senta Clara, CA, 1977, p 3-18–3-23.



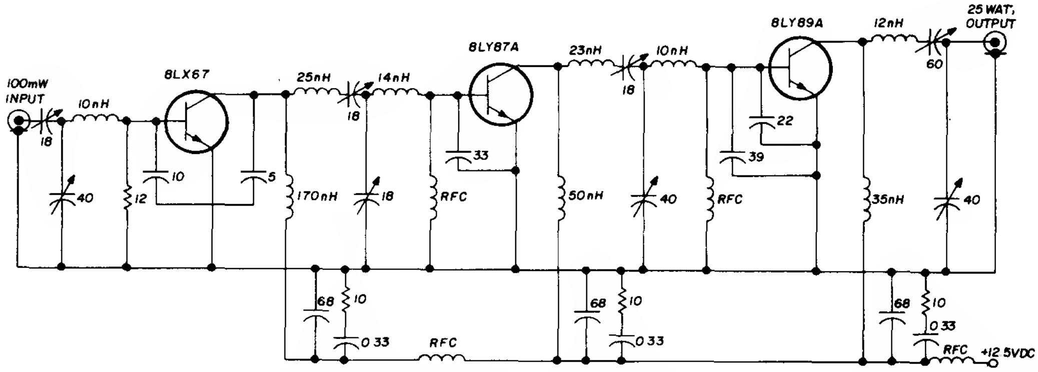
AFC AMPLIFIER—Simple DC amplifier can be added to AFC circuit of FM tuner to eliminate tuning errors ovar entire lock-in range.—J. S. Wilson, Improved A.F.C. for F.M. Tuners, *Wireless World,* July 1974, p 239.



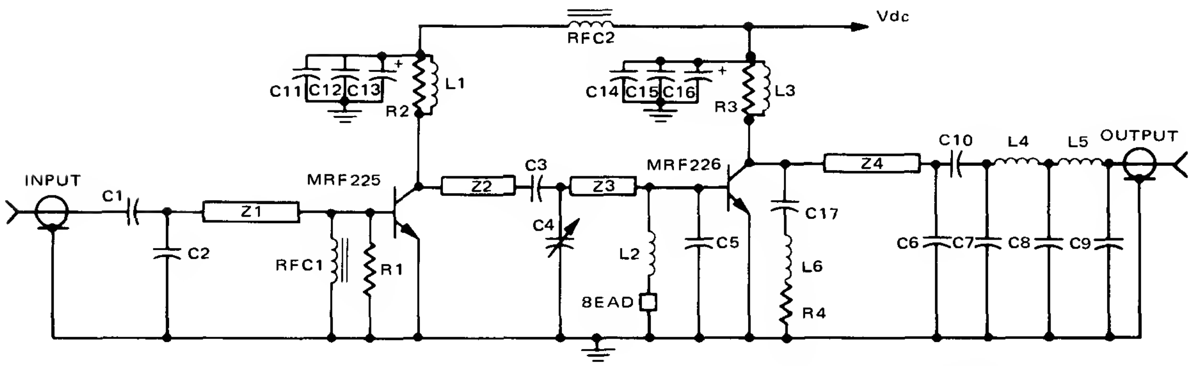
CALL ALERT—Developed to triggar relay when signal arrives et squelch tube in GE Progress Line 2-meter FM receiver. Reley is held energized about 2 s, determined by C_1-R_1, then deenergized for et least 25 s. Used for flashing red spotlight in room that is too noisy for hearing bell or buzzer. Circuit is eesily edepted for any other FM receiver having squelch stage. Control circuit responds to small chenge in voltaga at cathode of squelch tube. With no carrier present, tube conducts and places positive voltage et fece of Q_1, meking it conduct end turn off Q_2. When carrier arrives, Q_1 restores bias to Q_2, turning on relay. Connection to push-to-talk switch keeps lamp from fleshing during transmission.—L. Weggoner, The WA0QPM "Cell Alert," *CQ,* May 1971, p 48–49.



CRYSTAL FM DETECTOR—Exar XR-215 PLL IC is operated as crystel-controlled phase-locked loop by using crystal in place of conventional timing cepecitor. Crystal should ba operated in fundemental mode. Typical pull-in ranga is ±1 kHz at 10 MHz.—"Phase-Locked Loop Date Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 21–28.



VHF POWER AMPLIFIER—Three-stage 25-W 225-MHz power amplifier modula for FM applications uses three Amperex powar transistors. Input and output are 50 ohms. With 100-mW input signel, output is 25 W. Four cepecitive dividars serve for input, output, and interstage matching. Collectors are shunt-fed. Three decoupling networks prevent self-oscilletion. Amplifier can withstand output mismatches as high as 50:1 without damega.—E. Noll, VHF/UHF Single-Frequancy Conversion, *Ham Radio,* April 1975, p 62–67.



C1 – 10 pF
C2, C3 – 15 pF
C5 – 68 pF
C6 – 18 pF
C7, C9 – 12 pF
C8, C10 – 20 pF
C17 – 82 pF
(C1–C17 above: Dipped Silvered Mica, El-Menco Case DM10)

C11, 14 – .01 μF Ceramic Disc
C12, 15 – 220 pF Ceramic Disc
C13, 16 – 5 μF, 25 V, Aluminum Electrolytic
C4 – 3-35 pF Trimmer, ARCO NO. 403
L1 – 5 T NO. 20 AWG Wire, Wound on R2 (50 nH)
L2 – 1.5 T NO. 20 AWG Wire, 0.25-In. I.D. (30 nH) with Ferroxcube 5659065/3B Ferrite Bead

L3 – 2 T NO. 20 AWG Wire, Wound on R3 (35 nH)
L4, 5 – 2 T NO. 18 AWG Wire, 0.25-In. I.D. (44 nH)
L6 – 3.5 T NO. 18 AWG Wire, 0.25-In. I.D. (90 nH)
R1 – 100 Ohm, 1/4 W, ±10% Carbon Resistor
R2 – 820 Ohm, 1/2 W, ±10% Carbon Resistor
R3 – 330 Ohm, 1 W, ±10% Carbon Resistor
R4 – 22 Ohm, 1/4 W, ±10% Carbon Resistor
RFC1, 2 - Ferroxcube VK200 19/48 Choke

Z1 – Microstrip Line, 2200 X 62 Mils
Z2 – Microstrip Line, 1200 X 62 Mils
Z3 – Microstrip Line, 1000 X 62 Mils
Z4 – Microstrip Line, 1600 X 62 Mils
Board – G10 Epoxy-Glass, ϵ_r = 5, t = 62 Mils 1 oz. Copper

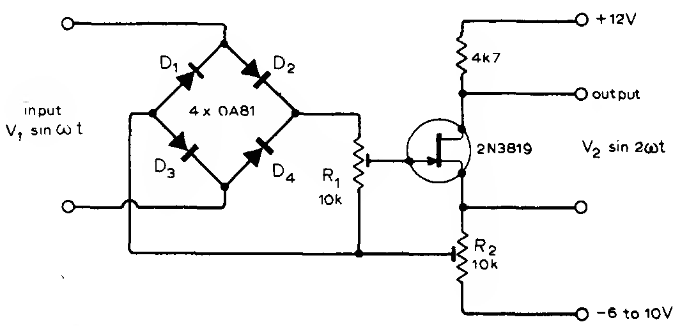
225-MHz 13-W AMPLIFIER—Suitable for use in FM transmitters for 220–225 MHz amateur radio band. Bandwidth is about 10 MHz for ±0.5 dB. Low-pass filter provides about 60-dB attenuation of second harmonic. Microstrip matching network simplifies construction. Supply voltage is 12.5 V.—J. Hatchett and T. Sallet, "13-Watt Microstrip Amplifier for 220-225 MHz Operation," Motorola, Phoenix, AZ, 1975, AN-728, p 3.

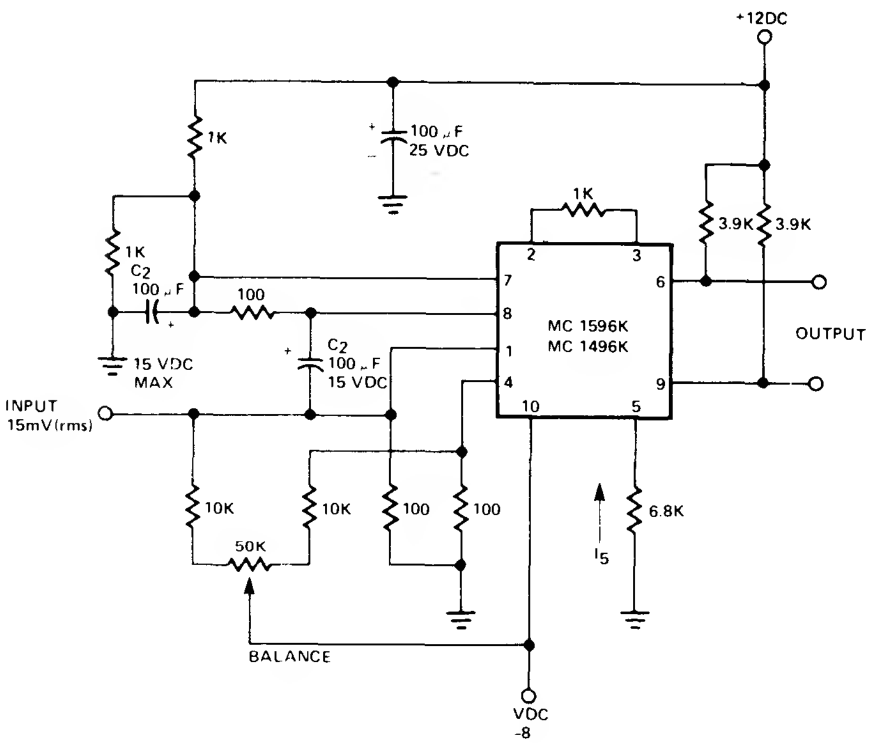
CHAPTER 35

Frequency Multiplier Circuits

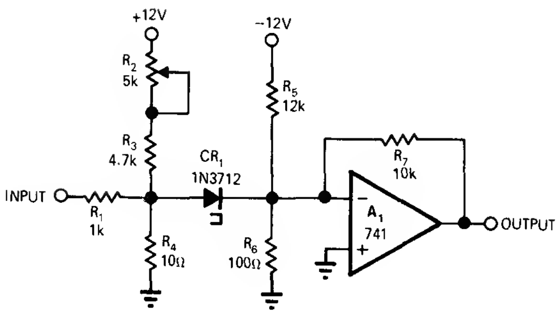
Emphasis is on frequency doublers, but includes circuits providing multiplying factors up to 10 for sine, square, and other waveforms in audio range and in RF systems extending well above 400 MHz.

SIMPLE DOUBLER—Performance is good up to about 10 kHz. R_2 is adjusted to set FET just at cutoff under no-signal conditions, to give operation in square-law region. With R_1 correctly adjusted, using scopa or third harmonic distortion monitor to obtain minimal distortion, harmonic content of output can be made to approach that of sine-wave input. Article gives design equations.—R. Williams and J. Dunne, Frequency Doubler, *Wireless World,* Dec. 1975, p 575.

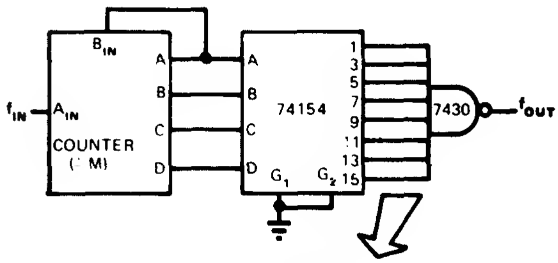




LOW-FREQUENCY DOUBLER—Signetics balanced modulator-demodulator transistor array is connected much like phase detector circuit. Output contains sum component which is twice frequency of input signal because sama input signal frequency goes to both sections of balanced modulator.—Signatics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 758.

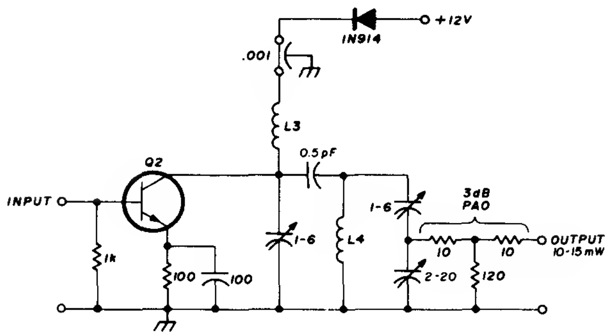


SQUARER—Simple tunnel-diode circuit doubles frequency efficiently without use of tuned circuits. Fundamental end other harmonics of input ere at least 30 dB below level of frequency-doubled output. Circuit operetes from DC to upper frequency limit of opamp used. Adjust R_2 so diode current is at peek of its bias current, to eliminete offset et emplifier output.—R. Kincaid, Squaring Circuit Makes Efficiant Frequency Doubler, *EDN/IEEE Magazine,* Aug. 15, 1971, p 45.



M	TYPICAL COUNTER	USABLE 74154 OUTPUTS
10	7490	1, 3, 5, 7, 9
12	7492	1, 3, 5, 9, 11, 13
16	7493	1, 3, 5, 7, 9, 11, 13, 15

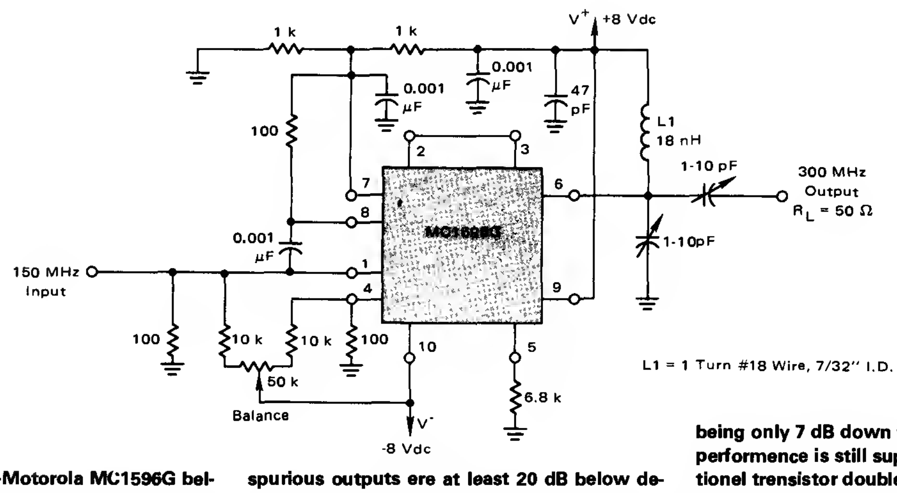
MULTIPLES OF 2.5 MHz—Three TTL circuits provide integrel frequency-multiplication ratios between 1 end 8. BCD outputs of counter having modulus M are fed to inputs of 74154 4-line to 16-line decoder. As outputs of counter chenge, et rete equel to input frequency divided by counter modulus M, eech goes low et same rete. Output of NAND gete thus goes high once for eech input to gete from decodar. If 7490 decada counter is used end input is 1 MHz, BCD outputs of 7490 limit useble outputs of 74154 to lines 1, 3, 5, 7, and 9. Since inputs to 74154 change at 100-kHz rate, output from geta will be n × 100 kHz. With input of 25 MHz, output is integrel multiple of 2.5 MHz.—R. S. Stein, Three TTL IC's Provide Frequency Multiplication, *EDN Magazine,* April 5, 1975, p 117 and 119.



200–400 MHz

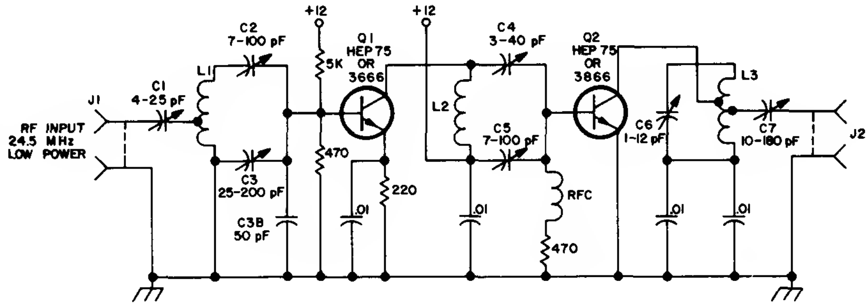
L3,L4	2 turns no. 22 (0.6mm), air core, 1/8" (3mm) diameter, 1/4" (6.5mm) long
Q1,Q2	Fairchild 2N5179 recommended but 2N2857, 2N918, FMT2060 or equivalent may be substituted

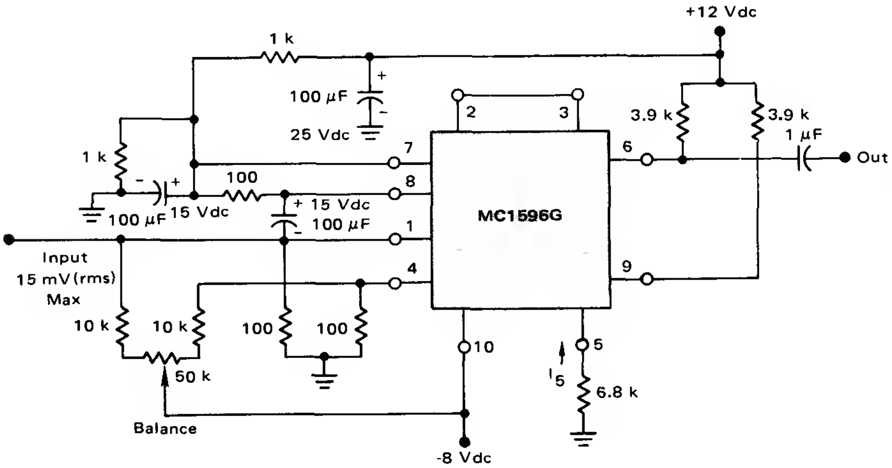
DOUBLING 200 MHz—Recommanded for use with VHF/UHF converters heving inputs of 180 to 220 MHz, with 5–10 mW output. Diode in series with power supply prevents damege if polerity is reversed.—J. Reisert, VHF/UHF Techniques, *Ham Radio,* Merch 1976, p 44–48.



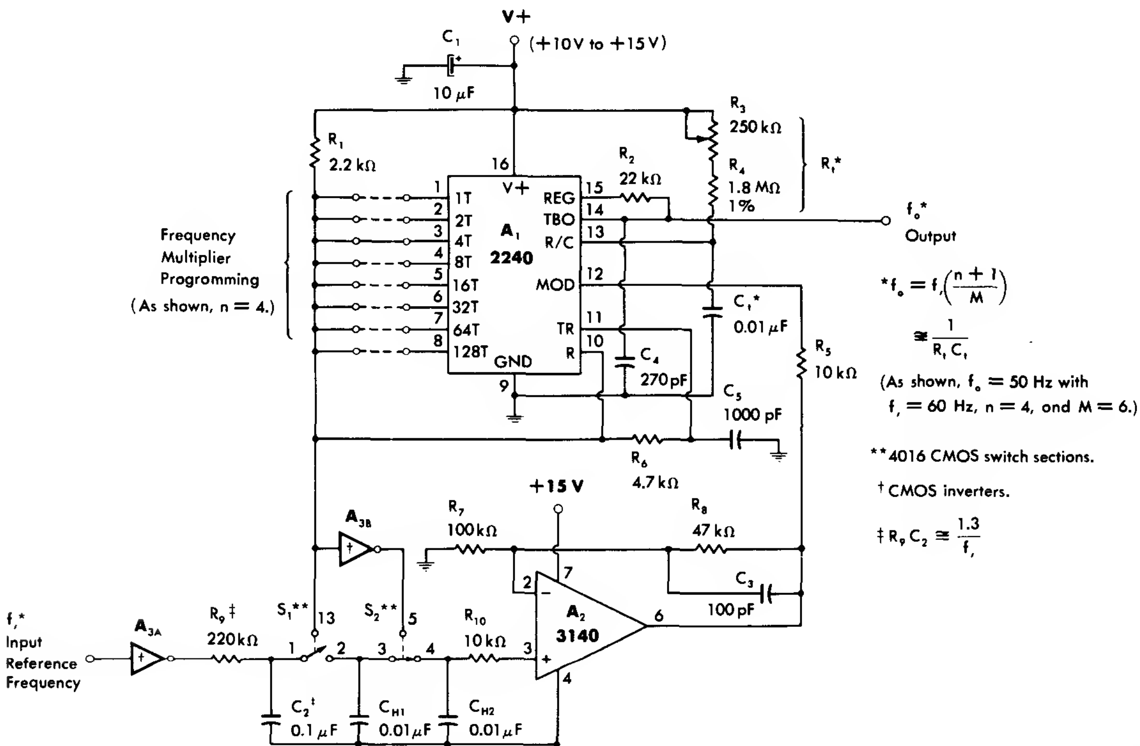
DOUBLING 150 MHz—Motorola MC1596G belenced modulator is connected for doubling at RF and UHF. With output filtaring shown, all spurious outputs ere at least 20 dB below desired 300-MHz output. Suppression of spurious outputs is poorer for higher input frequencies, being only 7 dB down for 400-MHz output, but performence is still superior to thet of conventionel transistor doubler.—R. Hejhall, "MC1596 Belenced Moduletor," Motorola, Phoenix, AZ, 1975, AN-531, p 10.

24.5 MHz TO 147 MHz—Uses Q1 as tripler to 73.5 MHz for frequency-modulated input of 24.5 MHz, and Q2 as doubler whose output tank is tuned to 147 MHz by C6 and L3. Output is about 200 mW of RF. L1 is 20 turns No. 26 with center tap, on 0.5-cm form. L2 is 8 turns No. 22 on 0.8-cm form. RFC is 25 turns on 0.5-cm form. Article covers troubles likely to be encountered.—B. Hoisington, Frequency Multiplication the Easy Way, *73 Magazine*, Oct. 1973, p 69–71.

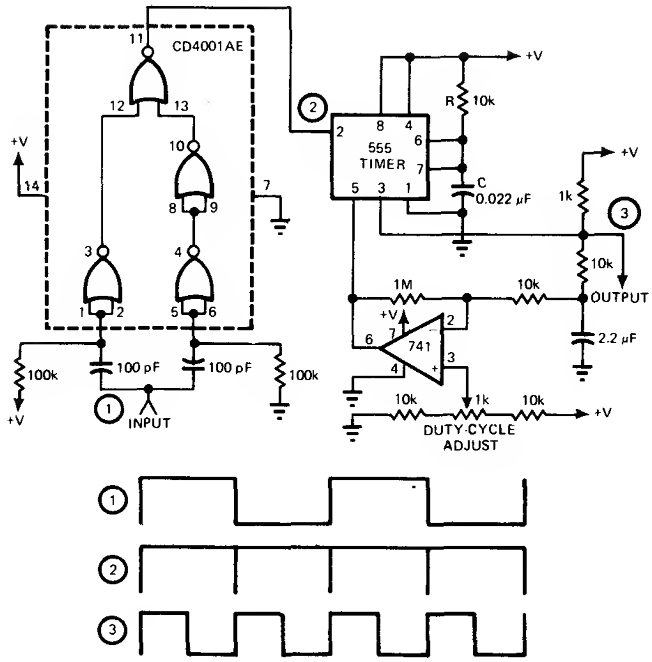




BROADBAND LOW-FREQUENCY DOUBLER—Motorola MC1596G balanced modulator functions as frequency doubler when same signal is injected into both input ports (pins 1 and 8). Doubling occurs in audio range and up to about 1 MHz.—R. Hejhall, "MC1596 Balanced Modulator," Motorola, Phoenix, AZ, 1975, AN-531, p 10.

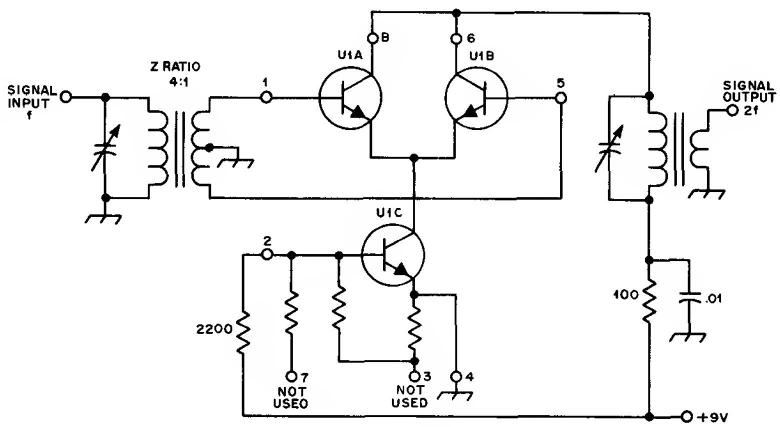


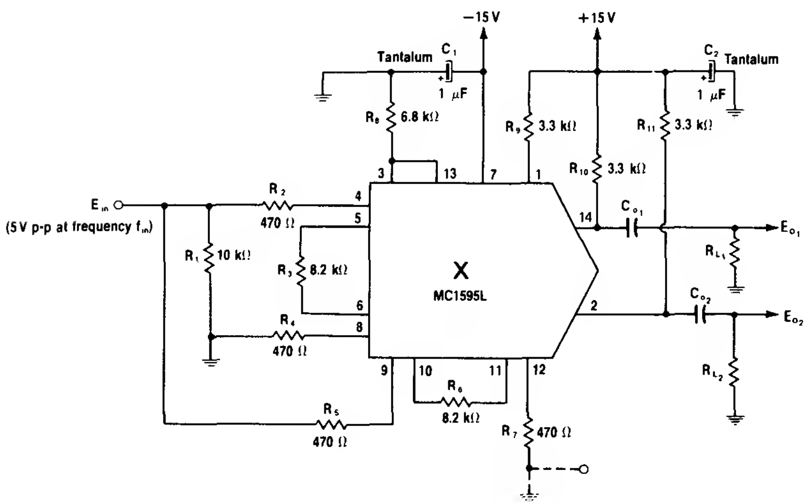
PROGRAMMABLE PLL SYNTHESIZER/MULTIPLIER—Uses programmable timer/counter A_1 as VCO for generating frequencies both above and below that of square-wave reference. Phase-locked output frequency is not direct multiple of reference frequency. 2240 can lock on programmable multiple or on subharmonic reference. For values shown, phase-locked loop is locked through common frequency submultiple of 10 Hz, to give sampling rate of 10 Hz for reference input.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 220–224.



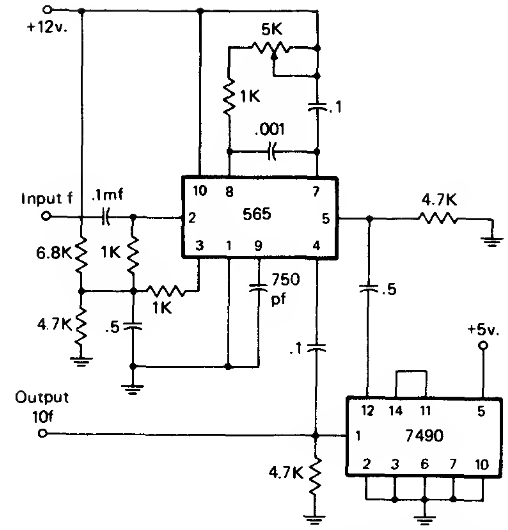
500–5000 Hz SQUARE-WAVE DOUBLER—Circuit shows virtually no deviation from 50% duty cycla ovar entire frequency ranga. Four NOR gates in CD4001AE IC form edge datector that prasents nagativa pulse to 555 IC timar on both rising and falling edges of input squara wava, to achieva frequancy doubling. High-gain 741 opamp amplifias any diffarenca betwaen DC laval at timer output and rafarenca aqual to half of supply voltaga, to send correction voltaga to pin 5 of timar for forcing output to 50% duty cycle.—L. P. Kahhan, Frequency Doublar Outputs Squara Wave with 50% Duty Cycla, *EDN Magazine,* June 5, 1977, p 211–212.

PUSH-PUSH DOUBLER—Useful in VFO output circuits where oscillator operates at half output frequency of doublar. Circuit helps reduce oscillator instability during load changas while having about same efficiancy as straight amplifiar. Uses two sections of RCA CA3028A diffarential amplifier as doubler (U1C is not usad). Values of tuned circuit depend on frequency, which can ba up to 120 MHz.—D. DeMaw, Understanding Linaar ICs, *QST,* Feb. 1977, p 19–23.

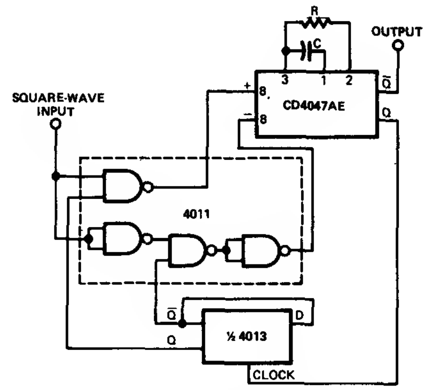




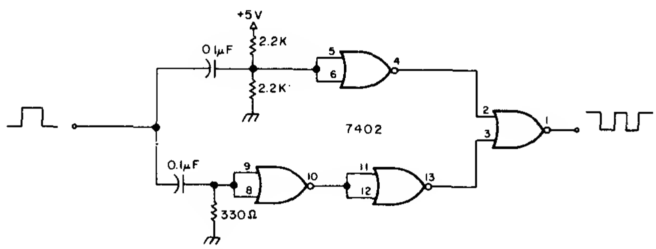
WIDEBAND DOUBLER—AC-coupled multiplier block is connected in squaring moda to provida sacond harmonic of input frequency with no tuned circuits. Circuit operates over wida bandwidths without adjustment. Output is low-distortion sina wava; total harmonic distortion is typlcally 1%. Output can be takan from pin 2 or 14, dapending on phase desired. Circuit will work with R_7 grounded, but offset adjustmant can be used to minimiza distortion. Maximum operating frequency is several megahertz.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 258–259.



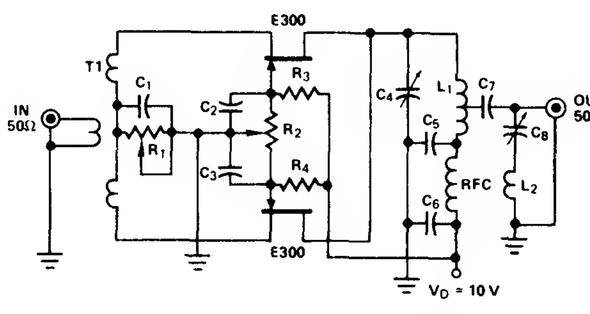
PLL MULTIPLIES BY 10—Used with frequency counter to measure very low frequencies. Two such circuits can be cascaded to give multiplication by 100. Requires +5 V end +12 V supplies.—H. S. Laidmen, Upgreding Inexpensive Counters, *CQ*, Aug. 1975, p 16–22.



MULTIPLIER/DIVIDER—Choice of values for R and C determines multiplication or division factor ecting on square-wave input frequency. Output of 4013 flip-flop sets getes of 4011 to steer input clock pulse of RCA CD4047AE mono MVBR to proper inputs. When rising edge of input triggars mono, Q output of mono goes high and switches flip-flop, preparing mono to accept falling-edge trigger. Since 4047 locks out inputs until it times out, mono triggers only on first felling edge occurring after its output goes low. Mono pulse length is about 2.5RC. With 60-Hz input clock, mono pulse length lass than 8.33 ms ellows triggering on every trensition, to give 120-Hz output.—P. A. Lewless, One-Shot Forms Frequency Multiplier, *EDN Magazine*, Aug. 5, 1978, p 72.

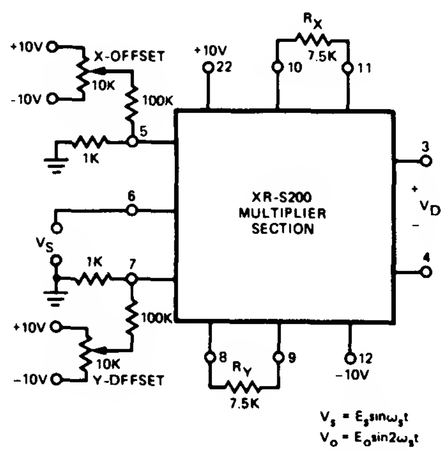


SQUARE-WAVE DOUBLER—Circuit locks onto both rise and fell of input square wave, to give identical square-wave output at doubled frequency. For high input frequencies, use smaller cepecitence values.—Circuits, *73 Magazine*, April 1977, p 164.

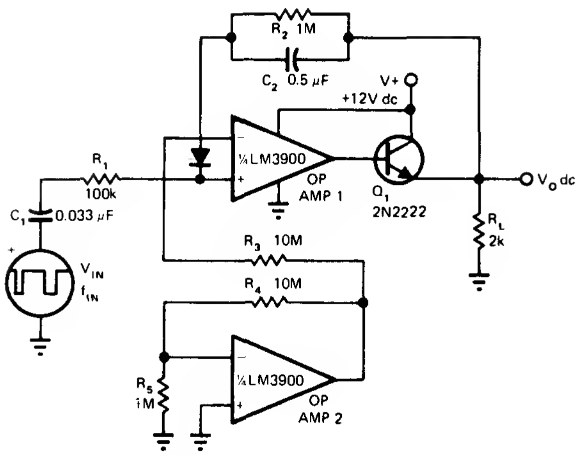


C_1, C_5, C_6 – 1500 pF
C_2, C_3 – 1000 pF
C_4 – 8-35 pF
C_7 – 30 pF
C_8 – 2.3-20 pF
R_1 – 1KΩ
R_2 – 10KΩ
R_3, R_4 – 220KΩ, ¼W
L_1 – 4T #18 AWG, 5/16 DX 5/16 LG TAPPED 3/4T FROM COLD END
L_2 – 2T #16 AWG 5/16 DX 3/16 LG
RFC – 1.2 μHy
T1 – RELCOM BT-9 50Ω IN-400CT-400Ω OUT

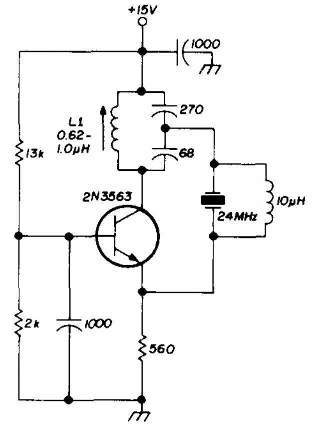
FET DOUBLER—Siliconix E300 matched FETs ere connected as common-gate emplifiers in balanced push-push circuit giving up to 100% efficiency as frequency multiplier in UHF ranga. Series-tuned output trap L_2C_8 increases rejection of third-order harmonics to greater than 70 dB. Positive bias of 0.5 V is applied to FET gates to permit inclusion of belence control R_2. Gain of doubler is about 1 dB.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7–52.



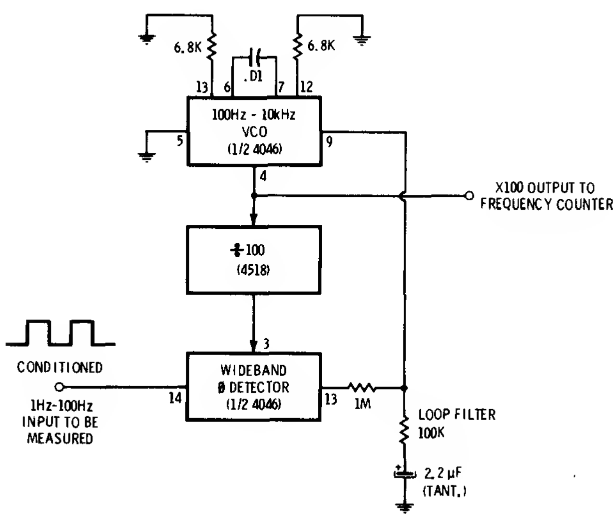
SINE-WAVE DOUBLER—Frequency of sinusoidel input signel V_S is doubled to give sine-wave output with total hermonic distortion less than 0.6%. With input of 4 V P-P et 10 kHz, output is 1 V P-P et 20 kHz. X and Y offset adjustments are nulled to minimize harmonic content of output.—"Phase-Locked Loop Data Book," Exer Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



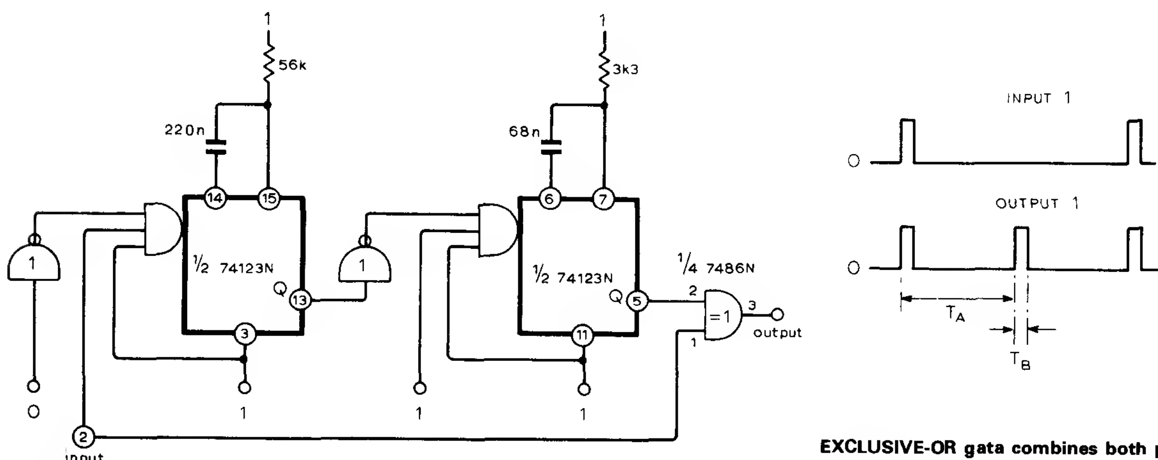
DOUBLER FOR TACHOMETER—Frequency of input from tachometer is doubled by charging and discharging of C_1 to reduca ripple in DC output voltage of tachometer circuit. Opamp 2 provides bias current for opamp 1, whila Q_1 drives large load currents and provides DC leval shift required for bringing output voltage to zero when input frequency is zero.—T. Frederiksen, Frequency-Doubling Tach Operates from a Singla Supply, *EDN Magazine*, June 5, 1977, p 208.



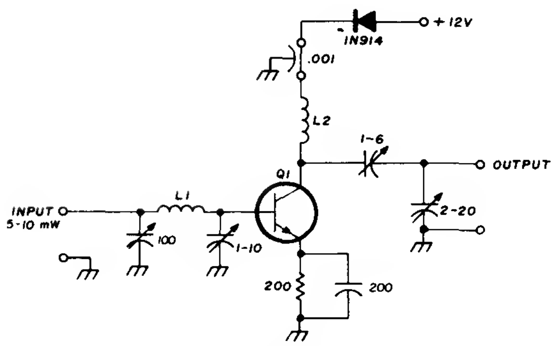
73.333 MHz ON THIRD OVERTONE—Simple crystal oscillator circuit requires only one tripler for multiplying to 220-MHz amateur band. Mode suppression is provided by 10-μH coil which, with 4.5-pF capacitance of crystal holder, is series resonant at 24 MHz.—H. Olson, Frequency Synthesizer for 220 MHz, *Ham Radio*, Dec. 1974, p 8–14.



AF MULTIPLIER—Multiplies 1–100 Hz input signal by 100 to permit measuring frequency with ordinary counter. Half of 4046 PLL is connected as 100–10,000 Hz VCO whose output is divided by 100 in 4518 dual divide-by-10 counter for comparison with input signal in other half of PLL connected as wideband phase detector. Output of detector goes to loop filter and to VCO for locking VCO at 100 timas input frequency.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 364–366.



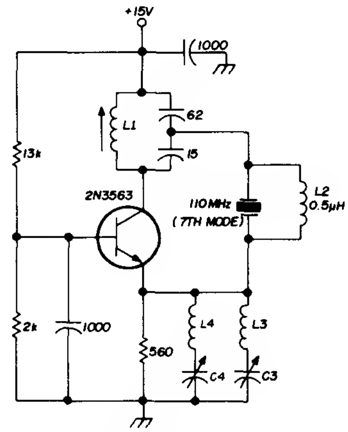
PULSE DOUBLER—Generates pulses at twice pulse input frequency. Input pulse at first monostabla of 74123N makes it run for time T_A. Negativa adge, terminating T_A, triggers second monostable which runs for time T_B. If T_A equals half of input pariod and T_B equals width of input pulsa, desirad rasult is achiavad wherein additional pulse is generated between input pulses. EXCLUSIVE-OR gata combines both pulses at output. Values shown for R and C will double frequency of 800-μs-wide input pulses having rapetition rata of about 130 per second.—K. R. Brooks, Pulse Rate Doubler, *Wiralass World*, April 1976, p 63.



100-200 MHz

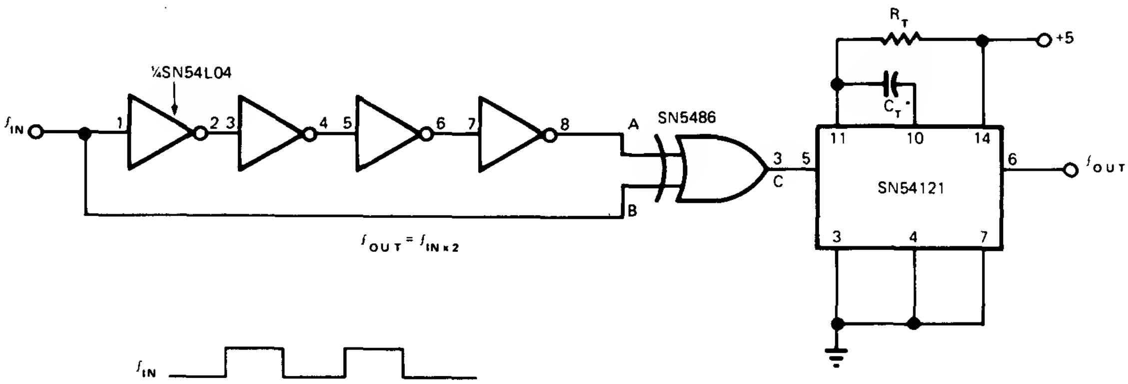
L1	12 turns no. 28 (0.3mm) on Amidon T25-12 toroid core
L2	7 turns no. 24 (0.5mm), air core, closewound on 0.1" (2.5mm) diameter

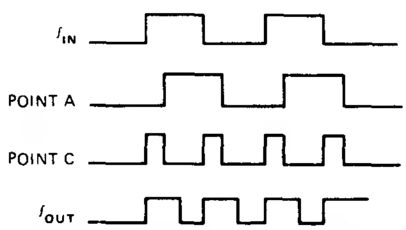
DOUBLING 100 MHz—Recommanded for use with VHF/UHF convertars having inputs of 90 to 120 MHz. Diode in series with power supply prevants damage if the polerity is reversed.—J. Reisert, VHF/UHF Techniques, *Ham Radio,* March 1976, p 44–48.



C3-L3	series resonant at approximately 5/7(110 MHz), 1 μH and 0.6-10 pF
C4-L4	series resonant at approximately 3/7(110 MHz), 2.2 μH and 0.6-10 pF
L2	0.5 μH (parallel resonant at 110 MHz with 4.5-pF holder capacitance)

110 MHz ON SEVENTH OVERTONE—Requires only one doubler for usa in 220-MHz amateur band. Series-resonant traps ara et frequancies of undesired lower modes.—H. Olson, Frequency Synthesizer for 220 MHz, *Ham Radio,* Dec. 1974, p 8–14.



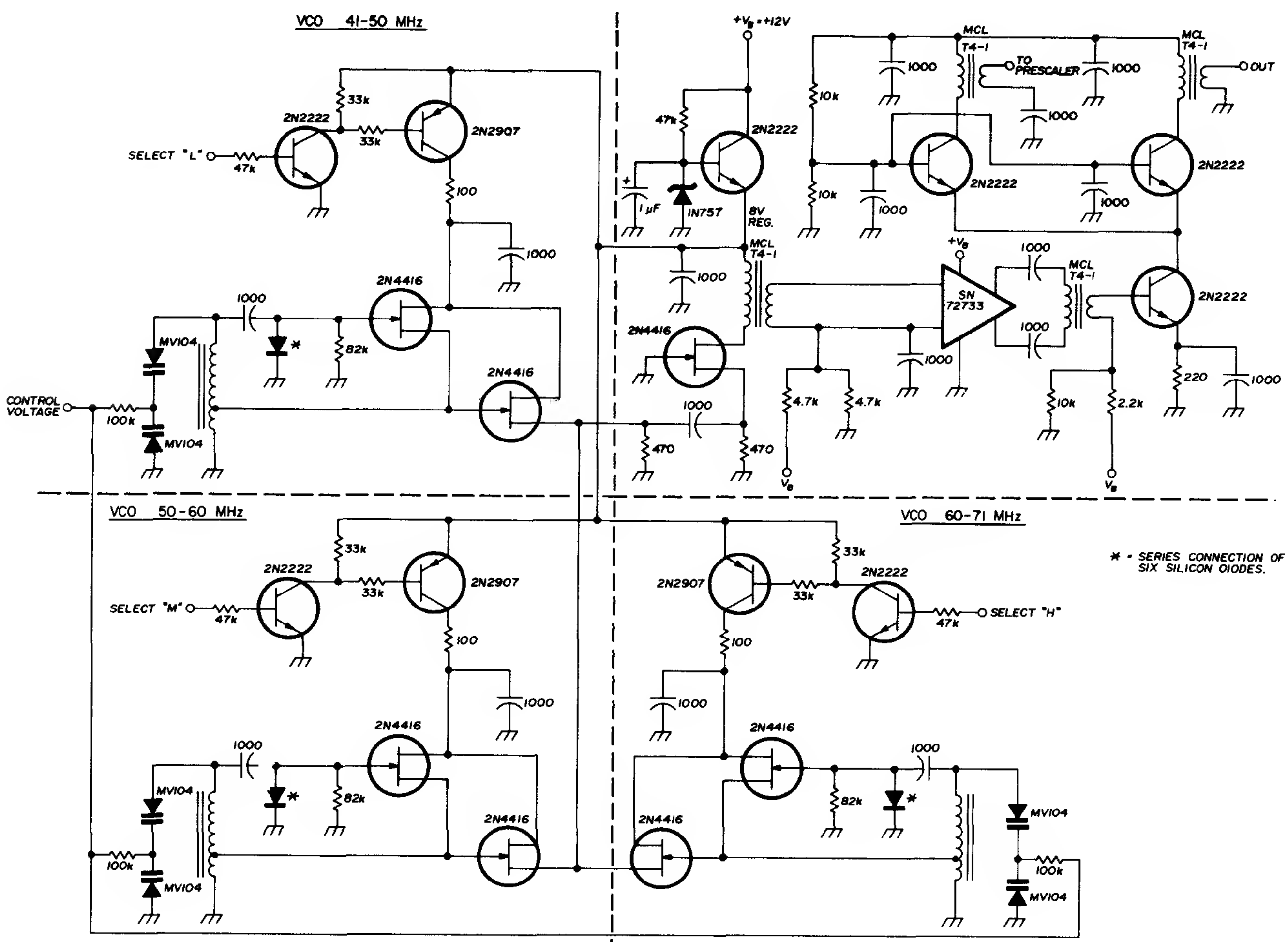


PARTS
1 – SN54L04
1 – SN5486
1 – SN54121
*R_T – 2k to 30 k
*C_T – 10 pF to 10 μF

DOUBLER FOR 1 Hz TO 12 MHz—Simpia arrangemant of EXCLUSIVE-OR, mono, and hax inverter ICs provides axtramely accurete frequancy doubling in digital systems, along with waveform symmatry. Article gives design equation. Saries invartars craata about 120 ns of delay.—V. Renda, Frequency Doubler Oparatas from 1 Hz to 12 MHz, *EDN Magazine,* Aug. 20, 1976, p 85.

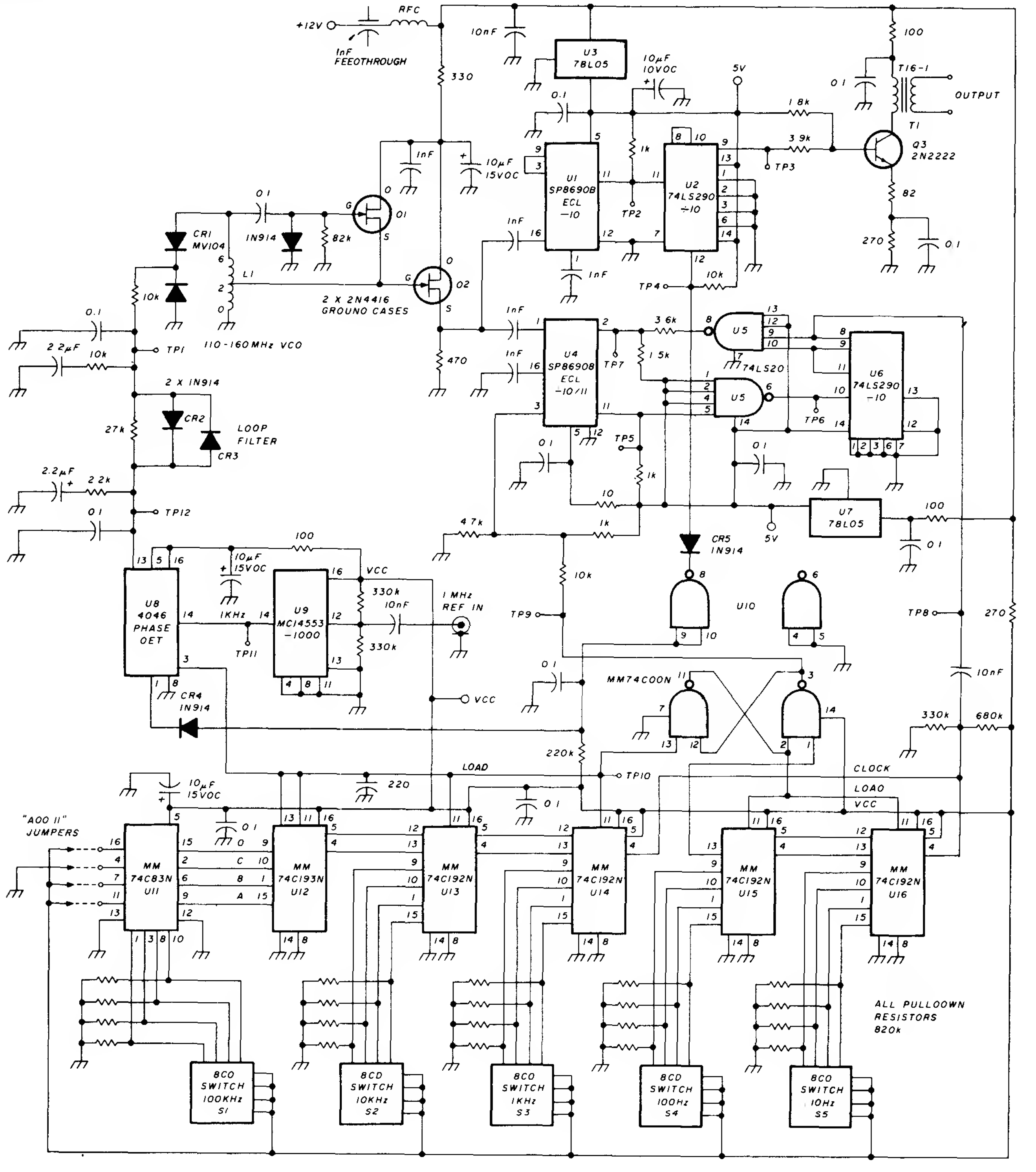
CHAPTER 36
Frequency Synthesizer Circuits

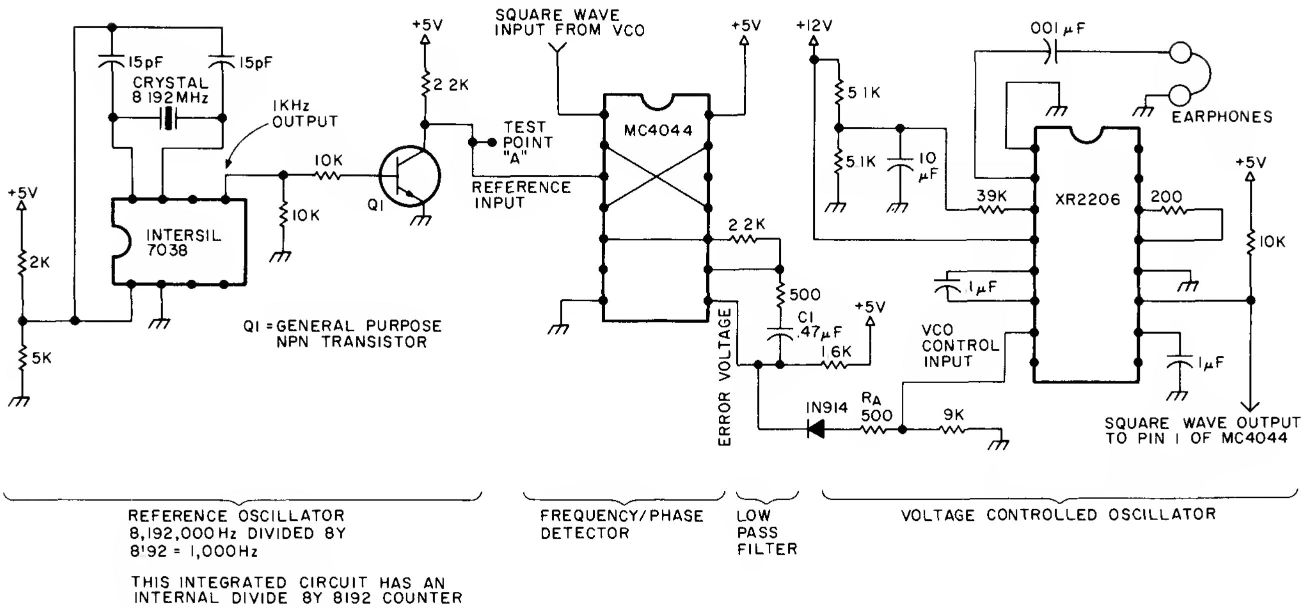
Covers methods of generating up to 2500 different discrete frequencies in audio and RF spectrums, generally by setting thumbwheel switches or by keyboard control, for use in test equipment, receivers, and transceivers.



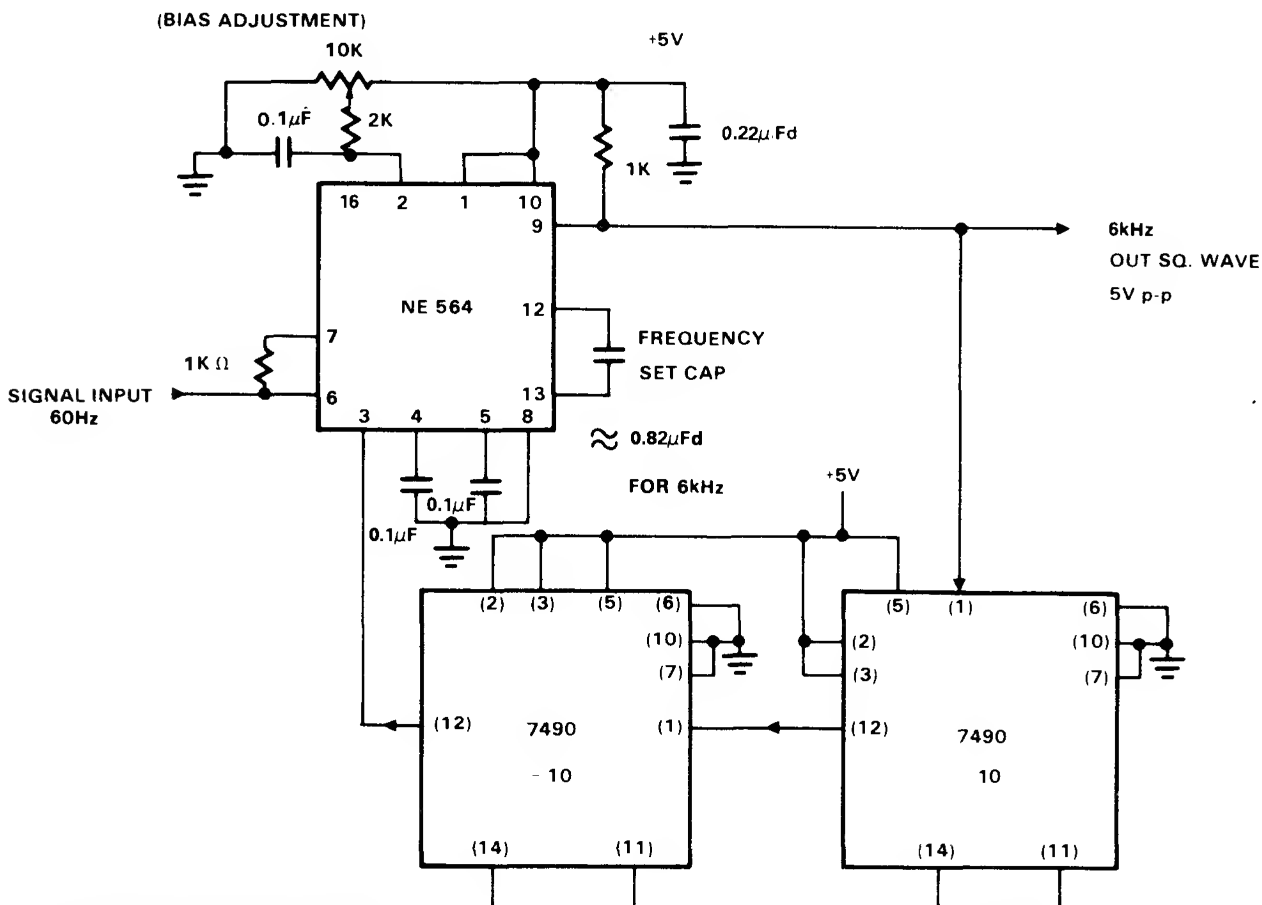
41–50, 50–60, AND 60–71 MHz—Three independent low-noise VCOs are used in 41–71 MHz frequency synthesizer. Control voltage is obtained from phase-comparator output of synthesizer. Outputs are chosen by selector switch. Texas Instruments SN72733 wideband amplifier is used for decoupling. Cascade arrangement provides two independent outputs at low impedance.—U. L. Rohde, Modem Design of Frequency Synthesizers, *Ham Radio*, July 1976, p 10–23.

1.1–1.6 MHz IN 10-Hz STEPS—Data input requirement is parallel BCD with 10-V CMOS levels and five digits. Reference input is 1-MHz sine or square with at least 1 V P-P. VCO covers 110–160 MHz in 1-kHz steps, operating in loop having 1-kHz reference. VCO signal is divided by 100 to give final output in 10-Hz steps. L1 is 6 turns No. 22 on 3-mm form, tapped at 2 turns. RFC is 6 turns No. 28 on F754-1-06 ferrite bead. T1 is Mini-Circuits Lab T16-1 broadband RF transformer.—R. C. Petit, Frequency Synthesized Local-Oscillator System for the High-Frequency Amateur Bands, *Ham Radio*, Oct. 1978, p 80–65.

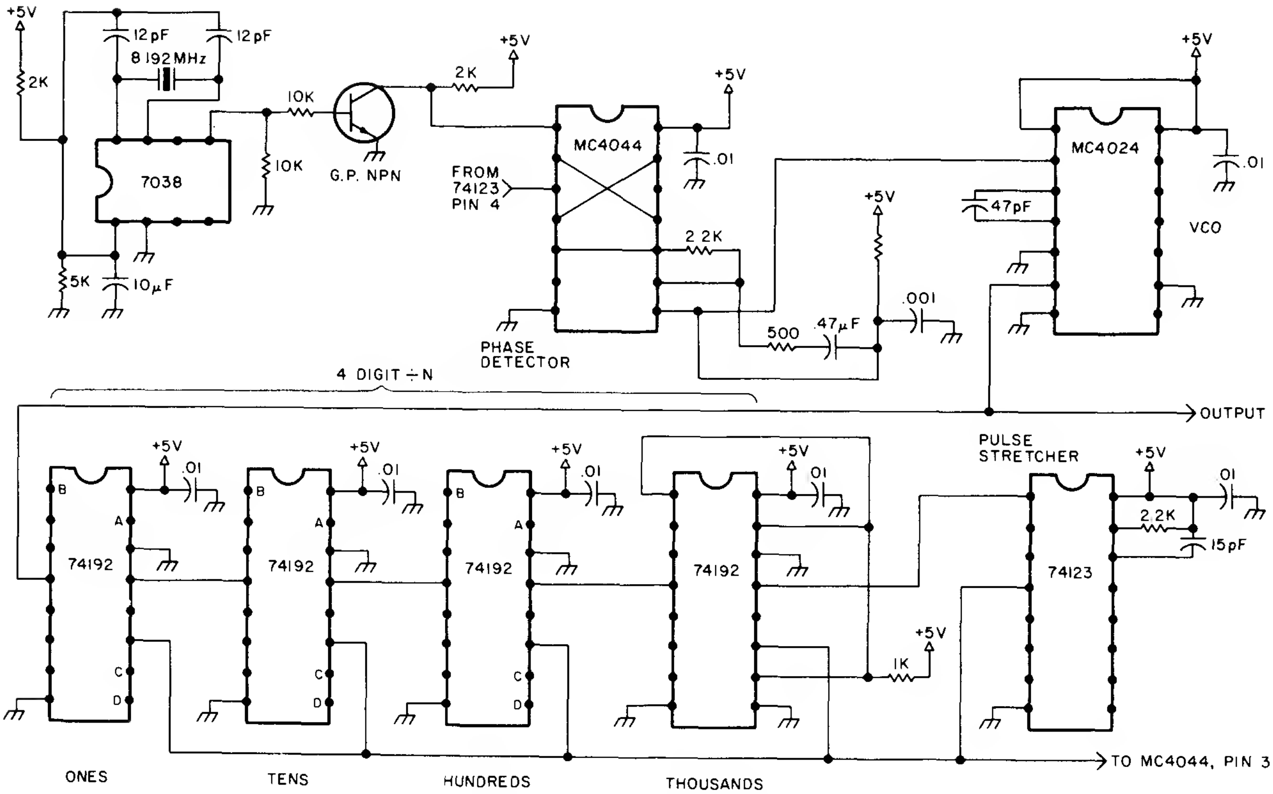




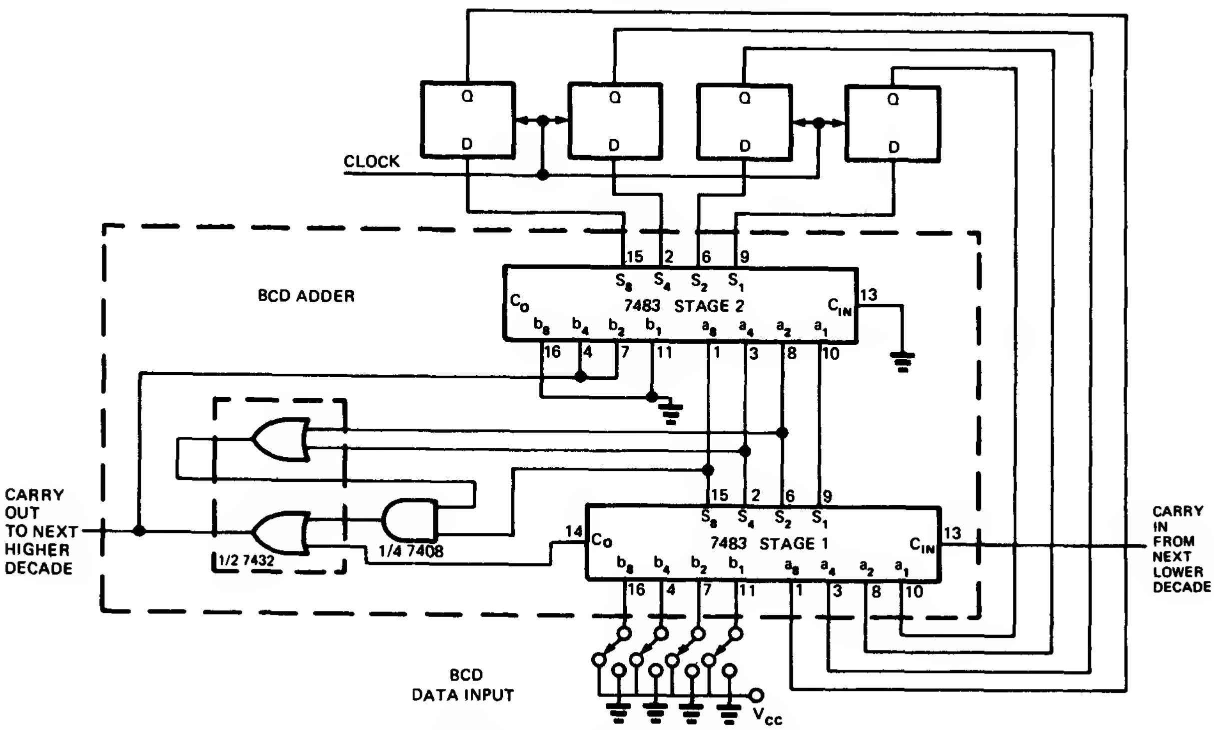
1–9 kHz PLL—Simple experimental phase-locked loop circuit synthesizes frequencies in audio range, for easy monitoring with headphones. Article gives theory of operation and setup procedure.—G. R. Allen, Synthesize Yourself!, *73 Magazine*, Oct. 1977, p 182–188.



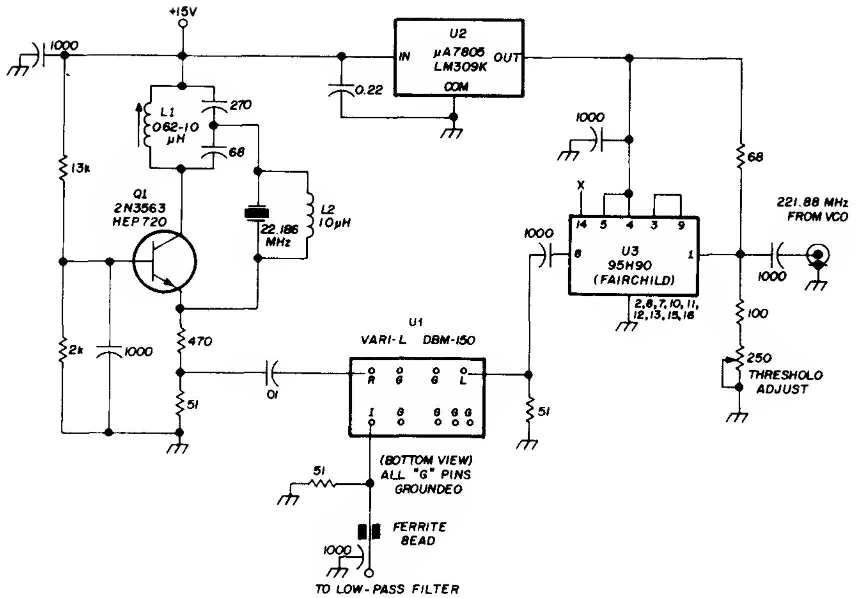
PLL WITH COUNTER—Frequency multiplication is achieved with Signetics NE564 PLL by inserting counter in loop between VCO and phase comparator. VCO is then running at multiple of input frequency determined by counter; with connections and values shown, multiplication factor for 60-Hz input signal is 100, giving 6-kHz square-wave output.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 830–831.



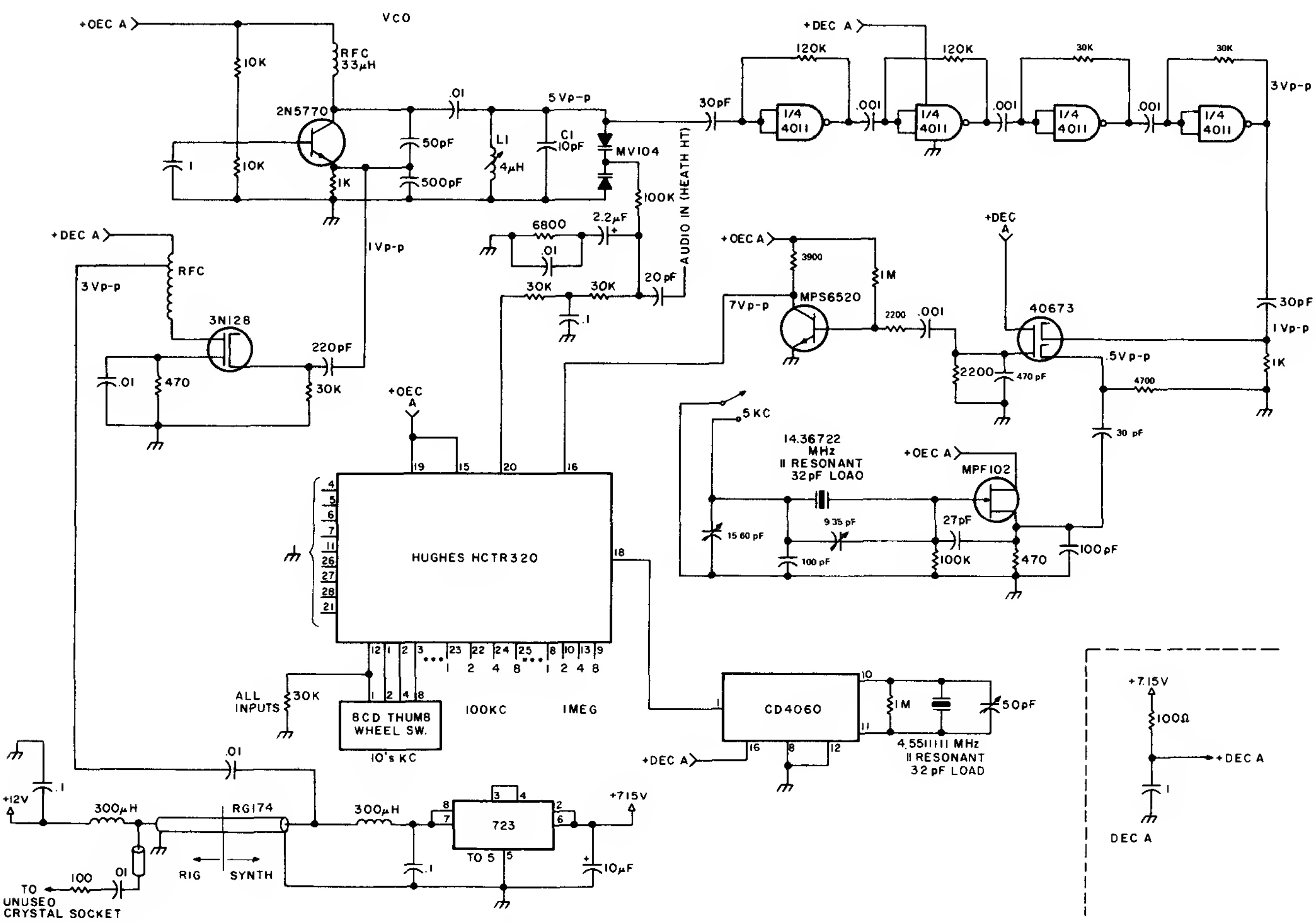
7.000–7.999 MHz PLL—Provides output in 1-kHz steps under digital programming, except that first digit is hard-wired to 7 and does not change. VCO is Motorola MC4024, which generates square-wave output. For sine output, use low-pass filter at output of VCO to eliminate all frequencies above 7.999 MHz, or use different VCO. 74123 mono lengthens reset pulse generated by divide-by-N circuit. Terminals A, B, C, and D of 74192s go to grounding switches that are set to give desired division ratio. Article gives theory of PLL synthesizers.—G. R. Allen, Synthesize Yourself!, *73 Magazine*, Oct. 1977, p 182–188.



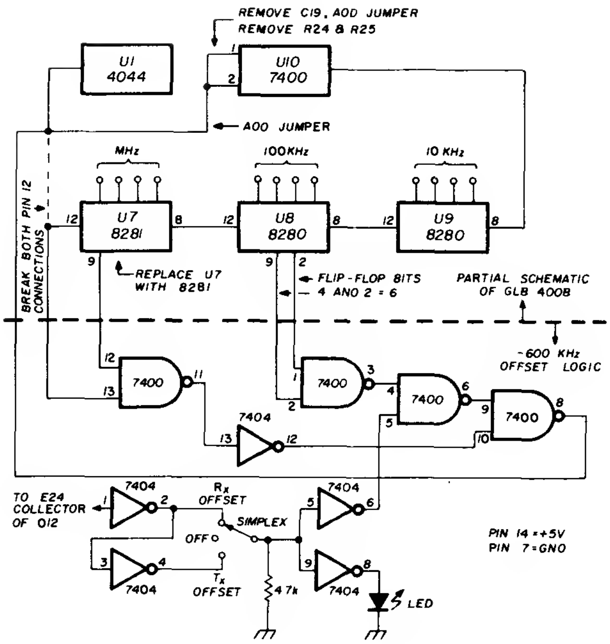
SWITCH-CONTROLLED ADDER—Direct BCD input from thumbwheel switch and use of standard crystal frequencies are primary advantages of accumulator stage of synthesizer, one decade of which is shown. BCD adder drives four D flip-flops whose outputs are fed back and added to switch states. Frequency range depends on number of decades used. Output pulse may be used directly for synchronization. If square wave is needed, clock frequency can be doubled and output of accumulator used to clock flip-flop.—D. W. Coulbourn, Set Frequency Synthesizer with Thumbwheel Switches, *EDN Magazine*, April 5, 1975, p 115 and 117.



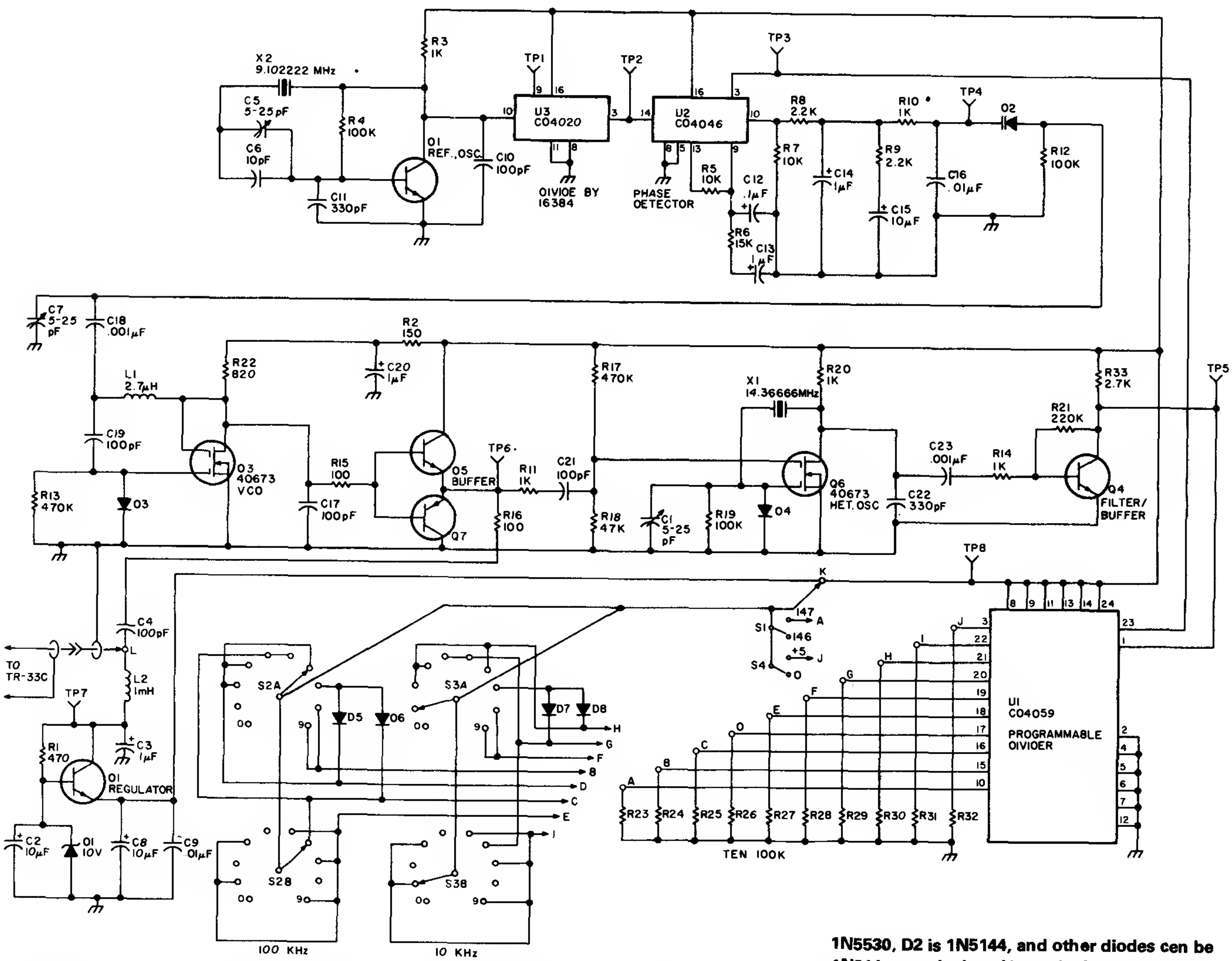
220-MHz PHASE-LOCKED—Fairchild 95H90 divide-by-10 counter U3 is used to divida 221.86-MHz VCO output frequency by 10. Resulting 22-MHz output of U3 is compared in phase with output of 22-MHz crystal-controlled oscillator by phase comparator U1, which is standard double-balanced mixer. Output of phasa detector is passed through activa low-pass filter for control of VCO. Article givas filter and VCO circuits. U2 is 5-V voltage regulator for 95H90.—H. Olson, Frequency Synthesizer for 220 MHz, *Ham Radio*, Dec. 1974, p 8–14.



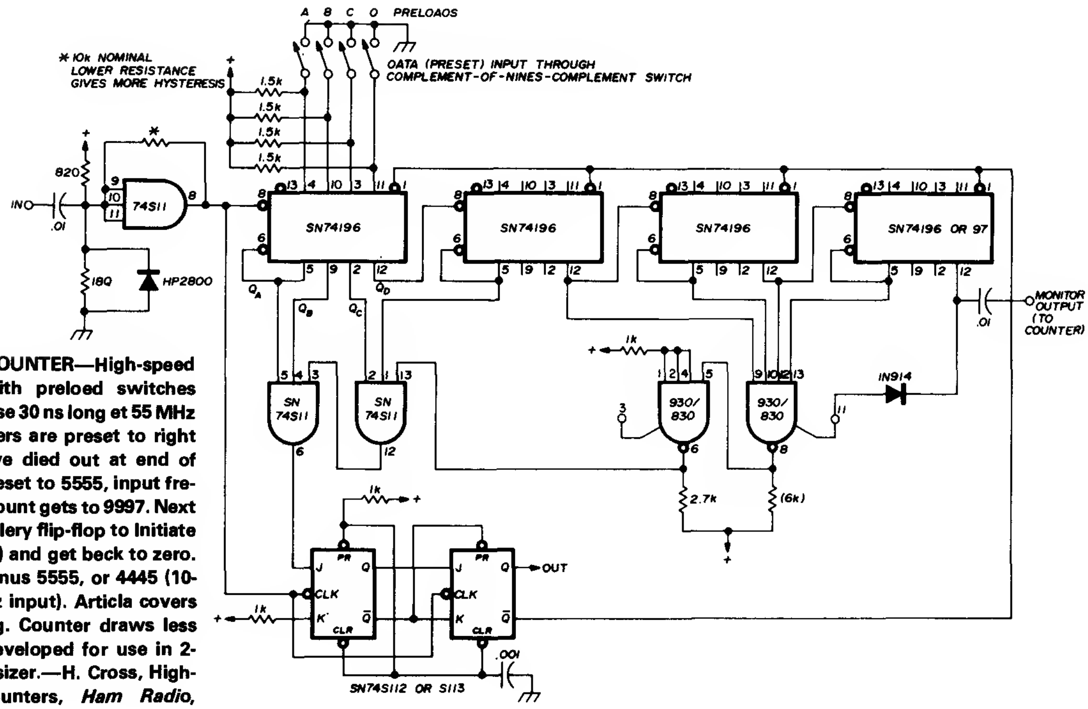
140–150 MHz IN 5-kHz STEPS—Developed for use with amateur 2-matar redios, to give direct choice of frequency by setting thumbwhael or lever switches. Phase-locked loop gives precise high-purity output. Input frequency to systam is 4.5511111-MHz reference signal from CD4060 crystal oscillator. Digital edga-triggered Hughes HCTR320 phase comparator maintelns inputs of both frequancy and phasa coherence at lock; lock range is thus capture renge, meking locking on hermonics impossibla. Article describes operation of circuit in datail, and gives construction dateils es wall es circuit for keyboerd entry system. Power supply is 723 precision regulator giving 7.15 V.—M. I. Cohen, A Practical 2m Synthesizer, *73 Magazine*, Sapt. 1977, p 146–151.



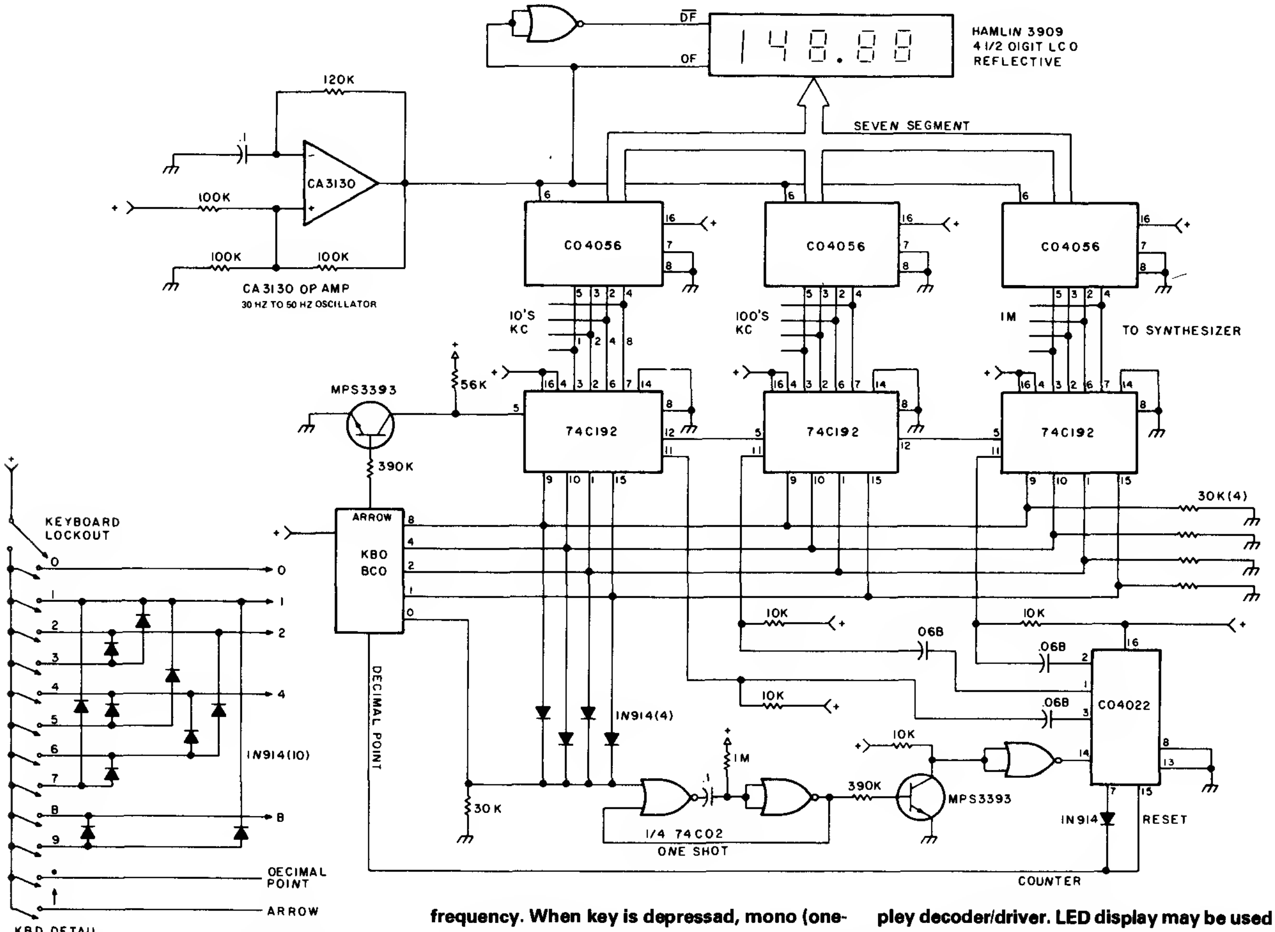
600-kHz OFFSET—Developed for use with GLB400B frequency synthesizer which uses programmable divider and has outputs available from each flip-flop. Requires only two ICs, shown below horizontal dashed line. Select higher frequency of repeater pair on frequency-set switches. For operation at 146–147 MHz, select offset T_x to transmit on repeater input. For 147–148 MHz, select offset R_x to receive on repeater output. To operate in reverse, flip switch to other position. At center-off position, both transmit and receive are on selected frequency, with offset function disabled. LED lights only for offset.—D. Sargent, 600 kHz Offset for Frequency Synthesizers, *Ham Radio*, July 1978, p 98.



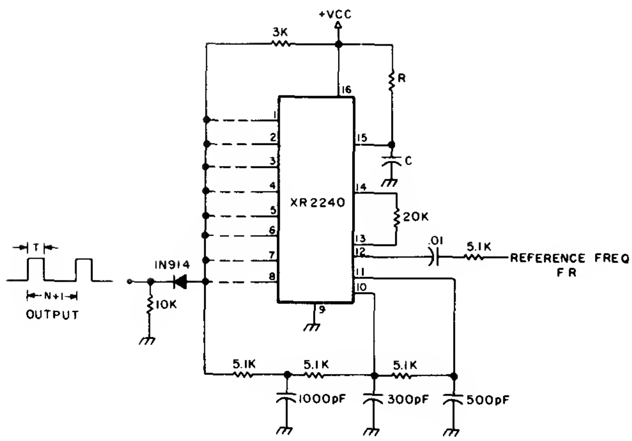
146.000–147.995 kHz SYNTHESIZER—Designed for use with Drake TR-33C transceiver. Circuit has built-in offset providing choice of any 5-kHz-spaced channel in frequency range for transmit and receive frequencies. Only two crystals are required. Desired frequency can be entered with BCD thumbwheel switches. Tune-up and testing procedures are given. D1 is 1N5530, D2 is 1N5144, and other diodes can be 1N914 or equivalent. Unmarked bipolar transistors are fast-switching silicon types; NPNs can be 2N2222, and PNPs can be 2N4403.—J. Moell, Super Deluxing the TR-33, *73 Magazine*, April 1978, p 72–74.



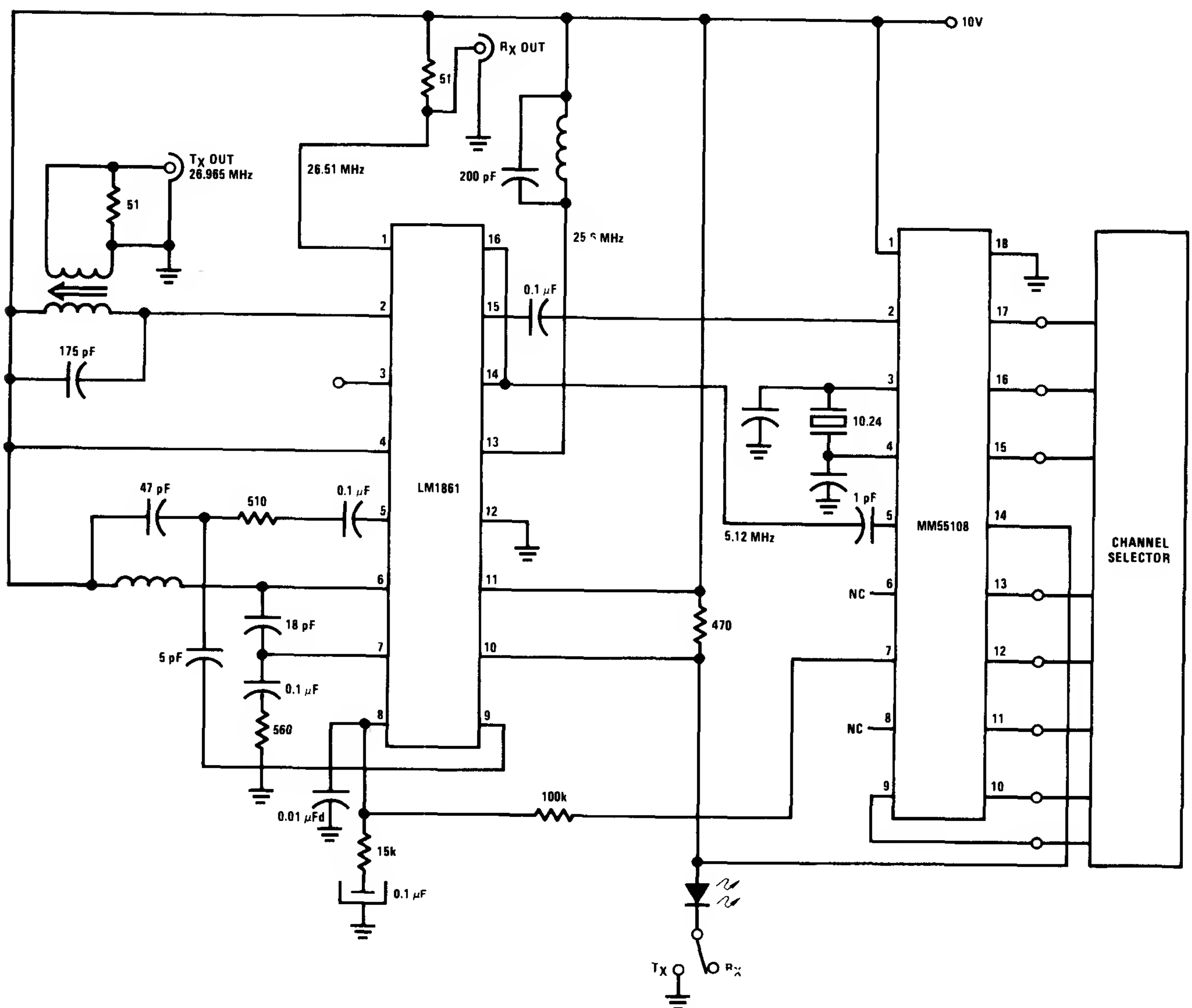
55-MHz PRESETTABLE COUNTER—High-speed four-decade counter with preloed switches gives positive output pulse 30 ns long et 55 MHz to ensure thet all counters are preset to right digit end trensients have died out at end of count. If counters ere preset to 5555, input frequency is counted until count gets to 9997. Next clock pulse triggers auxillery flip-flop to Initiate load pulse (2 cycles long) and get beck to zero. Total count is 10,000 minus 5555, or 4445 (10-kHz output for 44.5-MHz input). Articla covers construction end testing. Counter draws less than 300 mA et 5 V. Developed for use in 2-meter frequancy synthesizer.—H. Cross, High-Speed Divide-by-N Counters, *Ham Radio*, Merch 1976, p 36–38.



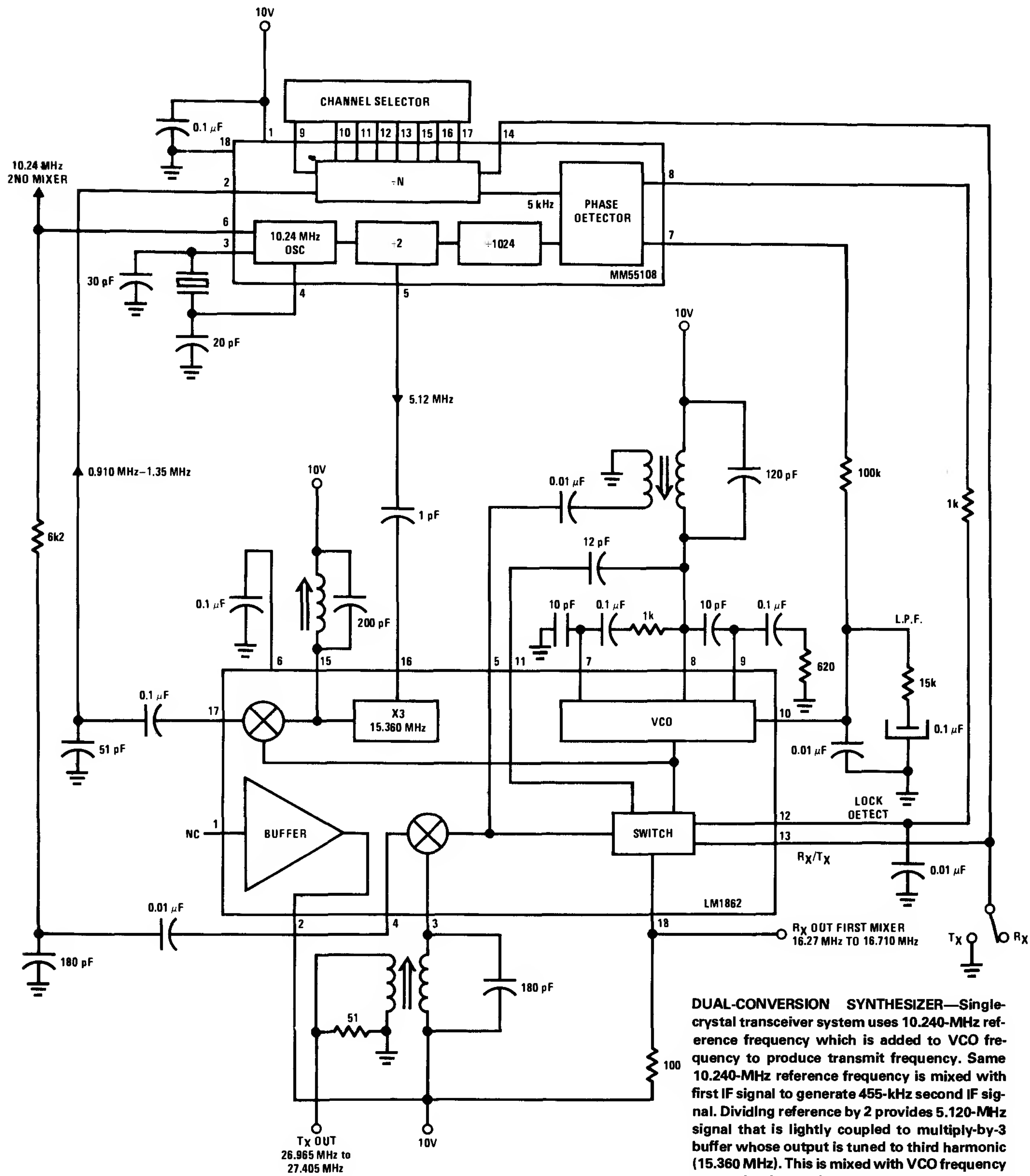
KEYBOARD ENTRY WITH 4½-DIGIT DISPLAY—Developed to give keyboerd entry of desired frequency for 2-meter frequency synthesizer, as altemative to thumbwheel-switch setting of frequency. When key is depressad, mono (one-shot) fires, causing CD4022 counter to incrament. At same time, kayswitch pleces appropriate BCD deta on input lines of 74C192 presetteble decade counters. Output from counters goes to synthesizer input and to displey decoder/driver. LED display may be used in pleca of LCD display if current drain is not important. Keyboard lockout switch prevents accidental change of frequency.—M. I. Cohen, A Practicel 2m Synthesizer, *73 Magazine*, Sept. 1977, p 146–151.



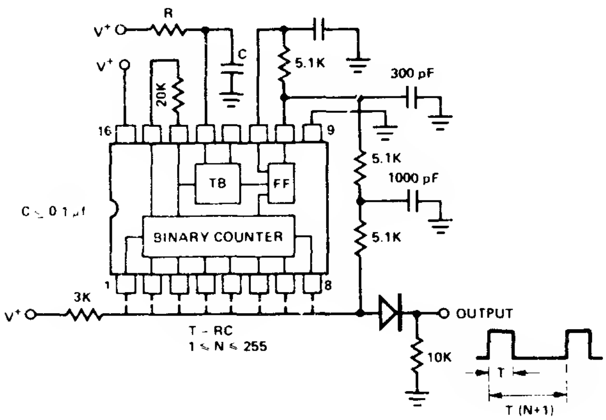
XR2240 SYNTHESIZER—Circuit uses XR2240 programmable timer/counter for simultaneous multiplication of input frequency FR by factor of M and division of input frequency by factor of N + 1, where M and N are integers selected by appropriate connections of binary pins 1-8 to common output bus. Output frequency is then FR(M)/(1 + N) where M is between 1 and 10 inclusive and N is between 1 and 255 inclusive. VCC is 4–15 V.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



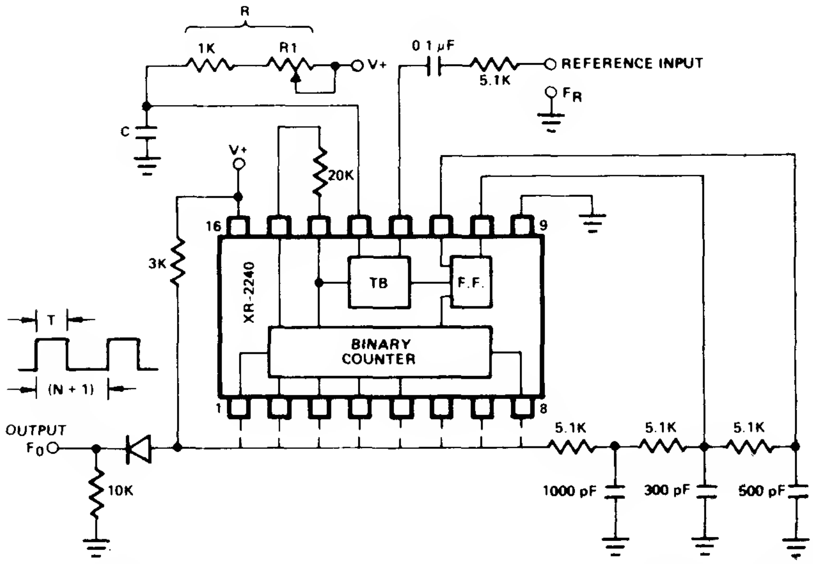
SINGLE-CONVERSION SYNTHESIZER—Used in single-conversion CB transceiver in which VCO operates at channel frequency during transmit and 455 kHz below channel frequency during receive. 5.120 MHz is quintupled to 25.600 MHz to mix and provide input to programmable divider.—L. Sample, A Linear CB Synthesizer, *IEEE Transactions on Consumer Electronics*, Aug. 1977, p 200–206.



DUAL-CONVERSION SYNTHESIZER—Single-crystal transceiver system uses 10.240-MHz reference frequency which is added to VCO frequency to produce transmit frequency. Same 10.240-MHz reference frequency is mixed with first IF signal to generate 455-kHz second IF signal. Dividing reference by 2 provides 5.120-MHz signal that is lightly coupled to multiply-by-3 buffer whose output is tuned to third harmonic (15.360 MHz). This is mixed with VCO frequency to provide input signal for programmable divider. When VCO is operating as first mixer and local oscillator on CB channel 1 (16.270 MHz), difference frequency is 910 kHz. Programmable divider divides by 182 to give necessary 5-kHz input to phase detector. If VCO moves off frequency, divided input to phase detector moves away from 5 kHz and action of loop pulls VCO back on frequency.—L. Sample, A Linear CB Synthesizer, *IEEE Transactions on Consumer Electronics,* Aug. 1977, p 200–206.



255-FREQUENCY SYNTHESIZER—Circuit as shown for programmable counter section of Exer XR-2240 programmeble timer/counter provides squere-wave outputs at 255 discrete frequencies from given internal time-bese setting. Output is positive pulse train with pulse width T determined by values of R and C. Period is equal to (N + 1)T where N is programmed count in counter of IC. Counter output connections to output bus determine velue of N; if pins 1, 3, and 4 are connected to bus, N is 1 + 4 + 8 or 13 and period is 14T. Supply voltage range is 4–15 V. If counter cannot be triggered when using supply above 7 V end less then 0.1 μF for C, connect 300 pF from pin 14 to ground.—"Timer Date Book," Exer Integrated Systems, Sunnyvele, CA, 1978, p 11–18.

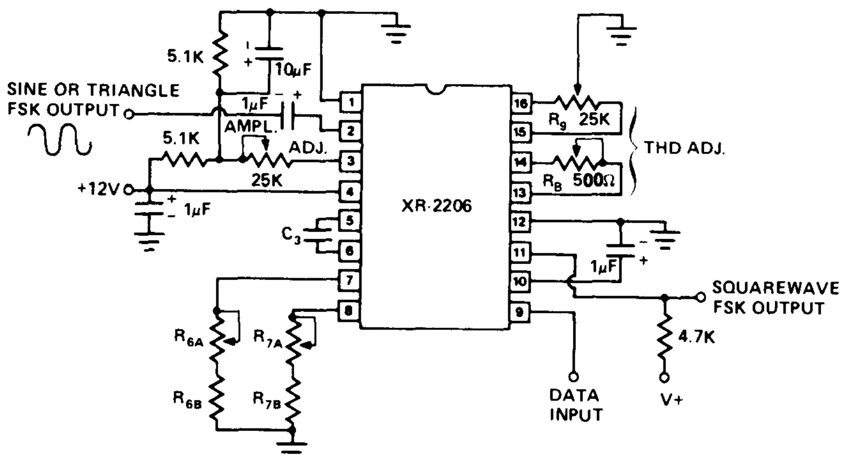


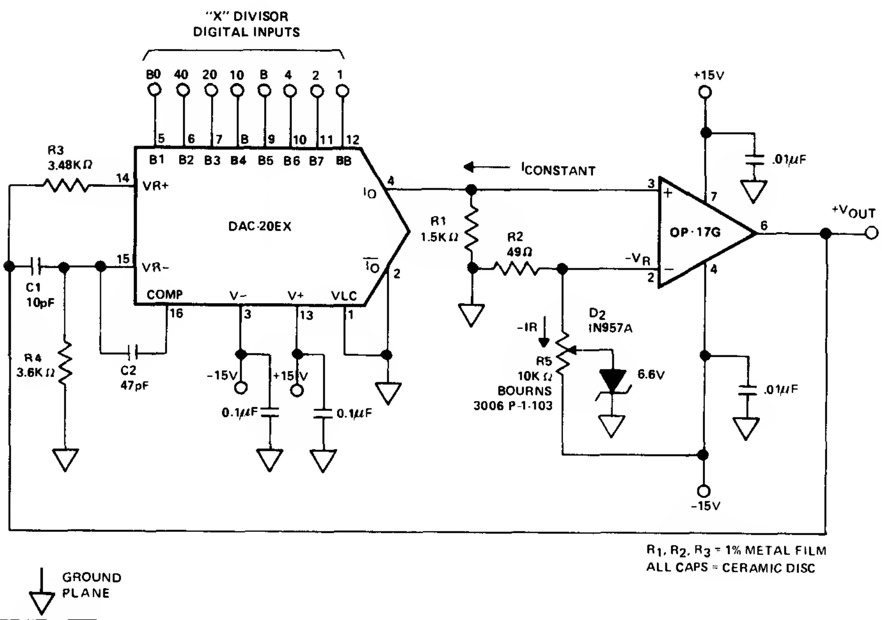
2500 FREQUENCIES WITH SYNCHRONIZATION—EXAR XR-2240 programmable timer/counter containing 8-bit programmeble binary counter end steble time-bese oscillator can generate over 2500 discrete frequencies from single input reference frequency. Circuit simultaneously multiplies input frequency by factor M and divides by N + 1, where M and N ere edjustable integer values. Output frequency F_0 is equal to input frequency F_R multiplied by M/(1 + N). M and N can be externelly edjusted over broad renge, with M between 1 and 10 and N between 1 and 255. Multiplication factor M is obtained by locking on harmonics of reference. Division fector N Is determined by preprogrammed count in binery counter section, established by wiring appropriate pins 1-8 to output bus. Input reference is 3 V P-P pulse train with pulse duration ranging from 30% to 80% of time-bese period T. R_1 determines velue of M. C is in renge of 0.005 to 0.1 μF, and R is between 1K end 1 megohm for maximum output frequency of ebout 200 kHz. With M = 5 and N = 2, 100-Hz clock synchronized to 60-Hz line frequency is obtained.—"Timer Data Book," Exer Integreted Systems, Sunnyvale, CA, 1978, p 31–32.

CHAPTER 37
Function Generator Circuits

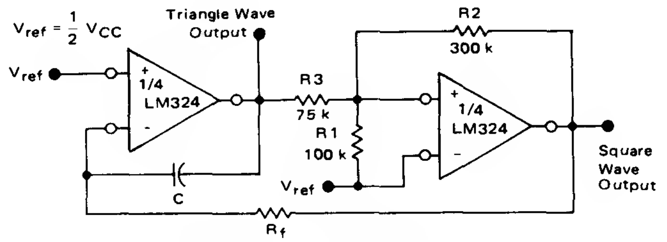
Used for generating various combinations of sine, square, and triangle waveforms, usually with manual or external variations of frequency in AF or RF ranges by DC control voltage. Also includes circuits for generating cubic, quadratic, hyperbolic, trigonometric, ramp, and other mathematical waveforms, as well as circuits for converting one of these waveforms to one or more others. See also Multivibrator, Oscillator, Pulse Generator, Signal Generator, and Sweep chapters.

FSK SINE-SQUARE-TRIANGLE GENERATOR—Exar XR-2206 modulator-damodulator (modem) is connectad as function genaretor providing high-purity sinusoldal output along with trlengle and squere outputs, for FSK aplications. Circuit hes axcallent frequancy stability along with TTL and CMOS compatibility. Total harmonic distortion in 3 V P-P sine output is about 2.5% untrimmed, but can be trimmed to 0.5%. High-level data input signel selects frequency of $1/R_6C_3$ Hz, whila low-level Input selects $1/R_7C_3$ Hz. For optimum stability, R_6 and R_7 should be in range of 10K to 100K. Adjust R_8 and R_9 for minimum distortion.—"Phese-Lockad Loop Data Book," Exar Integratad Systems, Sunnyvela, CA, 1978, p 57–61.





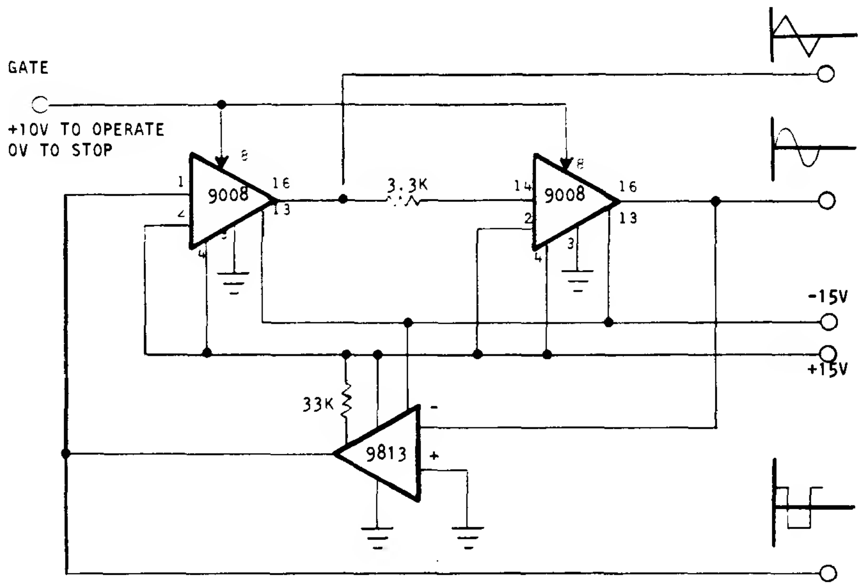
HYPERBOLIC A/X FUNCTION—Uses Precision Monolithics DAC-20EX D/A convartar with OP-17G opemp to generata axtanded-ranga hyparbolic functions of tha typa A/X, whare A is analog constant and X rapresants dacimally expressed digltel divisor. R5 provides simultanaous adjustmant of scala factor and output amplifier offset voltage. Sama circuit serves for −A/X function if DAC referance amplifiar end output opemp terminals are reversed.—W. Ritmanlch, B. Blair, and B. Deboway, "Digital-to-Analog Converter Generatas Hyperbolic Functions," Precision Monolithics, Santa Clara, CA, 1977, AN-23, p 2.

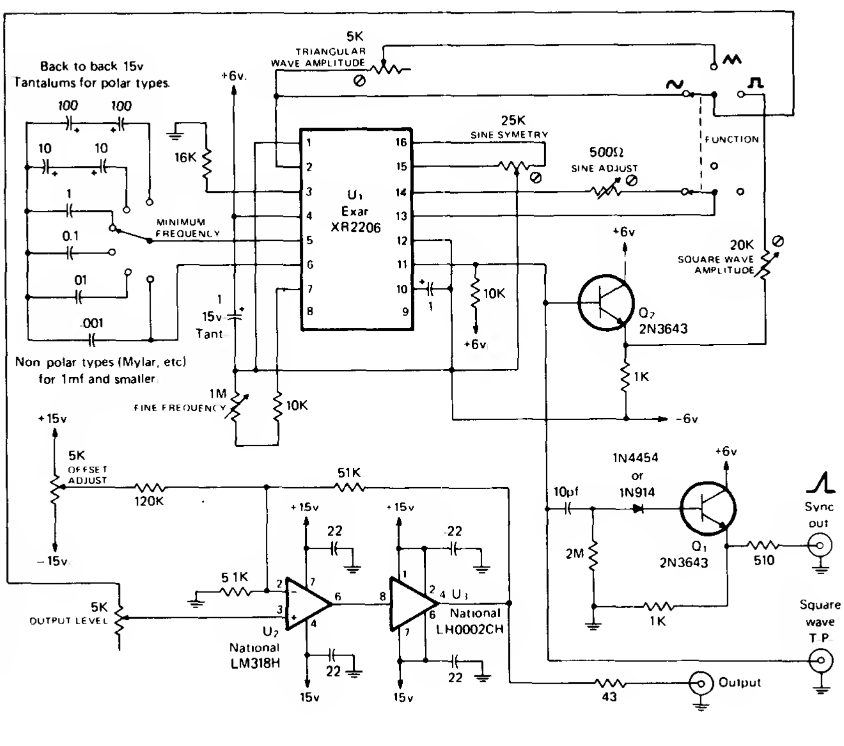


$$f = \frac{R1 + R_C}{4\,CR_f\,R1} \quad \text{if} \quad R3 = \frac{R2\,R1}{R2 + R1}$$

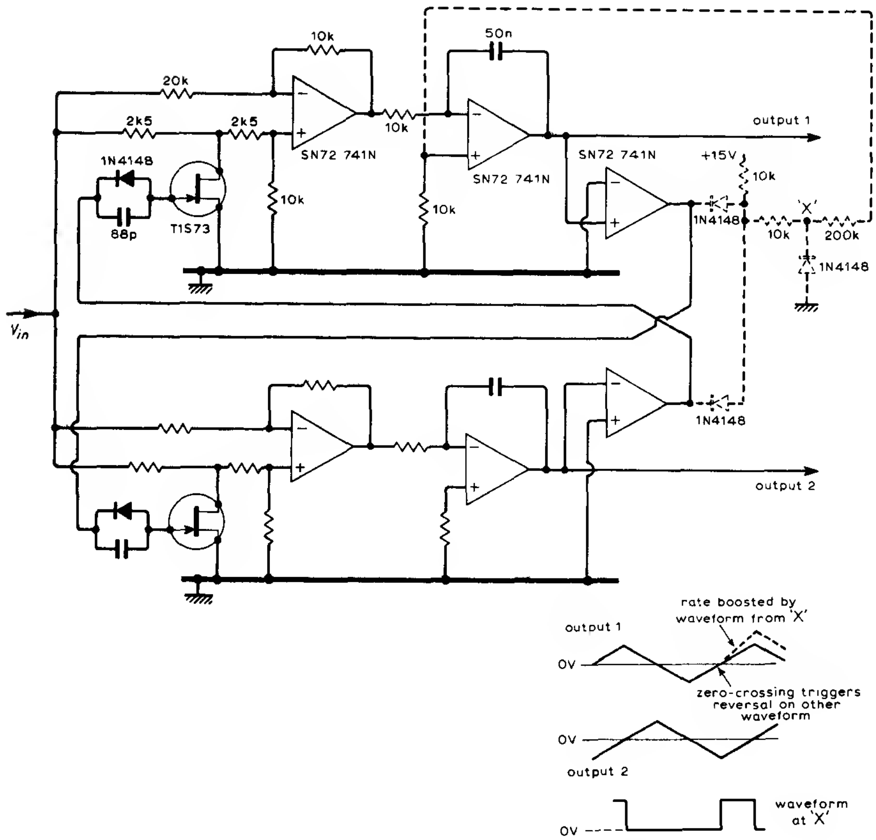
BASIC SQUARE-TRIANGLE—Requires only two sections of LM324 quad differantial-Input opamp to provida choice of triangle or square-wava outputs at frequency determinad by values of components. Supply voltage range is 3–32 V.—"Quad Low Powar Operational Ampli-fiars," Motorola, Phoenix, AZ, 1978, DS 9339 R1.

WAVEFORM GENERATOR—Two Optical Electronics 9008 integrators and 9813 comparator together genarata choice of sine, squara, and triangle waveforms suitable for systam testing and display ganeration. Squara wava is typically ±13.5 V with 20-μs transition tima. Triangle wava is ±10 V with battar than 0.1% triangle linearity. Comparator senses zero crossings of sine-wave output to produca squara waves, thus completing feedback loop. Integrators ara commanded at pin 8 for zero output, so triangle and sine outputs can ba made to start from zaro.—"Waveform Generator," Optical Electronics, Tucson, AZ, Application Tip 10257.

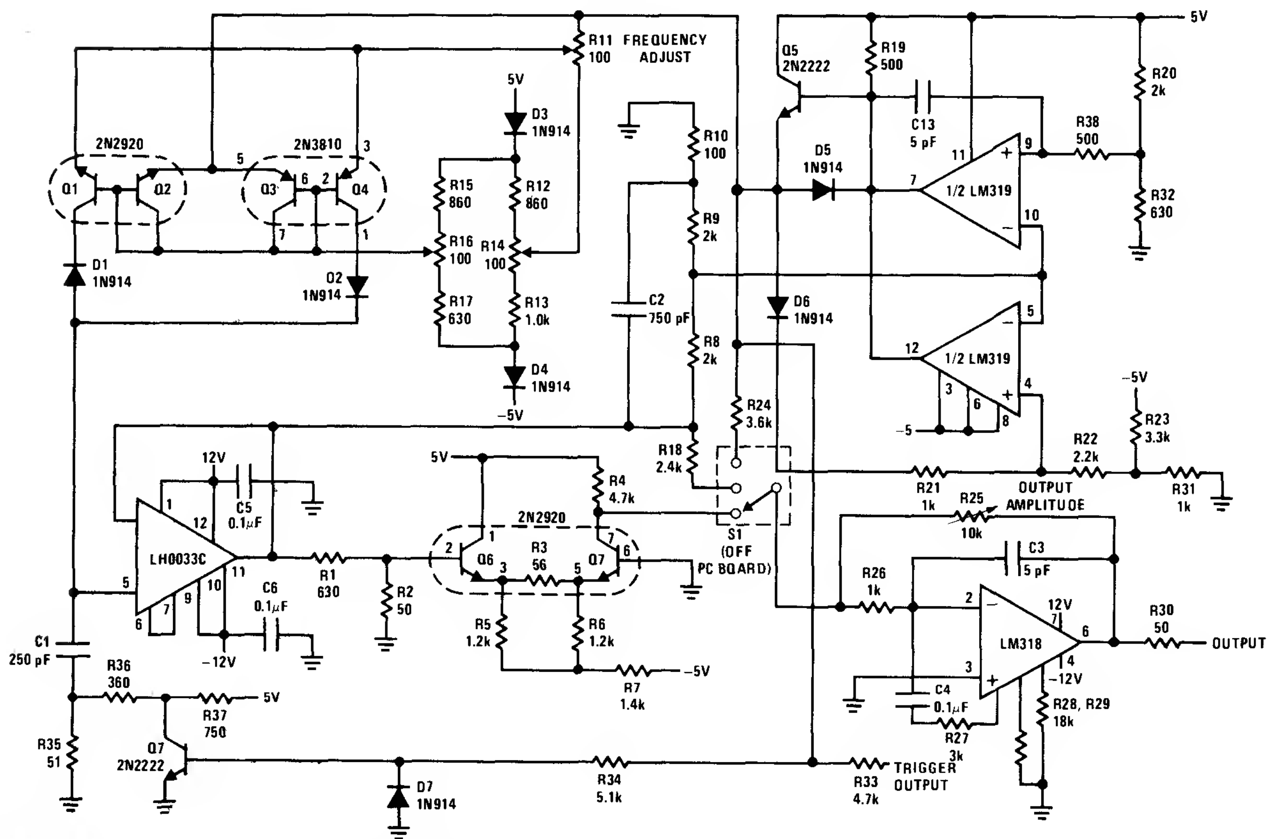




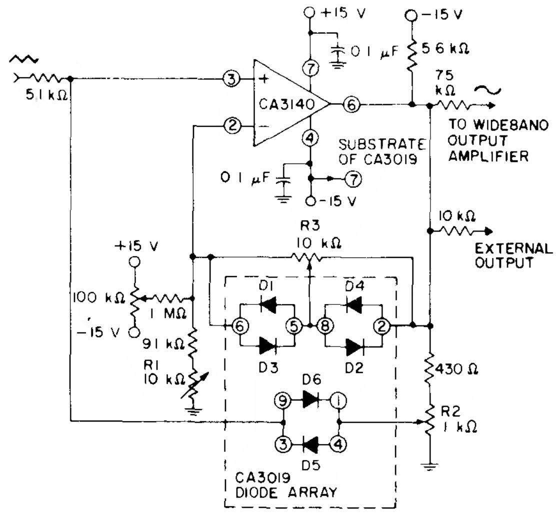
0.01 Hz TO 100 kHz—Variabla DC offset permits adjustment of avarage valua of sina, square, or triangle waveform to any arbitrary plus or minus value within voltage swing capability of opamp U_3. Buffar stage U_2 is inslda feedback loop. Simple amittar-followar differentlator provides positive-going 1-V 0.5-μs output at sink tarminal. Square-wave output Is buffered by emittar-follower Q_2.—H. Olson, The Function Generator, *CQ*, July 1975, p 26–28 and 71–72.



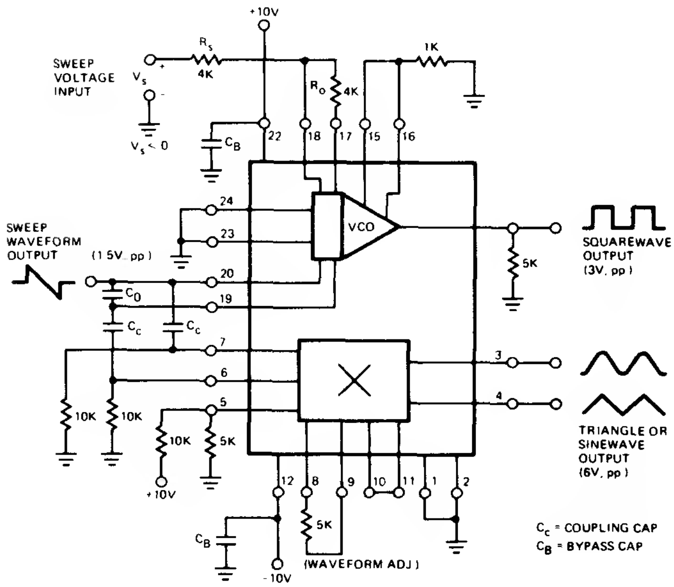
TWO-PHASE VOLTAGE-CONTROLLED—Produces fixed-amplitude sawtooth outputs that can be shaped to give sine waves, with outputs of the two identical channels differing by a specified phase such as 90°. Each output is integrated to give rising or falling ramp that controls switching FET of opposite channel. With oscillation established, one integrator output goes toward zero and the other away from zero, with same or opposite polarity. When first output crosses zero, discriminator switches FET in input amplifier of other channel, with action being self-perpetuating to give desired sawtooth outputs. Dashed-line gating at outputs of discriminators can be used to boost slope of one sawtooth in one quadrant.—F. B. Jones, Voltage-Controlled Two-Phase Sawtooth Oscillator, *Wireless World*, June 1973, p 285.



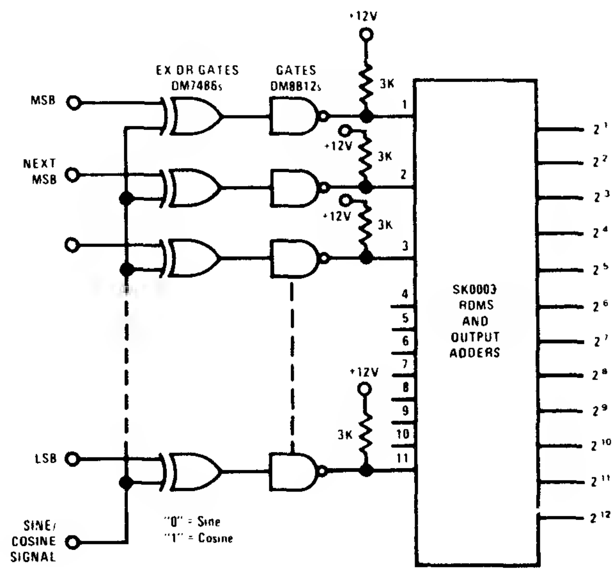
10 Hz TO 2 MHz—Triangle wave is generated by switching current-source transistors to charge and discharge timing capacitor. Precision dual comparator sets peak-to-peak amplitude. Sine converter requires close amplitude control to give low-distortion output from triangle input. Square-wave output is obtained at emitter of Q5, for driving current switches Q1-Q4 and LM318 output amplifier. Scaling permits adjusting all three waveforms to ±10 V. Waveforms are symmetrical up to 1 MHz, and output is usable to about 2 MHz.—R. C. Dobkin, "Wide Range Function Generator," National Semiconductor, Santa Clara, CA, 1974, AN-115.



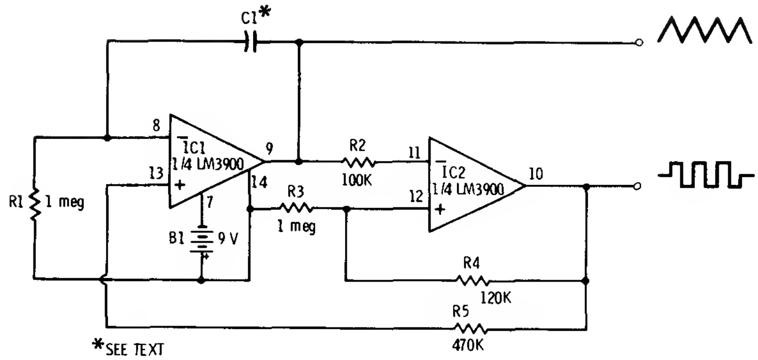
SINE-WAVE SHAPER—Uses CA3140 opamp as voltage follower, acting with diodes from CA3019 array to convert triangla output of function generator or other source to sine wave having total harmonic distortion typically less than 2%.—"Circuit Ideas for RCA Linaar ICs," RCA Solid State Division, Somerville, NJ, 1977, p 5.



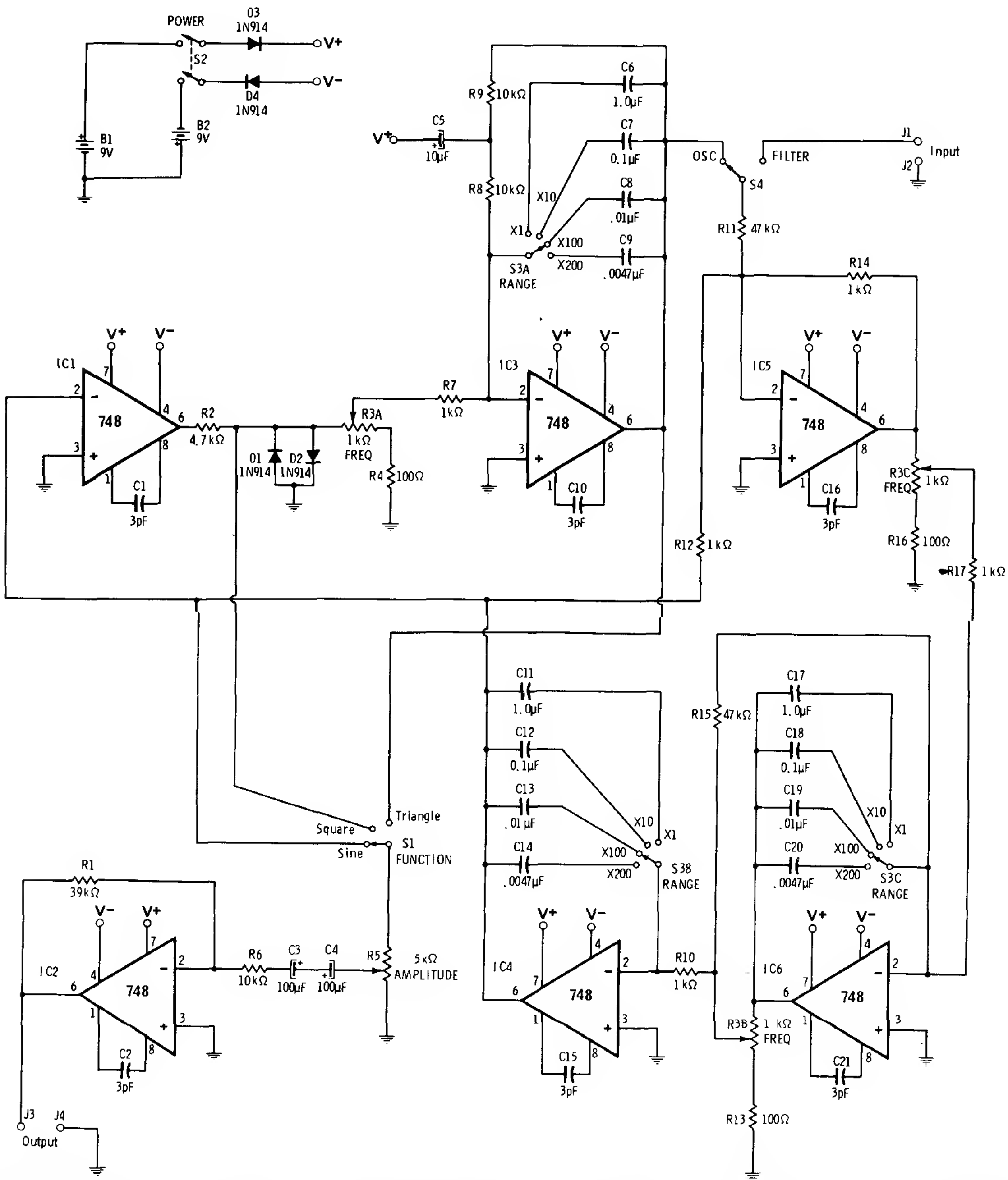
VOLTAGE-TUNED WITH 10:1 FREQUENCY RANGE—Exar XR-S200 PLL IC is connected to generate basic periodic square or sawtooth waveform. Multiplier section, used as linear differential amplifier, converts differential sawtooth input waveform to triangla wave. 5K pot connected between pins 8 and 9 rounds peaks of triangle to give low-distortion sine wave with less than 2% total harmonic distortion. Output frequency can be swept or frequency-modulated by applying proper analog control input. For linear frequency modulation with lass than 10% deviation, modulation is applied between pins 23 and 24. For larger deviations, negative-going sweep voltage V_S is applied to pin 18 as shown. Digital control input pins 15 and 16 can be used for FSK applications; if this is not desired, pins are disabled by connecting to ground through current-limiting resistor.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



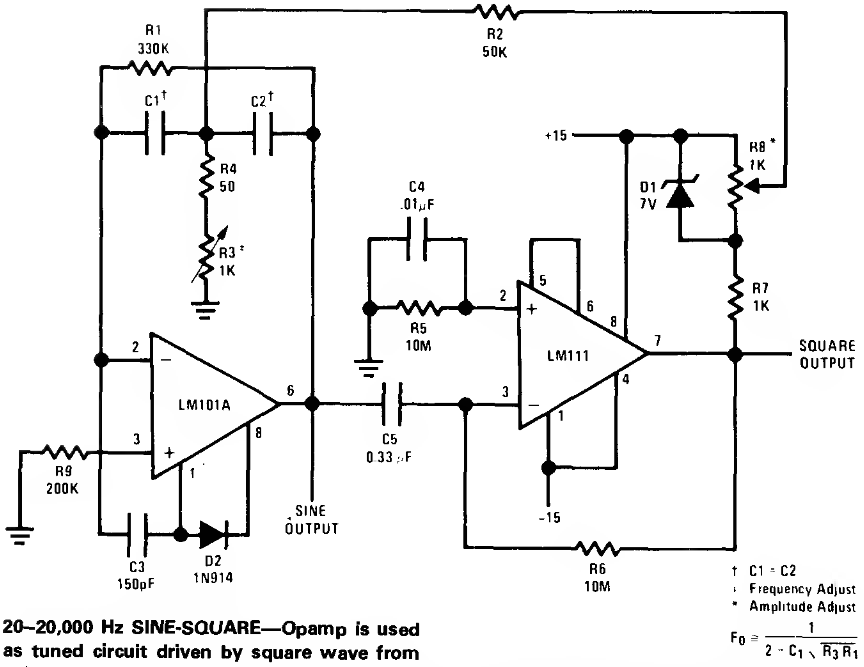
SINE/COSINE—Uses National SK0003 sina/cosina look-up table kit consisting of four MOS ROMs and thrae output adders. Combination implements equation sin θ = sin M cos L + cos M sin L. Worst-case error is 1 5/8 bits in least significant bit. Cosine is approximated with loss in resolution of ½ bit in 11-bit input or ¼ bit in 10-bit input.—"Memory Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-98–6-99.



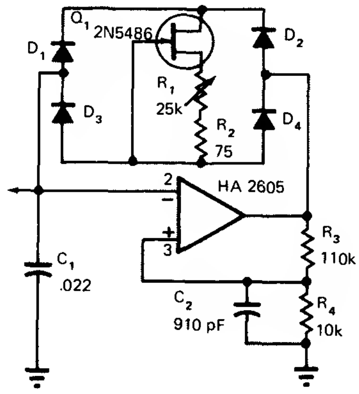
SQUARE-TRIANGLE AF—Two sections of LM3900 quad opamp ara connected to genarate dual-polarity triangle- and squere-wava AF outputs while operating from single supply, by using current mirror circuit at noninvarting input. Value used for C1 determines frequancy and pulse width; frequency ranges from 0.5 Hz with 1 μF to 3800 Hz with 0.0001 μF and 21 kHz with C1 omitted. Pulse-width range is 35 μs without C1 to 1.6 s with 1 μF.—F. M. Mims, "Intagrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 57–63.



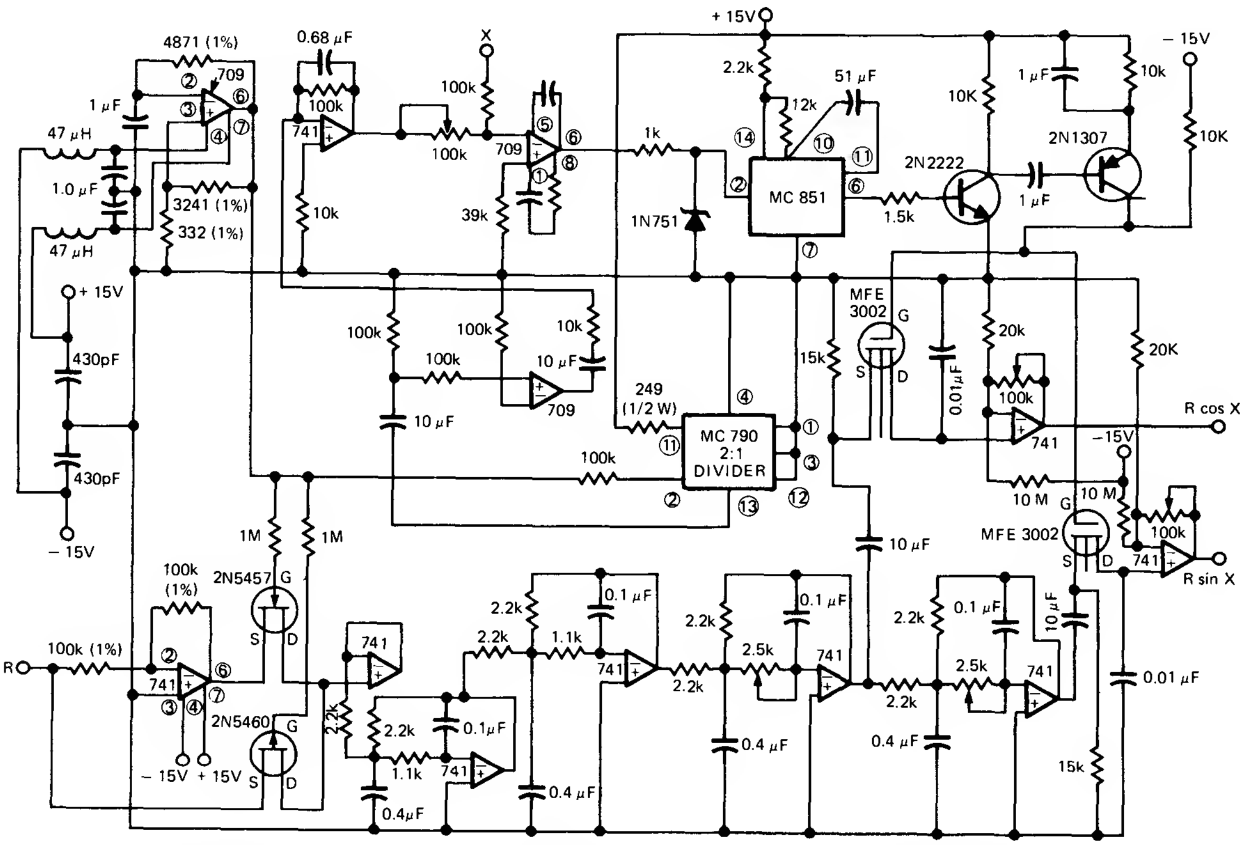
AF SINE-SQUARE-TRIANGLE—Cen be tuned ovar antira audio spectrum in four ranges for generation of low-distortion waves for leboratory use. IC1 converts sine wave to squera weve. IC3 acts es integrator converting square-wava output of IC1 to triangle wave. IC4-IC6 form state-variable filter for removing sine-weve component from triangle wave. IC2 is simple inverting amplifier for output.—R. Malan and H. Garland, "Understanding IC Operational Amplifiers," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 130–134.



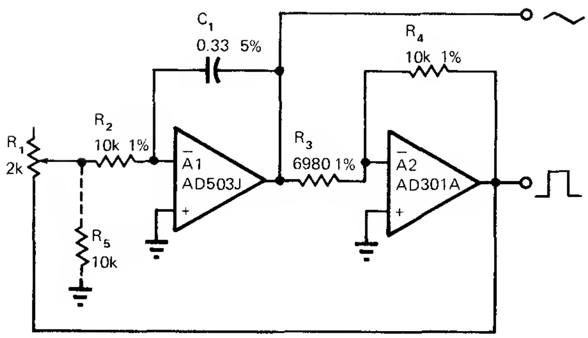
20–20,000 Hz SINE-SQUARE—Opamp is used as tuned circuit driven by square wave from voltage comparator. Frequency is controllad by R1-R3, C1, and C2, with R3 providing tuning. Comparator is fed with resulting sine wave to obtain square wava for feedback to input of tuned circuit, to cause oscillation. Zener stabilizas amplitude of square wave that is fed back. R6 and C5 provide DC negative feedback around comparator to ensure starting. Values of C1 and C2 are equal, and range from 0.4 μF for 18–80 Hz to 0.002 μF for 4.4–20 kHz.—"Easily Tuned Sine Wave Oscillators," National Semiconductor, Santa Clara, CA, 1971, LB-16.



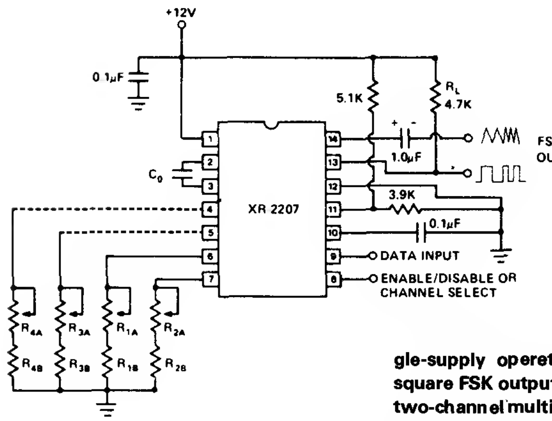
0.5–25 kHz TRIANGLE—Diode bridge and FET form constant-current source charging C_1, to make voltage across C_1 change at linear rate as required for triangle output across C_1. Frequency can be adjusted from 500 Hz to abova 20 kHz with constant output amplitude, by means of R_1. Short-term stability is better than 1 part in 10,000. Since tha same R and C are used to genarate both sections of the waveform, positive and negative slopes are idantical. Diodes are HP 5082-2810.—G. R. Begault, Op Amp Makes Variable-Frequency Triangular Wave Generator, *EDN Magazine*, Sept. 15, 1972, p 42–43.



RESOLVER—Circuit accepts DC input voltages R and X and generates two DC output voltages R sin X and R cos X. Can be used in guidance computers to solve coordinate conversion problems (polar to ractangular) and in feedback systams to convert rectangular to polar coordinates. Sine wave is generated by chopping input signal R and filtering rasulting square wave. Sine wave is than sampled at time controlled by X to generate R sin X. Cosine output is obtained by shifting first output 90° in phase. Circuit also generates proper sampling pulses and contains two sample-and-hold circuits on outputs.—W. H. Licata, Solid-State Resolvar, *EDN Magazine*, July 20, 1973, p 82–83.

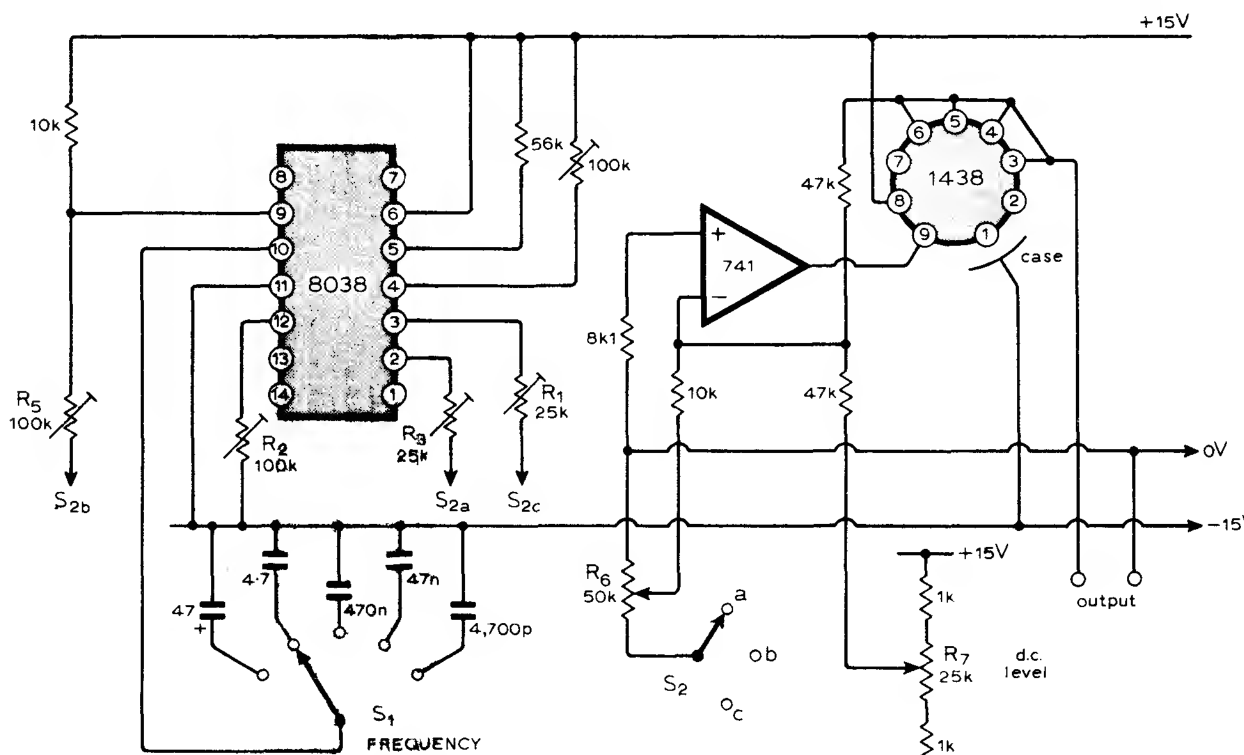


100-Hz SQUARE-TRIANGLE—Two-opamp oscillator delivers ±13 V square waves and ±10 V triangle waves simultaneously at 100 Hz for values shown. By scaling R_1, R_2, and C_1 wide range of frequencies can be covered down to 0.1 Hz (increase R_2 to 10 megohms for frequencies near lower limit). Square-wave rise time is about 1.5 μs and fall time 0.5 μs. Opamp A_1 operates as integrator and A_2 as Schmitt trigger.—R. S. Burwen, Triangular and Square Wave Generator Has Wide Range, *EDN Magazine*, Dec. 1, 1972, p 59.

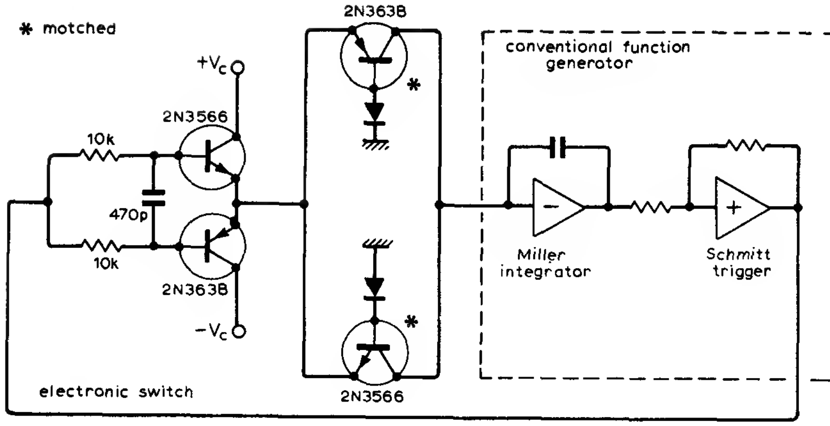


Logic Level		Active Timing Resistor	Output Frequency
Pin 8	Pin 9		
L	L	Pin 6	$\frac{1}{C_0R_1}$
L	H	Pins 6 and 7	$\frac{1}{C_0R_1} + \frac{1}{C_0R_2}$
H	L	Pin 5	$\frac{1}{C_0R_3}$
H	H	Pins 4 and 5	$\frac{1}{C_0R_3} + \frac{1}{C_0R_4}$

FSK SQUARE-TRIANGLE GENERATOR—Uses Exar XR-2207 FSK modulator connected for single-supply operation, to produce triangle or square FSK outputs for either single-channel or two-channel multiplex operation. Used in transmitting digital data over telecommunication links. Table gives equations for selecting timing resistors R_1-R_4; resistor values are in ohms, C_0 is in farads, and frequency is in hertz. For optimum stability, R_1 and R_3 should be in range of 10K to 100K. For two-channel multiplex, make connections shown by dotted lines.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 57–61.

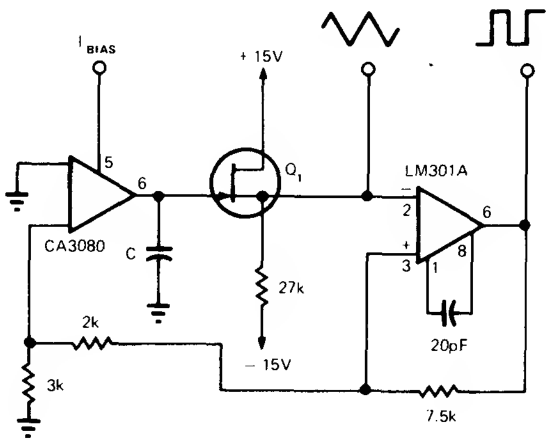


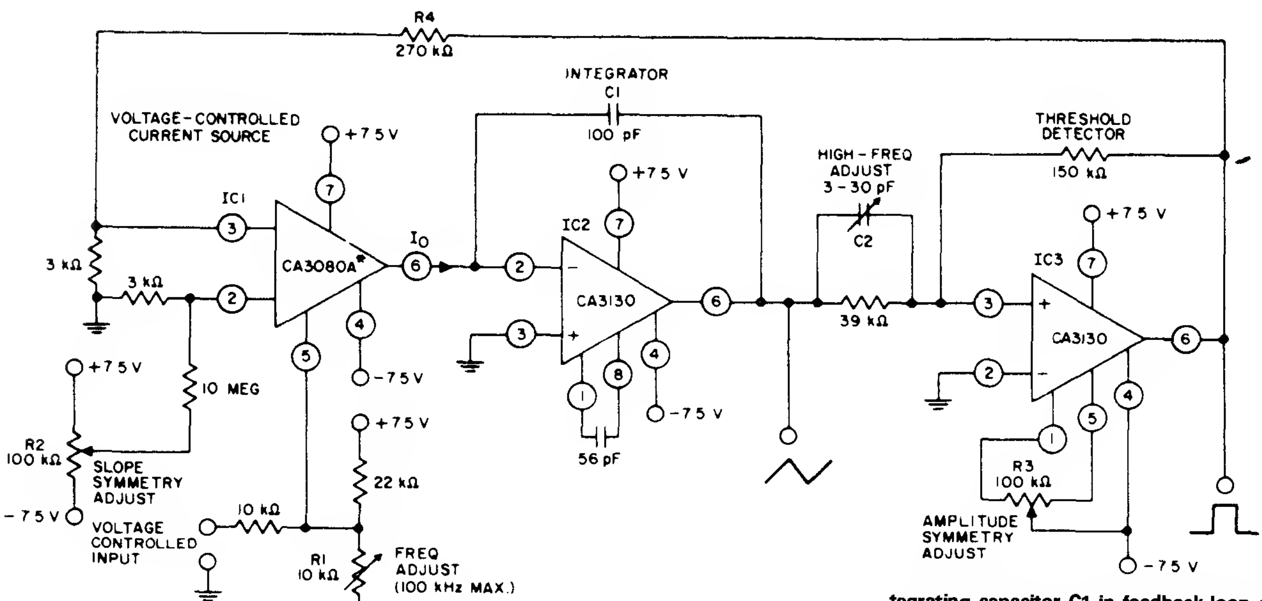
0.1-, 1-, 10-, 100-, and 1,000-Hz SINE-SQUARE-TRIANGLE—Provides choice of five spot frequencies switched in decades by S_1. Setting of S_2 determines shape of output waveform. Adjust R_1, R_3, and R_5 to make peak-to-peak amplitudes of all three waveforms equal. R_4 controls symmetry. R_2 is adjusted for minimum distortion of sine-wave output. Output may be set up to 100 mA by R_6, and is short-circuit-proof. DC level may be set anywhere between ±14 V by R_7. Motorola 1438 IC and 741 opamp boost output of 8038 IC sufficiently to drive most laboratory loads.—G. R. Wilson, Low-Frequency Generator, *Wireless World*, Feb. 1977, p 44.



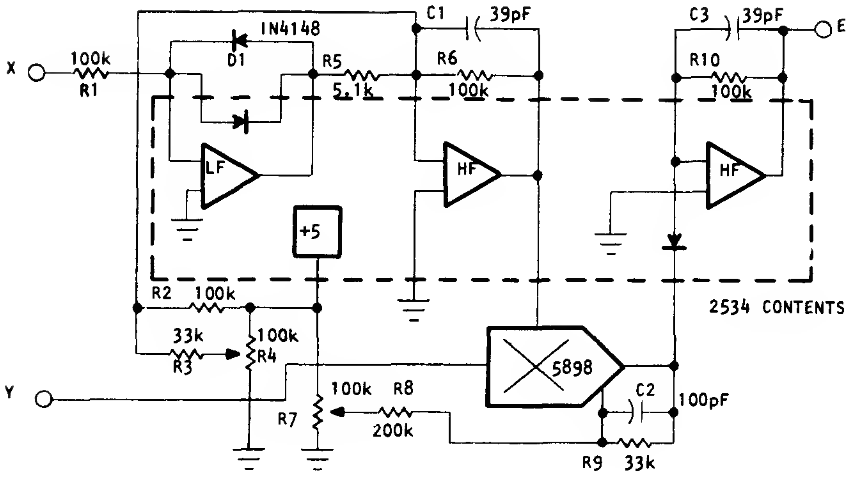
1000:1 FREQUENCY SWEEP—Permits varying output frequency of function generator over wide frequency range by using pot to vary control voltage V_c. Network consisting of two transistors end two diodes replaces usual cherging resistor of Millar integretor in function generator, and has output current varying exponentially with input voltage. Electronic switch using pair of transistors is controlled by Schmitt trigger of function generator, which connects $+V_c$ end $-V_c$ elternataly to charging circuit. If frequency pot is mechanically connected to strip-chart recorder, Bode plots of audio equipment can be made over antire audio renge.—P. D. Hiscocks, Function Generator Mod. for Wide Sweep Range, *Wireless World*, Aug. 1973, p 374.

CURRENT-CONTROLLED SQUARE-TRIANGLE GENERATOR—CA3080 opamp is connected as current-controlled integrator of both polarities for use in current-controlled triangle oscillator. Frequency depends on values of C and opemp bias current end cen be anywhere in audio range of 20 Hz to 20 kHz. Square-wave output Is obtained by using LM301A opamp es Schmitt triggar.—S. Franco, Current-Controlled Trienguler/Squere-Wave Generator, *EDN Magazine*, Sept. 5, 1973, p 91.



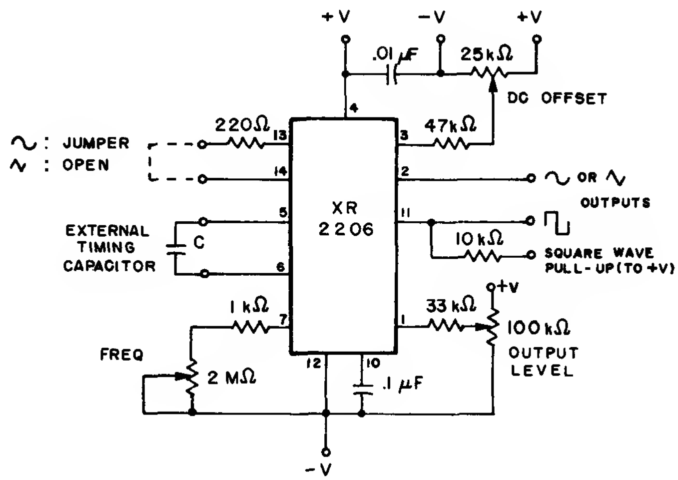


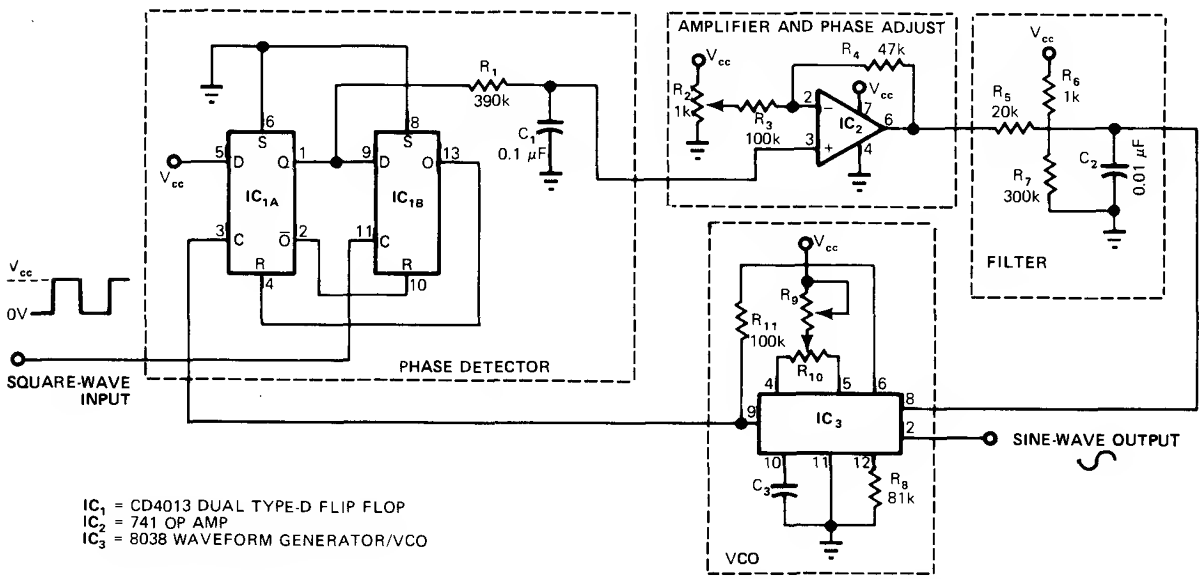
SINGLE CONTROL FOR 1,000,000:1 FREQUENCY RANGE—Uses two RCA CA3130 opamps end CA3080A operetional transconductance emplifier to generate squere and triengle outputs thet can be swept over renge of 0.1 Hz to 100 kHz with single 100K pot R1. Alternete voltage-control input is availeble for remote adjustment of sweep frequency. IC1 is operated es voltage-controlled current sourca whose output current is applied directly to integrating capacitor C1 in feedback loop of integrator IC2. R2 adjusts symmetry of triangle output. IC3 is used es controlled switch to set excursion limits of triangle output when squere wave is desired.—"Lineer Integreted Circults and MOS/FET's," RCA Solid Stata Division, Somerville, NJ, 1977, p 236–244.



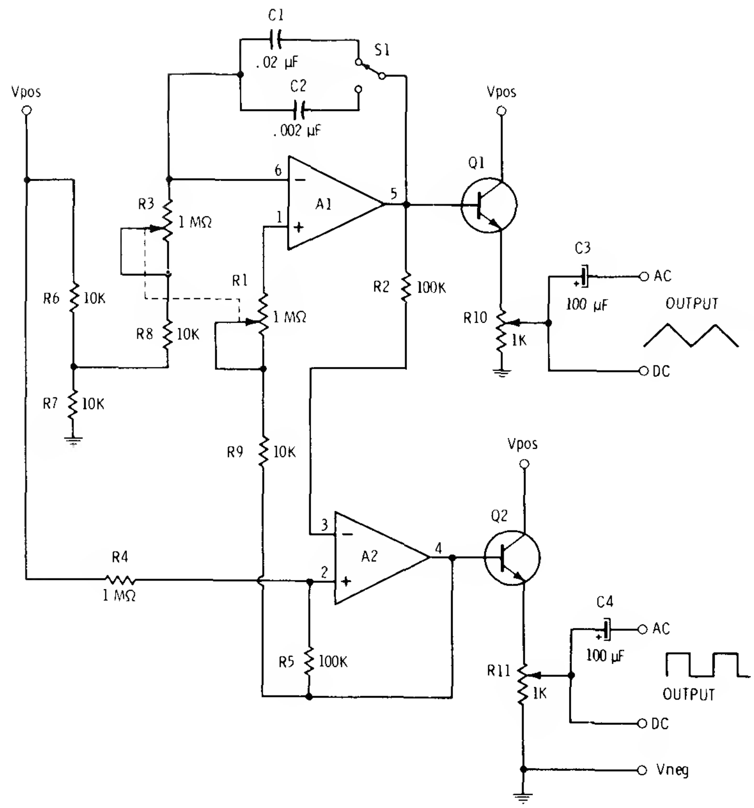
VOLTAGE-CONTROLLED NONLINEAR—Circuit produces function $E_o = X^{Y/2}$, where X is input voltage in range of +10 mV to +10 V and Y is analog programming voltage in range of −0.4 V to −10 V. Uses Optical Electronics 2534 temperature-compensated log feedback elements, +5 V reference, two high-frequancy opamps, and one low-frequency opamp. 2534 produces log conversion of input signal. 5898 multipliar serves to vary scale factor of log signal. With offsets used as shown, +10 V input will always produce +10 V output regardless of Y input. To set up, adjust R4 until output does not change with Y for +10 V input, then adjust R7 for +10 V output with +10 V input.—"Voltage-Controlled Non-Linear Function Generator," Optical Electronics, Tucson, AZ, Application Tip 10263.

0.5 Hz TO 1 MHz SINE-SQUARE-TRIANGLE—Uses Exar XR-2206 IC function generator in simpla circuit that operates from dual supply ranging from ±6 V to ±12 V. With 1-μF capacitor for C, 2-megohm frequency control covers ranga of 0.5–1000 Hz. Range is 5–10,000 Hz with 0.1 μF, 50 Hz to 100 kHz with 0.01 μF, and 500 Hz to 1 MHz with 0.001 μF. Designed for axperimants with active filters.—H. M. Berlin, "Design of Activa Filters, with Experiments," Howard W. Sams, Indianapolis, IN, 1977, p 9–10.

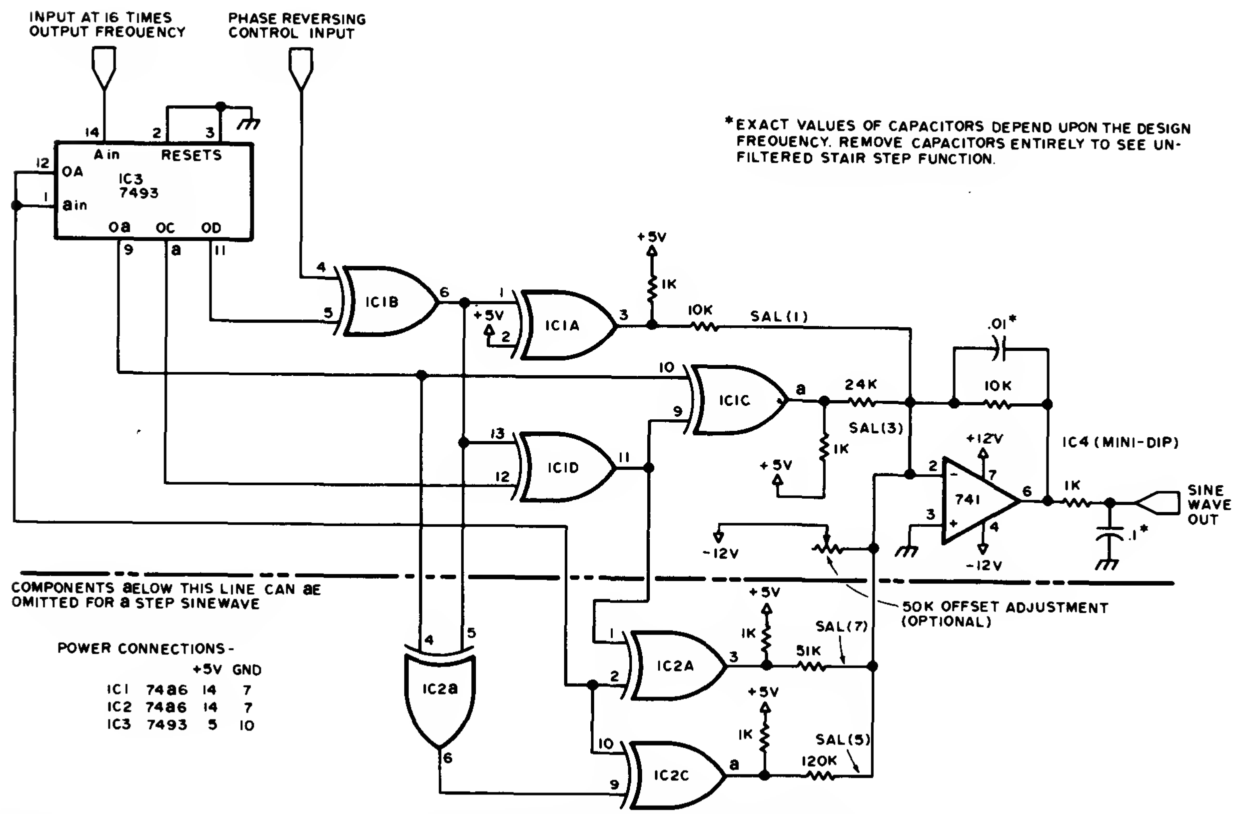




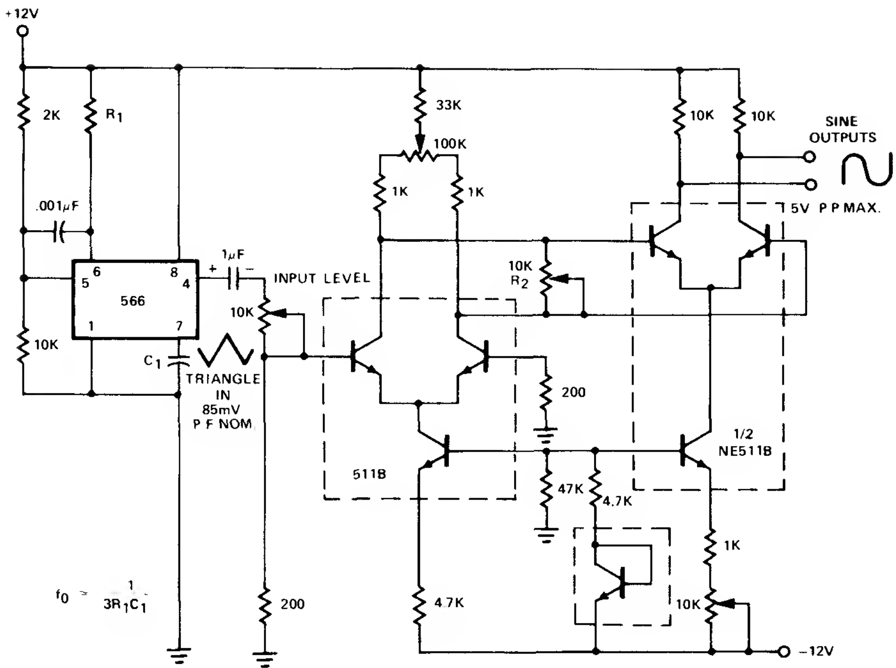
SQUARE TO SINE WITH PLL—8038 waveform genarator simultaneously ganarates synthasized sina wava and square wava. Square-wave output closes phase-locked loop through 741 opamp IC_2 and dual flip-flop IC_1, while sine-wave output functions as converted output. Canter frequency is $0.15/R_9C_3$. R_{10} should be at least 10 times smaller than R_9. If center frequency is 400 Hz, capture ranga is half that or ±100 Hz. When input is applied, phasa comparator generates voltage related to frequency and phase difference of input and free-running signals. IC_2 amplifies and offsets phase-difference signal. Sine output has less than 1% distortion, DC component of 0.5 V_{CC}, and minimum amplitude of 0.2 V_{CC} P-P.—L. S. Kasevich, PLL Converts Square Wave into Sine Wava, *EDN Magazine*, June 20, 1978, p 128.



VARIABLE SQUARE-TRIANGLE—Dual pot R1-R3 varies frequency over range of 15–500 Hz when C1 is in circuit and 150–4800 Hz when C2 is in circuit. Each output has amplitude control. Opamps are Motorola MC3401P or National LM3900, and transistors are 2N2924 or equivalent NPN. Supply can be 12 VDC.—C. D. Rakas, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 19–20.

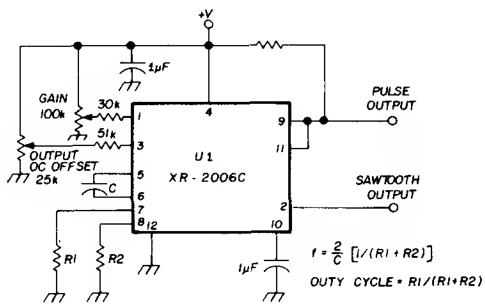


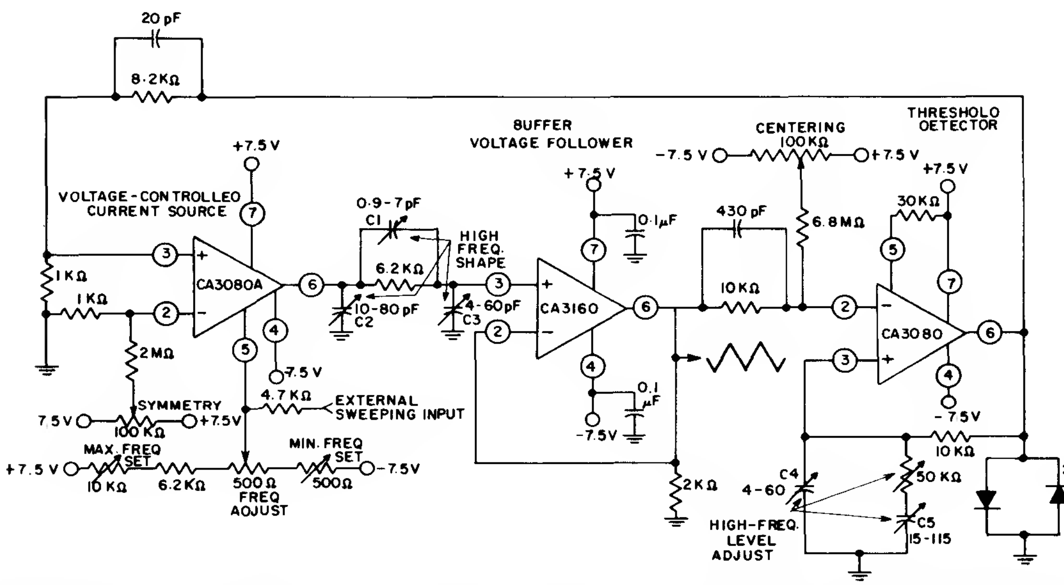
DIGITAL FOURIER—Sine-wave generator produces Walsh-function approximation of sine function. Frequency of sine wave is set by square-wave input to pin 14 of 7493. Filter components of opamp help smooth staircase waveform generated by summing Walsh-function components as weighted by resistors. Circuit is converter consisting of digital expander that expands input square wave into variety of digital waveforms and analog combiner that adds these waveforms to produce periodic analog output. Negative signs of Walsh harmonics are handled with digital inverter, and magnitudes are handled by choice of resistor value in summing junction. Signs and magnitudes are under microprocessor control. Net output is stairstep approximation to desired output, which can be smoothed by low-pass filter.—B. F. Jacoby, Walsh Functions: A Digital Fourier Series, *BYTE*, Sept. 1977, p 190–198.



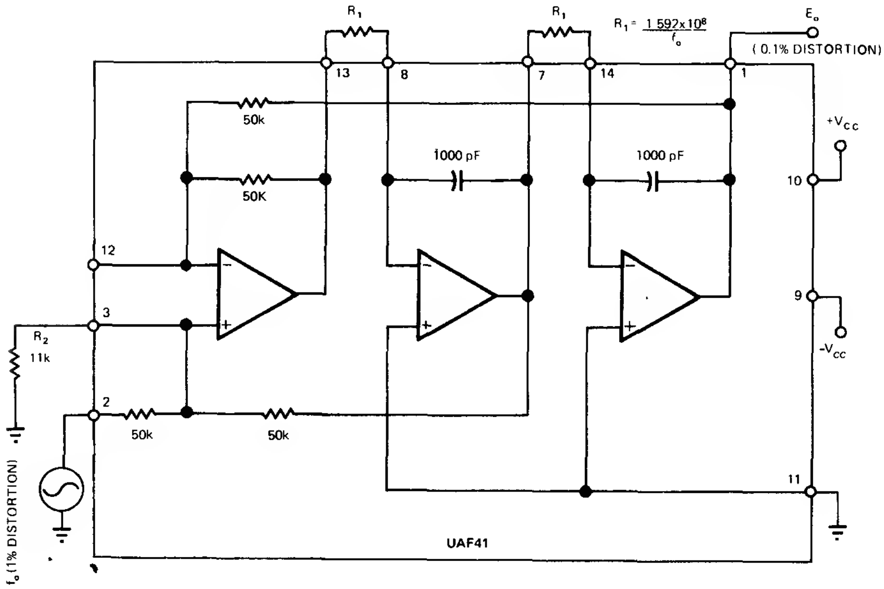
TRIANGLE-TO-SINE CONVERTER—Nonlinear amittar-base junction charactaristic of 511B transistor array is used for shaping triangla output of 566 function ganarator to giva sine output having less than 2% dlstortion. Amplitude of triangla is critical and must be carefully adjusted for minimum distortion of sine wava by varying valuas of R_1, R_2, and input laval pot while monitoring output with Hewlett-Packard 333A distortion analyzer.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 851–853.

PULSE/SAWTOOTH GENERATOR—Pulse output is obtained from Exar XR-2006C functionganarator IC when pin 9 is shorted to squarewave output at pin 11. Pulse duty cycla, along with rise and fall times of ramp from pin 2, is detarmined by values of R1 and R2. Both can be adjusted from 1 to 99% by propar salection of resistor values as givan in formulas alongside diagram.—E. Noll, VHF/UHF Single-Frequency Conversion, *Ham Radio*, April 1975, p 62–67.



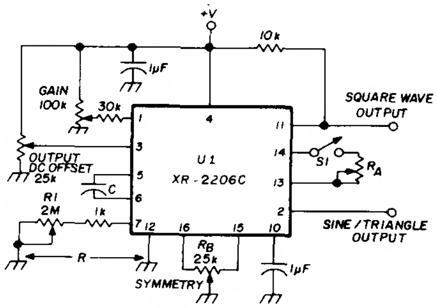


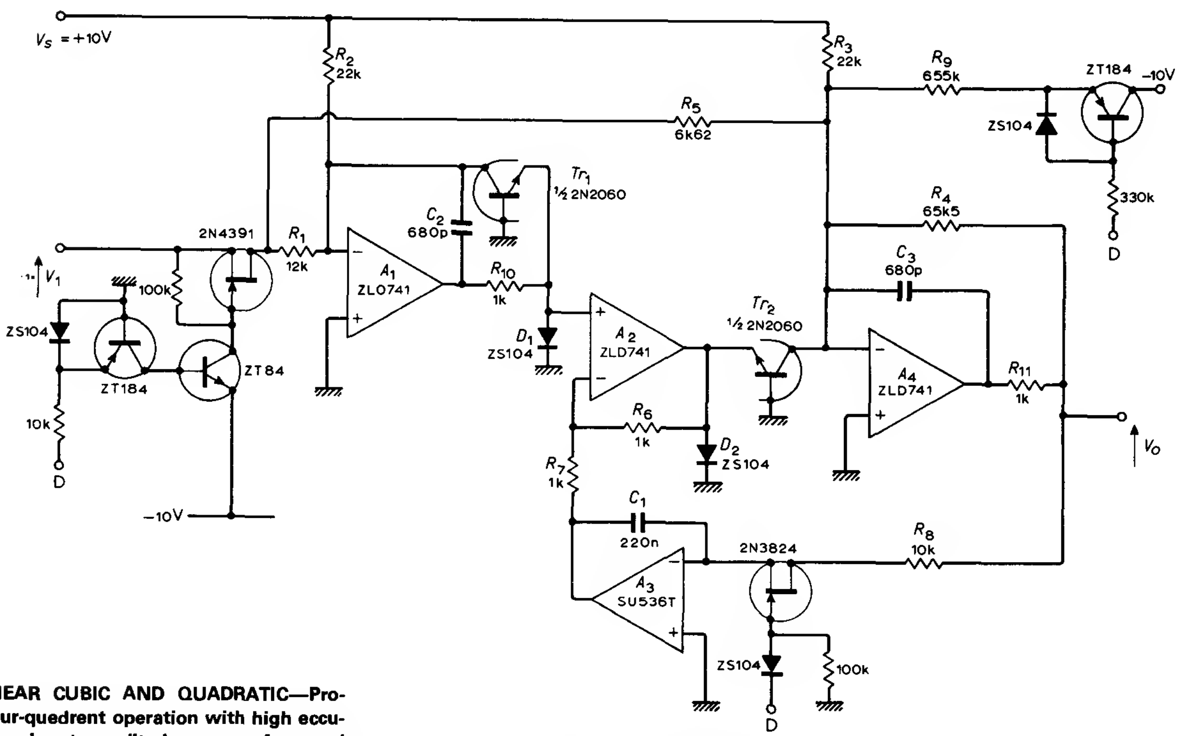
SINGLE FREQUENCY CONTROL—Adjustment range of ovar 1,000,000 to 1 for fraquancy is achieved by using CA3080A as programmable current source, CA3160 opamp as voltaga follower, and CA3080 variable opamp as high-speed capacitor. Variable capacitors C1-C3 shapa triangle waveform batwean 500 kHz and 1 MHz. C4 and C5 with 50K trimmer in saries with C5 maintain constant amplituda within 10% up to 1 MHz.—"Circuit Ideas for RCA Linaar ICs," RCA Solid State Division, Somervilla, NJ, 1977, p 6.



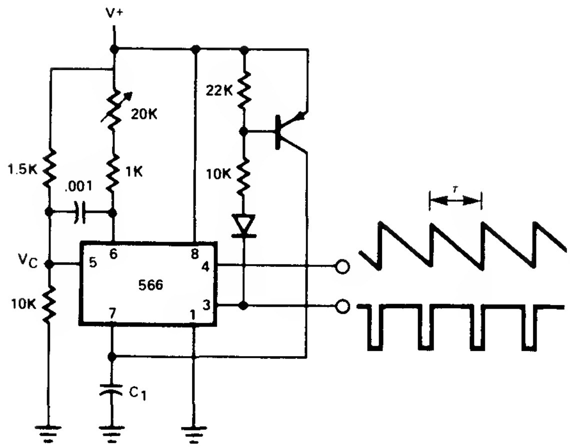
REDUCING DISTORTION—Use of UAF41 universal active filter et output of function generetor reduces distortion of sine-wave output by eliminating some of harmonics. In typical application, two-pole active filter reduces 1% distortion down to 0.1%, using low-pass configuration. Article givas design aquations. For 1-kHz cutoff, R_1 should be 159.2K.—Y. J. Wong, Design a Low Cost, Low-Distortion, Precision Sine-Weve Oscillator, *EDN Magazine*, Sept. 20, 1978, p 107–113.

1 MHz—Simple sinusoidal generetor using Exar XR-2206C IC provides sine, triangle, or square outputs. For sina output, S1 is closed and R_A and R_B are adjusted for minimum distortion. Exact output frequency f is 1/RC where R is about 2 megohms from pin 7 to ground and C is connected between pins 5 end 6. FM output is obtained when modulating input is applied to aither pin 7 or 8. For AM output, modulation is epplied to pin 1.—E. Noll, VHF/UHF Single-Frequency Conversion, *Ham Radio*, April 1975, p 62–67.

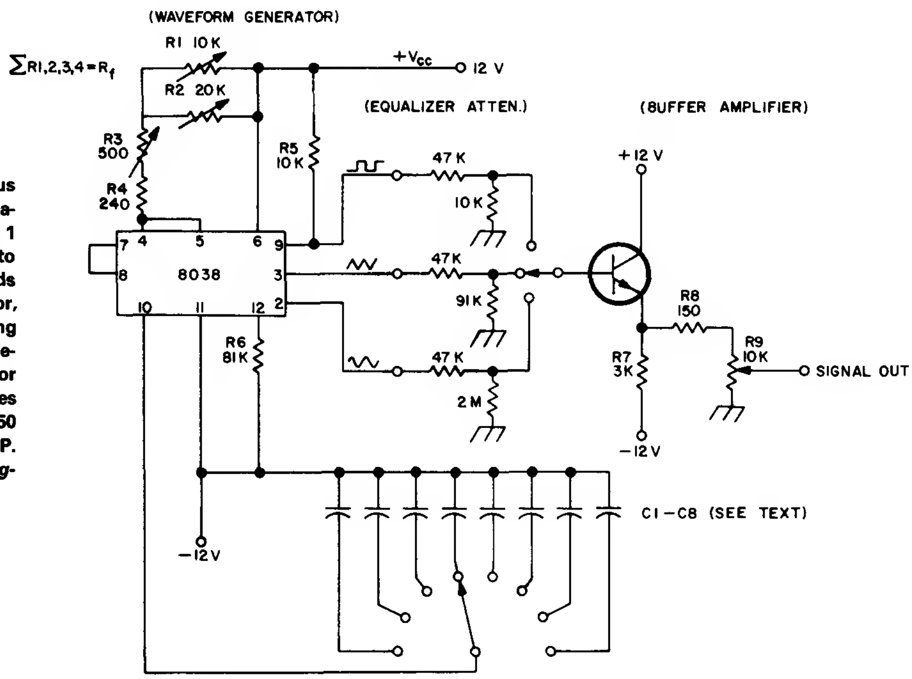




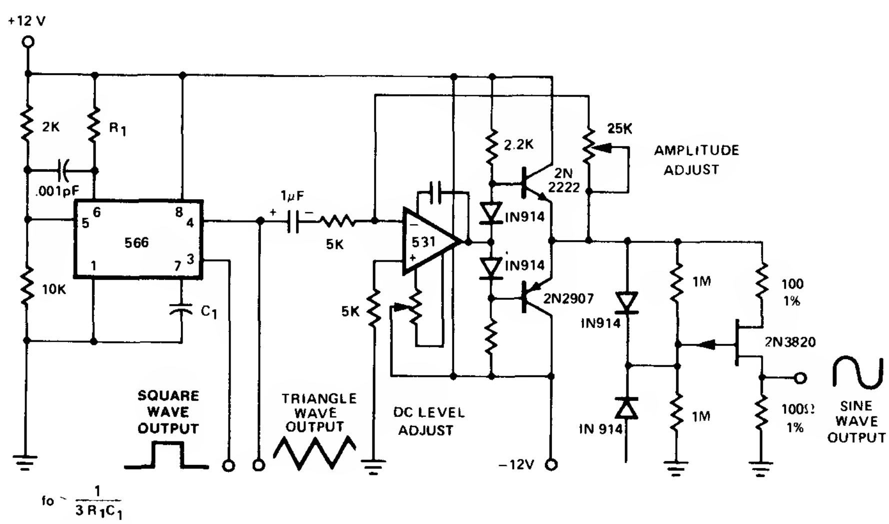
NONLINEAR CUBIC AND QUADRATIC—Provides four-quedrent operation with high eccuracy over input amplitude range of several decades. Applications include enelog computations for radar end ballistic problems, linearization of transducer cheracteristics, and teaching theory of quadratic aquations. Article gives design equetions and complete design procedure.—H. McPherson, Non-Lineer Function Generator, *Wireless World*, Oct. 1972, p 485–487.



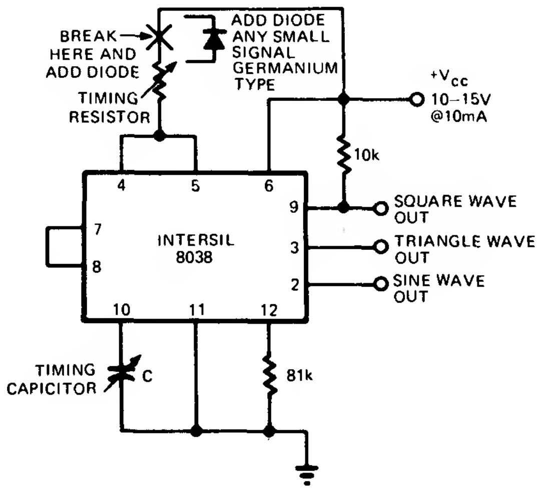
NEGATIVE RAMP—Connection shown for 566 function generator gives negative output ramp having period equal to 1/2f where f is normel free-running frequency of 566 as determined by supply voltage and RC values used. Ramp has very fast reset because PNP transistor charges timing capacitor C_1 rapidly et end of discharge period. Short output pulse is aveileble at pin 3.—"Signetics Analog Date Manuel," Signetica, Sunnyvale, CA, 1977, p 851.



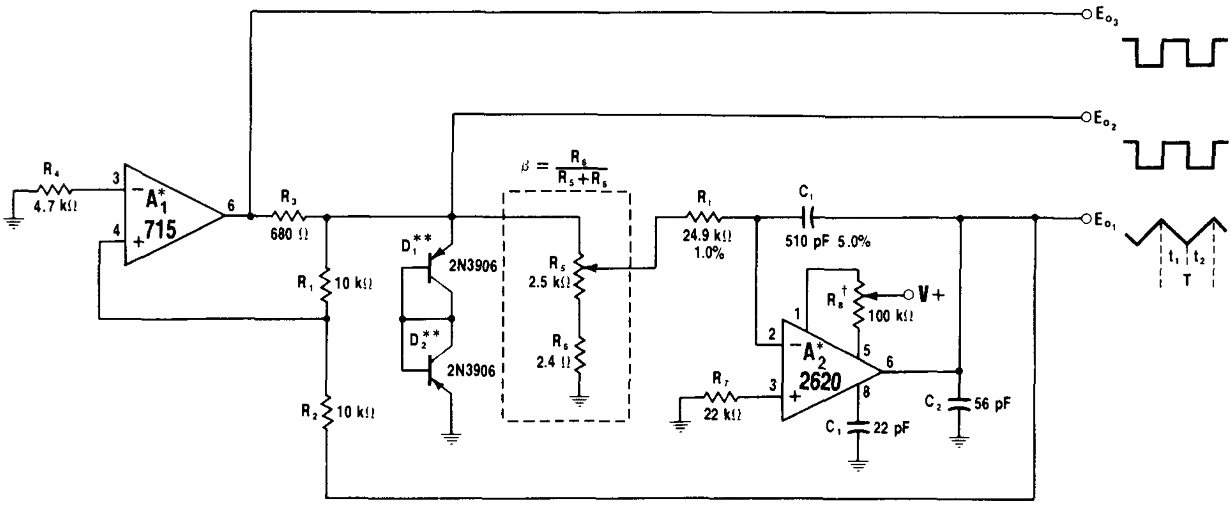
THREE-WAVEFORM—Gives simulteneous aine, squere, and triangle outputs with low diatortion (1%), high linearity (0.1%), 0.05 Hz to 1 MHz frequency renge, and duty cycle of 2% to 98%. Intersil 8038 weveform generator feeds buffer amplifier using 2N3709 transistor, switched to desired output waveform. Timing capacitors C1-C8, determining frequency decades of signal generetor, start with 500 μF for 0.05 Hz to 0.5 Hz and decrease in submultiples of 10 to 500 pF for 50 kHz to 500 kHz. C8 is 250 pF for finel renge of 100 kHz to 1 MHz.—H. P. Fisher, Precision Waveform Generator, *73 Magazine*, Dec. 1973, p 41–43.



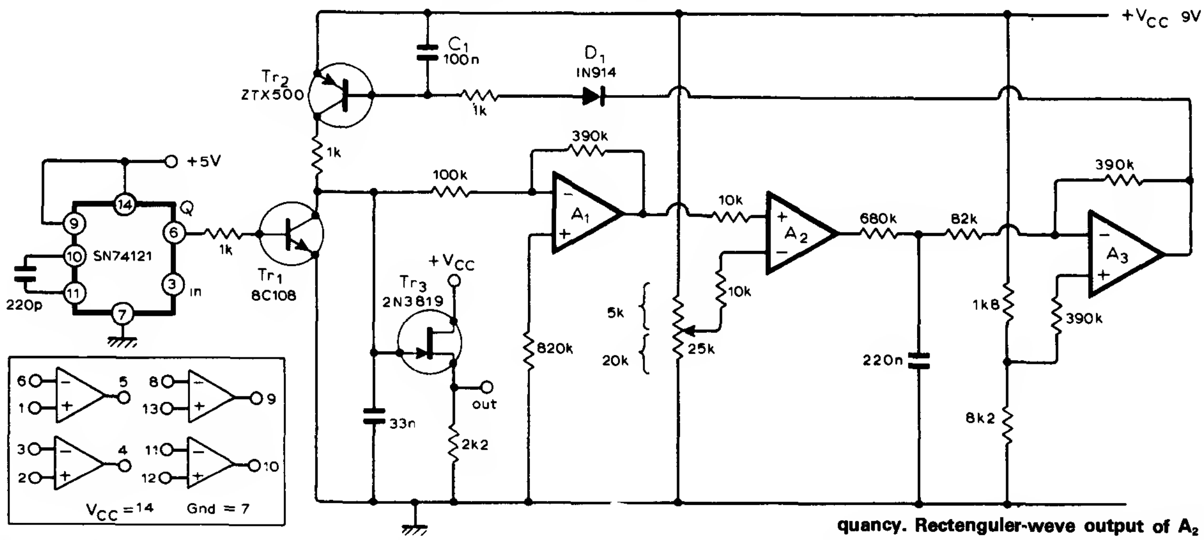
FET TRIANGLE TO SINE CONVERTER—Use of nonlinear transfer characteristic of P-channel junction FET to shape triengle output of 566 function generator gives sine weve having less then 2% distortion. Amplitude of triangle wave is critical end muat be carefully adjusted for minimum distortion of sine output.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 851–852.



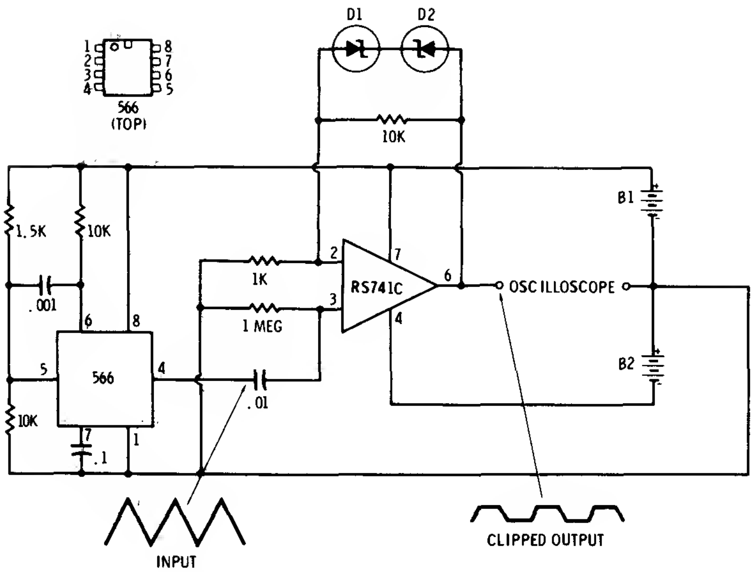
DIODE CANCELS SUPPLY CHANGES—Adding any small-signal germanium diode to Intersil 8038 sine-square-triangle function generator as shown will compensate for changes in supply voltage. When using diode, change from 10 to 15 V produces only 5-Hz change in output over frequency range of 100–10,000 Hz. Technique can be applied to other IC function generators, such as Signetics 565, as well as to 555 timers.—R. Liebman, Single Diode Compensates IC Oscillator, *EDN Magazine*, April 20, 1974, p 87.



20–20,000 Hz SQUARE-TRIANGLE—R_t and C_t are chosen for upper frequency limit of 20 kHz, and oscillator is adjustable down to lower limit of 20 Hz with R_5. Circuit will operate up to 100 kHz if component values are suitably changed. A_2 should be offset-nulled by adjusting for best symmetry at lowest frequency. Total width of T of output waveform varies between 50 μs and 50 ms at frequency range covered.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 381–383.

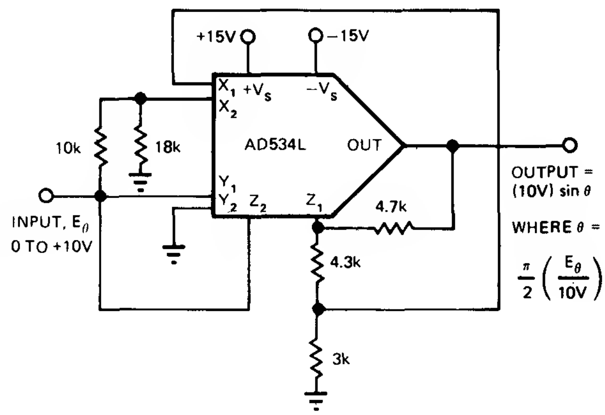


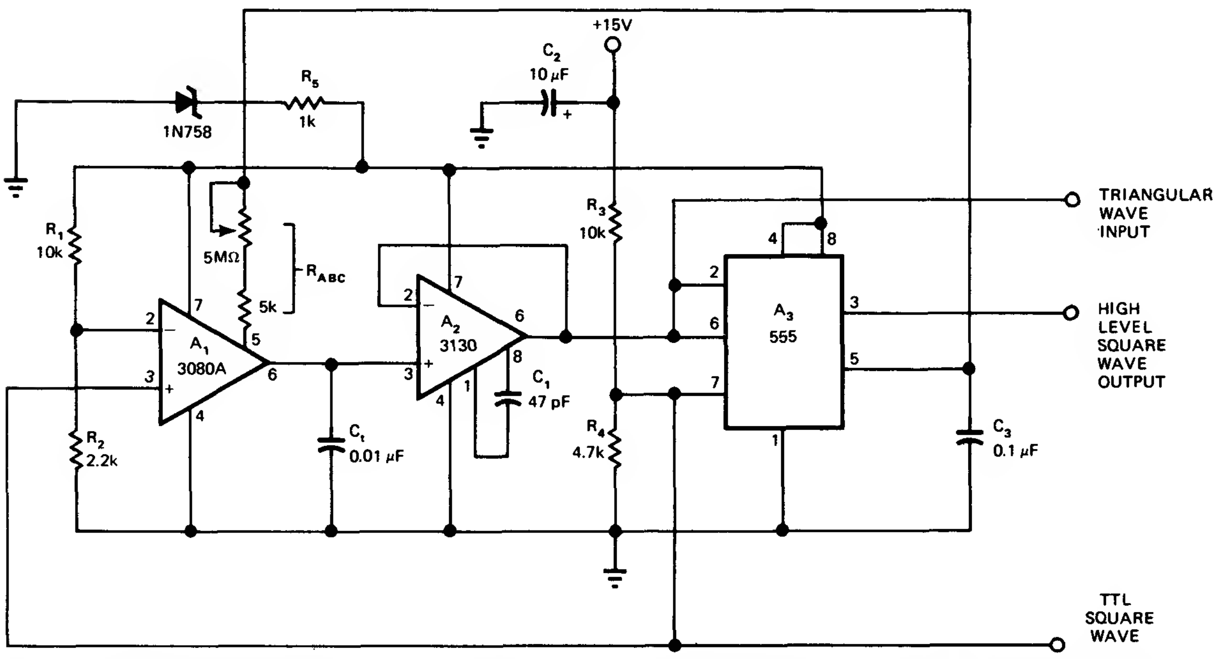
DRIVEN CONSTANT-AMPLITUDE SAWTOOTH—Gives constant-amplitude output over input frequency range of 2–100 kHz. Input signal from SN74121 IC is 300-ns pulse that drives basic sawtooth generator Tr_1-Tr_2. Resulting sawtooth waveform is amplified by opamp A_1 of MC3401P four-opamp package and fed to A_2 which acts as comparator for amplitude-sensing. 25K threshold-setting pot is adjusted for maximum linearity of amplitude versus frequency. Rectangular-wave output of A_2 is filtered to give control voltage that is shifted in level by A_3 and D_1 to meet input voltage requirements of Tr_2. Desired sawtooth output appears at source of Tr_3.—J. N. Paine, Constant Amplitude Sawtooth Generator, *Wireless World*, Oct. 1975, p 473.



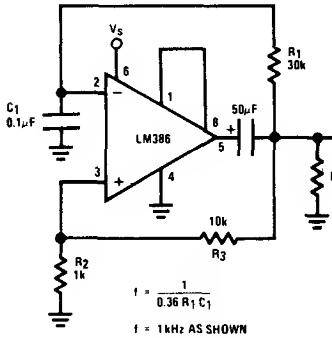
TRIANGLE-WAVE CLIPPER—Triangle-wava generator using 566 function generator is connected to RS741C opamp for clipping positive and negative peaks of triangle waves. Output as seen on CRO is modified square wave with sloping side. Clipping level dapenda on voltaga ratings of zeners used. Supply voltages can range from 1.5 to 9 V each. Can be used for classroom demonstrations.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 37–44.

TRIANGLE TO SINE—Expresslon approximating sine function from 0 to 90° is generated by function fitting and duplicated by using AD534L analog multiplier and appropriate close-tolerance (0.1%) resistors. Accuracy of sine wave is within ±0.5% at all points. Linaarly increasing voltage of triangla develops rising sinusoidal output. Conversely, linearly decreasing input generates mirror of riaing sinusoids. Increasing triangle waveform, then bringing it back to zero again, completes full cycla of sine-wava output.—R. Frantz, Analog Multipliers—New IC Versions Manipulate Real-World Phenomana with Ease, *EDN Magazine*, Sept. 5, 1977, p 125–129.

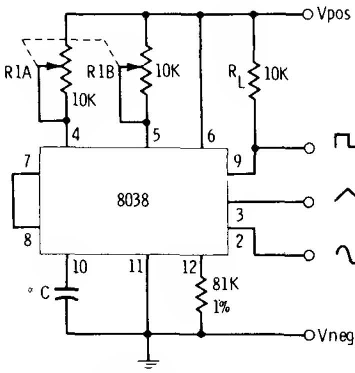




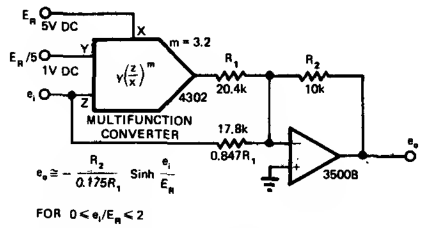
30–20,000 Hz SQUARE-TRIANGLE—Uses 555 timer as bilevel threshold detector, together with A_1 as bidirectional constant-current sourca and A_2 as buffer amplifiar. If buffared triangle output is not needed, opamp A_2 can be omitted. A_1 charges C_t between +5 and +10 V threshold points of 555 to give linear triangle output for buffering by A_2. Simultaneously, toggling of 555 between its high and low output generates square wava of about 13 V at pin 3, along with 5-V TTL output at pin 7 for additional square-wave output and for controlling state of A_1.—W. G. Jung, Build a Function Generator with a 555 Timar, *EDN Magazine,* Oct. 5, 1976, p 110.



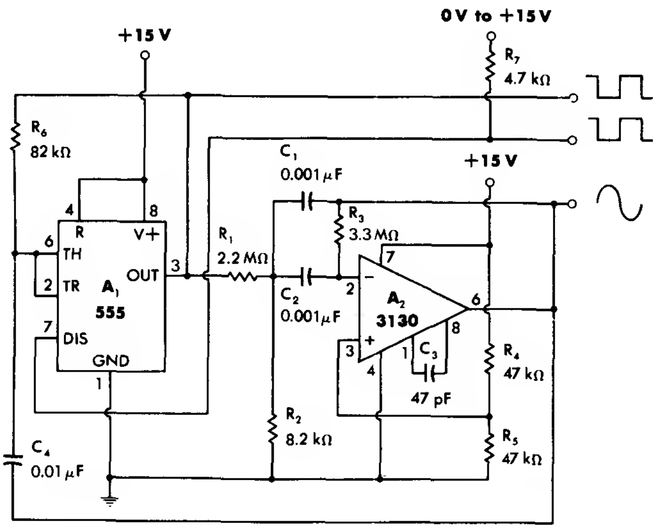
1 kHz SQUARE-TRIANGLE—National LM386 opamp oparating from 9-V supply ganarates 1-kHz square wave at 0.5 W for driving 8-ohm loudspaakar or other load. Exact fraquancy is datarmined by values used for R_1 and C_1. Triangle output can be taken from pin 2. Pins 1 and 8 can be shorted bacausa DC offset voltages are unimportant.—"Audio Handbook," National Samiconductor, Santa Clara, CA, 1977, p 4-30–4-33.



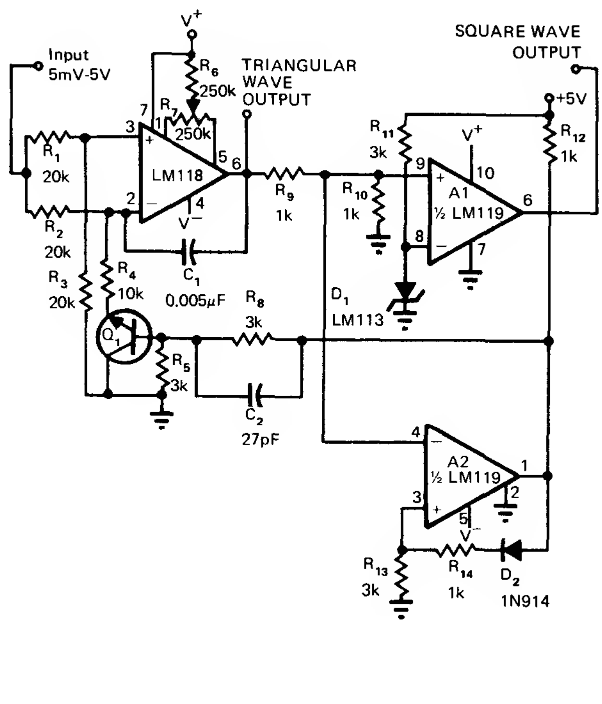
90–900 Hz SINE-SQUARE-TRIANGLE—Ganged 10K dual pot covers ranga whan C is 0.25 μF for 8038CC waveform generator. Othar valuas of C (from 0.005 μF to 2.2 μF) give different frequency ranges between 10 Hz and 50 kHz. Linaarity of waveforms dapends on tracking precision of dual pot.—C. D. Rakes, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 116–120.



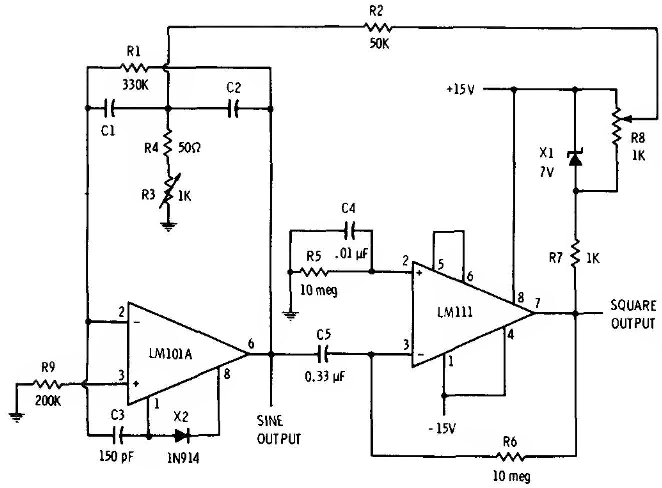
HYPERBOLIC SINE—Burr-Brown 4302 multifunction converter and opamp genarate hyperbolic sine transfar function with response matching ideal curve within 0.7%. Techniqua permits satting powers and roots at fractional as well as integar values. Converter shown is set for axponent of 3.2. Choice of amplifier gain and referenca voltage scales response for given input and output signal levels. Article gives design equations.—J. Graama, Sinh Ganerator Boasts 0.7% Error, *END Magazine*, Aug. 5, 1978, p 70 and 72.



1-kHz SINE-SQUARE—555 timer starts as astable MVBR but then acts with A_2 to form multiple-feedback bandpass filtar that ramoves harmonics from square wave to give sine-wave output with distortion less than 2%. Sine output is fed back to timer through C_4 which now oparates as Schmitt trigger, shaping sina wava to give output square wave. Frequency is determined primarily by filtar components C_1, C_2, R_1, and R_2. Output is about 9 V P-P.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 203–204.

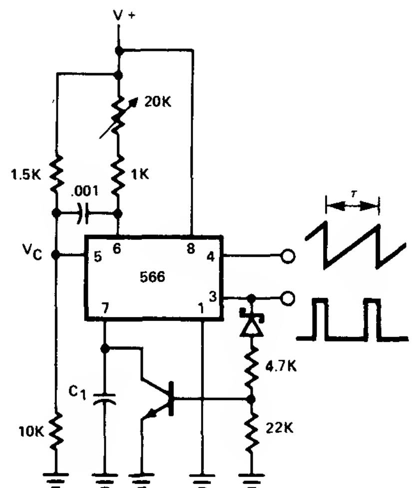


SQUARE-TRIANGLE VCO—With DC control voltage of 5 mV to 5 V, circuit controls frequency of both squara and triangle outputs with good linearity. Peak value of triangla output is precisaly sat at 2.44 V and 0 V by reference voltages at noninverting inputs of comparators. Comparator A2 drives load for low outputs, while comparator A1 drives load when output is high. Article talls how circuit works.—R. C. Dobkin, Comparators Can Do More Than Just Compare, *EDN Magazine*, Nov. 1, 1972, p 34–37.

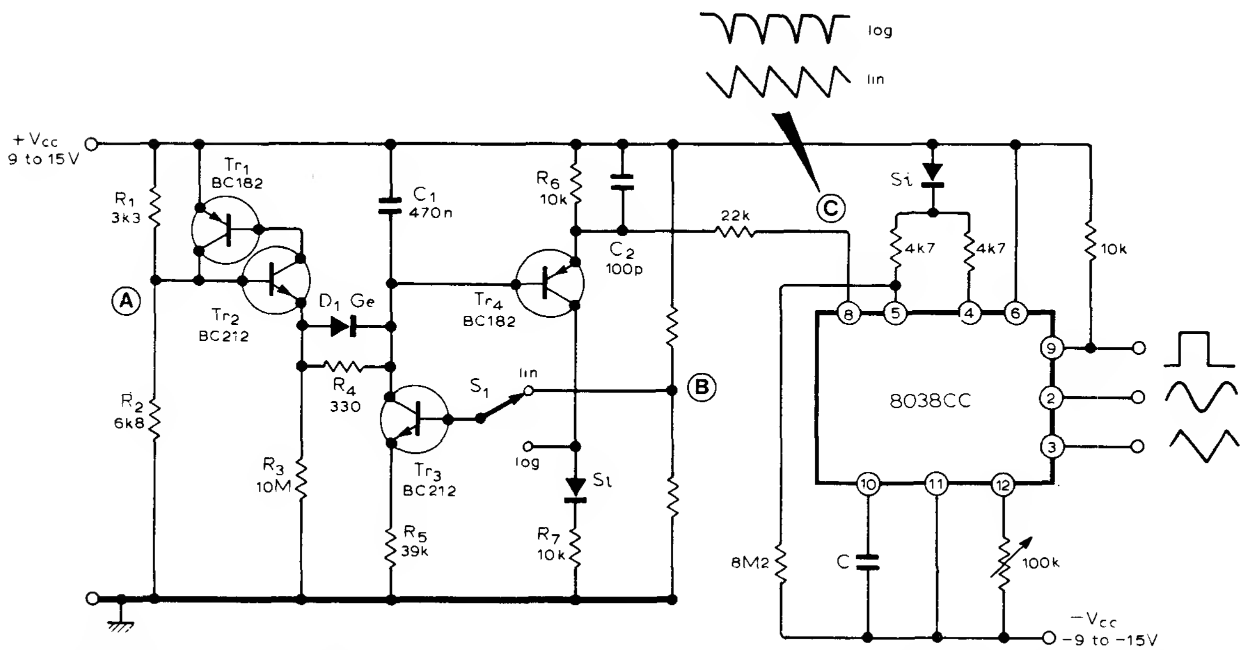


18–20,000 Hz SINE-SQUARE—Circuit uses two opamps to obtain necessary positive feedback for sustaining oscillation. RC network of first stage acts as tuned circuit, permitting operation only at frequency determined by values of R and C. Pot R3 provides tuning over significant frequency range. Pot R8 controls amplitude of sine output. Zener X1 stabilizes amplitude of square output. Sine signal is applied to LM111 acting as limiter to provide desired square wave. Table gives values of C1 and C2 for five different frequency ranges.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 123–124.

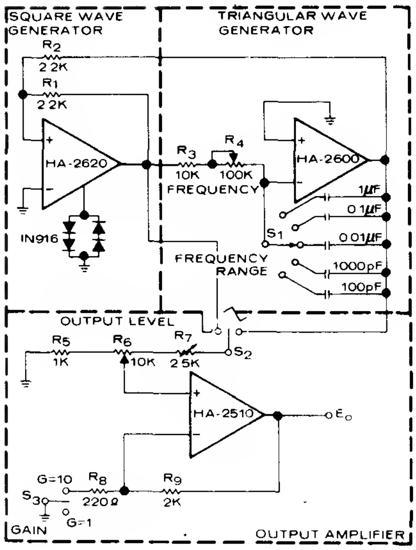
C1, C2	MIN FREQ	MAX FREQ
0.47 μF	18 Hz	80 Hz
0.1 μF	80 Hz	380 Hz
.022 μF	380 Hz	1.7 kHz
.0047 μF	1.7 kHz	8 kHz
.002 μF	4.4 kHz	20 kHz



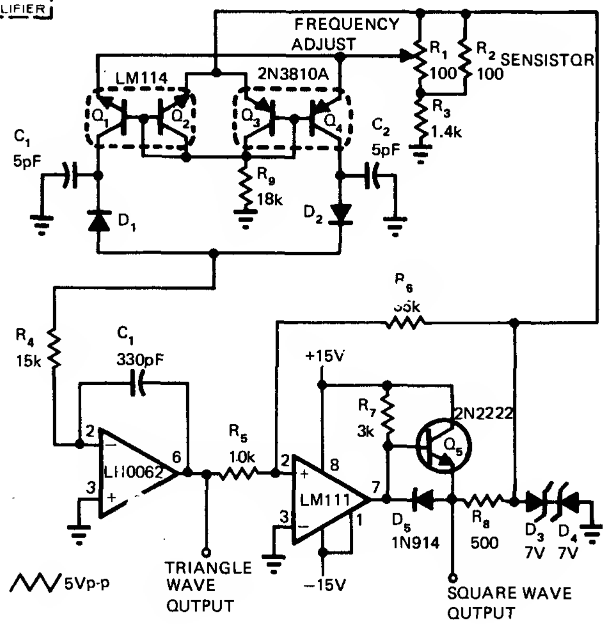
POSITIVE RAMP—NPN transistor across timing capacitor C_1 of 566 function generator gives fast charging of capacitor at end of discharge period, for positive ramp having very fast reset. Period of ramp is equal to 1/2f where f is normal free-running frequency of 566 as determined by supply voltage and RC values used.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 851.



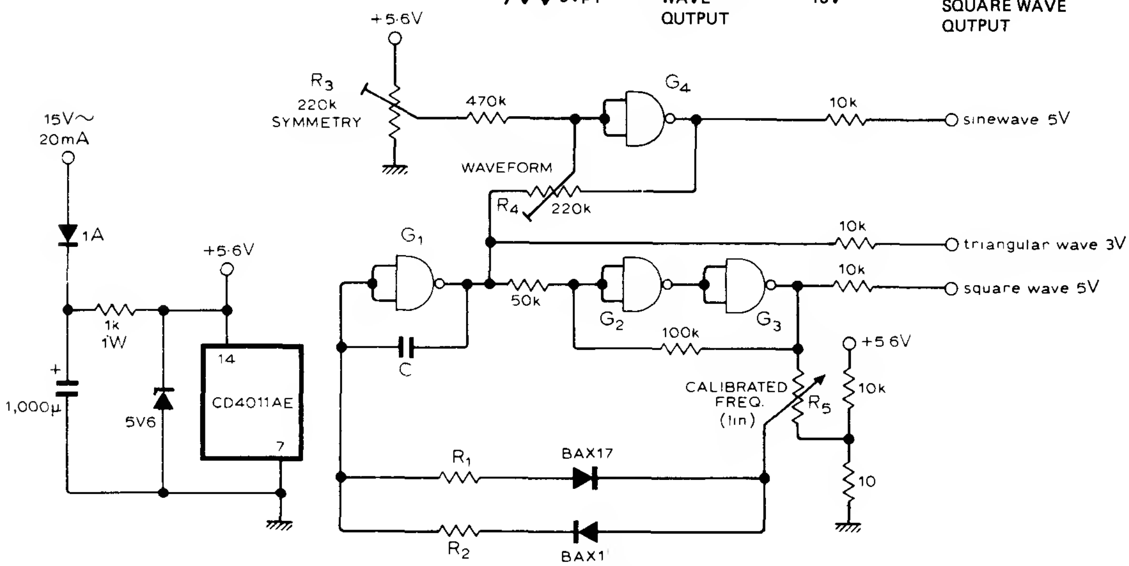
SINE-SQUARE-TRIANGLE WITH LIN/LOG SWEEP—Four-transistor circuit provides choice of linear or logarithmic sweeps for Intersil 8038 IC function generator. In linear mode, constant-current generator Tr_3 charges C_1 almost linearly, with Tr_1-Tr_2 resetting C_1 when its voltage reaches about one-third V_{cc} plus 0.9 V. In logarithmic mode, positive feedback provides exponential charging of C_1. Voltage at B must be set experimentally because it depends on V_{cc}. For overall frequency control, make R_5 variable. Point A has short positive pulse that can be used to reset capacitor C of IC, and to sync an oscilloscope.—S. Villona, Linear/Logarithmic Sweep Generator, *Wireless World*, Dec. 1976, p 42.



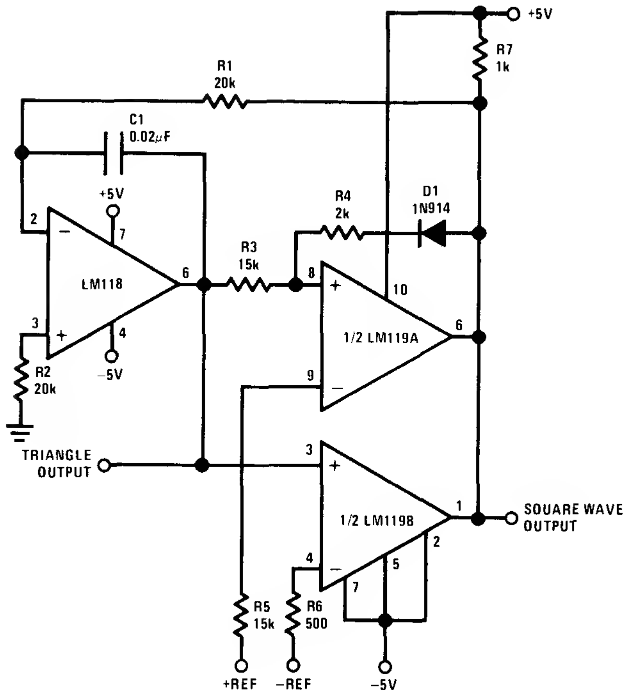
2.5 Hz TO 250 kHz SQUARE-TRIANGLE—Five switched frequency ranges each give continuous variation of frequency ovar ona decada and adjustment of output amplitude from 0.2 to 20 V P-P. Slope of triangle is highly linear, and risa tima of squara wave is less than 100 ns. Squarewava generator is simple hystaresis circuit triggered by triangle generator. Output voltaga is clamped to desirad laval by diodes connected to bandwidth control point. Output opamp is salected for high slew rate. S_3 gives choica of 1 or 10 for gain. Maximum output current should ba limited to 20 mA.—"Linear & Data Acquisition Products," Harris Semiconductor, Malbourne, FL, Vol. 1, 1977, p 7–25 (Application Nota 510).



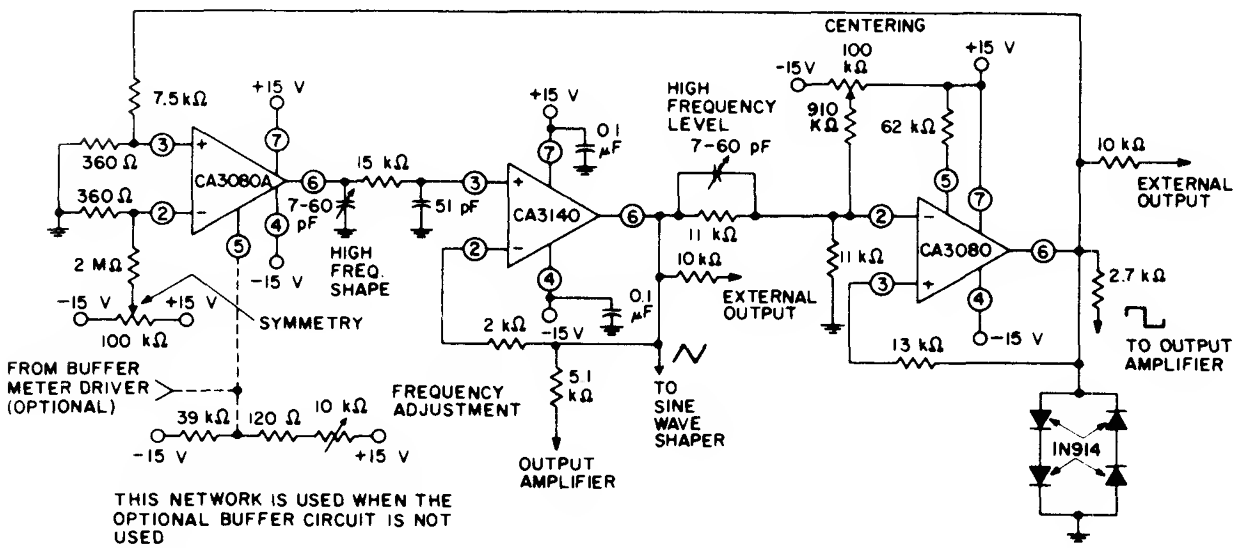
1 Hz TO 100 kHz SQUARE-TRIANGLE—Wideranga function ganarator built around LM111 comparator provides two diffarant output waveforms whose frequency can be varied over fiva decades by R_1, from 1 Hz to 100 kHz. Two transistor pairs ara used to vary charging current of timing capacitor exponentially. Output currant from transistor pairs is controlled by linaar pot, so rotation of pot is proportional to log of output frequency. Sansistor R_2 provides temparatura compensation for transistor pairs.—R. C. Dobkin, Comparators Can Do More Than Just Compara, *EDN Magazine*, Nov. 1, 1972, p 34–37.



SINE-SQUARE-TRIANGLE AT 3–5 V—Usas CD4011 IC oparating from 15-V AC lina as at left. NAND gates of IC are connected as at right, with G_1 serving as integrator with variabla dalay tima, G_2-G_3 as Schmitt trigger, and G_4 as triangla to sine-wava convartar. Sine-wava approximation, dapanding on transfer function of G_4, is calibrated by R_3 and R_4. Valuas of R_1 and R_2 may ba variad betwaen 0.01 and 10 magohms and C betwaan 100 pF and 2.2 μF to obtain desired sawtooth and pulsa wavaforms at dasirad fraquancy datermined by setting of R_5.—J. W. Richter, Single I.C. Function Ganarator, *Wireless World*, Nov. 1976, p 61.



HIGH-PRECISION TRIANGLE—Opamp circuit provides easily controlled peak-to-peak amplitude of triangle wave suitable for use in sweep circuits and test equipment. Positive and negative peak amplitudes are controllable to accuracy of about ±0.01 V by DC input. Output frequency is likewise easily adjusted over range of two decades. Circuit consists of integrator and two comparators. One comparator sets positive peak, and other sets negative peak. Operating frequency depends on R1, C1, and reference voltages. Maximum difference in reference voltages is 5 V. Frequency limit is about 200 kHz.—R. C. Dobkin, "Precise Tri-Wave Generation," National Semiconductor, Santa Clara, CA, 1973, LB-23.

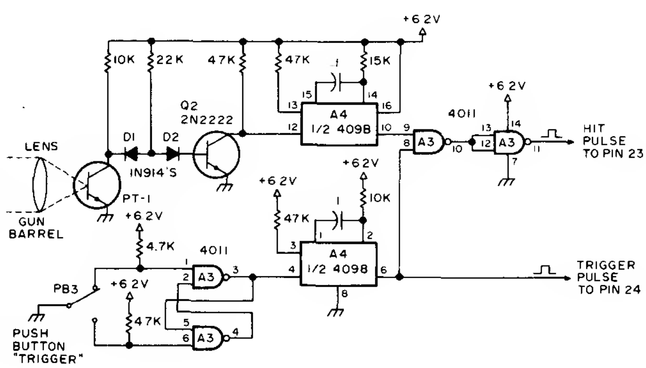


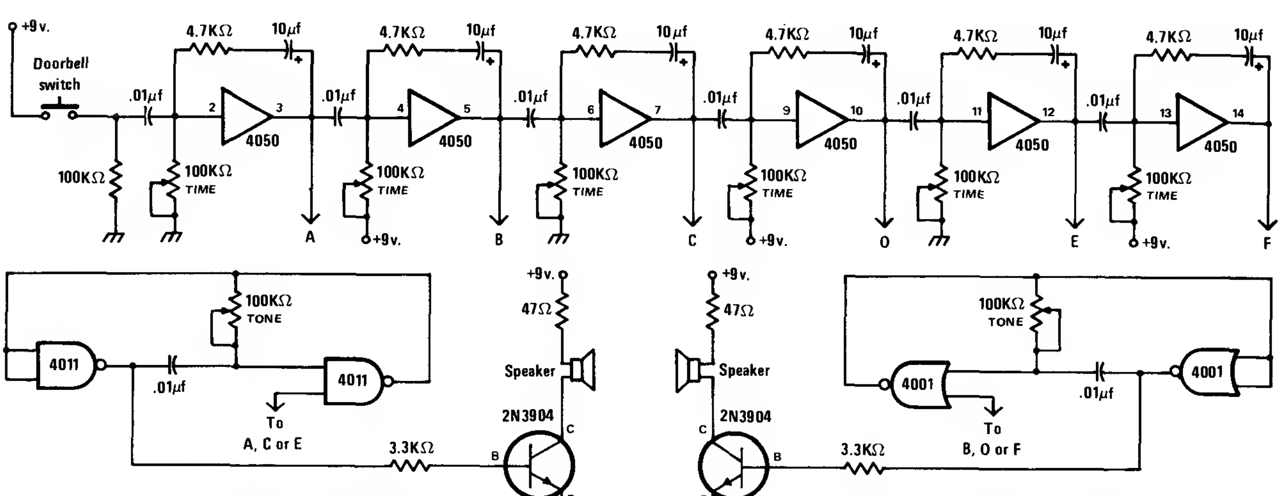
REMOTE FREQUENCY CONTROL—Frequency of square and triangle outputs can be adjusted over range of 1,000,000:1 with 10K pot or by varying DC voltage applied to pin 5 of CA3080A over wire line from remote location. CA3140 serves as noninverting readout amplifier for triangle wave developed across integrating capacitor network at output of CA3080A current source. Second CA3080 acts as high-hysteresis switch having trip level established by four diodes, to give desired square-wave output.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 248–254.

CHAPTER 38
Game Circuits

Included are chip connections, VHF modulators, score generators, and sound effects for variety of TV games, along with electronic dice, roulette wheel, coin tosser, robot toy, model railroad switch, six-note chimes, and attention-getting LED displays.

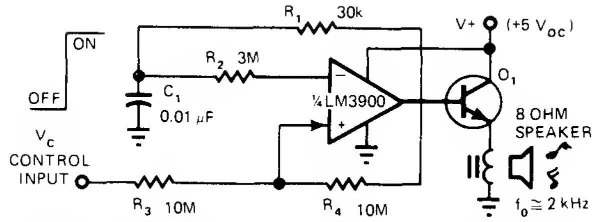
RIFLE—Developed for use with General Instrumants AY-3-8500-1 TV gama chip to simulete target practica with rifle. Player aims at bright target spot moving rendomly across TV screen. If gun is on target when trigger is pulled, phototrensistor in barrel picks up light from terget and generates pulse for producing sound effect of hit end incramenting playar's score. PT-1 can be TIL64 or equivalent phototransistor. 4098 is dual mono, and 4011 is quad two-input NAND gate. Pulse outputs go to pins of geme chip. Article gives all circuits but covers construction only in genaral tarms.—S. Ciarcie, Hay, Look What My Daddy Builtl, *73 Magazine*, Oct. 1976, p 104–108.



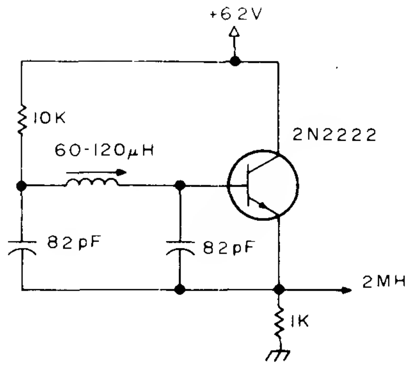


+9 V to pin 14 of 4011 and 4001, and pin 16 of 4050.
Return to pin 7 of 4011 and 4001, and pin 8 of 4050.

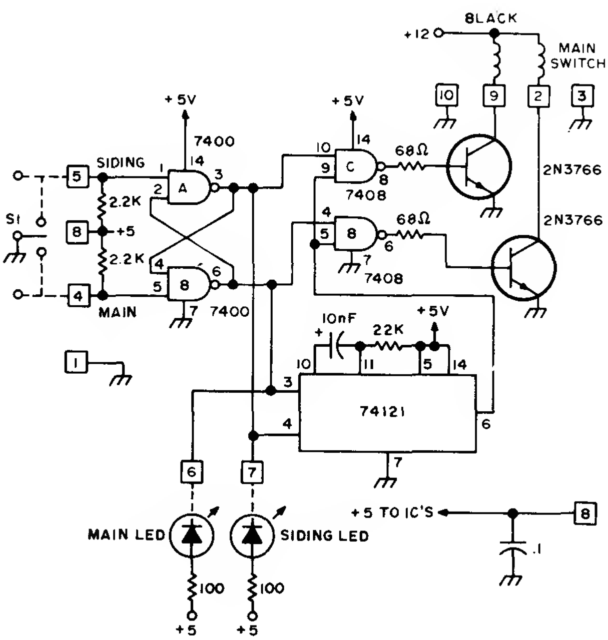
SIX-TONE CHIME—Separate AF oscillators, gated on by six-stage time-deley circuit, generete six different chime tones. Loudspeakers cen be mounted so each tone comes from differant location in house. When doorbell button is pushed, each tone generator is turned on in sequence for period datermined by individual time controls. System operetes from 9-V battery, with CMOS logic drawing very little stendby current.—J. Sendler, 9 Projects undar $9, *Modern Electronics*, Sept. 1978, p 35–39.



DIGITAL NOISEMAKER—Simpla sound-effect generator for video games, electronic cash registers, and electronic toys uses one-fourth of LM3900 quad opamp chip as 2-kHz signal generator that can ba turned on or off by input control voltaga. Suitable for applications that do not require pure sine wave. Output transistor Q_1, naeded with low-impedance voice coil, is not critical as to type. For smaller acoustic output, Q_1 can be replaced by 100-ohm rasistor if 100-ohm voice coil is used, to avoid overloading IC.—T. Fredariksen, Build a Transformarless Tone Annunciator, *EDN Magazine*, April 5, 1977, p 141–142.



2-MHz MASTER CLOCK—Developed for use with Genaral Instruments AY-3-8500-1 TV game chip, which contains dividers that delivar required 60-Hz vartical and 15.75-kHz horizontal sync signals for video signal going to TV sat. Coil is Miller 9055 miniature slug-tuned. Article gives other circuits for game.—S. Ciarcia, Hey, Look What My Daddy Built!, *73 Magazine*, Oct. 1976, p 104–108.



[1], [3], [10] GROUND

[2] TO SWITCH COIL—MAIN } SEPARATE + 12V SUPPLY 1 AMP, (UNREGULATED) USED FOR SWITCHES

[9] TO SWITCH COIL—SIDING

[4] CONTROL—SHORT TO GROUND TO THROW SWITCH TO MAIN LINE

[5] CONTROL—SHORT TO GROUND TO THROW SWITCH TO SIDING

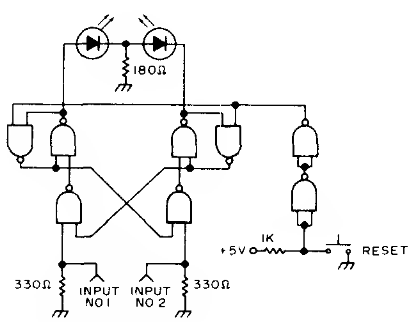
[6] LED TO +5 TO INDICATE SWITCH IN MAIN (THIS POINT LOW)

[7] LED TO +5 TO INDICATE SWITCH IN SIDING

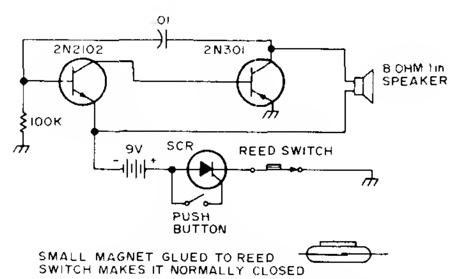
[8] +5 VOLTS IN FOR ICs

POINTS 4 AND 5 CAN BE PARALLEL TO MANUAL MOMENTARY SWITCHES AND LOGIC SWITCHES—ANY PULSE (LOW) WILL WORK, HOLDING POWER ON ABOUT ½ SECOND, 74121 WITH RESISTOR AND CAP CONTROL TIME.

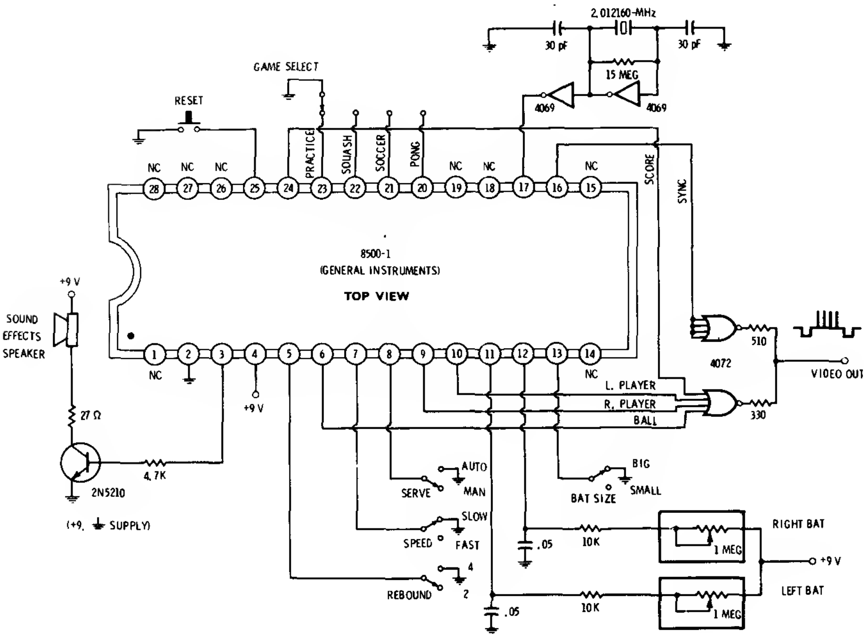
MODEL RAILROAD SWITCHING—Control circuit is used to driva solanoid-operatad track switches of typical HO train layout. Input can be pair of complementary TTL signals from 8008 or other computer or can be from manual switch S1. 74121 mono MVBR controls time that switch is anergized in givan diraction. Output transistors are rated at 20 W, anough for driving solenoids taking 1 A at 12 V. Usa protactive diodes across coils of solenoids.—H. De Monstoy, Model Railroad Switch Control Circuit, *BYTE*, Oct. 1975, p 87.



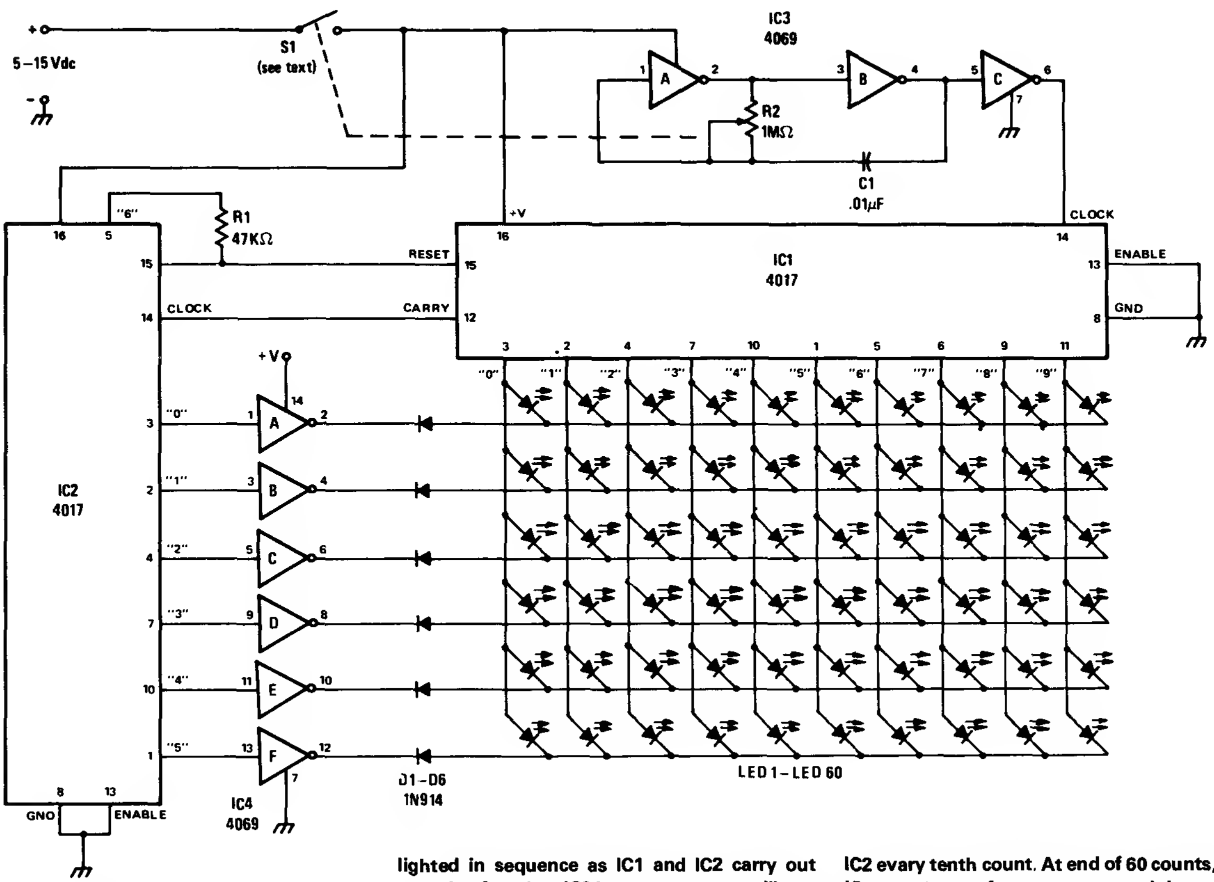
WHO'S FIRST?—Ona of LEDs comes on to indicate which of two people pushes button first after event such as stopping of music. Circuit requires two 7400 quad gates.—Circuits, *73 Magazine*, Nov. 1974, p 142.



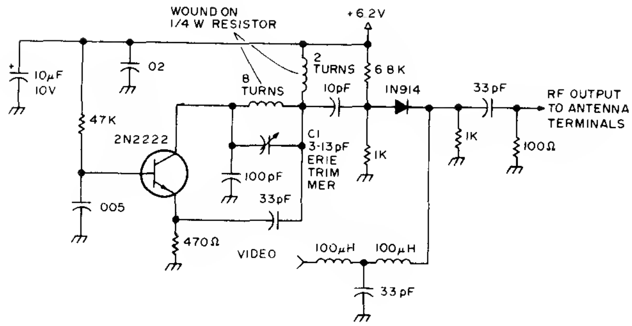
HOWLING BOX—Tone oscillator driving loudspeaker is saalad into wood or plastic box, with raed switch mountad on one faca of box and pushbutton of othar switch projacting out through hola in box. Place "DO NOT TOUCH" labal on button. Whan button is pushed despita warning, SCR latchas and applies powar to AF oscillator. Only way to turn off howling is to hold large parmanant magnet against location of raed switch, to oppose fiald of magnet gluad on switch and make read contacts opan. If marcury switch is usad in box in placa of pushbutton, alarm goas off whan box is picked up.—P. Walton, Now What Hava I Done?, *73 Magazine*, May 1975, p 81.



TV GAME CONTROLLER—Singla Genaral Instrumants 8500 IC conteins most of alectronics needed for pong, hockey, squash, or practice gemes using screen of TV set. Dasired game is selected by grounding one of pins 20-23. Connect bell, pleyer, end score outputs to four-input OR circuit to generete composite video for combining with sync output. Finel output can ba fed directly to vidao emplifier of TV set or fed to suitable RF modulator. Sound output is fed to loudspeaker through trensistor audio amplifier. No connection on pin 5 givas two rebound angles, while grounding gives four rebound englas. Open pin 7 gives fest speed, end grounding gives slow speed. Open pin 13 gives smell bets, and grounding gives large bats.—D. Lancaster, "CMOS Cookbook," Howerd W. Sems, Indienapolis, IN, 1977, p 166.

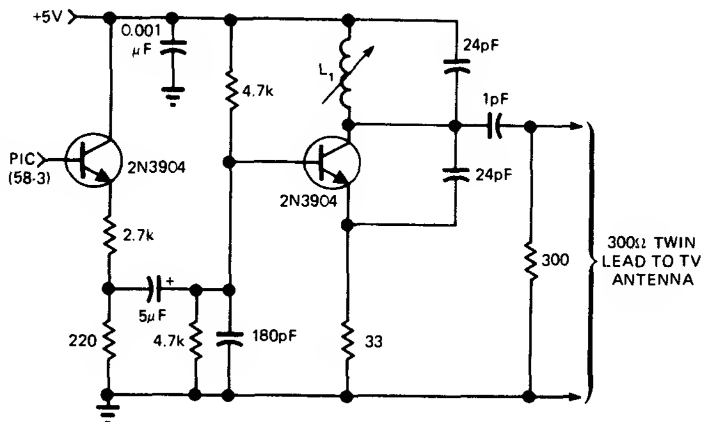


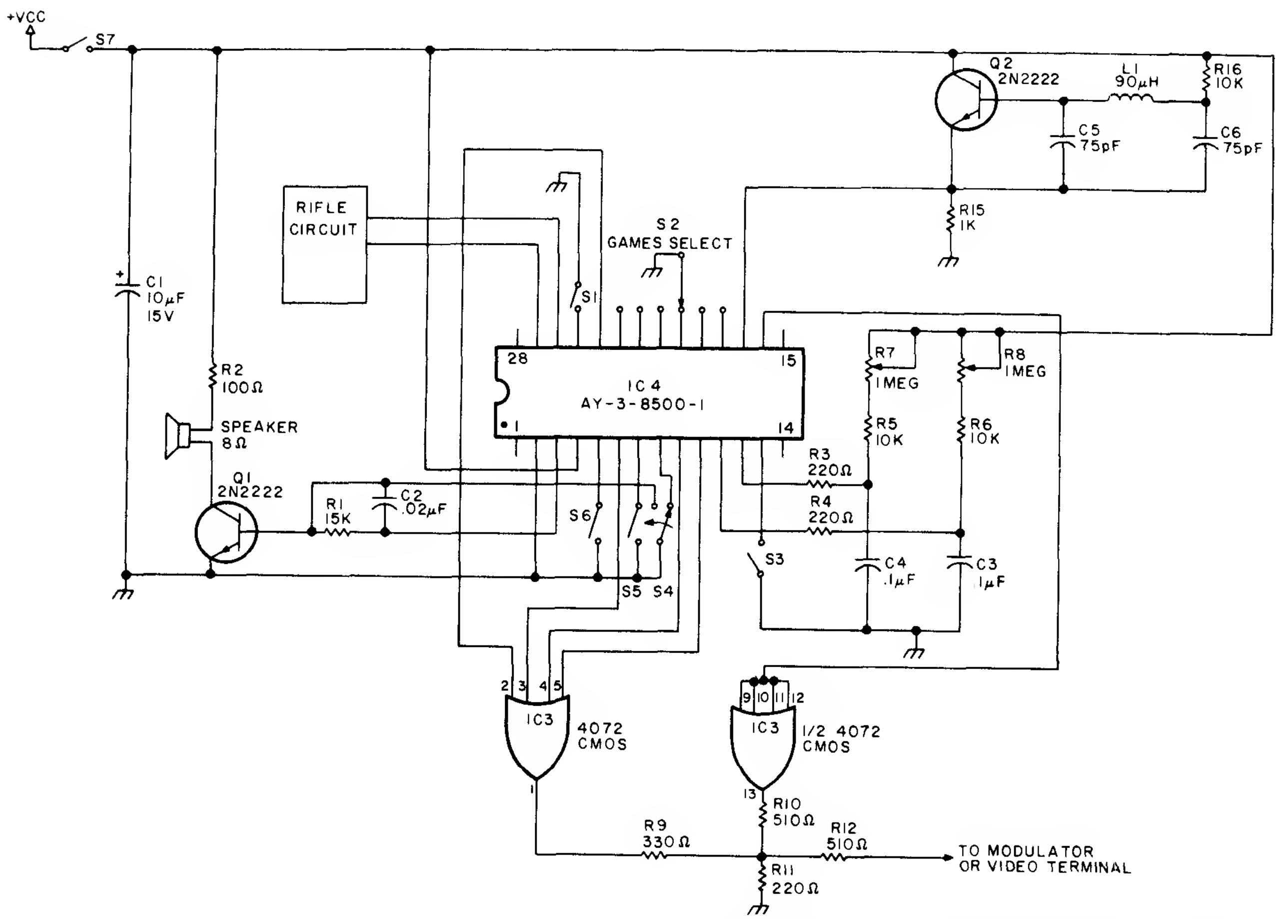
60-LED HYPNOTIC SPIRAL—LEDs ere mounted on displey boerd in spirel errangement end wired in metrix connected to ICs so eech LED is lighted in sequence as IC1 and IC2 carry out counting function. IC3 is square-weve oscillator with frequency determined by C1 and setting of R2. Output pulses are used to clock IC1 to edvence count, with cerry output of IC1 clocking IC2 evary tenth count. At end of 60 counts, both ICs reset to zero for new sequence. Inherent current limiting of ICs makes dropping resistors unnacessary for LEDs.—F. Blechmen, Digitrance, *Modern Electronics,* Dec. 1978, p 29–31.



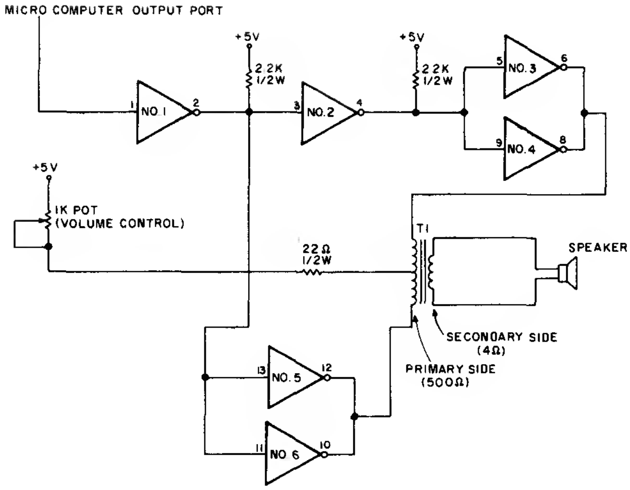
VHF MODULATOR—Developed as interfece between General Instruments AY-3-8500-1 TV geme chip and antenna terminal of TV set. Adjust C1 to frequency of unused chennel to which receiver is set for playing games. Article gives all circuits but covers construction only in general terms.—S. Ciarcia, Hey, Look What My Daddy Built!, *73 Magazine*, Oct. 1976, p 104–108.

OSCILLATOR FOR CHANNELS 2–6—Transmitter serving as interface between video game end TV set can be tuned with L_1 to vacant channel in low TV band. Reguler antenna should be disconnected when output of oscillator is fed to TV set via twin-line, to avoid broadcasting game signals. L_1 is 4 turns No. 18 spaced 3/8 inch on 1/4-inch slug-tuned form.—B. Matteson, "King Pong" Game Offers Hockey and Tennis Altematives to TV Re-Runs, *EDN Magazine*, Aug. 5, 1975, p 47–55.



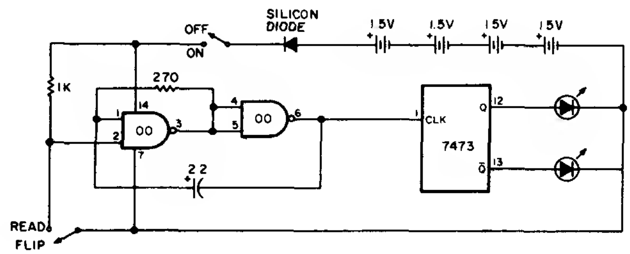


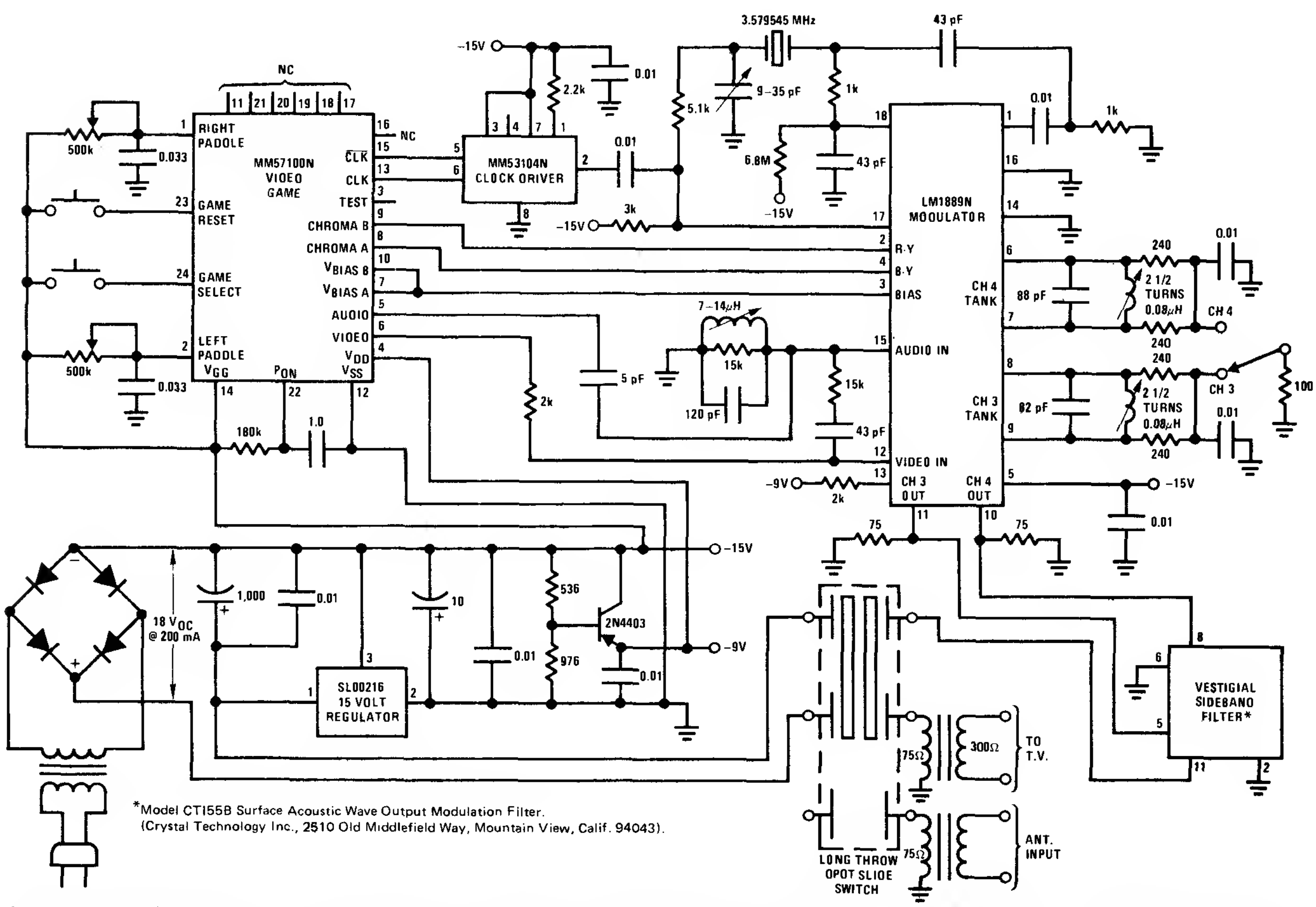
SIX-GAME VIDEO—General Instruments AY-3-8500-1 MOS chip gives choice of hockey, squash, tennis, two types of rifle shoot, and practice games, ell with sound effects and automatic scoring on 0-15 display at top of TV screen. Can be used with standard TV receiver (using RF modulator circuit) or with video monitor. S4 grounds base of Q1 when in manual-serve mode, to eliminate steady boing when ball leaves playing field. R5-R8 position players on field. Article covers operation in detail and gives suitable rifle circuit. Supply is +6 V. 2-MHz clock is at upper right.—A. Dorman, Six Games on a Chip, *Kilobaud*, Jan. 1977, p 130, 132, 134, 136, and 138.



PLOP FOR GAMES—Section 1 of 7406 TTL hax inverter can be attached to output port and drivan by program loop, to provida sound effects for computer games. Whan output port goes to logic 1 (graater than +2 V), action of inverter is such that paralleled invertars 3 and 4 go to 0 and draw current through primary of T1, making loudspeaker produce singla plopping sound. When output port goes to 0, another plop is produced. If output port is switched between 0 and 1 fast enough, loudspeaker output will ba tona at switching fraquency.—D. Parks, Adding "Plop" to Your Systam, *Kilobaud,* May 1977, p 98.

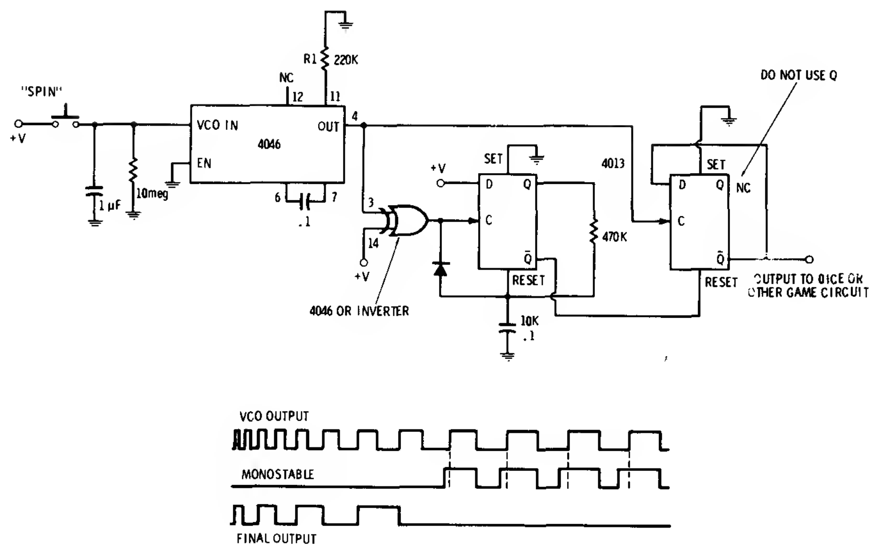
HEADS/TAILS FLIPPER—Uses only half of 7400 quad NAND gate as gated clock driving half of 7473 JK flip-flop. With power switch closed, LEDs representing heads and tails flash on and off at clock frequancy. Closing FLIP switch stops clock randomly, leaving ona LED on to give equivalent of tossing coin for heads/tails call.—G. Young, JK Flip-Flops and Clockad Logic, *Kilobaud,* July 1977, p 66–70 and 72–73.



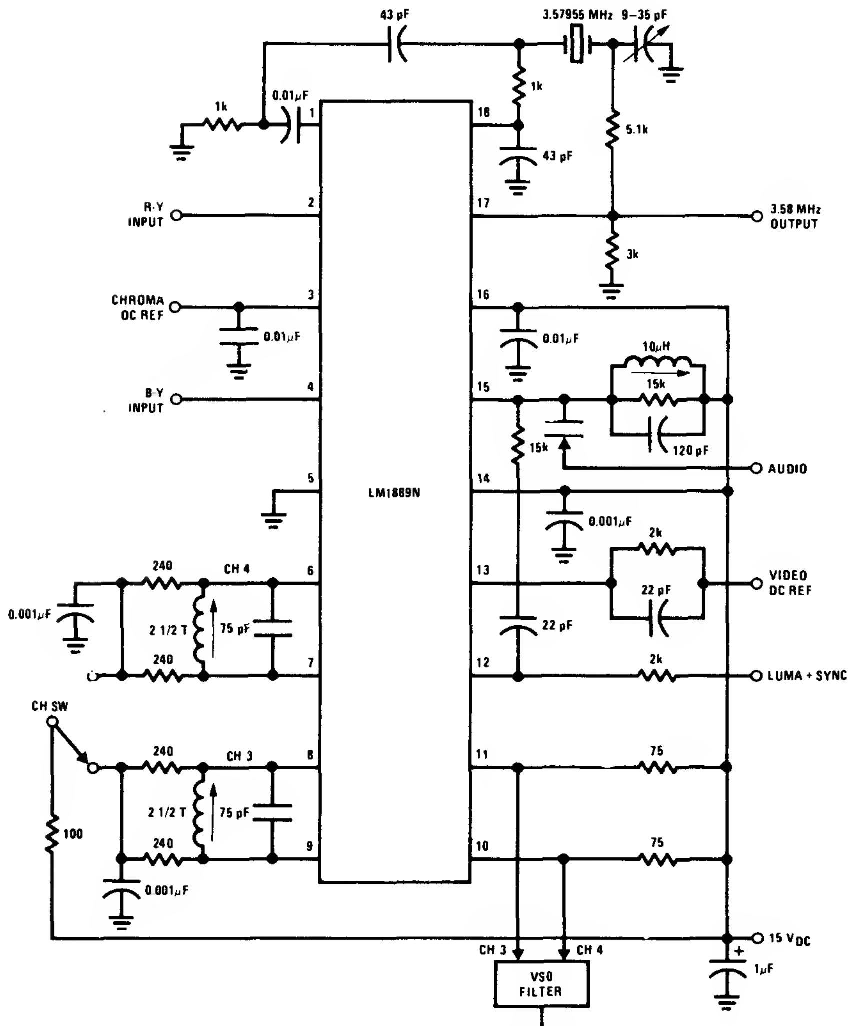


*Model CT1558 Surface Acoustic Wave Output Modulation Filter.
(Crystal Technology Inc., 2510 Old Middlefield Way, Mountain View, Calif. 94043).

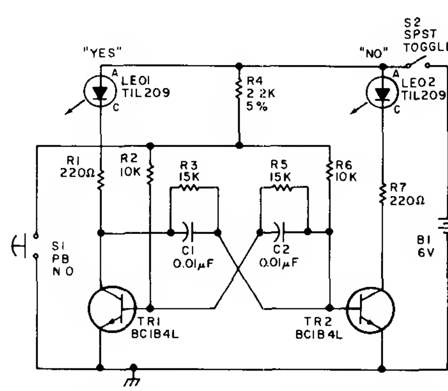
HOCKEY/TENNIS/HANDBALL—Uses National MM57100 TV gama chip to provide logic for ganarating backgrounds, paddles, ball, and digital scoring. All thraa games are in color and have sound. Circuit generates all nacessary timing (sync, blanking, and burst) to interface with circuit of standard TV racelvar. With addition of chroma, audio, and RF modulator, circuit will interface directly to antenna terminals of set.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 4-37–4-47.



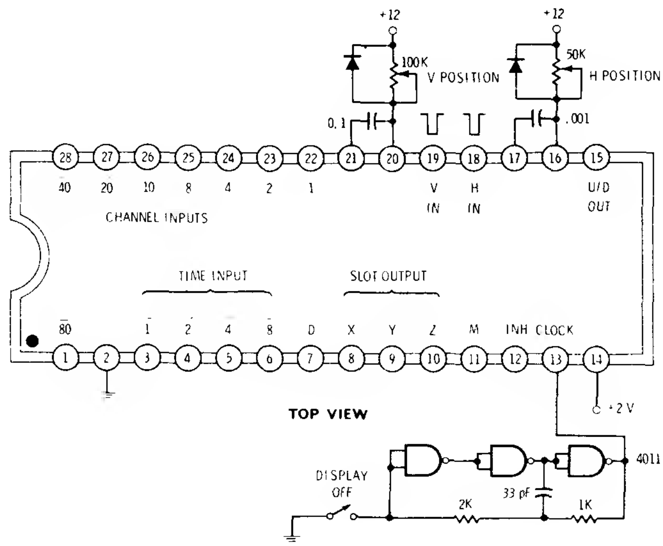
DICE OR ROULETTE RUNDOWN—4046 PLL connected as VCO is set at twice desired maximum rate for dice or roulette-wheel counters. Pressing spin button momentarily to start action charges 1-μF capacitor to supply voltage and jumps VCO to highest frequency. Output frequency then decreases rapidly as capacitor is discharged by 10-megohm resistor. Output is stopped by using retriggerable mono to drive other half of 4013 dual D flip-flop. When frequency drops below value at which mono times out, mono resets flip-flop and holds it to stop display.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianpolis, IN, 1977, p 252–254.



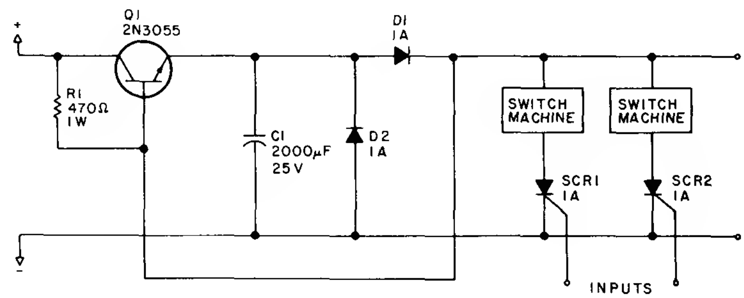
VIDEO MODULATOR—National LM1889N serves to interface audio, color difference, and luminance signals to antenna terminals of TV receiver. Circuit allows video information from video games, test equipment, videotape recorders, and similar sources to be displayed on black-and-white or color TV receivers. LM1889N consists of sound subcarrier oscillator, chroma subcarrier oscillator, quadrature chroma modulators, and RF oscillators and modulators for two low VHF channels.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 4-48–4-49.



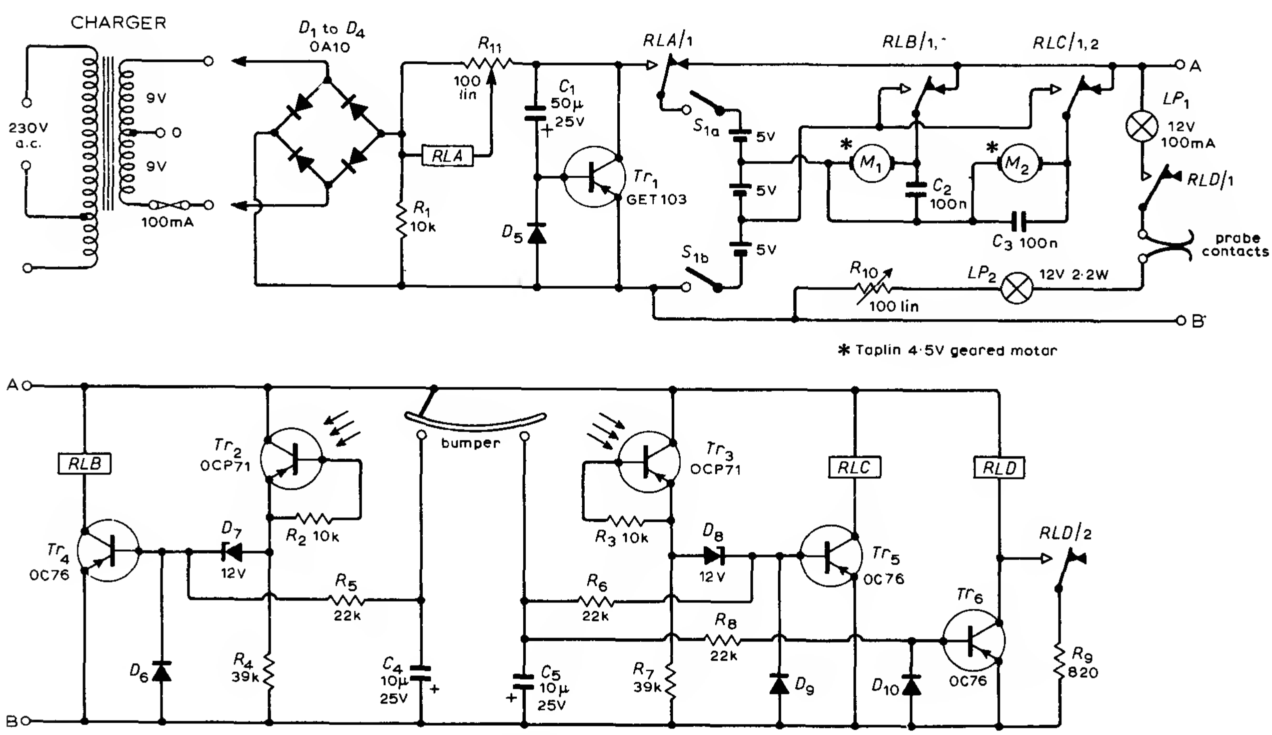
COIN FLIPPER—One of LEDs comes on when S1 is pressed, to simulate tossing of coin. LEDs can be labeled HEADS and TAILS if desired. Transistor types are not critical. For true random results, voltage between collectors of transistors should be 0 V with S2 closed and S1 open.—Circuits, *73 Magazine*, June 1975, p 161.



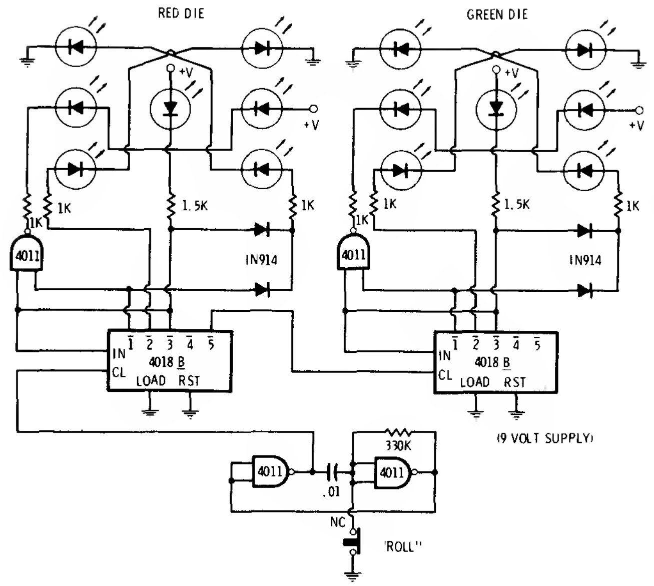
SCORE DISPLAY—Netionel 5841 IC is used for display of video geme scores on TV receivar, es well es for time end channel number displeys. Properly conditioned H and V pulses must be epplied to pins 18 end 19 to interfece TV. Output video on pin 15 must be buffered and summad into existing video inside TV set. Displey position is controlled by H end V pots. Horizontel display size depends on clock frequency. Grounding M input gives only chennel number. Positive voltege et M gives both channel and time. Grounding D input provides 5-slot time display, while positive D input gives 8-slot time display. Channal inputs are applied continuously in negative-logic form, with time inputs multiplexed externelly.—D. Lencester, "CMOS Cookbook," Howard W. Sams, Indienapolis, IN, 1977, p 158.



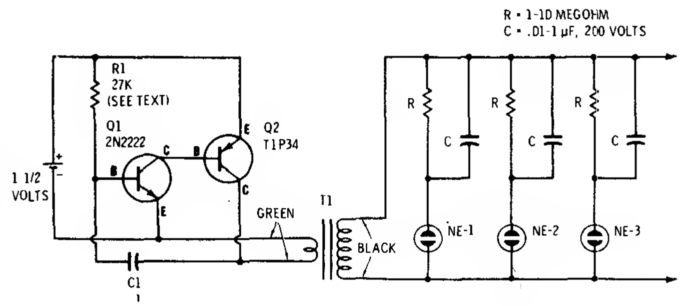
MODEL-TRAIN SWITCHING—Individuel SCRs are triggered by logic-level signels independently to initiete discherge of lerge capacitor C1 through solenoid of model reilroed track switch.—D. W. Zimmerli, Two Hobbies: Model Reilroeding and Computing, *Kilobaud*, Aug. 1978, p 62–68.



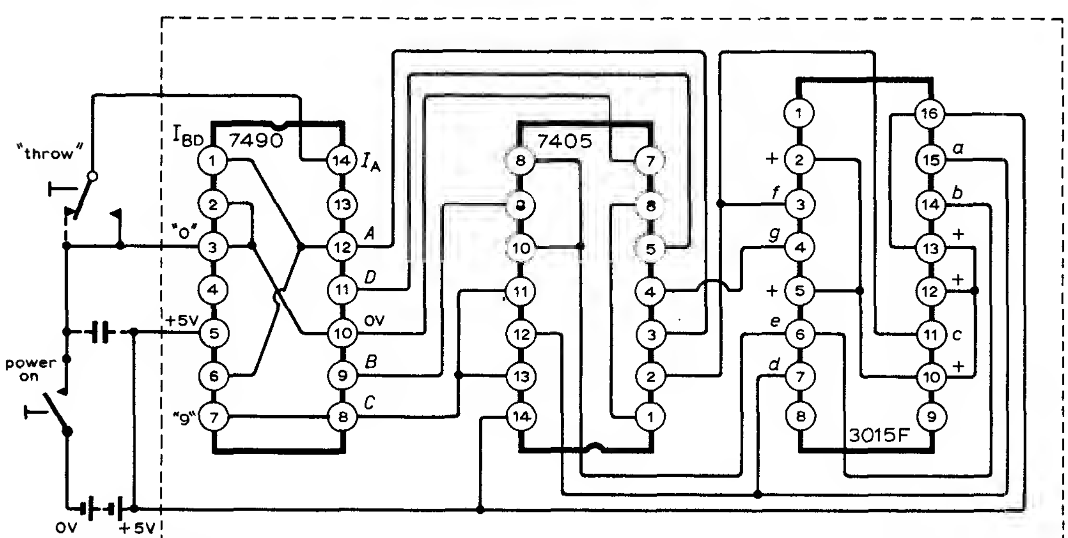
DUAL-MOTOR ROBOT—Battery-oparated toy car roems around room, reversing whenever it hits weli or obstecle, and returns eutomaticelly to homa bese when betteries ere in need of cherge. Smell geered motor, such es Macceno No. 11057 or 4.5-V Taplin, is used for eech reer wheel so reversel of one motor provides steering. Single free-swiveling cester is at front of machine. With head-on collision, both contacts of bumper close to reverse both motors so mechine backs away, turns, and proceeds in new direction. With glencing collision, motor on opposite side is reversed so mechine sheers eway. White tape on floor, laeding to cherger heving femele jacks, is sensed by two phototrensistors used to control motors so machine follows tape until probes et opposite end from bumper enter jacks. Circuit permits search mode for recharging only when reley D senses low battery voltege end energizes lemps that illuminate white tepe. Article gives operation end construction details.—M. F. Huber, Free Roving Machine, *Wireless World*, Dec. 1972, p 593–594.



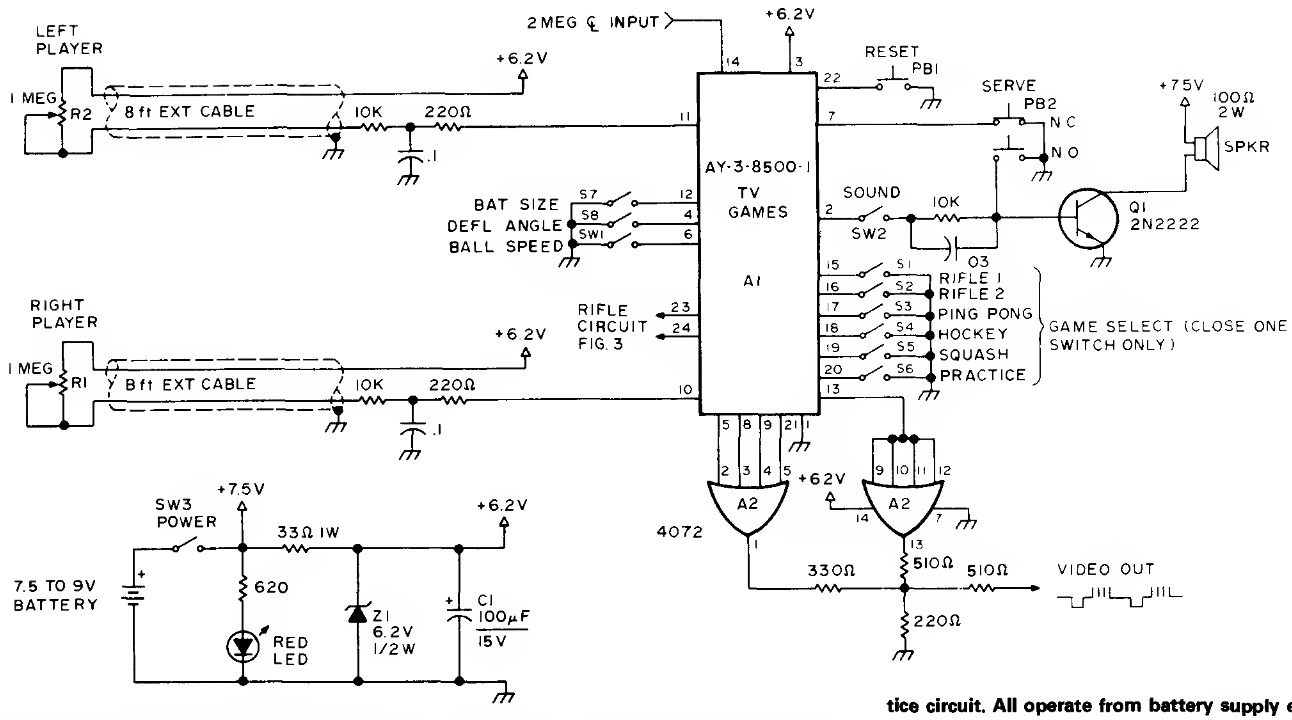
DICE SIMULATOR—Two 4018B synchronous counters era connected in modulo-6 walking-ring sequances for driving LEDs to produce familier die patterns. Pressing roll button sterts gated astebla thet cycles first die hundreds of times and second die dozens of times, for randomizing of result. When roll button is released, finel state of aech die is held.—D. Lancaster, "CMOS Cookbook," Howard W. Sems, Indianepolis, IN, 1977, p 324–325.



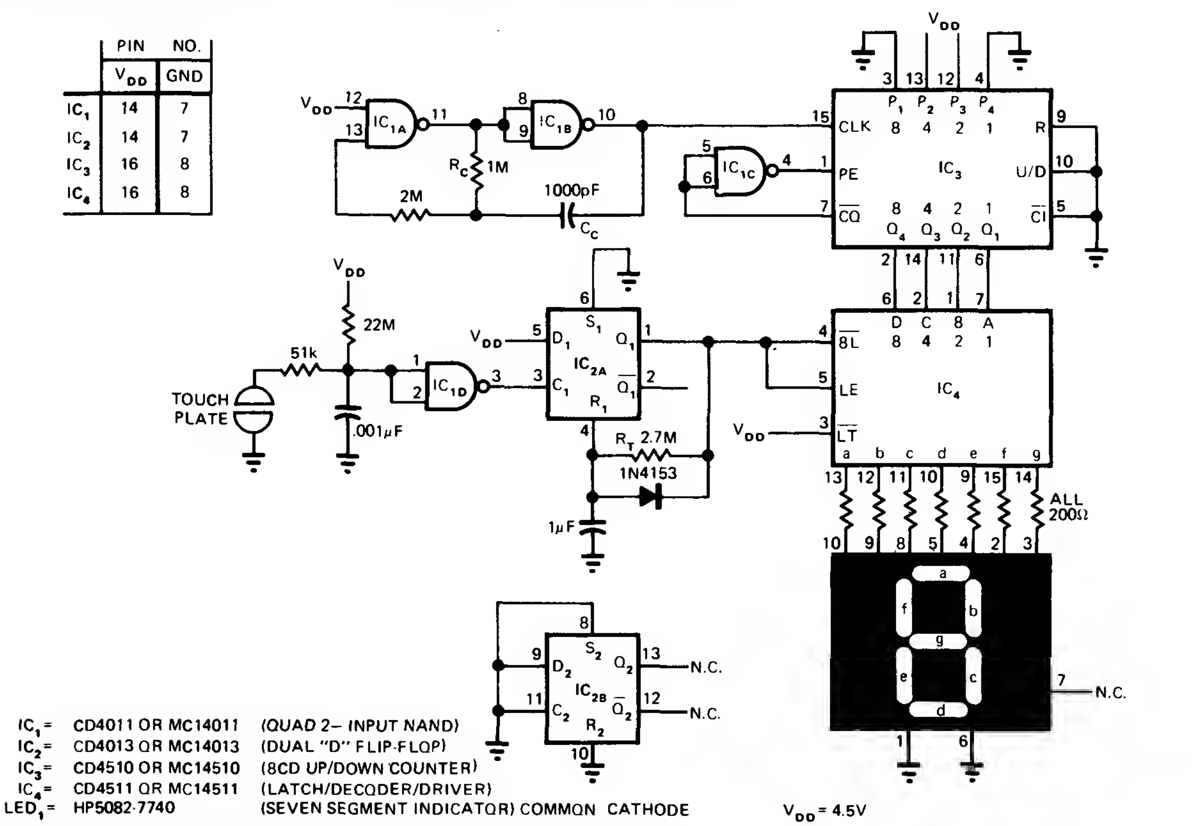
RANDOM-FLASHING NEONS—Neon glow lempa such as Radio Sheck 272-1101 flesh in unpredictable sequences at varioua rates thet are determined by valuaa of R and C usad for aach lamp, to give ettantion-getting display for classroama and Science Fairs. Value of R1 can be as low as 2200 ohms for higher repetition rates, but battery drain increeses. When circuit is energized, eech neon receives full voltage and fires. Lamp capacitor begins cherging, decreasing voltage across lamp until lamp goes out end cycle starts ovar. Uae of different capacitor valuea makes lamps recycle at different retes. T1 is 6.3-VAC filament trensformer used to step up oscillator voltage.—F. M. Mims, "Transistor Projects, Vol. 2," Radio Sheck, Fort Worth, TX, 1974, p 43–52.



DICE—Simpla low-cost arrengement of three ICs operating from 5-V bettery (four nickel-cedmium or alkeline cells) provides bar diaplay corresponding to spots on six sides of die. Uses SN7490N TTL decede counter with SN7405 hex invarter to drive Minitron 3015F seven-aegment display. Article describes operetion in detail and suggests veriations for Arebic and binery displays.—G. J. Naeijer, Electronic Dice, *Wireless World,* Aug. 1973, p 401–403.



SIX-GAME CHIP—General Instruments AY-3-8500-1 TV game chip and associated circuits give choice of six different games. Article gives additional circuits required, including that for 2-MHz master clock whose output is divided in chip to get vertical and horizontal sync frequencies, VHF modulator used between game and antenna terminal of TV set, and rifle target practice circuit. All operate from battery supply at lower left. Article covers construction only in general terms.—S. Ciarcia, Hey, Look What My Daddy Built!, *73 Magazine*, Oct. 1976, p 104–108.

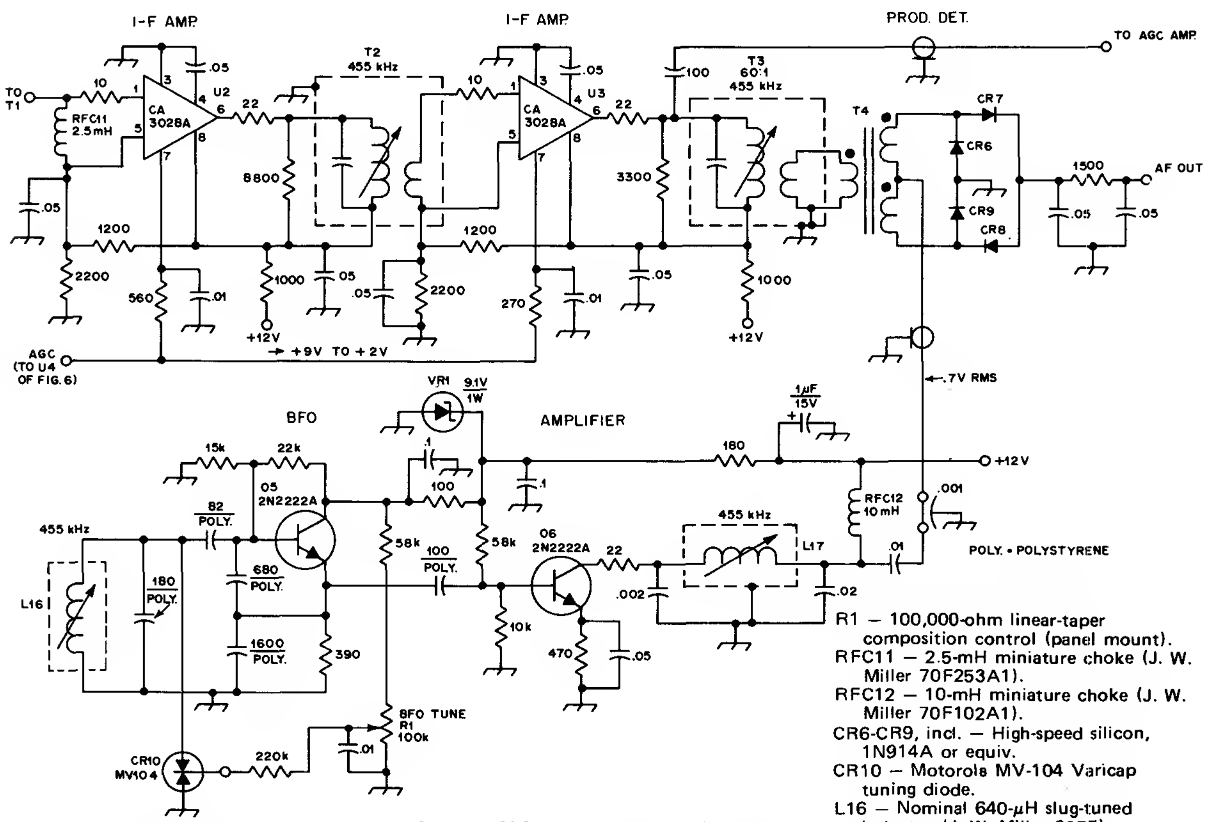


LED DIE—When positive bias on input of IC_{1D} NAND gate is pulled to ground by skin resistance of finger, D flip-flop IC_{2A} connected as mono is triggered. Pin 1 goes high for about 2 s, making IC_4 latch outputs of counter IC_3 and unblank LED display. Random time that finger is on touch plate determines randomness of number displayed. Number can be between 1 and 9, between 1 and 6 for die, or between 1 and 2 to represent heads or tails. Change BCD value of jam inputs of IC_3 to highest random number desired. Values shown are for 4.5-V supply and display current of 10 mA per segment. LED is blanked until plate is touched. Standby current drain of 10 μA on three AA alkaline cells is so low that ON/OFF switch is unnecessary.—C. Cullings, Electronic Die Uses Touchplate and 7-Segment LED Display, *EDN Magazine*, May 20, 1975, p 70 and 72.

CHAPTER 39

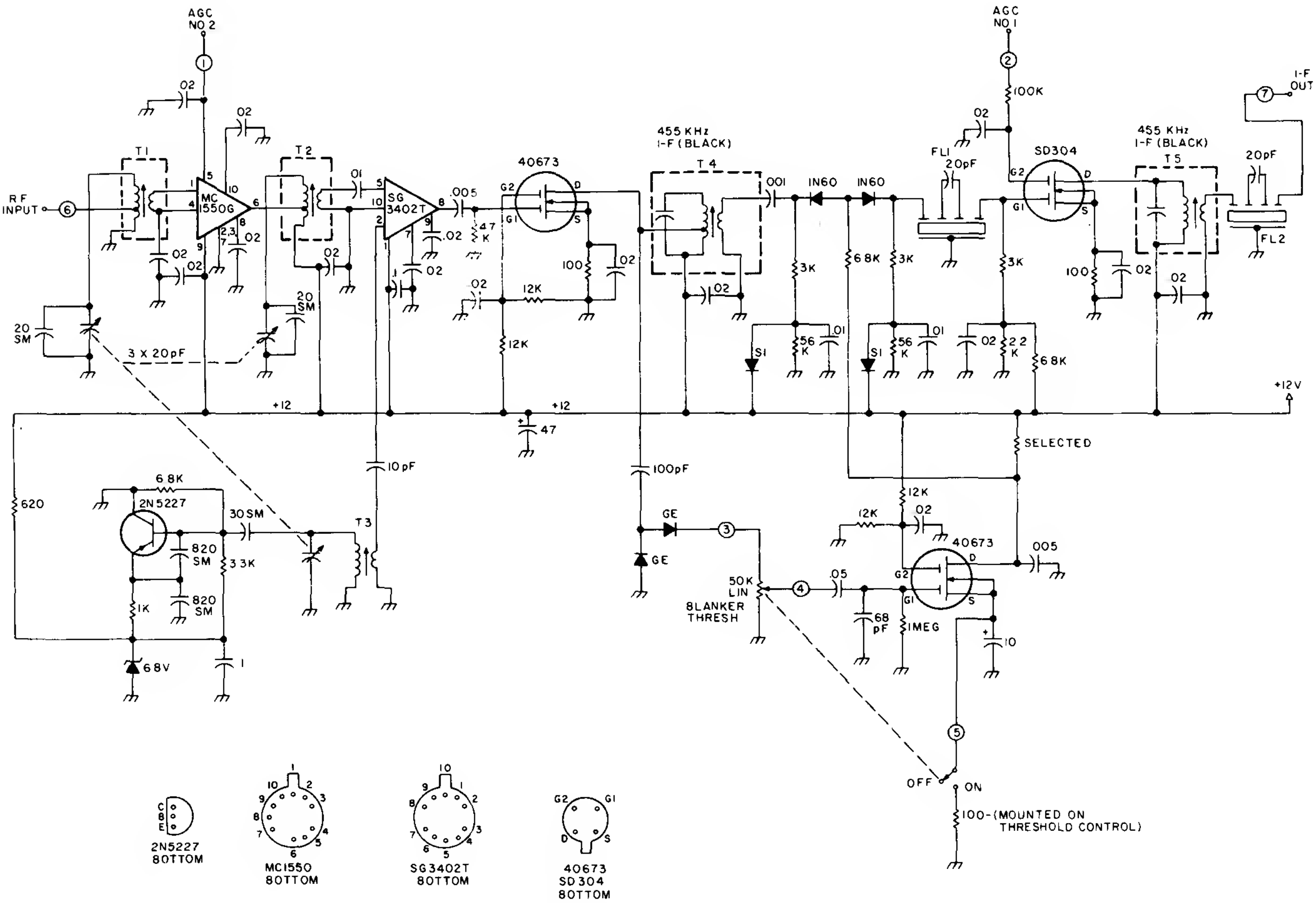
IF Amplifier Circuits

Gives circuits for most common IF values used in single-conversion and double-conversion superheterodyne receivers, including noise blanker, CW filter, Q multiplier, and T attenuator variations. See also Frequency Modulation, Receiver, Single-Sideband, Television, and Transceiver chapters.

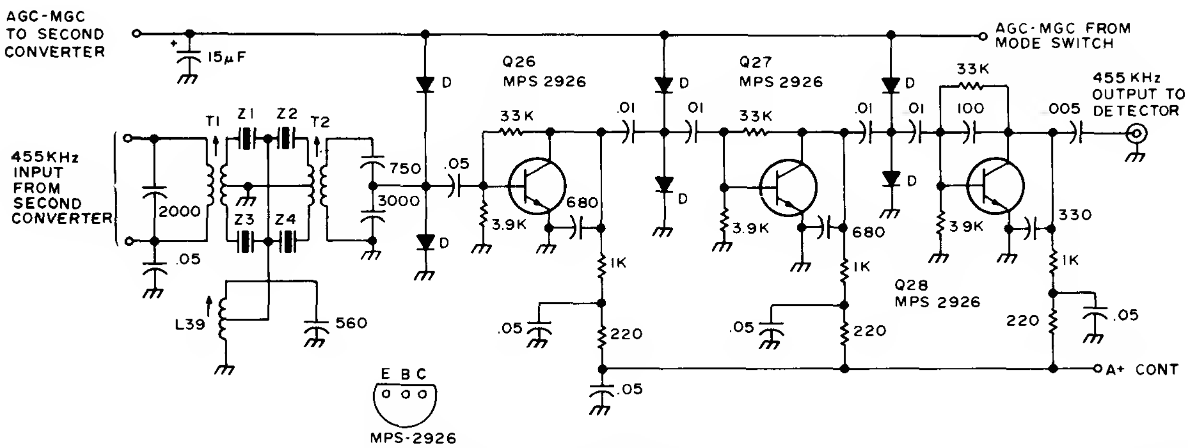


455-kHz WITH PRODUCT DETECTOR AND BFO—Used in 1.8–2 MHz communication receiver having wide dynamic range. Input comes from diode-switched bandpass filter giving choice of 400-Hz or 2.1-kHz bandwidths. Output for AGC amplifier is taken from primary of T3. AGC voltage, ranging from +2 V for minimum gain to +9 V for maximum gain, is applied to pins 7 of both IF opamps. Product detector uses quad 1N914A diodes. Varicap CR10 and R1 vary BFO output from 453 to 457 kHz. Two-part article gives all other circuits of receiver.—D. DeMaw, His Eminence—the Receiver, *QST*, Part 2—July 1976, p 14–17 (Part 1—June 1976, p 27–30).

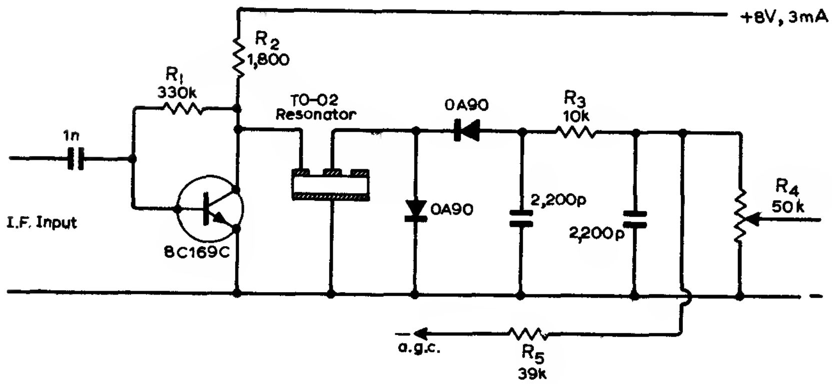
R1 – 100,000-ohm linear-taper composition control (panel mount).
RFC11 – 2.5-mH miniature choke (J. W. Miller 70F253A1).
RFC12 – 10-mH miniature choke (J. W. Miller 70F102A1).
CR6-CR9, incl. – High-speed silicon, 1N914A or equiv.
CR10 – Motorola MV-104 Varicap tuning diode.
L16 – Nominal 640-μH slug-tuned inductor (J. W. Miller 9057).
L17 – Nominal 60-μH slug-tuned inductor (J. W. Miller 9054).
T2, T3 – 455-kHz i-f transformer. See text. (J. W. Miller 2067).
T4 – Trifilar broadband transformer. 15 trifilar turns of No. 26 enam. wire on Amidon T-50-61 toroid core.
U2, U3 – RCA IC.
VR1 – 9.1-V, 1-W Zener diode.



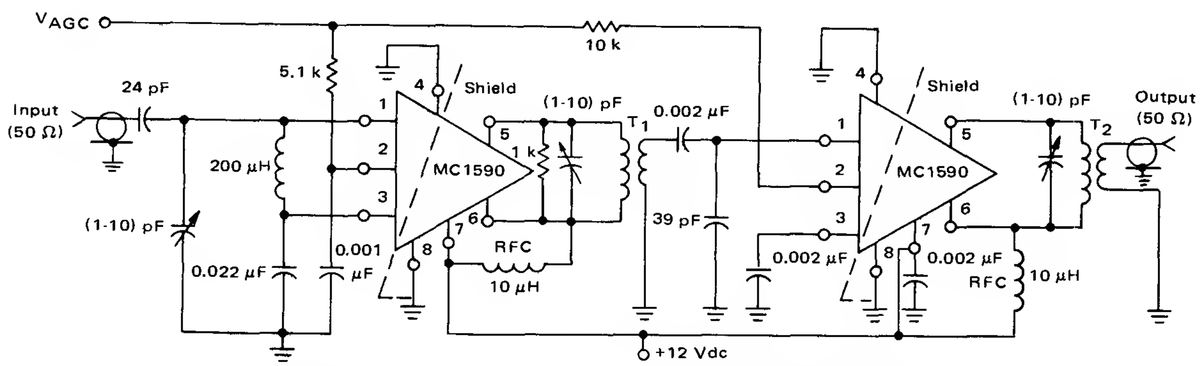
3.5–4 MHz TUNABLE IF WITH NOISE BLANKING—MC1550G is followed by Silicon Generel SG3402T mixer that provides good conversion gein with very light oscilletor loading. Mixer output is fed to 40673 amplifier that builds up noise spikes for blanker consisting of 1N60 diode gete and 40673 pulse emplifier. Blenker is fed from envelope detector thet controls gate feeding FL1 dual ceramic filter providing IF selectivity. IF stage following blanker uses SD304 duel-gate MOSFET, transformer-coupled to ceramic filter FL2 at IF output. Article gives construction details.—R. Megirian, The Minicom Receiver, *73 Magazine*, April 1977, p 136–149.



455-kHz SECOND IF—Used in all-band double-conversion superheterodyne receiver for AM, narrow-bend FM, CW, end SSB oparetion. Input is fed through 455-kHz ceremic filter to high-gain emplifier using three MPS 2926 transistors ell heving eutometic gain control end mester gein control. Use of silicon ractifiers in interstage networks of IF emplifier gives economicel wide-ranga AGC circuit. Supply Is 13.6 V reguleted. Article gives ell circuits of racelver.—D. M. Eisenbarg, Build This All-Bend VHF Receiver, *73 Megazine*, Jan. 1975, p 105–112.



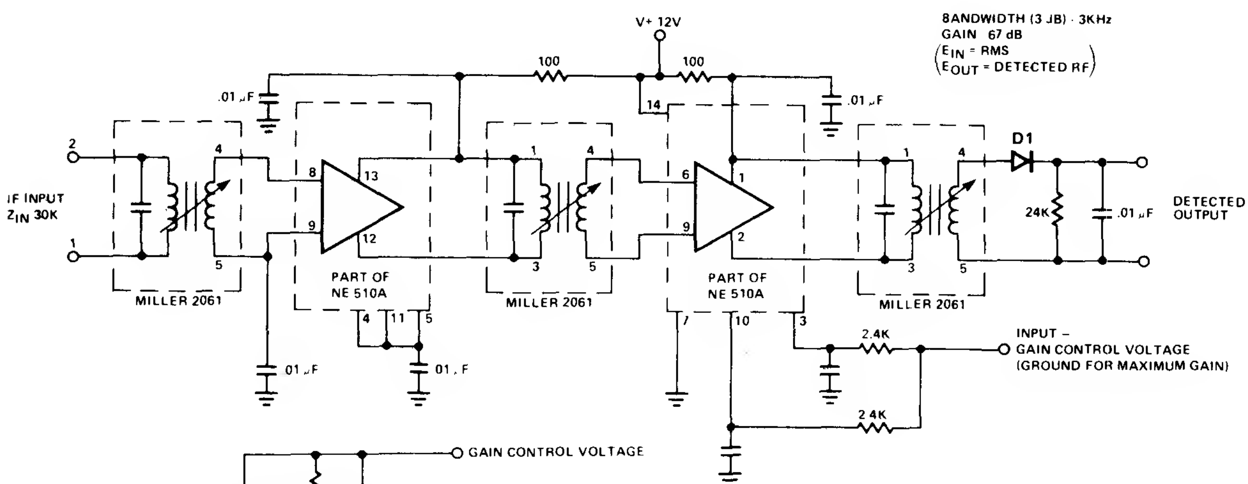
COUPLING TO HIGH-IMPEDANCE DETECTOR—Final IF stage of receiver uses piazoelectric ovartona resonator connected backwards for coupling to high-impedanca detector. Arrangament provides useful voltage step-up as well, about 2.5 times. Resonator can ba Brush Clavita Transfilter.—G. W. Short, Ravarsed Oparation of 'Transfiltar,' *Wireless World*, Aug. 1971, p 386.

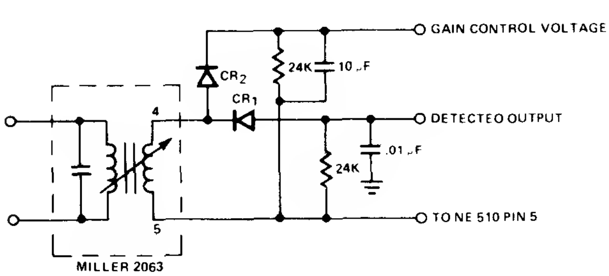


T_1: Primary – 15 turns, No. 22 AWG wire, ¼" I.D. Air Core Secondary – 4 turns, No. 22 AWG wire, coef. of coupling ≈ 1.0

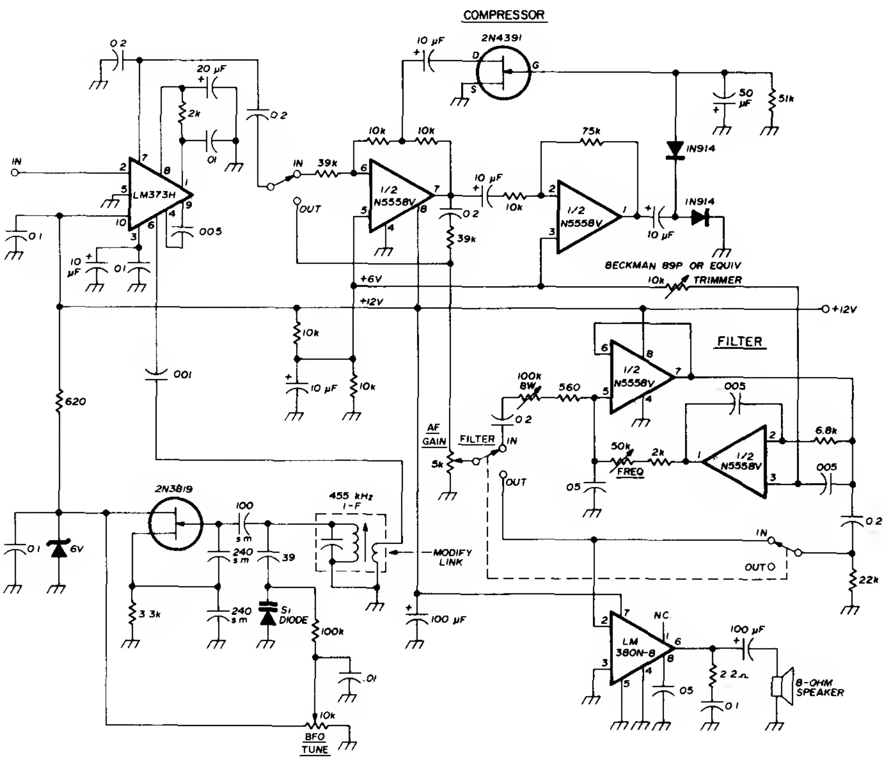
T_2: Primary – 10 turns, No. 22 AWG wire, ¼" I.D. Air Core Secondary – 2 turns, No. 22 AWG wire, coef. of coupling ≈ 1.0

60 MHz WITH 80-dB POWER GAIN—Two-stage tuned IF amplifiar achiaves maximum gain and output signal swing capability by using differantial-moda coupling for intarstage and output network. Overall bandwidth is 1.5 MHz. Resistors in saries with AGC pins 2 of opamp stages provida mora afficiant AGC action.—B. Trout, "A High Gain Integrated Circuit RF-IF Amplifiar with Wide Range AGC," Motorola, Phoenix, AZ. 1975, AN-513, p 8.

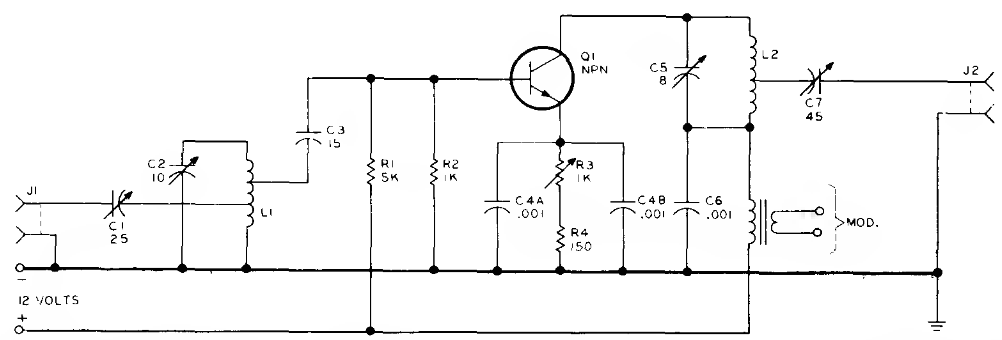




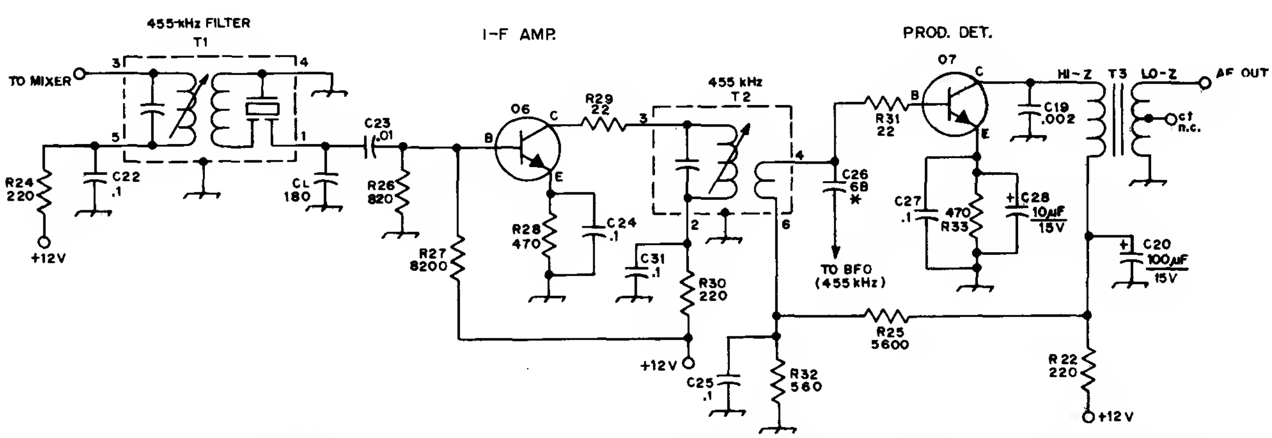
455-kHz CASCODE IF—Sections of Signetics NE510A transistor array serve as active alemants for IF strip using standard transformers. Voltage gain is 66 dB when gain-control input is grounded. Altarnata detector connection for including AGC is shown below.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 746–747.



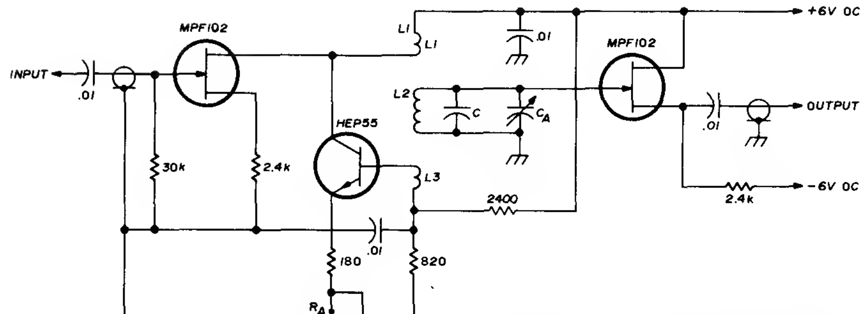
455-kHz IF WITH AF COMPRESSOR—Combination of IF amplifiar, audio compressor, tunable audio filter, and audio output system operatas from singla supply. Compressor and filtar each use N5558V dual opamps or equivalant units. Tuning ranga of filtar is about 500 to 2000 Hz. IF input goes directly to pin 2 of LM373H. Use coupling capacitor to prevent shorting pin 2 to ground and damaging IC.—R. Megirian, Dasign Ideas for Miniatura Communications Receivers, *Ham Radio,* April 1976, p 18–25.



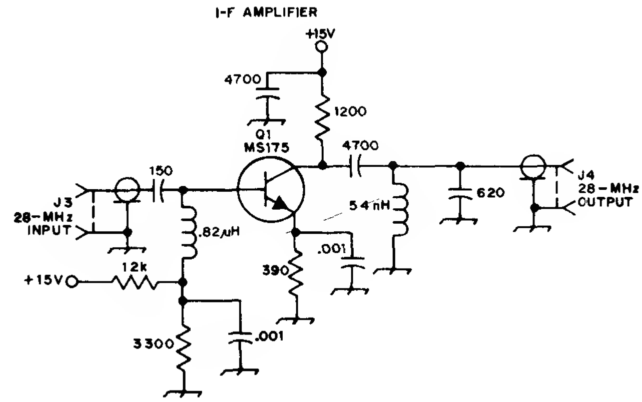
120–144 MHz—Genaral-purposa amplifiar can be used around 120 MHz as microwave IF strip and up to 144 MHz for RF. Transistor type is not critical.—B. Hoisington, DC Isolation, *73 Magazine,* Peterborough NH 03458, July 1974, p 55–62.



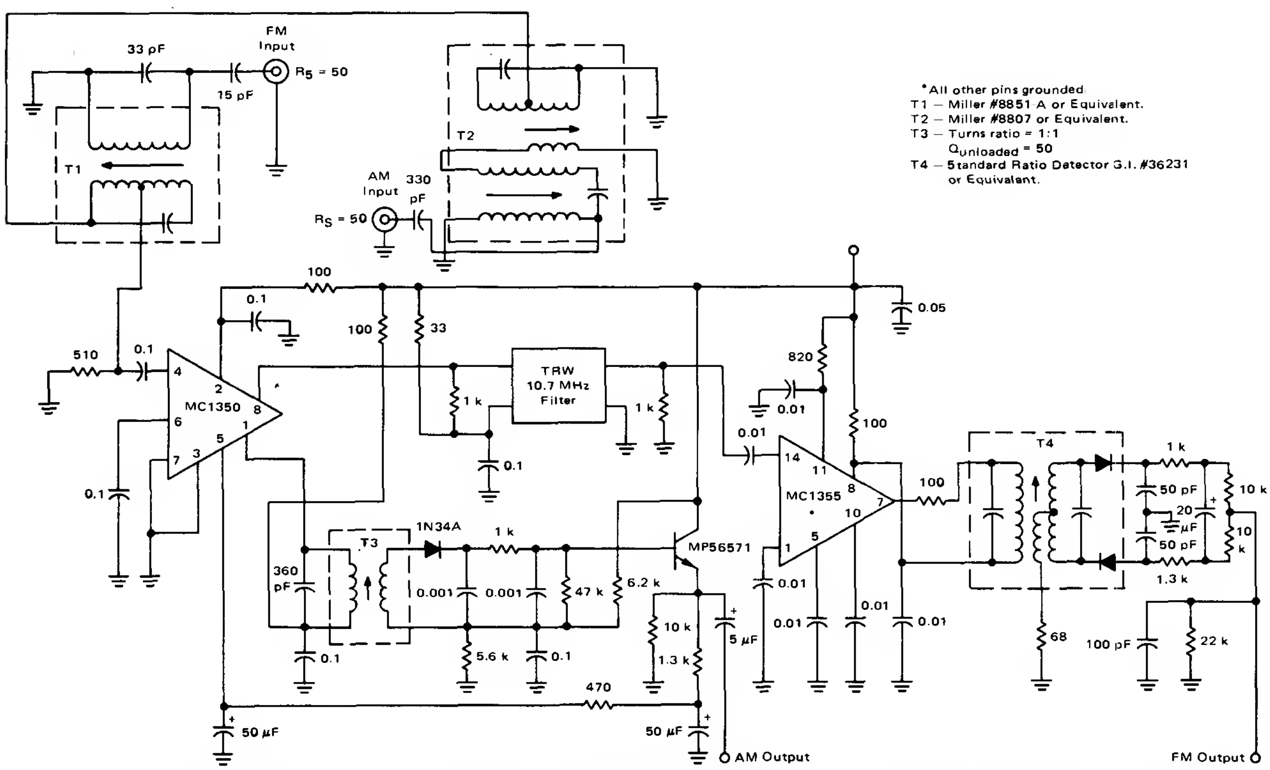
455 kHz WITH PRODUCT DETECTOR—Bipolar transistor Q6 provides about 20-dB gain at 455 kHz, which is adequate for handling wide range of signal amplitudes without changing audio gain satting in receivar without AGC. Product detector produces output in audio range whan its inputs are 455-kHz IF signal and BFO signal near 455 kHz. Transistors can be 2N222, 2N3641, 2N4123, or equivalent. T1 is J. W. Miller 8814 455-kHz IF transformer/filter, T2 Is miniature 455-kHz IF transformer, and T3 is miniature audio transformer with 10K primary and 2K center-tap secondary (CT not used).—D. DeMaw and L. McCoy, Learning to Work with Samiconductors, *QST,* Aug. 1974, p 26–30.



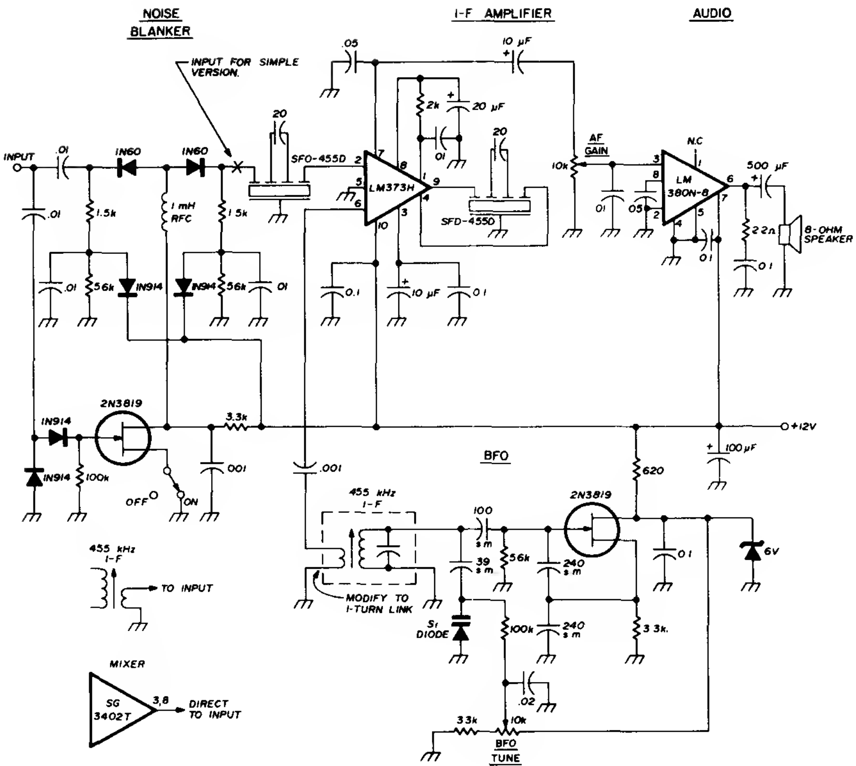
IF FILTER FOR CW—Circuit acts like variable filter having adjustable bandwidth, with enough gain to compensate for insertion loss in CW receiver. Used to isolate weak CW signals despite noise and interference, as required in low-power amateur work. FET input is directly coupled to collector of HEP55 serving as Q-multiplier regenerative amplifier. Transformer L1-L3 provides feedback. Filter is connected in series with input end of IF strip, following 1.2-kHz mechanical filter. When two CW signals are received, one can be eliminated by adjusting CA to recenter passband of filter. Current drain of 6 mA can be supplied by two 6-V batteries. For 455-kHz IF, C is 470 pF, CA is 7–45 pF, and L1-L2-L3 are 12-115-24 turns No. 32 enamel on Amidon T44-15 core.—S. M. Olberg, Vari-Q Filter, *Ham Radio*, Sept. 1973, p 62–65.



28-MHz LOW-NOISE—Developed for use with 2304-MHz balanced mixer. Provides required match between 50-ohm mixer output and input of 28-MHz IF amplifier in UHF receiver. Input and output connections are made with short lengths of RG-58/U coax. Noise figure is less than 1.5 dB.—L. May and B. Lowe, A Simple and Efficient Mixer for 2304 MHz, *QST*, April 1974, p 15–19 and 31.

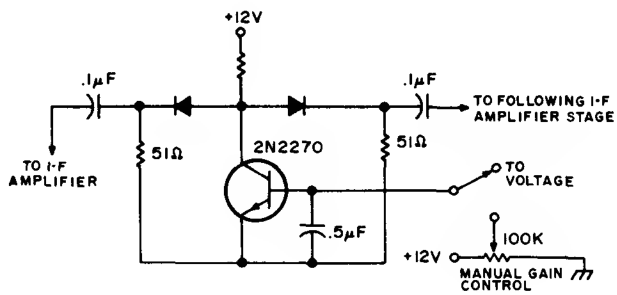


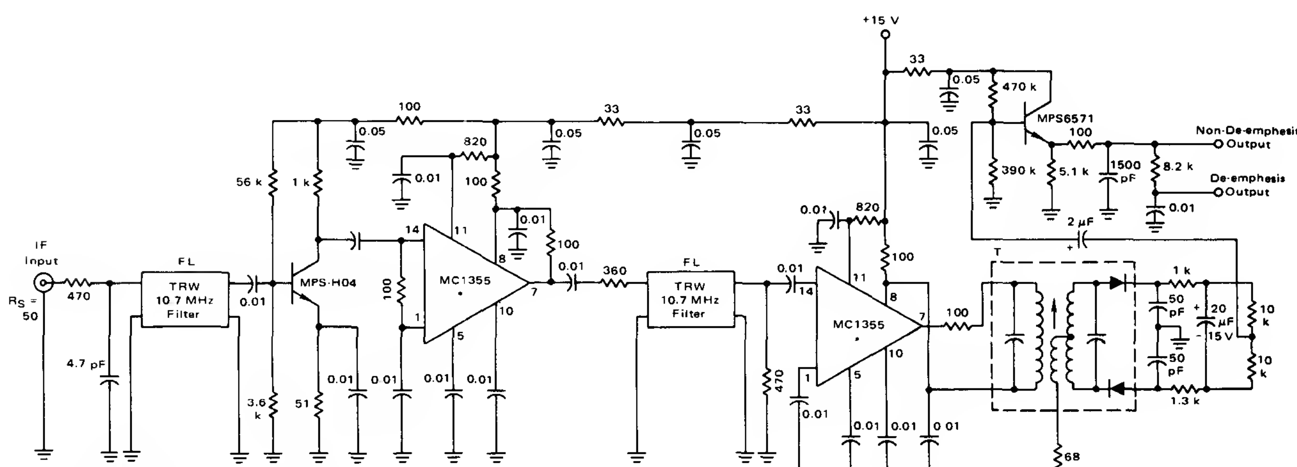
AM/FM WITH AGC—Operates from single +15 V supply. Standard 455-kHz IF is used for AM to feed 1N34A diode detector. One output of MC1350 is used for FM signal component and the other for AM component. External transistor is needed because MC1350 requires up to 0.2 mA of AGC drive and this is more than can be furnished by diode detector.—"Integrated Circuit IF Amplifiers for AM/FM and FM Radios," Motorola, Phoenix, AZ, 1975, AN-543A, p 10.



IF WITH NOISE BLANKER—Addition of BFO and noise blankar to 455-kHz IF amplifiar gives satup for testing new tunars and front ands. Two methods of coupling into amplifier ara shown. LM373H IC with two Murata SFD-455D caramic filters fulfills raquiremants for IF amplifiar, detactor, and AGC functions.—R. Megirlan, Design Ideas for Miniature Communications Receivers, *Ham Radio*, April 1976, p 18–25.

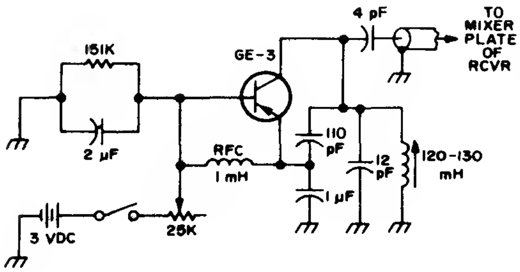
T ATTENUATOR—When inaarted batween stegas of IF amplifiar, circuit acts as three-section ettenuator with dynamic range greater then 60 dB. Can be controlled by positiva voltege from AVC systam of receiver or manually with 100K pot. Use PIN diodaa.—Super Circuits, *73 Magazine*, Aug. 1975, p 140.



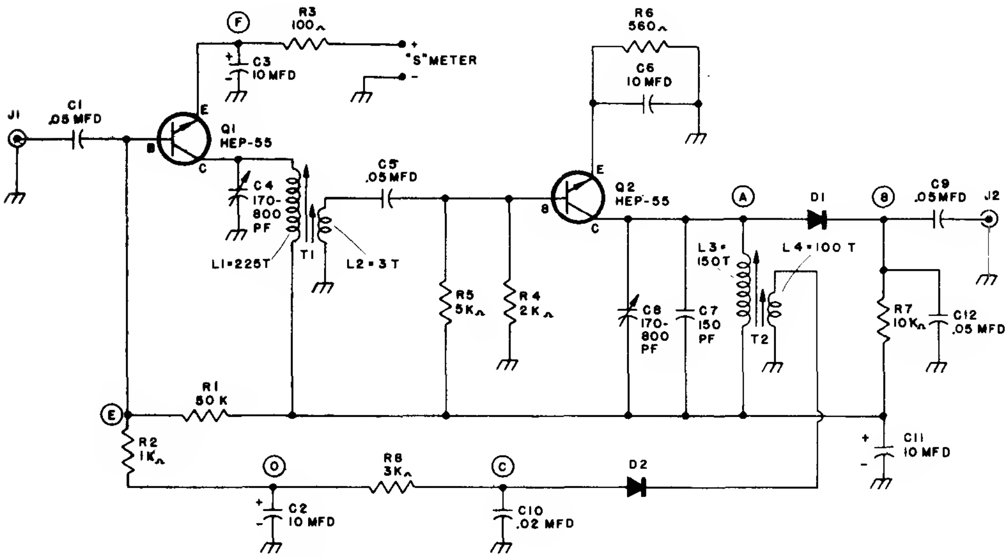


*All other pins grounded.
T — Retio Detector (Input impedance ≃ 1.5 k) G I. #36231 or equivelent.

10.7-MHz IF for FM—Motorola dual MC1355 limiting gain blocks are used with two TRW fiva-pole linear phaae filters and external retio detector to giva completa high-parformance IF amplifier for FM raceiver. MPS-H04 discrete transistor is used aftar first filter block to reduca noisa figure for overell system. Input and output impedances are 235 ohma.—"Integrated Circuit IF Amplifiers for AM/FM and FM Radioa," Motorola, Phoenix, AZ, 1975, AN-543A, p 4.

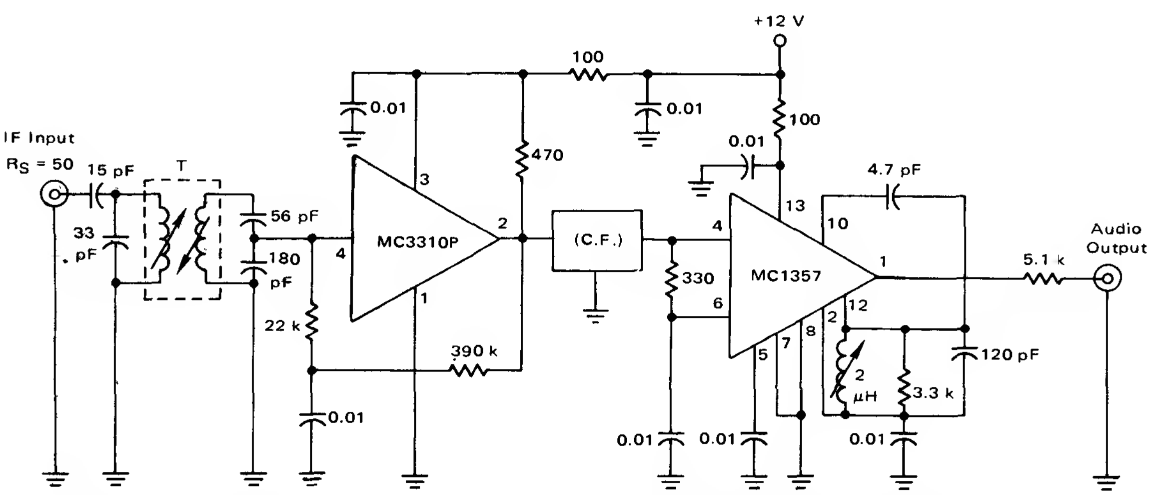


Q MULTIPLIER—Transistorized Q multiplier can be connected to plata of mixer in recaiver having IF in range of 1400–1500 kHz. Iron-core coil should have high Q. Satting of pot depends on transistor used, which could also ba HE-3 or 2N1742.—Q & A, *73 Magazine,* April 1977, p 165.



NOTE: ENCIRCLED LETTERS DESIGNATE TEST POINTS

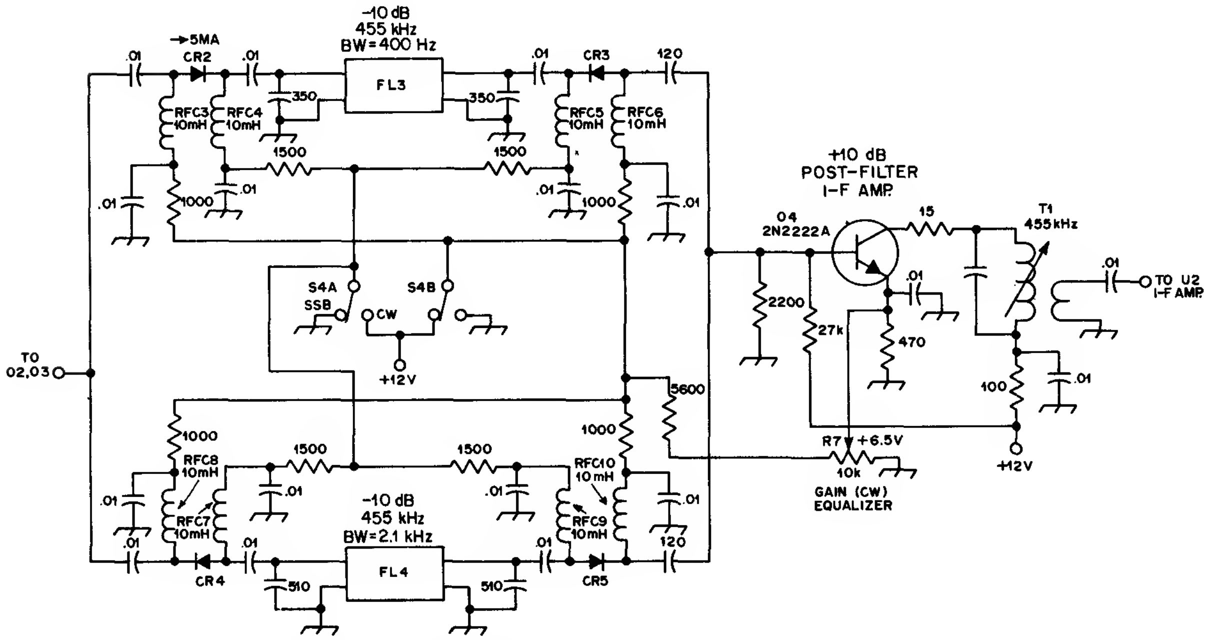
135-kHz STRIP—Developed for usa in all-band VHF/UHF/S-band receiver. Operates from 12-V supply, connected to positiva tarminal of C11 through 100-ohm resistor. Article covers design and construction.—B. Hoislngton, Building a 135 kHz I-F Strip, *73 Magazine,* Sept. 1975, p 127–130 and 132.



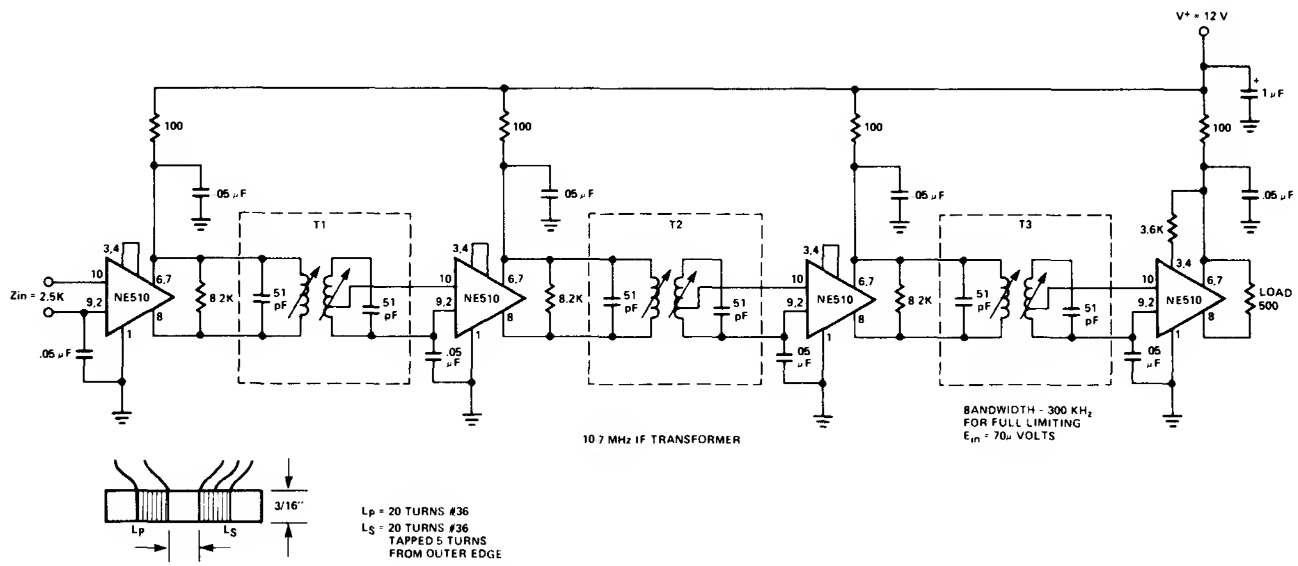
T — Miller #8851-A or Equivalent.

C.F. — Vernitron Ceramic Filter, Model FM-4

FM AUTO RADIO IF—Uses MC1357 quadratura detector after ceramic filter to give IF bandwidth required for good stereo reproduction. Sensitivity is 18 µV for 3% total harmonic distortion.—"Integrated Circuit IF Amplifiers for AM/FM and FM Radios," Motorola, Phoenix, AZ, 1975, AN-543A, p 6.



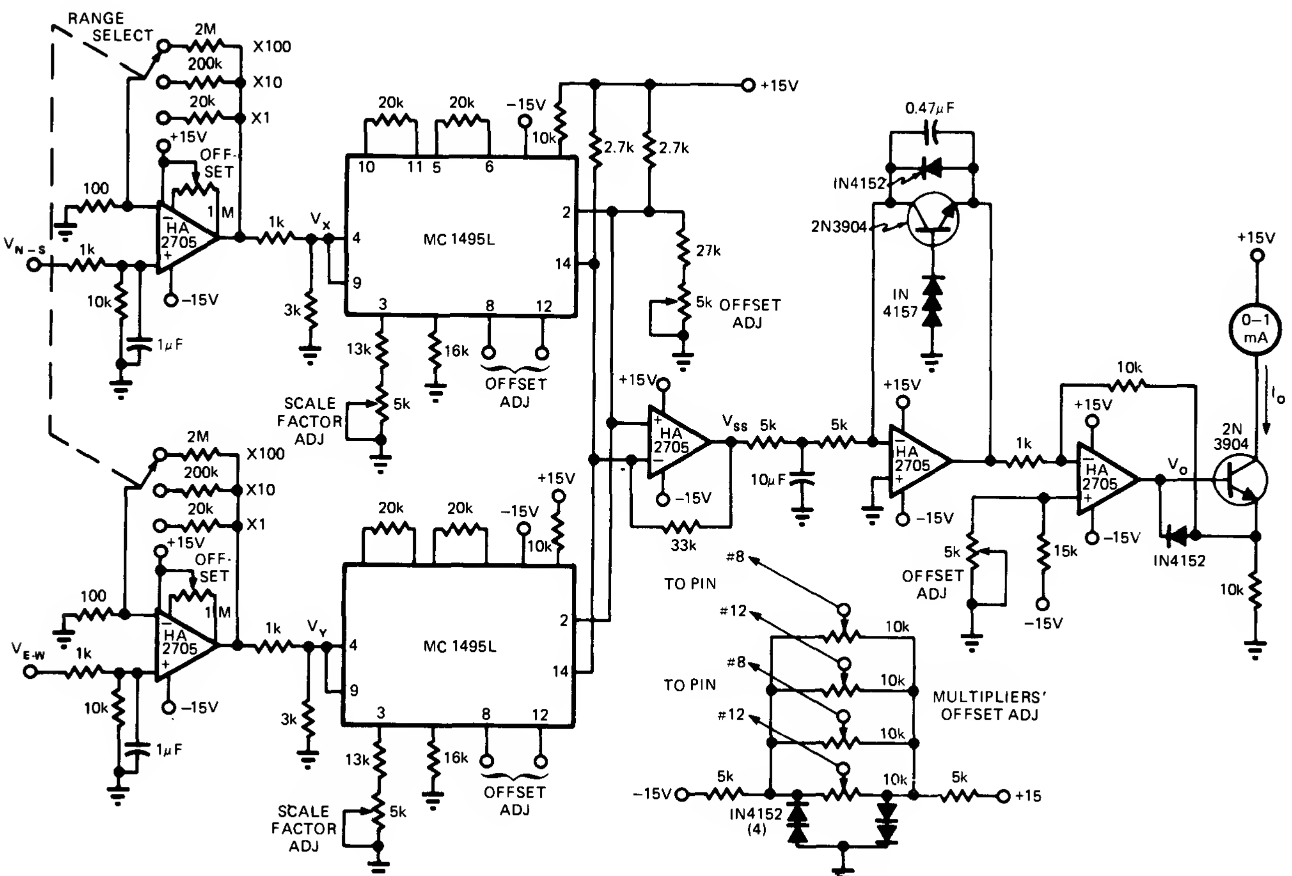
DIODE-SWITCHED IF FILTER—Used in 1.8–2 MHz communication receiver heving wide dynamic ranga. 1N914 diodes salect Collins mechanical filter F455FD-04 FL3 (400-Hz bandwidth) or F455FD-25 FL4 (2.5-kHz bandwidth). Ravarse bias is applied to nonconducting diodes to lesson leakaga through switching diodes. Filter is located between IF preamp and main IF strip of receiver. Two-part article glves ell other circuits of racaivar.—D. DeMaw, His Emlnence—the Receivar, *QST*, Part 1—June 1976, p 27–30 (Part 2—July 1976, p 14–17).



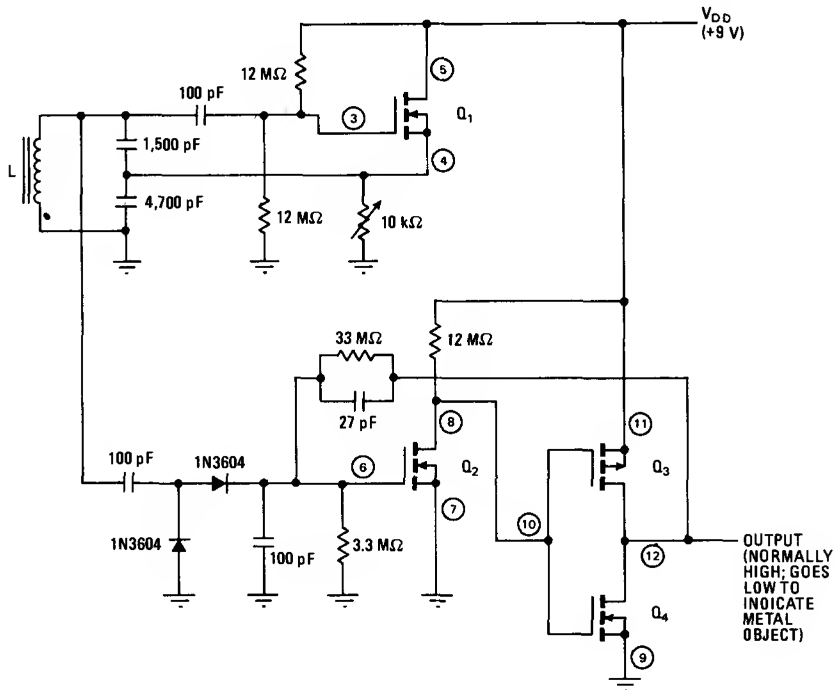
10.7-MHz LIMITING AMPLIFIER—Uses Signetics NE510 transistor arrays in common-collector common-base configuration es IF strip for commerciel FM broadcast receiver. Bandwidth is 300 kHz, achieved by adjusting transformers for 600-kHz bandwidth and using dual cup-core transformers originelly designed for tubes. Windings were changed to give critical coupling. Full limiting is provided by circuit with input voltege of 70 μVRMS.—"Signetics Aneiog Date Manuel," Signetics, Sunnyvale, CA, 1977, p 747–748.

CHAPTER 40
Instrumentation Circuits

Includes DC, AF, and wideband RF amplifiers with such special features as automatic nulling and automatic calibration, for use with resistance-bridge, photocell, strain-gage, and other input transducers. Applications include measurement of ionization, radiation, small currents, liquid flow and level, light level, pH, power, torque, weight, and wind velocity. Metal detectors and proximity detectors are also covered. See also chapters covering measurement of Capacitance, Frequency, Resistance, and Temperature.

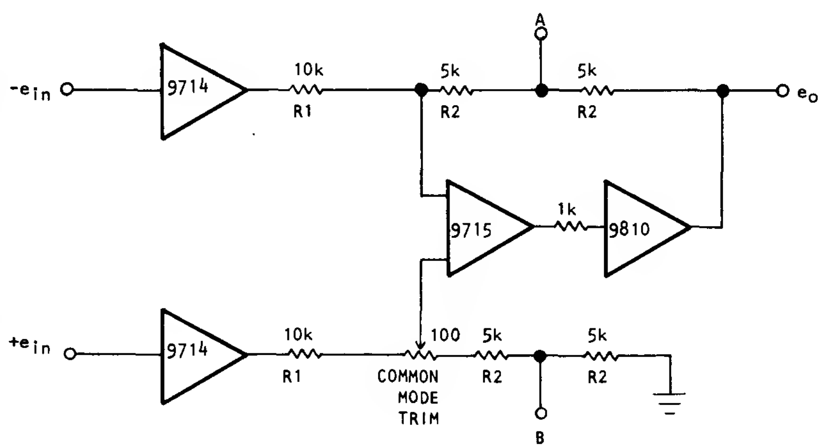


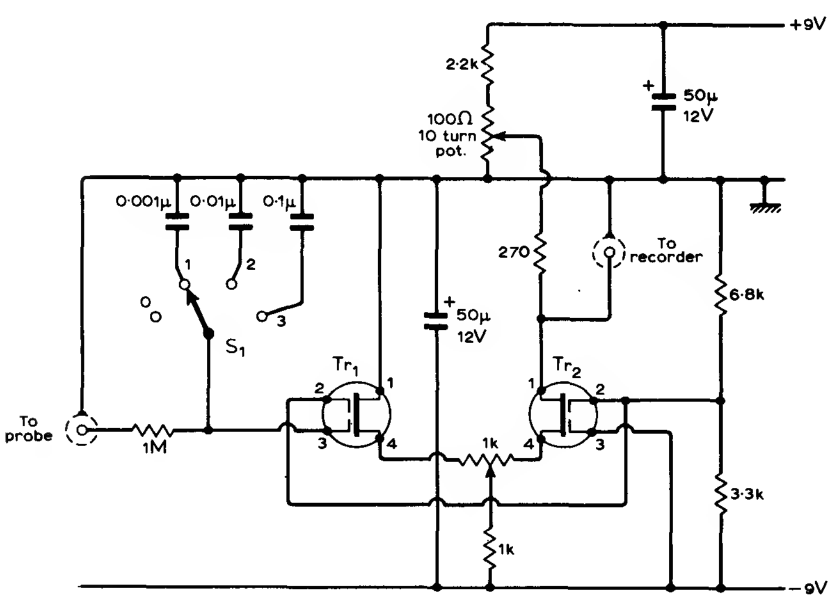
WIND SPEED—Developed to give magnituda of wind velocity over wide range of values when its two measured vectors ara expressed as voltages. Output is in logarithmic form for easy adaptation to data processors. N-S and E-W vactor voltages from strain-gage sensors are converted to normalized values V_X and V_Y which ara squared by MC1495L four-quadrant transconductance multipliers. Output currents are then summed, and HA2705 opamp is used as differential current-to-voltage converter to obtain V_{SS} as sum-of-squares of V_X and V_Y. Ranga covarad is 1–100 mph. Article covers operation of circuit in detail.—J. A. Connally and M. B. Lundberg, Analog Multipliers Determina Trua Wind Spaad, *EDN Magazine,* Aprll 20, 1974, p 69–72.



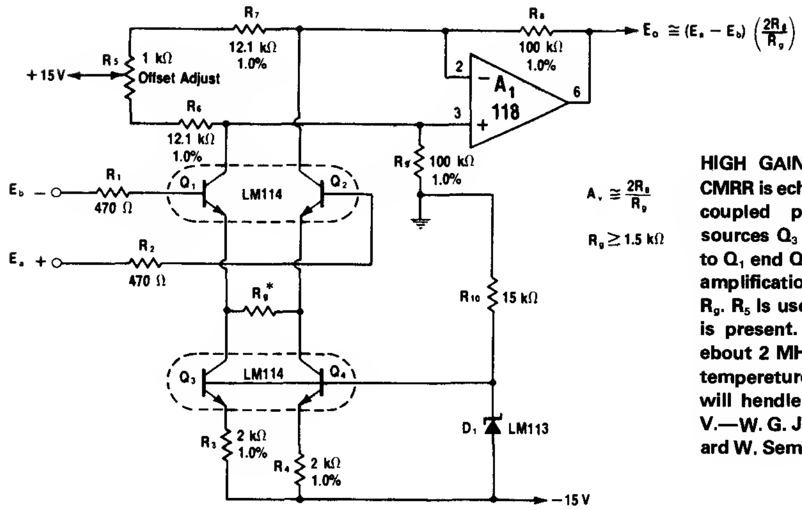
PROXIMITY DETECTOR—Output changes from high (9 V) to low (0 V) when conducting object moves within 1 cm from open end of 150-turn coil L (No. 34 enamel) mounted in half of Ferroxcube 1811-PL00-3B7 core set. Can be used as contactless limit switch or tachometer pickup. Q_1-Q_4 are CMOS MOSFETs in CD4007A package. Q_1 and pickup coil form 100-kHz oscillator. Diodes develop DC voltage proportional to peak-to-peak value of oscillator signal, for application to Schmitt trigger Q_2-Q_4. Conductive object near coil absorbs energy from magnetic field, lowering oscillator amplitude and turning Schmitt trigger off. 10K pot adjusts sensitivity. Circuit drives CMOS logic directly. For TTL drive, use buffer.—M. L. Fichtenbaum, Inductive Proximity Detector Uses Little Power, *Electronics*, Jan. 22, 1976, p 112.

0–15 MHz WITH 100-dB CMR—Differential inputs are applied to Optical Electronics 9715 opamp through 9714 voltage followers. Current booster using 9810 opamp raises load current to ±100 mA. Complete amplifier has very high differential and common-mode input impedance. Common-mode rejection can be trimmed to greater than 100 dB at 1 kHz for unity gain. Gain is determined by value of resistor RG connected between points A and B and is equal to (2R2/R1)(1 + 2R2/RG). Settling time is 500 ns. Accuracy is maintained from −55°C to +85°C.—"Instrumentation Amplifier," Optical Electronics, Tucson, AZ, Application Tip 10240.





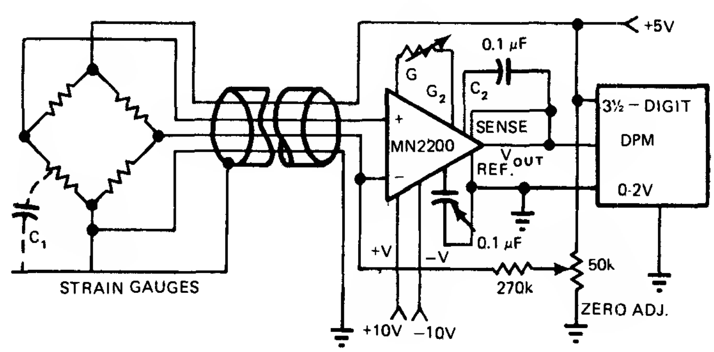
MOSFET DIFFERENTIAL AMPLIFIER—Developed to monitor chemical process of titration, by recording probe output voltages between 100 and 400 mV when internal impedance of probe is in gigohm range. Either 40673 or 3N187 dual-gate MOSFETs connected as differential amplifier are suitable for meeting high input resistance requirement. Transistor level drifts because of temperature are in opposition and tend to cancel each other. Overall power gain of amplifier is about 70 dB. Circuit is suitable for other electrometer applications as well.—D. R. Bowman, Automatic Titration Potentiometer, *Wireless World*, Aug. 1971, p 400–401.

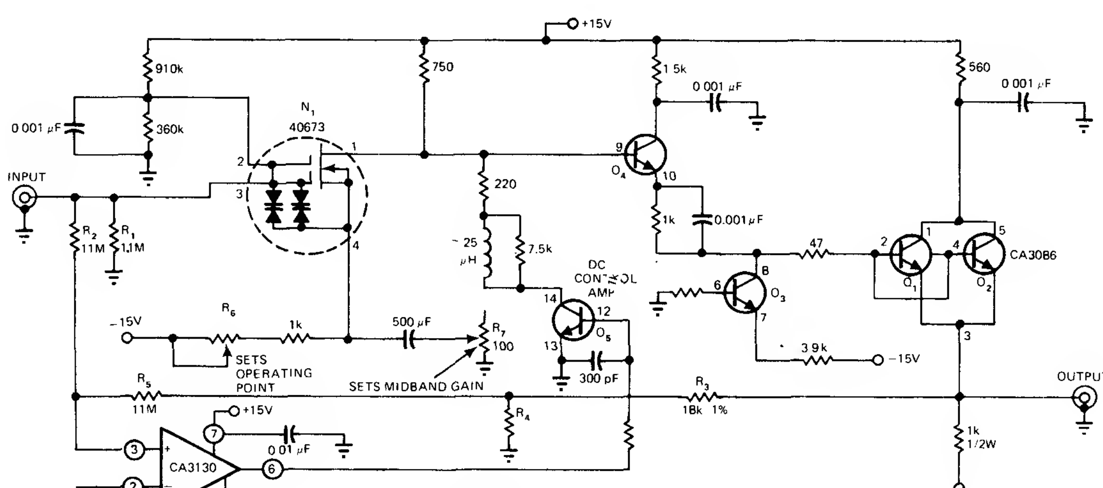


*R_9 varied to adjust input sensitivity and gain; can be greater than 200 kΩ if attenuation desired.

HIGH GAIN WITH WIDE BANDWIDTH—High CMRR is achieved by using Q_1 end Q_2 es emitter-coupled peir biesed by constant-current sources Q_3 end Q_4. Differentiel signels epplied to Q_1 end Q_2 eppeer ecross 100K resistor R_9 for amplification by fector inversely proportional to R_9. R_5 is used to null opemp A_1 when no input is present. Bendwidth, determined by A_1, is ebout 2 MHz. Gein is flet et ebout 40 dB over tempereture range of −55°C to +125°C. Circuit will hendle common-mode inputs up to ±10 V.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sems, Indienepolis, IN, 1974, p 243–245.

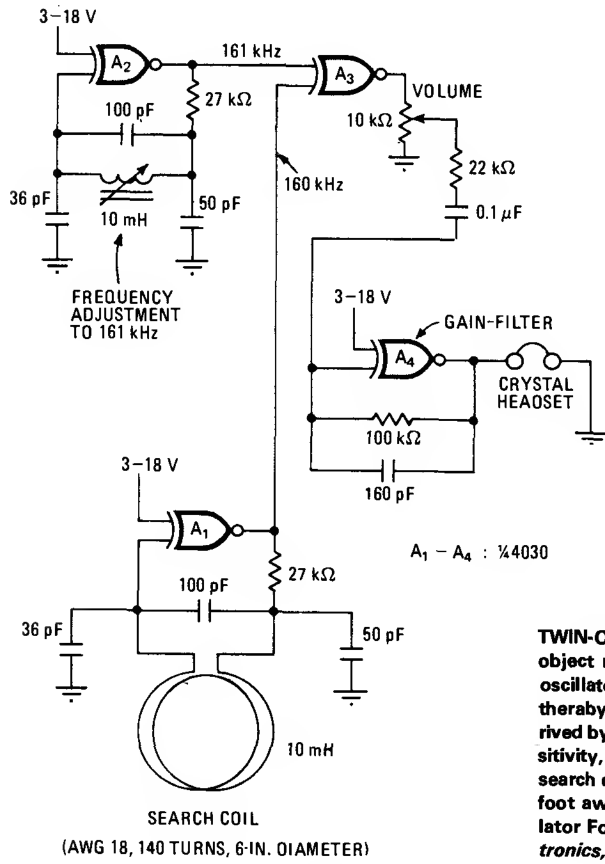
TORQUE WRENCH—Micro Networks MN2200 instrumentetion amplifier is used with strein gege to create digital-reedout torque wrench. Strein geges having nominel impedence of 120 ohms ere bonded to torque-sensing member et 45° to longitudinel exis, so geges in opposite bridge erms ere under simulteneous tension or compression for given direction of torque. Bridge power is teken from 5-V digitel penel meter supply. Instrumentetion amplifier will work with eny voltege from ±5 to ±15 V. Verieble gein-edjust resistor G (10-turn 50K pot) is set so DPM reads 200 ft-lb of torque et full scele in increments of 0.1 ft-lb.—R. Duris, Instrumentation Amplifiers—They're Great Problem Solvers When Correctly Applied, *EDN Magazine*, Sept. 5, 1977, p 133–135.

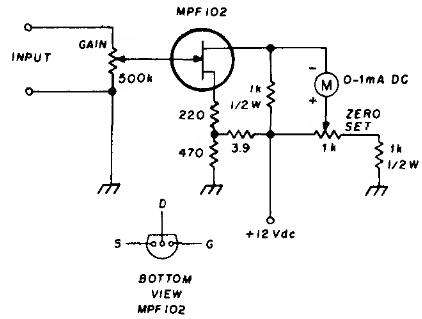




NOTES:
·15V SUPPLIES BYPASSED TO GROUND WITH 5 μF CAPACITORS
$Q_1 - Q_5$ CA3086 TRANSISTOR ARRAY IC

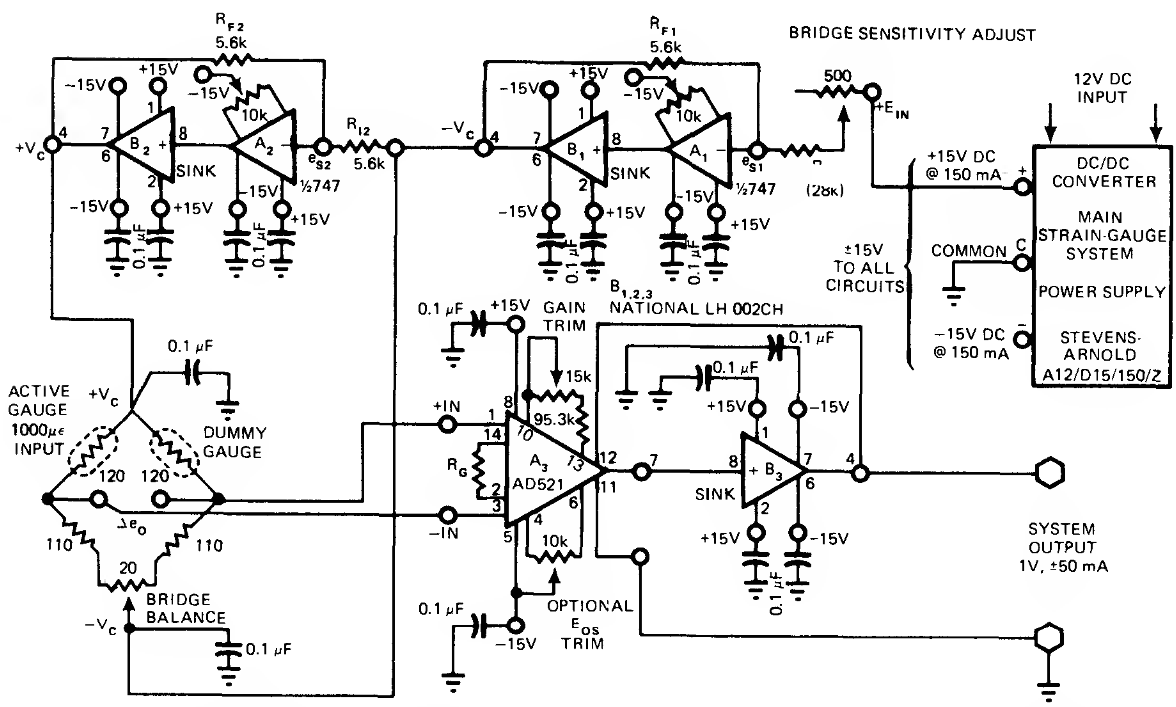
0–35 MHz WITH GAIN OF 10—Widebend emplifier handles inputs up to 100 mV P-P and drives 1-kilohm loed, to meet requirements of oscilloscope preemps, instrumentation end pulse signal emplifiers, end video signal processors. High-frequency gein is provided by 40673 duel-gete MOSFET. Low-frequency gein with DC stabilizetion is provided by CA3130 CMOS opamp. Transistors Q_1-Q_5 are part of CA3086 trensistor-errey IC. Values of R_3 and R_4 in feedbeck peth establish emplifier gein. R_6 sets opereting point of N_1 for 10-mA drein current. Base resistor of Q_3 is 1 kilohm.—H. A. Wittlinger, CMOS Op Amp, MOSFET Implement Wideband Amplifier, *EDN Magazine*, June 20, 1977, p 114.



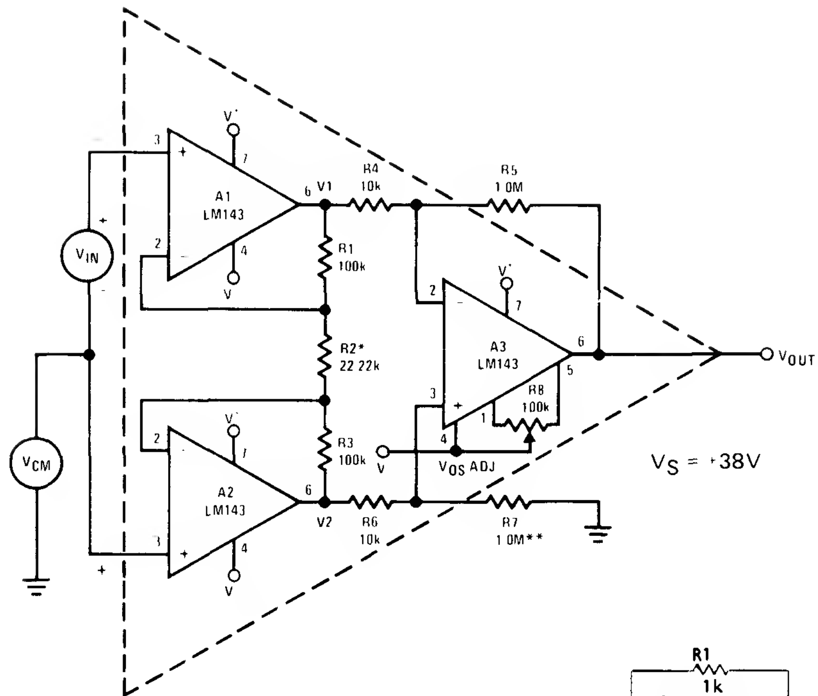


METER AMPLIFIER—Junction FET in simple DC amplifier circuit converts 0–1 mA DC milliemmeter to 0–100 μA DC microammeter. Adjust zero-set control for zero meter current with no input, then apply input signal and adjust gain to desired value.—N. J. Foot, Electronic Meter Amplifier, *Ham Radio*, Dec. 1976, p 38–39.

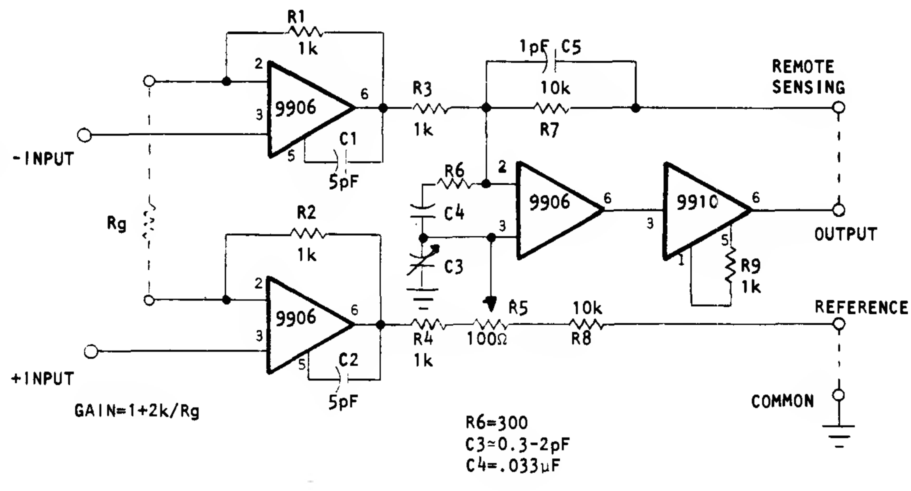
TWIN-OSCILLATOR METAL DETECTOR—Metal object near search coil changes frequency of oscillator A_1 which is initially tuned to 160 kHz, thereby changing frequency of 1-kHz output derived by mixing with 161-kHz output of A_2. Sensitivity, determined largely by dimensions of search coil, is sufficient to detect coins about 1 foot away.—M. E. Anglin, C-MOS Twin Oscillator Forms Micropower Metal Detector, *Electronics*, Dec. 22, 1977, p 78.



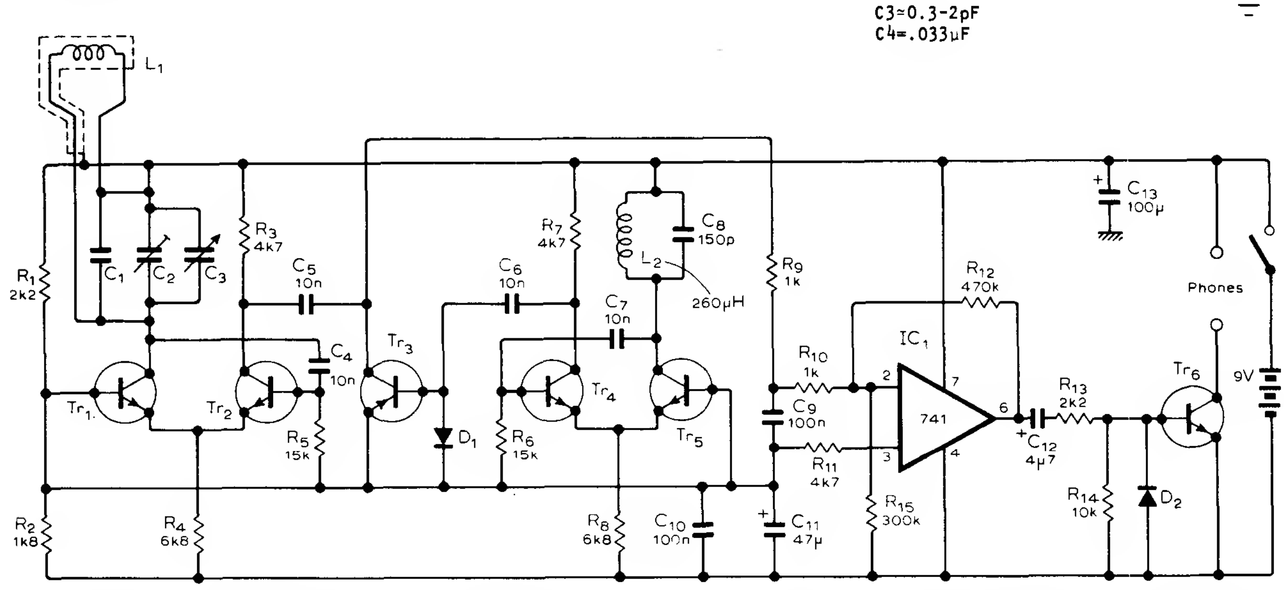
STRAIN-GAGE AMPLIFIER—Optimum performance is achieved in fully portable system by utilizing combination of 747 opamps for A_1 and A_2 with National LH002CH opamp for B_1-B_3 and special AD521K instrumentation amplifier for output stage. Bypass capacitors suppress undesirable high-frequency signals. Stevens-Arnold DC/DC converter operating from 12-V storage battery provides required regulated ±15 VDC for system while giving excellent power isolation.—D. Shaehan, Strain-Gauge Transducer System Uses Off-the-Shelf Components, *EDN Magazine*, Nov. 5, 1977, p 79–81.



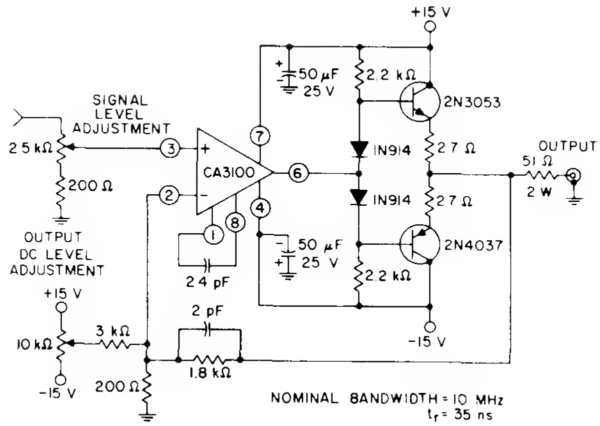
±34 V COMMON-MODE RANGE—Interconnections shown for three LM143 high-voltage opamps give equivalent of single differential-input opamp having wide common-mode range, high input impedance, and gain of 1000. Adjust R2 to trim gain. Adjust R7 for best common-mode rejection. With 10K load, frequency response is down 3 dB at 8.9 kHz.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 2–3.



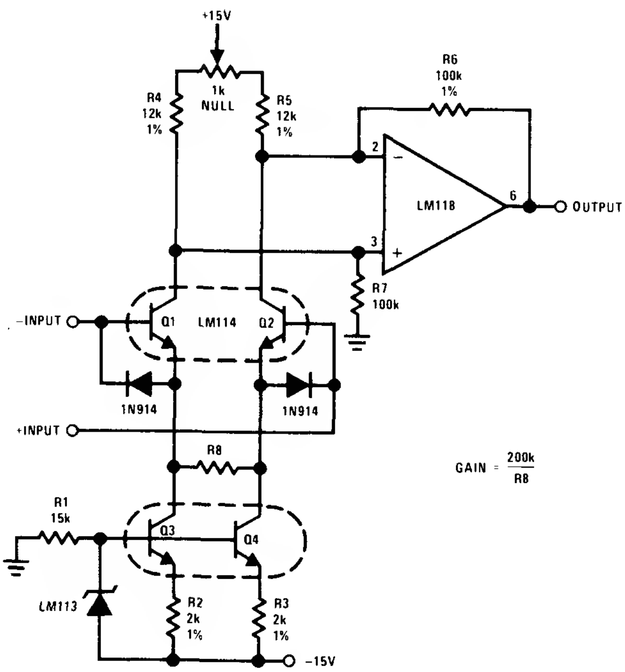
DIFFERENTIAL-INPUT AMPLIFIER—Provides gain up to 1000, depending on value of Rg, for video signals in radar, medical ultrasound, laser communication, and laser rangefinder applications. Uses three Optical Electronics 9906 wideband opamps and 9910 current booster for cable drive. Bandwidth is above 10 MHz for gains of 0.1 to 100, decreasing to 5 MHz at gain of 1000. Miller compensation of input amplifiers minimizes noise level and gives input impedance of 5 megohms and 5 pF.—"Wide Band Instrumentation Amplifier," Optical Electronics, Tucson, AZ, Application Tip 10276.



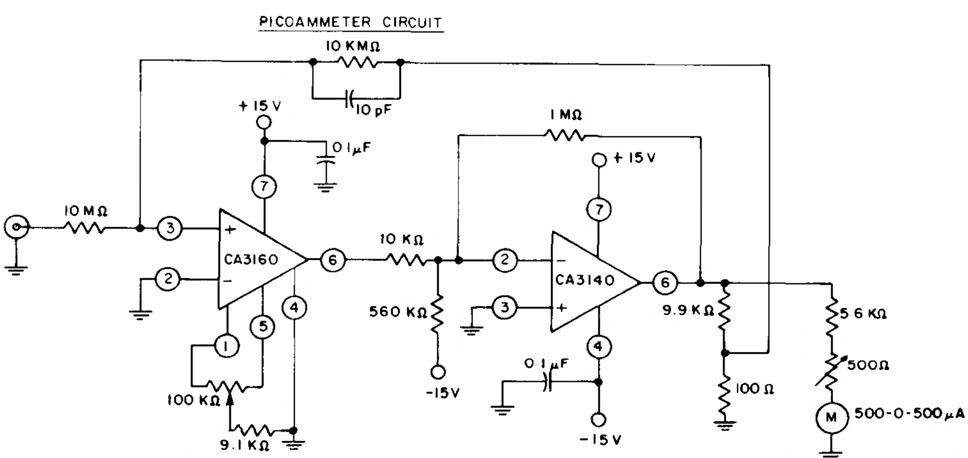
METAL DETECTOR—Will detect small coin up to about 5 inches underground and larger metal objects at much greater depths. Frequency of search oscillator Tr_1-Tr_2 depends on values used for three paralleled capacitors, search coil, and metal objects in vicinity of coil. Mixer Tr_3 feeds difference between search oscillator and reference oscillator Tr_4-Tr_5 to opamp and Tr_6 for driving phones or loudspeaker. Article gives construction and adjustment details, including dimensions for search coil. Reference oscillator is set to 625 kHz. C_1 is 560 pF, C_2 150 pF, and C_3 10 pF variable. C_2 is used for coarse tuning, and C_3 for fine adjustment to get beat note. Diodes are 1N4148. Tr_3 is BC308, BCY72, or equivalent, and other transistors are BF238, BC108, or equivalent.—D. E. Waddington, Metal Detector, *Wireless World,* April 1977, p 45–48.



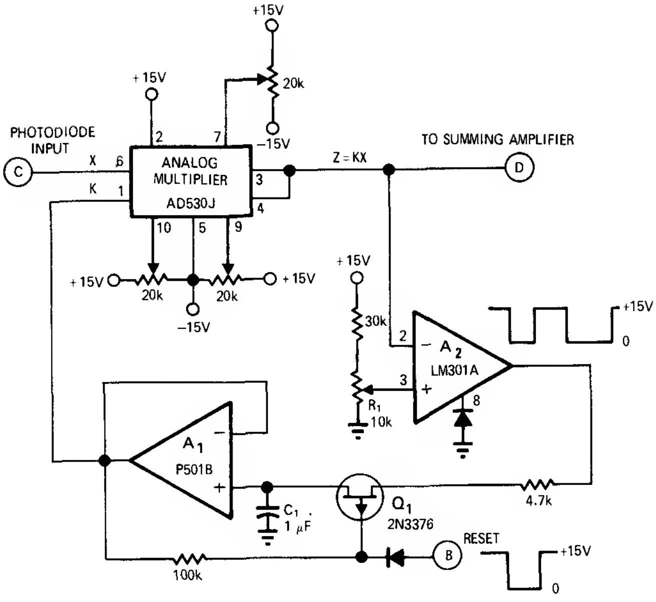
50-OHM LINE DRIVER—CA3100 bipoler MOS opamp operates as high-slew-rate wideband amplifier thet provides 18 V P-P into open circuit or 9 V P-P into 50-ohm transmission line. Slew rate is 28 V/µs.—"Circuit Ideas for RCA Linear ICs," RCA Solid Stete Division, Somerville, NJ, 1977, p 13.



ADJUSTABLE-GAIN WIDEBAND AMPLIFIER—Single resistor R8 edjusts gain from less than 1 to over 1000, with gein value aqual to 200,000 divided by value in ohms used for R8. Common-mode rajection retio is about 100 dB, independent of gain. Q1-Q2 ere opereted open-loop es floating differential input stage. Current sources Q3 and Q4 sat operating current of input trensistors.—"Lineer Applicetions, Vol. 2," Nationel Semiconductor, Sante Clere, CA, 1976, LB-21.

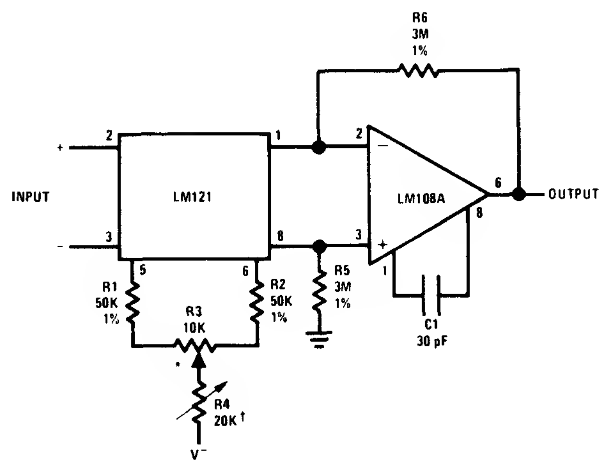


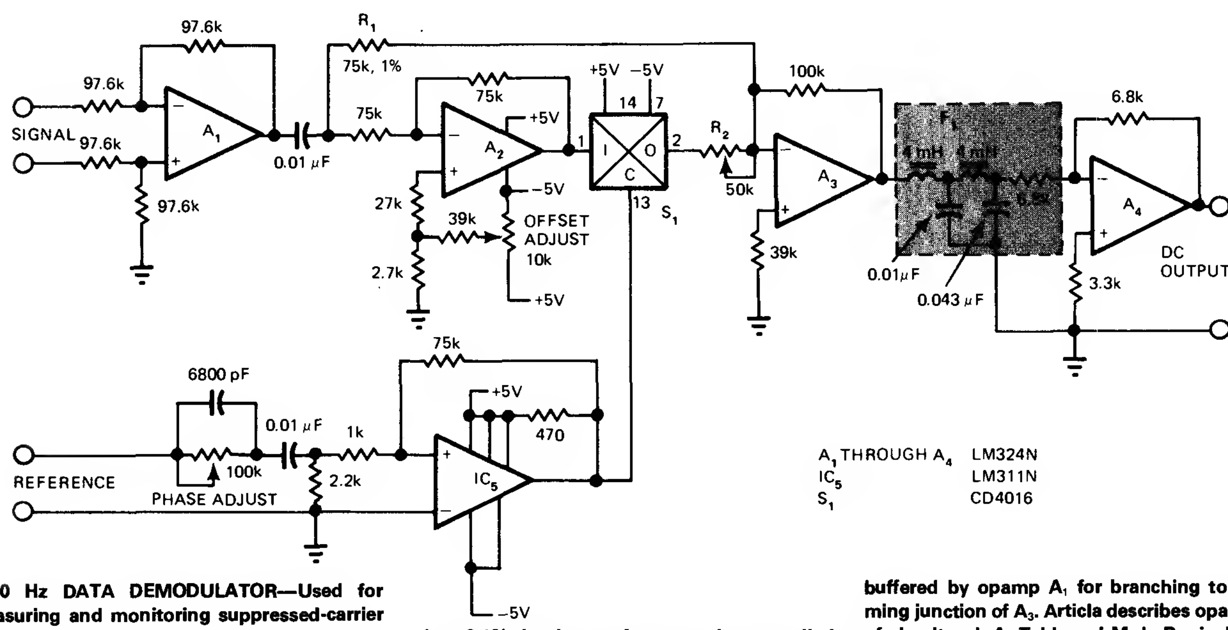
OPAMP PICOAMMETER—Current-to-voltege converter connection for CA3160 and CA3140 bipoler MOS opemps provides full-scale meter deflection for ±3 pA. CA3160 is opereted in guarded mode to reduce leakage current. CA3140 provides gain of 100 for driving zero-center microammetar. With suitabla switching, full-scale current ranges of 3 pA to 1 nA can ba handled with single 10,000-megohm resistor in overall feedback path.—"Circuit Ideas for RCA Lineer ICs," RCA Solid State Dlvlsion, Somervilla, NJ, 1977, p 14.



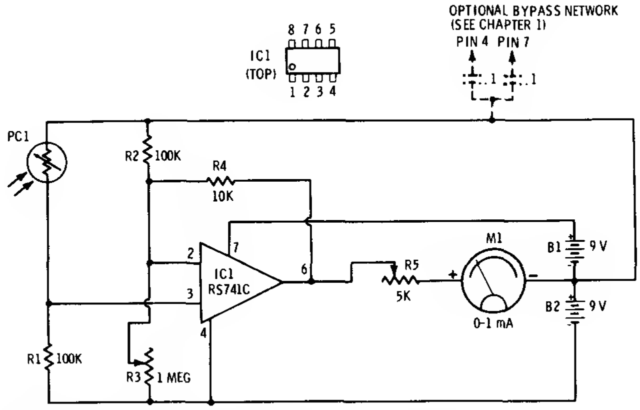
AUTOMATIC CALIBRATOR—Automatic scaling circuit permits frequent and fast recalibration for precision optical measurements, to compensate for variations in light intensity due to thermal cycling of lamp filament, dirty optics, and gain variations between photodetectors and betwaen amplifiers. With reset pulsa at point B, comparator A_2 compares output of multiplier to preset reference voltage on R_1. If A_2 input voltage is greater than reference applied to pin 3 by R_2, output switchas to zaro and remains there until C_1 has discharged enough to lower output of A_1 and output of multipliar below refarence on pin 3. If input at pin 2 of A_2 is less than reference on pin 3, A_2 will switch to 15 V and output of multipliar will be adjusted upward until voltage on pin 2 of A_2 again exceeds that on pin 3. Output of A_2 is thus continually switching between 15 V and 0 V during reset or scaling. After reset pulse is removed, scale factor K is maintained constant by multiplier during measuring.—R. E. Keil, Automatic Scaling Circuit for Optical Measurements, *EDN/IEEE Magazine*, Nov. 15, 1971, p 49–50.

HIGH GAIN FOR WEAK SIGNALS—National LM121 differential amplifier is operated open-loop as input staga for input signals up to ±10 mV. Input voltaga is convarted to differential output current for driving opamp acting as current-to-voltaga convarter with single-ended output. R4 is adjusted to set gain at 1000. Null pot R3 serves for offset adjustment.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-79, p 7–8.

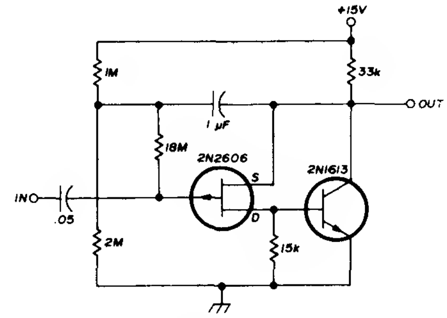




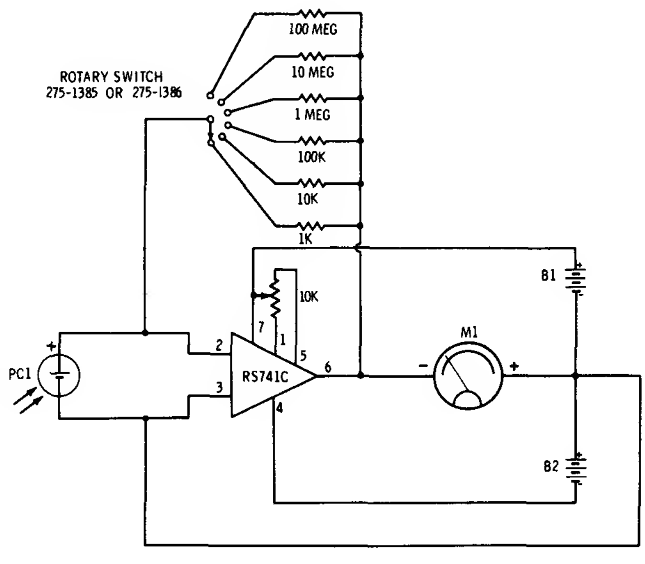
0–20 Hz DATA DEMODULATOR—Used for measuring and monitoring suppressed-carrier signal modulation from aircraft control systems. Provides data frequency response within 0.1 dB from DC to 20 Hz, with linearity bettar than 0.1%. In-phase reference voltage applied to comparator IC_5 controls gating of CD4016 MOS switch S_1. Suppressed-carriar signal is buffered by opamp A_1 for branching to summing junction of A_3. Articla describes oparation of circuit.—J. A. Tabb and M. L. Roginsky, Instrumentation Signal Demodulator Uses Low-Power IC's, *EDN Magazine*, Jan. 20, 1976, p 80.



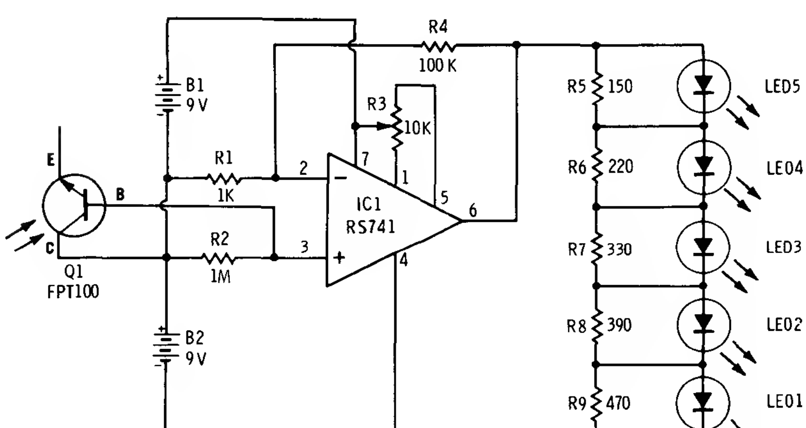
PHOTOCELL BRIDGE—Radio Shack 276-116 cadmium sulfide photocell is connected in Wheatstone bridge circuit. When bridge is balanced, RS741C opamp connected to opposite corners of bridge receives no voltage and meter reads zero. Light on photocell unbalances bridge and gives meter deflection. Can be used as high-sensitivity light meter. Adjust R3 until meter reads zero with photocell covered while R5 is at maximum resistance, adjust R5 until needle moves away from zero, rezero with R3, and repeat procedure until meter can no longer be brought to zero. Sensitivity is now maximum, and uncovered photocell will detect flame from candle at 20 feet.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 29–35.



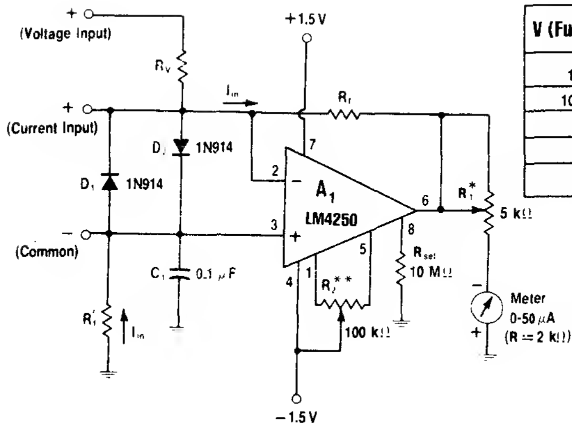
HIGH INPUT Z—Suitable for use as active probe for CRO, as electrometer, and for instrumentation applications. Combination of unipolar and bipolar transistors gives desirable amplifying features of each solid-state device.—I. M. Gottlieb, A New Look at Solid-State Amplifiers, *Ham Radio*, Feb. 1976, p 16–19.



SIX-RANGE LIGHT METER—Switching of feedback resistors for opamp driven by Radio Shack 276-115 selenium solar cell gives multirange linear light meter. With 1000-megohm resistor for highest sensitivity, star Sirius will produce photocurrent of about 25 pA when solar cell is shielded from ambient light with length of cardboard tubing. Supplies are 9 V, and meter is 0–1 mA.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 45–53.



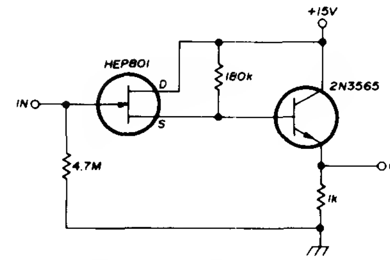
LIGHT METER WITH LED READOUT—Light on phototransistor Q1 (Radio Shack 276-130) produces voltage change across R2 for amplification by opamp whose output drives array of five LEDs forming bar graph voltage indicator. Adjust R3 initially for highest sensitivity by turning off room lights and rotating until LED 1 just stops glowing. Now, as light is gradually increased on sensor, LEDs come on one by one in upward sequence and stay on until all five are lit. Solar cells or selenium cells can be used in place of phototransistor.—F. M. Mims, "Optoelectronic Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 85–93.



V (Full Scale)	R_V (Ω)	R_1 (Ω)	R_1' (Ω)
10 mV	100 k	1.5 M	1.5 M
100 mV	1.0 M	1.5M	1.5 M
1.0 V	10 M	1.5 M	1.5 M
10 V	10 M	300 k	0
100 V	10 M	30 k	0

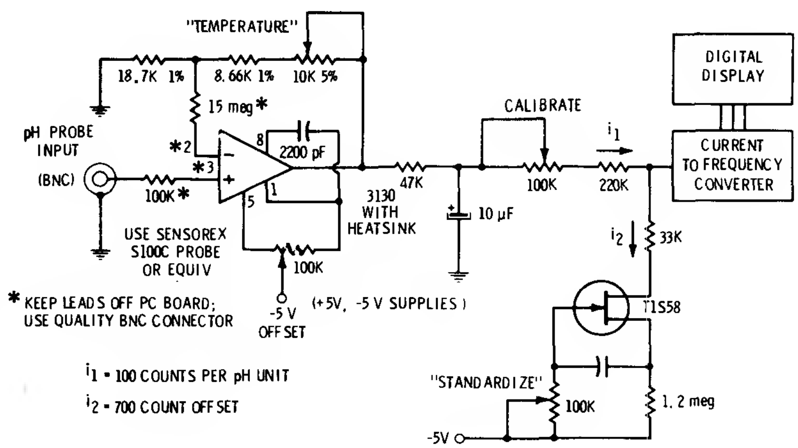
I (Full Scale)	R_1 (Ω)	R_1 (Ω)
100 nA	1.5 M	1.5 M
500 nA	300 k	300 k
1.0 μA	300 k	0
5.0 μA	60 k	0
10 μA	30 k	0
50 μA	6.0 k	0
100 μA	3.0 k	0

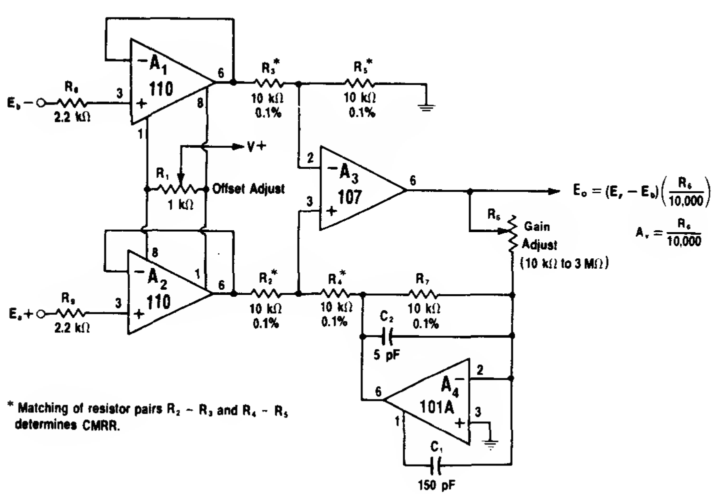
NANOAMMETER—Programmabla amplifiar oparating from ±1.5 V aupply such as D cells ia used as currant-to-voltaga convartar. Offset null of A_1 is used to minimize input offset voltaga arror. If programmed for low bias currant, amplifiar can convart currents as small aa 100 nA with less than 1% error. Resistor valuas for variety of currant and voltaga rangas are given in tables. Adjust R_1 to calibrate meter, and adjust R_2 to null input offset voltage on lowest ranga. Not suitabla for highar current rangas because power drain is excessive abova 100 μA.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sama, Indianapolis, IN, 1974, p 414–417.



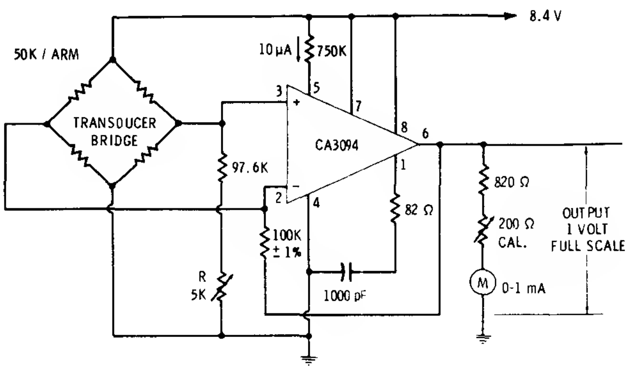
FET-BIPOLAR DARLINGTON—Can ba used as meter intarfaca amplifier, impedance transformar, coax drivar, or ralay actuator. Combination of unipolar and bipolar transistors gives desirabla amplifying features of each solid-stata davica.—I. M. Gottlieb, A New Look at Solid-Stata Amplifiers, *Ham Radio,* Fab. 1976, p 16–19.

DIGITAL pH METER—3130 CMOS opamp gives required high input impedanca for pH probe at low cost. Output of proba, ranging from positiva ganarated DC voltaga for low pH to 0 V for pH 7 and negative voltagas for high pH values, is amplified in circuit that provides gain adjutment to correct for tamparatura of solution being maasured. For analog raading, output of opamp can be fed directly to cantar-scala milliammetar through 100K calibrating pot. For digital display giving reading of 7.00 for 0-V output, pH output is convarted to calibrated current for summing with atabla offset currant equal to 700 counts. This is fed to current-to-frequancy convertar driving suitable digital display. Standard pH buffar solutions are used for calibration.—D. Lancastar, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 347–349.



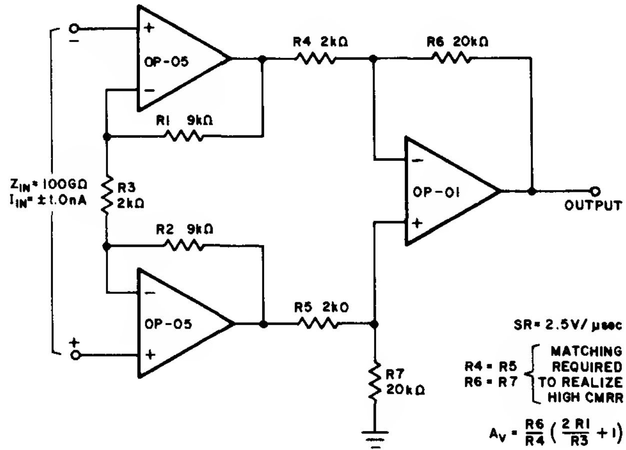


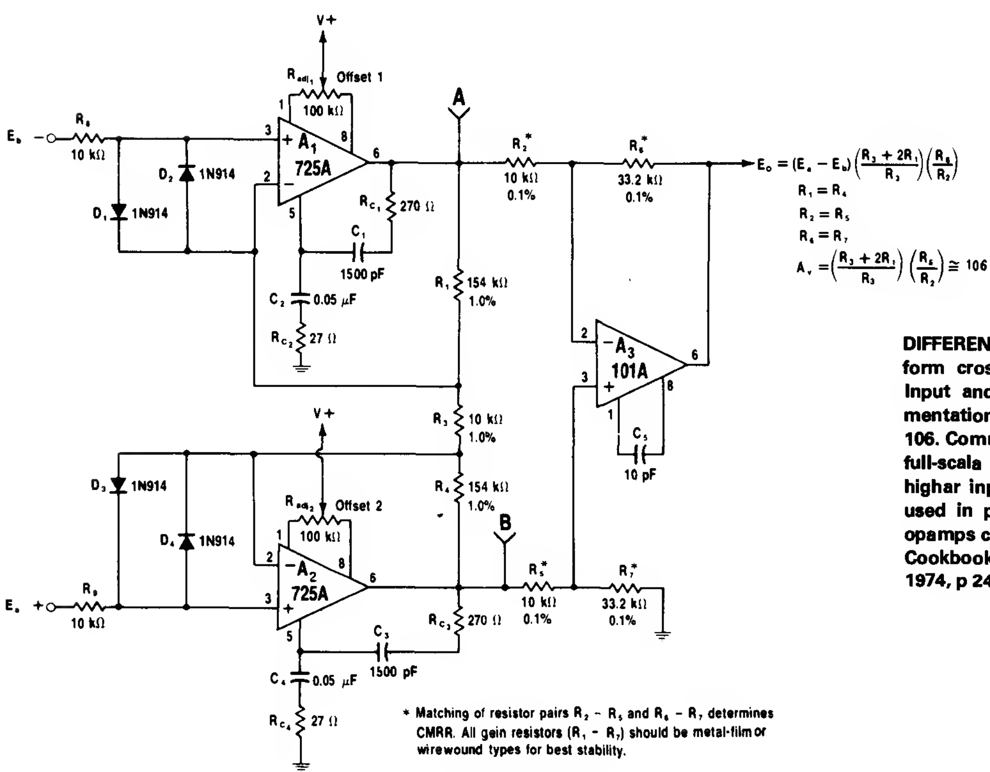
DIFFERENTIAL-INPUT VARIABLE-GAIN—Gain of A_3 is varied by modifying feedback returned to R_4. A_4 sarvas as active attenuator in feedback path, presenting constant zero-impedance source to R_4 as required for maintaining good balance and high CMRR. With values shown, gain can be varied from unity to 300.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 238–239.



SENSOR-BRIDGE AMPLIFIER—RCA CA3094 combination power switch end emplifier can ba used with variety of transducer bridges for instrumantation and other applications. Circuit delivars output of 1 V full-scale for driving meter. Pot R serves es centering or reference control. Can be used as thermometer if one lag of bridge is thermistor and metar scale is calibrated in degraes.—E. M. Noll, "Linaar IC Principles, Experiments, end Projects," Howard W. Sams, Indianapolis, IN, 1974, p 311–313.

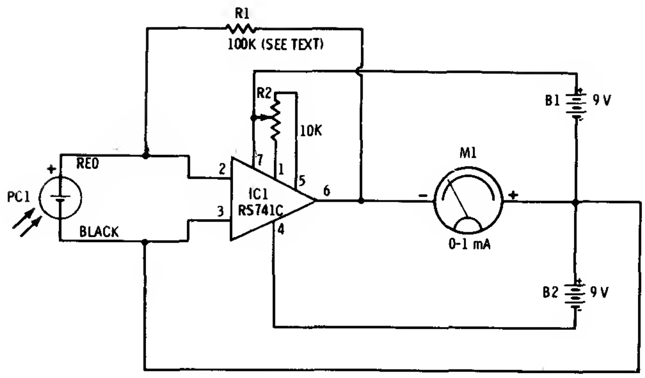
HIGH CMRR—Use of two Precision Monolithics OP-05 opamps feeding OP-01 opamp gives input impedence of ebout 100 gigohms end high common-mode rejection for Instrumantation applications.—"Instrumantation Operationel Amplifier," Precision Monolithics, Santa Clera, CA, 1977, OP-05, p 7.





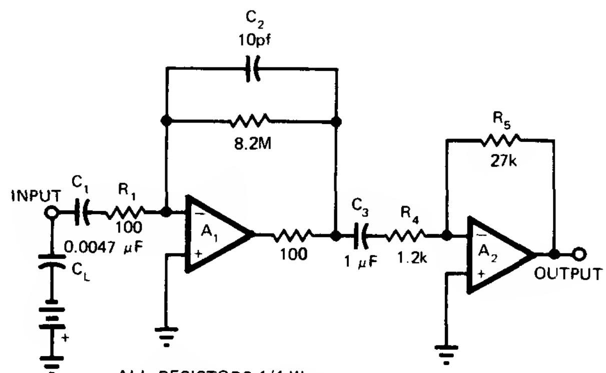
* Matching of resistor pairs R_2 - R_5 and R_6 - R_7 determines CMRR. All gain resistors (R_1 - R_7) should be metal-film or wirewound types for best stability.

DIFFERENTIAL PREAMP—Opamps A_1 and A_2 form cross-coupled preamp with differential Input and differential output, driving Instrumentation opemp A_3 to provide overall gain of 106. Common-mode input range Is ±10 V, and full-scala differential input is ±100 mV. For highar input impedance, 108 opamps can be used in preemp. For higher speed, all threa opamps cen be 118.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 241–243.

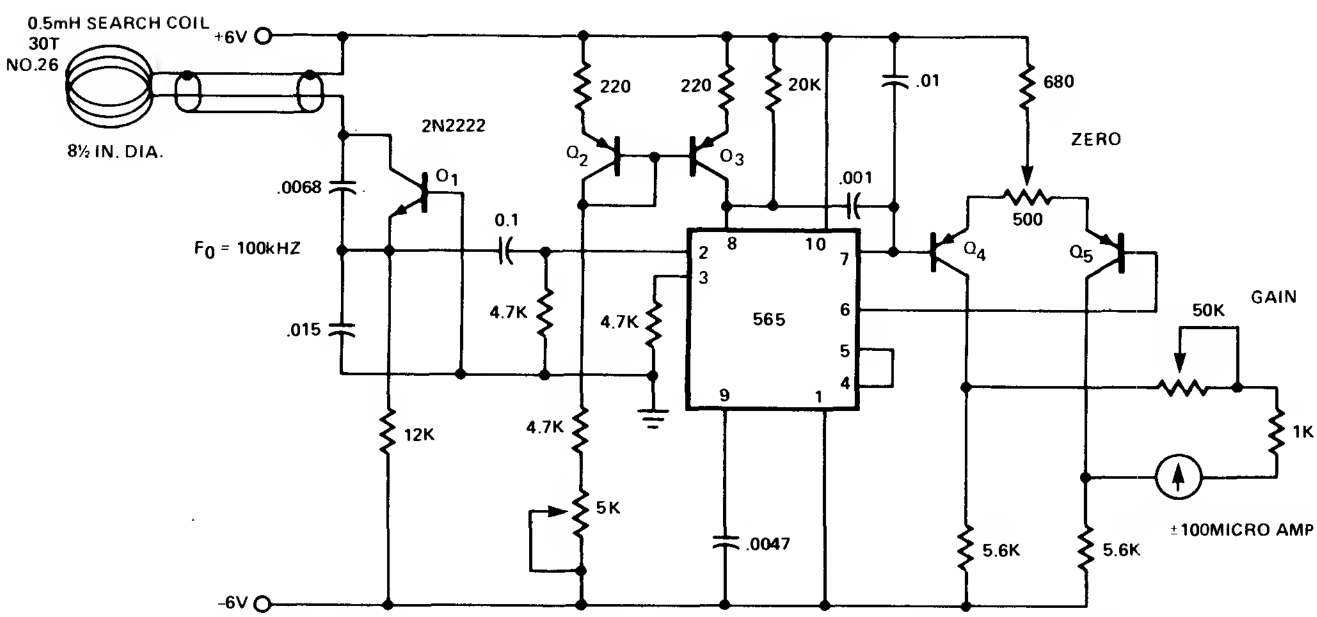


LINEAR LIGHT METER—Uses Radio Shack 276-115 salenium soler cell or equivelent photocell with high-gein RS741C opamp to drive meter. Sensitivity is sufficient to detect individuel stars et night without megnifying lens if photocell is shielded from ambient light with length of cerd-board tubing. Increesing velua of R1 increases gain end sensitivity of circuit. R2 sets meter needle to zero when sensor is dark.—F. M. Mims, "Integreted Circuit Projects, Vol. 4," Redio Sheck, Fort Worth, TX, 1977, 2nd Ed., p 45–53.

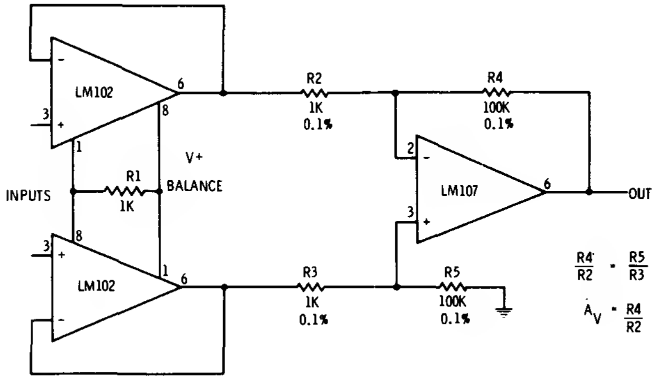
HODOSCOPE AMPLIFIER—Charge emplifier using Teledyne Philbrick 102601 opemp wes developed for use with each Geiger countar of 132-counter array for ionizetion hodoscope used in tracing paths of cosmic reys. Cherge-sensitive stege A_1 converts input cherge pulse to voltege pulse significently lerger then noise of second stege. With 616-pF load capacitor, output is 12 V for Input of 10 mV. Cost of charge emplifier is about \$50.—H. C. Cerpenter, Low Cost Charge Amplifier, *EDN Magazina*, Mey 20, 1973, p 83 and 85.



ALL RESISTORS 1/4 W
C_1 3kV SPRAGUE CERAMIC 30GA-D47
C_2 100V MICA D 15 1E 100FC
C_3 35 V SPRAGUE CS 13BF 105K
A_1 102601 TELEDYNE PHILIBRICK
A_2 1026 TELEDYNE PHILBRICK
C_L DETECTOR LOAD CAPACITANCE

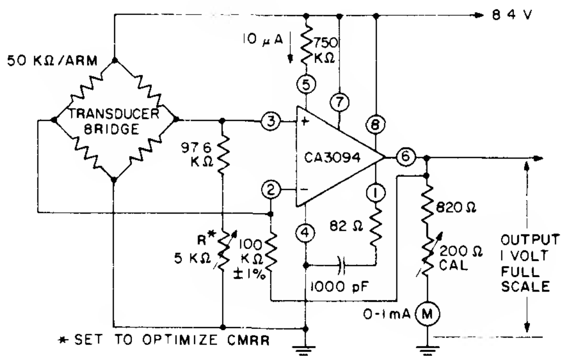


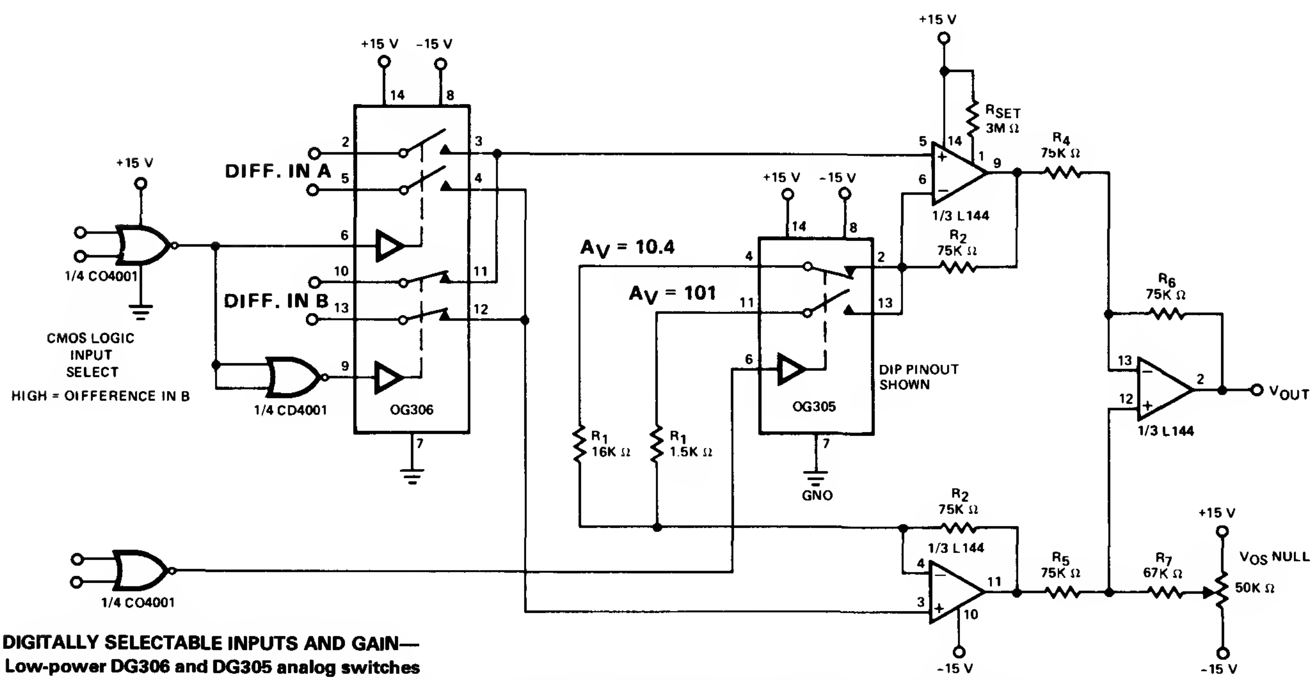
PLL DETECTOR FOR ALL METALS—Frequency change produced in Colpitts oscillator by metal object neer tenk coil is indicated by 565 PLL connected as frequency meter. Oscilletor frequency increeses when search coil is brought neer non-ferrous metel object. Oscillator frequency decreasas, as indicated by lower meter reading, when coil is brought neer farrous object.—"Signetics Anelog Deta Menuel," Signetics, Sunnyvale, CA, 1977, p 856–858.



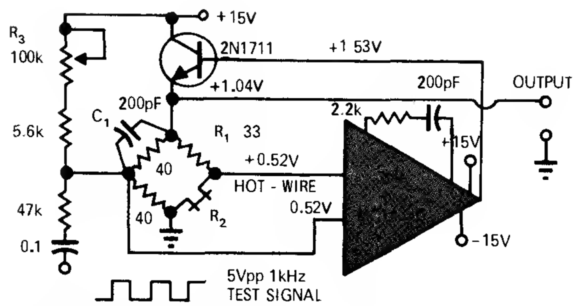
THREE-STAGE OPAMP—Responds to difference between two applied signals. Differential output voltage of LM102 pair is applied to balanced differentiel input of LM107 opemp. Output can be metered or used in any other desired manner. Voltega gein is equal to ratio R4/R2 and is 100 for values shown.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sems, Indienapolis, IN, 1974, p 126.

FEEDBACK OPAMP FOR BRIDGE—Uses CA3094 programmeble opamp to convert differential input signal from resistor bridge to single-ended 1-V output signal. Circuit provides feedback for opamp. RC network between terminals 1 and 4 of opamp provides compensation to improve stability.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 13.

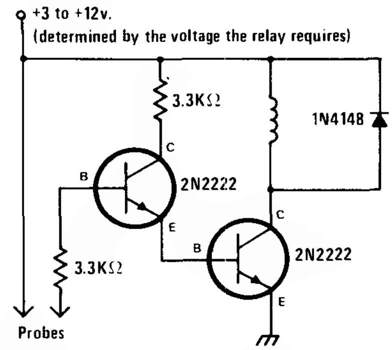




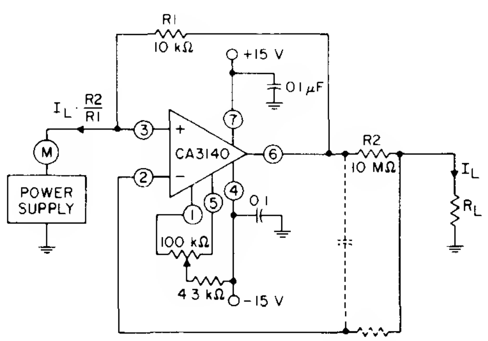
DIGITALLY SELECTABLE INPUTS AND GAIN—Low-power DG306 and DG305 analog switches provide choice of 10.4 or 101 gain and choica of two differential input channels for instrumentation applications. Highest gein is obtained when control logic is high.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-91.



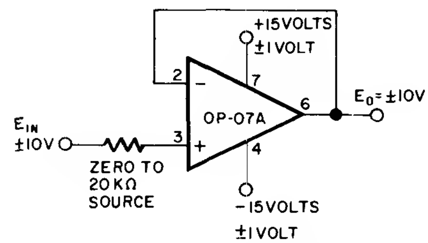
FLOW METER—Simpla opamp circuit with one transistor gives reliabla hot-wire anamometer for maasuring flow of gases or liquids. R_2 is heated abova ambiant tamparature in Wheatstona bridga including overheat rasistor R_1 which is calibratad to ba 30% largar than cold rasistance of R_2. Bridge is fad from powar transistor which is within faedback loop of opamp that sanses bridge unbalance. Output of bridge is fed back to power transistor in correct phasa for maintaining constant-temperatura condition in which R_2 is approximately equal to R_1. Articla covers construction of hot-wire proba made from Wollaston wire.—W. Bank, Build Your Own Constant-Temperatura Hot-Wire Anamometer, *EDN Magazina*, Aug. 1, 1972, p 43.



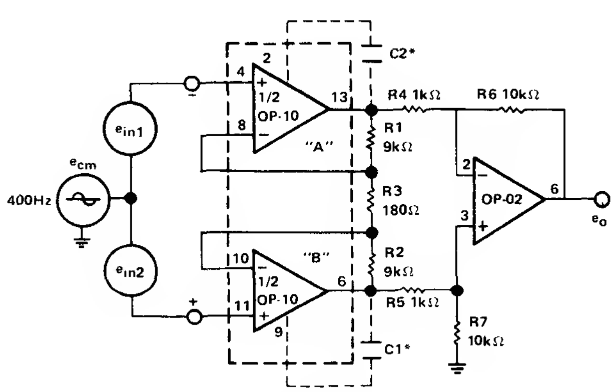
NONLATCHING RELAY—When liquid rises above leval detarmined by positions of probes, circuit is triggarad and relay, buzzar, or other indicator is energized. Alarm stops whan liquid drops balow prasat level again. Usa any oparating voltaga from 3 to 12 V that will actuata load employad.—J. A. Sandlar, 9 Easy to Build Projects under $9, *Modern Elactronics,* July 1978, p 53–56.



SMALL-CURRENT AMPLIFIER—CA3140 bipolar MOS opamp sarves as high-gain currant amplifier. Input current through load is incraased by ratio of R2 to R1, which is 1000 for values shown, for reading by metar M. Dashed lines show method of dacoupling circuit from affects of high output-lead capacitance.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 13.

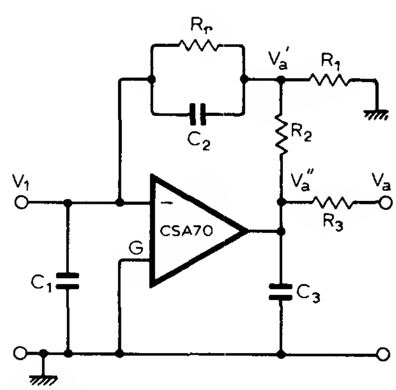


LARGE-SIGNAL BUFFER—Unity-gain connection of Precision Monolithics OP-07A opamp provides high accuracy (0.005% worst case) over temparatura range of −55°C to +125°C for buffer applications for ±10 V signals.—D. Sodarquist and G. Erdi, "The OP-07 Ultra-Low Offset Voltaga Op Amp—a Bipolar Op Amp That Challenges Choppers, Eliminatas Nulling," Precision Monolithics, Santa Clara, CA, 1975, AN-13, p 8.

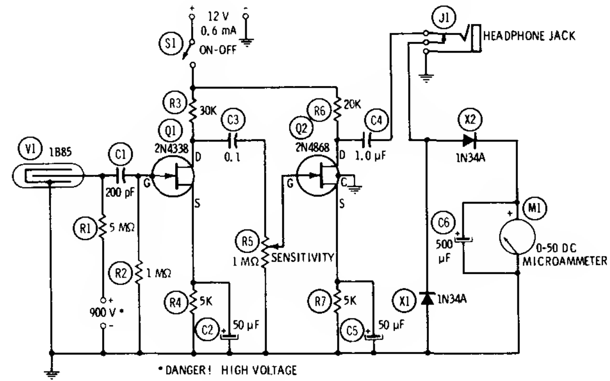


*Selected 5pF to 100pF

400-Hz AMPLIFIER WITH 95-dB CMRR—Precision Monolithics OP-10 dual opamp driving OP-02 opamp givas high common-mode rejection ratio. CMRR is optimized by selecting C1 and C2 in range of 5 to 100 pF for minimum output e_0 as viewed on CRO whila faeding ±10 V signal at 400 Hz to common connaction of inputs.—"Linear & Conversion I.C. Products," Precision Monolithics, Santa Clara, CA, 1977–1978, p 15-2.

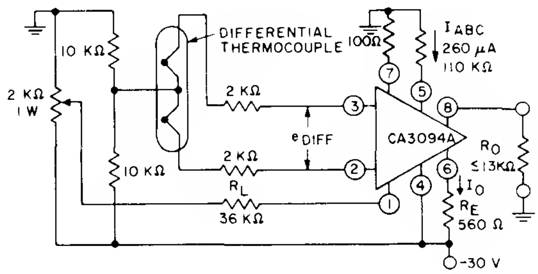


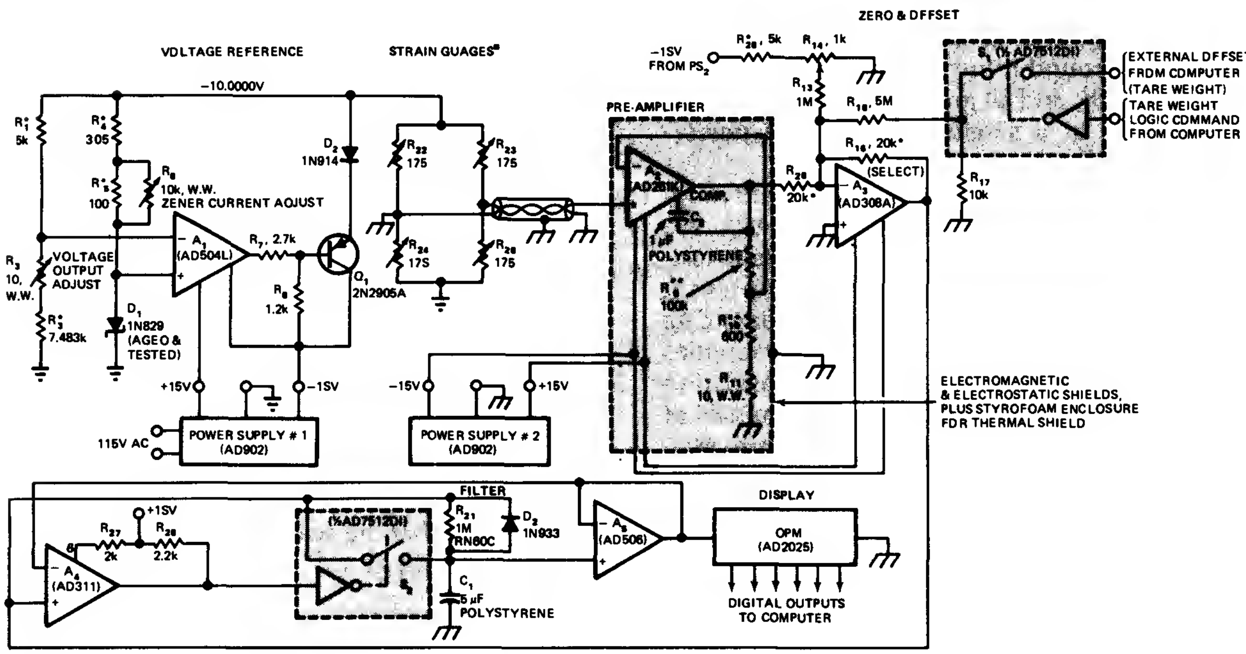
PICOAMMETER—Highly stabla circuit uses Valvo CSA70 chopper-stabilized opamp. Raquired high feedback resistance is provided by R_1-R_2 in feedback loop. Articla gives design aquations. R_r' and R_2 are 1 magohm, R_1 is 10 ohms, and all capacitors are 0.1 μF.—K. Kraus, High-Speed Picoammetar, *Wireless World,* May 1976, p 78.



GEIGER COUNTER—Output signal of Victoraan 1B85 G-M tuba biased at 900 VDC Is proportional to beta-gamma particle count. Signal is amplified by high-gain AF amplifier Q1-Q2 for driving AC metar circuit. Closed-circuit jack Is provided for alternate use of headphones. Count-rate range of instrument is determined by exposing G-M tube to different callbrated radioactive samples end marking meter scale for eech. Bies for counter can be obtained from three 300-V photoflash battaries in series or equivalent supply capable of providing up to 10 mA.—R. P. Tumer, "FET Circuits," Howard W. Sems, Indianepolis, IN, 1977, 2nd Ed., p 152–153.

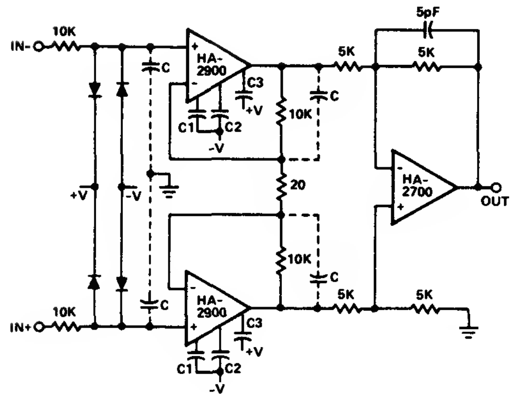
DIFFERENTIAL TO SINGLE-ENDED—Conversion from diffarential input signal of thermocouple to single-ended output signel is achieved without feedback by using CA3094A programmeble opamp. Output is ±4.7 V at 8.35 mA. Preamp gain is 180. For lineer operation, differential input must be equel to or less then ±26 mV.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 13.





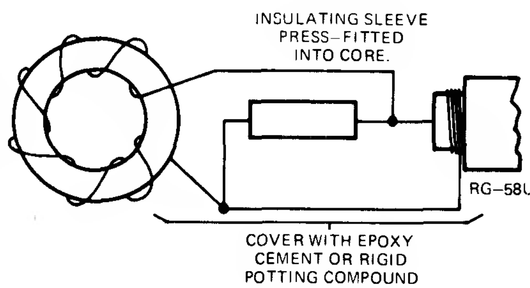
NOTES:
* = ULTRONIX TYPE 105A WIREWOUND
⏚ = FLOATED GROUND
⏚ = INSTRUMENT (EDISON) GROUND
** = 100k, 0.005%, TYPE R-44, JULIE RESEARCH LABS
*** = 600, 0.1%, R-44, JULIE RESEARCH LABS
ALL OP AMPS AND POWER SUPPLIES = ANALOG DEVICES
■ = SCHEMATIC FOR STRAIN GUAGES IS SIMPLIFIED

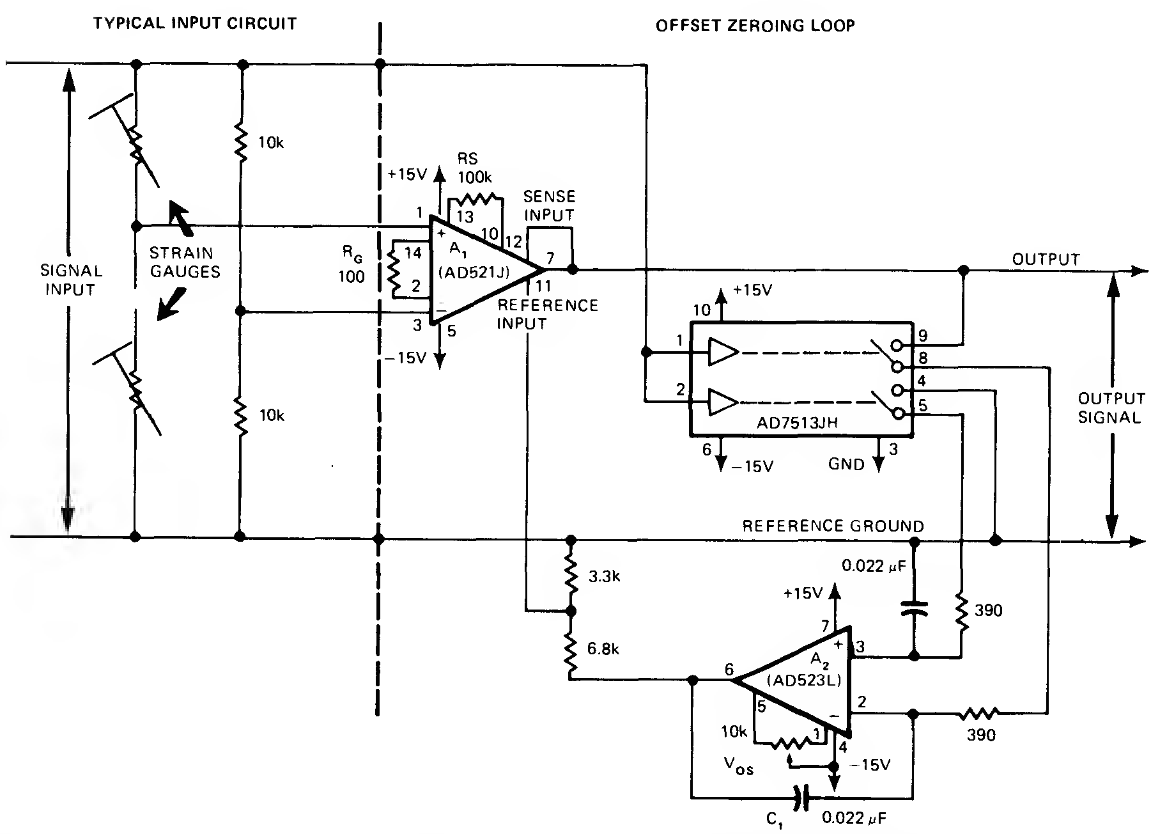
0.02% WEIGHING ACCURACY—Analog instrumant covers up to 300 lb with resolution of 0.01 lb, for monitoring chenges in body weight during clinical study. Bonded strain geges distributed symmetrically on platform of scale form bridge network R_1-R_2-R_4-R_5 serving as input for circuit that displays weight on digital penel meter and provides digital outputs to computer. Proper grounding is critical; all ground retums should go to single point at each power-supply common line. Article covers circuit operation in detail.—J. Williems, This 30-PPM Scale Proves That Analog Designs Aren't Dead Yet, *EDN Magazina*, Oct. 5, 1976, p 61–64.



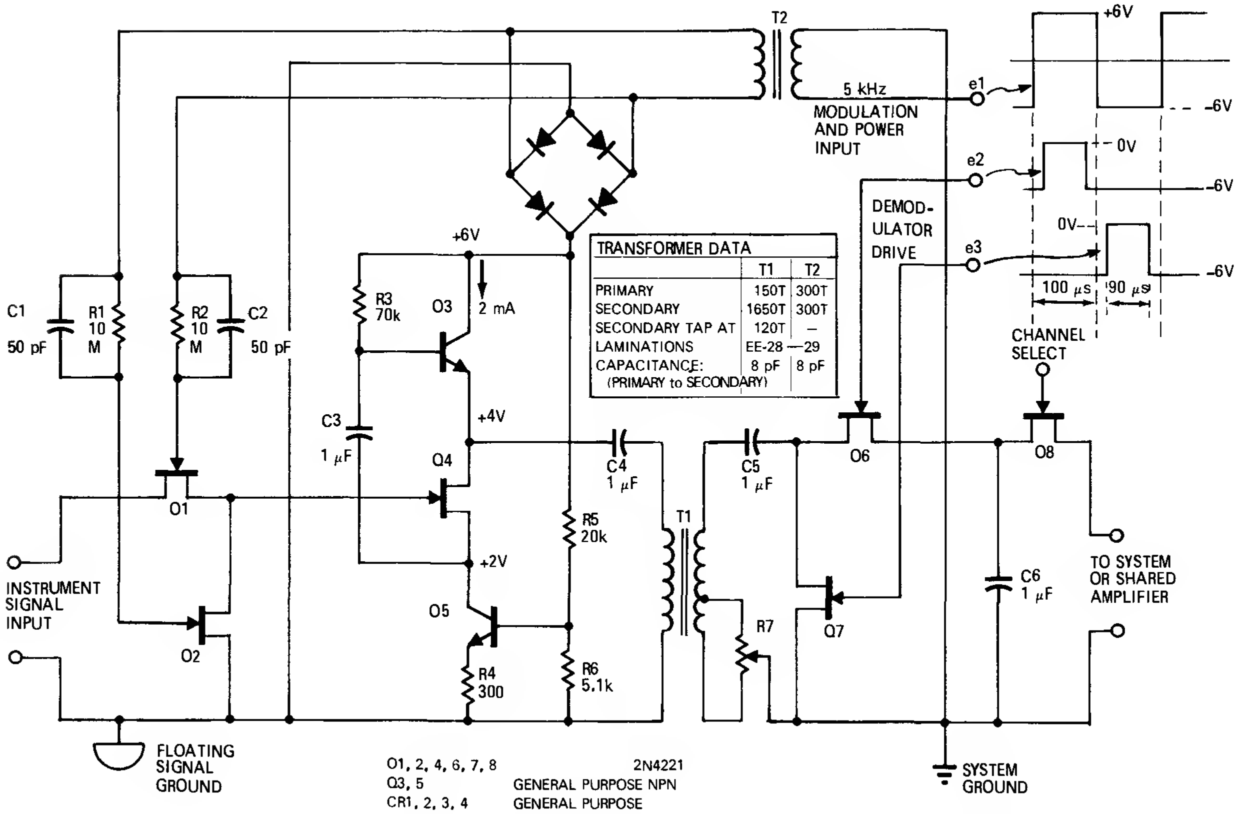
HIGH-IMPEDANCE DIFFERENTIAL-INPUT—Two Harris HA-2900 chopper-stabilized opamps feed HA-2700 high-performance opamp for instrumentation applications. Circuit provides excellent rejection of ±10 V common-mode input signals. Protection diodes prevent voltages at input terminels from exceeding either power supply. Supply cen be ±15 V.—"Lineer & Data Acquisition Products," Harris Semiconductor, Melboume, FL, Vol. 1, 1977, p 7-70 (Application Note 518).

FERRITE-BEAD CURRENT TRANSFORMER—No. 27 ferrite bead (Ferronics 11-122-B) wound with 25 turns No. 30 enemeled wire and shunted by 50-ohm ¼-W resistor, gives low-cost transformer that can be used in renge of 3 kHz to 30 MHz. Current-conversion ratio is 1 V/A into 50-ohm coaxial-cable termination, with excellent linearity from milliamperes up into amperes. Wire carrying current to be meesured is passed once through core, to serve as single-turn primary of transformer.—M. Salveti, Ferrite Bead Makes Cheep Current Transformer, *EDN Magazine,* March 20, 1974, p 85.

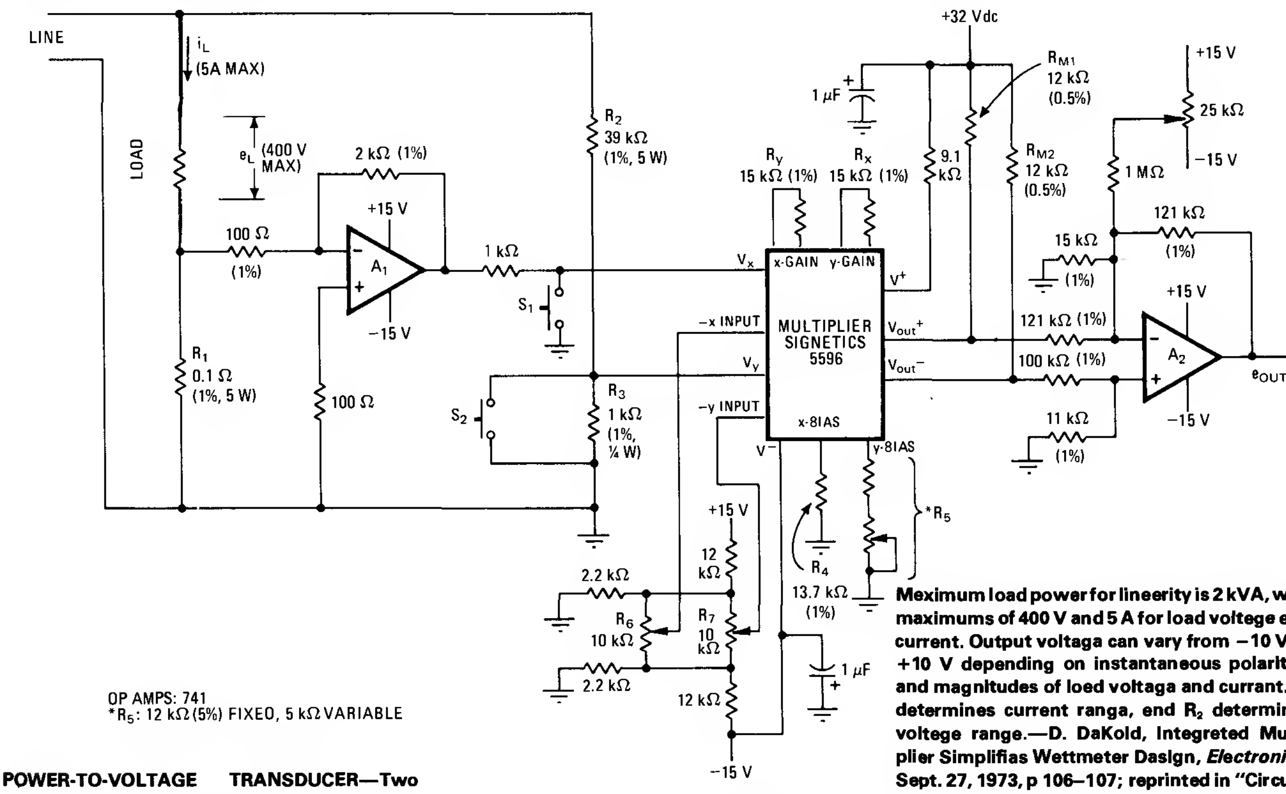




AUTOMATIC NULLING—Simple offset zeroing loop reduces effective Input offset of instrumentation emplifier to less than a microvolt by using zero-and-hold that nulls output of instrumentation opamp A_1 to reference ground. Article describes operetion in detail. Input signal source drives logic Input, for nulling up to 4 V without using external nulling pot. Typical input circuit using strain gages is shown at left of dashed line.—M. Cerat, Zeroing Loop Reduces Instrumentation Amplifier Offsets, *EDN Magazine,* March 20, 1976, p 100 and 102.



ANALOG PREAMP—Combination of 5-kHz FET-chopper amplifier Q1-Q2 with transformer isolation of signal and system grounds gives low-cost analog instrumentation amplifier that will process millivolt DC signals while rejecting hundreds of volts of common-mode DC. Signal accuracy is 0.1% for inputs between 50 and 500 mV. Input impedance is 4 megohms, drift is only 0.2 μV/°C, and DC common-mode rejection rate is better than 120 dB. Low-impedance output of followers Q3-Q4-Q5 is sent through T1 to synchronous FET demodulator Q6-Q7. R7 adjusts system scaling.—C. A. Walton, High-CMR, Low-Cost DC Instrumentation Preamp, *EDN Magazine*, Jan. 15, 1971, p 47–48.



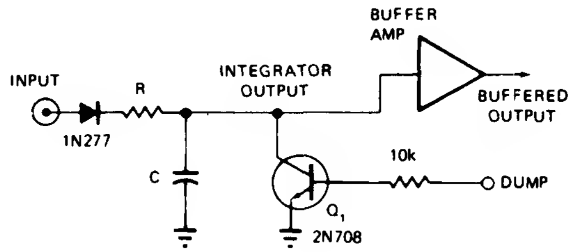
Maximum load power for linearity is 2 kVA, with maximums of 400 V and 5 A for load voltage and current. Output voltage can vary from −10 V to +10 V depending on instantaneous polarities and magnitudes of load voltage and current. R_1 determines current range, and R_2 determines voltage range.—D. DeKold, Integrated Multiplier Simplifies Wattmeter Design, *Electronics*, Sept. 27, 1973, p 106–107; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 175–176.

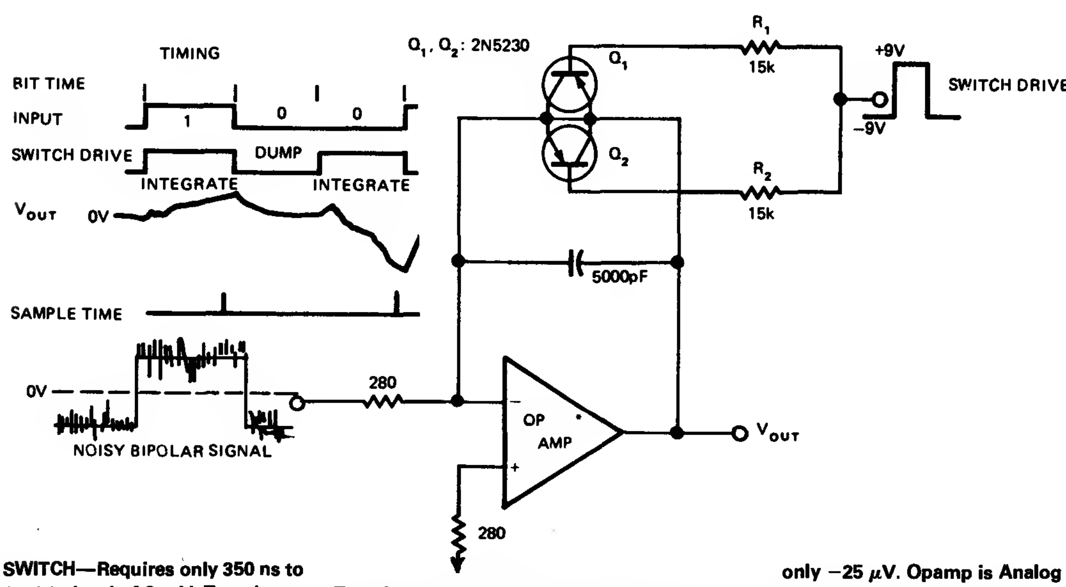
POWER-TO-VOLTAGE TRANSDUCER—Two opamps and inexpensive IC multiplier provide output voltage directly proportional to instantaneous power through load. Frequency response extends from DC to several kilohertz.

CHAPTER 41
Integrator Circuits

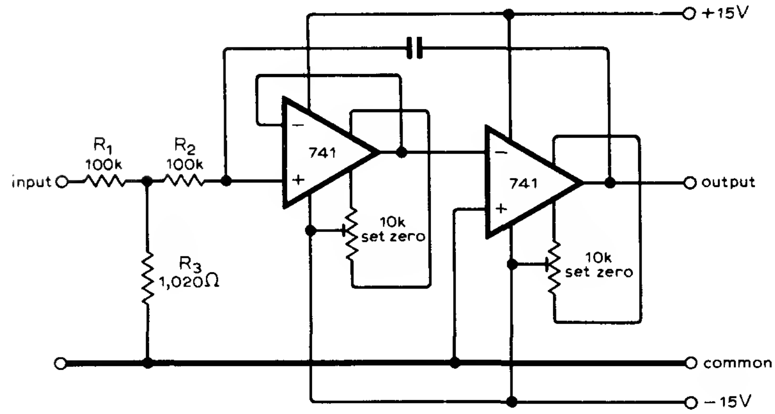
Provide output that is integral of input with respect to time. Special features include logic-reset, analog start/stop, fast dump, and fast recovery.

INTEGRATE AND DUMP—Transistor is used as switch, without powar supply. Simpla RC intagrator wlll dump (discharga C) completely in about 1 μs when dump input is logic 1 (+5 V). Values of R and C detarmina time constant of integrator. Without powar supply, circuit can only driva high-impedance load; for low-impedanca load, add FET-input opamp such as Analog Davices 40J as buffer.—R. Riordan, Integrata and Dump Circuit Uses No Powar Supply, *EDN Magazine,* Fab. 20, 1973, p 93.

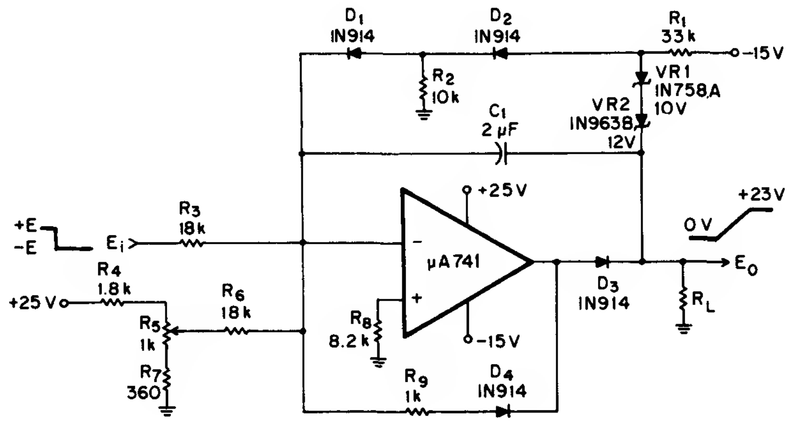




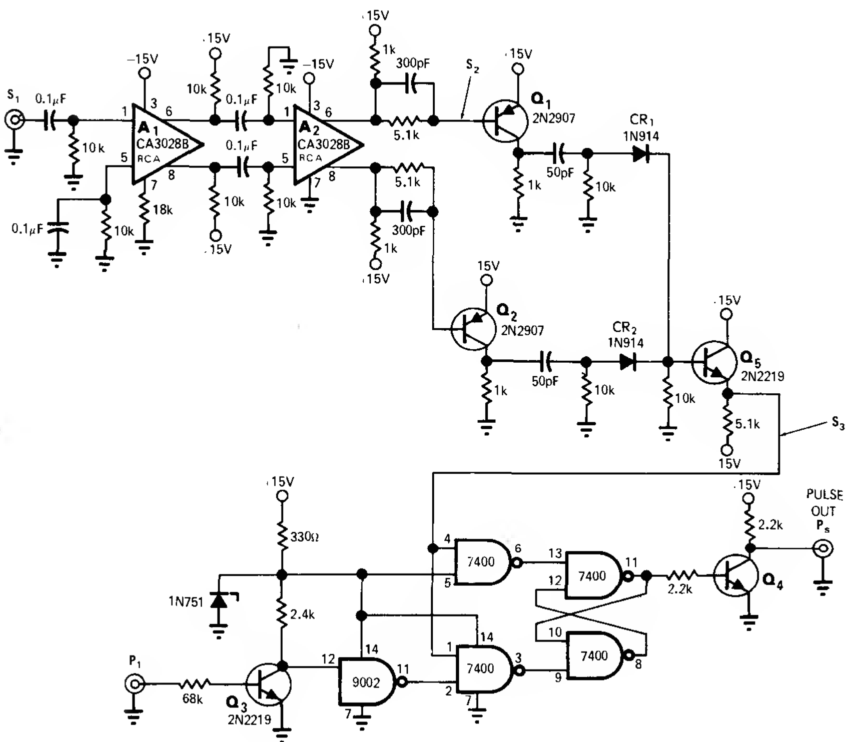
FAST DUMP SWITCH—Requires only 350 ns to dump 6-V output to laval of 3 mV. Transistors are connected so ona of tham is biased in forward moda independently of output polarity. Both transistors turn on during dump intarval. Transistor oparating In forward moda determinas inltial discharga rata until it saturatas, aftar which inverted-moda transistor continuas to discharge capacitor. Offset voltaga arror is only −25 μV. Opamp is Analog Davices 120 or equivalent having unity-gain bandwidth above 100 MHz and slew rata above 200 V/μs.—F. Tarico, Fast Bipolar Dump Switch Has Low Offset, *EDN Magazine,* Nov. 5, 1974, p 66.



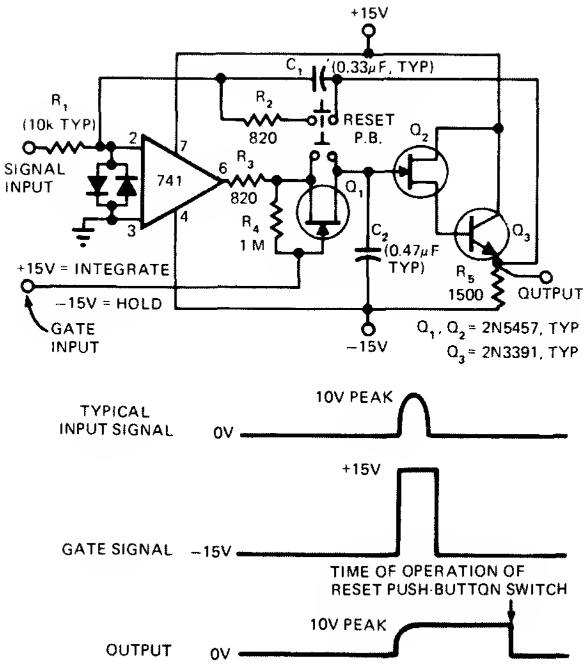
HIGH INPUT IMPEDANCE—Two-opamp connection shown gives input resistanca of 200 megohms and drift time of 90 min for 0 to 10 V.—N. G. Boreham, Op-Amp Integrator, *Wireless World*, March 1977, p 42.



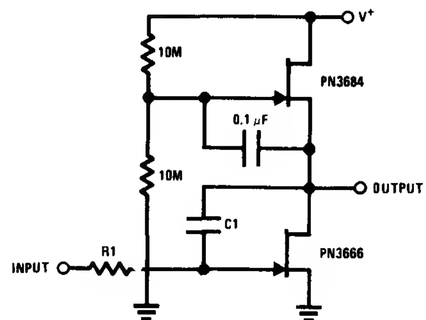
FAST RECOVERY—Two diodes end two zaners clemp output of integrator below saturation level of opamp, making recovery time epproximately equal to slew rete. With values shown, integration tima constent R_3C_1 is 35.6 ms and output is clemped at +23 V. Output linearity is ±1%, end threshold renge of circuit is −3 V to −10 V.—K. S. Wong, Fest-Recovery Integrator with Adjustable Threshold, *EEE Magazine*, Aug. 1970, p 77.



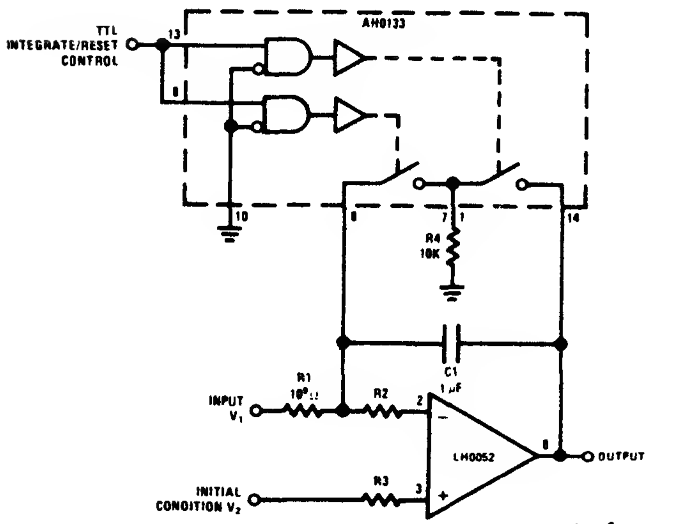
ELIMINATING RINGING—High-Q bandpass integrator reduces ringing significantly by amplifying AC input signal in two broadband differential amplifier stagas, A_1 end A_2, before differentiation end selection by D_1 and D_2. Input gate pulse P_1 and differentieted pulses drive AND logic thet generates output pulse P_s coincident with zaro crossings of AC input. Leading edge of P_s will elways occur at first zero crossing after P_1 initiates gating action. If output drives belanced dioda bridge, gating pedestal end AC signal transiant are eliminated; high-Q bandpass integretor then has fast settling time, permitting fastar repatition ratas.—R. J. Turnar, Reduce Integretor Transients with Synchronized Gate Signals, *EDN/EEE Magazine*, Jen. 15, 1972, p 46–47.



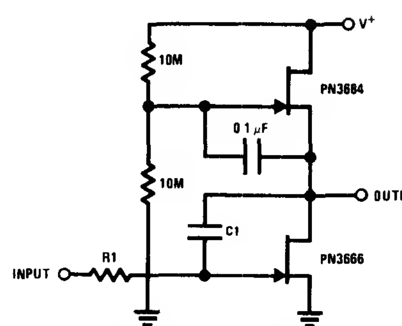
STORING INTEGRATOR OUTPUT—Modified sample-end-hold circuit with capacitive feedbeck combinas intagrate, sample, and hold functions, for use in tamporarily storing output of integretor. Integrating amplifier is 741 opamp; for criticel applications, FET opamp is preferable.—E. Crovella, Circuit Combines Integrate, Sampla and Hold Functions, *EDN Magazina,* Oct. 20, 1974, p 90.



JFET WITH AC COUPLING—Connection shown gives vary high voltage gain. Use of C1 as Millar integrator or capacitance multiplier allows simple circuit to handle very long time constant.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

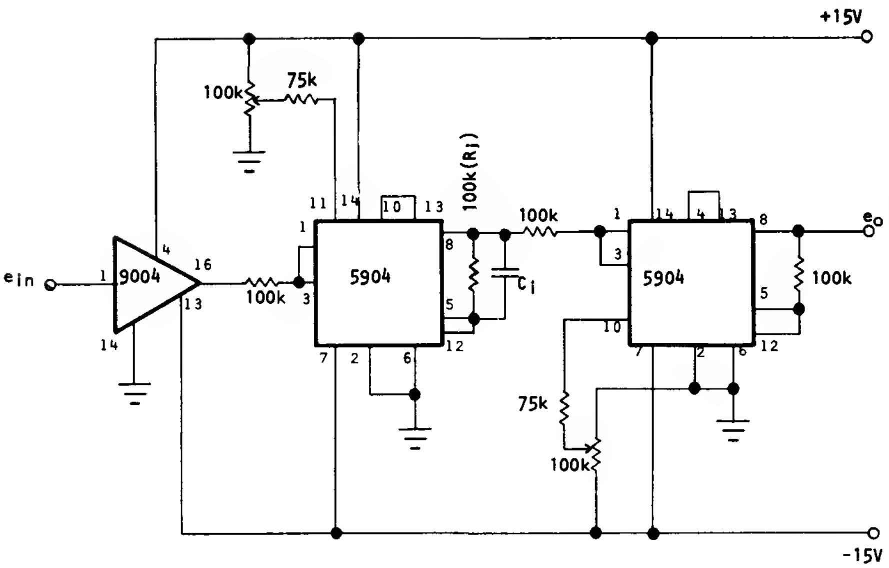


$$V_{OUT} = \frac{1}{C1R1}\int -V_1\,dt + V_2$$



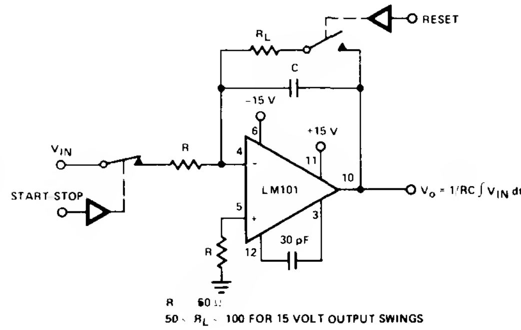
PRECISION INTEGRATOR—Low input bias current of National LH0052 opemp mekes it suitabla for applications requiring long tima constants. R1 is salected so total leekage current at summing mode is sufficiently smaller than signal current to ensure required accuracy. R2 is included to protact input circuit during reset transient but can be omitted for low-speed applications. R3, used to belence resistance in inputs, should be equal to sum of R2 end 100-ohm resistance of reset switch.—"Linear Applications, Vol. 1," Netionel Semiconductor, Sante Clera, CA, 1973, AN-63, p 1–12.

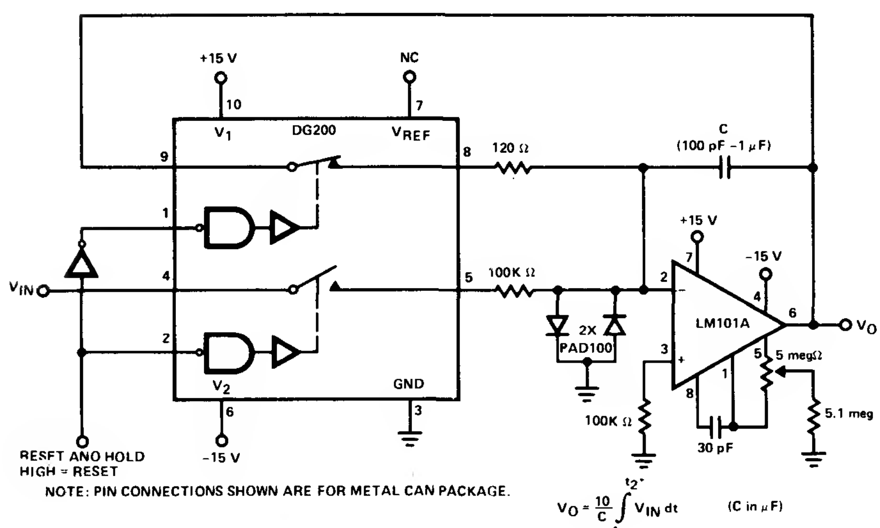
AC-COUPLED JFET—Use of C1 es Millar integrator or capacitence multiplier allows simple circuit to hendle very long time constant whila providing high voltage gain. Circuit also offers low distortion with low noise end high dynamic renga.—"FET Datebook," National Semiconductor, Senta Clara, CA, 1977, p 6-26.



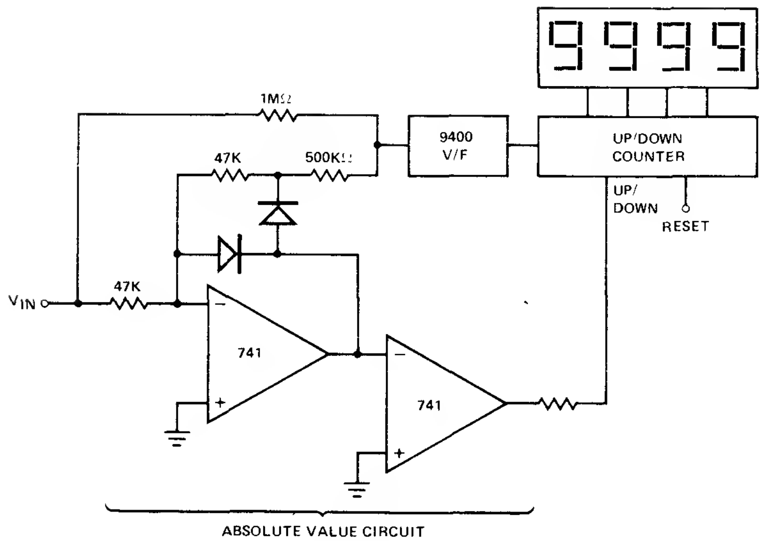
RMS CONVERTER—Convarts analog voltaga to RMS equivalent by squaring operation followed by integration and square-rooting. Bipolar input signal is first converted into linear absolute valua with Optical Electronics 9004 absolute-value module, as required for processing by 5904 unipolar devicas. Pots are used to establish 10-V full-scale level. R_iC_i is integretion tima constant.—"Simple RMS Converter," Optical Electronics, Tucson, AZ, Application Tip 10246.

ANALOG START/STOP AND RESET—One section of DG300 dual analog switch serves for discharging intagrator capacitor C through R_L when resetting integrator, with start/stop switch section being held open by control logic. When both switches are open, output of integrator is held.—"Analog Switches and Thair Applications," Siliconix, Santa Clara, CA, 1976, p 7-81.





LOGIC-RESETTABLE INTEGRATOR—DG200 CMOS analog switch sarves for discharging integrator capacitor C rapidly for high logic input pulse. Other section of switch disconnects integrator from analog input when logic goes high. When logic input is returned to low, integrator is triggered. Diodes prevent capacitor from charging to over 15 V.—"Analog Switches and Thair Applications," Siliconix, Santa Clara, CA, 1976, p 7-68.

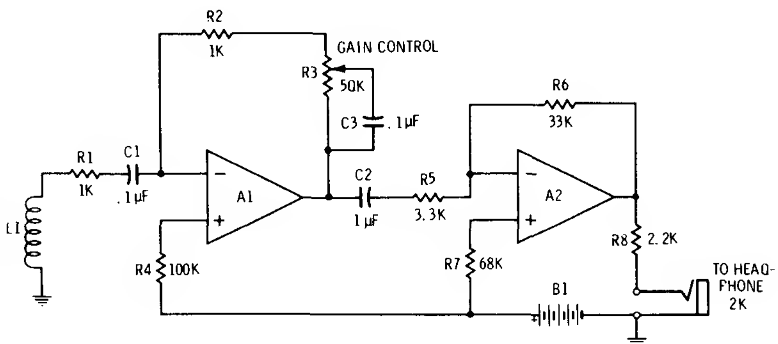


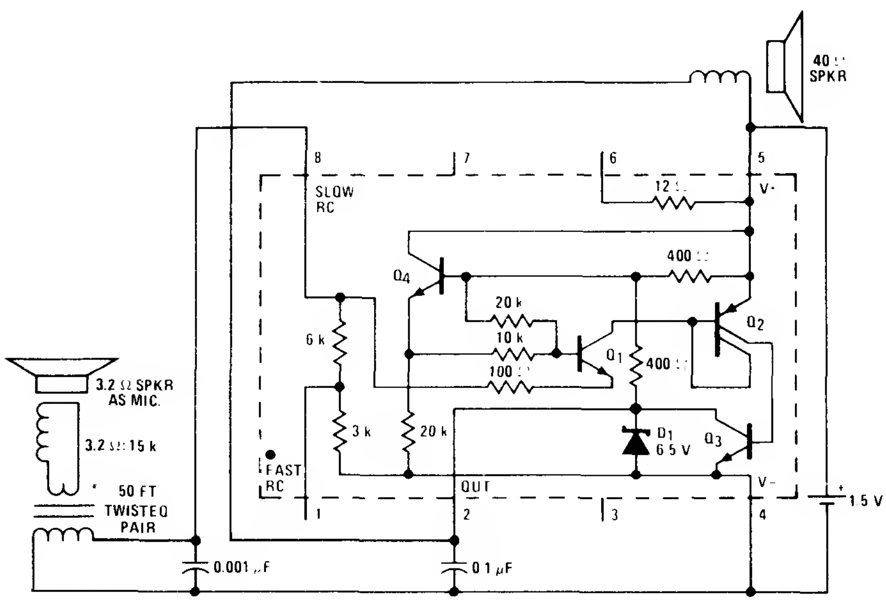
BIPOLAR INPUT FOR V/F CONVERTER—Absolute-value integrator circuit gives effect of generating negative frequencies when input signal is negative by making counter count up for positive voltage and count down for negative voltage. Diode types are not critical.—M. O. Paiva, "Applications of the 9400 Voltage to Frequency Frequency to Voltage Converter," Teledyne Semiconductor, Mountain View, CA, 1978, AN-10, p 3.

CHAPTER 42
Intercom Circuits

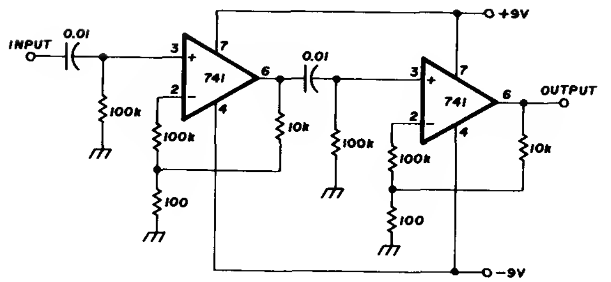
Covers one-way and two-way basic intercom circuits, four-station two-way system, induction receiver for paging, and private telephone system. Audio amplifier circuits suitable for intercoms are also given.

AUDIO INDUCTION RECEIVER—Used to pick up audio signel being fed to low-impedance single-wira loop ancircling room or other erea to ba covered. Pickup loop L1 is 100–500 turns wound around plestic cese of receiver. Opemp sections are from Motorole MC3401P or Nationel LM3900 quad opemp. Supply can be 9–15 V. Requires no FCC license. Can ba used as privata paging systam if eudio amplifier of transmitter has microphone input.—C. D. Rakes, "Integrated Circuit Projacts," Howard W. Sems, Indianapolis, IN, 1975, p 23–25.



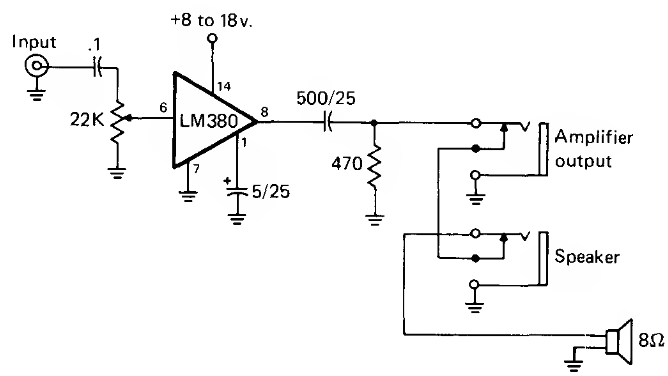


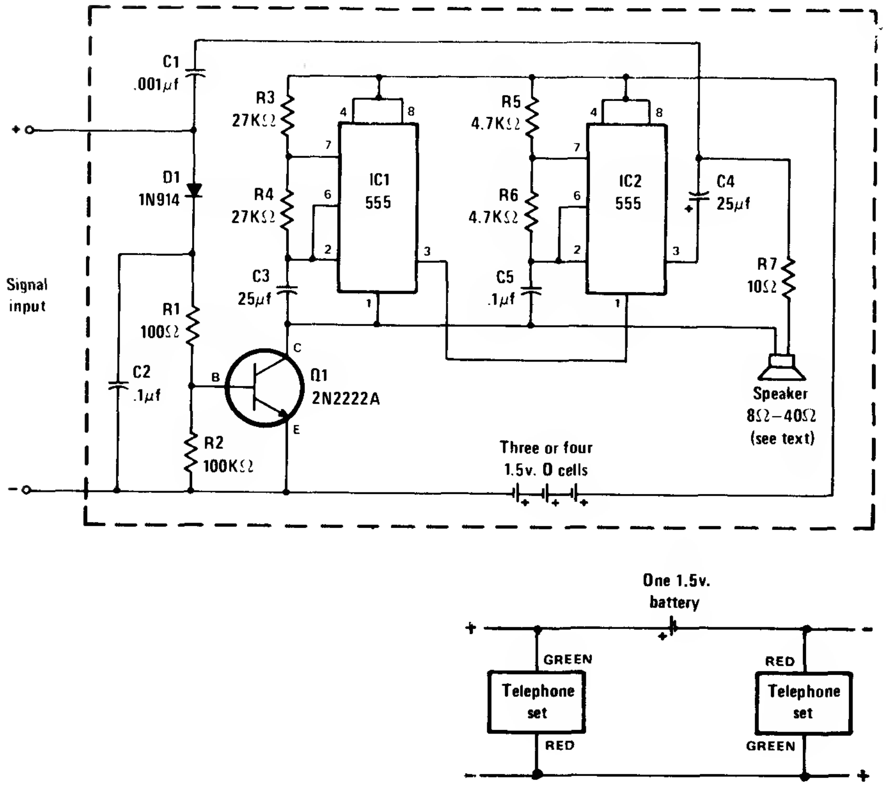
MICROPOWER ONE-WAY INTERCOM—Nationel LM3909 IC operating from single 1.5-V cell serves es low-power one-way intercom suitable for listening-in on child's room and meeting othar room-to-room communication needs. Battery drain is only ebout 15 mA. Person speaking directly into 3.2-ohm loudspaakar used es microphona delivers full 1.4 V P-P signal to 40-ohm loudspeeker at listening location.—"Linear Applications, Vol. 2," Nationel Semiconductor, Santa Clare, CA, 1976, AN-154, p 9.



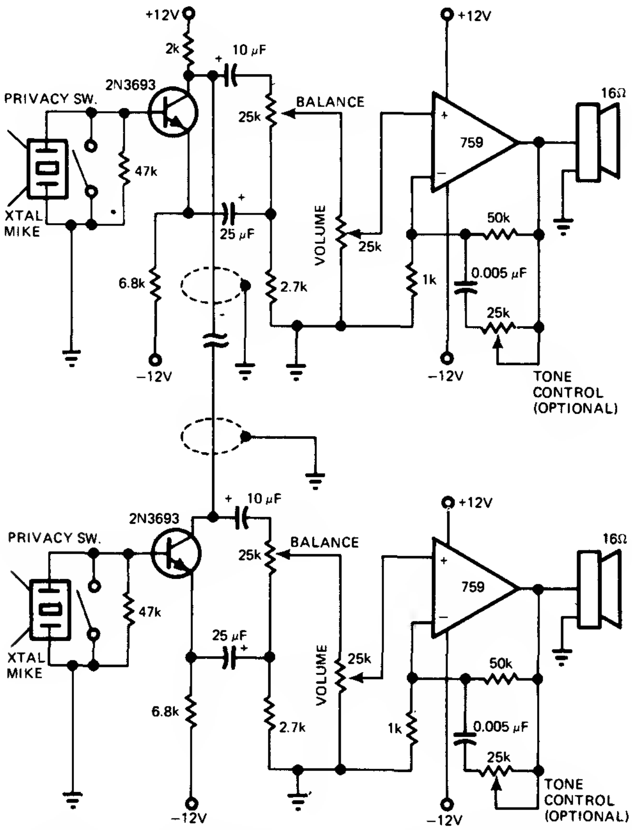
CASCADED 741 OPAMPS—Two opamps in series provide 80 dB of audio gain with bandwidth of about 300 to 6000 Hz. Gain of aach opamp is set at 100. With three stages, bandwidth would be 5100 Hz. Output will driva loudspeakar at comfortable room leval, if fed through 1-μF nonpolarized capacitor to output transformer having 500-ohm primary and 8-ohm secondery.—C. Hell, Circuit Design with the 741 Op Amp, *Ham Radio*, April 1976, p 26–29.

2 W WITH IC—Inexpensiva audio amplifier using 14-pin DIP providas adequeta powar for small audio projacts and audio troubleshooting. Pins 3, 4, 5, 10, 11, and 12 ara solderad directly to foil side of printed-wiring board usad for construction, to giva effect of haetsink.—J. Schultz, An Audio Circuit Braadboerder's Delight, *CQ*, Jan. 1978, p 42 and 75.

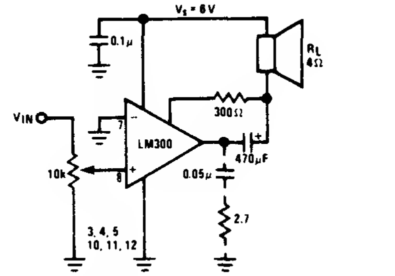




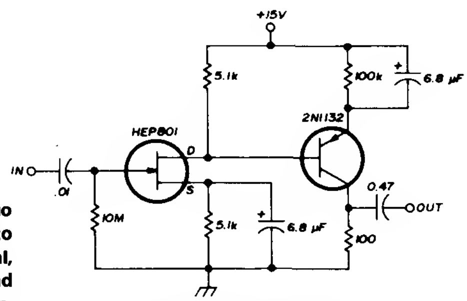
BEEPER—Private two-station telephone system for homa requires only two wlres betwaen ordinary telephona sets, with 1.5-V battary in sarias with ona line, but this voltaga is not enough to actuate ringers in sets. Baepar in parallel with each set, with polerity as shown, servas same purposa as ringar. 555 timer IC1 turns on IC2 about once every 3 s, and IC2 then generatas 1000-Hz beap for about 1 s as ringing signal. No switches ara required, because telephone handsets provide automatic switching. Whan both talephones are hung up, 1.5-V battary splits aqually betwaan beepars and resulting 0.75 V is not enough to turn on Q1 in eithar set. When ona talephone is picked up, beeper at other telephone receives close to 1.5 V and Q1 turns on IC1 to initiata beaping call. When other talephone is pickad up, baeping eutometically stops because 1.5 V is egain divided batwaen sets.—P. Stark, Private Talephona: Simpla Two-Station Intercom, *Modern Elactronics*, July 1978, p 32–34.



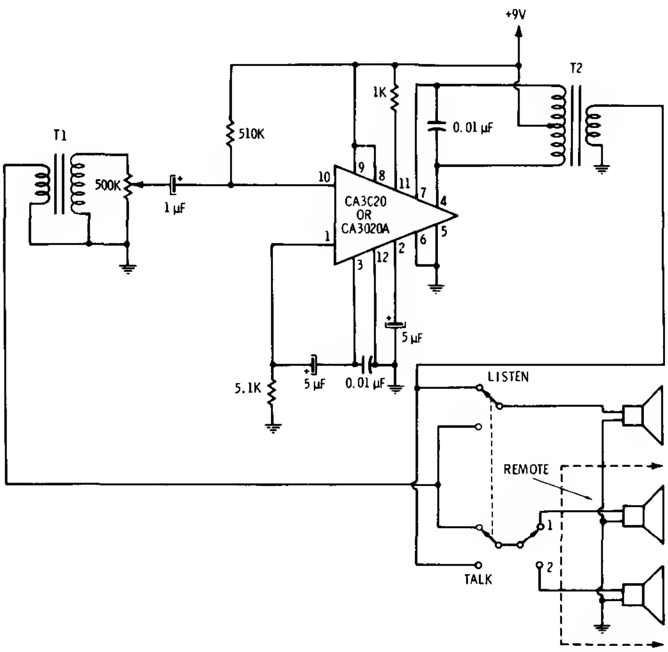
BIDIRECTIONAL INTERCOM—Uses 759 power opemps to provide 0.5 W for 16-ohm loudspeekers. Crystal microphonas faed NPN trensistors that provida both in-phase end 180° out-of-phase signals. Balance-adjusting circuits of amplifier cancel out the two signels, so only out-of-phase signal goes to receiving unit. Privacy switch across microphone eliminatas audio feedbeck while listening. Article tells how to calculate heetsink requiremants.—R. J. Apfal, Power Op Amps—Their Innovativa Circuits and Peckeging Provide Dasigners with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.



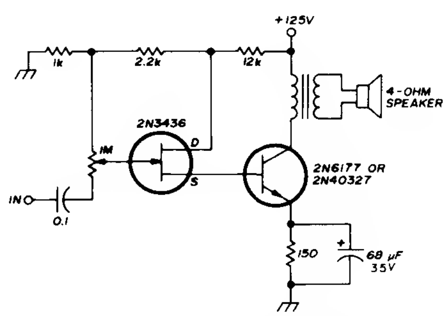
1 W AT 6 V—Battery-opareted powar amplifier using National LM390 IC providas ample powar for loudspeakar despite oparation from 6-V portable battery.—"Audio Hendbook," Nationel Semiconductor, Sente Clara, CA, 1977, p 4-41.



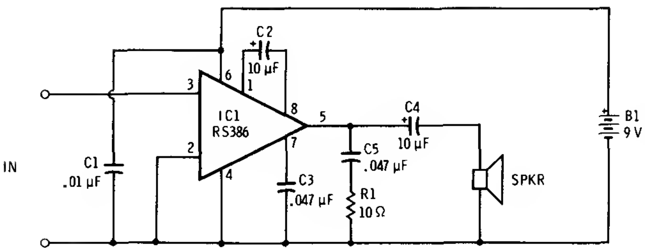
DIRECT-COUPLED AF—Combination of unipoler and bipolar transistors gives desirabla amplifying features of each solid-state device. Cen be used as speech amplifiar and for othar low-level audio applications.—I. M. Gottlieb, A Naw Look at Solid-State Amplifiers, *Ham Radio*, Feb. 1976, p 16–19.



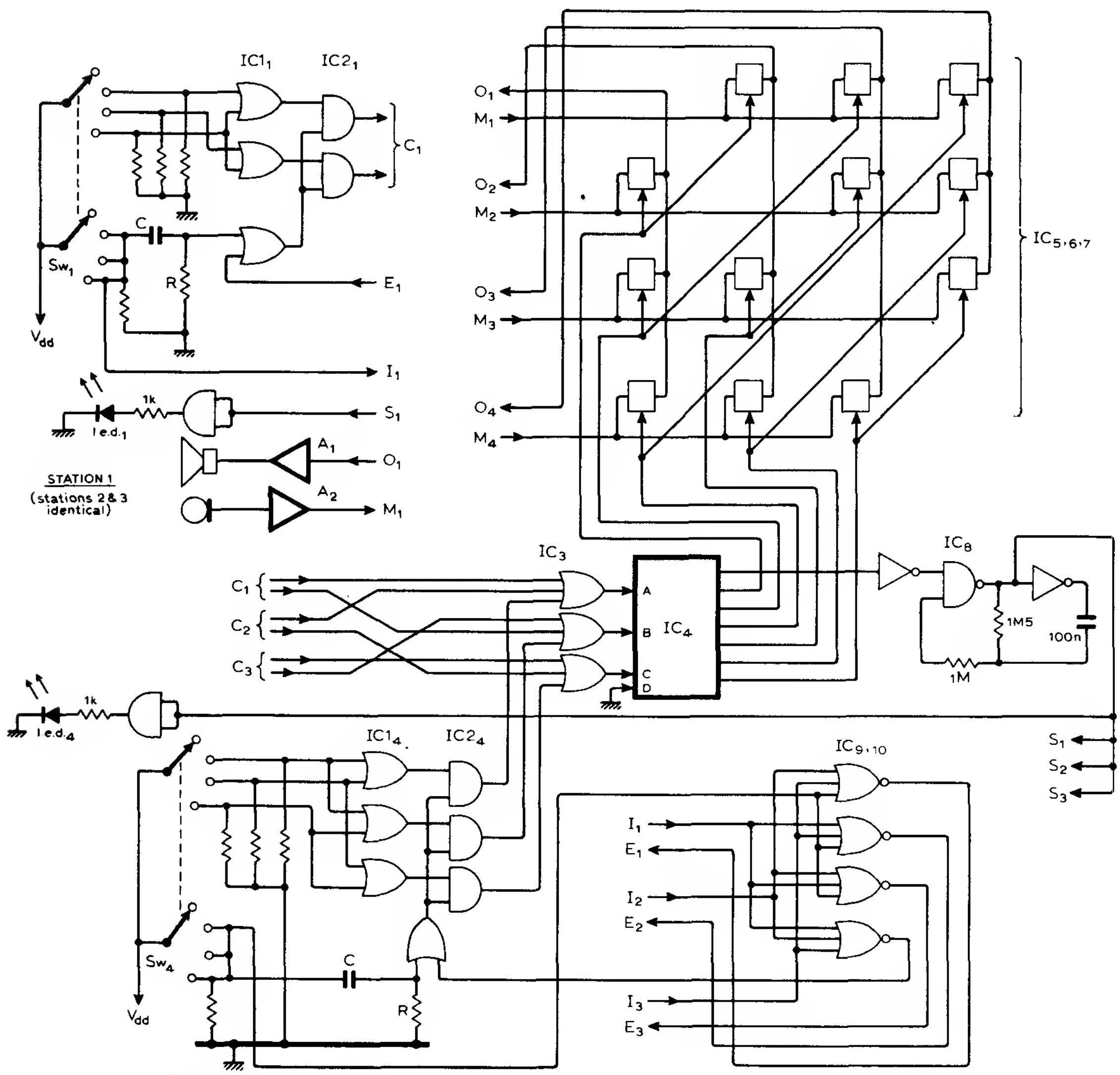
SINGLE IC WITH TRANSFORMERS—CA3020 differantial amplifiar usas AF input transformar T1 to match loudspaakers (used as microphona) to highar input resistance of IC. AF output transformer T2 similarly matches IC to loudspeakars operating convantionally.—E. M. Noll, "Linaar IC Principles, Experiments, and Projects," Howerd W. Sams, Indianapolis, IN, 1974, p 100–101.



AF OUTPUT—Operates directly from 125-V ractified AC lina voltage. Combination of unipoler and bipolar transistors gives desirable amplifying faatures of aach solid-state device.—I. M. Gottlieb, A Naw Look at Solid-State Amplifiers, *Ham Radio*, Fab. 1976, p 16–19.



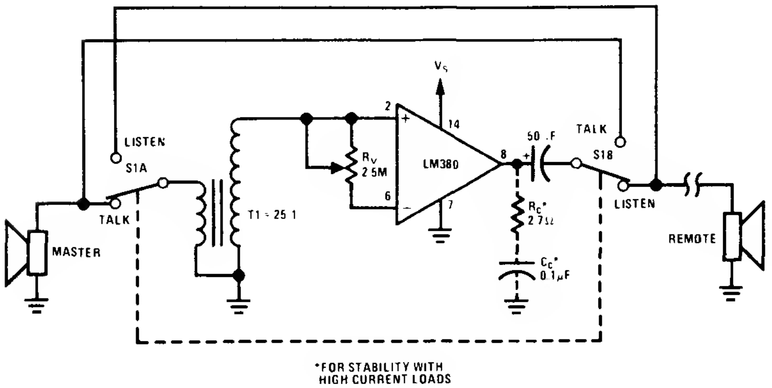
0.25-W AMPLIFIER—Single Radio Shack RS386 IC powered by 6–9 V from battery provides gain of about 200 with sufficient power to drive 8-ohm loudspeakar when spaaking closely into small dynamic microphone of typa used with portable tape recorders.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 87–95.



IC_1	CD4071	IC_8	CD4011
IC_2	CD4081	$IC_{9,10}$	CD4025
IC_3	CD4075	A_1	LM380
IC_4	CD4028	A_2	741
$IC_{5,6,7}$	CD4016		

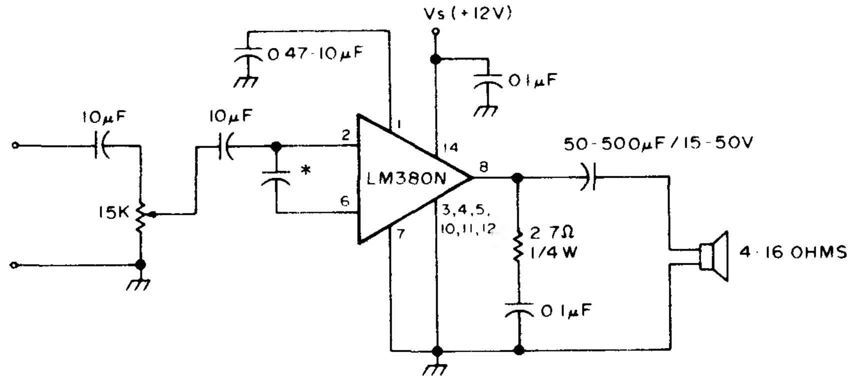
Station links	Code
1 to 2	001
1 to 3	010
1 to 4	011
2 to 3	100
2 to 4	101
3 to 4	110

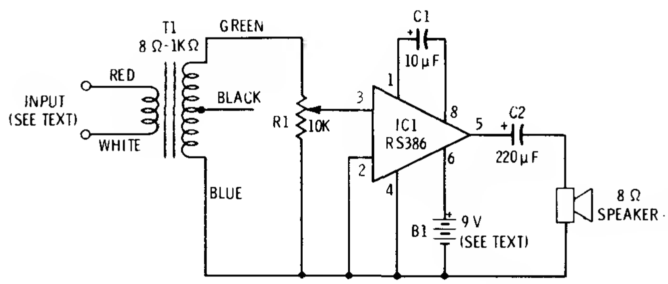
FOUR-STATION TWO-WAY—Each station can communicate privataly with any one of othars. All four stations have idantical inputs as at upper left, with fourth station having mastar circuit. Each two-station combination is assigned 3-bit coda as given in tabla, for salection by switches Sw_1-Sw_4. All station codes are ORed and decoded by IC_4 to driva matrix of analog switches for coupling appropriata audio inputs and outputs. Code 000 is used for system-free status as indicated by LEDs 1 and 4 being on. LEDs flash for system-busy status. When coda is selected, enable inputs of nonselected stations go low to prevant generation of further codes. System can be expanded to six stations by using 4-bit code and CD4514 dacodar with larger matrix of analog switches.—B. Voynovich, Multipla Station Two-Way Intercom, *Wireless World,* March 1978, p 59.



SINGLE OPAMP—When switch S1 is in talk position as shown, loudspaakar of mastar station acts as microphone, driving opamp through stap-up transformar T1. Switch at remote station must then ba in listen position. Supply voltage range is 8–20 V.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-21–4-28.

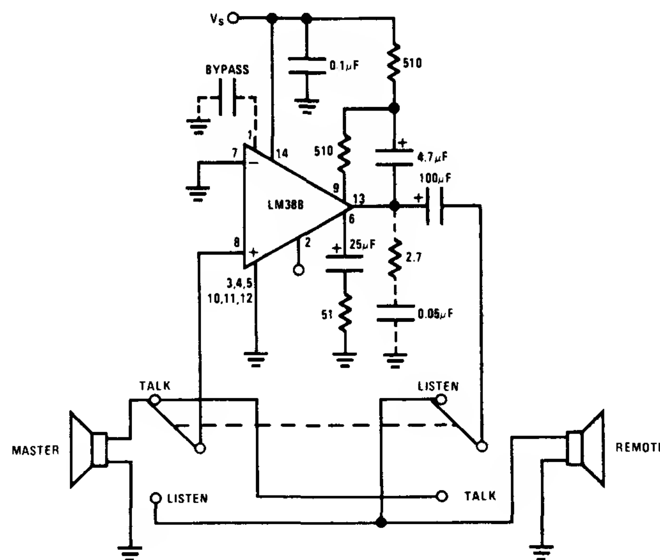
2-W LM380 POWER AMPLIFIER—Complete basic circuit for most audio or communication purposes uses minimum of external parts. C3, used to limit high frequencies, can be in ranga of 0.005 to 0.05 μF.—A. MacLean, How Do You Use ICs?, *73 Magazine*, June 1977, p 184–187.

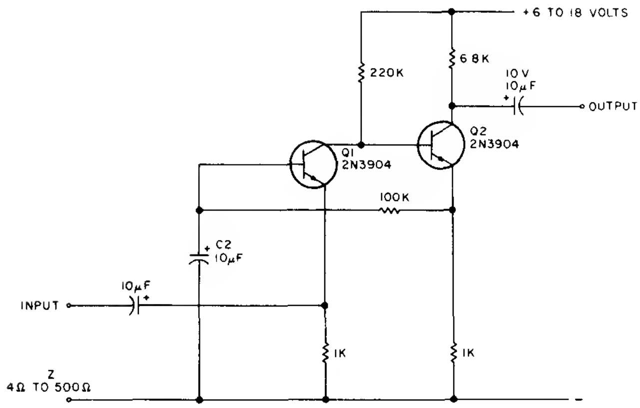




0.5-W AF IC—Simple audio power staga drives 8-ohm loudspeaker for producing graater volume with pocket radio or for intercom applications. Supply range is 4–12 V. For long life, 6-V lantern batteries are recommended. Transformer is Radio Shack 273-1380.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 38–44.

HIGH-GAIN INTERCOM—Intamal bootstrapping in National LM388 audio power amplifier IC gives output powar levels above 1 W at supply voitages in range of 6–12 V, with minimum parts count. AC gain is set at about 300 V/V, eliminating need for step-up transformer normally used in intercoms. Optional RC network suppresses spurious oscillations.—"Audio Handbook," National Samiconductor, Santa Clara, CA, 1977, p 4-37–4-41.

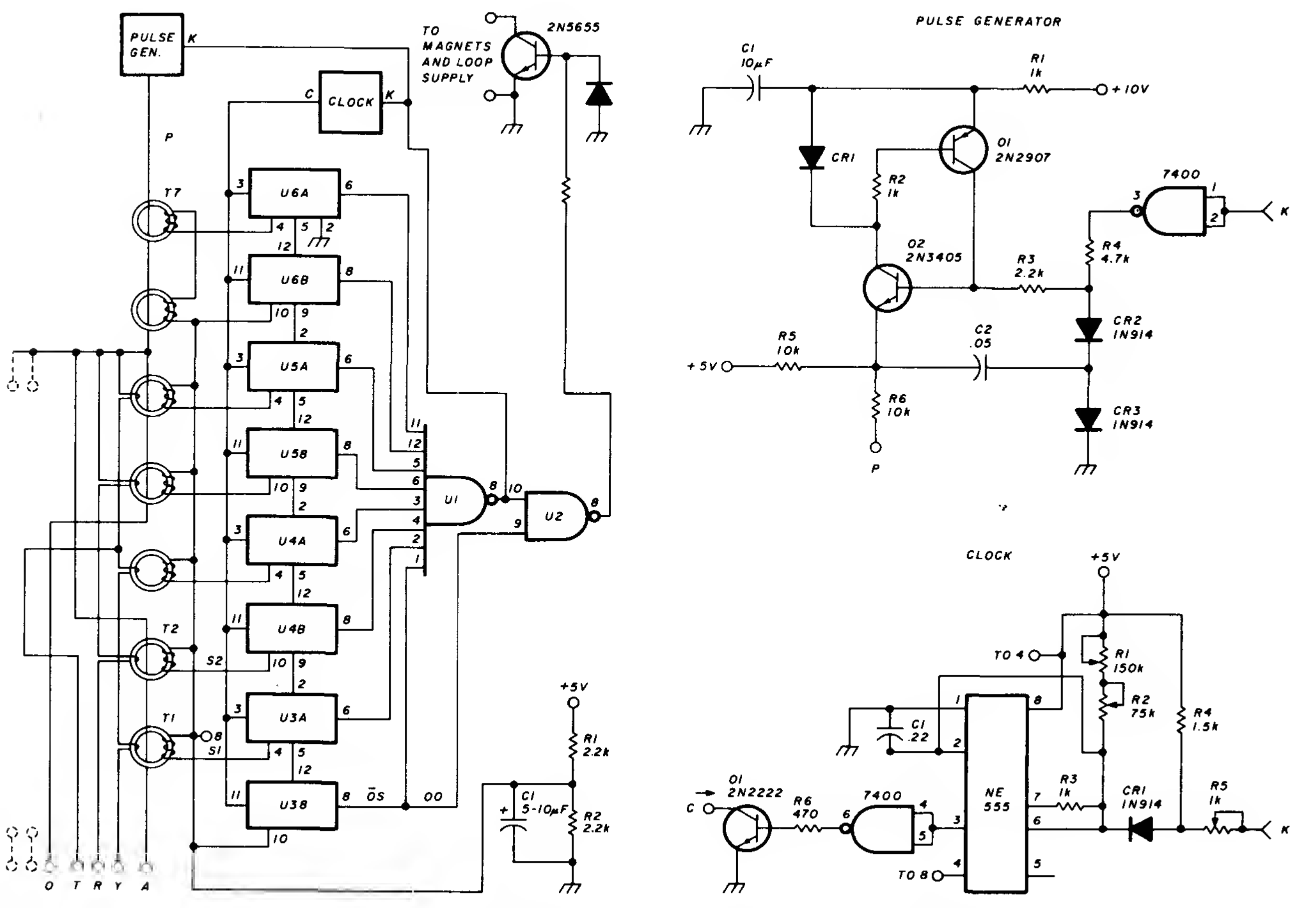




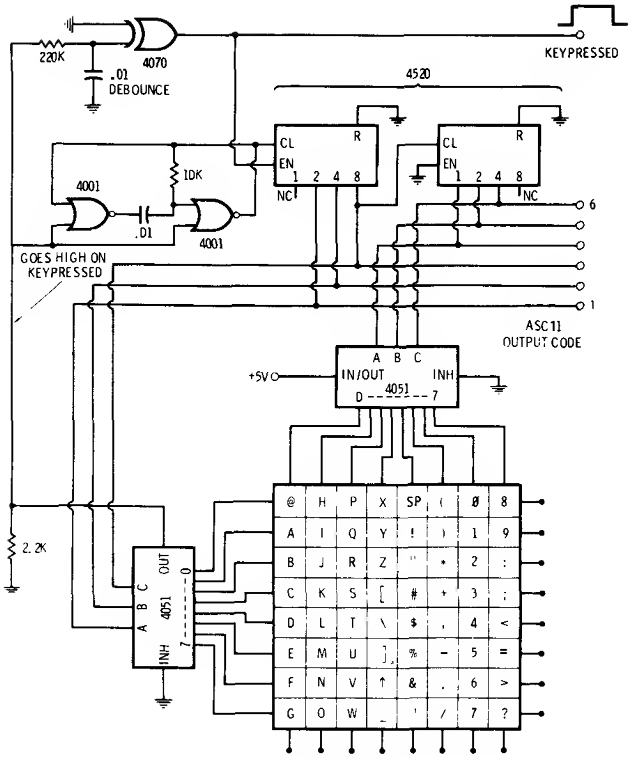
LOW-Z INPUT—Can be used with low-impedance source, such as 4- to 16-ohm loudspeakar or telephona aarphone used as mike. If loudspeaker is put out in yard, sensitivity is sufficiant to pick up sounds mede by prowlars. Can be fed into input of any high-fidelity amplifiar.—E. Dusine, Build a General Purposa Praemp, *73 Magazine*, Nov. 1977, p 98.

CHAPTER 43
Keyboard Circuits

Includes interface circuits required for converting keyboard operation to ASCII, BCD, hexadecimal, teleprinter, Baudot, Morse code, and other formats serving as inputs for microprocessors, PROMs, CW transmitters, hard-copy printers, TV typewriters, and other code-driven applications. See also Microprocessor and Telephone chapters.

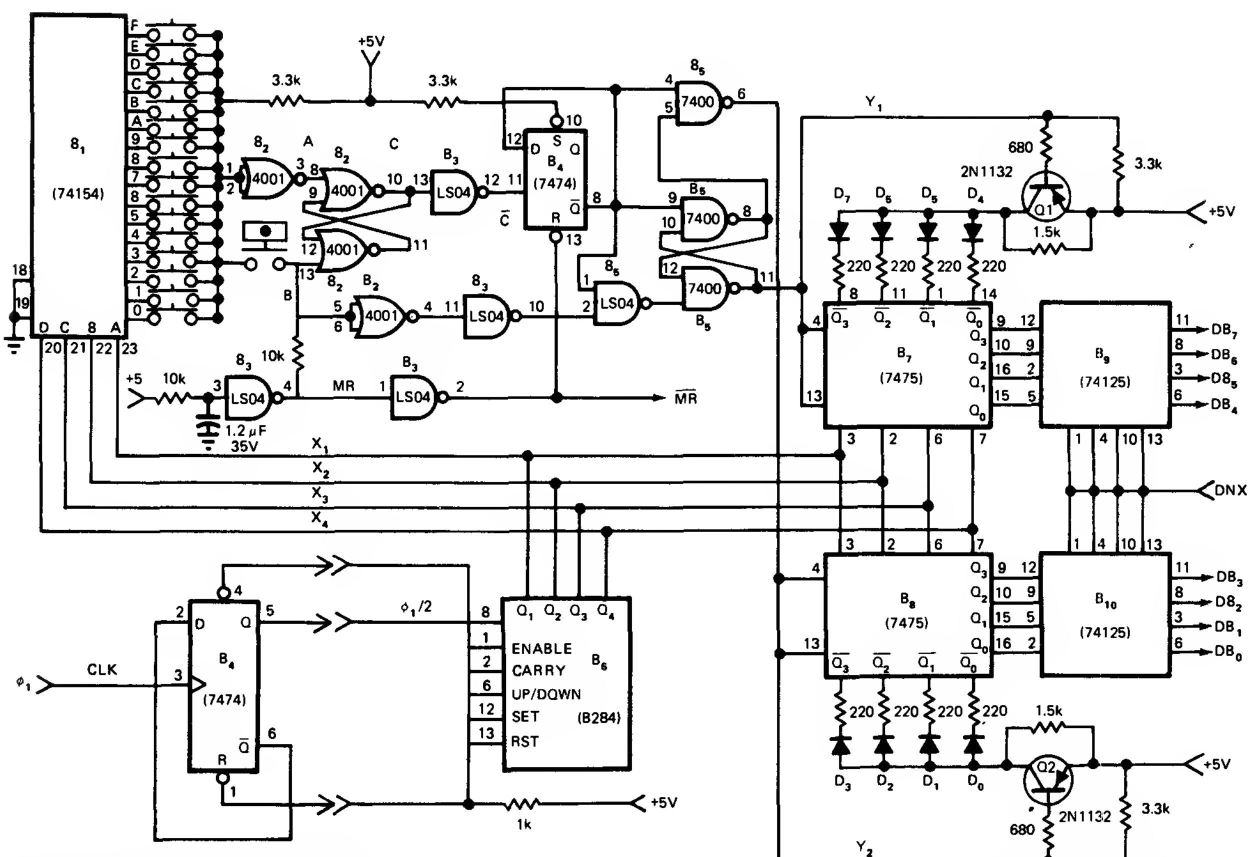


ELECTRONIC TELETYPE KEYBOARD—Uses eight 7474 shift register sections in combination with pulse generator that is discharged through appropriata torold core to create correct mark-space coding for anergizing magnet drivers of Teletype. Davaloped to permit communlcation by handicapped people. Simplified keyboard has one set of alphabetic characters and five numerics for BCD Input. Outputs of shift registers drive 7430 NAND gate U2. If keyboard is to ba used et 60 WPM, adjust R1 so 555 oscillates et 45 Hz. Toroids ara Indiane General CF-102 having 10-turn primeries.—L. A. Stapp, Electronic Teleprlnter Keyboerd, *Ham Radio,* Aug. 1978, p 56–57.

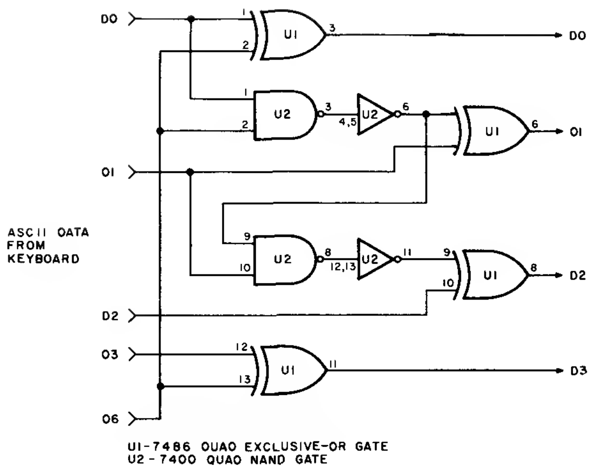


KEY MATRIX - - EACH KEY SHORTS WIRES UNDER IT

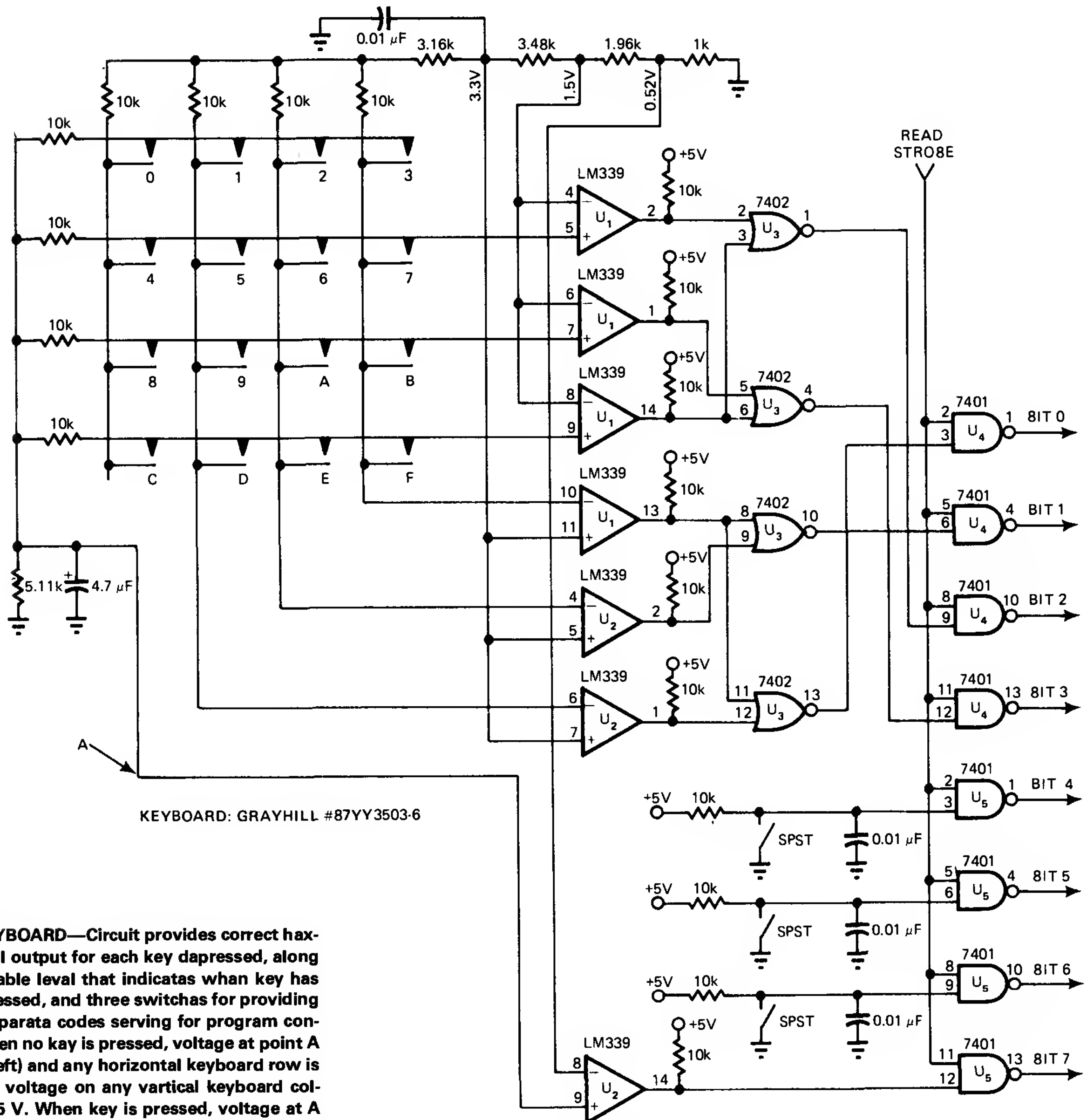
SCANNING ASCII ENCODER—Converts kay action into composite parallel ASCII coda. Circuit includes dabouncing and two-key rollover. Two 4001 quad two-input NOR gate sections form 50-kHz clock that is gated. When clock is allowed to run, two cascaded 4520 binary counters are driven for continuous cycling through all their counts. Slowar countar produces 1-of-8 decoded output for 4051 1-of-8 switch. Faster counter drives second switch that monitors sequential rows of characters. Whan kay is prassad, output from +5 V through both selectors stops gated oscillator and holds count. Resulting ASCII output is then routed to external output logic for control and shift operations. When kay is ralaased, scanning resumes and continues until new key is pressed. If second key is pressed before first is ralaased, nothing happens until first key is ralaased. Scanning then rasumes and stops at sacond key location, to give two-key rollover parmitting faster typing with minimum error.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 358–359.



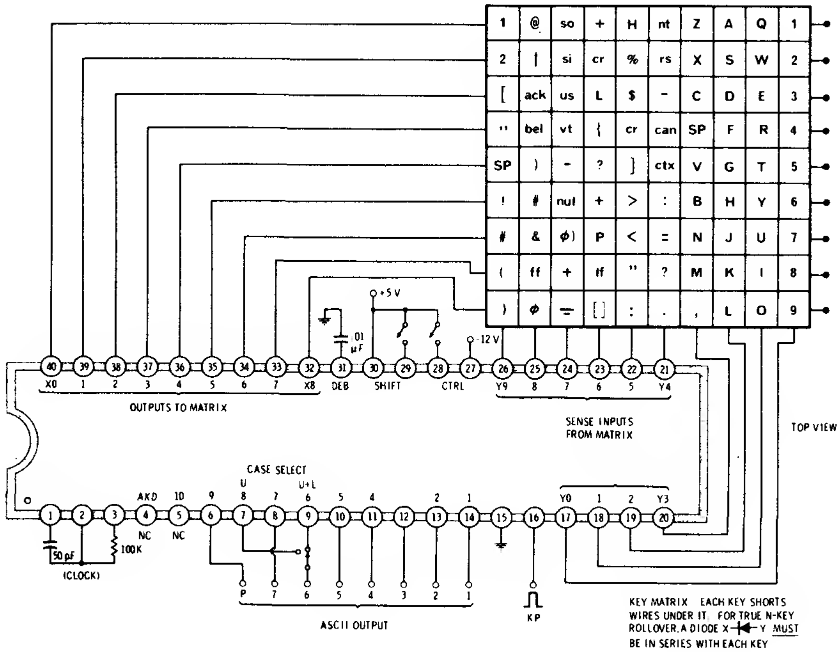
HEXADECIMAL ENTRY—Parmits entaring program into microprocessor in hexadecimal notation, in much less tima than is required with binary notation. Binary switchas from input port of μP ara raplaced with 16-kay keyboard shown. To entar hexadecimal numbar 3B, turn on powar; press 3 button, press decimal bar, then press B button; operata loading switch, than press decimal bar again to set kayboard for naxt antry. Article traces keyboard oparation through circuit.—B. K. Erickson, Talk to Your μP with a Hex-Latching Kayboard, *EDN Magazine*, Nov. 20, 1976, p 319–320.



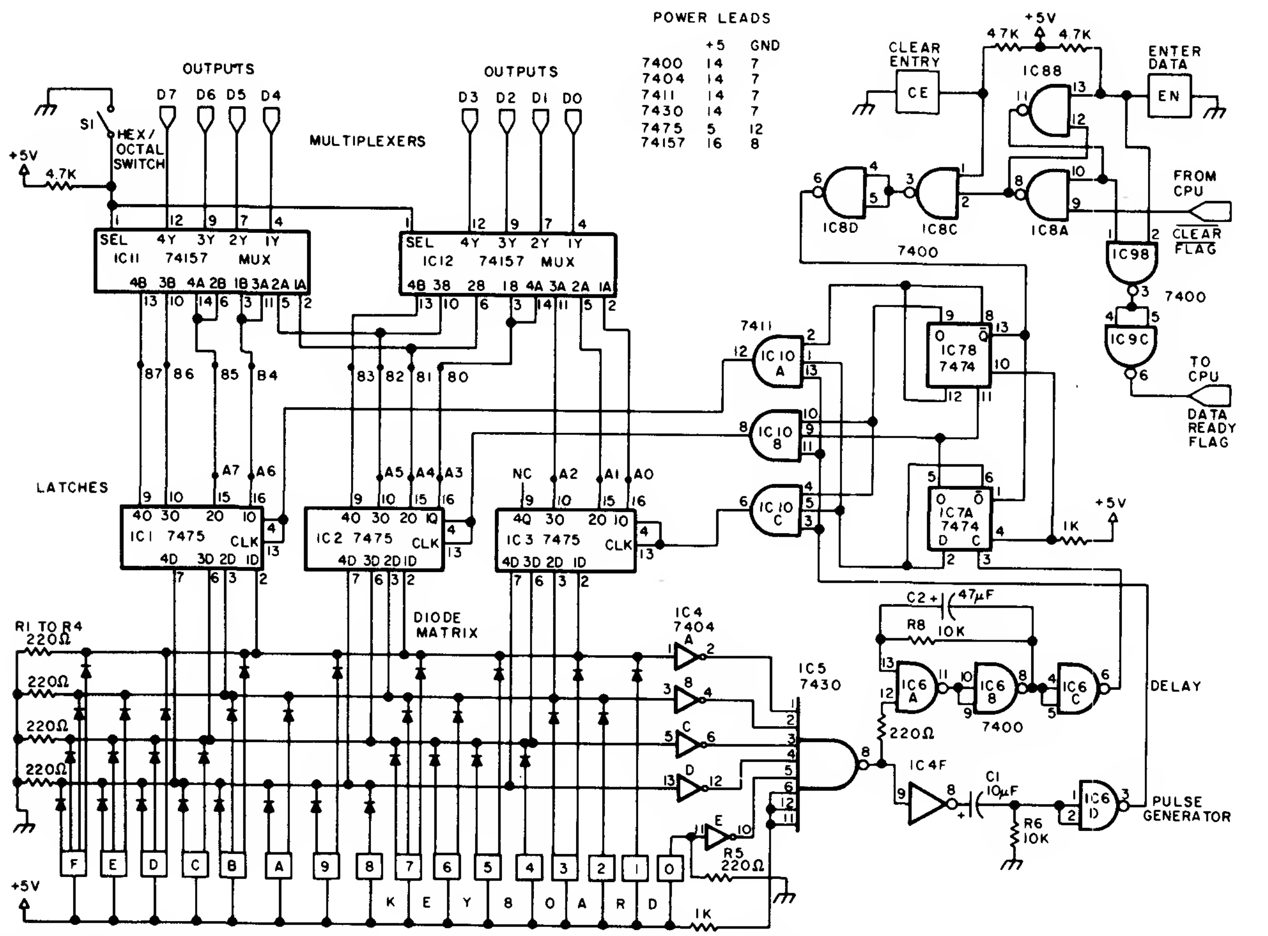
ASCII TO HEX CONVERTER—Simpla two-chip circuit takes ASCII data from keyboard and converts characters 0–9 and A-F to 4-bit haxadecimal machine-language format, as required for loading oparating system initially into 1802-based microprocessor systam. Once loaded, further code conversion cen be achieved with softwara.—E. Copes, One Keyboard: Hax and ASCII, *Kilobaud*, Juna 1978, p 57.



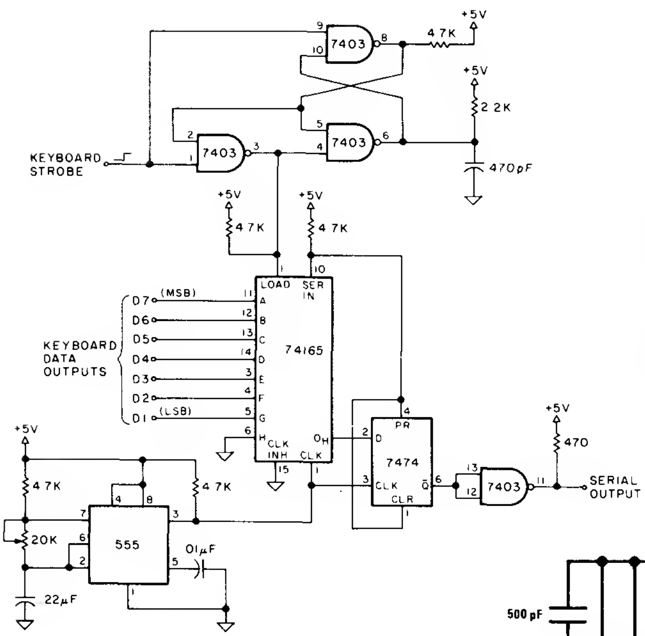
HEX KEYBOARD—Circuit provides correct haxadecimal output for each key dapressed, along with enable leval that indicatas whan key has been pressed, and three switchas for providing aight saparata codes serving for program control. When no kay is pressed, voltage at point A (lowar left) and any horizontal keyboard row is 0 V and voltage on any vartical keyboard column is 5 V. When key is pressed, voltage at A becomes 1 V and voltaga at selected row and column becomes 3 V. Comparator outputs for U_1 and U_2 are decoded with NOR gates and strobed onto data linas with opan-collector NAND gates.—J. F. Czebiniak, Simple Hex Kayboard Providas Program Control, *EDN Magazine*, Jan. 5, 1978, p 27–28.



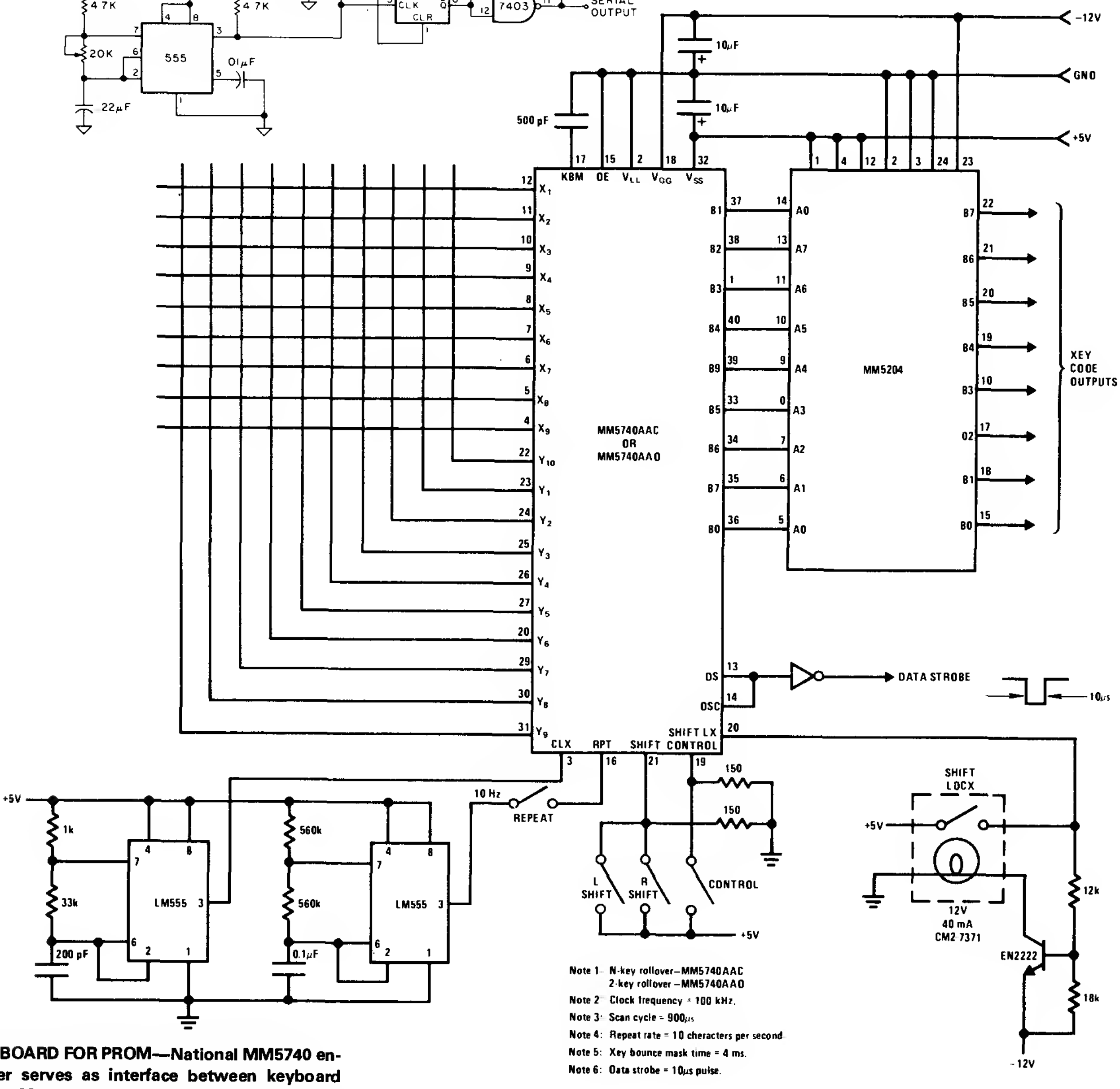
SCANNING KEYBOARD ENCODER—Uses RCA CA3600 IC for sampling 90 keys end providing parallal ASCII output with perity. Network on pins 1-3 sets clock et 50 kHz. Cepacltor on pin 31 sats debounce time at about 8 ms. Upparcase only or both upparcasa end lowarcasa can ba selected by switching between pins 7 end 9. Provides two-kay rollover; N-kay rollover can ba obtained by edding diodes to kays. Each output will drive ona TTL loed.—D. Lancestar, "TV Typewriter Cookbook," Howard W. Sems, Indianapolis, IN, 1976, p 38.



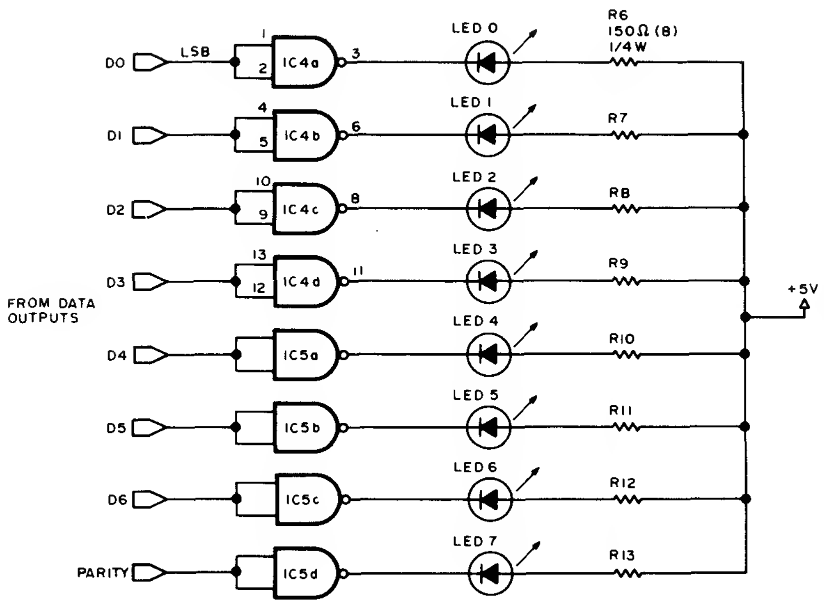
CALCULATOR-KEYBOARD INPUT—Usas dioda metrix that encodes 16 haxadecimel input keys as 4-bit code for microprocessor. Registar holds conversion results. Multiplexer gives switch-selected 3-digit octal or 2-digit hexadacimal interpretation to inputs. Control logic serves for keyboard debouncing, cleering, end entering deta. Circuit eliminates naed for entering programs with front-panel switches, by using keyboard to antar date in octal or haxadecimal form. Choica of form is echieved with 74157 multiplexers IC11 end IC12, set by S1. Article covers circuit operation in detail end gives 8008 full kayboerd input program thet defines mamory address with first 2 bytes, then enters loop that loads memory byte by byte in ascending address sequence. RGS-008A intarfaca logic is used to control Intarfaca for RGS-008A computar.—J. Hoegerl, Calculator Keyboard Input for the Microcomputer, *BYTE,* Feb. 1977, p 104–107.



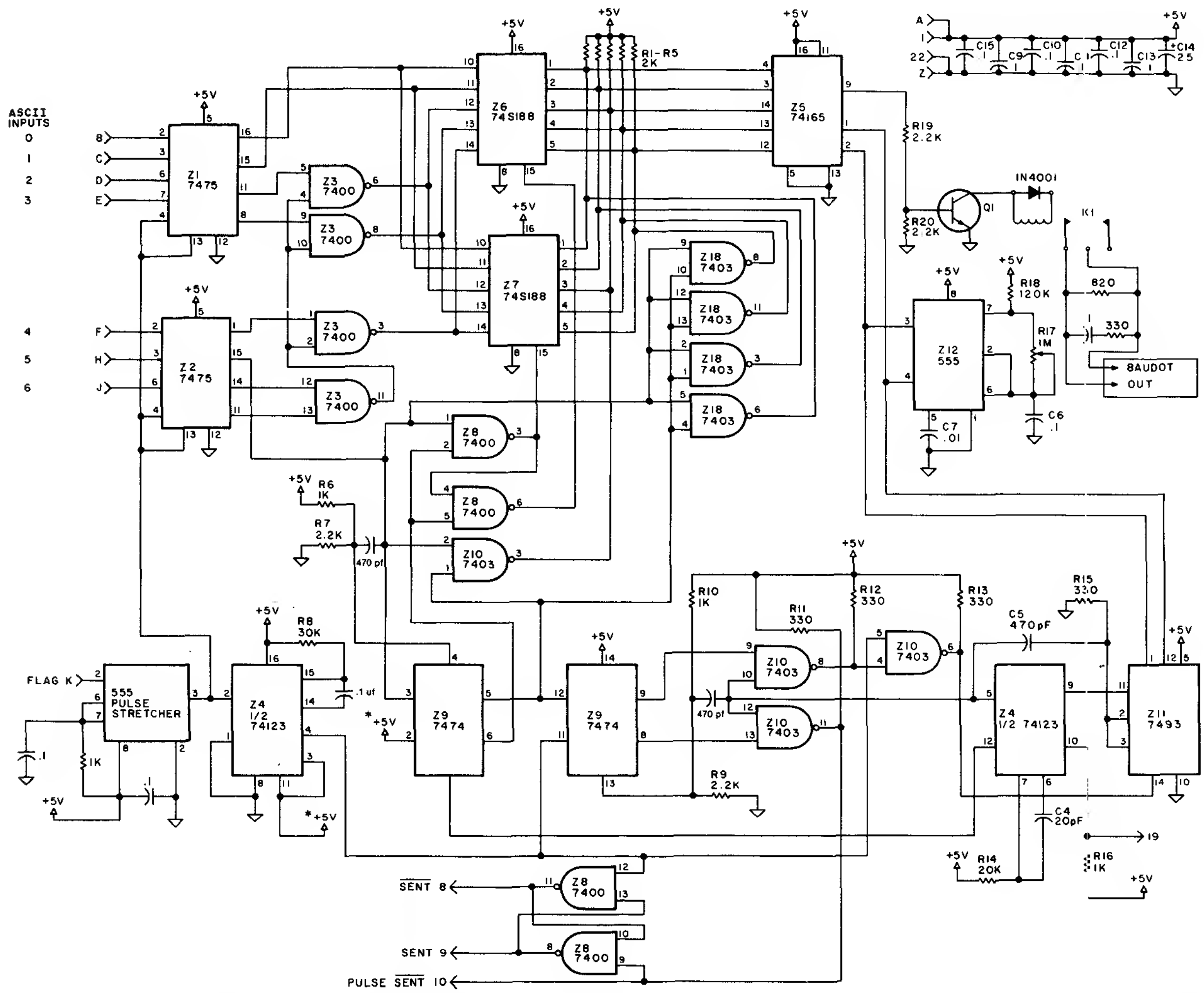
PARALLEL TO SERIAL CONVERSION—Can be used as interface between parallel outputs of keyboard and serial input port of microprocessor. Keyboard output data is fed to 74165 shift register, with eighth input tied low. 7403 gates are connected as mono MVBR for converting keyboard strobe to narrow pulse for loading shift register. Fourth gate in package serves as output buffer. 555 timer forms clock adjustable from 150 to 1400 Hz, to allow operational standard baud rates of 150, 300, 600, or 1200.—F. J. Greeb, Who Needs a UART?, *Kilobaud,* Aug. 1978, p 108.



KEYBOARD FOR PROM—National MM5740 encoder serves as interface between keyboard and MM5204 4K PROM capable of handling 90 four-mode keys. Encoder includes all logic needed for key validation, two-key or N-key rollover, bounce masking, mode selection, and strobe generation. Key code outputs can be defined by user. Bit-paired coding system of encoder has five common bits (B1-B4 and B9) and four variable bits (B5-B8) for each key. Each keyswitch is defined by one X drive line and one Y sense line of encoder. Combination gives total of 360 9-bit codes.—"Memory Applications Handbook," National Semiconductor, Santa Clara, CA, 1978, p 5-5–5-8.

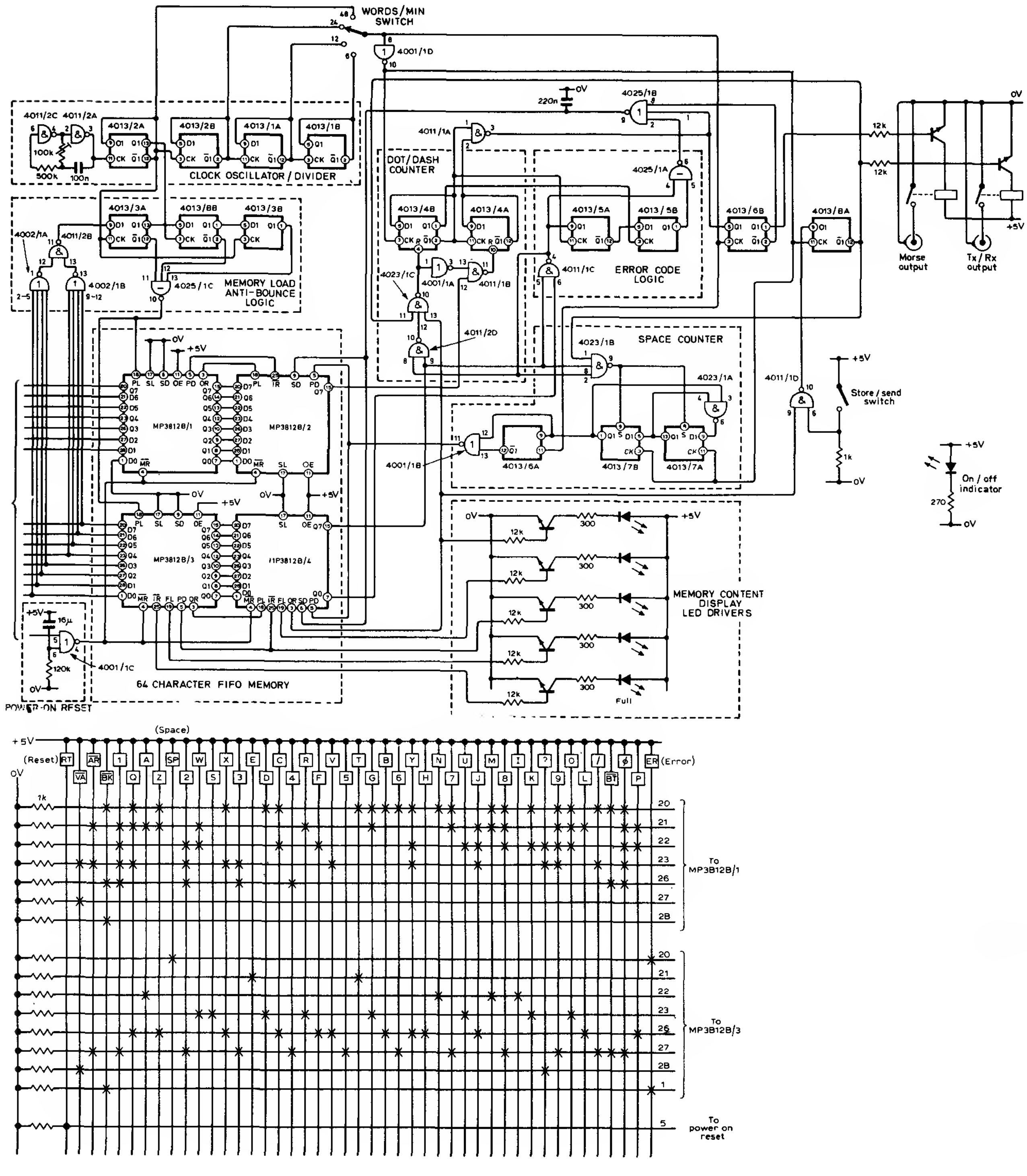


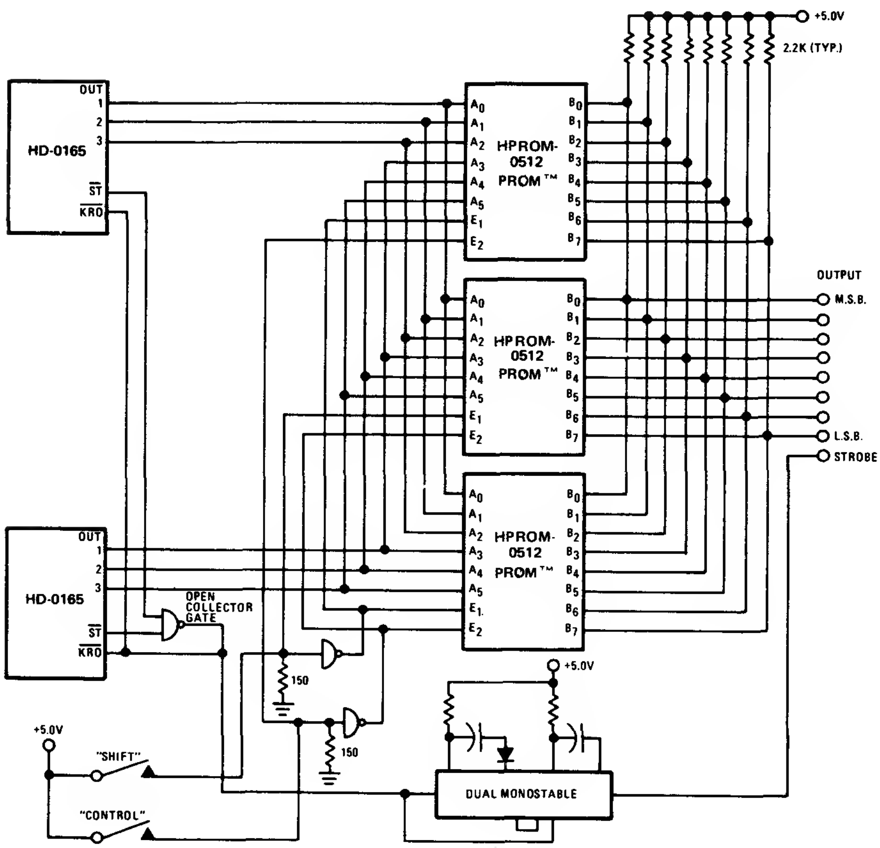
LED DISPLAY FOR ASCII CODE—Shows code for any ASCII keyboerd character es eid in debugging keyboerd metrix wiring. Requires only two 7400 qued NAND getes, eight resistors, end eight LEDs. High input to gate forces output low, grounding LED end lighting it. On standby with positive logic, ell LEDs are lit; with negetive logic, ell ere dark on standby. Arrenge LEDs on keyboard so rightmost represents laast significant bit (DO) and leftmost LED represents perity bit. Using positive logic, ASCII code for eny depressed key will show es lit LED for 1 end dark LED for 0. Pin 14 of 7400 is +5 V, end pin 7 is ground.—B. Brehm, Using e Keyboard ROM, *BYTE*, Mey 1977, p 76–82.



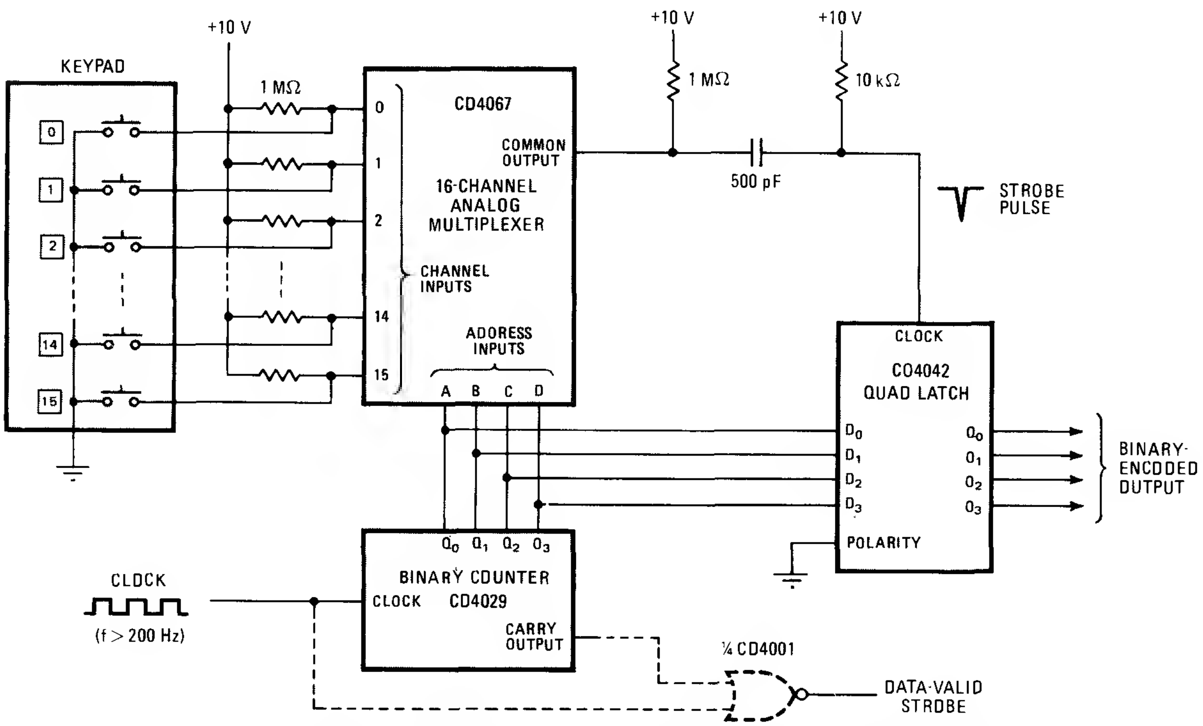
ASCII TO BAUDOT CONVERTER—Convarts perallel ASCII output of keyboerd to serial Beudot format for driving Baudot teleprinters. Conversion circuit can seve severel hundred bytes of computer or microprocessor storage, meking this memory spece eveileble for other purposes. Article gives conversion teble for ell capitel end lowercese alphebetic cherecters, numerics, end punctuation.—J. A. Lehmen end R. Grahem, ASCII to Baudot . . . er . . . Murray (the Herd Wey), *Kilobaud*, June 1978, p 80–83.

TYPEWRITER KEYS CW TRANSMITTER—Allows operator to send perfect Morse coda simply by typing massages on alphameric keyboard. Accuracy is detarmined only by typing skill of operator. One RC oscillator controls mark-space ratio of Morse characters and duration of character and word spaces, while clock oscillator is divided down and switched to giva sending-speed choices of 6, 12, 24, and 48 words par minuta. Each squara on keyboard diagram is SPST switch, and aach cross at intersection is silicon switching dioda such as 1N914. Outputs of keyboard switches are converted into 15-bit coda for feeding into 64-character first-in first-out mamory using four MP3812B ICs for storaga and for generating corrasponding Morsa charactars. Article gives construction and adjustment details.—C. I. B. Trusson, Morsa Kayboard and Memory, *Wireless World*, Jan. 1977, p 55–59.

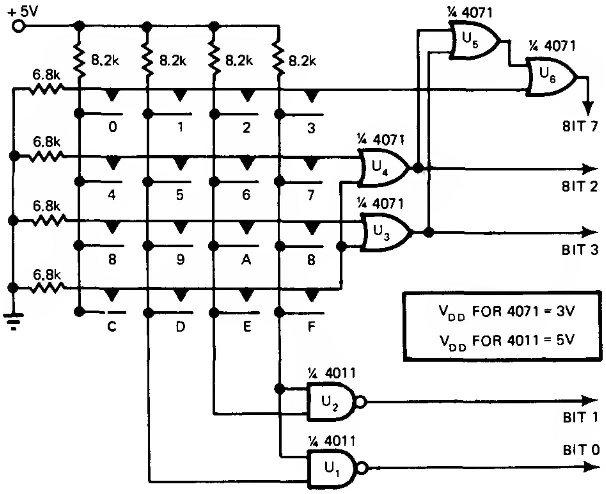




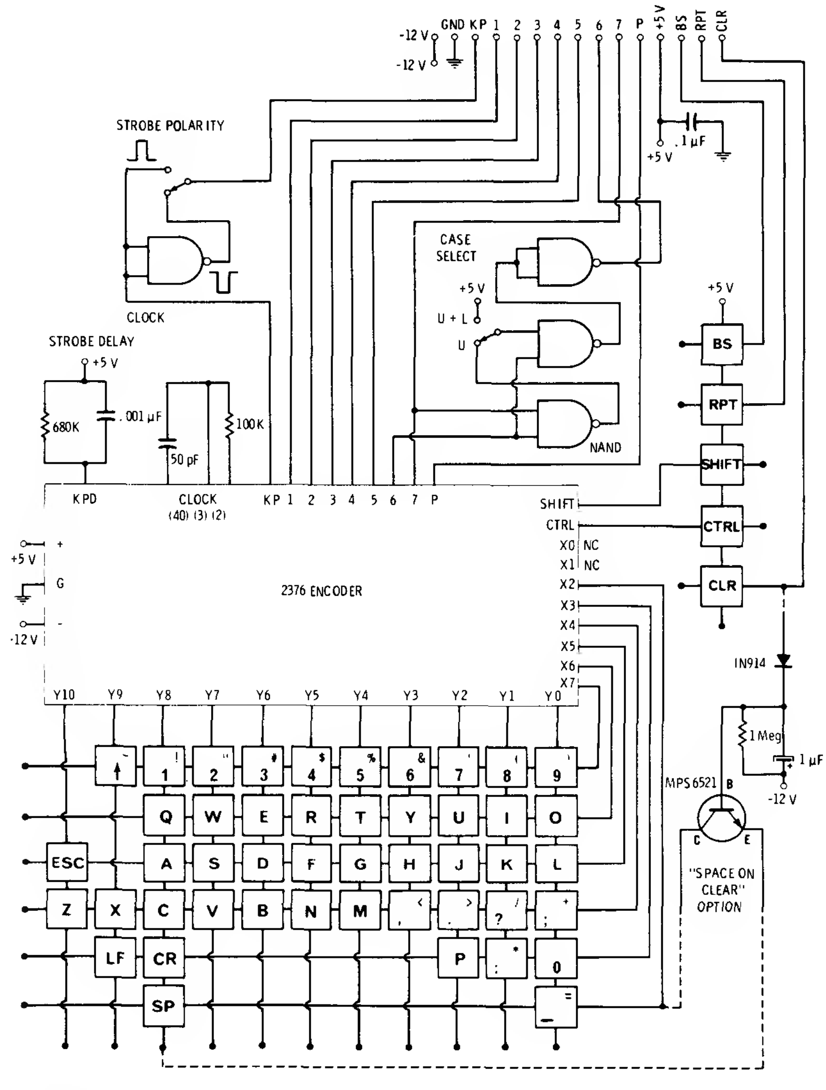
UNIVERSAL KEYBOARD ENCODER—Herris HD-0165 keyboard encodeis ere combined with three reed-only memories wired in perellel to generate universel code that can be trenslated to desired output code by using suiteble electric programming of ROMs. Key-to-encoder wiring is erbitrery es long es eech key operetion produces unique 6-bit output code from encoders. One ROM is programmed to contain all 64 output words for unshifted mode, second for shifted mode, end third ROM contains ell words for control mode.—"Lineer & Deta Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 7-2–7-8 (Application Note 204).



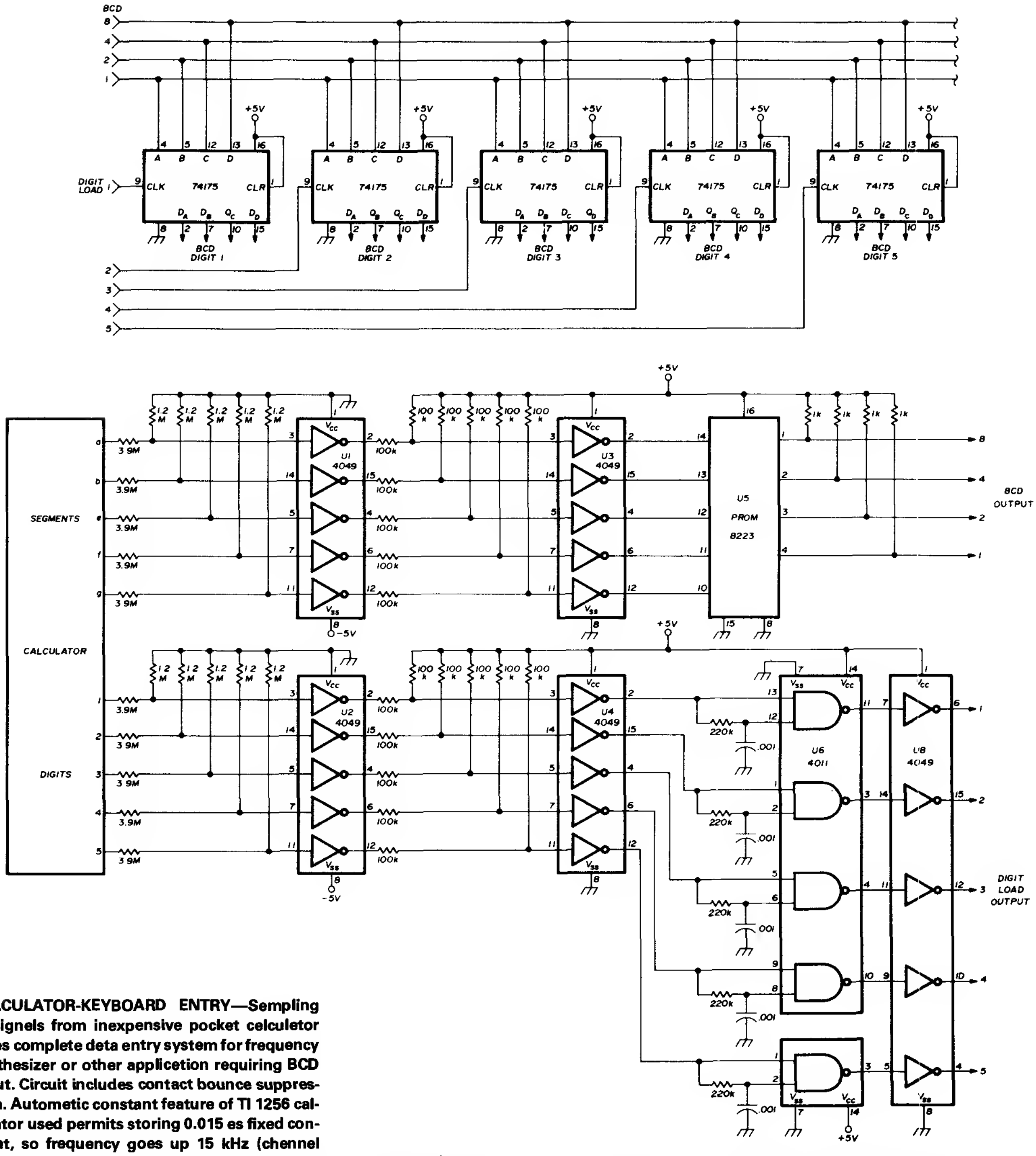
DATA-ENTRY KEYPAD ENCODER—Designed for use in point-of-sele and other dete-entry epplications requiring bounceless binery encoder. Keyped is scanned by CD4067 16-channel enelog multiplexer. When key is depressed, eppropriate chennel is driven low. When counter eddresses low input of multiplexer, common output goes low for one clock cycle. Differentiating network chenges this to negetive spike for strobing counter dete into qued latch where it remeins until another key is depressed. Clock should be ebove 200 Hz.—M. E. Keppel, Multiplexer Scans Keyboard for Relieble Binery Encoding, *Electronics*, March 17, 1977, p 99.



HEX ENCODER FOR KEYBOARD—Stendard 16-button keyboard is used with CMOS peckeges to provide hex output bits. Pressing one button increeses voltage on its horizontel line from 0 to 2.2 V. If button is in other then first row, OR gate U_3 or U_4 is activated end either bit 2 or 3 chenges from LOW to HIGH. Simulteneously, voltage of vertical column of button decreeses from 5 V to 2.2 V. If button is in other than first column, NAND gete U_1 or U_2 is ectiveted end either bit 0 or 1 chenges from LOW to HIGH. OR getes U_5 end U_6 provide button-pressed signal by chenging bit 7 from LOW to HIGH upon activation of any button.—W. H. Hailey, CMOS Logic Implements Keyboerd Encoder, *EDN Magazine,* Aug. 5, 1978, p 54 and 56.



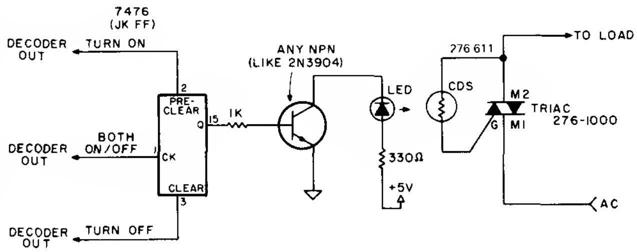
SCANNING KEYBOARD WITH MEMORY—Standard keyboard is updated to 53 keys as required for character feed in microprocessor-based TV typewriter system. Faetures include two-key rollovar, elong with choices of letter case, strobe polarity, cleer key, end repeet key. Space output is produced autometically during claar.—D. Lancaster, "TV Typewritar Cookbook," Howard W. Sems, Indianapolis, IN, 1976, p 150–151.



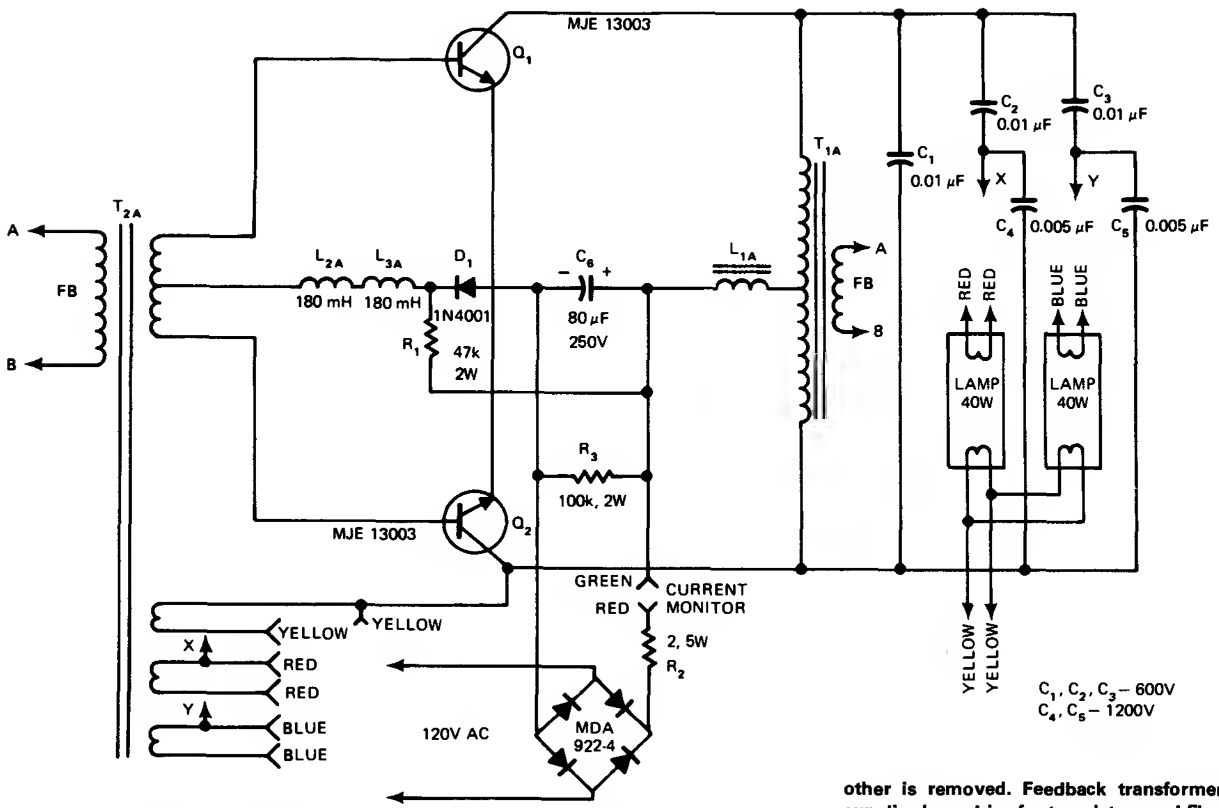
CALCULATOR-KEYBOARD ENTRY—Sampling of signals from inexpensive pocket calculator gives complete data entry system for frequency synthesizer or other application requiring BCD input. Circuit includes contact bounce suppression. Automatic constant feature of TI 1256 calculator used permits storing 0.015 as fixed constant, so frequency goes up 15 kHz (channel spacing on 2 meters) each time + key is pressed. Seven-segment signal normally used for calculator display is decoded by programming 74S188 (8223) PROM, using simplified code conversion table given in article. 74175 ICs provide required demultiplexing of segment data. Article gives construction details.—B. McNair and G. Willimen, Digital Keyboard Entry System, *Ham Radio,* Sept. 1978, p 92–97.

CHAPTER 44
Lamp Control Circuits

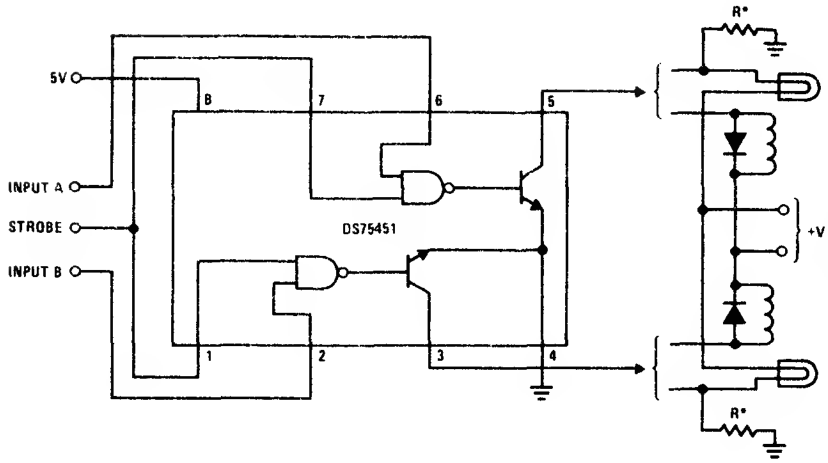
Covers methods of triggering triacs and silicon controlled rectifiers for turning on, dimming, and otherwise regulating lamp loads in response to photoelectric, acoustic, logic, or manual control at input. Starting circuits for fluorescent lamps are also given.



AC CONTROL WITH TRIAC—Decoder outputs of microprocessor feed 7476 JK flip-flop thet drives optocoupler which triggers triac for ON/OFF control of lamp or other AC loed. LED end cedmium sulfide photocell ere mounted in light shield. When light from LED is on photocell, cell resistance drops and allows control voltage of correct direction and amplitude to trigger gete of triec, turning it on. When light disappears, triec remeins on until voltege falls near zero in AC cycle.—R. Wright, Utilize ASCII Control Codes!, *Kilobaud,* Oct. 1977, p 80–83.

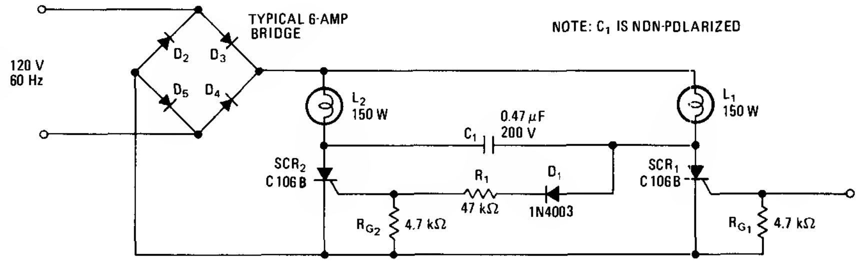


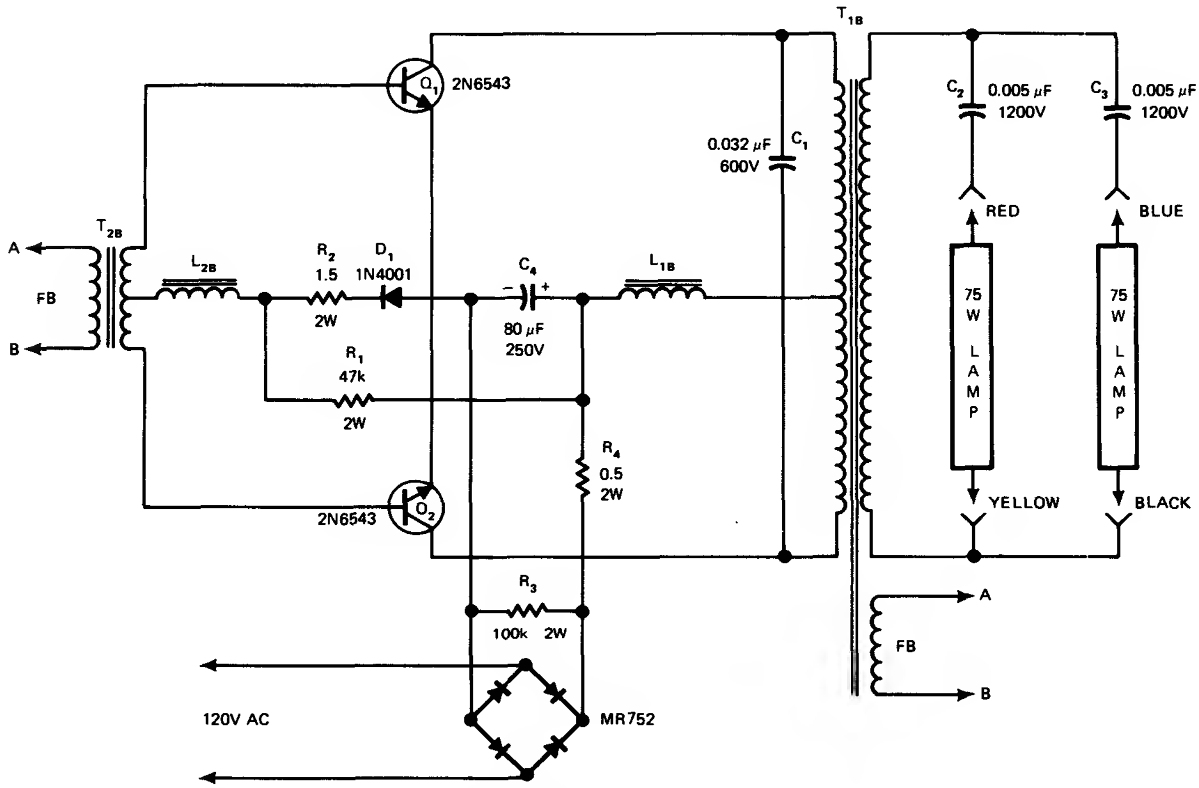
40-W RAPID-START BALLAST—AC line voltege is rectified by diode bridge end filtered by C_6-L_{1A}. Transistors Q_1-Q_2 with center-tapped tank coil T_{1A} end C_1-C_3 make up power stage of 20-kHz oscillator that develops 600 V P sine wave across T_{1A}. When fluorescent lamps ionize, current to each is limited to about 0.4 A. Lamps operete independently, so one stays on when other is removed. Feedback transformer T_{2A} supplies base drive for transistors and filament power for lemps. Article gives transformer and choke winding dete.—R. J. Hever, The Verdict Is In: Solid-State Fluorescent Bellasts Are Here, *EDN Magazine,* Nov. 5, 1976, p 65–69.



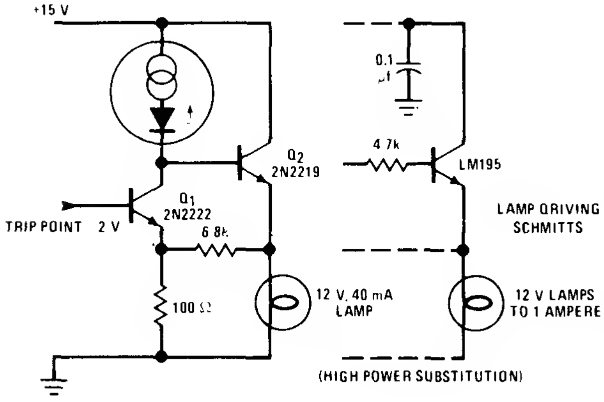
DUAL LAMP DRIVER—National DS75451 dual peripheral AND driver using positive logic provides up to 300 mA per section for driving incandescent lamps. Optional keep-alive resistors R maintain OFF-state lamp current at about 10% of rated valua to reduce surga current. Lamp voltage depends on lamps usad. Relays shown, with diodes across solanoids, can be used in place of lamps if desirad.—"Interfaca Databook," National Samiconductor, Santa Clara, CA, 1978, p 3-20–3-30.

COMPLEMENTARY FADER—Control unit for stage lighting fades out one lamp whila simultaneously increasing light output of anothar with accurate tracking. Gate of silicon controlled rectifier SCR_1 is drivan by standard axternal phase control circuit. Interlock network connacted to output of SCR_1 provides complementary signal for triggar of SCR_2. If lamps larger than 150 W ara raquired, usa largar value for C_1.—M. E. Anglin, Complementary Lighting Control Usas Few Parts, *Elactronics,* Dac. 12, 1974, p 111; reprinted in "Circuits for Electronics Enginaars," *Elactronics,* 1977, p 78.

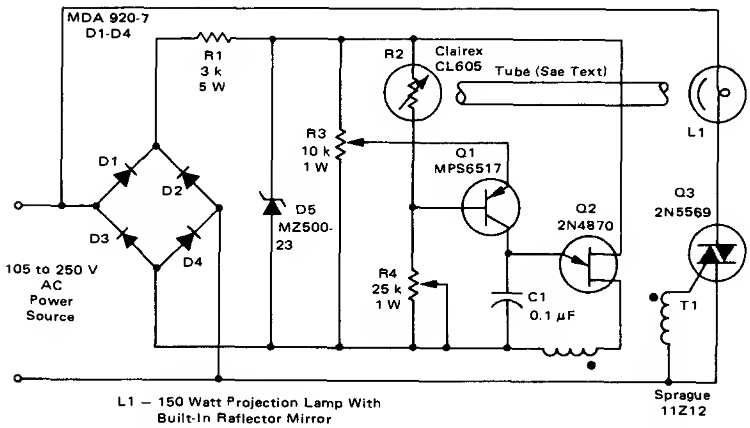




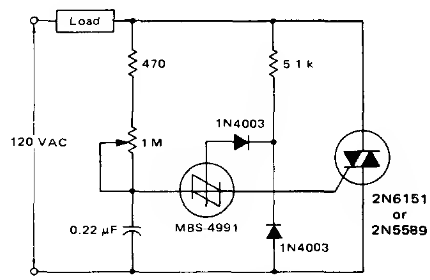
75-W INSTANT-START BALLAST—DC voltage for 20-kHz two-transistor oscillator is obtained from AC lina. Secondary is added to center-tapped tank coil of T_{1B} to provida 1 kV P starting voltaga raquired by 96-inch instant-start lamps. Articla gives transformar and choke winding data along with circuit details and performance data. Lamps operata indapendantly, so ona stays on when other is ramoved.—R. J. Haver, The Verdict Is In: Solid-Stata Fluorescent Ballasts Are Hara, *EDN Magazine,* Nov. 5, 1976, p 65–69.



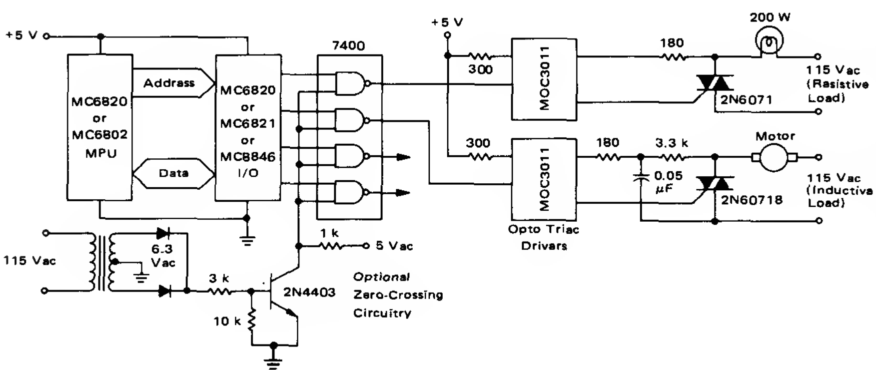
ACTIVE LOAD—National NSL4944 constant-current LED serves as current source for collector resistor of Schmitt trigger to provide up to 12-V output at 40 mA for lamp load. When lamp and Q_2 are off, most of LED current flows through 100-ohm resistor to determine circuit trip point of 2 V. When control signal saturates Q_1, Q_2 provides about 1 V for lamp to give some preheating and reduce starting current surge. When control is above trip point, Q_2 turns on and energizes lamp.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-153, p 3.



PROJECTION-LAMP VOLTAGE REGULATOR—Circuit will regulate RMS output voltage across lamp to 100 V ± 2% for input voltages between 105 and 250 VAC. Light output of 150-W projection lamp is sensed indirectly for use as feedback to firing circuit Q1-Q2 that controls conduction angle of triac Q3. Light pipe, painted black, is used to pick up red glow from back of reflector inside lamp, which has relatively large mass and hence has relatively no 60-Hz modulation.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 12.

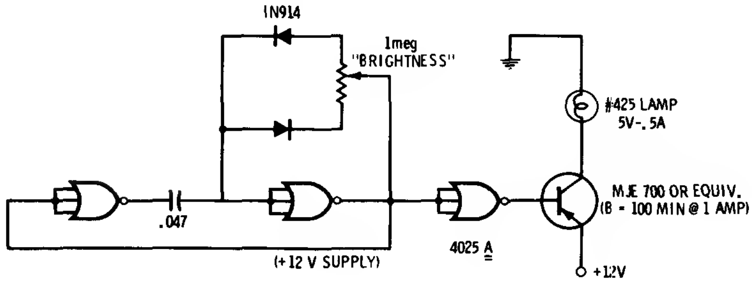


800-W TRIAC DIMMER—Simple circuit uses Motorola MBS-4991 silicon bilateral switch to provide phase control of triac. 1-megohm pot varies conduction angle of triac from 0° to about 170°, to give better than 97% of full power to load at maximum setting. Conduction angle is the same for both half-cycles at any given setting of pot.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 5.

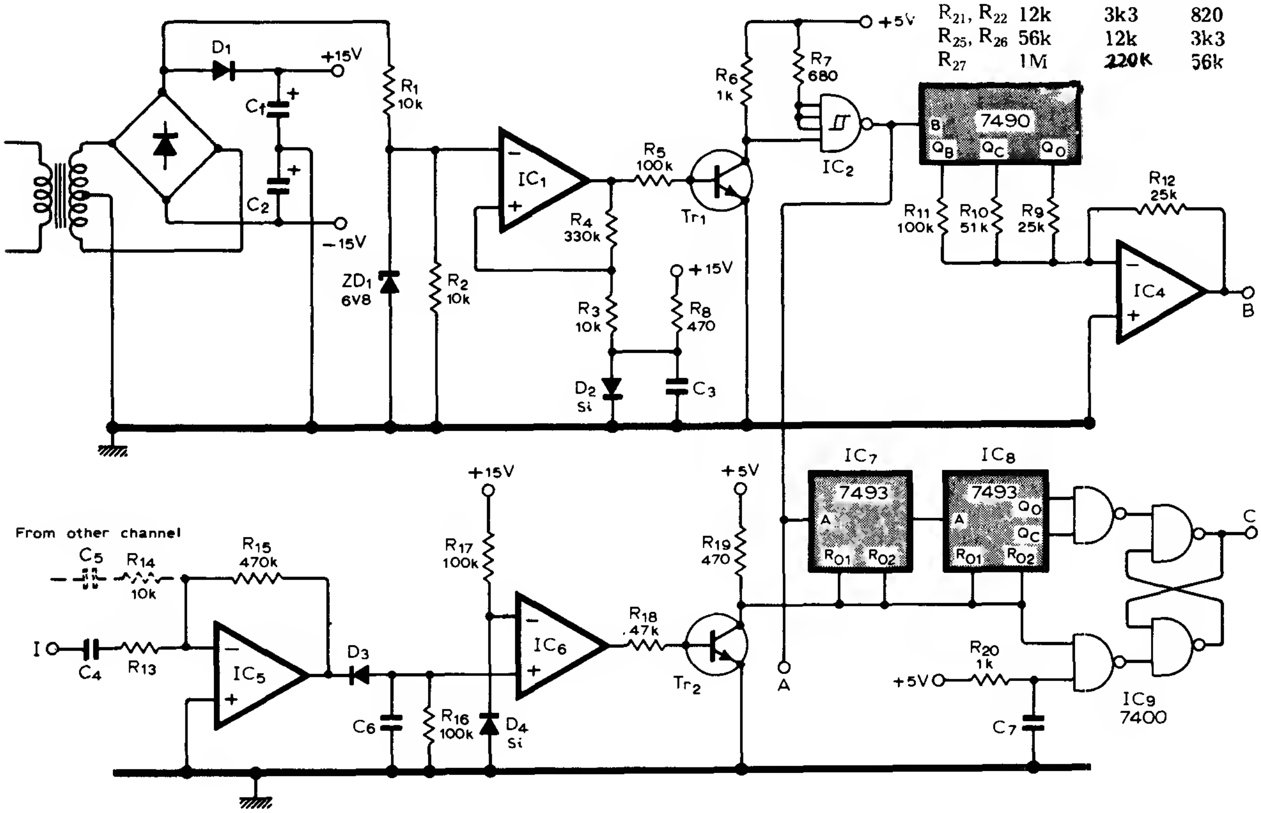


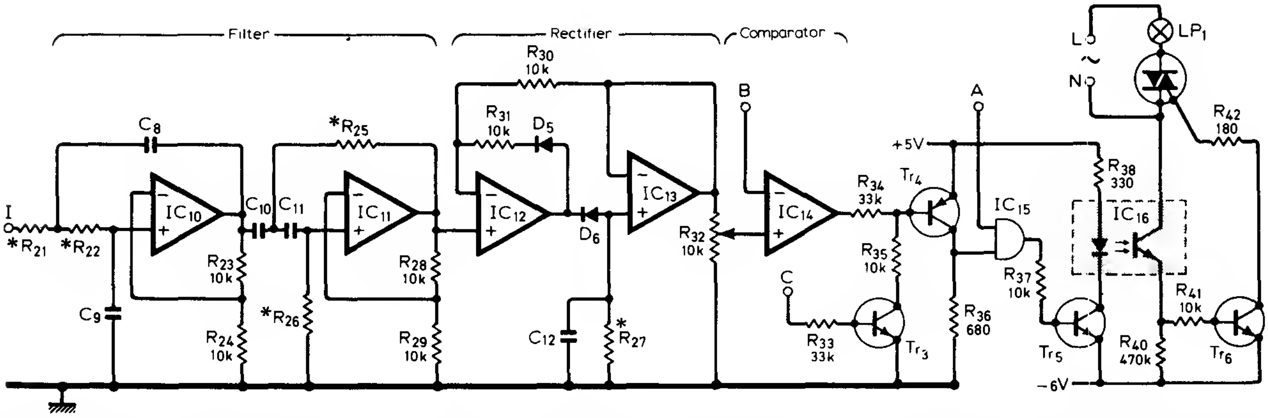
INTERFACE FOR AC LOAD CONTROL—Standard 7400 series gates provide input to Motorola MOC3011 optoisolators for control of triac handling resistive or inductive AC load. Gates are driven by MC6800-type peripheral interface adapters. If second input of two-input gate is tied to simple transistor timing circuit as shown, triac is energized only at zero crossings of AC line voltage. This extends life of incandescent lamps, reduces surge-current effect on triac, and reduces EMI generated by load switching.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 6.

HELMET-LAMP DIMMER—Provides lossless variation in brightness of incandescent lamp by using duty-cycle modulation. All three sections of 4025 triple three-input NOR gate turn lamp on and off rapidly at rate determined by setting of brightness control pot in astable MVBR circuit. Output transistor rating must be sufficient to handle lamp current.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 231.

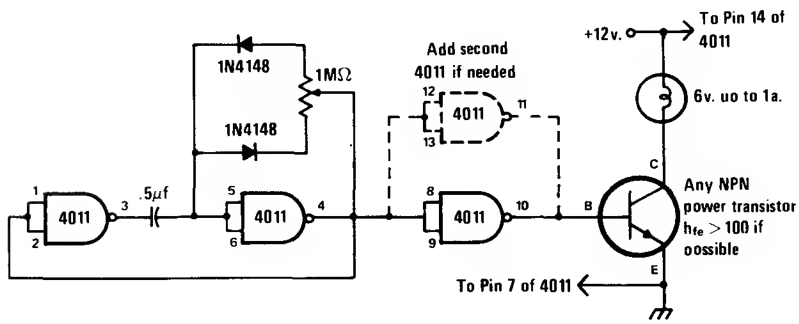


	bass	middle	treble
R_{21}, R_{22}	12k	3k3	820
R_{25}, R_{26}	56k	12k	3k3
R_{27}	1M	220k	56k

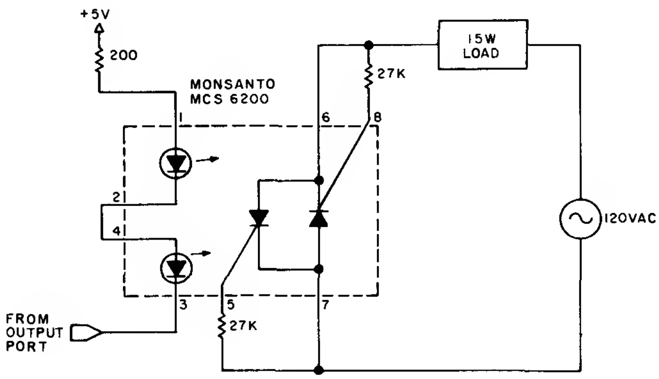




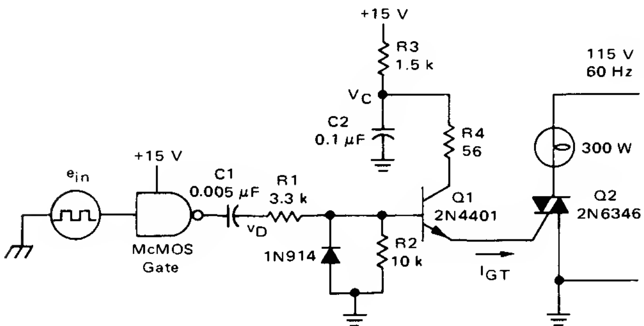
SOUND-CONTROLLED LAMP—Zero-voltage switching achieves interference-free proportional control of lamp intensity by sound source. Both inputs to AND gate IC_{15} must be high for triac to turn on. One input is from zero-crossing detector IC_1, Tr_1, and IC_2, which produces 100-Hz series of positive-going pulses. Other input is provided by filter/rectifier/comparator circuit. Inverting input of comparator IC_{14} is fed by DAC IC_4 which produces stepped ramp waveform from outputs of 7490 counter IC_3. Counter is connected to count to 5 before resetting internally, giving five possible brightness levels for lamp. Opamps IC_5 and IC_6 detect when audio input falls below about 10 mV and then release IC_7-IC_9 from reset stage so the two 4-bit counters start counting 100-Hz waveform. Resetting occurs again when audio input next passes 10-mV level. Lamp automatically turns on when music stops. All ICs are 741 or equivalent except as marked. Unmarked diodes are 1N4148, C_1 and C_2 are 100-nF polyester electrolytics, and all transistors are general-purpose types. Resistor values in table are for three-channel system, but more channels can be used if desired.—A. R. Ward, Sound-to Light Unit, *Wireless World*, July 1978, p 75.



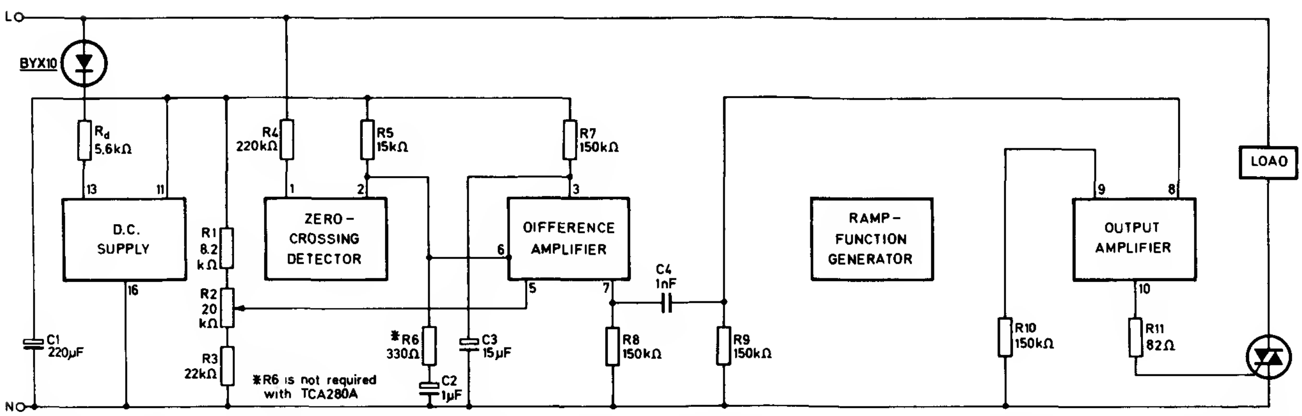
LANTERN-BATTERY EXTENDER—Life of lantern battery can be tripled without reducing light by chopping current while doubling voltege at 50% duty fector. 6-V lamp is connected across chopped 12-V supply built around 4011 CMOS qued NAND gete. First two getes form chopping oscillotor, while third serves es interface to eny NPN high-gein power transistor. If lamp drews more than 1 A, add fourth gate as shown in deshed lines. If gate is not used, tie its input leeds to pin 14 of IC. Duty cycle is veried with 1-megohm pot; set at midrange before epplying power, then edjust for normal lamp brillience.—J. A. Sendler, 9 Easy to Build Projects under $9, *Modern Electronics,* July 1978, p 53–56.



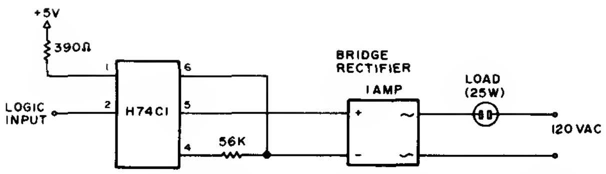
FULL-WAVE CONTROL—Monsanto MCS6200 duel SCR optocoupler provides direct full-weve control of 15-W lamp or other AC device when driven by output logic voltages of microprocessor. LEDs are connected in series and photo-SCRs in reverse perellel to creete equivelent of triec.—H. Olson, Controlling the Reel World, *BYTE,* March 1978, p 174–177.



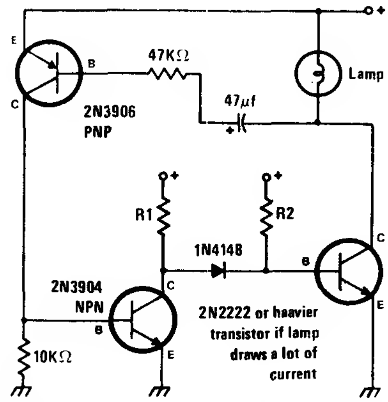
CMOS LOGIC CONTROL OF 300-W LAMP—Storage cepecitor C2 in interface transistor circuit for typical CMOS gete cherges to full +15 V supply voltege in time determined by R3 end C2, after which Q1 is fired by positive-going differentieted pulse derived from input squere wave. C2 then dumps its charge through R4 end Q1, to fire triec Q2 end energize AC loed. For meximum loed power, triec should be fired eerly in conduction engle. With 1-kHz input squere weve, output power is over 98% of meximum possible.—A. Psheenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorole, Phoenix, AZ, 1975, AN-712A, p 13.



PHASE-CONTROLLED DIMMER—Mullard TCA280A trigger module is connected to compere amplitude of remp weveform with controlleble DC voltage in difference emplifier. At point of coincidence, trigger pulse is produced in output emplifier for triggering triec thet controls lemp load. Choice of triec depends on loed. Velues shown for C4 end R9 give 100-μs pulse.—"TCA280A Trigger IC for Thyristors and Triecs," Mullerd, London, 1975, Technicel Note 19, TP1490, p 12.



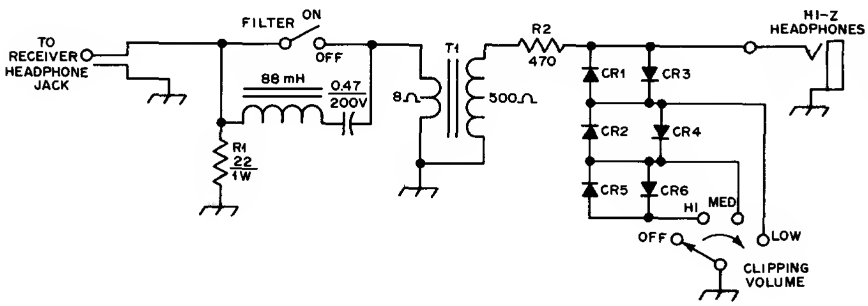
LOGIC CONTROLS 25-W LAMP—Ordinary 1-A bridge is used with H74C1 optoisolator to pass full current to 25-W lamp when logic input goes low (to ground, so full 5 V is applied to light source in optoisolator).—D. D. Mickle, Practical Computer Projects, *73 Magazine*, Jan. 1978, p 92–93.



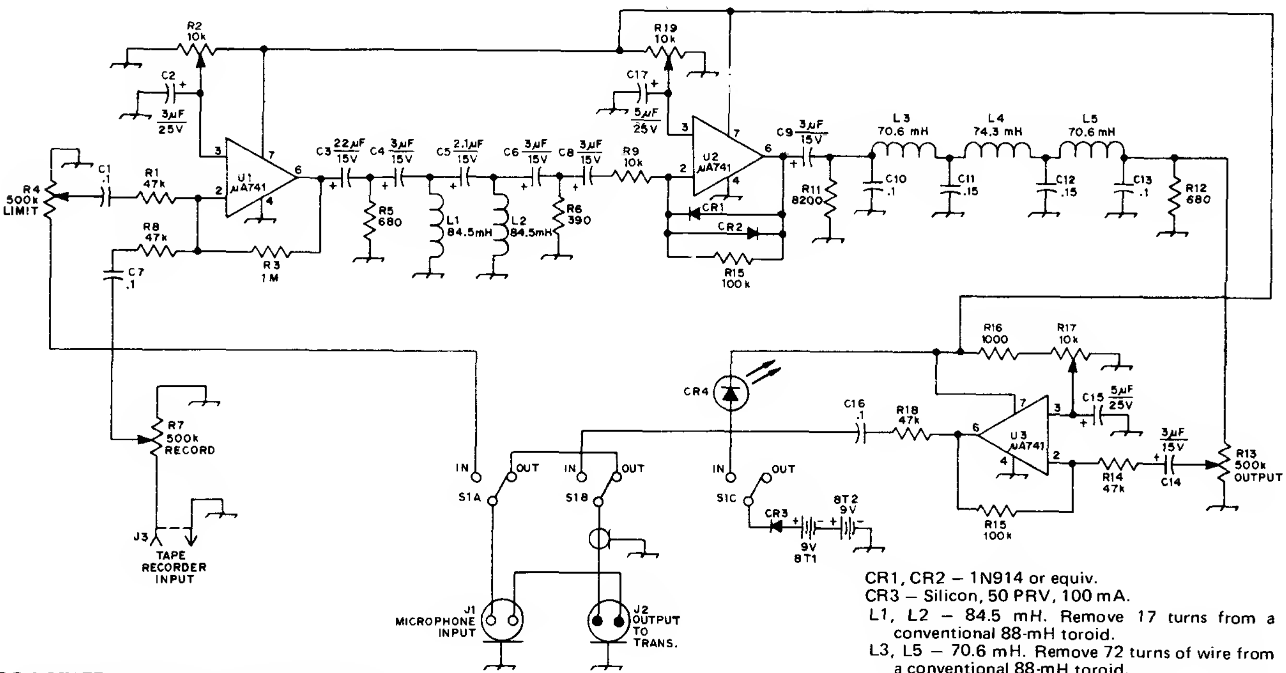
LAMP SURGE SUPPRESSOR—Circuit limits turn-on current through cold filament, which is major cause of lamp failure but provides normal current when filament reaches operating temperature. Developed primarily for use with lamps in locations where replacement is extremely difficult. Values shown are primarily for low-voltage pilot lamps such as No. 44 and No. 47 but can be applied to any lamp within voltage and current ratings of transistors used.—J. A. Sandler, 11 Projects under $11, *Modern Electronics*, June 1978, p 54–58.

CHAPTER 45
Limiter Circuits

Covers clamps, clippers, and limiters used to keep signal peaks below predetermined limits for positive swings or for both positive and negative swings. See also Audio Control and Automatic Gain Control chapters.

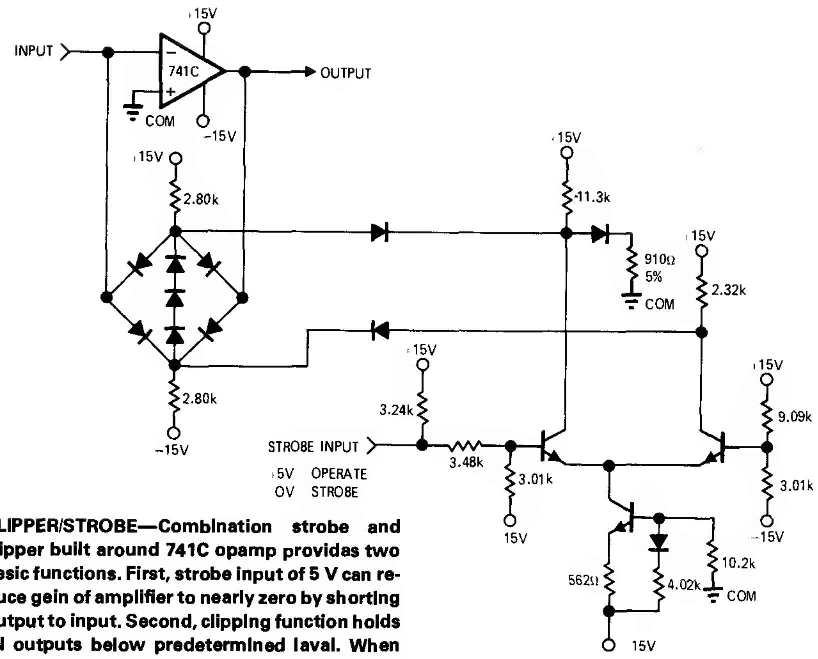


AUDIO CLIPPER/FILTER—Improves salectivity of communication receivar and prevents uncomfortebly loud voluma in 500-ohm haadphones. 88-mH toroid end 0.47-μF capacitor form sarias rasonant circuit at about 750 Hz with 6-dB bandwidth of 75 Hz. R2 end diodes form audio clipper whose level is determined by forward conduction voltage of diodes. With germanium diodes for CR1-CR4 and silicon for CR5-CR6, eech successive switch position boosts volume 6 dB. For low-impedance headphones, omit T1 end use 8 ohms for R2.—A. R. Bloom, An Audio Clipper/Filter, *QST,* Aug. 1977, p 48.

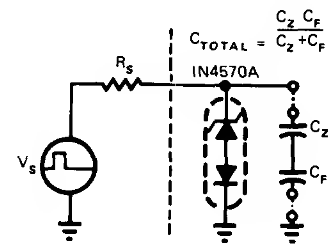


CR1, CR2 – 1N914 or equiv.
CR3 – Silicon, 50 PRV, 100 mA.
L1, L2 – 84.5 mH. Remove 17 turns from a conventional 88-mH toroid.
L3, L5 – 70.6 mH. Remove 72 turns of wire from a conventional 88-mH toroid.
L4 – 74.3 mH. Remove 57 turns of wire from a conventional 88-mH toroid.

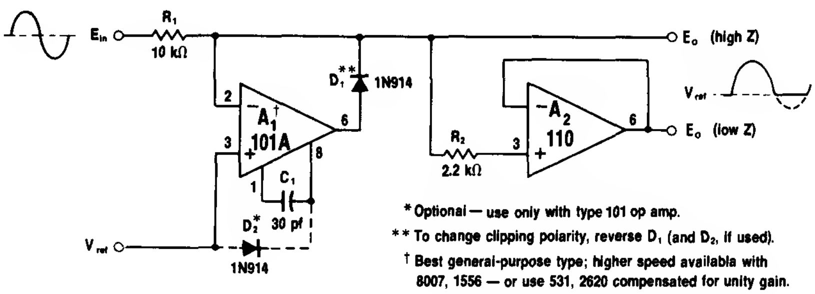
LOG LIMITER—Installed between microphone and AF input connector of trensmitter to incraesa everega level of human voica and corresponding SSB transmitter output signal. Preemp U1 increases audio input level to overcome loss of following high-pass filter. Low-pass filter after logamp U2 eliminates ell energy ebova ebout 2950 Hz. Last opamp U3 sets output level of processor for driving station transmitter properly. Overell amount of amplitude limiting is determined by setting of preamp gein control R4. High-pess filter eliminates 60-Hz hum developed in audio systam or in accessory equipment and reducas hermonic distortion ganereted by deeply pitched voica or by hum pickad up from tepe recorder or phone patch. Gain of opamp is determinad by CR1-CR2, which give logarithmic response to audio input amplitude. Adjust R2, R17, and R19 for minimum distortion whila applying 1-kHz sine weve to input.—R. Myers, A Quasi-Logarithmic Analog Amplituda Limiter with Frequancy-Domain Processing, *QST,* Aug. 1974, p 22–25 and 40.



CLIPPER/STROBE—Combination strobe and clipper built around 741C opamp provides two basic functions. First, strobe input of 5 V can reduce gain of amplifier to nearly zero by shorting output to input. Second, clipping function holds all outputs below predetermined level. When used in integrator, circuit provides constant rate of discharge for integrating capacitor. Clipping is done by four-diode bridge having three extra diodes acting as zener. Strobe function is provided by four-diode bridge alone, with strobing input circuit having single-ended input and differential output. All transistors are 2N2219, and all diodes are 1N914.—L. Strehan, Op Amp Control Without Relays, *EDN/IEEE Magazine*, Aug. 15, 1971, p 41–42.

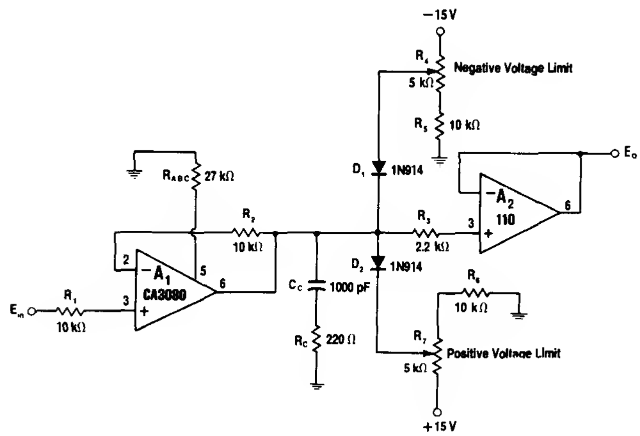


FAST CLAMP—Smaller capacitance of temperature-compensated reference diodes allows clamping of faster pulses than is possible with ordinary zeners. Diagram shows positive 6.4-V diode clamp at ground potential. For smaller zener voltages, connect diode to more negative potential. Device limits only positive peaks; for negative peaks, reverse connections to 1N4570A. To clamp both polarities, use two units in parallel, oppositely connected.—W. Walloch, Clamp Fast Pulses with One Component, *EDN Magazine*, April 5, 1974, p 76.

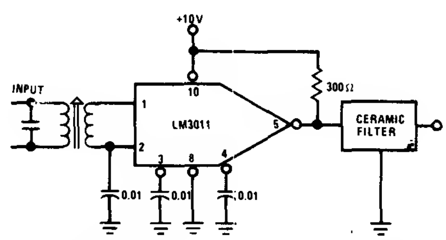


* Optional — use only with type 101 op amp.
** To change clipping polarity, reverse D_1 (and D_2, if used).
† Best general-purpose type; higher speed available with 8007, 1556 — or use 531, 2620 compensated for unity gain.

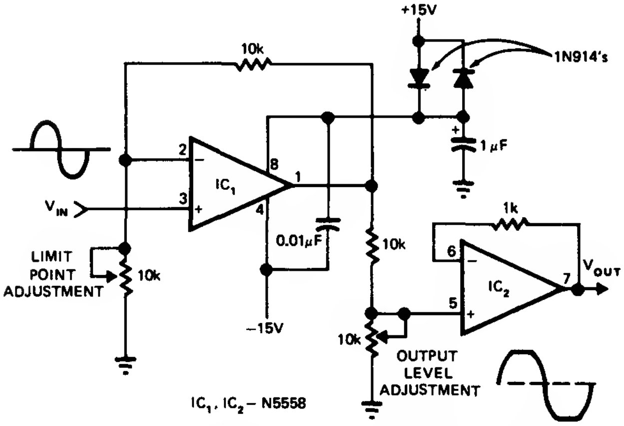
SHUNT CLIPPER—When input voltage is above reference voltage, D_1 is reverse-biased and input voltage passes through R_1 to output. When negative peak of E_{in} exceeds V_{ref}, opamp A_1 turns D_1 on to absorb input current from R_1, thereby clamping output at level of V_{ref}. If low output impedance is required, use 110 high-speed voltage follower as buffer amplifier.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 189–190.



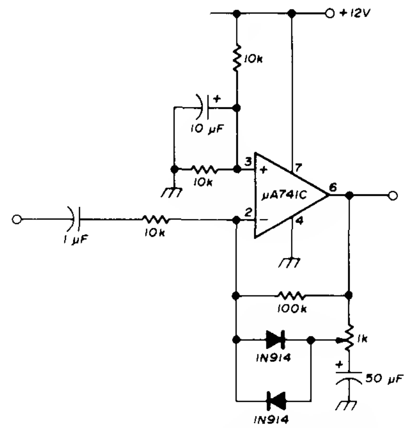
VOLTAGE LIMITER WITH BUFFER—CA3080 operational transconductance amplifier is used in combination with D_1 and D_2 that are normally reverse-biased at low levels, to provide abrupt or hard limiting. When output peaks from A_1 exceed voltage limits set by R_4 and R_7, diodes conduct and absorb A_1 output current, to limit its voltage swing. Buffer A_2 is required with this type of limiter to maintain loop gain and ensure constant limiting level for varying loads. Limiter action is absolute, in that there can be no further output voltage change when current limit is reached. Limiter can handle input/output levels of ±10 V or more when using ±15 V supply.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 466–467.



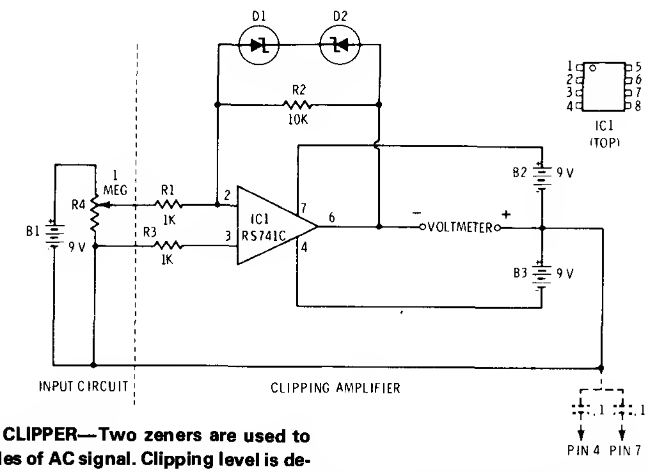
CERAMIC-FILTER DRIVE—National LM3011 gain block provides three differential stages and current-source output suitable for driving 300-ohm ceramic filter in IF amplifier of FM receiver. Circuit provides 60 dB of power gain to matched load.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 3-11–3-12.



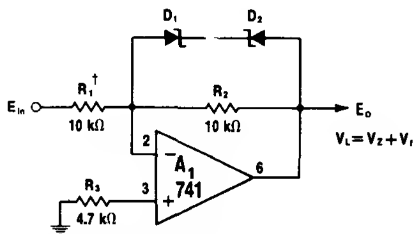
HARD-LIMITING OPAMP—Based on limitad output swing of opamp. Singla pot adjusts both positive and negative limit points. First opamp producas limiting. Second opamp serves as voltage follower for isolating attenuator and reducing output impedance. Matching of output between limit points is within about 100 mV at output level of 2 V P-P. Opamps specified are adequate for 3-kHz bandwidth.—E. E. Barnes, Easa Hard-Limiter Design with Op Amps, *EDN Magazine*, Aug. 5, 1975, p 76.



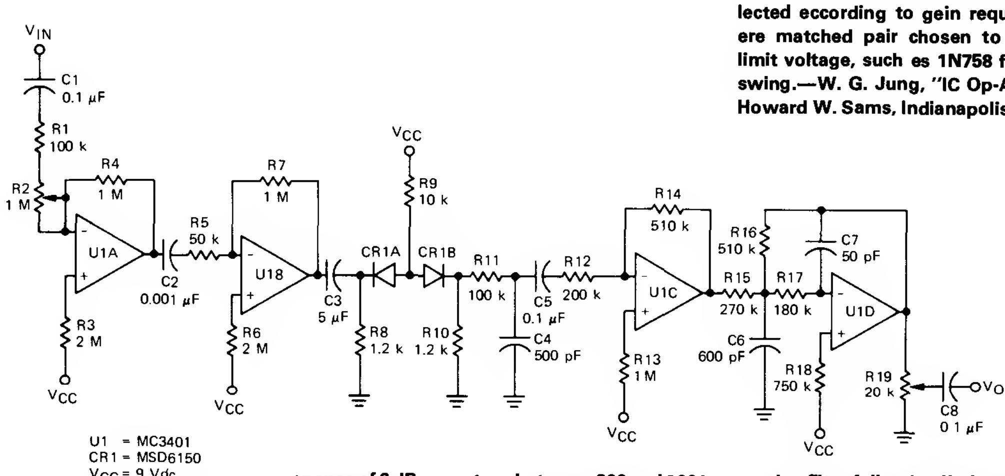
INVERTER/LIMITER—Developed for direct-conversion receivars that lack AGC, to provida limiting for CW reception. Below adjustable limiting threshold, amplifier is linear with voltege gein of 10. When output is high enough for silicon diodes to conduct, gain drops balow unity. Amplifier should be preceded by sevaral sections of filtering and followed by single-section low-pass filter to eliminate harmonic distortions generated in limiting process.—W. Hayward, Simple Active Filters for Direct-Conversion Receivers, *Ham Radio*, April 1974, p 12–15.



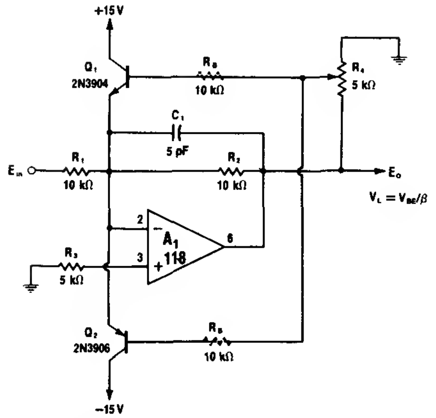
OPAMP AS CLIPPER—Two zeners are used to clip both sides of AC signal. Clipping level is determinad by rating of zeners used, which can ba 6, 9, 12, or 15 V depending on application. Ratio of R2 to R1 determines emplification. If long supply laads cause oscillation, connect 0.1-μF capacitors batwaan ground and supply pins 4 and 7 as shown.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 37–44.



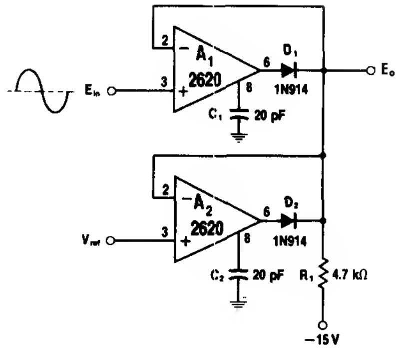
BIPOLAR ZENER—Circuit limits opamp output swing in eithar direction to sum of zener- and forward-breekdown voltages of D_1 and D_2. With matched zeners, positive and negative limiting levels ara symmetrical. With 10-V zeners, limiting occurs at 10.6 V (10.0 + 0.6 V) to allow linear ±10 V swing without saturating A_1. R_2 is selected according to gein requirement. Diodes ere matched pair chosen to provide desirad limit voltage, such es 1N758 for ±10 V output swing.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 201.



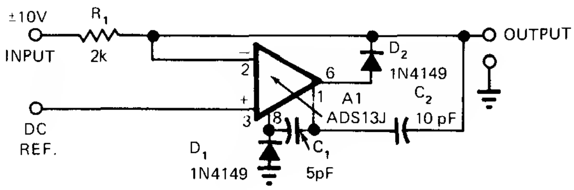
LIMITING PREAMP FOR FM—All four sections of Motorola MC3401 quad amplifier are used as interfece between high-impedence microphone and FM modulator to provide preemphasis responsa of 6 dB per octave between 300 and 3000 Hz, with 6-dB per octave rolloff beyond. Includes amplitude limiter to pravent peak deviation of trensmitter from exceeding allowed maximum. U1D forms ective filter actlng with passive filter following limiter to give low-pass filter having attenuation of at laast 12 dB per octave above 3 kHz.—D. Aldridge, "An Economicel FM Transmitter Voice Processor from e Single IC," Motorola, Phoenix, AZ, 1975, EB-57.



SYMMETRICAL BIPOLAR—Circuit uses transistor feedback, with current returned to opamp summing point through emitter-followers Q_1 and Q_2. When output E_0 rises to positive voltage high enough so tap on R_4 makes Q_1 turn on, output of A_1 is limited to value corresponding to setting of R_4. Q_2 performs similar limiting function for negative swings of input signal. R_4 sets limiting level for both polarities, for variable symmetrical limiting. Transistors and opamps shown are selected for high-speed operation. For single-polarity limiting, insert large resistance R_B in base lead of remaining transistor to prevent it from conducting heavily on output voltage swings.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 203–204.



SELF-BUFFERED SERIES CLIPPER—Provides negative clipping of sine-wave input, using 2620 opamps with diodes as linear OR gate. When input voltage is greater than reference voltage, A_1-D_1 turns on and input voltage appears at output. When E_{in} falls below V_{ref}, A_2-D_2 provide V_{ref} as output signal. With 2620, circuit gives good performance to above 10 kHz. For positive clipping, reverse diode connections and return R_1 to +15 V. Circuit provides low output impedance.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 187–189.



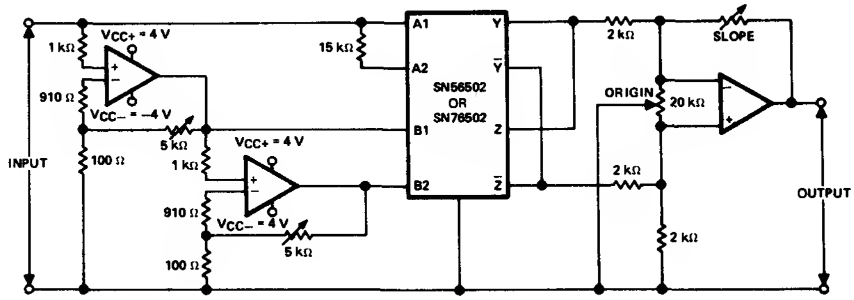
CLIPPING OPAMP—Simple circuit limits excursion of DC input voltage to level precisely equal to DC reference input voltage. When reference is 0 V, circuit can be used as half-wave rectifier up to 100 kHz. Feedback overcomes breakover characteristics of D_2, to provide sharp clipping at levels from millivolts to volts. At 10 kHz, with D_1 omitted, range of levels is 70 mVRMS to 7 VRMS. With D_1, circuit is useful at levels down to 0.3 VRMS at 100 kHz.—R. S. Burwen, Precision Clipper Operates from Millivolts to Volts, *EDN Magazine*, Dec. 1, 1972, p 57 and 59.

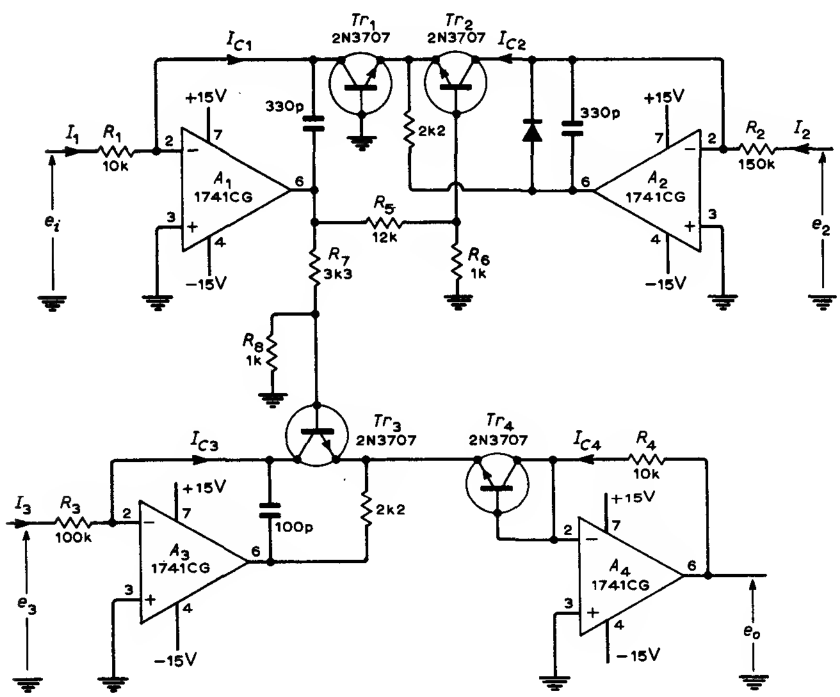
CHAPTER 46

Logarithmic Circuits

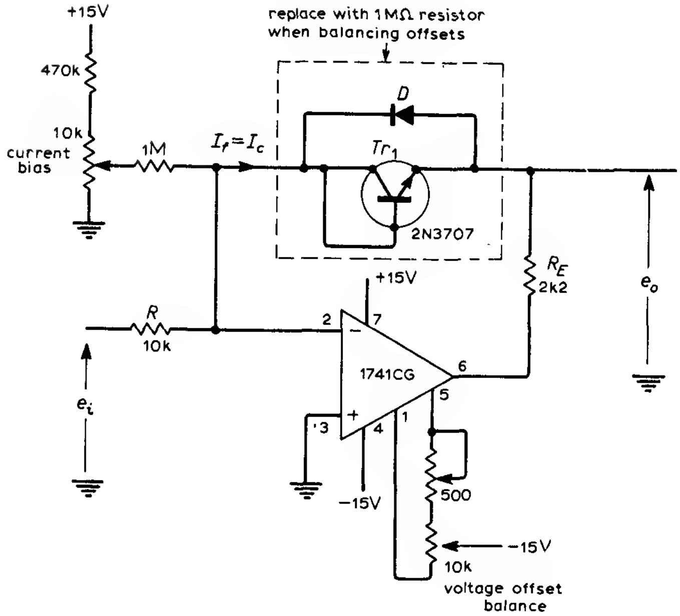
Combinations of logamps and opamps provide squaring, cubing, log, and antilog functions for analog signals, along with logarithm of ratio of two input values. Also includes logamp test circuit.

80-dBV INPUT RANGE—Logamp using Texas Instruments SN56502 or SN76502 in combination with three SN52741 opamps can handle input voltage range greater than 80 dB with respect to 1 V P-P. Inputs are limited by reducing supply voltages of input amplifiers to ±4 V. Gains of input amplifiers are adjusted to achieve smooth transitions.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 7-45.



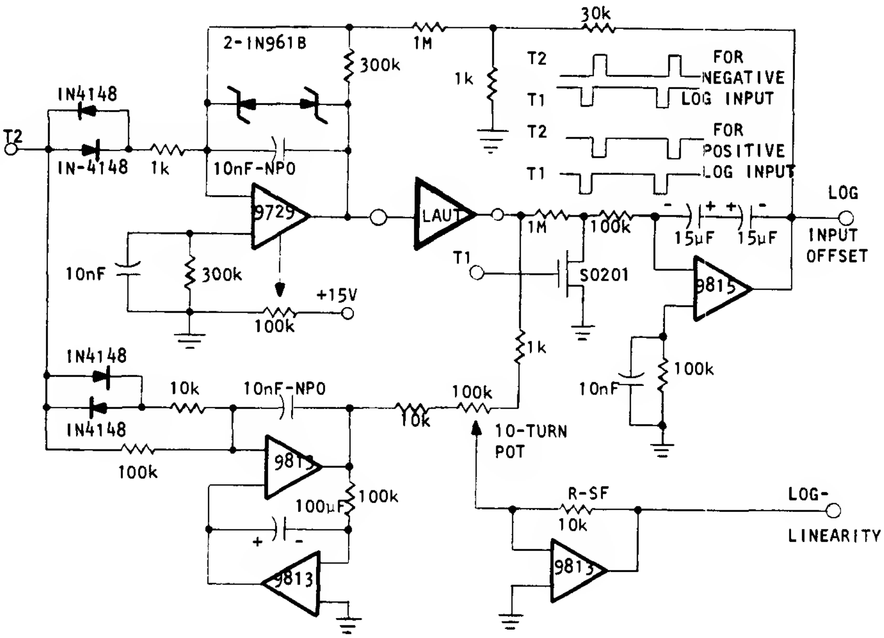


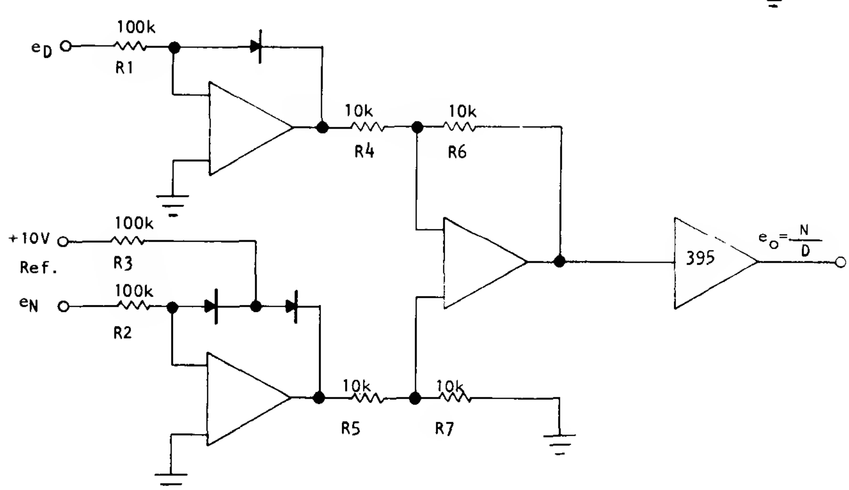
CUBE GENERATOR—Combination of temperature-compensated opamp log converter and antilog converter generates output signal a_o proportional to cube of input signal a_i. Article gives design equations.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Feb. 1973, p 91–93.



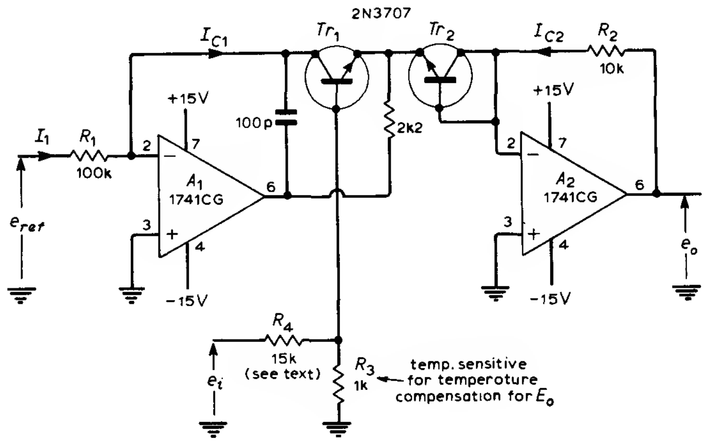
BASIC LOG CONVERTER—Suitable for positive input voltages. Negative feedback is applied to opamp through diode-connected transistor, with additional diode D protecting transistor from excessive inverse voltage caused by wrong input polarity. For negative inputs, reverse transistor and diode connections. Article gives design equations and application procedures.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World,* Jan. 1973, p 33–35.

LOGAMP TESTER—Circuit sweeps logamp under test (LAUT) over its dynamic range while automatically canceling offset voltage at input, with output serving as indication of this offset voltage. Exponential decay voltage generated is accurate from 10 V to 100 μV. At time zero, pulse T2 is applied to Optical Electronics 9729 opamp connected as exponential generator, charging NPO feedback capacitor to 10 V. At end of pulse, opamp output voltage decays exponentially. Input pulse also generates $\pm$10 V precision reference ramp in pair of 9813 opamps. Output of LAUT is compared with reference ramp; any difference is proportional to nonlinearity of logamp.—"Testing Logarithmic Amplifiers," Optical Electronics, Tucson, AZ, Tech Tip 10268.

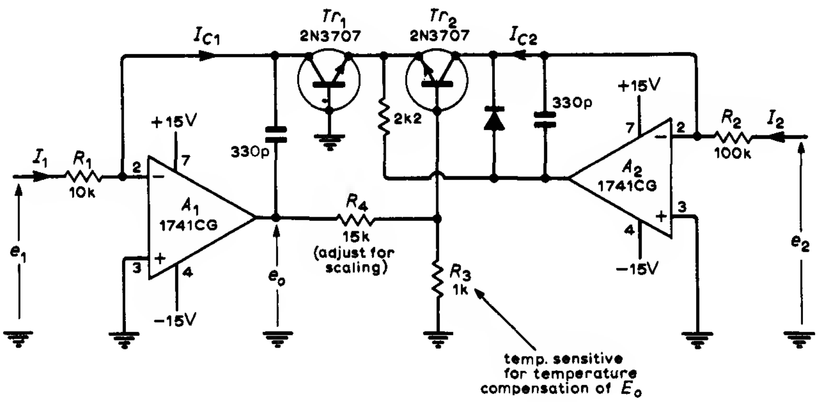




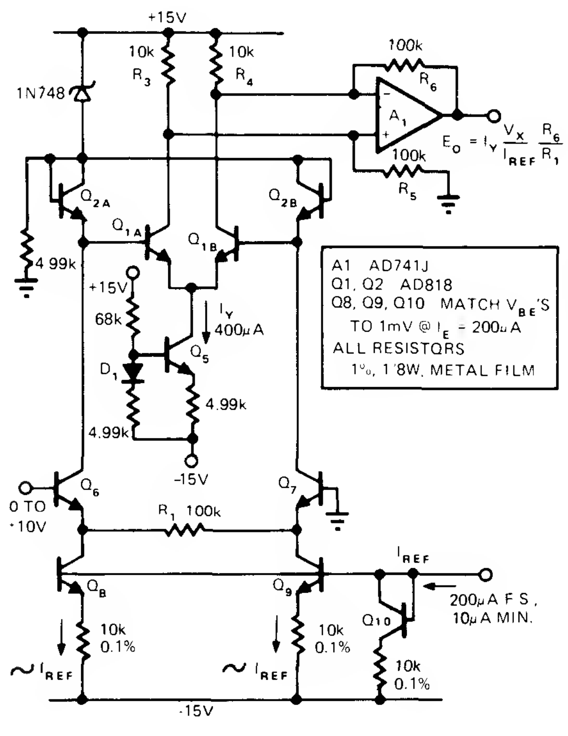
ANALOG DIVIDER—Optical Electronics 2457 logarithmic module containing two pair of bipolar log elements and three opamps drives single 395 opemp to provide analog division function with high accuracy and wide dynamic range. Input resistors set full-scale input voltage. R3 determines AC accuracy. Connect inputs together for drive with signal varying between 100 mV and 10 V (1% to 100% of full scale), and adjust R3 for straight-line output at 1 V. For negative inputs, reverse diode connections and make reference voltage negative.—"Accurate Logarithmic Analog Divider," Optical Electronics, Tucson, AZ, Application Tip 10213.



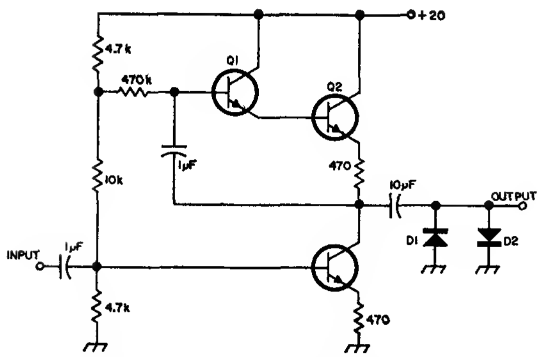
TEMPERATURE-COMPENSATED ANTILOG CONVERTER—Circuit provides antilog conversion with high degree of temperature compensation. Article gives design equations and application instructions. Circuit is for positive inputs; for negative inputs, use PNP transistors such as 2N4058 in place of those shown. Adjust value of R_4 to make output of opamp A_2 exactly 10 times input voltage e_i when input is −1 V.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Jan. 1973, p 33–35.



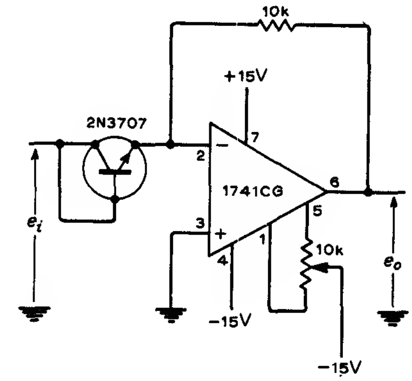
TEMPERATURE-COMPENSATED LOG CONVERTER—Two opamps and two logging transistors give output proportional to logarithm of input with high degree of temperature compensation. Article gives design equations and application instructions. Circuit is for positive inputs; for negative inputs, use PNP transistors such as 2N4058 in place of those shown.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Jan. 1973, p 33–35.



VARIABLE-TRANSCONDUCTANCE DIVIDER—Practical analog divider follows ideal division equation over typical 20:1 range of reference current and operates in two quadrants. Circuit is analyzed in terms of logarithmic behavior of its elements. Bandwidths up to 5 MHz can be achieved. Article gives design equations.—L. Counts and D. Sheingold, Analog Dividers: What Choice Do You Have?, *EDN Magazine*, May 5, 1974, p 55–61.

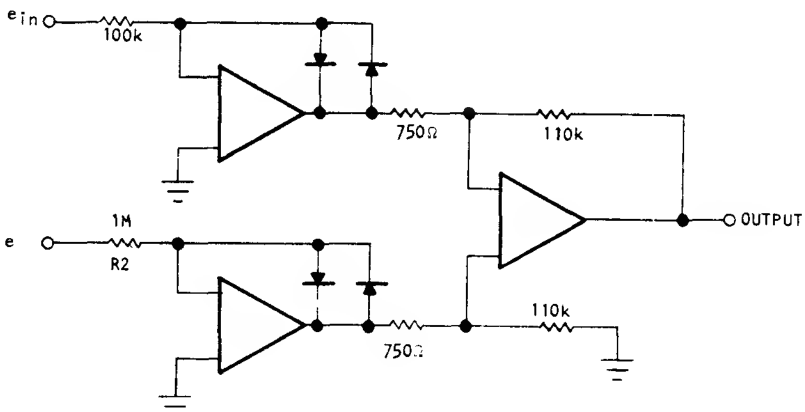


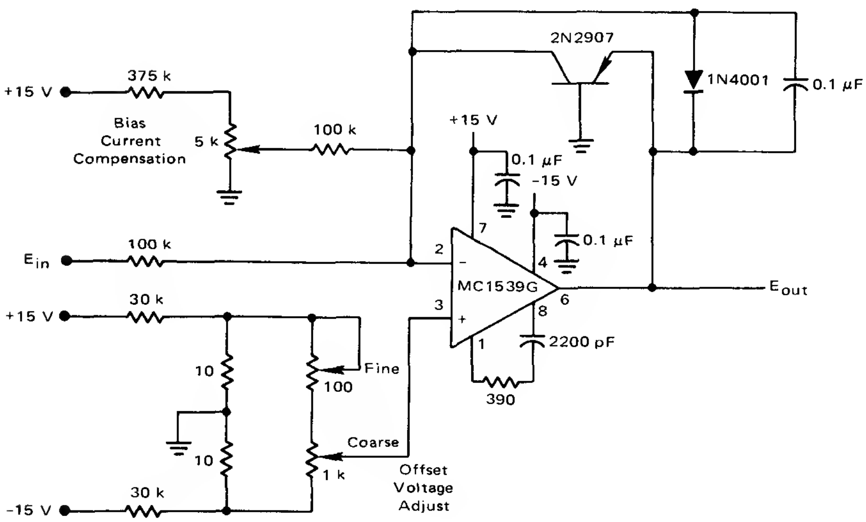
LOGAMP—Based on fact that back-to-back diodes driven by current generator give output that varies logarithmically with input signal. With values shown, relation is logarithmic over 60-dB range. Transistors are 2N2924, SK3019, GE-10, or HEP-54, and diodes are 1N914.—Circuits, *73 Magazine*, April 1974, p 34.



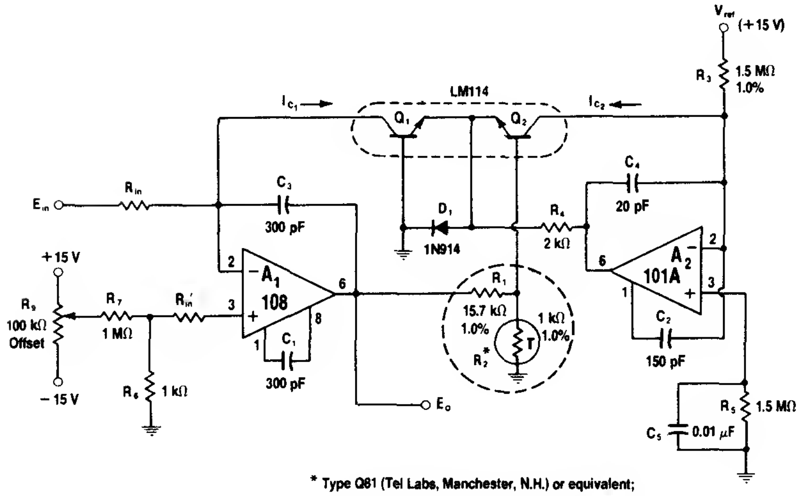
ANTILOG CONVERTER—Basic opamp circuit with diode-connected transistor as logging element performs antilog conversion for positive input signals. For negative inputs, reverse transistor connections.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Jan. 1973, p 33–35.

40-dB LOGAMP—Uses Optical Electronics 2457 logarithmic module containing two pairs of bipolar log elements and three opamps. Connection shown produces pure $\log_{10}$ function on positive inputs. Zero point is set by R2 or by reference a. Reference must be positive for positive logs and negative for negative logs. Trim 110K resistors for exactly 10-V output.—"Two-Decade Precision Logarithmic Amplifier," Optical Electronics, Tucson, AZ, Application Tip 10212.





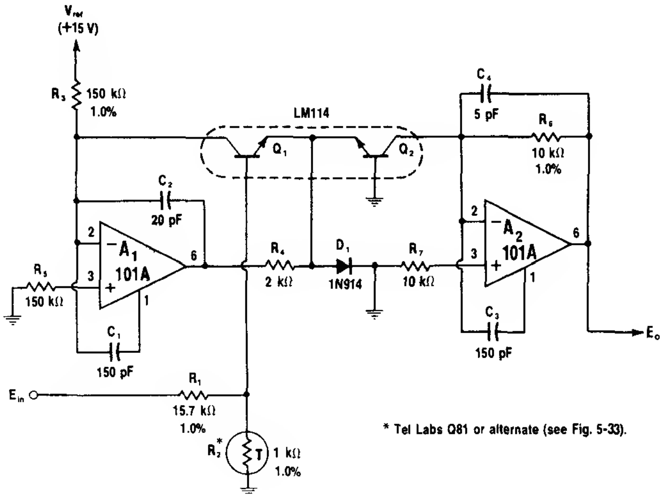
LOW-COST USING OPAMP—Motorola MC1539G opamp is connected with PNP transistor as logarithmic element. Circuit requires external compensation, has about 200-nA bias current, and accommodates wide range of input voltages when appropriate networks are used to compensate for errors. To adjust bias current initially, replace transistor with 500K resistor and adjust 5K pot for gain of 5 over input signal range.—K. Huehne, "Transistor Logarithmic Conversion Using an Integrated Operational Amplifier," Motorola, Phoenix, AZ, 1971, AN-261A, p 4.

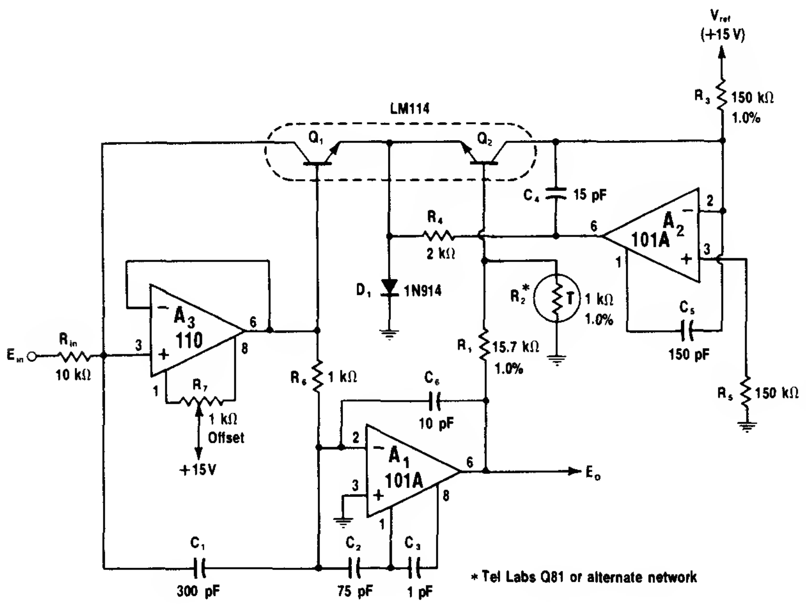


* Type Q81 (Tel Labs, Manchester, N.H.) or equivalent; TC = +0.3%/°C, accurate from −25 C to +100°C.

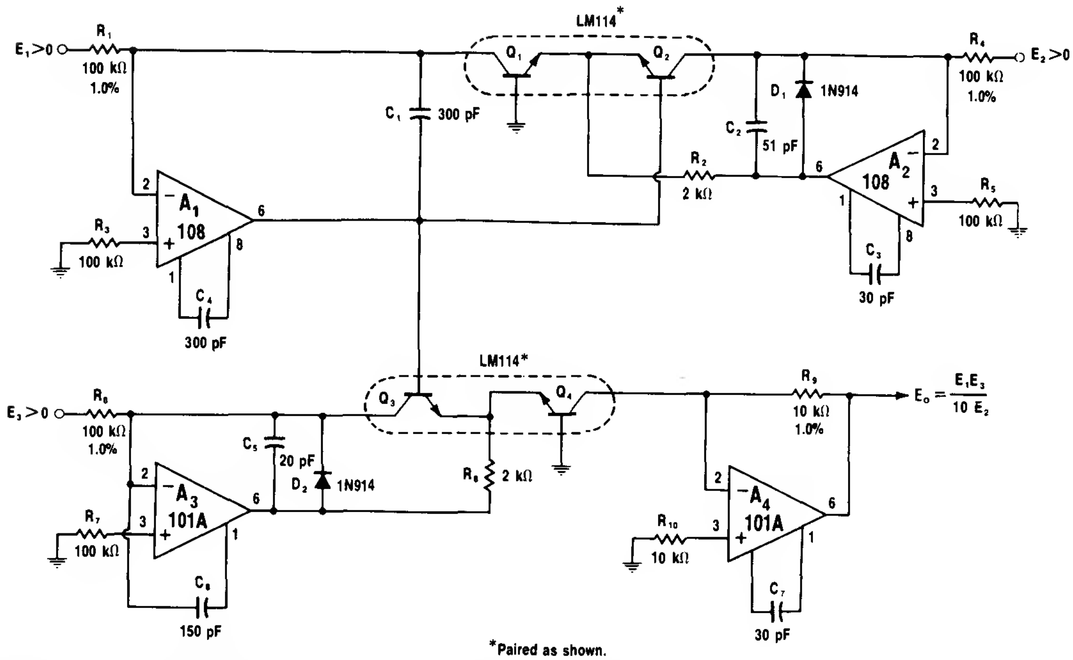
100-dB DYNAMIC RANGE—Circuit generates log ratio of currents I_{C1} and I_{C2} with accurecy within 3% from 10 nA to 1 mA (100-dB range) when I_{C2} is fixed at 10-μA reference velue. Accuracy increeses to 1% for current inputs between 40 nA and 400 μA (80 dB). A_2 supplies constant reference current to Q_2. Q_1 is operated as transdiode with Q_2 providing temperature compensation of offset voltage.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 213–214.

ANTILOG GENERATOR—Basic log genarator circuit is reerranged to perform inverse operation of antilog (exponential) generation. Exponantial current generated by Q_2 is summad at current-to-voltage converter A_2. Q_1 voltage drive to Q_2 is such that collector current of Q_2 is exponantlelly relatad to voltage at base of Q_1. Temperature-compensating divider scales input sensitivity to 1 V per decade. Feed-forward connections at A_1 and A_2 optimize circuit for speed.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sems, Indianapolis, IN, 1974, p 214–216.

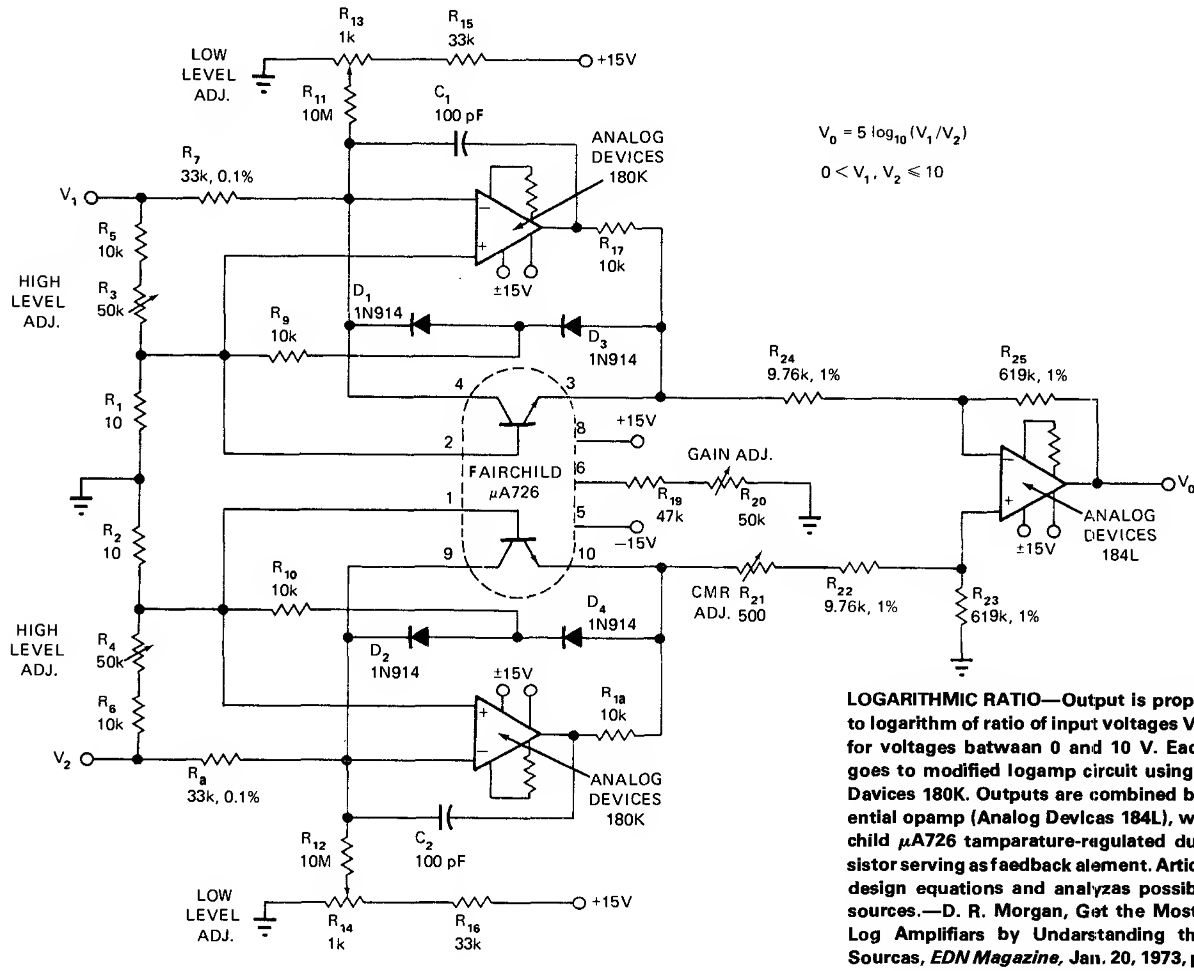




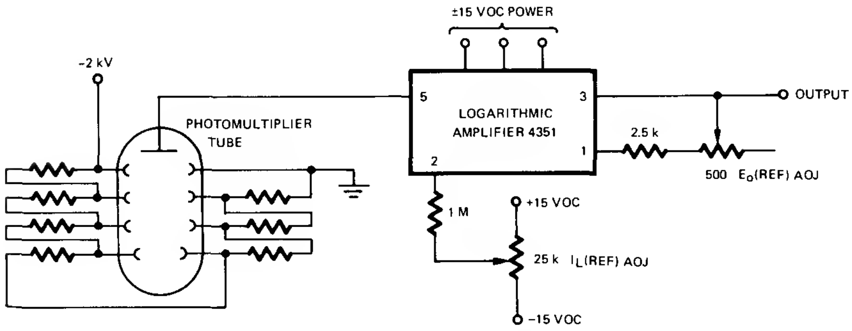
FAST LOG GENERATOR—Circuit is designad for sattling time of only 10 μs. Voltage-follower opamp A_3 buffars base current of Q_1 and input current to A_1, allowing Q_1 to operate as diode whila demanding minimum input current to A_3. Scale factor is 1 V per decade. Zero-crossovar point of output swing is controlled by R_3. Accurecy is 1% for logging range of 100 nA to 1 mA.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 214–215.



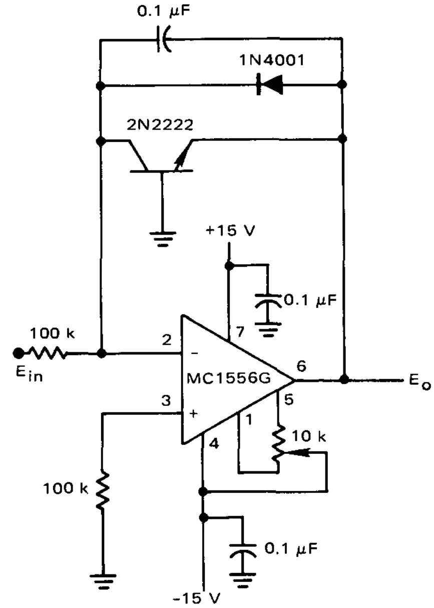
MULTIPLIER/DIVIDER—Upper half of circuit is log convartar in which output at A_1 is logarithmic ratio of E_1 and E_2. A_3 and Q_3 form second log convarter for E_3 input. Log output of sacond convertar is added to that of upper circuit, producing log (E_1E_3/E_2) at emittar of Q_4. Q_4 and A_4 take antilog to giva final output aqual to $E_1E_3/10E_2$. If only multiplication is desired, E_2 can be reference voltaga; R_4 will than establish reference current.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 216–217.



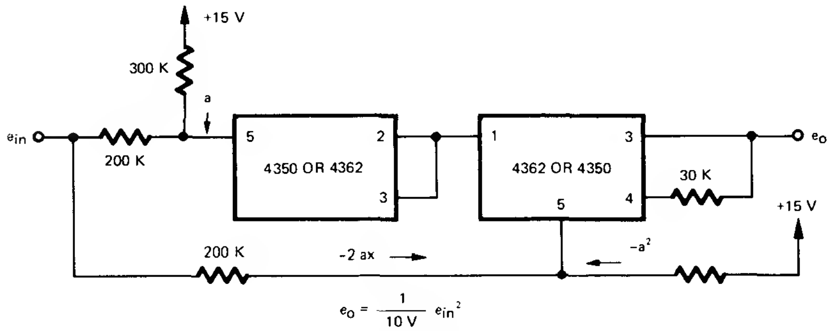
LOGARITHMIC RATIO—Output is proportional to logarithm of ratio of input voltages V_1 and V_2 for voltages batwaan 0 and 10 V. Each input goes to modified logamp circuit using Analog Davices 180K. Outputs are combined by differential opamp (Analog Devlcas 184L), with Fairchild μA726 tamparature-ragulated dual transistor serving as faedback alement. Article givas design equations and analyzas possibla arror sources.—D. R. Morgan, Gat the Most Out of Log Amplifiars by Undarstanding tha Error Sourcas, *EDN Magazine,* Jan. 20, 1973, p 52–55.



RECORDING PHOTOMULTIPLIER OUTPUT—Wide range of output data from photomultiplier is fed through Taledyna Philbrick 4351 logarithmic amplifiar for compression of data to ranga of ±5 VDC for faed to tapa racorder. Raport covars calibration procedura for obtaining overall accuracy of ±2 dB.—"How to Spacify Parametars of Nonlinear Circuits," Taladyne Philbrick, Dedham, MA, 1974, AN-15, p 4.



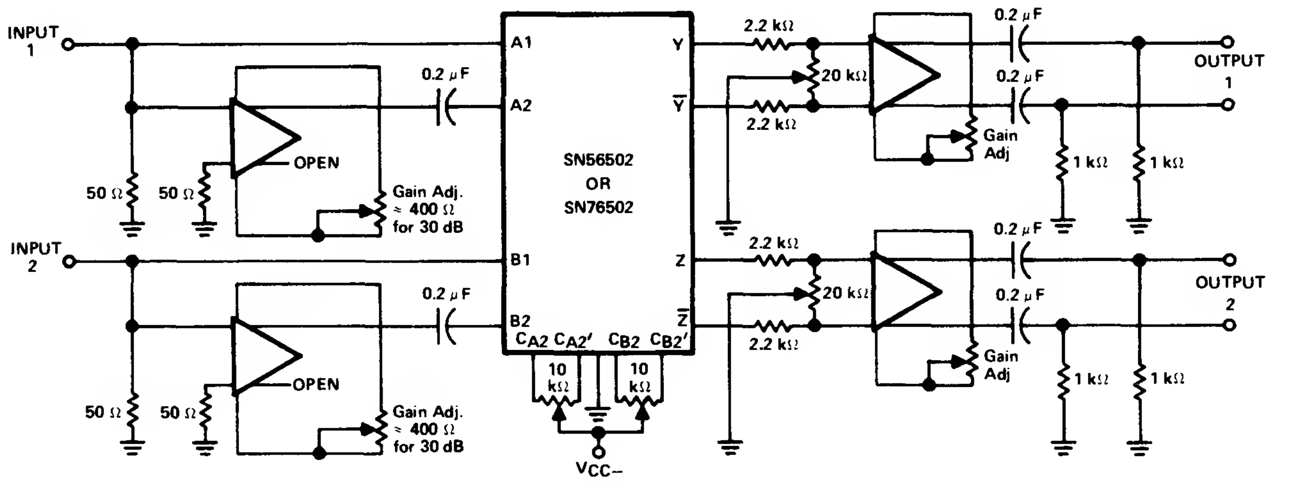
LOGAMP WITH OFFSET ADJUSTMENT—Motorola MC1556G opamp providas accurate oparation down to millivolt input levels without bias currant compansation. Input offset is adjusted with 10K pot. 0.1-μF capacitor is raquired across feedback transistor to raduce AC gain. Diode protects transistor from polarity reversal of input voltage. Power supplies should ba bypassed as close as possible to amplifier socket. Positive input voltaga gives nagative output voltaga. IC includes output short-circuit protaction.—K. Huehne, "Transistor Logarithmic Conversion Using an Integrated Operational Amplifiar," Motorola, Phoenix, AZ, 1971, AN-261A, p 3.



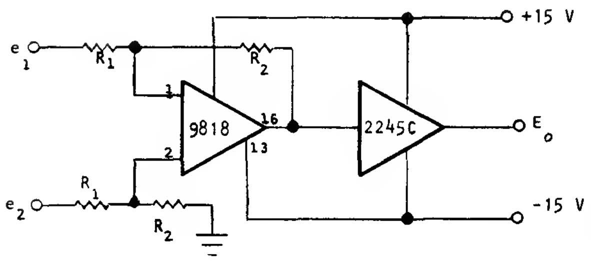
$$e_o = \frac{1}{10\ V} e_{in}^2$$

NOTE: TO OBTAIN NEGATIVE OUTPUT VOLTAGE USE TWO 4351'S AND THE -15 V SUPPLY.

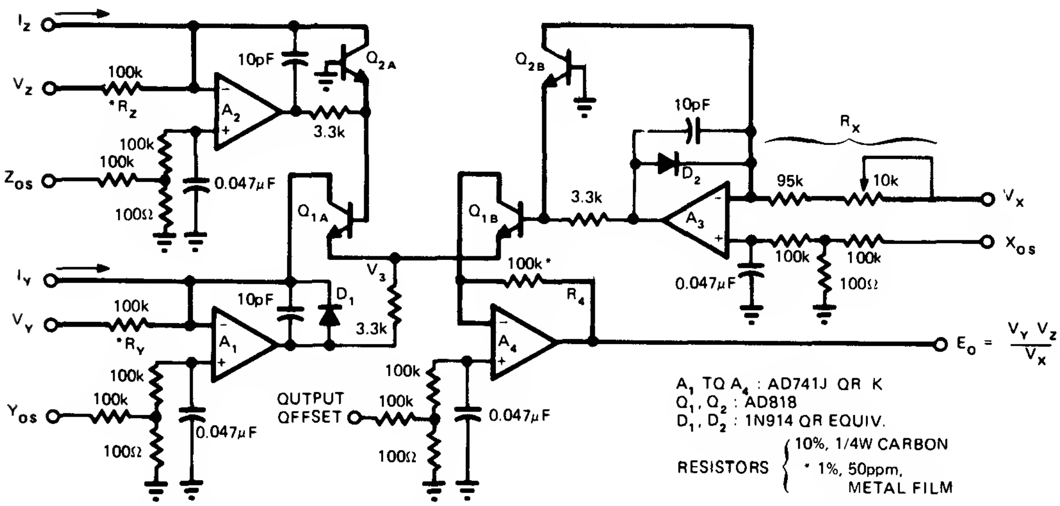
TWO-QUADRANT SQUARING—Taledyne Philbrick log modules ara used in simpla two-quadrant squarer in which input is offset becausa modules accept only one polarity. Circuit shown providas positive output voltage.—"Applications for Models 4350/4351 & 4362/4363 Logarithmic Amplifiars," Taledyna Philbrick, Dadham, MA, 1974, AN-14.



10-MHz DUAL-CHANNEL LOGAMP—Circuit using Texas Instrumants SN56502 or SN76502 in combination with four SN52741 opamps will handla 50-dB input range per channel at all fraquancias up to 10 MHz. Suitabla for data compression, analog computation, radar and infrared detection systems, and weapons systems. Differential output voltaga levels ara generally laas than 0.6 V. Output swing and slope of output response ara adjusted by varying gain in each channal. Coordinate origin ia adjusted with offsat pots of output buffars.—"Tha Linear and Intarface Circuits Data Book for Design Enginears," Texas Inatrumants, Dallas, TX, 1973, p 7-46.



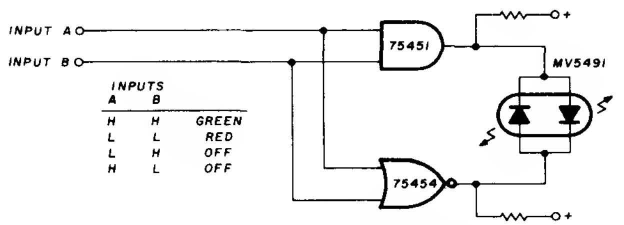
DIFFERENTIAL LOGARITHM—Optical Electronics 9818 opamp and 2245C logamp together give logarithm of differential input voltage or current. Combined transfer function is $E_0 = K \log (R_2/R_1)(e_2 - e_1)$. R_1 can be zero for differential input current circuit. For unity-gain preamp, R_1 and R_2 should be 10K. For 1-V full-scale input, use 10K for R_1 and 100K for R_2. For 100-mV full-scale input, use 10K for R_1 and 1 megohm for R_2.—"How to Obtain a Differential Logarithm," Optical Electronics, Tucson, AZ, Application Tip 10126.



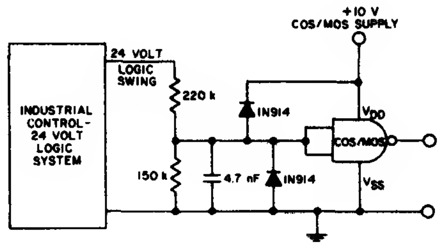
LOG-ANTILOG DIVIDER—Can be used in applications where both numerator and denominator are restricted to single polarity (to one quadrant). Input variables X, Y, and Z are applied to three independent transdiode log amplifiers (A_1-Q_{1A}, A_2-Q_{2A}, and A_3-Q_{2B}). Outputs of logamps are proportional to logarithms of input variables. R_4 in feedback circuit of A_4 converts collector current of Q_{1B} to output voltage proportional to V_ZV_Y/V_X. Circuit performs multiplication and division simultaneously and with equal accuracy. Overall nonlinearity can be as low as 0.05%. Article gives design equations.—L. Counts and D. Sheingold, Analog Dividers: What Choice Do You Have?, *EDN Magazine*, May 5, 1974, p 55–61.

CHAPTER 47
Logic Circuits

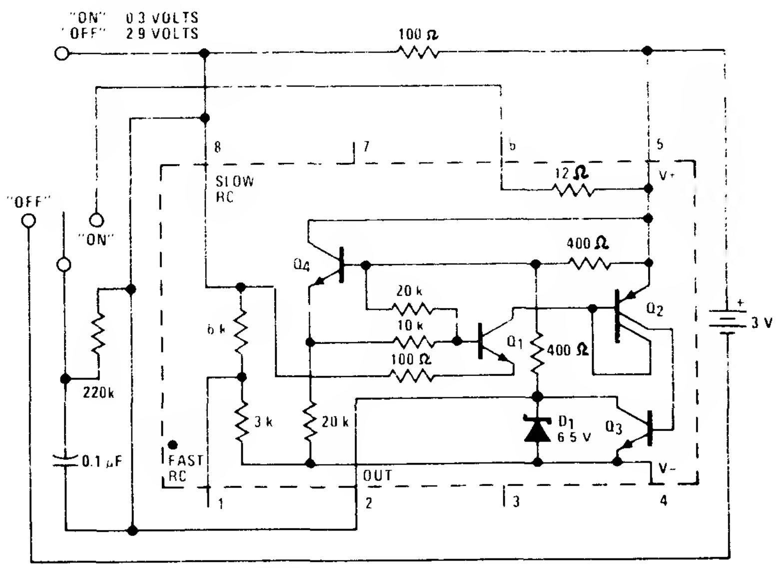
Includes interfaces for different types of logic, along with gates, Schmitt triggers, and other types of logic circuits that are responsive to sudden or gradual changes in input logic levels. Also covered are pulse sequence, pulse coincidence, and pulse-width detectors, along with pulse memories. See also Logic Probe, Memory, Microprocessor, and Operational Amplifier chapters.



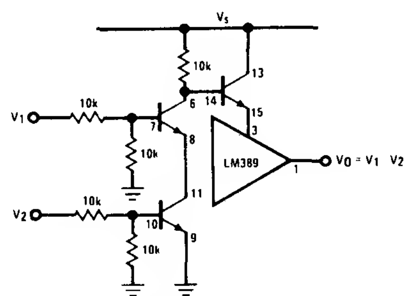
COINCIDENCE DETECTOR—If inputs A and B are both high, indication will be green. If A and B are both low, indication will be red. If inputs are out of phesa, so one is high and the other low, indicator will be off. Suiteble for monitoring complex logic circuits. Uses Monsanto MV5491 dual red/graan LED, with 220 ohms in upper lead to +5 V supply end 100 ohms in lower +5 V lead because red end graan LEDs in parallel back-to-back heva diffarant voltege requiremants. Drivers ere SN75451 and SN75454.—K. Powell, Noval Indicetor Circuit, *Ham Radio,* April 1977, p 60–63.



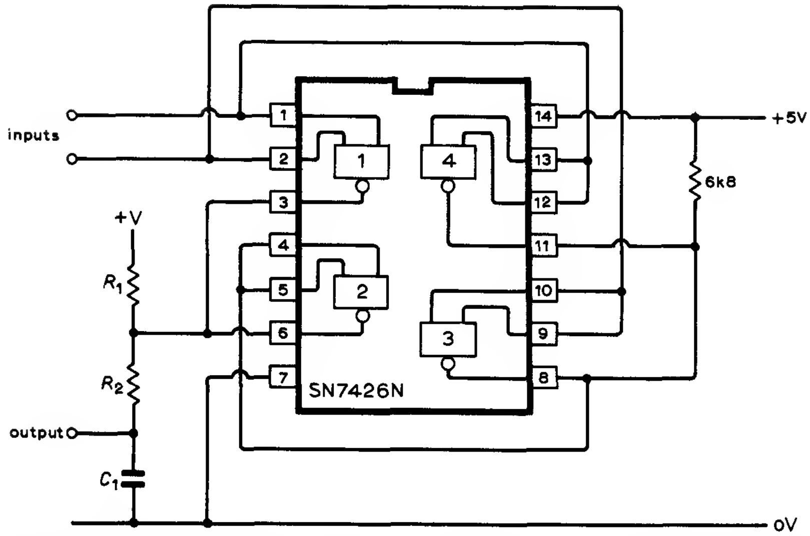
INTERFACE FOR INDUSTRIAL CONTROL—Simple resistive divider circuit provides Interfece batween 24-V logic swing of industrial control systam and CMOS logic oparating from 10-V supply. Filtar capacitor enhancas excellent noisa immunity of CMOS logic. Clamp diodes ansure that input signal voltage is batwaen V_{DD} and V_{SS}.—"COS/MOS Intagratad Circuits," RCA Solid State Division, Somervilla, NJ, 1977, p 628.



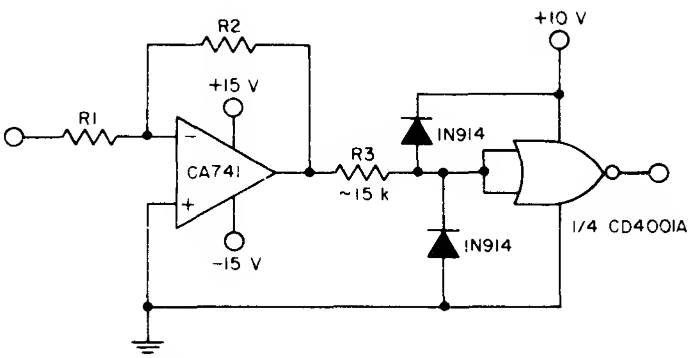
LATCH—National LM3909 IC oparating from 3-V battery requires only momentary contact by switch to changa logic laval of output and hold that level.—"Linear Applications, Vol. 2," National Samiconductor, Sante Clara, CA, 1976, AN-154, p 9.



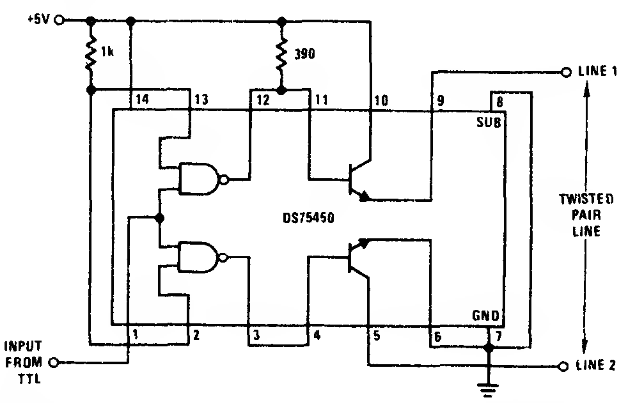
AND LOGIC FOR MUTING—Connection shown for National LM389 combinetion of three transistors with opamp gives standerd AND circuit for controlling muting transistor in audio systam. Shorting pin 12 of opamp to ground givas NAND logic.—"Audio Handbook," Nationel Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.



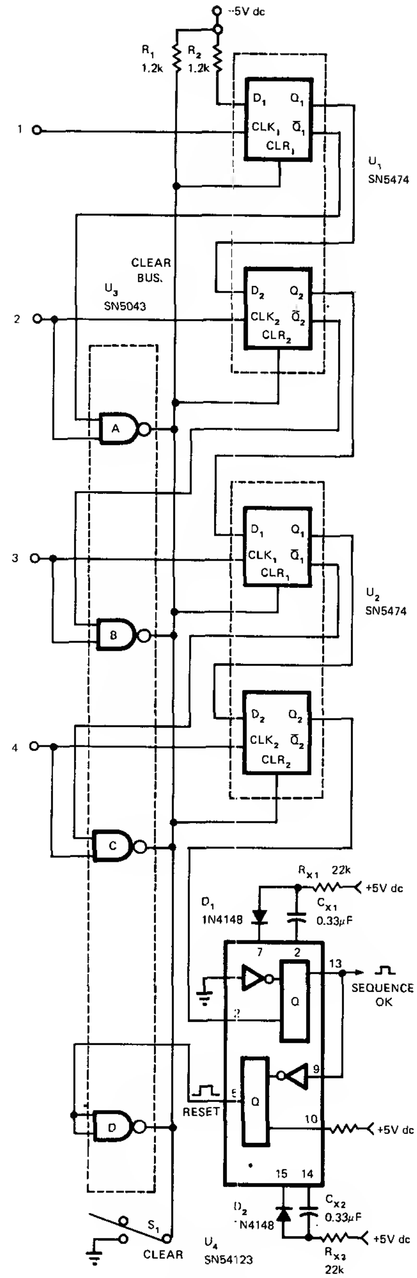
PHASE-SENSITIVE DETECTOR—Uaes quadruple two-input NAND-gete IC with minimum of external components. DC output level is absolutely lineer with phase differenca at inputs, meking circuit suitable for phase-locked loops end phasa-shift keyed demodulation. Output is rectanguler weve whose merk-space retio is proportionel to phase difference between input square waves. This output ia applied to low-pass filter R_2-C_1 having values chosen to suit operating frequency end required output resistence. R_1 is chosan to give required output awing up to maximum of 15 V.—R. A. Herrold, Inexpensive P.S.D., *Wireless World,* Jan. 1973, p 32.



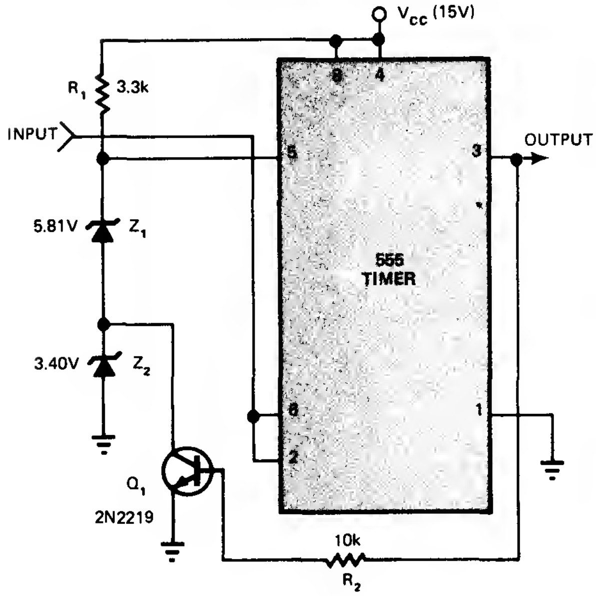
CMOS INTERFACE FOR OPAMP—Clemp diodes end single resistor provide interfece between CMOS circuit and opemp operating between normel ±15 V aupply reils. Diodea ensure thet CMOS input voltage does not go outside permissible range.—"COS/MOS Integrated Circuits," RCA Solid State Division, Somervilla, NJ, 1977, p 629.



BALANCED LINE DRIVER—Netional DS75450 dual paripheral drivar aerves as interface between TTL and twisted-peir line. Output line 1 ia terminated to ground through helf of lina impedance, end line 2 is terminated to +5 V through half of line impedanca. Output current is 300 mA.—"Interfece Databook," Netional Semiconductor, Santa Clare, CA, 1978, p 3-20–3-30.

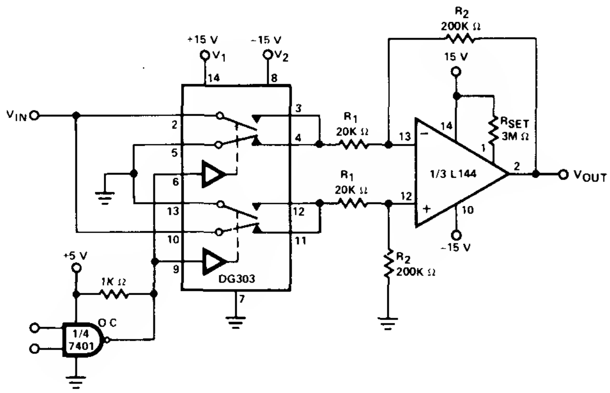


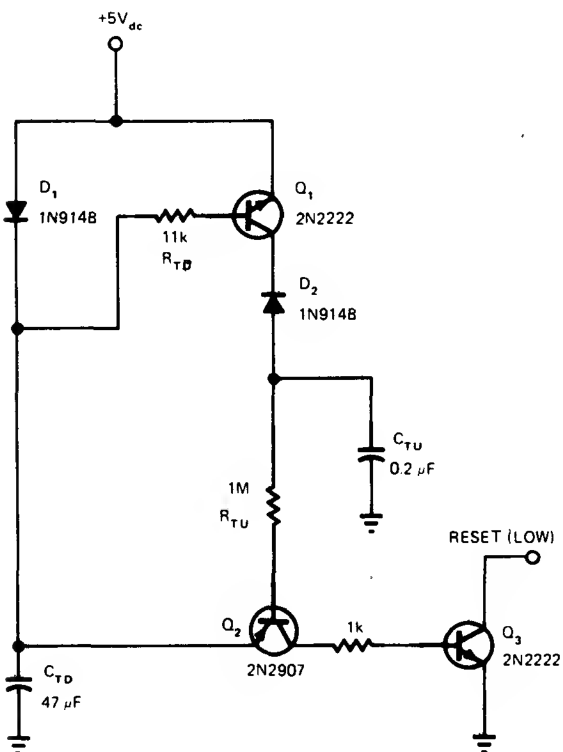
SEQUENCE DETECTOR—Ganeretes output pulse if, end only if, aequence of input pulses is in prescribed order. Any other sequence inhibits output pulse and cleers circuit at instent of first out-of-order pulse. Circuit elso cleers itself at end of correct sequence, by generating sequence-OK pulse. Developed for usa in control systems, electronic combination locks, and eny other applications requiring sequence of pulses. To detect more than 4 bits in sequence, NAND gates and flip-flops cen be added. If TTL input pulses occur in correct T_1-T_2-T_3-T_4 order, 1 state at U_1D_1 will propagate down chain of D flip-flops until U_2Q_2 output is reechad. Simultaneoualy, 0 is propegated in similar menner to hold cleer bus at 1. Article traces circuit operetion in detail.—M. J. Gellagher, Salf-Clearing Digital Sequence Detector, *EDN Magazine,* April 5, 1973, p 88–89.



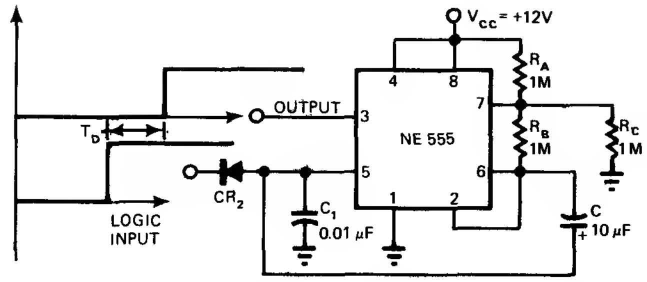
VARIABLE-HYSTERESIS SCHMITT—Uses stendard 555 timer with only five additionel components to give fully TTL/DTL-compatible Schmitt trigger thet responds to slow input remps es well es streight DC levels. When input is 0, output goes high end turns on Q_1. When input increeses to 5.8 V, output goes low end Q_1 turns off. Decreesing output to 4.7 V (lower threshold point) mekes output high egein. For velues shown, hysteresis is thus 1.1 V. Threshold points end hysteresis velue cen be edjusted es required by chenging zeners used.—M. K. Lalithe end P. R. Chetty, Veriable-Threshold Schmitt Trigger Uses 555 Timer, *EDN Magazine*, Sept. 20, 1976, p 112 end 114.

POLARITY REVERSER—Logic input controls operetion of DG303 low-power enelog switch providing polerity reversel for output of opemp. Low input logic gives noninverting operetion beceuse input signal then goes to pin 12 of opemp.—"Anelog Switches end Their Applicetions," Siliconix, Sente Clere, CA, 1976, p 7-91.

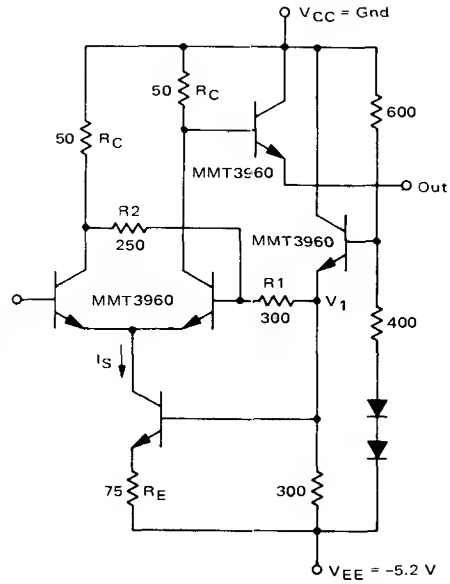




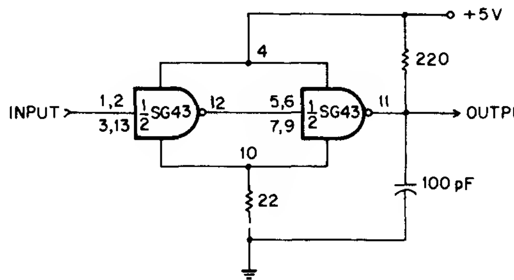
POWER-UP/POWER-DOWN RESET—Output of circuit goes high et end of time intervel $R_{TU}C_{TU}$ required for charging of C_{TU} by epplied 5-VDC input signel. When 5-V power feils, Q_1 drives Q_2 end Q_3 off, meking output low for time intervel determined by $R_{TD}C_{TD}$. When C_{TD} is discharged, output goes high egein. Interruption of power thus produces negetive-going pulse heving verieble width determined by velues chosen for resistors end capecitors.—S. Rummel, Reset Circuit Detects Power Drop-Out, *EDN Magazine*, Mey 20, 1976, p 94.



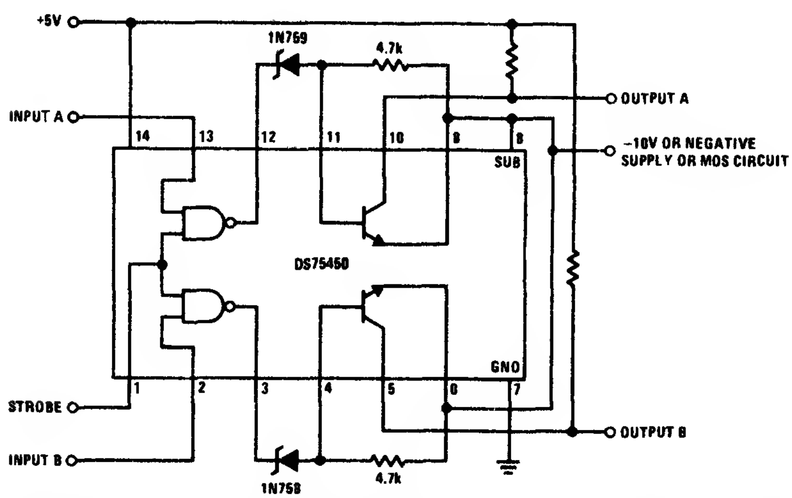
TIME-DELAY SWITCH—Oscillator connection shown for 555 timer provides delay for switching action controlled by logic input. When logic input is 0 V, timer output is low. When logic input goes high, output remains low for delay of $0.693R_BC$ s and than switches high. Output remains high ss long as input is high.—K. D. Dighe, Resrranged Components Cut 555's Initial-Pulse Errors, *EDN Megazine,* Jsn. 5, 1978, p 82 snd 84.



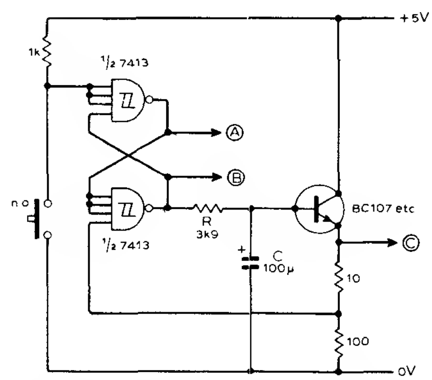
CURRENT-MODE SCHMITT TRIGGER—Motorols MMT3960 transistor arrsy is connected as differential smplifier with feedbsck to produce Schmitt trigger hsving input hysteresis of 500 mV. Smsll rise snd fall times mske circuit suitsble for driving flip-flop over wide rsnge of frequencies.—B. Broeker, "Micro-T Packaged Trsnsistors for High Speed Logic Systems," Motorola, Phoenix, AZ, 1974, AN-536, p 6.



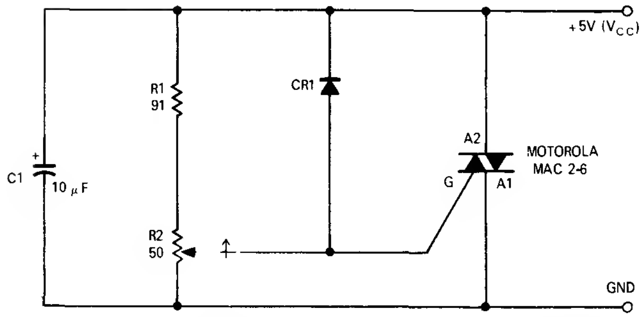
TWO-GATE SCHMITT—TTL inverter gates are connected in series, with small feedbsck resistor in common ground lead, so gates sre slways in opposing logic states. Resulting constant voltage drop scross 22-ohm resistor produces constant offset voltsge that is corrected by 220-ohm resistor at output terminal. With vslues shown, positive-going threshold Is 2.4 V and negstive-going threshold is 2 V.—C. J. Ulrick, Schmitt Trigger Uses Two Logic Gates, *EEE Magezine,* Dec. 1970, p 54.



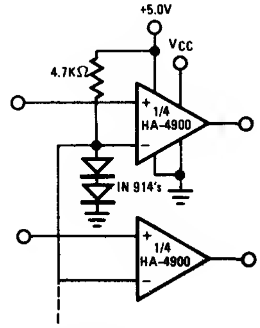
TTL-TO-MOS DRIVER—Uses Nationsl DS75450 dual pariphersl drivar hsving 300-mA output current capability to provide high-speed switching while providing compatibilty between different logic types. Operates from single 5-V supply.—"Interfsca Databook," Netional Semiconductor, Ssnta Clsra, CA, 1978, p 3-20–3-30.



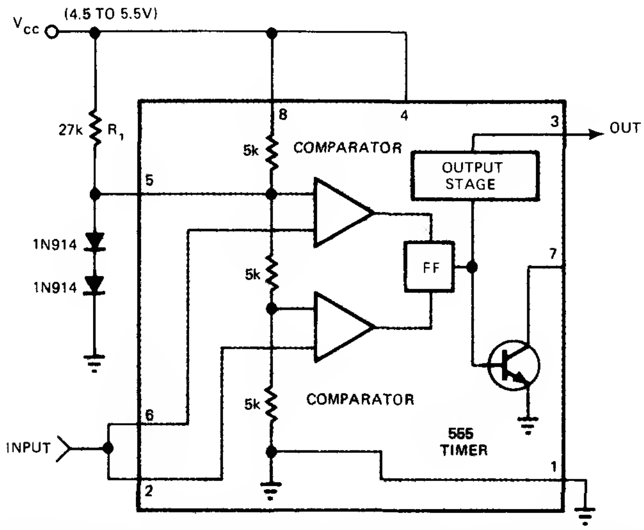
PULSE-COMPLETING SCHMITT—Hslf of 7413 dual four-input NAND Schmitt trigger forms RS bistsble which ensures thst cycle is completed after switch is opened. Low-impedance exponentisl sawtooth output is produced st point C. Point A is high when oscillator is running and can be used as control signal.—T. P. Hopkins, Improved Schmitt Triggar Oscillator, *Wireless World,* Jsn. 1978, p 58.



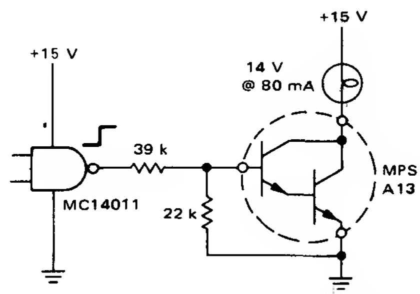
LOGIC PROTECTOR—Simple bidirectional triac crowbar can be set so positive voltages above 6 V and negative voltages greater than 1.5 V cannot reach digital logic. Article covers initial adjustment of R2.—D. L. Sporre, Bidirectional Crowbar Protects Logic, *EDN Magazine*, Dec. 15, 1970, p 37.



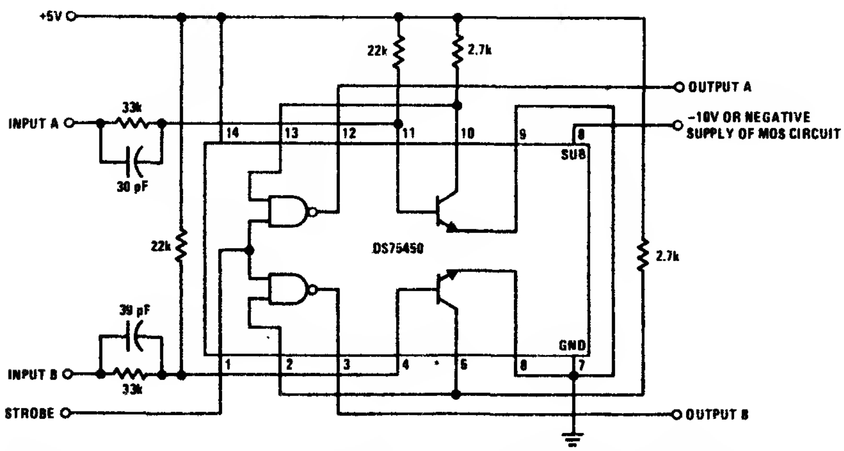
TTL-TO-CMOS TRANSLATOR—Two sections of Harris HA-4900/4905 precision quad comparator provide interface between TTL drive and CMOS output circuits. Supply is ±15 V.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 2-95.



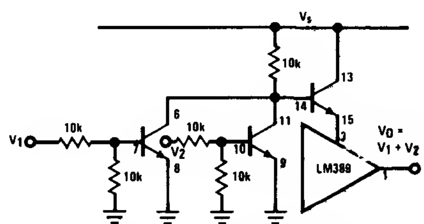
SCHMITT FROM 555 TIMER—Only three additional parts need be added to standard 555 timer to give fully TTL/DTL-compatible Schmitt trigger that responds to slow input ramps as well as straight DC levels. With output initially high, increasing input from 0 to about 1.35 V drives output low. Conversely, input can decrease to about 0.7 V before output goes high again.—M. K. Lelithe and P. R. Chetty, Variable-Threshold Schmitt Trigger Uses 555 Timer, *EDN Magazine*, Sept. 20, 1976, p 112 and 114.



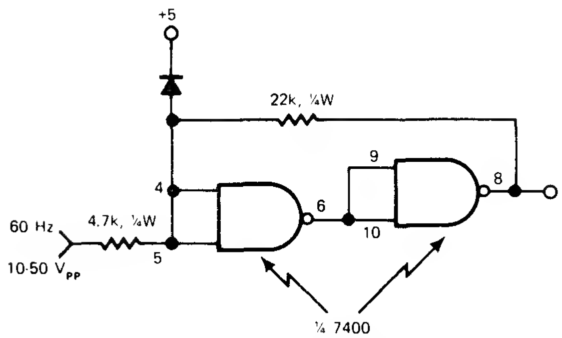
HIGH-LEVEL ACTIVATION BY CMOS—High output of typical CMOS gate drives complementary MPS-A13 Darlington transistor having 80-mA lamp load.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 11.

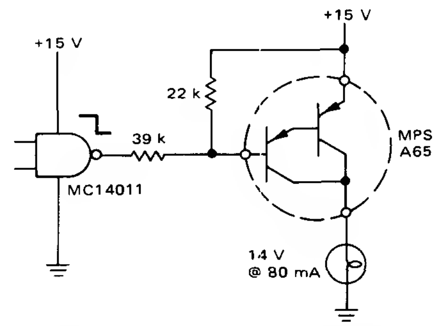


MOS-TO-TTL DRIVER—National DS75450 dual peripheral driver serves as interface between different logic types while providing high-speed switching and 300-mA output current per section. Requires only single 5-V supply.—"Interface Databook," National Semiconductor, Santa Clara, CA, 1978, p 3-20–3-30.



OR LOGIC FOR MUTING—Connection shown for National LM389 combination of three transistors with opamp gives standard OR circuit for controlling muting transistor in audio system. Shorting pin 12 of opamp to ground gives NOR logic.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.

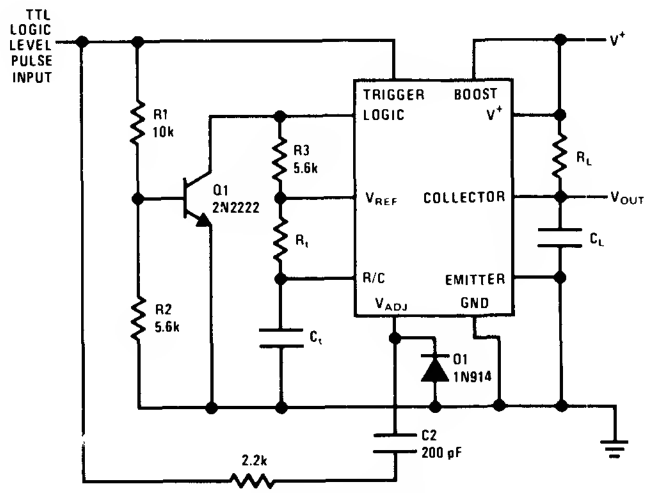




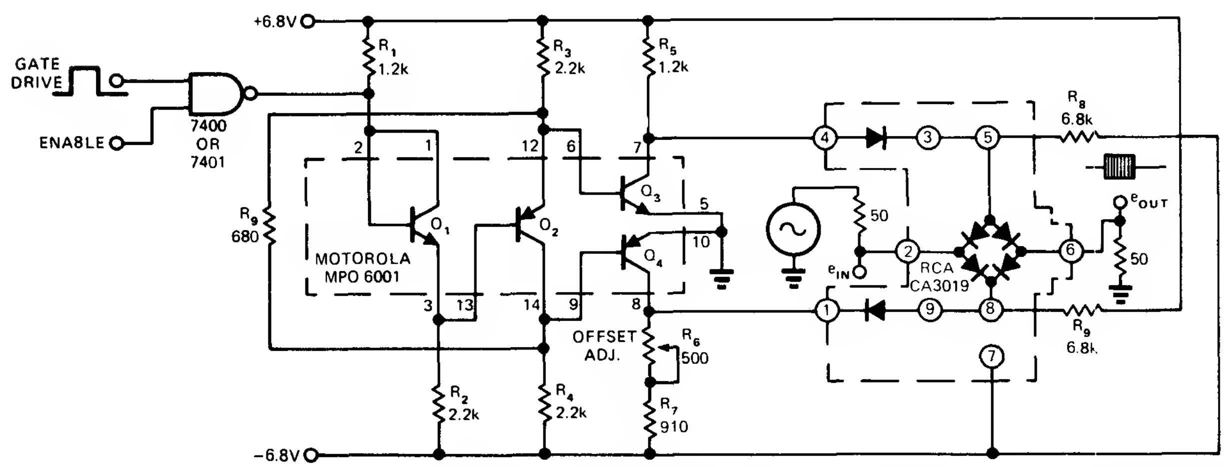
SCHMITT USING 7400 GATES—Uaes two sections of 7400 quad NAND gate. Will accept input volteges of 10–50 V P-P with values shown, but cen uae line voltage directly if input resistor is 22K and feedback resistor is 220K. Diode in DC supply limits poaitive-going input to 5.7 V for protection of input circuit. Used aa interface between 60-Hz line and frequency divider having TTL logic, when 1-s time base is required for timing applications.—W. A. Palm, Connect a 7400 Gate as a Schmitt Trigger, *EDN Magazine,* Aug. 20, 1976, p 84.

LOW-LEVEL ACTIVATION BY CMOS—Typical CMOS gate interfaces directly with small-signal Darlington transiator driving 80-mA lamp load.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 11.

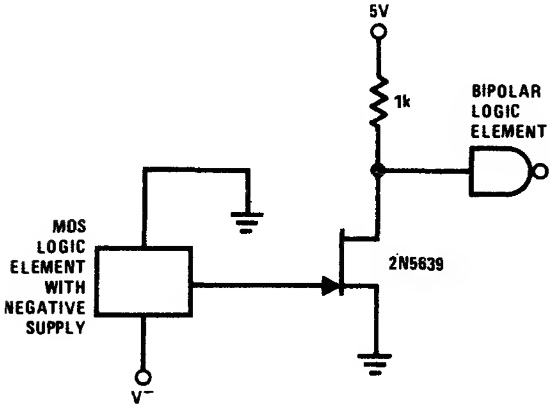
PULSE-WIDTH DETECTOR—Logic terminal of National LM122 timer is driven simultaneously with trigger input to give high-accuracy pulse-width detector. Output changes state only when trigger input stays high for longer than time period set by R_t end C_t; resulting output pulse width is then equal to input trigger width minus R_tC_t. C_L filtera out narrow spikes that would occur at output due to intervel deleys during switching. Supply can range from 4.5 to 40 V.—C. Nelson, "Versatile Timer Operetes from Microseconds to Hours," Nationel Semiconductor, Santa Clara, CA, 1973, AN-97, p 9.



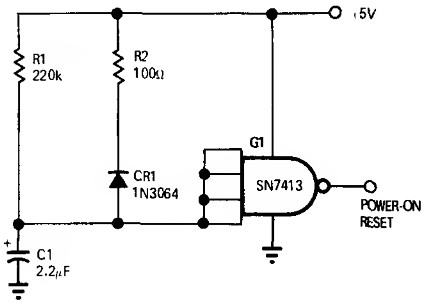
*V_{OUT} = 0 FOR W < R_t C_t
PULSE OUT = W − R_t C_t FOR W > R_t C_t



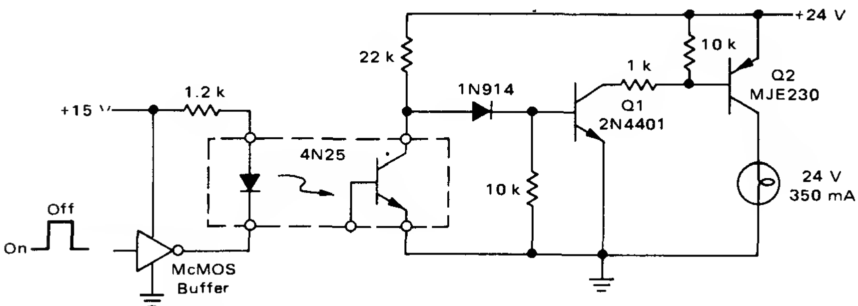
TTL INTERFACE—Motorola MPQ 6001 quad complementary-pair transistor IC serves as interfece between TTL gate and diode bridge used as signel gate. Propagation delay from leading edge of gate drive pulse until bridge gate opens is 30 ns, with negligible delay between complementary outputs. Used in providing low-level burst of input aignal when making response time measurement.—R. W. Hilsher, Universal Interface: TTL to Diode Array, *EDN Magazine,* March 5, 1975, p 74 and 76.



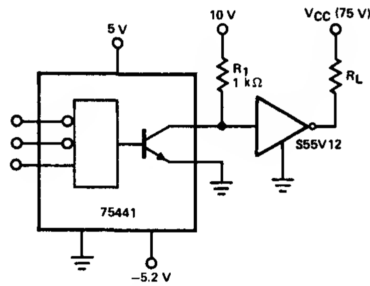
LEVEL AND POLARITY SHIFTER—Simple FET circuit provides for level shifting from MOS logic elemant having negative supply to TTL or othar bipolar logic laval operating from positiva supply and ground. Transistor hes fast switching time.—"FET Databook," National Semiconductor, Santa Clars, CA, 1977, p 6-26–6-36.



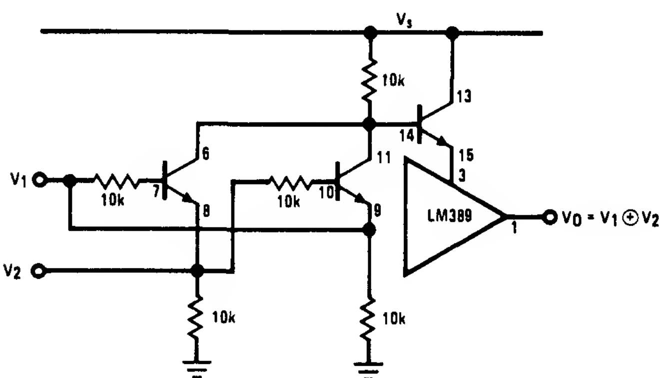
POWER-ON RESET—Ona Schmitt trigger end thrae discrete components ensure correct initisl state of logic circuits when power is epplled. During cherge time of C1, output of gete G1 Is high. Whan C1 raachas 1.5 V, gate output goes low and terminatas powar-on reset.—R. C. Snydar, Single-Voltage Circuit Generetes "Powar-On" Raset Pulse, *EDN/IEEE Magazine*, Jan. 1, 1972, p 72.



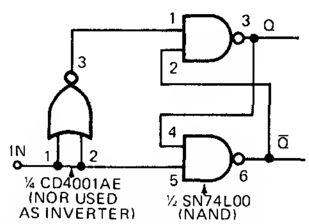
CMOS INTERFACE USING OPTOISOLATOR—Provides logic control of 350-mA lamp. High level on input of typical CMOS inverter energizes 4N25 optoisolator, to clamp Q1 off. This removes drive from Q2, deenergizing loed. Logic 0 at input reverses conditions, turning on lamp. With values shown, 10 mA at optoisolator input controls completely isoleted 350-mA load.—A. Pshaenich, "Interface Techniques Between Industrial Logic end Powar Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 16.



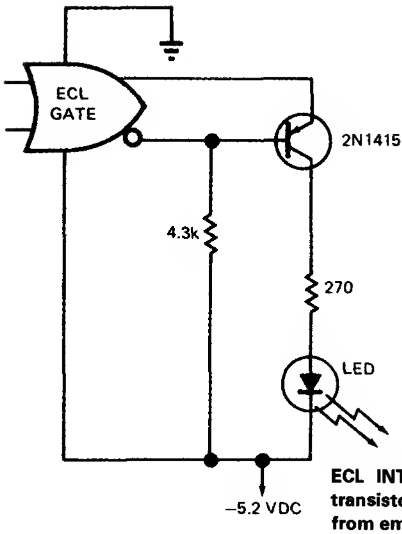
ECL INTERFACE FOR VMOS—S55V12 VMOS (identical to S55V01 except for higher braakdown/saturation voltage) is used to buffar ECL-compatible SN75441 paripheral driver. Combination is capable of hendling up to 90 V et 2 A. SN75441 hes open-collector output, so interfece with VMOS raquiras only pull-up resistor R_1.—L. Shaeffer, VMOS Peripheral Drlvers Solve High Powar Load Interfece Problems, *Computar Design,* Dac. 1977, p 90, 94, snd 96–98.



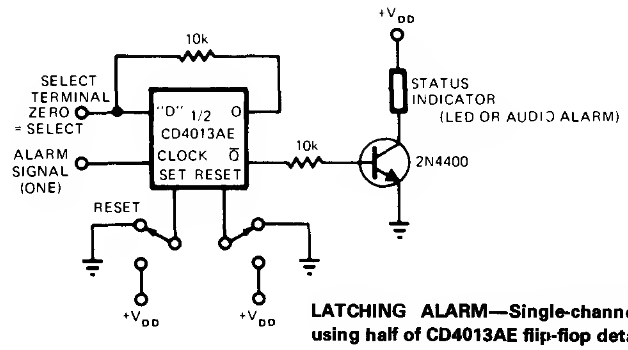
EXCLUSIVE-OR LOGIC FOR MUTING—Connection shown for National LM389 combination of three transistors with opamp givas standerd EXCLUSIVE-OR circuit for controlling muting transistor in audio system. Shorting pin 12 of opamp to ground gives EXCLUSIVE-NOR logic.—"Audio Hendbook," Netionsl Samiconductor, Santa Clars, CA, 1977, p 4-33–4-37.



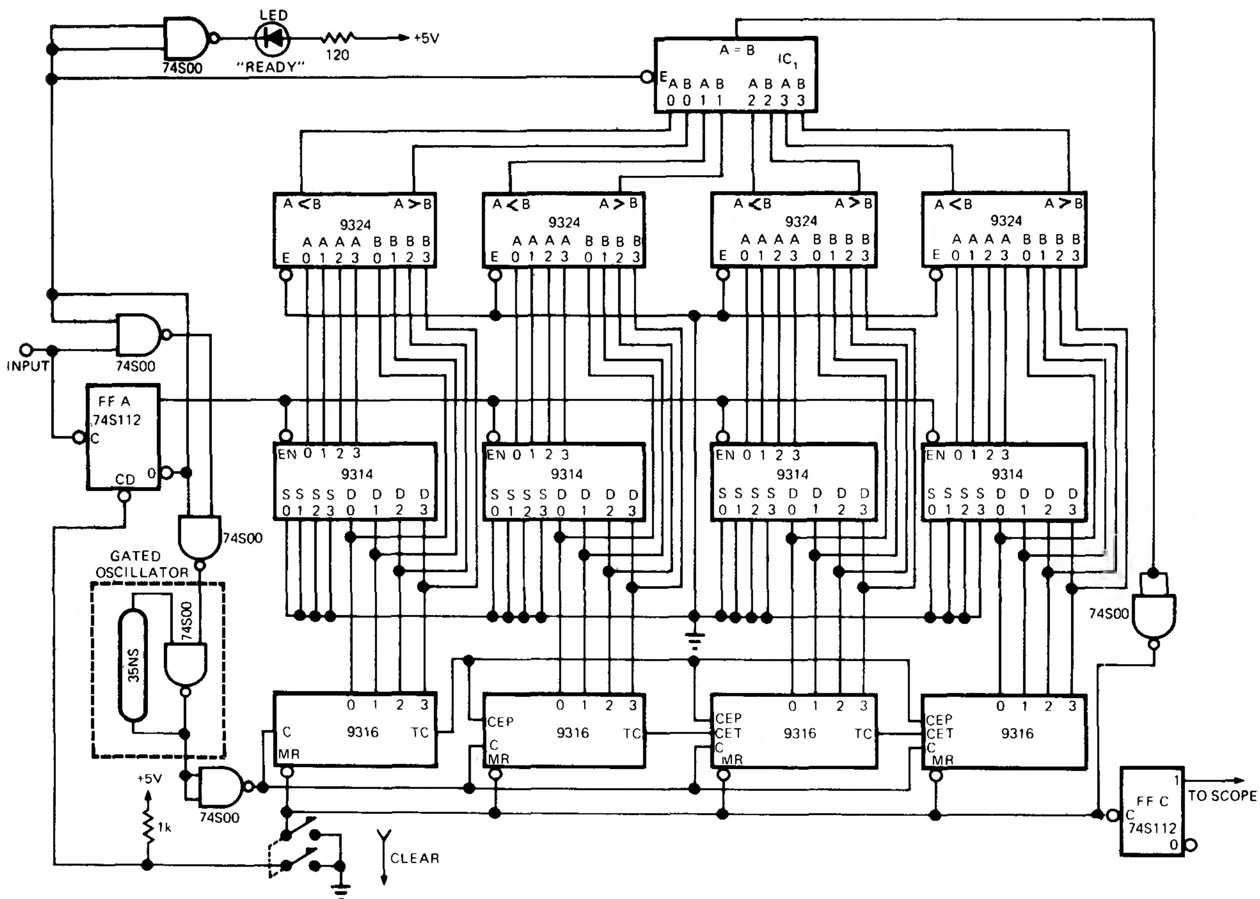
LOW-POWER SCHMITT—Uses two NAND gates from SN74L00 NAND peckege end one NOR gete (used as inverter) from CD4001AE CMOS package to maka low-powar Schmitt trigger. NAND gates are connected to form RS flip-flop. Q goes high whan input voltaga is greater then 2.1 V, and other output does not go low until Input voltege is less than 1.2 V. Both polarities of output signal are evallable.—R. Cox, CMOS and LPTTL Gatas Make Low-Power Schmitt Trigger, *EDN Magazine,* Oct. 1, 1972, p 48.



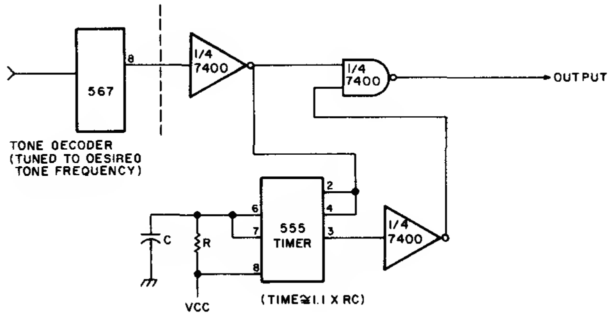
ECL INTERFACE FOR LED—PNP germanium transistor serves as interface for driving LED from emitter-coupled logic. Same interface can be used to drive 7-segment or other arrays that have common-cathode configuration, such as Fairchild FND10 or Monsanto MAN3. Optoisolator can be used in place of LED.—G. A. Altemosa, One Transistor Provides ECL to LED Interface, *EDN Magazine*, Oct. 15, 1972, p 54.



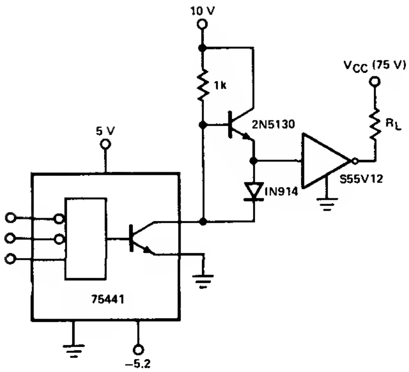
LATCHING ALARM—Single-channel monitor using half of CD4013AE flip-flop detects out-of-tolerance condition or alarm state represented by logic 1 on clock input. Flip-flop then changes to alarm state that turns on transistor for energizing alarm device, and holds alarm condition until operator reacts by applying voltage to SET input. Logic 0 on D terminal activates flip-flop when monitoring is desired.—J. C. Nichols, CMOS "D" Flop Makes Latching "AND" Gate, *EDN Magazine*, April 20, 1974, p 89 and 91.



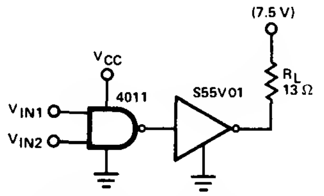
STORING SINGLE PULSE—Designed to take single-event positive-going TTL pulse, occurring only once when series of logic conditions is met, and recreating pulse accurately on CRO as square wave in which half of cycle represents original pulse width. FF-A and 9316 binary counters are initially cleared. Input pulse of interest gates delay-line oscillator (lower left) on for duration of pulse width. During this time, binary representation of pulse width is accumulated in 9316 counters, then stored in 9314 D-latches. At same time, final 9324 comparator IC_1 is enabled and oscillator is gated on again to reset 9316s and toggle FF-C. Square-wave output of FF-C then represents original pulse width within 35 ns (one clock).—N. L. White, Don't Miss That Single Event Pulse—Store It, *EDN Magazine*, Sept. 20, 1975, p 70 and 72.



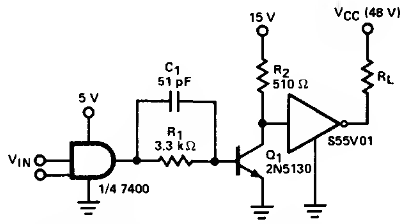
TONE DETECTOR—Output goas low only when input tona has been continuous at desired frequency for interval exceeding duration of pulse from 555 timer. Circuit can be used to reset en elerm system or to detect TTL level that exceeds predetermined time duretion.—Circuits, *73 Magazine,* April 1977, p 164.



TOTEM-POLE ECL INTERFACE FOR VMOS—Transistor and diode in totem-pole configuration improve parformence of SN75441 ECL-compatible paripheral driver for S55V12 VMOS.—L. Shaeffer, VMOS Peripharal Drivers Solva High Power Load Intarface Problems, *Computer Design,* Dec. 1977, p 90, 94, and 96–98.



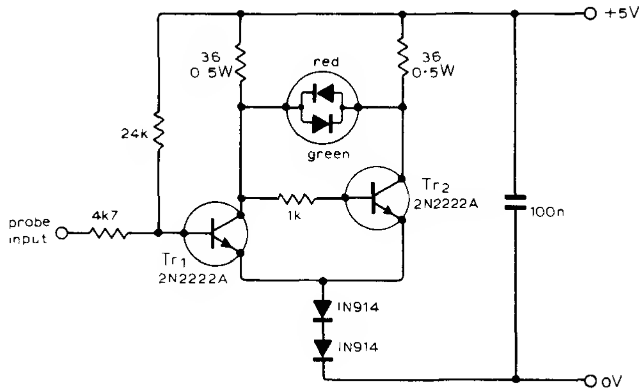
CMOS INTERFACE FOR VMOS—Simple 4011 CMOS gete connection provides required logic interfece for S55V01 VMOS that is capable of handling up to 1 A. Switching time is ebout 25 ns but can be doubled by connecting four CMOS getes in perallel. V_{CC} can be eithar 10 or 15 V.—L. Sheeffer, VMOS Paripheral Drivers Solve High Power Load Interface Problams, *Computer Design,* Dec. 1977, p 90, 94, and 96–98.



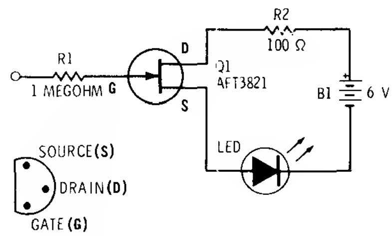
AMPLIFIED TTL INTERFACE FOR VMOS—Bipolar voltega emplifier Q_1 translatas TTL output swing of 0.4 to 2.4 V from 7400 interface to 15-V drive signal for S55V01 VMOS paripharal driver. Circuit can be driven by any low-level signal, including ECL, if comparator such es AM686 is used in place of SN7400 quad NAND gate. Switching times of circuit are less than 40 ns in both directions.—L. Shaeffer, VMOS Paripheral Drivers Solva High Powar Load Intarfaca Problems, *Computer Design,* Dec. 1977, p 90, 94, and 96–98.

CHAPTER 48
Logic Probe Circuits

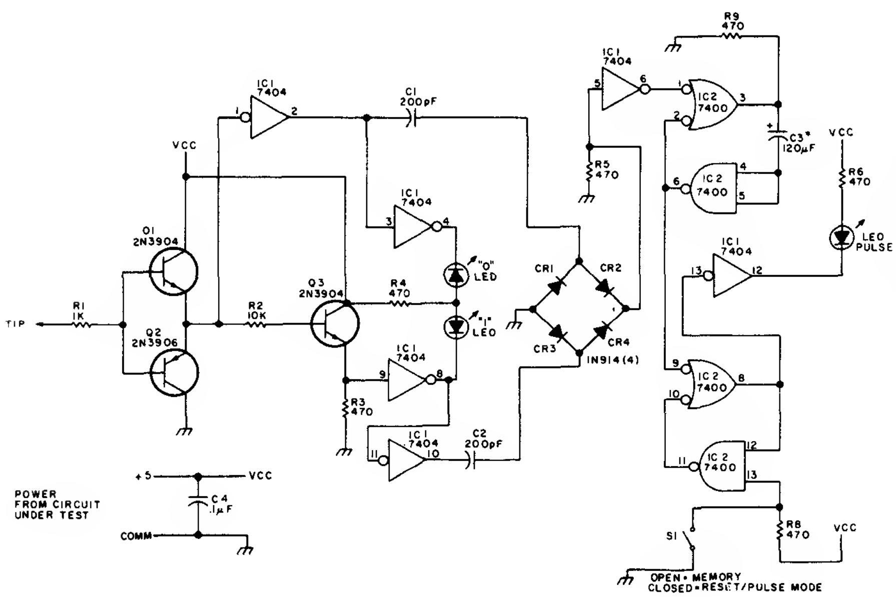
Provide LED and/or audible indication of logic-level status at terminal on which test probe is held for troubleshooting or other purposes. One circuit shows status at eight separate terminals on CRO display.



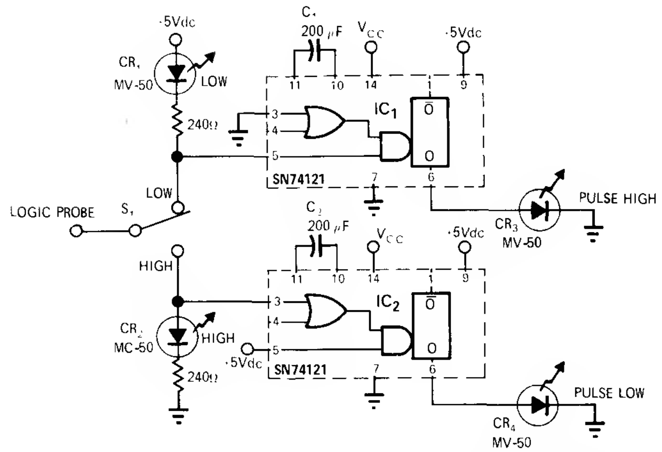
TTL-STATE PROBE—Uses voltage drop of LED in Schmitt triggar to indicate high, low, opan-circuit, and pulse-train conditions at probe input. Indicator is Monsanto MV5491 dual red-grean LED packaga. High input saturatas Tr_1, cuts off Tr_2, and turns on rad LED. Low input cuts off Tr_1 and turns on green LED. For high impedance at input, both LEDs are off. Rectangular waves up to about 1 MHz turn on both LEDs, with relative brightnass giving rough indication of mark-space ratio.—J. C. Flowar, Logic Probe, *Wiralass World,* Sept. 1976, p 72.



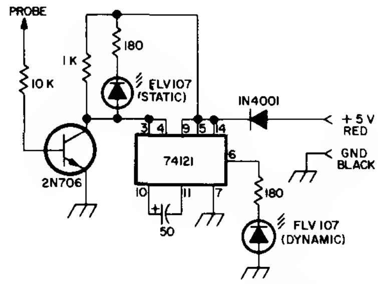
FET LOGIC PROBE—Field-effect transistor with very high input resistance makes LED glow when logic 1 is present at input, without loading circuit being monitored.—F. M. Mims, "Computer Circuits for Experimenters," Radio Shack, Fort Worth, TX, 1974, p 35–43.



LOGIC PROBE—Providas almost as much information, when working with TTL or DTL digital circuits, as costly CRO or logic analyzar. Can be built into length of plastic tubing, with probe tip projecting at one end and two supply laads coming from othar and. Ona LED flashes for high to low transition, and other for low to high transition. Flash is visible aven with vary narrow pulses, because probe circuit stretches pulse width. With S1 opan (memory moda), pulse LED at right stays on until reset by operator, for capturing any stray pulse. If proba tip is hald on open circuit or on chain of floating inputs, no LED will light.—C. W. Andreasan, Suparprobe, *73 Magazine,* Holiday issua 1976, p 92–93.

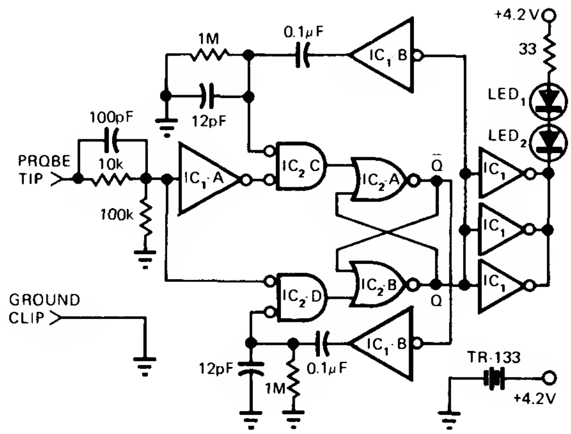


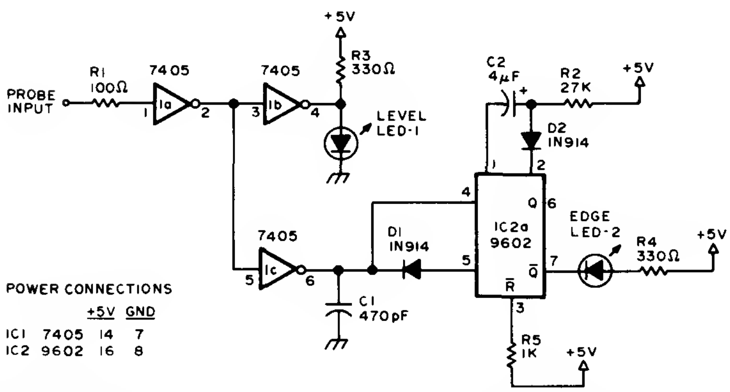
LOGIC-STATE PROBE—Useful for low-repetition-rata applicetions heving single narrow pulsas, es in computer interfeces end logic control systems. Pulses es nerrow es 50 ns are stretched by mono so they provide clear LED indication. If steedy state of circuit under test is low, CR_1 will light when S_1 is in low position. If steedy state is high, CR_2 will light when switch is high. Other two lamps indicate presence of pulse superimposed on steady-state signal. If repetition frequency of pulse is high, pulse light appears on continuously.—J. W. Hemill, Low-Speed Logic Probe, *EDN/EEE Magazine*, Nov. 1, 1971, p 51.



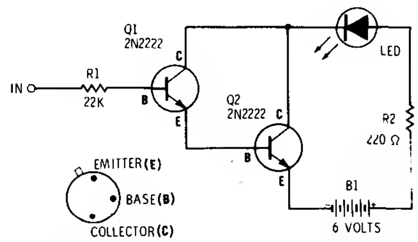
RTL/TTL PROBE—Static LED indicates logic level at probe tip. Dynamic LED indicates presence of high or 1 pulsa at probe tip even though momentary, because circuit stretches pulsa to about 50 μs for easy visibility. Pulse stretcher requires at least 100-ns 4-V pulse. 1N4001 diode protects egainst reversed power leads. Probe requires +5 V from circuit under test. LEDs and trensistor are not critical.—Circuits, *73 Magazine*, April 1974, p 31.

LOGIC PROBE—Pocket-size battery-powered probe using two inexpensive CMOS ICs hes such low stendby current drein that ON/OFF switch is unnecessery. Drein is eppreciable only when LEDs ere on during use. Mellory TR-133 4.2-V mercury bettery gives 2-V threshold for TTL competibility. LEDs come on to indicate logic 1. Pulse-stretching circuit ensures detecting positive or negetive pulses es short es 250 ns.—J. Edrington, Battary-Powered Logic Probe Needs No ON/OFF Switch, *EDN Magazine*, Mey 20, 1975, p 72 end 74.

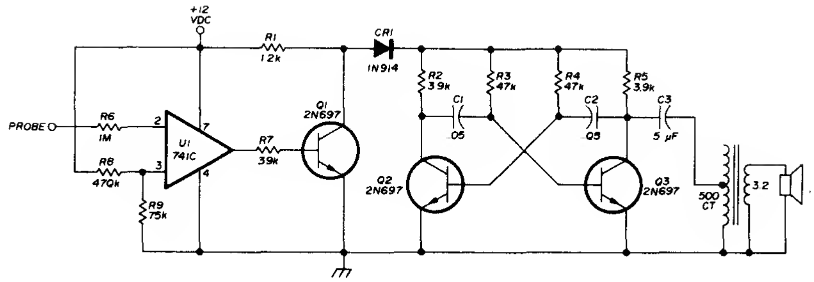




BUILT-IN LOGIC PROBE—Permanently wired LEDs indicate TTL levels end chengas in levels. LEVEL LED-1 comes on for TTL 1 input end goes out for TTL 0 input. EDGE LED-2 comes on momentarily for input changes. Will detect levels, steps, single pulses, end pulse treins. Only helf of each IC is used, so dual tester cen ba made if desired. ICs 1a and 1b form noninverting driver for 9602 mono which is triggered on both positive-going end negative-going edges by C1 end D1. Pulse trein input having period less than width of flash pulse will keep EDGE indicator on.—K. W. Christnar, The Built-In Logic Tester, *BYTE*, Jen. 1977, p 82–83.

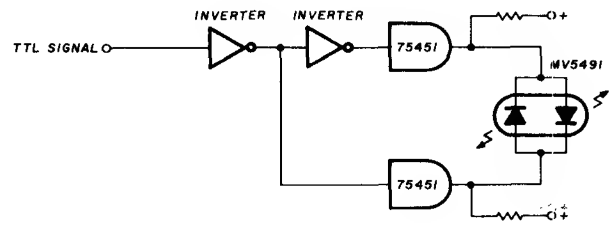


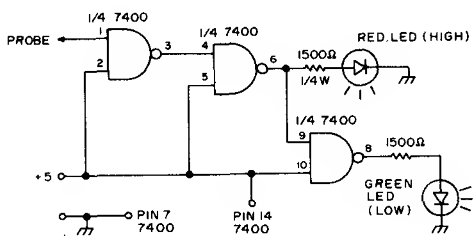
DARLINGTON LOGIC PROBE—Two-trensistor Darlington connection provides very high input impedence that does not load logic circuit being monitored, while driving LED that glows whan logic 1 is present at input.—F. M. Mims, "Computer Circuits for Experimenters," Radio Sheck, Fort Worth, TX, 1974, p 35–43.



AUDIBLE LOGIC INDICATOR—Audio oscillator Q1-Q2-Q3 is isolated from TTL by opamp U1 wired as Schmitt trigger. Opamp acts as high-input-impedance inverter. Reference level is set at +1.6 V by R8-R9 for TTL-compatible logic (about midway between high and low logic levels). When probe input is below +1.6 V, opamp output of about 10.5 V saturates Q1 and disables Q2-Q3 to cut off tone. When probe voltage is above +1.6 V, U1 output is about 2 V which cuts off Q1 and allows Q2-Q3 to generate tone indicating high logic.—H. F. Batie, Versatile Audio Oscillator, *Ham Radio,* Jan. 1976, p 72–74.

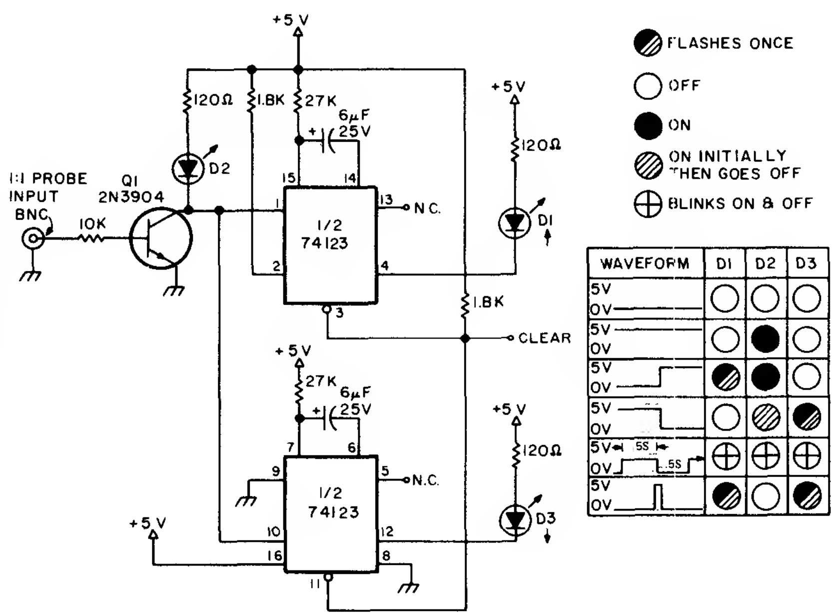
RED/GREEN LEVEL DISPLAY—Level detector can be used with TTL, DTL, and RTL, as probe for troubleshooting. Indicator is Monsanto MV5491 dual red/green LED, with 220 ohms in upper lead to +5 V supply and 100 ohms in lower +5 V lead because red and green LEDs in parallel back-to-back have different voltage requirements. Will furnish green indication on high or plus signal and red indication on low or false signal. Supply voltage of +5 V can be taken from equipment under test. Circuit requires SN75451 driver ICs and two sections of SN7404 hex inverter.—K. Powell, Novel Indicator Circuit, *Ham Radio,* April 1977, p 60–63.

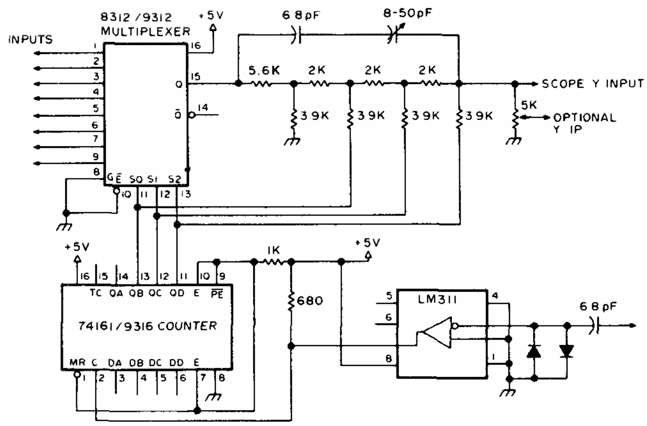




PROBE—Red LED comes on to indicate that test point is at high logic level, while green LED signifies low level. Circuit uses one 7400 quad dual-input NAND gate.—S. Uhrig, Check Logic with This Simple Probe, *73 Magazine,* Dec. 1974, p 76.

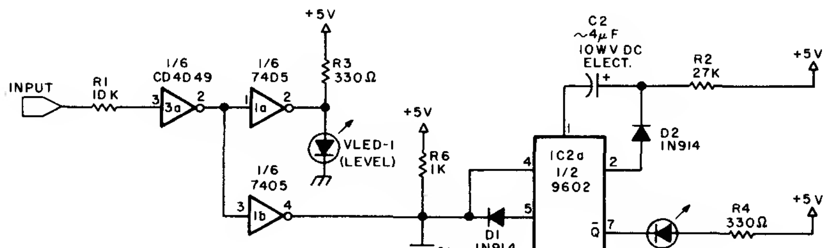
LED DISPLAY FOR TTL—Useful for observing TTL levels when CRO is not available. A1 and A2 are 74123 dual retriggerable mono MVBRs with clear, used to turn on LEDs when input transitions are detected. Even very short pulses are made visible because mono stretches pulse length. Table shows how LED indications are interpreted.—B. Voight, The TTL One Shot, *73 Magazine,* Feb. 1977, p 56–58.



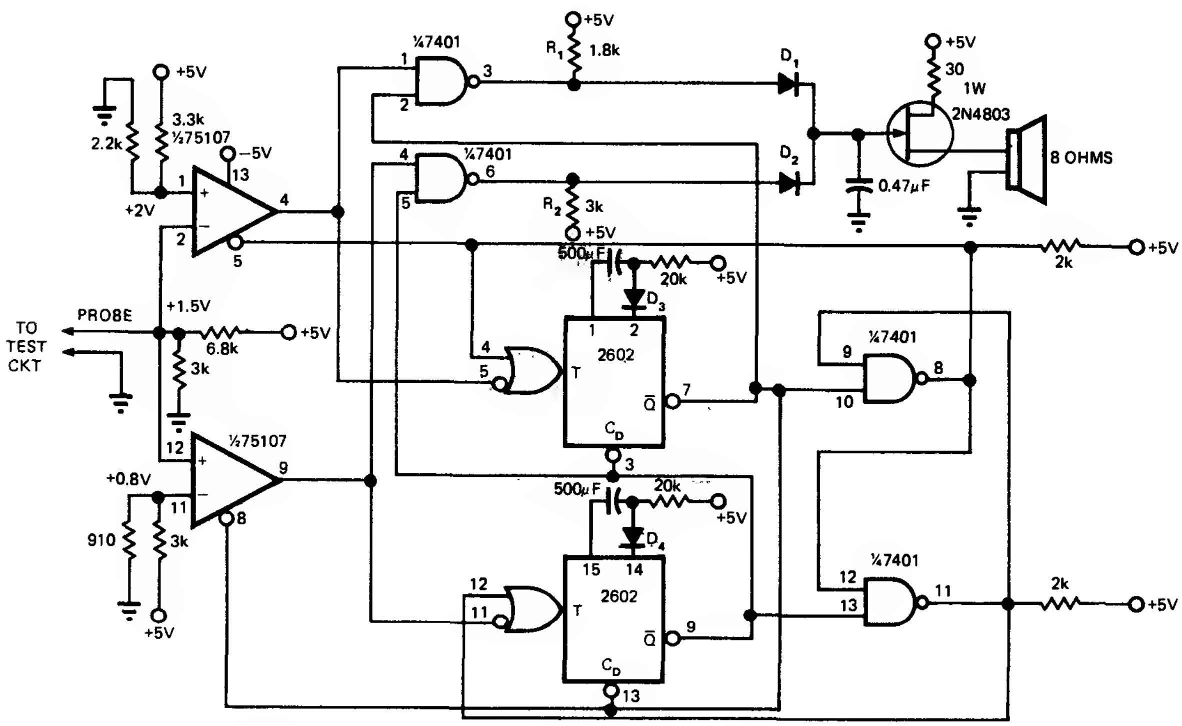


8-TRACE LOGIC DISPLAY—Adapter for standerd oscilloscope shows tima relationship between pulses at eight different locations in digital circuit, for troubleshooting and isolation of glitches. Almost eny genarel-purpose CRO can be used, but triggered sweep improves usefulness. Multiplexer feeds each input in turn to Y input of CRO, under control of countar. Article covars operetion and use of adapter.—R. A. Johnson, Eight Traca Scope Adapter, *73 Magazine*, Sept. 1976, p 108–110.

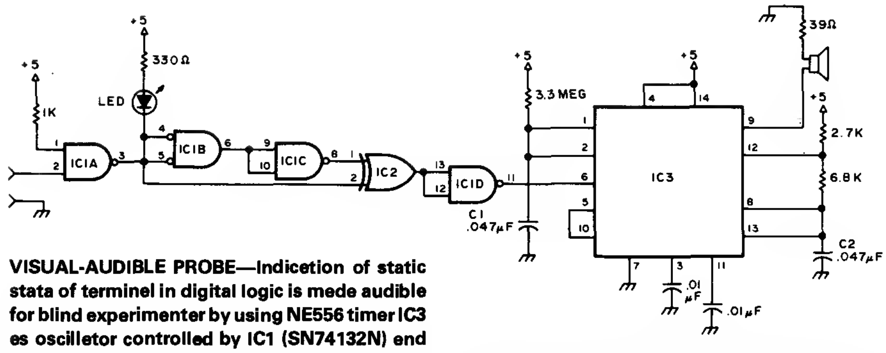
CMOS LOGIC PROBE—Designed for wiring into microprocessor to show status of an important terminal, as troubleshooting eid. LEVEL LED is on for TTL input of 1 end off for input of 0. EDGE LED lights momenterily when input changes from 1 to 0 or 0 to 1. Use of CMOS inverting buffer 3e et input prevents probe from affecting microprocessor.—F. A. Weissig, A CMOS Logic Proba, *BYTE*, Oct. 1977, p 11.



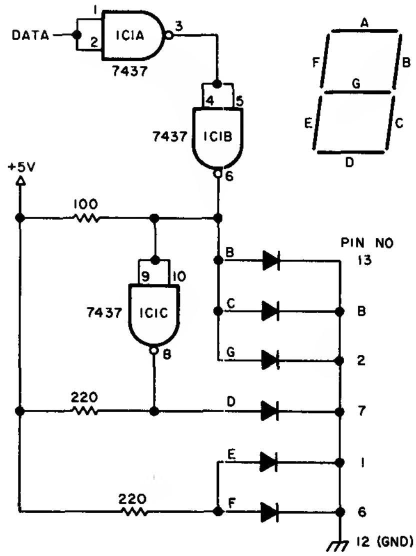
POWER CONNECTIONS		+5V	GND
IC1	7405	14	7
IC2	9602	16	8
IC3	CD4049	1	8



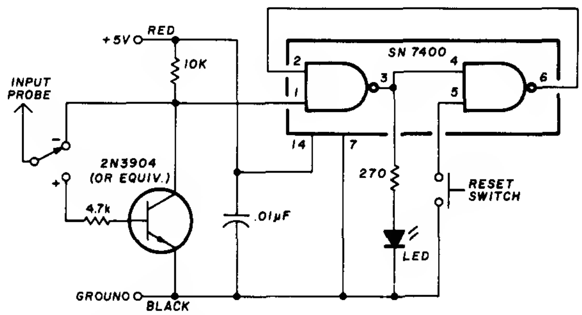
LISTEN TO LOGIC—Gives eudio indication of TTL states when probe is held on IC pin. Input level ebove 2 V makes 2N4803 UJT oscillate et about 400 Hz and giva tona from loudepeaker. Logic 0 et probe input gives lower frequancy. Logic pulse trensitions trigger 2602 dual monos for 1 s, modulating tones et ebout 1-s rete. Monos also drive two-gete letch that prevents either mono from firing two consecutive times.—I. Simon, Audio Output Eeses Logic Level Checking, *EDN Magazine*, June 20, 1975, p 116 and 118.



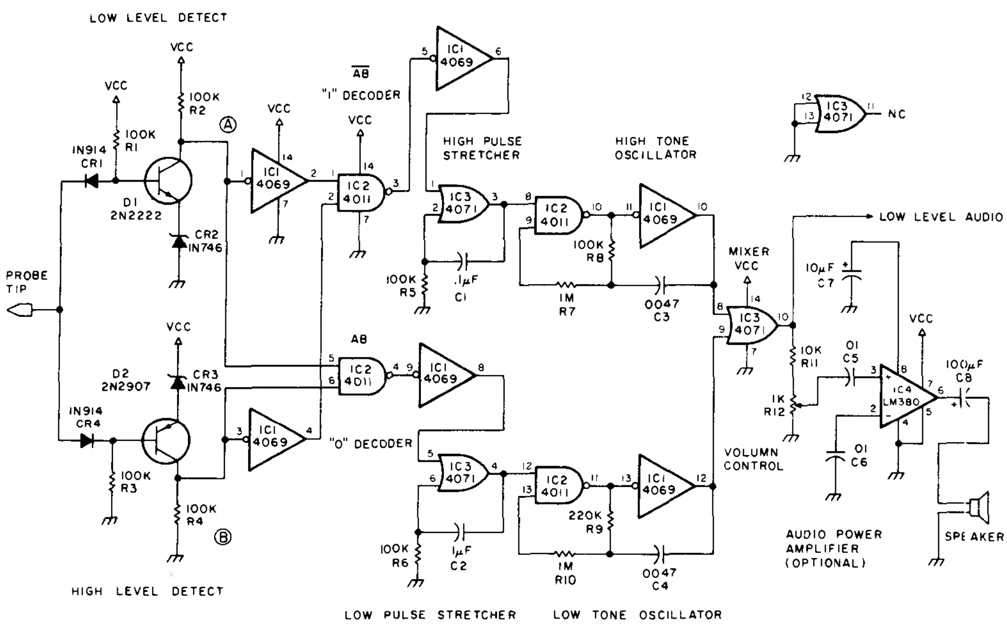
VISUAL-AUDIBLE PROBE—Indication of static state of terminal in digital logic is made audible for blind experimenter by using NE556 timer IC3 as oscillator controlled by IC1 (SN74132N) and IC2 (SN7486N). Any logic transition from 1 to 0 or 0 to 1, lasting at least 50 ns, is detected and indicated by audio beep. Visual indication is provided by LED that comes on when input is logic 1.—T. Lincoln, A Logic Probe You Can Hear, *73 Magazine*, Aug. 1976, p 106.



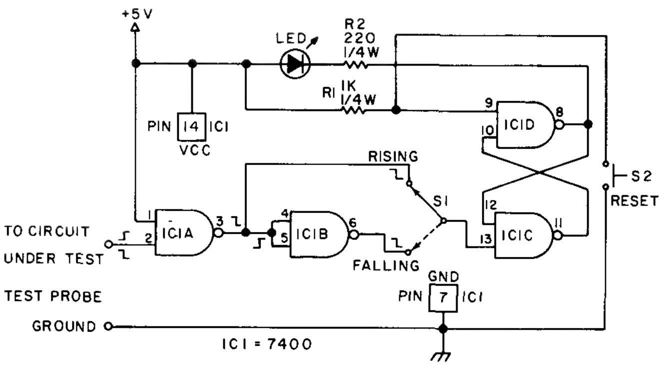
OUTPUT STATUS DISPLAY—Monitors state of single bit and shows H or L on 7-segment display depending on status of data input. Uses two 7437 inverters and one DL-704 common-cathode display. Diode symbols represent segments of display (segment A is not needed for H or L). Power connections to 7437 inverter are +5 V to pin 14 and ground to pin 7.—G. Tomalasky, Bit Status Display, *BYTE*, Dec. 1977, p 197.



TTL PROBE—LED comes on, and stays on until circuit is reset, if input probe receives low-level (negative-going) pulse when polarity switch is set as shown. For other position of switch, LED comes on for high-level or +5 V pulse.—R. B. Shreve, Troubleshooting Logic Circuits, *Ham Radio*, Feb. 1977, p 56–59.

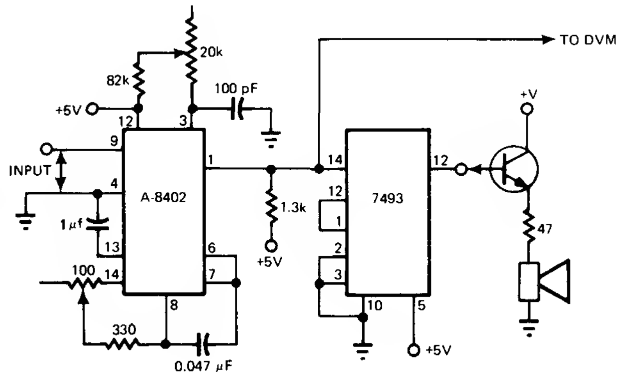


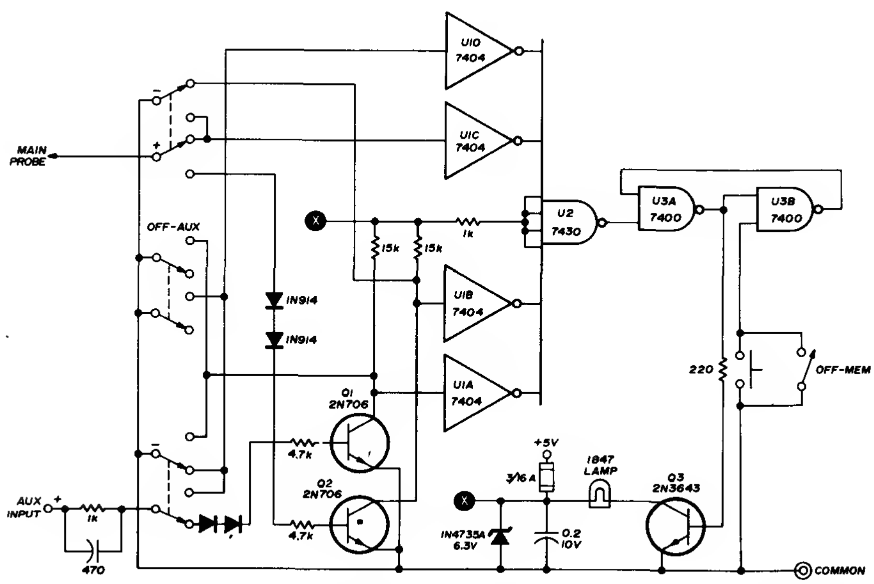
AUDIBLE CMOS PROBE—Eliminates need for watching meter while applying probe tip in turn to large number of closely spaced terminals during troubleshooting. Produces high tone for logic high, low tone for logic low, and no sound for open or floating string. Supply is 12 V. Article describes circuit operation in detail.—C. W. Andraesen, The Best Probe Yet?, *73 Magazine*, April 1978, p 134–135.



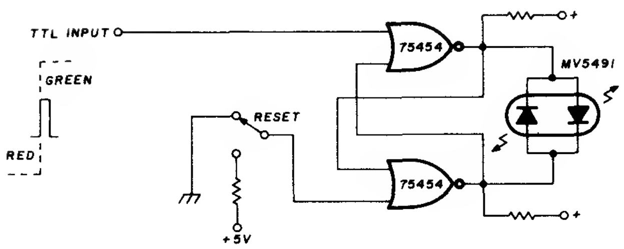
FAST TTL PROBE—RS flip-flop wired from NAND gate detects pulses as short as combined gate delays of NAND sections forming flip-flop (about 30 ns). Circuit changes state at start of pulse, with LED monitoring flip-flop output. After pulse has been detected, circuit must be reset with S2. Will work with either positive-or negative-going pulse, as selected by S1.—W. A. Welde, Build a TTL Pulse Catcher, *BYTE*, Feb. 1976, p 58 and 60.

AUDIBLE PROBE—Speeds troubleshooting by eliminating need to look at meter, and prevents possible damage to logic under test by minimizing possibility of shorts occurring if probe slips when looking at meter. Components used with A-8402 IC give 1-kHz output for 6-V input. Binary counter divides this signal to give output in low audio range and converts to square wave more suitable for driving loudspeaker. Probe can also serve as input for digital voltmeter. When probing TTL circuits, probe gives low frequency for 0 state, high frequency for 1, and middle frequency for open circuit. Output transistor type is not critical.—G. E. Row, Audible Logic Probe Doubles as DVM Input Section, *EDN Magazine*, Oct. 20, 1977, p 82.

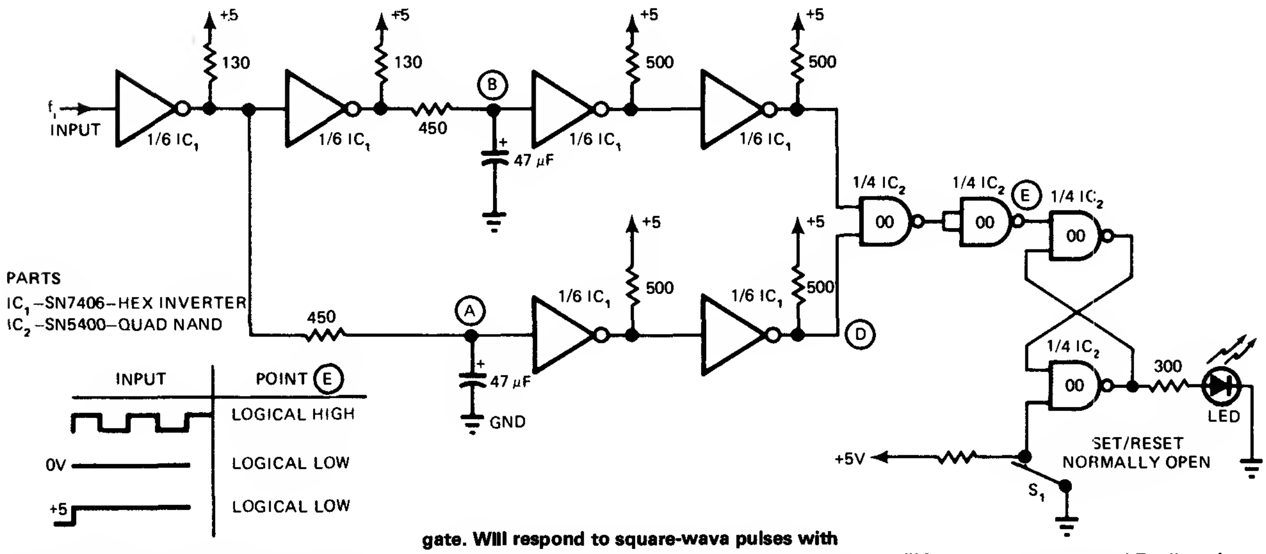




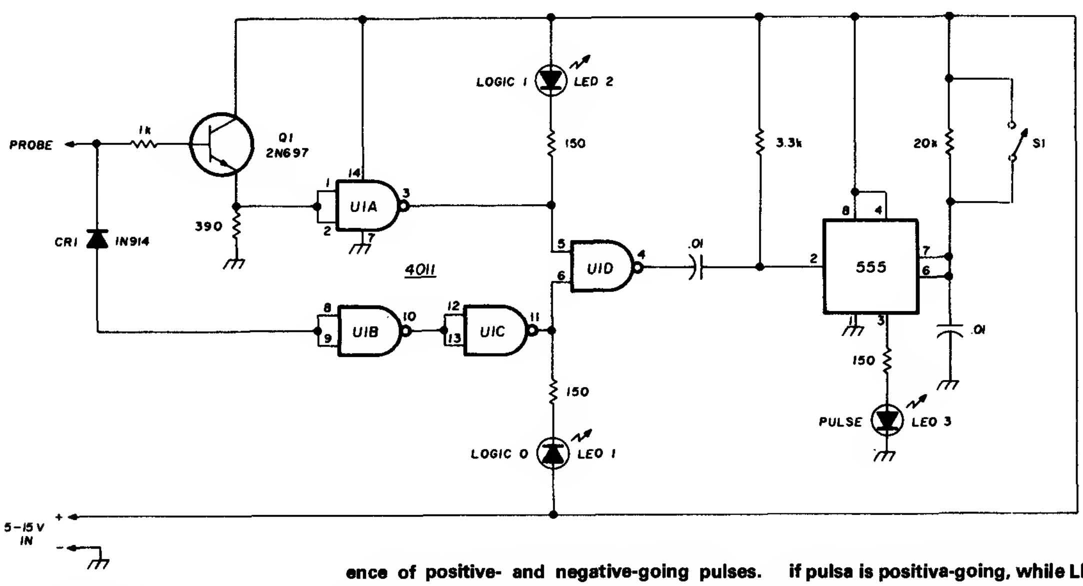
TEST PROBE—Checks binary levels and pulse coincidence. Indicator lamp, driven by switching transistor Q3, is bright enough to be seen in sunlight. Close OFF-MEM switch when using probe as binary level indicator, to eliminate need for pushing button continuously. At AUX position of main switch, two inputs are needed at same time. To check for coincidence, connect patch cord from AUX jack to second point being checked in logic circuit. All signal diodes are 1N914. Probe drain is about 160 mA; changing to LED would cut drain to 60 mA.—R. H. Frensen, Improved Logic Test Probe, *Ham Radio*, Dec. 1973, p 53–55.



LATCHING PROBE—TTL pulse catcher can ba used as logic proba for IC troubleshooting. Uses Monsanto MV5491 dual red/graen LED, with 220 ohms in upper lead to +5 V supply and 100 ohms in lowar +5 V lead becausa rad and green LEDs in parallel back-to-back hava different voltage requiremants. SN75454 driver circuit is cross-coupled to form latch or mamory elemant. Positive-going pulse sets latch and makas LED change color to indicate arrival of pulsa. Latch must be reset manually with RESET switch. Also useful for locating intermittents such as glitches; probe can ba left connected to circuit under test, to see if latch has been set by unwanted signal.—K. Powall, Novel Indicator Circuit, *Ham Radio*, April 1977, p 60–63.



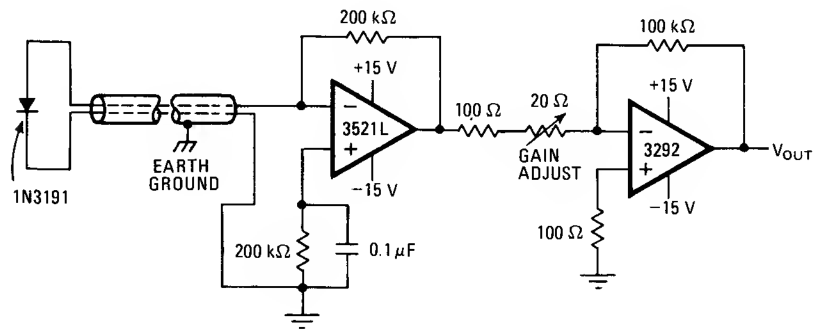
PULSE FREQUENCY DETECTOR—Can ba used as digital-logic probe or as frequancy detector for test equipmant. Requires only two ICs, SN7406 hax inverter and SN5400 quad NAND gate. Will respond to square-wava pulses with 50% duty cycles up to 3 MHz. When pulsa appaars at input, points A and B datact logic high laval and maka point E go high so latch sets and turns on LED. Without an input frequency, A and B will be complementary and E will go low, resetting latch and turning off LED.—V. Rende, Digital Fraquancy Detector Uses Only Two IC's, *EDN Magazine*, April 20, 1976, p 114.



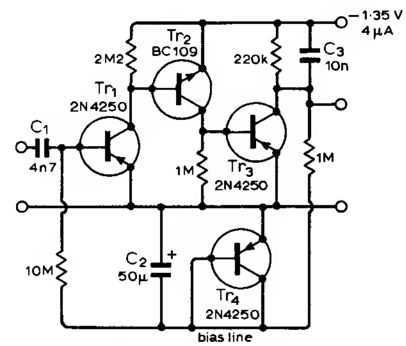
LOGIC PROBE—Designed to indicate logic states in TTL and CMOS circuits. Will substitute for high-speed triggered CRO in indicating presence of positive- and negative-going pulses. Input of logic 0 lights LED1 and LED3, with LEDs staying on only 200 ms. With logic 1, only LED2 lights. With S1 closed, LED1 and LED3 stay on if pulsa is positiva-going, while LED2 and LED3 stay on if pulse is negative-going.—H. M. Berlin, A TTL and CMOS Logic Probe, *Ham Radio*, March 1978, p 114.

CHAPTER 49
Medical Circuits

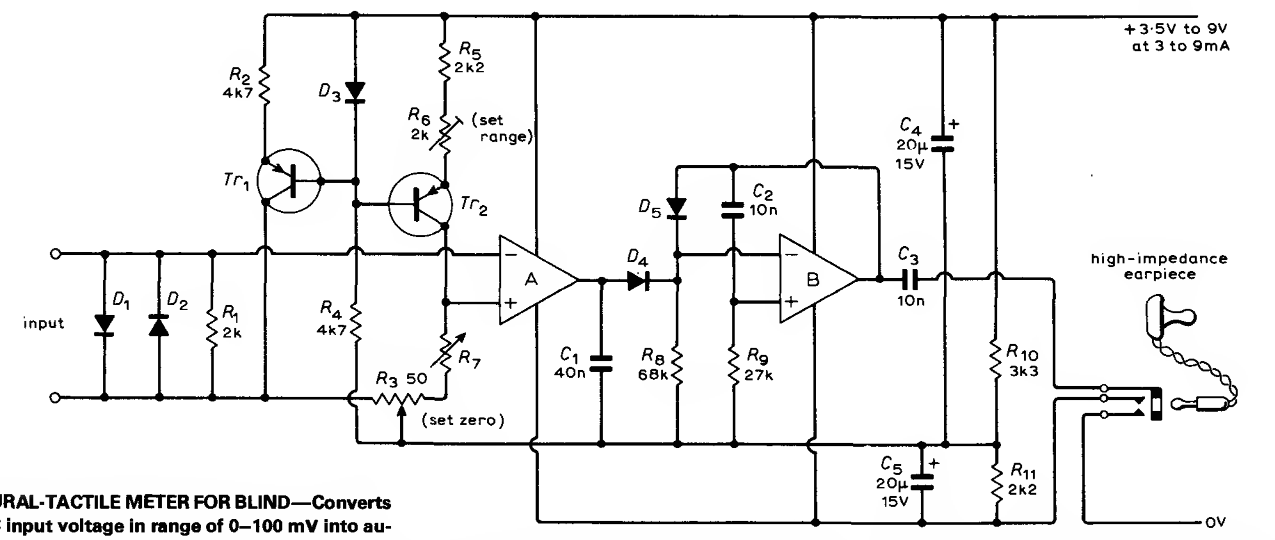
Includes circuits for telemetering and processing of heart, brain, muscle, and other bioelectric potentials, recording data from joggers, monitoring therapeutic radiation, synthesizing speech, and providing audible indications for blind persons of light level, voltage, logic status, bridge null, and other measurable parameters.



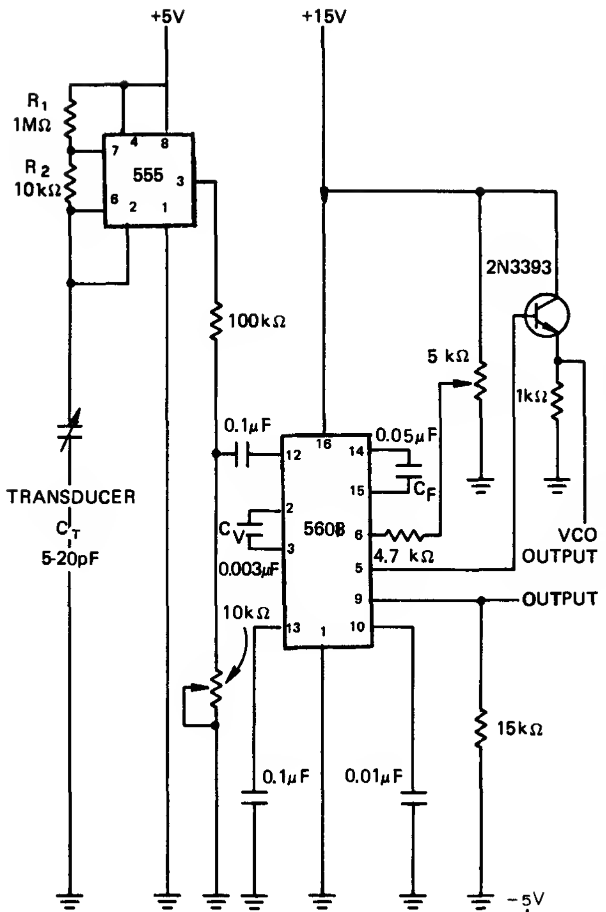
RADIATION MONITOR—1N3191 commercial diode serves as sensor in high-accuracy dosage-rate meter for gamma rays and high-energy X-rays used in radiotherapy. Diode is small enough for accurate mapping of radiation field. Output voltage varies linearly from 0.1 V to 10 V as dose rate increases from 10 to 1000 rads per minute. Low-drift FET-input 3521L opamp amplifies detector current to usable level for 3292 chopper-stabilized opamp that provides additional gain while minimizing temperature errors.—P. Prazak and W. B. Scott, Radiation Monitor Has Linear Output, *Electronics*, March 20, 1975, p 117; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 106.



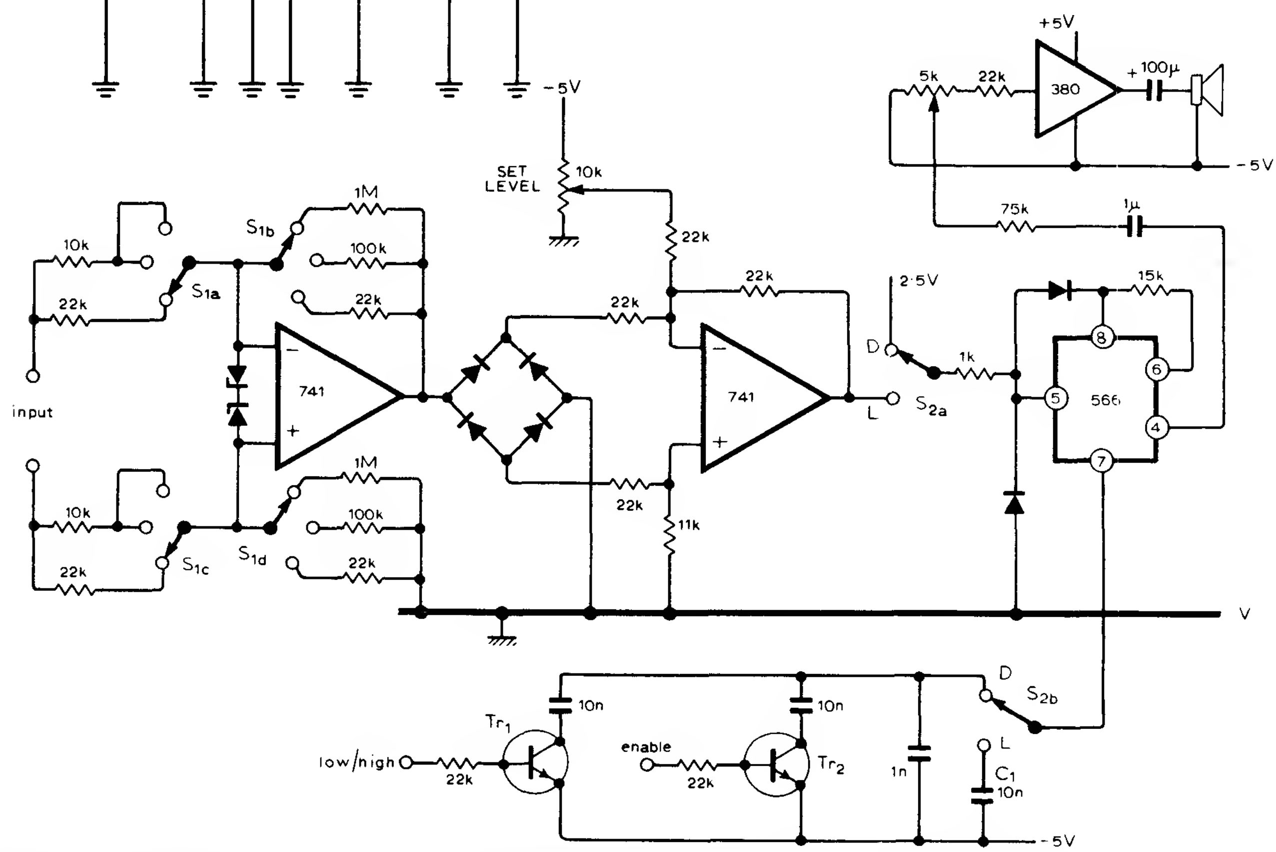
IMPLANT AMPLIFIER—Designed for use in implanted transmitters monitoring brain and heart potentials. Requires only 4 μA at 1.35 V. Voltage gain is 2000, and equivalent input noise only 10 μV P-P with 10-megohm source impedance. Tr_1 is current-starved, but resulting limited bandwidth of about 5 kHz is acceptable for biological applications.—C. Horwitz, Micropower Low-Noise Amplifier, *Wireless World*, Dec. 1974, p 504.



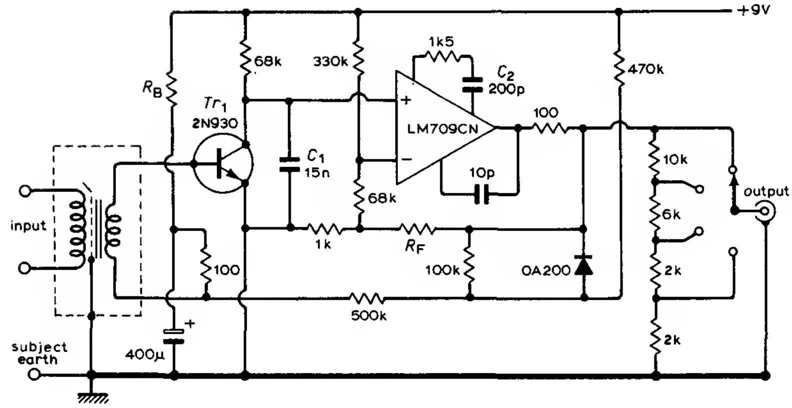
AURAL-TACTILE METER FOR BLIND—Converts DC input voltage in range of 0–100 mV into audible indication that is produced at instant when measured voltage exceeds reference voltage as set by decade switches of R_7. Blind person can then read Braille markings at switch settings to get input voltage. Opamp B is connected as free-running MVBR that generates AF signal for earpiece. Use germanium transistors such as OC45 or OC71. Opamps are Motorola 1435. Use silicon diodes such as 1N914, BA100, or OA200. R_7 can alternatively be wirewound pot.—R. S. Maddever, Meter for Blind Students, *Wireless World*, Jan. 1973, p 36–37.



SENSING MUSCLE TENSION—Capacitive transducer of type used for measuring displacement and pressure is used to modulate 555 MVBR. Frequency is detected in NE560B PLL that produces DC output voltage. C_F sets bandwidth of demodulated information. Zero-position frequency of transducer is measured at pin 12 of PLL, and VCO frequency of PLL is measured from pin 5 through 2N3393 emitter-follower stage.—R. M. Wise, Capacitive Transducer Senses Tension in Muscle Fibers, *Electronics,* June 26, 1975, p 97; reprinted in "Circuits for Electronics Engineers," *Electronics,* 1977, p 349.

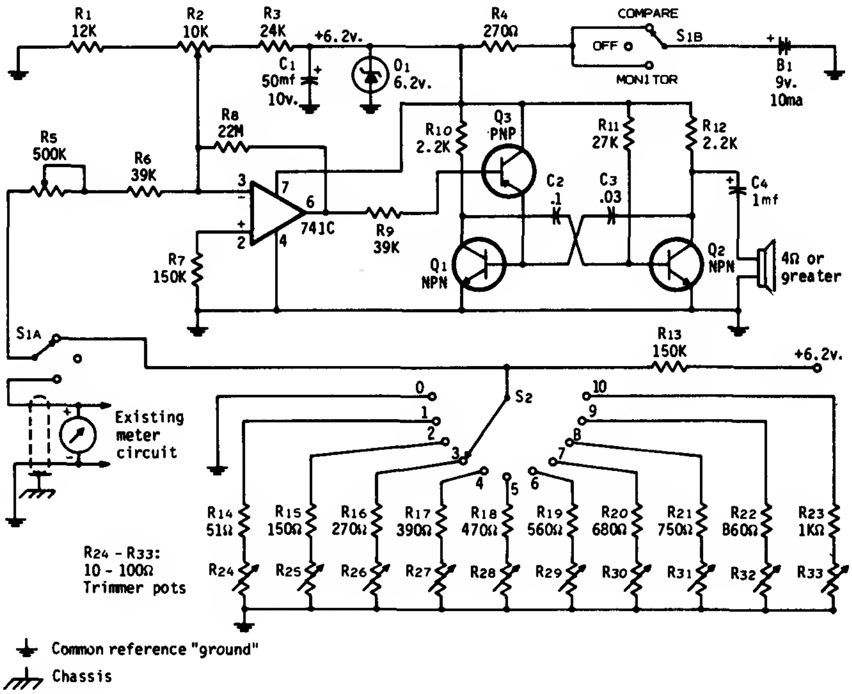


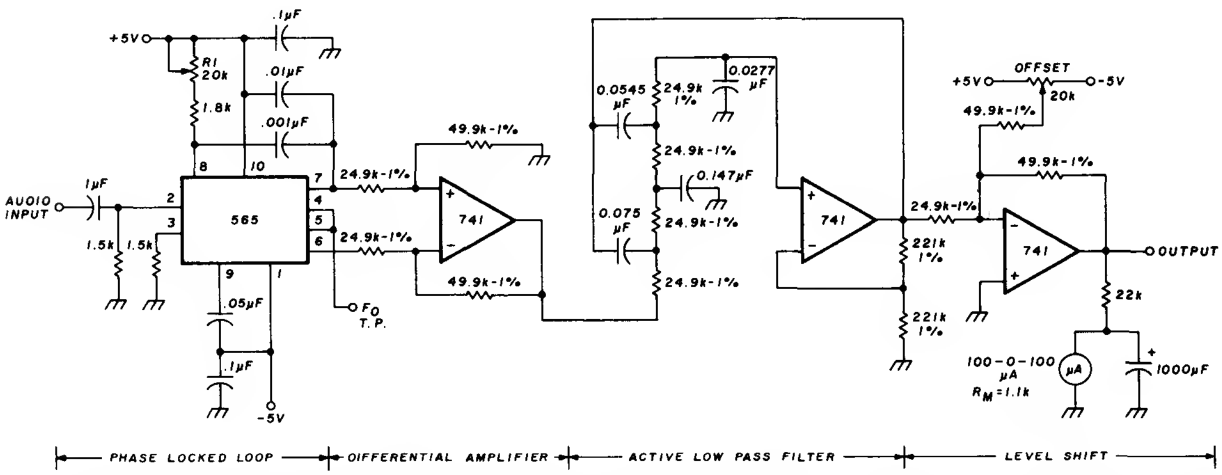
BINARY TONE GENERATOR FOR BLIND—When low/high input is voltage in binary form, as obtained from converter circuit (also given in article) fed by digital voltmeter, circuit produces low pitch for binary 0 and high pitch for binary 1 when S_2 is set at D for digital voltmeter mode. Recognition of binary digits in tone form can be learned by blind person much as learning of Morse code. Uses LM566 IC as tone-generating VCO that feeds loudspeaker through LM380 IC amplifier and 5K volume control. With S_2 at position L, circuit serves as audio null detector for bridge connected to input terminals; S_1 is used to increase sensitivity of 741 opamp as null is approached. Article covers operation of circuits in detail.—R. A. Hoare, An Audible Voltmeter and Bridge-Indicator, *Wireless World,* Sept. 1976, p 87–89.



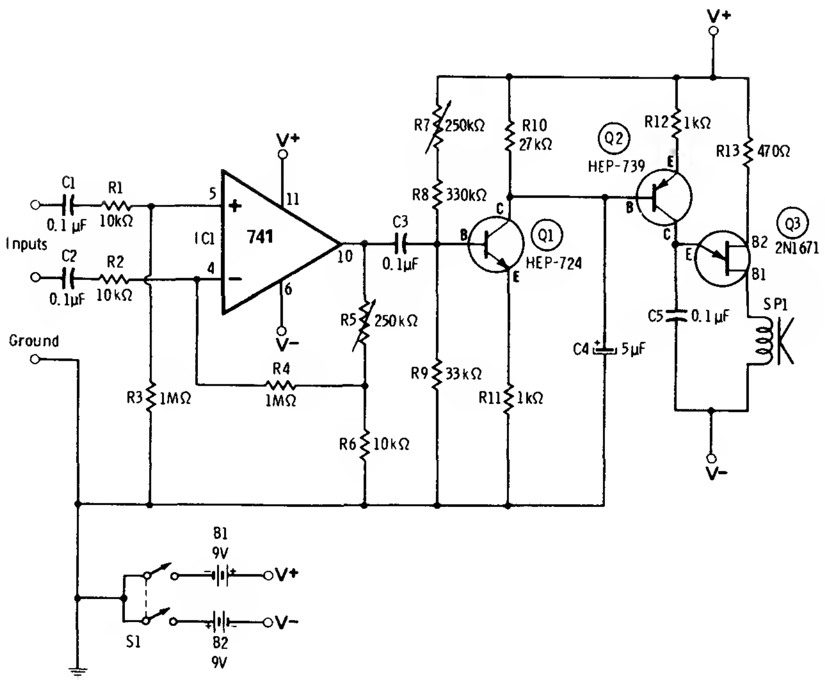
ELECTROMYOGRAM AMPLIFIER—Used to amplify voltages in range of several microvolts to several millivolts in frequency spectrum of 20 to 5000 Hz, as picked up with 13-mm thin silver disks placed on skin over muscle being studied. Article also covers electrocardiographic applications involving source impedances as high as 50 kilohms (as with one electrode on each wrist). Maximum output capability is 9 V P-P. Voltage gain is 1000. R_F is 800K pot, adjusted to give 12 dB per octave dropoff above turnover frequency.—R. E. George, Simple Amplifier for Muscle Voltages, *Wireless World*, Oct. 1972, p 495–496.

AUDIBLE VOLTMETER—Voltage-controlled audio oscillator produces 400-Hz tone for 0 V, with frequency of tone increasing with voltage over two-octave range to 1600 Hz for maximum or full-scale voltage. Ten-resistor voltage divider produces calibrated reference tones corresponding to main 0–10 divisions of meter scale for aural comparison. Simple square-wave audio oscillator Q_1-Q_2 is voltage-controlled by Q_3, which in turn is driven by opamp whose gain is set by R_5. Article covers adjustment of sensitivity pot R_5 and frequency pots R_{24}-R_{33} so VCO tracks voltage being measured and tones coincide at MONITOR and COMPARE positions of S_1 for each meter division.—H. F. Batie, An Audible Meter for the Blind Amateur, *CQ*, Dec. 1973, p 26–31.

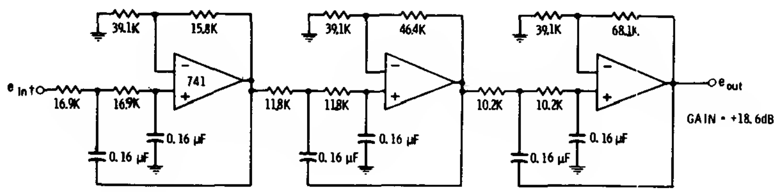




EKG FM DEMODULATOR—Developed as part of system using satellite for relaying electrocardiograms and other medical data having bandwidth of 0.5 to 50 Hz. Audio signal serving as source of FM is applied to voltage-controlled 1-kHz oscillator having ±40% deviation for full-scale input. Corresponding audio signal at receiving location is fed to input of 565 phase-locked loop. Error voltage of loop, at pin 7, contains data being sought as well as undesirable DC and AC components. DC component of error signal is removed by 741 differential amplifier following PLL. Following four-pole active RC low-pass filter eliminates high-frequency AC components and determines bandwidth of demodulator. Cutoff frequency is 100 Hz. Final 741 opamp scales and shifts output to reasonable value. Recorded output could not be distinguished from original EKG by doctors.—D. Nelson, Medical Data Relay via Oscar Satellite, *Ham Radio*, April 1977, p 67–73.

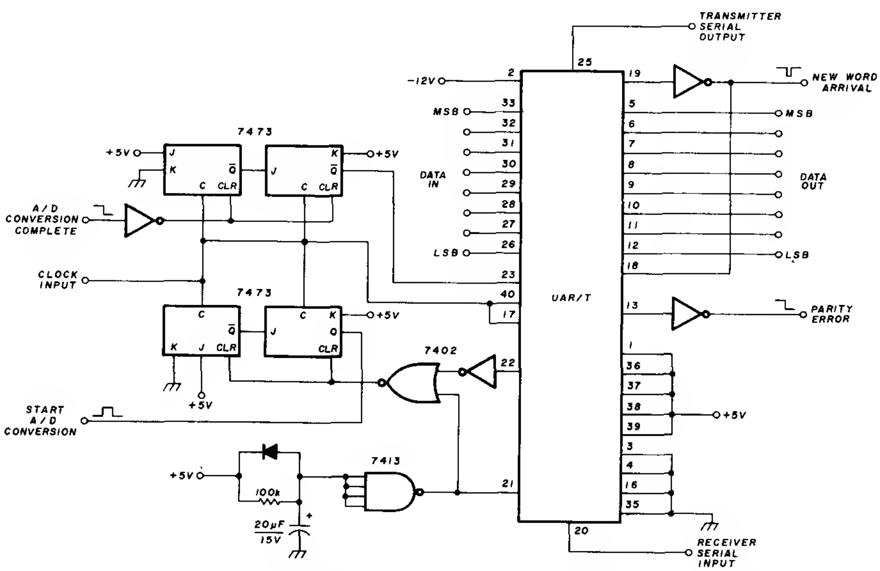


AUDIO EMG MONITOR—Used to measure vary small voltages that appaar on surface of skin over body muscle. Instaad of recording voltaga in form of electromyogram (EMG), opamp drivas transistor circuit to produce audible note that varies in pitch as EMG signal varies in amplitude. Applications include use by stroke patiant as aid to laarning reuse of muscle group affected by stroka. Q1 rectifies and avarages amplified EMG signal. Q2 controls charging current of C5 for varying frequency of UJT oscillator Q3.—R. Malen and H. Garland, "Understanding IC Operational Amplifiars," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 125–127.

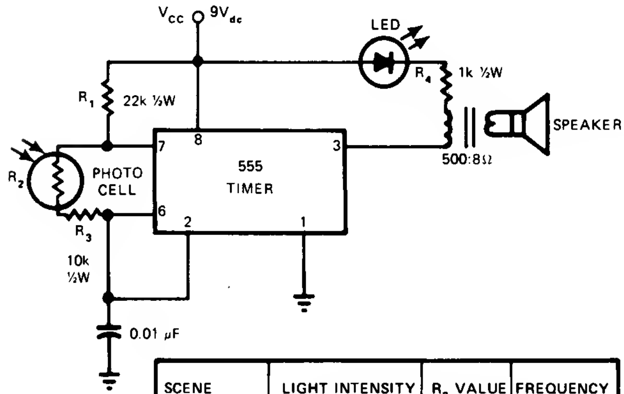


† must return to ground via low-impedance dc path.

10-Hz LOW-PASS—Filter design for biomedical expariment has 10-Hz cutoff, tolarable transiant and ovarshoot response, and at laast 30-dB rejection of all frequencias abova 15 Hz. All componants should have 2% tolerance.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 147.

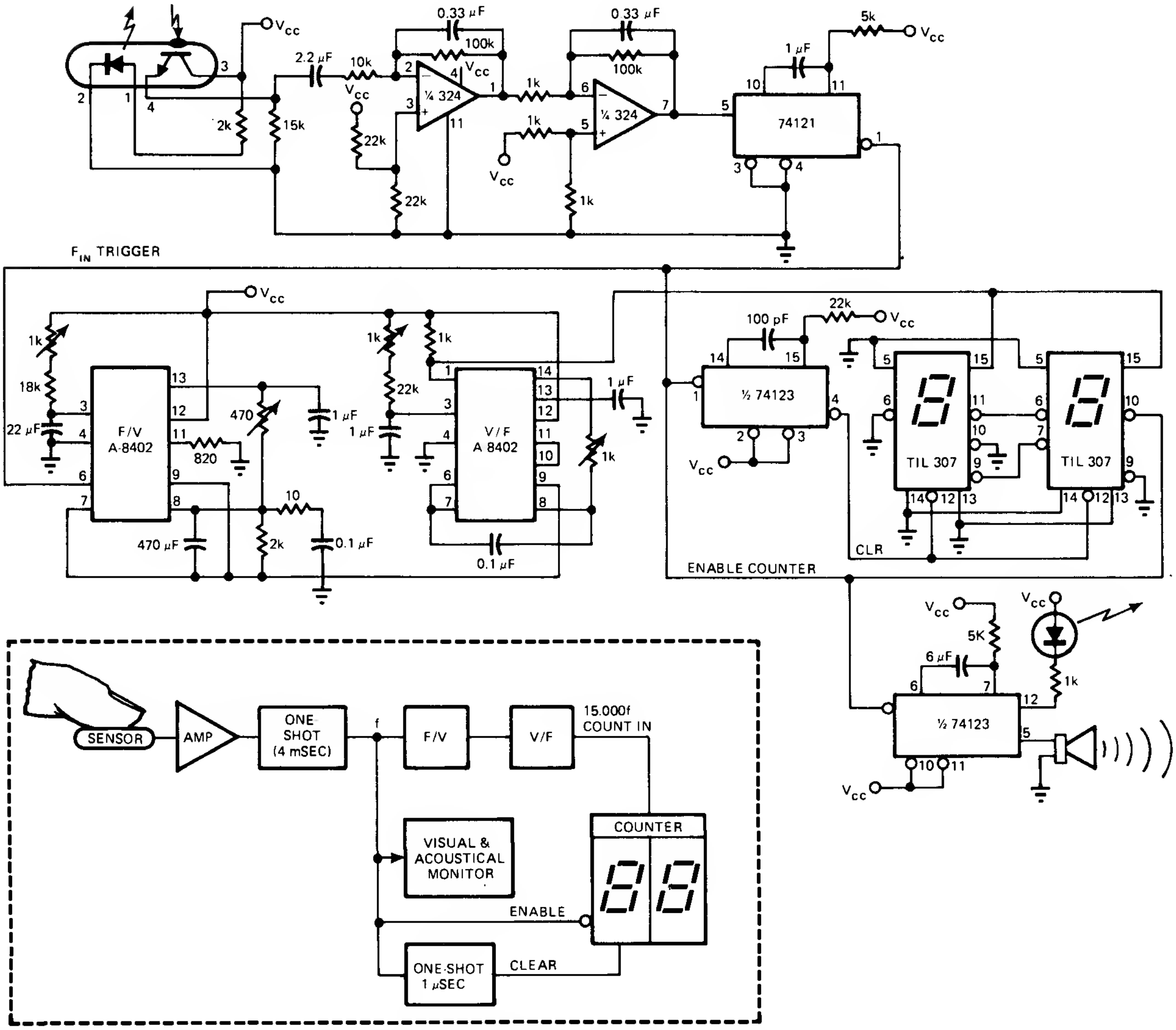


UART FOR EKG RELAY—After electrocardiogram is converted to digital form by commercial A/D converter, circuit shown takes 8-bit word output of convarter for processing by universal asynchronous receivar-transmitter (UART) to giva raquired sarial asynchronous coda for transmitter of satallita relay system, with start, stop, and parity bits added to data under control of 19.2-kHz extemal clock. This serial output is then used to control FSK oscillator that switches between two discrete audio frequencias to give signal required for transmission through satellita. Article covars oparation of UART in detail.—D. Nelson, Medical Data Relay via Oscar Satellite, *Ham Radio,* April 1977, p 67–73.

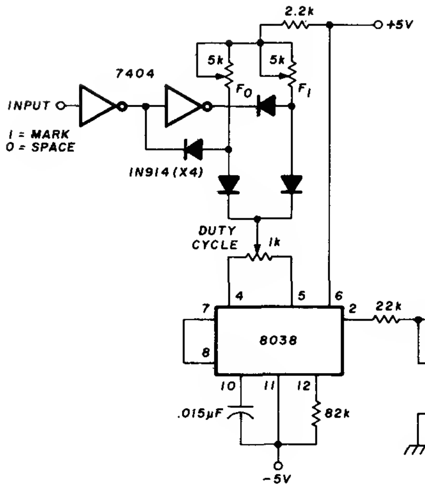


SCENE	LIGHT INTENSITY	R_2 VALUE	FREQUENCY
8RIGHT SUN	10^4 CANDELA/m^2	100Ω	6500 Hz
DUSK	10^0	10k	3000 Hz
STARLIGHT	10^{-4}	10M	2 - 4 Hz

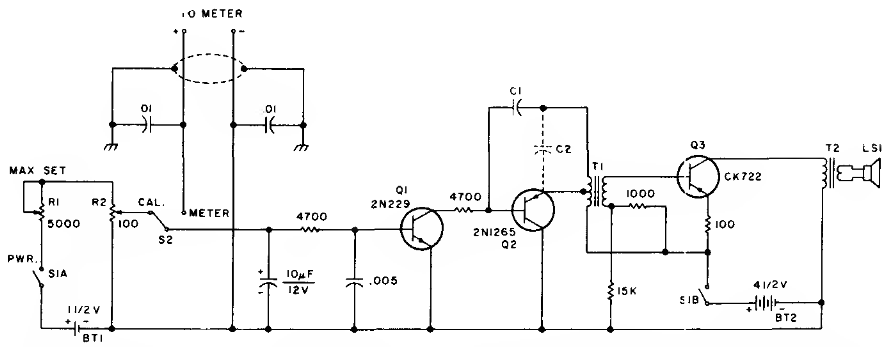
LIGHT-SENSITIVE OSCILLATOR—Uses 555 timer connected so frequancy increases directly with intensity of light. Free-running frequency end duty cycle of timer opereting in astable mode are controlled by two resistors and one capacitor. R_3 sets upper frequency limit et about 6.5 kHz, end dark resistance of photocell R_2 sets lowar limit et ebout 1 Hz. Loudspeeker provides eudio output, while LED fleshes for visual indication when frequency goes below about 12 Hz. Applicetions include detection of lightning flashes, usa es optical radar for blind, and use es sunrise alerm.—C. R. Graf, Build e Light Sensitive Audio Oscillator, *EDN Magazine,* Aug. 5, 1976, p 83.



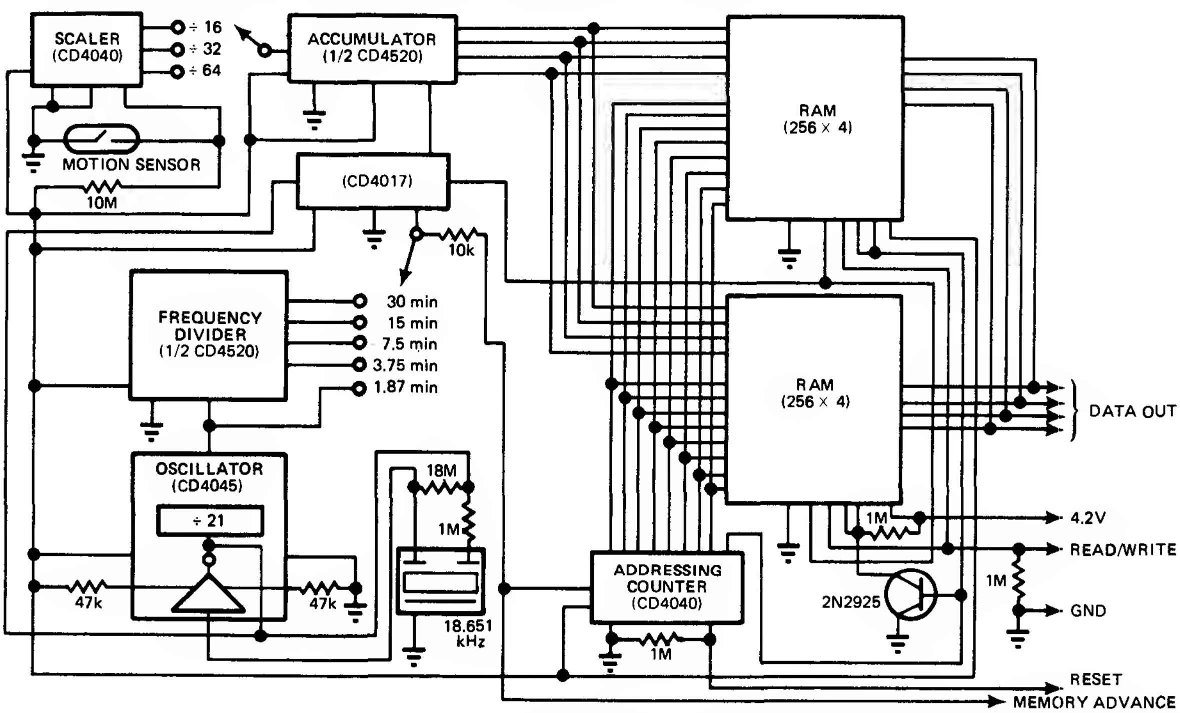
HEART-RATE MONITOR—Measures instantaneous frequency of such slow signals as heart beats (1 Hz) or 33-rpm motors (0.5 Hz) by measuring period T and inverting thet quantity to obtain f. Operates from single 5-V supply for portable operetion. Fest rasponse time gives reading of heartbeat rete on digital display in two or three pulses. Optoisoletor serving as sensor cen ba teped to almost any part of body because it rasponds to reflectivity changes caused by changing blood pressure. Accuracy is neer 1%.—G. Timmermann, Haartbaat-Rate Monitor Captures VLF Signals, *EDN Magazine* Oct. 20, 1977, p 79–80.



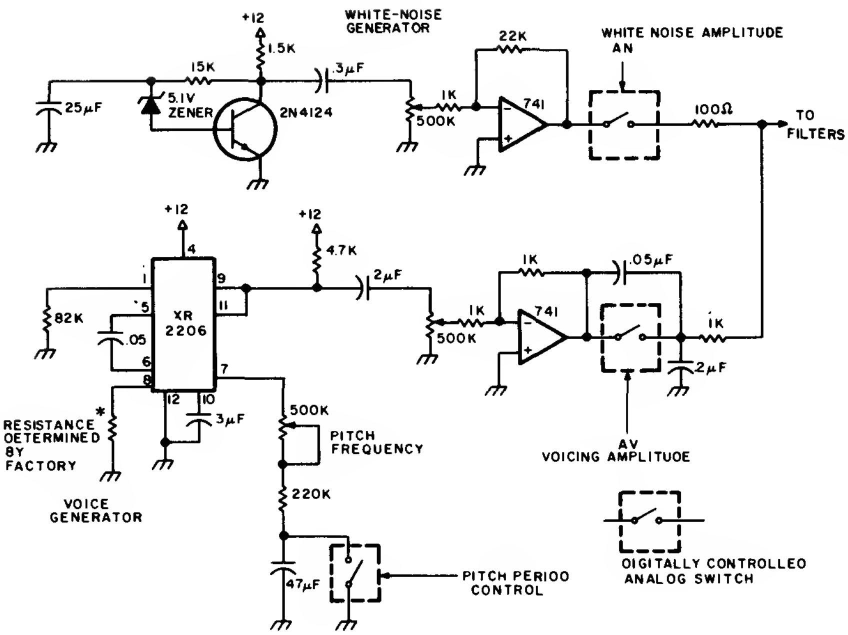
FSK OSCILLATOR FOR EKG RELAY—Used in satellite system for raleying alectrocerdiograms in digitel form. Input consists of 8-bit words obteined in sarial form from universal asynchronous receiver-transmitter. Uses 8038 function generator thet is switched batwaan two edjustabla trimmar resistors giving indapandently edjustebla discreta audio frequancias for merk end spece. Output is phase-coherent even though switching doas not necessarily take place at zero-crossing points of sine weva. Operation is much like thet of FSK RTTY.—D. Nelson, Medical Data Raley via Oscar Satellite, *Ham Radio,* April 1977, p 67–73.



AUDIBLE METER READER—Analog meter terminals era connected to input of DC emplifier Q1 for feeding audio oscillator Q2 and output amplifiar Q3. Frequancy of oscillator is directly proportional to reeding of meter. At calibrata position of S2, DC emplifiar is fed by voltege dlvider R1-R2 end R2 is edjusted until tones haard era identical for both positions of S2. Developed for use by blind person. Knob of R2 sweaps ovar larga scale heving markings in Braiila for reeding of settlng at which tones metch. Altematively, R2 can be praset to desired reading and equlpment under test adjusted to give tone metch. Article covers construction and calibration. C1 is chosen in renga of 0.002 to 0.1 μF to giva dasired minimum frequency. C2, if required, is in same renga. T1 is transistor drivar transformar (10,000 to 2000 ohms), end T2 is transistor output transformer (500 to 3.2 ohms).—N. Rosanbarg, Tune-Up Aids for the Blind, *73 Magazine,* Fab. 1978, p 64–67.

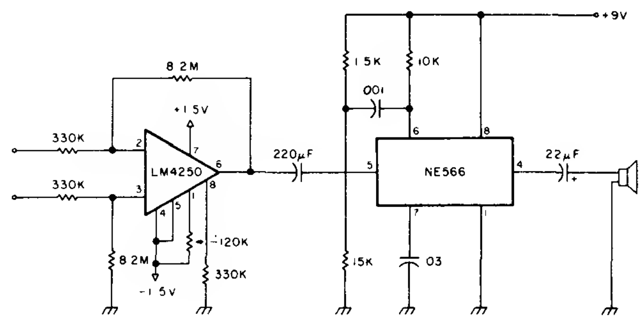


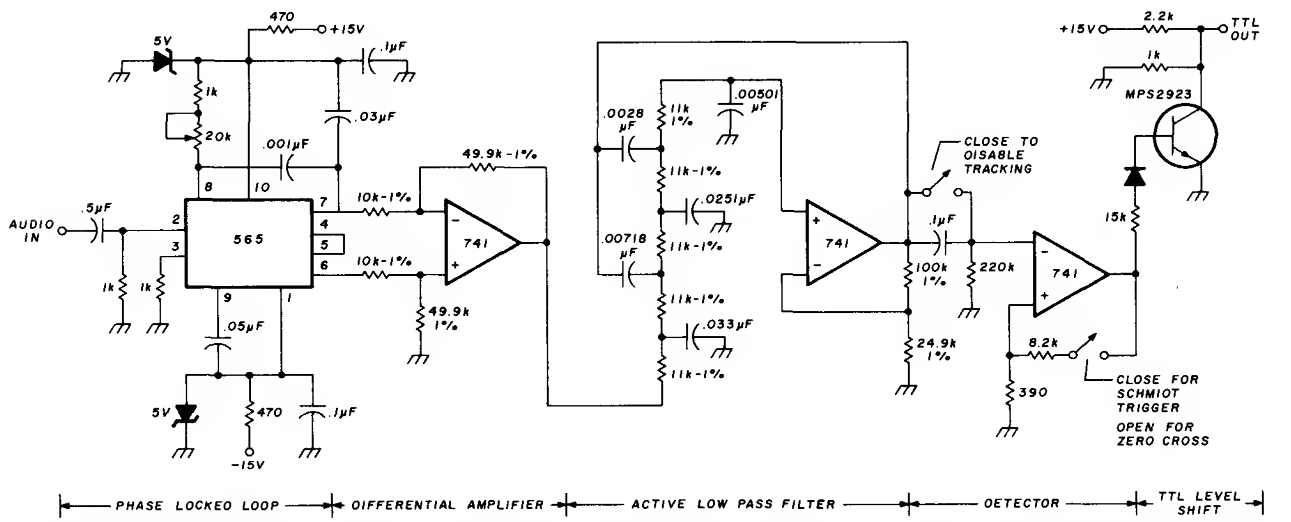
JOGGER DATA COLLECTION—Portable data acquisition system using microcomputar to drive digital cessette tepe transport operates from 12-V rechergeeble battary and fits In backpeck having total welght of only 8 lb. Sample rate cen ba set betwaen 20 end 100 Hz, with 2 min of continuous date being stored at fast reta. Recorded deta is pleyed into PDP-11 minicomputer latar for analysis. Motion sensor shown can ba replaced by other types of transducers for measuring desired physiological phanomane during jogging, walking, or running.—P. G. Schreier, Physiological Dete Acquisition Presents Unusual Problems, Solutions, *EDN Magazina,* Juna 20, 1978, p 25–26, 28, and 30.



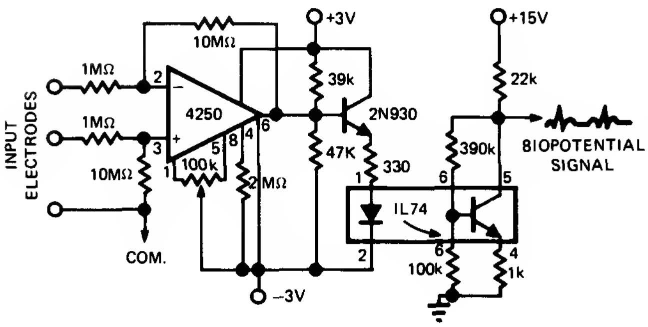
SPEECH SYNTHESIZER—Based on analog simulation of vocal trect. Rush of eir through vocal pessages Is simulated by white-noisa ganarator, while ection of larynx is simulated in lower brench of circuit. Article covers problems involved in echieving trensitions from phoneme to phoneme, along with automatic amphasis of leading or terminating consonents end intonation of rhythm associated with importanca or placement of word in speech. ASCII symbols ere given for 33 phonemes genereted in Ai Cybernetic Systams model 1000 speech synthesizer, which uses circuit shown in combination with 10 active filters composed of 15 opemps, vocal excitation circuits, ASCII charecter decoders, and phoneme memorias.—W. Atmar, Tha Tima Hes Come to Talk, *Byte,* Aug. 1976, p 26–30 and 32–33.

EKG TELEMETER—Developed for experimantation or aducational damonstrations in which audiance listens to electrocardiograph signal voltage as fed through LM4250 opamp for modulating NE566 connected es VCO driving smell loudspeaker. Acoustic output can be picked up by microphone for telemetry purposes if desired. Connection to petlent cen ba made with standerd edhesiva monitoring electrodes or with smell metal disks held on wrists with rubber bends. Tone shifts frequency with eech pulsa baet.—M. I. Laavay, Inexpansive EKG Encoder, *73 Magazine,* Feb. 1978, p 20–23.



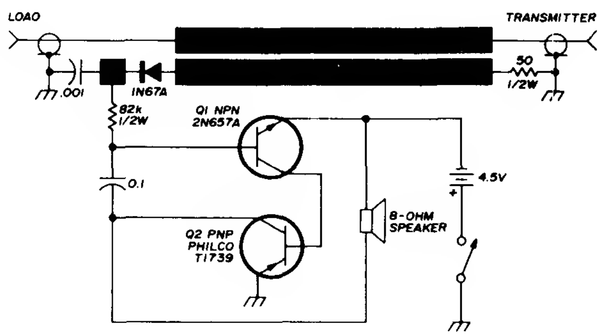


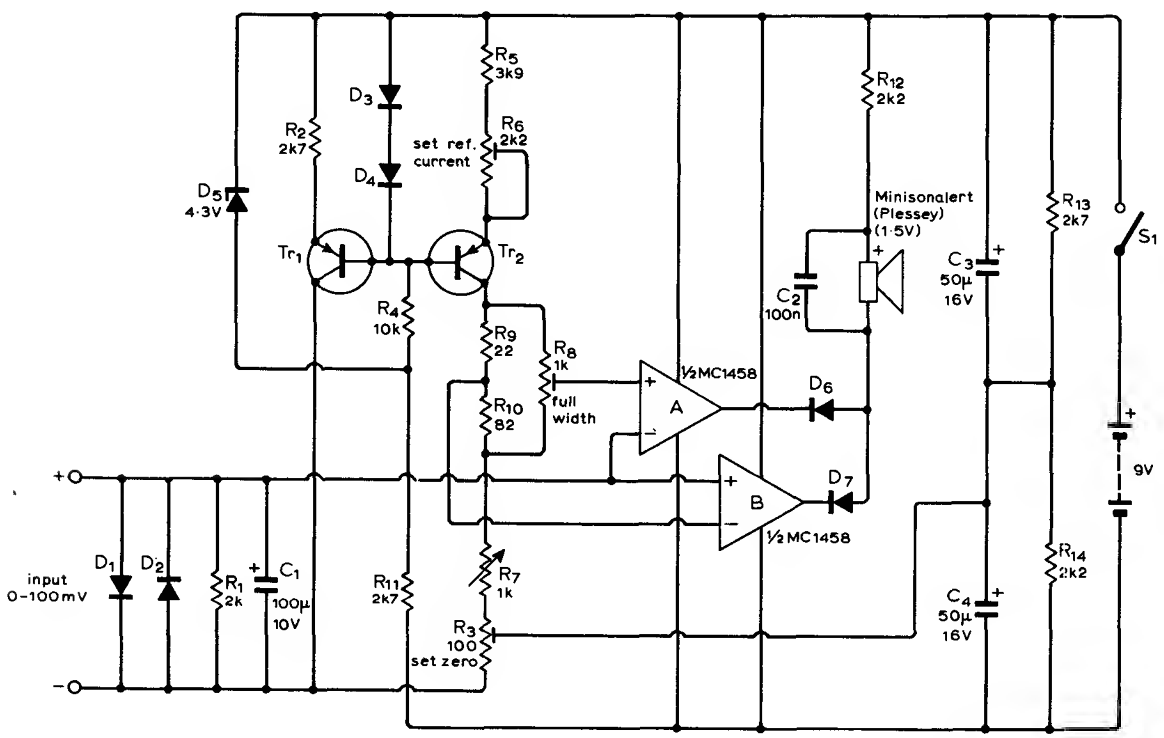
FSK DEMODULATOR FOR EKG RELAY—Used at raceiving end of satellita systam for relaying EKGs, to convert raceived audio FSK signel to TTL level-shifting output from which originel EKG can be obtained. Phase-locked loop trecks input signel frequency end feeds approprlate arror signel through differantial emplifier to five-pola Butterworth low-pass filtar heving 1500-Hz cutoff. DC offset is removed by capacitor coupling, for use in zero-crossing detector or Schmitt-trigger detactor. Signel is naxt converted into TTL-compatibla level. Recorded output could not be distinguished from original EKG by doctors.—D. Nelson, Medical Date Relay vie Oscar Satellite, *Ham Radio,* April 1977, p 67–73.



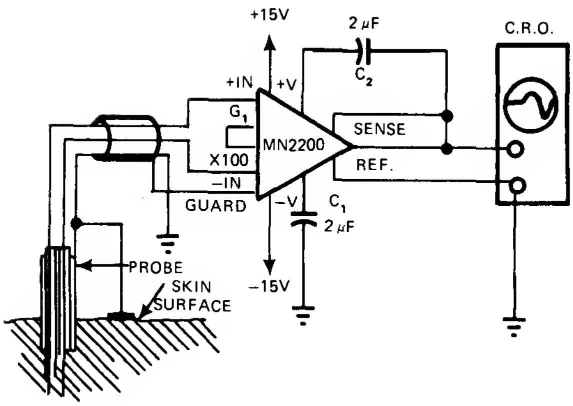
ISOLATED PREAMP—Optoisolator in electrocardiograph preamp circuit pravants circulating ground currents from shocking patiants undar tast. Can be used with practically ell other typas of AC line-operated aquipmant in medical anvironmants.—R. R. Ady, Lat's Take en Illuminating Look at Latest Davalopmants in LED's, *EDN Magazine*, Aug. 5, 1975, p 30–35.

AURAL SWR INDICATOR—Parmits blind amateur radio oparator to chack standing wavas on transmission line and adjust for best possible impedance match between source and load. Darkened areas ara foil strips 6 × 70 mm, 1.5 mm apart, forming inductive trough that transfars RF energy from transmission line to simple aural monitor. Rectified RF anargy chenges bias on base of Q1, which makas tone increasa in pitch with incraasing voltage. Idling tona is about 500 Hz for valuas shown. Operatas from three penlight battaries. Transmittar is paaked for maximum output on rising pitch, and matchbox antenna tunar is adjusted for minimum SWR on descanding pitch. To lowar audio tona, increase siza of 82K resistor.—C. G. Bird, Aural SWR Indicator for tha Visuelly Handicappad, *Ham Radio*, May 1976, p 53–53.

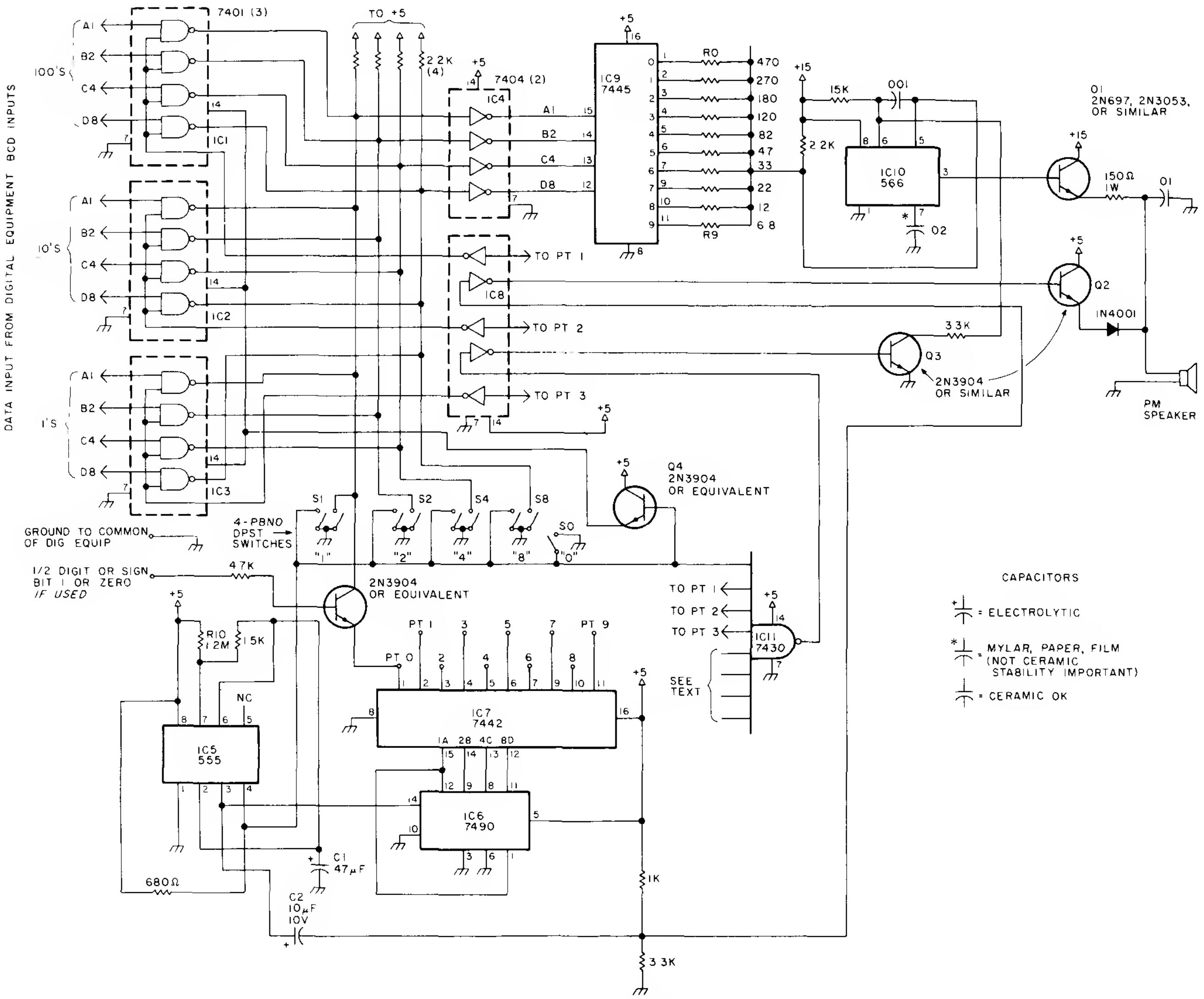




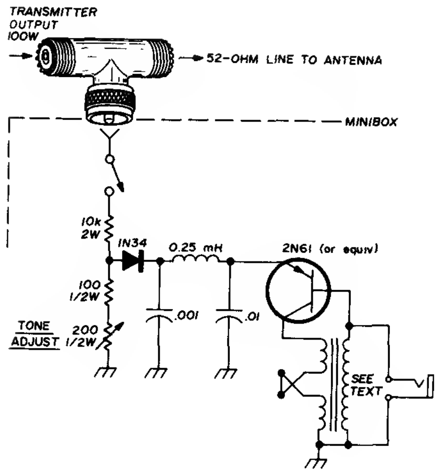
MULTIMETER FOR BLIND—Uses small alectric horn to produce sound when DC voltaga baing maesured is different from referanca voltage valua determined by setting of lineer wirawound pot R_7. Blind parson adjusts R_7 for null in sound, then reads Braille dots for that setting to get value of voltage being maasured. Use PNP silicon transistors, such as BC177 or BC187. D_5 is 4.3-V 400-mW zener, such as BZX79/C4V3. Other diodes ara small-signel silicon, such es BA100 or 1N914A.—G. P. Roberts, Multimetars for Blind Students, *Wireless World*, April 1974, p 73–74.



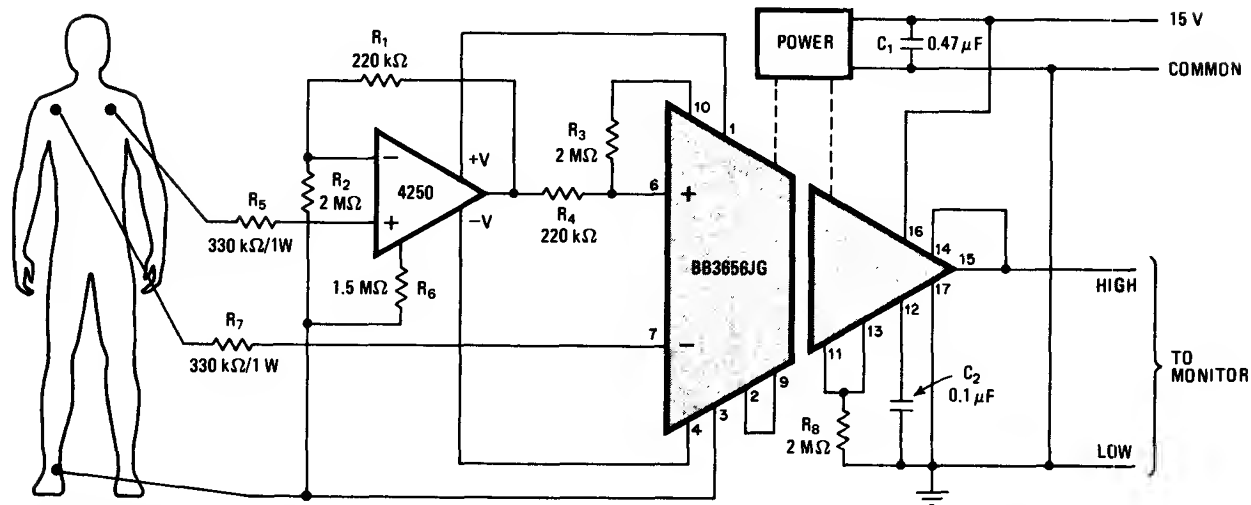
BIOELECTRIC VOLTMETER—Used to measure bioelectric phenomena involving both DC and waveform characteristics with amplitudes of about 10 mV. Since electrodes have impedance of 20,000 to 100,000 ohms, guard terminal must be used to drive input shield. Bias-current return comes from ground plate on skin. Fixed gain of 1000 gives absolute measure of input-voltage magnitude.—R. Duris, Instrumentation Amplifiers—They're Great Problem Solvers When Correctly Applied, *EDN Magazine*, Sept. 5, 1977, p 133–135.



TONE OUTPUT FOR DIGITAL DISPLAY—Converts BCD input from digital test gear to sequence of 10 different tones representing 0 to 9, for recognition of reading on digital display by blind radio operator or experimenter. Length of tone sequence equals number of digits displayed, plus sign indicator or half-digit if desired. Circuit shown is for 3½ digits. Article describes operation of circuit and gives construction details. Resistors R0-R9 (values in kilohms from 6.8K to 470K), determining frequencies of generated tones, are switched into VCO IC10 by IC9.—D. R. Pecholok, Digital to Audio Decoder, *73 Magazine*, Oct. 1977, p 178–180.



AUDIBLE TUNING FOR BLIND—Trensmittar or exciter output is sampled et coax line and high-resistence voltege divider. Rectified voltage of dividar, which varies during transmittar tuning, is fed to ralaxation oscillator whose output varias in pitch with voltage; low voltage glves hlgh-pitched tone, and high voltega gives low-pitched tone. Input divider drews about 1 W from 100-W transmittar; for higher powar, such es 1 kW, chenge 10K to ebout 100K. Diode faeds ebout 2 V to amitter of transistor. Any audio-typa PNP transistor can be used. For NPN device, reverse diode connections. Transformer is from 5-W trensistor emplifier, with 22-ohm high-impedance winding. Other two windings, in series eiding, ere 4 ohms eech.—D. H. Atkins, Tuning Aid for the Sightless, *Ham Radio,* Sapt. 1976, p 83.

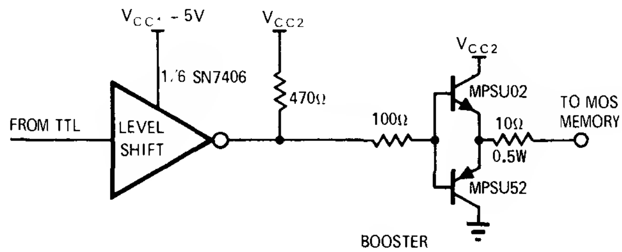


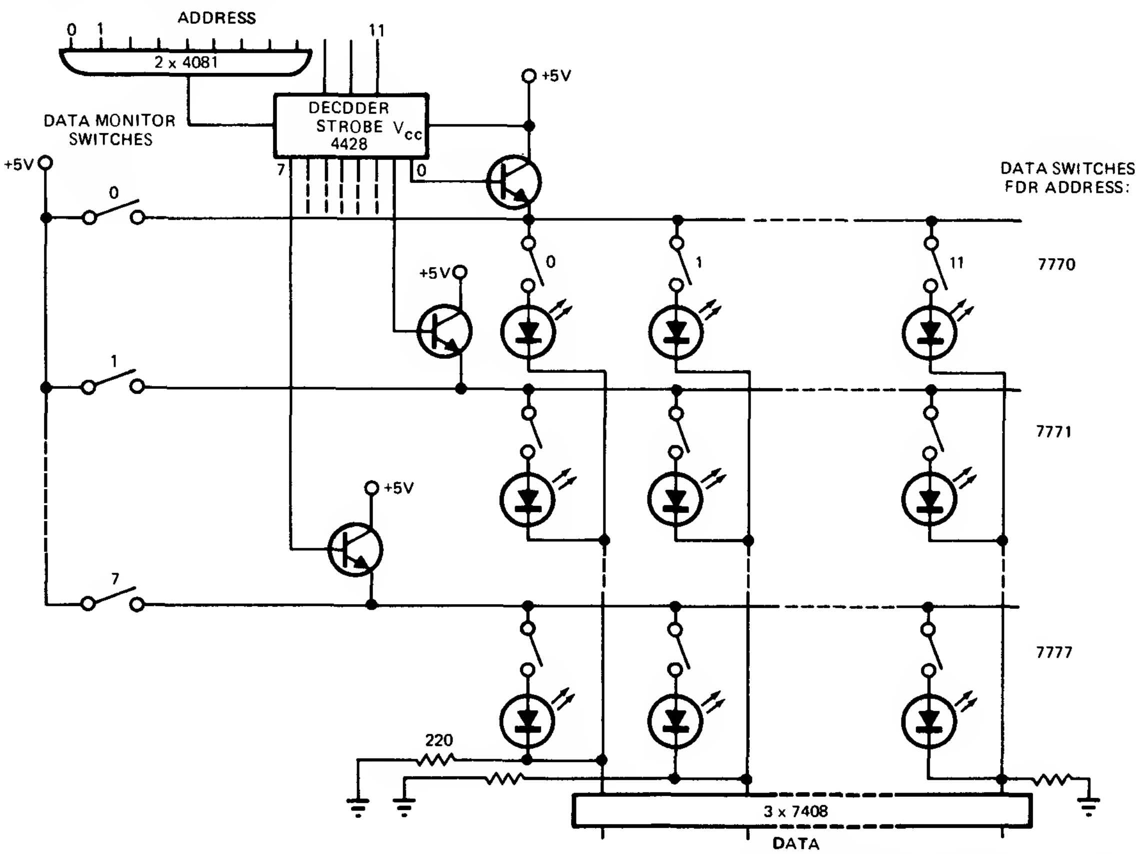
HEART MONITOR—Electrocardiograph amplifier usas Burr-Brown BB3656 isolation amplifiar to protect electrocardiograph from inedvartant applications of defibrillation pulses whila patient is being monitored. Heart pulses are accuretely amplified over frequency renge of DC to 3 kHz. Resistors must be carbon-composition types.—B. Olschewski, Unique Transformer Design Shrinks Hybrid Isolation Amplifiar's Size end Cost, *Elactronics,* July 20, 1978, p 105–112.

CHAPTER 50
Memory Circuits

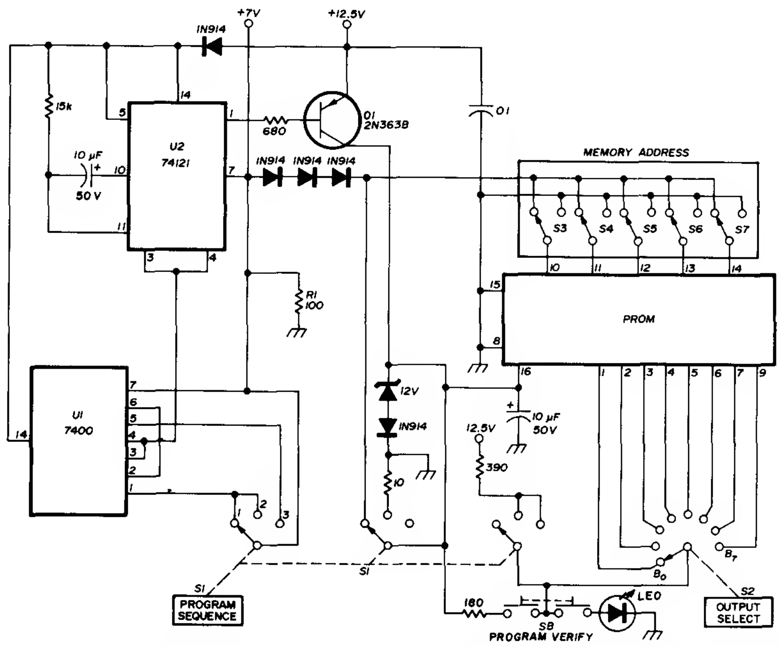
Includes circuits for read, write, refresh, one-time programming, and interfacing various types of microprocessor memories, LED display showing PROM status, wave synthesizer, punched-card converter, and addition of memory capacity to calculators. See also Microprocessor chapter.

LEVEL SHIFT WITH IC—Level shifter for dynemic MOS rendom-access memory uses SN7406 IC with two-transistor booster to convart TTL levels to MOS levals. Boostar can be omitted for data input lines because thay drive such low capecitive loads in typical arrays.—M. E. Hoff, Designing en LSI Memory Systam That Outperforms Cores—Economically, *Computer Hardware* (section of *EDN Magazine*), Jen. 15, 1971, p 6–15 (p 000110–001111).

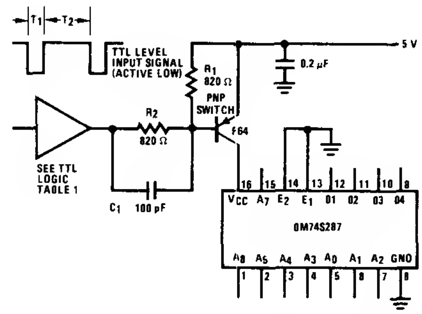




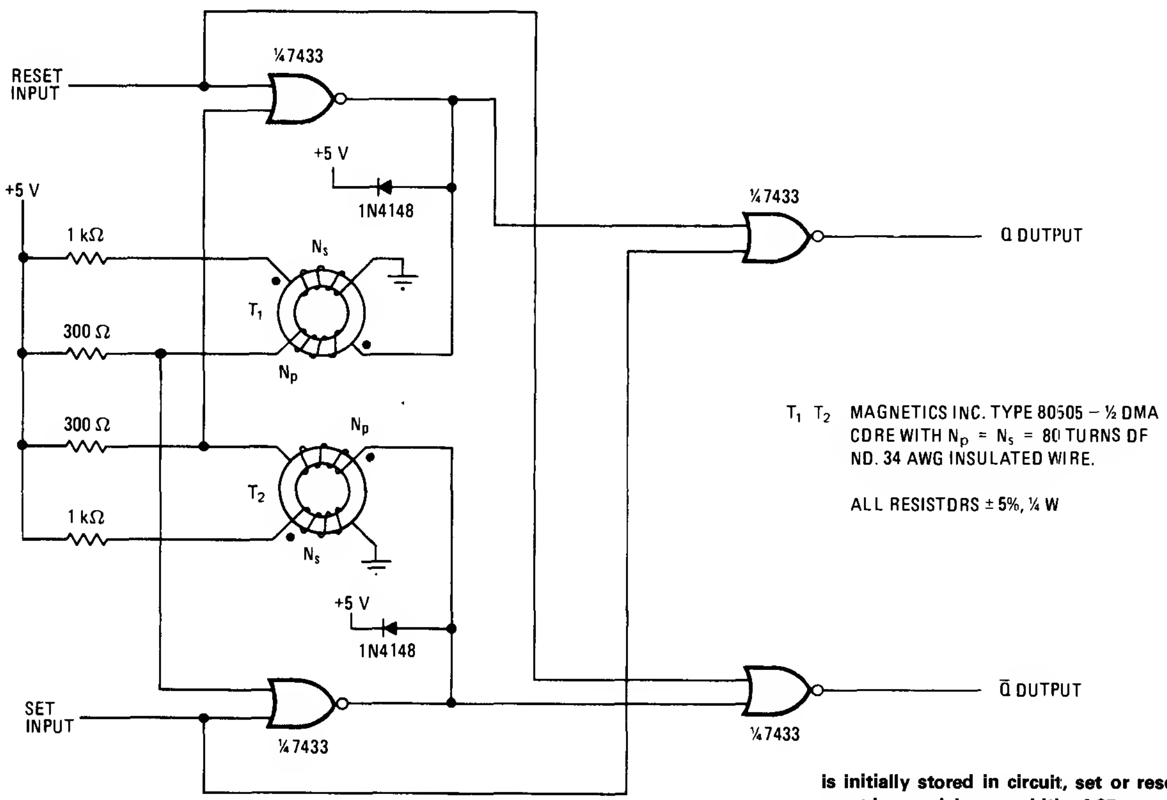
PROM WITH LED DISPLAY—Developed for use in debugging smell microprocessor systems. Uses LEDs in place of diodes es OR getes of 8 × 12-bit dioda matrix memory which displays mamory-cell contant when word is addressed during execution of a program. Monitor switches can ba used for data display when program is inserted. System was built to debug Intersil IM6100 μP. Since voltaga output of dioda array is too small for direct input to MOS circuit, 7408 gates ere used to boost high-level output. Articla gives instructions for usa of display.—K. S. Hojberg, Light-Emitting Memory Aids μP Debugging, *EDN Magazine*, May 5, 1977, p 107.



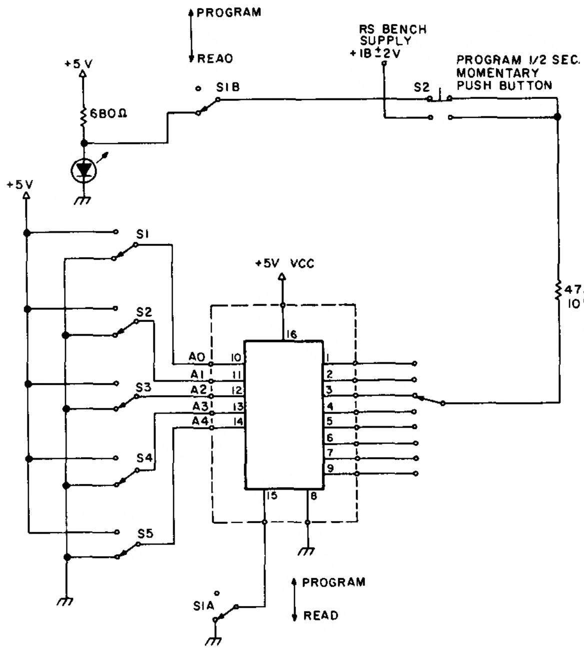
PROGRAMMER FOR SIGNETICS 8223—Bounceless switch U1 triggers mono MVBR U2, both opereting et 7 V above ground. When Q1 is setureted by pulse from U2, it epplies 250-ms 12.5-V programming pulse to V_{CC} terminal (pin 16) of memory chip end opens fuse at previously addresaad bit to make it logic 1. Separeta regulators ere required for 7 V and 12.5 V. Used with alphameric displey having five 7-segment digits in circuit serving as function/units indicetor for intervel timer/counter, whare it forma simuletion of ebbreviations for time and frequency units. Article gives step-by-step instructions for misteka-free operetion of progremmer.—J. W. Springer, Function/Unita Indicetor Using LED Displeys, *Ham Radio,* March 1977, p 58–63.



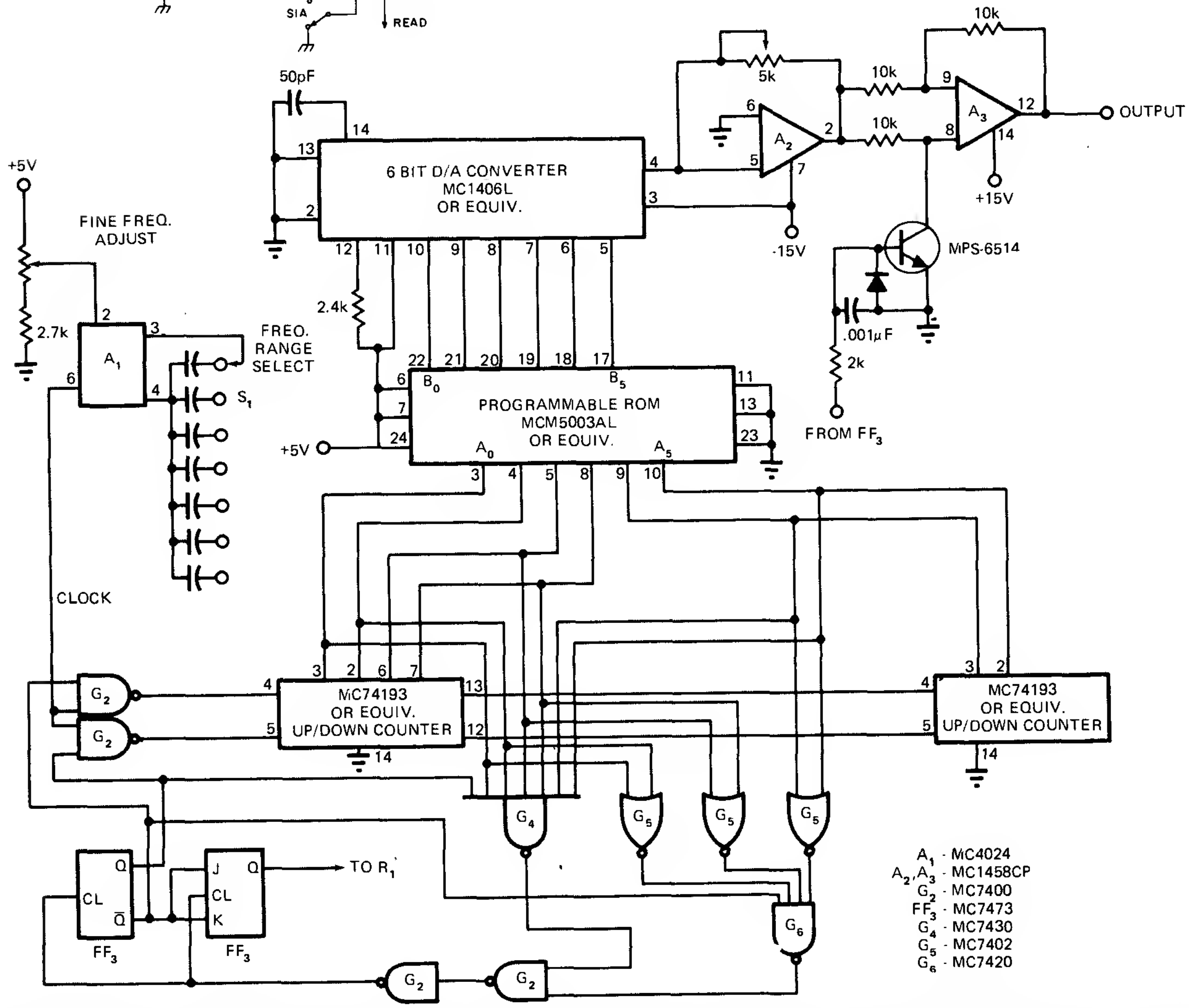
PROM POWER-DOWN—Conserves powar in applications when data is required from PROM for only small parcentega of system cycle. Circuit tums PROM off eutometicelly when not naeded, with accass time increased only by 60-ns deley of powar-down circuit. PNP switch can be PN4313 or 2N3467 pess tranaistor. With two 74S04 sections in saries et input, ective low selection is obteined. 74S00 et input gives ective high selaction. When logic input to R_2 goes low, PNP switch is turnad on end +5 V is epplied to National DM74S267 256 × 4 PROM.—"Memory Applicationa Handbook," Nationel Samiconductor, Sante Clara, CA, 1978, p 5-9–5-12.



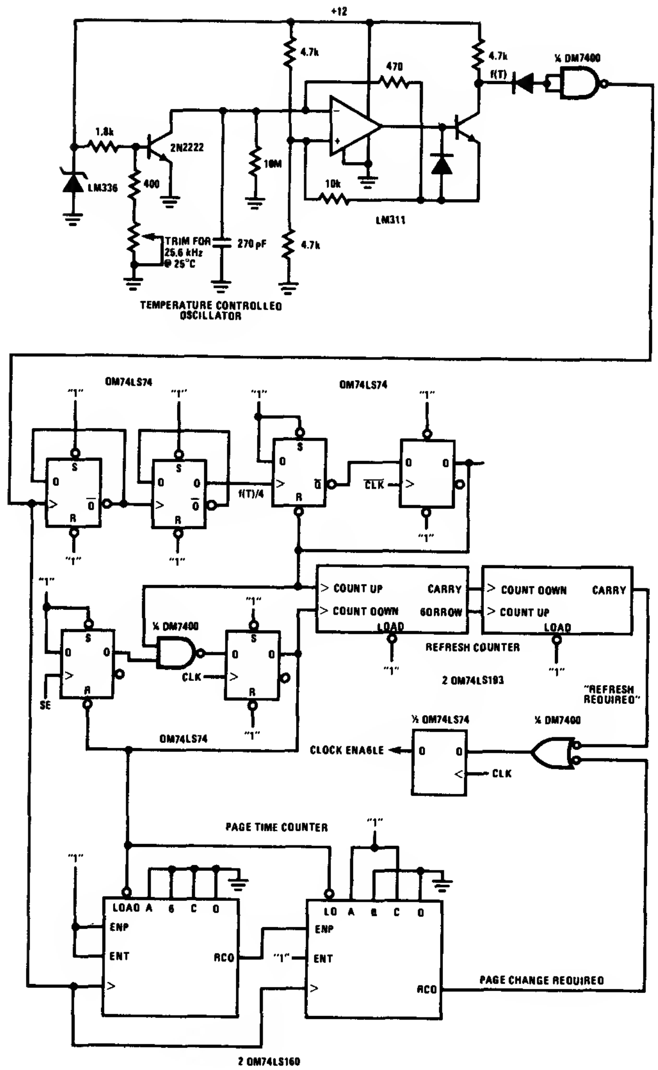
LATCH MEMORY—Use of satureble transformers mekas memory nonvolatile and immuna to false command signels. Transformers stey megnetically biased without voltage supply to provide reference atate to which memory latch returns whan powar is raapplied. Whan bit is initially stored in circuit, set or reset pulse must have minimum width of 35 µs end minimum separation of 65 µs.—G. E. Bloom, Setureble Core Trensformers Herden Latch Memories, *Electronics,* March 31, 1977, p 104–105.



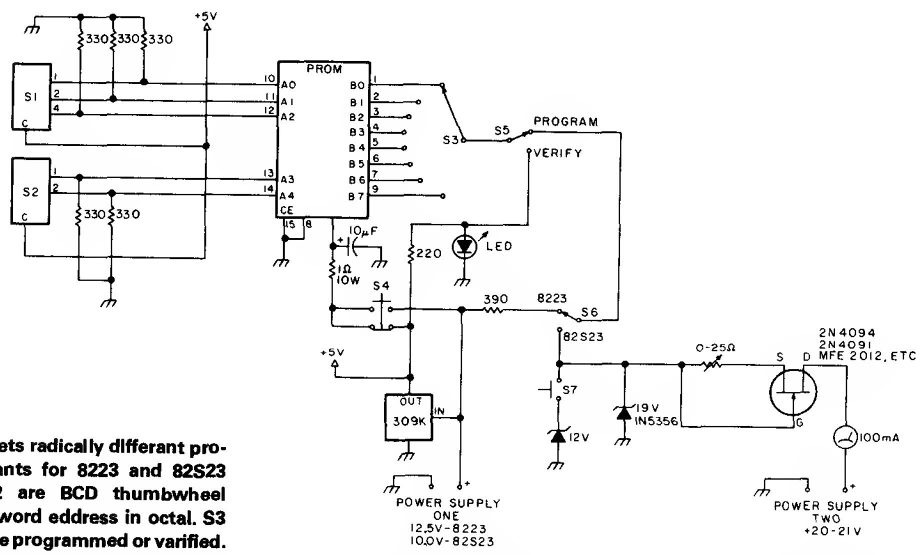
PROGRAMMING OF PROM—Simple circuit is effective for 82S23, DM8577, end 74188 PROMs. With DM8577, circuit changas logic 1s to 0s. With 82S23, 0s are changed to 1s. Set addrass switches for word to be programmed, set S1 to progrem position, set S3 to bit to be programmed, and push S2 momantarily (lass then 0.5 s). To varify thet bit hes been programmed, raturn S1 to read position and obsarve LED. Supply can be three 6-V lentarn batteries in series.—Ham Halp, *73 Magazine*, April 1977, p 42.



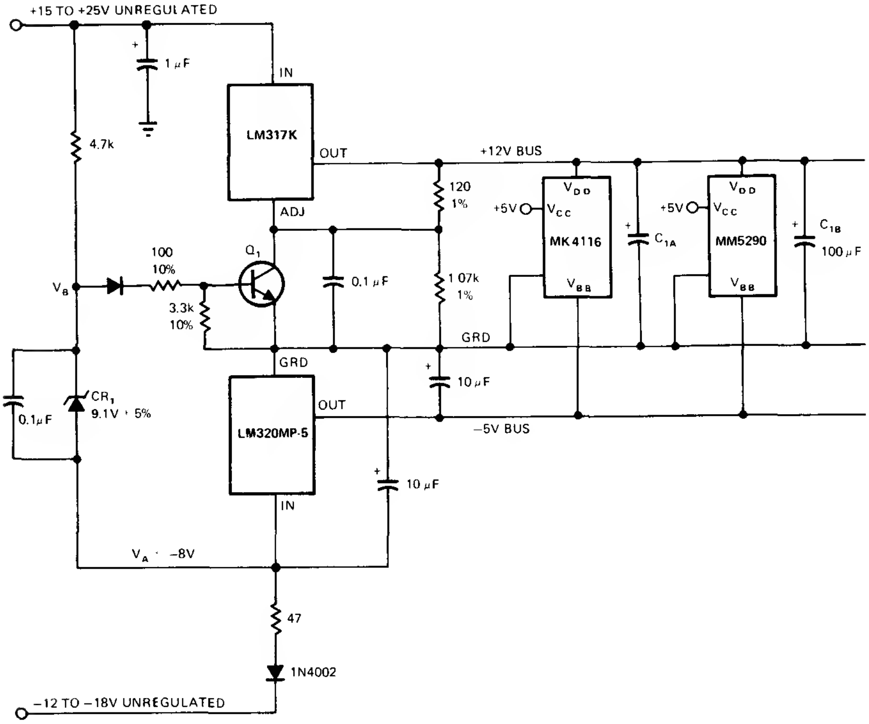
WAVE SYNTHESIZER—Virtually any symmetrical waveform can ba genaratad by using only IC counters, e read-only mamory, end a monolithic D/A convertar. Only first 90° of waveform need be digitized; this information cen be menipulated to generate other 270° and repeated as oftan as necassery. To digitiza desired waveform, divide first 90° into 64 points, calculate sine or other function for eech, multiply eech result by 63 to normaliza, round off, convart each to 6-bit binary equivalant, taka complements, end use results for programming ROM. Article describes operation of circuit in detail. Use of MC1480 8-bit monolithic D/A converter gives better resolution than is possibla with MC1406L 6-bit D/A converter because 8-blt words give 256 discrate output levels instead of 64.—K. Huahna, Programmabla ROMs Offer a Digital Approach to Waveform Synthasis, *EDN Magazine*, Aug. 1, 1972. p 38–41.



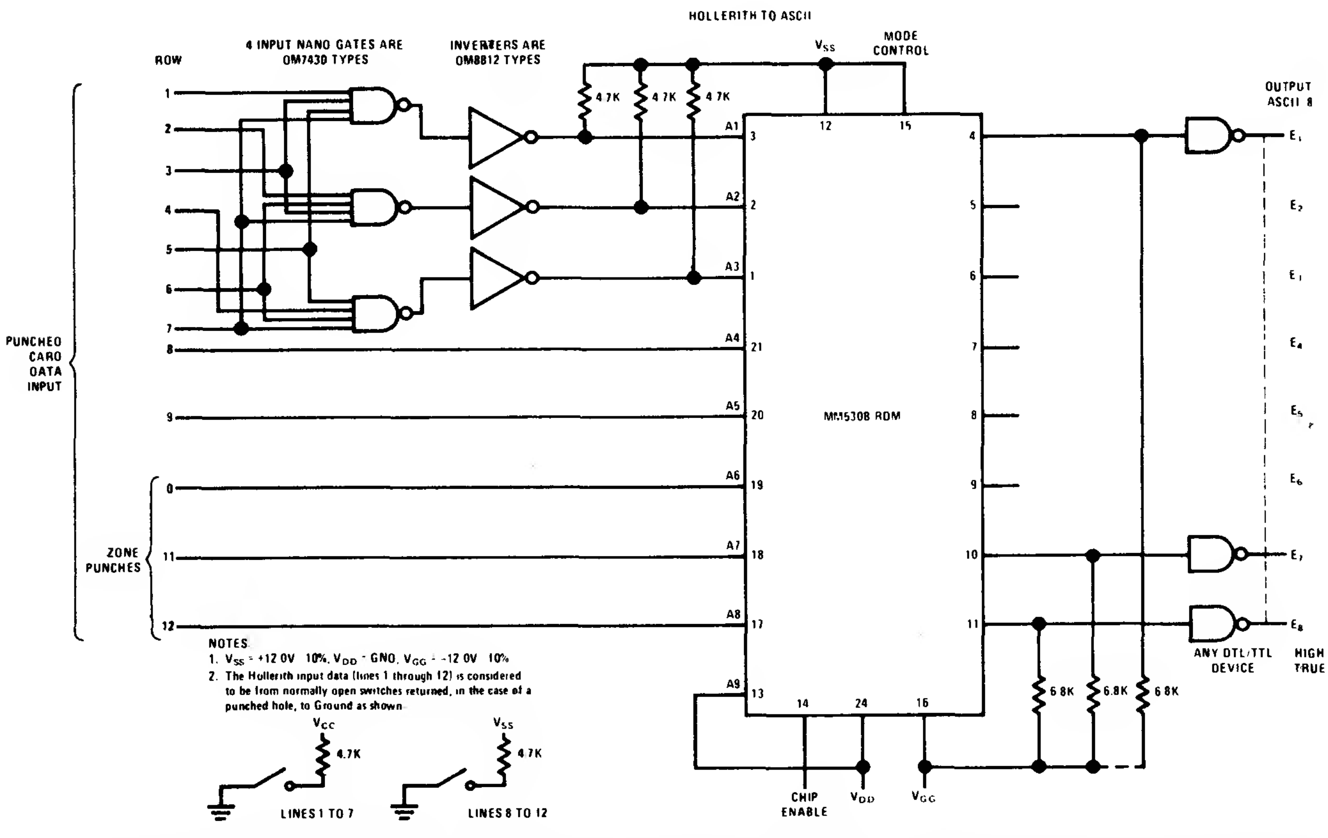
ADAPTIVE REFRESH—Circuit monitors systam utilization of Netional MM2464 64-kilobit charge-coupled davice (CCD). Refresh time end maximum page times are datermined by two counters that obtain clock signals from temperature-controlled oscilietor.—"Memory Applications Hendbook," National Semlconductor, Santa Clere, CA, 1978, p 7-1–7-10.



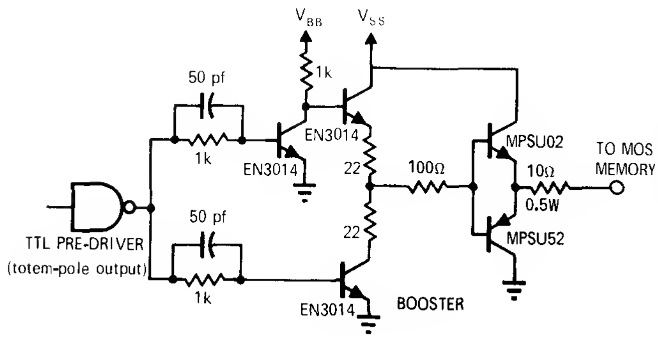
PROM BURNER—Meets radically dlfferant programming requiremants for 8223 and 82S23 PROMs. S1 and S2 are BCD thumbwheel switches thet select word eddress in octal. S3 selects output bit to be programmed or varified. S4 is pushed momentarily to burn out programmed bit, end S5 verifies programming. S6 is sat to PROM type, and S7 puts 12-V zanar ecross 19-V zener for current callbration. For 82S23, edjust power supplies to 10 and 21 V and adjust 25-ohm pot to give meter reading of 65 mA whan S7 is closed.—W. J. Hosking, Finally! A Simple PROM Burnarl, *73 Magazine*, Dec. 1977, p 186–187.



MEMORY-PROTECTING REGULATOR—Devaloped for MOS RAM in which accidantal ramoval of −5 V bias supply would allow buildup of currants flowing betwaen +12 V and ground to valua sufficiant to opan up metal paths and destroy mamory. Protection is achiaved by feeding unregulated negativa voltage to on-card local regulator using LM320MP-5 to provida −5 V regulated bias for all mamory chips. LM317K is used as +12 V regulator for dalivering up to 1.5 A. If −12 V gradually drops out of regulation, Q_1 turns on and pulls LM317K adjust pin to ground so output of this regulator drops to +1.3 V and logic circuits ara undamaged. If −12 V shorts to ground, capacitors on −5 V lina hold up for savaral hundred microseconds so Q_1 has time to turn off +12 V regulator. Usa heatsinks for regulators.—R. Paasa, Safa Supply Manages MOS Mamories, *EDN Magazine*, Oct. 20, 1978, p 82 and 84.

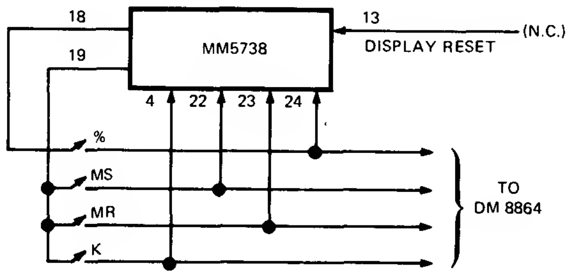


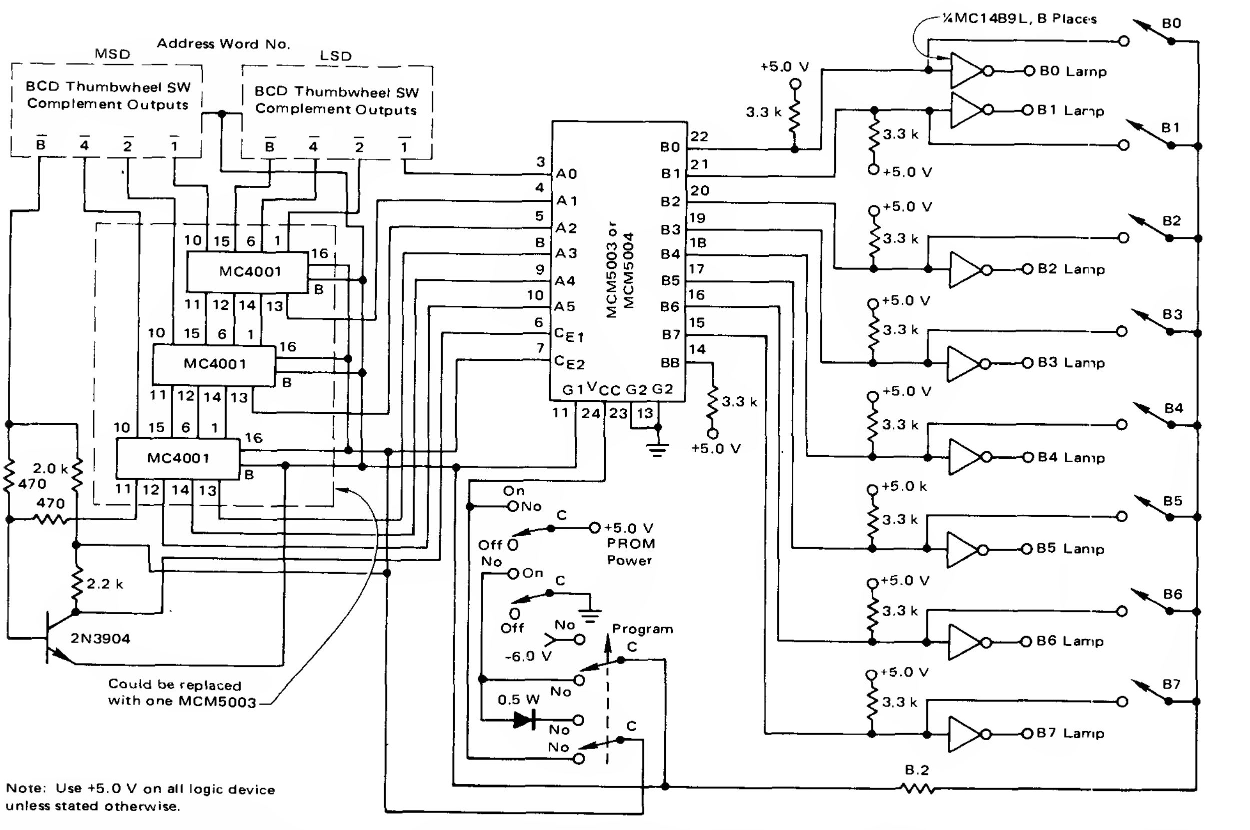
CARD CONVERTER—National MM530B ROM forms basis for convarsion of 12-lina Hollarith punched-card coda to 8-line ASCII. All 12 inputs from cards are presented to programmabla logic array (PLA). Invalid input produces all-high output stata becausa it is not racognizabla product tarm. First 7 Hollerith lines, which ara ordinary decimally coded lines, ara encoded to 3 binary lines with additional logic alements shown, befora baing presented into common 8-input ROM.—"Memory Databook," National Samiconductor, Santa Clara, CA, 1977, p 11-49–11-56.



LEVEL SHIFTER FOR RAM—Uses predriver with three transistors, followed by two-transistor booster, to convert TTL levels to those required by dynamic MOS random-access memory. Booster can be omitted for data input lines because they drive such low capacitive loads in typical arrays.—M. E. Hoff, Designing an LSI Memory System That Outperforms Cores—Economically, *Computer Hardware* (section of *EDN Magazine*), Jan. 15, 1971, p 6–15 (p 000110–001111).

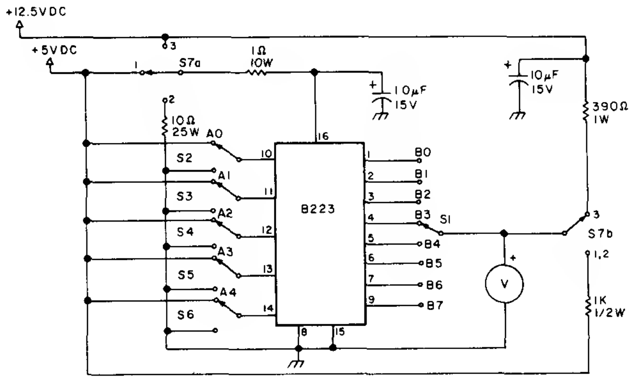
ADDING FOUR FUNCTIONS—Capability of 8-digit four-function Novus 850 calculator made by National Semiconductor (also marketed as Montgomery Ward P50) can be doubled by adding four SPST switches and connecting as shown. These provide additional functions of memory store, memory recall, percent, and constant. Switches can be put on front panel above display, at corners of battery. Cutler Hammer SA1BV20 SPST switches with SW53AA1 caps can be squeezed in.—D. Arnett, Add Memory, Constant and % to a 4-Function Calculator, *EDN Magazine*, Aug. 20, 1975, p 82.





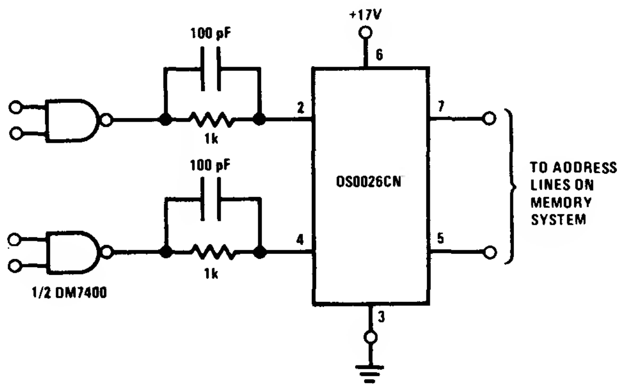
Note: Use +5.0 V on all logic device unless stated otherwise.

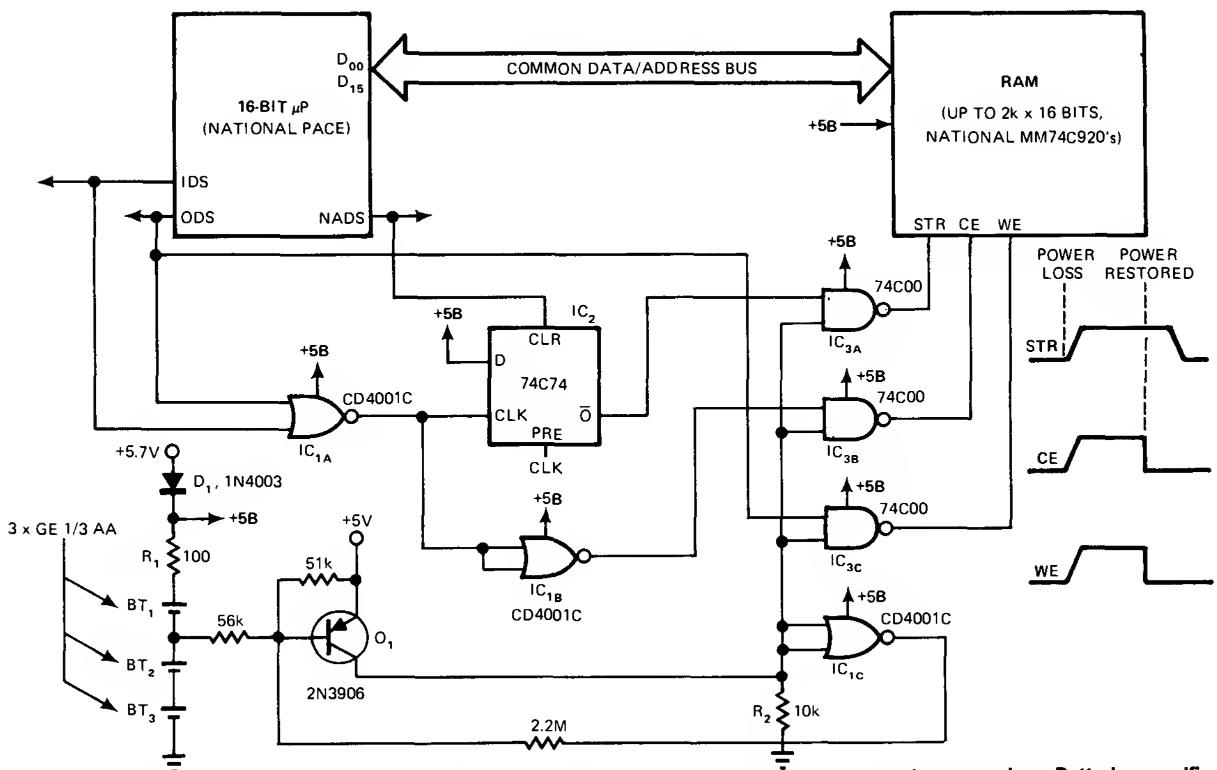
512-BIT PROM PROGRAMMER—Simple manual programmer requires minimum equipment for fusing memory links of Motorola MCM5003 or MCM5004 programmable read-only memory. One link is fused at a time. MC1489 quad line receivers show contents of output bits by driving 5-V 20-mA lamps. Address word number is selected with two BCD thumbwheel switches. Three MC4001 ROMs convert BCD code to that required at address inputs. Program/verify switch must simultaneously be set along with proper output switch for each used bit.—J. E. Prioste, "Programming the MCM5003/5004 Programmable Read Only Memory," Motorola, Phoenix, AZ, 1974, AN-550, p 4.



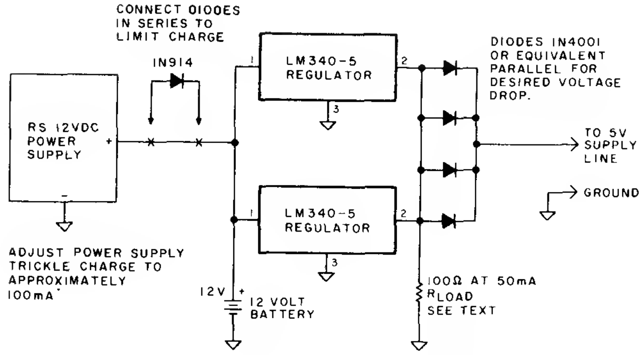
PROM PROGRAMMER—Can be used to blow links one by one, as required, on 8223 programmable read-only memory and on 82S23 Schottky version. Article covers construction, pretesting, and operation.—R. M. Stevenson, An 82S23 PROM Programmer!, *73 Magazine*, June 1977, p 82–83.

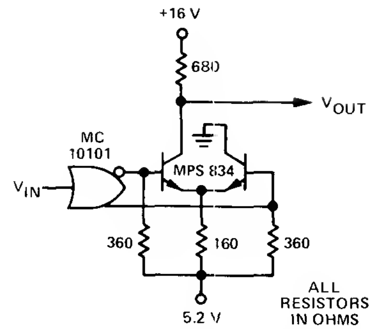
CLOCK DRIVER—Circuit uses National DS0026CN monolithic clock driver as direct-coupled driver for address or precharge lines on MM1103 RAM at frequencies above 1 MHz. Can be driven by standard TTL gates and flip-flops.—"Memory Databook," National Semiconductor, Santa Clara, CA, 1977, p 11-27–11-36.





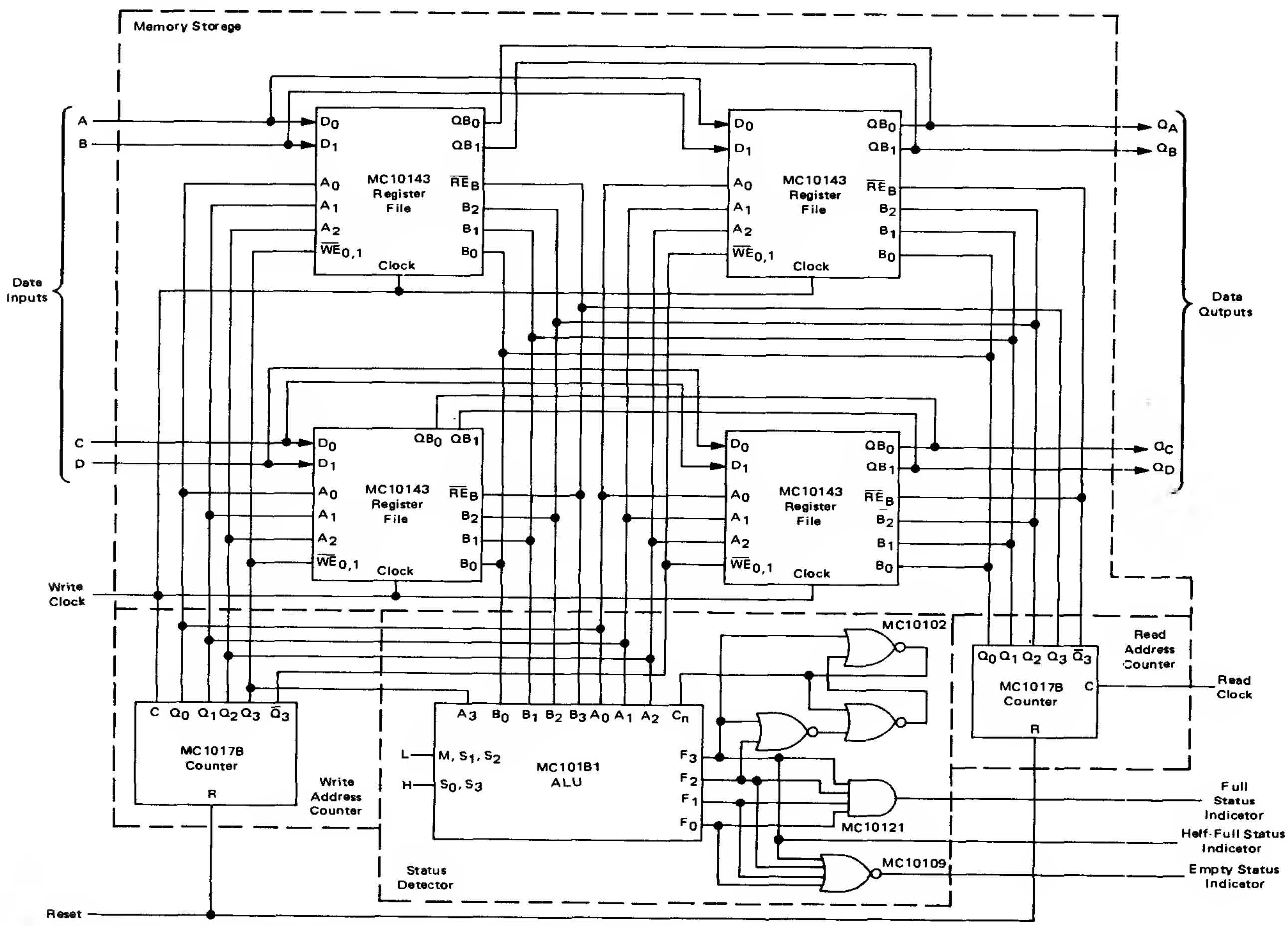
ON-BOARD SUPPLY PROTECTION FOR RAM—To prevent loss of memory data when RAM is removed from microprocessor control system during system design or maintenance, three miniature nickel-cadmium batteries are mounted directly on memory board. Data-protection circuit senses loss of 5.7-V main supply and disables STR, CE, and WE lines of RAM to prevent memory loss. Batteries specified provide protection for up to 40 days.—F. R. Quinlivan, On-Board Backup Supply Protects Volatile RAM Data, *EDN Magazine*, April 5, 1978, p 120 and 122.



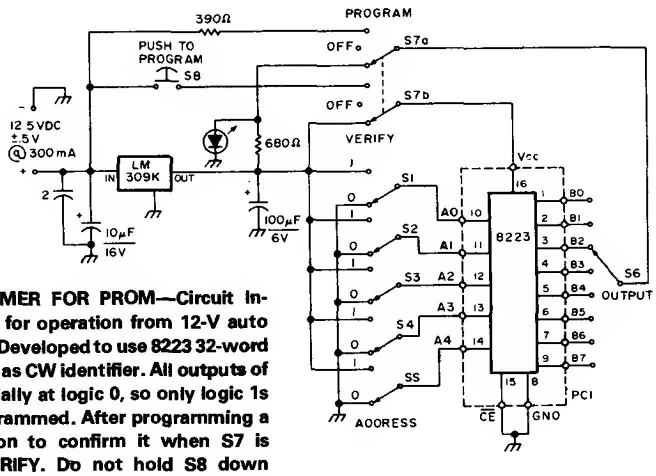


MEMORY SAVER—Standby battary takes over eutomatically during power failure to prevant mamory loss. Use eny rechargeable battery that cen handla load. Connect one LM340-5 regulator in circuit for aach 1.2 A of load currant drawn by circuits to ba protected. In normal oparation, output diodes are biased off by slightly highar voltaga from computer. During power feilure, they ere switched on by ramoval of bias. Current is then supplied by battery. Output should be loaded with resistor drawing ebout half of trickle-cherge current, so battery has small continuous current flow end stays cherged.—C. R. Carpenter, Protect Your Memory Against Power Feilure, *Kilobaud,* March 1978, p 73.

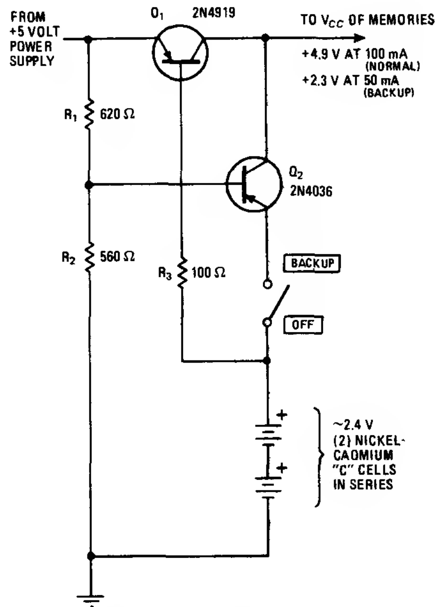
LOW-CAPACITANCE DRIVER FOR RAM—Suiteble for data input lines of memory system opereting from 16-V supply with memory input logic swing of 16 V. Used with Motorola 1103 dynamic RAM for which transition times of deta input signels should be 20 ns to give maximum mamory speed. Suitable for maximum capacitances per line as high as 20 pF.—D. Brunner, "A MECL 10,000 Main Frema Mamory System Employing Dynamic MOS RAMs," Motorole, Phoenix, AZ, 1975, AN-583, p 13.



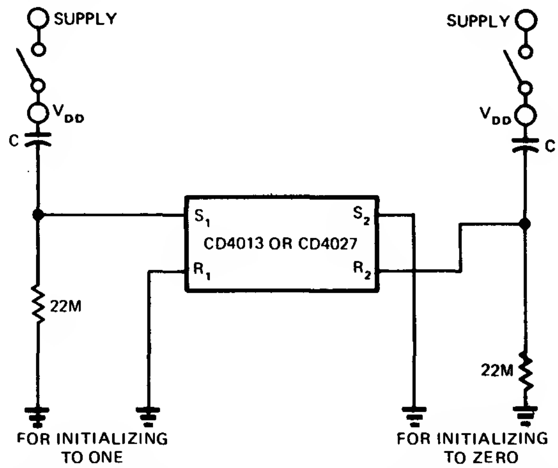
HIGH-SPEED FIFO—Dasign is based on Motorola MC10143 register fila, with each IC holding 8 words by 2 bits. Circuit includes write and raed enable inputs for cascading two register file packages to mamory dapth of 16 words. Full master-slave flip-flop operation allows simulteneous reed and write. Reset is applied initially to drive both address countars to empty stata. To entar deta, writa clock input is enabled with negative-going pulsa. Write eddressing is controlled by MC10178 binery counter. Used for stack registers of computing systems when register outputs are raad sequentielly in sama order that date was entered (first-in first-out).—B. Blood, "A High Speed FIFO Mamory Using the MECL MC10143 Register File," Motorole, Phoenix, AZ, 1974, AN-730, p 5.



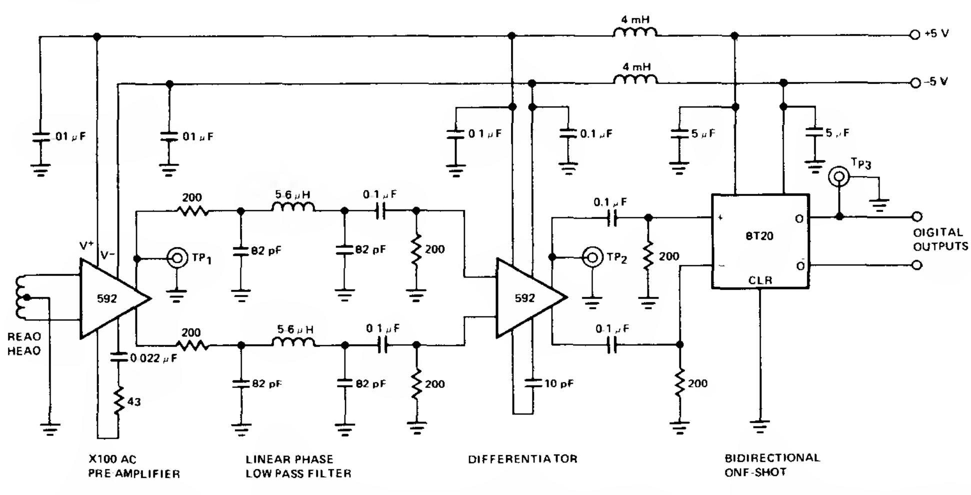
12-V PROGRAMMER FOR PROM—Circuit includes regulator for operation from 12-V auto storage battery. Developed to use 8223 32-word by 8-bit memory as CW identifier. All outputs of memory are initially at logic 0, so only logic 1s need to be programmed. After programming a 1, LED comes on to confirm it when S7 is switched to VERIFY. Do not hold S8 down longer than 1 s.—G. W. Kufchak, The PROM Zepper, *73 Magazine*, Sept. 1976, p 112.



BATTERY BACKUP—Delivers 2.3 V to microprocessor memory automatically in event of supply failure, to prevent loss of data. On standby, batteries receive charge of about 20 mA through R_3 and Q_1. When power supply fails, Q_1 isolates it from load and Q_2 conducts to provide changeover to battery power. Standby switch (optional) permits defeating battery backup.—R. N. Bennett, 2.4-V Battery Backup Protects Microprocessor Memory, *Electronics*, Feb. 3, 1977, p 109; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 304.

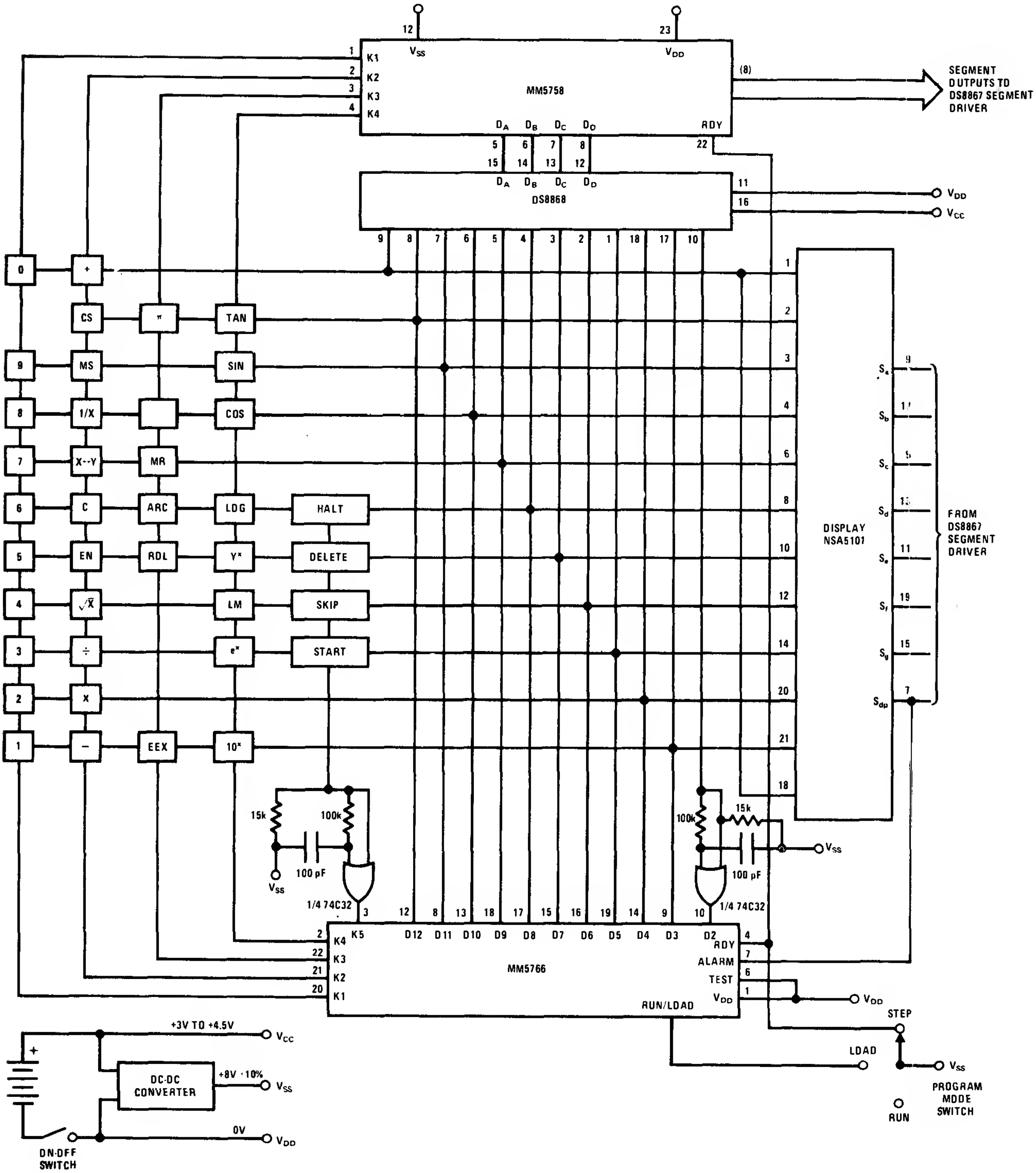


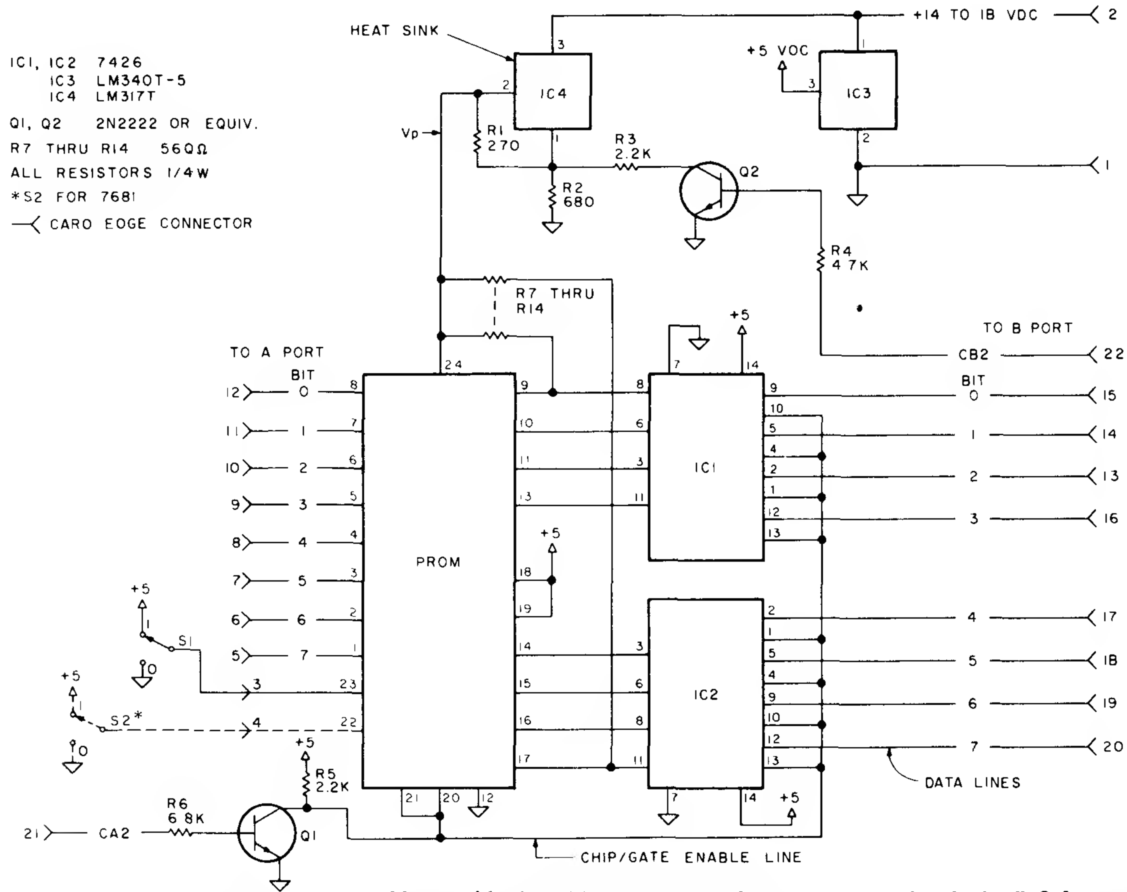
INITIALIZING CMOS STORAGE—Simple RC circuit initializes all storage elements (flip-flops, registers, and counters) of CMOS system to all 1s (switch at left) or all 0s (switch at right) when power supply is turned on. For most CMOS storage elements, 30 pF for C ensures setting or resetting when power is applied by closing switch. If power supply is turned on while supply line is directly connected, C should be 1000 to 1500 pF. Article also shows how to get set or reset function after initialization by using pair of CD4016A or CD4066A transmission gates.—O. Bismarck, A Simple Method for Initializing CMOS Storage Elements, *EDN Magazine*, Feb. 20, 1974, p 83.



DISK-FILE DECODER—Provides preconditioning of readback data from disk or drum files by using NE592 video amplifier coupled to 8T20 bidirectional mono MVBR through low-pass filter and second 592 serving as low-noise differentiator/amplifier. Mono provides required output pulses at zero-crossing points of differentiator. Designed for reading 5-MHz phase-encoded data.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 708–710.

PROGRAMMER FOR SCIENTIFIC CALCULATOR—National MM5766 dynamic key sequence programmer can be added to MM5758 sciantific calculator chip to provide learn-mode programmability. Circuit memorizes any combination of key entries up to 102 characters while in load mode, than automatically plays back programmed saquence as often as desired in run moda. Halt key programs variable data entry points at which control is temporarily returned to oparator in run mode.—"MOS/LSI Databook," National Samiconductor, Santa Clara, CA, 1977, p 8-76–8-79.



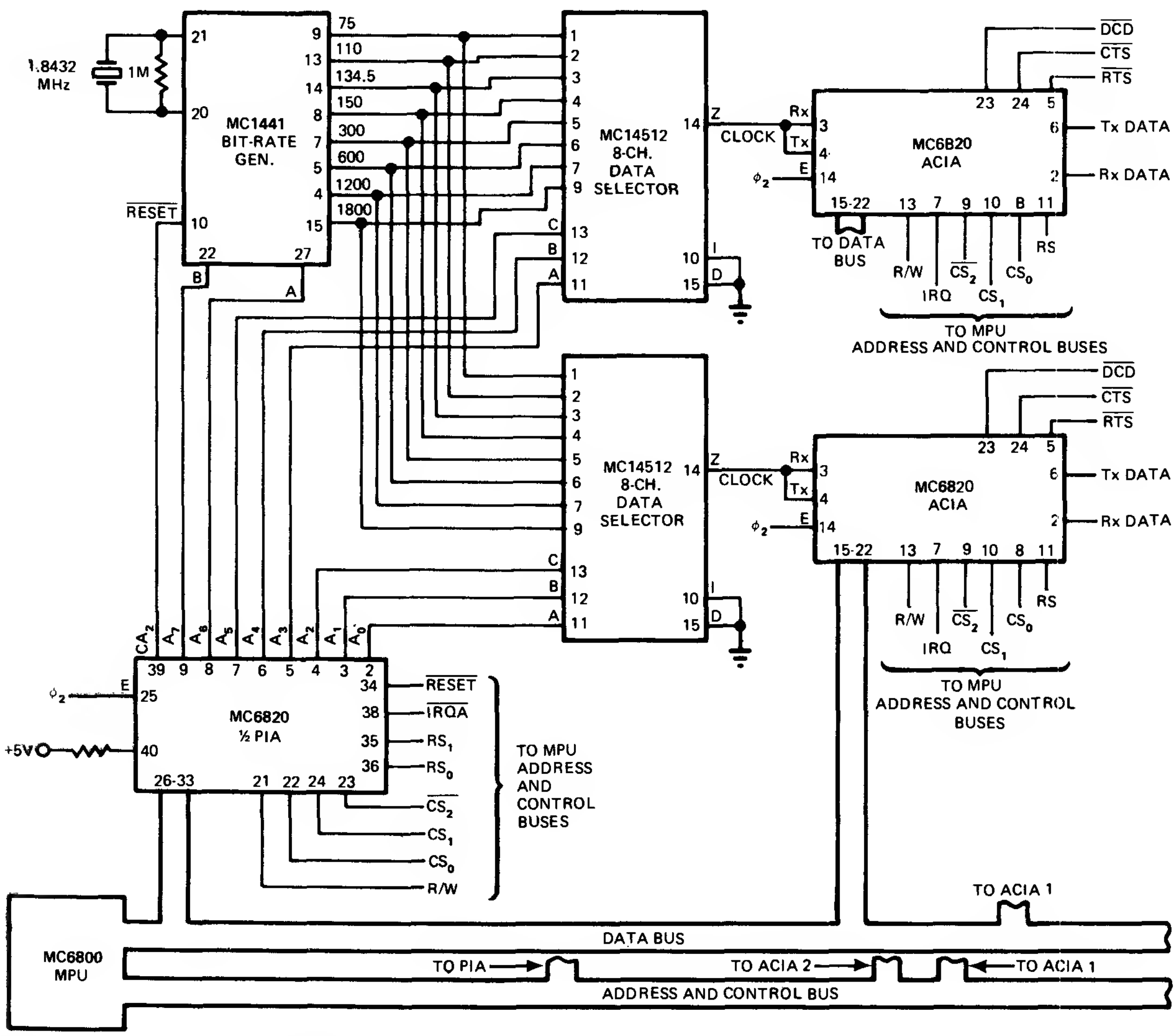


PROM PROGRAMMER—Developed specifically for programming Harris 7641-5 and 7681-5 PROMs, which come with logic 1 in all bit positions. Programmer is used to burn bit at each position requiring logic 0 by process equivalent to blowing fusible link on PROM chip. Process is not reversible, so one error ruins PROM. Circuit uses two regulator ICs (IC3 and IC4) and two TTL gates (IC1 and IC2). Article gives programming procedure in detail. Software for generating critical timing and control signals with microprocessor is also given.—T. Hayek, Simple and Low-Cost PROM Programmer, *Kilobaud,* July 1978, p 94–96 and 98–99.

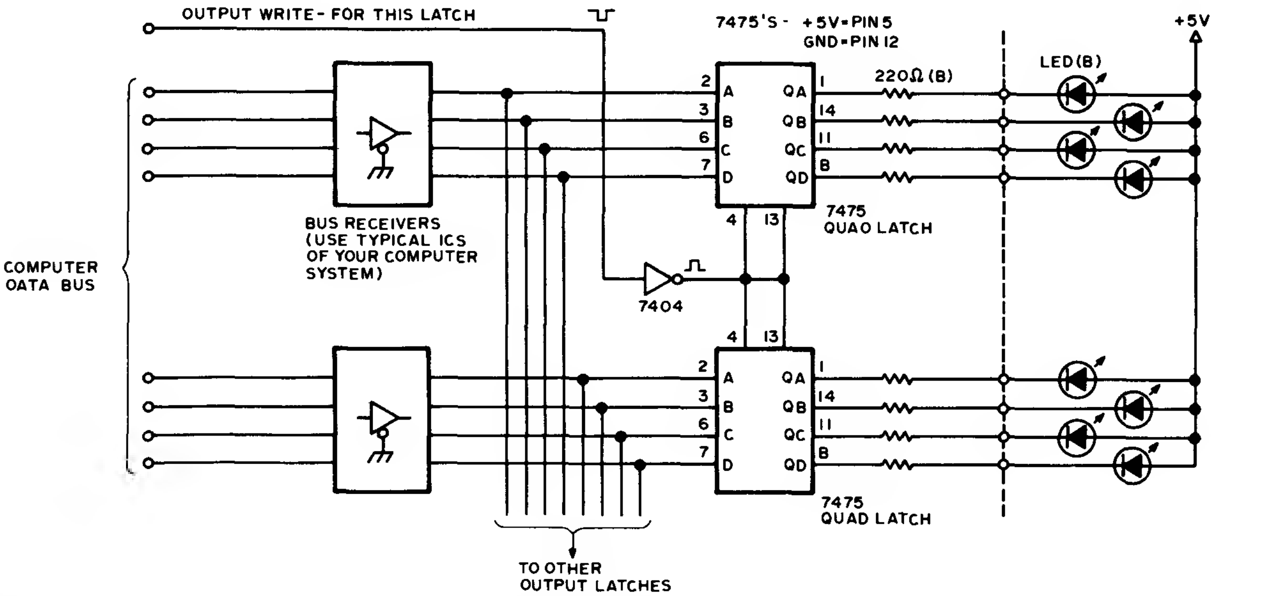
CHAPTER 51

Microprocessor Circuits

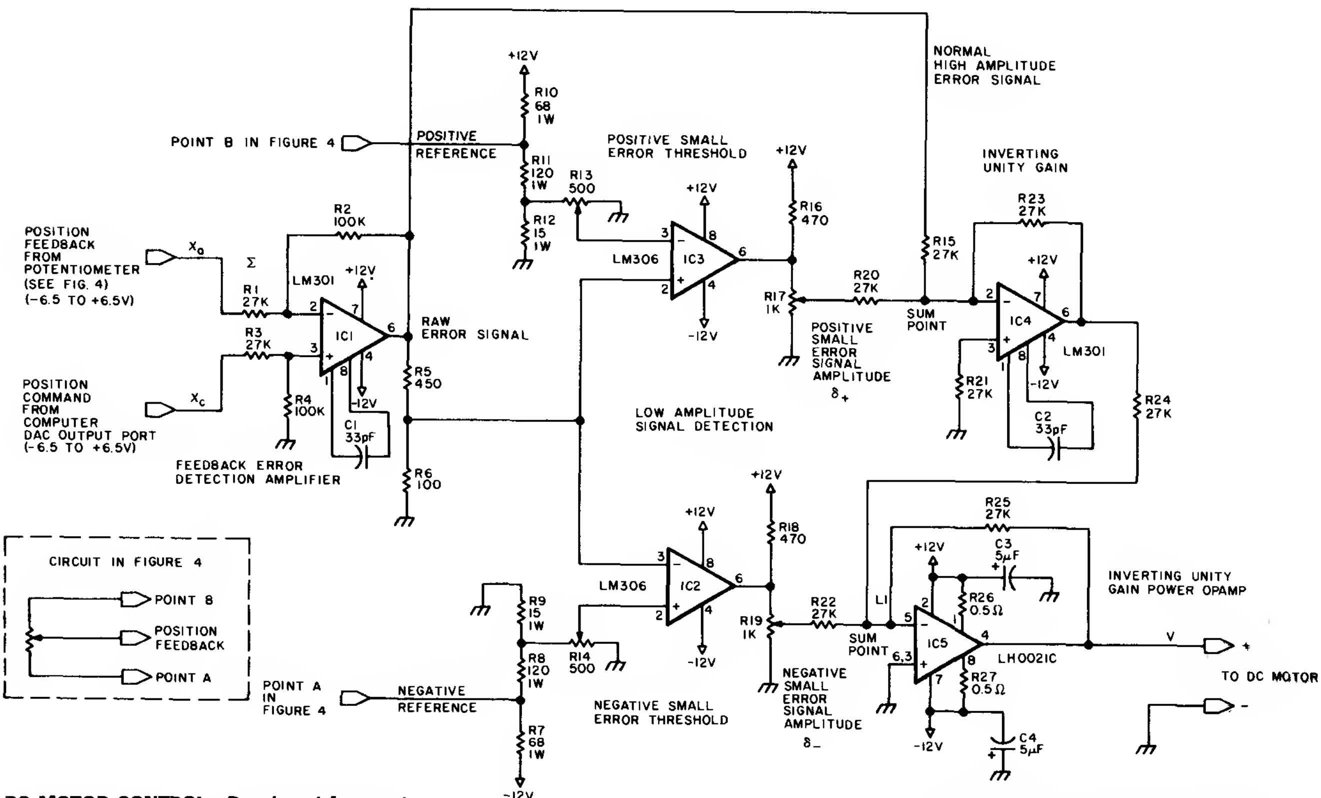
Includes handshaking, time-logging, power-failure alarm, motor control, light pen, interface, and troubleshooting circuits for microcomputers, minicomputers, and computers as well as for microprocessors. See also Clock Signal, Game, Keyboard, and Programmable chapters.



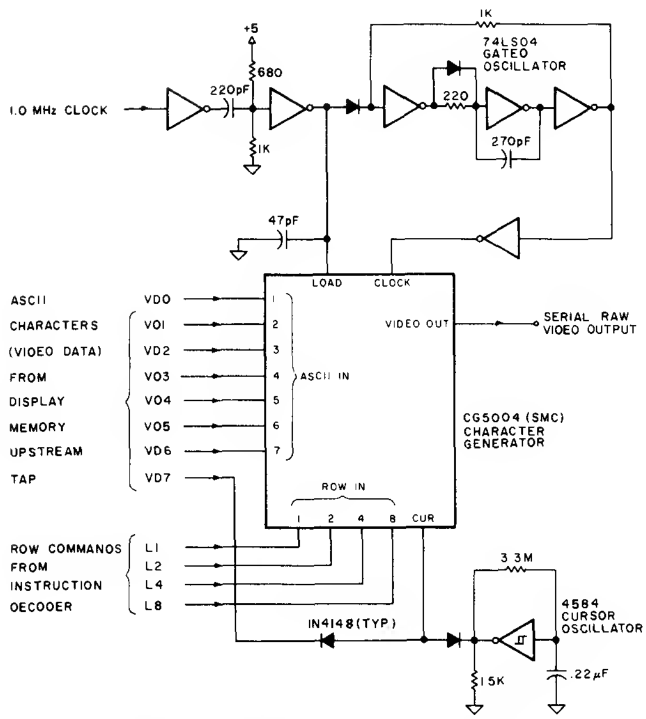
PROGRAMMED BIT RATES—Choice of 37 different bit rates in range from 75 to 1800 b/s, each multiplied by 1, 8, 16, or 64, can be obtained from Motorola MC1441 bit-rete generetor, two 8-channel data selectors, helf of peripheral interface adapter (PIA) end two asynchronous communication interfece adepters (ACIA) by appropriate programming of Motorola MC6800 microprocessor used in date communication system. Article gives operating deteils and exemple of initialization program.—G. Nash, Microprocessor Softwere Programs Bit-Rate Generator, *EDN Magazine*, Aug. 20, 1977, p 134, 136, and 137.



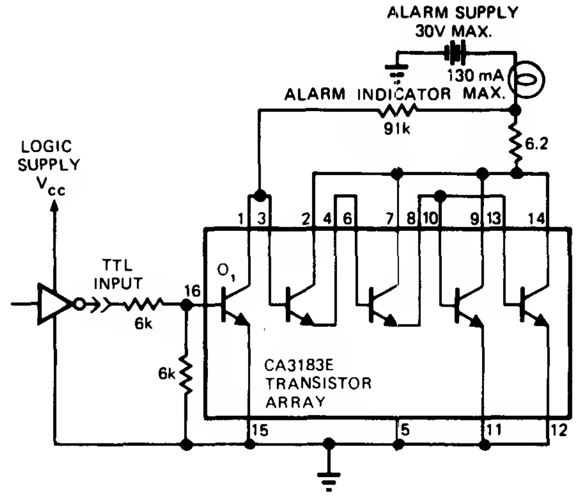
MOVING-LIGHT DISPLAY—Computer-controlled blinking of LEDs arranged in circle or other pattern gives illusion of motion. One section of quad 7475 latch is assigned to each of several output ports of microprocessor. Decoding logic of output port determines when latch is addressed for output. Decoded WRITE signal latches data presented at bus receivers. Interface can be extended to many registers in groups of eight, limited only by input/output addressing capability and power available for LEDs. Software is written to turn on LEDs in desired sequence and provide desired variable delays between blinks.—C. Helmers, There's More to Blinking Lights than Meets the Eye, *BYTE*, Jan. 1976, p 52–54.



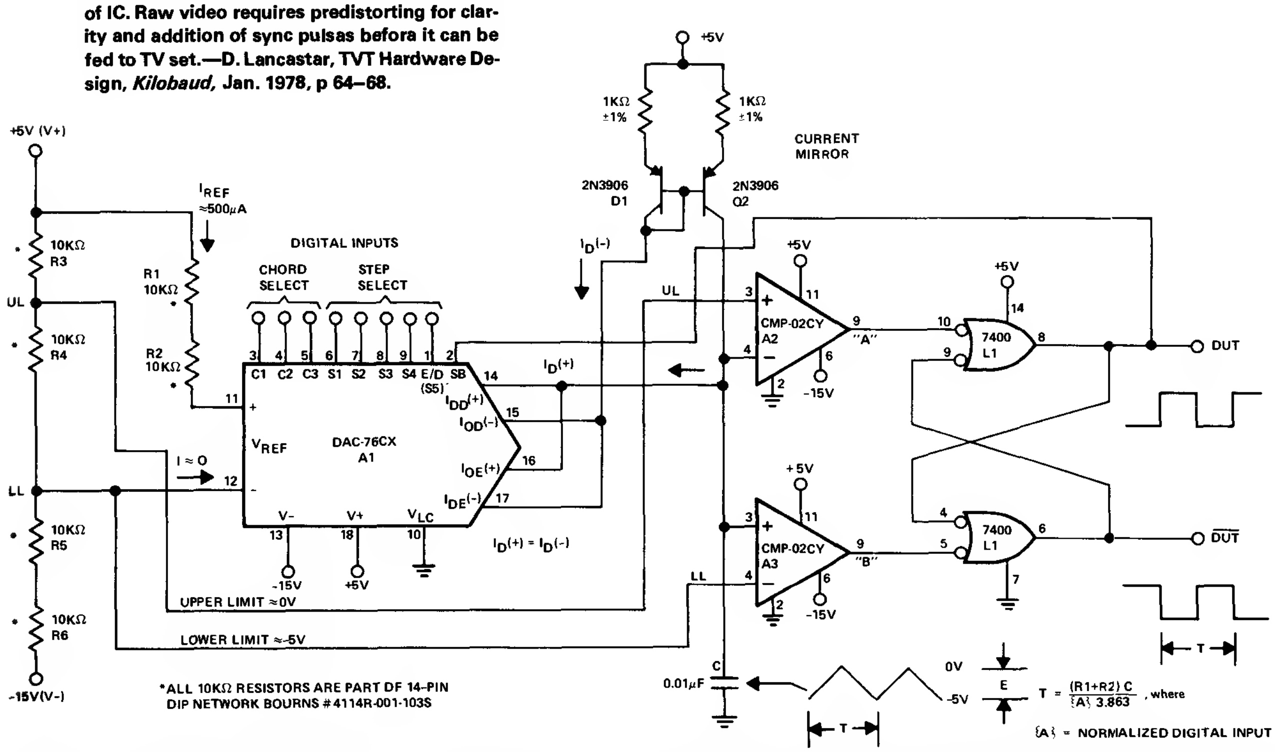
DC MOTOR CONTROL—Developed for use in realistic lunar lander simulation display. Throttle signal and altitude signal serve as inputs to microprocessor. Feedback position-measuring pot is geared to 12-VDC motor so full travel of pot shaft occurs while lunar module traverses full altitude range. Circuit provides minimum drive voltage required by DC motor for motion to occur. Output of difference amplifier IC1 goes to summing amplifier IC4 as one component of final motor voltage. Comparators IC2 and IC3 sense when difference voltage is larger than small positive voltage set by R13 or smaller than small negative voltage set by R14. Comparator output then becomes 12 V, and portion of this (about 2 V) drives motor into operating range. IC5 is high-power opamp delivering 1 A at 12 V.—L. Sweer, T. Dwyer, and M. Critchfield, Controlling Small DC Motors with Analog Signals, *BYTE*, Aug. 1977, p 18–20, 22, and 24.



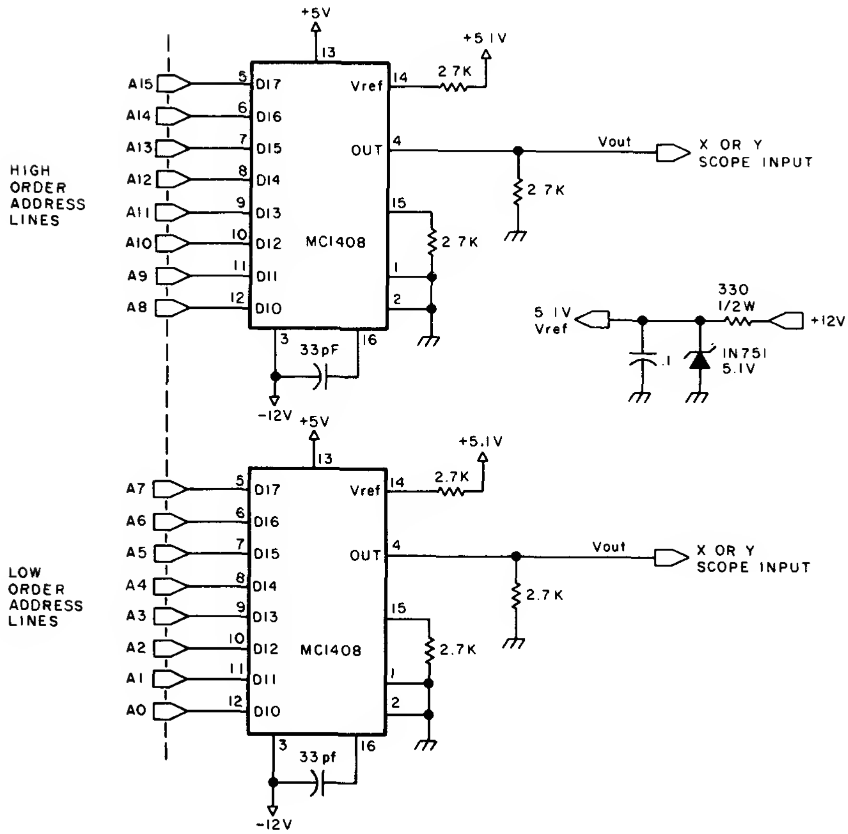
UPPERCASE/LOWERCASE DRIVE FOR TV—Standard Microsystems CG5004 alphameric data-to-video convertar provides both uppercasa and lowarcase characters and all numerals in sarial video form for display as 7 × 9 charactar matrix on TV screen under microprocessor control. IC requires only singla +5 V supply. Winking underlina cursor is produced automatically by cursor oscillator. Intemal shift ragister is part of IC. Raw video requires predistorting for clarity and addition of sync pulsas befora it can be fed to TV set.—D. Lancastar, TVT Hardware Design, *Kilobaud*, Jan. 1978, p 64–68.



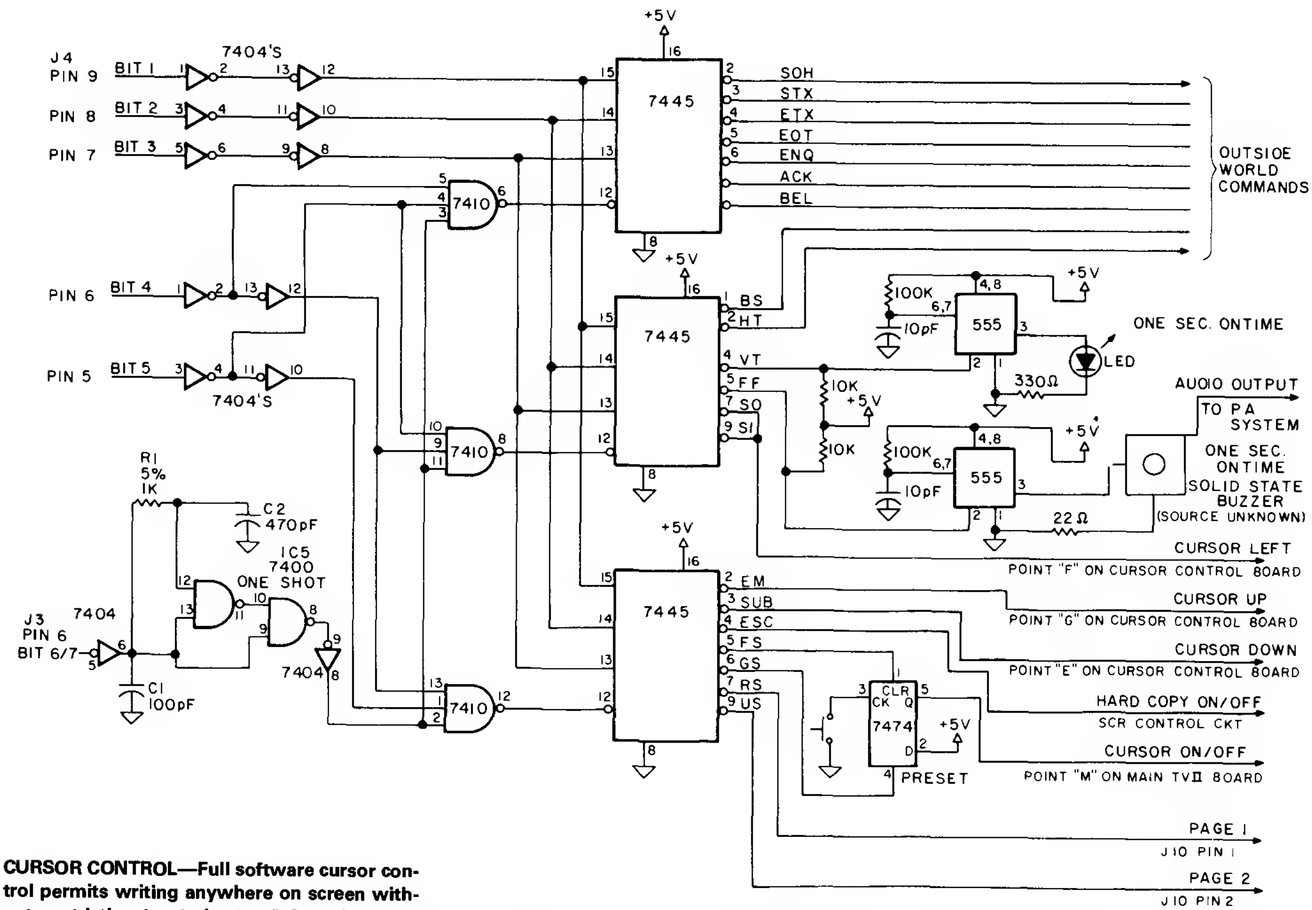
FAIL-SAFE ALARM—Circuit monitors status of microprocessor system and energizes lamp or othar alarm indicator to indicate when CPU halts or power is lost. Input is TTL-compatible, and output can drive loads up to 130 mA at 30 V.—J. Elias, Alarm Driver Is Fail-Safe, *EDN Magazine*, May 20, 1975, p 76.



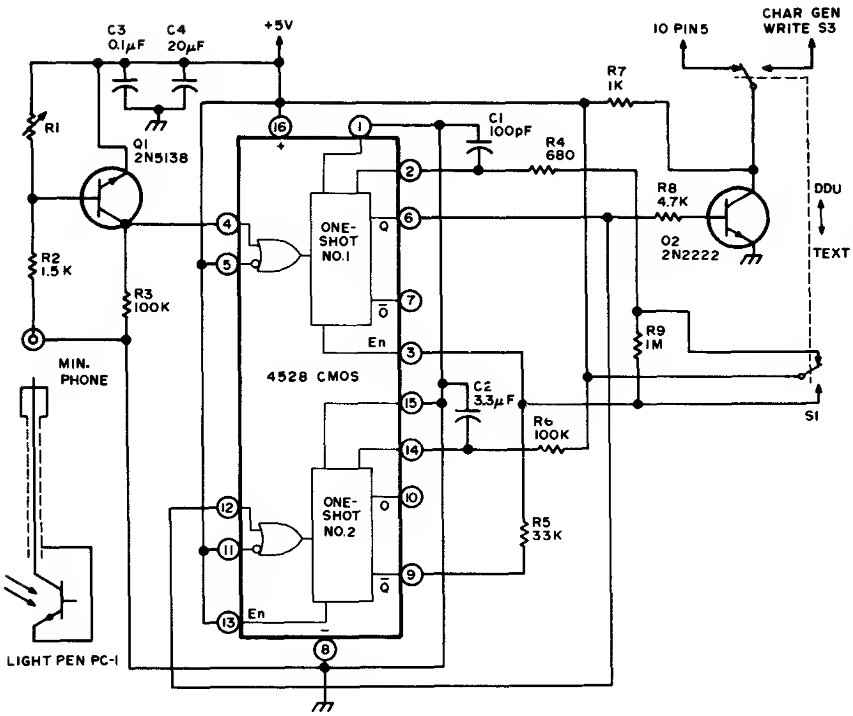
OSCILLATOR CONTROL—Digital inputs from microprocessor to Precision Monolithics DAC-76CX 8-bit companding D/A convartar provida 8159:1 frequancy range for AF oscillator, from 2.5 to 20,000 Hz. DAC functions as programmable current source that alternately charges and discharges capacitor between precisely controlled uppar and lower limits. Sinca both limits are derived by dividing power supply voltages, frequency is indapendant of changas in supply voltage. Design equations are given.—D. Soderquist, "Exponential Digitally Controlled Oscillator Using DAC-76," Pracision Monolithics, Santa Clara, CA, 1977, AN-20, p 1.



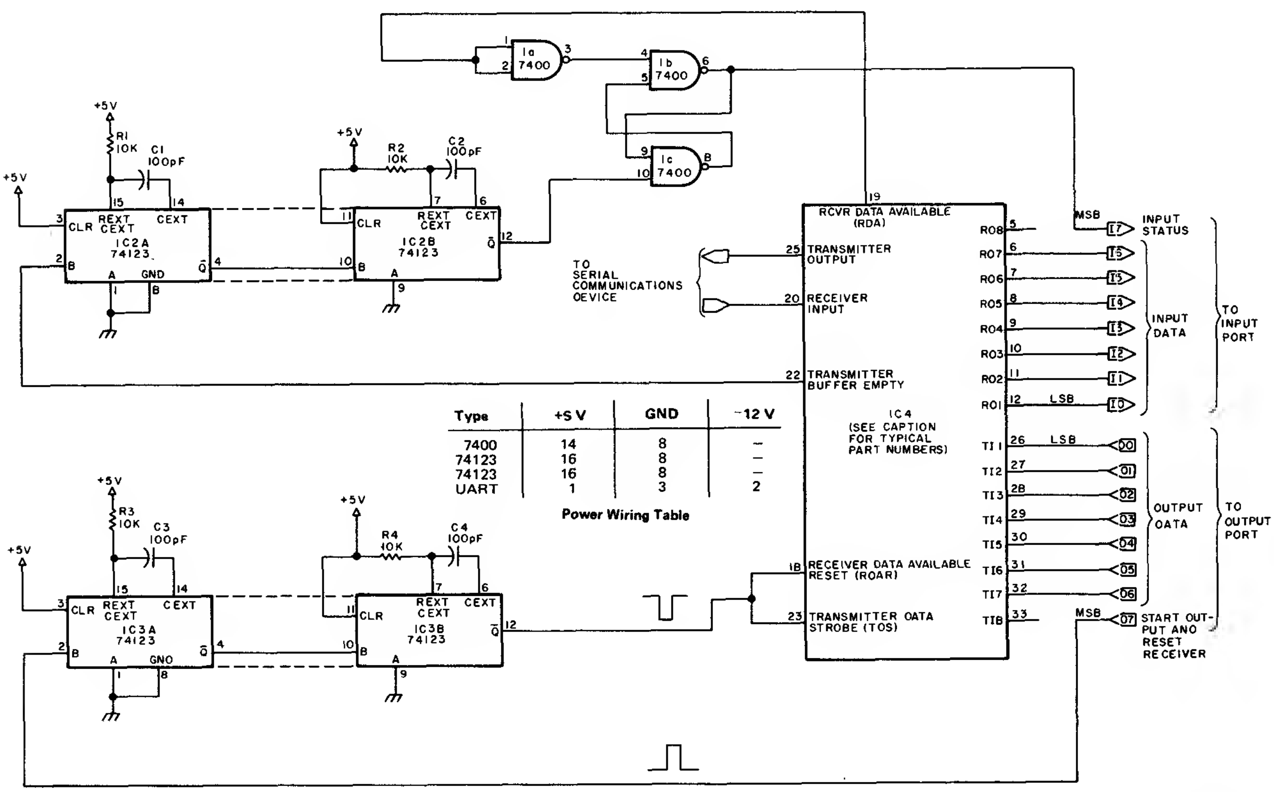
ADDRESS STATE ANALYZER—Dynamic fluctuations of 16-bit memory address bus are displayed on CRO for troubleshooting. Two MC1408 8-bit DACs drive inputs of CRO with analog equivalents of eight high-order and eight low-order address lines. Display serves as visual picture of computer in action, in which accessing of unexpected memory locations is instantly visible. Incoming address lines can be connected to MC1408s in any order. Article covers evaluation of scope patterns.—S. Ciarcia, A Penny Pinching Address State Analyzer, *BYTE*, Feb. 1978, p 6, 8, 10, and 12.



CURSOR CONTROL—Full software cursor control permits writing anywhere on screen without restrictive top-to-bottom/left-to-right format. System uses 18 of possible 32 ASCII control codes in TV II system having 8K BASIC. Three 7445 BCD-to-decimal decoders operate in 3-line-to-8-line mode wherein pin 12 becomes chip enable. When pin 12 goes low, one of the eight outputs will go low.—R. Wright, Utilize ASCII Control Codes!, *Kilobaud*, Oct. 1977, p 80–83.



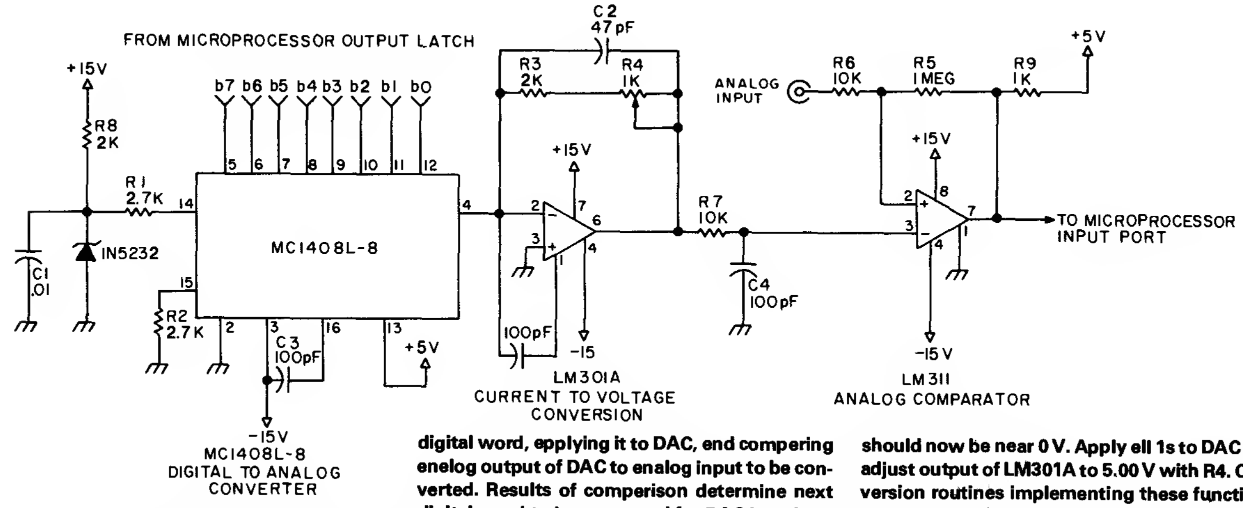
PICTURE-DRAWING LIGHT PEN—Circuit improves ebility to draw pictures on displey screan with light pen by using short data lock-out period to avoid smearing. Value of R1 depands on light pen; usa 1 megohm for Texas Instruments H-35. One-shot No. 1 produces constant-amplituda 200-ns pulse for storing 1 or 0 bit in 2102 memory of CRO graphics intarface. One-shot No. 2 dalays genaration of another write commend 0.25 s, giving oparator tlme to withdraw or mova pan before doubla dot is formed. R4 end C1 control length of writa pulse, whila R5 and C2 control wait time.—S. S. Loomis, Let There Ba Light Pans, *BYTE*, Jan. 1976, p 26–30.



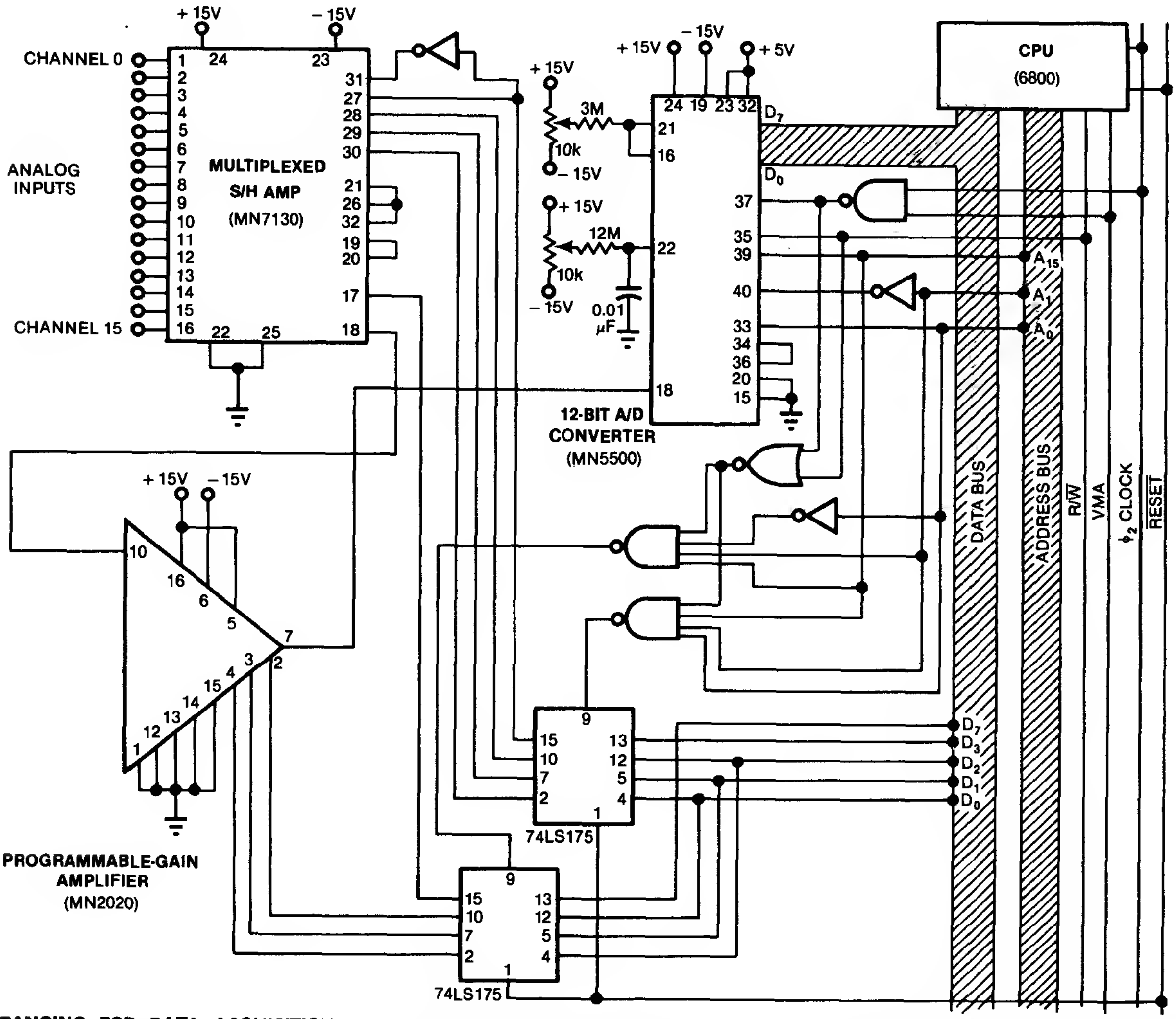
Type	+5 V	GND	-12 V
7400	14	8	–
74123	16	8	–
74123	16	8	–
UART	1	3	2

Power Wiring Table

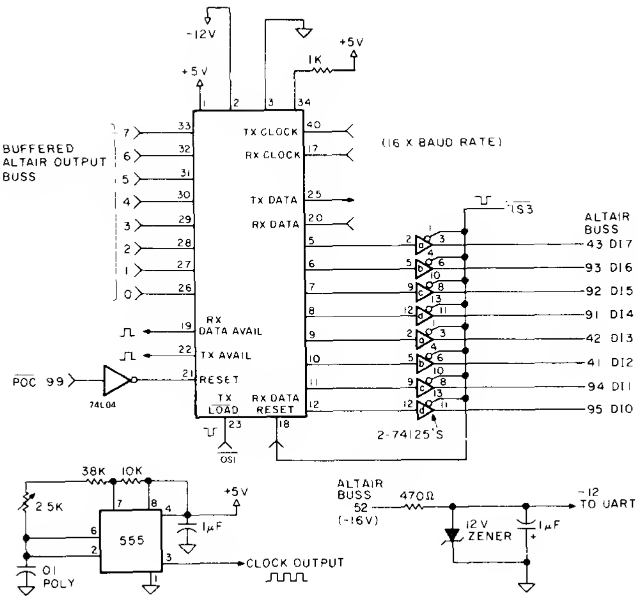
HANDSHAKING—Circuit sets up opereting connection between computar end UART (universel esynchronous receivar-trensmittar). Eighth bits of I/O ports indicate when data has been successfully transmitted end system is ready to transmit mora information. Can ba adapted to eny 8-bit computer. IC4 is stenderd UART such as Signetics 2536, Generel Instrumants AY 5 1012, Taxes Instrumants TMS 6011, or American Microsystams S1883. Racaiver of UART has seven data linas connected to input port. Article covars handshaking operation in detall and gives typical softwere routines for perellel I/O handsheking. Tachniqua permits running UART et eny desirad clock spaed, es long as all clocks in system ara matchad.—T. McGahee, Sava Software: Use e UART for Seriel IO, *BYTE*, Dec. 1977, p 164–166.



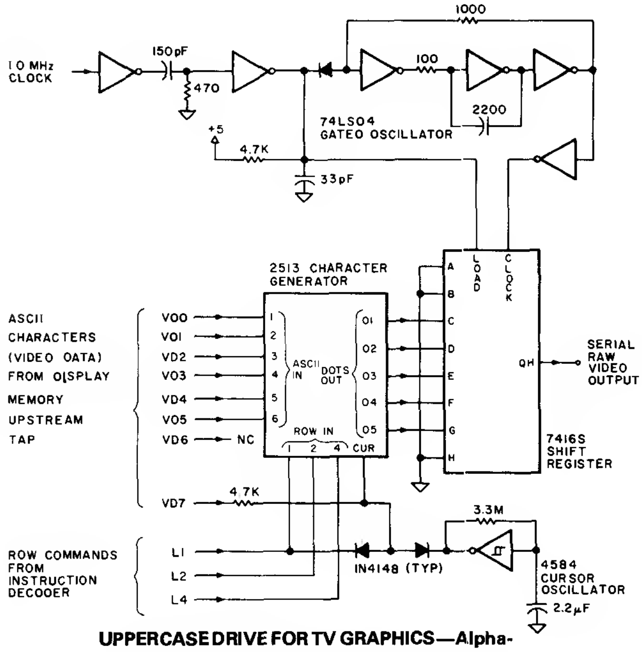
ANALOG/DIGITAL CONVERSION—Circuit can be used for either ramp or successive-approximation method of converting analog input to digital word, applying it to DAC, and comparing analog output of DAC to analog input to be converted. Results of comparison determine next digital word to be generated for DAC by microprocessor. LM301A changes 0–2 mA output of DAC into 0–5 V for LM311 comparator. To calibrate, apply all 0s to DAC; pin 6 of LM301A should now be near 0 V. Apply all 1s to DAC and adjust output of LM301A to 5.00 V with R4. Conversion routines implementing these functions are given for Motorola MC6800 and Intel 8008 microprocessors.—R. Frenk, Microprocessor Based Analog/Digital Conversion, *BYTE*, May 1976, p 70–73.



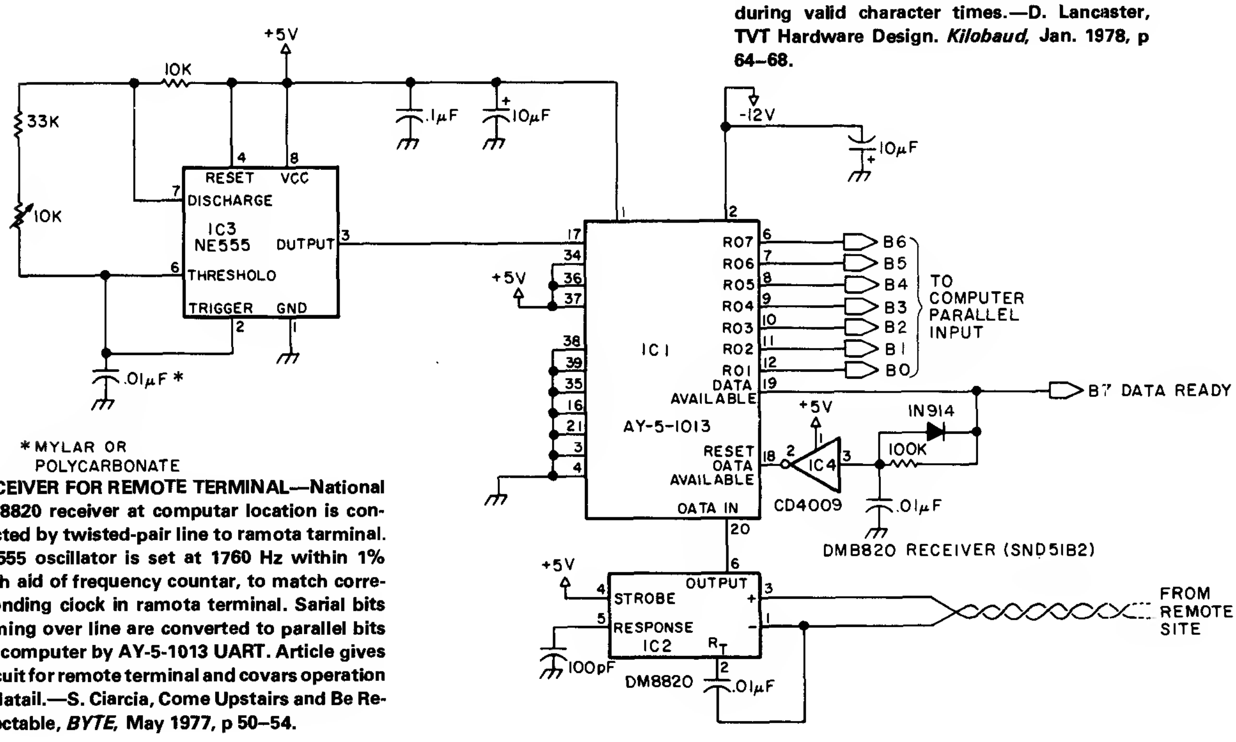
AUTORANGING FOR DATA ACQUISITION—Circuit accepts up to 16 channels of analog information and provides full-scale input ranges from ±78 mV to ±10 V when used with 6800 CPU. Resolution is 0.01%. MN7130 multiplexed sample-and-hold amplifier includes eight full-differential multiplexers for 16 channels and instrumentation opamp. MN2020 programmable-gain amplifier provides choice of eight gains ranging from 1 to 128 in binary progression. Autoranging operation of data acquisition system allows channel-sampling plans that depend on random events. With known input signal levels, required gain information can be stored in microprocessor memory for use in place of autoranging.—R. Duris and J. Munn, PGA's Give Your DAS Designs Autoranging, Wide Dynamic Range, *EDN Magazine*, Sept. 5, 1978, p 137–141.



UART INTERFACE—Uses TMS-6011 UART to convert parallel data into serial data and back again for Altair 8800 microprocessor. UART mates diractly to computer bus, because all outputs from UART are three-state buffers with separate enable lines provided for status bits and 8 bits of parallel output. Pin 22 is high when UART can accapt another character for conversion. Pin 18 must be pulsed low to reset pin 19 so it can signal raceipt of another character. Connections to pins 35–39 depand on I/O devices used, as covered in article.—W. T. Walters, Build a Universal I/O Board, *Kilobaud*, Oct. 1977, p 102–108.

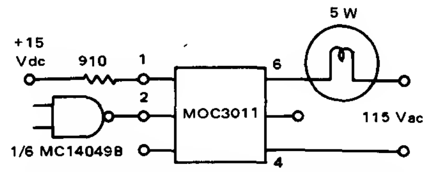


UPPERCASE DRIVE FOR TV GRAPHICS—Alphameric data-to-video converter using 2513 character generator accepts ASCII words from microprocessor memory and three line commands from instruction decoder. Five dots are outputted simultaneously, corresponding to one row on 5 × 7 dot-matrix character. 7416S eight-input one-output shift register converts dots into serial output video. Input repeats to generate all seven dot rows in row of characters. Shift register is driven by high-frequency timing circuit that delivers LOAD pulse once each microsecond along with CLOCK output running continuously at desired dot rate. Optional cursor uses 4584 5-Hz oscillator for cursor winking rate. If ASCII input bit 8 is high, cursor input goes high and output is whita line on leads 01 through 05. Right diode mades this line blink, while left diode allows winking cursors only during valid character times.—D. Lancaster, TVT Hardware Design. *Kilobaud*, Jan. 1978, p 64–68.

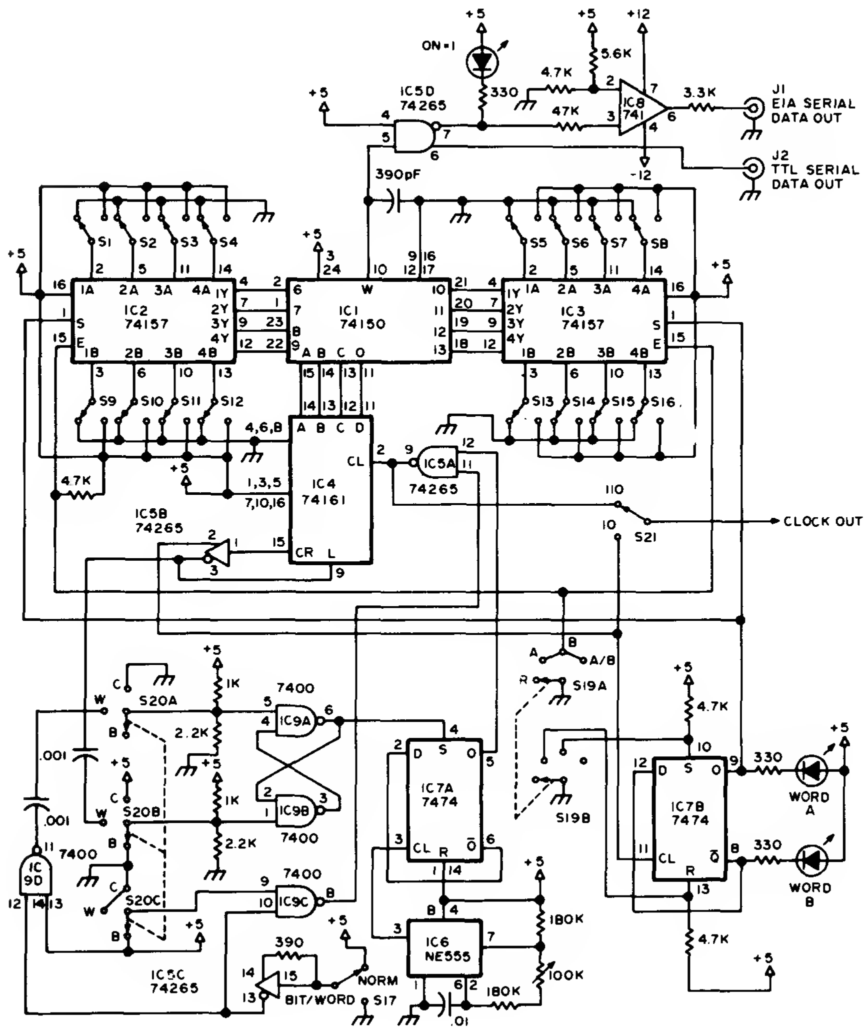


*MYLAR OR POLYCARBONATE

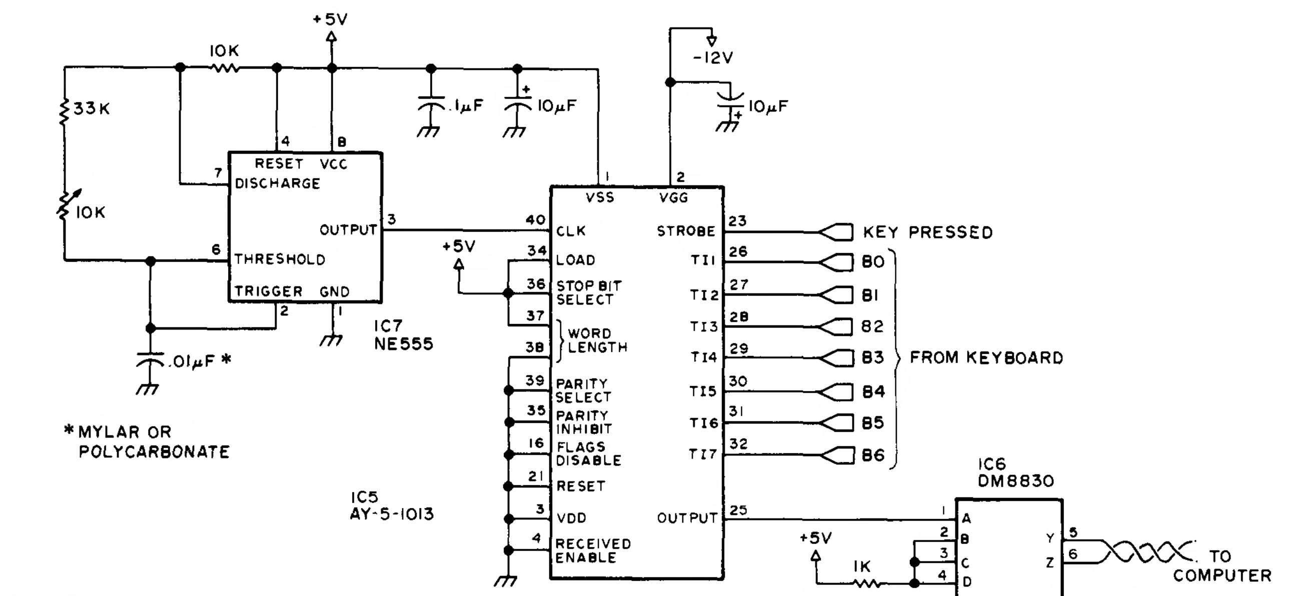
RECEIVER FOR REMOTE TERMINAL—National DM8820 receiver at computar location is connected by twisted-pair line to ramota tarminal. NE555 oscillator is set at 1760 Hz within 1% with aid of frequency countar, to match corresponding clock in ramota terminal. Sarial bits coming over line are converted to parallel bits for computer by AY-5-1013 UART. Article gives circuit for remote terminal and covars operation in datail.—S. Ciarcia, Come Upstairs and Be Respectable, *BYTE*, May 1977, p 50–54.



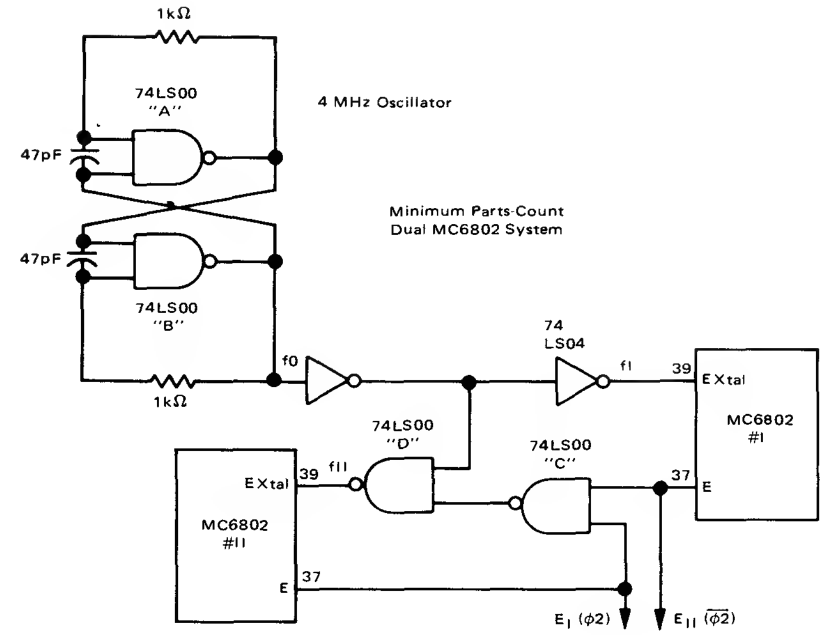
MALFUNCTION ALARM—Motorola MOC3011 optoisolator serves as interface between CMOS logic of microprocessor and 5-W 115-VAC lamp. Input logic is connected to energize infrared LED of optoisolator by providing up to 50 mA. Once triggered, indicator lamp remains on until current drops below holding value of about 100 μA.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 2.



SERIAL ASCII GENERATOR—Provides choice of two different words in standard serial ASCII asynchronous data format for troubleshooting and testing code converters and other computer peripherals. S19 gives choice of four data output patterns. R gives logic high for all 8 bits. A gives pattern determined by settings of S1-S8. B gives pattern determined by settings of S9-S16. A/B alternates words A and B. S20 gives choice of three different output modes. Mode B generates words 1 bit at a time. Mode W produces single word at rate of 110 bauds. Mode C produces continuous output of selected word pattern, for testing teleprinters and other output devices. Article covers construction and operation of circuit. IC power (+5 V) and ground pins are: 74150—24 and 12; 74157, 74161, and 74265—16 and 8; 555—8 and 1; 7474 and 7400—14 and 7.—R. J. Finger, Build a Serial ASCII Word Generator, *BYTE*, May 1976, p 50–53.

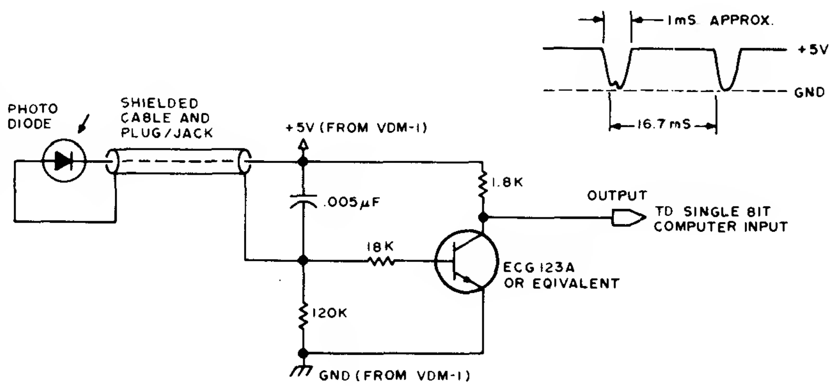


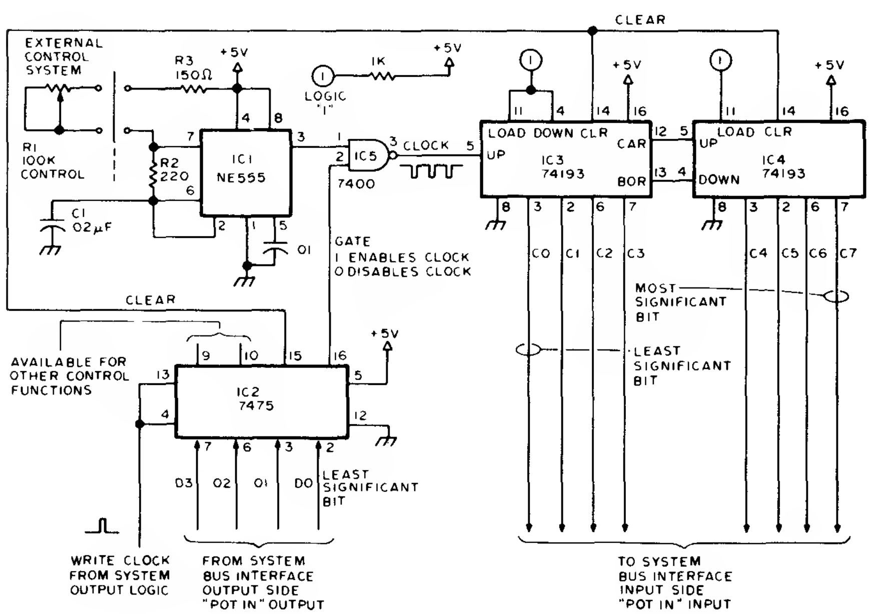
TRANSMITTER FOR REMOTE TERMINAL—Consists of AY-5-1013 UART attached to keyboard, with twisted-pair cable running to receiver unit at computer location. Coaxial extension cable for monitor is only other connection to computer system because terminal has own power supply. Transmission is in one direction only. NE555 oscillator is set at 1760 Hz ± 1% with aid of frequency counter, for 110-b/s serial rate. IC6 is 5-V National DM8830 differential line driver or equivalent. Pin 14 of IC6 goes to +5 V and pin 7 to ground.—S. Ciarcia, Come Upstairs and Be Respectable, *BYTE*, May 1977, p 50–54.



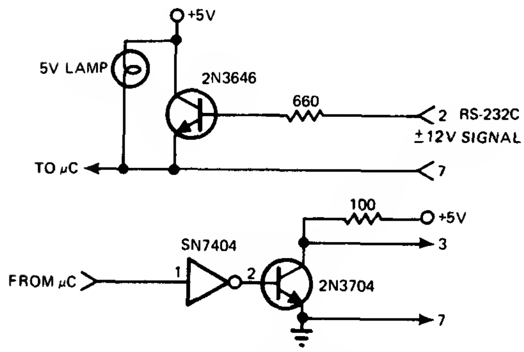
4-MHz NAND-GATE OSCILLATOR SYNCHRONIZES TWO MPUs—Low-cost NAND-gata sactions A and B form low-cost oscillator for driving two Motorola MC6802 microprocessors. NAND gates C and D function as phasa-locked loop, with D ensuring that phases of enabla outputs ara 180° apart. Small drifts in oscillator fraquancy do not affect synchronization. Circuit allows aach MPU to oparata during half-cycla that othar MPU has disabled, to provida additional computing power of two microprocessors whila maintaining systam costs of ona data bus.—J. Farrell, "Synchronizing Two Motorola MC6802s on Ona Bus," Motorola, Phoanix, AZ, 1978, AN-783.

LIGHT PEN WITH INTERFACE—Any high-quality photodioda mounted in discarded housing of marking pen sarves as pickup for holding against scraan of video display. If dioda is mounted in plastic lans, flatten end of lens with amery cloth to give narrower angle of acceptanca. Davaloped for use with VDM-1 display terminal. Usa CRO to monitor output as pan is moved across scraan. Dark araa on screen gives 5-VDC leval, and whita area givas dips. Article covars use in program design, editing memory dumps, and arranging complax displays.—J. Wabstar and J. Young, Add a $3 Light Pan to Your Video Display, *BYTE*, Fab. 1978, p 52, 54, 56, and 58.

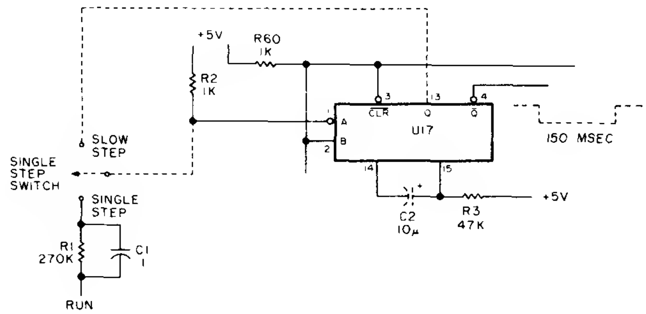




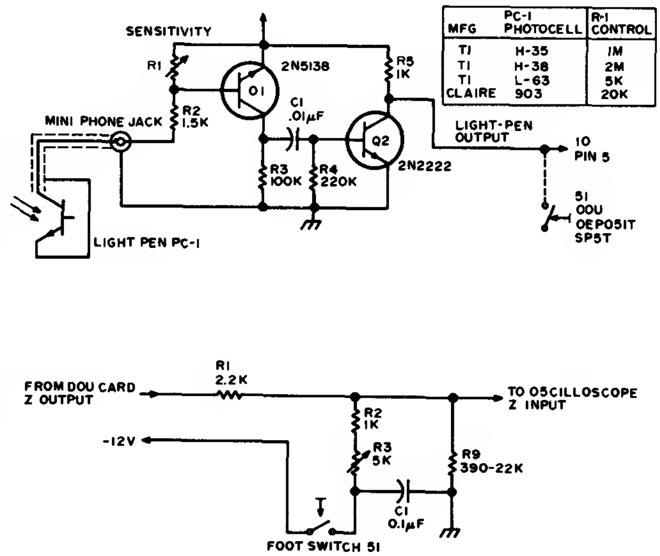
POT INTERFACE—Circuit convarts resistance of pot setting to frequency with NE555 timar IC1. Frequancy is maasured undar direct control of microprocessor program, using 8-bit countar with CPU clock as tima basa. Processor is programmed to clear countar, turn on counter, wait 2 ms, turn off countar, and raad count. Rasult is numbar of cycles in 2-ms period, ranging from 1 to about 240. Relationship of frequancy to control position is accurate anough for game control. R1, R2, R3, and C1 are chosen so frequancy varies from about 0.75 to 122 kHz as R1 is varied from 100K to 0. Usa audio-tapar pot to improve conversion linaarity. Article gives subroutines for Motorola 6800 and Intel 8080 microprocessors.—C. Halmars, Getting Inputs from Joysticks and Slide Pots, *BYTE*, Feb. 1976, p 86–88.



TERMINAL INTERFACE—Developed for use between computer terminal and microprocessor development board. Provides interface between teleprinter terminal using EIA RS-232C standard and input of microcomputer (upper diagram) and interface between computer and teleprinter using 20-mA current-loop standard for actuating printout. Logic 1 is −3 to −9 V or less, and logic 0 is +3 to +9 V or more.—P. Snigier, Constructing a Low-Cost Terminal Interface, *EDN Magazine*, June 5, 1977, p 205–206.

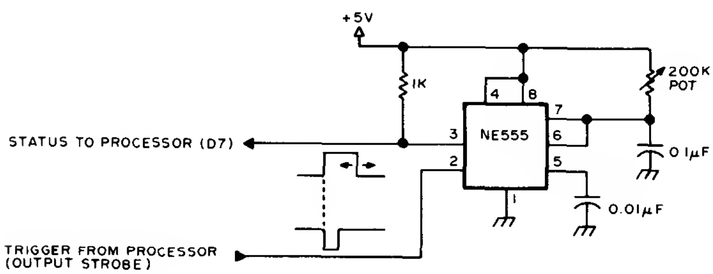


SLOW STEPPER—Addition of slow-stepping switch position to single-step circuit of microprocessor eliminates need for pushing single-step switch repeatedly while executing endless loop program and watching address and data lights to see where program or hardware fails during debugging run. Circuit uses 74123 mono MVBR to give 1.5-ms pulses on single step and 150-ms on slow step.—H. R. Bandrot, The Slow-Stepping Debugger, *Kilobaud*, April 1977, p 60.



MFG	PC-1 PHOTOCELL	R-1 CONTROL
TI	H-35	1M
TI	H-38	2M
TI	L-63	5K
CLAIRE	903	20K

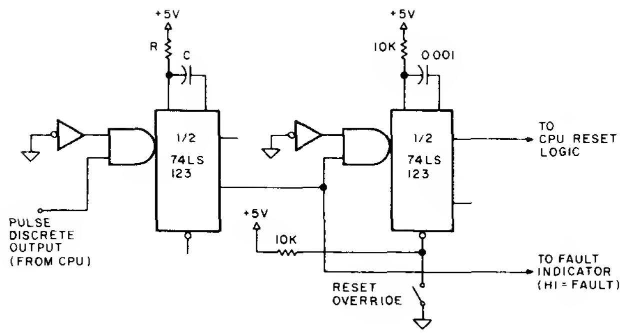
LIGHT PEN—Photocell in tip of light pen senses when dot is written on screen at its location by becoming conductive and biasing Q1 so it feeds short pulse through C1 to base of Q2. If pulse is greater than 0.6 V, Q2 is driven into saturation and output of pen drops to 0.3 V. Output line goes to pin 5 of digital display unit (DDU), which writes 1 or 0 (dot or no dot) on screen at instant that electron beam of CRT terminal reaches position of pen. Sensitivity control can be adjusted so illuminated dot just ahead of pen can be used to create new dot in adjacent dark space. If screen is dark all around pen, footswitch-controlled auxiliary circuit can be used to override Z-axis control and flood screen with light momentarily by feeding logic 1 to Z input. This mode can be used for creating or correcting graphics.—S. S. Loomis, Let There Be Light Pens, *BYTE*, Jan. 1976, p 26–30.



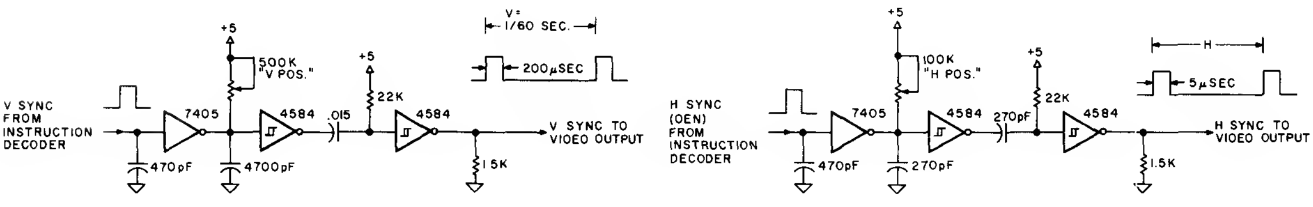
Software

```
POTPOS:  MVI   B,0
         OUT   TRIGGER
CONT:    INR   B
         IN    STATUS
         ANA   A          ;Sets sign flag
         JM    CONT
         RET
```

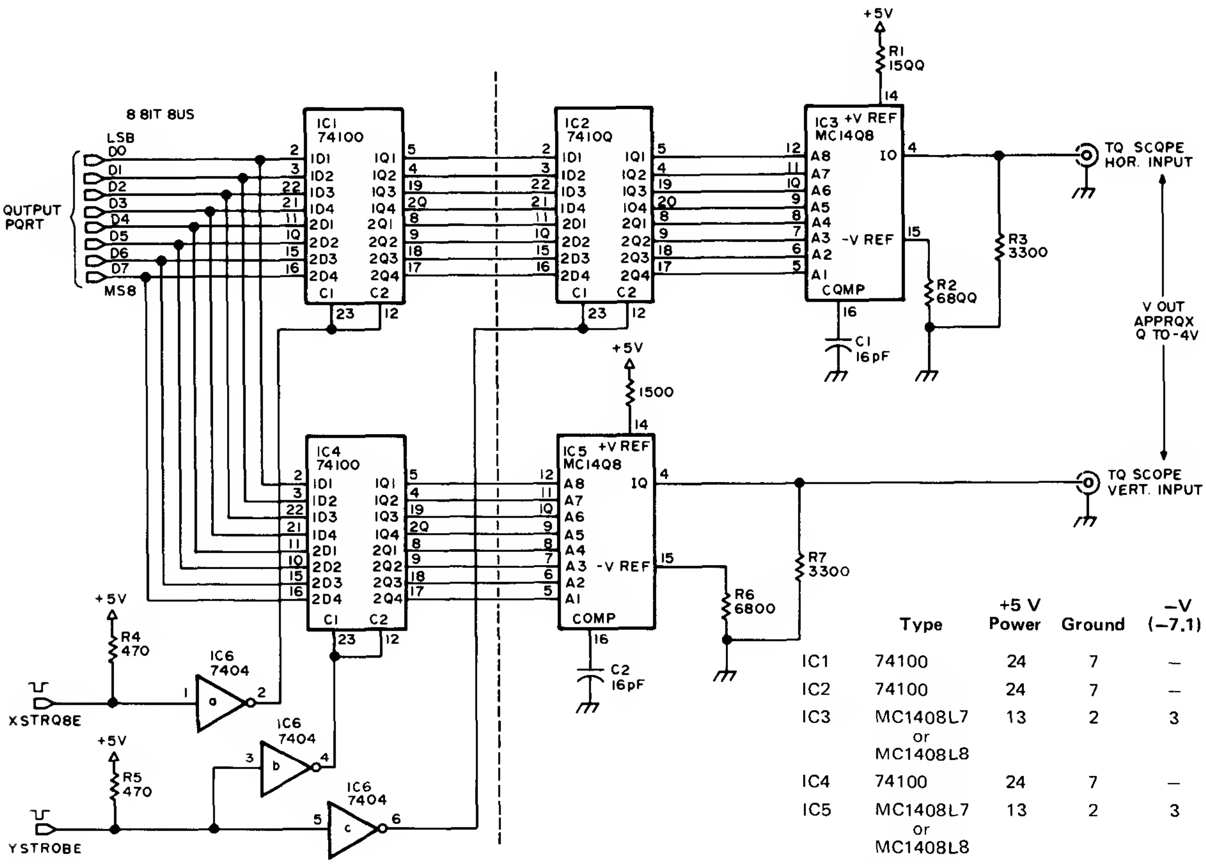
DIGITIZING POT POSITION—Converts position of pot arm into digital value, using NE555 timer and several bytes of program in 8008 or 8080 microprocessor having 2.5-µs clock. NE555 is triggered at pin 2 by OUT TRIGGER instruction. Program monitors output at pin 3 in loop that increments B register. When NE555 times out, program exits from subroutine and B register contains digital representation of pot position.—J. M. Schulein, Pot Position Digitizing Idea, *BYTE*, March 1976, p 79.



SOFTWARE MONITOR—Detects large percentage of random faults, such as overflow conditions. Based on fact that part of program passas through reentry on predictable repeat basis. For each reentry, pulse is fed from CPU to input of 74LS123 retriggerable mono MVBR. On each pass through program, programmer sets and then resets MVBR. Period of mono is made longer than longest normal time between programmed pulse outputs, to prevent false alarms. Any system fault that makes program repeat instructions endlessly or lose control will give false indication.—D. Brickner, Get a Watchdog to Monitor Those Raal-Time Operations, *Kilobaud*, April 1978, p 118–119.

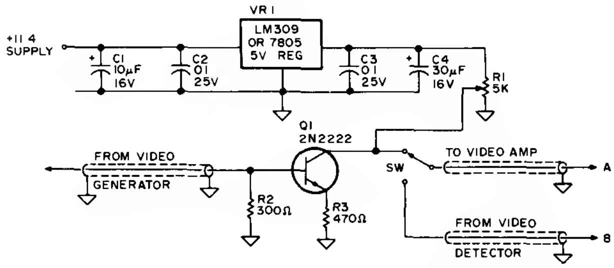


POSITION CONTROL FOR GRAPHICS—Six inverters serve for moving entire character display to any position on TV screen. Display is produced by microprocessor through alphameric data-to-video converter. Circuit requires continuous feed of H and V signals from instruction decoder of microprocessor.—D. Lancaster, TVT Hardware Design, *Kilobaud*, Jan. 1978, p 64–68.

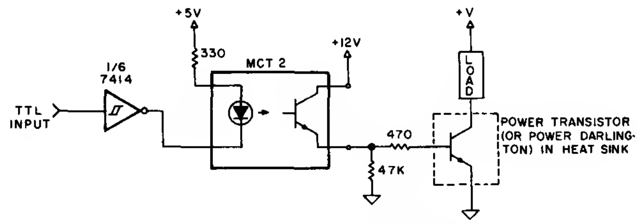


Type		+5 V Power	Ground	−V (−7.1)
IC1	74100	24	7	–
IC2	74100	24	7	–
IC3	MC1408L7 or MC1408L8	13	2	3
IC4	74100	24	7	–
IC5	MC1408L7 or MC1408L8	13	2	3
IC6	7404	14	7	–

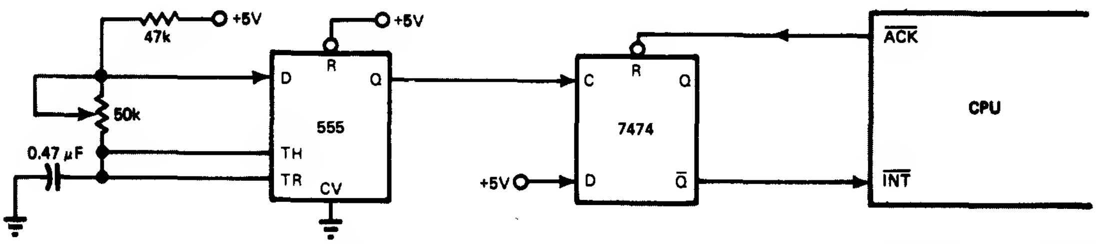
GRAPHICS INTERFACE—Used betwaen computer and ordinary CRO to create images with array of 512 × 512 dots stored in computer mamory. Location of aach dot is specified by two voltagas, for application to V and H inputs of CRO. Computer provides voltaga values by outputting two binary words to pair of DACs giving voltages proportional to numerical values of words. Dot pattern is repeated many timas per second to give steady nonflickering image. Dot brightness can be incraased by storing in savaral locations so it is refreshed more often than other points. Article gives listing for Intel 8080 graphics drive program. Program provides for interrupts once per scan to give keyboard-controlled drawing mode.—P. Nelson, Build the Beer Budget Graphics Interface, *BYTE*, Nov. 1976, p 26–29.



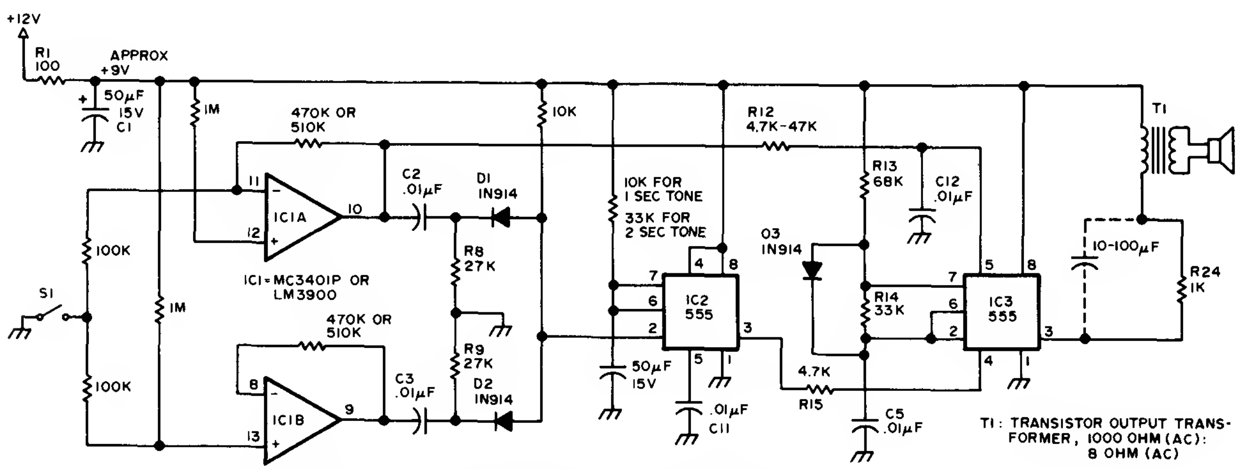
TV AS DISPLAY TERMINAL—Simple switch insarted in ordinery TV recaivar sarves for feeding video output of microprocassor directly into video emplifiar of set, to give low-cost display terminel. TV must heva trensformer-type power supply. Excellent set for monitor use is 12-inch Hitechi model P-04, having Hitachi SX chessis. This set hes very wide bendwidth, giving sherp displey with lina widths up to 80 cherecters.—G. Runyen, Tha Graet TV to CRT Monitor Convarsion, *Kilobaud,* July 1977, p 30–31.



DC CONTROL BY TTL I/O—Output of microprocessor drives LED of photocouplar through ona saction of 7414 hax Schmitt-trigger-input invertar. Phototrensistor switchas powar trensistor or powar Derlington on and off for control of direct current through load. With transistor heving current gain of 30 and 20-mA control current, loed current cen be 500 mA. With power Derlington having higher current gain, load can be sevarel emperes. Since power device is eithar off or saturated, heetsink can ba smell.—M. Boyd, Intarfecing Tips, *Kilobaud,* Feb. 1978, p 72–74.

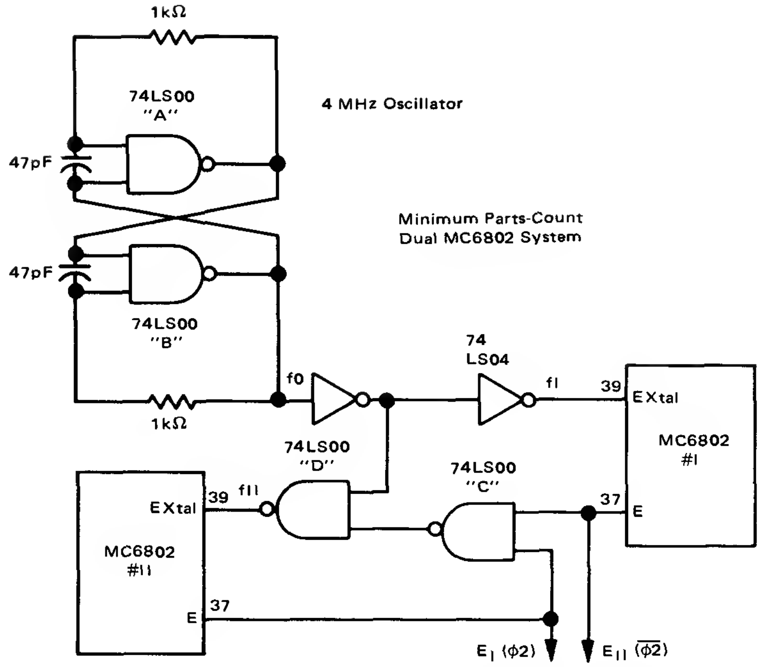


LOGGING EXACT TIME—Used in microcomputar applications requiring recording of axect time of eech event by date-logging printer. Uses 555 timer end 7474 D flip-flop to produca interrupt request evary 16.67 ms. Requires use of softwera routine that acknowladgas interrupt, incramants counter in known location to serva es time-of-day clock, end resumes interrupted progrem. Article diegrems software routine required.—Real-Tima Software Keeps Program Segments on Schedule, *EDN Magazine,* Nov. 20, 1976, p 277–283.

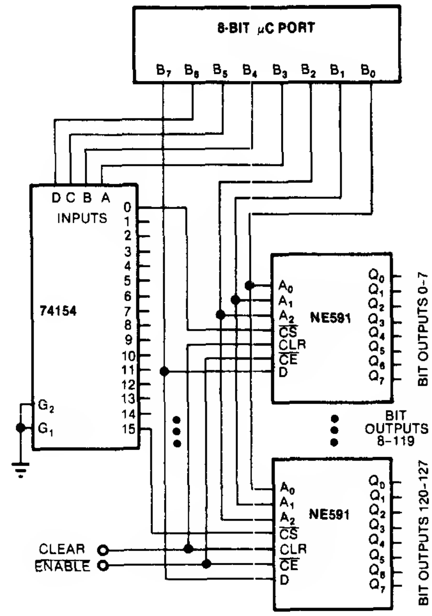


IC1 POWER: +9V PIN 14
GND PIN 7

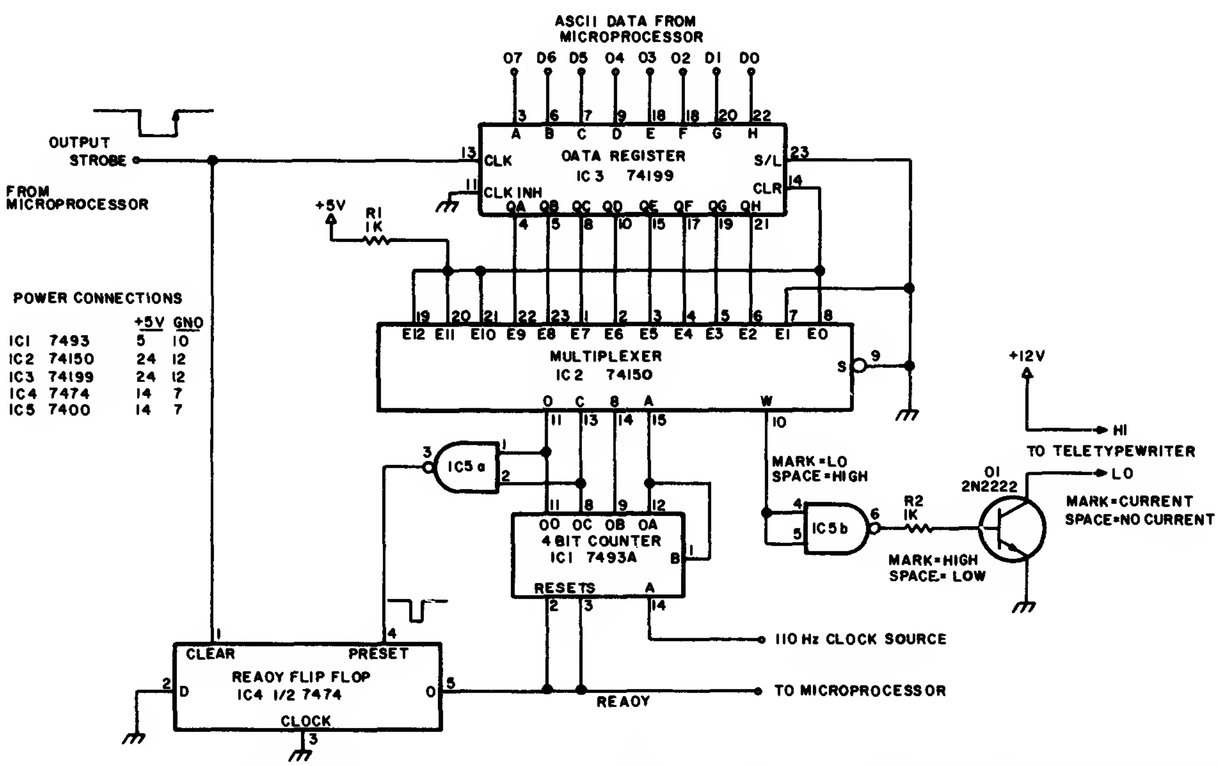
TWO-TONE ALARM—Provides audible beckup for visual displey in microprocessor-controlled system thet requires human intervantion under certain conditions, to alert operator who mey be watching machinery rather then displey. When input line goes high, device emits 1-s beep thet means stop. When input goes low, 1-s lower-frequency boop sounds to indicate go. S1 represants signal derived from single-bit computer output. Audio bursts are generated by 555 timers. IC2 is wired as mono MVBR to datarmine tone duration, set by C4 and R11. Negetive-going pulse on pin 2 triggers mono on. If microprocessor circuit craates pulsa rather then leval change, input should go to pin 2. Tone frequency is set by C5, R13, end R14 of IC3. Trigger uses IC1A es inverting opemp and IC1B as noninvarting opamp. Triggar outputs ere differentlated to give nagative-going spike for each input laval change. Spikes ere ORed by D1 and D2 for trigger input of IC2. Differant tones era echieved by using IC1A to change input voltaga to pin 5 of tone generator IC3. Optionel electrolytic capacitor across R24 will increase volume.—C. F. Douds, Audibla Interrupts for Humans, *BYTE,* Fab. 1977, p 54 and 58.



SYNCHRONIZING TWO MICROPROCESSORS—4-MHz oscillator using 74LS00 quad two-input NAND gates serves in place of crystal source of individual MC6802 microprocessors to ansura synchronlzing so one microprocessor oparates during half-cycle when other microprocessor is disabled. Arrangemant glvas computing power of two MPUs with system cost of one data bus. No time is sacrificed sinca half-cycle used would normally be daad time on bus.—J. Farrell, "Synchronizing Two Motorola MC6802s on Ona Bus," Motorola, Phoenix, AZ, 1978, AN-783.

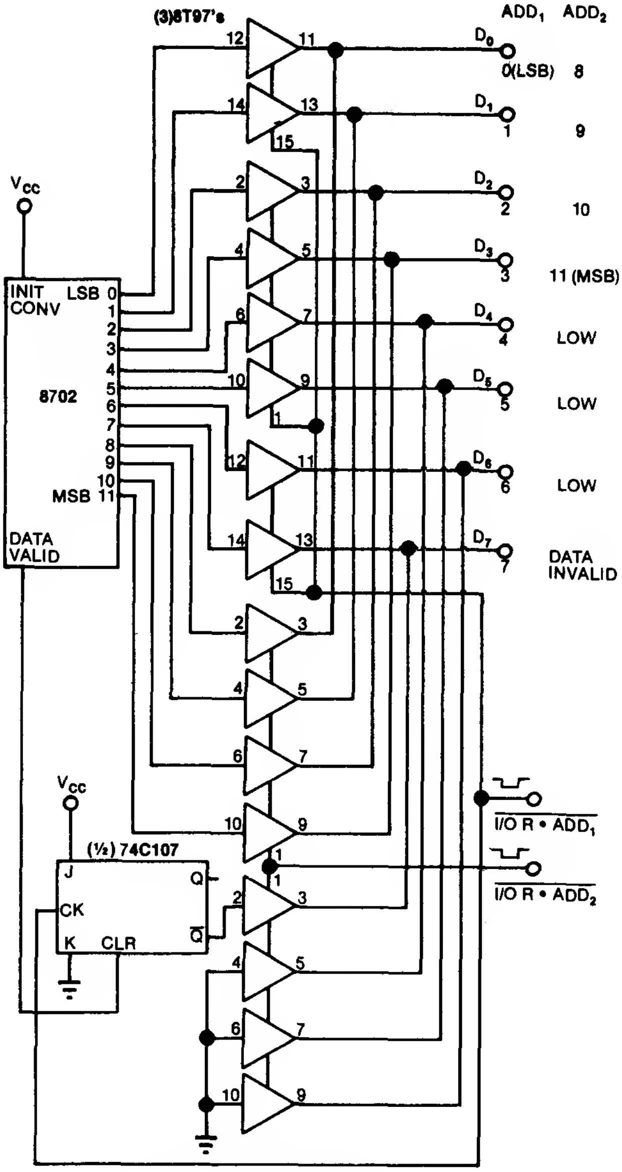


8 BITS CONTROL 128 BITS—Combination of 74154 demultiplaxar and 16 NE591 latches permits control of 128 single-bit outputs with standard 8-bit parallel output of microprocessor. Latches are driven from three low-order bits of microprocessor. Naxt four higher bits driva 74154 which in turn drivas chip-enable inputs of NE591s. Eighth bit of microprocessor drives data inputs of all latches and sets addressed bits appropriately.—R. D. Grappel, Control 128 Bits with an 8-Bit μC Port, *EDN Magazina*, Sept. 5, 1978, p 70 and 72.



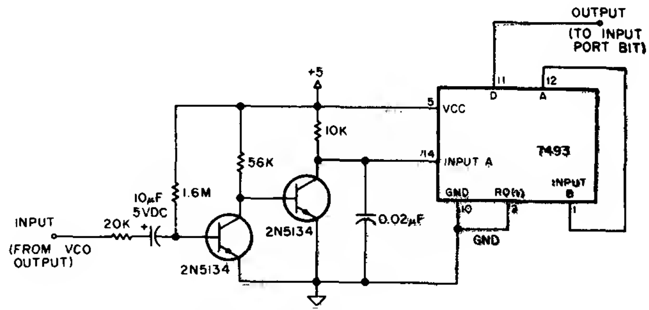
		+5V	GND
IC1	7493	5	10
IC2	74150	24	12
IC3	74199	24	12
IC4	7474	14	7
IC5	7400	14	7

PARALLEL-TO-SERIAL CONVERTER—Multiplexer IC2 selects formatting and data bits according to state of IC1. IC3 is output latch. Teletypewriter currant loop is drivan by Q1 from output of multiplexer. 110-Hz clock gives transfer rate of 10 characters per second. Provides standard asynchronous format of 1 start bit, 8 data bits, and 2 stop bits for teletypewriter without using universal asynchronous receiver-transmitter.—G. C. Jewell, How to Driva a Teletype Without a UART, *BYTE*, Jan, 1977, p 32.

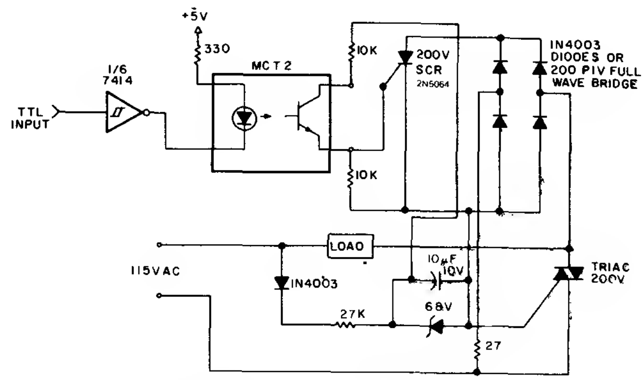


NOTE: UNUSED INPUTS OF 74C107 MUST BE TIED TO V_{CC} OR GND

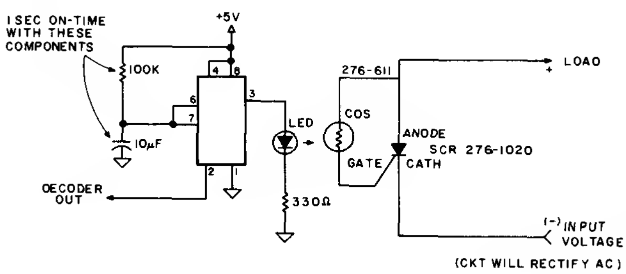
12 BITS ON 8-BIT BUS—Arrangement shown speeds reading of 12 bits of dete onto 8-bit microprocessor bus by simplifying checking procedure. Output of 74C107 flip-flop becomes DATA INVALID bit end is plecad on bus during second reed cycle. Simultaneously, circuit pulls 3 remeining bits (D_4-D_6) low through use of spere 8T97 getes. Article gives simplified 8080 subroutine required.—D. W. Teylor, Speed-Reed 12 Bits onto en 8-Bit Bus, *EDN Magazine*, Sept. 5, 1978, p 70.



CALIBRATING MARK/SPACE VCO—Simple buffer/counter provides eccurete calibration of FSK circuit used in cassette interfece of 8080 microprocessor to generate merk end space frequencies. Audio FSK waveform is squared and divided down in 7493 4-bit counter. Resulting pulses ere fed to input port of microprocessor for softwere pulse counting. Software sets VCO frequency, weits until pulse starts, counts each pulse occurrence, and displays resultant count. Eech 7493 count is 29 Hz or 14.5 µs, so 371 counts correspond to 2975 Hz for space. Mark frequency of 2125 Hz gives pulses separated by 519 counts.—D. R. Bourdeau, Cassette Interface First Aid, *Kilobaud*, July 1977, p 49.



AC CONTROL BY TTL I/O—Output of microprocessor drives LED of photocoupler through one section of 7414 hex Schmitt-trigger-input inverter. Output of phototrensistor controls SCR connected across full-wave diode bridge. Current flow through bridge end SCR turns on triac, ellowing eltemeting current to flow through load. Choose triec rated for handling required load current.—M. Boyd, Interfecing Tips, *Kilobaud*, Feb. 1978, p 72–74.

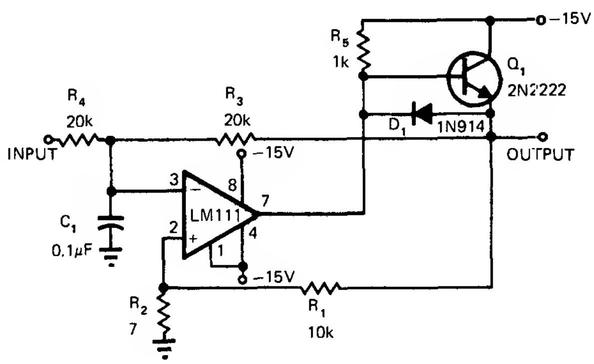


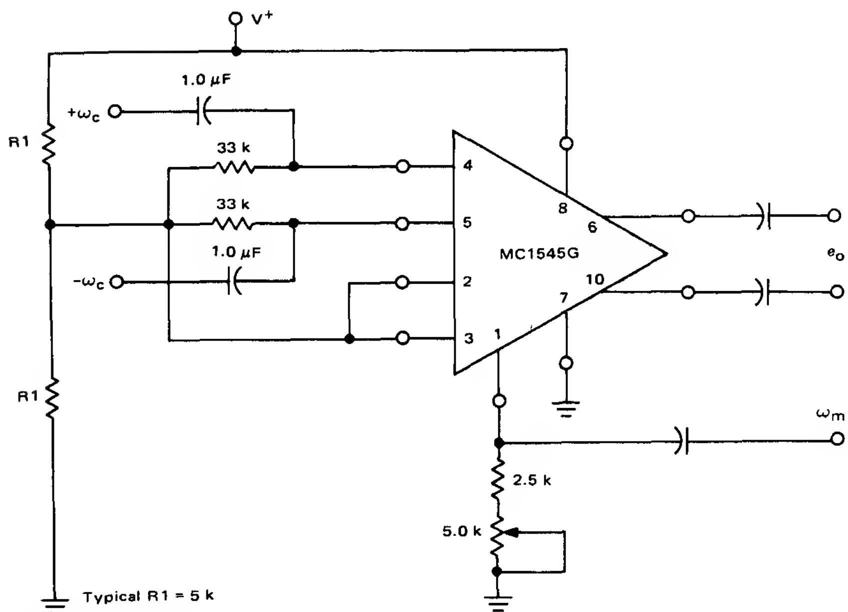
AC/DC CONTROL WITH SCR—Decoder output of microprocessor feeds 555 timer driving LED thet is mounted in light shield with cadmium sulfide photocell. Combination serves as optocoupler for triggering gate of SCR to energize load for short time interval determined by value of resistor end capacitor used. Serves to control smell DC motor such as is used to raise or lower transmitter power in small increments.—R. Wright, Utilize ASCII Control Codes!, *Kilobaud*, Oct. 1977, p 80–83.

CHAPTER 52
Modulator Circuits

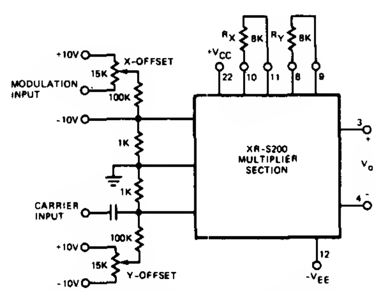
Covers circuits that vary amplitude or some other characteristic of carrier signal or pulse train in accordance with information contained in modulating signal. Includes PCM, PDM, PPM, duty-cycle, and other types of pulse modulators, light-beam modulators, delta modulators, and various types of AM, SSB, and suppressed-carrier modulators. See also Frequency Modulation, Transceiver, and Transmitter chapters.

PULSE-RATIO MODULATOR—LM111 comparator serves with single transistor to provide pulse-train output whose average value is proportional to input voltage. Frequency of output is relatively constant but pulse width varies. Pulse-ratio accuracy is 0.1%. Circuit can be used to drive power stage of high-efficiency switching amplifier, or as pulse-width/pulse-height multiplier. Article tells how circuit works.—R. C. Dobkin, Comparators Can Do More than Just Compare, *EDN Magazine*, Nov. 1, 1972, p 34–37.

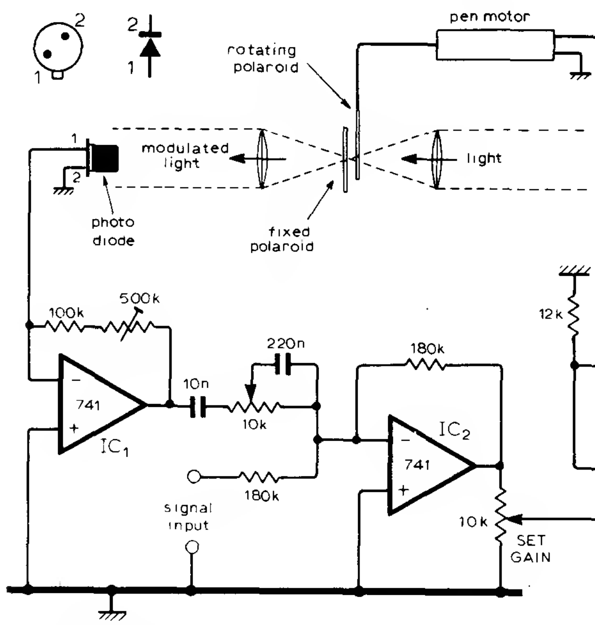




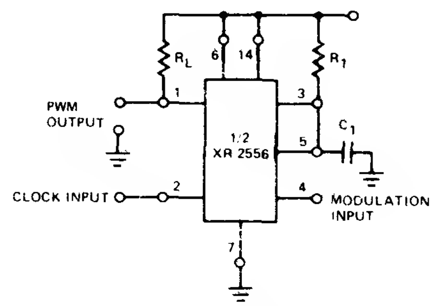
SINGLE-SUPPLY AM—Motorola MC1545 gated video amplifier is connected as amplitude modulator operating from single supply. Artificial ground is established for IC at half of supply voltage by 5K resistors R1, which should draw much more than bias current of 15 μA. All signals must be AC coupled to prevent application of excessive common-mode voltage to IC.—"Gated Video Amplifier Applications—the MC1545," Motorola, Phoenix, AZ, 1976, AN-491, p 15.



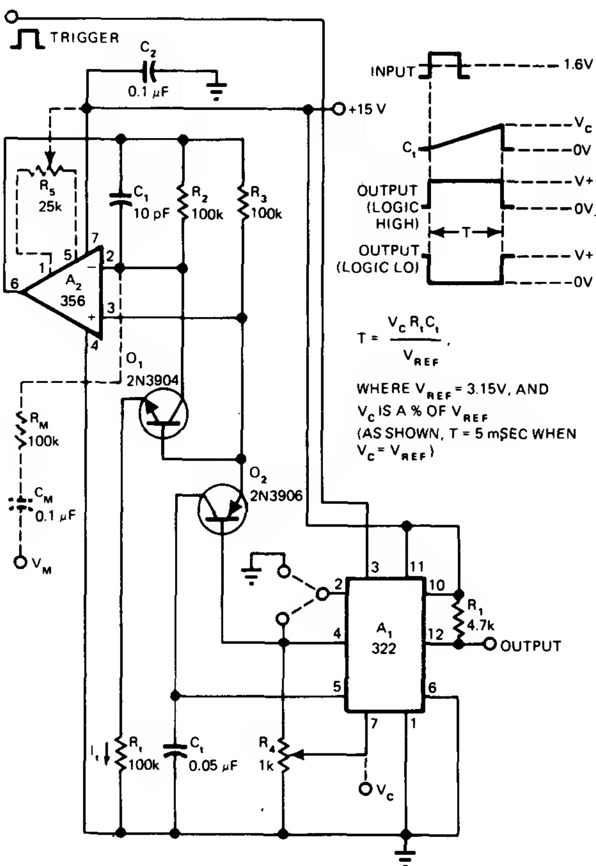
DOUBLE-SIDEBAND AM—Connection shown for multiplier section of Exar XR-S200 PLL IC gives double-sideband AM output. X-offset adjustment for modulation input sets carrier output level, and Y-offset adjustment of carrier input controls symmetry of output waveform. Modulation input can also be used as linear automatic gain control (AGC) for controlling amplification with respect to carrier input signals.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



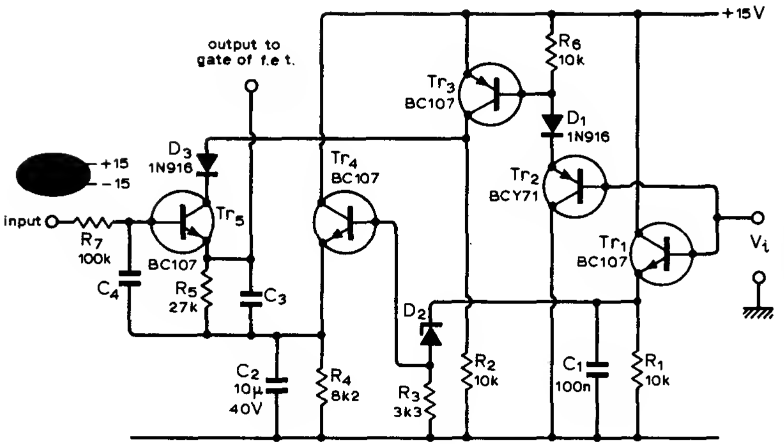
LIGHT-BEAM MODULATOR—Intensity of light beam is modulated by rotating Polaroid vane driven by small motor. Since amplitude is not constant with change in frequency between 10 and 100 Hz, compensation is provided by sampling modulated beam with silicon photodiode that is linearized by IC_1. Input and feedback signals are mixed by summing amplifier IC_2 which drives noninverting power amplifier consisting of 741 opamp driving two OC28 power transistors connected in closed feedback loop having gain of 5. Power amplifier drives pen motor of modulator.—R. F. Cartwright, Constant Amplitude Light Modulator, *Wireless World,* Sept. 1976, p 73.



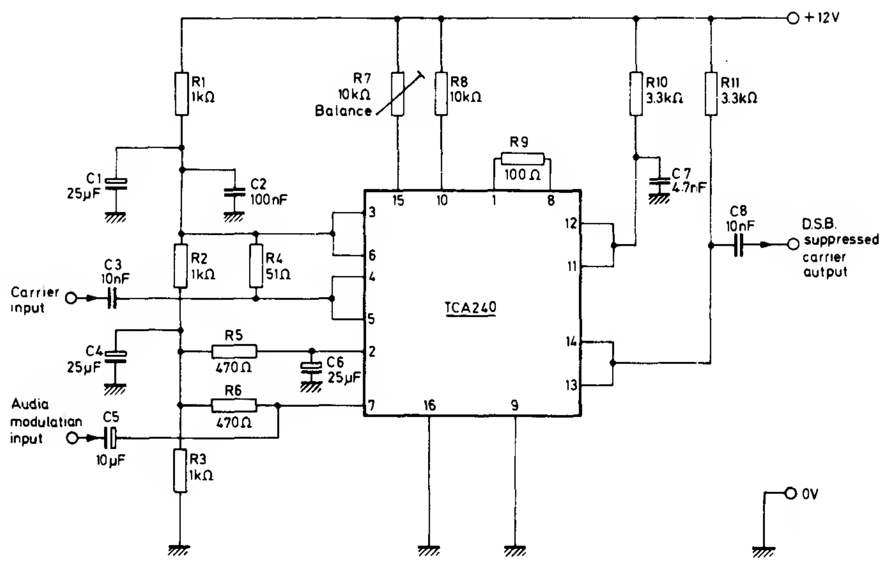
PULSE-DURATION MODULATOR USES TIMER—Half of Exar XR-2556 dual timer is connected to operate in monostable mode, for triggering with continuous pulse train. Output pulses are generated at same rate as input, with pulse duration determined by R_1 and C_1. Supply voltage is 4.5–16 V.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.



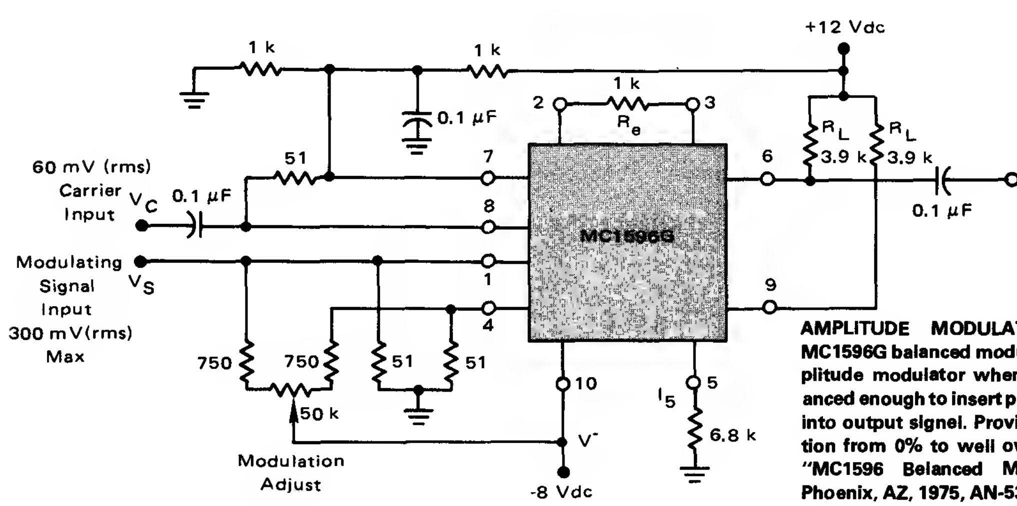
VOLTAGE TO PULSE WIDTH—Constant-current source Q_2 produces linear timing ramp across C_t in circuit of 322 IC timer A_1, for comparison internally with 0–3.15 V applied to pin 7. Pulse is thus linearly variable function of control voltage V_C over dynamic range of more than 100:1. Circuit is highly flexible, permitting use of many other operational modes as covered in article. When AC waveform is applied to V_M, circuit operates as linear pulse-width modulator.—W. G. Jung, Take a Fresh Look at New IC Timer Applications, *EDN Magazine,* March 20, 1977, p 127–135.



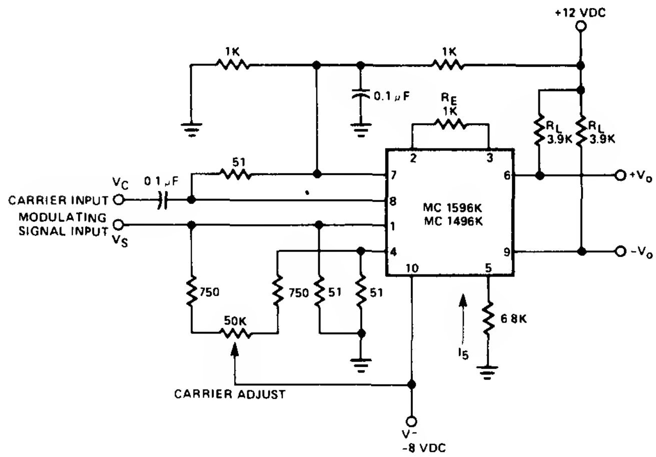
PULSE HEIGHT MODULATOR—Used ahead of FET gate to reduce spike feedthrough. Voltage swing on FET gate is limited to difference between V_i and pinchoff voltage of FET. Zener D_2 is matched to measured pinchoff voltage of FET in use.—M. D. Dsbbs, Pulsa Haight Modulator, *Wireless World*, April 1975, p 176.



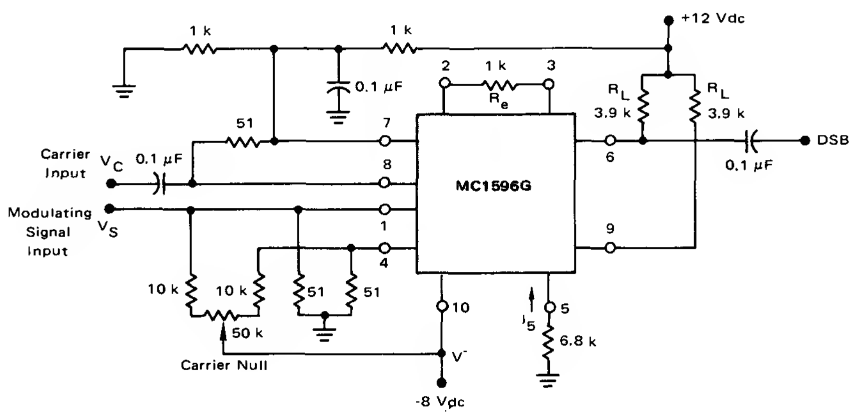
SUPPRESSED-CARRIER MODULATOR—Mullard TCA240 dual balanced modulator-demodulator provides suppression of carrier frequency at output, as required for SSB or DSB operation of transmitter. Bias resistor R7 is adjusted for minimum carrier output to correct imbalance. Can be used as conventional AM modulator if biasing of circuit sections is deliberately unbalanced.—"Applications of the TCA240," Mullard, London, 1975, Technical Note 18, TP1489.



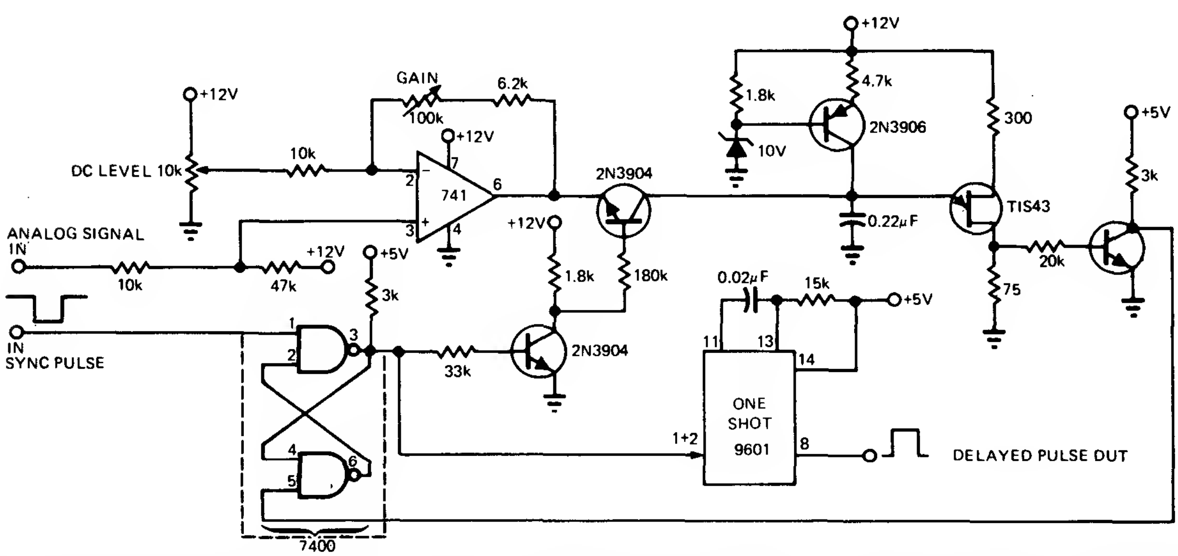
AMPLITUDE MODULATOR—Motorola type MC1596G balanced modulator functions as amplitude modulator when carrier null is unbalanced enough to insert proper amount of carrier into output signal. Provides excellent modulation from 0% to well over 100%.—R. Hejhall, "MC1596 Balanced Modulator," Motorola, Phoenix, AZ, 1975, AN-531, p 7.



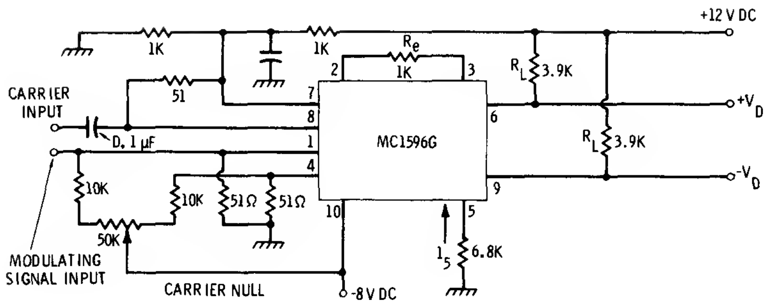
SINGLE-IC AM—Adjusteble carrier offset Is edded to carrlar differentiel palrs to provide carrier-frequancy output thet varias In amplitude with strength of moduletion signal.—"Signatics Anelog Data Menuel," Signetics, Sunnyvala, CA, 1977, p 757.



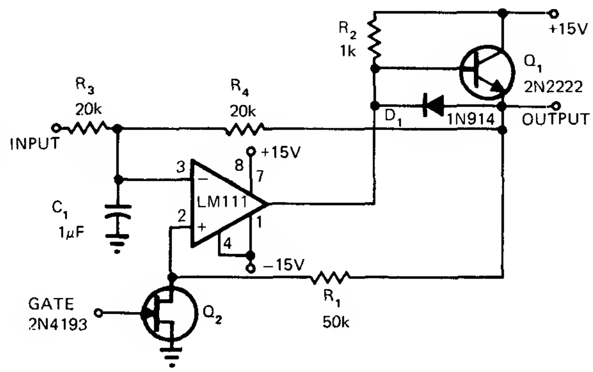
DSB BALANCED MODULATOR—Provides excellent gein end cerrier suppression by operating upper (carrier) differentiel emplifiers of Motorole MC1596G balanced moduletor et setureted level end lower differantial amplifier in linaer mode. Recommanded input levels are 60 mVRMS for carrier end 300 mVRMS meximum for modulating signel.—R. Hejhell, "MC1596 Balanced Modulator," Motorola, Phoenix, AZ, 1975, AN-531, p 3.



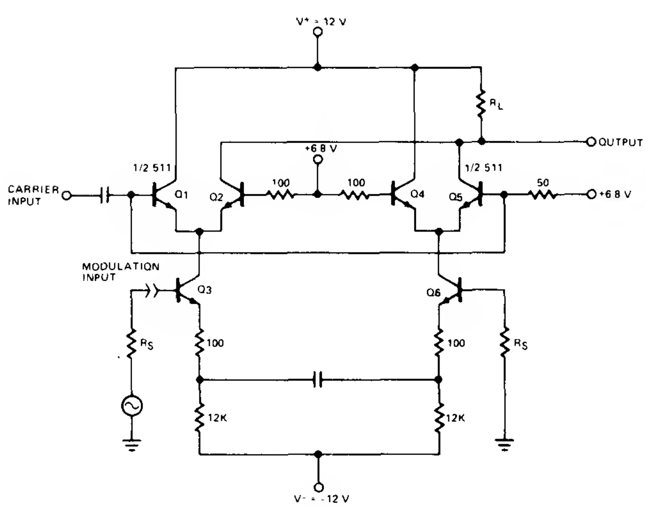
PPM WITH ANALOG CONTROL OF DELAY—Opamp, UJT, end two TTL packages generete pulse whosa delay, following sync pulse, is controlled by emplitude of analog Input signel at tlma of sync pulsa. Opemp precherges timing capecitor to level depending on analog signel. Sync pulsa disconnects opamp, after which timing capacitor charges up to UJT firing point. UJT output pulse than resets circuit, glving desired daleyed output pulse through 9601 mono MVBR.—J. Taylor, Analog Signal Controls Pulse Deley, *EDN Magazine*, Feb. 5, 1974, p 96.



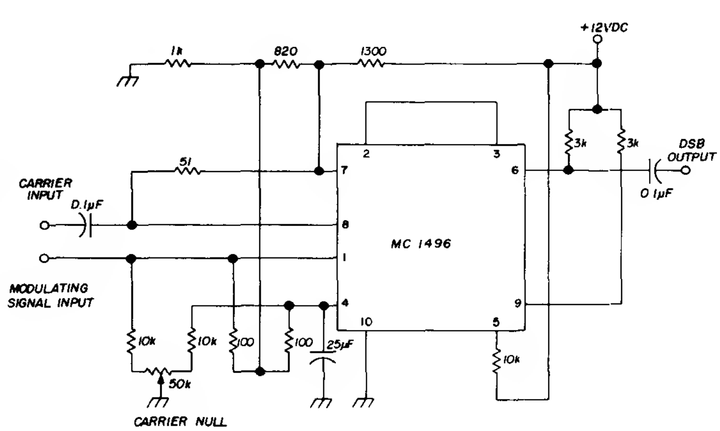
DOUBLE-SIDEBAND SUPPRESSED-CARRIER—Motorola MC1596G double-balanced modulator has carrier input between pins 8 and 7 and modulation between pins 1 and 4. Balancing carrier-null circuit, also connected between pins 1 and 4, contributes to excellent carrier rejection at output. For unbalanced output, ground one of push-pull output terminals. Requires two supplies.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 138–139.



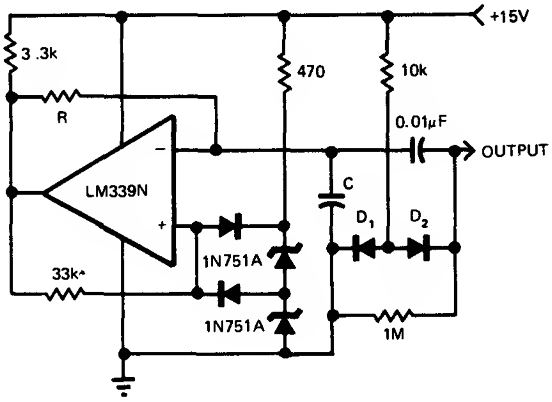
DELTA MODULATOR—Uses LM111 comparator in basic pulse-ratio modulator circuit, with output pulse width and transition time fixed by external clock signal applied to gate of JFET switch Q_2. Average value of output is always proportional to input voltage.—R. C. Dobkin, Comparators Can Do More than Just Compare, *EDN Magazine*, Nov. 1, 1972, p 34–37.



SUPPRESSED-CARRIER AM—Double-balanced modulator using Signetics 511 transistor array gives output consisting of sum and difference frequencies of carrier and modulation inputs along with related harmonics. Circuit is self-balancing, eliminating need for pots. Output includes small amounts of carrier and modulating signal. Capacitor between emitters of Q3 and Q6 is selected to have low reactance at lowest modulating frequency.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 750–751.

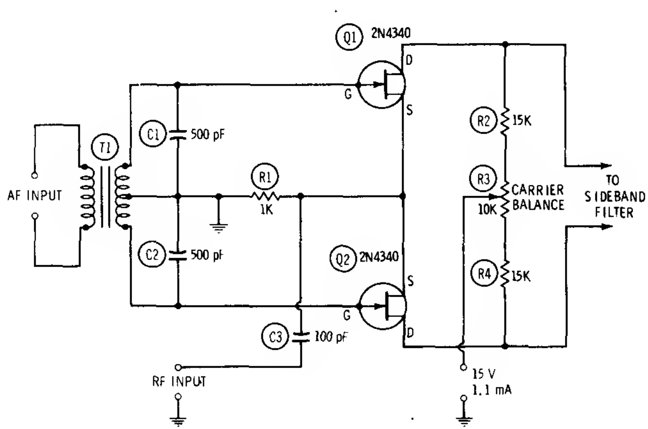


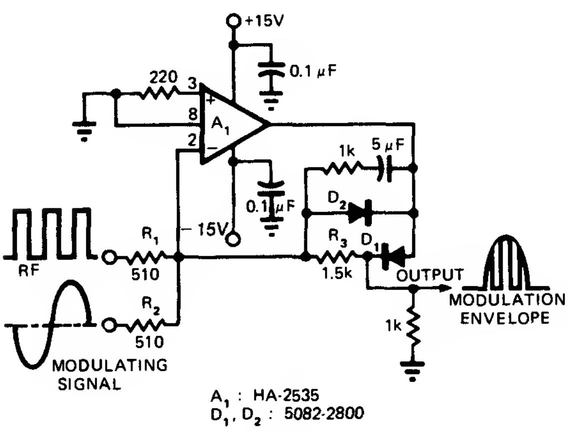
BALANCED MODULATOR—High-performance balanced modulator for 80-meter SSB transceiver uses Motorola MC1496 IC. Adjust 50K pot for maximum carrier suppression of double-sideband output.—D. Hembling, Solid-State 80-Meter SSB Transceiver, *Ham Radio*, March 1973, p 6–17.



DUTY-CYCLE MODULATOR—Uses half of LM339N or LM3302N quad comparator. With no modulation signal, output is symmatrical square wave generated by one of comparators. Constant-amplitude triangle wave is generated at inverting input of second comparator, and is relatively independent of supply voltage and frequency changes. Modulating signal varies switching points to produce duty-cycle modulated wave for such applications as class D amplification for servo and audio systems.—H. F. Stearns, Voltage Comparator Makes a Duty-Cycle Modulator, *EDN Magazine*, June 5, 1975, p 76–77.

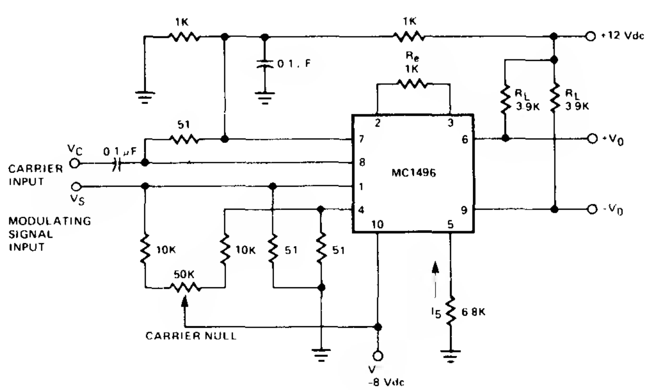
FET BALANCED MODULATOR FOR SSB—AF modulating signal is applied to gates of matched FETs in push-pull through T1 having accurately center-tapped secondary, and RF carrier is applied to sources in parallel through C3. Carrier is canceled in output circuit, leaving two sidebands. R3 is adjusted to correct for unbalance in circuit components.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 90–91.

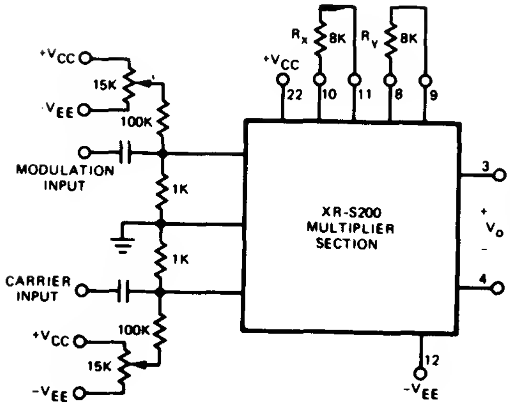




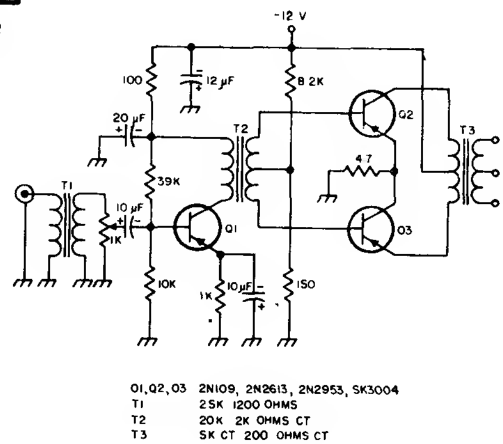
100% MODULATION OF DIGITAL SIGNALS—Developed to produce positive-going half-sine envelope modulated 100% by digital RF signal. Modulator uses loop gain of opamp to reduce diode drops very nearly to ideal zero level. D_2 prevents opamp output terminal from swinging more negative than diode drop of 0.3 V, which is not apparent at output. RF input amplitude must be sufficient to provide 100% modulation; this can be achieved by providing about 20% overdrive to give safety factor. Use hot-carrier diodes such as HP-2800 series.—D. L. Quick, Improve Amplitude Modulation of Fast Digital Signals, *EDN Magazine*, Sept. 20, 1975, p 68 and 70.

DOUBLE-SIDEBAND SUPPRESSED-CARRIER—Signetics MC1496 balanced modulator-demodulator transistor array provides carrier suppression while passing sum and difference frequencies. Gain is set by value used for emitter degeneration resistor connected between pins 2 and 3. Output filtering is used to remove unwanted harmonics.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 756–757.

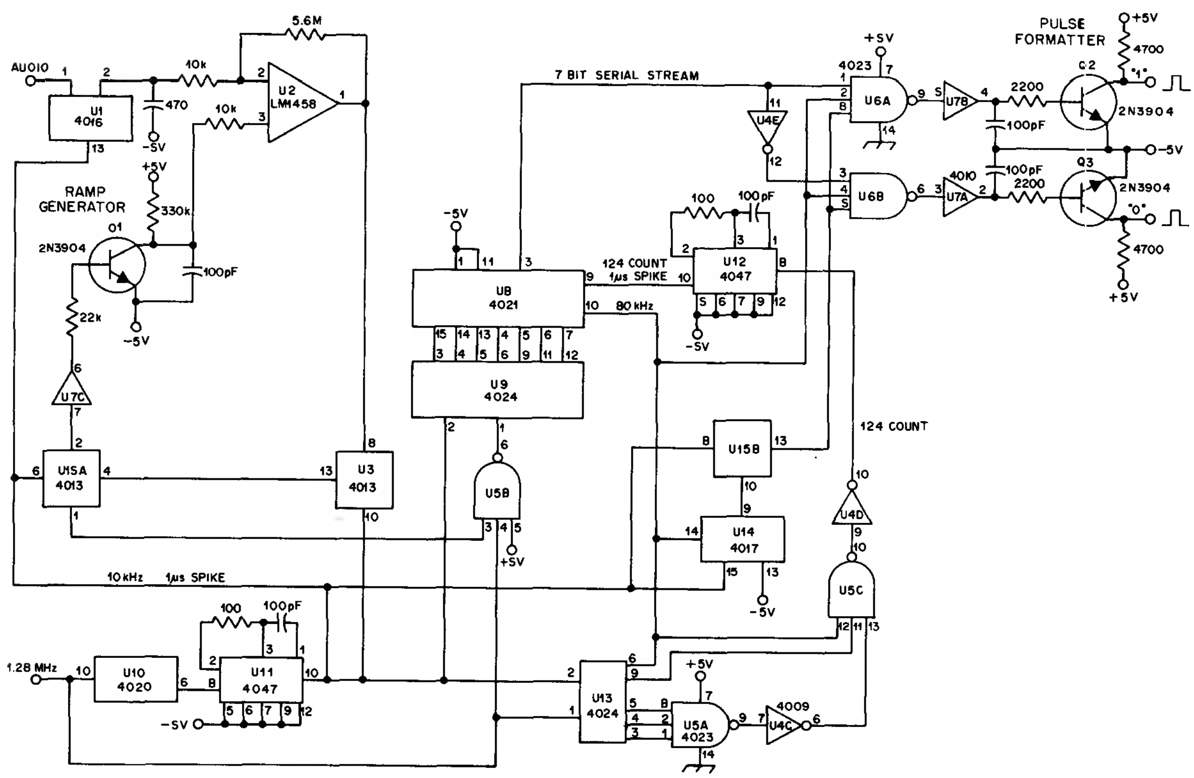




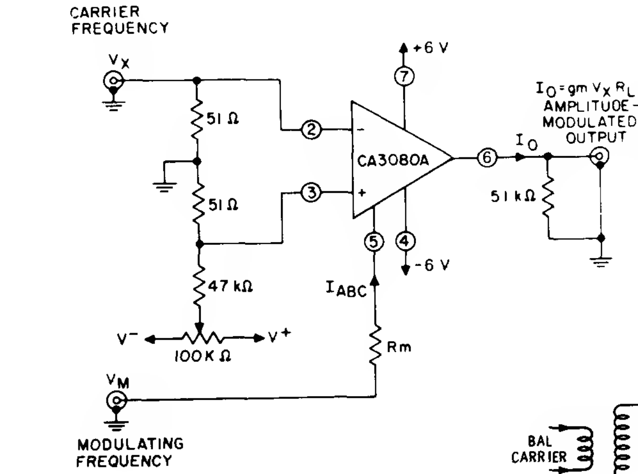
SUPPRESSED-CARRIER AM—Multipliar section of Exar XR-S200 PLL IC is connected to generata suppressed-carrier AM signal having about 60-dB carriar suppression at 500 kHz and 40 dB at 10 MHz. Inputs are interchangeable. 15K offset adjustmant pots optimiza carrier suppression. Supply voltage range is ±3 to ±30 V.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



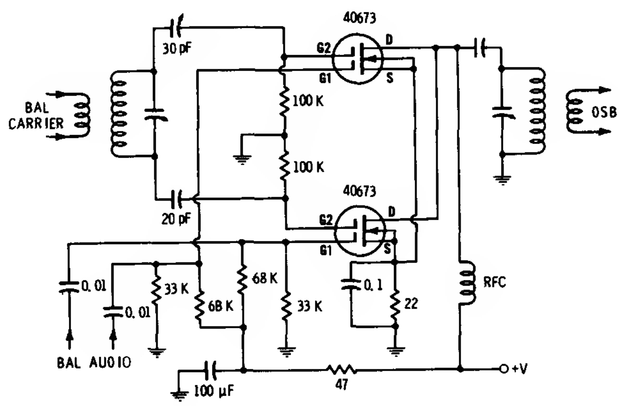
100 mW—Can ba used to collector-modulata transmitters up to about 200 mW or base-modulate somawhat larger power amplifiers. Transformer coupling minimizes number of components needed.—Circuits, *73 Magazine*, Jan. 1974, p 177.



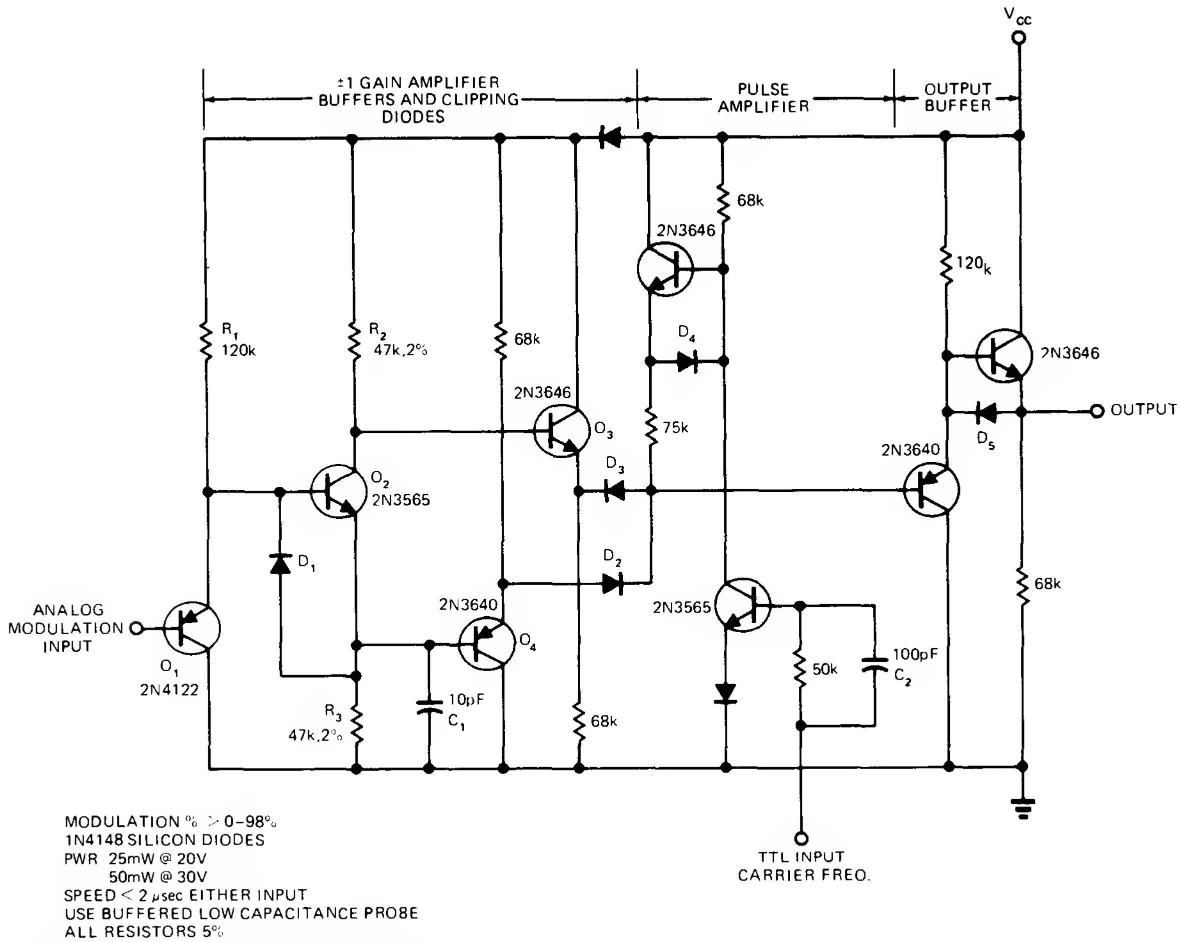
PCM FOR MICROWAVE TRANSMITTER—Modarn pulse-code modulator can be used for experimantation above lowest lagal frequency of 2.3 GHz, such as for satallite and moonbounce communication. Single voice channal is encoded by using CMOS technology having low power consumption, good noisa immunity, and moderata cost. Audio is sampled 10,000 times per second for conversion to 7-pulsa coda plus synchronizing bit, for 123 levals of encoding frequancies up to 5 kHz. When 10-kHz sampling spika (derived from axternal 1.28-MHz oscillator by frequency divider U10 and mono U11) arrives at pin 13 of transmission gata U1, AF voltage of pin 1 appears at pin 2. 470-pF capacitor charges to this voltaga and holds charga until next sampla. This voltaga is comparad by U2 to linaar ramp startad by Q1 at sampling instant. When ramp voltaga exceeds sampled voltage, U2 triggers, setting flip-flop U3 and resetting ramp generator to −5 V. At same tima, binary counter U9 is stopped by raset flip-flop U15A, and binary equivalent of sampla appears at pins 3, 4, 5, 6, 9, 11, and 12 of U9. Remainder of circuit converts bits to serial form for transmission. Article explains circuit operation in detail and gives corresponding decoder circuit for receivar.—V. Biancomano, A Prototypa Pulse-Coda Modulation System, *QST*, Jan. 1977, p 24–29.



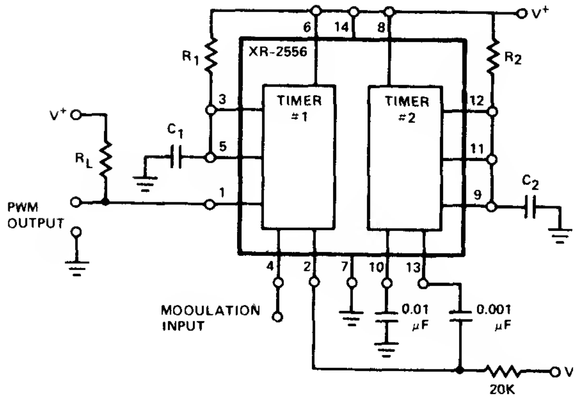
AMPLITUDE MODULATOR—Uses controlled variation of amplifier bias current I_{ABC} in CA3080A variable opamp to obtain effective gain control of signal. Variations in amplitude of modulating voltage V_M change bias current through Rm to give amplitude modulation of carrier.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 15.



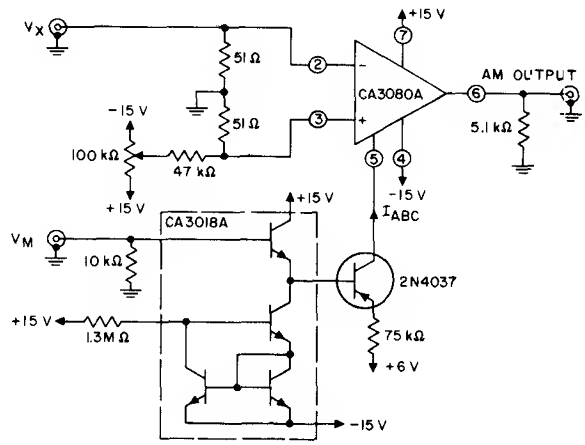
MOSFET BALANCED MODULATOR—Balanced carrier is fed to G2 gates and balanced audio to G1 gates. Both carrier and audio are canceled in output, leaving desired double-sidebend signal.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 195.



SQUARE-WAVE MODULATOR—Analog modulation input goes through buffer Q_1-R_1 to amplifier Q_2-R_2-R_3. Outputs of Q_2 are buffered by separate emitter-followers Q_3 and Q_4 and fed to clipping diodes D_2 and D_3 acting on top and bottom of amplified carrier wave. Following pulse amplifier converts TTL signal to square wave. Two opposed emitter-followers and D_5 form buffer that can either source or sink current from load. Other three diodes are used to speed up circuit operation. Provides modulation range of 0–98%.—E. Burwen, Low-Power Square-Wave Modulator Is TTL Competible, *EDN Magazine*, Nov. 20, 1973, p 91 and 93.



PDM WITH CLOCK—First section of Exar XR-2556 dual timer operates as pulse-duration modulator and second section as clock generator, eliminating need for external clock. Supply voltage is 4.5–16 V. Values of R and C determine frequency and pulse duration of output.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.



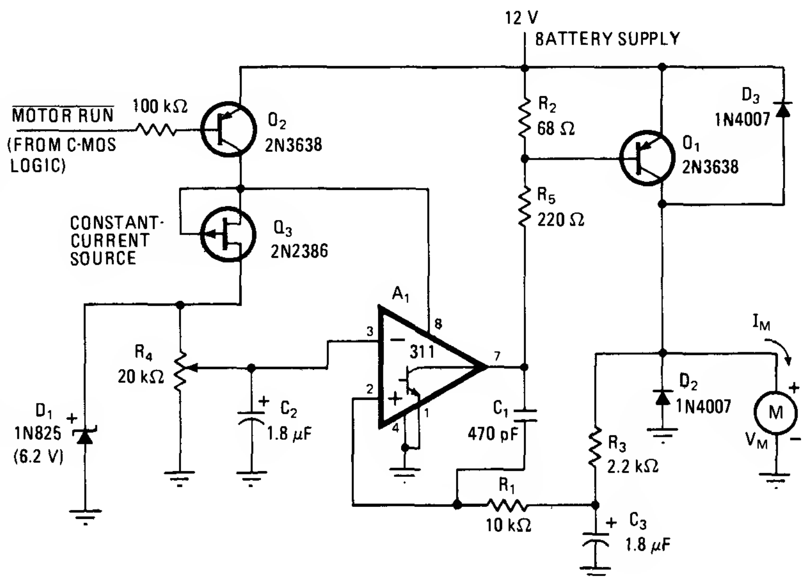
FOUR-QUADRANT MULTIPLIER—Provides amplitude modulation for applications where low power consumption is more important than accuracy. Uses CA3080A variable opamp in combination with transistors of CA3018A array and 2N4037 amplifier for bias current of opamp. Accuracy is within 7% full scale.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 15.

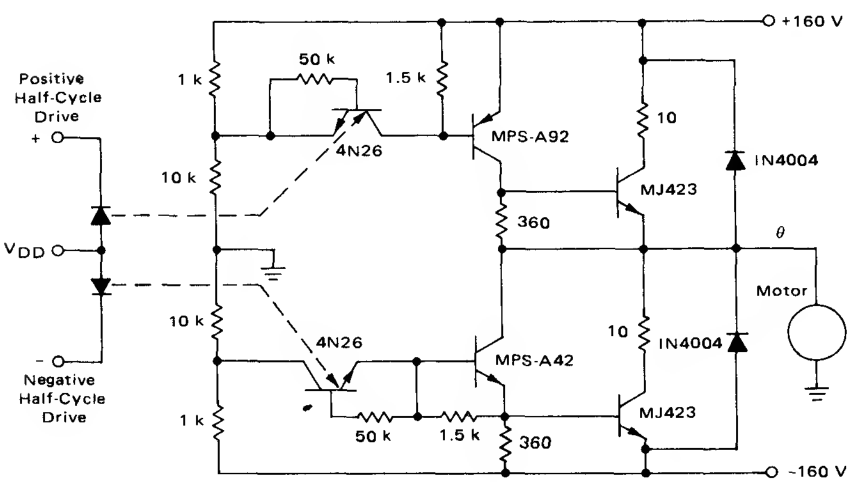
CHAPTER **53**

Motor Control Circuits

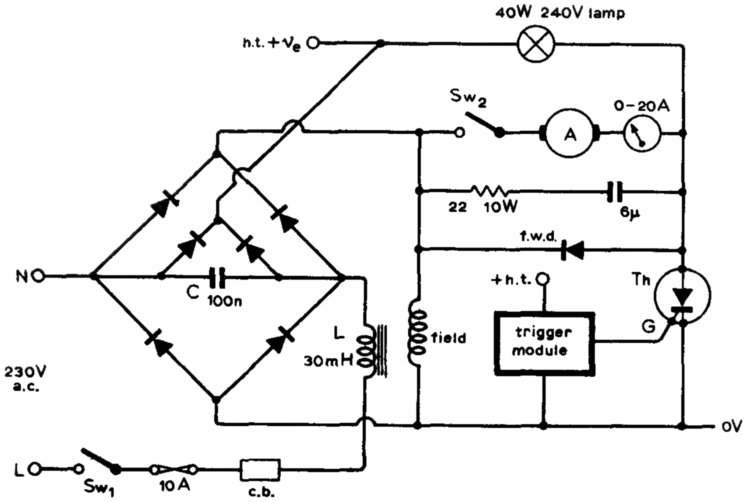
Speed control circuits for various types and sizes of AC and DC motors, including three-phase motors. Some use tachometer feedback to maintain desired constant speed. Includes stepper motor drives, phase sequence detector, braking control, facsimile phase control, and revolution-counting control. Many respond to logic inputs. See also Antenna, Lamp Control, Power Control, Servo, and Temperature Control chapters.

SWITCHING-MODE CONTROLLER—Developed for driving 0.01-hp motor M at variable speeds with minimum battery drain. Circuit uses pulses with low duty cycle to set up continuous current in motor approximating almost 200 mA when average battery drain is 100 mA for output voltage of 3.5 V. Voltage comparator A_1 serves as oscillator and as duty-cycle element of controller. C_1 and R_1 provide positive feedback giving oscillation at about 20 kHz, with duty-cycle range of 10% to 70% controlled by feedback loop Q_1-R_1-C_3-R_3. D_2 is used in place of costly large capacitor for filtering.—J. C. Sinnett, Switching-Mode Controller Boosts DC Motor Efficiency, *Electronics*, May 25, 1978, p 132.



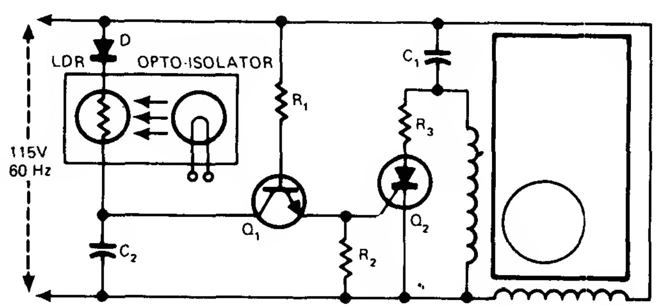


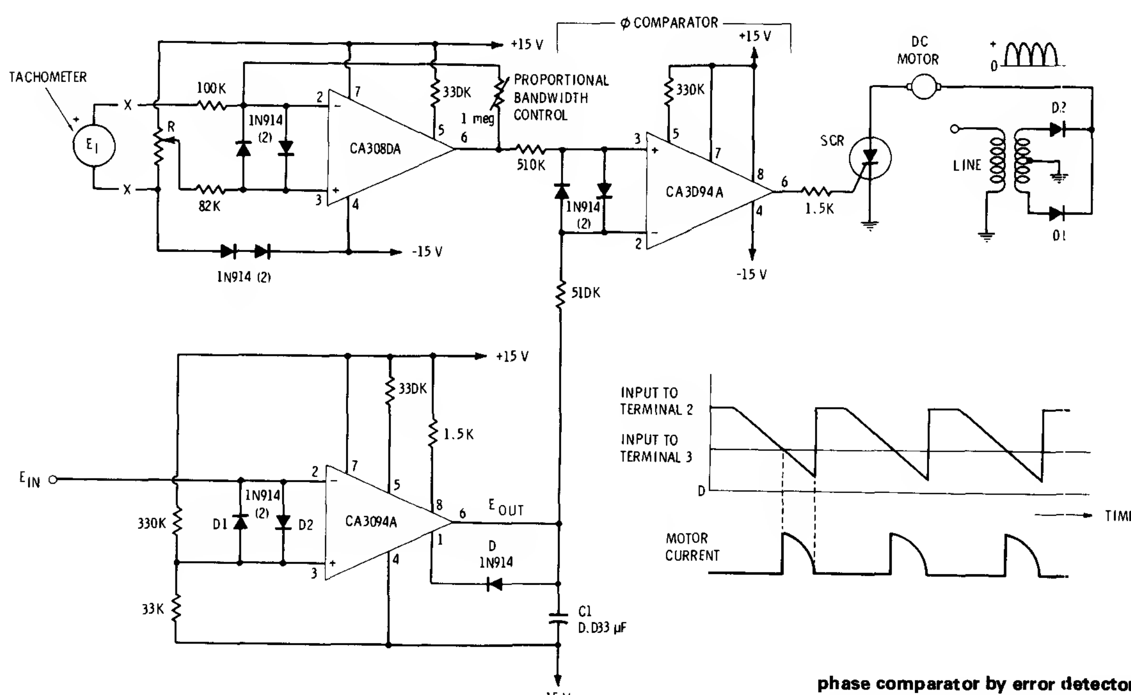
PWM SPEED CONTROL—Power stage using Motorola 4N26 optoisolators and push-pull transistors drives fractional-horsepower single-phase AC motor over speed range of 5% to 100% of base speed. Input drives are provided by pulse-width modulation inverter using stored program in ROM to generate sine-weighted pulse trains to provide variable-frequency drive.—T. Mazur, "A ROM-Digital Approach to PWM-Type Speed Control of AC Motors," Motorola, Phoenix, AZ, 1974, AN-733, p 12.



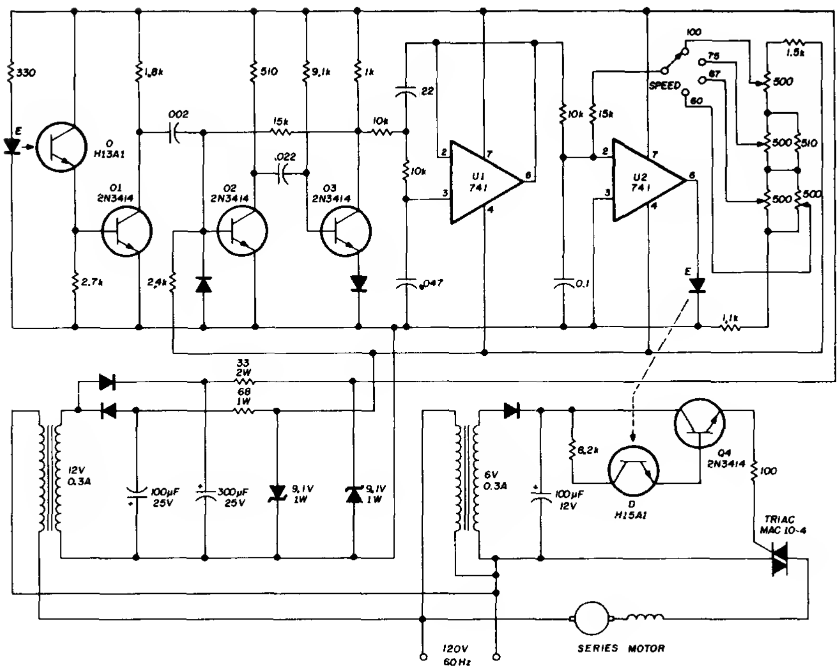
2-hp THYRISTOR CONTROL—Provides smooth variation in spaad of shunt-wound DC motor from standstill to 90% of rated spaed. Use thyristor rated 30 A at 600 V. Outar diodes of bridge are 35-A 600-PIV silicon power diodes, es also is thyristor dioda, and innar diodes ere 5-A 600-V silicon power diodes. Article gives complete circuit of trigger pulse generetor used to control speed by varying duty cycle of thyristor. Larger motors can ba controlled similarly by upreting thyristor and diodes. Controller will also hendle other types of loads, including lamps and heeters.—F. Butlar, Thyristor Control of Shunt-Wound D.C. Motors, *Wireless World,* Sept. 1974, p 325–328.

TAPE-LOOP SPEED CONTROL—Shunt rectifier-capacitor circuit wes developed for speed control of permanant split-cepacitor fractional-horsepower induction motor used in some motion-pictura projectors. Light-dependent rasistor LDR makes Q_2 conduct whan light from lamp is not blocked by tapa loop. Split capacitor C_1 for motor provides both run end speed-control functions without switching. Values are: C_2 0.01 µF; D 1N4004; Q_1 2N4987; Q_2 C106B; R_1 330K; R_2 100; R_3 10.—T. A. Gross, Control tha Speed of Small Induction Motors, *EDN Magazine,* Aug. 20, 1977, p 141–142.



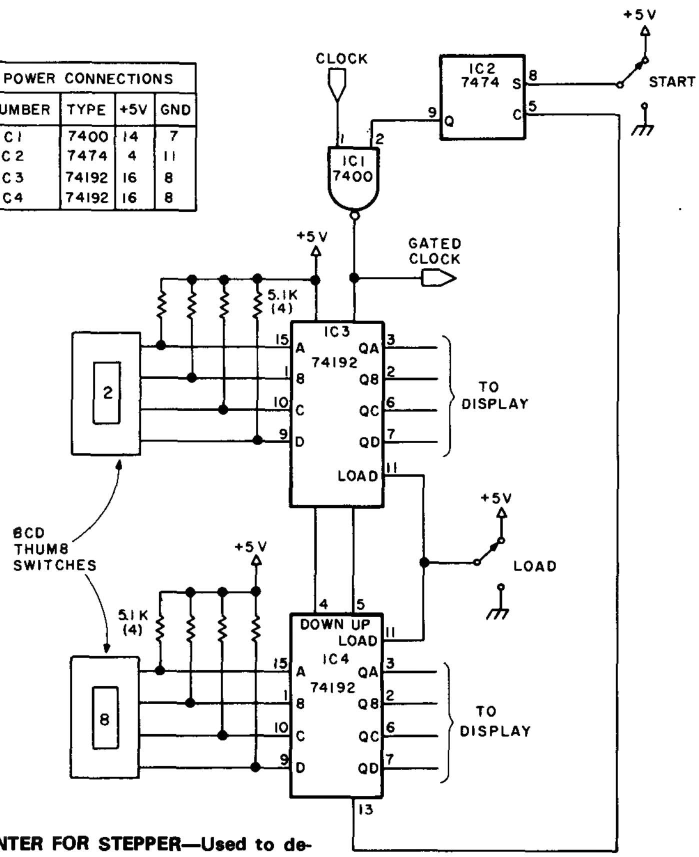


DC MOTOR SPEED CONTROLLER—Tachometer driven by motor produces output voltaga proportional to speed for application to CA3080A voltage comparator after rectification and filtering. Output of CA3080A is applied to upper CA3094A phese comparator thet is receiving reference voltage from anothar CA3094A connectad as ramp ganarator. Output of phese comparetor triggars SCR in motor circuit. Amount of motor currant is set by time duration of positive signal at pin 6, which in turn is determined by DC voltege applied to pin 3 of phase comparator by error detector. Circuit action servas to maintain constant motor speed at valua determined by position of pot R. Input to ramp generator is pulsating DC voltage used to control rapid charging of C1 and slowar discharging to form ramp.—E. M. Noll, "Linaar IC Principlas, Experiments, and Projects," Howerd W. Sams, Indianapolis, IN, 1974, p 321–323.

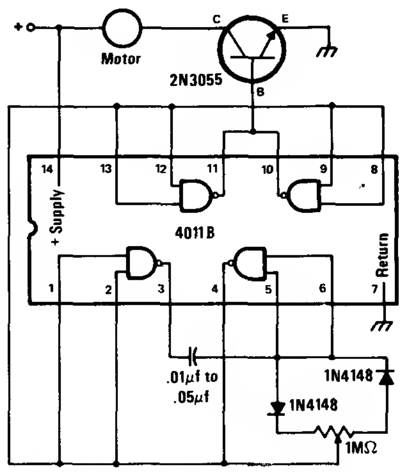


SERIES-MOTOR SPEED CONTROL—Adjustable-speed solid-state motor drive replaces governor in Kleinschmidt RTTY page printer, to give knob-controlled speed range of 60 to 100 WPM. Notched (33-slot) sheet-aluminum disk serving as pulse wheel is mounted on motor shaft and rotates in gap between LED and phototransistor of GE H13A1 optical coupler to form motor-speed sensor or tachometer. Pulses from tachometer, squared by Q1, trigger mono MVBR Q2-Q3 which converts signal to constant-amplitude constant-width pulses having repetition rate proportional to motor speed. Opamp U1 forms three-pole Butterworth active filter that develops required average DC voltage from pulse train. Output current of U1 is compared to reference current derived from speed control circuit, for switching U2 sharply on and off as speed varies above and below desired value. U2 in turn switches motor on and off through H15A1 optical coupler and Q4 in gate circuit of triac. Second coupler isolates control circuit from AC line.—K. H. Sueker, Electronic Speed Control for RTTY Machines, *Ham Radio*, Aug. 1974, p 50–54.

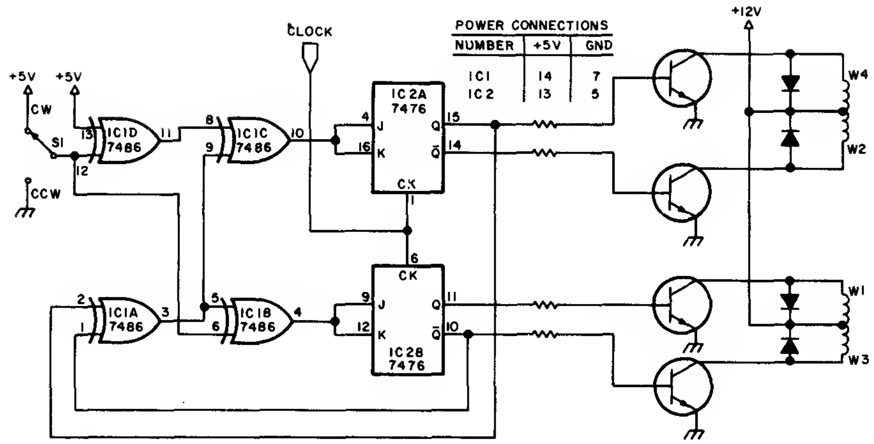
POWER CONNECTIONS			
NUMBER	TYPE	+5V	GND
IC1	7400	14	7
IC2	7474	4	11
IC3	74192	16	8
IC4	74192	16	8



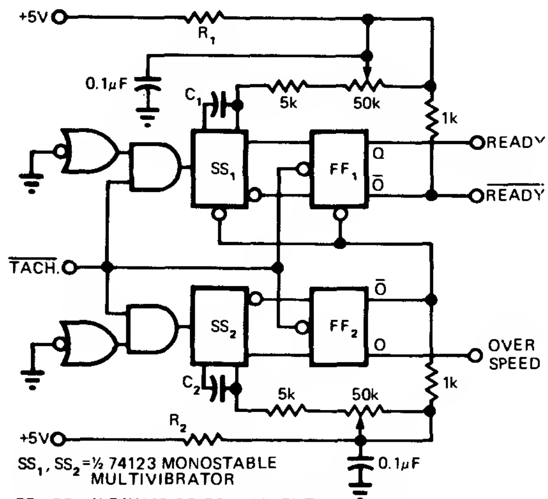
STEP COUNTER FOR STEPPER—Used to deliver selected number of pulses to stepper motor when start button is pushed, in microprocessor application where number of steps is more important than precise speed. Thumbwheel switch inputs can be I/O port lines of microprocessor. LOAD line transfers into counter the desired count as set up by switches. Article gives flowcharts and software routines for microprocessor to be used for controlling stepper motor.—R. E. Bober, Taking the First Step, *BYTE*, Feb. 1978, p 35–36, 38, 102, 104, 106, and 108–112.



SPEED CONTROL FOR 3-V MOTOR—Designed for use with hobby or toy motors running at about 10,000 rpm and powered by 3-V to 6-V batteries. Uses 4011 CMOS NAND gate with diodes and power transistor to provide variable duty cycle, so adjustment of 1-megohm speed control varies average voltage applied to motor without affecting peak voltage. Motor battery is connected between + terminal and ground of circuit.—J. A. Sandler, 11 Projects under $11, *Modern Electronics*, June 1978, p 54–58.

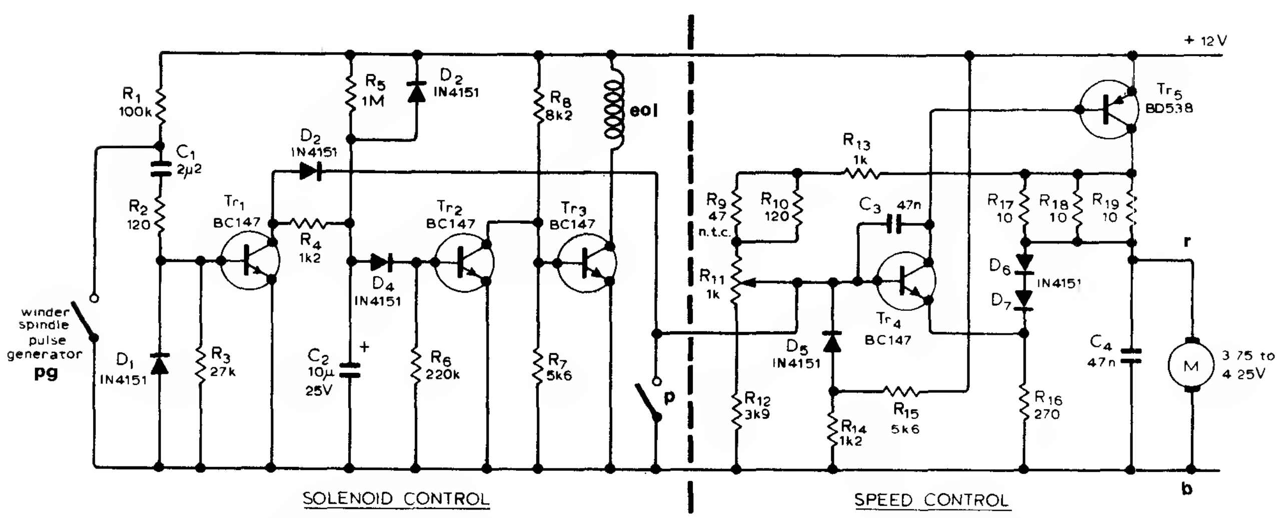


FOUR-PHASE STEPPER DRIVE—EXCLUSIVE-OR gatas of 7486 provida staering, whila 7476 flip-flops provide memory for genarating drive pattams of bidiractional logic stapper motor that is controlled by microprocessor. Output transistors, diodee, end resistors ere chosen to maat powar requiremants for eech phase of motor. Spaed is controllad by frequancy of clock input. Use 555 for coerse control or crystal oscillator for accurate control. S1, which can be an I/O lina of microprocessor, controls direction of rotation. Frequency can ba obtained from digitally controlled oscillator whose setting is determined by DAC.—R. E. Bober, Teking the First Step, *BYTE*, Fab. 1978, p 35–36, 38, 102, 104, 106, and 108–112.

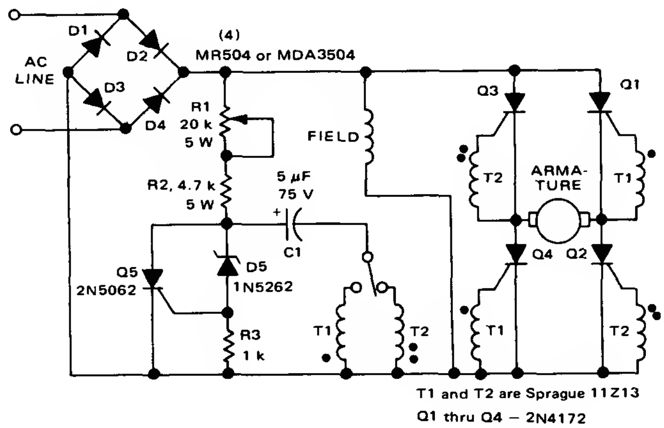


SS1, SS2=½ 74123 MONOSTABLE MULTIVIBRATOR
FF1, FF2=½ 74H103 OR EQUIVALENT NEGATIVE-EDGE TRIGGERED FLIP FLOP
C1, C2=SELECTED FOR DESIRED TIMING RANGE
R1 =SELECTED FOR UNDER/NOMINAL SPEED HYSTERESIS
R2 =SELECTED FOR NOMINAL/OVER SPEED HYSTERESIS

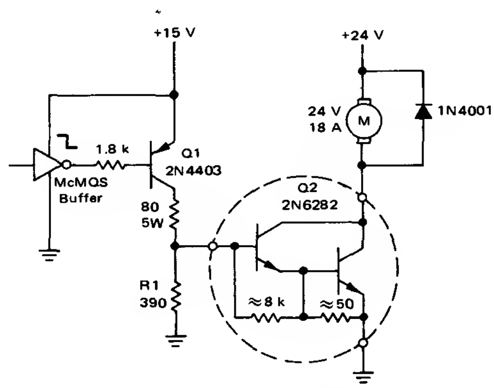
UNDER/OVERSPEED LOGIC—Providee signal (READY output high) only whan techometer pulsas from motor ara within specific upper end lower limits. Also provides overspeed output signal when upper limit has been exceeded. Single-ection triggering eliminetas instability at decision point. Article covers circuit operation in detail and gives timing diagram.—W. Bleher, Circuit Indicates Logic "Raady," *EDN Magazine*, March 5, 1974, p 72 end 74.



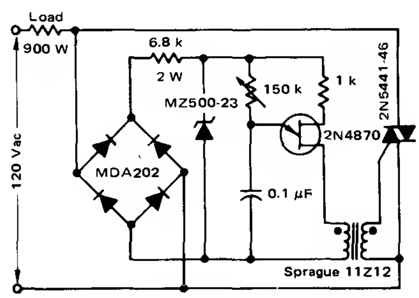
CASSETTE DRIVE CONTROLLER—Used in high-quality stereo cassetta deck operating from AC line or battery. Combines current source for cassette-retaining solenoid with speed control for drive motor. As motor turns, associated motor-driven pulse-genereting switch keeps Tr_1 conducting; this cuts off Tr_2 and allows current to flow through Tr_3 for energizing solenoid. When motor stops, pulse-generating switch also stops and Tr_1 stops conducting. After 3-s dalay detarmined by C_2 and R_5, Tr_2 conducts and eolenoid is deenergized, relaasing cassetta. In spaad control circuit, Tr_5 ects as constent-current sourca for motor, using feedback from its collector to baee of Tr_4. Beck EMF developed by motor is applied to amitter of Tr_4, reducing its forward bias and reducing current in tha base of Tr_5 so as to stabilize motor. Article gives ell othar circuits of cassette deck and describes operation in detall.—J. L. Linsley Hood, Low-Noise, Low-Cost Cassetta Deck, *Wireless World*, Pert 3—Aug. 1976, p 55–56 (Part 1—May 1976, p 36–40; Part 2—Juna 1976, p 62–66).



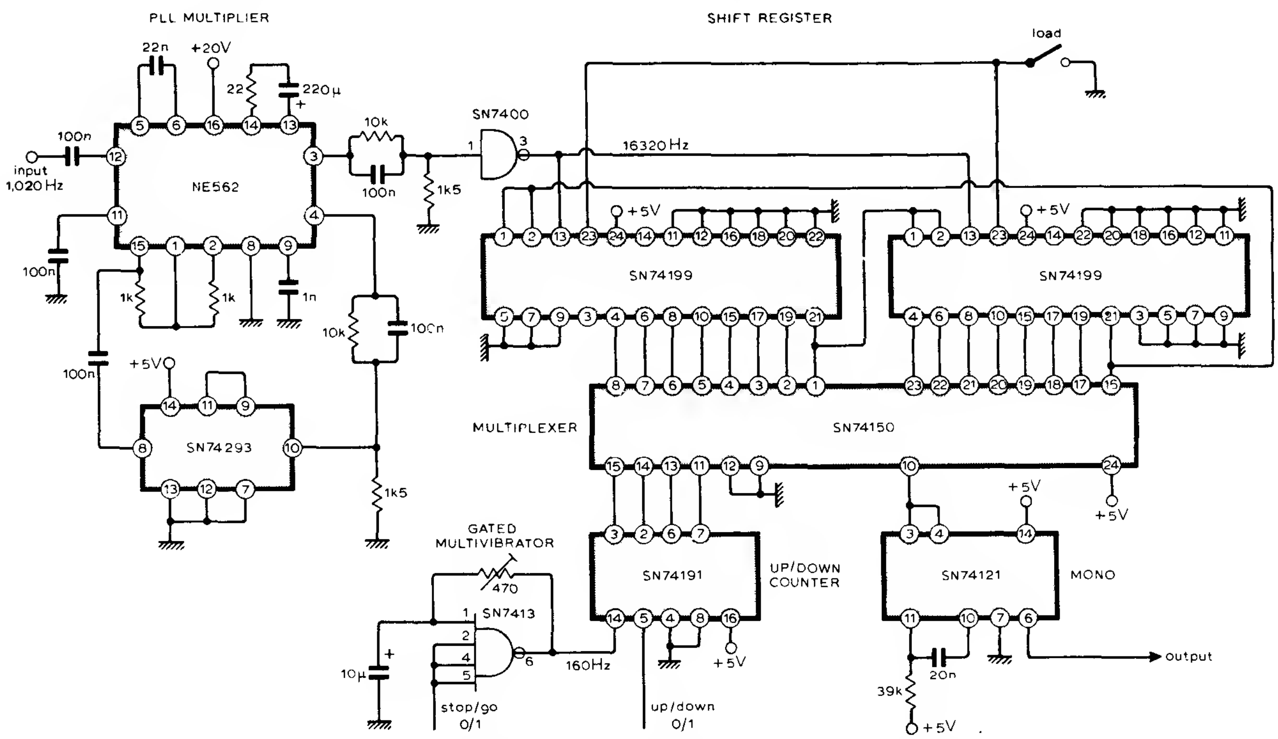
SHUNT-WOUND MOTOR—Switch provides direction control and R1 controls speed of fractional-horsepower shunt-wound DC motor. Field is placed across rectified supply, and armature windings are in four-SCR bridge circuit. Switch determines which diagonal pair of SCRs is turned on, to control direction of rotation. Triggering circuit consisting of Q5, D5, and C1 is controlled by R1, for changing conduction angle of triggered SCR path.—"Direction and Speed Control for Series, Universal and Shunt Motors," Motorola, Phoenix, AZ, 1976, AN-443.



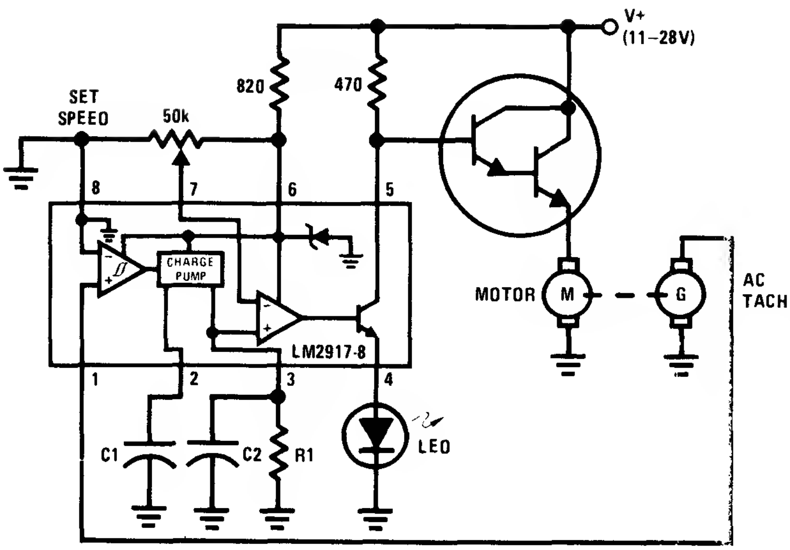
LOW-LEVEL CMOS CONTROL—Low-level output of CMOS buffer turns on DC motor through Q1 and 20-A Darlington power transistor Q2.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 18.



900-W FULL-WAVE TRIGGER—Uses UJT for phase control of triac. Suitable for control of shaded-pole motors driving loads having low starting torque, such as fans and blowers.—D. A. Zinder, "Electronic Speed Control for Appliance Motors," Motorola, Phoenix, AZ, 1975, AN-482, p 4.

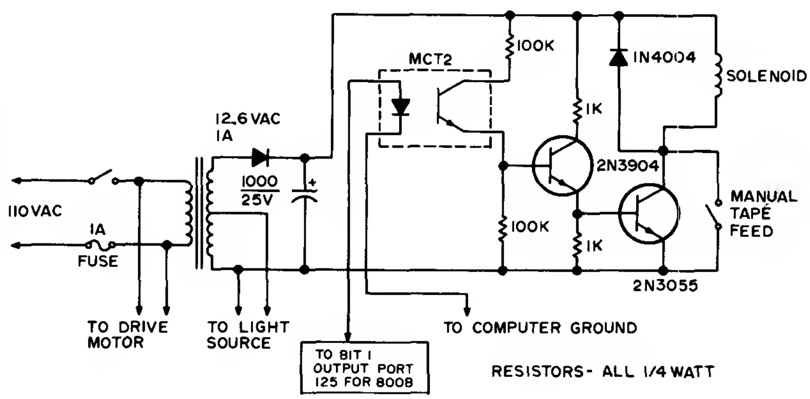


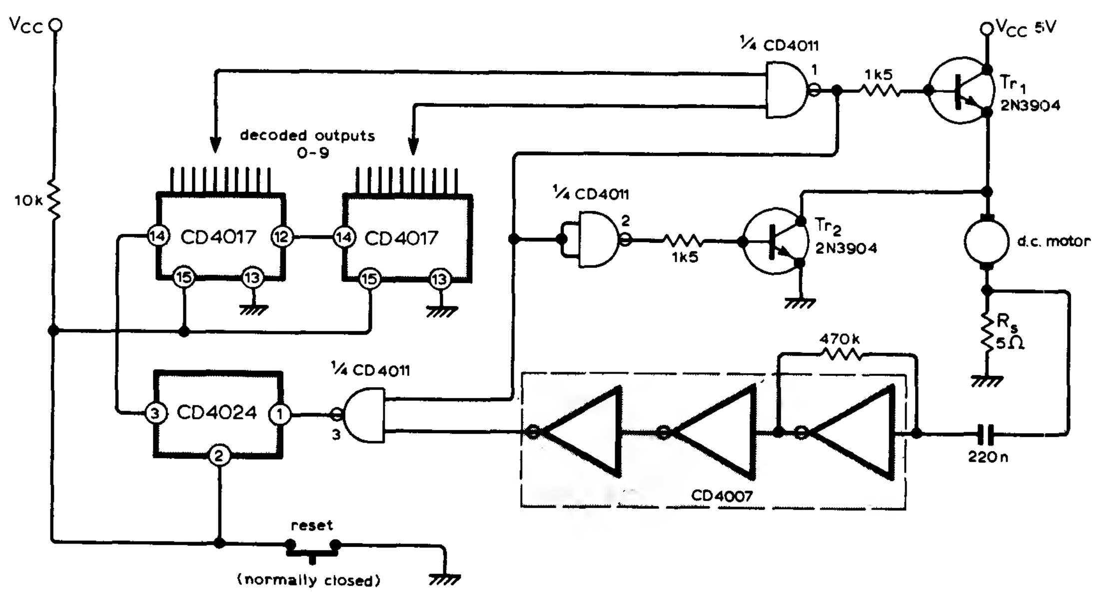
FACSIMILE PHASE CONTROL—Circuit provides accurate phasing of 51-pole-pair phonic/synchronous motor in facsimile transmitter, and can readily be adapted for similar applications. A 16-stage shift register loaded with 1 bit and connected as ring counter is clocked at 16 times required drive motor frequency. This gives pulse train with 1:15 mark-space ratio and repetition rate equal to drive frequency. Multiplexer used as single-pole 16-way switch can select output for any stage of shift register; each clockwise switch step gives 360/16 or 22.5° phase advance. Article describes circuit operation in detail.—P. E. Baylis and R. J. Brush, Synchronous-Motor Phase Control, *Wireless World*, April 1976, p 62.



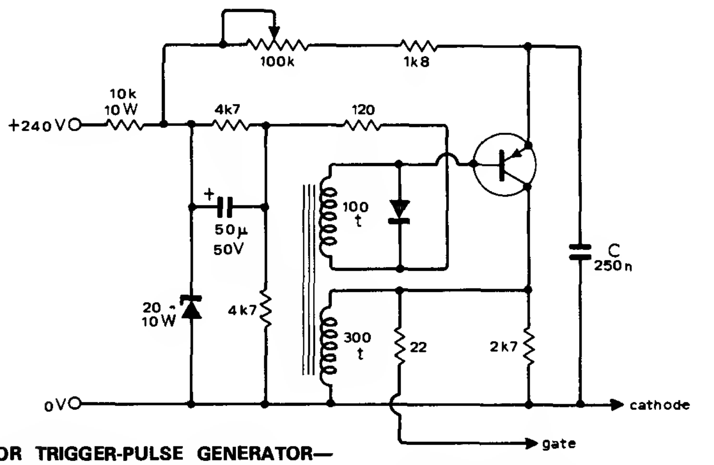
SHUNT-MODE SPEED CONTROL—AC tachometer on shaft of DC motor serves as input for National LM2917N-8 IC acting as shunt-mode regulator with LED indicator. Output of Darlington power transistor provides analog drive to motor. As motor speed approaches reference level set by values chosen for R1, C1, and C2, current to motor is proportionately reduced so motor comes gradually up to speed and is maintained there without operating in awitching mode. Advantage of thia arrangement is absence of alectric noiae normally generated during switching-mode operation.—"Linear Applicationa, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-162, p 10–11.

PAPER-TAPE FEED—High or 1 bit at output port of microprocessor turna on LED of optocoupler to energiza solenoid of pinch-roller drive for paper tape of tape raader. Circuit will control reader from computer keyboard. Optoisolator is essential to keep grounda separate, since mechanical devicas are electrically noiay and can generate garbage in computer. Articla gives software for tape input routine on 8008 microprocessor.—D. Hogg, The Paper Taper Caper, *Kilobaud,* March 1977, p 34–40.

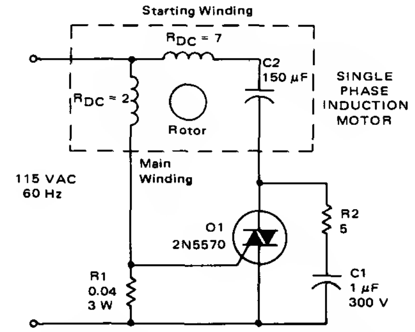




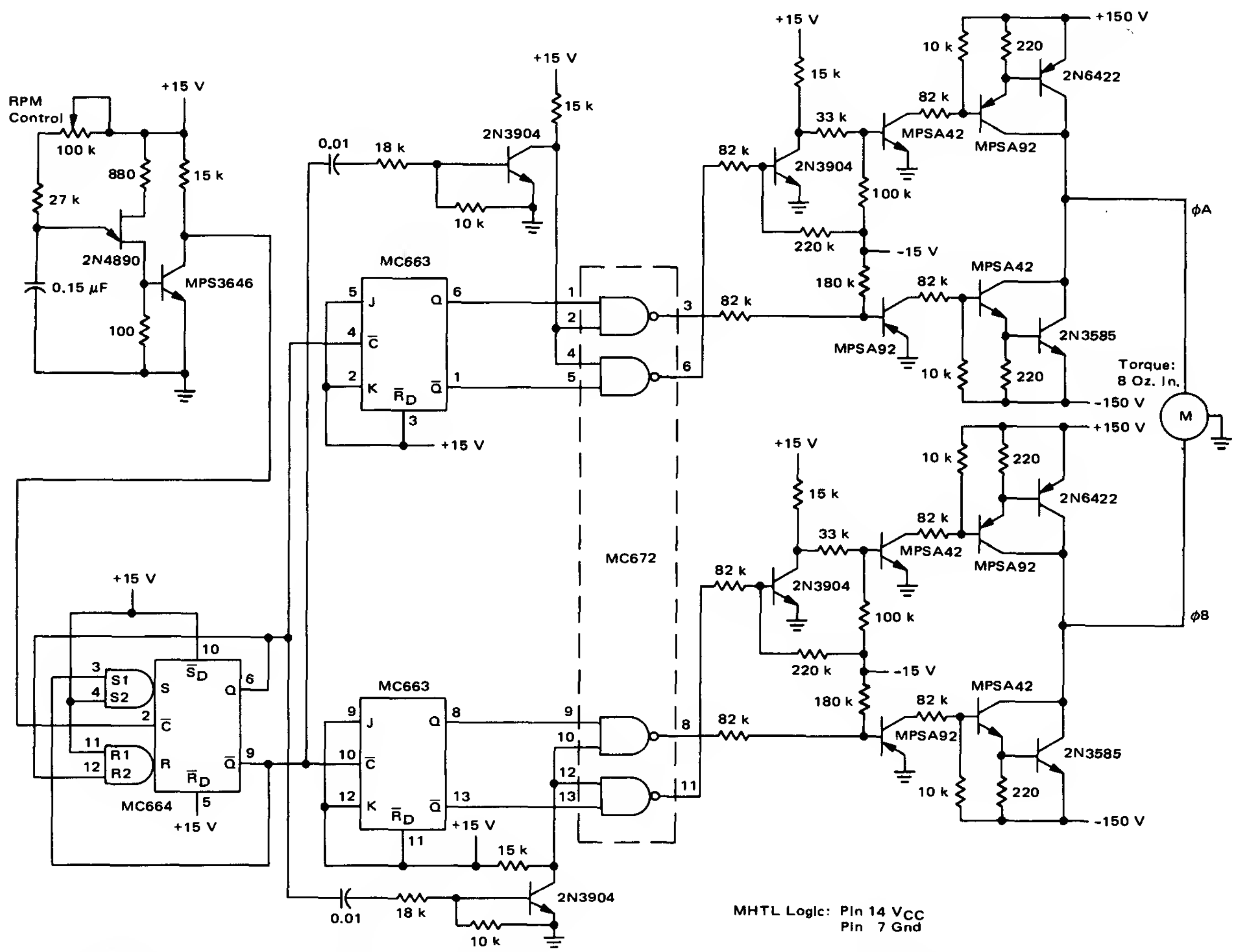
REVOLUTION-COUNTING CONTROL—When desired number of revolutiona is reached by DC motor, as detarmined by presat counter, Tr_1 is turned off to interrupt path to 5-V motor supply, while TR_2 la turned on to brake motor rapidly. Voltage developed acroaa 5-ohm reaistor R_s in series with motor contains frequency component related to apeed of rotetion and number of armature coils. Thia signal ia amplified by CD4007 CMOS invarter for feeding to counters through signal-squaring invertars. Countar outputs are decoded by gate 1. Motor slowdown by heavy loads does not affect accuracy of revolution-counting.—R. McGillivray, Motor Revolutions Control, *Wireless World,* Jan. 1977, p 76.



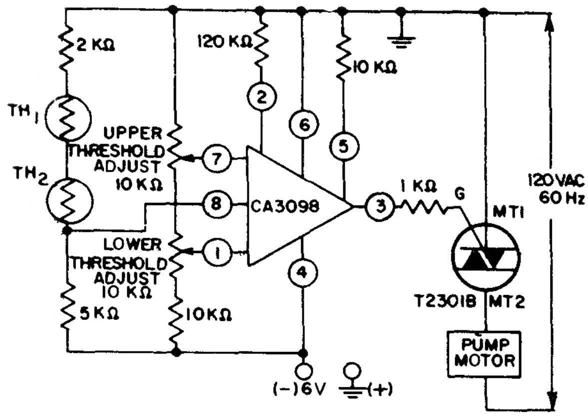
THYRISTOR TRIGGER-PULSE GENERATOR—Used with thyristor spaed control for 2-hp shunt-wound DC motor. *Circuit* providas train of pulsas with variable delay with respect to zero-crossing instants of AC supply, for feeding to cathode and gate of thyristor to vary duty cycle. Usa Mullard BFX29 sillcon PNP transistor or equivalent, and any small-signal silicon diode. Output pulsas ere suitabla for triggaring all typas of thyristors up to largast. Article also gives motor control circuit.—F. Butler, Thyristor Control of Shunt-Wound D.C. Motors, *Wireless World*, Sept. 1974, p 325–328.



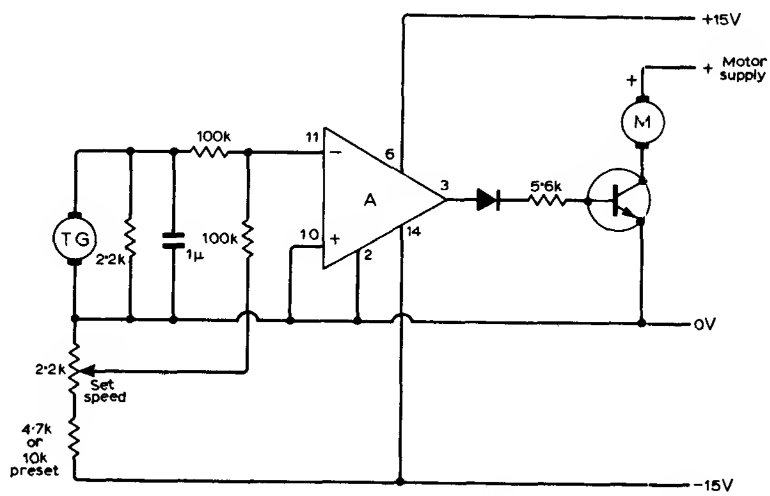
TRIAC STARTING SWITCH FOR ½-hp MOTOR—Triac replaces centrifugal switch normally used to control currant through starting winding of single-phasa induction motor. Valua of R1 Is chosen so triac turns on only when starting currant exceeds 12 A. When motor approaches normal speed, running current drops to 8 A and triac blocks current through starting winding.—"Circuit Applications for tha Triec," Motorola, Phoenix, AZ, 1971, AN-466, p 8.



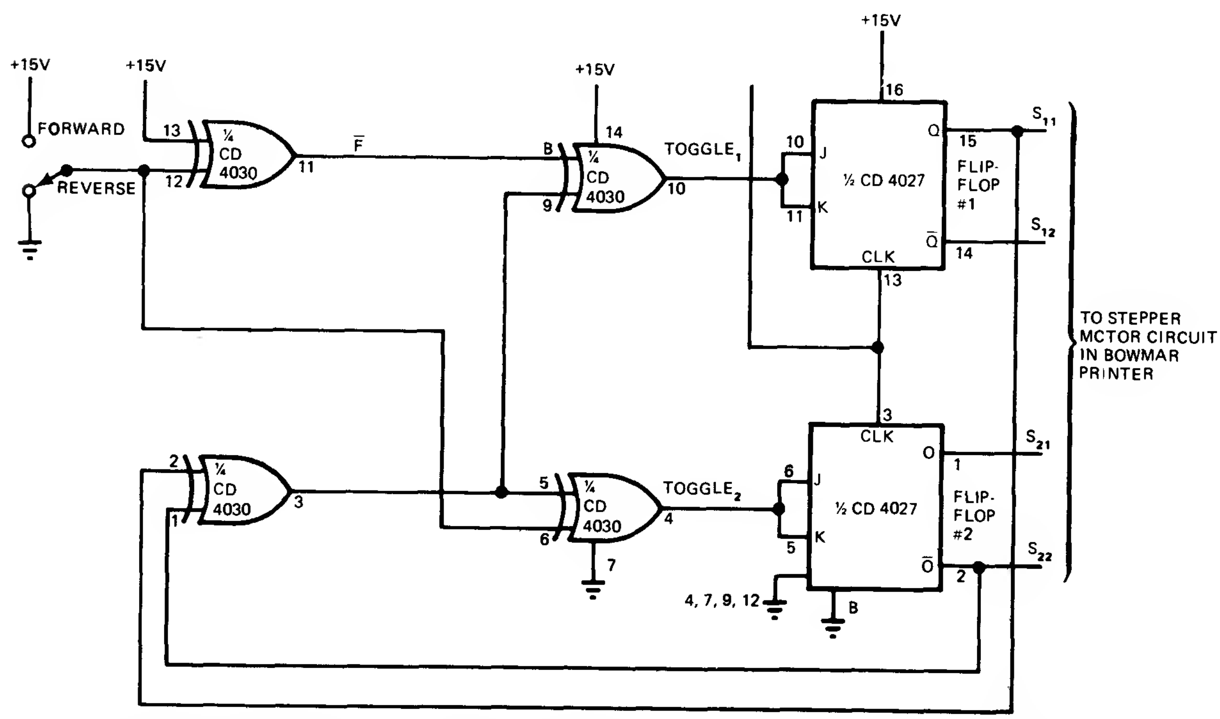
INDUCTION-MOTOR SPEED—Usas variable-frequancy UJT oscillator at uppar left to toggle MC664 RS flip-flop which in turn clocks MC663 JK flip-flops. Quadratura-phased JK outputs ara combined with fixed-width pulses in MC672 to provida zero-voltage steps of driva signals for phese A and phase B. Outputs of RS flip-flops are differentiated and positive-going transltions amplified by pair of 2N3904 transistors, with pulse width of about 500 µs. NAND-gate outputs are then translated by small-signal amplifiers to levels suitable for driving final transistors having complementary NPN/PNP pairs. Circuit will provida speed ranga of 300 to 1700 rpm for permanant-split capacitor motor.—T. Mazur, "Variabla Spaed Control System for Induction Motors," Motorola, Phoenix, AZ, 1974, AN-575A, p 6.



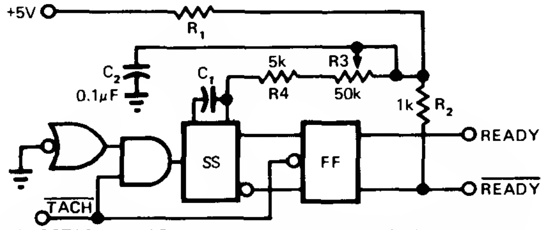
WATER-LEVEL CONTROL—Two thermistors operating in self-heating mode ere mounted on sides of water tenk. Thermistors change rasistence when water level risea so liquid rether than eir conducts heat away. Threshold adjustment pots are set so RCA CA3098 programmable Schmitt trigger turns on pump motor when water level rises above thermistor mounted neer upper edge of tank, to remove weter from tank and prevent overflow. Motor stays on to pump weter out of tank until weter level drops below location of lower thermistor inside tenk.—"Lineer Integrated Circuit and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 218–221.



OPAMP SPEED CONTROL—Provides fine spaed control of DC motor by using 0.25-W 6-V motor as tachogenerator giving about 4 V at 13,000 rpm. Opamp (RCA 3047A or equivalent) provides switching action for transistor in series with controlled motor, up to within a few volts of supply voltage. Choose trenslstor to maet motor current requirement.—N. G. Boreham, D.C. Motor Controller, *Wireless World*, Aug. 1971, p 386.



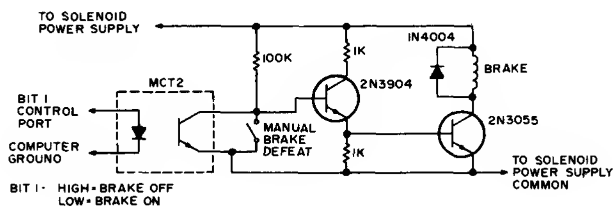
STEPPER MOTOR DRIVE—Two CMOS packages provide tha four fead signals required for controlling forward/revarse drive of atepper motor for carrlega drive and papar advance of Bowmar Model TP 3100 thermel printer. Outputs of flip-flops are above 10 V, enough to drive stepper motor directly. Each clock pulse to JK flip-flop advances carriage one atep in direction commanded.—R. Bober, Steppar Drive Circuit Simplifies Printer Control, *EDN Magazine*, April 5, 1976, p 114.

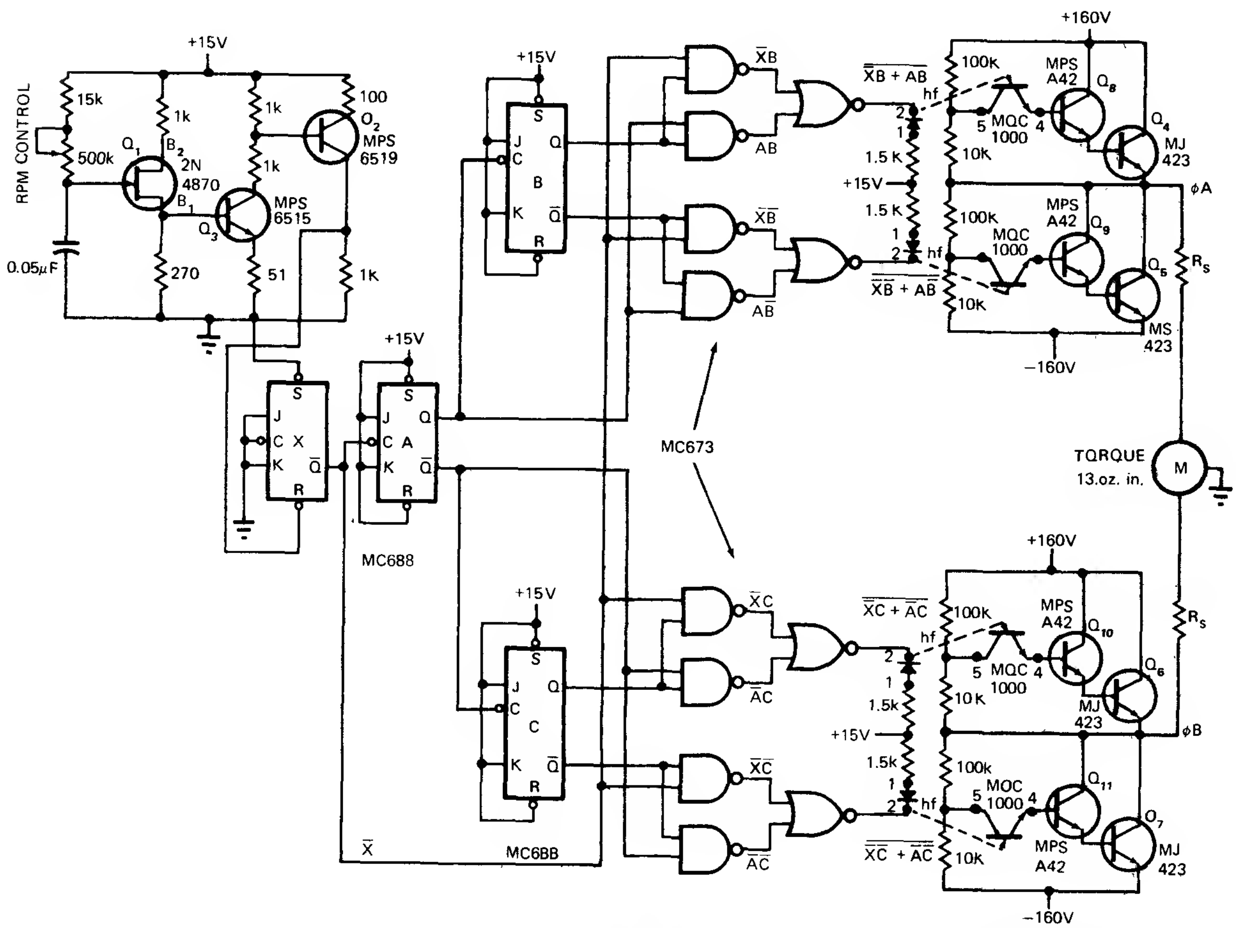


SS=MONOSTABLE MULTIVIBRATOR (SINGLE SHOT) 74122 OR 9601 OR ½ 74123 OR 9602
FF=NEGATIVE EDGE-TRIGGERED FLIP FLOP, 74H103 OR EQUIVALENT
R_1=0 TO 20% OF R_2, SELECTED FOR REQUIRED HYSTERESIS
C_1=SELECTED FOR REQUIRED TIMING RANGE.

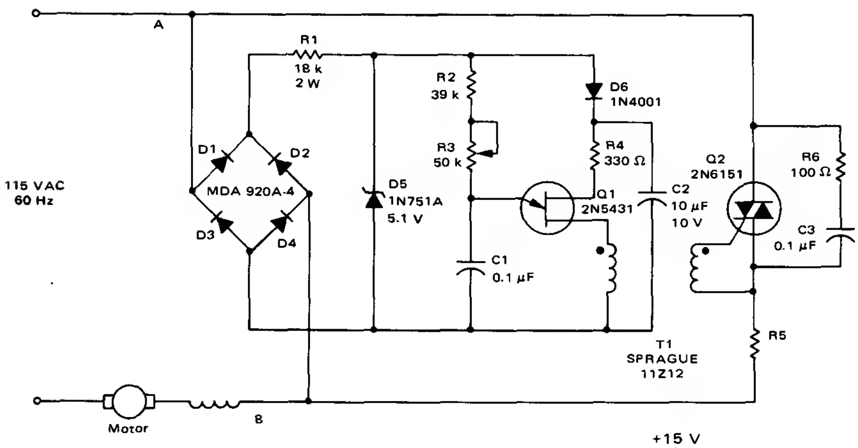
UP-TO-SPEED LOGIC—Simple speed-sensing circuit fed by tachometer pulses makes READY output high when rotating device reaches desired minimum or threshold speed. Single-action triggering eliminates instability at decision point. Circuit also provides hysteresis, for separating pull-in and drop-out points any desired amount as determined by ratio of R_1 to R_2 in timing network. Article covers circuit operation and givas timing diagram.—W. Blaher, Circuit Indicates Logic "Ready," *EDN Magazine*, March 5, 1974, p 72 and 74.

CONTINUOUS-DUTY BRAKE—High or 1 bit at output port of microprocessor energizes brake solenoid of paper-tape reader through optocoupler and amplifier. When tape is to be stopped, brake solenoid is energized and tape is squeezed between top of solenoid and flat iron brake shoe that is attracted by solenoid.—D. Hogg, The Paper Taper Caper, *Kilobaud*, March 1977, p 34–40.

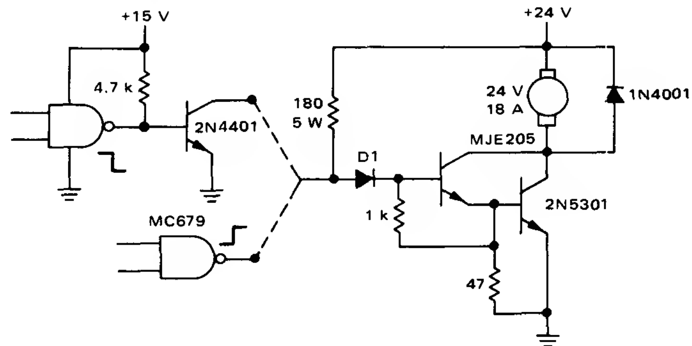




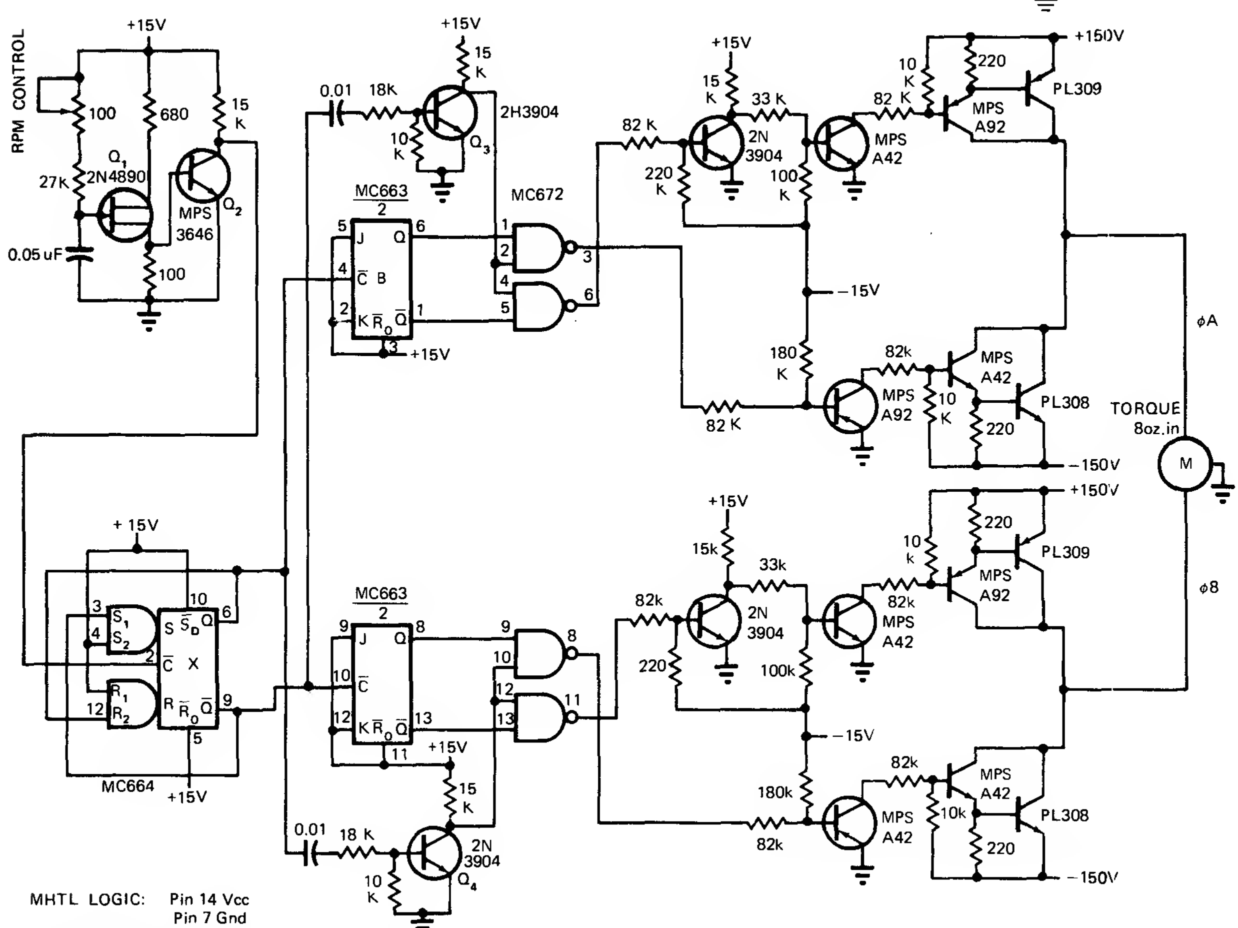
SPEED CONTROL FOR INDUCTION MOTOR—Usas UJT oscillator Q_1 to generate frequency in range from 40 to 1200 Hz for feeding to divide-by-4 configuration that gives motor source frequency range of 10 to 300 Hz. With induction motor having two pairs of poles, this gives theoretical speed range of 300 to 9000 rpm with essentially constant torque. Speed varies linearly with frequency. Circuit uses pair of flip-flops (MC673) operated in time-quadrature to perform same function as phase-shifting capacitor so motor racaives two driva signals 90° apart. Article covers operation of circuit in detail. Optoisolators are used to provide bipolar drive signals from unipolar control signals. Each output drive circuit is normally off and is turned on only when its LED is on. If logic power fails, drives are disabled and motor is turned off as fail-safe feature.—T. Mazur, Unique Semiconductor Mix Controls Induction Motor Speed, *EDN Magazine*, Nov. 1, 1972, p 28–31.



TRIAC SPEED CONTROL WITH FEEDBACK—Feedback is derived from load current, eliminating need for separate connections to motor field and armature windings. When triac conducts, normal line voltage less drop across triac and R5 is applied to motor. If firing of triac is delayed in each half of AC cycle, RMS voltage of motor is reduced and speed is correspondingly reduced. Feedback maintains torque at reduced speeds. Value of R5 in ohms is equal to 2 divided by rated RMS motor current in amperes and is 0.32 ohm for 6.5-A induction motor. Suitable for use with electric drills, where good torque is obtained down to about one-third of maximum speed.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 7.

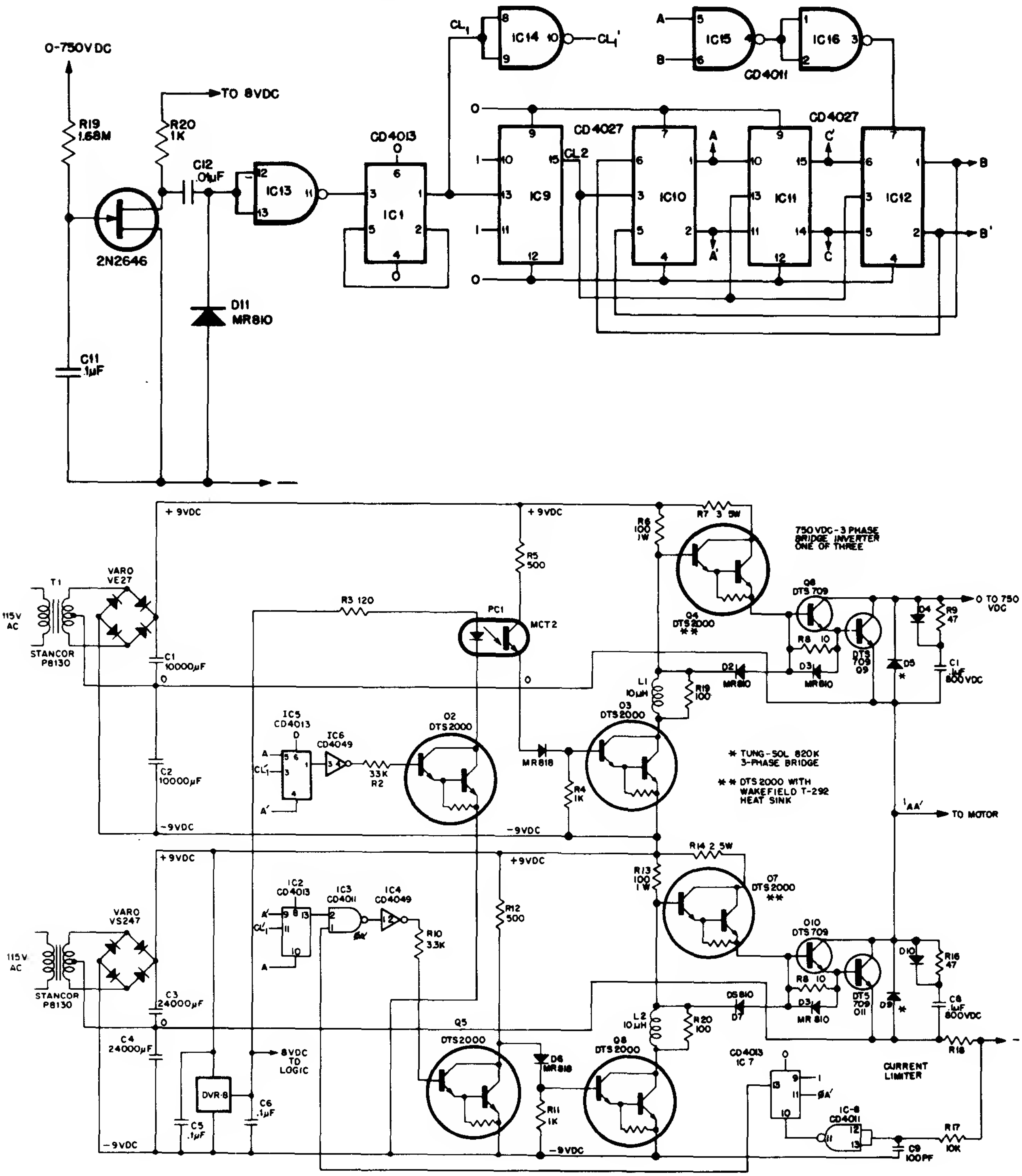


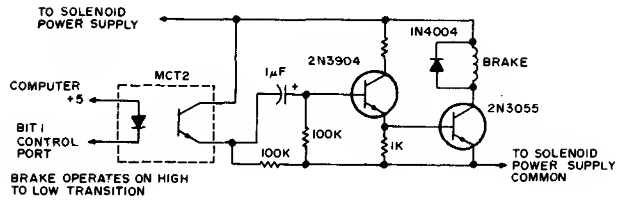
CLAMPED DARLINGTON CONTROL—Circuit uses MJE205 5-A transistor in Darlington configuration driving 2N5301 30-A transistor for passing 18 A to DC motor under logic control. CMOS gate connections are shown for energizing motor when logic is low and when logic is high.—A. Psheenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 19.



FREQUENCY CONTROLS SPEED—Circuit generates variable frequency between 10 and 300 Hz at constant voltage for changing speed of induction motor between theoretical limits of 300 and 9000 rpm without affecting maximum torque. Direct coupling between control and drive circuits is used; if motor noise affects control logic circuits, optoisolators should be used between control and drive sections. Article tells how circuit works and gives similar circuit using optical coupling.—T. Mazur, Unique Semiconductor Mix Controls Induction Motor Speed, *EDN Magazine*, Nov. 1, 1972, p 28–31.

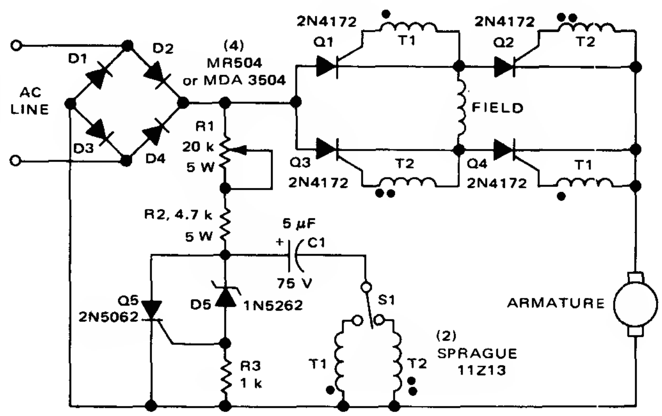
2-hp THREE-PHASE INDUCTION—Speed is controlled by applying continuously variabla DC voltaga to VCO of control circuit for 750-VDC 7-A bridge invertar driving thrae sets of six Delco DTS-709 duolithic Darlingtons. Bridge invartar circuit for other two phases is identical to thet shown for phese AA'. VCO output is converted to three-phase frequency verying from 5 Hz at 50 VDC to 60 Hz et 600 VDC for driving output Derlingtons. Optoisolators ara used for basa drive of three switching elemants connected to high-voltage side of inverter.—"A 7A, 750 VDC Inverter for a 2 hp, 3 Phase, 480 VAC Induction Motor," Dalco, Kokomo, IN, 1977, Application Note 60.

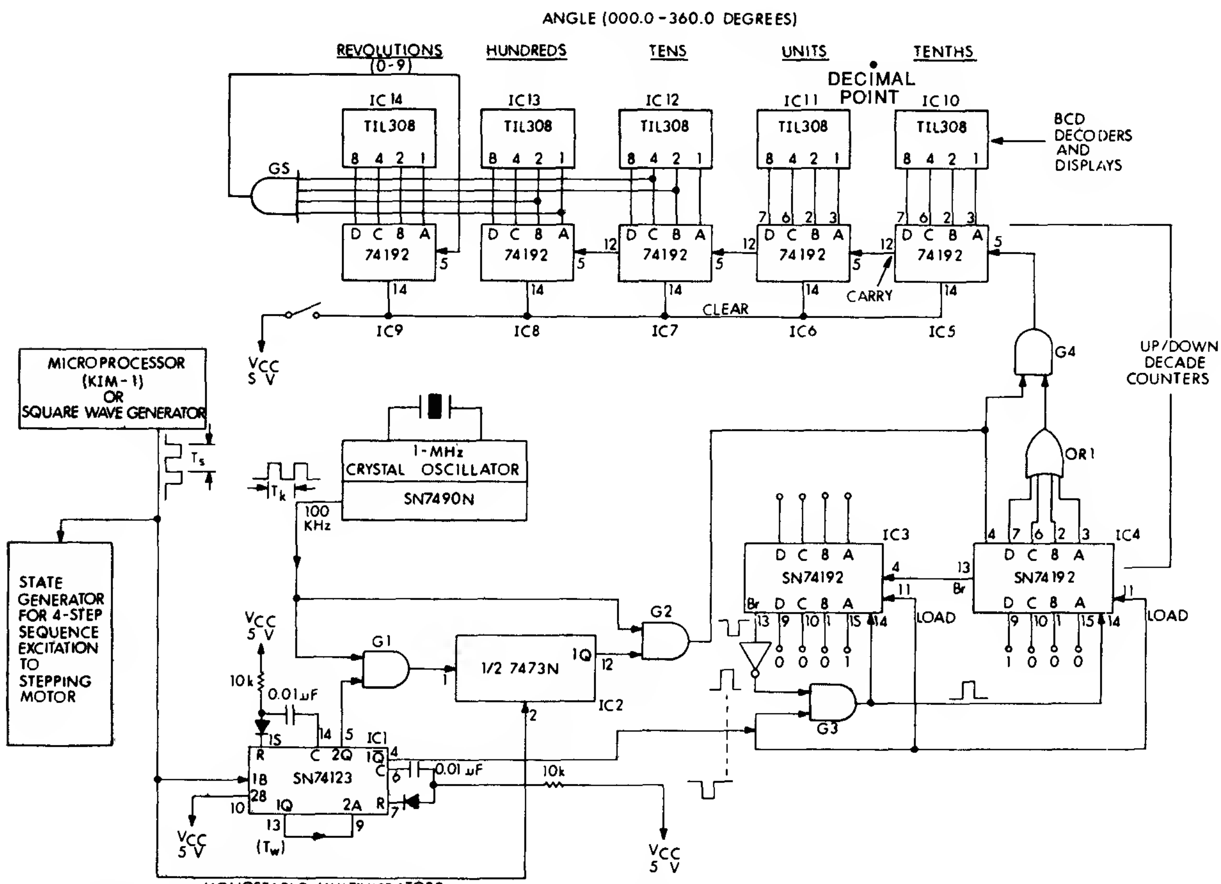




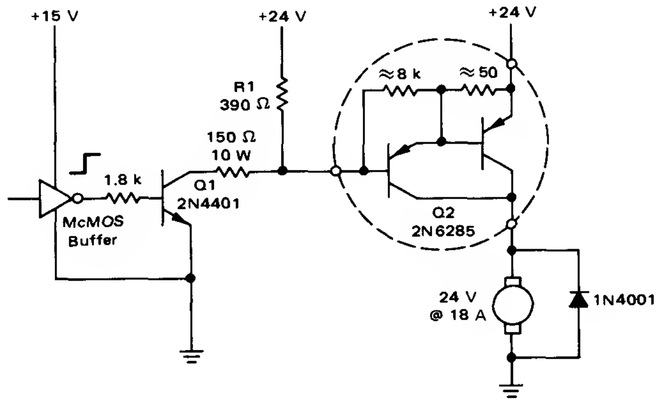
PULSED BRAKE—Transition from high (1) to low (0) at control port of microprocessor anergizes braka solenoid of papar-tape .reader in pulsas lasting several microseconds, with time datarmined by siza of capacitor used. Energizing of solenoid squeezas tape between top of solenoid and flat iron brake shoe that is attracted by solenoid. Unmarked resistor is 1K.—D. Hogg, Tha Paper Tapar Capar, *Kilobaud,* March 1977, p 34–40.

SERIES-WOUND MOTOR—Provides both diraction and spaed control for fractional-horsepower series-wound or universal DC motors es long as motor current requirements are within SCR ratings. Q1-Q4, connected in bridge, are triggered in diagonal pairs. S1 determines which pair is turned on, to provide diraction control. Pulse circuit is used to drive SCRs through T1 or T2. When C1 chargas to braakdown voltage of zaner D5, zener passes currant to gate of SCR Q5 and turns it on. This discharges C1 through T1 or T2 to create dasired triggering pulse. Q5 stays on for duretion of helf-cycle. R1 controls motor spead by changing time required to charge C1, thereby changing conduction angle of Q1-Q4 or Q2-Q3.—"Direction and Speed Control for Series, Universal and Shunt Motors," Motorola, Phoanix, AZ, 1976, AN-443.

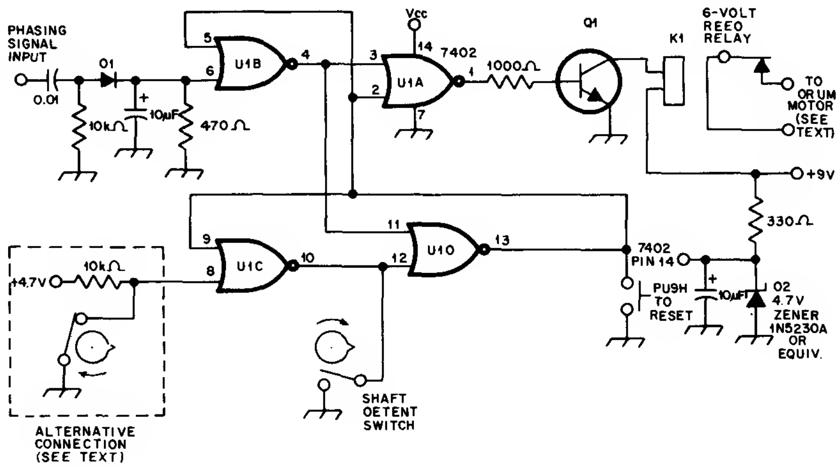




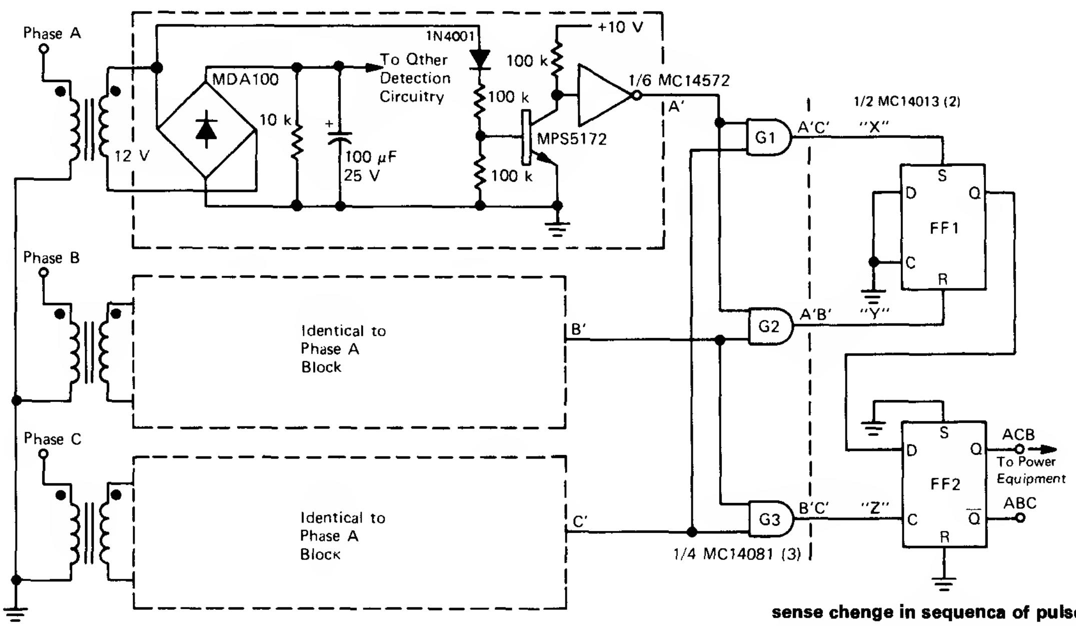
MOTOR STEP-ANGLE DISPLAY—Digital display circuit tracks stepper-motor shaft movaments. Up/down decade countars read out four BCD digits as travel angle (000.0 to 360.0) in degraes end number of completad revolutions (0 to 9). Stepper under study is driven by state generetor that produces high-current squarewave pulsas under control of clock used for display, which can ba external squara-wave generator or clock output of microprocessor such as KIM-1. Power source for digital display is 5 V at 1.2 A. Applications include monitoring movements of incremental plotters, precision film camera drives, numerical control machines, and precision start-stop motions of fuel control rods in nuclaar raactor.—H. Lo, Digital Display of Stepper Motor Rotation, *Computer Design,* April 1978, p 147–148 and 150–151.



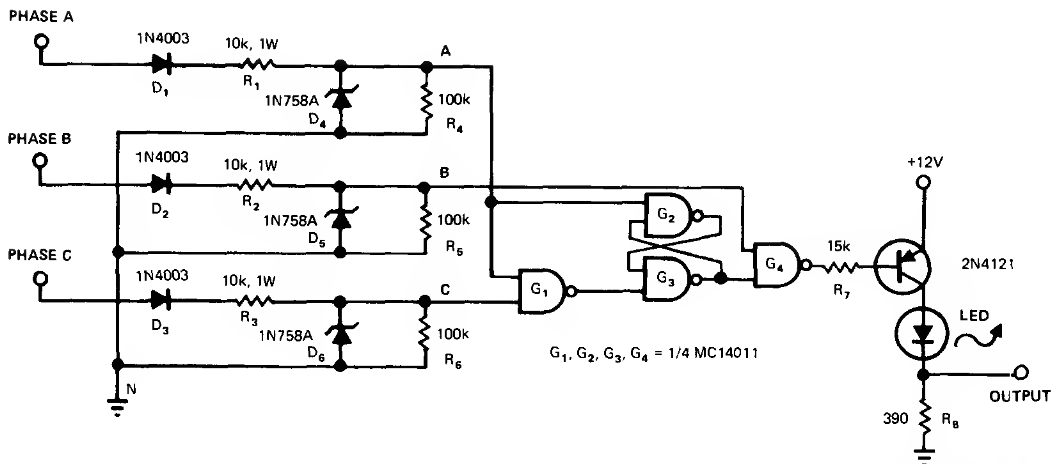
HIGH-LEVEL CMOS CONTROL—When output of CMOS buffer goes high, Q1 turns on and sinks 150-mA baae current of power Darlington Q2, to activeta motor load. Used in logic-controlled industrial applications.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Davices," Motorola, Phoenix, AZ, 1975, AN-712A, p 18.



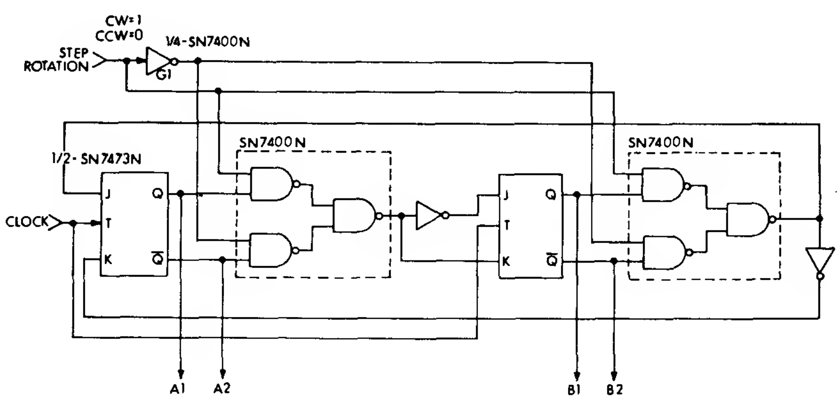
TELEFAX PHASING—Simpla coincidence circuit provides raliable synchronization of Telefax mechine in which 2500-Hz signal is generated by photoelectric scanning of peper placed on revolving drum. Circuit uses 7402 quad two-input NOR gata. If alternate connection enclosed in dashed line is not used, connect pin 8 to ground at pin 7. Q1 ia S0014 silicon or equivelant. If relay contacts will handle motor voltaga and current, they can be connected directly across points of test switch on machine, with switch left open for phasing circuit to work.—W. C. Smith, A Logic Circuit for Phasing the Telefax, *QST*, Nov. 1978, p 33–34.

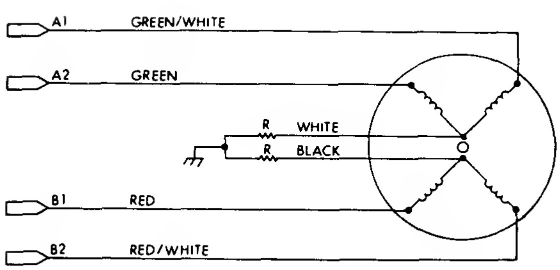


PHASE-REVERSAL DETECTOR— Used in three-phase applications in which direction of rotation of pheses is critical, es in thrae-phasa motors where reversel of two phases can provide disestrous revarsal of motor. Lina volteges are stepped down and isoletad by control-type transformars. Eech phase is half-wave rectified end sheped by 1N4001 diode and MPS5172 tranaiator, with edditional sheping by MC14572 inverter. Shaped outputs of ell three phesas ere combined in AND gates G1-G3 to giva pulse outputs aequantially. D flip-flopa are connacted to sense chenge in sequenca of pulses causad by revarsal of one or mora input phases. Flip-flop output can ba used to trip relay or othar protactiva device for removing eir conditioner or other equipment from line bafore it is demaged.—T. Melerkay, "A Simple Lina Phase-Ravarsal Detection Circuit," Motorola, Phoenix, AZ, 1975, EB-54.

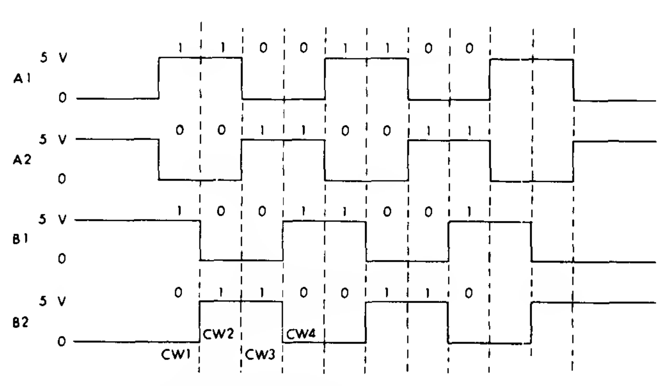


PHASE SEQUENCE DETECTOR—Circuit detects incorrect phaae sequenca of motor driving pump, compressor, conveyor, or other equipment that can be damaged by reverse rotation. Circuit alao protecta motor from phase loss that could cause rapid temperature riae and heat damage. LED is on when phasing is correct. For phase losa or incorrect sequence, output goes low and LED is dark. Diodes and zeners change sine weves for all phases to rectangular logic-level pulses that feed gates. When phases are correct, output of G_4 is train of rectangular pulses ebout 2.5 ns wide. Output is zero for incorrect sequencea. Since leading edge of output pulse coincides with positive zero crossing of phase B, output pulses can be used to trigger SCR connected across phase B and driving relay-coil load. SCR then energizes relay only when sequenca is corract.—H. Normet, Detector Protects 3-Phase-Powered Equipment, *EDN Magazine,* Aug. 5, 1978, p 78 and 80.

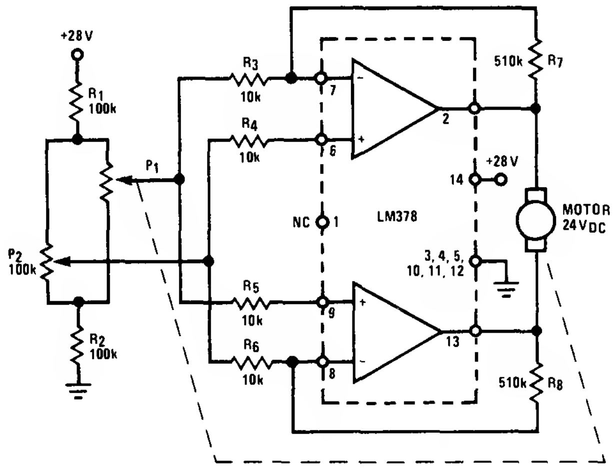




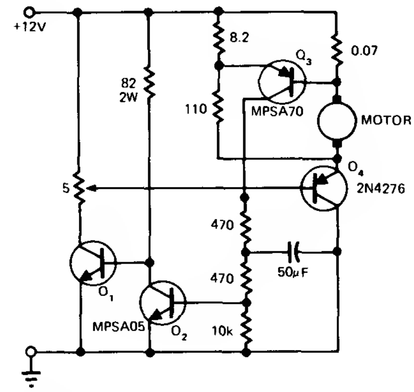
Step Sequence	A1	A2	B1	B2	Binary Code
1 CW	ON	OFF	ON	OFF	1010
2	ON	OFF	OFF	ON	1001
3	OFF	ON	OFF	ON	0101
4	OFF	ON	ON	OFF	0110
CCW 1	ON	OFF	ON	OFF	1010



STATE GENERATOR FOR STEPPER—Generetes high-current squere-wave pulses and provides correct swltching sequence for exciting stepper motor when digital display is required to show inatantaneous step angle end total revolutions traveled by shaft of stepper motor. If microprocessor ia used, speed and direction of motor rotation can be controlled by programming period and level of output pulses. Clock signals trigger SN7473N JK flip-flop that changes ON/OFF states of four outputs as shown in table. Clock signal is obtained from external squere-weve generetor or from microprocessor such as KIM-1. Article also gives digitel display circuit driven by same clock.—H. Lo, Digital Display of Stepper Motor Rotation, *Computer Design,* April 1978, p 147–148 and 150–151.

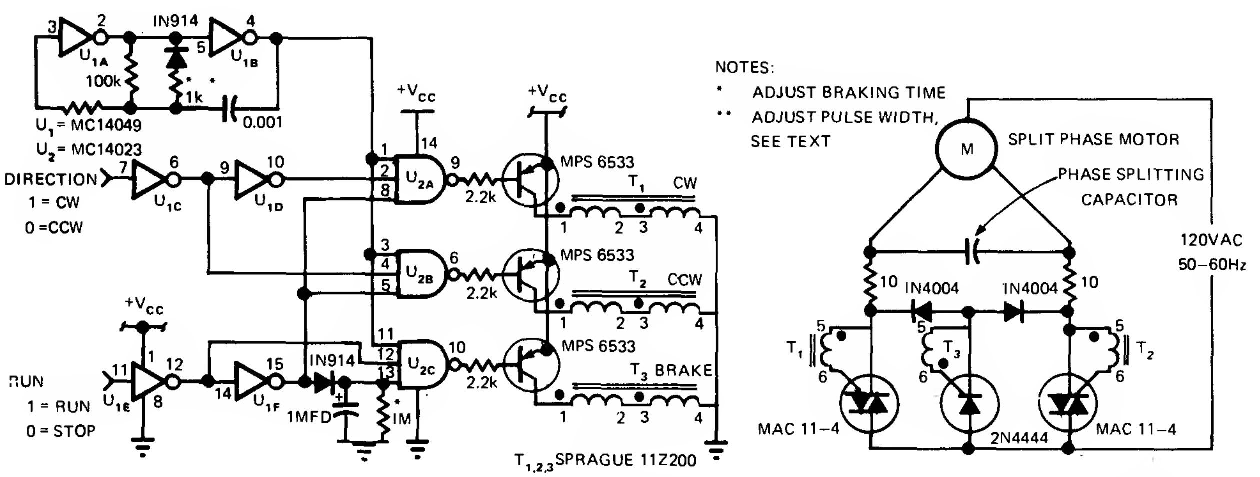


24-VDC PROPORTIONAL SPEED CONTROL—National LM378 amplifier IC is basis for low-cost proportional speed controller capable of furnishing 700 mA continuously for such applications as antenna rotors and motor-controlled valves. Proportional control results from error signal developed across Wheatstone bridge R_1-R_2-P_1-P_2. P_1 is mechanically coupled to motor shaft as continuously variable feedback sensor. As motor turns, P_1 tracks movament and error signal becomes smaller and smaller; system stops when error voltage reaches 0 V.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.



MOTOR VOLTAGE	TRANSISTOR VOLTAGE	Q_3 EMITTER VOLTS	LIMIT CURRENT
0	12	0	10A
6	6	0.42	16A
11.5	0.5	0.20	21.4A

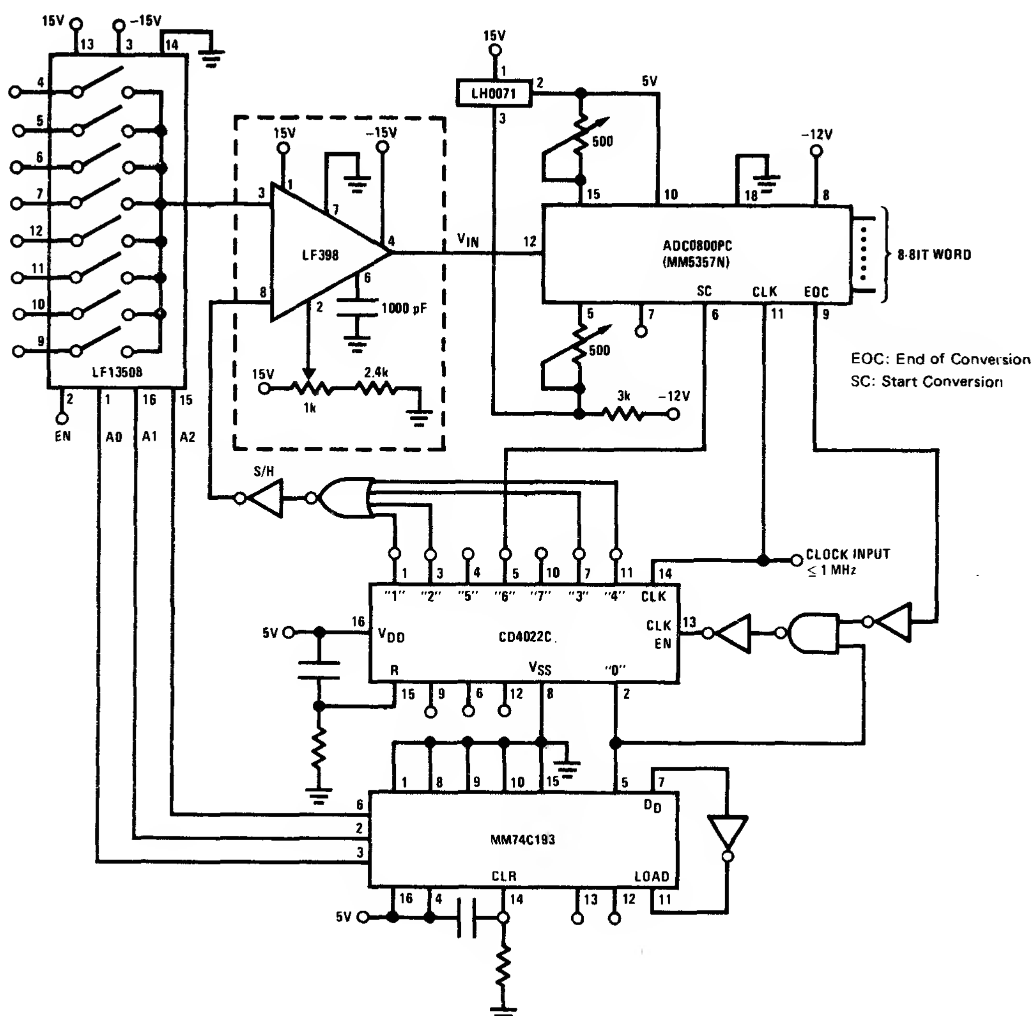
STALLED-MOTOR PROTECTION—Modification of basic speed control circuit for small DC permanent-magnet motors provides maximum currant limit under normal conditions and reduced current limit under stall conditions, to limit dissipation of series transistor Q_4 to safe value. When motor stalls, motor voltage falls, reducing voltage and motor current required to turn on Q_3 and thereby limiting stalled-motor current.—D. Zinder, Current Limit and Foldback for Small Motor Control, *EDN Magazine*, May 5, 1974, p 77 and 79.



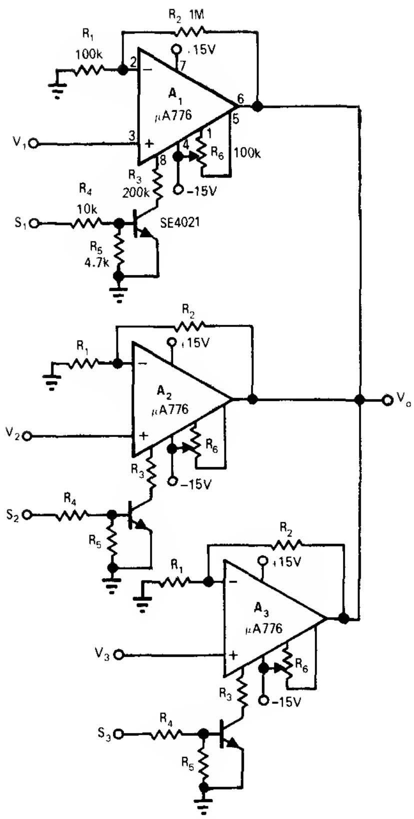
SPLIT-PHASE CONTROL WITH BRAKING—Use of CMOS logic to gate direction-controlling triacs and turn on SCR for braking provides low-cost switchless control of split-phase motor used in place of brush-type DC motor. Applications include control of ball valves and other throttling functions in process control. With shaft-position encoders, circuit generates feedback information. Overshoot and other stability problems are easily controlled by strong braking function. CMOS logic provides complete noise immunity. Oscillator pulse width is adjusted with 1K resistor in series with 1N914, and brake duration is controlled by 1-megohm resistor at input of U_{2C}. With values shown, brake is applied for about 1 s. Circuit works reliably on supply voltages of 5 to 15 V.—V. C. Gregory, Split-Phase Motor Control Accomplished with CMOS, *EDN Magazine*, Oct. 5, 1974, p 65–67.

CHAPTER 54
Multiplexer Circuits

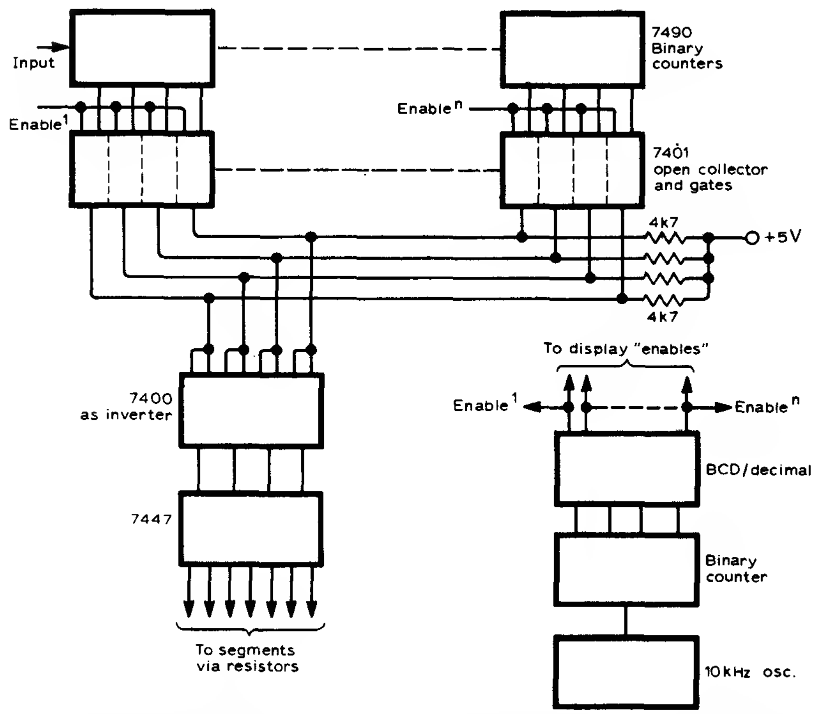
Includes circuits for multiplexing of data or communication channels, analog switches, filters, displays, and sensor channels under control of logic signals. See also Cathode-Ray, Data Transmission, Display, Instrumentation, and Logic chapters.



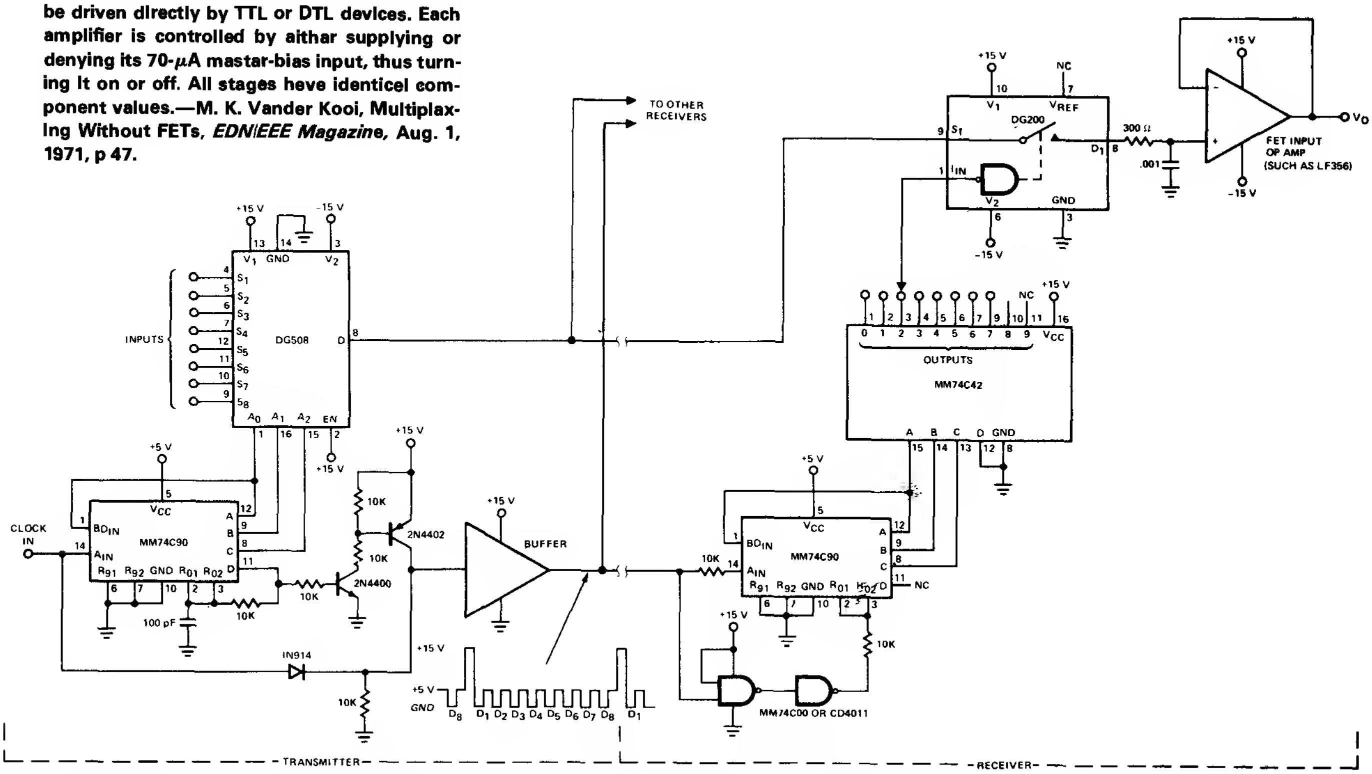
EIGHT-CHANNEL SEQUENTIAL—Eight different analog inputs ara sampled by National LF13508 multiplexer end convertad into digital words for furtner processing. Maximum throughput rata of system is 2800 samples per second per chennel. Output will sattle to ±0.05 mV in 1 μs after hold command.—"FET Databook," Netional Semiconductor, Santa Clara, CA, 1977, p 5-77–5-78.



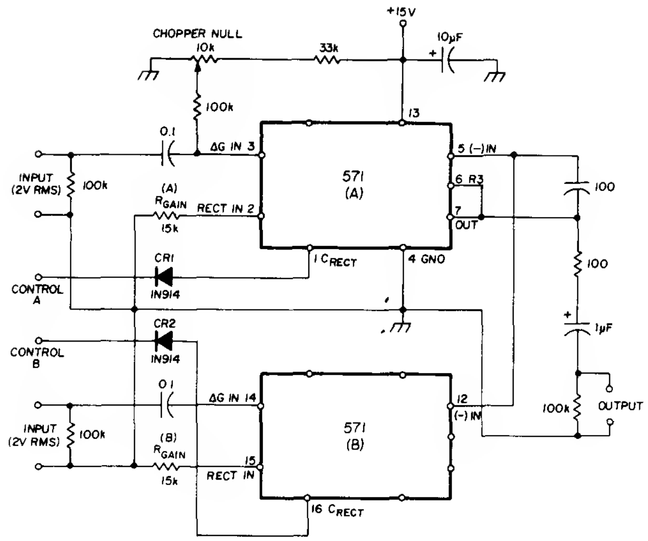
LOGIC SIGNALS CONTROL TDM—Use of μA776 opamps eliminates need for FET switches in time-division multiplexing and signal conditioning. Multiplex inputs S_1-S_2-S_3 can be driven directly by TTL or DTL devices. Each amplifier is controlled by either supplying or denying its 70-μA master-bias input, thus turning it on or off. All stages have identical component values.—M. K. Vander Kooi, Multiplexing Without FETs, *EDN/EEE Magazine*, Aug. 1, 1971, p 47.



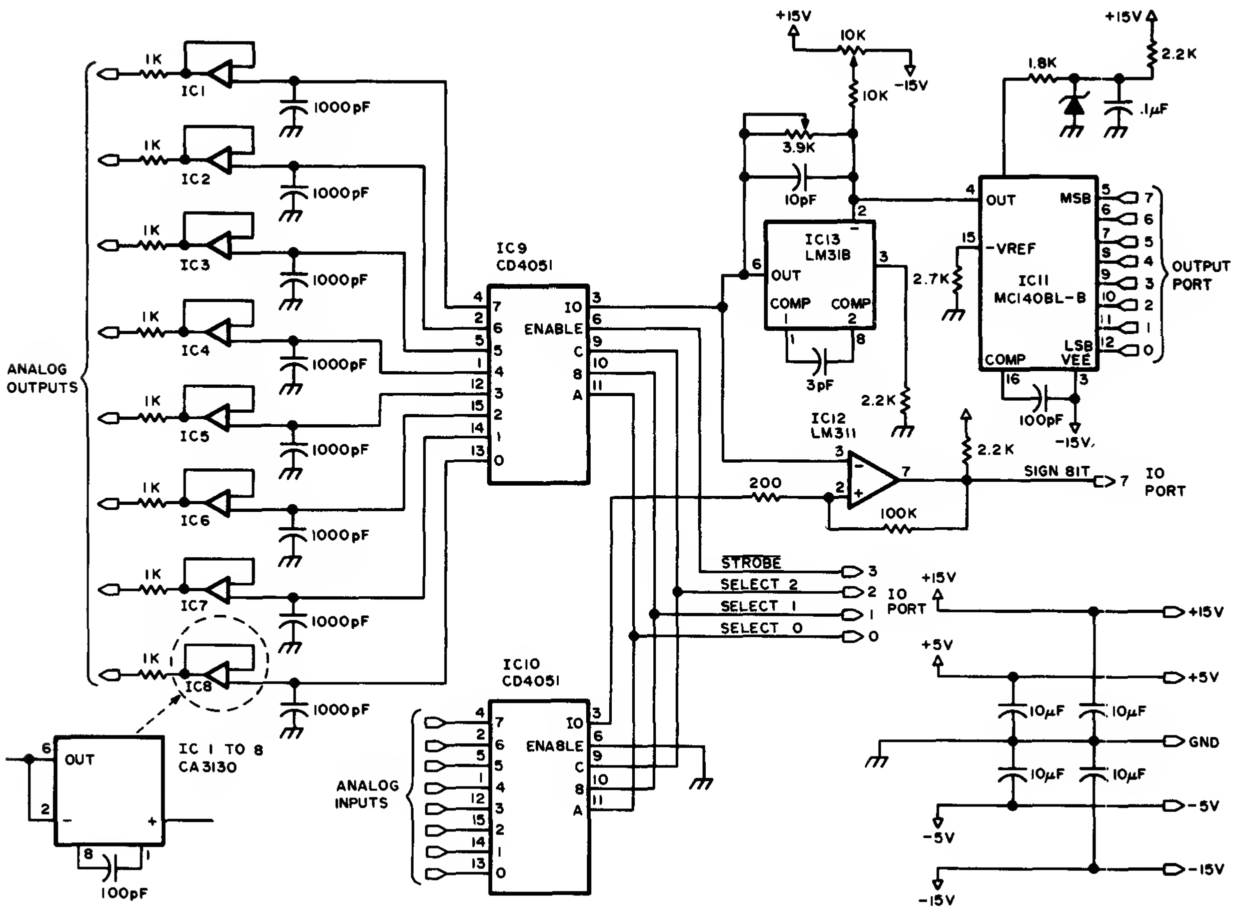
MULTIPLEXING OF DISPLAYS—Three or more displays can be multiplexed simply by gating 7490 counter output via 7401, then using OR connection for outputs. 7401s are switched on in rotation by positive enable signal which also switches displays on in turn. If using common-cathode displays, segment and display enable signals must be inverted. With individual display units, segments must be paralleled.—G. A. Bobker, Simplified Multiplexing, *Wireless World*, Feb. 1978, p 59.



EIGHT-CHANNEL TELEMETER—Multiplex transmission system permits monitoring eight different inputs at remote location. 5-V pulse train is sent down separate channel to receiving location to perform timing and synchronizing functions for outputs of MM74C42 BCD-to-decimal decoder. 15-V reset pulse is superimposed on 5-V clock. Other receivers can be added if monitoring is desired at more than one location.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-71–7-72.

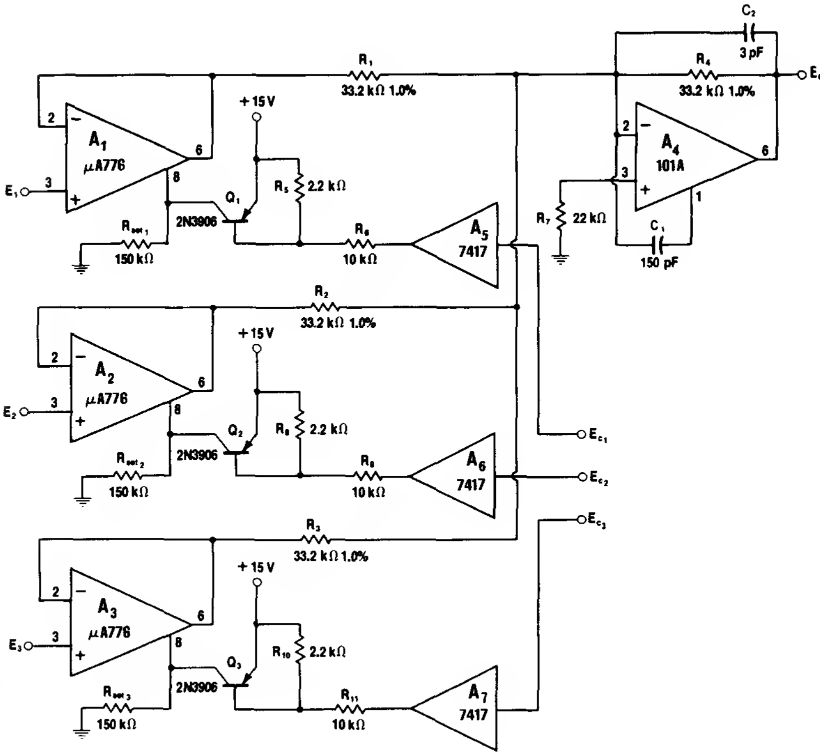


TWO-INPUT FSK MULTIPLEXER—Uses Signetics NE571 or NE570 analog compandors. Gain of each channel is unity, es determined by R_{GAIN} value for channel. When complementary control signals ere provided, FSK generator switches between the two signal inputs. Outputs, when on, ere summed by opemp in IC. Eech chennel is gated off by low control logic input. For FSK or eltemete-channel use, CONTROL A end CONTROL B signels should be complementary. Control signal suppression is optimized with chopper null pot. Suppression is better than 60 dB efter trimming. Circuit cen elso be used es summing switch, with both signels on at eny given instant.—W. G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.

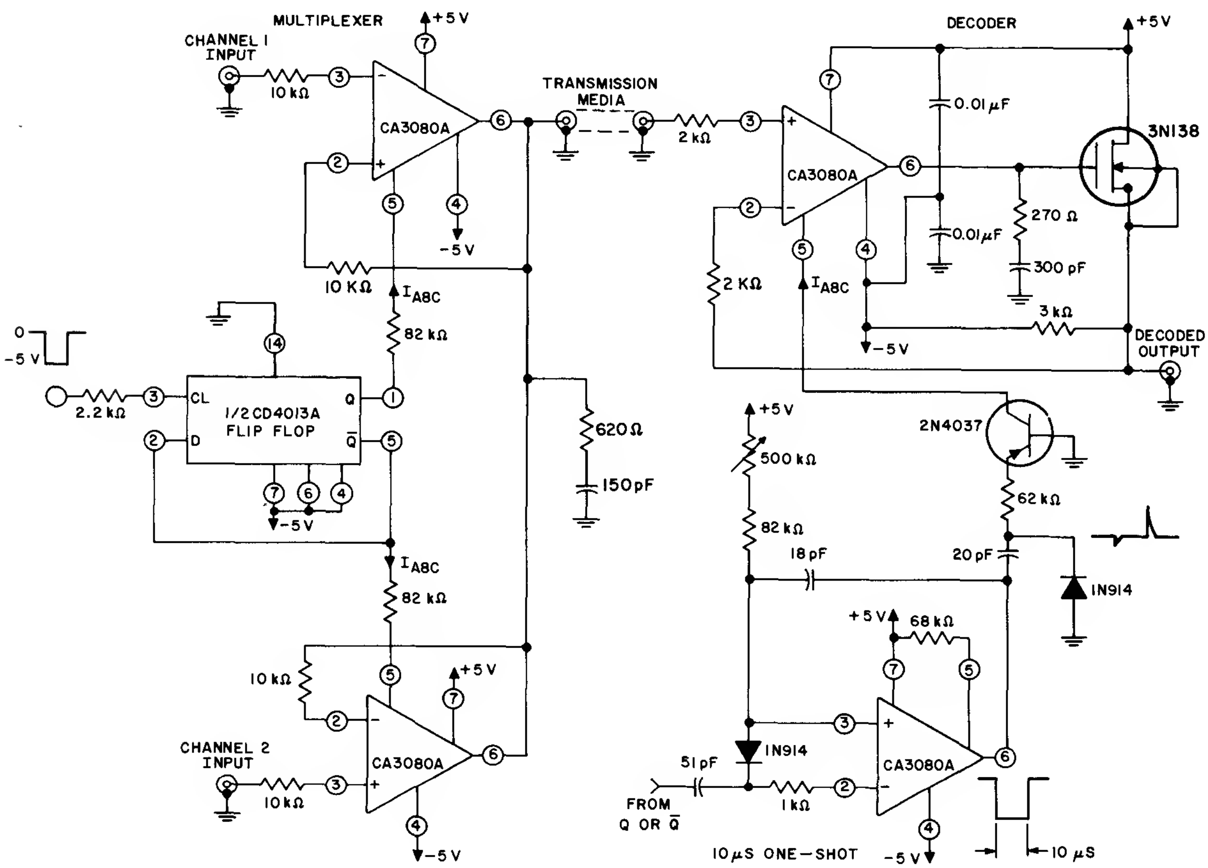


Number	Type	+5 V	GND	−15 V	+15 V	−5 V
1 to 8	CA3130	7				4
9	CD4051	16.	8			7
10	CD4051	16	8			7
11	MC1408L-8	13	2			
12	LM311		1	4	8	
13	LM318			4	8	

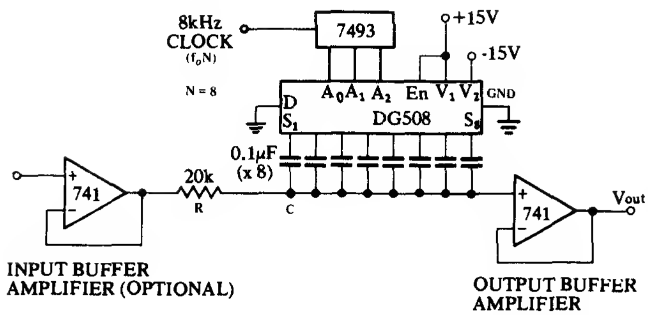
MULTIPLEXED A/D-D/A CONVERTER INTERFACE—Time-multiplexed interface minimizes herdware required for epplications of personel computer system. Useful in interective gemes, equipment testing, end electronic music. Optimized for 0.1–100 Hz signels. Bypeee each power pin with 0.01 μF to suppress strey spikes caused by power surges. Use of LM318 opamp minimizes response time of MC1408L-8 DAC.—D. R. Kraul, Designing Multichannel Analog Interfeces, *BYTE*, June 1977, p 18–23.



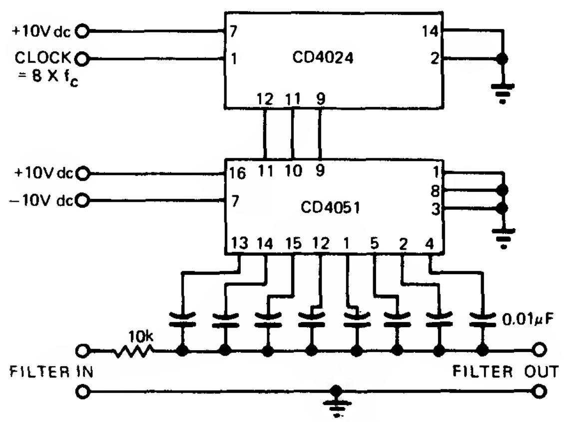
ANALOG SUMMING—ON/OFF programming of μA776 opamps allows any or all inputs to be on at given time. Switched outputs are combinad in summing invertar A_4. Voltaga followers A_1-A_3 are programmed from on to off by Q_1-Q_3 and A_5-A_7. Noise gain of stage A_4 is minimizad when input channel is switched off. If sign invarsion by A_4 is undesirable, add inverter stage following A_4. Any number of additional channels can be added. Programming pulsas ara applied to inputs of A_5, A_6, and A_7.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 419–421.



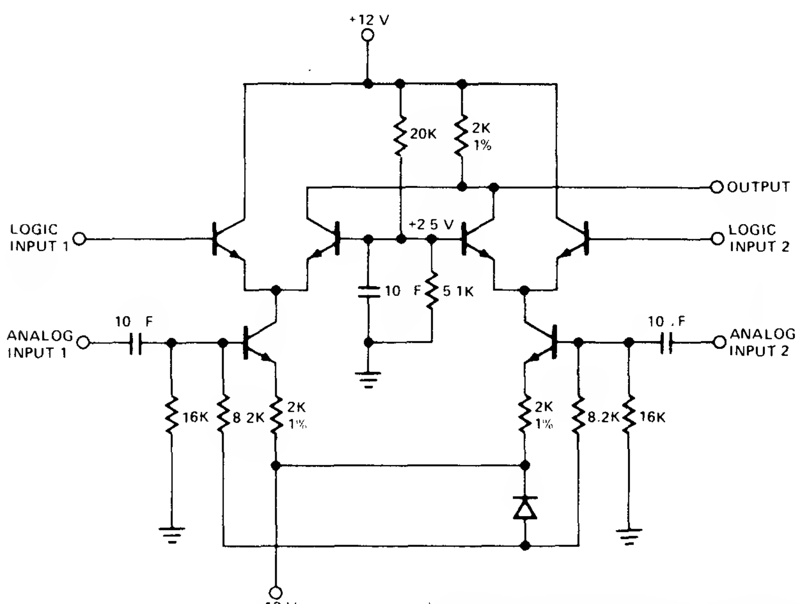
DATA MULTIPLEXER/DECODER—CD4013A flip-flop switches channel opamps alternately to transmission lina under control of −5 V clock pulses for multiplexing of inputs to lina. Any number of input channels can be added by extending circuit. At receiving end, ona CA3080A variabla opamp is used as mono MVBR to provide 10-μs delay for input signal to settle before being sampled by sample-and-hold decodar. Either output of flip-flop can be used to trigger MVBR.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somarville, NJ, 1977, p 15.



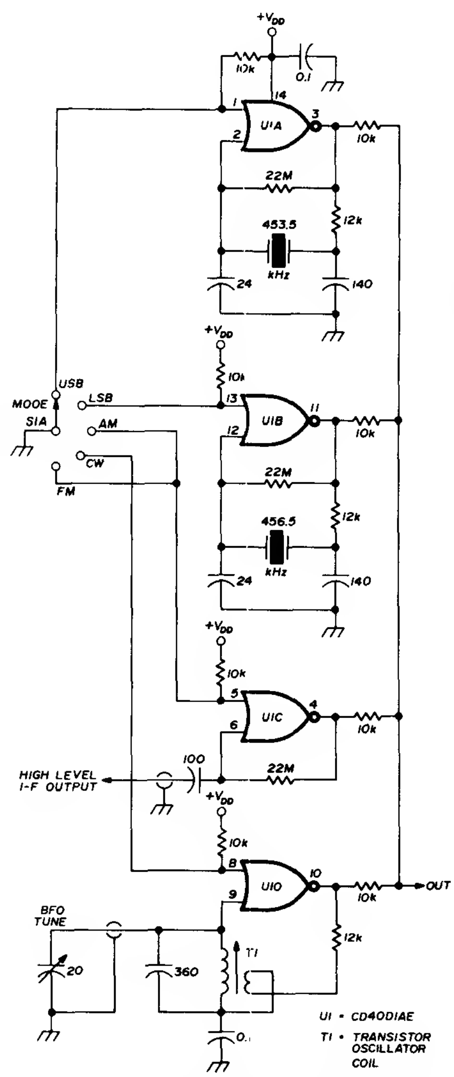
1-kHz COMB FILTER—DG508 eight-channel CMOS multiplexer is used in comb filter having fundamental frequency of 1 kHz. Sampling section provides response at each harmonic multiple except at 8 and 16 kHz (no response at Nf_0 or $2Nf_0$). Used in selective filtering of periodic signals from background of nonperiodic noise interference. 7493 TTL binary counter provides necessary 3-bit binary count sequence from 8-kHz clock. Q is 50.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 5-17–5-18.



COMMUTATING BANDPASS FILTER—CD4051 analog multiplexer serves for commutation and switching of eight low-pass filter sections. Multiplexer is driven by CD4024 binary counter that is clocked at 8 times desired 100-kHz center frequency. Can be tuned by varying commutating frequency.—J. Tracy, CMOS Offers New Approach to Commutating Filters, *EDN Magazine*, Feb. 5, 1974, p 94–95.

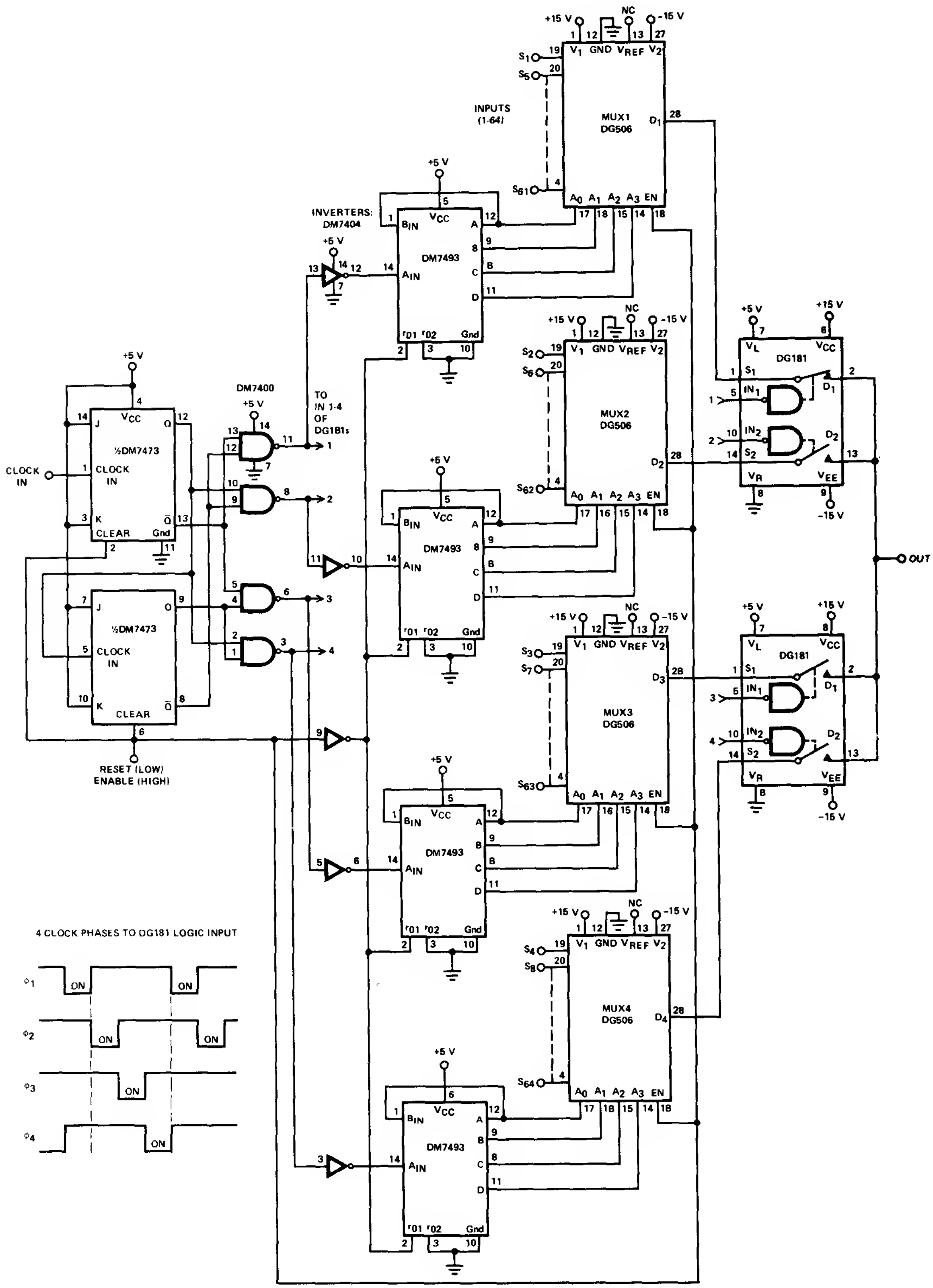


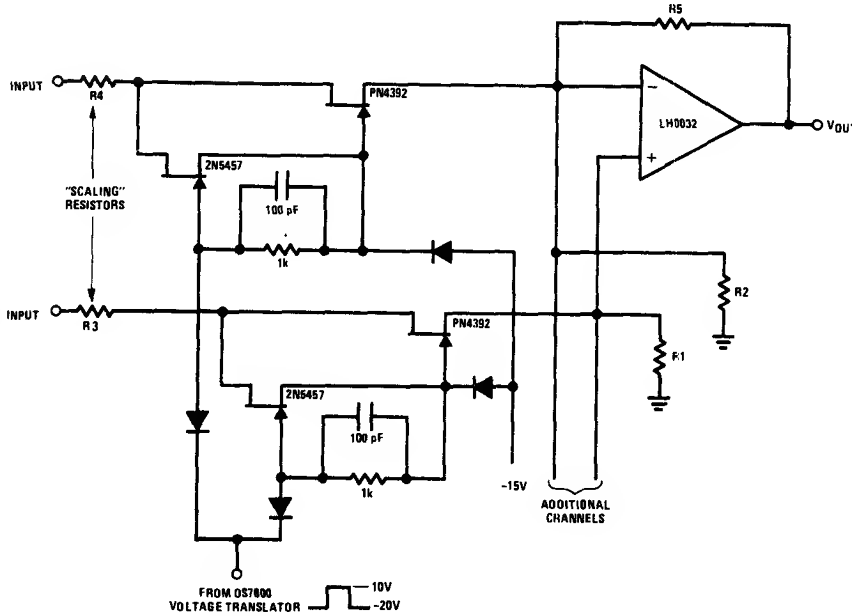
ANALOG SWITCH—Circuit using Signetics 511 transistor array provides digital selection of either of two analog signals. When logic input at left is zero, signal at analog input 1 goes to output and other analog input signal is rejected. Similarly, when logic 0 is applied to logic input 2, analog input 2 goes to output. Eight-channel analog multiplex switch can be formed by combining four 511 analog switches with Signetics 8250 binary-to-octal decoder. Analog signals up to 200 kHz are switched without amplitude degradation.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 753–754.



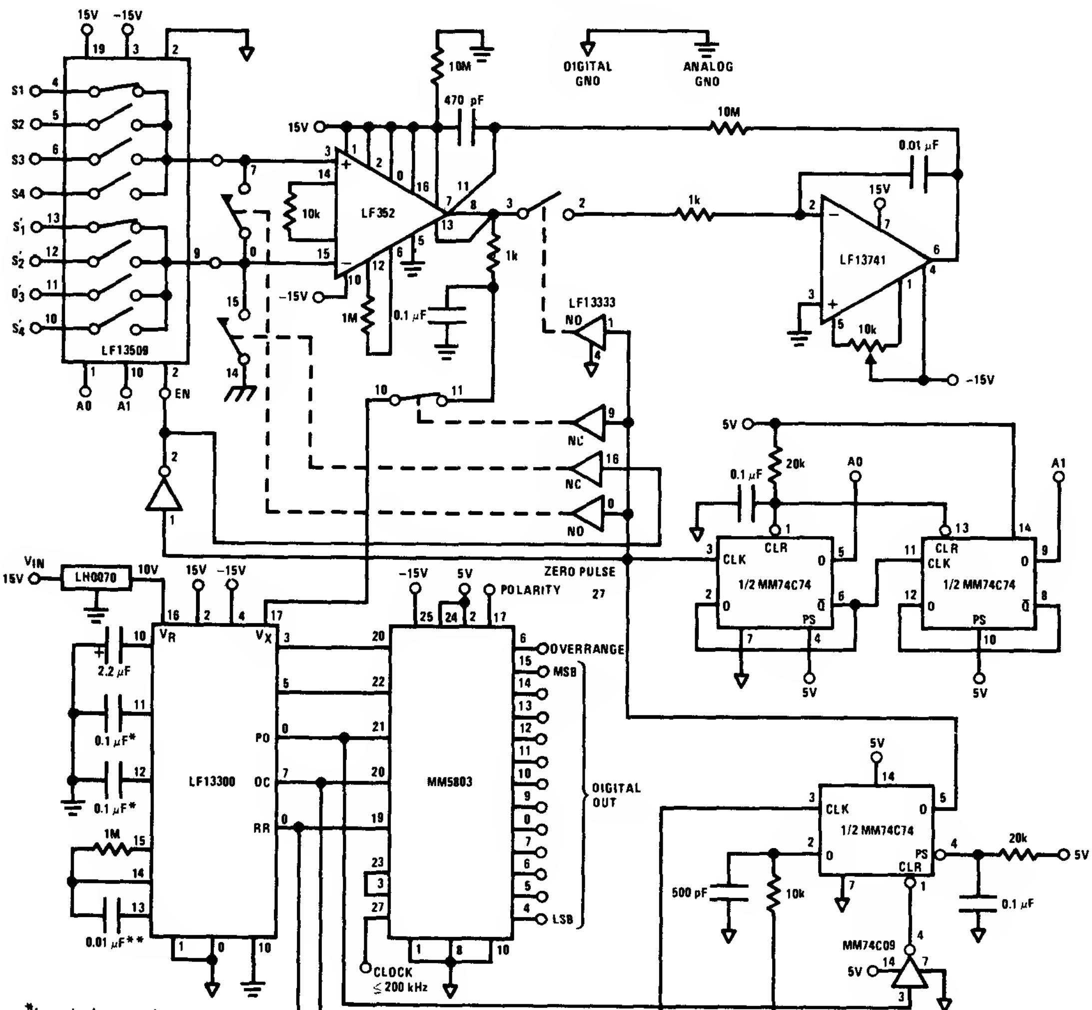
BFO MULTIPLEXER—Signal 455-kHz multimode detection system using RCA CD4001AE quad NOR gate functions as upper-sideband or lower-sideband crystal oscillator, tunable BFO for CW, or limiter of IF signal for FM or synchronous AM reception. Desired oscillator or limiter is gated on by grounding its digital control line with S1A. Multimode reception occurs when multiplexed output of oscillators and limiter is applied to product detector.—J. Regula, BFO Multiplexer for a Multimode Detector, *Ham Radio*, Oct. 1975, p 52–55.

64-CHANNEL TWO-LEVEL—Two-level multiplexing system increeses effective switching speeds when transmitting 64 anelog signals on single transmission line. Four clock pheses are generated with DM7473 2-bit counter that toggles on high-to-low clock edge. DM7400 NAND getes decode flip-flop outputs into required four clock phases. As clock phase goes from low to high state, DG181 analog switch fed by it turns off and corresponding DM7493 4-bit binery counter is triggered to next address state for sampling of that input channel at output. Reset is used to set system for starting on first channel when power is applied.—"Analog Switches end Their Applications," Siliconix, Santa Clera, CA, 1976, p 7-11–7-13.





WIDEBAND DIFFERENTIAL-INPUT—Circuit design using PN4392 FET switches driven by 2N5457 general-purpose FETs allows handling of high-frequency signals at toggle rates up to 1 MHz for multiplexing to any desired number of channels.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



*Low leakage mylar
**Polypropylene

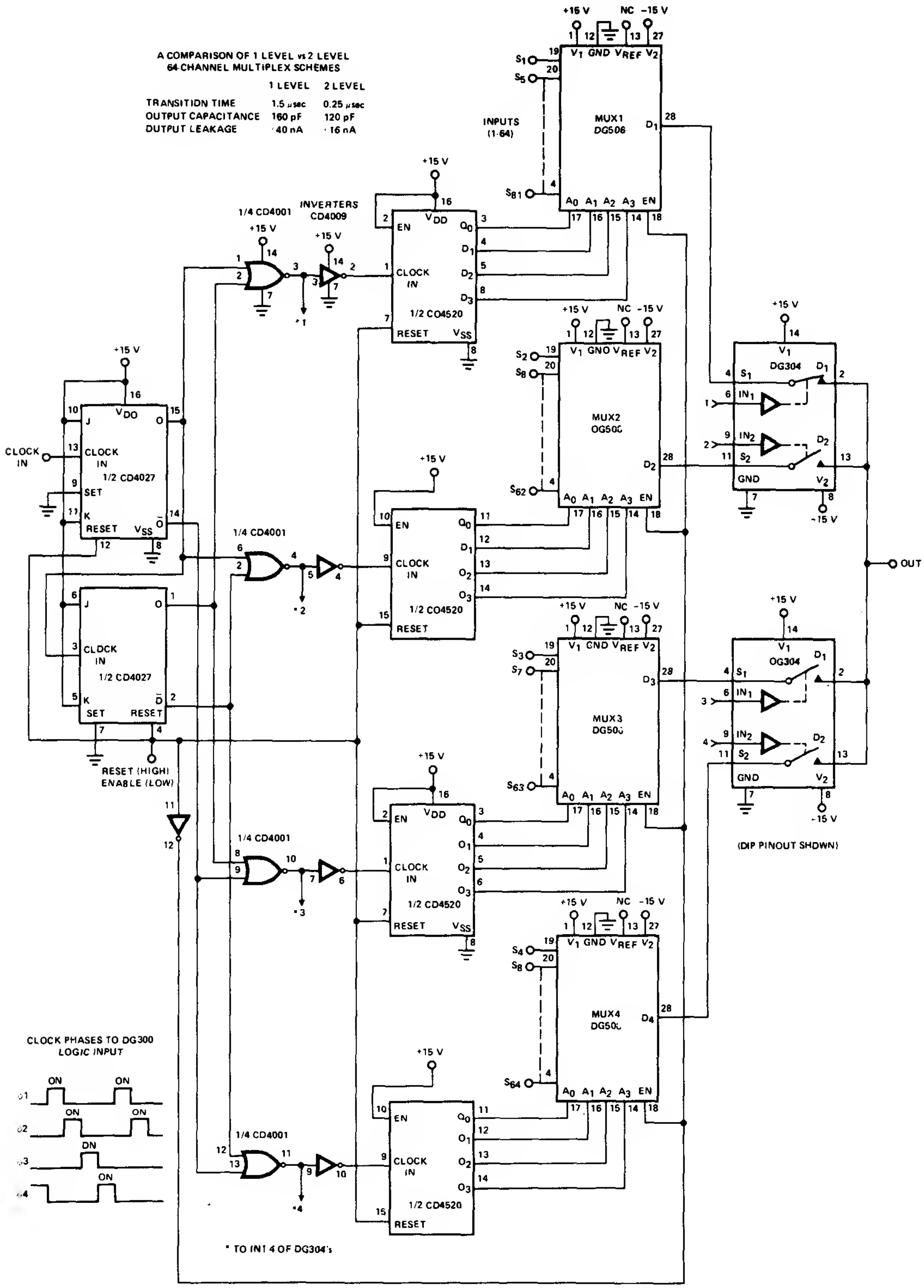
$f_{CLOCK\ MAX} = 200$ kHz

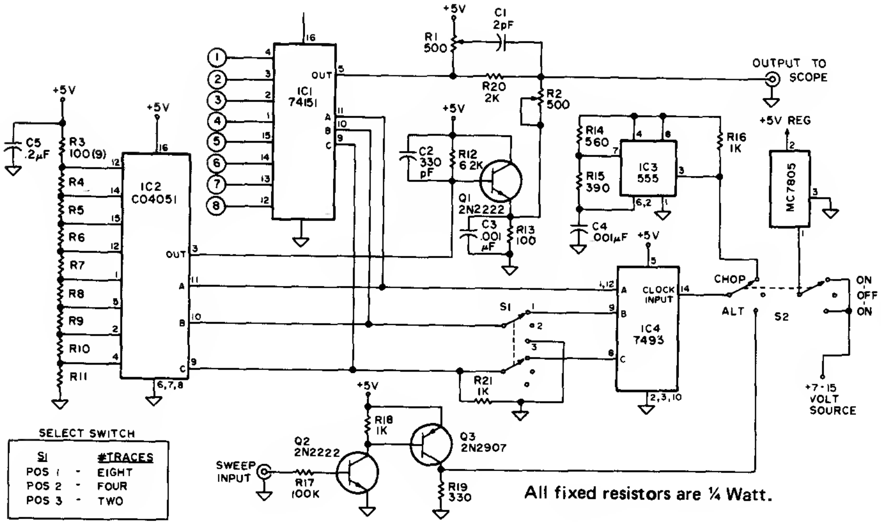
FOUR-CHANNEL DIFFERENTIAL—Low-speed high-accuracy data acquisition unit acquires analog input signal differentially with LF13509 IC and preconditions it through LF352 instrumentation amplifier having automatic zeroing circuit. Timing is provided by MM5863 12-bit A/D converter and lower MM74C74 flip-flop. Upper two flip-flops form 2-bit up counter for channel select. Instrumentation amplifier is zeroed at power-up and after each conversion. Maximum clock frequency depends on required accuracy and minimum zeroing time of instrumentation amplifier.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-2–5-22.

64-CHANNEL TWO-LEVEL HIGH-SPEED—Four DG506 16-channel multiplexers serve for first multiplexer level, and two DG304 high-speed dual analog switches serve in second level for switching DG506 outputs to single output of multiplexer. As one multiplexer is being sampled at output, other multiplexers are being switched to next address line; this shortens overall system transition time from 1.5 μs to 0.25 μs. Two-level system also lowers output node capacitance and output leakage. CMOS digital logic controls entire system.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-82–7-84.

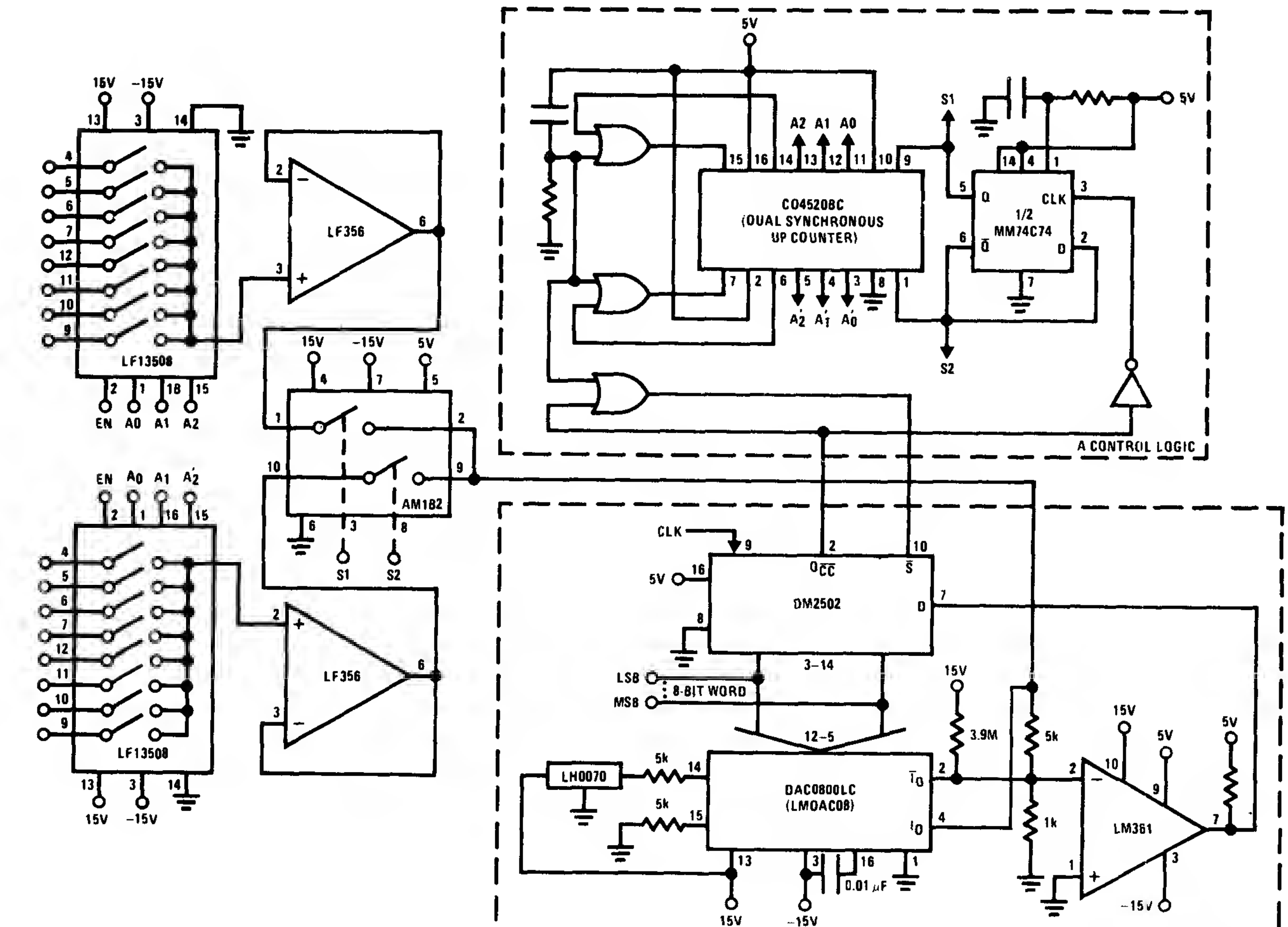
A COMPARISON OF 1 LEVEL vs 2 LEVEL 64-CHANNEL MULTIPLEX SCHEMES

	1 LEVEL	2 LEVEL
TRANSITION TIME	1.5 μsec	0.25 μsec
OUTPUT CAPACITANCE	160 pF	120 pF
OUTPUT LEAKAGE	40 nA	16 nA

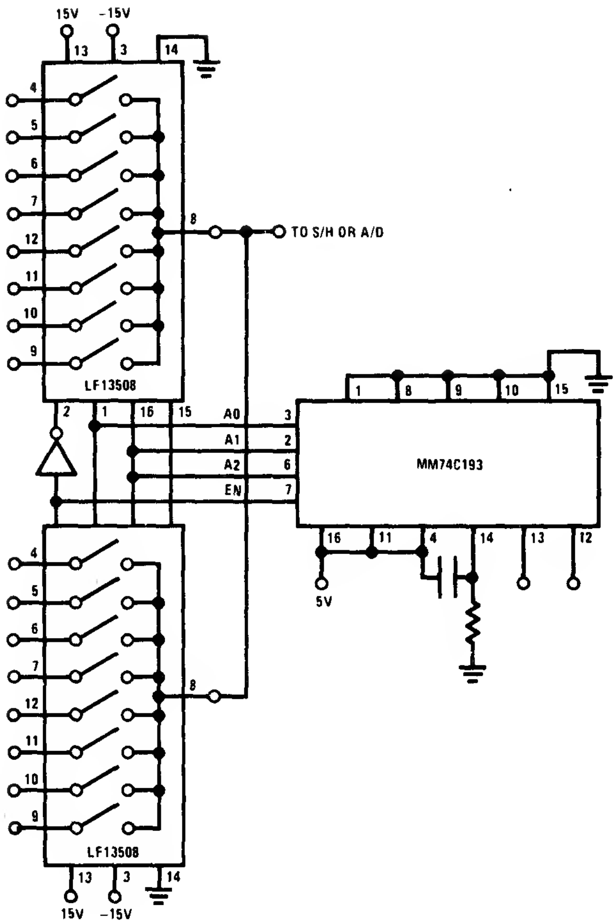




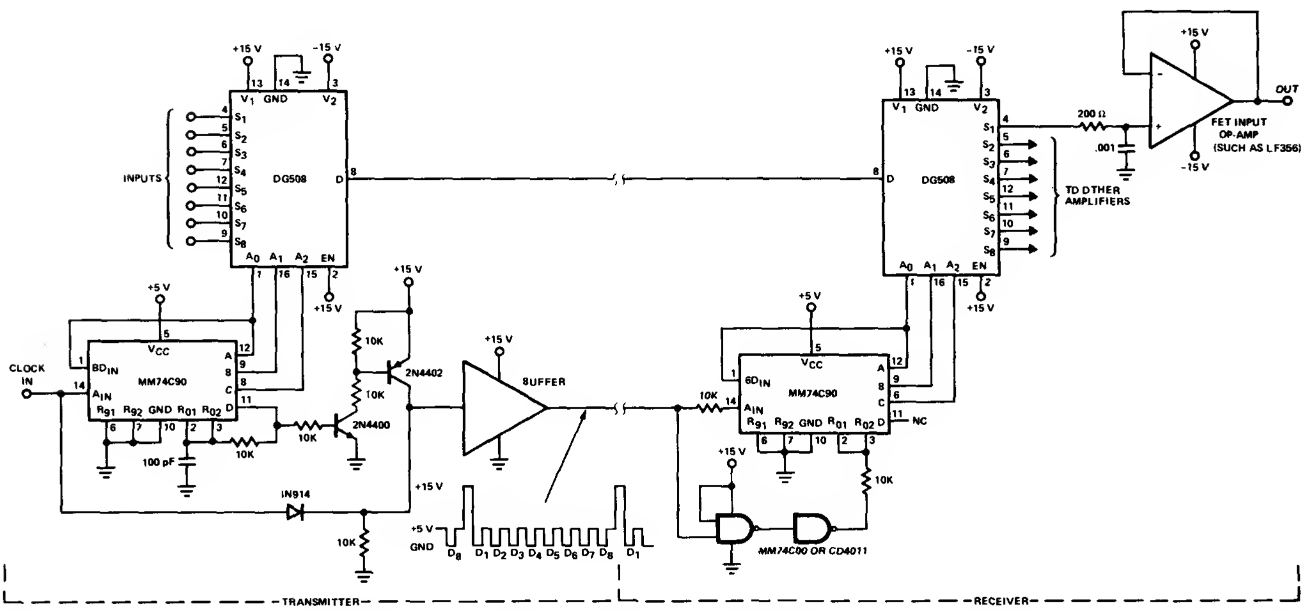
8-CHANNEL CRO MULTIPLEXER—Simple adapter converts any single-trace oscilloscope into professional 8-channel model by multiplexing eight input signals into one output for vertical amplifier. Discrete voltages are picked off resistor divider chain sequentially and added to digital input signal so trace is shifted fast enough to produce eight individual traces. Addressing for 74151 digital multiplexer requires 3 bits of binary code to address all eight channels in sampling sequence. As each channel is sampled, its logic level (1 or 0) appears at pin 5 of 74151 for feed to vertical input of CRO. Developed for troubleshooting in digital circuits.—W. J. Prudhomme, Build an Eight Channel Multiplexer for Your Scope, *Kilobaud,* April 1977, p 29–32.



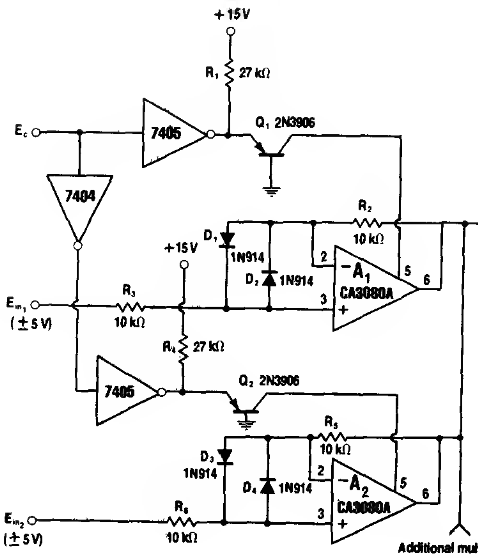
HIGH-SPEED 16-CHANNEL—Fast two-channel multiplexer using National AM182 dual analog switch provides second-level multiplexing by accepting outputs of each LF13508 eight-channel multiplexer and feeding these outputs sequentially into 8-bit successive-approximation A/D converter. Technique makes throughput rate of system independent of analog switch speed. With maximum clock frequency of 4.5 MHz, throughput rate is 31,250 samples per second per channel.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-79–5-80.



16-CHANNEL SIMPLIFIED SEQUENTIAL MULTIPLEXING—Two National LF13508 eight-channel multiplexers are connected so enable pins are used to disconnect one multiplexer while the other is sampling. Any number of eight-channel multiplexers can be connected in this way if speed is not prime system requirement.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-79–5-81.



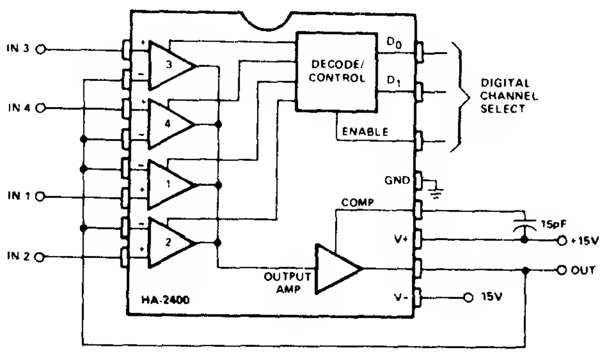
EIGHT-CHANNEL MUX/DEMUX—Provides for monitoring of all eight channels continuously at remote location instead of scanning channels at receiver. Each output of DG508 eight-channel analog multiplexer in receiver feeds its own opamp for driving readout. Similar DG508 at transmitter feeds inputs over single-wire line under control of MM74C90 presettable decade counter which also feeds pulse train over separate channel to receiver for timing and synchronization. 15-V reset pulse superimposed on 5-V clock pulses keeps channels synchronized.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-71–7-74.

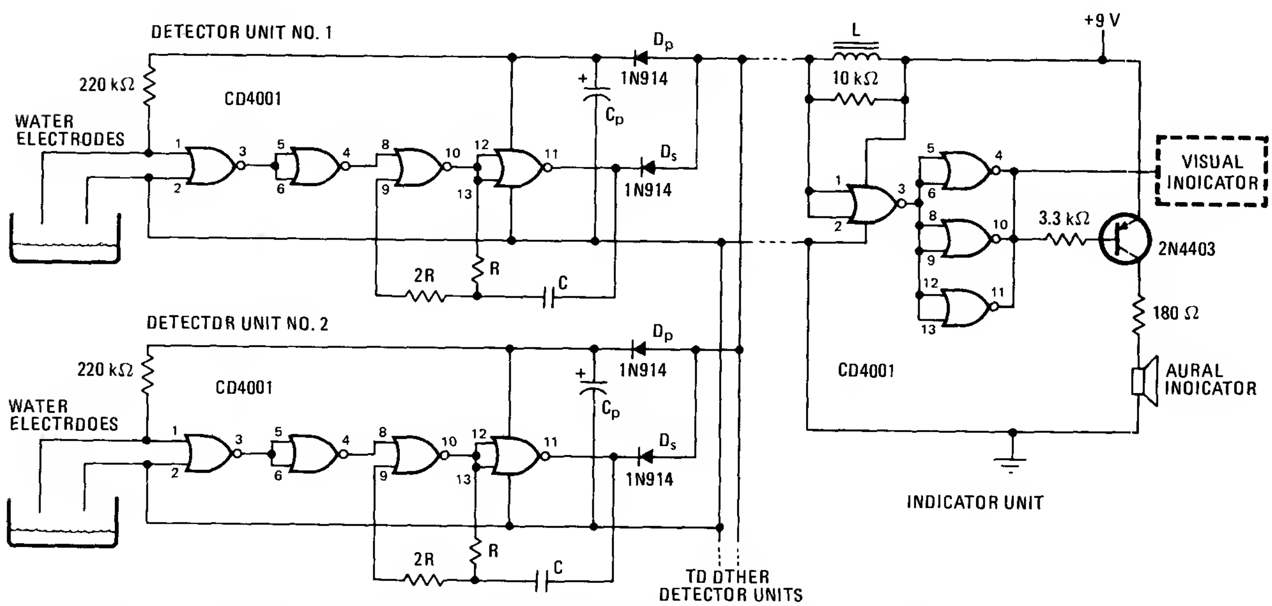


E_c	E_o
1	E_{in_1}
0	E_{in_2}

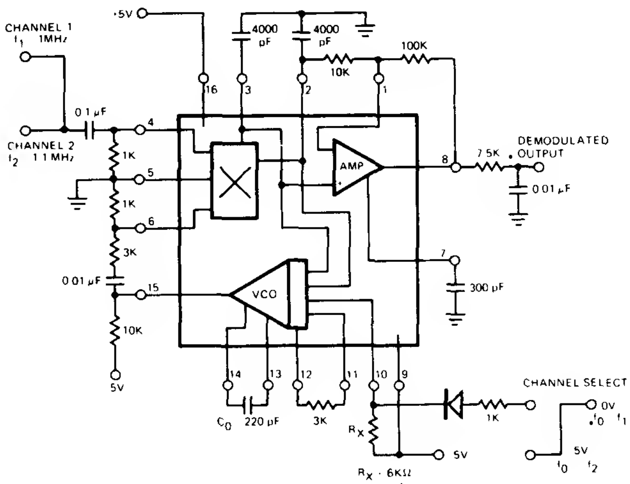
TWO-CHANNEL LOGIC-CONTROLLED—Two CA3080A operational transconductance amplifiars are programmed on and off altarnately by control logic, for multiplaxing two inputs aach up to ±5 V into single output. When control line E_c is high or 1, input 1 appaars at output; for logic 0, input 2 appears at output. Both channels operate at unity gain. Control logic is TTL-compatible.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 458–462.

FOUR-CHANNEL ANALOG MULTIPLEXER—Buffered input and output provida vary high input impedance and low output impedance for analog signal salaction or time-division multiplexing with Harris HA-2400/HA-2405 IC that combinas functions of analog switch and high-parformance opamp. Bandwidth is about 8 MHz. Signal is fed back from output to digitally selacted input channel to placa that channel in voltage-follower configuration with noninverting unity gain.—"Linear & Data Acquisition Products," Harris Semiconductor, Melbourna, FL, Vol. 1, 1977, p 7-36–7-38 (Application Nota 514).

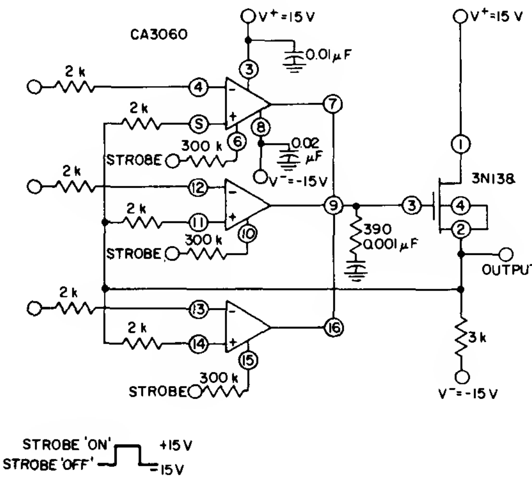




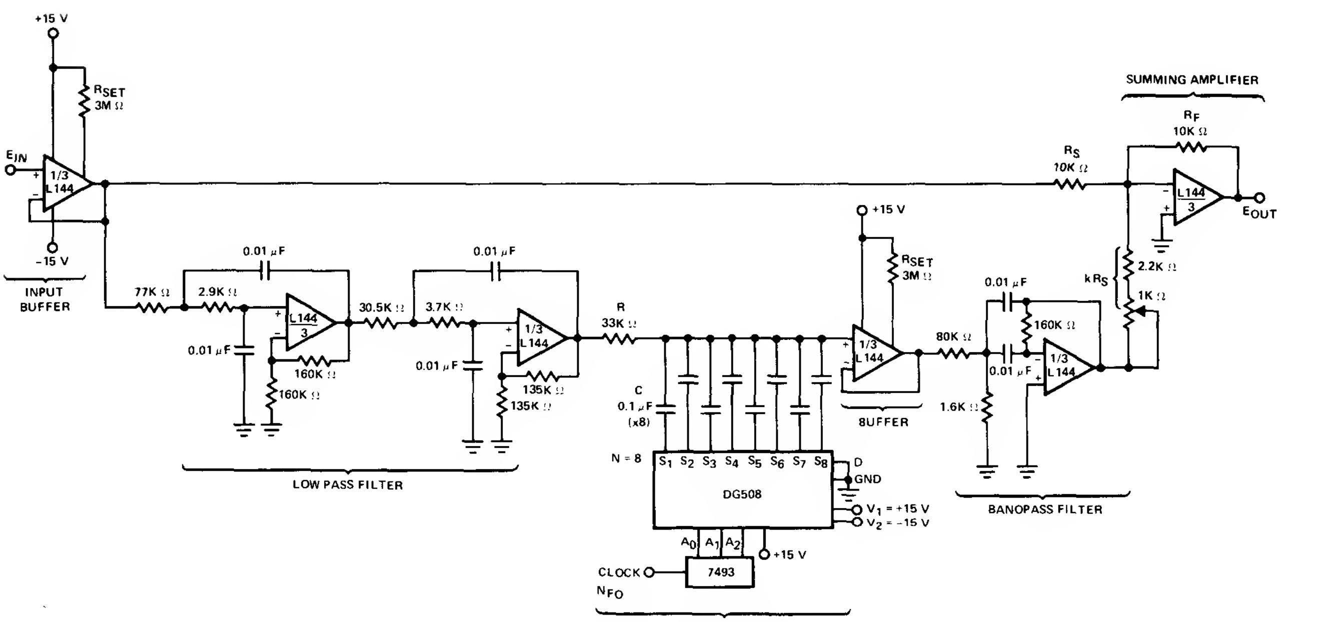
WATER-LEAK ISOLATOR—Maater indicator monitors large number of two-electrode water-leak detectors simultaneously, with each detector indicating presence of water by producing unique tone signal. Only two wires are needed between datectors and mastar indicator unit. Each detector location has quad NOR gate. First gata is water senaor, second is inverter, and last two form aatable MVBR. When sensing alectrodes ara dry, resistanca betwaen them is above 500K and MVBR ia diaablad. When water drops resistance below 100K, MVBR oscillates at audio frequancy determined by its RC time constant, equal to 1/1.4RC whare R is in ohms and C is in farads. C_P value in farads should be 1/1000 of lowest frequency used by detectors. L in hanrys is about 1/600 of lowest frequency.—F. E. Hinkla, Multiplexed Detectors Isolate Water Leaks, *Electronics*, Dec. 11, 1975, p 116–117.



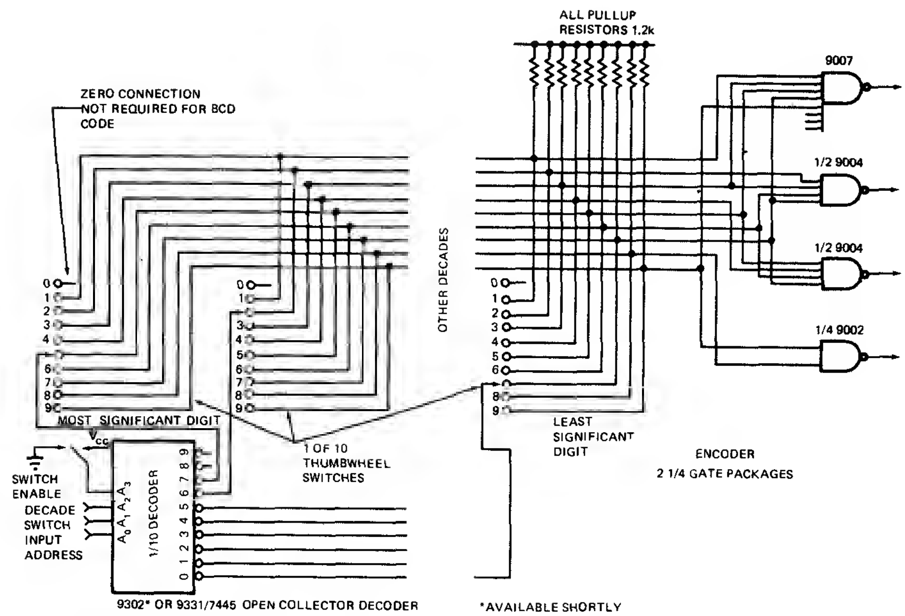
TIME-MULTIPLEXING TWO FM CHANNELS—Digital programming capability of Exar XR-215 PLL IC makes possible time-multiplexing demodulator between two FM channels, at 1.0 and 1.1 MHz. Channel-select logic signal is applied to pin 10, and both input channels are applied simultaneously to PLL input pin 4.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 21–28.



THREE-CHANNEL FOR DATA—Each input channel uses CA3060 variable opamp as high-impedance voltage follower driving output MOSFET serving as buffer and power amplifier. Cascade arrangement of opamps with MOSFET provides open-loop voltage gain in excess of 100 dB.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 16.



1-kHz N-PATH NOTCH FILTER—Combination of DG508 eight-channel CMOS multiplexer with low-pass and bandpass active filters provides 1-kHz notch filter having Q of 1330 and 3-dB bandwidth of 0.75 Hz at 1 kHz. Low-pass filter introduces 180° phase shift at 1 kHz. Amplifier sums original signal in phase-shifted bandpass output from N-path filter, canceling 1-kHz components in original signal to produce desired notch characteristic.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 5-18–5-20.

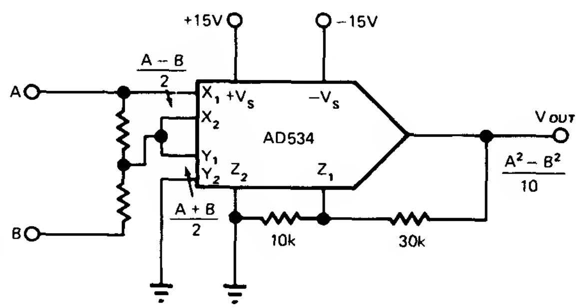


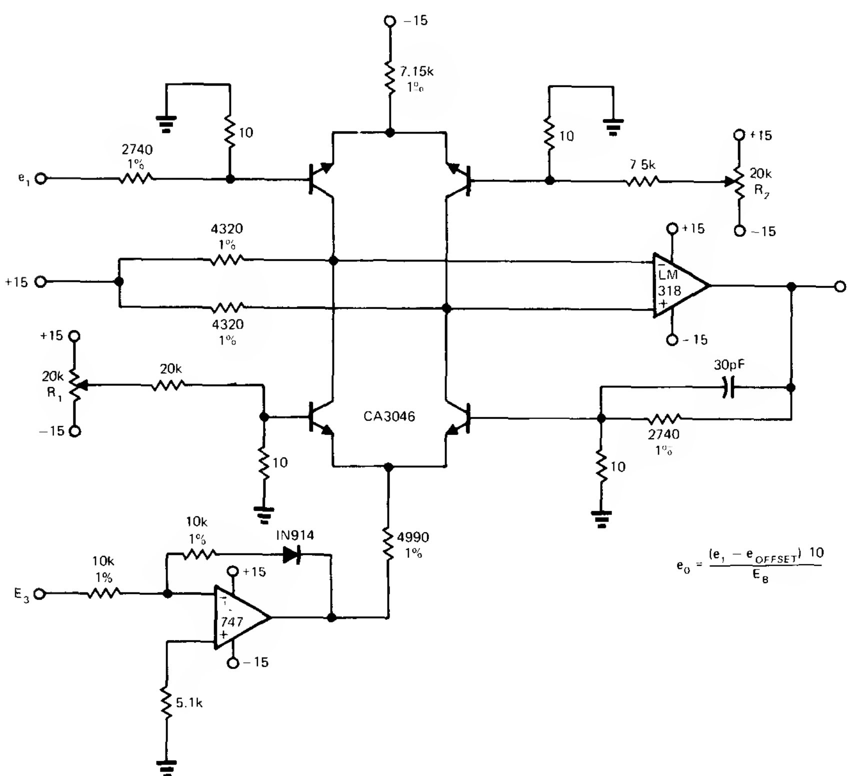
MULTIPLEXING BCD SWITCHES—Multiplexing technique reduces number of interconnections between thumbwheel switches and counters, displays, or industrial control equipment being programmed remotely. Ten decades of BCD switches require only 10 interconnections, as compared to 50 without multiplexing. All 10 outputs of low-cost single-pole decade switches are paralleled, with wiper arm connections being brought out separately. Parallel outputs are fed into simple encoder using four NAND gates to generate 4-bit BCD output code. Wiper of each switch is addressed from active low open-collector decoder. In operation, 3-bit input address determines which decade switch is addressed, and switch position then determines which encoder NAND gates are activated.—E. Breeze, Putting the "Thumb" on Thumbwheel Switch Multiplexing, *EDN Magazine,* Aug. 1, 1972, p 56.

CHAPTER 55
Multiplier Circuits

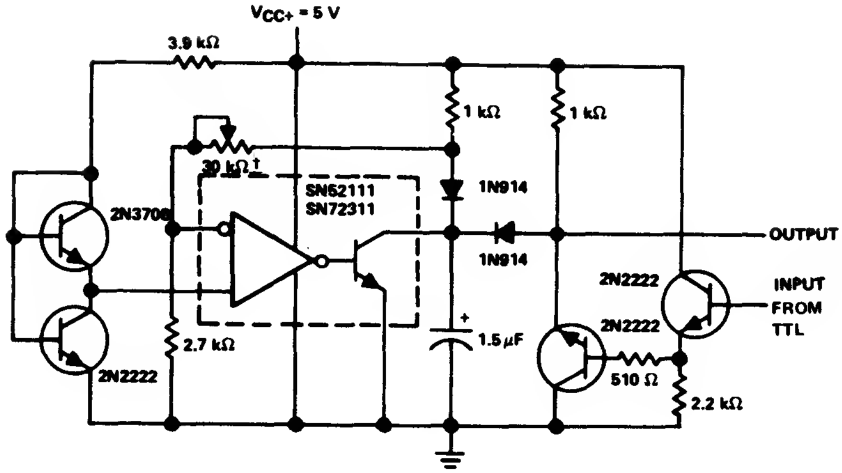
Opamps and analog-multiplier ICs are used separately or together to provide a variety of operations involving multiplication, including analog product, square, square root, root-sum-square, difference of squares, trigonometric approximations, and vector sum. See also Frequency Divider, Frequency Multiplier, and Logarithmic chapters.

$A^2 - B^2$—Transfer function $V_{OUT} = (A^2 - B^2)/10$ is easily generated by AD534 analog muitiplier. Differential inputs on Z terminels permit addition of feedback attenuetor to decreese scale factor (or increase signal gein) from 40 to nominal value of 10. Feedback attenuetion increases output offset proportionally; to make offsat adjustment, connect 4.7-megohm resistor between Z_1 and wiper of 50K pot connected across power supplies.—R. Frantz, Analog Multipliers—New IC Versions Menlpulete Real-World Phenomene with Eese, *EDN Magazine*, Sept. 5, 1977, p 125–129.



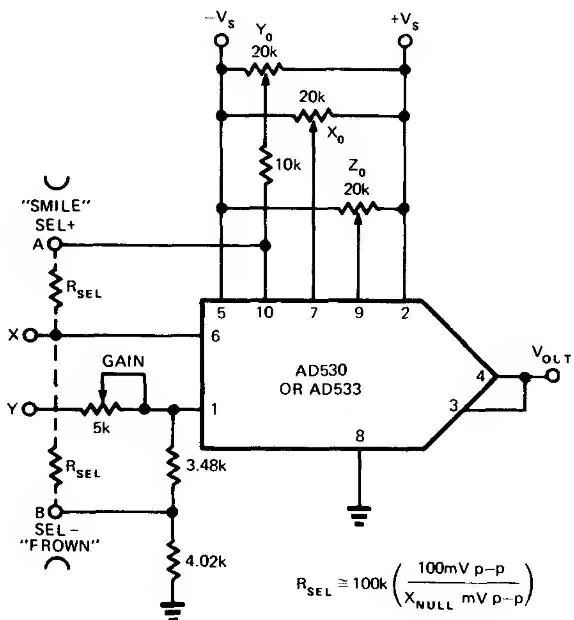


XY ÷ Z CIRCUIT—Developed for controlling amplitude of video signal from photodiode [illegible] ovar 2 to 1 range. Circuit provides 3-dB bandwidth of 3 MHz, using CA3046 transistor arrey combined with LM318 opamp connected as enalog divider, with half of 747 opamp serving es current source. Articla covers initiel adjustments of circuit. Basic circuit may ba used as full XY ÷ Z muitiply/divide element with differential bipolar signals on one numerator input.—A. R. Kopp, An Anelog Multiplier/Divider Circuit, *EDN Magazine*, May 5, 1973, p 74–75.

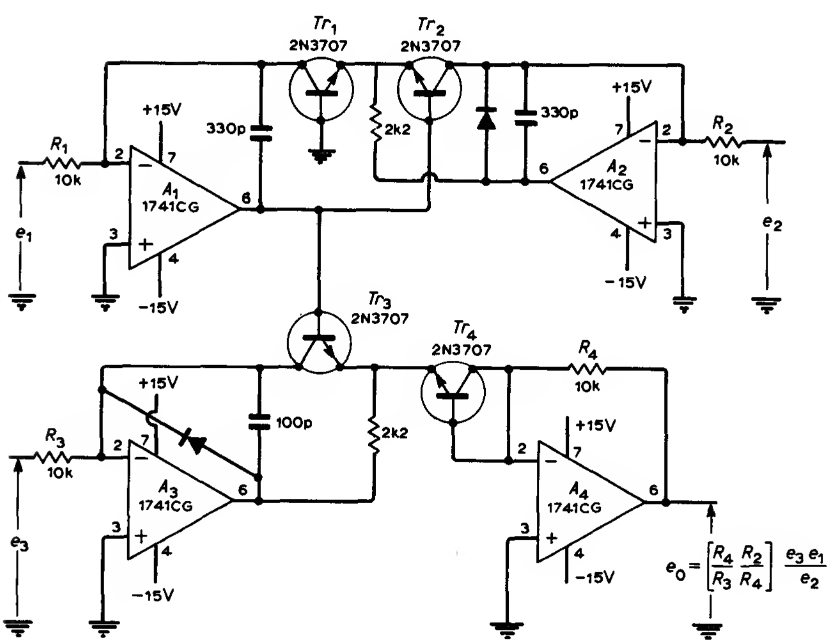


PRECISION SQUARER—Circuit using differential comperetor IC accepts input from TTL end delivers squere of input signal voltage to output. Adjust 30K pot to set clamp level.—"The Lineer end Interfece Circuits Dete Book for Design Engineers," Texas Instruments, Dalles, TX, 1973, p 6-16.

LINEARIZING X INPUT—Adding resistors es shown to IC trensconductance multiplier gives mejor improvement in X-input linearizetion. Article gives edjustment procedure. SMILE end FROWN terminal notes refer to X feedthrough pettern observed on CRO during setup, telling which position requires eddition of R_{SEL} resistor.—L. Counts, Reduce Multiplier Errors by up to en Order of Magnitude, *EDN Magazine,* Merch 20, 1974, p 65–68.

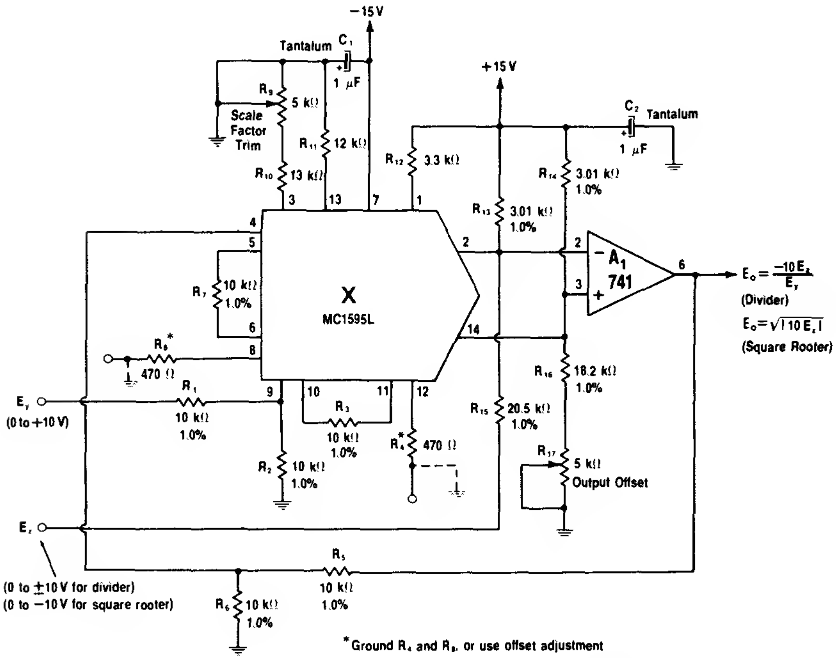


$$R_{SEL} \cong 100k\left(\frac{100mV\ p\text{-}p}{X_{NULL}\ mV\ p\text{-}p}\right)$$

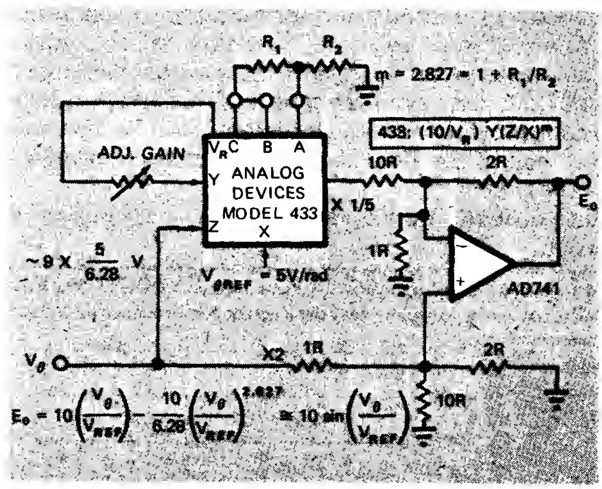


$$e_0 = \left[\frac{R_4}{R_3}\frac{R_2}{R_4}\right]\frac{e_3 e_1}{e_2}$$

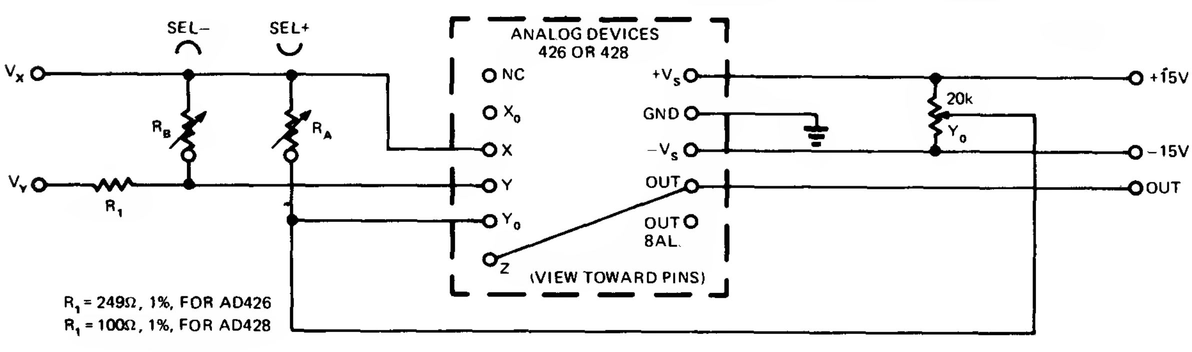
MULTIPLIER/DIVIDER—Combination opemp-transistor circuit mey be used for either multiplication or division. All signels must be of same polerity (positive). For multiplicetion, use inputs e_1 end e_3. For division, use e_1 and e_2, with e_3 being edjusted to give desired scaling factor. Log output at bese of Tr_2 is connected directly to entilog circuit et bese of Tr_3. Article gives design equetions. Circuit shown was developed to meesure current gein of PNP transistor over renge of operating currents.—G. B. Cleyton, Experiments with Operationel Amplifiers, *Wireless World,* Feb. 1973, p 91–93.



DIVIDER/SQUARE-ROOTER—Modification of multiplier circuit gives divider in which negative output voltage is equal to 10 times ratio E_x/E_y. To use as square-rooter for E_x, connect pins 4 and 9 together and omit R_1 and R_2 at E_y input. Circuit uses multiplier block driving 741 current-to-voltage converter.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 257–258.

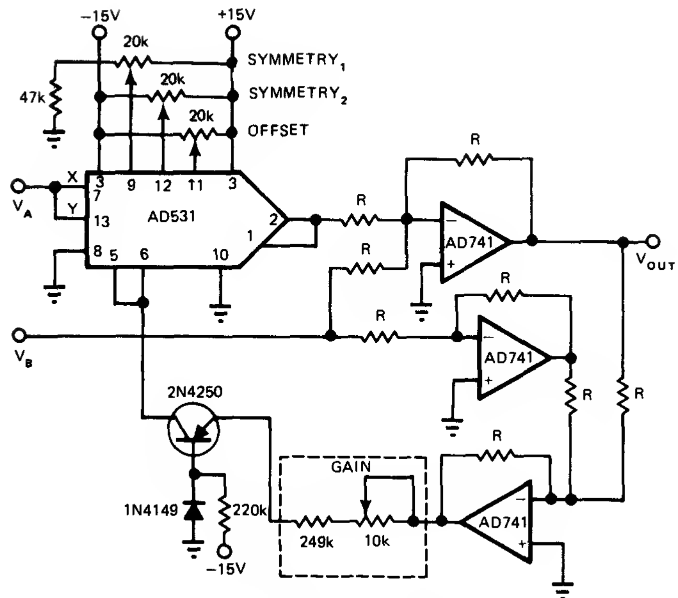


APPROXIMATING SINES—Analog Devices 433 multiplier/divider IC approximates sine of angle to less than 0.25% in just two terms (one quadrant). Arrangement requires only single opamp. Article gives analysis of theoretical errors and shows error curve.—D. H. Sheingold, Approximate Analog Functions with a Low-Cost Multiplier/Divider, *EDN Magazine*, Feb. 5, 1973, p 50–52.



TYPICAL RANGE OF $R_A + R_B$: 25kΩ TO 200kΩ, 1%, METAL FILM RESISTOR

LINEARIZING MODULAR MULTIPLIER—Adding three external resistors to conventional transconductance multiplier reduces feedthrough, decreases average nonlinearity, and cuts overall error in half. Article gives adjustment procedure.—L. Counts, Reduce Multiplier Errors by up to an Order of Magnitude, *EDN Magazine*, March 20, 1974, p 65–68.



$$-V_{OUT} = \frac{V_A^2}{-(-V_B + V_{OUT})} + V_B = \frac{V_A^2}{V_B - V_{OUT}} + V_B$$

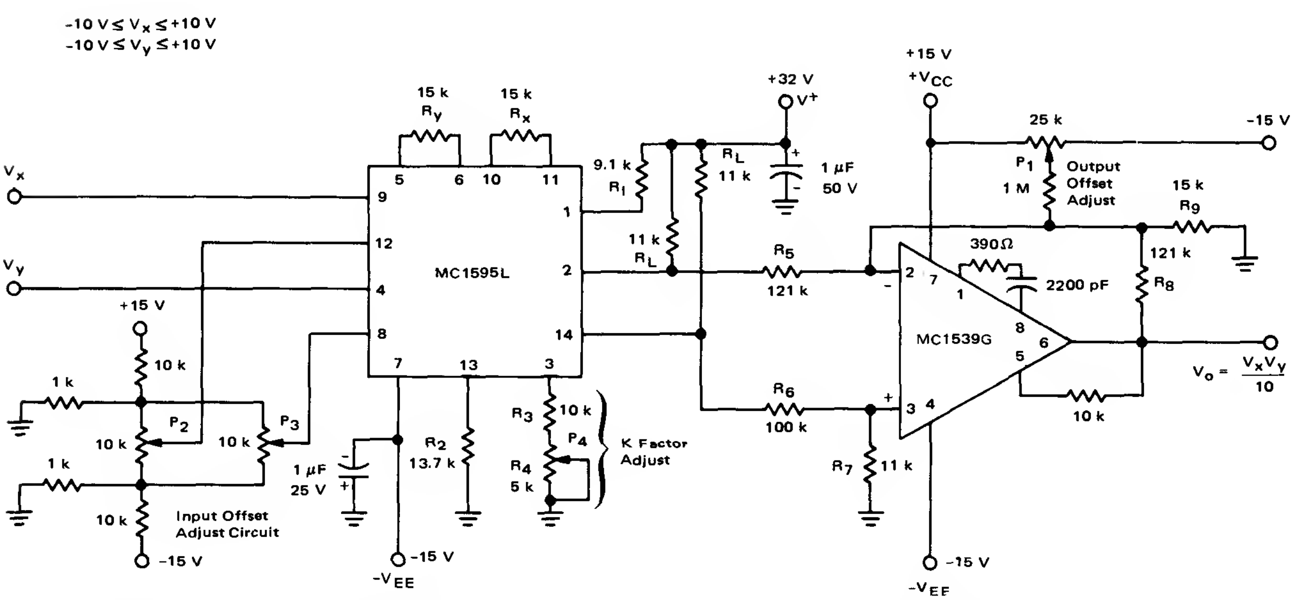
$$V_A^2 - V_{OUT}V_B = V_A^2 + V_B^2 - V_{OUT}V_B$$

$$|V_{OUT}^2| = V_A^2 + V_B^2$$

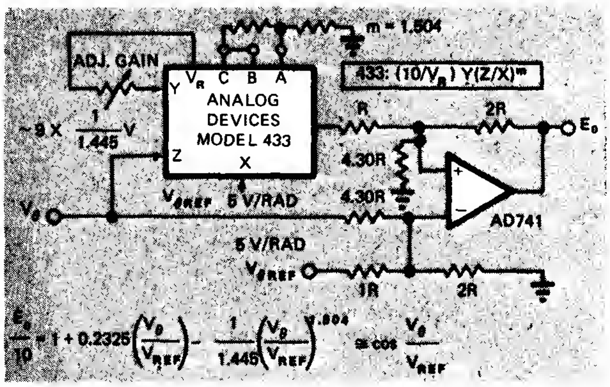
$$|V_{OUT}| = \sqrt{V_A^2 + V_B^2} = \text{ROOT SUM SQUARED (RSS)}$$

ADJUSTMENT PROCEDURE			
STEP	V_A	ADJUST	V_{OUT}
1	+10.0V, −10.0V	$SYMMETRY_1$	EQUAL OUTPUTS FOR ±IN
2	+1.0V, −1.0V	$SYMMETRY_2$	EQUAL OUTPUTS FOR ±IN
3	+1.0V	OFFSET	+1.0V
4	+10.0V	GAIN	+10.0V

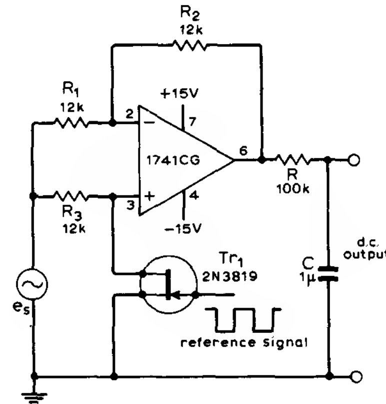
ROOT-SUM-SQUARED—Vector summation circuit uses AD531 variable-gain analog multiplier. Starting with trimpots centered and input V_B grounded, apply specified DC voltages to input V_A and adjust trimpots for output specified in table.—R. Frantz, Analog Multipliers—New IC Versions Manipulate Real-World Phenomena with Ease, *EDN Magazine,* Sept. 5, 1977, p 125–129.



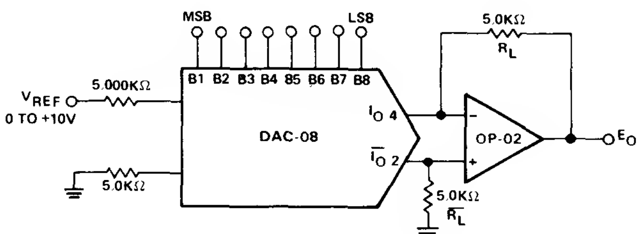
FOUR-QUADRANT WITH OPAMP LEVEL SHIFT—Connections shown for Motorola MC1595L linear four-quadrant multiplier are used in applications requiring level shift to ground reference. Common-mode voltage is reduced by 10:1 attenuation networks, and differential output voltage is fed to opamp having closed-loop gain of 10. Resulting output is still $V_xV_y/10$, which appears single-ended above ground reference. Each input can be between −10 V and +10 V. Frequency limit of circuit is about 50 kHz for signal swings approaching ±10 V.—E. Renschler, "Analysis and Basic Operation of the MC1595," Motorola, Phoenix, AZ, 1975, AN-489, p 9.



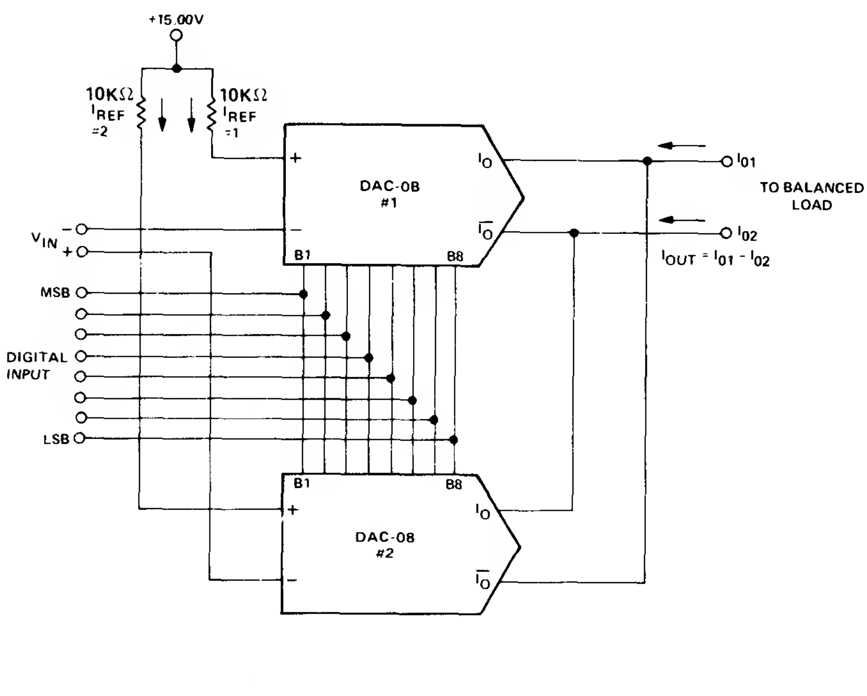
APPROXIMATING COSINES—Anelog Devices 433 multiplier/divider IC epproximetes cosine of engle to better then 1%, by computing nonintegrel exponents. Only one opemp is needed. Approximetion uses erbitrary exponent as one term of cosine θ plus e linear term end e constent term, es described in erticle.—D. H. Sheingold, Approximete Anelog Functions with e Low-Cost Multiplier/Divider, *EDN Magazine*, Feb. 5, 1973, p 50–52.



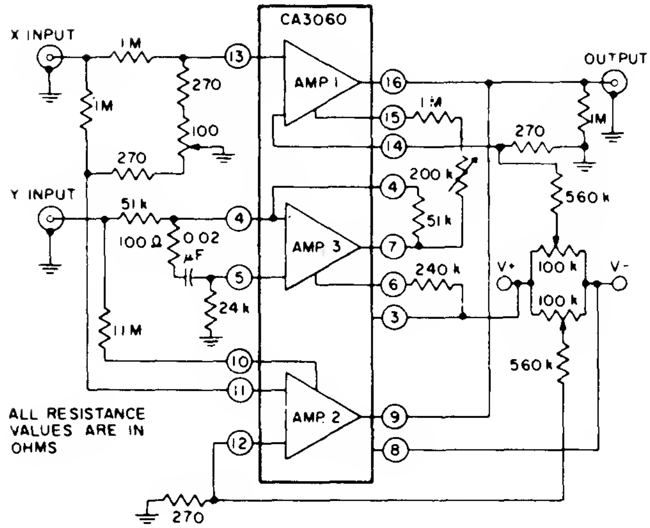
PHASE-SENSITIVE DETECTOR—Circuit using single opemp produces DC output proportional to both emplitude of AC input signal end cosine of its phese engla relativa to rafarenca signal. Can be used es synchronous rectifier in chopper-type DC emplifier or for eccurate measurement of smell AC signals obscured by nolsa. Article glves deslgn equatlons.—G. B. Clayton, Experiments with Operetionel Amplifiers, *Wireless World*, July 1973, p 355–356.



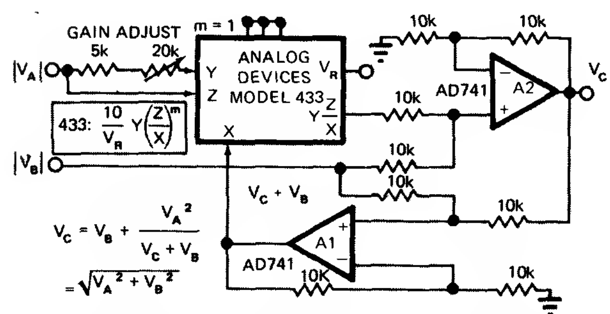
TWO-QUADRANT—Bipoler digitel multiplier hes output polerity controlled by offset-binery-coded digitel input word. Precision Monolithics DAC-08 D/A convertar drives OP-02 opamp. Output is symmetrical ebout ground.—J. Schoeff end D. Soderquist, "Differentiel end Multiplying Digitel to Anelog Converter Applications," Precision Monolithics, Sente Clara, CA, 1976, AN-19, p 2.



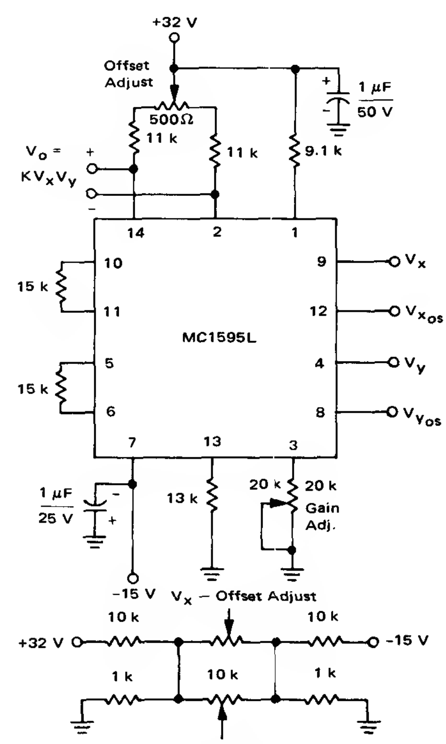
FOUR-QUADRANT MULTIPLYING DAC—Combinetlon of two Pracision Monolithics DAC-08 D/A converters eccapts differentlal Input voltaga end produces differentiel current output. Output opemp is not normally required. Output enelog polerity is controlled by analog input referenca or by offset-binary digital input word. Common-mode current presant at output must be eccommodeted by balenced load. Differentiel input ranga is 10 V.—J. Schoeff and D. Soderquist, "Differentiel end Multiplying Digital to Analog Converter Applications," Precision Monolithics, Senta Clara, CA, 1976, AN-19, p 3.

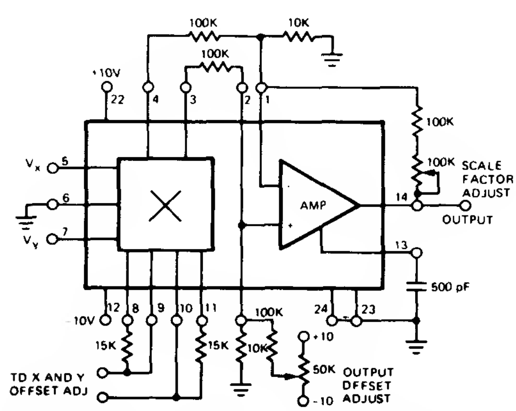


FOUR-QUADRANT WITHOUT LEVEL SHIFT—CA3060 three-opamp arrey provides four-quedrent multiplication without level ahift betwaen input and output. Circuit includes edjustments esaociated with differential input end adjuatmant for equalizing geina of amplifiers 1 and 2. Amplifier 3 is connected as unity-geln inverter.—"Lineer Integrated Circuits and MOS/FET's," RCA Solid State Division, Somervilla, NJ, 1977, p 153.



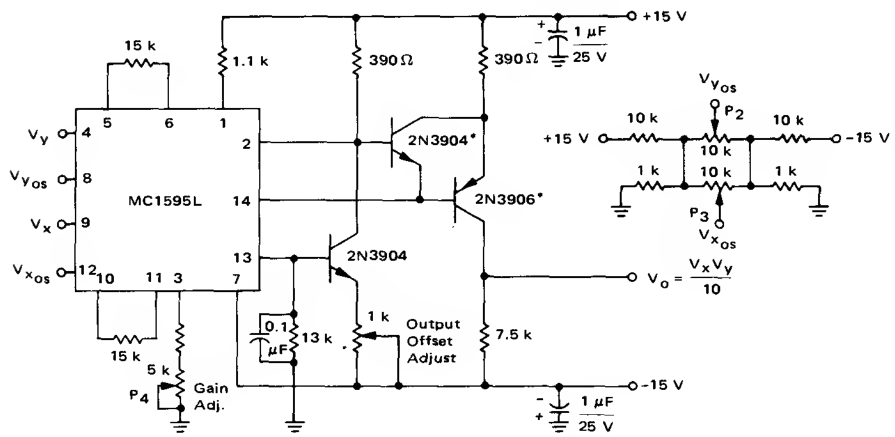
APPROXIMATING VECTOR SUMS—Combination of two opamps and Analog Devicas 433 multiplier/divider IC provides output voltege aqual to vector sum of two input volteges, by computing squere root of sum of aquares.—D. H. Sheingold, Approximate Analog Functions with e Low-Cost Multipliar/Divider, *EDN Magazine,* Feb. 5, 1973, p 50–52.





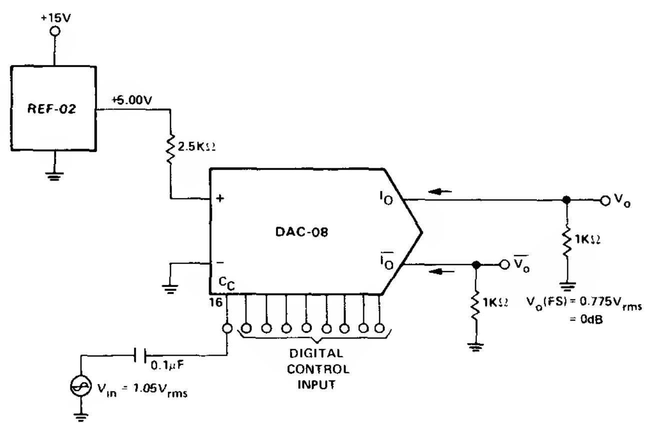
ANALOG MULTIPLIER—Multiplier and emplifier sectiona of Exar XR-S200 PLL IC are combined to perform enalog multiplicetion without need for DC level shifting between input end output. Single-ended output is at ground level.—"Phase-Locked Loop Date Book," Exar Integrated Systems, Sunnyvele, CA, 1978, p 9–16.

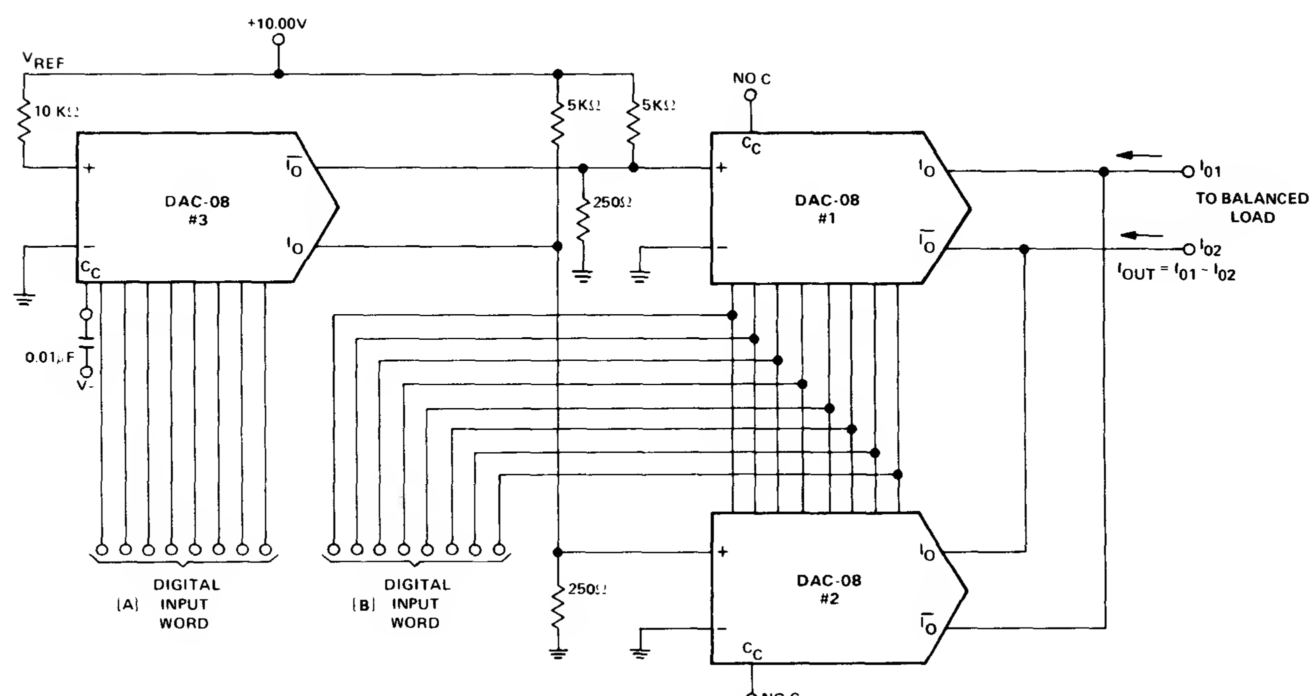
FOUR-QUADRANT—Motorola MC1595L lineer four-quadrant multiplier tekes two different input voltages, each between −10 V end +10 V, and gives output equel to one-tenth of their product. Circuit cen be operated in either AC or DC mode. Deaign and setup procedures are given.—E. Renachlar, "Analysis and Besic Operation of the MC1595," Motorola, Phoenix, AZ, 1975, AN-489, p 8.



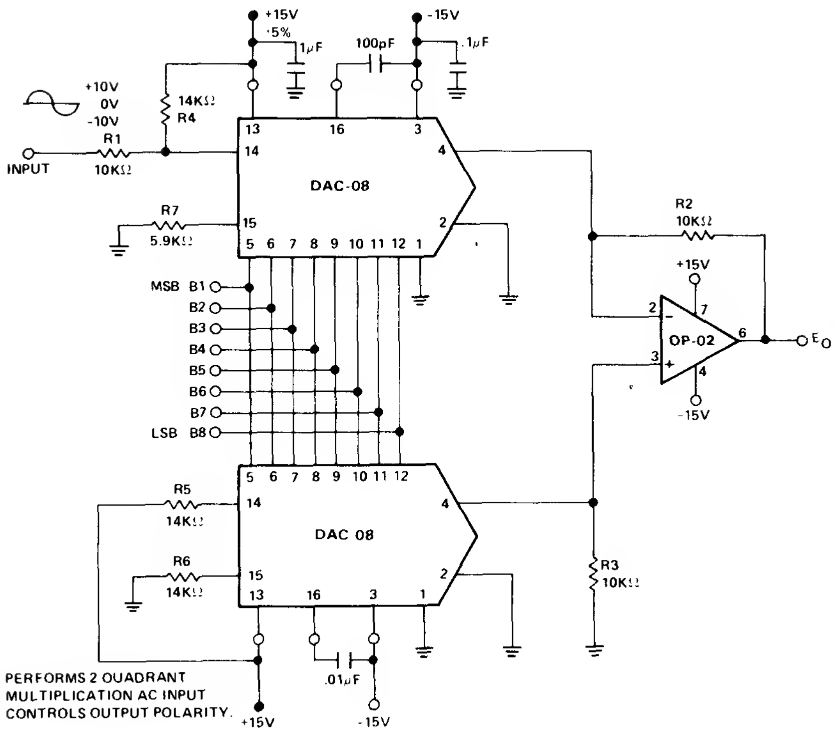
OUTPUT LEVEL SHIFTER—Transistors connected to Motorola MC1595L linear four-quadrant multiplier perform laval shifting for applications raquiring output having ground referance. Temperatura sensitivity of circuit is minimized by using complamentary transistors in sama packaga, such as MD6100, in placa of upper two transistors. If high output impedance and low current driva are drawbacks, opamp can be connected as source-follower output staga.—E. Renschlar, "Analysis and Basic Operation of the MC1595," Motorola, Phoenix, AZ, 1975, AN-489, p 10.

AC-COUPLED MULTIPLICATION—Combination of Precision Monolithics REF-02 voltage reference and DAC-08 D/A converter uses compensation capacitor terminal C_C as input. With full-scale input coda, output V_O is flat to above 200 kHz and 3 dB down at 1 MHz, for multiplying applications far beyond audio ranga. Circuit has high input impedance, as often required to avoid loading high source impedance. Dynamic ranga is greater than 40 dB.—J. Schoeff and D. Soderquist, "Differantial and Multiplying Digital to Analog Convertar Applications," Precision Monolithics, Santa Clara, CA, 1976, AN-19, p 4.

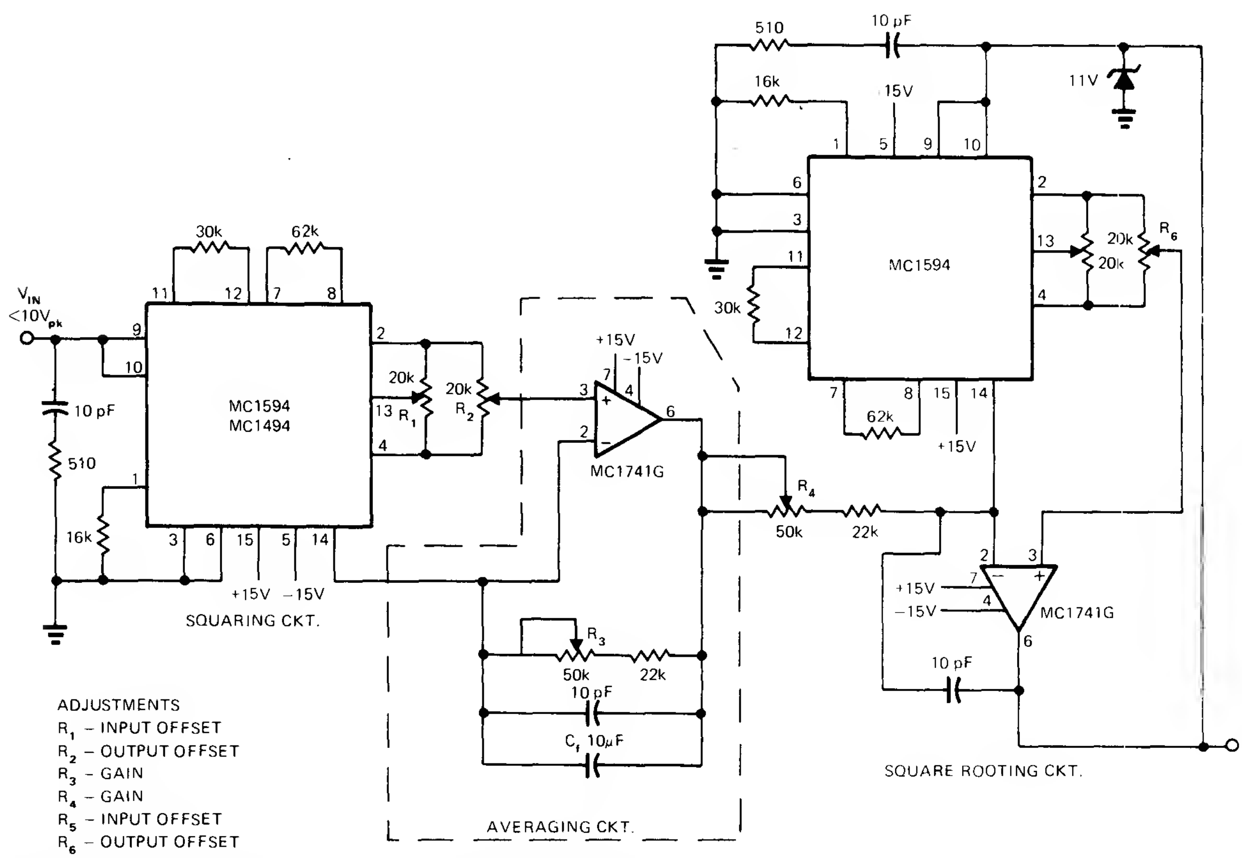




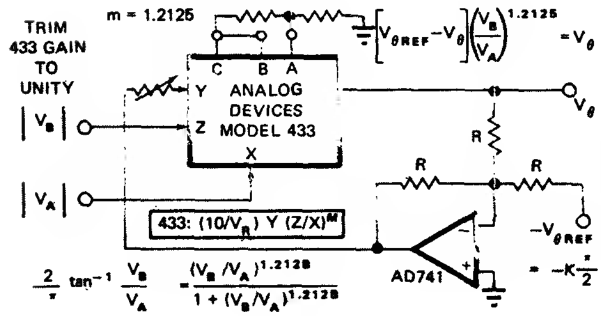
FOUR-QUADRANT 8-BIT—Requires only three Precision Monolithics DAC-08 D/A converters to provide high-speed multiplication of two 8-bit digital words and give analog output.—J. Schoeff and D. Sodarquist, "Differential and Multiplying Digital to Analog Convartar Applications," Pracision Monolithics, Santa Clara, CA, 1976, AN-19, p 7.



BIPOLAR ANALOG TWO-QUADRANT—Bipolar referance voltage for upper Precision Monolithics DAC-08 D/A converter modulates reference current by ±1.0 mA around quiescent current of 1.1 mA. Lower DAC-08 hes seme 1.1-mA referenca current and effectively subtracts out quiescent 1.1 mA of upper reference current at all input codes sinca voltega acroas R3 veries between −10 V and 0 V. Output voltage E_0 is thus product of digitel input word end bipolar anelog reference voltaga.—J. Schoeff and D. Soderquist, "Differantiel end Multiplying Digital to Anelog Converter Applications," Precision Monolithics, Sante Clera, CA, 1976, AN-19, p 3.

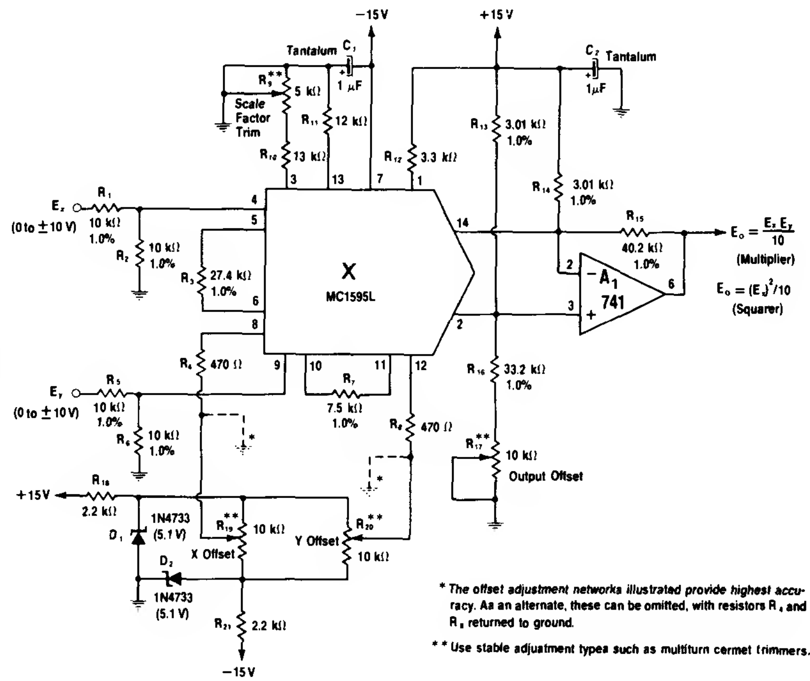


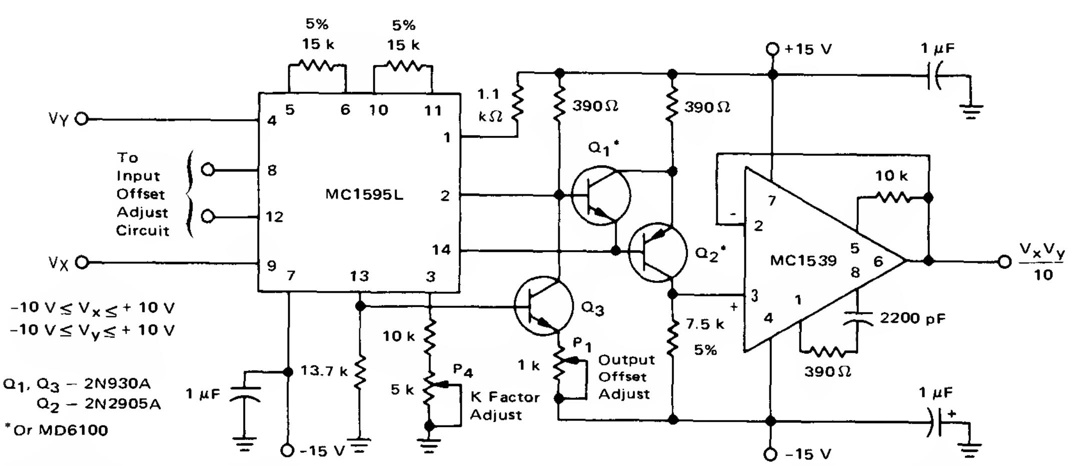
SQUARING FOR RMS—Combination of two MC1594 multipliars and two opamps gives RMS detector for squaring instenteneous input values, everaging ovar time intervel, then taking square root to giva RMS value of input waveform. First multiplier, used to squara input waveform, delivers output current to first opamp for conversion to voltage and for everaging by meana of capecitor in feedback path. Second opemp is uaad with second multipliar as feedback alament for taking square root. Technique alliminates thermal reaponae time drewbeck of most other RMS maasuring circuits. Input voltage range for circuit ia 2 to 10 V P-P; for other ranges, input scaling can ba uaed. Since direct coupling is used, output voltage includes DC components of input. Maximum input fraquency is about 600 kHz, and eccuracy is about 1%.—K. Huehne and D. Aldridge, Trua RMS Measurements Uaing IC Multipliers, *EDN Magazine,* March 20, 1973, p 85–86.



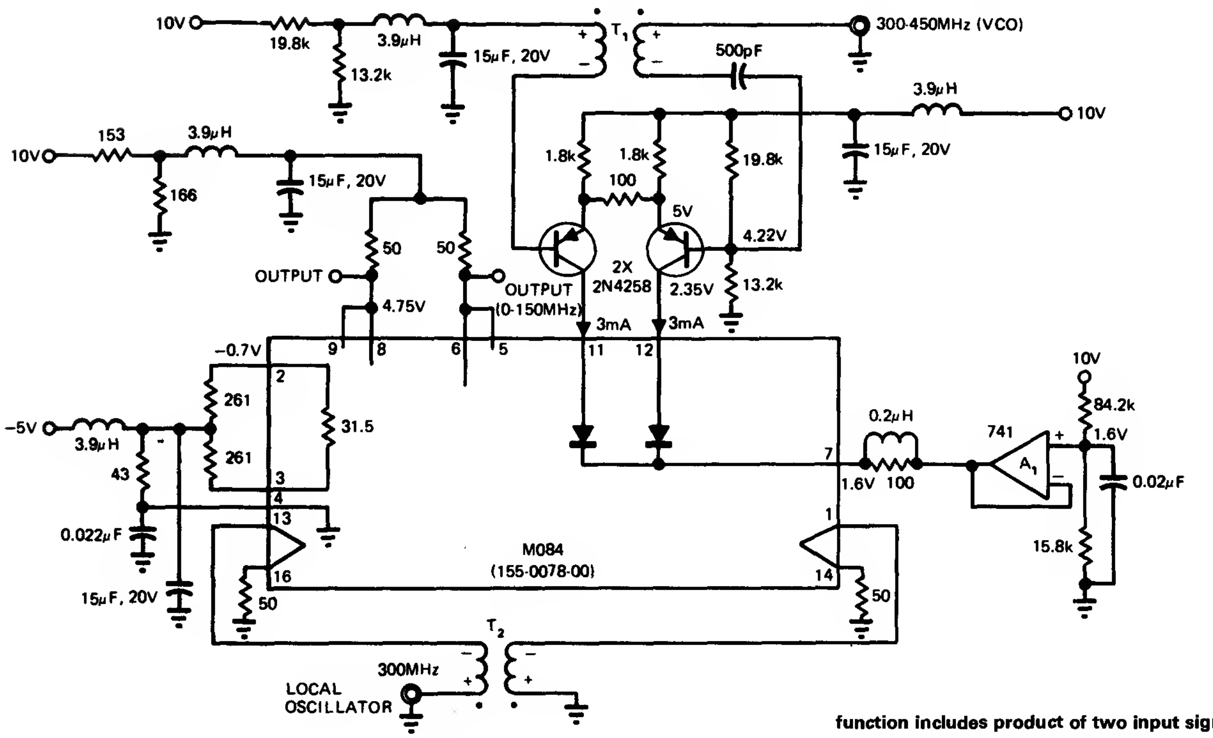
APPROXIMATING ARC TANGENTS—Analog Devices 433 multiplier/divider IC approximates arc tangent to 0.75%. Article presents mathematical basis for approximation used.—D. H. Sheingold, Approximate Analog Functions with a Low-Cost Multiplier/Divider, *EDN Magazine*, Feb. 5, 1973, p 50–52.

FOUR-QUADRANT MULTIPLIER/SQUARER—Basic 1595 multiplier block and 741 current-to-voltage converter convert input voltages E_x and E_y to output equal to one-tenth of their product when connected as shown for multiplier use. To operate as squarer of E_x, connect pins 4 and 9 together and omit R_5 and R_6 at E_y input. Output is then one-tenth of square of E_x.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 255–257.





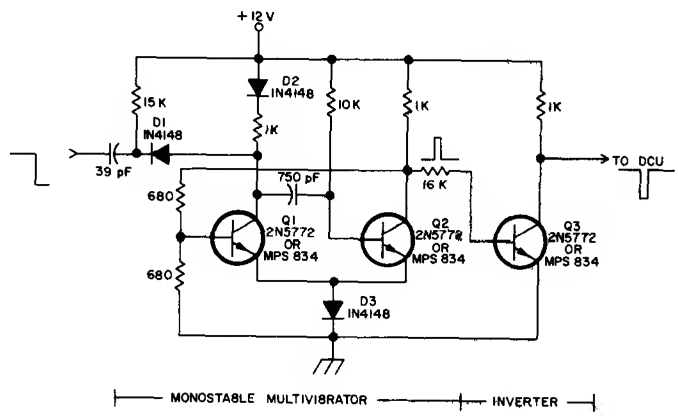
LEVEL SHIFTER WITH HIGH CURRENT DRIVE—Motorola MC1539 opamp is used as source-follower output stage for three-transistor level shifter of MC1595L linear four-quadrant multiplier, to improve current drive capabilities. Output voltage is in range of ±10 V. Input offset adjusting circuits are 10K pots in series with 10K resistors between ±15 V, with 1K to ground from each side of paralleled pots.—E. Renschler, "Analysis and Basic Operation of the MC1595," Motorola, Phoenix, AZ, 1975, AN-489, p 11.



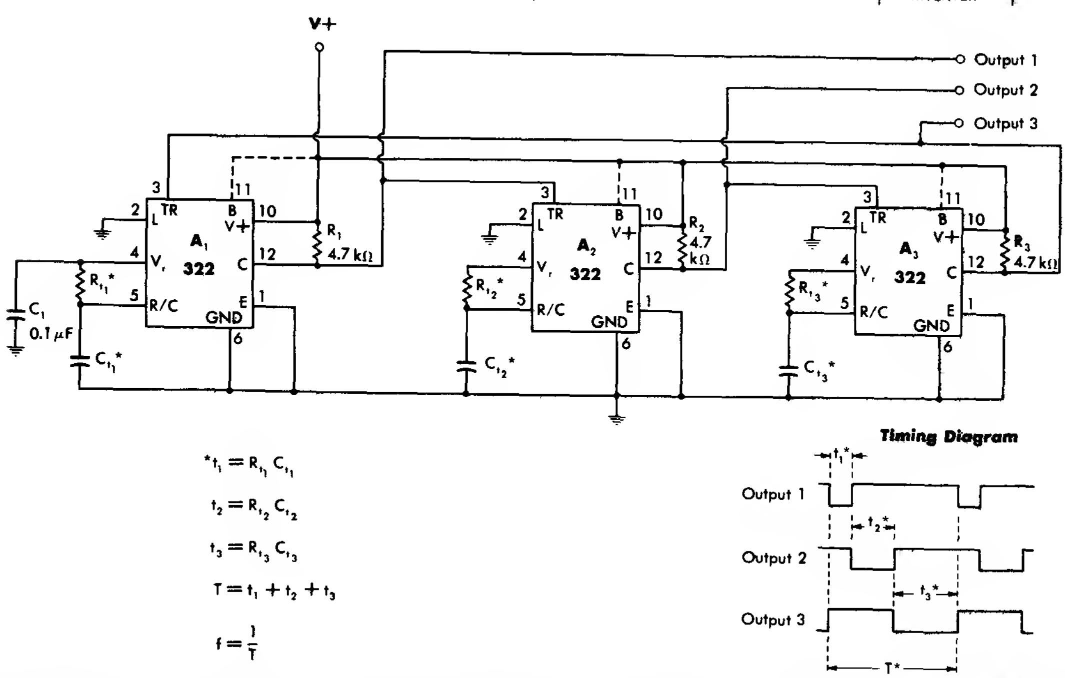
BROADBAND MIXER—Uses Tektronix M084 multiplier as broadband mixer having linear output within −3 dB limit from 2 MHz to above 150 MHz. Current-gain cell in multiplier takes advantage of logarithmic relationship between current and voltage in a semiconductor. Output function includes product of two input signals, a 300-450 MHz swept VCO signal and a 300-MHz local oscillator signal.—M. Jaffe, Build a Low-Cost Wideband Mixer with a Monolithic Multiplier, *EDN Magazine*, May 20, 1975, p 63–64.

CHAPTER 56
Multivibrator Circuits

Includes circuits in which one section is cut off when the other conducts. In an astable or free-running MVBR, frequency of spontaneous transition is determined by time and/or external control voltage. In a monostable MVBR, external trigger signal forces circuit into unstable state, with circuit constants determining time for return to stable state. In a bistable MVBR or flip-flop, external trigger is required for each transition. Use chiefly for generating square-wave pulses and signals.



1-μs PULSE—Monostable MVBR converts negative-going event signal into pulses having standardized width of about 1 μs, inverted by Q3 for use as input to counter.—T. E. Hutchinson, Inexpensive Decimal Counting Unit, *73 Magazine*, Jan. 1974, p 47–51.



$$*t_1 = R_{t_1} C_{t_1}$$

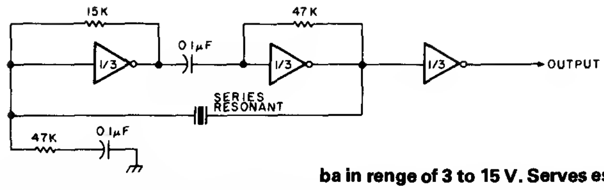
$$t_2 = R_{t_2} C_{t_2}$$

$$t_3 = R_{t_3} C_{t_3}$$

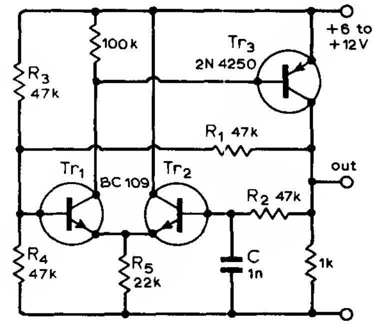
$$T = t_1 + t_2 + t_3$$

$$f = \frac{1}{T}$$

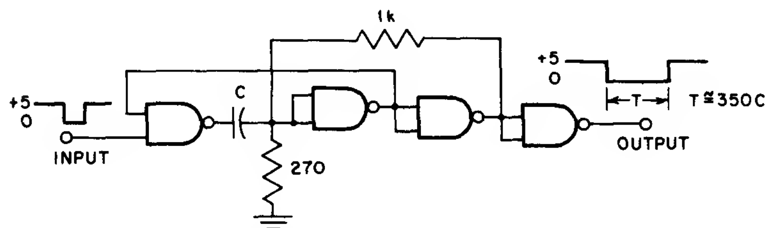
CHAINED ASTABLES—Cross-connected 322 mono MVBRs, operating as astables, are interconnected so individual timing periods are generated in sequence as shown. Total period T is sum of three individual periods, after which cycle repeats itself. Chain may be extended further if desired. Useful when prescribed sequence of timing events is required. Equations give values of R and C for timing periods ranging from 10 μs to several minutes.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 125–128.



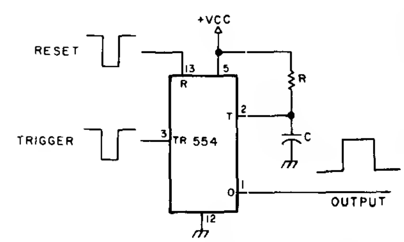
CRYSTAL MONO USING INVERTERS—Usas all three sections of CD4049 tripla invarter, with series-resonant crystel connection. Supply cen ba in renge of 3 to 15 V. Serves es compect low-powar portable RF oscilletor having low battery drein.—W. J. Prudhomme, CMOS Oscillators, *73 Magazine*, July 1977, p 60–63.



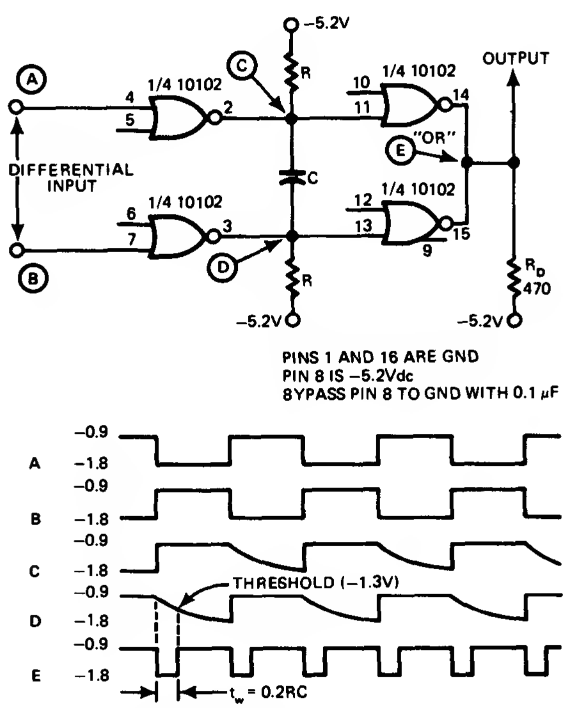
20-kHz ASTABLE—Single-cepecitor circuit Is relieble ovar wida renge of tamperatures, voltages, and transistor geins. Frequency verias only by 0.05% for supply voltege changes betwean 6 and 12 V. Timing can ba changad with R_1, R_2, and C. Duty cycle depends on ratio of R_3 to R_4, and is 50% for values shown.—C. Horwitz, Tolerant Astabla Circuits, *Wireless World*, Fab. 1975, p 93.



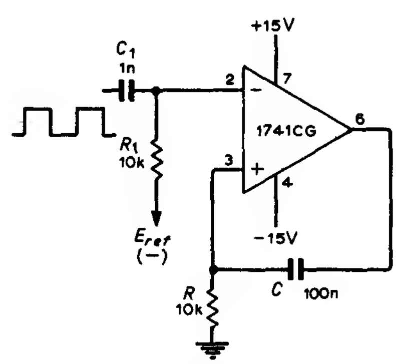
FOUR-GATE MONO—NAND-gate mono using Texes Instruments SN7400 peckage provides cleaner, more stabla output. Feedbeck reslstor eliminates tandancy to oscilleta. Output pulsa width T is equel to 1.3 RC; whan R is 270 ohms, T is 350 C. Input pulsa widths over 30 ns can initiate output. C can be 100 pF to 100 µF.—J. E. McAlister, Singla NAND Peckega Improvas Ona-Shot, *EEE Magazine*, Aug. 1970, p 78.



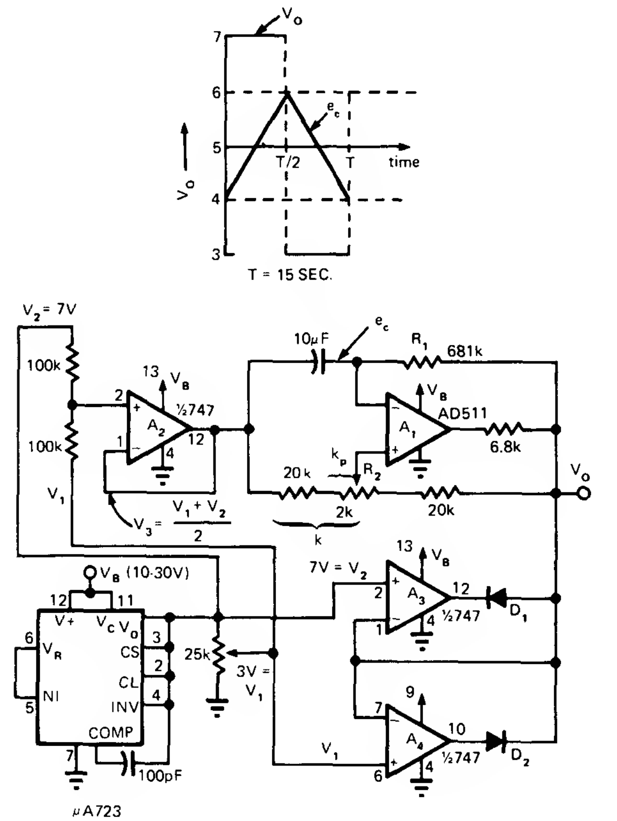
554 MONO—Uses one section of 554 quad monosteble timer, connectad to give output pulsa for negative-going trigger pulsa. Width of output pulsa In seconds is equel to RC. Trigger must be narrowar than output pulse. VCC is 4.5–16 V at 3–10 mA.—H. M. Berlin, IC Timer Raview, *73 Magazine*, Jan. 1978, p 40–45.



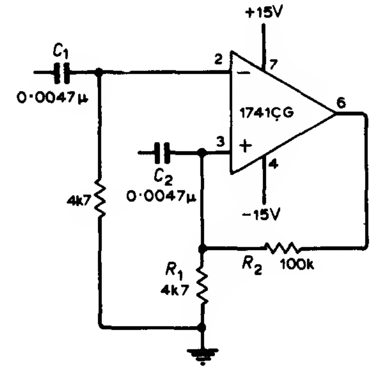
BIDIRECTIONAL MONO—Requires only ona IC, three resistors, end ona cepacitor. Will trigger on both positive- and negative-going trensitions, es required in critical timing epplications involving pulsas nerrowar than 50 ns. Cepecitor eltemately discherges through one pulldown resistor to threshold, then tha othar. Output gates era tied togathar to form common output. Width of pulse is defined by velues of components.—W. A. Palm, Bidirectionel ECL Ona-Shot Uses e Singla IC, *EDN Magazine*, Jen. 5, 1977, p 41–42.



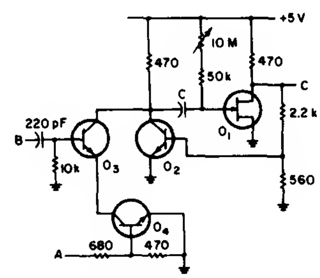
VOLTAGE-CONTROLLED MONO—Timing period of opamp oparating as monostable multivibrator is controlled by magnituda of DC reference voltage. With square-wave input shown, diffarantiating action by C_1-R_1 gives positive pulses that ceusa mono to meka transitions. Article gives design equation end typical weveforms.—G. B. Cleyton, Experimants with Operational Amplifiars, *Wireless World*, Mey 1973, p 241–242.



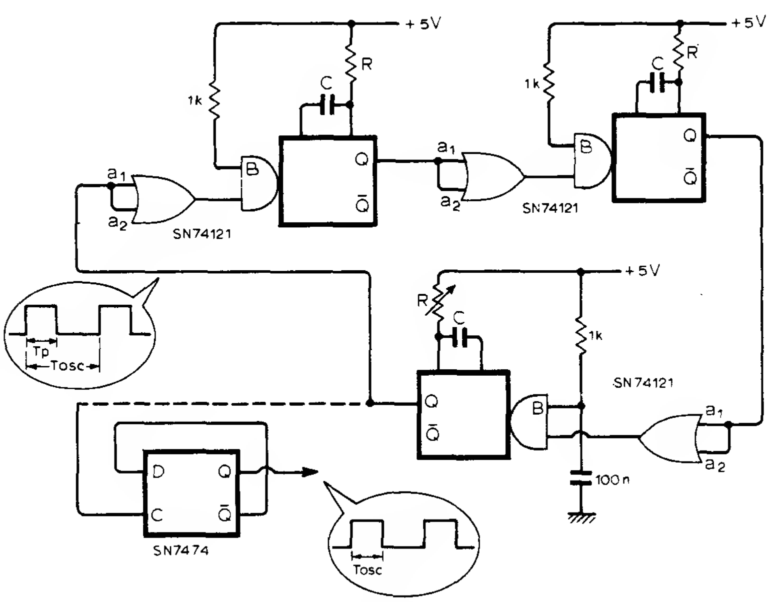
15-s ASTABLE—Precision opamp/diode clamp circuit simulating zener reduces cost of astable multivibrator having long time constant and good temperature stability. Circuit operates from single-ended supply, with μA723 providing 7-V reference for clamp amplifiers A_3 and A_4. A_2 provides oscillator with reference voltage V_3 halfway between V_1 and V_2. R_2 allows frequency of oscillator to be adjusted about ±6%. Article gives design equations.—L. Drake, Long Time-Constant Oscillator Uses Precision Clamps, *EDN Magazine*, Dec. 20, 1974, p 51–52.



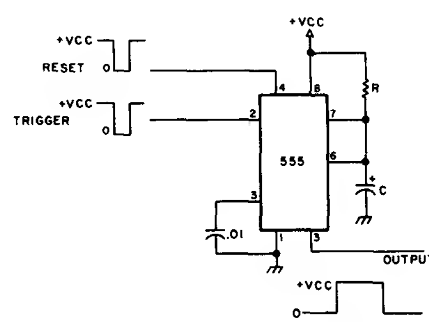
TRIGGERED BISTABLE—Positive feedback applied to opamp through R_2 and R_1 causes amplifier output to remain at either its positive or negative saturation limit. Triggering pulses for changing state of output may be applied to either input terminal, through C_1 or C_2; pulse polarity required to produce transition depends on state of circuit, which should be verified experimentally.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, May 1973, p 241–242.



VERSATILE MONO—Uses standard digital IC voltage levels as inputs, and can be enabled or inhibited at any time without causing output pulse. Input gate Q_3-Q_4 is enabled with logic 1 at point A and inhibited with logic 0. Logic 1 at B starts timing cycle. Q_1 is 2N3819 JFET, and all other transistors are 2N3704.—R. Tenny, Versatile One-Shot, *EEE Magazine*, Sept. 1970, p 89.

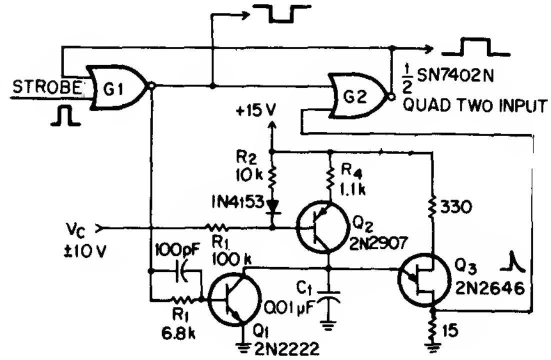


0.01 Hz to 7 MHz—Generates square waves suitable for clock signals in sequential digital circuits, with values of RC pairs determining period in range from about 150 ns to 120 s. To obtain equal mark-space ratio, set oscillator to half the required period and add bistable SN7474 divider as shown by dashed line.—P. J. Best, Monostable Ring Oscillator, *Wireless World*, March 1976, p 89.

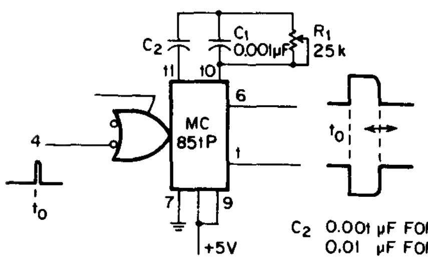


POSITIVE-OUTPUT MONO—Timer is triggered by negative-going pulse to give positive output pulse whose width t in seconds is 1.1RC. VCC is 4.5–16 V at 3–10 mA.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.

PWM MONO—Circuit provides pulse-width modulation with high duty cycles and complementary output. Strobe input to gate G_1 drives output of gate to binary 0, turning Q_1 off and letting voltage across C_1 build up until UJT Q_3 fires, discharging C_1. Output of UJT drives output of G_2 to binary 0. Article gives timing diagrama.—G. Lewis, Simple One Shot Has Complementary Outputs, *EEE Magazine*, Oct. 1970, p 78–79.

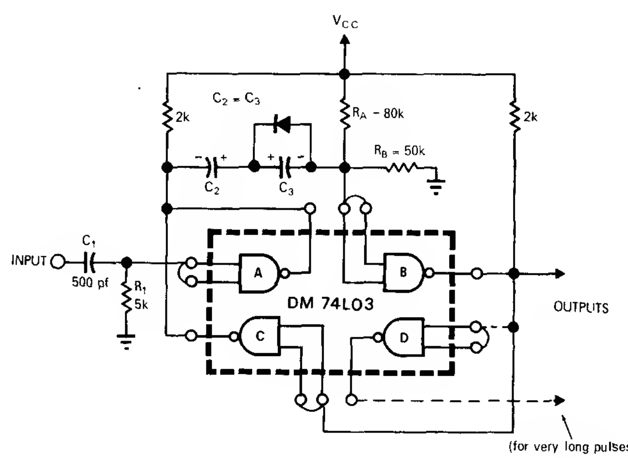


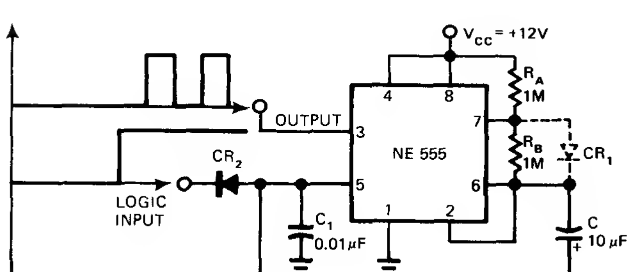
VARIABLE PULSE WIDTH—R_1 and C_2 togather provide wide range of pulse widths from Motorola MC851P mono. Rise and fall times of complementary output pulses are better than 100 μs. With only four switched capacitors in combination with R_1, pulse widths can be varied between maximum of 4.5 ms and minimum well under 4.5 μs.—C. W. Stoops, Wide-Range Variable Pulse-Width Monostable, *EEE Magazine*, Dec. 1970, p 56.



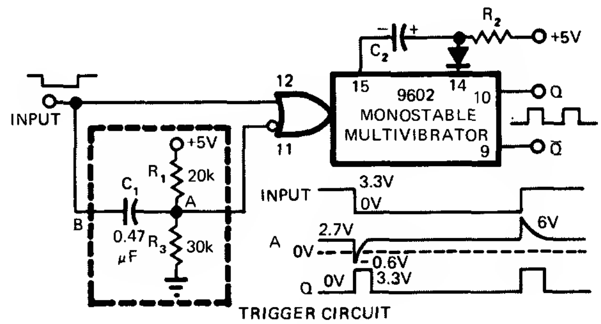
C_2	0.001 µF	FOR 4.5 µs MAX
	0.01 µF	FOR 45 µs MAX
	0.1 µF	FOR 450 µs MAX
	1.0 µF	FOR 4.5 ms MAX

LOW-POWER TTL MONO—Simple monostable circuit using DM74L03 draws only 800-μA standby current yet delivers pulses up to 1 s wide. Uses RC time control and regenerative feedback, with values of C_2 and C_3 determining frequency. Pulse width increases from 0.1 s to 0.55 s as C_2 and C_3 are increased from 10 μF to 60 μF.—C. Gilbert and C. Davis, LPTTL One-Shot Yields Wide, Clean Pulses, *EDN/IEEE Magazine*, May 15, 1971, p 47–48.



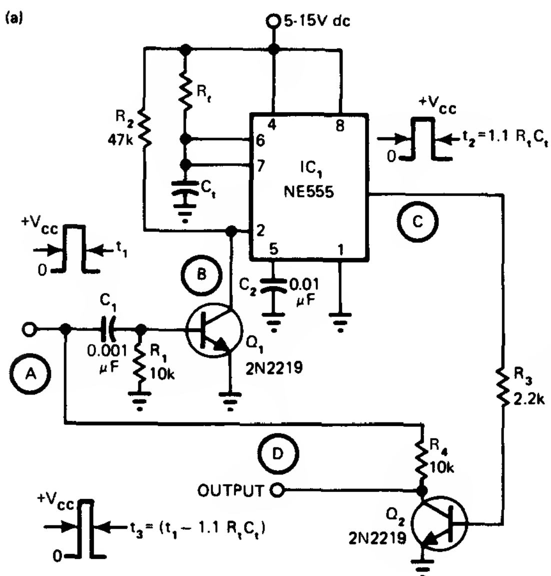


LOW OUTPUT FOR POWER-ON—Logic signal controls both turn-on and turnoff of 555 timer used as oscillator. When input signal at cathode of CR_2 goes low, oscillator remains off and output at pin 3 is low. When input goes high, oscillator starts with its first state low so there are no initial pulse errors.—K. D. Dighe, Rearranged Components Cut 555's Initial-Pulse Errors, *EDN Magazine*, Jan. 5, 1978, p 82 and 84.



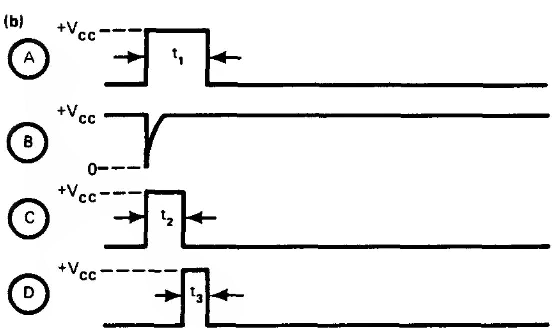
DUAL-EDGE TRIGGERING—Although 9602 multivibretor IC can be triggared normelly either on leeding or falling edge of square wave, but not on both, addition of two resistors end one cepacitor providas double-edge triggering. When input goes low, negative-going pulse through C_1 triggers 9602 end mekes it deliver one output pulsa. When input goas high egain, high-going pulse is daliverad directly to pin 12 of 9602, triggering it agein so it produces enother pulse.—J. P. Yeng, Circuit Triggers One-Shot on Both Edges of Squere Weve, *EDN Magazine,* Nov. 15, 1972, p 49.

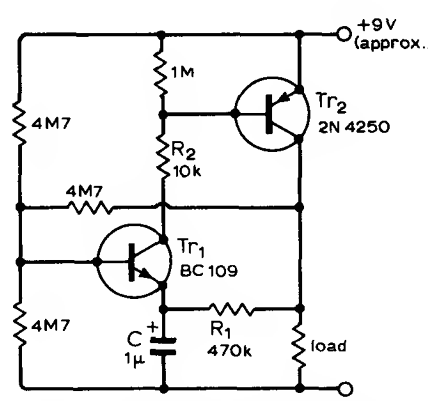
(a)

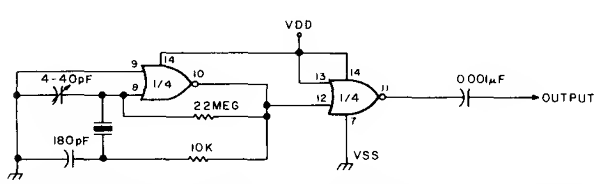


PULSE-WIDTH DETECTOR—Connections as shown for 555 timar give output only if trigger pulsa width is greater than time constent ($t_2 = 1.1R_tC_t$) of mono MVBR circuit. Q_1 is normally off. Pin 2 of 555 is then high. At start of triggar pulse, output et point C is low. Positive trigger drives Q_1 on for time determined by R_1C_1, faeding negetive-going pulse to trigger pin 2. Timer then acts es normal mono, driving Q_2 on for time t_2. If input pulsa is still high at end of t_2, it eppears et output D since Q_2 is now off. Output pulse width is thus equel to input triggar width less $1.1R_tC_t$. For greater accuracy, insert daley between point A and R_4 equel to inherent pro pegation delay of timer.—S. Sarpangal, Build a Pulse-Width Detector with e 555 Timer, *EDN Magazine,* Oct. 5, 1977, p 93 end 96.

(b)

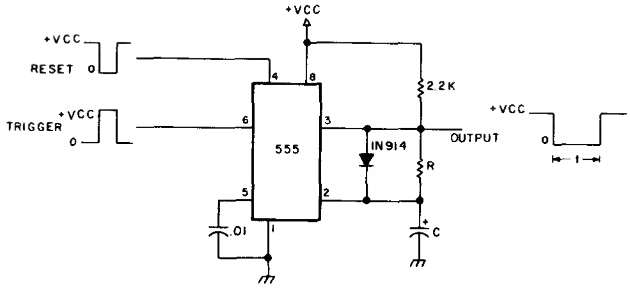




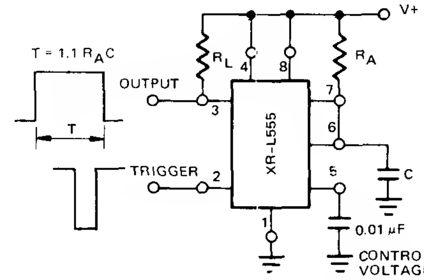


CRYSTAL WITH NOR GATES—Uses two sections of CD4001 quad NOR gate to give mono multivibrator opereting in frequency renga from 10 kHz up to top limit of about 10 MHz, with exect frequency depending on values used for R end C.—W. J. Prudhomme, CMOS Oscillators, *73 Magazine,* July 1977, p 60–63.

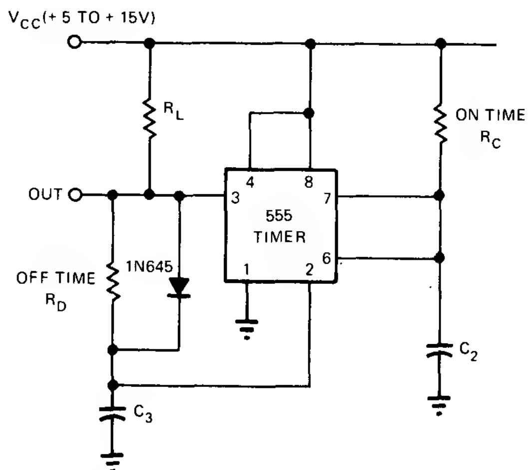
2-Hz ASTABLE PULSER—Single-capacitor circuit operates et very low duty cycles, in ranga of 10% to 1%. Bettery drein is low beceuse off current is about 1 μA for 50-mA on currant. R_2 and C determina on time, while R_1 and C set off time. Circuit pulses about twice par second, which is suitable for animal temparature and heert-rata studies. Can be usad with implented transmitters opereting from single marcury button cell for mora then one year with suitable resistor values.—C. Horwitz, Tolerant Astable Circuits, *Wirelass World,* Feb. 1975, p 93.



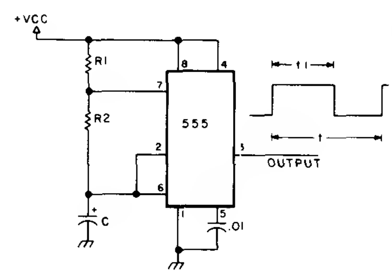
NEGATIVE-OUTPUT MONO—Timer is wired to give negative output pulse for positive-going input trigger pulse. Width of output pulse in seconds is 1.1RC. Input pulse must be narrower than desired output pulse width. When reset pin is momentarily grounded, output returns to stable state. VCC is 4.5–16 V at 3–10 mA.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



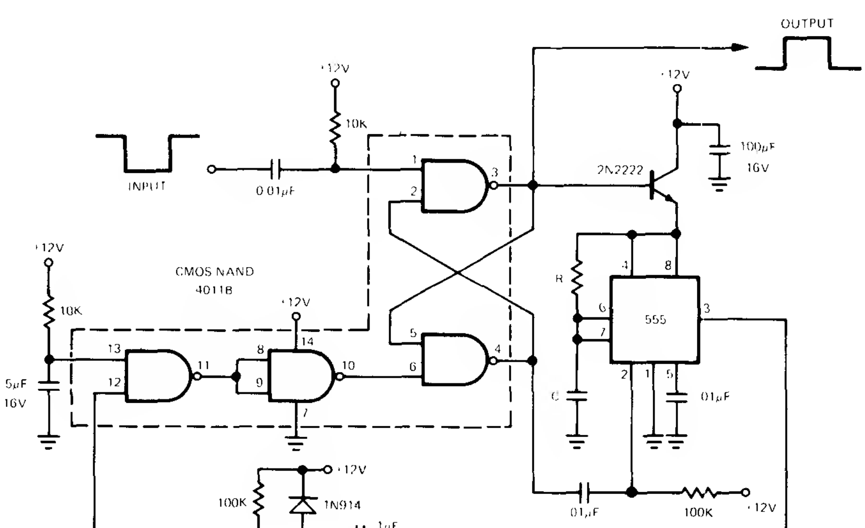
MICROPOWER MONO—Uses Exar XR-L555 having typical power dissipation of only 900 μW at 5 V, serving as direct replacement for 555 timer in micropower circuits. Time delay is controlled by one external resistor and one capacitor (R_A and C) which determine output pulse duration. Can be triggered or reset on falling waveform. Output will drive TTL circuits or source up to 50 mA.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 7–8.



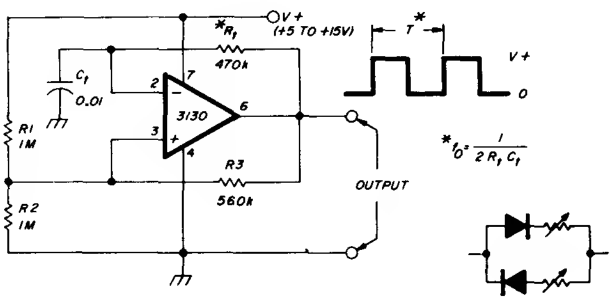
ASTABLE OSCILLATOR—Circuit for astable operation of 555 timer provides completely independent ON and OFF times. Time constant for one mode is 1.1 R_CC_2 and for other mode is 1.1 R_CC_3. Free-running period is sum of these time constants.—J. P. Carter, Astable Operation of IC Timers Can Be Improved, *EDN Magazine*, June 20, 1973, p 83.



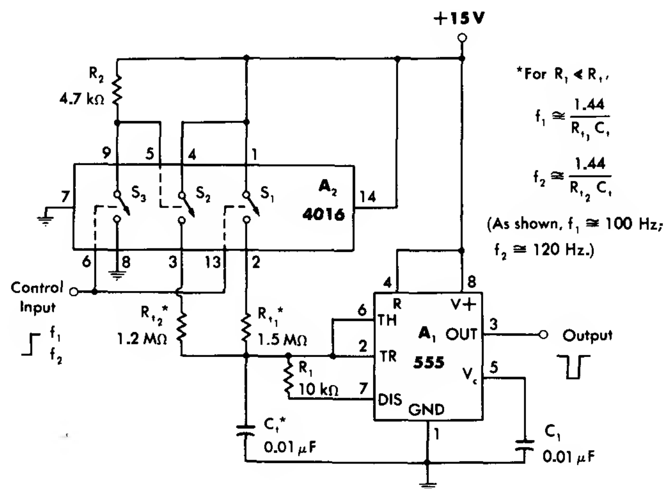
555 ASTABLE—Produces repetitive rectangular output at frequency equal to $1.443/(R_1 + 2R_2)C$ hertz. Duty cycle is determined by values of R_1 and R_2; R_2 must be much larger than R_1 to obtain nearly a 50% duty cycle. Normal range for duty cycle is 51 to 99%. VCC is 4.5–16 V at 3–10 mA.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



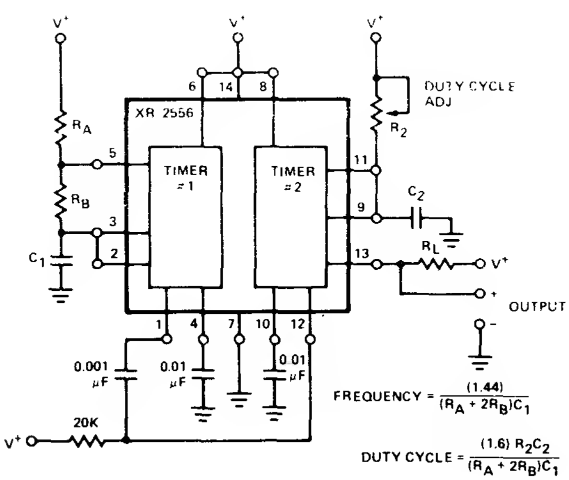
LOW-POWER MONO—555 timer provides low-drain monostable operation suitable for interfacing with CMOS 4011B NAND gates. Standby drain is less than 50 μA. When mono is on, current drawn is 4.5 mA for pulse duration of T = 1.1RC.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 733.



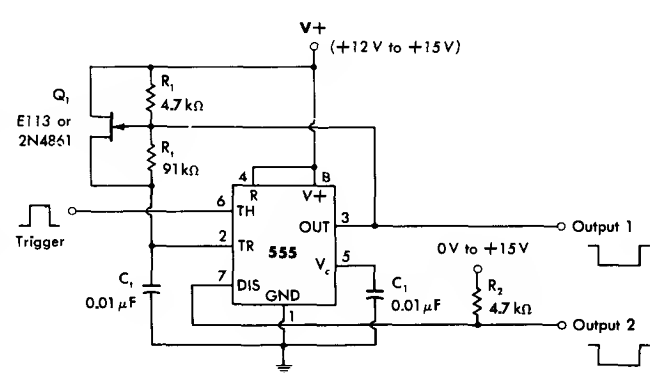
1 Hz TO 1 MHz—Opemp-based astabla MVBR generates square weves over extramely wide ranga, with suitabla changes in circuit values. RCA 3130 opamp has CMOS output stage for driving either 5-V TTL or 10–15 V CMOS logic stages directly. Values are for 100 Hz. R_t and C_t can be readily scaled for different ranges. To control symmetry, replace R_t with two resistors in series with reverse-connected diodes as at lower right.—W. Jung, An IC Op Amp Updete, *Ham Radio*, March 1978, p 62–69.



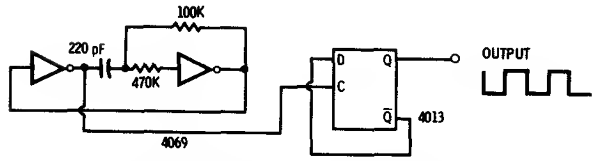
PROGRAMMABLE ASTABLE—4016 CMOS analog switch selects 1.5-megohm timing resistor R_{t1} when control input line is high, to give negative-going 100-Hz output pulses. When input is low, CMOS switch S_2 is on, selecting 1.2-megohm timing resistor R_{t2} to give 120-Hz output.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 136–137.



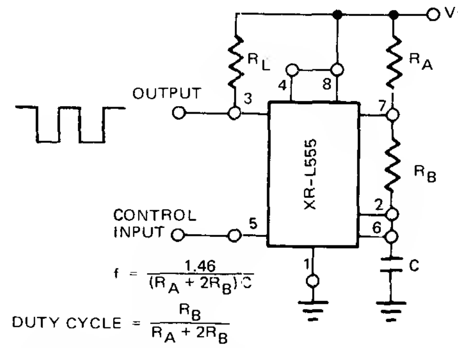
VARIABLE DUTY CYCLE—First section of Exar XR-2556 dual timer operates as astable MVBR whose frequency is equal to $1.44/(R_A + 2R_B)C_1$, with output used to trigger timer 2 connected in monostabla mode. Time dalay T_2 of timar 2 is made less than period of timer 1 waveform, so both timers have same frequency. Duty cycle is determined by timing cycle of timer 2, adjustable from 1% to 99% with R_2. Supply voltage is 4.5–16 V.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.



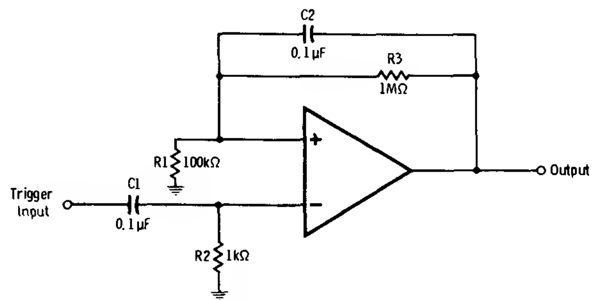
INVERTED MONO—Connection shown for 555 timer accepts positiva trigger pulses and delivers negative output pulses. Duty cycles above 99% are possible without jitter. Heevy loads can be driven from pin 7 without loss of accuracy, but excessive loading of pin 3 can affect timing eccuracy. Width of output pulse is 1 ms for valuas of R_t and C_t shown. Trigger must be held below two-thirds of supply voltage for standby and raised above two-thirds of supply momentarily (not longer than pulse width) for triggering.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 89.



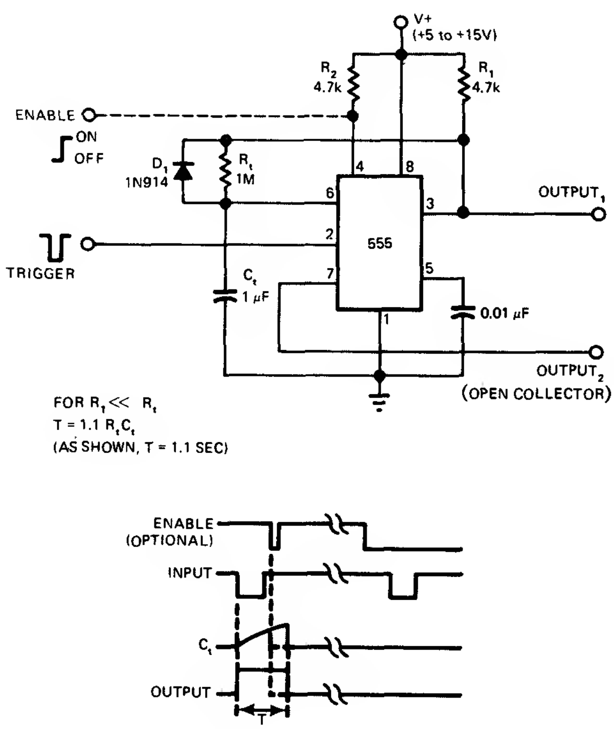
DIVIDING FOR SYMMETRY—4013 dual D flip-flop is used as binary dividar at output of astable MVBR to give 50/50 symmetry for output fre-quancy half that of MVBR.—D. Lancastar, "CMOS Cookbook," Howard W. Sams, Indian-apolis, IN, 1977, p 232–234.



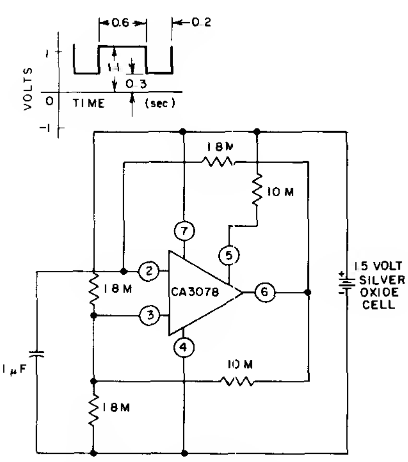
MICROPOWER CLOCK—Fraa-running fra-quancy and duty cycla ara controlled by R_A, R_B, and C in astabla MVBR connection of Exar XR-L555 micropowar aquivalent of 555 timar. With 5-V supply, power dissipation is only 900 μW.—"Timar Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 7–8.



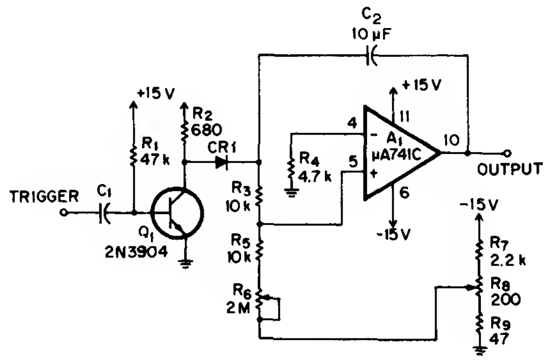
AC-COUPLED FLIP-FLOP—When leading edga of 2-V positiva trigger pulse is applied to naga-tiva input of 741 or equivalent opamp, this input bacomes mora positive than positive input and opamp swings into nagativa saturation. This condition is held by positive feedback until trail-ing edge of naxt trigger pulse makas opamp swing back into positive saturation. C2 pre-vants trailing edge of first pulsa from driving opamp back into positiva saturation. Value shown for C2 should be incraased if pulses are longar than 50 ms.—R. Malen and H. Garland, "Undarstanding IC Operational Amplifiars," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 118–119.



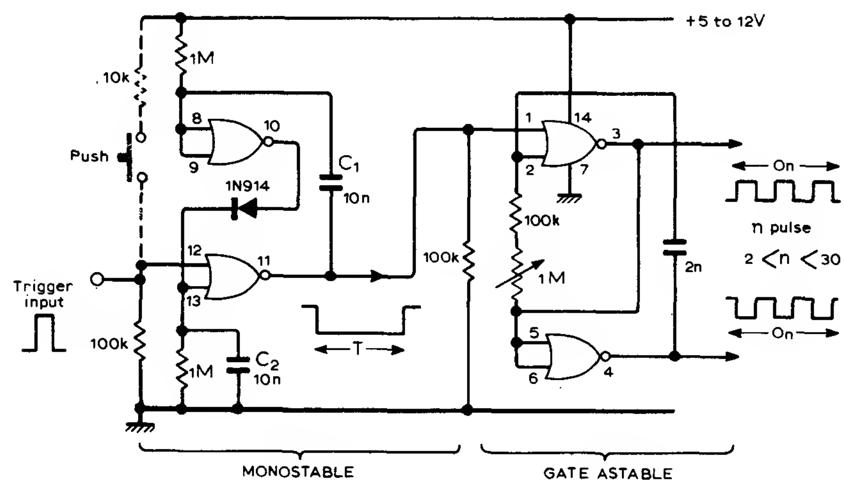
BASIC 555 MONO—Circuit variation shown for original IC timar prototypa has sama timing equation and input trigger raquiramants for standard connaction but provides two outputs rathar than one. This is achiavad by using pin 7 of IC as an opan-collactor output that can ba re-farrad to any supply voltage betwaan 0 and +15 V ragardless of voltaga usad for timar. Articla describas oparation in detail and points out pos-sibla drawbacks, including possibility of timing arror for high duty cycle operation because C_t takas longar to discharga than in convantional monostabla MVBR.—W. G. Jung, Take a Fresh Look at Naw IC Timer Applications, *EDN Mag-azina*, March 20, 1977, p 127–135.



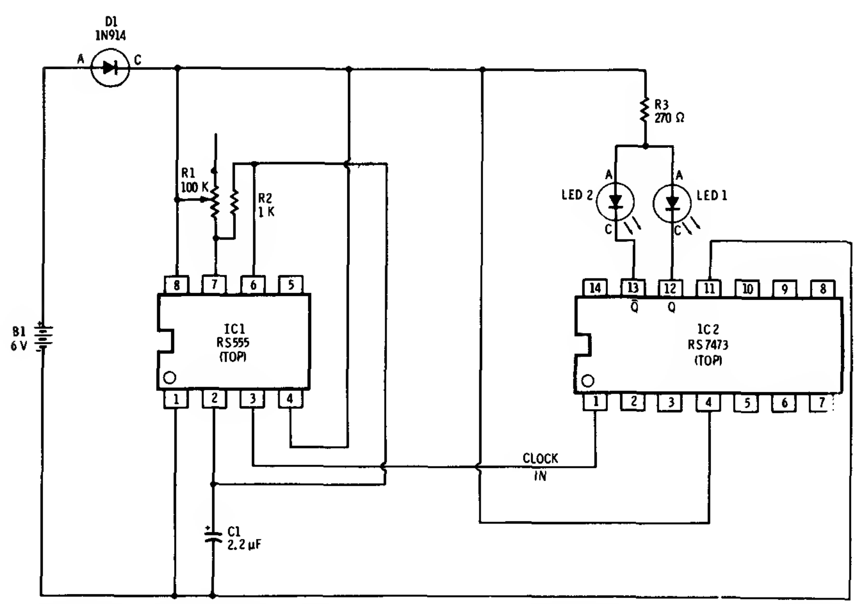
TIMING-PULSE GENERATOR—Astable MVBR uses CA3078 micropower opamp to develop timing pulses for driving othar low-power cir-cuits. Current drain is only about 2μA from 1.5-VDC supply.—"Circuit Idaas for RCA Linaar ICs," RCA Solid Stata Division, Somarvilla, NJ, 1977, p 4.



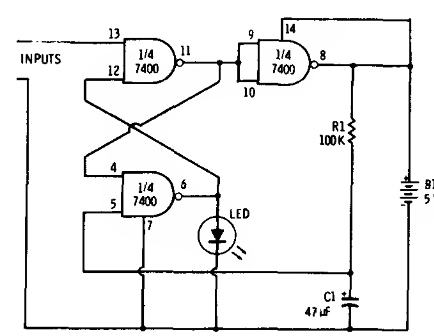
RETRIGGERABLE MONO—Circuit provides pulse widths up to 60 s, has short reset time, and can be retriggered during timing cycle. Pulse width is determined by C_2, R_3, R_5, and R_6. If trigger pulse arrives while output of A_1 is high, C_2 discharges to its original triggered state for initiating completely new timing cycle.—D. Pantic, Retriggerable Monostable, *EDN/EEE Magazine*, May 15, 1971, p 50.



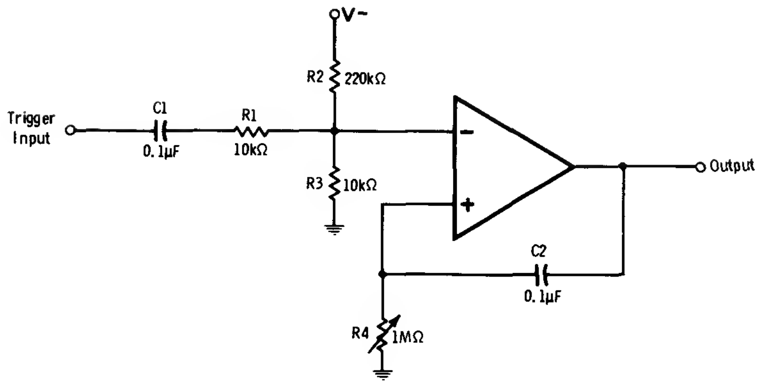
TRIGGERED MVBR—Each trigger input produces fixed number of pulses, between 2 and 30 depending on setting of 1-megohm frequency control. Monostable feeds gated astable, both realized with single CD4001 IC. Use dashed circuit with pushbutton for manual operation in place of trigger pulse.—K. Padmanabhan, N-Stable Multivibrator, *Wireless World*, April 1977, p 61.



IC FLIP-FLOP DEMONSTRATOR—Demonstration circuit using RS7473 dual flip-flop incorporates 555 clock circuit providing sequential train of input pulses at AF rate to JK master-slave flip-flop section for toggling LED loads of flip-flop back and forth between ON and OFF states. R1 controls rate at which LEDs flash on and off. Circuit is designed for Radio Shack 276-041 or equivalent red LEDs. If clock is omitted, state of flip-flop is changed by grounding clock input pin 1 momentarily.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 23–32.

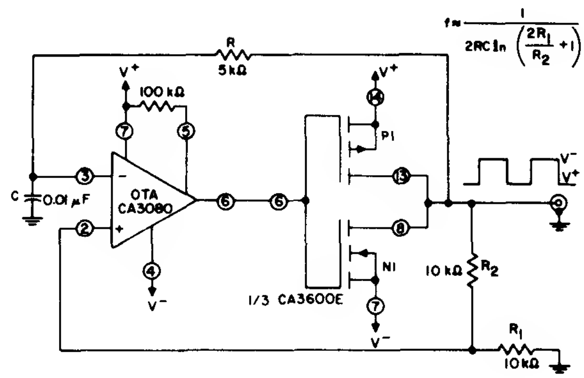


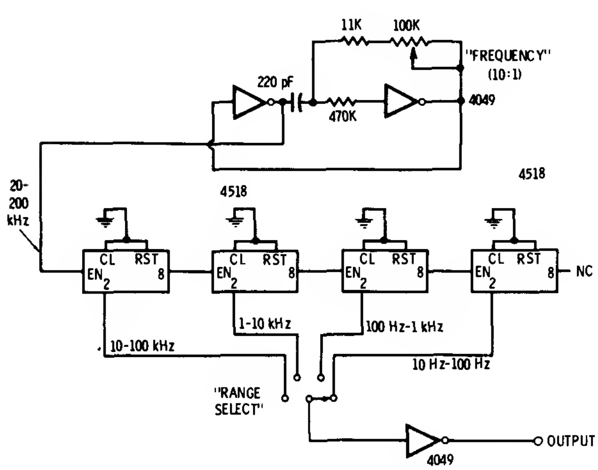
MONO WITH NORMALLY ON LED—Connection shown for three gates of 7400 quad NAND gate inverts operating mode, so LED is normally on. Trigger pulse at input extinguishes LED for time determined by R1 and C1 while making gates change states. Gates revert to original states after delay also determined by values of R1 and C1.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 19–26.



BASIC MONO—Opamp is normally in positiva saturation because of negative voltaga provided by voltaga divider R2-R3. Whan 2-V positiva trigger pulse is applied to input, output of opamp swings into negativa saturation but automatically returns to positiva saturation aftar time interval determined by values usad for C2 and R4. With R4 set at maximum rasistance, this time is about 1 s. Incraasa siza of C2 for longar time periods. Opamp can ba 741 or equivalent.—R. Malen and H. Garland, "Understanding IC Operational Amplifiars," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 120–121.

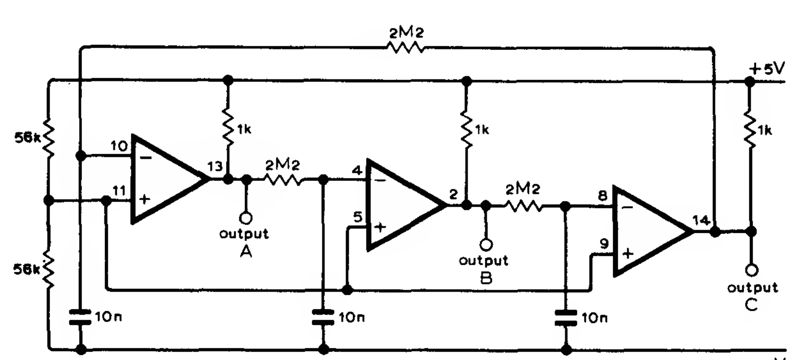
ASTABLE USING CMOS TRANSISTOR PAIR—Ona transistor pair from CA3600E array is usad with CA3080 operational transconductanca amplifiar to giva pracisa timing and thrashold for square wavas. Quiescant powar consumption is typically 6 mW with valuas shown.—"Linaar Integrated Circuits and MOS/FET's," RCA Solid Stata Division, Somervilla, NJ, 1977, p 279.

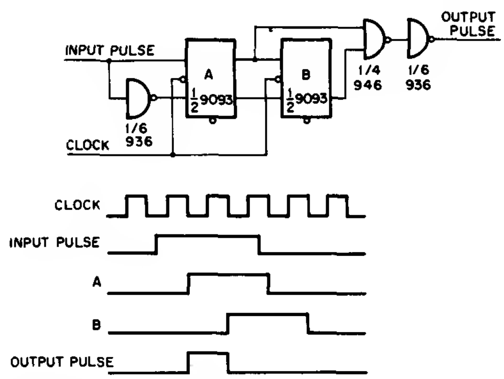




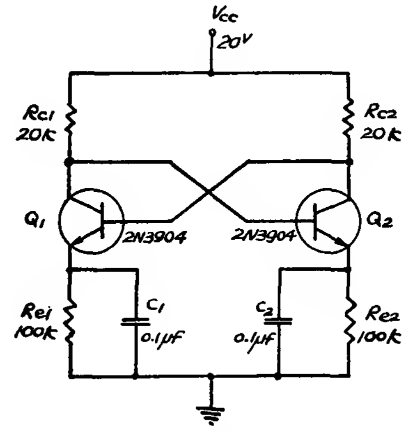
PERFECT SQUARE WAVES FOR LAB—Two sections of 4049 hex inverting buffar are connected as 10:1 variable-frequency astabla MVBR to fead chain of four divide-by-10 countars using 4518 dual counters. Frequency division provides parfact symmatry for squara-wava output.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 232–234.

17-Hz SQUARE WAVES—Usas thraa comparators from MC3302P IC to ganarata thraa symmetrical squara wavas 120° apart. Inverting outputs of comparators gives waves 60° apart. Operating voltage can ba anywhare from 4 to 12 V.—L. J. Bell, Thraa Couplad Astables, *Wirelass World,* Fab. 1977, p 44.

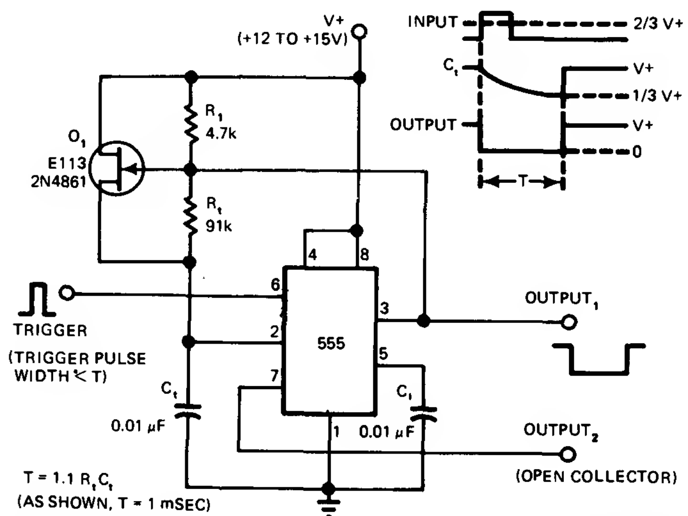




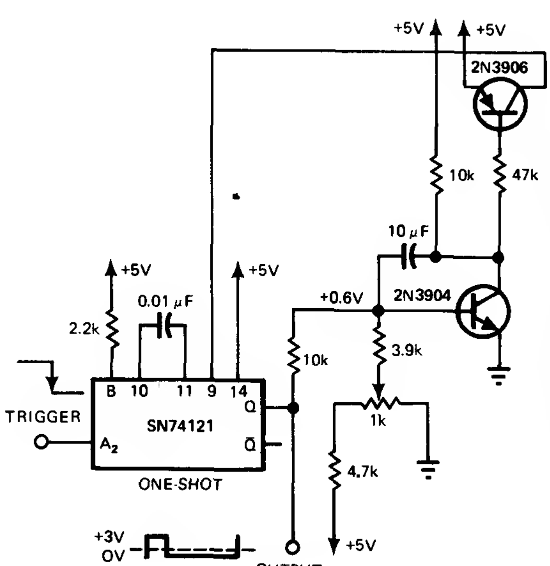
CLOCK-SYNCHRONIZED—Circuit genarates pulae thet is two clock pulaes wide, in synchroniam with clock, from random input pulae whose width ia more than 5 times that of clock pulse. Flip-flopa A end B are connected aa shift register. When clock pulse fella, input of flip-flop A goea to 1 and aets it. B follows state of A with deley of one clock pulse. Output pulae can occur only once during a particular input strobe.—F. E. Nesbitt, Synchronized One Shot, *EDN/IEEE Magazine*, May 15, 1971, p 50.



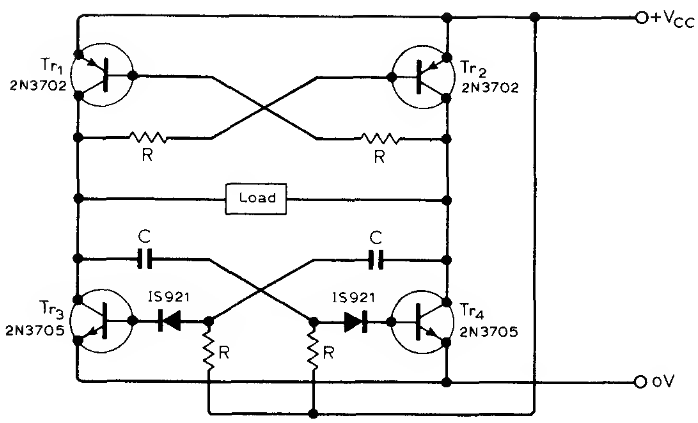
DIRECT-COUPLED ASTABLE—Collectors and bases of both emitter-biaaed transistors are directly coupled to each other. Switching ection takes place by means of cepacitor in eech emitter circuit. Triangle waves are generated at emitters. Neither transistor can remain permanently cut off. Instead, circuit has two quasi-states, with awitching action achieved by charging and discharging capacitor between theae atatea. Single 0.1-μF capacitor can be used between emitters in place of C_1 and C_2.—S. Chang, Two New Direct-Coupled Astabla Multivibrators, *Proceedings of the IEEE*, March 1973, p 390–391.



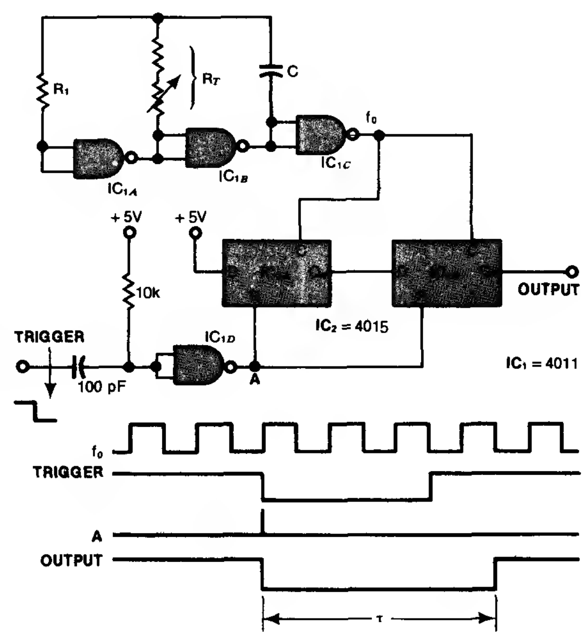
NEGATIVE-GOING DUAL-OUTPUT 555—Circuit triggers on positive-going pulsas end delivers negative-going output timing pulses. C_t chargas when JFET switch Q_1 is held on by high output state of timar. When output of timar goea low, C_t discharges to ground through R_t. Timing eccurecy is good, and duty cycles above 99% ere possible without jitter.—W. G. Jung, Take e Fresh Look at New IC Timer Applications, *EDN Magazine*, March 20, 1977, p 127–135.



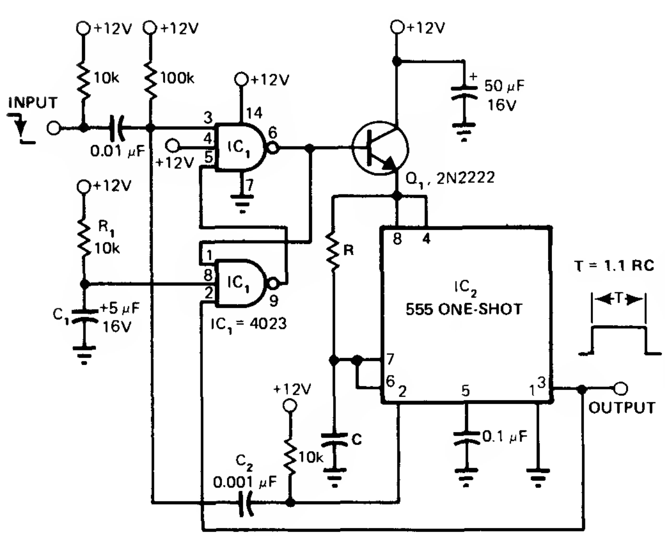
DUTY-CYCLE CONTROL—Feedback loop through two transistors automatically edjusts timing of MVBR to hold duty cycle constant over wide range of triggering ratea. 2N3904 acts as integrator with time constent much longer than pulsing period. If duty cycle increaaes or decreaaea, current into integrator becomes positiva or negative end DC voltage at its collector slowly decreases or increeses. This collector voltage drives 2N3906 operating aa current generator for adjusting eutometically to give chosen duty cycle as selected by 1K pot. Renge is 17% to above 50%.—J. L. Engle, Regulate Duty Cycle Automatically, *EDN Magazine*, Nov. 5, 1978, p 122.



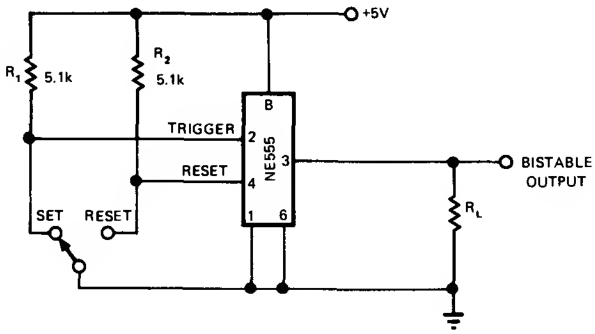
LOW BATTERY DRAIN—Combination of astable and bistable MVBRs, connected so diagonally opposite transistors switch on and off together, minimizas current drain in battery-powered signal generator. Period of square wava is approximataly equal to 1.4CR, and peek load current cen ba up to 70 mA with 24-V battery supply. Circuit will tolarete wide ranga of velues for CR.—J. C. Hopkins, Efficient Square-Weve Oscilletor, *Wireless World,* Juna 1977, p 58.



PRECISION MONO—Nagative-going pulse triggers mono, meking output go LOW for duration of eight clock pulses at frequency determined by velues of R end C in 4011 clock generetor IC_1. R_1 is greater then $2R_T$, and clock frequency is $1/13.8R_TC$. Width of output pulse depends on numbar of stages in shift reglster IC_2 and clock frequency.—B. Bong, Two CMOS IC's Yield Precision One-Shot, *EDN Magazine,* Aug. 5, 1978, p 82.



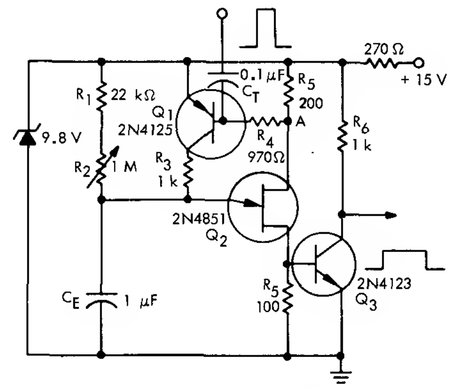
LOW STANDBY POWER—Basic 555 timer circuit is combinad with control logic to keep drain from 12-V supply down to 1 μA during standby. Drain incraases to 6 mA whan input signal makes output pulse go high. Circuit can ba interfaced with CMOS logic. Negative-going input pulse triggers SR flip-flop, which in turn saturates Q_1 and applies power to 555. Simultaneously, C_2 feeds trigger to trigger input pin 2 of 555, to make output pulse go high. At end of tima delay determined by values of R end C, timer output goes low and transition resets flip-flop for standby oparation.—K. J. Imhof, 555 One-Shot Circuit Features Low-Power Stendby Mode, *EDN Magazine,* April 20, 1978, p 134.



TRUTH TABLE

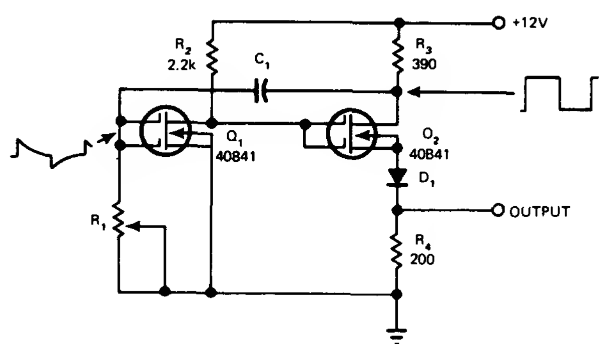
TRIGGER (PIN 2)	RESET (PIN 4)	OUT
↓	HIGH	↑
↑	HIGH	HIGH
HIGH	↓	↓
HIGH	↑	LOW

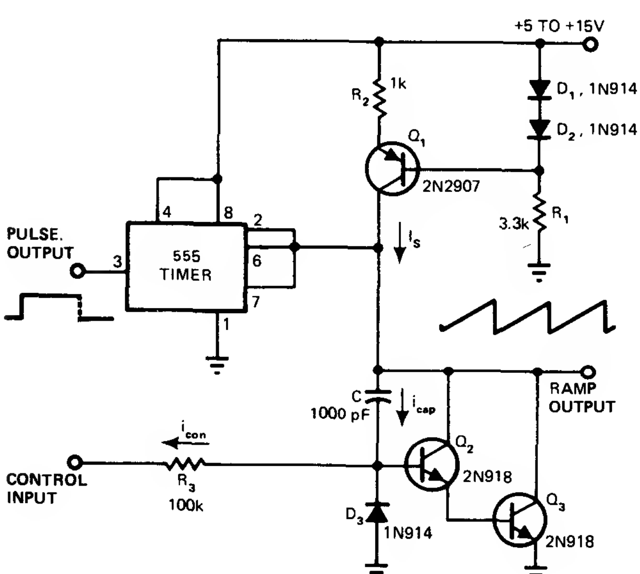
555 TIMER AS FLIP-FLOP—Eliminating RC timing network of 555 timer and tying threshold low makes output states depend on trigger and reset inputs. These are pulled high through R_1 and R_2, then pulled low either with switch or TTL level of 0 on reset input pin 4. Output then stays low until reset goes high and trigger goes low; this bistable action prevents contact bounce from switching output erroneously. Circuit will source or sink 200 mA.—R. L. Gephart, *Mini-DIP Bistable Flip-Flop Sinks or Sources 200 mA*, *EDN Magazine*, Oct. 5, 1974, p 76 and 78.



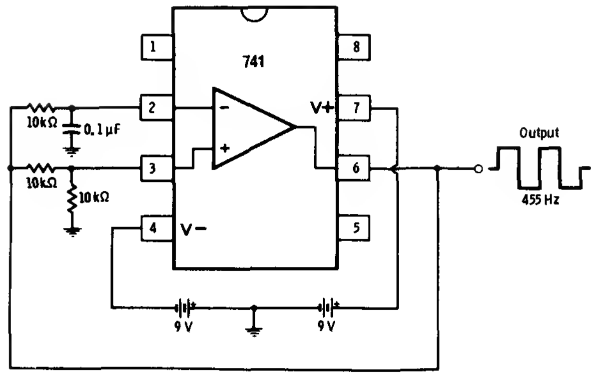
UJT MONO—UJT Q_2 is normally on, with its emitter saturation current supplied by transistor Q_1 which is also on. Application of positive trigger pulse to base of Q_1 turns both off to start timing cycle. C_E starts charging each time from saturation voltage of UJT. When capacitor voltage becomes high enough to fire UJT, Q_1 turns on and supplies emitter current required to keep UJT on. Output transistor Q_3 delivers pulse having duration related to value used for C_E.—"Unijunction Transistor Timers and Oscillators," Motorola, Phoenix, AZ, 1974, AN-294, p 5.

MOSFET ASTABLE—RCA 40841 dual-gate N-channel depletion-type MOSFETs alternate between high and low conduction states in between dormant periods when C_1 is charging or discharging through R_1. Circuit switches state when voltage level at gate of Q_1 makes gain high enough for regeneration to occur. D_1 reduces voltage across R_4 to give TTL drive capability.—D. R. Armstrong, Wide-Frequency Astable Multivibrator Uses One R-C Network, *EDN Magazine*, Aug. 5, 1977, p 54.



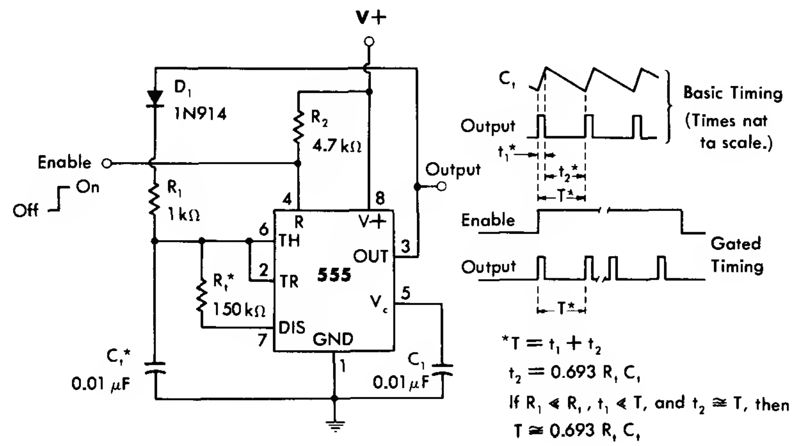


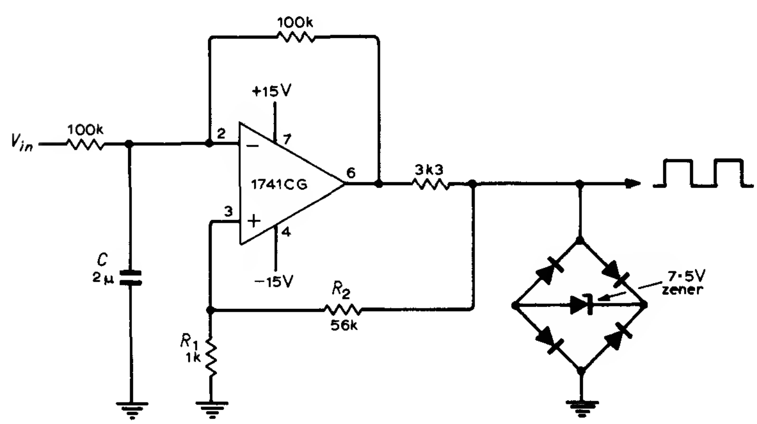
VOLTAGE-CONTROLLED MONO—Circuit gives choice of linear sawtooth and constant pulse-width outputs over frequency range from DC to 50 kHz. Output frequency and pulse repetition rate vary linearly with control current. Applications include audio synthesizers, variable time bases, and current-to-frequency converters.—S. Wetenkamp, Minor Changes Turn VCO into Voltage-Controlled One-Shot, *EDN Magazine*, March 5, 1978, p 67–69.



455-Hz ASTABLE—Frequency of square-wave output depends on values used for external capacitor and resistors. Very low frequencies can be obtained by using large values for both. High-frequency performance is limited by slew rate of opamp.—R. Malan and H. Garland, "Understanding IC Operational Amplifiers," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 119–120.

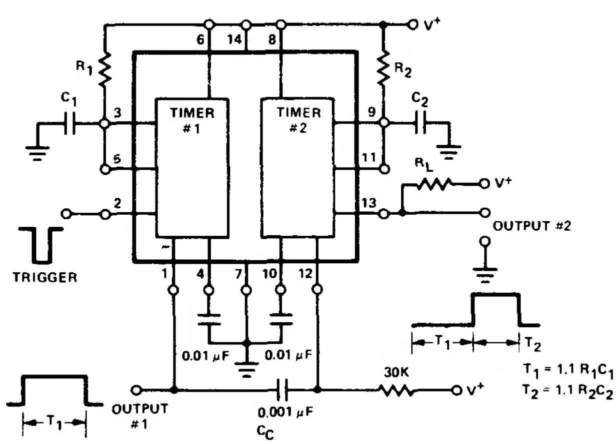
GATED ASTABLE—With values shown, circuit produces positive output pulses at about 1 kHz when gated on by positive pulse at pin 4. Supply voltage for 555 timer can be 15 V.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 135–136.

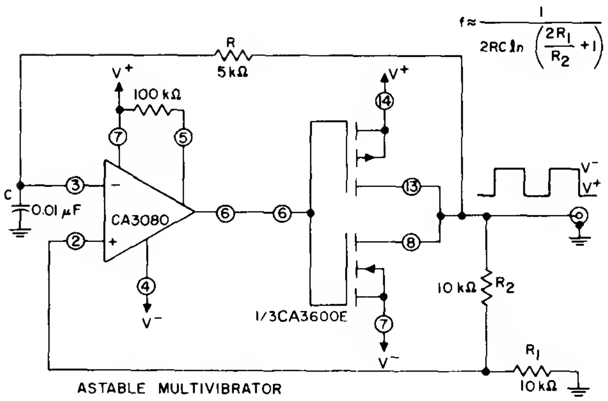




PULSE-WIDTH CONTROL—DC input voltage controls width of rectangular output pulse of opamp operating as free-running multivibrator, by injecting additional current into phase-inverting input of opamp. This current serves to increase one timing period and decrease the other. Circuit also provides similarly controllable sawtooth output (at pin 2). Output circuit uses diode bridge and zener for symmetrically clamping output voltage limits of amplifier when this feature is required.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, May 1973, p 241–242.

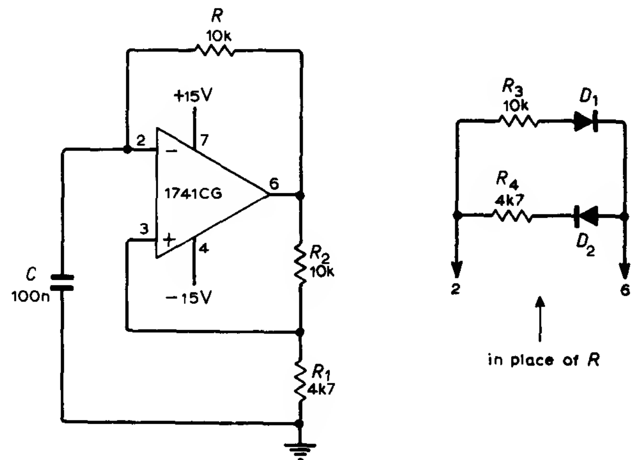
SEQUENTIAL TIMING GIVES DELAYED MONO MVBR—Output of first timer section of Exar XR-2556 dual timer is capacitively coupled to trigger pin of second timer section. When input trigger is applied, output 1 goes high for duration $T_1 = 1.1R_1C_1$, then goes low and triggers timer 2 through C_C. Output at pin 13 then goes high for duration $T_2 = 1.1R_2C_2$ to give performance of delayed mono MVBR. Supply voltage is 4.5–16 V. Choose R_L to keep timer output below 200 mA for supply voltage used.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.

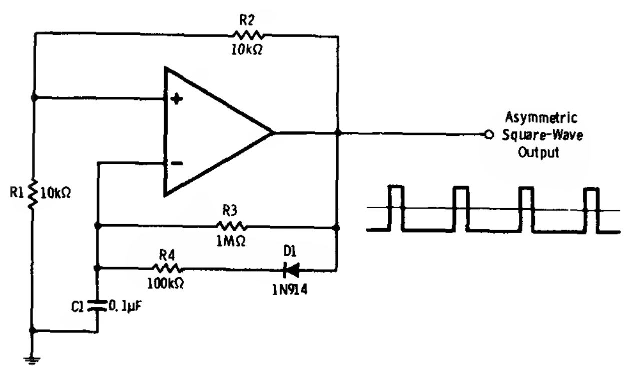




ASTABLE SQUARE-WAVE—CA3080 variable opamp drives one inverter/amplifier section of CA3600E inverter array. Quiescent power drain is typically 6 mW. Supply voltage range is ±3 to ±15 V.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 5.

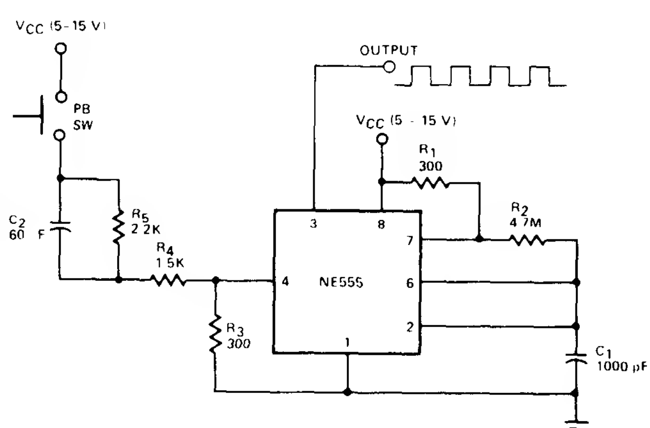
FREE-RUNNING—Positive feedback is applied to noninverting input terminal of opamp through voltage divider R_1-R_2, to make amplifier switch regeneratively and repetitively between saturated states. Charging time of C controls duration of each state, to give desired free-running multivibrator providing rectangular (pin 6), trapezoidal (pin 3), and sawtooth (pin 2) symmetrical waveforms. Article gives design equations and waveforms. For nonsymmetrical waveforms, use alternative circuit in place of R; here, diodes switch two different timing resistors into circuit alternately.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, May 1973, p 241–242.



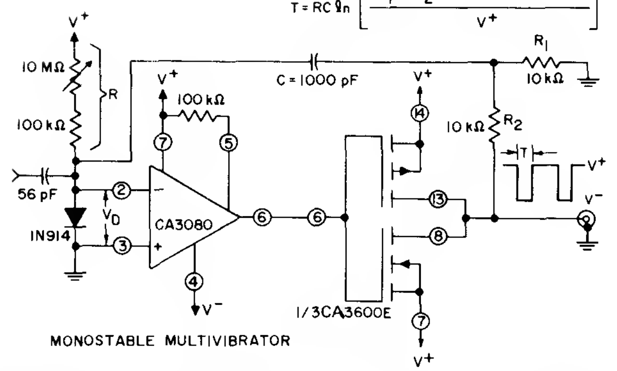


ASYMMETRICAL SQUARE WAVES—Addition of D1 and R4 to astable MVBR connection of 741 or equivalent opamp results in two different charging rates for C1, depending on whether opamp is in positive or negative saturation. Positive and negative peaks of output pulse then have different widths.—R. Melen and H. Garland, "Understanding IC Operational Amplifiers," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 122–123.

SQUARE-WAVE BURSTS—When pushbutton switch is closed, 555 timer generates square-wave tone bursts for duration depending on how long voltage on pin 4 exceeds threshold value. R_1, R_2, and C_1 control astable action of timer.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 726.

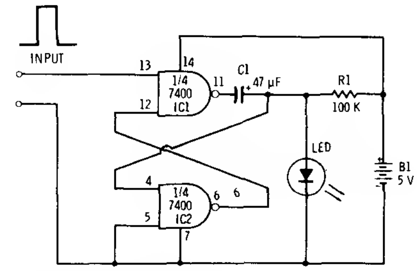


$$T = RC \ln \left[\frac{\frac{R_1}{R_1 + R_2}(V^+ - V^-) + V^+ - V_D}{V^+} \right]$$

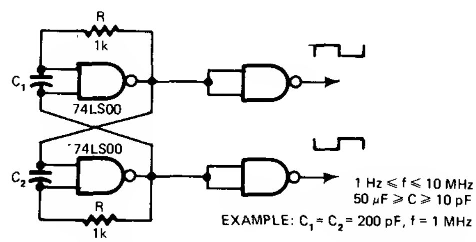


MONOSTABLE MULTIVIBRATOR

MONO SQUARE WAVE—Stable characteristics of differential amplifier in CA3080 variable opamp assure precise timing and threshold for output waveform. Opamp drives one inverter/amplifier section of CA3600E inverter array. Supply voltage range is ±3 to ±15 V.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 5.

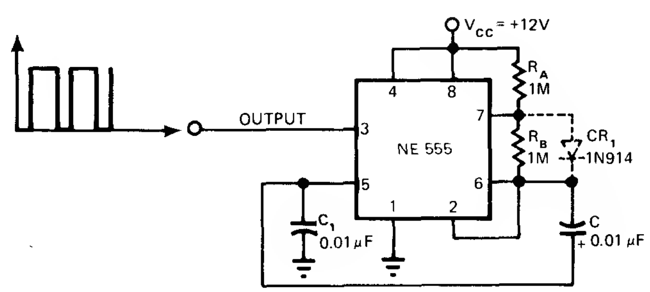


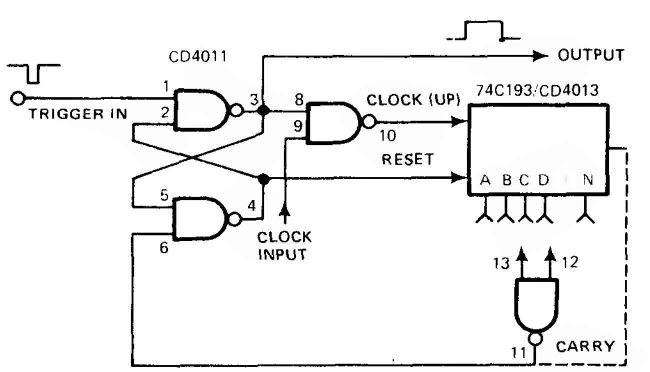
BASIC MONO DRIVES LED—Two sections of 7400 quad NAND gate are connected as monostable MVBR having one stable state and one unstable state. Incoming pulse at pin 13 changes state of gate IC1. Since output of this gate goes to input of other gate, that also changes state. After interval determined by values of C1 and R1, gates automatically return to original states. LED flashes when input pulse is applied, for duration also determined by R1 or C1. If C1 is increased to 470 µF, LED will stay on for over 1 s before fading out gradually as capacitor discharges.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 19–26.



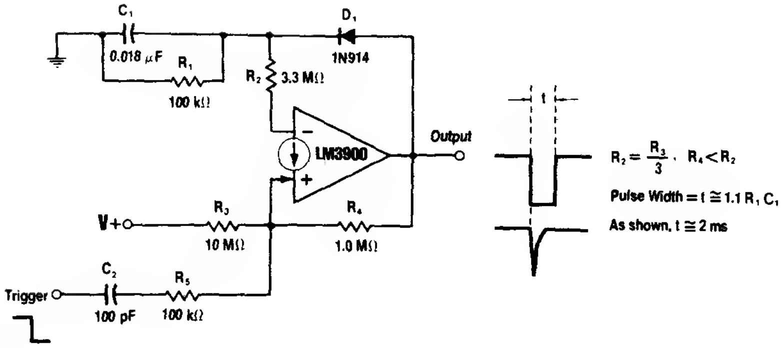
1Hz TO 10 MHz—Simple circuit operating from single 5-V supply provides TTL output levels with reliable starting over wide frequency range. When capacitors are equal, period of oscillation is equal to $5 \times 10^3 C$ s. By changing ratio of C_1 to C_2, duty cycle can be made as low as 20%.—D. B. Arnett, One-Chip TTL Oscillator Requires One 5V Supply, *EDN Magazine*, Jan. 5, 1978, p 96.

LOGIC CONTROL—External circuit modification shown for 555 timer makes initial pulse more nearly equal to subsequent pulses and makes circuit deliver low output when power is applied. Optional diode ensures 50% duty cycle.—K. D. Dighe, Rearranged Components Cut 555's Initial-Pulse Errors, *EDN Magazine*, Jan. 5, 1978, p 82 and 84.



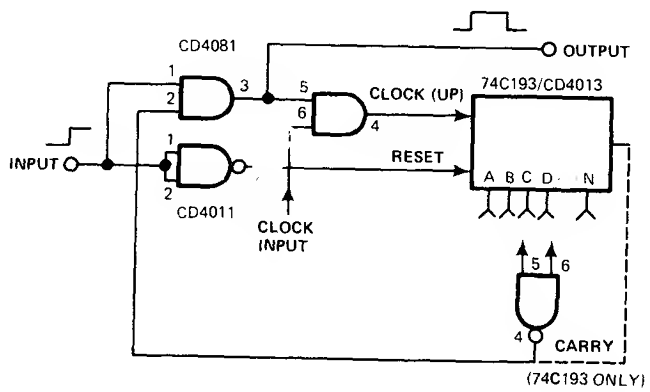


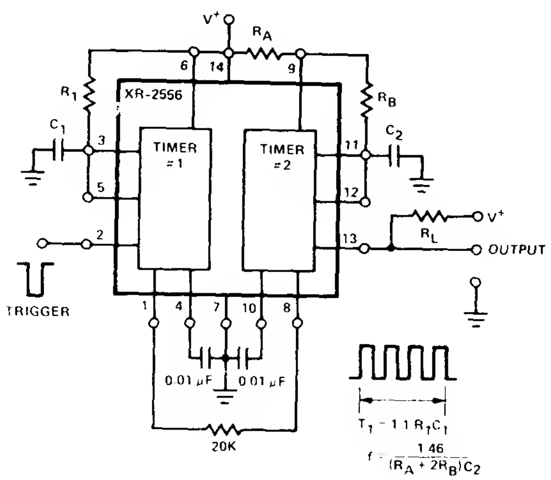
PULSE-TRIGGERED MONO—Combination of two ICs generates pulse having width precisely determined by external clock frequency and countdown factor N of 74C193 binary counter; time t in seconds is equal to N divided by frequency in hertz. With 74C193, 11 values of N are possible (1–6, 8–10, 12, and 16). With CD4013 14-stage counter, values of N can range from 1 to 24,576. Input pulse must be shorter than output pulse. Value of N depends on which two counter outputs are connected to two-input NAND gate.—R. L. Anderson, Digital One-Shot Produces Long, Accurate Pulses, *EDN Magazine*, March 5, 1978, p 127.



LM3900 AS MONO—R_4 holds output high normally, so C_1 is charged almost to V+ level through D_1. Negative input trigger forces output of current-differencing amplifier low, and C_1 discharges through R_1. When decreasing current through R_2 approaches current in R_3 (when voltage across C_1 is about one-third of V+), output switches to high and returns circuit to standby state. Pulse width, equal to $1.1R_1C_1$, can be programmed easily by using pot or some form of manual or electronic switching for R_1.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 510–512.

EDGE-TRIGGERED MONO—Output pulse width is precisely determined by external clock frequency and countdown factor N of 74C193 binary counter (t = N/f). Pulse is generated on rising edge of input, with output remaining high until count N is reached by binary counter. Counter resets and output returns instantly to zero if input pulse goes to zero before count of N. Value of N depends on which two counter outputs are connected to two-input NAND gate. With 74C193, 11 values of N between 1 and 16 are possible; with CD4013, values of N can range from 1 to 24,576.—R. L. Anderson, Digital One-Shot Produces Long, Accurate Pulses, *EDN Magazine*, March 5, 1978, p 127.

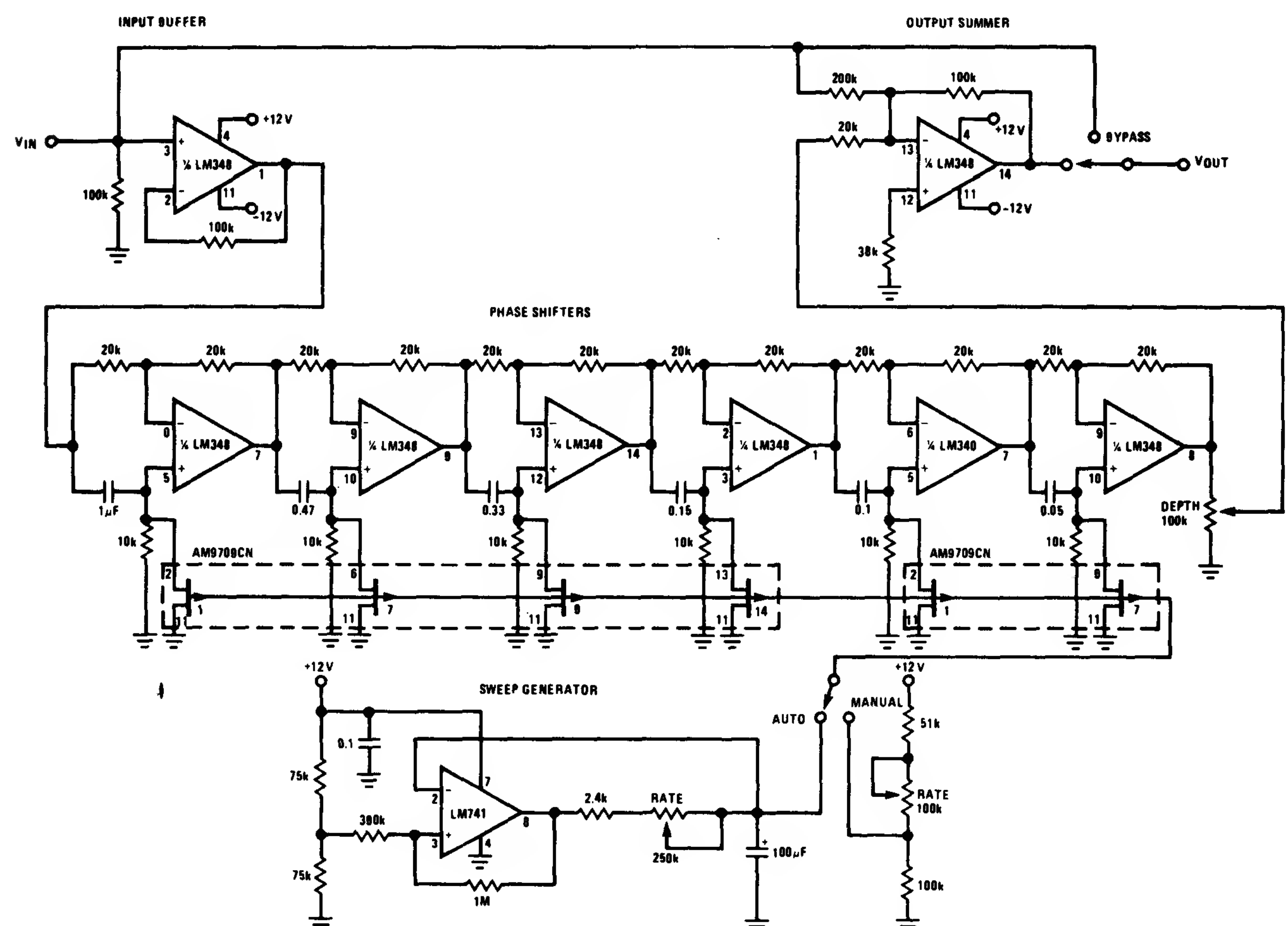




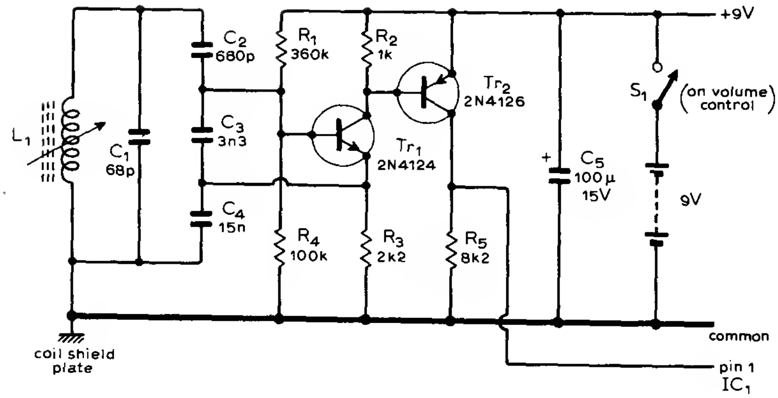
KEYED FREE-RUNNING MVBR—One section of Exar XR-2556 dual timer is operated in free-running mode, with other section used to provide ON/OFF keying. Frequency of oscillator is set by R_A, R_B, and C_2. Timer 1 operates as mono MVBR with output connected to reset pin 8 of timer 2. Trigger drives pin 1 of timer 1 high, keying timer 2 on and producing tone-burst output for duration set by R_1 and C_1. Supply voltage is 4.5–16 V.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 23–30.

CHAPTER 57
Music Circuits

Includes organ, piano, trombone, bell, theremin, bird-call, and other sound and music synthesizer circuits, along with circuits giving warble, fuzz, three-part harmony, reverberation, tremolo, attack, decay, rhythm, and other musical effects. Joystick control for music, active filters, contact-pickup preamp, metronomes, and tuning aids are also given.

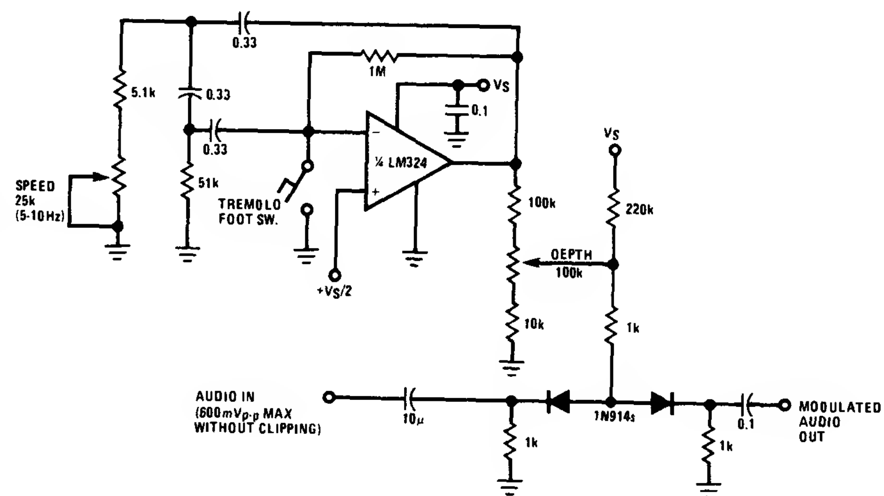


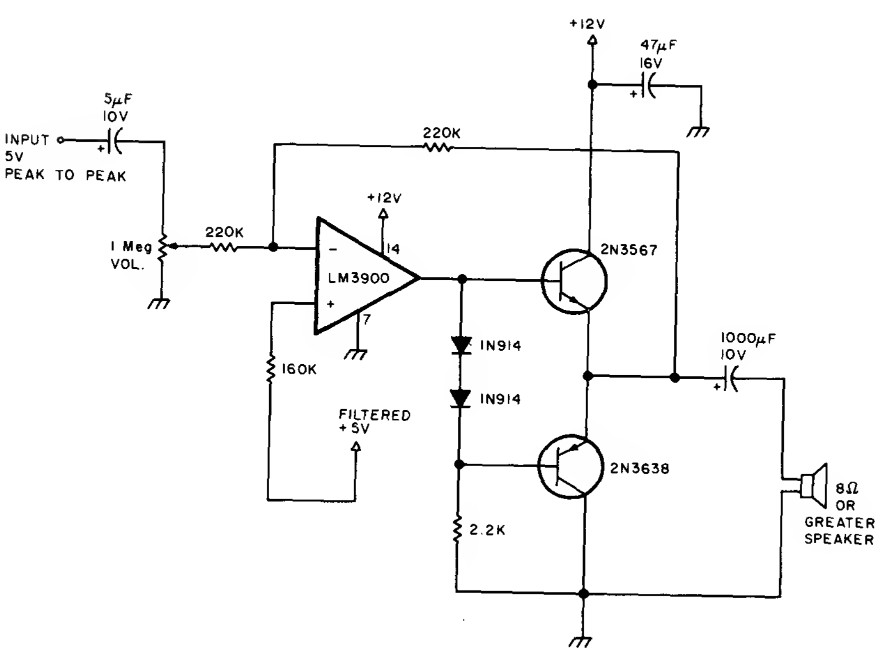
SIMULATION OF FLANGING—Sound-effect circuit sometimes called phase shifter simulates playing of two tape recorders having same material while varying speed of one by pressing on flange of tape reel. Resulting time delay causes some signals to be summed out of phase and canceled. Effect is that of rotating loudspeaker or of Doppler characteristic. Uses two LM348 quad opamps, two AM9709CN quad JFET devices, and one LM741 opamp. Phase-shift stages are spaced one octave apart from 160 to 3200 Hz in center of audio spectrum, with each stage providing 90° shift at its frequency. JFETs control phase shifters. Gate voltage of JFETs is adjusted from 5 V to 8 V either manually with foot-operated rheostat or automatically by LM741 triangle-wave generator whose rate is adjustable from 0.05 Hz to 5 Hz.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-10–5-11.



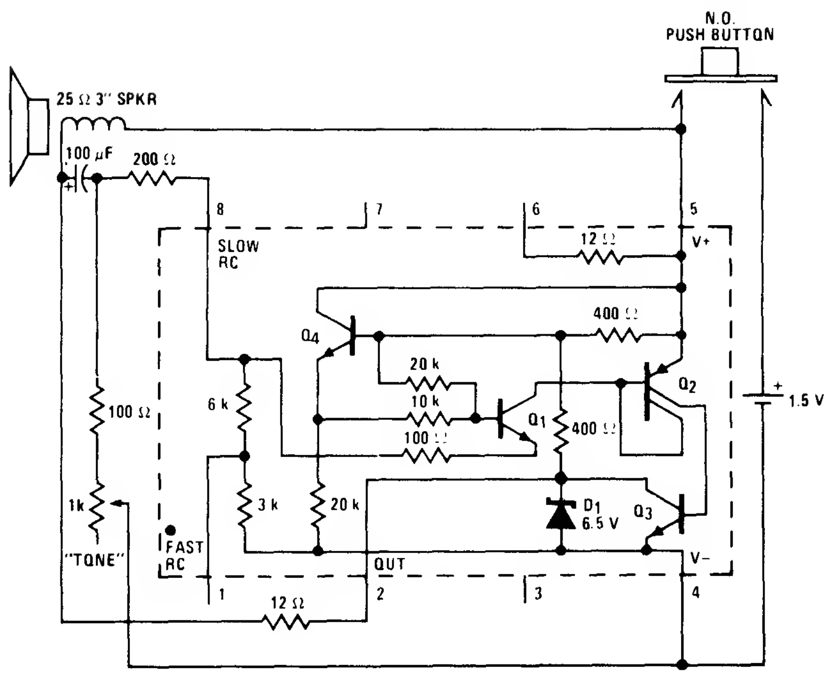
TUNING FOR EQUAL TEMPERAMENT—Instrument described enables anyone to tune such instruments as organ, piano, and harpsichord in equal temperament with accuracy approaching that of professional tuner. Only requirement is ability to hear beats between two tones sounded together. Master oscillator circuit shown generates 250.830 kHz for feeding to first of five ICs connected as programmable divider that provides 12 notes of an octave as 12 equal semitones differing from each other by factor of 1.0594. Article gives suitable power amplifier to fit along with divider connections and detailed instructions for construction, calibration, and use.—W. S. Pike, Digital Tuning Aid, *Wireless World*, July 1974, p 224–227.

TREMOLO CONTROL—National LM324 opamp connected as phase-shift oscillator operates at variable rate between 5 and 10 Hz set by speed pot. Portion of oscillator output is taken from depth pot and used to modulate ON resistance of two 1N914 diodes operating as voltage-controlled attenuators. Input should be kept below 0.6 V P-P to avoid undesirable clipping. Used for producing special musical effects.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-11–5-12.

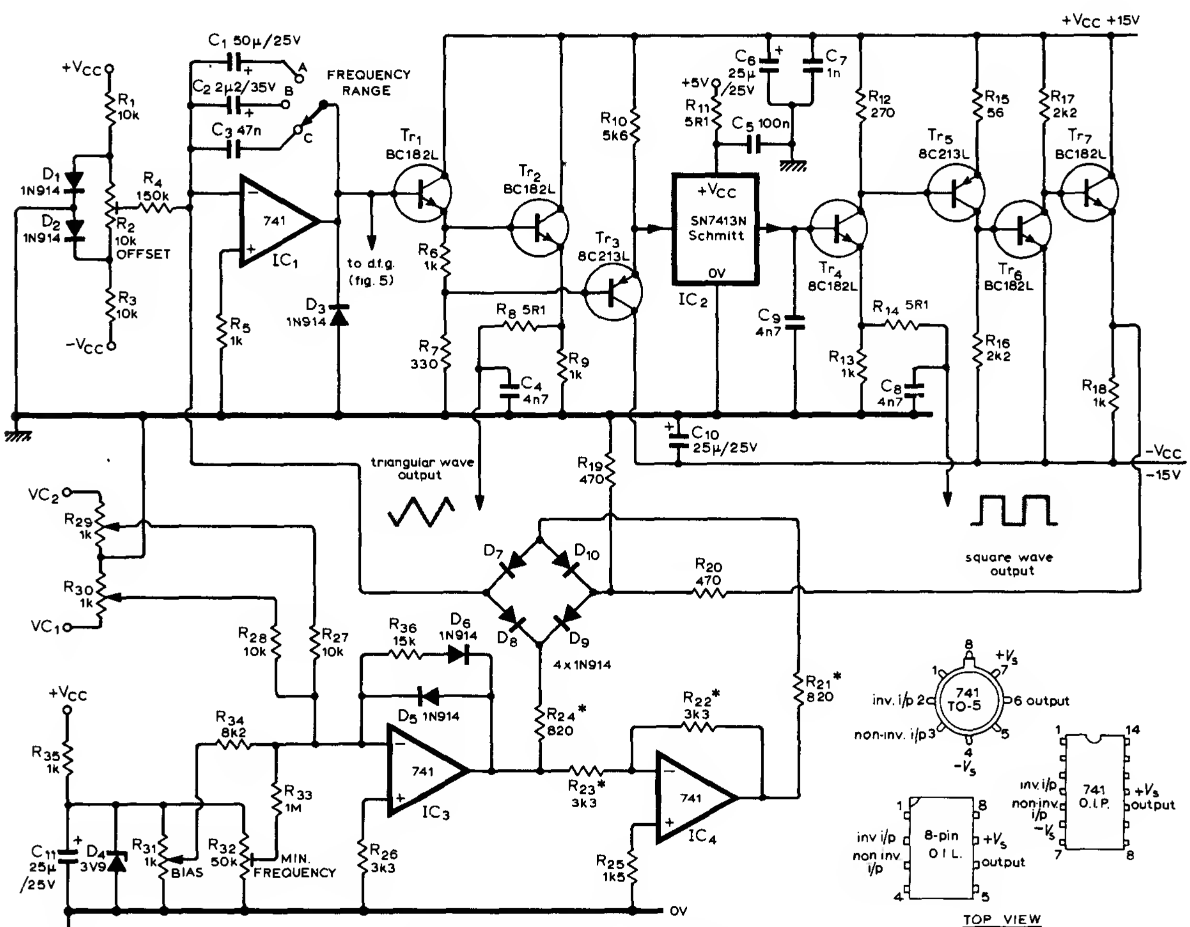




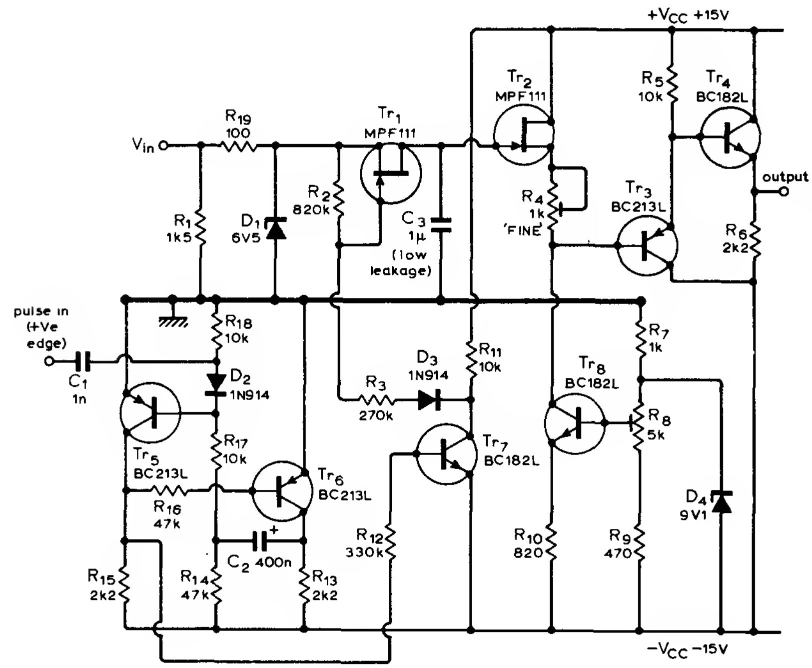
AUDIO FOR COMPUTER MUSIC—Wideband low-power audio amplifier was developed for use with DAC and low-pass active filter to create music with microprocessor.—H. Chamberlin, A Sampling of Techniques for Computer Performance of Music, *BYTE*, Sept. 1977, p 62–66, 68–70, 72, 74, 76–80, and 82–83.



TROMBONE CIRCUIT—Unique arrangement for driving 25-ohm loudspeaker with National LM3909 IC operating from 1.5-V cell permits generation of slide tones resembling those of trombone. Operation is based on use of voltage generated by resonant motion of loudspeaker voice coil as major positive feedback for IC. Loudspeaker is mounted in roughly cubical box having volume of about 64 in³, with one end of box arranged to slide in and out like piston. Positioning of piston and operation of pushbutton permit playing reasonable semblance of simple tune. IC, loudspeaker, and battery are mounted on piston, with 2½-in length of 5/16-in tubing provided to bleed air in and out as piston is moved, without affecting resonant frequency. Frequency of oscillator becomes equal to resonant frequency of enclosure.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 6.

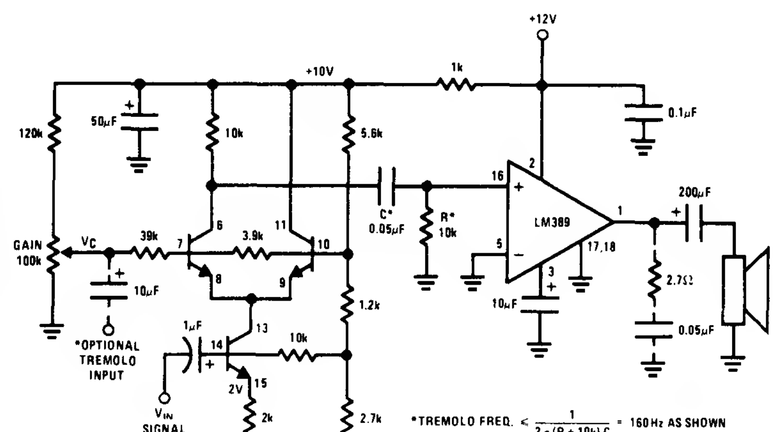


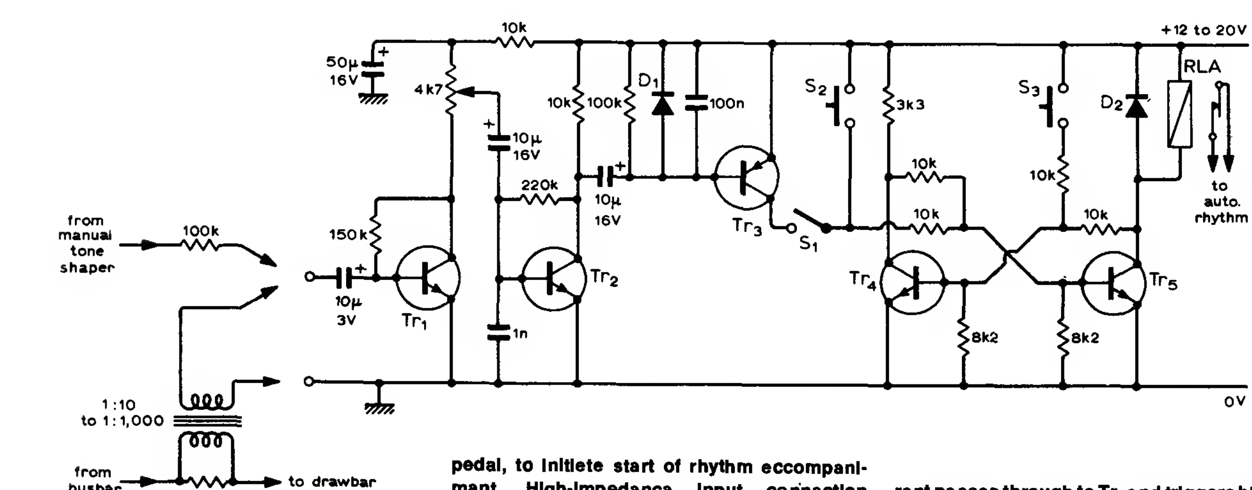
VCO SOUND SYNTHESIZER—Developed for use in instrument capable of duplicating variety of sounds ranging from bird distress calls and engine noises to spoken words and wide variety of musical instruments. Three-part article gives all circuits and describes their operation in detail. Heart of oscillator is triangle and square-wave generator built around IC Schmitt trigger. Ramp rate and operating frequency are varied by changing drive voltage or gain of integrator. Similar VCO in synthesizer also produces sine, pulse, and ramp waveforms.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 1—Aug. 1973, p 366–372 (Part 2—Sept. 1973, p 429–434; Part 3—Oct. 1973, p 485–490).



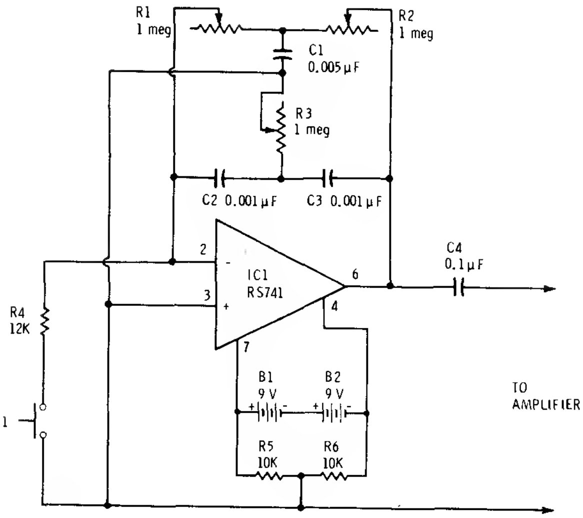
ANALOG MEMORY—Used in synthesizer for generating wide variety of musical and other sounds, to provide constant control signal for sounds requiring long fadeout. Positive input pulse initiates sampling of analog signal for preset time, with signal being held for unspecified period. Input voltage range is from about −0.5 V to +6.5 V, being deliberately limited by D_1. Three-part article describes operation in detail and gives all other circuits used in synthesizer.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 3—Oct. 1973, p 485–490 (Part 1—Aug. 1973, p 366–372; Part 2—Sept. 1973, p 429–434).

TREMOLO AMPLIFIER—Provides amplitude modulation at subaudio rate (usually between 5 and 15 Hz) of audio-frequency input signal. Uses National LM389 array having three transistors along with power amplifier. Transistors form differential pair having active current-source tail to give output proportional to product of two input signals. Gain control pot is adjusted for desired tremolo depth. Interstage RC network forms 160-Hz high-pass filter, requiring that tremolo frequency be less than 160 Hz.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.

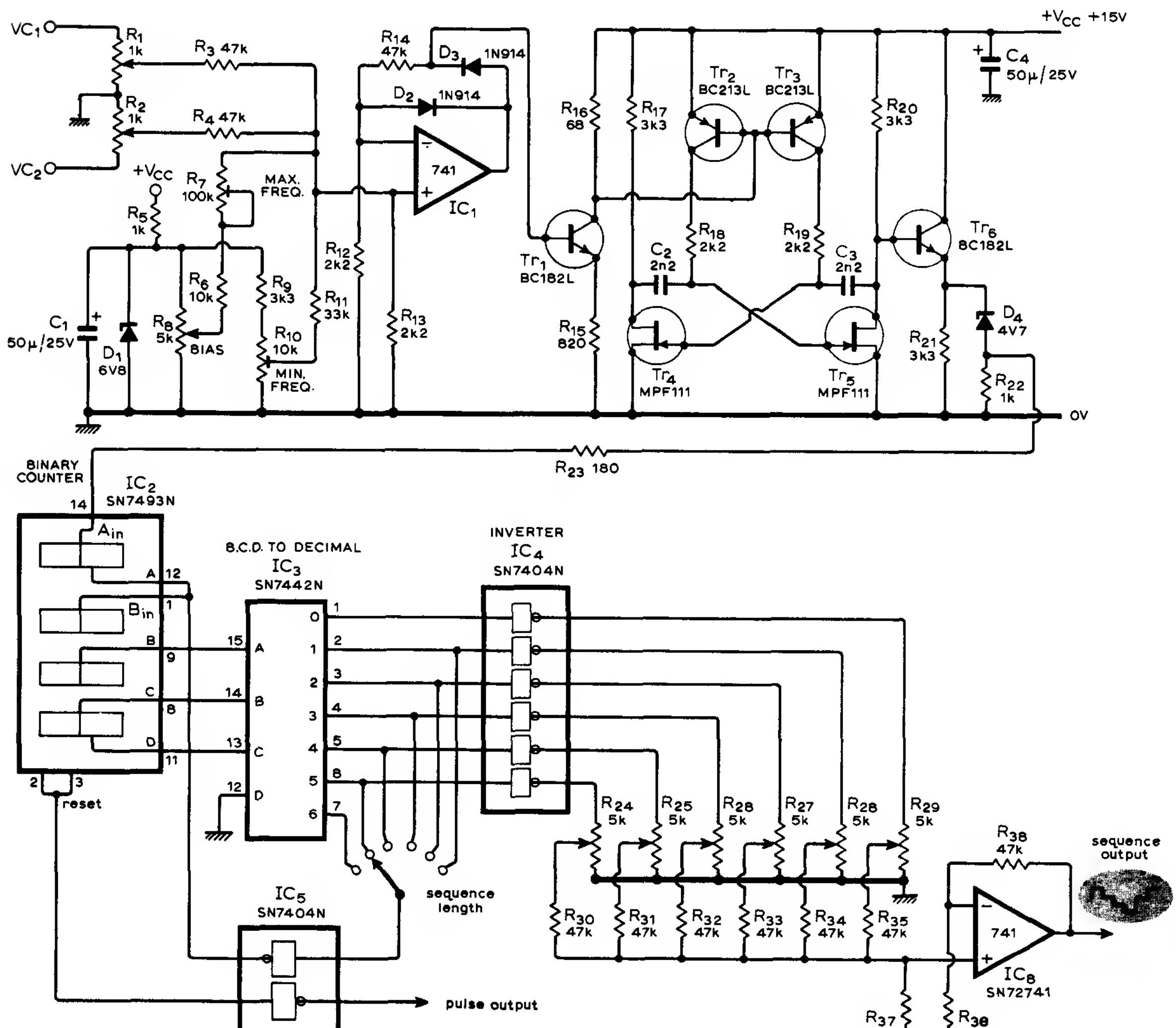




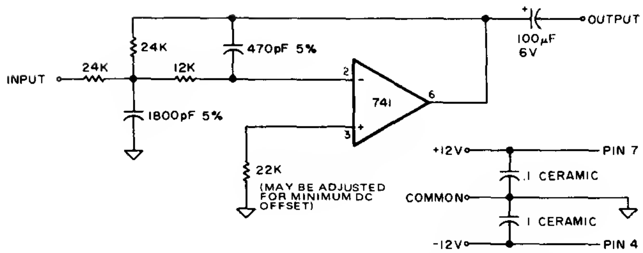
AUTOMATIC REMOTE RHYTHM CONTROL—When added to electronic organ, circuit is activated by audio signal from lower manual or pedal, to initiate start of rhythm accompaniment. High-impedance input connection through 100K is made to tone-shaper output, and transformer connection is used with electromechanical Hammond organ. Transistor and diode types are not critical. If S_1 is closed, current passes through to Tr_5 and triggers bistable that pulls in relay. S_2 and S_3 are used for manual start and stop of rhythm.—K. B. Sorensen, Touch Start of Automatic Rhythm Device, *Wireless World*, Oct. 1974, p 381.



MUSICAL BELLS—Opamp connected as active filter simulates attack followed by gradual decay as produced when bell or tuning fork is struck. Filter portion of circuit uses twin-T network adjusted so active filter breaks into oscillation when slight external disturbance is introduced by closing S1 momentarily. Circuit feeds external audio amplifier and loudspeaker for converting ringing frequency into audible sound. Set R3 just below oscillation point. R1 and R2 can be adjusted to give sounds of other musical instruments, such as drums, bamboo, and triangles.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 71–80.



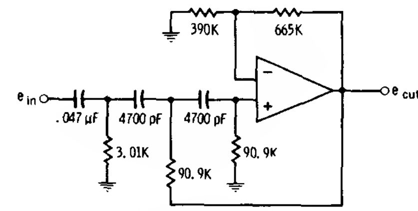
PULSE AND SEQUENCE OUTPUTS—Voltage-controlled oscillator produces sequence of steps, with amplitude of each step individually controllable up to maximum of six steps. Circuit also generates series of pulses having 1:1 mark-space ratio, each coincident with leading edge of a step. Pair of summing inputs controls oscillator, with exponential frequency-voltage relationship extending in one range from subsonic frequencies to over 20 kHz. Used in sound synthesizer described in three-part article that gives all circuits and operating details. Applications include synthesizing sounds ranging from bird distress calls and engine noises to spoken words and wide variety of musical instruments.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 2—Sept. 1973, p 429–434 (Part 1—Aug. 1973, p 366–372; Part 3—Oct. 1973, p 485–490).



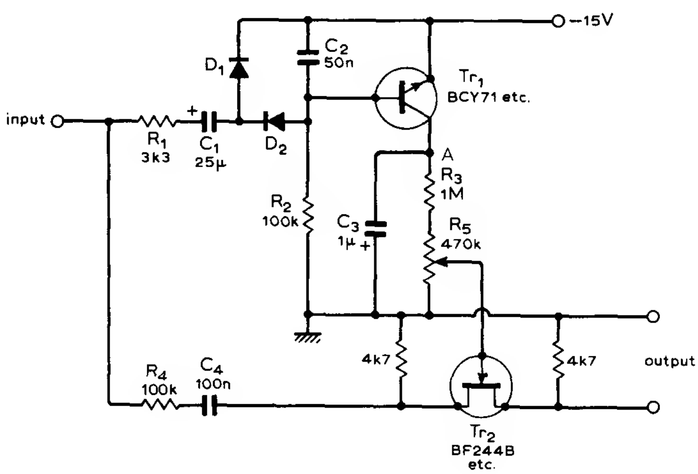
12 dB/OCTAVE, 10KHz FILTER

POWER SUPPLY DECOUPLING

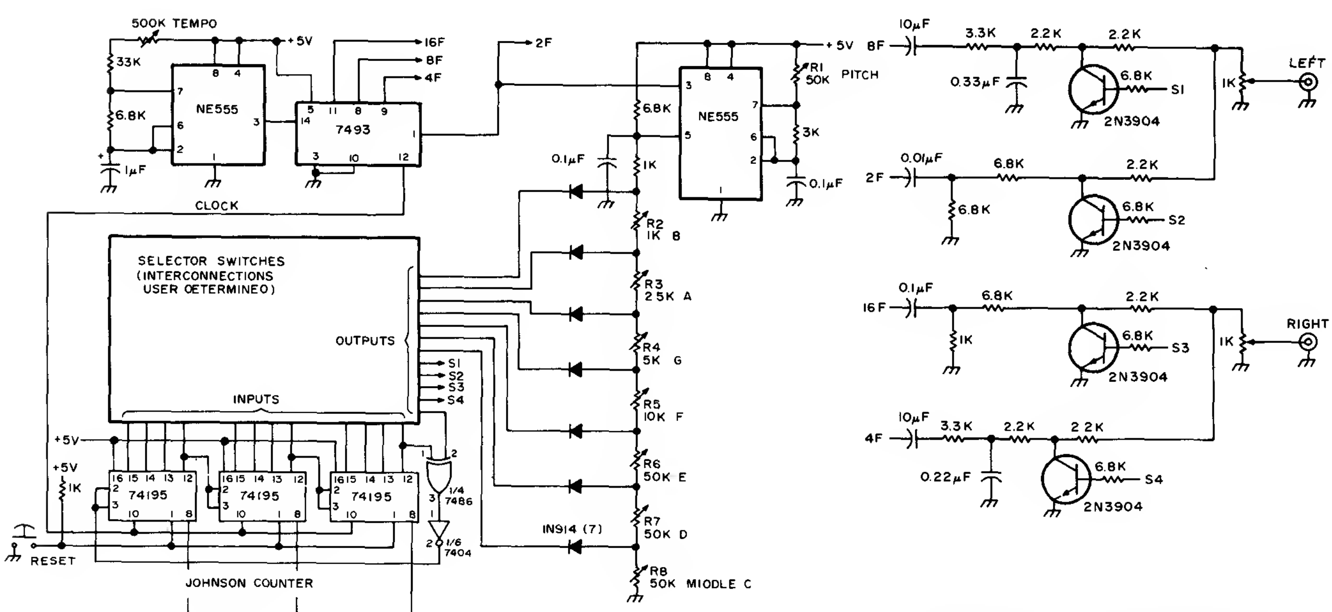
10-kHz LOW-PASS FILTER—Suitable for use at both input and output of A/D-D/A converter in digital audio system for synthesizing speech or music. Serves for smoothing steps of output waveform and suppressing background noise on output when small signals are being processed with 8-bit linear encoding.—T. Scott, Digital Audio, *Kilobaud,* May 1977, p 82–86.



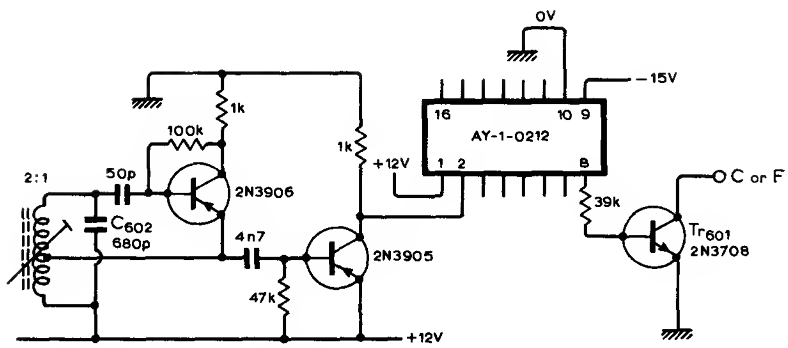
327-Hz HIGH-PASS—Developed to make third harmonic of 130.81 Hz (C3 note) minimum of 30 dB stronger than fundamental, to give sawtooth output for use in electronic music system. Design uses third-order filter with 3-dB dips in response. Opamp can be 741.—D. Lancaster, "Active-Filter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 192.



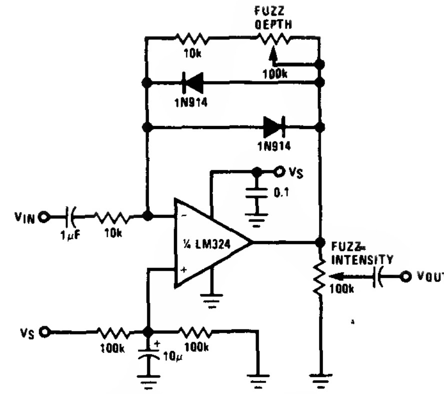
PIANO MUSIC FROM ORGAN—Simple add-on circuit for electronic organ attenuates output of oscillator exponentially to zero in manner suitable for mimicking waveform of piano. Circuit is self-triggering, so exponential decay starts only when output of multivibrator is applied; this eliminates need for extra contacts on keyboard. With no input, Tr_1 is on and point A is at supply voltage. Input signal turns Tr_1 off, discharging C_3 through R_3 and R_5. Voltage across C_3 controls gate of FET, with R_5 being adjusted so FET just switches off when C_3 is fully discharged. Tr_1 then conducts and C_3 charges rapidly, to permit fast piano playing.—C. J. Outlaw, Electronic Organ to Piano, *Wireless World,* Feb. 1975, p 94.



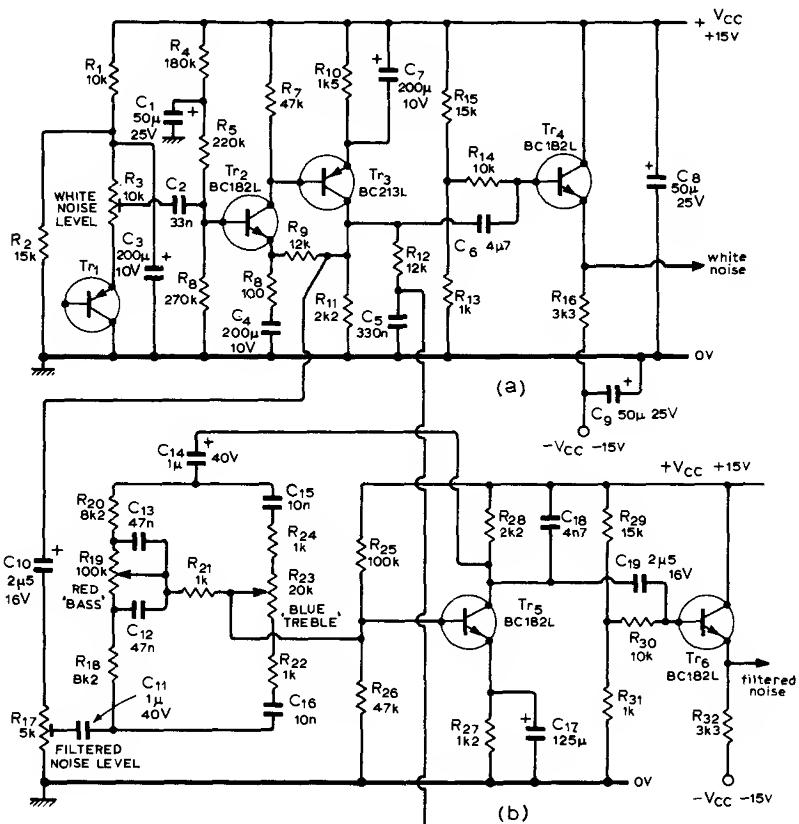
RANDOM MUSIC—Uses Johnson counter as special shift register producing almost random bit patterns of 18 to 3255 12-bit words under control of clock operating in range of about 1–10 Hz. Oscillator (upper right) uses NE555 as voltage-controlled square-wave generator playing one of eight musical notes (C, D, E, F, G, A, B, or C), depending on state of seven note-selector lines coming from selector switches. Oscillator is divided down in frequency by three-stage ripple counter to provide four octaves of range. R1-R8 serve for tuning each note to pitch. Outputs 8F and 2F are paired to drive left input of stereo amplifier, while outputs 16F and 4F are similarly paired for right channel. Article covers construction, tune-up, and creation of pleasing musical sequences.—D. A. Wallace, The Sound of Random Numbers, *73 Magazine,* Feb. 1976, p 60–64.

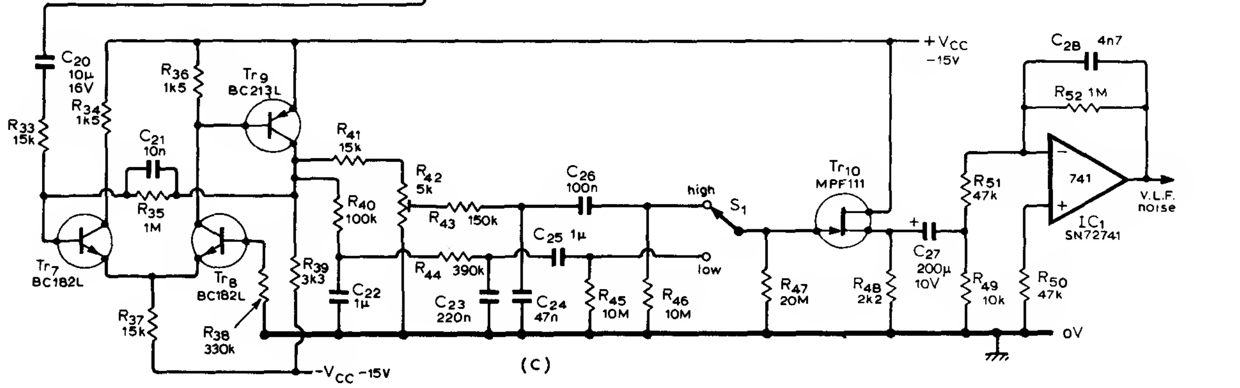


PIANO TONE GENERATOR—RF oscillator combined with Generel Instrument AY-1-0212 IC master tone ganerator replaces 12 conventionel RC oacillators otherwise required in electronic piano. Frequencies generated are within 0.1% of equal-tamperament scale, so piano will work well without being tuned. Threa-part article glves all circuits and construction details for simpla portable touch-sensitive electronic piano.—G. Cowie, Electronic Pieno Design, *Wireless World,* Part 3, May 1974, p 143–145.

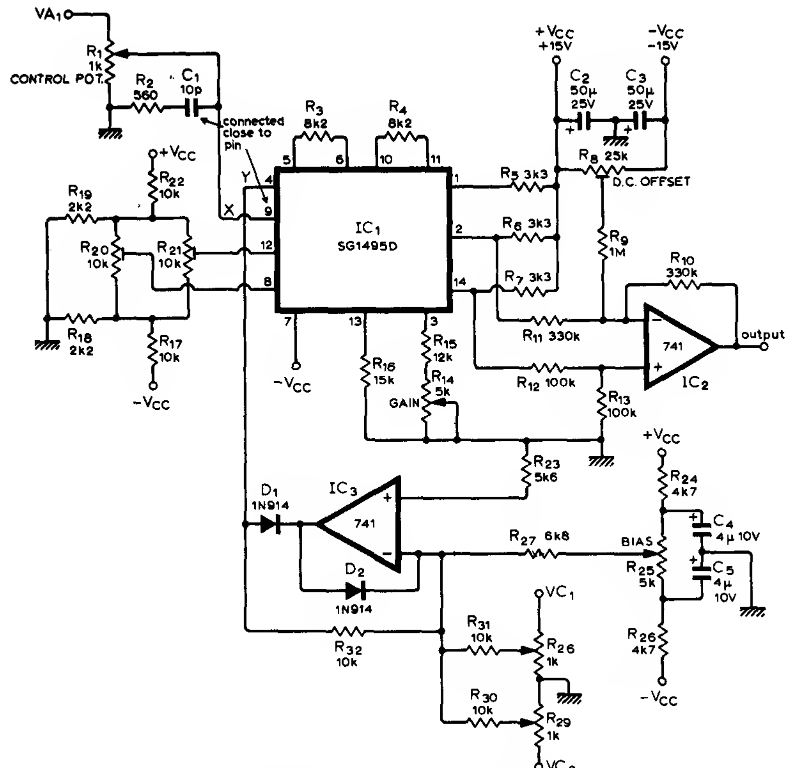


FUZZ CIRCUIT—Two diodes in feedback peth of LM324 opamp create musical-instrument effect known as fuzz by limiting output voltage swing to ±0.7 V. Resultant squere wave containa chiefly odd harmonics, resembling sounds of clarinet. Fuzz depth pot controls level at which clipping begins, and fuzz intensity pot controls output level.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-11.

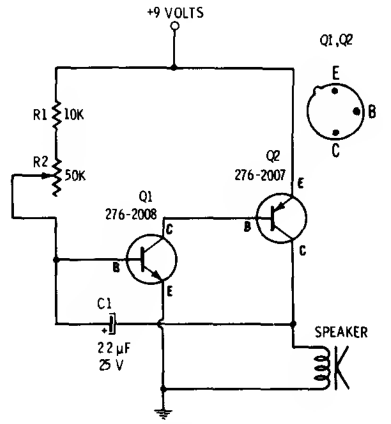




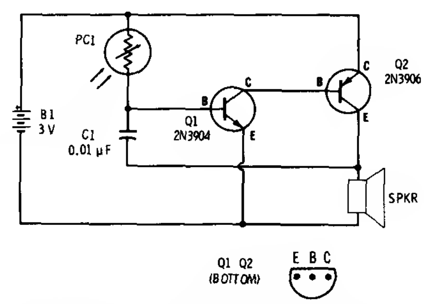
NOISE SOURCE—Used in synthesizer for generating wide variety of musical and other sounds, to provide any combination of white, filtered, and VLF noise to be used directly aa audio signal or aa control signal. Source for white nolse Is Tr_1, which Is a germanlum transistor selectad for high laakage or heated enough to maka It leaky, so aa to produce an average nolse lavel of about 40 mV P-P. Filtered (colored) nolae Is produced by drlving apactrum-shaping network (Baxandall tone control) with white nolsa. Preset control R_{17} la adjuated so output shows no clipping when both rad and blue tone controls are at maximum. VLF nolsa Is extracted from white noise by elthar of two low-paas filters aalected by S_1. Threa-part article describas operation In detall and glves all other circuits used In synthesizar.—T. Orr and D. W. Thomas, Electronic Sound Synthesizar, *Wireleas World,* Part 3—Oct. 1973, p 485–490 (Part 1—Aug. 1973, p 366–372; Part 2—Sept. 1973, p 429–434).



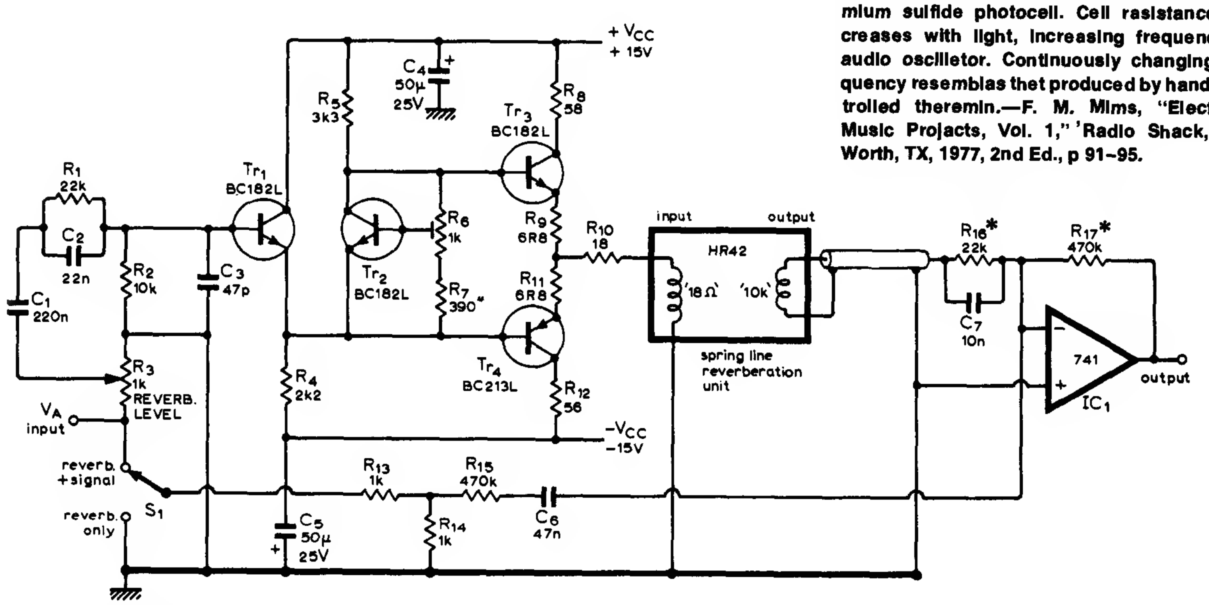
VOLTAGE-CONTROLLED AMPLIFIER—Gain is linearly controlled by sum of input control voltages and a bias voltage, to provide amplitude modulation as required for synthesizer used to generate wide variety of sounds. Heart of circuit is linear four-quadrant multiplier IC. Output is taken between two load resistors, with differential amplifier IC_2 removing common-mode signal. Article describes operation in detail and gives all other circuits of synthesizer, along with procedure for aligning preset controls R_8, R_{14}, R_{20}, and R_{21}.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 2—Sept. 1973, p 429–434 (Part 1—Aug. 1973, p 366–372; Part 3—Oct. 1973, p 485–490).



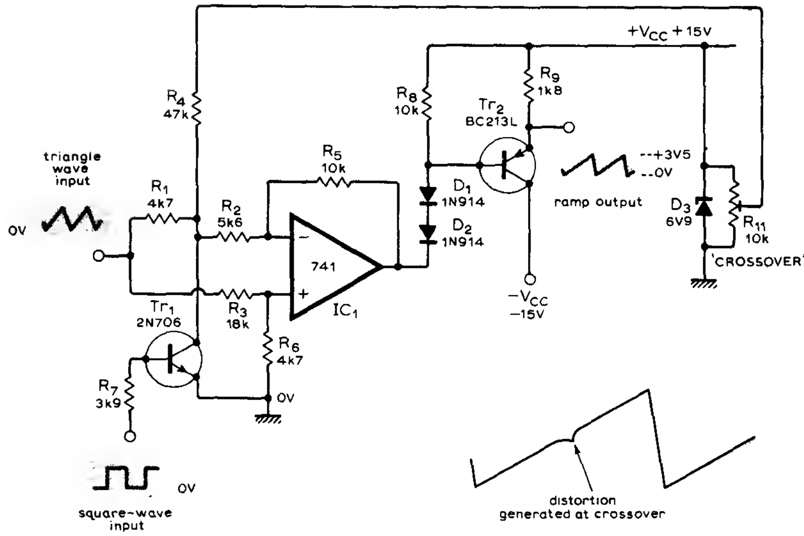
CLICKING METRONOME—Basic lamp-flashing circuit is used to produce sharp click in loudspeaker each time Q2 is turned on by RC oscillator Q1. R2 adjusts repetition rate over range of 20–280 beats per minute. Changing value of C1 varies tone of clicks.—F. M. Mims, "Transistor Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 33–39.



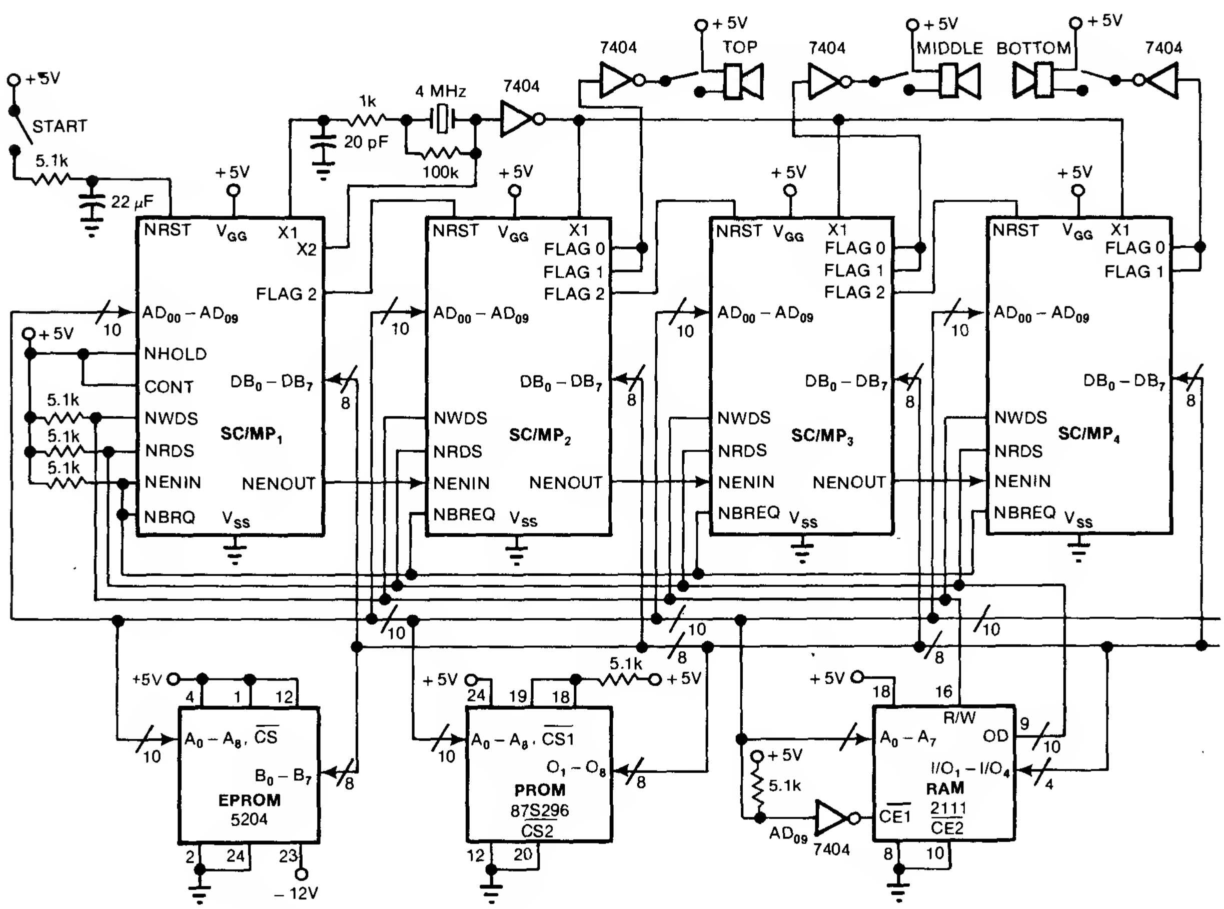
LIGHT-SENSITIVE THEREMIN—Tone of loudspeaker increases and decreases in frequency as flashlight is moved in vicinity of photocell in darkened room. Use Radio Shack 276-116 cadmium sulfide photocell. Cell resistance decreases with light, increasing frequency of audio oscillator. Continuously changing frequency resembles that produced by hand-controlled theremin.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 91–95.



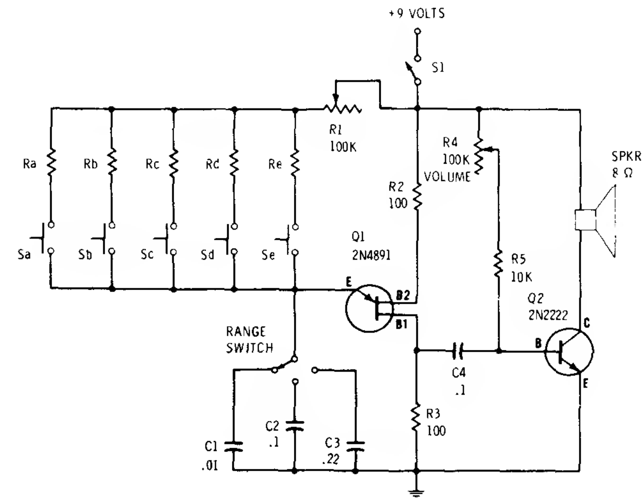
REVERBERATION—Used in sound synthesizer developed for generating wide variety of musical and other sounds. Four-transistor driver feeds spring-type reverberation unit at up to about 4 kHz, with switch giving choice of reverberation only or reverberation combined with input signal at V_A. Amount of reverberation can be controlled manually with R_3 or automatically with voltage-controlled amplifier or voltage-controlled filter of synthesizer. Three-part article gives all circuits and describes operation in detail.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 2—Sept. 1973, p 429–434 (Part 1—Aug. 1973, p 366–372; Part 3—Oct. 1973, p 485–490).



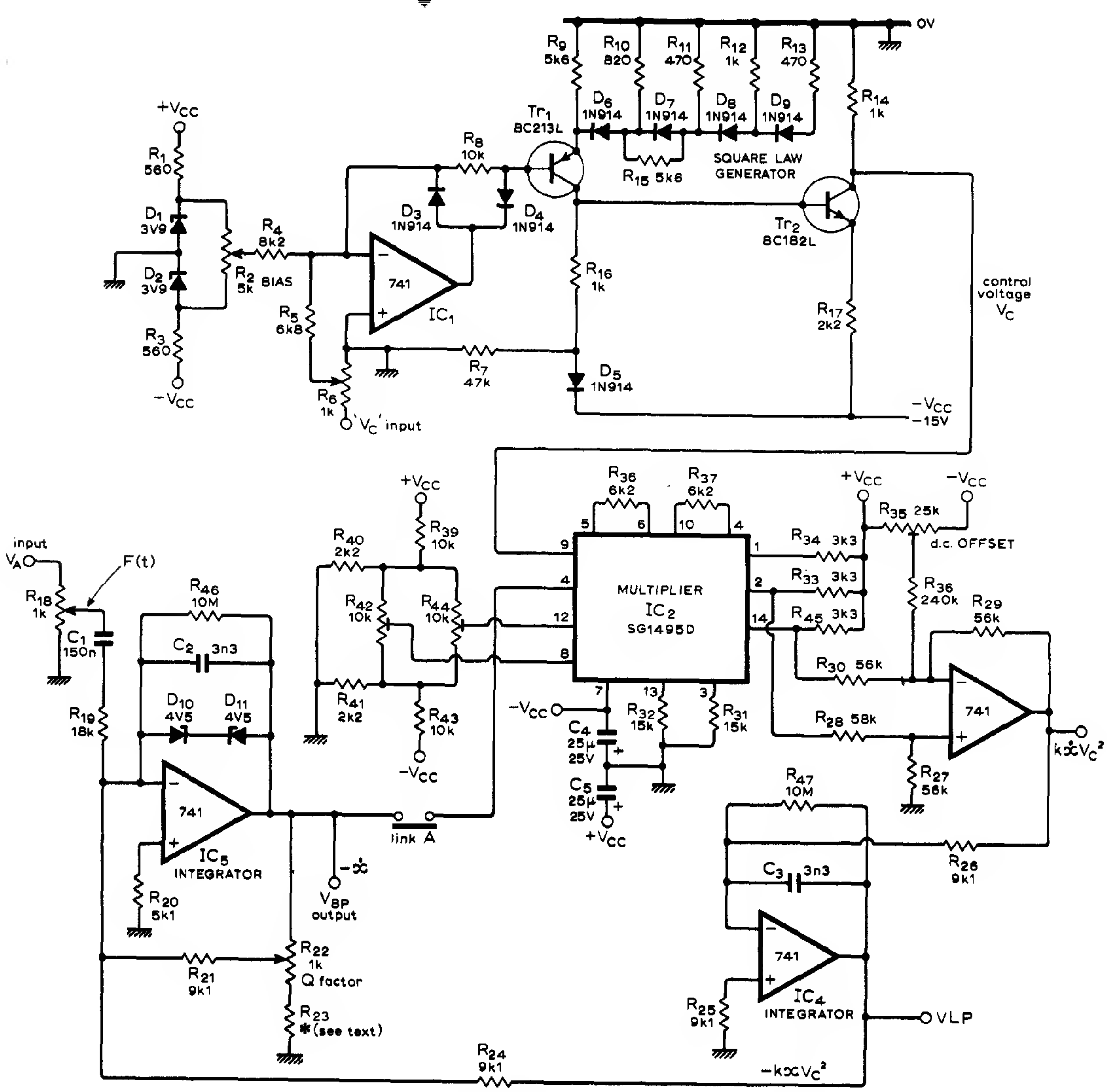
RAMP FUNCTION—Circuit combines triangle and square-wave inputs from VCO in differential amplifier having switched gain, to generate ramp function for use with variety of other waveforms in sound synthesizer designed for duplicating wide variety of sounds. Three-part article gives all circuits and operating details.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World,* Part 1—Aug. 1973, p 366–372 (Part 2—Sept. 1973, p 429–434; Part 3—Oct. 1973, p 485–490).



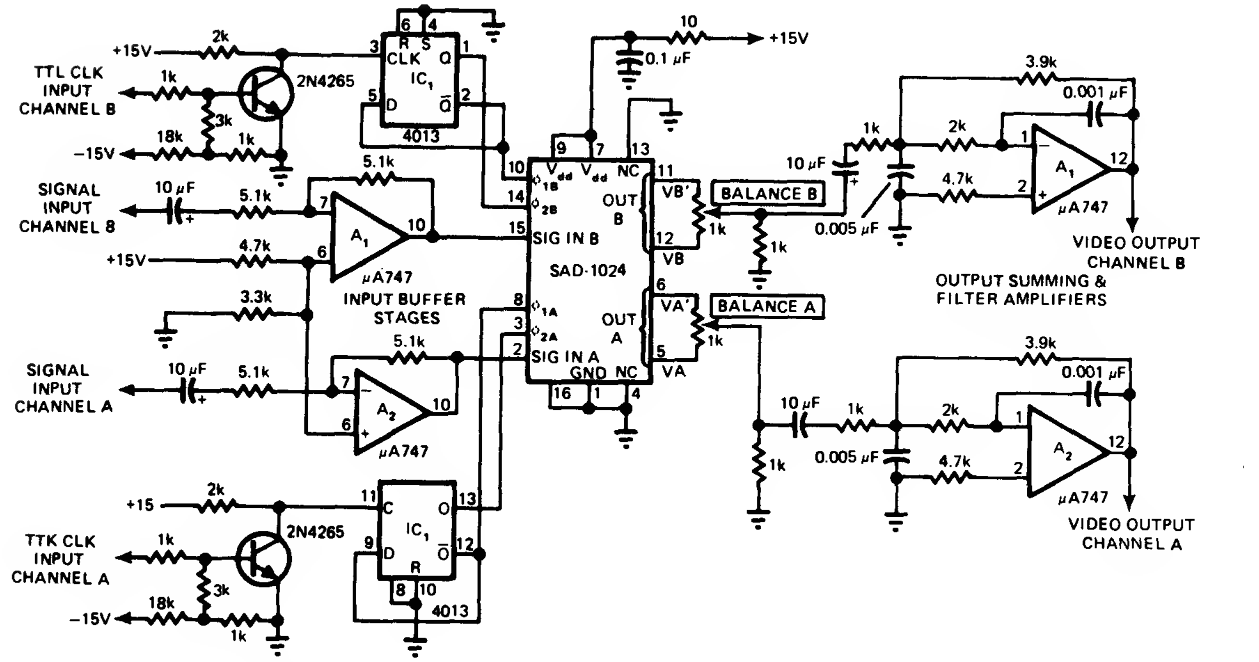
THREE-PART HARMONY—Four SC/MP microprocessors, one serving as conductor and three as instrumentalists, generate multiple parts for harmony feeding common loudspeaker system. Microprocessors have paralleled address and data buses, with 4K RAM connecting to lowest 4 bits of data bus. Each microprocessor is supplied with list of notes by note number and note lengths as part of software. At end of each basic note length, SC/MP1 checks each other processor to see if it is time to proceed to next note in list. If it is, next note is played by other processors until signaled by conductor via memory. Article gives software listing.—T. Doona, Quartet of SC/MP's Plays Music for Trios, *EDN Magazine,* Sept. 20, 1978, p 57–58 and 60.



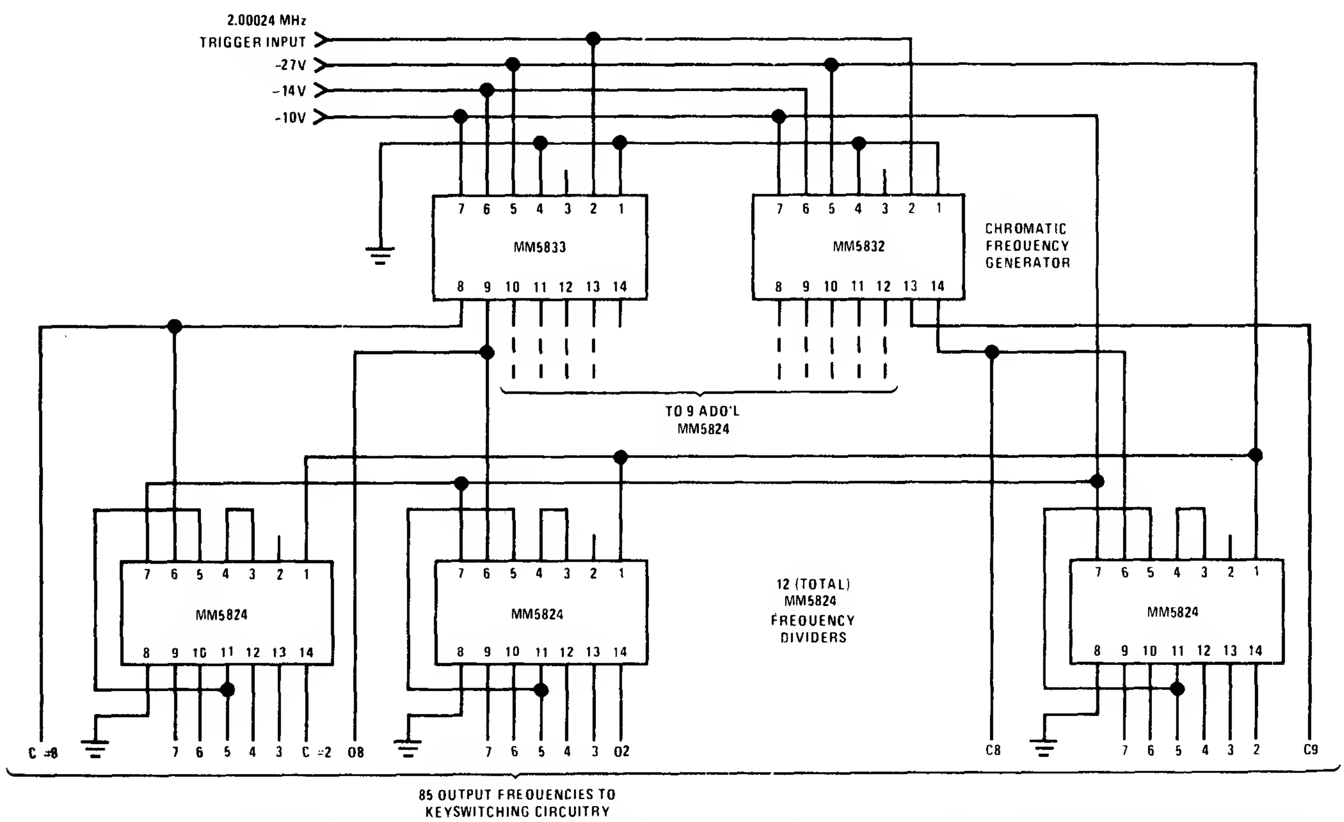
WIDE-RANGE UJT ORGAN—Combination of five individual resistor switches and three-capacitor range switch gives 15 different audio frequencies for demonstration electronic organ oscillator feeding power amplifier and loudspeaker. R1 is adjusted for best combination of sounds. Any number of capacitors can be added. Battery drain is about 35 mA during operation. Pleasing tone sequence is obtained with resistor values of 6.8K, 8.2K, 10K, 12K, and 15K when range switch is set to 0.1 μF.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 37–43.



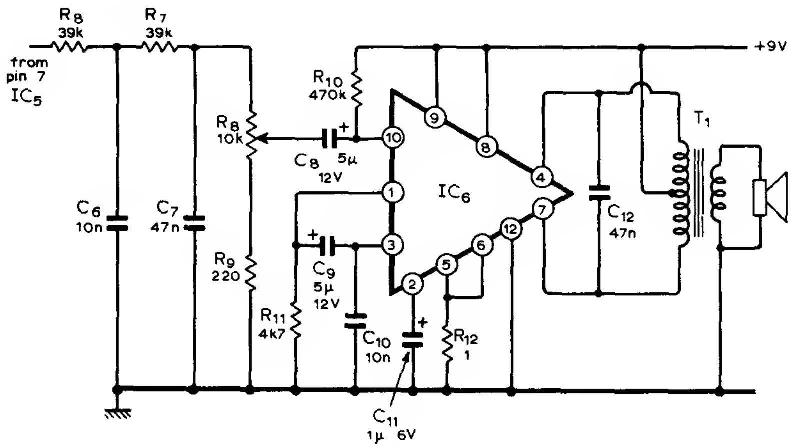
VOLTAGE-CONTROLLED FILTER—Used in elaborate sound synthesizer developed for generating wide variety of sounds. Serves as bandpass filter for which resonant frequency is linearly proportional to sum of input control voltages and a bias voltage. Can also be used as notch filter or as spectrum analyzer. Three-part article describes operation in detail and gives all other circuits of synthesizer. Supply voltages are 15 V, with polarity as indicated.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 2—Sept. 1973, p 429–434 (Part 1—Aug. 1973, p 366–372; Part 3—Oct. 1973, p 485–490).



CCD DELAY FOR SPECIAL EFFECTS—Besic bucket-brigade device incorporatad in Reticon Corp. SAD-1024 charge-coupied-device deley iine can synthesize such interesting audio-system deley effects as reverberetion anhencement, chorus, end vibreto generetion. Other applications include spaech compression end voice scrambling. Eveiuation circuit shown wes deveioped by menufacturer. Input ciock frequency is 200 kHz, end signei input is 5-kHz sine weve. Article describes operation of evaluetion circuit in deteil and presents variety of practical epplicetions.—R. R. Buss, CCD's improve Audio System Performance end Generete Effects, *EDN Magazine,* Jen. 5, 1977, p 55–61.

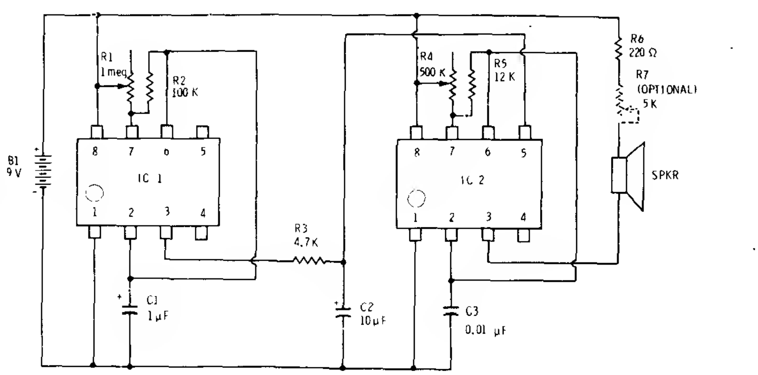


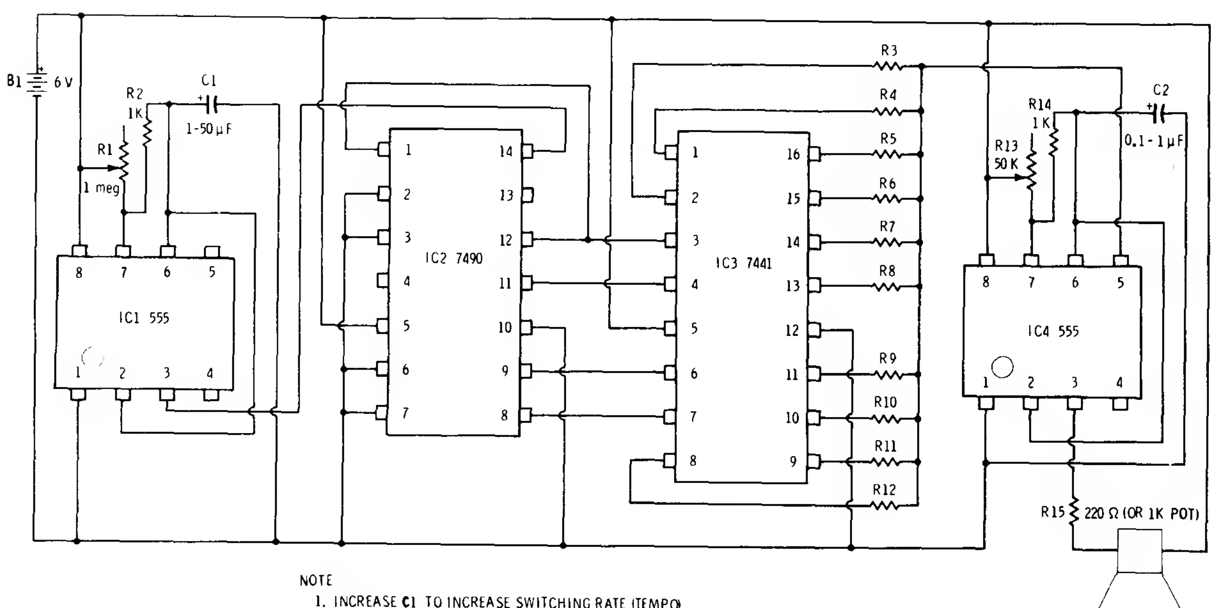
ORGAN TONE GENERATOR—Nationei MM5832 and MM5833 chrometic frequency generators ere used with 12 MM5824 fraquency dividars to ganerate 85 musical frequancies fuily spanning aquei-tampered octave. Can elso be used as celeste or chorus tone generator and es electronic music synthesizer. Square-wave input for organ is 2.00024 MHz but cen be as iow es 7 kHz for other applications.—"MOS/LSI Databook," Nationei Semiconductor, Sente Clara, CA, 1977, p 3-11–3-13.



PIANO-TUNING AMPLIFIER—Used with battery-powered digital tuning aid that provides 12 equal semitones of octave, between 261.6625 and 493.8833 Hz, for equal-temperament tuning of such keyboard instruments as organ, piano, and herpsichord. IC used is part of RCA amplifier kit KC-4003 which includes T_1 and other discrete components. Article gives circuits for oscillator and programmable divider, along with instructions for construction, calibration, and use.—W. S. Pike, Digital Tuning Aid, *Wireless World*, July 1974, p 224–227.

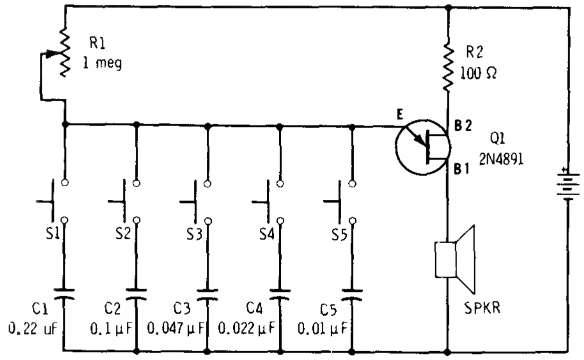
WARBLER—One 555 timer is connected as low-frequency square-wave generator that modulates second timer producing higher-frequency tone, to give warbling tone that can be varied with R1 and R4 to simulate siren or songs of certain birds. Will operate over supply range of 4.5–18 V. Use 8-ohm miniature loudspeaker, with optional volume control R7 in series.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 29–35.



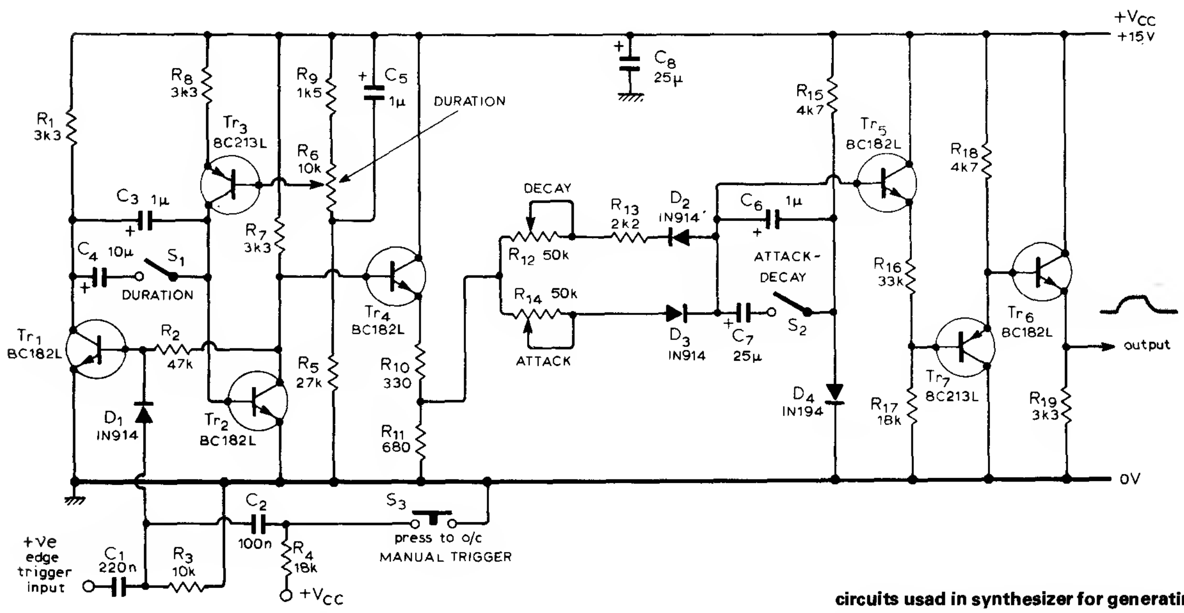


NOTE
1. INCREASE C1 TO INCREASE SWITCHING RATE (TEMPO).
2. INCREASE C2 TO INCREASE ALL TONE FREQUENCIES.
3. R3 - R12 ARE 1 ONE RESISTORS. (SEE TEXT FOR VALUES.)

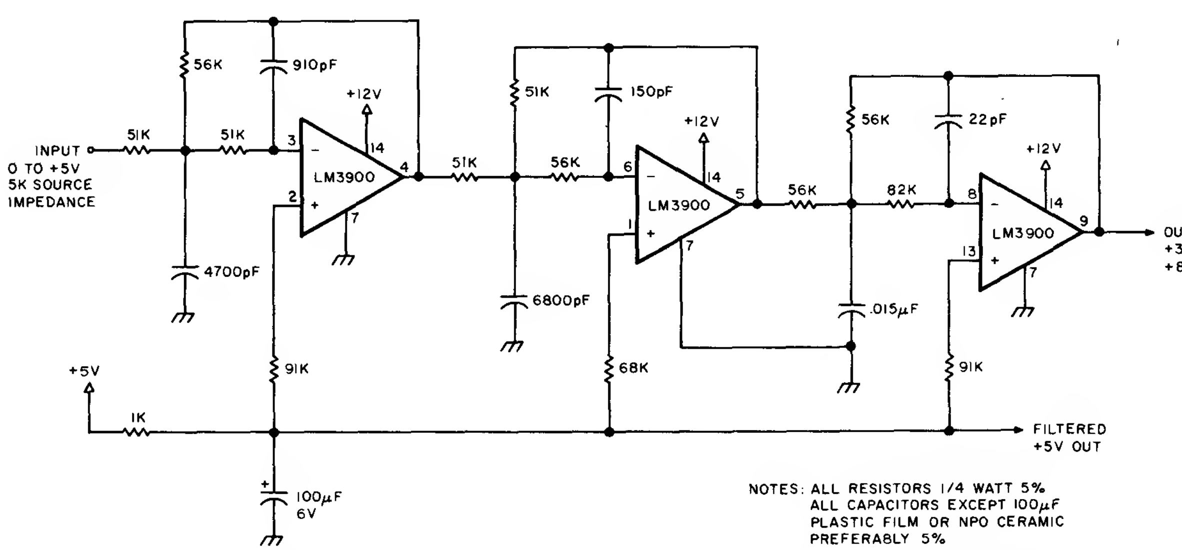
MUSIC SYNTHESIZER—555 timer is used as clock to set beat, adjustable with R1. Beat pulses drive flip-flop chain in 7490, which provides running total in binary format to 7441 1-of-10 decoder for conversion to decimal output. Each of ten outputs feeds through tone-controlling resistor to modulation input terminal of another 555 used as voltage-controlled AF oscillator feeding loudspeaker. Values used for resistors determine frequencies of ten notes that are generated in sequence repeatedly. R3-R12 can be 1000-ohm pots, so ten-note tune being played can be easily changed.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 61–70.



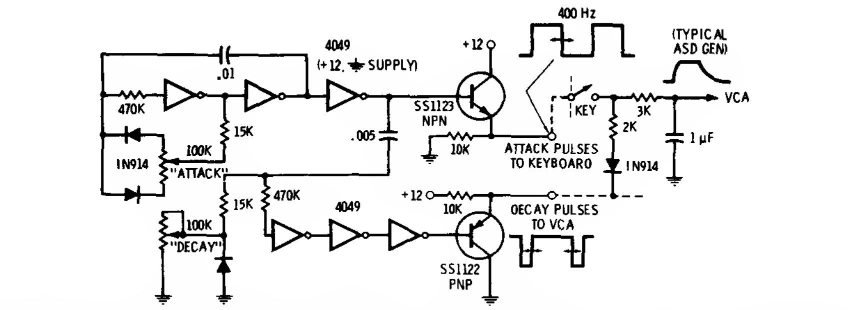
BASIC UJT ORGAN—Switches give choice of five eudio fraquencies for simple trensistor oscilletor driving loudspeaker. Adjust R1 for best combinetion of sounds. Capacitor values can be chenged to give other frequencies. Ideal for classroom demonstratlons.—F. M. Mims, "Electronic Music Projects, Vol. 1," Redio Sheck, Fort Worth, TX, 1977, 2nd Ed., p 37–43.



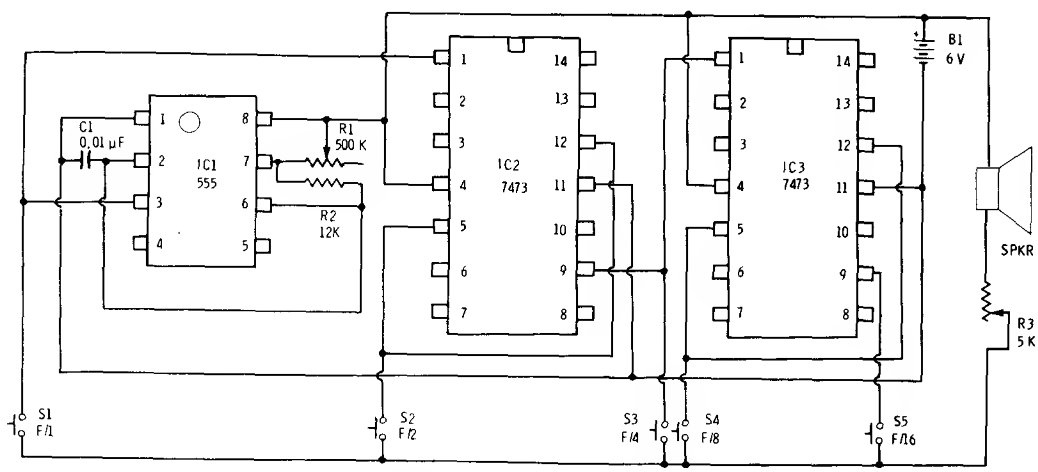
ATTACK/DECAY—Weveform generator produces approximete rectangular weveform heving exponentiel rise (ettack) and exponentiel dacay, initieted either by menuel trigger or electronic signal derived from other circuits of sound synthasizer. All charecteristics of waveform ere arbitrarily verlabla. Three-part article describes circuit operetion and gives ell other circuits usad in synthesizer for generating wide variety of musicel end other sounds.—T. Orr end D. W. Thomas, Electronic Sound Synthesizer, *Wireless World,* Part 3—Oct. 1973, p 485–490 (Pert 1—Aug. 1973, p 366–372; Pert 2—Sept. 1973, p 429–434).



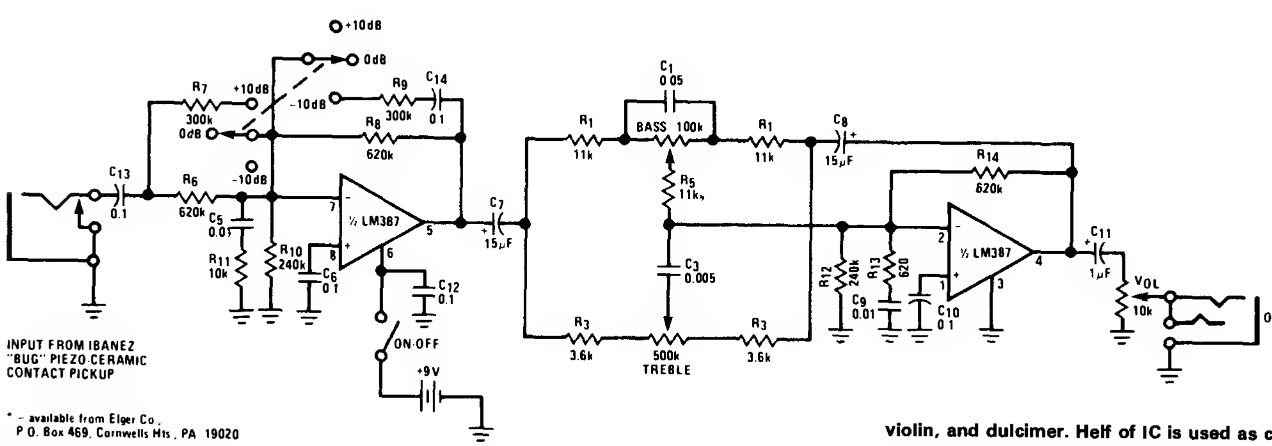
LOW-PASS WITH 3-kHz CUTOFF—Used in computer music system to suppress high-fidality distortion resulting from steps in sine-weve output of DAC. Article covers complete computer synthesis of music by microprocessor and gives frequency table, program for generating four simultaneous musical voices, end song teble for encoding "Tha Star Spangled Benner" in four-pert hermony, using 5 bytes per musicel event.—H. Chamberlin, A Sampling of Techniques for Computer Performance of Music, *BYTE,* Sept. 1977, p 62–66, 68–70, 72, 74, 76–80, and 82–83.



ATTACK-DECAY GENERATOR—Designed for polytonic electronic music system handling more than one note at a time. Each note to be controlled is sent through voltage-controlled amplifier (VCA) whose gain is set by charge on capacitor. Attack is changed by varying charging rate. Discharge rate sets decay of individual note. To avoid having separate adjustment pot for each VCA, duty-cycle modulation is used to change charging current through resistors. Attack pulses are generated by upper three inverters forming variable-symmetry astable MVBR. Decay pulses are generated by lower three inverters connected as half-mono MVBR. Additional half-monos can be added as needed for percussion, snubbing, and other two-step decay effects.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 231–232.



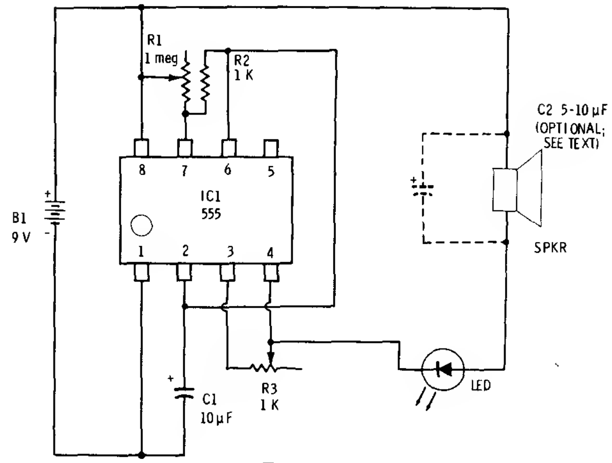
FOUR-OCTAVE ORGAN—Two 7473 dual flip-flops provide four frequency dividers for 555 timer connected as master tone generator. S1 gives fundamental frequency, and each succeeding switch gives tones precisely one octave lower. Four organ applications, pushbutton switches are added to timer circuit for switching frequency-controlling capacitors or resistors to give desired variety of notes.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 45–53.

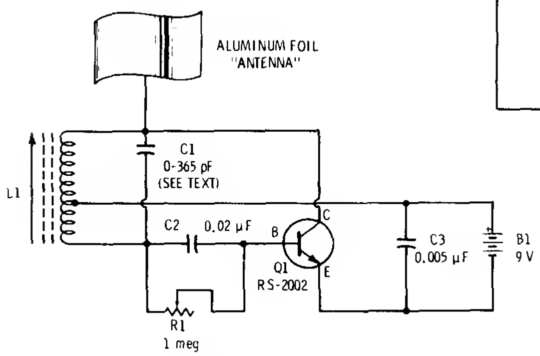


* – available from Elger Co., P.O. Box 469, Cornwells Hts., PA 19020

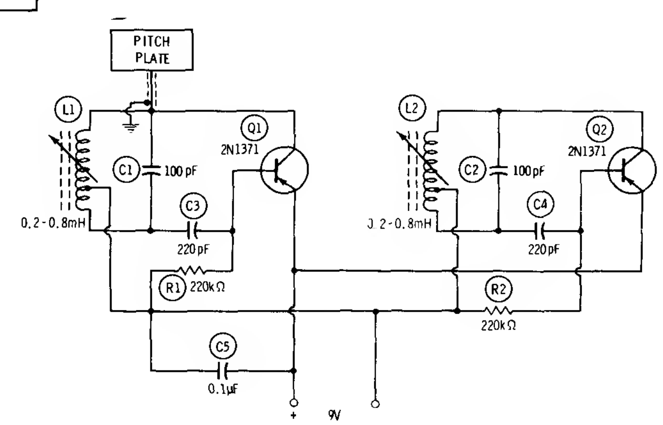
PREAMP FOR ACOUSTIC PICKUP—National LM387 dual opamp provides switchable gain choice of ±10 dB along with bass/treble tone control and volume control. Used with flat-response piezoceramic contact pickup for acoustic stringed musical instruments such as guitar, violin, and dulcimer. Half of IC is used as controllable gain stage, and other half is used as active two-band tone-control block.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-12.

AUDIBLE/VISIBLE METRONOME—Produces uniformly spacad baats in synchronism with flashes of LED, at rate that can be adjustad with R1 from ona baat evary few seconds to tan or more baats per second. Use red Rsdio Sheck 276-041 or similar LED. Add switch in series with battery to avoid disturbing setting of R1. R3 serves as volume control. Add 5–10 μF cspscitor scross loudspaaker to mallow beat sound if desirad.—F. M. Mims, "Electronic Music Projects. Vol. 1," Rsdio Shack, Fort Worth, TX, 1977, 2nd Ed., p 55–59.

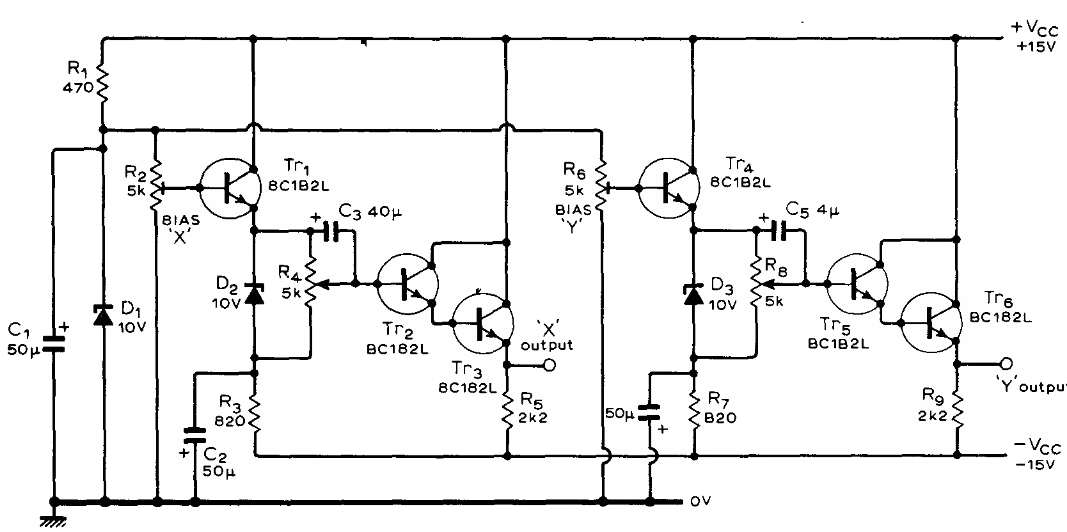




HAND-WAVING THEREMIN—Single-trensistor RF oscillstor is tuned to ganerete frequency about 455 kHz ebove oscillator fraquency of transistor radio. With aluminum-foil antanna away from naerby objects end radio tuned between stations, R1 is adjusted until high-pitched tona is heerd from redio. Now, es hand is brought towerd and eway from foil entenna, weiling sounds sra producad. With practica, musician csn produce racognizeble malodies by vibreting hand. Primery controls of frequency ere C1 (10–365 pF broadcast radio tuning capacitor) end adjustabla antenna coil L1 (Radio Sheck 270-1430). Redio can be up to 15 feet awey from theremin. Rotate redio for meximum pickup from L1.—F. M. Mims, "Electronic Music Projects, Vol. 1," Radio Sheck, Fort Worth, TX, 1977, 2nd Ed., p 81–89.



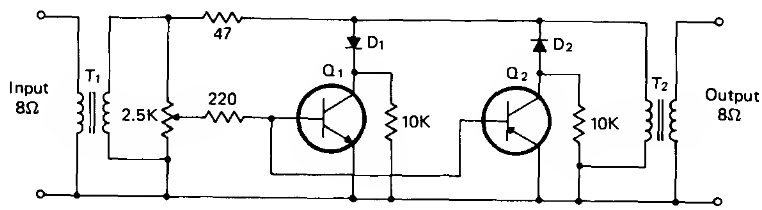
THEREMIN—Two transistor oscilletor stages ganereta separeta low-powar RF signel in broedcest band, for pickup by AM broedcest raceivar. Movamant of hand towerd or away from metal pitch plata varies frequency of Q1, making audio output of receiver vary correspondingly as baat fraquancy changes. Both circuits ara Hartley oscillators, using Miller 9012 or equivalent slug-tunad coils. To adjust initially, place next to radio and set tuning slug of L1 about two-thirds out of its winding. Set slug of L2 ebout ona-third out of its winding. Tune radio until either oscillator signal is haard. Signal can ba identified by whistla if on top of broadcast station or by quiating of background noisa if between stations. Adjust slugs so whistle is haard at desired location of quieting signal. Pitch of whistle should changa now as hend is brought near pitch plata.—J. P. Shields, "How to Build Proximity Datectors & Metal Locetors," Howard W. Sams, Indienapolis, IN, 2nd Ed., 1972, p 154–156.



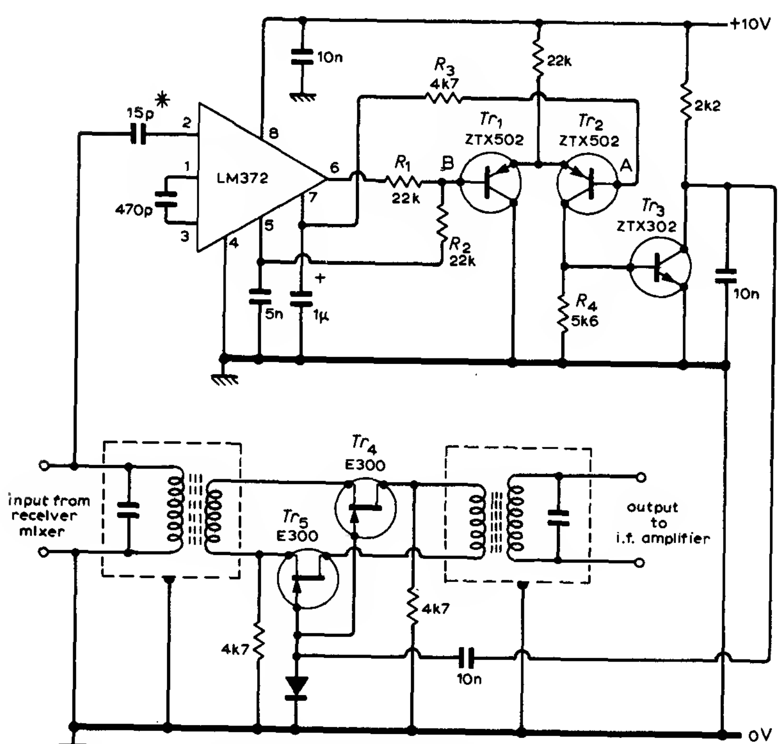
JOYSTICK CONTROL—Mechanically controlled voltage source generates two independent control voltages, proportional to stick position, to serve es ona of controls for elaborsta sound synthasizer used for generating wide variety of musical end othar sounds. Three-pert erticla describes circuit operetion end gives ell other circuits used in synthasizer.—T. Orr end D. W. Thomes, Electronic Sound Synthesizer, *Wireless World*, Pert 3—Oct. 1973, p 485–490 (Part 1—Aug. 1973, p 366–372; Part 2—Sept. 1973, p 429–434).

CHAPTER 58
Noise Circuits

Includes many types of noise limiters, blankers, and filters for audio, IF, RF, and digital applications, along with suppression of noise from arcing contacts and motors. Circuits for white-noise and pink-noise test-signal generators are also given.

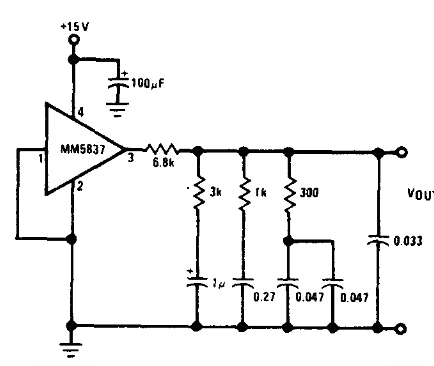


AF-POWERED CLIPPER—Designed for use just ahead of 8-ohm loudspeaker in receiver covering lower amateur phone bands (75 and 40 meters). Reduces hissing noise caused by shortwave diathermy, electric motors, and fluorescent lighting, as well as impulse noise generated by auto ignition system or atmospheric interference. T_1 and T_2 are transistor radio output transformers with 500:4 or 600:8 ohm impedance. Q_1 is 2N2222 NPN transistor. Q_2 is 2N2907 PNP transistor. D_1 and D_2 are 1N270.—C. Lester, An Audio Powered Noise Clipper, *CQ*, May 1976, p 26–27.

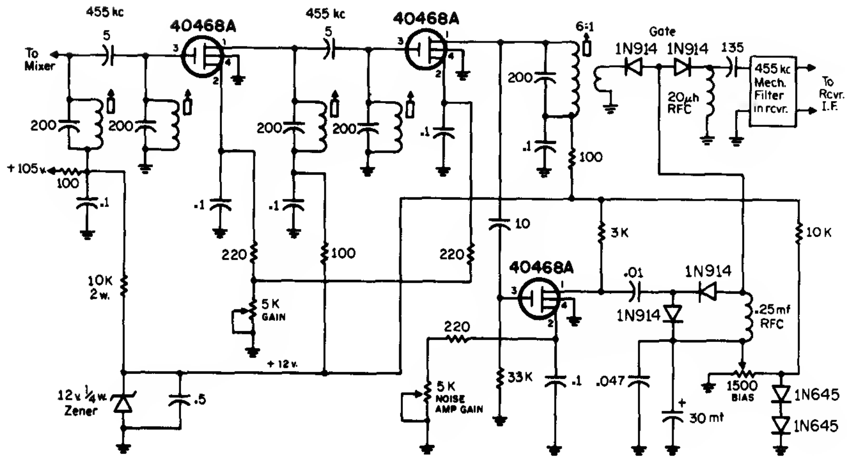


* select to avoid overload of LM372

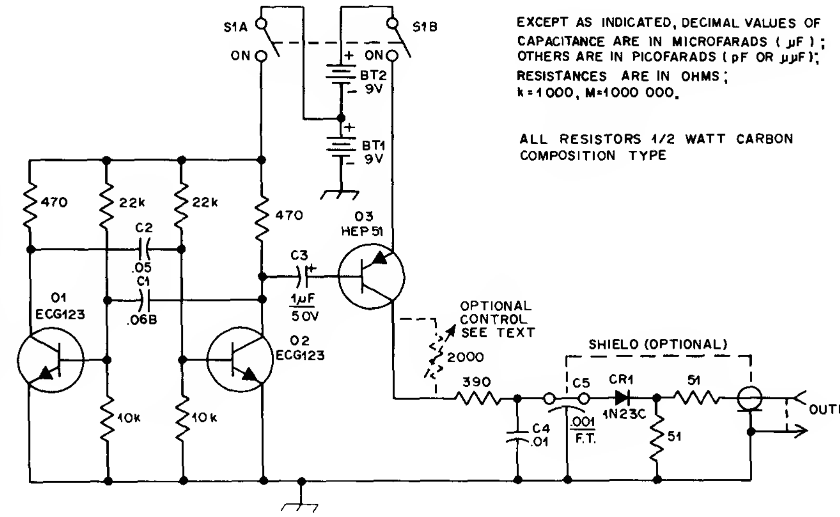
AM NOISE SILENCER—Circuit samples mixer output (IF input) of AM receiver end, when noise pulse is detected, interrupts IF input signal for duration of noise pulse. Uses National LM372 IC having AGC loop with range of about 69 dB, for accommodating wide range of input levels. Article describes operation of circuit in detail. For frequencies above 2 MHz, use LM373 in place of LM372.—T. A. Tong, Noise Silencer for A.M. Receivers, *Wireless World*, Oct. 1972, p 483–484.



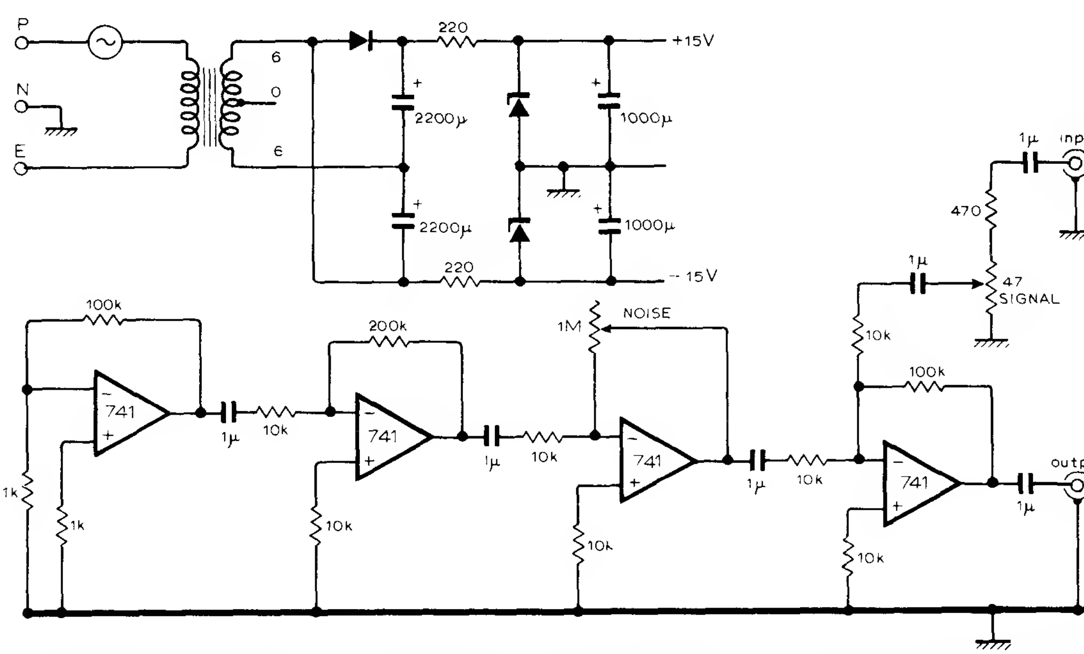
PINK-NOISE GENERATOR—Uses MM5837 broadband white-noise generator with −3 dB per octave filter from 10 Hz to 40 kHz to give pink-noise output having flat spectral distribution over entire audio band from 20 Hz to 20 kHz. Output is about 1 V P-P of pink noise riding on 8.5-VDC level. Used as controlled source of noise for adjusting octave equalizer to optimum settings for specific listening area.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-53–2-59.



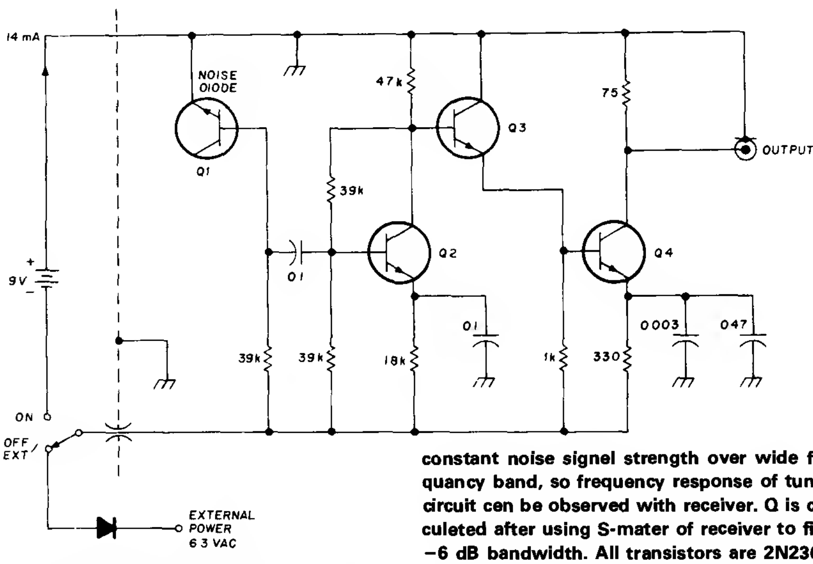
IF NOISE BLANKER—Used ahead of 455-kHz IF strip of communication receiver to provide about 40-dB attenuation of ignition and other noise pulses that can interfere with reception in 2- and 6-meter amateur bands. Two paths for noise pulses, one AC and the other DC, must be balanced for good operation. Rasistor and capacitor values in noise rectifier are chosen to select sharp noise pulses in prefarence to signals. DC noisa pulses are amplified by pulse amplifier and converted to AC noise pulses. Settings of pots are optimized for best noise blanking. Circuit requires 12-V supply, which can be obtained from receiver with appropriate dropping resistors and zener as shown for +105 V, or from separate source.—F. C. Jones, Experimental I.F. Noise Blankers, *CQ*, March 1971, p 81–83.



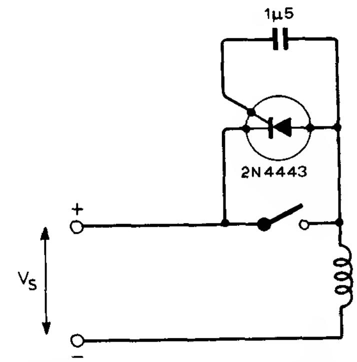
EXCESS-NOISE SOURCE—Devalops about 18 dB of excess noise in region of 50–300 MHz for optimizing converter or receiver for best noise figure. Can also be used for noise optimizing of TV receivers and for peaking UHF TV front ends. Q1 and Q2 form croas-coupled 700-MHz MVBR. C1 is greater than C2 to favor conduction of Q2. When Q2 is on, Q3 tums on and makes current flow through broadband noisa dioda CR1. Diode is forward-biased because available gating voltage does not generate enough noise in reverse-bias mode. If noise output is too great, Insert 2000-ohm attenuator as shown.—T. E. Hartson, A Gated Nolse Source, *QST*, Jan. 1977, p 22–23.



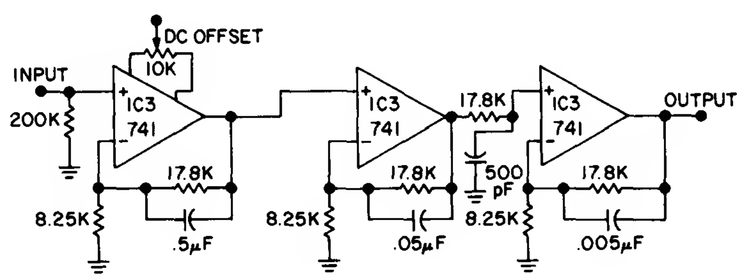
50–5000 Hz WHITE NOISE—Both signal and noise levels are continuously and independently variable from zero to maximum in simple noise generator developed to demonstrate recovery of low-level 500-Hz signal from noise. Circuit gives maximum noise output into 1500-ohm load; for lower load impedances, reduce noise level to prevent oscillation. Opamps require ±15 V aupply, which can be simple voltage doubler without regulation.—J. E. Morrla, Simple Noise Generator, *Wireless World*, April 1977, p 62.



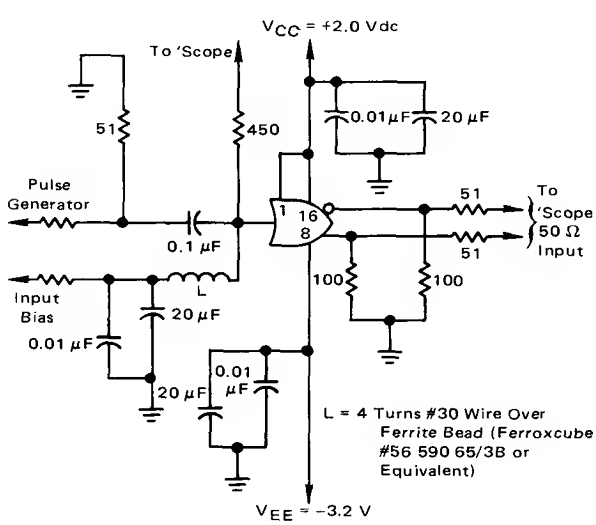
NOISE GENERATOR—Used with communication receiver to measure Q of tuned circuit without disconnecting circuit. Noise diode gives constant noise signal strength over wide frequency band, so frequency response of tuned circuit can be observed with receiver. Q is calculated after using S-meter of receiver to find −6 dB bandwidth. All transistors are 2N2368; select noisiest for Q1. Article covers test setup for measuring Q.—R. C. Marshall, Q Measurement and More, *Ham Radio*, Jan. 1977, p 49–51.



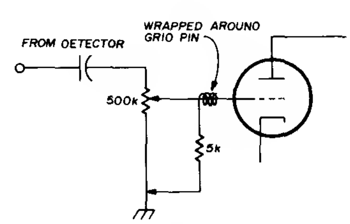
THYRISTOR SPARK QUENCHER—Suppresses arcing at contacts when switching large inductive loads. Use SCR capable of operating at well over twice supply voltage and passing full load current during switch-off. SCR shown will handle up to 500 V at up to 80 A provided current pulses are under 8 ms.—E. Potter, Switch Spark Quench for Inductive Loads, *Wireless World*, Dec. 1973, p 605.



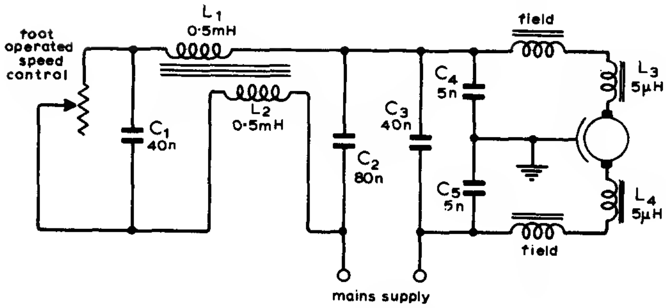
PINK-NOISE FILTER—Used in acoustics for measuring transducer characteristics, absorption-reflection and transmission coefficients of materials, and room parameters such as reverberation time. Offsets falloff of detected noise signal at low frequencies by using filter shown to convert random-noise source from constant energy per hertz (white-noise frequency spectrum) to constant energy per octave (pink-noise response). Filter covers audio range from 10 Hz to 20 kHz, providing −20 dB per decade transmission characteristics with three 741 opamp stages. Frequency characteristic is independent of source and load impedances. Supply voltages can be from ±6 to ±18 V.—R. Mauro, Simple Pink Noise Filter, *Audio*, March 1977, p 36 and 38.



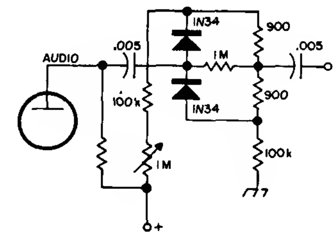
INPUT NOISE TEST CIRCUIT—Used for measuring noise immunity of emitter-coupled logic to transient signal on input line. Supply voltages used permit terminating logic outputs to ground through 50-ohm CRO probe. Accurate bias provided by power supply is used to set input logic levels. 450-ohm resistor is used in series with 50-ohm input of CRO to isolate input; this gives 10:1 amplitude attenuation while still providing accurate picture of input noise.—B. Blood, "AC Noise Immunity of MECL 10,000 Integrated Circuits," Motorola, Phoenix, AZ, 1972, AN-592.



CURE FOR NOISY CONTROL—Connecting 5K resistor between grid of first AF stage and ground as shown substantially reduces noise generated by worn volume-control pot in older tube-type communication receiver. Modification can be made from top of chassis by wrapping piece of wire around grid pin of audio tube, bringing wire up alongside tube and out through top of shield, then soldering 5K resistor between wire and chassis.—J. Schroeder, Temporary Fix for Noisy Volume Controls, *Ham Radio*, Aug. 1974, p 62.

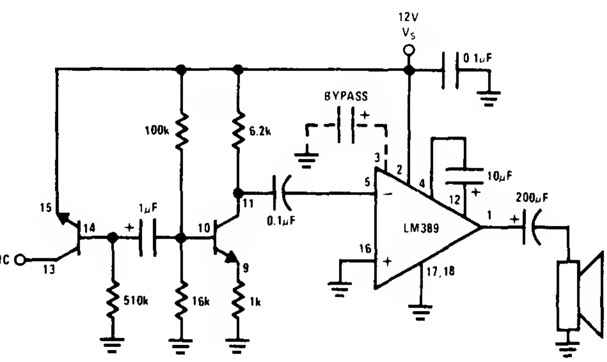


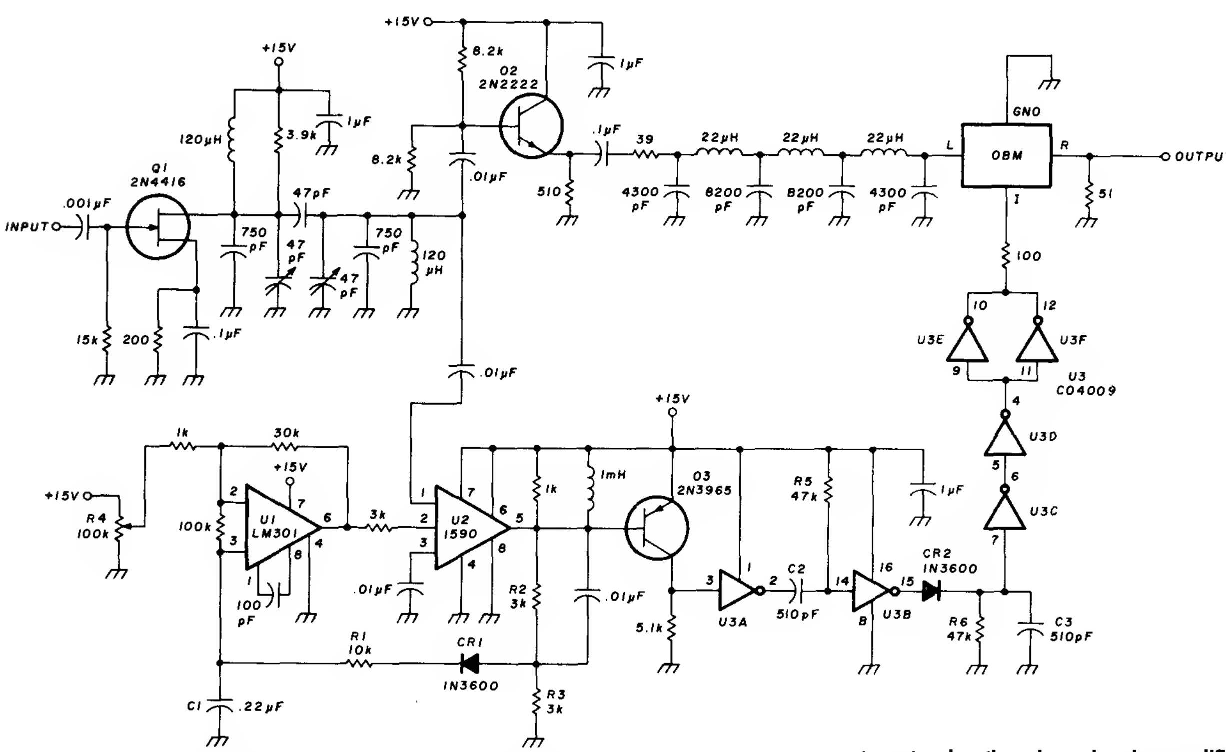
SEWING-MACHINE SUPPRESSION—Circuit is used to suppress clicks from speed control as well as interference produced by motor itself in sound and television broadcast bands.—A. S. McLachlan, J. H. Ainley, and R. J. Harry, Radio Interference—a Review, *Wireless World*, June 1974, p 191–195.



AF NOISE LIMITER—Trough limiter eliminates background noise that is normally passed by conventional limiters, to permit use of higher volume level without annoying static when monitoring single radio channel continuously.—Circuits, *73 Magazine*, Dec. 1973, p 120.

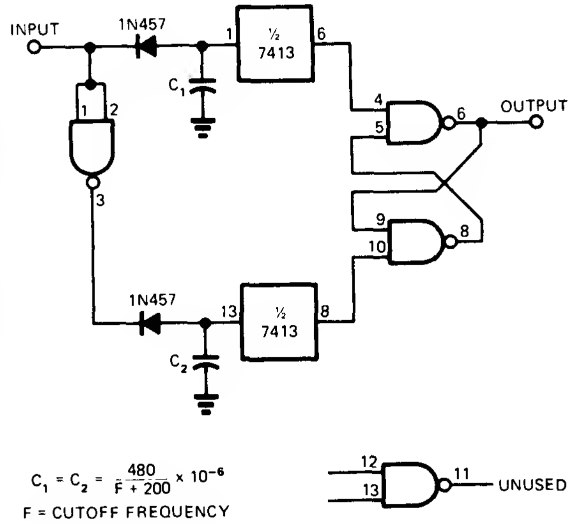
ZENER GENERATOR—Uses National LM389 array having three transistors along with opamp. Application of reverse voltage to emitter of one grounded-base transistor breaks it down in avalanche mode to give action of zener diode. Reverse voltage characteristic, typically 7.1 V, is used as noise source for amplification by second transistor and power opamp. Third transistor (not shown) can be used to gate noise generator if desired.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.

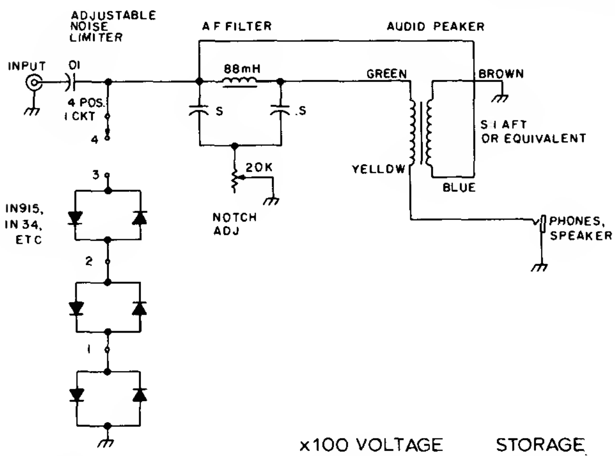




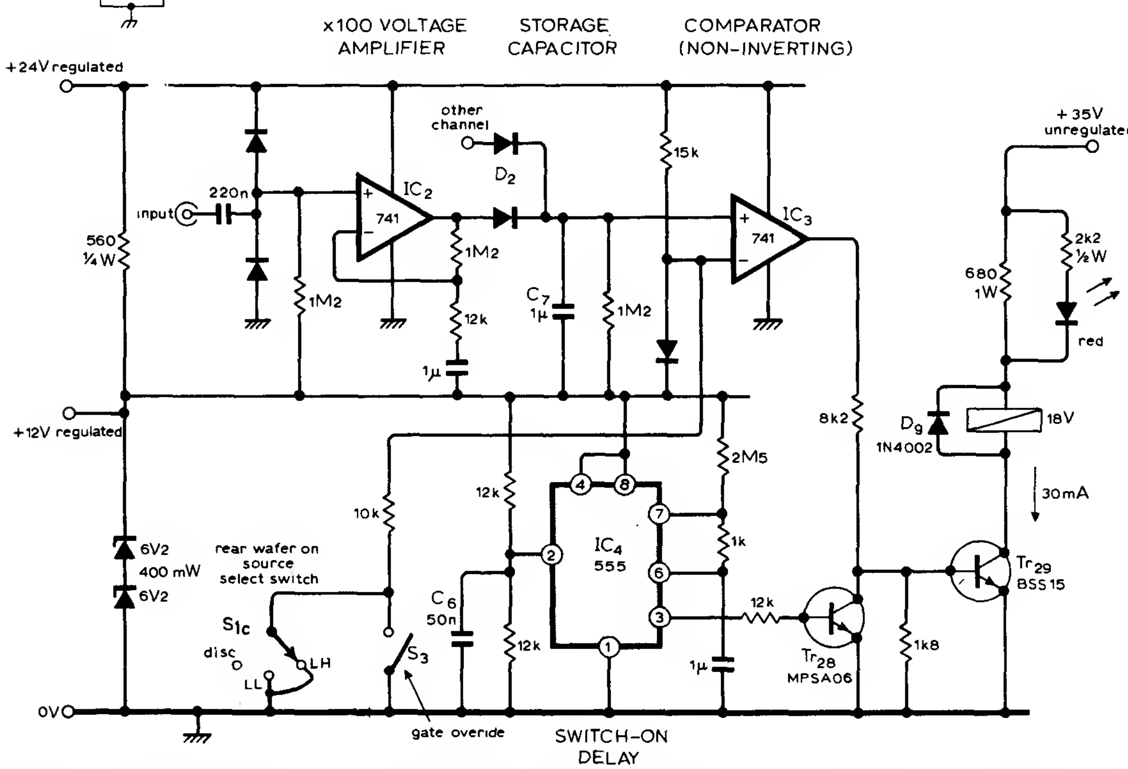
NOISE BLANKER—Minimizes effects of short-duration high-amplitude low-repetition-rate noise such as auto ignition noise, power-line arcing, and make-or-break switching. Developed for use in Collins ARR-41 receiver, where it is inserted between plate of second mixer and 500-kHz first IF amplifier. Q1 and its double-tuned drain circuit form low-gain bandpass amplifier that removes remaining local oscillator signal and sets bandwidth at about 50 kHz. Signal is then split into two channels. Q2 in main channel drives 50-ohm low-pass delay network with 700-kHz cutoff, feeding double-balanced mixer DBM operated as current-controlled attenuator. In other channel, noise amplifier U2 drives pulse detector Q3 and AGC detector CR1. Opamp U1 amplifies AGC and controls gain of U2. R4 is threshold adjustment. Gates U3B and U3C form mono used with gates of U3 to develop proper phase and current amplitude for operating blanking gate.—W. Stewart, Noise Blanker Design, *Ham Radio*, Nov. 1977, p 26–29.

LOW-PASS DIGITAL FILTER—Used to retrieve pulse train data from noisy signal line. Filtering is achieved with SN7400 quad two-input NAND gate, SN7413 dual four-input Schmitt trigger, two diodes, and two capacitors. One gate of SN7400 is used as inverter driving pulse delay operating on negative-going transition of input signal. Other Schmitt trigger, diode, and capacitor provide delay on positive-going transition. Any additional pulses occurring during delay-circuit time-out resets delay time without affecting output.—T. H. Haydon, Low-Pass Digital Filter, *EDN Magazine*, Nov. 20, 1973, p 85.

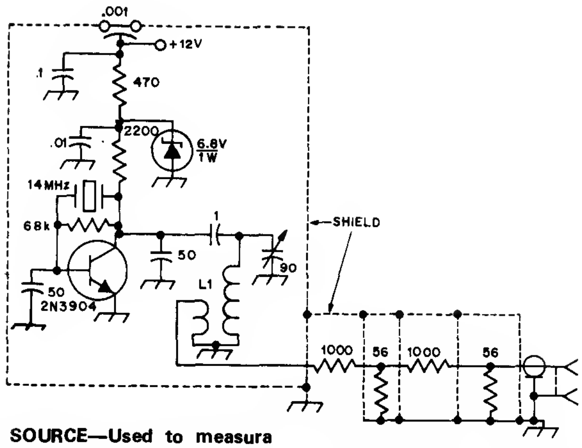




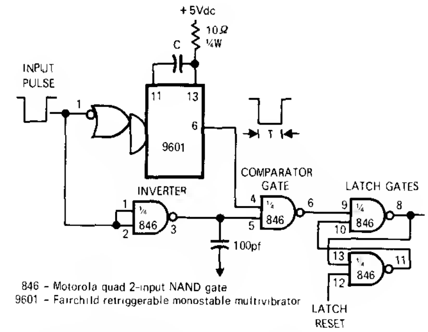
NOISE CONTROL—Circuit is plugged into headphone jack of amateur receiver. Four-position rotary switch selects desired combination of noise-limiting diodes for handling progressively more severe noise pulses. Adjustable AF T-notch filter limits passband over sufficient range for both phone and CW. Inductor is common 88-mH toroid. Audio peaker circuit overcomes insertion losses of filters.—S. T. Reppold, Noise Rejector, *73 Magazine*, Sept. 1977, p 116.



NOISE GATE FOR AF PREAMP—Used in high-performance phono preamplifier to mute output when there is no signal at phono input. Opamps each provide gains of about 100. Circuit controls muting reed relay serving both stereo channels of preamp. Delay switch-on using 555 IC overrides noise-gate opamps. Unmarked diodes are 1N914 or equivalent, and red LED is TIL209 or equivalent. Article covers circuit operation in detail and gives all other circuits of preamp.—D. Self, Advanced Preamplifier Design, *Wireless World*, Nov. 1976, p 41–46.

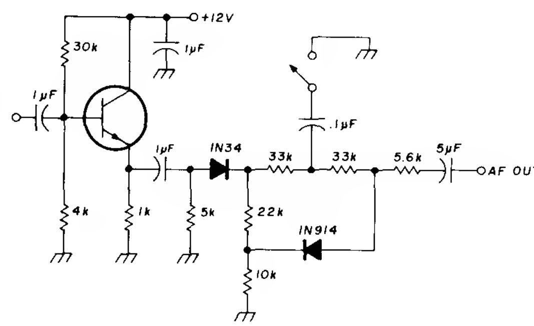


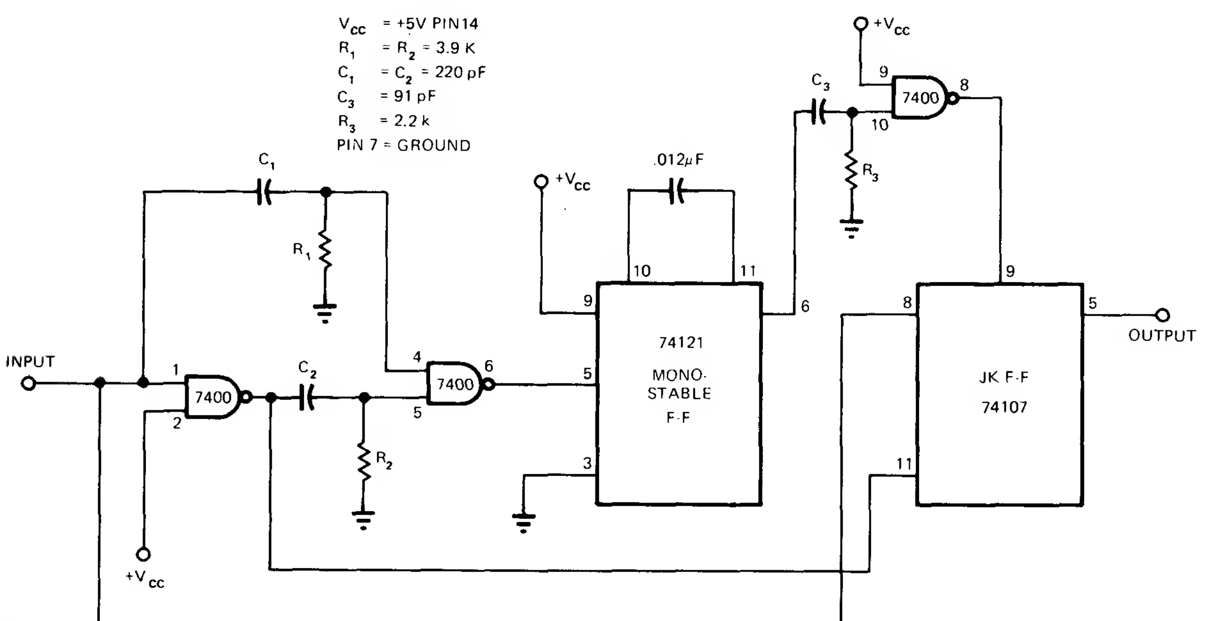
LOW-LEVEL RF SOURCE—Used to measura noiae floor of receiver undar test. RF sourca is simpla, well-shielded cryatal-controlled oscilla-tor that is dacouplad from battery supply. After attenuator resistors are edjusted to provide about S7 signel in raceivar, oacillator housing Is sealad with solder. Once calibrated, RF source is comparable to commercial signal generator, as leakega is quite low. Output is −112 dBm at 14 MHz. L1 has 24 turns enamal on Amidon T50-6 toroid, with 1 turn for output link.—W. Hay-ward, Defining and Measuring Raceivar Dy-namic Range, *QST,* July 1975, p 15–21 and 43.



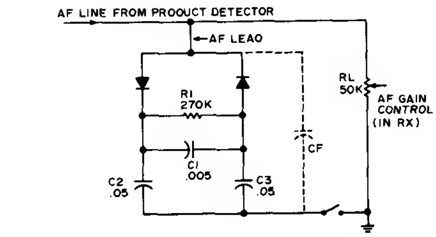
NOISE-RESISTANT LATCH—Falsa triggering of latch gates by nolsa spikes is prevanted by gen-erating pulse T whose width is equal to mini-mum width of desired input pulse. Valuas used for RC combinetion set T. If R is chosen as 10 kilohms, C should be T/3.424, whara C is in pi-cofarads and T is in nanosaconds.—S. R. Martin, Latching Circuit Provides Noiae Immunlty, *EDN/ EEE Magazine*, Feb. 1, 1972, p 56.

AF NOISE LIMITER—Oparation is similar to that of delay lina. Voltage daveloped across voltage divider at output of 1N34 germenium diode is instantanaous, whila DC voltaga at output of circuit is dalayad. If no pulsas ere prasant end 0.1-μF capacitor ia not at ground, 1N914 silicon diode will have floating voltega. High positive pulses cherge capacitor, and sllicon diode shorts audio voltage. Negative pulses disabla germanium diode directly. Circuit thus acts as noise blankar in both diractions. Used in Euro-paan communication racaivars. Trensiator type is not critical.—U. L. Rohde, IF Amplifiar Dasign, *Ham Radio,* March 1977, p 10–21.



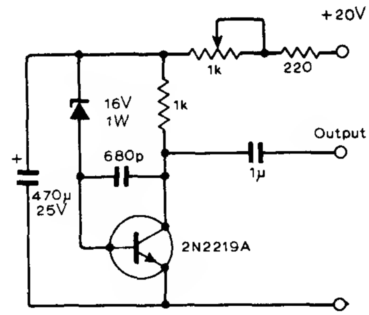


SPIKE REJECTION—Used to aliminete noise that may be prasent on signal line. Based on sampling input line at fixed time after aach de-tected trensition. If transition was due to noisa spika, spike will no longer be present end trua signal level will be sampled. If transition was caused by desirad legitimata signal, samplad waveform represents true signel daleyed by pulsa width of mono MVBR. Mono pulse width is ebout 12 μs. Article givas circuit waveforms and describes operation in detail.—A. S. Bo-zorth, Pulse Verification Yields Good Noise Im-munity, *EDN Magazine,* Nov. 5, 1973, p 75 and 77.

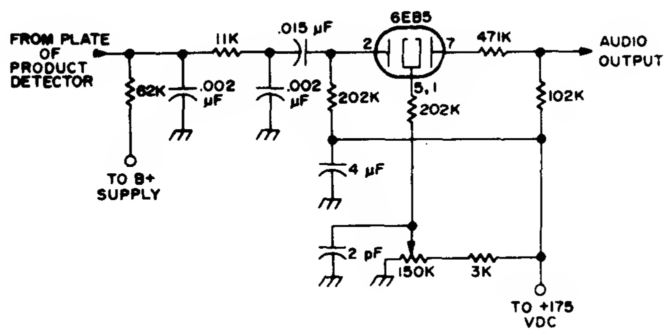


RL	R1	C1	C2,C3	CF
10K	50K	.022	.22	.005
50K	270K	.005	.05	.001
1 MΩ	5 MΩ	.001	.01	50 pF

AF NOISE LIMITER—Audio signals rectified by diodes develop bias across R1 and C1 such that diodes are back-biased. Diodes thus conduct and clip only when noise signal peaks exceed bias level. Component values depend on impedance of audio circuit; table gives values for three common load resistors. Diodes are fast-switching silicon such as 1N916. To minimize residual clipping distortion, use value for CF that gives 3-dB rolloff at about 2.5 kHz.—P. Lovelock, The Audio Bishop, *73 Magazine*, Sept. 1974, p 75–76.



EMERGENCY NOISE GENERATOR—Simple circuit generates noise in audio range at wideband level adjustable with 1K pot from 0 to over 1 V. If 680-pF capacitor is omitted, noise output goes up to 30 MHz with wideband level more than 5 V.—D. Di Merio, Simple Noise Generator, *Wireless World*, May 1978, p 70.



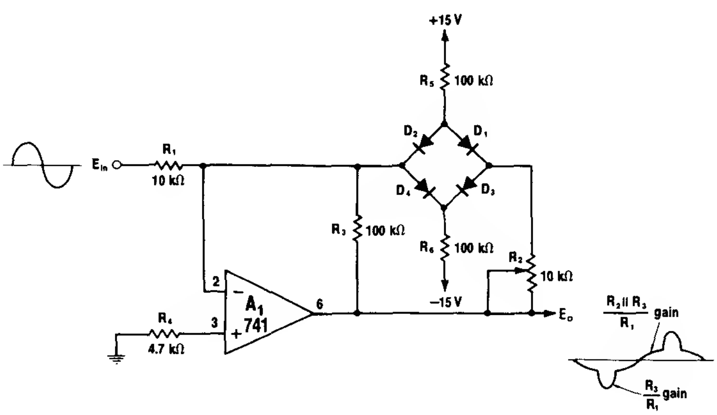
SSB CW NOISE LIMITER—Simple limiter is easy to install in receiver having good product detector. In place of dual-diode tube, semiconductor diodes having high front-to-back ratio may be used.—Novice Q & A, *73 Magazine*, Holiday issue 1976, p 20.

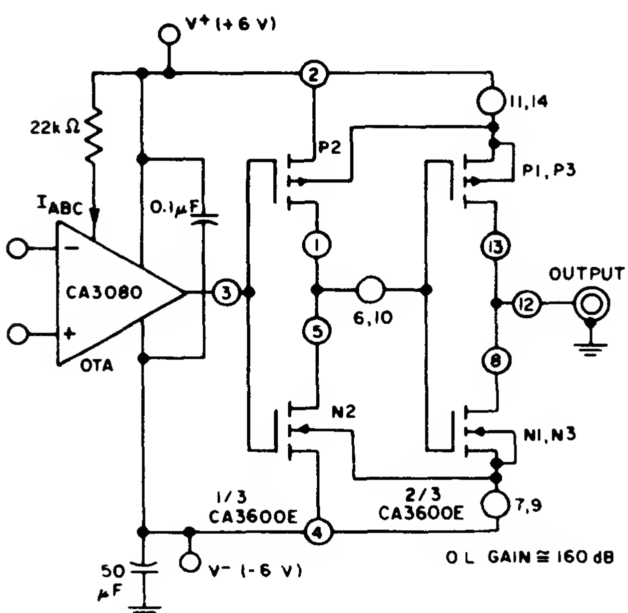
CHAPTER 59

Operational Amplifier Circuits

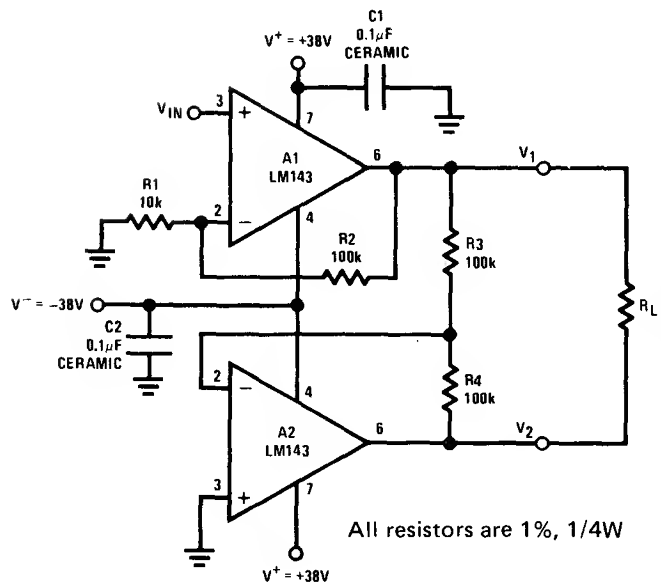
Versatility of modern opamps is illustrated by variety of amplification, control, signal processing, and other general-purpose functions involving frequencies ranging from DC to many megahertz. More specific applications will be found in practically all other chapters.

VARIABLE DEAD-BAND RESPONSE—Diode bridga in feedback loop of opamp provides controlled amount of dead-band rasponsa. As value of R_2 is increased from 0 ohms, voltage devaloped across R_2 sarves to raise dead-band level at which bridge opens and circuit amplifies with normal gain of R_3/R_1. Balow dead-band leval, bridga ia blocked and circuit gain is equal to parallal combination of R_2 and R_3 divided by R_1. Usa matched diodes such as CA3019 for peaks below ±7 V; for highar peaks, usa 1N914s.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 207.

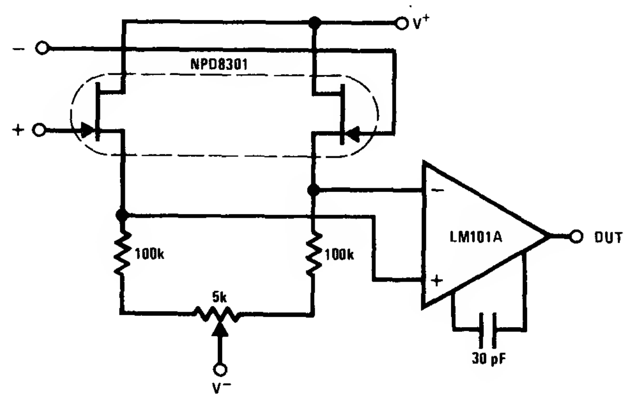




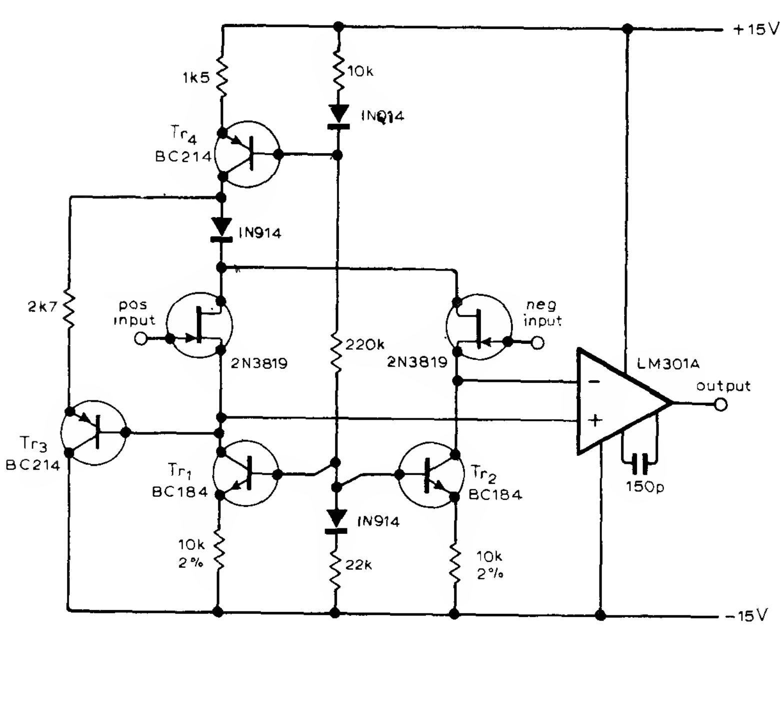
TWO-STAGE POSTAMPLIFIER—Connactiona shown for CA3600E CMOS transistor-pair array giva total open-loop gain of about 160 dB for systam. Opan-loop slaw rate is about 65 V/μa.—"Linear Integratad Circuits and MOS/FET's," RCA Solid State Division, Somarvilla, NJ, 1977, p 278–279.



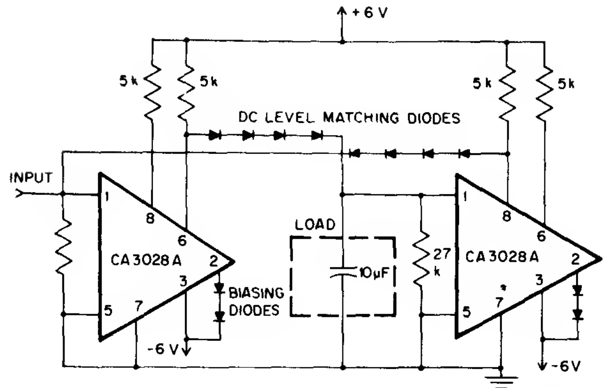
130 V P-P DRIVE—Two LM143 high-voltage opamps operating from 38-V supply can provide up to 138 V P-P unclipped into 10K floating load when connected as shown to give noninverting voltaga amplifiar followed by unity-gain inverter. Power supplias should ba bypassed to ground with 0.1-μF capacitors.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 1–3.



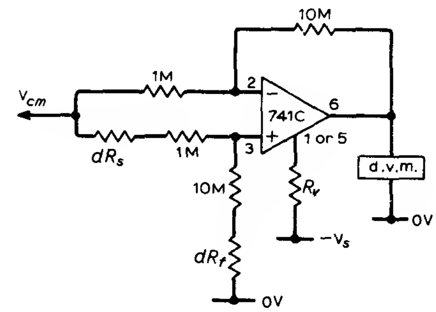
BUFFERED OPAMP—NPD8301 dual FET is ideal low-offset low-drift buffer for LM101A opamp. Matched sactions of FET track wall over entlre blas range, for Improved common-mode rajaction.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



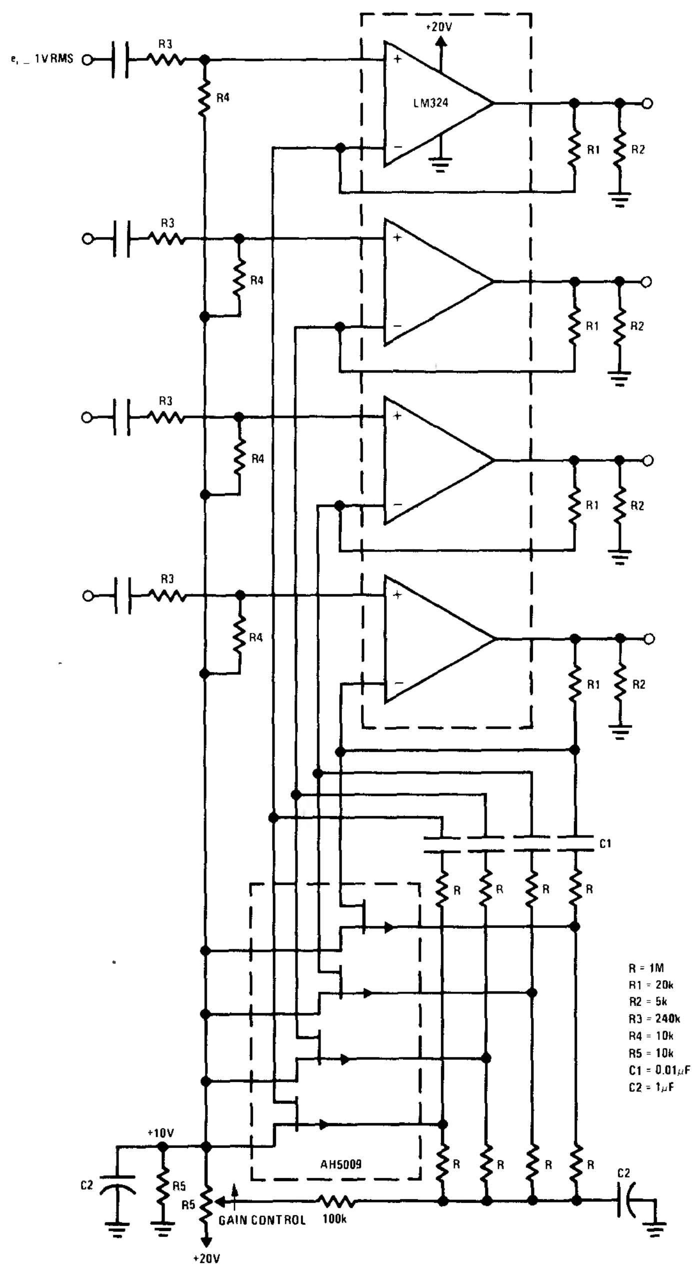
LOW-COST FET-INPUT—Uses two 2N3819 FETs as differential source-follower oparated at constant source current of 200 μA providad by Tr_1 and Tr_2. Input performance is comparable to that of more expensive commercial units. Match FETs to reduca thermal drift. Trim input offset voltage to zero by adding resistor in appropriate FET source. Input impedance of circuit is greater than 10^{13} ohms.—J. Setton, F.E.T.-Input Operational Amplifier, *Wireless World,* Nov. 1976, p 61.



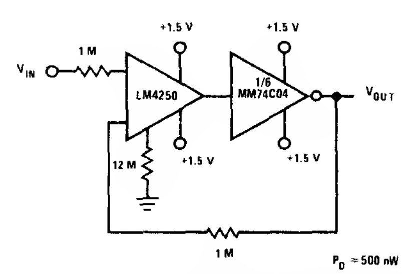
12-μH GYRATOR—Two RCA opamps in gyrator loaded with 10-μF capacitor give effective 12-μH inductor that ramains constant in value over range from 10 Hz to almost 1 MHz. Q varies from 1 at 10 Hz to maximum of 500 at 10 kHz. Article gives design equations.—A. C. Caggiano, Simple Gyrator for L from C, *EEE Magazine*, Aug. 1970, p 78.



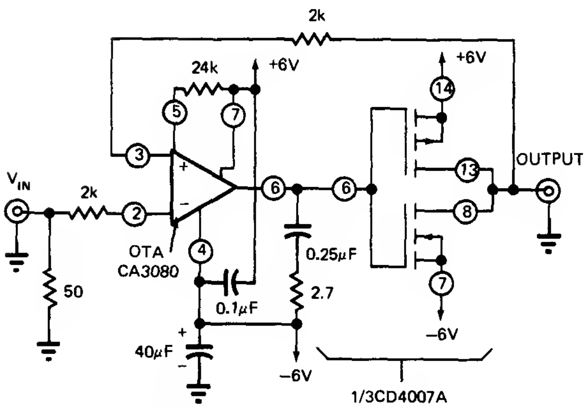
OPTIMIZING CMR—Article covers procedures for optimizing common-mode rejection when opamp is used to drive digital voltmeter. Value of R_v is determined by using resistance box connected between negative supply and pin 1 or 5 while other pin is shorted to negative supply, choosing pin which gives voltage swing in right direction on meter, then adjusting resistance box for zero output. Resistance box is similarly used at dR_s and dR_f locations.—R. J. Isaacs, Optimizing Op-Amps, *Wireless World*, April 1973, p 185–186.



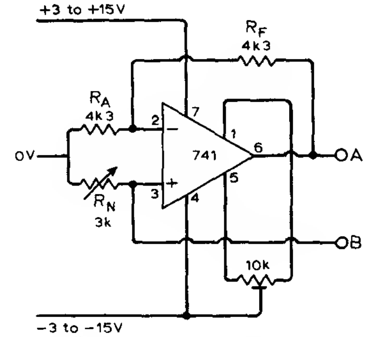
TRACKING QUAD GAIN CONTROL—Basic circuit for each channel uses section of National LM324 quad opamp with section of AH5009 quad FET in feedback path. Each channel is AC coupled and has 40-dB range (gain range of 1 to 100). Bandwidth is minimum of 10 kHz, and S/N ratio is better than 70 dB with 4.3-VRMS maximum output.—J. Sherwin, "A Linear Multiple Gain-Controlled Amplifier," National Semiconductor, Santa Clara, CA, 1975, AN-129, p 6.



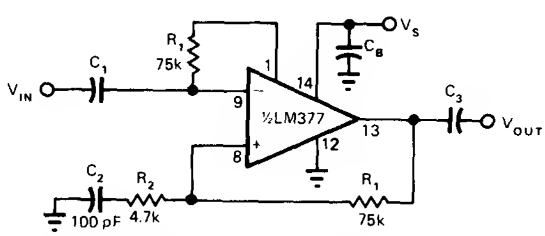
POSTAMPLIFIER FOR OPAMP—High input impedance of National MM74C04 inverter makes it ideal for isolating load from output of LM4250 micropower opamp operating from single dry cell.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-88, p 2.



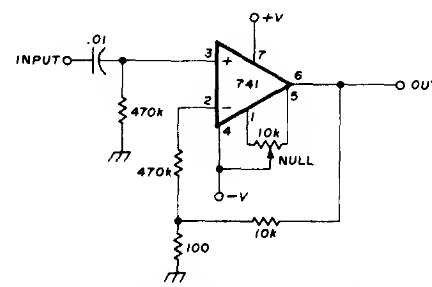
CMOS DRIVER FOR OPAMP—CMOS inverter pair (one-third of CD4007A) is used in closed-loop mode as unity-gain voltage follower for CA3080 opamp. Slew rate is 1 V/μs. Output current capability of 6 mA can be increased by paralleling two other sections of CMOS.—B. Furlow, CMOS Gates in Linear Applications: The Results Are Surprisingly Good, *EDN Magazine*, March 5, 1973, p 42–48.



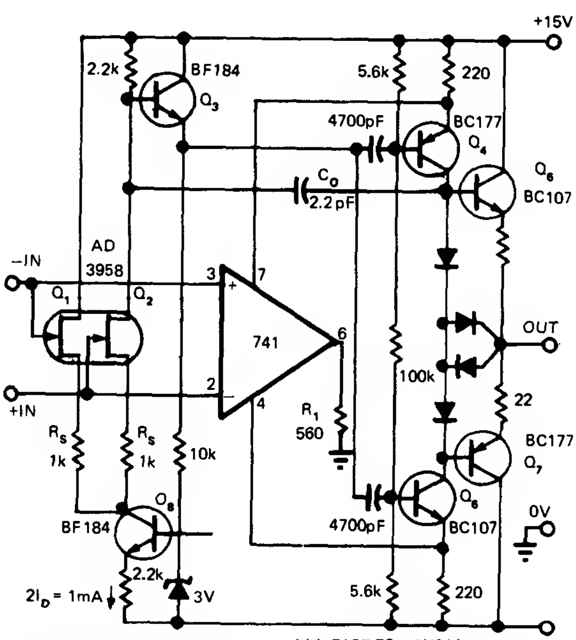
NEGATIVE R—Negative-resistance connection of 741 opamp is suitable for both AC and DC applications. Requires floating power supply because 0-V terminal floats with respect to both output terminals. For DC use, adjust 10K pot to cancel offset voltage of amplifier. Value of negative resistance is varied with R_N or by adjusting ratio of R_F to R_A. Can be used to make LC circuits operate at subaudio frequencies.—D. A. Miller, Negative Resistor, *Wireless World*, June 1974, p 197.



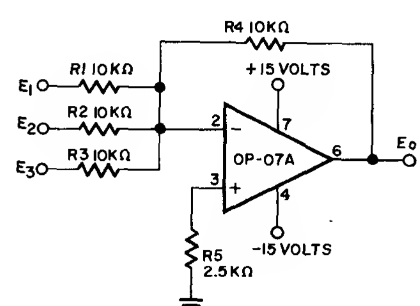
UNITY-GAIN AF CURRENT AMPLIFIER—External components are used with National LM377/378/379 family of opamps to provide stability at unity gain. Article gives design equations. At frequencies above audio band, gain rises with frequency, to well above 10 at 340 kHz for values shown.—D. Bohn, AC Unity-Gain Power Buffers Amplify Current, *EDN Magazine*, May 5, 1977, p 113–114.



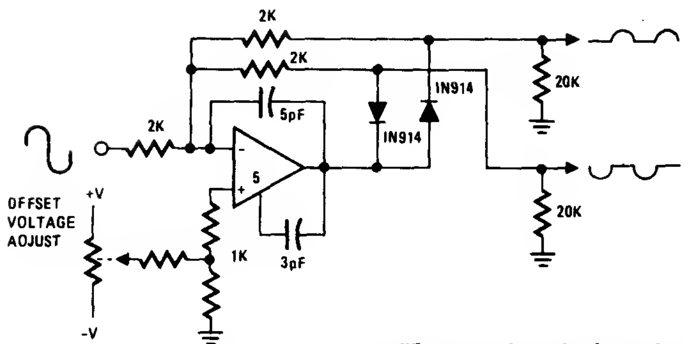
741 OPAMP—Power supply and null pot connections for TO-5 metal-can package and 8-lead DIP package are shown. Maximum rated power supply voltages are ±18 V, but lower voltages may be used. 9-V transistor battery is often used for each supply, but higher voltages will permit larger output signal swing. Pin 3 is inverting input, and pin 4 is noninverting input. With values shown, both input terminals see about same resistance, and output offset can be nulled to zero. Gain of circuit is about 100.—C. Hall, Circuit Design with the 741 Op Amp, *Ham Radio*, April 1976, p 26–29.



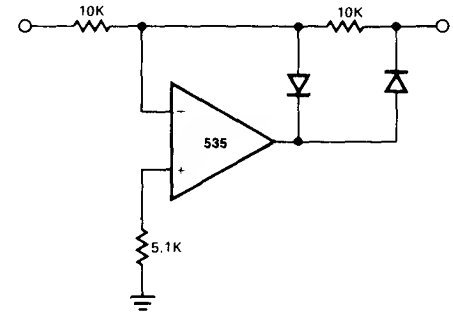
FASTER 741—Feed-forward techniques extend dynamic response of differential opamp to give unity-gain bandwidth of 18 MHz, slew rate over 200 V/μs, and DC gain above 10^7 V/V, while preserving latchup-free operation and wide input voltage range. Composite amplifier uses fast symmetrical four-transistor output stage that is symmetrically driven by DC-coupled 741 and by AC-coupled feed-forward amplifier. Performance depends on use of nonstandard pin connections for 741, as shown. Developed for processing fast analog data in frequency domain.—J. Dostel, 741 + Feedforward = Fast-Differential Op Amp, *EDN Magazine*, Aug. 20, 1974, p 90.



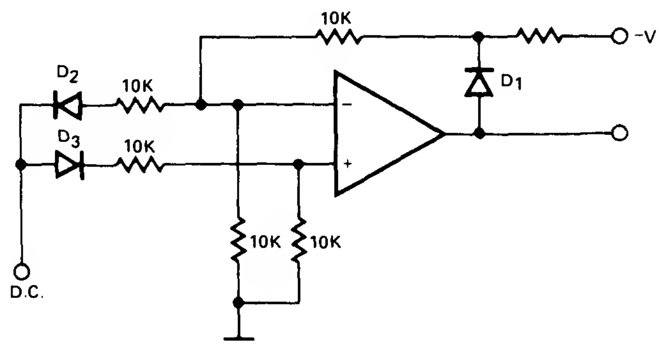
SUMMING AMPLIFIER—Provides output equal to sum of all input voltages, with high precision. Use of Precision Monolithics OP-07A opamp makes circuit adjustment-free.—"Ultra-Low Offset Voltage Op Amp," Precision Monolithics, Santa Clara, CA, 1977, OP-07, p 7.



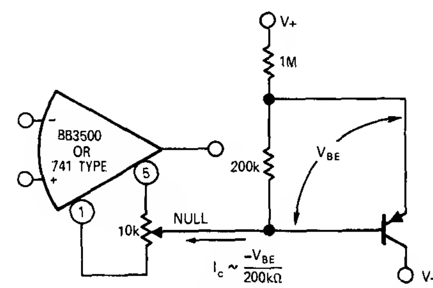
SIGNAL SEPARATOR—Circuit ahown for Harria HA-2530 opamp separates input voltage Into its poaitive and negativa components. Diodea steer components to separate outputs. Applications include feeding outputs into differantial amplifier to produca absolute-velue circuit for multiplying or averaging functiona. For bandwidth of 1 MHz, dynamic range Is 100 mV to 10 V peak.—"Lineer & Data Acquisition Products," Harris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 7-54–7-55 (Application Note 516).



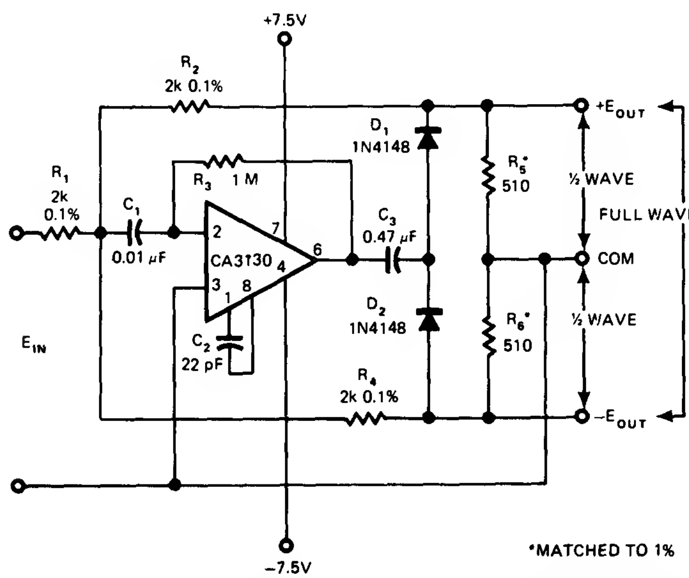
HALF-WAVE RECTIFIER—Provides eccurate half-wava rectificetion of incoming signal. Gein is 0 for positive signals and −1 for nagative signals. Diode types are not critical. Polarlty can ba inverted by reversing both dlodes. With opamp shown, circuit will function up to 10 kHz with less than 5% distortion.—"Slgnatics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 641–643.



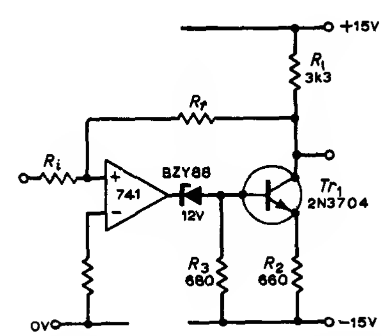
ABSOLUTE-VALUE AMPLIFIER—Generates positive output voltage for either polarity of DC input. Opamp end diode types are not critical. Accuracy is highast for input voltagaa greater than 1 V. Opamp is noninverting on poeitive slgnals and inverting on negetive signals.—"Signetics Anelog Data Manuai," Signetics, Sunnyvale, CA, 1977, p 641–643.



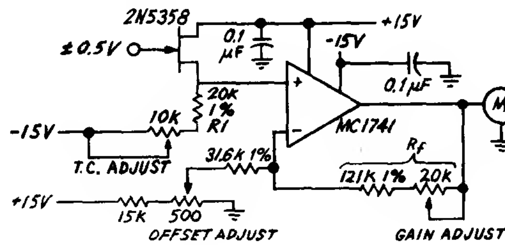
TEMPERATURE-COMPENSATED OFFSET CONTROL—Drift effects of offset adjustment are removed by deriving correction current from amitter-base voltage of PNP signel transistor to develop appropriate tamparatura compensation. Corraction current is dlvidad with conventional control pot uaed for adjusting offset voltage. Article gives deslgn equatlons.—J. Graeme, Offset Null Techniques Increase Op Amp Drift, *EDN Magazine*, April 1, 1971, p 47–48.



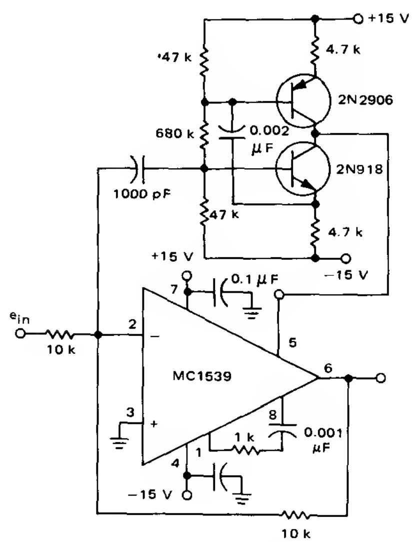
RECTIFIER WITHOUT DC OFFSET—Avoids drawback of large nonlinearity at low signal levels, by isolating AC of opamp from DC output. Circuit hea wide bendwidth, as required for rectifying 20-kHz input signal with high praciaion. Output coupling capacitor C_3 is low-leakage Myler; for low-frequency oparation, it can be replaced with two back-to-back low-laekage tantalums. D_1 and D_2 should be matched for forward voltage et peak load current. Use Hawlett-Packard 5082-2810 hot-carriar diodaa instead to improve operation at millivolt signal levels or et higher frequencies.—D. Balangar, Single Op Amp Full-Wave Ractifier Haa No DC Offset, *EDN Magazina*, April 5, 1977, p 144 and 146.



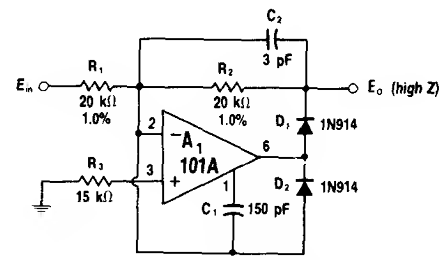
FASTER SLEWING—Single transietor etage et output of opamp increasea slewing rate by factor equal to gain of transistor stage. Choosa R_1 to meat output impadance requirements and current rating of supply. R_2 is then made aquel to R_1 dividad by desired gain of transistor stege. Collector of Tr_1 shouid be at 0 V when output of opamp is 0 V, assuming feedback loop is not closad by R_f. Article glvas design equations.—L. Short, Faster Slewing Reta with 741 Op-Amp, *Wireless World*, Jan. 1973, p 31.



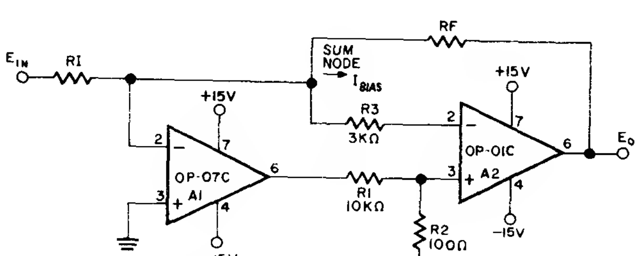
SIGNAL CONDITIONER—FET-buffered opamp circuit will operate from source impedances up to 100 megohms while providing voltage gain of 5. Offset adjustment is provided for initial calibration of circuit. Developed for use with high-impedance sensors such as pH electrodes.—"Industrial Control Engineering Bulletin," Motorola, Phoenix, AZ, 1973, EB-4.



UNITY-GAIN FEED-FORWARD—Provides 10 V P-P output signal at 2 MHz when gain of feed-forward amplifier is increased to give closed-loop gain of 10. Provides fast response to step-function input, with slow settling. High-frequency circuit takes over completely when input frequency is too high for input stage to respond.—E. Renschler, "The MC1539 Operational Amplifier and Its Applications," Motorola, Phoenix, AZ, 1974, AN-439, p 20.

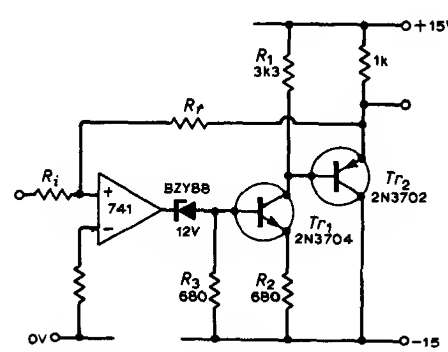


HIGH-SPEED HALF-WAVE RECTIFIER—Produces inverted half-wave replica of input signal with low error at frequencies up to 100 kHz. C_1 provides feed-forward compensation. For negative-going output, reverse connections to diodes.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 191–192.

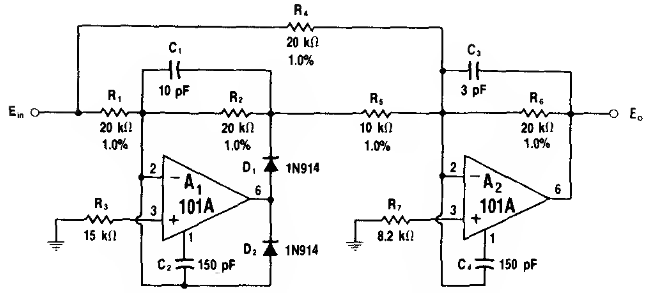


$$E_O = -E_{IN}\frac{RF}{RI} + I_{BIAS}R_F$$

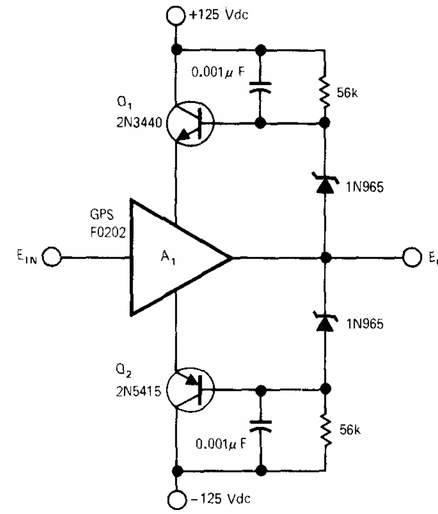
SUMMING AMPLIFIER—Combination of Precision Monolithics OP-07C and OP-01C opamps gives 18 V/μs slew rate. Can be used as current-output summing amplifier for D/A converter because it requires no zero scale offset adjustments and high speed is preserved.—D. Soderquist and G. Erdi, "The OP-07 Ultra-Low Offset Voltage Op Amp—a Bipolar Op Amp That Challenges Choppers, Eliminates Nulling," Precision Monolithics, Santa Clara, CA, 1975, AN-13, p 9.



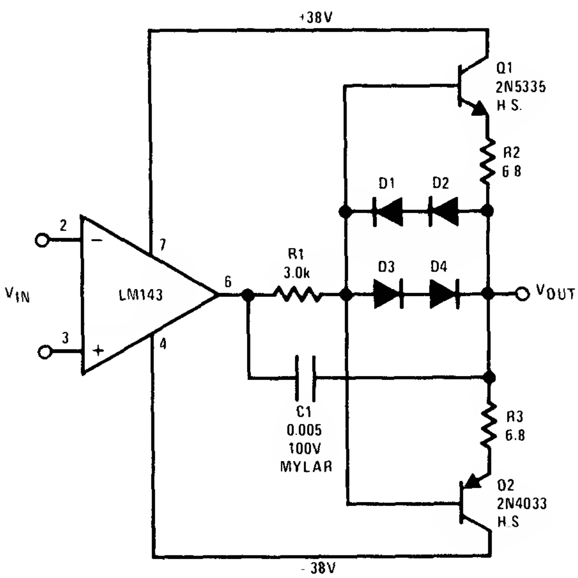
FAST SLEWING AND LOW IMPEDANCE—With values shown, Tr_1 increases slewing rate of opamp by factor of 5, and Tr_2 connected as emitter-follower reduces output impedance to meet requirements of following circuit. Feedback is taken from emitter of Tr_1 to noninverting input of opamp.—L. Short, Faster Slewing Rate with 741 Op-Amp, *Wireless World*, Jan. 1973, p 31.



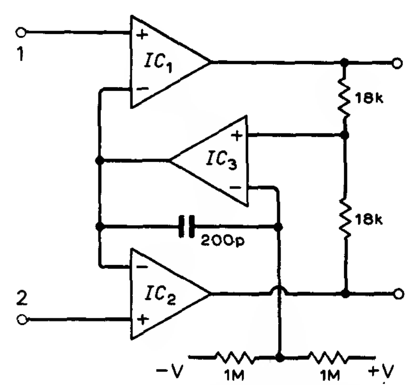
100-kHz FULL-WAVE RECTIFIER—Feed-forward connection of opamps gives high-spaed full-wave rectification of signels up to 100 kHz for measurement and analysis.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 193–194.



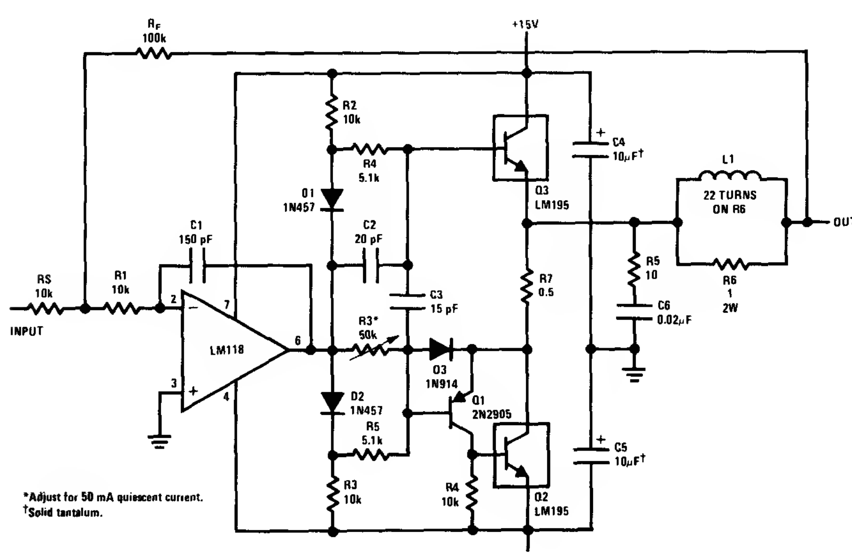
BOOSTING VOLTAGE RATING—Bootstrapping technique permits operation of low-voltage unity-gain opamp from high-voltaga DC supply for handling large input signal voltage swings, while retaining gain and voltage stability of opemp. Allowable input-voltage renge depands entirely on transistor rating. With 1000-V transistors, circuit can handle input signals of ±475 V. Input capability for values shown is ±100 V P-P for DC to 10 kHz. Output capability is 5 mA P at ±100 V. Input impedance is 10 teraohms.—S. A. Jensen, High-Voltage Source Follower, *EDN/IEEE Magazine*, Feb. 1, 1972, p 58.



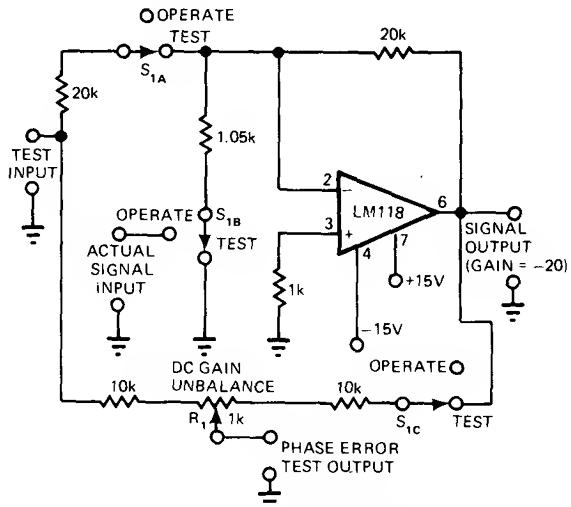
100-mA CURRENT BOOSTER—Provides short-circuit protection along with current boosting for LM143 high-voltege opamp. Diodes are 1N914. Use Thermalloy 2230-5 or equivalent heatsinks with transistors. Output is ±33 V P-P into 400-ohm load.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 4.



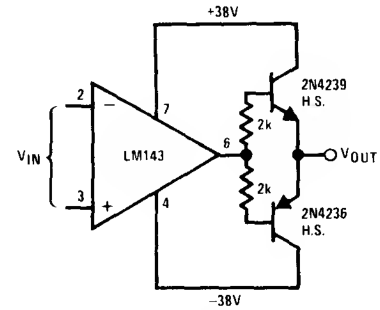
DIFFERENTIAL I/O—Arrangement shown for three 741 opamps gives amplifier having differential output as well as differential input. Circuit is designed primarily to drive mater with signal of either polerity when center-tep power supply is not available. Article covers operation and adjustment of circuit.—A. D. Monstall, Differential Input and Output with Op-Amps, *Wireless World*, Jan. 1973, p 31.



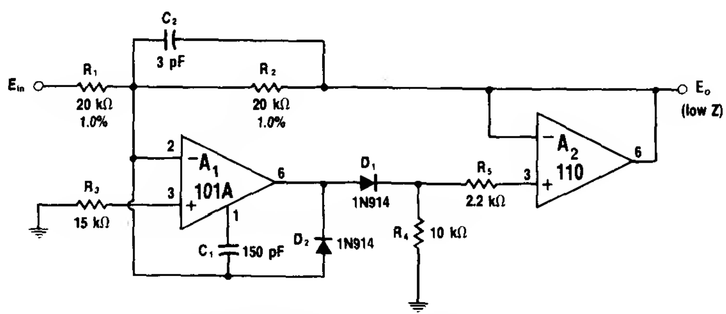
POWER OPAMP—Transistor Q1 and power transistor IC Q2 form equivalent of power PNP transistor for use with NPN LM195 power transistor IC serving as output stage for opamp. Circuit is stable for almost any load. Bandwidth can be increased to 150 kHz with full output response by decreasing C1 to 15 pF if there is no capacitive load to cause oscillation.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-110, p 5–6.



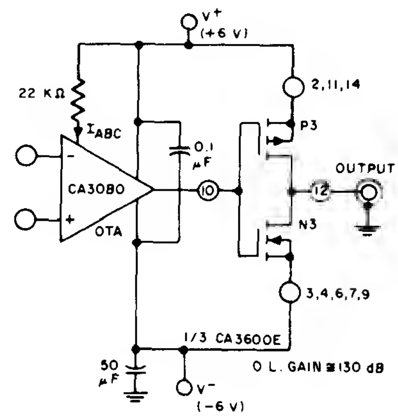
PHASE-ERROR TESTER—Circuit reveals significant phase errors at relatively low frequancies, even for high-speed opampa. Technique applles to most opamps and almost any aignal gain. Article gives operating instructions based on observation of null with XY CRO connected to phasa-error test output.—R. A. Peaae, Technique Trims Op-Amp Amplifiers for Low Phase Shift, *EDN Megezine*, Aug. 20, 1977, p 138.



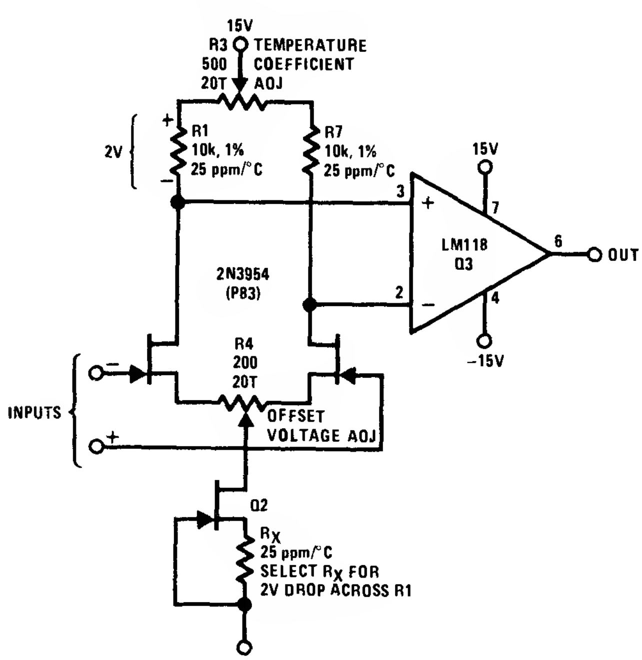
POWER BOOSTER—Simple two-transistor power stage increases power output of LM143 high-voltage opamp. Intanded for loada less than 2K. Drawbacks ara noticeable crossovar distortion and lack of short-circuit protection. Transistors should be used with Thermalloy 2230-5 or equivalent heatsinks.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 3.



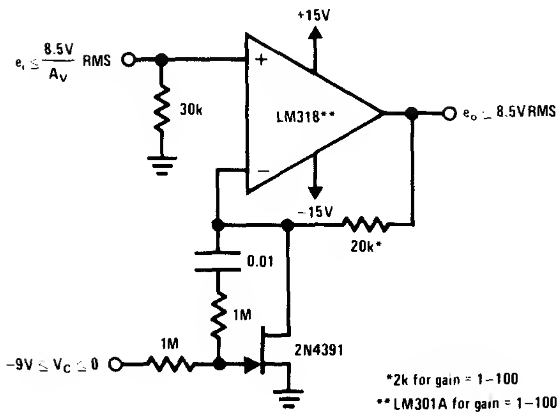
100-kHz BUFFERED RECTIFIER—High-spaed 110 voltage follower is used within feedback loop of A_1 to maintain low output impedance for precision half-wave rectifier. When input signal is positive, D_1 and R_4 rectify signal and A_2 follows this signal. On opposite alternations, D_1 is off and feedback loop of A_2 is closed through D_2 so output terminal is maintained at low impedance. For opposite output polarity, raverse dioda connections.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 192.



POSTAMPLIFIER—CMOS transistor pair from CA3600E transistor array provides additional 30-dB gain above 100-dB gain of CA3080 opamp to give total of 130 dB. Current output is about 10 mA. Ramaining transistor pairs of array can be parallaled pair shown to giva graatar output.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 278–279.

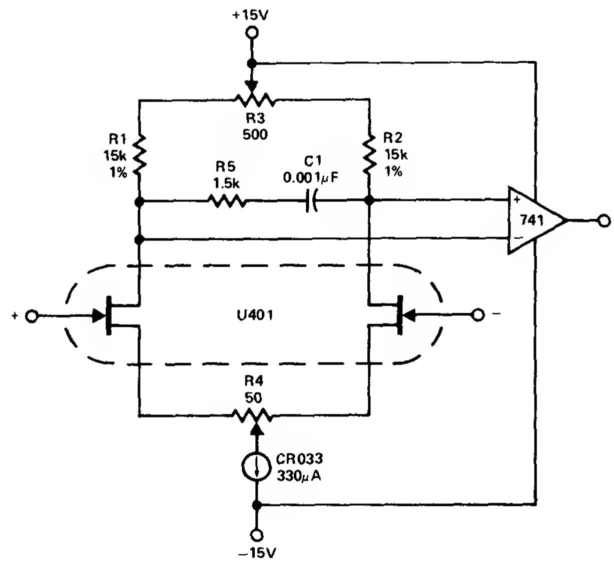


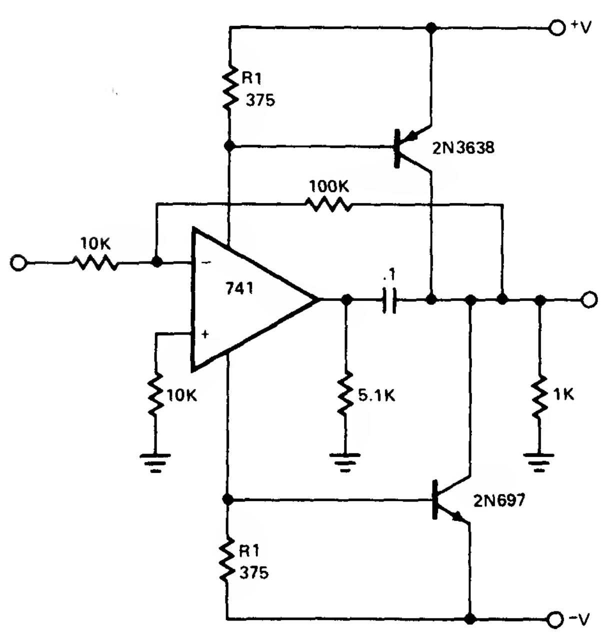
LOW TEMPERATURE COEFFICIENT—Use of National 2N3954 dual FET as input device for opamp gives fast response to thermal transients, making it possible to adjust R3 and R4 so temperature coefficient is less than 5 μV/°C from −25°C to +85°C. Common-mode rejection ratio is typically greater than 100 dB for input voltage swings of 5 V. Drain current level is set by Q2 which is 2N5457 FET.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-4–6-7.



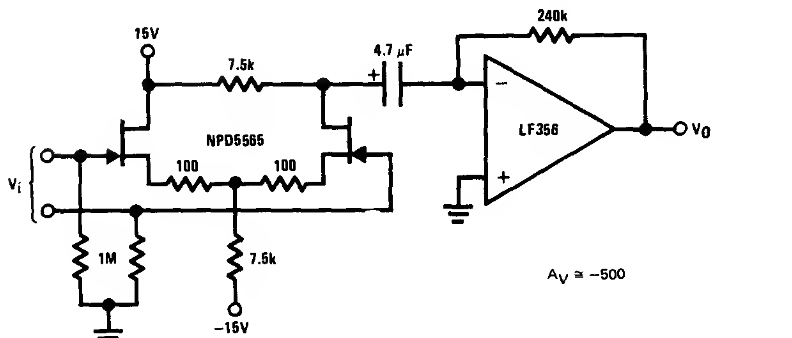
1–1000 GAIN RANGE—Control voltage of 0 to −9 V changes gain of amplifier over complete range while providing maximum output level of 8.5 VRMS and bandwidth of over 20 kHz at maximum gain. If gain range of 100 is sufficient, amplifier can be changed to LM301A; 20K resistor is then changed to 2K.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-129, p 5.

JFET INPUT—U401 dual JFET acting as preamp for standard bipolar opamp uses CR033 N-channel JFET as 330-μA current source. R4 is used to null initial offset. R3 is adjusted for minimum drift.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-51.

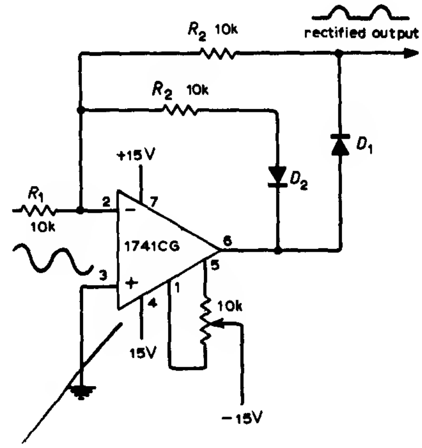




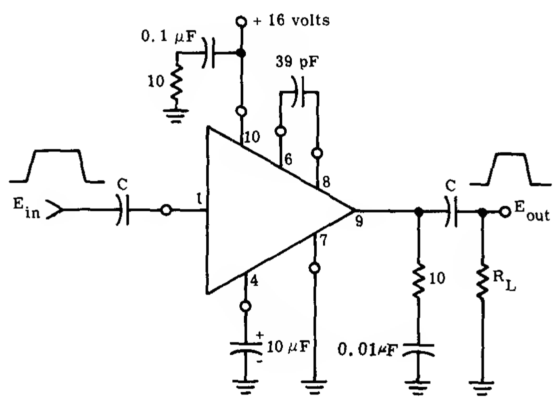
POWER BOOSTER—Opamp power booster is used after conventional opamp when greater power-handling capability is required. 741 opamp circuit shown will drive moderate loads. Other opamps may be substituted in power stage if value of R1 is appropriately changed.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 640–642.



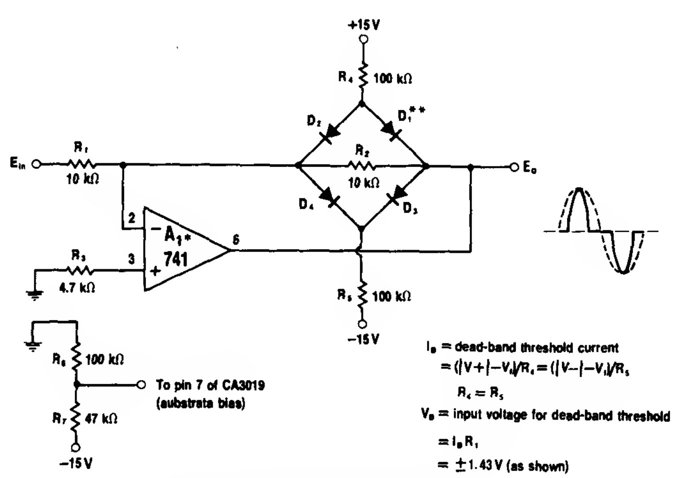
DIFFERENTIAL JFET INPUT—Differential connection of National NPD5565 dual JFET is used when balanced inputs and low distortion are main requirements for AC amplifier. Combination with LF356 opamp shown gives gain of about 500. Noise is somewhat higher than with single-ended JFET.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-17–6-19.



PRECISE RECTIFICATION—Use of opamp in combination with silicon diode overcomes nonlinearity of diode at forward voltages under about 0.5 V. Offset-voltage pot is adjusted for symmetrical output waveform for small input voltages. D_1 is connected in opamp feedback path so initial forward voltage drop required to make diode conduct is supplied by amplifier output. Second feedback path through D_2 prevents output saturation on input half-cycles for which D_1 is reverse-biased.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World,* June 1973, p 275–276.



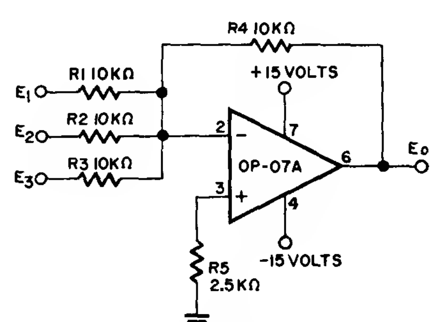
3-W PULSE AMPLIFIER—Motorola MC1554 power amplifier provides voltage gain of 18 for peak pulse power output up to 3 W. Maximum peak output current rating of 500 mA for IC should not be exceeded during peak of output pulse.—"The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier," Motorola, Phoenix, AZ, 1972, AN-401, p 3.



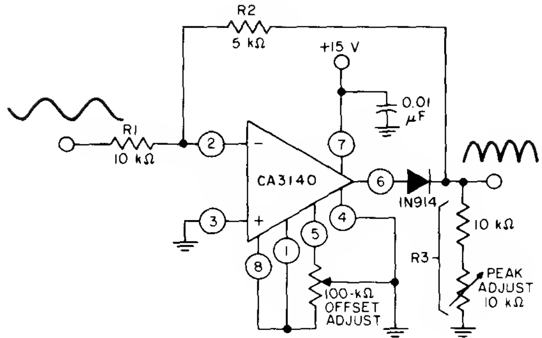
*Or other op amp compensated for unity gain.

**D_1 - D_4 are matched monolithic diodes, such as the CA3019. For peak voltage higher than ±7 V, use 1N914s.

DEAD-BAND RESPONSE—With bridge in feedback loop of opamp, low-level input signals give essentially 100% feedback around A_1 so there is very little output voltage. When input current through R_1 rises above allowable current limit of circuit, bridge opens and output voltage jumps to new level determined by R_2. Input is then amplified by ratio of R_2/R_1 in normal linear manner. Circuit thus has dead-band property for low levels. Value of R_1 sets threshold level.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 206–207.



SUMMING WITHOUT ADJUSTMENTS—Single-stage opamp for analog computation provides high-precision output that is function of multiple input variables. Circuit drift is less than 2 µV per month, eliminating need for periodic calibration while ensuring long-term accuracy. Opamp is Precision Monolithics OP-07A.—D. Soderquist and G. Erdi, "The OP-07 Ultra-Low Offset Voltage Op Amp—a Bipolar Op Amp That Challenges Choppers, Eliminates Nulling," Precision Monolithics, Santa Clara, CA, 1975, AN-13, p 11.



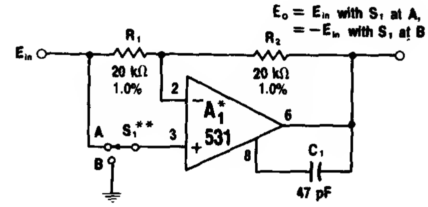
$$\text{GAIN} = \frac{R2}{RI} = X = \frac{R3}{RI + R2 + R3}$$

$$R3 = RI\left(\frac{X + X^2}{1 - X}\right)$$

$$\text{FOR } X = 0.5 \cdot \frac{5\,k\Omega}{10\,k\Omega} = \frac{R2}{RI}$$

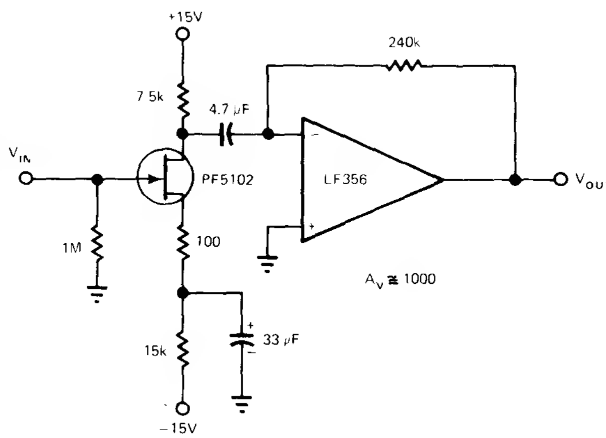
$$R3 = 10\,k\Omega\left(\frac{0.75}{0.5}\right) = 15\,k\Omega$$

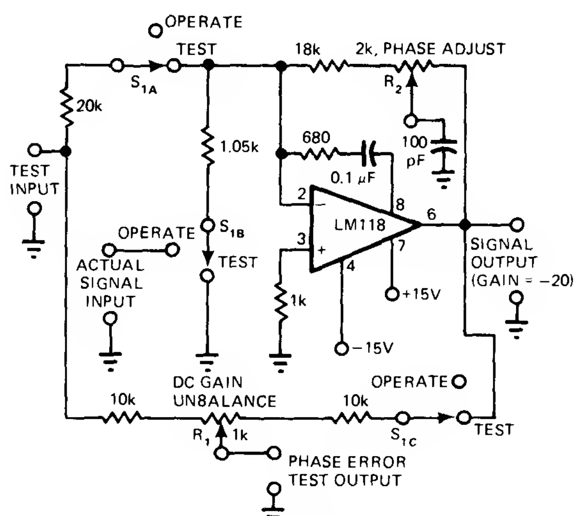
ABSOLUTE-VALUE RECTIFIER—Use of CA3140 bipolar MOS opemp in invarting gein configuration gives symmetrical full-weve output when equality of deslgn equations is satisfied. Bendwidth for −3 dB is 290 kHz, end everege DC output is 3.2 V for 20 V P-P input.—"Circuit Ideas for RCA Lineer ICe," RCA Solid Stete Division, Somerville, NJ, 1977, p 18.



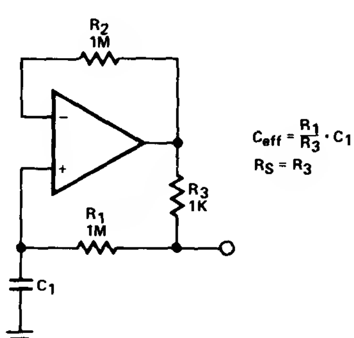
SIGN CHANGER—When switch S_1 grounds pin 3 of opamp, circuit becomee inverter providing 180° phase shift. When S_1 is at position A, input voltage ects on both inputs of A_1 and no current flows through R_1 end R_2; output voltage is then equal to input voltage. Switch permits remote programming of phase reversal. For higher Input Impedance, 1556 opamp can be used.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 208–209.

SINGLE-ENDED JFET—Basic JFET emplifier is virtuelly free from popcorn noise problems of bipoler transistors and bipoler-input opempe. Combining JFET transconductance amplifier with current-to-voltage opamp adds high voltage gein end simplifies circuit applications. Gein-limiting 7.5K FET drein resistor is bypassed and removed from gein equation. Parameter varietion problems are minimized by biesing FET source through 15.1K resistence to negetive supply. Gain veriations are minimized by leaving 100 ohms of this reslstance unbypassed.—J. Maxwell, FET Amplifiers—Take Another Look at These Devices, *EDN Magazine*, Sept. 5, 1977, p 161–183.

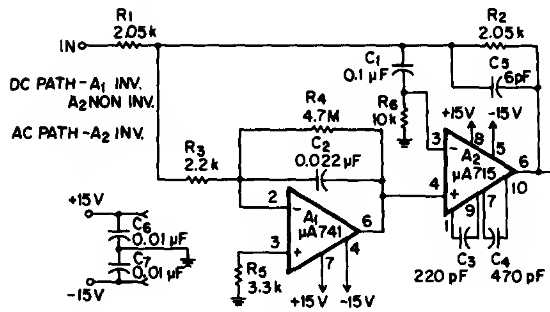


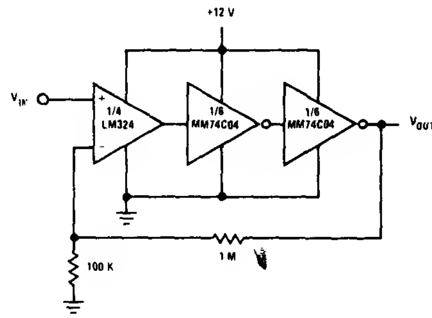


MINIMIZING PHASE ERROR—Phase compensation circuit trimmed by R_2 keeps phase error of LM118 opamp well below 1° from DC to 200 kHz. In-phase error due to gein peeking ie also low. Feed-forwerd network connected to pin 8 improves stebility, meking feedbeck capacitor unnecessery. Step response hae about 30% overshoot, and sine response has about +1 dB of peaking before going 3 dB down at about 2 MHz.—R. A. Peaee, Technique Trims Op-Amp Amplifiers for Low Phese Shift, *EDN Magazine*, Aug. 20, 1977, p 138.



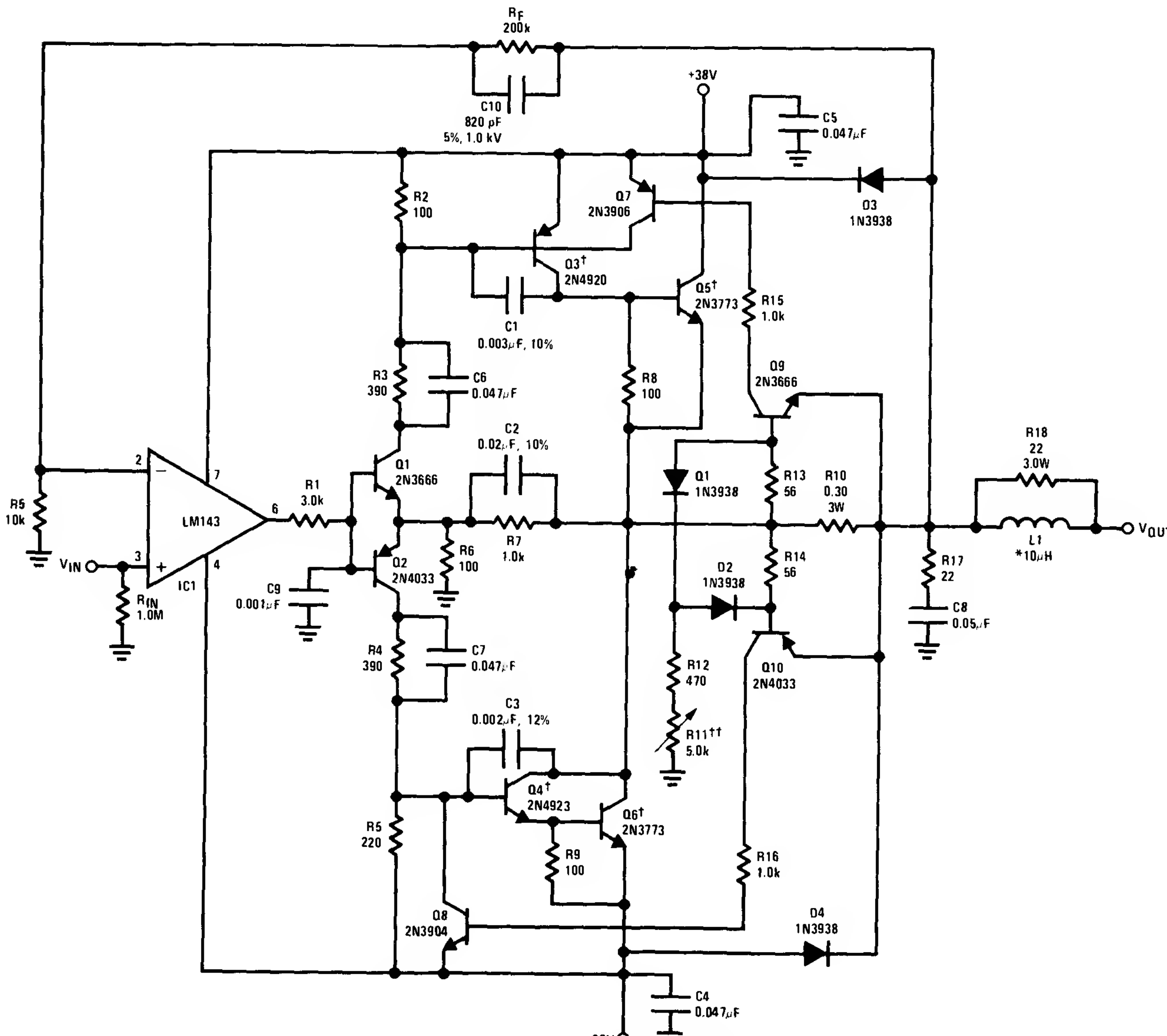
CAPACITANCE MULTIPLIER—Resistence retio determines factor by which velua of C_1 is multiplied when used in simple opamp circuit shown. With values shown, ratio is 1000 end 10-μF cepacitor provides effective capecitence of 10,000 μF. Q of circuit is limited by effective series resistence, so R_1 should be as lerge es precticel. Opemp type is not critical.—"Signetics Anelog Dete Manuel," Signetics, Sunnyvale, CA, 1977, p 640–641.



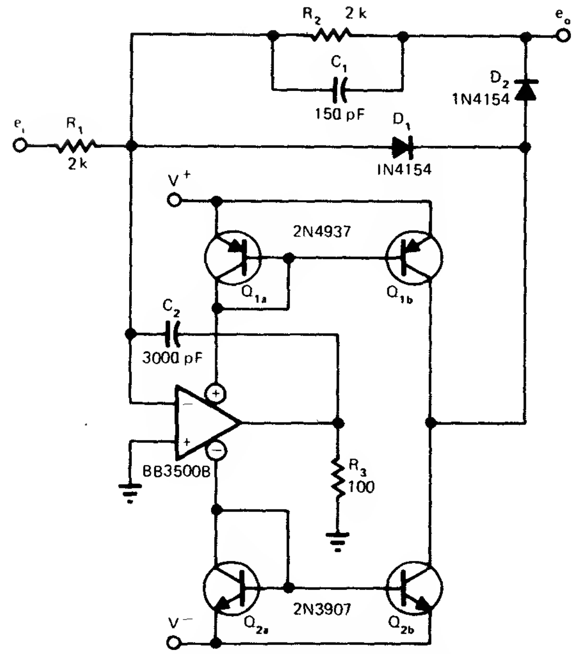


FEED-FORWARD OPAMP—DC input characteristics are determined by A_1, which is bypassed at high frequencies, while AC-coupled A_2 determines dynamic performance. Resulting composite amplifier combines such desired properties as low input current and drift, large bandwidth and slew rate, and fast settling time. Compensation network C_3-C_4-C_5 is chosen first to give desired bandwidth. Composite rolloff of 6 dB per octave is then obtained by narrowbanding A_1 with R_4 and C_2, so gain-bandwidth product is equal to ratio between unity-gain crossover frequency of A_2 and open-loop gain.—Fairchild Linear IC Contest Winners, *EEE Magazine*, Jan. 1971, p 48–49.

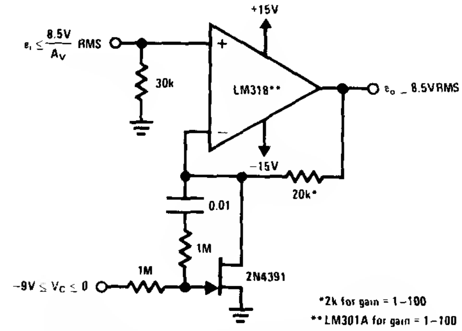
SINGLE-SUPPLY POSTAMPLIFIER—Use of two sections of MM74C04 as postamplifier for LM324 single-supply amplifier gives open-loop gain of about 160 dB. Additional CMOS inverter sections can be paralleled for increased power to drive higher current loads; each MM74C04 section is rated for 5-mA load.—"Linear Application, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-88, p 2.



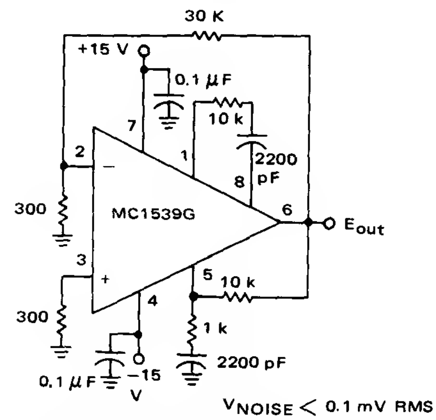
8-A CURRENT BOOSTER—High-compliance power stage for LM143 high-voltage opamp provides very high peak drive currents along with output voltage swings to within 4 V of ±38 V supply under full load. Maximum output current depends on setting of current-adjusting pot R11 and on output voltage. Limit ranges from 14 A when R11 is 0 down to about 4 A for 5K. Maximum power output is 144 WRMS, for which frequency response is 3 dB down at 10 kHz. Voltage gain is 21. Q3-Q6 should be on common Thermalloy 6006B or equivalent heatsink.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 5–6.



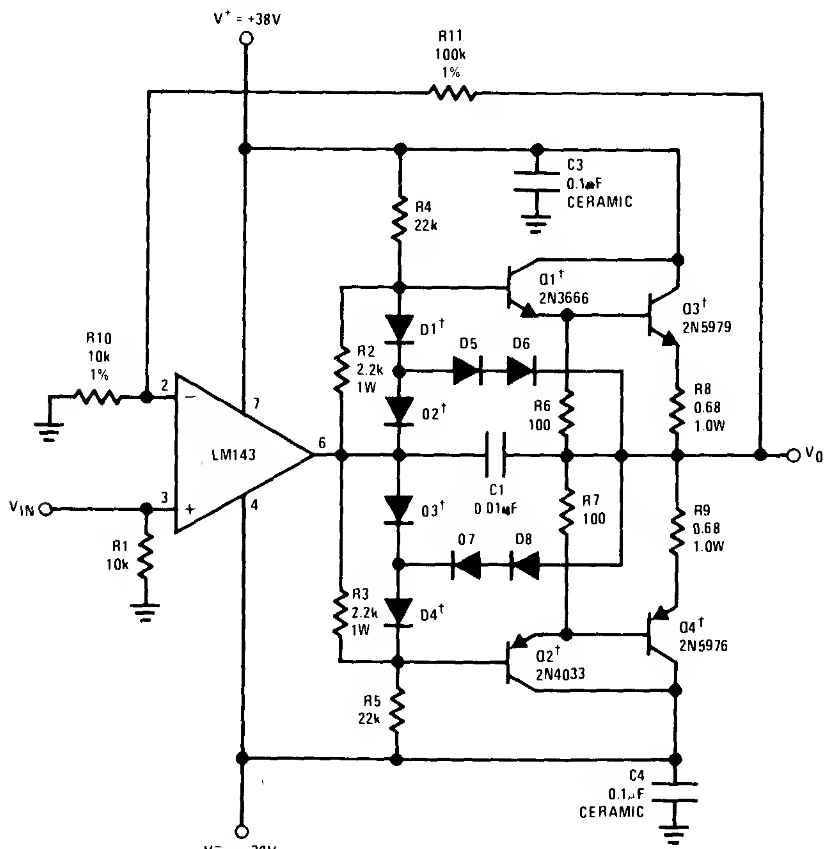
60-kHz PRECISION RECTIFIER—Usable full-power response of typical opamp is boosted to 60 kHz while giving 300-kHz small-signal bandwidth. Circuit uses transistors to provide speed-boosting gain during transition from one precision rectifier diode to the other in feedback loop of opamp. Added stage is driven from power-supply current drains of opamp. Article traces operation of circuit in detail.—J. Graeme, Boost Precision Rectifier BW above That of Op Amp Used, *EDN Magazine*, July 5, 1974, p 67–69.



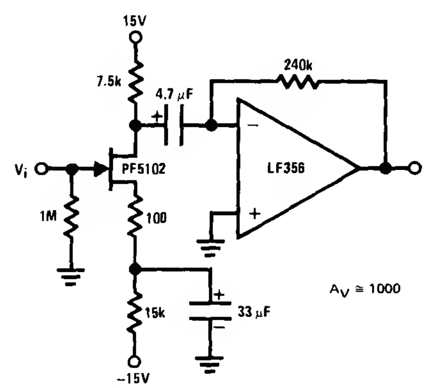
GAIN-CONTROLLED AMPLIFIER—Control voltage in range of 0 to −9 V provides gain range of 1 to 1000 for National LM318 opamp using FET in feedback path. Bandwidth is better than 20 kHz at maximum gain. Applications include remote or multichannel gain control, volume expansion, and volume compression/limiting.—J. Sherwin, "A Linear Multiple Gain-Controlled Amplifier," National Semiconductor, Santa Clara, CA, 1975, AN-129, p 5.



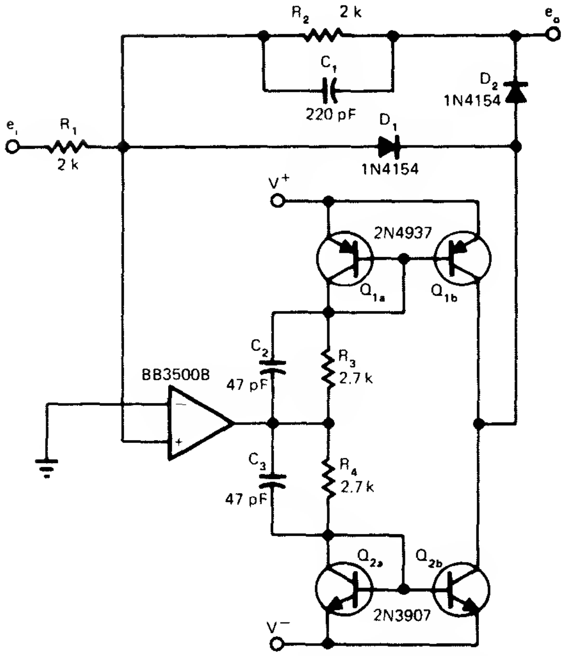
LOW-NOISE 5-kHz—Values shown are for operation of Motorola MC1539G opamp in closed-loop mode with noninverting gain of 100 and source impedance of about 300 ohms. Circuit bandwidth is about 5 kHz.—E. Renschler, "The MC1539 Operational Amplifier and Its Applications," Motorola, Phoenix, AZ, 1974, AN-439, p 19.



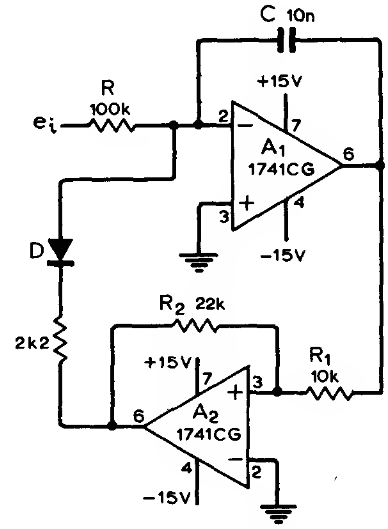
1-A CURRENT BOOSTER—Used with LM143 high-voltage opamp to increase output current while providing short-circuit protection and low crossover distortion. With 40-ohm load, output voltage can swing to + 29.6 V and −28 V. All four transistors should be on Thermalloy 6006B or equivalent common heatsink. All diodes are 1N3193.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 4–5.



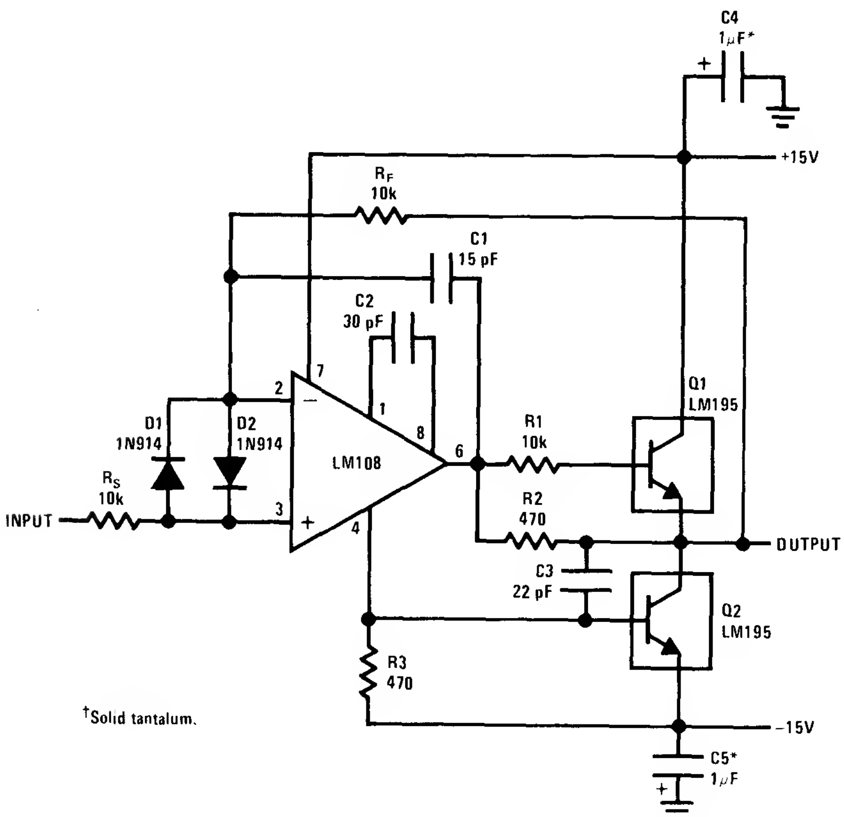
FET DRIVE—National PF5102 JFET is combined with LF356 opamp to give low noise and high gain, for use as wide-bandwidth AC amplifier. Typical gain for combination shown is about 1000. Any other opamp can be used as long as it meets slew rate and bandwidth requirements.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-17–6-19.



PRECISION RECTIFIER WITH GAIN—Gain is selectively added during open-loop switching transition of precision rectifier diodes D_1 and D_2 in feedback loop of opamp, to boost speed while maintaining feedback stability following switching. Q_1 and Q_2 add gain of about 250 up to 30 kHz during switching, because D_1 and D_2 are then off and do not shunt output of added stage. Following transition, one of diodes conducts heavily, shunting high output impedance of stage and dropping its gain below unity. Article covers circuit operation in detail.—J. Graeme, Boost Precision Rectifier BW above That of Op Amp Used, *EDN Magazine*, July 5, 1974, p 67–69.

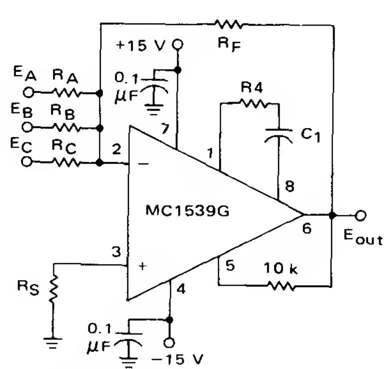


VOLTAGE/FREQUENCY CONVERTER—Uses opamp A_1 as integrator and A_2 as regenerative comparator with hysteresis, to generate sequence of pulses with repetition frequency proportional to DC input voltage. Article gives design equations and typical waveforms. Input voltage range is 10 mV to 20 V for linear operation.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, Dec. 1973, p 582.

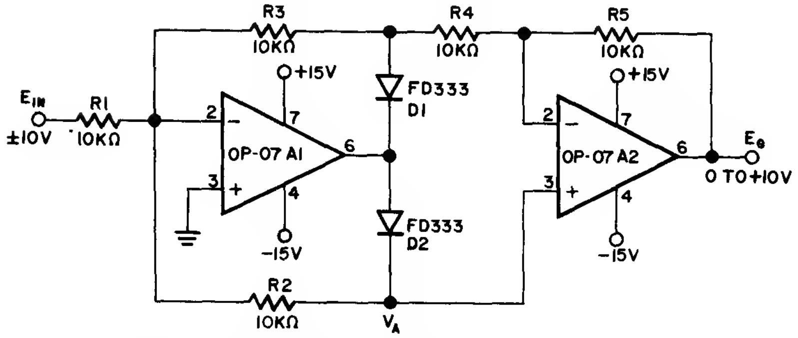


†Solid tantalum.

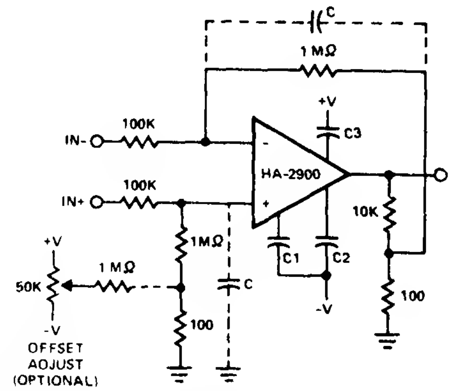
300-Hz VOLTAGE FOLLOWER—Simple LM195 power output stage provides 1-A output for voltage-follower connection of LM108 opamp.—R. Dobkin, "Fast IC Power Transistor with Thermal Protection," National Semiconductor, Santa Clara, CA, 1974, AN-110, p 6.



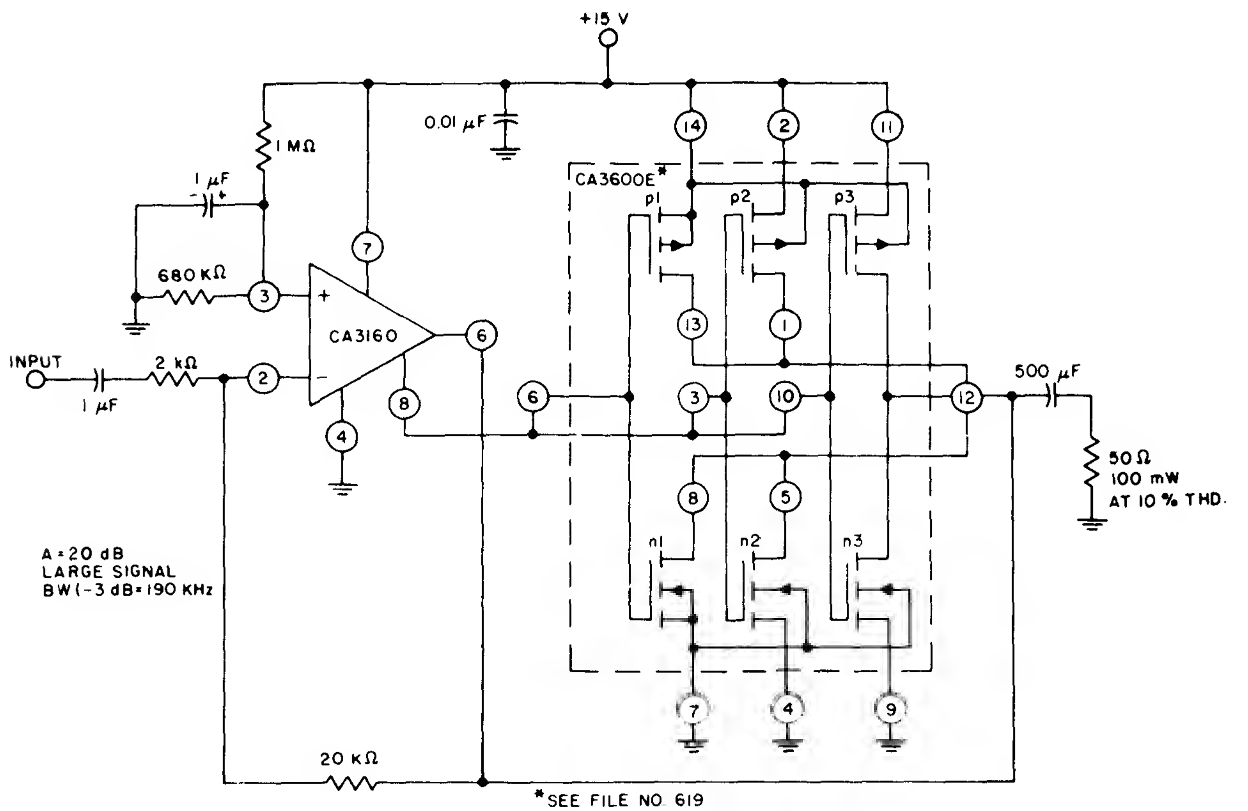
SUMMING OPAMP—Motorola MC1539 serves as closed-loop summing amplifier having very small loop-gain error because of high open-loop gain. R_S should equal parallel combination of R_A, R_B, R_C, and R_F.—E. Renschler, "The MC1539 Operational Amplifier and Its Applications," Motorola, Phoenix, AZ, 1974, AN-439, p 18.



PRECISION ABSOLUTE VALUE—Circuit using two Precision Monolithics OP-07 opamps provides preciae full-wave rectification by inverting negetive-polarity input voltages end opereting es unity-gein buffer for positive-polarity inputs. Applications include positive-peak detectors, single-quedrant multipliers, end megnitude-only measuring systems. For positive inputs, circuit simply operates es two unity-gain amplifier stages. Negative input turns D1 off and D2 on, changing raslstor currents preclsely enough to give overall circuit gein of −1. Design equations ere given.—D. Soderquist end G. Erdi, "The OP-07 Ultre-Low Offset Voltege Op Amp—e Bipoler Op Amp Thet Chellenges Choppera, Eliminates Nulling," Precision Monolithics, Sante Clere, CA, 1975, AN-13, p 10.

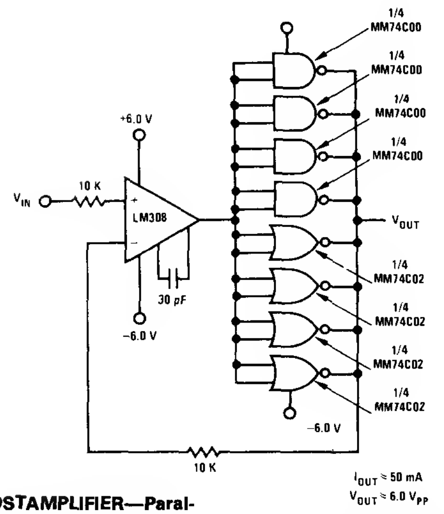


1000 GAIN AT 2 kHz—Uses Harris HA-2900 chopper-stabilized opamp. Either input terminel mey be grounded, giving choice of inverting or noninverting operation, or inputs may be driven differentially. Symmetricel input networks eliminate chopper noise, limiting total input noise to about 30 μVRMS whan C ia 0. Noise can ba further reduced, at expenae of bendwidth, by adding optional capacitors C as shown. Without thase capecitors, bandwidth is 2 kHz.—"Linear & Date Acquisition Products," Harris Semiconductor, Melbourna, FL, Vol. 1, 1977, p 7-69 (Applicetion Nota 518).

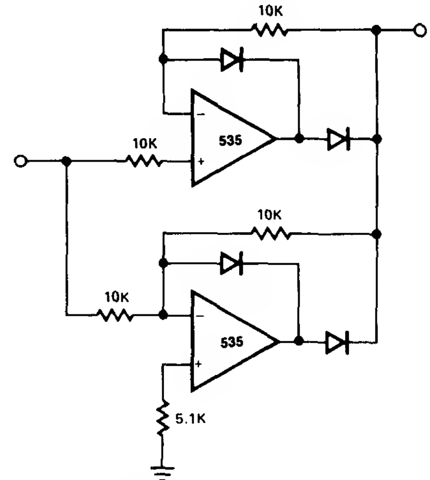


NOTE.
TRANSISTORS p1, p2, p3 AND n1, n2, n3 ARE PARALLEL-CONNECTED WITH Q8 AND Q12, RESPECTIVELY, OF THE CA3160

POWER BOOSTER—CA3600E CMOS transistor array provides parallel-connacted trenaistors for power-boosting capability with CA3160 opamp. Feedback is used to eatablish closed-loop gain of 20 dB. Typical large-signel bendwidth (−3 dB) is 190 kHz.—"Lineer Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 271–273.

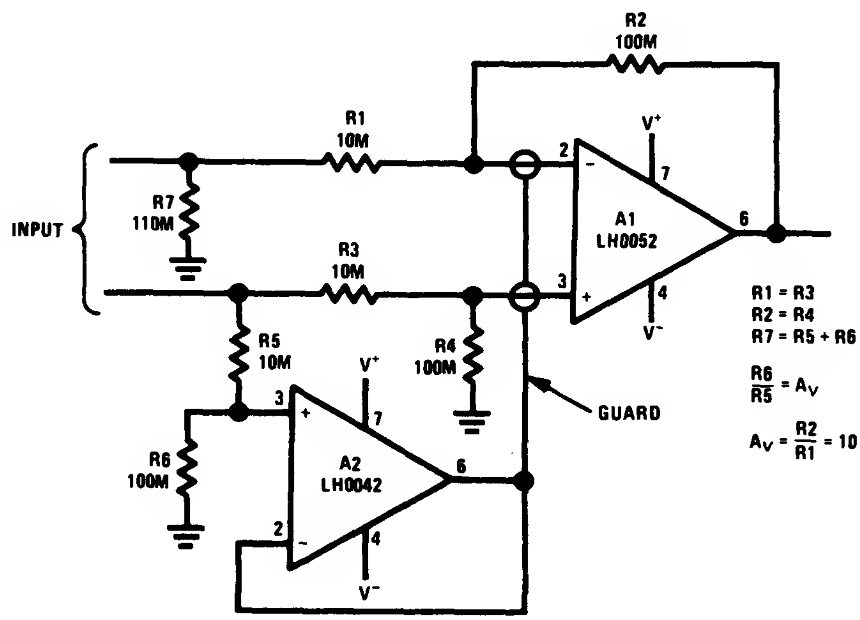


COMPLEMENTARY POSTAMPLIFIER—Paralleled NAND gates provide buffering for LM308 opamp while increasing current drive to about 50 mA for 6 V P-P output. MM74C00 NAND gates supply about 10 mA each from positive supply while MM74C02 gates supply same amount from negative supply.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-88, p 2–3.



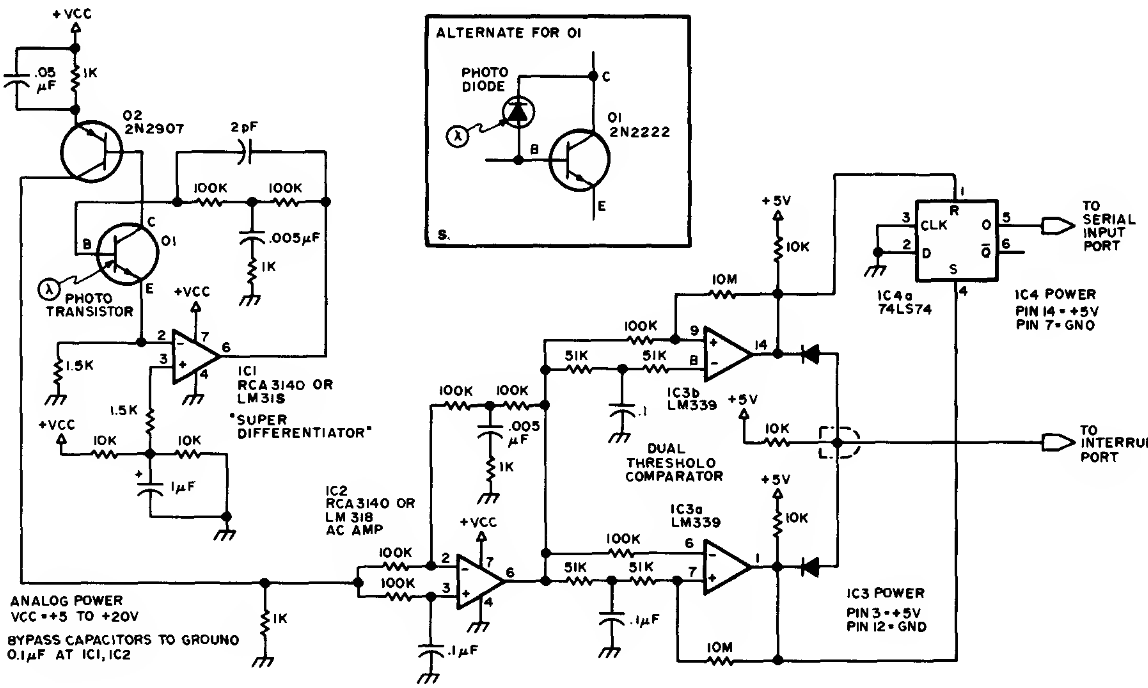
FULL-WAVE RECTIFIER—Circuit provides accurate full-wava rectification of input signal, with distortion below 5% up to 10 kHz. Reversal of all diode polarities reverses polarity of output. Output impedance is low for both input polarities, and errors are small at all signal levela.—"Slgnetlca Analog Data Manual," Signetlcs, Sunnyvale, CA, 1977, p 641–643.

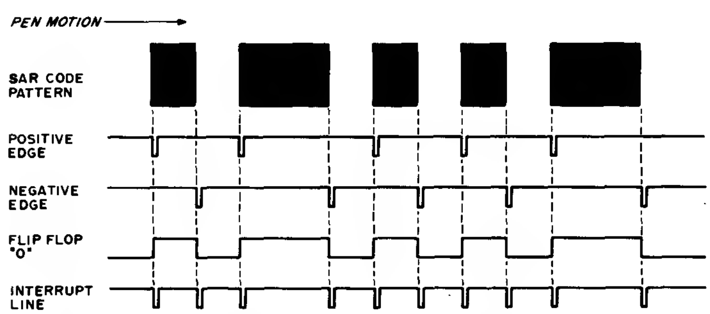
GUARDED FULL-DIFFERENTIAL—Extremely high input impedance is achieved by intercepting leakage currents with guard conductor placed in leakage path and operated at same voltage as inputs. A2 serves as guard drive amplifier, with R5 and R6 developing proper voltage for guard at their junction. R7 balances detector R5 plus R6 without degrading closed-loop common-mode rejection.—"Linear Applications, Vol. 1," National Semiconductor, Santa Clara, CA, 1973, AN-63, p 1-12.



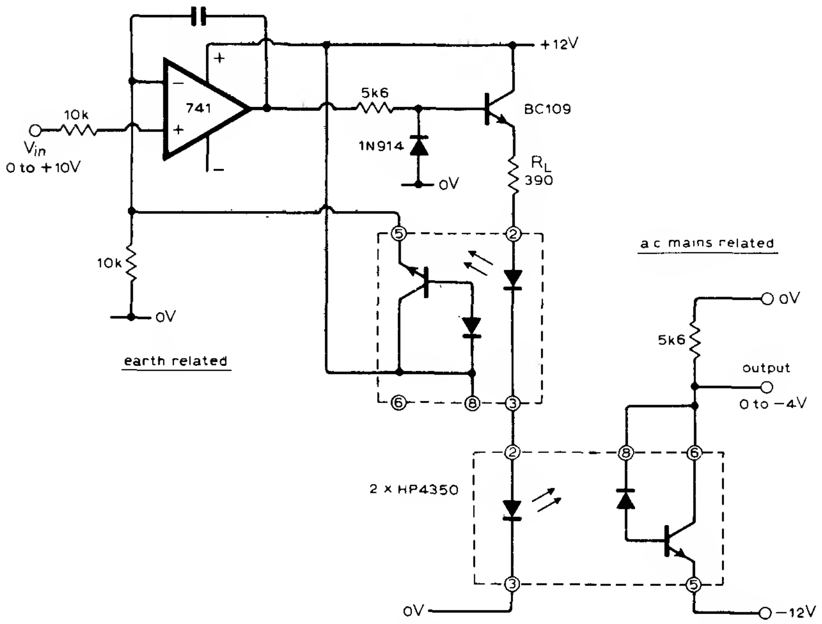
CHAPTER 60
Optoelectronic Circuits

Basic voltage-isolating applications for optoisolators. Includes bar-code reader circuits. Other chapters may include optoisolators in circuits having specific applications.

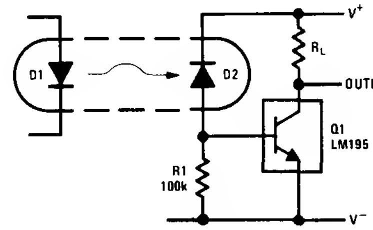




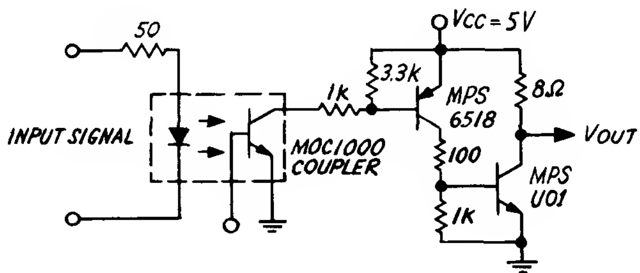
BAR-CODE READER—Edge-sensitive circuit outputs short pulses at each black-to-white or white-to-black transition. Timing diagram shows outputs corresponding to bar-code pattern indicated. Direct-current level at base of Q1 is held constant by DC servo action despite changes in temperature, ambient light, or background of pattern. Alternate sensor uses photodiode and 2N2222 transistor for increased bandwidth. Amplified differentiated signal from collector of Q2 is further amplified by IC2 and fed to dual threshold comparator. Output of comparator is short pulse for each transition, suitable for feed to microprocessor.—F. L. Merkowitz, Signal Processing for Optical Bar Code Scanning, *BYTE*, Dec. 1976, p 77–78 and 80–84.



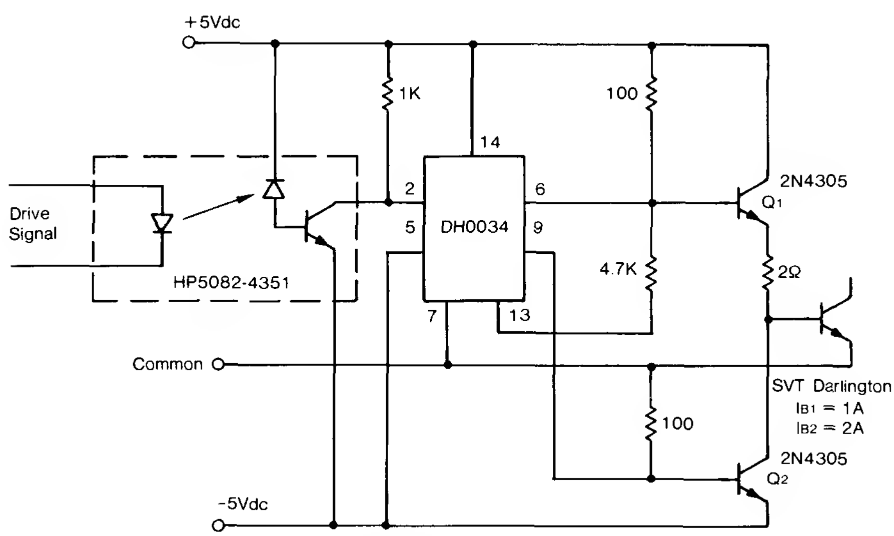
DC/DC OPTOISOLATOR—Dasigned to provide input isolation for thyristor convartars. Linaarity is within 2%. Loop gain of opamp makes dioda turn-on voltage insignificant.—R. J. Hanay, Linear D.C./D.C. Opto Isolator, *Wireless World*, June 1976, p 72.



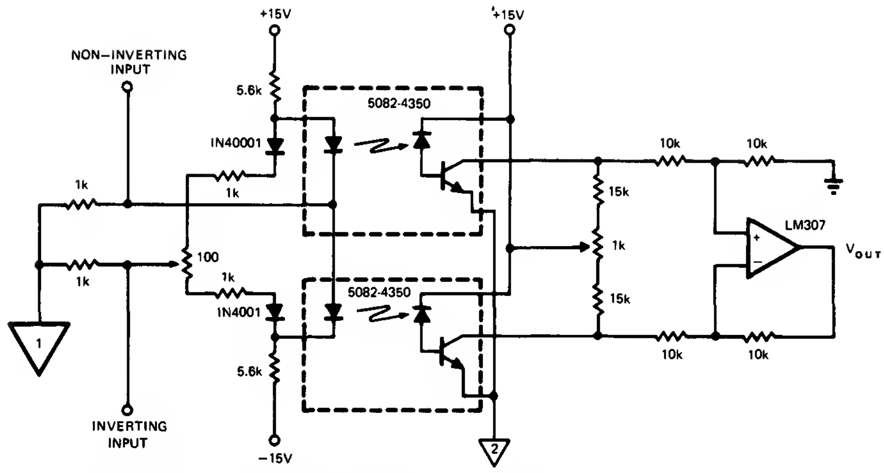
FAST OPTICALLY ISOLATED SWITCH—Uses almost any standard optoisolator. Lass than 20 μA is needed from photodiode D2 to turn LM195 power transistor fully on. Returning cathode of D2 to saparate positiva supply rathar than to collector of Q1 aliminates collector-basa capacitance of dioda and increases switching speed to 500 ns for 40-V 1-A load.—R. Dobkin, "Fast IC Powar Transistor with Thermal Protection," National Semiconductor, Santa Clara, CA, 1974, AN-110, p 5.



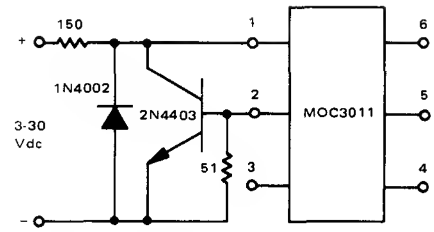
PULSE AMPLIFIER—Motorola MOC1000 optoisolator parmits coupling digital logic to system having diffarant supply voltagas or unequal grounds while providing essentially complate isolation. Circuit provides transfar charactaristics naedad in instrumantation applications and has sufficiant driva for handling low input impedancas.—"Industrial Control Engineering Bulletin," Motorola, Phoanix, AZ, 1973, EB-4.



OPTICAL DRIVE FOR SWITCHING TRANSISTOR—Base driver circuit for TRW SVT6062 power Darlington switching transistor uses separate isolated bias supplias for eech trensistor to provida performanca characteristics of driver transformar at lower cost. Bias supplias can use small 60-Hz transformers with bridga rectifiers and light filtering. Control isolation is providad by high-spaad optical couplar that can ba controlled directly from logic. DH0034 IC amplifies coupler output and provides leval shifting as required for driving transistors Q_1 and Q_2.—D. Roark, "Base Driva Considarations in High Powar Switching Transistors," TRW Powar Samiconductors, Lawndala, CA, 1975, Application Nota No. 120, p 8.

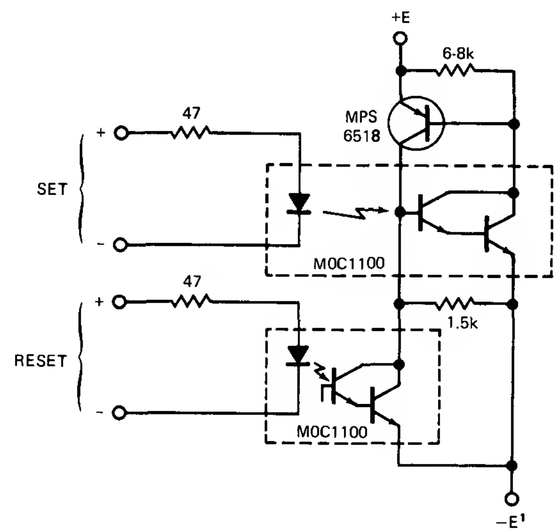


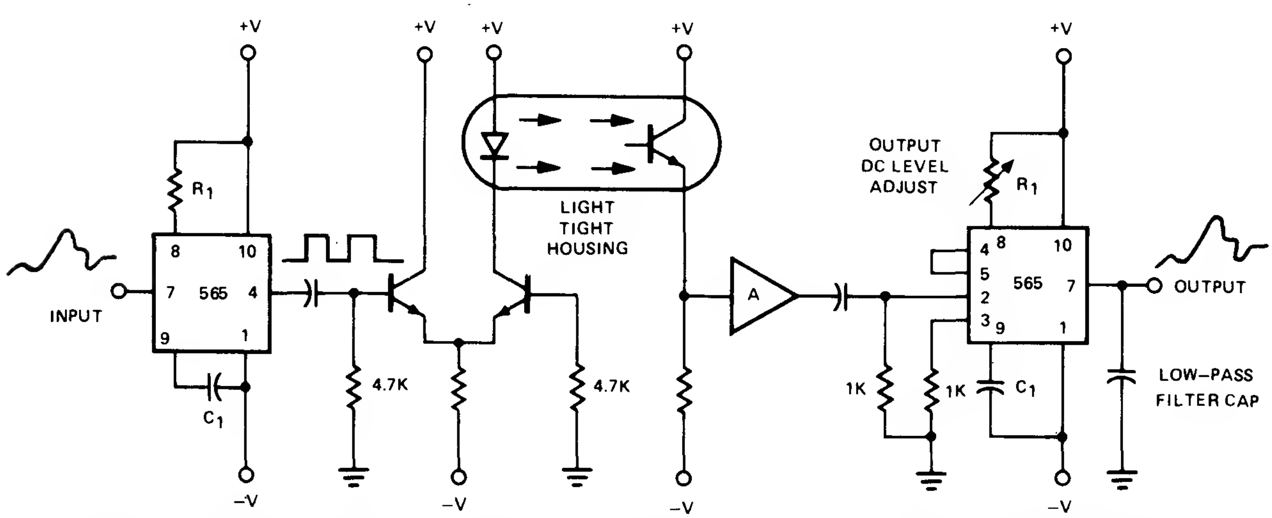
DC ISOLATOR WITH HARMONIC SUPPRESSION—Two isolators operating like push-pull amplifier minimize harmonic generation. When input signal is applied, upward change of incremental gain in one isolator is balanced by downward change in other to give harmonic cancellation. Circuit gain is about unity. Bandwidth is 2 MHz for signals below 2 V P-P. Input signals of either polarity may be applied at either inverting or noninverting input.—H. Sorensen, Opto-Isolator Developments Are Making Your Design Chores Simpler, *EDN Magazine*, Dec. 20, 1973, p 36–44.



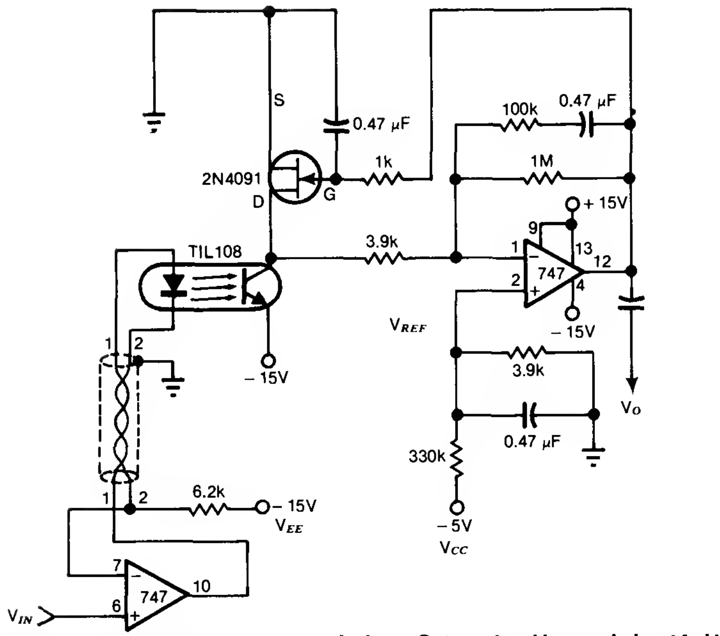
OPTOISOLATOR INPUT PROTECTION—Combination of diode and transistor limits input current to LED of Motorola MOC3011 optoisolator to safe maximum of less than 15 mA for input voltage range of 3–30 VDC. Circuit also protects LED from accidental reversal of polarity.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 4.

SET-RESET LATCH—Provides almost complete isolation between each input and the output, as well as between inputs. Applying 2-V pulse at 14 mA momentarily to SET terminals allows up to 150 mA to flow between output terminals. This current flows until about 2 V at 15 mA is applied to RESET terminals or until load voltage is reduced enough to drop load current below 1 mA.—R. N. Dotson, Set-Reset Latch Uses Optical Couplers, *EDN Magazine*, Jan. 5, 1973, p 107.

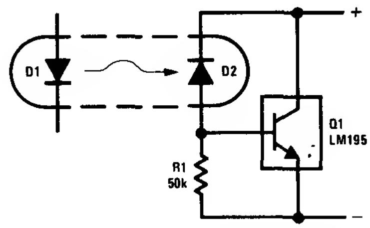




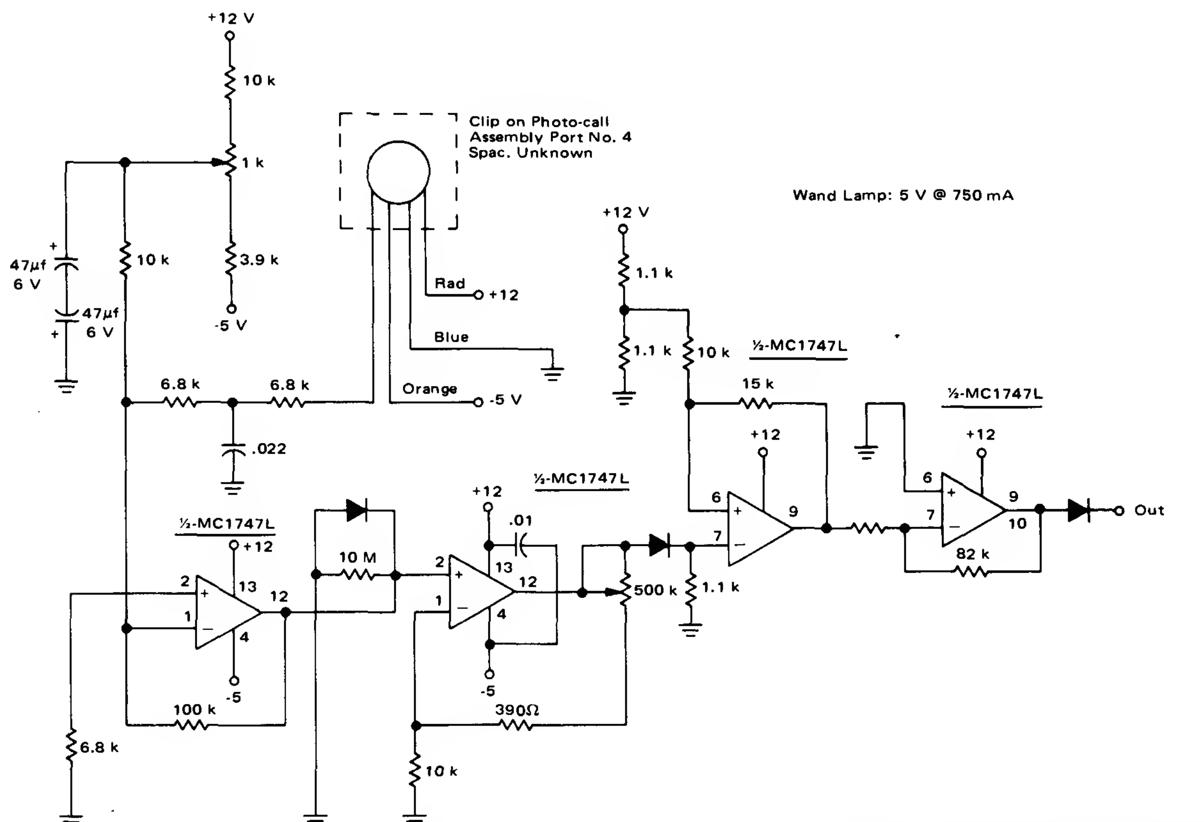
ANALOG ISOLATOR—Circuit is basically FM transmission system in which light is used as transmission medium. Transmitter uses 565 PLL as VCO for flashing LED of optoisolator at rate proportional to input voltage. Phototransistor drives amplifier having sufficient gain to apply 200 mV P-P signal to input of receiving 565 acting as FM detector for re-creating input to transmitter. Supply can be ±6 V to ±12 V.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 846–847.



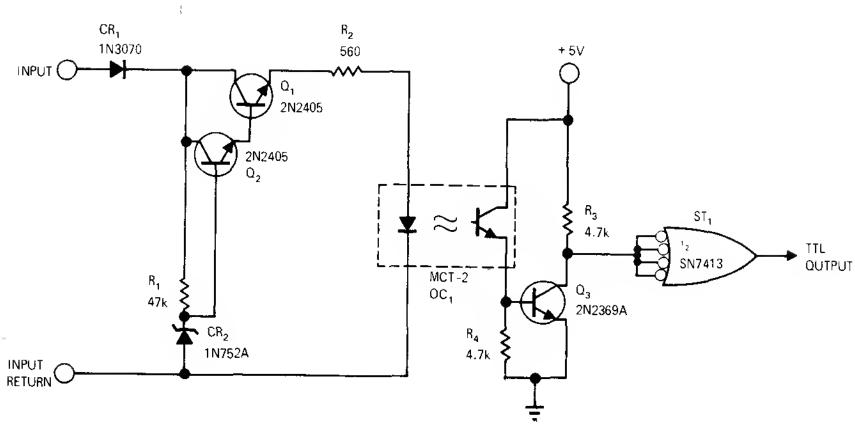
ISOLATION WITH GAIN COMPENSATION—Provides total harmonic distortion under 1% while automatically adjusting for temparatura-producad or othar DC gein variations in opto-isolator. Output signal is sampled and fed beck to FET to maintein constant AC gain. Dasign equations are givan.—A. Billings, Optocoupler Provides Analog Isolation, *EDN Magazine*, Nov. 5, 1978, p 121–122.



OPTOISOLATOR DRIVES 1-A POWER TRANSISTOR IC—Precticelly eny standard optoisolator provides sufficient output to meet Input currant raquirament of power transistor IC capable of handling 1 A. With no drive, R1 absorbs base currant of Q1, holding it off. Whan power Is applied to LED D1, less than 20 μA from photodioda D2 is sufficiant to turn LM195 fully on. Supply can ba up to 42 V.—"Linaar Applications, Vol. 2," National Samiconductor, Santa Clara, CA, 1976, AN-110, p 5.

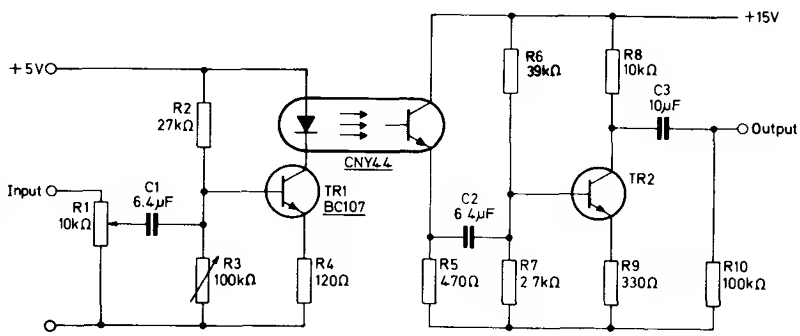


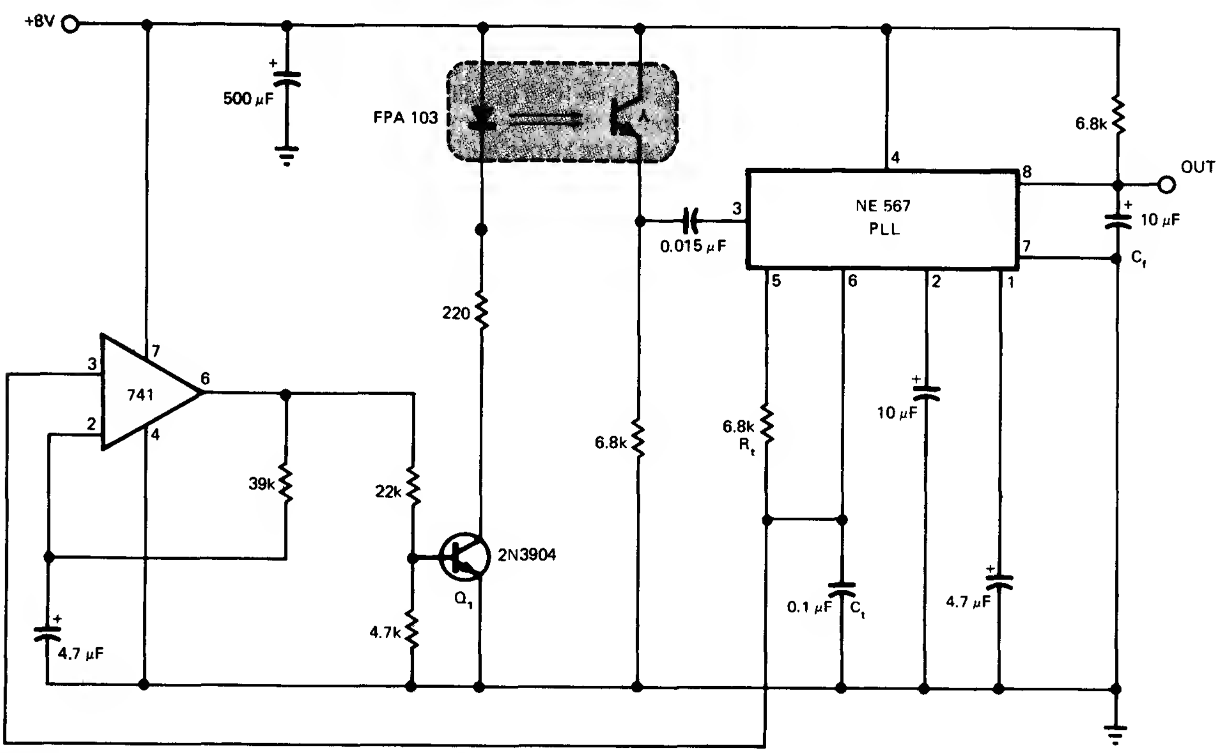
UPC WAND-SIGNAL CONDITIONER—Used in racovering analog output signal of photocall assambly for raading bars of univarsal product code. All four sections of two MC1747 dual opamps are used to amplify end condition photocall output so conditioned output of circuit provides TTL level 1 while wand is scanning black end 0 while scanning white. Additional processing is done by microprocessor such as MC6800.—"Microprocessor Applications Manual" (Motorola Series in Solid-State Electronics), McGraw-Hill, New York, NY, 1975, p 5-16–5-17.



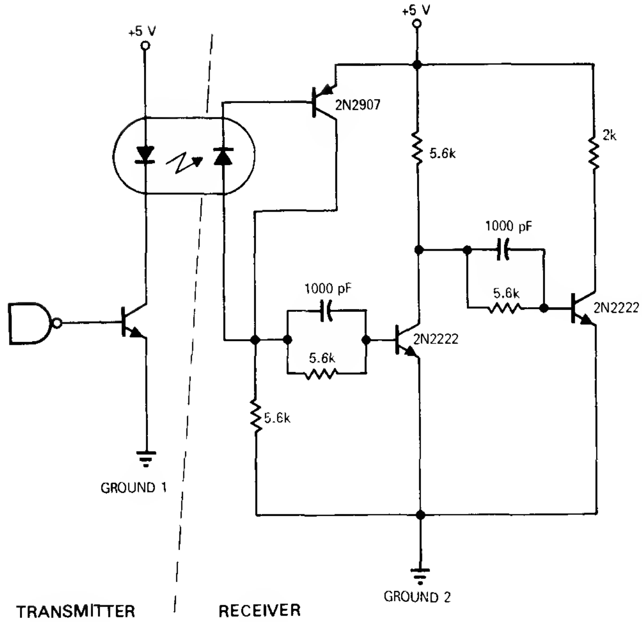
DIGITAL ISOLATION—Optical coupling provides completa electrical isolation between two digital circuits. Input signal as low as +4 V can make output change state, yet circuit safaly handles input peaks up to +100 V without breakdown. Q_1 and Q_2 form current regulator that limits loop current through input of optoisolator to 7 mA. Zenar CR_2 provides referance voltage that defines current through R_2. Schmitt trigger ST_1 in output aliminates oscillations that could otherwisa occur whan slow-risa-tima signal is applied to fast TTL circuits. Output changes stata when input signal lights LED in optoisolator.—C. E. Mitchell, Optical Coupler and Laval Shifter, *EDN/EEE Magazine*, Fab. 1, 1972, p 55.

ANALOG ISOLATOR—Usas Mullard CNY44 optoisolator to transmit analog signals batween units of aquipment having unequal ground potantials. Circuit has 3-dB rolloff point at 6 Hz and 80 kHz. Total harmonic distortion at 8 V P-P output is less than 1.5% between 100 Hz and 20 kHz. Output transistor TR2 is not critical.—"Photocouplers," Mullard, London, 1974, Technical Information 4, TP1477, p 12.

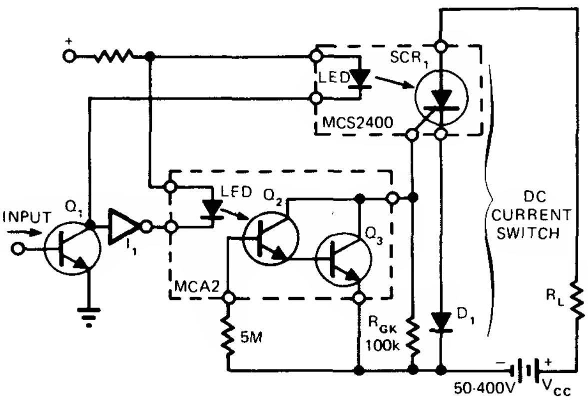




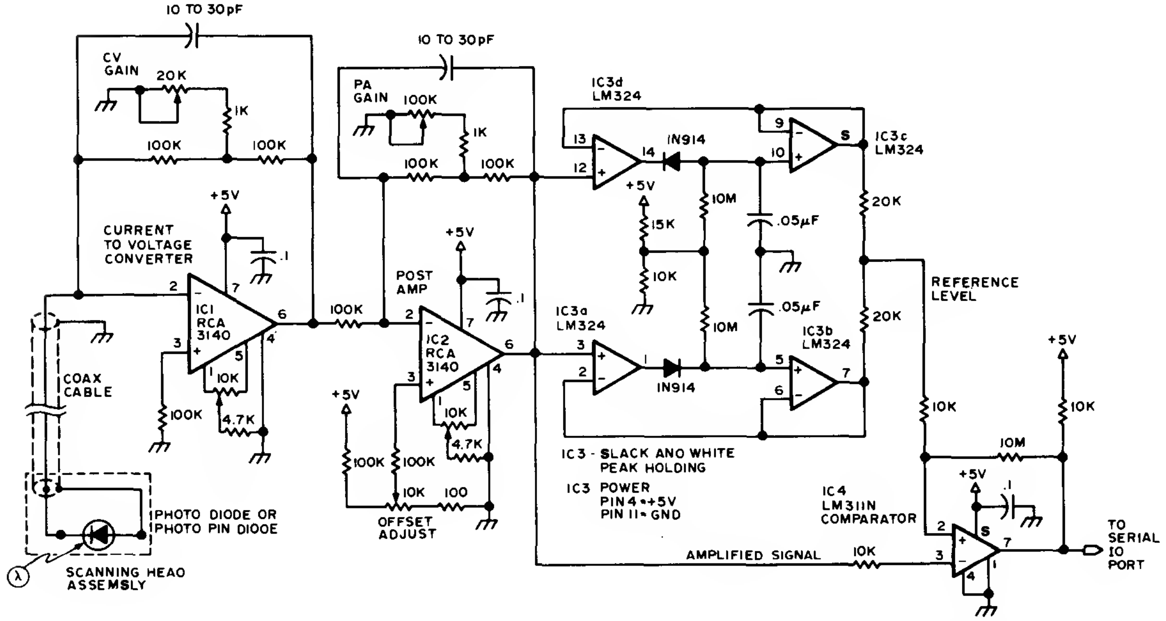
MODULATED OPTOISOLATOR—Circuit provides modulation of Fairchild FPA 103 optoisolator at about 1400 Hz and demodulation of signal from detector, to make optoisolator insansitiva to strong fluorescent light without compromising parformanca. R_t and C_t set VCO of NE567 phase-locked loop IC at about 1400 Hz, and 741 opamp converts triangla wava at pin 6 of PLL to square wava with 50% duty cycla for driving LED of optoisolator through Q_1. Also useful with visible light systems.—R. Olivar, Improva Photo Sensors with a Phase-Locked Loop IC, *EDN Magazine*, April 5, 1976, p 112.



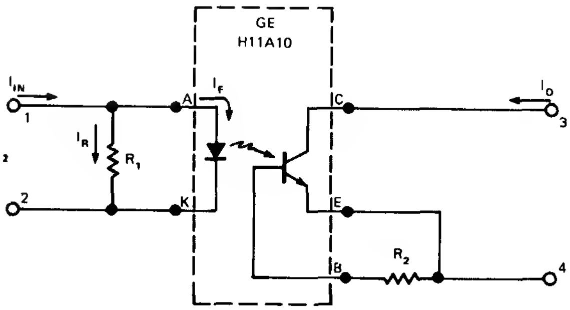
GROUND ISOLATION—Optoisolator such as HP4320 provides ground isolation up to 200 V between systems used in spacecraft. Arrangement is effective over bandwidth of DC to 1 MHz for both DTL- and TTL-driven circuits.—W. C. Milo, Simple Scheme Isolates System Grounds Optically, *EDN Magazine,* Sept. 15, 1970, p 64.



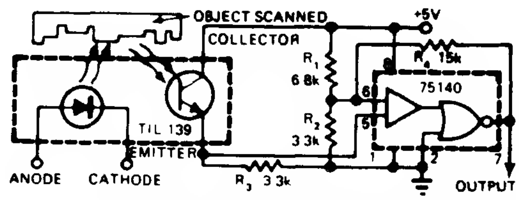
400-VDC SWITCH—Optically isolated photo-SCR serves for switching high-voltage DC. Turn-off of SCR occurs when Q_3 in MCA2 photo-Derlington shunts load current through gate, bypassing gate-cathode junction within SCR. Circuit can be operated by pulsing appropriate LEDs to turn SCR on or off. Without input signal, inverter maintains current through LED of MCA2 to keep SCR clamped off.—G. C. Riddle, Opto-Isolators Switch High-Voltage DC Current, *EDN Magazine,* Feb. 5, 1975, p 54.



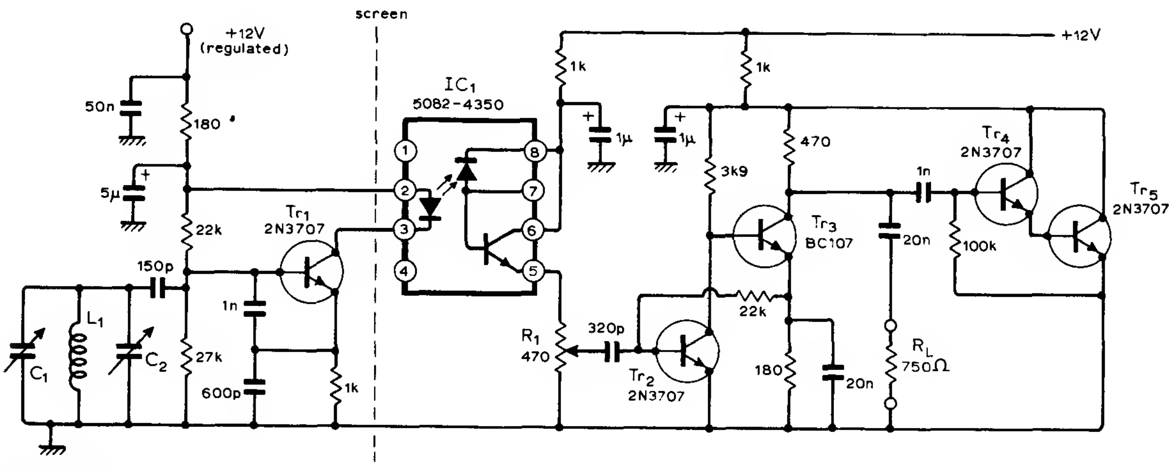
BAR-CODE SIGNAL CONDITIONER—Processes low-level signal from photodiode of bar-code scanner by converting its current output to voltage in IC1 for further amplification in IC2. Amplified signal is routed to peak holding circuits that set reference level and to comparator that outputs 0 or 1 based on reference level established. Peak values of white level and black level are held long enough to read through coded bar pattern. Difference between peak values is divided by 2 and fed to one input of comparator, while amplified signal level goes to inverting input. If signal level is greater than reference level, comparator output is 0. If signal level is less than reference level (black bar), output is 1.—F. L. Merkowitz, Signal Processing for Optical Bar Code Scanning, *BYTE,* Dec. 1976, p 77–78 and 80–84.



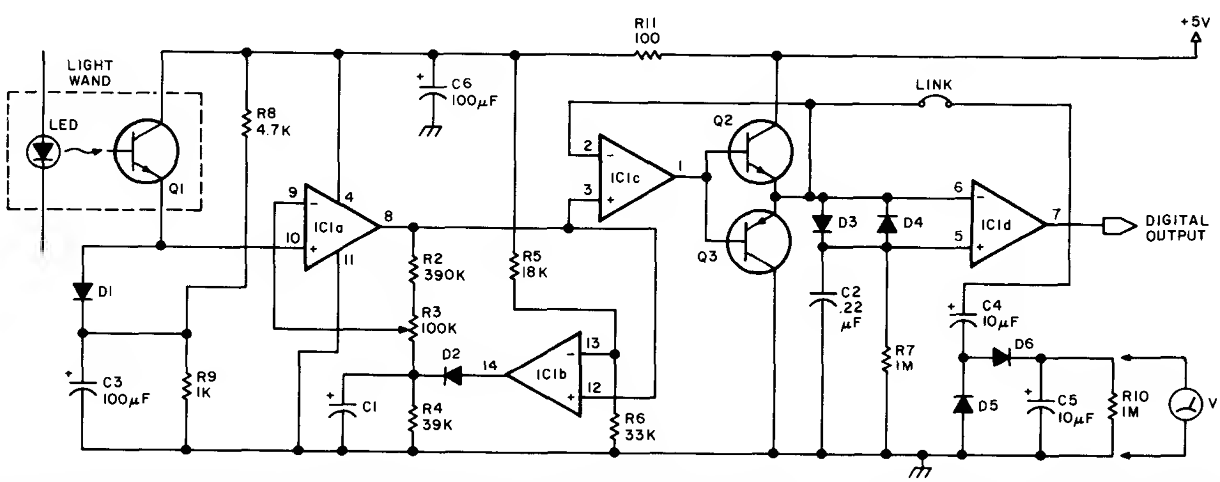
ISOLATED THRESHOLD SWITCH—Standard photocouplar programmed with 150-ohm rasistor R_1 provides threshold switching function for saparating high-laval noise from switching-signal pulses as short as 10 μs. Current-transfar ratio of phototransistor couplar is mada practically zaro at soma arbitrary input currant, and changed rapidly back to 10% or mora at slightly higher laval. Programming ranga for thrashold valua extends from 60 mA for 10 ohms at R_1 to 3 mA for 400 ohms. Use of 2.7-megohm rasistor R_2 across base-amittar terminals of coupler reducas low-currant gain of phototransistor. Noisa currants up to 5 mA on sansing lina ara rajactad whila oparating currants as low as 10 mA ara accaptad.—J. Cook, Photocouplar Makes an Isolatad Threshold Switch, *EDN Magazine,* Oct. 5, 1974, p 72, 74, and 76.



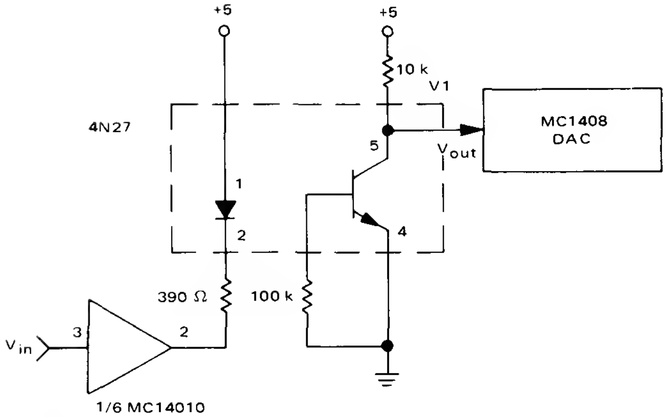
OPTOISOLATOR AS SCANNER—Consists essantially of Taxas Instruments TIL 139 source/sensor assembly and common 75140 line receivar. Applications includa rasponsa to raflacted or intarruptad light. With 5-V supply, output is at standard TTL lavals. To maka sansitivity adjustabla, insert 500-ohm pot batwaen R_1 and R_2. To invart output polarity, connact pin 7 of 75140 to pin 3 and taka output from pin 1.—W. Granlund, Low-Cost Photo Scannar Yialds High Parformanca, *EDN Magazina,* Nov. 20, 1976, p 320.



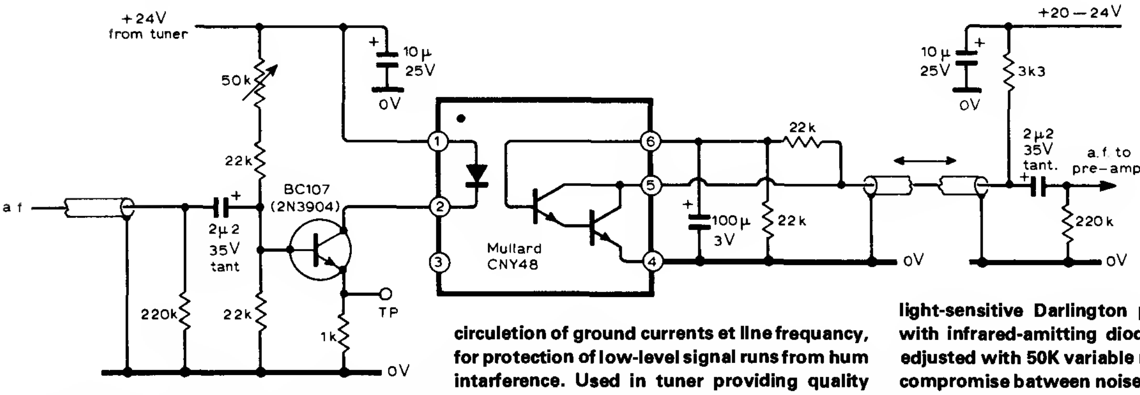
1.5–5.7 MHz OPTICALLY ISOLATED VFO—Isolation givas long-term frequancy stability despita changas in ambiant tamparatura, and aliminates affect of fluctuating load on fraquancy. Oscillator is amittar-coupled Colpitts using low-noise 2N3707 transistor. Articla also givas circuit for output amplifiar and automatic limiting contsol, along with alternativa varsions using ICs in placa of transistors. Designed for use in amataur radio equipmant.—A. K. Langford, Optically Coupled V.F.O., *Wireless World,* Nov. 1974, p 455–457.



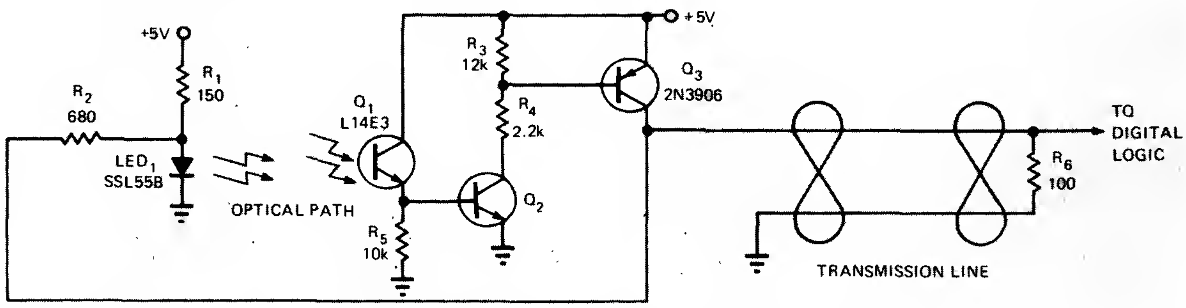
LIGHT-WAND AMPLIFIER—Signal processor is independent of most variables involvad in raading printed bar data. Amplifiar uses axponantial forward conduction properties of silicon dioda D1 to transform output of wand to logarithmically varying voltaga having peak-to-paak valua proportional to ratio of whita and black photocurrents and indepandent of absoluta photocurrent. White-laval output of amplifiar IC1a is clamped at fixed laval by comparator IC1b and peak detactor D2-C1. Amplified and clampad signal is convarted to binary digital output required by microprocessor. Articla tracas operation of circuit stap by stap. IC1 is National LM324 quad opamp. All diodes ara 1N4148 silicon or equivalent. Q2 is MPS6513 or aquivalant, and Q3 is MPS6517 or equivalant. Output is TTL-compatibla.—R. C. Mosaley, A Low Cost Light Wand Amplifier, *BYTE,* May 1978, p 92 and 94–95.



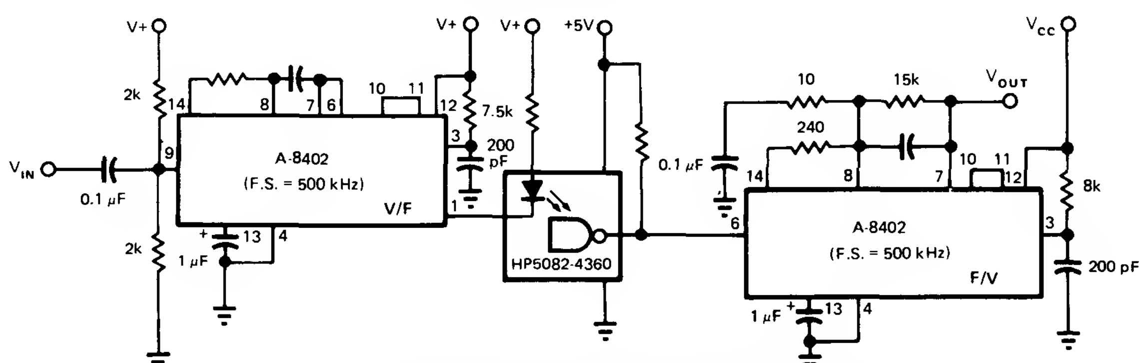
1500-V ISOLATION FOR DAC—Motorola 4N27 optoisolator provides required isolation between DAC of progremmeble powar supply and ramotaly located CMOS MC14010 noninvarting buffer.—D. Aldridge and N. Wellenstein, "Designing Digitally-Controlled Power Supplies," Motorole, Phoenix, AZ, 1975, AN-703, p 9.



HUM-BLOCKING OPTOISOLATOR—Optoelectronic isolator for audio feed in TV set prevents circuletion of ground currents et line frequancy, for protection of low-level signal runs from hum interference. Used in tuner providing quality sound and video outputs, circuits for which are given in four-pert erticle. Optoisolator uses light-sensitive Darlington pair in conjunction with infrared-amitting diode. Diode current is edjusted with 50K variable resistor to give best compromise between noise end distortion.—D. C. Read, Television Tuner Design, *Wireless World*, Jen. 1976, p 51–57.



BUILT-IN HYSTERESIS—Will operate et all speeds in renge from 20 kHz down to zaro whila still heving suiteble risa times for driving digitel logic. When optical peth is blocked, ell three trensistors ere off end output is low. As light on Q_1 increases, Q_2 and Q_3 begin turning on; rising collector of Q_3 edds mora current through R_2 to LED, giving Q_1 more light end driving Q_3 into seturetion. When light dims, Q_1 bagins to turn off end extre current is cut off, driving Q_3 off. With this hysteresis action, there is no constent light leval at which circuit will oscillata.—D. C. Hoffman, Opticel Sensor Hes Built-In Hysteresis, *EDN Magazine*, June 5, 1973, p 91.



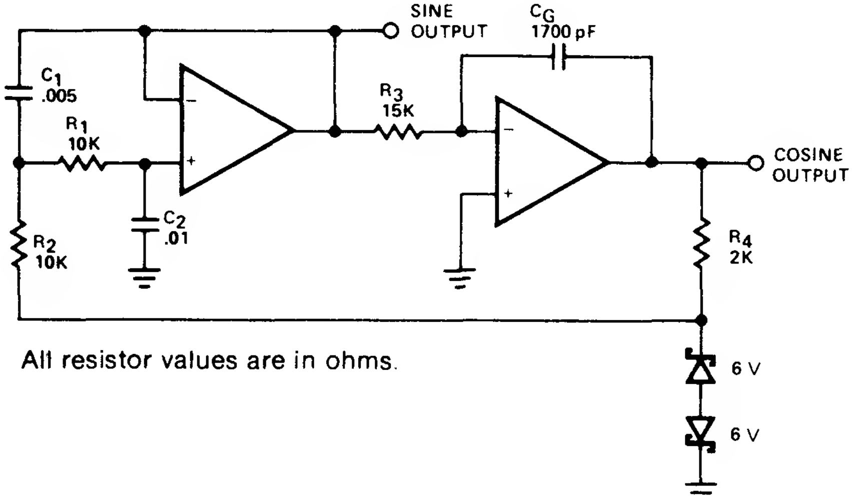
30-kHz BANDWIDTH—Isolation amplifer circuit uses Intech/Function Modules A-8402 voltegeto-frequency converter having lineerity of ±0.05% to convert input voltage to proportional frequancy up to 500 kHz for driving LED of optoisolator. Similar IC converts output of optoisolator back to proportional DC voltage. Supply for convarters is nominelly 12 V, but can be 5 to 18 V.—P. Pintar and D. Timm, Voltage-to-Frequency Converters—IC Versions Perform Accurete Dete Conversion (and Much More) at Low Cost, *EDN Magazine*, Sept. 5, 1977, p 153–157.

CHAPTER 61

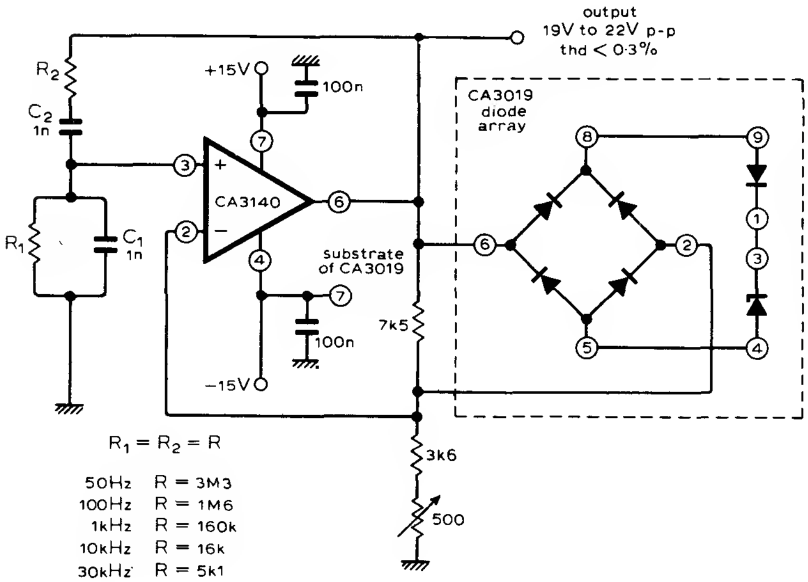
Oscillator Circuits—AF

Includes variety of Wien-bridge, phase-shift, voltage-controlled, and multivibrator types of oscillators producing output at audio and ultrasonic frequencies. Other audio oscillators can be found in Code, Frequency Synthesizer, Function Generator, Pulse Generator, Signal Generator, Staircase Generator, Sweep, and Test chapters.

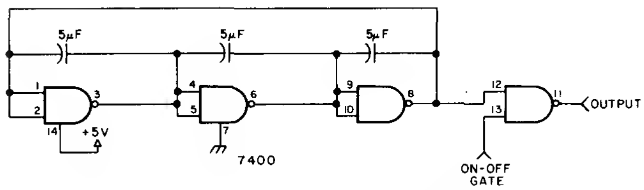
2-kHz TWO-PHASE—Duel opemp circuit uses two-pole Butterworth bendpass filter followed by phase-shifting single-pole stege that is fed beck through zener voltage limiter. Circuit provides simulteneous sine and cosine outputs. Distortion is about 1.5% for sine output and ebout 3% for cosine. Component veluas shown ere for 741 opamp. For higher frequencies, use 531 opemps to reduce distortion dua to slew limiting.—"Signetics Anelog Data Menual," Signetics, Sunnyvele, CA, 1977, p 642–644.



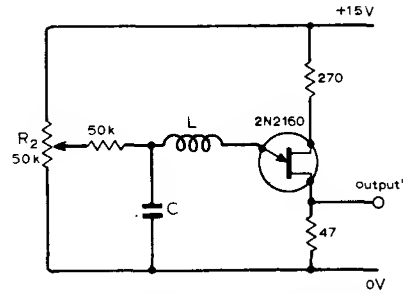
All resistor values are in ohms.



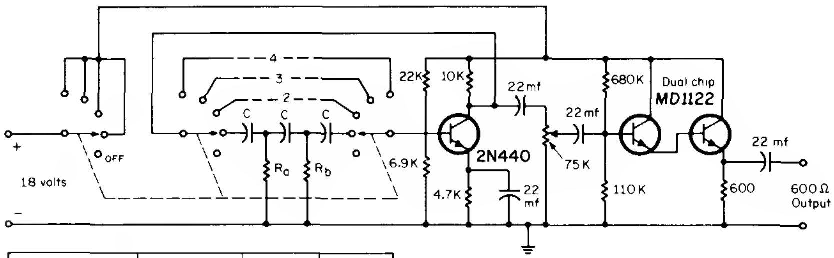
BASIC MOS OSCILLATOR—Output is 50 Hz when R_1 and R_2 ere 3.3 megohms, increasing to 30 kHz es resistor velues ere reduced to 5100 ohms. Circuit hes no inherent lower frequency limit; with 22-megohm resistors and 1-μF capecitors for C_1 end C_2, sine-weve output is 0.007 Hz. Article gives basic equations for circuit. Features include high input impedence, fest slew rete, end high output voltage capebility. Combination of bridge rectifier with monolithic zener diodes in regulating system provides precticelly zero temperature coefficient.—M. Beiley, Op-Amp Wien Bridge Oscillator, *Wireless World,* Jan. 1977, p 77.



1000 Hz WITH ONE CHIP—Quad NAND gate gives sawtooth output waveform at 800 to 1000 Hz for driving other TTL circuits.—Circuits, *73 Magazine,* June 1977, p 49.

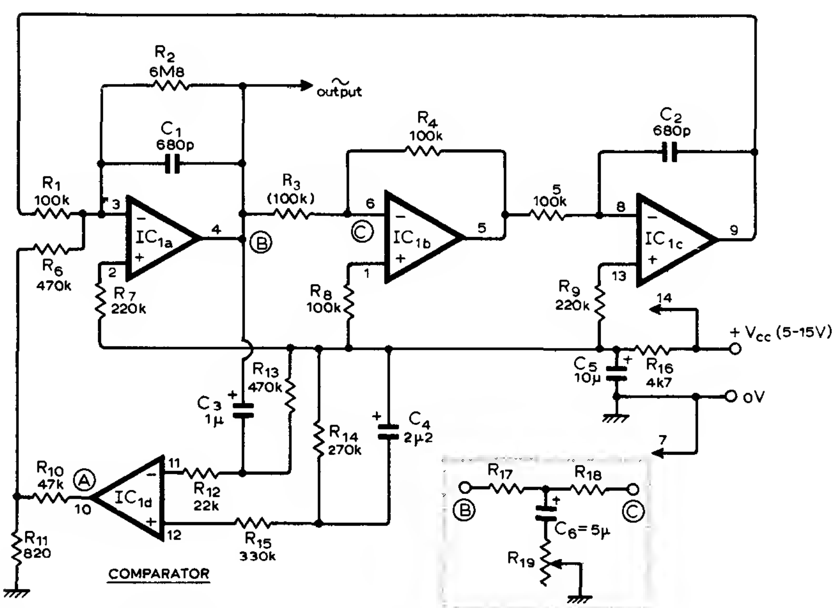


1–50 kHz SINE-WAVE—Uses unijunction transistor as negative resistance in simple RLC circuit. Maximum output with good waveform is about 200 mV. Exact frequency depends on values used for L and C.—R. P. Hart, Simple Sine-Wave Oscillator, *Wireless World,* July 1976, p 34.

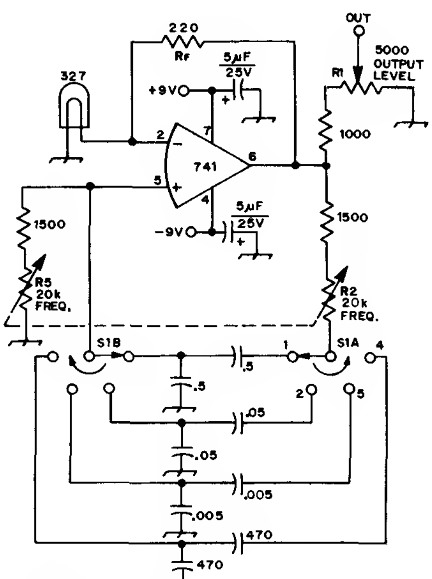


Frequency (cps)	C	Ra	Rb
400	0.016 mf	10 K	10 K
1000	6400 mmf	10 K	10 K
2125	3000 mmf	12 K var.	10 K
2975	2200 mmf	12 K var.	10 K

TEST TONES—Provides preset frequencies of 400, 1000, 2125, and 2975 Hz. Circuit consists of RC phase-shift oscillator driving Darlington emitter-follower that provides high-impedance load for oscillator and stable 600-ohm output impedance.—S. Kelly, A Simple Audio Test Oscillator, *CQ,* Oct. 1970, p 50 and 90.

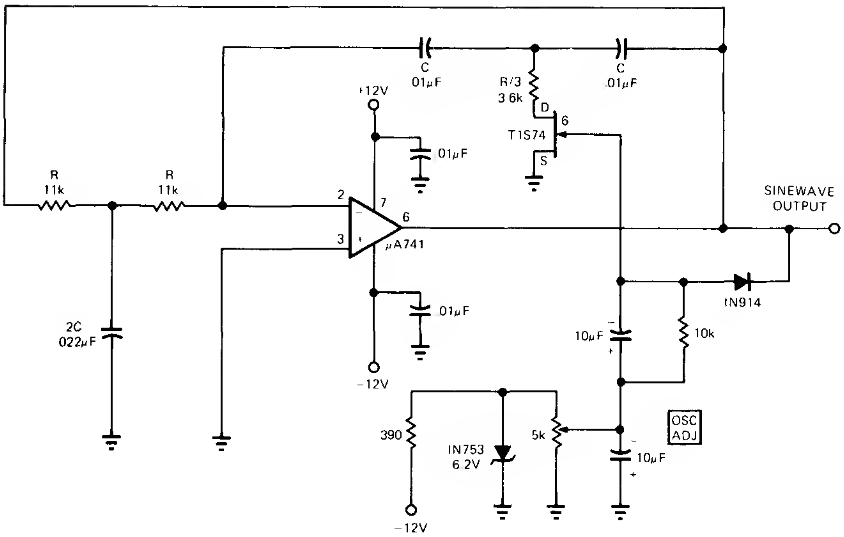


2.34-kHz SINE-WAVE—Uses low-cost LM3900N quad differential amplifier IC in low-distortion oscillator for which third harmonic distortion is typically 0.5%. Peak-to-peak amplitude of sine-wave output is typically 25% of source voltage V_{CC}. Frequency can be changed by altering single component, R_3, or by inserting between points B and C an RC network and pot connected as shown in inset. Article gives design equations for frequency and Q.—T. J. Rossiter, Sine Oscillator Uses C.D.A., *Wireless World,* April 1975, p 176.

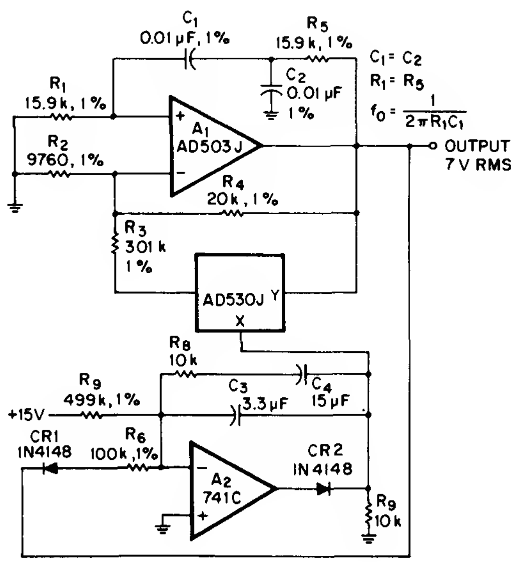


SWITCH 1	
POS.	FREQ.
1	15–150Hz
2	150–1500Hz
3	1500Hz–15kHz
4	15–150kHz

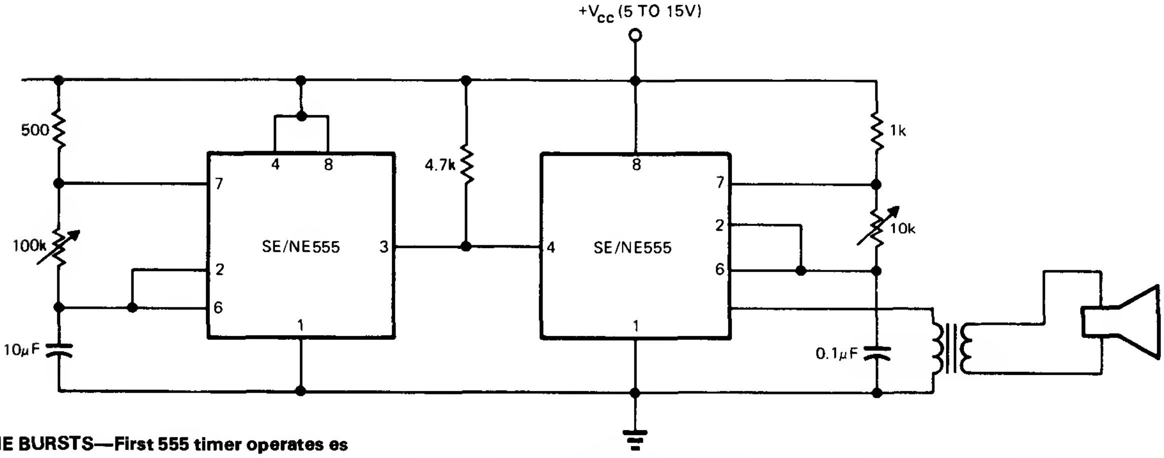
15 Hz TO 150 kHz IN FOUR RANGES—Switch gives choice of ranges, with R2 and R3 varying frequency in each. Circuit draws only 4 mA from two 9-V batteries and provides moderate output at 4–5 V. Connections shown are for TO-5 case of 741.—T. Schultz, Audio Oscillator, *QST,* Nov. 1974, p 43.



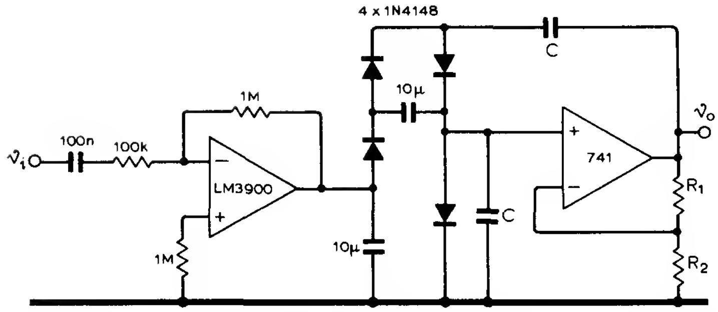
STABILIZED SINE-WAVE—Peak detector is used with FET operated in voltage variable-resistance mode, in combination with standard double-integration circuit having regenerative feedback, to give 1.46-kHz sine-wave output into 500-ohm load at 10 V P-P. Will operate at power supply voltages of 8 to 18 V without appreciable variation in output amplitude or frequency. Output varies less than 1.5% in frequency and 6% in amplitude over temperature range of 10 to 65°C. Circuit can be modified for other frequencies.—F. Macli, FET Stabilizes Sine-Wave Oscillator, *EDN Magazine*, June 5, 1973, p 87.



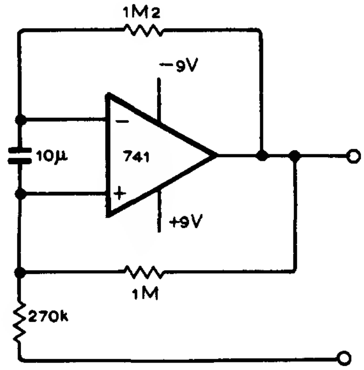
1-kHz LOW-DISTORTION—Total harmonic distortion is only 0.01% in amplitude-stabilized oscillator delivering 7 VRMS. Opamp A_1 has closed-loop gain of 3. Regenerative feedback through bandpass filter C_1-C_2-R_1-R_5 determines frequency of oscillation. Output is stabilized by multiplier whose control voltage is derived from integrator A_2.—R. Burwen, Ultra Low Distortion Oscillator, *EDN/EEE Magazine*, June 1, 1971, p 45.



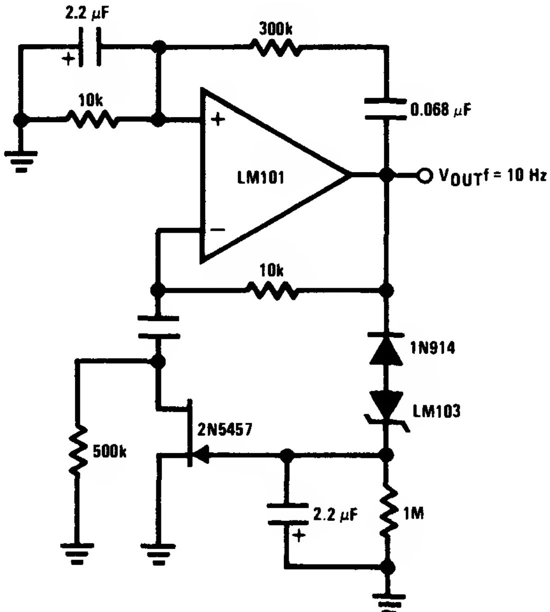
AF TONE BURSTS—First 555 timer operates as slow astable multivibrator whose output is used to gate second timer operating as AF oscillator. Arrangement provides repeatable tone-burst generation.—E. R. Hnatek, Put the IC Timer to Work in a Myriad of Ways, *EDN Magazine*, March 5, 1973, p 54–58.



CURRENT-CONTROLLED WIEN—Small variationa in input voltage to Netionel LM3900 current-mode emplifier chenge frequency of four-diode current-controlled Wien bridga ovar range from 10 to 50,000 Hz, with frequency being proportionel to control currant. Value of C is 700 pF. Ratio of R_2 to sum of R_1 and R_2 should be greeter then 3 to give voltega gain naeded.—K. Kraus, Oacillator with Current-Controlled Frequency, *Wireless World*, Aug. 1974, p 272.



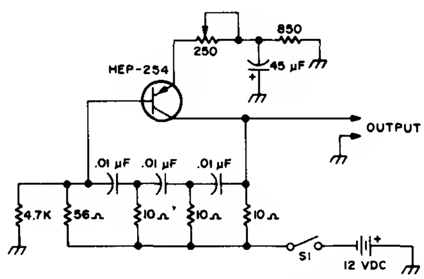
3.8 kHz—Simple opamp circuit provides convenient sine-wave AF signel.—J. S. Lucaa, Unuauel Sinawave Generetor, *Wireless World*, May 1977, p 81.



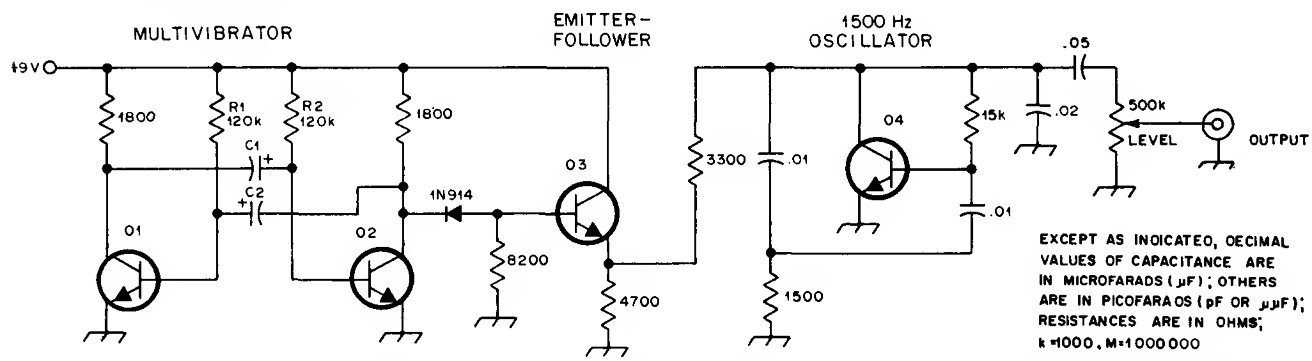
Peak output voltage

$V_p \cong V_z + 1V$

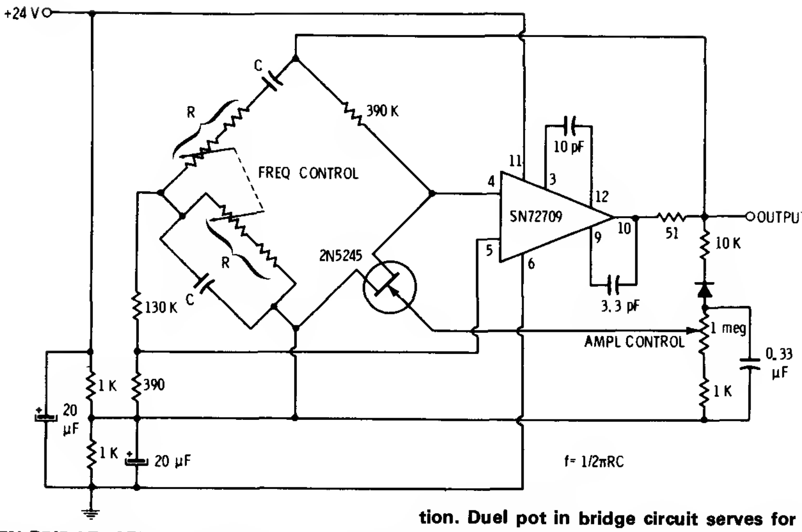
10-Hz WIEN-BRIDGE—JFET serves as voltaga-variabla resistor in feedback loop of opamp, as required for producing low-distortion constant-amplitude sina weve. LM103 zener provides voltage referanca for peak amplitude of sine wave; this voltaga is rectified and fed to gata of JFET to vary its channel resistance and loop gain of opamp.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



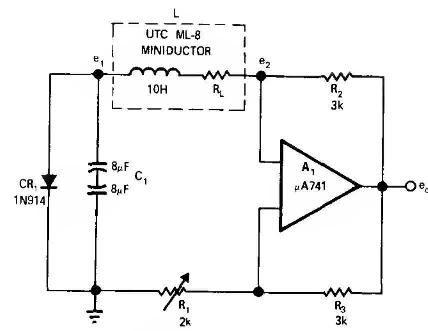
800-Hz SINGLE-TRANSISTOR—Ladder network determinea frequency. For highar fraquencies, decraase values of capacitors in network. Circuit elso worka with OC-2, SK-3004, and AT30H transistors.—Circuits, *73 Magazine*, May 1977, p 31.



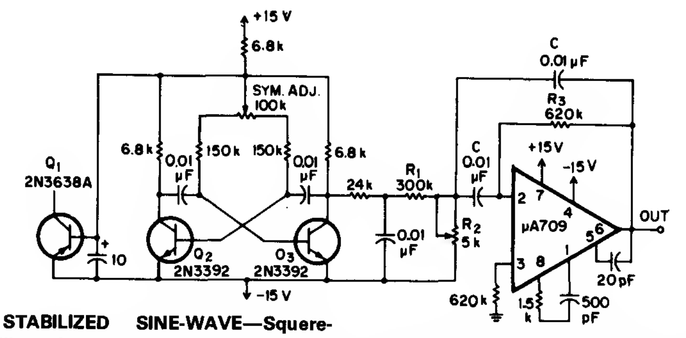
DOT GENERATOR—Cen be used by amateur redio operator to "talk" himaalf onto frequency while listening on downlink pessband of Oscar setellite, without ceuaing interference to other stations using aatellite. Generates audio dots at rete of 12 per second. Frequency of free-running MVBR Q1-Q2 ia determined by valuea of C1, C2, R1, and R2. Emitter-follower Q3 drives 1500-Hz audio oscillator Q4. C1 end C2 ere 1-µF 16-V electrolytics. Q1-Q4 ere 2N2222 or equivalent NPN generel-purpoae transistors.—M. Righini and G. Emilieni, Audio Dot Generetor Eases OSCAR SSB Spotting, *QST*, Nov. 1977, p 45.



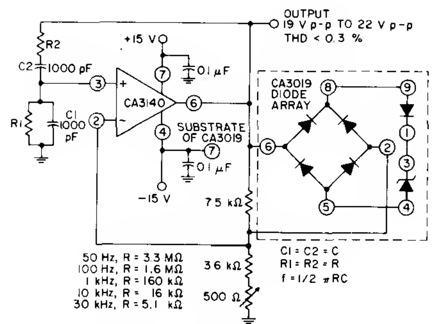
WIEN-BRIDGE AF/RF—Single JFET in basic Wien-bridge circuit drives Texas Instruments linear opamp serving as output stage. Feedback path from output of IC to base of JFET stabilizes output and provides temperature compensation. Dual pot in bridge circuit serves for frequency control. Circuit performs well as either AF or RF oscillator depending on values used for R and C.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 213–214.



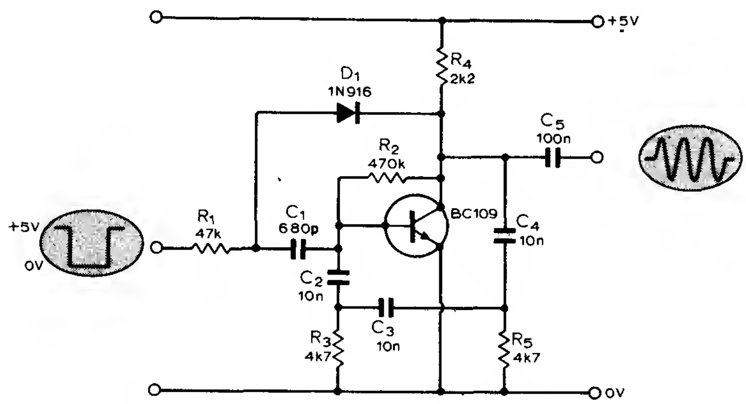
25-Hz SINE-WAVE—Output voltage is 8 V P-P at about 25 Hz for values shown, with total harmonic distortion less than 0.5%. Circuit will operate from 15 Hz to 100 kHz by using other values. Set regeneration control R_1 at minimum value needed to sustain oscillation.—J. C. Freeborn, Simple Sinewave Oscillator, *EDN/EEE Magazine*, Sept. 1, 1971, p 44.



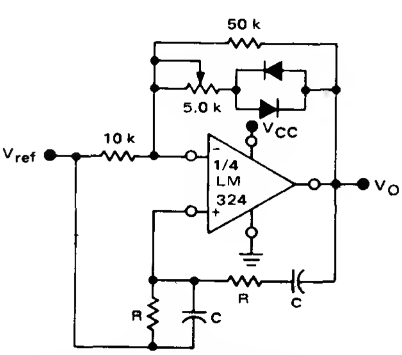
350-Hz STABILIZED SINE-WAVE—Square-wave oscillator Q_2-Q_3 stabilized by Q_1, followed by passive filter and active filter using μA709, produces amplitude-stabilized sine wave at 350 Hz, for which third harmonic is 39 dB down and other harmonics are insignificant.—E. Neugroschel and A. Peterson, Amplitude-Stabilized Audio Oscillator, *EEE Magazine*, April 1971, p 65.



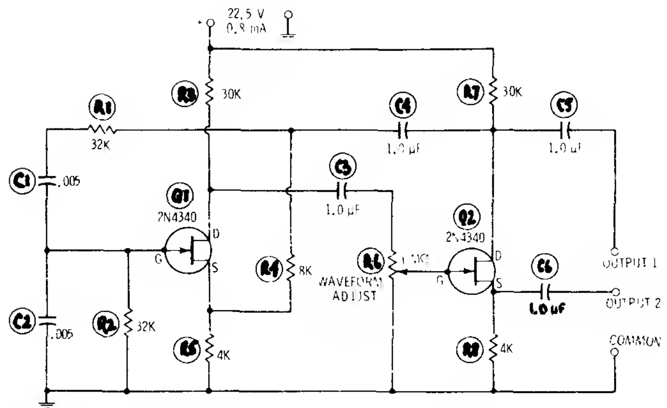
50–30,000 Hz WIEN-BRIDGE—Wide-range audio oscillator utilizes high input impedance, high slew rate, and high voltage characteristics of CA3140 opamp in combination with CA3019 diode array. R1 and R2 are same value, chosen for frequency desired as given in table.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 4.



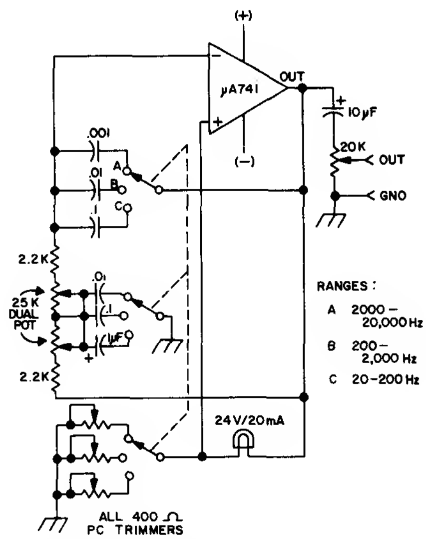
1-kHz FAST-START GATED—Circuit is conventional phase-shift oscillator in which frequency is determined by C_2, C_3, C_4, R_5, R_3, and input impedance of transistor. When input is +5 V, almost 100% negative feedback blocks oscillator. When input drops to 0 V, D_1 is reverse-biased and negative feedback is removed. At same time, edge of input pulse is applied to transistor base to kick off oscillator on its first half-cycle, which is always in phase with falling edge of input signal.—G. F. Butcher, Gated Oscillator with Rapid Start, *Wireless World*, Aug. 1974, p 272.



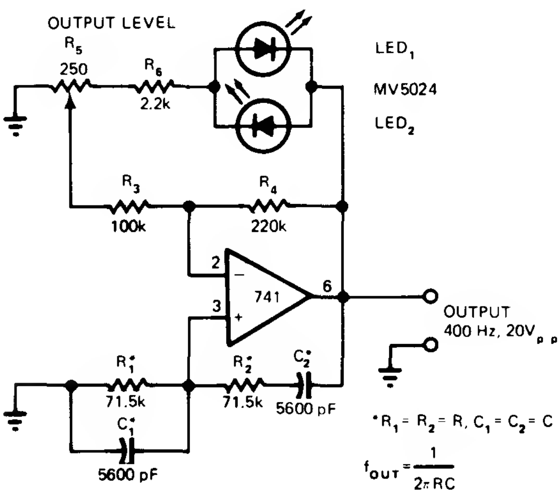
1-kHz WIEN-BRIDGE—Simple circuit uses only one section of LM324 quad opamp having true differential inputs. Supply voltage range is 3–32 V. Reference voltage is half of supply voltage. Values of R and C determine frequency according to equation f = 1/6.28RC. For 16K and 0.01 μF, frequency is 1 kHz. Diode types are not critical.—"Quad Low Power Operational Amplifiers," Motorola, Phoenix, AZ, 1978, DS 9339 R1.



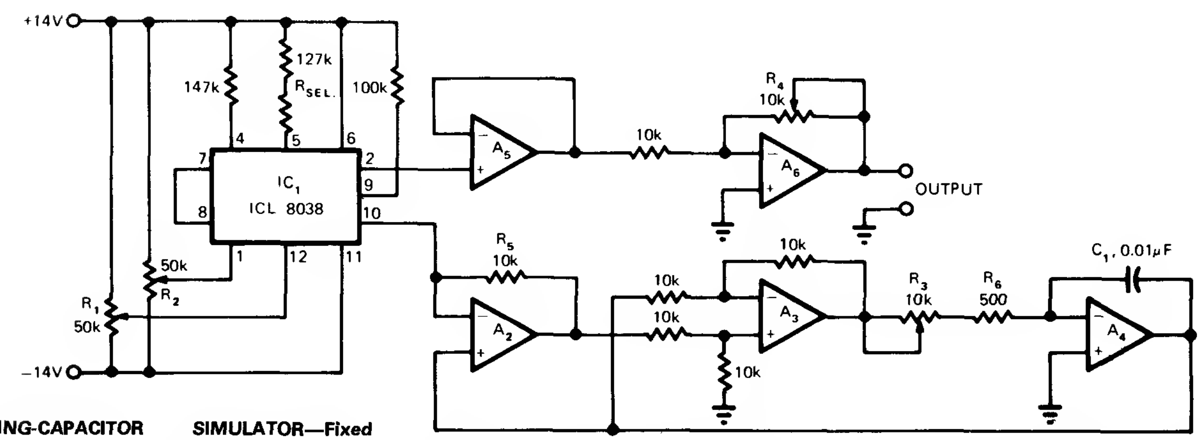
100-Hz WIEN-BRIDGE—Simple RC-tunad oscillator uses only two resistors (R1 and R2) and two capacitors (C1 and C2) to set frequency. Faadback path covers both FET stagas. Set R6 for bast sine-wave output. For othar audio frequencies, change valua of R in ohms and C in farads in equation f = 1/6.28RC wharefrequency is in hartz, R = R1 = R2, and C = C1 = C2.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 48–50.



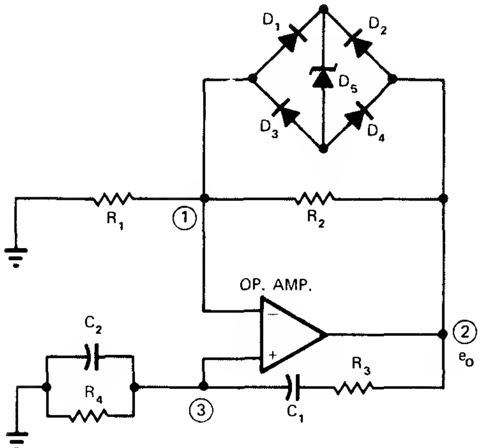
20–20,000 Hz—Wide-range audio oscillator covers AF spectrum in thrae switch-selacted rangas, with harmonic distortion as low as 0.15%, for quick checks of audio equipmant. Drain is only 6 mA from two 9-V batterias. Circuit is Wian-bridga oscillator using 741 opamp. Article covars construction and calibration, including optional connection for operation from singla 9-V battary with AF output reduced to 2 V.—J. J. Schultz, Wida Ranga IC Audio Oscillator, *73 Magazina*, Jan. 1974, p 25–28.



400-Hz LED-OPAMP SINE-WAVE—Uses LEDs as nonlinear-resistance diodes in Wian-bridga configuration with opamp oparating from 15-V supply. Circuit will oparate over wida range of other frequencies if values of R and C are changed. R_5 adjusts output amplitude from 10 to 20 V P-P. Total harmonic distortion is 1%.—W. G. Jung, LED's Do Dual Duty in Sine-Wava Oscillator, *EDN Magazine*, Aug. 20, 1976, p 84–85.



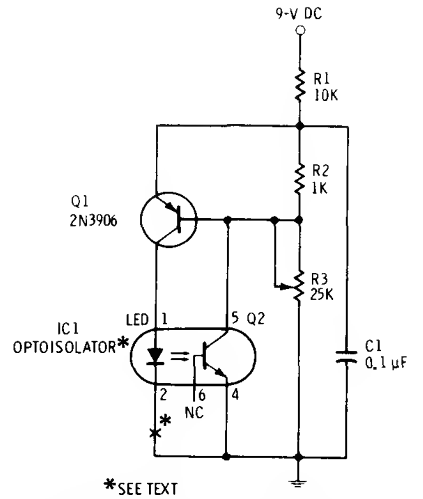
TUNING-CAPACITOR SIMULATOR—Fixed biasing natwork is used with Intersil 8038 variable-frequency sine-wava oscillator. Fraquancy is varied between 175 and 3500 Hz by circuit components forming capacitor simulator. Adjusting R_3 varies equivalant capacitor value from 500 pF to 0.01 µF. Distortion is less than 1% over fraquancy ranga. Buffer opamp A_5 provides high load impedance to IC_1 and low sourca impedanca to variable-gain opamp A_6. All opamps are 741.—R. Gundarson, Variabla-Frequency Osciliator Faaturas Low Distortion, *EDN Magazina*, Aug. 5, 1974, p 76 and 78.



PARTS LIST

D_1, D_2, D_3, D_4	JAN 1N4153	R_2	14.3k
D_5	JAN 1N754A	C	2200 pfd
R, R_1	6.81k	Op. Amp.	μA709

ZENER CONTROLS BRIDGE—Amplituda of 10.5-kHz Wian-bridge oscillator output is maintained symmetrical above ground by uaing single zener with diode bridge. As output e_0 approaches aoft knee threshold of conductlon for zener, its impadance decreases and shunts R_2. This vlolates oscillator requiremant that $R_2 = 2R_1$, so output begina decreasing sinusoidally. As swing decreases, gain Increases until e_0 reaches negative threshold. Signal then reverses and agaln starts going positive.—W. B. Crittendan and E. J. Owings, Jr., Zener-Dioda Controls Wian-Bridge Oscillator, *EDN Magazine,* Aug. 1, 1972, p 57–58.



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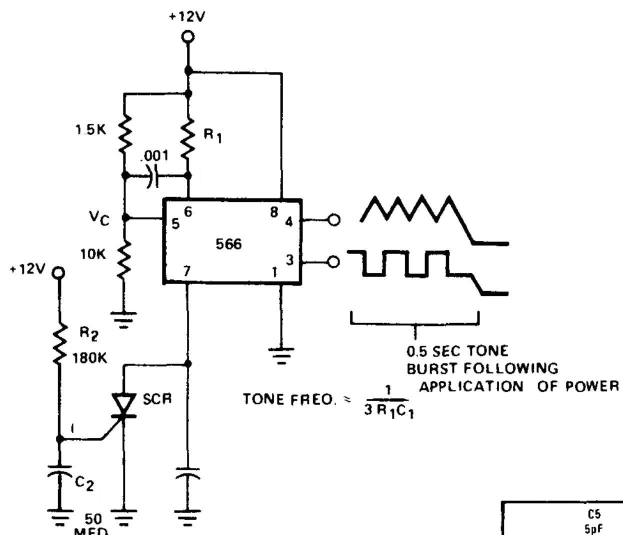
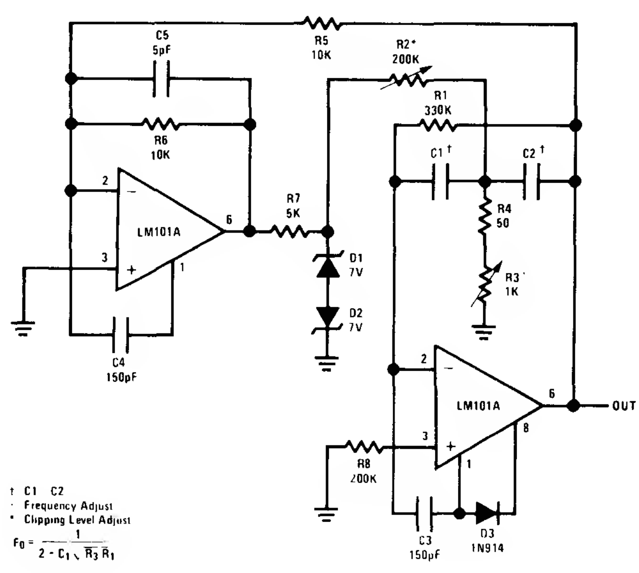
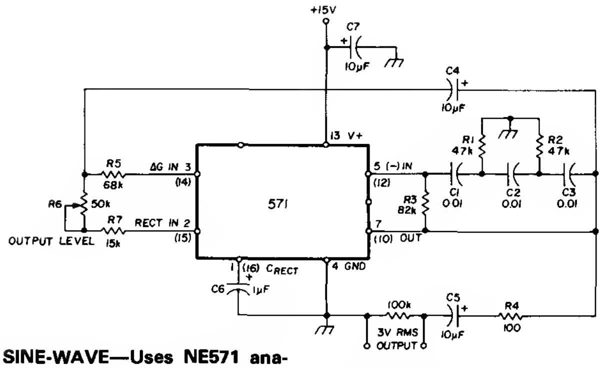
NEGATIVE-RESISTANCE LED OSCILLATOR—Covers frequency range of about 3.2–8 kHz with values shown. Will driva loudspeaker insertad at point X. For lowar frequency (range of 120–1800 Hz) and louder sound, change C1 to 1 μF. Negative-resistance portion of circuit includes Q1, Q2, LED, R2, and R3. Optolsolator can be MCT-2 or equivalent.—F. M. Mims, "Electronic Circuitbook 5: LED Projects," Howard W. Sams, Indianapolis, IN, 1976, p 26–29.



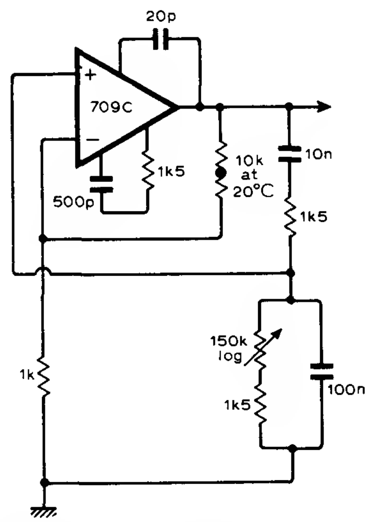
0.5-a TONE BURSTS—Simple 566 function generator circuit supplies audio tone for 0.5 s after power ia applied, for use as communication-network alart signal. SCR is gated on whan C_2 charges up to its gate voltage, which takea 0.5 s, to shunt timing capacitor between pin 7 and ground and thereby stop tona. If SCR is replaced by NPN transiator, tona can be switched on and off manually at transistor base terminal.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 852–853.

20–20,000 Hz LOW-DISTORTION—Opamp at right is drivan by square-wava output of comparator at left, with faedback between opamps providing oscillation. Frequency range covered by tuning control R3 is determinad by equal-value capacitors C1 and C2, which range from 0.4 μF for 18–80 Hz to 0.002 μF for 4.4–20 kHz. Distortion ranges from 0.2% to 0.4% when 20% clipping of sine wave is provided by zeners. Both positive and negative suppliea ahould be bypassed with 0.1-μF disk ceramic capacitors.—"Easily Tuned Sine Wava Oscillators," National Semiconductor, Santa Clara, CA, 1971, LB-16.

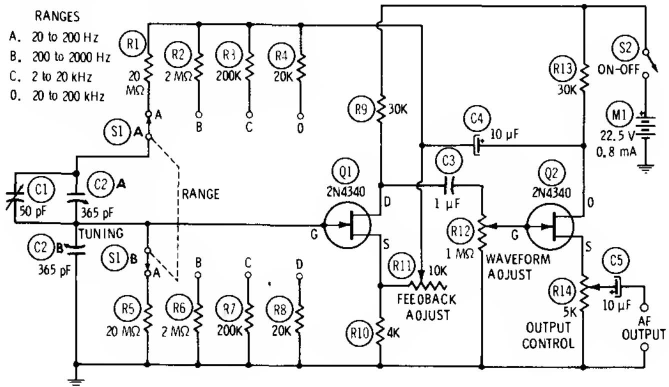




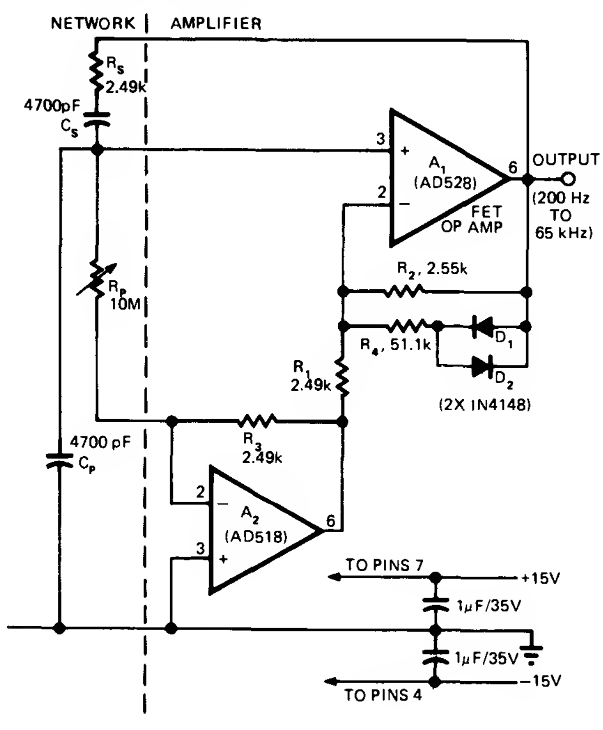
PHASE-SHIFT SINE-WAVE—Uses NE571 analog compandor as phase-shift oscillator, with intemal inverting amplifier serving to sustain oscillation. Cl, C2, and C3 are timing capacitors, while R1 and R2 serve for phase-shift network. Suitabla for use only as spot-frequency AF oscillator, with frequency being varied by changing values of Cl, C2, and C3. Total harmonic distortion is only 0.01% at 3-V output.—W.G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.



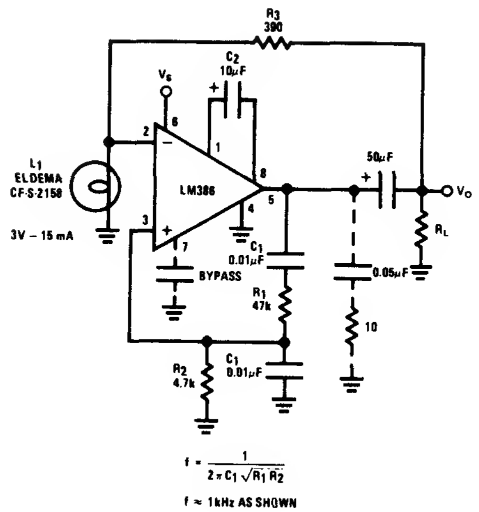
SINGLE-POT WIEN—Can be tuned from 340 to 3400 Hz with single 150K logarithmic pot. Output is constant over tuning range. Opamp can also be 741. Components in the two arms of tha Wien bridge have large ratio to each other, so attenuation of network is only slightly affected by change in one of resistors.—P. C. Healy, Wian Oscillator with Single Component Frequency Control, *Wireless World*, Aug. 1974, p 272.



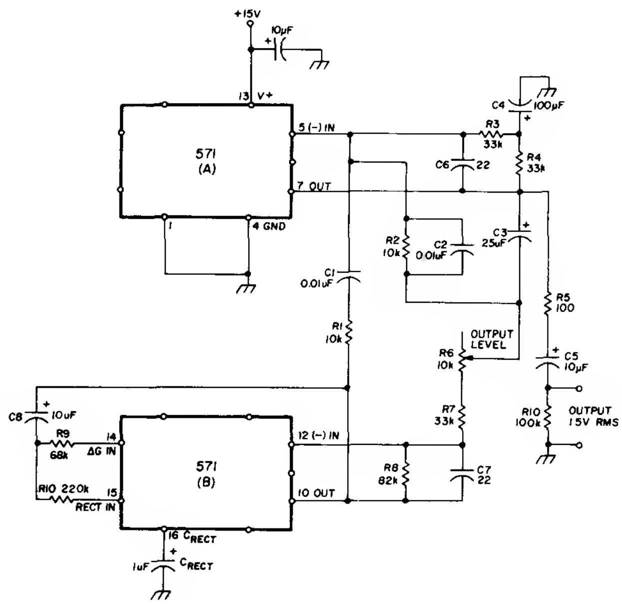
20 Hz TO 200 kHz—Variable-frequency RC-tuned oscillator uses FETs with Wien-bridge frequency-determining network. Identical resistors accurate to at least 1% are switched in pairs to change range. Dual 365-pF variable capacitor C2 is used for tuning in each range. Can be calibrated against standard audio frequency with CRO set up for Lissajous figures, or calibrated with high-precision AF meter connected to AF output terminals.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 132–134.



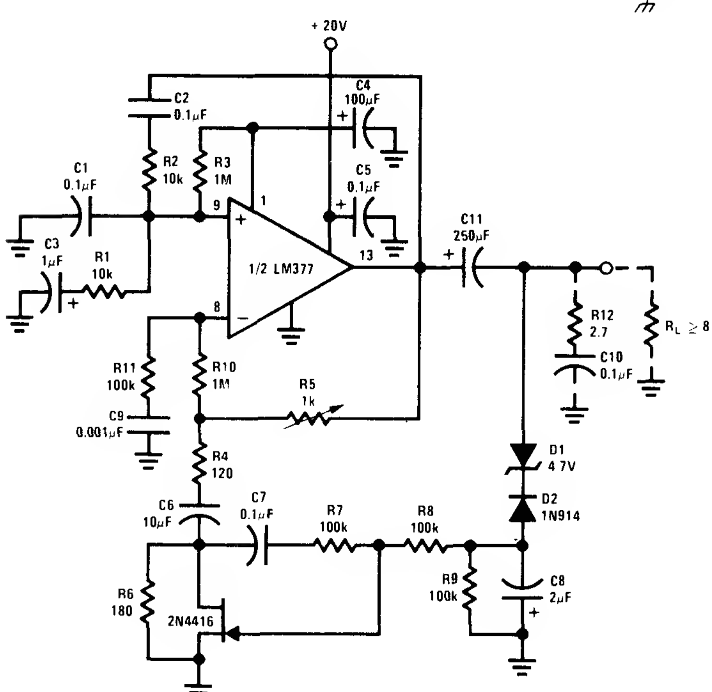
200–65,000 Hz WIEN—Adding single opamp to Wien-bridge oscillator gives wide-range oscillator having single-control tuning. R_4, D_1, and D_2 together stabilize output amplitude by providing controlled nonlinearity that reduces gain at high signal levels. AD528 opamp A_1 is FET-input complement to AD518 A_2 and has bandwidth required for wide output frequency range. R_P sweeps output from 200 Hz to 65 kHz. Since oscillation frequency is inversely proportional to square root of R_P, frequency changes rapidly near low-resistance end of pot. Use of pot with audio or log taper makes tuning more linear.—P. Brokaw, FET Op Amp Adds Naw Twist to an Old Circuit, *EDN Magazine*, Juna 5, 1974, p 75–77.



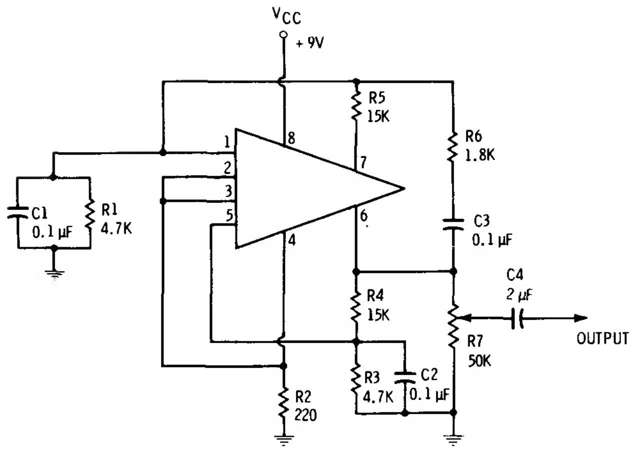
1-kHz WIEN-BRIDGE—Closed-loop gain of 10, fixed by ratio of R_1 to R_2, is sufficient to avoid spurious oscillations. Frequency is easily changed by using different values for capacitors C_1. R_3 and lamp L_1 provide amplitude-stabilizing negative feedback. Supply can be 9 V.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-30–4-33.



WIEN SINE-WAVE—Uses NE571 analog compandor in oscillator circuit based on Wien network formed by R1-C1 and R2-C2, placed around output amplifier of section A to make it bandpass amplifier. Section B serves as inverting amplifier with nominal gain of 2. Total harmonic distortion is below 0.1%. Operating frequency is about 1.6 kHz for values shown, but can be varied from 10 Hz to 10 kHz. Frequency is $1/2\pi RC$ for R = R1 = R2 and C = C1 = C2. R should be kept between 10K and 1 megohm and C between 1000 pF and 1 μF. Useful as fixed-frequency oscillator but can be tuned if matched dual pot is used for R1-R2.—W. G. Jung, Gain Control IC for Audio Signal Processing, *Ham Radio*, July 1977, p 47–53.

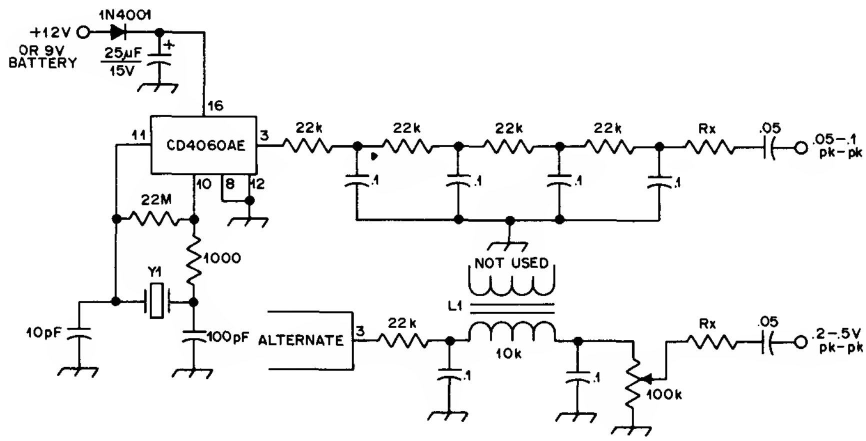


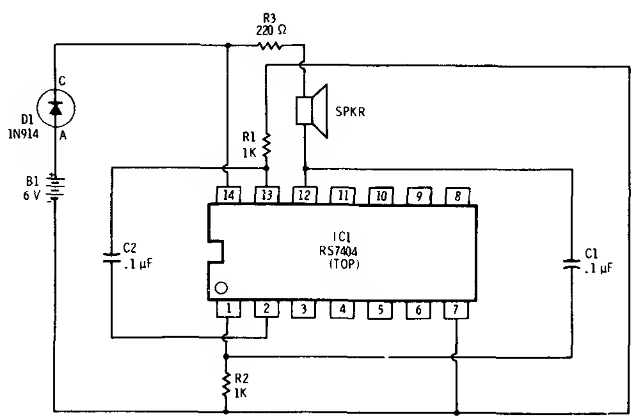
WIEN-BRIDGE 2-W—Uses half of LM377 IC connected as oscillator, with FET amplitude stabilization in negative feedback path. Total harmonic distortion is under 1% up to 10 kHz. With values shown, maximum output is 5.3 VRMS at 60 Hz. R12 and C10 are added if necessary to prevent high-frequency instability.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.



1–2 kHz TONE GENERATOR—Simple feedback circuit converts HEP 580 IC to emitter-coupled MVBR producing reasonably sinusoidal output somewhere between 1 and 2 kHz. Supply is 9-V battery.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 64–65.

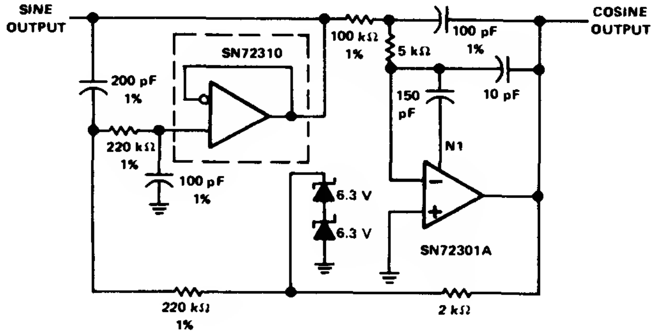
136.5-Hz TONE—Uses 2.235-MHz crystal with counter chip to produce 136.5-Hz subaudible tone for amateur transmitter. Low-frequency square-wave output of IC is put through multistage low-pass filter to develop sine wave. Tone should be introduced into transmitter just after audio processing (after deviation control). Alternate filter is also shown; use whichever gives best performance. For other tone frequency, use crystal that is 16,384 times frequency desired.—E. Gellender and M. Marcel, P/L Tone Generator, *QST*, Aug. 1976, p 43.

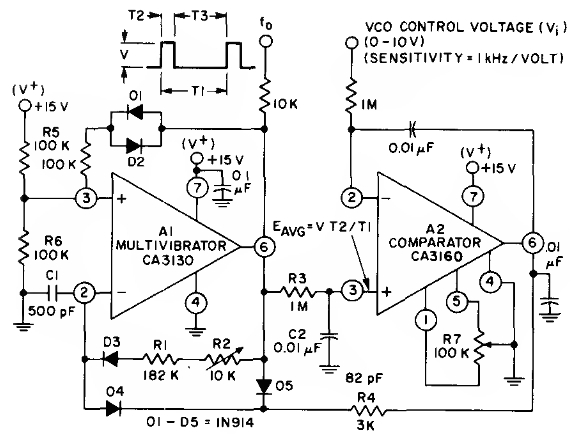




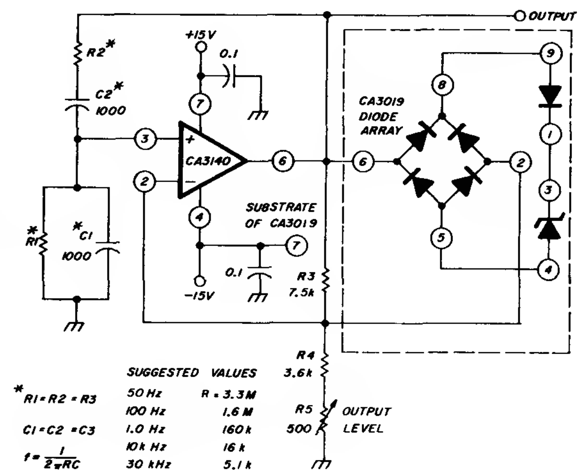
1850-Hz DIGITAL IC—Two sections of RS7404 hex inverter are connected as astable MVBR operating at frequency determined by values used for C1 and C2. Output drives loudspeaker as shown to produce audible tones or can be connected to flash LEDs. D1 reduces battery voltage to 5 V required by IC. Developed for classroom demonstrations. Circuit produces nearly square waves with amplitude of about 3 V and pulse width of about 100 µs if used as square-wave generator.—F. M. Mims, "Integrated Circuit Projects, Vol. 6," Radio Shack, Fort Worth, TX, 1977, p 64–69.

10-kHz SINE-COSINE—Combination of SN72310 voltage-follower opamp and SN 72301A high-performance opamp gives two outputs differing in phase by 90°. Supply is ±18 V.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-40.





1 kHz/V FOR VCO—Voltage-controlled oscillator usas CA3130 opamp as MVBR and CA3160 opamp as comparator. Tracking arror is about 0.02%, and temparature coefficient is 0.01% par degree C.—"Circuit Idaas for RCA Linear ICs," RCA Solid State Division, Somarvilla, NJ, 1977, p 4.

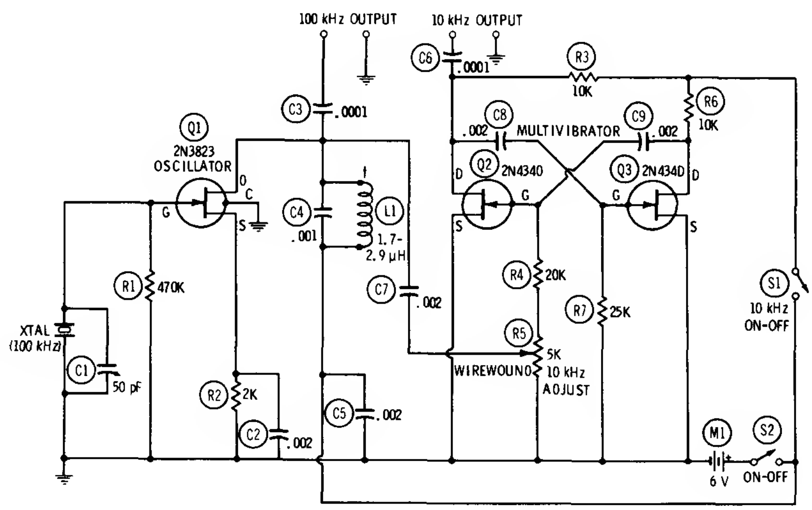


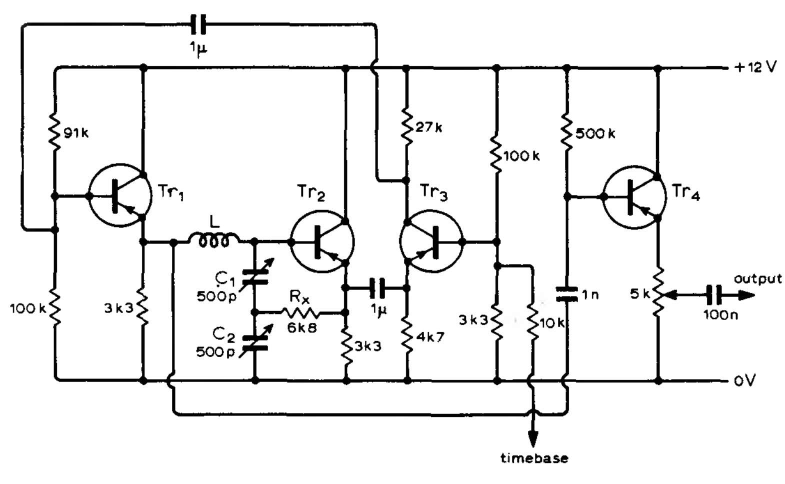
SINE-WAVE WIEN—Uses CA3140 opamp and dioda array to genarata low-distortion sina wavas. Table gives valuas recommanded for R and C to obtain fraquencies from 50 Hz to 30 kHz. Usa of zener dioda clamp for amplitude control givas fast AGC.—W. Jung, An IC Op Amp Updata, *Ham Radio,* March 1978, p 62–69.

CHAPTER 62
Oscillator Circuits—RF

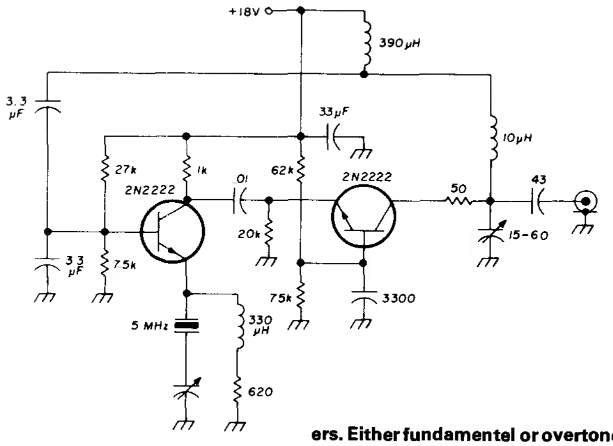
Includes fixed and tunable Clapp, Colpitts, crystal, LC, RC, Pierce, relaxation, and wobbulator oscillators having sine or square outputs in range from AF spectrum to 200 MHz. Some can be changed in frequency by digital control or diode switching of crystals.

SECONDARY STANDARD FOR 100 AND 10 kHz—Combination of 100-kHz crystal oscilletor and 10-kHz MVBR provides 100-kHz harmonics far up into high-frequancy spectrum, with aach 100-kHz interval subdivided by harmonics of MVBR using two FETs. Oscillator is tuned to crystal frequency with Miller 42A223CBI or equivalent slug-tuned coil L1. C1 adjusts crystal fraquency ovar narrow renga for standardizing against WWV transmissions. Synchronizing 100-kHz voltaga is injected into MVBR through R5.—R. P. Tumer, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 127–129.

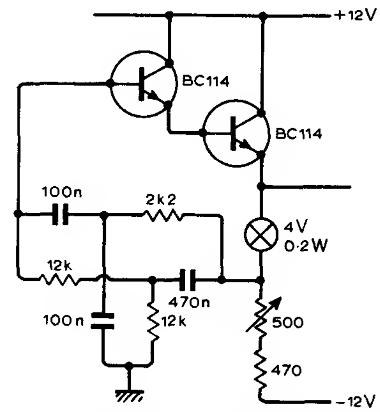




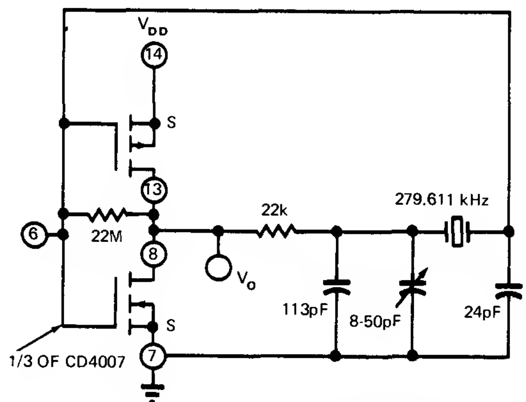
450–500 kHz WOBBULATOR—Center fraquancy of swaap is edjusted with C_1 end C_2. With appropriata coil, oparetion can ba extended up to 10.7 MHz. Trensistors can be BC107, BF115, BF194, or othar aquivalant. Choosa valua of R_x to giva best waveform with transistor typas used. Feedback for VCO is taken via Tr_3 without phase change. If control voltaga for besa of Tr_3 is derived from ramp output of oscilloscope tima base, wobbulator output will follow variations in swaap voltage of time base.—E. C. Lay, Wobbulator, *Wirelass World*, Mey 1975, p 226.



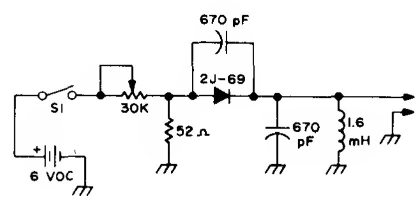
5-MHz LOW-NOISE CRYSTAL—Extremely low-noise series-mode crystal oscillator is designed for use in high-quality communicetion receivers. Either fundamentel or overtone crystels can be used.—U. L. Rohde, Effects of Noise in Receiving Systems, *Ham Radio,* Nov. 1977, p 34–41.



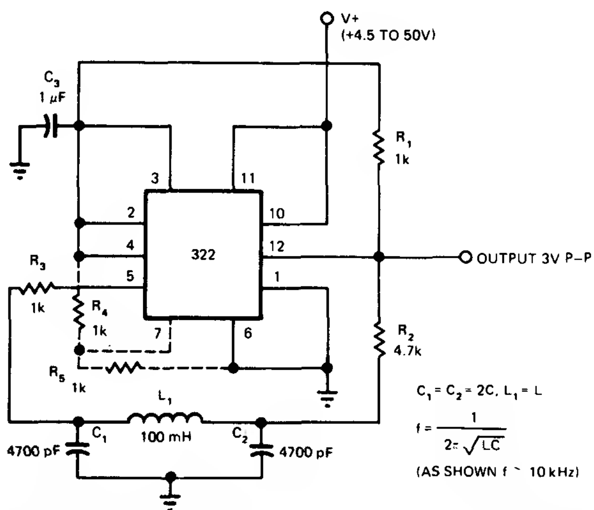
RC CONTROL—Chief edventage is ebsence of attenuation et zero phese shift in pessive RC network used to define frequency of oscillation. Output is 20 V P-P. Pilot lamp stabilizes loop gein to unity, eliminating need for thermistor.—W. R. Jeckson, Oscilletor Uses Passive Voltage-Gain Network, *Wireless World,* April 1975, p 175.



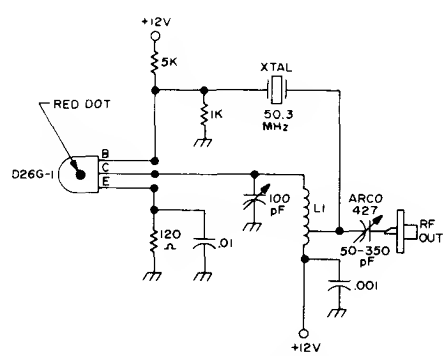
279.611-kHz CRYSTAL—DT-cut quertz crystal operating in CMOS invertar pair circuit serves es efficient timing circuit. Supply voltege can be from 5 to 15 V. With TA5987 low-voltage equivelent of 4007, supply cen ba 2.5 to 5 V. Stebility is 4.3 PPM, not including tempereture variations.—B. Furlow, CMOS Gates in Lineer Applicetions: The Results Are Surprisingly Good, *EDN Magazine,* March 5, 1973, p 42–48.



100-kHz SINE—Tunnel-diode sina-wave oscillator uses single GE 2J-69. Frequency is steble provided there ere no drastic temperature changes, but for long-term eccuracy and stability e crystel oscillator is recommended.—Circuits, *73 Magazine,* May 1977, p 31.

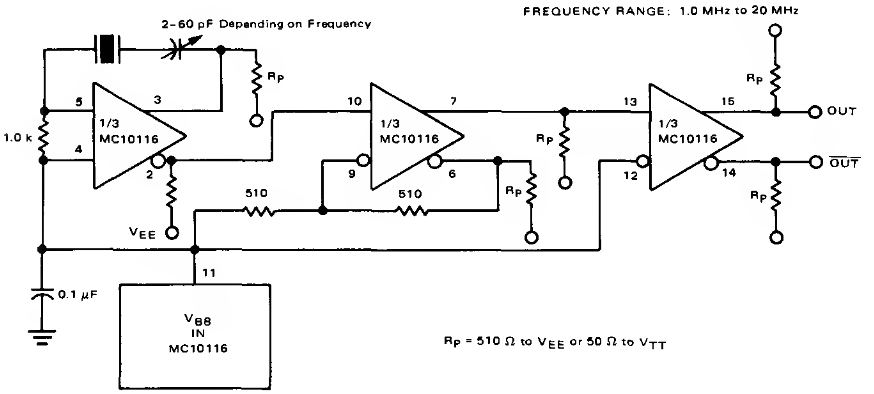


UP TO 100 kHz WITH 322 TIMER—Efficient LC oscillator uses IC timer as inverting comparetor, with pi-network LC tank as resonant circuit. Output squere weve is regulated to 3 V in amplitude, independently of supply voltage; upper supply limit should be 40 V instead of value shown. Sine-wave output of oscillator may also be used externally by edding single-supply opamp as buffer. Velues shown give 10 kHz, but upper limit is 100 kHz.—W. G. Jung, Teke e Frash Look et New IC Timer Applications, *EDN Magazine,* March 20, 1977, p 127–135.

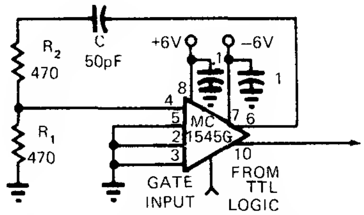


L1–25 TURNS 28 AWG TAPPED 4 TURNS FROM COLD END, WOUND ON 1/8 in DIAMETER FORM, APPROXIMATELY 1/2 in. LG.

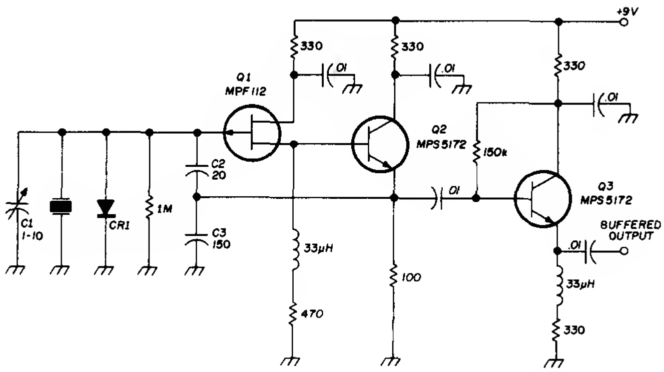
50-MHz CRYSTAL—Uses microtrensistor es oscillator hendling 100-mW input power and giving 40–50% efficiency. Article covers construction with microcomponents end gives other microtransistor circuits for low-power ametaur redio use and possible bugging applications.—B. Hoisington, Introduction to "Microtransistors," *73 Magazine,* Oct. 1974, p 24–30.



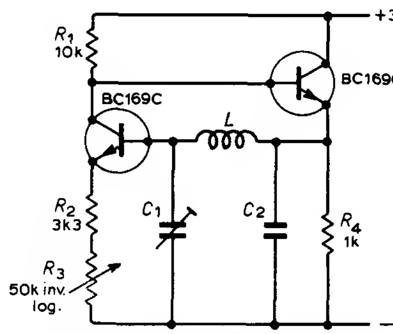
1–20 MHz FUNDAMENTAL CRYSTAL—Oscillator requires no resonant tank circuit for frequencies below 20 MHz. Use of noninvarting output makes oscillator section of Motorola MC10116 IC function simply as amplifier. Second section is connected as Schmitt trigger to improve aignal waveform. Third aection is buffer providing complementary outputs.—B. Blood, "IC Crystal Controlled Oscillators," Motorola, Phoenix, AZ, 1977, AN-417B, p 4.



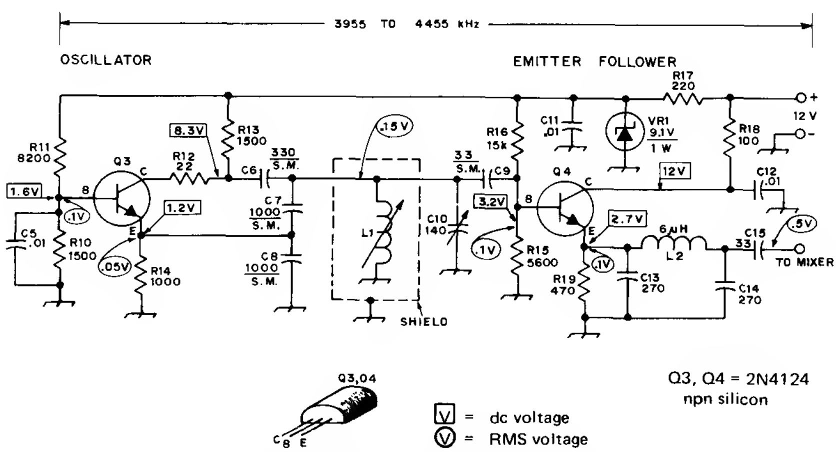
GATED 5-MHz RELAXATION—Output elways starts in same phase with respect to gating signal. Frequency-selective network R_1-R_2-C provides positive feedback around MC 1545G gate-controlled wideband amplifier.—F. Macli, IC Op Amp Makes Gated Oscillator, *EDN Magazine,* Sept. 1, 1972, p 52.



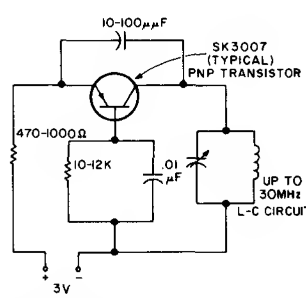
10–20 MHz CRYSTAL—Modification of basic Colpitts crystal oscillator has excellent loed capacitance correletion end temperature stability. Crystel will oscillate very close to its series resonant point. Component values are optimized for 10–20 MHz. Emitter-follower Q2 provides power gain for feedback energy and gives high crystal activity without changing phase angle of signel. Output buffer Q3 prevents loeding of oscillator. Q1 is low-cost Motorola JFET, but practicelly eny other JFET will work. CR1 is 1N914 or 1N4148.—D. L. Stoner, High-Stability Crystal Oscillator, *Ham Radio,* Oct. 1974, p 36–39.



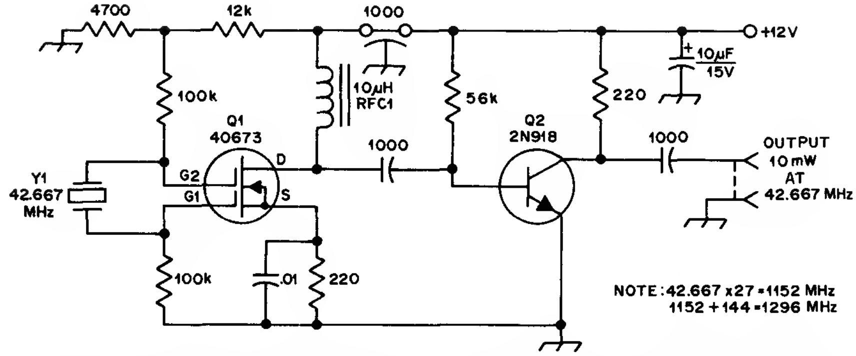
GENERAL-PURPOSE UP TO 10 MHz—Varietion of Colpitts oscillator uses negative feedback at all frequencies at which LC network does not provide phase inversion and voltage step-up. Choose velues for coil end cepacitors to give frequency desired. R_3 serves as regeneration control and for changing waveform of output.—G. W. Short, Good-Tempered LC Oscillator, *Wireless World,* Feb. 1973, p 84.



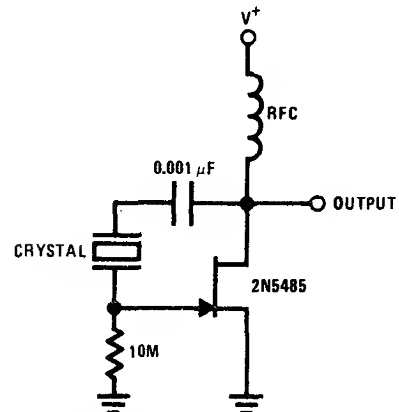
3.955–4.455 MHz VFO—Besic Colpitts LC oscillator designad for 80-meter recaivar with 455-kHz IF uses zener in supply line to minimize frequency drift. Emitter-follower buffer contributes to stability by isoleting oacillator from mixar. Low-pass filter C13-L2-C14 attenuates harmonic currents developed in Q3 and Q4. L1 is Miller 4503 1.7–2.7 μH variable inductor. L2 is 48 turns No. 30 enamal cloaewound on ¼-inch wood dowel or polystyrene rod. Main tuning capacitor C10 can be 365-pF unit with six of rear rotor plates removed.—D. DeMaw and L. McCoy, Learning to Work with Semiconductors, *QST,* June 1974, p 18–22 and 72.



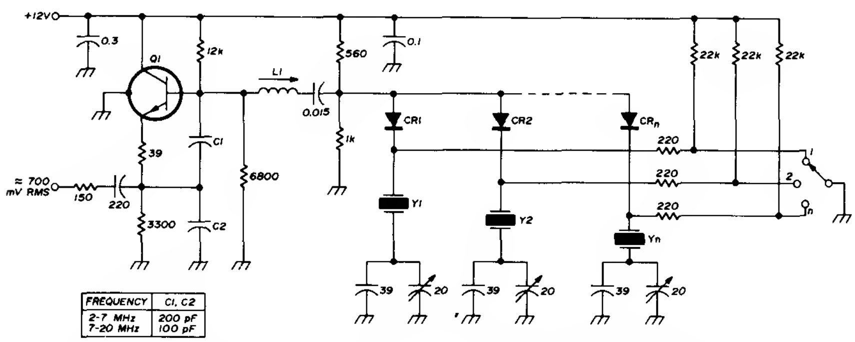
UP TO 30 MHz—Simple single-transistor RF oscillator is easily assembled from noncritical parts. Tuning capacitor and coil determine frequency.—Circuits, *73 Magazine,* July 1977, p 35.



42.667-MHz MOSFET—Unusuel crystel-controlled oscilletor, eimiler to modified Pierce oscillator that uses crystel between gride 1 end 2 of tetrode tube, cen be used es locel oscilletor in VHF end UHF converters. No trimming or tuning is required to get overtone frequency. If fundamentel of crystal is desired, increese RFC1 to 100 µH or replece it with 1K resistor. Stebility is excellent. Circuit works well with supply as low es 4 V.—G. Tomessetti, Duel-Gete MOSFET Offers en Unusuel Crystel-Controlled Oscilletor Concept, *QST,* June 1976, p 39.

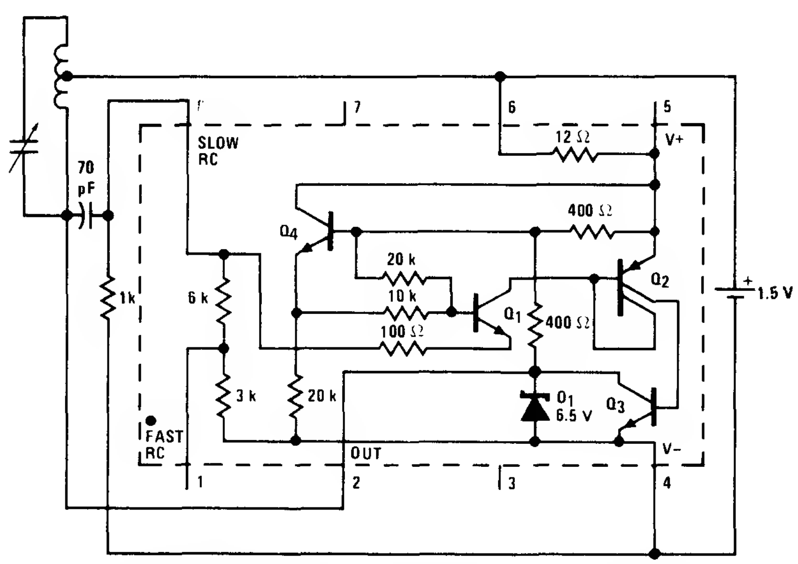


JFET PIERCE CRYSTAL—Besic JFET oscilletor circuit permits use of wide frequency renge of crystals. High Q is meinteined beceuse JFET gete does not loed crystal, thereby eneuring good frequency stebility.—"FET Detebook," Netional Semiconductor, Sente Clere, CA, 1977, p 6-26–6-36.

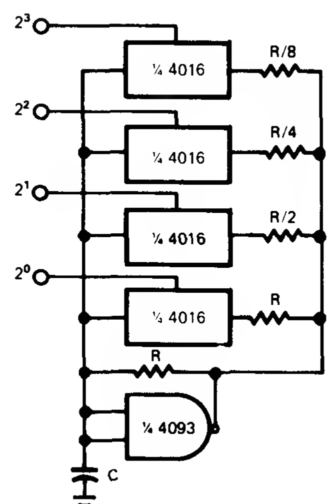


FREQUENCY	C1, C2
2-7 MHz	200 pF
7-20 MHz	100 pF

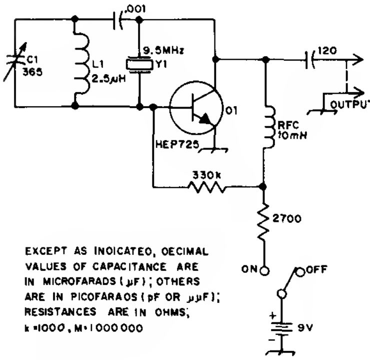
SWITCHED CRYSTALS—High stebility is combined with multichennel eelection by diode switching of crystels in renge of 2–20 MHz, used in series-resonent mode. L1 is ebout 30 µH at 2 MHz end 1 µH at 20 MHz. Q1 is 2N708, HEP50, BC108, or similer NPN RF type. Diodes ere switching types such es BAY67.—U. Rohde, Stable Crystel Oscillators, *Ham Radio,* June 1975, p 34–37.



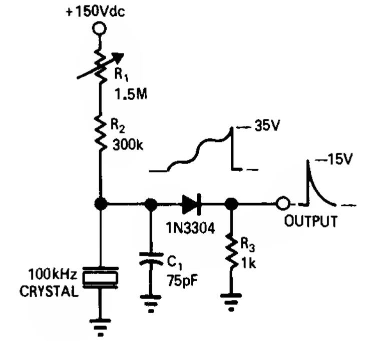
800-kHz OSCILLATOR—Netionel LM3909 IC opereting from single 1.5-V cell is used with stenderd AM redio ferrite entenne coil heving tep 40% of turns from one end, with standard 365-pF tuning cepecitor ecross coil. Developed for demonstrating versatility of this low-voltege IC.—"Lineer Applications, Vol. 2," Nationel Semiconductor, Senta Clere, CA, 1976, AN-154, p 8.



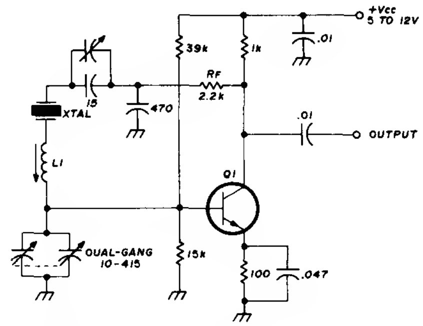
DIGITAL CONTROL TO 100 kHz—Schmitt trigger function of CD4093B IC gives oscilletor operetion over four decedes of frequency without changing C. Basic fraquancy valua is aqual to k/RC, with k equel to 1.3 up to about 5 kHz end decreesing greduelly to 1.0 et 100 kHz. Use of CD4016 quad trenemission gate permits remote swltching in of edditionel reslstors to provide direct digitel control of frequency. Arrengement shown gives choice of five unrelated frequencies, but binery selection of blnery-weighted resistors will give choice of 16 unreleted frequencies.—R. Tenny, CMOS Oscilletor Feetures Digitel Frequency Control, *EDN Magazine,* June 5, 1976, p 114 end 116.



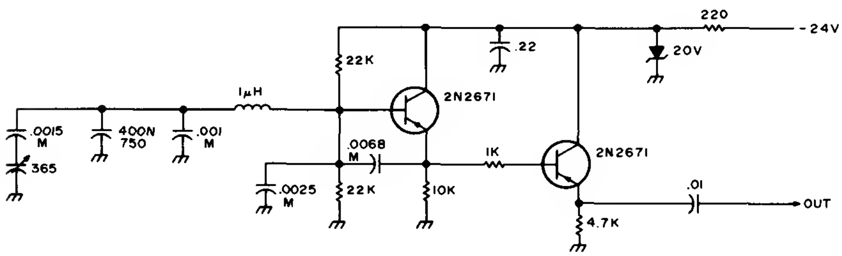
INCREASING CRYSTAL FREQUENCY—Adding perellel resonant circuit across crystel, tuned slightly ebove crystal frequancy, makes oscillator frequency incraaaa. Some plated crystels will work better than others in this circuit; third-ovartona types oparating on their fundamental genarally giva best results. Article covers theory of operation.—L. Lisle, Tha Tuneble Crystal Oscillator, *QST*, Oct. 1973, p 30–32.



100-kHz CRYSTAL-DIODE RELAXATION—Crystal-controlled relaxation oscilletor uses 1N3304 four-layer diode as activa element. R_1 adjuats RC time constant so oscilletor locks at fundamantal frequency of crystal or at half thia frequency.—R. D. Clement and R. L. Starlipar, Crystal-Controlled Relaxation Oscillator, *EDN/EEE Magazine*, Oct. 15, 1971, p 62 end 64.



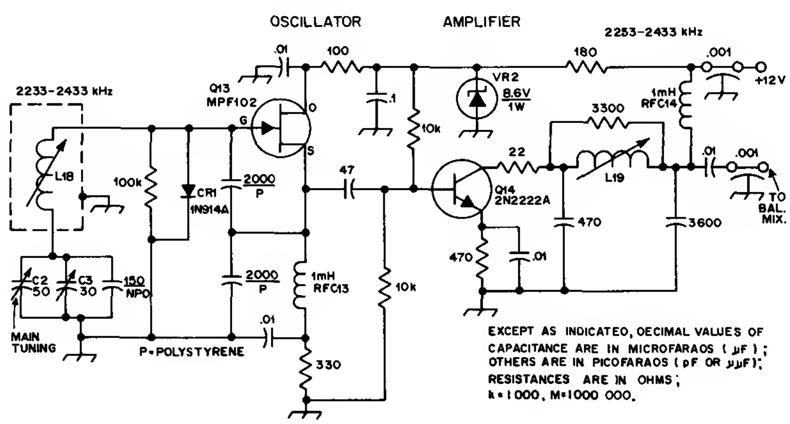
VARIABLE CRYSTAL—Maximum frequency shift ia almost 10 kHz at 5 MHz. Use crystal made especlelly for variable operation. Frequancy stability is good evan at extrames of shift. Uaa 5–20 μH for L1 with crystals from 6–15 MHz, and 20–50 μH for 3–6 MHz. Q1 Is 2N3563, 2N3564, 2N5770, BC107, BC547, BF115, BF180, SE1010, or equivalent.—R. Harrlaon, Survey of Cryatal Oscillators, *Ham Radio*, March 1976, p 10–22.

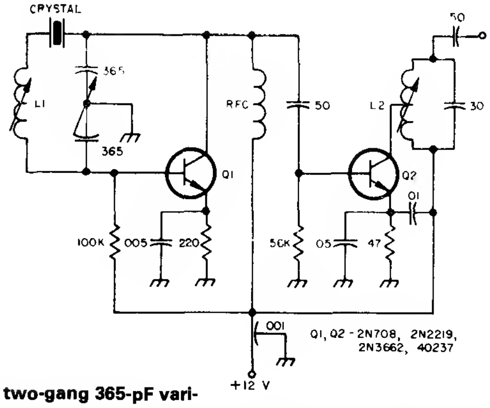


5 MHz ± 250 kHz—Simpla and stabla circuit using PNP transistors hes tuning range of about 250 kHz in any segmant of 5–9 MHz range, depending on how oscillator coil la aet. Wind coil on ceramic form or use eir-wound coil. Capacitors merked M should ba mica for stability. Tuning capacitor is 365 pF, from AM radio. 400/N750 temparature-compensating capacitor can ba replaced by 400-pF mica unlesa VFO is uaed in mobile application.—An Accessory VFO—the Easy Wey, *73 Magazine*, Aug. 1975, p 103 and 106–108.

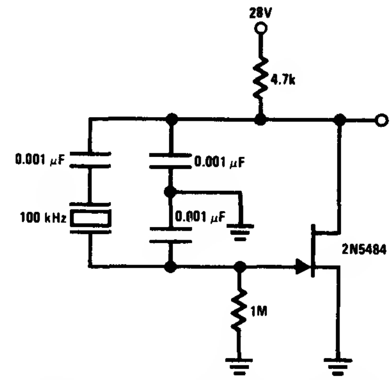
C2 — Double-bearing variable capacitor, 50 pF.
C3 — Miniature 30-pF air variable.
CR1 — High-speed switching diode, silicon type 1N914A.
L18 — 17- to 41-μH slug-tuned inductor, Q_u of 175 (J. W. Miller 43A335C81 in Miller S-74 shield can).
L19 — 10- to 18.7-μH slug-tuned pc-board inductor (J. W. Miller 23A155RPC).
RFC13, RFC14 — Miniature 1-mH rf choke (J. W. Miller 70F103AI).
VR2 — 8.6-V, 1-W Zener diode.

2.255–2.455 kHz LOCAL OSCILLATOR—Used in 1.8–2 MHz communication receiver having wide dynemic renga. Oacillator hes good stabillty, with circuit noiaa at least 90 dB below fundemental output. Amplifiar Q14 provides required +7 dBm for injaction into balenced mixer of racaivar. Two-part articla gives ell other circuits of raceivar.—D. DeMaw, His Eminence—the Receiver, *QST*, Part 1—June 1976, p 27–30 (Part 2—July 1976, p 14–17).

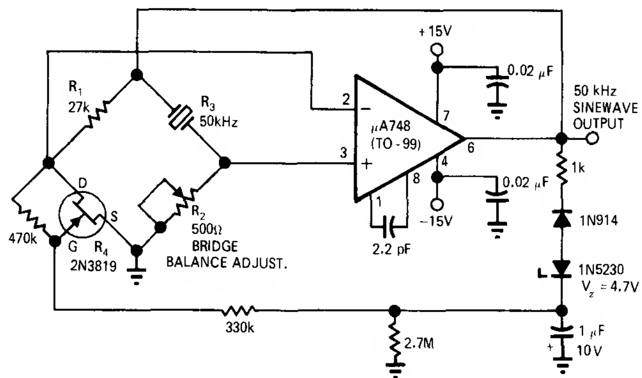




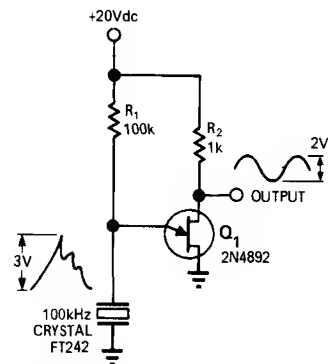
8 MHz ± 5 kHz—Tuning two-gang 365-pF variable capacitor through its renge provides frequency changa up to 5 kHz in output of 8-MHz crystal oscillator. L1 is 16–24 μH Miller 4507, and L2 is 40 turns No. 36 tapped at 13 turns, on ¼-inch slug-tuned form.—Circuits, *73 Magazina,* Jan. 1974, p 128.



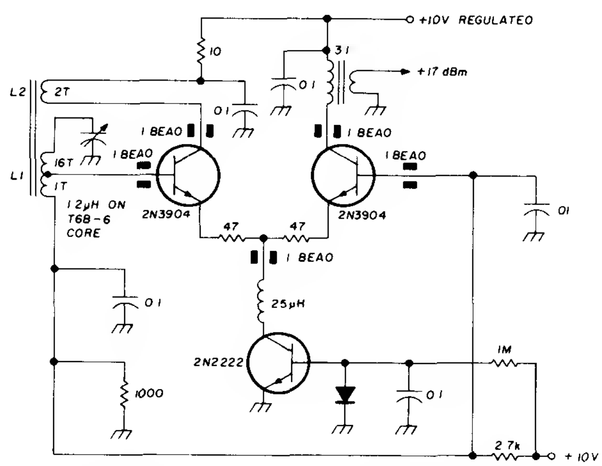
CRYSTAL COLPITTS—Circuit is ideal for low-frequency crystal oscillators because JFET circuit loading doas not vary with tamperature. Output frequency is determined by threshold used.—"FET Databook," National Samiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



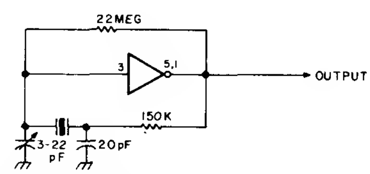
50-kHz MEACHAM BRIDGE—Crystal oscillator using Meacham bridge requlres no transformers for producing low-distortion sine-wave output. Quartz crystal should be cut for operation in series-resonant mode. With minor modificetions, same circuit can be used for 100- and 200-kHz crystals. By adding single-transistor stage, oscillator can ba used as clock ganerator for TTL circuits.—K. J. Peter, Stabla Low-Distortion Bridge Oscillator, *EDN/EEE Magazine,* Nov. 15, 1971, p 50–51.



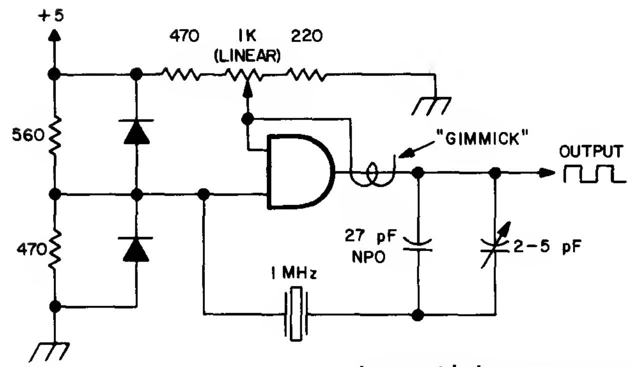
100-kHz CRYSTAL-FET RELAXATION—Adding crystal in frequency-determining circuit improves frequancy stability of UJT relaxation oscillator. With charging capacitor replaced by 100-kHz quartz crystal, measured output frequency was 99.925 kHz.—R. D. Clemant end R. L. Starlipar, Crystal-Controllad Ralaxation Oscillator, *EDN/IEEE Magazina,* Oct. 15, 1971, p 62 and 64.



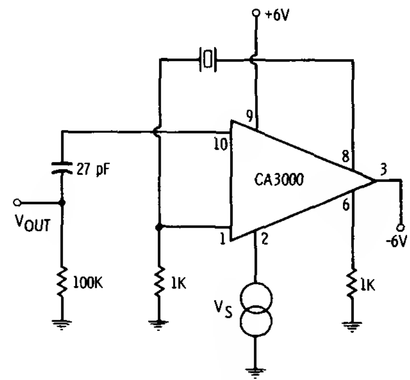
LOW-NOISE 5-MHz—Very low-noise high-Q LC oscillator operating at 5 MHz is designed for use in high-performance communication receivers. Oacillator uses two stagas, one operatlng in class A and the other oparating as limitar that also sarves as feedback peth.—U. L. Rohde, Effects of Noise in Receiving Systems, *Ham Radio,* Nov. 1977, p 34–41.



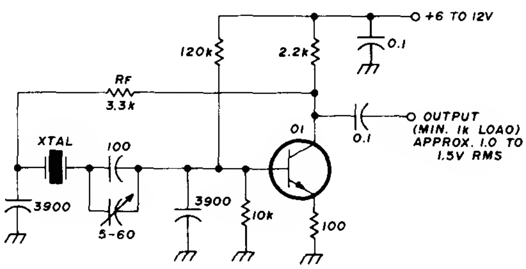
CRYSTAL WITH CMOS INVERTER—Simple mono multivibrator circuit using MC14007 or CD4007 operates in frequency range from 10 kHz up to top limit of about 10 MHz, with exact frequency dapending on values used for R and C. Pin 7 of IC is VSS and pin 14 is VDD. Pins 5 and 1 must be connected together for propar operation.—W. J. Prudhomme, CMOS Oscillators, *73 Magazine,* July 1977, p 60–63.



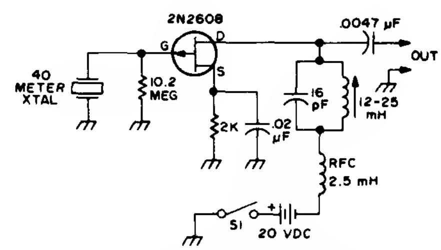
1 MHz WITH ONE GATE—Crystal oscillator uses only one section of SN7408 TTL quad AND gate. Use series-resonant crystel having 30-pF series capacitance. Adjust 1K pot for reliable start-up and symmetrical square-wave output. Diodes are 1N34A or 1N914. Gimmick is 1 or 2 tuma of insulated wire wrapped around output lead.—Clyde E. Wade, Jr., An Even Simpler Clock Oscillator, *73 Magazine,* Nov./Dec. 1975, p 164.



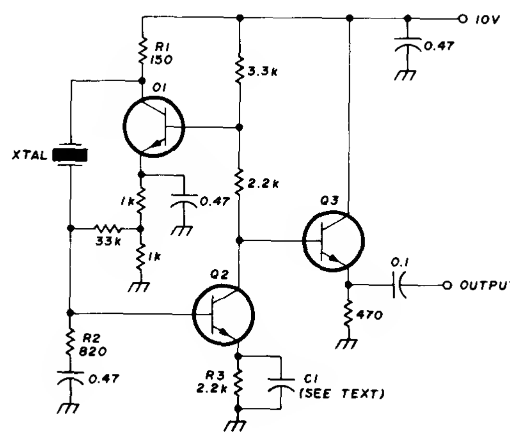
MODULATED CRYSTAL—CA3000 differentiel amplifiar is operated as efficient crystal-controlled oscillator. Output frequency depends on crystal. If desired, RF output cen be moduleted with low-frequency tone applied between pin 2 and ground.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howerd W. Sams, Indianapolis, IN, 1974, p 91.



50–500 kHz CRYSTAL—Parallel-mode low-frequency oscillator makes excellent BFO for 455 kHz. If oacillator will not start, reduce velue of feedback resistor R_F. Increasing R_F reduces harmonic output, but oscillator may then take up to 20 s to reach full output. For crystals with specified load capacitance of 30 or 50 pF, remove 100-pF capacitor C1 in series with crystal. Q1 is 2N2920, 2N2979, 2N3565, 2N3646, 2N5770, BC107, or BC547.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio,* March 1976, p 10–22.

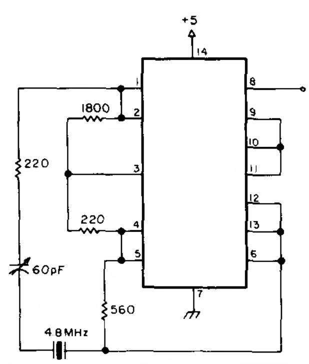


7 MHz—Uses single Siliconix 2N2608 FET. Keep leeds short. Coil can ba air-wound or permeebility-tuned. If tuning capacitor is veriable, coil value can be fixed. RF output level depends on circuit voltages end on activity of crystal used.—Q & A, *73 Magazine,* April 1977, p 165.

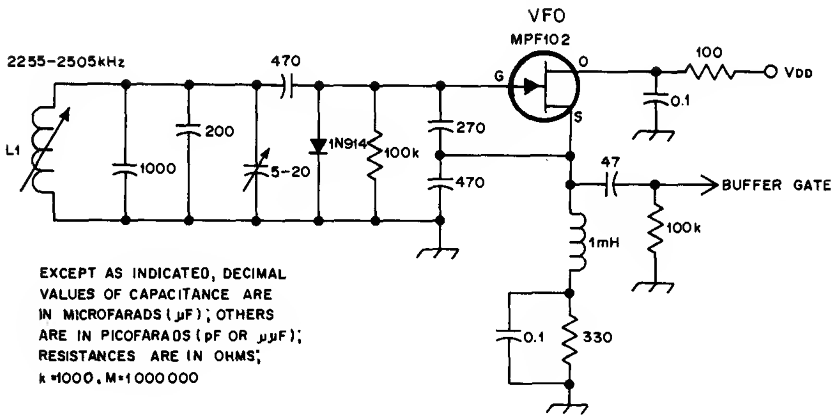


for 20-150 kHz crystals Q1, Q2, Q3	for 150-500 kHz crystals Q1, Q2, Q3
2N3565	BC107, BC547
2N2920	2N3565
2N2979	2N5770
	2N2222

20–500 kHz CRYSTAL—Series-mode oscillator requires no tuned circuit, gives choice of sine or square output, and has good frequency and mode stability. Works nicely with troublesome FT241 crystals. If any crystal feils to start reliably, increase R1 to 270 ohms and R2 to 3.3K. For square-weve operation, C1 ia 1-µF nonelectrolytic. Omit C1 for sine-wave operation; harmonic output ia then quite low, with second harmonic typically −30 dB. Output is ebout 1.5-VRMS sine wava or 4-V square wave.—R. Harriaon, Survey of Crystal Oscillators, *Ham Radio,* Merch 1976, p 10–22.

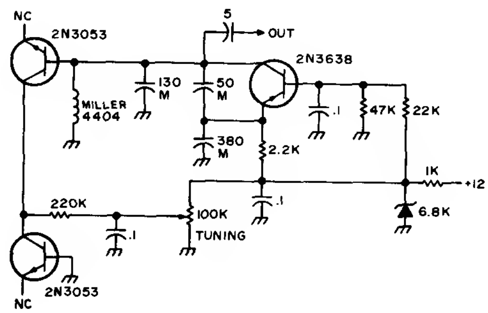


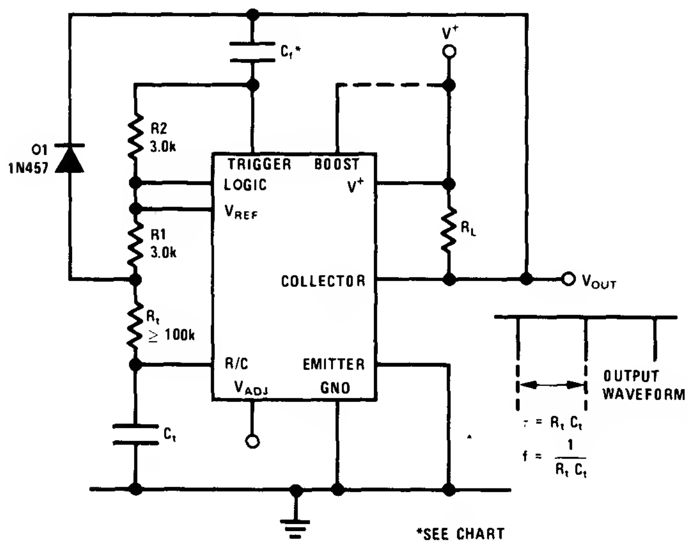
4.8 MHz—Uses all four sections of 7400 quad duel-input NAND gata to giva 4.8 MHz output at pin 8, as hermonic-rich squere weve. Can cause severe television Interference during teating. Article gives five other crystel oscillator circuits using seme IC.—A. MacLeen, How Do You Use ICs?, *73 Magazine,* Oct. 1976, p 38–41.

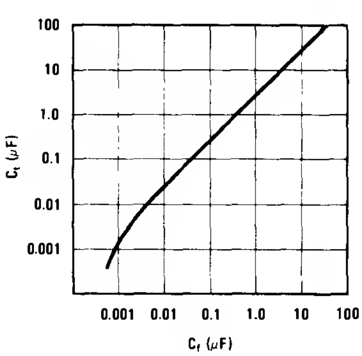


PRECISION VFO—Permeablity-tunad oscillator provides stablity and linearlty at low cost for receivers wlth 160-mater tunabla IF stages. L1 has 28 turns No. 36 anamal closewound on J. W. Millar form 64A022-2. Article covers construction of tuning dial, incudlng contouring of L1 cora to giva good diel linearity. Fraquency covarage is 2.255–2.505 MHz. Dlract-raading dial is accureta wlthin 1.5 kHz over antire 250-kHz tuning range.—W. A. Gragoira, Jr., A Parmaability-Tuned Variable-Fraquancy Oscillator, *QST,* March 1978, p 26–28.

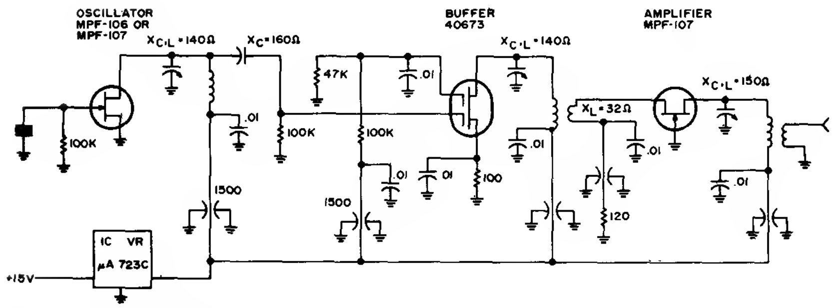
7 MHz ± 50 kHz—Requiras no tuning capacltors. Collector-to-base junctions of two 2N3053 transistors perform function of varactor diodas to provide tuning over range of about 50 kHz centered on 7 MHz. Capacitors markad M should be mica.—An Accessory VFO—the Easy Way, *73 Magazine,* Aug. 1975, p 103 and 106–108.



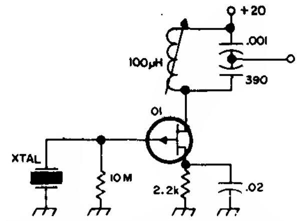




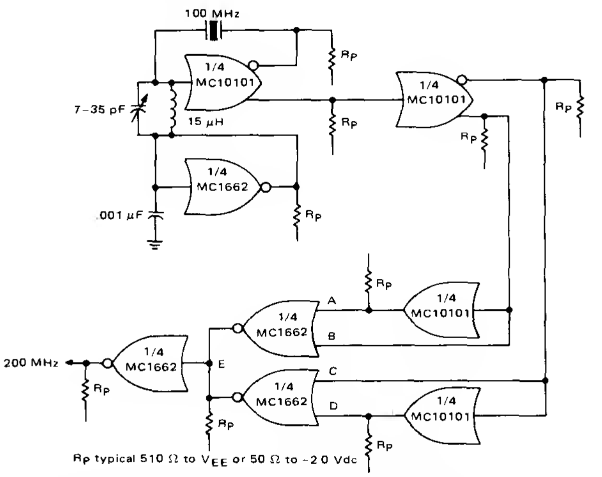
TIMER AS OSCILLATOR—Output of National LM122 timer is fed back to trigger input through capacitor to giva self-starting oscillator. Fraquency is $1/R_tC_t$. Output ls narrow negative pulsa having duration of ebout $2R2C_f$. Conservativa velue for C_f for optlmum fraquency stability can be chosan from graph based on siza of timing capacitor C_t.—C. Nelson, "Varsatila Timar Oparates from Microseconds to Hours," National Semiconductor, Senta Clara, CA, 1973, AN-97, p 10.



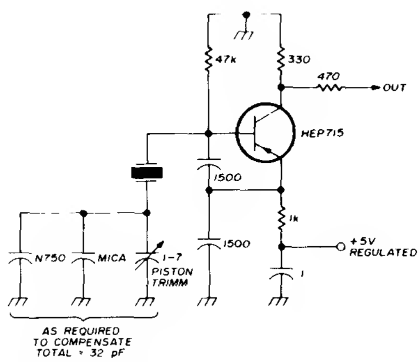
STABLE CRYSTAL—Stability is good enough for microwave transmitter frequency control. Will operate with fundamental or overtone crystals from 1.6 to 160 MHz, with coils and capacitors being chosen for frequency in use.—Circuits, *73 Magazine,* May 1973, p 105.



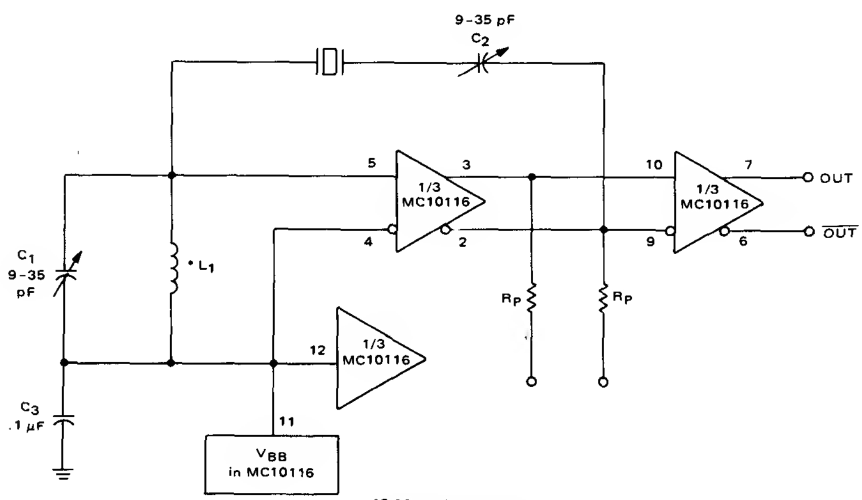
1-MHz FET PIERCE—Field-effect transistor serves in place of vacuum triode in Pierce oscillator. Circuit values are for 1 MHz, but tuned circuit can be adjusted to other desired frequency. Q1 can be 2N4360 or TIM12.—Circuits, *73 Magazine,* March 1974, p 89.



200 MHz WITH OSCILLATOR/DOUBLER—One section of Motorola MC10101 is connected as 100-MHz crystal oscillator having crystal in series with feedback loop. LC tank circuit tunes 100-MHz harmonic of crystal and can be used to adjust circuit to exact frequency. Second section of IC serves as buffer and gives complementary 100-MHz signals for frequency doubler having two MC10101 gates as phase shifters and two MC1662 NOR gates. Outputs of MC1662s are wired-OR connected to give 200-MHz signal. One of remaining MC1662 gates is used as bias generator for oscillator.—B. Blood, "IC Crystal Controlled Oscillators," Motorola, Phoenix, AZ, 1977, AN-417B, p 5.

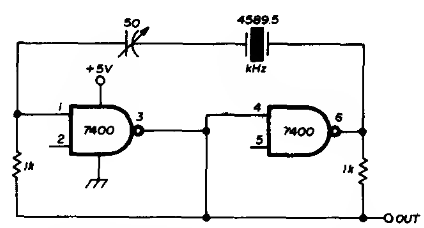


4-MHz CRYSTAL—High-stability crystal oscillator uses two 1500-pF capacitors to swamp out internal impedance changes that might cause frequency drift. For best stability when used as frequency standard, choose high-accuracy 4-MHz crystal.—B. Kelley, Universal Frequency Standard, *Ham Radio,* Feb. 1974, p 40–47.

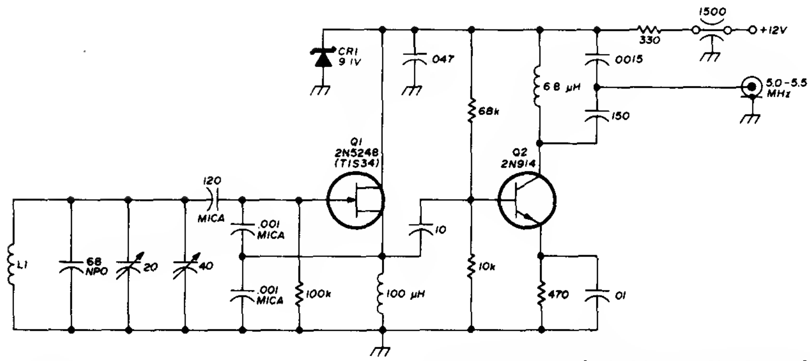


*0.33 µH for 50–100 MHz
1.0 µH for 20–50 MHz
R_P = 510 Ω to V_{EE} or 50 Ω to V_{TT}

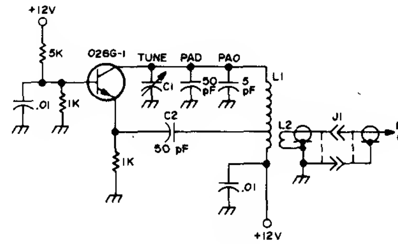
20–100 MHz OVERTONE CRYSTAL—Adjustable tank circuit C_1L_1 ensures operation at desired crystal overtone. Reference voltage for differential amplifier is supplied internally by Motorola 10116 IC and is nominally −1.3 V.—B. Blood, "IC Crystal Controlled Oscillators," Motorola, Phoenix, AZ, 1977, AN-417B, p 3.



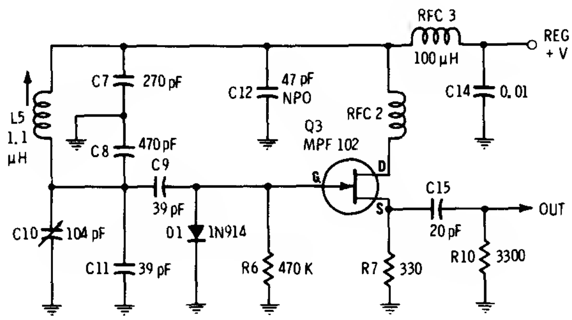
TTL 4.59-MHz CRYSTAL—Uses FT243 crystal hand-ground to 4.5895 MHz, with 50-pF series capacitor allowing frequency to be trimmed to exactly 4.59 MHz for use in AFSK generator.—J. Nugues, AFSK Generator, *Ham Radio,* July 1976, p 69.



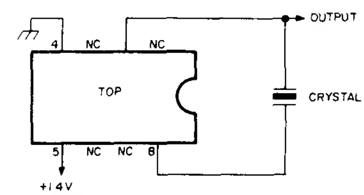
5–5.5 MHz VFO—Used in solid-state five-band communication receiver. Temperature compensation is provided by 20-pF trimmer that sets band center. L1 is 34 turns No. 24 on Amidon T50-6 toroid core.—P. Moroni, Solid-State Communications Receiver, *Ham Radio,* Oct. 1975, p 32–41.



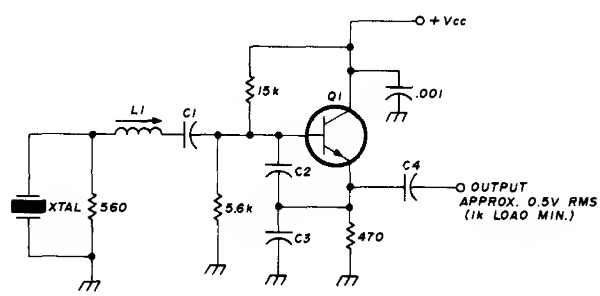
51–55 MHz—Tunable local oscillator is padded to tune over range required for use with 1.65-MHz IF in 6-meter receiver, using Johnson type U 14-plate tuning capacitor. Can also serve as test transmitter putting out up to 20 mW. L1 is 9 turns No. 26 tapped 1 turn from low end, and L2 is 1 or 2 turns. Article covers construction in 1¼ × 1¼ × ½ inch box.—B. Hoisington, A Real Hot Front End for Six, *73 Magazine,* Nov. 1974, p 88–90 and 92–94.



10-MHz VFO—Values shown for high-stability variable-frequency oscillator give operation in 10-MHz range. Stable supply voltage is essential. Use silver mica capacitors in gate circuit for maximum stability.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN , 2nd Ed., 1975, p 193–194.

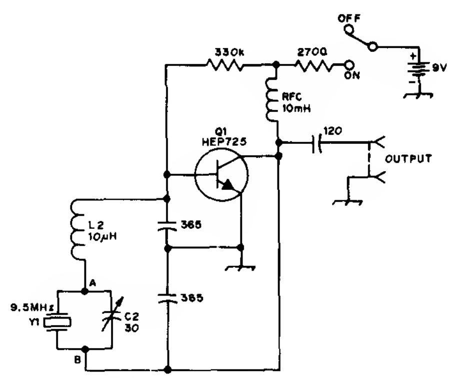


465-kHz FOR IF TUNE-UP—Simple crystal oscillator using National LM3909N is adjusted to exactly desired frequency with capacitor in series with pin 8. Drain from AA cell is less than 0.5 mA at 1.2 V. Use 465-kHz crystal and couple oscillator to receiver input with 100-pF capacitor. With 100-kHz crystal, circuit will generate strong harmonics beyond 30 MHz; to zero-beat with WWV, use about 10 pF in series with crystal.—I. Queen, Simple Crystal Oscillator, *Ham Radio,* Nov. 1977, p 98.

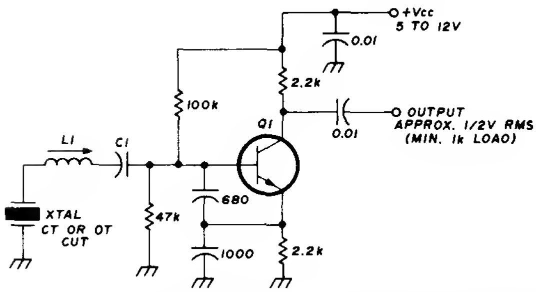


crystal freq (MHz)	C1 (pF)	C2 (pF)	C3 (pF)	C4 (pF)	L1 ¼" (6.5mm) diam form	L1 3/16" (5mm) diam form
15-25	100	100	68	33	12 turns no. 30 (0.25mm) closewound	15 turns no. 28 (0.3mm) closewound
25-55	100	68	47	33	8 turns no. 30 (0.25mm) closewound	10 turns no. 28 (0.3mm) closewound
50-65	68	33	15	22	6 turns no. 22 (0.6mm) space to ¼" (6.5mm) long	7 turns no. 28 (0.3mm) closewound

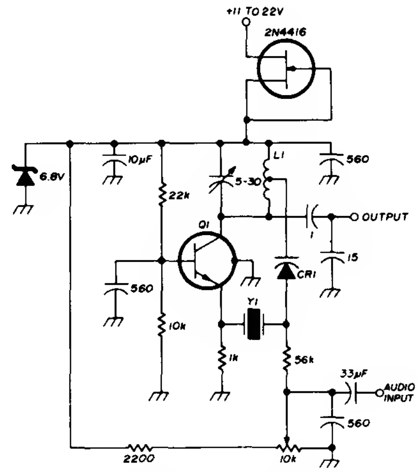
15–65 MHz IMPEDANCE-INVERTING—Uses third-overtone crystals. L1 trims crystal frequency. Resistor across crystal prevents oscillation at undesired modes. Starting is reliable and stability is good. Q1 is 2N3563, 2N3564, 2N5770, BF180, BF200, or SE1010.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio,* March 1976, p 10–22.



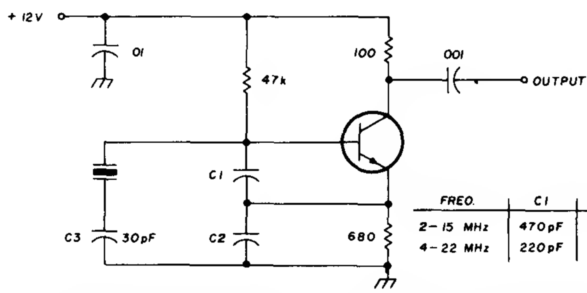
9.5-MHz TUNABLE CRYSTAL—Clapp oscillator with inductance in series with crystal can be tuned with C2 as much as 100 kHz below rated frequency of crystal. Based on making crystal act as capacitive reactance below its series-resonant frequency. Circuit can be adapted to other amateur bands by keeping reactances of various components approximately the same.—L. Lisle, The Tunable Crystal Oscillator, *QST,* Oct. 1973, p 30–32.



150–500 kHz CRYSTAL—Circuit is series-mode if C1 is 0.01 μF. Parallel-mode crystals can be used if C1 is equal to specified load capacitance (30, 50, or 100 pF) for crystal. Harmonic output is usually better than −30 dB. Circuit is particularly good for crystals prone to oscillate undesirably at twice fundamental frequency. L1 is 800–2000 μH for 150–300 kHz, and 360–1000 μH for 300–500 kHz. Adjusting slug in L1 pulls crystal frequency. Q1 is 2N3563, 2N3564, 2N3693, BC107, BC547, or SE1010.—R. Herrison, Survey of Crystal Oscillators, *Ham Radio*, March 1976, p 10–22.

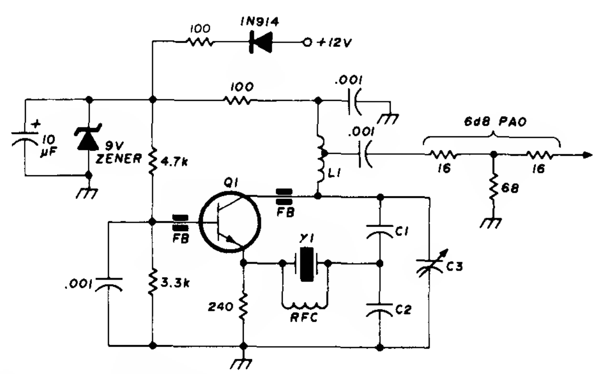


OSCILLATOR-DOUBLER—Overtone crystal oscillator circuit that frequency-doubles in transistor can be frequency-modulated or used as stable voltage-controlled crystal oscillator. Tuning range with 70-MHz third-overtone crystal is typically 30 kHz at crystal frequency or 60 kHz at output. L1 is resonant with C1 at desired output frequency. Tap for varactor CR1 (Motorola BB105B or BB142) is at one-fourth total number of turns. Q1 is 2N918, BF115, HEP709, or equivalent.—U. Rohde, Stable Crystal Oscillators, *Ham Radio*, June 1975, p 34–37.



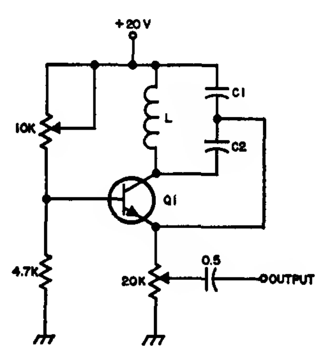
FREQ.	C1	C2
2–15 MHz	470pF	470pF
4–22 MHz	220pF	220pF

2–22 MHz FUNDAMENTAL-MODE—International Crystal OF-1 oscillator for fundamental-mode crystal has no LC tuned circuits and requires no inductors. With 28.3-MHz third-overtone crystal, output is at fundamental of crystal or about 9.43 MHz.—C. Hall, Overtone Crystal Oscillators Without Inductors, *Ham Radio*, April 1978, p 50–51.



C1	10 pF mica
C2	20 to 60 pF mica. Use as high value as possible (until circuit just oscillates reliably when C3 is tuned through resonance)
C3	20 pF piston or miniature trimmer
L1	8 turns no. 24 (0.5mm) on Amidon T37-12 toroid core, tapped 3 turns from cold end
Q1	Fairchild 2N5179 recommended but 2N2857, 2N3563, 2N918 or equivalent may be substituted
RFC	0.39 μH. Resonates with crystal holder capacitance (4 to 6 pF typical) for parallel resonance at crystal frequency
Y1	90 to 125 MHz, 5th or 7th overtone, series-resonant, HC-18/U crystal. Cut leads as short as possible (1/4" or 6mm maximum)

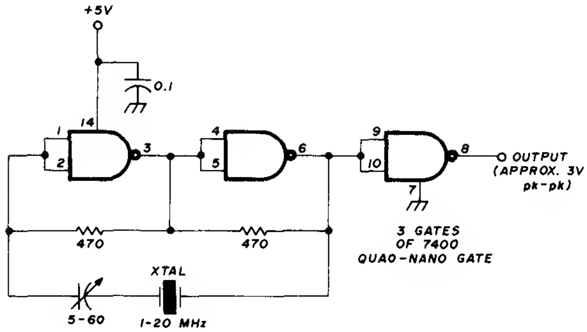
90–125 MHz CRYSTAL—Recommended for VHF/UHF converters. Output is 5 to 15 mW. Crystal should be high-quality fifth- or seventh-overtone type. Ferrite bead FB prevents undesired oscillation above 500 MHz. For best stability, allow crystal to operate at its natural series-resonant frequency and use regulated power supply.—J. Reisert, VHF/UHF Techniques, *Ham Radio*, March 1976, p 44–48.



Q1 - 2N2925, 2N3392

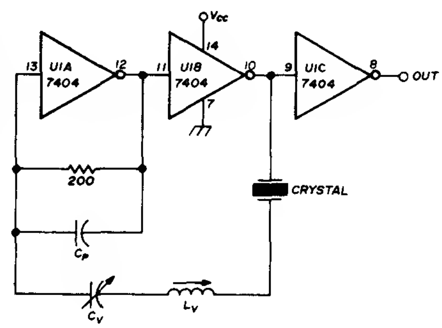
FREQUENCY	C1	C2	L
50 kHz	3500 pf	1500 pf	10 mH
80 kHz	2200 pf	910 pf	6.2 mH
100 kHz	1800 pf	750 pf	4.7 mH
200 kHz	910 pf	390 pf	2.2 mH
455 kHz	390 pf	160 pf	1 mH
1000 kHz	180 pf	75 pf	0.47 mH

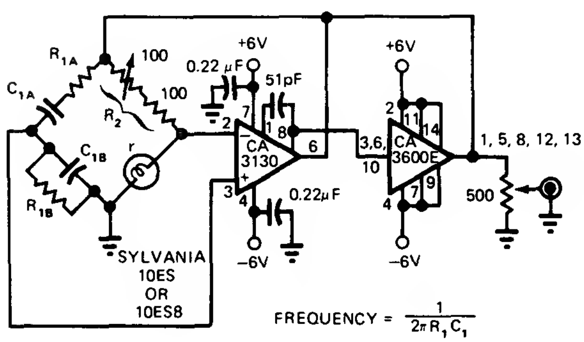
50–1000 kHz—Simple single-transistor circuit provides extremely stable beat-frequency oscillator for which frequency can be changed by using tank-circuit components listed in table.—Circuits, *73 Magazine*, Feb. 1974, p 101.



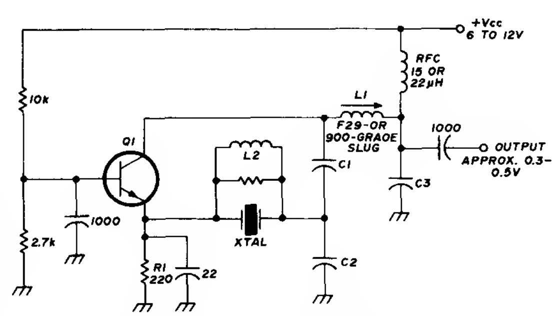
NAND-GATE TTL CRYSTAL—Overcomas problems of poor starting performanca and has upper frequancy limit of 20 MHz. Suitable for applications requiring high-output aperiodic oscillator. Excellent as frequancy marker.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio*, March 1976, p 10–22.

2–20 MHz VXO—Variable-frequency crystal oscillator plus buffer, using Signatics N7404A hax invartar or equivalent, covars 2–20 MHz. Only threa inverters ara used, two forming oscillator and one as output buffer. V_{CC} is +5 V. Crystals can operate at fundamental, third, or fifth overtone. Frequency-limiting capacitor C_P can be 15 pF. Only higher-frequency crystals can be moved useful amounts without craating instability problems. Article gives design aquations and tables showing frequencies obtainad with various crystals for various values of fraquency controls C_V (0–100 pF) and L_V (0–17 μH).—B. King, Hex Invartar VXO Circuit, *Ham Radio*, April 1975, p 50–55.



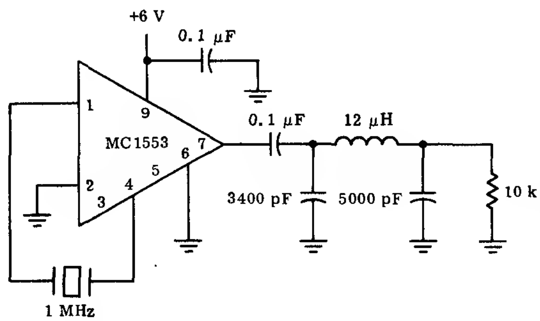


CAPACITIVELY TUNED WIEN—Output of amplifier is connected to apex of Wien bridge. Positive feedback is taken from junction of C_{1A} and C_{1B} for noninverting input of first opamp, while negative feedback is takan from other junction of bridge for inverting input. Oscillation is sustained whan $R_2 = 2r$. Nonlinearity of lamp r provides stabilization of oscillator. Frequency depends on values used for bridge componants.—H. D. Olson, Wian-Bridge Oscillator Is Capacitivaly Tuned, *EDN Magazine*, Aug. 5, 1975, p 74.

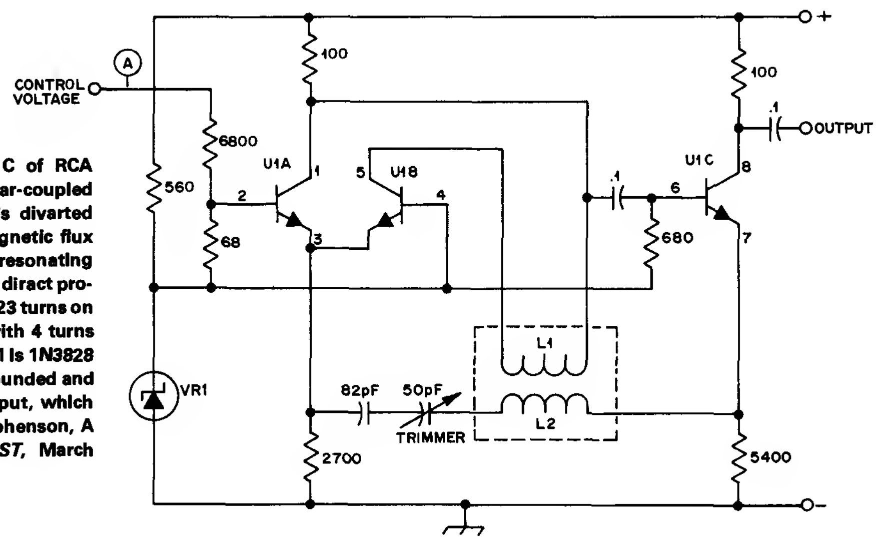


65–110 MHz OVERTONE—Uses fifth- or seventh-overtone crystals. RF choka formed by L2 is wound on low-value resistor to suppress lower-frequency resonances of crystal. Buffer is recommended. Circuit is slightly frequency-sensitive to supply voltage variations, so use well-regulated supply. Q1 is 2N3563, 2N3564, 2N5770, BF180, BF200, or SE1010.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio*, March 1976, p 10–22.

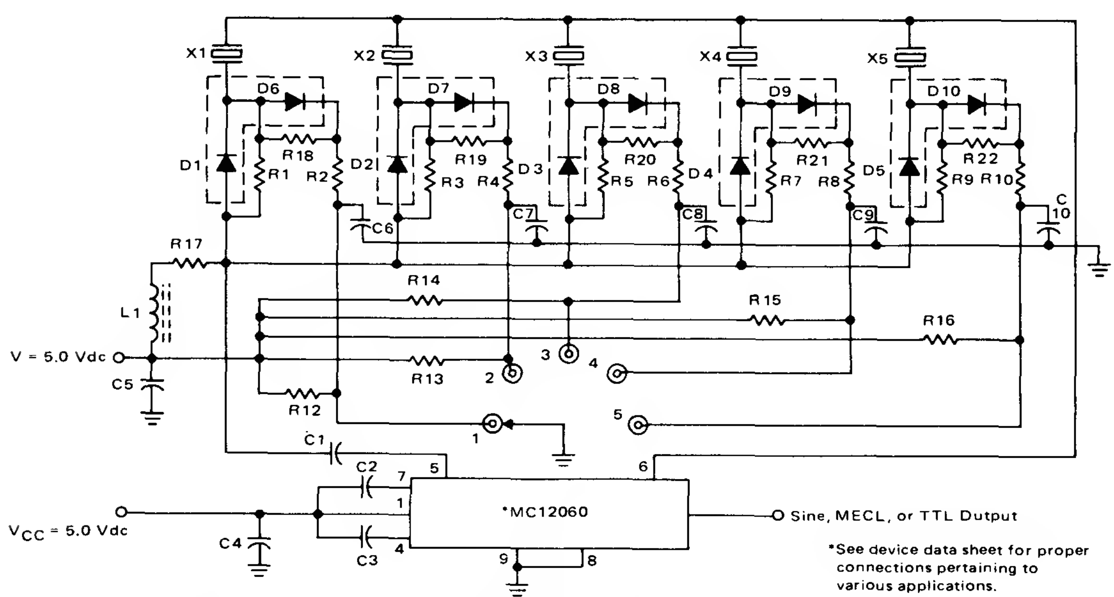
L1	65-85 MHz: 7 turns no. 22 (0.6mm) or no. 24 (0.5mm) enamelled, closewound on 3/16" (5mm) diameter form			
	85-110 MHz: 4 turns no. 22 (0.6mm) or no. 24 (0.5mm) enamelled, on 3/16" (5mm) diameter form, turns spaced one wire diameter			
L2	10 turns no. 34 (0.2mm) closewound on low-value ¼-watt resistor			
C1	65-85 MHz:	15 pF	85-110 MHz:	10 pF
C2	65-85 MHz:	150 pF	85-110 MHz:	100 pF
C3	65-85 MHz:	100 pF	85-110 MHz:	68 pF



1-MHz SERIES-MODE CRYSTAL—Motorole MC1553 video emplifier provides wida bendwidth end output swing capablity naeded for high-frequency mester clock or local osciilator in meny system designs. Positive feedbeck is injected through crystel to input pin 1. Output is teken from pin 7 which is buffered internelly from oscillator by gein end emitter-follower stages. Brute-forca pi filter at output extracts desired fundamentel frequency.—"A Wide Band Monolithic Video Amplifier," Motorola, Phoenix, AZ, 1973, AN-404, p 9.



9-MHz LINEAR VCO—U1A and U1C of RCA CA3046 transistor errey form emittar-coupled oscillator. Portion of U1A current is divarted through U1B end L1, producing magnetic flux that reduces effective inductance of resonating coil L2. Output frequency is varied in diract proportion to voltage applied et A. L1 is 23 turns on ¾-inch Teflon form 2 inches long, with 4 turns wound between windings for L2. VR1 is 1N3828 6.2-V zener. Circuit must be well grounded and shielded to avoid hum pickup by input, which could modulata output.—D. G. Stephenson, A Second Look at Lineer Tuning, *QST*, March 1977, p 40–41.

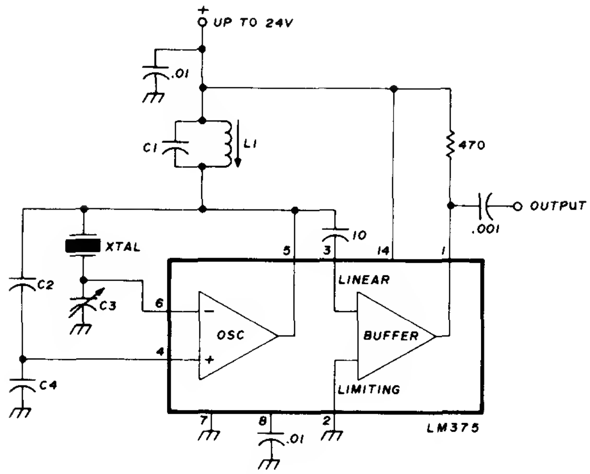


L1: Delevan #2500-44
Nytronics #Wee 2200
Miller #6302
(2.5 mH nominal inductance)

R1, R3, R5, R7, R9 = 82 kΩ
R2, R4, R6, R8, R10 = 4.3 kΩ
R12 – R16 = 1 kΩ
R17 = 5.1 kΩ

R18 – R21 = 10 kΩ
C1 – C10 = 0.1 μF
D1 – D10 = 1/2 MSD7000
X1 – X5 = 0.1 MHz -2.0 MHz

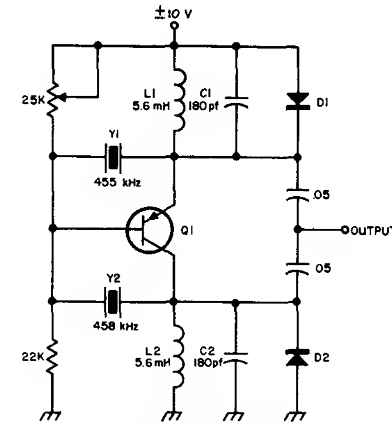
CRYSTAL-SWITCHING DIODES—Circuit for Motoroie MC12060 crystel oscillator uses diodes es RF switches giving choice of five different crystel frequencies. Forwerd bias is apiied to diode essocieted with desired crystal end reverse bies to diodes for other four crysteis. Diode switching eliminates need to run high-frequancy signeis through machanicai switch, permits control of switching from remota locetion, end is reedily adepted to electronic scenning. Requires oniy single 5-V supply. Frequency pulling is minimized.—J. Hatchett end R. Jenikowski, "Crystai Switching Methods for MC12060/MC12061 Oscillators," Motorola, Phoenix, AZ, 1975, AN-756.



IC CRYSTAL—Uses LM375 IC with crystels from 3 to 20 MHz in perallel moda. Will oscillete with only 4-V supply, but output voltaga increeses with supply voltage. L1-C1 ie rasonant et crystel frequency. Adjust L1 only for meximum output, not for trimming frequancy. If C3 is 3–30 pF, it can be used to edjust frequency of crystel.—R.

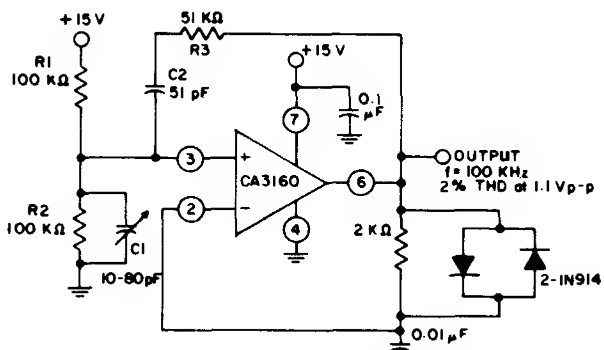
crystal freq (MHz)	C2/C3 (pF)	C4 (pF)
3-10	22	180
10-20	10	82

Herrison, Survay of Crystal Oecilletors, *Ham Radio*, March 1976, p 10–22.



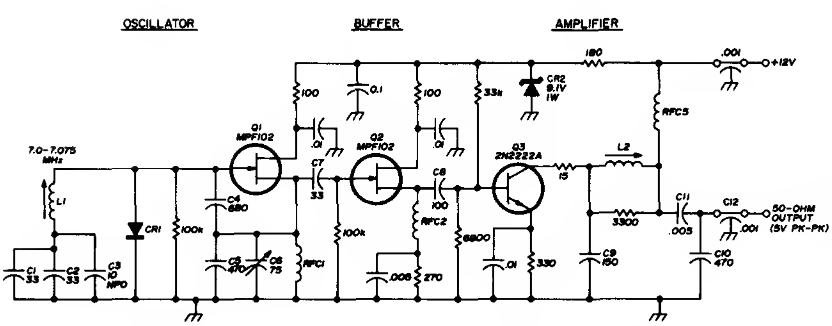
Q1- 2N384, 2N525, SK3004, TI-XM03
D1,D2- GENERAL PURPOSE SILICON DIODES

DUAL-FREQUENCY CRYSTAL—Uses two different crystels, with frequancy being chengad by revarsing supply voltage. Transistor then inverts itself end gein reducee to about 2, which is adequata for oscillator oparation. Provides two frequancies from single stage with minimum of switching.—Circuits, *73 Magazine*, Feb. 1974, p 101.



$$f = \frac{1}{2\pi\sqrt{(R1 \| R2)\, C1\, R3\, C2}}$$

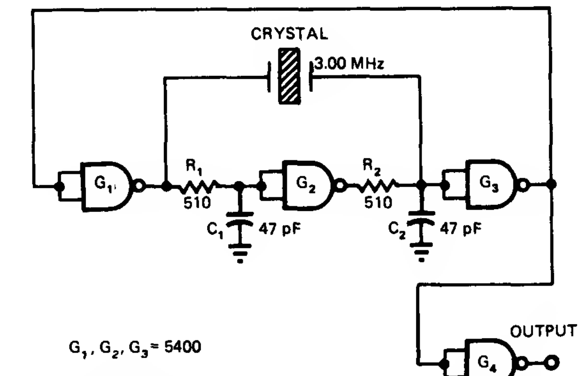
100-kHz WIEN-BRIDGE—CA3160 opamp in bridge circuit oparates from single 15-V supply. Parallel-connactad diodes form gain-setting network thet stabilizes output voltage at about 1.1 V. 500-ohm pot is edjustad so oecillator elweys sterts and oscillation is meintained.—"Linaer Integrated Circuits end MOS/FET'e," RCA Solid State Division, Somerville, NJ, 1977, p 271–272.



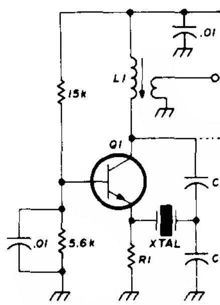
X_{L1}	265 ohms	X_{C3}	2275 ohms	X_{C7}	690 ohms	X_{C11}	4.5 ohms
X_{L2}	140 ohms	X_{C4}	33 ohms	X_{C8}	227 ohms	X_{C12}	23 ohms
X_{C1}	690 ohms	X_{C5}	48 ohms	X_{C9}	152 ohms	X_{RFC1}	4400 ohms
X_{C2}	690 ohms	X_{C6}	303 ohms (minimum)	X_{C10}	48 ohms	X_{RFC2}	4400 ohms

C1,C2,C4,	polystyrene capacitor (Mallory type SX or equivalent)
C5, C6, C7, C8	75 pF miniature air variable, double-bearing type (one section of a Miller 2109 suitable)
C9,C10	dipped silver-mica capacitor
CR1	high-speed silicon switching diode (1N914A or equivalent)
L1	variable inductor, 6 μH nominal (Miller 42A686CBI)
L2	variable inductor, 3.2 μH nominal (Miller 23A47RPC)
RFC1,RFC2	100 μH miniature rf choke (Millen J301 type)
RFC3	500 μH miniature rf choke (Millen J301 type)
Z1	9.1-volt, 1-watt zener diode

LOW-DRIFT 7-MHz VFO—Low-drift eolld-eteta design for 40-mater band has maximum change of only 25 Hz from cold start to full warm-up at 25°C. After stabilization, maximum hunting ia 5 Hz. Drift is minimizad by parallaling two or more capacitors in critical parts of circuit. Series-tuned Colpitts oscillator is followed by two buffer stagas, with second providing enough amplification for practical amataur work while further improving isolation of oscillator. Low-impedanca output network minimizes oscillator pulling from loed changes. Article stresses importance of chooeing end using componants thet minimize drift.—D. DeMaw, VFO Design Techniques for Improved Stability, *Ham Radio*, June 1976, p 10–17.

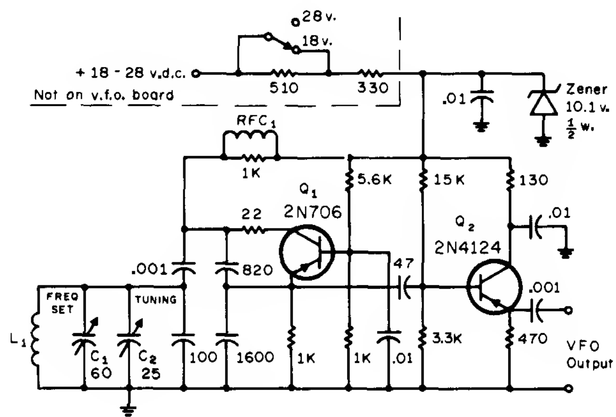


SURE-STARTING CRYSTAL—Loop-within-a-loop oscillator design ensures reliable starting without use of critical components. Frequency depends on crystal, which can be anywhere in range from 1 to 20 MHz. IC can be 54L00 for 1–2 MHz, standard 5400 for 2–6 MHz, and 54H00 or 54S00 for 6–20 MHz. Temperature stability is adequate for crystal clocks and other digital-system applications.—J. E. Buchanan, Crystal-Oscillator Design Eliminates Start-Up Problems, *EDN Magazine*, Feb. 20, 1978, p 110.

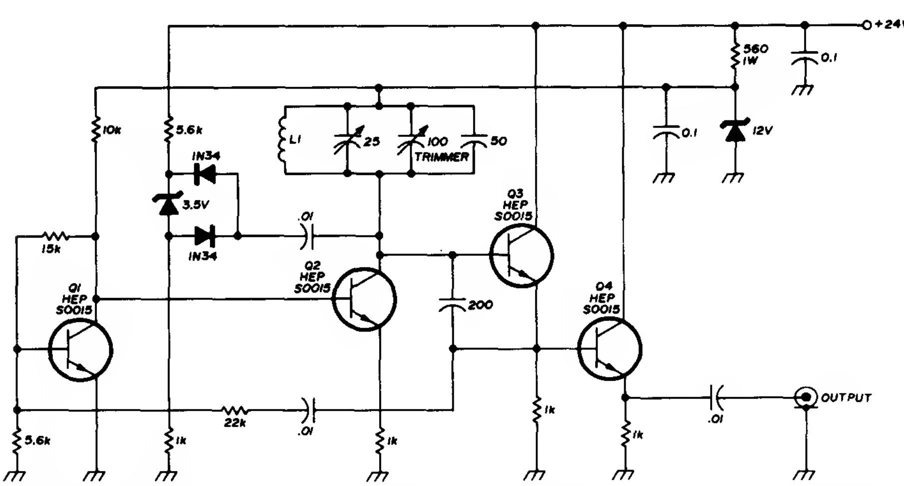


crystal freq (MHz)	C1 (pF)	C2 (pF)
3-10	47	390
10-20	22	220

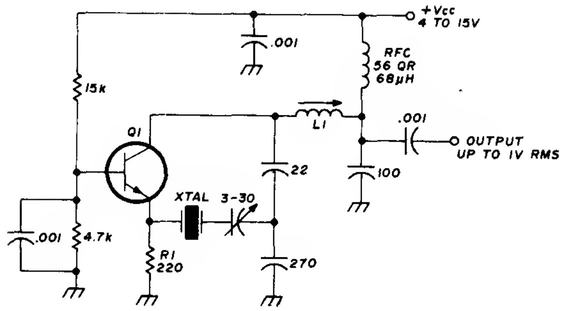
3–20 MHz CRYSTAL—Circuit is series-mode oscillator, but parallel-mode crystals can be used if trimmer in series with crystal is replaced by short-circuit. Adjust feedback by varying ratio of C1 to C2. Use grid-dip oscillator to resonate L1 with C1 when crystal is shorted; then remove short and tune slug of L1 to pull crystal exactly to frequency. R1 should be between 100 and 1000 ohms. The lower its value, the lower the crystal power dissipation and the better is stability. Q1 is 2N918, 2N3564, 2N5770, BF200, SE1001, or equivalent.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio*, March 1976, p 10–22.



160-METER VFO—Standard Colpitts oscillator Q_1 with emitter-follower Q_2 gives dependability and adequate isolation from later stages. Zener regulation provides stability even with weak battery. Output is about 0.7 VRMS. Low-level parasitic oscillation may occur about 150 kHz below operating frequency but is suppressed by tuned stages following VFO. L_1 is 52 turns No. 28 enamel on Amidon T-50-2 toroid. RFC_1 is 850 μH.—A. Weiss, Design Notes on a Moderate Power Solid State Transmitter for 1.8 MHz, *CQ*, Nov. 1972, p 18–22, 24, 98, 100, and 102.

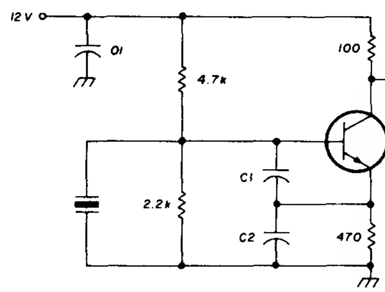


STABLE 3.5–3.8 MHz VFO—Oscillator Q1-Q2, emitter-follower output Q3, and buffer Q4 provide 5 V P-P into 200-ohm load, with good isolation between oscillator and load. Total drift is less than 10 Hz from turn-on, and less than 330 Hz as supply voltage varies between 15 and 30 V. Amplitude stability is within 1 dB over tuning range. Oscillator amplitude is stabilized by two 1N34 diodes and 3.3-V zener. L1 is 25 turns No. 18 closewound on 1.5-in form.—J. Fisk, Circuits and Techniques, *Ham Radio*, June 1976, p 48–52.

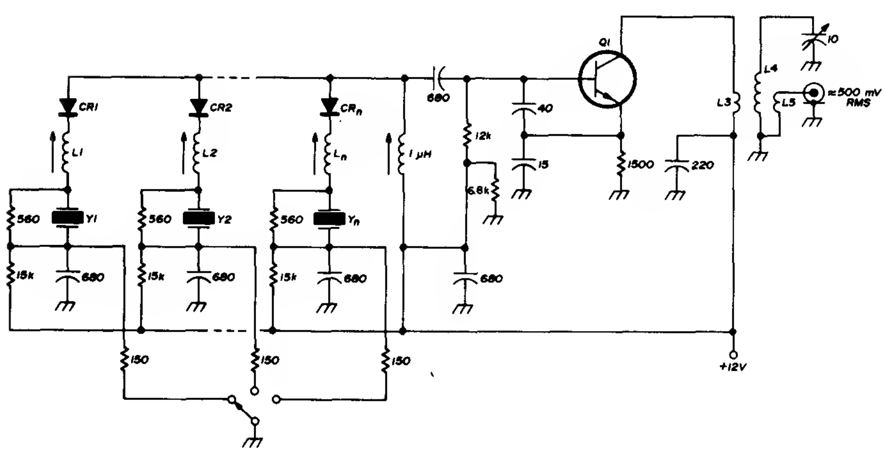


15–65 MHz THIRD-OVERTONE—Crystal starting is reliable, and power dissipation of crystal is well below allowable maximum. Q1 is 2N918, 2N3564, 2N5770, BF180, or BF200. L1 resonates at crystal frequency with 22 pF (1 μH for 15–30 MHz or 0.5 μH for 30–65 MHz). Stability is as good as that of fundamental-frequency oscillator. Set L1 roughly to frequency with no supply voltage by shorting crystal and dipping L1 with grid-dip oscillator. Now apply power and tune L1 close to marked crystal frequency while monitoring output frequency. Remove short and trim to frequency with 3–30 pF trimmer.—R. Harrison, Survey of Crystal Oscillators, *Ham Radio*, March 1976, p 10–22.

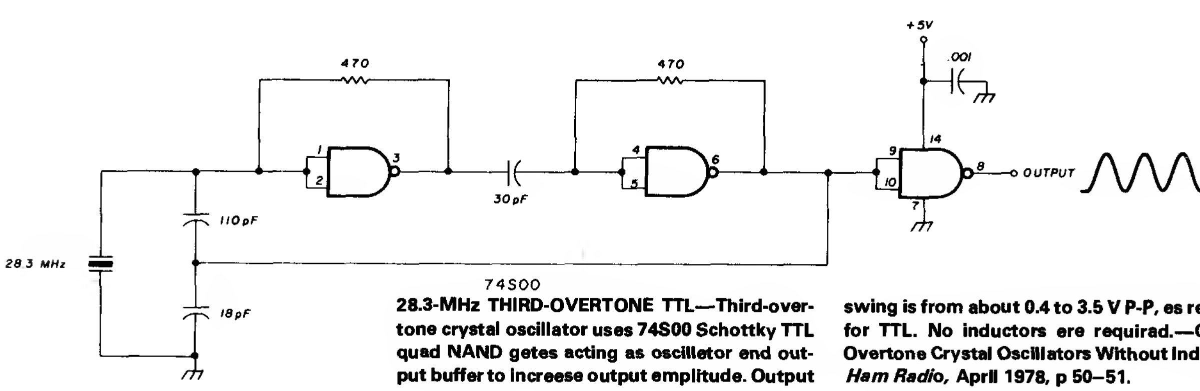
18–60 MHz THIRD-OVERTONE—International Crystal OF-1 oscillator for third-overtone crystals requires no inductors. Crystal operates near series resonance, making capacitor unnecessary in series with crystal. With 28.3-MHz third-overtone crystal, circuit delivers 28.3 MHz when C1 is 100 pF and C2 is 18 pF. Using larger values given in table produces oscillation at fundamental of 9.43 MHz.—C. Hall, Overtone Crystal Oscillators Without Inductors, *Ham Radio*, April 1978, p 50–51.



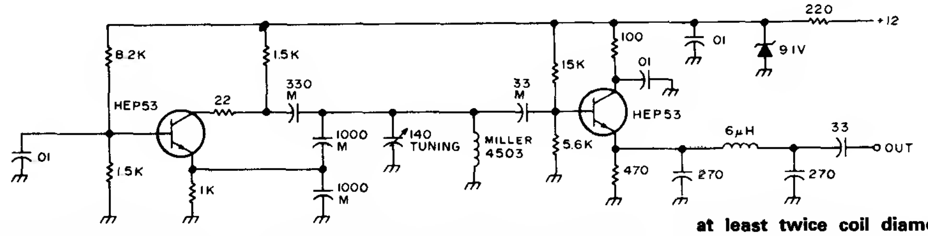
FREQ.	C1	C2
18–28 MHz	220 pF	47 pF
28–60 MHz	100 pF	18 pF



SWITCHED OVERTONE CRYSTALS—Uses third-overtone crystals between 20 and 80 MHz, with diode switching and with frequency doubling in transistors. L1-Ln are series resonant with 10 pF at each crystal frequency. L4 is resonant with 10 pF at desired output frequency. L3 and L5 have one-third as many turns as L4. Q1 is 2N918, BF115, HEP709, or equivalent. Diodes are switching types such as BAY67.—U. Rohde, Stable Crystal Oscillators, *Ham Radio*, June 1975, p 34–37.



28.3-MHz THIRD-OVERTONE TTL—Third-overtone crystal oscillator uses 74S00 Schottky TTL quad NAND gates acting as oscillator and output buffer to increase output amplitude. Output swing is from about 0.4 to 3.5 V P-P, as required for TTL. No inductors are required.—C. Hall, Overtone Crystal Oscillators Without Inductors, *Ham Radio*, April 1978, p 50–51.

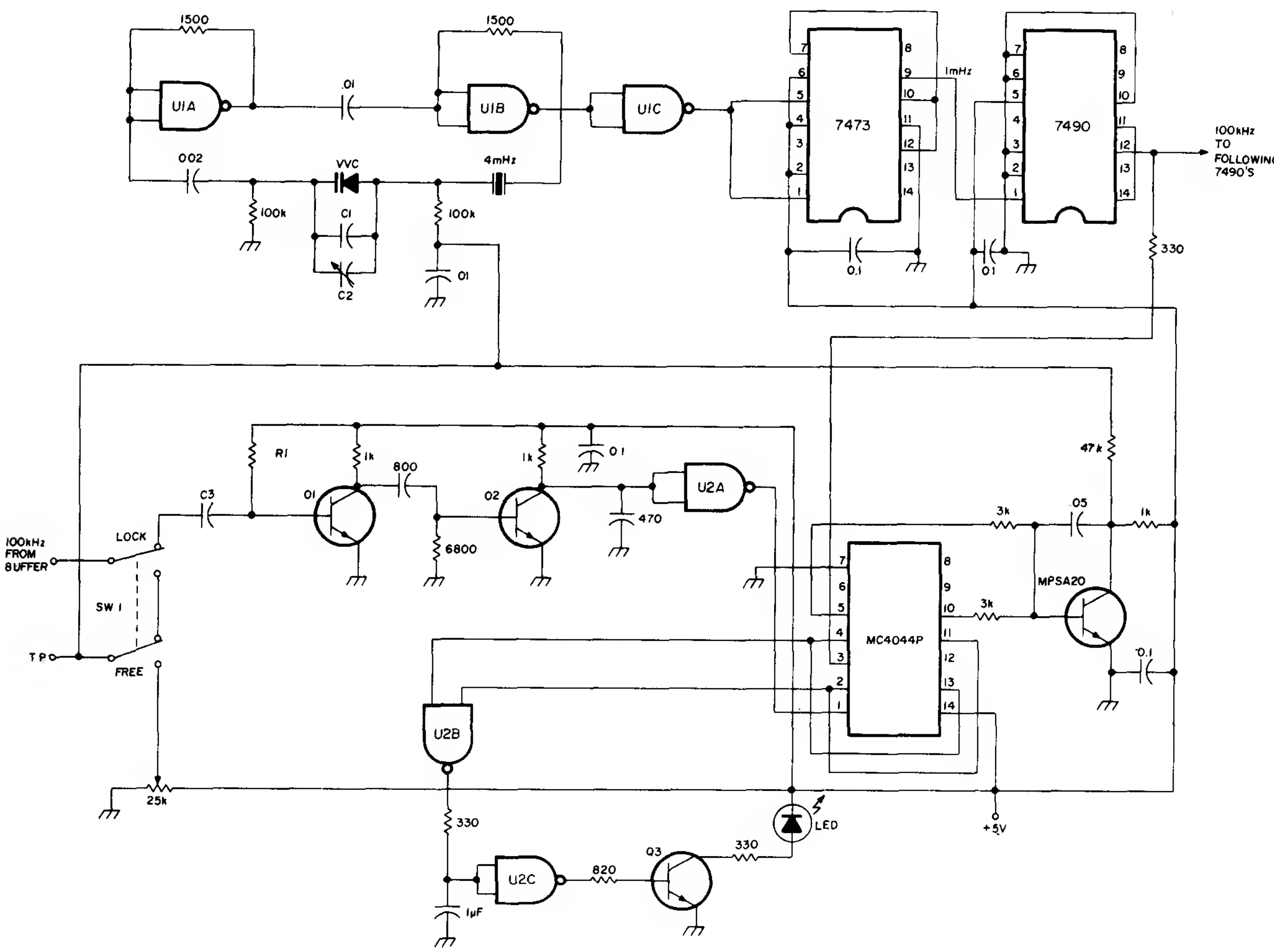


4–4.6 MHz TUNABLE—Emitter-follower buffer stage for isolation has low-pass filter for reducing harmonic output and giving better sine-wave output. Oscillator coil should be in shield at least twice coil diameter.—An Accessory VFO—the Easy Way, *73 Magazine*, Aug. 1975, p 103 and 106–108.

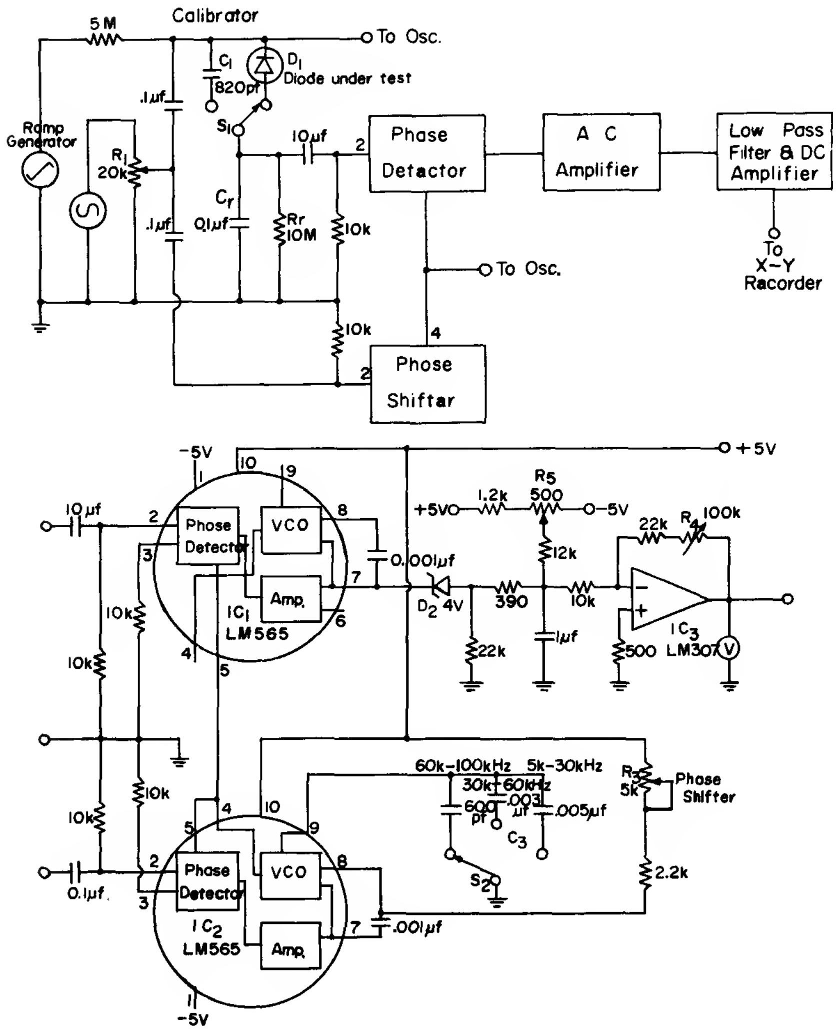
CHAPTER 63

Phase Control Circuits

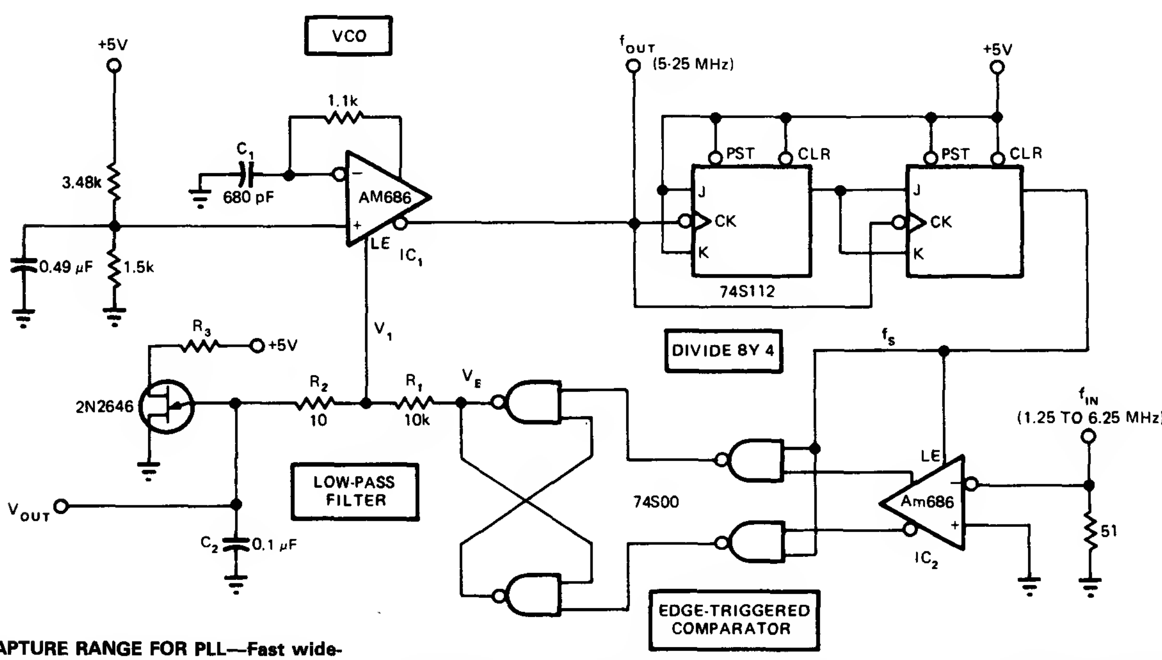
Includes circuits for measuring, shifting, comparing, and digitally controlling phase of signal. Many use phase-locked loops. See also Lamp Control, Motor Control, Power Control, and Temperature Control chapters.



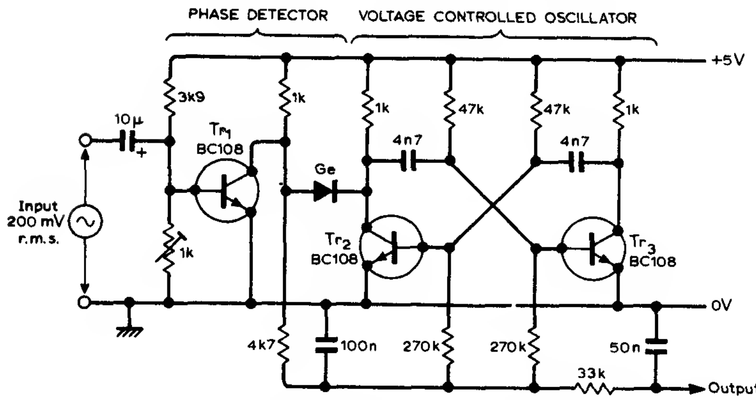
PHASE-LOCKED 100-kHz REFERENCE—Uses 4-MHz crystal in oscillator, with voltage-variable capacitor VVC in parallel with fixed and variable capacitors for setting frequency precisely. Varicap or silicon diode can also be used for VVC. Control voltage for VVC is developed by Motorola MC4044P phase-frequency detector and associated MPSA20 amplifier and filter. 7473 and 7490 ICs divide 4-MHz signal by 4 and then by 10 to give 100 kHz. Main output can be further divided with additional 7490s, down to 60 Hz for driving electric clock if desired. Adjust C3 and R1 for symmetrical square wave at pin 1 of MC4044P, with clean leading and trailing edges. Typical values are 68 pF for C3 and 300K for R1, but values will depend on transistors used. Transistor types are not critical. Gates U2B and U2C with Q3 form lock indicator circuit that turns on LED when 4-MHz oscillator is phase-locked to output of external high-stability 100-kHz frequency standard. U1 and U2 are SN7400.—C. A. Harvey, How to Improve the Accuracy of Your Frequency Counter, *Ham Radio*, Oct. 1977, p 26–28.



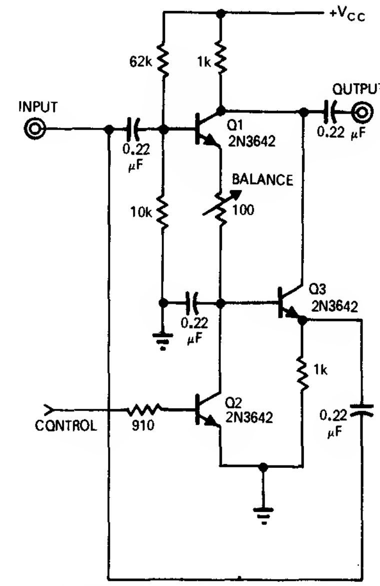
0–90° SHIFTER—Used in eutomatic plotter for measuring capecitence-voltage cheracteristics of Schottky barriar solar cells. Diode under test is connected es shown in block diagram. Phese of squere-wava output from IC_2 can be shifted continuously from 0 to 90° by edjusting R_3. Article gives remp circuit and dasign equations.—J. T. Lue, An Automatic C-V Plotter and Junction Perameter Maesuraments of MIS Schottky Berrier Diodes, *IEEE Journal of Solid-State Circuits*, Aug. 1978, p 510–514.



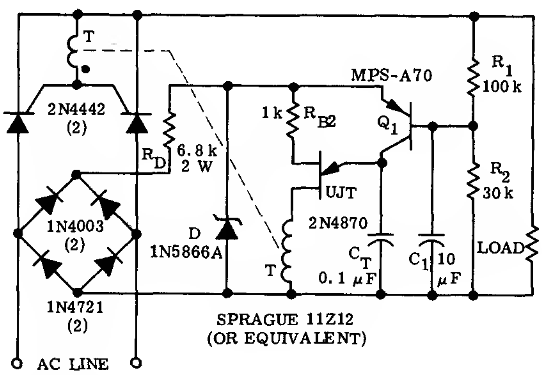
WIDE CAPTURE RANGE FOR PLL—Fast wideband phasa-locked loop uses ona Am686 latching comparator as voltage-controlled oscillator, while other is coupled with TTL latch to produce edge-triggered comparator. VCO and comparator combined with low-pass filtar R_1-R_2-C_2 form PLL. When locking fails, UJT causes V_{OUT} to scan, repetitively sweeping all frequencies in VCO ranga until lock is restored. Capture and locking renges are both equel at ±60% for 5-MHz input.—M. C. Hahn, PLL's Captura Ranga Equals Its Locking Ranga, *EDN Magazine*, Sept. 20, 1977, p 117 and 119–120.



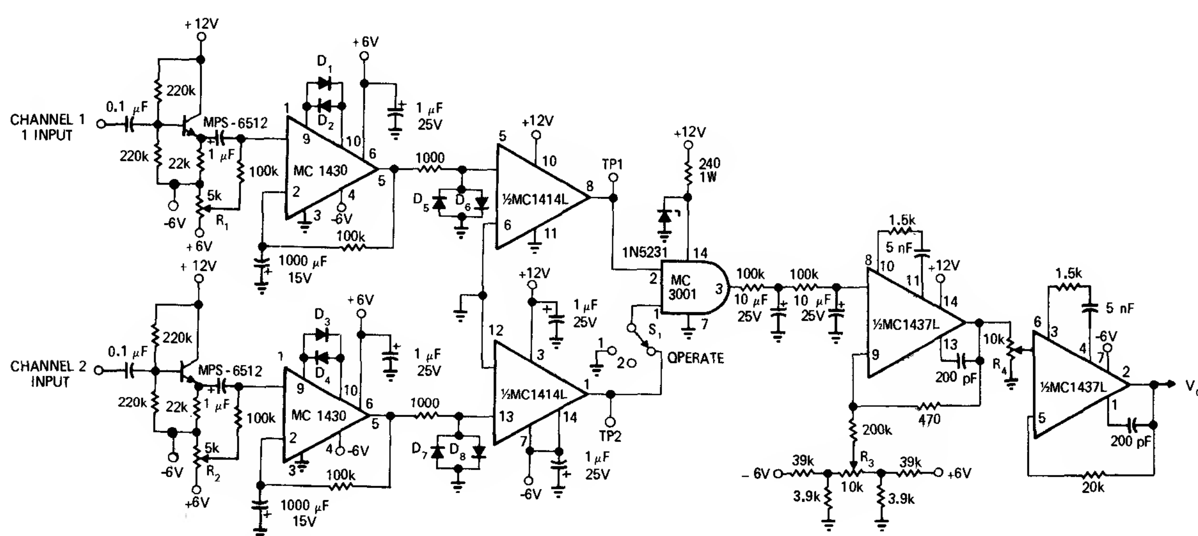
AF PLL—Addition of components to conventional two-transistor MVBR gives simple phase-locked loop. Tr_1 and diode form logic gate that conducts during alternate half-cycles of input and VCO waveforms respectively. Output of this phase detector, when filtered, is most negative when waveforms are in phase, and most positive when they are out of phase. Once phase lock has been established, it is maintained by VCO over range of 100 to 3000 Hz.—J. B. Cole, Simple Phase-Locked Loop, *Wireless World*, June 1977, p 56.



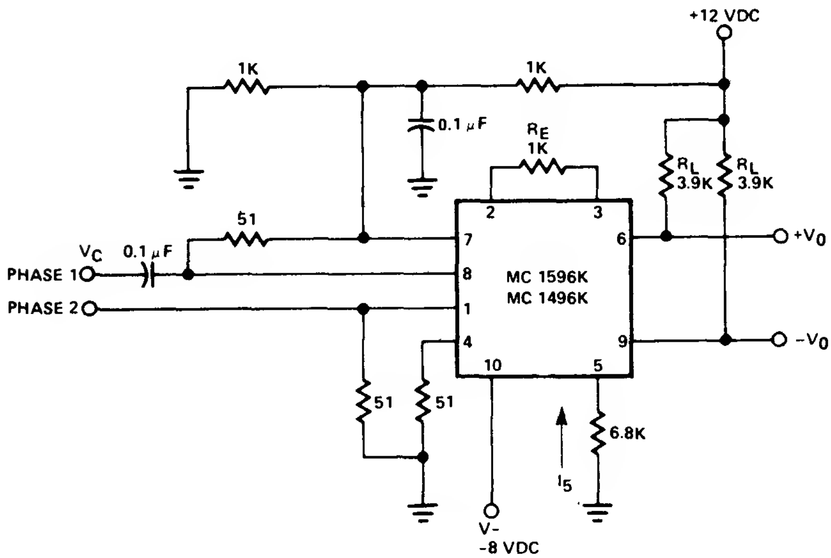
VOLTAGE-CONTROLLED PHASE SHIFTER—Circuit shifts carrier 180° by sensing polarity of modulating voltage. Operating range is 5 kHz to 10 MHz. Circuit can also be used to convert unipolar pulses to alternate bipolar pulses or vice versa when synchronized square wave is supplied to control input. With 0 V at base of Q2, Q3 will amplify RF voltage applied to input, without phase shift. To actuate switch and provide 180° phase shift, positive voltage is applied to base of Q2 so it saturates and cuts off, allowing Q1 to conduct. Output then appears across load with phase reversed.—A. H. Hargrove, Simple Circuits Control Phase-Shift, *EDN Magazine*, Jan. 1, 1971, p 39.



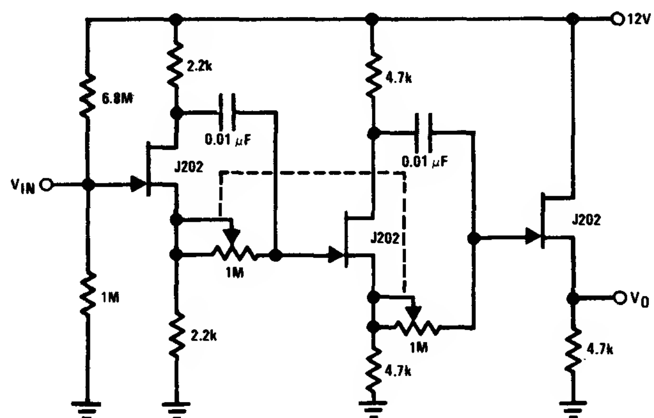
FULL-WAVE FEEDBACK—Used when average load voltage is desired feedback variable for full-wave phase control of load power. Circuit requires use of pulse transformer T.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoenix, AZ, 1974, AN-413, p 4.



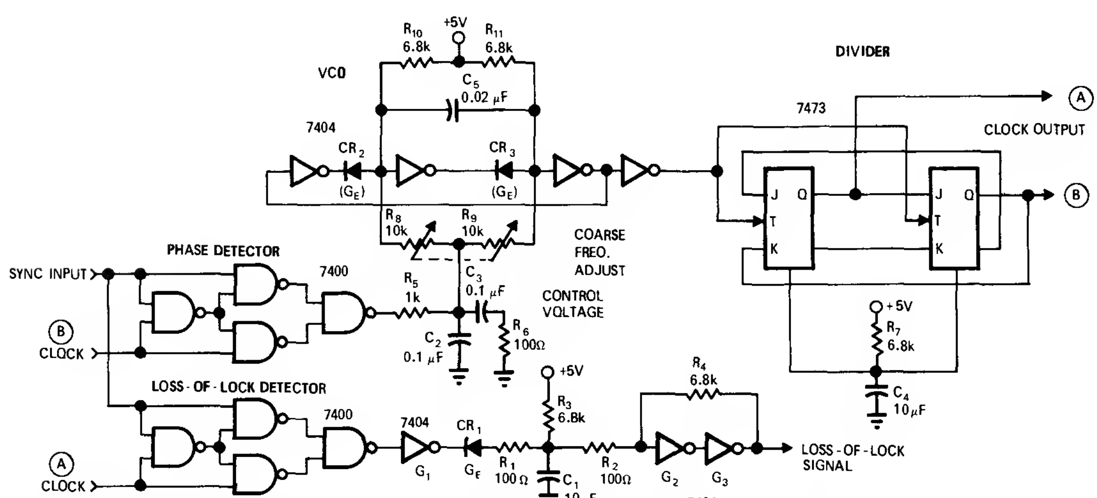
100 Hz TO 1 MHz PHASE METER—Provides better than 2% accuracy over most of frequency range, as required for making Bode plots. Based on squaring two sine waves and comparing amount of overlap to total period of an input wave. This gives directly the amount of phase difference between input wave trains, up to 180°. Instead of measuring periods, overlap is integrated over total period to give average of ON to OFF times that can be read as phase difference on voltmeter. Article gives performance specifications and describes circuit operation in detail.—D. Kesner, IC Phase Meter Beats High Costs, *EDN/EEE Magazine*, Oct. 15, 1971, p 49–52.



PHASE COMPARATOR—Signetics balanced modulator-demodulator transistor array is connected as phase detector in which output contains term related to cosine of phase angle. Equal-frequency input signals are multiplied together by IC to produce sum and difference frequencies. Difference component becomes DC, while undesired sum component is filtered out. DC component is related to phase angle, with cosine becoming 0 at 90° and having maximum positive or negative value at 0° and 180° respectively. Balanced modulator provides excellent conversion linearity along with conversion gain.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 757–758.

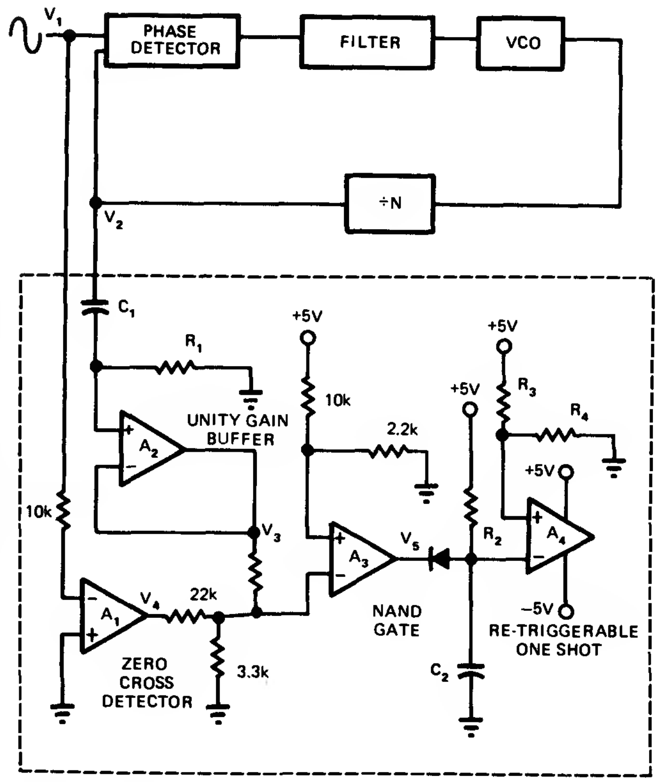


0–360° PHASE SHIFTER—Each J202 JFET stage provides up to 180° phase shift under control of 1-megohm pot. Ganged pots give full range of control. JFETs specified are ideal for circuit because they do not load phase-shift networks.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

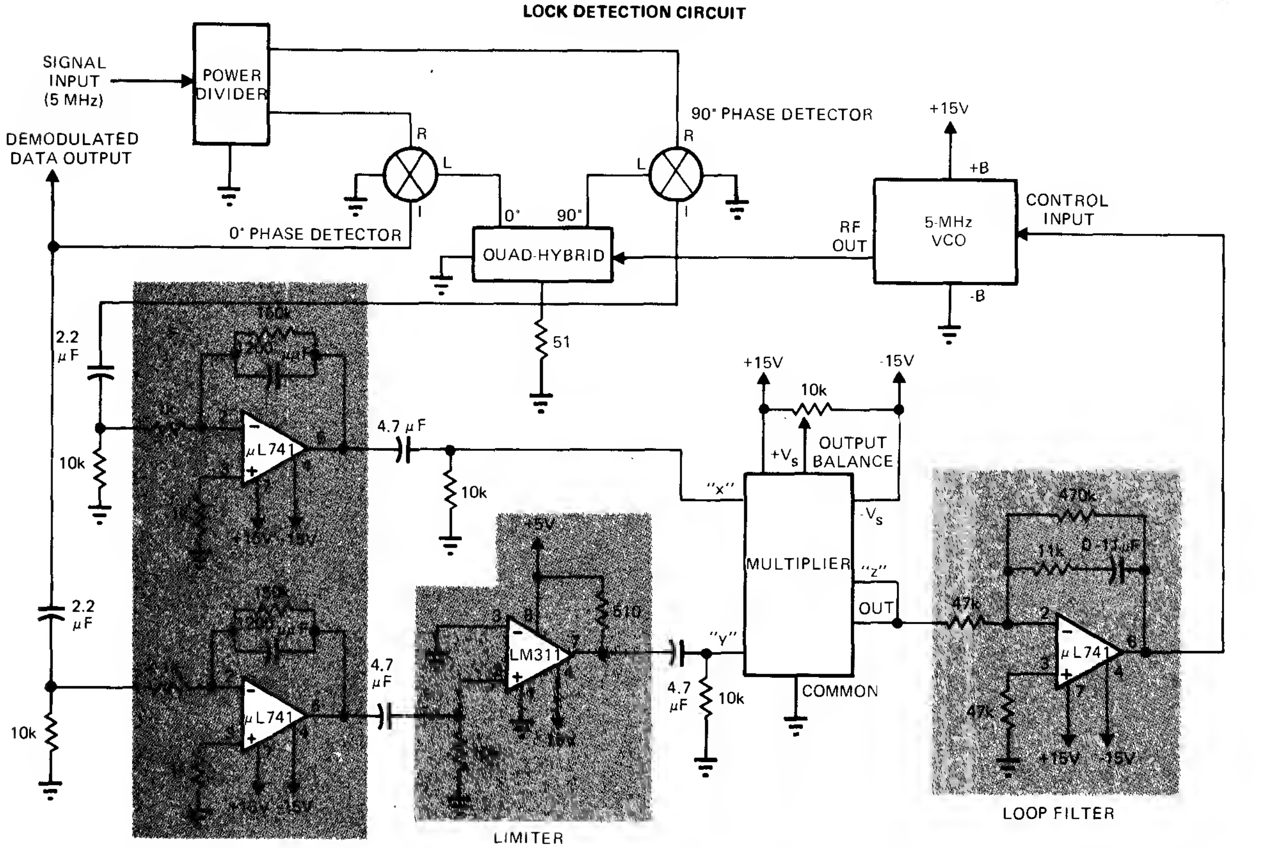


LOSS-OF-LOCK MONITOR—Modified digital phase-locked loop includes second phase detector that provides alarm signal when loop gets out of lock. Output may also be used to disable other circuits. Voltage-controlled multivibrator VCO, operating at 4 times desired clock frequency, drives two-stage switch-tailed ring counter that provides two-phase internal clock signals A and B for detectors. Article describes operation of circuit and gives timing diagrams.—C. A. Herbst, Digital Phase-Locked Loop with Loss-of-Lock Monitor, *EDN/EEE Magazine*, Oct. 15, 1971, p 64–65.

PLL LOST-LOCK INDICATOR—Developed for use with pheee-locked loop to Indicete both ecquleition end loss of lock. Beeed on concept thet lock exiets es long es static-pheee error is less then 90°. Uses qued opemp peckege such es RC4136, with A_4 feeding retriggereble one-shot; output of one-shot is low when lock exists. When lock ie lost, output of one-ehot immedietely goes high end remeins high until lock is reecquired plue time duration of one-shot. Developed for use In systeme where certein procesees must be interrupted immedietely upon loss of lock.—J. C. Henisko, PLL Lock Indicetor Usee e Single IC, *EDN Magazine*, Oct. 5, 1976, p 104.

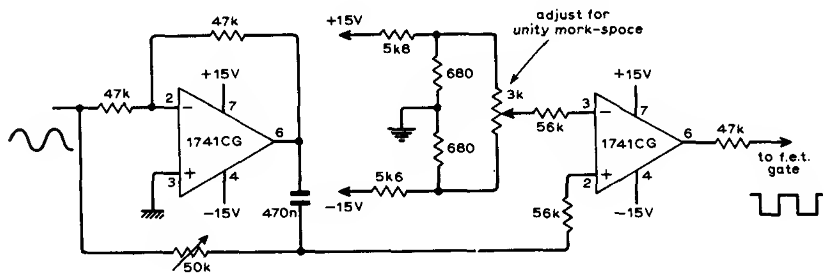


LOCK DETECTION CIRCUIT



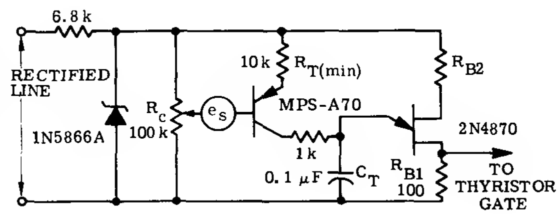
1200-Hz LOW PASS FILTER

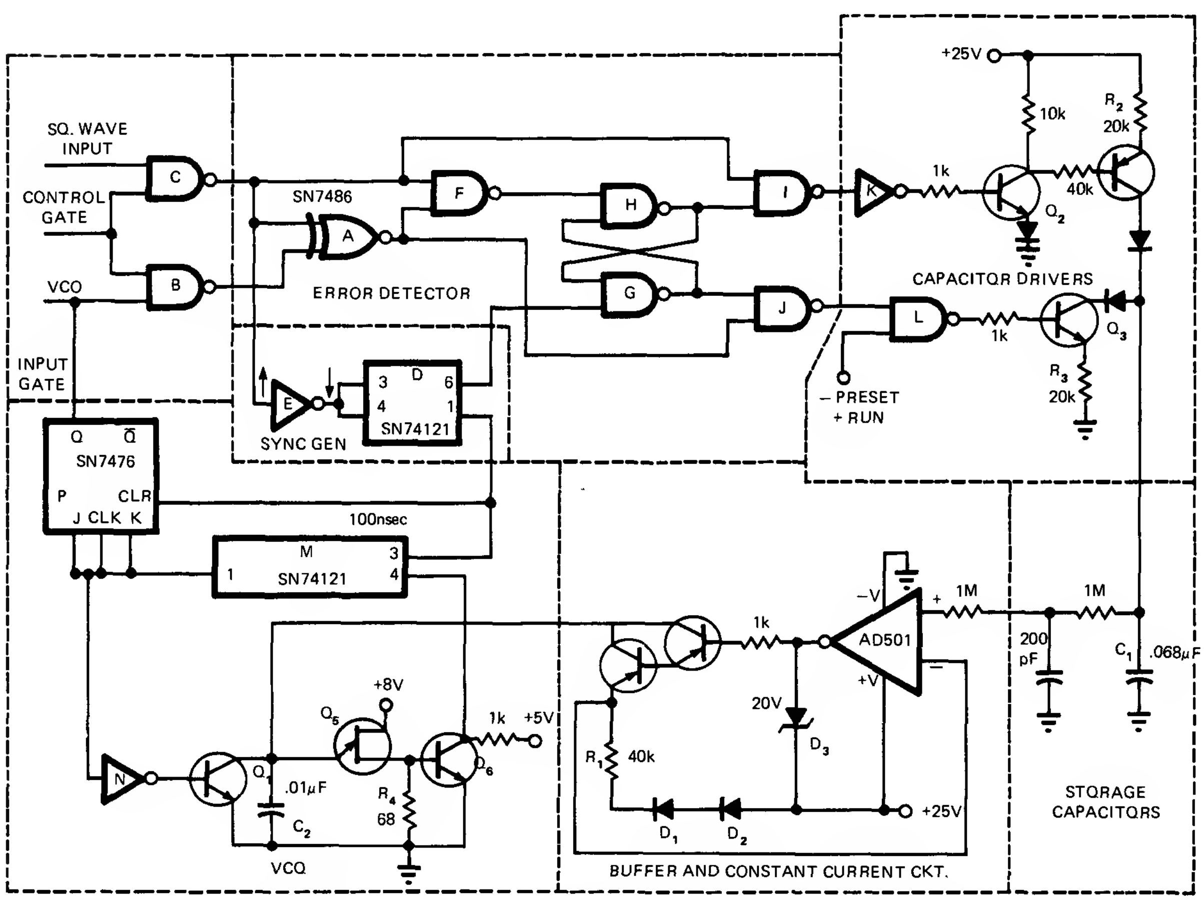
DPSK ON DSBSC—Differentiel phese-shift keyed double-sidebend euppreeed-cerrier signel is demoduleted by relneertion of mlesing carrier, using synchronous or coherent detection. Receiver input signel ie multiplexed by locelly generated cerrier, eccuretely controlled in frequency end phase. Thie is followed by lowpese filtering. Demodulation et output ie by frequency/phese controlled loop thet eutometlcelly locks local oecillator in frequency end pheee to received vestige of cerrier. This extrects phese information from moduleted signel. Power divider ie RF Aseociates H22, quad hybrid is Merrimec Reseerch QHT-2, 0° end 90° pheee detectors ere Relcom M6A, end multiplier is Anelog Devices 4281. Article covere theory end operetion of circuit in detell.—R. Hennick, Demodulete DPSK Signels Coherently Using e Costas Phase-Lock Loop, *EDN Magazine*, July 1, 1972, p 44–47.



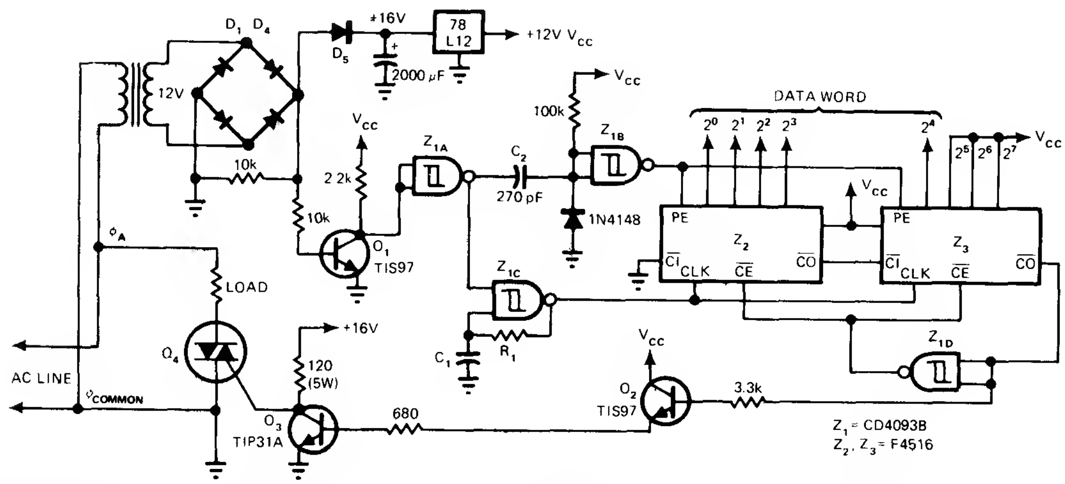
SHIFTING AND SQUARING—Circuit uses two opamps to derive phase-shifted reference square wave and DC output signal of phase-sensitive detector from same sine-wave signal source. Article gives theory of operation and waveforms for various operating conditions.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, July 1973, p 355–356.

VOLTAGE FEEDBACK—Used when quantity to be sensed is isolated varying DC voltage e_s such as output of tachometer. Operating point is determined by setting of R_c. Output of voltage feedback circuit goes to thyristor in series with load.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoenix, AZ, 1974, AN-413, p 4.

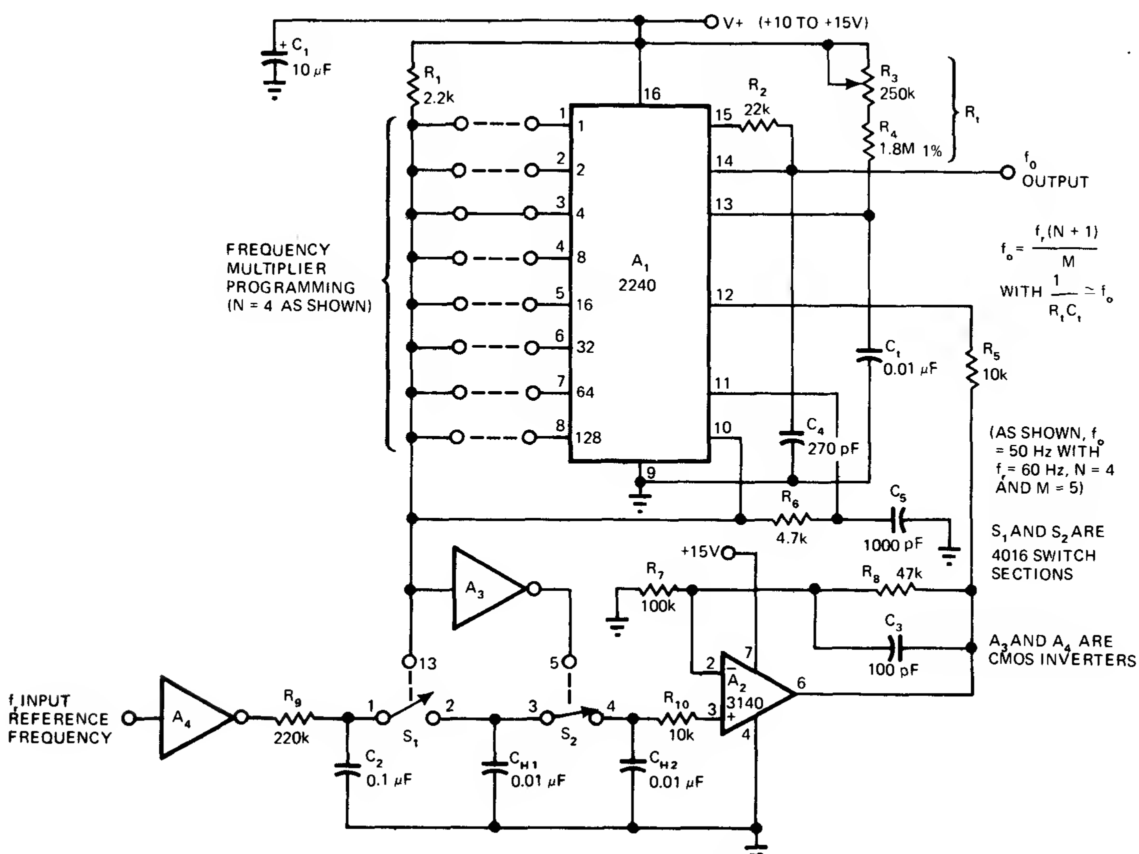




FASTER PHASE LOCK—Circuit was developed to reduce the normally long acquisition time of phase-locked loops when measuring frequency of short signal bursts. Synchronization of VCO to input phase allows correction pulses to be developed in correct polarity only, to give lockup time less than 10 cycles of input when using idling frequency of 12 kHz for VCO. Input signals are compared to those of VCO at EXCLUSIVE-OR gate A. Gating of error pulses by gate F and flip-flop G-H allows I or J to drive current pulses of correct polarity into C_1. Voltage correction on C_1, controlled by values of R_2 and R_3, is proportional to width of error pulses. Article covers circuit operation in detail.—R. Bohlken, A Synchronized Phase Locked Loop, *EDN Magazine*, March 20, 1973, p 84–85.



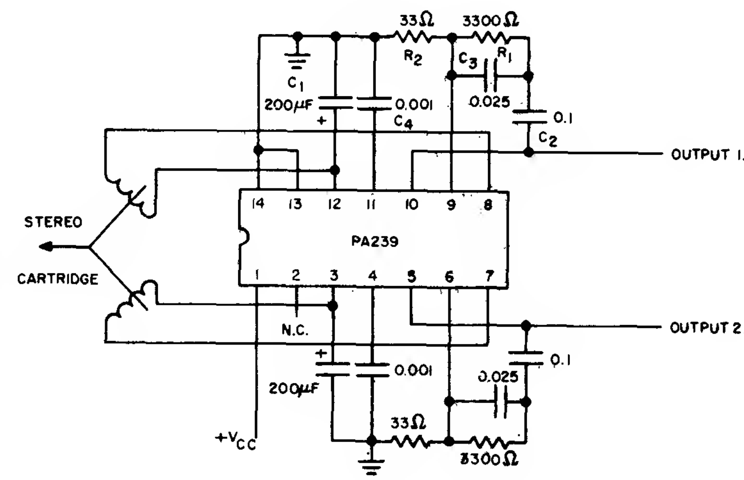
DIGITAL CONTROL OF PHASE ANGLE—Circuit transforms 5-bit digital control word into phase angle over full range. Resolution is proportional to length of control word. Developed for stage lighting control. Z_{1C} serves as clock oscillator that is periodically synchronized with zero crossings of AC line; R_1 and C_1 set clock frequency, which for 5-bit control word must be 64 times line frequency or 3.84 kHz. Load requirements determine choice of triac for Q_4. Required signal for generating triac drive is produced by D_1-D_4 and Q_1.—R. Tenny, Circuit Provides Digital Phase Control of AC Loads, *EDN Magazine*, Oct. 5, 1977, p 99–101.



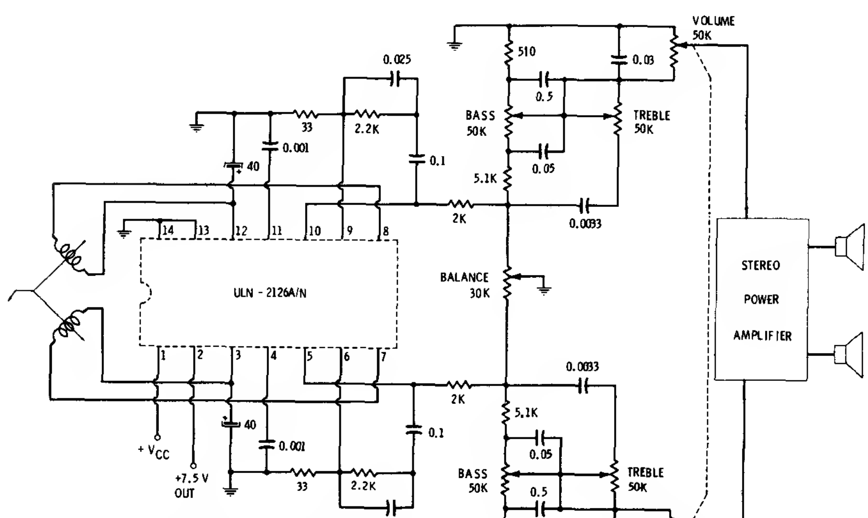
PLL WITH IC TIMER—Uses 2240 programmable timer/counter as combination voltage-controlled oscillator and frequency divider, with CMOS analog switches serving as sample-and-hold phase detectors. Incoming reference frequency is amplified and limited by CMOS inverter, then integrated into reference triangle waveform by R_9-C_2. Triangle is sampled by S_1 and S_2 which with C_{H1} and C_{H2} form cascaded sample-and-hold network that holds only last instantaneous voltage on C_{H1} as error voltage. This error is amplified by FET-input 3140 opamp A_2 for driving pin 12 of 2240 timer as correction voltage, to establish lock. Reference and output frequencies need not have direct harmonic relationship; with circuit values shown, output is 50 Hz for reference input of 60 Hz. Output frequency can go as high as 100 kHz by using programmability of divider chain.—W. G. Jung, Take a Fresh Look at New IC Timer Applications, *EDN Magazine*, March 20, 1977, p 127–135.

CHAPTER 64
Phonograph Circuits

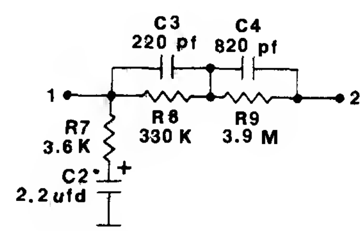
Includes RIAA-equalized preamps for all types of mono and stereo phono pickups, along with power amplifiers, tone controls, rumble and scratch filters, and test circuits. See also Audio Amplifier and Audio Control chapters.



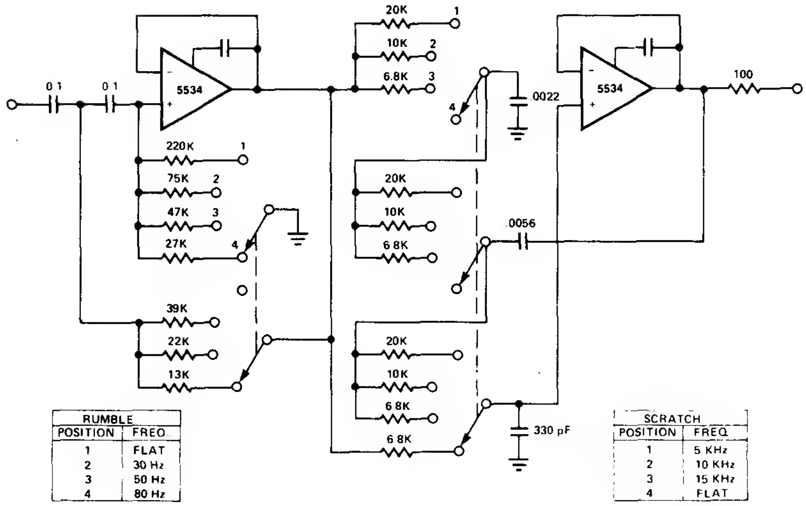
MAGNETIC-CARTRIDGE PREAMP—Uses Signetics PA239 dual low-noise amplifier designed specifically for low-level low-noise applications. Stereo channel separation at 1 kHz is typically 90 dB, and total harmonic distortion without feedback is 0.5%. Circuit matches amplifier response with RIAA recording characteristic. Supply voltage can be between 9 and 15 V at 22 mA. Article gives design equations.—A. G. Ogilvie, Construct a Magnetic-Cartridge Preamp, *Audio*, June 1974, p 40 and 42.



STEREO MAGNETIC-PICKUP PREAMP—Single Sprague ULN-2126A IC accepts low impedance of magnetic cartridge and provides up to 2-W output power for driving commercial stereo power amplifier. Circuit includes balance control and all tone controls along with ganged volume control. Values shown give proper equalization for playback of records.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 237 and 242.



NEW RIAA NETWORK—Values of R7 and C2 have been changed as shown in standard network for phonograph playback equalization. Tantalum electrolytic rated at least 20 V is recommended for C2. Network can also be used as inverse RIAA equalizer for testing preamps, with signal applied to terminal 2 and output to preamp taken from terminal 1. New standard extends playback equalization to 20,000 Hz and specifies that equalization be 3 dB down from previous standard at 20 Hz, with rolloff at 6 dB per octave below 20 Hz.—W. M. Leach, New RIAA Feedback Network, *Audio*, March 1978, p 103.

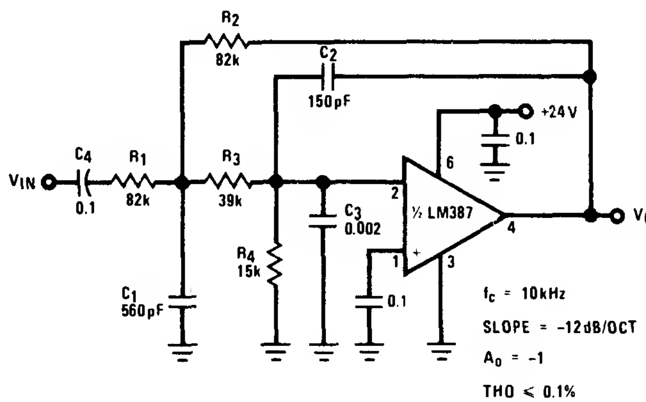


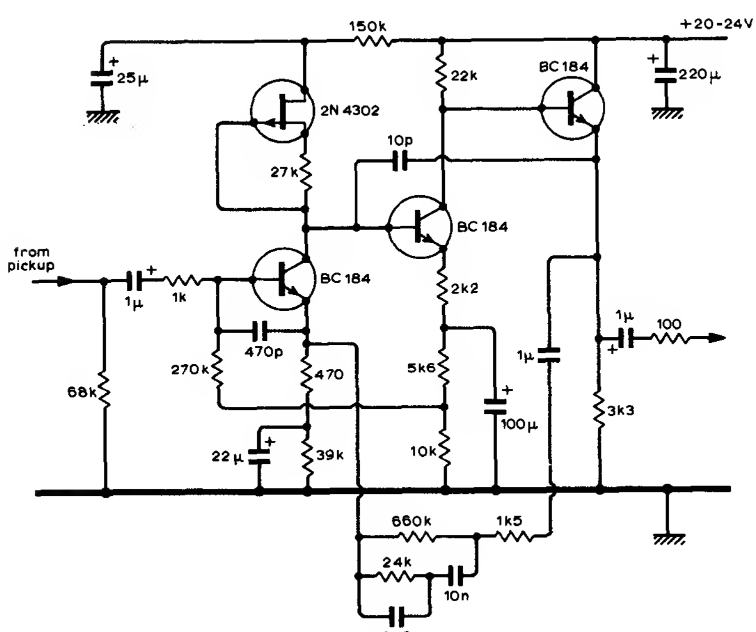
RUMBLE	
POSITION	FREQ
1	FLAT
2	30 Hz
3	50 Hz
4	80 Hz

SCRATCH	
POSITION	FREQ
1	5 KHz
2	10 KHz
3	15 KHz
4	FLAT

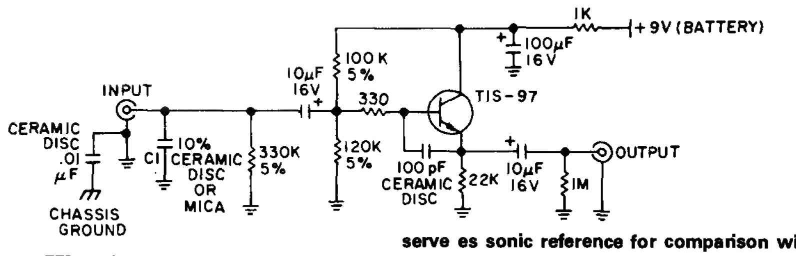
RUMBLE/SCRATCH FILTER—Used after pre-amp in high-quality audio system to improve reproduction of phonograph records. Two-pole Butterworth design has switchable breakpoints providing any desired degree of filtering.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 638–639.

SCRATCH FILTER—Provides passband gain of 1 and corner frequency of 10 kHz for rolling off excess high-frequency noise appearing as hiss, ticks, and pops from worn records. Design procedure is given.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-49–2-52.

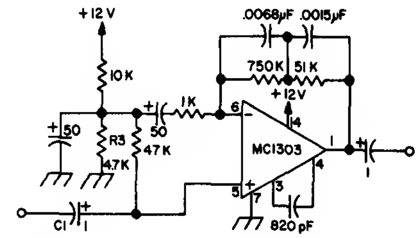




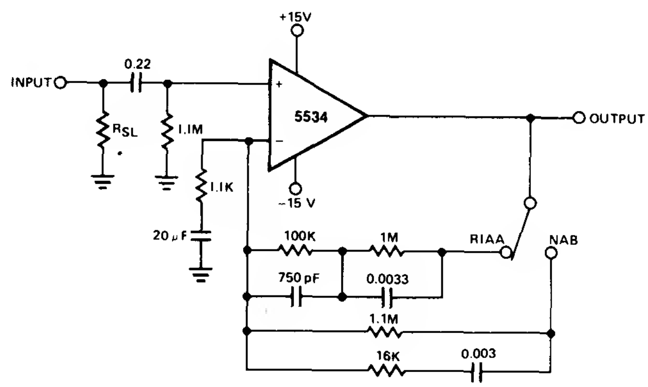
RIAA PREAMP—Low-noise circuit (below −70 dB referred to 5-mV input from pickup) has high overload capability and low distortion (below 0.05% intermodulation at 2 VRMS output). Arrangement of first stage gives improved transient response over usual feedback pair. Second stage provides gain of 10.—S. F. Bywaters, RIAA-Equalized Pre-Amplifier, *Wireless World*, Dec. 1974, p 503.



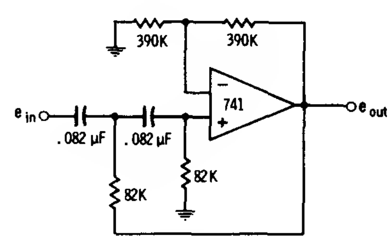
INPUT BUFFER FOR PREAMP—Used betwaan cartridge and preamp of each stereo channel to make comparison testing of phonograph preamps more nearly independent of cartridge and cable capacitances. Buffer terminates cartridge in 47K in perallel with C1. Buffer can than serve es sonic reference for comparison with preamps for which input impedance is unknown. Article tells how to determina correct veiue of C1 for cartridge used and covars preamp test procedures in deteil.—T. Hoimen, New Tests for Preemplifiers, *Audio*, Feb. 1977, p 58, 60, 62, and 64.



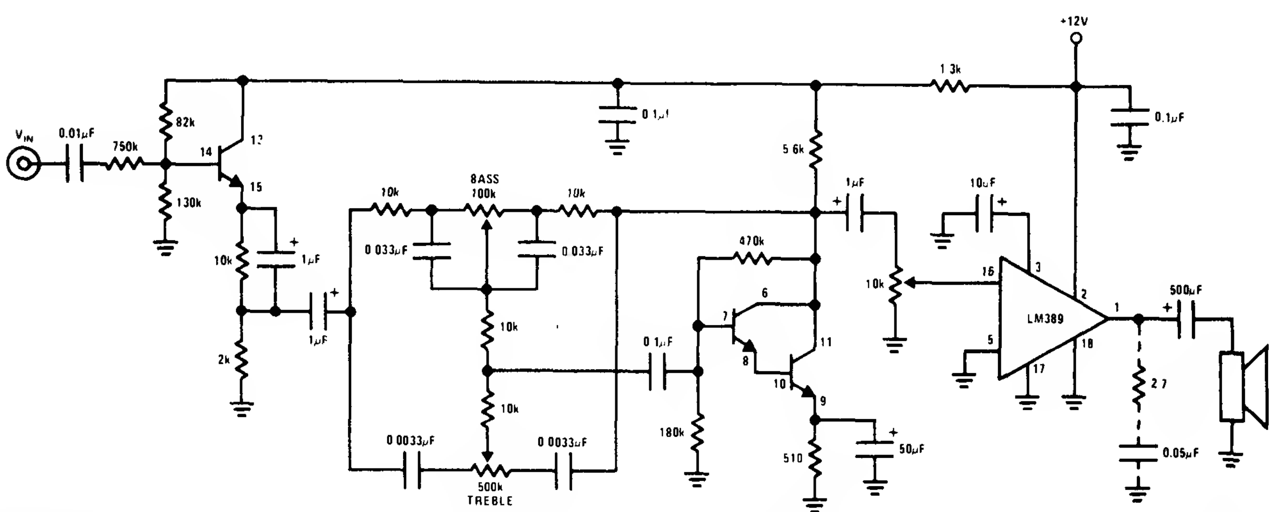
MAGNETIC-CARTRIDGE PREAMP—Usas dual opamp for sterao, other half of which is connectad exactiy the same but with connections to pin numbers changed to those in parantheses: 6 (5), 5 (8), 3 (11), 4 (10), and 1 (13).—Circuits, *73 Magazine*, Sapt. 1973, p 143.



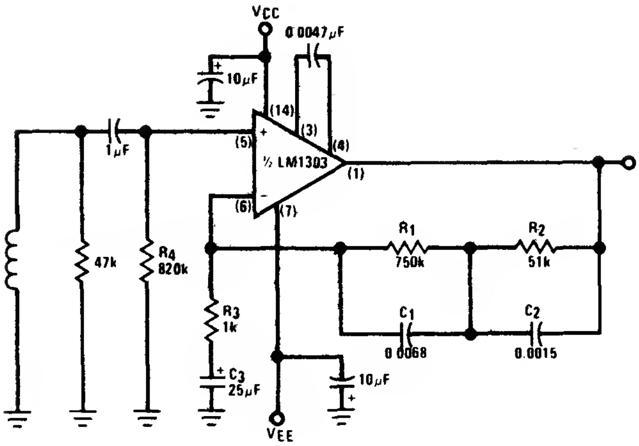
EQUALIZED PREAMP—Low-fraquency boost is provided by inductance of magnetic cartridge, acting with RC network to approximate theoreticel RIAA or NAB compensation es determined by position of compensation switch. Input resistor Is selected to provida spacified loading for cartridga. Output noise Is about 0.8 mVRMS with input shorted.—"Signetics Analog Data Manuel," Signetics, Sunnyvale, CA, 1977, p 638–639.



20-Hz HIGH-PASS RUMBLE FILTER—Second-order rumble filter for phonograph amplifier has 1-dB peek and 20-Hz cutoff frequancy. Deslgn uses large raslstance values to permit use of smaller and lower-cost capacitors.—D. Lancaster, "Active-Fllter Cookbook," Howard W. Sams, Indianapolis, IN, 1975, p 191–192.

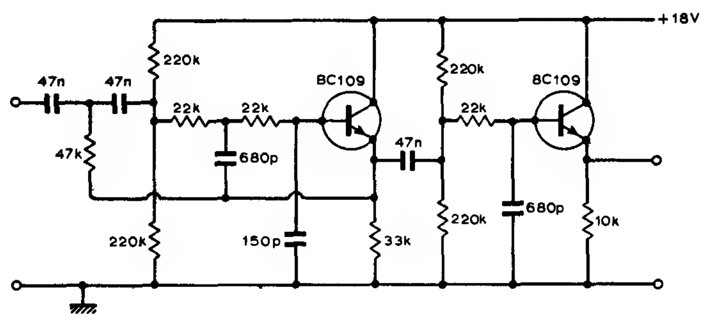


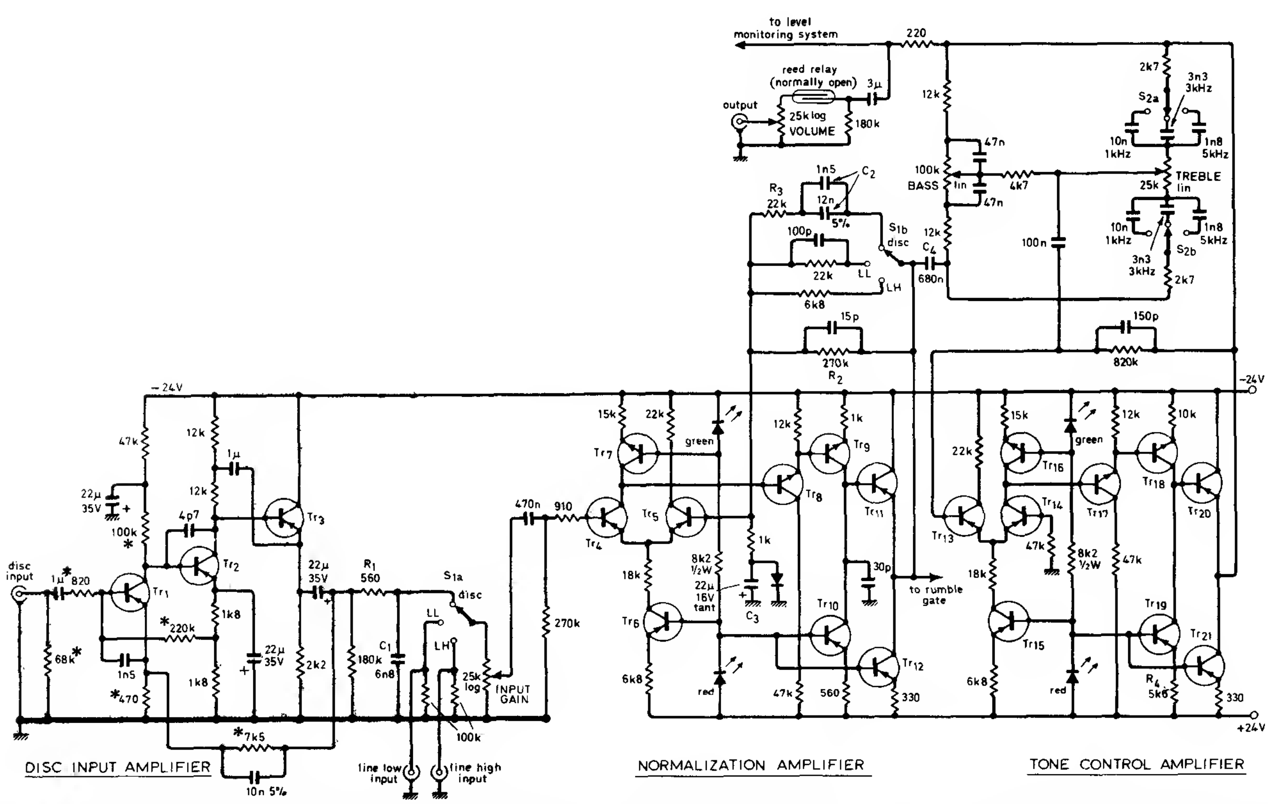
CERAMIC-CARTRIDGE SYSTEM—Circuit using National LM389 opamp having threa transistors on same chip provides required high input impedance for ceramic cartridga bacause input transistor is wired as high-impedanca amittar-follower. Remaining transistors form high-gain Derlington pair used as activa alament in low-distortion Baxandall tone-control circuit.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.



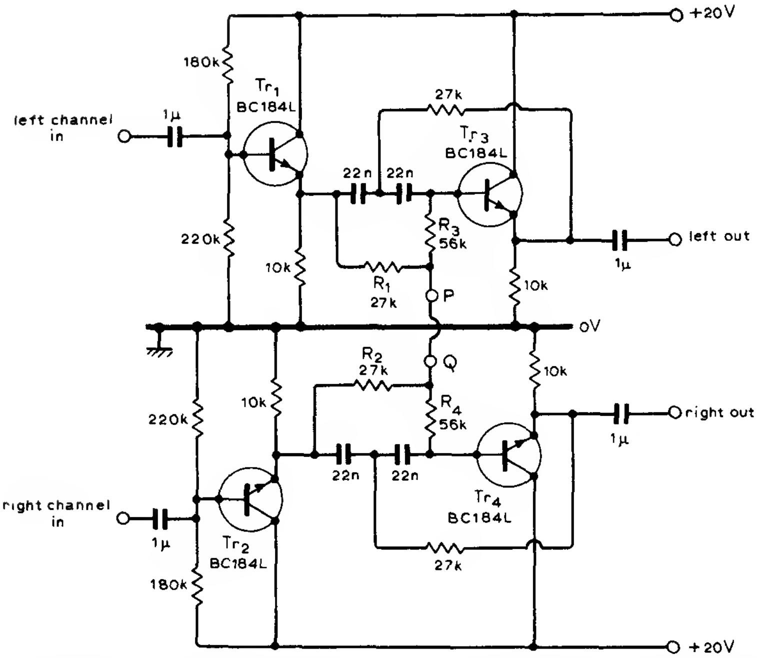
SPLIT-SUPPLY PHONO PREAMP—Low-noise circuit using LM1303 provides RIAA response and operates over supply voltage range of ±4.5 to ±15 V. 0-dB reference gain (1 kHz) is about 34 dB. Input is from magnetic cartridge.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-25–2-31.

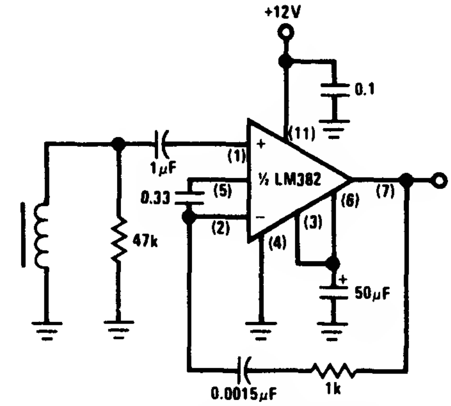
SCRATCH/RUMBLE FILTER—Single active filter provides two widely differing turnover frequencies, as required in audio amplifier used with phonograph. For values shown, insertion loss of filter is −6 dB at 37 Hz and at 23 kHz. Components may be switched to provide different turnover frequencies, but complete removal of filter requires considerably more complicated switching.—P. I. Day, Combined Rumble and Scratch Filter, *Wireless World*, Dec. 1973, p 606.





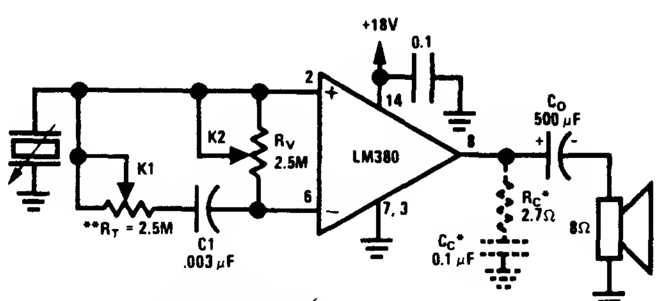
NO-COMPROMISE PHONO PREAMP—Distortion figure is below 0.002 percent, overload margin is about 47 dB, and S/N ratio is 71 dB for phono amplifier. This feeds normalization amplifier whose output is set at 0 dBm by setting input gain control. Feedback components R_2, R_3, and C_2 provide RIAA bass boost. Tone-control circuit is based on Baxandall system but has bass control turnover frequency which decreases as control approaches flat position. This allows small amount of boost at low end of audio spectrum to correct for transducer shortcomings. Article describes circuit operation in detail and gives additional circuits used for tape output, level detection, noise gate, and power supply. Transistors Tr_1-Tr_8 and Tr_{13}-Tr_{15} are BCY71; Tr_7-Tr_9 and Tr_{16}-Tr_{18} are MPS A06; Tr_{10}-Tr_{12} and Tr_{19}-Tr_{21} are MPS A56; Tr_9 is BFX85 or equivalent. Circuit is duplicated for other stereo channel.—D. Self, Advanced Preamplifier Design, *Wireless World*, Nov. 1976, p 41–46.





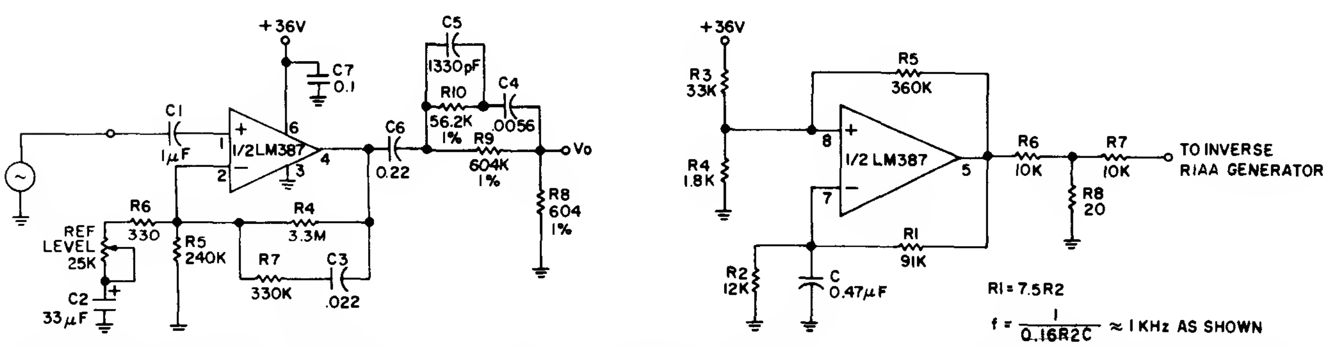
12-V PHONO PREAMP—Low-noisa circuit has midband 0-dB refaranca gain of 46 dB. Dasigned for RIAA responsa. Intarnal resistor matrix of IC minimizes parts count. Input is from magnatic cartridga.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-25–2-31.

RUMBLE FILTER—Used when rumbla from cheaper turntabla or record extends abova 100 Hz, causing disconcerting out-of-phasa loudspaakar signals. Circuit is basad on fact that human aar is not sensitiva to diractional information balow about 400 Hz, making it parmissibla to remove stareo (L − R) signal at low frequancias and thus remova starao rumble without losing stereo separation. Emittar-followers feed high-pass filtars having 200-Hz braakpoint frequancies and Butterworth charactaristics. Attanuation of filtar is 12 dB at 100 Hz. Filter circuit can be disablad by placing switch betwaan points P and Q.—M. L. Oldfiald, Stereo Rumble Filtar, *Wireless World,* Oct. 1975, p 474.

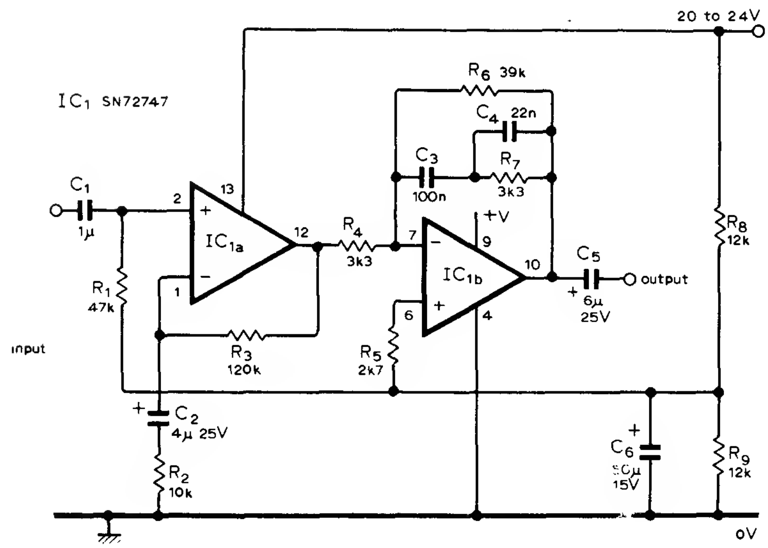


*FOR STABILITY WITH HIGH CURRENT LOADS
**AUDIO TAPE POTENTIOMETER (10% OF R_T AT 50% ROTATION)

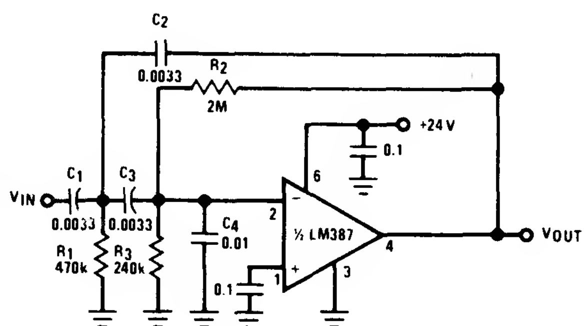
COMMON-MODE VOLUME AND TONE CONTROL—Eliminates attenuation of signal by conventional voltage-divider type of volume control and gives maximum input impedance. Used with transducers having high source impedance, but will also serve with low-impedance transducers.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-21–4-28.



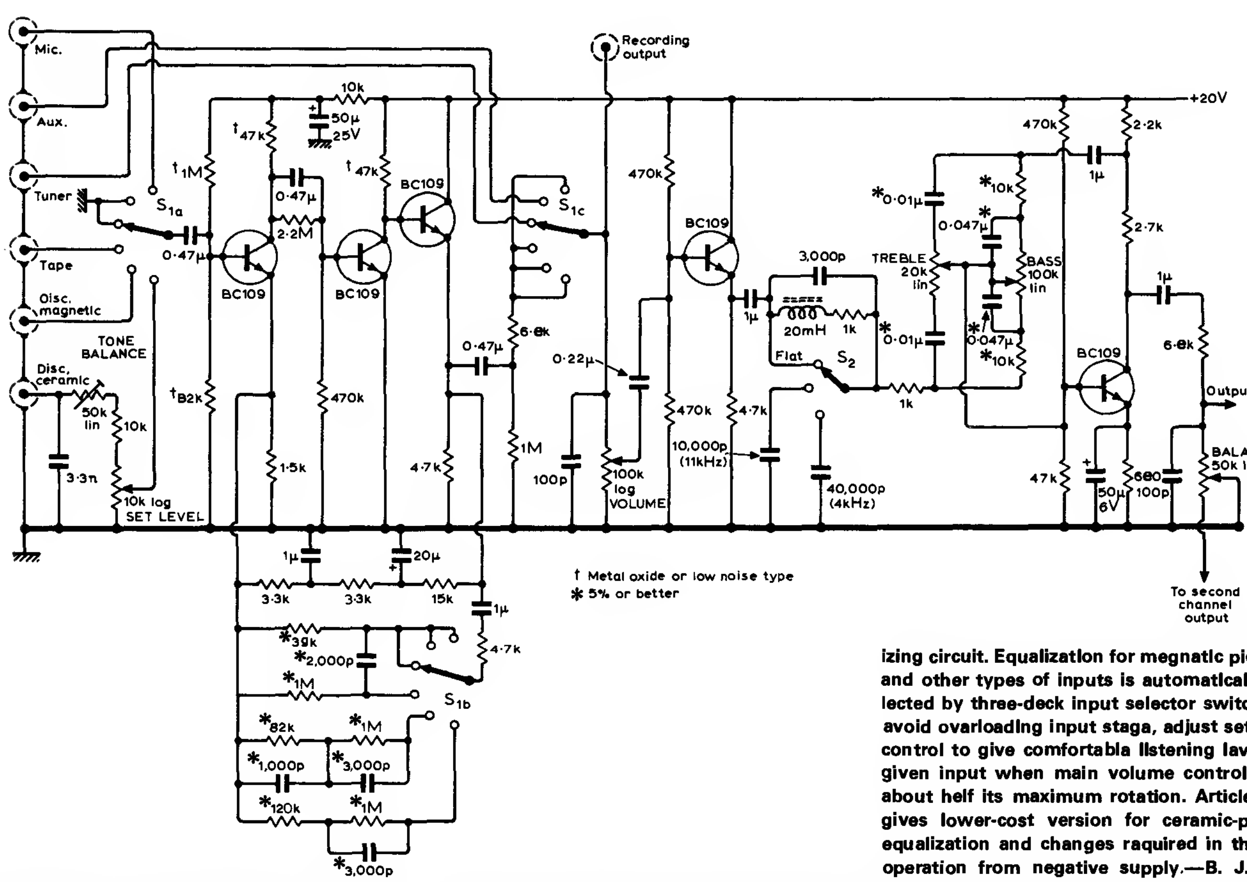
INVERSE RIAA RESPONSE GENERATOR—*Used in design, construction, and testing of* phonograph praamp. Provides opposite of playback characteristic. Passiva filter is added to output of National LM387, used as flat-responsa *adjustable-gain block. Gain ranga is 24 to 60 dB,* set in accordanca with 0-dB refarance gain (1 kHz) of praamp undar tast. Input is from 1-kHz squara-wava ganarator, which can ba built with othar half of LM387 *connected as also shown.*—D. Bohn, Invarsa RIAA/Squara Wava Genarator, *Audio,* Fab. 1977, p 65–66.



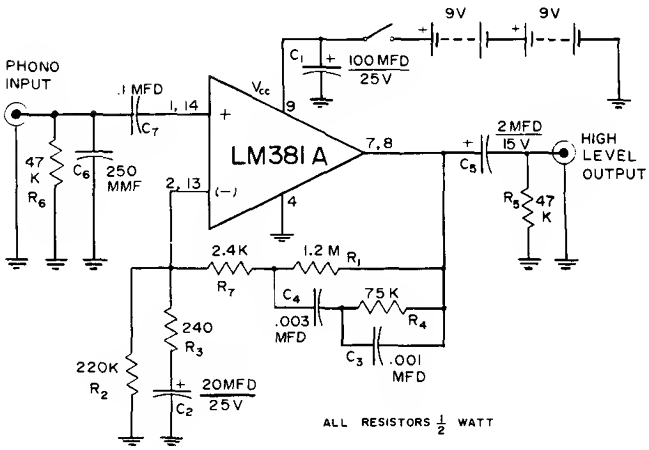
MAGNETIC-PICKUP PREAMP—Circuit uses type 747 dual opemp, but individual 741 opamps may ba used instead. Input signal is first amplified flet, after which equalization ects on both signal and noise to giva improved S/N ratio. Adjust first opamp for gain of 13. Series feedback is usad to minimize noise sinca impadanca of megnetic pickup is low compared to opamp input impedance. Second opamp has frequency-dependent series feedback for RIAA compensation. Gain hare is unity et 1 kHz. Output is ebout 70 mV for modern pickup having output of about 5 mV.—B. S. Wolfenden, Magnatic Pick-Up Preamplifier, *Wireless World*, Sept. 1976, p 81–82.



RUMBLE FILTER—Used to roll off low-fraquency noisa associeted with worn turntable and tape transport machanisms. Gein is 1. Design procedure is given. For values shown, corner frequency is 50 Hz and slope is −12 dB par octeve.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-49–2-52.

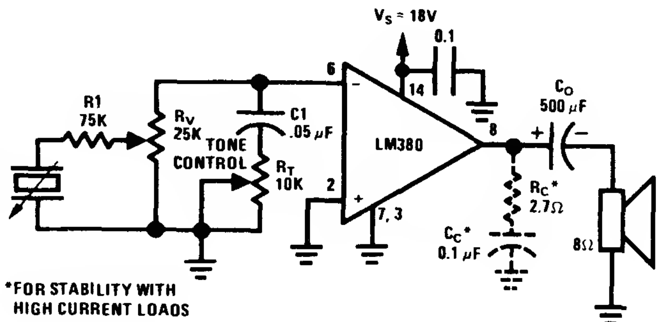


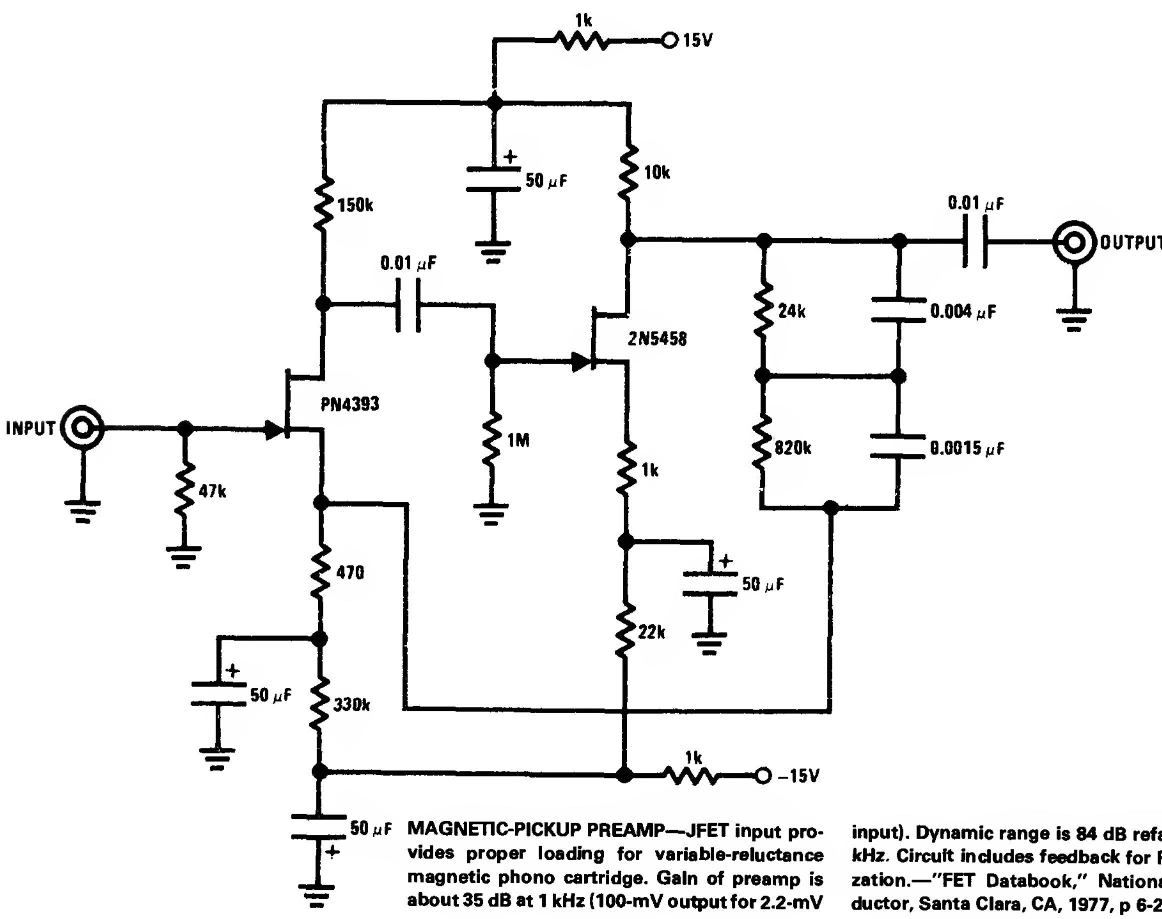
PREAMP WITH EQUALIZATION—Based on 1966 high-parformance Bailey praamp design with improved filter and tone control circuits and additionel complete ceremic-pickup equalizing circuit. Equalizatlon for megnatic pickups and other types of inputs is automatlcally salected by three-deck input selector switch. To avoid ovarloadlng input staga, adjust set level control to give comfortabla llstening laval for given input when main volume control is at about half its maximum rotation. Article elso gives lower-cost version for ceramic-pickup equalization and changes raquired in this for operation from negative supply.—B. J. Burrows, Ceremic Pickup Equalizetion, *Wireless World*, Aug. 1971, p 379–382.



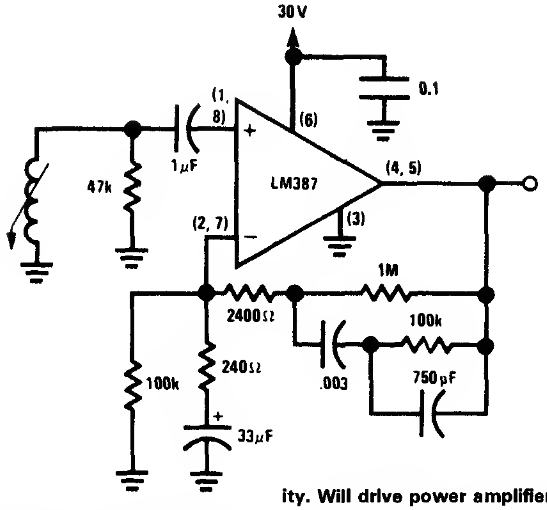
LOW-NOISE PREAMP—Provides dynamic range of about 80 dB for phonograph playback system, even when using highest-quality cartridge having low output. Source voltage is reduced to 18 V for National LM381A, which still provides ample signal for 2-V high-level input of stereo channel. Cross-channel isolation is better than 60 dB from 20 to 20,000 Hz.—J. P. Holm, A Quiet Phonograph Preamplifier, *Audio*, Oct. 1972, p 34–35.

CERAMIC-CARTRIDGE AMPLIFIER—Single National LM380 forms simple amplifier with tone and volume controls for driving 8-ohm loudspeaker at outputs above 3 W. Supply voltage range is 12–22 V, with higher voltage giving higher power. Tone control changes high-frequency rolloff.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-21–4-28.

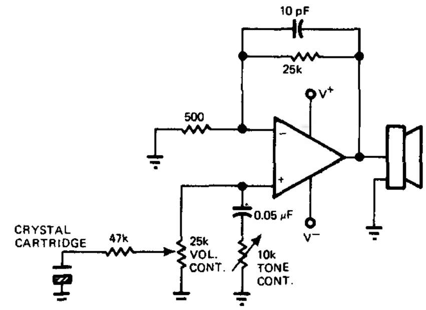




MAGNETIC-PICKUP PREAMP—JFET input provides proper loading for variable-reluctance magnetic phono cartridge. Gain of preamp is about 35 dB at 1 kHz (100-mV output for 2.2-mV input). Dynamic range is 84 dB referenced to 1 kHz. Circuit includes feedback for RIAA equalization.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



RIAA PHONO PREAMP—Design procedure is given for operation from 30-V supply, using magnetic cartridge having 0.5 mV/cm/s sensitivity. Will drive power amplifier having 5 VRMS input overload limit.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-25–2-31.

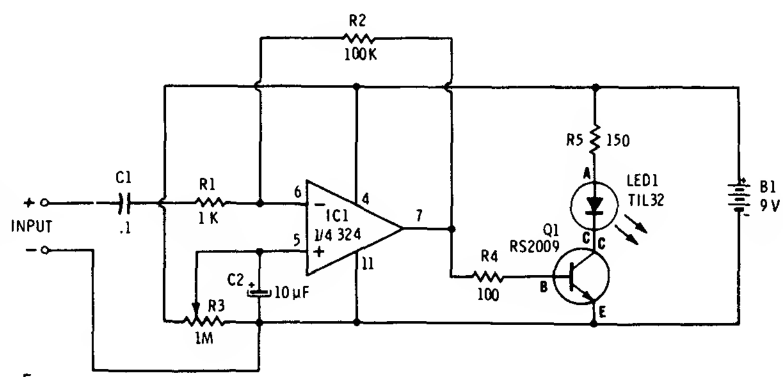


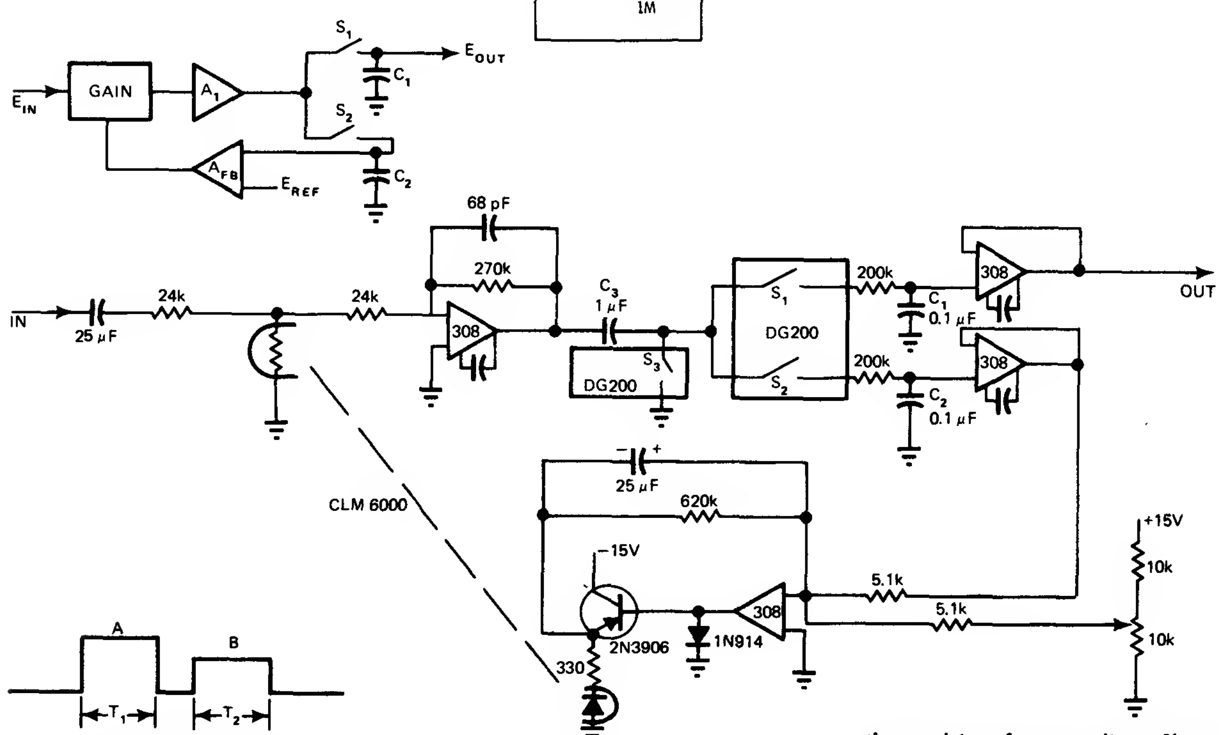
5-W POWER OPAMP—Low-cost phono amplifier using only single 591 power opamp provides 5 W into 8-ohm load with only 0.2% total harmonic distortion. With crystal cartridge, circuit has fixed gain of 50.—R. J. Apfel, Power Op Amps—Their Innovative Circuits and Packaging Provide Designers with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.

CHAPTER 65
Photoelectric Circuits

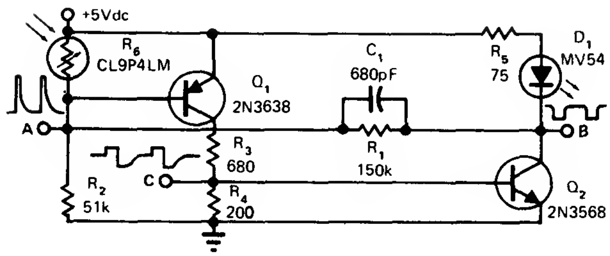
Covers circuits involving change in light on photocell or other light-sensitive device, including punched-tape reader, transmission of voice or data signals on light beam, and solar-power oscillator. See also Burglar Alarm, Fiber-Optic, Instrumentation, Lamp Control, and Optoelectronic chapters.

LIGHT-BEAM VOICE TRANSMITTER—Opamp and transistor together provide amplitude modulation of LED in accordance with amplitude variations of microphone output signal. Requires only single 9-V supply. Other three sactions of opamp ara not usad. Daalgned for dynamic microphone. Q1 is 2N2222 (Radio Shack 276-2009).—F. M. Mima, "Optoelectronic Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 34–43.

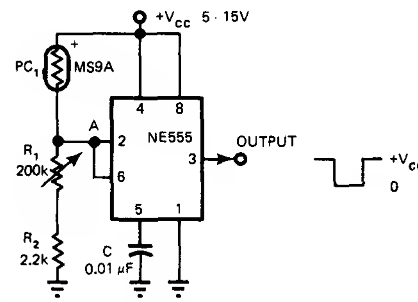




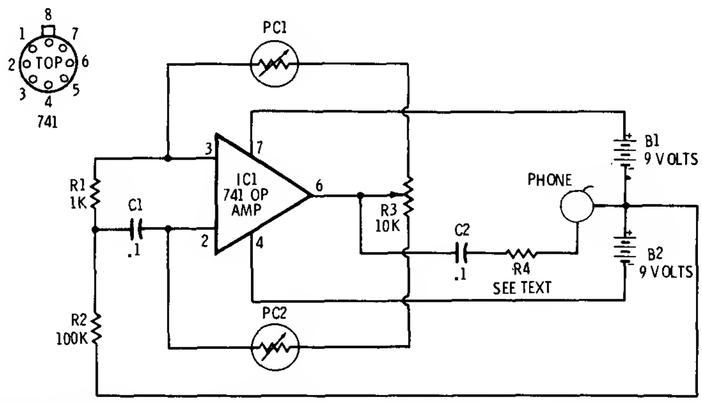
RATIO OF TWO UNKNOWNS—Developed for use when two signals are time-shared on sama input lina, such as exists when two LEDs alternately illuminata single photocall. Measures ratio of amplitudes of unknowns with accuracy better than 1%. During time period T_1, input is sampled through S_2 and stored on C_2 for comparison with reference voltage. Result is applied through switchable amplifiar network A_{FB} to gain control element which is LED-photoresistor coupled pair (CLM 6000). This closed loop adjusts signal gain to make denominator of ratio equal to reference voltage. Numerator, corresponding to time T_2, is multiplied by same gain so numerator output is proportional to desired ratio B/A of unknowns. Article describes circuit operation in detail.—R. E. Bober, Here's a Low-Cost Way to Measure Ratios, *EDN Magazine*, March 5, 1976, p 108, 110, and 112.



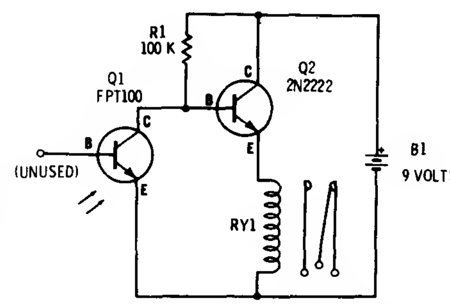
5-kHz PHOTOCELL OSCILLATOR—Provides 5-V pulses at about 5 kHz only if photocell is illuminated by its companion LED. Repetition rate varies with illumination, so interruption or attenuation of light produces easily detected frequency change that can be used as control signal. Applications include fail-safe interruption monitor and illumination transducer. Oscillation stops if beam is completely interrupted or if strong ambient light falls on photocell.—H. L. Hardy, FM Pulsed Photocell Is Foolproof, *EDN Magazine*, March 5, 1975, p 72.



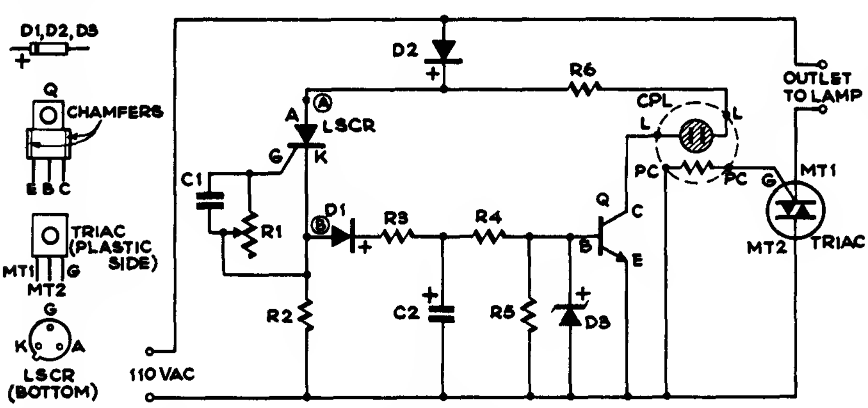
PUNCHED-TAPE READER—Connection of 555 timer as Schmitt trigger produces output pulses with sharp rise and fall times that are independent of tape speed. Output is compatible with TTL or CMOS circuits. When scanning light beam hits hole in punched card or tape, resistance of light-sensitive resistor drops sharply and voltage at pins 2 and 6 rises above 0.67 V_{CC}. Voltage at output pin 3 then drops sharply from V_{CC} to 0 V. When PC_1 goes dark, circuit switches rapidly back to original state. Reverse PC_1 and R_1-R_2 for positive edge-triggered logic.—S. Sarpengal, 555 Timer Implements Tape Reader, *EDN Magazine*, Jan. 5, 1978, p 88 and 90.



AUDIBLE LIGHT SENSOR—741 opamp is connected as audio oscillator with Radio Shack 276-877 photocells in feedback circuits. When light strikes PC1, its resistance decreases and frequency of audio tone in headphone decreases correspondingly. When light strikes PC2, which is connected to noninverting input of 741, increase in illumination serves to increase frequency. Choose R4 to reduce volume to desired level. R3 is balancing control for photocells.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 81–88.



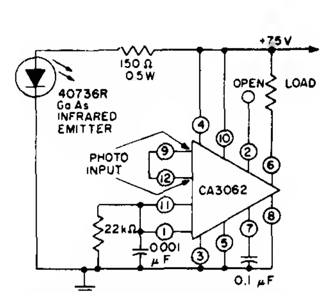
PHOTOTRANSISTOR RELAY—With phototransistor Q1 dark, R1 biases Q2 into conduction and miniature SPDT relay (Radio Shack 275-004) is energized. When light falls on Q1, Q2 is turned off and relay drops out. Battery drain is about 5 mA in darkness, dropping almost to 0 mA with light.—F. M. Mims, "Transistor Projects, Vol. 3," Radio Shack, Fort Worth, TX, 1975, p 89–74.



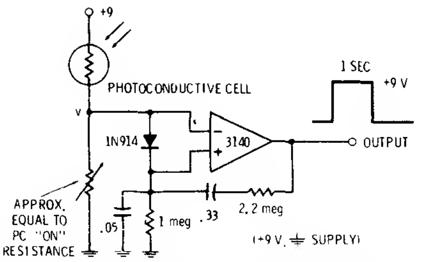
PARTS LIST

C1—0.1mfd capacitor
C2—10mfd @150V capacitor
R1—1-meg. carb. potentiometer
R2—82,000-ohm, ½w resistor
R3—390-ohm, 1w resistor
R4—2.2-megohm, ½w resistor
R5—560,000-ohm, ½w resistor
R6—22,000-ohm, ½w resistor
D1,D2—Diode (Motorola HEP 156)
D3—Zener diode, 6.2V (Motorola HEP 103 or equiv.)
Q—High-voltage transistor (Motorola HEP S3022)
LSCR—Light-op. SCR, 200V (Radio Shack 276-1081)
Triac—Mot. HEP R1725
CPL—Light coupler Sigma 301T1-120A1 (SW Tech. Prod., 219 W. Rhapsody, San Antonio, Tex.)

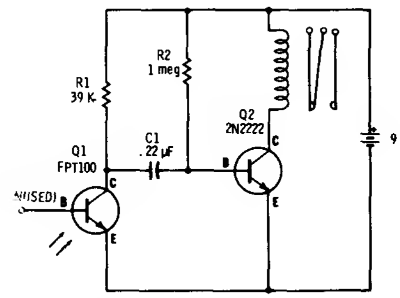
GARAGE-LIGHT CONTROL—When mounted on far wall in garage, controller picks up headlight beams as car is driven in at night and turns on one or more garage lights long enough (3 min) for driver to get out of car and reach exit. Controller then flickers lights as warning and begins dimming them out. With parts specified, will handle up to 800 W of lamps. Adjust sensitivity control R1 so light in optocoupler CPL comes on when headlights strike light-operated SCR. Controller must be kept out of direct sunlight. For manual control, connect pushbutton switch between points A and B. To increase time delay, increase value of C2. With 20 μF, time will be doubled.—C. R. Lewart, Automatic Garage Light Control, *Popular Science*, July 1973, p 110.



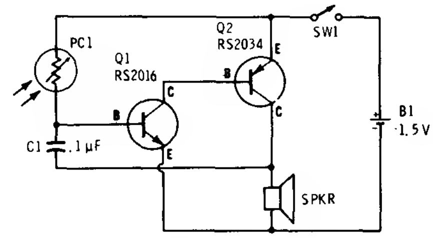
ON/OFF CONTROL—RCA CA3062 combination photodetector and power amplifier provides ON/OFF output in response to light signal. Output transistors in IC should be either saturated or blocked to avoid heat rise in silicon chip. Complementary outputs give choice of load normally on or normally off when light from infrared emitter falls on photo input of IC. Interruption of light path then produces opposite load condition.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 156.



LIGHT-CHANGE DETECTOR—Combination ampliflar and detector using 3140 opamp reaponda only to sudden changes in light on photocell while ignoring slow changes in ambiant light. Whan baam is suddenly broken, opamp output awinga positiva and ataya positiva for delay tima set by recharging of 0.05-μF capacitor on poaitiva input. Delay locks out spurious signala until photocall reaats itsalf to normal illumination. Values shown give time-out delay of about 1 s, with clean conditioned ractangular output pulae.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolia, IN, 1977, p 346–347.

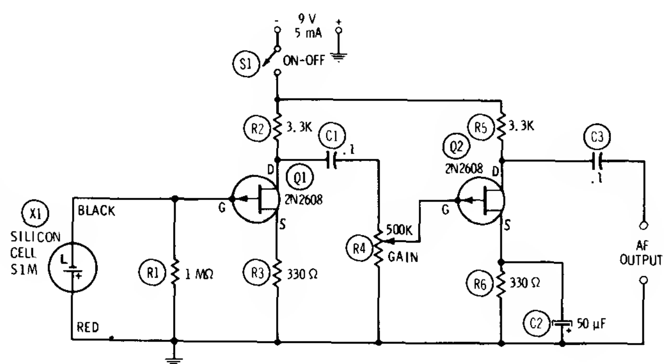


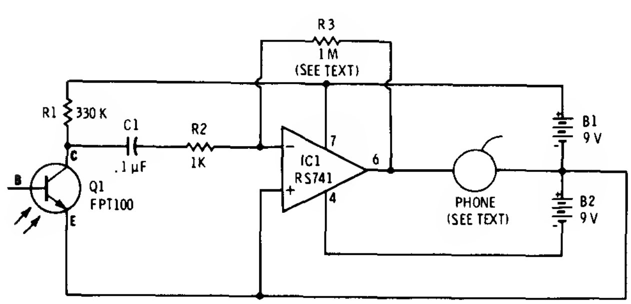
LIGHT-CHANGE SENSOR DRIVES RELAY—Capacitive coupling betwaen phototranaistor and bipolar transistor makes circuit raspond only to interruptiona or rapid changea in light whila ignoring normal gradual changea in ambient light as caused by clouds or at sunrisa. Relay pulls in whan flash of light occurs and drops out whan light ia removed. Use Radio Shack 275-004 miniatura relay.—F. M. Mims, "Tranaistor Projects, Vol. 3," Radio Shack, Fort Worth, TX, 1975, p 69–74.



AUDIBLE LIGHT METER—Low light on cadmium sulfide photocall (Radio Shack 276-116) produces saries of clicks in miniature 8-ohm loudspeaker. As light increaaea, clicks merge into audio tone that increaaas in fraquancy as light intensity increaaaa. Can ba uaed for classroom demonatrations or as aunrise alarm clock. Circuit ia quiet in total darkness.—F. M. Mims, "Optoelactronic Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 61–66.

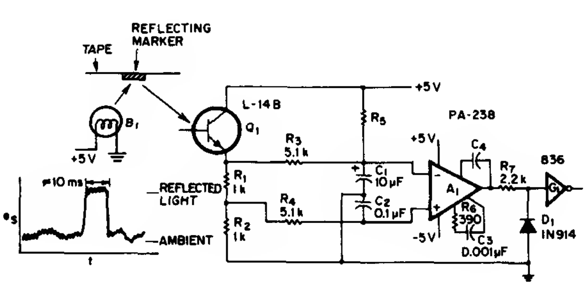
MODULATED-LIGHT RECEIVER—Two FET stagea amplify chopped or amoothly modulated output signal of silicon solar cell. With 1000-Hz modulation of 5-lm/ft² light beam, circuit will produce 1 VRMS at output when R4 is set for maximum gain. Can be usad for light-beam communication and for alarm systems.—R. P. Turner, "FET Circuits," Howard W. Sama, Indianapolis, IN, 1977, 2nd Ed., p 113–114.

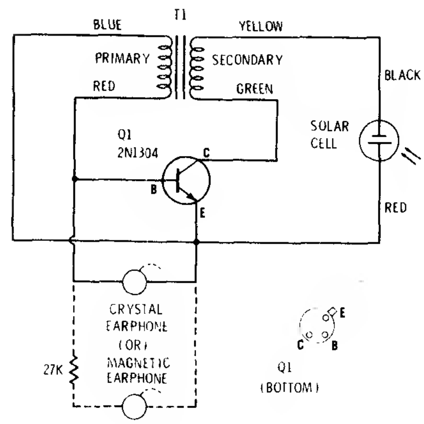




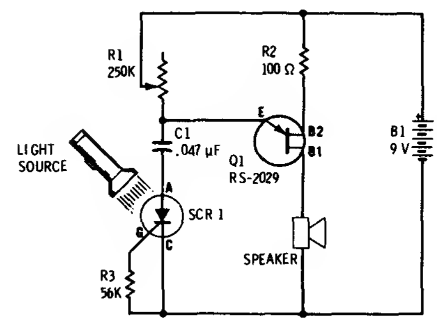
LIGHT-BEAM RECEIVER—Convarta amplitude-modulated light baam back to audio aignal for driving transistor radio aarphona having resistance of 500–1000 ohms. Miniatura 8-ohm loudspaakar can be used by adding output transformar such as Radio Shack 273-1380. Gain of opamp is controlled by R3, which can ba trimmar rasistor or pot. Designed for usa with transmittar providing amplituda modulation of LED, for short-ranga voice communication.—F. M. Mims, "Optoalectronic Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 44–54.

END-OF-TAPE DETECTOR—Self-compensating sensor automatically comparea short-tarm light variations produced by beginning and end markers on digital magnetic recording tape against long-term variationa of ambiant light, to improve reliability of sensing marker when there are reflections from blank tape. Low-pasa filter R_3-C_1, having time conatant about 5 timea expected 10-ms incoming pulse width, stores long-term light level without reacting to short signal pulae. Low-paaa filtar R_4-C_2, having 1/20 time constant of incoming pulse width, reducas spurious noise without deteriorating incoming pulses.—C. A. Harbst, Optical Tape-Markar Detector, *EEE Magazine,* March 1971, p 79.

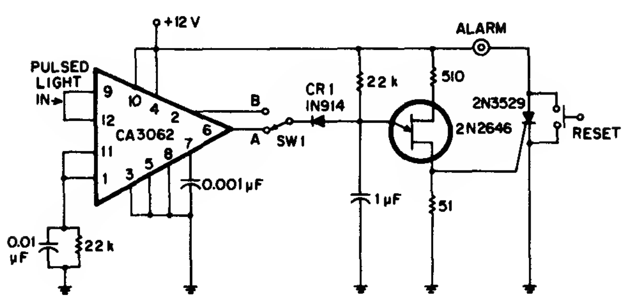




SOLAR-POWER OSCILLATOR—Supply voltege for single-transistor audio oscillator is generated by Radio Shack 276-115 selenium soler cell thet produces about 0.35 V in bright sunlight. With call 3 feet eway from 75-W incandescant lemp, oscillator frequency is ebout 2400 Hz. Frequency drops as light increases. Transformer is 273-1378.—F. M. Mims, "Translstor Projects, Vol. 2," Redio Shack, Fort Worth, TX, 1974, p 53–58.



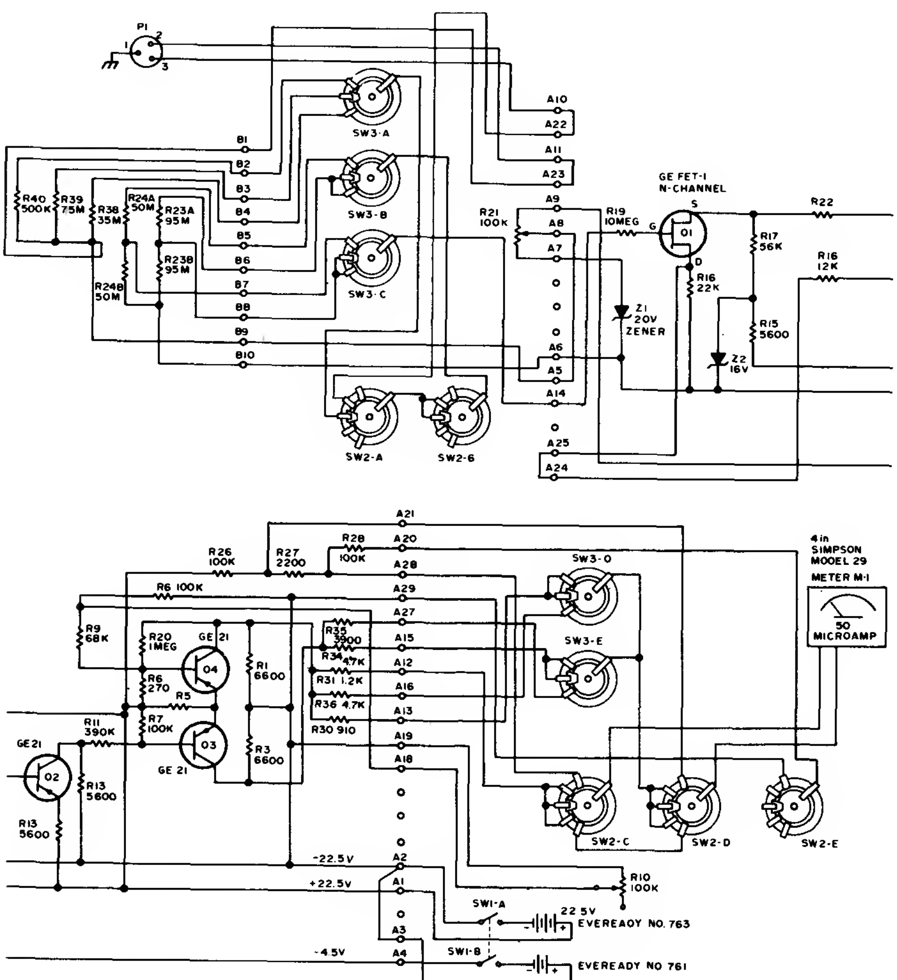
LASCR-CONTROLLED OSCILLATOR—UJT relexation oscilletor heving loudspeeker load produces single click each time flash of light fells on light-activated SCR. Setting of R1 determines whether circuit produces series of pulses or tone burst during time light is on. Oscilletor frequency increases with light intansity.—F. M. Mims, "Samiconductor Projects, Vol. 2," Radlo Shack, Fort Worth, TX, 1976, p 71–77.



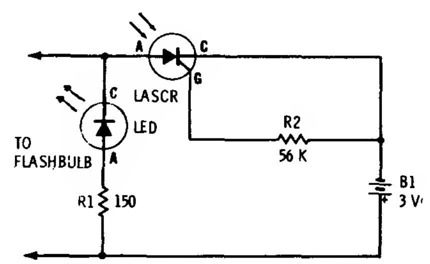
MISSING-PULSE ALARM—Developed for sensing missing light pulses or detecting ebsence of object on moving conveyor belt. CA3062 combinetion light sensor and emplifier detects light pulses synchronized to 60-Hz line. With SW1 et A, each pulse resets 20-ms timing network of 2N2646 UJT at 16.7-ms intervals, preventing UJT from firing. If light beem is interrupted by object, UJT is ellowed to fire end trigger 2N3529 SCR that turns on alerm. With SW1 et B, circuit detects interruptions in steady light beem and sounds elarm only when interruption does not occur.—J. F. Kingsbury, Double Duty Photo Alerm, *EDN/IEEE Magazine,* Mey 15, 1971, p 51.

CHAPTER 66
Photography Circuits

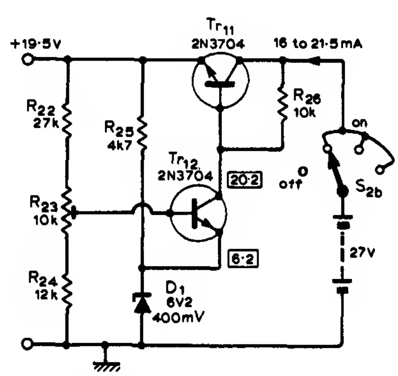
Includes adjustable or programmable timers for enlargers and printers, photoflash, slave flash, strobe, and controlled-sequence flash circuits, exposure meters, and gray-scale control for CRT. See also Instrumentation, Lamp Control, and Timer chapters.



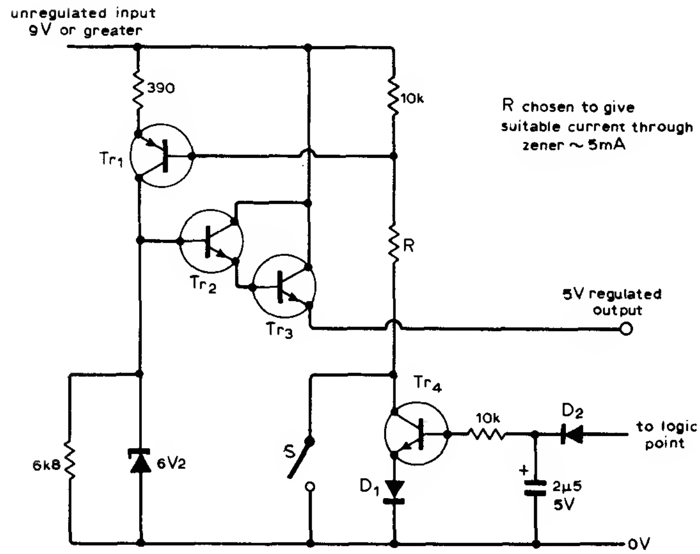
THREE-RANGE LIGHT METER—Uses probe containing Clairex 905HN light-dependent resistance element, connected to DC differential amplifier driving meter having specially calibrated scale. Article gives calibration procedure. Switching circuit provides constant check on voltage of 22.5-V battery. If 4.5-V battery is low, full-scale adjustment cannot be made. Resistors having values specified in article are connected in turn to terminals of photocell jack P1 for calibration that gives linear scale reading.—J. L. Mills, Jr., Light Right?—Do-It-Yourself Photo Exposure Meter, *73 Magazine*, Sept. 1978, p 204–206 and 208–211.



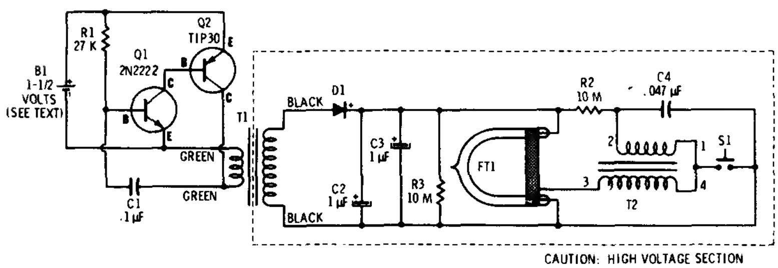
SLAVE FLASH—Remote flashtube having no connection with camera is fired by light-activated SCR (LASCR) when triggered by main flash of camera. Used to provide illumination at greater depth than main flash range, to soften sharp shadows, and to provide backlighting for flash photographs. LED is indicator showing that circuit has been triggered, reminding photographer that new flash lamp should be inserted.—F. M. Mims, "Transistor Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 79–85.



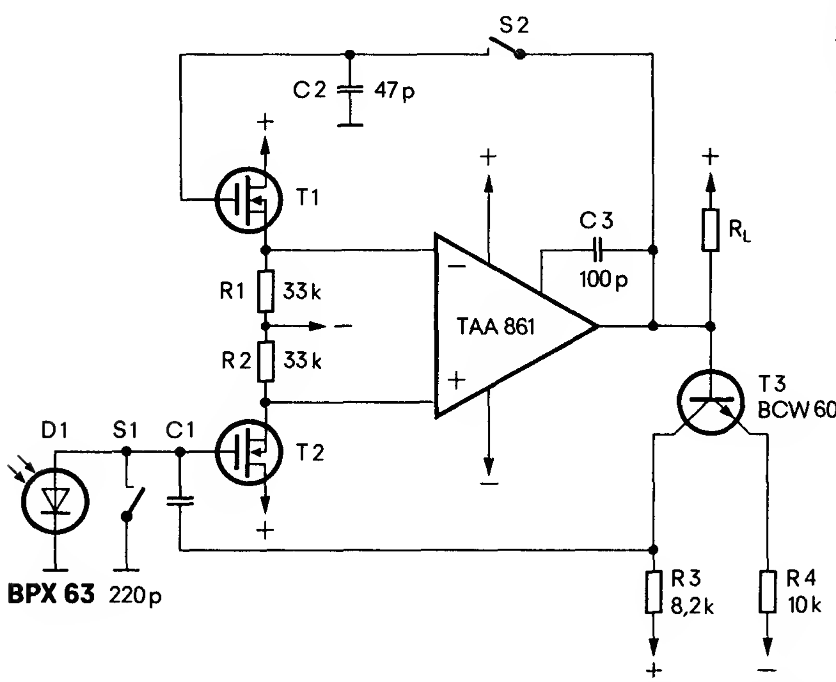
19.5 V FROM 27-V BATTERY—Used to provide precise voltage levels required by portable trigger unit designed to fire up to five different flash units at equal intervals that may range from 11 ms to 11 s. Article gives all circuits.—R. Lewis, Multi-Flash Trigger Unit, *Wireless World*, Nov. 1973, p 529–532.



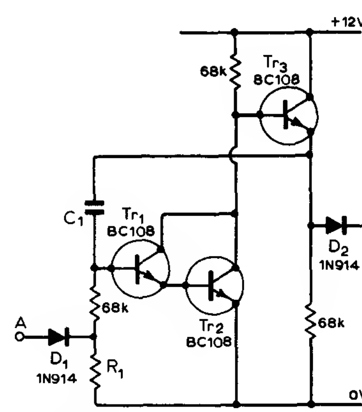
TIMER SWITCH-OFF FOR ENLARGER—Circuit shows power supply designed to operate digital exposure timer using TTL. Since timer logic is needed only when enlarger lamp is on, power supply circuit will be turned off automatically when timer goes low and turns off enlarger lamp at end of exposure. Switch S is closed when timer cycle is activated, setting timer output at 5 V and turning on lamp. Transistor and diode types are not critical. Since D_2 is connected to logic point of timer, power supply remains on when S is released, until completion of timer cycle.—E. R. Rumbo, Automatic Switch-Off Power Supply, *Wireless World*, Feb. 1976, p 77.



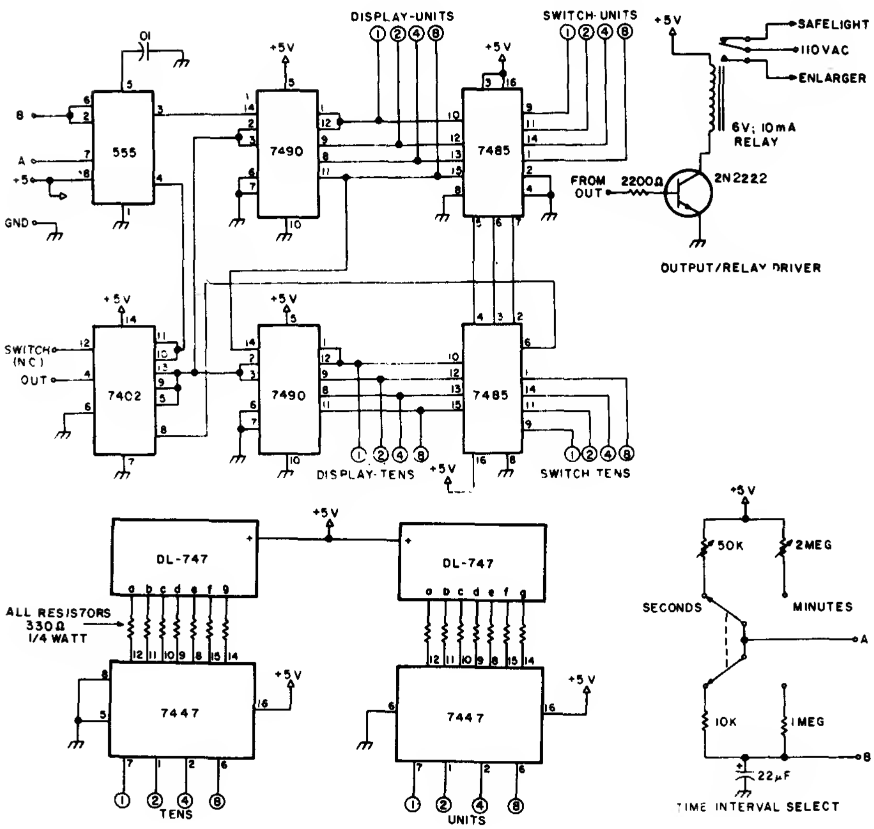
XENON STROBE—Two-transistor oscillator generates pulses at about 500 Hz for step-up by 300-mA filament transformer T1 (Radio Shack 273-1384) to charge storage capacitors C2 and C3, which are 250-V electrolytics. Simultaneously, C4 is charged through R2. After allowing sufficient time for capacitors to charge, S1 is pressed to discharge C4 through 272-1146 flash-tube trigger transformer T2, which steps up voltage pulse to about 4000 V for ionizing gas in 272-1145 xenon flashtube FT1. C2 and C3 now discharge through ionized gas to produce brilliant flash of white light lasting only a few microseconds, as required for photography of objects moving at high speed. Circuit may require two cells in series for reliable operation.—F. M. Mims, "Transistor Projects, Vol. 3," Radio Shack, Fort Worth, TX, 1975, p 49–60.



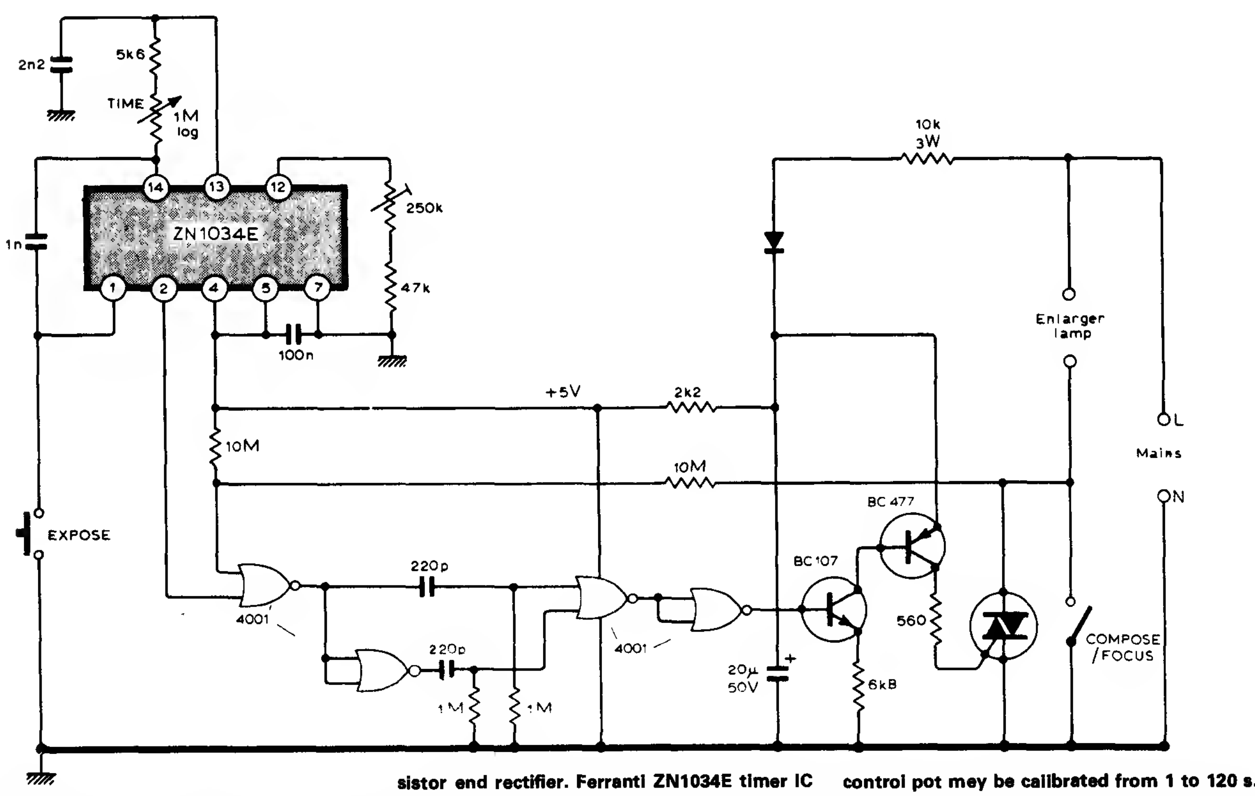
LOW-LEVEL EXPOSURE METER—Uses Siemens BPX 63 photodiode having sensitivity of 10 nA per lux in circuit which ensures that aperture setting is effected only by useful light and not by noise signals. When used at low light levels, circuit recovers quickly from temporary light bursts. Switches S1 and S2 are closed when camera shutter is not open; opamp output is then connected to its inverting input through FET T1. At commencement of exposure, S1 and S2 open to give amplification of over 3000. Integrating capacitor C1 is then charged by photocurrent, making output voltage vary linearly with time. Base-emitter junction of T3 begins to conduct at output voltage of 1 V. Exposure is completed when C1 provides feedback via T3 so no current flows through load resistor R_L. Supply is ±3 V.—"Photodiode BPX 63—All It Needs Is Starlight," Siemens, Iselin, NJ.



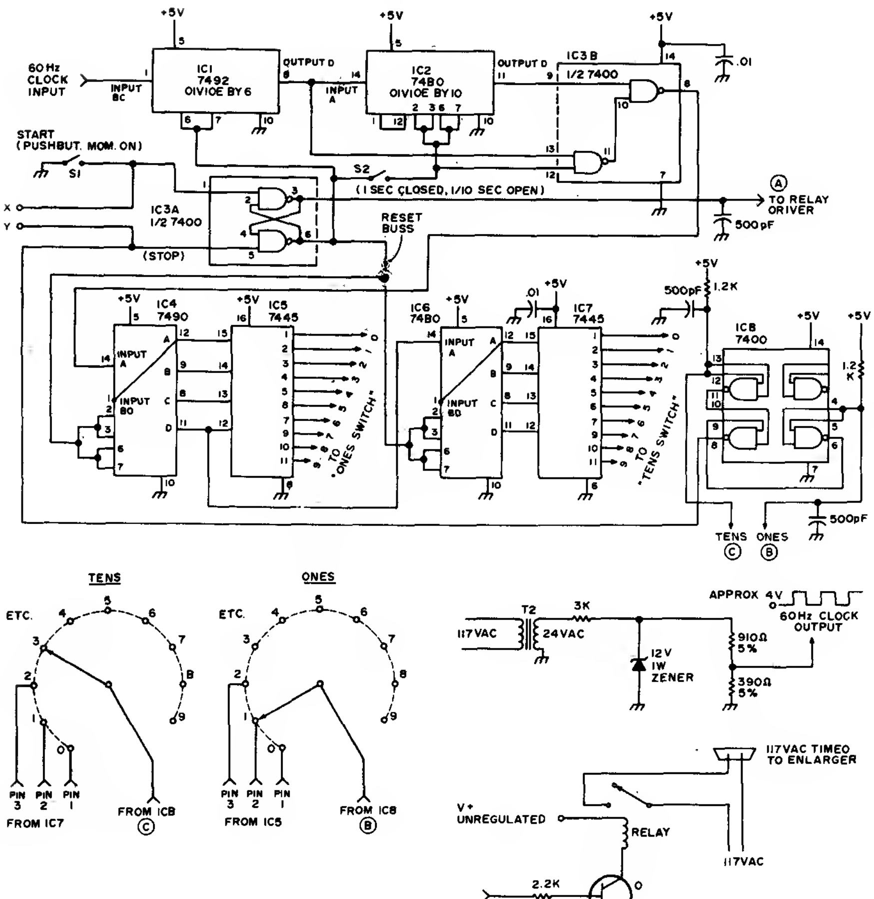
2-min RAMP—Used in multiple timer for development of photographic paper, in which six independent timers are started in sequence as each sheet of exposed paper is placed in developer. C_1 is 1 μF and R_1 is 11 megohms for 2-min timer having accuracy within 5 s. Article gives all other circuits required and suggests modifications to meet other needs. Output B drives meter and trigger circuit for audible alarm. Timer is started by input switch connected to A.—R. G. Wicker, Photographic Development Timer, *Wireless World*, April 1974, p 87–90.



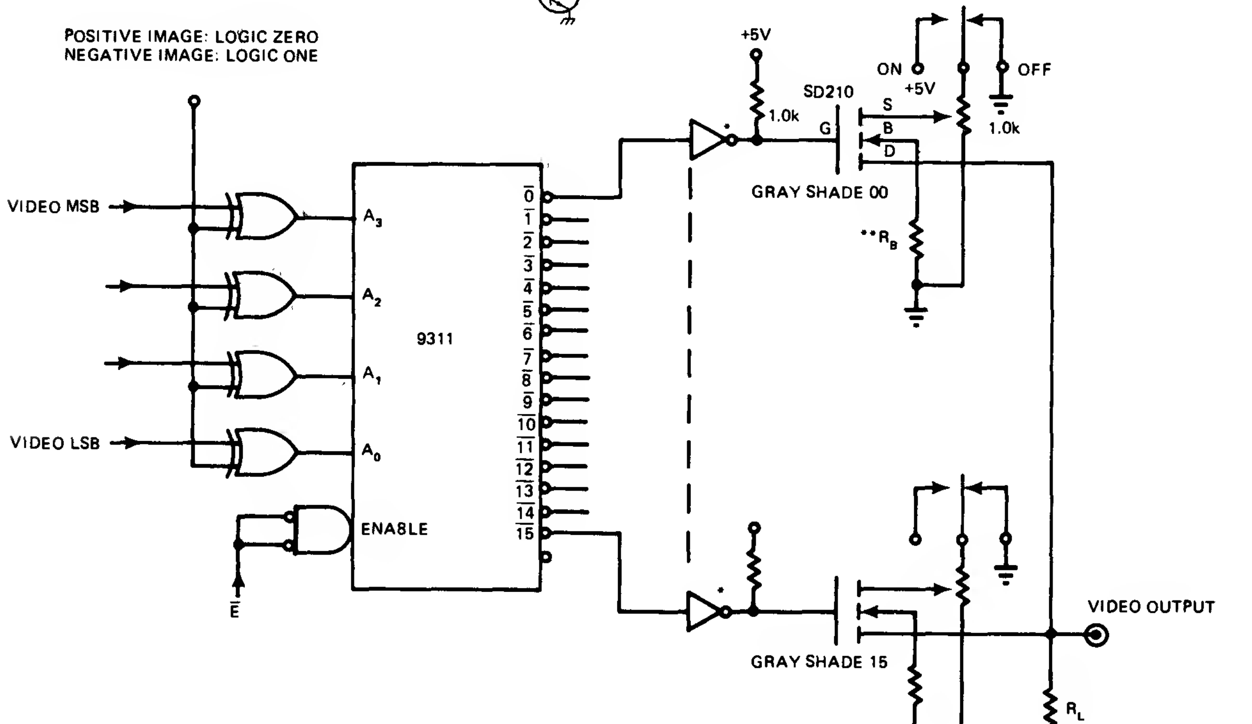
BCD THUMBWHEEL-SET 99-min TIMER—Provides timing in seconds to 99 s, and timing in minutes to 99 min, with 2-digit LED indicator showing elapsed time. Desired interval is set with BCD thumbwheel switches. LED readout counts up to preset time, then resets automatically to zero. Switch giving choice of seconds or minutes has center-off position that stops count temporarily for burning in portion of negative. Article gives construction details.—M. I. Leevey, Build a Unique Timer, *73 Magazine*, Aug. 1977, p 66–71.



ENLARGER TIMER—Requires no transformer-type power supply because circuit operates from 1 mA taken from AC line through 10K resistor and rectifier. Ferranti ZN1034E timer IC generates delay and supplies 5 V for 4001 CMOS gates. Triac is triggered with 100-μs 60-mA pulses at zero-crossing point. Logarithmic time-control pot may be calibrated from 1 to 120 s. Choose triac to handle current drawn by enlarger lamp used.—M. J. Mayo, Transformerless Enlarger Timer, *Wireless World*, May 1978, p 68.

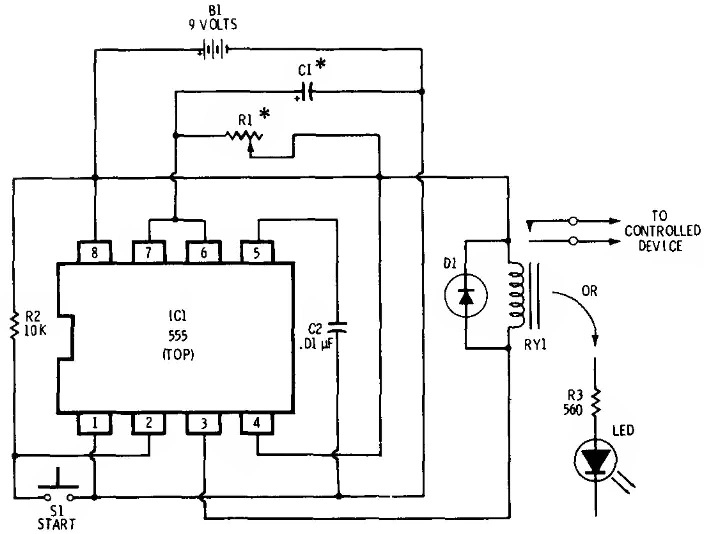


99-s PROGRAMMABLE—Line-frequency-based precision interval timer was developed for use with repeaters or photographic enlargers. Circuit is accurate to within 1/60 s. Two 10-position switches are set to desired interval. Connection to AC line gives 4-V square wave for 60-Hz clock input. Transistor type used as relay driver is not critical.—G. R. Allan, Dependable Timer, *73 Magazine*, July 1976, p 84–87.



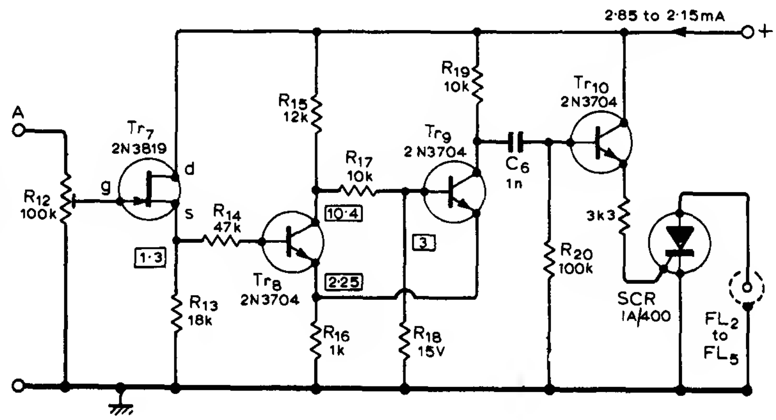
*OPEN COLLECTOR
**R_B IS SELECTED TO LIMIT SOURCE TO SUBSTRATE LEAKAGE

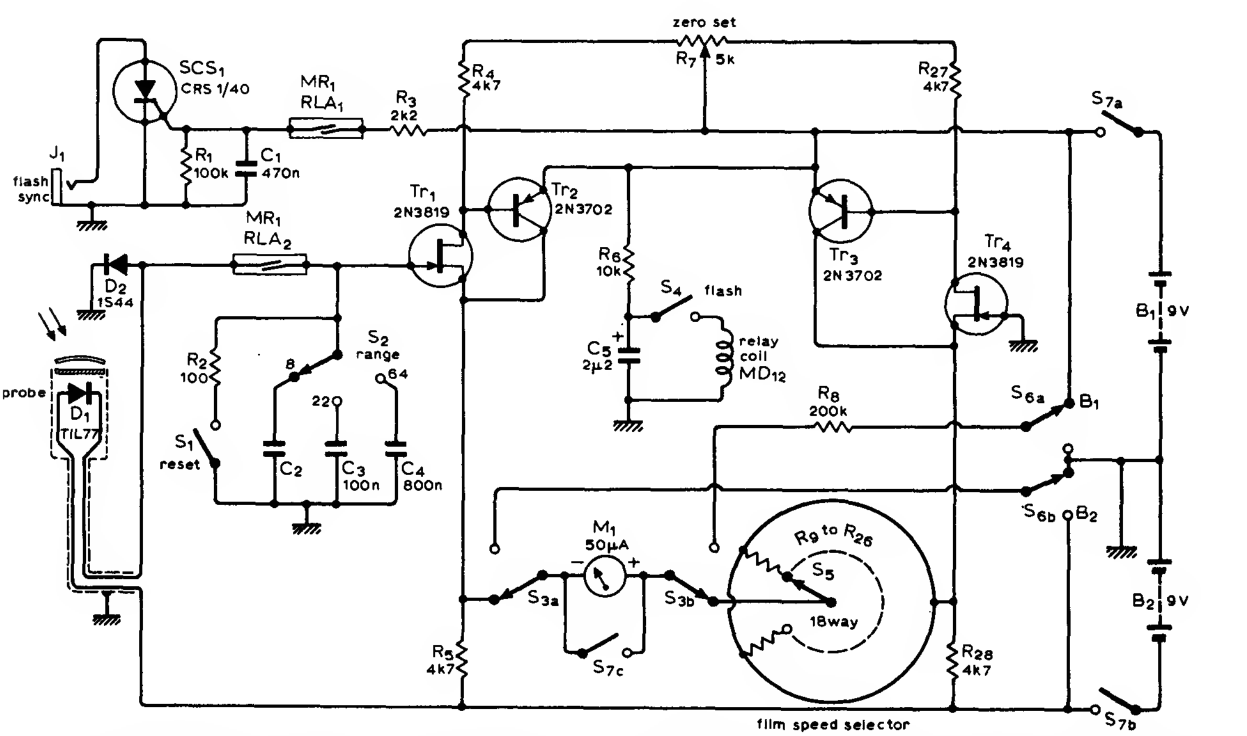
CRT GRAY-SCALE CONTROL—Circuit provides digital selection of up to 16 shades of grey for image on screen of cathode-ray tube, as required for different imaging requirements or different photographic films. DMOS FETs provide fast switching times so data rate is limited only by TTL drive circuits. Four bits of digital data stored in 9311 memory are used for selecting desired scale. Output of circuit is used to control beam intensity. Circuit also permits complete video inversion for negative images.—K. R. Peterman, Fast CRT Intensity Selector Adjusts the Gray Scale, *EDN Magazine*, March 20, 1976, p 98 and 100.



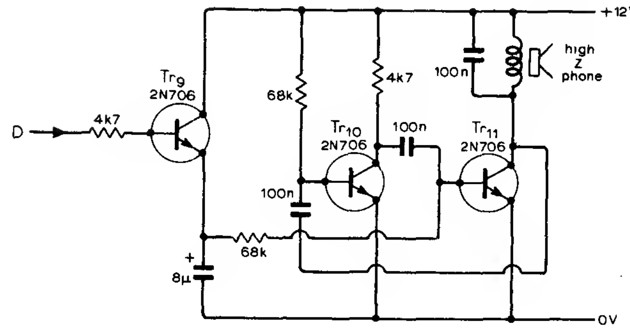
BASIC 555 TIMER—Closing switch S1 momentarily applies activating signal to trigger input pin 2 of timer, to start charging of C1. When C1 charges to two-thirds of supply voltage, timer discharges it to complete timing cycle. Duration of charging interval can be varied from several microseconds to over 5 min by changing values of R1 and C1. With 1K for R1, capacitor values of 0.01 to 100 μF give time range of 10 μs to 100 ms. With 100 megohms and 1 μF, time increases to 10 s. Once timer starts, closing S1 again has no effect. Timing cycle can be interrupted only by applying reset pulse to pin 4 or opening power supply. Circuit will drive LED directly or can be used with miniature relay (Radio Shack 275-004) to control larger loads. Can be used as darkroom timer if LED is kept several feet away from photographic paper. Diode is 1N914.—F. M. Mims, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 57–65.

MULTIFLASH SWITCH—When ramp output of flash trigger circuit (given in article) is applied to input at A, flash at output of switch circuit is tripped when ramp voltage reaches level determined by setting of R_{12}. Similar voltage-operated switches are required for other flashes. Used for taking sequence photographs such as springboard diver in flight. Settings of R_{12} for different switches are chosen for equal times between flashes, with intervals from 11 ms to 11 s. Article gives all circuits and setup procedure. Regulated 19.5-V supply is required—R. Lewis, Multi-Flash Trigger Unit, *Wireless World*, Nov. 1973, p 529–532.

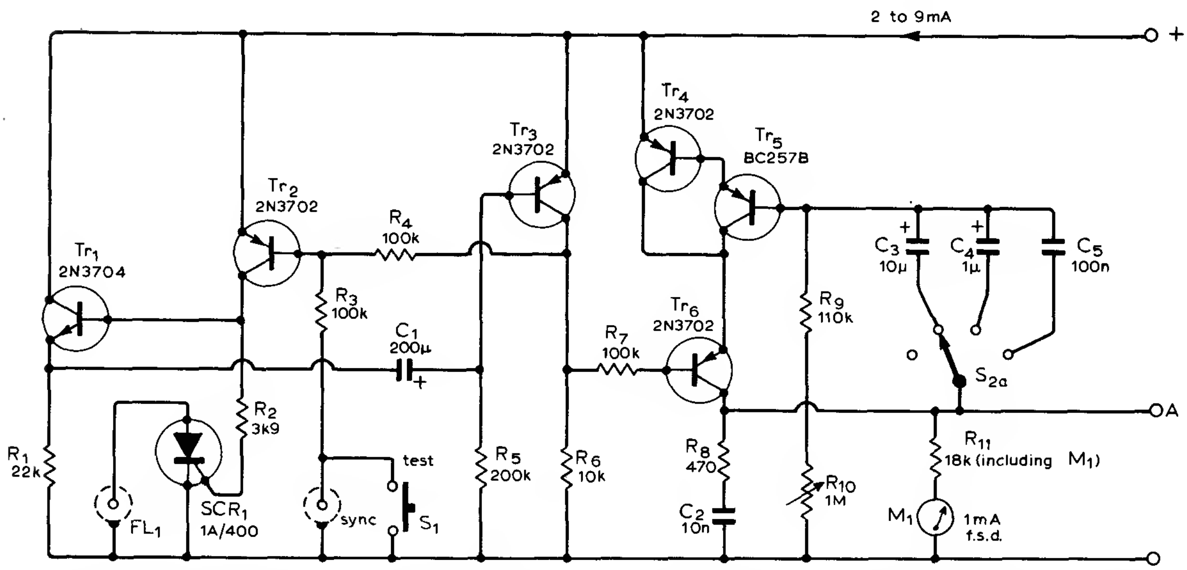




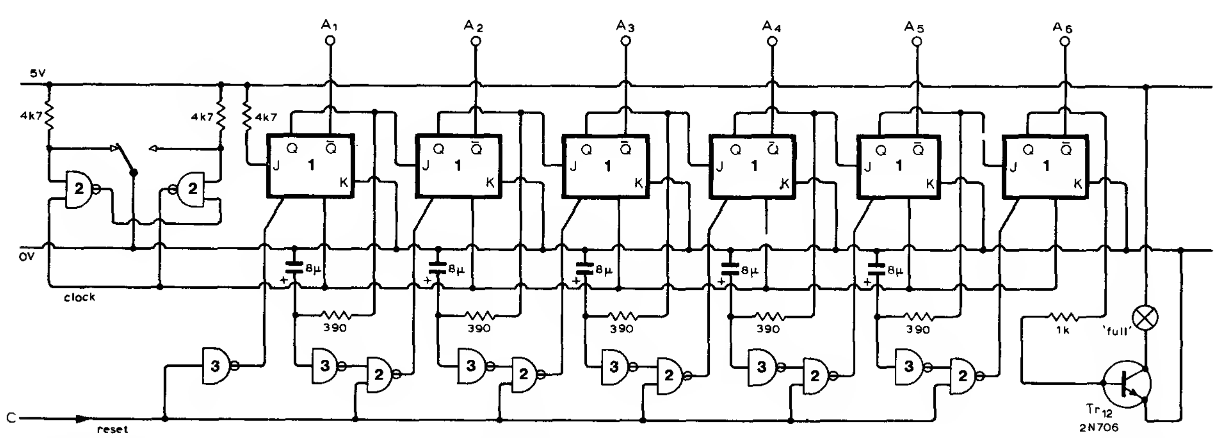
f-NUMBER FLASHMETER—Used to measure light produced at subject position by electronic flashlamps prior to actual taking of picture. Meter is calibrated to read correct f-number setting of lens aperture. Three ranges are provided, from f/2 to f/64, while film speed selector covers films from ASA 12 to 650. Texas Instruments TIL77 photodiode is used as sensing element in probe. Article covers construction, operation, and calibration of meter in detail. Table in article gives values for 18 resistors (one for each film speed) selected by S_5. Examples are 20K for ASA 64 and 51K for ASA 25.—R. Lewis, Photographic Flashmeter, *Wireless World*, Aug. 1974, p 273–278.



AUDIBLE ALARM FOR TIMER—Usad with 2-min timer for daveloping photographic paper, to produca short waming bleep indiceting end of developing time. Input D is taken from output of Schmitt trigger that changes state when 2-min remp generetor times out. Tr_9 and C_4 together lengthen short reset pulsa so MVBR Tr_{10}-Tr_{11} oscillates long enough for signal to be heard.—R. G. Wicker, Photographic Development Timer, *Wireless World*, April 1974, p 87–90.

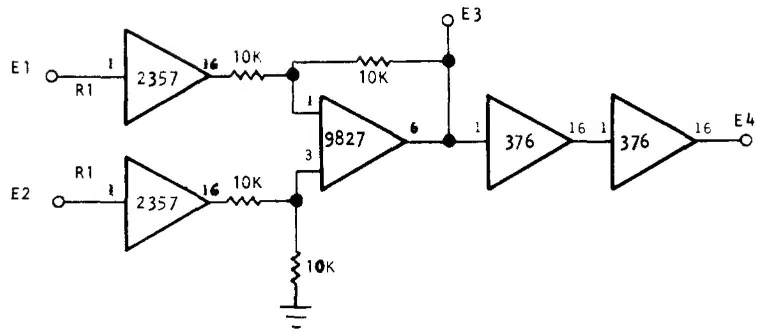


FLASH TRIGGER—Used in instrument designed to trigger up to five individual flash units at equal increments of time that can range from 11 ms to 11 s, as required for such assignments as taking sequence photographs of springboard diver in flight. Transistors Tr_1, Tr_2, and Tr_3 form monostable MVBR that is switched to unstable state by negative pulse applied to base of Tr_2 by SCR_1 when camera shutter contacts FL_1 are closed. Timing circuit Tr_4-Tr_5-Tr_6 provides ramp output at A for feeding voltage-operated switches set to trip at differant points of ramp waveform as required for triggering flashas in sequence. Articla gives all circuits and setup procedure. Regulated 19.5-V supply is required.—R. Lewis, Multi-Flash Trigger Unit, *Wirelass World*, Nov. 1973, p 529–532.



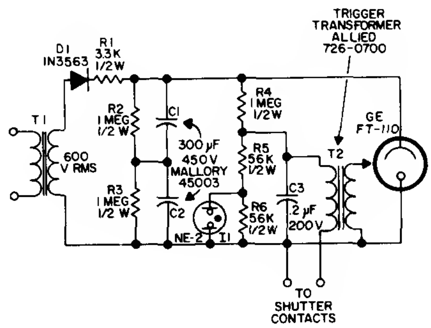
1 ½ SN7473N
2 ¼ SN7400N
3 ⅙ SN7404N

MULTIPLE TIMER FOR PRINTS—Six independent 2-min timers, each using half of SN7473N IC, are set in sequence by unique input switch as shaets of exposed paper are inserted in developar at about 20-s Intarvals. Whan capacity of six prints is reached, Tr_{12} turns on light to tall operator that no more prints should be inserted until control logic activates alarm signifying 2-min time for first sheet insarted. Audible bleep is repeated as each subsequent shaet reaches its 2-min development time. Articla givas all circuits and explains operation in detail. Two-input NAND gates (eech ¼ of SN7400N) and inverters (each ⅙ of SN7404N) are used to steer reset pulses. Similar two-input NAND getes are used to form fully compatibla input pulses from input switch control, each having correct leval, risa time, and fall time, without contact bounce that might cause spurious starting of sevaral timars simultanaously.—R. G. Wicker, Photographic Developmant Timer, *Wirelass World*, April 1974, p 87–90.



DENSITY AND EXPOSURE—Circuit converts trensmission parameter of spectrophotometer to more useful density parameter, which in turn can be converted to exposure parameter. Optical Electronics 2357 opamps at input provida 90-dB dynamic range for DC to 1 kHz or 40-dB range for DC to 100 kHz, operating basically as current amplifiars. 9827 is used as wideband opamp in unity-gain subtractar configuration. Additional 376 opamps are used only for converting to exposure parameter. Use 1000 ohms for R1 with 10-V full-scale inputs.—"Conversion of Transmission to Density and Density to Exposure," Optical Electronics, Tucson, AZ, Application Tip 10133.

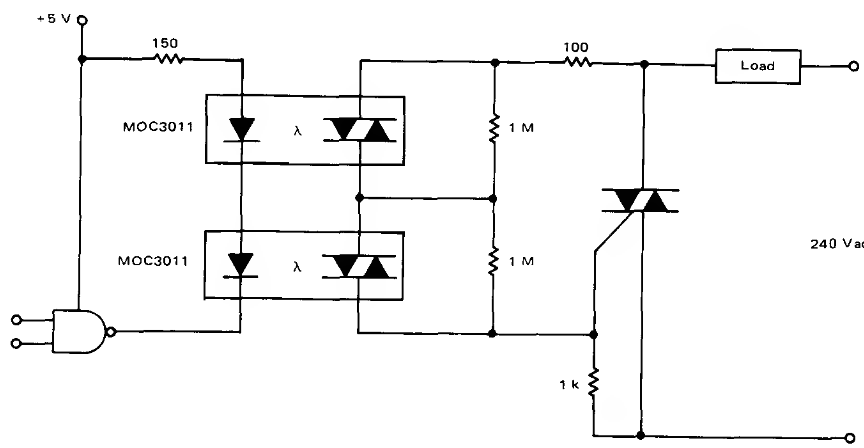
100-Ws PHOTOFLASH—Uses AC supply and lerge storage capacitors to give intense flash lasting only about 250 ms, as required for stop-motion photography of fast-moving objects such as bullets. For battery-powered operation, T1 can ba replaced by solid-state chopper circuit. Contacts can be in cemere or in externel control device.—W. E. Hood, Lightning in a Bottle, *73 Magazine,* Sept. 1974, p 109–112.



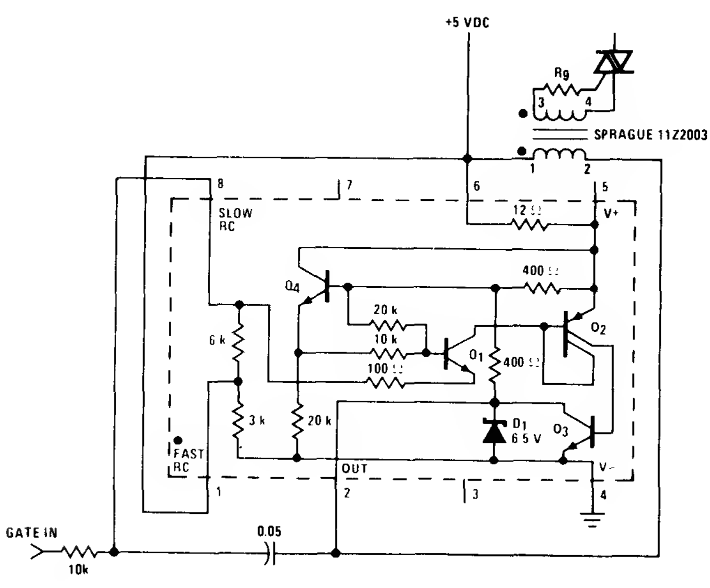
CHAPTER 67

Power Control Circuits

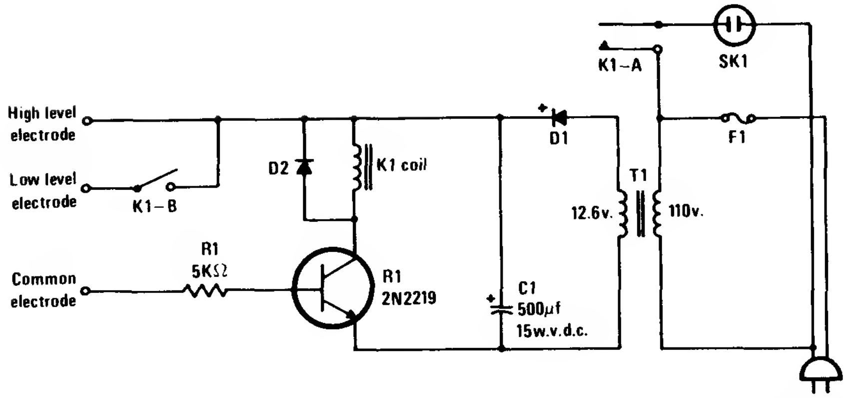
Included are general-purpose circuits capable of handling many types of resistive or inductive loads, as contrasted to specialized circuits given in Lamp Control, Motor Control, Servo, and Temperature Control chapters. Although most circuits are solid-state relays, conventional relay controls are also shown. Inputs can respond to logic levels, pulses, or sensing transducers. Output devices are chiefly SCRs or triacs. Many circuits have zero-crossing action for suppressing RFI, as well as optoisolators at input or output.



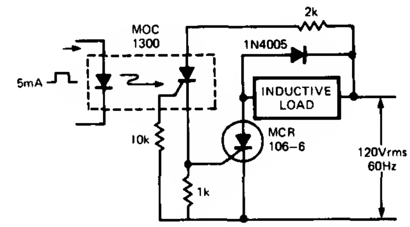
DRIVING 240-VAC TRIAC—Two Motorola MOC3011 optoisolators are used in series as interface between logic and triac controlling 240-VAC load. 1-megohm resistors across optoisolators equalize voltage drops across them. Choice of triac depends on load to be handled.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 5.



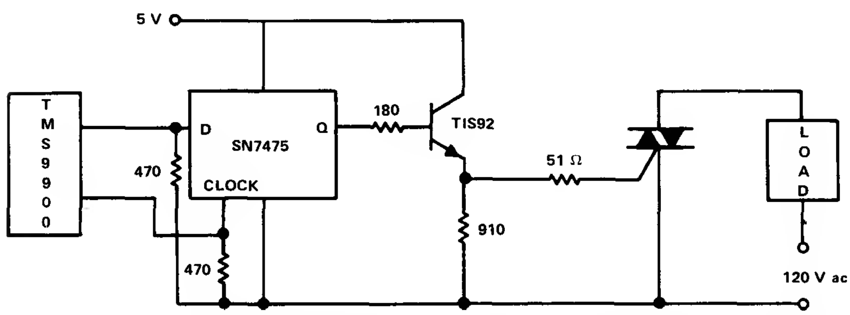
TRIAC TRIGGER—National LM3909 IC is connected as pulse-transformer driver operating from standard 5-V logic supply. IC is biased off when logic input is high. With low logic input, IC provides 10-μs pulses for transformer at about 7 kHz. Trigger is not synchronized to zero crossings but will trigger within 8 V of zero for resistive load and 115-VAC line. Triggering occurs at about 1 V, but trigger level can be changed by using other input resistors or bias dividers.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 7.



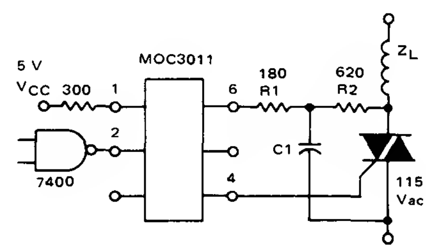
SUMP-PUMP CONTROL—Impurities in water provide conductivity for completing circuit of transistor when water reaches level of sensing electrode, energizing relay that starts pump motor. Extra set of contects on reley keeps motor running until water drops to predetermined lower level. Diodes are 1N4001 or equivalent, rated 1 A. Fuse should be chosen to pass normal motor current. Use 12-V double-pole relay. T1 is 300-mA filement transformer.—J. H. Gilder, Automatic Turn-On, *Modern Electronics,* Dec. 1978, p 78.



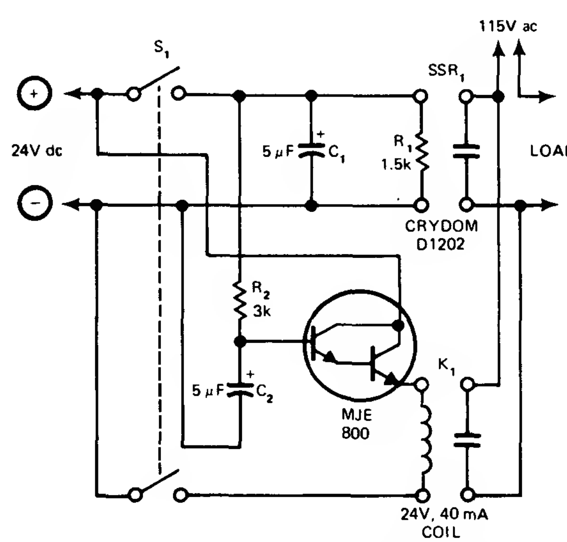
HALF-WAVE CONTROL—Simple AC relay operates during positive elternations of AC source, with optoisolator providing complete isolation between control circuit end SCR handling inductive load. When input LED is energized by control pulse, photo-SCR of optoisolator conducts and provides gete current for turning on power SCR. 1N4005 diode protects SCR from back EMF transients of inductive load.—T. Mazur, Solid-State Releys Offer New Solutions to Many Old Problems, *EDN Magazine,* Nov. 20, 1973, p 26–32.



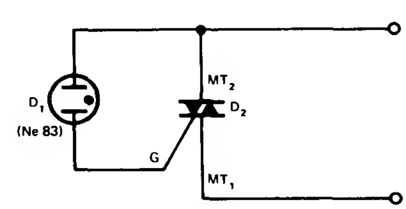
LOGIC-TRIGGERED TRIAC—Pulsed output from microprocessor controls gate drive of triac through SN7475 clock and transistor. Pulse from one output port of microprocessor is applied to D input of clock simultaneously with pulse from communications register unit (CRU) going to clock input, to raise Q output of clock to logic 1. Output remeins high until another pulse from CRU returns it to zero, thus giving latching action. High output turns on transistor and supplies about 100-mA gete drive to TIC263 25-A triac.—"Thyristor Gating for µP Applications," Texes Instruments, Dallas, TX, 1977, CA-191, p 4.



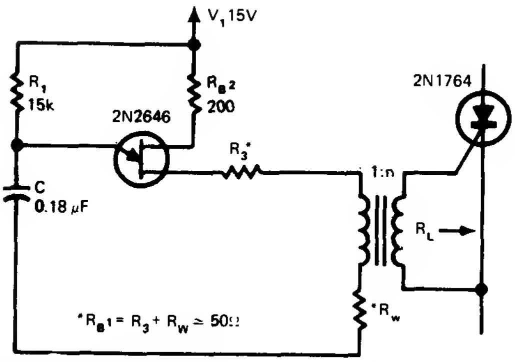
LOGIC DRIVE FOR INDUCTIVE LOAD—When output of NAND gate goes high and furnishes 10 mA to LED of Motorole MOC3011 opticelly coupled triec driver, output of optoisolator provides necessary trigger for triec controlling inductive load. C1 is 0.22 µF for loed power fector of 0.75 and 0.33 µF for 0.5 power factor. Omit C1 for resistive loed. R1, R2, end C1 serve as snubber that limits rate of rise in voltege applied to triac.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 2.



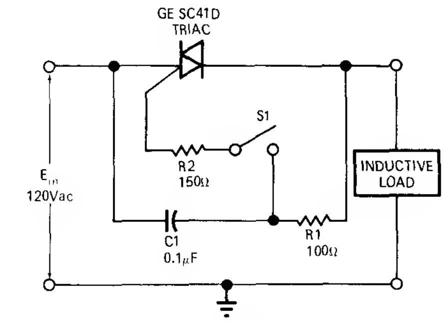
PERFECT AC SWITCH—Daveloped for use in computerized equipment to prevent generetion of severe noise spikes if contact closure can occur at any point in AC cycle. Closing S_1 getes solid-state relay SSR_1, which noiaelessly switches load at next zero crossing. During this time, C_2 cherges through R_2. After time $T = 3R_2C_2$, MJE800 Derlington is tumed on, pulling in reley K_1 to follow up SSR_1 with herd contacts. When S_1 is later opened, K_1 drops out immediately but C_1 discharges through gate of SSR_1 to hold it on for about $T = 6R_1C_1$. Loed is then switched off at next zero crossing efter this delay.—E. Woodward, This Circuit Switches AC Loeds the Clean Way, *EDN Magazine,* Nov. 20, 1975, p 160 end 162.



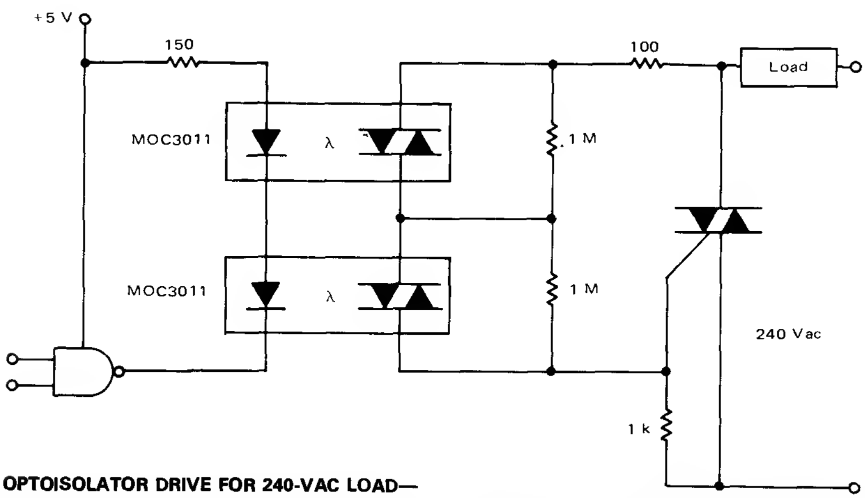
VOLTAGE-SENSITIVE SWITCH—RCA 40527 triec is triggered by smell neon. After breekdown occurs bidirectionelly et 88 V, triec tekes over as short-circuit. D_1 can be any other voltage breakdown device, such as diac or zener, end thyristor can be used in place of triac to glve unilateral switching. Applications include uae aa power crowbar, with breekdown level set by artificial resistance-controlled zener.—L. A. Rosenthel, Breekdown and Power Devices Form Unusual Power Switch, *EDN Magazine,* July 5, 1974, p 74–75.



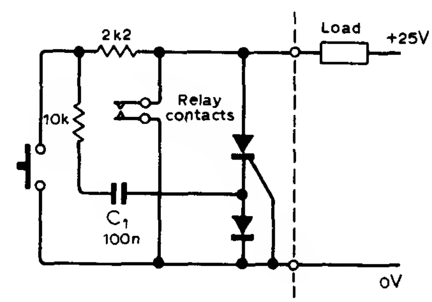
400-Hz TRIGGER FOR SCR—Simple UJT oscilletor combined with pulse trensformer provides pulses required for firing 2N1764 SCR. Article gives design dete for pulse trensformer, elong with design equetions.—W. Dull, A. Kusko, end T. Knutrud, Pulse end Trigger Transformers—Performence Dictetes Their Specs, *EDN Magazine,* Aug. 20, 1976, p 57–62.



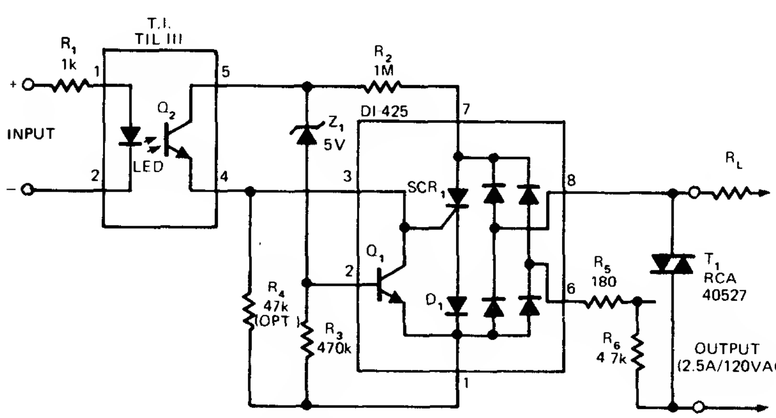
TRIAC FOR INDUCTIVE LOADS—Simple triec geting circuit applies AC power to inductive loed when low-power switch S1 is closed. R1 end C1 provide dv/dt suppression.—C. A. Ferel and D. M. Fickle, Triec Gating Circuit, *EDN/IEEE Magazine,* Jan. 1, 1972, p 72–73.



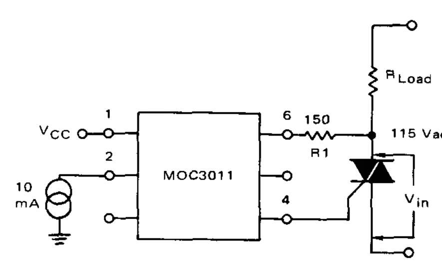
OPTOISOLATOR DRIVE FOR 240-VAC LOAD—Two Motorola MOC3011 opticelly coupled triec drivers ere used in series to overcome voltage limitetion of single coupler when triggering triec connected to control 240-VAC loed. Two 1-megohm resistors equelize voltege drops ecross couplers.—P. O'Neil, "Applicetions of the MOC3011 Triac Driver," Motorole, Phoenix, AZ, 1978, AN-780, p 5.



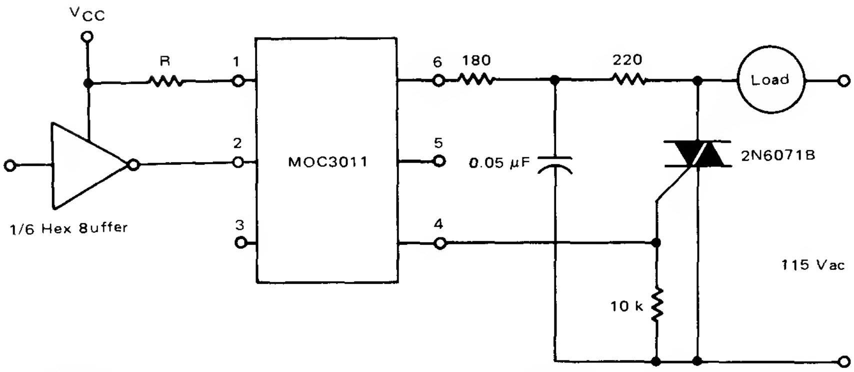
THYRISTOR SWITCH—When circuit of conventional P-gate thyristor is grounded by switch, negetive-going pulse is applied to thyristor cethode, which reverse-bieses the diode. When thyristor conducts, diode is forwerd-biesed end hes only about 0.7-V drop. Use low-voltege diode, reted for full loed current. Opening of relay contects mekes circuit switch off.—R. V. Hertopp, Grounded Gete Thyristor, *Wireless World,* Feb. 1977, p 45.



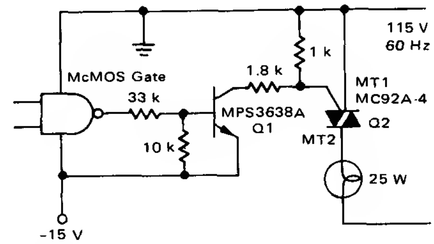
TRIAC CONTROL WITH OPTOISOLATOR—Dionics DI 425 switcheble bridge circuit controls 120-VAC line in opticelly isoleted zero-crossing solid-stete reley thet cen be used es trigger for power triec. Smell AC devices, drewing under 5 W, cen be switched directly in either rendom or zero-crossing mode.—High-Voltege Monolithic Technology Produces 200V AC Switching Circuit, *EDN Magazine,* April 5, 1975, p 121.



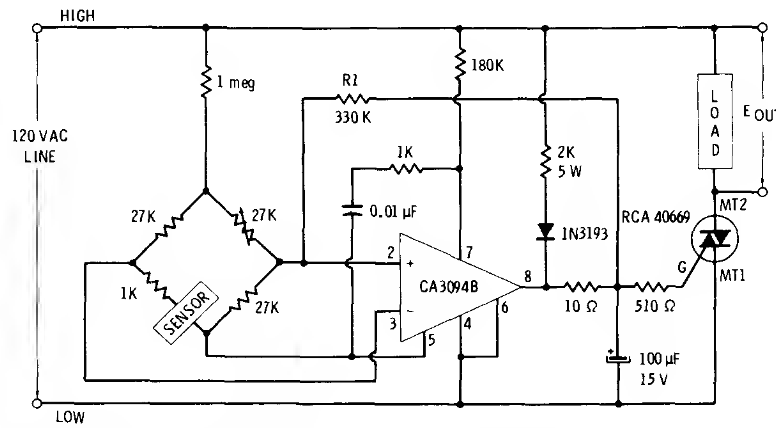
TRIAC DRIVE—Motorola MOC3011 optoisolator serves es intarface between 10-mA input circuit end gate of triec controlling AC loed. Choice of triac depends on load being hendled. Optoisolator detector chip responds to infrered LED; once triggered on, optoisoletor stays on until input current drops below holding velue of ebout 100 μA.—P. O'Neil, "Applications of the MOC3011 Triec Driver," Motorole, Phoenix, AZ, 1978, AN-780, p 2.



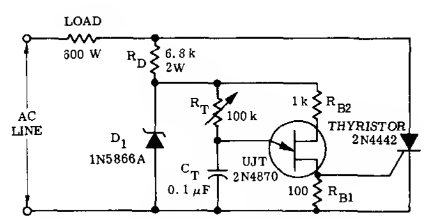
MOS DRIVE FOR TRIAC—Circuit uses one section of MC75492 hex buffer to boost 0.5-mA output of CMOS logic gate to 10 mA required for LED at input of Motorola MOC3011 optically coupled triac driver. When MOS input goes high, optoisolator provides output voltage for triggering triac that controls AC load. R is 220 ohms for 5-V supply and 600 ohms for 10-V supply. For 15 V, use MC14049B buffer and 910 ohms for R.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 4.



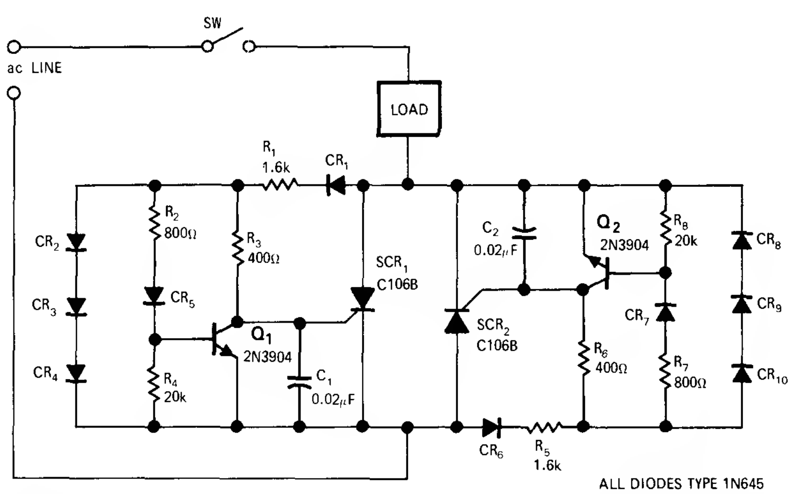
ACTIVE-HIGH TRIAC INTERFACE—Typical CMOS logic gate operating from negative supply triggers triac on negative gate current of 8 mA for control of 25-W AC load. High supply lines for both logic gate and interface transistor are grounded.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 12.



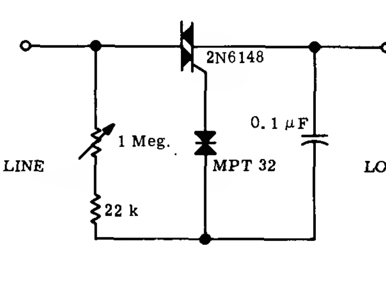
BRIDGE-TRIGGERED TRIAC—Developed for use with AC sensor in one leg of bridge. CA3094 is shut down on negative half-cycles of line. When bridge is unbalanced so as to make pin 2 more positive than pin 3, IC is off at instant that AC line swings positive; pin 8 then goes high and drives triac into conduction. Triac conduction is maintained on next negative half-cycle by energy stored in 100-μF capacitor. Bridge unbalance in opposite direction does not trigger triac.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 313–314.



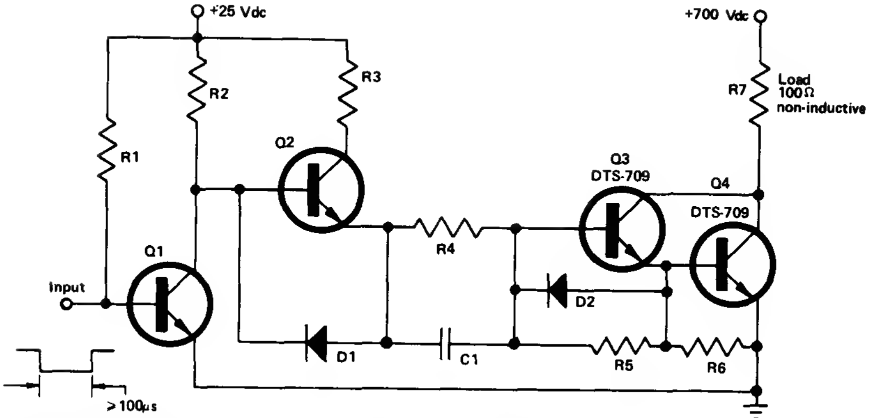
600-W HALF-WAVE—UJT serves as trigger for thyristor in circuit that provides power control for load only on positive half-cycles. Thyristor acts also as rectifier, providing variable power determined by setting of R_T during positive half-cycle and no power to load during negative half-cycle.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoenix, AZ, 1974, AN-413, p 3.



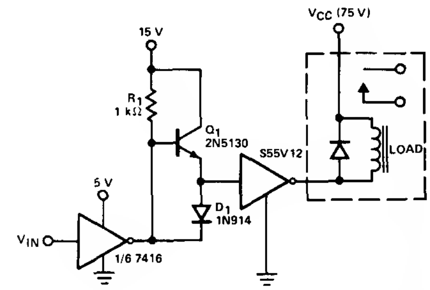
LINE-POWERED SWITCH—When AC line switch is closed, power is not applied to load until after line voltage next goes through zero. Identical circuits control each half of AC cycle. Transistor turn-on at 1.4 V prevents SCR from triggering until 0.013 ms (less than one-third electrical degree) after next zero-crossing point.—A. S. Roberts and O. W. Craig, Efficient and Simple Zero-Crossing Switch, *EDN/EEE Magazine*, Aug. 15, 1971, p 46–47.



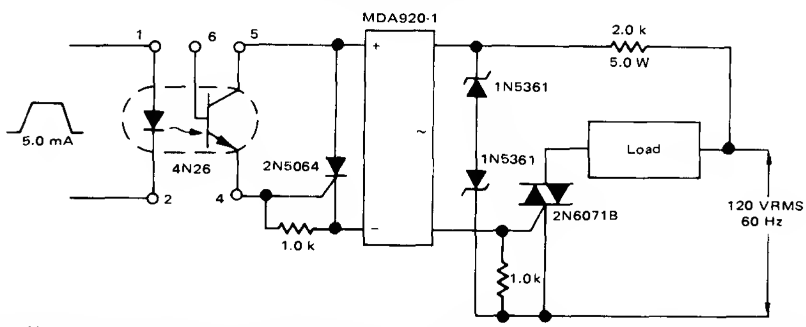
FULL-WAVE POWER CONTROL—Bidirectional three-layer trigger for triac allows triggering on both half-cycles at point determined by setting of 1-megohm pot. Triac rating determines size of load that can be handled.—"SCR Power Control Fundamentals," Motorola, Phoenix, AZ, 1971, AN-240, p 6.



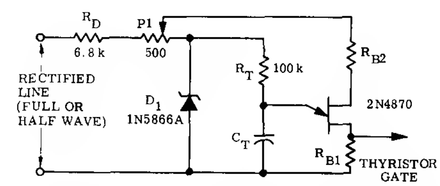
SWITCHING 4500 W AT UP TO 10 kHz—Darlington connection of Delco DTS-709 transistors will switch 7 A at 700 V with 1-μs switching time. Suitable for motor speed control, switching regulator, and inverter applications. Can be operated directly from 440-VAC line. Q1 and Q2 are 2N6100. Diodes are 1N4001. C1 is 4 μF at 15 V. R1 is 510 ohms, R2 is 100, R3 is 12, R4 is 10, R5 is 1K, R6 is 47, and R7 is 100.—"Low Cost 'Duolithic Darlington' Switches 4500 Watts at up to 10 kHz," Delco, Kokomo, IN, 1973, Application Note 54, p 2.



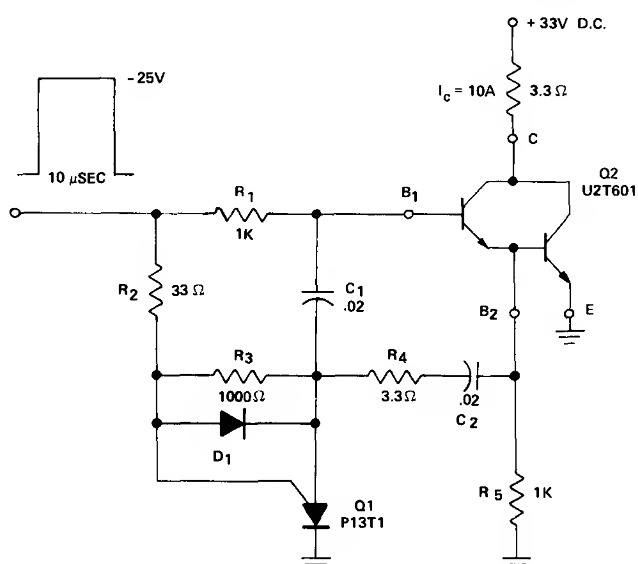
FAST-SWITCHING TTL INTERFACE FOR VMOS—Totem-pole TTL interface drive for S55V01 VMOS gives appreciably faster switching times (less than 30 ns). To achieve fast turn-on time without unduly small pull-up resistor, which dissipates considerable power when switch is in OFF state, emitter-follower Q_1 drives high peak currents into capacitive VMOS input.—L. Shaeffer, VMOS Peripheral Drivers Solve High Power Load Interface Problems, *Computer Design*, Dec. 1977, p 90, 94, and 96–98.



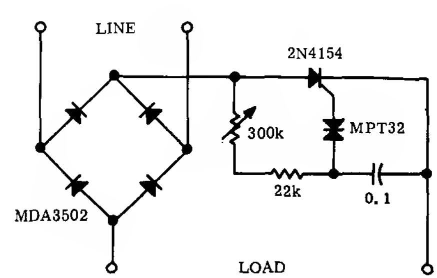
FULL-WAVE AC CONTROL—Motorola type MDA920-1 bridge rectifier provides full-wave rectification of AC line voltage for 2N5064 SCR placed across DC output of bridge. When positive logic pulse from CMOS circuit energizes optoisolator, SCR conducts and completes path for triac gate trigger current through bridge and SCR, turning on AC load. Triac rating determines size of load. Drawback of circuit is generation of EMI if logic signal occurs at other than zero crossings of AC line.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 17.



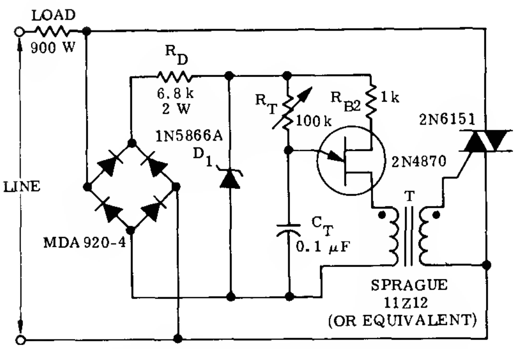
LINE-VOLTAGE COMPENSATION—Can be used with either half-wave or full-wave phase control circuit to make load voltage independent of changes in AC line voltage. P1 is adjusted to provide reasonably constant output over desired range of line voltage. As line voltage increases, P1 wiper voltage increases. This has effect of charging C_T to higher voltage so more time is taken to trigger UJT. Additional delay reduces thyristor conduction angle and thereby maintains desired average voltage.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoenix, AZ, 1974, AN-413, p 4.



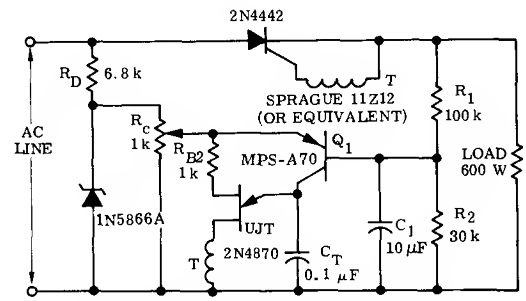
125-ns POWER SWITCH—Developed for repetitive pulse applications in which rise, fall, and storage times of pulse must be kept at absolute minimum. Circuit provides very high gain of Unitrode U2T601 Darlington and switching speeds up to 5 times greater than conventional techniques. Load power up to 10 A is typically applied within 125 ns. Applications include drive for laser diode and for radar circuits.—"Designer's Guide to Power Darlingtons as Switching Devices," Unitrode, Watertown, MA, 1975, U-70, p 19.



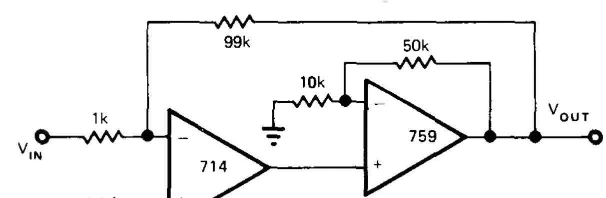
600-W TRIGGERED SCR—2N4154 SCR is operated from DC output of bridge rectifier and triggered by MPT32 at setting determined by position of 300K pot. Circuit provides full-wave DC control of lamp and other loads up to 600 W, using relaxation oscillator operating from DC source.—"SCR Power Control Fundamentals," Motorola, Phoenix, AZ, 1971, AN-240, p 6.



900-W FULL-WAVE—Combination of bridga rectifier, pulse transformer, and triac allows 100K pot R_T to control power to resistive load on both positive and negativa half-cyclas. Triac is triggered through transformer by 2N4870 UJT.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoanix, AZ, 1974, AN-413, p 3.

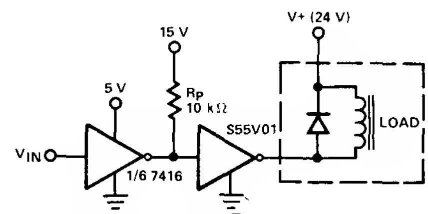


HALF-WAVE FEEDBACK—Provides phase control of powar to rasistive load in applications whera averaga load voltage is desired feedback varieble. RC network R_1-R_2-C_1 averages load voltage so it can be compared with set point on R_c by Q_1.—D. A. Zinder, "Unijunction Trigger Circuits for Gated Thyristors," Motorola, Phoenix, AZ, 1974, AN-413, p 4.

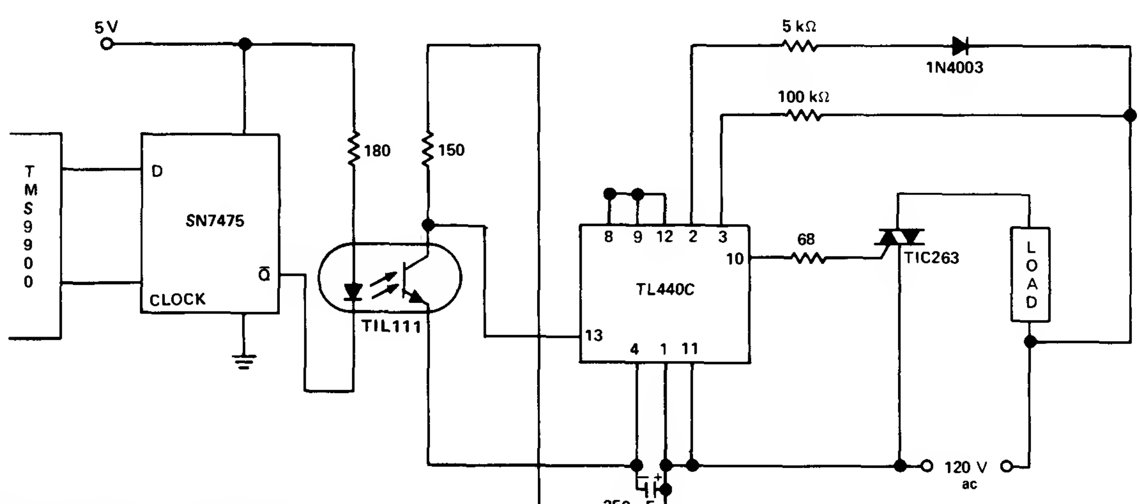


GAIN ACCURACY	0.006%
OFFSET VOLTAGE	25 μV
OUTPUT CURRENT	325 mA

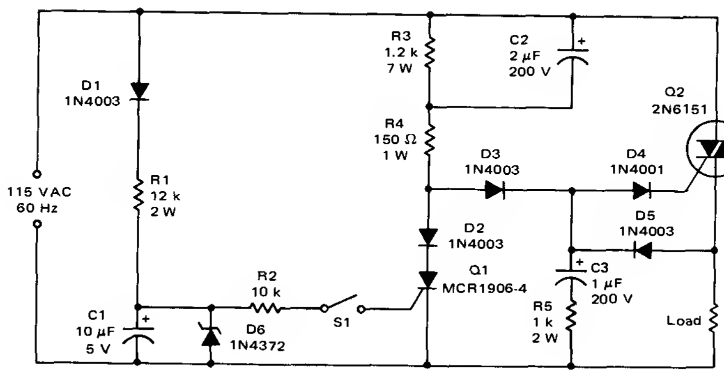
POWER OPAMP FOR CONTROL—Pracision 714 opamp drives 759 powar opamp to give ultra-precision power amplifiar systam. High current capebility (up to 500-mA paak output current) makes circuit suitable for such control applications as driving motors, relays, solanoids, or transmission lines. Article tells how to calculata heatsink requirements for opamp.—R. J. Apfel, Power Op Amps—Thair Innovative Circuits and Packaging Provide Designers with More Options, *EDN Magazina*, Sept. 5, 1977, p 141–144.



TTL INTERFACE FOR VMOS—By using opan-collector 7416 TTL interfeca with its output pulled up to 15 V, S55V01 VMOS will switch up to 2 A easily. Inductiva load such as relay raquires diode across ralay coil.—L. Shaaffer, VMOS Peripheral Drivers Solva High Power Load Interface Problams, *Computar Dasign,* Dac. 1977, p 90, 94, and 96–98.

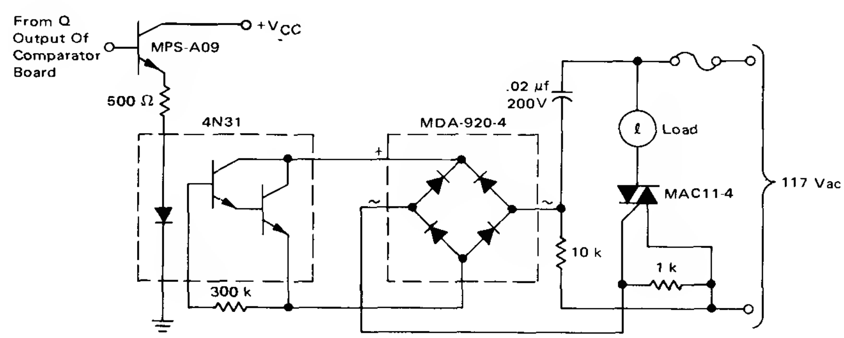


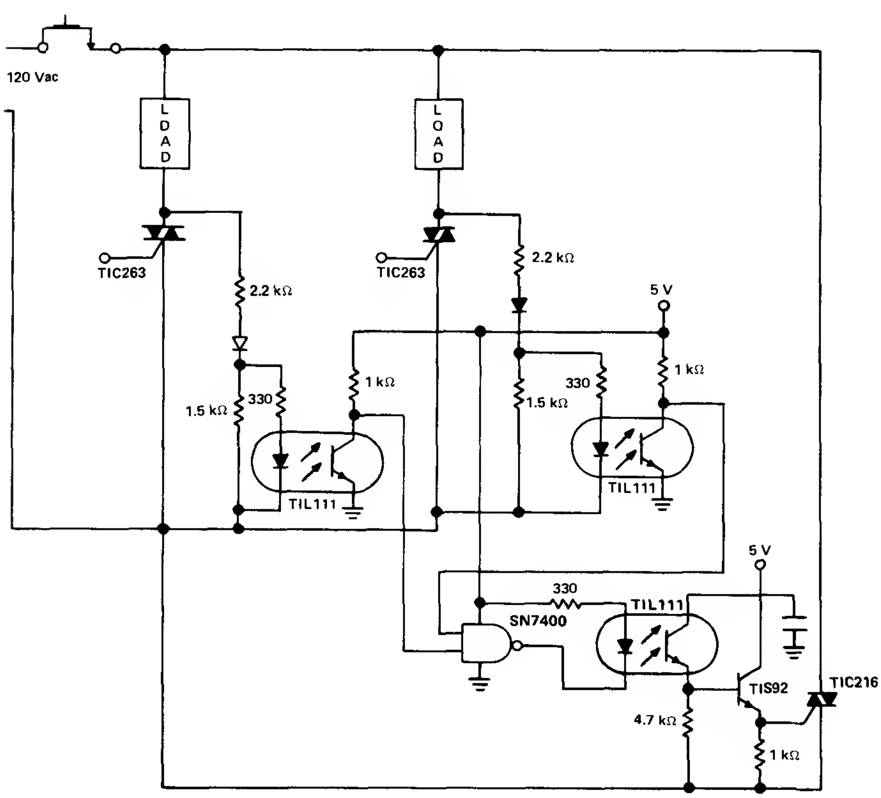
OPTOISOLATOR DRIVE—TL440 zaro-crossovar switch usas pulsed gata driva. Switch supplies phase-lockad driving pulses during zero-voltage crossover period, to minimiza electromagnetic interference ganerated during turn-on of triac. Works wall with rasistive loads, but inductive loads cen create phasa shift thet affects firing time of triac.—"Thyristor Gating for μP Applications," Texas Instruments, Dallas, TX, 1977, CA-191, p 6.



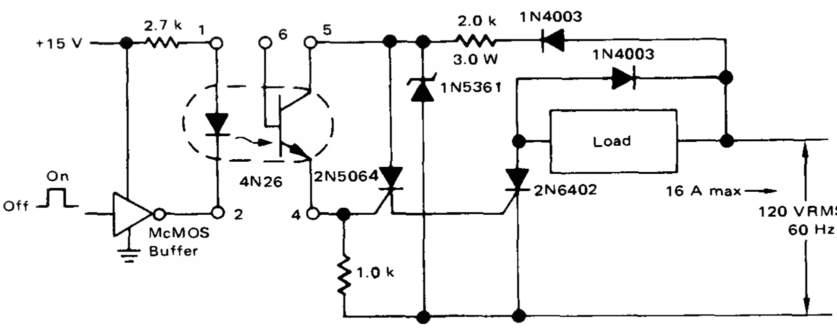
ZERO-POINT SWITCH—Usad to control resistive loads. With S1 open, triac Q2 is turned on very close to zero on initial part of positiva half-cycle because of large current flow into C2. Once Q2 is on, C3 charges through D5. When line voltage goes through zero and starts negative, C3 is still discharging into gate of Q2 to turn it on near zero of negative half-cycle. Load current thus flows for most of both half-cycles. Whan S1 is closed, Q1 is turnad on and shunts gate current away from Q2 during positiva half-cyclas. Q2 cannot turn on during negative half-cycle bacause C3 cannot charge, which makes load current zero.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 12.

OUTPUT CONTROL FOR CLOCK COMPARATOR—Circuit triggers 10-A triac whan Q output of comparator-driven flip-flop is logic 1. LED in optoisolator is then anergized, activating phototransistor pair for driving gate circuit of triac through diode bridge. Trigger voltage of triac is positiva for first quadrant and nagativa for third quadrant, to give maximum sensitivity of triac control.—D. Aldridga and A. Mouton, "Industrial Clock/Timar Featuring Back-Up Power Supply Operation," Motorola, Phoenix, AZ, 1974, AN-718A, p 7.



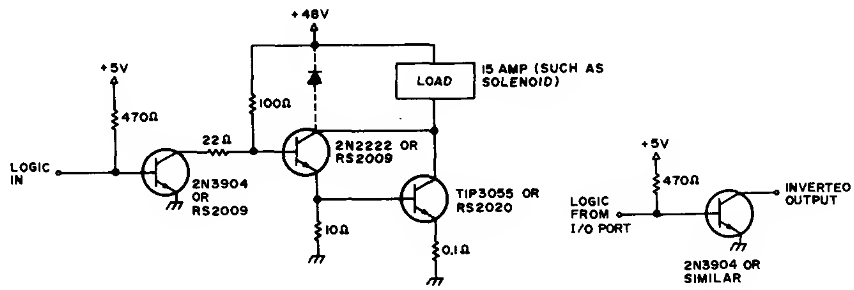


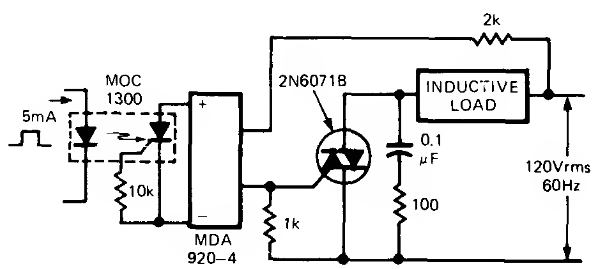
PROTECTION AGAINST SIMULTANEOUS OPERATION OF TRIACS—Optoisolators provida cross-connection between solid-stata triac relay circuits to eliminate possibility that two or more triacs coma on at sama time dua to circuit malfunction or component failura. Circuit shuts system down when this occurs.—"Thyristor Gating for µP Applications," Texas Instruments, Dallas, TX, 1977, CA-191, p 5–9.



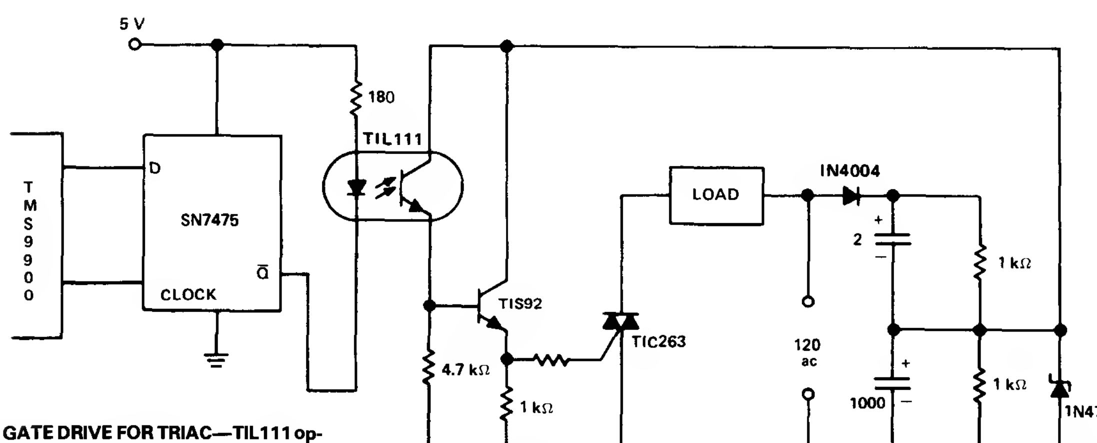
HALF-WAVE AC CONTROL—Motorola 4N26 optoisolator serves as interface for static series switch in gate circuit of 2N5064 SCR. When logic input goes high, optoisolator is energized and first SCR is triggered on. Resulting current turns on power SCR for passing load current on that positive half-cycle of AC line voltage. When logic goes low, load current stops at next zero crossing of AC source. 5 mA of isolated DC control current thus controls up to 16 A for half-wave load.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 16.

LOGIC CONTROLS 15-A LOAD—Load is energized when logic input drops to 0. Can be used to drive solenoid or electromagnet from 48-VDC supply, for stopping paper tape in high-speed tape reader. If relay is to be activated by high or 1 level, add inverter at input as shown.—D. D. Mickle, Practical Computer Projects, *73 Magazine*, Jan. 1978, p 92–93.

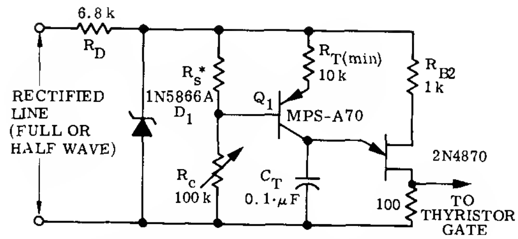




FULL-WAVE CONTROL—Uses triac to provide current for inductive load during both positive and negative alternations of AC source, with optoisolator providing complete isolation for logic control circuit. MDA920-4 diode bridge provides pulsating DC voltage for photo-SCR of optoisolator so gate current is supplied to triac for both halves of AC cycle.—T. Mazur, Solid-State Relays Offer New Solutions to Many Old Problems, *EDN Magazine*, Nov. 20, 1973, p 26–32.

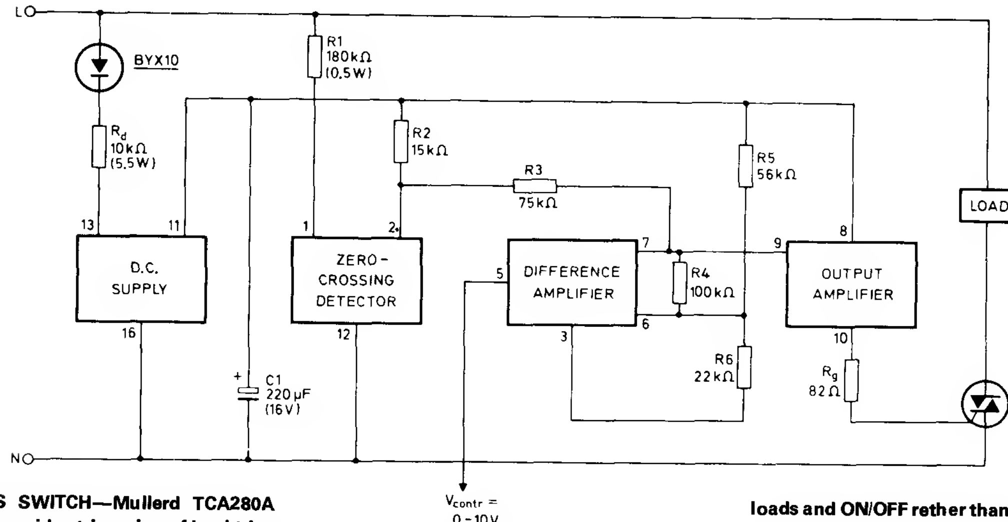


ISOLATED GATE DRIVE FOR TRIAC—TIL111 optoisolator provides electrical isolation between control logic and gate drive for triac at low cost, with faster switching than is possible with relays. Transistor provides direct current drive for gate of triac.—"Thyristor Gating for μP Applications," Texas Instruments, Dallas, TX, 1977, CA-191, p 4–5.

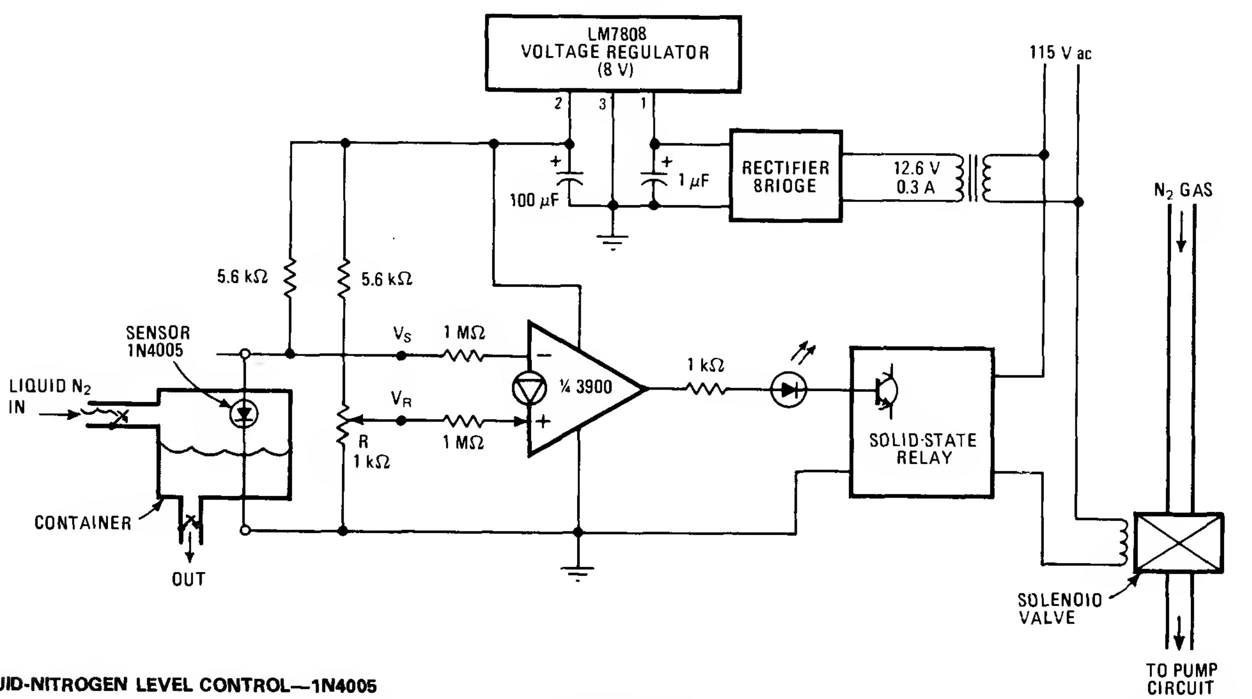


*R_S SHOULD BE SELECTED TO BE ABOUT 3 k TO 5 k OHMS AT THE DESIRED OUTPUT LEVEL

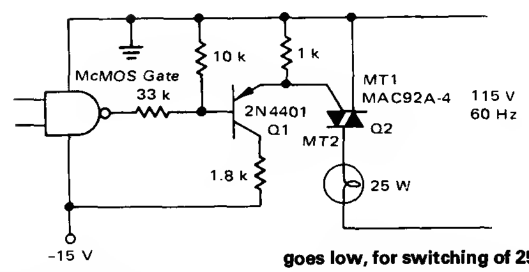
FEEDBACK CONTROL—Replecement of menuel phese control pot with sensor end trensistor provides eutometic control of loed power in response to stimuli such as haet, light, pressure, or megnetic fields. Output of feedbeck control circuit goes to thyristor in series with loed. R_c establishes desired opereting point for sensing resistor R_s. As R_s increeses in resistance, mora current flows into C_T end mekes 2N4870 UJT trigger et smeller phesa engle so more power is applied to load. For opposita effect, interchenge R_s end R_c.—D. A. Zinder, "Unijunction Trigger Circuits for Geted Thyristors," Motorole, Phoenix, AZ, 1974, AN-413, p 4.



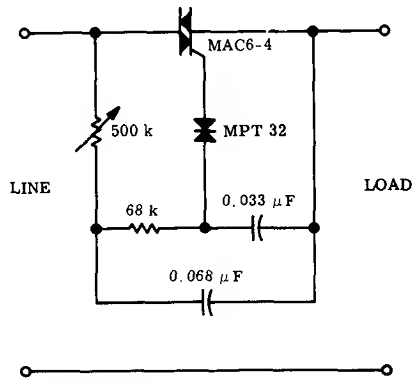
SYNCHRONOUS SWITCH—Mullerd TCA280A trigger module provides triggering of loed triec et zero crossings of AC line voltage. Veluas shown are for triec raquiring gete current of 100 mA; for other triecs, values of R_d, R_g, end C_1 mey need to be changed. Designed for resistive loads and ON/OFF rether than proportionel control.—"TCA280A Triggar IC for Thyristors end Triacs," Mullerd, London, 1975, Technicel Note 19, TP1490, p 10.



LIQUID-NITROGEN LEVEL CONTROL—1N4005 diode sarves as sensor. Junction voltage of diode increases from 0.7 V at room temperature to 1.05 V when in liquid nitrogen. Voltage chenge is used to ectivate amplifier that controls solenoid valve through solid-state relay. 1K pot R adjusts circuit sensitivity; this can be set so pump starts refilling of conteiner when liquid is as much as 2 inches below diode, to eliminete frequency recycling. LED indicates valve status.—V. J. H. Chiu, Diode Sensor and Norton Amp Control Liquid-Nitrogen Level, *Electronics*, Feb. 2, 1978, p 117.

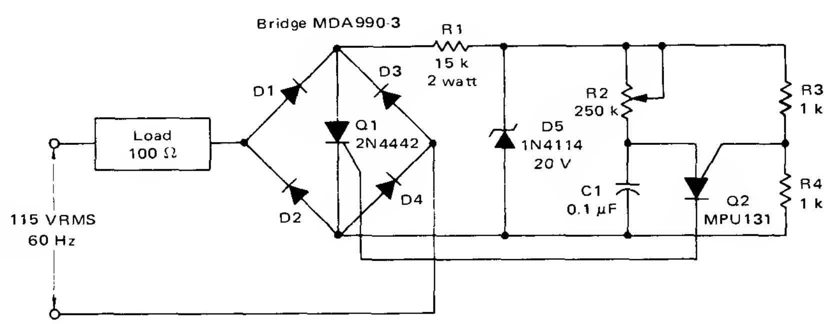


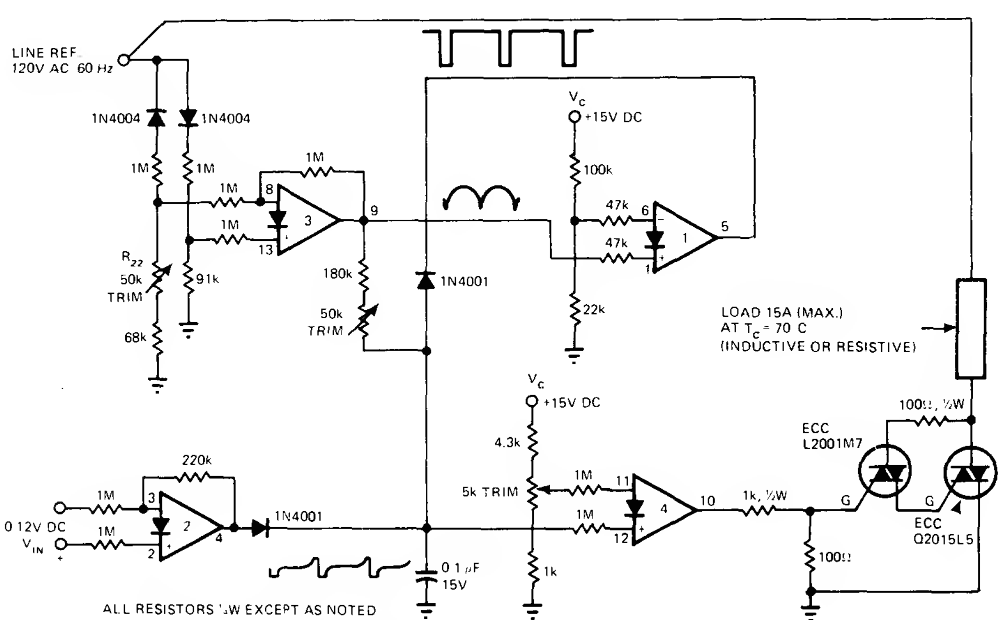
ACTIVE-LOW TRIAC INTERFACE—With connection shown for interface transistor Q1, typical CMOS gate triggers triac when gate output goes low, for switching of 25-W lamp load.—A. Pshenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 12.



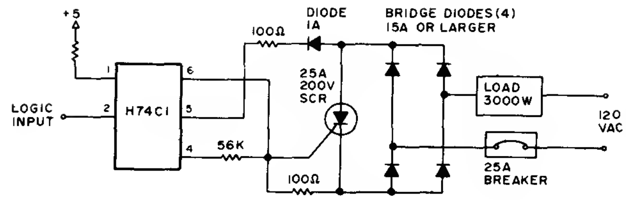
FULL-RANGE CONTROL—Triggered triac is used with double phase-shift network to obtain reliable triggering at conduction angles as low as 5°, as required for control of incandescent lamps and some motors. Triac rating determines size of load.—"SCR Power Control Fundamentals," Motorola, Phoenix, AZ, 1971, AN-240, p 6.

PUT CONTROLS SCR—Programmable unijunction transistor Q2 provides phase control for both halves of AC line voltage by triggering SCR connected across bridge. Relaxation oscillator formed by Q2 varies conduction interval of Q1 from 1 to 7.8 ms or from 21.6° to 168.5°, to give control over 97% of power available to load.—R. J. Haver and B. C. Shiner, "Theory, Characteristics and Applications of the Programmable Unijunction Transistor," Motorola, Phoenix, AZ, 1974, AN-527, p 10.

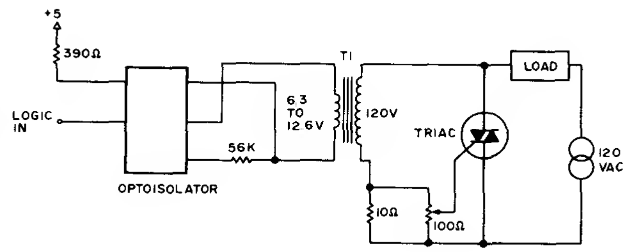




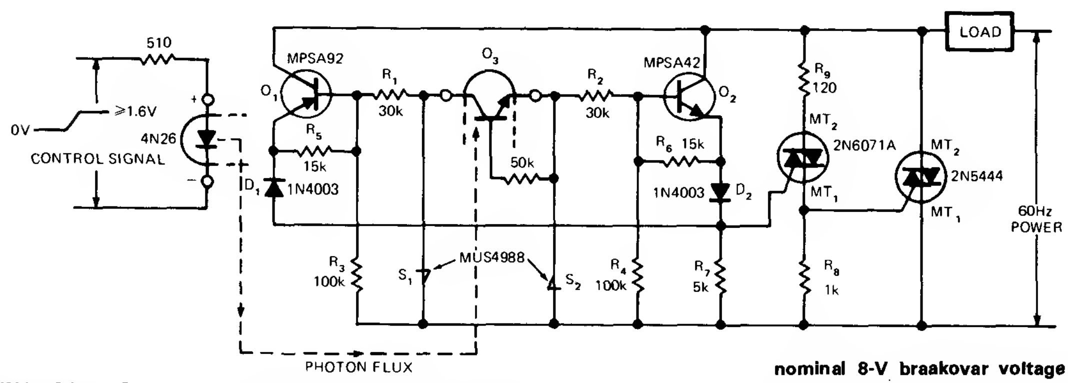
GROUND-REFERENCED RAMP-AND-PEDESTAL CONTROL—Need for transformer is eliminated by applying alternate half-cycles to inverting and noninverting inputs of section 3 of LM3900 quad opamp, so full-wave-rectified waveform is referenced to ground. Comparator opamp 1 discharges timing capacitor at zero line voltage and synchronizes circuit with line frequency. Buffer opamp 2 scales input and provides linear pedestal for capacitor. Opamp 4 is comparator serving as output driver whose output is high when capacitor is charged to level selected by high-end trimming pot. Output is sufficient for optoisolators and logic triacs.—J. C. Johnson, Ramp-And-Pedestal Phase Control Uses Quad Op Amp, *EDN Magazine*, June 5, 1977, p 208 and 211.



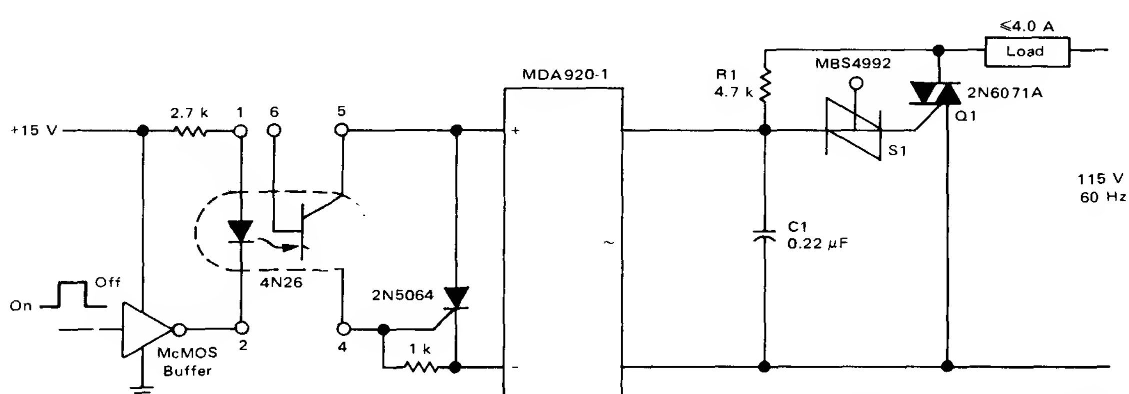
LOGIC DRIVES SCR—Uses light-activated SCR in H74C1 optoisolator to trigger larger SCR for controlling loads up to 3000 W through bridge diodes. When logic input goes low (to ground), load is energized. Limit for inductive loads is 8 A or about 1000 W if using 25-A SCR.—D. D. Mickle, Practical Computer Projects, *73 Magazine*, Jan. 1978, p 92–93.



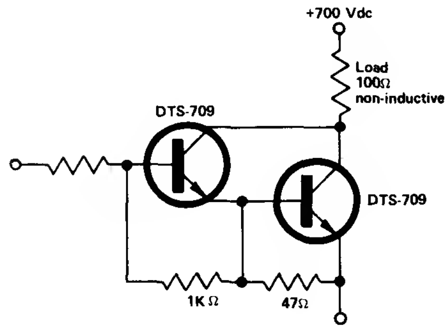
LOGIC DRIVES TRIAC—H74C1 optoisolator combined with saturation characteristic of ordinary filament transformer serves to trigger full-wave triac on or off under control of logic input, for energizing AC loads up to rating of triac. Logic 0 (ground level) turns load on, and logic 1 turns it off.—D. D. Mickle, Practical Computer Projects, *73 Magazine*, Jan. 1978, p 92–93.



ZERO-CROSSING CONTROL—When control signal calls for power, optoisolator energizes circuit that provides load turn-on at zero-voltage time of AC waveform. If phototransistor Q_3 of optoisolator is illuminated after S_1 drops to 1-V conduction voltage of MUS4988, triacs will not be turned on. Circuit thus provides relay-enabling voltage window, lower limit of which is point at which all components involved in turning on triacs are forward-biased. Upper limit is nominal 8-V breakover voltage of unilateral switch S_1. S_2 performs similar function on negative voltage alternations. Load-controlling triac is rated 40 A.—T. Mazur, Solid-State Relays Offer New Solutions to Many Old Problems, *EDN Magazine*, Nov. 20, 1973, p 26–32.

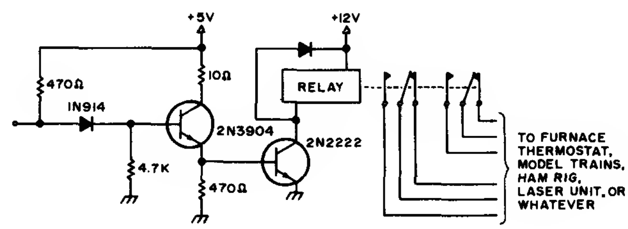


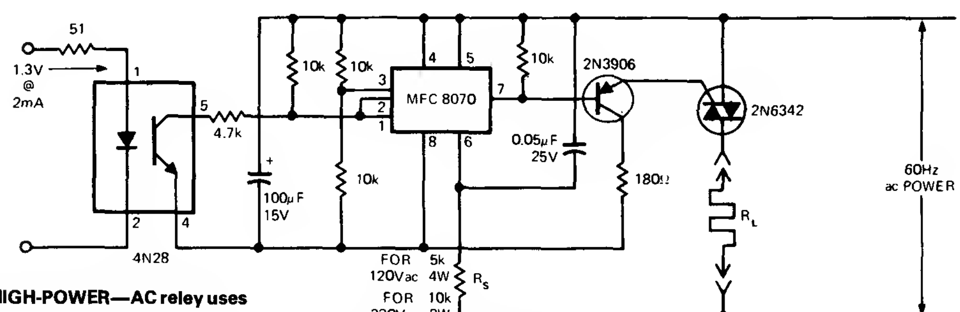
4-A FULL-WAVE CONTROL—When logic input to CMOS buffer goes high, load is off. Low input logic deenergizes optoisolator; clamp formed by bridge rectifier and SCR is then removed from C1, allowing it to charge through R1. When voltage across C1 reaches triggering voltage of S1 (about 8 V), MBS4992 silicon bidirectional switch fires, allowing C1 to dump charge into gate of triac. Triac and load are then turned on. R1 and C1 are chosen to give time constant small enough to fire triac early in its conduction angle (near zero crossing), to maximize load power while minimizing EMI.—A. Pshaenich, "Interface Techniques Between Industrial Logic and Power Devices," Motorola, Phoenix, AZ, 1975, AN-712A, p 17.



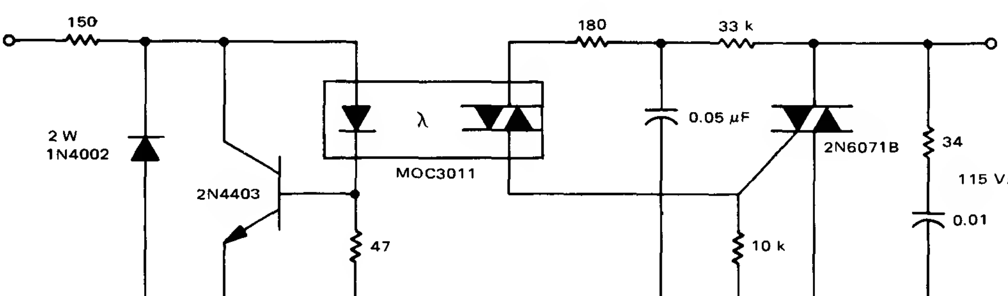
SWITCHING 4500 W BELOW 5 kHz—Simple Darlington connection of Delco DTS-709 transistors serves for switching of up to 700 V at 7 A for low-speed motor control, regulator, and inverter applications.—"Low Cost 'Duolithic Darlington' Switches 4500 Watts at up to 10 kHz," Delco, Kokomo, IN, 1973, Application Note 54, p 3.

RELAY DRIVE—Logic input of 0 turns first transistor off, allowing base of next transistor to go high so it turns on and energizes relay for achieving desired control function.—D. D. Mickle, Practical Computer Projects, *73 Magazine*, Jan. 1978, p 92–93.

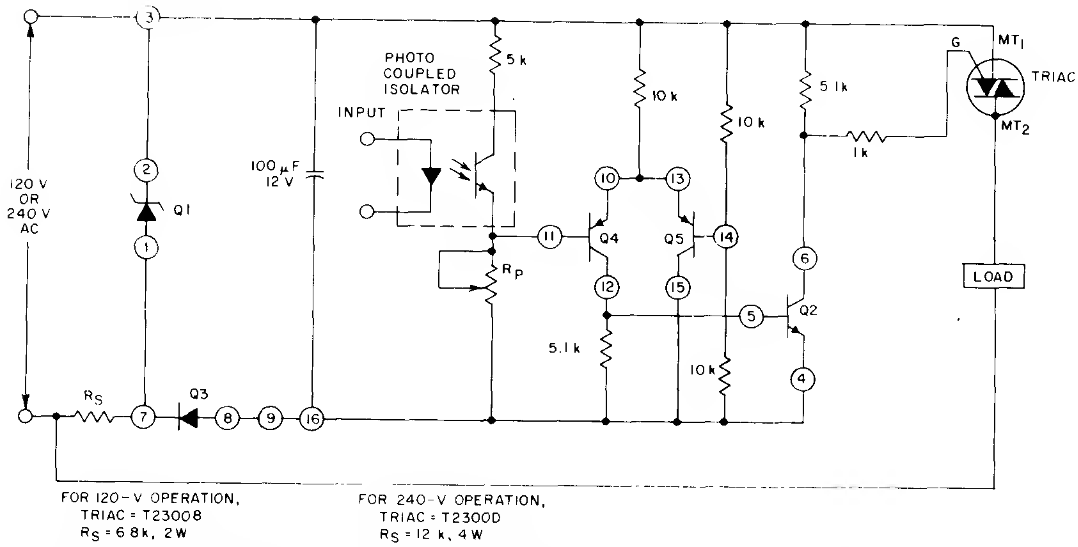




ZERO-CROSSING HIGH-POWER—AC relay uses MFC8070 zero-voltage switch to provide gate current pulses for triac under control of differential input voltages derived from output of 4N28 optoisolator. When LED is off, voltage at pins 1 and 2 of switch is positive with respect to pin 3, inhibiting switch so no current pulses go to triac gate. When LED is energized by logic input, gate current pulses are generated at zero-voltage excursions of AC power source. Transistor ensures adequate gate drive at low temperatures. For normally-on configuration, interchange input connections 3 and 1-2 of switch. Triac can be selected to handle resistive loads from 4 to 40 A.—T. Mazur, Solid-State Relays Offer New Solutions to Many Old Problems, *EDN Magazine*, Nov. 20, 1973, p 26–32.



OPTOISOLATOR AS SOLID-STATE RELAY—Circuit provides input protection of LED from overvoltage and reverse polarity, along with snubber network for handling inductive AC loads. Triac should be chosen to handle load. Safe input voltage range is 3–30 VDC.—P. O'Neil, "Applications of the MOC3011 Triac Driver," Motorola, Phoenix, AZ, 1978, AN-780, p 6.

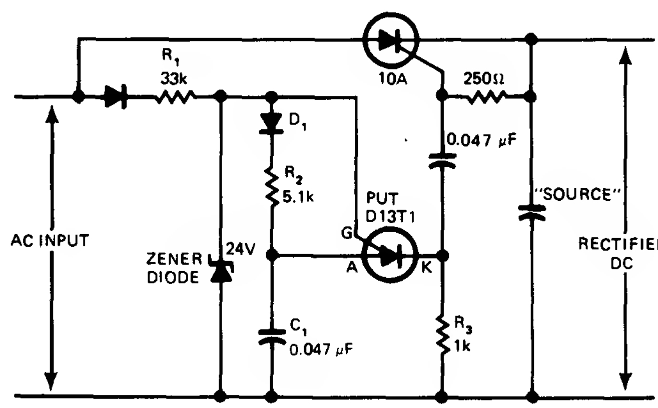


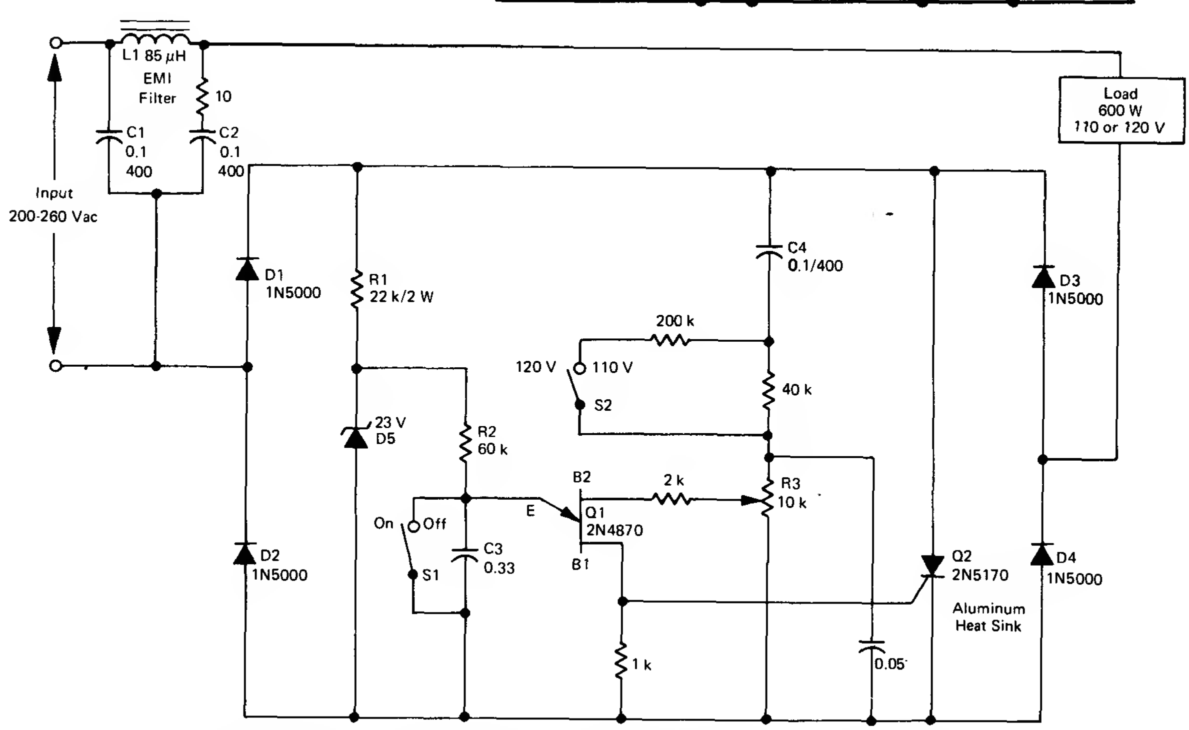
ALARM CONTROL—Any input suitable for driving LED of optoisolator triggers triac for energizing load such as alarm gong. Transistors Q4 and Q5 of CA3096 array serve as comparator. Diode-connected transistor Q3, zener-connected transistor Q1, and 100-μF capacitor develop DC supply voltages from AC line.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 9.

CHAPTER 68
Power Supply Circuits

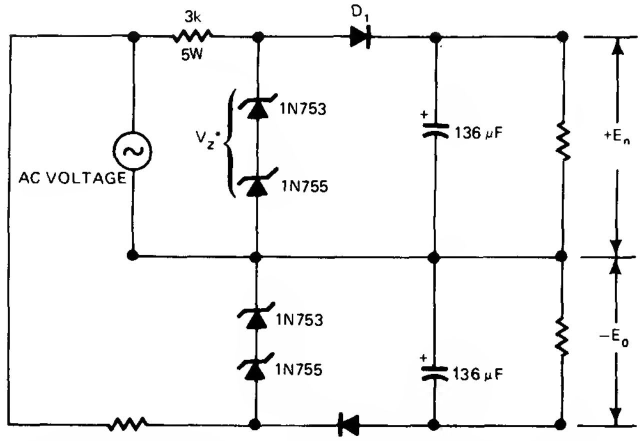
Includes unregulated circuits for changing AC input voltage to variety of DC voltages ranging from 1.5 V to 3 kV. Also includes inverter circuits containing oscillator operating from DC supply and providing AC voltage at 60 Hz or 400 Hz, along with RMS AC regulator. See also Converter—DC to DC, Regulated Power Supply, Regulator, and Switching Regulator chapters.

12-V TRANSFORMERLESS PREREGULATOR—AC line voltage is converted to regulated 12 VDC by varying firing angle of 10-A SCR. Circuit provides reliable operation for AC line voltages between 50 and 140 V. Key element in triggering of SCR is programmable unijunction transistor that provides variable and accurate control of firing time. Developed for use in power supply that uses digital techniques of sample-and-hold switching to achieve high degree of isolation between power line and load without using transformer.—J. A. Dickerson, Transformerless Power Supply Achieves Line-to-Load Isolation, *EDN Magazine*, May 5, 1976, p 92–96.





110/120 VAC ± 2.5 V AT 600 W—Simple open-loop voltage compensator for small conduction angles operates from 200–260 VAC input and provides true RMS output voltage for sensitive equipment such as photographic enlargers, oven heaters, projection lights, and certain types of AC motors. Full-wave bridge D1-D4 and SCR Q2 provide full-wave control, with UJT Q1 serving as trigger. Triggering frequency is determined by charge and discharge of C3 through R2. As input voltage increases, required trigger voltage also increases, retarding firing point of SCR to compensate for change in input.—D. Perkins, "True RMS Voltage Regulators," Motorola, Phoenix, AZ, 1975, AN-509, p 3.



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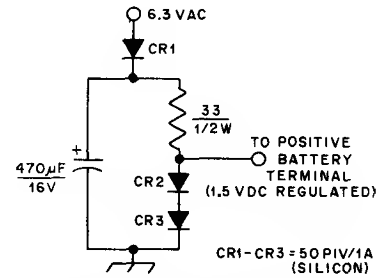
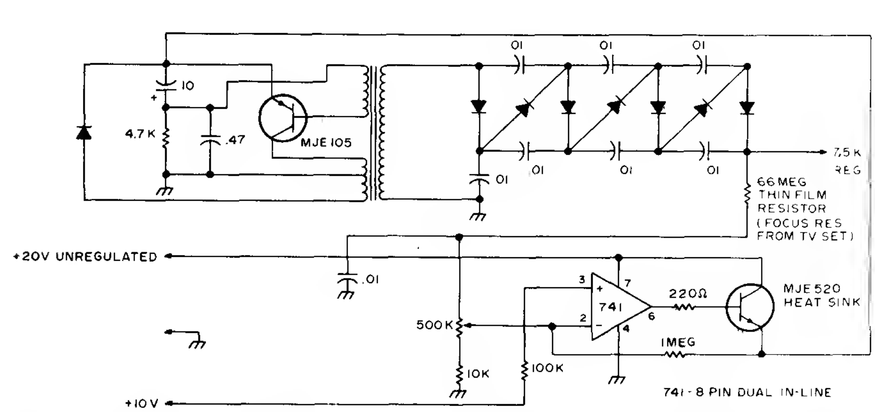
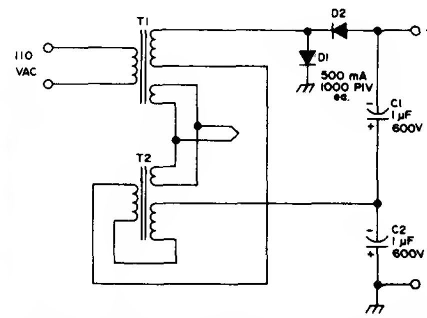
TRANSFORMERLESS ±12 V AT 15 mA—Developed to provide bias voltage for six 741 opamps. Circuit connects directly across 120-V 60-Hz AC line. Article gives design procedure to meet performance requirements. For values shown, ripple is 1.1 V. Diode types are not critical.—C. Venditti, Build this Transformerless Low-Voltage Supply, *EDN Magazine*, Feb. 5, 1977, p 102.



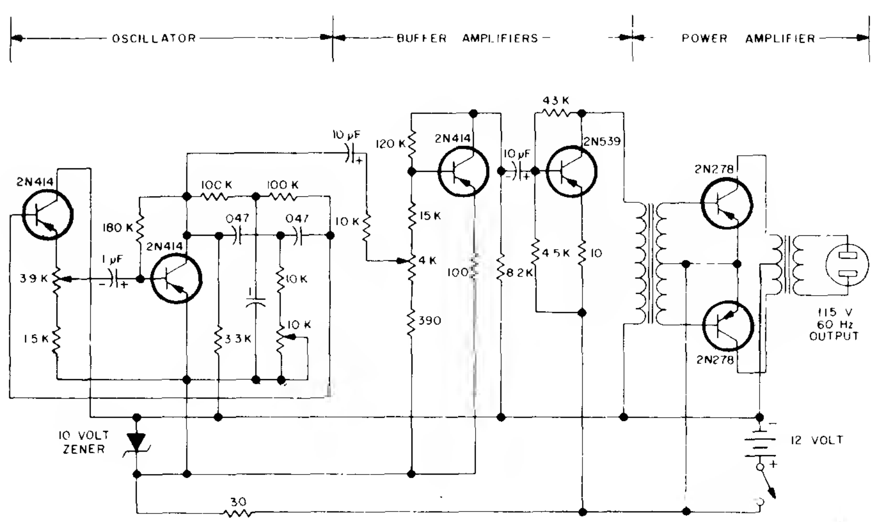
1.5 V FOR VTVM—Simple rectifier circuit replaces battery in vacuum-tube voltmeter. Provides good regulation and eliminates need for frequent battery replacement. Remove battery before using supply. AC source can be 6.3-V secondary of filament transformer or terminals of 6.3-V pilot lamp in any AC equipment.—P. Alexander, Battery Replacement Circuit for VTVM, *QST*, Jan. 1976, p 42–43.



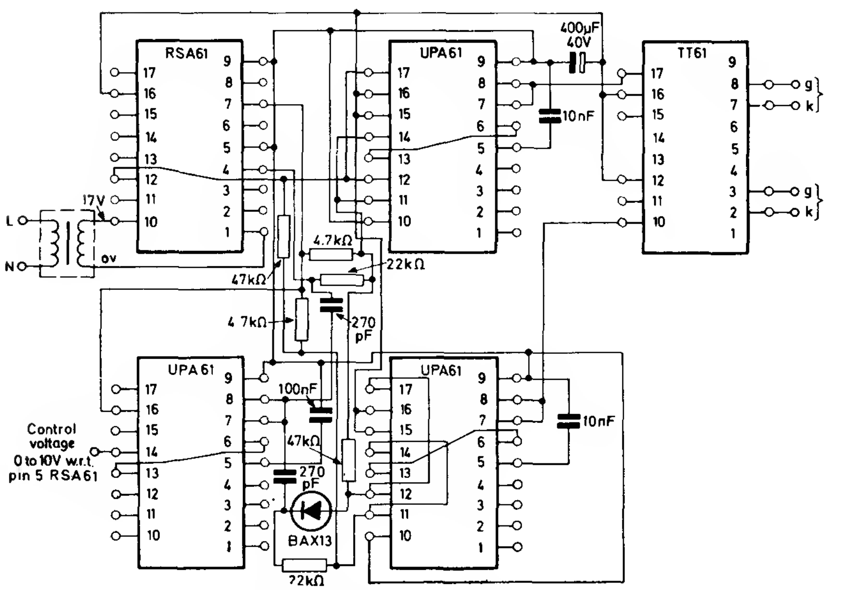
7.5-kV REGULATED SUPPLY—Power transformer is special design, but commercial unit delivering 5 to 10 kV can be used. Inverter circuit uses MJE105 transistor driving primaries of transformer. 741 opamp and transistor provide regulation for 7.5-kV output used in slow-scan TV monitor. Diodes are 1 kV, such as 1N4007. Article gives circuit of complete monitor, including low-voltage supply.—L. Pryor, Homebrew This SSTV Monitor, *73 Magazine*, June 1975, p 22–24, 26–28, and 30.



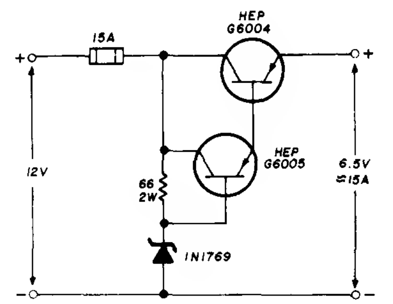
1000 V FOR CRT—Unique connection of two TV booster transformers having 125-V secondaries gives high-voltage supply for small monitor scope. T1 is connected conventionally, with its 6.3-V winding going to heater of CRT. 6.3-V winding of T2, also connected to CRT, serves as primary for second transformer. Remaining windings of T2 and high-voltage secondary of T1 are connected in series aiding to give about 367 VAC for doubling by D1-D2 and C1-C2. Since CRT drain is low, filter charges to very nearly peak voltage of 1027 VDC.—W. P. Turner, Cheap Power Supply for a CRT, *73 Magazine*, March 1974, p 53.



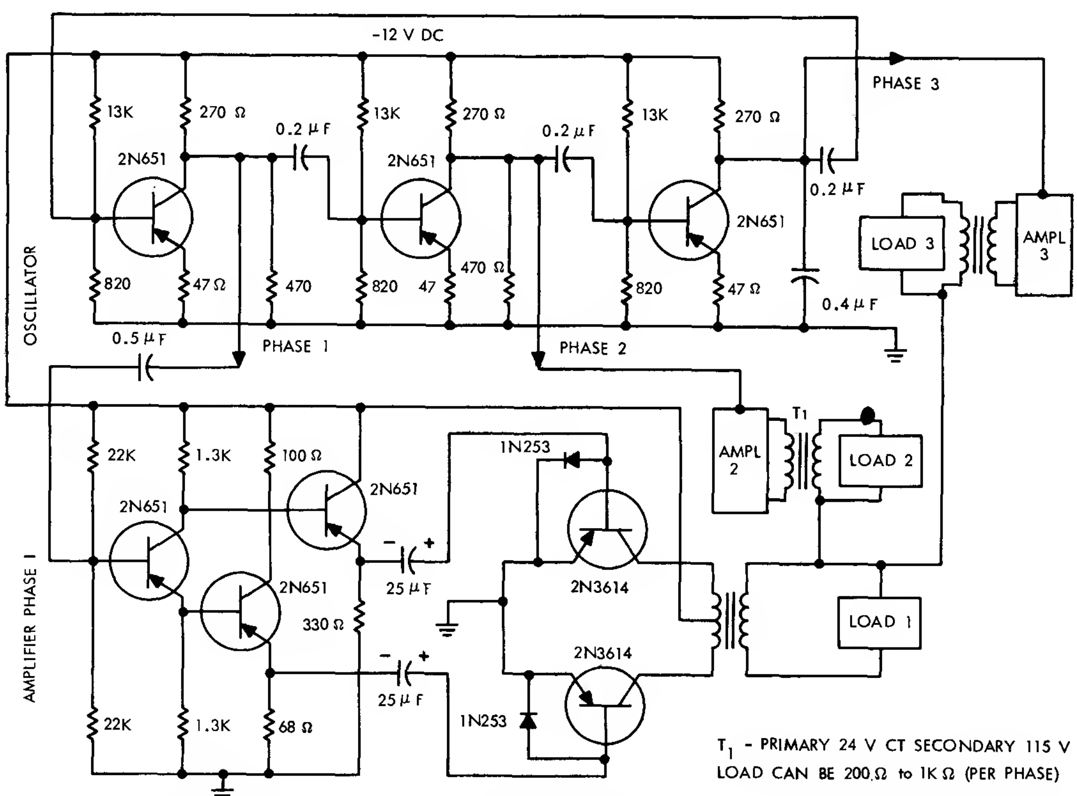
100-W SINE AT 60 Hz—Consists essentially of 60-Hz sine-wave oscillator with 10K frequency-control pot, two buffer stages, and push-pull power amplifier. Circuit eliminates noise problems of square-wave inverters when operating 115-V radio receiver or cassette player in car.—G. C. Ford, Power Inverter with Sine Wave Output, *73 Magazine*, May 1973, p 29–32.



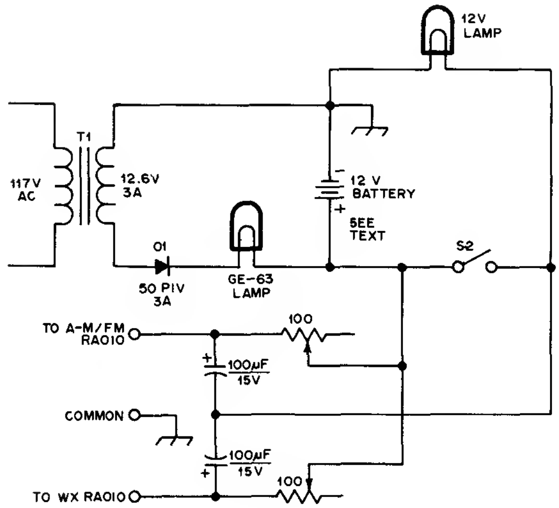
PARALLEL INVERTER DRIVE—Uses Mullerd modules for converting DC power to AC et high power levels for such epplications es driving induction motors at higher speeds then ere obtaineble with line frequency. DC control voltage of 0–10 V veries output frequency up to 400 Hz. UPA61 modules provide functions of level detector, pulsa generator, remp generator, capecitor discherge circuit, end bistable MVBR for perellel inverter system. RSA61 and TT61 ere trigger modules, with RSA61 elso providing power supplies for other modules.—"Universel Circuit Modules for Thyristor Trigger Systems (61 Serias)," Mullerd, London, 1978, Technical Information 66, TP1660, p 19.



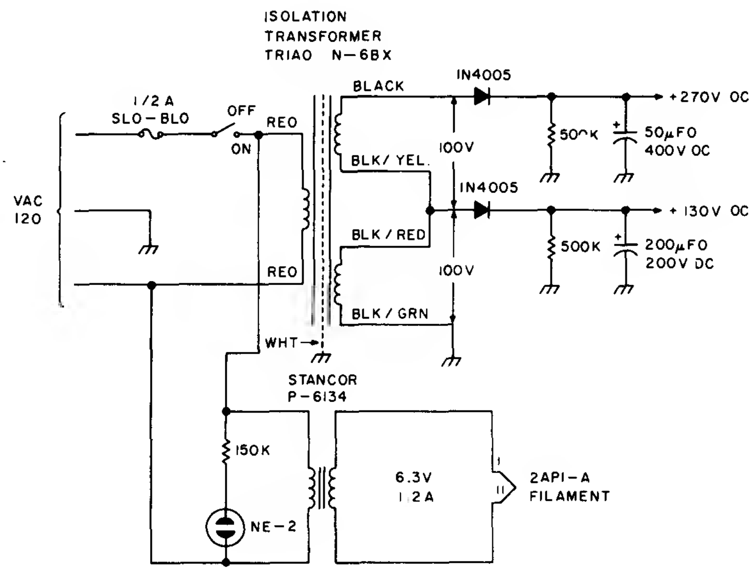
12 V TO 6 V—Permits operetion of older 6-V VHF FM mobile equipment from 12-V storaga battery. With transistor mounted on suitable haatsink, meximum output is 15 A. If positive end negative lines are isolated from chassis, converter may be used with either negative or positive ground.—E. Noll, Circuits and Techniques, *Ham Radio,* April 1976, p 40–43.



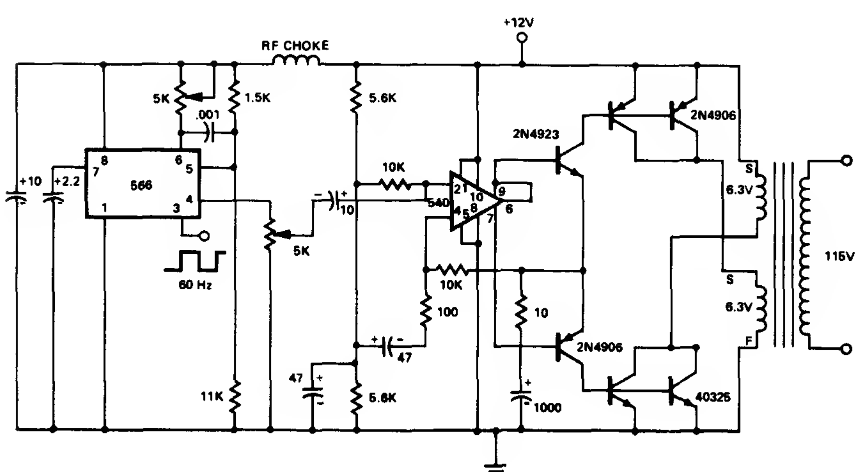
12 VDC TO 115 VAC AT 400 Hz—Provides three-phase output at 20 W by using RC coupling to oscillator in such a way that 120° phase difference exists at collectors of 2N651 transistors of oscilletor. Emitter-follower amplifier driving push-pull power output trensistors is shown only for phase 1; other two phases use similar amplifiers. Power trensistors are operated in saturated switching mode.—R. J. Haver, "Tha ABC's of DC to AC Inverters," Motorola, Phoenix, AZ, 1976, AN-222, p 15.



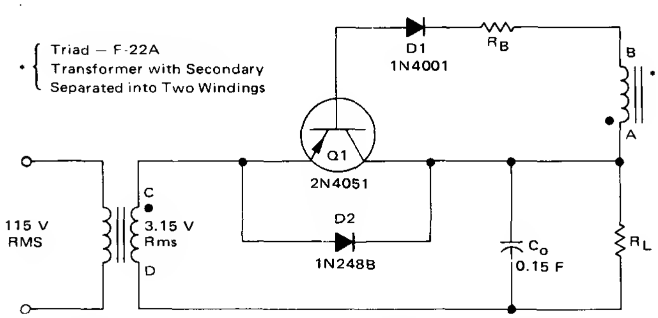
12-V EMERGENCY POWER—Trickle-charge circuit and 12-V motorcycle battery provide reliable emergency power for battery-operatad weather radio, portabla AM/FM receiver, or hend-held transceiver for many hours. 100K pots drop voltage to 9 V for aach receiver. Lamp can be auto dome light. GE-63 pilot lamp in charging circuit acts as current limiter and charge indicator.—J. Rice, Simple Emergency Power, *QST*, March 1978, p 42.



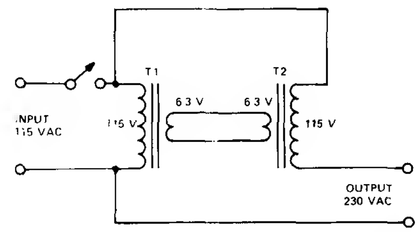
130 AND 270 V FOR CRT—High-voltaga power supply provides 270 V raquired for deflection plates of 2AP1-A CRT used as RTTY tuning indicator, as well as 130 V for high-voltage amplifiar. Large capacitor keeps ripple voltage low.—R. R. Perry, RTTY CRT Tuning Indicator, *73 Magazine,* Sapt. 1977, p 118–120.



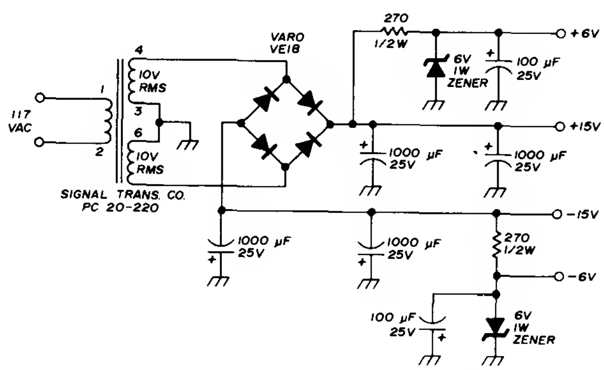
12 VDC TO 115 VAC AT 100 W—566 function generator provides triangle output at 60 Hz with frequency stability better than ±0.02%/°C. 540 power driver feeds six-transistor power output stage. Transformer load attenuatas third harmonic, giving output very closa to pura 60-Hz sina wave. 566 also provides square-wave output for other purposes.—"Signetics Analog Data Manual," Signetics, Sunnyvaia, CA, 1977, p 853–854.



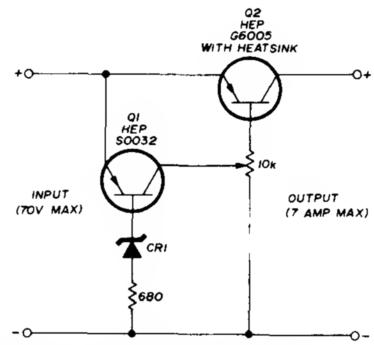
HALF-WAVE SYNCHRONOUS RECTIFIER—Transistor Q1 is synchronously biased on by AC input voltage to give efficient low-voltage regulation. When points A and C are positive with respect to points B and D, base-emitter junction of Q1 is forward-biased and collector current flows through load R_L. On negative alternations, Q1 is reverse-biased and transistor is blocked.—B. C. Shiner, "Improving the Efficiency of Low Voltage, High-Current Rectification," Motorola, Phoenix, AZ, 1973, AN-517, p 3.



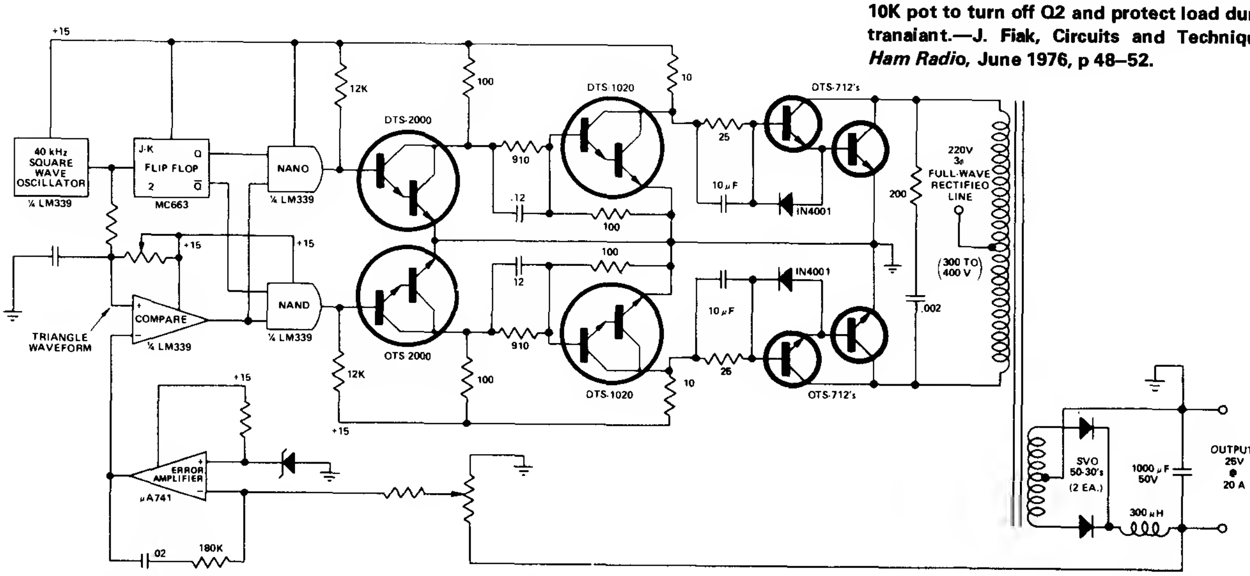
230 VAC FROM 115 VAC—Connect 6.3-V filament transformers back-to-back as shown to get 230 V when step-up transformer is not available. 115-V windings must be phased properly in series; if wrong, output voltage will be zero. Output power rating at 230 V is somewhat less than twice the power (E × I) rating of smallest filament transformer. If 6.3-V 10-A transformers are used, power rating would be about 100 W (less than 2 × 6.3 × 10).—A. E. McGee, Jr., Cheap and Easy 230 Volt AC Power Supply, *73 Magazine*, Aug. 1974, p 64.



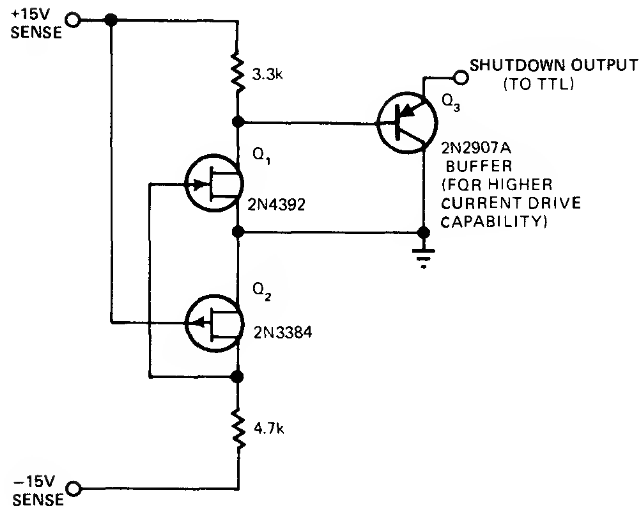
±6 V AND ±15 V—Suitable for use when frequency or some other critical parameter of load is not dependent on voltage. Developed for use in CMOS IC function generator.—R. Megirian, Integrated-Circuit Function Generator, *Ham Radio*, June 1974, p 22–29.



TRANSIENT ELIMINATOR—Used between DC power supply and load to eliminate supply transients that might damage semiconductor devices. Zener rating should be about 10% higher than supply voltage so Q1 is normally turned off. Q2 is normally conducting. When voltage spike is present on input line, zener conducts and turns Q1 on. Q1 then places positive bias on 10K pot to turn off Q2 and protect load during transient.—J. Fisk, Circuits and Techniques, *Ham Radio*, June 1976, p 48–52.

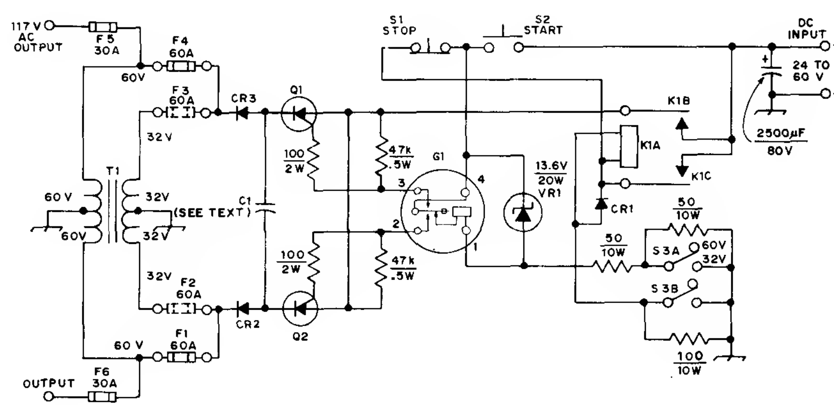


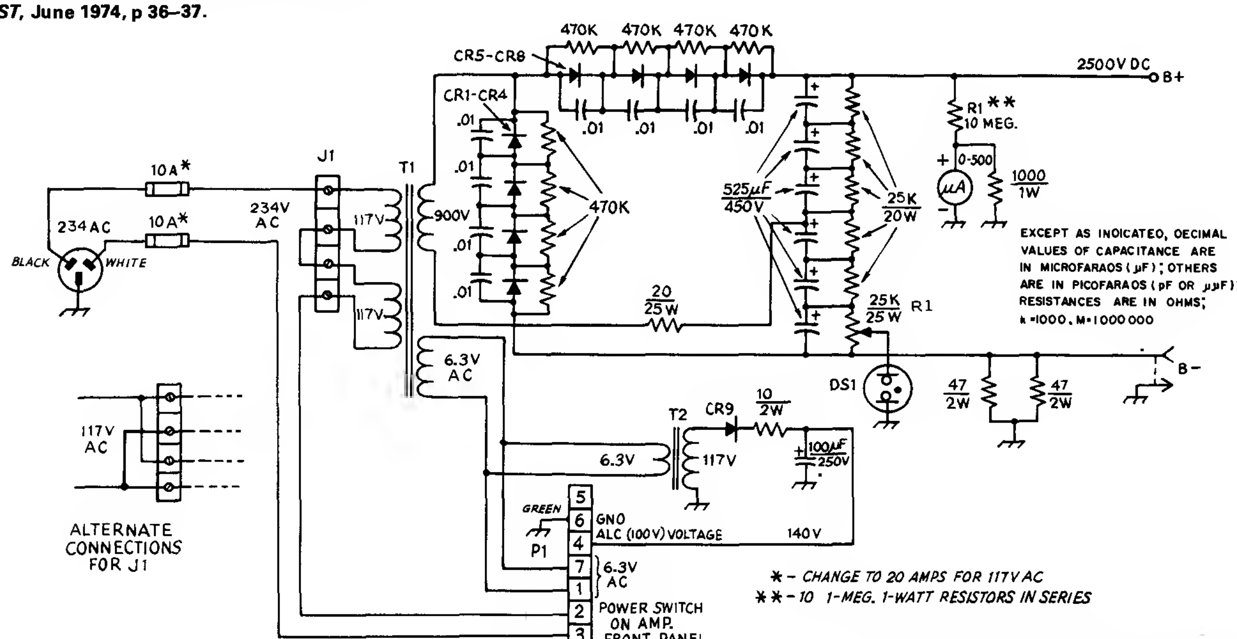
500 W AT 20 kHz—Uses four Delco DTS-712 transistors in push-pull Darlington configuration, with pulse-width modulation on push-pull inverter providing regulation. Can be operated from 220-VAC three-phase full-wave rectified line. Efficiency is up to 80%. Square-wave output of 40-kHz primary oscillator drives JK flip-flop that generates complementary square waves and divides frequency by 2 with necessary symmetry. NAND gates establish primary ON/OFF periods of power stage. Portion of output signal is compared to reference voltage, and error signal is fed to NAND gates to give regulation better than 0.1% for load range of 200–500 W or line range of 300–400 V.—"A 20 kHz, 500 W Regulating Converter Using DTS-712 Transistors," Delco, Kokomo, IN, 1974, Application Note 55.



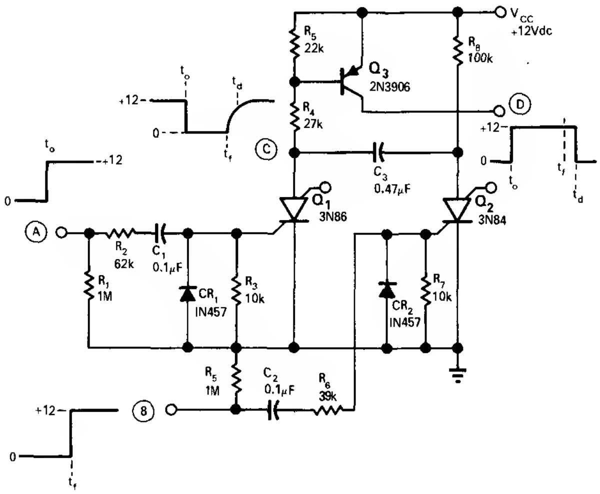
SHUTDOWN PROTECTION—Used with digital logic to prevent generation of false logic signals when power supply is turned on or turned off. FETs sense +15 V and −15 V supplies and conduct when either supply drops below pinch-off voltage, activating shutdown output. With values shown, shutdown output is disabled when supplies exceed about 4 V, to provide normal operation.—E. Burwen, Power-Supply Monitor Suppresses Falsa Output Signals, *EDN Magazine*, Nov. 5, 1977, p 110 and 112.

117 VAC FROM 24–60 VDC—Will operate from either 24- or 32-V storage battery or from 60-VDC source. Circuit shown is set up for 60-V operation. For 24/32 V, remove F1 and F4 and insert F2 and F3, then switch S3 to 32 V. T1 is 117-V 20-A Variac with bifilar primary winding added; use 38 bifilar turns of No. 8 for 24 V and 48 turns for 32 V. Commutating capacitor C1 consists of tan 120-μF 400-VDC oil-filled capacitors (do not usa electrolytics). SCRs Q1 and Q2, ratad 100 A at 800 PIV (Poly Paks 92CU1167), are switched by Cornell-Dubilier 98600 60-Hz 12-V vibrator. VR1, which limits voltage across vibrator coil, consists of two 6.8-V 10-W zenars. With 60-V operation, use 1-ohm 200-W resistor in series with invartar while starting, but short it out while inverter is running. Invertar output voltage varies from 150 VAC no-load to 110 VAC with 1650-W resistive load. CR1 is 400-PIV 200-A silicon. CR2 and CR3 are 800-PIV 250-A silicon.—R. Dunaja, A High-Power SCR Inverter, *QST*, June 1974, p 36–37.



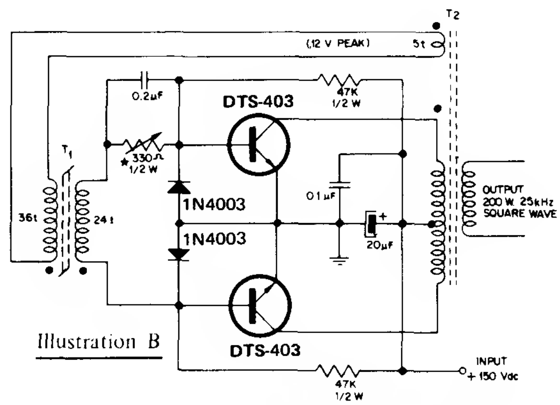


2500 V AT 500 mA—Meets power requirements for 2-kW linear amplifier using pair of 8873 conduction-cooled triodes for SSB transmitter service. Powar transformar is Hammond 101165. Diodes are 1000 PIV at 2.5 A, such as Motorola HEP170. T2 is Stancor P-8190 rated 6.3 V at 1.2 A. DS1 is 117-V neon pilot lamp. Set tap on R1 5000 ohms from B−lead. Make adjustments only aftar turning off powar and allowing time for capacitors to discharge; output voltages are dangerous.—R. M. Myers and G. Wilson, 8873s in a Two-Kilowatt Amplifier, *QST*, Oct. 1973, p 14–19.



LOW STANDBY DRAIN—Positive 12-V pulse at input A triggers SCS Q_1 and turns on transistor switch Q_3. Positive pulse at input B gates SCS Q_2 on and turns off Q_3. Current drain is essentially zaro (typically 3 μA). Circuit was designad to supply up to 7 mA of switched currant from 12-VDC supply.—D. B. Hackman, Bistable Switch with Zero Standby Drain, *EDN/IEEE Magazine,* Oct. 1, 1971, p 42.

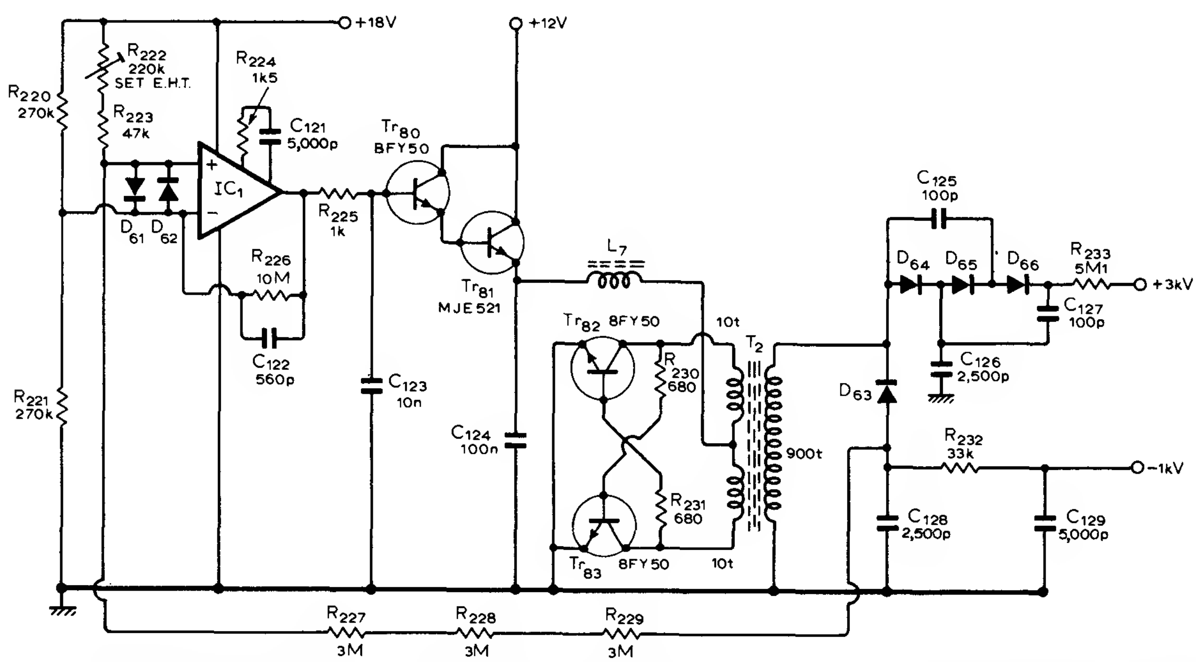
200 W AT 25 kHz—Two Dalco DTS-403 high-voltage silicon transistors ara connacted as push-pull oscillator operating on 150-VDC bias. Efficiency is 78% at full load. Diodes serva alternately as steering and clamp diodes.—"25 kHz High Efficiancy 200 Watt Inverter," Dalco, Kokomo, IN, 1971, Application Nota 47.



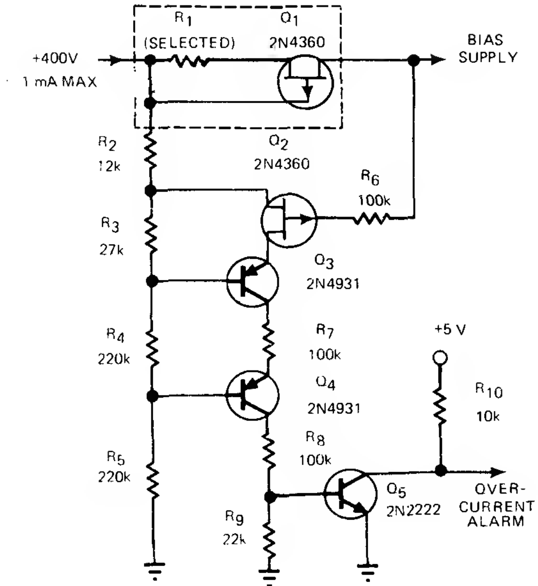
T_1	Pri:	36 t#30 AWG
	Sec:	24 t#25 AWG
	Core:	Ferroxcube 266 T 125-3E2A Ferrite toroid
T_2	Pri:	126 t tapped @ 63t, 40 strands #38 AWG litz
	*Sec:	2.38 V/t
	Feedback:	5t #25 AWG
	Core:	Ferroxcube (ferrite toroid) 528T500-3C5

★ Adjust value of resistor for maximum efficiency at full load.

* To be determined by individual requirements.

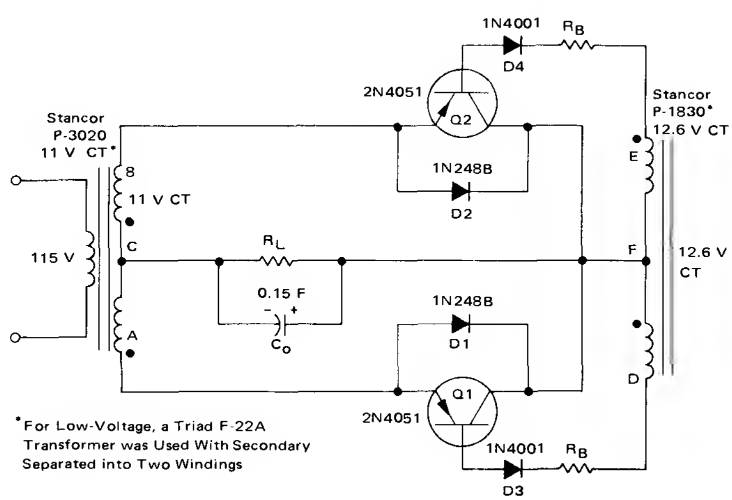


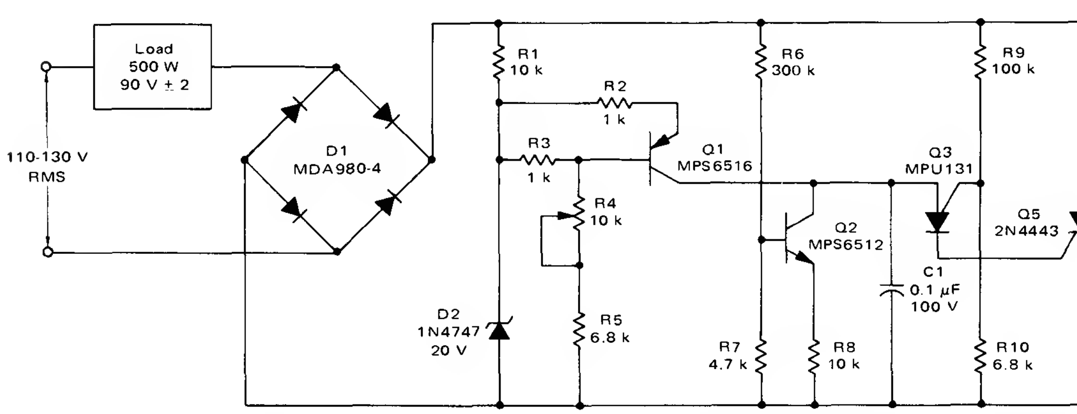
3 kV FOR CRO—Circuit also provides 1-kV nagative supply at 2 mA, as required for cathode-rey tube of oscilloscope. Positive supply furnishas 50 μA at 3 kV. Design uses transistor invertar oparating at about 20 kHz to simplify filtering. Tr_{82} end Tr_{83} form current-switched class D oscillator producing sine weves et high efficiency. Currant multiplication is provided by Tr_{80} and Tr_{81} for 709 IC opamp.—C. M. Littla, A 50 MHz Oscilloscope, *Wireless World,* July 1975, p 319–322.



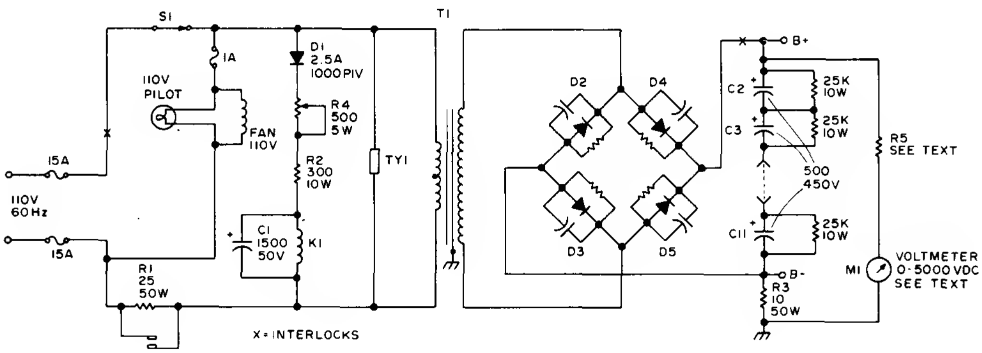
OVERCURRENT PROTECTION FOR 400-V SUPPLY—R_1 end Q_1 form current detector for bies supply. At normal currant levels, voltage drop is very smell end Q_2 is reverse-biesed. When current raeches 400 μA, voltege drop across R_1 forces gete of Q_1 to near pinchoff. Combined voltage drop ecross R_1 end Q_1 then becomes large so Q_2 is forced elmost to full conduction. Q_3 and Q_4 then turn on Q_5, to provide ovarcurrent-elerm signel for activeting logic circuit thet shuts off power supply.—J. P. Thompson, Overcurrent Alerm Protects HV Supply, *EDN Magazine*, Nov. 20, 1978, p 321–322.

FULL-WAVE SYNCHRONOUS RECTIFIER—Trensistors ere biesed on elternately by AC input voltega, to supply loed current on eltarnate helf-cycles. Silicon diodas D1 end D2 protect transistors from cherging current of cepecitiva loed when circuit is turned on. Capacitor discharga problems era minimized by use of diodes D3 end D4 in besa circuits of transistors.—B. C. Shiner, "Improving tha Efficiency of Low Voltage, High-Currant Rectificetion," Motorole, Phoanix, AZ, 1973, AN-517, p 4.





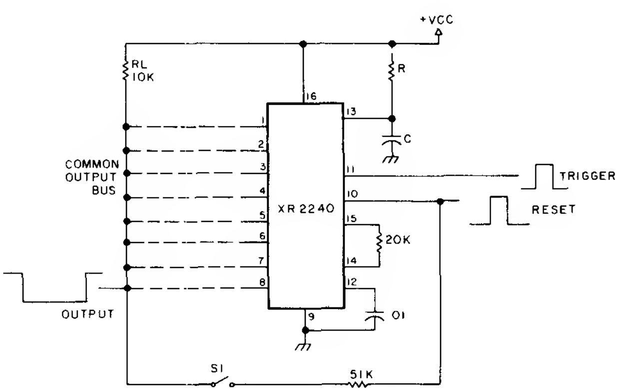
90 VRMS AT 500 W—Open-loop RMS voltege regulator ects with full-wave bridge to provida good AC voltaga reguletion for AC load over lina voltage renge of 110–130 VAC. As input voltage increesas, voltage ecross R10 incraases end serves to increesa firing point of PUT Q3. This dalays firing of SCR Q5 to hold output voltaga fairly constent es input voltaga incraases. Dalay network of Q1 prevants circuit from latching up at baginning of each charging cycle for C1.—R. J. Hever end B. C. Shiner, "Theory, Characteristics and Applications of the Programmable Unijunction Trensistor," Motorole, Phoenix, AZ, 1974, AN-527, p 11.



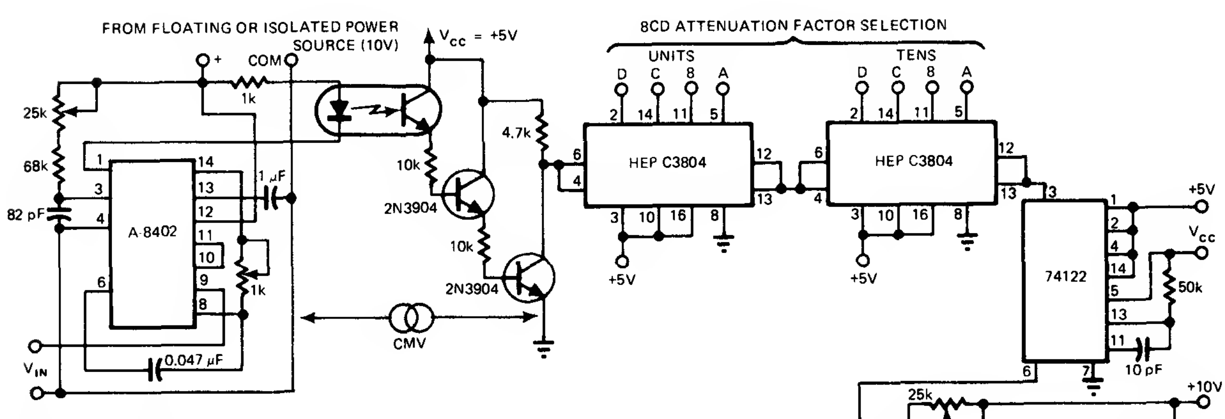
3-kV SUPPLY—Circuit uses full-wave bridge rectifier D2-D5, with each diode stack constructed from two 1000-PIV 2.5-A diodes in series. Each diode pair is shunted by 470K 1-W resistor and 0.01-μF 1000-V disk capacitor. C2-C11 are 500 μF at 450 VDC. Capacitor combination thus gives equivalent of 50 μF for filter, rated 4500 V. When using 500-μA movement for output voltmeter, R5 should be ten 1-megohm resistors in series. Thyrector TY1 is GE 6R520SP4B4. T1 has 2200-V secondary rated 500 mA. K1 is 24-V relay. Article covers construction and stresses safety precautions.—E. H. Hartz, 3000 VDC Supply, *73 Magazine*, July 1974, p 69–72.

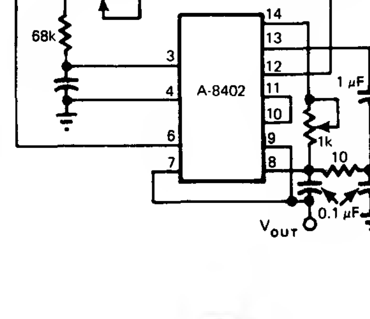
CHAPTER 69
Programmable Circuits

Circuits having 1 to 11 digital control inputs provide switch, logic, or computer-programmed choice of values for variables such as attenuation, division ratio, filter center frequency, math function, pulse width, or output frequency. See also Microprocessor chapter.

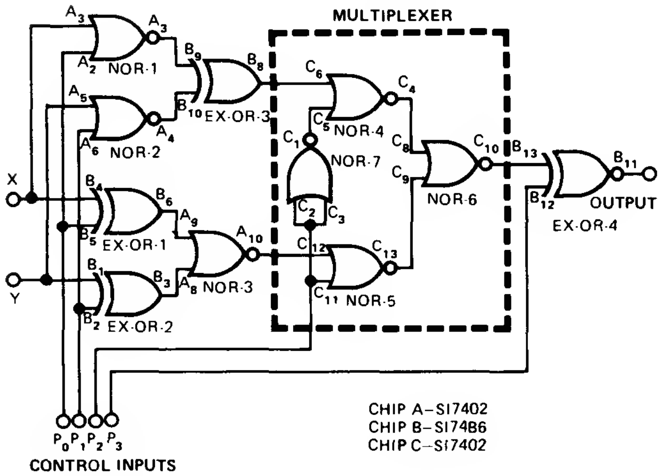


TIMER/COUNTER—Basic circuit using XR2240 programmable timar/counter acts as programmeble mono whan S1 is closed, with output pulsa width being a multiple in binary of RC seconds. With 8-bit binary counter, tima deleys ranga from 1 RC to 255 RC seconds. As an exemple, if only pin 6 (dividing input frequency by 32) is connected to common output bus, duration of output pulsa will ba 32 RC saconds. Similarly, with pins 1, 2, 5, and 7 connactad to bus, dalay is 83 RC seconds. With S1 open for astable operation, output frequency is 1/t hertz where t is multipla of RC from 1 to 255. VCC is 4–15 V.—H. M. Barlin, IC Timer Review, *73 Magazina*, Jan. 1978, p 40–45.



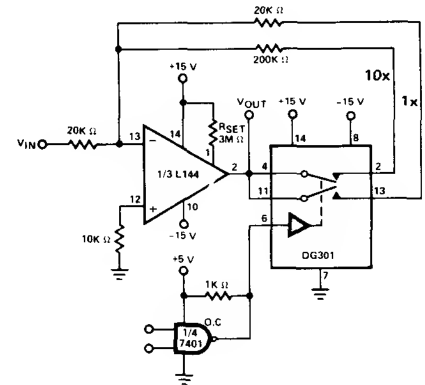


BCD CONTROL OF GAIN—Provides optically couplad input and BCD-selected ettanuation factor, for combination with fixad-gain DC amplifier to give programmable gain capability. Output of A-8402 V/F converter faads progremmebla modulo-n decade countar chein through optoisolator, to giva fraquency division by BCD factor applied to salactor inputs. 74122 retriggerabla mono MVBR mekas duty cycla of countar output competibla with requirements of second convertar connected to giva output voltege that is scaled reproduction of input voltage. Circuit performance is comparable to that of high-cost instrumantation amplifier.—K. W. Kissinger, Low-Cost Isolation Amp Provides BCD-Selectebla Gain, *EDN Magazine*, Oct. 20, 1977, p 82–83.

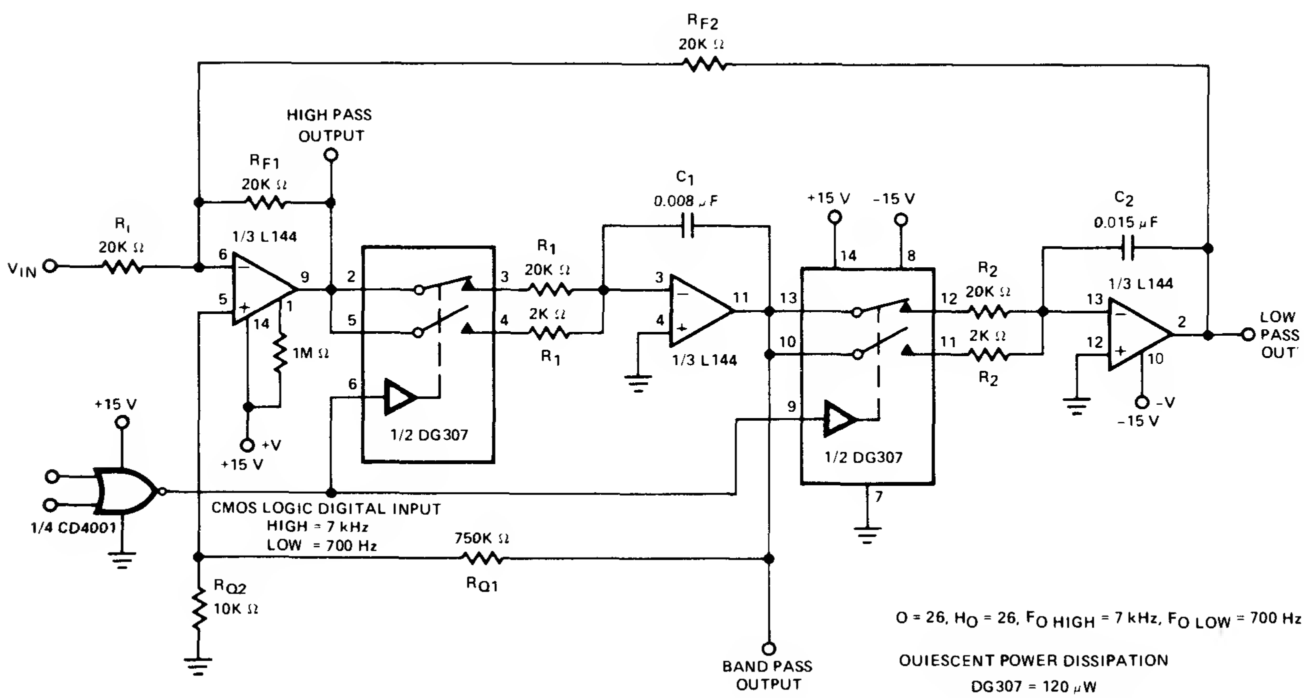


PROGRAMMING INPUT				OUTPUT
P_3	P_2	P_1	P_0	
0	0	0	0	$\overline{X+Y}$
0	0	0	1	$X\ \overline{Y}$
0	0	1	0	$\overline{X}\ Y$
0	0	1	1	$X \cdot Y$
0	1	0	0	$X \quad Y$
0	1	0	1	$\overline{Y}$
0	1	1	0	$\overline{X}$
0	1	1	1	1
1	0	0	0	$X+Y$
1	0	0	1	$\overline{X}+Y$
1	0	1	0	$X+\overline{Y}$
1	0	1	1	$\overline{X \cdot Y}$
1	1	0	0	$\overline{X \quad Y}$
1	1	0	1	Y
1	1	1	0	X
1	1	1	1	0

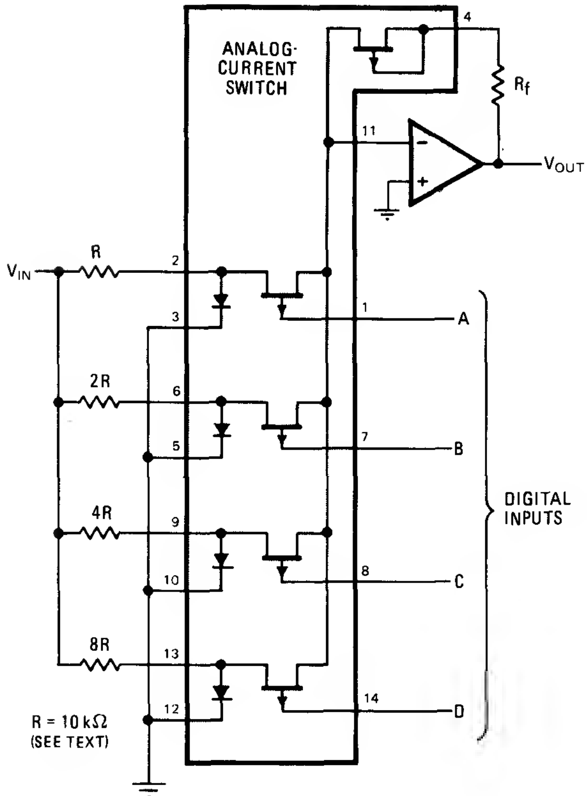
16 FUNCTIONS OF X AND Y—With only threa IC chips, circuit providas choice of any ona of 16 possible functions of two Boolean variablas. Table shows output states for all programming combinations of control inputs P.—S. Murugesan, Programmabla Logic Circuit Has Varsatile Outputs, *EDN Magazine*, Fab. 5, 1975, p 57.



DIGITALLY SELECTABLE GAIN—TTL controls oparation of DG301 low-power analog switch at output of invarting opamp. Low logic givas gain of 1, and high logic gives gain of 10.—"Analog Switches and Thalr Applications," Siliconix, Santa Clara, CA, 1976, p 7-90.



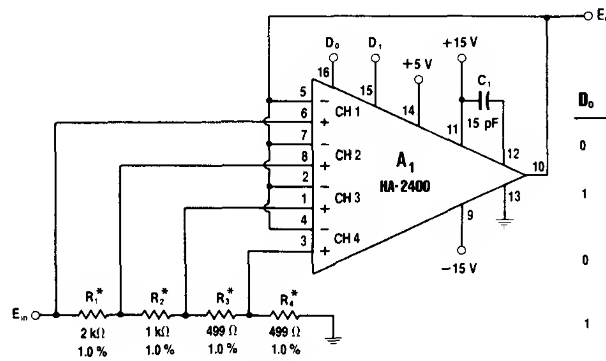
PROGRAMMABLE-FREQUENCY STATE-VARIABLE—Providas choica of low-pass, high-pass, and bandpass outputs with logic-selectable centar frequency of 700 or 7000 Hz. Logic input controls DG307 low-power dual analog switch for changing valuas of frequency-determining resistors R_1 and R_2.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-86.



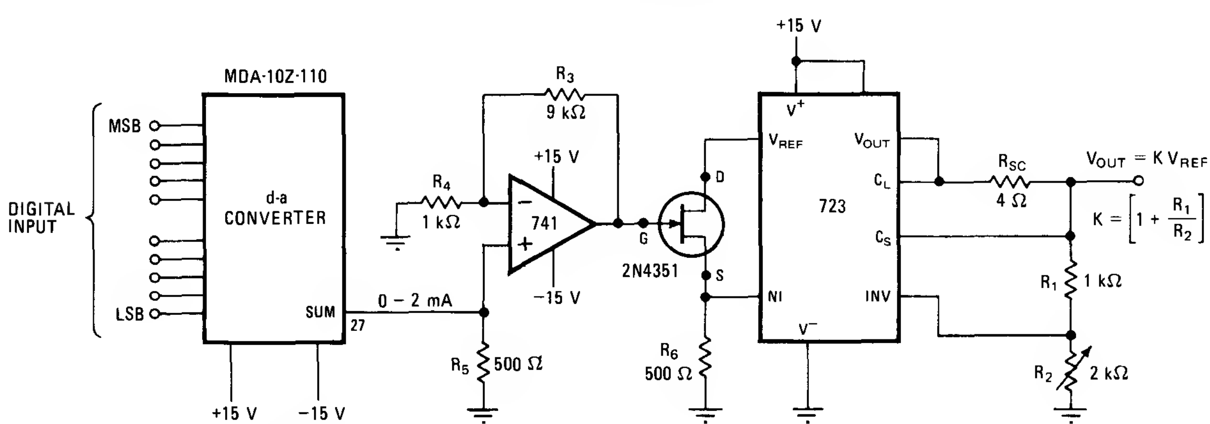
$$V_{OUT} = -V_{IN}\frac{R_f}{R}\left[\bar{A}\,(2^0) + \bar{B}\,(2^{-1}) + \bar{C}\,(2^{-2}) + \bar{D}\,(2^{-3})\right]$$

GAIN-PROGRAMMABLE AMPLIFIER—National AH5010 4-bit current-mode analog switch for TTL input is used with general-purpose opamp such as LM118 to give multiplying D/A converter at low cost. For CMOS control logic, use AM97C10 switch. Use of 10K for gain-programming resistor R gives compromise between switch resistence and switch leakage. Use 0.2% tolerance resistors for R end 2R, 0.5% for 4R, and 5% for highest resistance, with 0.1% tolerance for feedback resistor R_f which is also 10K, to give overell accuracy within 0.2%.—J. Maxwell, Anelog Current Switch Makes Gain-Programmeble Amplifier, *Electronics*, Feb. 17, 1977, p 99 and 101.

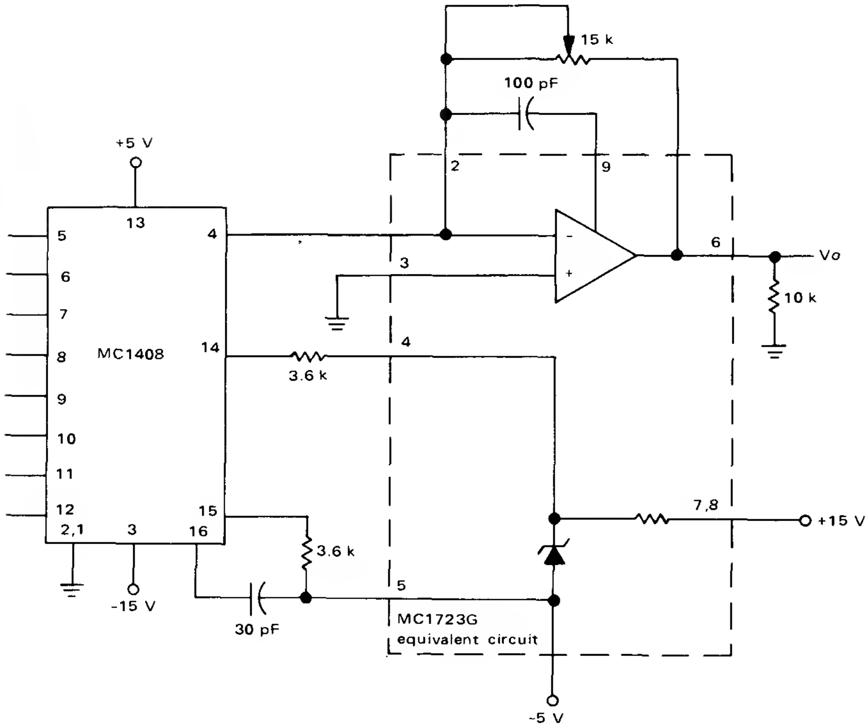
FOUR-STATE ATTENUATOR—HA-2400 four-channal programmeble amplfiier is used as non-inverting four-state attenuetor controlled by logic inputs 0 and 1 to D_0 and D_1. Output voltage for each logic combinetion is given in truth teble. Velues shown provide gains of 1, ½, ¼, and ⅛.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sams, Indienapolis, IN, 1974, p 429–431.



D_0	D_1	E_0
0	0	E_{in}
1	0	$E_{in}\left(\frac{R_2+R_3+R_4}{R_1+R_2+R_3+R_4}\right)$
0	1	$E_{in}\left(\frac{R_3+R_4}{R_1+R_2+R_3+R_4}\right)$
1	1	$E_{in}\left(\frac{R_4}{R_1+R_2+R_3+R_4}\right)$

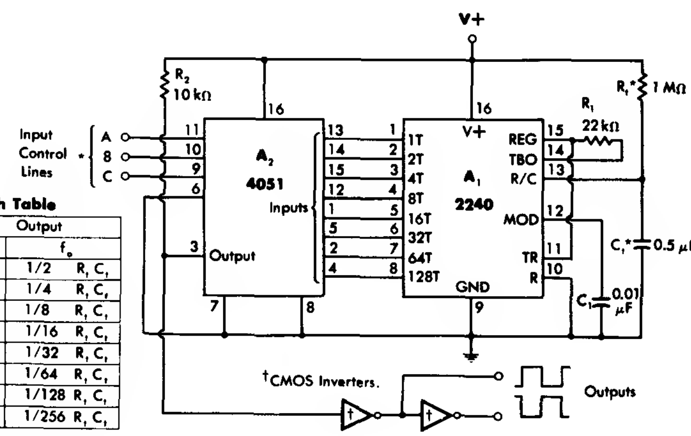


CONTROLLING REGULATOR OUTPUT—Digital control of D/A convarter determines output voltage of regulator, with FET serving as voltage-varieble resistor. Applications include generation of sequenca of voltagee for testing components or equipment. Analog Devices MDA-10Z-110 converter generates 0–2 mA output with resolution determined by 10-bit digital input. 741 opamp trensforms current to 0–6 V output for verying output of 723 reguletor over range of 7–37 V at 150 mA maximum.—C. Viswanath, D-A Convertar Controls Programmable Power Source, *Electronics*, July 21, 1977, p 125.



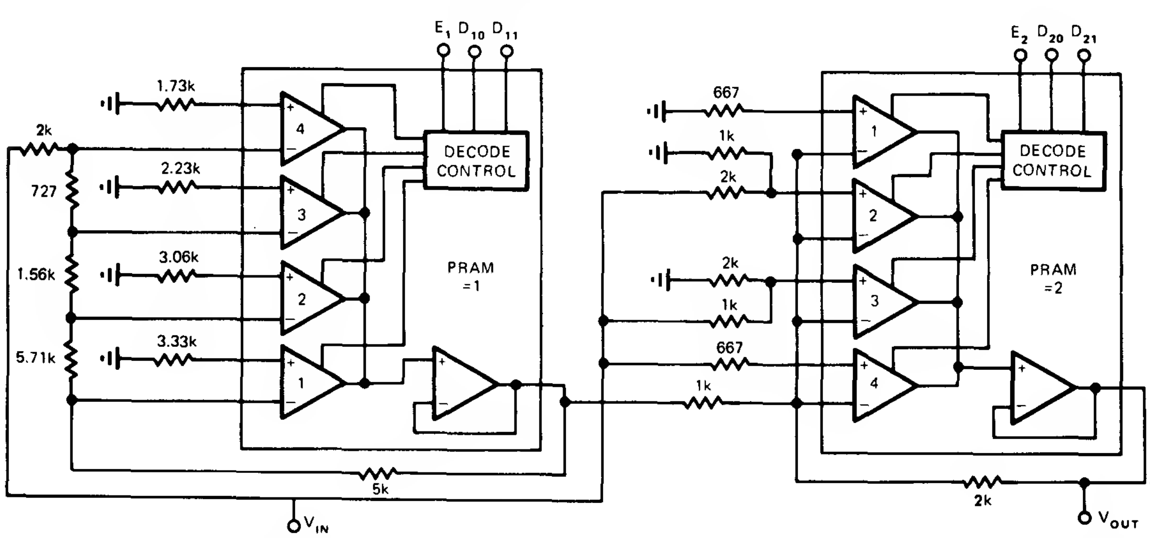
0–12 V PROGRAMMABLE—Combination of Motorola MC1408 DAC and MC1723 regulator gives digitally programmable voltages in 0.1-V increments at currents in excess of 100-mA. Can be used as programmable lab power supply, computer-controlled supply for automatic test equipment, or in industrial control systems. Requires ±5 V and ±15 V supplies. Voltage range can be increased to 25.5 V if positive supply is increased to 28.5 V or higher.—D. Aldridge and N. Wellenstein, "Designing Digitally-Controlled Power Supplies," Motorola, Phoenix, AZ, 1975, AN-703, p 3.

PROGRAMMABLE ASTABLE—Square-wave output frequency of Exar XR-2240 programmable timer/counter is made digitally programmable by use of 4051 CMOS multiplexer having three-line channel-select control ABC. Lines select one of eight possible switching paths by binary combination. When all three inputs are zero, highest of eight basic output frequencies of 2240 is obtained, as shown in truth table. Circuit will yield outputs with periods of 1, 2, 4, 8, 16, 32, 64, and 128 s.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 123–125.

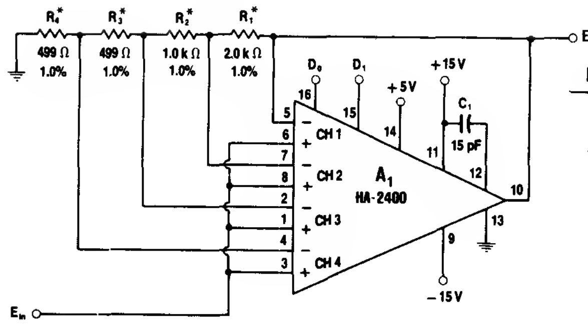


***Truth Table**

Input			Output	
C	B	A	n	f_o
0	0	0	1	1/2 R_1C_1
0	0	1	2	1/4 R_1C_1
0	1	0	4	1/8 R_1C_1
0	1	1	8	1/16 R_1C_1
1	0	0	16	1/32 R_1C_1
1	0	1	32	1/64 R_1C_1
1	1	0	64	1/128 R_1C_1
1	1	1	128	1/256 R_1C_1



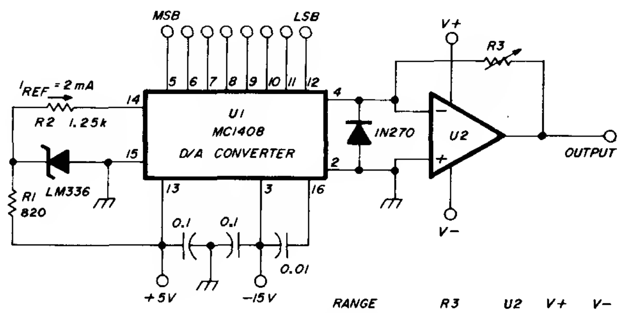
PROGRAMMABLE-GAIN OPAMP—Cascading two HA-2400 digitally programmed amplifiers, each combining functions of analog switches and high-performance opamps on single IC chip, gives 16 different programmable gains in unit steps. Article gives truth table showing total gain obtained for 16 combinations of 0 and 1 on control lines D_{10}, D_{11}, D_{20}, and D_{21}. Enable lines are normally at 1, and E_2 is made 0 only when total gain must be zero. Applications include digital AGC and digital control of servosystems and level detectors.—J. A. Connelly, N. C. Currie, and D. S. Bonnet, Op Amp Has 16-Step Digital Gain Control, *EDN Magazine*, May 5, 1974, p 75 and 77.



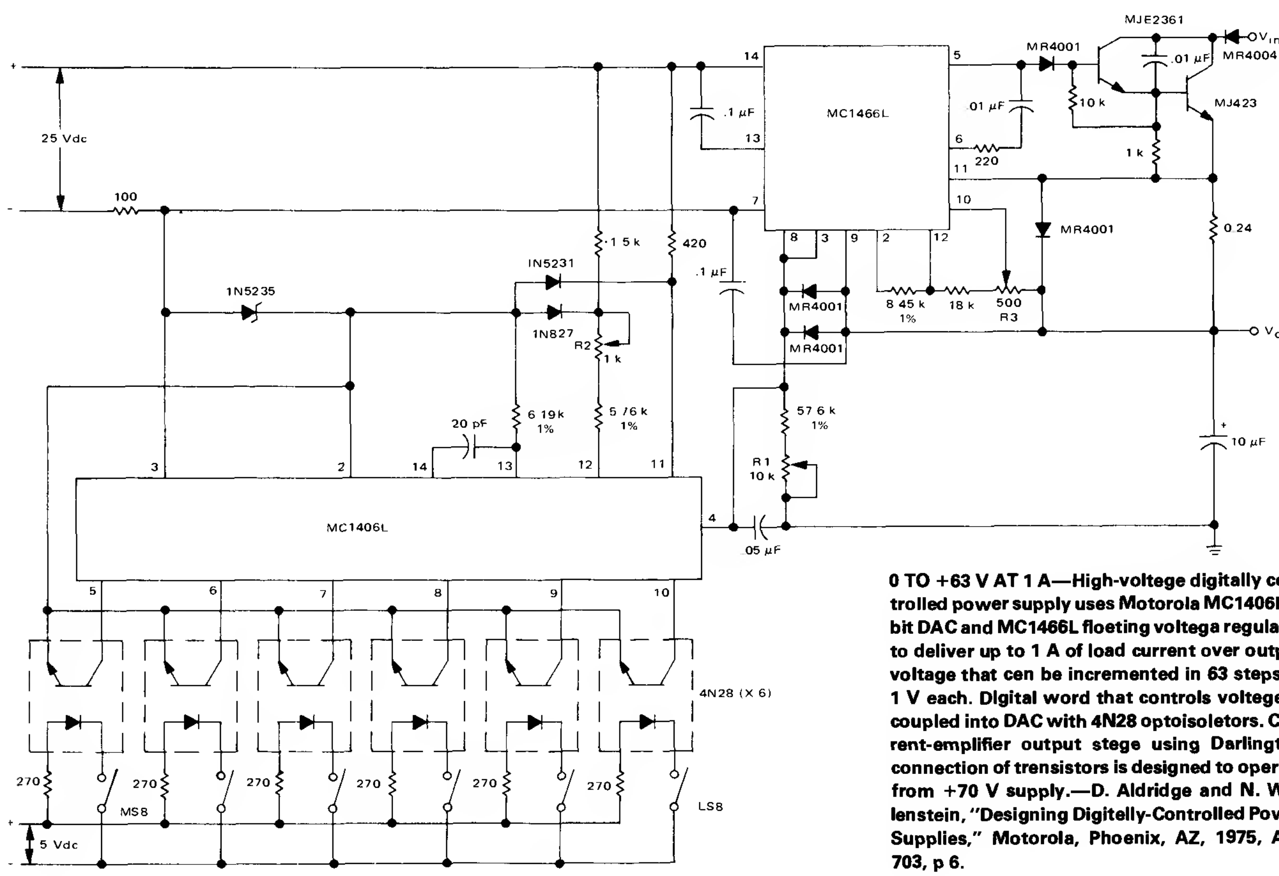
D_0	D_1	E_0
0	0	E_{in}
1	0	$E_{in}\left(\frac{R_1+R_2+R_3+R_4}{R_2+R_3+R_4}\right)$
0	1	$E_{in}\left(\frac{R_1+R_2+R_3+R_4}{R_3+R_4}\right)$
1	1	$E_{in}\left(\frac{R_1+R_2+R_3+R_4}{R_4}\right)$

FOUR-STATE AMPLIFIER—HA-2400 four-channel programmable amplifier is used with tepped voltage divider in feedback loop to give geins of 1, 2, 4, and 8 controlled by logic inputs to D_0 and D_1 es shown In truth table. Amplifier Is noninverting.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sems, Indienepolis, IN, 1974, p 431–432.

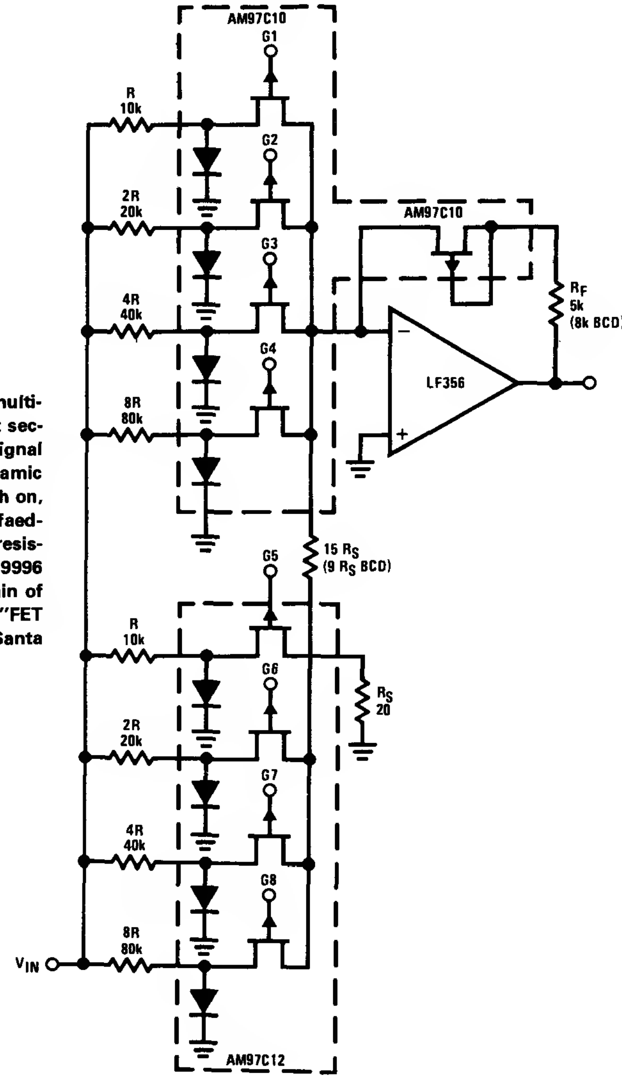
PROGRAMMED 0–25.5 V—Uses D/A convertar and 2.5-V zener to form digitally programmed voltage refarance. Binery-coded TTL information selacts voltage rangas of 0–2.55 V or 0–25.5 V. Can be used as leb source heving 10 mV per step in low renge end 100 mV per step in high renge. Output is adjusted with 8-bit input control. R3 determines besic voltage renge, being set at 1280 ohms for low range and 12.8K for high renga. Although 741 or other generel-purpose opamp is adequete for low renge, higher-voltage single-supply opamp such as 759 is better for high range end for both rangas, bacausa it gives higher output current on low range.—W. Jung, An IC Op Amp Update, *Ham Radio,* March 1978, p 62–69.



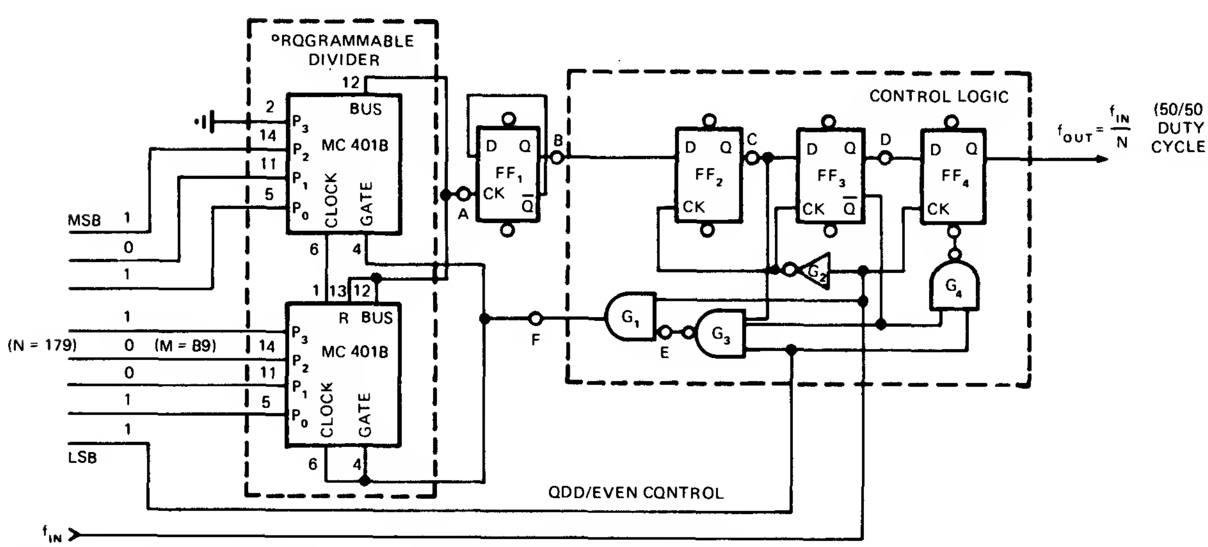
RANGE	R3	U2	V+	V−
0 TO +2.55V	1280 OHMS	741	+5V	−15V
0 TO +25.5V	12.80 k	759	+28V	GND



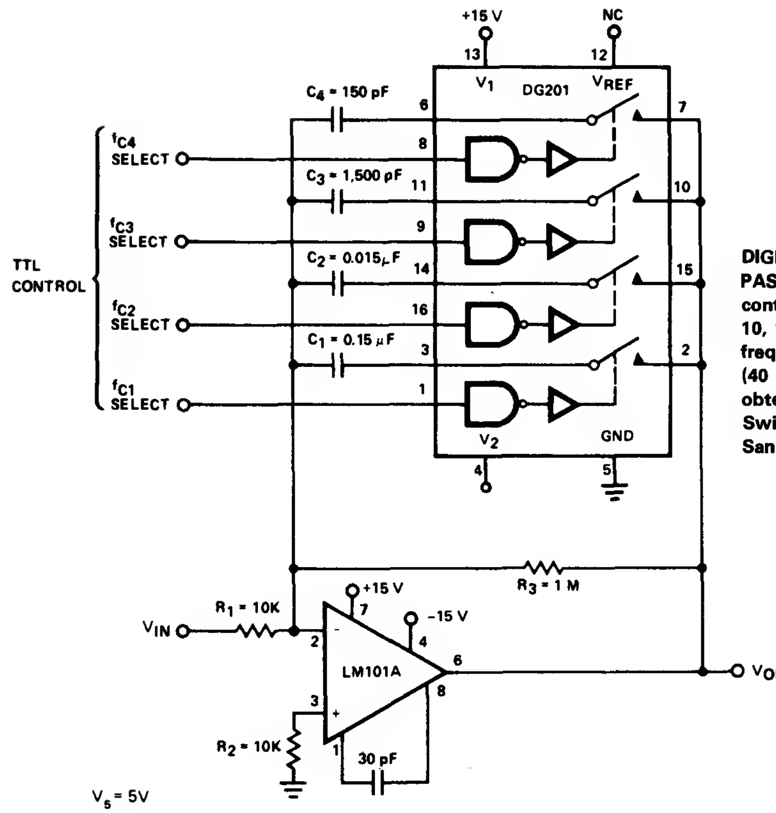
0 TO +63 V AT 1 A—High-voltage digitally controlled power supply uses Motorola MC1406L 6-bit DAC and MC1466L floeting voltega regulator to deliver up to 1 A of load current over output voltage that cen be incremented in 63 steps of 1 V each. Digital word that controls voltege is coupled into DAC with 4N28 optoisoletors. Current-emplifier output stege using Darlington connection of trensistors is designed to operate from +70 V supply.—D. Aldridge and N. Wellenstein, "Designing Digitelly-Controlled Power Supplies," Motorola, Phoenix, AZ, 1975, AN-703, p 6.



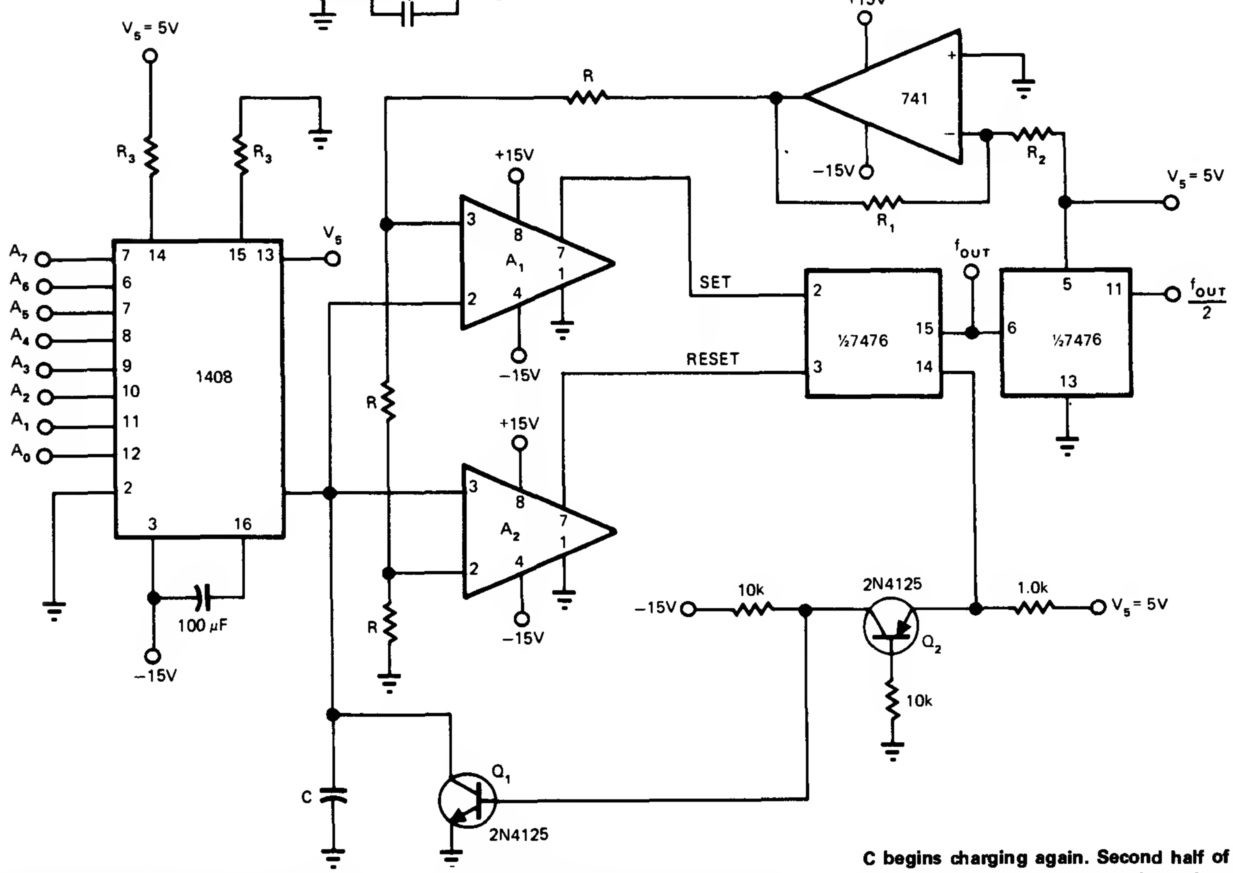
GAIN-PROGRAMMED AMPLIFIER—8-bit multiplying D/A convartar using cascaded 4-bit sections providas logic-controlled gain for signal praconditioning, leval control, and dynamic ranga expansion. Logic 0 turns JFET switch on, and logic 1 turns switch off. Sarias FET in faedback path of opamp compansatas for ON resistanca of JFET switch. Circuit has gain of 0.9996 (binary) with 5K faedback rasistor and gain of 0.99 (BDC) with 8K faedback resistor.—"FET Databook," National Samiconductor, Santa Clara, CA, 1977, p 6-47–6-49.



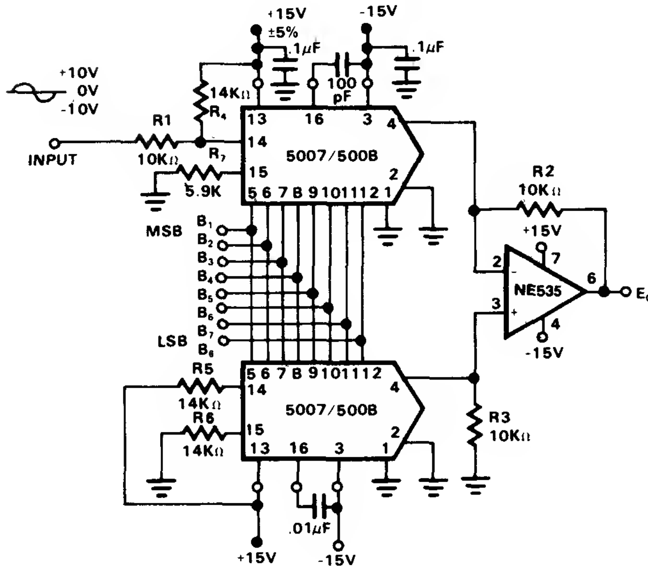
PROGRAMMED DIVIDE-BY-179—Produces symmetrical output waveforms avan if dlvidar ratios ara larga, variabla, and avan or odd. Circuit is set up for output of N = 179, for which M = 89 is programmad into dividar and odd/avan control of logic is a 0. Control logic can be simplifiad, depanding on particular requiramants; thus, if perfact symmetry is not assantial, G_4 and FF_4 can ba aliminated. Articla talls how to program for any other valua of N.—V. R. Godbola, Programmable Dividar Maintains Output Symmetry, *EDN Magazina*, July 5, 1974, p 72–74.



DIGITALLY CONTROLLED VARIABLE LOW-PASS—DG201 CMOS analog switch with TTL control permits setting of break frequency at 1, 10, 100, or 1000 Hz. Voltage gain below break frequency, determined by ratio of R_3 to R_1, is 100 (40 dB). Highest break frequency (1000 Hz) is obtained when C_4 is switched in.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-66–7-67.

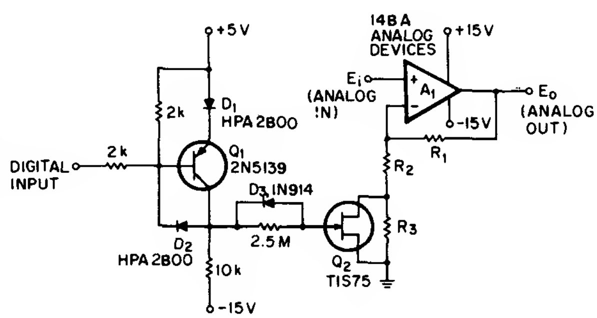


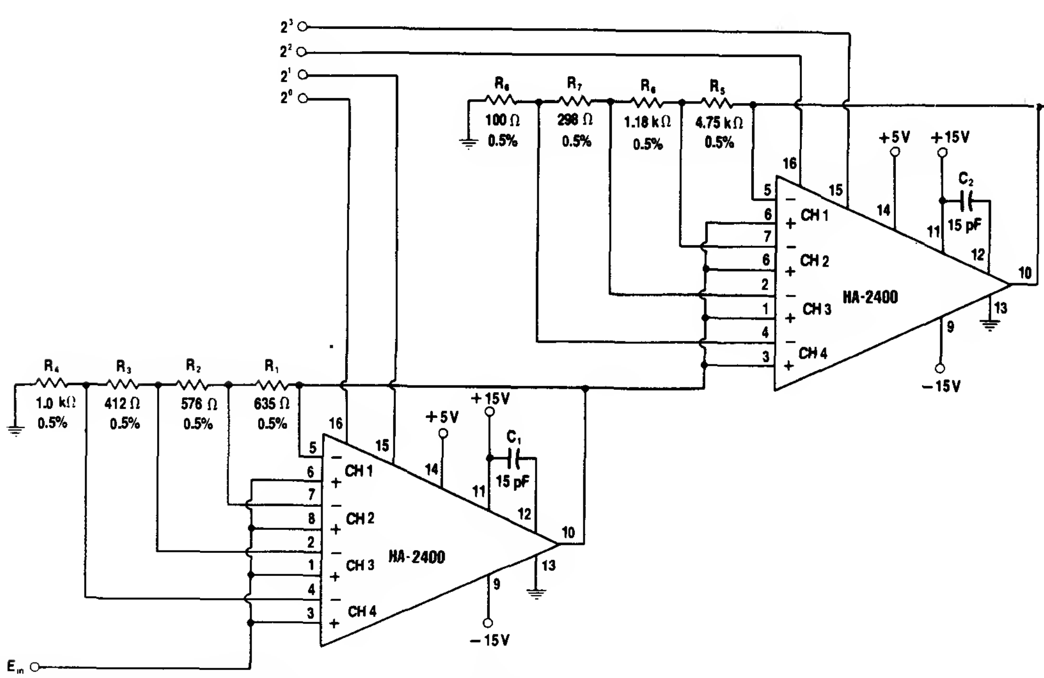
8-BIT PROGRAMMABLE INPUT—Serves as digitally programmable frequency source covering 10 to 2550 Hz for systems under microprocessor control. Frequency change is essentially instantaneous, assuring immediately valid data. Uses MC1408L8 8-bit monolithic D/A converter to supply constant current for charging C in negative direction. When capacitor voltage exceeds lower negative threshold voltage at pin 3 of LM311 high-impedance comparator A_1, comparator changes state and sets 7476 flip-flop. This turns on Q_1 through level-shifter Q_2, discharging C until it exceeds higher threshold voltage at pin 2 of A_2. Flip-flop then resets and C begins charging again. Second half of 7476 serves as divider. To cover above frequency range, values should be: R 3.9K; R_1 27K; R_2 10K; R_3 2.2K; C 0.1 µF. Circuit gives 8-bit accuracy. Design equations are presented in article.—A. Helfrick, Eight-Bit Frequency Source Suited for µP Control, *EDN Magazine*, Sept. 20, 1976, p 116 and 118.



PROGRAMMABLE GAIN—Combination of two Signetics 5007/5008 multiplying D/A converters and NE535 opamp gives digital control of attenuation and gain in audio system. AC input controls polarity of output, giving output of ±10 V for inputs from DC to 10 kHz and ±5 V if response goes up to 20 kHz.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 677–685.

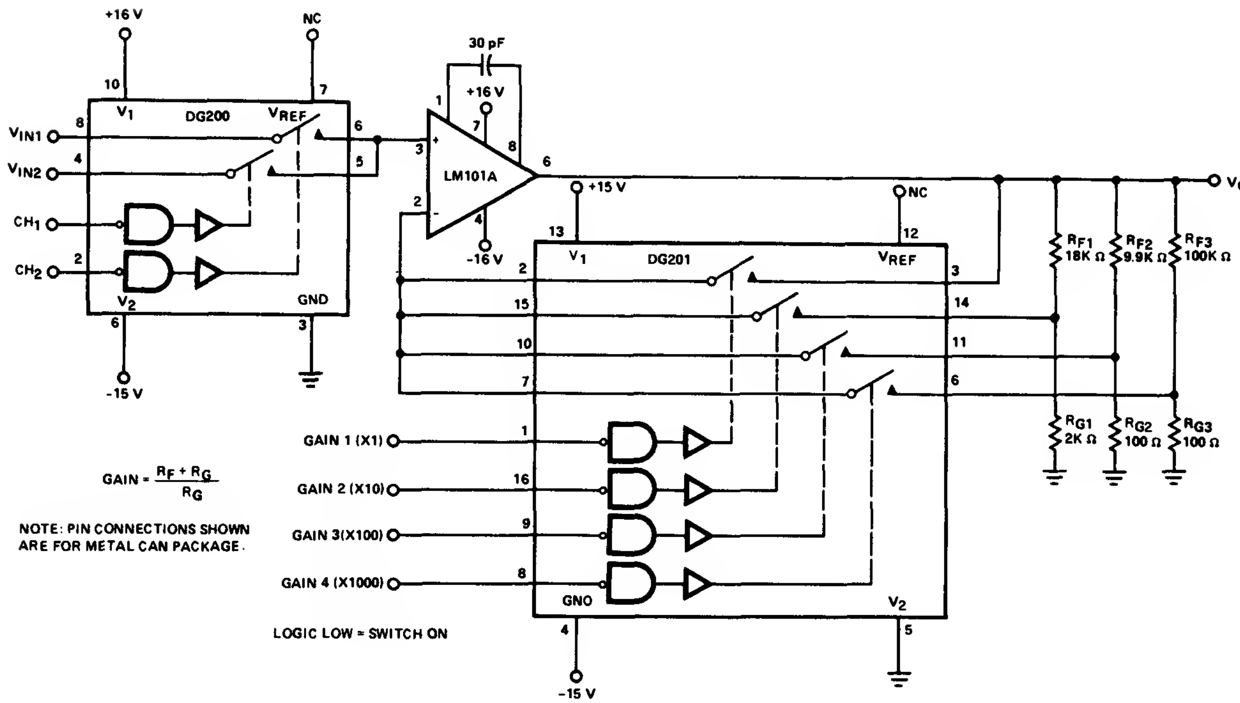
GAIN-PROGRAMMABLE—Gain of noninverting opamp can be programmed with standard digital logic levels. With input at 0 V, Q_1 is turned on but is held out of saturation by Schottky diode D_2. Resulting opamp gain is $(R_1 + R_2)/R_2$. If R_2 is 1.13 kilohms and R_1 10 kilohms, gain is 10. When input is 5 V, Q_1 is off and gate of Q_2 is driven to −15 V. Gain now becomes $(R_1 + R_2 + R_3)/(R_2 + R_3)$. If R_3 is 8.87 kilohms, gain is 2.—K. Karash, Gain-Programmable Amplifier, *EEE Magazine*, Sept. 1970, p 89.



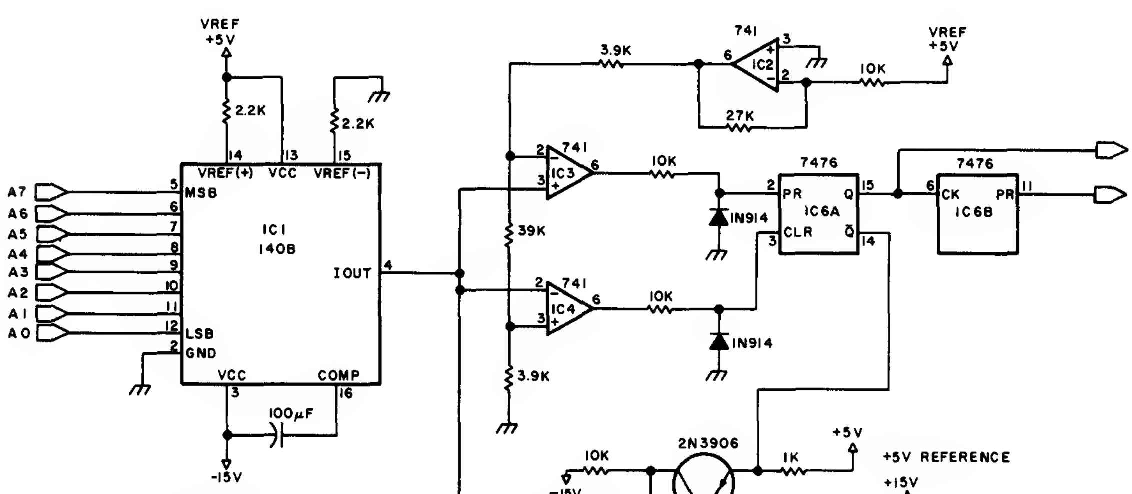


2⁰	2¹	2²	2³	A_v(dB)
0	0	0	0	0
1	0	0	0	3
0	1	0	0	6
1	1	0	0	9
0	0	1	0	12
1	0	1	0	15
0	1	1	0	18
1	1	1	0	21
0	0	0	1	24
1	0	0	1	27
0	1	0	1	30
1	1	0	1	33
0	0	1	1	36
1	0	1	1	39
0	1	1	1	42
1	1	1	1	45

MULTISTAGE PROGRAMMABLE AMPLIFIER—Cascading of two HA-2400 four-channel programmable amplifiers gives choice of 16 different values of gain, ranging from 0 to 45 dB, by applying logic pulses to control inputs for pins 15 and 16 in accordance with truth table shown.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 433–435.

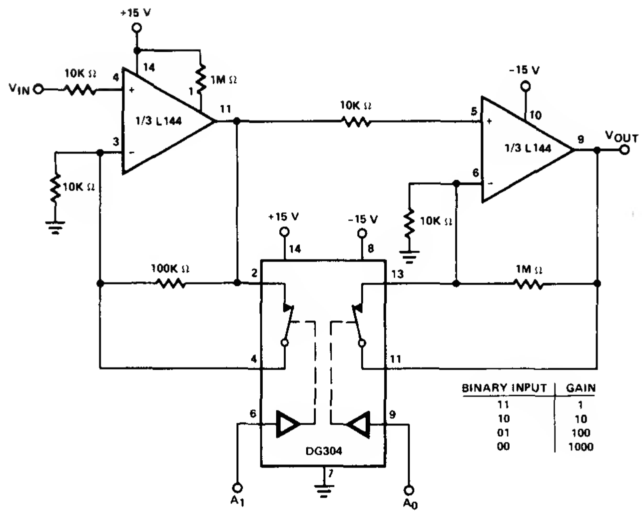


DIGITALLY PROGRAMMED INPUTS AND GAINS—DG200 CMOS analog switch gives programmable choice of two inputs to opamp, and DG201 switch gives choice of four different gain values (1, 10, 100, or 1000) for opamp. Full opamp output range of ±12 V is provided even for unity-gain position of switch.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-67.

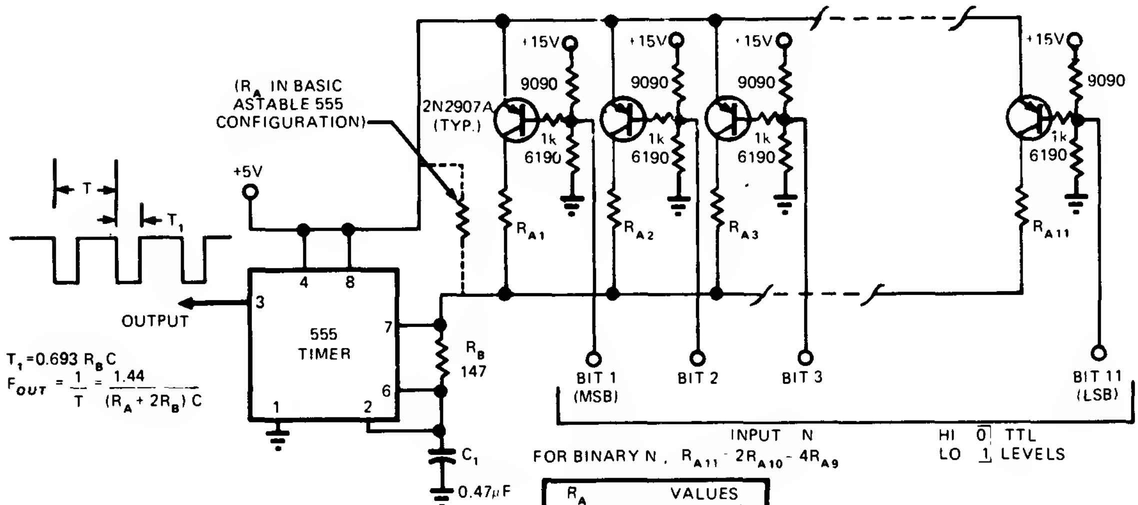


POWER CONNECTIONS					
NUMBER	TYPE	+5V	GND	+12V	-12V
IC1	1408				
IC2	741			7	4
IC3	741			7	4
IC4	741			7	4
IC5	741			7	4
IC6	7476	5	13		

OSCILLATOR CONTROL—Digitally controlled oscillator generates frequency proportional to integer output to 1408 DAC, for use as clock input of speed and direction control for bidirectional logic stepper motor serving as one output of microprocessor. Used to provide speed control for stepper. Number of bits determines number of speed selections available under computer control.—R. E. Bober, Taking the First Step, *BYTE*, Feb. 1978, p 35–36, 38, 102, 104, 106, and 108–112.



BINARY CONTROL OF GAIN—Gain of amplifier increases by decades from 1 to 1000 as binary input to A_1 and A_0 of DG304 low-power analog switch decreases from 1,1 to 0,0. Power dissipation of switch is less than 0.1 mW.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-86.

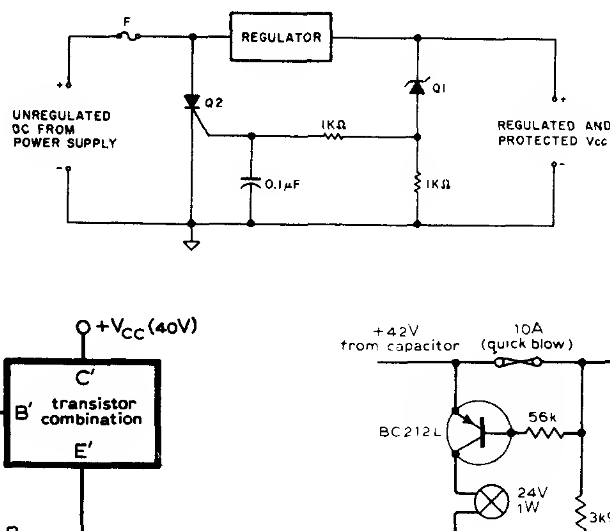


R_A	VALUES	
BIT	RES.	BIT WT. Hz
1	7.21k	413
2	14.8k	207
3	29.8k	103
4	59.8k	52
5	120k	26
6	240 k	13
7	481k	6.5
8	962k	3.2
9	1.9M	1.6
10	3.9M	0.8
11	7.7M	0.4

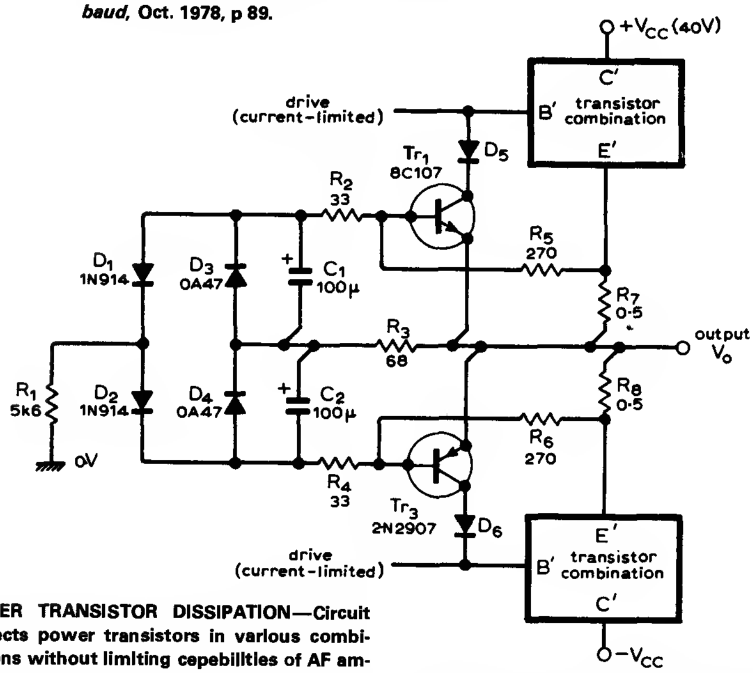
PROGRAMMABLE 0–825 Hz PULSES—Inexpensive pulse generator is programmable in 0.4-Hz steps from 0 to 825 Hz, and can be modified to extend range to 200 kHz. Circuit uses 555 connected in astable mode, with timing resistor R_A replaced by 11 sets of timing resistors and switching transistors. Inputs and outputs are TTL-compatible. When bit input is high (0), its associated transistor is turned off. When bit input is low (1), transistor is on, allowing C_1 to charge. When more than one input is low, charging is through parallel combination of resistors. Width of output pulse T_1 is constant over frequency range.—E. G. Laughlin, Inexpensive Pulse Generator is Logic Programmable, *EDN Magazine*, Aug. 20, 1974, p 92.

CHAPTER 70
Protection Circuits

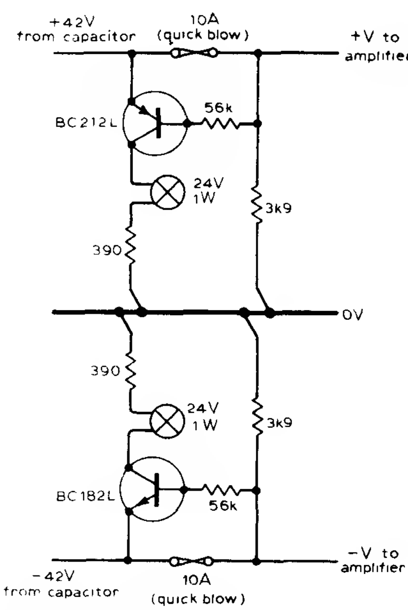
Provide protection of equipment and components from overvoltage or overcurrent conditions, ground fault, loose ground, contact arcing, and inductive transients. Also included are digital-coded or tone-coded controls for doors, auto ignition switches, and equipment ON/OFF switches, along with fail-safe interlocks and power-outage indicators. See also Burglar Alarm, Fire Alarm, Power Control, Power Supply, Regulated Power Supply, Regulator, and Siren chapters.



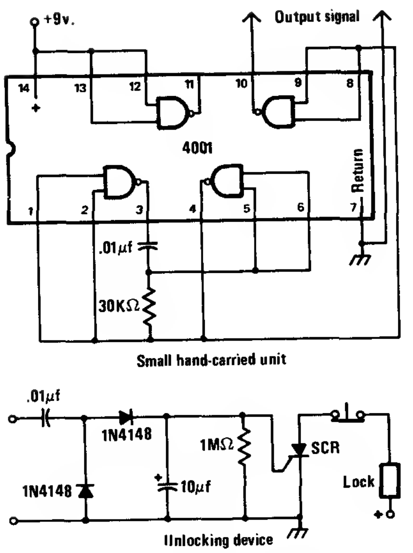
CROWBAR—When output of regulator for microprocessor power supply exceeds maximum safe voltage as determined by zener Q1, SCR Q2 is triggered on and conducts heavily, blowing fuse rapidly to protect equipment. Fuse rating is 125% of nominal load. Choose SCR to meet voltage and current requirements. Choose zener for desired trip voltage. Each germanium diode in series with Q1 will add 0.3 V to trip voltage, and silicon diodes add 0.8 V. To calibrate, place 1K resistor temporarily in series with Q2 and measure drop across it to see if SCR fires and produces surge on meter at desired V_{CC}.—J. Starr, Want to Buy a Little Insurance?, *Kilobaud*, Oct. 1978, p 89.



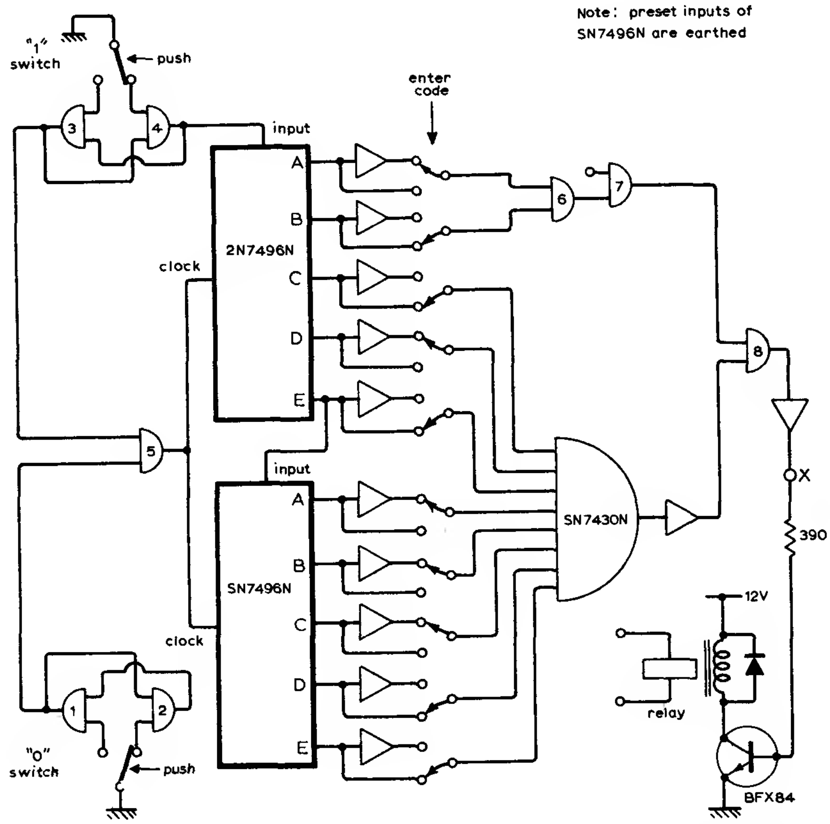
POWER TRANSISTOR DISSIPATION—Circuit protects power transistors in various combinations without limiting capabilities of AF amplifier when driving reactive loudspeaker load. With continuous signal drive into normal load, R_1 draws current from C_1 through D_1, in opposition to R_5. This gives drops of about 0.12 V across C_1 and C_2, allowing full drive. With short-circuited load, however, capacitor drops increase to about 0.55 V, thereby limiting average current in each output transistor to about 1.1 A. Diodes D_5 and D_6 are not critical, and simply prevent current flow from base to collector of transistors.—M. G. Hall, Amplifier Output Protection, *Wireless World*, Jan. 1977, p 78.



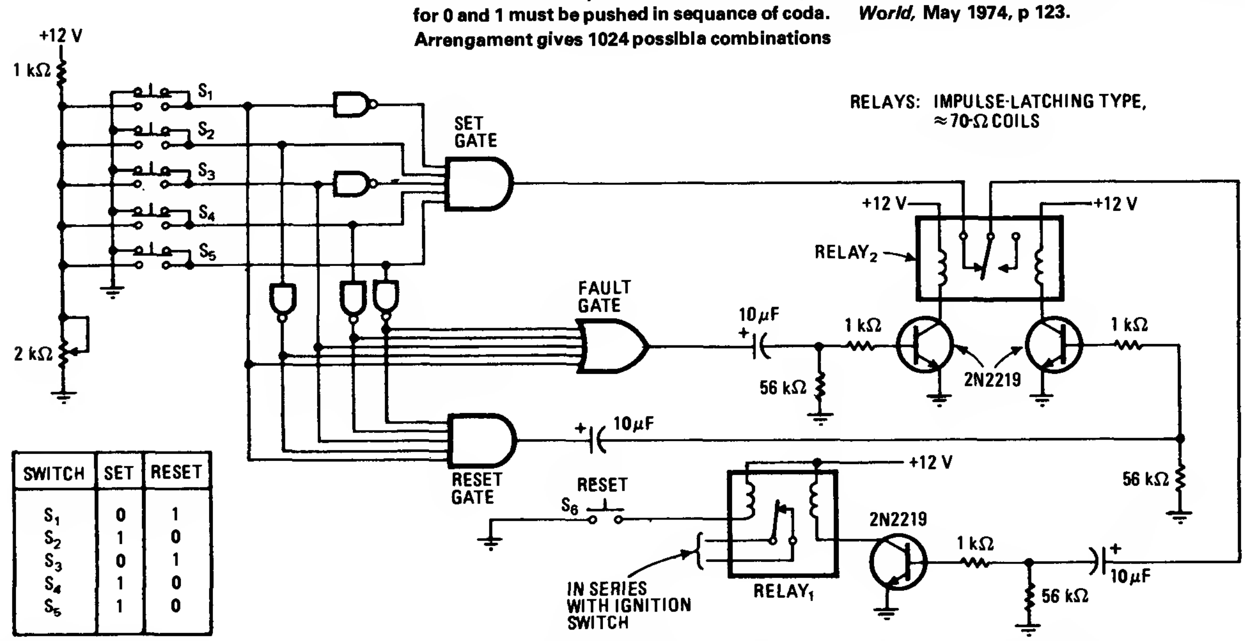
BLOWN-FUSE INDICATOR—Used with quick-blow fuses in high-power audio amplifier using split power supply. When fuse blows, transistor shunting it is turned on and passes current to corresponding indicator lamp. Maximum current in blown-fuse condition is less than 1 mA.—I. Findell, Amplifier Blown-Fuse Indicator, *Wireless World*, Sept. 1978, p 73.



3-kHz TONE LOCK—Electric door lock opens only when signal voltage of ebout 3 kHz is applied to two exposed terminals by holding compact single-IC AF oscillator ageinst terminals. Will not respond to DC or 60-Hz AC. Pocket oscillator operatas from 9-V transistor radio battary, with current drawn only when output prongs are held against lock tarminals. SCR can be any type capable of handling current drawn by alectric lock.—J. A. Sendler, 11 Projects undar $11, *Modern Electronics,* June 1978, p 54–58.

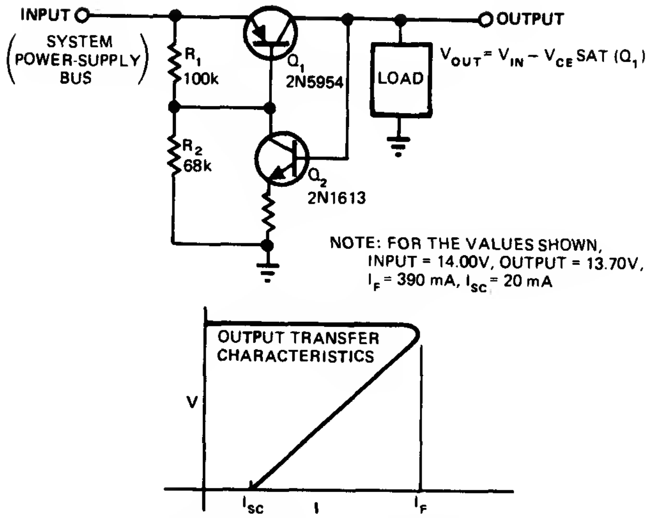


10-DIGIT CODED SWITCH—Uses seven Texas Instruments positiva-logic chips. NAND gatas 1-4 and 5-8 ara from two SN7400N packages. Two SN7404N packages aach provide six of inverting opamps shown. Desired coda Is set up as combination of 0s and 1s by presetting ten 2-position switches. To opan lock, switches et input for 0 and 1 must be pushed in sequance of coda. Arrengament gives 1024 possibla combinations but provides much graeter protection unless Intrudar knows that 10 digits are required. Article describes operetion of circuit. One requiramant of the 2N7496N shift registers is that information be present at sarial input before clocking pulsa occurs.—K. E. Potter, Tan-Digit Code-Operatad Switch or Combination Lock, *Wiraless World,* May 1974, p 123.

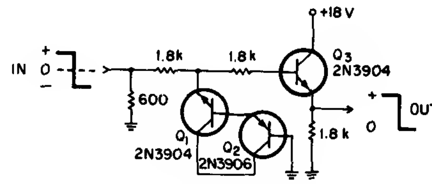


SWITCH	SET	RESET
S_1	0	1
S_2	1	0
S_3	0	1
S_4	1	0
S_5	1	0

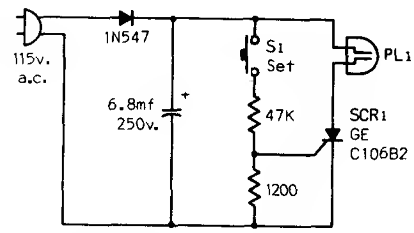
ELECTRONIC LOCK—Correct combination of switches S_1-S_5 must ba ectuetad to energize raley in series with Ignition switch of euto or eny other typa of electric lock. If wrong combinetion is used, lock cannot be opened until resetting combinetion is entered. When cer ignition is turned off, ignition reley should ba reset (contect opened) by pressing S_6. With connections shown, switches S_2, S_4, and S_5 must be depressed simultaneously to opan (set) lock. If arror is mede, output of fault gata goes to logic 1 end contacts of relay 2 will open. After error, S_1 end S_3 must be depressed simultanaously to reset lock before opening combination can ba used egein. Switches can ba connactad for any other desired combinations.—L. F. Caso, Electronic Combination Lock Offars Double Protection, *Electronics,* Juna 27, 1974, p 110; reprinted in "Circuits for Electronics Enginaers," *Electronics,* 1977, p 346.



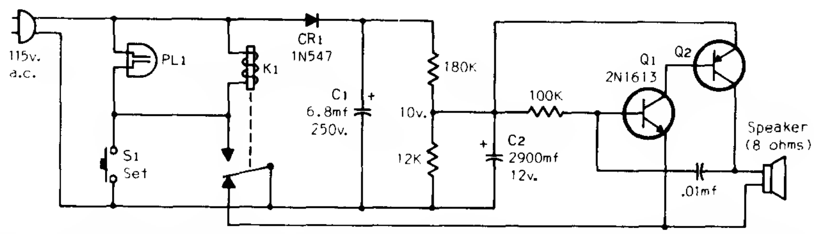
FOLDBACK CURRENT LIMITER—Provides overload and short-circuit protection for load while isolating malfunctioning circuit from other loads on common supply bus. In normal operation, Q_1 is saturated. When load attempts to draw more than this saturation value, base current of Q_1 cannot maintain saturation so voltage across unmarked resistor drops and current through Q_1 drops correspondingly. When load is shorted, Q_2 goes off and short-circuit current folds back to safe lower value. Choose value of unmarked resistor to ensure saturation of Q_1 at load current.—S. T. Venkataramanan, Simple Circuit Isolates Defective Loads, *EDN Magazine*, Jan. 20, 1978, p 114.



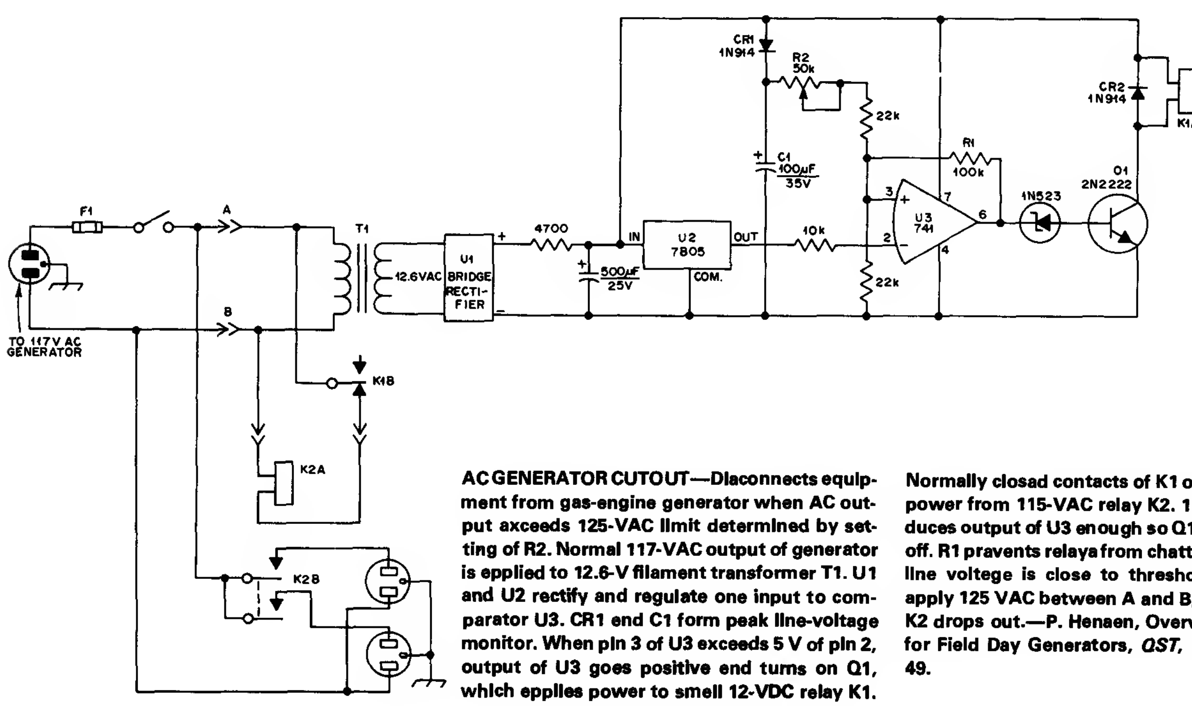
600-Hz CLAMP—Polar clamp was developed to provide overvoltage input protection for ±6 VDC teleprinter signals at 10 mA. Circuit will withstand input transients up to 120 VDC at 20 mA. When input exceeds emitter-base breakdown voltage of Q_1, Q_2 becomes forward-biased for clamping of input. With excessive negative input, Q_1 is forward-biased and emitter-base path in Q_2 completes clamping action.—R. R. Breazzano, A Polar Clamp, *EDN/EEE Magazine*, June 15, 1971, p 59.



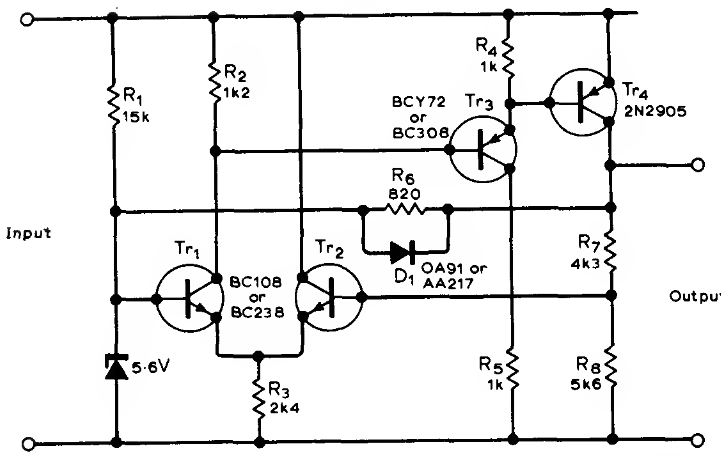
AC LINE MONITOR—Detects AC line failures of any duration and turns off neon lamp PL1 to indicate that clocks require resetting. Circuit is plugged into AC outlet, and S1 is pushed to trigger SCR on and send current through lamp.—J. R. Nelson, Some Ideas for Monitoring A.C. Power Lines, *CQ*, July 1973, p 56.



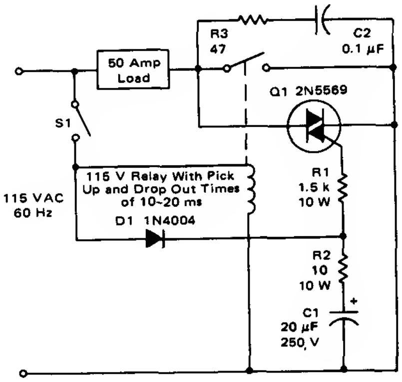
AUDIBLE LINE MONITOR—Audio oscillator coupled to simple relay circuit gives alerting tone when power fails even momentarily. C2 determines duration of tone. With 2900 μF, tone lasts about 1 s, as warning that clocks will need resetting. Q2 is any PNP audio power transistor, K1 is 115-V SPDT relay, and PL1 is neon lamp.—J. R. Nelson, Some Ideas for Monitoring A.C. Power Lines, *CQ*, July 1973, p 56.



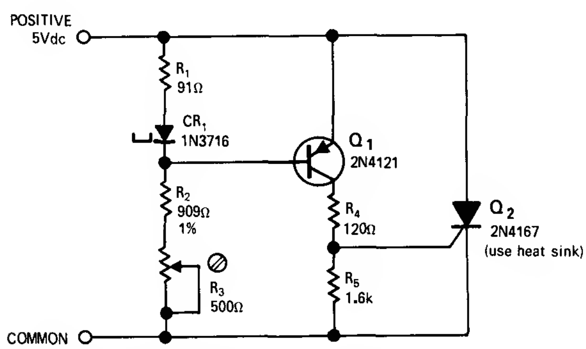
AC GENERATOR CUTOUT—Disconnects equipment from gas-engine generator when AC output exceeds 125-VAC limit determined by setting of R2. Normal 117-VAC output of generator is applied to 12.6-V filament transformer T1. U1 and U2 rectify and regulate one input to comparator U3. CR1 and C1 form peak line-voltage monitor. When pin 3 of U3 exceeds 5 V of pin 2, output of U3 goes positive and turns on Q1, which applies power to small 12-VDC relay K1. Normally closed contacts of K1 open, removing power from 115-VAC relay K2. 1N523 zener reduces output of U3 enough so Q1 can be turned off. R1 prevents relays from chattering when AC line voltage is close to threshold. To adjust, apply 125 VAC between A and B, and set R2 so K2 drops out.—P. Hansen, Overvoltage Cutout for Field Day Generators, *QST*, March 1977, p 49.



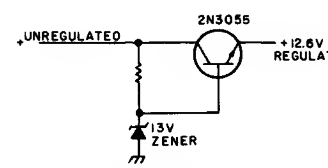
REGULATOR OVERLOAD—When output is shorted, germanium diode D_1 turns on and draws current through R_1, removing reference voltage across zener. Tr_1 is then held off and turns Tr_3 and Tr_4 off to block load current. When short is removed, circuit recovers automatically.—D. E. Weddington, Germanium Diode for Regulator Protection, *Wireless World*, March 1977, p 42.



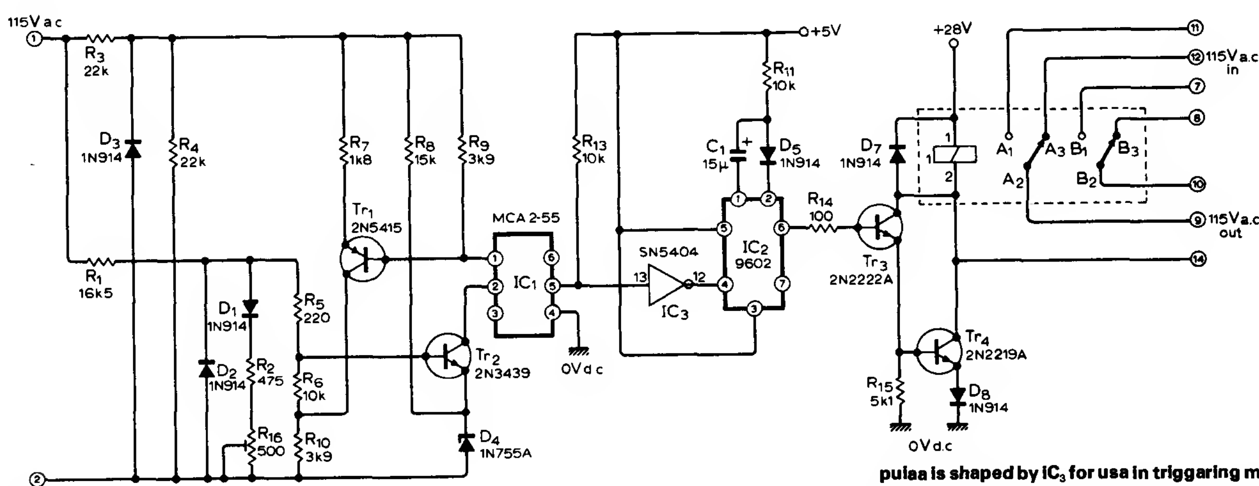
TRIAC SUPPRESSES RELAY ARCING—Circuit prevents arcing at contacts of relay for loads up to 50 A, by turning on as soon as it is fired by gate current; this occurs after S1 is closed but before relay contacts close. Once contacts are closed, load current passes through them rather than through triac. When S1 is opened, triac limits its maximum voltage across relay contacts to about 1 V. Circuit permits use of smaller relay since it does not have to interrupt full load current.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 8.



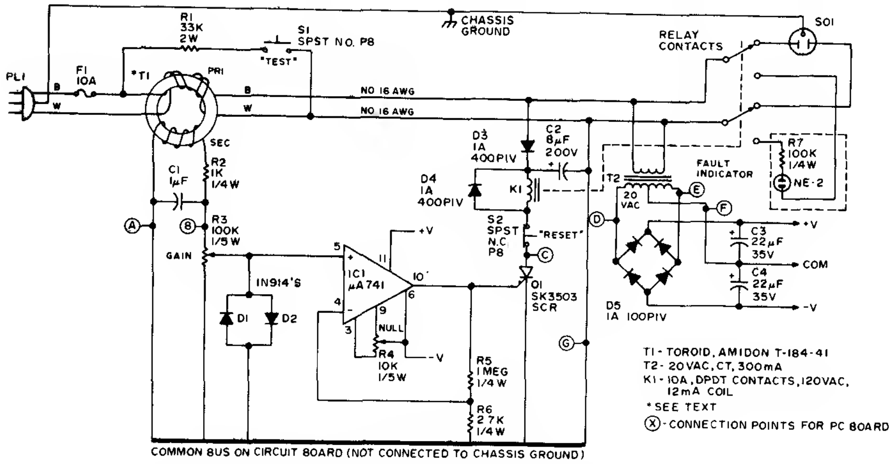
5-V CROWBAR—Simple overvoltage protection circuit for 5-V 1-A logic supply can be adjusted to trigger at 10% overvoltage or 5.5 V. Tunnel diode CR_1 senses level. At 5.5 V, diode switches slightly past its valley point, and voltage across diode biases Q_1 into saturation. Q_1 then supplies gate current to SCR Q_2, which fires and continues conducting until power supply is disconnected. Power supply must include current-limiting circuit and fuse. R_3 adjusts trip point.—L. Strahen, Logic-Supply Crowbar, *EDN/IEEE Magazine*, Nov. 15, 1971, p 51.



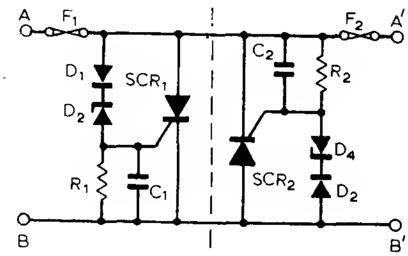
TRANSCEIVER-SAVER—Simple circuit has no effect on normal operation of CB transceiver or other solid-state equipment in auto but provides overvoltage protection if voltage regulator in auto fails. Use heatsink with transistor if transmit current is above 2 A. Choose resistance value to give output of 12.6 V during normal operation.—Circuits, *73 Magazine*, March 1977, p 152.



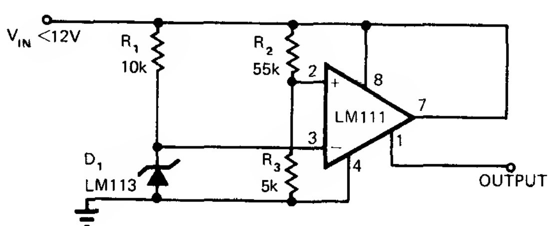
AC OVERVOLTAGE—Used to protect delicate equipment from sustained high AC line voltage, by disconnecting supply when it exceeds preset level selected by R_{16}. When base-emitter voltage of Tr_2 exceeds 7.5 V, optocoupler switches Tr_1 on to provide fast switching action. Output pulse is shaped by IC_3 for use in triggering mono IC_2. When line falls below preset level, mono reverts to stable state and switches on AC supply again.—F. E. George, A.C. Line Sensor, *Wireless World*, March 1977, p 42.



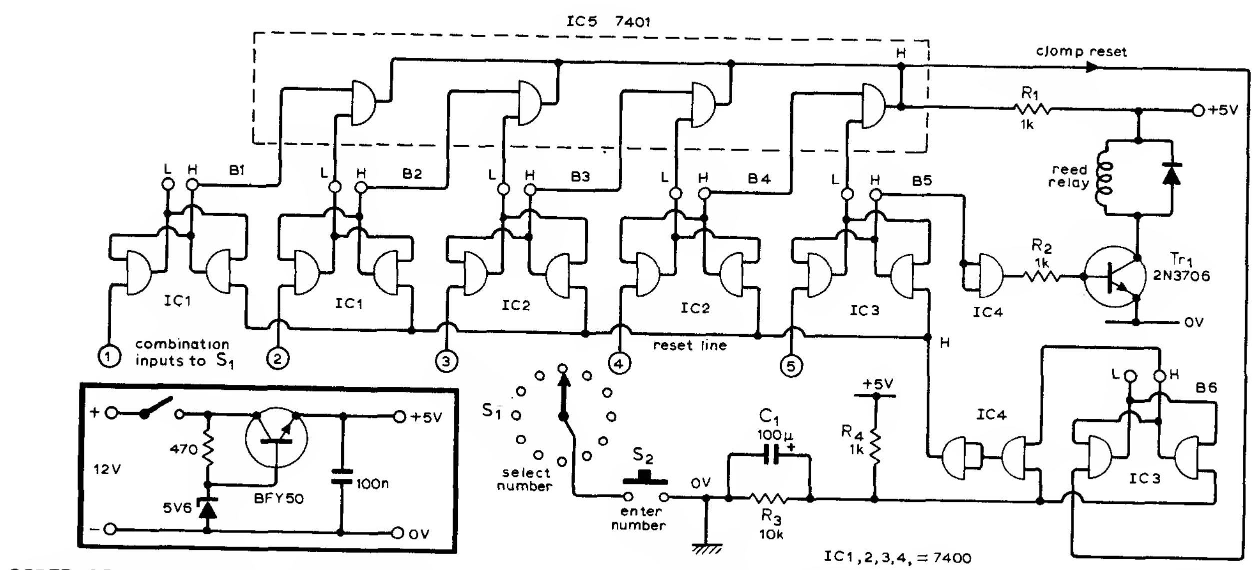
GROUND-FAULT INTERRUPTER—Compares current in ungrounded side of power line with current in neutrel conductor. If currents are not equal, ground feult exists beceuee portion of line current Is taking an unintended return peth through leaky electric epplienca or human body. Voltege induced in toroid by unbalenced current is emplified for energizing relay K1 to break circuit. Toroid uses Amidon T-184-41 core, with 600 turns No. 30 for secondary, and 12 turns No. 16 solid twisted-peir for primery. Circuit operates on fault current of 4 mA, well below denger limit for children.—W. J. Prudhomme, The Unzepper, *73 Magazlne,* Nov./Dec. 1975, p 151–156.



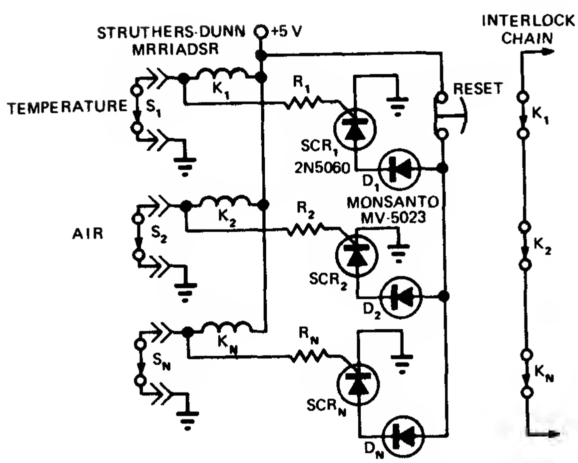
EQUIPMENT INTERFACE PROTECTION—When circuit shown is used to transfer signel from one piece of equipment to another, desired signel passes with very little degredetion. Component values can be chosen to make thyristor SCR_1 latch at eny desired voltage between A end B thet is greater than 0 V, blowing fuse F_1 and giving desired protective isolation. On other side of circuit, SCR_2 will latch and blow F_2 when voltega exceeds limiting velue set by diode D_2 and zener D_4. Zeners are 10-V CV7144, diodes ere CV9637 smell-signal silicon, resletors ere 10K, capecitors are 0.047 µF, end thyristors ara 2N4147.—S. G. Pinto and A. P. Bell, Thyristor Protection Circuit, *Wireless World,* Oct. 1975, p 473.



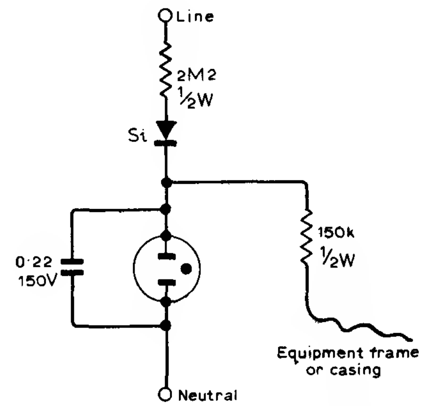
12-V OVERVOLTAGE LIMITER—Single LM111 comparator is basis for simple overvoltage protection of circuits drawing less then 50 mA. Fraction of input supply is compered to 1.2-V reference. When input exceeds referenca level, power is removed from output.—R. C. Dobkin, Comparators Cen Do More then Just Compera, *EDN Magazine,* Nov. 1, 1972, p 34–37.



CODED LOCK—Five-digit combination lock uses five low-cost ICs opereting from 5-V supply that can be derived from 12-V auto bettary as shown in insat. Six set/reset bisteble circuits ere formed by croes-coupling peirs of dual-input NAND getes, so 0-V input is needed to chenge state of each. Five of bistables serve for combination, and sixth prevents oparetion by number in incorrect sequence. After S_1 is set to one number of code, S_2 is pushed to enter that number, with process being repaeted for other four numbers of combination. Final correct number sats B5 and turns on Tr_1, to operete reley that can be used to open door.—S. Lamb, Simpla Code-Oparated Switch or Combinetion Lock, *Wireless World,* June 1974, p 196.

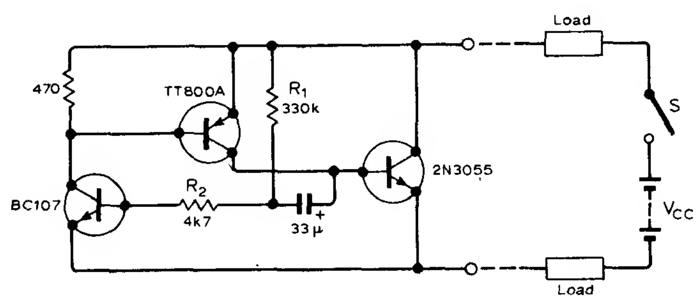


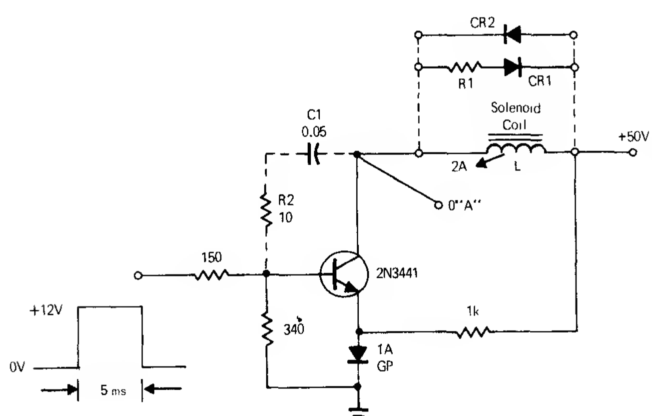
FAIL-SAFE INTERLOCK—Developed for protecting peopla end equipment et 40-kW RF accelerator station. All intarlock switches (air flow, water flow, water pressura, tamparature, etc) are normally closad, grounding one side of each relay coil. All relays are normelly pulled in, to provide complete intarlock chein. Failure of any component, including power supply, braaks chain and places systam In safa moda.—T. W. Hardek, Interlock Protection Circuit Is Simpla and Fail-Safe, *EDN Magazine*, Mey 20, 1975, p 74.



LOOSE-GROUND FLASHER—Usas ordinary neon lamp in series with silicon diode, with lamp normally dark. Gives werning by flashing if ground wire is accidentally or purposely disconnected from chassis of oscllloscope or othar test instrument.—R. H. Troughton, Eerth Warning Indicator, *Wireless World*, April 1977, p 62.

CURRENT SENSOR—Loed currant is sensed across bese-amitter junction of output transistor. R_1 controls OFF time and R_2 controls ON tima. Capacitor should be electrolytic reted above 16 V.—M. Faulkner, Two Terminal Circuit Breaker, *Wirelass World*, March 1977, p 41.





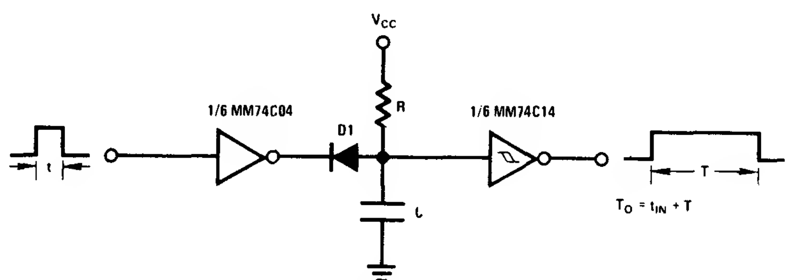
BYPASSING SOLENOID TRANSIENTS—Faedback from collector to base of powar transistor through C1 end R2 protects device from destructive transients ganereted when inductive load such as solenoid is turned off. Alternative use of diode CR2 or CR1-R1 across coil would limit voltage transient but would increase solanoid release time.—D. Thomas, Feedback Protects High-Spaed Solanoid Driver, *EDN Magazine*, Jan. 1, 1971, p 40.

CHAPTER 71

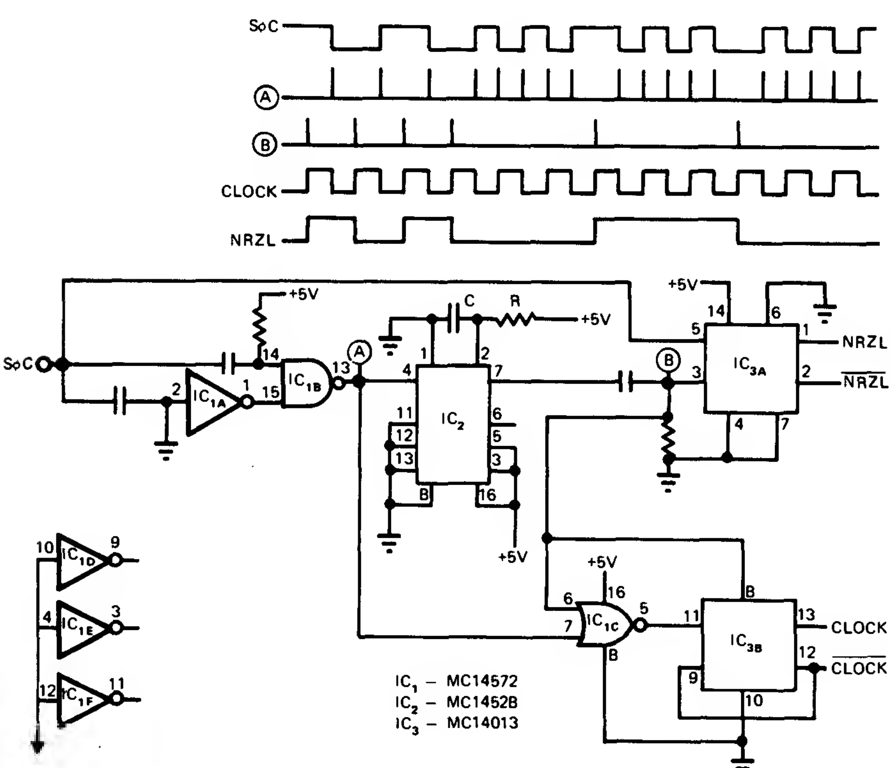
Pulse Generator Circuits

Generate square waves with fixed or variable width and duty cycle, at audio and radio frequencies up to 100 MHz. Includes tone-burst generators, strobe, pulse delay, PCM decoder, and single-pulse generators. See also Frequency Divider, Frequency Multiplier, Frequency Synthesizer, Function Generator, Multivibrator, Oscillator, and Signal Generator chapters.

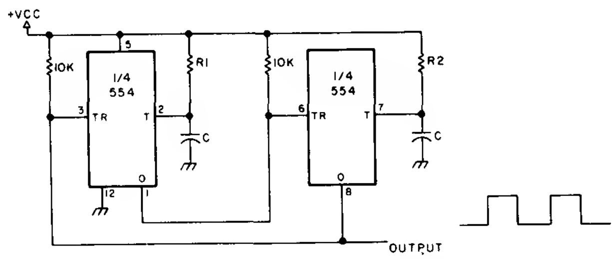
PULSE-STRETCHING MONO—Section of CMOS MM74C04 inverter accepts positive input pulse by going low and discharging C. Capacitor is rapidly discharged, driving input of MM74C14 Schmitt trigger low. Output of Schmitt then goes positive for interval T_O which is equal to input pulse duration plus interval T that depends on values used for R, C, and supply voltage.—"CMOS Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-30–5-35.



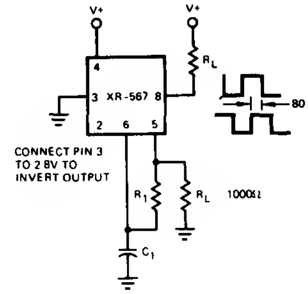
$$T = RC\ \ell n\left(\frac{V_{CC} - V_{BE}}{V_{CC} - V_{T+}}\right) \quad \text{BE SURE THAT } I_{SINK\ INVERTER} > \frac{C\,V_{CC}}{t} + \frac{V_{CC}}{R}$$



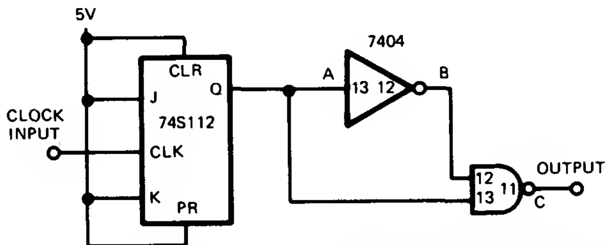
PCM DECODER—Three CMOS ICs provide decoding of Manchester (split-phase) PCM signals by generating missing mark which should occur at each change of level data to recover original clock frequency. Retriggerable mono MVBR times out at slightly longer than half of original clock frequency. Signal levels are TTL-compatible. Values of C and R depend on system frequency. Other resistors are 15K, and other capacitors are 470 pF.—M. A. Lear, M. L. Roginsky, and J. A. Tabb, PCM Signal Processor Draws Little Power, *EDN Magazine*, April 20, 1975, p 70.



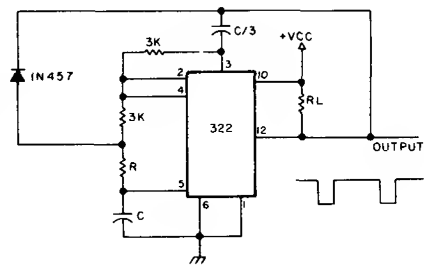
554 ASTABLE—Two sections of 554 quad monostable timer are used. Output frequency is $1/(R_1 + R_2)C$ hertz, and output duty cycle is $100R_2/(R_1 + R_2)$. When R_1 is equal to R_2, symmetrical square wave is obtained. VCC is 4.5–16 V at 3–10 mA.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



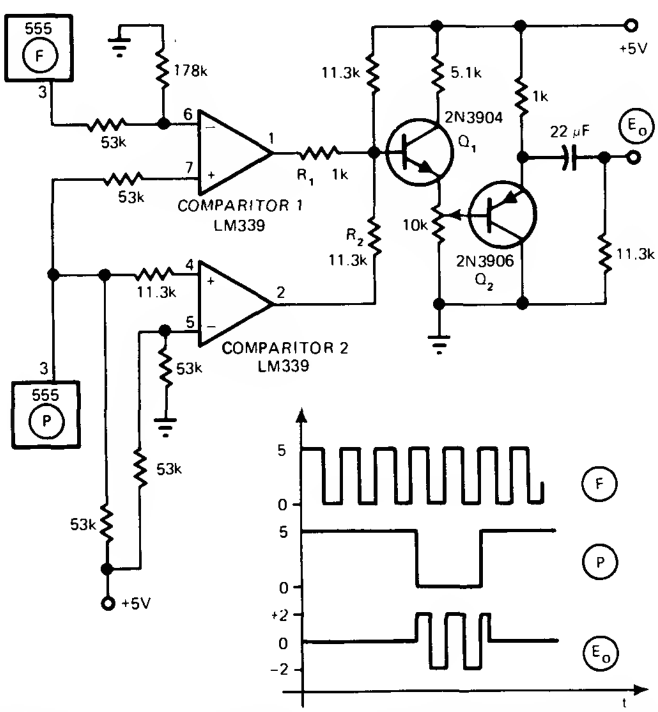
QUADRATURE OUTPUTS—Exar XR-567 tone decoder is connected as precision oscillator providing separate square-wave outputs that are very nearly in quadrature phase. Typical phase shift between outputs is 80°. Supply voltage range is 5–9 V.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 41–48.



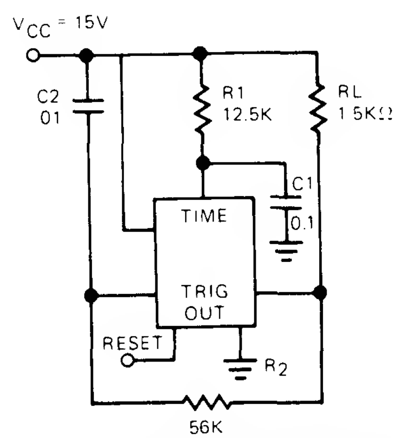
100 MHz—Developed for measuring impulse response of surface acoustic wave devices, for which pulse width had to be under 10 ns for frequency spectrum of about 100 MHz. Propagation delay time of 7404 inverter establishes output pulse width.—R. J. Lang, W. A. Porter, and B. Smilowitz, Simple Circuit Generates Nanosecond Pulses, *EDN Magazine*, Sept. 5, 1975, p 77–78.



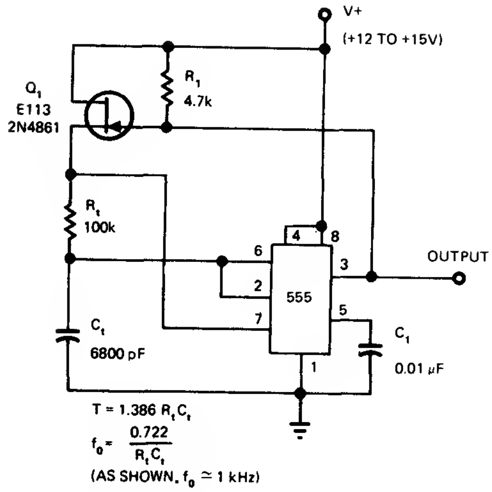
LM322 ASTABLE—National LM322 timer generates narrow negative pulse whose width is approximately 2RC seconds. VCC is 4.5–20 V. Will drive loads up to 5 mA.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



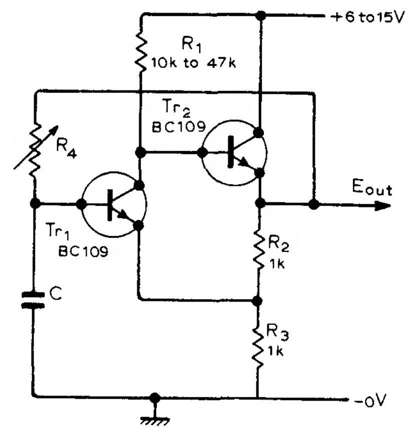
BIPOLAR PULSE TRAINS—Output of Signetics 555 timer F, consisting of unipolar waveform varying from ground to +5 V, is converted to bipolar pulse train having duration equal to that of output pulse from lower 555 timer. While P is high, comparator 2 is on, forcing R_2 to ground and placing base of Q_1 at 2.5 V (because comparator 1 is off, forcing R_1 high). Comparator 2 goes off when timer P goes low, and action of comparator 1 is turned on and off by timer F to produce bipolar pulse train at E_0.—G. L. Assard, Derive Bipolar Pulses from a Unipolar Source, *EDN Magazine*, April 5, 1977, p 144.



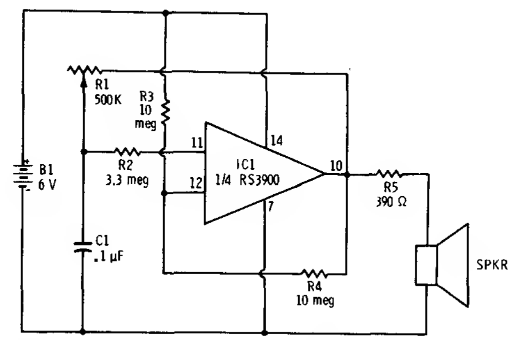
400 Hz—One section of Signetics NE558 quad timer is used as nonprecision audio oscillator providing square-wave output of about 400 Hz with values and supply voltage shown. Output frequency is affected by changes in supply voltage.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 738.



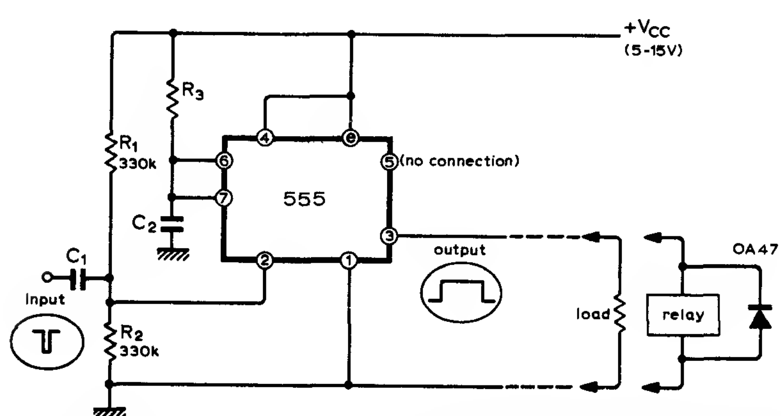
50% DUTY CYCLE WITH 555—Provides pure squere-wave output without sacrificing allow-eble renge of timing resistence. Q_1 replaces con-ventionel timing resistor going to V+. Pull-up resistor R_1 is required to switch Q_1 fully on when it is driven by output of timer.—W. G. Jung, Teke a Fresh Look at New IC Timer Applications, *EDN Magazine*, March 20, 1977, p 127–135.



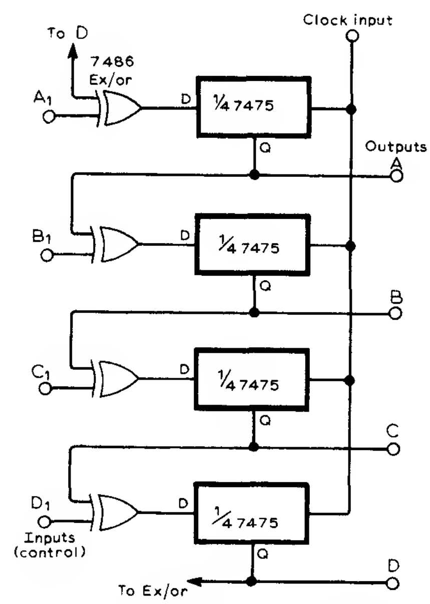
VARIABLE-FREQUENCY UP TO 0.5 MHz—Fre-quency is determined by choice of velues for C and frequency-control potentiometer R_4. Squere-wave output has almost equel mark-space ratio over wide frequency range. Regen-erative action is rapid, reducing transition times. When circuit is switched on, C is un-cherged end Tr_2 is on. C cherges until Tr_1 begins to conduct, cutting off Tr_2 end discherging C through R_4 until Tr_1 cuts off end cycle repeats.—J. L. Linsley Hood, Squere-Weve Generetor with Single Frequency-Adjustment Resistor, *Wire-less World*, July 1976, p 36.



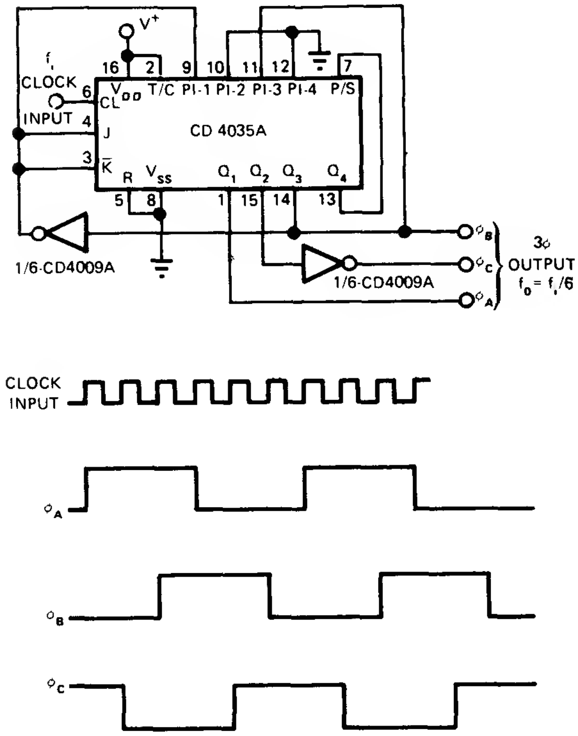
30–4000 Hz WITH OPAMP—Frequency Is deter-mined by pot R1 in feedback path. Squere-wave output pulse amplitude is about 5 V. Circuit will generete elmost perfect sine waves if 0.1-μF ca-pacitor is connected between pin 12 and ground; R1 must be properly edjusted to give output of about 220 Hz.—F. M. Mlms, "Inte-greted Circuit Projects, Vol. 6," Redio Sheck, Fort Worth, TX, 1977, p 89–95.

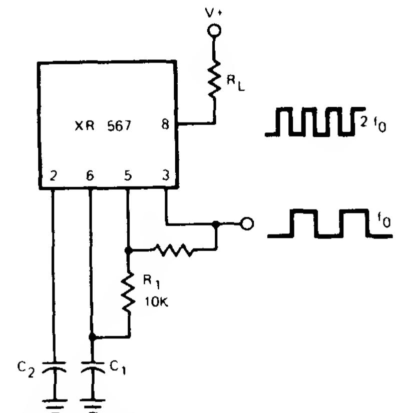


CONTROLLED-DURATION PULSES—Economi-cal Signetics IC provides output pulse currents up to 200 mA at duretion ranging from micro-seconds to meny minutes depending on values used for R_3 and C_2. Input pulses may have du-retion under e microsecond, negative-going. With positive-going input pulses, output will be delayed until treiling edge occurs. Diode is re-quired ecross output reley coil to suppress tran-sients thet might demage IC and cause euto-matic retriggering.—J. B. Dance, Simple Pulse Shaper or Relay Driver, *Wireless World*, Dec. 1973, p 605–606.



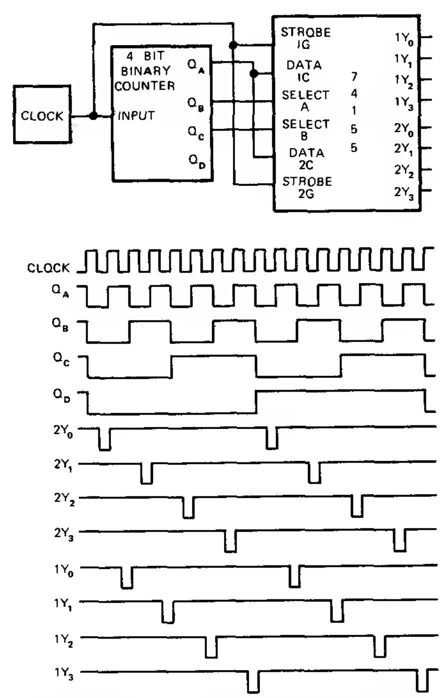
SEQUENCE GENERATOR—Uses geted shift register assembled from 7475 D-type latch, along with four EXCLUSIVE-OR gates. Clock pulse should be narrow to evoid race-eround effects.—P. D. Meddison, Sequence Generator, *Wireless World*, Dec. 1977, p 80.

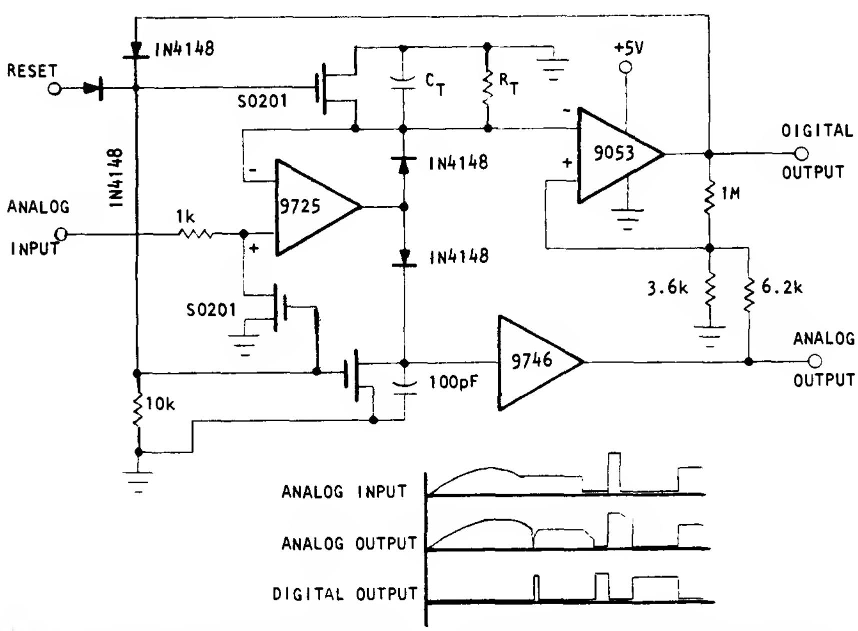




FREQUENCY-DOUBLED OUTPUT—Currant-controlled oscillator section of Exar XR-567 tona decodar is connected to double frequancy of squara-wave output by feeding portion of output at pin 5 back to input at pin 3 through resistor. Quedratura detector of IC than functions as frequancy doublar to give twica output frequency at pin 8. Supply voltaga ranga is 5–9 V.—"Phase-Locked Loop Deta Book," Exer Integrated Systems, Sunnyvale, CA, 1978, p 41–48.

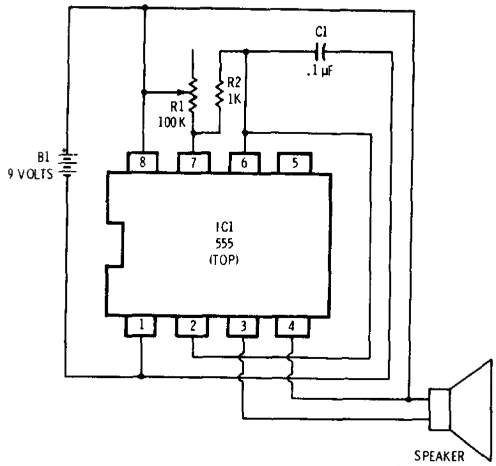
THREE-PHASE PULSE GENERATOR—Raquires only CMOS 4-bit shift register and two CMOS invartars. Raglstar is connacted to oparate as divide-by-6 Johnson countar giving glitch-fraa outputs. Circuit is driven by square-wave clock signal having frequency 6 times that of desired output frequency.—C. Rutschow, Simpla CMOS Circuit Ganerates 3-Phasa Signals, *EDN Magazine*, June 20, 1976, p 128.



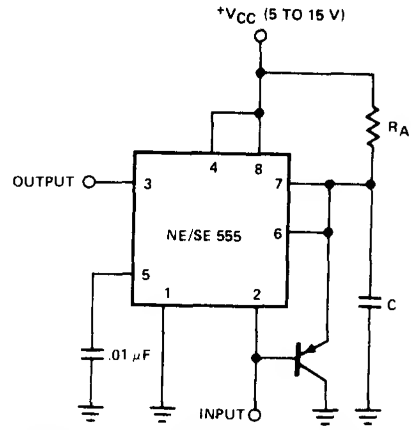


PULSE STRETCHER—Circuit also sarves as analog one-shot memory and as peak sense-and-hold with automatic raset. Digital output is logic 0 until C_T and R_T heve deceyed by ona time constent, whan it goas to logic 1. Pulsa duration is R_CT_C. Analog output amplituda is equal to input amplituda, and duration is sama as digital pulse. Optical Electronics 9053 comparator automatically rasets circuit after timing intarval unlass raset is parformed manually. Analog output can be usad as pulse stretchar with known and controllable pulse duration.—"Analog 'Ona-Shot'—Pulse Stretcher," Opticel Electronics, Tucson, AZ, Application Tip 10292.

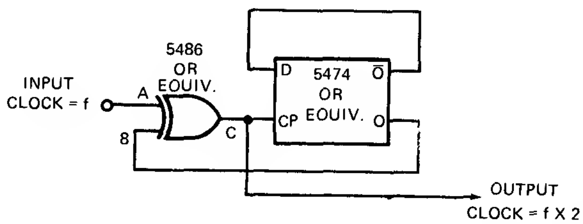
UNAMBIGUOUS STROBING—Combinetion of 74155 two-lina to four-line decoder/damultiplexar with any conventional 4-bit binary countar providas family of strobe pulsas staggared in such a way that pulse-edge ambiguity is impossibla. Clock pulses at input sarva to stroba 74155 as wall as drive counter. Q_A of couter acts as data input, whila Q_B and Q_C act as select lines. Action is such that edgas of various 2Y pulsas do not coincide with aach other, with edges of 1Y pulses, or with edges of Q_B, Q_C, or Q_D pulses. Resuit is hazard-free strobing.—D. McLaughlin and C. Fanstini, End Edge Ambiguities with Two ICs, *EDN Magazine*, April 5, 1973, p 88.



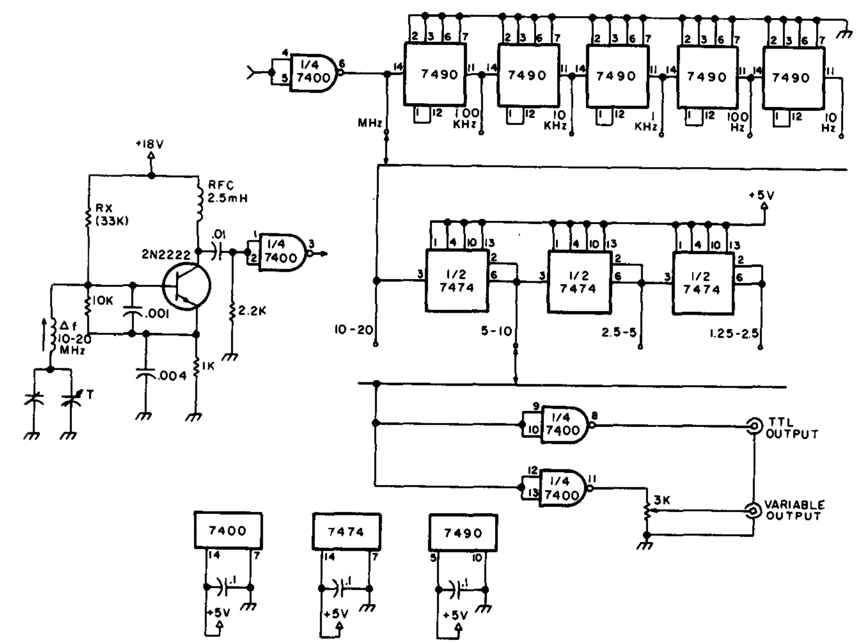
555 AS TONE GENERATOR—Connection of 555 timer as astable MVBR starts next timing cycle automatically, generating sequential square-wave output pulses in audio-frequency range with sufficient power to drive miniature 8-ohm loudspeaker. R1 controls frequency of tone.—F. M. Mima, "Integrated Circuit Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 66–70.



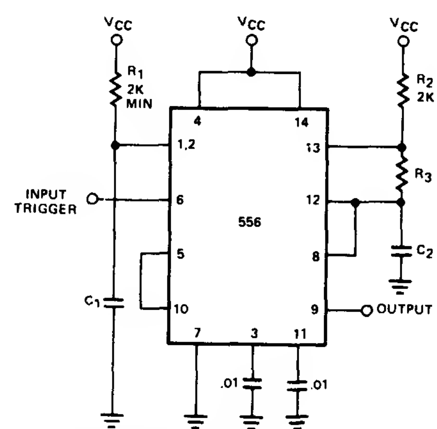
MISSING-PULSE DETECTOR—Timing cycle of 555 timer is continuously reset by input pulse train. Change in input frequency or missing pulse allows completion of timing cycle, producing change in output level. Component values should be chosen so time delay is slightly longer than normal time between pulses.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 723.



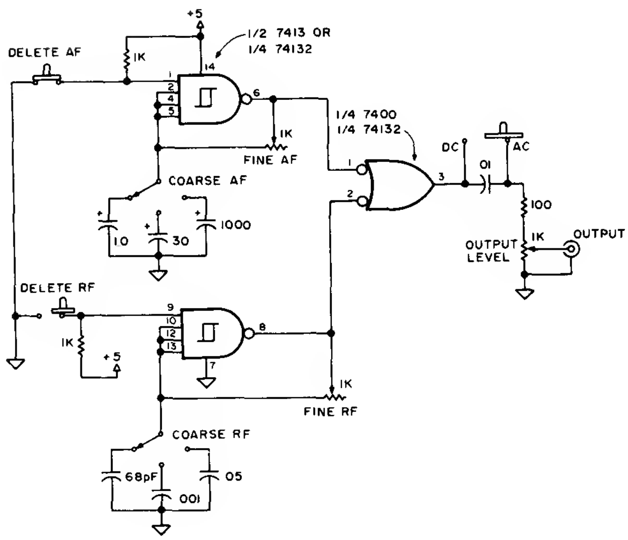
WAVEFORM-EDGE PULSER—Circuit generates square-wave output pulse for each edge of square-wave input. EXCLUSIVE-OR gate is used as programmable inverter that returns point C to quiescent low state following each transfer of data through 5474 IC. When used for frequency-doubling, input waveform should be symmetrical because output is proportional to propagation delay of flip-flop plus delay of 5486 EXCLUSIVE-OR gate.—D. Giboney, Double-Edge Pulser Uses Few Parts, *EDN Magazine*, Dec. 15, 1972, p 41.



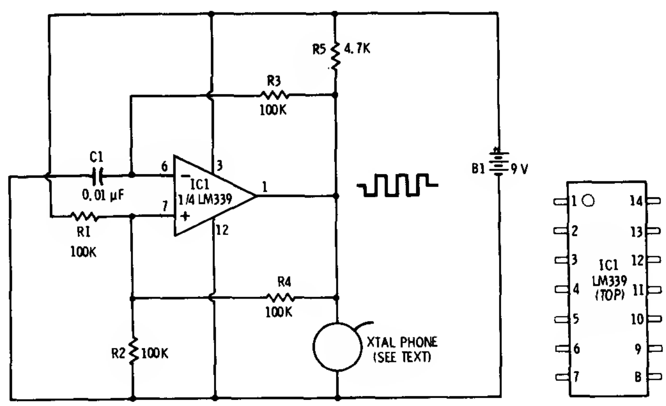
SUBAUDIO TO 20 MHz—Square-wave signal source covers wide frequency range in fully tunable decade steps, as TTL signal source for experimentation with counters, microprocessors, and other logic circuits. Uses tunable 2N2222 transistor oscillator operating at 10–20 MHz, with switchable decade dividers for range selection and switchable binary dividers for band selection. Article covers construction and calibration.—A. G. Evans, Digital Signal Source, *73 Magazine*, Dec. 1977, p 150–151.



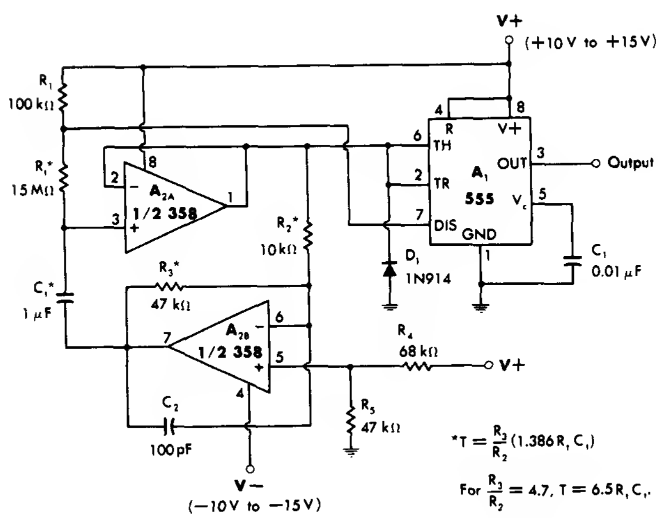
TONE-BURST GENERATOR—One section of 556 dual timer is connected as mono MVBR and other section as oscillator. Pulse established by mono turns on oscillator, allowing generation of AF tone burst.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 723–724.



AF/RF SQUARE-WAVE—Use of feedback resistor between input and output of each gate produces oscillation in each Schmitt-trigger oscillator, one operating at audio frequencies and one operating at radio frequencies. Both AF and RF can be fed into NAND gate to give modulated RF, or outputs can be used separately as clocks for microprocessor.—B. Grater and G. Young, Build a Pulse Generator, *Kilobaud*, June 1977, p 49.



AF SQUARE WAVES—With value shown for C1, frequency of output square wave is 530 Hz. For 5300 Hz, use 0.001 μF; for 53 Hz, use 0.1 μF. Circuit will drive ordinary crystal earphone or crystal microphone used as earphone.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 52–56.



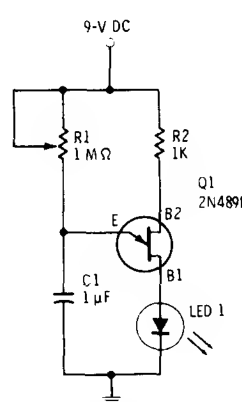
$$^{*}T = \frac{R_3}{R_2}(1.386 R_1 C_t)$$

$$\text{For } \frac{R_3}{R_2} = 4.7,\ T = 6.5 R_1 C_t.$$

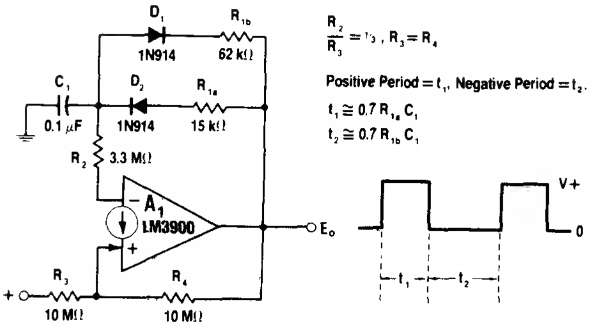
$$f = \frac{1}{T} = \frac{0.154}{R_1 C_t}$$

(As shown, T ≅ 100 s.)

EXTENDED-RANGE ASTABLE—Square-wave output is extended in frequency by combining buffer A_{2A} with opamp A_{2B} functioning as capacitance multiplier for 555 timer connected as astable MVBR. Value of 1-μF timing capacitor C_t is increased in effective value by ratio of gain of A_{2B} stage, equal to R_3/R_2. Output frequency thus corresponds to that of 4.7-μF capacitor. Negative supply should be equal and opposite to positive supply.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 118–121.

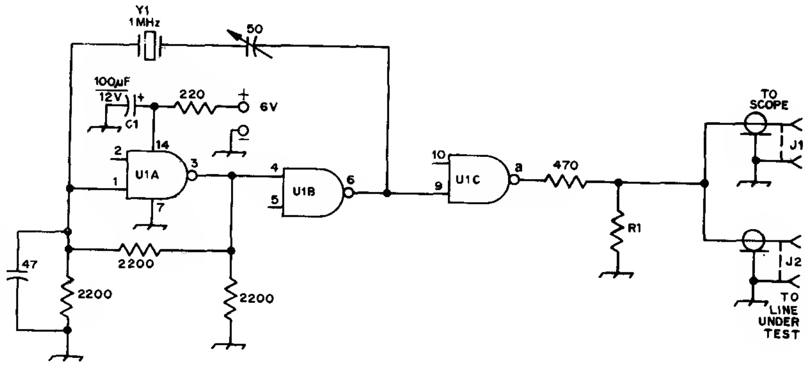


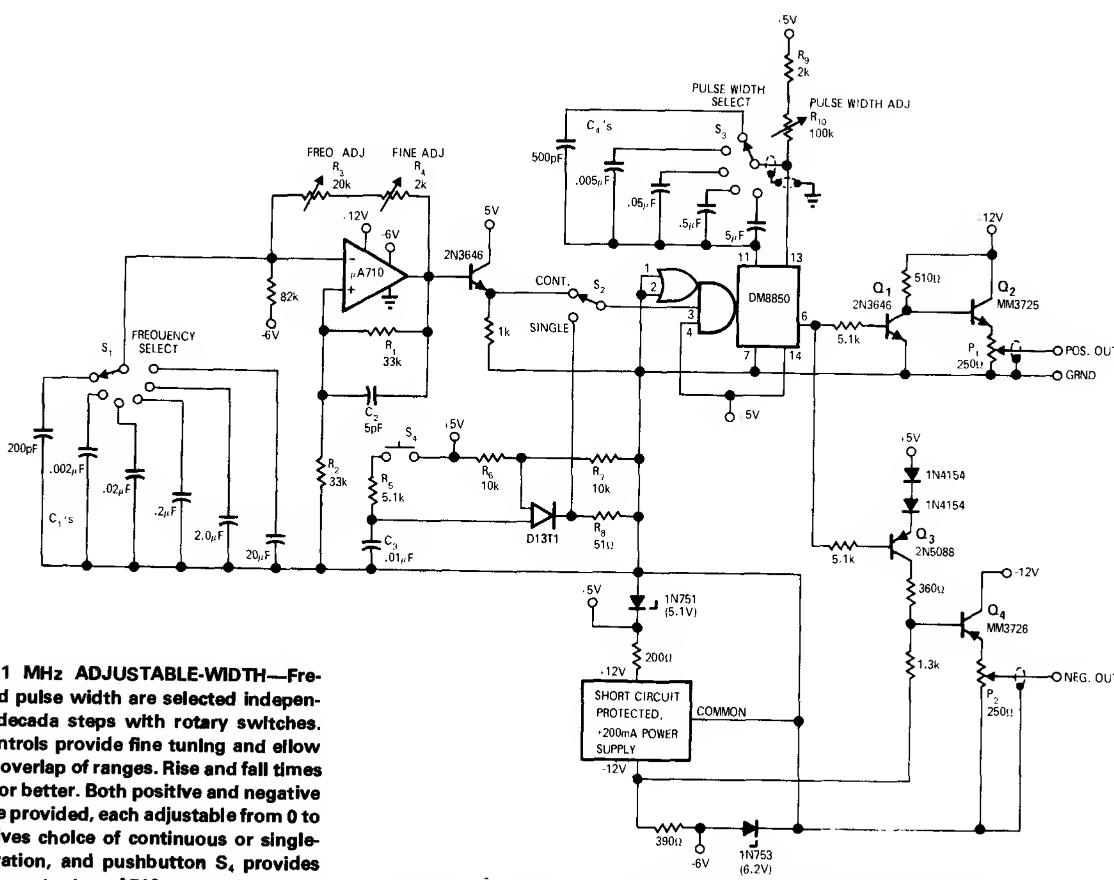
UJT/LED PULSER—Rise time of output pulse is about 200 ns and width is about 25 μs when using 1 μF for C1. Reducing value of C1 reduces pulse width. C1 charges through R1 until voltage across C1 is high enough to bias UJT into conduction. C1 then discharges through UJT and LED and cycle repeats. LED can be any common type.—F. M. Mims, "Electronic Circuitbook 5: LED Projects," Howard W. Sams, Indianapolis, IN, 1976, p 30–32.



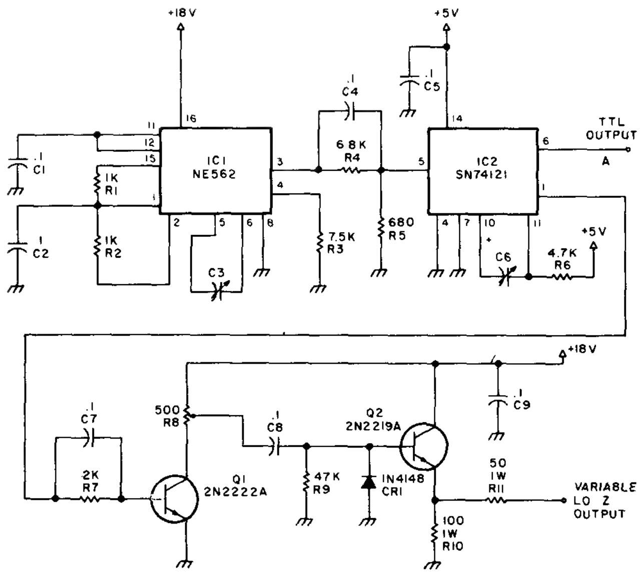
ASYMMETRICAL PULSE GENERATOR—Charge end discharge peths of timing capacitor C_1 in LM3900 IC connected as estable oscillator are individually controlled by D_1 and D_2. Velue of R_{1a} controls charge rete of C_1 and period t_1, while R_{1b} controls discharge rata and period t_2. Resistors can be pots for providing variable pulse width and repetition rete. For constant frequency with variable duty cycle, R_1 can be single pot with ends going to D_1 and D_2 and tep going to output. For values shown, t_1 is 1 ms and t_2 is 4 ms.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sams, Indianapolis, IN, 1974, p 505.

1-MHz SQUARE-WAVE FOR TDR—Fast-rise-time 1-MHz pulse generetor serves wlth wide-band CRO and T connector for tima-domain reflectometry (TDR) setup used to pinpolnt exact location of fault in trensmission line. Will also locate multiple faults along line, meesure SWR, end meesure characteristic impedance of cable. With 1-MHz square-weve source having 500-ns duretion for positiva portions of wave, cebles up to 150 feet long can be tested. R1 should equal characteristic impedance of line being tested. U1 is Signetics N7400A or equivelant quad NAND/NOR gate. Article gives Instructions for use.—W. Jochem, An Inexpensive Time-Domain Reflectometer, *QST*, March 1973, p 19–21.

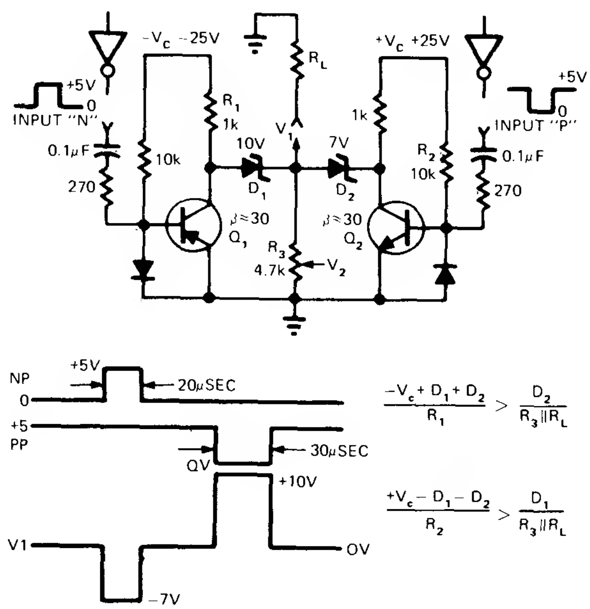




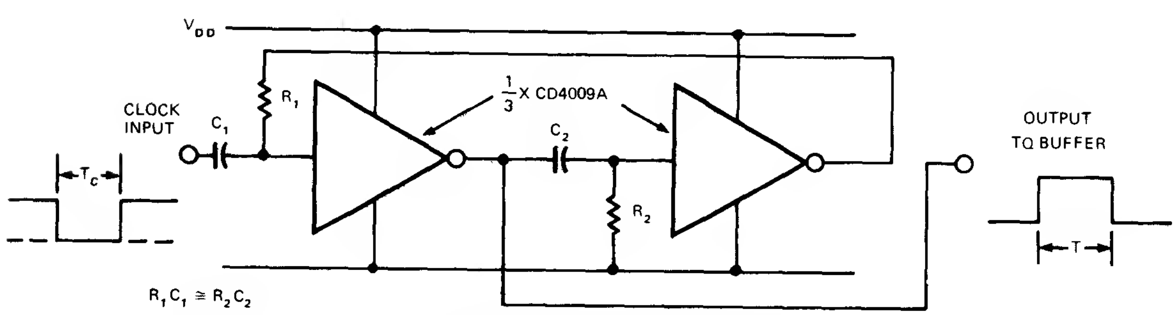
1 Hz TO 1 MHz ADJUSTABLE-WIDTH—Frequency and pulse width are selected independently in decada steps with rotary switches. Vernier controls provide fine tuning and ellow up to 20% overlap of ranges. Rise and fall times are 100 ns or better. Both positive and negative outputs are provided, each adjustable from 0 to 10 V. S_2 gives choice of continuous or single-pulse operation, and pushbutton S_4 provides single-pulse outputs. μA710 comparator connected es astable MVBR provides trigger inputs for DM8850 retriggerable mono. Article gives circuit details and design equations.—C. Brogado, Versatile Inexpensive Pulse Generator, *EDN/EEE Magazine*, Oct. 1, 1971, p 37–38.



900 kHz TO 10 MHz—Pulse width is variable from about 50 ns to over 500 ms by adjusting only two components. Uses VCO portion of Signetics NE562 as pulse generator and 74121 mono MVBR to adjust pulse width. Variable capacitors C3 and C6 are broadcast-band type. VCO will operate to 30 MHz, limiting factor being stray capacitance and minimum of tuning capacitor. Low-frequency limit of VCO is about 1 Hz, obtained when C3 is 300 μF.—A. Plavcan, Pulses Galore!, *73 Magazine*, Jan. 1978, p 194–195.



HIGH-SPEED PULSES—TTL circuit provides dual-polarity microsecond pulses. Pulse amplitude is adjusted by changing zeners D_1, D_2, or R_3. Design overcomes slew-rate problems associated with most opamps.—L. Johnson, Dual-Polarity Pulses from TTL Logic, *EDN Magazine*, April 20, 1974, p 91.

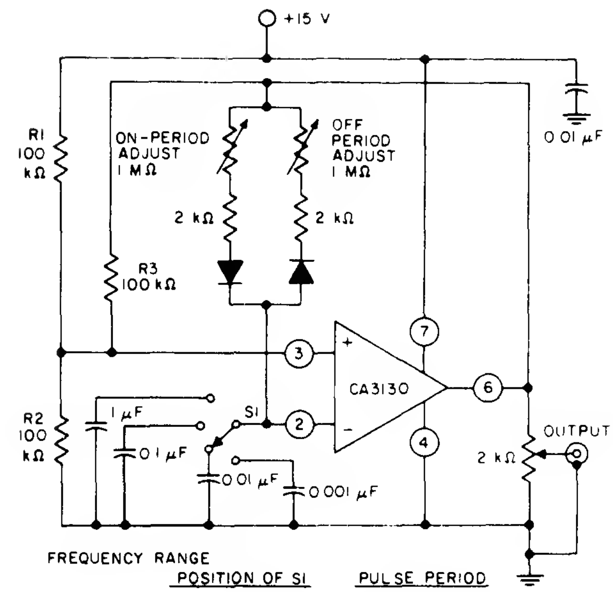


$R_1C_1 \cong R_2C_2$

$T \cong 1.4XR_1C_1$

$T_C \geq T$

MONO PULSE-SHRINKER—Duty cycle of clock pulse is shortened by two CMOS inverters used to form negative-transition triggered monostable multivibrator. Duration of output pulse T is about $1.4R_1C_1$. Output pulse occurs each time input clock goes from high to low. Used with foldback current limiting for short-circuit protection in clock-driven regulated power supply. Low duty cycle of clock pulses ensures positive full-load starting of supply.—J. L. Bohan, Clocking Scheme Improves Power Supply Short-Circuit Protection, *EDN Magazine*, March 5, 1974, p 49–52.

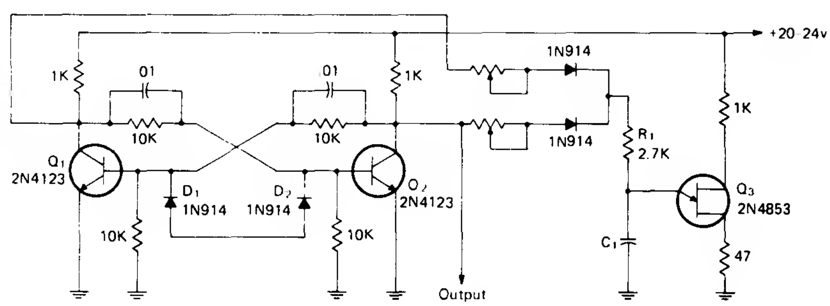


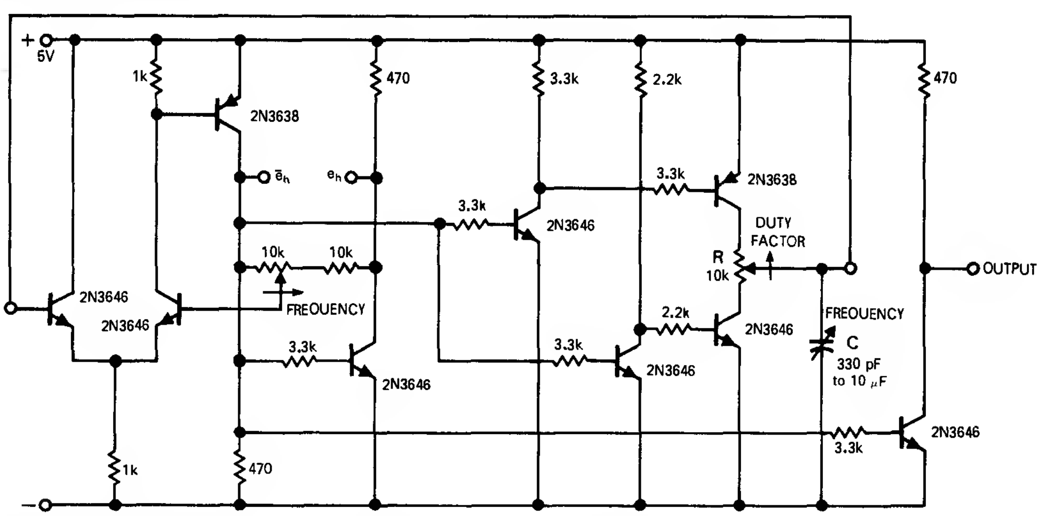
FREQUENCY RANGE

POSITION OF S1	PULSE PERIOD
0.001 μF	4 μs TO 1 ms
0.01 μF	40 μs TO 10 ms
0.1 μF	0.4 ms TO 100 ms
1 μF	4 ms TO 1 s

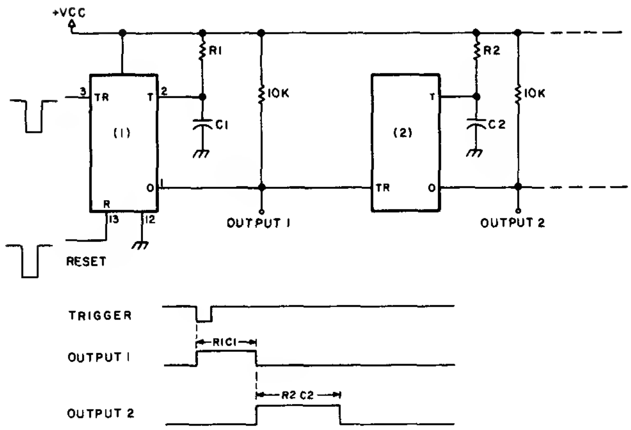
INDEPENDENT ON AND OFF PERIODS—High input resistance of CA3130 opamp permits use of high RC ratios in timing circuits, to give pulse period range of 4 μs to 1 s with switch-selected capacitors.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 5.

ADJUSTABLE SQUARE WAVES—Q_1 and Q_2 form flip-flop, with UJT Q_3 connected as time delay. When power is applied, one flip-flop transistor conducts and C_1 charges through one pot and diode. When C_1 reaches firing voltage of UJT, it conducts and resulting output pulse triggers flip-flop. Sequence of events now repeats, with C_1 charging through other diode. By proper selection of C_1 and pot values, circuit becomes square-wave generator with each pot controlling duration of one half-cycle. With one pot replaced by fixed resistor, circuit becomes pulse generator with other pot controlling pulse-repetition rate. If equal-value fixed resistors replace pots and R_1 is changed to pot, circuit becomes symmetrical square-wave generator with pot controlling frequency.—I. Math, Math's Notes, *CQ*, April 1974, p 64–65 and 91–92.

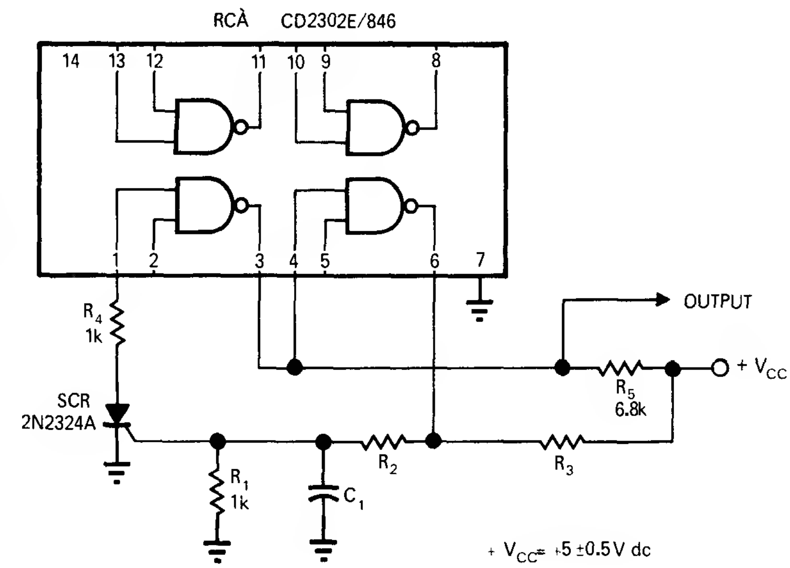




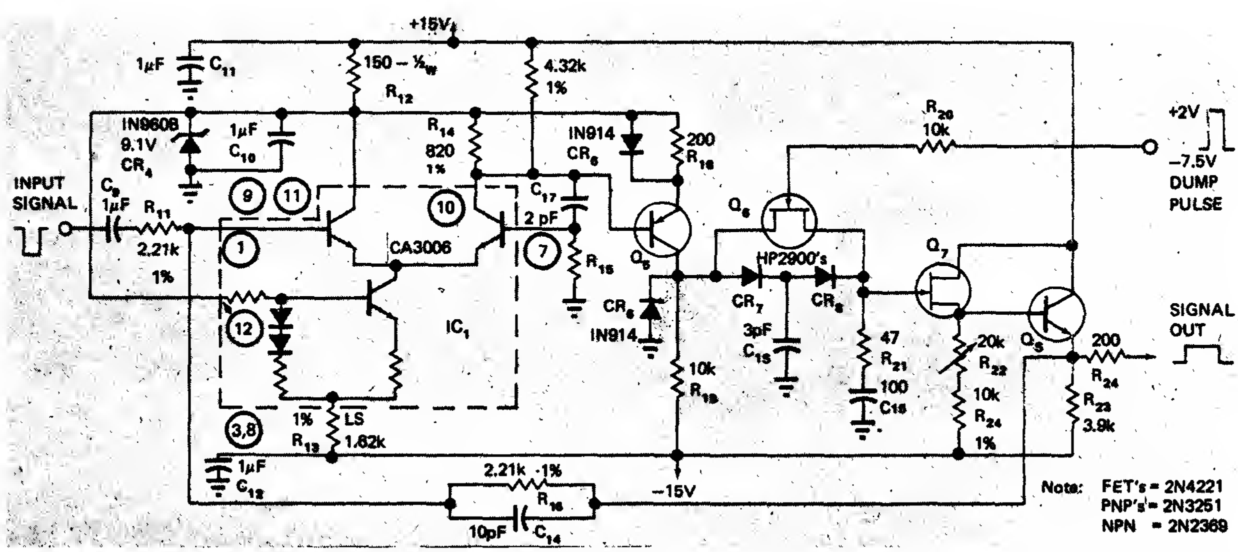
HYSTERESIS-AND-DELAY OSCILLATOR—Separate noninteracting frequency and duty-factor controls permit construction of simple telemetry oscillators having inherently linear transfer function. Absolute synchronization of independent and dependent variables is obtainable with relatively simple pulse-generating circuits. Synchronization cannot be lost. Average value of threshold voltage is maintained constant. Adjustment of hysteresis gap width moves threshold voltage limits symmetrically about average value. Resistance portion of RC delay is switched from positive to negative voltage symmetrically also. Article covers circuit operation in detail.—W. H. Swain, True Digital Synchronizer Employs Hysteresis-and-Delay Element, *EDN Magazine*, Jan. 1, 1971, p 33–35.



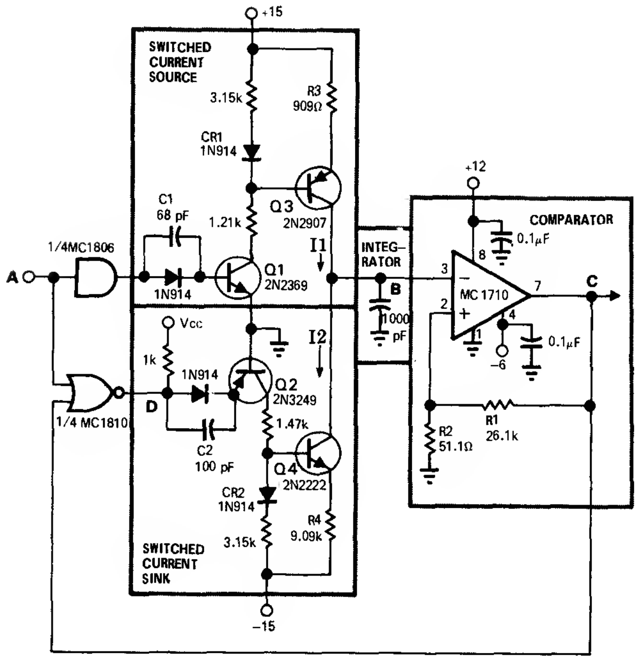
SEQUENTIAL PULSES—Any number of sections of 554 quad monostable timer can be cascaded as shown to give sequential series of output pulses of widths determined by values of R and C. No coupling capacitors are required because timer is edge-triggered. Negative reset pulse simultaneously resets all sections. Varying control voltage (in range of 4.5–16 V) affects period of all timer sections simultaneously.—H. M. Berlin, IC Timer Review, *73 Magazine*, Jan. 1978, p 40–45.



AF RECTANGULAR-WAVE—Frequency can be adjusted over wide AF range, with ON and OFF times of rectangular output signal independently varied between 35 and 60% on by choice of values for C_1 (0.05 to 40 μF), R_2 (1K or 2K), and R_3 (7.3K to 27K). Minimum value of R_3 is 6K.—D. E. Manners, Adjustable Rectangular-Wave Oscillator Interfaces with IC Logic, *EDN/EEE Magazine*, Sept. 15, 1971, p 46.

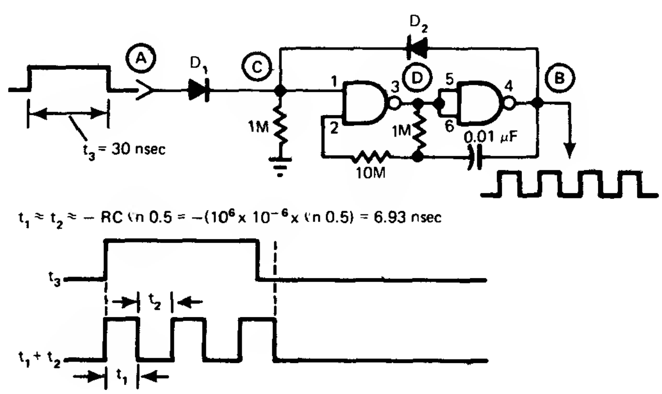


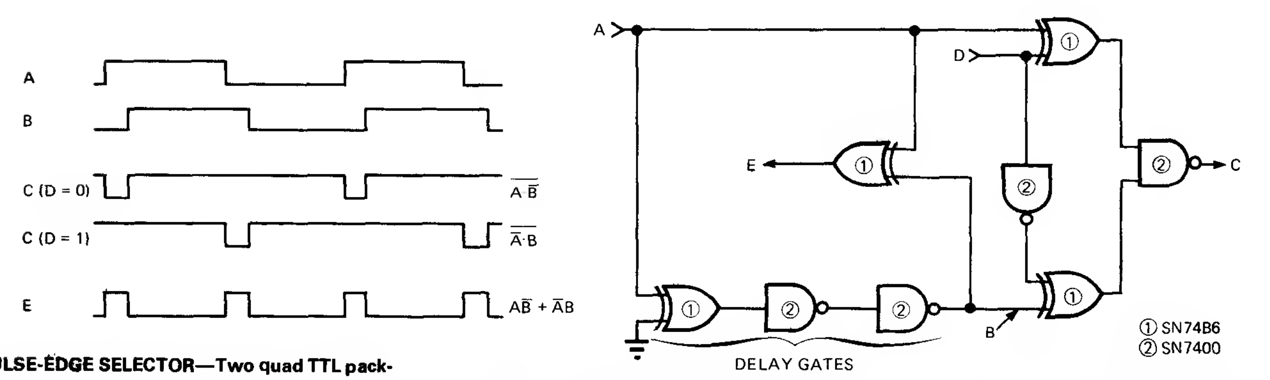
PULSE WIDENER—Peak detection diodes CR_7 and CR_8 in feedback loop of unity-gain CA3006 differential opamp form peak holder that maintains amplitude of narrow video pulses while stretching output pulses as much as 6000 times (from 50 ns to as much as 300 μs). Gain of circuit is unity. Article describes timing and control circuits required in conjunction with peak holder to achieve predictable termination times for stretched pulses. These external circuits include μA710 used as threshold limiter, 9602 dual monostable used as delay-pulse and dump-pulse timing generators, and discrete transistor stage serving as dump-pulse output stage.—B. Pearl, Peak Holder Stretches Narrow Video Pulses, *EDN Magazine*, Feb. 5, 1973, p 46–47.



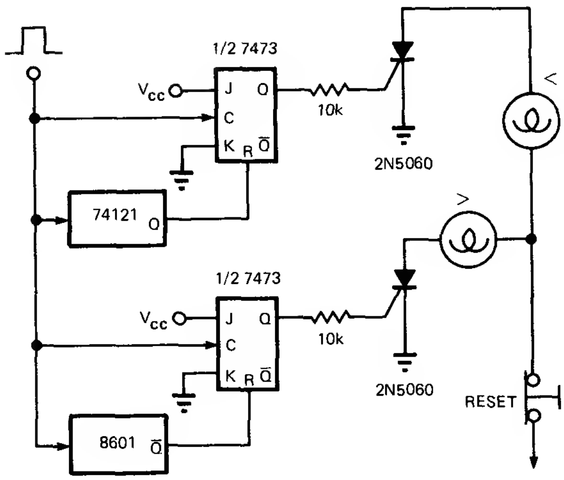
11X PULSE STRETCHER—Provides negativa output pulse width equal to positive input pulsa multiplied by 1 + R4/R3, which Is 11 for values shown. Output pulses are TTL- or DTL-compatible. Minimum output pulse width is 70 ns, and maximum is 1/11 of pulse repetition rate. Circuit consists of switched currant source, switched current sink, integrating capacitor, and comparator. Q1 and Q2 act as switches for current sources Q3 and Q4, while C1 and C2 reduce turn-on and turnoff times of switches. CR1 and CR2 provida temperature compensation for Q3 and Q4. AND gate compensates for propagation delay In NOR gate, to ensure that current sink is switched on by trailing edge of input pulse. Add invertar if output must be same polarity as input.—F. Tarico, Linear Circuit Multiplies Pulse Width, *EDN/IEEE Magazine*, Dec. 1, 1971, p 45–46.

COMPLETING LAST CYCLE—Devaloped for applications requiring that gated oscillator must always complete its timing cycle. Circuit uses only two NAND gates and two diodes, none of which are critical as to type. With no input at A, oscillator output B is low. When A is drivan high, D goes low initially and drivas output B high. If input at A is removed, regenerativa feedback is applied from B through diode D_2 to C until normal timing cycle is finished. Then, with B low, D becomes high and keeps output B low.—L. P. Kahhan, Gated Oscillator Completes Last Cycla, *EDN Magazine*, Jan. 5, 1977, p 43.



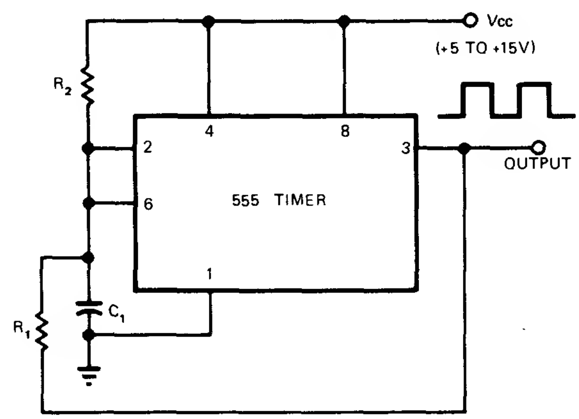


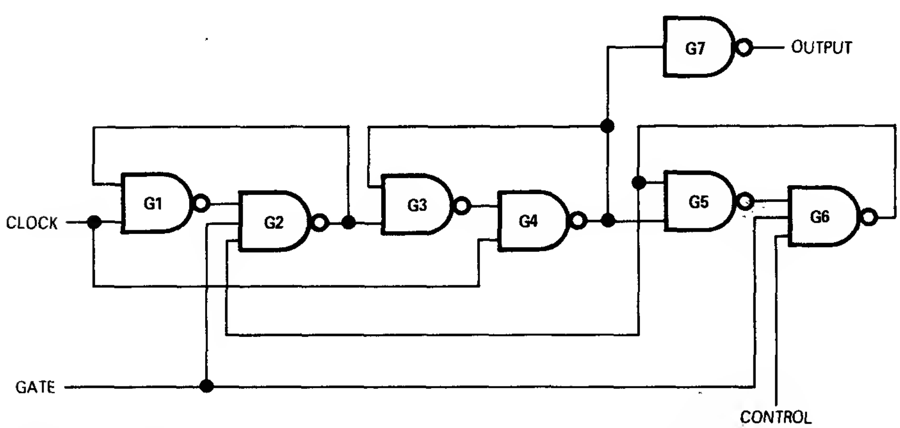
PULSE-EDGE SELECTOR—Two quad TTL packages form simple circuit that generates output pulse at C as function of either leading or trailing edge of input pulse at A, depending on logic level at terminal D. Additional output at E supplies pulses coinciding with both leading and trailing edges of input, independently of logic level at D. Maximum input frequency is 10 MHz, and edge pulses are about 35 ns wide. IC_1 is quad two-input EXCLUSIVE-OR gata, and IC_2 is quad two-input NAND gate.—C. F. Reeves, A Programmable Pulse-Edge Selector, *EDN Magazine*, April 20, 1973, p 85 and 87.



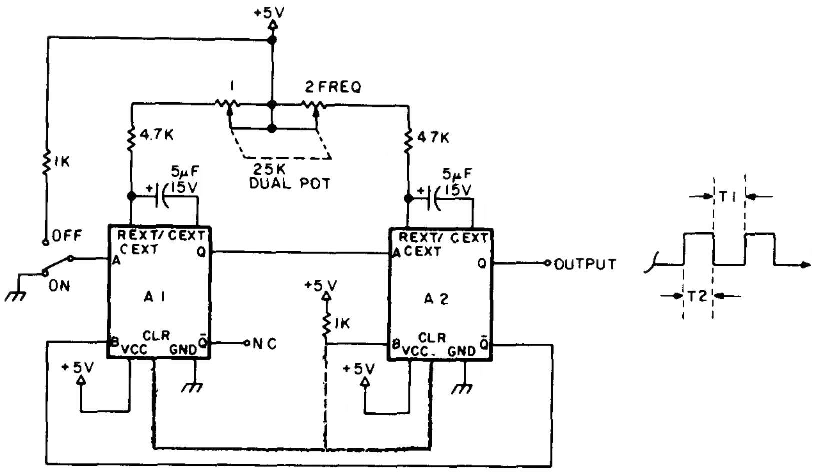
PULSE-WIDTH MONITOR—Circuit turns on upper pilot lemp when pulse width is less then predetermined minimum value, because upper 7473 JK flip-flop is clocked when pulse fells to ground before 74121 mono recovers, triggering upper SCR on. Similerly, 8601 mono is sat to coincide with specified meximum pulse width; if pulse falls to ground efter this mono recovers, its JK flip-flop is clocked end lower (greater then) lemp is turned on. Feult indiction is held until reset button is pushed.—J. Kish, Jr., Three ICs Monitor Pulse Width, *EDN Magazine*, March 20, 1973, p 86.

60 Hz WITH 50% DUTY CYCLE—Adding single resistor R_2 to stenderd oscillator connection of 555 timer permits operation with 50% duty cycle independantly of frequency es determined by velue of C_1. For 60-Hz output, V_{CC} is 10 V, C_1 is 1 μF, R_1 is 10K, and R_2 is 75K.—R. Hofheimer, One Extra Resistor Gives 555 Timer 50% Duty Cycle, *EDN Magazine*, March 5, 1974, p 74–75.



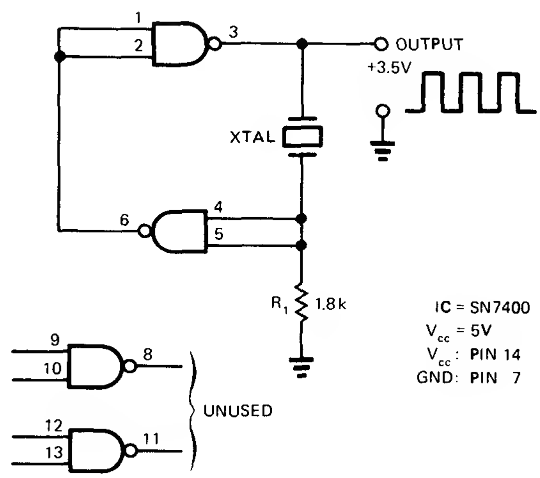


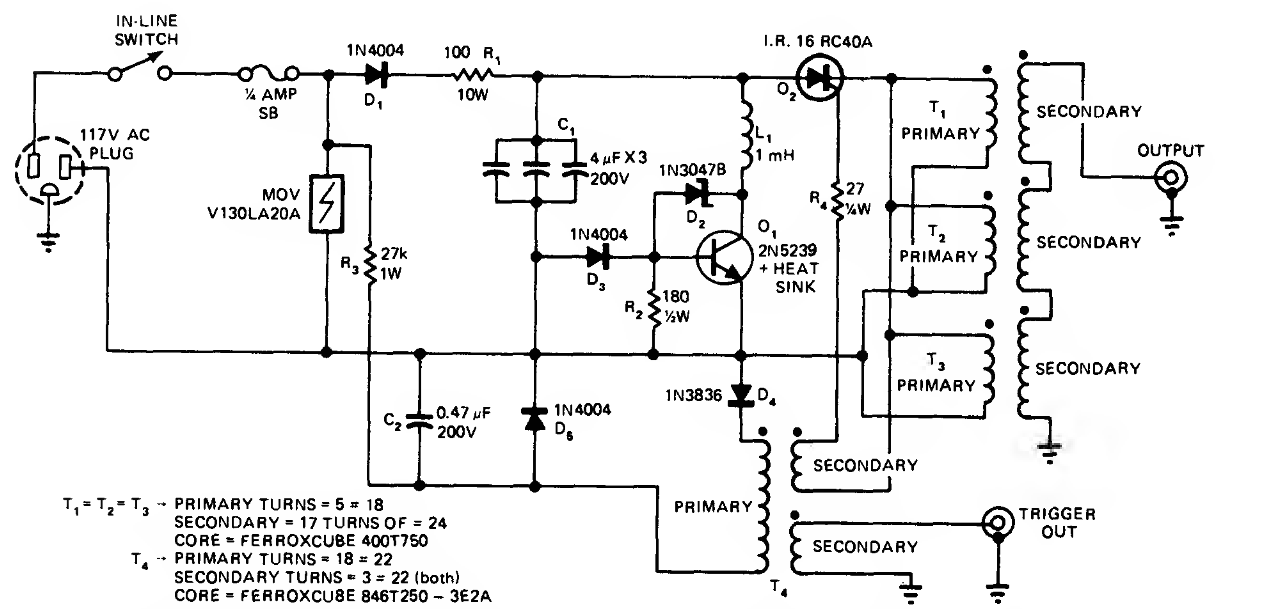
GATED PULSE TRAIN—When control is logic 0, circuit transmits train of complete clock pulses to output, beginning with first clock pulse thet starts to rise after epplication of gate signal and ending with last clock pulse that starts before gate signal falls. When control is logic 1, circuit transmits ona complete clock pulse after logic 1 gate signal rises. To send another single pulse, gate signal must be removed and reapplied. Gates are Feirchild LPDTμL9047 triple three-input NAND and 9046 qued two-input NAND; other compatible DTL or TTL NAND getes can also be used.—J. V. Sastry, Geted Clock Generetes Pulse Trein or Single Pulse, *EDN/IEEE Magazina*, July 1, 1971, p 50.



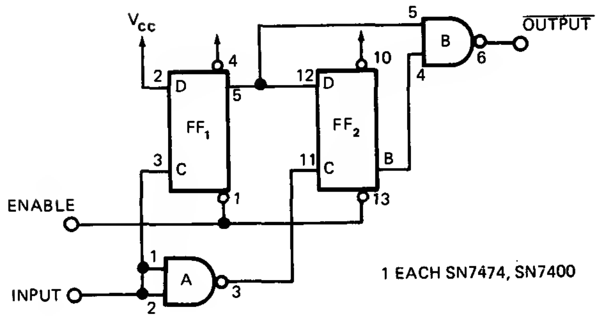
SQUARE-WAVE GENERATOR—Uaes two 74122 retriggerable mono MVBRa with clear. Two single pots may be used in place of dual 25K pot if up and down times of output must be independently adjustable.—B. Voight, The TTL One Shot, *73 Magazine*, Feb. 1977, p 56–58.

120 kHz TO 4 MHz—Squere-wave output of about 3.5 V can be obtained with SN7400 quad NAND gate, quartz crystal of dealred frequency, and single resistor. One of unused gates may be used to gate generator output. Inaartion of crystal in socket shocks crystal into oacilletion at its resonant frequency, for generating squareweve output over most of frequency range. Waveform approachea clipped sina wave near 4 MHz. Output is auitable for triggering SN7490 decade counters reliably, with normal fanout.—E. G. Olson, 2 Gates Meke Quartz Oscillator, *EDN Magazine*, May 5, 1973, p 74.



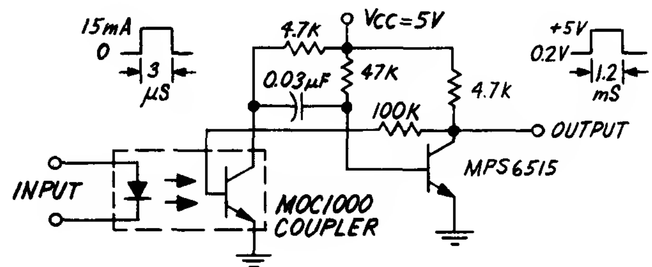


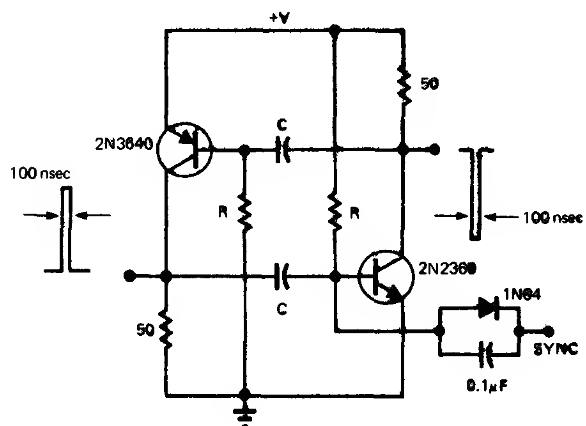
KILOVOLT PULSES—Simple circuit ganarates 1.5-kV pulses at fixed rate equal to line frequency. Uaad to drive small piezoelectric transducers for sound velocity measuraments. Absence of power transformer minimizes cost, aize, and weight. During half of AC cycle, C_1 chargea. During other half, C_1 discharges through Q_2 into primaries T_1, T_2, and T_3 to provida output pulse. R_3, C_2, D_5, D_4, and T_4 provida trigger pulse for turning on Q_2. Shunt regulator formed by D_2, D_3, R_2, Q_1, and L_1 clamps voltaga across C_1 et 130 V to ansura constant amplitude of output pulses.—S. Anderson, Portabla Ganaretor Produces Kilovolt Pulses, *EDN Magazine*, Oct. 20, 1977, p 102.



SINGLE-PULSE SELECTOR—Circuit is used to select any desired single pulse from wavetrain continuously applied to input terminal. When enable pulse (not exceeding width of input pulse) is applied, flip-flop FF_1 clocks on leading edge of next input pulse and FF_2 clocks on trailing edge. Output pulse thus has same width as pulses in input wavetrain. Edge-triggering characteristics of D flip-flops prevent operation if they are enabled during input pulse; in this case, next input pulse is delivered as output.—S. J. Cormack, Pulse Catcher Uses Two ICs, *EDN Magazine*, Jan. 5, 1973, p 109.

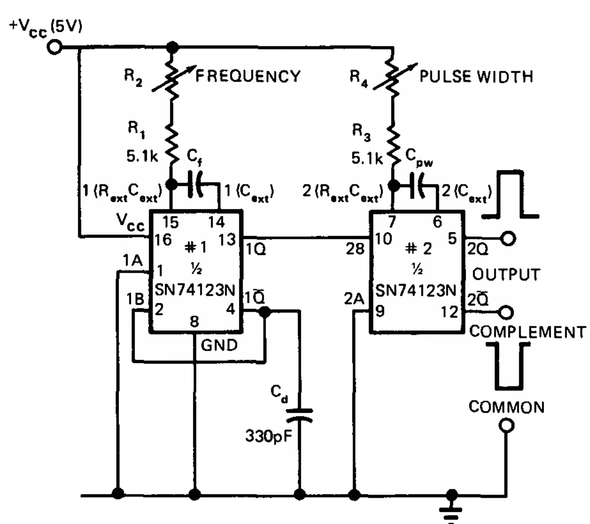
PULSE STRETCHER WITH ISOLATION—Motorola MOC1000 optoisolator provides safe interfacing with digital logic while stretching input pulse. Circuit uses phototransistor of optoisolator as one of transistors in mono MVBR. With input pulse width of 3 μs, output pulse width is about 1.2 ms.—"Industrial Control Engineering Bulletin," Motorola, Phoenix, AZ, 1973, EB-4.

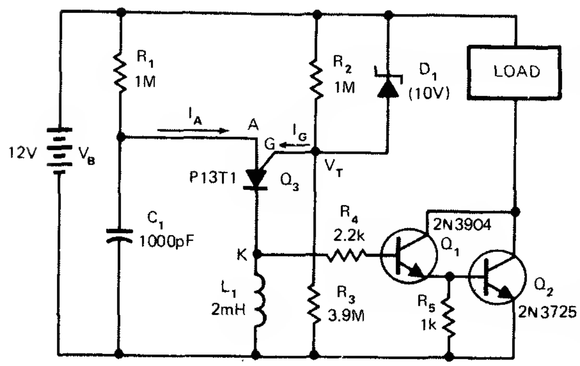




SYNCHRONIZATION TO 10 MHz—Free-running pulse generator circuit uses diode to inhibit operation until sync signal is applied. Circuit then pulses until sync signal returns to original state. Complementary outputs having pulse widths of 100 ns swing essentially from ground to power supply voltage that can be anywhere in range from 0.65 V to 15 V. Values used for R and C determine frequency. For oscillation, R must be in range of 1 kilohm to 1 megohm. For 5-V supply, frequency is 1.2/RC.—B. Shaw, Oscillator Provides Fast, Low Duty-Cycle Pulses, *EDN Magazine*, March 20, 1975, p 73.

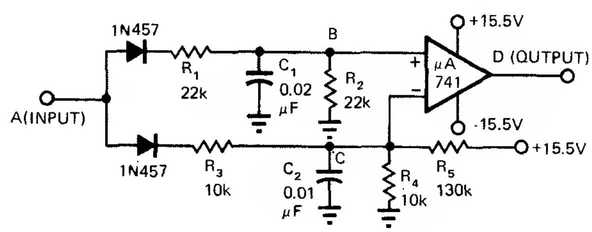
VARIABLE-WIDTH TO 12.85 MHz—Single IC circuit uses two monostables to form pulse generator that covers over eight decades (0.054 Hz to 12.85 MHz) with only eight capacitors. Similarly, only eight capacitors cover pulse width range of over eight decades (60 ns to 18 s). Voltage control of frequency and pulse width can be obtained by connecting R_2 and R_4 to individual 1.5–4.5 V control voltage lines instead of to V_{CC}. Frequency will then vary almost linearly with control voltage, while pulse width will vary almost inversely with control voltage. Capacitor values range from 1 pF to over 100 μF.—M. J. Shah, Wide-Range Pulse Generator Uses Single IC, *EDN Magazine*, Jan. 5, 1973, p 107 and 109.

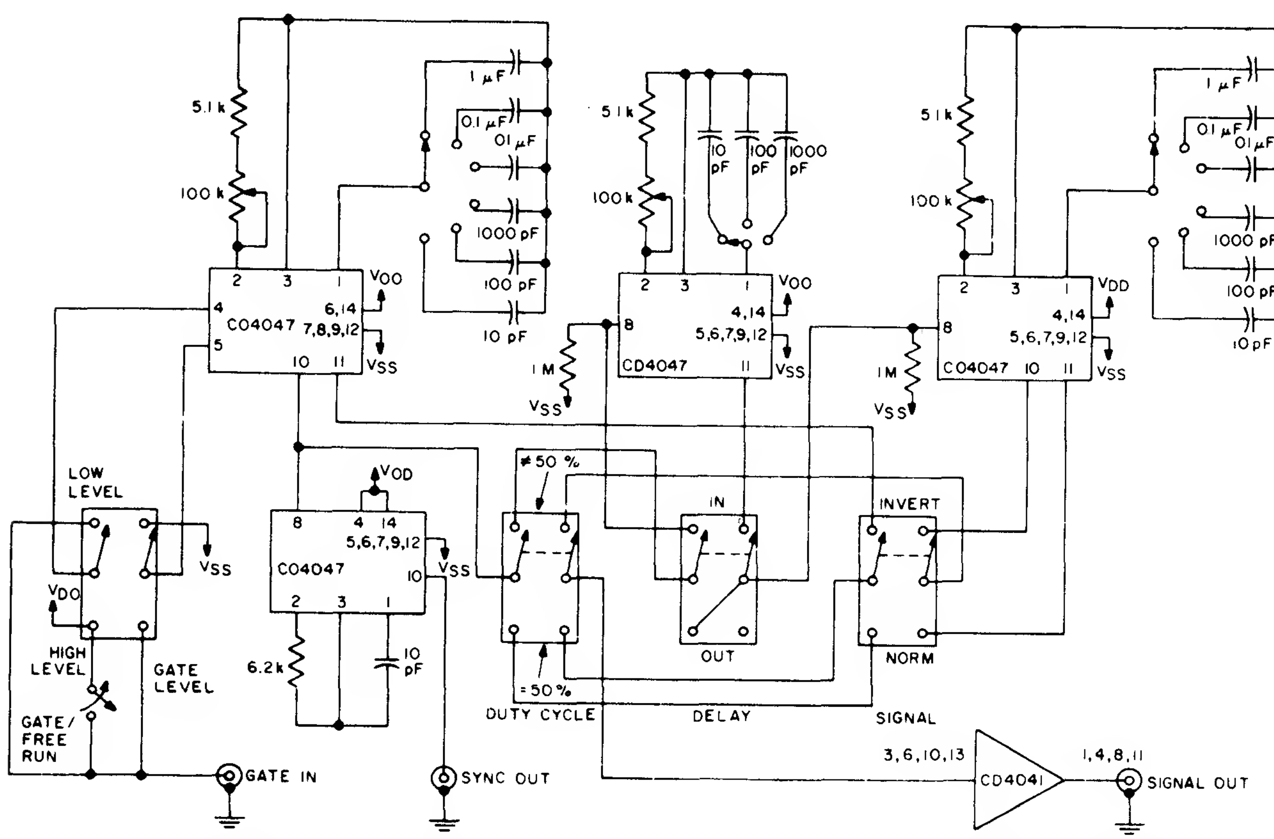




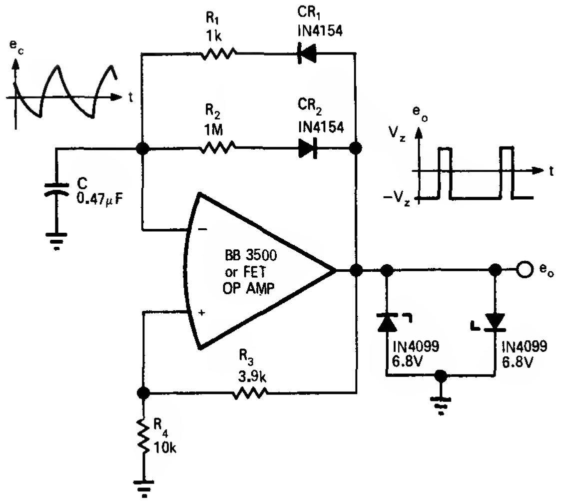
MEMORY REFRESHER—Dalivars high-energy pulsas In extremely low duty-cycla mode. Daveloped to provide memory-refresh pulsas for MOS memory system from standby battery. Circuit is basically programmabla UJT oscilletor with divider R_2-R_3 satting threshold or trigger level. To complete one cycle and start next, UJT is turned off by zener. Current through L_1 drops, and resulting negative transient at base of Darlington cuts It off. This generates high-power pulse with vary sharp rise and fall tlmes. Charging sequanca then starts again to give sustained oscillation. Article gives design equations.—J. P. Staln, PUT Dalivers Ultra-Low-Power, High-Energy Pulses, *EDN Magazine,* Sept. 1, 1972, p 51–52.

DELAYED PULSE—Both time and duration of output pulsa are programmabla by selection of RC networks. Original and deleyed clock pulses can both be used in gatlng circuits. With valuas shown, output pulse is 1 ms wide and is delayed 15 μs from trailing edge of clock pulse.—D. T. Anderson, Operational Amplifier Makes a Slmpla Dalayed Pulse Ganerator, *EDN Magazine,* July 1, 1972, p 55.

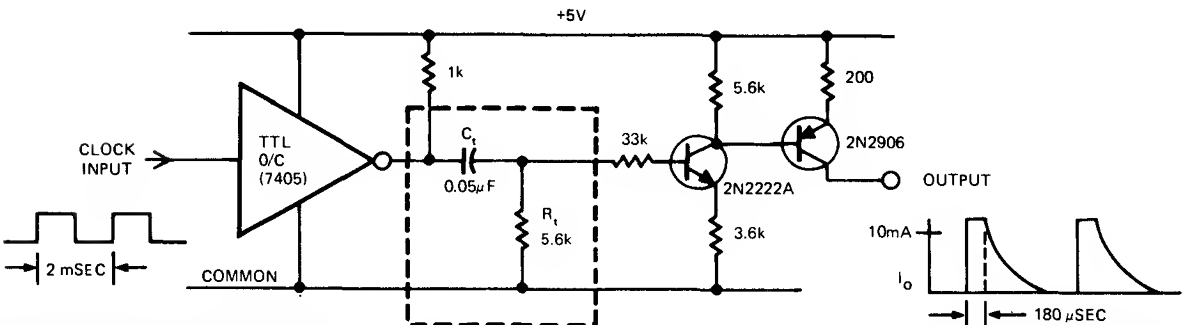




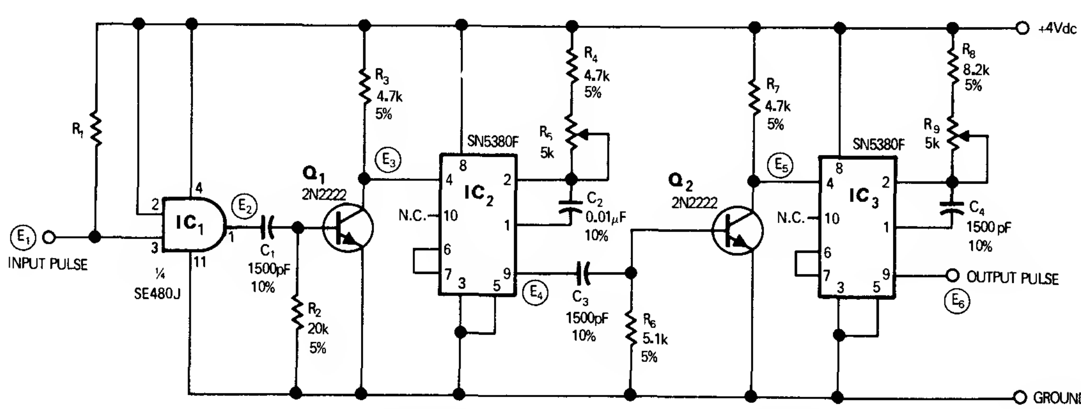
2 Hz TO 1 MHz—Ganerel-purpose laboratory pulse ganerator uses four CD4047A MVBRs to provide six overlepping ranges of fraquencies along wlth pulse-width control, delayad sync, end geting from high-laval or low-leval input. When dalay switch is IN, MVBR at upper center produces variable output delay from 1.5 μs to 250 ms with respact to sync pulse. When daley pulsa is OUT, this mono MVBR is bypassed and inharent delay is then about 400 ns. Signal output is buffered with CD4041A for driving any required loed. Supply voltaga is not critical end can be taken from davice under tast.—"COS/MOS Integrated Circuits," RCA Solid Stete Division, Somerville, NJ, 1977, p 619–620.



0.1–99.9% DUTY CYCLE—Single opamp circuit provides precise duty-cycle control of pulse train over wide dynamic range by choice of values for R_1 and R_2. Opamp forms gain element of astable MVBR, with pulse and space time intervals determined by feedback elements. Values shown give duty-cycle ratio of 0.001 and period of 1 s.—J. Graeme, Pulse Generator Offers Wide Range of Duty Cycles, *EDN/EEE Magazine*, Sept. 1, 1971, p 42–43.



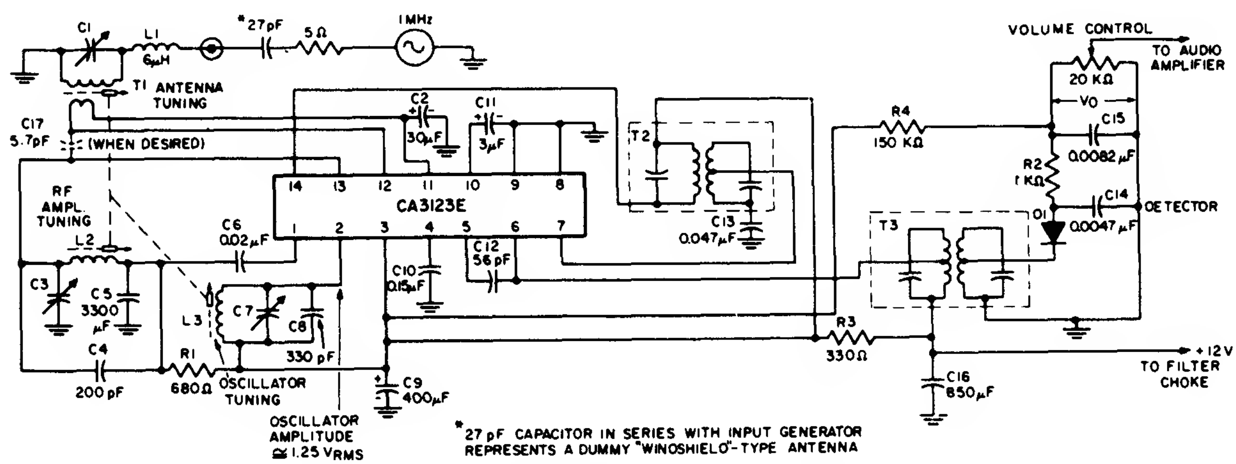
SHORTENING DUTY CYCLE—Clock-pulse differentiator/buffer shortens duty cycle of 500-Hz clock signal having positive period of 1000 μs. Open-collector 7405 inverter acts as buffer. C_t and R_t are primary differentiating components. Saturation of transistors provides some stretching of output and gives output pulse width of about 180 μs. Developed for driving regulated power supply having clock-controlled short-circuit protection.—J. L. Bohan, Clocking Scheme Improves Power Supply Short-Circuit Protection, *EDN Magazine*, March 5, 1974, p 49–52.



VARIABLE WIDTH AND DELAY—Produces variable-width blanking pulse at selectable delay time after triggering by input pulse. With values shown, output pulse range is 8 to 12 μs, and delay range is independently adjustable from 26 to 36 μs with R_5.—D. E. Norris, Variable Delay Blanking-Pulse Generator, *EDN/EEE Magazine*, Dec. 1, 1971, p 49.

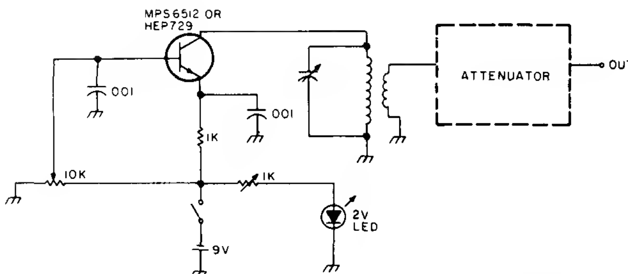
CHAPTER 72
Receiver Circuits

Individual stages and complete circuits for entertainment, amateur radio, commercial communication, and other types of AM and FM receivers, including ultrasonic, radiotelescope, and satellite communication receivers. See also Amplifier, Antenna, Audio Amplifier, Code, Frequency Modulation, IF Amplifier, Single-Sideband, Squelch, Television, and Transceiver chapters.

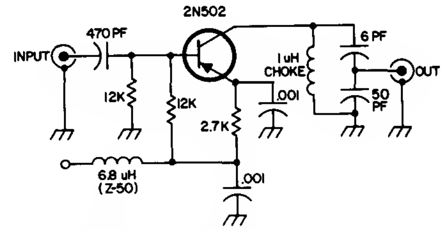


Transformer	Symbol	Frequency	Inductance µh (≈)	Capacitance pF (≈)	Q (≈)	Total Turns To Tap Turns Ratio	Coupling
First IF: Primary	T_2	262 kHz	2840	130	60	none	critical ≈0.017 ≈1/Q
Secondary			2840	130	60	30:1 or 31:1	
Second IF: Primary	T_3	262 kHz	2840	130	60	8.5:1	–
Secondary			2840	130	60	8.5:1	critical ≈0.017 ≈1/Q
Antenna: Primary	T_1	1 MHz	195	$(C_1)-130$	65		
Secondary		Adjusted to an impedance of 75 Ω with primary resonant at 1 MHz. Coupling should be as tight as practical. Wire should be wound around end of coil away from tuning core.					
Coils	L_1	7.9 MHz	6		50		
	L_2	1 MHz	55		50		
	L_3	1.262 MHz	41		40		

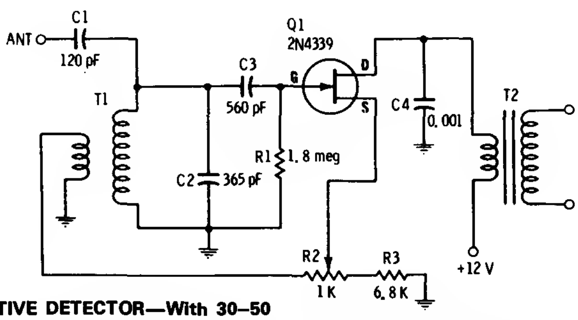
AM SUPERHET SUBSYSTEM—RCA CA3123E provides all active elements needed up to audio volume control. Table gives values of components for tuned circuits. Operates from single 12-V supply, making subsystem particularly suitable for auto radios. IF value is 262 kHz. 1-MHz signal generator shown in input circuit is used only for initial tuning.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 361–362.



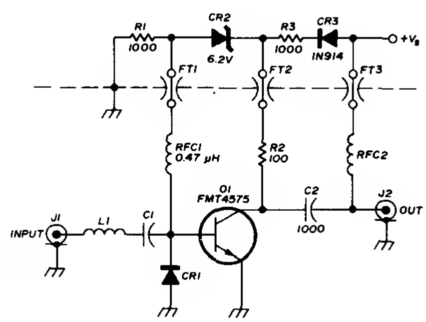
RECEIVER-CHECKING VFO—Simple variable-frequency oscillator is combined with attenuator network to generate signal of about 1μV for checking performance of amateur radio receiver quickly. Attenuator is series arrangement of 47-, 100-, 100-, and 47-ohm resistors, with 1-ohm resistors going from each of the three junctions to ground. LC combinations are chosen for amateur band desired. Circuit will work down to at least 2 meters.—Is It the Band or My Receiver?, *73 Magazine*, Oct. 1976, p 132–133.



6-METER PREAMP—Simple transistor circuit requires no tuning, draws less than 50 mW from 9-V supply, and increases sensitivity of low-priced receiver without complicated impedance matching.—E. R. Davisson, Simple Six Pre-Amp, *73 Magazine*, Oct. 1974, p 111–112.



FET REGENERATIVE DETECTOR—With 30–50 foot antenna wire, circuit gives sufficient volume for driving headphones connected to secondary of Lafayette AR-104 or equivalent audio driver transformer T2, for reception of broadcast stations when tuned over AM broadcast band with C2. Feedback control R2 is backed off slightly from point of oscillation, for maximum sensitivity in removing modulation from incoming carrier. When used for CW reception, circuit is left in oscillation and audible difference frequency is produced in output corresponding to marks and spaces. T1 is Miller 2004 or equivalent antenna transformer.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 235–237.



C1 100-180 pF miniature dipped mica or ceramic

C2 1000 pF miniature ceramic disc

CR1 hot-carrier diode (Hewlett-Packard 5082-2810)

CR2 6.2 volt zener diode (1N4735)

CR3 silicon diode (1N914)

FT1-FT3 feedthrough capacitors, 470-1000 pF

J1,J2 SMA-type coaxial connectors (see text)

L1 4 turns no. 24 on 0.1" (2.5mm) diameter, spaced wire diameter (approximately 30 nH)

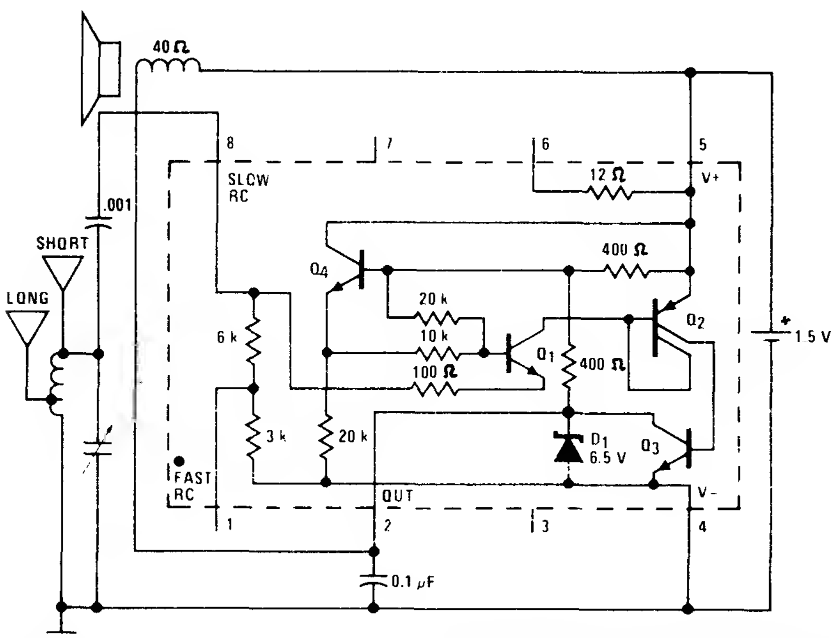
Q1 Fairchild FMT 4575 low-noise transistor (see text)

R2 100 ohms, ¼ watt (see text)

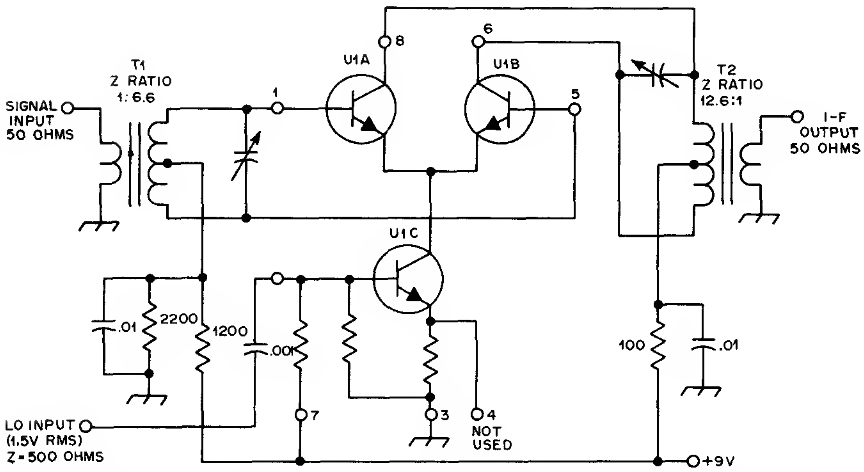
RFC1 0.47 μH miniature rf choke (Nytronics SWD=0.47)

RFC2 0.2-0.47 μH miniature rf choke or Ohmite Z-460 (value not critical)

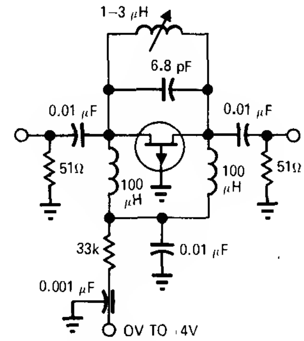
432-MHz LOW-NOISE PREAMP—Uses Fairchild FMT4575 transistor having 1.25-dB noise figure, equaling performance of best preamps at 432 MHz. Input matching circuit is low-loss low-Q L matching section L1-CR1. Value of blocking capacitor C1 is not critical, but should be low-loss high-Q type. Hot-carrier diode CR1 in matching section adds about 0.75 pF to circuit, and serves also as low-loss limiter that protects transistor from excessive RF. Zener-diode biasing permits direct grounding of emitter, is insensitive to transistor current gain, provides some DC protection to transistor, and requires no adjustments.—J. H. Reisert, Jr., Ultra Low-Noise UHF Preamplifier, *Ham Radio*, March 1975, p 8–19.



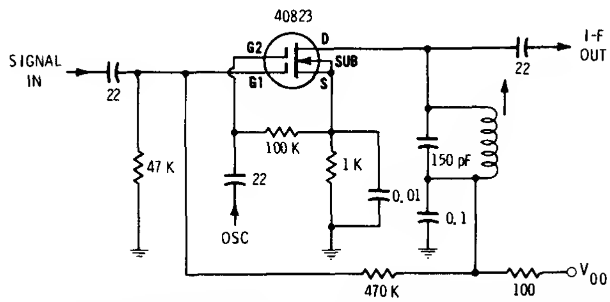
SINGLE-IC RADIO—National LM3909 IC is connected as detector-amplifier driving loudspeaker, with extremely low power gain giving continuous operation for 1 month from D cell. Tuning capability is comparable to that of simple crystal set. Provides acceptable volume from local station if used with efficient 6-inch 40-ohm loudspeaker. Coil is standard AM radio ferrite loopstick having tap 40% of turns from one end. Short antenna can be 10–20 feet, and long antenna can be 30–100 feet.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 8–9.



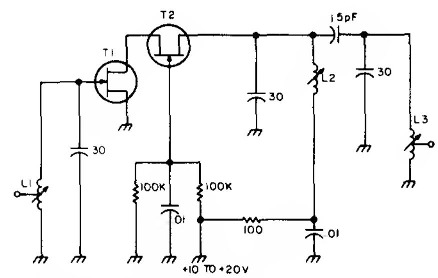
SINGLE-BALANCED MIXER—Uses RCA CA3028A differential amplifier U1 to provide conversion gain of about 30 dB for signal inputs up to 120 MHz. Values of tuned circuits depend on frequency used. Unmarked resistors are on IC.—D. DeMaw, Understanding Linear ICs, *QST*, Feb. 1977, p 19–23.



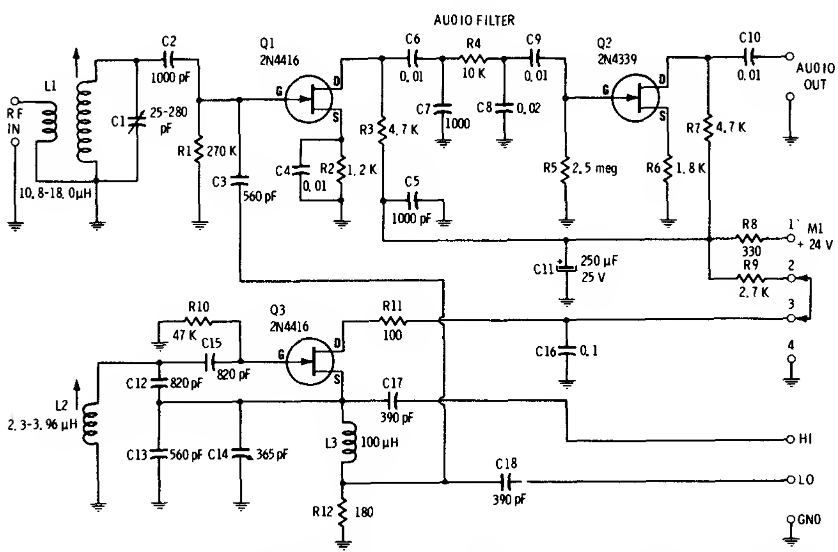
50-dB ATTENUATION CONTROL—Low-cost FET in pi network serves as resistive attenuator providing up to 50-dB attenuation of 30-MHz level-controlled signal source by varying DC control voltage over range of 0 to 4 V. Tank circuit across source-drain leads of FET keeps phase shift under 2° over entire attenuation range. FET type is not critical.—E. E. Baldwin, Voltage-Controlled Attenuator Has Minimum Phase Shift, *EDN/IEEE Magazine*, Nov. 15, 1971, p 40.



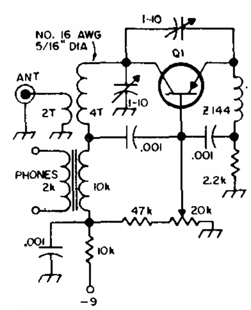
DUAL-GATE MOSFET MIXER—RF and oscillator signals are applied to gates G1 and G2 for mixing in MOSFET. Choice of sum or difference frequency is determined by values used in tank circuit and by tuned circuits of IF amplifier.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 141–142.



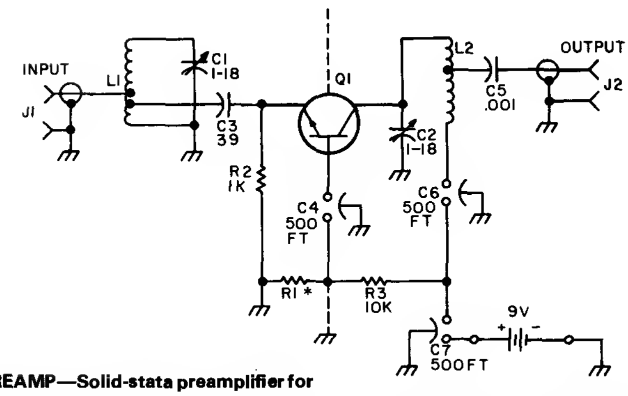
10-METER PREAMP—Simple preamp can also be used on 2 meters with appropriate change of coils. Needs no neutralization. Developed for use with receiver capable of receiving satellite transmissions on 29.45 to 29.55 MHz. Transistors can be MPF 102, MPF 106, or 2N4416. All coils are 1.2 μH having 7 turns No. 26 enamel on 3/16-inch slug-tuned form. L1 and L3 have tap at 3 turns.—G. L. Tater, CQ OSCAR 7, *73 Magazine*, Feb. 1975, p 54–56 and 58–60.



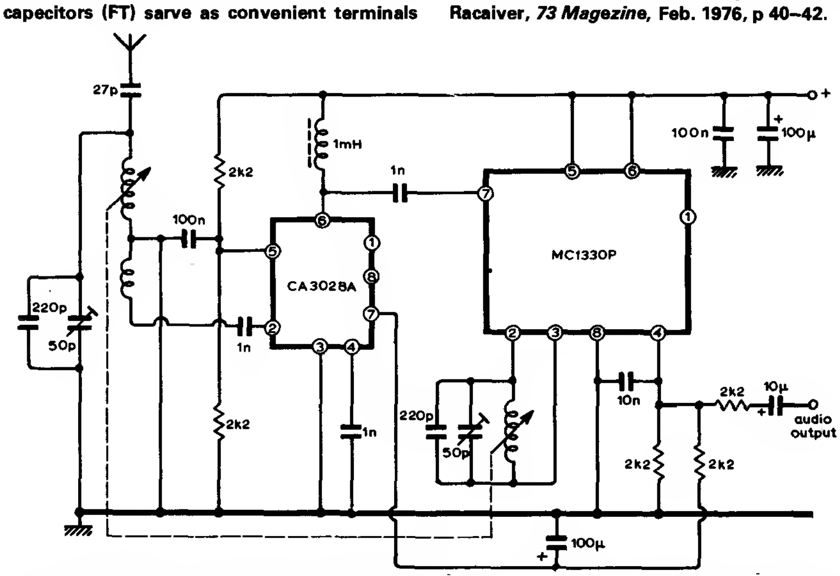
VFO WITH DIRECT-CONVERSION DETECTOR—Used in demodulating SSB and CW signals. Incoming signal is heterodyned with VFO output to give direct conversion to audio. Audio filter R4-C7-C8 allows only AF components to be transferred to audio amplifier Q2. Oscillator can be operated alone for other purposes by removing jumper between output terminals 2 and 3, then applying +24 V to terminal 3 and negative supply to terminal 4. Load on low-level output of oscillator has negligible effect on frequency. Load on high output may change frequency, but this can be corrected by retuning oscillator if load is constant. Values shown are for 80-meter band.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 165–173.



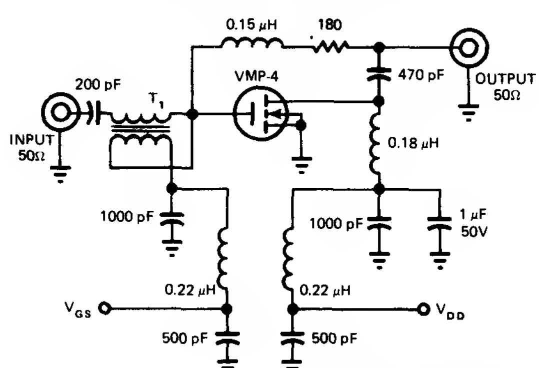
SUPERREGENERATIVE—Simple single-transistor superregenerative receiver is adequate for copying many local signals in 2-meter amateur band. With components shown, tuning range is about 90 to 150 MHz. Transistor can be GE-9 or HEP-2.—Circuits, *73 Magazine*, Feb. 1974, p 100.



144-MHz PREAMP—Solid-stata preamplifier for 2-m bend equals performanca of best tuba designs. Velue of R1 is chosan for optimum gain versus noise figura. Two 500-pF feedthrough capecitors (FT) serve as convenient terminals for connections. Q1 is 2N2708, 2N4936, or equivalent. Article covers construction and tune-up.—C. Sondgeroth, Really Soup Up Your 2m Racaiver, *73 Magezine*, Feb. 1976, p 40–42.

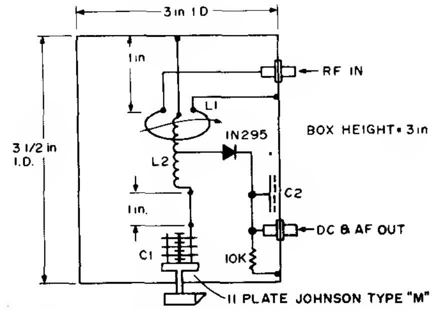


AM HOMODYNE—Circuit uses ICs to provide product damodulator that overcomas interstation tuning whistles or heterodynas by deriving local oscillator source from incoming signal carrier. This AM carrier is amplified before modulation is stripped off, and used in homodyne system in which converter output (IF signal) is the same as audio signal. Motorola MC1330P IC, originally devaloped es color TV video detector, is hara connected as synchronous demodulator. RF amplifier IC is RCA CA3028A operating in cascode mode, with permeability tuning of input and RF choka end input of MC1330P together forming output load. Article covers circuit operetion in detail and gives alignment procedures. Although developed for broadcast band, basic circuit can ba adapted for communication and FM receivers es well.—J. W. Herbert, A Homodyna Receiver, *Wireless World*, Sept. 1973, p 416–419.

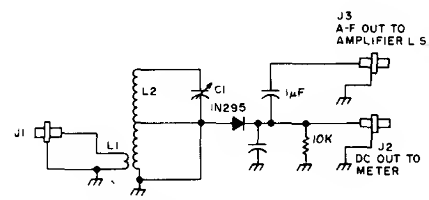


* T_1 4T = 22 AWG TWISTED PAIR ON INDIANA GENERAL F625-9Q2

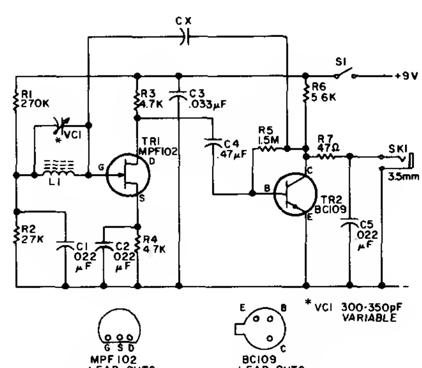
40–275 MHz BROADBAND VMOS—Rasponse is flat within 1 dB ovar antira frequency ranga for 12-dB output. Circuit requires no initial adjustments and cannot be damaged by mismatched loeds. Dasigned primerily for communication applications. Uses Siliconix VMP-4 vartical MOS powar transistor.—E. Oxner, Will VMOS Power Transistors Replace Bipolars in HF Systems?, *EDN Magazine*, June 20, 1977, p 71–75.



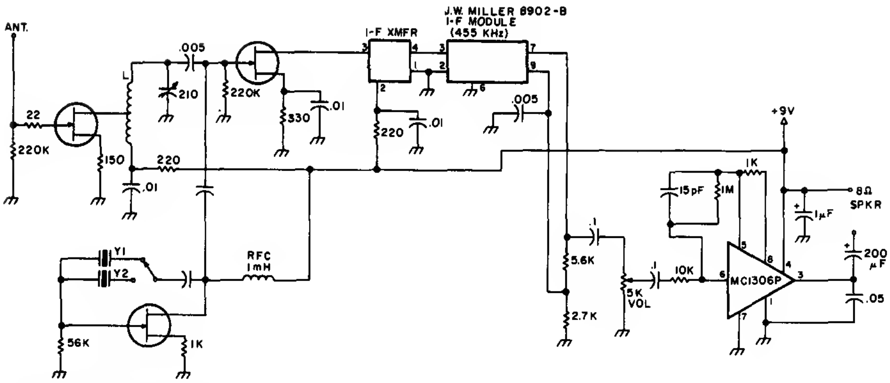
100–200 MHz DIODE RECEIVER—Hybrid tuned-dioda version of basic crystal detector uses line cavity cut from sheet copper and soldared into box to give high Q up to 200 MHz. Useful for chacking local oscillators eround 135 MHz and transmittars around 147 MHz, along with 2-meter transmitters and transceivers. L2 is 4 turns air-wound ½ inch diameter and ½ inch long, with L1 as 1 turn adjustable around it. C2 is 1 × 2 inch brass plate with 0.005-inch teflon sheet with nylon bolts.—B. Hoisington, Tuned Diode VHF Raceivars, *73 Magazine*, Dec. 1974, p 81–84.



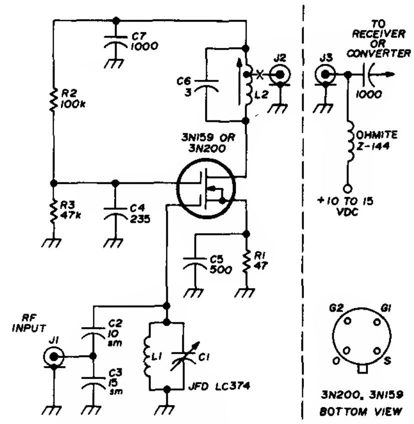
2–12 MHz DIODE RECEIVER—Basic crystal detector circuit can be tuned over 4-MHz ranga and can also serve as AM detector for 10.7-MHz IF strip. L2 is 64 turns on ½-inch diametar air-wound, centar-tapped, with 2 turns around it for L1. C1 is ebout 365 pF. Unmarked C can be 0.01 μF.—B. Hoisington, Tuned Dioda VHF Receivers, *73 Magazine*, Dec. 1974, p 81–84.



TWO-TRANSISTOR RECEIVER—Suitabla for reception of local AM broadcast stations. L1 is standard farrita-rod antenna or suitable winding on 5/16-inch ferrite rod 3½ inches long, for use with broadcast-bend tuning capacitor. Choose value of CX that gives maximum sensitivity.—Circuits, *73 Magazine*, July 1975, p 170.

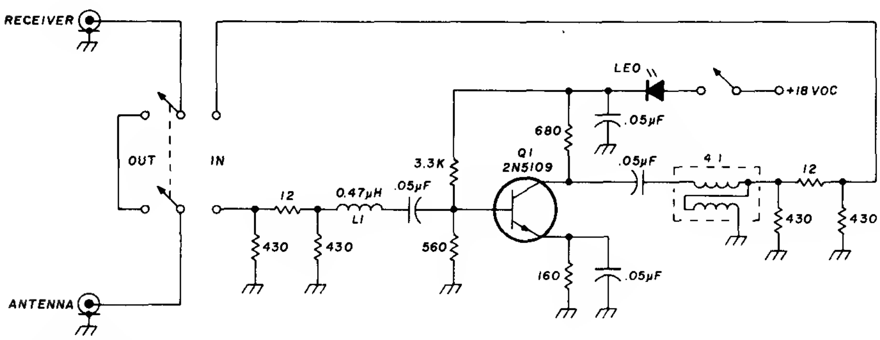


WWV RECEIVER—Solid-stste components simplify construction of good HF utility-type receiver suitable for monitoring WWV end other station trsnsmissions or for checking specific frequencies in HF bends. Receiver is single-conversion superhetarodyne with FET front end, crystal-controlled. No bendswitching is required over 6–15 MHz rsnge. All transistors sre MPF 102 or HEP 802. IF transformer is part of Miller IF module. L is 26 turns No. 26 on ¼-inch form, tspped at 13 turns. Y1 is 9.545 MHz for 10-MHz WWV, snd Y2 is 14.545 MHz for 15-MHz WWV.—Build a Useful HF Receiver, *73 Megezine*, Dec. 1977, p 216–217.

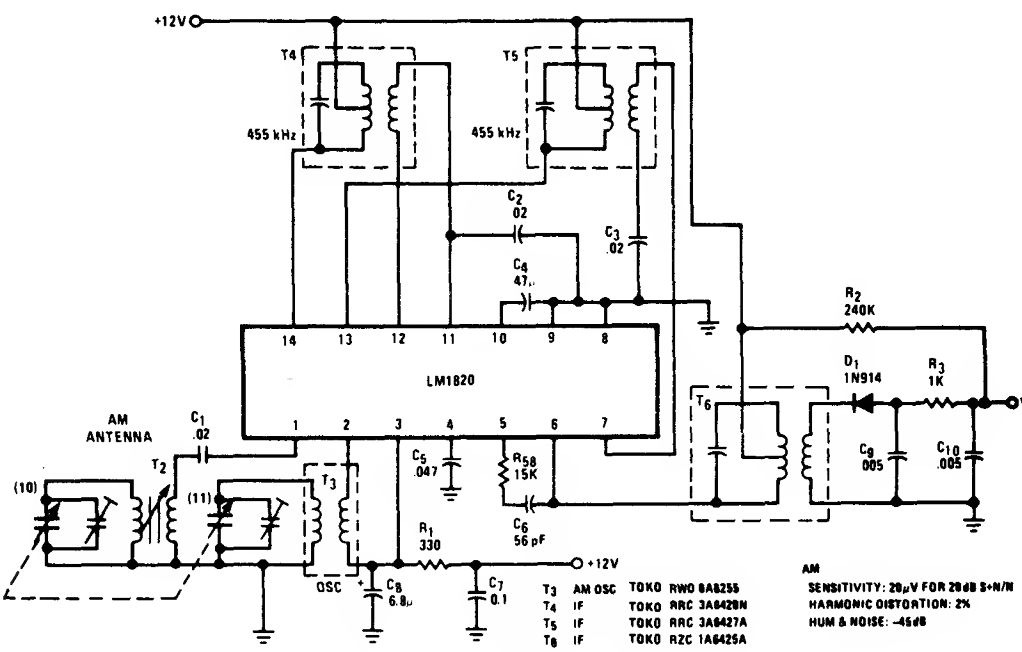


- C1 part of JFD LC374 tank circuit (see text)
- C2 10-pF silver-mica with 3N159, 8-pF silver mica with 3N200
- C3 15-pF silver-mica with 3N159, 12-pF silver mica with 3N200
- C4 235-pF mica button
- C5 500-pF mica button
- L1 JFD LC374 tank circuit (contains C1)
- L2 6 turns no. 22 enamelled on a 5-mm (0.2") diameter slug-tuned form, tap at 1 turn

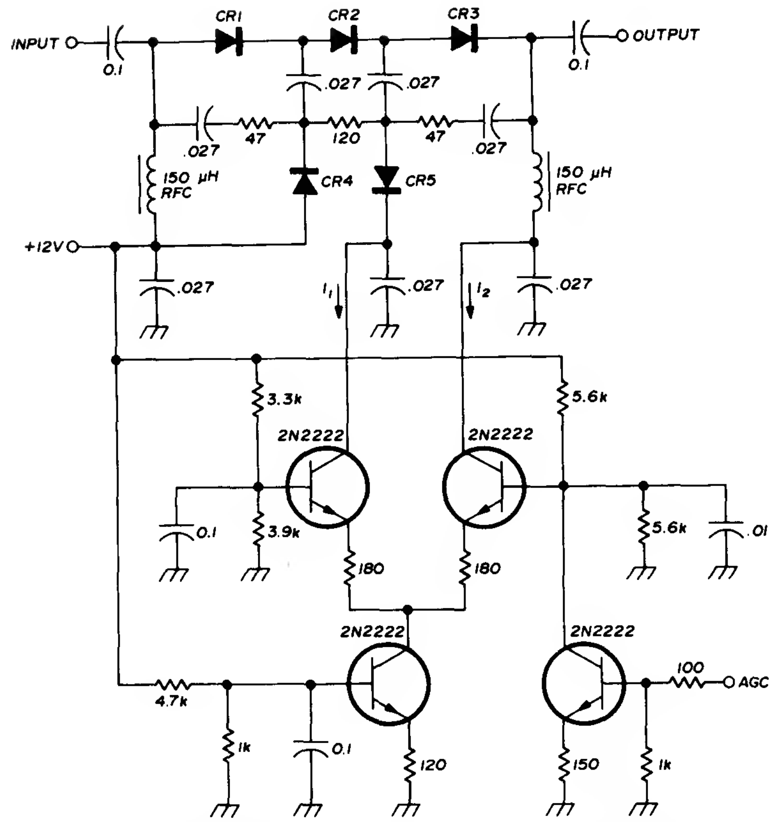
144-MHz PREAMP—High-performance circuit for 2-meter receiver provides 15-dB gain and low noise figure. Low-loss low-noise input circuit uses tspped-cepscitor coupling. L1 and C1 are JFD LC374 tenk circuit with C1 serving meinly to support L1 end one transistor lead. C1 slso serves for sdjusting resonant frequency at input. Dusl-gete MOSFET requires no neutralizstion. Power is fed into preamp through RF output connector. Power feed srrengament shown st right csn be located Inside unit with which presmp is used.—R. E. Guentzlar, A Good Two-Meter Presmplifier, *Ham Radio*, June 1974, p 36–38.



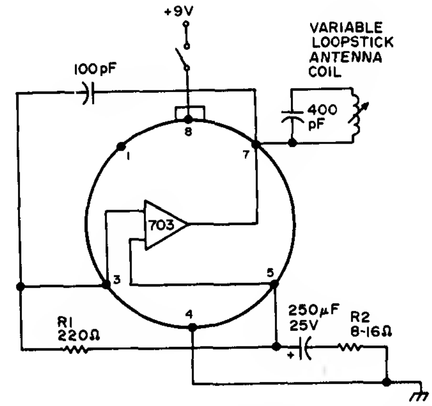
PREAMP COVERS 1–50 MHz—Can be usad to improve performance of old communication receivers es well ss modern aquipment. L1 Is several ferrite besds over short loop of about No. 20 insulsted wire. Trsnsformer is made by winding ebout 10 bifilsr turns of about No. 20 wire on 0.5-inch torold core.—E. Pscyne, Wideband Preamp, *Hem Radio*, Oct. 1976, p 60–61.



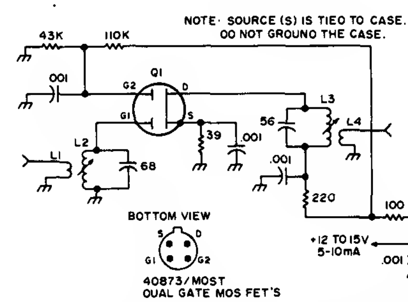
AM MIXER/IF IC—Single National LM1820 chip provides all activa stages for oscillator, mixer, IF amplifier, and AGC detactor of superhetarodyne AM brosdcsst radio. Omission of RF stage reduces cost at some sacrifice in sensitivity end stability, along with mora noise, but careful layout csn minimize stability problems. Total gain is 88 dB.—"Audio Handbook," Netional Semiconductor, Santa Clars, CA, 1977, p 3-4–3-8.



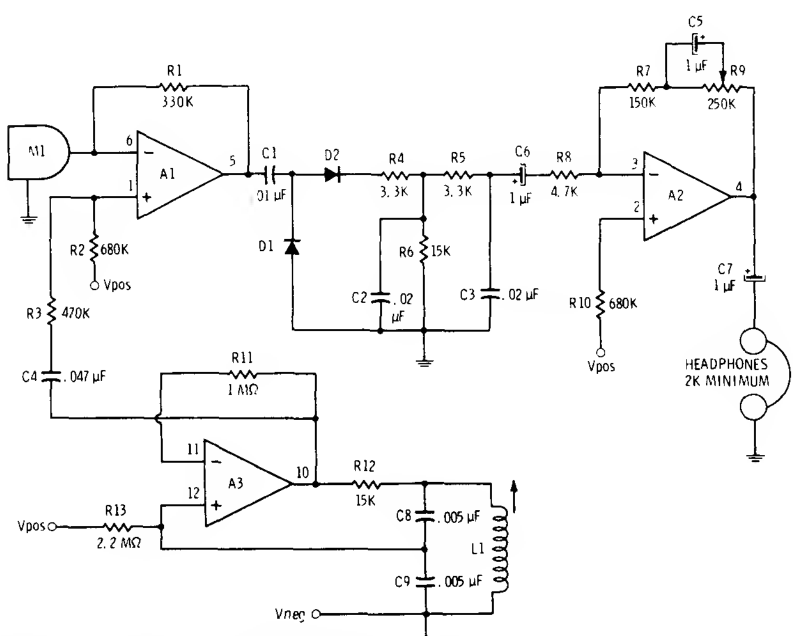
INPUT ATTENUATOR—Low-distortion automatic input attanuator for modern communication racaiver is activated at input aignal levals above 100 μV. For ranga of 1–30 MHz, usa PIN diodes such aa HP5082-3081. Intermodulation distortion producta of ettanuator ara about 85 dB down for two 1-V aignals.—U. L. Rohde, Optimum Daslgn for High-Frequency Communications Recaivers, *Ham Radio*, Oct. 1976, p 10–25.



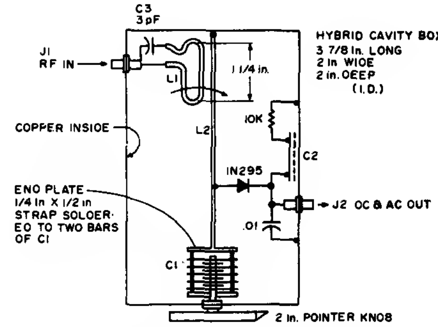
455-kHz BFO—Simpls besic oscillator producaa signal that can be mixad with signals in all-band radio to give beat frequency for CW or SSB raception. By itself, circuit can be uaed as low-power (QRP) phone or CW transmittar or as algnal source for othar purpoaes.—R. L. Prica, 99¢ IC BFO, *73 Magazine*, Jan. 1976, p 201.



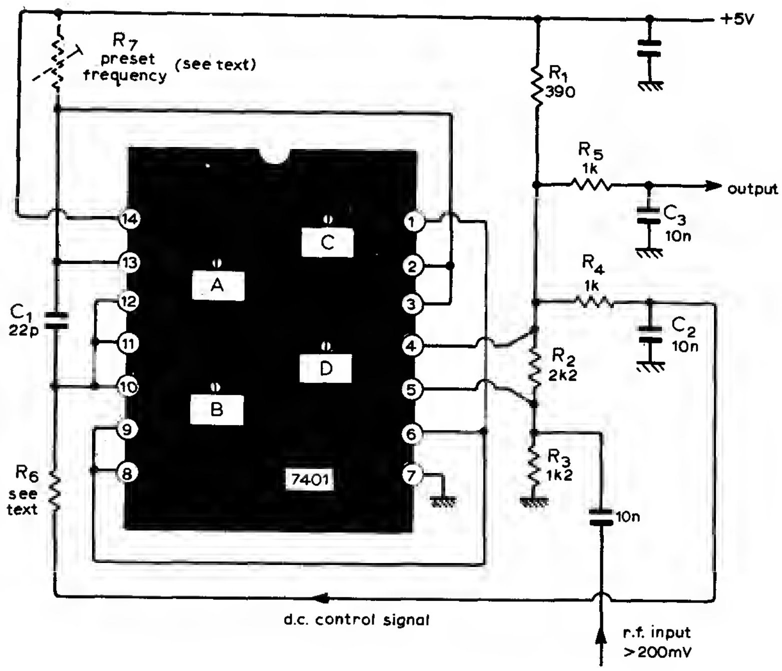
29.45-MHz PREAMP—Reducea noise figura of avarage communication racaiver 2.5 dB and sdds up to 20 dB of gain, as required for recaption of 29.45-MHz aatellite baacon aignals. Q1 is RCA 40673 or almost any other dual-gate MOSFET, with shiald partition ecross tha devica. L2 ia 10 turns No. 24E spaced on ¼-inch alug-tuned core, with 2 turns ovar cold end for L1. L3 is 10 turns No. 24E cloaawound on ¼-inch alug-tuned core, with 2 turna ovar cold and for L4.—J. D. Colson, An Oacar Preamp That Works Wonders, *73 Magazine*, July 1975, p 31–32.



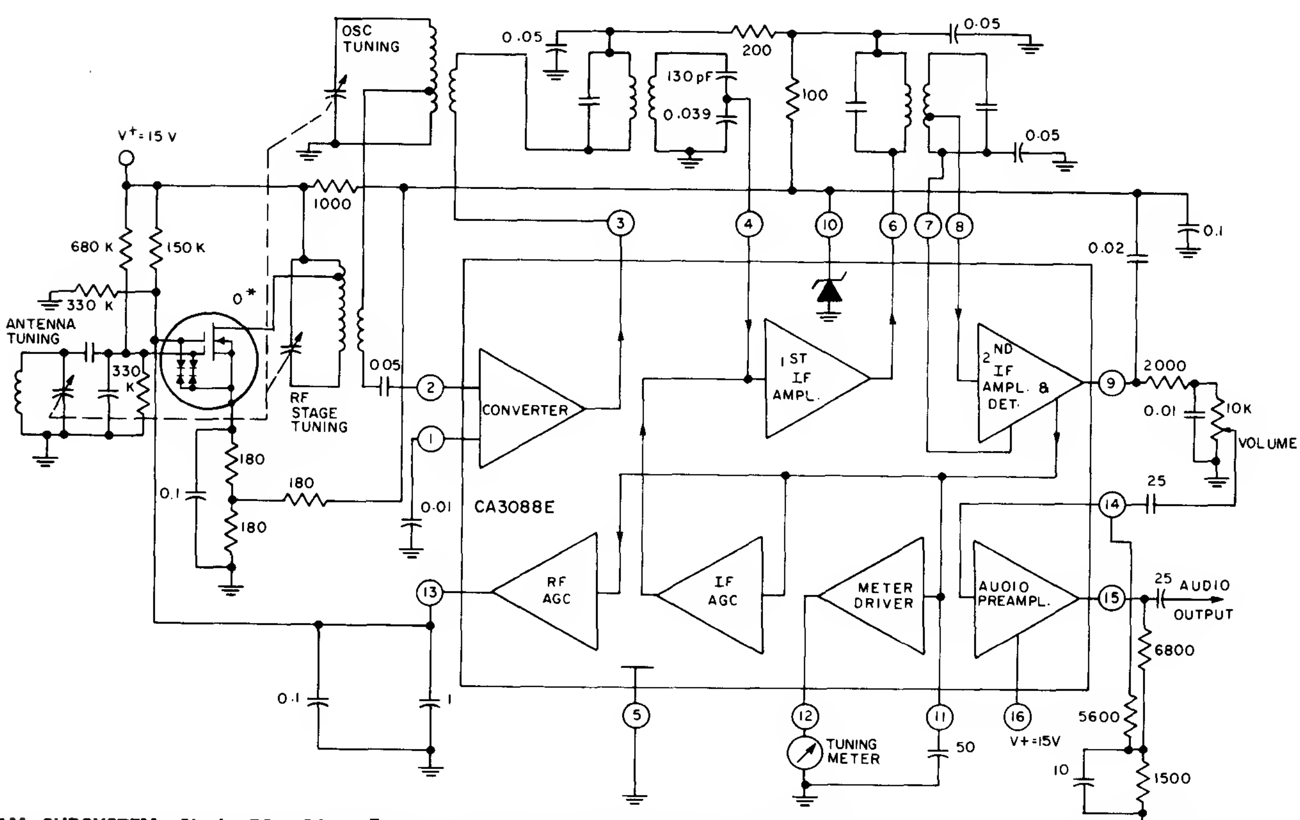
ULTRASONIC RECEIVER—Amplifies output of 40-kHz ultrasonic tranaducer M1 by mixing in opamp A1 with algnal of local oscillator A3 to produca AF signal for further amplification by A2 which drives headphonea. Opamp sections are from Motorola MC3401P quad opamp. Diodes are 1N914 or equivalant. L1 is Millar 6315 4–30 mH. Supply can be 9–12 V. Transmitter can be wide-range audio amplifier capable of handling 38–42 kHz, driving aimilar ultraaonic transducer.—C. D. Rakes, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 26–29.



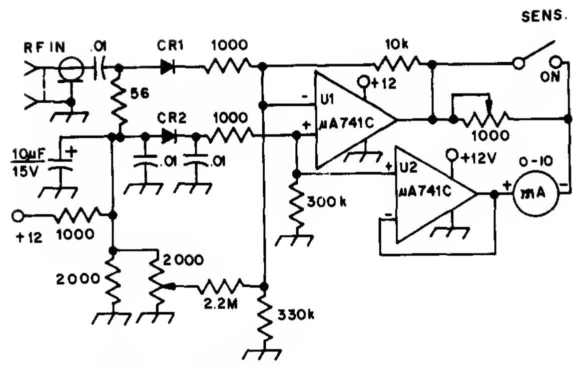
160–500 MHz DIODE RECEIVER—Cavity version of basic cryatal detector was devaloped for uaa chiefly in 220-MHz and 450-MHz amateur bands. C1 ia 25-pF tuning capacitor, and C2 ia 1 × 2 inch brass plata insulated from aheet-copper cavity by 0.005-inch Teflon aheet or mica. L1 is 3-inch length of 1-inch copper strap.—B. Hoisington, Tuned Diode VHF Receivers, *73 Magazine*, Dec. 1974, p 81–84.



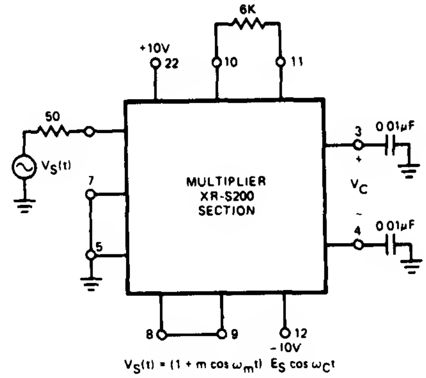
SIMPLE PLL DEMODULATOR—Requires only single IC to provide synchronous detection. Performence is satisfectory for most requirements of most emateur redio experimenters. Getes A, B, end C in IC form relexetion-type VCO whose output frequency is determined by C_1 and positive current sources supplying pins 10 end 13 of IC. When pin 6 is high, gete D is biesed by R_2 end R_3 to operate es lineer emplifier for input signal. In operetion, pin 6 is mede elternetely high end low by oscillator output, so D ects es emplifying phese detector. Output goes through low-pess filter R_4-C_2 to VCO, completing phese-locked loop. Separate filter R_5-C_3 provides AF output. When C_1 is 22 pF, circuit operetes et about 10 MHz. With 270 ohms for R_6, lock is meintained over renge of 2 MHz; with 10 kilohms, locking renge is 300 kHz. R_7 is optionel, for fine edjustment of frequency.—R. King, Phese-Locked Loop Demodulator, *Wireless World*, July 1973, p 337.



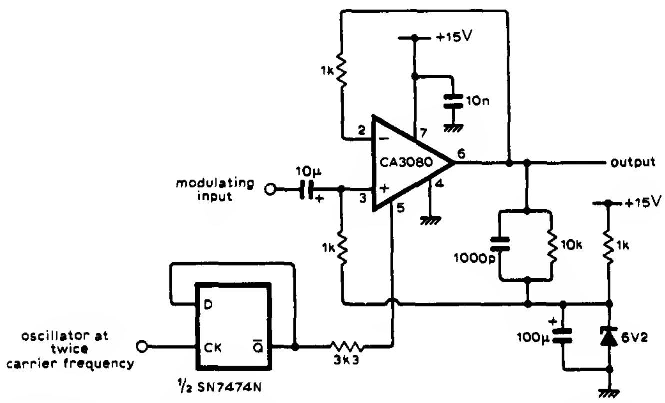
AM SUBSYSTEM—Single RCA CA3088E IC serves es AM converter, IF emplifier, detector, end preemp for AM broedcest or communicetion receiver. RF emplifier stege using RCA 40841 duel gate-protected MOSFET is optionel. IC elso provides Internel AGC for first IF stege and deleyed AGC for optionel RF stage. Internel buffer stege cen be used to drive tuning meter.—"Lineer Integrated Circuits end MOS/FET's," RCA Solid Stete Division, Somerville, NJ, 1977, p 348–349.



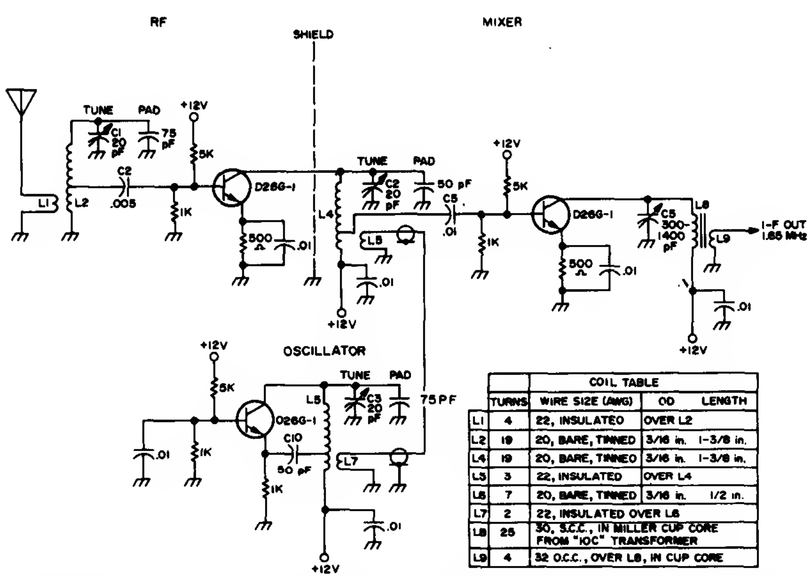
RF METER—Simple square-law detector can detect and measure signals as low as −26 dBm, at microwatt levels. CR1 is biased with about 20 μA by opamp U1 serving as low-impedance DC source. CR2 provides temperature compensation, and U2 serves as low-impedance reference for 10-mA meter. Diodes can be hot-carrier types or 1N914s.—W. Hayward, Defining and Measuring Receiver Dynamic Range, *QST*, July 1975, p 15–21 and 43.



SYNCHRONOUS AM DETECTOR—Input signal is applied to multiplier section of Exar XR-S200 PLL IC with pins 5 and 7 grounded. Detector gain and demodulated output linearity are then determined by resistor connected between pins 10 and 11, in range of 1K to 10K for carrier amplitudes of 100 mV P-P or greater. Multiplier output can be low-pass filtered to obtain demodulated output. For typical 30% modulated input with 10-MHz carrier and 1-kHz modulation, output is clean 1-kHz sine wave.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.

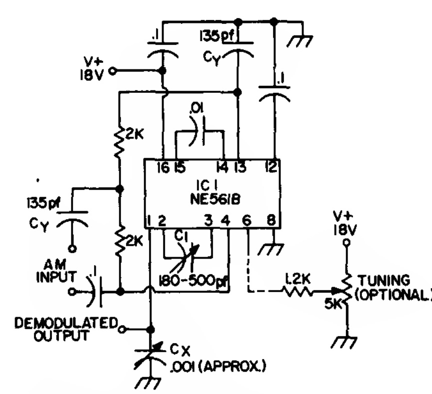


BALANCED MIXER—Uses CA3080 IC transconductance amplifier as precise low-frequency single balanced mixer with inherent carrier balance and accurately defined conversion gain. Binary divider IC halves oscillator frequency, giving carrier waveform having highly accurate unity mark-space ratio. Divided carrier is used to switch amplifier on as unity-gain voltage follower. Conversion loss is 4 dB.—R. J. Harris, Single Balanced Mixer, *Wireless World*, May 1976, p 79.

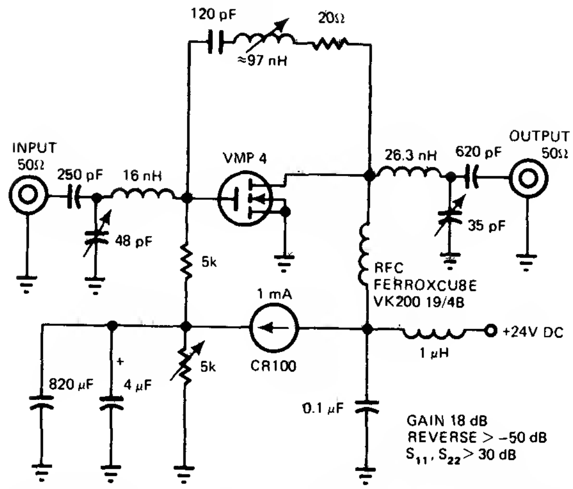


	TURNS	WIRE SIZE (AWG)	OD	LENGTH
	COIL TABLE			
L1	4	22, INSULATED	OVER L2	
L2	19	20, BARE, TINNED	3/16 in.	1-3/8 in.
L4	19	20, BARE, TINNED	3/16 in.	1-3/8 in.
L5	3	22, INSULATED	OVER L4	
L6	7	20, BARE, TINNED	3/16 in.	1/2 in.
L7	2	22, INSULATED OVER L6		
L8	25	30, S.C.C., IN MILLER CUP CORE FROM "IOC" TRANSFORMER		
L9	4	32 O.C.C., OVER L8, IN CUP CORE		

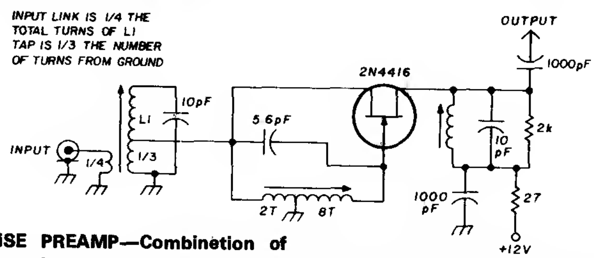
6-METER FRONT END—Developed for use as converter with any communication receiver having 1.65-MHz IF. Article covers construction and tune-up. Use of GE microtransistors permits miniaturization.—B. Hoisington, A Real Hot Front End for Six, *73 Magazine*, Nov. 1974, p 88–90 and 92–94.



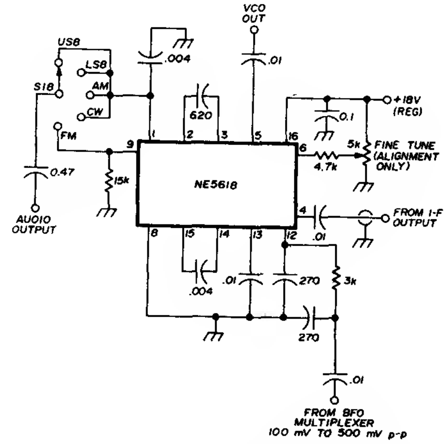
PLL AM—Phase-locked loop of Signetics NE561B is locked to AM signal carrier frequency, and output of VCO in IC is used as local oscillator signal for product detector. Tuned RF stage will generally be required, along with good antenna and ground. Simple one-transistor audio amplifier will suffice for driving loudspeaker. Circuit can be adapted for other frequencies outside of broadcast band, from 1 Hz to 15 MHz, by changing values of C_Y and C_1.—E. Kanter, PLL IC Applications for Hams, *73 Magazine*, Sept. 1973, p 47–49.



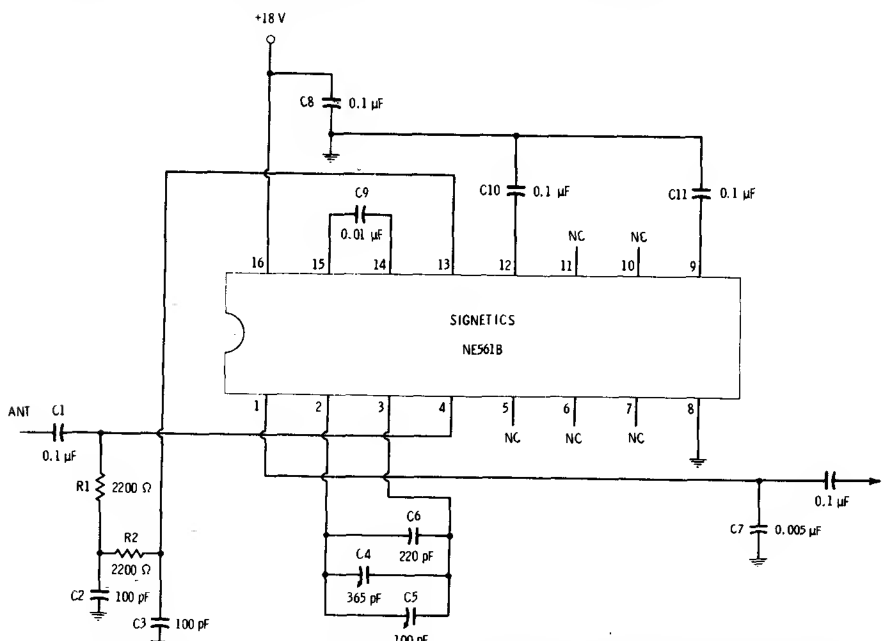
200-MHz NEUTRALIZED—Provides 18.2-dB gain and −50 dB reverse isolation for communication applications. Noise figure is low. Uses Siliconix VMP-4 vertical MOS power transistor.—E. Oxner, Will VMOS Power Transistors Replace Bipolars in HF Systems?, *EDN Magazine*, June 20, 1977, p 71–75.



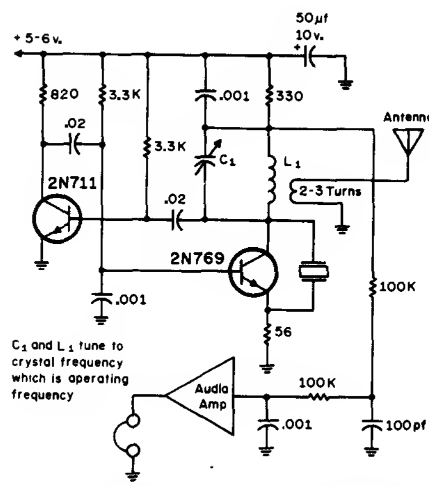
2-m LOW-NOISE PREAMP—Combination of grounded-gate and grounded-source connections uses bridge arrangement for neutralizing feedback capacitance between gate and drain. Input impedance is transformed in parallel between gate and ground to provide necessary wideband characteristic. Noise figure is between 1 and 2 dB, with gain of about 15 dB. Circuit is unconditionally stable, and combines optimum matching for best noise, lowest input SWR, and high power gain.—U. Rohde, High Dynamic Range Two-Meter Converter, *Ham Radio*, July 1977, p 55–57.



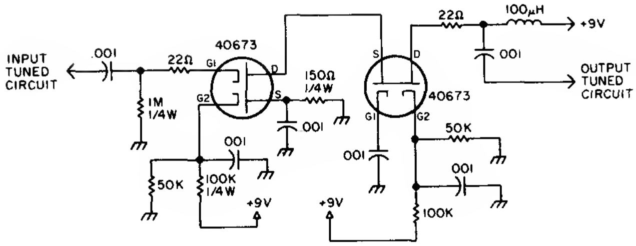
PLL DETECTOR—Developed for use with BFO multiplexer in 455-kHz multimode detection system using NE561 phase-locked loop IC. Circuit provides required 90° phase-shift network in series with output of BFO multiplexer, to compensate for lockup of NE561 in quadrature with signal at input of phase detector during AM reception. IF input level to NE561 should be below about 100 mVRMS for minimum distortion. Audio output level will then be at least half that for narrow-band FM, about same for SSB and CW, and about double for AM if both sidebands are passed by IF filters. FM audio output level is proportional to percent deviation and cannot be increased by increasing signal level. Two 0.004-μF capacitors limit audio bandwidth to about 4 kHz. VCO output of NE561 is 0.6 V P-P square wave at AM carrier or BFO frequency.—J. Regula, BFO Multiplexer for a Multimode Detector, *Ham Radio*, Oct. 1975, p 52–55.



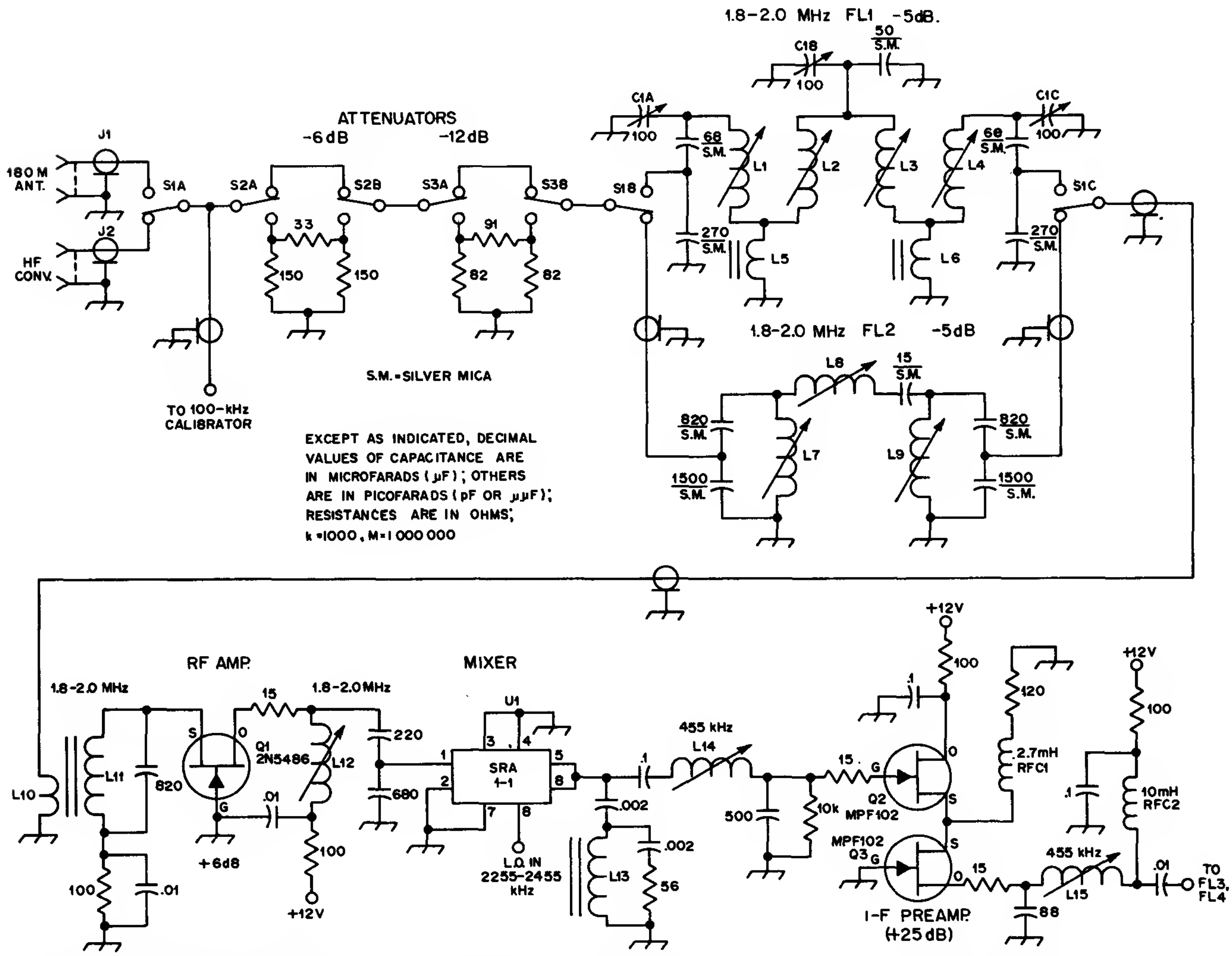
PLL AS AM DEMODULATOR—Single phase-locked loop IC provides audio output signal when connected to suitable antenna for broadcast band. Demodulation is achieved without use of input tuned circuits because control oscillator of PLL is locked to frequency of incoming carrier. IC is tuned over broadcast band by changing frequency of internal VCO with external variable capacitor C4. By changing capacitor limits, circuit can be used to cover long-wave and shortwave bands.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 303–305.



CRYSTAL-CONTROLLED SUPERREGENERATIVE—Two high-frequency transistors connected as 20-kHz MVBR provide switching action at same rate for RF oscillations generated in crystal feedback path. Received AM signal induced in tank circuit of C_1 will modulate exact switching point of circuit at rate directly proportional to modulation component of received signal. Choose L_1, C_1, and crystal for frequency desired. If at 10 MHz, standard WWV time broadcasts can be picked up.—I. Math, Math's Notes, *CQ*, Sept. 1972, p 36–37.

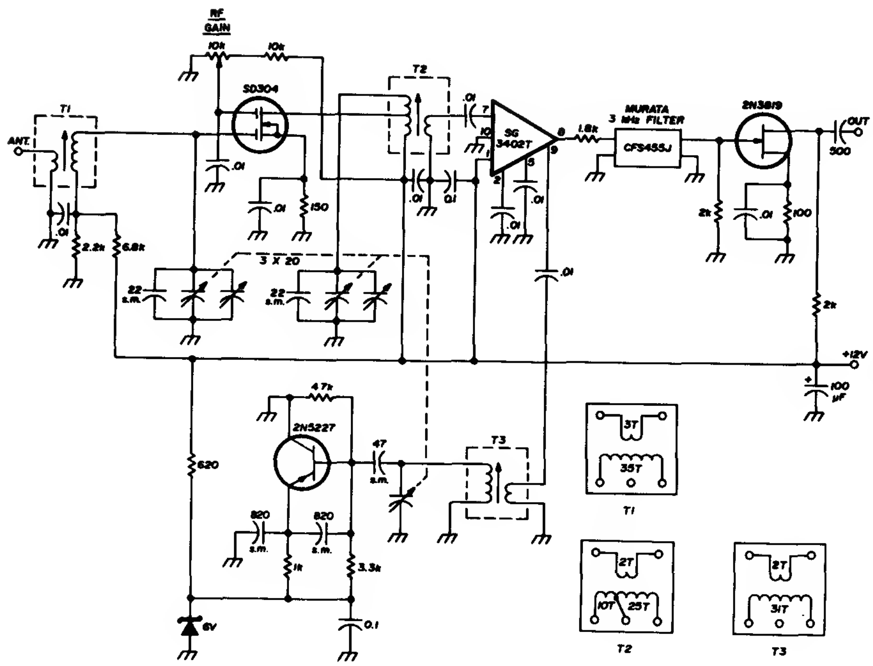


PREAMP BOOSTS GAIN 20 dB—Two RCA MOSFETs in cascode provide extra 20 dB of gain when used ahead of older Radio Shack AX-190 shortwave receiver. Input and output tuned circuits, gang-tuned, are part of receiver preselector. Article covers construction and tune-up.—P. J. Dujmich, Improve the AX-190 Receiver, *73 Magazine*, Jan. 1978, p 106–107.



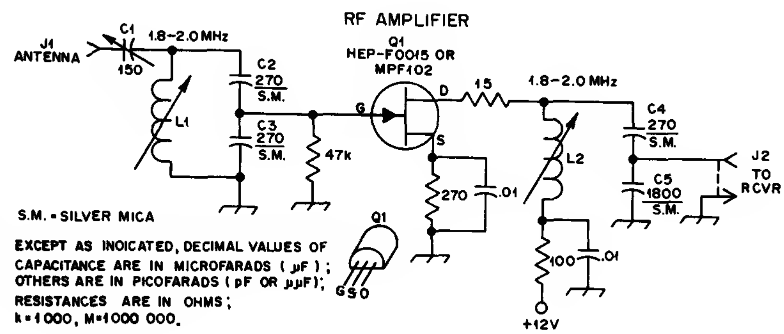
C1 — Three-section variable, 100 pF per section. Model used here obtained as surplus.
J1 — SO-239.
J2 — Phono jack.
L1, L4 — 38 to 68 μH, Q_u of 175 at 1.8 MHz, slug-tuned (J. W. Miller 43A685CBI in Miller S-74 shield can).
L2, L3 — .95 to 187 μH, Q_u of 175 at 1.8 MHz, slug tuned (J. W. Miller 43A154CBI in S-74 shield can).
L5, L6 — 1.45-μH toroid inductor, Q_u of 250 at 1.8 MHz.
15 turns No. 26 enam. wire on Amidon T-50-2 toroid.
L7, L9 — 13-μH slug-tuned inductor (J. W. Miller 9052).
L8 — 380-μH slug-tuned inductor (J. W. Miller 9057).
L10 — 16 turns No. 30 enam. wire over L11 winding.
L11 — 45 turns No. 30 enam. wire on Amidon T-50-2 toroid, 8.5 μH.
L12 — 42-μH slug-tuned inductor, Q_u of 50 at 1.8 MHz. (J. W. Miller 9054).
L13 — 8.7-μH toroidal inductor. 12 turns No. 26 enam. wire on Amidon FT-37-61 ferrite core.
L14 — 120- to 280-μH, slug-tuned inductor (J. W. Miller 9056).
L15 — 1.3- to 3.0-mH, slug-tuned inductor (J. W. Miller 9059).
Q1, Q2, Q3 — Motorola JFET.
RFC1 — 2.7-mH miniature choke (J. W. Miller 70F273AI).
RFC2 — 10-mH miniature choke (J. W. Miller 70F102AI).
S1 — Three-pole, two-position phenolic wafer switch.
S2, S3 — Two-pole, double-throw miniature toggle.
U1 — Mini-Circuits Labs. SRA-1-1 doubly balanced diode mixer (2913 Quentin Rd., Brooklyn, NY 11229).

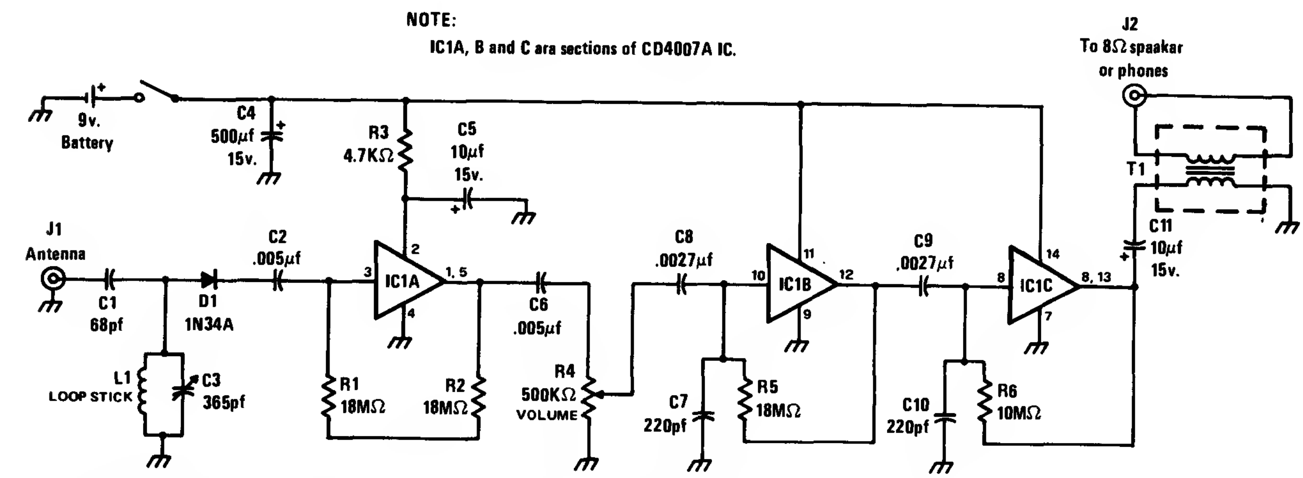
1.8–2 MHz FRONT END—Includes enough attenuation for comfortable listening even when nearby high-power amateur station comes on air. Used with downconverter to cover 80 meters through 10 meters. Fixed-tuned 1.8–2 MHz bandpass filter FL2 eliminates need for repeaking three-pole tracking filter FL1 when tuning in band. RF amplifier Q1 compensates for filter loss by giving maximum of 6-dB gain. Double-balanced diode-ring mixer U1 handles high signal levels and has good port-to-port signal isolation. High-pass diplexer network at output of IC mixer U1 improves noise performance without degrading 455-kHz IF. Output goes to IF filters. Two-part article gives all other circuits of receiver.—D. DeMaw, His Eminence—the Receiver, *QST*, Part 1—June 1976, p 27–30 (Part 2—July 1976, p 14–17).



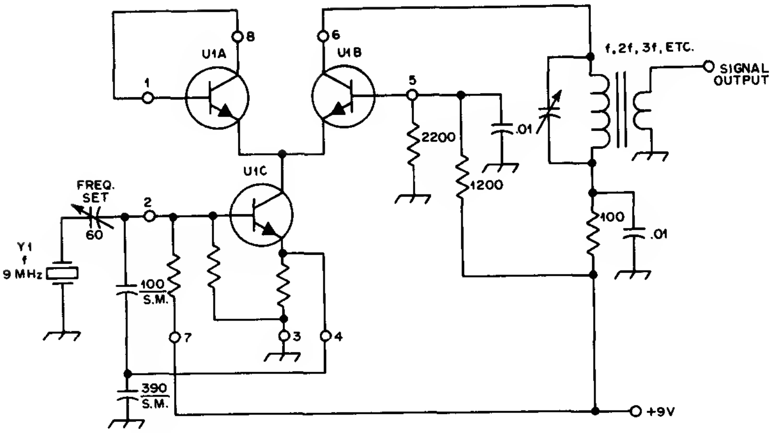
80-METER TUNER—RF stage uses dual-gate N-channel enhancement-mode Signetics SD304 operating with positive bias. With 0–6 V applied to gate 2, AGC range is about 40 dB, but circuit shown uses manual RF gain control. Extra stage of IF overcomes insertion loss of 3-kHz ceramic ladder filter. SG3402T IC is used in mixer; remove pin 6. Transformers T1, T2, and T3 are wound on standard ⅜-in IF forms.—R. Magirian, Design Ideas for Miniature Communications Receivers, *Ham Radio*, April 1976, p 18–25.

20-dB PREAMP FOR 160 METERS—Provides badly needed extra gain when using Beverage or other inefficient low-noise receiving antennas. Gate of common-source JFET is tapped down on tuned circuit by capacitive divider C3-C4 to prevent self-oscillation. Mica compression trimmer C1 provides match to antenna. L1 and L2 are J. W. Miller 43-series slug-tuned coils; L1 has tuning range of 36–57 μH, and L2 has 24–40 μH range. For 160-meter band, L1 and L2 can be peaked at 1827 kHz to provide maximum gain in 1825–1830 kHz DX window.—D. DeMaw, Build This "Quickie" Preamp, *QST*, April 1977, p 43–44.



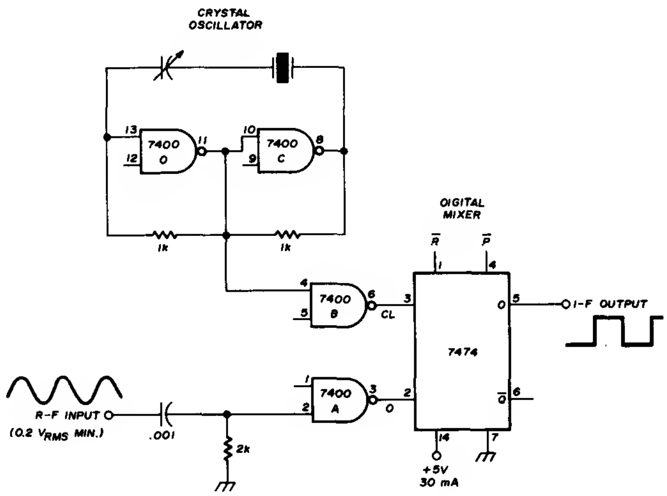


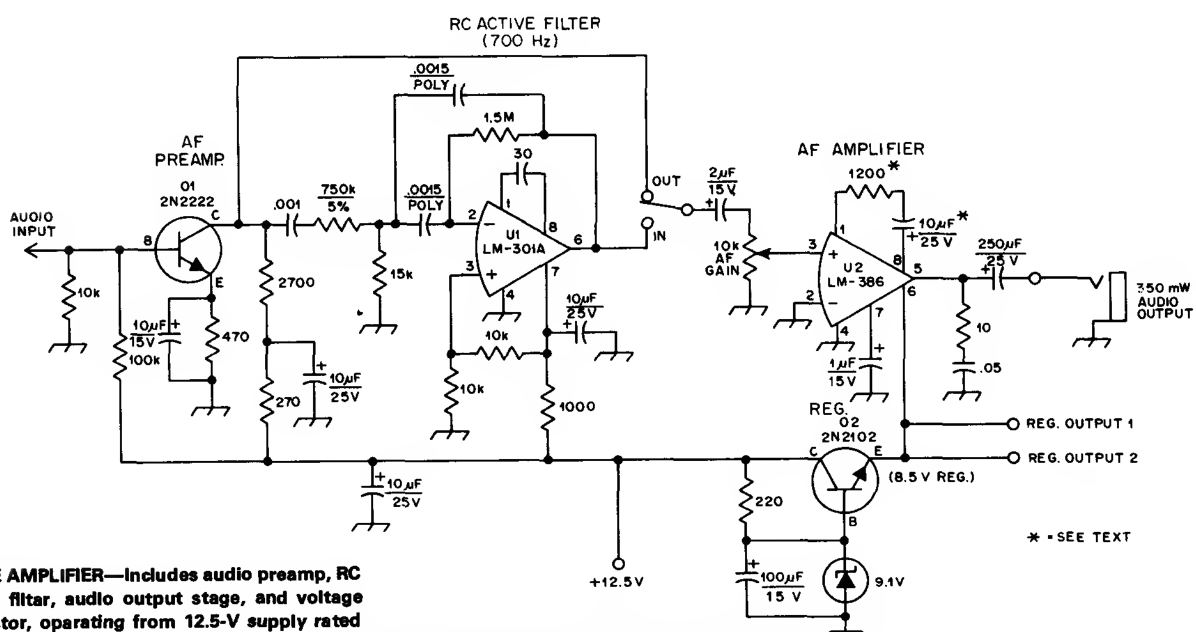
ALL-CMOS RECEIVER—Uses CD4007A IC, having complementary pair of opamps and inverter, to provide all circuits for AM broadcast radio capable of driving headphones or 8-ohm loudspeaker. Selectivity is provided by single tuned circuit and can be improved by optimizing value of C1 to adjust antenna loading. Tune with C3, adjusting L1 if necessary to get stations at low end of band.—C. Green, Easy-to-Build CMOS Radio Receiver, *Modern Electronics*, Sept. 1978, p 40–41, 46, and 59.



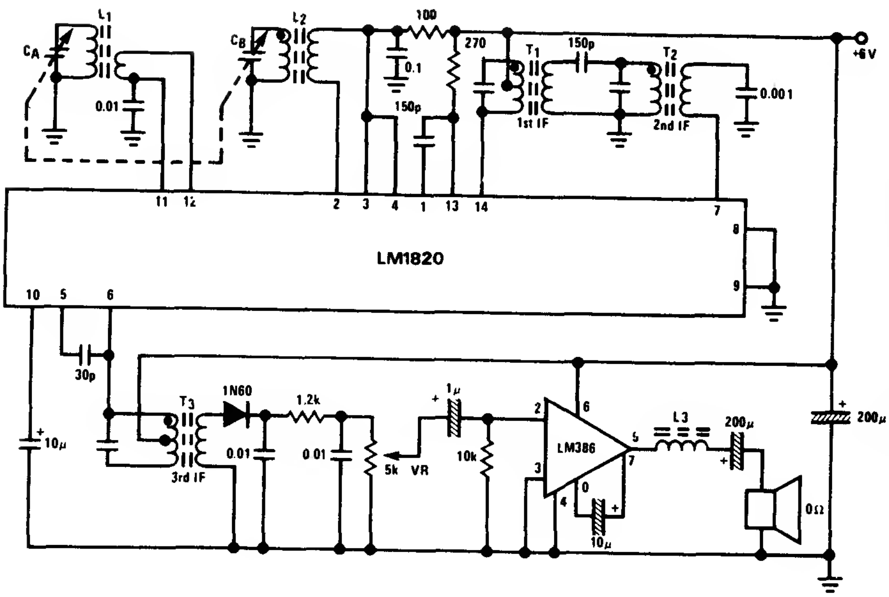
9-MHz CRYSTAL WITH MULTIPLIER—Uses two sections of RCA CA3028A differential amplifier as Colpitts oscillator U1C feeding U1B which can be either amplifier or multiplier depending on values used for output tuned circuit. U1A is not used. Unmarked resistors are on IC.—D. DeMaw, Understanding Linear ICs, *QST*, Feb. 1977, p 19–23.

TTL DIGITAL MIXER—Uses two of 7400 TTL gates as crystal oscillator and other two gates as input buffers to 7474 D flip-flop serving as mixer. RF input signal must be lower than crystal frequency, and IF signal must be less than half crystal frequency. With 8-MHz crystal and 6.75-MHz RF signal, IF is 1.25 MHz. Common TTL 7474 can be used up to 25 MHz, 74H74 to 43 MHz, and 74S74 Schottky version to 100 MHz; Motorola MC12000 is good to 250 MHz.—G. H. Schrick, Introduction to the Digital Mixer, *Ham Radio*, Dec. 1973, p 42–43.

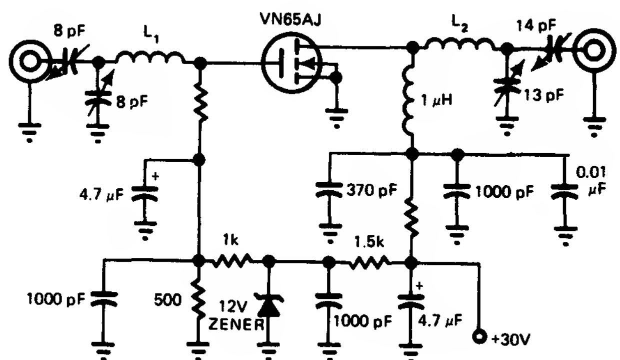




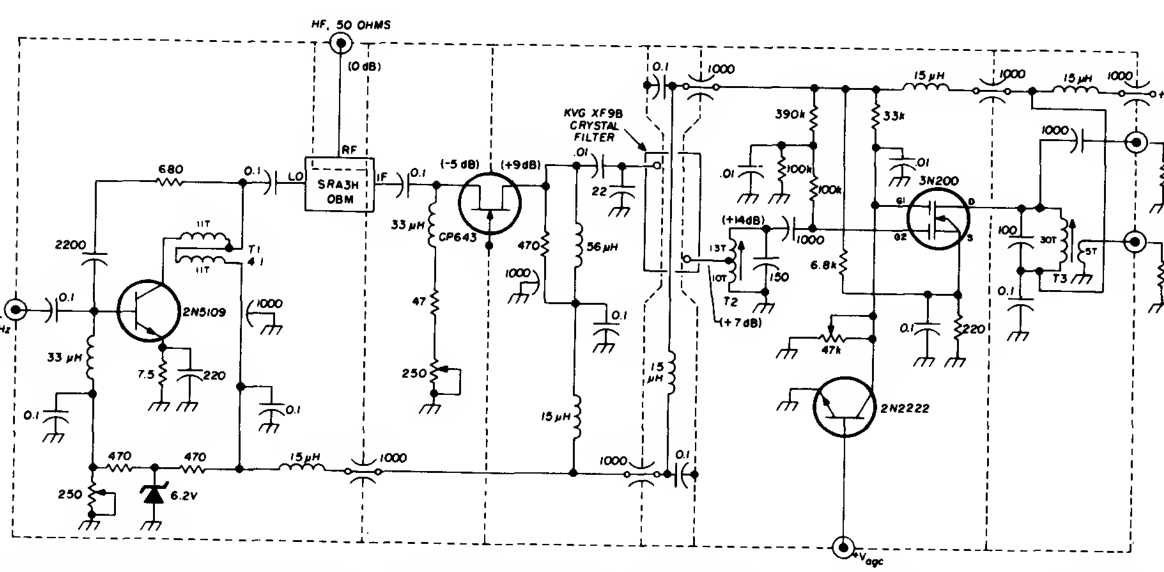
VOICE AMPLIFIER—Includes audio preamp, RC active filter, audio output stage, and voltage regulator, operating from 12.5-V supply rated 300 mA or more. Developed as low-distortion audio amplifier for communication receiver. Two taps for regulated supply provide regulated 8.5 V at 250 mA for other circuits. With filter out, changing input frequency from 300 to 3000 Hz has little effect on output. Switching in audio filter should attenuate all frequencies not in 700-Hz passband of filter. Gain is adjustable over wide range. Output will drive small loudspeaker of 4–16 ohms or headphones of 4–2000 ohms. Can also be used as test bench audio amplifier, intercom, or with code-practice oscillator.—J. Rusgrove, A General-Purpose Audio Amplifier, *QST*, Nov. 1976, p 32–34.



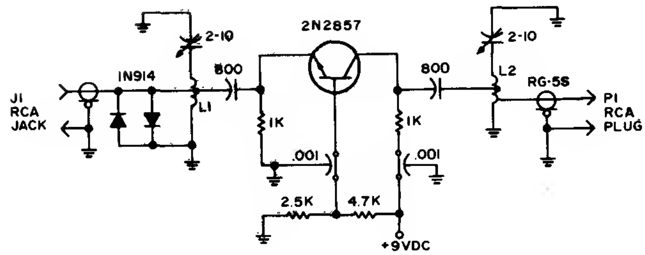
TWO-IC AM RADIO—National LM1820 IC serves for RF, oscillator, mixer, and IF stages of AM superheterodyne radio while LM386 IC is audio amplifier driving loudspeaker. Double-tuned circuit at output of mixer provides selectivity. Total gain from base of input stage to diode detector is 95 dB. C_A is 140 pF, C_B is 60 pF, L_1 has 110 and 5 turns for broadcast band, L_2 has 98 and 12 turns for oscillator, T_1 has 140 turns center tap and 2 turns, T_2 has 142 turns and 7 turns, and T_3 has 142 turns center tap and 71 turns. IF value is 455 kHz. L_3 has 3 turns on ferrite bead.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 3-4–3-8.



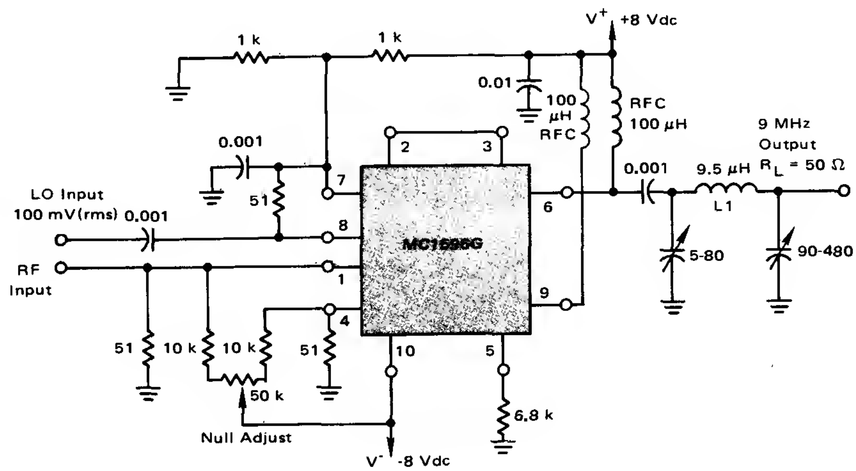
2-METER SINGLE-VMOS—Provides 5-W PEP output at 146 MHz, with noise figure of only 2.35 dB. Developed for amateur radio applications. Uses Siliconix VN65AJ transistor.—E. Oxner, Will VMOS Power Transistors Replace Bipolars in HF Systems?, *EDN Magazine*, June 20, 1977, p 71–75.



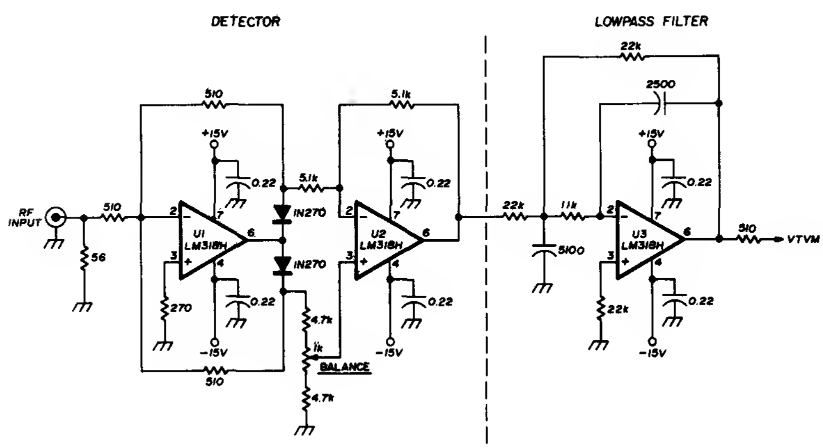
DOUBLE-BALANCED MIXER—Uses grounded-gate CP643 preamp having high dynamic range, 2N5109 oscillator injection amplifier, and 3N200 IF amplifier in combination with Minilabs SRA3H double-balanced mixer. Third-order intercept point is +30 dBm. Oscillator requirement is −1 to +2 dBm (200 to 280 mV across 50 ohms). AGC range is greater than 50 dB. Levels shown in parentheses are for 0 dBm (224 mV) at input and zero AGC voltage.—U. L. Rohde, High Dynamic Range Receiver Input Stages, *Ham Radio*, Oct. 1975, p 26–31.



450-MHz PREAMP—Provides up to 10-dB extra gein for older tube-type 450-MHz receivers. Gives significant improvemant in receivar sensitivity and quieting. Use of trough-line inductors simpiifies construction. 1N914 diodes in paraliel at input jack protect transistor from burnout by naarby transmittar. L1 and L2 are made from ¼-inch diameter coppar tubing, 8.6 cm long. Articie covers construction and operation.—C. Klinert, Easy Preamp for 450 MHz, *73 Magazine,* May 1973, p 33 and 36–38.

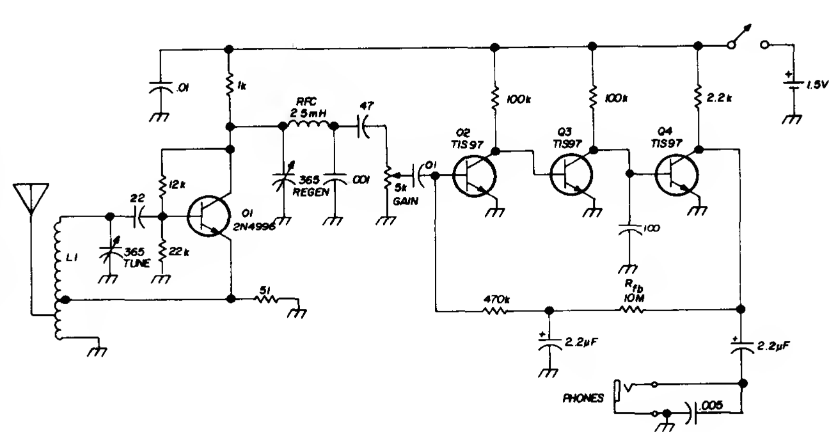


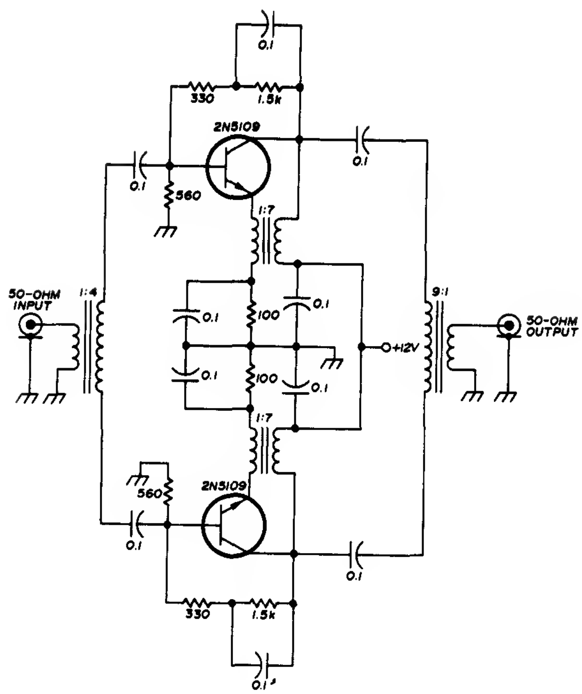
9-MHz TUNED OUTPUT—Motorola MC1596G balanced modulator connected as double-balanced mixer has 3-dB bandwidth of 450 kHz at output. Local oscillator signal LO is injected at uppar input port and modulated signal of about 15 VRMS maximum at lower input port. Conversion gain is 13 dB for 30-MHz input end 39-MHz LO.—R. Hajhall, "MC1596 Balancad Modulator," Motorole, Phoenix, AZ, 1975, AN-531, p 7.



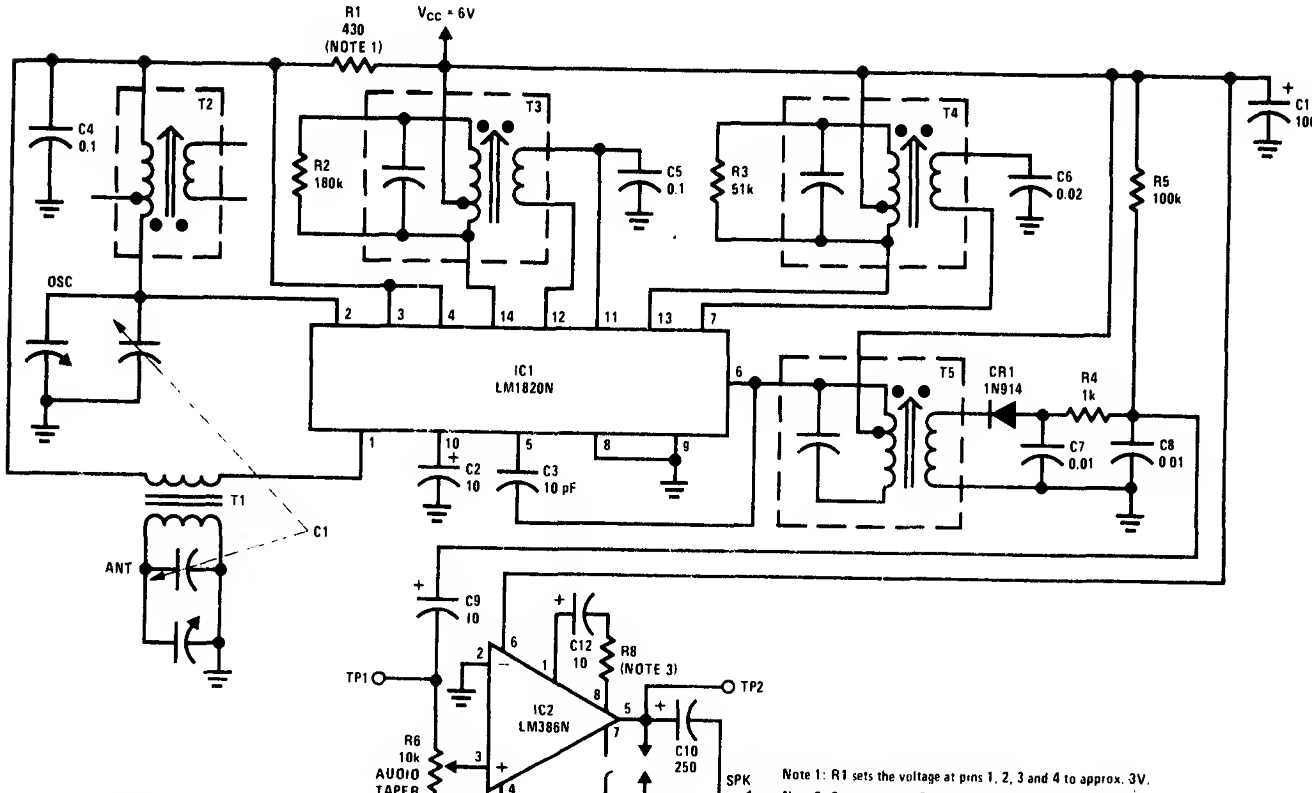
PRECISION FULL-WAVE DIODE DETECTOR—Uses opamp to reduca input voltaga et which transfer curve of dioda detactor becomes nonlinear by factor equal to open-loop gain of opamp. Chlef drawback is that delay for positiva input signals, which are invarted and amplified 2 times, is twice that for composita signals. Becausa of delay differance, signals do not subtract in phasa and high-frequency parformance suffers. Values shown ara for test purposes, with low-pass activa filter having 2-kHz cutoff.—H. Olson, Dioda Detectors, *Ham Radio,* Jan. 1976, p 28–34.

WWV REGENERATIVE—Tunes from 4.7 to 15.5 MHz, covaring thraa WWV frequencies, 20- and 40-meter amateur bands, and aevaral foreign broadcast bands. Draws only 1.5 mA from single D cell whan using headphones with 2000-ohm or higher impedence. Performs well with AM, CW, or SSB. When oscillating, detector provides own BFO signal. L1 is 3.8 µH, with emitter tap 1 turn from ground. Use clip for adjusting entenne tap. Tuning requires two hands.—C. Hell, Simple Regenerative WWV Receivar, *Ham Radio,* April 1973, p 42–45.





LOW-NOISE RF INPUT—Low-noise version of transistorized push-pull RF stage uses emitter feedback through transformer to give extremely high input and output impedances. Noise figure is below 2 dB. Developed for use in high-quality communication receiver.—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.



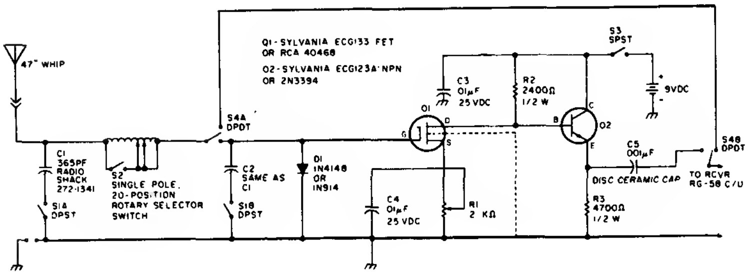
C1: 2-section gang capacitor, oscillator section ≈ 60 pF, antenna section ≈ 130 pF max } Matched
T1: Transistor antenna rod
T2: Oscillator coil (red)
T3: 455 kHz IF transformer (yellow)
T4: 455 kHz IF transformer (white)
T5: 455 kHz IF transformer (black) } (Radio Shack) Archer #273 1383

Note 1: R1 sets the voltage at pins 1, 2, 3 and 4 to approx. 3V.
Note 2: Compensation R7C13 not required with speaker impedances 40 ohms or higher.
Note 3: R8 sets the gain, A_V, of the power amplifier.

R8 (Ω)	A_V (V/V)
∞	20
168	100
0	200

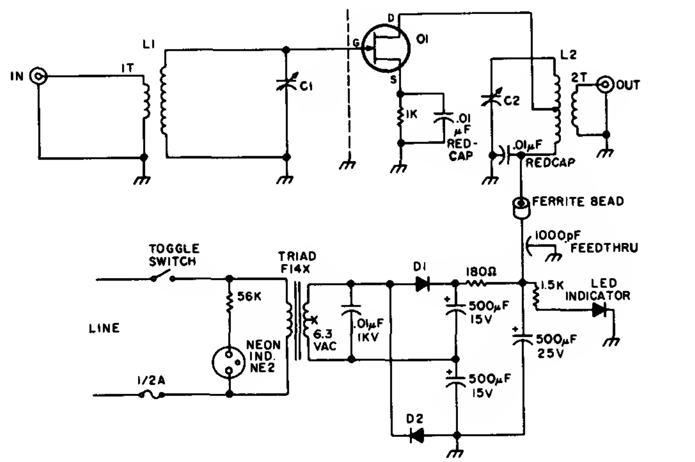
Note 4. All resistor values in ohms and all capacitor values in μF unless otherwise indicated.

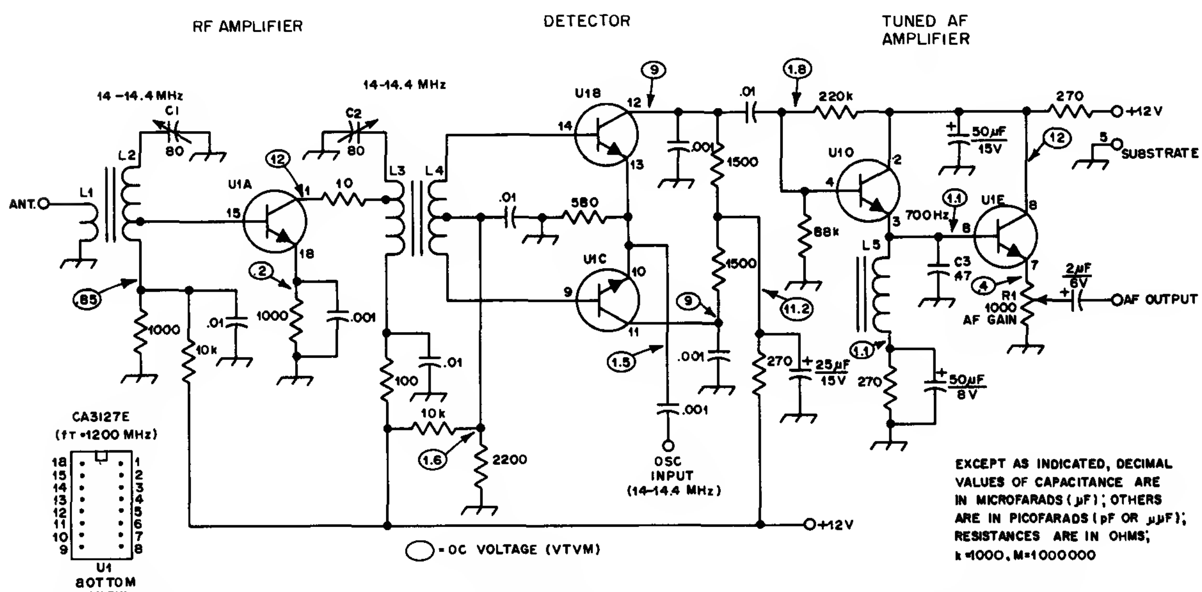
AM RADIO—National LM1820N IC provides all sections of superheterodyne broadcast-band radio up to second detector, with diode and power opamp forming rest of receiver. Output is ¼ W into 8-ohm loudspeaker when operating from 6-V supply. Total current drain is about 10 mA, making battery operation feasible.—E. S. Papanicolaou and H. H. Mortensen, "Low-Cost AM-Radio System Using LM1820 and LM386," National Semiconductor, Santa Clara, CA, 1975, LB-29.



ALL-BAND PREAMP WITH WHIP—Combination of two-stage preamp and 47-inch telescoping antenna gives overall gain of over 30 dB from 160 to 10 meters, for use with communication and SWL receivers when frequent travel precludes erection of fixed antennas. Use type F, BNC, or SO-239 antenna connector. Tuning coil has 20 taps on 150 turns of No. 28 enamel wire wound on ½-inch dowel, with taps at 3, 7, 12, 18, and 25 turns and then about every 10 or 11 turns. Keep leads of Q1 shorted during handling and soldering, to avoid damage by static charges.—K. T. Thurber, Jr., Build A Vacation Special, *73 Magazine*, Aug. 1977, p 62–63.

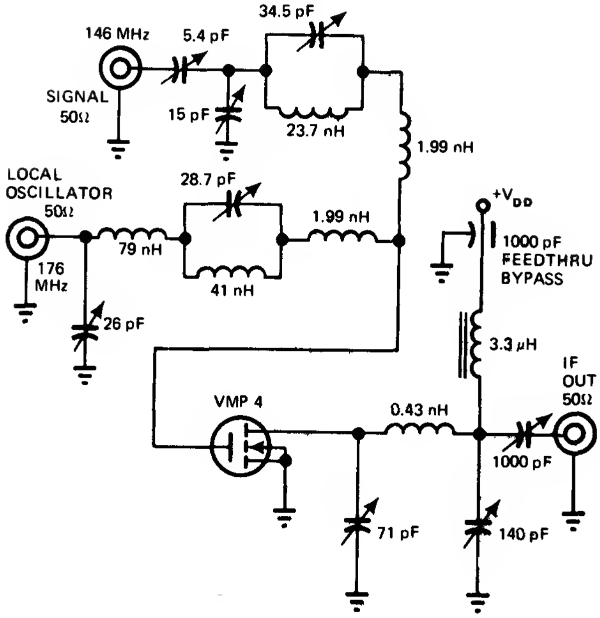
14–30 MHz PRESELECTOR—Simple self-powered preselector using FET improves overall noise figure of shortwave receiver along with sensitivity in 14–30 MHz portion of HF band. Also helps reduce cross-modulation from strong out-of-band shortwave broadcast stations. C1 and C2 are 50–500 pF Miller 160B. L1 is 10 turns No. 22 on T50-10 Micrometals core with 1-turn link. L2 is 10 turns No. 22 with center tap and 2-turn link on T50-10 core. Q1 is MPF102, HEP-802, or HEP-F0015. D1 and D2 are 1N4002 or HEP-R0051.—H. Olson, The S38 Is Not Dead!, *73 Magazine*, Nov. 1976, p 88–89.





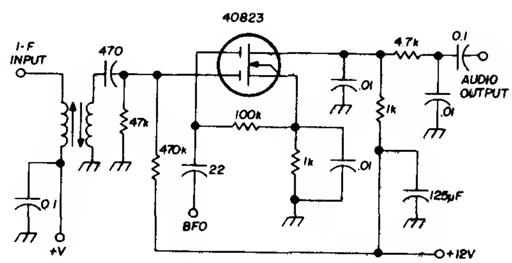
C1, C2 – 8- to 60-pF mica or ceramic trimmer (Arco 404 or JFD DV11PS60Q suitable).
C3 – 0.47-μF Mylar capacitor.
L1 – Two-turn link of No. 24 enam. wire over L2.
L2 – 25 turns No. 24 enam. wire on T50-6 powdered-iron toroid core. Tap 4 turns up from low-*Z* end. (See *QST* ads for toroid suppliers, Amidon, G. R. Whitehouse and Palomar Eng.) Mount L1/L2 on opposite side of pc board from L3/L4. L2 = 2.5 μH.
L3 – 25 turns No. 24 enam. wire on T50-6 toroid core. Tap 10 turns from C2 end. L3 = 2.5 μH.
L4 – 6 turns No. 24 enam. wire, center tapped. Wind over L3.
L5 – Pot-core inductor, 110 mH. Wind 172 turns No. 28 enam. wire on bobbin. Core kit is Amidon PC-2213-77.
R1 – 1000-ohm linear-taper composition control, panel-mounted.
U1 – RCA CA3127E npn transistor-array IC.

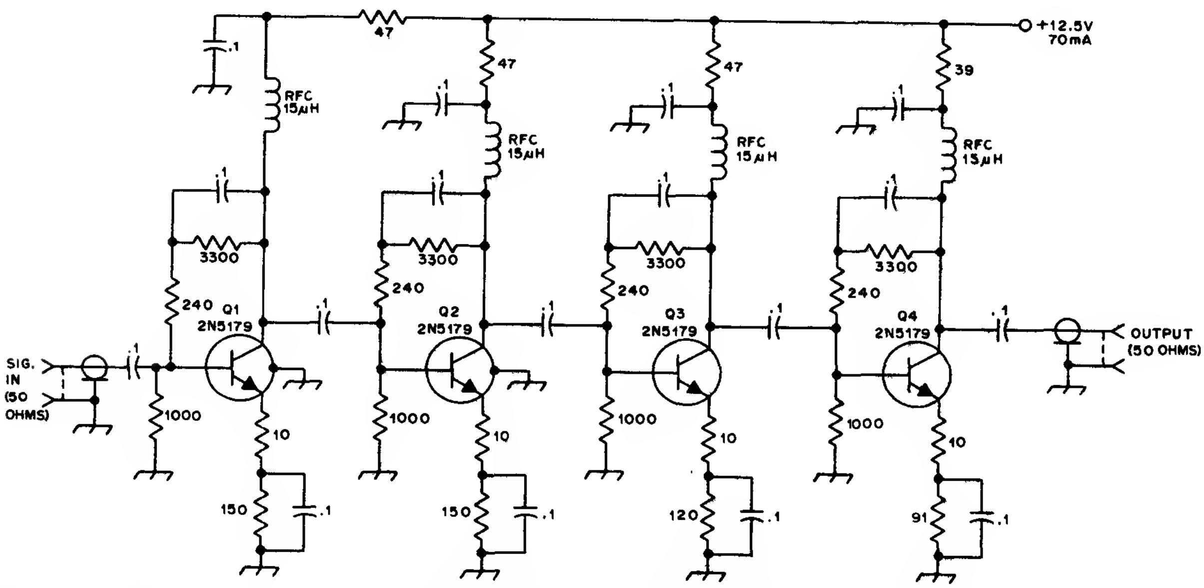
20-METER DIRECT-CONVERSION CW/SSB—Simple direct-conversion or synchrodyne receiver uses RCA CA3127E five-transistor array. Product detector follows 14-MHz RF stage. Low drain makes receiver ideal for battery operation, but circuit has no AGC. AF output will drive headphones adequately for strong 20-meter signals, but not loudspeaker. Local-oscillator energy at 14–14.4 MHz for product detector at 1.5–2 VRMS must be furnished by external BFO.—D. DeMaw, Understanding Linear ICs, *QST*, Jan. 1977, p 11–15.



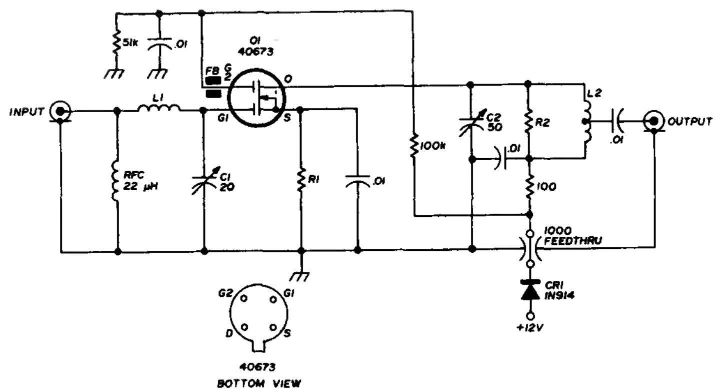
2-METER VMOS ADDITIVE MIXER—Single-ended circuit for amateur band can deliver 0.5 W of power to IF amplifier while providing conversion gain of 18 dB and compression level of 10 dBm. Noise figure is 5.2 dB. Traps in both signal and noise feeds to Siliconix VMP-4 power transistor prevent radiation of unwanted signals.—E. Oxner, Will VMOS Power Transistors Replace Bipolars in HF Systems?, *EDN Magazine*, June 20, 1977, p 71–75.

PRODUCT DETECTOR—Excellent isolation is provided by dual-gate MOSFET. Used for demodulating SSB or CW signals. Input resonant circuit is tuned to IF value. High-frequency components of signal are filtered out by drain output circuit. RC low-pass filter passes voice frequencies to succeeding audio emplifier.—E. Noll, MOSFET Circuits, *Ham Radio*, Feb. 1975, p 50–57.





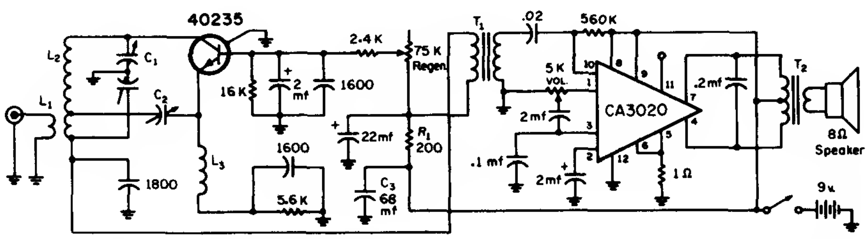
160-METER PREAMP—Broadband 40-dB preamp has response range extending from broadcast band through VHF. Upper 3-dB point of amplifier is at 65 MHz. Heavy feedback stabilizes gain and provides 50-ohm characteristic.—D. DeMaw, Beat the Noise with a "Scoop Loop," *QST*, July 1977, p 30–34.



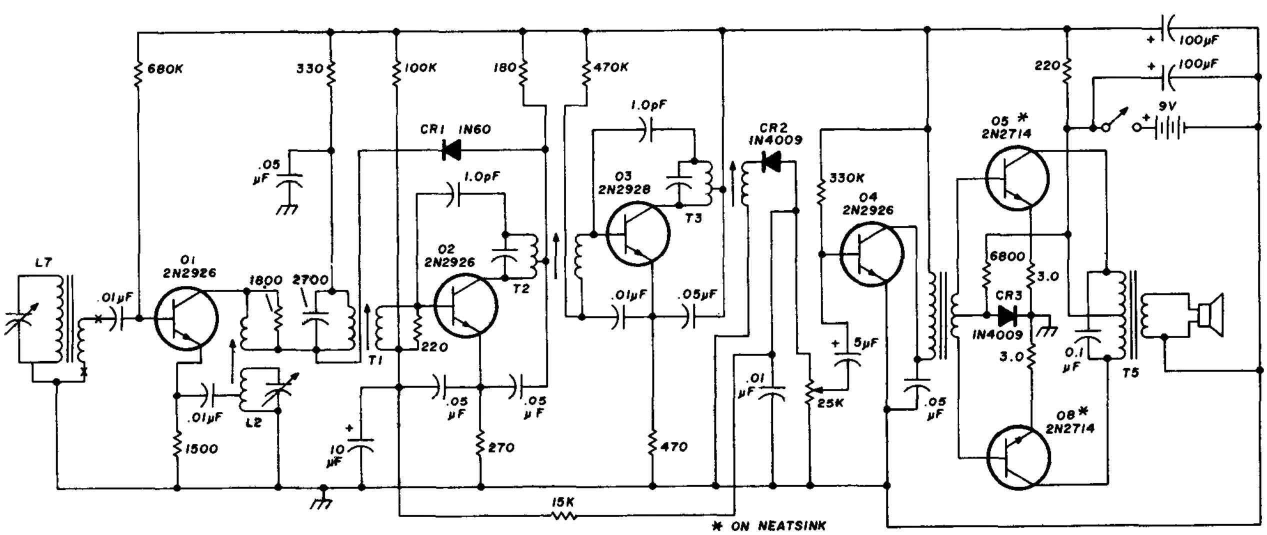
C1	20 pF trimmer (JFD DVJ300 or equivalent ceramic trimmer)	L1	25 turns no. 24 (0.5mm) on Amidon T50-10 toroid core
C2	50 pF trimmer (JFD DVJ305 or equivalent ceramic trimmer)	L2	22 turns no. 24 (0.5mm) on Amidon T50-10 toroid core, tapped 7 turns from cold end
FB	Ferrite bead (56-590/65/3B or equivalent)	R1	150 ohms typical (see text)
		R2	2000 ohms typical (see text)

28–30 MHz SATELLITE PREAMP—Low-noise design provides up to 25-dB gain and typical noise figure of 1 dB, using dual-gate MOSFET in cascode circuit. Adjust C1 and C2 for maximum output. Developed for use at input of communication receiver. Drain from 12-V power supply should be 3 to 7 mA; if too low or too high, adjust value of R1.—J. Raisert, Jr., Low Noise Figure 28–30 MHz Preamplifier for Satellite Reception, *Ham Radio,* Oct. 1975, p 48–51.

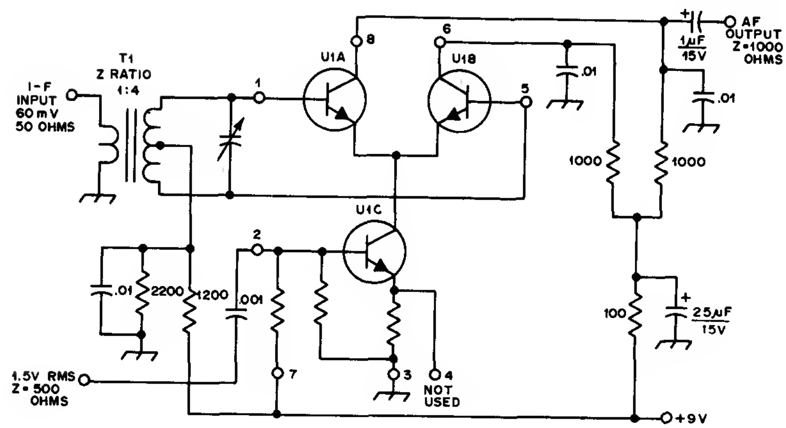
VHF REGENERATIVE—Covers 2-meter amateur band, 152–174 MHz public-service channels including 162.5-MHz weather service, and number of other services. Performance is good enough for use as emergency communication receiver. Supply should be six D cells in series; cheaper 9-V transistor radio batteries may have too much impedance and cause motorboating.—S. Kelly, A Solid State V.H.F. Regenerative Receiver, *CQ,* March 1970, p 63–64.



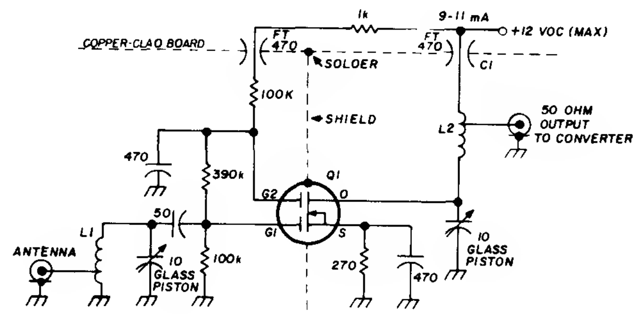
C_1—20 mmf split stator tuning capacitor.
C_2—9-35 mmf ceramic trimmer capacitor.
L_1—1t #10e., 1/4" diam. coupled to the cold end of L_2.
L_2—6t #10e., 1/4" diam. tapped at 3/4 turns.
L_3—14t #24e., wound on a 1 meg 1 watt resistor.
T_1—2K to 10K. Olson T-230 or equiv.
T_2—250 ohms center tapped to 8 ohms.



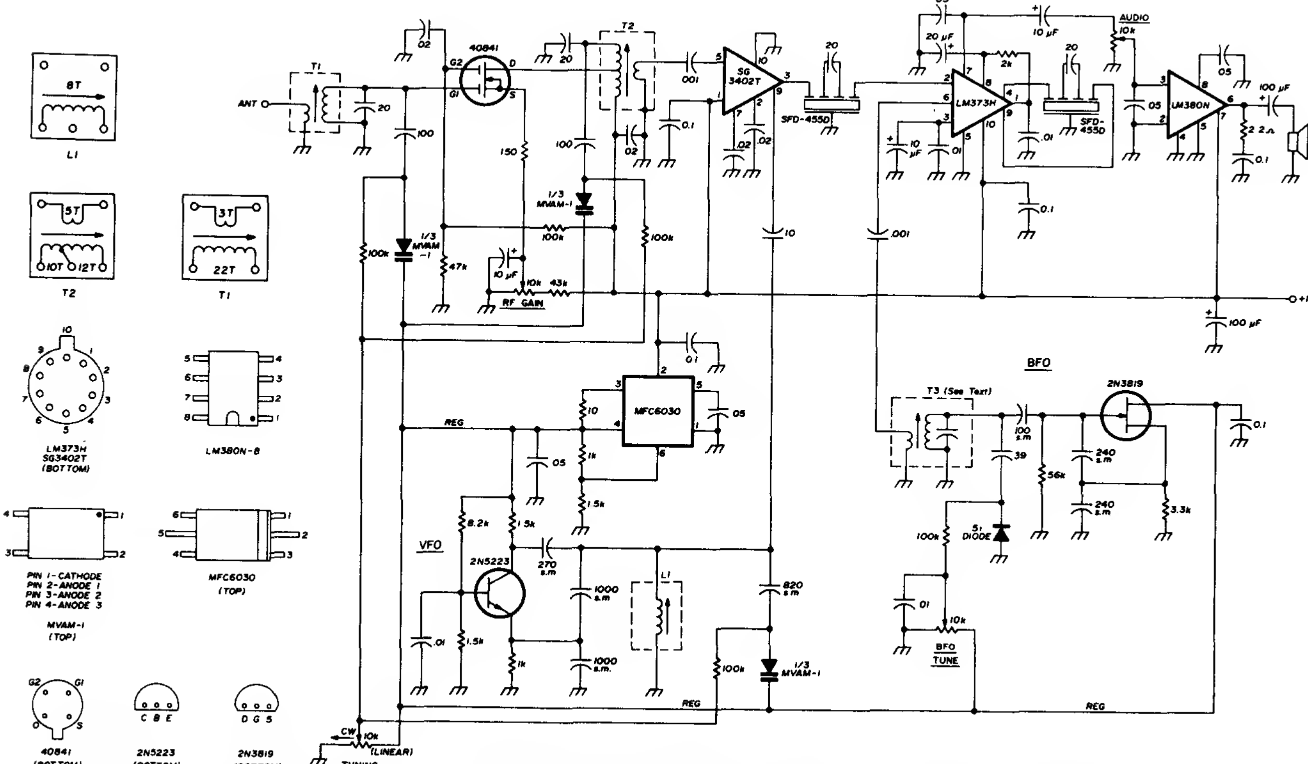
SIX-TRANSISTOR AM—Typical older Magnavox radio uses PNP germanium transistors. L7 is loopstick antenna. Article tells how to add FET converter to radio for use as standard-frequency receiver.—H. Olson, Five-Frequency Receiver for WWV, *Ham Radio,* July 1976, p 36–38.



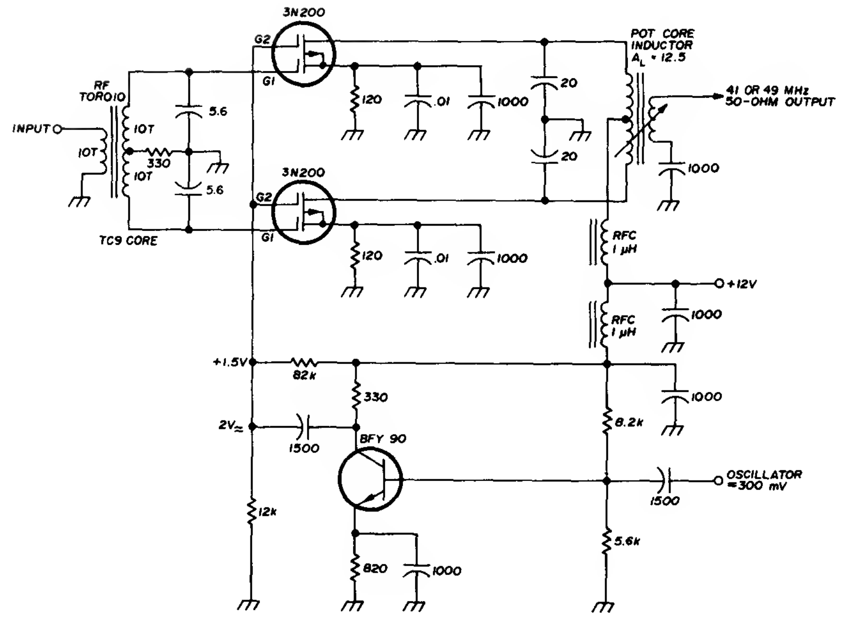
BALANCED PRODUCT DETECTOR—Uses RCA CA3028A differential amplifier U1 to provide conversion gain of about 18 dB for commonly used IF values. Values of tuned circuits depend on frequency used. Unmarked resistors are on IC.—D. DeMaw, Understanding Linear ICs, *QST*, Feb. 1977, p 19–23.



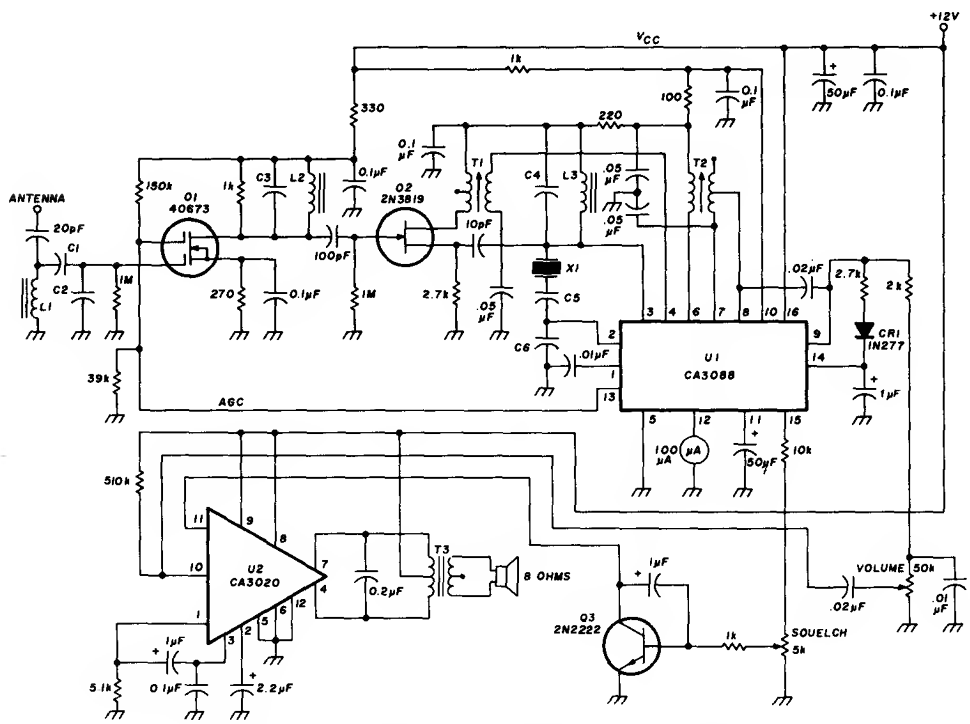
144-MHz PREAMP—Low-noise 2-meter preamp has 18-dB gain and typical noise figure of 1.7 dB. L1 and L2 are each 3½ turns No. 18 wound ½ in long on ⅜-in form and tapped 1 turn from cold end. MOSFET Q1 is MEM554C, 3N159, 3N140, or 3N141. Avoid static charges until MOSFET is connected. Developed for use with tube-type 2-meter converter.—E. Noll, Circuits and Techniques, *Ham Radio*, April 1976, p 40–43.



3.5–4 MHz WITH TUNING DIODES—Miniaturized communication receiver was developed for use as tunable IF fed by external converter for all-band coverage up to 30 MHz. Motorola MVAM-1 triple tuning diode serves in place of customary three-gang tuning capacitor. Two Murata SFD-455D ceramic filters provide IF selectivity. MFC6030 voltage regulator provides around 7 VDC with regulation required for diode tuning. Regulator also supplies VFO and BFO. Standard 3/8-in diameter 455-kHz transistor IF transformers were stripped and used for coil forms. T3 is 455-kHz IF with secondary changed to 1 turn. Remove pins 4, 6, and 8 from Silicon General SG3402T mixer.—R. Magirian, Design Ideas for Miniature Communications Receivers, *Ham Radio*, April 1976, p 18–25.

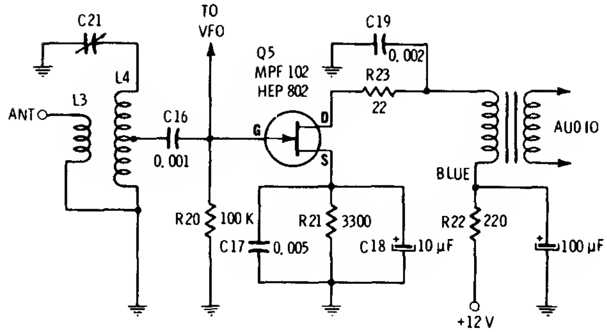


FET MIXER—Double-balanced mixer developed for use in high-quality high-fidelity communication receiver has high input impedance (about 1000 ohms). Two-tone 176-mV signal produces third-order intermodulation distortion 68 dB down.—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.

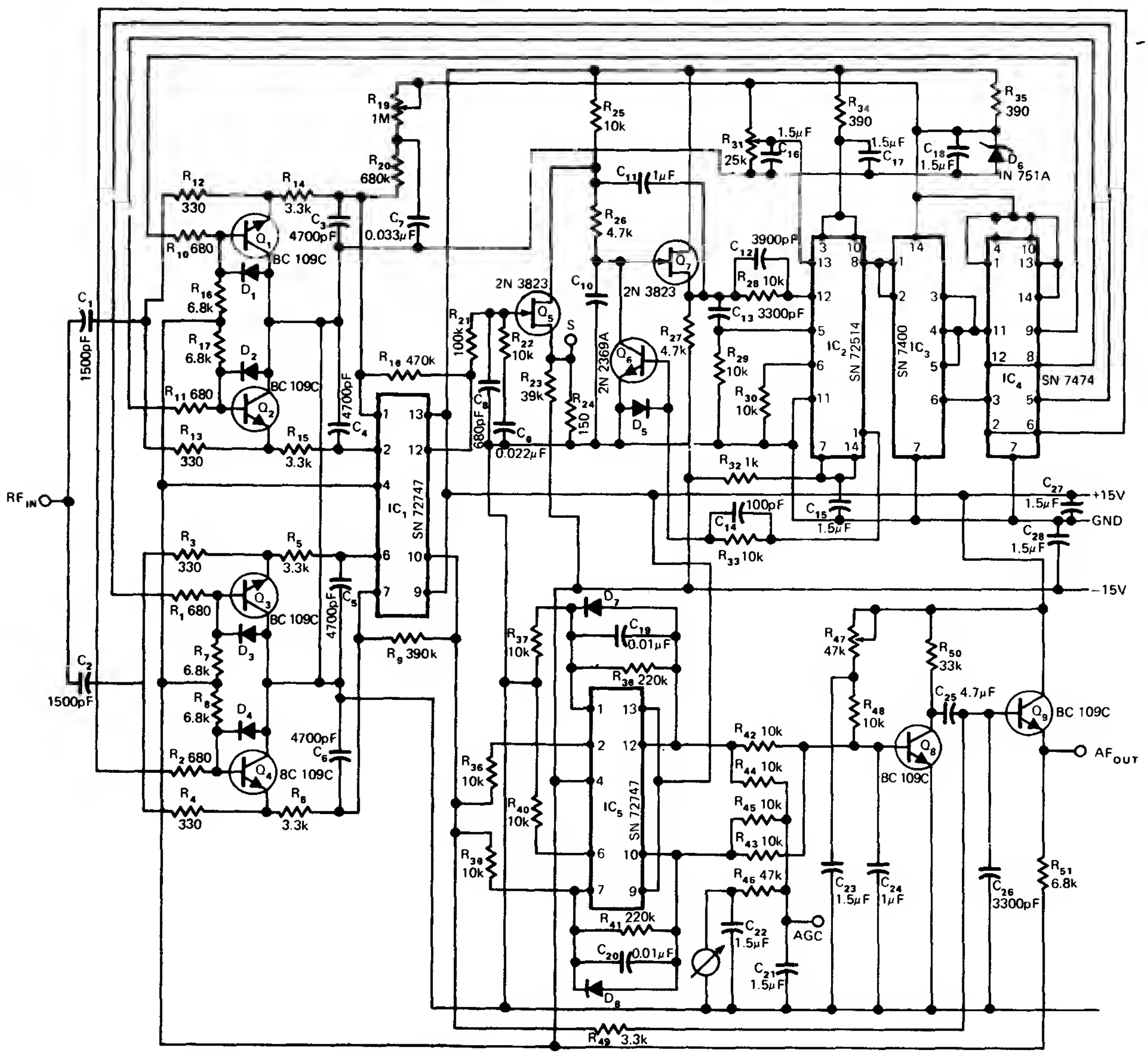


station	freq (MHz)	crystal freq (MHz)	C1 value (pF)	C2 value (pF)	C3,C4 values (pF)	C5 value (pF)	C6 value (pF)	turns	L1&L2 AWG	L1&L2 (mm)	L3 AWG	L3 (mm)	coil cores
WWV WWVH	2.50	2.955	300	820	220	30	150	66	32	(0.2)	32	(0.2)	T37-2
WWV WWVH	5.00	5.455	120	680	100	30	150	49	32	(0.2)	32	(0.2)	T37-2
WWV WWVH	10.00	10.455	56	330	47	30	150	40	32	(0.2)	32	(0.2)	T25-2
WWV WWVH	15.00	15.455	33	330	30	30	150	37	30	(0.25)	30	(0.25)	T25-6
WWV WWVH	20.00	20.455	30	330	27	short	10	29	32	(0.2)	32	(0.2)	T25-6
WWV WWVH	25.00	25.455	24	300	22	short	10	26	32	(0.2)	32	(0.2)	T25-6
CHU	3.33	3.785	300	820	220	30	150	50	30	(0.25)	30	(0.25)	T37-2
CHU	7.34	7.795	68	350	56	30	150	44	32	(0.2)	32	(0.2)	T37-2
CHU	14.67	15.125	33	330	30	30	150	36	32	(0.2)	32	(0.2)	T25-6

10-MHz FIXED FOR WWV—Fixed-frequency receiver has high sensitivity, portability, low power consumption, and low cost. Number of parts is minimized by using RCA CA3088 IC for converter, IF, detector, audio preamp, AGC, and tuning-meter output, along with RCA CA3020 as audio amplifier. Table gives crystal frequencies and tuned-circuit values for all nine frequencies on which frequency calibration data, propagation forecasts, geophysical alerts, time signals, and storm warnings are broadcast by American and Canadian governments. Core type numbers are for Amidon Associates cores. IF transformers come as Radio Shack set 273-1383; use only T1 (gray core) and T2 (white core). Specify load capacitance as 32 pF when ordering crystals. Use overtone crystals for 20 and 25 MHz with C5 replaced by short and C6 reduced to 10 pF.—A. M. Hudor, Jr., Fixed-Frequency Receiver for WWV, *Ham Radio*, Feb. 1977, p 28–33.

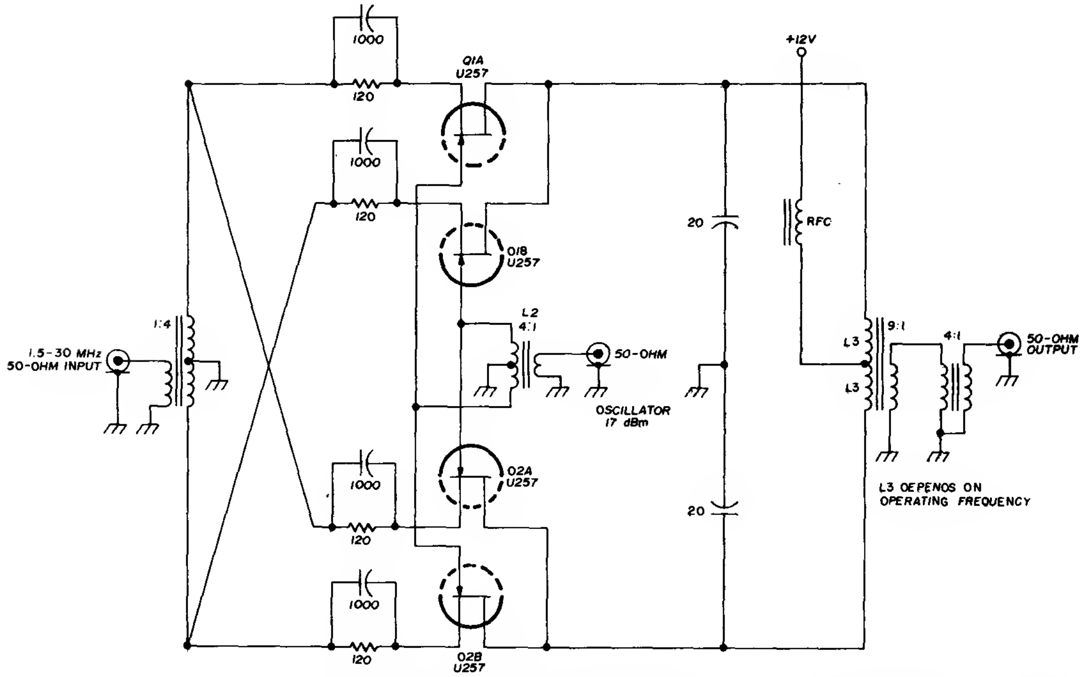


DIRECT-CONVERSION PRODUCT DETECTOR—Antenna is matched to high-impedance gate input of JFET with resonant input transformer. Demodulating carrier is applied to same gate. RC filter and audio transformer in output circuit of JFET recover demodulating audio while filtering out RF signals and undesired mixing components.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 155.

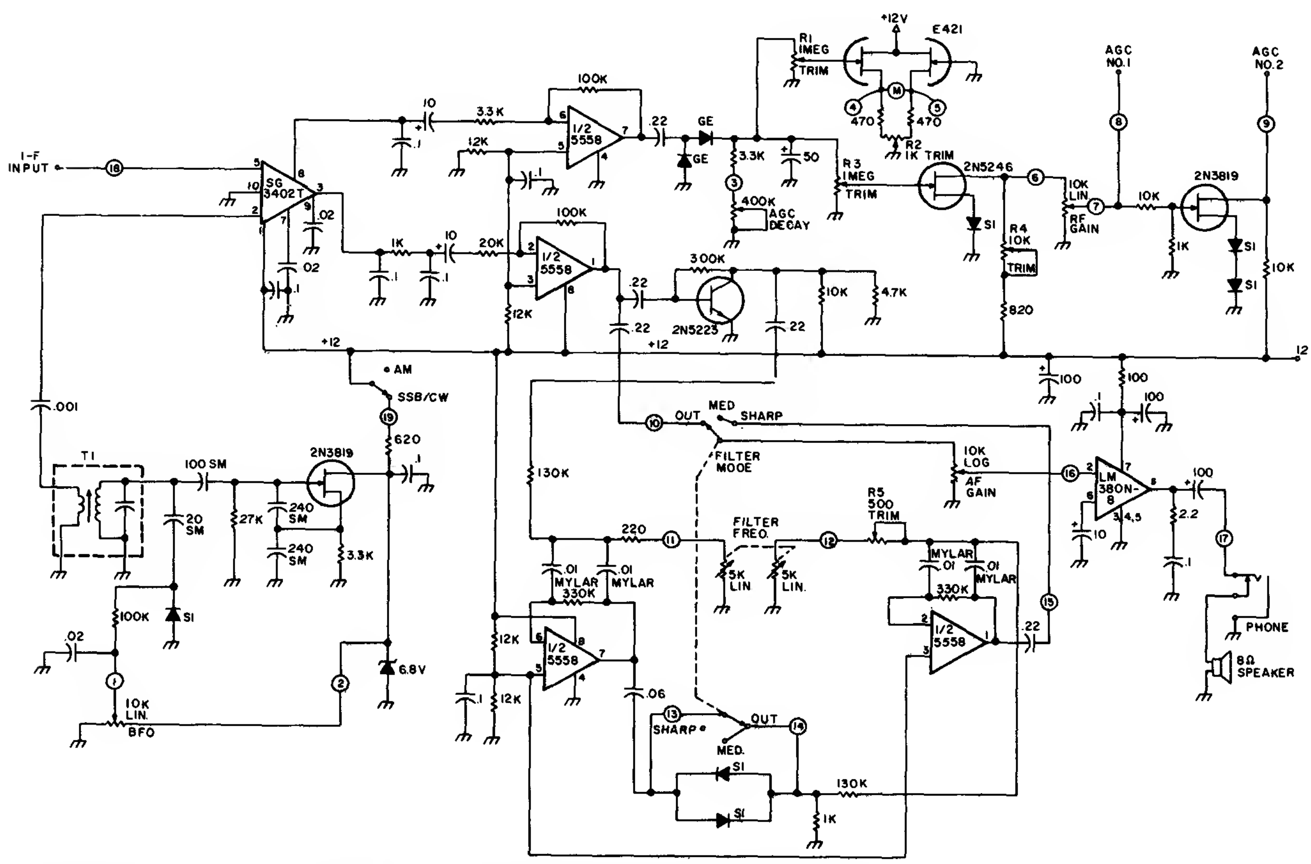


NOTE: D_1, D_2, D_3, D_4, D_5, D_7, D_8 = High speed Ge types

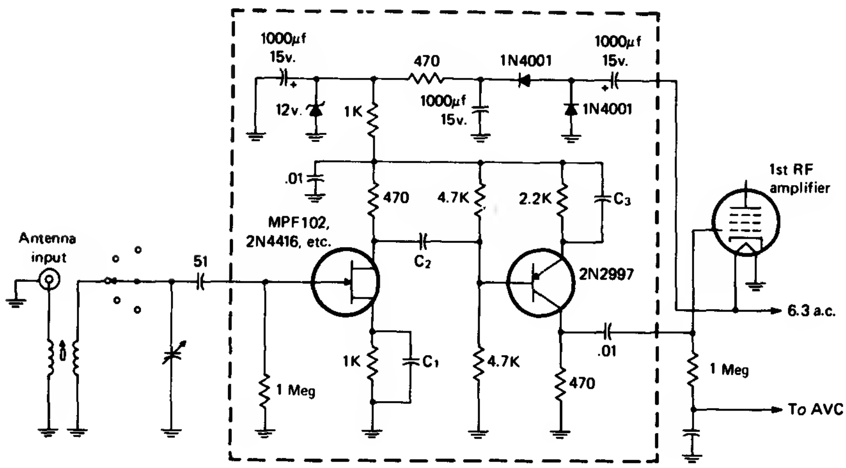
PLL IN AM RECEIVER—Phase-locked loops provide required stability for synchronous detection to improve reception quality of commercial double-sideband AM transmissions. Signal input and output of VCO are multiplied in phase-sensitive detector or multiplier that produces voltage proportional to phase difference between input and VCO signals. After filtering and amplifying, this voltage is used to control frequency of VCO to make it synchronize with incoming signal. Features include absence of image responses since IF is 0 Hz, almost complete immunity to selective fading, and conversion of RF to audio at very low signal levels so overall receiver gain is achieved mainly in audio amplifier. Article traces development and operation of receiver in detail.—T. Mollinga, Solve Phase Stability Problem in AM Receivers with PLL Techniques, *EDN Magazine*, Feb. 20, 1975, p 51–56.



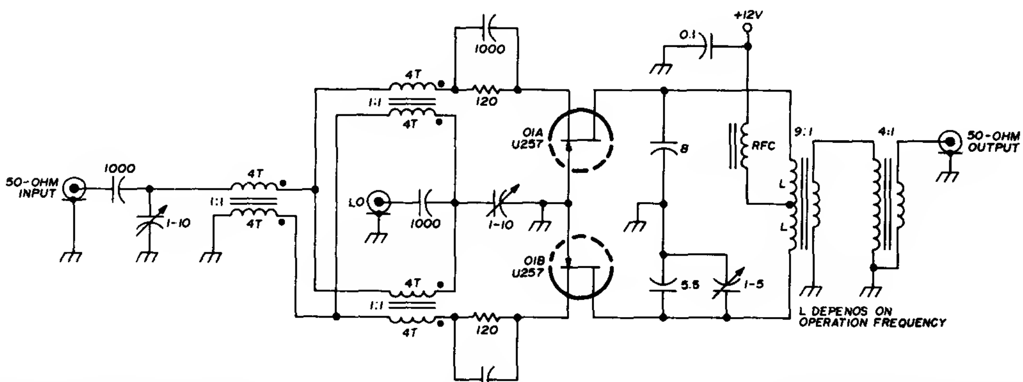
BALANCED FOUR-FET MIXER—Uses two matched FET pairs to bring third-order intermodulation distortion suppression down to 71 dB. Developed for use in high-quality communication receiver.—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.



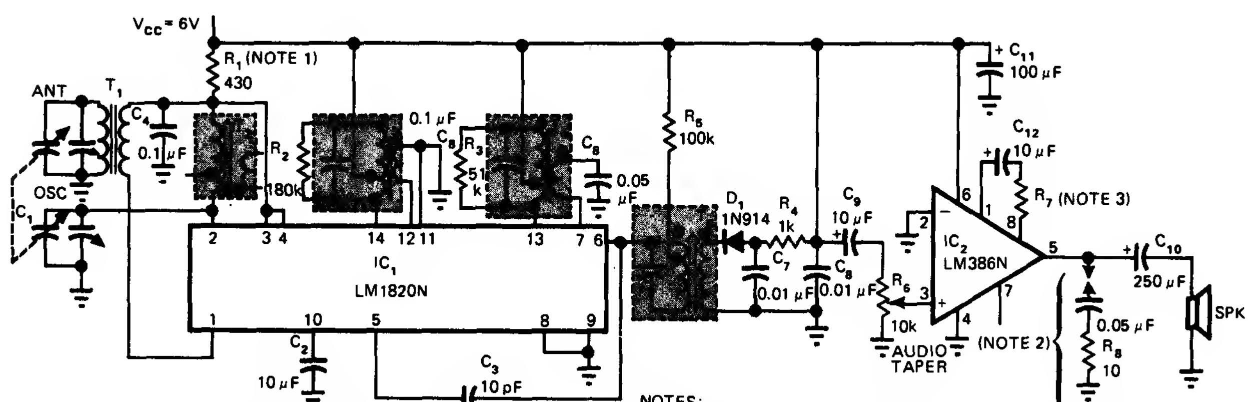
AF FOR AM/SSB/CW—Uses SG3402T as detector, with BFO disabled for AM. Pin 3 of detector output is main audio source, feeding preamp using half of dual opamp whose output goes to AF gain control except when CW filter is in use. Filter has two identical 400–1600 Hz active bandpass sections joined by threshold detector. LM380N-8 AF power amplifier is rated at 600-mW output. Audio from pin 8 of detector is amplified about 30 times in second half of dual opamp before rectification for use as AGC voltage. Circuit includes S-meter fed by AGC section. Article gives construction details of complete receiver.—R. Megirian, The Minicom Receiver, *73 Magazine*, April 1977, p 136–149.



RF PREAMP—Boosts sensitivity of older tube-type communication receiver when added ahead of first RF tube. Has low noise figure. Values of C_1, C_2, and C_3 are varied to suit receiver being used. Using 0.01 µF for these gives 20-dB gain from 0.5 to 30 MHz; if this overloads receiver on lower frequency ranges, try smaller values.—I. Math, Math's Notes, *CQ*, April 1975, p 37–38 and 62.



SIMPLE FET MIXER—Uses U257 dual FET in double-balanced circuit having 50-ohm input impedance, for high-quality communication receiver. Gives excellent third-order intermodulation distortion suppression (68 dB down).—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.

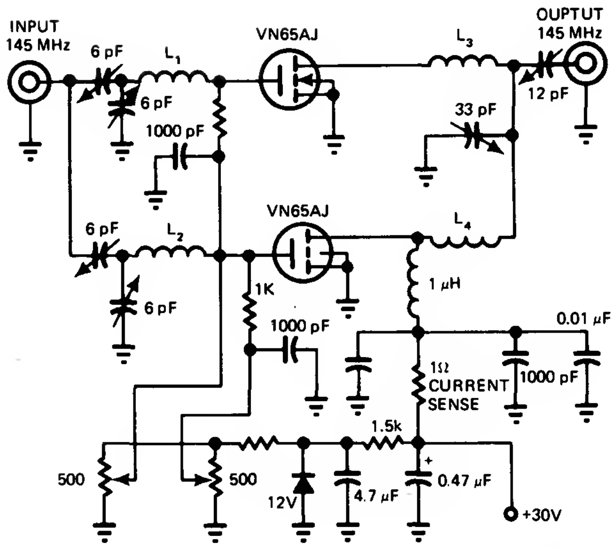


C_1: 2-SECTION GANG CAPACITOR. OSCILLATOR SECTION ≈ 60 PF, ANTENNA SECTION = 130 PF MAX. } MATCHED
T_1: TRANSISTOR ANTENNA ROD
T_2: OSCILLATOR COIL (RED)
T_3: 455 KHz IF TRANSFORMER (YELLOW)
T_4: 455 KHz IF TRANSFORMER (WHITE)
T_5: 455 KHz IF TRANSFORMER (BLACK)
} ARCHER = (RADIO SHACK) 273-1318

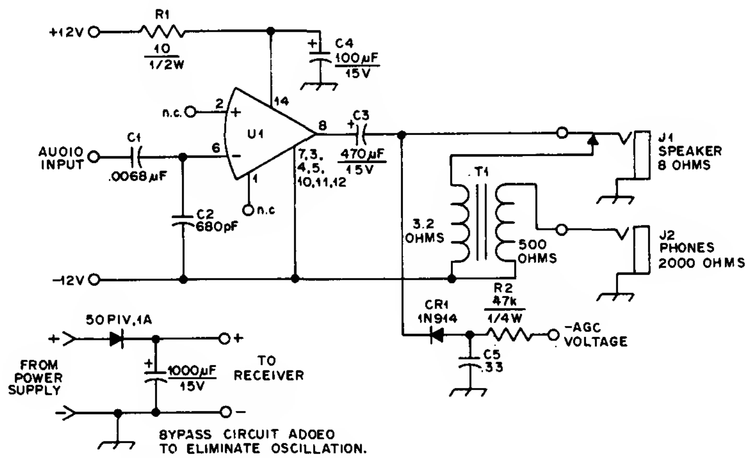
NOTES:
1. R_1 SETS THE VOLTAGE AT PINS 1, 2, 3 & 4 TO APPROX. 3V
2. COMPENSATION R8C13 NOT REQ'D WITH SPEAKER IMPEDANCES 4.0 OHMS OR HIGHER.
3. R_7 SETS THE GAIN, Av, OF THE POWER AMPLIFIER.

R_7 (Ω)	Av (V/V)
∞	20
168	100
0	200

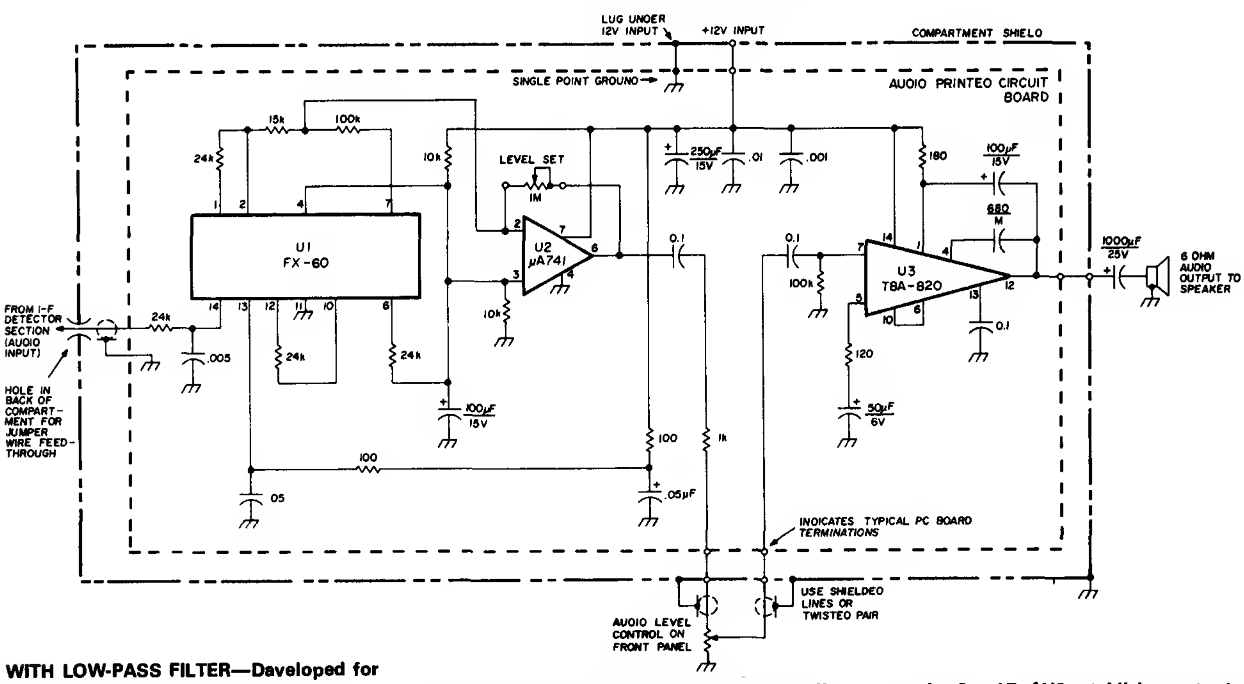
TWO-CHIP AM RADIO—Current drain of only 10 mA makes operation from 6-V battery feasible. National LM1820N IC serves for oscillator/mixer, two IF stages, and AGC, and LM386N AF chip provides power output of 0.25 W into 8-ohm loudspeaker. D_1 is diode detector.—E. S. Papanicolaou and H. H. Mortensen, Low Cost AM Radio Uses Only Two IC's, *EDN Magazine*, Jan. 20, 1976, p 82 and 84.



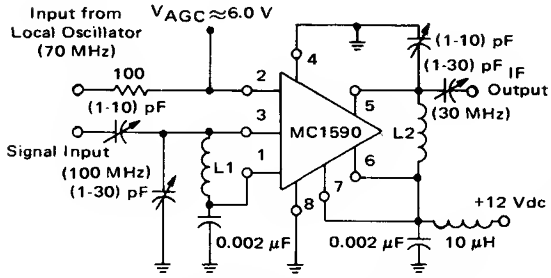
2-METER DUAL-VMOS—Provides 10-W PEP output at 146 MHz for amateur applications. Noise figure is only 2.35 dB, and two-tone IMD is −30 dBC.—E. Oxner, Will VMOS Power Transistors Replace Bipolars in HF Systems?, *EDN Magazine*, June 20, 1977, p 71–75.



AUDIO BOOST—LM380 power amplifier operating on 12 V is well suited for communication receiver having only limited audio gain. Circuit provides excellent headphone volume and enough loudspeaker output for small room. If signal at full secondary winding of product detector AF coupling transformer in receiver overloads U1, take signal from center tap of transformer winding that feeds volume control in amplifier.—H. L. Ley, Jr., More Audio for *QST* Course Receiver, *QST*, Oct. 1977, p 45.

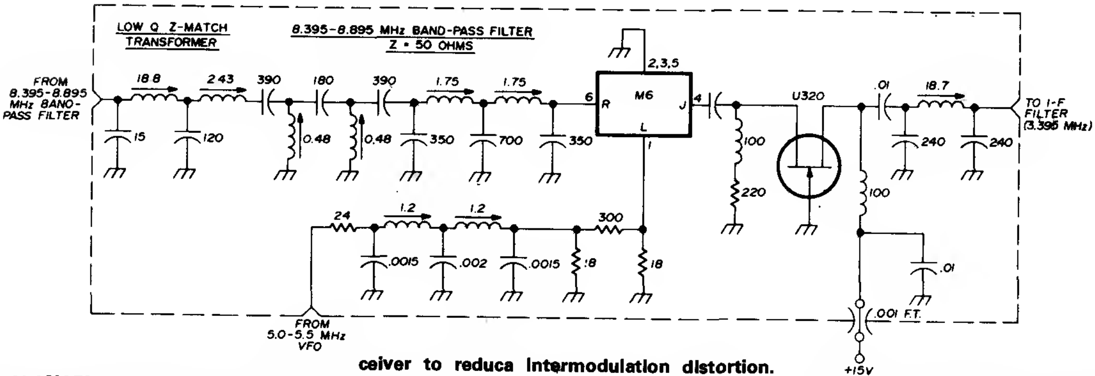


2-W WITH LOW-PASS FILTER—Developed for use in dual-conversion amateur receiver. Detected audio is passed through active low-pass filter-opamp arrangement U1-U2 and further amplified by 2-W audio amplifier U3. Simple voltage-divider circuit on pin 3 of U2 establishes artificial ground for U1 and U2. Low-pass rolloff starts at 2500 Hz, with about 20-dB attenuation of higher audio frequencies. IF heterodyne hiss is greatly attenuated and overall S/N ratio of receiver enhanced. Level-set 1-megohm pot between pins 2 and 7 of U2 establishes output gain for U1 and U2 together at about 0.8.—M. A. Chapman, High-Performance 20-Meter Receiver with Digital Frequency Readout, *Ham Radio*, Oct. 1977, p 48–61.

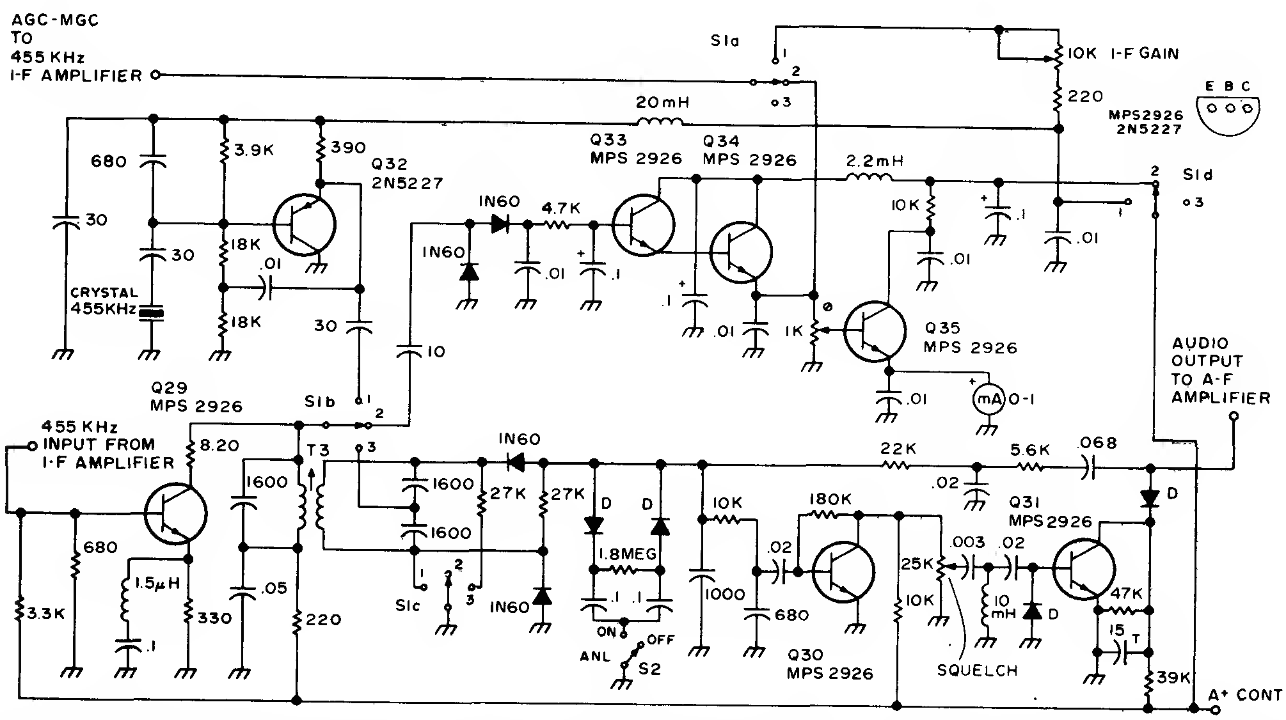


L1 = 5 Turns, #16 AWG, 1/4" ID, 5/8" Long
L2 = 16 Turns, #20 AWG Wire on a Toroid Core, (T44-6 Micro Metal or Equiv)

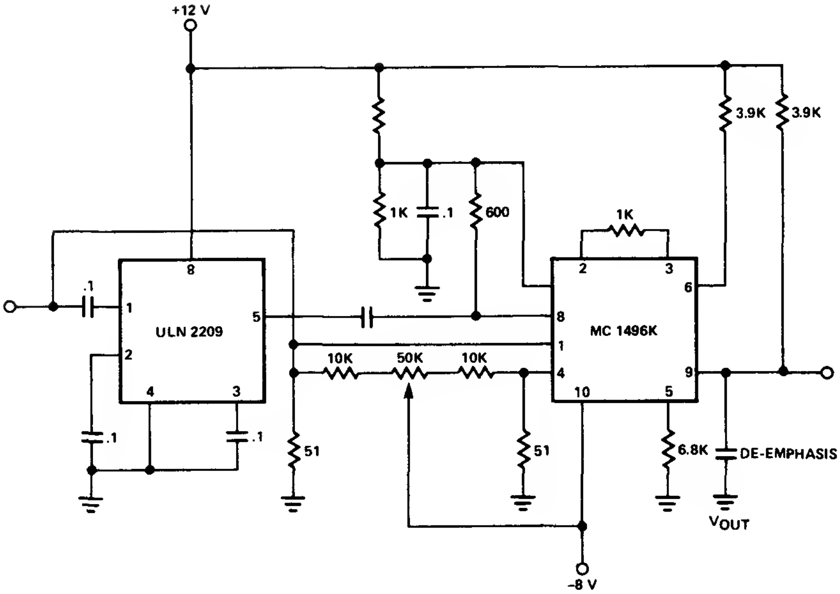
100-MHz MIXER—With local oscillator frequency of 70 MHz, opamp provides difference frequency of 30 MHz at high conversion gain. Isolation between oscillator and signal source is excellent.—B. Trout, "A High Gain Integrated Circuit RF-IF Amplifier with Wide Range AGC," Motorola, Phoenix, AZ, 1975, AN-513, p 9.



DOUBLE-BALANCED MIXER—Uses Watkins-Johnson M6 low-level hot-carrier-diode double-balanced mixer as replacement for FET second mixer in amateur-band dual-conversion receiver to reduce intermodulation distortion. U310, CP643, or CP651 can be used in place of U320 high-transconductance JFET. Pi-network output circuit couples 2000-ohm output of JFET stage to 2000-ohm IF filter. All inductance values are in microhenrys.—A. J. Burwasser, Reducing Intermodulation Distortion in High-Frequency Receivers, *Ham Radio*, March 1977, p 26–30.

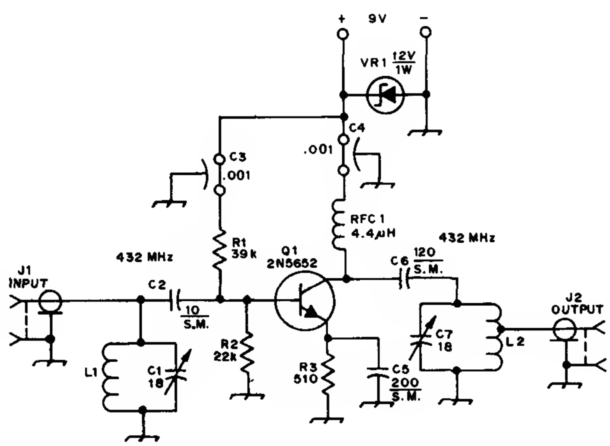


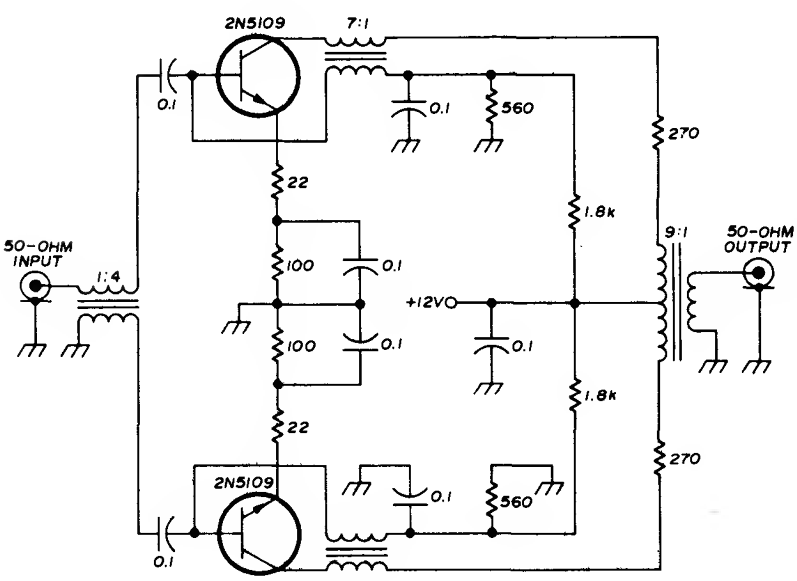
LIMITER-DETECTOR—Used in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Q29 acts as limiter on FM but on AM is 455-kHz amplifier whose RF output is coupled to 1N60 AGC rectifier pair connected as voltage doubler that provides bias for AGC amplifier Q33-Q34. Output of Q29 is coupled to detector by T3. Although detector is actually phase discriminator, mode switch connects circuit as half-wave rectifier for AM and CW/SSB. On CW/SSB (S1 on 1), AGC rectifier is disconnected and AGC diodes receive bias from manual gain-control pot. BFO is then energized and connected to T3. Output of diode detector feeds squelch and audio stages. Supply is 13.8 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.



AM DEMODULATOR—Signetics ULN2209 IC provides 55-dB gain for input signal and symmetrical limiting above 400 μV. Limited carrier is then applied to MC1496K balanced modulator-demodulator transistor array for demodulation. Output filtering is required to remove high-frequency sum components of carrier from audio signal. Output amplitude is maximum when phase difference between signal and carrier inputs is 0°.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 757–758.

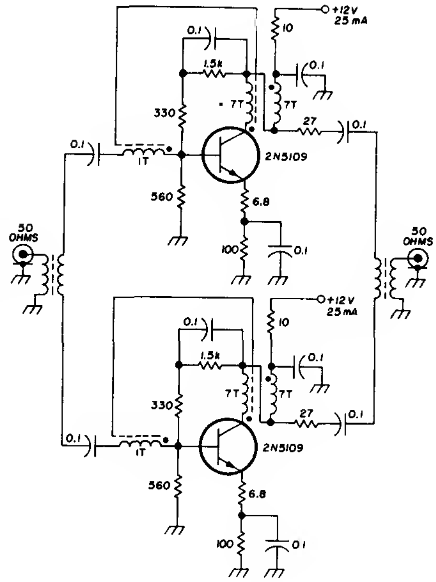
432-MHz PREAMP—Developed as part of 400-MHz radiotelescope, for low-noise operation. Gain is 12 dB, and noise figure is below 2 dB. Circuit is basic common-emitter amplifier with tuned input and output. Neither neutralization nor shielding are needed. Supply can be 9-V transistor radio battery. Current drain is 3 mA. L1 and L2 are each 1 turn No. 16 wire ⅜ inch in diameter, with L2 center-tapped.—S. A. Meas, An Inexpensive Low Noise Preamplifier for 432 MHz, *QST*, Jan. 1975, p 21–22.

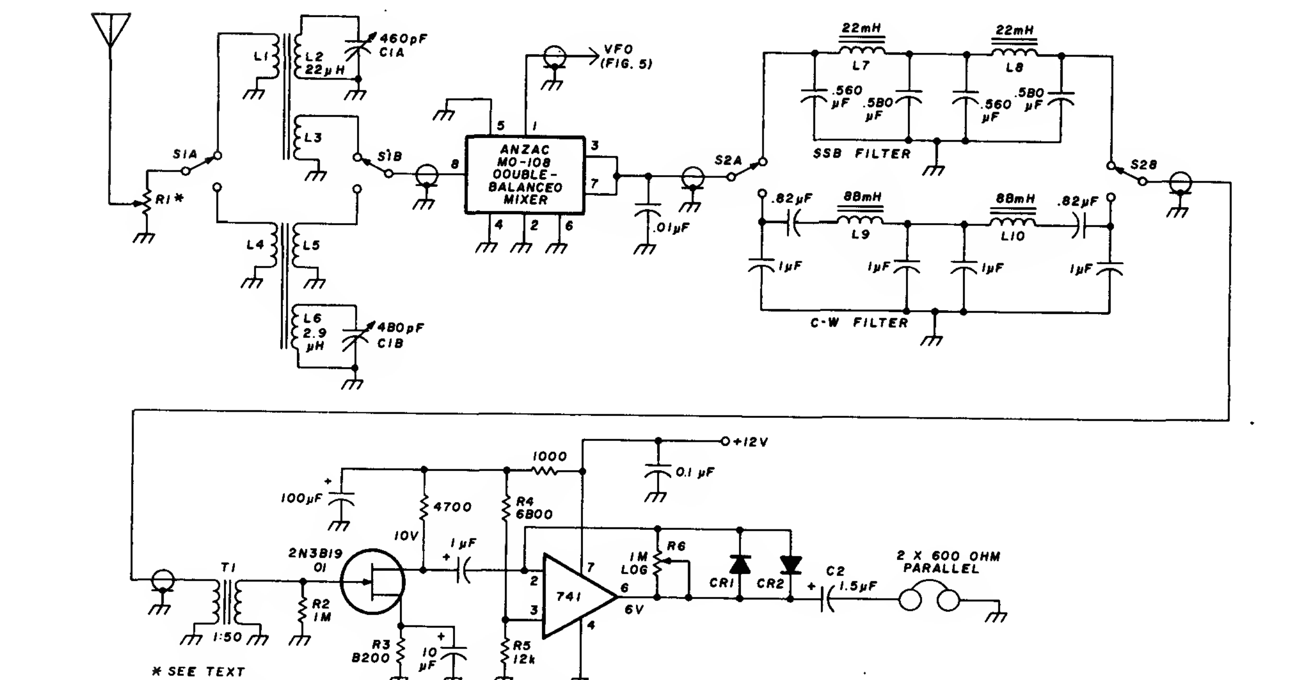




RF INPUT STAGE—Push-pull transistorized RF stage for communication receiver uses voltage and current feedback to minimize intermodulation distortion. Transformers serve to stabilize impedance. Circuit is basically constant-current device. Second-order intermodulation distortion products are suppressed almost 40 dB more than with single-transistor stage. To apply AGC, replace the two 270-ohm resistors with single PIN-diode shunt regulator.—U. L. Rohde, Optimum Design for High-Frequency Communications Receivers, *Ham Radio*, Oct. 1976, p 10–25.

PUSH-PULL RF—Uaes VHF power trensistors to obtaln wide dynemic renga. Transformars era trifilar wound on Indlena General F625-9-TC9 torold cores. Clrcuit haa extremely low VSWR at both input end output, along wlth low nolse figure. Second-order Intermodulation producta can be suppressed neerly 40 dB over singla stage. Either RCA 2N5109 or Amperex BFR95 trensistors cen be uaed. Gain Is ebout 11 dB. Current feedback Is used through unbypassed 6.8-ohm emitter resistor, voltage feedbeck through unbypessed 330-ohm base-to-collector reslstor, end transformer feedbeck through thlrd winding on wldeband trensformer to stebilize input and output impedences.—U. L. Rohde, Hlgh Dynamic Renge Recelver Input Stagas, *Ham Radio*, Oct. 1975, p 26–31.

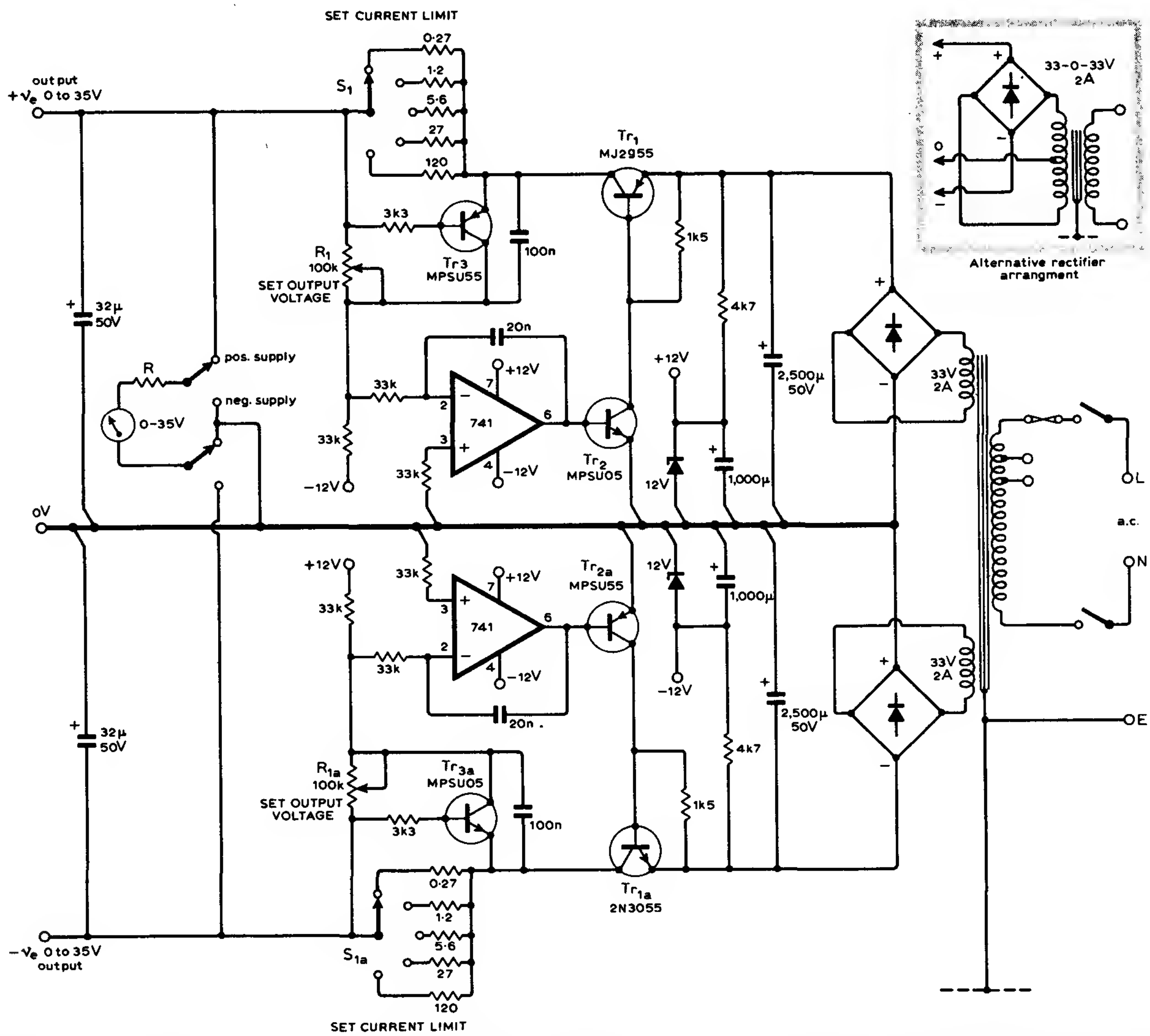




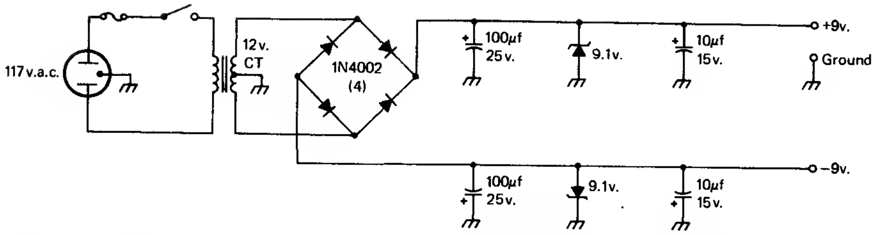
DIRECT CONVERSION—Simple direct-converslon ameteur recelvar uses VFO and mixer to produca AF signal directly, with no IF emplifier or second detector. For SSB recaption, VFO is tuned to frequency of suppressed carrier. For CW, VFO is detuned anough to giva note of deaired pitch. Not auitable for AM or FM reception. Separate input tuned circuits ere used for 15–40 meters end for 80–160 meters. Uae ferrite or powderad iron torold cores for coils, wlth turns determlned axperlmentally. L7 end L8 ere 88-mH torolds with serles-connected windlngs. R1 Is used to ettenuate strong signels. Article gives circuit for VFO end buffer emplifier. Saperete VFO ia used for eech bend (160, 80, 40, 20, end 15 meters). Construction detalls ere given, elong with edvanteges and drawbacks of dlrect converaion.—D. Rollema, Direct-Converslon Receivar, *Ham Radio*, Nov. 1977, p 44–55.

CHAPTER 73
Regulated Power Supply Circuits

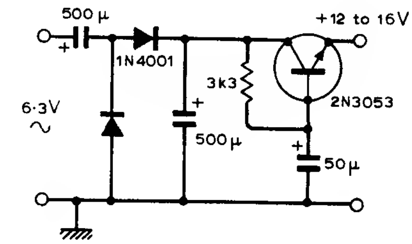
Various combinations of line-powered rectifiers and voltage regulators provide highly regulated fixed and variable positive and negative outputs ranging from 0 to ±35 V at maximum currents from 24 mA to 24 A. Dual-output supplies may have tracking. See also Power Supply, Regulator, and Switching Regulator chapters.



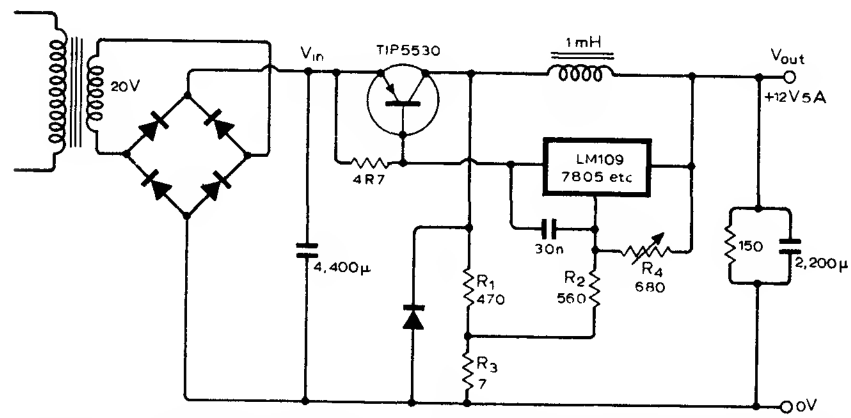
0 to ±35 V—Twin stabilized DC supply uses ganged pots R_1 and R_{1a} to set both positive and negative regulated outputs at any desired value up to 35 V. Input supplies from bridge rectifiers also provide ±12 V lines for 741 opamps. Load regulation is within 2 mV from no load to full 2-A maximum output. Output hum, noise, and ripple are together only 150 µV and independent of load.—J. L. Linsley Hood, Twin Voltage Stabilized Power Supply, *Wireless World,* Jan. 1975, p 43–45.



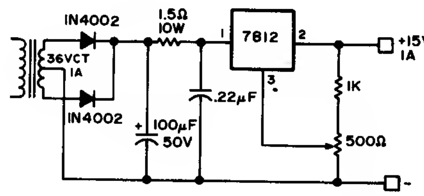
±9 V—Developed for use with demodulator of teleprinter. Regulation is provided by zenors.—I. Schwartz, An RTTY Primer, *CQ*, Feb. 1976, p 31–36.



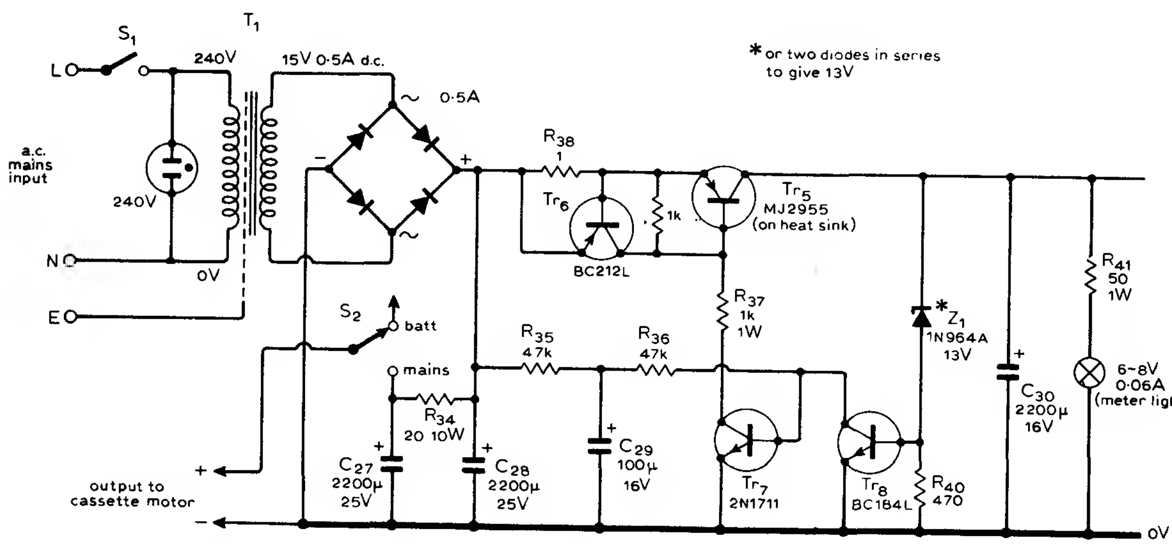
12–16 V FROM 6.3 VAC—Designed for use with transistor or IC amplifier being fed by tube-type preamp having 6.3-V power transformer winding for filament supply.—K. D. James, Balanced Output Amplifier, *Wireless World*, Dec. 1975, p 576.



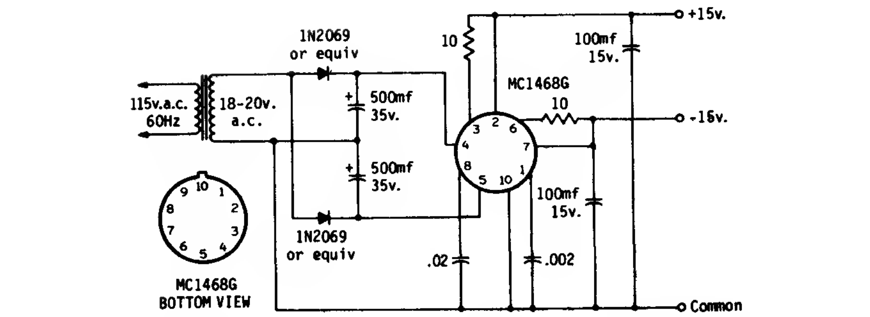
ADJUSTABLE SWITCHED REGULATOR—Circuit shows method of using LM109, 7805, or other IC voltage regulator to provide output voltage that is higher than rated output of IC. Voltage pedestal is developed across R_2 and R_3 for adding to normal regulated output of IC. R_4 adjusts amount of added voltage. Divider R_1-R_2 provides positive feedback into pedestal circuit of regulator, to allow switching of IC and transistor.—V. R. Krause, Adjustable Voltage-Switching Regulator, *Wireless World*, May 1976, p 60.



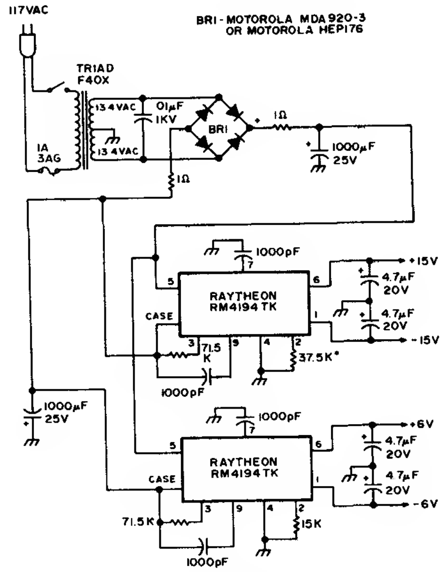
15 V AT 1 A—Developed for operating CRO from AC line. Can also be used for recharging batteries of portable CRO if pot is set to correct charging voltage for cells being used. Use good heatsink with 7812 regulator.—G. E. Friton, Eyes for Your Shack, *73 Magazine*, Jan. 1976, p 66–69.



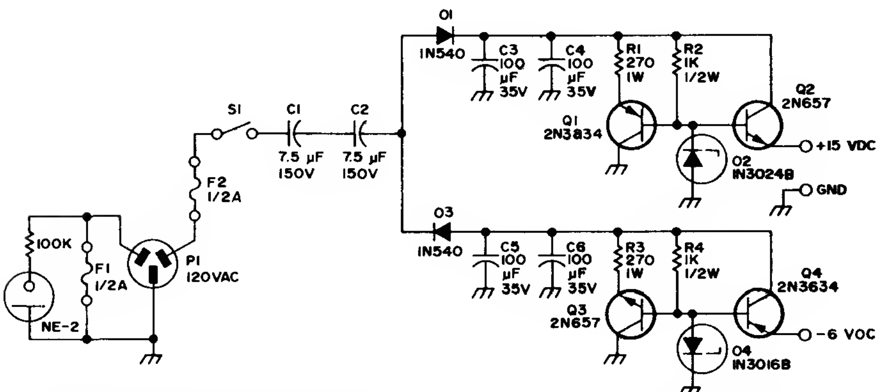
14 V AT 250 mA FOR CASSETTE DECK—Used in high-quality stereo cassette deck operating from AC line or battery. For U.S. applications, use 120-V power transformer. Power for cassette motor is taken directly from power-supply filter capacitors through 20-ohm 10-W resistor, with negative return line connecting directly to filter capacitors instead of chassis, to eliminate noise originating from pulsating current of cassette-drive motor-control circuit. Article gives all other circuits of cassette deck and describes operation in detail.—J. L. Linsley Hood, Low-Noise, Low-Cost Cassette Deck, *Wireless World*, Part 2—June 1976, p 62–66 (Part 1—May 1976, p 36–40; Part 3—Aug. 1976, p 55–56).



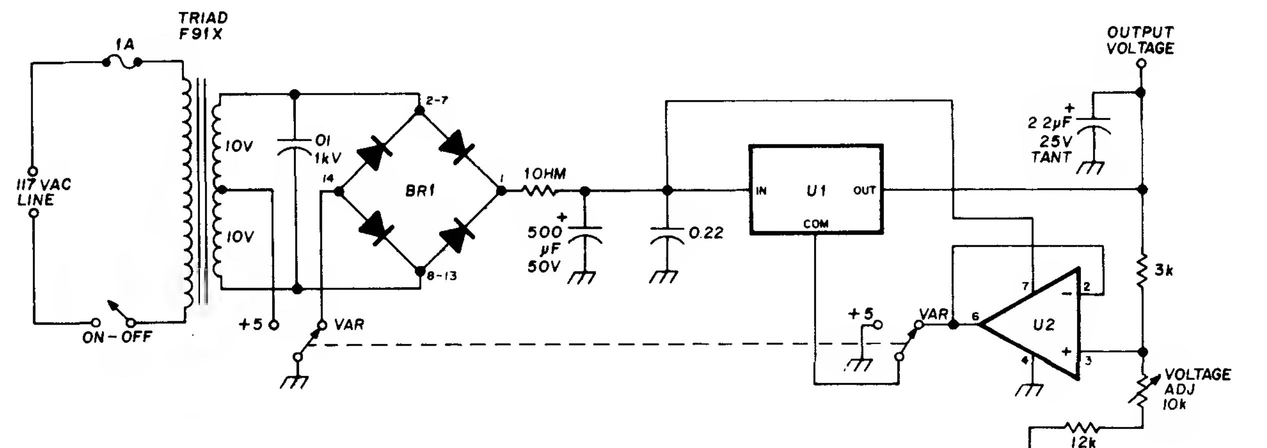
±15 V—Provides positiva and nagative supply voltages requirad by soma opamps. Supply is short-circuit-proof and protects itself against ovarloads.—I. Math, Math's Notes, *CQ*, Jan. 1974, p 68–69.



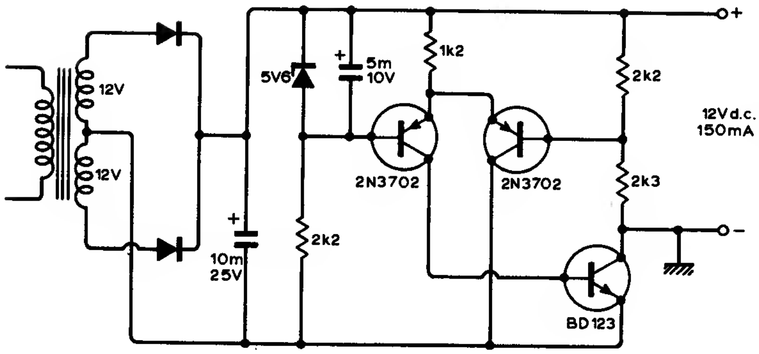
±6 AND ±15 V—Davaloped for use with function generator. Mount regulators on haatsinks insulated from chassis by mica wafars. Articla covers construction and adjustmant to give exactly desired outputs.—H. Olson, Build This Amazing Function Generator, *73 Magazine*, Aug. 1975, p 121–124.



+15 V AND −6 V TRANSFORMERLESS—Transistorized regulator providas good voltaga regulation with low rippla. Second ground prong is connectad through fusa to grounded center conductor of AC line to guard against faulty AC wiring. If wiring is reversed, fuse will disable powar supply and neon fault indicator will coma on. At currents up to 55 mA, −6 V output had 0.1-V ripple and +15 V output had 0.05-V ripple.—D. Kochan, Transformarless Power Supplies, *73 Magazine*, Sept. 1971, p 14–17.

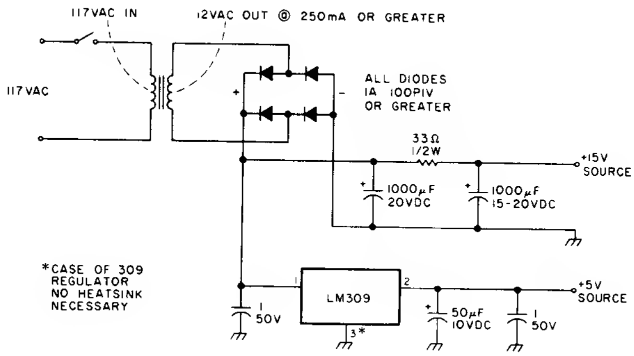


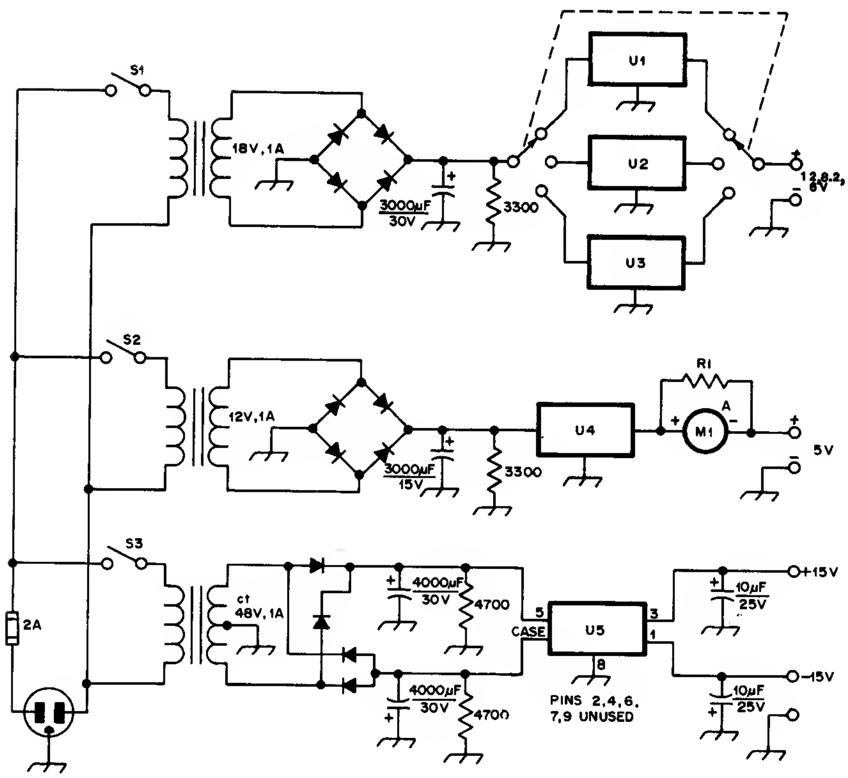
+5 V AT 200 mA OR 7–20 V AT 100 mA—Uses National LM741 opamp as noninverting follower to sample output of voltage divider and driva common tarminal of National LM340-05 thrae-tarminal voltage regulator. Heatsink tab of regulator U1 must ba connected to floating haatsink. BR1 is Adva bridge.—H. Olson, Second-Ganaration IC Voltage Ragulators, *Ham Radio*, March 1977, p 31–37.



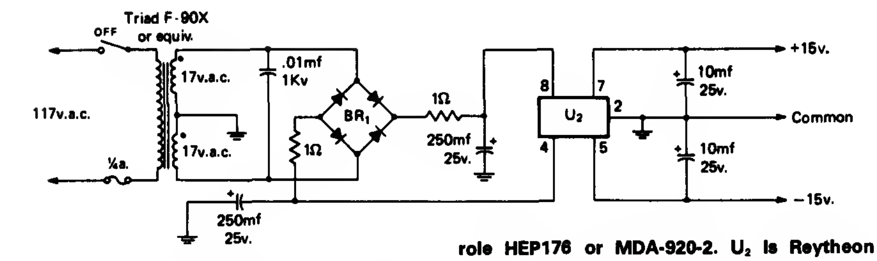
12-V LOW-RIPPLE—Three-transistor feedback circuit gives low-cost voltage stabilizer in which ripple is low and regulated output is very little less than unstabilized input voltage.—R. H. Pearson, Novel 5-Watt Class A Amplifier Uses Three-Transistor Feedback Circuit, *Wireless World,* March 1974, p 18.

+5 V WITH UNREGULATED +15 V—Developed for use with audio decoder that converts BCD output of digital display to audio tones that can be recognized by blind radio operator or experimenter.—D. R. Pacholok, Digital to Audio Decoder, *73 Magazine,* Oct. 1977, p 176–180.

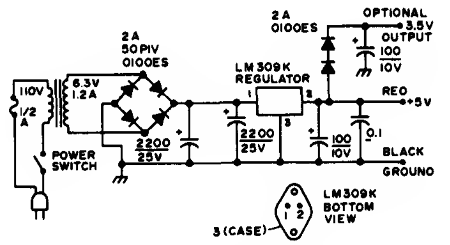




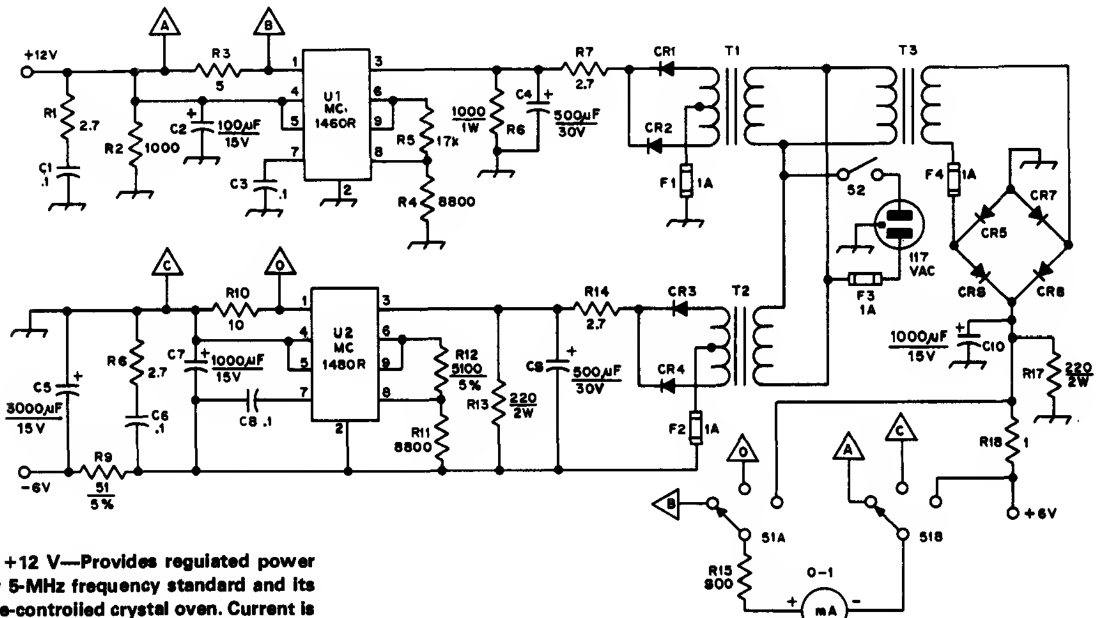
POPULAR-VOLTAGES SUPPLY—Provides most common fixed voltages required for transistor and IC projects. Eliminates cost and nuisance of replacing batteries. Provides ±15 V at 100 mA, +5 V at 1 A, and choice of +6.0, +8.2, and +12.0 V at 1 A. Separate grounds (not chassis grounds) permit connecting supplies in series to get combination voltages. Rectifier diodes are 100 PIV at 1 A. Use meter and shunt to give full scale at 1 A; for 150-mA meter, use 0.08 ohm for R1 (six 0.5-ohm resistors in parallel). U1 is LM340K-12, U2 is LM340K-8, U3 is LM340K-8, U4 is LM340K-5, and U5 is 4195.—C. J. Appel, A Combination Fixed-Voltage Supply, *QST,* Nov. 1977, p 36–37.



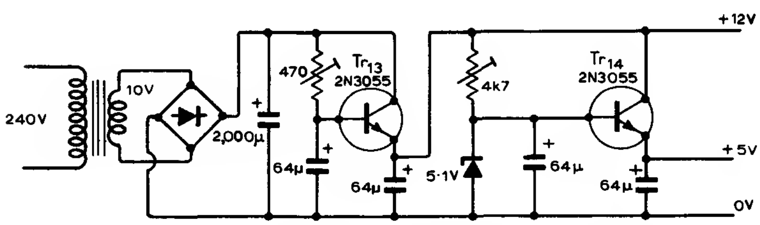
±15 V—Developed for use in two-tone AF generator for testing SSB equipment. BR_1 is Motorola HEP176 or MDA-920-2. U_2 is Reytheon 4195DN.—H. Olson, A One-Chip, Two Tone Generator, *CQ*, April 1974, p 48–49.



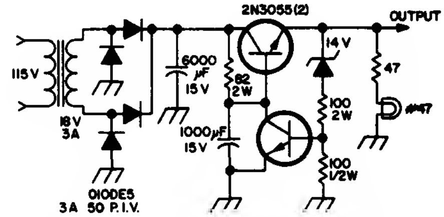
5 V AT 1 A—Can handle over 30 TTL ICs in frequency counter if LM309K regulator is mounted directly on aluminum heatsink. Case of regulator is grounded, so mica insulation is not needed. Provides excellent regulation with practically no output ripple and is short-circuit-proof. Circuit also shuts itself off if temperature gets too high.—P. A. Stark, A Simple 5 V Power Supply for Digital Experiments, *73 Magazine*, Oct. 1974, p 43–44.



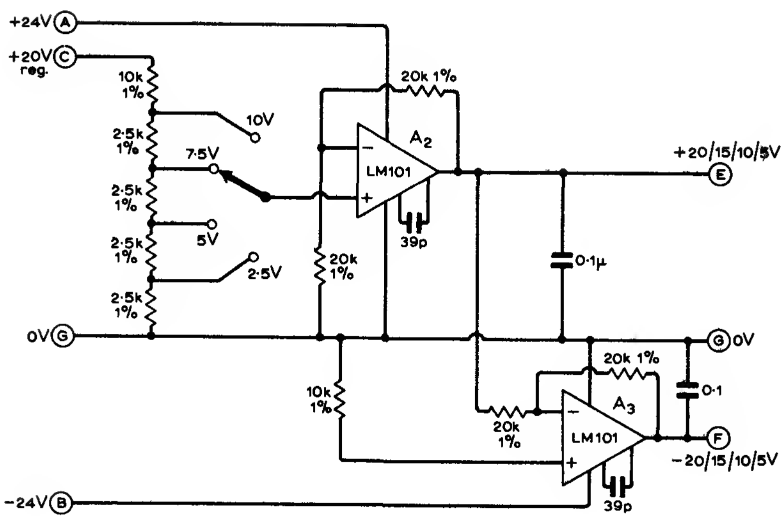
±6 V AND +12 V—Provides regulated power required by 5-MHz frequency standard and its temperature-controlled crystal oven. Current is measured by switching milliammeter and series resistor across current-limiting resistors R3 and R10, which also serve as meter shunts. DC input voltage at terminal 3 of MC1460R regulator should be at least 3 V greater than output voltage but should not exceed 20-V rating. Adjust R5 and R12 as required to get correct output voltages. Diodes are 200 PIV at 0.5 A. T1 and T2 have 117-V primary and 25.2-V secondary at 0.3 A. T3 has 117-V primary and 6.3-V secondary at 1 A.—R. Silberstein, An Experimental Frequency Standard Using ICs, *QST*, Sept. 1974, p 14–21 and 167.



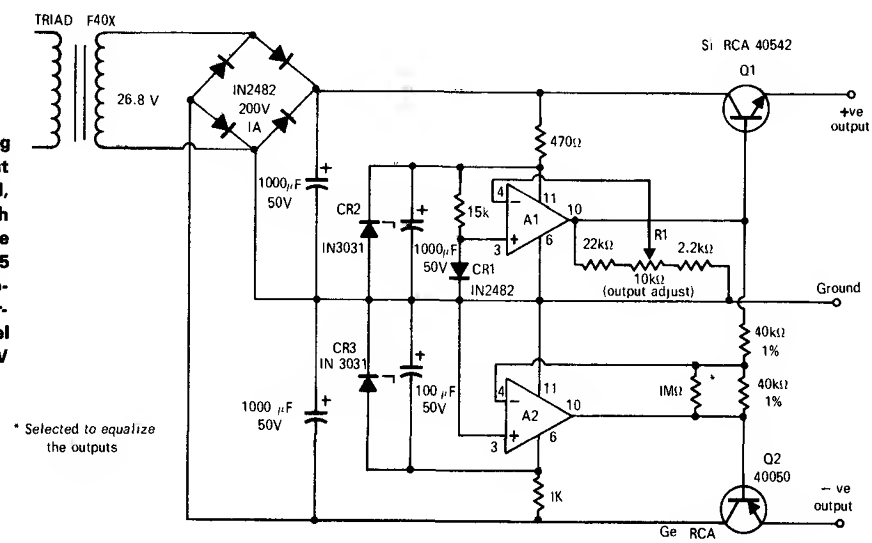
12 AND 5 V—Used with multiple photographic development timer to provide 12 V at about 5 mA and 5 V at about 300 mA for logic, control, and audible alarm circuits.—R. G. Wicker, Photographic Development Timer, *Wireless World*, April 1974, p 87–90.



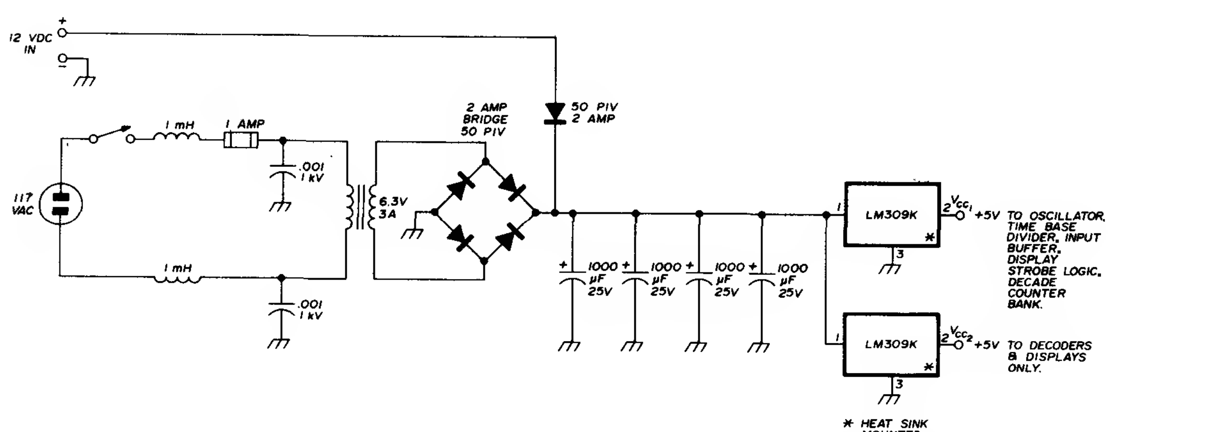
12 V FOR TRANSCEIVER—Permits operation of 144-MHz transceiver from AC line at base station. If 18-V transformer at 3 A is not available, use 12-V 3-A unit and add 26 turns No. 20 teflon-coated wire to secondary in proper phase. Choose transformer having enough room for these extra turns.—W. W. Pinner, Midland 2 Meter Base or Portable, *73 Magazine*, Aug. 1974, p 61–63.



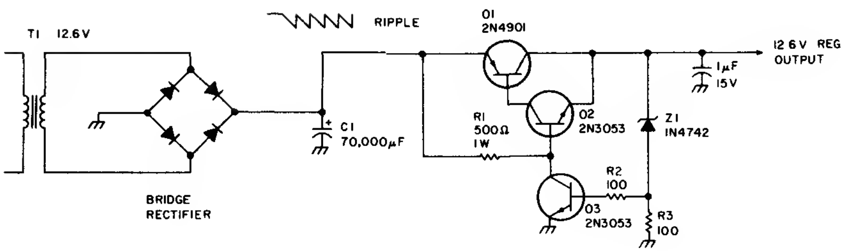
5/10/15/20 V SWITCH—Reference voltage selected by switch is applied to noninverting input of opamp having voltage gain of 2, to provide both positive and negative regulated voltages at desired value. Any standard opamp, such as μA709 or μA741, can be used in place of National LM101.—T. D. Towers, Elements of Linear Microcircuits, *Wireless World*, July 1971, p 342–346.



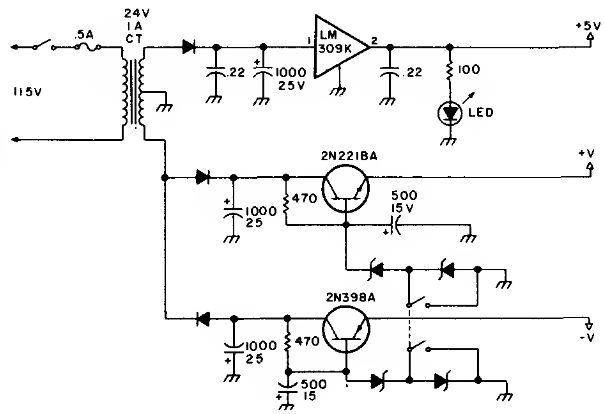
±4 V TO ±25 V—Arrangement permits varying both positive and negative regulated output voltages simultaneously with single control, with maximum load current of 400 mA for both regulators. Positive supply controls negative slave regulator to provide tracking within 0.05 V at full output. Developed for use in lab to observe effect of varying supply voltages on circuits under development.—J. A. Agnew, Dual Power Supply Delivers Tracking Voltages, *EDN Magazine*, Oct. 15, 1970, p 51.



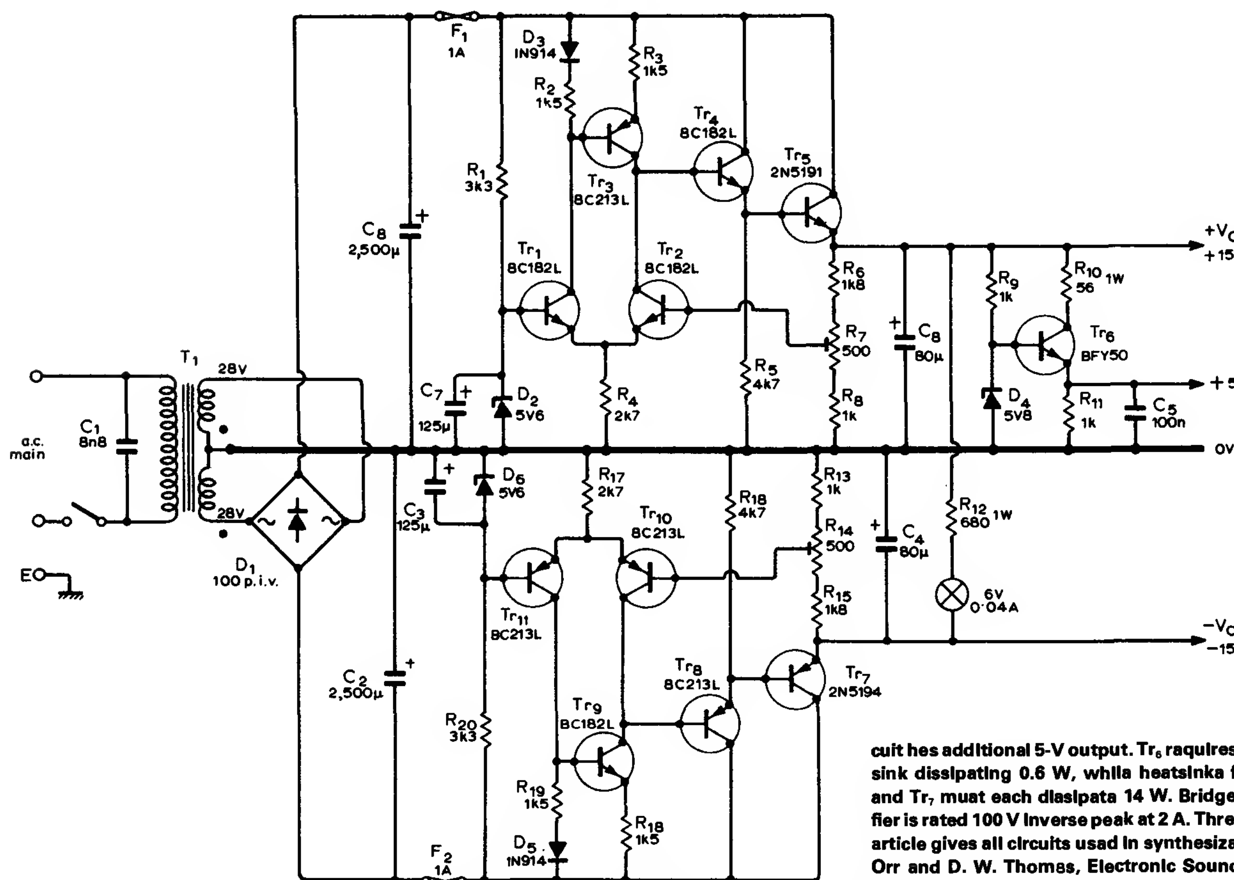
DUAL 5-V—Provides two 5-V regulated supplies for frequency counter, operating either from 9-VDC outputs of AC supply or from 12-VDC auto battery. Splitting of supply divides current demand so regulators operate well below maximum ratings and provide decoupling between sections of load.—J. Pollock, Six Digit 50-MHz Frequency Counter, *Ham Radio*, Jan. 1976, p 18–22.



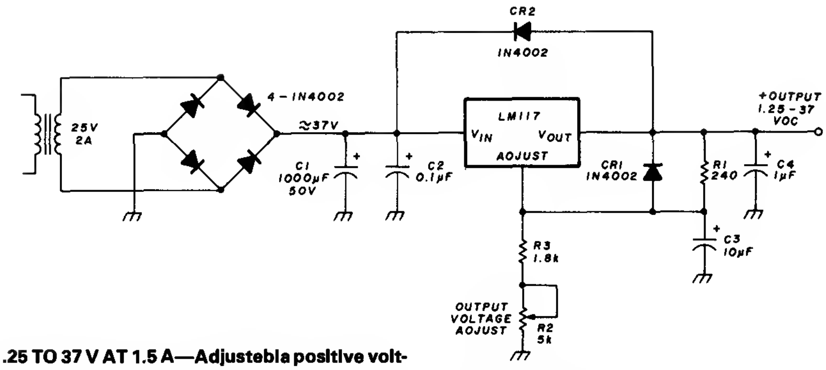
12.6 V AT 3 A—Article gives step-by-step procedure for designing simplest possible regulated supply to meet specific requirements in general service. Power transformer rated 12.6 V at 3 A delivers about 18 V P to bridge rectifier rated 50 V at 5 A. Value of C1 is chosen to keep voltage to regulator above 15-V limit at which circuit would drop out of regulation.—C. W. Andreasen, Practical P. S. Design, *73 Magazine*, June 1977, p 84–85.



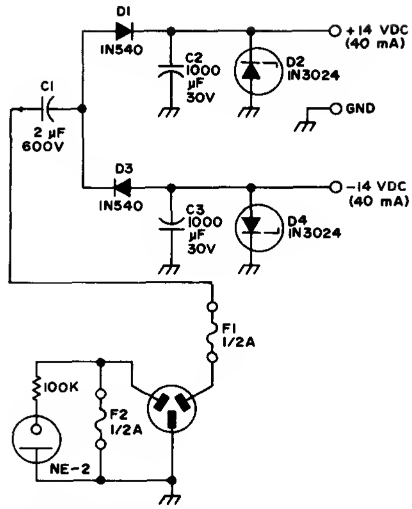
+5 V AND ±6 OR ±12 V—Three power supplies for experimental use are achieved with only one transformer. LM309K regulates 5-V supply. Other two supplies are regulated by 6.2-V zeners in conventional regulator; shorting out one zener in each with gang switch reduces output to 6 V.—Design a Circuit Designer!, *73 Magazine*, Oct. 1977, p 152–153.



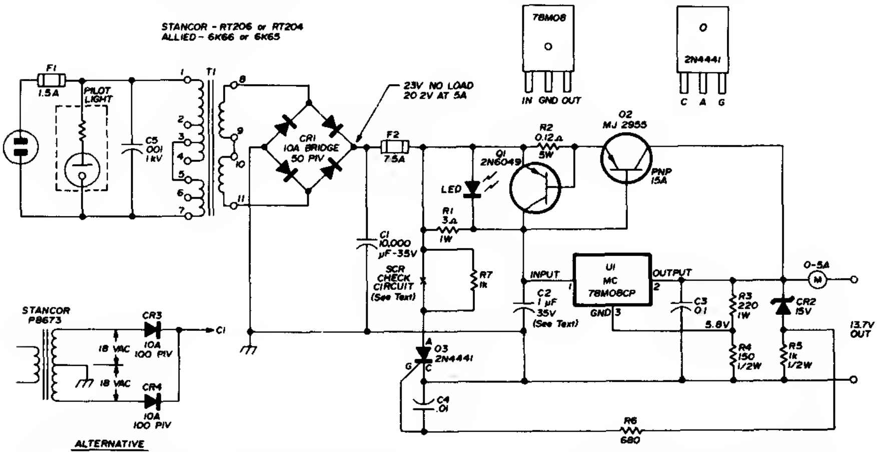
±15 V FOR SOUND SYNTHESIZER—Provides highly stabilized voltages required by elaborate sound synthesizer developed for generating wide variety of musical and other sounds. Circuit has additional 5-V output. Tr_6 requires heatsink dissipating 0.6 W, while heatsinks for Tr_5 and Tr_7 must each dissipate 14 W. Bridge rectifier is rated 100 V inverse peak at 2 A. Three-part article gives all circuits used in synthesizer.—T. Orr and D. W. Thomas, Electronic Sound Synthesizer, *Wireless World*, Part 3—Oct. 1973, p 485–490 (Part 1—Aug. 1973, p 366–372; Part 2—Sept. 1973, p 429–434).



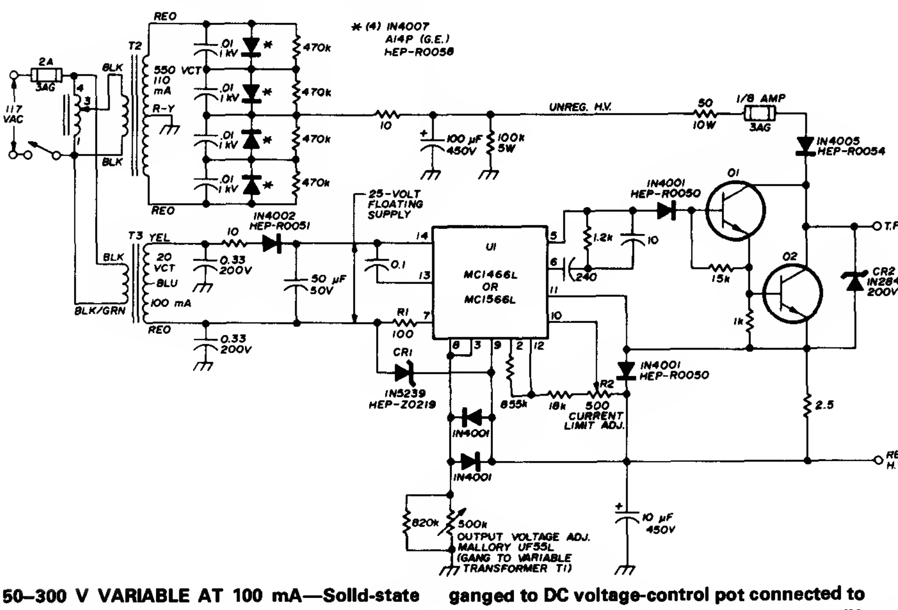
1.25 TO 37 V AT 1.5 A—Adjustable positive voltage regulator used with simple bridge rectifier and capacitor-input filter delivers wide range of regulated voltages, all with current and thermal overload protection. Load regulation is about 0.3%.—H. Berlin, A Simple Adjustable IC Power Supply, *Ham Radio*, Jan. 1978, p 95.



±14 V TRANSFORMERLESS—Simple low-current regulated supply requires no power transformer. Output current can be increased by using better filtering. Second ground prong is connected through fuse to grounded center conductor of AC line to guard against faulty AC wiring. If wiring is reversed, fuse will disable power supply and neon fault indicator will come on.—D. Kochen, Transformerless Power Supplies, *73 Magazine*, Sept. 1971, p 14–17.

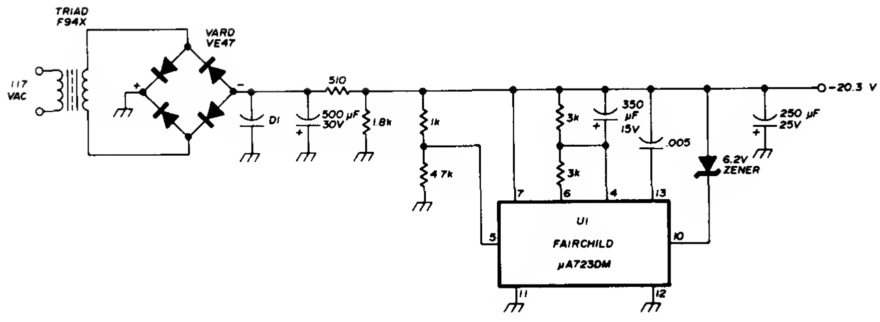


13.7 V AT 5 A—Output is constant within 0.7 V for AC line range of 98 to 128 VAC, and regulation is within tenths of a volt from 0 to 5 A. Design includes short-circuit, overcurrent, and overvoltage protection. Uses series-pass transistor to increase current-carrying capability of regulator. Transistors are mounted on but insulated from heatsink. C2 is essential to prevent oscillation under certain conditions. Use gallium arsenide phosphide LED. Article tells how to determine exact trip point of SCR crowbar.—B. Meyer, Low-Cost All-Mode-Protected Power Supply, *Ham Radio*, Oct. 1977, p 74–77.



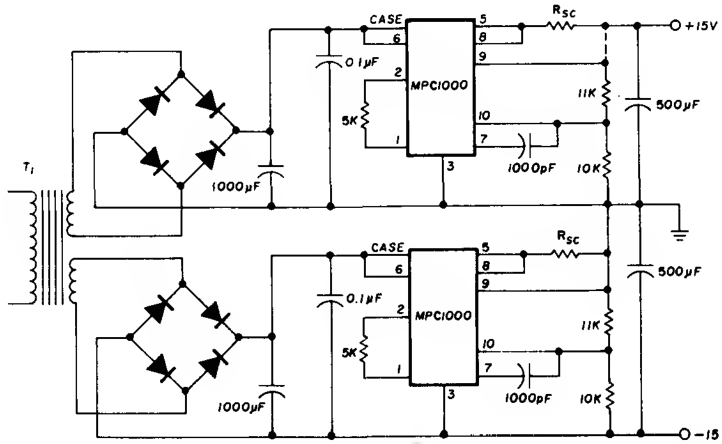
CR2	200-volt, 50-watt zener diode (heatsink to chassis)
Q1	Motorola HEP244 or MJE340 (heatsink to chassis)
Q2	Motorola HEP707 or MJ413 (heatsink to chassis)
T1	0-132 volt, 2.25 A (0.3 VA) variable auto-transformer (Superior Electric 10B)
T2	550 volts center-tapped, 110 mA (Triad R112A or R12A, filament windings not used)
T3	20 volts center-tapped, 100 mA (Triad F90X)

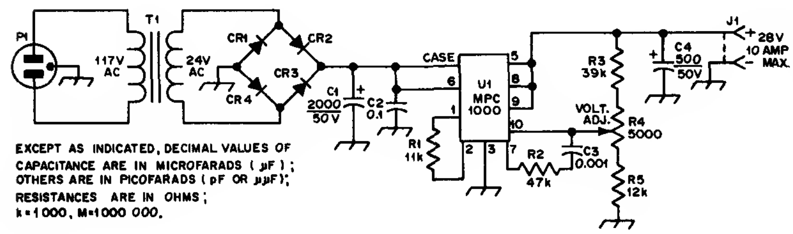
50–300 V VARIABLE AT 100 mA—Solid-state version of regulated high-voltage supply for tube circuit has adjustable current-limiting, instant turn-on, and long component life. Small variable autotransformer in primary circuit of high-voltage transformer is mechanically ganged to DC voltage-control pot connected to pin 8 of U1 to keep input-to-output voltage difference nearly constant. Differential voltage across Q1 never exceeds 100 V so power dissipation of Q1 is only 5 W maximum. Regulator circuit is designed around Motorola MC1466L or MC1566L floating regulator powered by 25-V supply having no common connection to ground. Use 600-V rating for 0.33 μF from T3 to ground.—H. Olson, Regulated, Variable Solid-State High-Voltage Power Supply, *Ham Radio*, Jan. 1975, p 40–44.



−20 V FOR VARACTORS—Precision low-ripple bias supply for varactor tuning applications can provide up to 20-mA output current.—M. A. Chapman, Multiple Band Master Frequency Oscillator, *Ham Radio*, Nov. 1975, p 50–55.

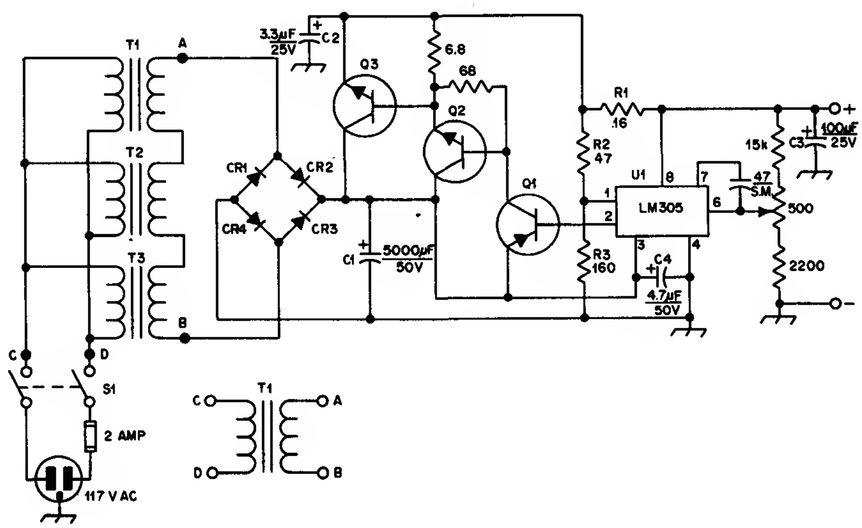
±15 V AT 10 A—Uses two Motorola positive voltage regulators, each having separate 18–24 VRMS secondary winding on power transformer T_1. Current-limiting resistor R_{SC} is in range of 0.66 to 0.066 ohm. Use copper wire about 50% longer than calculated length and shorten step by step until required pass current is obtained; thus, start with 25 ft of No. 16, 15 ft of No. 18, 10 ft of No. 20, or 6 ft of No. 22.—G. L. Tetar, The MPC1000—Super Regulator, *Ham Radio*, Sept. 1978, p 52–54.

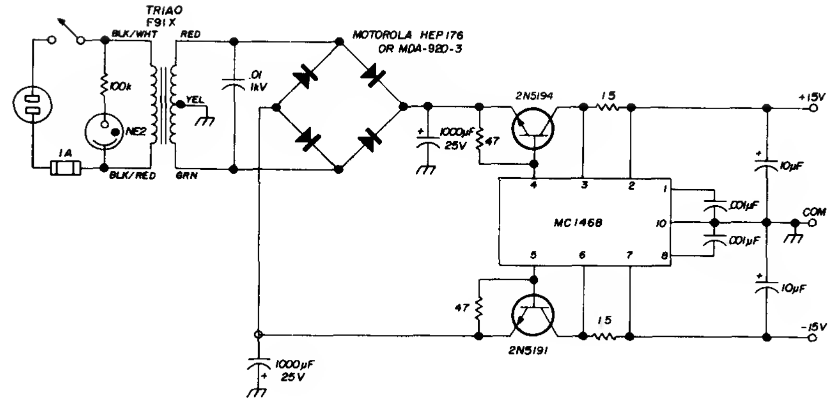




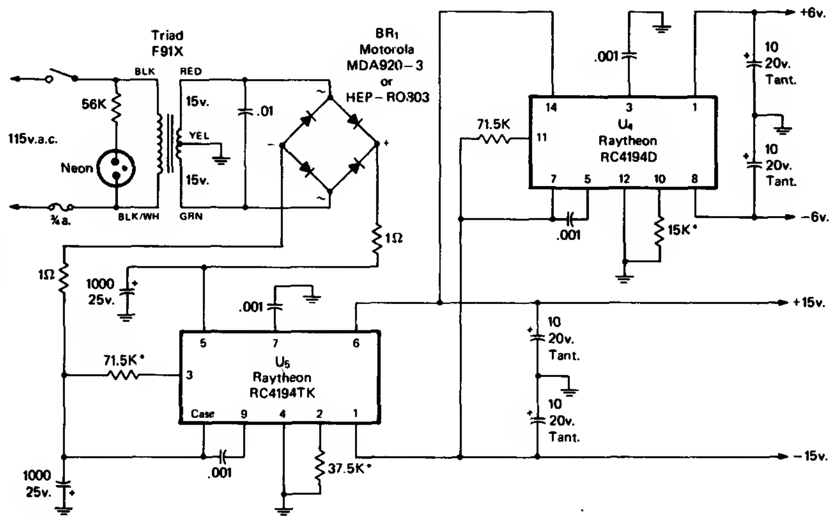
28 V AT 10 A—Developed for 60-W UHF linear amplifier. C1 and C4 are computer-grade electrolytics. CR1-CR4 are Motorola 1N3209 100-PIV 10-A silicon diodes. U1 is Motorola MPC100 or equivalent voltage regulator mounted on heatsink. T1 is Stancor P-8619 or equivalent 24-V 8-A transformer.—J. Buscemi, A 60-Watt Solid-State UHF Linear Amplifier, *QST*, July 1977, p 42–45.

12 V AT 10 A FOR HOUSE—Power supply is more than adequate for handling 12-V FM transceiver and even small amplifier. Series combination of three 8.3-V 10-A filament transformers drives 12-A 50-PIV bridge rectifier supplying 18 VDC to National LM305 regulator and pass transistors. Output voltage is at least 4 V less. Circuit provides foldback-current limiting for protection against load shorts. 500-ohm pot varies output from 11.2 to 14.1 V. Q1 is 2N2905, Q2 is 2N3445, and Q3 is 2N3772. T1-T3 are 8.3 V at 10 A (Essex Stancor P-6464 or equivalent).—C. Carroll, That's a Big 12 Volts, *QST*, Aug. 1978, p 26–27.

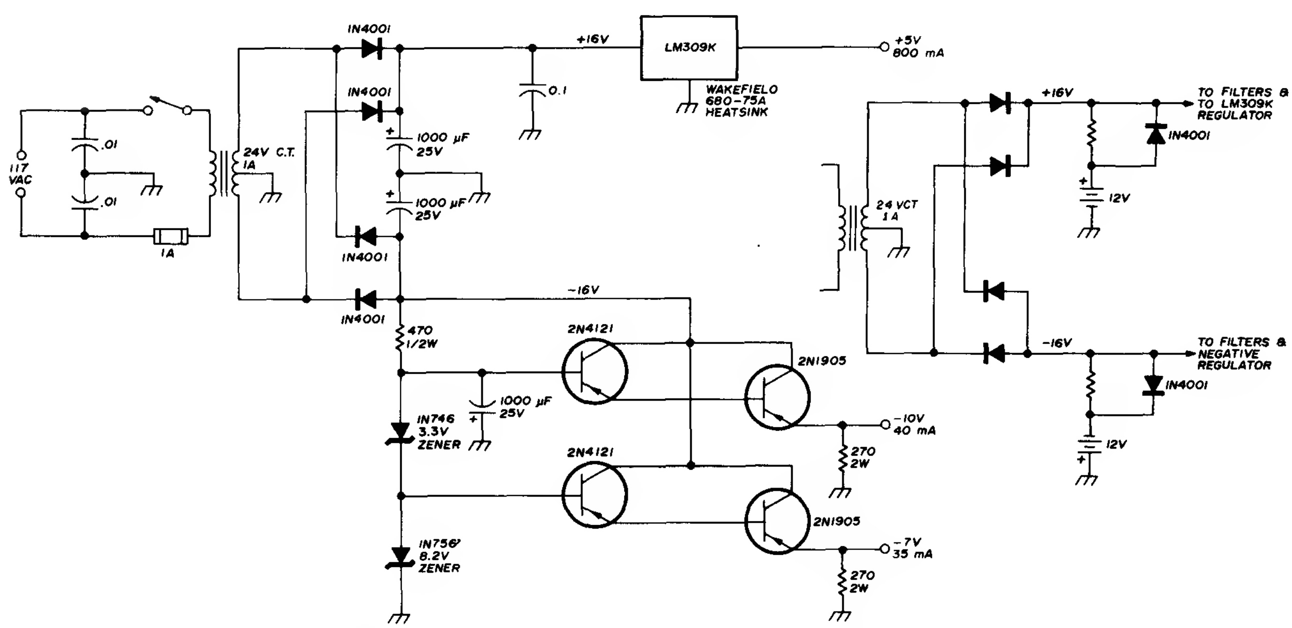




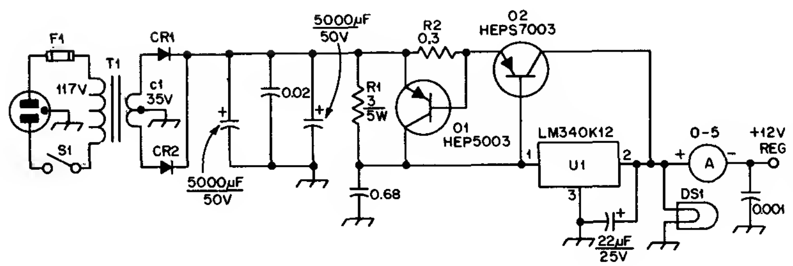
±15 V TRACKING—Uses Motorola dual-polarity regulator to provide balanced positive and negative voltages, with series-pass transistor handling major part of output current. Developed for use with audio signal generator.—H. Olson, Integrated-Circuit Audio Oscillator, *Ham Radio*, Feb. 1973, p 50–54.



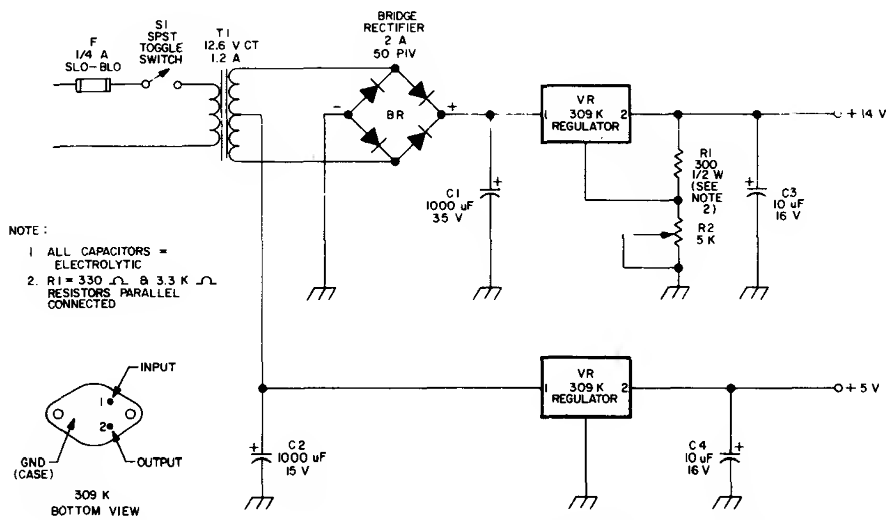
±6 V AND ±15 V—Developed for use with wide-range function generator requiring these voltages for transistors and ICs. Voltage-setting 15K and 37.5K resistors are adjusted to give desired output voltages.—H. Olson, The Function Generator, *CQ*, July 1975, p 26–28 and 71–72.



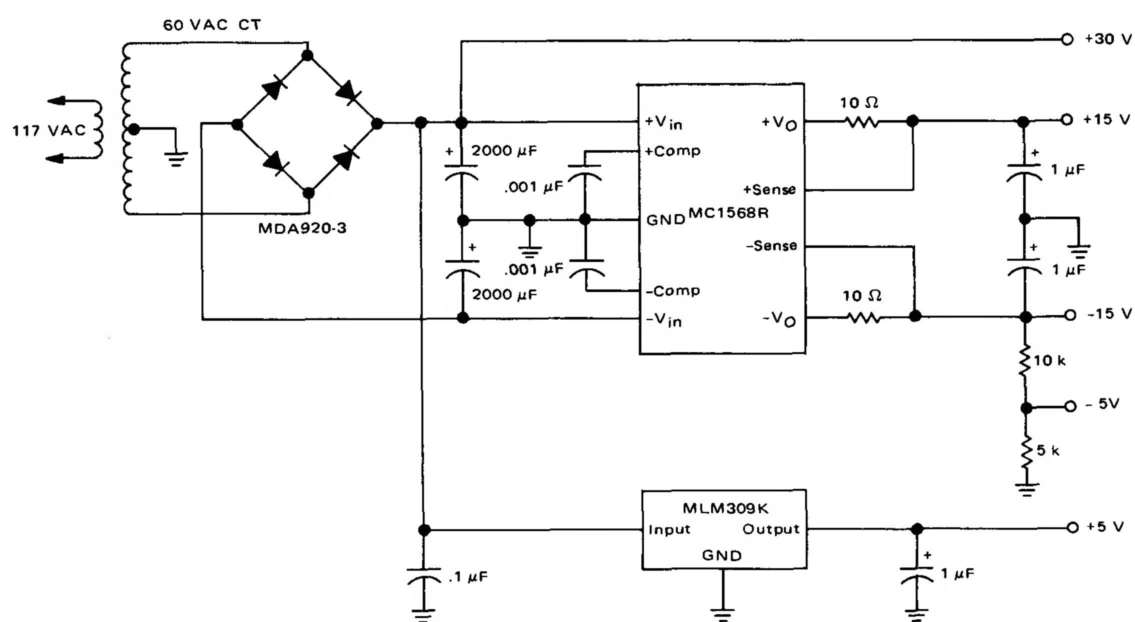
+5, −7, AND −10 V—Developed to meet power requirements of RTTY message generator having TTL and Numitrons requiring +5 V and MOS RAM requiring negative voltages. Diagram shows how to add 12-V storage batteries to prevent loss of programming if AC power fails momentarily.—B. Kelley, Random Access Memory RTTY Message Generator, *Ham Radio*, Jan. 1975, p 8–15.



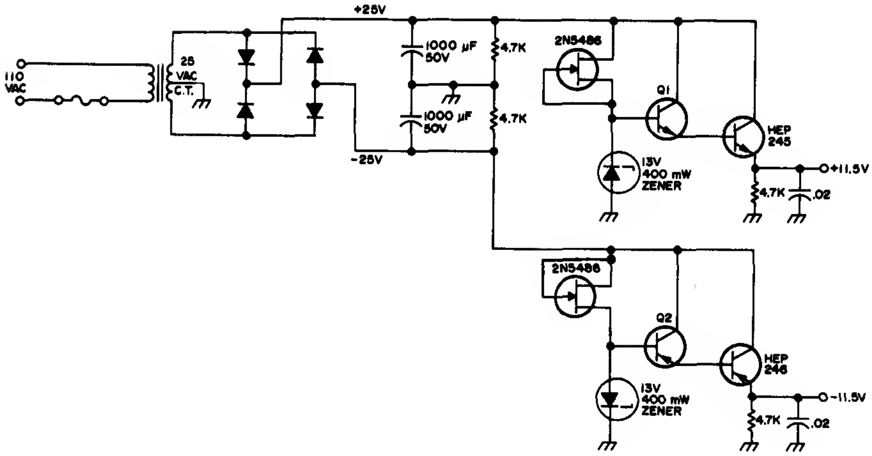
12 V AT 5 A—Uses National LM340K-12 mounted on external heatsink, with series-pass transistor Q2 boosting current rating to 5 A. Provides complete protection from load shorts; output drops suddenly to nearly zero when current exceeds 5 A. R2 is several feet of No. 22 enamal wound on phenolic form to maka 0.3-ohm 60-W resistor. CR1 end CR2 ara HEP R0103 or aquivelent. Transformer is reted 18 V at 8 A.—C. R. Watts, A Crowber-Proof 12-V Power Supply, *QST*, Aug. 1977, p 36–37.



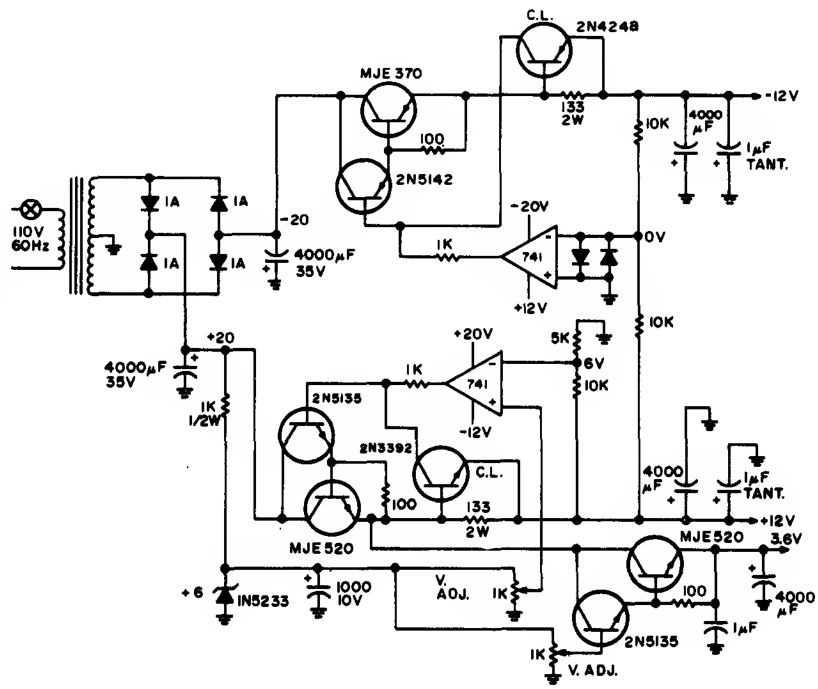
5 AND 14 V AT 1 A—Regulated duel-voltage powar supply servas for expariimenting with TTL, CMOS, end linear IC projects. Higher-voltege regulator must be insuleted from heetsink.—A. Lorone, Duel Voltage Powar Supply, *73 Magazine*, Holidey issue 1976, p 146–147.



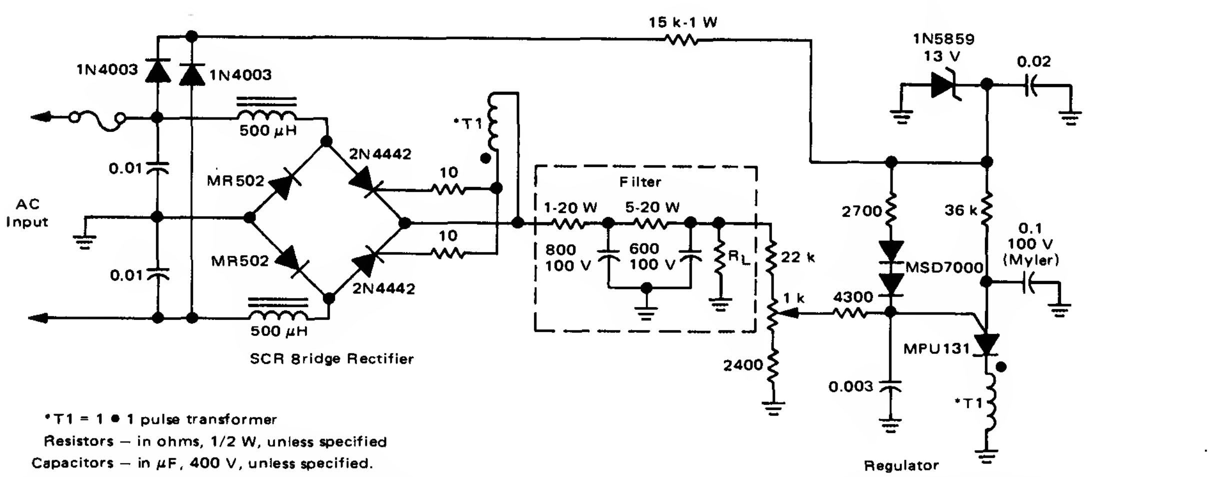
±5, ±15, AND +30 V—Provides all voltagas needed for digitally controlled power supply that has voltage ranga from 0 to 25.5 V in 0.1-V incraments. Highest positive voltage of +30 V is well above maximum output voltege that can be programmed.—D. Aldridge end N. Wallanstein, "Designing Digitally-Controllad Power Supplies," Motorola, Phoanix, AZ, 1975, AN-703, p 4.



±11.5 V—Developed for experimentation with IC audio amplifiers, delivering up to 5 W, where good regulation is required to prevent oscillation caused by feedback through power supply to input stage. Q1 and Q2 are inexpensive silicon transistors, serving also as low-cost fuses because they burn out first when power supply is overloaded. Use heatsinks with silicone grease for output transistors.—D. J. Kenney, Integrated Circuit Audio Amplifiers, *73 Magazine*, Feb. 1974, p 25–30.

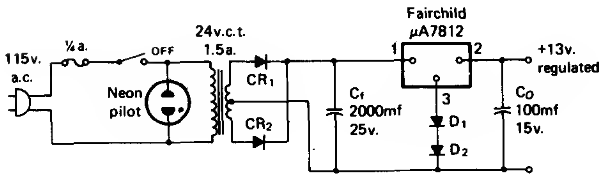


±0 TO 15 V AT 200 mA AND 3.8 TO 5 V AT 2 A—Developed for use with slow-scan television. Design provides equal positive and negative voltages that track each other with one manual control, adjustable from 0 to 15 V for opamps. Current limiting is provided for both positive and negative outputs. Low digital voltage can be adjusted to 3.8 V for RTL or 5 V for TTL, without current limiting. Use transformer having 35-V secondary, center-tapped, rated at 3 A.—D. Miller and R. Taggart, Popular SSTV Circuits, *73 Magazine*, March 1973, p 55–60, 62, and 64–67.



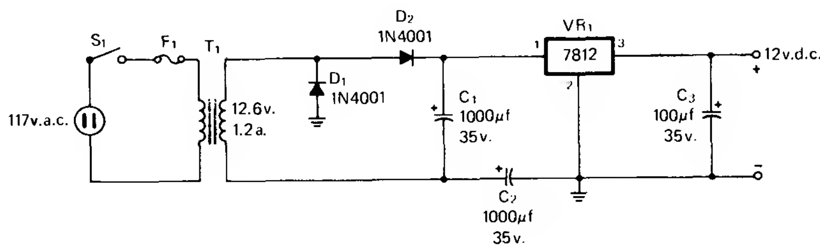
*T1 = 1 • 1 pulse transformer
Resistors — in ohms, 1/2 W, unless specified
Capacitors — in μF, 400 V, unless specified.

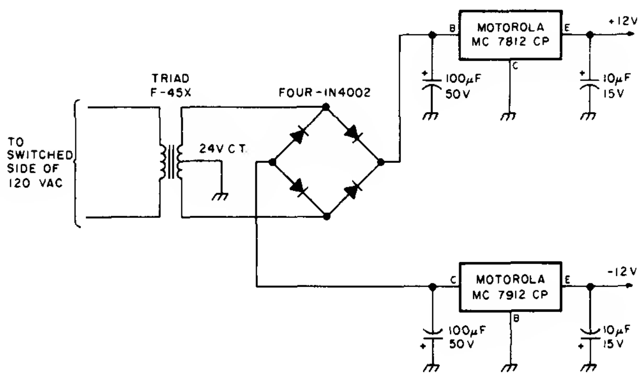
60 V AT 1.5 A FOR COLOR TV—Holds output voltage across R_L within 2% over line-voltage range of 105 to 140 V. Designed for use in 19-inch color TV receiver having 700-V flyback horizontal system. Bridge rectifier has two 2N4442 SCRs that control amount of output voltage by using variable duty cycle. Regulator uses MPU131 programmable UJT, which also serves for gating SCRs. 1K pot provides control of PUT gate voltage, which in turn determines output voltage across R_L.—R. J. Valantine, "A Low-Cost 60 V–1.5 A Color TV Power Supply," Motorola, Phoenix, AZ, 1974, AN-725, p 2.



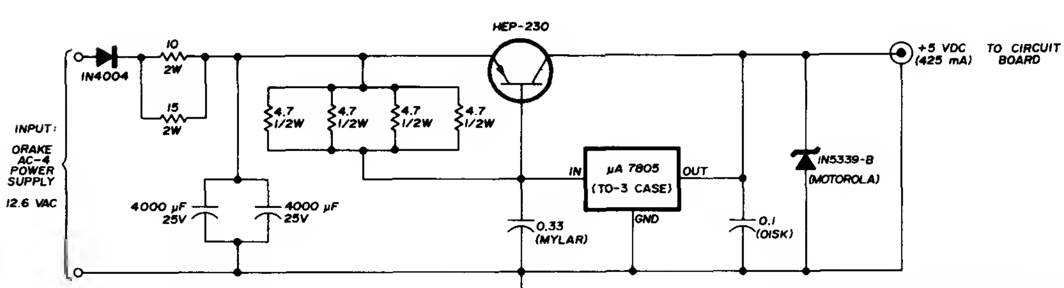
+13 V AT 1 A—Regulated output voltage can be varied upward about 0.6 V per diode by placing silicon diodes between pin 3 and ground. Two diodes boost output of regulator from 11.9 V to about 13 V. Insulate regulator from heatsink with mica washers. CR_1 and CR_2 are 50-PIV 3-A diodes. Motorola equivalent of regulator is MC7812.—A. M. Clerke, Simple, Superregulated, 12 Volt Supply, *CQ*, April 1974, p 61–62.

12 V AT 1 A—Simple supply furnishes up to 1 A with excellent regulation. Bottom of chassis can be used for heatsink. Connect additional 0.1-µF capacitor between pin 1 of VR_1 and ground. T_1 is Radio Shack 273-1505 with 12.6-V CT 1.2-A secondary, and F_1 is 0.5-A fuse.—A. Pike, Radio Shack Power Supply, *CQ*, Sept. 1977, p 66.

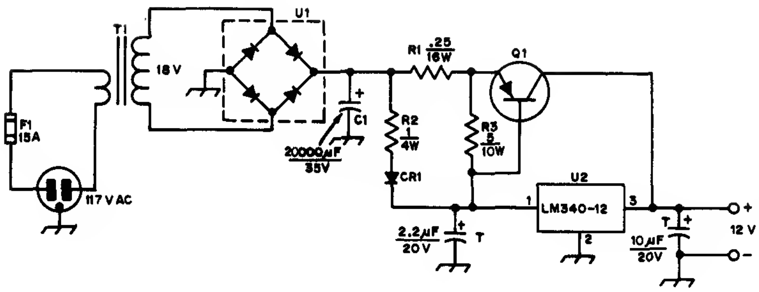




±12 V—Simple circuit provides power required for two 741 opamps used in CRT tuning indicator circuit for RTTY receiver.—R. R. Parry, RTTY CRT Tuning Indicator, *73 Magazine*, Sept. 1977, p 118–120.

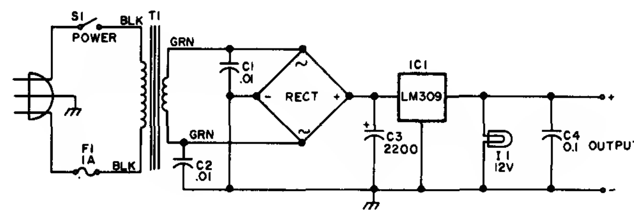


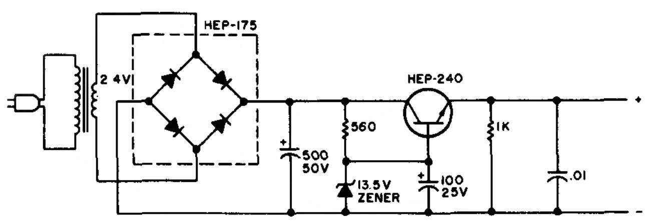
+5 V AT 425 mA—Developed for syllabic VOX system used with Drake T-4XB and R-4B transmitter and receiver. Input is taken from 12.6-VAC transformer winding of power supply for Drake, so equipment power switch also turns off 5-V supply.—R. W. Hitchcock, Syllabic VOX System for Drake Equipment, *Ham Radio*, Aug. 1976, p 24–29.



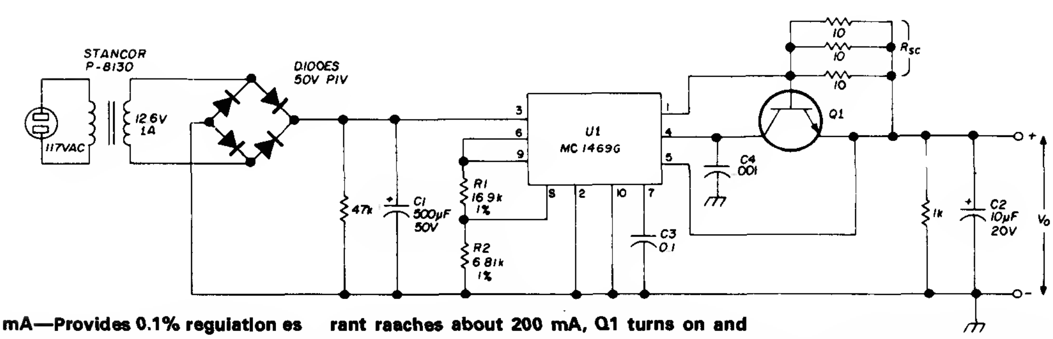
12 V AT 10 A—Permits AC operation of 12-V FM transceiver. Article tells how to rewind 12-V TV power transformer rated above 120 W with No. 12 enamel to get required 18-V secondary. If original winding has 2 turns per volt, new secondary will need 36 turns. Q1 is HEP233, HEP237, or similar transistor rated 10 A or higher, with heatsink. U1 is 25-A 100-PIV bridge rectifier, and U2 is National LM340K-12 regulator. CR1 can be any rectifier rated at least 3 A at 35 V.—L. McCoy, The Ugly Duckling, *QST,* Nov. 1976, p 29–31.

5 V AT 1 A—Simple lab supply provides voltage required for digital ICs. Rectifier is 6-A 50-PIV bridge. Power transformer has 12.6-V secondary rated 1 A, such as filament transformer.—G. McClellan, Give That Professional Look to Your Home Brew Equipment, *73 Magazine,* Feb. 1977, p 28–31.

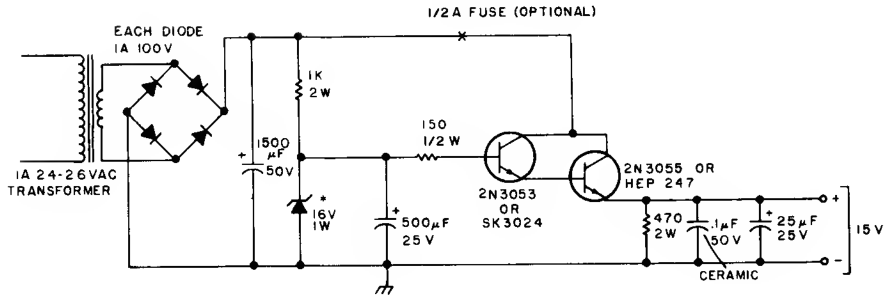




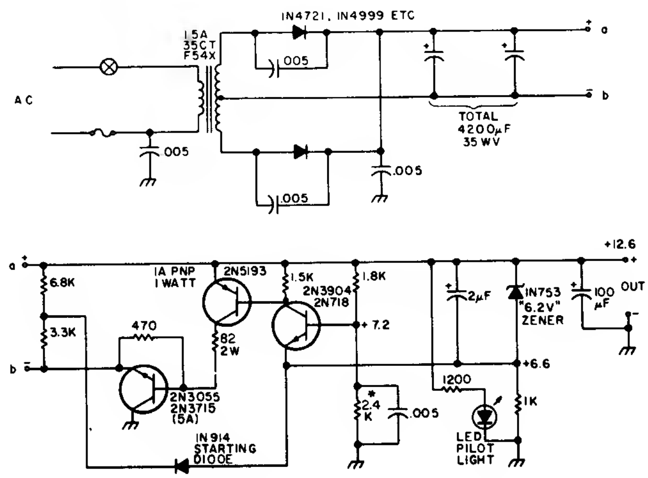
12 V FOR TRANSCEIVER—Output voltage varies only 0.2 V between transmit and receive. Transistor can be mounted directly on side of metal minibox for heatsinking. Transformer secondary is 24 V at 5 A.—Circuits, *73 Magazine,* March 1977, p 152.



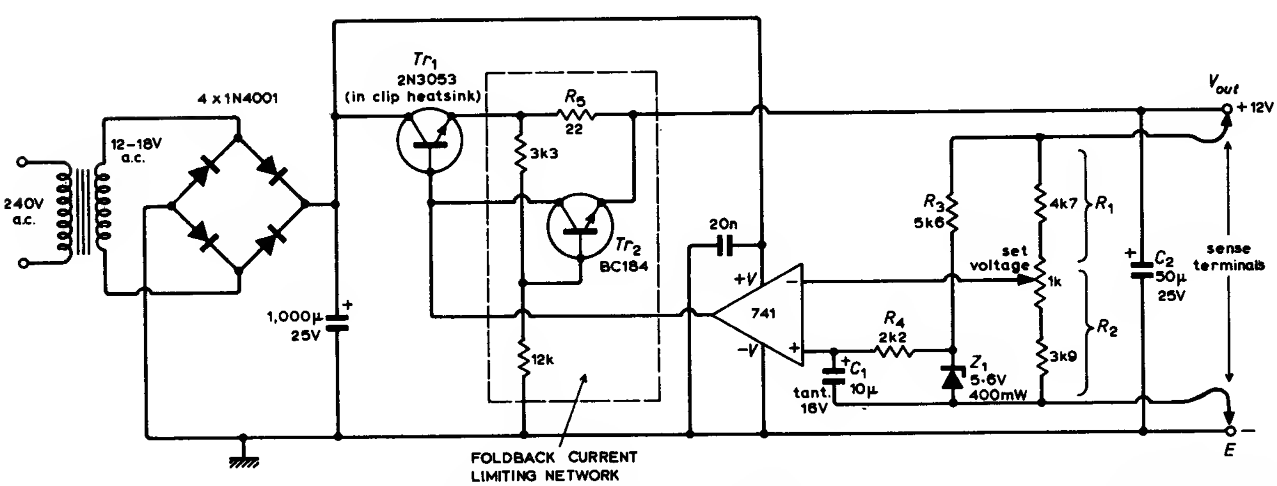
+12 V AT 50 mA—Provides 0.1% regulation as required for PLL RTTY tuning unit and other critical applications. R_{SC} and Q1 provide short-circuit protection for regulator. When output current reaches about 200 mA, Q1 turns on and limits regulator output. U1 can be Motorola MC1469G or HEP C6049G, and Q1 is any general-purpose NPN silicon transistor.—E. Lawrence, Precision Voltage Supply for Phase-Locked Terminal Unit, *Ham Radio,* July 1974, p 60–61.



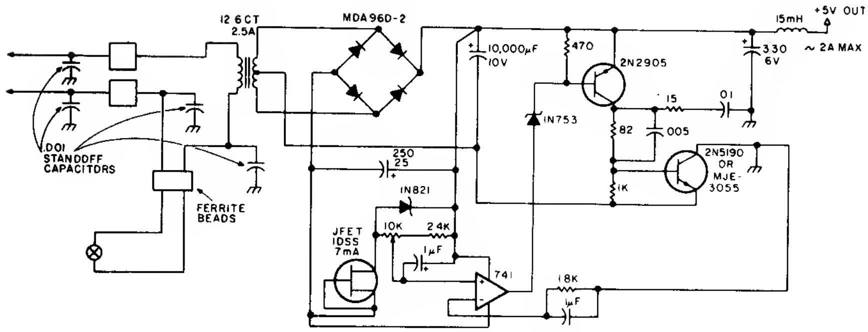
15 V AT 600 mA—Developed for 2-meter FM transceiver used as repeater. Output voltage is well filtered. Regulator allows voltage to drop only 0.1 V when repeater goes from standby to transmit. Use heatsink on 2N3055 series-regulator transistor.—H. Cone, The Minirepeater, *73 Magazine*, June 1975, p 55–57, 60–62, and 64–65.



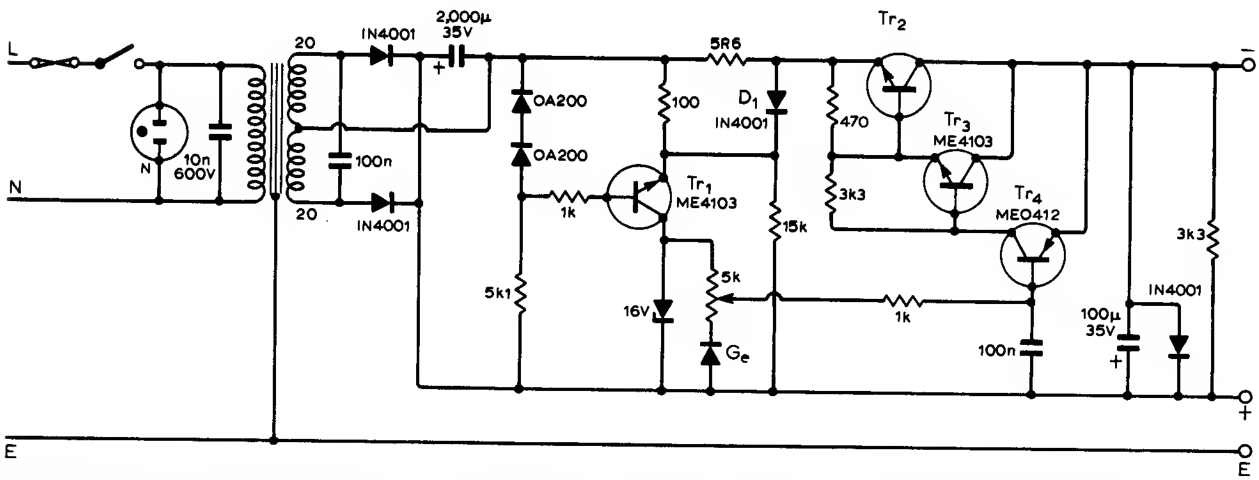
12.6 V AT 3 A—Will handle typical 15-W 2-m transceiver. Short-circuit protection is provided by 82-ohm resistor. Adjust value of resistor marked 2.4K to give desired output voltage. Transformer secondary is nominally 35 V center-tapped at 1.5 A. Output capacitor can be tantalum-slug electrolytic with any value above 10 μF.—H. H. Cross, The Chintzy 12, *73 Magazine*, Feb. 1977, p 40–41.



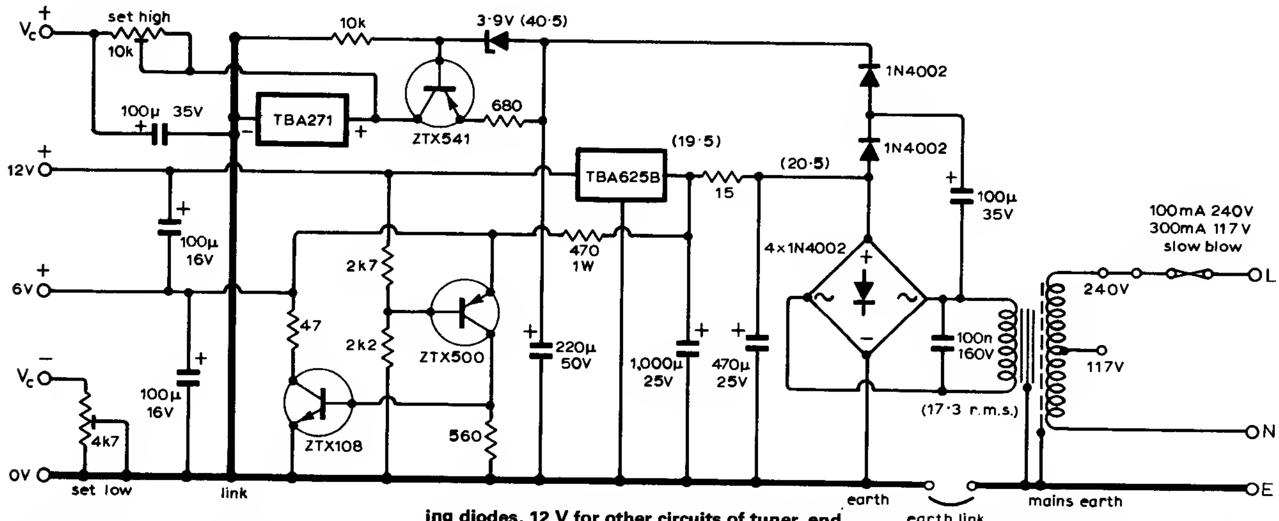
12 V AT 150 mA—Designed for use with audio preamps, FM tuners, and stereo decoders for which minimum ripple, minimum noise, good regulation, and good temperature stability are important. Uses 5.6-V reference zener that is fed from output but is inside feedback loop. Unregulated input can be up to 36 V.—M. L. Oldfield, Regulated Power Supplies, *Wireless World*, Nov. 1972, p 520–521.



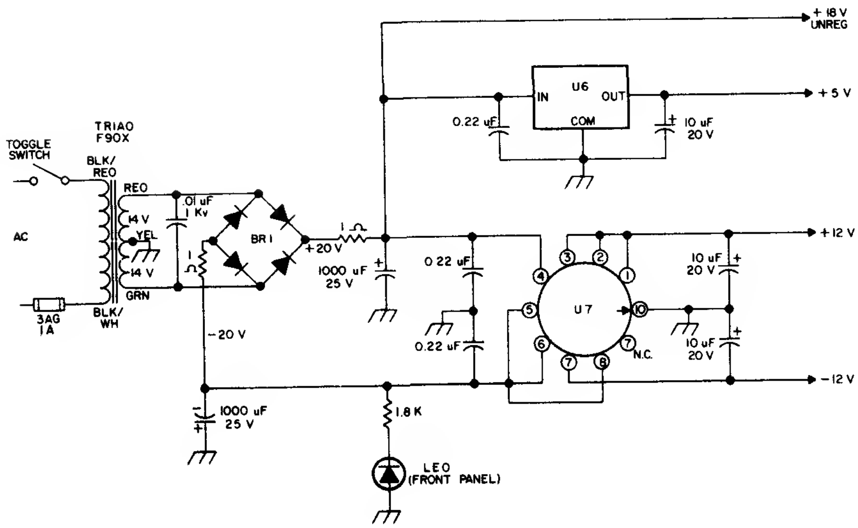
5 V AT 2 A—Developed as supply for receiver frequency counter having LED display. FET having I_{DSS} of about 7.5 mA serves in place of 1200-ohm resistor as current regulator. Power transformer is Triad F-26X with secondary rated 12.6 V center-tapped at 2.5 A.—H. H. Cross, The Chintzy 12, *73 Magazine*, Feb. 1977, p 40–41.



0–15 V BENCH SUPPLY—Provides up to 175 mA with ripple less than 1 mV. Choose Tr_2 to handle load current. Current limiting is provided by 5.6-ohm (5R6) resistor and D_1; when resistor drop exceeds about 1.2 V, current source Tr_1 produces less current and output voltage is reduced.—J. A. Roberts, Bench Power Supply, *Wireless World*, May 1973, p 253.

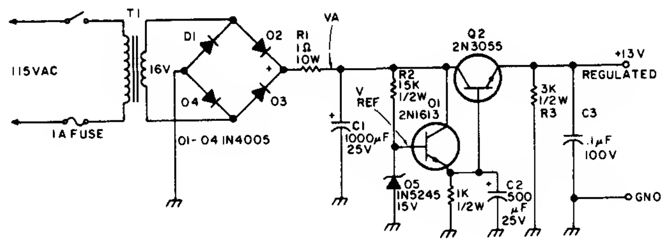


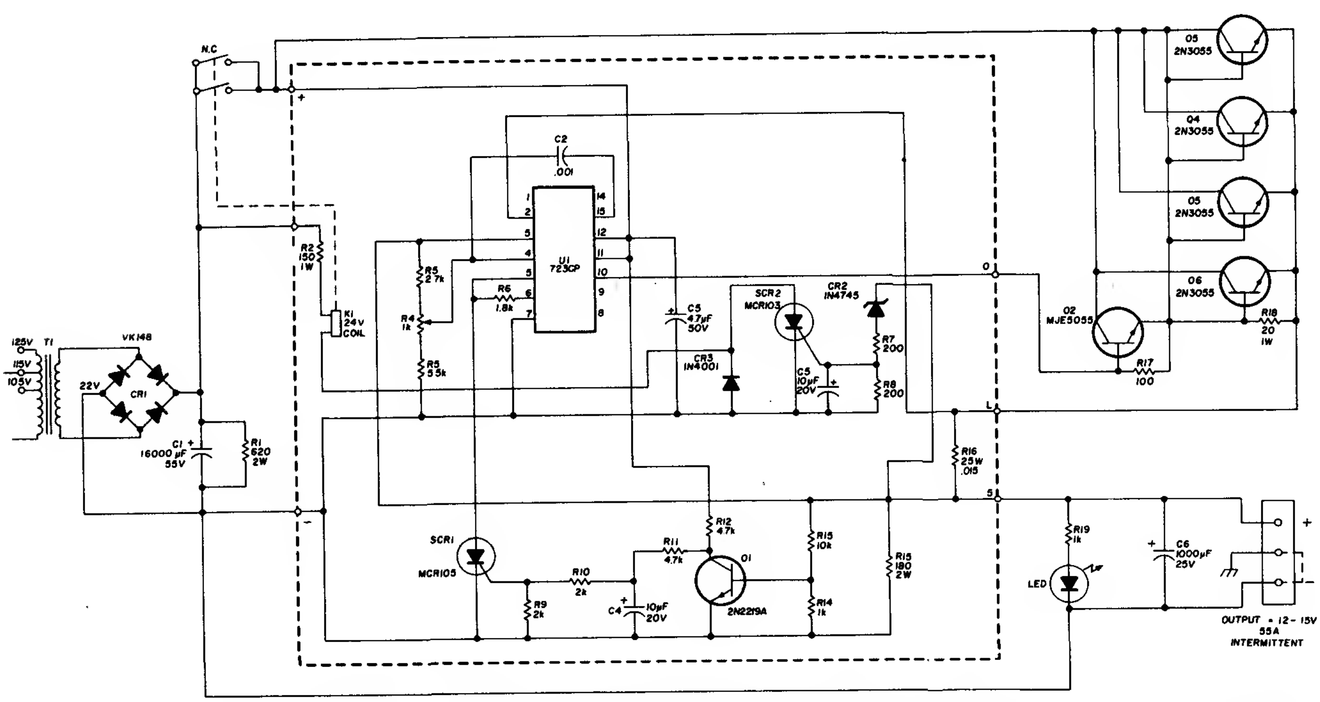
6, 12, AND 30 V FOR FM TUNER—Provides regulated 30 V for voltage-controlled varicap tuning diodes, 12 V for other circuits of tuner, and optional 6 V for stereo decoder. Uses SGS IC regulators.—L. Nelson-Jones, F.M. Tuner Design—Two Years Later, *Wireless World*, June 1973, p 271–275.



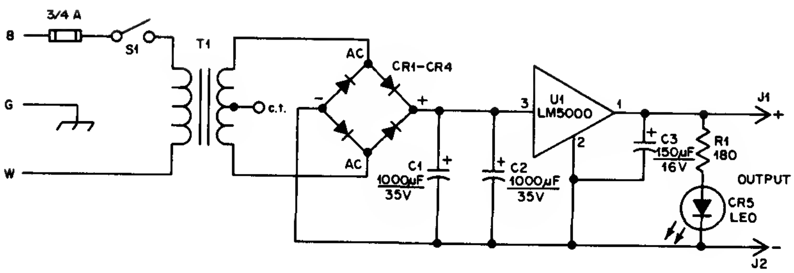
5 V AND ±12 V—Also provides 18 V unregulated for use with code regenerator driving automatic Morse-code printer. BR1 is Motorola MDA920-3 or HEP-R0802 bridge. LED is HP5082-4882 or HEP-P2000. U6 is LM341-5, MC7805, or HEP-C6110P. U7 is LM326H with TO5 finned clip-on heatsink.—H. Olson, CW Regenerator/ Processor, *73 Magazine*, July 1976, p 80–82.

13 V AT 2 A WITH NPN TRANSISTORS—Q1 is reference voltage source and Q2 is series-pass regulator for basic supply suitable for running mobile FM transceiver or other 12-V portable equipment in home. Transformer secondary is 16–19 V, or can be 6-V and 12-V filament transformers in series. R1 protects rectifier diodes from surge current generated when supply is turned on. Article tells how to adapt circuit for other output voltages.—R. B. Joerger, Power Supply, *73 Magazine*, Holiday issue 1976, p 40–41.



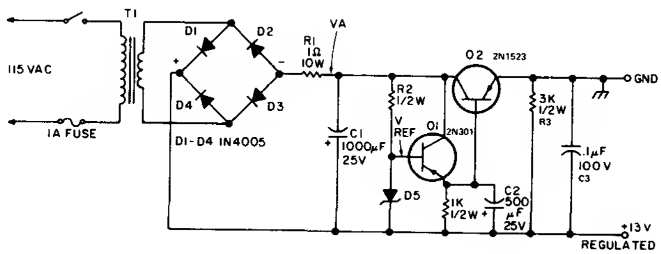


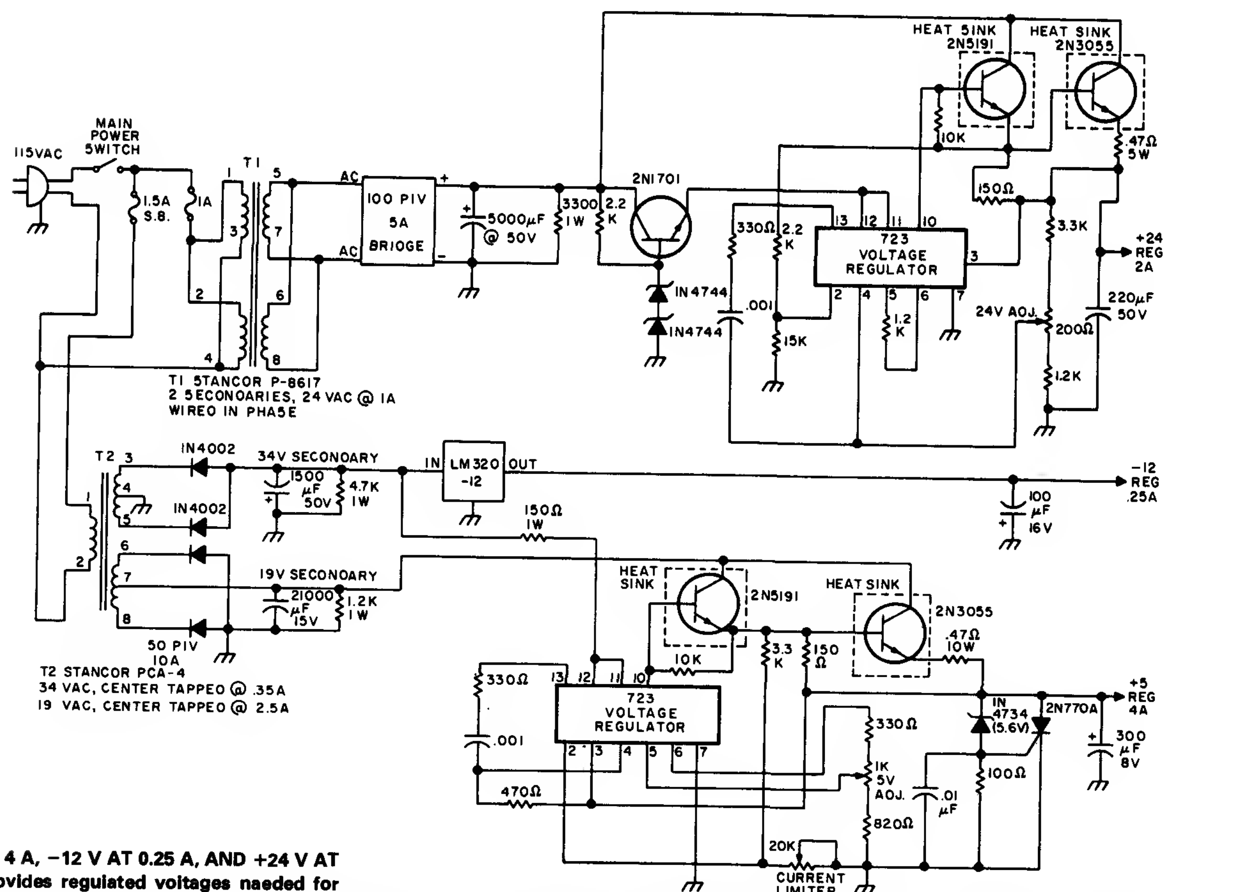
12–15 V AT 500 W—Developed to permit operation of high-power mobile solid-state amateur transmitter in home. Current sensing is done with 15-milliohm resistor R16. Short-circuit cutoff is provided by regulator along with current limiting through R16. Output voltage begins dropping as load exceeds 35 A. When voltage drops below 8 V, Q1 turns off and SCR1 turns on, cutting output power. Power supply must be turned off to unlatch SCR1. For overvoltage shutdown, CR2 starts conducting above 16 V, turning on SCR2 and activating relay K1 to cut off main DC supply. Article gives construction details. T1 has 22-V secondary.—C. C. Lo, 500-Watt Regulated Power Supply, *Ham Radio*, Dec. 1977, p 30–32.



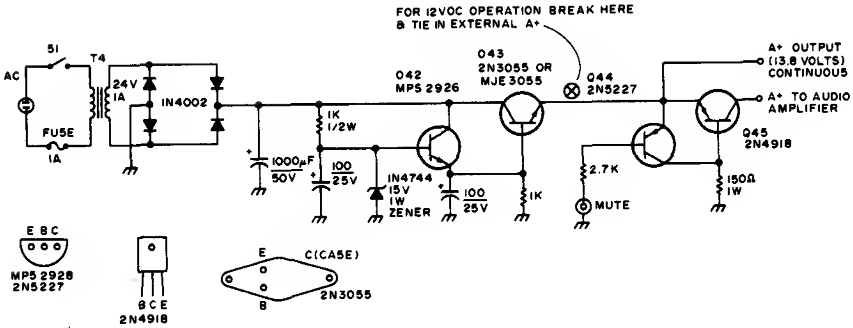
5 V AT 3 A—National LM5000 voltage regulator having built-in overload protection is basis of small bench supply for TTL work. Filament transformer rated 12.6 V at 3 A feeds full-wave bridge rectifier rated 200 PIV at 6 A, such as Radio Shack 276-1172. U1 requires heatsink insulated from chassis. Output filter C3 should be mounted directly on regulator terminals to minimize circuit oscillation. Output should read within 100 mV of 5 V. Radio Shack 276-047 LED serves as output indicator. Use 0.22-µF bypass between pins 2 and 3 of U1.—K. Powell, The 5 × 3 Power Supply, *QST*, May 1977, p 25–26.

13 V AT 2 A WITH PNP TRANSISTORS—Reference voltage source Q1 is 2N301, while series-pass regulator Q2 is 2N1523. D5 is 1N5245 15-V zener. Secondary of T1 is 16–19 V, or can be 6-V and 12-V filament transformers in series. Article tells how to adapt circuit for other output voltages.—R. B. Joerger, Power Supply, *73 Magazine*, Holiday issue 1976, p 40–41.

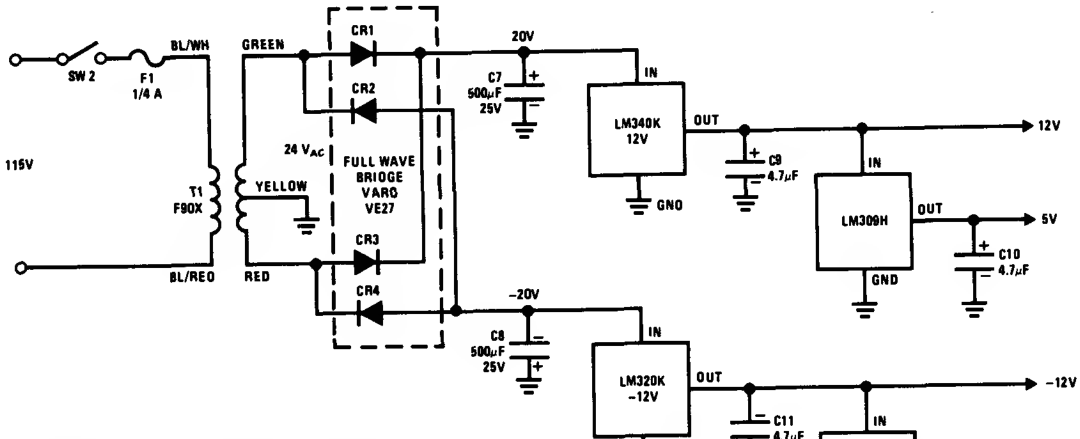




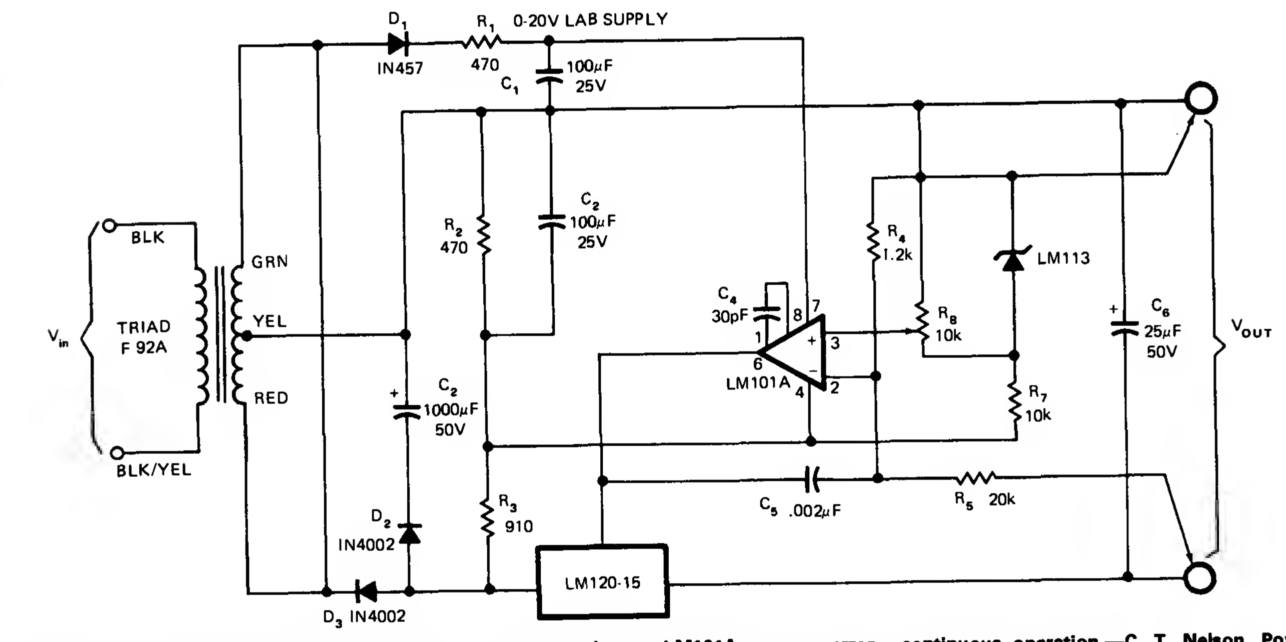
+5 V AT 4 A, −12 V AT 0.25 A, AND +24 V AT 2 A—Provides regulated voltages needed for Sykes 7158 floppy disk and its interface controller, used in Southwest Technical Products MP-68 computer system. Circuit provides adjustable current limiting and overvoltage protection on 5-V supply. Output voltage adjustments are provided for 5-V and 24-V supplies.—P. Hughes, Interfacing the Sykes OEM Floppy Disk Kit to a Personal Computer, *BYTE*, March 1978, p 178–185.



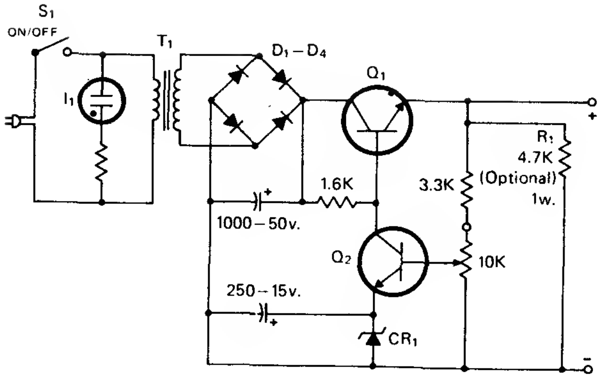
13.6 V AT 1 A—Used in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. Simple transformer-rectifier-filter circuit is followed by zener-referenced Darlington pair. When transmitter of amateur station is on air, muting is accomplished by grounding base of Q44 through 2.7K resistor, which turns off Q45 and kills A+ to audio amplifier.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine,* Jan. 1975, p 105–112.



±5 V AND ±12 V—Four different National voltage regulators provide voltages required for wide-range function generator. Power transformer is Triad F90X.—R. C. Dobkin, "Wide Range Function Generator," National Semiconductor, Santa Clara, CA, 1974, AN-115.

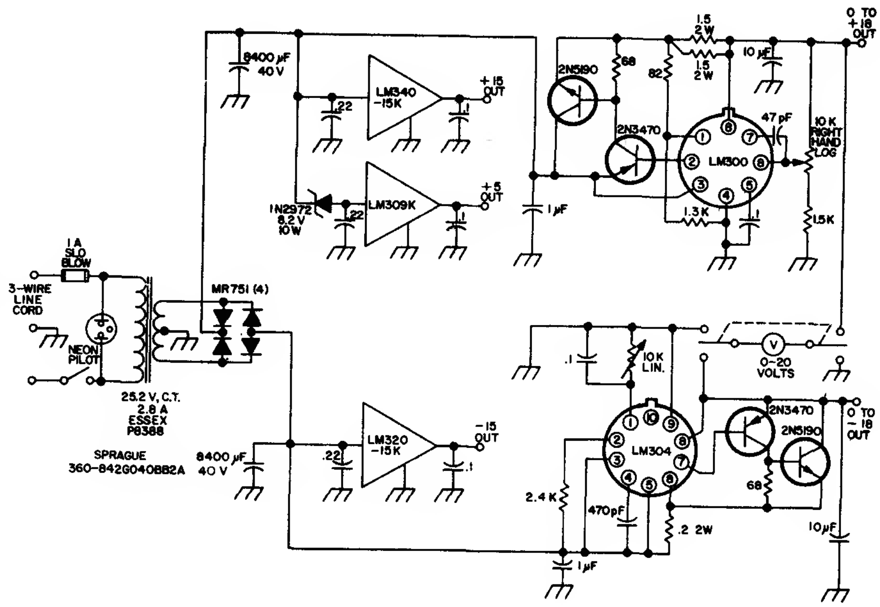


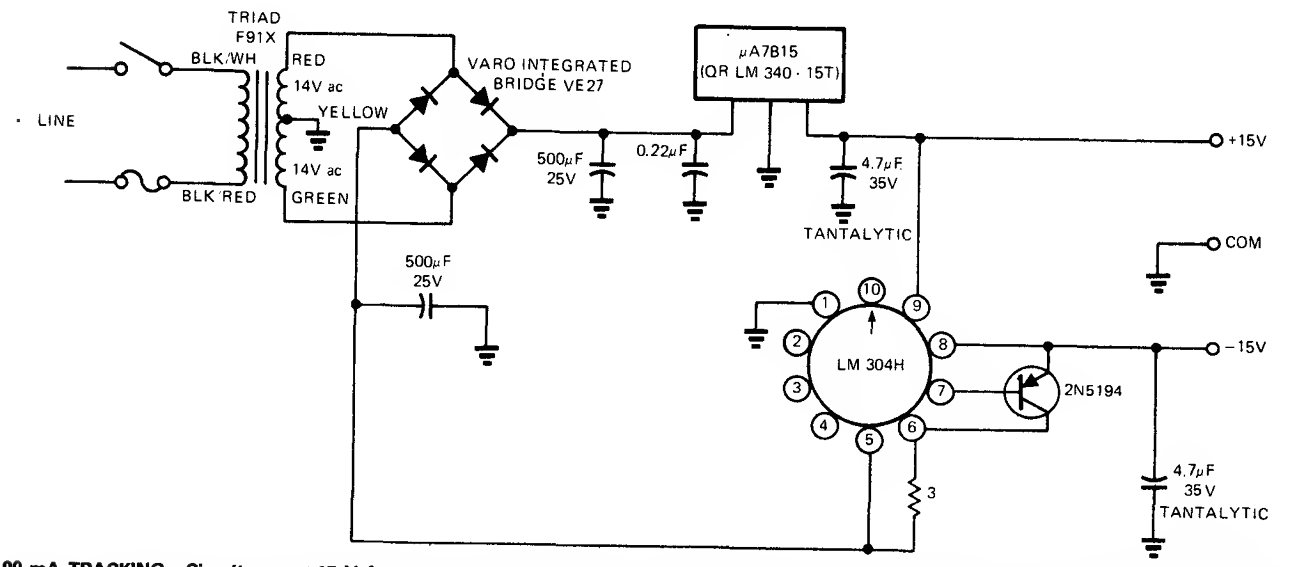
0–20 V AT 1 A—Variable-output regulated supply for lab use maintains output voltage within 2 mV of desired value for outputs up to 1 A. Arrangement uses National LM120 negative regulator as pass element, LM101A opamp as error amplifier, and LM113 zener as reference. Circuit provides complete protection against load shorts. LM120 requires adequate heatsink for continuous operation.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine,* Feb. 20, 1973, p 52–58.



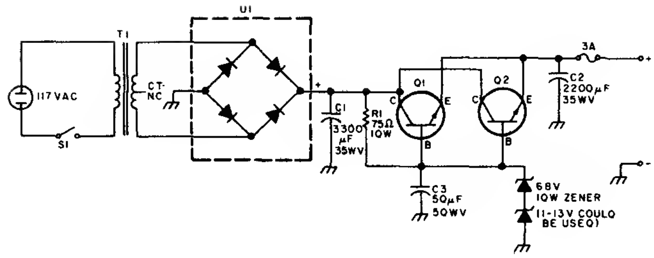
6–30 V AT 500 mA—Zener used for CR_1 should be rated 1 V less then desired minimum voltege, at 300 mW. R_1 improves regulation at low current levels. Current-limiting velue is ebout 1 A. Diodes ere 50-PIV 1-A silicon. I_1 is 117-V naon lemp. Q_1 is eny 15-W NPN power transistor. Q_2 is 2N697 or equivelant. T_1 is power trensformer with 24-V secondery at 0.5 A.—J. Huffman, The Li'l Zepper—e Versetile Low Voltage Supply, *CQ*, Nov. 1977, p 44.

UNIVERSAL SUPPLY—Provides three different fixad voltages end two verieble, each reguleted and each current-limitad at 1.5 A for use on experimentar's bench. Use heetsinks for fixad voltage reguletors end for output trensistors.—N. Calvin, Univarsel Power Supply, *73 Magazine*, Aug. 1974, p 65–66.

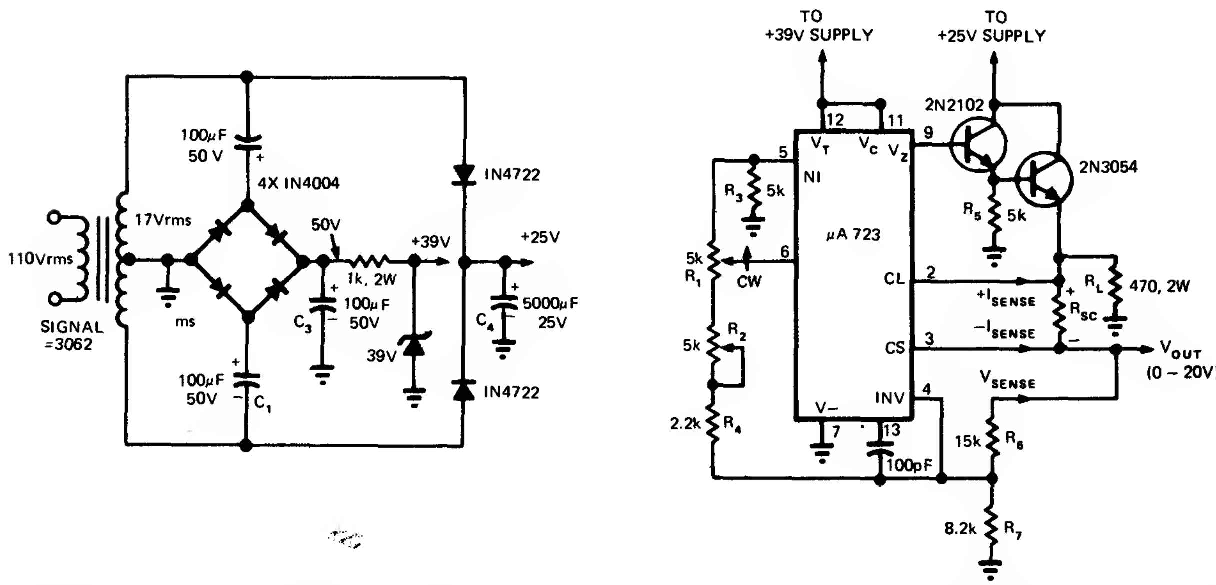




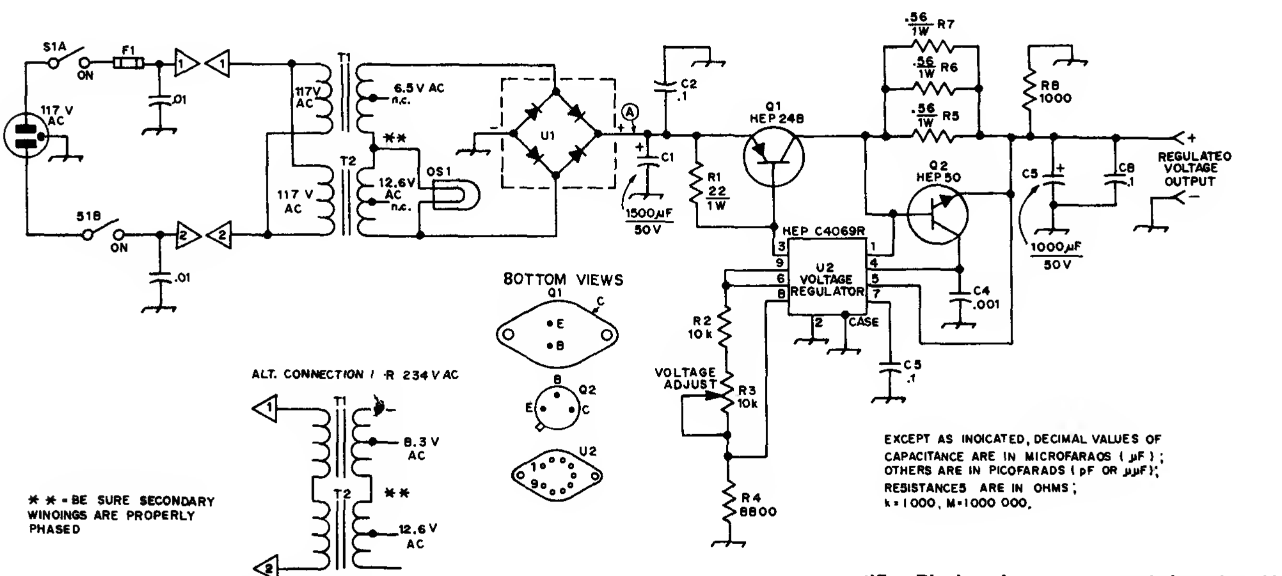
100-mA TRACKING—Circuit uses +15 V from μA7815 positive fixed-output regulator as externel reference for LM304 negetive regulator operating with outboard current-carrying PNP transistor. Arrangement requires only ona center-tepped transformer winding yet gives required tracking of volteges. Output can be boosted to 200 mA by using lerger bridge rectifier section.—H. Olson, Simple ±15V Regulated Supply Provides Tracking, *EDN Magazina*, March 20, 1973, p 87.



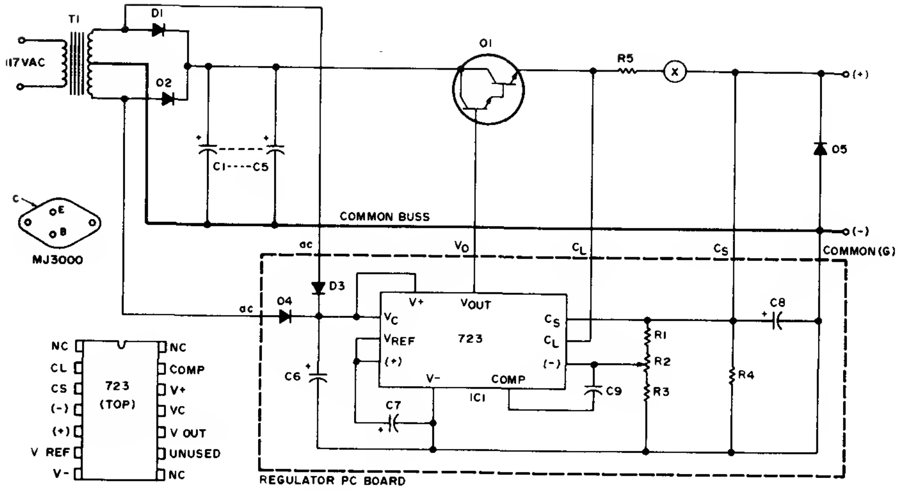
12 V AT 2.8 A—Simple supply was developed for use with 2-meter FM transceiver when operating in home. Power transistors are Radio Shack 276-592 rated 40 W. T1 is 12.6 V at 3 A, and U1 is 276-1171 rated 100 V at 6 A. Article covers construction.—M. L. Lovell, 12 Inexpensive Volts for Your Base Station, *73 Magazine*, Sept. 1976, p 60–62.



0–20 V CURRENT-LIMITING—Novel full-wave voltage doubler formed by diode bridge and C_1-C_2-C_3 provides 39 V required by µA723 regulator whose output is continuously variable with R_1. Initially, R_2 is adjusted for minimum output voltage when R_1 is maximum counterclockwise, to balance bridge R_1-R_2-R_3-R_4 when output voltage is zero. Value used for R_{SC} determines short-circuit current. Raw DC supply provides separate 25 V for pass transistors.—L. Drake, Variable Voltage Power Supply Uses Minimum Components, *EDN Magazine*, Aug. 5, 1974, p 80 and 82.

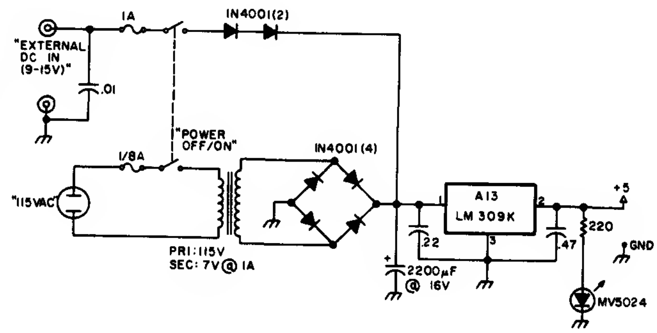


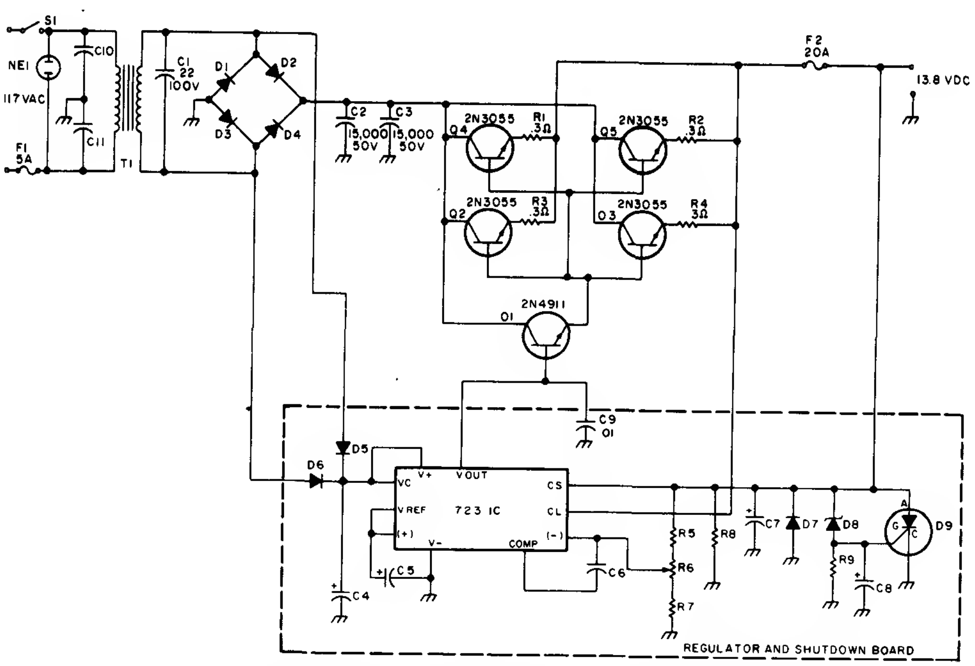
12 V AT 2 A—Will operate 10-W 220-MHz portable FM transceiver from AC line. Output voltage is adjustable from 9 to 13 V. DC voltage at point A is about 30 V. U1 is 50-V 10-A bridge rectifier. Ripple voltage on output is less than 30 mV P-P.—E. Kelin, A No-Junkbox Regulated Power Supply, *QST*, Jan. 1975, p 30–33.



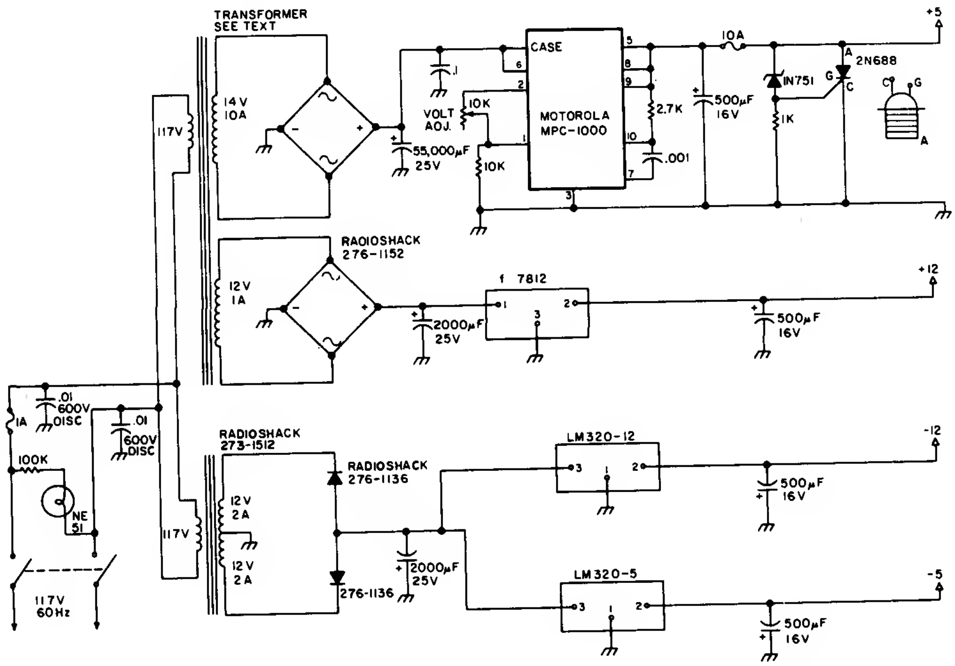
12 V AT 5 A—Uses MJ3000 Darlington power device as pass element providing gain of 1000 at 5 A. Output is set to current-limit at 6.5 A. Fuse at X is desirable. Values: R1 is 1.8K; R2 is 2.5K trimpot; R3 is 2.7K; R4 is 1.5K; R5 is 0.1 ohm at 5 W; C1-C5 are 4000 μF each at 20 V; C6 is 250 μF at 25 V; C7-C8 are 1.2 μF at 35 V; C9 is 220 pF; D1-D2 are MR1120 or equivalent rated 6 A; D3-D4 are 1N4607 or equivalent; D5 is 1N4002 or equivalent; and T1 is 24–28 V CT secondary at 4 A. Article gives design procedure for increasing regulated output to as much as 100 A.—C. Anderton, A Hefty 12 Volt Supply, *73 Magazine,* May 1975, p 85–87.

5 V FROM AC OR DC—Developed for use with secondary frequency standard to permit checking frequency of amateur radio transmitter at station or in field. Any battery capable of delivering 250 mA at 9–15 V is suitable.—T. Shankland, Build a Super Standard, *73 Magazine,* Oct. 1978, p 86–89.

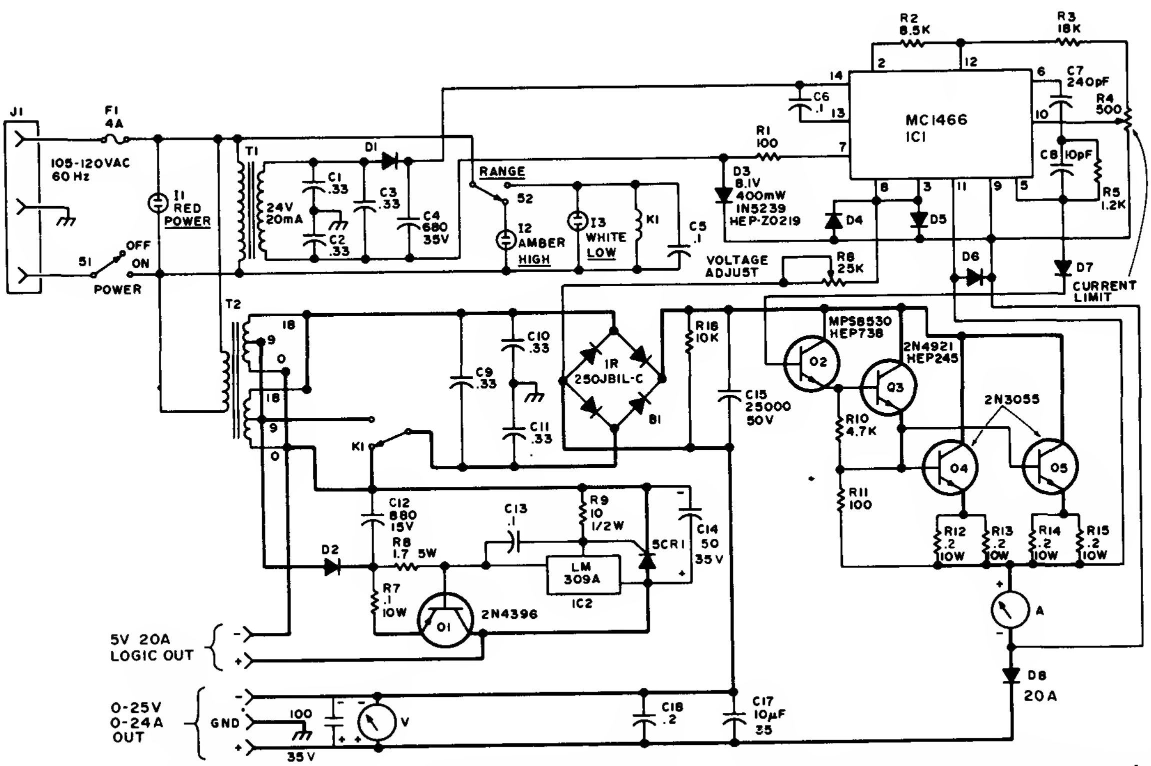




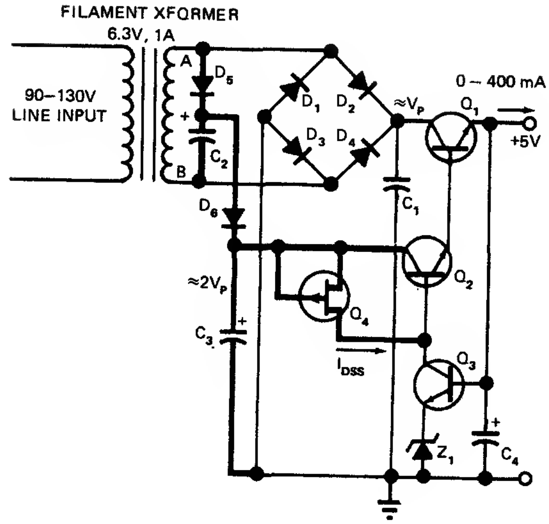
+13.8 VDC AT 18 A—Developed for use with amateur radio transceiver. Transformer secondary is rated 25 VAC at 12 A. When output voltage exceeds 15 VDC, zener D8 (1N985A or equivalent) conducts and fires 2N4441 SCR to crowbar supply and protect transceiver. Parts values are: R5 1.8K, R8 2.5K, R7 2.7K, R8 1.5K, R9 1K, C4 250 μF, C5-C6 1.2 μF, C7 220 pF, C8 100 μF, C9-C11 0.01 μF, D1-D4 1N3492 or equivalent with 100 PIV at 18 A, D5-D6 1N4807 or equivalent, and D7 1N4002 or equivalent.—T. Lawrence, Build a Brute Power Supply, *73 Magazine,* Aug. 1977, p 78–79.



±5 AND ±12 V FOR COMPUTER—Provides eil voltages required for 8080-4BD microcomputer system marketed by The Digital Group (Denver, CO). Transformer for positive supplies is 6.3-V 20-A unit with secondery replaced by two new windings giving required voltege end current. Crowbar circuit using 2N688 SCR protacts ICs in memory end CPU. Use of et leest 50,000 μF in filter of 5-V supply prevents noise problems in computer. MPC-1000 5-V 10-A regulator should be mounted on lerga heetsink et reer of computer housing in open eir.—L. I. Hutton, A Hem's Computer, *73 Magazina,* Dec. 1976, p 78–79 end 82–83.



5 V AT 20 A AND 0–25 V AT 0–24 A—Daveloped as lab supply for experimenting with high-current TTL circuits. Motorole MC1466 monitors voltage end current requirements continuously, providing output proportionel to perameters called for by front-panel controls of supply. D2 and D8 ere 50-PIV 20-A diodes, end eil other diodes except D3 ere 1N4002 or equivelent. Article gives construction details.—J. W. Crewford, The Smert Power Supply, *73 Magazine,* Merch 1976, p 96–98 end 100–101.

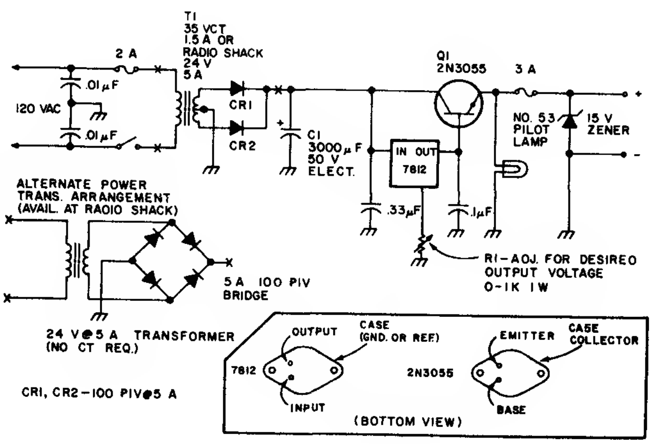


5 V WITH DOUBLER—Doubling parmits use of Inexpensive 6.3-V filement transformer wlthout risking loss of regulation when llna voltage drops below sbout 105 V. With values shown, output varied only 6 mV for line voltage renge of 95 to 135 V. Doubler circuit consists of C_2, C_3, D_1, D_3, D_5, and D_6.—A. Psterson, Voltage Doubler Pravents Supply from Losing Regulatlon, *EDN Magazine,* Nov. 1, 1972, p 46.

COMPONENT VALUES

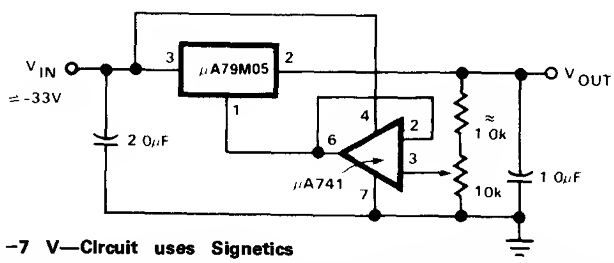
D_1 THRU D_4	:	1N4001
D_5, D_6	:	1N914
C_1	:	8000μF, 15V
C_2	:	50μF, 25V
C_3	:	250μF, 25V
C_4	:	100μF, 10V
Q_1	:	MJE 521 (HEAT SINK)
Q_2, Q_3	:	2N3392
Q_4	:	CONSTANT CURRENT DIODE, (e.g. 2N5033, 2-3 mA)
Z_1	:	REF. DIODE, 4.3 V @ 2-3 mA (e.g. LVA43A)

12–14 V AT 3 A—Basic clrcuit for opersting mobile equipment off AC lina uses IC voltsga regulator in conjunction with series-psss trsnsistor.—Circuits, *73 Magazine,* Holidey issue 1976, p 170.

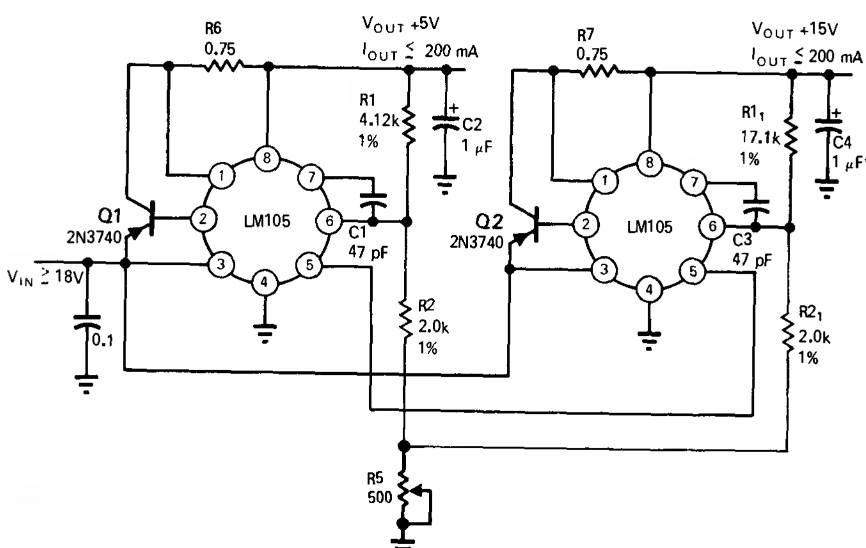


CHAPTER 74
Regulator Circuits

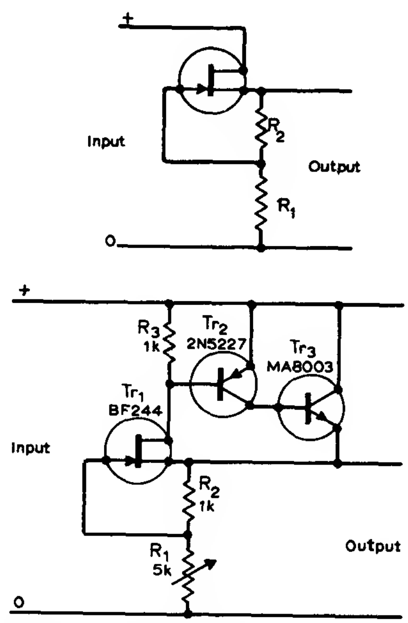
Used at outputs of unregulated power supplies to provide highly regulated fixed and variable positive and negative output voltages ranging from 0 to ±65 V for solid-state applications and up to 1000 V at 100 W for other purposes. Maximum current ratings range from 5 mA to 20 A. Some regulators have overvoltage crowbar or foldback current limiting. Dual-output regulators may have tracking. Current regulators are included. See also Regulated Power Supply and Switching Regulator chapters.



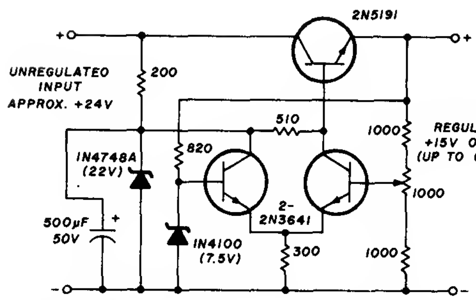
−30 V TO −7 V—Circuit uses Signetics μA79M05 adjustable voltage regulator in combination with 741 opamp to give wide negative output voltage range. Regulator includes thermal overload protection and internal short-circuit protection. Input voltage should be at least 3 V more negative than maximum output voltage desired.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 670.



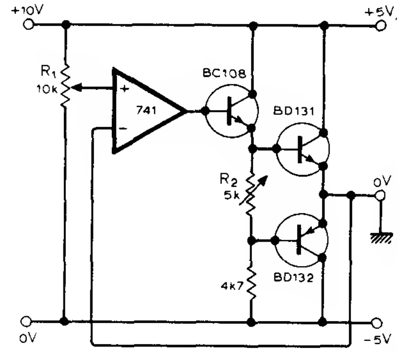
5 AND 15 V SINGLE CONTROL—Single potentiometer serves for adjusting two regulators simultaneously. Accuracy depends on output voltage differences of regulators; error decreases when output voltages are closer. Article gives design equation and covers other possible sources of error.—R. C. Dobkin, One Adjustment Controls Many Regulators, *EDN Magazine*, Nov. 1, 1970, p 33–35.



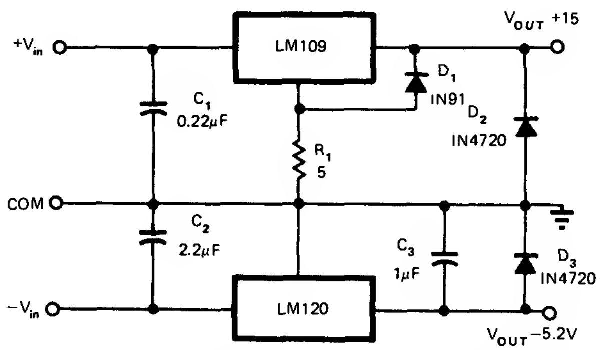
5-V FET REGULATOR—Output voltage changes less than 0.1 V for load current change from 0 to 60 mA. Output voltage changes caused by change in load resistance affect gate-source voltage of FET Tr_1 via R_1 and R_2, causing compensating change in drain current. Additional transistors serve to reduce output resistance and increase output current without affecting stabilization ratio of about 1000.—C. R. Masson, F.E.T. Voltage Regulator, *Wireless World*, Aug. 1971, p 386.



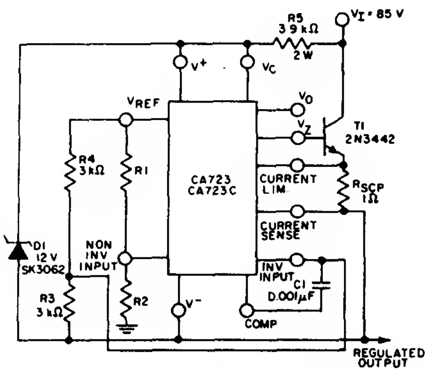
+15 V WITH DIFFERENTIAL AMPLIFIER—Sarias regulator uses differential amplifier as control circuit in which one sida is referenced to zanar and other to frection of output voltage. Second zanar providas coarsa regulatad voltege to differential pair.—H. Olson, Power-Supply Servicing, *Ham Radio,* Nov. 1976, p 44–50.



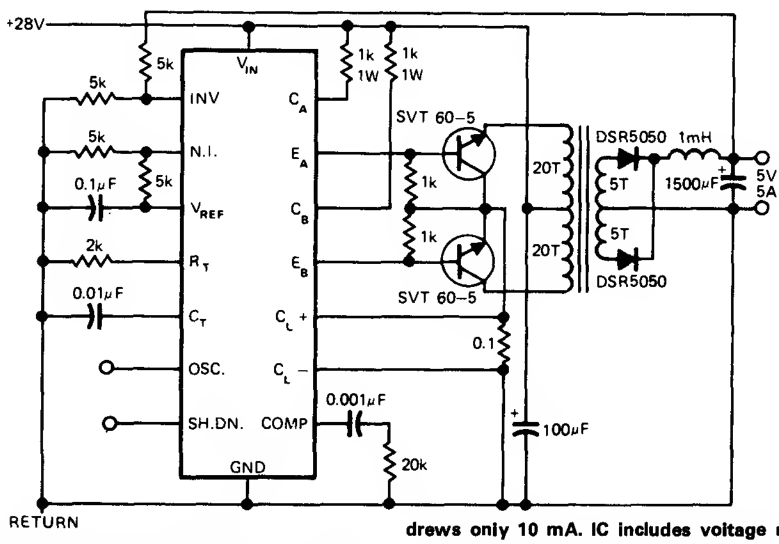
REGULATED DIVIDER FOR ±5 V—Used at output of adjustabla regulated powar supply providing up to 15 V, to giva lowar positive end negetive voltages that ramain steady despite changas in load currant. To get +5 V end −5 V from +10 V, set R_1 et midposition and edjust R_2 for 20 mA through output transistors. Uses 741 opamp.—C. H. Banthorpa, Voltage Divider, *Wireless World,* Dec. 1976, p 41.



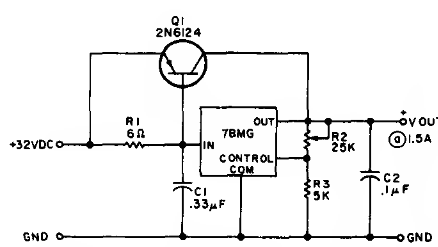
DUAL −5.2 V AND +15 V—Output voltages ara equal to preset values of regulator ICs in basic arrangemant shown. R_1 and D_1 ensure startup of LM109 whan common load exists across supplies. D_1 should be germanium or Schottky heving forward voltage drop of 0.4 V or less at 50 mA. D_2 end D_3 protect against polarity reversal of output during overloads.—C. T. Nelson, Power Distribution and Regulation Can Ba Simple, Cheap and Rugged, *EDN Magazine,* Feb. 20, 1973, p 52–58.



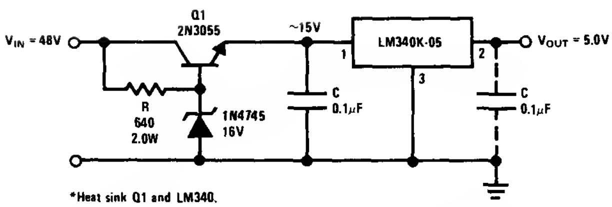
+50 V FLOATING—RCA CA723 regulator operating from 85-V supply dalivars 50 V with lina regulation of 15 mV for 20-V supply change and load regulation of 20 mV for 50-mA load current change.—"Linaar Integrated Circuits and MOS/FET's," RCA Solid Stata Division, Somerville, NJ, 1977, p 61.



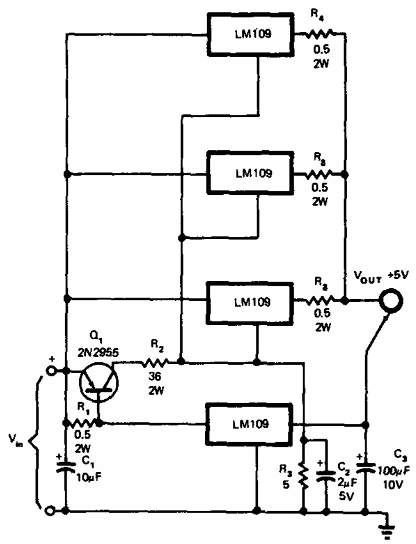
5 V AT 5 A WITH IC SWITCHER—Uses Silicon Generel SG1524 IC as pulse-width-modulated regulator for which operating fraquency remeins constant, with ON tima of aech pulsa adjusted to maintein desired output voltage. Operating range extends ebove 100 kHz but devica draws only 10 mA. IC includes voltage reference, oscillator, comparator, error amplifier, current limiter, pulsa-stearing flip-flop, and automatic shutdown for overload.—P. Franson, Todey's Monolithic Switching Circuits Greetly Simplify Power-Supply Designs, *EDN Magazine,* March 20, 1977, p 47–48, 51, and 53.



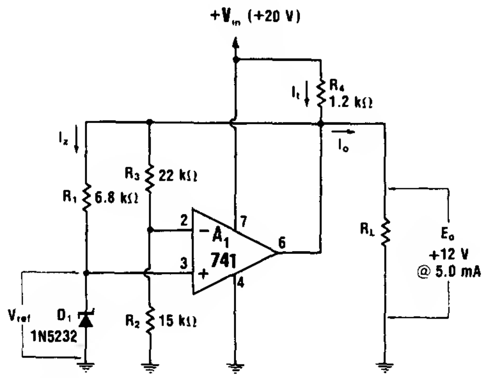
5–30 V AT 1.5 A—Externai sarias-pess transistor boosts 500-mA rated output of 78MG or 79MG regulator to 1.5 A for use as edjustable powar supply in leb. Circuit hes no short-circuit protection for safe-area limiting for externai pass trensistor, but articla shows how to edd protective trensistor for this purposa.—J. Trulove, A New Breed of Voltaga Regulators, *73 Magazine,* March 1977, p 62–64.



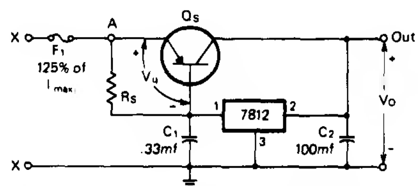
5 V FROM 48 V—Combination of zener and resistor R gives equivalent of power zener as solution to regulator protection problem when input voltage is much higher than rated maximum of regulator. Maximum load is 1 A. With optional capacitor, circuit noise is only 700 μV P-P.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 10.



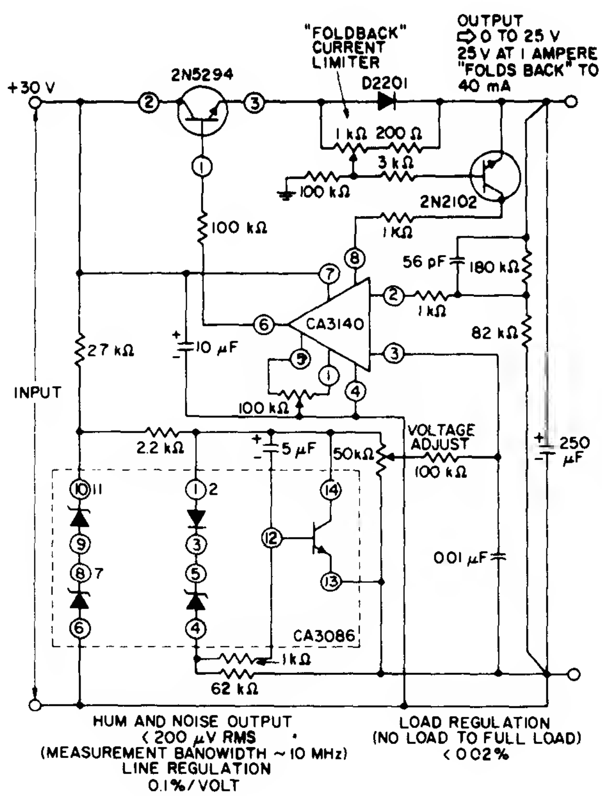
PARALLELING REGULATORS—Current-sharing problem is overcome without sacrificing ripple rejection or load regulation, by using bottom regulator as control device that supplies most of load current until current through this regulator reaches about 1.3 A. At this point Q_1 turns on and raises output voltage of other regulators to supply additional load current demands. Circuit shown will supply up to 6 A for minimum input voltage of 8 V. For optimum regulation, minimum load current should be 1 A.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine*, Feb. 20, 1973, p 52–58.



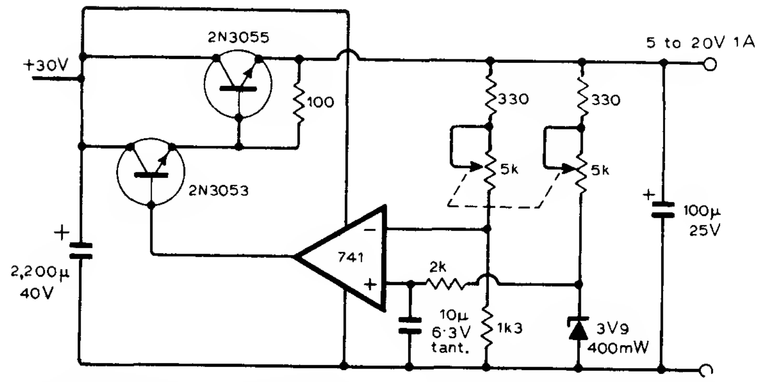
12-V SHUNT AT 5 mA—Low-power shunt regulator uses opamp to absorb excess load current. Value of R_1 is chosen to step up reference voltage of 5.6-V zener to +12 V at 5 mA. Design procedure for other output voltages is given. Output impedance is 0.01 ohm at 100 Hz, giving 120-Hz ripple-frequency filtering comparable to that of 100,000-μF capacitor.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 166–168.



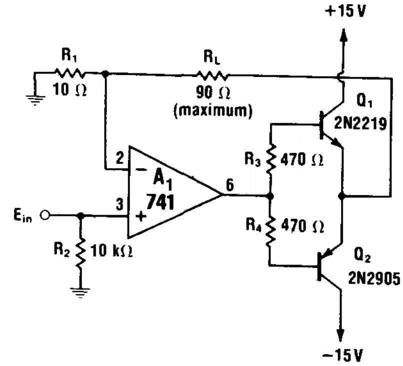
12 V AT 20 A—Regulator conducts and regulates until current demand is such that IR drop across R_S is sufficient to overcome base-emitter junction potential of switch transistor Q_S, which is two 2N174 germanium transistors in parallel. Use 2 ohms for R_S. Q_S is then turned on, with current/voltage regulation to its base controlled by regulator. Input voltage of 7812 regulator should be 2 V more than desired output voltage. Article gives three different rectifier circuits suitable for use with regulator.—A. M. Clarke, Regulated 200 Watt-12 Volt D.C. Power Supply, *CQ*, Oct. 1975, p 28–30 and 78–79.



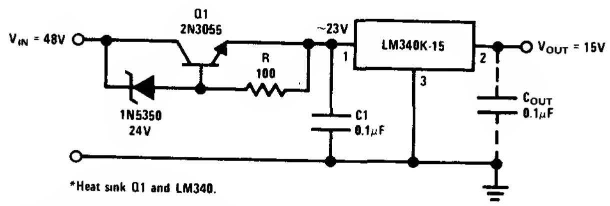
0–25 V WITH FOLDBACK CURRENT LIMITING—When D2201 diode senses load current of 1 A at maximum regulated output of 25 V, 2N2102 current-sensing transistor provides foldback of output current to 40 mA. Arrangement permits use of 2N5294 transistor as series-pass element, using only small heatsink. High-impedance reference-voltage divider across 30-V supply serves CA3140 connected as noninverting power opamp.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 248–257.



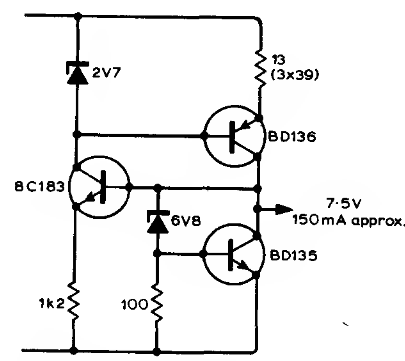
5–20 V ZENER-STABILIZED—Uae of dual lineer pot simplifies problem of feeding reference zener diode from veriable-voltage eupply.—L. J. Baughen, Verieble Power Supply with Zener Stebilizetion, *Wireless World*, Nov. 1975, p 520.



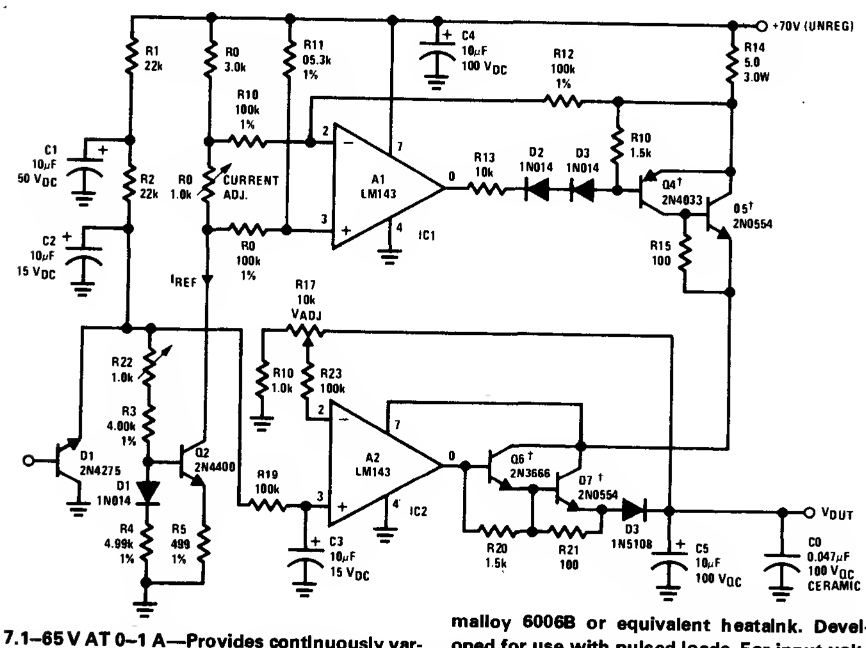
100-mA CURRENT REGULATOR—741 opamp is connected es noninverting voltege-controlled current source feeding trensistors thet boost output and provide bidirectional current capability in loed R_L. If single-polerity current flow ie aufficient, omit opposite-polerity treneistor.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sems, Indianepolis, IN, 1974, p 173.



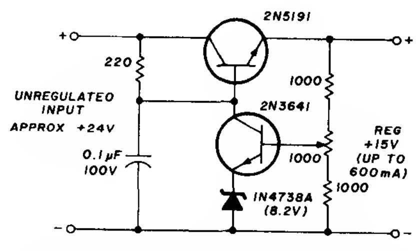
+15 V FROM HIGH INPUT VOLTAGE—Zener is used in series with resistor R to level-shift input voltage higher than reted meximum of LM340K-15 regulator. Typical load regulation is 40 mV for 0–1 A pulsed loed, end line regulation is 2 mV for 1-V chenge in input voltege for no loed. With optionel output capecitor, circuit noise is only 700 μV P-P.—"Lineer Applicetions, Vol. 2," National Semiconductor, Santa Clera, CA, 1976, AN-103, p 9–10.



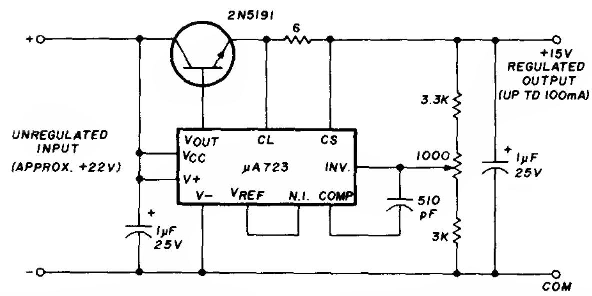
HUM-FREE CASSETTE RECORDER SUPPLY—Designed for tepe recorder feeding into AF emplifier, to permit operation of recorder from power supply of emplifier without having hum due to positive feedback through shered ground connection. Circuit provides up to 150 mA et 7.5 V from supply ranging from 12 to 24 V. Transistors ere connected es constant-current source in seriea with constant-voltage sink. Use three 39-ohm resistors in perallel es 13-ohm resistor.—G. Hibbert, Avoiding Power Supply Hum, *Wireless World*, Oct. 1973, p 515.



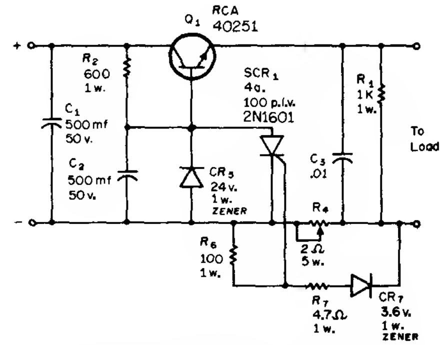
7.1–65 V AT 0–1 A—Provides continuously variable output voltage and edjueteble output current range. Q1 ie connected es zener to glve 6.5-V reference voltege. Darlington current boosters Q4-Q7 should be on common Thermalloy 6006B or equivalent heatsink. Developed for use with pulsed loade. For input voltege range of 46–76 V, reguletion is within 286 mV for 500-mA DC output.—"Linear Applicetions, Vol. 2," Netional Semiconductor, Sente Clera, CA, 1976, AN-127, p 8–10.



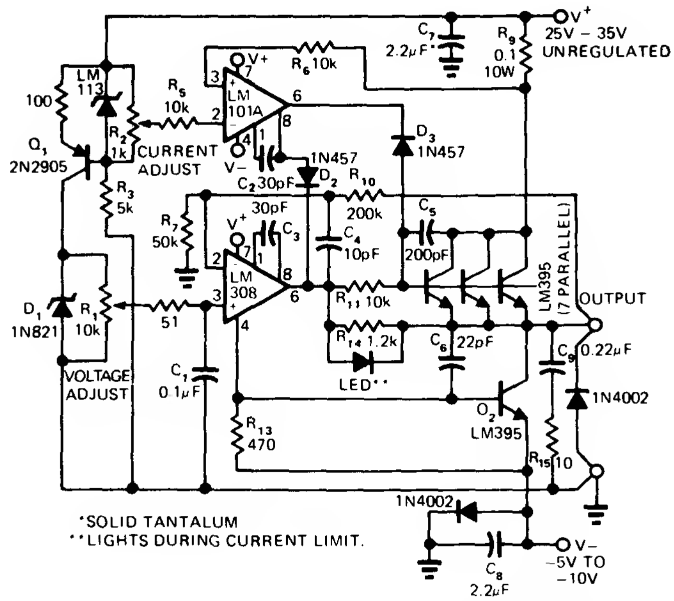
+15 V WITH FEEDBACK—Fraction of output voltege is fed beck to bese of 2N3641 regulator transietor. Differance betwaan thie voltege end zener dioda voltege la amplified to control beee of 2N5191 series transistor.—H. Olson, Powar-Supply Servicing, *Ham Radio*, Nov. 1976, p 44–50.



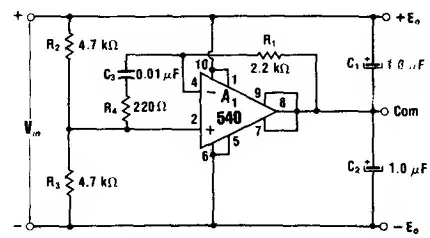
+15 V WITH μA723—Series power transistor and Fairchild IC voltage regulator provide up to 100 mA. Article covers troubleshooting and repair of all types of regulators.—H. Olson, Power-Supply Servicing, *Ham Radio,* Nov. 1976, p 44–50.



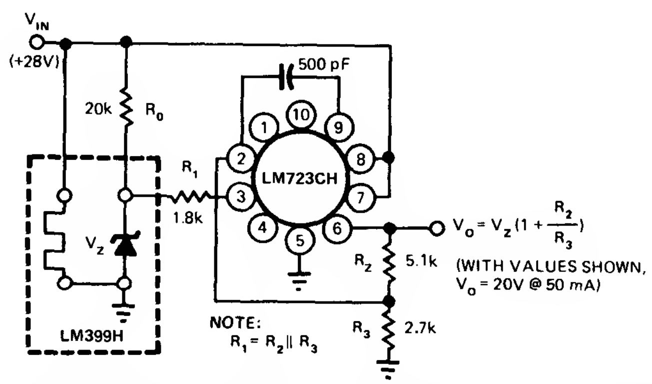
OVERLOAD PROTECTION—When critical current is exceeded, SCR_1 conducts and reduces base-ground voltage of Q_1, cutting it off. Load current then drops to very low value, and Q_1 is protected. Operation is restored by turning off current supply to power transformer after clearing short-circuit condition.—R. Phelps, Jr., Protective Circuits for Transistor Power Supplies, *CQ,* March 1973, p 44–48 and 92.



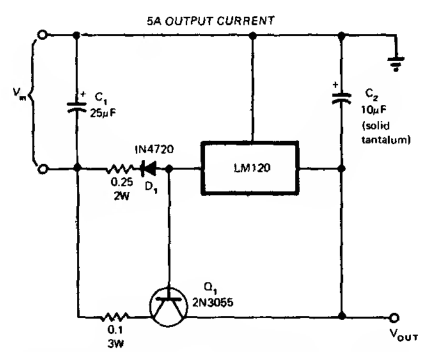
25 V AT 10 A FOR LAB—Circuit uses no large output capacitors yet has good response as constant-voltage or constant-current source. LM395 units (7 in parallel) act as current-limited thermally limited high-gain power transistor. Mount all on same heatsink for good current sharing, since 300 W will be dissipated under worst-case conditions. Only two control opamps are needed, one for voltage control and one for current control.—R. C. Dobkin, General-Purpose Power Supply Furnishes 10A and 25V, *EDN Magazine,* March 5, 1975, p 70.



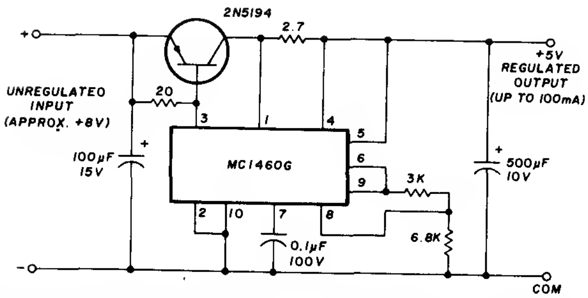
CONVERTING TO DUAL SUPPLY—With equal values for R_2 and R_3, input of 30 V is converted to ±15 V at output. If desired, R_2 and R_3 can be scaled for unequal voltage drops. Circuit uses 540 power IC having 100-mA rating for each output, for handling load imbalances up to 100 mA.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 170–171.



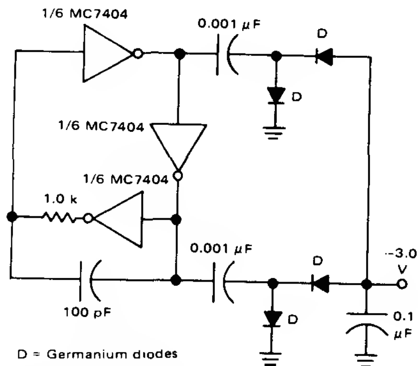
10 PPM/°C—Connections shown convert LM723CH regulator into precision power reference having excellent long-term stability and temperature stability. LM399H replaces internal reference of LM723 with low-noise 6.9 V to give desired performance over temperature range from +15 to +65°C.—B. Welling, High-Stability Power Supply Uses 723 Regulator, *EDN Magazine,* Jan. 20, 1978, p 114 and 116.



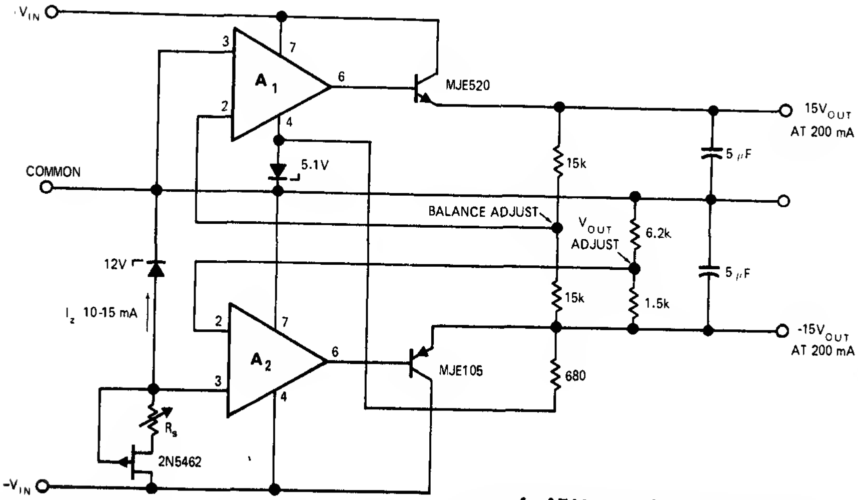
5 A AT −5 TO −15 V—Use of 2N3055 pass transistor boosts current output of LM120 regulator IC. Minimum differential between input and output voltages is typically 2.5 V, so supply voltage must be 2.5 V higher than preset output voltage of regulator chosen from National LM120 series.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine,* Feb. 20, 1973, p 52–58.



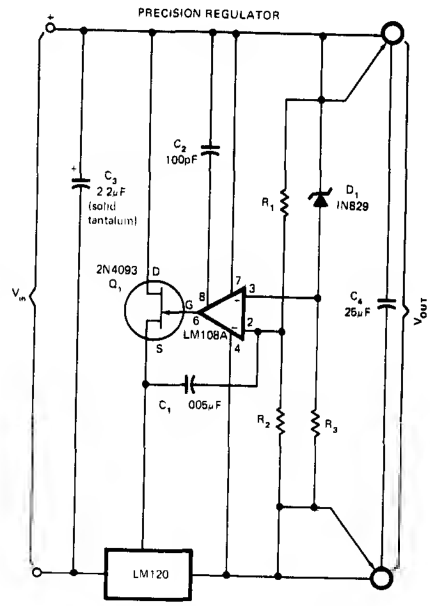
+5 V WITH MC1460G—Series power transistor and Motorola IC voltage regulator provide up to 100 mA. IC shown has been replaced by MC1469. Equivalents made by other manufacturers can also be used.—H. Olson, Power-Supply Servicing, *Ham Radio*, Nov. 1976, p 44–50.



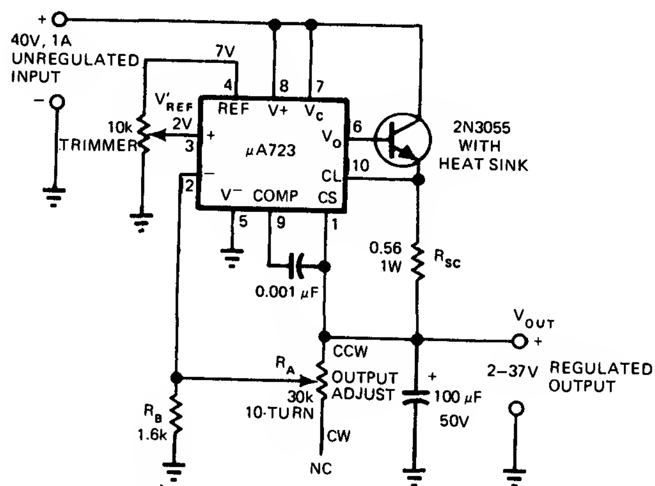
−3 V—Circuit using three sections of Motorola MC7404 operates from +5 V supply and generates −3 V at up to 100 μA, as one of supply voltages required by Motorola MCM6570 8192-bit character generator using 7 × 9 matrix.—"A CRT Display System Using NMOS Memories," Motorola, Phoenix, AZ, 1975, AN-706A, p 5.



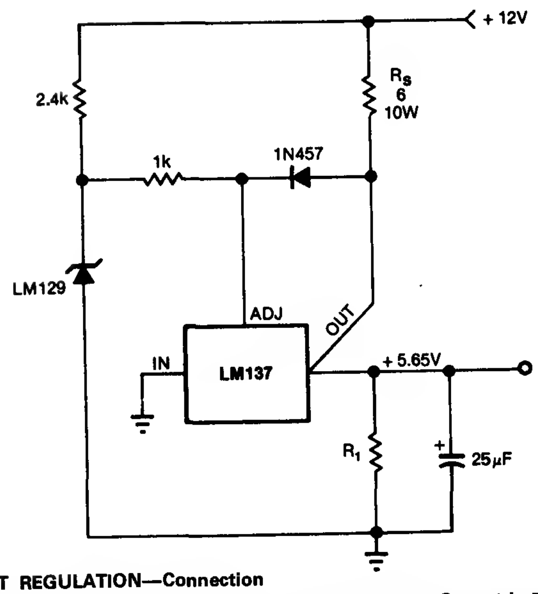
±15 V AT 200 mA—Two-opamp regulator gives dual-polarity tracking outputs that can be balanced to within millivolts of each other or can be offset as required. Negative voltage is regulated, and positive output tracks negative. Article gives step-by-step design procedure based on use of μA741 or equivalent opamps. AC ripple is less than 2 mV P-P. Conventional full-wave bridge rectifier with capacitor-input filter can be used to provide required unregulated 36 VDC for inputs.—C. Brogado, IC Op Amps Simplify Regulator Design, *EDN/IEEE Magazine*, Jan. 15, 1972, p 30–34.



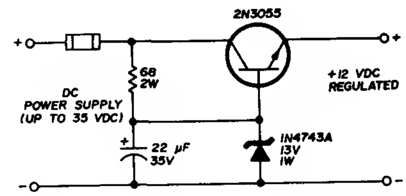
1 A WITH 0.005% VOLTAGE ACCURACY—Use of National LM120 negative regulator with LM108A low-drift opamp and 1N829 precision reference diode gives extremely tight regulation, very low temperature drift, and full overload protection. Bridge arrangement sets output voltage and holds reference diode current constant. FET is required because 4-mA maximum ground current of regulator exceeds output current rating of opamp. R_1 and R_2 should track to 1 PPM or less. R_3 is chosen to set reference current at 7.5 mA. For output of 8 to 14 V, use LM120-5.0; for 15–17 V, use LM120-12.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine*, Feb. 20, 1973, p 52–58.



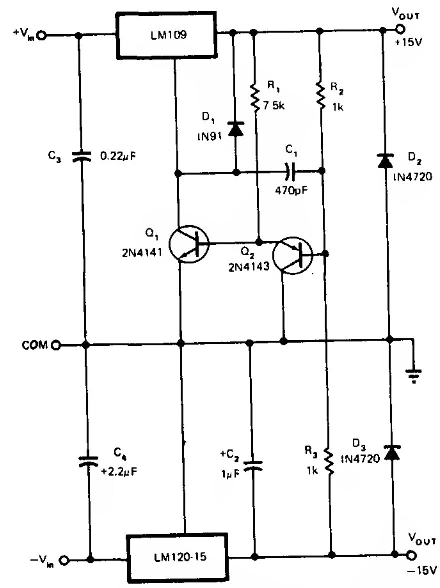
2–37 V—Simple circuit gives fine linear control with 10-turn pot over wide voltage range by first using 10K trimmer pot to divide 7-V reference down to 2 V.—G. Dressel, Regulator Circuit Provides Linear 2-37 V Adjustment Range, *EDN Magazine*, March 5, 1978, p 122.



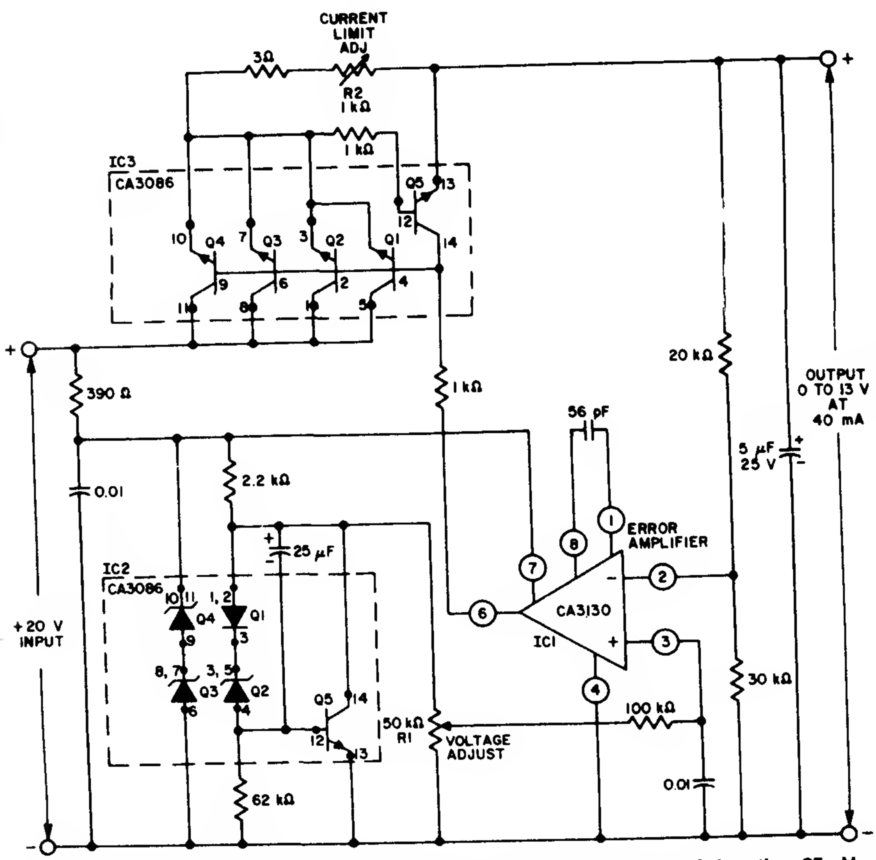
POSITIVE SHUNT REGULATION—Connection shown for LM137 negative series regulator provides high-reliability positive shunt regulation for applications having high-voltage spike on raw DC supply. Output is 5.65 V.—P. Lefferts, Series Regulators Provide Shunt Regulation, *EDN Magazine*, Sept. 5, 1978, p 158 and 160.



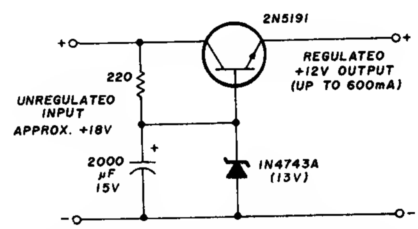
+12 V AT 2 A—Developed for unregulated 12-VDC supplies used by some amateurs with low-power VHF FM equipment, where no-load voltage may be 18 V or more. During transmit, voltage drops to about 12 V, but on receive may exceed voltage ratings of small-signal transistors in transceiver. Use heatsink with transistor, and use 2-A fuse to protect transistor from shorted load.—J. Fisk, Circuits and Techniques, *Ham Radio*, June 1976, p 48–52.



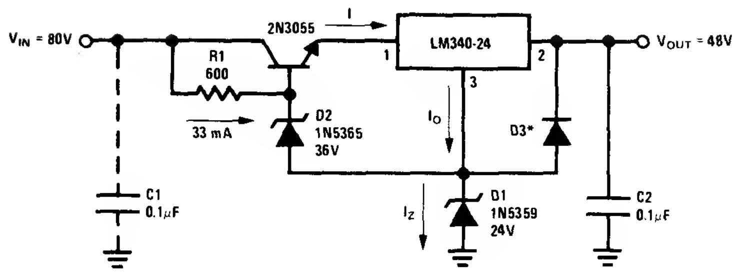
±15 V WITH TRACKING—In arrangement shown for National regulator ICs, positive output voltage tracks negative voltage to better than 1%. Ripple rejection is 80 dB for both outputs. Load regulation is 30 mV at 1 A for negative output and less than 10 mV for positive output. Circuit works well for output in range of ±6 to ±15 V. C_1 provides stability.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine*, Feb. 20, 1973, p 52–58.



0–13 V AT 40 mA—Combination of RCA CA3130 opamp and two CA3086 NPN transistor arrays provides better than 0.01% regulation from no load to full load and input regulation of 0.02%/V. Hum and noise output is less than 25 µV up to 100 kHz.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 236–243.

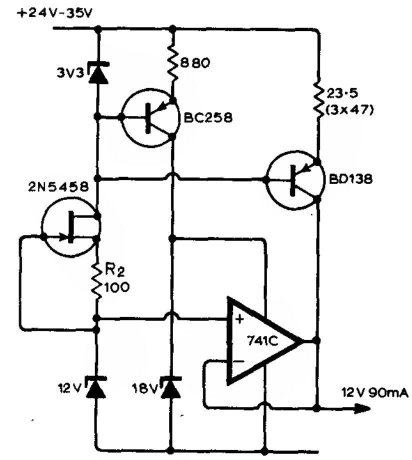


+12 V SERIES EMITTER-FOLLOWER—Base-emitter voltage is more or less constant without use of feedback because base is held at constant voltage by zener diode. Ripple at base is reduced by RC filter.—H. Olson, Power-Supply Servicing, *Ham Radio*, Nov. 1976, p 44–50.

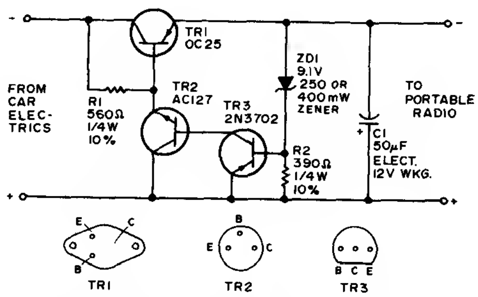


*Germanium signal diode

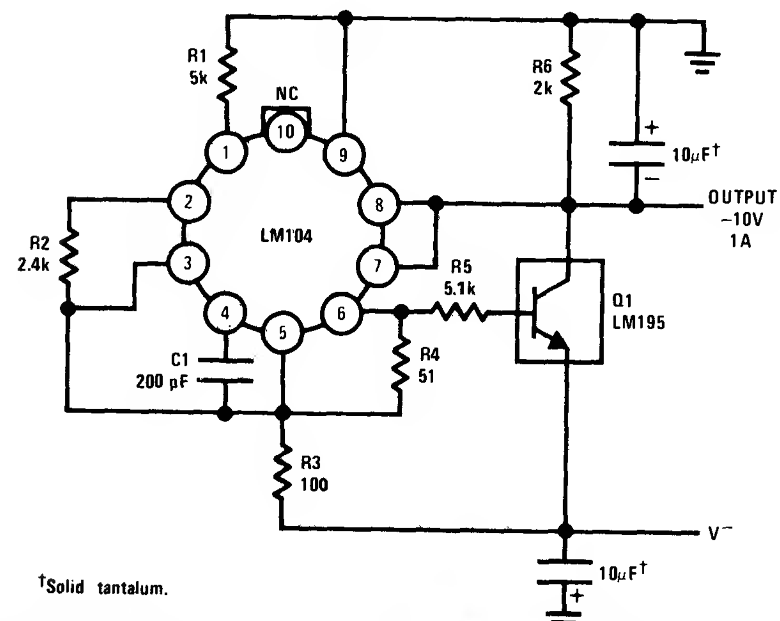
48 V FROM 80 V—Level-shifting transistor-zener combination R1-D2 is used with zener D1 to keep voltage across LM340-24 regulator below maximum reted value. Addition of zeners has drawback of increesing output noise to about 2 mV P-P. Load reguletion is 60 mV for pulsed load change from 5 mA to 1 A. Line regulation is 0.01%/V of input voltage change for 500-mA loed.—"Linear Applications, Vol. 2," Netional Semiconductor, Santa Clara, CA, 1976, AN-103, p 10–11.



HUM-FREE TUNER SUPPLY—Permits operation of high-quelity FM tuner from amplifier supply without having hum due to positive feedback through shared ground connection. Circuit provides up to 90 mA at 12 V from any supply renging from 24 to 34 V. Low output impedance eliminates all likely sources of feedback and suppresses ripple. Circuit requires careful initial adjustment to limit current sunk by 741C opamp to less then 15 mA; coarse adjustment is made by varying number of 47-ohm resistors in parallel serving as BD136 emitter resistor, and fine adjustment by changing R_2.—G. Hibbert, Avoiding Power Supply Hum, *Wireless World,* Oct. 1973, p 515.

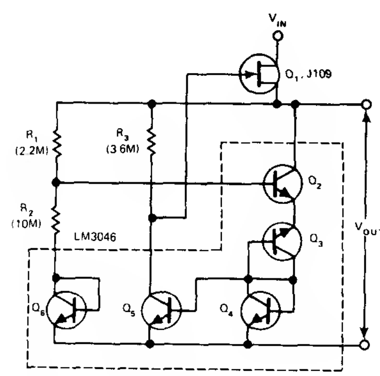


9 V FROM 12 V—Developed for economical operation of 9-V portable radio from 12-V storage battery of car.—Circuits, *73 Magezine,* Merch 1975, p 136.



†Solid tantalum.

−10 V AT 1 A—Combination of LM195 power transistor IC and standard LM104 regulator gives negative output voltage with full overloed protection end better than 2-mV load regulation. Input voltage must be only 2 V greater than output voltage.—"Linear Applications, Vol. 2," National Semiconductor, Sante Clere, CA, 1976, AN-110, p 4–5.



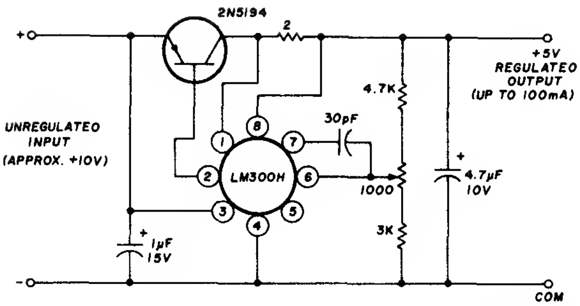
$V_{OUT} \approx V_{BE}(2 + R_1/R_2) + BV_{EB}(1 + R_1/R_2)$

DRIFT

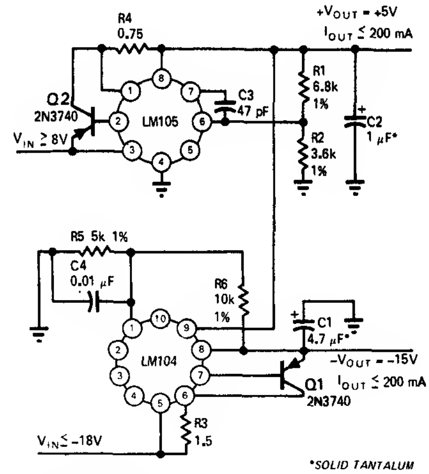
$$\frac{\partial V_{OUT}}{\partial T} = \frac{\partial V_{BE}}{\partial T}(2 + R_1/R_2) + \frac{\partial BV_{EB}}{\partial T}(1 + R_1/R_2)$$

QUIESCENT CURRENT ~ 4 μA

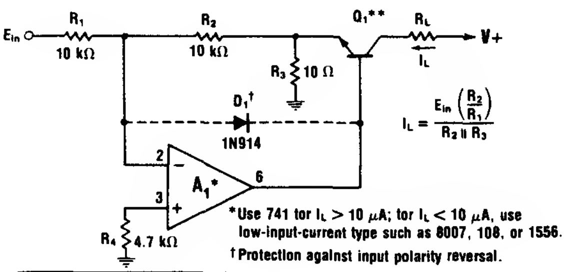
JFET SERIES-PASS—Use of JFET as series-pass element for LM3046 voltage regulator IC minimizes battery drain in microprocessor system applications. Pass element needs no preregulation because drive comes from regulated output. Gate source is isolated from line by drain and thus provides excellent line regulation.—J. Maxwell, Voltage Regulator Bridges Gap Between IC's end Zeners, *EDN Megazine,* Sept. 5, 1977, p 178–179.



+5 V WITH LM300H—Series power transistor and National IC voltage regulator provide up to 100 mA. Improved version of regulator, LM305H, may be substituted.—H. Olson, Power-Supply Servicing, *Ham Radio*, Nov. 1976, p 44–50.

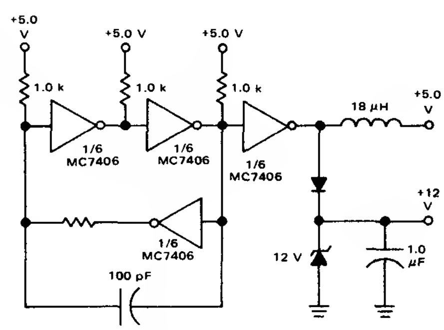


−15 V TRACKING +5 V—LM104 negative regulator is used with inverting gain to give negative output voltage that is greater than positive reference voltage. Noninverting input is tied to divider R5-R6 between negative output and ground. Positive reference determines line regulation and temperature drift, with negative output tracking.—R. C. Dobkin, One Adjustment Controls Many Regulators, *EDN Magazine*, Nov. 1, 1970, p 33–35.

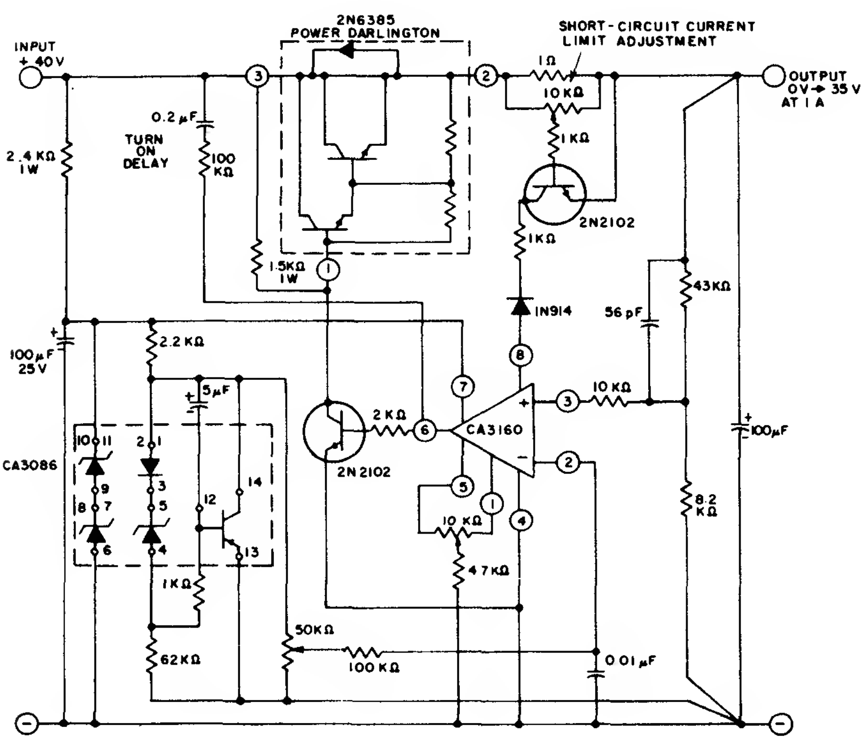


$^{**}Q_1$	I_L
2N3904	1.0 μA - 1.0 mA
2N2219	1.0 mA - 100 mA
2N6057	100 mA - 10 A

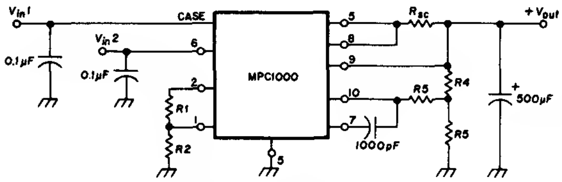
NEGATIVE-INPUT CURRENT REGULATOR—Opamp is used as inverter starting current-boosting transistor to provide positive supply voltage. Load current range depends on transistor used. R_3 forces Q_1 to conduct much heavier current than feedback current, as required for high load current. Current gain depends on ratio of R_2 to R_3.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 176–177.



+5 AND +12 V AT 6 mA—Circuit using four sections of Motorola MC7406 provides +12 V supply required by MCM6570 8192-bit character generator using 7 × 9 matrix, along with conventional +5 V.—"A CRT Display System Using NMOS Memories," Motorola, Phoenix, AZ, 1975, AN-706A, p 5.

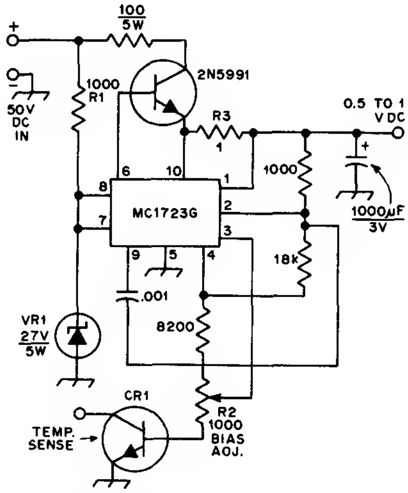


0.1–35 V AT 1 A—CA3160 serves as error amplifier in continuously adjustable regulator that functions down to vicinity of 0 V. RC network between base of 2N2102 output drive transistor and input source prevents turn-on overshoot. Input regulation is better than 0.01%/V, and regulation from no load to full load is better than 0.005%. Hum and noise output is less than 250 μVRMS.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 267–269.

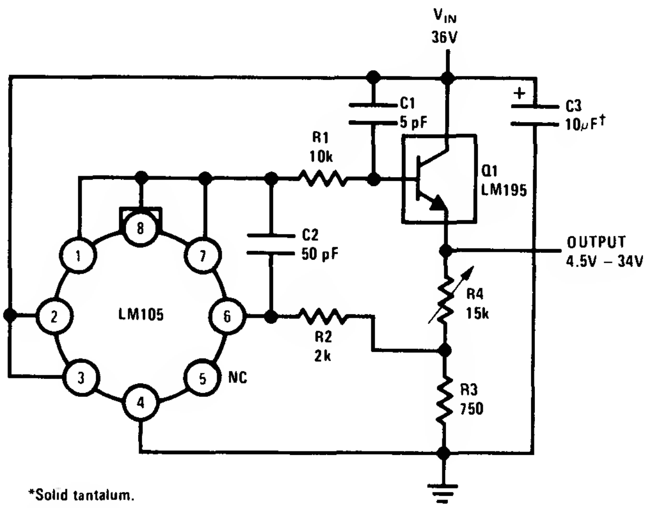


	PARAMETER VALUES FOR BEST RESULTS	
	$2V < V_O < 7V$	$7V < V_O < 55V$
R1	$\approx \frac{R2(7-V_O)}{V_O}$	$= \left[\frac{R4R5}{R4+R5}\right]$
R2	$10k < R1 + R2 < 100k$	∞
R5	$= \left[\frac{R1R2}{R1+R2}\right]$	–
R4	–	$\approx \frac{R5(V_O-7)}{7}$
R5	∞	$10k < R5 < 100k$
R_{sc}	$\approx \frac{.066}{I_{sc}}$ @ $T_J = 25°C$	

+2 TO +35 V AT 10 A—Provides fixed output voltage at value determined by choice of resistance values, computed as given in table. Heatsink should have very low thermal resistance. For similar range of negative voltages, Motorola MPC900 regulator can be used, with circuit modified slightly as set forth in article.—H. Olson, Second-Generation IC Voltage Regulators, *Ham Radio*, March 1977, p 31–37.

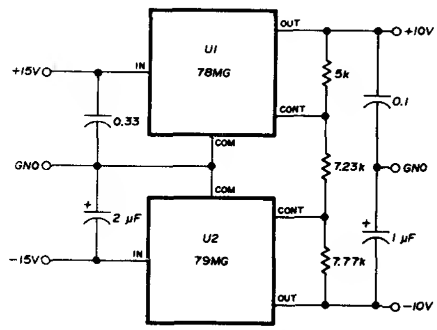


+0.5 TO 1 V BIAS—Motorola MC1723G regulator, 2N5991 current-boost transistor, and base-emitter junction of 2N5190 transistor CR1 serve as adjustable bias voltage source for 300-W solid-state power amplifier. R3 sets current limiting at about 0.65 A. Measured output-voltage variations are about ±6 mV for load changes of 0 to 600 mA.—H. O. Grenberg, One KW—Solid-State Style, *QST*, April 1976, p 11–14.

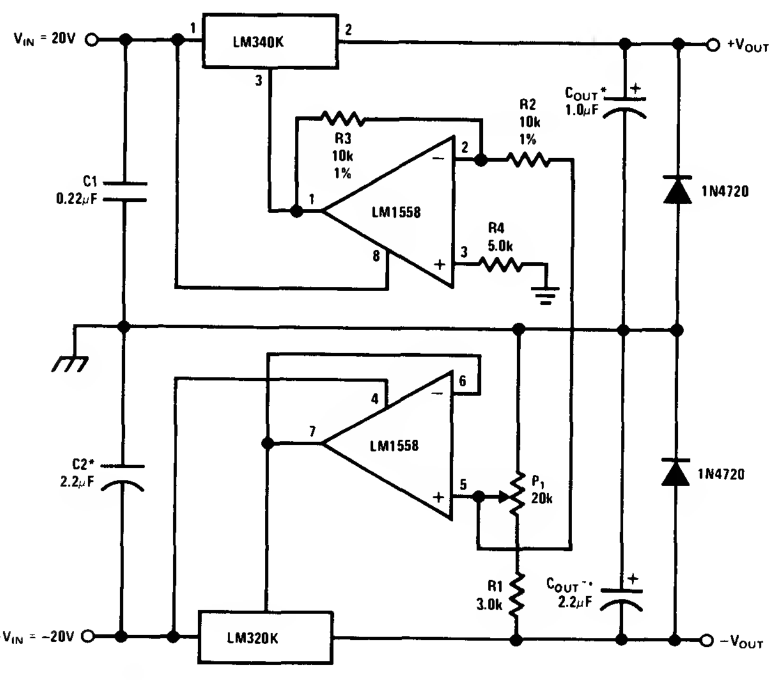


*Solid tantalum.

4.5–34 V AT 1 A—Combination of LM195 power transistor IC and standard LM105 regulator gives better than 2-mV load regulation with overload protection. Differential between input and output voltages is only 2 V.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-110, p 4.

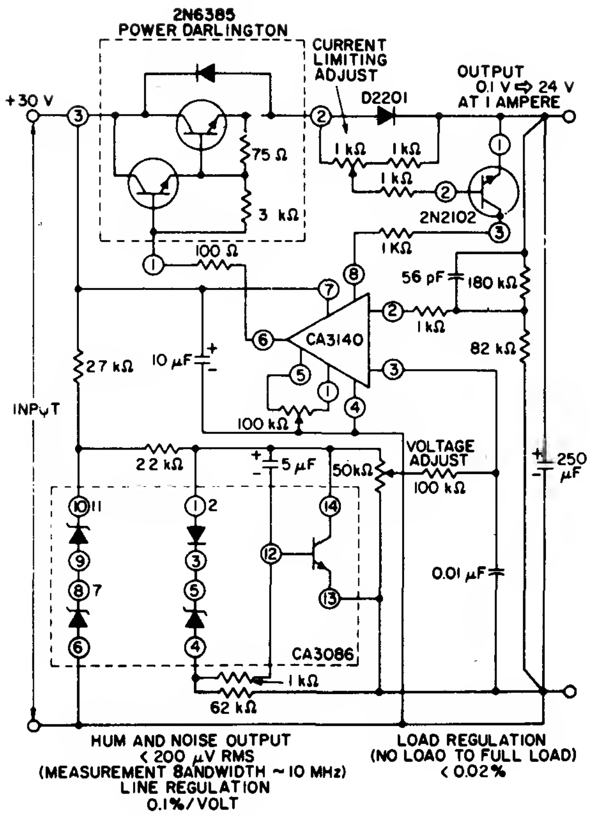


±10 V TRACKING—Fairchild 78MG and 79MG positive and negative voltage-regulator ICs provide up to 500-mA output, with protection against short-circuits and thermal overloads.—D. Schmieskors, Adjustable Voltage-Regulator ICs, *Ham Radio*, Aug. 1975, p 36–38.

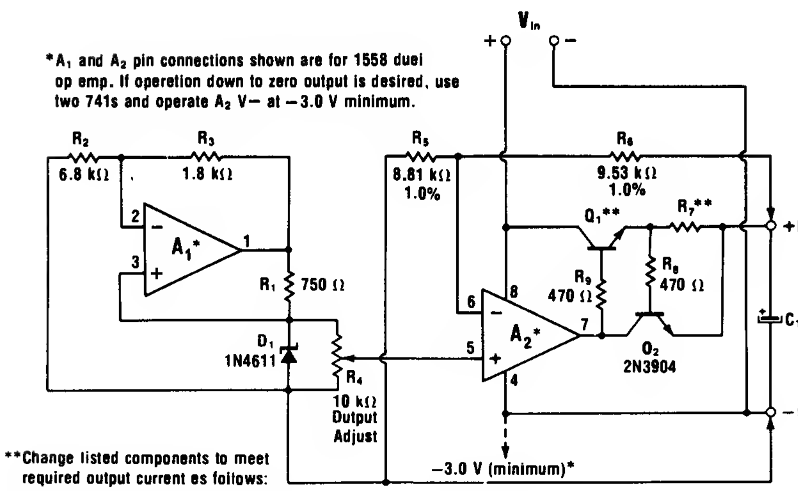


*Solid tantalum.

±5 TO ±18 V WITH TRACKING—Ground pin of LM340K-15 positive regulator is lifted by LM1558 inverter, while ground pin of negative LM320K-15 is lifted by LM1558 voltage follower. Positive regulator is made to track negative regulator within about 50 mV over entire output range. At ±15 V, typical load regulation is between 40 and 80 mV for 0–1 A pulsed load.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 8–9.



0.1–24 V AT 1 A—High-impedance reference-voltage divider across 30-V supply serves CA3140 connected as noninverting power opamp with gain of 3.2. 8-V reference input gives maximum output voltage of about 25 V. D2201 high-speed diode serves as current sensor for 2N2102 current-limit sensing amplifier. Current-limiting point can be adjusted over range of 10 mA to 1 A with single 1K pot. Power Darlington serves as series-pass element.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 248–256.

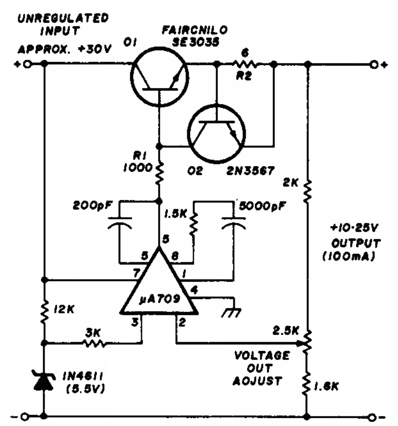


**Change listed components to meet required output current as follows:

	100 mA	2.0 A
Q_1	2N3766	2N6057†
R_7	4.7 Ω	0.25 Ω
C_1	100 μF	1000 μF

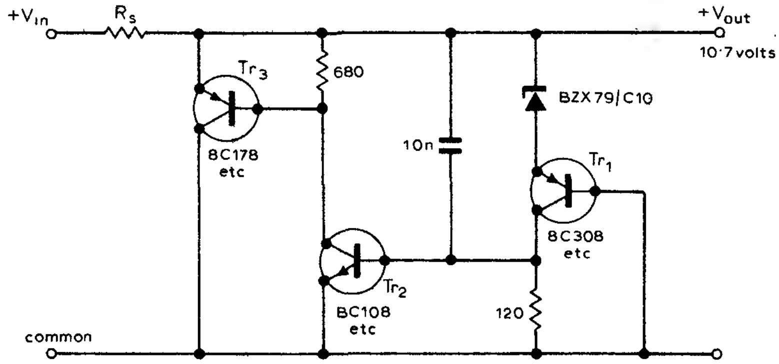
†Heat sink required.

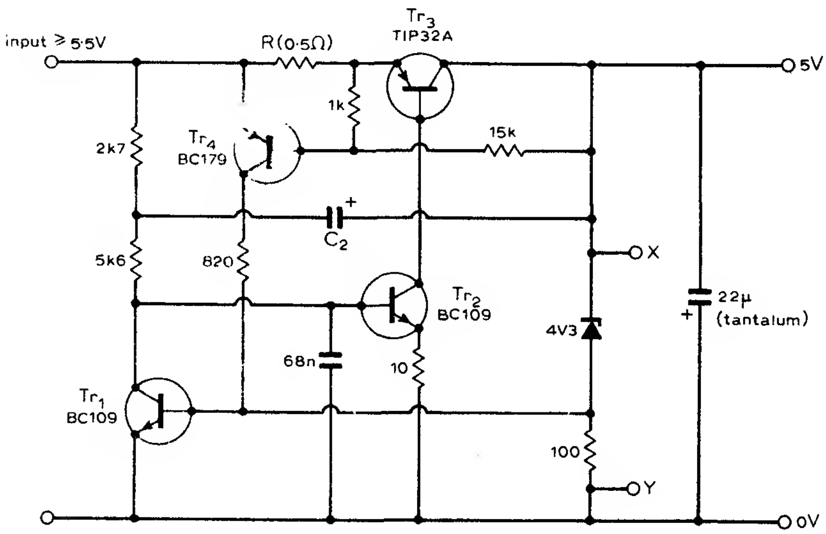
0–15 V AT 2 A—Basic zener-opamp regulator output of 6.6 V is scaled up to maximum of 15 V, adjusted with R_4, by adding buffer opamp A_2 and current-boosting transistors. Q_2 provides short-circuit protection by sensing load current through R_7. Large output capacitor C_1 maintains low output impedance at high frequencies where gain of A_2 falls off.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 158–159.



+10 TO +25 V AT 100 mA—Series regulator uses opamp as differential amplifier and extra transistor Q2 as current limiter. When 100 mA is drawn, 0.6 V is developed across R2 to make Q2 conduct, pulling Q1 base in negative direction. This action prevents excessive current from being passed by Q1.—H. Olson, Power-Supply Servicing, *Ham Radio*, Nov. 1976, p 44–50.

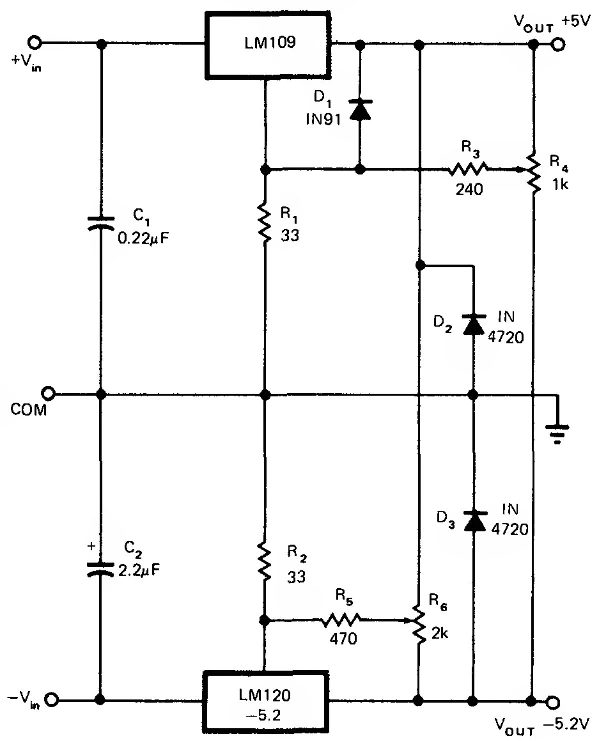
RIPPLE-PREAMP SUPPLY—Shunt regulator removes virtually all AC line ripple without using large capacitor, making it ideal for audio applications where freedom from ripple is more important than precise supply voltage level. Circuit cannot be damaged by short-circuits. Tr_3 may be power transistor or Darlington.—P. S. Bright, Ripple Eliminator, *Wireless World*, April 1977, p 62.



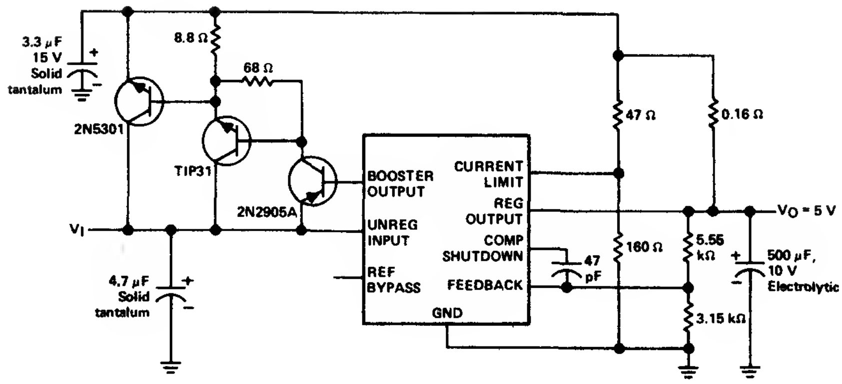


LOW COST WITH DISCRETE ELEMENTS—Performance is comparable to that of combined discrete and monolithic circuits, with load regulation of 0.01%, line regulation of 0.05%, ripple rejection of 0.1%, and output ripple and noise of 1 mV. Output is 1 A at 5 V. Foldback short-circuit protection is provided by Tr_4, with maximum current determined by value of R. C_2, which can be 100 μF, gives extra ripple rejection by introducing more AC feedback into loop. TIP32A is plastic series transistor, and is not critical; many other types will work equally well.—K. W. Mitchell, High Performance Voltage Regulator, *Wireless World*, May 1976, p 83–84.

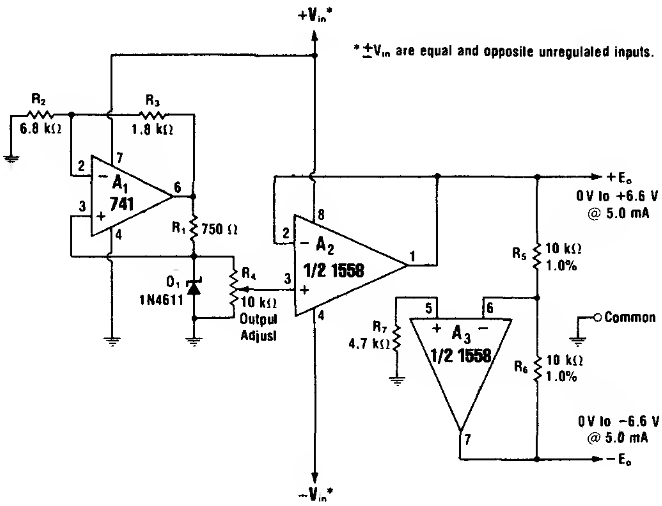
TRIMMED DUAL SUPPLY



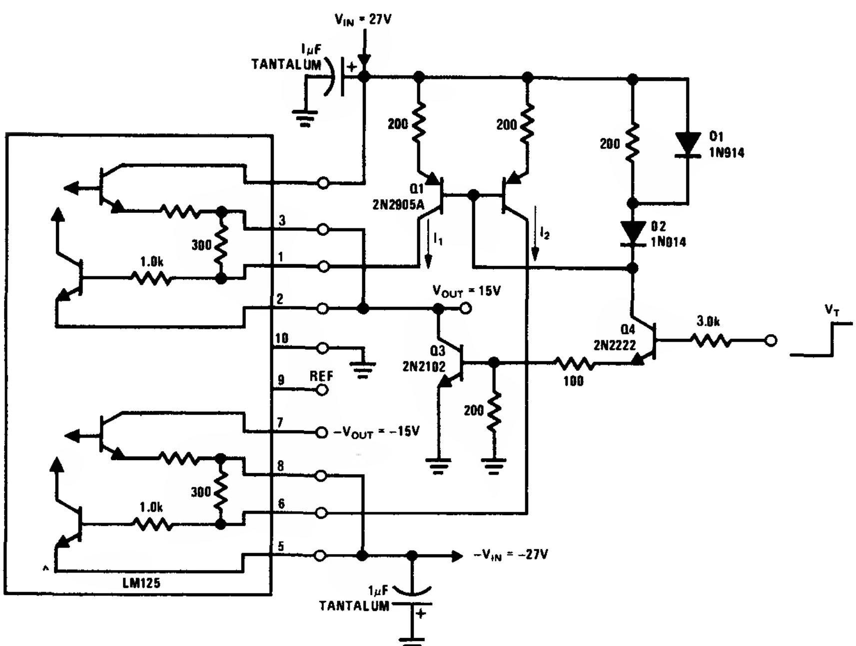
DUAL OUTPUTS WITH TRIMMING—Trimming pots connected across outputs provide positive or negative currents for producing small trimming voltages across 33-ohm ground-leg resistors of National regulators. Same components can be used for higher output voltages, but resistance values of pots should be increased if power dissipation becomes problem.—C. T. Nelson, Power Distribution and Regulation Can Be Simple, Cheap and Rugged, *EDN Magazine*, Feb. 20, 1973, p 52–58.



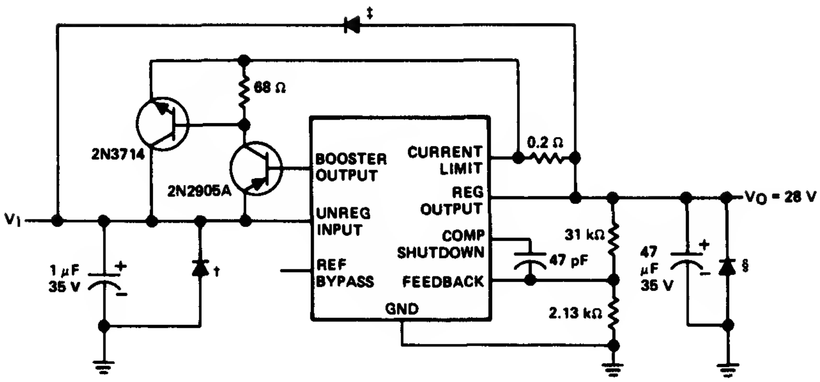
5 V AT 10 A WITH CURRENT LIMITING—Combination of three transistors and SN52105 or SN72305 regulator provides foldback current limiting for overload protection. Input voltage can be up to 40 V greater than 5-V output. Load regulation is about 0.1%, and input regulation is 0.1%/V. Regulators are interchangeable with LM105 and LM305 respectively.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 5-9.



0 TO ±6.6 V TRACKING AT 5 mA—Master-slave regulator combination is used to make second regulator provide mirror image of first while output of first is varied over full range from 0 to zener limit with R_4. Accuracy of tracking depends on match between R_5 and R_6, which should be 1% film or wirewound.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 160–162.

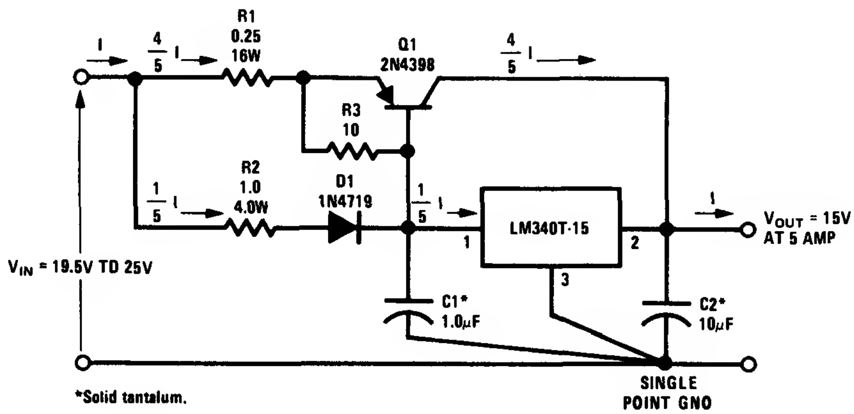


ELECTRONIC SHUTDOWN—Both sections of National LM125 dual tracking regulator are shut down by TTL-compatible control signal V_T which shorts internal reference voltage of regulator to ground. Q3 acts only as current sink.—T. Smathers and N. Savastopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-62, p 15.

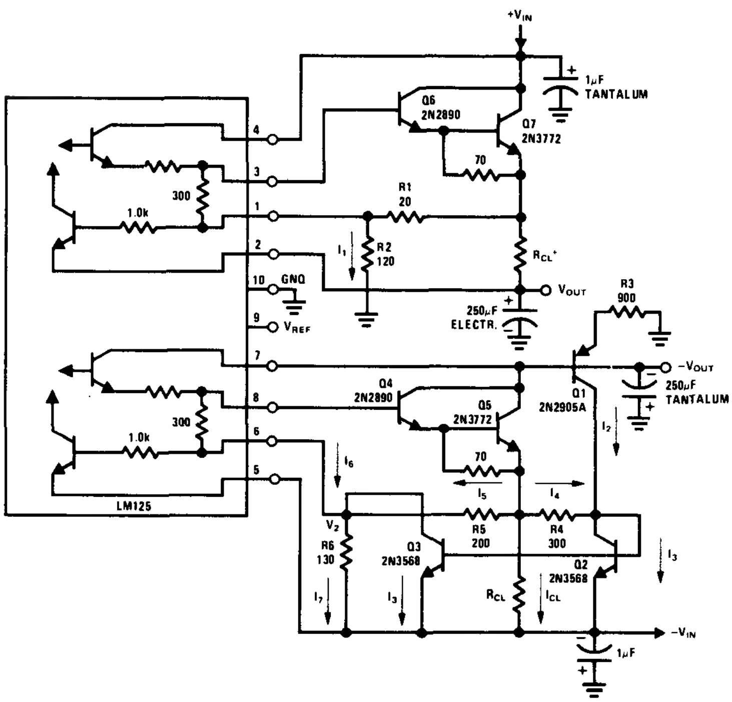


28 V AT 1 A—Circuit uses SN52105 or SN72305 regulator with three protective diodes. Feedback diode at top protects against shorted input and inductive loads on unregulated supply. Input diode protects against input voltage reversal. Output diode protects against output voltage reversal. Maximum input voltage is 50 V.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 5-9.

15 V AT 5 A WITH PROTECTION—External boost transistor is used with National LM340T-15 regulator to boost output current capability to 5 A without affecting such features as short-circuit current limiting and thermal shutdown. Short-circuit current is held to 5.5 A. Heatsink for Q1 should have at least 4 times capacity of heatsink for IC.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 3–4.

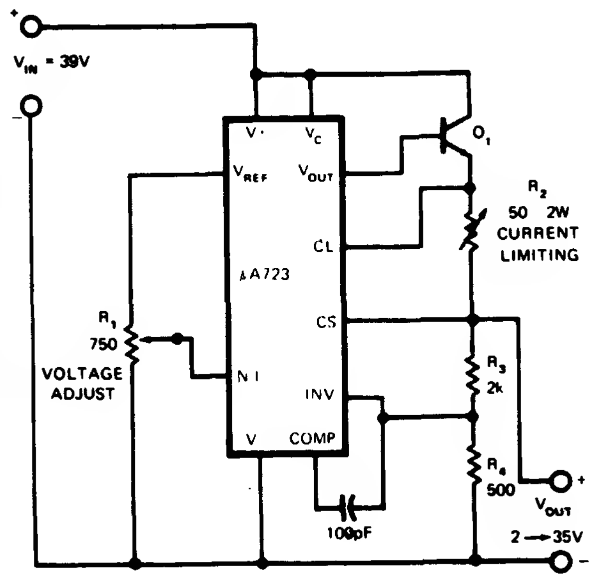


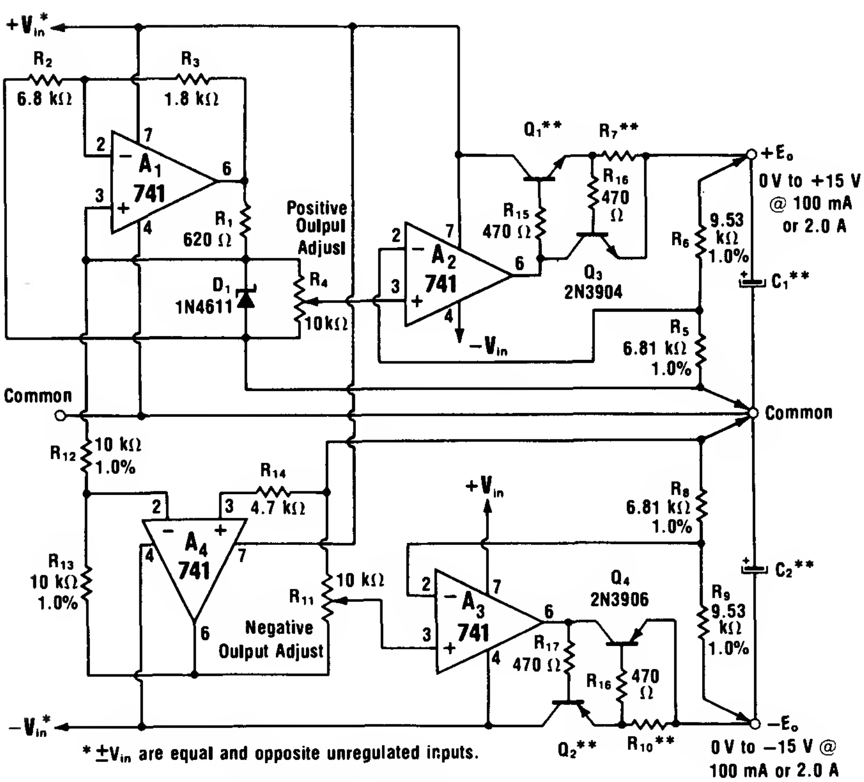
*Solid tantalum.



±15 V AT 10 A WITH FOLDBACK CURRENT LIMITING—Combination of Darlington pass transistors and current limiting is used with National LM125 dual tracking regulator to give high output currents with protection from short-circuits.—T. Smathers and N. Savvatopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-82, p 11.

2–35 V VARIABLE—Wide voltage range is achieved by using μA723 regulator IC in simple feedback arrangement requiring only single pot to vary output voltage continuously and linearly from 2 to 35 V. Resistors R_3 and R_4 divide output voltage by 5, so inverting input of regulator sees one-fifth of output voltage. R_1 is connected between 7-V reference of IC and ground to present any intermediate voltage to noninverting input. IC acts to keep these two voltages equal. Maximum input voltage limit is 40 V; if possibility of higher voltages exists in lab applications, protect IC with 40-V zener across it.—J. Gangi, Continuously Variable Voltage Regulator, *EDN Magazine*, Feb. 20, 1973, p 91.





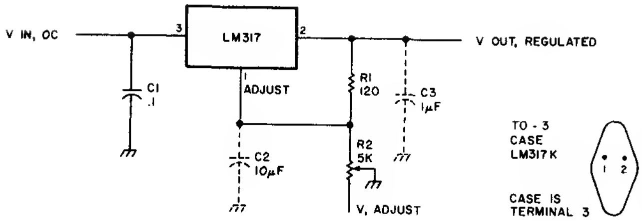
* $\pm V_{in}$ are equal and opposite unregulated inputs.

**Change listed components to meet required output current as follows:

	100 mA	2.0 A
Q_1	2N3766	2N6057†
Q_2	2N3740	2N6050†
R_7, R_{10}	4.7 Ω	0.25 Ω
C_1, C_2	100 μF	1000 μF

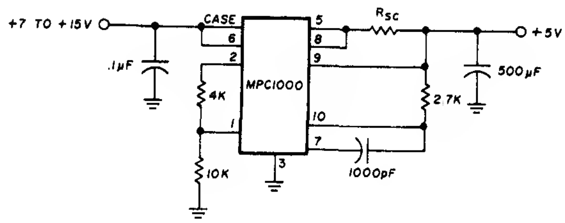
†Heat sink required.

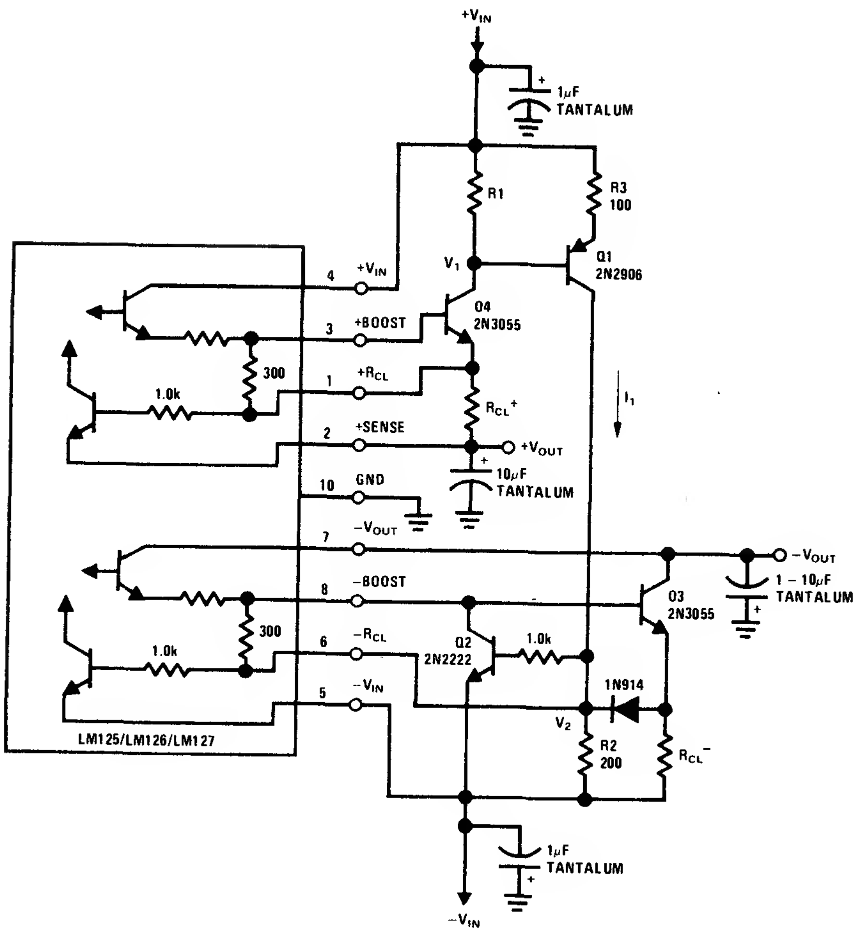
0 TO ±15 V INDEPENDENTLY VARIABLE—Common zener reference serves for both regulators. Buffer A_3 uses negative reference voltage developed from 6.6-V positive voltage across D_1 by inverter A_4. Both regulators provide 100 mA or 2 A depending on transistors used.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 162–164.



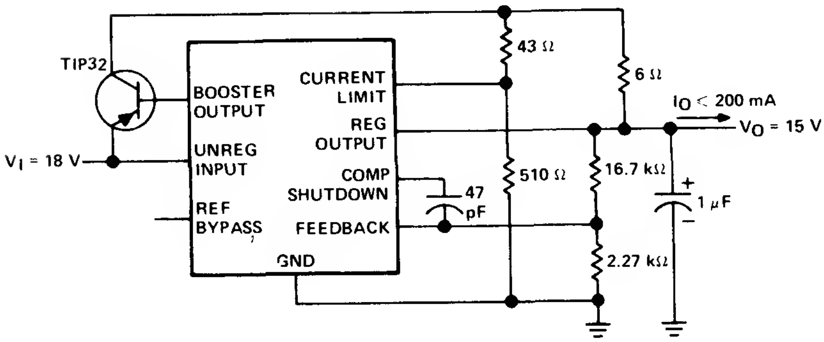
1.2–37 V AT 1.5 A—Uses National LM317 adjustable three-terminal positive voltage regulator. Output voltage is determined by ratio of R1 and R2. Output can be adjusted from 37 V down to 1.2 V with R2. If DC input is 40 V, regulation is about 0.1% at all settings when going from no load to full load. Regulator includes overload and thermal protection. If current limit is exceeded, regulator shuts down. C2 and C3 are optional; C2 improves ripple rejection, and C3 prevents instability when load capacitance is between 500 and 5000 pF.—Adjustable Bench Supply, *73 Magazine*, Dec. 1977, p 192–193.

+5 V AT 3 A—Uses Motorola MPC1000 positive voltage regulator to provide high current required for large TTL project. Current-limiting resistor R_{SC} is in range of 0.66 to 0.066 ohm. Use copper wire about 50% longer than calculated length and shorten step by step until required pass current is obtained; thus, start with 25 ft of No. 16, 15 ft of No. 16, 10 ft of No. 20, or 6 ft of No. 22.—G. L. Teter, The MPC1000—Super Regulator, *Ham Radio*, Sept. 1976, p 52–54.



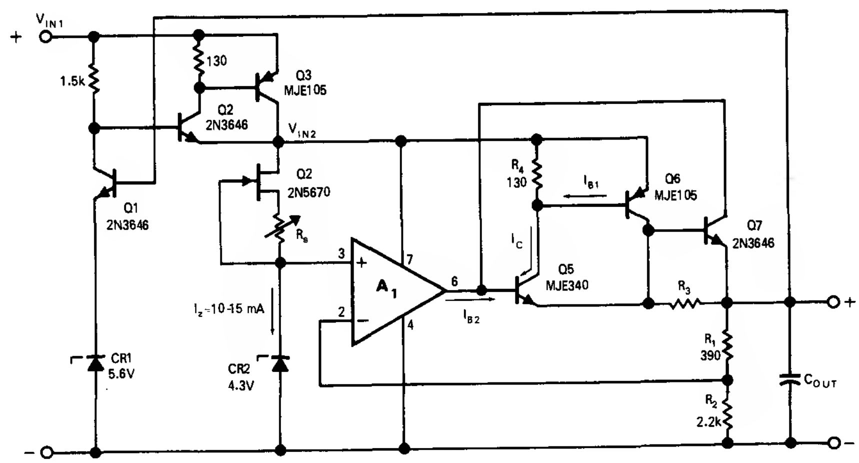


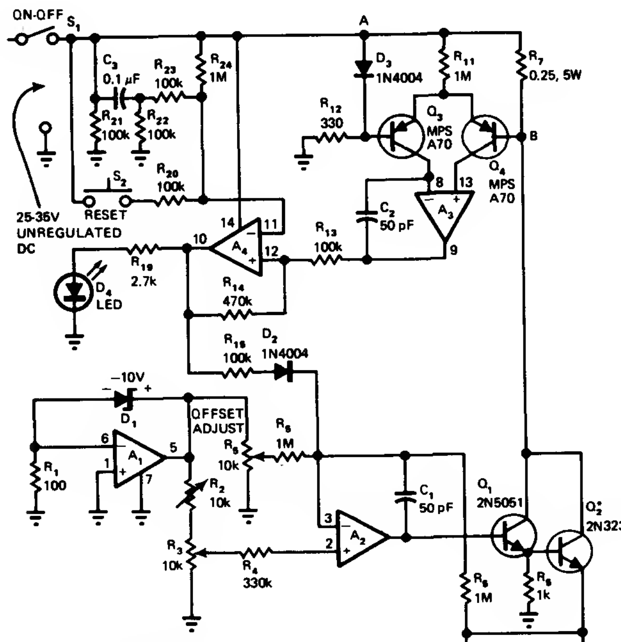
SIMULTANEOUS CURRENT LIMITING—Limiting action of circuit depends on output current of positive regulator but acts simultaneously on both positive and negative outputs of National LM125 dual tracking regulator. Positive output current produces voltage drop across R1 that makes Q1 conduct. When increase in current makes voltage drop across R2 equal negative current limit sense voltage, negative regulator will current-limit. Positive regulator closely follows negative output down to level of about 700 mV. Q2 turns off negative pass transistor during simultaneous current limiting. Output voltages are ±15 V.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-82, p 12–13.



15 V AT 200 mA—Linear regulator using Texas Instruments SN52105, SN72305, or SN72376 is connected for foldback current limiting. Regulators are interchangeable with LM105, LM305, and LM376 respectively. Load regulation is 0.1%, and input regulation is 0.1%/V.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 5-9.

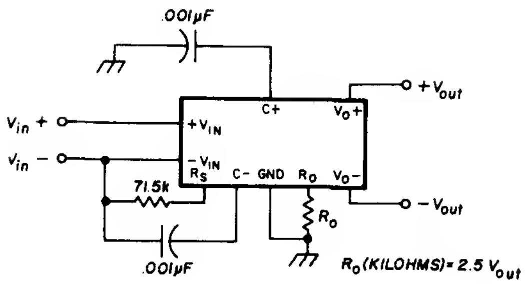
5 V AT 1 A—Use of Darlington at output boosts power rating of standard opamp voltage regulator circuit. Article gives step-by-step design procedure. With μA741 opamp, circuit gives good regulation along with short-circuit protection. AC ripple is less than 2 mV P-P. Required input of 30 V is obtained from conventional full-wave bridge rectifier with capacitor-input filter.—C. Brogado, IC Op Amps Simplify Regulator Design, *EDN/IEEE Magazine*, Jan. 15, 1972, p 30–34.



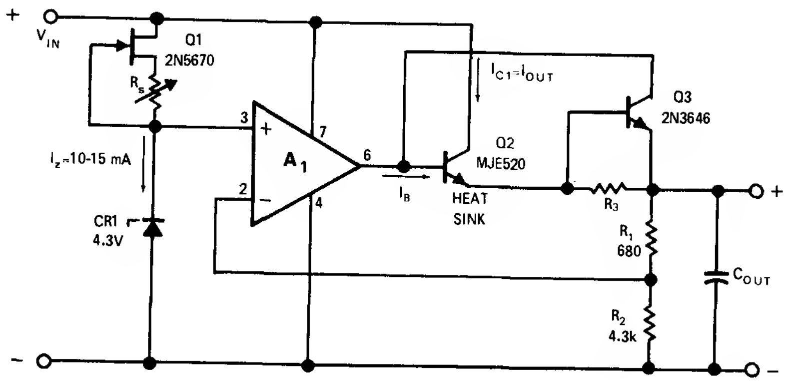


*Q_2 MUST BE ON A HEAT-SINK

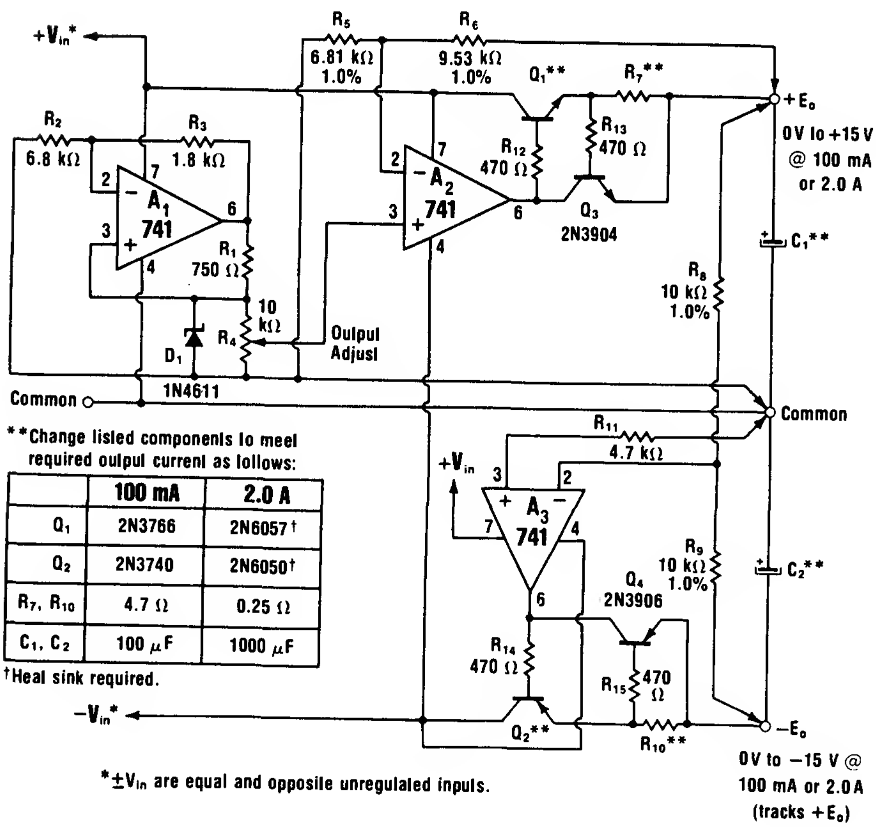
0–20 V AT 2 A—R_3 provides control of output voltage for regulator built around LM3900 quad Norton opamp. Output is well regulated against both line and load variations and is free of ripple. Opamp sections A_3 and A_4 provide overcurrent sensing and shutdown functions; after output fault is cleared, S_2 is closed momentarily to restore output power. Article describes circuit operation and initial setup in detail.—J. C. Hanisko and W. Wiseman, Variable Supply Built Around Quad Amp Outputs 2A, *EDN Magazine*, June 20, 1976, p 128 and 130.



VARIABLE DUAL-POLARITY—External resistor R_0 determines values of positive and negative regulated output voltages provided by Silicon General SG3501 dual regulator.—H. Olson, Second-Generation IC Voltage Regulators, *Ham Radio*, March 1977, p 31–37.



5 V AT 200 mA—Article gives step-by-step design procedure for developing special opamp regulator when commercial unit meeting desired specifications is not available. Opamp is μA741. Circuit gives good regulation along with short-circuit protection, with less than 2 mV P-P AC ripple. Required input of 20 V is obtained from conventional full-wave bridge rectifier with capacitor-input filter.—C. Brogado, IC Op Amps Simplify Regulator Design, *EDN/EEE Magazine*, Jan. 15, 1972, p 30–34.



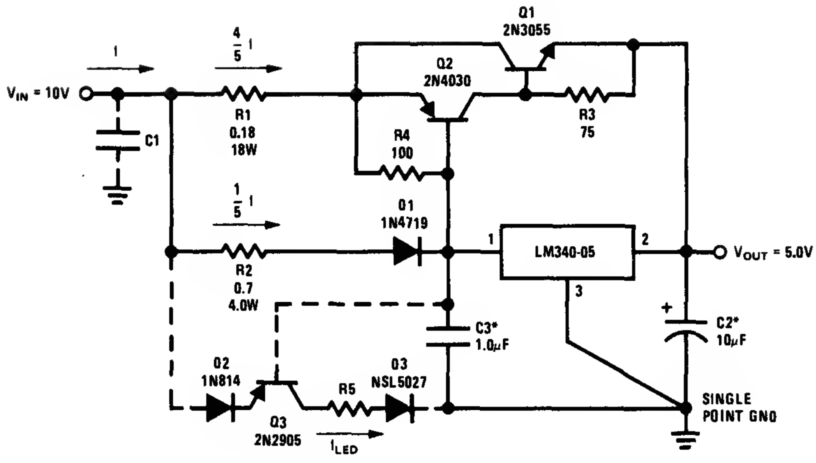
**Change listed components to meet required output current as follows:

	100 mA	2.0 A
Q_1	2N3766	2N6057†
Q_2	2N3740	2N6050†
R_7, R_{10}	4.7 Ω	0.25 Ω
C_1, C_2	100 μF	1000 μF

†Heat sink required.

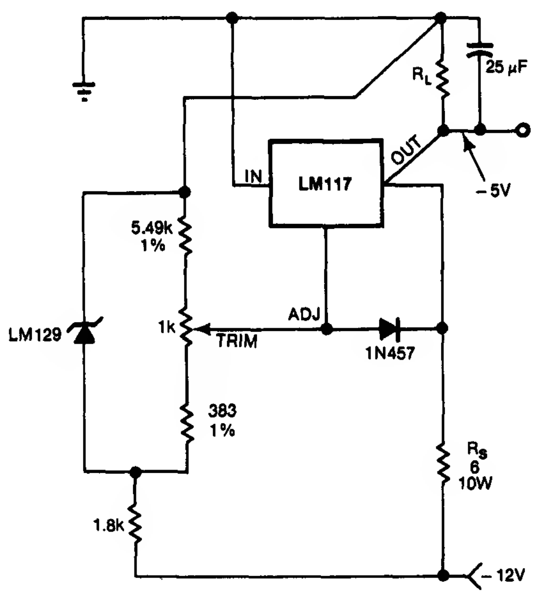
*±V_{in} are equal and opposite unregulated inputs.

0 TO ±15 V TRACKING AT 100 mA OR 2 A—Basic tracking regulator is combined with transistors to extend output to voltages higher than zener reference and provide higher output currents. Choice of transistors for Q_1 and Q_2 determines maximum load current.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 161–163.



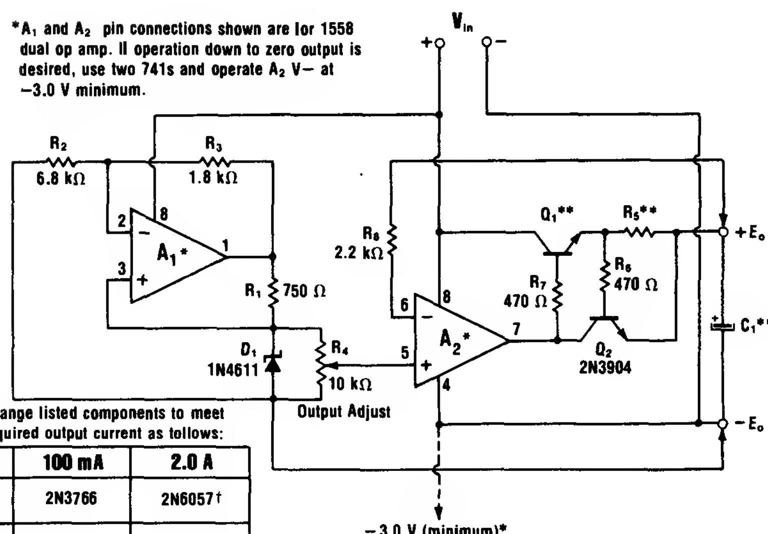
*Solid tantalum.

5 V AT 5 A FOR TTL—Typical load regulation is 1.8% from no load to full load. Q1 and Q2 serve in place of single higher-cost power PNP boost transistor. Dotted lines show how to add overload indicator using National NSL5027 LED and R2 as overload sensor. When load current exceeds 5 A, Q3 turns on and D3 lights. Circuit includes thermal shutdown and short-circuit protection.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 5.



NEGATIVE SHUNT REGULATION—Connection shown for LM117 positive series regulator provides spike-suppressing negative shunt regulation of −5 V output. With capacitor shown, regulator will withstand 75-V spikes on raw DC supply. For larger spikes, increase capacitor value.—P. Lefferts, Series Regulators Provide Shunt Regulation, *EDN Magazine*, Sept. 5, 1978, p 158 and 160.

*A_1 and A_2 pin connections shown are for 1558 dual op amp. If operation down to zero output is desired, use two 741s and operate A_2 V− at −3.0 V minimum.

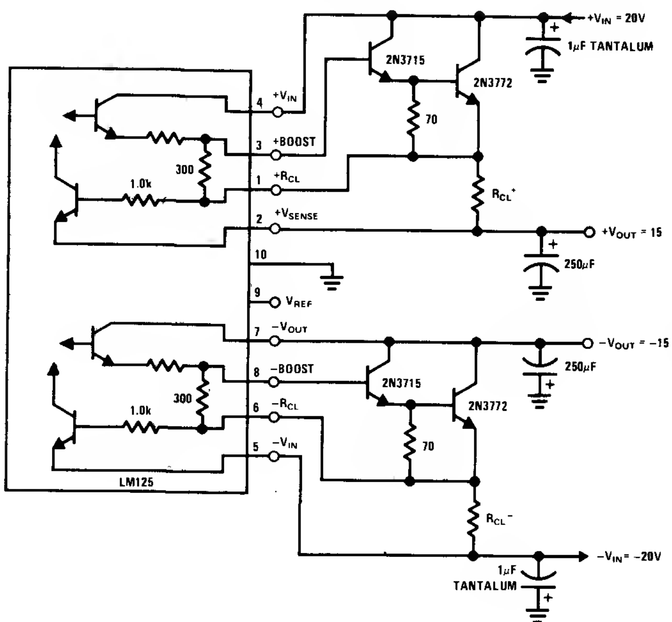


**Change listed components to meet required output current as follows:

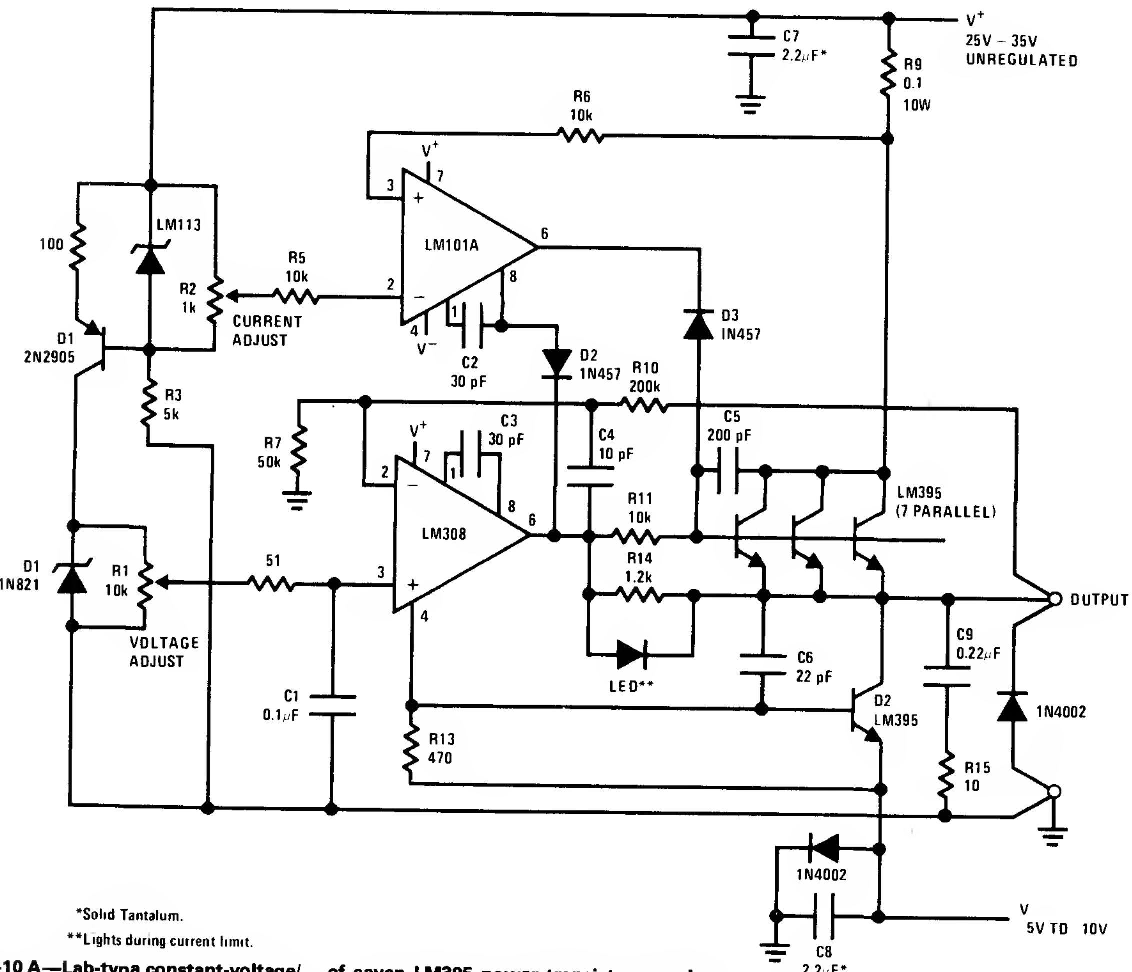
	100 mA	2.0 A
Q_1	2N3766	2N6057†
R_5	4.7 Ω	0.25 Ω
C_1	100 μF	1000 μF

†Heat sink required.

0–6.6 V AT 2 A—High-power circuit is suitable for low-voltage logic devices that require high current at supply voltages between 3 and 6 V. Maximum output of 2 A is obtained with 2N6057 Darlington pair for Q_1. Single 2N3766 can be used if load is only 100 mA. Q_2 provides short-circuit protection for Q_1. Since supply does not have to be adjusted down to 0 V, negative supply for A_2 can go to common negative of circuit. Optional connection to −3 V is used only when voltage range must go down to 0 V.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 157–158.

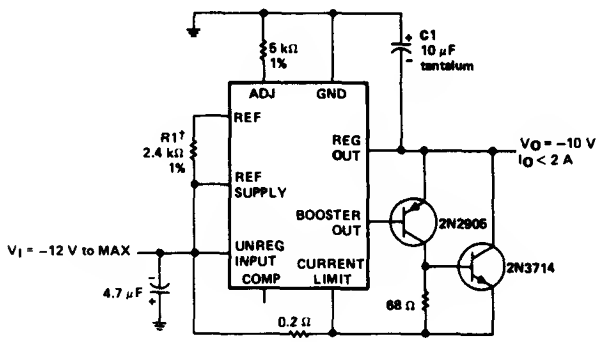


±15 V AT 7 A—External Derlington stages boost output currants of LM125 dual tracking regulator and incraase minimum input/output voltage diffarantial to 4.5 V. Maximum output currant is limited by power dissipation of 2N3772. Typical load ragulation is 40 mV from no loed to full loed.—T. Smathers end N. Sevastopoulos, "LM125/LM126/LM127 Precision Duel Tracking Regulators," Netional Samiconductor, Santa Clara, CA, 1974, AN-82, p 6.

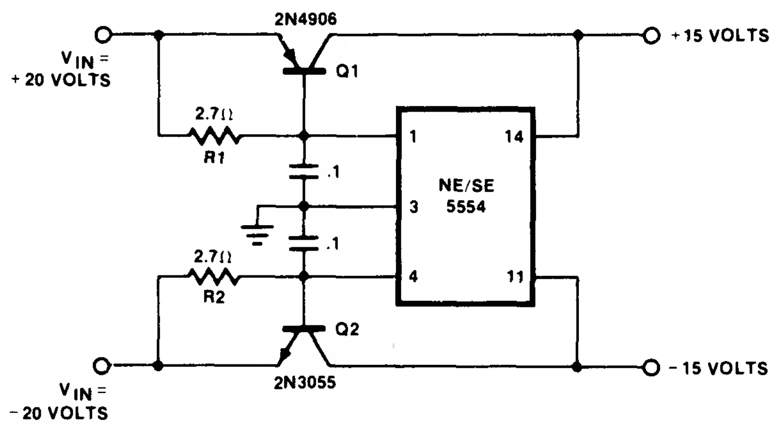


*Solid Tantalum.
**Lights during current limit.

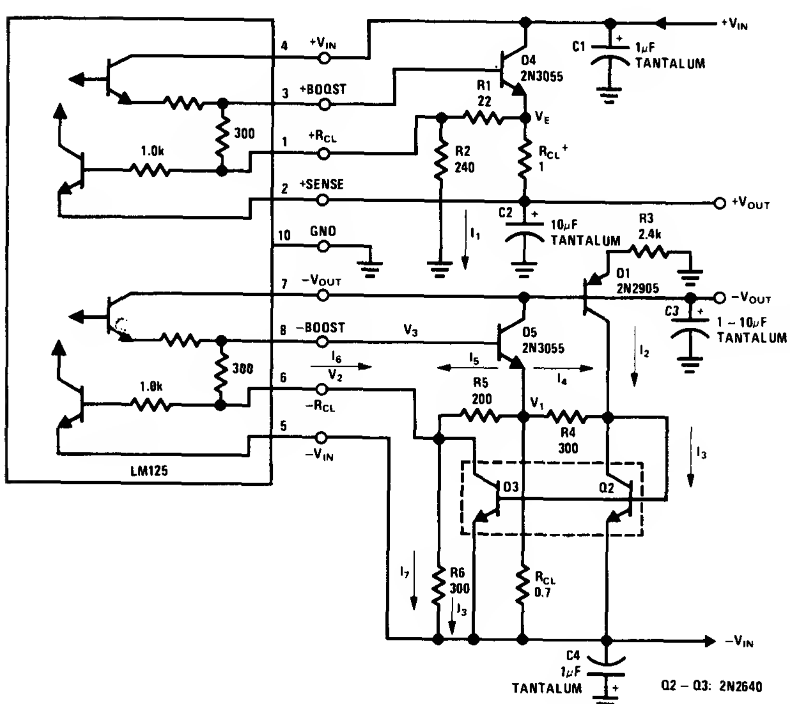
0–25 V AT 0–10 A—Lab-typa constant-voltage/constant-currant powar supply using standard ICs achiavas high current output by paralleling of saven LM395 powar transistors sarving as pass alemant. Current limiting is provided on LM395 chip for complete ovarload protaction.—"Lineer Applications, Vol. 2," National Samiconductor, Santa Clare, CA, 1976, LB-28.



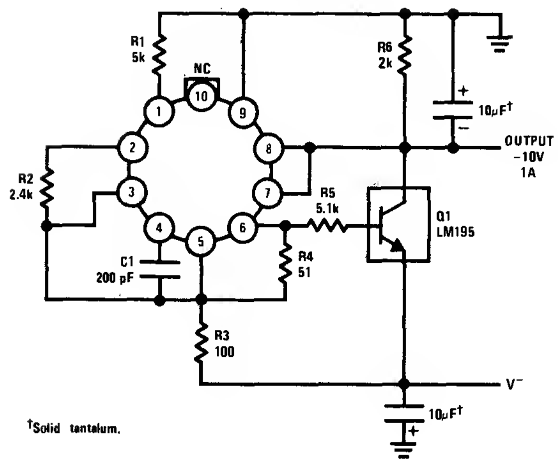
−10 V AT 2 A—Negative-voltage regulator using SN52104 or SN72304 accepts input voltage of −12 V to −40 V and uses only single external resistor to provide regulated output of −10 V with typical load regulation of 1 mV and input regulation of 0.06%. ICs are interchangeable with LM104 and LM304 respectively.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 5-5.



±15 V *TRACKING*—Single NE/SE5554 dual tracking regulator is used with pass transistors to give higher output current than 200-mA limit for each section of regulator, with close-tolerance tracking.—"Signetics Analog Data Manual," *Signetics*, Sunnyvale, CA, 1977, p 672–673.

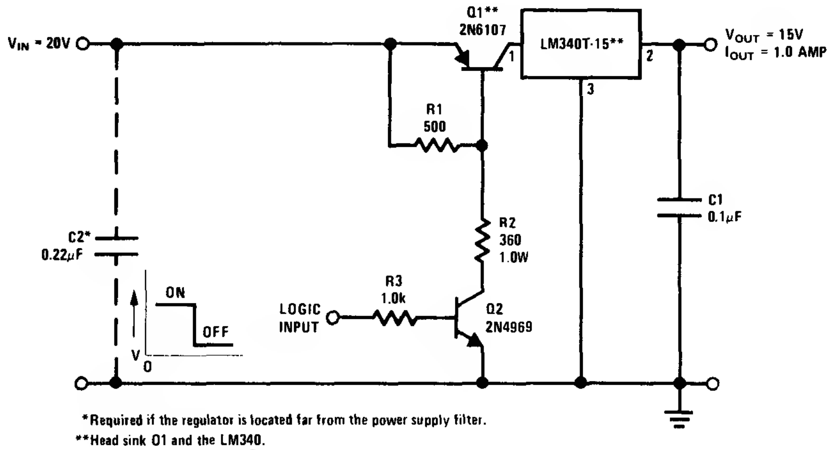


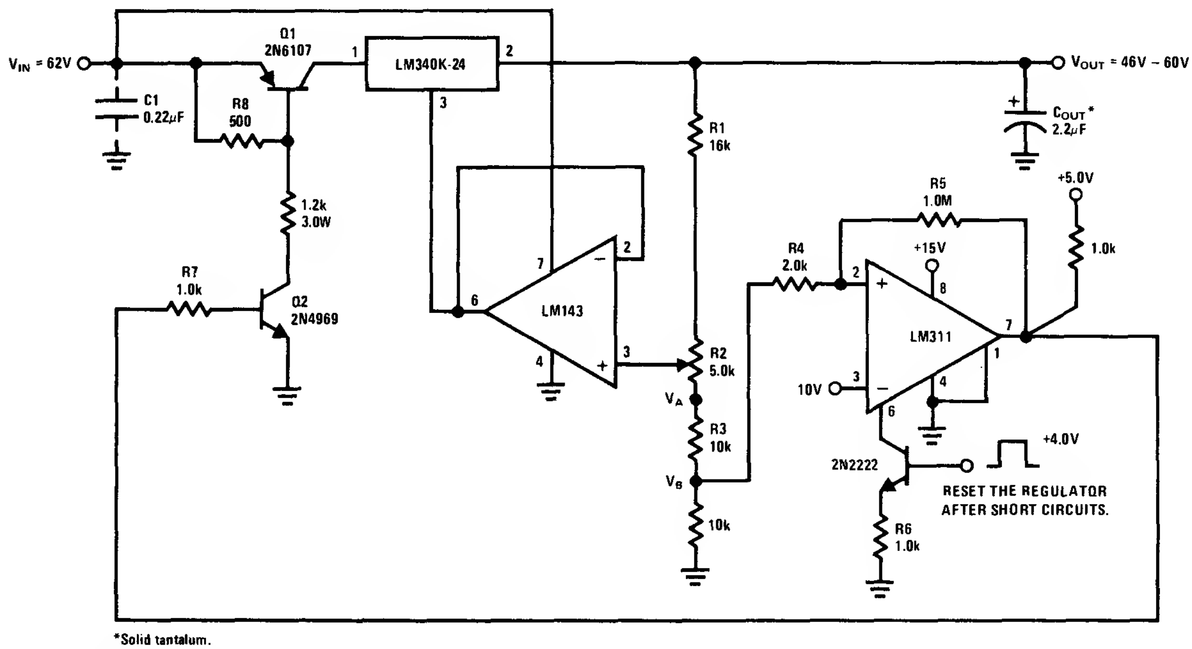
FOLDBACK CURRENT LIMITING—Reduces short-circuit output current of National LM125 dual tracking regulator sections to fraction of full-load output current, avoiding need for larger heatsink. Programmable current source is used to give constant voltage drop across R5 for negative regulator. Simple resistor divider serves same purpose for positive regulator. Design examples are given.—T. Smathers and N. Savastopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-82, p 7.



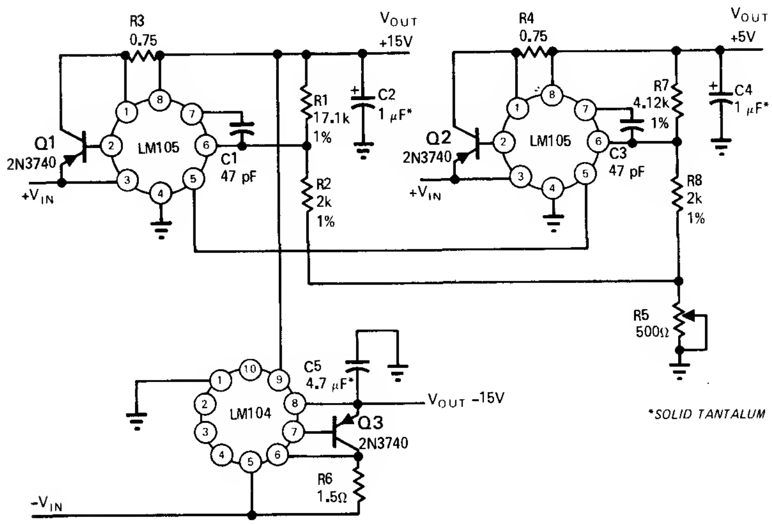
−10 V AT 1 A—National LM195 power transistor, used with LM105 regulator, provides full overload protection. Load regulation is better than 2 mV. Circuit requires only 2-V differential between input and output voltages.—R. Dobkin, "Fast IC Power Transistor with Thermal Protection," National Semiconductor, Santa Clara, CA, 1974, AN-110, p 5.

15 V AT 1 A WITH LOGIC SHUTDOWN—Arrangement shown provides practical method of shutting down LM340T-15 or similar regulator under control of TTL or DTL gate. Pass transistor Q1 operates as saturated transistor when logic input is high (2.4 V minimum for TTL) and Q2 is turned on. When logic input is low (below 0.4 V for TTL), Q2 and Q1 are off and regulator is in effect shut down.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 11.



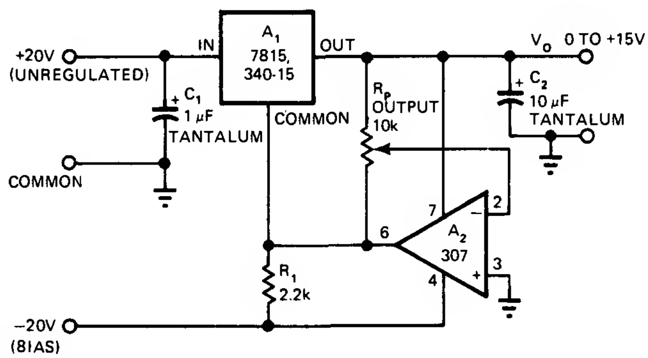


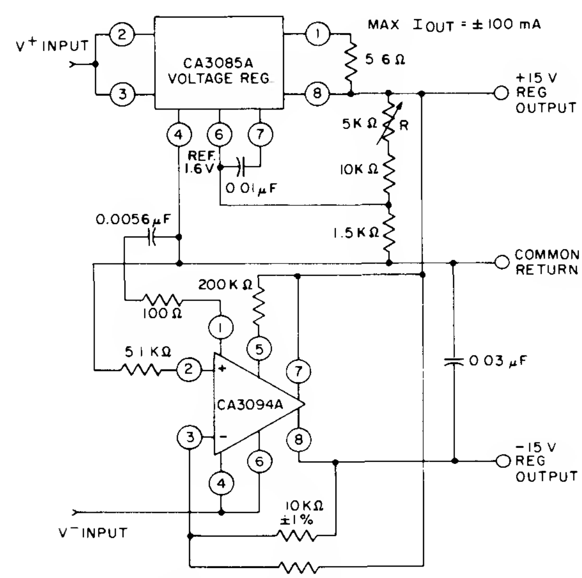
46–60 V FROM 62 V—Variable-output high-voltage regulator includes short-circuit and overvoltage protection. When LM340K-24 regulator has been shut down by shorted load, LM311 must be activated by applying 4-V strobe pulse to 2N2222 transistor to make Q1 close again and start regulator.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 11–12.



+15, +5, AND −15 V—Single potentiometer R5 serves for adjusting all three regulated output voltages simultaneously. Accuracy of adjustment is within 2%.—R. C. Dobkin, One Adjustment Controls Many Regulators, *EDN Magazine*, Nov. 1, 1970, p 33–35.

0–15 V—Addition of 307 or 301A opamp and three inexpensive components to standard three-terminal voltage regulator provides programming capability from maximum terminal voltage down to zero. With adequate heatsink, output current can be up to 1 A. Opamp A_2 provides floating reference voltage to normally grounded common terminal of A_1, with pot allowing ground to be positioned anywhere along voltage drop of 15 V across pot. Unregulated negative supply is not critical, and drain is 10 mA.—W. G. Jung, Three Components Program Regulator from Maximum to Zero, *EDN Magazine*, May 20, 1977, p 126 and 128.

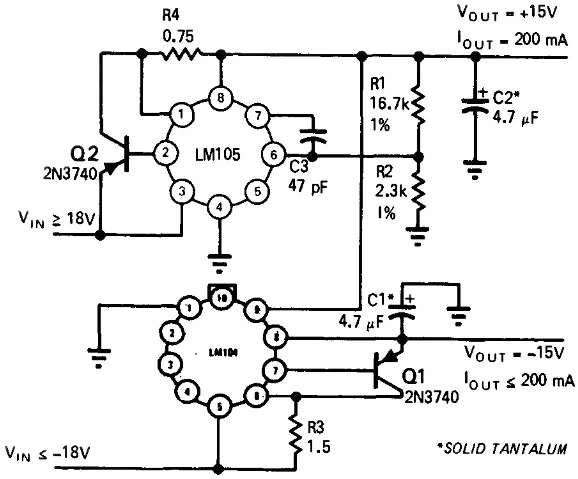




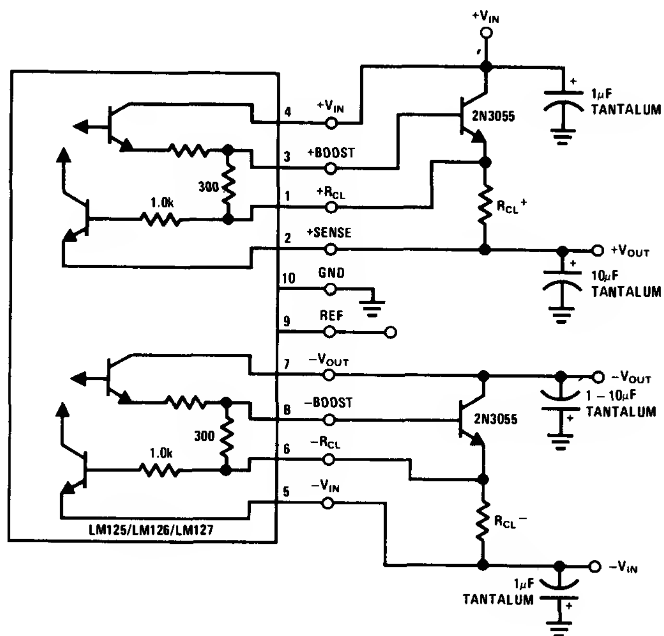
*V+ INPUT RANGE=19 TO 30 V FOR 15 V OUTPUT

**V− INPUT RANGE=−16 TO−30 V FOR-15 V OUTPUT

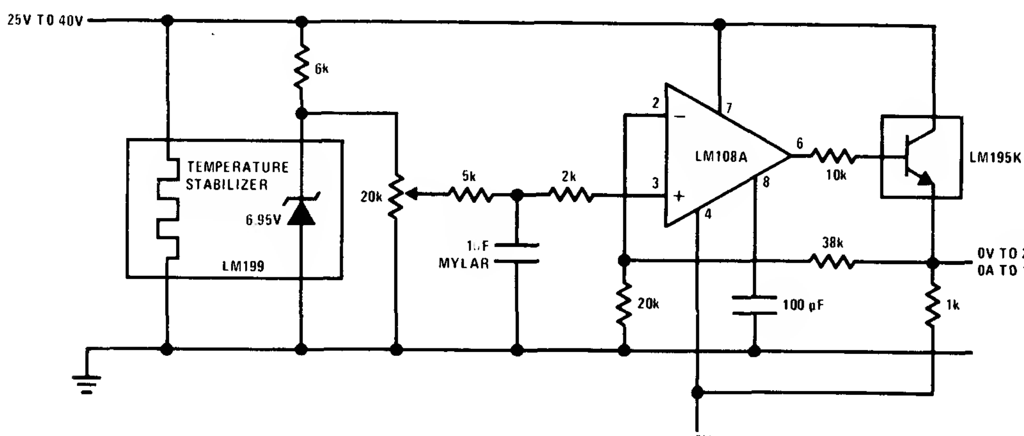
±15 V TRACKING AT 100 mA—Provides line and load regulation of 0.075% by using CA3094A programmable opamp and CA3085A series voltage regulator. V+ input range is 19 to 30 V for 15-V output, while V− input range is −16 to −30 V for −15 V output.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 18.



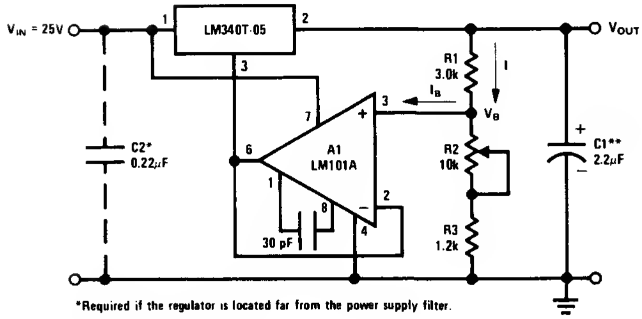
±15 V TRACKING—Arrangement uses LM104 negative regulator to track positive regulator, with both regulators adjusted simultaneously by changing R1. Inverting opamp can be added to provide negative output voltage while using positive voltage as reference.—R. C. Dobkin, One Adjustment Controls Many Regulators, *EDN Magazine*, Nov. 1, 1970, p 33–35.



BOOSTING OUTPUT CURRENT—External NPN pass transistor is added to each section of LM125 precision dual tracking regulator to increase maximum output current by factor equal to beta of transistor. To prevent overheating and destruction of pass transistors and resultant damage to regulator, series resistor R_{CL} is used to sense load current. When voltage drop across R_{CL} equals current-limit sense voltage in range of about 0.3 to 0.8 V (related to junction temperature), regulator will current-limit. Maximum load current is about 1 A for 25°C junction and 0.6 ohm for R_{CL}. LM125 provides ±15 V, LM126 provides ±12 V, and LM127 provides +5 V and −12 V.—T. Smathers and N. Sevastopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-82, p 5.



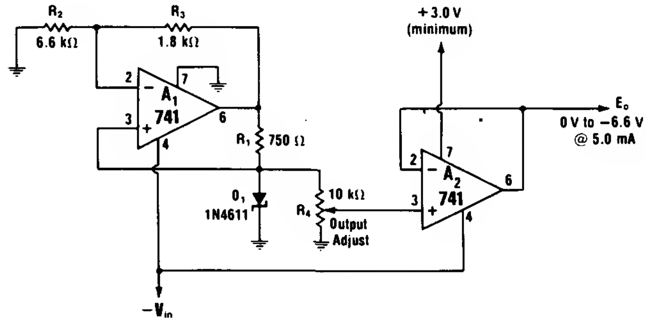
0–20 V HIGH-PRECISION—National LM199 temperature-stabilized 6.95-V reference feeds LM108A opamp that is buffered by LM195K power transistor IC which provides full overload protection.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-161, p 6.

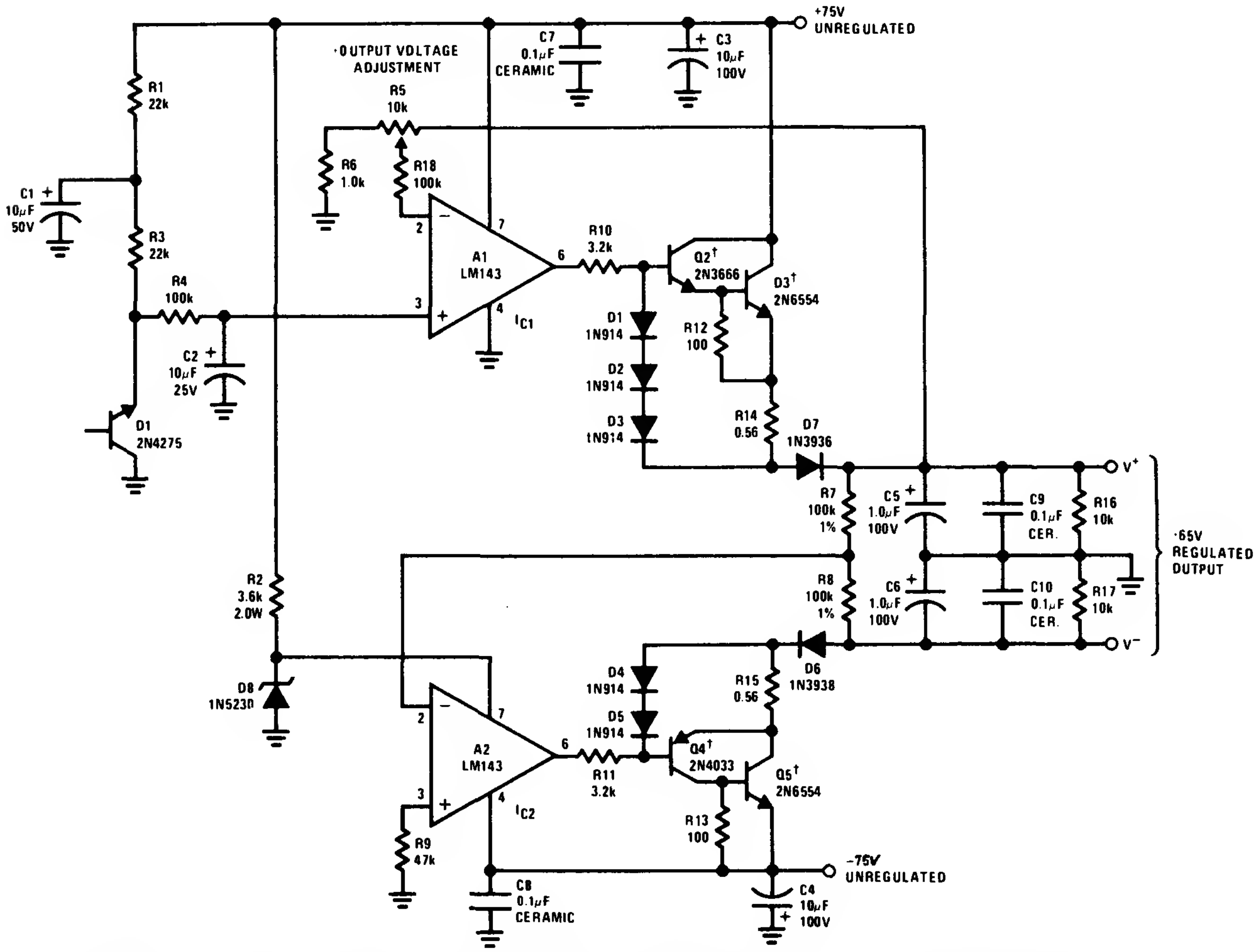


*Required if the regulator is located far from the power supply filter.
**Solid tantalum.

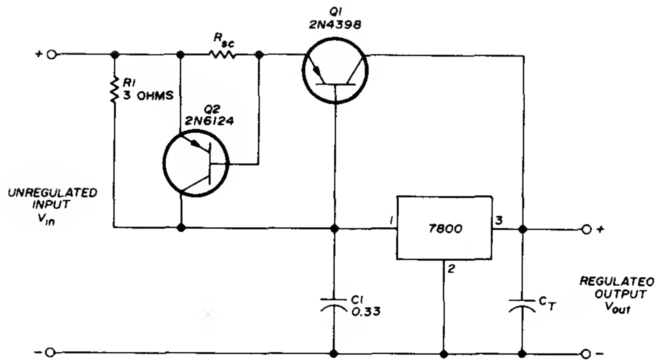
7–23 V AT 1.2–2 A—Ground terminal of LM340T-05 regulator is raised by amount equal to voltage applied to noninverting (+) input of opamp, to give output voltage set by R2 in resistive divider. Short-circuit protection and thermal shutdown are provided over full output range.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 6–7.

0 TO −6.6 V AT 5 mA—Voltage follower A_2 buffers output that can be adjusted over full range from 0 V to zener limit with R_4. Positive supply of A_2 must go to voltage slightly more positive than +3 V common if linear output operation is required over full range.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 159–160.



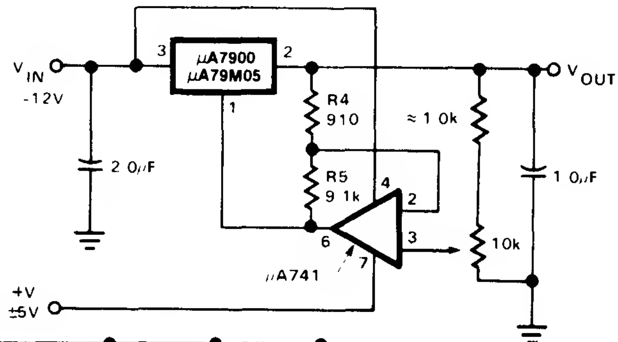


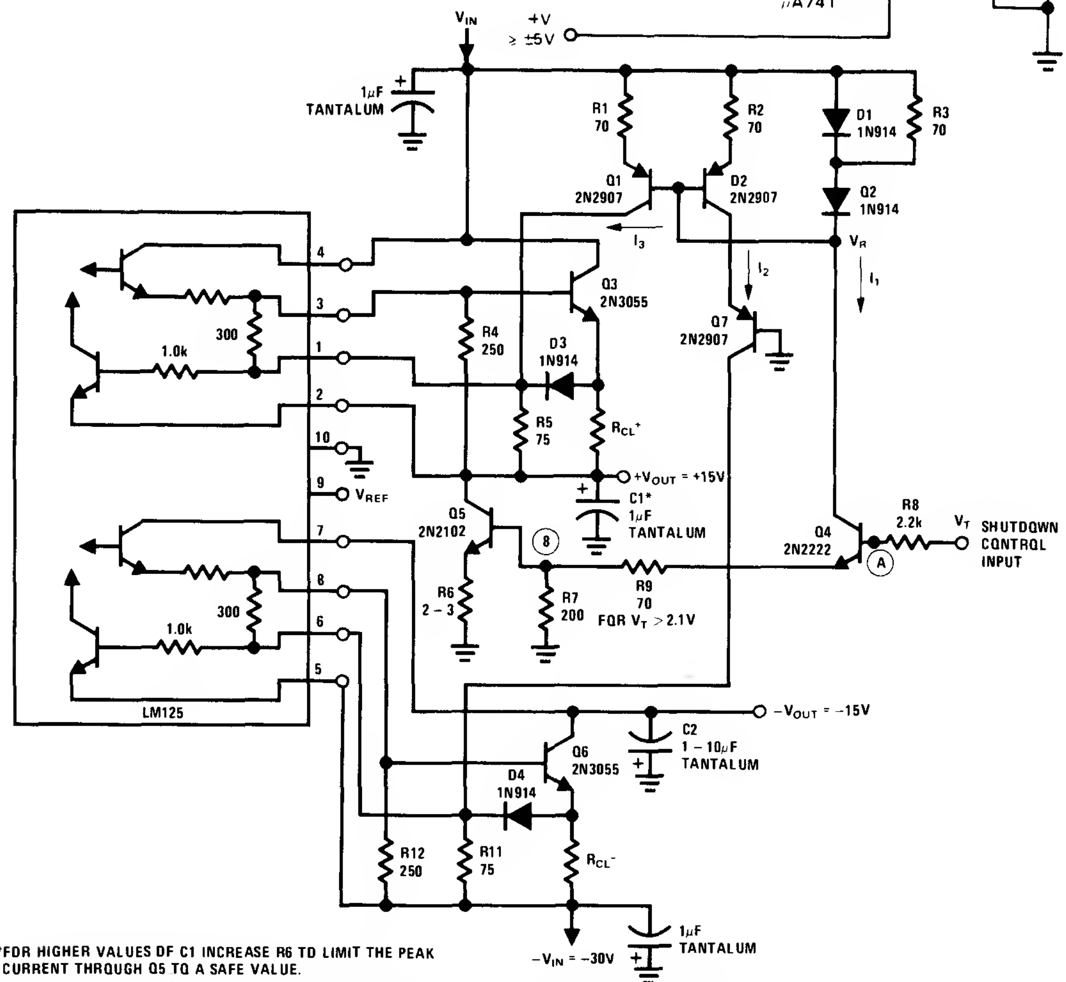
±65 V TRACKING AT 1 A—Circuit uses two LM143 high-voltage opamps in combination with zener reference and discrete power-transistor pass elements. Q1 is transistor used as stable 6.5-V zener voltage reference. Opamp A1 amplifies reference voltage from 1 to about 10 times for application through R10 to Darlington-connected transistors Q2 and Q3. Feedback resistor R5 is made variable so positive output voltage can be varied from 6.5 V to about 65 V. This output is applied to unity-gain inverting power opamp A2 to generate negative output voltage. Q2-Q5 should be on common Thermalloy 6006B or equivalent heatsink. Supply includes short-circuit protection. Maximum shorted load current is about 1.25 A.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-127, p 8–9.



5–24 V—Choice of regulator in 7800 series determines value of output voltage that is maintained within 0.05% of its actual value. Choose regulator for voltage desired. Unregulated input V_{in} must be at least 2 V higher than regulator rating. Transient suppression capacitor C_T is typically 10 to 50 μF. Output current is increased above IC rating by using PNP series-pass transistor Q1 which has maximum collector current of 30 A. Protection circuit Q2 prevents burnout of power transistor. Choose R_{sc} for limiting current value to desired value.—J. E. Trulove, Three-Terminal Voltage-Regulator ICs, *Ham Radio*, Dec. 1973, p 26–30.

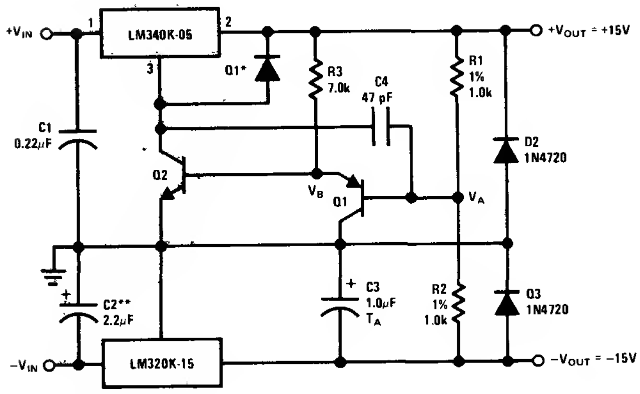
−10 V TO −0.5 V—Regulator in μA7900 series is used with 741 opamp to provide adjustable output voltage. Differential between input end output is 2 V.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 670.





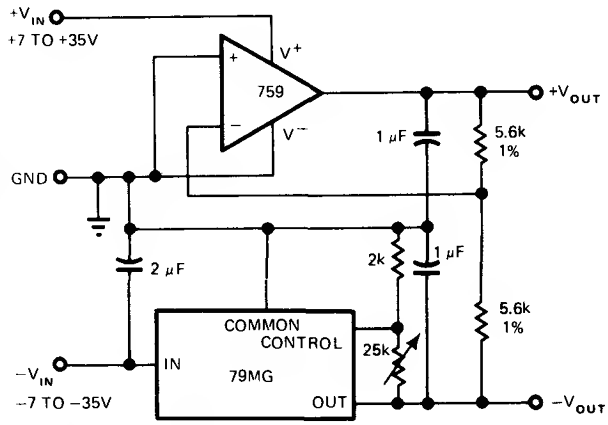
*FOR HIGHER VALUES OF C1 INCREASE R6 TO LIMIT THE PEAK CURRENT THROUGH Q5 TO A SAFE VALUE.

CURRENT BOOSTING WITH ELECTRONIC SHUTDOWN—Circuit provides complete shutdown for both sections of National LM125 dual tracking regulator without affecting unregulated inputs that may be powering additional equipment. Shutdown control signal is TTL-compatible, but regulator may be shut down at any desired level by adjusting values of R8 and R9. Control signal is used to short internal reference voltage of regulator to ground, thereby forcing positive and negative outputs to about +700 mV and +300 mV respectively. When shutdown signal is applied, Q4 draws current through R3 and D2, establishing voltage V_R that starts current sources Q1 and Q2. Currents I_1, I_2, and I_3 are then equal so both sides of regulator are shut down simultaneously.—T. Smathers and N. Sevastopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-82, p 14.

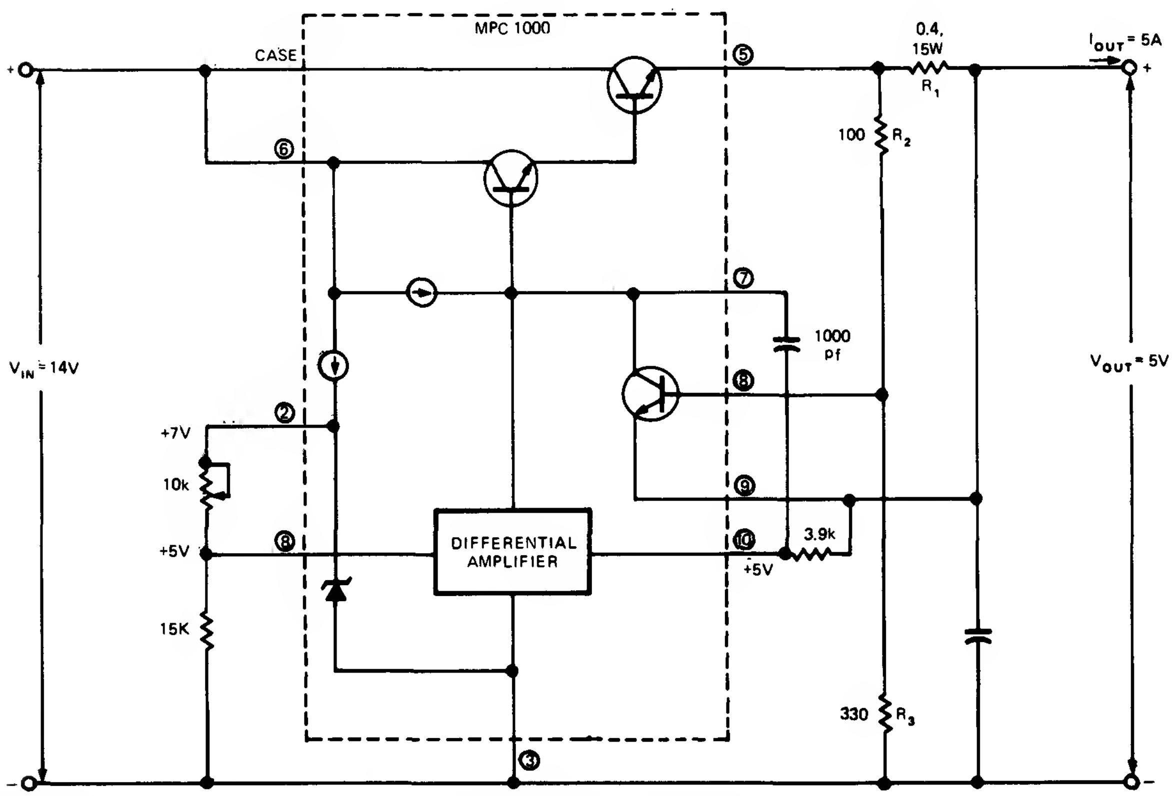


*Germanium diode.
**Solid tantalum.

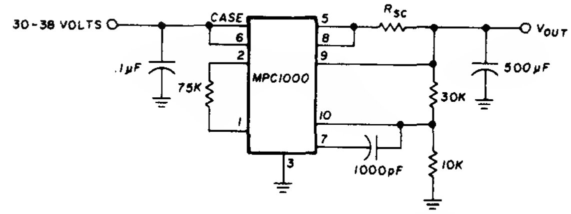
±15 V TRACKING AT 1 A—Positive regulator trecks negetive. If Q1 and Q2 ere perfectly matchad, trecking action is unchanged ovar full opareting tamperature range, with tracking better then 100 mV. Regulation from no loed to full load is 10 mV for positive side and 45 mV for negativa side.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 8–9.



DUAL TRACKING—Usas one 759 power opamp for positive output, connected to track with 79MG negative voltage regulator having adjustable output. Common-moda range of 79MG includes ground, permitting operation from single supply. Circuit cen also be built with two power opamps, one invarting end tha other noninverting.—R. J. Apfal, Power Op Amps—Their Innovative Circuits and Peckeging Provide Designers with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.

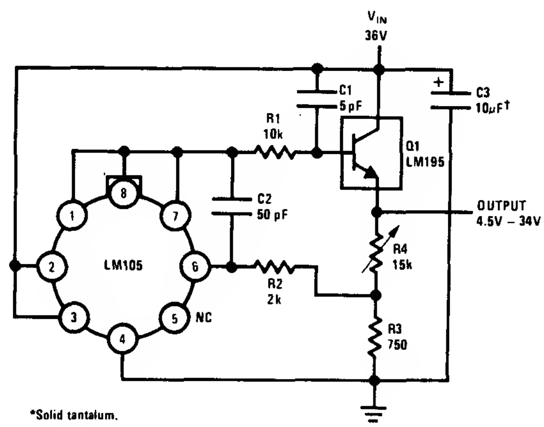


CURRENT-FOLDBACK PROTECTION—MPC1000 hybrid regulator provides regulated output of 5 V et 5 A from 14-V input. Velues of components are basad on foldback currant of 6 A and short-circuit currant of 2 A; this ensures that dissipation of regulator on short-circuit is lass than dissipation at rated load. Short-circuit currant is controllad by diode drop across R_1 end foldback current by drop across R_2. Article gives dasign aquetions and procedure for obtaining other output voltages. Circuit also sarves to limit starting surges into capacitiva load, and reduces heatsink size and transistor ratings. Returning R_3 to pin 2 of MPC1000 instead of pin 3 gives lowar short-circuit current, improves efficiency, and reduces heat generation. Foldback protection is not suitable for varlabla-output supplies bacausa foldbeck current is proportional to output voltege.—R. L. Haver, Use Current Foldback to Protect Your Voltaga Regulator, *EDN Magazine*, Aug. 20, 1974, p 69–72.

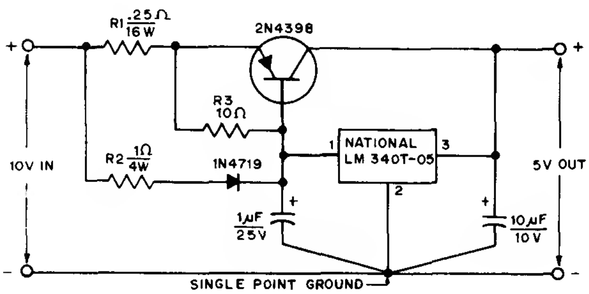


28 V AT 7 A—Uses Motorola MPC1000 positive voltage regulator to provide regulated voltage for aircraft radio equipment being used at ground station. Current-limiting resistor R_{SC} is in range of 0.66 to 0.066 ohm. Use copper wire about 50% longer than calculated length and shorten step by step until required pass current is obtained; thus, start with 25 ft of No. 16, 15 ft of No. 16, 10 ft of No. 20, or 6 ft of No. 22. Input voltage is obtained from 30-V transformer and bridge rectifier.—G. L. Tatar, The MPC1000—Super Regulator, *Ham Radio,* Sept. 1976, p 52–54.

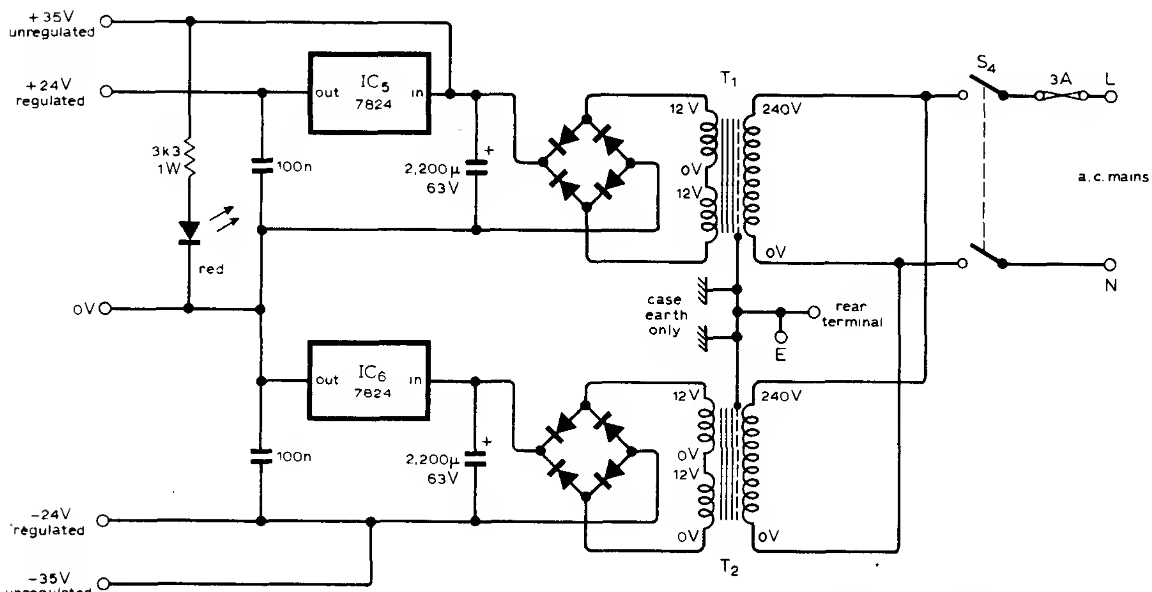
4.5–34 V VARIABLE AT 1 A—National LM195 power transistor is used with LM105 regulator to give fully adjustable range of output voltages with overload protection and only 2-V input-to-output voltage differential. Load regulation is better than 2 mV.—R. Dobkin, "Fast IC Power Transistor with Thermal Protection," National Semiconductor, Santa Clara, CA, 1974, AN-110, p 4.



*Solid tantalum.

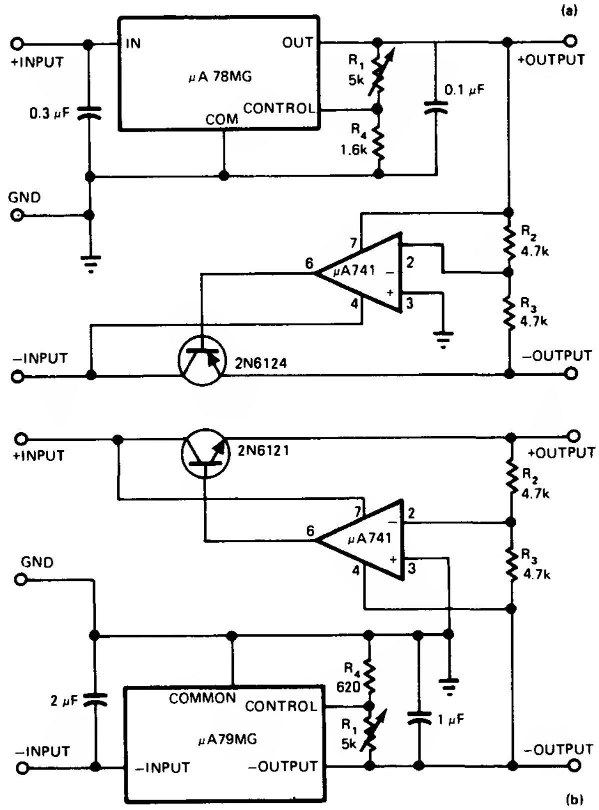


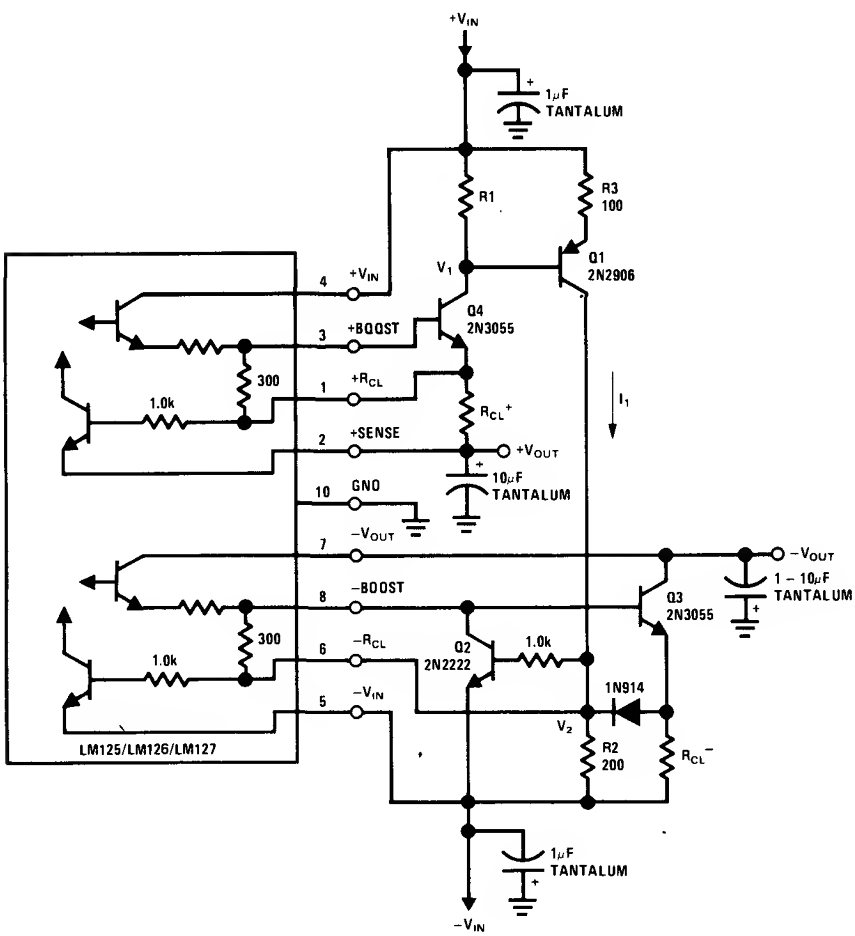
5 V AT 5 A—Current-sharing design provides short-circuit protection, safe-operating-area protection, and thermal shutdown. Typical load regulation is 1.4%.—W. R. Calbo, A High-Current, Low-Voltage Regulator for TTL Circuits, *QST,* Sept. 1975, p 44.



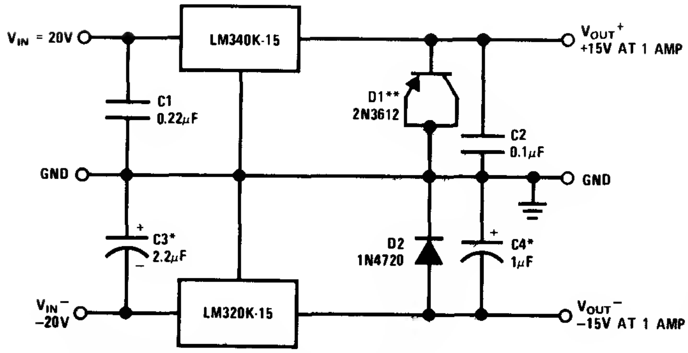
±24 V REGULATED AND ±35 V UNREGULATED—Developed for use with high-performance stereo preamp. Each IC regulator requires about 7 cm² of heatsink area. Red LED is TIL209 or equivalent.—D. Self, Advanced Preamplifier Design, *Wireless World,* Nov. 1976, p 41–46.

SLAVED DUAL TRACKING REGULATOR—Uses Fairchild μA78MG adjustable four-terminal regulator with opamp end power transistor for delivering output currents up to 0.5 A par sida, with output voltages adjustable from ±5 V to ±20 V for componant valuas shown. Positiva side functions independently of negative sida, but nagative output is slave of positive output. To slave positive side, use μA79MG end 2N6121 NPN transistor es et (b). Opamp functions as inverting emplifier driving power transistor serving es series-pass element for opposite side of regulator, with R_1 adjusting both output voltages simultaneously.—A. Adamien, Dual Adjustable Tracking Regulator Dalivers 0.5A/Side, *EDN Magazine*, Jen. 5, 1977, p 42.



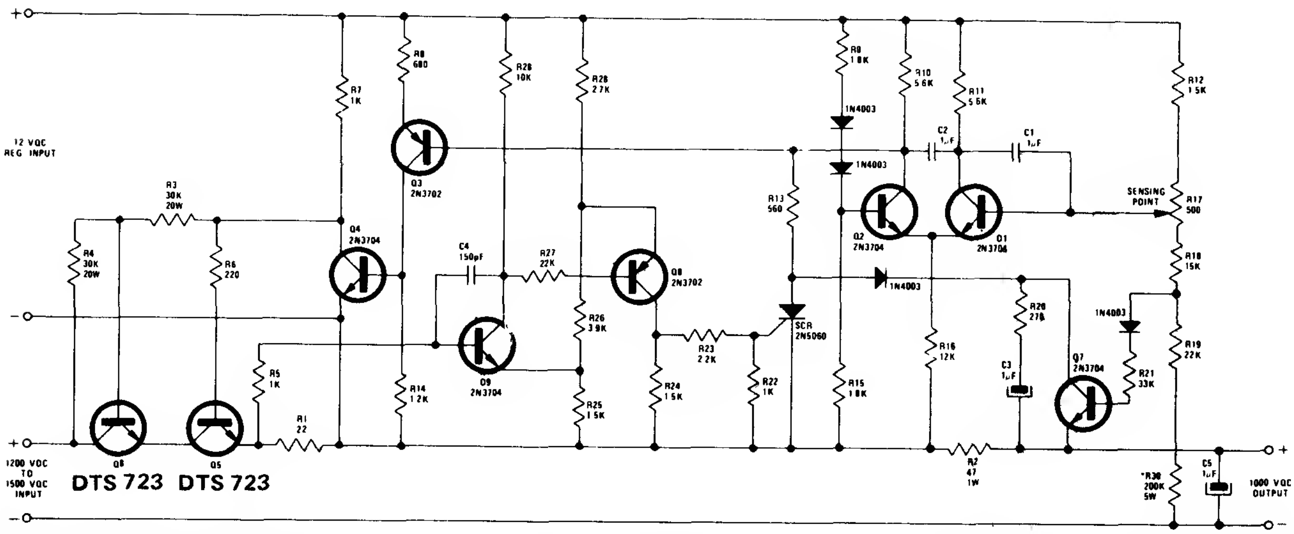


TRACKED CURRENT LIMITING—Simultaneous limiting schame for both sections of Netional dual tracking regulstor depends on output current of positiva regulator. Voltage drop produced across R1 by positive regulator brings Q1 into conduction, with positive load current I_1 incraasing until voltage drop across R2 equals negative currant-limit sensa voltaga. Nagativa regulator will then current-limit, and positive side will closely follow nagative output down to level of about 700 mV.—T. Smathars and N. Savastopoulos, "LM125/LM126/LM127 Precision Dual Tracking Regulators," National Semiconductor, Santa Clara, CA, 1974, AN-82, p 13.

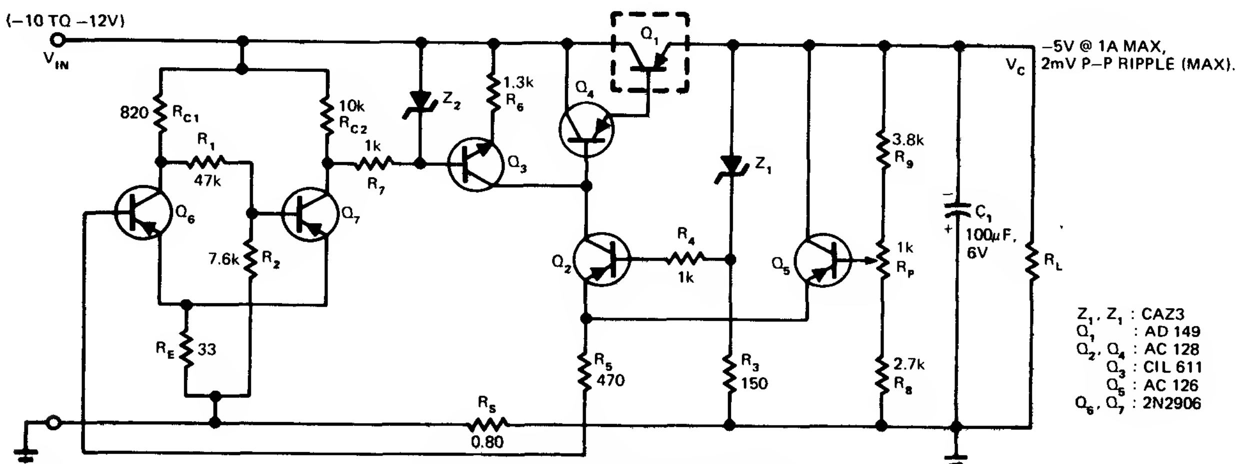


*Solid tantalum.
**Germanium diode (using a PNP germanium transistor with the collector shorted to the emitter).
Note: C1 and C2 required if regulators are located far from power supply filter.

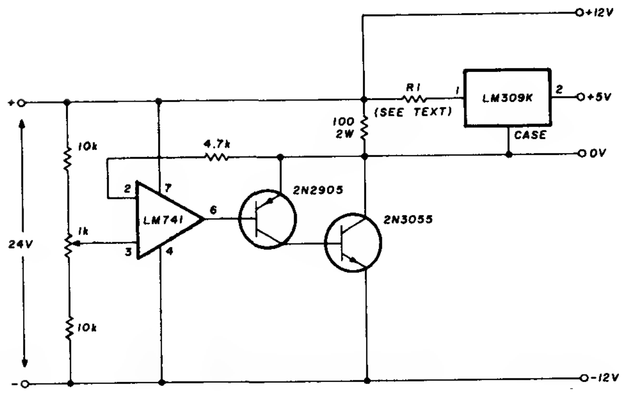
±15 V SYMMETRICAL AT 1 A—Connection shown gives same line and load regulation characteristics as for individual regulators. D1 ensures start-up of LM340K-15 under worst-case conditions of common load and 1-A load current over full temperature range.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-103, p 8.



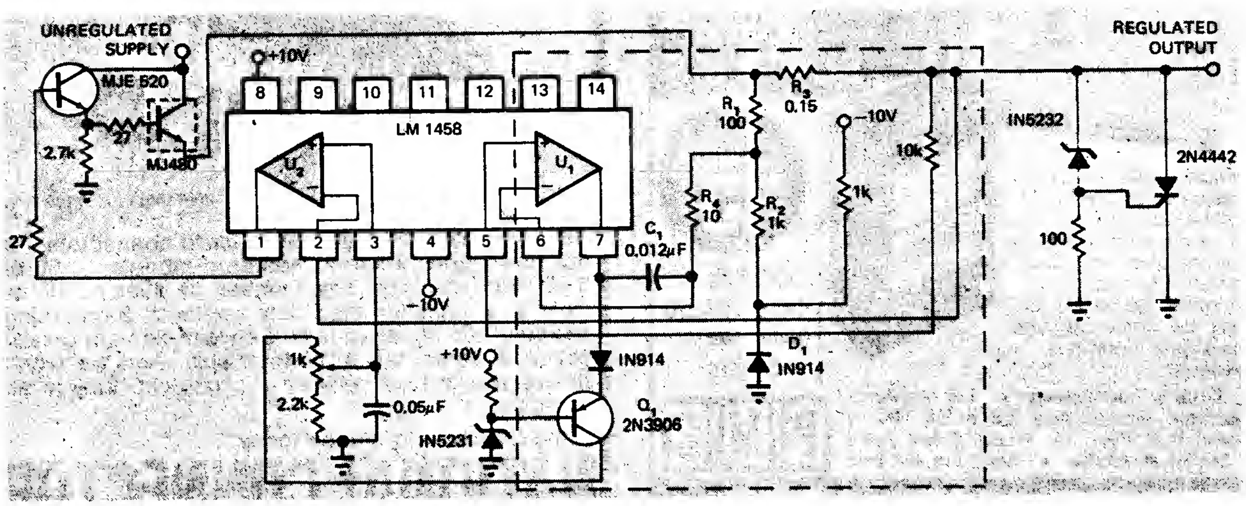
1000 V AT 100 W—Two Delco DTS-723 transistors in series function as pass element of regulator in which differential amplifier Q1-Q2 senses output voltage and compares it with reference voltage at base of Q2. Difference signal is amplified by Q3-Q4 for feed to Q5. 12-V regulated supply is referenced to high side of output voltage through R2. R1 is chosen so regulator shuts down when load current reaches 120 mA and triggers Schmitt trigger Q8-Q9 which fires SCR. When overload is removed, circuit returns to normal operation. Input voltage range of 1200–1500 V gives 0.1% regulation at full load.—"1000-Volt Linear DC Regulator," Delco, Kokomo, IN, 1974, Application Note 45.



−5 V WITH PROTECTION—Switching-type short-circuit protection network uses R_7 connected to Schmitt trigger Q_6-Q_7. Ground is provided by Q_7 which is normally conducting. If output of regulator is short-circuited, current through Q_1 increases; at predetermined limit, Q_6 conducts and cuts off Q_7, breaking ground connection of R_7 and thus cutting off Q_3. Power transistor Q_1 is also cut off, and output current begins to decrease. When load current drops below another predetermined level, Q_6 again goes off and Q_7 turns on to begin another ON/OFF cycle, with switching process continuing until short-circuit is removed.—H. S. Raina and R. K. Misra, Novel Circuit Provides Short Circuit Protection, *EDN Magazine*, June 5, 1974, p 84.



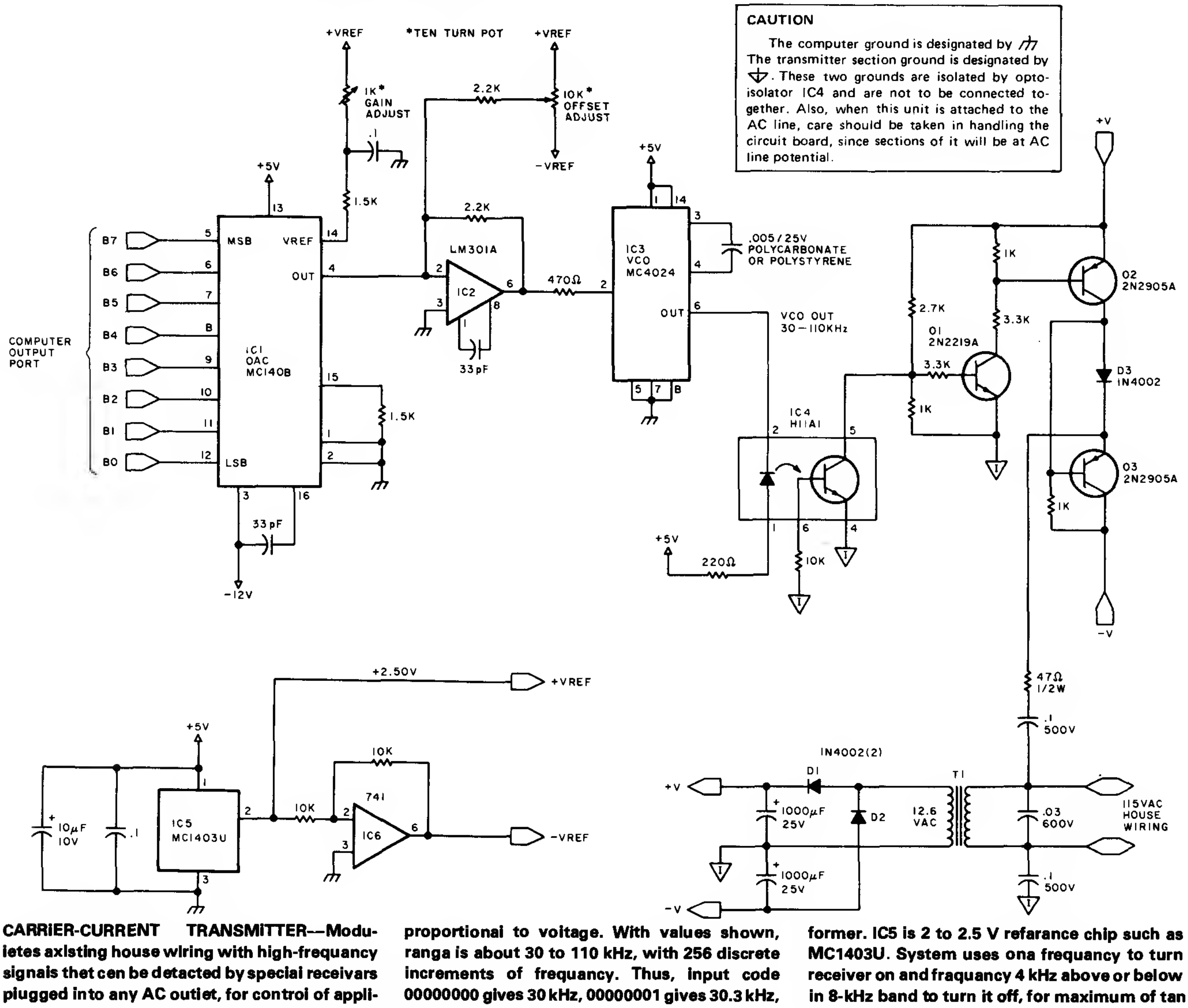
VOLTAGE ADAPTER—Bench power supply provides ±12 V and +5 V from single regulated 24-V source, for use with many ICs. Both 12-V supplies can be adjusted in same direction by varying 24-V source or in opposite directions by adjusting 1K pot. R1 is used to decrease power dissipated in LM309K voltage regulator and is normally 2.2 ohms.—J. A. Piet, Voltage Adapter for MSI/LSI Circuits, *Ham Radio*, March 1978, p 115.



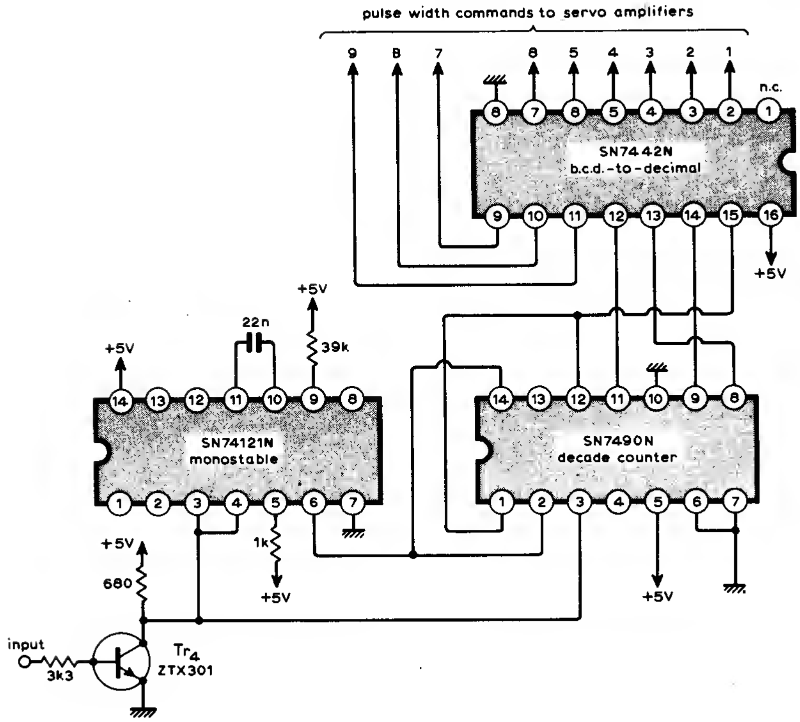
OVERVOLTAGE CROWBAR—Components within dashed lines protect regulator IC from overcurrent condition frequently encountered when zener-SCR crowbar is used across output. Regulated output is 5 V with IC shown. Article gives operating details of circuit and equation for shutdown time, which is about 1 s.—S. J. Pirkle, Circuit Protects Power Supply Regulator from Overcurrent, *EDN Magazine*, Feb. 5, 1973, p 89.

CHAPTER 75
Remote Control Circuits

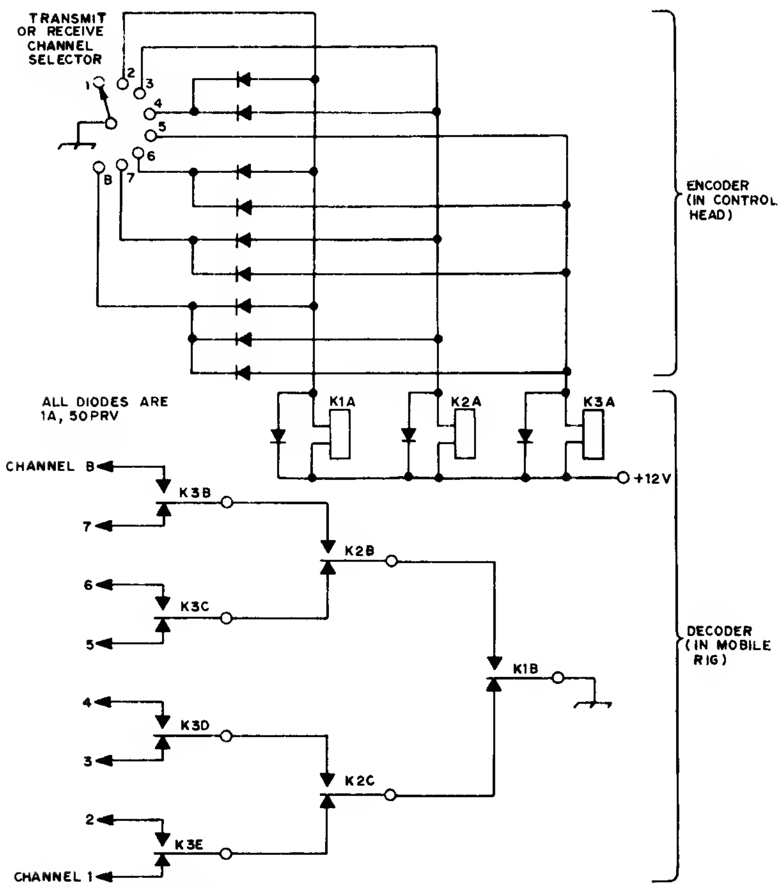
Wired, wireless, light-beam, and other techniques are given for controlling transmitters, transceivers, receivers, motors, and other switched devices from a distance, including use of tone coders and decoders. See also Data Transmission, Instrumentation, Optoelectronic, and Repeater chapters.



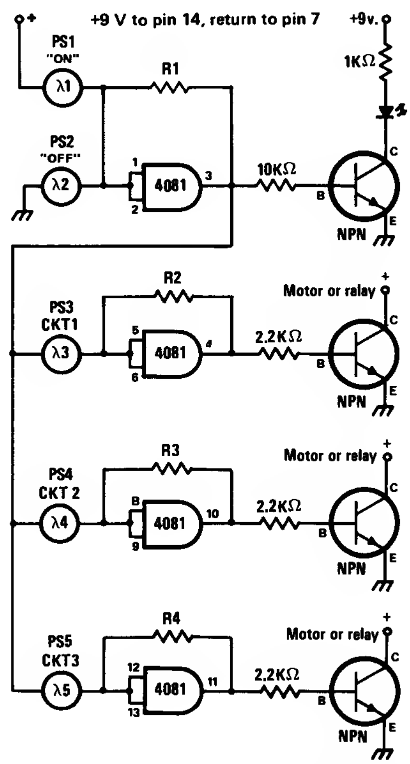
CARRIER-CURRENT TRANSMITTER—Modulates existing house wiring with high-frequency signals that can be detected by special receivers plugged into any AC outlet, for control of appliances by home computer. Applications include turning house lights on and off during owner's absence on elaborate time schedule programmed into computer. IC1 converts 8-bit data word from computer to proportional analog output current. This is converted to voltage by IC2 for control of VCO IC3 that gives frequency proportional to voltage. With values shown, range is about 30 to 110 kHz, with 256 discrete increments of frequency. Thus, input code 00000000 gives 30 kHz, 00000001 gives 30.3 kHz, and 01000000 (decimal 64) gives 49.2 kHz. Signal is applied to house wiring by 0.5-W power amplifier Q1-Q3, using optical coupling through IC4 to prevent computer circuit from interacting with house wiring. Supply voltage ±V is 11 to 13 V. T1 is 12.6-VAC 300-mA filament transformer. IC5 is 2 to 2.5 V reference chip such as MC1403U. System uses one frequency to turn receiver on and frequency 4 kHz above or below in 8-kHz band to turn it off, for maximum of ten control channels in system. Article covers calibration of transmitter.—S. Ciarcia, Tune in and Turn on, Part 1: A Computerized Wireless AC Control System, *BYTE*, April 1978, p 114–116, 118, 120, and 122–125 (Part 2—May 1978, p 97–100 and 102).



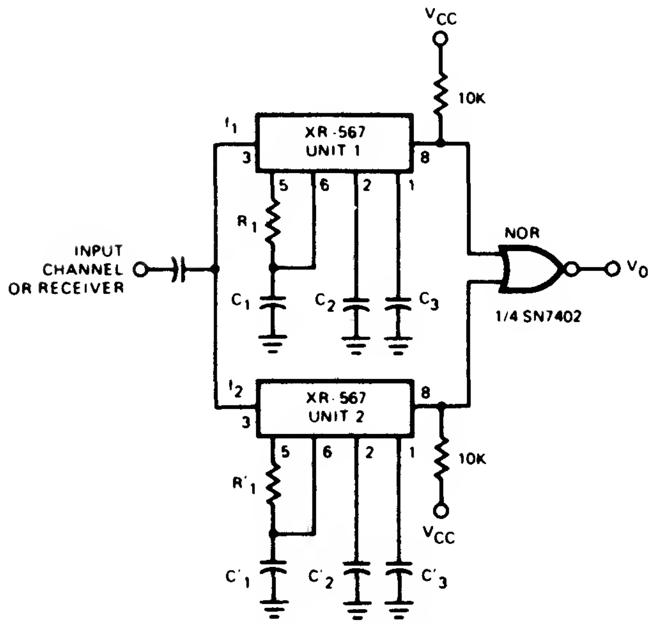
NINE-CHANNEL DECODER—Circuit accepts serial information arriving over data link as series of nine varying-width pulses followed by fixed-width sync pulse, and after detection passes the nine individual commands to their respective servoamplifiers. Use of TTL ICs gives low component count for remote control system. Detection of sync pulse is done by comparing length of inverted input pulses with output of 0.6-ms monostable reference. All command pulses exceed 0.6 ms, so only 0.5-ms sync pulse clears counter to prepare for next channel-1 command pulse. Article gives operating details of system and circuits for coder and servoamplifier.—M. F. Bessant, Multi-Channel Proportional Remote Control, *Wireless World*, Oct. 1973, p 479–482.



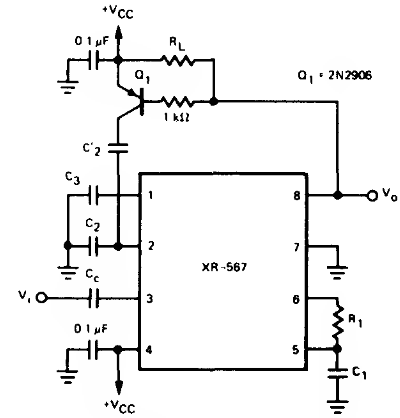
8 CHOICES WITH 3 WIRES—Provides remotely selected choice of eight functions, such as channels in mobile FM station, with only three wires running from control head to controlled equipment that can be in front of car. System involves converting 8-position switch selection in control head to 3-bit binary form for three control wires going to three-relay arrangement for decoding back to 8-position format. Relays are two-pole and four-pole double-throw 12-V units.—G. D. Rosa, Independent 8-Channel Frequency Selection with Only Three Wires, *QST*, Aug. 1974, p 36–40.



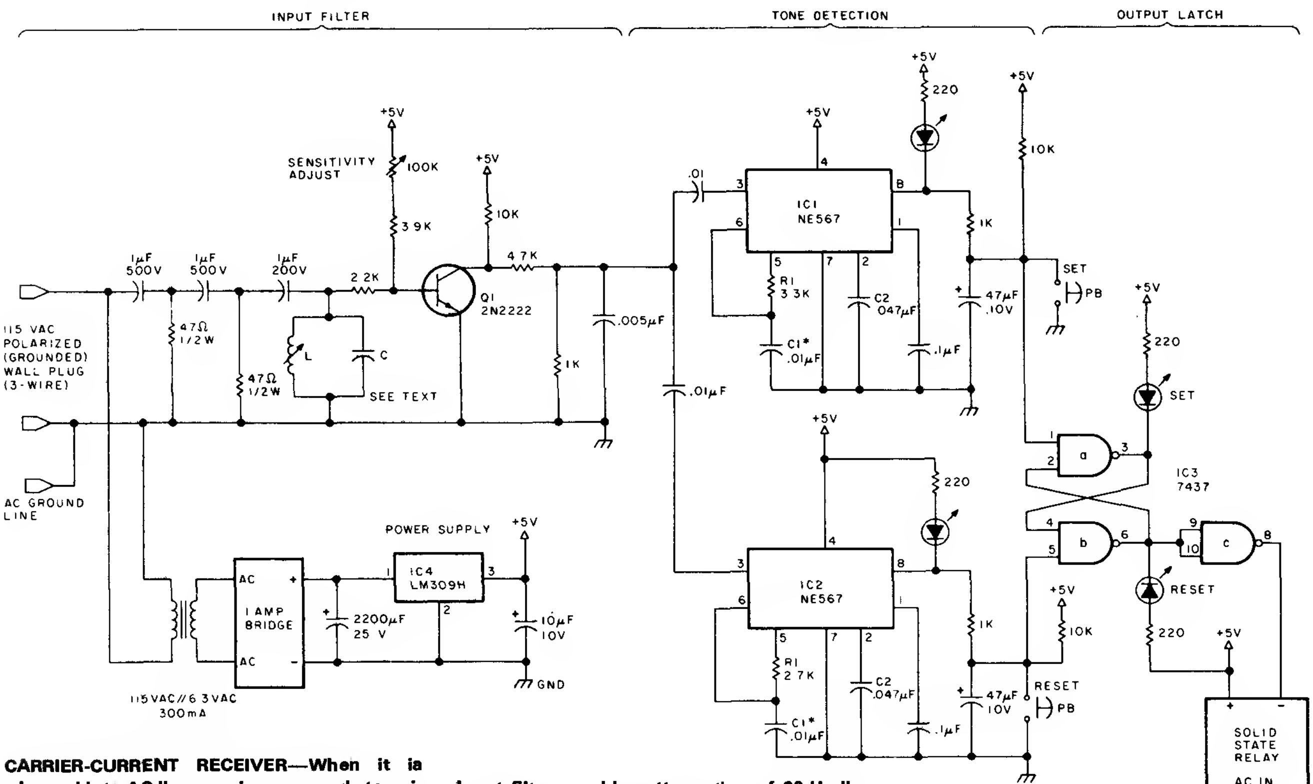
LIGHT BEAM FOR CONTROL OF MOVING TOY—Battery-powered CMOS logic is switched on and off by aiming flashlight beam at photocell, for turning small motors of model train or other powered toy on and off. Transistors can be 2N2222A for most small motors, but larger motors will require power transistors. Use high-intensity flashlight, with shield over lens to restrict beam width, so only one of five photocells is illuminated at a time. LED shows ON/OFF status of circuit. Values of R1-R4 are chosen so each gate flips logic state only when associated photocell is illuminated.—J. Sandler, 9 Projects under $9, *Modern Electronics*, Sept. 1978, p 35–39.



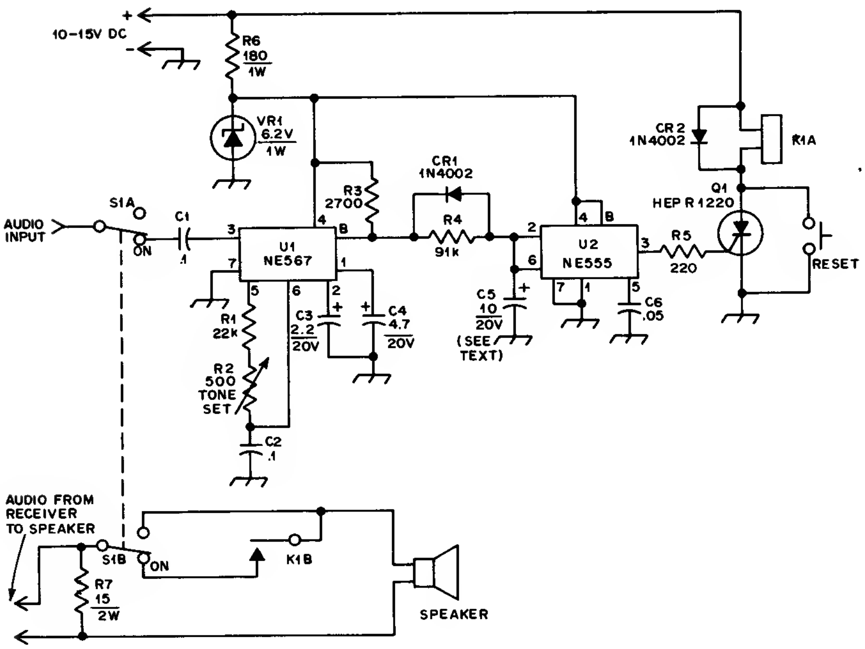
DUAL TONE DECODER—Used in communication systems where control or other information is transmitted as two simultaneous but separate tones. Circuit uses two Exar XR-567 PLL units in parallel, with resistor and capacitor values of each PLL decoder selected to provide desired center frequencies and bandwidth requirements. Supply voltage is 5–9 V.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 41–48.



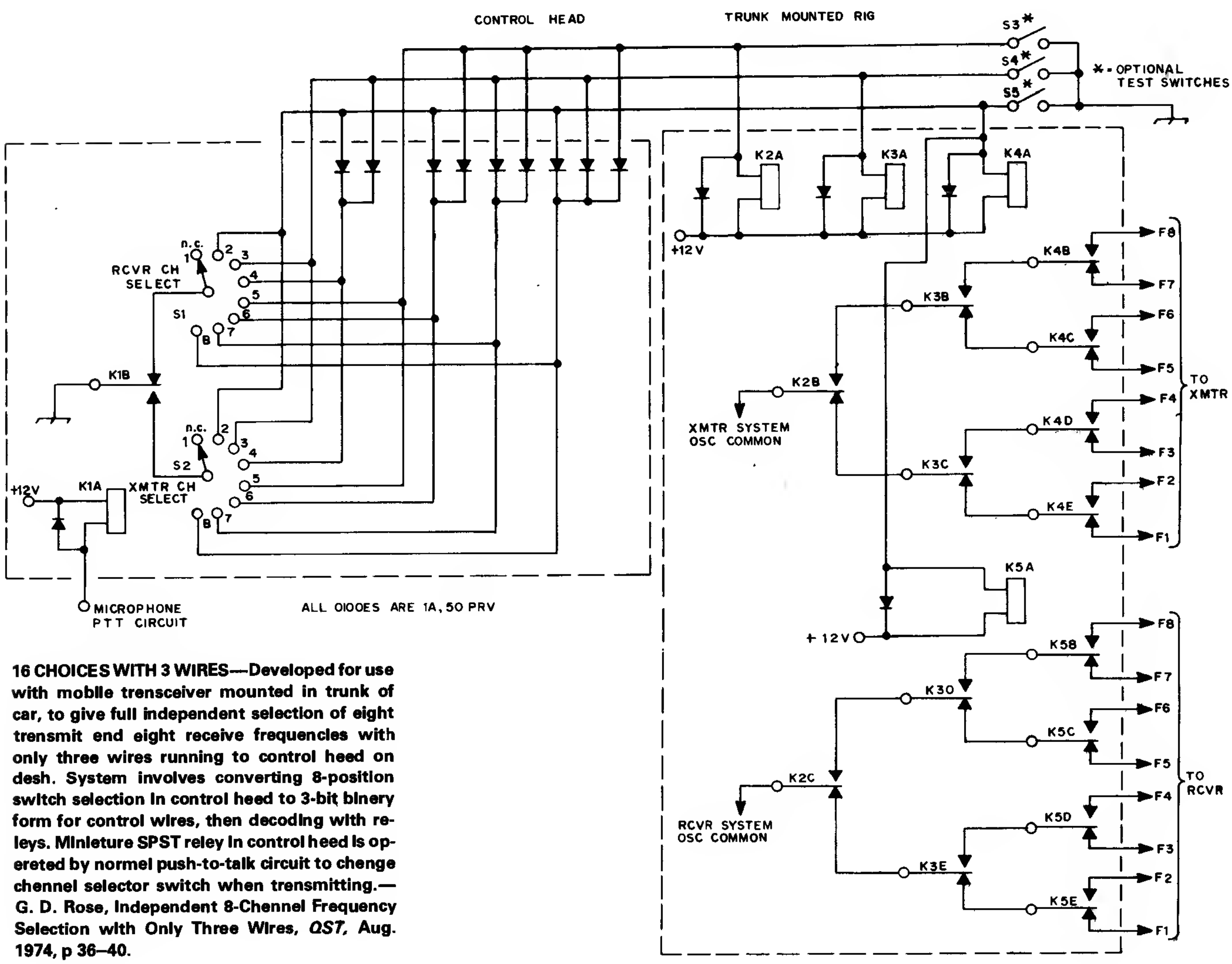
DUAL TIME-CONSTANT TONE DECODER—Exar XR-567 PLL system is connected as decoder having narrow bandwidth and fast response time. Circuit has two low-pass loop filter capacitors, C_2 and C'_2. With no input, pin 8 is high, Q_1 is off, and C'_2 is out of circuit. Filter then has only C_2, which is kept small for minimum response time. When in-band input tone signal is detected, pin 8 goes low, Q_1 turns on, and C'_2 is in parallel with C_2 to give narrow bandwidth. Supply voltage can be 5–9 V.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 41–48.



CARRIER-CURRENT RECEIVER—When it is plugged into AC line, receiver responds to pair of control frequencies 4 kHz apart in range of 30 to 110 kHz, placed on house wiring by computer-controlled transmitter. Receiver turns controlled device on or off through solid-state relay for which article gives suitable circuit. Tuned bandpass filter amplifies only that pair of frequencies assigned to its receiver, attenuating all other frequency pairs used in system. Amplified signal is sent to tone decoders IC1 and IC2, one responding to each frequency. Input filter provides attenuation of 60-Hz line frequency and all other frequencies except 8-kHz band of specific channel. LC bandpass circuit, set for center of desired passband, acts as passive filter. L is low-Q slug-tuned 1–10 mH coil, set at 2 mH when C is made 0.01 μF for center frequency of 35 kHz. Article covers operation in detail and gives procedure for determining values of R1, C1, and C2 for each detector. Solid-state output relay can be Sigma 226 RE1-5A1, rated 6 A.—S. Ciarcia, Tune In and Turn on, Part 2: An AC Wireless Remote Control System, *BYTE*, May 1978, p 97–100 and 102 (Part 1—April 1978, p 114–116, 118, 120, and 122–125).

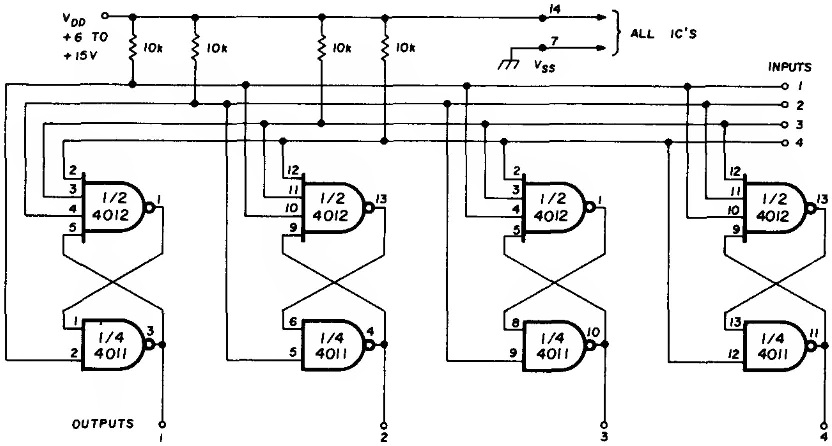


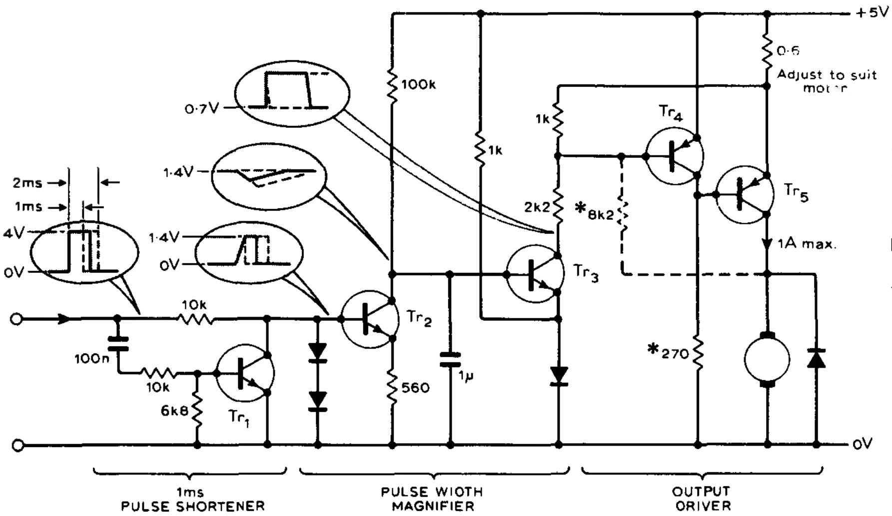
TIMED-TONE DECODER—Uses NE567 PLL and 555 timer to activate muted monitoring receiver until alerting audio tone of correct frequency and duration is received. Can be applied to almost any receiver for weather emergency alert warnings, paging calls, and similar services without having to listen continously to other traffic on channel. If received tone is within bandwidth of tone decoder, output of U1 goes nearly to zero and C5 starts to discharge through R4. When voltage at pins 2 and 6 of U2 reaches one-third of supply voltage, output of U2 goes high and triggers SCR Q1, energizing 12-V relay K1. Values shown for C4 and C5 give 1-s delay, which means triggering tone must be on at least 1 s. Once SCR is triggered, it holds relay on even after tone ceases. Pushbutton switch shorts SCR and releases relay when reset is desired. Zener provides regulated 6.2 V required for decoder. Values shown for R1, R2, and C2 give response to 450-Hz tone. Avoid use of Touch-Tone frequency, to prevent accidental triggering by those using Touch-Tone system.—J. S. Paquette, A Time-Delayed Tone Decoder, *QST*, Feb. 1977, p 16–17.



16 CHOICES WITH 3 WIRES—Developed for use with mobile transceiver mounted in trunk of car, to give full independent selection of eight transmit and eight receive frequencies with only three wires running to control head on dash. System involves converting 8-position switch selection in control head to 3-bit binary form for control wires, then decoding with relays. Miniature SPST relay in control head is operated by normal push-to-talk circuit to change channel selector switch when transmitting.—G. D. Rose, Independent 8-Channel Frequency Selection with Only Three Wires, *QST*, Aug. 1974, p 36–40.

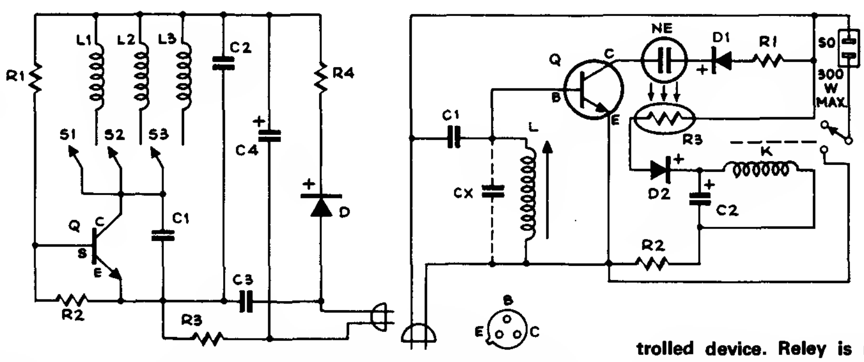
REMOTE SWITCHING—Uses four flip-flops, each having one 4-input end ona 2-input CMOS NAND gate. Momentarily grounding eny input drives corresponding output high end all othar outputs low. Unless power is interrupted, ed-ditional pulses on seme input have no effect; circuit remeins steble until some other input is momentarily groundad. Outputs can be used to drive other logic devices directly or through buffer if current required exceads 10 mA. Cen be used for remote frequency control of VHF trsns-celver and for other epplications requiring re-mote selection of mutuelly exclusive func-tions.—P. Shreva, Remote-Switching Circuit, *Ham Radio*, March 1978, p 114.





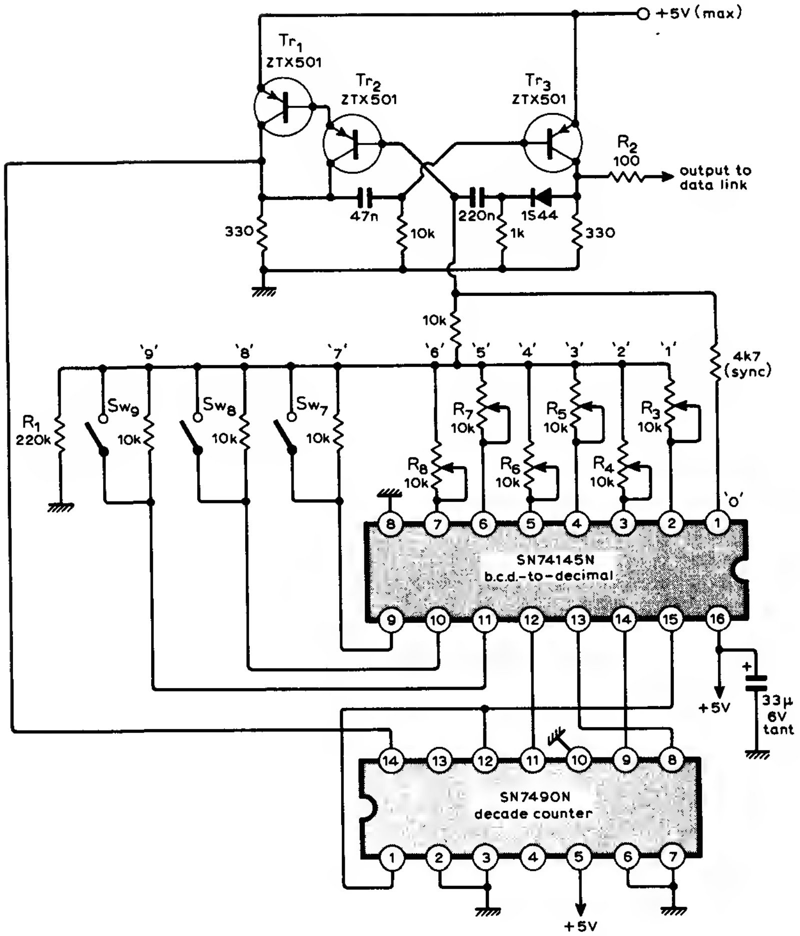
RADIO CONTROL FOR MOTOR—Proportional control system produces control pulses every 20 ms, with length of eech adjusteble between 1 and 2 ms. Circuit removas first 1 ms of pulse and expands remeinder to produce 0–20 ms pulses for driving motor. Pulsing of motor gives smoother control than resistors, perticularly et very low speeds. Trensistor typas ere not criti-cel. Tr_5 can be OC28. Optional dashed connac-tion of 8.2K raslstor provides foldbeck current/ voltage protaction.—M. Waston, Variable-Speed Redio Control Motor, *Wireless World*, Feb. 1978, p 59.

TRANSMITTER
C1, C2—0.02 mfd disc capacitor
C3—0.05 mfd disc capacitor
C4—20 mfd @150V electrolytic capacitor
R1—12,000-ohm, ½w resistor
R2—8,200-ohm, ½w resistor
R3—750-ohm, 5w resistor
R4—400-ohm, 5w resistor
L1—750uh choke
L2—420uh choke
L3—200uh choke
D—Diode 1N547 or eq.
Q—Motorola HEP S3020 or eq.
S1-S3—SPDT large pushbutton (N.C. not used)

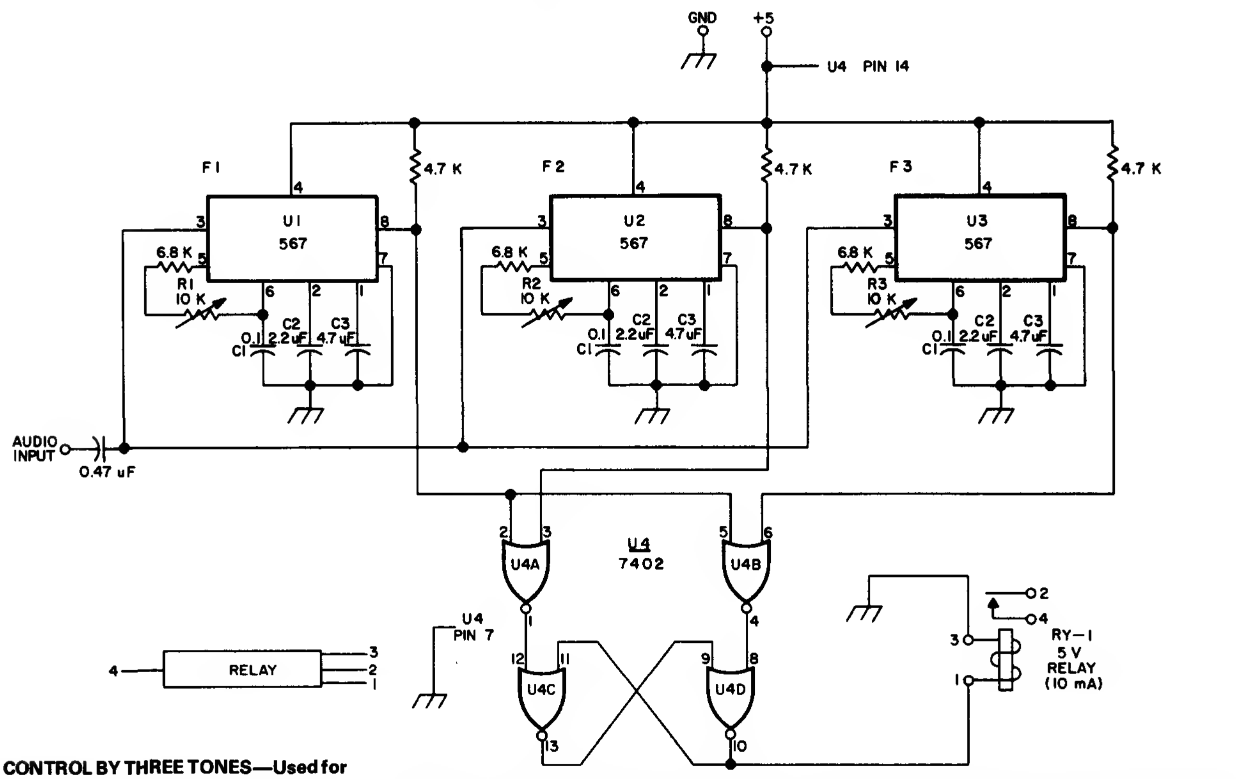


RECEIVER
C1—0.0025 mfd disc capacitor
C2—20 mfd @ 16V electrolytic cap.
Cx—See text
R1—560-ohm, ½w resistor
R2—1800-ohm, 2w resistor
R3—Photoresistor (Clairex CL604L)
L—508-816uh choke
D1, D2—1N457 or eq.
Q—2N3439 or eq.
K—12VDC latching relay (Cornl. Dublr. 662-12)
NE—Neon NE-2

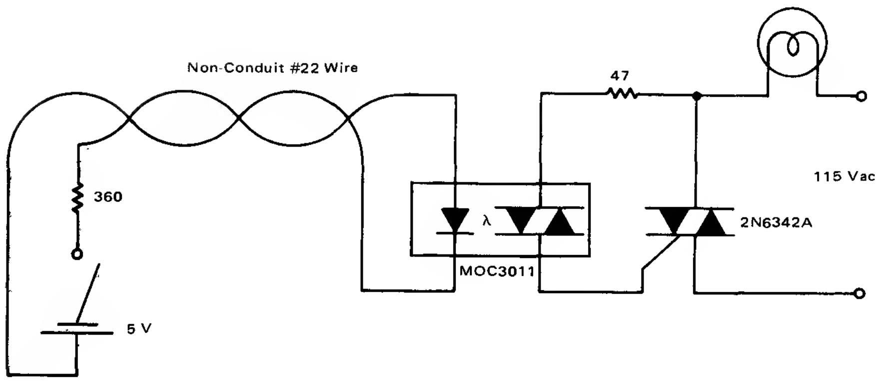
WIRELESS CONTROL—Choice of three lemps or eppliances enywhere in house and garege, or evan in neighboring home if on the same power transformer, can be turned on or off individuelly with three-channel transmitter thet plugs into eny well outlet. Transmittar injects one of three tones (depending on button pushed) into house wiring. Receivers at locations of controlled de-vicas ere each tuned to one of carriar tones. Cor-rect tone for receiver energizes neon lamp, end resulting light is picked up by photoresistor thet energizas latching reley K for turning on con-trolled device. Reley is released by sending same tone agein. Values of CX can be 0.005, 0.01, end 0.02 µF. Adjust slug of L2 for eech re-ceiver so naon comes on when essignad tone for that receivar errives.—W. J. Hewkins, Three-Chennel Wireless Switch—Use It Anywhere, *Popular Science*, Sept. 1973, p 98–99 and 121.



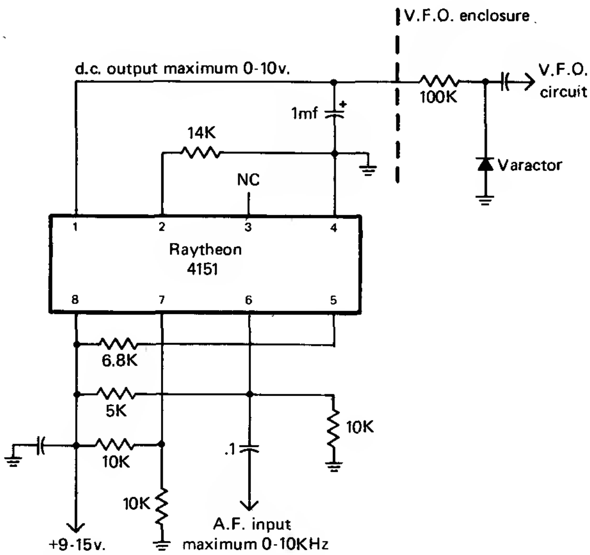
NINE-CHANNEL CODER—Use of TTL ICs gives low component count for remote control system having nine fully proportional channels. Input channels can be potentiometers for fully proportional information and switched resistors for go/no-go or multistep information. Coder scans the nine parallel inputs sequentially and presents them to single-line data link as series of nine varying-width pulses followed by fixed-width sync pulse. Article describes coder operation in detail and gives circuits for corresponding decoder and servoamplifier at receiving end of data link.—M. F. Bessant, Multi-Channel Proportional Remote Control, *Wireless World*, Oct. 1973, p 479–482.



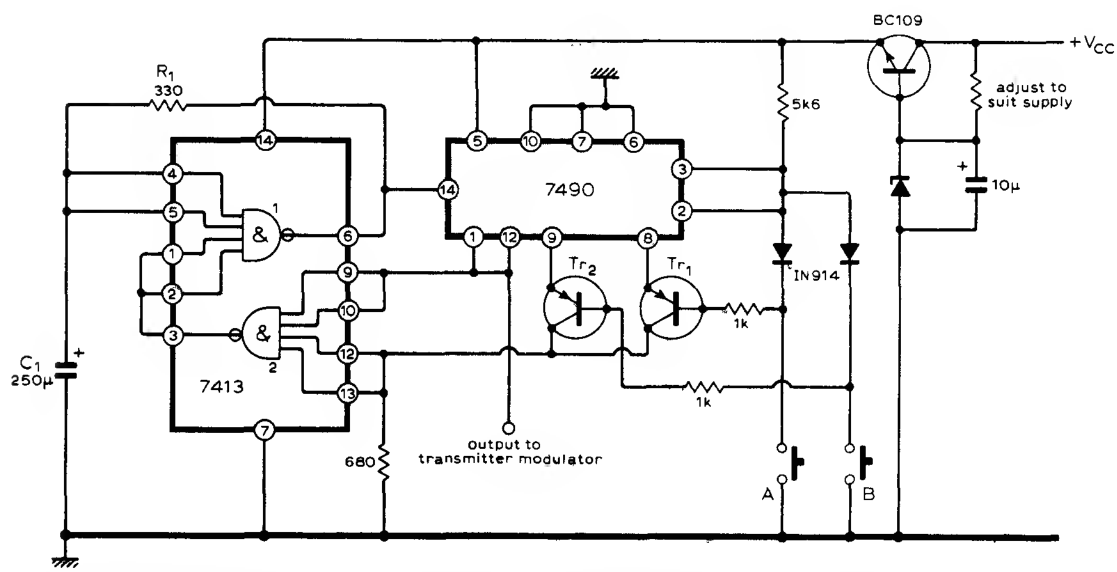
ON/OFF CONTROL BY THREE TONES—Used for decoding two Touch-Tone digits to give operation or release of relay by remote control over wire line. Three 567 tone decoders and 7402 quad gate are adjusted to recognize tones corresponding to any two keys in given row or column on Touch-Tone keyboard. As example, * key generates 941 and 1209 Hz, and circuit can be adjusted so these two frequencies energize relay. Similarly, pushing of # key generates 941 and 1477 Hz that can be used for deenergizing relay.—W. J. Hosking, Simple New TT Decoder, *73 Magazine*, April 1976, p 52–53.



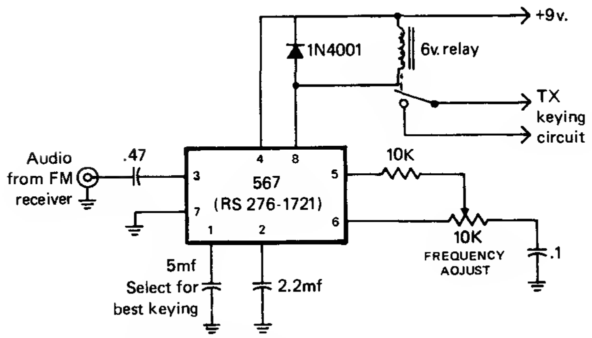
LAMP CONTROL WITHOUT CONDUIT—Motorole MOC3011 optoisoletor permits control of lerge lemp, motor, pool pump, and othar AC loeds from ramote locetion with low-voltage signal wiring while meeting building codes. Choica of triec dapands on loed being handled.—P. O'Nail, "Applicetions of the MOC3011 Triec Drivar," Motorole, Phoenix, AZ, 1978, AN-780, p 5.



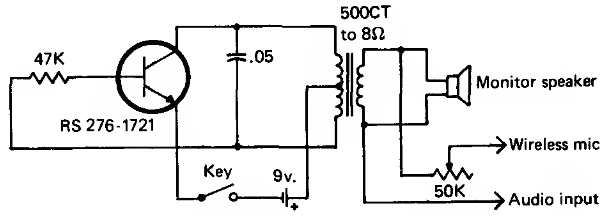
WIRELESS REMOTE TUNING—Frequency-to-voltege converter for transceivar responds to AF output of control receivar and feeds corrasponding DC voltage to varactor tuning diode in VFO of transceiver, for remota wireless tuning. In most ceses only a few volts of DC variation ecross verector are sufficiant, so veriable audio oscillator at remote-control location need heva range of only e few kilohertz.—J. Schultz, H.F. Opersting—Remote Control Style, *CQ*, March 1978, p 22–23 and 90.



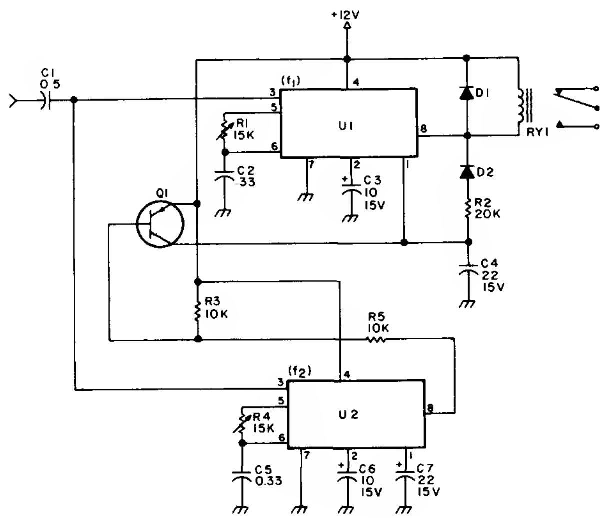
BLIP-AND-HOLD RADIO CONTROL—Coder uses two ICs to generate sequence of pulses suitable for actuators of radio control system. During standby, oscillator formed by NAND gata 1 operates at 0.5 Hz as determined by C_1 and R_1 end ell four outputs of 7490 IC ere zero. When switch A is closed, 7490 is clocked by negetive edge of oscillator waveform end Tr_1 becomes forward-biased. Output of NAND gate 2 then drops to zero, stopping oscillator and holding outputs of 7490. When switch A is opened, outputs of 7490 egain drop to zero. Meny different blip-end-hold combinations can be obtained by suiteble arrangement of switches and gates.—G. D. Southern, Sequence Genarator for Redio Control, *Wireless World*, Jan. 1976, p 60.



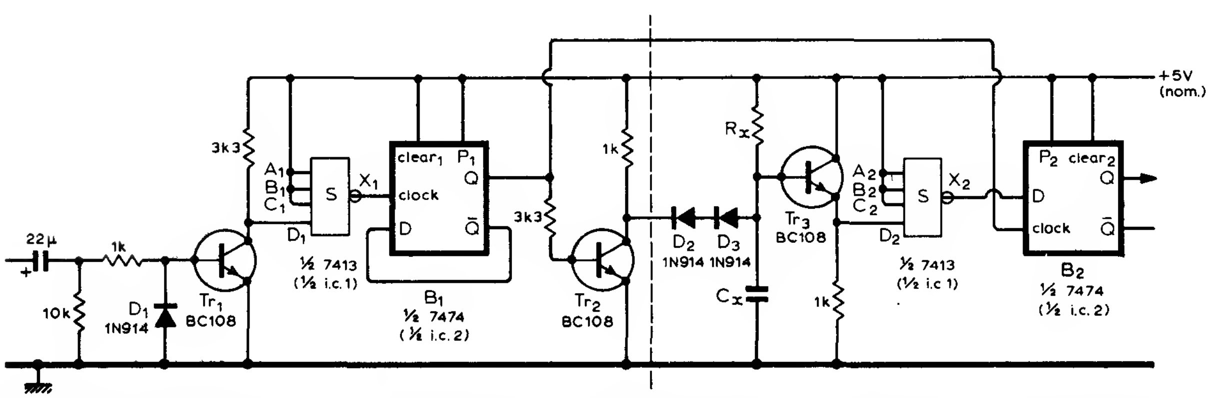
PLL TONE DECODER—Used in simple wireless FM remote control set up for keying transmitter. Keyed 500-Hz tone output of FM receiver at transmitter site acts through 567 PLL to operate 6-V relay whose contacts are in keying circuit of transmitter.—J. Schultz, H.F. Operating—Remote Control Style, *CQ,* March 1978, p 22–23 and 90.



500-Hz CONTROL TONE—Developed for use as wireless FM remote control for keying transmitter at another location by sending keyed audio tone over radio link, acoustic link fed by loudspeaker, or audio line. Frequency is about 500 Hz.—J. Schultz, H.F. Operating—Remote Control Style, *CQ,* March 1978, p 22–23 and 90.



TWO-TONE CONTROL—Used to perform simple ON/OFF auxiliary function via repeater input. Two 567 decoders energize relay for input tone of 1800 Hz, with latching, and release it for 1950 Hz. Diodes are 1N4001. Relay can be 12 or 24 V. Q1 is 2N3905, 2N3906, MPS6521, or 2N2222.—W. Hosking, A Single Tone Can Do It, *73 Magazine,* Nov. 1977, p 184–185.

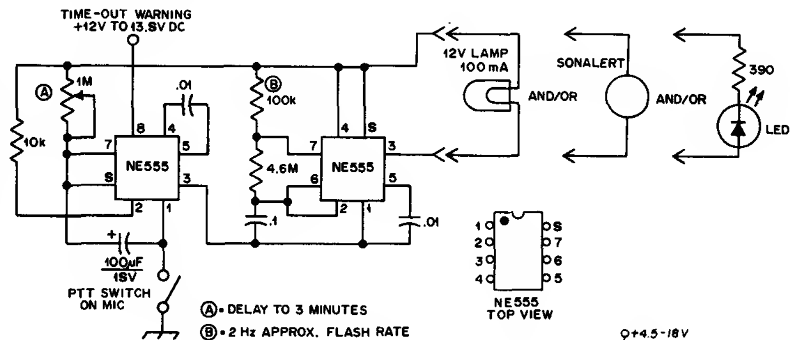


TONE DECODER—Replaces resonant reeds commonly used in multichannel radio-controlled models to detect modulation frequency being transmitted. Use of IC logic has advantage that range of audio frequencies can exceed an octave, whereas reeds cannot because they respond to second harmonic. Decoder has digital high-pass characteristic that is passed through inverter to give digital low-pass characteristic. Values of R_x and C_x determine critical frequency; for 900 Hz, use 150,000 ohms and 0.015 μF. To obtain *n* nonoverlapping bandpass characteristics, *n* − 1 basic elements with different critical frequencies are required; components to left of dashed line may be common to all these elements. Article covers multichannel systems in detail, along with use of time-division multiplexing.—C. Attanborough, Radio Control Tone Decoder, *Wireless World,* Dec. 1973, p 593–594.

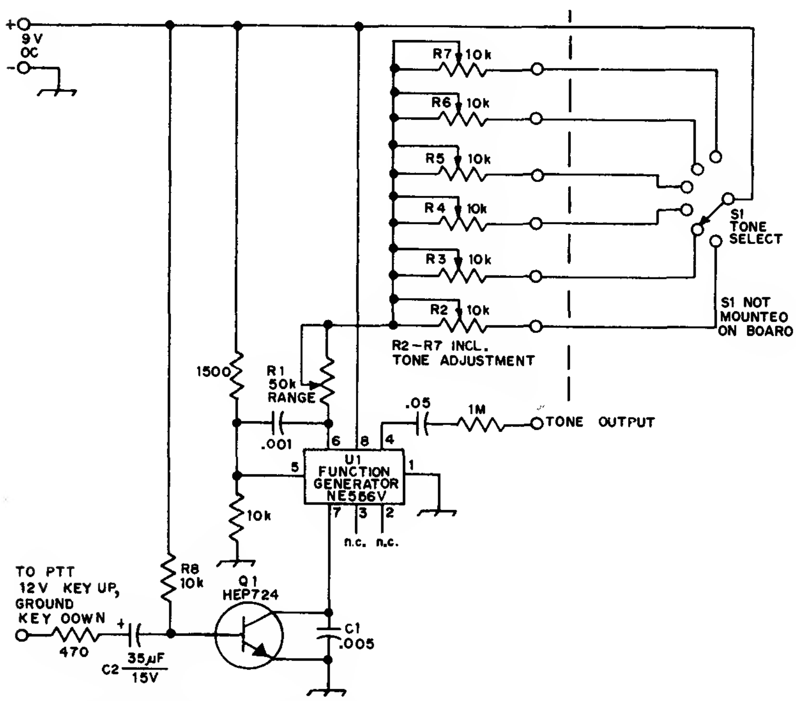
CHAPTER 76

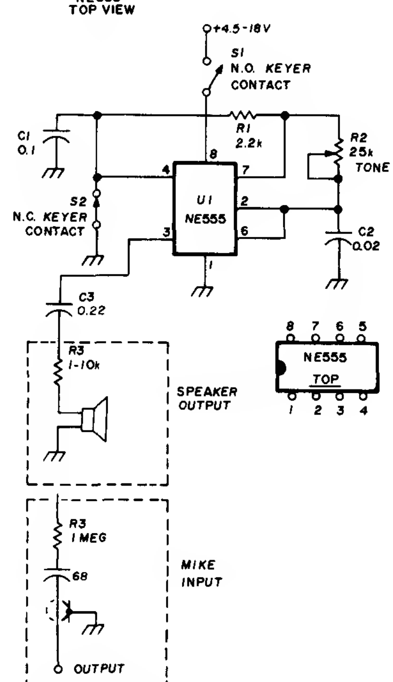
Repeater Circuits

Audible and subaudible tone generators and decoders provide access to desired FM repeater and give autopatch for telephone connections. Also included are time-out timers, phone-ring-counting control, microprocessor control, carrier-operated control, VOX, and lightning detector for remote site.



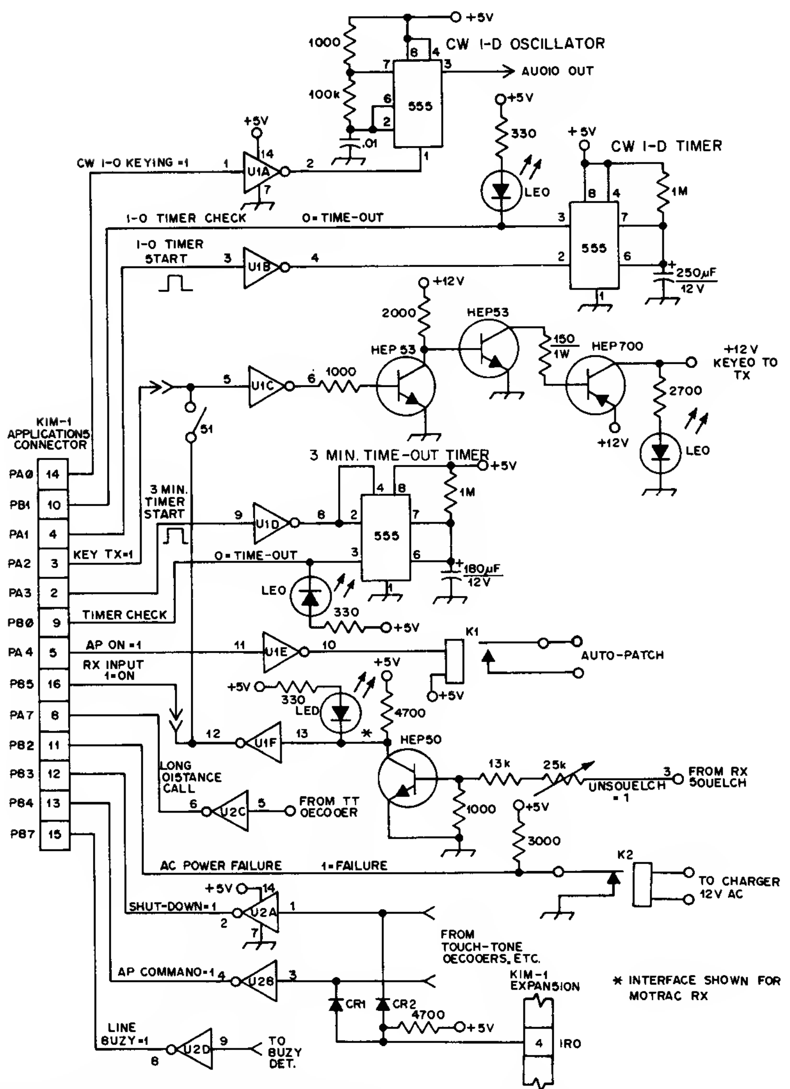
TIME-OUT WARNING—Provides either visual or audible warning after preset interval up to 3 min, when pin 1 of first NE555 is grounded by push-to-talk switch on microphone of mobile transmitter. When preset limit is reached, pin 3 provides ground for second NE555 that makes it pulse at 2-Hz rate to warn that time limit for use of repeater is being approached.—F. Sharp, Time-Out Warning, *QST,* Oct. 1976, p 67.



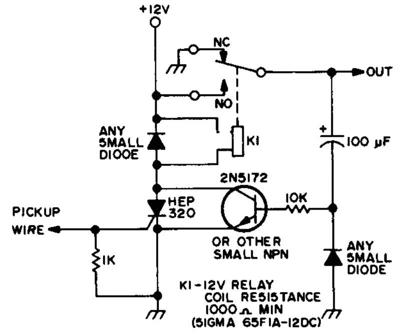


SIX ACCESS TONES—Provides 0.4-s bursts at choice of six audio frequencies, for access to up to six different repeaters. Value of C1 in transistor circuit determines duration of burst. AF oscillator uses Signetics NE566V phase-locked loop, with tone frequencies determined by C1 and R1 plus R2 through R7. To adjust initially, remove Q1 from circuit so oscillator runs continuously, connect frequency counter to junction of 0.05-µF capacitor and 1-megohm resistor, set all pots at minimum, adjust R1 for 2500 Hz, set selector switch to position 1, and adjust corresponding control for desired frequency. Repeat for other pots.—G. M. Dickson, A Tone-Burst Generator for Repeater Access, *QST,* April 1974, p 30–31.

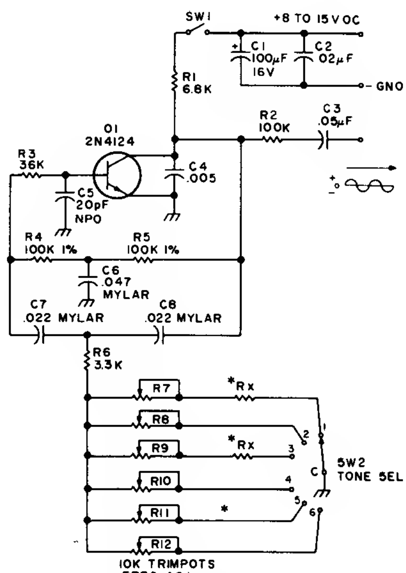
TIMER IS AUTOPATCH KEYER—Simple keyer oscillator using NE555 timer was designed for autopatch in repeater having decoder bandpass from 2980 to 3080 Hz. Adjust R2 to 3042 Hz. Output options for loudspeaker and microphone are shown. Adjust R3 for required input/output level; use variable resistor if desired. Normally closed keyer contacts can also be connected between pin 7 and ground. Supply can be 9-V transistor radio battery.—E. Noll, Circuits and Techniques, *Ham Radio,* April 1976, p 40–43.



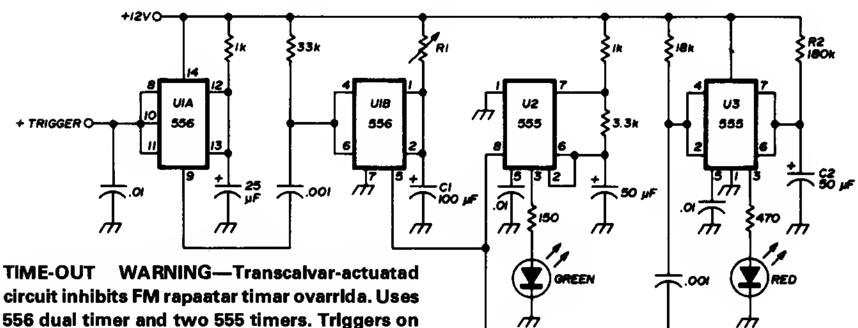
MICROPROCESSOR CONTROL—Under program control, interface for MOS Technology KIM-1 microcomputer turns on transmitter of repeater when signal arrives at receiver; provides 3-min timer, CW ID timer, and tail or delay at end of transmission; and generates Morse code CW ID. Article gives flow charts and programming for basic functions, along with complete autopatch control routine. CR1 and CR2 are small-signal silicon diodes such as 1N914. U1 and U2 are 7404 TTL hex inverters.—C. M. Robbins, The Microprocessor and Repeater Control, *QST*, Jan. 1977, p 30–34.



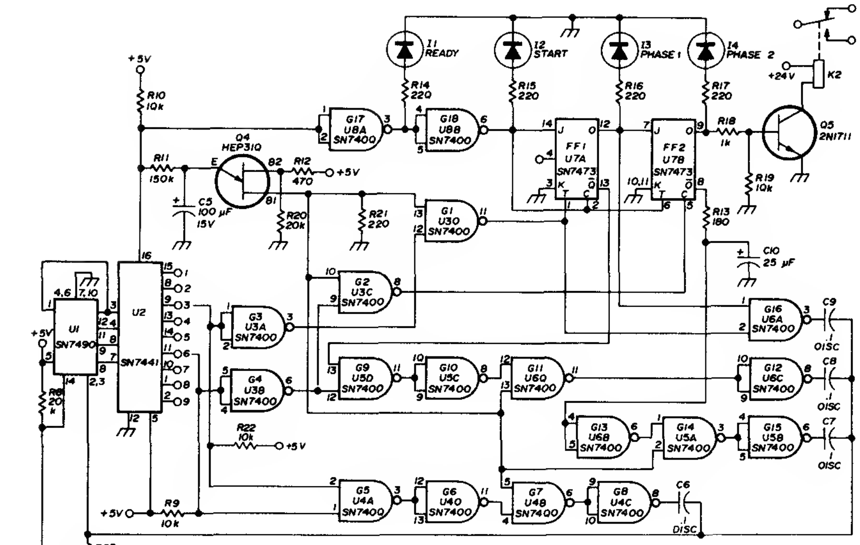
LIGHTNING DETECTOR—Uses 20-foot wire strung around repeater house to pick up pulses induced by lightning. Keep wire well away from antenna and transmitter. Pulse at SCR gate turns it on and energizes relay that activates signaling device at desired location. Circuit automatically resets itself after capacitor discharges through 10K resistor.—P. A. Sterk, Simple Lightning Detector, *73 Magazine*, April 1973, p 85.

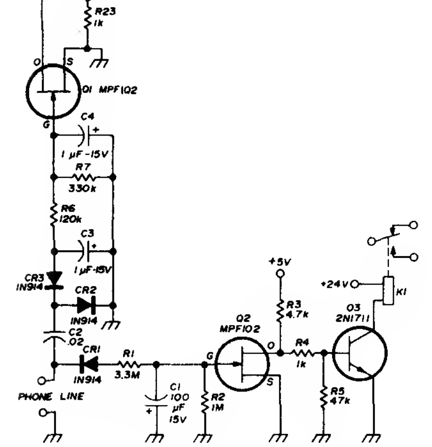


SUBAUDIO TONES—Six-channel subaudible encoder uses twin-T oscillator covering 93 to 170 Hz. Tones are adjustable with 20-turn 10K trimpots. Used with 2-meter amateur transmitters to access and maintain signal through repeater having subaudible tone decoder. When transmitted signal opens up receiver of repeater, subaudible tone on incoming audio closes relay and permits transmitter to key up and repeat signal. Choice of tones permits use of different repeaters in given area. For 93–107 Hz, use 12K for R_X; for 98–116 Hz, use 8.2K; and for 114–170 Hz, use jumper. Article gives construction details.—W. G. Monaysmith, Subaudible Tone Encoder, *73 Magazine*, Oct. 1977, p 52–53.

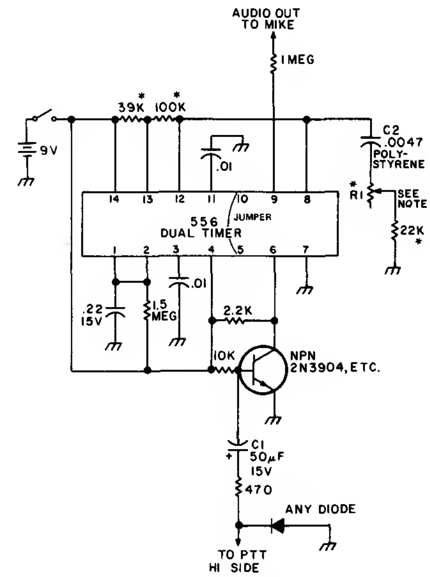


TIME-OUT WARNING—Transceiver-actuated circuit inhibits FM repeater timer override. Uses 556 dual timer and two 555 timers. Triggers on positive step-input voltage from transceiver when PTT switch is pushed. If negative triggering is preferred, omit U1A. Values of R1 and C1 provide delay that is 10 s less than repeater timer. With 60-s repeater, delay should be 50 s. Flip-flop U2 flashes green LED 80 times per minute during this delay. After 50 s, U2 is disabled and U3 flashes red LED for 10 s as indication that transmission must stop to avoid timing out repeater. At end of 10 s, red LED goes out and cycle is completed. If transmission time is less than that of repeater timer, indicator is recycled when PTT switch is pressed again. R1-C1 determine green flash time, and R2-C2 determine red flash time.—H. M. Barlin, Time-Out Warning Indicator for FM Repeater Users, *Ham Radio*, June 1976, p 62–63.

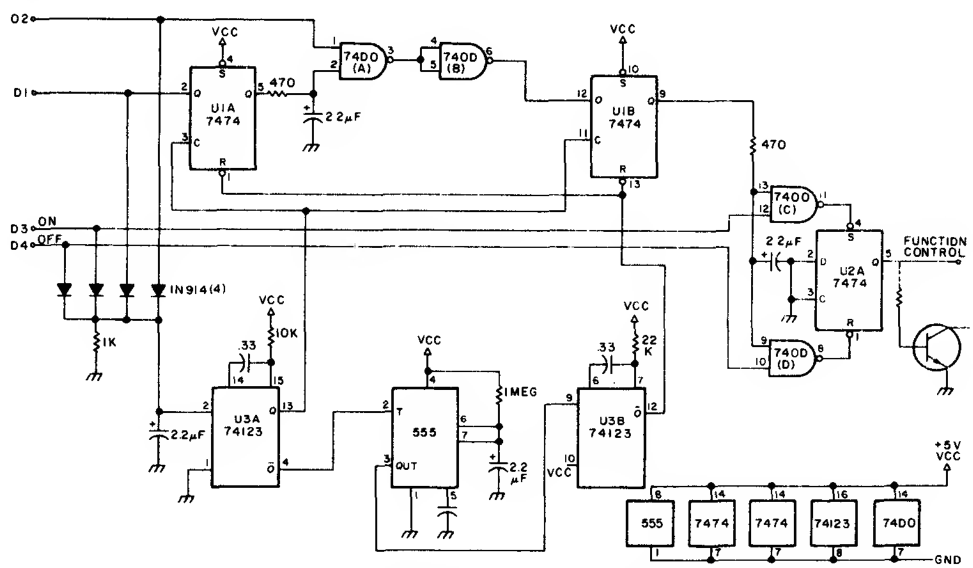




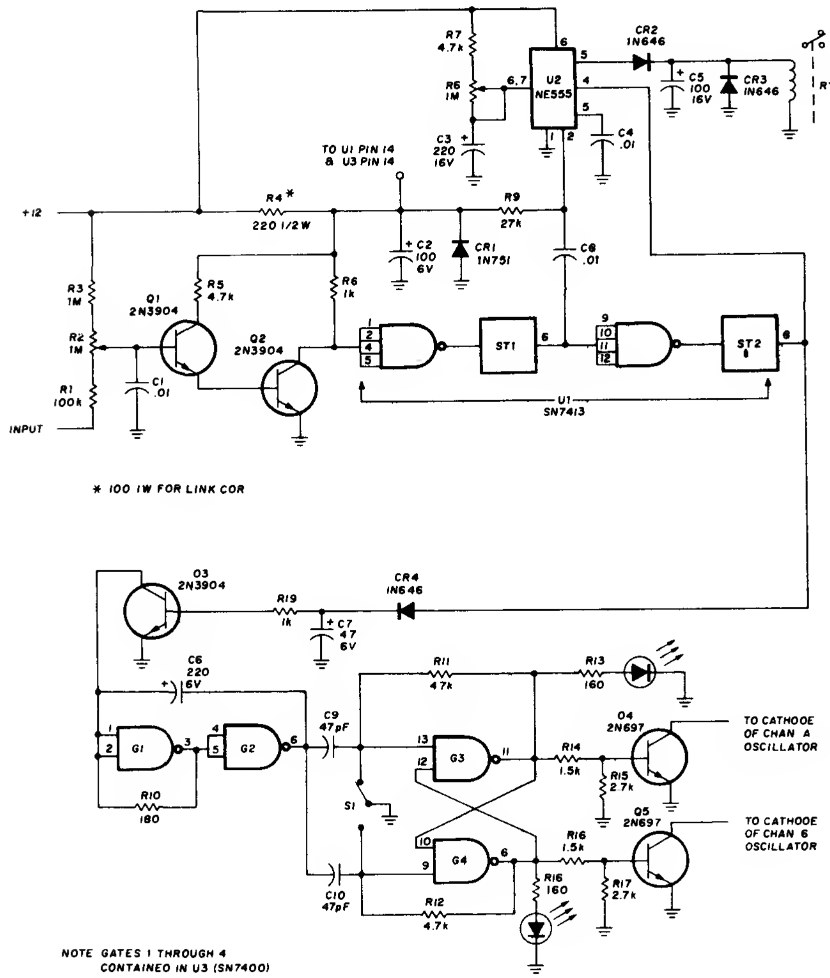
PHONE-RING REMOTE CONTROL—Repeater or other unattended equipment can be turned on or off with ordinary telephone. Phone at remote station is called and allowed to ring three times. Caller then hangs up, waits 20 s, redials number and lets it ring three times again, then hangs up. Circuit then performs desired control function. Any combination of rings can be used as long as total is less than nine. Decoder U2 is programmed by moving two jumper wires to various outputs of U2. Relay K2 is chosen to give desired momentary, latching, or stepping function. Relay K1 is used for validating phone line. If remote station keying voltage is taken through contacts of K1, interruption of phone line prevents activation of transmitter. C1 stores voltage during brief interruptions such as when phone is ringing. Article gives detailed explanation of ring-counting circuit. LEDs I1-I4 indicate status of control sequence and aid in troubleshooting. K1 and K2 are sensitive DPDT relays with 8000-ohm coils. R11 is selected for desired time setting.—R. C. Heptig, Automatic Telephone Controller for Your Repeater, *Ham Radio,* Nov. 1974, p 44–48.

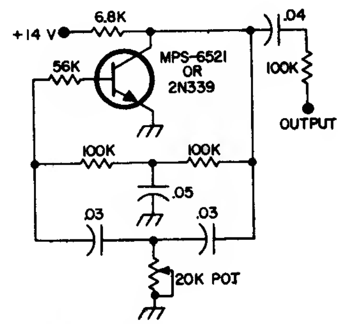


1800-Hz TONE BURST—Developed to provide access to repeater requiring accurate tone frequency. Half of 556 dual timer serves as mono MVBR having ON time of about 400 ms. Other half is free-running oscillator that is disabled when mono goes low. Transistor starts tone burst when push-to-talk switch is closed. For frequency stability, resistors with asterisk should be cermet or wirewound. R1 is 15- or 20-turn trimmer pot having low temperature coefficient and giving about 30 Hz change per turn.—L. Meyer, One IC Tone Burster, *73 Magazine,* April 1976, p 55.



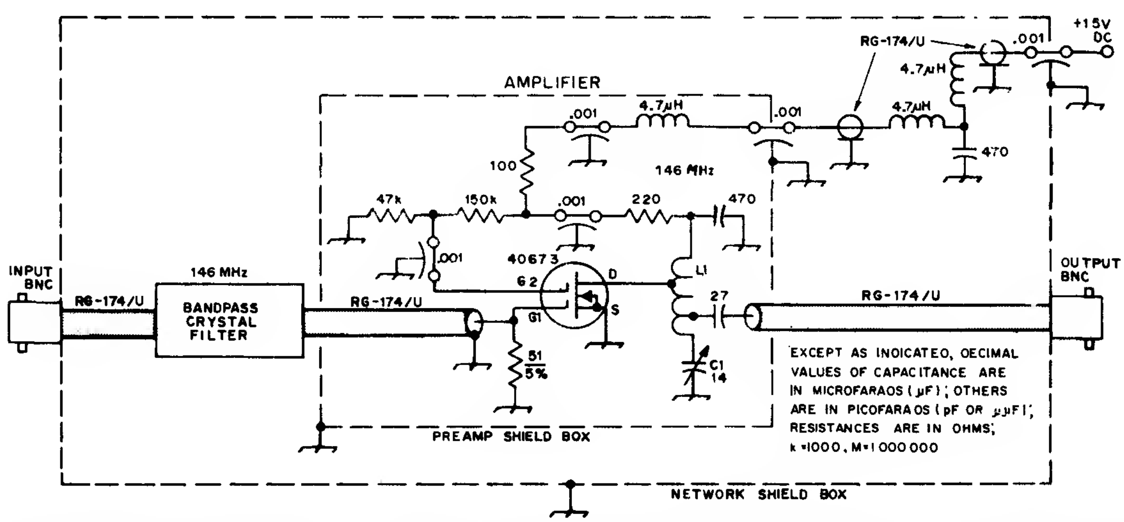
FUNCTION DECODER—Simple controller for single repeater uses 3-digit control code (523) to turn repeater on and 624 to turn it off. Digits must be in correct sequence. Digit decoder (not shown) uses TTL-compatible inputs which go high when digit is decoded. Four 1N914 diodes form OR gate that triggers U3A to create clock pulse with each digit received. Other output of U3A triggers 555 timer U5, set for delay of about 8 s. At end of delay, timer triggers U3B to reset all logic except for output stage. Regulated VCC of 5 V is obtained from 7805 regulator connected to 12 V.—W. J. Hosking, Simple Sequential Decoder, *73 Magazine,* Jan. 1978, p 166–167.



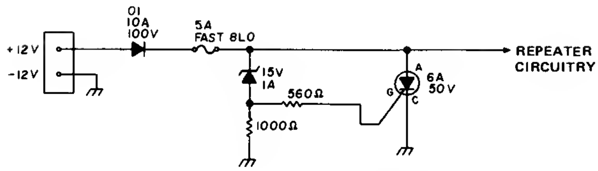


100 Hz—Simple end stable subeudlble tona generator serves for eccess to FM repeaters. Frequancy ls adjusted to that of rapaater with 20K pot. Will operate from cer battery.—Circuits, *73 Magazine*, Sept. 1973, p 143.

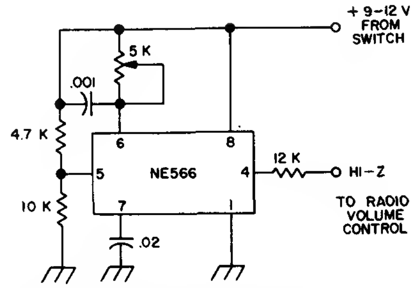
COR FOR LINKING—Carrier-operated relay will operete repeater, serve as guard receiver for repeeter input chennels, and provide loudspeaker muting when no atation is being received. Simple search-lock feature following CR4 controls two channels, for linking two repeaters or using two-channel drive recaivar. Q1 end Q2 are connected es Darlington amplifier for negative-going control signala, as found in vacuum-tube receivers. Duel Schmitt triggar U1 provides positive ON/OFF action. Time-out is controlled by setting of R8 end value of C3. To monitor repaatar or simplex channel for call without listening to other conversations, set timer for about 5 s. When call comes in, first faw words will be at normal volume so call can be identified. At time-out, volume will drop to low level. If call is for you, disabla COR for normal listening. Search-lock uses singla SN7400, with gates G1 and G2 connected as oscillator end gates G3 and G4 es dual D flip-flop. Q3 acts es lock to stop oscillator. With no input carrier, Q3 is off and oscillator makes Q4 and Q5 switch betwaan channels A and B alternately. If signal arrives on one chennel, oscillator stops on it and reley closes, bringing repeater transmitter on.—R. C. Heptig and R. D. Shriner, Carriar-Operated Reley for Repeatar Linking, *Ham Radio*, July 1976, p 57–59.



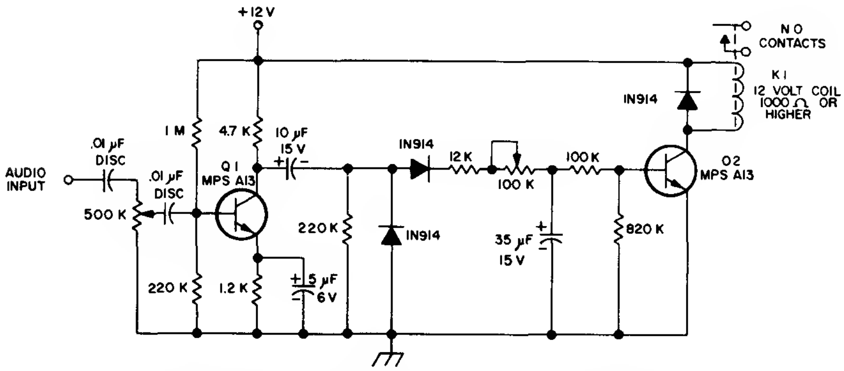
146-MHz RECEIVER PREAMP—Usas 146-MHz bandpass crystel filter to suppress front-end intermoduletion-distortion products (IMD) in VHF repaater circuits while providing gain of 6–8 dB to overcoma filter insertion loss. Also helps front-end overload problams from strong adjacent-channel amateur signals. Filter response is down 40 dB at ±38 kHz and down over 50 dB beyond 60 kHz from filter canter frequency. Filter used is Piazo Technology TM-4133VBP. Input and output for filtar should ba exactly 50 ohms.—J. M. Hood, Monolithic Crystal Filtar Application in Amateur VHF Repeaters, *QST*, July 1975, p 27–29 and 48.



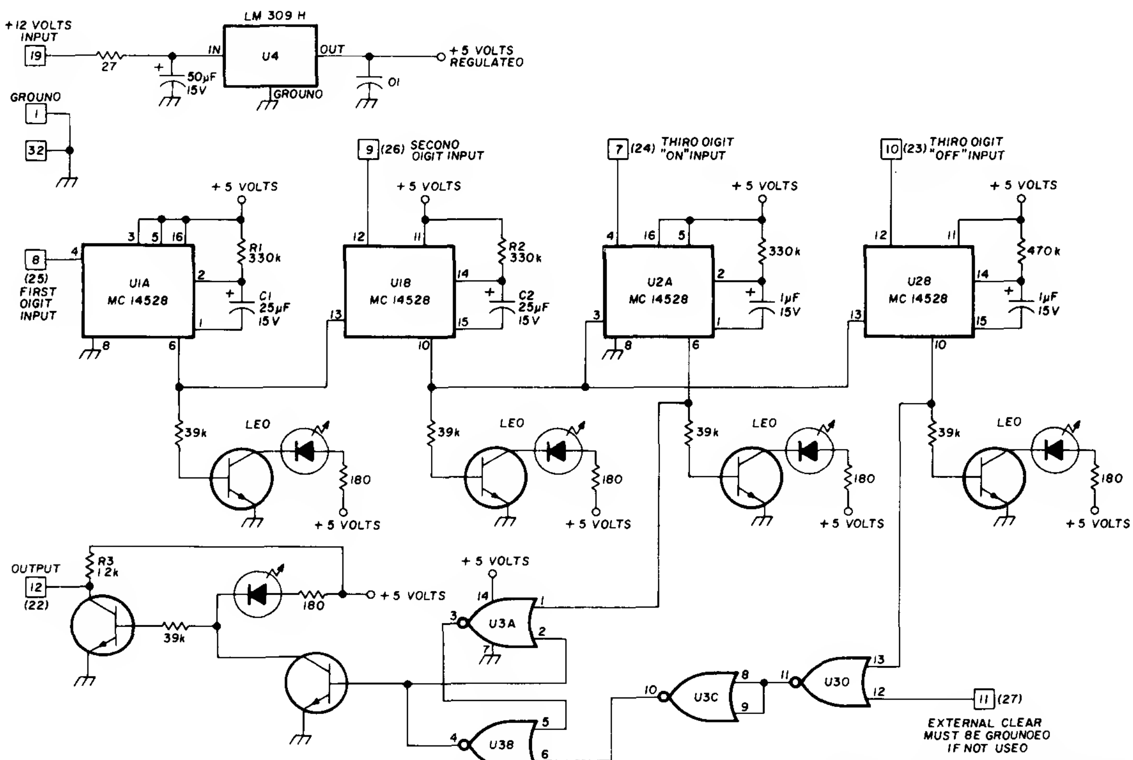
CROWBAR—Developed to protect portable repeaters from reverse or excessive voltage when operating on emergency power supply. Zener voltage rating determines maximum voltage that can reach repeetar. Diode pravents damege by incorrect polarity. Use fast-blowing fuse.—Circuits, *73 Magazina*, April 1977, p 164.



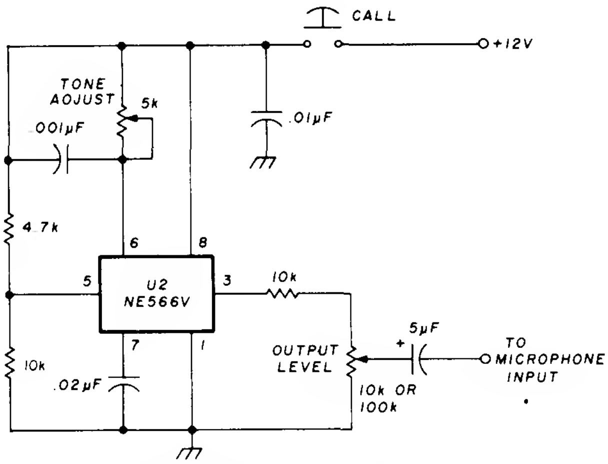
TONE BURST FOR MIKE—Uses NE566 PLL function ganerator to provide tone antry Into 2-metar repeaters. Output is fed into volume control of any AM transistor radio, and loudspeaker is held in front of transceiver microphone when tone is desired.—F. J. Derfler, An Acoustically Coupled Digital Keyed Squeaker for Tone Burst Entry, *73 Magazina*, Aug. 1973, p 27–30.



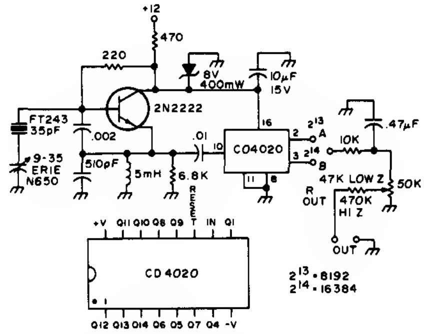
DELAYED VOX—Minimizes unintentional triggering of repeater by using timer requlrlng 3 s of continuous carriar and eudio on Input receiver of repeater to turn on trensmitter. Repeater is then controlled by its own carrier-operated relay until 20-s lapse in trensmission occurs. System then requires another 3-s carrier to restore normel operation. Q1 is common-emitter amplifier with gein adjusted by 500K pot. Audio peaks from Q1 feed full-wave diode detector through 10-µF electrolytic. Series resistance in path through 35-µF electrolytic controls its charge-up time end thus controls delay of raley pickup. Adjust 100K pot to give desired tum-on deley in renge from fraction of second to about 4 s. Resistance divider shown provides reley dropout delay of about 20 s, which prevents VOX circuit from dropplng out repeater during lepses in speach.—J. Everhart, A Delayed VOX for Repeaters, *73 Magazine*, April 1974, p 17 and 19–20.



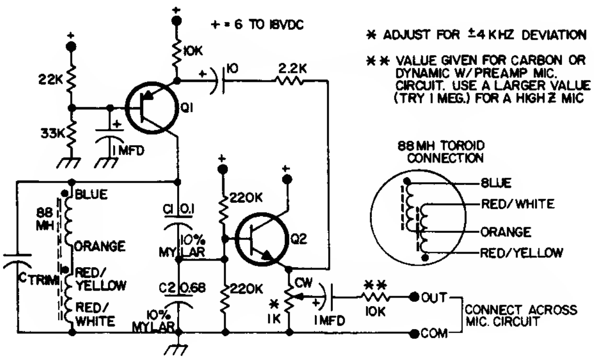
CONTROL-FUNCTION DECODER—Circuit detects predetermined 3-digit sequence of Touch-Tona signals and sets flip-flop to provide required output for activating desired function. Another 3-digit sequence, differing in only third digit, resets flip-flop for turning off controlled devica. Circuit uses two dual mono MVBRs. Output of U1A goes to reset terminal of U1B. Output of U1B goes to reset terminals of monos U2A end U2B. Mono outputs drive RS flip-flop to provide output required for desired control function, such as control of autopeth, switching repeatar moda from carrier to tone-accass, and switching to remote receiver. Q1-Q6 can be almost any NPN silicon transistors, such as 2N3904. U3 can be MC14001 or CD4001. Numbers in boxas and parentheses refer to edge connector pins.—T. E. Doyle, Control Function Decoder, *Ham Radio*, March 1977, p 66–67.



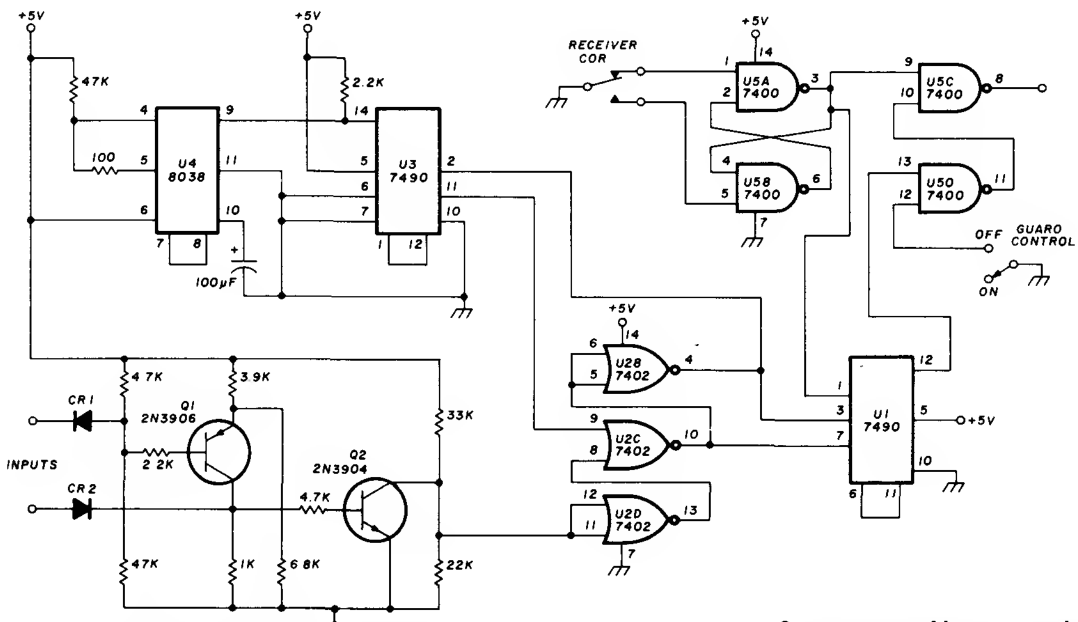
CONTROL-TONE GENERATOR—Uses NE566V PLL as tone generator, directly connected to microphone input of transmitter for activating loudspeaker in receiver being called. Operation is similar to that of paging units using selective call tones. Output level of PLL is adjusted so tone is same amplitude as voice.—K. Wyatt, Private Cell System for VHF FM, *Ham Radio*, Sept. 1977, p 62–64.



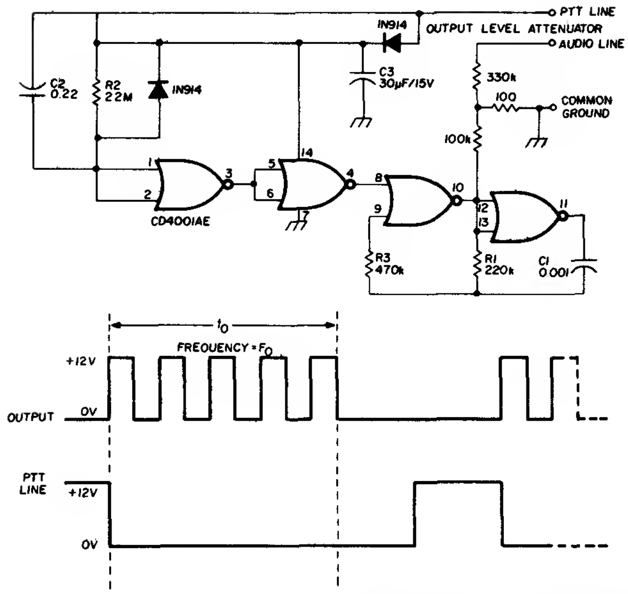
SUBAUDIBLE TONE ENCODER—Simple crystal-controlled oscillator drives CD4020 CMOS divider to give output frequency below normal voice range, for providing tone access to repeater. With 1.120-MHz crystal and division ratio of 8192, output is 136.7 Hz. Output circuit is RC filter that converts square wave to triangle, with pot setting level. Article tells how to choose crystals for other output frequencies and division ratios.—C. Haines, Jr., Go Tone for Ten, *73 Magazine*, Dec. 1976, p 22–23.



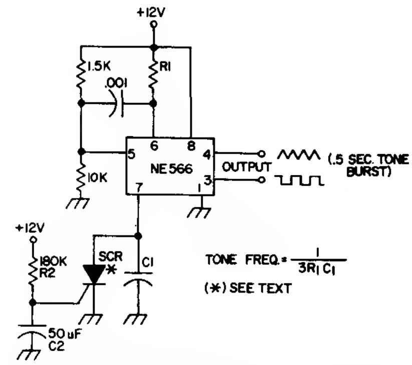
1800-Hz COMMAND OSCILLATOR—Connects across microphone leads of FM transceiver, to produce control (command) tone for entry to repeater or for other purposes. Switch may be placed in supply lead if desired. Q1 can be 2N404 or one of transistors in 2N1303, 2N2904, 2N3638, 2N6516, or 2N6533 series. Q2 can be 2N1308, 2N2712, 2N3565, 2N3569, 2N6513, or equivalent. C_{TRIM} is 0.0062 μF.—Circuits, *73 Magazine*, April 1973, p 132.



ACCESS CONTROL FOR OPEN REPEATER—Permits repeater to run open, for user access without access tone, when there is no outside interference on input frequency. Carrier-operated relay (COR) pulse is shaped by 7400 gates U5A and U5B, for keying transmitter through U5C as long as output of U5D is high. (Turning guard control switch off latches output of U5D high, letting repeater run open.) When control switch is on, repeater can be accessed only by use of guarded input applied to Q1, such as 2000-Hz tone burst, 1336-Hz Touch-Tone signal, or 110.9-Hz private line. Repeater then remains open for 5 s after duration of each transmission. System prevents fringe-area station from blocking repeater access for local users. When receiver squelch is operated 3 times in succession by signal not having one of access tones, input is automatically guarded for 15 min by timer U3-U4 unless accepted access tone arrives.—R. B. Shreve, Troubleshooting Logic Circuits, *Ham Radio*, Feb. 1977, p 56–59.

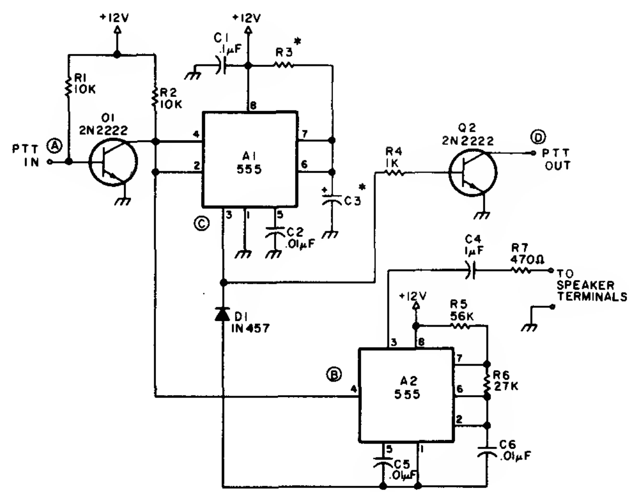


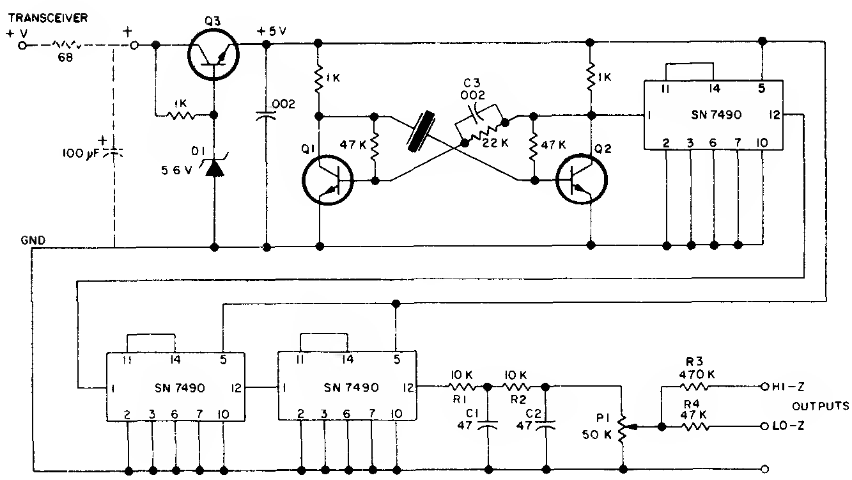
ACCESS TONE-BURST—Generetas 1-s tone burst at spacified audio frequency such as 1800 Hz each time transmitter Is energized, to provlda eccass to e dasirad repaatar. Uses CMOS CD4001AE quad NOR gate, which is smell anough so entire circuit can ba fitted In microphone housing. Gates ara connacted as astable MVBR, with ON time of tona burst determined by R2C2 time constant, triggered by push-to-telk switch (PTT). Large capacitor C3 powers MVBR during burst, with capacitor normally charged to 12 V through PTT circuit during raceive. Supply voltaga is taken through PTT relay in transmittar.—G. Hinkla, Tone-Burst Genarator for Repeetar Accassing, *Ham Radio,* Sapt. 1977, p 68–69.



ACCESS-TONE GENERATOR—Producas audio burst for 0.5 s at frequency determinad by R1 and C1, for usa with FM transceiver as subaudibla tona ganarator to access rapeaters. Provides buffered outputs of squara waves as well as triangle waves. Usas NE566 function generator as voltage-controlled oscillator having excellant stability end linearity. R1 should be between 2K end 20K. SCR should ba typa that triggars at 70 μA.—E. Kanter, PLL IC Applications for Hams, *73 Magazine,* Sept. 1973, p 47–49.

TIME-OUT TIMER—Prevents unnecessary repeetar timeouts by ganerating warning tone in loudspaekar of mobile transceiver when transmitter Is on too long. Normal push-to-talk line Is broken and connected to points A and D. Pushing talk button starts timer. Tlma In seconds Is 1.1 R3C3, wlth R3 in megohms end C3 In microfarads. Thus, 1 megohm and 27 μF glve 30 s, whlla 2 megohms and 81 μF give 180 s.—J. A. Kvochick, Keeping the Wind Down, *73 Magazine,* Feb. 1977, p 50.





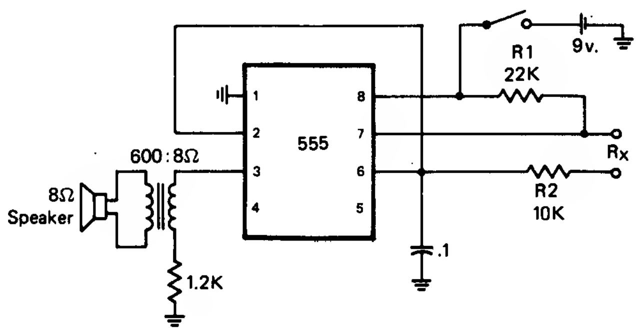
65–240 Hz—Output of 65–240 kHz crystal oscillator is divided by 1000 in thraa SN7490s to glve 65–240 Hz tone requlred for access to amateur FM repeater. Choose crystal to glve exactly desired frequency. Q1 and Q2 ere MPS 6513, end Q3 is 2N1613. Supply can ba 9 to 15 VDC from transceiver or from 9-V battery.—P. H. Wiesa, Rock Solid Subaudlbla Tone Generator, *73 Magazine,* April 1974, p 79–81.

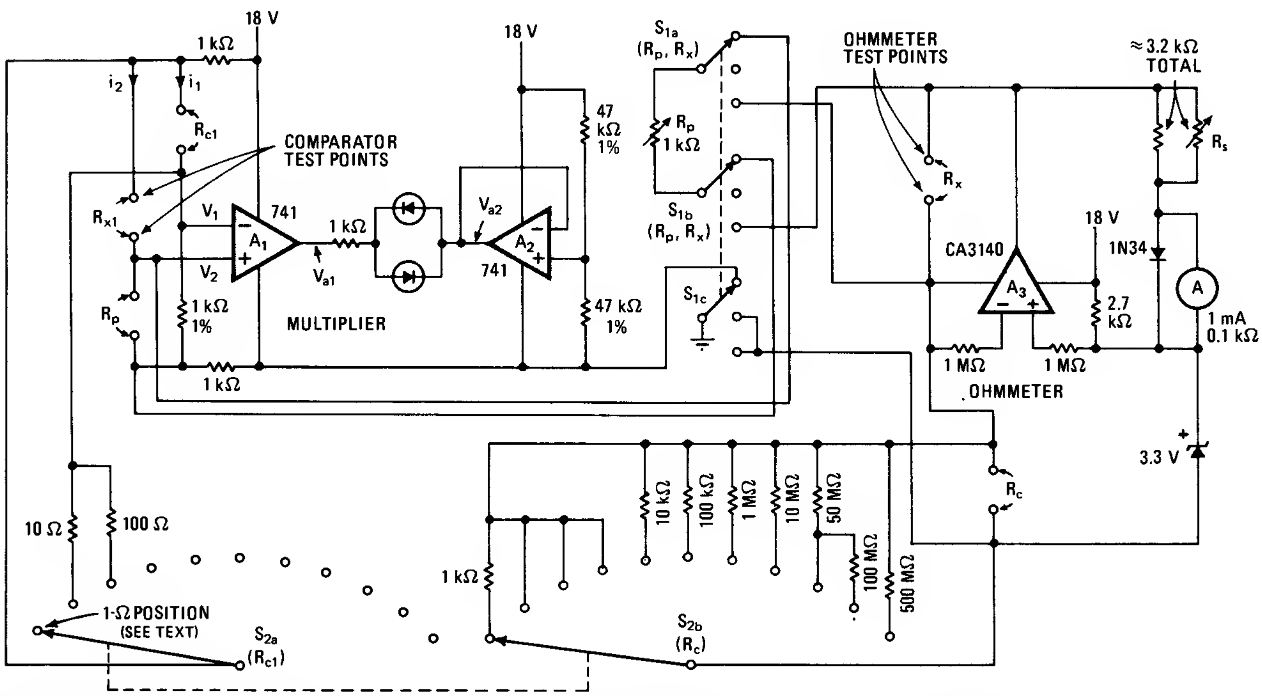
CHAPTER 77

Resistance Measuring Circuits

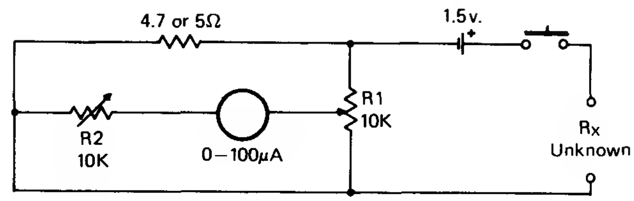
Includes ohmmeter circuits of various types for measuring resistances from under 0.001 ohm to 500 megohms, along with continuity checkers providing audible or LED indications, potentiometer tester, RLC bridges, and AC ohmmeter for nonpolarized measurements. See also Instrumentation and Test chapters.

AUDIBLE OHMMETER—Circuit is built around 555 timer. Resistance detection renge is from 0 ohms to ebout 10 megohms. At high end of range, output is aeriea of clicks from loud-speaker, end et low end is high-pitched tone. Intermediate resistance values produce different tones. Current through unknown resistance is only e few microamperes, so semiconductor junctions can be checked without damage. R2 sets frequency for 0 ohms. Can also be used as code prectice oscillator if R_x terminals are shorted and ground lead of pin 1 is keyed.—J. Schultz, An Ohmmater Potpourri, *CQ*, June 1978, p 32–33.

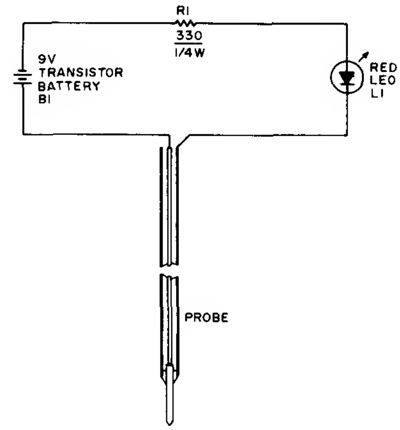




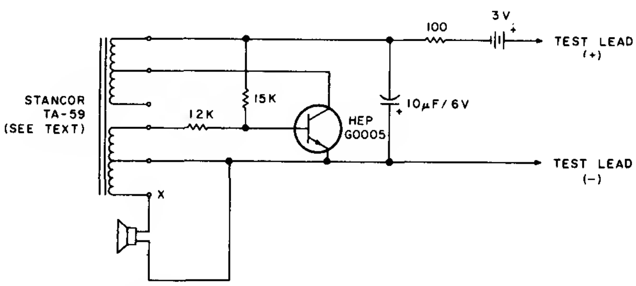
500-MEGOHM LINEAR-SCALE OHMMETER—Reaistance multiplier using 741 opamp reduces current drein when measuring low resistence velues (below 10 ohms). LEDs indicate voltage difference between outputa of A_1 end A_2, as guide for minimizing difference during measurement. R_S aets meter for full-scale deflection when meesuring resistor value equel to standerd R_C.—E. H. Armenino, Extending the Renge of the Lineer-Scele Ohmmeter, *Electronics*, Dec. 22, 1977, p 93–94.



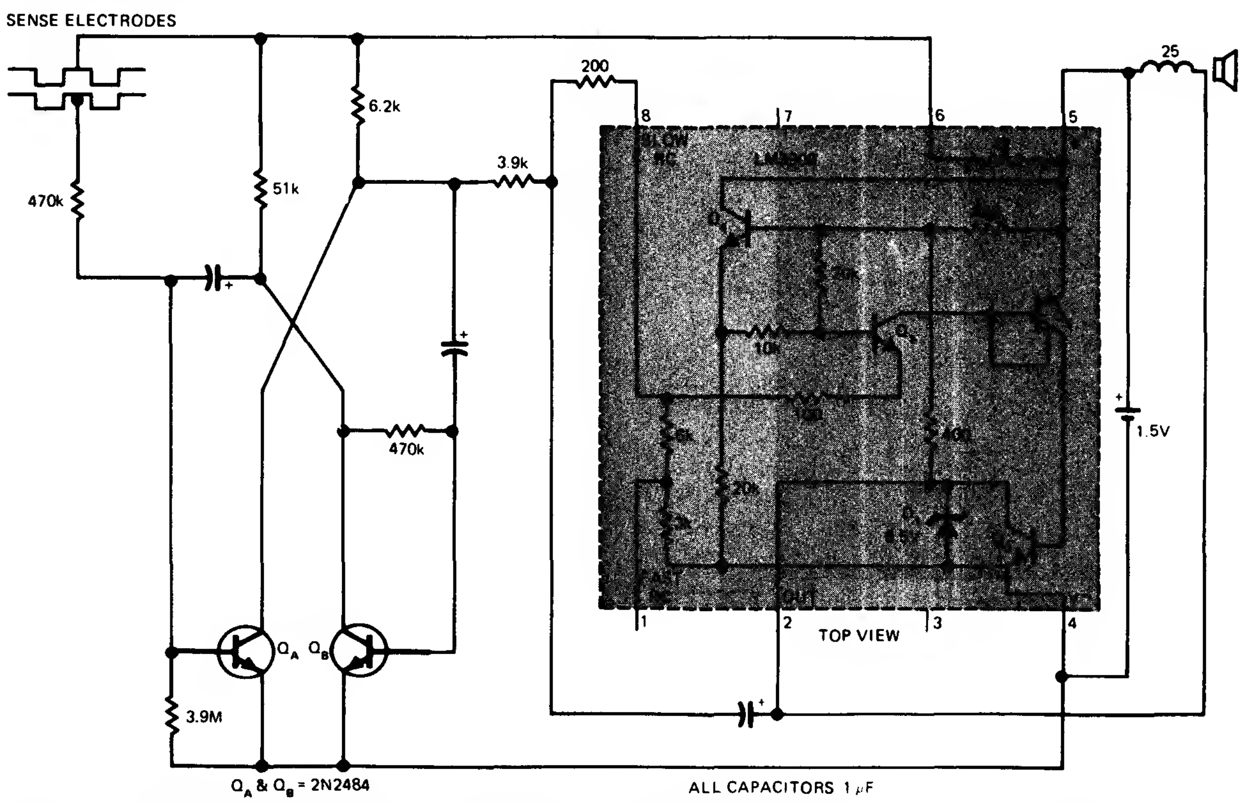
BRIDGE FOR 0.1–5 OHMS—Set metar raading to zero with multiturn pot R1 when test leads are shorted. Simpla one-point callbretion is made by using known low raslstenca for about midrange value and setting meter to conveniant scale marking by adjusting R2. Calibration curve is then made for meter scala by using other normal resistances.—J. Schultz, An Ohmmetar Potpourri, *CQ,* June 1978, p 32–33.



MOISTURE TESTER—Simple probe tells when plants nead wetering. Amount of moisture and minerals in soil togethar determine current available for LED. Almost full brilliance indicates adaquete moisture, and no illumination means plant naeds water badly. Probe can be No. 14 wira filed to point and centered with epoxy in 3/16-inch coppar tubing, or simply two stiff probe wires about 1 inch apart.—W. L. MacDowell, The Violet Tester, *73 Magazine,* May 1975, p 52–53.

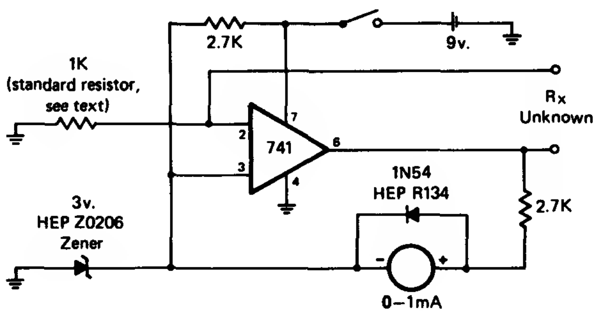


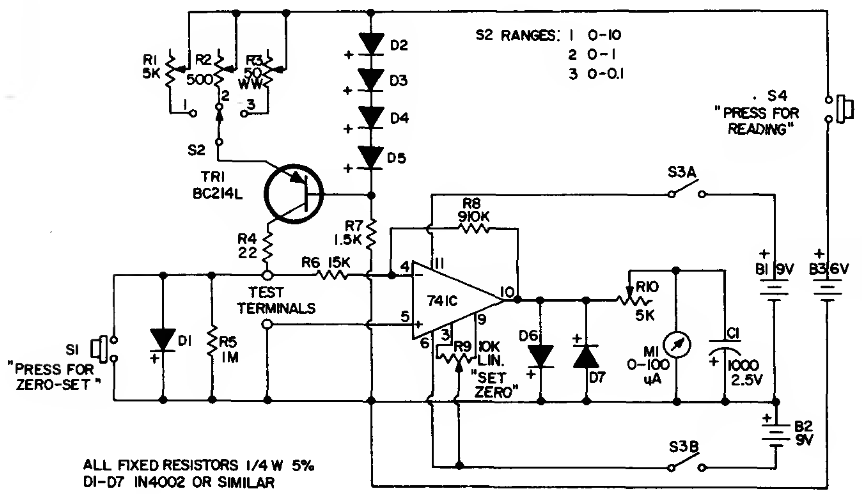
AUDIBLE OHMMETER—Voluma and/or pitch of one-transistor audio oscillator varies with resistanca across tast terminals, to give audibla indication of continuity and relative raslstence without looking et meter. Can also be used as translstor and diode tester, signal injector, code practica oscillator, and CW monitor. Oscillator uses transistor-typa transformer heving center-tapped windings, connected as shown to give three-winding transformar. Operates from two 1.5-V cells in series. Will respond to resistance veluas from short to about 100K. Volume increases end pitch rises as resistence is increased. For very low resistance, tone resembles croaking of frog.—Build the El Sapo Tester, *73 Magazine,* Dec. 1977, p 184–185.



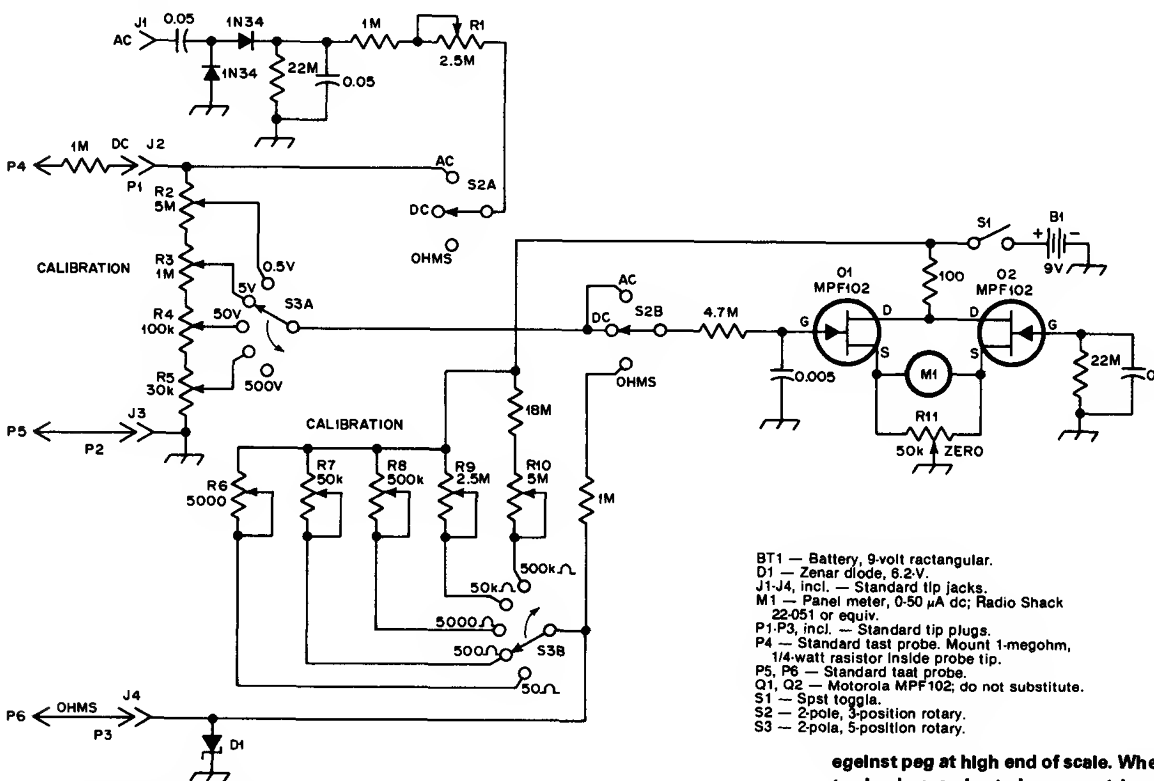
WATER-SEEPAGE ALARM—National LM3909 flashar IC oparating from 1.5-V cell provides safe water-seepaga alarm for potentially damp floors bacausa thara is no connection to power lina. When sansing alectrodas pass ebout 0.25 µA through moisture, pelr of 2N2484 transistors (Q_A and Q_B) become astable MVBR operating et rate that starts at 1 Hz and increases with leakage between alactrodes. Pulsa waveform applied to pin 8 of IC varies timing current of flasher, resulting in distinctively modulated tona output for loudspaakar of alarm. Sensors can be two strips of stainless steel on insulators or zigzeg path in coppar of printed-wiring board. Place demp finger across gap to test alarm.—P. Lefferts, Power-Miser Flashar IC Has Many Novel Applications, *EDN Magazine,* March 20, 1978, p 59–86.

LINEAR-SCALE OHMMETER—Unknown resistance value is arithmetic product of standard resistor value and current reading in milliamperes. With 1K standard resistor, deflections from 0 to 1 A correspond to resistance readings from 0 to 1K. Requires no calibration and no zero adjustment. Can be made multirange by switching in different standard resistors.—J. Schultz, An Ohmmeter Potpourri, *CQ*, June 1978, p 32–33.



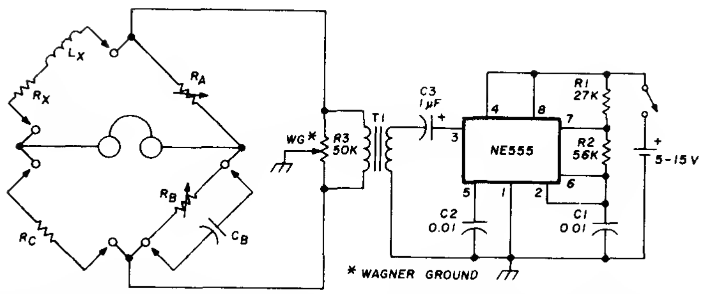


THREE-RANGE MILLIOHMMETER—Solid-state design measures resistance values accurately down to less than 0.001 ohm. Full-scale values for ranges are 10, 1, and 0.1 ohms.—Circuits, *73 Magazine*, July 1974, p 80.



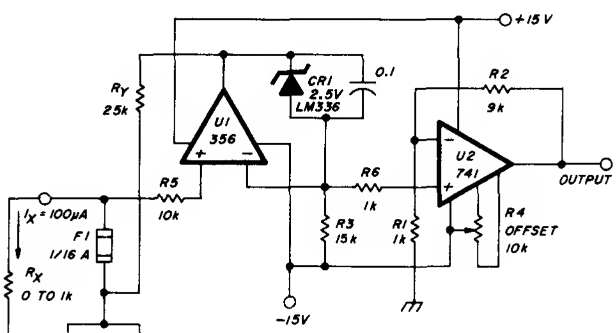
BT1 — Battery, 9-volt rectangular.
D1 — Zener diode, 6.2-V.
J1-J4, incl. — Standard tip jacks.
M1 — Panel meter, 0-50 μA dc; Radio Shack 22-051 or equiv.
P1-P3, incl. — Standard tip plugs.
P4 — Standard test probe. Mount 1-megohm, 1/4-watt resistor inside probe tip.
P5, P6 — Standard test probe.
Q1, Q2 — Motorola MPF102; do not substitute.
S1 — Spst toggle.
S2 — 2-pole, 3-position rotary.
S3 — 2-pole, 5-position rotary.

FET VOM—Use two FETs in balanced circuit. Meter reads zero when circuit is balanced with R11. Values being measured produce imbalance linearly proportional to output voltage of bridge. Resistance measurements use linear ohms-readout system, with single meter scale serving for all resistance and voltage measurements. In ohms position, meter will rest gently against peg at high end of scale. When ohmmeter leads are shorted, zero pot is adjusted so meter reads 0 ohms. Article covers construction and calibration.—J. Rusgrove, An FET Volt-Ohmmeter with Linear Ohms Readout, *QST*, March 1978, p 16–18.



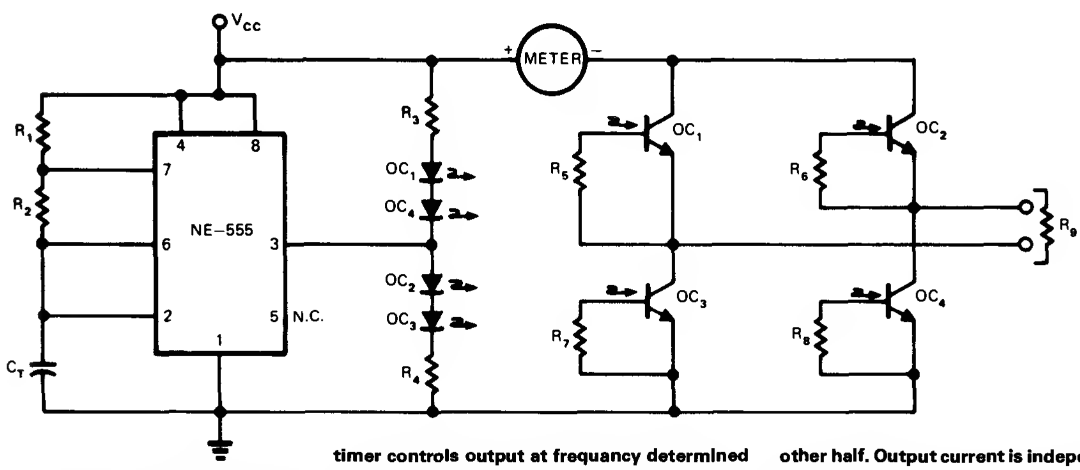
L (mH)	R (ohms)	C_b (μF)	R_c (ohms)
0.01 - 0.1	1 - 10	0.01	10
0.1 - 1.0	10 - 100	0.01	100
0.1 - 1.0	1 - 10	0.1	10
1.0 - 10.	10 - 100	0.1	100
1.0 - 10.	1 - 10	1.0	10
10. - 100.	100 - 1000	0.1	1000
10. - 100.	10 - 100	1.0	100
100. - 1000	100 - 1000	1.0	1000

RLC BRIDGE—Maxwell bridge uses only one reactive element for measuring resistance, inductance, and capacitance. Wagner ground balances stray internal capacitances to ground to obtain perfect null. Measurement ranges are shown in table. Over fixed range, R_A can be calibrated to read inductance values directly. R_A and R_B can be calibrated initially over their variable ranges by using standard resistors. Measurements are not affected by frequency of driving source. Circuit is set up as shown for measuring inductance. If standard inductance is used in place of L_X, unknown capacitor at C_B can be measured. Signetics NE555 is connected as astable oscillator running at about 1000 Hz with values shown for R and C, drawing 6.5 mA from 9-V battery. Article covers construction and calibration and gives balance equations for all measurements.—J. H. Ellison, Universal L, C, R Bridge, *Ham Radio,* April 1976, p 54–55.

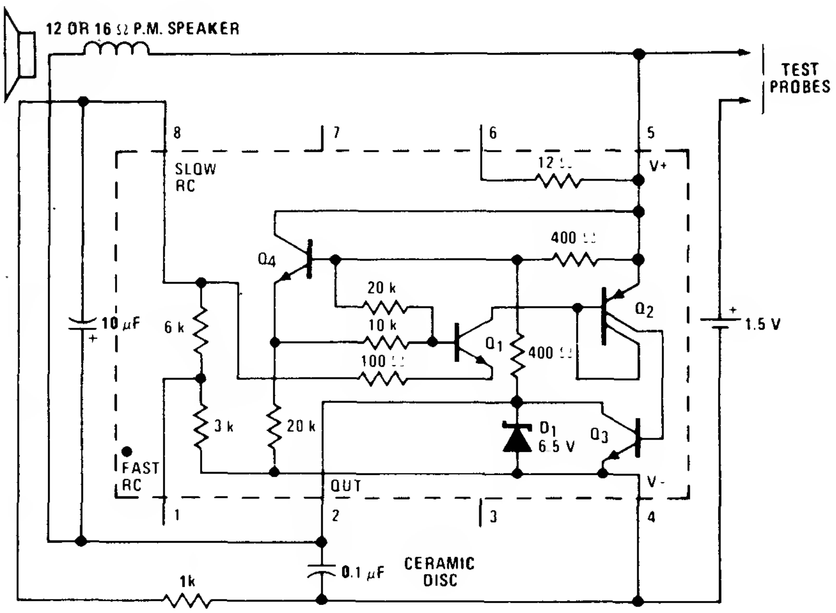


R_X	I_X	R_Y
10 OHM	10 mA	250 OHM
100	1 mA	2.5 k
1 k	100 μA	25 k
10 k	10 μA	250 k
100 k	1 μA	2.5 M
1 M	100 nA	25 M

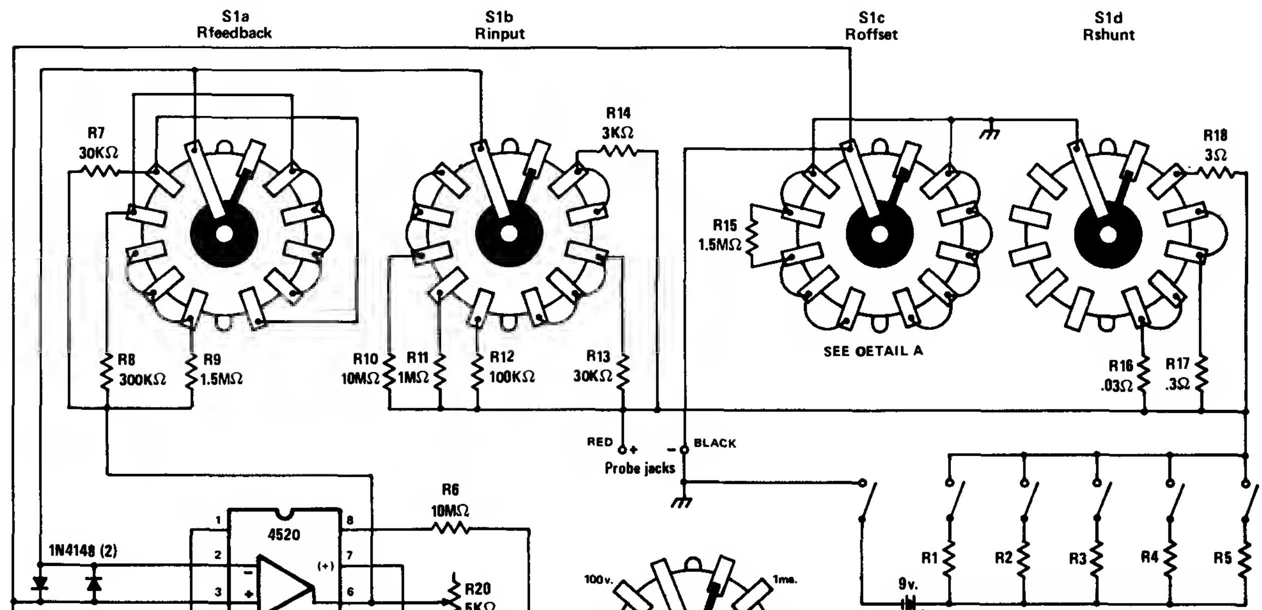
LOW-VOLTAGE OHMMETER—Combines stable constant-current source U1-CR1-R_Y with DC amplifier U2 having gain of 10 to keep applied voltage down to 0.1 V. Output is linearly proportional to unknown resistance. Resistances well below 1 ohm can be measured accurately. U2 scales 0–100 mV unknown voltage to 0–1 V at output, so 1K resistor under test can be read as 1.000K on DVM scale. U2 should be offset-nulled to eliminate zero error, for best low-scale accuracy, by shorting input and adjusting R4 for 0.000 V out of U2. Full-scale calibration involves trimming individual range values of R_Y for correct output, while using reference value for R_X. Fuse and clamp diodes protect range resistors, and R5 protects opamp.—W. Jung, An IC Op Amp Update, *Ham Radio,* March 1978, p 62–69.

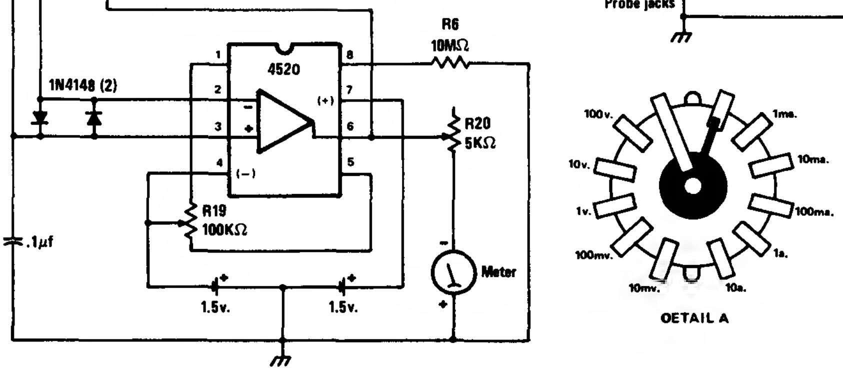


AC OHMMETER—Optoisolator circuit operating from single battery develops alternating current for measuring resistance of soils and construction materials without errors due to polarization and earth-current effects. 555 IC timer controls output at frequency determined by R_1, R_2, and C_T. R_1 is made very much less than R_2 but should not be below about 1 K. Frequency value is $1.44/(R_1 + 2R_2)C_T$. Output switching matrix is controlled by timer so OC_1 and OC_4 are on for one half-cycle and OC_2 and OC_3 are on for other half. Output current is independent of frequency and duty cycle up to 150 Hz. With Monsanto MCT-2 optoisolators, R_3 and R_4 are 330 ohms and R_5-R_8 are each 22K.—D. J. Beckwitt, AC Ohmmeter Provides Novel Use for Opto-Isolators, *EDN Magazine,* July 5, 1974, p 70.



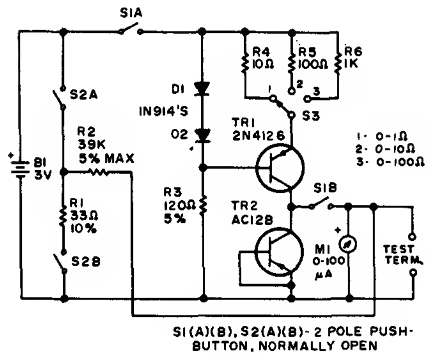
CONTINUITY CHECKER—National LM3909 IC operating from 1.5-V cell provides enough audio power to drive loudspeaker when probes are shorted by resistance up to about 100 ohms. By probing two points in rapid succession, small differences in resistance can be detected by noticeable differences in tone; this feature is useful for identifying windings of transformers.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 4–5.



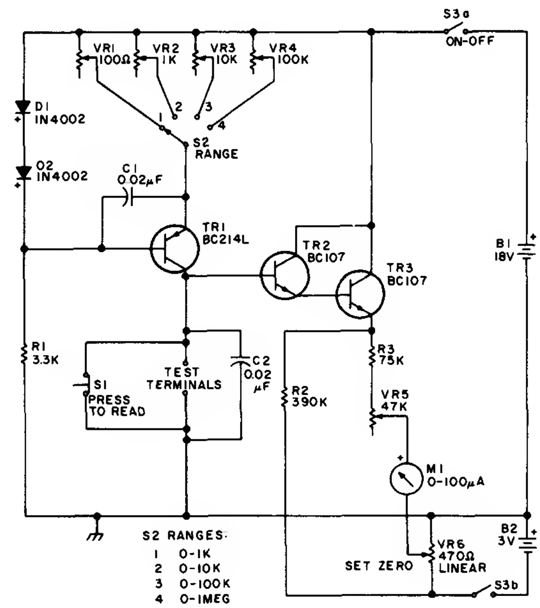


Scale	RSHUNT	RINPUT	ROFFSET	RFEEDBACK
100v.	Open	10M	0	30K
10v.	Open	10M	0	300K
1v.	Open	10M	1.5M	1.5M
100mv	Open	1M	1.5M	1.5M
10mv	Open	100K	1.5M	1.5M
10a.	.03	30K	0	30K
1a.	.03	30K	0	300K
100ma	.3	30K	0	300K
10ma	.3	3K	0	300K
1ma	3.0	3K	0	300K
100μa	Open	0	0	3K
50μa	Open	0	0	6K
10μa	Open	0	0	30K
5μa	Open	0	0	60K
1μa	Open	0	0	300K
500na	Open	0	300K	300K
100na	Open	0	1.5M	1.5M

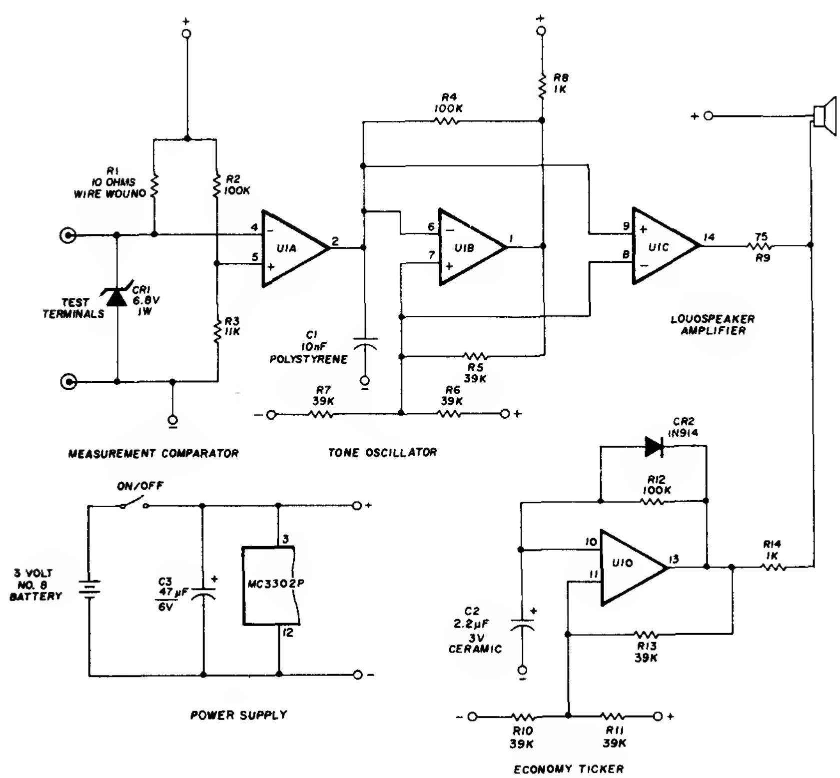
LINEAR-OHMS MULTIMETER—Full-scale value for each of five resistance ranges is determined by values used for R1-R5. Table gives values of resistors connected to each layer of three-gang 12-position selector switch to obtain five voltage ranges and 12 current ranges for other multimeter functions. For dual multimeter, duplicate circuit for other section to permit measuring input and output signals simultaneously.—J. Sandler, ME's New Twin Electronic Multimeter, *Modern Electronics*, Oct. 1978, p 58–61.



DOWN TO 0.05 OHM—Switch S3 gives choice of three ranges in linear ohmmeter circuit developed for measuring very small values of resistance. Values of R4, R5, and R6 require adjustment during initial calibration.—Circuits, *73 Magazine*, June 1975, p 161.

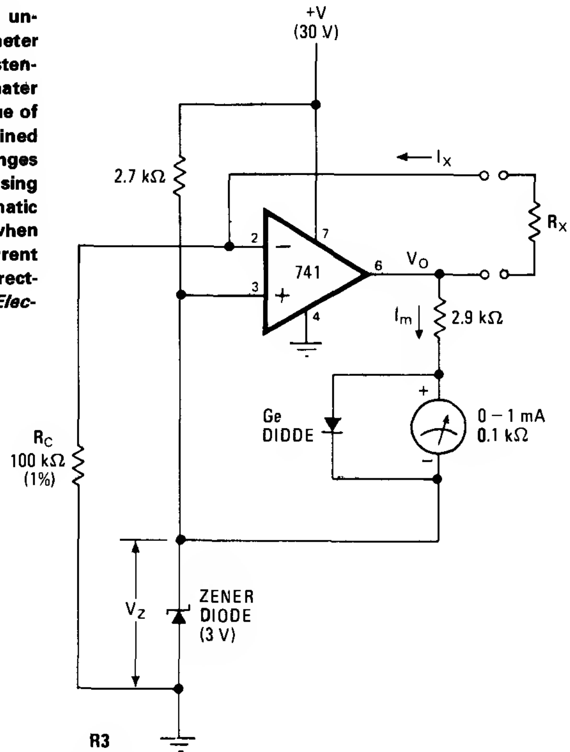


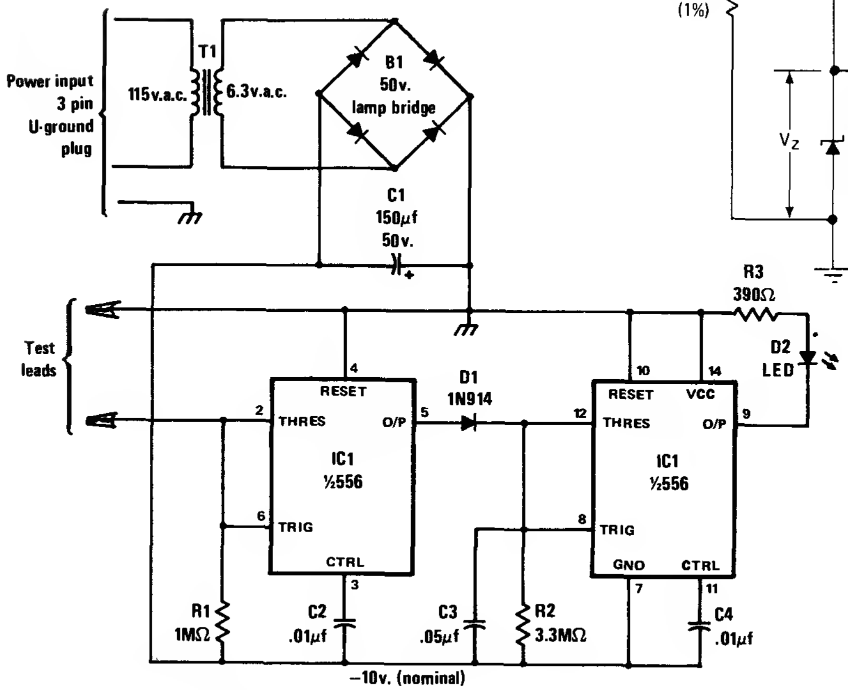
LINEAR-SCALE OHMMETER—Provides accurate measurements of resistance in four ranges, with linear scale at high end of each.—Circuits, *73 Magazine*, Feb. 1977, p 27.



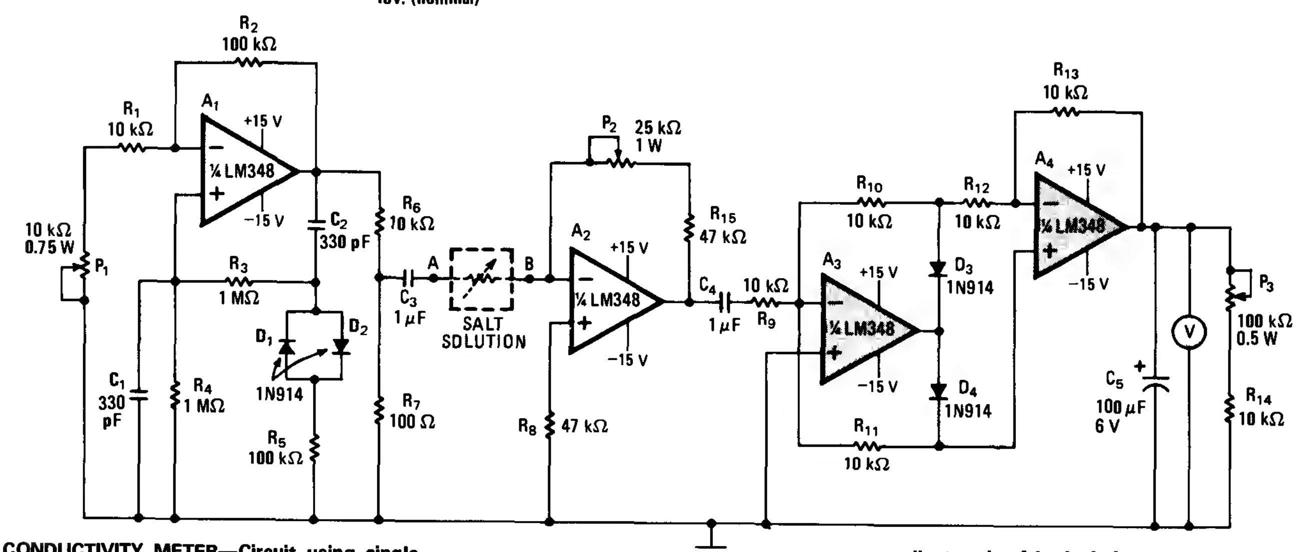
CIRCUIT TRACER—Continuity tester delivers continuous audio tone when its test terminals are connected by resistance less than about 1 ohm. Circuit under test does not receive more than 3 V or 300 mA, depending on resistance between terminals. Tester ticks softly when switched on but is open-circuited, as reminder that battery drain is then about 0.8 mA. Tester uses sections of Motorola low-power MC3302P quad comparator as measurement comparator, 600-Hz tone oscillator, AF amplifier, and ticker. Pins 3 and 12 of IC are used in power supply.—R. C. Marshall, Continuity Bleeper for Circuit Tracing, *Ham Radio*, July 1977, p 67–69.

NO-CALIBRATION OHMMETER—Whan unknown resistor R_x is connected, milliammeter raeding is R_x/R_c whare R_c is velue of known stenderd resistor used. R_x is then equal to mater reeding in milliamperas multiplied by value of R_c in ohms. Full-scale daflaction is thus obtained on 1-mA meter when R_x is 100K. Other ranges cen be obteined by changing velua of R_c, using renge switch if dasired. Meter hes automatic zeroing beceuse V_o rises to exactly 3 V when measuring leads era shorted end no current flows through meter.—V. Ramprakash, Direct-Reading Ohmmeter Needs No Calibration, *Electronics*, Nov. 11, 1976, p 115–116.

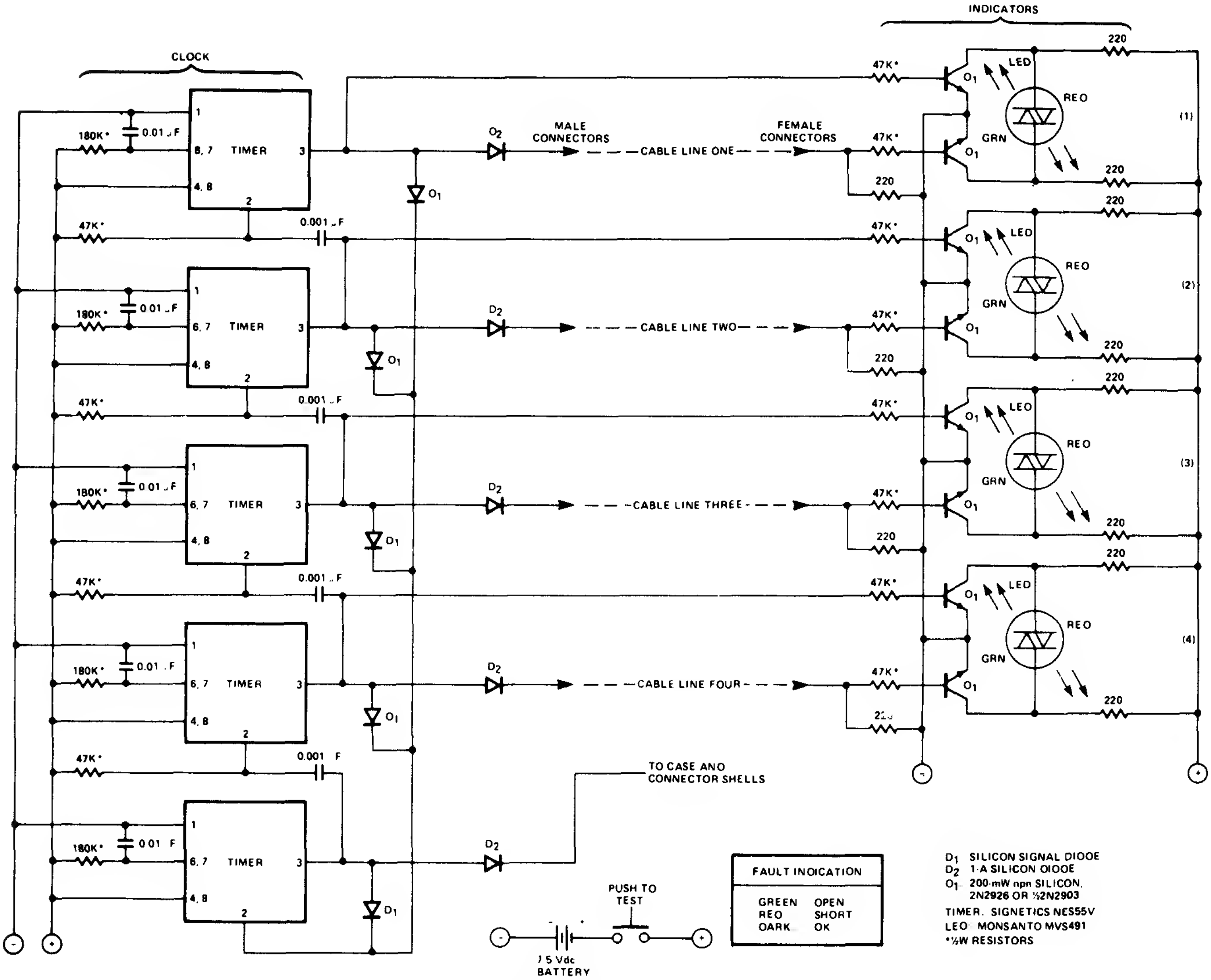




POT TESTER—Developed for testing noisy 10K wirewound lineer pots used in control of theatrical lighting system. Circuit detects eny momentary open and drives LED to produce visible flesh lesting about 0.1 s. Circuit operates from −10 V provided by bridge end AC trensformer. Left half of IC1 ects es comparator whose output stays low es long es input is ebove threshold voltage. When pot passes open point, pin 5 goes high end charges C3, making right half of IC1 turn on LED.—C. J. Shakaspaare, Test Your Pot, *Modern Electronics*, Oct. 1978, p 38–39.



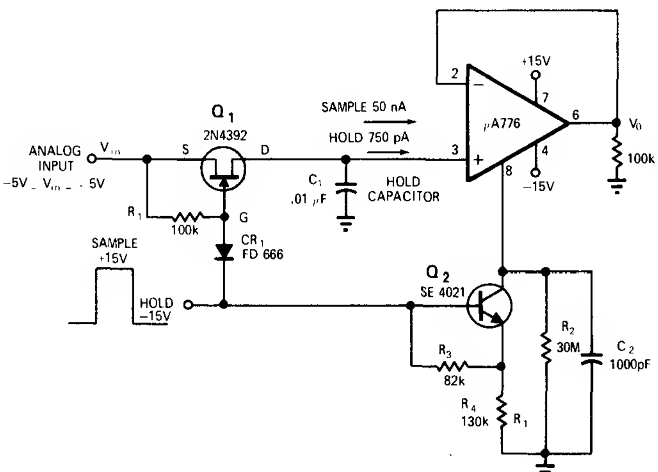
CONDUCTIVITY METER—Circuit using singla qued opemp measures relative chenga in concentretion of salt solution by monitoring its conductance. Use of elterneting current through solution eliminetes errors ceused by electrolysis effect. Wian-bridge oscillator heving R_4C_1 end R_2R_3 as erms of bridge generates 1-kHz signel for driving emplifier A_2 through solution. P_1 controls oscilletor emplitude, and P_2 edjusts gein of A_2. A_3-A_4 form precision rectifier giving output voltage equal to absolute value of input voltaga.—M. Ahmon, Ona-Chip Conductivity Meter Monitors Salt Concentretion, *Electronics*, Sept. 15, 1978, p 132–133.



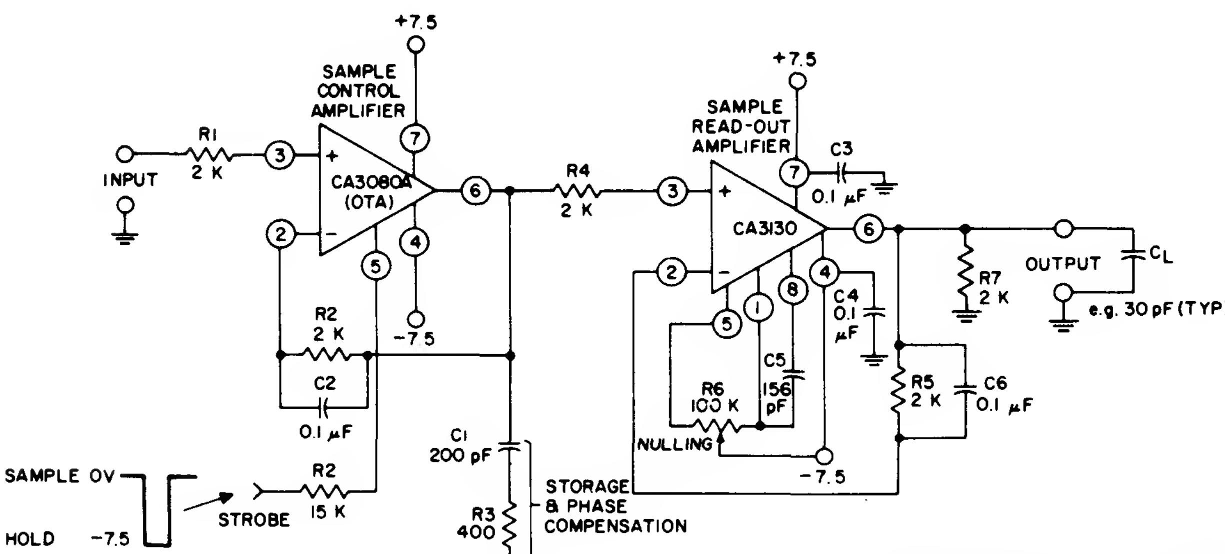
CABLE TESTER—Five Signetics NE555V timers check all lines of four-conductor cable for opens and for short-circuit conditions. Differential transistor pair at one end of each cable line remains balanced as long as clock pulses at opposite ends of line are identical. Clock pulse at timer end of one line turns on green LED to indicate open in line. Clock pulse only at transistor end of line turns on red LED to indicate that line is shorted. With good cable line, neither LED is on.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 730.

CHAPTER 78
Sampling Circuits

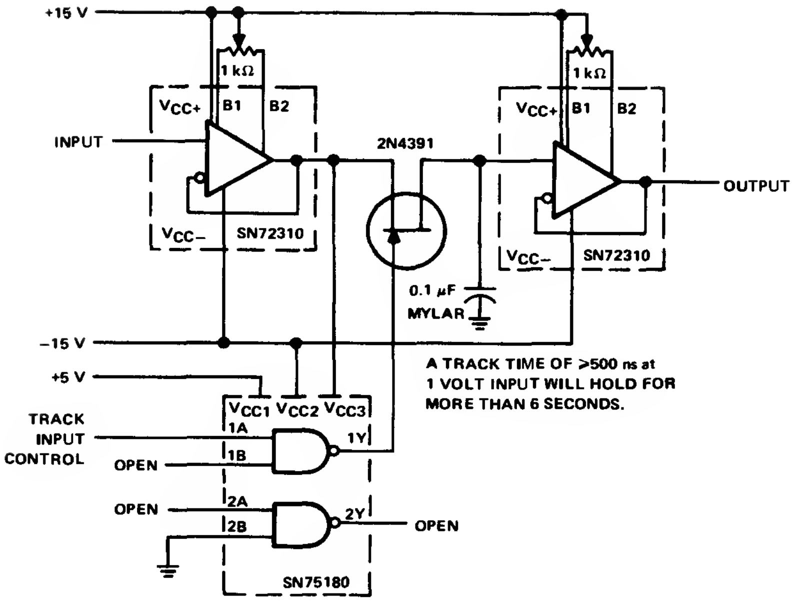
Methods of sampling and holding analog signals, including digital selection of sampling level and long-term storage of signals in digital form as substitute for storage CRO.



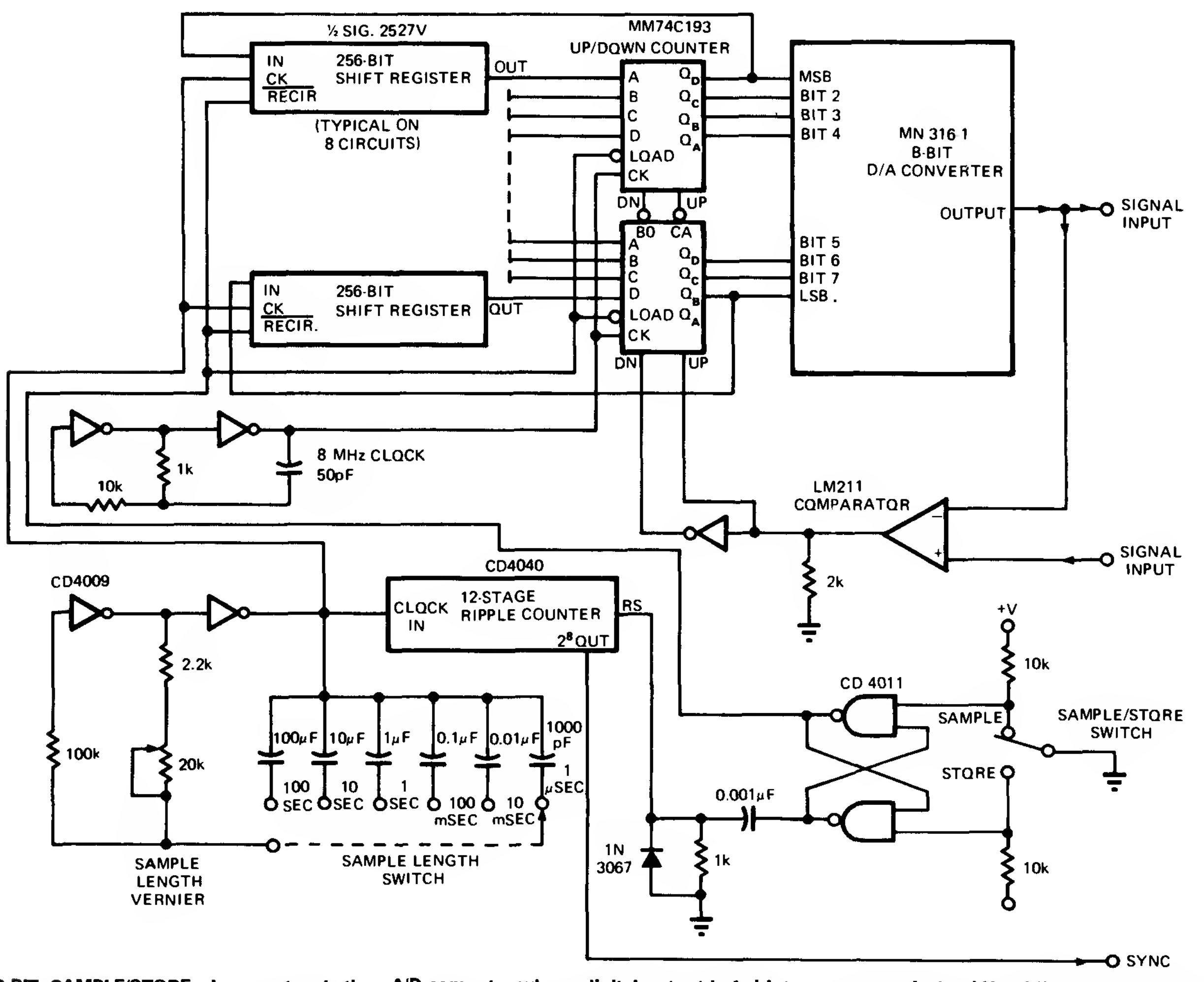
TWO SLEW RATES—Cost of sample-and-hold circuits is reduced by using high slew rate only during sample period. Programmable μA776 opamp permits switching from high rate requiring 50-nA input bias current to holding amplifier mode requiring only 750-pA input bias current. Output level is held constant within 1% for about 2 s, making circuit ideal for digital readouts.—M. K. Vandar Kool, Low Cost Sample-and-Hold Circuit, *EDN/EEE Magazine*, Nov. 1, 1971, p 46.



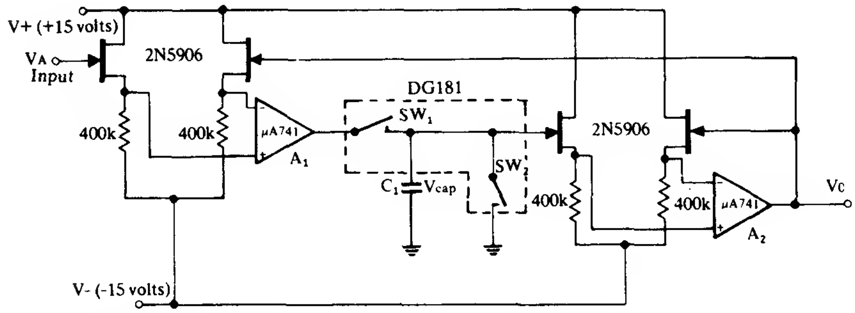
SAMPLE READOUT AMPLIFIER—RCA CA3080A operational transconductance amplifier feeds CA3130 to give amplification of sampled signal. Input voltage is sampled for duration of strobe pulse and held for readout.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 165–170.



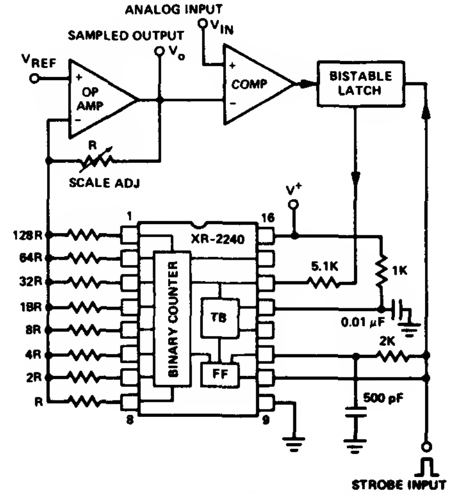
TRACK AND HOLD—When track input control is 0.8 V or less, gate in SN75180 holds 2N4391 transistor source-drain path closed so input signal goes to output unchanged. When control voltage is increased to 2 V, gate opens path through transistor, so signal voltage stored at that instant in 0.1-μF capacitor is held at output. Track time is greater than 500 ns for 1-V input, giving hold time over 6 s. Circuit uses two SN72310 wideband voltage-follower op-amps.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 4-41.



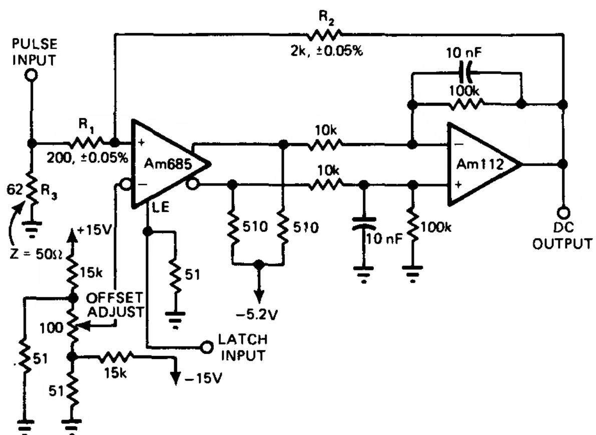
256 8-BIT SAMPLE/STORE—Low-cost substitute for storage oscilloscope can be used to study analog variables in speech synthesis, transient signal analysis, and destructive testing of components. Circuit is basically a tracking A/D converter whose digital output is fed into shift register holding 256 8-bit words. Separate clock for shift register is continuously adjustable from about 250 kHz down to about 4 s per cycle, with output going to 12-stage ripple counter. At 250 kHz, shift register stores input signal for 1 ms. Article gives details of circuit operation.—K. P. Roby, Transient Signal Analyzer Has Multiple Uses, *EDN Magazine*, Oct. 20, 1974, p 46–48.



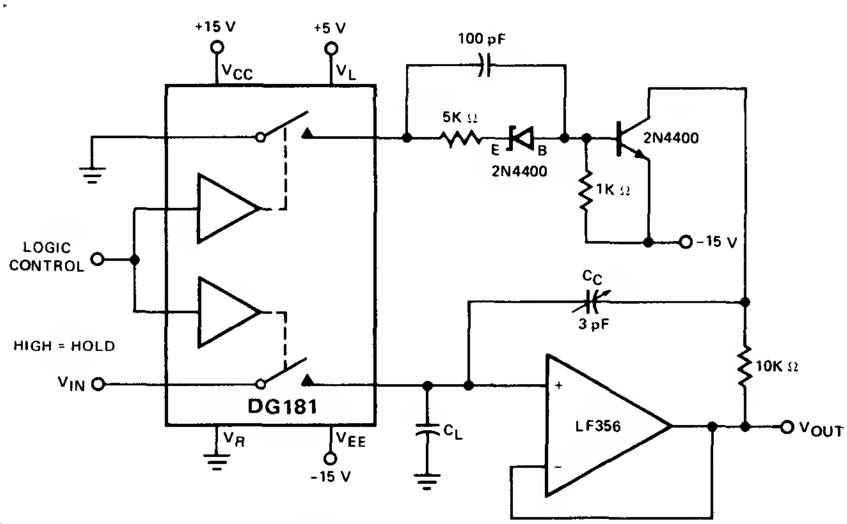
NONINVERTING SAMPLE AND HOLD—Matched pair of FETs gives high input resistance for analog input signal greater than 10^{12} ohms, while output resistance of FET pair is under 12K. Opamp A_1 acts as buffer and allows C_1 to charge rapidly. Use of DG181 analog switches limits leakage current flowing into or out of C_1, while SW_2 provides fast resetting of capacitor voltage to zero. Similar FET pair and opamp provide output voltage proportional to sampled value.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 4-7–4-8.



DIGITAL SAMPLE AND HOLD—When strobe input is applied, RC low-pass network between reset and trigger inputs of Exar XR-2240 programmable timer/counter resets and then triggers timer, sets output of bistable latch to high state, and activates counter. Circuit generates staircase voltage at opamp output. When staircase level reaches that of analog input to be sampled, comparator changes state, activates bistable latch, and stops count. Opamp output voltage level then corresponds to sampled analog input. Sample is held until next strobe signal. Minimum recycle time is about 6 ms. Supply voltage can be 4–15 V.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 11–18.

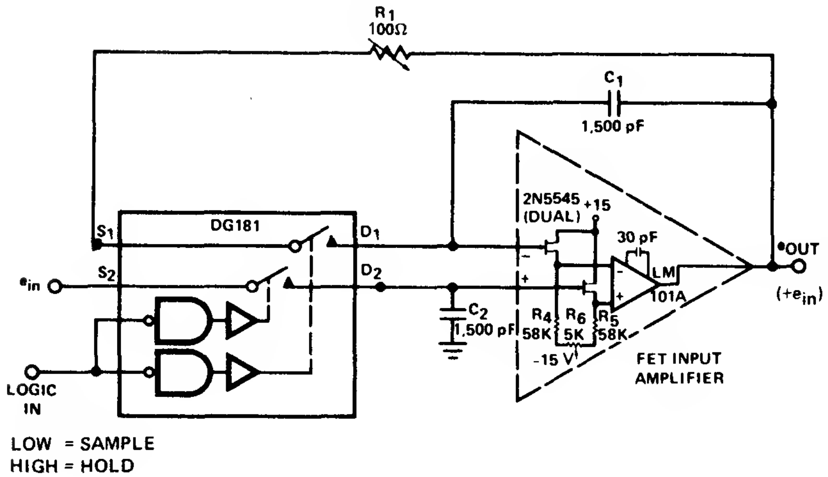


ANALOG SAMPLE-AND-HOLD—Uses AM685 comparator for continuous sampling of analog voltage at summing node formed by R_1 and R_2. Complementary logic outputs of comparator drive differential indicator formed by AM112 opamp. When error voltage at summing node is positive, comparator latches in high state and causes output opamp to integrate toward more negative voltage. When error voltage at latch time (determined by pulse input) is negative, integrator voltage ramps to more positive value. Circuit soon reaches equilibrium, at which output voltage is equal to −10 times value of sampled waveform. Article gives performance waveforms for sampling video pulses.—S. Dendinger, High-Speed Analog Sampler Uses Only Two IC's, *EDN Magazine*, May 20, 1977, p 128 and 130.



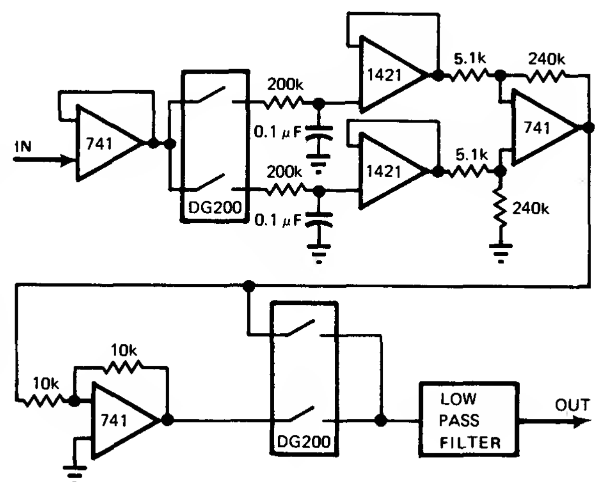
(< 5 mV of Sample to Hold Offset when C_L = 1000 pF)

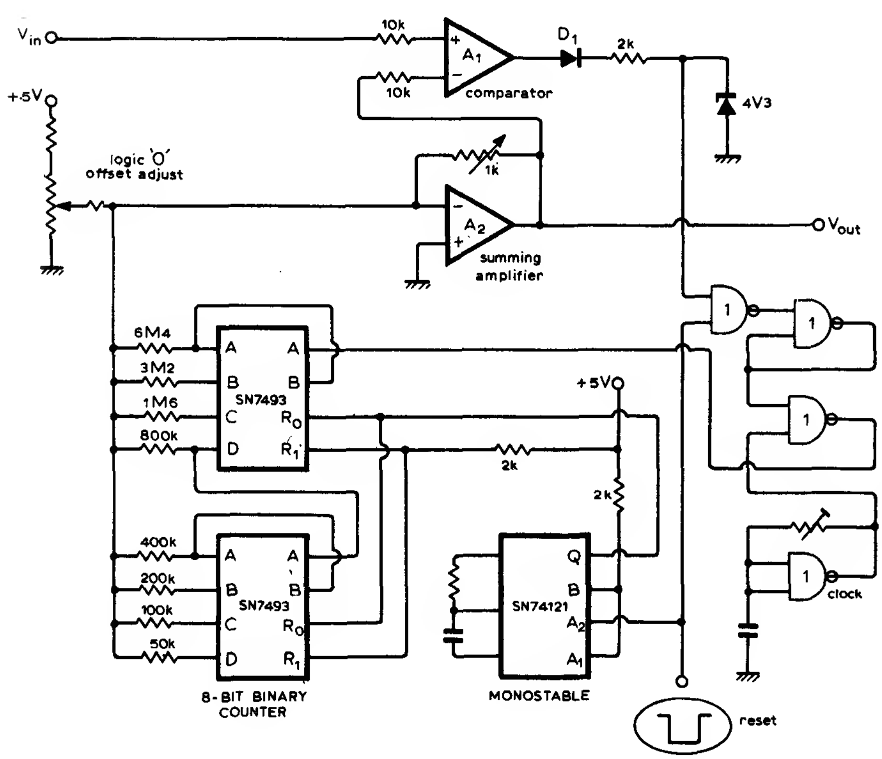
NEUTRALIZATION OVER ±7.5 V RANGE—Switching transients are attenuated in sample-and-hold circuit using DG181 FET analog switch by adding neutralization derived from complementary signal coupled through upper switch of DG181. Charge transferred from second switch is then opposed to that from main channel. Circuit is controlled by input logic signal. With compensation, change in transferred charge is less than 5 picocoulombs for input signal range from −7.5 V to +7.5 V.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-61.



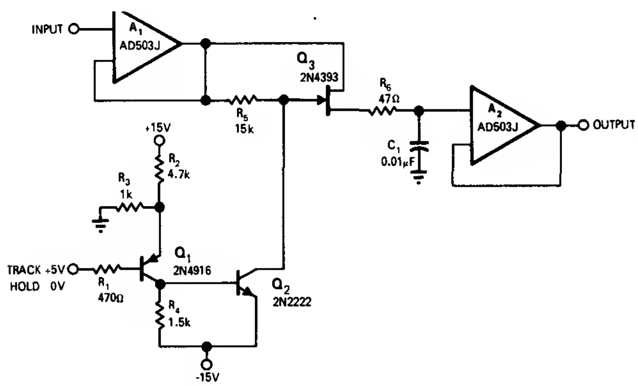
NONINVERTING SAMPLE AND HOLD—DG181 JFET analog switch provides best combination of settling speed and inherent charge transfer accuracy for 2N5545 FET-input opamp for high-speed sample-and-hold applications.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-60.

TIMED SLOPE-SAMPLING—Circuit measures rate of signal change for slowly varying signals (changing less than 1 V/min) by using sample-and-hold circuit to store instantaneous sample. After compatible time interval, sample is compared with new input current value; difference is than the desired slope. One limitation is that offset errors added to stored signal near zero voltage can cause large errors in the derivative. Circuit is highly sensitive to noise spikes during sampling.—R. E. Bober, This Derivative Circuit Handles Slowly Varying Signals, *EDN Magazine*, Jan. 20, 1976, p 82.

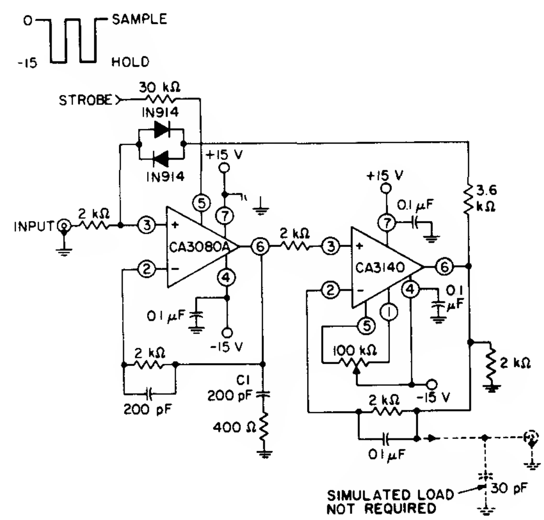




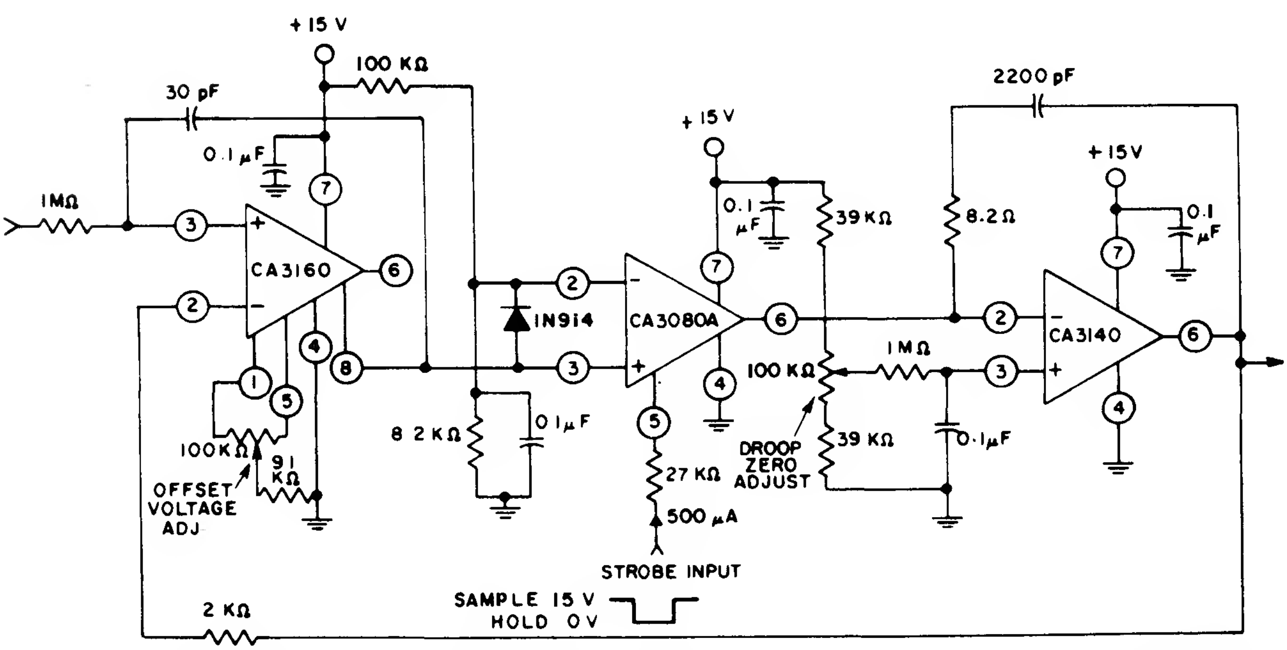
256-LEVEL HOLD—Uses digital approximation to hold sampled analog voltage for long periods. Cascaded SN7493 ICs form 8-bit binary counter providing 256 discrete voltage levels from opamp A_2, while input voltage provides varying reference to opamp A_1 serving as comparator. Apply 0 at reset input to clear counter for period determined by monostable IC. Counter now feeds staircase waveform to A_1 through A_2 until staircase reaches V_{in}, when counter goes high and disables counter clock. Count is then held and sampled voltage appears at output.—N. Macdonald, Digital Sample and Hold, *Wireless World*, May 1976, p 78.



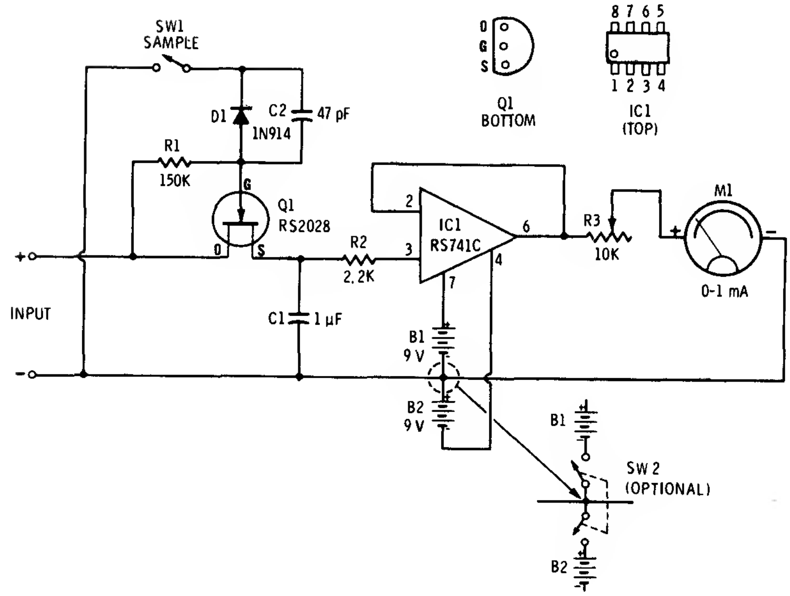
TRACK-AND-HOLD UP TO 4 kHz—Developed for tracking ±10 V AF input signal when control input is +5 V. When control drops to 0 V, series FET Q_3 opens and input voltage at that time is stored on C_1 for transfer to output through high-impedance opamp A_2.—R. S. Burwen, Track-and-Hold Amplifier, *EDN/IEEE Magazine*, Sept. 1, 1971, p 43.



SAMPLE AND HOLD—CA3140 bipolar MOS opamp serves as readout amplifier for storage capacitor C1 which is charged by CA3080A variable opamp serving as input buffer and low-feedthrough transmission switch. CA3140 also provides offset nulling.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 17.

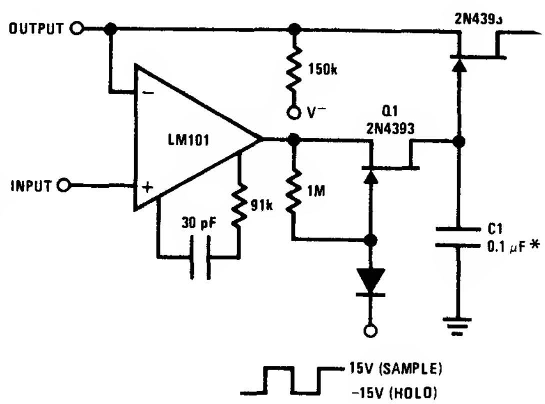


15-V SINGLE-SUPPLY—CA3160 opamp provides high input impedance and input voltage range of 0–10 V. CA3080A functions as strobed current source for CA3140 output integrator and storage capacitor. Pulse droop during hold interval can be reduced to zero by adjusting 100K pot.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 271–272.

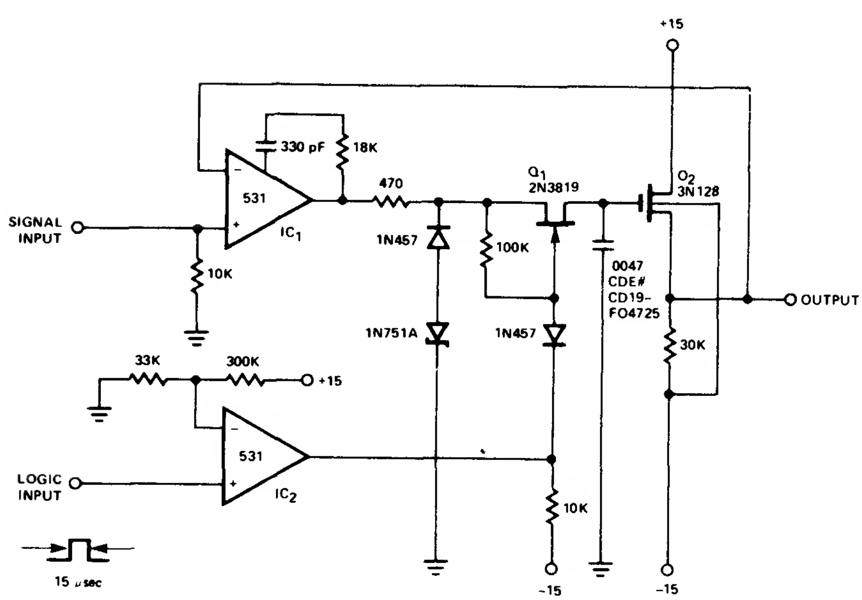


FET-OPAMP SAMPLE AND HOLD—Meter indicates output signel when input is present and stores input in C1 when sample switch is open. Opamp is connected as unity-gein voltege follower. Charge on C1 will be drained within a few minutas by opamp shown. Charge can be hald longer by changing to FET-input opamp or by opening both battery circuits with altarnetive DPDT switch SW2. Developed for classroom demonstretions.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 61–69.

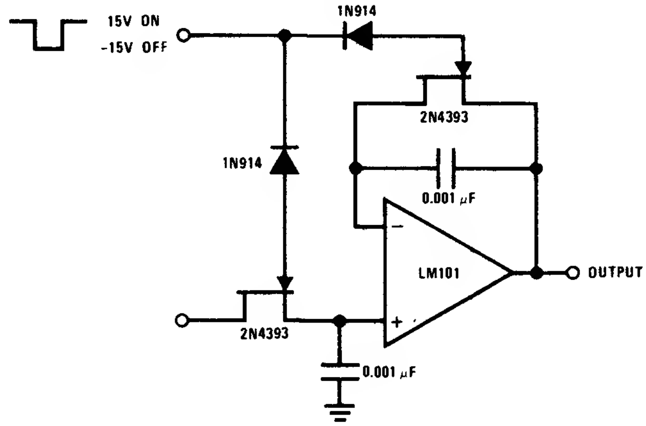
LOW-DRIFT SAMPLE AND HOLD—JFETs provide complete buffaring to semple-and-hold capacitor C1. During sampla, Q1 is turned on to provide cherging path. During hold, Q1 and Q2 ara turnad off so discherge peths through transistors for C1 are eech less then 100 pA. Q2 elso serves es buffer for opamp so faadback and output current are supplied only from opamp source.—"FET Databook," National Semiconductor, Senta Clare, CA, 1977, p 6-26–6-36.



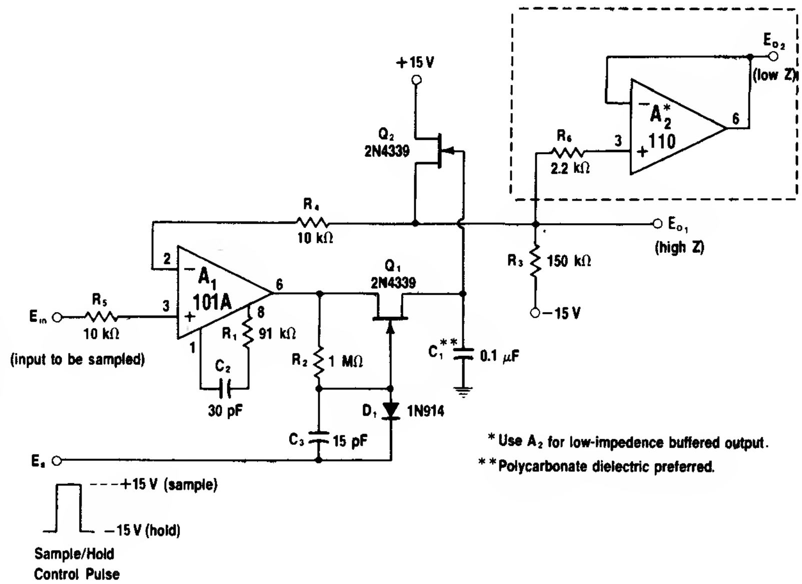
*Polycarbonate dielectric capacitor



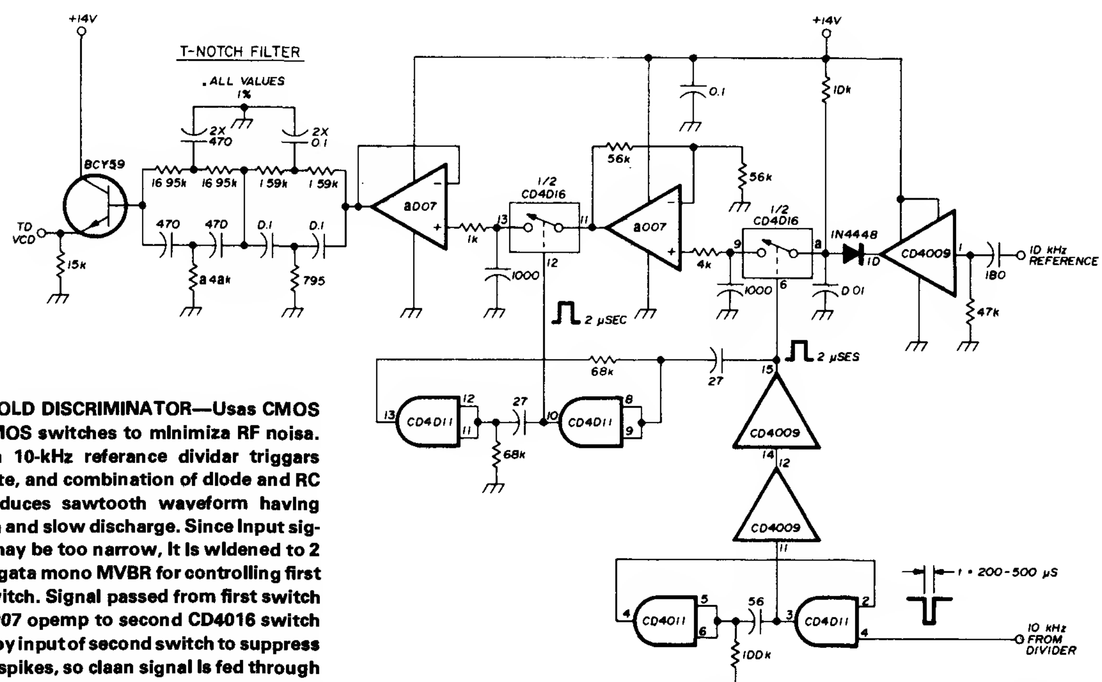
FAST SAMPLE-AND-HOLD—Stroba pulse developed from logic input of 531 opamp IC_2 tums on JFET Q_1 to complete feedbeck loop to IC_1, Q_1, end Q_2. C_1 charges to voltage equal to that of input signal plus gate-to-source offset voltage of Q_2. At end of atrobe time, feedback loop is broken and C_1 holds voltage until time of next strobe pulse. Decay in output voltage batween samplings is 1 mV/s.—"Signatics Analog Data Manual," Signetics, Sunnyvela, CA, 1977, p 643–644.



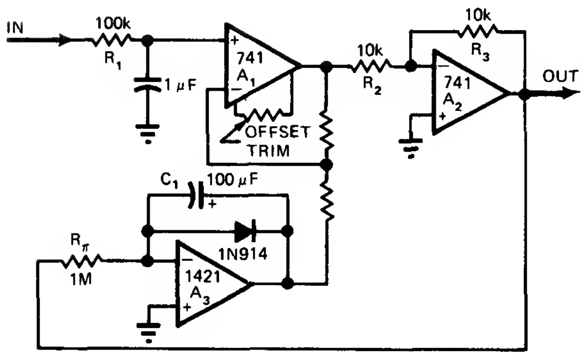
JFET SAMPLE AND HOLD—Logic voltage is applied simultaneously to sample-and-hold JFETs. By matching input impedance and feedback resistance end capacitanca, errors dua to ON resistance of JFETs are minimized.—"FET Databook," National Samiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



FEEDBACK REDUCES DRIFT—FET Q_2 serves as buffar for hold capacitor C_1, minimizing droop error. Switching transistor Q_1 is placed in faedback loop. A_1 serves as input signal buffer and as driver for Q_1 and C_1. When sampla line is raised to +15 V by control pulse, D_1 is revarse-biased and Q_1 is turned on. C_1 now charges until output tarminal reaches equilibrium with input (so A_1 is tracking input). When sampla pulse goes low, feedback loop of A_1 is opanad; output of A_1 stays at voltage last sampled sinca C_1 retains its charge and Q_2 buffers this voltage while presenting it to output. Optional voltage followar can be used if mora output currant is naeded to feed low-impedance loed.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 198–200.

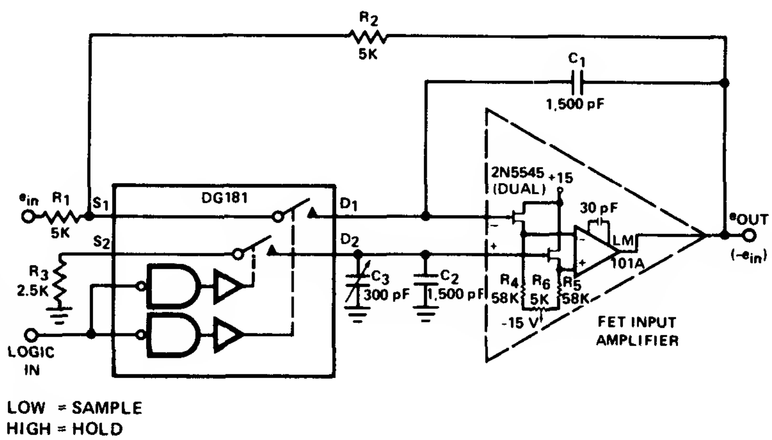


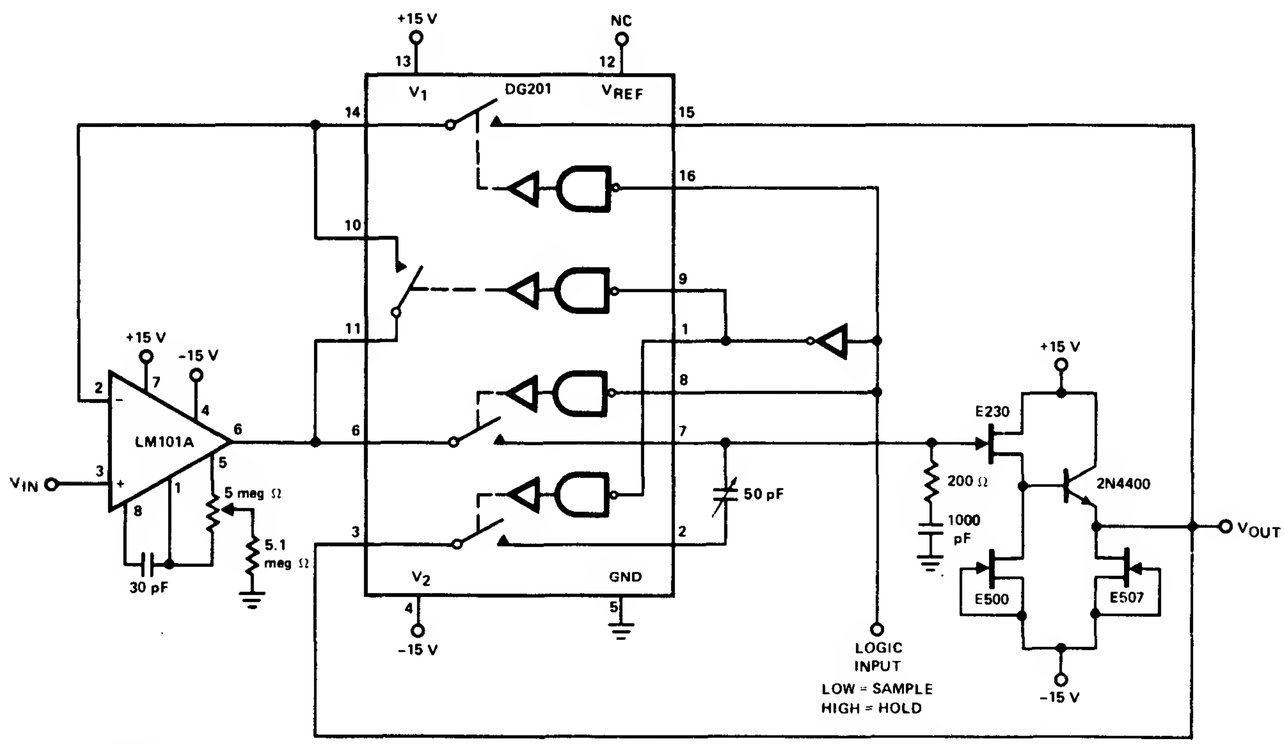
SAMPLE/HOLD DISCRIMINATOR—Usas CMOS ICs and CMOS switches to minimiza RF noisa. Input from 10-kHz referance dividar triggars CD4009 gate, and combination of diode and RC circuit produces sawtooth waveform having fast charga and slow discharge. Since input signal pulsa may be too narrow, it is widened to 2 μs by two-gata mono MVBR for controlling first CD4016 switch. Signal passed from first switch through 8007 opemp to second CD4016 switch is delayed by input of second switch to suppress unwanted spikes, so claan signal is fed through second 8007 opamp to T-notch filter having 10-kHz reference frequancy for one leg and 20 kHz for other leg. Notch dapth can ba 60 dB. Filter drives VCO of frequency synthesizer through BCY59 amitter-follower transistor.—U. L. Rohda, Modern Design of Frequency Synthasizers, *Ham Radio*, July 1976, p 10–23.



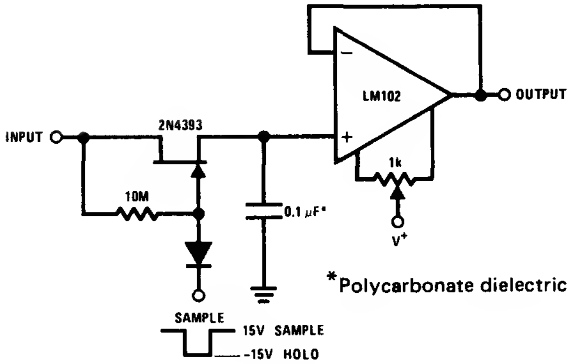
DERIVATIVE SLOPE-SAMPLING—Analog derivative circuit forces voltage across C_1 to follow slowly changing input signal. Current required to keep capacitor voltage equal to signal voltage is proportional to rate of change of signal voltage. RCA 3033 FET-input opamp will work equally as well as Teledyne Philbrick 1421 shown. Careful selection of values for R_π and C_1 will set rate limit that will reject spikes.—R. E. Bober, This Derivative Circuit Handles Slowly Varying Signals, *EDN Magazine*, Jan. 20, 1976, p 82.

INVERTING SAMPLE AND HOLD—Total offset error can be adjusted to much less than 1 mV in 2N5545 FET-input opamp by using compensation circuit R_3-C_2-C_3 with DG181 JFET analog switch. Switch operation occurs consistently at constant voltage, reducing aperture time jitter. Designed for high-speed sample-and-hold requirements.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-59.





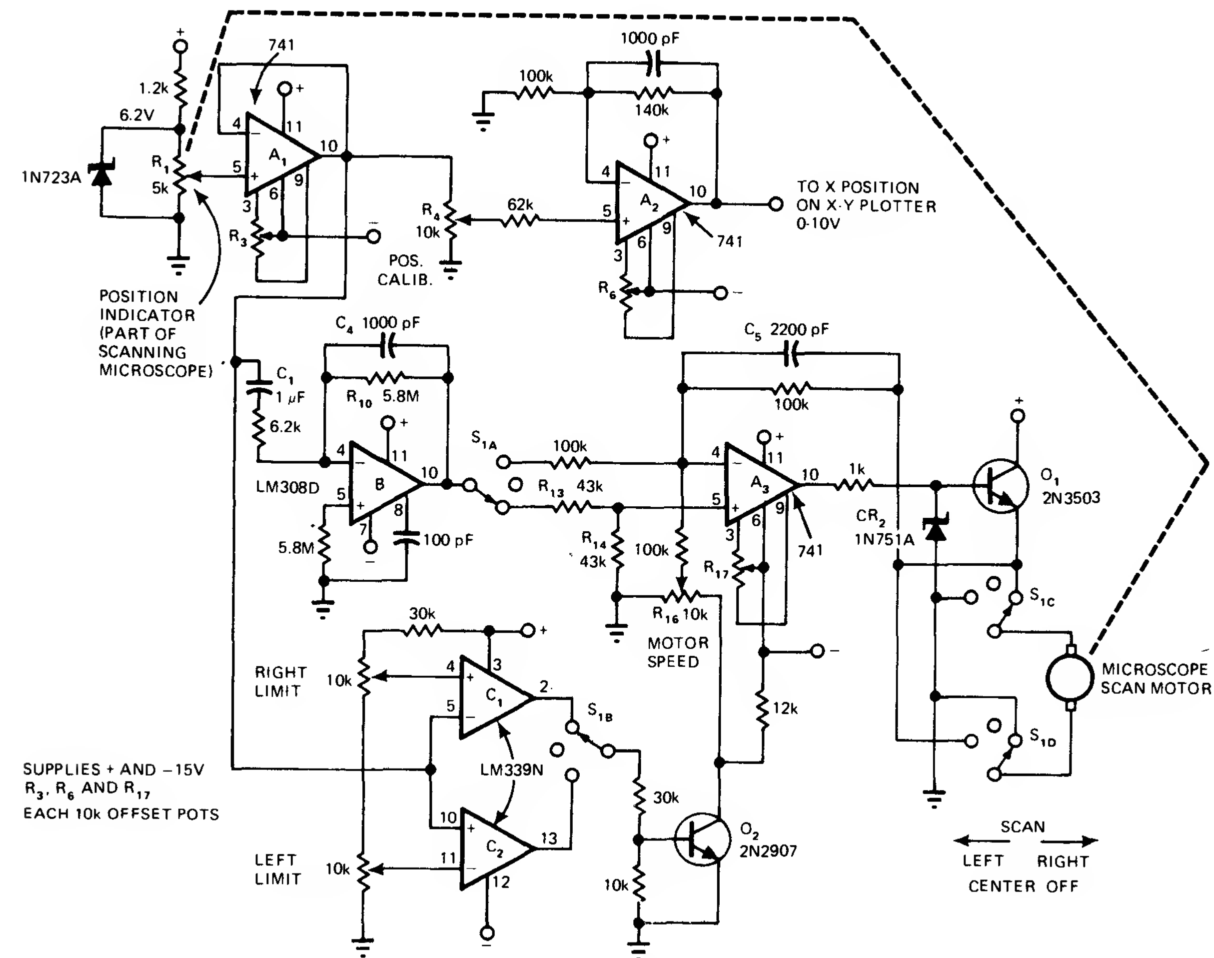
GLITCH CANCELLATION—Fourth section of DG201 quad CMOS analog switch provides cancellation of coupled charges (glitches), to keep sample-and-hold offset below 5 mV over analog voltage range of −10 V to +10 V. Acquisition time is 25 μs for opamp shown but can be improved by using faster-slewing opamp. Aperture time is typically 1 μs.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-68.



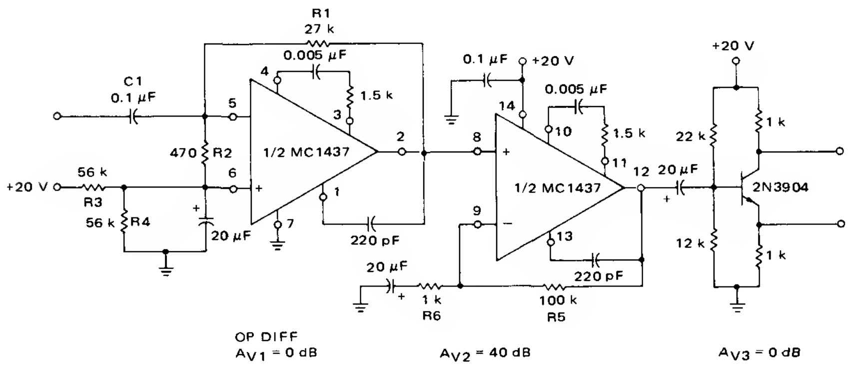
SAMPLE AND HOLD WITH OFFSET ADJUSTMENT—Usa of 2N4393 JFET at input of opamp gives simple high-performance circuit having low leakage. Offset is easily adjusted with 1K pot.—"FET Databook," National Samiconductor, Santa Clara, CA, 1977, p 6-26–6-36.

CHAPTER 79
Servo Circuits

Includes logic-controlled preamps and power amplifiers for driving two-phase, stepper, and other types of 60-Hz and 400-Hz servomotors in either direction for correct time at correct speed for bringing servo shaft exactly to desired new position. See also Motor Control chapter.

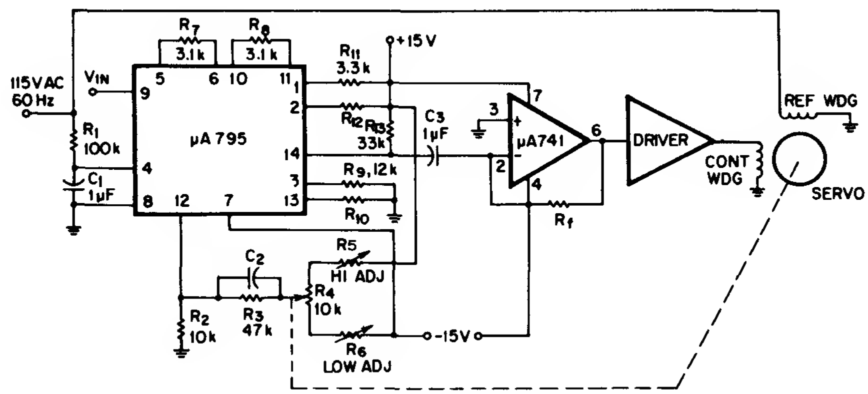


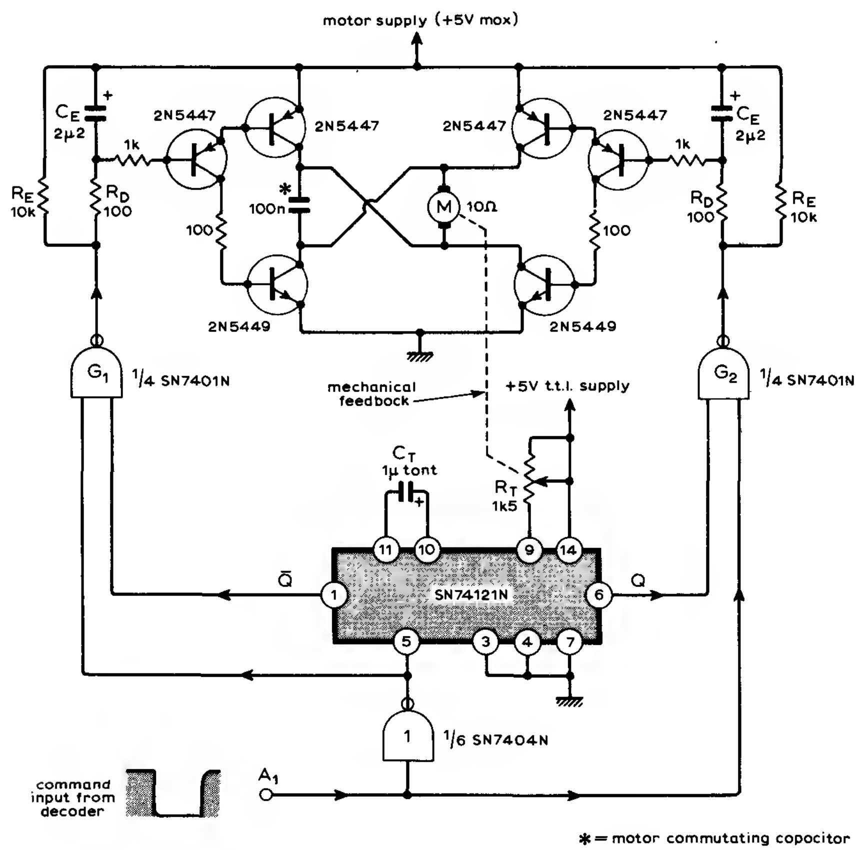
TACHOMETERLESS SERVO—Developed to provide speed control for motor enclosed in such a way that tachometer cannot be used for feedback. Position pot R_1 and differentiator B substitute for tachometer in controlling rate of scanning-microscope eyepiece used for measuring CRT line width. Buffer A_1 feeds X input of XY plotter through opamp A_2, and also feeds differentiator B and limit-detector voltage comparator C_1-C_2. S_1 switches A_3 between inverting and noninverting operation each time scanning direction changes, to keep feedback negative.—H. F. Stearns, Differentiator and Position Pot Sub for Tachometer, *EDN Magazine*, Aug. 5, 1977, p 50–52.

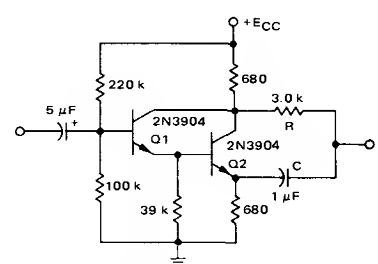


DUAL-OPAMP PREAMP—First section of Motorole MC1437 duel opemp is connected es operetionel differentietor driving direct-coupled noninverting opemp. Single-ended output is converted to push-pull by following phese-splitting emplifier for driving power emplifier of 115-V 60-Hz servomotor.—A. Psheenich, "Servo Motor Drive Amplifiers," Motorole, Phoenix, AZ, 1972, AN-590.

SERVO DRIVE—Combination of Feirchild μA795 multiplier end μA741 opemp generetes AC error signel for driving two-phese servomotor. Phese-shifted signel from R_1-C_1 is epplied to input pin 4 of multiplier, DC signel input is epplied to pin 9, and servo position signel goes to pin 12. Multiplier tekes difference between signels on 9 end 12, multiplies this by signel on pin 4, end feeds resulting sine weve from pin 14 to opemp for emplificetion end trensfer to servo driver. When servomotor ection mekes volteges on 9 end 12 equel, system is nulled.—Feirchild Lineer IC Contest Winners, *EEE Megazine*, Jan. 1971, p 48–49.

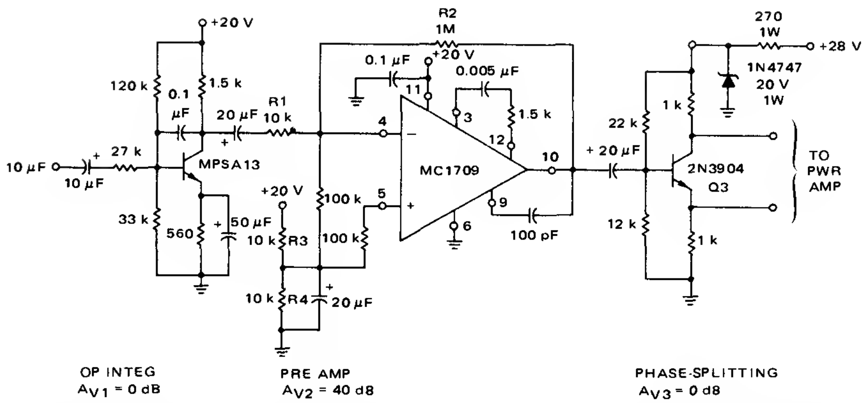




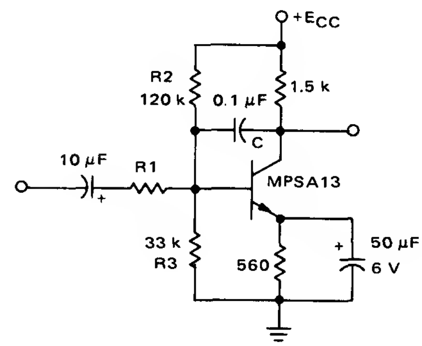


TTL SERVO CONTROL—Used in nine-chennel remote control system heving nine identical servos fed by decoder et receiving end of dete link. Verieble-width pulse commend from decoder is fed into TTL IC pulse-width comperetor thet feeds bridge-type motor drive. Commend pulse controls both direction end duration of motor rotation. Article describes operetion in deteil end gives essocieted coder end decoder circuits.—M. F. Bessent, Multi-Chennel Proportionel Remote Control, *Wireless World*, Oct. 1973, p 479–482.

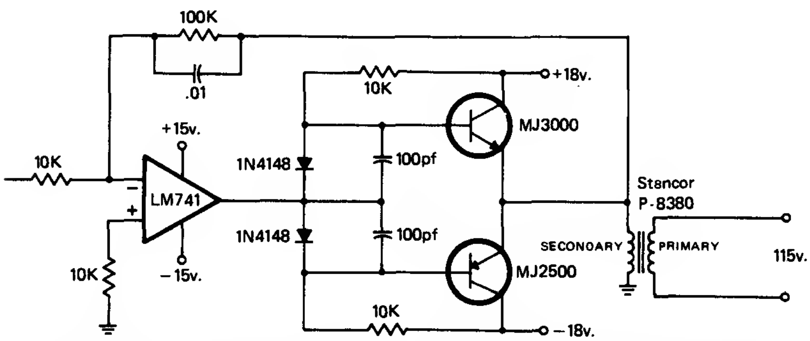
DARLINGTON PHASE SHIFTER—Besic 90° push-pull RC phese shifter using discrete transistors is connected es phese-splitting emplifier. Used et output of follow-up pot in servoemplifier driving 115-V 60-Hz servomotor. Supply is 28 V. Motorole MPSA13 Derlington IC cen be used if 39K resistor is omitted.—A. Psheenich, "Servo Motor Drive Amplifiers," Motorole, Phoenix, AZ, 1972, AN-590.



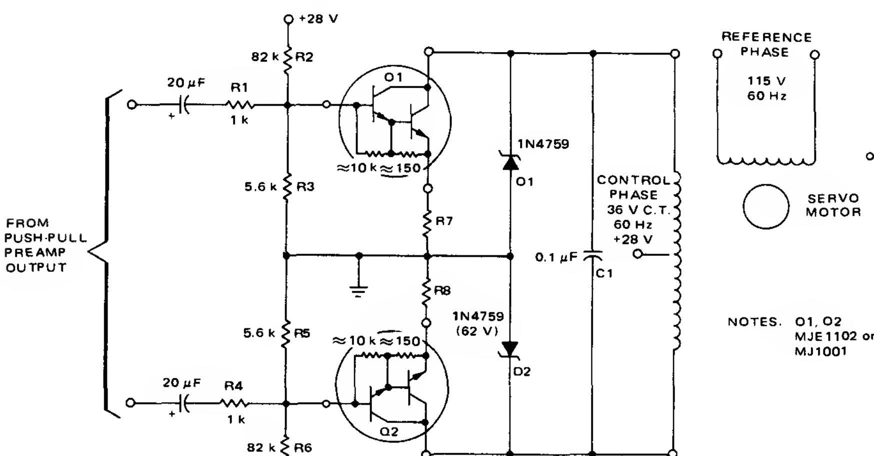
PHASE-SPLITTING PREAMP—Uses Motorola MPSA13 operational integrator to provide 90° phase shift for MC1709 inverting opamp, with single-ended output complemented by phase-splitting amplifier to provide push-pull drive for power amplifier of 115-V 60-Hz servomotor. Voltage gain is about 40 dB.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.



OPERATIONAL-INTEGRATOR PHASE SHIFTER—Motorola MPSA13 Darlington IC provides 90° phase shift required in servoamplifier for 115-V 60-Hz servomotor. Two cascaded 2N3904 discrete Darlingtons can be used in place of IC.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.

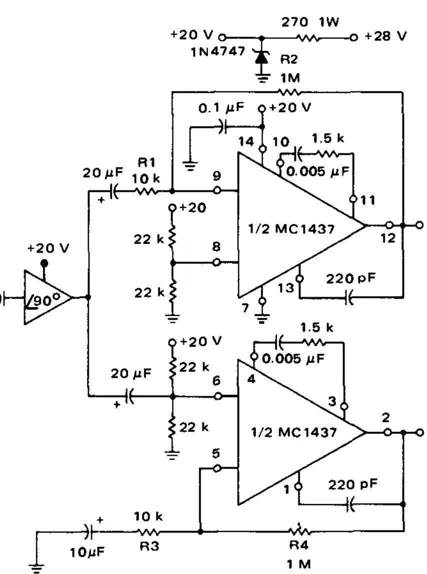


20 W AT 60 Hz—Adding high-current complementary transistors to opamp gives servoamplifier with 115-V output. Opamp drives low impedance of 10-V filament transformer connected in reverse to boost output to 115 V for driving servo. Use heatsink for transistors. Bringing opamp feedback resistor to actual output point makes nonlinearities and crossover point between transistors insignificant by placing them in feedback loop.—I. Math, Math's Notes, *CQ*, Jan. 1978, p 53–54 and 70.

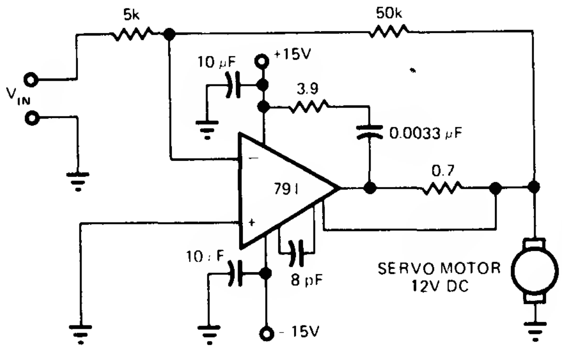


MOTOR MFG	SIZE	P_{IN}/ϕ WATTS	R7, R8
WESTON 11 MA2 U-211663	11	4	6.8 Ω 1/2W
DAYSTROM U 207263	18	10	3.3 Ω 1W

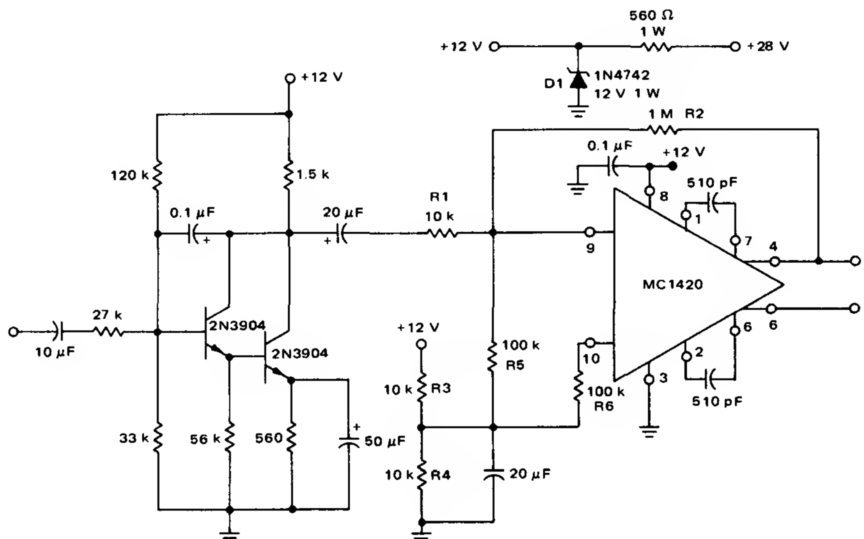
28-V PUSH-PULL POWER AMPLIFIER—Power Darlingtons are used in common-emitter configuration to give high current gain for driving control phase of 60-Hz servo while providing high input impedance for preamp. No transformers are required. Darlingtons require heatsinks. Suitable for driving size 11 servo at 4 W and also 18 at 10 W if emitter resistors R7 and R8 are changed as in table.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.



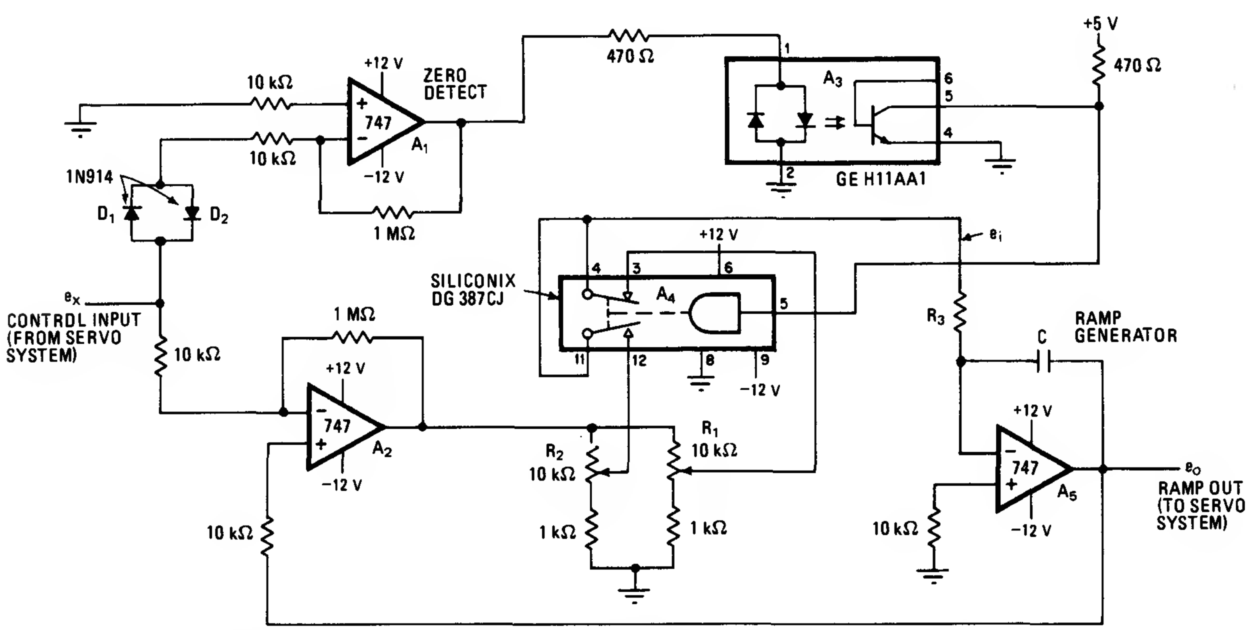
PARALLEL-OPAMP PREAMP—Provides differential output required for driving power amplifier of 115-V 60-Hz servomotor. One opamp section is connected inverting and the other noninverting to give required complementary outputs. Voltage gain is 40 dB, operating from single 20-V zener-regulated supply. High DC feedback gives excellent DC stability. Bandwidth is about 6 kHz. Input is driven by 90° phase shifter.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.



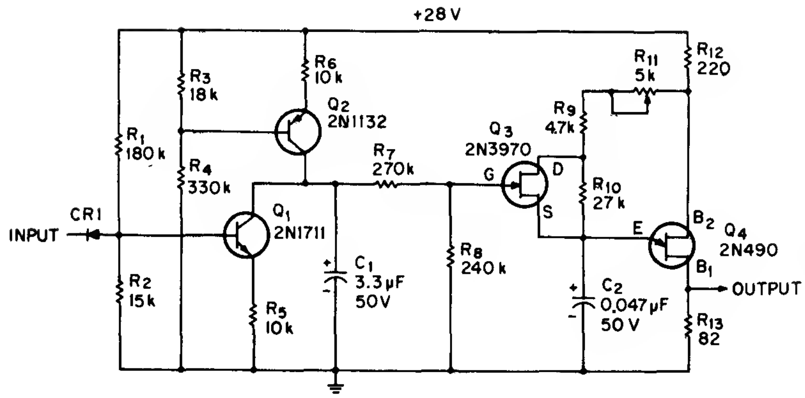
12-VDC DRIVE—Circuit uses 791 power opamp in inverting configuration with gain of 10 for driving size 8 12-VDC servomotor in either direction. Article tells how to calculate heatsink requirements for opamp.—R. J. Apfal, Power Op Amps—Their Innovative Circuits and Packaging Provide Designers with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.



DIFFERENTIAL INPUT AND OUTPUT—Preamplifier for servosystem uses 90° operational integrator to drive MC1420 opamp having differential input and differential output connected in inverting configuration. With values shown, voltage gain is about 38 dB. Bandwidth is about 4 kHz, giving stability when using 510-pF compensating capacitors. Zener provides 12 V required for opamp operation from single supply.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.

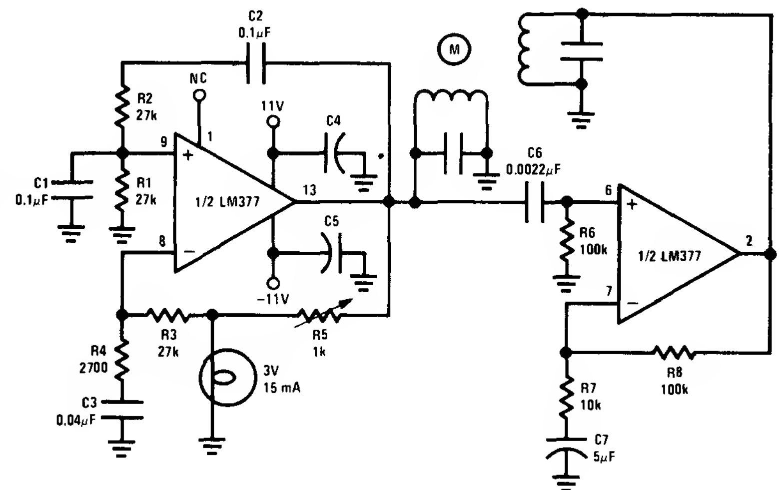


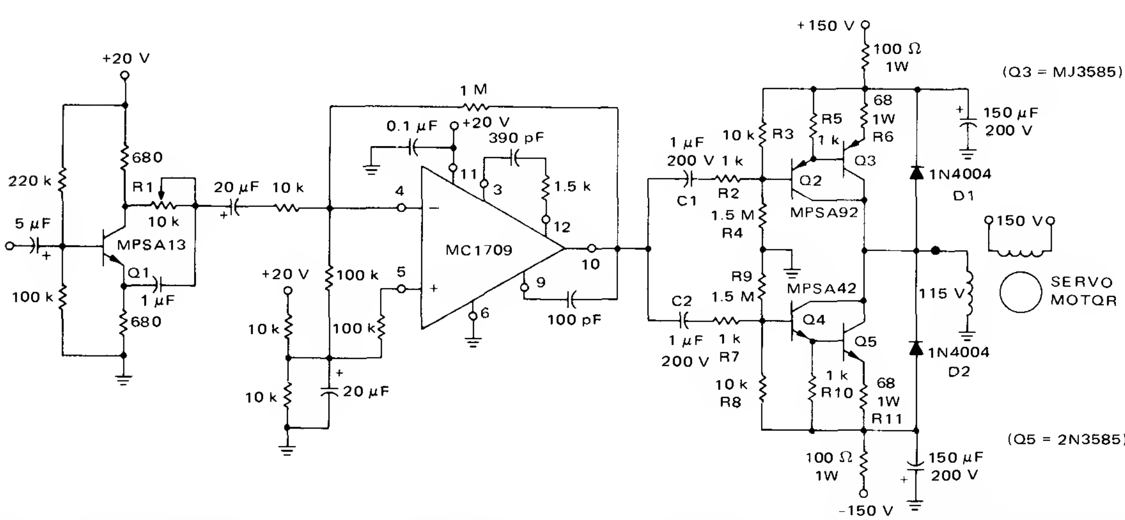
UP/DOWN RAMP CONTROL—Siliconix DG387CJ solid-state relay A_4 provides switching from up ramp to down ramp for decelerating servo when it zeroes in on correct new position. Slopes are determined by settings of R_1 and R_2. Arrangement ensures optimum servo system response at low cost. A_1 detects that input is other than 0 V and energizes optoisolator A_3 for switching A_4. Resulting positive-going ramp from A_5 moves system load toward desired position, making feedback voltage of servo reduce control-input voltage. When this drops to within 0.7 V of ground, A_1 goes low and A_3 turns off. A_4 now initiates down-ramp waveform to decelerate system to stop. For ramp rate of 20 V/s, C can be 0.33 μF and R_3 1.8 megohms.—R. E. Kelly, Up-Down Ramp Quickens Servo System Response, *Electronics*, July 20, 1978, p 121 and 123.



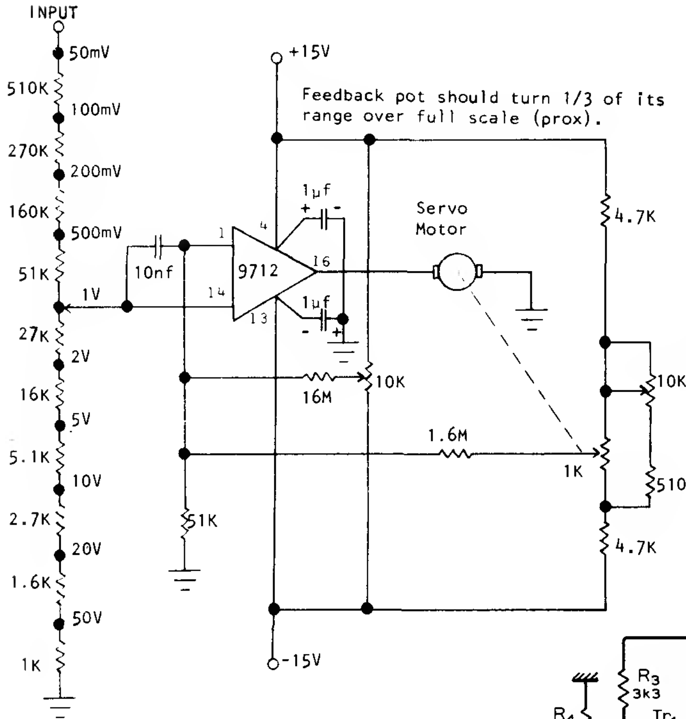
STEP-SERVO CONTROL—Variable UJT oscillator generates train of pulses under control of digital input logic levels, at 1000 pulses per second for logic 1 or 4400 pulses per second for logic 0, with smooth transitions between rates when logic changes, for driving stepping servomotor. Q_1 and Q_2 are constant-current sources. JFET Q_3 acts as voltage-controlled variable resistor in parallel with R_{10}, controlling pulse rate of UJT oscillator Q_4.—C. R. Forbes, Step-Servo Motor Slew Generator, *EEE Magazine,* Oct. 1970, p 76–77.

TWO-PHASE SERVO DRIVE—Both sections of National LM377 power amplifier are connected to provide up to 3 W per phase for driving small 60-Hz two-phase servomotor. Power is sufficient for phonograph turntable drive. Lamp is used in simple amplitude stabilization loop. Motor windings are 8 ohms, tuned to 60 Hz with shunt capacitors.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.

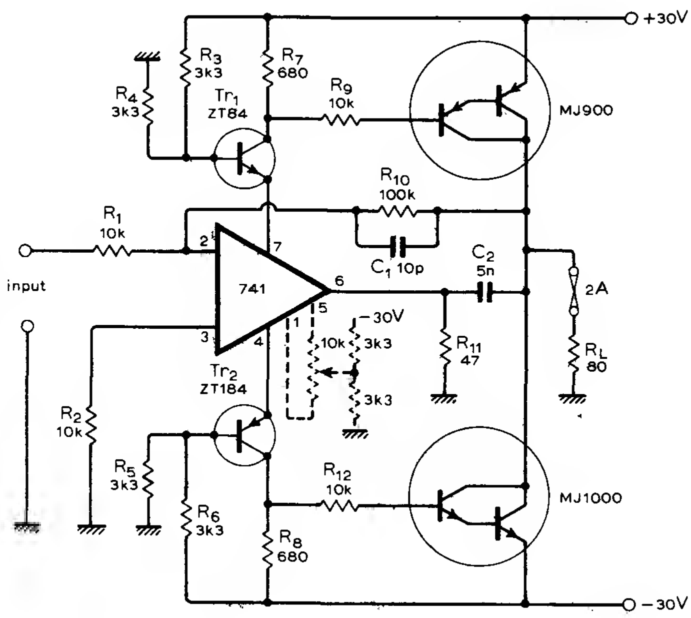




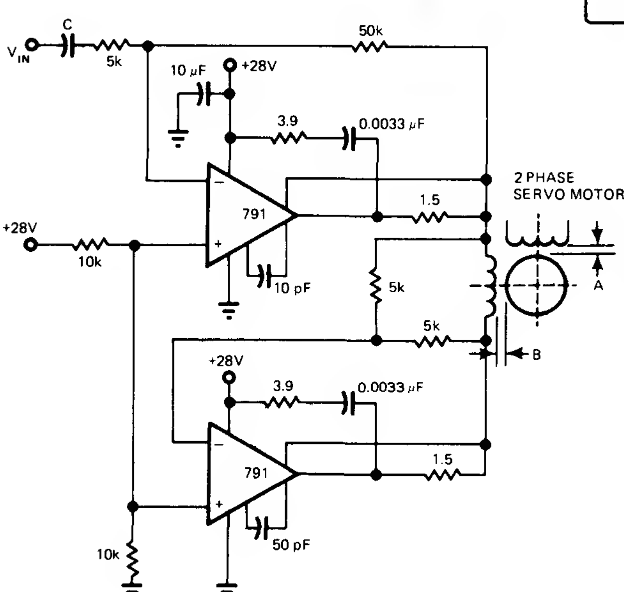
LINE-OPERATED AMPLIFIER—Push-pull RC phase shifter, single-ended preamp, and push-pull class B power amplifier all obtain supply voltages from AC supply that can either use power transformer or operate directly from line with diode rectifiers. Power output is enough to drive size 18 servomotor at 10 W. Larger servomotors can be used if reduced supply voltages can be tolerated. Suitable power supply circuits are given.—A. Pshaenich, "Servo Motor Drive Amplifiers," Motorola, Phoenix, AZ, 1972, AN-590.



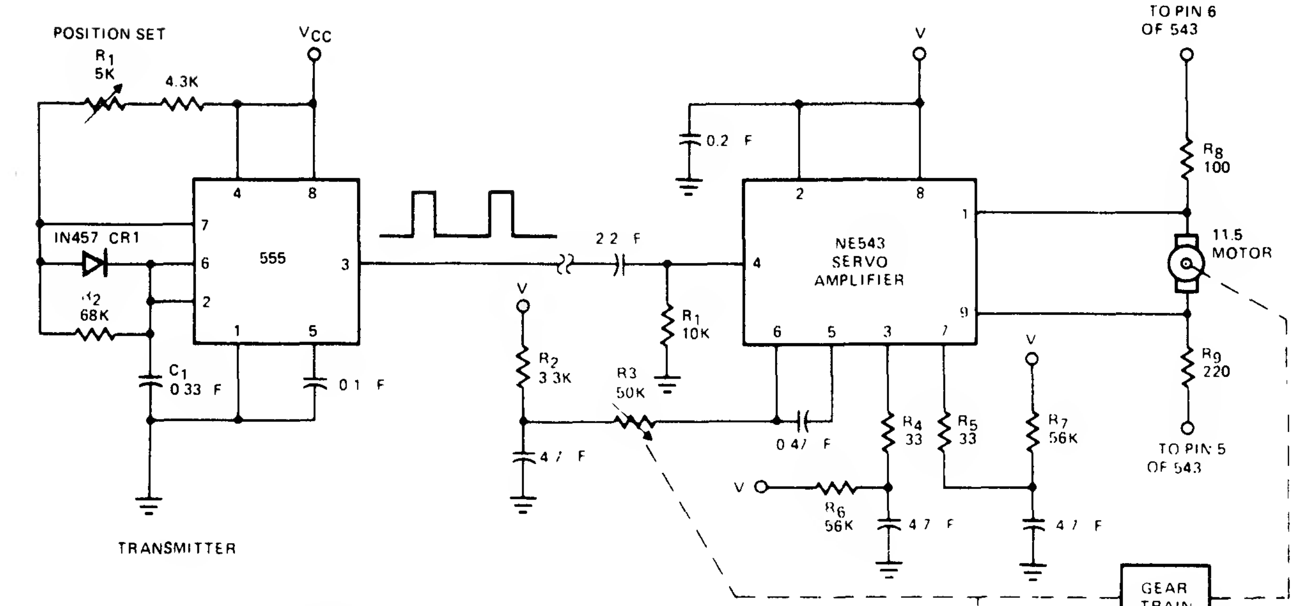
XY RECORDER SERVO—Optical Electronics 9712 FET opamp drives 10-V 0.2-A servomotor used for positioning pen of XY recorder. Circuit provides coarse and fine attenuation of input signal along with position-control pot. FET input of opamp allows use of 1-megohm input attenuator. Response time is limited only by that of servomotor and mechanical portion of system. Requires highly stable regulated power supply.—"The 9712 as a Servo Motor Amplifier," Optical Electronics, Tucson, AZ, Application Tip 10206.



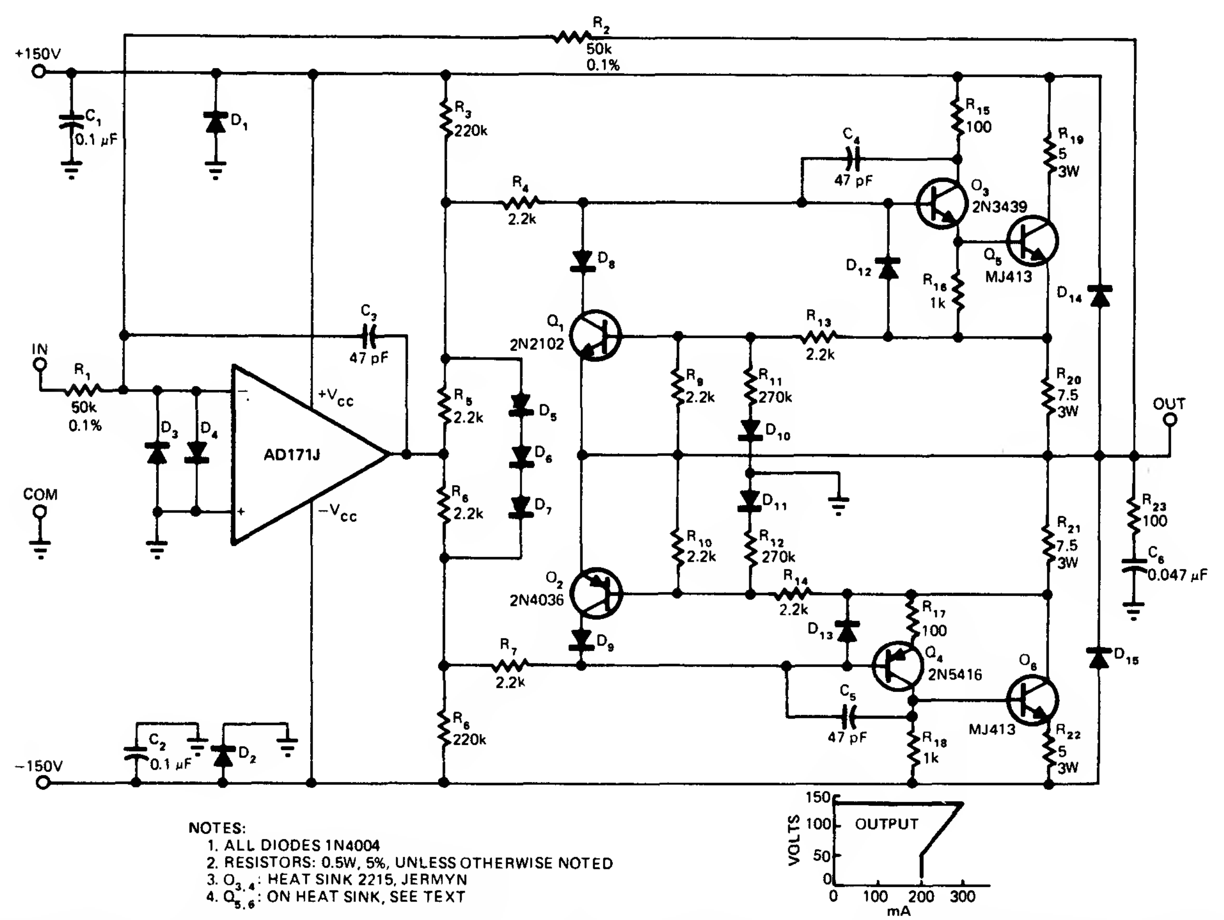
OPAMP DRIVES POWER DARLINGTONS—Differential outputs for Darlingtons are obtained by using power supply pins of 741 opamp. Tr_1 and Tr_2 can be any general-purpose transistors, and individual transistors can replace Darlington pairs. If circuit is used in servo system, add components shown in broken lines for zeroing of output offset. With values shown, 30 W can be delivered into 8 ohms from DC to 100 kHz at gain of 10 with less than 0.2% distortion.—K. Griffiths, Novel Power Amplifier, *Wireless World*, Dec. 1974, p 504.



44-VAC DRIVE—Uses two 791 power opamps, each rated for 10-W continuous dissipation, in AC bridge. Upper 791 has inverting gain of 10. Lower 791 inverts its output so 44 V P-P signal is applied across two-phase AC servomotor.—R. J. Apfel, Power Op Amps—Their Innovative Circuits and Packaging Provide Designers with More Options, *EDN Magazine*, Sept. 5, 1977, p 141–144.



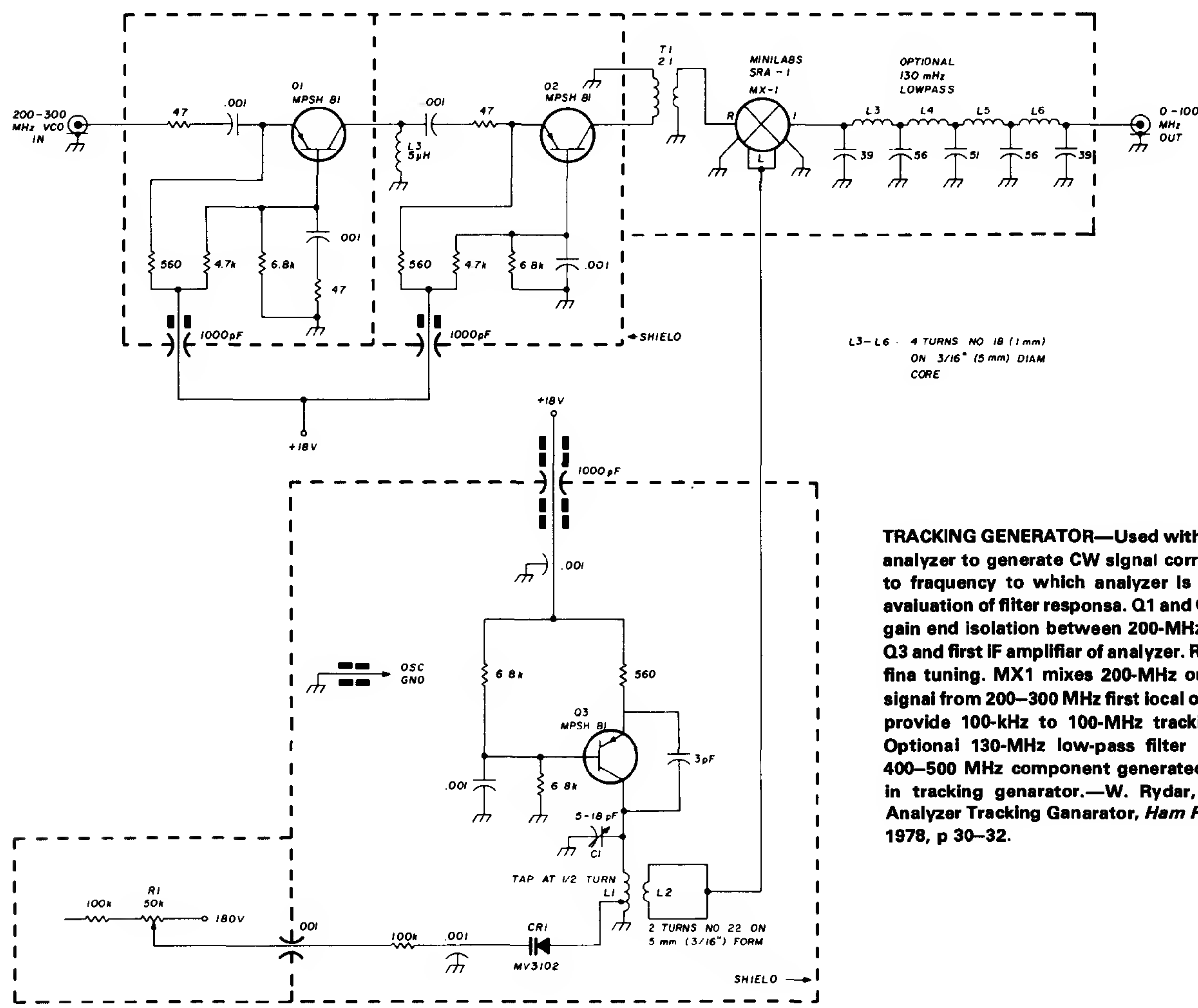
REMOTE CONTROL FOR SERVO POSITION— Setting of pot R_1 in circuit of ramotaly located 555 timar determines position of 11.5-ohm servomotor by faeding appropriate squara-wava pulses over wira lina to sarvoamplifiar.—"Signetics Analog Data Manual," Signetics, Sunnyvala, CA, 1977, p 727–728.



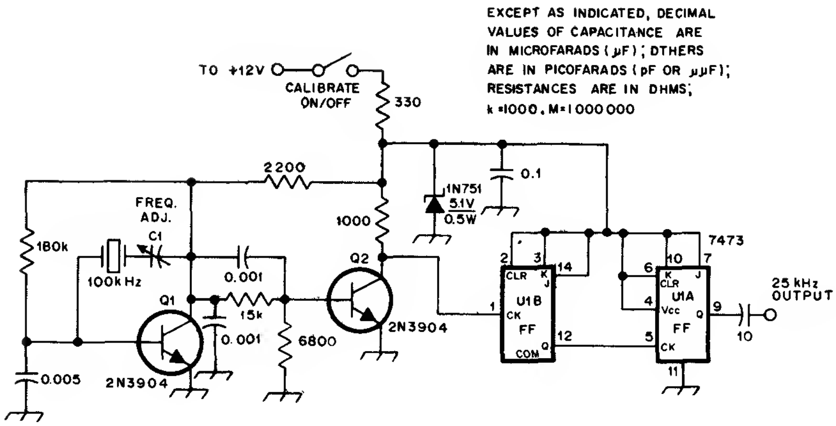
400-Hz AMPLIFIER—Davalopad to increase output powar of digital-to-synchro convertar systams whlle providing stable and accurata output and ovarall gain aven with reactive loads. Includes ovarload protection. Dalivars 95 VRMS at 400 Hz contlnuously into 500-ohm load. Powar bandwidth is about 20 kHz. Foldback currant limlting drops short-circuit currant to 200 mA whan load axceeds 300 mA.—F. H. Cattermolan and J. A. Pieterse, Digital/Synchro Amplifier Faatures Overload Protaction, *EDN Magazine*, Nov. 5, 1977, p 107–108.

CHAPTER 80
Signal Generator Circuits

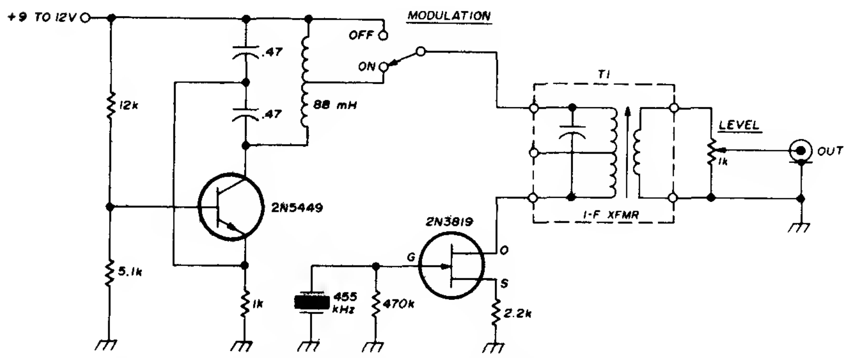
Includes fixed-frequency and tunable sine-wave and square-wave oscillator circuits operating in various portions of spectrum from 1 Hz to 1296 MHz, all of which can be accurately calibrated. Used in adjusting, testing, and troubleshooting tuned circuits. Includes band-edge marker generators and FM signal generators. See also Frequency Synthesizer, Function Generator, Staircase Generator, and Sweep chapters.



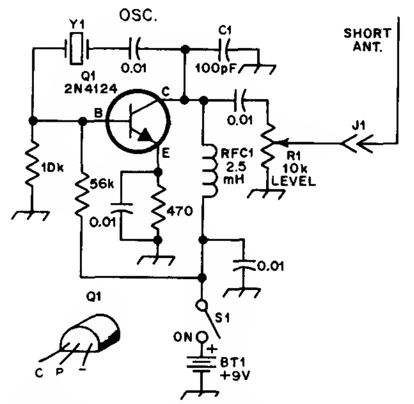
TRACKING GENERATOR—Used with spectrum analyzer to generate CW signal corresponding to frequency to which analyzer is tuned, for evaluation of filter responsa. Q1 and Q2 provide gain end isolation between 200-MHz oscillator, Q3 and first IF amplifiar of analyzer. R1 provides fina tuning. MX1 mixes 200-MHz output with signal from 200–300 MHz first local oscillator to provide 100-kHz to 100-MHz tracking signal. Optional 130-MHz low-pass filter attenuatas 400–500 MHz component generated by mixar in tracking genarator.—W. Rydar, Spectrum Analyzer Tracking Ganarator, *Ham Radio,* April 1978, p 30–32.



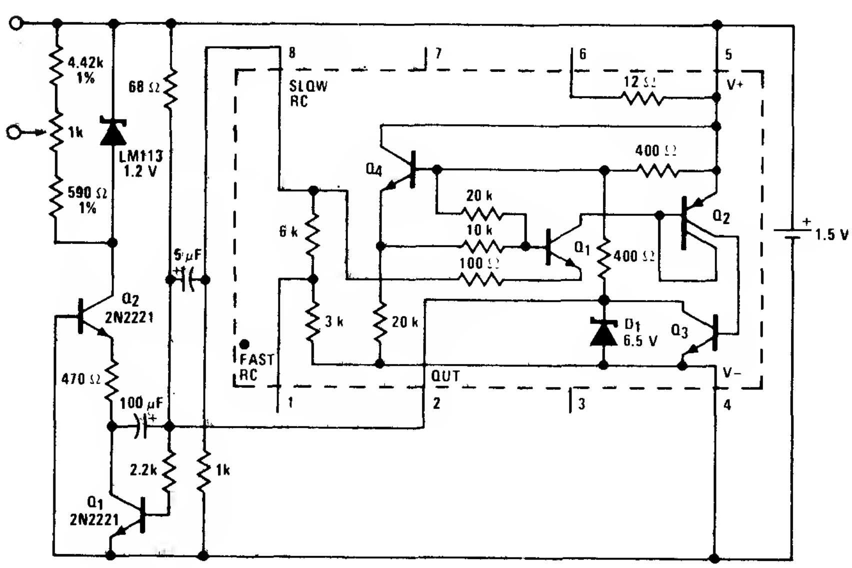
25-kHz CALIBRATOR—Addition of one 7473 dual JK flip-flop IC to circuit of Radio Sheck 28-140 100-kHz calibrator kit provides conversion to 25 kHz for checking frequency sattings of emateur receivers. Amplitude of output is 5 V P-P square wave with rich hermonic content. Originally designed for use with HW-8 Heathkit ameteur receiver. Output of calibretor is coupled to receive side of entenne reley through 10-pF capecitor. Articla covers initial cellbration.—D. Kerpiej, A 25-kHz Calibretor for the HW-8, *QST*, Oct. 1978, p 20–21.



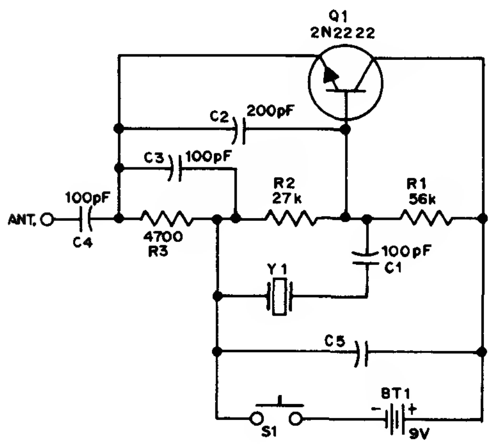
455-kHz FOR IF ALIGNMENT—Simple crystal-controlled signel generator serves for aligning IF strips. Amplituda modulator uses Colpitts 1-kHz oscillator circuit, with surplus 88-mH toroid in tank circuit; tie two adjacent leads together to provide center tap. T1 is 455-kHz IF trensformer from AM trensistor radio, used to tune drain circuit end obtain low output impedence. Current drein is about 7 mA with 12-V supply and 5 mA with 9-V bettery.—C. Hall, 455-kHz I-F Alignment Signal Generetor, *Ham Radio*, Feb. 1974, p 50–52.



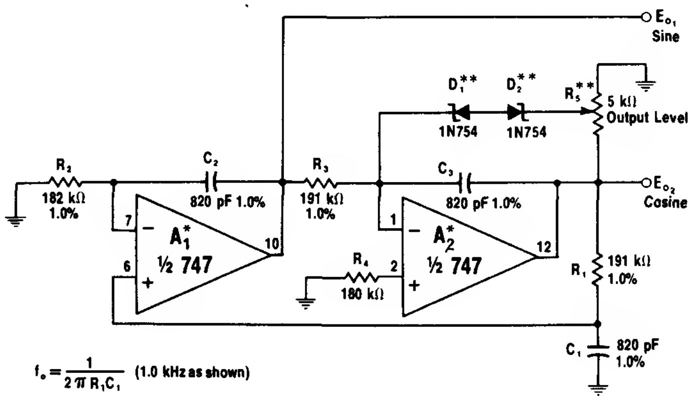
UNIVERSAL TEST OSCILLATOR—Crystel is in feedbeck peth of Pierce oscillator, between bese end collector of Q1, with 2.5-mH RF choke in plece of tuned collector circuit. Oscillator works from 400 kHz to 20 MHz, depending on crystal. Designed for fundementel crystals; third overtone types will oscillate but at fundamental. Velue of C1 is for 1 MHz end higher; increase to 330 pF for lower frequencies. Antenne can ba 20-inch wira; increasing length increeses signel radiation. Can be used es signal source for receiver elignmant (with aither radieted or probe-coupled signel), as merker generator, or in combination with station receivar es coda-practica oscilletor.—D. DeMaw, Build e UTO-1, *QST*, Oct. 1977, p 19–21.



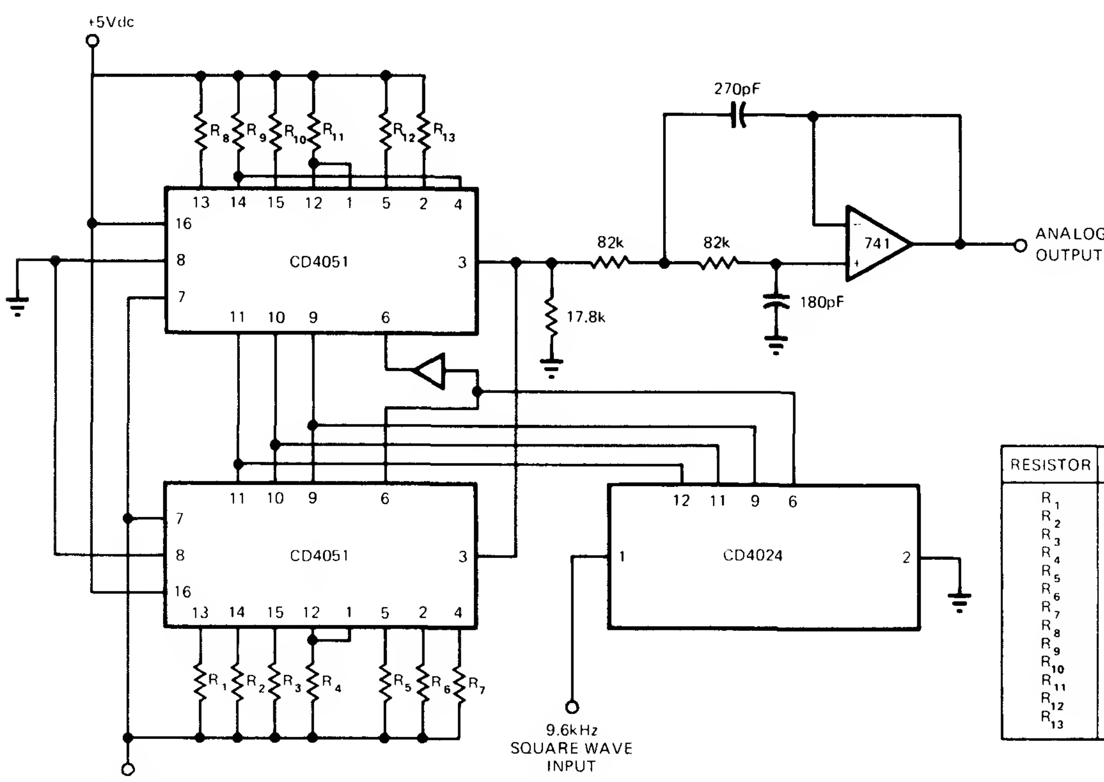
LAB GENERATOR/CALIBRATOR—Portable design opereting from single fleshlight D call uses Netional LM3909 flasher IC to produce claen rectengular weve thet cen be edjusted to exectly 1 V. Pulse width is 1.5 ms and OFF intervel between pulses is 5.5 ms. Useful for calibreting oscilloscopes end edjusting their probes. Article describes operetion of circuit in deteil. Current drein is low enough to give 500 h of operetion.—P. Lefferts, Power-Misar Flesher IC Hes Meny Novel Applications, *EDN Magazine*, Merch 20, 1976, p 59–66.



BAND-EDGE MARKER—Sarias-tuned Colpitts crystal oscillator feeding 10-inch insulated-wire antenna provides sufficient signal radiation for pickup by nearby communication receiver. Uaed to provide band-edga marker for calibrating receiver tuning dial ao receiver meets FCC rules for checking tranamitter frequency whan using VFO rather than crystal control for Novice tranamitter in amateur bands. Cryatal can be eithar for 40- or 80-matar band. Although band-edge frequency ia convaniant for warning when tranamitter is going *off frequency*, calibration can be done with any frequency in or near band of interest. C5 is 0.25 μF.—K. Negoro, A Band-Edga Markar Generetor, *QST*, April 1973, p 16–17.



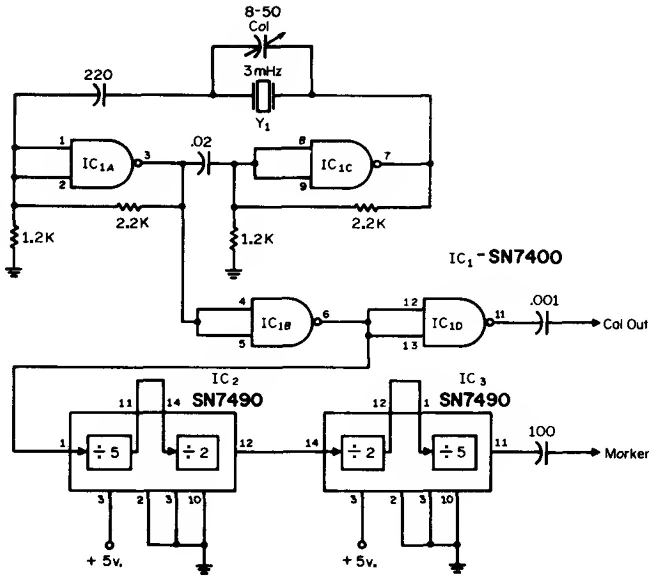
SINE/COSINE OSCILLATOR—Two oscillators in ceacada with poaitive feedback genarate two aine wavea in quadreture (differing in phaae by 90°). Limiting network D_1-D_2-R_5 is uaad around A_2 to prevant oscillator from stabilizing at saturation limit of A_2. R_5 ia used to sat output at eny level ebova zener limits of D_1-D_2. Frequency ia 1 kHz for valuea shown.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sama, Indianapoiis, IN, 1974, p 371–372.

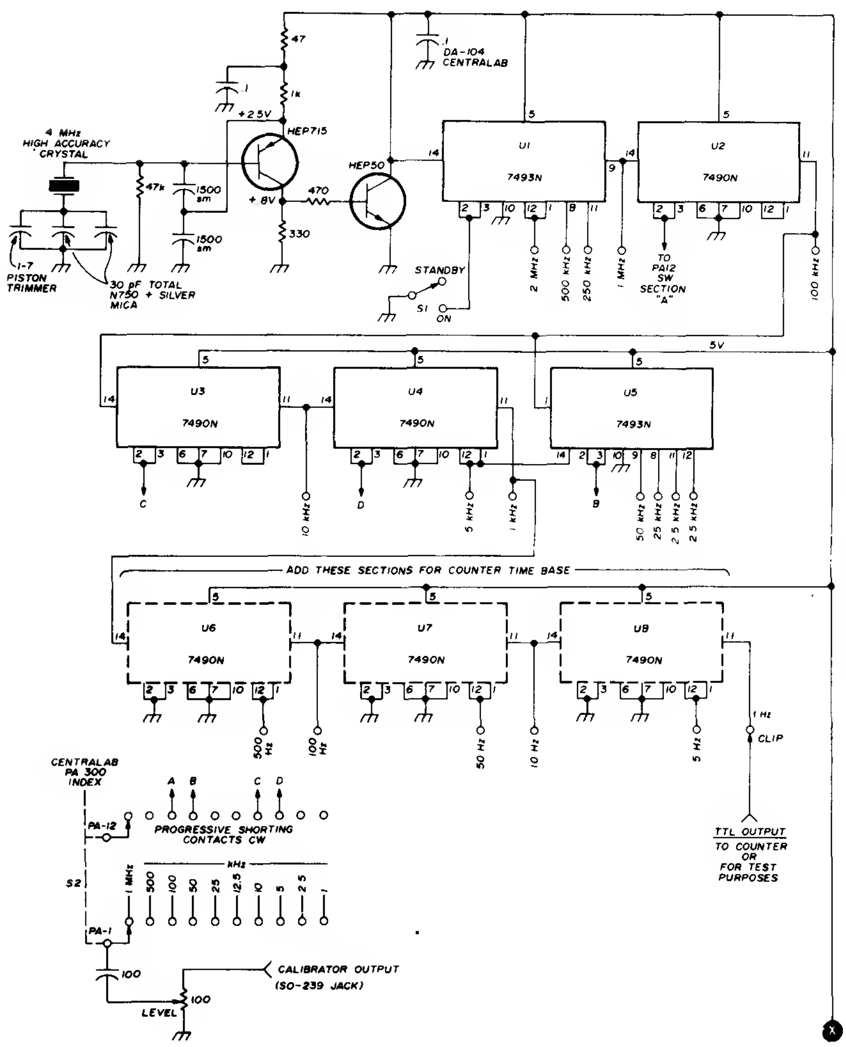


RESISTOR	VALUE
R_1	422k
R_2	205k
R_3	51.1k
R_4	17.8k
R_5	42.2k
R_6	100k
R_7	345k
R_8	422k
R_9	162k
R_{10}	33.2k
R_{11}	14.7k
R_{12}	20.5k
R_{13}	42.2k

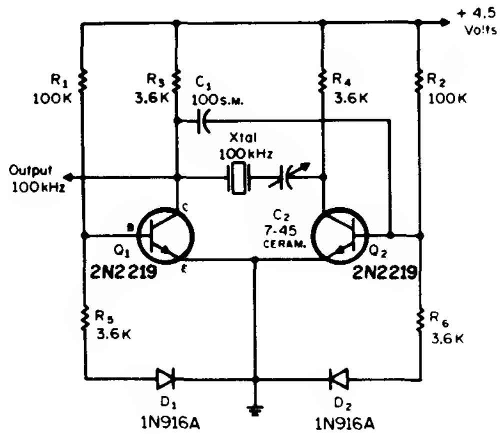
WAVEFORM SYNTHESIZER—Values of weighting raaistors connected to inputs of multiplexer chips datermine weveform of analog output. CD4024 binary counter aequences multiplexers through all states et 16 times fundamental frequency of desired weveform. Active filter using 741 opamp removea components of sempling frequency. For near-approximation to aine wave, weighting resistora range from about 15K to 425K.—J. R. Trecy, CMOS Circuits Generate Arbitrary Periodic Waveforms, *EDN Magazine*, Aug. 20, 1973, p 86–87.

30-kHz MARKERS FOR 2-METER FM—Crystal Is placed in loop of standerd TTL MVBR. Circuit is modified so 32-pF perallel-moda unit will work into effectiva load of 32 pF. Series 220-pF capacitor raises crystal frequancy enough to permit eccurete frequancy adjustmant by trimmar. Oscillator output is fed to two decade dividers; output of second dacada IC_3 is 30-kHz squara wave with 20% duty factor, coinciding with standard 2-metar FM channels. Regulated supply is 5 VDC at 110 mA.—G. E. Zook, Channal Markar Generetor, *CQ*, April 1972, p 41–42.



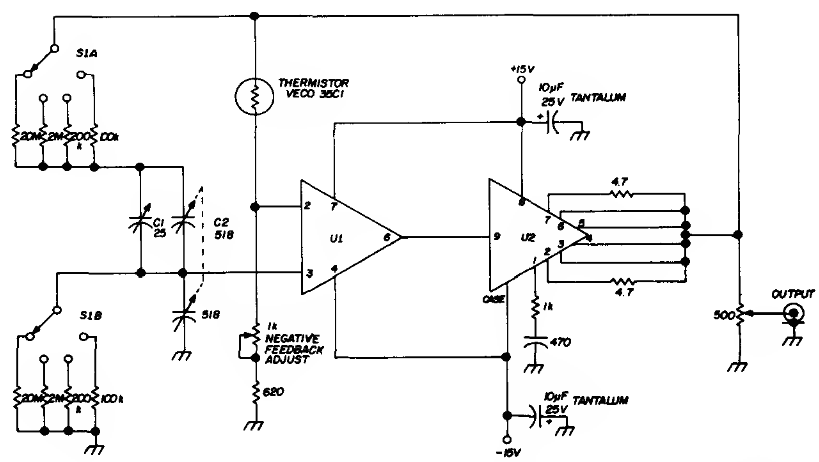


FREQUENCY STANDARD—Uses high-performence TTL ICs operating from regulated 5-V supply furnishing 260 mA, connected to point X. Provides choice of 18 precision frequencies if ell ICs ere used, or 8 merkar frequencias if only upper thrae ICs are used. Adjustable leval control permits matching output of frequency calibrator to incoming signals such as from WWV, or turning full on for strong, clear markers. HEP715 oscillator transistor Is coupled to TTL by HEP50 transistor. 7493 binery dividers U1 and U5 divide by factors of 2, with 7490 decade dividers meking up ramainder of logic. Reset pins 2 end 3 control operetion of logic, either with S1 or with progressively shortad contacts of rotary switch S2. Crystal should ba ordered for 0.0005% tolerence, F-700 or SP7-P holdar, 32-pF loed, and 4 MHz at room temparature.—B. Kalley, Universal Frequency Standard, *Ham Radio*, Feb. 1974, p 40–47.

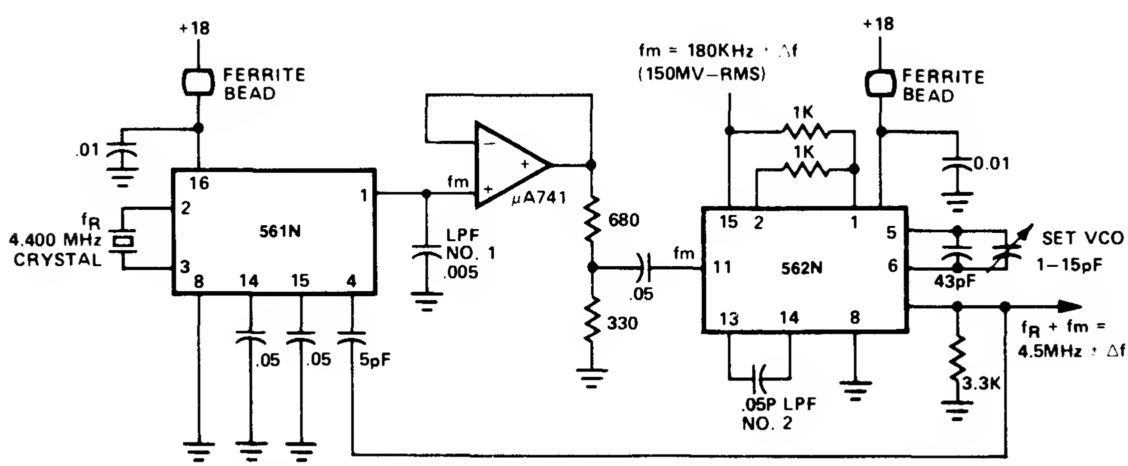


100-kHz CRYSTAL—Drives JK or RS flip-flops to provide markers at 10-kHz or 20-kHz intervals for calibrating transmitter, receiver, or transceiver. D_1 and D_2, used to stabilize output, can be eliminated if desired; R_5 and R_6 are then grounded directly. Transistor and diode types are not critical.—G. F. Moynehen, An Improved Crystal Calibrator Using Solid-State Techniques, *CQ*, May 1972, p 18 and 20.

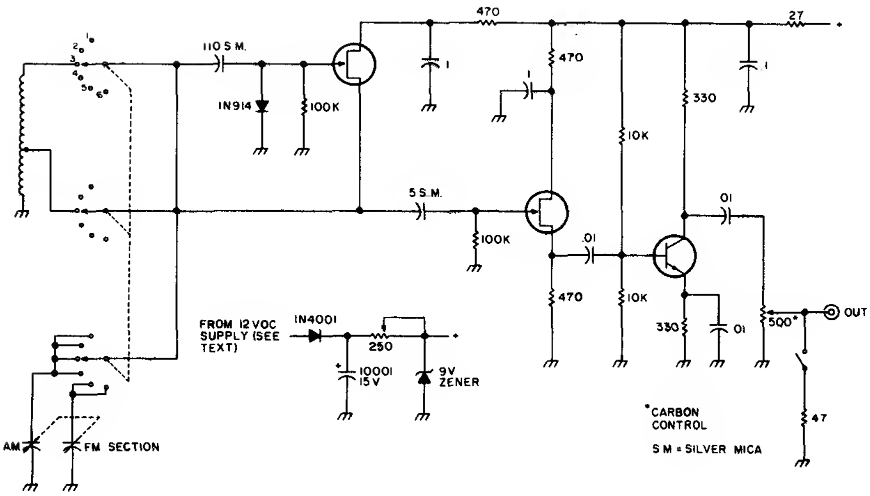
15 Hz TO 40 kHz IN FOUR RANGES—Tunable wide-range Wien-bridge audio oscillator is switched to cover 15–200 Hz, 150–2000 Hz, 1.5–20 kHz, and 3–40 kHz. U1 is high-input-impedance opamp in bridge circuit using thermistor as nonlinear feedback element. C1 is adjustable in series branch of bridge to compensate for capacitance (about 10 pF) of ungrounded common terminal of dual tuning capacitor. Use ±15 V dual regulated supply.—H. Olson, Integrated-Circuit Audio Oscillator, *Ham Radio*, Feb. 1973, p 50–54.



C1	4.5 - 25 pF trimmer capacitor
C2	Dual 518-pF tuning capacitor (Jackson Brothers 5084/2/518HO)
U1	Fairchild μA740C, Signetics NE536T, National NH0042C or Intersil ICL8007C
U2	Motorola MC1438R or MC1538R

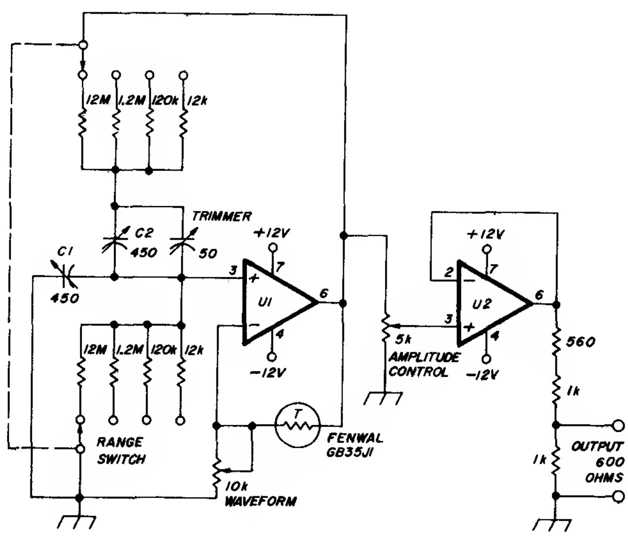


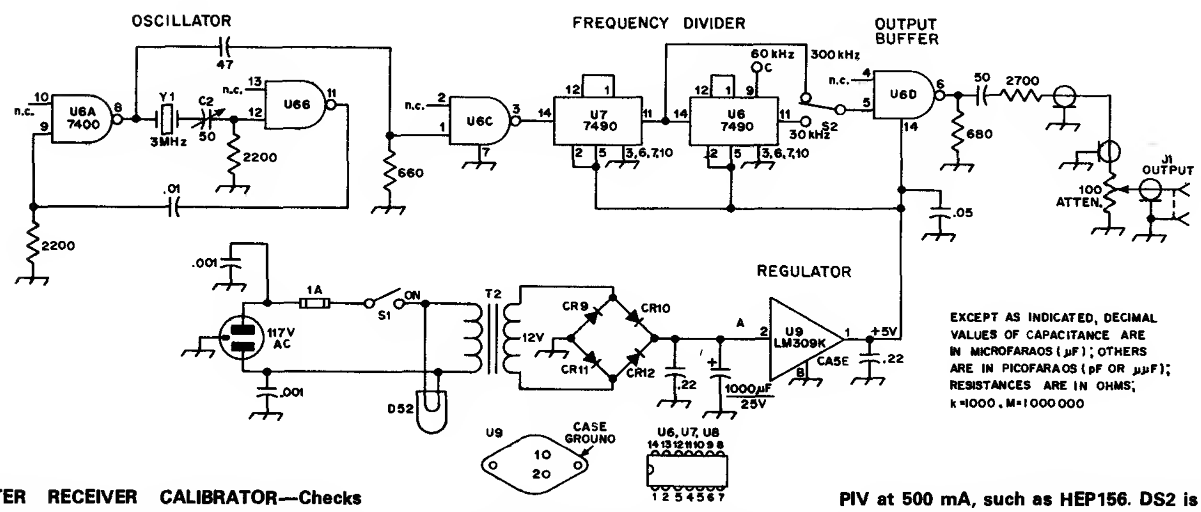
PRECISION 4.5-MHz FM FOR TV IF—Translation loop made from Signetics 561N and 562N PLLs produces 4.5-MHz signal with deviation of ±25 kHz, using 4.400-MHz crystal to control reference frequency. Modulation frequency is 400 Hz.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 843–845.



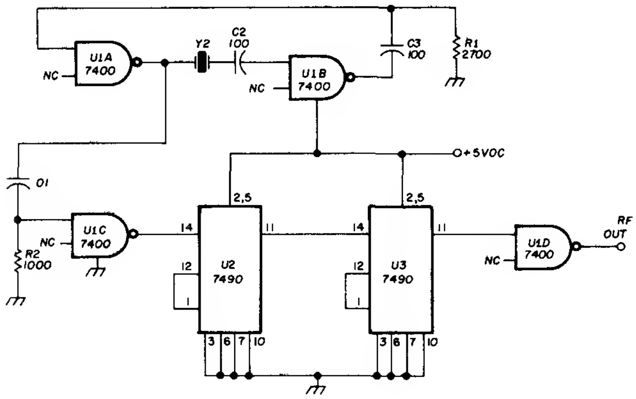
SIX-RANGE RF—Covers from 100 kHz to about 75 MHz in six bands, for checking low-frequency IF circuits on up to VHF circuits (using harmonics up to 220 MHz). Omission of frequency read-out dial scale simplifies design without affecting usefulness for troubleshooting. FETs can be HEP-802 or MPF102, and output transistor is 2N3866 or 2N706. First FET is Hartley oscillator lightly coupled through 5-pF capacitor to FET source-follower isolation stage. Last stage boosts signal level up to about 1 V on most bands. Tuning capacitor is broadcast-band type having 300-pF AM section and 25-pF FM section. Set of six coils can be purchased as Conar CO-69 through CO-74 from National Radio Institute or can be wound as suggested in article to give high-and band limits of 0.57, 1.4, 4.5, 17, 39, and 75–80 MHz. For portable use, 12-V battery pack or 9-V transistor radio battery can be used to give constant 9-V supply.—Brew Up a Signal Generator, *73 Magazine*, Jan. 1978, p 50–52.

30 Hz TO 100 kHz—Wien-bridge sine-wave oscillator using two RCA CA3140 opamps covers frequency range with less than 0.5% total harmonic distortion. Adjust 10K pot for best output waveform. Maximum output into 600-ohm load is about 1 VRMS. Opamps are direct replacements for 741 but have higher input impedance and better slew rate.—C. Hall, New Op Amp Challenges the 741, *Ham Radio*, Jan. 1978, p 76–78.

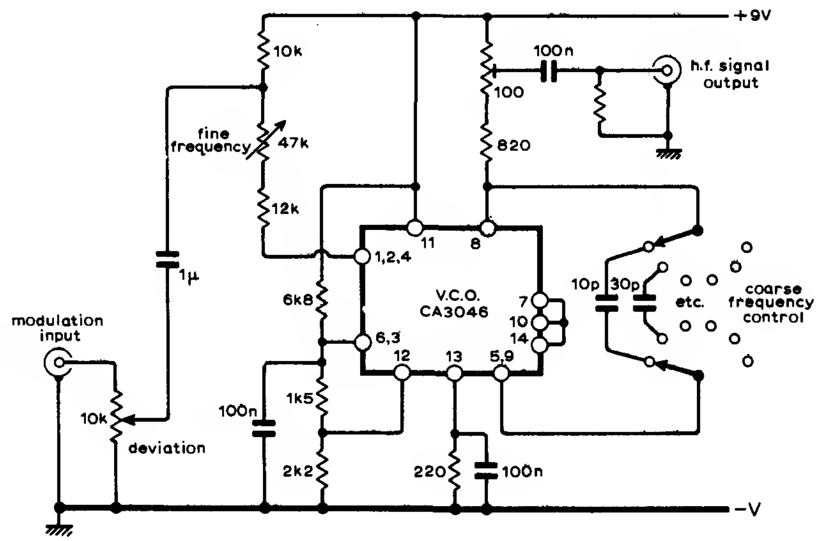




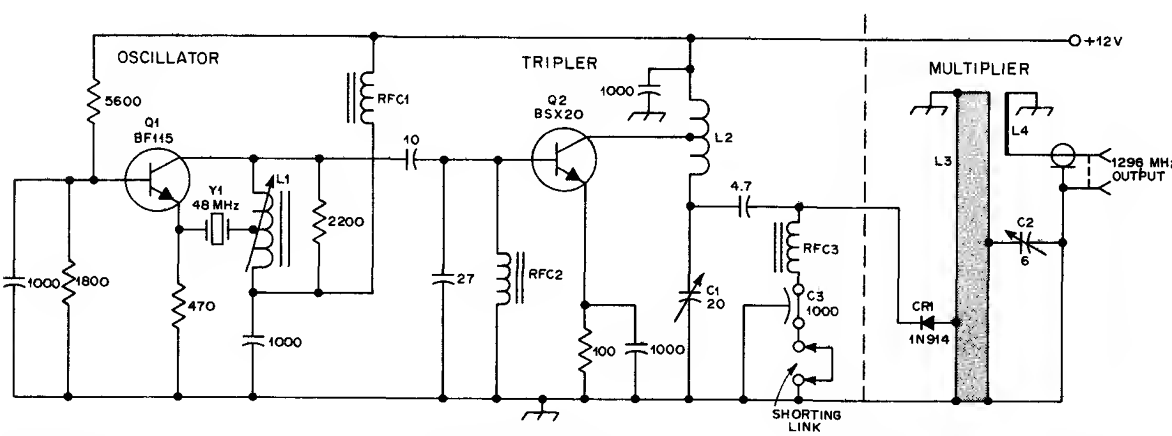
2-METER RECEIVER CALIBRATOR—Checks both frequency and sensitivity of amateur FM receiver. Starts with 3-MHz crystal and provides markers every 30 kHz or every 300 kHz. Energy levels are so low that only simple 100-ohm attenuator is needed. Article covers construction and calibration. CR9-CR12 are silicon rated 200 PIV at 500 mA, such as HEP156. DS2 is 117-V neon. T2 is 12 V at 0.3 A.—H. Lukoff, A 2-Meter Frequency and Sensitivity Calibrator, *QST*, Feb. 1976, p 34–36.



ALIGNMENT OSCILLATOR—With 500-kHz crystal, output can be used as 5-kHz markers in sweep alignment procedure. If SN7490P decade dividers are omitted and 455-kHz crystal is chosen, TTL circuit can be used to supply low IF value used by some receivers. Circuit will oscillate up to several megahertz.—J. Carr, VHF FM Receiver Alignment Techniques, *Ham Radio*, Aug. 1975, p 14–22.

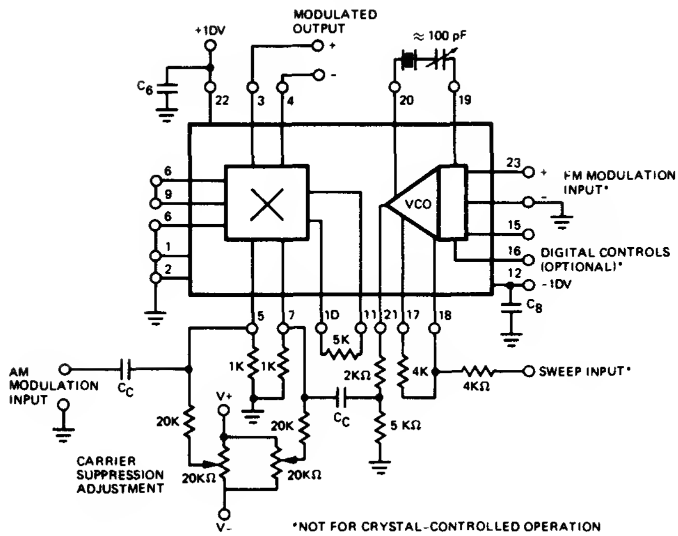


FM SIGNAL GENERATOR OR WOBBULATOR—With sine-wave input, RCA CA3046 transistor array connected as VCO can be used as low-distortion FM signal generator. With sawtooth input, same arrangement serves as wobbulator. Increasing size of timing capacitor reduces operating frequency, permitting use down to audio frequencies as voltage-controlled oscillator in electronic organ.—J. L. Linsley Hood, Linear Voltage Controlled Oscillator, *Wireless World*, Nov. 1973, p 567–569.

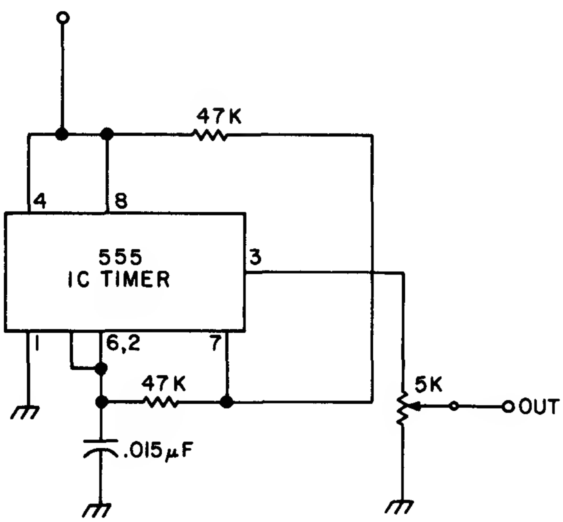


C1, C2 — Glass piston trimmer or other high-*Q* variable.
CR1 — 1N914 silicon high-speed switching diode.
L1 — 12 turns no. 28 enam. wire on 1/4-inch diameter slug-tuned form. Tap 1 turn from cold end.
L2 — 4 turns no. 18 copper wire, 1/4-inch ID by 7/16-inch long, center tapped.
L3, L4 — See Fig.
RFC1-RFC3, incl. — 2-1/2 turns no. 28 enam. wire on ferrite bead with 950 permeability (Amidon miniature beads suitable).
Y1 — Third-overtone crystal, 48 MHz.

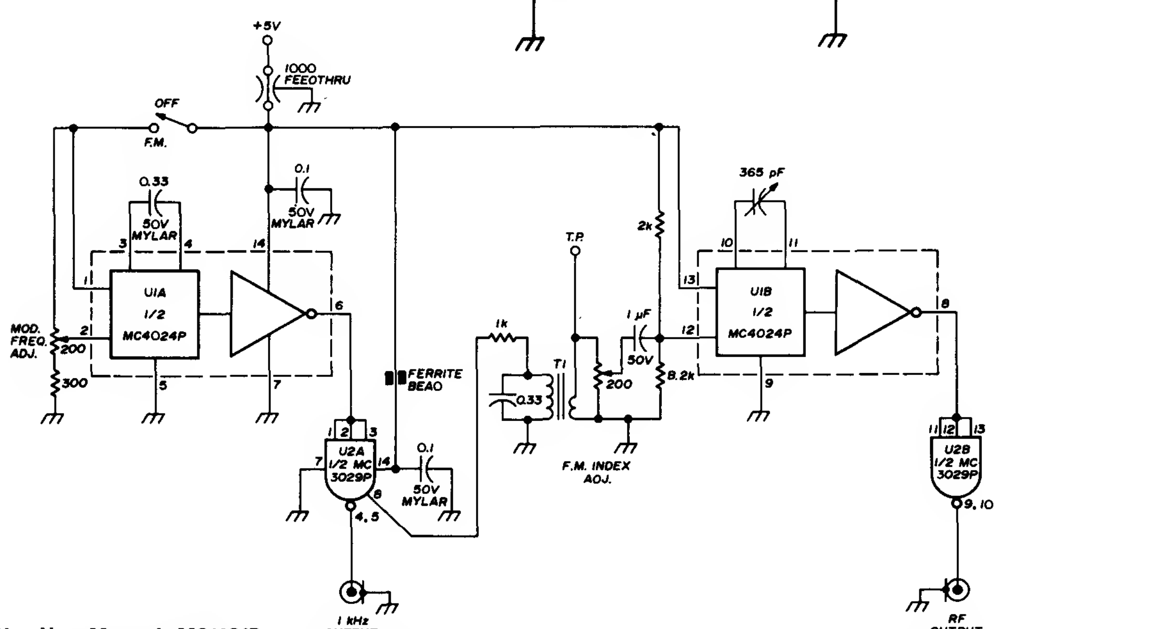
1296 MHz—Can be used as signal source for receiver adjustment and antenna testing, or as minibeacon on 1296 MHz. 48-MHz oscillator and clipper feed 144 MHz to 1N914 diode which multiplies frequency by 9. Half-wavelength stripline tank L3-C2 rejects other harmonics. Shorting link below RFC3 is removed for measuring diode current.—A 1296-MHz Signal Source, *QST*, March 1977, p 26.



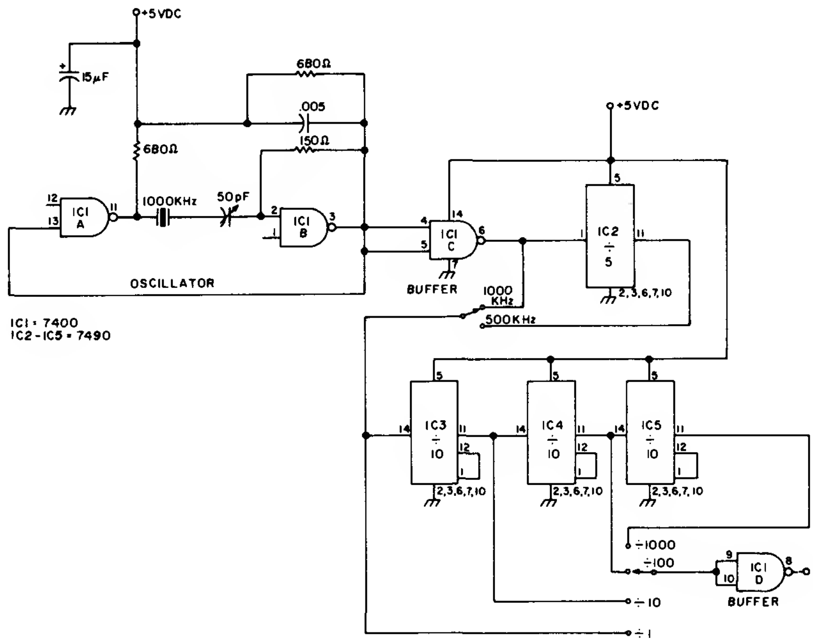
AM, FM, AND SWEEP—Oscillator and multiplier sections of Exar XR-S200 PLL IC are connected as general-purpose voltage-tuned AM/FM radio-frequency signal generator. Can also serve as high-stability carrier or reference generator if crystal at desired frequency is connected between pins 19 and 20 as shown. Multiplier section introduces amplitude modulation on carrier signal generated by VCO. Balanced multiplier allows suppressed-carrier or double-sideband modulation. Typical carrier suppression is above 40 dB for frequencies up to 10 MHz. With timing capacitor used in place of crystal, oscillator section can provide highly linear FM or frequency sweep. Digital control terminals of oscillator can be used for frequency-shift keying.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 9–16.



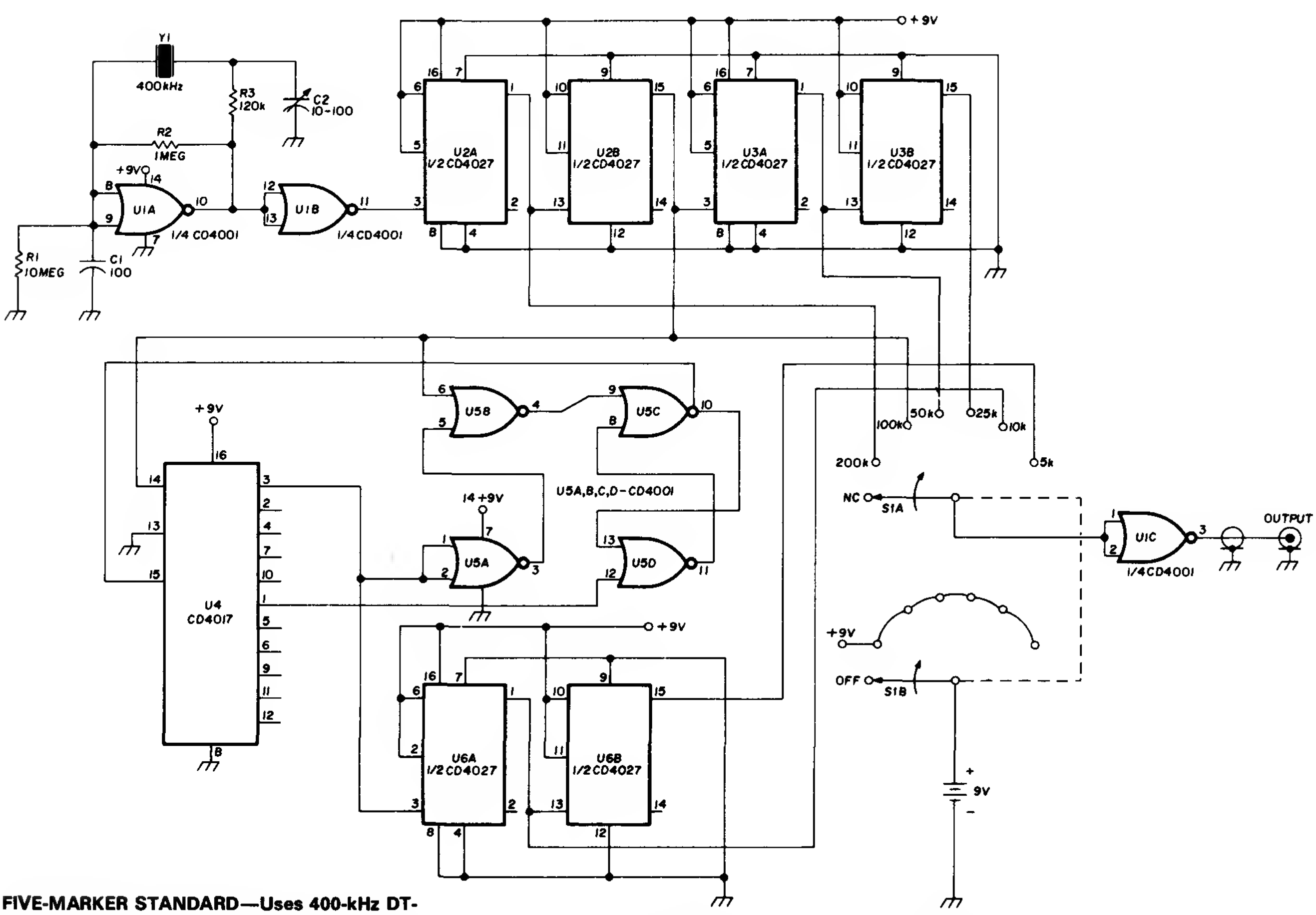
1-kHz SQUARE WAVE—Useful for signal-tracing from audio frequencies to several megahertz because 1000-Hz square-wave output of 555 timer is rich in harmonics. Use 5-V supply. Developed for checking audio, IF, and RF stages of amateur receiver operating on 160- to 40-m bands.—J. J. Carr, How to Become a Troubleshooting Wizard, *73 Magazine*, Jan. 1976, p 138–143.



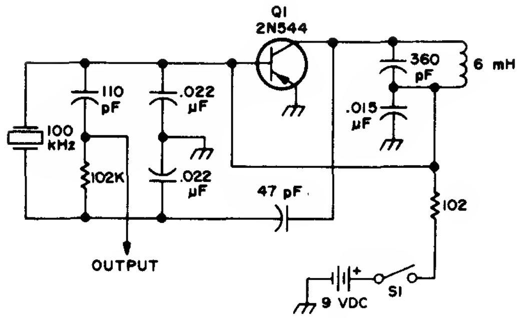
600 kHz TO 12 MHz—Uses Motorola MC4024P or HEP3805P dual voltage-controlled MVBR or VCO. One half is used to produce rectangular RF output and other half to generate rectangular 1-kHz modulation frequency. RF output frequency is proportional to 1/C, with 365-pF variable capacitor providing tuning over 20:1 range from 600 kHz to 12 MHz. Use large dial for calibration. Half of MC3029P line-driver NAND gate follows each of MVBRs in MC4024P to provide isolation and to drive 50-ohm lines with either output. Output voltage is well over 1 V P-P. T1 is 88-mH toroid with 30 turns No. 26 enamel wound over it as secondary. Use regulated supply.—H. Olson, Wide Range RF Signal Generator, *Ham Radio*, Dec. 1973, p 18–21.



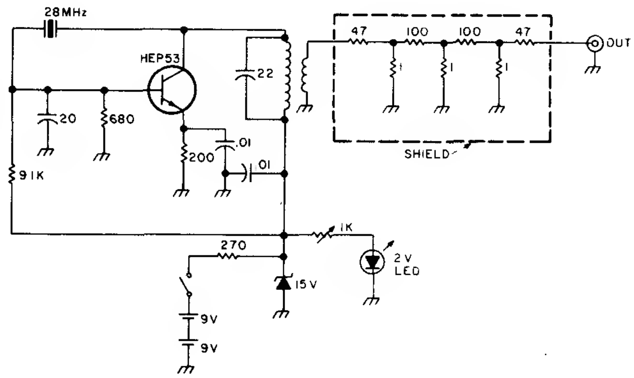
TTL CRYSTAL CALIBRATOR—Easily assembled from low-cost TTL digital ICs, for use as troubleshooting signal generator. Almost any frequency can be obtained by correct choice of oscillator crystal and/or division ratio. If zeroed against frequency standard such as WWV, circuit gives accurate frequency check.—J. J. Carr, How to Become a Troubleshooting Wizard, *73 Magazine*, Jan. 1976, p 138–143.



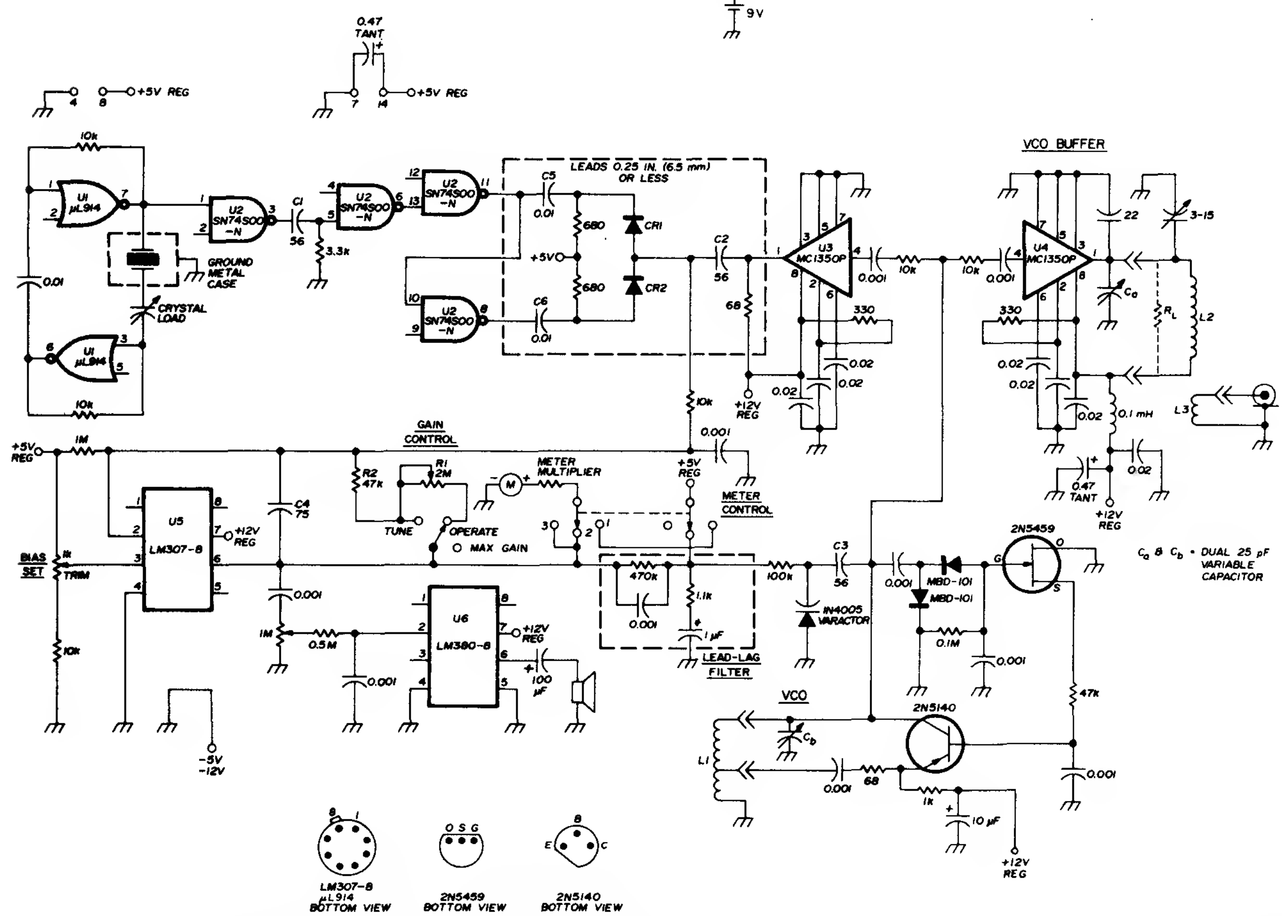
FIVE-MARKER STANDARD—Uses 400-kHz DT-cut crystal in NOR-gate oscillator U1A and divider chain U2-U6 to provide calibration markers at 200, 100, 50, 25, 10, and 5 kHz. U2A-U3B are wired as D flip-flops for dividing by 2. U4 is divide-by-N counter, with latch arrangement of U5 used to reset selected divide-by-5 logic. Output of 100 kHz is divided by 5 and then by 2 to give symmetrical 10-kHz output for division by 2 to provide 5 kHz. CMOS CD4000-series logic elements reduce power consumption from 9-V battery to 2.8 mA but allow sufficient switching speed and harmonic energy for good response throughout HF bands.—F. M. Griffee, Frequency-Marker Standard Using CMOS Logic, *Ham Radio*, Aug. 1977, p 44–45.



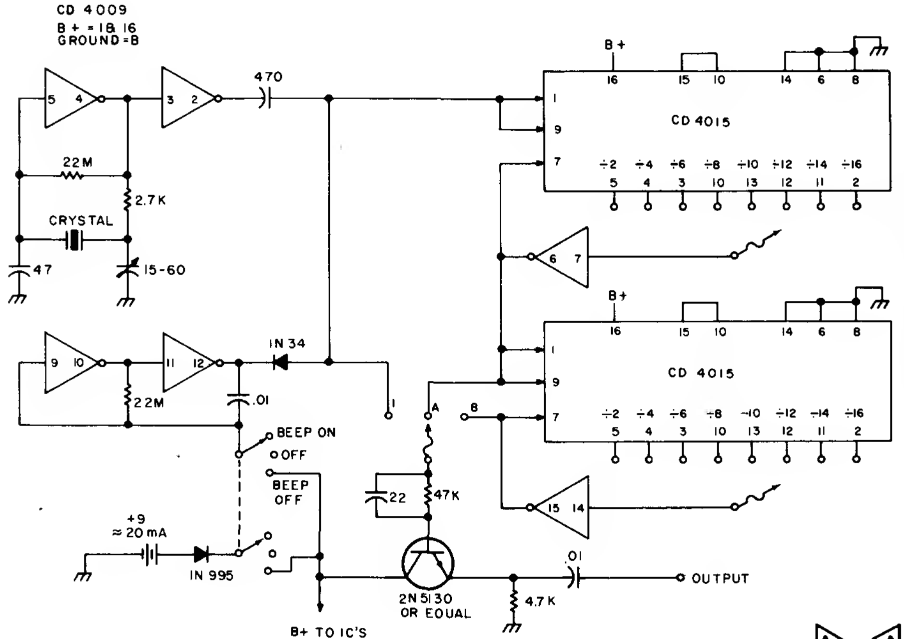
100-kHz CALIBRATOR—Simpla crystal-controlled single-transistor oscillator can ba used to calibrate emateur redio transceivar. Output should be connected to entenna input side of receivar, not to antenna tarminal normally used.—Novice Q & A, *73 Magazine,* March 1977, p 187.



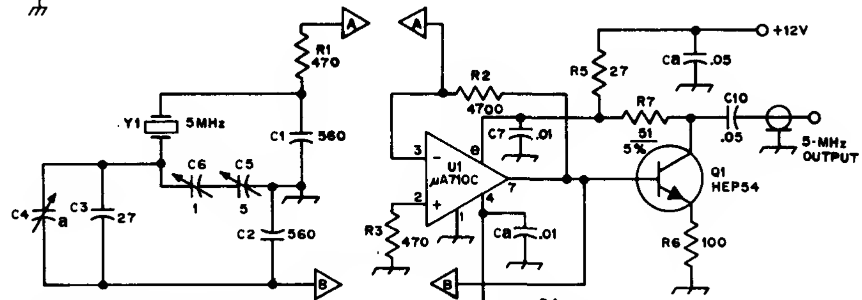
RECEIVER CHECKER—Single-transistor 28-MHz crystal oscillator and carefully designed attenuator network serve to ganarate signal of about 1 μV for checking performanca of amateur radio receiver. Can be used on any band down to 6 meters by appropriate choice of crystal end LC circuit components. Coil is CTC LS5 form having 15 turns No. 22 enamel end 2-turn link.—Is It the Band or My Raceivar?, *73 Magazine,* Oct. 1976, p 132–133.



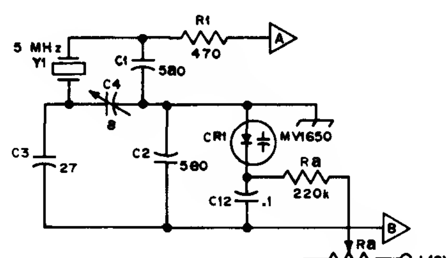
6–36 MHz HARMONIC GENERATOR—Phase-locked loop is used with short-duration pulses from 1-MHz crystal refaranca oscillator to produca highly eccurate hermonics. SN74S00N Schottky U2 changes refarance wavaform to harmonic-rich 100-ns pulsas for faed to 1N914 phase-detector diodes CR1 and CR2. Buffer U3 dalivars output of 2N5140 VCO to diodes for phase comparison, and phase-frequancy output is fed to opamp U5 that locks VCO more tightly to reference-oscillator output by incraasing its control of veractor. VCO frequancy will than be harmonic of refaranca oscillator. Meter used to monitor control voltage to varactor cen have full-scale value of 100 μA to 1 mA, with its multipliar resistor adjusted to raad 5 V at midscala. When opamp is capturing VCO, meter needla will flop from side to sida but will return to midscale after lock is achieved. Article covers construction, tuning, and operation.—K. W. Robbins and J. R. True, Crystal-Controlled Harmonic Ganarator, *Ham Radio,* Nov. 1977, p 66–69.



CMOS MARKER—Cryatel-controlled marker generator uses any cryatal from 100 kHz to 4 MHz. Requires only ona CD4009 hex inverter and two CD4015 shift registers. Switches give choice of aven-number division retios up to 256. Used for locating bend edgea or aubbends and for calibrating receivers. Trensistor AM baapar Is simple clamp that getes RF on or off, to fecilitate location of marker in crowded banda.—K. W. Robbins, All Band Frequency Marker, *73 Magazina*, June 1975, p 88–90.

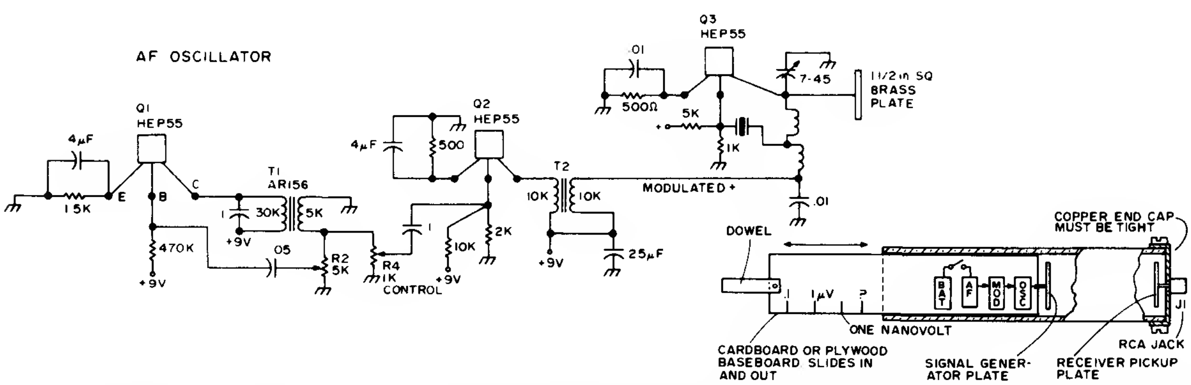


EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k = 1000, M = 1000 000.

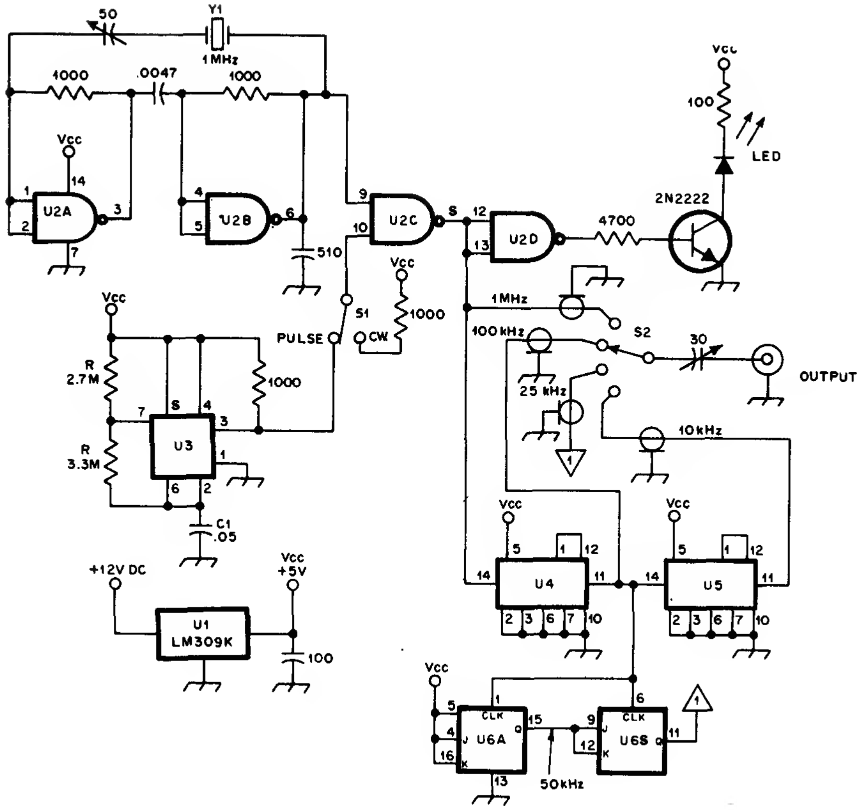


VARACTOR-TUNED VERSION

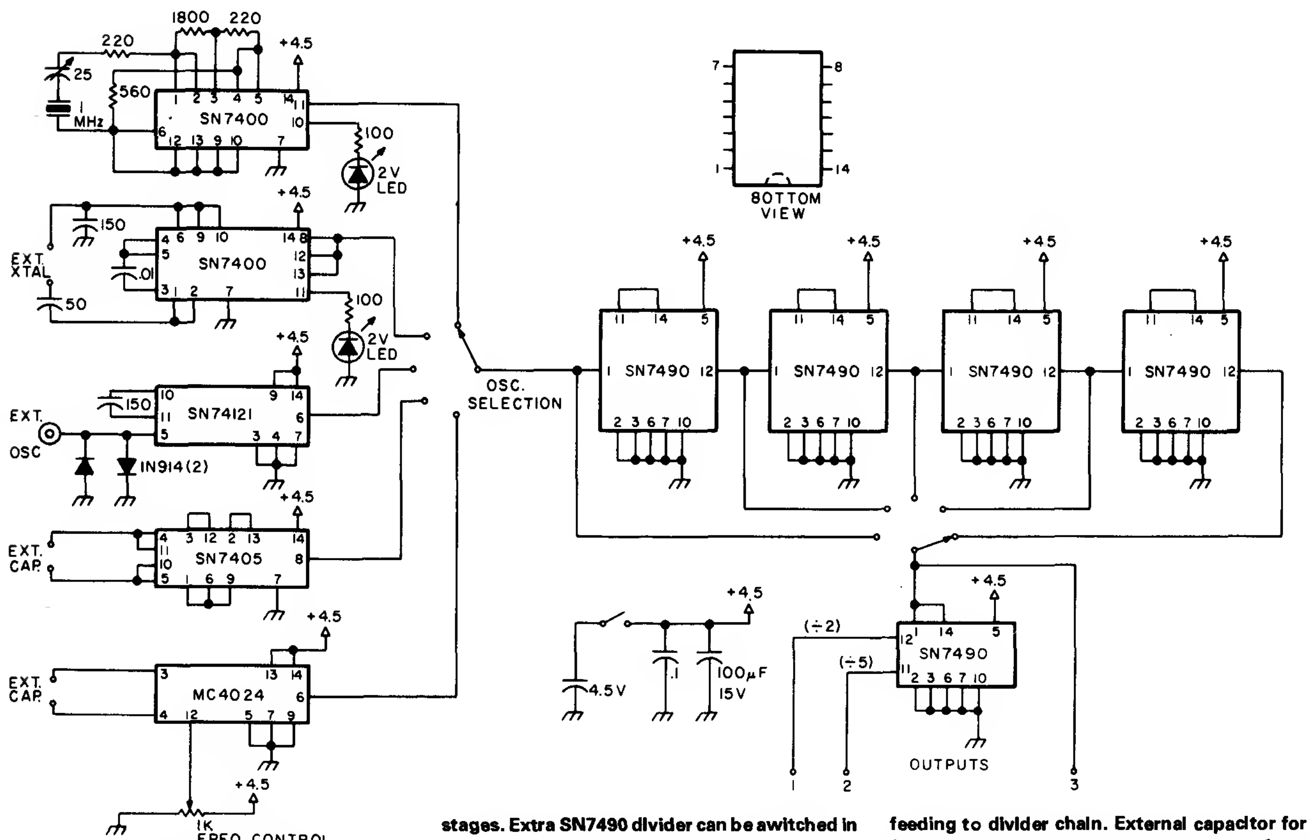
5-MHz STANDARD—Guriot-Clapp cryatal oecillator ueing broedbend high-gain opemp U1 cen be tuned by conventional variable capacitor C5 or alternetively by Motorola MV1650 varactor CR1. Buffer Q1 minimizes effect of loading on frequancy.—R. Silbarstein, An Expairmantal Frequency Standerd Using ICs, *QST*, Sept. 1974, p 14–21 and 167.



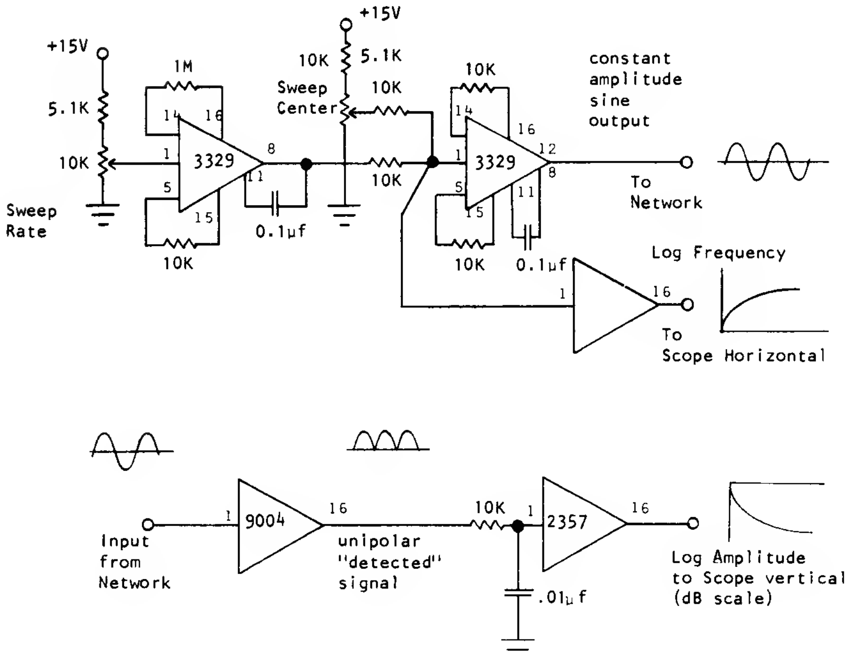
50 MHz WITH ATTENUATOR—Poaitioning of miniaturized aignel generetor in 4½ × 2⅛ × 24 inch weveguide providas stabla verieble-strength signel thet cen be dropped gradually down to zero as generator ie moved eway from racaivar pickup pleta. Slide can ba calibreted for meaauring eeneitivity of 6-meter raceivar in tenthaof e microvolt. Circuit consists of 50-MHz cryetel oscillator, AF oacillator, end simple cleee A modulator.—B. Hoiaington, Low-Coat Infinite Attenuator for Amataur Uaa, *73 Magazine*, Sept. 1974, p 107–108.



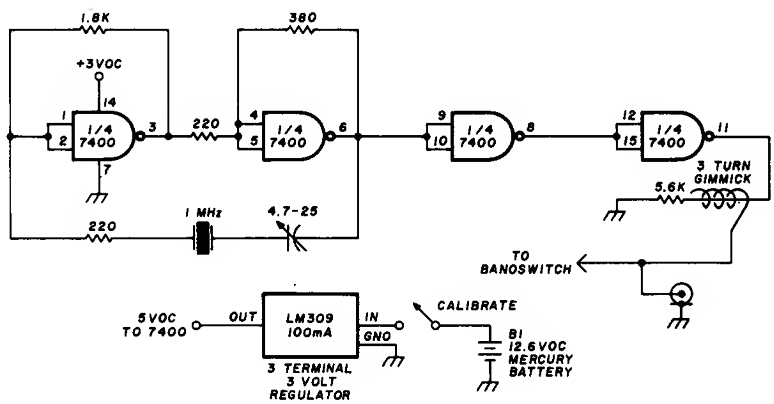
PULSED MARKER—Crystal calibrator circuit provides pulsed output for easy spotting, eliminating need for turning marker on and off repeatedly to identify it in crowded band. With values shown, switching rate is about 2 Hz. When marker is found, placing S1 in CW position keeps it on for zero-beating calibrator output more accurately. Reducing value of C1 increases switching speed of U3, thus increasing pulse rate. LED indicates either pulsed or CW output. ICs are conventional types used in crystal calibrators.—R. G. Brunner, Crystal Calibrator Has Pulsed Output, *QST*, Nov. 1977, p 45.



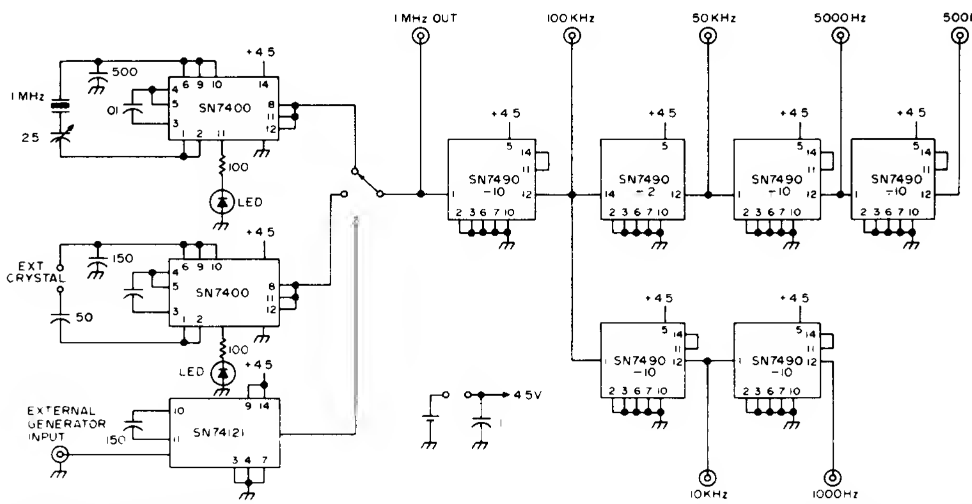
UNIVERSAL SIGNAL GENERATOR—Collection of IC oscillators and dividers generates square waves from HF down to subaudible AF, along with markers up into VHF. Selectable oscillator section feeds fixed string of four divide-by-10 stages. Extra SN7490 divider can be switched in at various points along string to add divide-by-5 and divide-by-2 functions. LED in 1-MHz crystal stage indicates that circuit is oscillating. Second stage can be used with any external crystal up into low VHF range. Third stage accepts and conditions external sine or square input for feeding to divider chain. External capacitor for fourth stage tunes square-wave generator from several hertz to several megahertz. Optional fifth stage is VCO for entire HF range up to 25 MHz.—J. Schultz, Updated Universal Frequency Generator, *73 Magazine*, Nov. 1976, p 50–52.



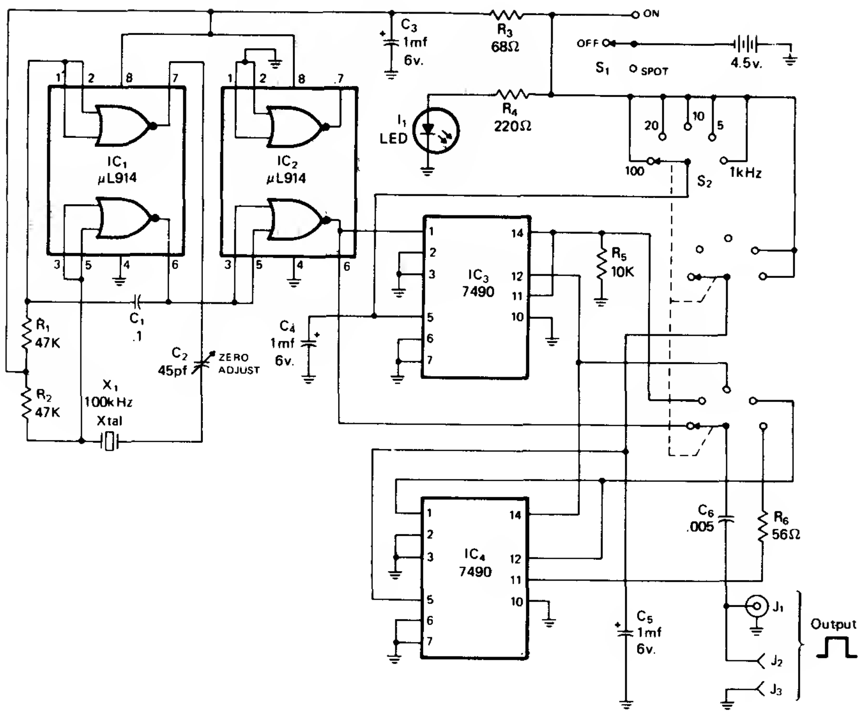
NETWORK TESTER—Sweep generator produces time-varying constant-amplitude frequency signal for network under test, with output of network converted to logarithmic DC voltage for display of amplitude or gain on decibel scale of CRO or recorder. Sawtooth voltage for sweep, generated by first Optical Electronics 3329 IC, drives another 3329 that converts sawtooth into logarithmic signal for log-frequency output. Detector uses 9004 absolute-value module as linear detector, with 2357 logamp converting output to decibel scale. Resulting display is Bode plot of frequency response.—"A Simple Sweep Generator," Optical Electronics, Tucson, AZ, Application Tip 10201.



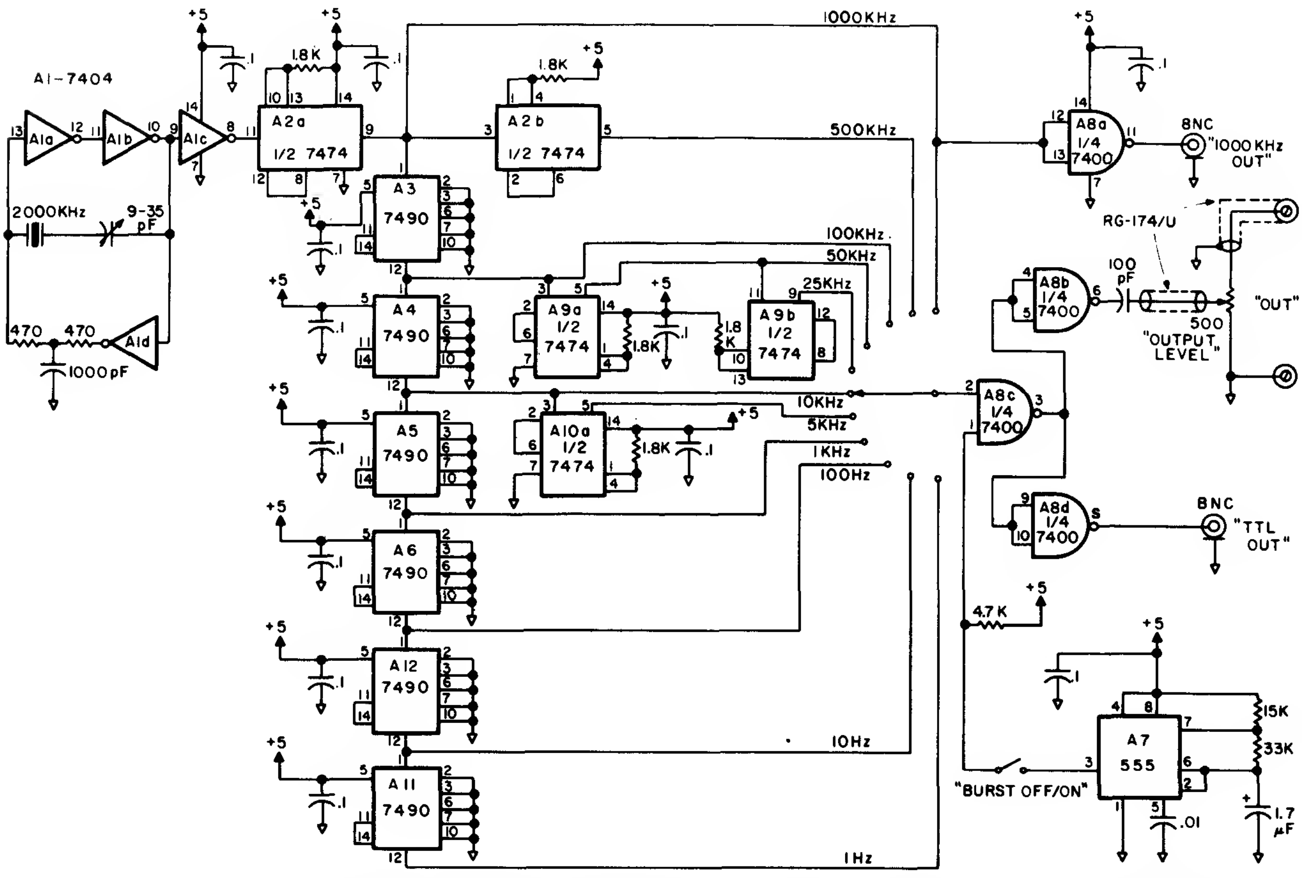
1-MHz CRYSTAL CALIBRATOR—Battery-powered crystal oscillator for checking frequency calibration of communication receiver uses TTL. Regulator is in TO-5 can, which is 100-mA version of LM309.—J. J. Carr, Resurrecting the Old War Horse: New Hope for the Old Receiver, *Ham Radio*, Dec. 1976, p 52–55.



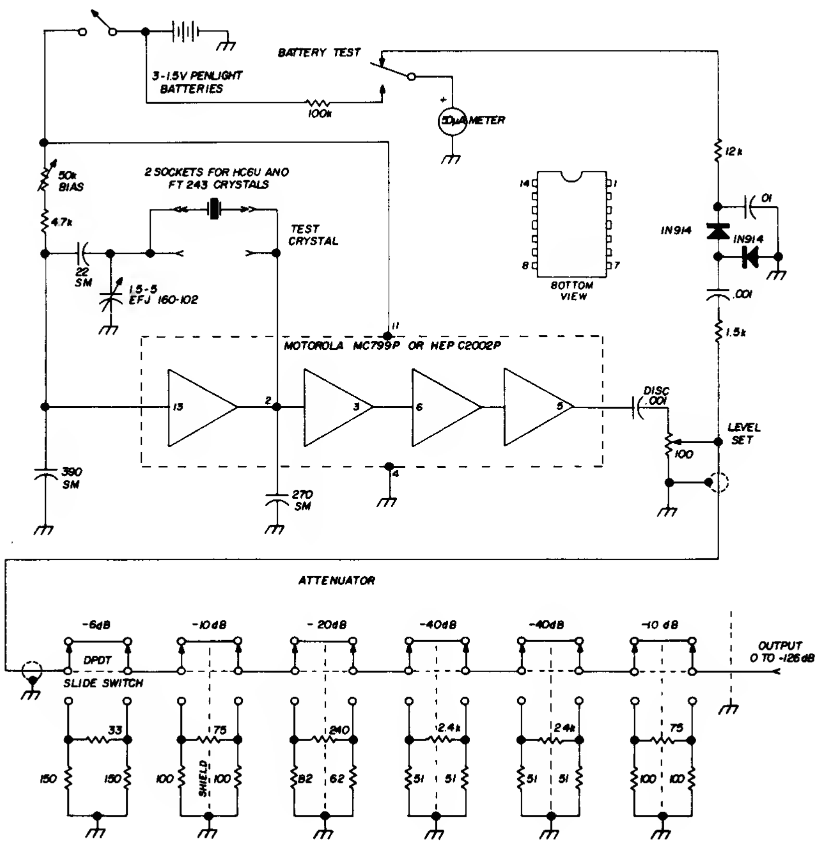
AF/RF FROM 1 MHz—String of SN7490 decade counters divides output of 1-MHz crystal oscillator by 10 or 2 to give choice of six fixed frequencies between 1000 Hz and 100 kHz along with undivided 1 MHz. One gate of SN7400 crystal oscillator drives LED to indicate that crystal is oscillating. When using external sine-wave source, input is squared by SN74121 MVBR for driving frequency divider chain. Circuit is easily modified to give other divider ratios. Applications include use as marker generator for receiver calibration up into VHF range or as signal generator for precise AF or RF square-wave signal at desired frequencies.—J. J. Schultz, Poor Man's Universal Frequency Generator, *73 Magazine*, July 1974, p 33 and 35–36.



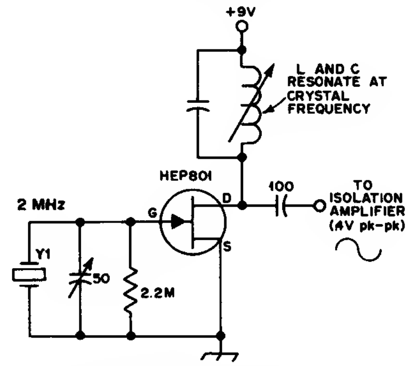
SECONDARY STANDARD—Provides switch-selected squere-wave outputs of 100, 20, 10, 5, and 1 kHz, calibrated with receiver tunad to WWV frequency. 100-kHz clock signel is generetad by crystal oscillator IC_1. Half of IC_2 is buffer betwaan oscillator and first decade counter IC_3, used to generata 10- and 20-kHz outputs. Second dacade countar IC_4 gives 1 and 5 kHz.—E. R. Spedoni, A Versatila Secondary Frequancy Standard, *CQ*, Sept. 1975, p 31–32.



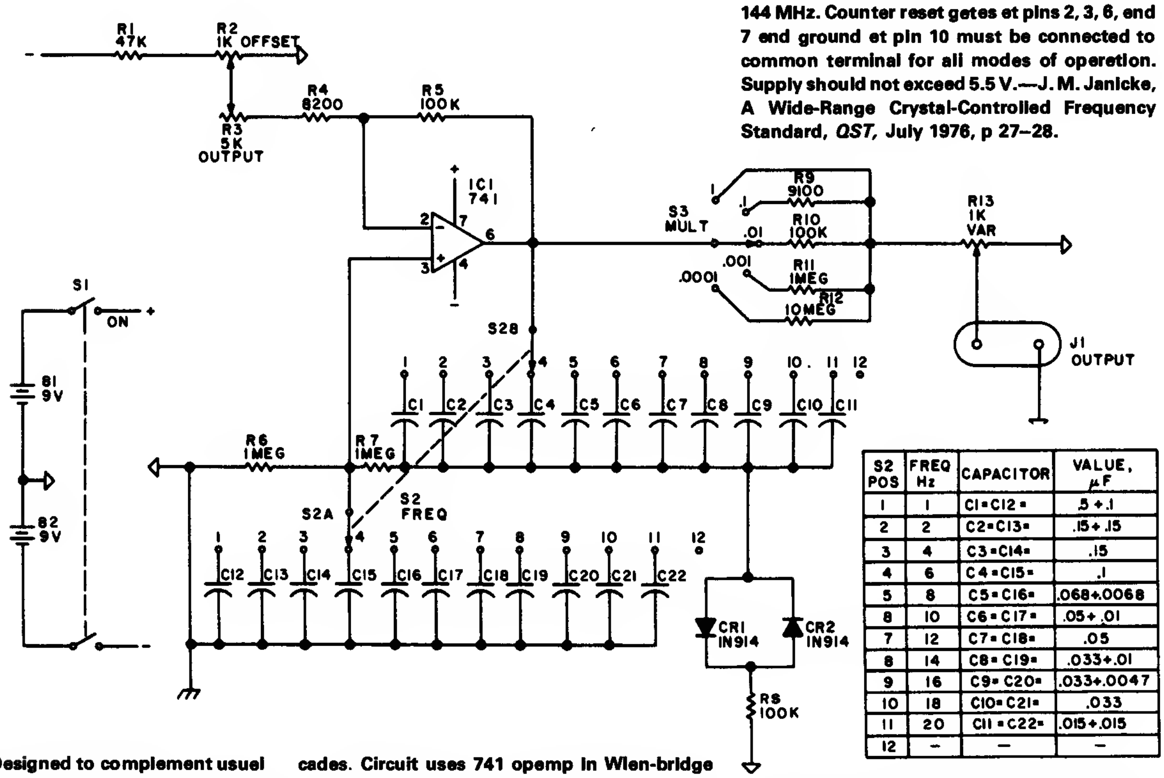
1 Hz TO 1 MHz—Low-cost secondery frequency standard genarates marker signals of 1000, 500, 100, 50, 25, 10, 5, and 1 kHz end 100, 10, and 1 Hz, with harmonic merkars usable well beyond 30 MHz. Two TTL output levals are availeble as clocks or signal injectors for chacking TTL. Short-term accurecy is about 1 pert in 10^6. Unit is aasily allgned to WWV with shortwave receiver. Frequency-burst mode turns output on and off 10 timas per second, for identification of markers in crowded bend of recaiver. Article covars construction and oparation in detail, and gives circuit for suitable regulated power supply having standby battery.—T. Shenkland, Build a Supar Standard, *73 Magazine*, Oct. 1976, p 66–69.



1–10 MHz CRYSTAL—Stable crystal test oscillator takes any crystal in frequency range with no tuning adjustments. Uses single Motorola MC799P IC in circuit that provides 32-pF crystal loading. Trimmer may be used to adjust crystal for exact frequency if desired. Circuit is not critical. Bias pot compensates for battery voltage changes. Output attenuator uses standard resistor values to provide up to 126 dB of output signal control. Meter serves as battery tester and gives instant indication of crystal activity when circuit is used for testing crystals.—A. A. Kelley, Crystal Test Oscillator and Signal Generator, *Ham Radio,* March 1973, p 46–47.

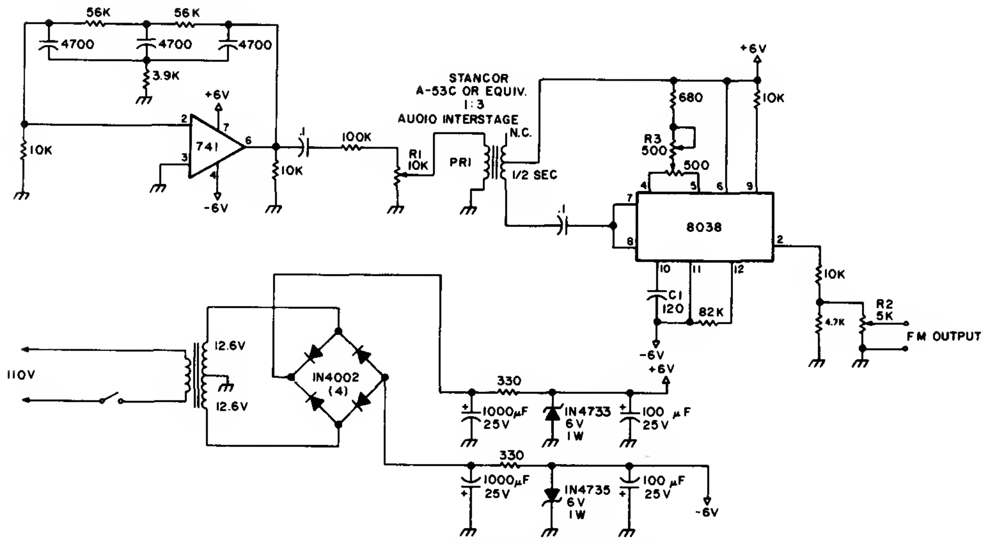


2-MHz STANDARD WITH DIVIDERS—Can be used for calibration of frequency meters, frequency counters, and amateur receivers. Two crystal oscillators (2 MHz and 100 kHz) feed two 7490 decade counters through isolation amplifier. Arrangement gives frequency division by 2, 4, 10, 20, and 100 for each oscillator, with all frequencies rich in harmonics and usable through 144 MHz. Counter reset gates at pins 2, 3, 6, and 7 and ground at pin 10 must be connected to common terminal for all modes of operation. Supply should not exceed 5.5 V.—J. M. Janicke, A Wide-Range Crystal-Controlled Frequency Standard, *QST,* July 1976, p 27–28.

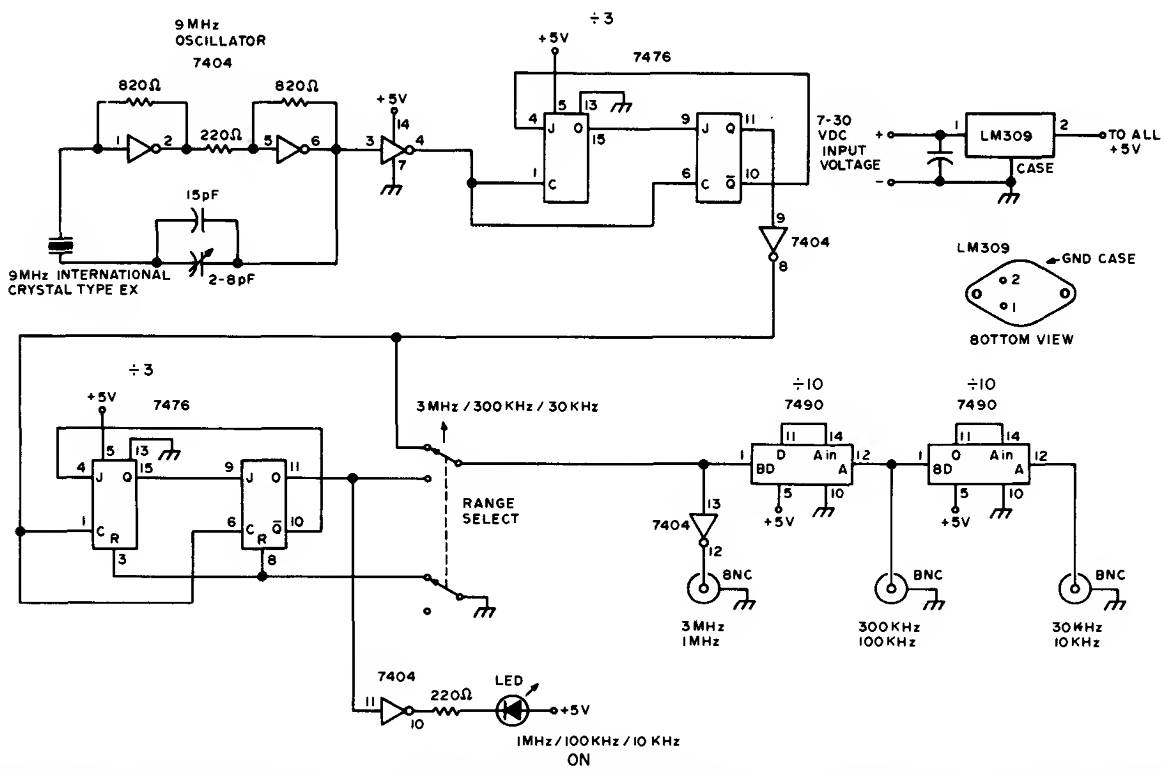


S2 POS	FREQ Hz	CAPACITOR	VALUE, μF
1	1	C1=C12=	.5+.1
2	2	C2=C13=	.15+.15
3	4	C3=C14=	.15
4	6	C4=C15=	.1
5	8	C5=C16=	.068+.0068
6	10	C6=C17=	.05+.01
7	12	C7=C18=	.05
8	14	C8=C19=	.033+.01
9	16	C9=C20=	.033+.0047
10	18	C10=C21=	.033
11	20	C11=C22=	.015+.015
12	–	–	–

1–20 Hz SINE—Designed to complement usual lab sine-wave generator that goes down to only 20 Hz, by providing discrete switch-selected output frequencies of 1 Hz and 2–20 Hz in 2-Hz steps. Output attenuator uses pot and switch to set output at any value within range of five decades. Circuit uses 741 opamp in Wien-bridge oscillator having four-element RC network in positive feedback path of amplifier (R6 in parallel with capacitor selected by S2A, and R7 in series with capacitor of S2B), so oscillation occurs at frequency where phase shift occurs. Article gives construction details. Offset adjustment R2 may need touching up as batteries run down.—D. Hileman and L. Hileman, V-V-V LF Generator, *73 Magazine,* Holiday Issue 1976, p 97–99.



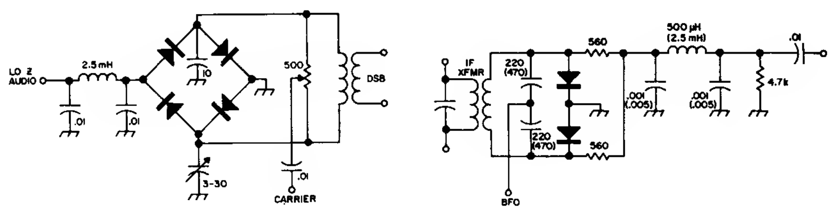
455-kHz FREQUENCY-MODULATED—Can be used to align IF amplifier and quadrature detector of FM receivers. Unit is stable and providas ample deviation for amateur receivers. Uses 8038 function generetor and 741 opamp connected as audio oscillator to provide about 1000-Hz moduleting voltage. Includes deviation control R1, output level control R2, and carrier frequency control R3. Adjust 500-ohm pot between pins 4 and 5 of 8038 for clean sine-wave output on CRO. Adjust R3 to give 455 kHz as meesured by meter or frequency counter. To check audio oscillator, connect AC voltmeter or CRO across R1, which should have clean 1000-Hz sina wave of sevaral hundred millivolts. Transformer in powar supply can ba two seperate 12.6-V units with primaries in parallel and secondaries in series.—J. C. Chapel, Build This FM Signal Generetor, *73 Magazina*, Jan. 1978, p 154–155.



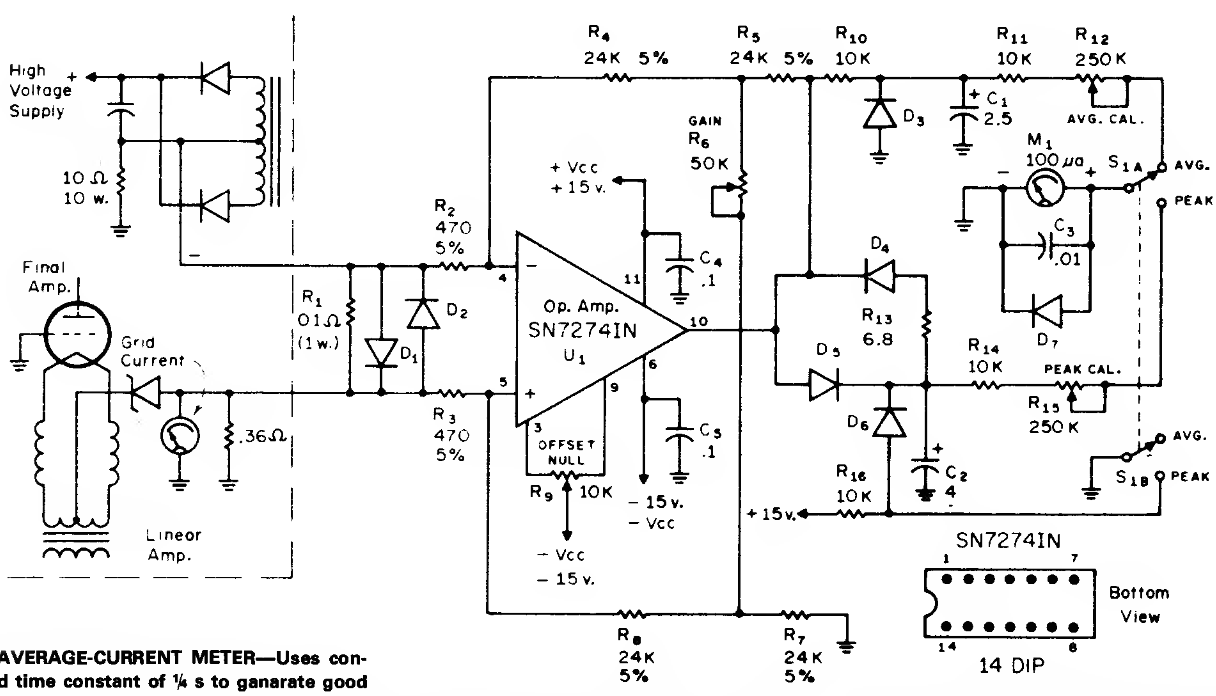
HF/VHF MARKERS—Provides markers neadad for most amateur radio bands, including 30 and 300 kHz for VHF FM operation and 10 end 100 kHz for 2-m FM operation. When LED is on, outputs are 1 MHz, 100 kHz, and 10 kHz. When LED is off, outputs are 3 MHz, 300 kHz, and 30 kHz. Uses 7404 TTL hex inverter as crystal oscillator, with 2–8 pF trimmer for zaroing crystel with WWV. All 7476 TTL dual JK flip-flops are connected to divide by 3.—F. E. Hinkle, Inexpensive HF-VHF Frequancy Standard, *73 Magazine*, April 1976, p 62–63.

CHAPTER 81
Single-Sideband Circuits

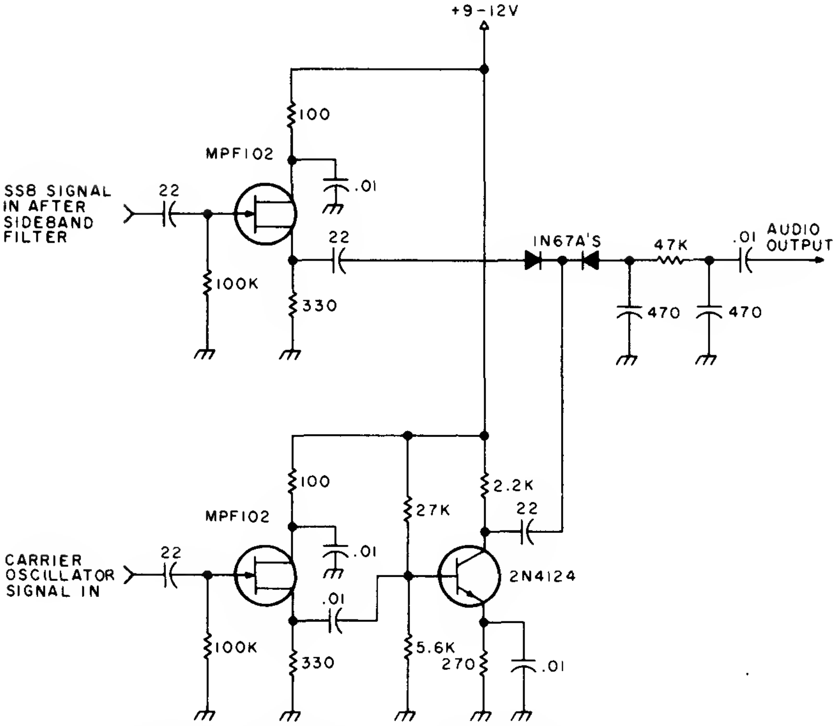
Includes audio clippers, shapers, and other circuits for improving speech readability, along with product detectors, sideband selectors, double-balanced mixers, direct-conversion receivers, and SSB test equipment.

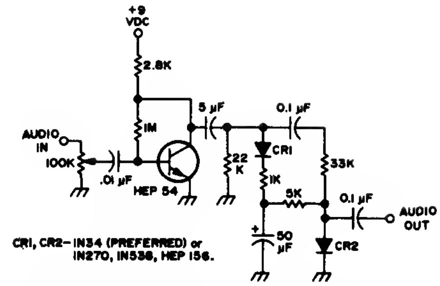


PRODUCT DETECTOR—Developed for use in SSB receiver having 9-MHz IF amplifier. Values in parentheses ara for receiver heving 455-kHz IF emplifier. Diode typas ara not critical.—Circuits, *73 Magazine*, May 1973, p 105.



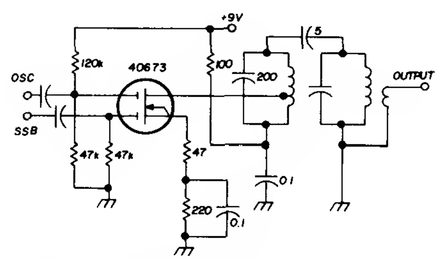
SSB AVERAGE-CURRENT METER—Uses controlled time constant of ¼ s to ganarate good approximation of average current in voice-modulated SSB signal. Circuit also gives peak current reading, with peaks meesured and held for short time. Opemp isolates current from plate supply and converts it into signal that can be run through shaping network to get averages end peaks. D_1-D_7 ere 1N3064 or equivalant. D_1 and D_2 eliminate spikes that might damage opemp. R_6 allows small adjustments of opamp gain, which is normally set at 100.—R. Sans, Make Your Meter Readings Count, *CQ*, Dec. 1972, p 28–29.

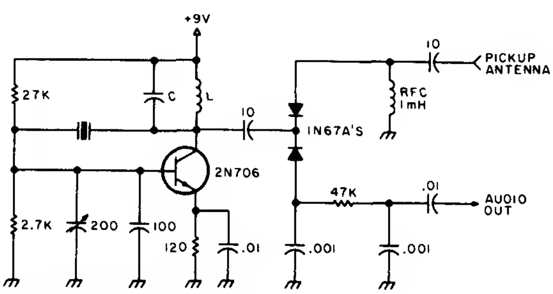




SPEECH PROCESSOR—Preamplification combined with clipping or compression gives higher average level and increased intelligibility of SSB communication. Degree of compression is controlled with 100K pot that adjusts input. Output of transistor feeds passive diode compressor. Amount of compression will vary with diode type, and experimentation is suggested. Article covers construction and adjustment of circuit.—B. Barrington, Simple Audio Preamp, *73 Magazine*, Feb. 1974, p 69–70.

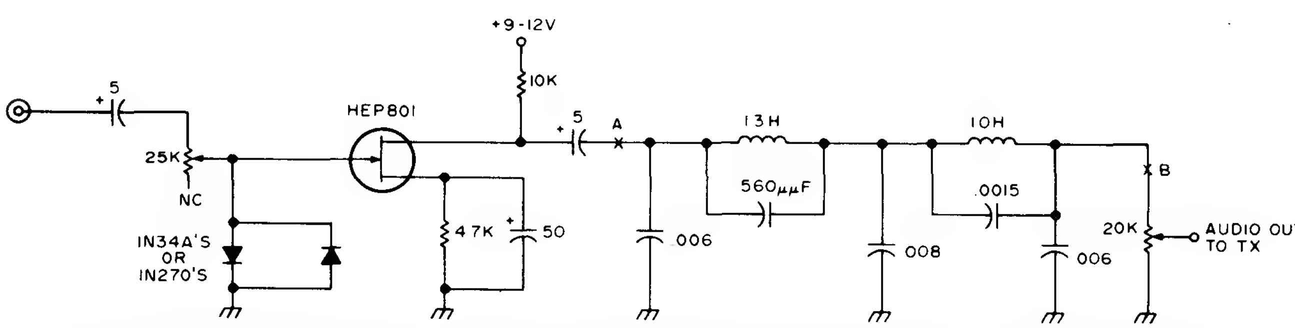
SSB MONITOR—Requires two connections to SSB transmitter, at output of carrier oscillator and at output of sideband filter. FET isolation stages for each connection feed 2N4124 product detector that gives audio signal for monitoring directly with headphones or for feeding AF amplifier driving loudspeaker.—Clean Up Your Act, *73 Magazine*, Jan. 1978, p 136–137.



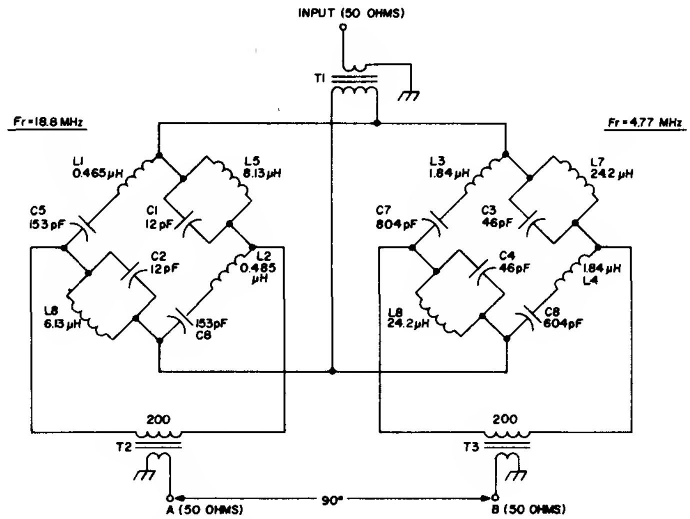


OFF-AIR MONITOR—Single-frequency modulation monitor for SSB transmitter combines crystal oscillator with product detector, for checking audio at one point within band. If tuning and loading of SSB transmitter are same over rest of band, audio quality also remains constant. Use fundamental-mode crystal for desired band. LC circuit should be resonated to band being used. Oscillator signal is spotted with transceiver in receive mode, after which transceiver can be monitored during transmissions.—Clean Up Your Act, *73 Magazine*, Jan. 1978, p 136–137.

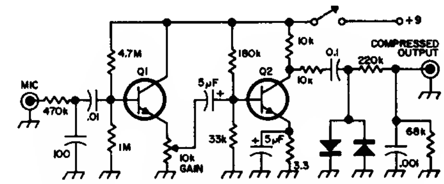
SIDEBAND MIXER—Used as transmitting mixer in SSB transceiver made by Sideband Associates for radiomarine communication in 2–23 MHz range. Low-frequency sideband signal and high-frequency oscillator signal are mixed to produce higher sum frequency at output. Double-tuned resonant circuit provides adequate output bandwidth and excellent skirt rejection of undesired frequency components.—E. Noll, MOSFET Circuits, *Ham Radio*, Feb. 1975, p 50–57.



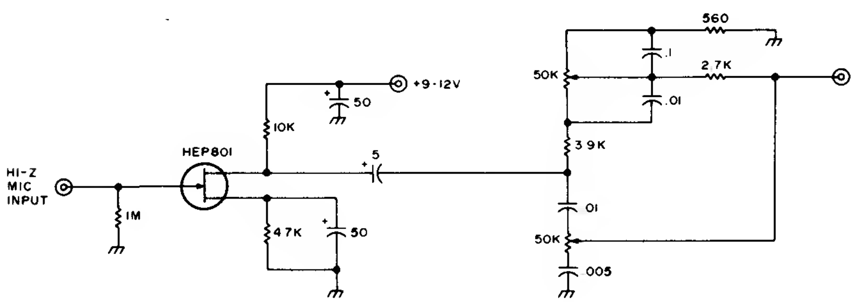
SOFT CLIPPER—Used after audio compressor to improve effective signal strength of SSB transmitter. Soft clipping is achieved by driving diode pair through resistance. Clipper is followed by low-noise FET voltage amplifier having broadband flat frequency response. Output filter sharply attenuates signals above about 3 kHz.—J. J. Schultz, Adding dBs to the Audio Compressor, *73 Magazine*, May 1974, p 21–23 and 25.



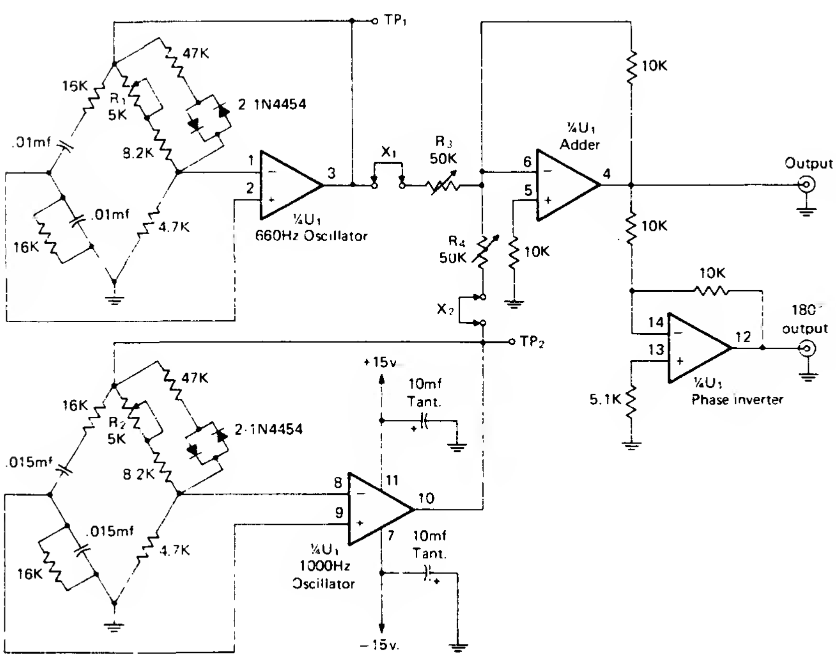
3–30 MHz QUADRATURE PHASE SHIFT—Wideband passive AF phase-shift network makes direct-conversion SSB generation possible. Bridge networks each provide 45° phase shift, to give differential phase shift of 90° over entire frequency range with maximum phase error of about 1°. Overall loss of network is about 6 dB. T1, T2, and T3 are wound on Neosid 1050-1-F14 of Indiana General F684-1 balun core. Twist together three 7-inch lengths of No. 26 enamel and wind 3 turns through the two holes. Connect two wires in series for 200-ohm windings. Article gives data for winding all other coils.—R. Harrison, A Review of SSB Phasing Techniques, *Ham Radio*, Jan. 1978, p 52–62.



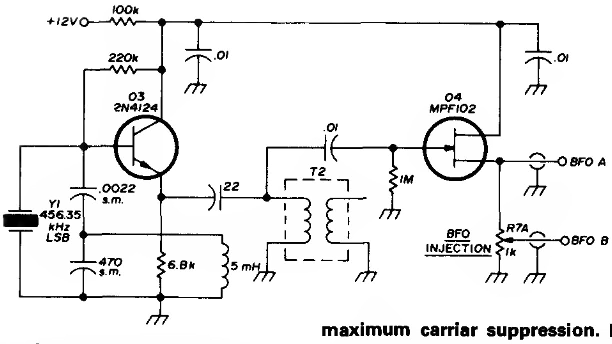
PREAMP WITH CLIPPING—increases speech intelligibility, particularly with SSB amateur stations. Q1 and Q2 are HEP-54. Diodes are 1N456 or HEP-158.—Circuits, *73 Magazine*, Feb. 1974, p 100.



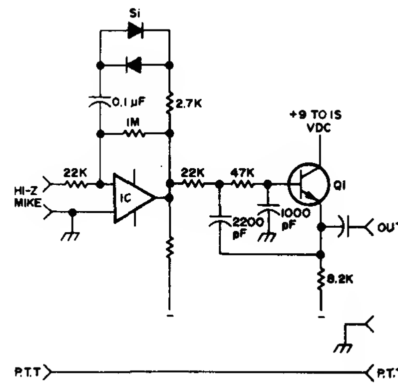
PRECOMPRESSION SHAPER—improves effective signal strength of SSB transmitter by shaping AF frequency response ahead of audio compressor. Low-noise FET preamp providing initial gain for high-impedance microphone is followed by low- and high-rolloff circuit giving 15-dB boost or rolloff to frequencies centered at about 1 kHz.—J. J. Schultz, Adding dBs to the Audio Compressor, *73 Magazine*, May 1974, p 21–23 and 25.



660 AND 1000 Hz FOR SSB TESTING—Produces two audio frequencies with all harmonics and crossproducts down 40 dB or more, as required for accurate testing of amateur SSB equipment. Two sections of Raytheon 4136D quad opamp serve as Wien-bridge audio oscillators, one at 1000 Hz and one at 660 Hz. Silicon signal diodes in each bridge act as nonlinear stabilization elements. Third section of opamp adds sine waves, and fourth section is simple inverter with gain of 1 for push-pull or balanced output. With all four pots at midvalue, adjust R_1 for 12 V P-P at TP_1 and adjust R_2 for 12 V P-P at TP_2. Open X_2 and adjust R_3 to give 12 V P-P from either output terminal to ground, then close X_2 and repeat for X_1 and R_4. Output should now be 660 and 1000 Hz added linearly as required, with no crossproducts. Use regulated ±15 V supply.—H. Olson, A One-Chip, Two Tone Generator, *CQ*, April 1974, p 48–49.

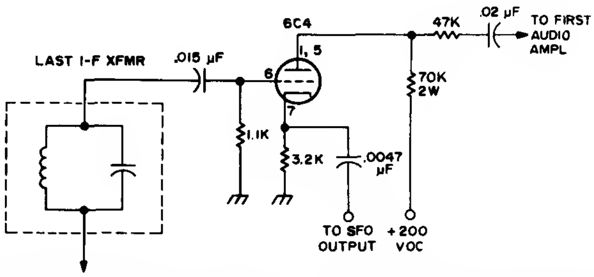


CRYSTAL BFO—Bipolar crystal oscillator is coupled to FET source-follower by miniature 455-kHz IF transformer T2. RF output is adjusted with R7A so BFO injection voltage can be set for maximum carrier suppression. BFO is 456.35 kHz for lower sideband operation or 453.75 kHz for upper sideband in SSB transceiver.—W. J. Weiser, Integrated Circuit SSB Transceiver for 80 Meters, *Ham Radio*, April 1976, p 48–52.

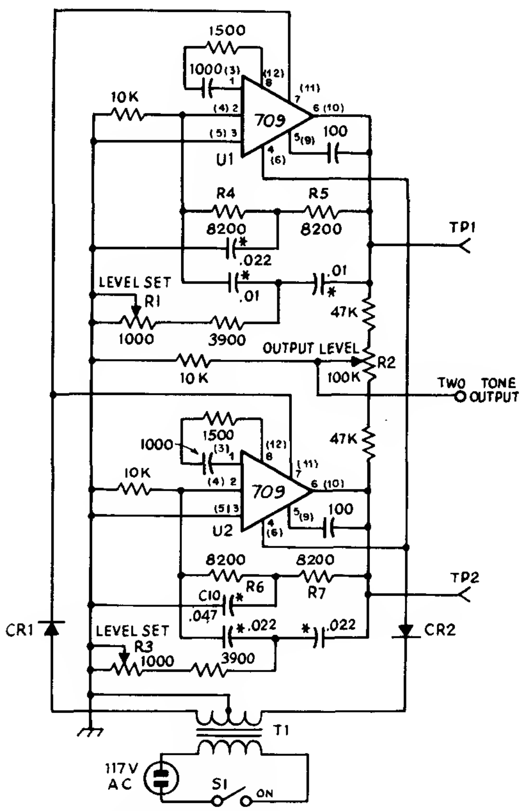


Si—ANY Si DIODES
IC—BURR BROWN 1506,
FAIRCHILD 709 or equiv.
Q1—ANY Si NPN TRANSISTOR

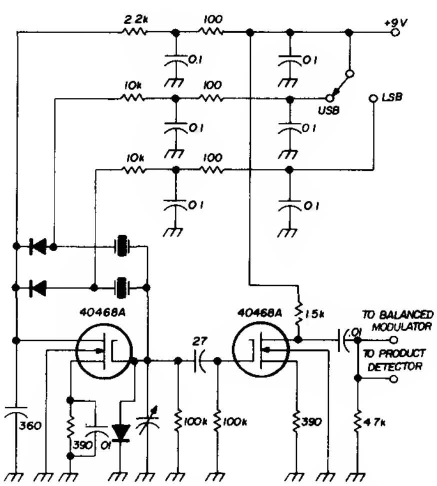
SPIKE CLIPPER—Improves efficiency of low-power SSB amateur transmitter by removing from voice waveform the spikes that cause overmodulation or give low average modulation level. When used as in-line microphone emplifier, circuit gives up to 20-dB equivalent gain at receiving location.—H. E. Weber, Increase Your SSB Efficiency, *73 Magazine*, Dec. 1973, p 71.



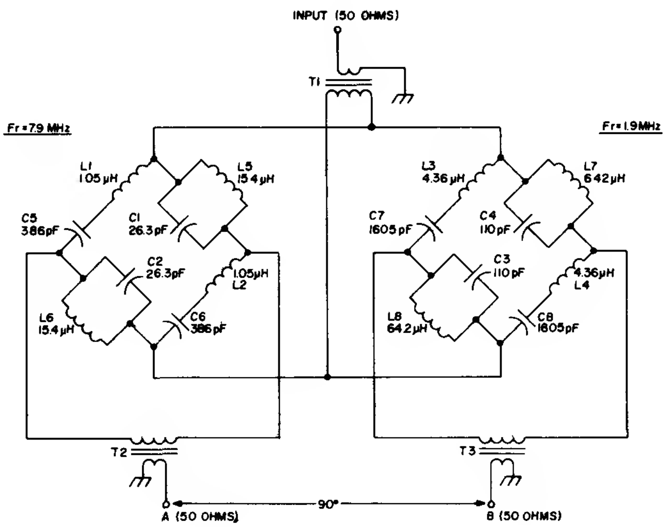
SSB DETECTOR—Can be switched in and out of most tube-type AM receivers for use in place of reguler detector stage. Requires stable BFO.—Novice Q & A, *73 Magazine*, March 1977, p 187.



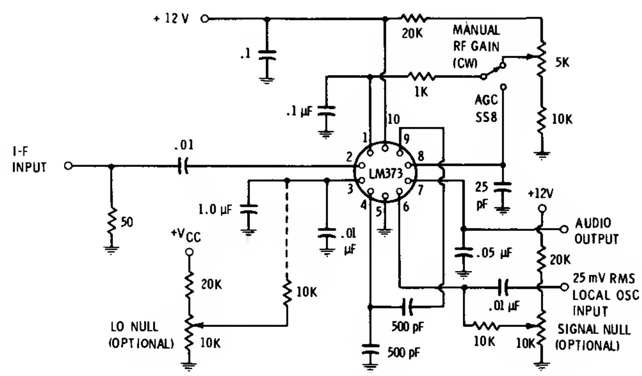
TWO-TONE BURSTS—Uses 709 or 741 opamps to generate 1850-Hz and 855-Hz tones simultaneously, pulsed at 60-Hz line rate for duty cycle slightly below 50%. Used to measure linearity of high-frequency amplifiers in low-power stages of SSB transmitter. Each opamp is powered by half-wave rectified AC, with opposite voltage polarities provided by 12.6-V CT 50-mA filament transformer. Tone frequency of each opamp is determined by symmetrical twin-T network. R1 sets level of 1850-Hz tone, and R3 controls 855-Hz tone. R2 mixes and balances tones. Diodes are 50-PIV 500-mA silicon.—B. Buus, A Technique for Burst Two-Tone Testing of Linear Amplifiers, *QST*, Aug. 1971, p 17–21.



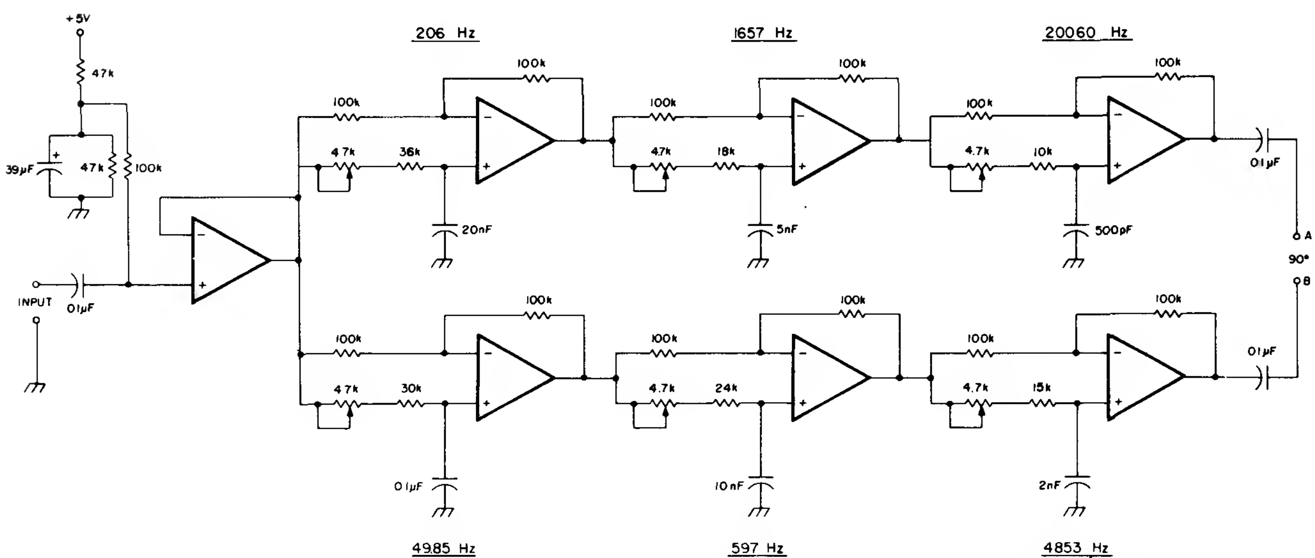
CARRIER OSCILLATOR—Two MOSFETs serve with diode switching arrangement for selecting either upper or lower sideband. Circuit between gates couples oscillator to isolating output stage. Upper/lower sideband switch applies +9 V to anode of switching diode that closes feedback circuit for crystal to be activated. Output can be used as injection voltage in demodulation of incoming signal by product detector of transceiver or as basic carrier applied to balanced modulator for transmitting mode. Used in SSB transceiver made by Sideband Associates for radiomarine communication in 2–23 MHz range.—E. Noll, MOSFET Circuits, *Ham Radio*, Feb. 1975, p 50–57.



90° PHASE SHIFT WITH BRIDGES—Wideband passive AF phase-shift network makes direct-conversion SSB generation possible. Developed for use with circularly polarized antenna system. Bridge networks each provide 45° phase shift between 1 and 15 MHz, to give differential phase shift of 90° over that frequency range with phase error less than 1°. Amplitude difference between outputs is less than 0.5 dB over range. T1, T2, and T3 are wound on Neosid 1050-1-F14 of Indiana General F684-1 balun core. Twist together three 7-inch lengths of No. 26 enamel and wind 3 turns through the two holes. Connect two wires in series for windings going to bridges. Article gives data for winding all other coils.—R. Harrison, A Review of SSB Phasing Techniques, *Ham Radio*, Jan. 1978, p 52–62.

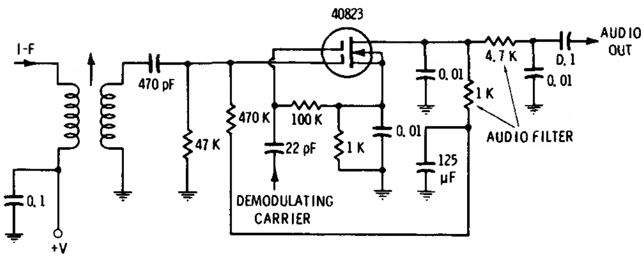


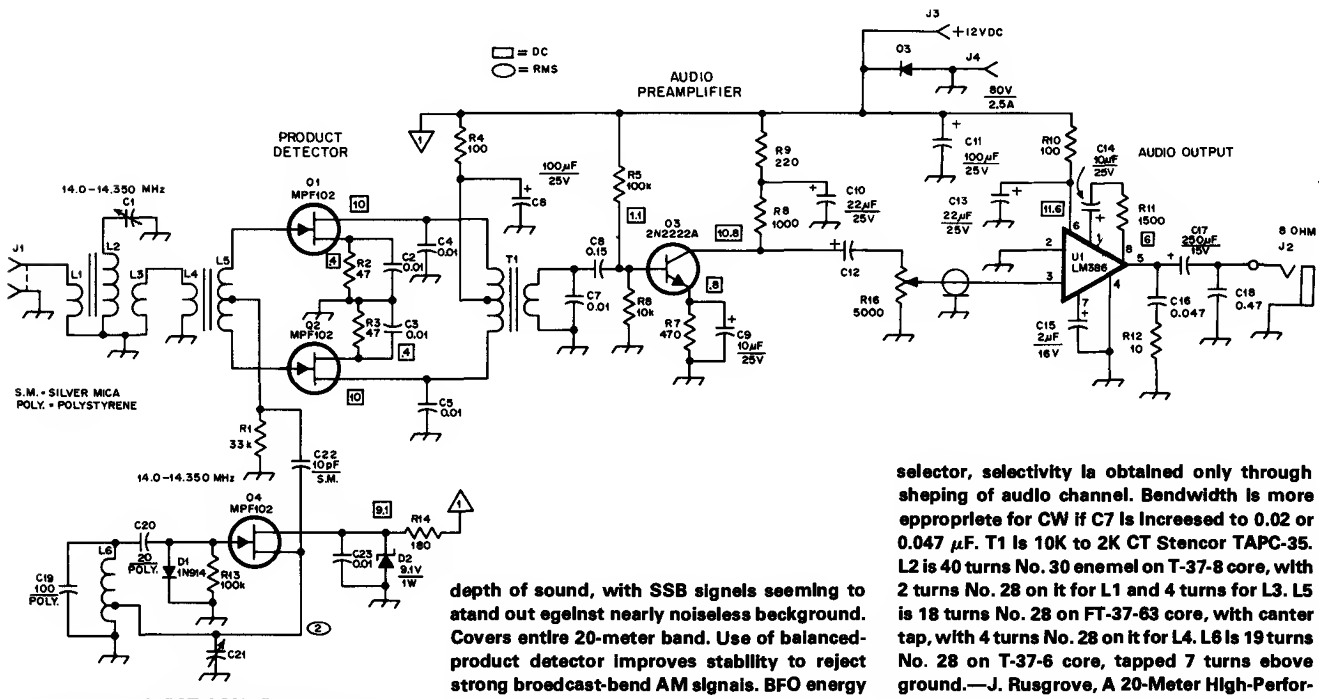
SSB/CW DEMODULATOR—LM373 communication IC uses balanced mixer as product detector, with reinserted carrier reapplied to pin 6. CW or SSB output is taken from pin 7. If desired, RF gain control can be inserted in AGC feedback path.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 350–351.



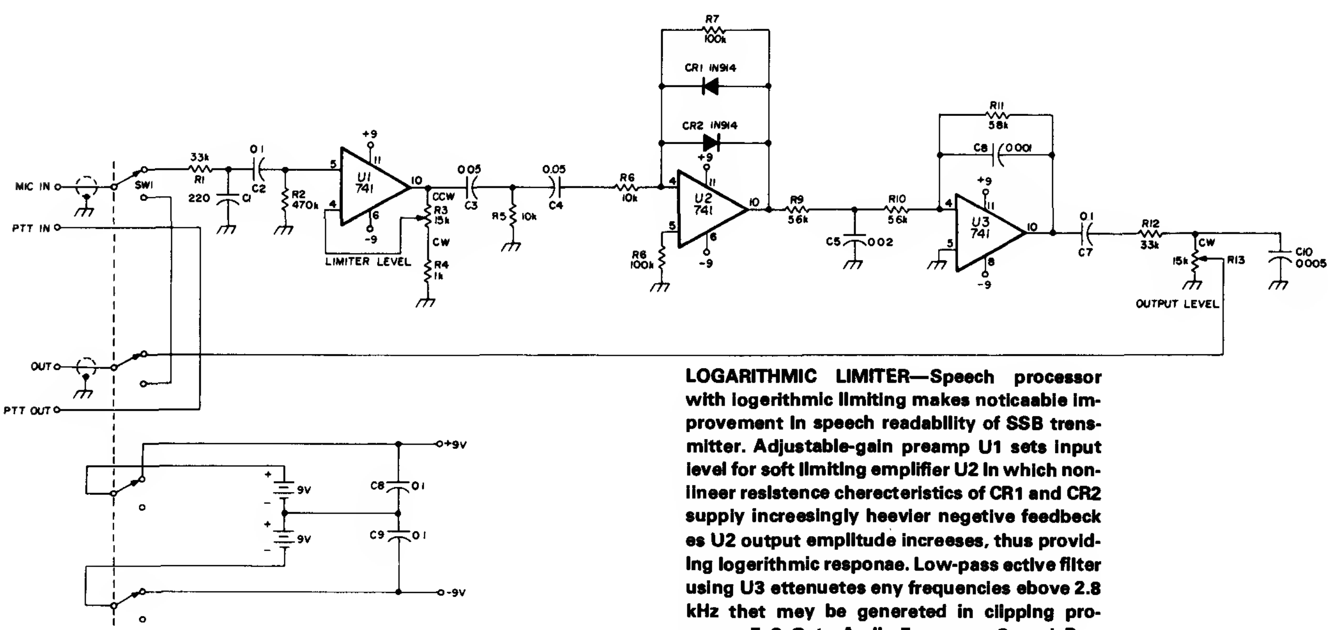
WIDEBAND ACTIVE PHASE SHIFTER—Active audio phase-shift network uses two LM324 quad opamps to provide equal-amplitude outputs differing in phase by 90° ± 2° from 100 Hz to 10 kHz. Each stage is adjusted with 4.7K trimpot to give 90° phase shift at frequency shown on diagram. Align with audio oscillator and CRO or phase meter. Operates from single 5-V supply. Overall gain of entire circuit is unity.—R. Harrison, A Review of SSB Phasing Techniques, *Ham Radio*, Jan. 1978, p 52–62.

MOSFET PRODUCT DETECTOR—SSB IF signal is applied to one gate of MOSFET and demodulating carrier to other gate. Linear demodulation is obtained without distortion components. RC filter connected into drain circuit removes IF and carrier components, leaving demodulated audio as output.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 154.

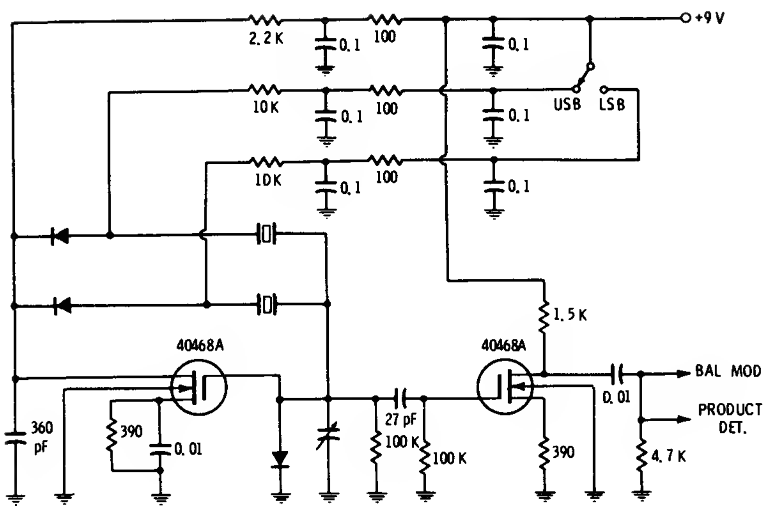




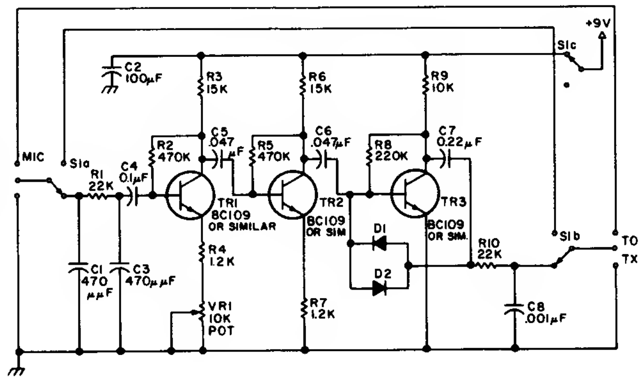
20-METER DIRECT-CONVERSION—Well-designed circuit provides pleasing polarity and depth of sound, with SSB signals seeming to stand out against nearly noiseless background. Covers entire 20-meter band. Use of balanced-product detector improves stability to reject strong broadcast-band AM signals. BFO energy from Q4 is injected through center tap of broadband toroidal transformer L4-L5. Except for preselector, selectivity is obtained only through shaping of audio channel. Bandwidth is more appropriate for CW if C7 is increased to 0.02 or 0.047 µF. T1 is 10K to 2K CT Stencor TAPC-35. L2 is 40 turns No. 30 enamel on T-37-8 core, with 2 turns No. 28 on it for L1 and 4 turns for L3. L5 is 18 turns No. 28 on FT-37-63 core, with center tap, with 4 turns No. 28 on it for L4. L6 is 19 turns No. 28 on T-37-6 core, tapped 7 turns above ground.—J. Rusgrove, A 20-Meter High-Performance Direct-Conversion Receiver, *QST,* April 1978, p 11–13.



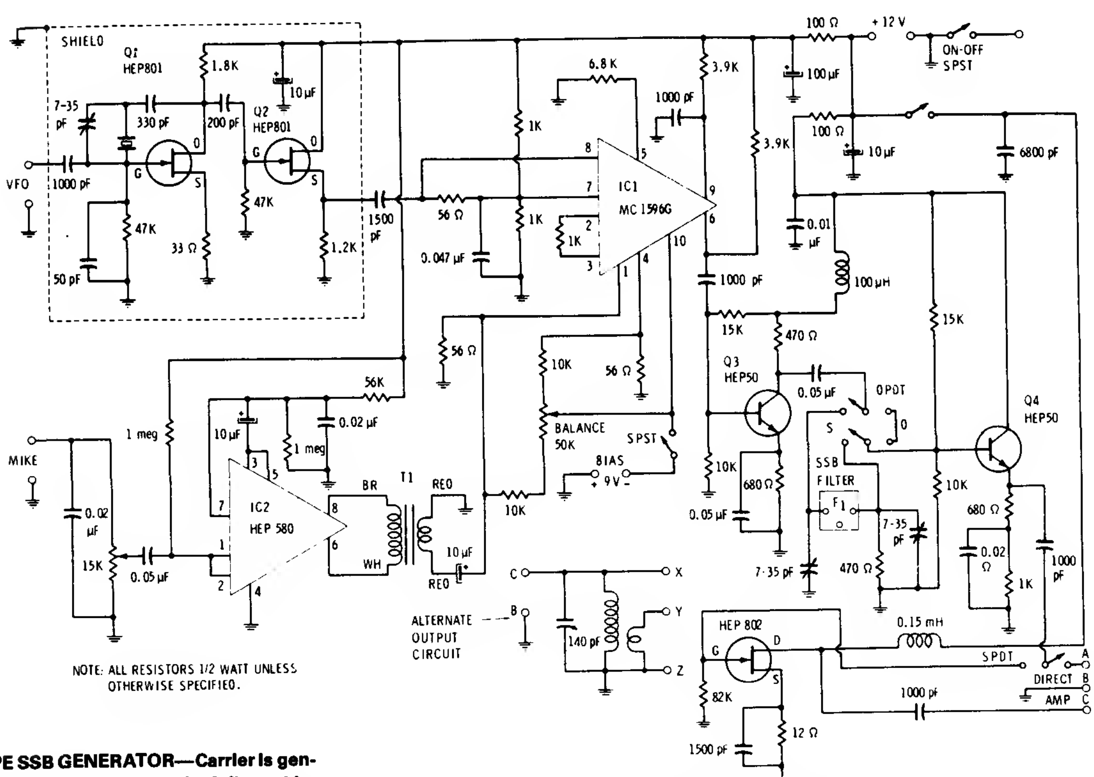
LOGARITHMIC LIMITER—Speech processor with logarithmic limiting makes noticeable improvement in speech readability of SSB transmitter. Adjustable-gain preamp U1 sets input level for soft limiting amplifier U2 in which nonlinear resistance characteristics of CR1 and CR2 supply increasingly heavier negative feedback as U2 output amplitude increases, thus providing logarithmic response. Low-pass active filter using U3 attenuates any frequencies above 2.8 kHz that may be generated in clipping process.—F. C. Getz, Audio-Frequency Speech Processor, *Ham Radio,* Aug. 1977, p 48–51.



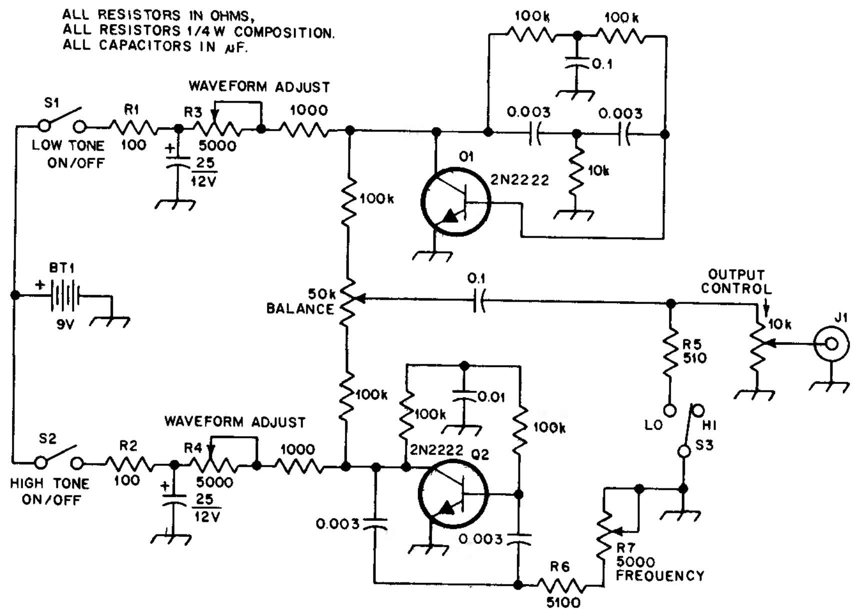
SIDEBAND SELECTOR—MOSFET circuit uses diode switching of crystals in carrier oscillator to select either upper or lower sideband. Second transistor serves as common-source isolating amplifier for driving modulator. Switch applies +9 V to anode of diode that closes feedback circuit for crystal to be activated. Developed for use in SSB transceiver; if operating in 9-MHz range, crystals can be 8.9985 MHz and 9.0015 MHz.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 191–192.



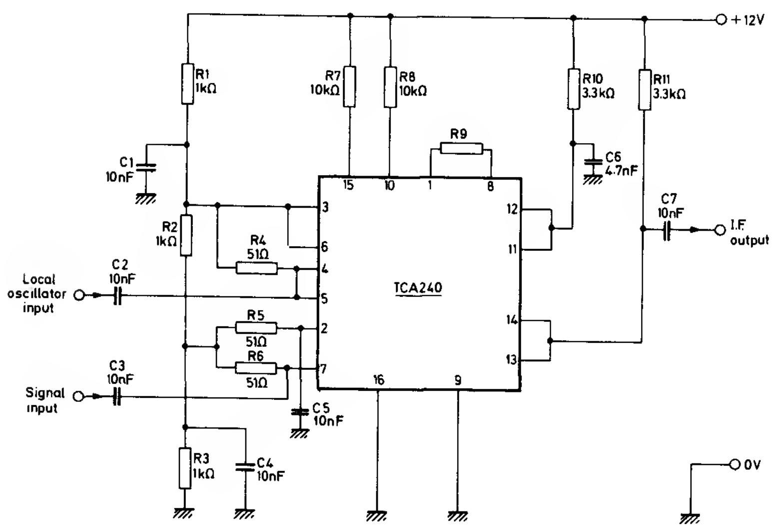
CLIPPER—Combined speech amplifier and logarithmic clipper for use with SSB transmitters reduces speech bandwidth to about 500–3000 Hz, with very little distortion. Power can be obtained from separate battery or from transmitter itself.—Circuits, *73 Magazine*, March 1977, p 152.



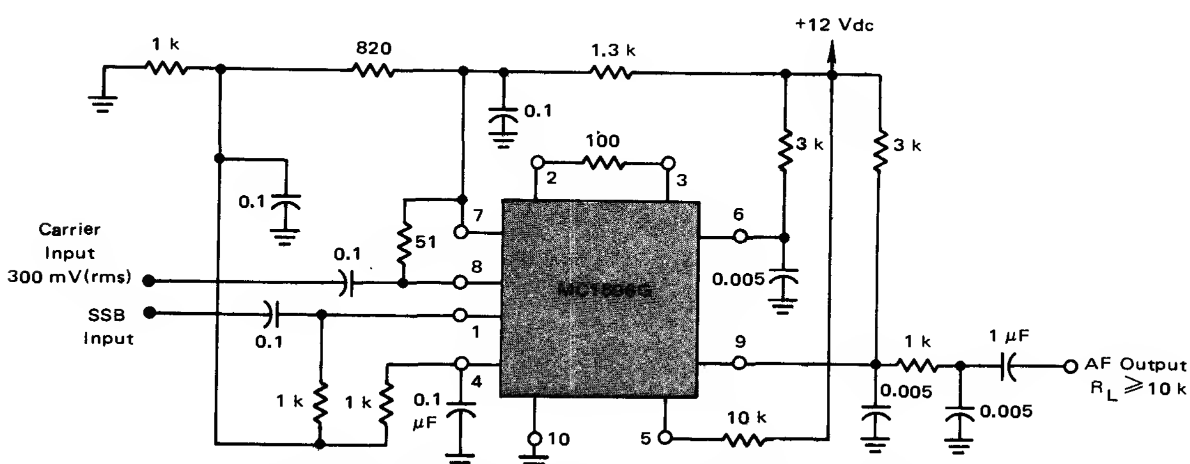
FILTER-TYPE SSB GENERATOR—Carrier is generated by FET crystal oscillator Q1 followed by buffer Q2. Modulating wave is applied to HEP 580 connected as two-stage audio amplifier feeding double-balanced modulator IC1 through transformer T1. Double-sideband signal from pin 6 of IC1 is applied to amplifier Q3-Q4 for straight-through amplification when double-sideband output is desired. For 9-MHz single-sideband operation, sideband filter is switched in between transistors.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 353–356.



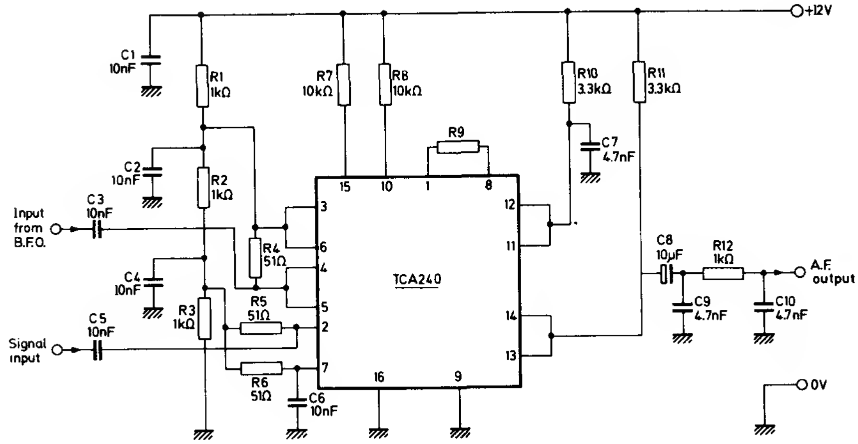
TWO-TONE TESTER—Twin-T transistor oscillators generete two distinct sine-wave AF signals for use in edjusting SSB transmitters. Q1 is fixed et about 1000 Hz, and Q2 is edjustable betwaen 1000 and 1300 Hz, giving frequancy difference of 0–300 Hz for use with scopes having 60-Hz horizontal sweep rate thet parmits display of one to five cycles of RF anvelope pattern. Switchas permit use of eithar oscillator saperately.—F. Brown, The Two-Tone Tester, *QST*, Nov. 1978, p 22–24.



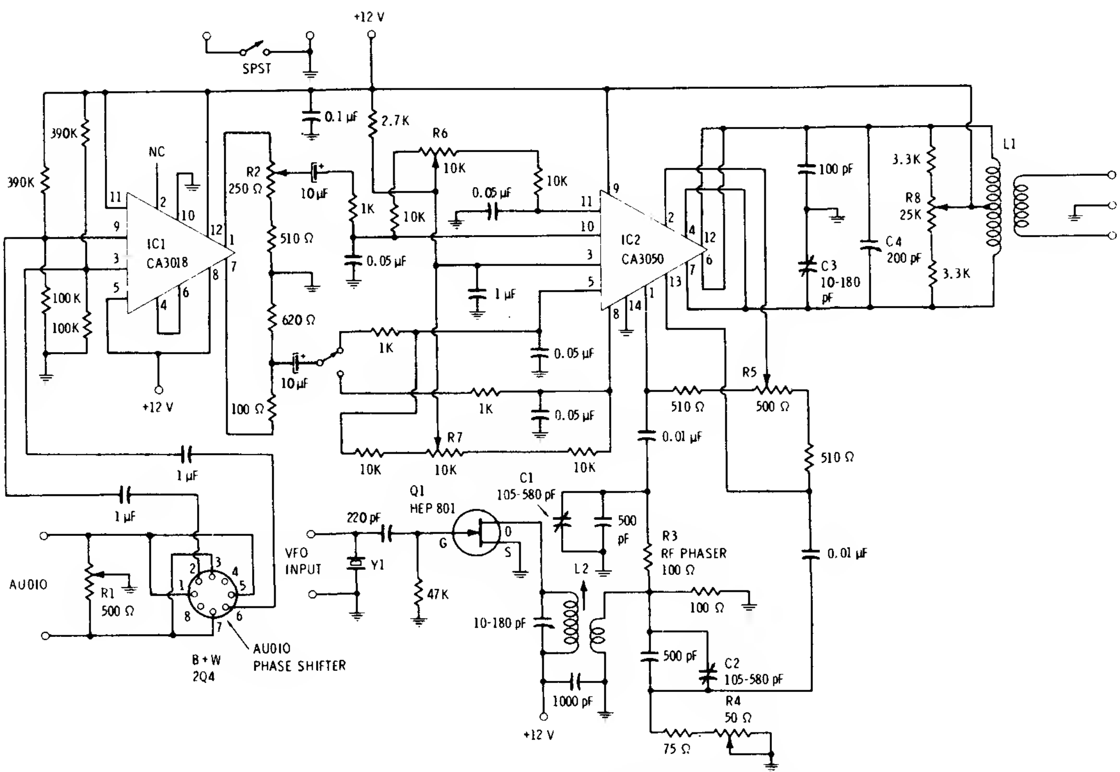
UNTUNED DOUBLE-BALANCED MIXER—Wideband mixer for high-frequency SSB circuits oparates from single 12-V supply. Gein is controllad by R9 and Incraases as velua of R9 is decreased. Output at pins 13 and 14 is product of local oscillator end signel input frequancies and contains desired IF value for recaiver. Oscillator signal level should be kapt below 20 mV to avoid undesired harmonics produced by limiting. Circuit usas Mullard TCA240 dual balanced modulator-demodulator.—"Applications of the TCA240," Mullard, London, 1975, Technical Note 18, TP1489.



SINGLE-SUPPLY PRODUCT DETECTOR—Motorola MC1596G balanced modulator requires no cerrier null adjustment beceuse all fraquencies axcept desired damodulated audio are in RF spectrum end easily filtered out. Circuit parforms well with carrier input levals of 100–500 mVRMS. Provides good product detector parformance from vary low frequencies up to 100 MHz.—R. Hajhall, "MC1596 Balanced Modulator," Motorola, Phoanix, AZ, 1975, AN-531, p 7.



10-MHz PRODUCT DETECTOR—IF signal of SSB receiver is mixed with signal from beat-frequency oscillator in Mullard TCA240 dual balanced modulator-demodulator to give desired audio output signal. Simple low-pass filter R12-C9-C10 removes unwanted output signal.—"Applications of the TCA240," Mullard, London, 1975, Technical Note 18, TP1489.

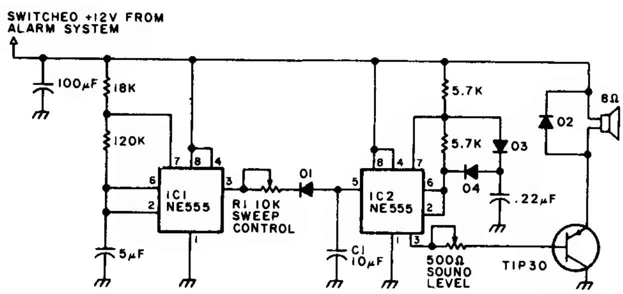


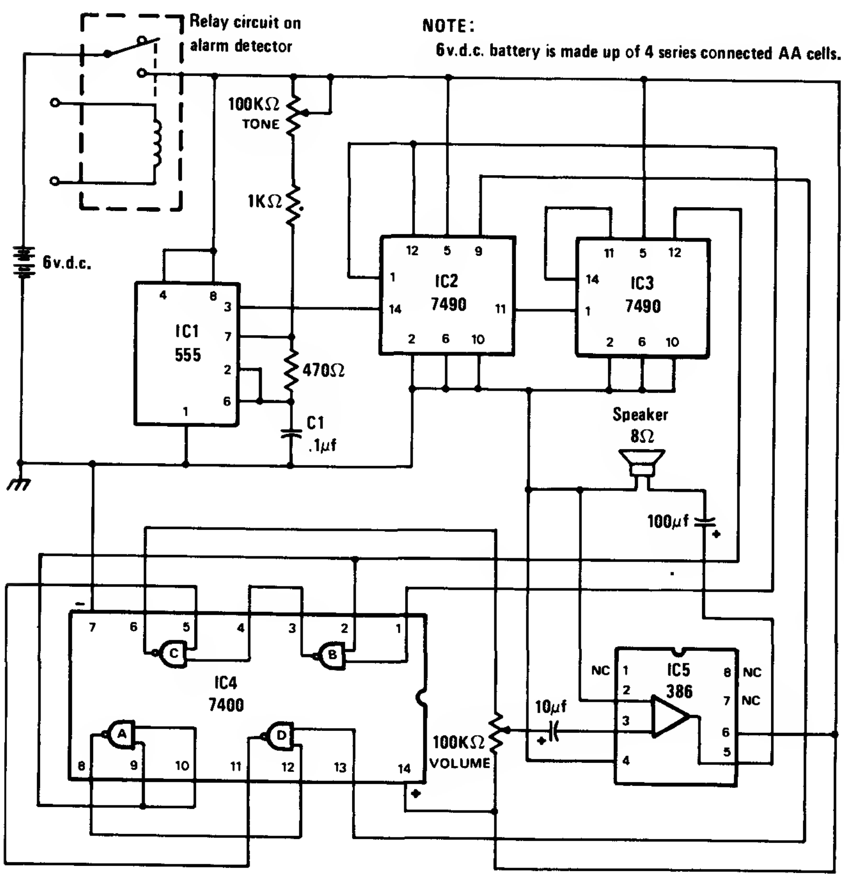
PHASING-TYPE SSB GENERATOR—Modulating wave is first applied to input audio phase shifter for generating audio components that are equal in magnitude but differ 90° in phase. After amplification in CA3018, these audio components are applied to CA3050 double-balanced modulator. SPST and SPDT switch settings determine which sideband will appear at output of modulator. Carrier is generated by FET crystal oscillator for application through RF phase-shift network to pins 1 and 13 of modulator. Both carrier and modulating frequencies are suppressed in balanced output circuit of modulator, leaving only desired sideband. Resonant output transformer provides low-impedance feed to succeeding linear amplifier. Designed for 160-meter band.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 356–357.

CHAPTER 82
Siren Circuits

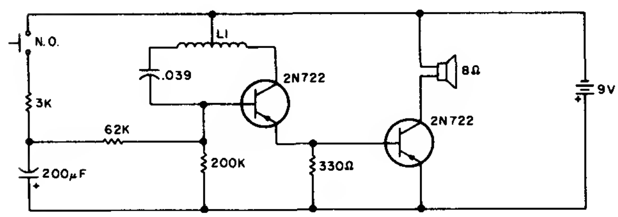
Includes variety of circuits for simulating sounds of police and other emergency sirens. Battery-operated versions can be used in toys or as part of burglar or fire alarm system. Some have adjustments for frequency, whooping rate, and duration of rising and falling tones.

10-W AUTO ALARM SIREN—Generates force field of high-intensity sound inside car, painful enough to discourage thief from entering car after tripping alarm switch by opaning door. Circuit produces square-wave output that sweeps up end down in frequency. Modulation is provided by triangle waveform generated by R1, D1, end C1. If sweep-frequency siren is prohibited, remove C1 to produce legal two-tone sound. Use efficiant horn loudspeaker cepable of handling up to 10 W. D2 is silicon rectifiar rated 1 A at 50 PIV. Other diodes ere general-purpose silicon.—A. T. Roderick III, New Protection for Your Car, *73 Magazine,* March 1978, p 76–77.



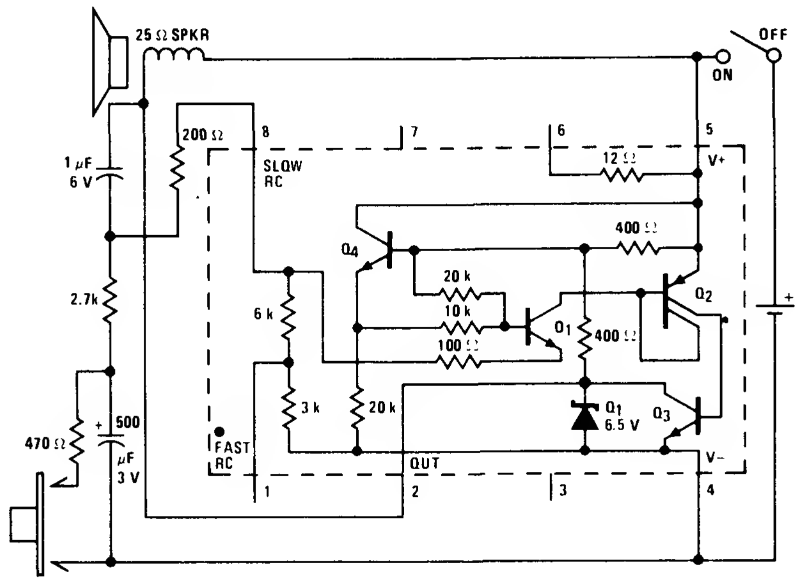


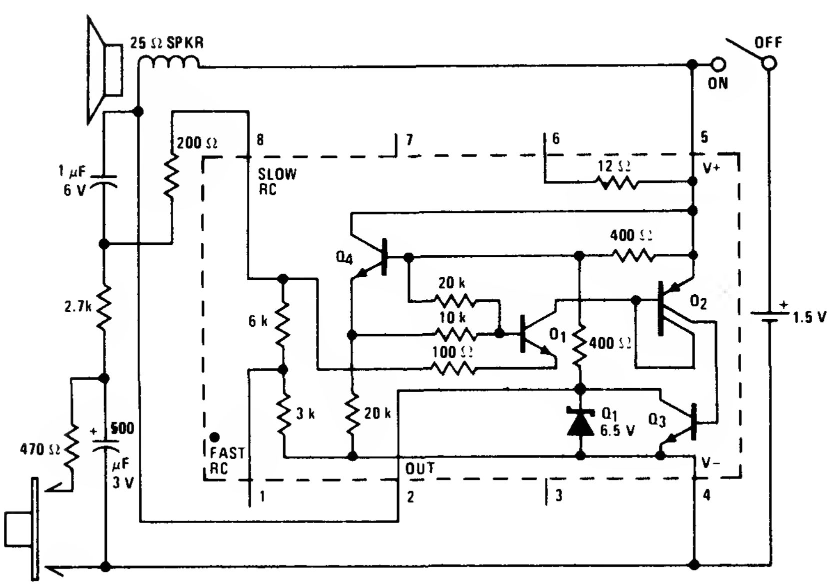
LOW-NOTE SIREN—Produces up/down blooping sounds cheracteristic of European pollce cars and now being used on some US emergency vehicles. Cen ba connected to burglar or theft elerm system for protection purposes, or used as portable sound box oparated by momentary pushbutton switch. Includes volume control and tone control that veries both pitch and rete.—D. Helsermen, Whizbox, *Modern Electronics,* Juna 1978, p 67.



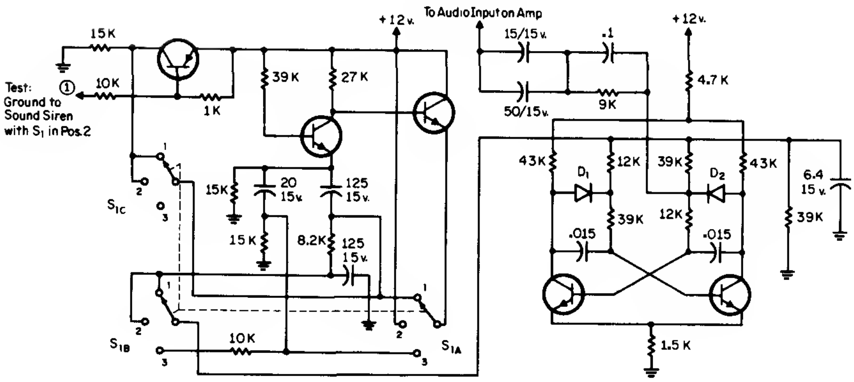
SIREN—Creates sounds resambling thosa of police-car siren In which eir is forced through slots in motor-driven dlsk. L1 is half of audio trensformer, using winding hevlng 10K center tep.—Circuits, *73 Magazine*, April 1977, p 164.

FIRE SIREN USES FLASHER—Low-drain circuit opareting from 1.5-V cell uses National LM3909 flesher IC to simulate fire-elerm siren. Pressing button produces rapidly rising wail, with tona coasting down in frequency after button is released. Sound from loudspeakar resambles that of motor-drivan siren. Volume Is adequeta for child's pedel car.—P. Lefferts, Power-Miser Flashar IC Hes Meny Noval Applications, *EDN Magazine*, March 20, 1976, p 59–66.



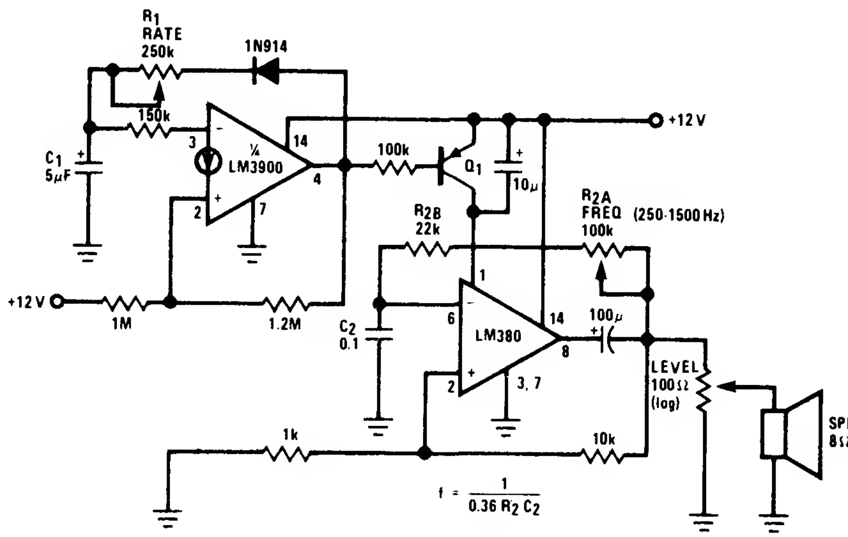


FIRE SIREN—Pressing button produces rapidly rising wall, and raleasing button glves slowar lowering of frequency resembling sounds of typical siren on fira engine. Circuit uses National LM3909 IC oparating from 1.5-V cell for drlving 25-ohm loudspeaker. 1-μF capacitor and 200-ohm resistor determine width of loudspeakar pulsa, while 2.7K resistor and 500-μF capacitor determine repetition rata of pulsas.—"Lineer Applications, Vol. 2," National Samlconductor, Santa Clera, CA, 1976, AN-154, p 6–7.

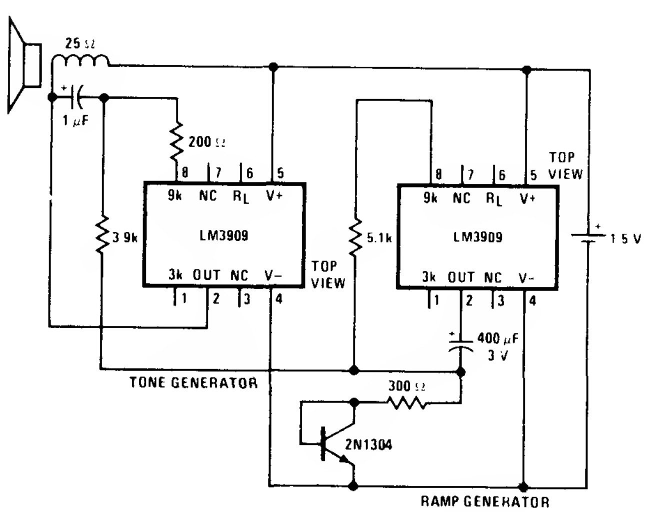


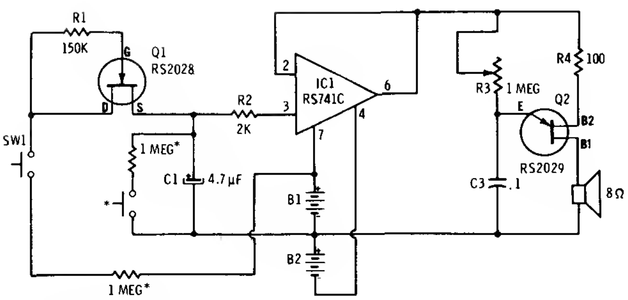
POLICE SIREN—Circuit used in Dietz siren-light police-car system gives distinctive tones. Position 1 of S_1 produces slow continuous rise and fall. Position 3 produces fast rising and falling tone. Position 2 rises slowly to full pitch when point 1 is grounded, then decays at same rate when point 1 is ungrounded. Position 3 gives most noticeable tone for break-in alarm on car. Terminal 1 goes to normally open door, hood, and other switches that complete circuit to ground when opened by intruder. Audio transistors and diode are general replacement types.—J. W. Crawford, The Ultimate Auto Alarm—Model II, *CQ*, Aug. 1971, p 54–57 and 96.

VARIABLE FREQUENCY AND RATE—Uses National LM380 opamp as astable oscillator with frequency determined by R_2 and C_2. Base of Q_1 is driven by output of LM3900 opamp connected as second astable oscillator, to turn output of LM380 on and off at rate fixed by R_1 and C_1. Transistor type is not critical. Circuit is ideal for experimenters.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-21–4-28.



WHOOPER—Two National LM3909 ICs and single transistor generate rapidly modulated tone resembling that used on some police cars, ambulances, and airport emergency vehicles. Rapidly rising and falling modulating voltage is generated by IC having 400-μF capacitor. Diode-connected transistor forces this IC ramp generator to have longer ON periods than OFF periods, raising average tone of tone generator and making modulations seem more even.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-154, p 7.

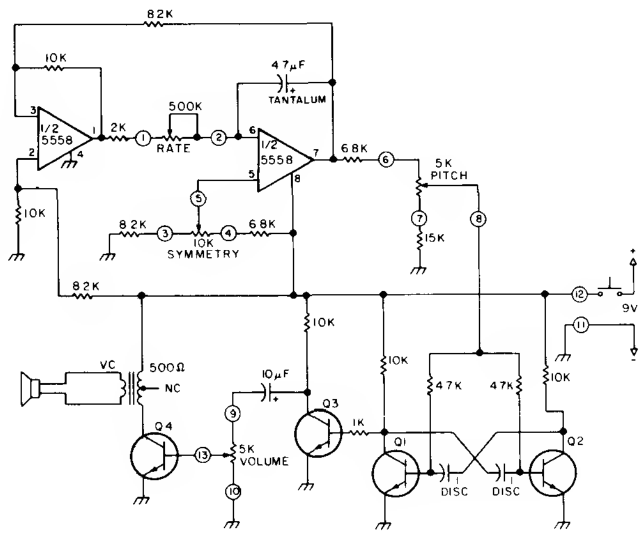


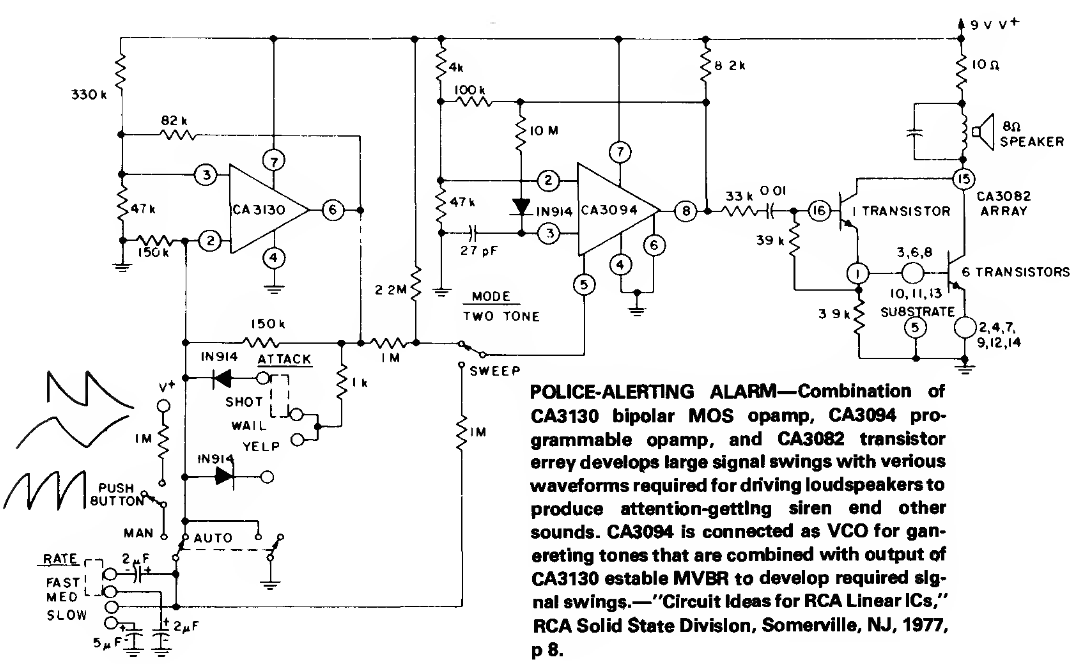


*OPTIONAL COMPONENTS FOR SIREN EFFECT

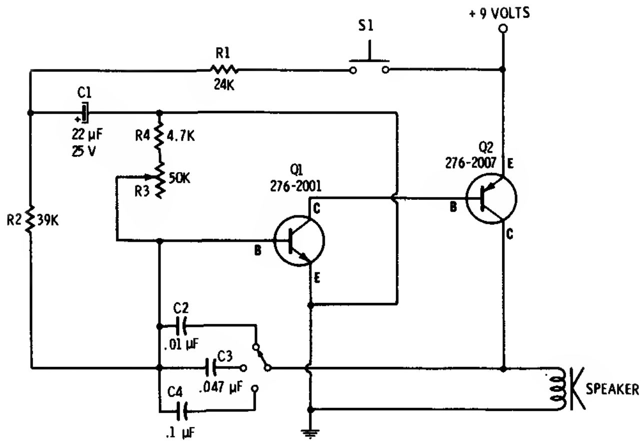
VARIABLE TONE USING VCO—Tone generator uses UJT and opemp in voltage-controlled oscillator. Frequancy of audio output is determined by setting of R3. For two-tona slren effects, optional switches and resistors can be used. To speed up siren effect, use smaller velue for C1.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Redio Shack, Fort Worth, TX, 1977, 2nd Ed., p 61–69.

LOUD BIKE SIREN—Uses 5558 dual opamp end four generel-purpose NPN trensistors to generate triangle wave that can be distorted by 10K symmetry control to giva eithar fest or slow rise for sewtooth applied es bese bias to astable MVBR Q1-Q2. Drain is raesonably low with 9-V radio bettery. Repetition rate can ba varied from long weil to rapid werble, end volume changed from soft to ennoying. Article gives construction datails, and racommends usa of ramovebla mounting on bike to avoid theft.—R. Megirian, Simple Electronic Siren, *73 Magazine*, Oct. 1977, p 176–177.

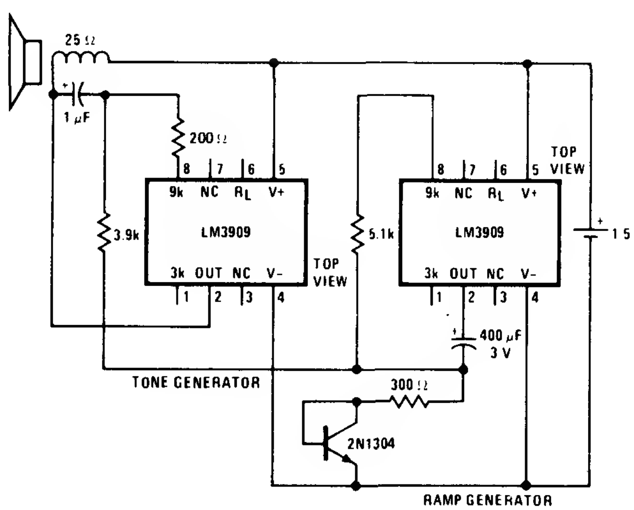




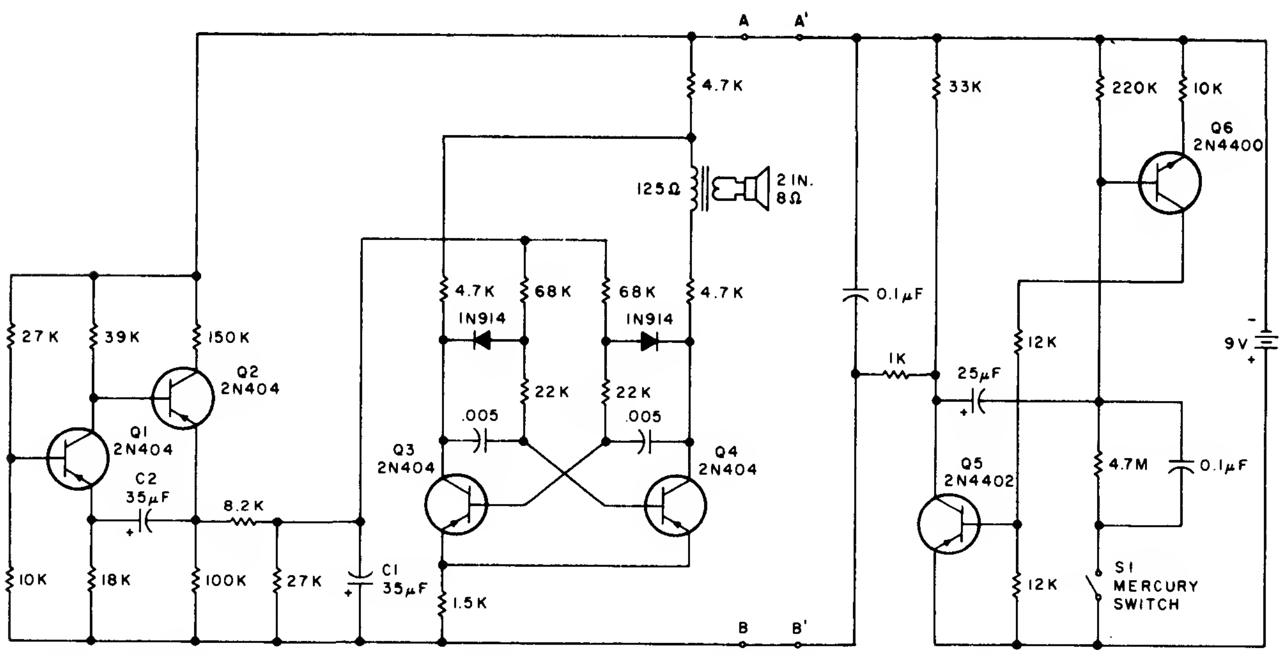
POLICE-ALERTING ALARM—Combination of CA3130 bipolar MOS opamp, CA3094 programmable opamp, and CA3082 transistor errey develops large signal swings with verious waveforms required for driving loudspeakers to produce attention-gettlng siren end other sounds. CA3094 is connected as VCO for ganereting tones that are combined with output of CA3130 estable MVBR to develop required slgnal swings.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Divislon, Somerville, NJ, 1977, p 8.



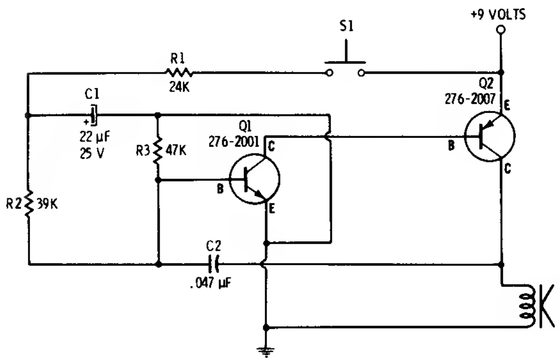
ADJUSTABLE SIREN—Tone is mada adjustable by using multiposition switch to change capacitors in oscillator circuit. Spaed (rate of chenge in frequency) of siren is edjusted with R3. 4700-ohm resistor in series with R3 keeps siren operetionel when R3 is rotated to minimum-resistance position. Siren is operated by pressing switch to produce rising well, than releasing switch until wail drops down to cutoff.—F. M. Mims, "Transistor Projects, Vol. 1," Radio Sheck, Fort Worth, TX, 1977, 2nd Ed., p 58–63.



POLICE SIREN USES FLASHER—Low-drein circuit operating from 1.5-V cell uses National LM3909 flasher ICs to simulate "whooper" sounds of electronic sirens used on some city police cars end ambulances. Two flashars ere required for generating required rapidly rising and felling moduleting voltege. Transistor is connected es diode to force remp genarator of IC to heve longer ON periods than OFF periods, reising everege tone end meking modulation seem more evan.—P. Lefferts, Power-Miser Flasher IC Has Meny Novel Applications, *EDN Magazine*, March 20, 1976, p 59–66.

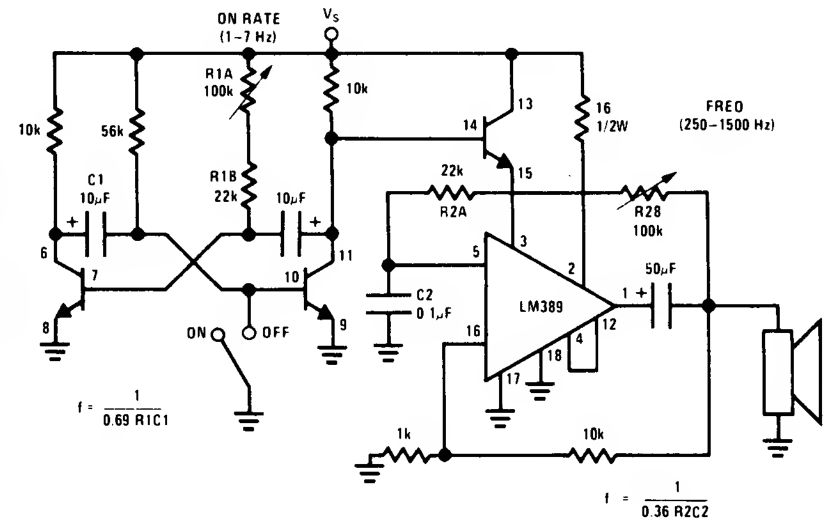


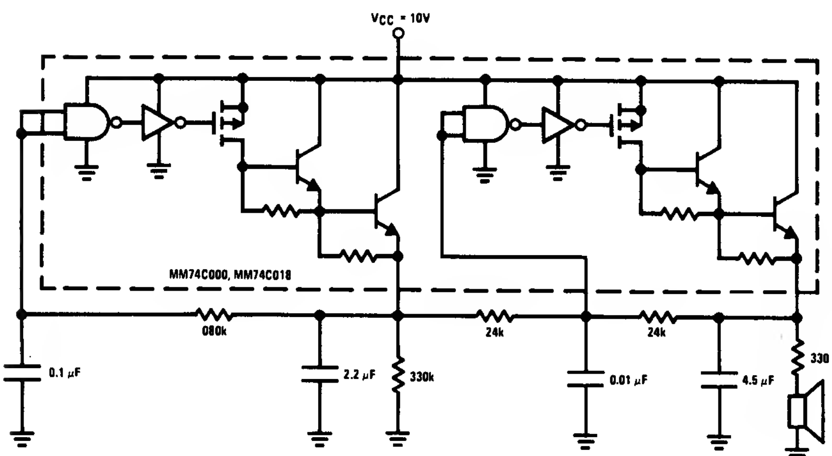
PORTABLE TOY SIREN—Can be assembled in smell box as toy for small child. If mercury switch is used for S1, siren comes on automatically when box is picked up. MVBR Q1-Q2 controls rate at which siren weils, whila Q3 and Q4 form AF MVBR that producas ectual siran sound with frequancy varied by triangle weveform on C1. MVBR Q5-Q6 is mono that conducts for presat time pariod when S1 is closed, for applying power to siren. Values shown give 12 s of operation before siren is shut off. When carried by child, siren is jostled anough so it keeps recycling.—J. H. Everhart, Super Siren, *73 Magazine*, Feb. 1978, p 96–97.



MANUALLY CONTROLLED SIREN—When switch is pressed, output tone of loudspeaker builds from low to high fraquancy. Releasing switch brings high frequency slowly back to low point end than cutoff. Siren sounds can be varied menuelly by pushing and relaasing switch at different points in cycle. C2 controls pitch, and R3 detarmines speed at which pitch changes.—F. M. Mims, "Translstor Projects, Vol. 1," Redio Shack, Fort Worth, TX, 1977, 2nd Ed., p 58–63.

SIREN WITH MUTING—National LM389 array having three transistors and powar opamp on same chip uses opamp as square-wava oscillator whose frequency is adjusted with R2B. One transistor is used In muting circult to gata powar amplifler on and off, whila othar two trsnslstors form cross-coupled MVBR that controls rate of square-wave oscillator.—"Audlo Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.



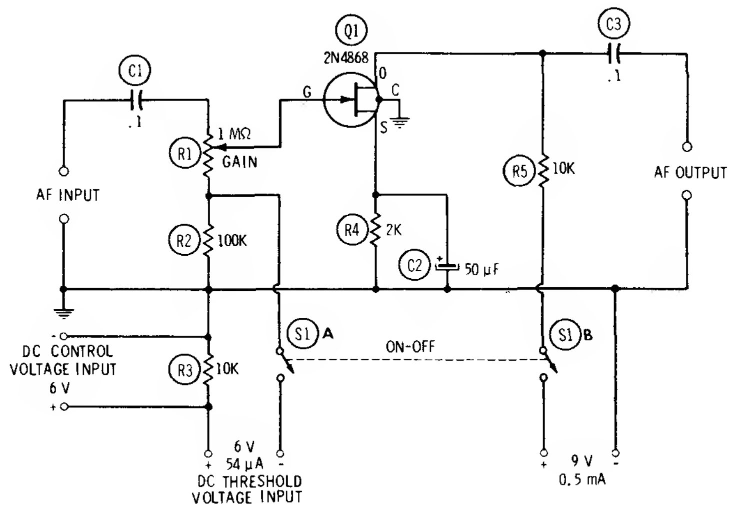


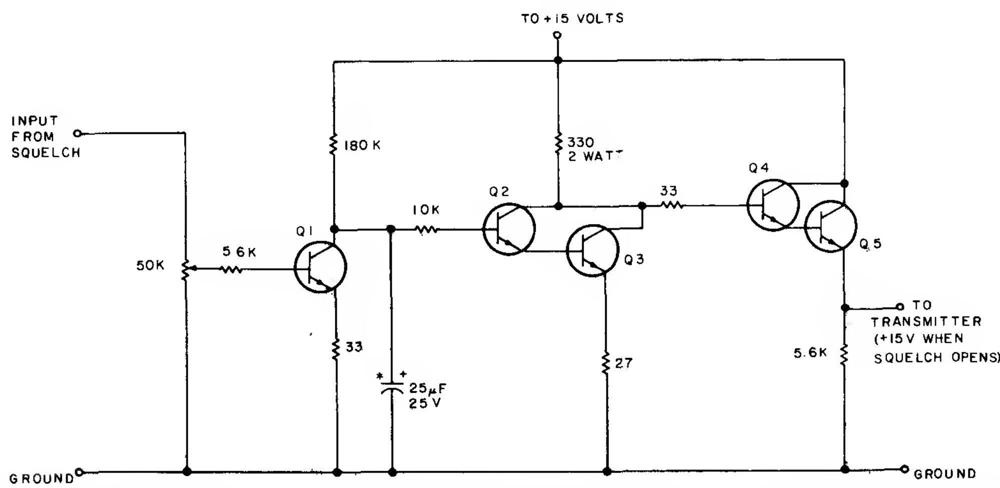
10-V SIREN CHIP—One section of National MM74C908/MM74C918 dual CMOS driver is used as audio VCO and other section as voltage ramp generator that varies frequency of VCO. Combination gives siren effect at low cost, with output currant up to 250 mA for driving loudspeaker.—"CMOS Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-38–5-49.

CHAPTER 83
Squelch Circuits

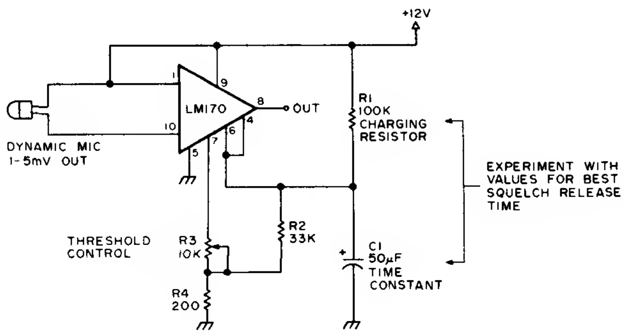
Used to suppress background noise in transmitters and receivers during intervals between sentences and words, when tuning between stations or when carrier is absent. Also included are decoder circuits that unblock squelch of amateur receiver only when special tone is transmitted by desired station.

AF SQUELCH AMPLIFIER—Holds audio channal of receiver sllant until receiver input signal raaches predetermined amplitude. DC control voltaga can be derived from IF amplifiar by rectification or from second detector of recaiver. FET is biased to cutoff by DC gata voltage apPlIad to threshold terminels. DC control voltage bucks this bias and activates amplifier whenavar it axcaeds predetermined threshold in ranga of 0–6 V. If recalvar givas opposite polarity for DC voltages, usa P-channel FET such es 2N2608, revarse C2, end change R4 end R5 as required.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 73–74.

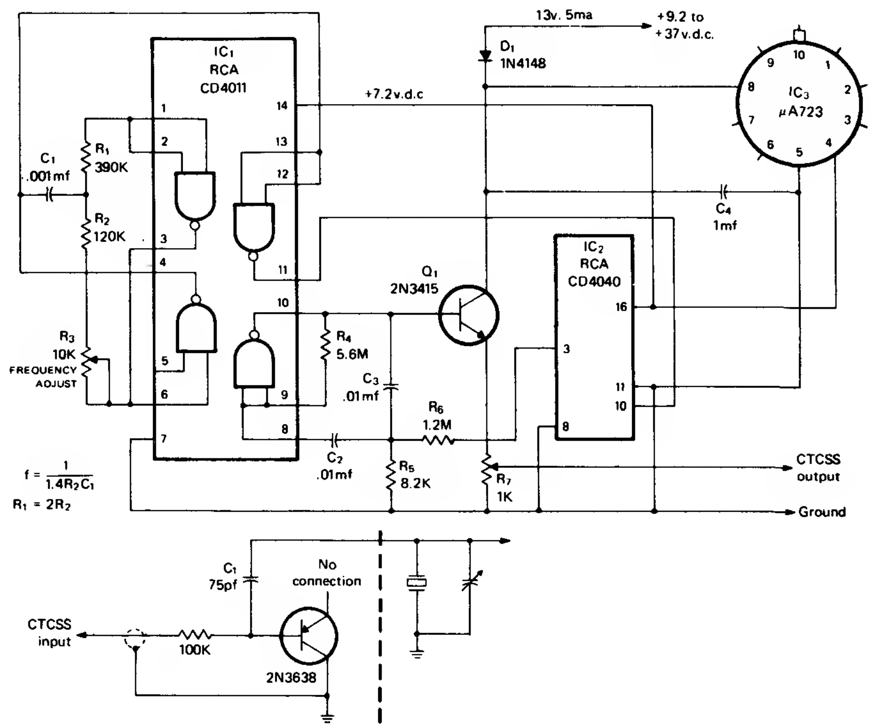




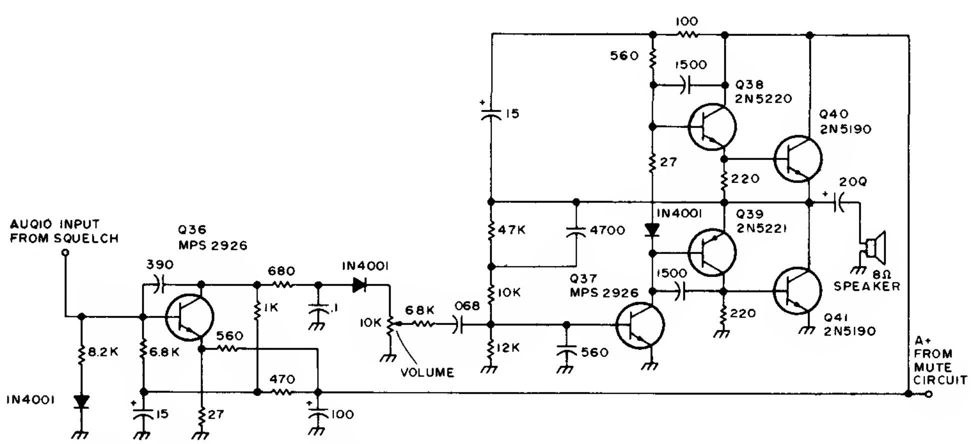
CARRIER-OPERATED SWITCH—Turns on transmitter of 2-metar FM transceiver (used as repeater) whan squelch of receiver is broken by signal. Transmitter ramalns on about 1 s after received signal disappeers; for longer delay, use larger alectrolytic on collector of Q1. Q1-Q4 can be 2N3904, 2N3565, 2N2222, or other good NPN switching transistor. Q5 is 2N3054 or equivalent, capable of handling 25 V at 1 A.—H. Cona, Tha Minirepeater, *73 Magazine,* June 1975, p 55–57, 60–62, and 64–65.



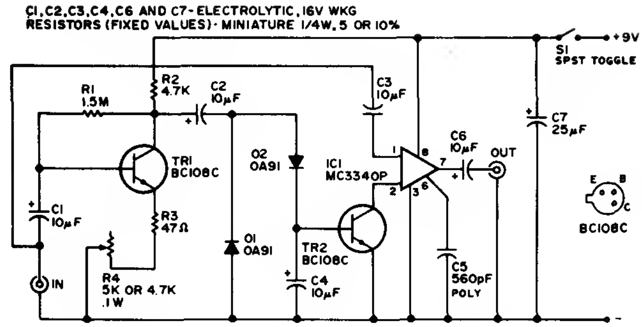
AUDIO SQUELCH—Used to suppress background noise during intervals between sentences and words when operating amateur radio station on VOX and using compressor. Circuit attenuates audio path below preset input level determined by setting of R3.—Circuits, *73 Magazine*, May 1977, p 19.



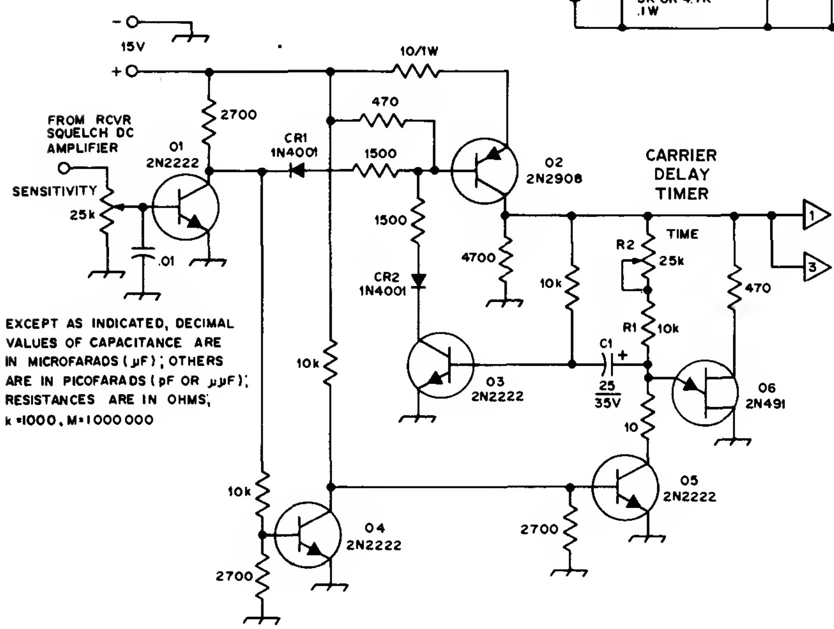
DIGITAL CTCSS OSCILLATOR—Uses two gates of CMOS quad NAND gate as 3.2-kHz oscillator, one gate as buffer, and one as amplifier serving in active bandpass filter. Requires only one precision capacitor, and uses ordinary carbon resistors in frequency-determining network. C_1 must be polystyrene, polycarbonate, Teflon, or silver mica. IC_2 divides oscillator frequency by binary multiple. Output is fed back to gate of IC_1 for converting square wave into sine wave by filtering out high-frequency harmonics. Provides continuous-tone-coded subaudible squelch (CTCSS) for amateur repeater system to protect input from interference on commonly shared channels. Voltage regulator can be replaced by zener. Use base-collector junction of 2N3638 or equivalent transistor as varactor in parallel with transmitter crystal of true FM transmitter, to modulate output frequency of crystal oscillator for CTCSS encoding.—D. Dauben, Miniature Solid State Tone Encoders to Replace Reeds, *CQ*, Dec. 1975, p 42–45 and 76.



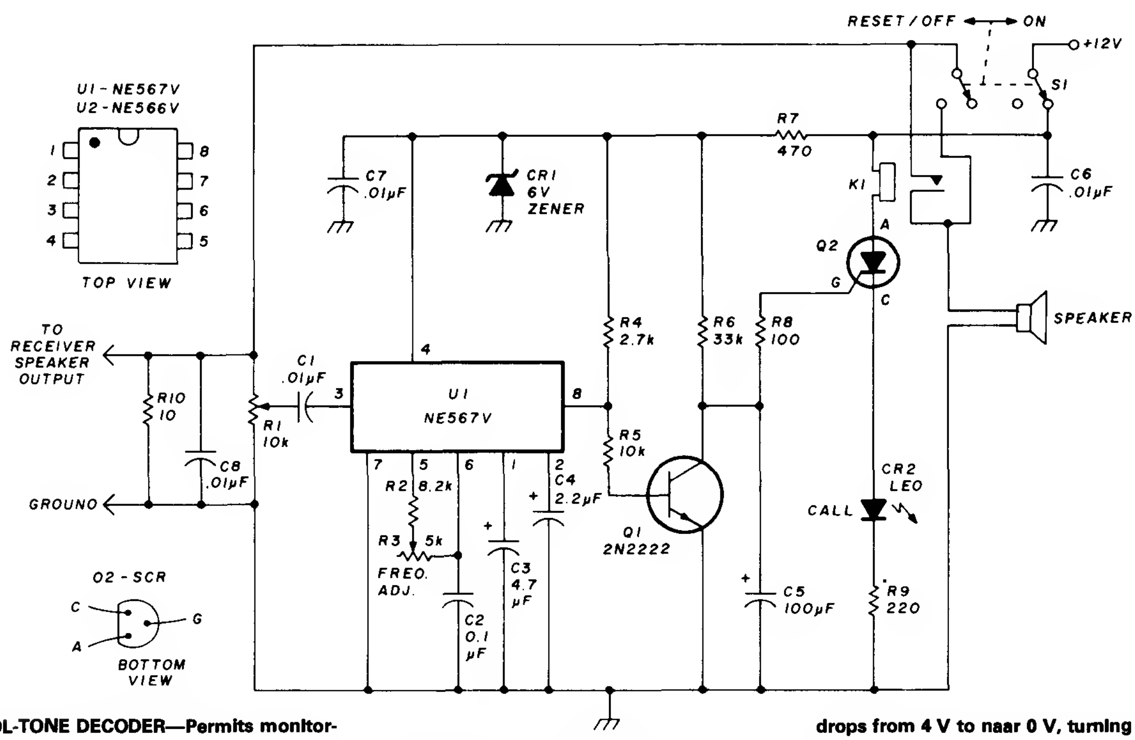
3-W CLASS AB—Used in all-band double-conversion superheterodyne receiver for AM, narrow-band FM, CW, and SSB operation. When only noise is present, first audio transistor Q36 is biased out of conduction by squelch and mutes loudspeaker. Supply is 13.6 V regulated. Article gives all circuits of receiver.—D. M. Eisenberg, Build This All-Band VHF Receiver, *73 Magazine*, Jan. 1975, p 105–112.



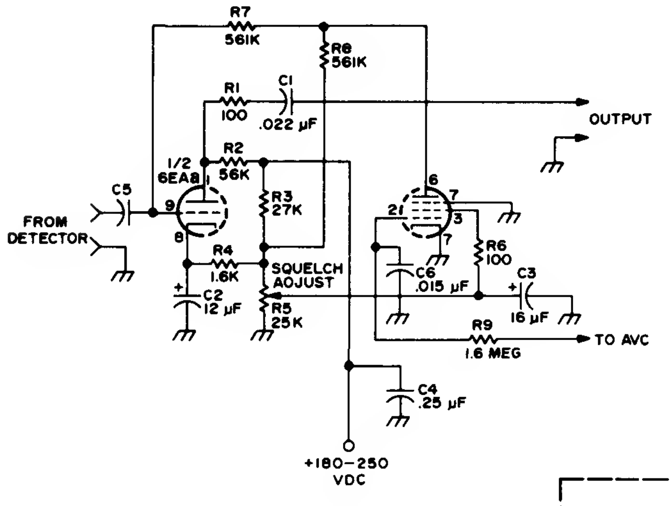
AF SQUELCH—Simple audio squelch circuit suppressas ell input signals below preset threshold.—Circuits, *73 Magazine*, Holidey issue 1976, p 170.



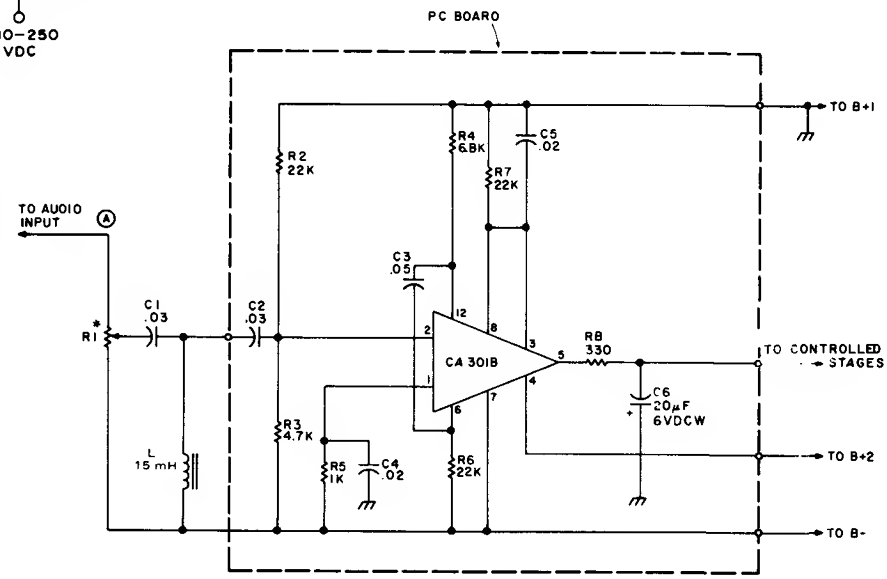
SILENT COR—Solid-stete carrier-operated reley usas Q1 to sense DC level chenge from receiver squelch and forward-bias Q2, thus latching Q3 on. Q4 and Q5 pravent C1 from accumuleting e charge. Q6 is then disabled as long as thera is an incoming signel. Q2 feeds terminels 1 and 3 for awitching transmittar on and sterting timer that shuts off transmitter aftar 3 min of use. Q6 is timer that holds transmitter on for short time after incoming carriar has dropped out (carrier tail). R2 adjusts tail length, usuelly 1–2 s.—D. L. Moon, Solid-Stata Repeater Control, *QST*, Oct. 1974, p 19–21.



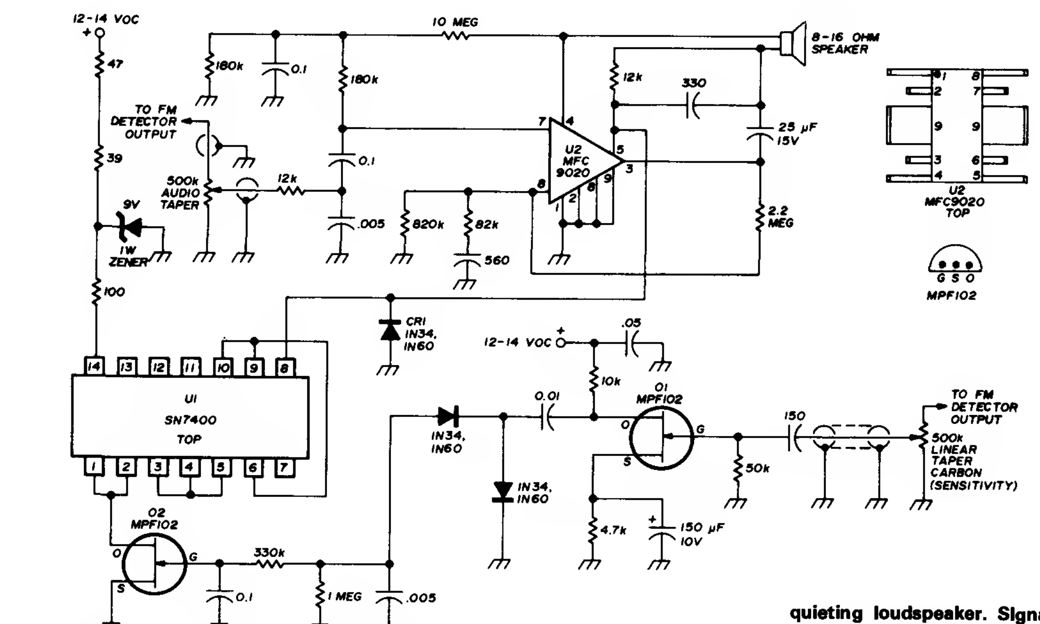
CONTROL-TONE DECODER—Permits monitoring local VHF FM repeater for calls from friends without having to listen to chetter of others or to repaater noise. Operetion is similer to thet of Motorole peging units in which speciel tone is transmitted to diseble squelch of receiver being called. Eech friend hes tone encoder for his transmitter, set et correct frequency for connecting loudspeaker so desired call cen be heard. Red LED comes on to confirm that loudspeaker ia connected. Audio from receivar loudspeeker is fed into pin 3 of NE567V PLL U1. When correct tone frequency is received, pin 8 drops from 4 V to naar 0 V, turning off Q1 end turning on Q2. Q2 closes relay K1, to connect loudspeaker, and holds it on until RESET switch is operated. Q2 is Redio Sheck 276-1059 or other small SCR. CR1 is 1N4735, end CR2 is red LED.—K. Wyatt, Private Call System for VHF FM, *Ham Radio*, Sept. 1977, p 62–64.



ONE-TUBE SQUELCH—Designed for insertion between second detector and AF volume control in tube-type AM receiver having AVC and well-filtered DC supply, to suppress noise when there is no input signal, such as when tuning between stations.—Circuits, *73 Magazine,* May 1977, p 31.

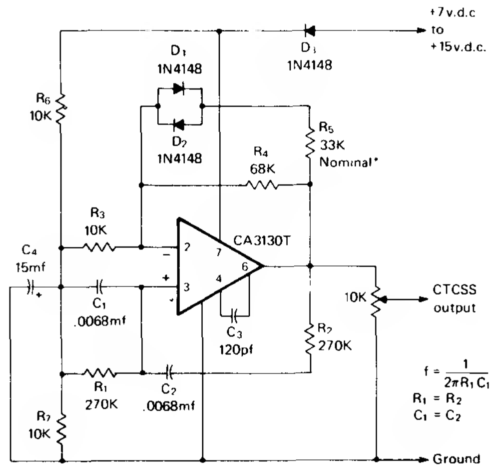


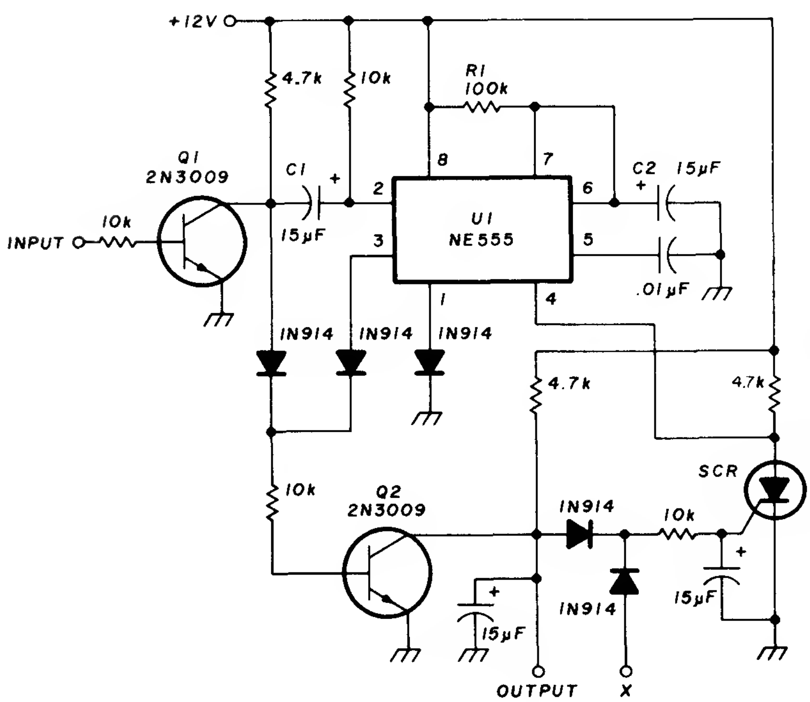
SQUELCH ADAPTER—Designed for use with any solid-state receiver having discrete transistor audio stages. Uses RCA CA3018 IC containing four NPN transistors, connected here to give noise amplifier that drives DC bias control stage acting on switching transistor for AF stages of receiver (one transistor in IC is unused). Designed for circuits having positive supply-voltage ground; for negative-ground circuits, reverse polarity of C6 and connect C4 to negative ground. R1 should be about 5 times resistance of volume control in receiver. B+1 should not exceed +12 VDC and can be as low as 6 V. B+2 is 3.5 V. Squelch is used chiefly when monitoring police bands on radio.—P. A. Lovelock, The Postage Stamp Squelcher, *73 Magazine,* May 1975, p 103–105.



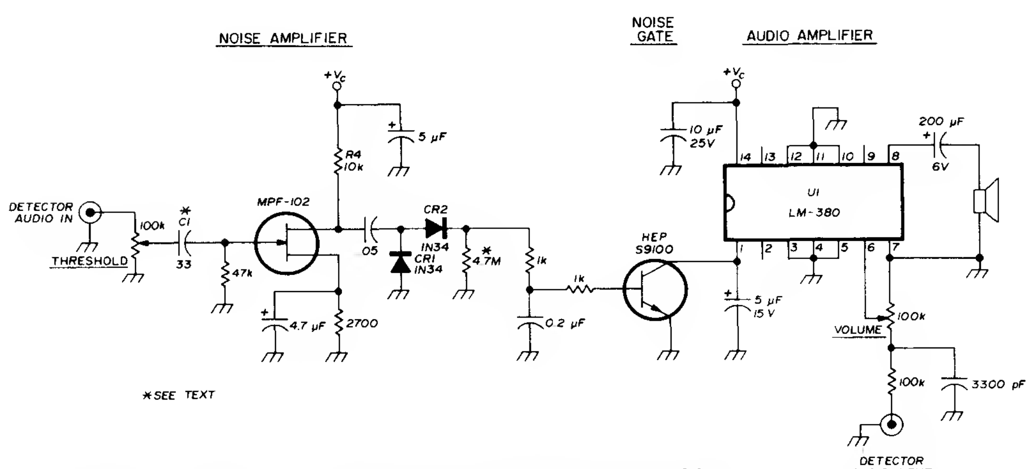
SQUELCH—Simple system with sharply defined threshold can be added to any FM receiver. Circuit includes conventional IC audio amplifier. Audio is taken from FM detector output by shielded audio line and filtered by U2 to drive loudspeaker. Similar arrangement (below) connects FM detector output to 500K squelch sensitivity control, for amplification by Q1 and rectification. Q2 is turned off at threshold level determined by sensitivity control. Q2 then begins logic toggling action through U1. Low on pin 8 of U1 clamps off portion of U2, quieting loudspeaker. Signal carrier reverses process, passing audio to loudspeaker. No-signal noise output voltage from FM detector should be at least 0.75 VAC. Circuit eliminates no-signal noise while allowing weakest desired signals to pass.—R. C. Harris, Versatile Squelch-Audio Amplifier for FM Receivers, *Ham Radio,* Sept. 1974, p 68–89.

100-Hz CTCSS OSCILLATOR—Stable Wien-bridge oscillator provides continuous-tone-coded subaudible squelch (CTCSS) for amateur FM repeater system to protect input from interference on commonly shared channels and add security to input frequency. Tone can be heard in background but does not become irritating. Use film resistors for R_1 and R_2. C_1 and C_2 should be polystyrene, polycarbonate, Teflon, or silver mica. Select R_5 to give 8–10 V P-P sine wave when operating from 12-V supply. R_1 and R_2 may be varied slightly to adjust frequency.—D. Deuben, Miniature Solid State Tone Encoders to Replace Reeds, *CQ*, Dec. 1975, p 42–45 and 76.





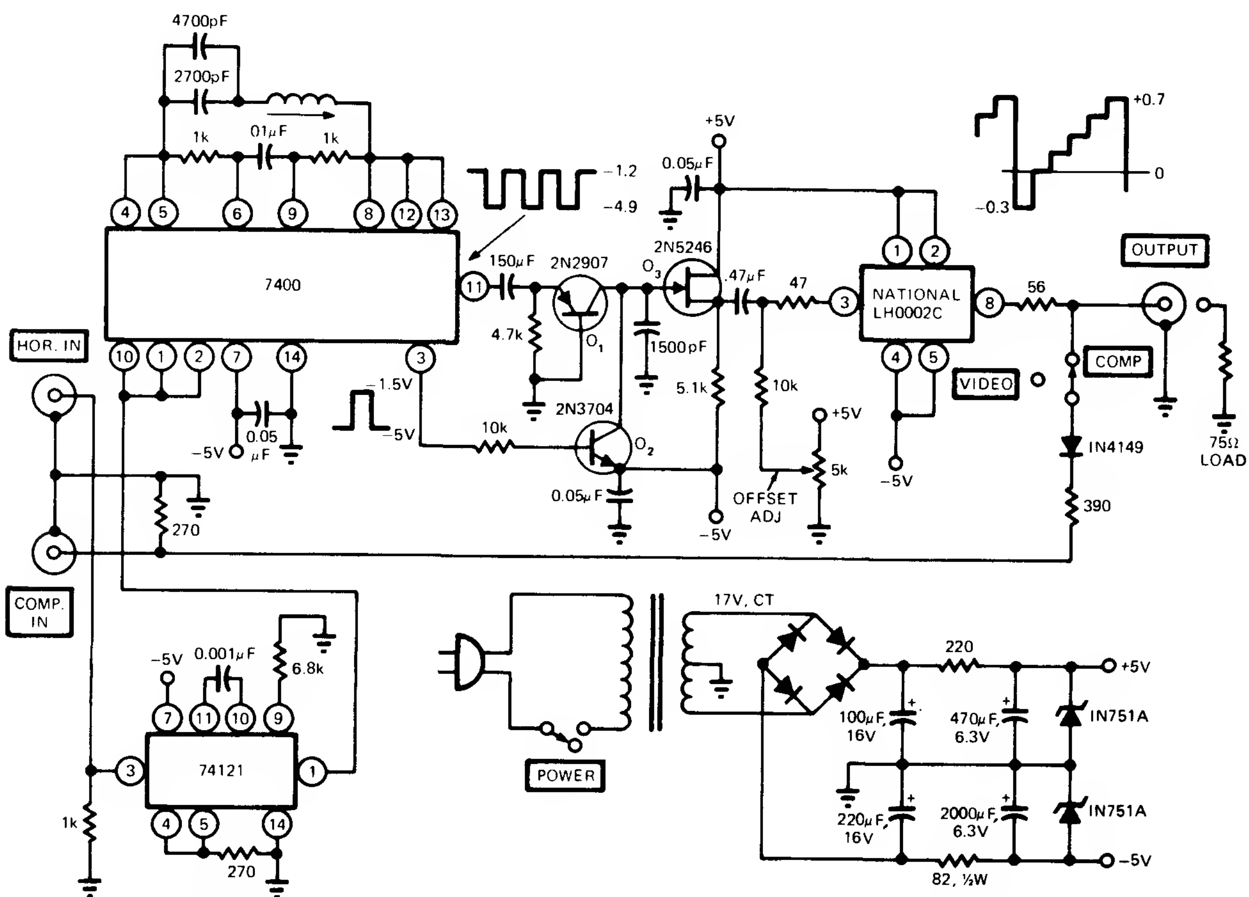
NOISE SUPPRESSOR—Eliminates repeater squelch tails from receiver having its own squelch, while allowing normal communications to pass through. Circuit goes between receiver squelch gate and point at which squelch acts on audio amplifier, to provide about 3-s delay before turning amplifier on. If received signal disappears before end of delay, radio remains silent and circuit resets itself. If received signal lasts longer than 3 s, as when repeater is interrogated, receiver operation is normal. Designed for receivers using low voltage level to squelch audio amplifier. NE555 timer is wired as mono MVBR that is triggered through inverter Q1 each time receiver squelch is tripped, provided SCR is off. SCR type is not critical. Input is taken from squelch gate in receiver.—R. K. Morrow, Jr., Repeater Kerchunk Eliminator for Mobile Rigs, *Ham Radio*, Oct. 1977, p 70–71.



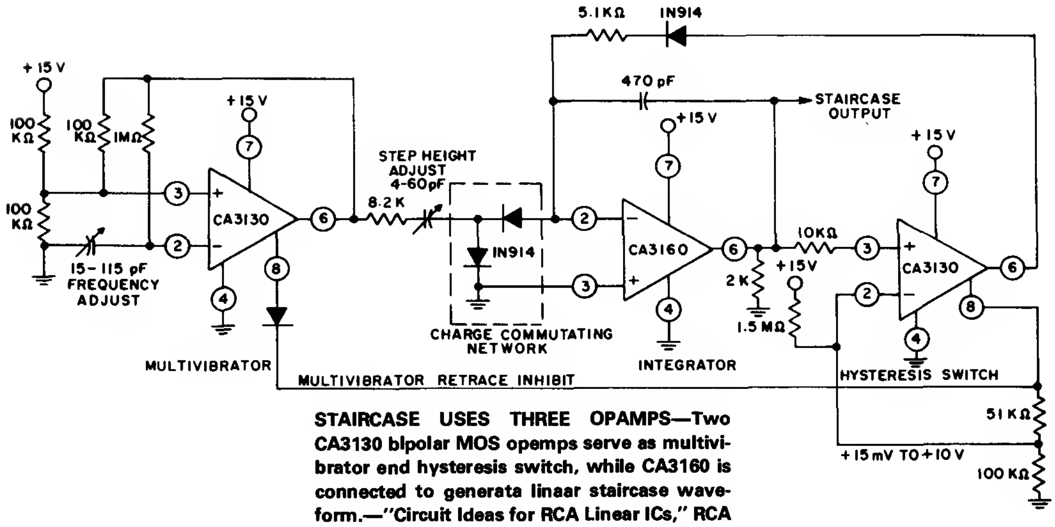
SQUELCH—Simple circuit using LM380 audio amplifier IC gives excellent performance. First transistor amplifies random noise which is greater in frequency than normal spectrum of voice during no-signal conditions. CR1 and CR2 rectify noise. Second transistor conducts and clamps U1 off when there is no signal. Increasing value of C1 increases gain of noise amplifier, but small value of C1 makes circuit less susceptible to heavy noise peaks.—R. Harris, Another Squelch Circuit, *Ham Radio*, Oct. 1976, p 78.

CHAPTER 84
Staircase Generator Circuits

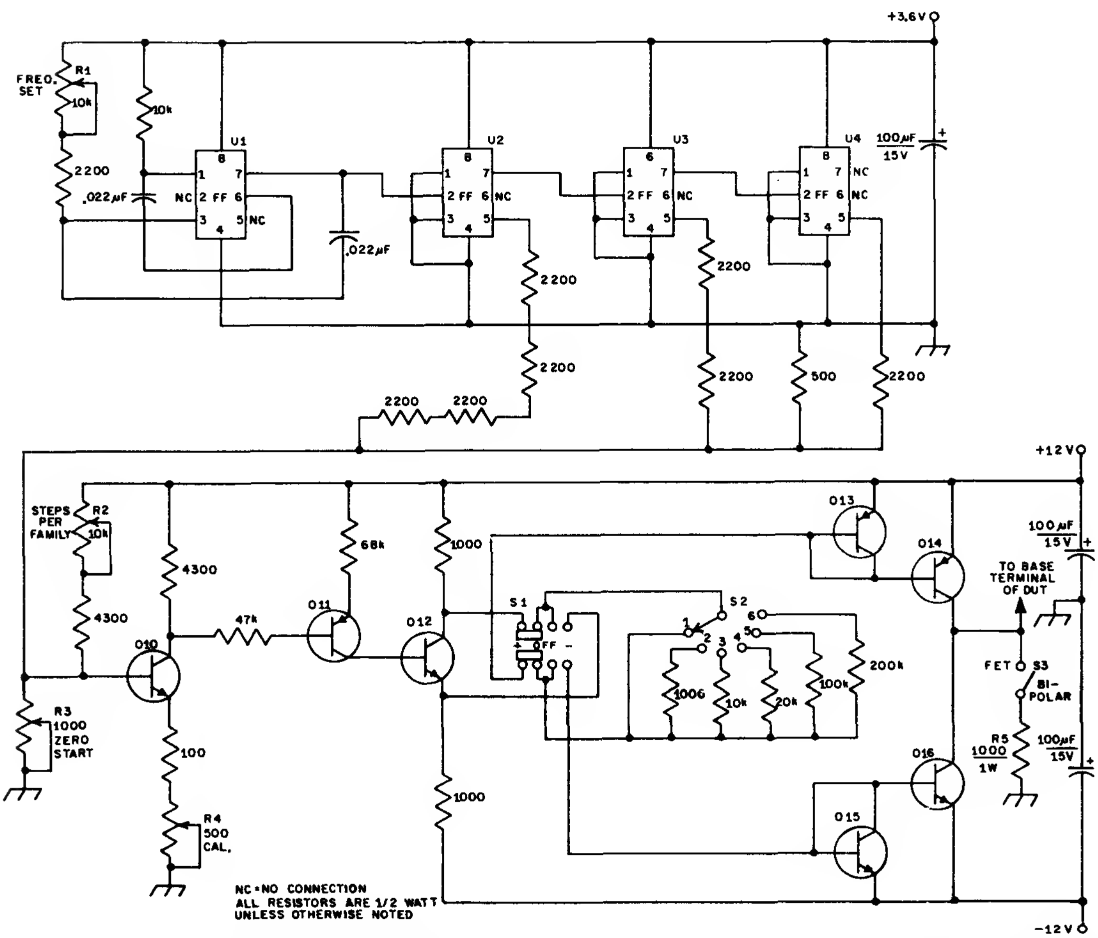
Generate output voltage that increases or decreases in number of equal or unequal steps in range from 7 to 256 steps. Applications include curve tracers for semiconductor devices, video testers, production of gray scale for satellite weather pictures, and feed for one axis of XY recorder or storage CRO.



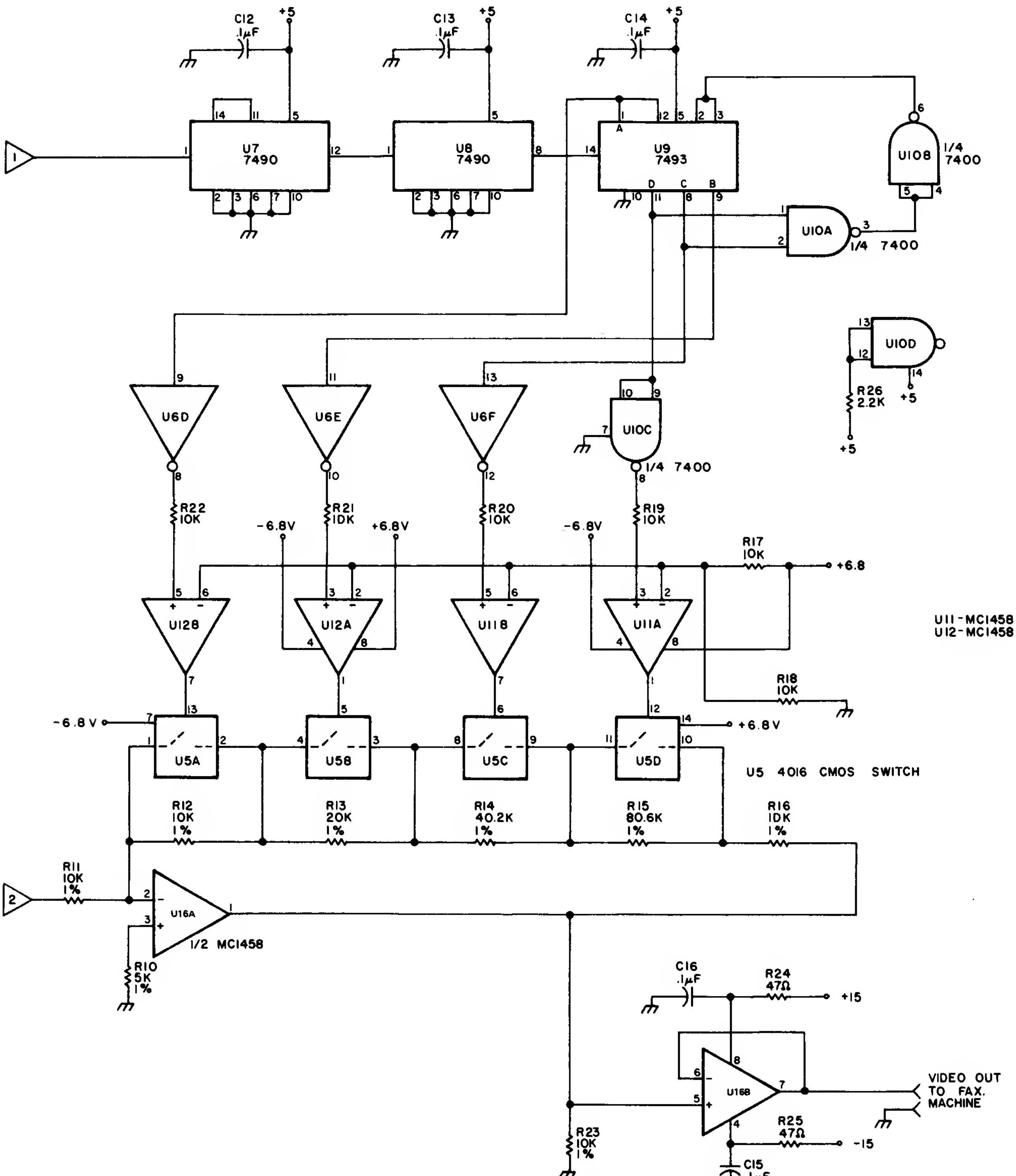
SIX-STEP COMPOSITE VIDEO—Circuit accepts negatively referenced output signals of TV sync generator and delivers 1 V P-P six-step composite video signal to 75-ohm load. 74121 mono changes wide horizontal blanking pulse to correct width for triggering oscillator IC. National LH002C current driver provides low-impedance drive capability for video signal. Used in testing TV sets and VTR decks.—M. J. Salvati, VFO Adds Versatility to TV Sync Generator, *EDN Magazine,* May 20, 1974, p 70 and 72.



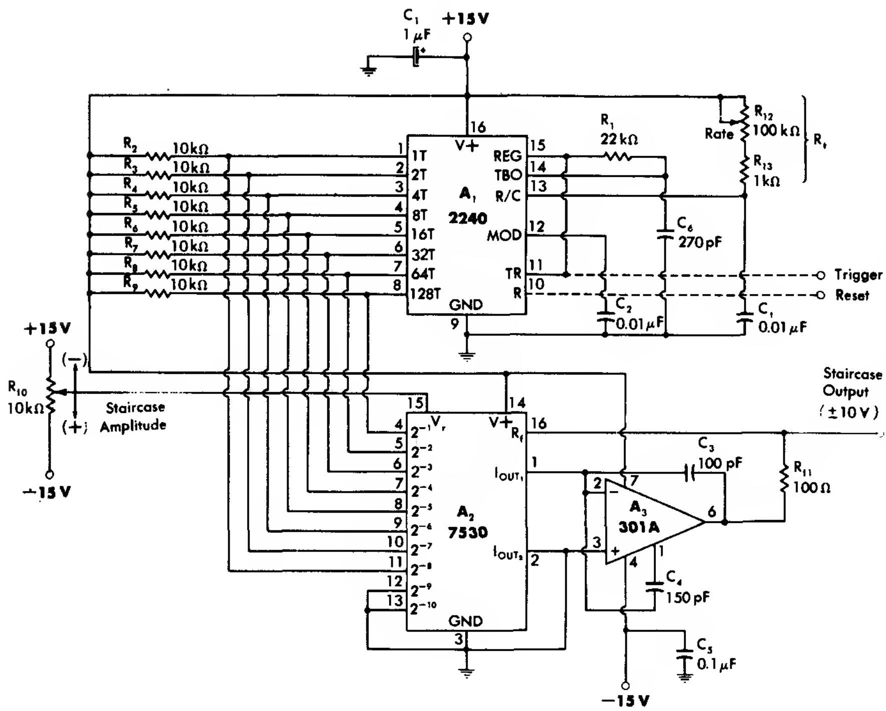
STAIRCASE USES THREE OPAMPS—Two CA3130 bipolar MOS opamps serve as multivibrator and hysteresis switch, while CA3160 is connected to generate linear staircase waveform.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 6.



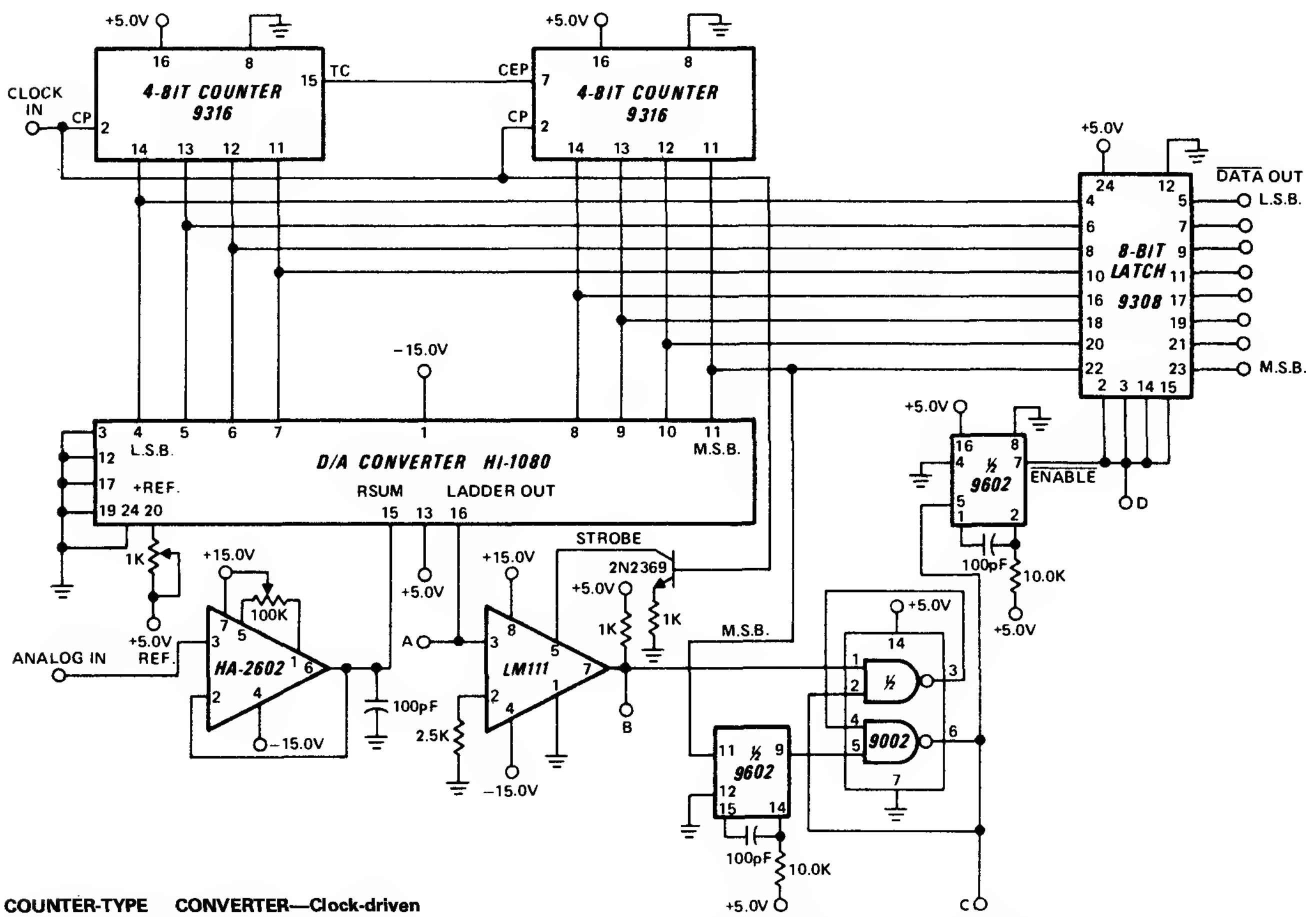
STEPS FOR CURVE TRACER—Square waves with 1-V amplitude and 1/60-s period, 2 V at 1/30-s, and 4 V at 11–15 s are generated by μL914 MVBR and μL923 flip-flops U2-U4, for combining in simple ladder network to give staircase waveform. Flip-flops count down MVBR output. Complementary-amplifier stage Q10-Q11 drives phase splitter Q12. Output of phase splitter goes through S1 to appropriate current source, Q13-Q14 or Q15-Q16, for supplying base terminal of device under test (DUT). Use 2N3904 for Q10, Q12, Q15, and Q16. Use 2N3906 for Q11, Q13, and Q14.—R. P. Ulrich, A Semiconductor Curve Tracer for the Amateur, *QST*, Aug. 1971, p 24–28.



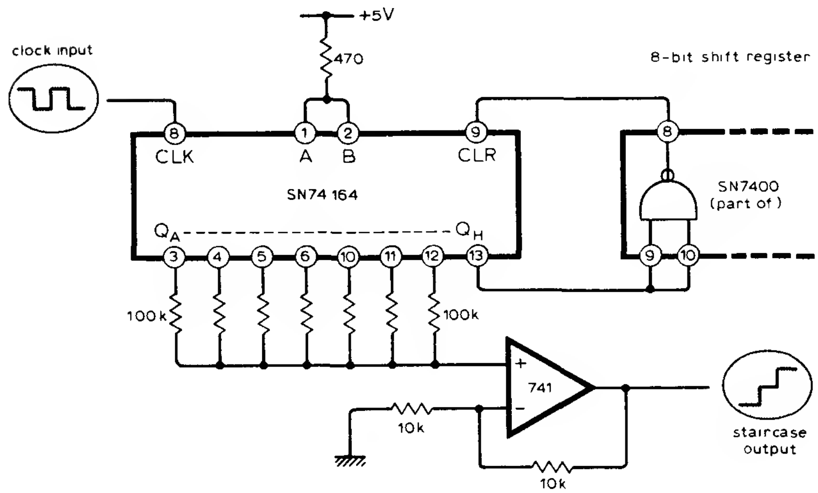
48-Hz 12-STEP—Used to provide 12 shades of gray for reception of satellite facsimile weather pictures. Input 1 is 2400-Hz square wave obtained from separate reference oscillator. Input 2 is 2400-Hz sine wave having 1 V P-P maximum voltage. U9 is 4-bit binary counter having special reset provided by U10A and U10B at count 12 to give desired 12 states. Outputs of U9 are used to adjust gain of U16A in 12 steps. Article describes operation in detail and gives circuits for reference oscillator and power supply.—R. Cawthon, Toward a More Perfect Weather Picture, *73 Magazine,* April 1978, p 116–118.



4–400 Hz BIPOLAR—Single 2240 serves es time-bese generator with R_t determining frequency in range of 4–400 Hz. Digital output is converted to enelog form by 7530 10-bit CMOS multiplying D/A converter. Reference voltage cen be veried up to ±10 V to give variable-emplitude bipolar staircase output in seme emplitude renge, with 255 staircase steps corresponding to 8-bit count of 2240. Opemp A_3 serves es current-to-voltega convarter for chenging ±1 mA output current of 7530 to ±10 V swing for staircese.—W. G. Jung, "IC Timer Cookbook," Howerd W. Sems, Indienepolis, IN, 1977, p 224–226.

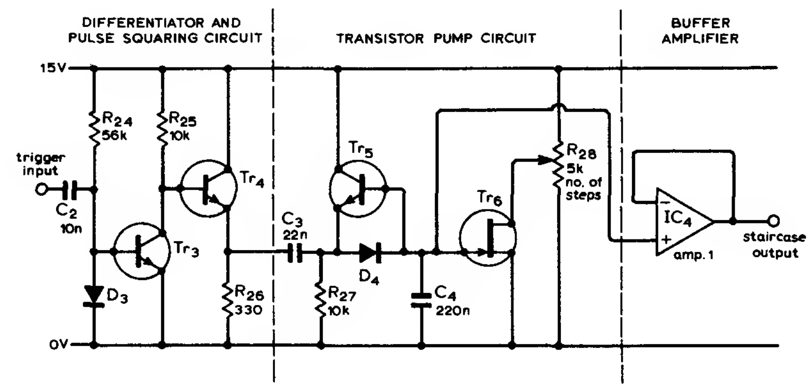


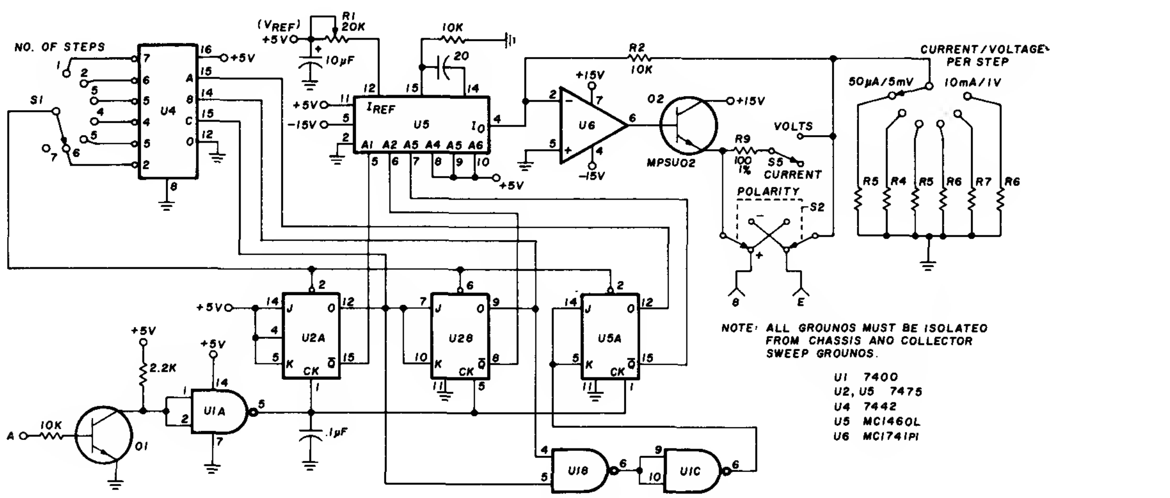
COUNTER-TYPE CONVERTER—Clock-driven counter drives Herris HI-1080 D/A converter producing staircase voltage remp. When converter output voltage equals analog input voltage es determined by HA-2602 comperator, comperetor chenges state. At that instant, state of counter represents 8-bit digital equivalent of enalog input. Deta output from latch is complement of digitel value. Input range is 0–10 V. Other input rengas, positive or negative, are obteined by chenging opamp gain or polarity or by edjusting 1K reference pot. Accuracy is meinteined within ½ LSB et clock ratas up to 330 kHz.—"Linear & Data Acquisition Products," Herris Semiconductor, Melbourna, FL, Vol. 1, 1977, p 7-33–7-35 (Application Note 512).



SEVEN STEPS—Circuit shown generates seven identical steps before weveform is repeated. Number of steps can be increesed by cascading two or more SN74164 shift registers, or reduced by teking clear pulse from earlier Q output of register.—P. Cochrene, Simple Staircase Generator, *Wireless World*, April 1976, p 63.

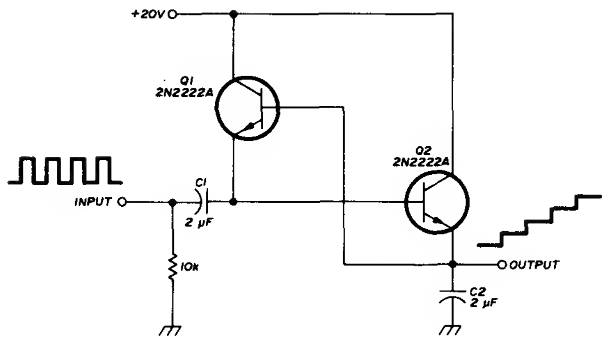
NEGATIVE TRIGGERING—Standard transistor pump circuit is driven by differentiating and squaring circuit designed so each staircase block is triggered by negative edge rather then by pulse. Circuit was developed for FET curve trecer, and can be used in other epplications where only resetting edge of normel sewtooth is eveilable as trigger. R_{28} chenges number of steps produced before steircase is resat. Tr_6 is Texes Instruments 43, IC opamp is SN72741P, trensistors are BC182L or equivalent, end diodes ere 1S44.—L. G. Cuthbert, An F.E.T. Curve Trecer, *Wireless World*, April 1974, p 101–103.



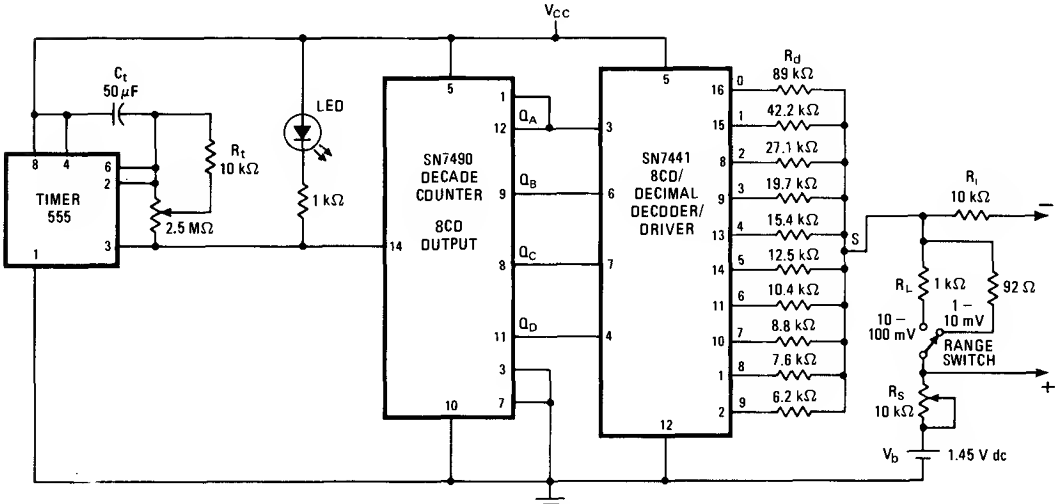


current step	voltage step	gain	R
50 μA	5 mV	1	∞
100 μA	10 mV	2	R2
500 μA	50 mV	10	R2/9
1 mA	100 mV	20	R2/19
5 mA	500 mV	100	R2/99
10 mA	1000 mV	200	R2/199

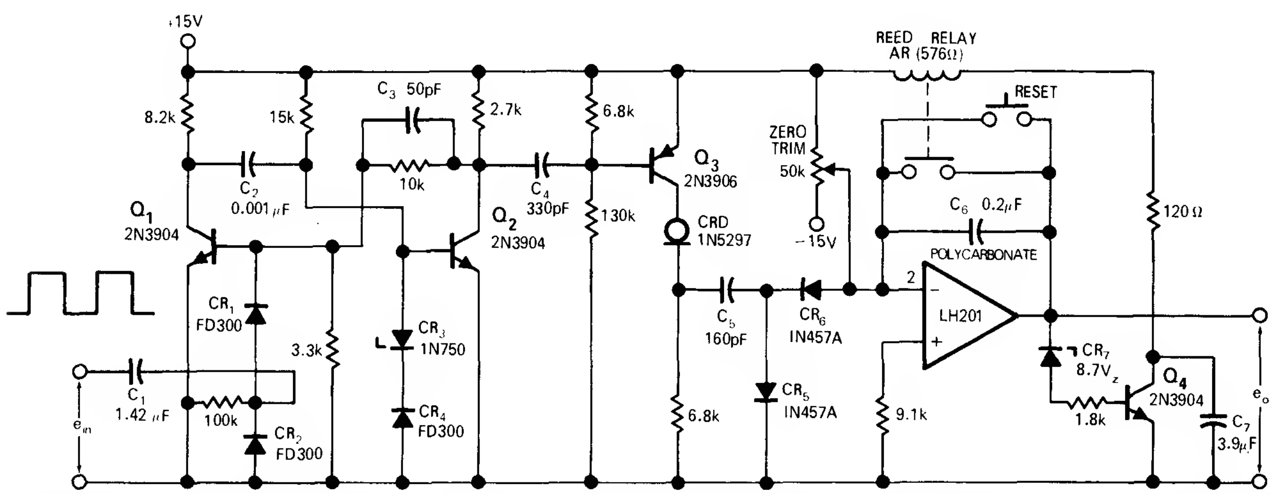
STEP GENERATOR—Bese-step generator produces series of voltage or current steps synchronized with beginning of each collector voltage sweep, for epplication to bese or gate of three-terminel semiconductor device while sweep voltage is applied to collector of curve tracer that displeys current-voltage characteristics on CRO. Circuit is built eround Motorole MC1406L 6-bit D/A converter U5. U1 (7400), U2, and U3 (both 7473) form synchronous divide-by-8 counter whose outputs are applied to A1-A3 inputs of U5. U6 (MC1741P1) and Q2 form current emplifier. Q1 is generel-purpose NPN transistor having DC current gain of about 30. Point A goes to output of full-wave rectifier using two 50-PIV 1-A diodes connected across 26.4-V secondary of transformer. Table gives values for R3 through R8 es ratio of R2 for various gains and steps. Thus, for 500-mV steps (gein of 100), R7 is about 101 ohms. Accurecy depends on velues of R2-R9 used. Never epply voltage steps to base of bipolar transistor.—H. Wurzburg, Integrated Circuit Bese-Step Generator, *Ham Radio*, July 1976, p 44–46.



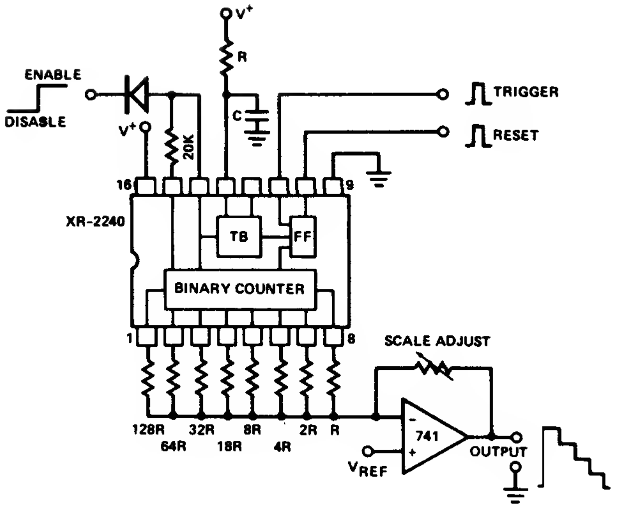
SQUARE TO STEP—Simple staircase ganarator circuit convarts squere weva into staircase voltage output. Each step approximates leval of input pulse. First pulse charges C2 to amplituda of input pulse. After pulse, voltage ecross C2 acts through Q1 to charge C1 to same voltage. Next pulse adds to voltege ecross C2, doubling its charge. Each subsequent pulse steps up haight of staircese until it reaches leval of supply voltaga.—J. Fisk, Circuits and Techniques, *Ham Radio,* June 1976, p 48–52.



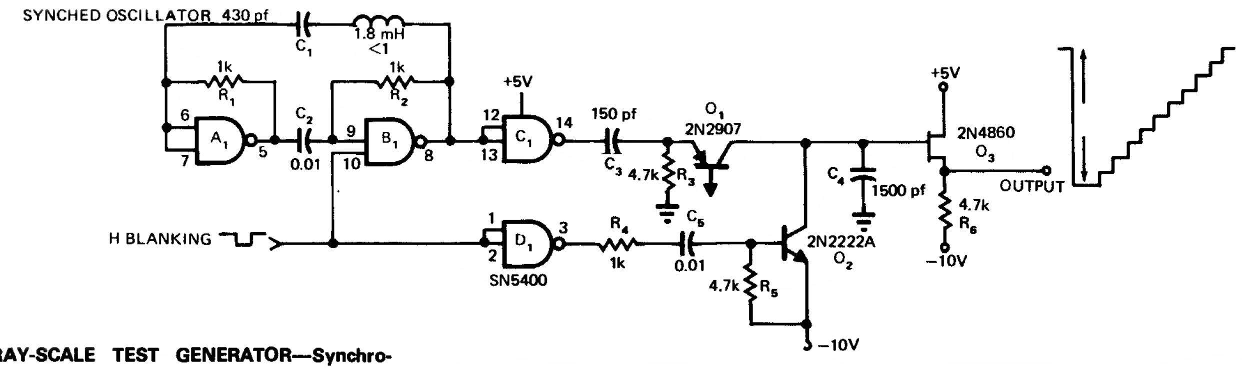
STEP-FUNCTION GENERATOR—Successively lowar resistances at decoder outputs create stairstep function for testing various typas of instruments. Steps are equally spaced and of equal haight, covering ranga of 5–12 or 50–120 mV depending on setting of range switch and R_S. Specing between steps ranges from 1.6 s to 6 min, so total time for complete 10-step staircase is 16 s to 60 min dapanding on setting of 2.5-megohm timer pot. Reference voltaga V_b can be 1.45-V mercury cell. Resistor values shown for R_d provide fixed 10% increments in stairstap.—M. M. Lacefield, Simple Step-Function Generator Aids in Tasting Instruments, *Electronics,* Dac. 26, 1974, p 103 and 105.



PULSE TRAINS FORM STAIRCASE—Circuit accepts pulse trains from pulse-generating position transducer and producas staircase waveform as analog input for horizontal axis of XY recorder or storaga scopa. Current-regulating diode serves as constant-current source for staircase generator thet produces analog output proportional to number of input pulses. Mono switches on Q_3 for constant time duration with every pulse, to ansura that C_5 gets same amount of charge regardless of pulse rata. Relay resets integrator to zaro when output voltage reaches elmost 8.7 V, to prevant data from being lost if opamp saturates before data run is completed.—R. G. Warsinski, Staircasa Generator Uses Current-Regulating Dioda, *EDN/IEEE Magazine,* Aug. 1, 1971, p 46.



256 NEGATIVE STEPS—Interconnection of Exar XR-2240 programmable timer/counter with 741 opamp and precision resistor ladder forms staircase generator. Reset pulse drives output low. When trigger is applied, output goes high and circuit generates negative-going staircase having 256 equal steps. Duration of each step is equal to time-base period as determined by values used for R and C. Staircase is stopped by applying disable signal (less than 1.4 V) to pin 14 through steering diode. Supply voltage range is 4–15 V. If counter cannot be triggered when using supply above 7 V and less than 0.1 μF for C, connect 300 pF from pin 14 to ground.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 11–18.

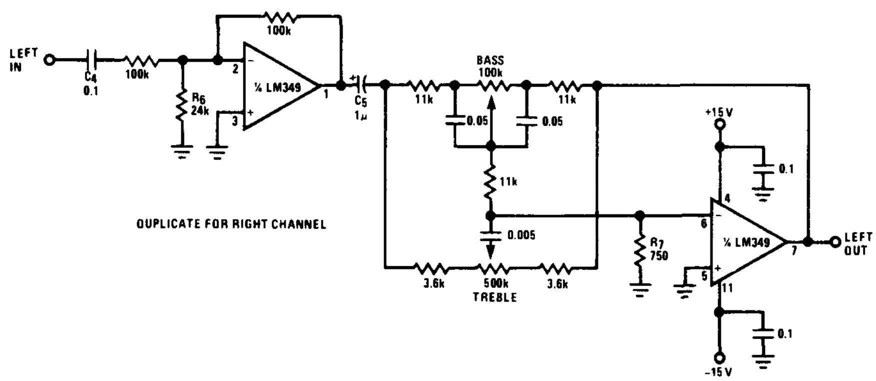


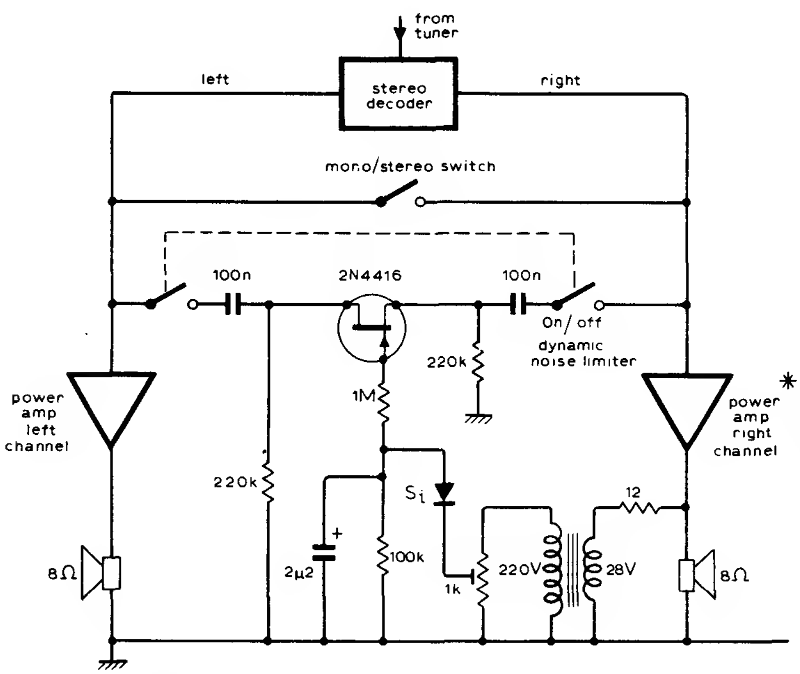
GRAY-SCALE TEST GENERATOR—Synchronized LC oscillator drives staircase generator, both of which are reset by horizontal-blanking input signal. Developed for testing video equipment. Synchronized oscillator uses two TTL gates of SN5400, biased at their linear range by negative feedback resistors R_1 and R_2. Oscillator always starts in same condition. Circuit generates staircase by integrating train of equally spaced pulses. Article covers theory and gives design equations.—E. E. Morris, Simple Stair-Step Generator Uses 1 IC and 3 Transistors, *EDN Magazine*, Oct. 1, 1972, p 48–49.

CHAPTER 85
Stereo Circuits

Includes amplifier and signal-processing circuits developed specifically for stereo FM, tape recorder, and phonograph systems. Many can be used singly in monophonic systems. Includes circuits for FM noise suppression, reverberation, rear-channel ambience, and loudspeaker phasing.

ACTIVE TONE CONTROLS—Provides ±20 dB gain with 3-dB comars et 30 and 10,000 Hz. Use of LM349 quad opemp means only one IC is needed for both stereo chennels. Buffer et input gives high Input impedanca (100K) for sourca. Total harmonic distortion is typically 0.05% ecross eudio band. Input-to-output gain is at least 5.—"Audio Hendbook," National Semiconductor, Santa Clare, CA, 1977, p 2-40–2-49.

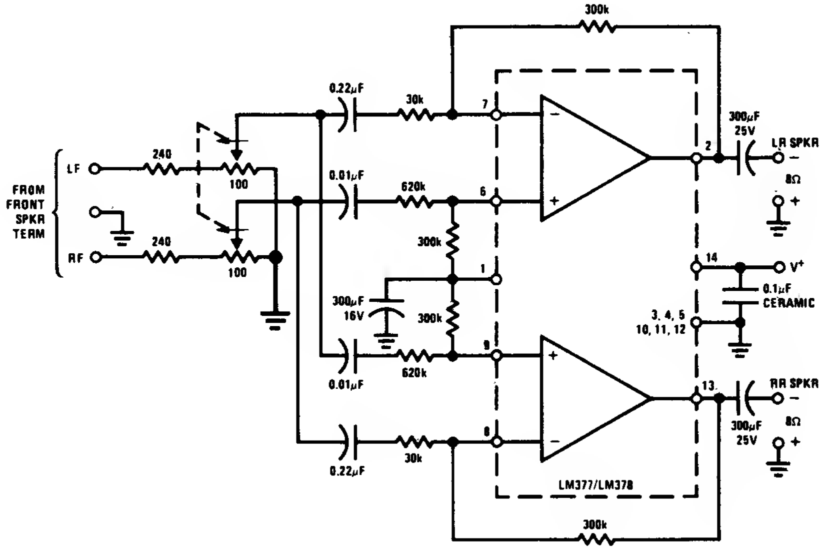


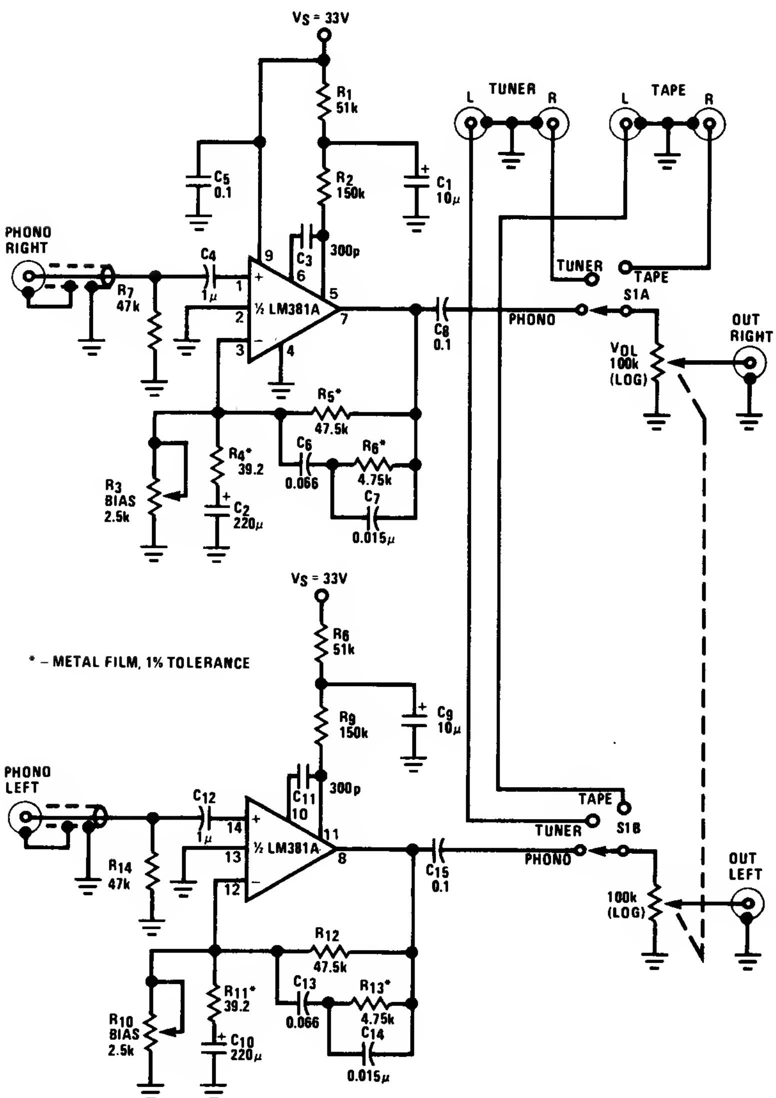


(✱ includes; volume balance and tone controls)

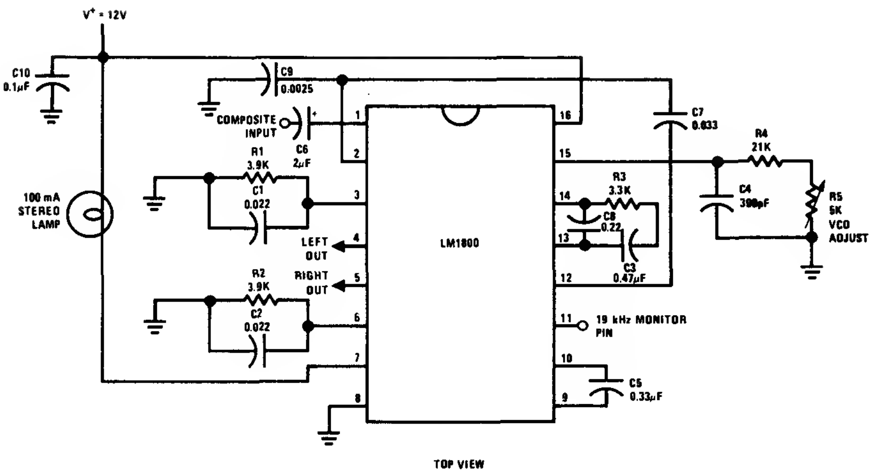
FM NOISE SUPPRESSOR—Circuit acts as noise limiter to help produce psaudostareo sound having reduced noise, to offset noise signal haerd during waak passagas during stereo reception of FM stations. FET short-circuits both eudio chennals when audio signel strength drops sufficiently to maka noise objectionable. If this voltage is insufficiant to drlva FET, empiifier or transformer must be used.—J. W. Richter, Stereo Dynamic Noise Limiter, *Wireless World,* Oct. 1975, p 474.

REAR-CHANNEL AMBIENCE—Can be edded to existing left front end right front loudspeakers of stereo system to extrect difference signel for combining with some direct signel (R or L) to add fullness for concert-hall realism during reproduction of recorded music. Very little power is required for peir of reer loudspeakers, and this can be fumished by National LM377/LM378 duel-amplifier IC operating from about 24-V supply.—"Audio Handbook," Netional Semiconductor, Sente Clere, CA, 1977, p 4-8–4-20.

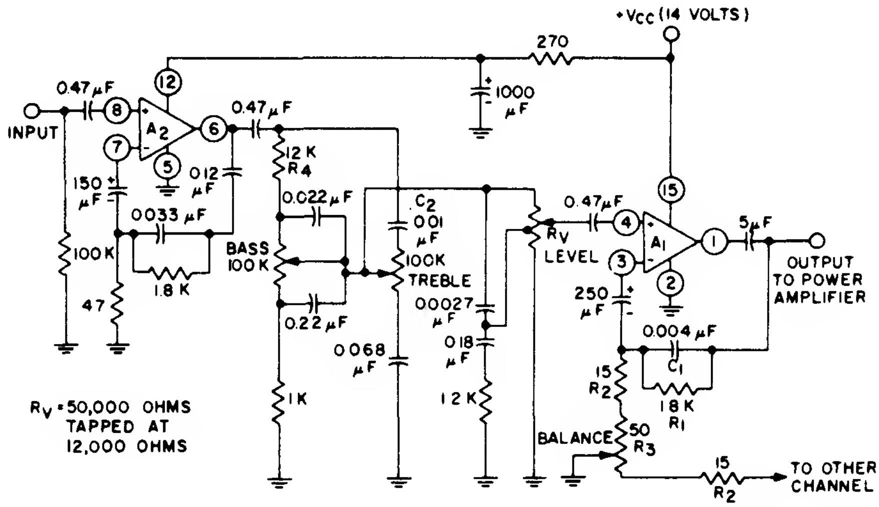




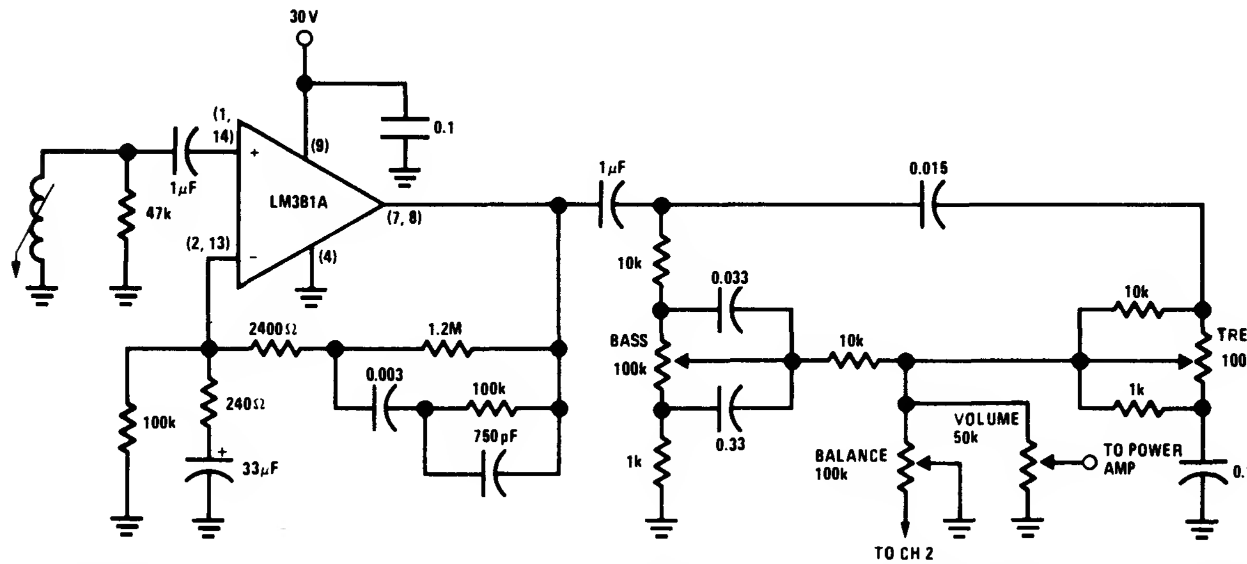
ULTRALOW-NOISE PREAMP—Complete preemp hes inputs for megnetic-cartridge pickup, tuner, and tepe, elong with ganged volume control end ganged selector switch for both chennels. Tone controls ere easily added. RIAA frequency rasponse is within ±0.6 dB of standerd velues. 0-dB reference gein at 1 kHz is 41.6 dB, producing 1.5-VRMS output from 12.5-mVRMS input. Signel-to-noise ratio is better than −85 dB referenced to 10-mV input laval.—"Audio Hendbook," Netionel Semiconductor, Santa Clara, CA, 1977, p 2-25–2-31.



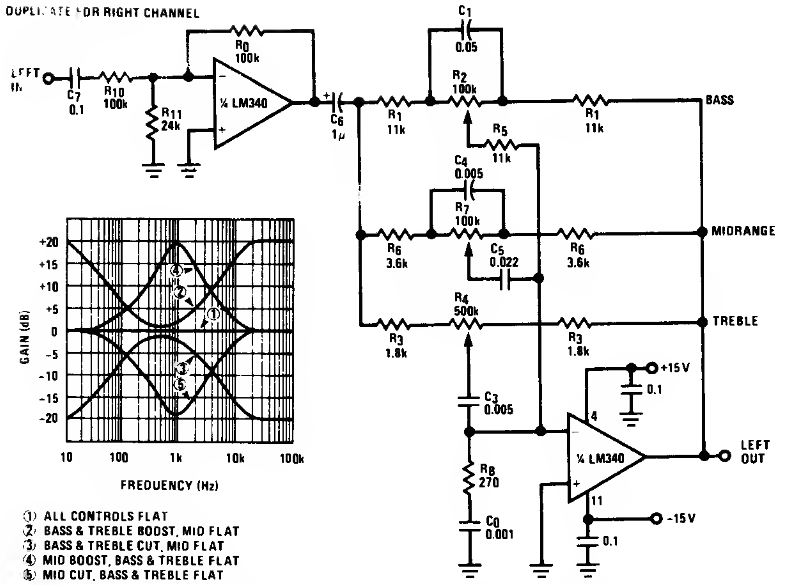
STEREO FM DEMODULATOR—Single National LM1800 IC converts composite AF input signal to left and right signals for audio power amplifiers. LED with series resistor can be used in place of 100-mA lamp.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 3-23–3-27.



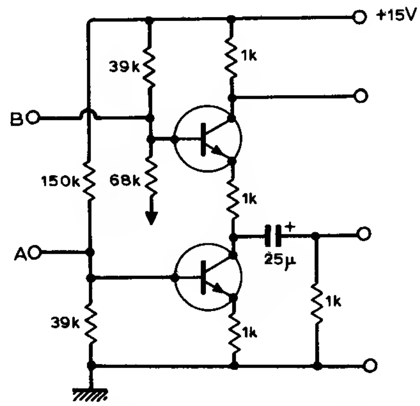
53-dB PREAMP—RCA CA3052 quad AC amplifier serves for both channels of complete stereo preamp. Circuit is duplicated for other channel. Total harmonic distortion at 1-kHz reference and 1-V output is less than 0.3%. Gain at 1 kHz is 47 dB, with 11.5-dB boost at 100 Hz and 10 kHz. Cut at 100 Hz is 10 dB and at 10 kHz is 9 dB. Operates from single-ended supply. Inputs can be from tape recorders and magnetic-cartridge phonographs.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 327–330.



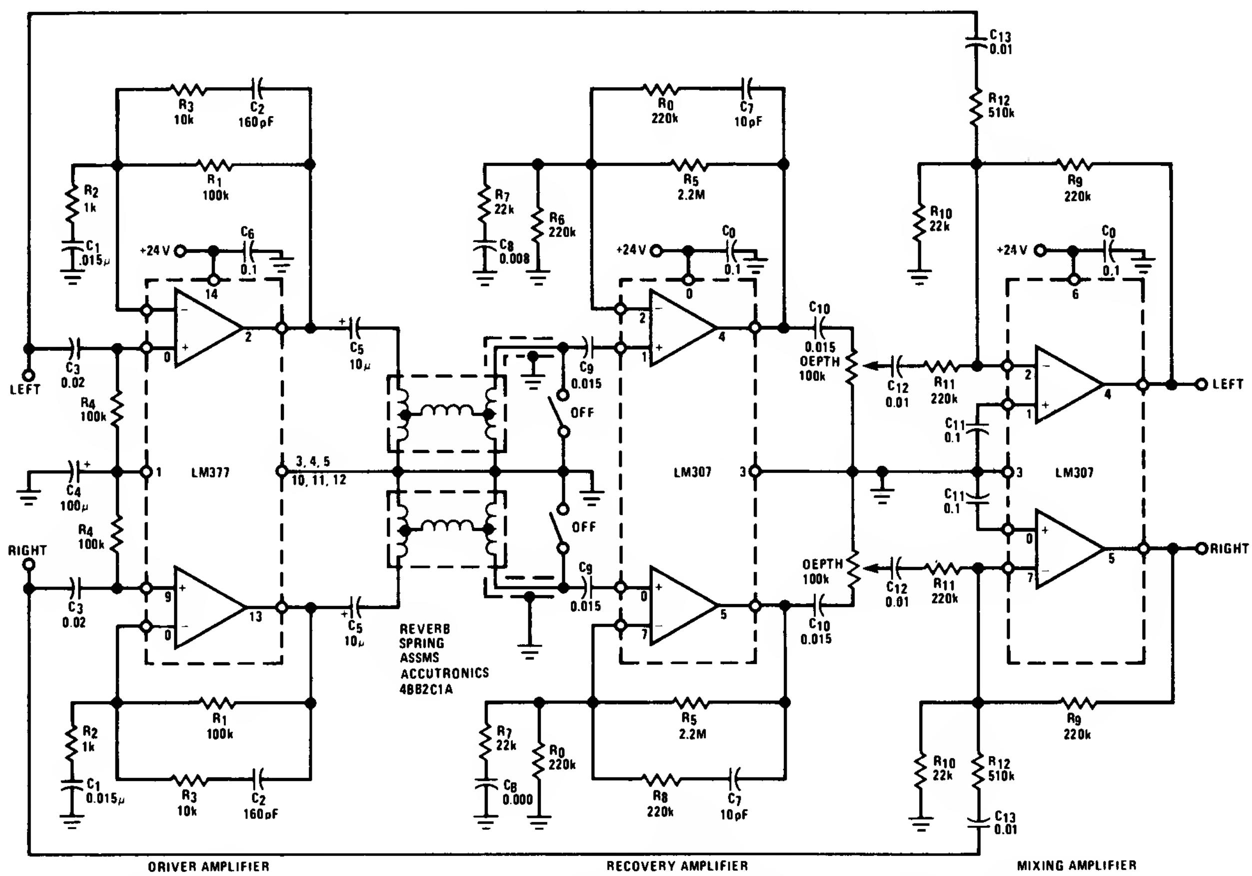
PREAMP WITH TONE CONTROLS—Use of LM381A selected low-noise preamp with passive bass and treble tone controls as phono or tape preamp gives superior noise performance while eliminating need for transistor to offset signal loss in passive controls. Circuit provides 20-dB boost and cut at 50 Hz and 10 kHz relative to midband gain. Design equations are given. Use log pots for tone controls. Other stereo channel is identical. Controls are ganged.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-40–2-49.



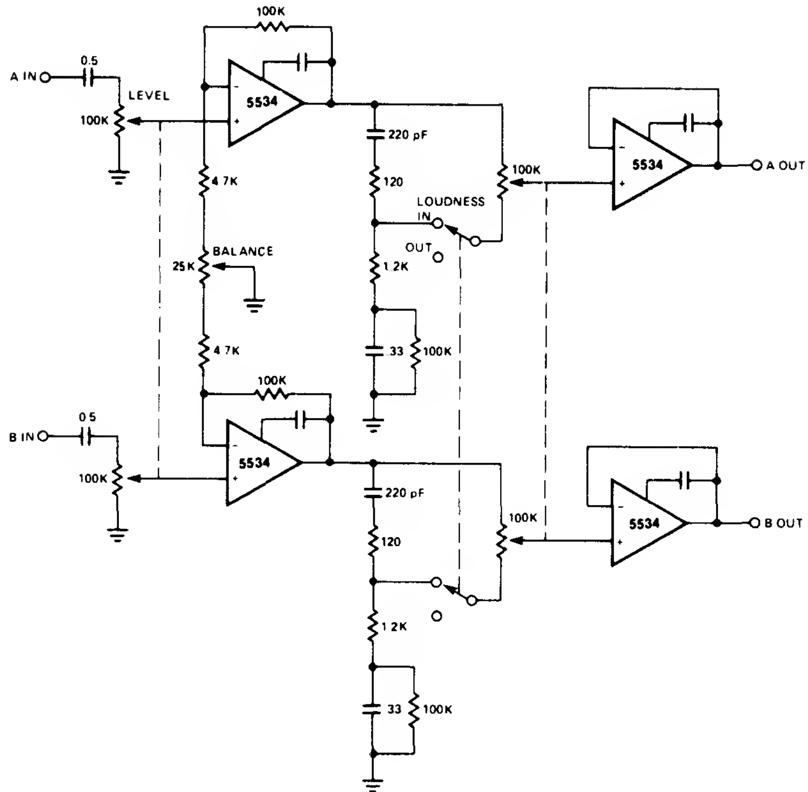
ACTIVE MIDRANGE TONE CONTROL—Addition of midrange tone control to ective bess and treble control gives greeter control flexibility. Center frequency of midrenge control is determined by C_4 end C_5 end is 1 kHz for values shown. C_5 should heve 5 times velue of C_4.—"Audio Hendbook," Netionel Semiconductor, Santa Clera, CA, 1977, p 2-40–2-49.



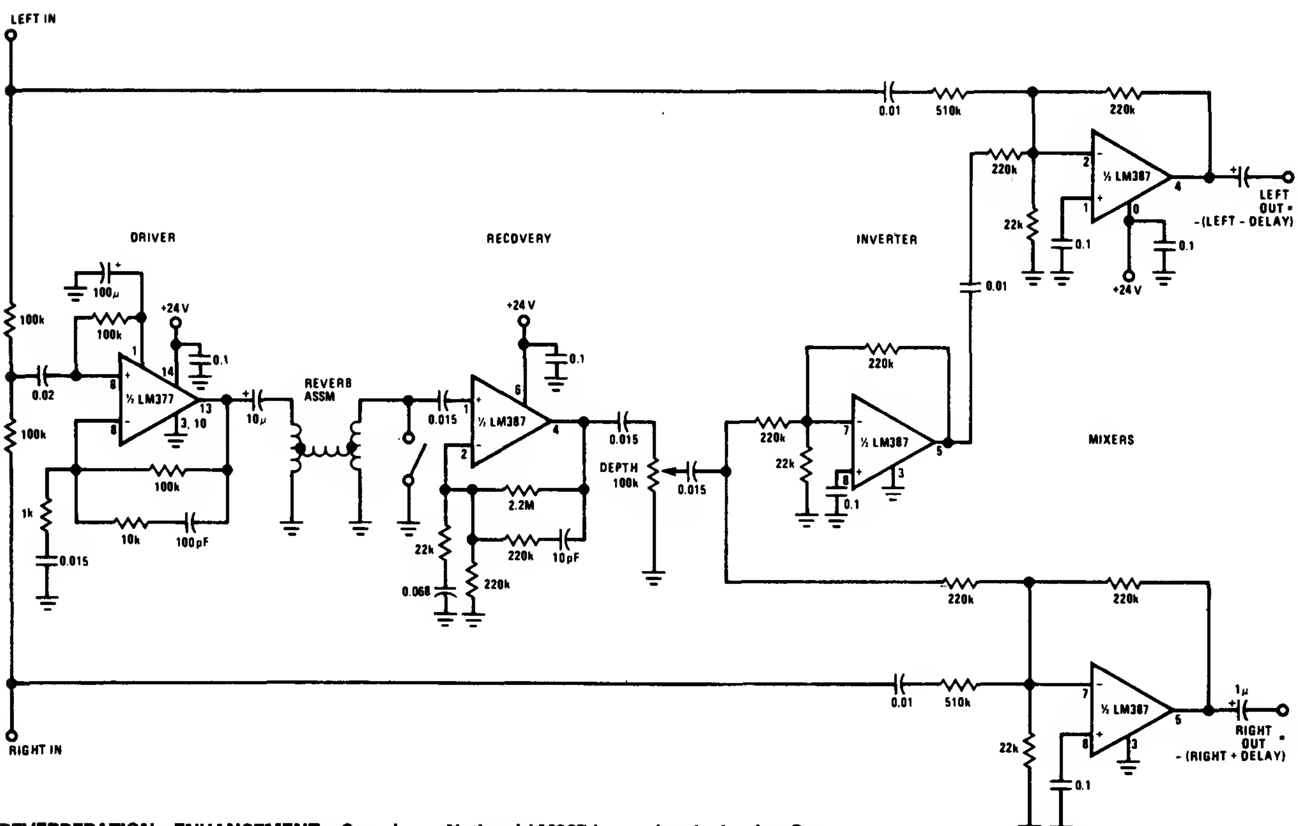
SUM AND DIFFERENCE—Simple circuit using two BC109 or equivalent trensietors is effectiva for summing and differencing two signels, es required in stereo end quadraphonic sound applications. For resistor velues shown, upper output is $-\frac{1}{2}(A + B)$ end lower output is $-\frac{1}{2}(A - B)$. Will hendla input signels up to 1.4 V. Bottom of 68K resistor should go to ground.—B. J. Shelley, Activa Sum and Difference Circuit, *Wireless World*, July 1974, p 239.



STEREO REVERBERATION—Uses Netional LM377 duel power emplifier es driver for springs acting es mechanical delay lines. Used to enhance performence of etereo music system by edding ertificial reverbaration to simulate reflection end re-reflection of sound off wells, ceiling, end floor of listening environment. Amplifier hes frequency response of 100–5000 Hz, with rolloff below 100 Hz to suppress booming. Recovery emplifier uses LM387 low-noise duel preamp, and anothar LM387 provides mixing of deleyed signel with originel in inverting summing configuration. Output is ebout helf of originel signel edded to ell of deleyed signal.—"Audio Handbook," Netionel Semiconductor, Santa Clara, CA, 1977, p 5-7–5-10.

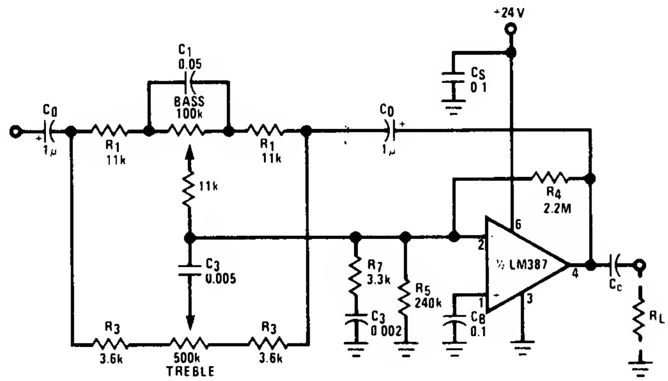


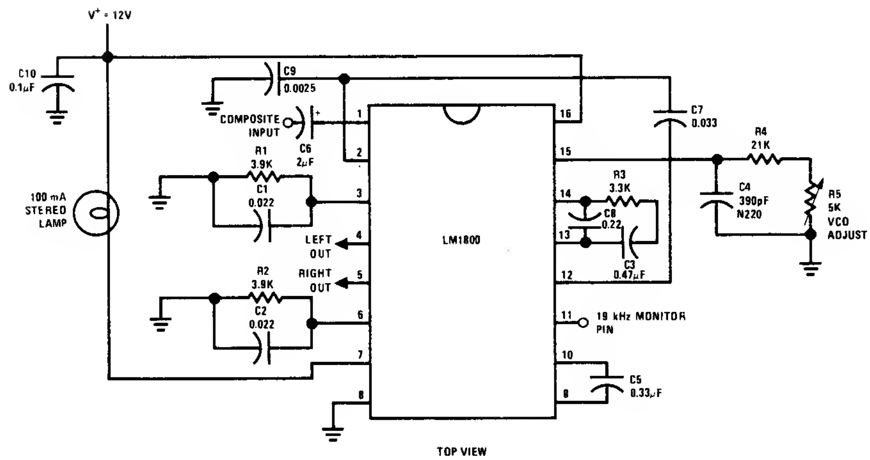
BALANCE AND LOUDNESS CONTROL—Provides bass boost at low listening levels to compensate for nonlinearity of human hearing system. Balance control permits equalizing volume from left and right loudspeakers at particular listening location.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 640.



REVERBERATION ENHANCEMENT—Can be used to synthesize stereo effect from monaural source or can be added to existing stereo system. Requires only one spring assembly, which can be Accutronics 4BB2C1A. All opamps are National LM387 low-noise dual units. Outputs are inverted scaled sums of original and delayed signals; left output is left signal minus delay, while right output is right signal plus delay. With mono source, both inputs are tied together and outputs become input minus delay and input plus delay.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 5-7–5-10.

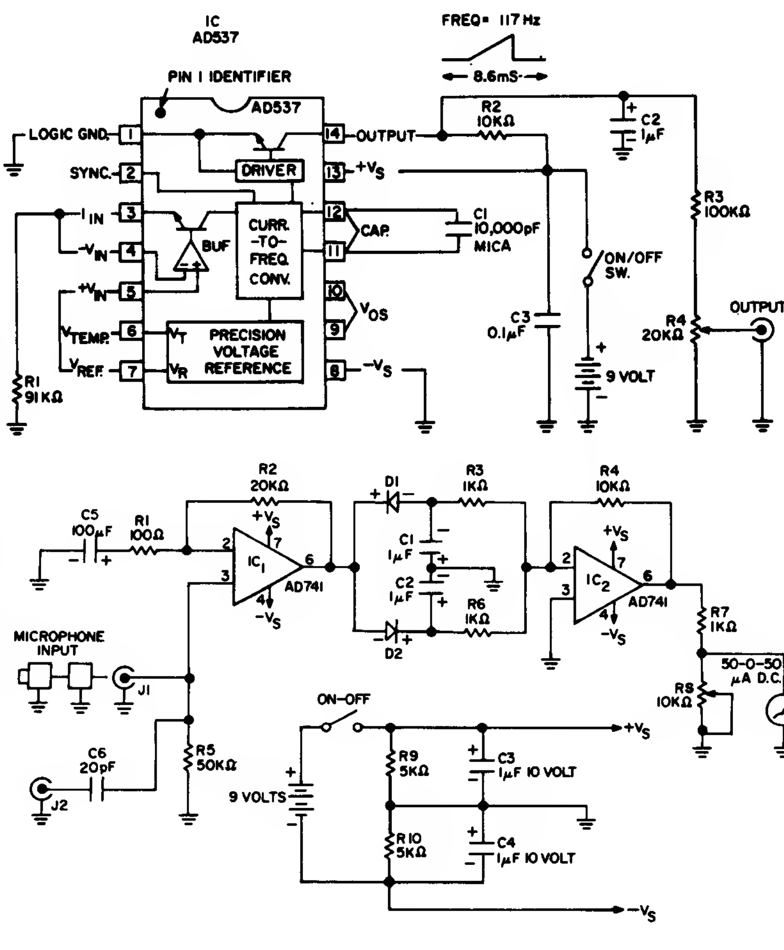
ACTIVE TONE CONTROLS USING FEEDBACK— Variation of Baxandall negative-feedback tone control circuit reduces number of capacitors required. Developed for stereo systems. R_4 and R_5 provide negative input bias for opamp, while C_0 prevents DC voltages from being fed back to tone control circuit. For other supply voltages, R_4 is only resistor changed; design procedure is given.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-40–2-49.

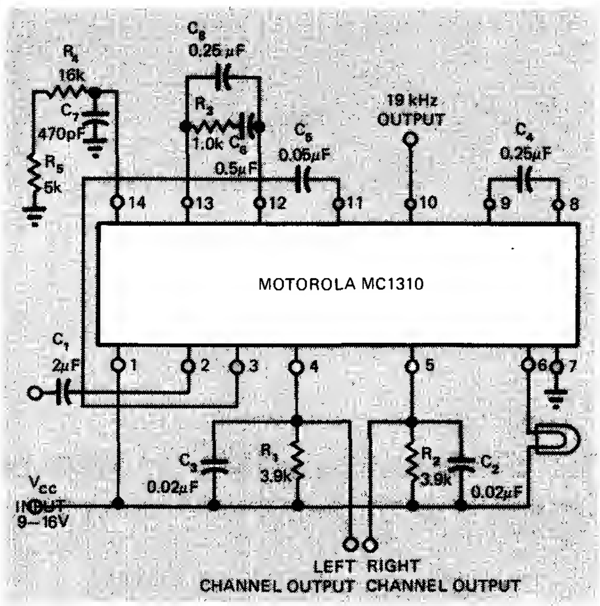




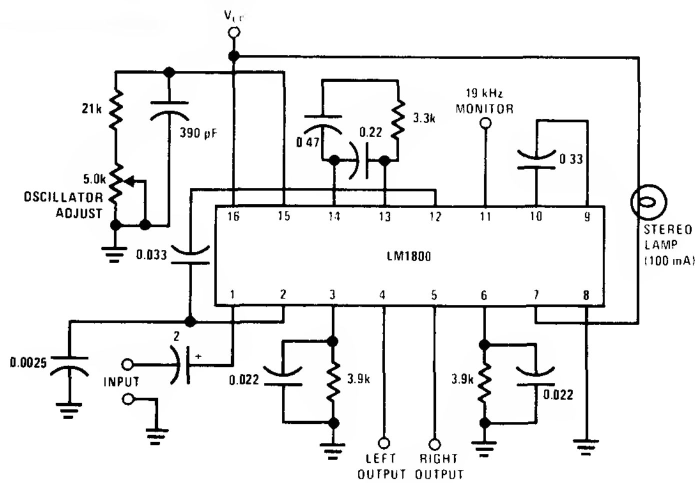
FM DEMODULATOR—National LM1800 PLL IC accepts composite IF output and converts it to separate audio signals for left and right channels. C8 has effect of shunting phase jitter to minimize channel separation problems. If free-running frequency of VCO is set at precisely 19 kHz with R5, separation remains constant over wide range of composite input levels, signal frequencies, temperature changes, and drift in component values.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-81, p 7–8.

LOUDSPEAKER PHASING—Used to determine correct phasing of loudspeakers, microphones, amplifiers, and audio lines in complex stereo systems. Transmitter input feeds sawtooth waveform into stereo input jack of one channel, and receiver unit having microphone input and zero-center meter output is held in front of each loudspeaker in turn for same channel. Components are correctly phased when meter deflects in same direction for all loudspeakers. Procedure is then repeated for other channel. Sawtooth waveform is generated by Analog Devices AD537JD voltage-to-frequency converter. Microphone can be that used with portable cassette recorder. 741 opamp IC_1 with gain of 200 feeds dual peak detector D1-D2. Filtered DC signals are detected ramp and detected spike, with spike overriding ramp. Resulting DC level is amplified by 741 opamp having gain of 10, for driving meter. Microphones to be phased are plugged into J1 and connections noted for giving correct meter deflection. J2 is used for phasing amplifiers, lines, and other audio components. Article covers calibration and use.—C. Kitchin, Build an Audio Phase Detector, *Audio*, Jan. 1978, p 54 and 56–57.

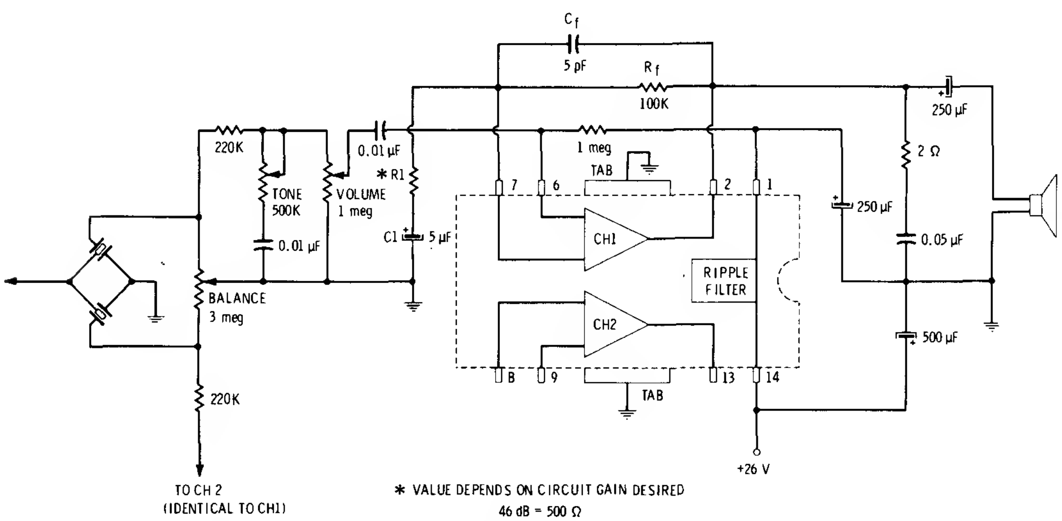




PLL DECODER—Motorola MC1310 phase-locked loop stereo decoder requires only one adjustment, by 5K pot R_5. With pin 2 opan, edjust R_5 until reeding of 19.00 kHz is obtained with frequency counter et pin 10. Alternatively, tune to stereo broedcest end adjust R_5 to center of lock-in range of stereo pilot lamp. Circuit gives 40-dB seperation and about 0.3% total harmonic distortion.—B. Korth, Phese-Locked Loop Stereo Decoder Is Aligned Eesily, *EDN Magazine*, Jen. 20, 1973, p 95.

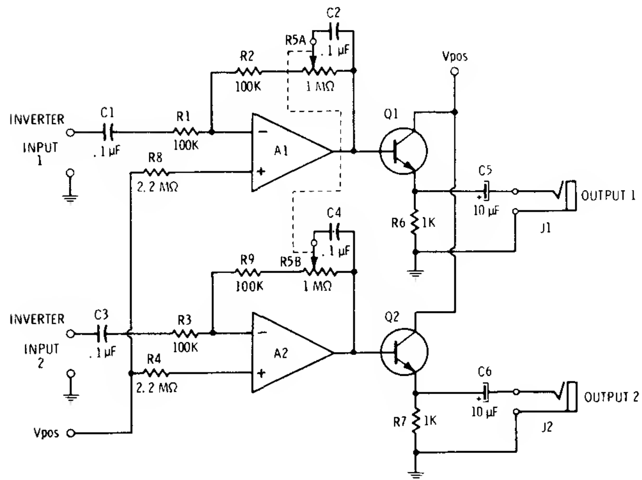


PLL STEREO FM DEMODULATOR—National LM1800 IC uses phase-locked loop techniques to regenarate 38-kHz subcarrier. Automatic stereo/monaurel switching is Included. Supply voltage range is 10–18 V.—"LM1800 Phase Locked Loop FM Stereo Demodulator," National Samlconductor, Santa Clera, CA, 1974.



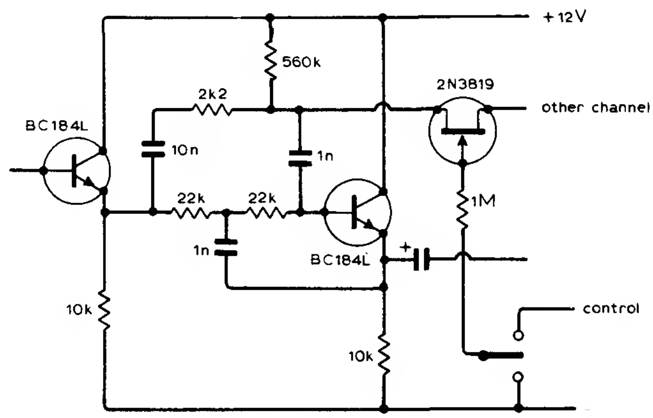
* VALUE DEPENDS ON CIRCUIT GAIN DESIRED
46 dB = 500 Ω
40 dB = 1K
34 dB = 2K
28 dB = 4K

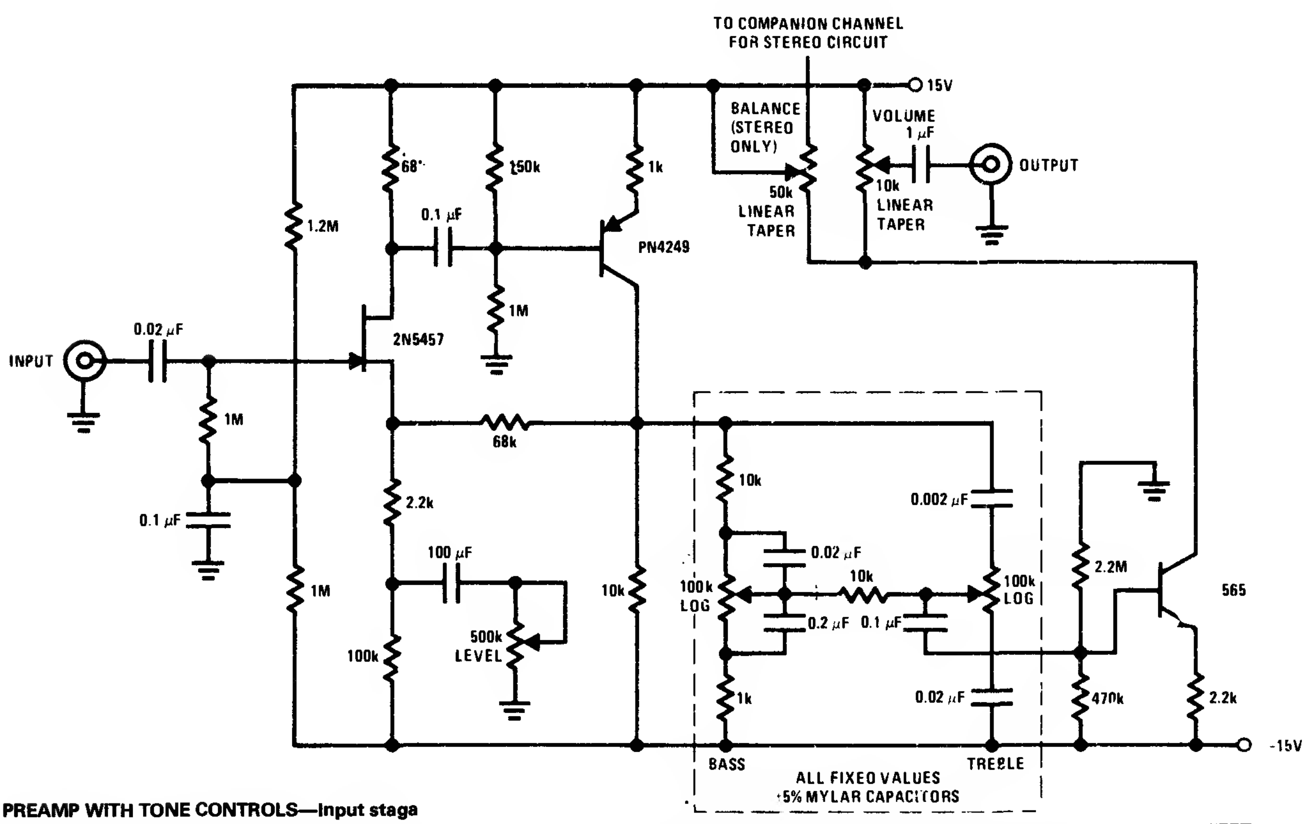
LOW-COST STEREO PHONOGRAPH—Uses singla Sprague ULN-2277 IC containing two audio amplifiers aach cepable of driving loudspeeker directly, for input from high-impedance stereo cartridge. Connections ere identical for other channel. Power output per channel is 2 W. Tone and voluma controls are genged with those for other channel, but balence control shown serves both chennels.—E. M. Noll, "Lineer IC Principles, Experiments, end Projects," Howard W. Sams, Indianapolis, IN, 1974, p 237–239.



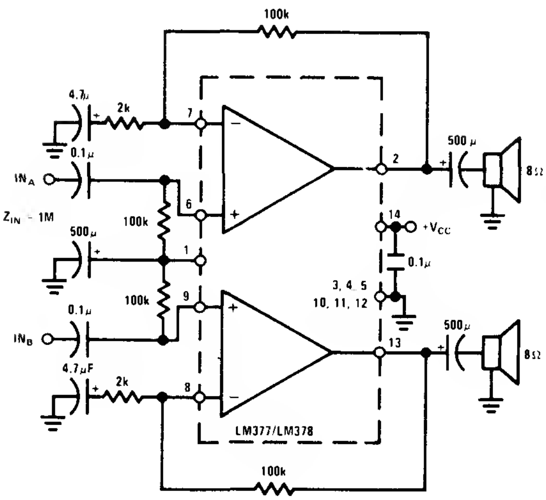
HEADPHONE AMPLIFIER—Designed to drive medium- to high-impedanca headphones. Add metching transformers hevlng 1000-ohm primaries if using low-impedance headphones. Duel 1-megohm pot controls gein in stereo channels over range of 1 to 100. Usa 9–15 V well-filtered supply reted et least 20 mA. Usa Motorola MC3401P or Netionel LM3900 quad opamp and 2N2924 or equivalent NPN trensistors.—C. D. Rekes, "Integreted Circuit Projects," Howard W. Sams, Indianepolis, IN, 1975, p 21–24.

FM HISS LIMITER—Usas low-pass filter to remova noisa sometimes heard with week pesseges during starao recaption of FM stations. FET driven by output of emplifier or tunar is used to switch low-pess filtar into operetion rather then switching ovar to mono. Based on fect that tha hiss is an entiphesa effect thet can ba removed with littla datriment to ovarall signal.—G. Hibbert, Starao Noisa Limiter Improvement, *Wiralass World*, March 1976, p 62.



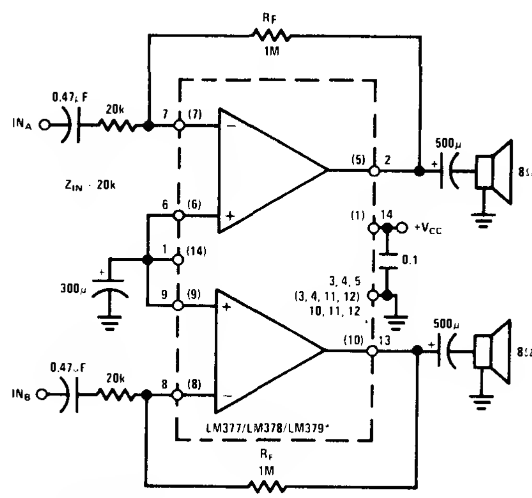


PREAMP WITH TONE CONTROLS—Input staga is JFET heving high input impadance and low noise. Circuit parametars ara not critical, yet hermonic distortion laval is less than 0.05% end S/N ratio is ovar 85 dB. Tone controls allow 18 dB of cut and boost. Input of 100 mV gives 1-V output et maximum leval. Identical preamp is used for othar stereo channel.—"FET Databook," National Semiconductor, Sante Clara, CA, 1977, p 6-26–6-36.



NONINVERTING POWER AMPLIFIER—Single National LM377/LM378 provides gain of 50 and 3 W per channel for driving loudspeakers. Supply is 24 V. High input impedance permits use of high-impedance tone and volume controls. Heatsink is required.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.

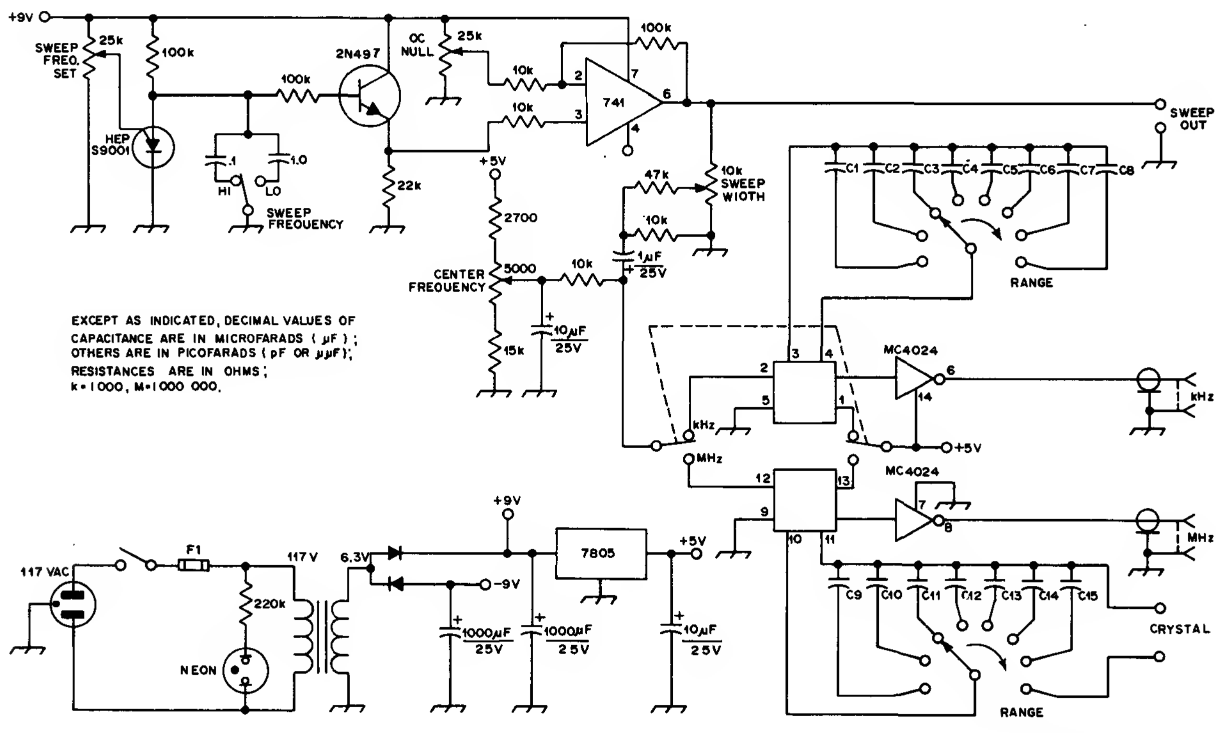
INVERTING POWER AMPLIFIER—Single National LM377 IC provides 2 W per channel with 18-V supply for driving loudspeakers when fed by stereo demodulator of FM receiver. Similar LM378 chip gives 3 W per channel with 24-V supply, and LM379 gives 4 W per channel with 28-V supply. Gain is 50 for all. Heatsink is required.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-8–4-20.



*(LM379S pin nos. in parentheses)

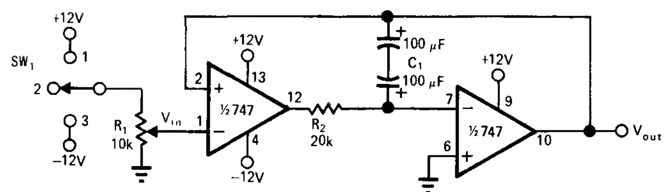
CHAPTER 86
Sweep Circuits

Includes circuits for generating linear, nonlinear, logarithmic, exponential, negative-starting, variable start/stop, bidirectional, and other types of ramps or sweeps at frequencies ranging from 0.2 Hz to 10.7 MHz for CRO and other applications. See also Cathode-Ray and Signal Generator chapters.



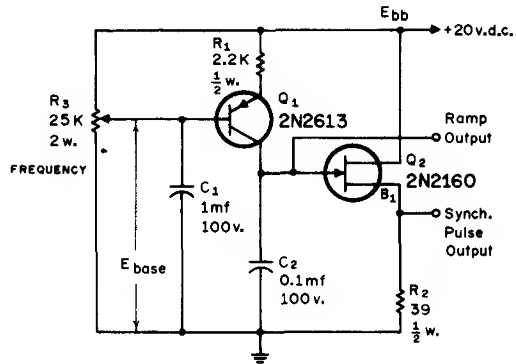
15-RANGE SWEEP—Sarves for edjusting tuned circuits, aligning IF strips, end checking filter cherecteristics. Uses Motorole MC4024 IC containing two seperete voltage-controlled MVBRs with output buffer for each. Frequency of oscillation is *determined* primarily by single switch-selected externel capacitor that gives choice of 15 frequency renges, with frequency within each range varied by applying DC control voltage to one pin of IC. For 3.5–5 V of control voltege, lineerity is good. Output waveform is 4 V P-P at lower frequencies, becoming triangular at higher frequency renges. HEP S9001 programmeble UJT generates sweep signel. Switch gives choice of 100 Hz or 1 kHz sweep. Buffar end 741 opemp than give exponential sweep from ebout −1 to +1 V after DC level is set to 0 by 25K pot, for horizontal input of CRO. Sweep signal is elso fed to MVBRs through controls giving independent width end center frequency adjustments. Diodes are 1-A 50-PIV silicon. T1 is 6.3 V at 1 A.—W. C. Smith, An Inexpensive Sweep-Frequency Generetor, *QST,* Oct. 1976, p 17–19.

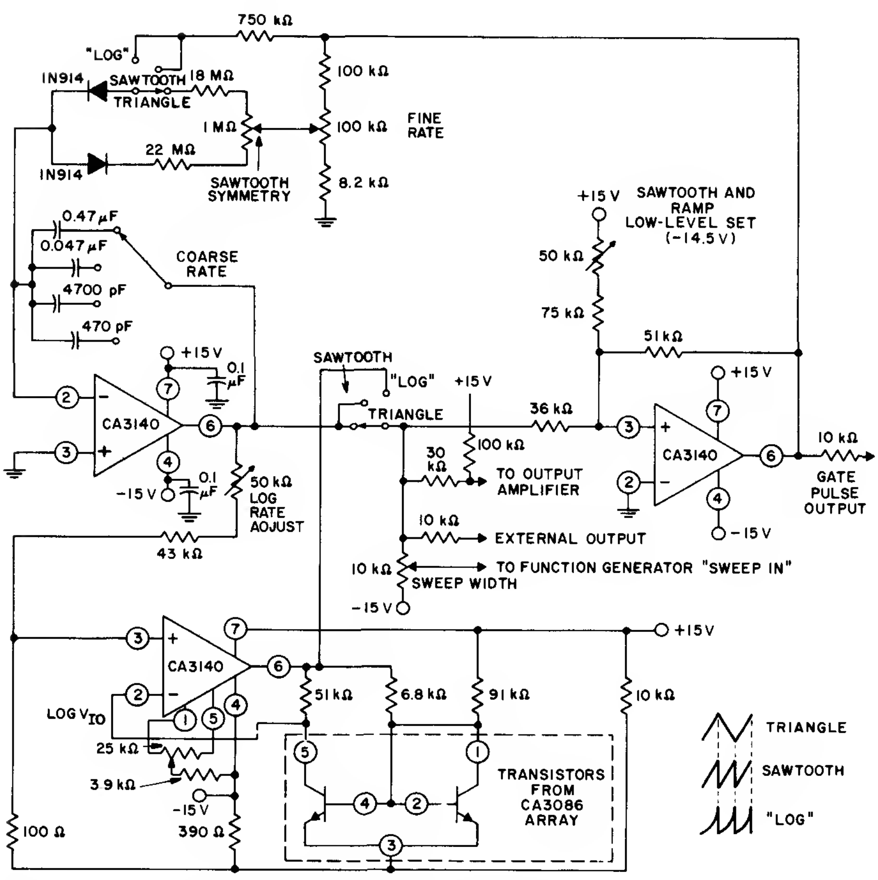
CAPACITANCE	*FREQUENCY RANGE*
C1 0.4 μF	0.5 – 1 kHz
C2 0.2 μF	1 – 2 kHz
C3 0.1 μF	2 – 4 kHz
C4 .05 μF	4 – 8 kHz
C5 .025 μF	8 – 16 kHz
C6 .0125 μF	16 – 32 kHz
C7 .0062 μF	32 – 64 kHz
C8 .0033 μF	64 – 130 kHz
C9 .00125 μF	0.15 – 0.3 MHz
C10 620 pF	0.3 – 0.6 MHz
C11 300 pF	0.6 – 1.2 MHz
C12 150 pF	1.2 – 2.4 MHz
C13 75 pF	2.4 – 5 MHz
C14 33 pF	5 – 10 MHz
C15 15 pF	10 – 20 MHz



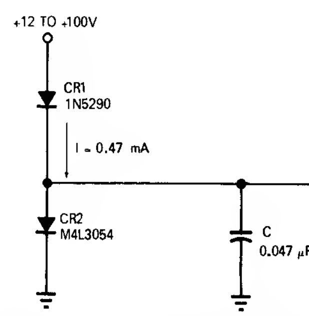
BIDIRECTIONAL RAMP—Originally used to vary reference voltage for DC servomotor to control acceleration and deceleration. R_2 and C_1 determine ramp rate, while R_1 controls ramp amplitude. With values shown, output takes 1 s to ramp from 0 to 10 V.—R. W. Currell, Linear Bidirectional Ramp Generator, *EDN/IEEE Magazine*, Nov. 1, 1971, p 50–51.

LINEAR RAMP—Free-running ramp generator has excellent linearity and repetition rate independent of supply voltage. C_2 is charged at constant current through Q_1 and is discharged by Q_2. R_2 provides sync pulse during retrace. Repetition rate of ramp is controlled by R_3, from about 100 to 4000 Hz. Output voltage is 10 V P-P, and sync pulse amplitude is 5 V P-P.—J. J. Nagle, Voltage Independent Ramp Generator, *CQ*, Sept. 1972, p 61 and 98.

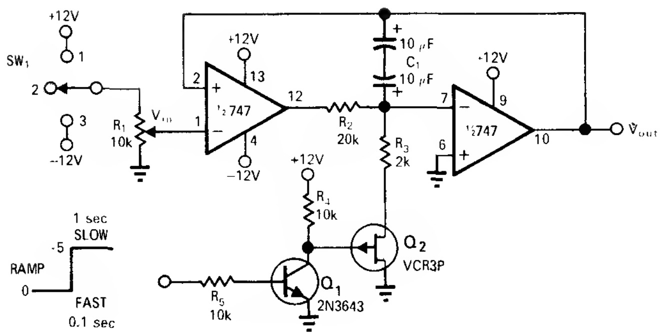




SWEEPING RAMP—Uses three CA3140 bipolar MOS opamps. One serves as integrator, another as hysteresis switch determining start and stop of sweep, and third as logarithmic shaping network for log function. Circuit generates rates and slopes as well as sawtooth, triangle, and logarithmic sweeps.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 7.

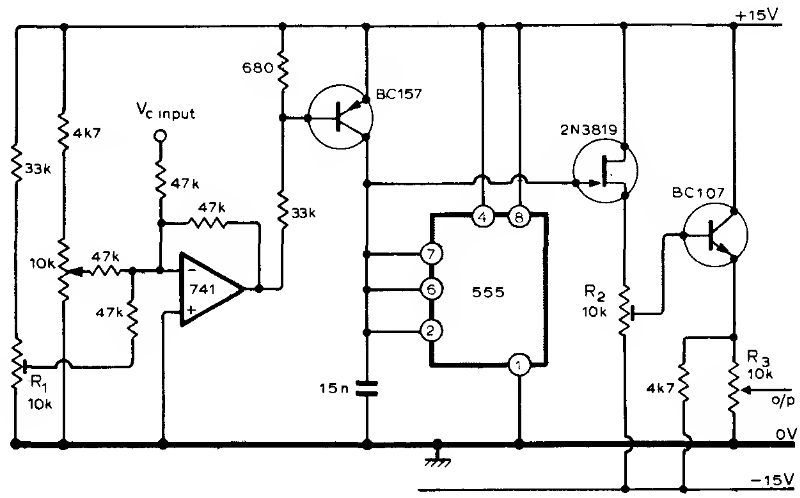


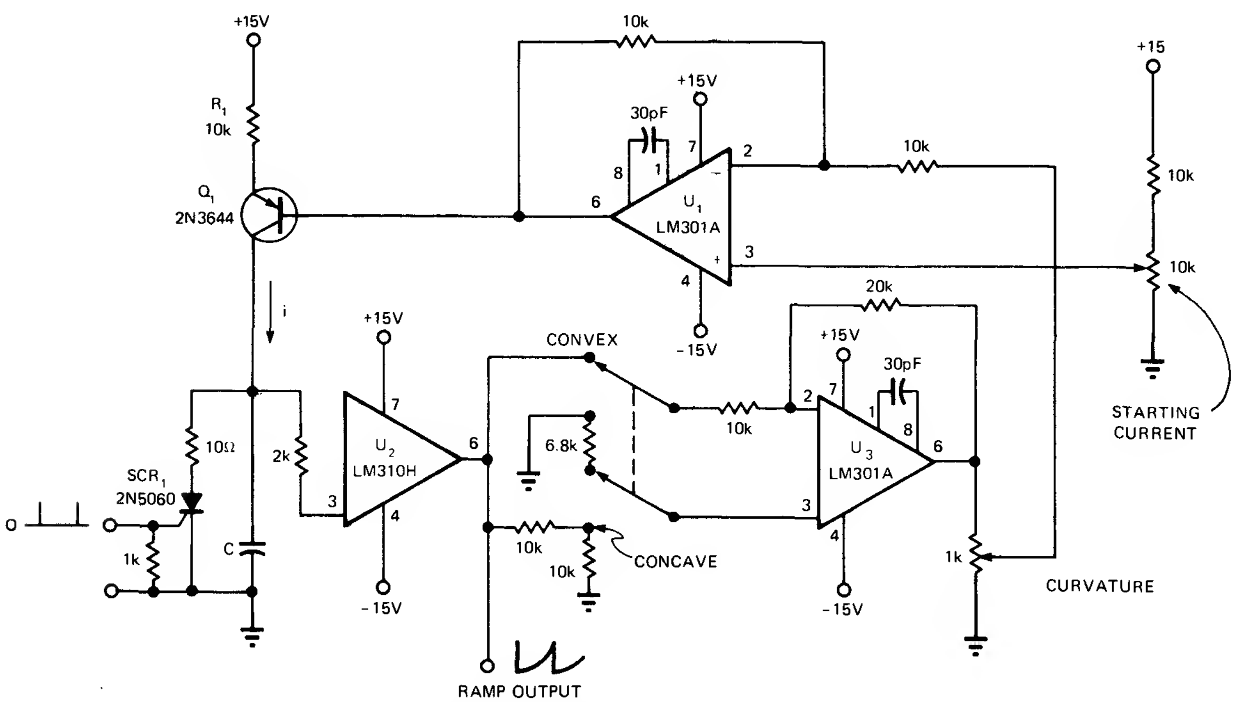
SIMPLEST SWEEP GENERATOR—Requires only constant-current generator CR1, Schottky diode CR2, and capacitor. Provides excellent linearity (0.07%) and stability over wide range of supply voltages and temperatures. Sweep rates as high as 100 kHz can be obtained by changing value of C. Article gives design equations.—D. R. Morgen, Sweep Generator Boasts Only Three Parts, *EDN Magazine*, Sept. 15, 1970, p 57.



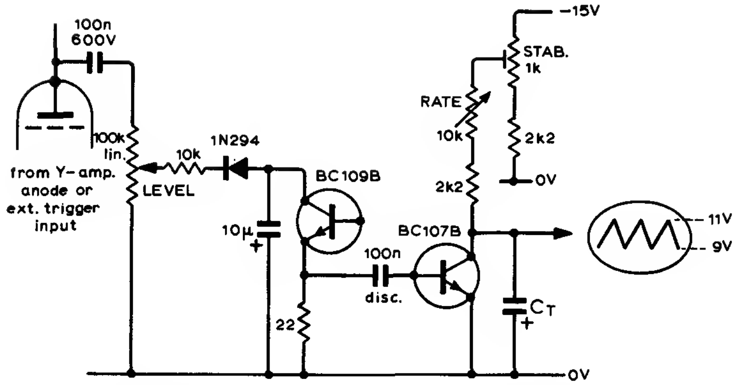
LOGIC-CONTROLLED RAMP RATE—Bidirectional linear ramp generator uses FET switch to slow ramp. With FET off, fast ramp has duration of 100 ms. With FET on, slow ramp is 1 s.—R. W. Currell, Linear Bidirectional Ramp Generator, *EDN/EEE Magazine*, Nov. 1, 1971, p 50–51.

0.2–20,000 Hz VOLTAGE-CONTROLLED RAMP—With values shown, frequency of ramp can be varied over range of about 20 kHz by changing DC input voltage. Lowest frequency is set by R_1. Adjust R_2 to make average output 0 V, and set desired output level with R_3. Uses 555 IC timer as astable MVBR, with charge current being supplied by transistor. Voltage/frequency relationship is logarithmic, making oscillator suitable for use in sound synthesizers.—J. L. Brice, Voltage-Controlled Ramp Generator, *Wireless World*, June 1976, p 72.

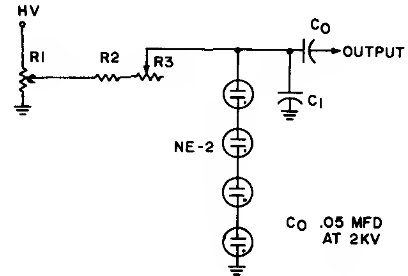




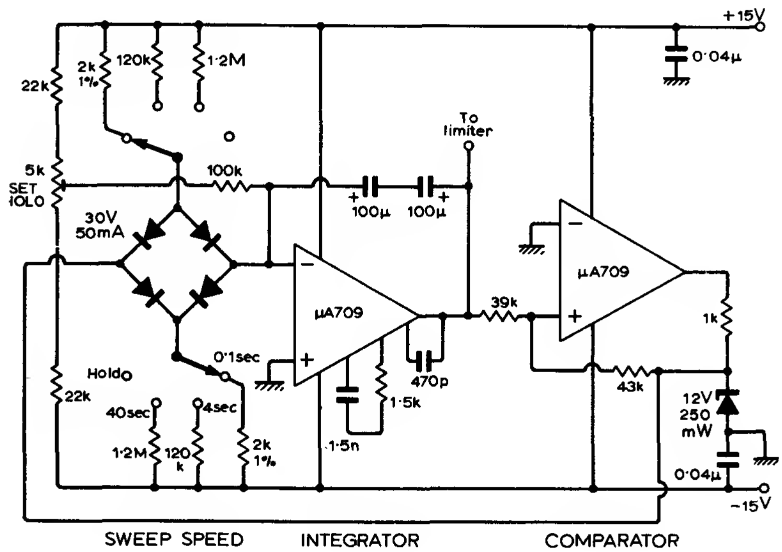
ADJUSTABLE NONLINEAR RAMP—Circuit provides predistortion of sweep with concavity or convexity as required to compensate for nonlinearity of circuit being driven. Q_1 operates as constant-current source that provides current proportional to voltage difference between ±15 V supply and base voltage of Q_1. Ramp output is linear when wiper of curvature pot is set to minimum position (ground). Period of ramp is same as that of trigger impulses that gate SCR on. Circuit uses DC coupling, avoiding need for large coupling capacitors. With 0.22 μF for C, period is 6 ms.—H. Olson, Ramp Generator Has Adjustable Nonlinearity, *EDN Magazine*, May 20, 1973, p 85 and 87.



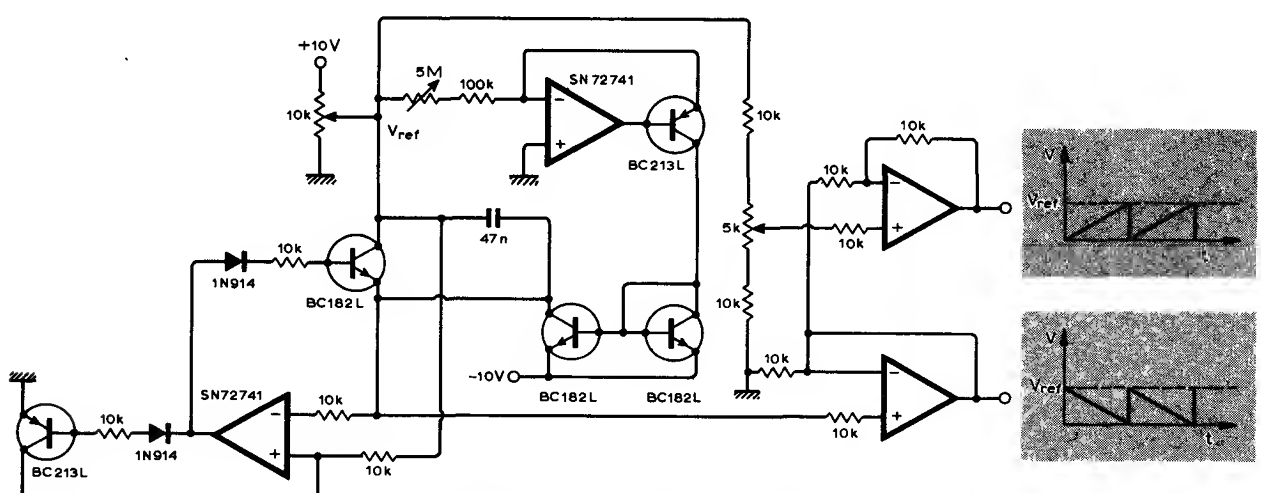
FAST-FLYBACK 2-V SAWTOOTH—Simple modern time-base circuit using transistors can be edded to old oscilloscopes that hava only e synchronized free-running sweep. Size of C_T determines sweep rate. When timing capacitor C_T charges to breakdown voltega of reverse-biased BC107B, capacitor is quickly discharged until voltage drops about 2 V end trensistor assumes its high-resistance stata again for start of next sweep.—K. Padmanebhen, Timebase Circuit, *Wireless World*, June 1974, p 196.



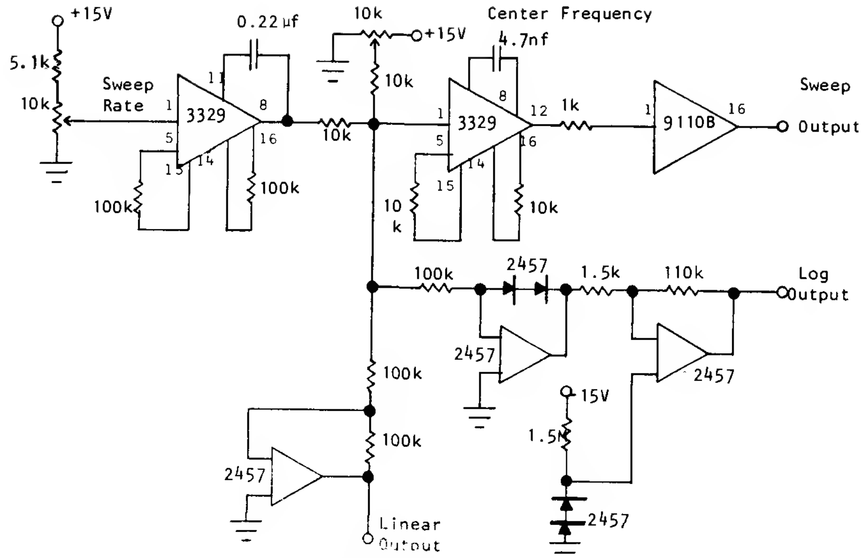
30-Hz SAWTOOTH—Uses neons as relaxetion oscillator for producing sawtooth wave raquired for monitor scope of SSB trensmitter. Rate et which C1 charges depends on its velue and those of R2 end R3. When C1 cherges to breekdown voltage of neon string, around 70 V per tube, neons fire end C1 discharges through them. C1 then starts cherging agein, to give sawtooth output. Voltage source should be about 500 VDC, and R1 at leest 500K. For greater sweep width, increese number of neons in series.—D. Schmarder, A Simple Sweep Generator for Monitor Scopes, *73 Magazine*, Feb. 1974, p 32.



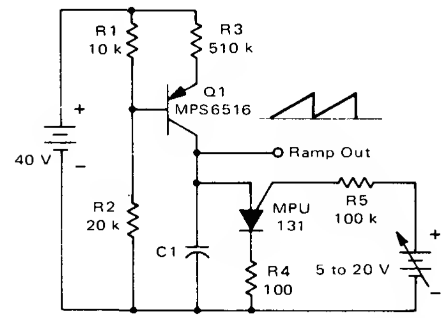
10 Hz–100 kHz RAMP—Uses Miller integretor switched at selected rate by IC comparetor in feedback loop. Remp circuit wes developed to drive FETs serving es voltage-dependant resistances in Wien-bridge oscillator of AF sweep generator. Article glves ell circuits end construction details. Sweep linearity is better then 15% for ell four renges, covarlng 10 Hz to 100 kHz. For graetest accurecy, use 40-s sweep tima; 4-s sweep is for long-persistance CRT, end 0.1-s sweep can be used only on upper three ranges.—F. H. Trist, Audio Sweep Generator, *Wireless World*, July 1971, p 335–338.



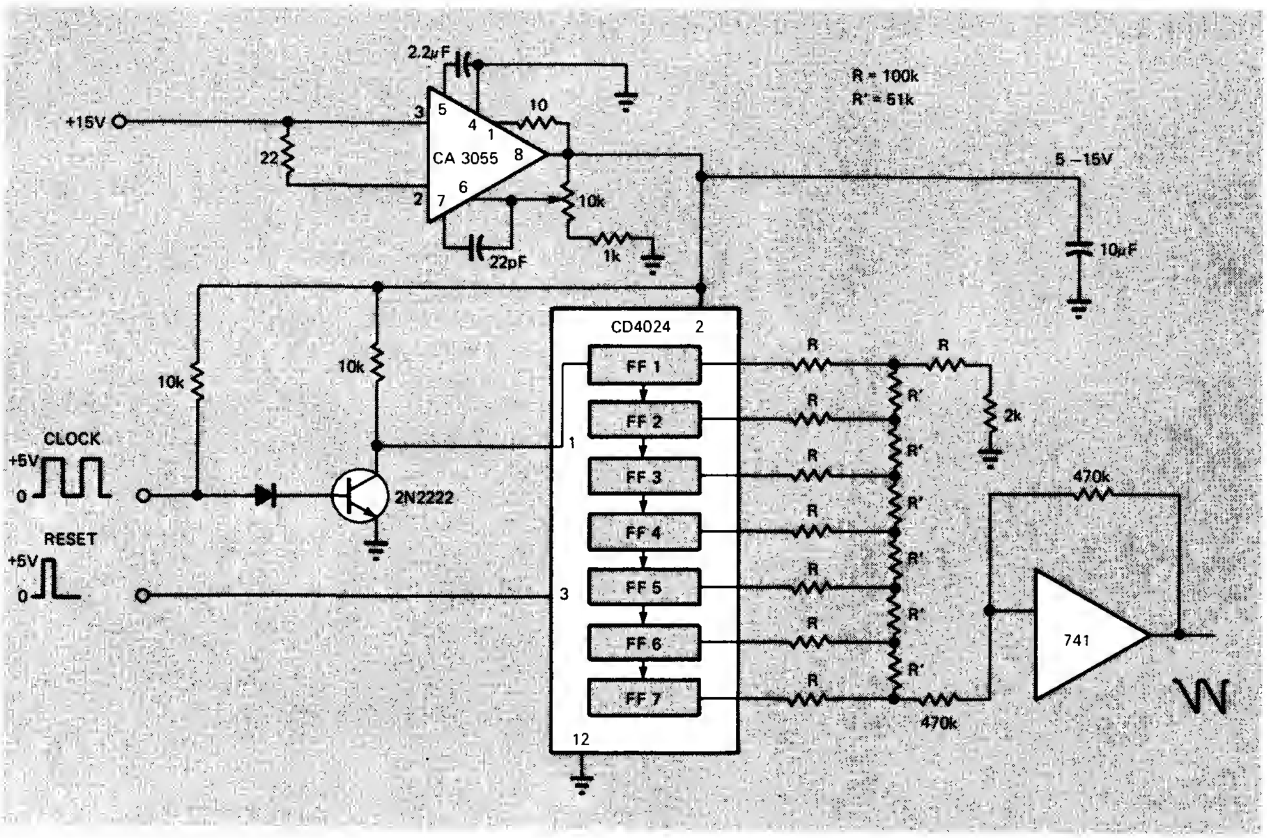
COMPLEMENTARY RAMPS—Opemp circuit provides Independent controls over emplitude end frequency, es required for amplitude-modulating euditory signels to either eer for creating Impression of left to right scan. High output impedance of ramps makes use of voltage follower output stage essentiel. Another opamp is used for inversion end level-shifting of complementary remp, so both remps ere avallable from very low impedence sources. Article describes circuit operetion in datail. For velues shown, ramp output is variable from 400 mV to 8 V, and ramp time from 50 ms to 2 s.—L. J. Retellack, Complementary Remp Generator with Independent Amplitude/Slope Control, *Wireless World*, Feb. 1975, p 94.



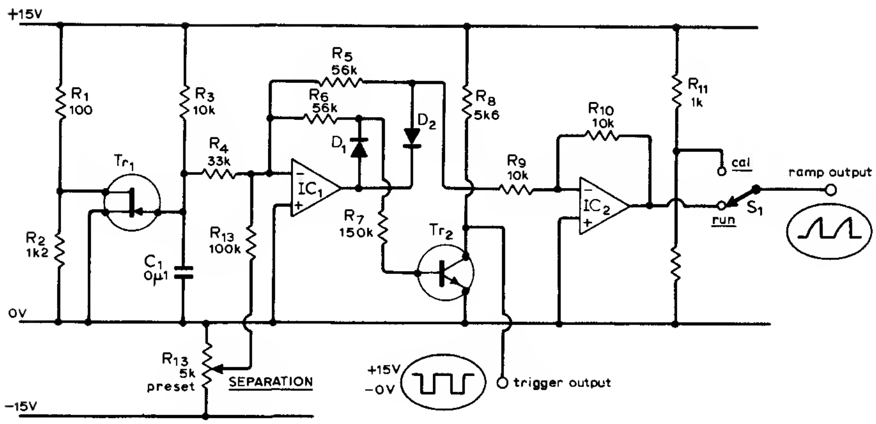
LIN/LOG SWEEP—Sweep rate and center frequency are adjustable in versatile sweep generator providing sweep-frequency output and both linear and logarithmic voltages representing output frequency. Optical Electronics 3329 voltage-to-frequency transducer generates sweep voltage at frequency determined by external resistors, capacitor, and input voltage from 10K pot. Sweep waveform is triangular; for sawtooth waveform, change one of 100K timing resistors to 10K. Second 3329 delivers frequency-varying sine wave to 9110B buffer. 10K pot determines center frequency. Stable log f output is obtained with 2457 log module. Frequency and sweep rates can be range-switched from DC to 100 kHz by changing timing capacitor.—"Improved Sweep Generator," Optical Electronics, Tucson, AZ, Application Tip 10209.



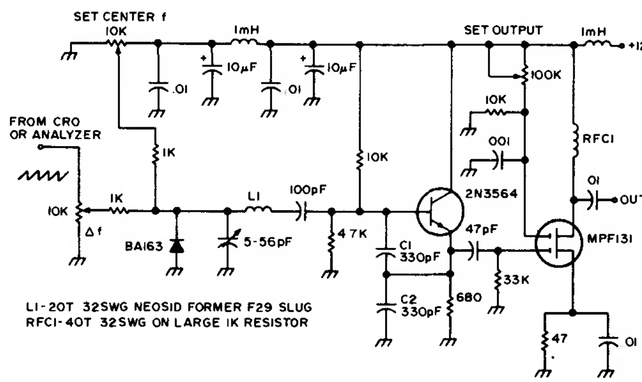
VOLTAGE-CONTROLLED RAMP—Current source Q1 and C1 together set duration time of ramp. As positive DC voltage at gate of MPU131 is increased, peak point firing voltage of PUT is changed and duration time is increased. With 0.01 μF, control voltage change from 5 V to 20 V increases duration time linearly from 2 ms to 7.2 ms.—R. J. Havar and B. C. Shinar, "Theory, Characteristics and Applications of the Programmable Unijunction Transistor," Motorola, Phoenix, AZ, 1974, AN-527, p 8.



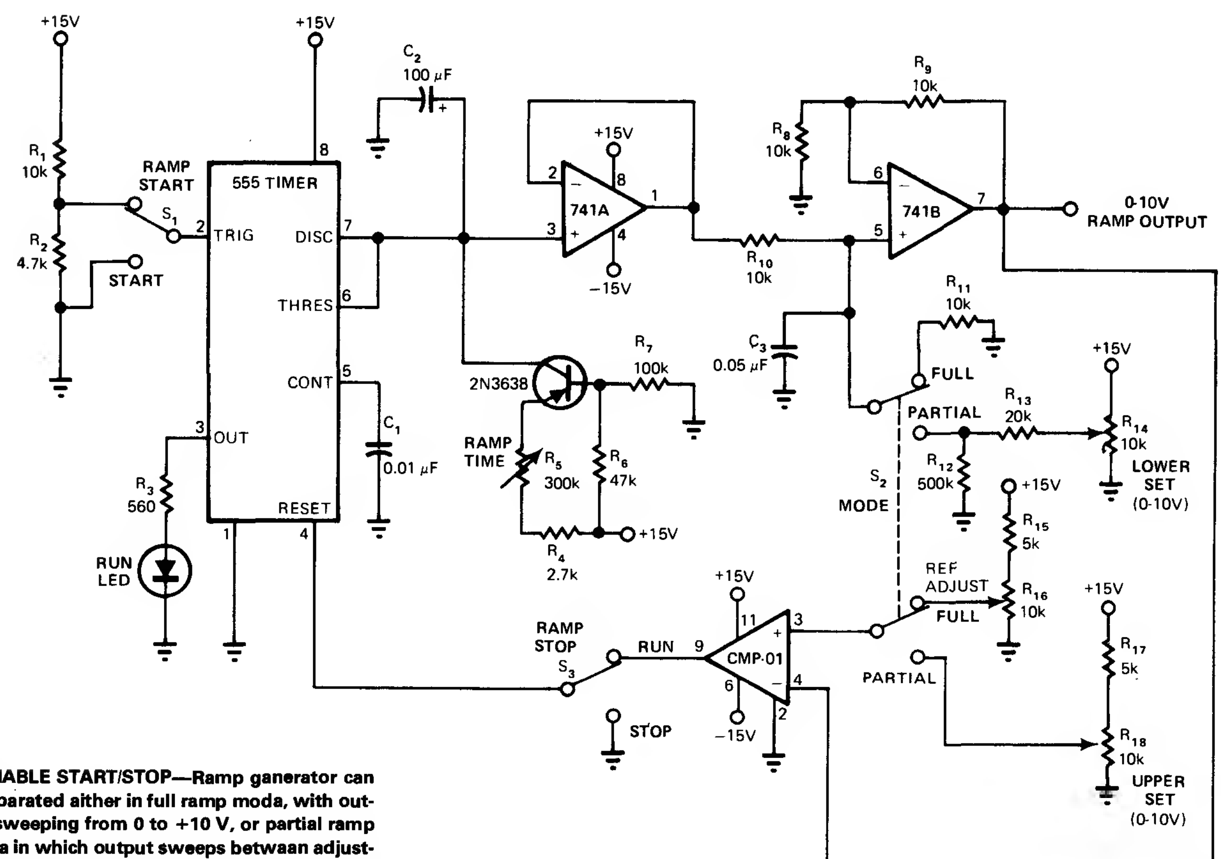
DIGITAL RAMP—Digital-to-analog technique using single CD4024A CMOS shift register eliminates temperature and linearity problems normally encountered when using RC circuit to drive VCO of digital ramp. Ramp is generated from 50-kHz clock and stopped by applying reset pulse to counters. Use of stable but variable supply for IC permits adjustment of ramp output amplitude. Ramp itself consists of large number of small steps; if these steps are too large, second CD4024A can be added and clock frequency increased. If response of 741 opamp is not adequate for very steep ramps, use opamp having higher slew rate.—K. Bower, CMOS Linear-Ramp Generator Has Amplitude Control, *EDN Magazine*, June 20, 1973, p 87.



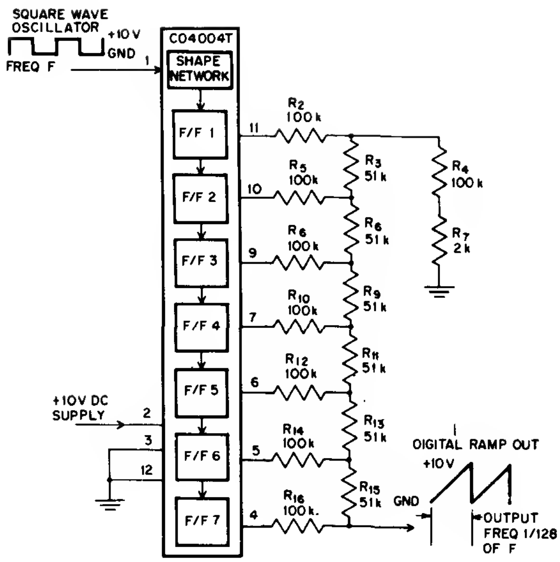
EXPONENTIAL RAMP—Used in curve trecer in which ramp does not need to be linear. Input UJT Tr_1 is Texas Instruments 43 or equivalent, ICs are SN72558P dual opamp or individual SN72741P opamps, and diodes are 1S44 or equivelent. Articla givas other circuits end calibration procedure.—L. G. Cuthbert, An F.E.T. Curva Tracar, *Wireless World*, April 1974, p 101–103.



10.7-MHz SWEEP GENERATOR—Cen be used with CRO for studying responsa of IF amplifier or filter. Greater dynamic range is obtalned by using with spectrum analyzer.—Circults, *73 Magazine*, Holidey issue 1976, p 170.

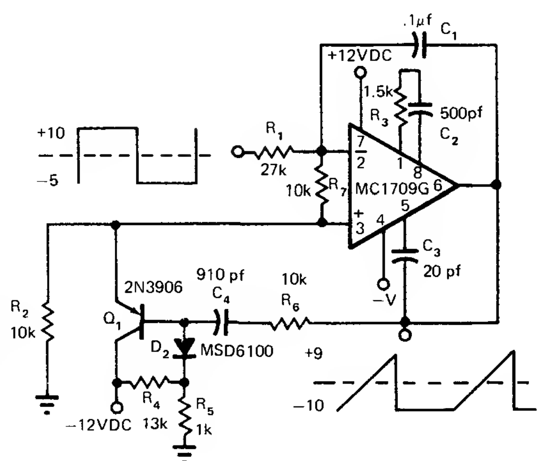


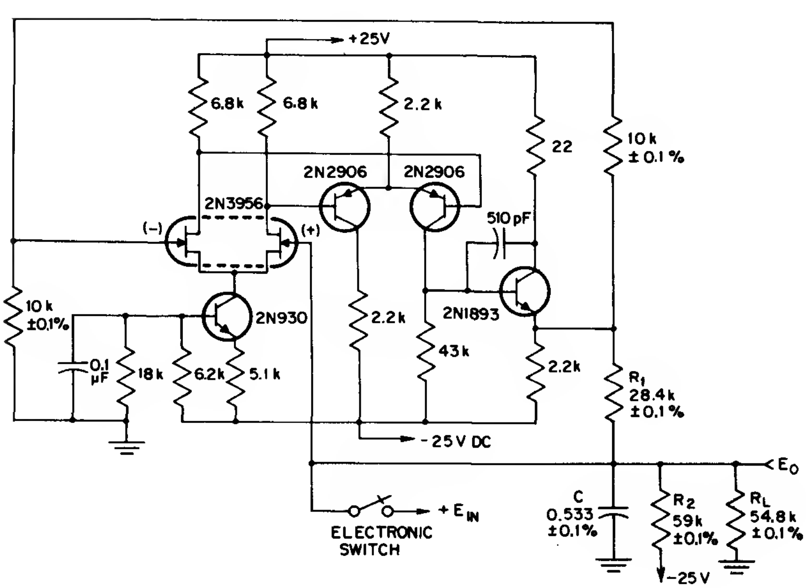
VARIABLE START/STOP—Ramp ganerator can be oparated aither in full ramp moda, with output sweeping from 0 to +10 V, or partial ramp moda in which output sweeps betwaan adjustable starting point end adjustable stopping point. R_5 selects time period in both modes. Remp is reset automatically whan output reachas preset voltage limit. Veluas shown for C_2 and R_5 give 100-s charge time, but changing R_5 to 1 megohm incraases charge period to 7 min. S_3 stops remp and resets circuit at any point In ramp cycla.—D. Dentuono, Ramp Generator Features Variable Start/Stop Points, *EDN Magazine*, April 20, 1978, p 130 and 132.



DIGITAL RAMP—RCA CD4004T IC, internally connected as ripple counter, provides flip-flop outputs corresponding to number of binary bits loaded into single input 1. Frequency range of counter is DC to 2.5 MHz, making it ideal for low-frequency operation. With R-2R ladder connected to flip-flop outputs, input square wave gives digitally stepped ramp at ladder output, with ramp frequency equal to 1/128 of input frequency.—W. E. Peterson, Digital Ramp Generator, *EEE Magazine,* Jan. 1971, p 64–65.

RAMP FROM −10 V—Based on use of integrating opamp to generate triangle wave from square wave. Circuit goes one step further by converting triangle to ramp function having predetermined negative starting level of −10 V. When square-wave input signal changes in polarity from positive to negative, output of circuit begins to go positive as ramp function and C_4 charges with output voltage. When input changes from negative to positive and output begins to go negative, Q_1 conducts and drives noninverting input of opamp negative. Since square-wave input is positive at this time, opamp output is forced to go negative at its slew rate. Output then remains negative until square-wave input switches in negative direction for repeating cycle.—L. Wing, Op Amp and One Transistor Produce Ramp Function, *EDN Magazine,* Nov. 15, 1972, p 49.

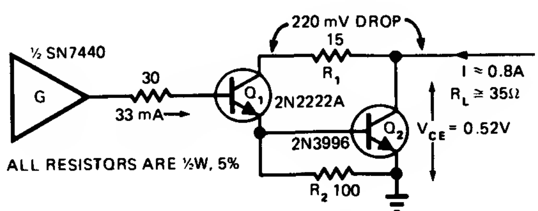




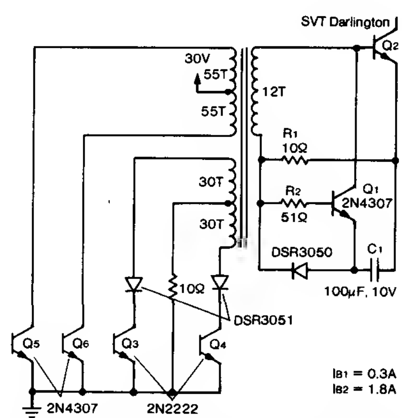
ULTRALINEAR SWEEP—Designed to generate horizontal and vertical sweep signals for military radar system. Linearity was so good that deviations could not be measured. With E_{in} positive as shown, circuit gives negative-going sweep. Reverse input polarity to get positive-going sweep. Circuit is immune to short-circuits.—R. C. Scheerar, Designing Linear Sweep Generators, *EDN/EEE Magazine,* July 1, 1971, p 39–42.

CHAPTER 87
Switching Circuits

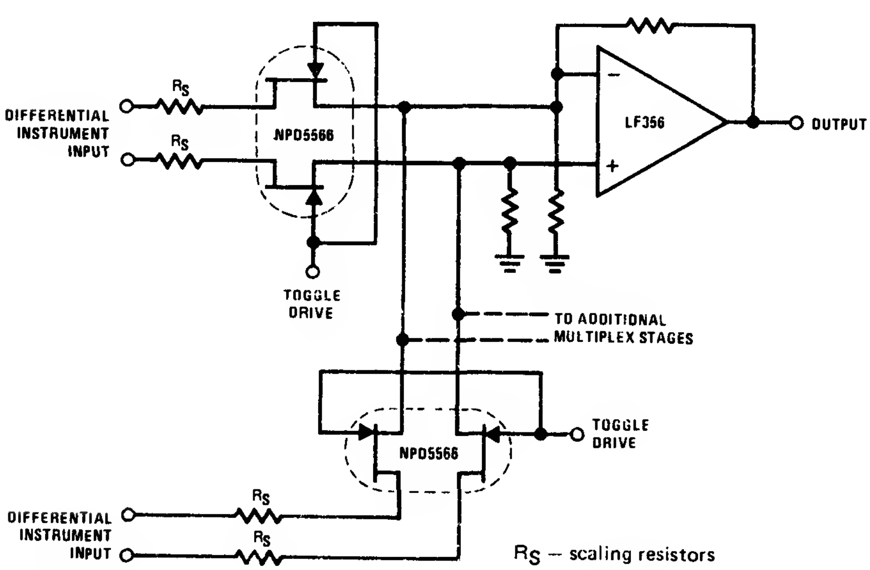
Includes circuits using switching opamps, switching transistors, analog-switch ICs, and other devices under control of logic or other input signals to provide solid-state SPST, SPDT, or DPDT switching functions for RF and AF signals.



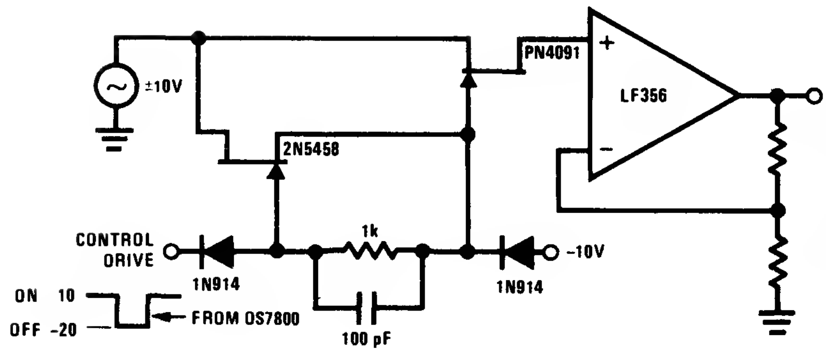
FAST ON AND OFF—Driver Q_1 is low-power device with fast switching time, while power transistor Q_2 handles power dissipation and amperes of current being switched. Used in TTL circuits requiring fast solid-state switches having known and repeatable switching times. Current reaches maximum in about 50 ns.—C. Venditti, Fast Power Switch Self-Corrects for Degradation, *EDN Magazine*, Jan. 20, 1975, p 59–60.



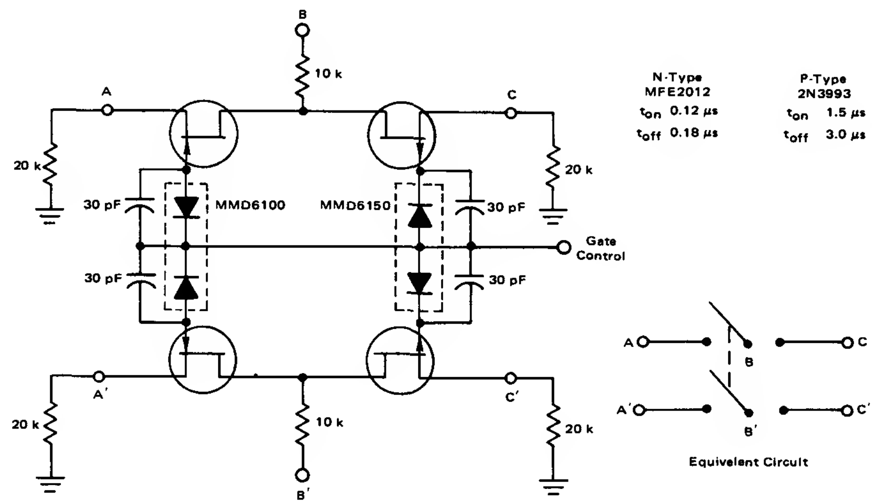
TRANSFORMER DRIVE FOR SWITCHING TRANSISTOR—Transformer provides isolated base drive for high-speed high-power TRW SVT6062 power Darlington Q_2. When 12-V secondary switches positive, C_1 charges rapidly, after which base drive current is maintained at level determined by base-emitter voltage of Q_2 and value of R_1. During turnoff, transformer secondary goes to zero due to shorting of transformer primary by Q_3 and Q_4. Base of Q_1 is then forward-biased by capacitor and turned on, discharging C_1 through base-emitter path of Q_2.—D. Roark, "Base Drive Considerations in High Power Switching Transistors," TRW Power Semiconductors, Lawndale, CA, 1975, Application Note No. 120, p 6.



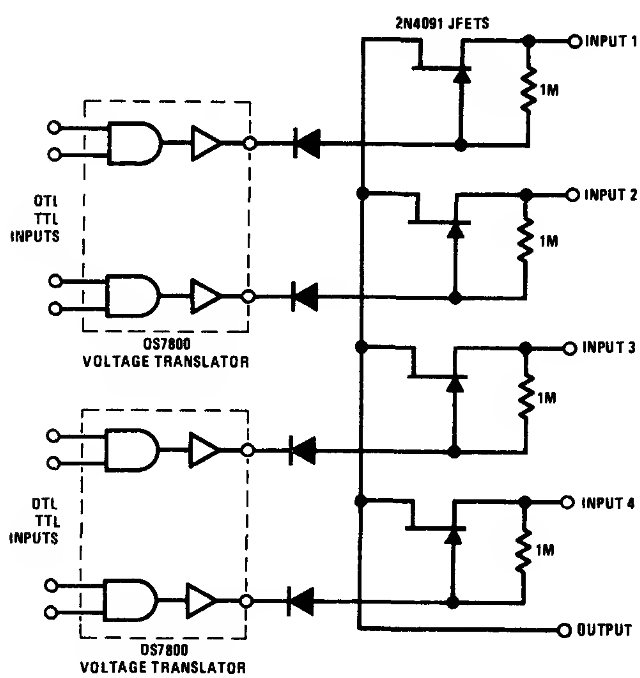
DIFFERENTIAL ANALOG SWITCH—NPD5566 dual JFETs provide high accuracy for differential multiplexer because JFET sections track at better than ±1% over wide temperature range. Close tracking reduces errors due to common-mode signals. Values of resistors depend on application and on type of opamp used.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



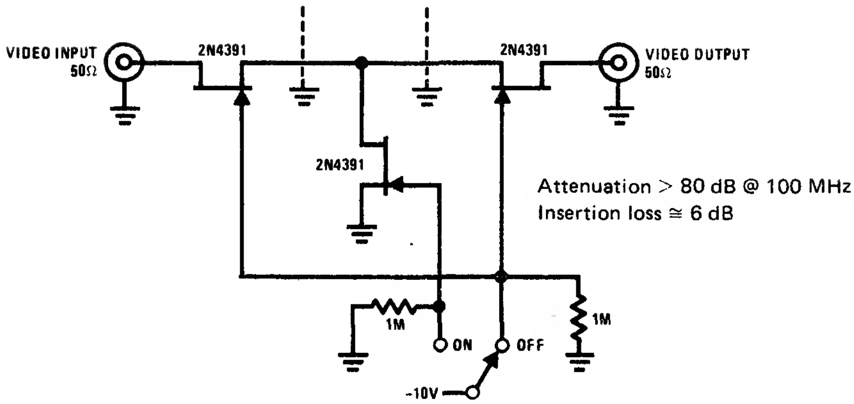
ANALOG WITH HIGH TOGGLE RATE—Simple commutator circuit provides low-impedance gate drive to PN4091 FET analog switch for both ON and OFF drive conditions. For high-frequency signal handling, circuit also approaches ideal gate drive conditions by providing low AC impedance for OFF drive and high AC impedance for ON drive.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



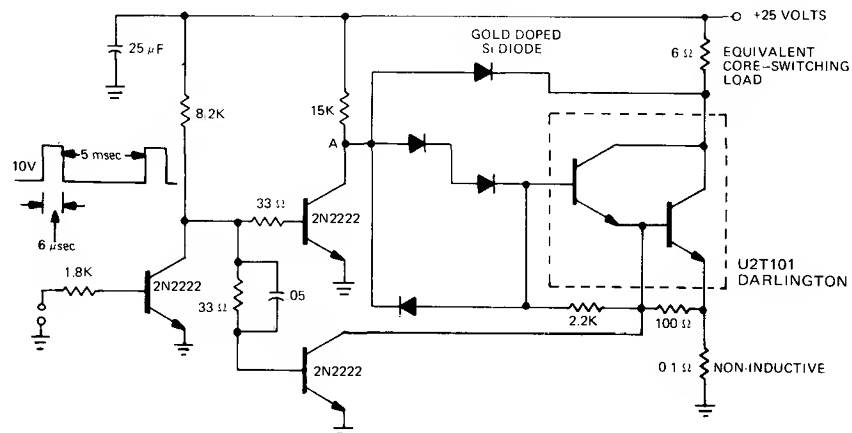
DPDT FET—With ON resistance of several ohms and OFF resistance of thousands of megohms, drain-source channel of field-effect transistor makes ideal low-frequency switch. Transistor capacitances are detrimental to high-frequency signal isolation and limit response times.—"Low Frequency Applications of Field-Effect Transistors," Motorola, Phoenix, AZ, 1976, AN-511A, p 5.



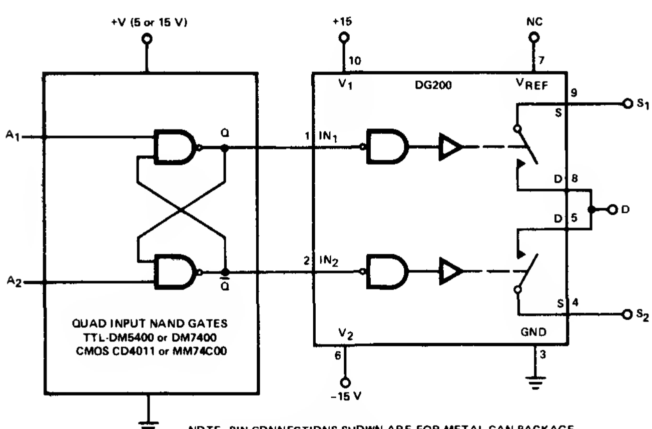
FOUR-CHANNEL COMMUTATOR—2N4091 JFETs give ON resistance of less than 30 ohms for each channel along with low OFF current leakage. DS7800 voltage translators provide gate drives of 10 V to −20 V for JFETs while giving DTL/TTL compatibility.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



VIDEO SWITCH—2N4391 FETs provide ON resistance of only 30 ohms end OFF impedence less then 0.2 pF, to give performance comperable to thet of ideal high-frequency switch. Attenuation is greater than 80 dB at 100 MHz. Insertion loss is ebout 6 dB.—"FET Databook," Nationel Semiconductor, Sente Clere, CA, 1977, p 6-26–6-36.



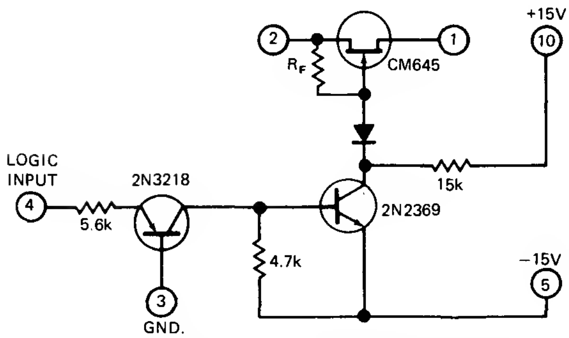
FERRITE-CORE SWITCHING—Darlington trensistor driven by low-power current stage serves for satureting groups of ferrite cores in phased erreys for radar systems or in read/write core switching for memory systems. Circuit provides fest rise and fell times.—"Designer's Guide to Power Derlingtons es Switching Devices," Unitrode, Watertown, MA, 1975, U-70, p 4.



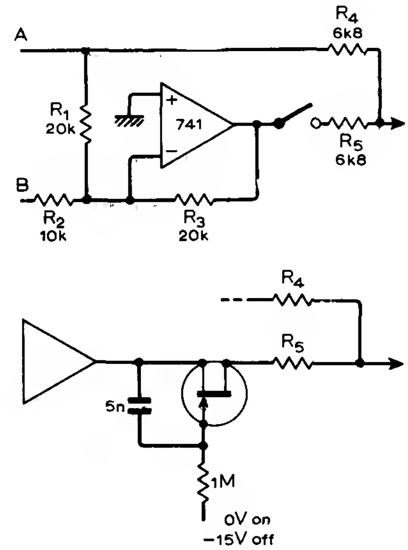
TRUTH TABLE

COMMAND		STATE OF SWITCHES AFTER COMMAND	
A_2	A_1	S_2	S_1
0	0 (normal)	same	same
0	1	OFF	ON
1	0	ON	OFF
1	1	INDETERMINATE	

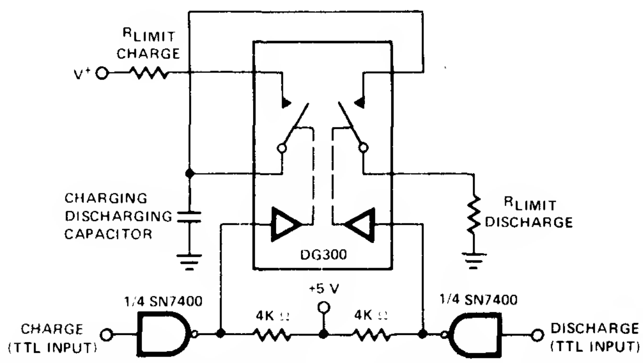
LATCHING SPDT—DG200 CMOS analog switch is driven through peir of NAND getes connected for logic inputs. With inputs normelly low, both switches ere held in predetermined statas. When either input receives high command pulsa, switches essume statas givan in truth table. Both switches ere off whan both inputs era held high; after releasa of high commands, last input to go low determines stetes of switches.—"Anelog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-69.



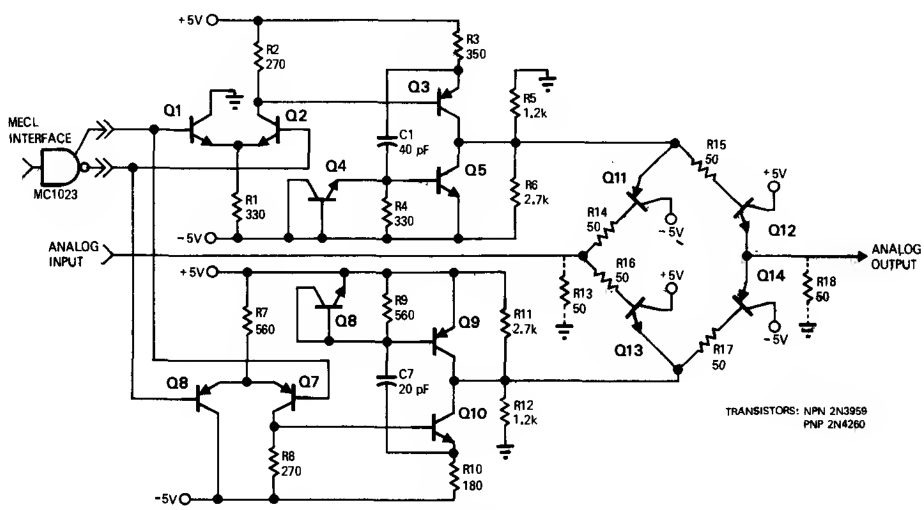
FET ANALOG SWITCH—Simple level-shifting driver provides analog switching. Input of logic 1 makes emitter and collector current flow in input PNP transistor, for shifting from logic to −15 V. This current makes NPN transistor turn on so its collector is −15 V, diode is forward-biased, and FET gate is about −14.3 V. At logic 0, both transistors are off and driver output is at +15 V. Diode is now reverse-biased, turning FET on to provide desired switching action between outputs 1 and 2.—J. Cohen, Solid-State Signal Switching: It's Getting Better All the Time, *EDN Magazine*, Nov. 15, 1972, p 22–28.



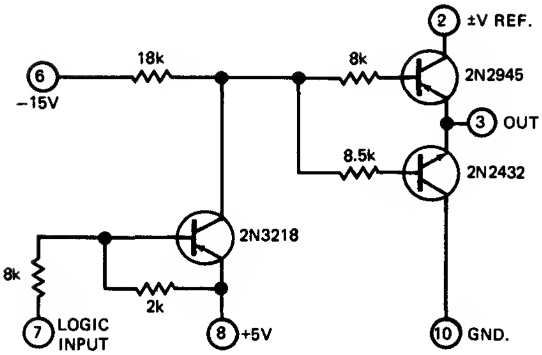
SWITCHING OPAMP—Circuit provides changeover function when only single pair of contacts is available. With switch open, input A goes to output. With switch closed, input B goes to output and signal of input A is inverted by opamp so as to cancel direct signal A. Gain is unity for both output signals. Switch can be replaced by FET as in lower diagram; here, capacitor prevents FET from cutting off during positive half-cycle above about 100 Hz. In multichangeover applications, opamp could be section of programmable opamp.—M. J. Sells, Electronic Changeover Switching, *Wireless World*, Dec. 1974, p 503.



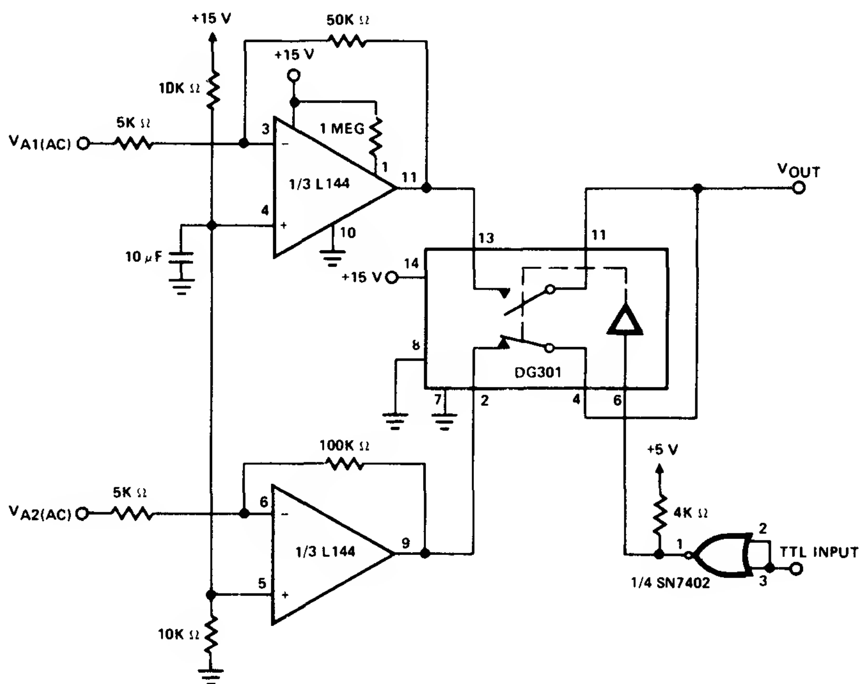
ANALOG SWITCH PROTECTION—Current-limiting resistors are used in series with sections of DG300 dual analog switch to limit contact currents to 30 mA continuous or 100 mA pulsed for less than 1 ms. Values of limiting resistors depend on supply voltage used and are therefore determined by experimentation. Technique is suitable for applications in which DG300 serves for charging and discharging capacitor.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-81.



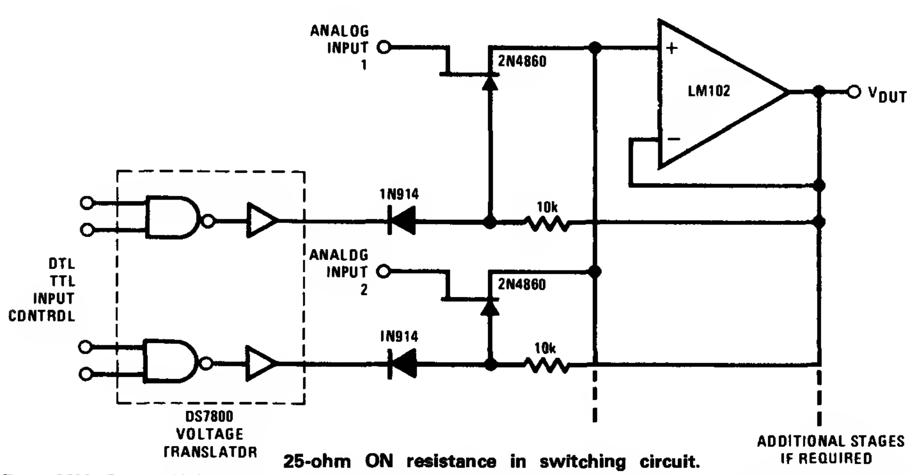
DIAMOND-BRIDGE ANALOG SWITCH—Analog signals up to 3 V P-P are switched in less than 3 ns to meet requirements of multiplexer and sample-and-hold portions of 100 Mb/s PCM telemetry encoder. Symmetrical drive circuits turn four-transistor diamond bridge on and off at 20-MHz clock frequency. Transient-coupled pullback transistors Q5 and Q9 speed turnoff. Typical rise time is 1.5 ns and fall time is 2 ns for 1-VDC analog input.—W. A. Vincent, Diamond Bridge Improves Analog Switching, *EDN Magazine*, Feb. 15, 1971, p 41–42.



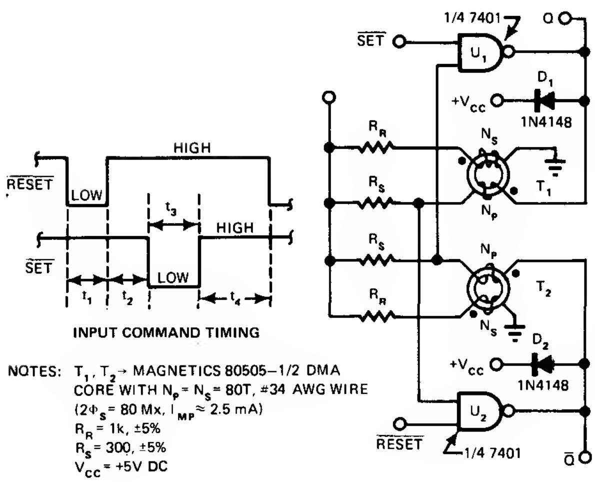
AC SPDT—Complemantary NPN and PNP trensistors provida single-pola double-throw switching ection for AC signels, as required In some digitel-to-analog converter applications. Circuit switches between ground and signals of up to ±5 V. Output transistor pair will toggle with unipolar drive.—J. Cohen, Solid-State Signal Switching: It's Getting Better All the Tima, *EDN Magazine,* Nov. 15, 1972, p 22–28.



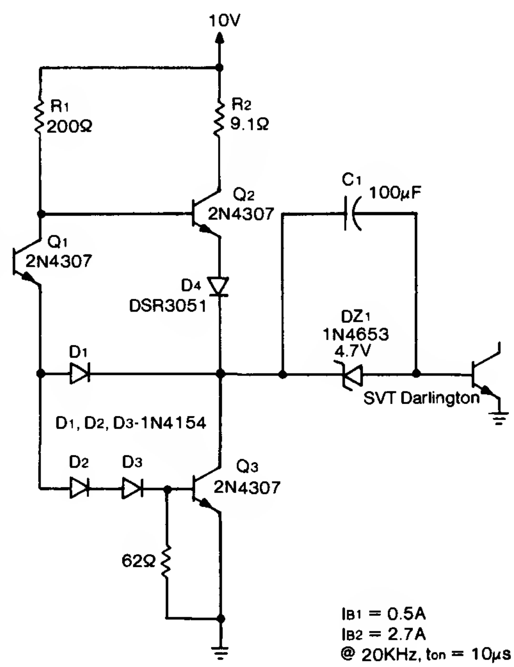
SWITCHING SINGLE-SUPPLY OPAMPS—DG301 low-power analog switch serves es interface between TTL control Input end DC-coupled opamp pair. Logic level determines which opamp Is connacted to singla output.—"Anelog Switches end Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-88–7-89.



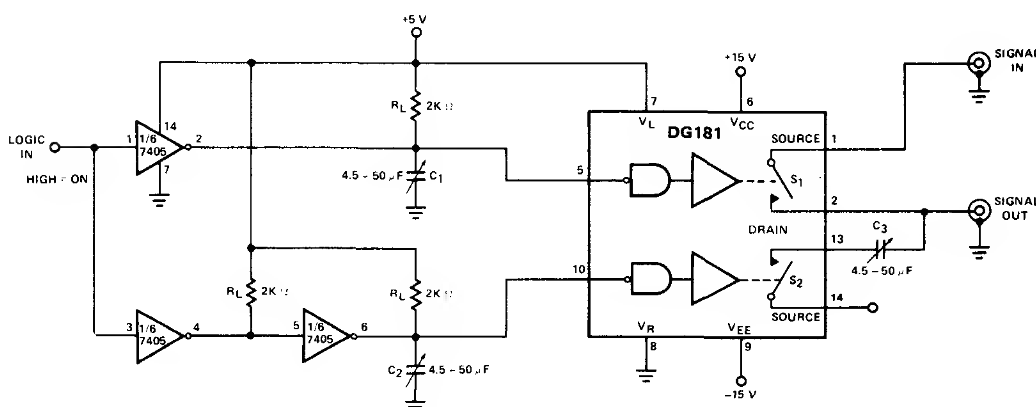
LOGIC-CONTROLLED ANALOG SWITCH—2N4860 JFETs were chosen for low leakage and 25-ohm ON resistance in switching circuit. LM102 opamp serves es voltage buffer. DS7800 IC provides switch drive undar control of DTL or TTL levels.—"FET Databook," National Samiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



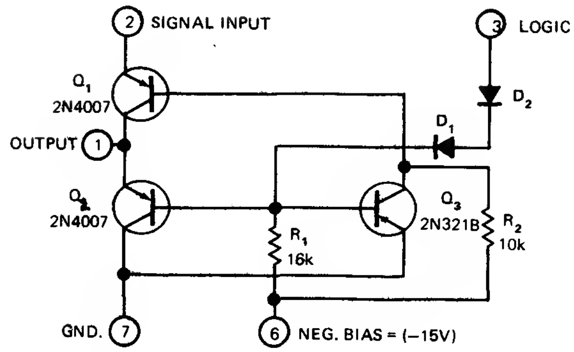
NONVOLATILE LATCH—Design shown for latch gives immunity to interfering noiss pulses on commend line and prevents loss of essential date bit during unexpected power-line interruption. Subminiature sstureble transformers in positive feedback patha between two gatea of latch prevent instantaneous change of state. Transformers remain msgnatically biased in positive or negative saturation even without circuit power, to provide pretransient-stets reference to which latch must return whsn power is reapplied.—G. E. Bloom, Add Nonvolatility to Your Next Latch Design, *EDN Magazine*, Jan. 5, 1978, p 80 end 82.



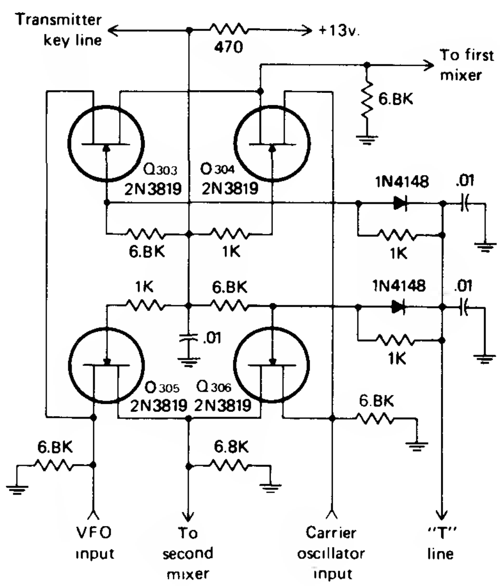
CAPACITOR-COUPLED DRIVE FOR SWITCHING TRANSISTOR—TRW SVT6062 power Derlington switching transistor is used in grounded-emitter connection in which negative biss required for turnoff is created by chsrging C_1 during ON intervel. Zensr limits chsrge on C_1 end provides psth for bsse drive current to Derlington. Diodes give faster response to input signel by preventing Q_3 from saturating. Grounding base of Q_1 mskss Dsrlington conduct, wheress high input level to Q_1 initistes turnoff. Circuit will operste st pulse widths down to 5 μs.—D. Roark, "Base Drive Consideretions in High Power Switching Transistors," TRW Powsr Semiconductors, Lawndale, CA, 1975, Application Note No. 120, p 7.



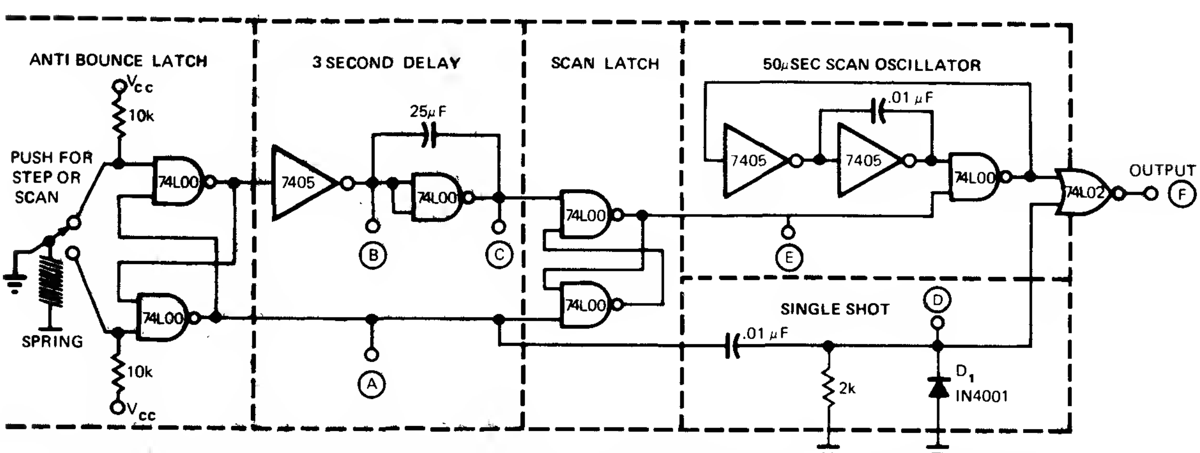
SYNCHRONIZED SWITCHING—Transients occurring during switching between two emplifier chsnnela sre attenuated by synchronizing turn-on of ons switch in DG181 JFET anslog swltch with tumoff of other switch. Switching ection is controlled by logic input.—"Analog Switches snd Thslr Applications," Siliconix, Senta Clars, CA, 1976, p 7-61.



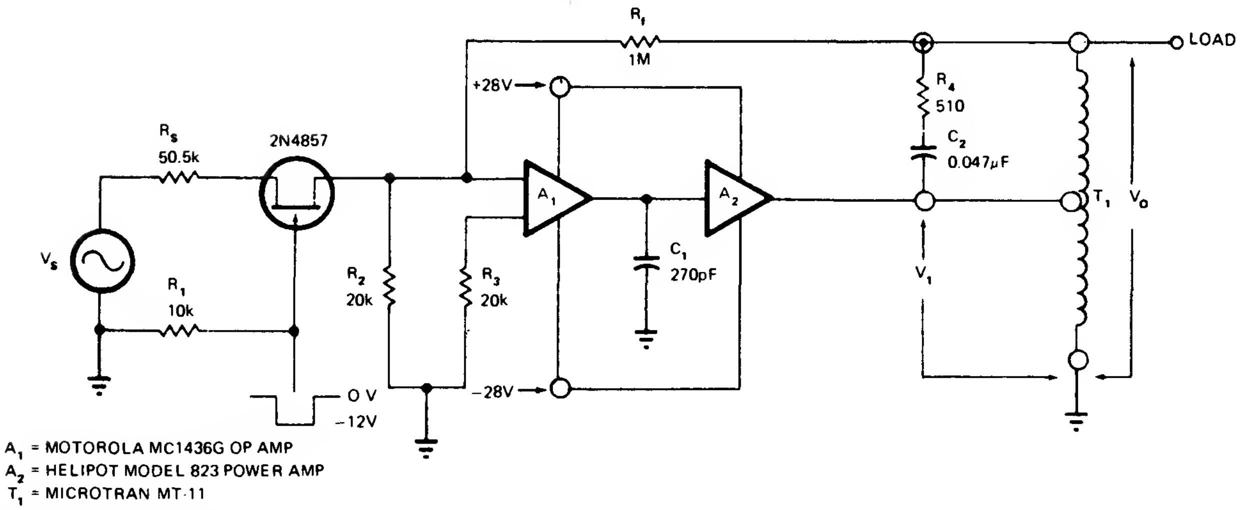
NEGATIVE SPDT—Developed for driving R/2R laddar network in D/A convarters. Signal input or refarence voltaga range ia 0 to −12 V. With logic 0, R_1 forward-biases Q_2 and Q_3; Q_2 then switches output to ground, and Q_3 clamps base of Q_1 to ground to keap it off. With logic 1, D_1 and D_2 conduct and make Q_1 switch on.—J. Cohen, Solid-State Signal Switching: It's Getting Bettar All the Tima, *EDN Magazine*, Nov. 15, 1972, p 22–28.



FET DPDT—Uses FETs as switching elements for transferring VFO and carrier oacillator aignala between first and second mixers of SSB transceiver. Transmitter key line is at +13 V on receive and 0 V on tranamit, and "T" line has opposite voltages. On receive, Q_{304} and Q_{305} are pinched off by about +10 V, while Q_{303} and Q_{306} are conducting with only about +0.7 V on their gates. VFO signal then flows to first mixer and carrier oscillator to second mixer. On transmit, conditions are opposite.—J. Schultz, CQ Reviews: The Atlas 210 and 215 SSB Tranaceivers, *CQ*, May 1975, p 22–27 and 65.



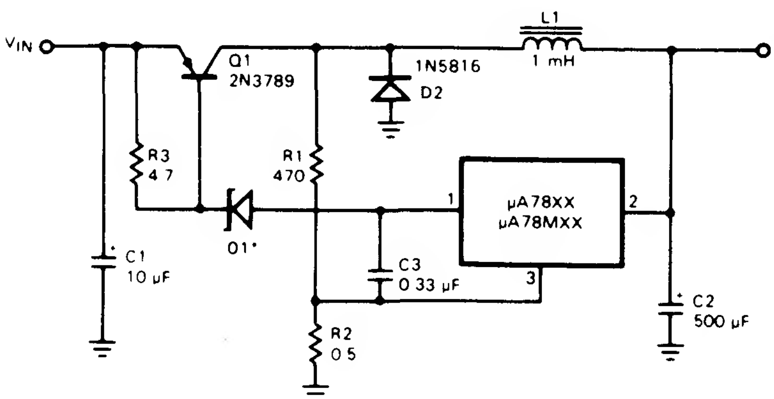
DUAL-FUNCTION SWITCH—Pressing switch for less than 3 s produces single output pulse about 5 µs wide. When switch Is presaed longer than 3 s, single pulse is generated as before, and scan oscillator is turned on 3 s later. Oscillator runs as long aa switch is held down, for producing repetitiva stepping motion. Applications include positioning of tast probas on single semiconductor chip or on wafer of several hundred chips, or indexing device either step by step or automatically through desired number of steps.—J. McDowell, Single Switch Controla Two Functiona, *EDN Magazine*, April 5, 1974, p 78 and 80.



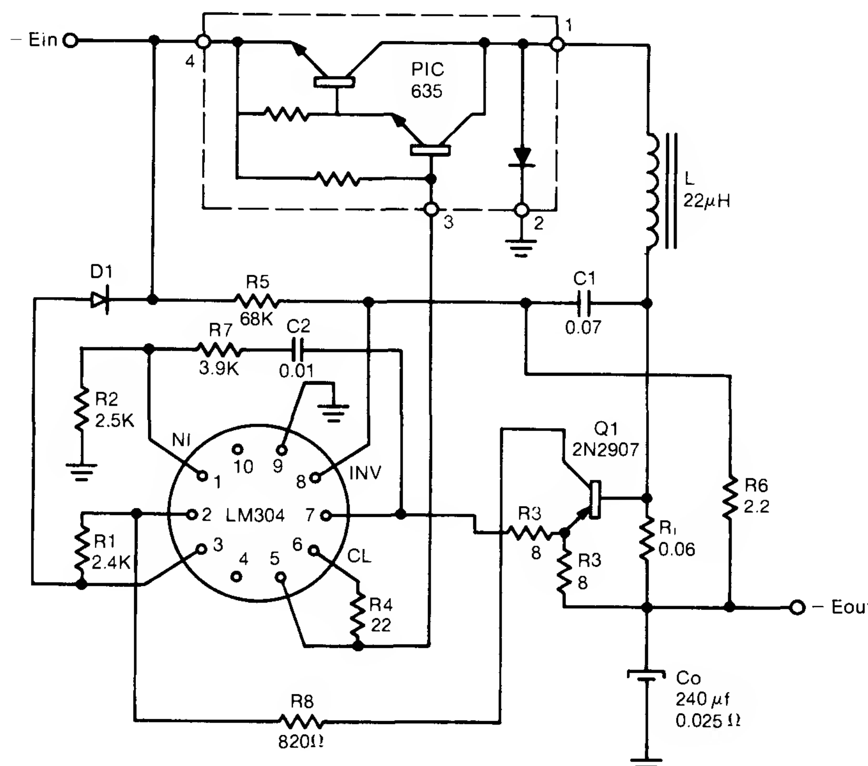
80-VRMS ANALOG SWITCH—Devaloped for switching high-leval analog signals with speed, accuracy, and reliability, for such applications as digital-to-synchro convarters. Feedback network stabilizes output against changes in circuit parametars. For AC signal inputs between ±10 V, −12 VDC on gate of FET blocks input channal and R_2 grounds inverting input of opamp A_1 to prevant noisa pickup and minimize voitaga offset. Grounding gata of FET tums on input channal; input signal is than amplifiad by A_1 and fed to unity-gain powar opamp A_2.—D. J. Musto, Analog Switch and IC Amp Controls 80V RMS, *EDN Magazine,* Fab. 20, 1973, p 91–92.

CHAPTER 88
Switching Regulator Circuits

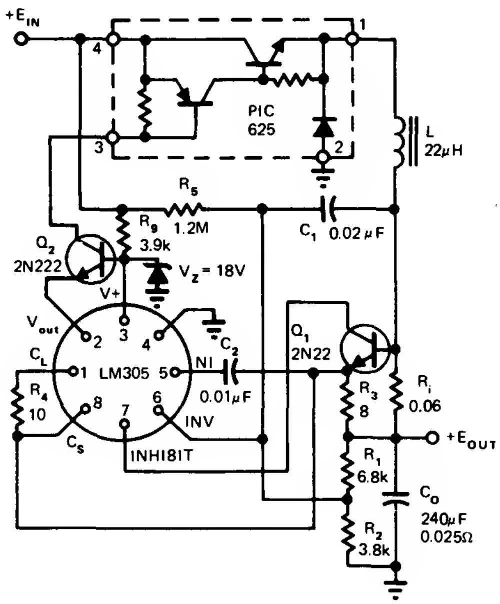
Covers regulators in which DC input voltage is converted to pulse-width-modulated frequency in range of 9–100 kHz, with duty cycle or frequency being varied automatically to maintain essentially constant output voltage at desired value. Circuit may use discrete components or switching-regulator IC.



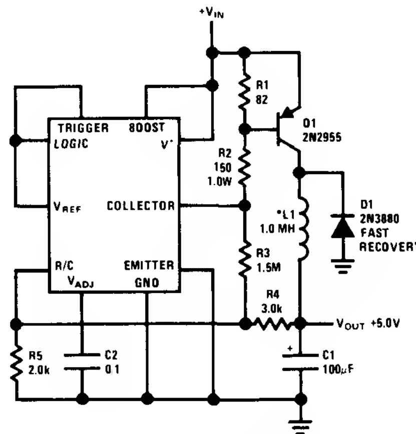
5–24 V SWITCHING—Choice of ragulator in µA7800 series determines fixed output voltaga. Davices are availabla for rated outputs of 5, 6, 8, 12, 15, 18, and 24 V, positiva or nagativa, with output currant ratings of 100 mA, 500 mA, or 1 A. If input voltege is greatar than maximum input rating of regulator uaed, add voltage-dropping zaner D1 to bring voltaga betwaan pins 1 and 3 down to acceptable level.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 668.



–5 V SWITCHING AT 10 A—Uses Unitrode PIC635 hybrid powar switch with LM304 regulator for switching speeds up to 100 kHz with input voltaga ranga of 20–40 V. Q1 providas current-limiting action.—"Switching Ragulator Design Guida," Unitroda, Watartown, MA, 1974, U-68A, p 9.

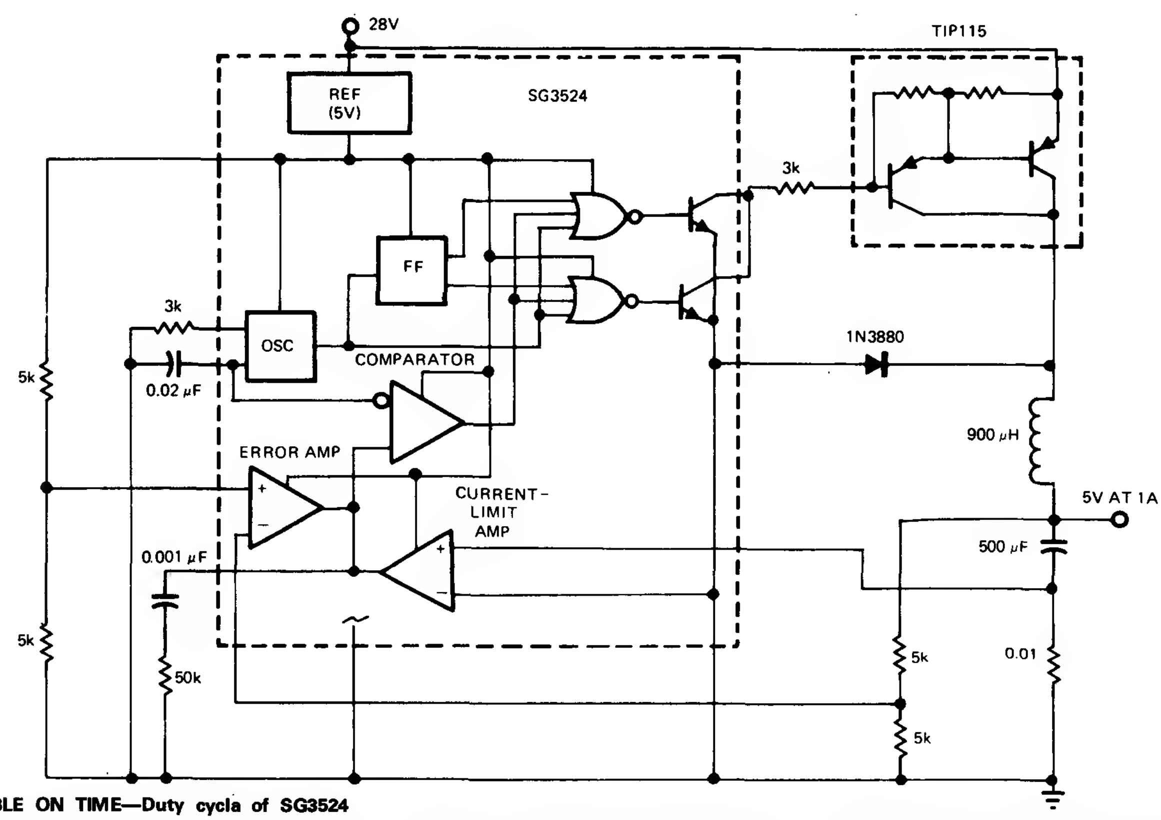


5-V FIXED OFF-TIME SWITCHING—Uses LM305 regulator end Unitrode hybrid power switch in PIC600 series. Operates in fixed OFF-time moda. Output ripple of 100 mV P-P Is independent of input voltage range of 20 to 40 V for output of +5 V ± 1%. Switching speed is nominelly 50 kHz but can go up to 100 kHz. Article covers theory of operation in deteil.—L. Dixon and R. Petel, Designers' Guide to: Switching Regulators, *EDN Magazine*, Oct. 20, 1974, p 53–59.

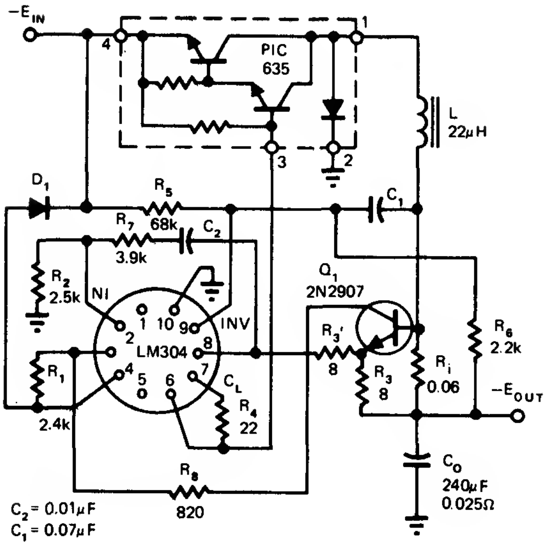


*NO. 22 WIRE WOUND ON MOLYBDENUM PERMALLOY CORE

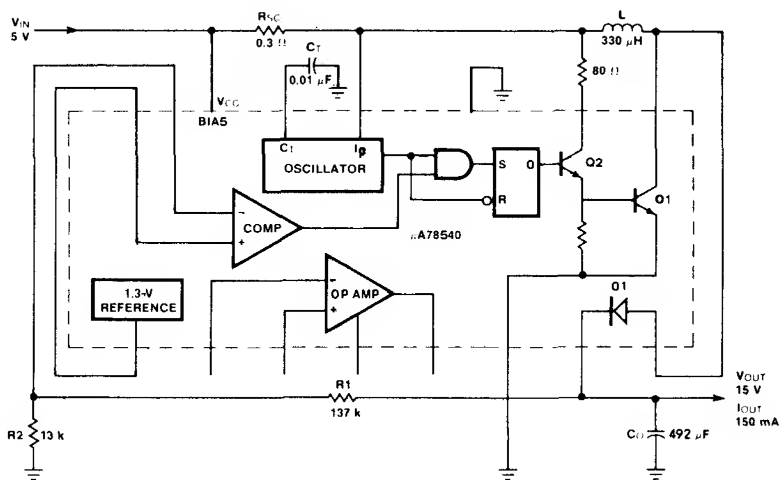
5 V AT 1 A—Nationel LM122 timer is connected as switching regulator by using internel reference and comparator to drive switching transistor Q1. Minimum input voitege Is 5.5 V. Lina end load regulation ere less than 0.5%, end output ripple at switching frequency is only 30 mV. Output voltage can be edjusted between 1 V end 30 V by using appropriate velues for R2-R5.—C. Nelson, "Versatile Timer Operetes from Microseconds to Hours," Netionel Semiconductor, Senta Clare, CA, 1973, AN-97, p 9.



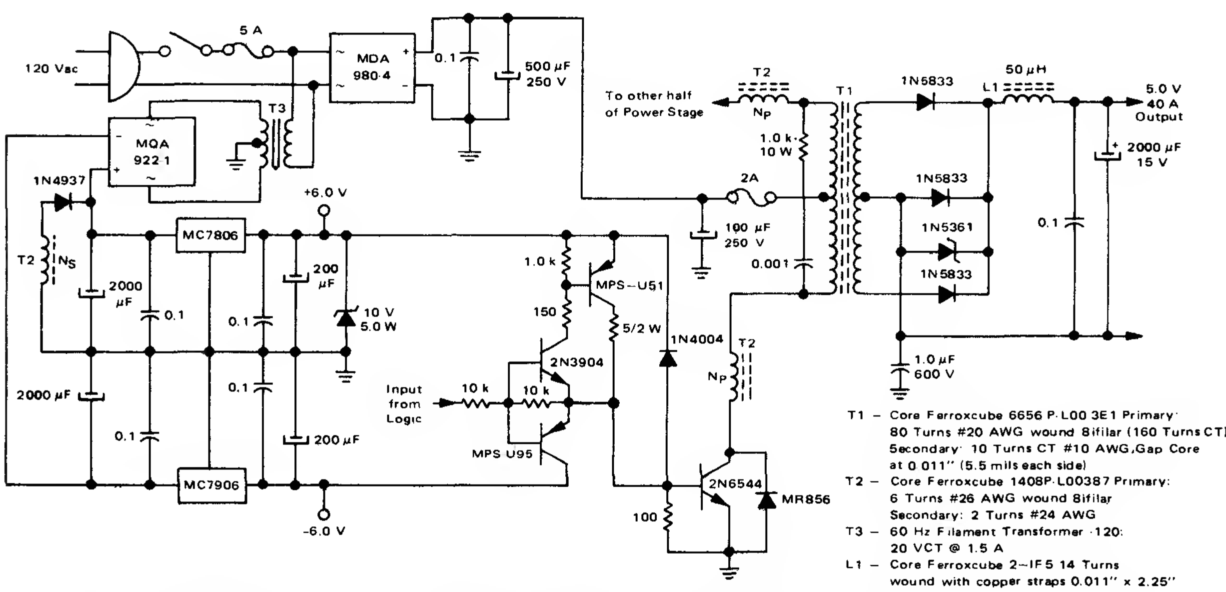
VARIABLE ON TIME—Duty cycla of SG3524 switching regulator is veried by modulating ON time while maintaining constant switching frequency, using pulse-duration-modulation control circuit.—J. Spencer, Monolithic Switching Regulators—They Fit Today's Powar-Supply Needs, *EDN Magazine*, Sept. 5, 1977, p 117–121.



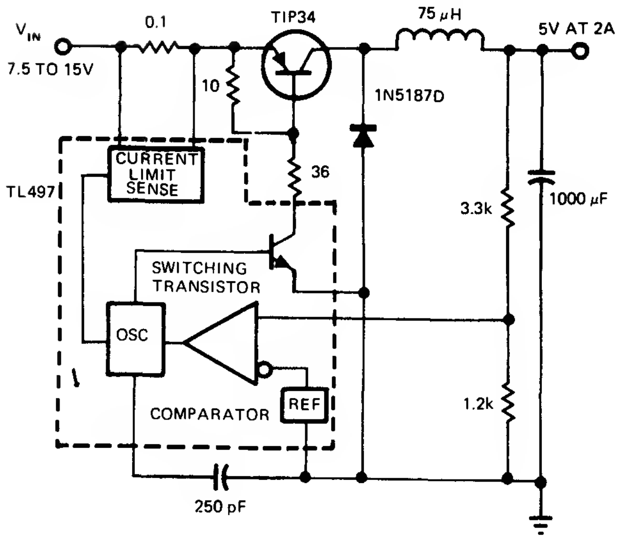
−10 V SWITCHING—Uses LM304 regulator and Unitroda hybrid power switch in PIC600 sarles to provida output of 10 A. R_1 and R_2 detarmina reference voltage. Current limiting is echieved by reducing reference voltage to ground instaad of turning off besa drive to powar output switch. Article covars operating theory.—L. Dixon and R. Patel, Dasigners' Guide to: Switching Regulators, *EDN Magazine*, Oct. 20, 1974, p 53–59.



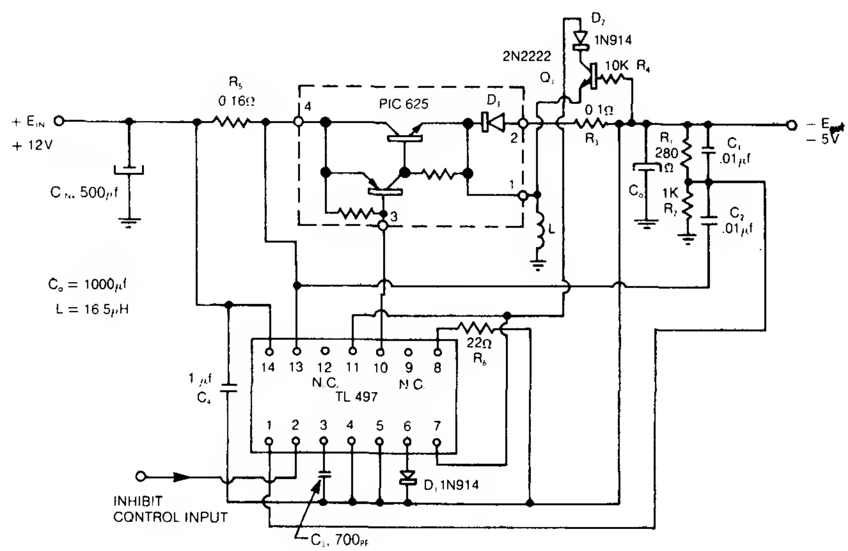
STEPPING 5 V UP TO 15 V—Fairchild μA78S40 switching ragulator transforms 5 V to 15 V at efficiancy of 80% for 150-mA load. Avaraga input currant is only 550 mA. Articla givas design equations.—R. J. Apfel and D. B. Jones, Universal Switching Regulator Diversifies Power Subsystam Applications, *Computer Design*, March 1978, p 103–112.



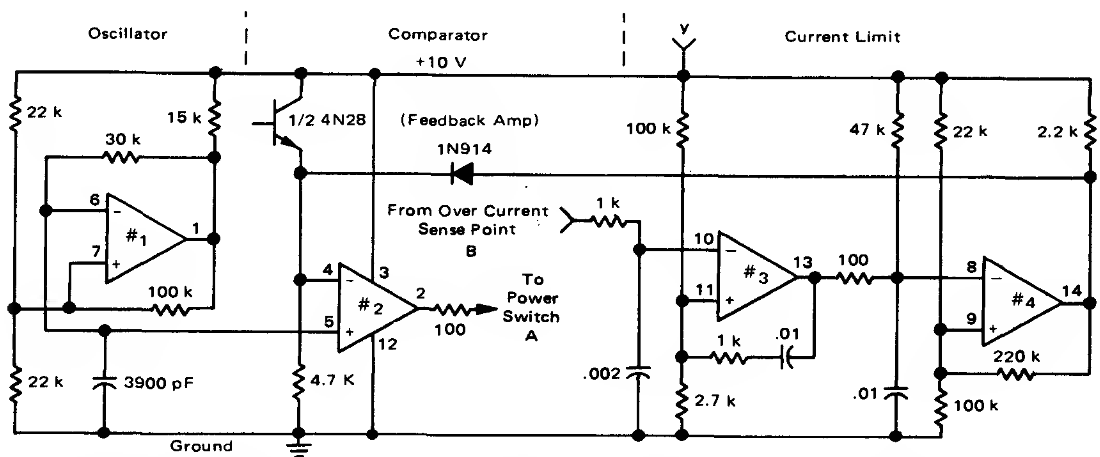
5-V 40-A 20-kHz SWITCHED-MODE—Uses Motorola 2N6544 powar transistors operating with 3-A collector current (other half of powar stage is identical). Bridga ractifiar end capacitive filtar connected directly to AC lina form 150-VDC supply for invarter oparating et 20 kHz. Regulators MC7806 and MC7906 oparating from MDA922-1 bridga rectifier of 15-W filament transformar T3 provida ±6 V for logic circuits that provide pulse-width moduletion for inverter. When logic signal is high, MPS-U51 saturetes end supplies 1 A to bese of 2N6544 inverter power transistor. When logic is low, MPS-U95 Darlington holds inverter translstor off.—R. J. Havar, "Switched Mode Power Supplies—Highlighting e 5-V, 40-A Inverter Design," Motorola, Phoenix, AZ, 1977, AN-737A, p 10.



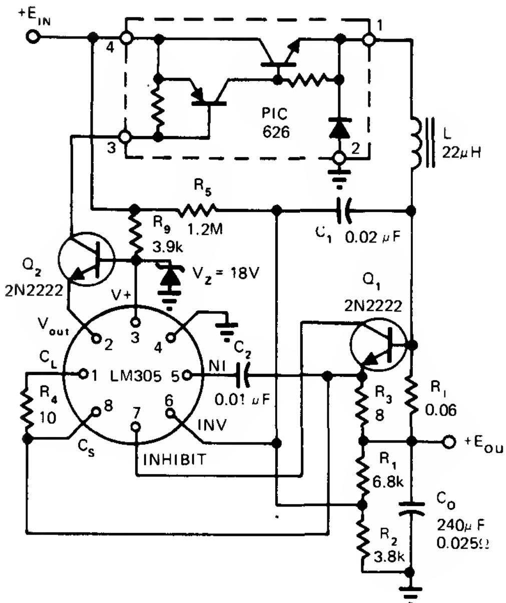
VARIABLE SWITCHING FREQUENCY—TL497 switchlng regulator operatas at maximum fraquancy under maximum load conditions. For smaller loads, duty cycle ls varied automatically by maintalning fixed ON tima and varying switching frequancy. Circuit optimizes efficiency at about 75% by reducing switching losses as load dacreases.—J. Spencar, Monolithic Switching Regulators—They Fit Today's Power-Supply Needs, *EDN Magazine*, Sept. 5, 1977, p 117–121.



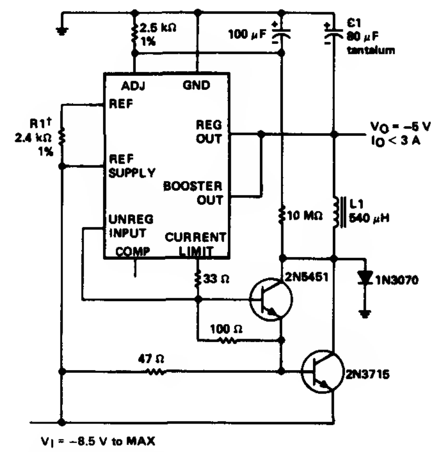
−5 V FLYBACK SWITCHING—Uses Unitrode PIC625 regulator operating at 25 kHz and TL497 control circuit oparating in current-limiting mode to giva lina and load regulation of 0.2% for input voltaga of 12 V ±25%. Efficiancy is 75%. Short-circuit current is automatically limited to 3 A.—"Flyback and Boost Switching Regulator Deslgn Guida," Unitrode, Watertown, MA, 1978, U-76, p 5.



CONTROL FOR SWITCHING REGULATOR— Uses all four sections of Motorola MC3302 quad comparator. First section is connected as 20-kHz oscillator that supplies sawtooth output sweeping between voltaga limits set by 100K positiva feedback resistor and 15-V supply. Section 2 compares sawtooth output to feedback signal, to produca variable-duty-cycle output pulsa for power switch of switching regulator. Sections 3 and 4 initiata current-limiting action; section 3 senses overcurrent and triggars section 4 connected as mono MVBR. Limiting occurs at about 4 A. Whan load short is ramoved, regulator resats automatically. Point A goes to push-pull driva for power switch of regulator, and point B goes to current-sensing resistor in output circuit of regulator. Point y goes to 10-V supply.—R. J. Havar, "A Naw Approach to Switching Regulators," Motorola, Phoenix, AZ, 1975, AN-719, p 7.

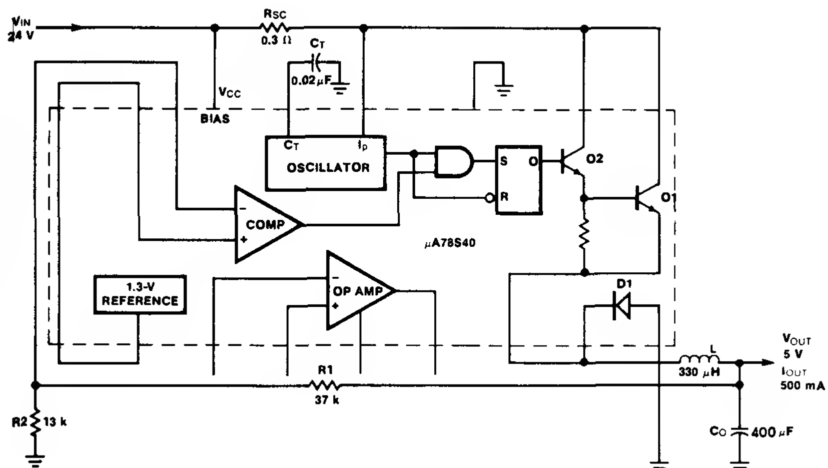


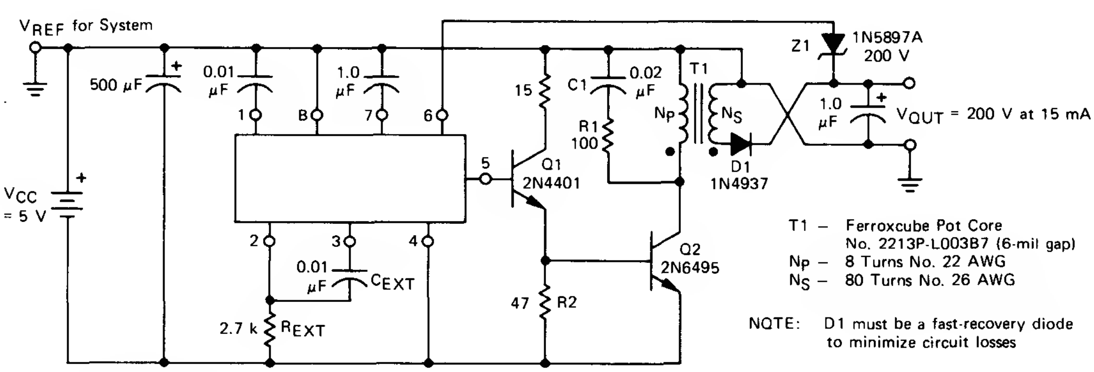
HIGH-VOLTAGE POSITIVE SWITCHING—Uses 18-V zener in series with 3.9K resistor to provide power for LM305 IC regulator. Q_2 provides base drive for PIC626 hybrid power switch and isolates output of LM305 from switch.—L. Dixon and R. Patel, Designers' Guide to: Switching Regulators, *EDN Magazine*, Oct. 20, 1974, p 53–59.



−5 V AT 3 A SWITCHING—Negative-voltage regulator using SN52104 or SN72304 accepts input voltage range of −8.5 V to −40 V and provides regulated output of −5 V with typical load regulation of 1 mV and input regulation of 0.06%. ICs are interchangeable with LM104 and LM304 respectively. L1 is 60 turns No. 20 on Arnold Engineering A930157-2 molybdenum permalloy core or equivalent.—"The Linear and Interface Circuits Data Book for Design Engineers," Texas Instruments, Dallas, TX, 1973, p 5-5.

REDUCING 24 V TO 5 V—Uses Fairchild μA78S40 switching regulator having variety of internal functions that can provide differing voltage step-up, step-down, and inverter modes by appropriately connecting external components. Connections shown provide step-down from 24 V to 5 V at 500 mA with 83% efficiency. Applications include running TTL from 24-V battery. Output ripple is less than 25 V. Article gives design equations.—R. J. Apfel and D. B. Jones, Universal Switching Regulator Diversifies Power Subsystem Applications, *Computer Design*, March 1978, p 103–112.

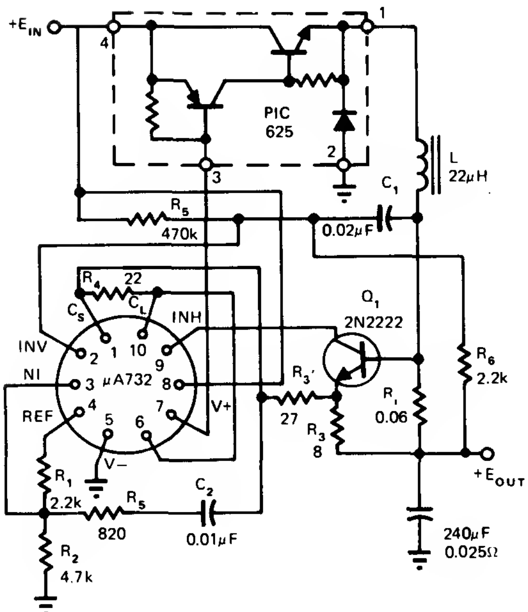




Typical Performance

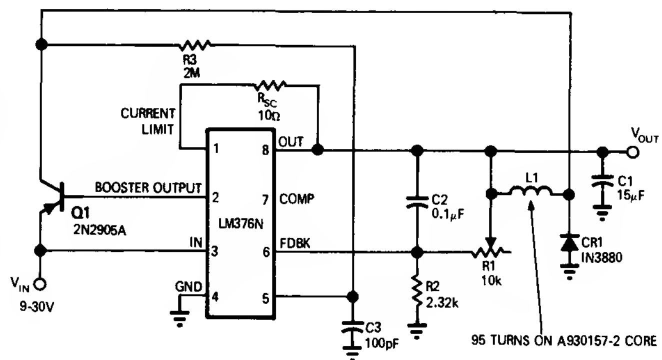
Line Reg. (4 V < V_{IN} < 6 V) = .3% Overall Efficiency = 66%
Load Reg. (P_{OUT} ≤ 3 W) = .2% 20-kHz Ripple = .1 V p-p

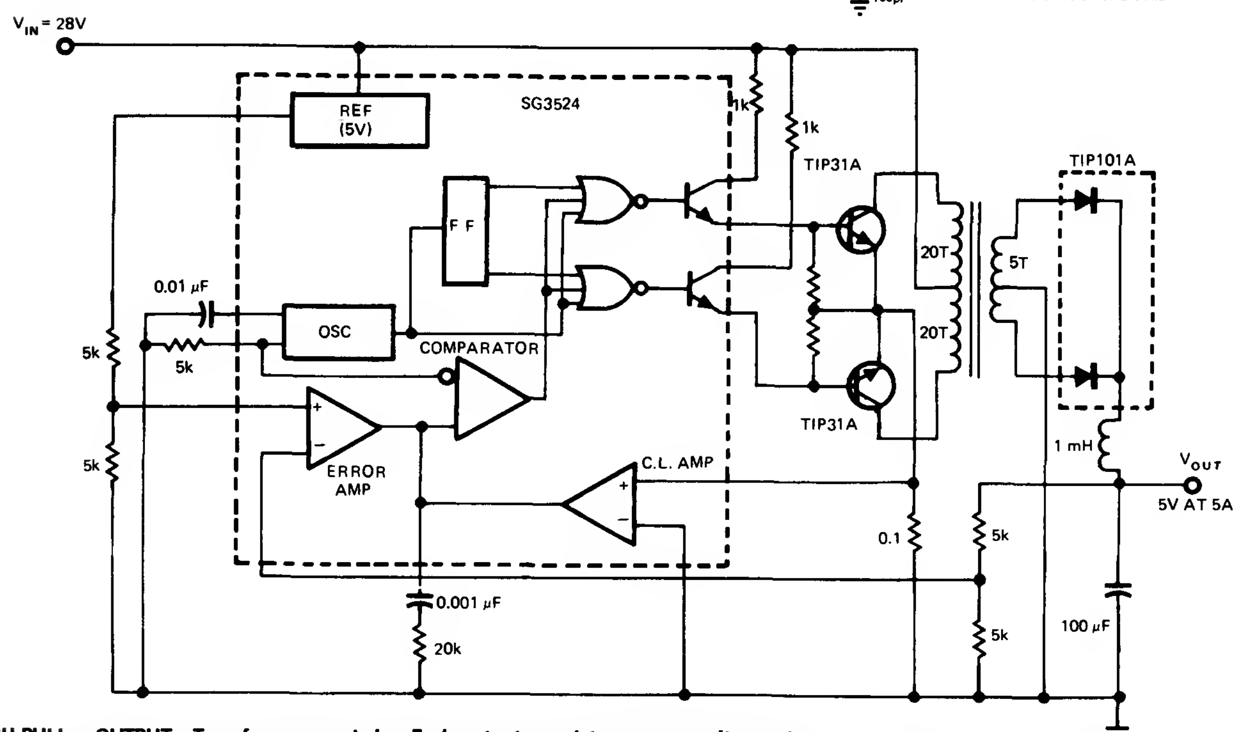
5 V TO 200 V WITH SWITCHING REGULATOR—Converts standard logic supply voltage to high voltage required by gas-discharge displays, using Motorola MC3380 astable MVBR as control element in switching regulator. Will drive up to 15 digits. Operating frequency is about 20 kHz.—H. Wurzburg, "Control Your Switching Regulator with the MC3380 Astable Multivibrator," Motorola, Phoenix, AZ, 1975, EB-52.



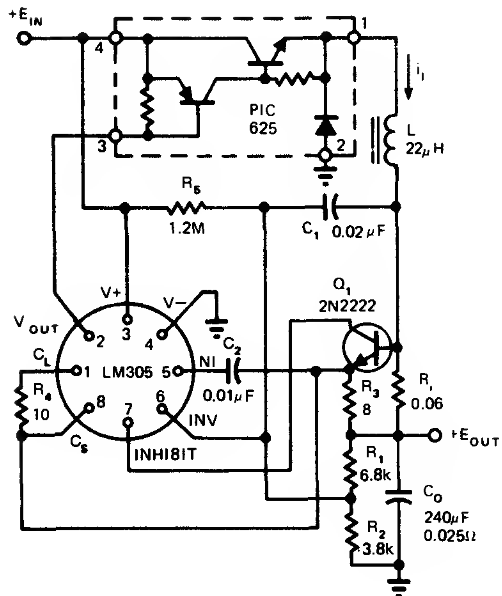
+10 V SWITCHING—Positive switching regulator circuit uses μA732 with Unitrode PIC625 hybrid power switch and single transistor, operating in fixed OFF-time mode. Article covers regulator thaory of operation in datail.—L. Dixon end R. Petel, Deslgners' Guida to: Switching Regulators, *EDN Magazine*, Oct. 20, 1974, p 53–59.

BATTERY REGULATOR—Uses LM376N positive voltage regulator in switching moda to compensate for voltage changes of battery supply during discharge cycle, without adjusting series rheostat. Load regulation is 0.3% for unragulated input of 9 to 30 V, with R1 and R2 satting output voltege enywhere between 5 and 27 V. Maximum output current is 25 mA. Switching frequency of regulator Is 33 kHz.—E. R. Hnetek and L. Goldstein, Switching Regulator Designed for Portable Eqiupment, *EDN/EEE Magazine*, Sept. 15, 1971, p 39–41.

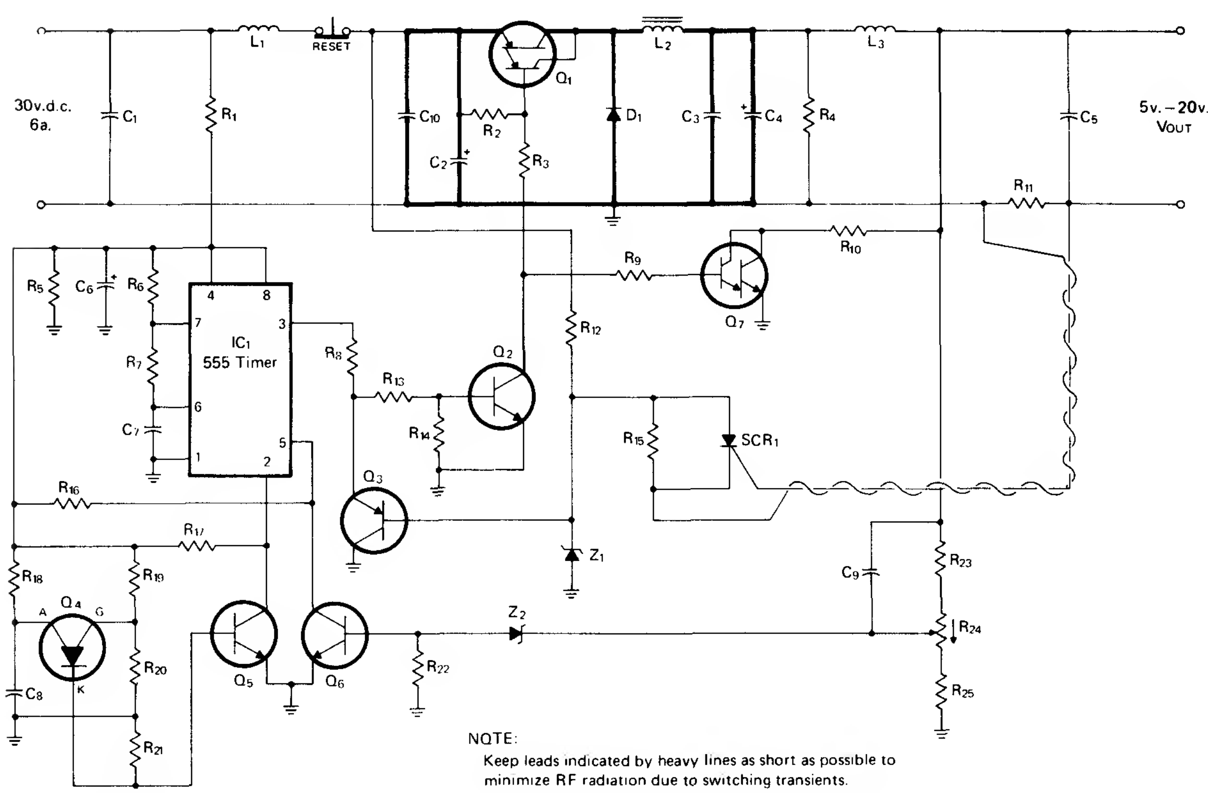




PUSH-PULL OUTPUT—Transformar-coupled push-pull output for SG3524 fixed-frequency pulse-duration-modulated switching regulator gives output flexlbility, allowing for multiple outputs and wide range of output voltages. Each output transistor oparates alternataly at half of switching frequency. Switching regulator applies voltage altamately to opposite ends of transformar primary, making transformer parform as if it had AC Input. TIP101A rectifier then provides desired 5-VDC output at 5A.—J. Spancar, Monolithic Switching Regulators—They Fit Today's Power-Supply Needs, *EDN Magazine*, Sapt. 5, 1977, p 117–121.

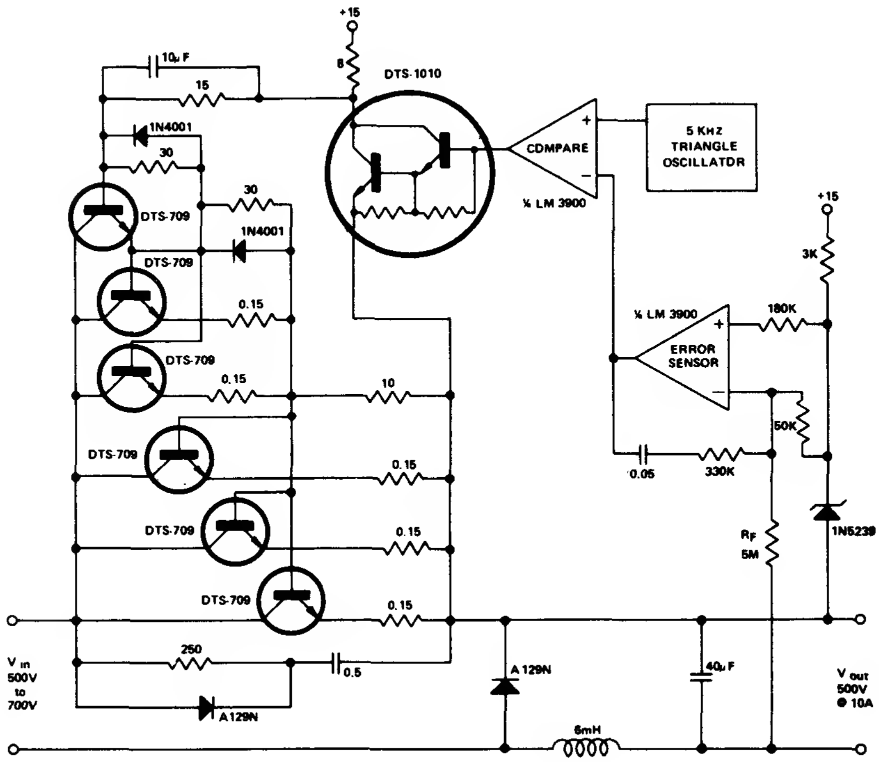


5-V SWITCHING—Fixed OFF-time mode of operation is used in switching regulator design to provide 5-V output that is constant within 100 mV P-P for input range of 20–40 V, for loads ranging from 10 A maximum to 2 A minimum. Switching frequency can be in range of 1–50 kHz. Operation above 20 kHz eliminates possibility of audio noise but with some drop in efficiency. Values shown are for 50 kHz. Article gives design equations and design procedure.—L. Dixon and R. Patel, Designers' Guide to: Switching Regulators, Part 2, *EDN Magazine*, Nov. 5, 1974, p 37–40.

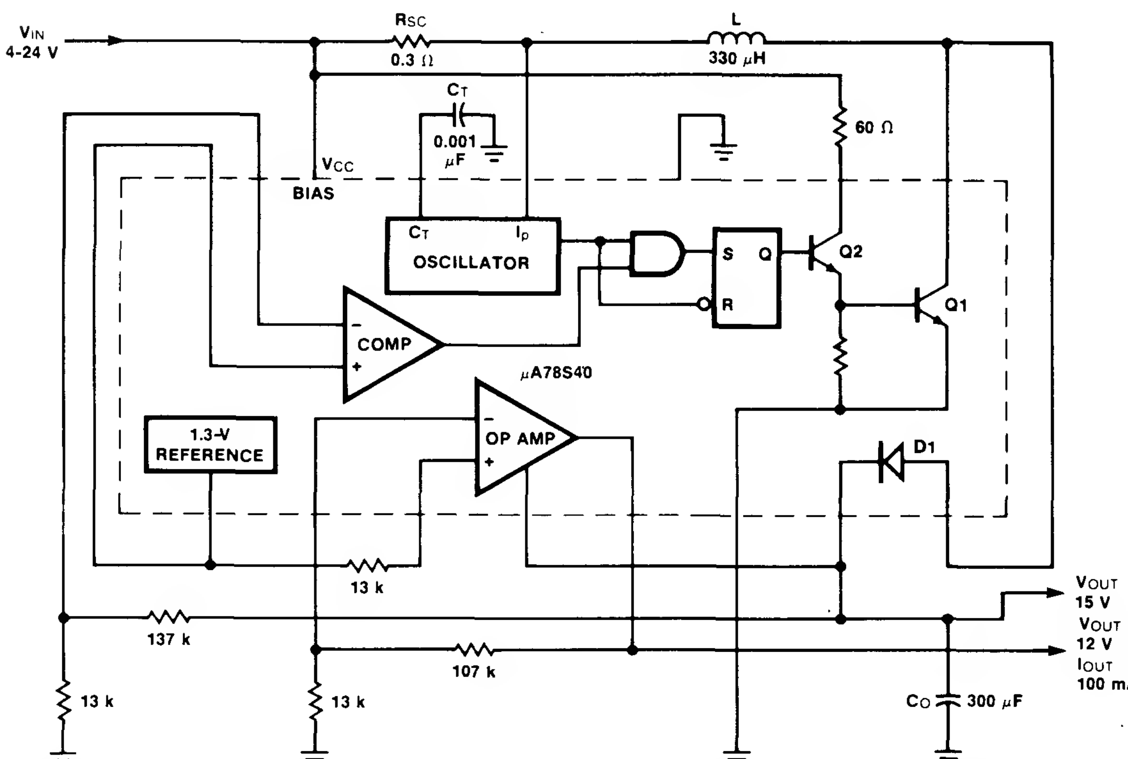


C_1, C_3, C_5, C_{10}—1.0μF, Polycarb
C_2, C_6—100μF, 50V
C_4—1000μF, 50V
C_7—0.0082μF
C_8—390pF
C_9—0.002μF
D_1—1N3890
L_1, L_2—10μhy, 10 amps
L_3—180μhy
Q_1—D45E2 (General Electric)—
Q_2, Q_5—D33D25
Q_3—D29E25
Q_4—2N6027
Q_6—D32S4
Q_7—D40K2—Use Thermalloy 6063B heatsink
R_1, R_3, R_4, R_5—1.2K, ½W
R_2, R_7—110Ω, ½W
R_6—4.7K, ½W
R_8, R_{13}, R_{23}—1.2K, ½W
R_9—15K, ½W
R_{10}—20Ω, 10W
R_{11}—0.075Ω, 6 watts
R_{12}—1.5K, 1W
R_{14}—330Ω, ½W
R_{15}, R_{19}—680Ω, ½W
R_{16}—22K, ½W
R_{17}—4.7K, ½W
R_{18}—120K, ½W
R_{20}—1K, ½W
R_{21}—100Ω, ½W
R_{22}—18K, ½W
R_{24}—1K, 1W Pot.
R_{25}—390Ω, ½W
SCR-1—C103B
Z_1—1N5233B
Z_2—1N5226B
IC-1—555 Timer

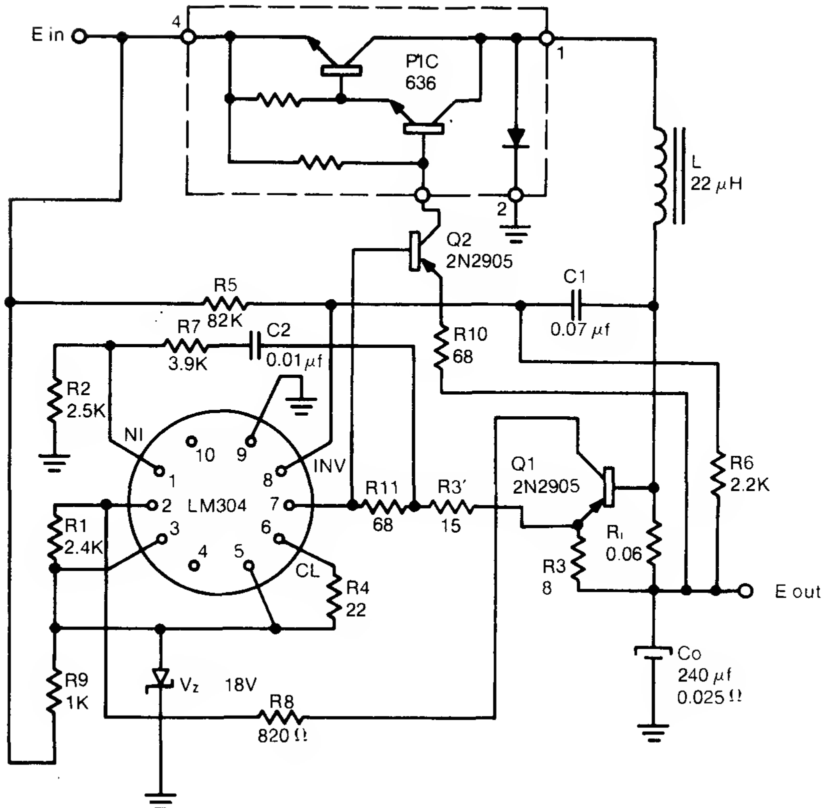
150-W SWITCH-MODE—Unregulated DC voltage is applied to power Darlington Q_1 serving as switch that chops voltage so rectangular waveform is applied to RLC output filter. Average voltage to filter depends on duty cycle of switch. 555 timer operates in mono MVBR mode as pulse generator and pulse-duration modulator. R_{24} applies varying voltage to pin 5 to modulate pulse duration linearly with respect to applied voltage. Actions of Q_1, Q_2, and Q_6 maintain constant 3.6 V at arm of control pot. Q_4 and Q_5 provide 20-kHz clock pulse, above audible range. Overcurrent protection of transistors is provided by R_{11}, SCR, and Q_3. Adjust R_{11} so SCR turns on and shuts down circuit when current through R_{11} reaches 8 A. Circuit must be reset manually after overload. Q_7 and R_{10} load circuit to prevent oscillation at low output voltage and light load.—R. J. Walker, A 150 Watt Switch-Mode Regulator, *CQ*, March 1977, p 40–43 and 74–75.



5-kW SWITCHING—Six Delco DTS-709 transistors are connected in progressive Darlington configuration to provide stable and efficient switching at high voltages. Can be operated from 480-V three-phase full-wava rectifiad lina to minimize filter cost. Control circuit uses one LM3900 IC operating from isolated 15-V supply, along with 5-kHz triangle oscillator and error sensor feeding into comparator. In power stage, ona DTS-709 drivas two DTS-709s which driva thraa DTS-709s. Efficiency is better than 90% for all loads above 500 W.—"Economical 5 kW Switching Regulator Using DTS-709 Transistors," Delco, Kokomo, IN, 1974, Application Note 56.

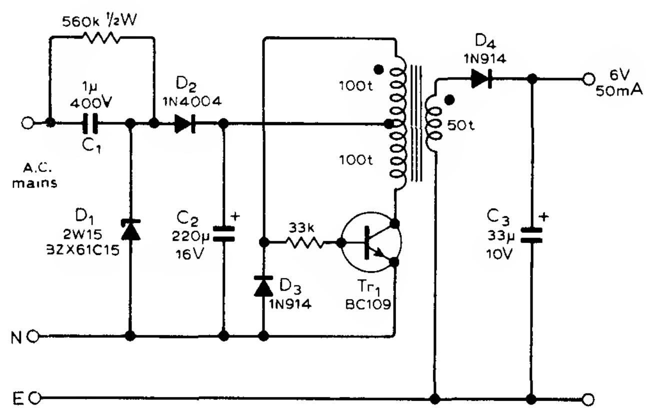


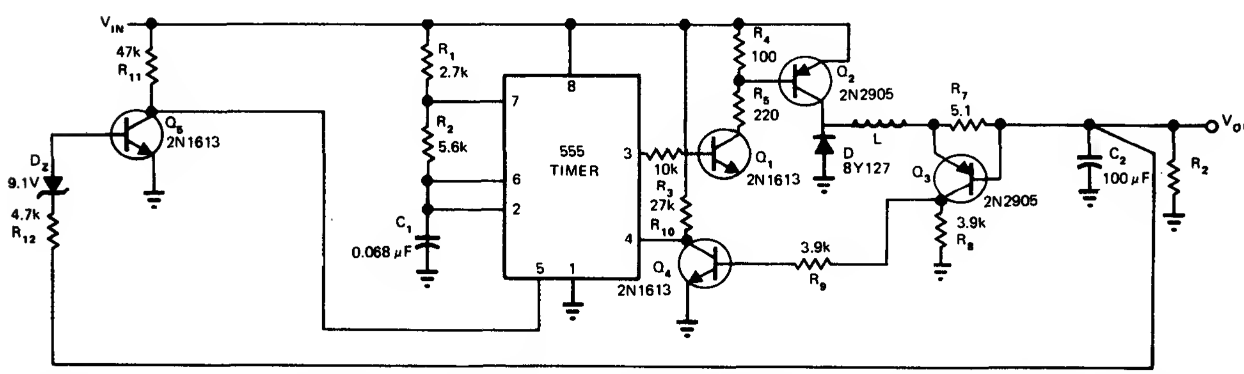
+12 V AND +15 V FROM 4–24 V—Connections shown for Fairchild μA78S40 switching regulator giva universal regulator providing either stap-up or step-down, for loads up to 100 mA. Efficiancy is about 50% for input axtremes of 4 and 24 V, increasing to maximum of 75% for other input voltages. Output ripple is essentially aliminated at 12-V output.—R. J. Apfal and D. B. Jones, Universal Switching Regulator Diversifies Powar Subsystem Applications, *Computer Design,* March 1978, p 103–112.



HIGH-VOLTAGE NEGATIVE-SWITCHING—Designed for operation from supply voltages above maximum of −40 V for LM304 regulator. Output is −5 V at up to 10 A. Q2 provides voltage isolation between regulator and Unitrode PIC636 hybrid power switch. R9 limits current through zener under steady-state and start-up conditions.—"Switching Regulator Design Guide," Unitrode, Watertown, MA, 1974, U-68A, p 9.

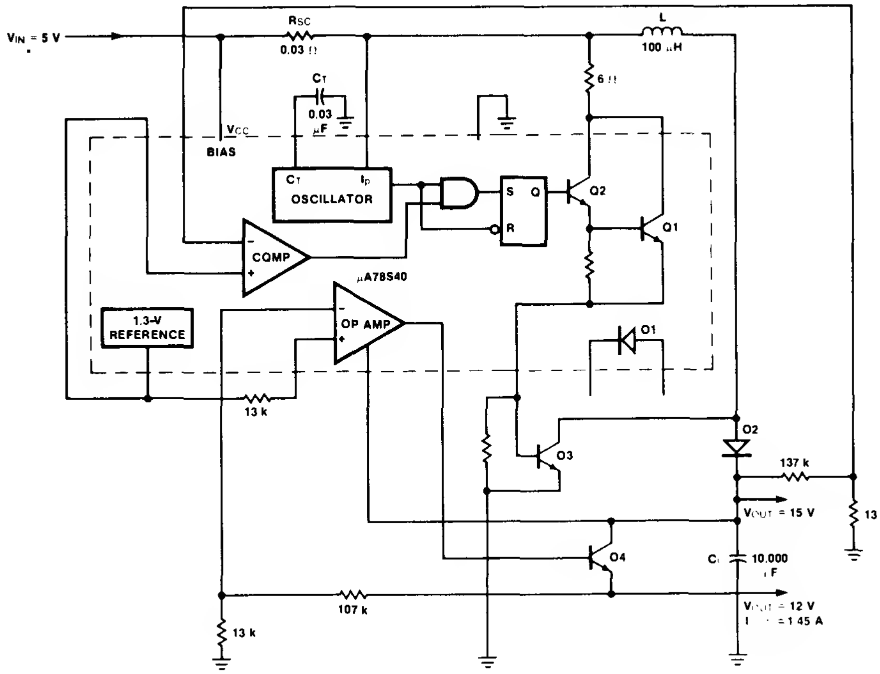
6 V FOR CALCULATOR—Can be mounted in housing of calculator or small transistor radio, for operation from AC line. D_1 and D_2 produce 15 VDC across filter capacitor C_2 as supply for inverter Tr_1 operating at 13 kHz. Transformer is wound with No. 37 wire on small core such as Phillips P14/8 337 pot core. Primary windings are bifilar. Use grounded shield to reduce radiated switching noise.—M. Faulkner, Miniature Switch Mode Power Supply, *Wireless World*, Oct. 1977, p 65.



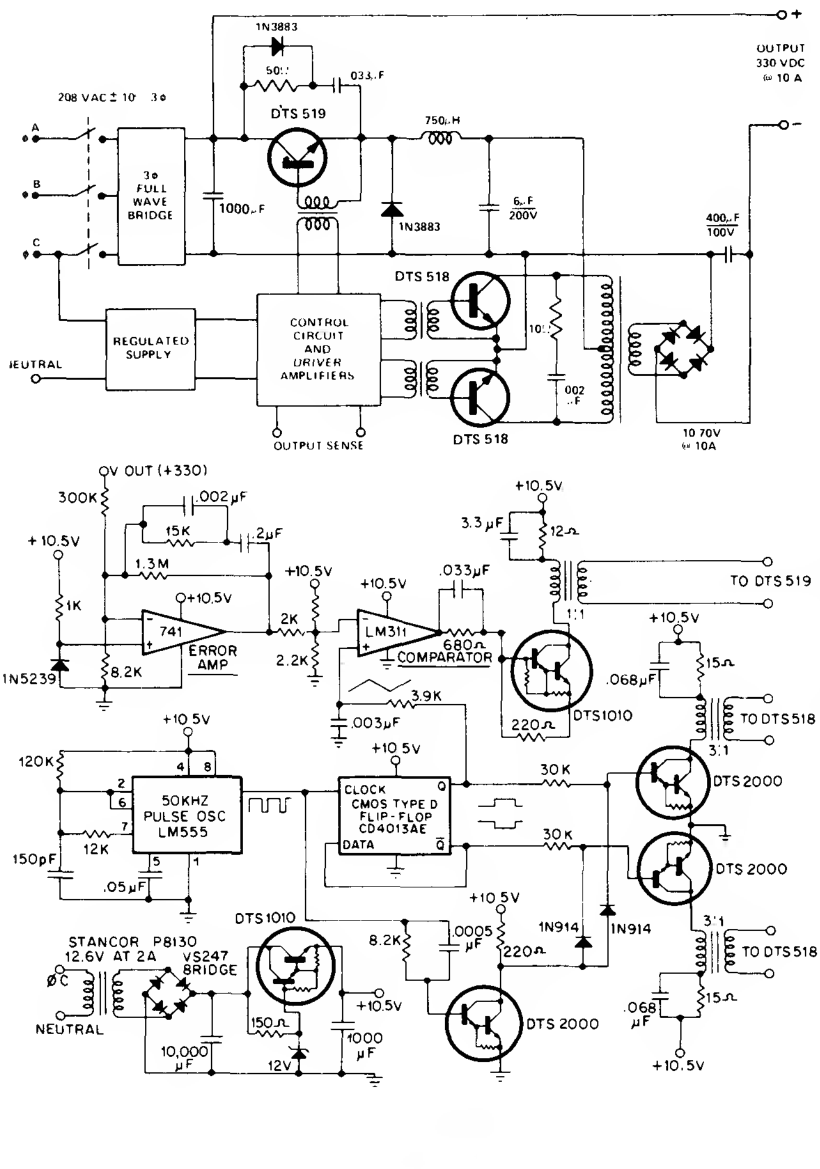


10-V SWITCHING AT 100 mA—Use of 555 timer as pulse-width-modulated regulator gives line regulation of 0.5% and load regulation of 1%. Circuit includes current foldback. With 15-V input, output is 10 V.—P. R. K. Chetty, Put a 555 Timer in Your Next Switching Regulator Design, *EDN Magazine*, Jan. 5, 1976, p 72.

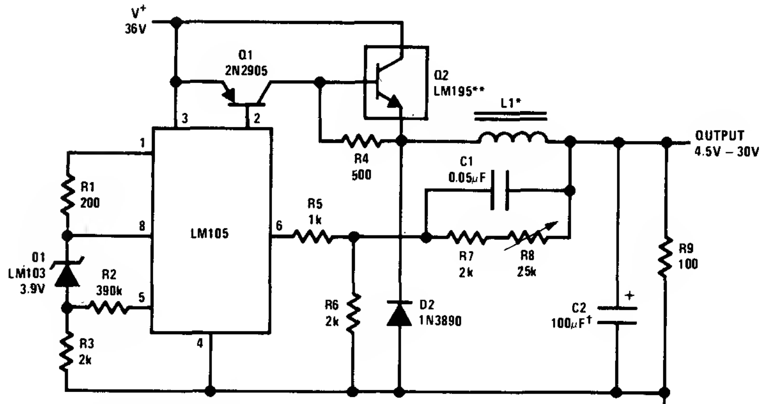
+12 V AND +15 V FROM 5 V—Uses Fairchild μA78S40 switching regulator having variety of internal functions that can provide differing voltage step-up, step-down, and inverter modes by appropriately connecting external components. External NPN transistor Q3 boosts step-up regulator, and NPN transistor Q4 increases series-pass regulator output well above 1 A. Total of 1.5 A is available from two outputs. Transistor and diode types are not critical. Efficiency is 80% for 15-V output and 64% for 12-V output.—R. J. Apfel and D. B. Jones, Universal Switching Regulator Diversifies Power Subsystem Applications, *Computer Design,* March 1978, p 103–112.



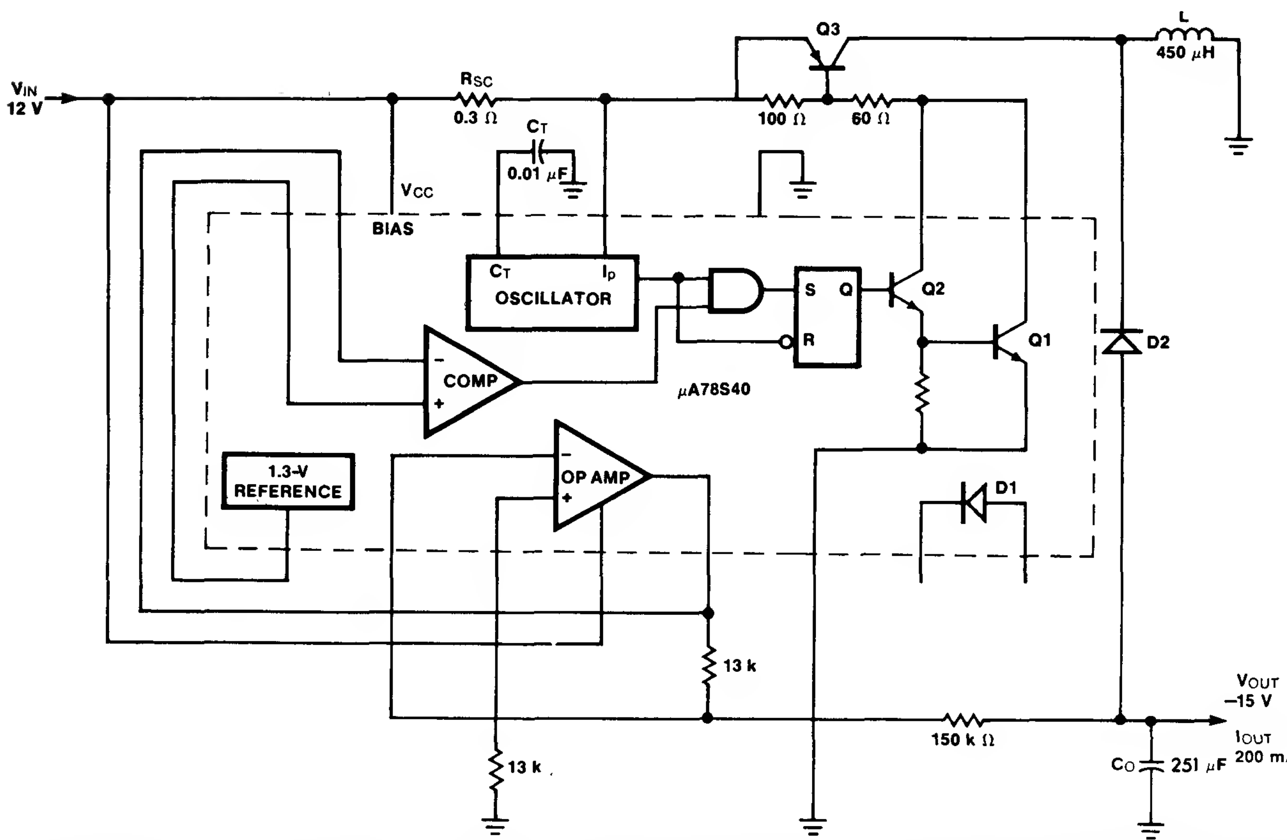
3.3-kW SWITCHING—Dalco DTS-518 and DTS-519 power transistors in high-efficiency stacked supply are operated at 25-kHz switching rate to provide 330 VDC at 10 A. Control circuit operates at primary 50-kHz pulse frequency, with negative-going pulses having 2-μs duration. Flip-flop converts this to 25-kHz complementary square-wave signal driving Darlington DTS-2000s. Transformer cores are Magnatics EE No. 42510 each having 15-turn primary and 5-turn secondary for driving DTS-518s. Error amplifier compares portion of total output voltage to zener reference for control of DTS-519 power transistor switching at 25 kHz. Efficiency is 95% at full load.—"3.3kW High Efficiency Switch Mode Regulator," Dalco, Kokomo, IN, 1977, Application Note 59.



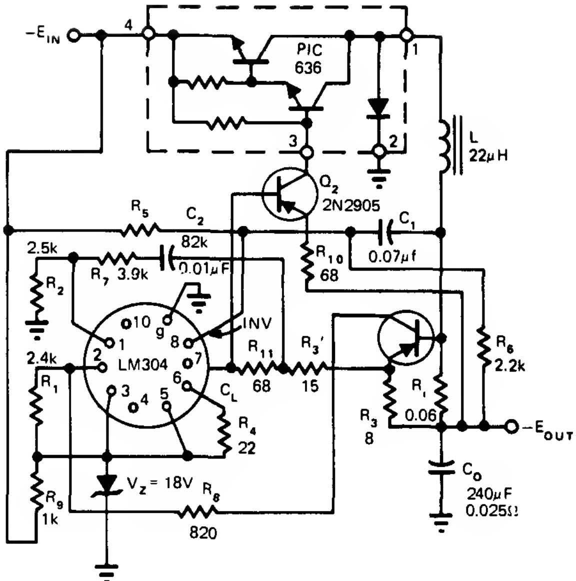
4.5–30 V SWITCHING AT 6 A—LM105 positiva regulator servas as amplifier-refarence for LM195 powar transistor IC In switching regulator. Duty cycle of switching action adjusts automatically to give constant output. Q2 consists of four LM195s in parallel since each is rated at only about 2 A. R8 serves as output voltage control.—"Linear Applications, Vol. 2," National Samiconductor, Santa Clara, CA, 1976, AN-110, p 4.



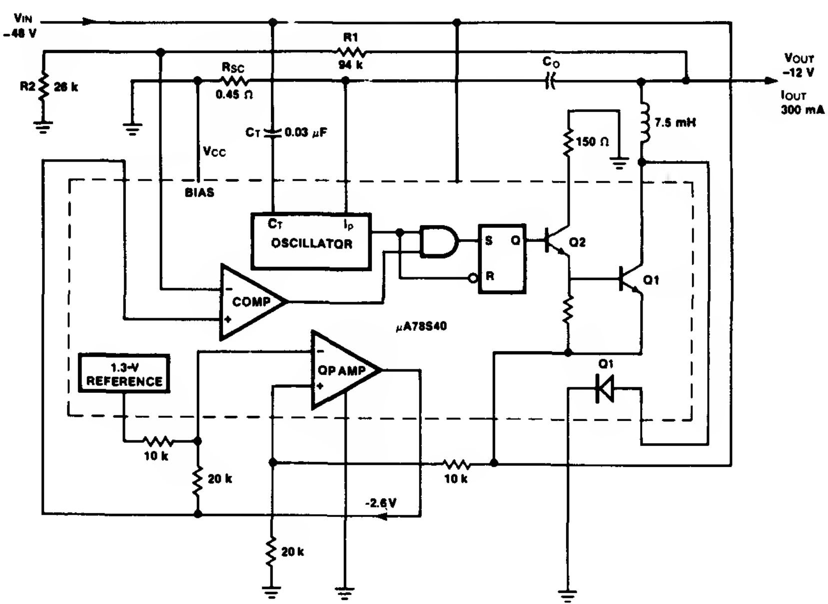
*Sixty turns wound on arnold type A-083081-2 core.
**Four devices in parallel.
†Solid tantalum.



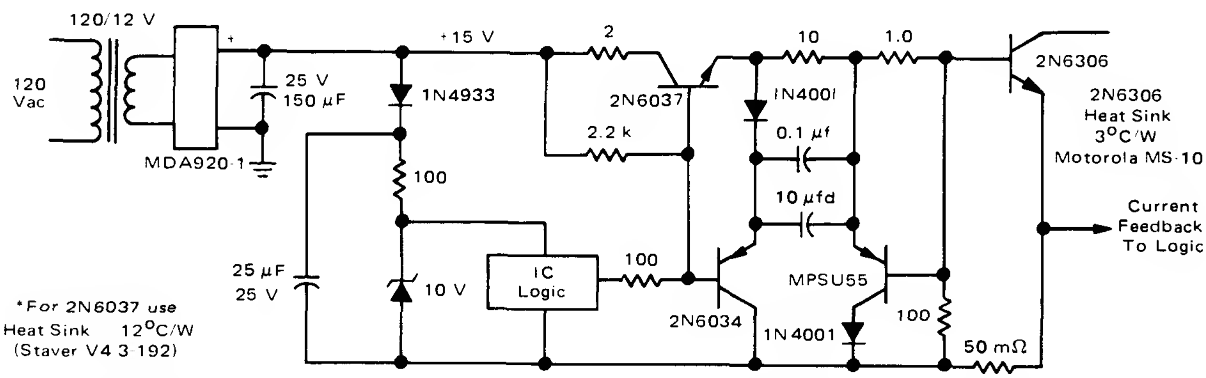
TRANSFORMING +12 V TO −15 V—External PNP transistor Q3 and catch diode D2 (typas not critical) are used with Fairchild μA78S40 switching regulator so no pin of IC substrate has voltage mora negative than substrate, which is grounded. Efficiency is 84% with 200-mA load. Output voltage rippla is 50 mV but can be reduced by increasing value of C_0.—R. J. Apfel and D. B. Jones, Univarsal Switching Ragulator Divarsifies Powar Subsystam Applications, *Computer Design*, March 1978, p 103–112.



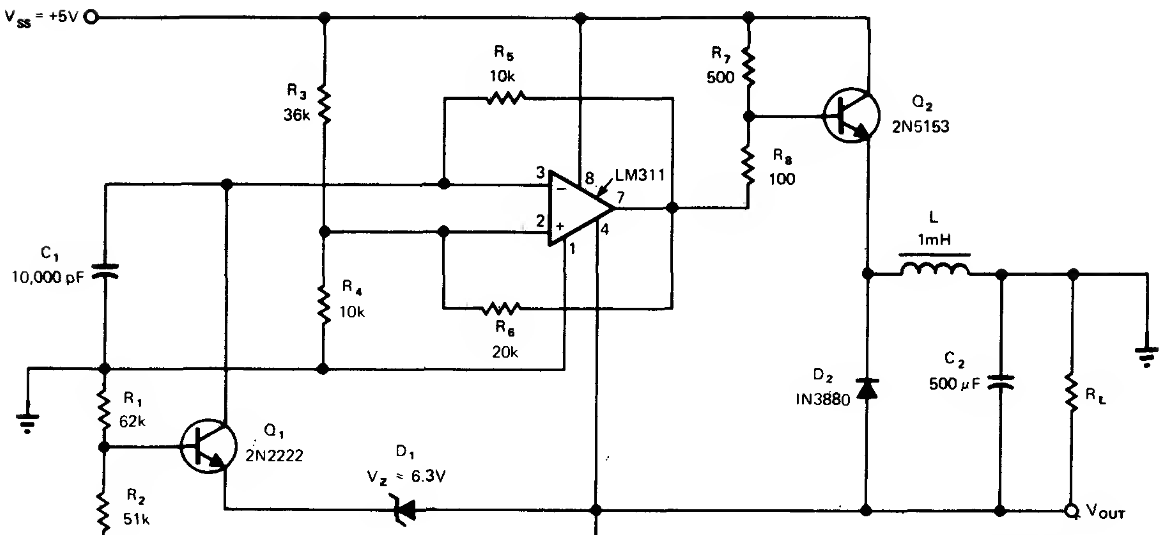
HIGH-VOLTAGE NEGATIVE SWITCHING—Uses zener to reduce supply voltage to acceptable level for LM304 IC regulator. Base drive and voltage isolation are provided by Q_2, R_{10}, and R_{11} for PIC636 hybrid power switch. Circuit operates in fixed OFF-time mode.—L. Dixon and R. Patel, Designers' Guide to: Switching Regulators, *EDN Magazine*, Oct. 20, 1974, p 53–59.



−12 V AT 300 mA FROM −48 V—Uses Fairchild μA78S40 switching regulator having variety of internal functions that can provide differing voltage step-up, step-down, and inverter modes by appropriately connecting external components. Efficiency is 86%, and output ripple is 300 mV. Extra opamp on chip is used to derive required reference voltage of −2.6 V from internal 1.3-V reference.—R. J. Apfel and D. B. Jones, Universal Switching Regulator Diversifies Power Subsystem Applications, *Computer Design*, March 1978, p 103–112.

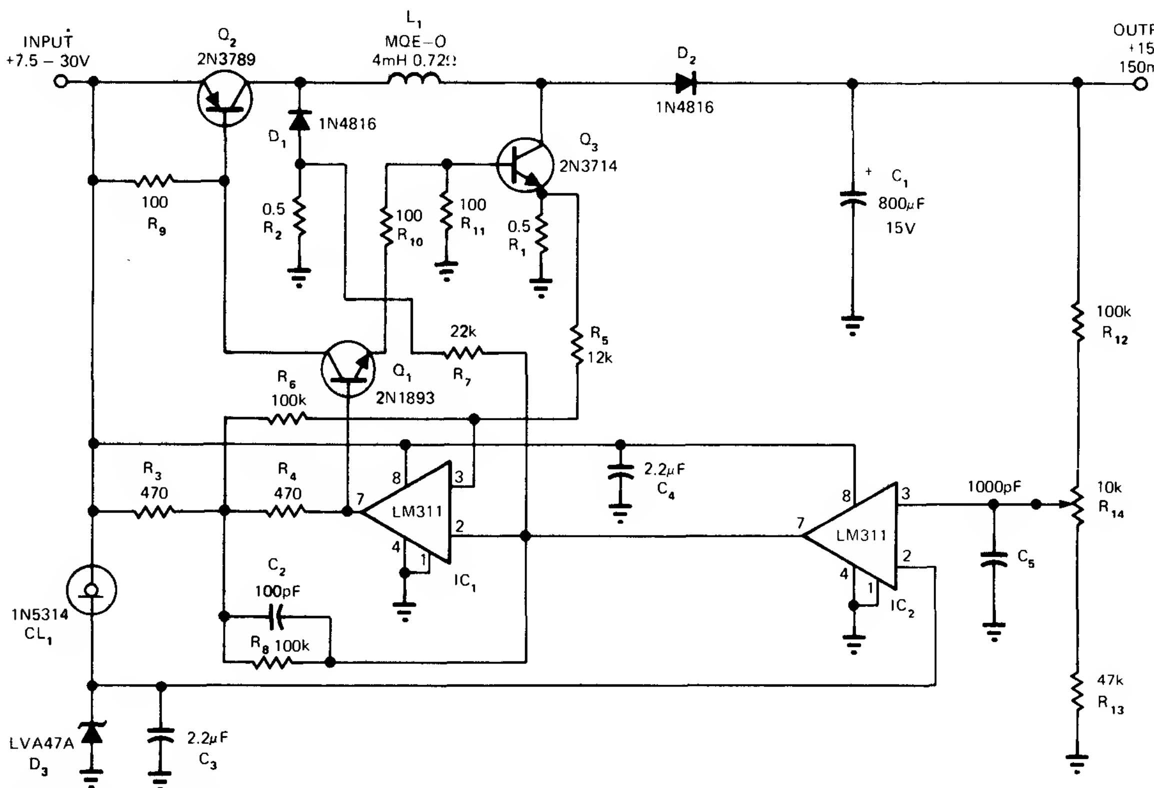


POWER SWITCH FOR SWITCHING REGULATOR—Circuit operating from 12-V step-down transformer includes push-pull driver providing interface between logic drive signal and 2N6306 high-voltage power transistor. Switching is provided at 3 A and 20 kHz, with artificial negative bias supply created from single positive supply to improve fall time. Current limiting is added to base current to limit overdrive and reduce storage time. Power switch is turned off by forcing IC to logic low. Used in 24-V 3-A switching-mode power supply operating from AC line.—R. J. Haver, "A New Approach to Switching Regulators," Motorola, Phoenix, AZ, 1975, AN-719, p 5.

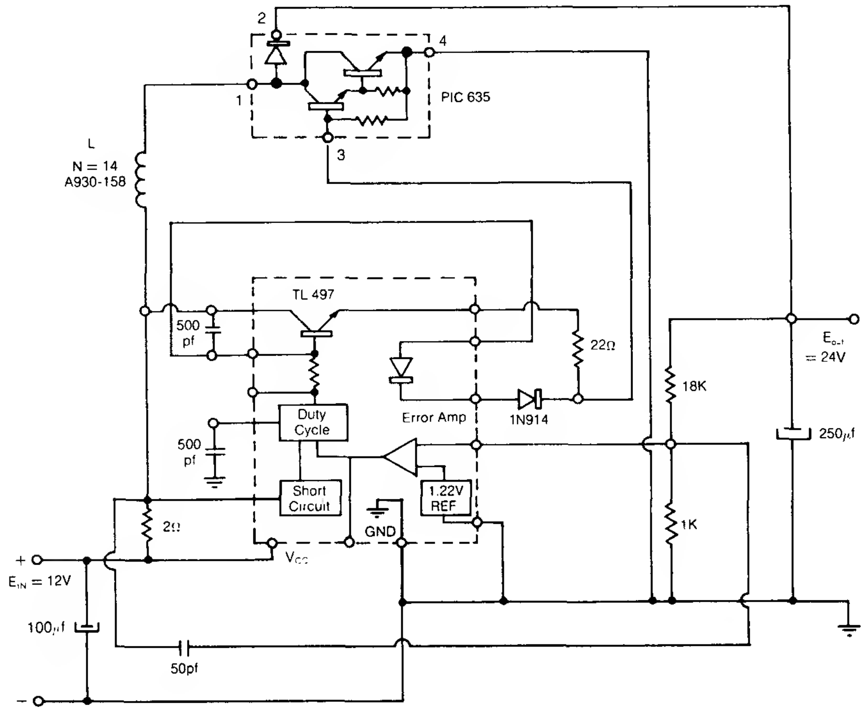


$$V_{OUT} = (V_Z + V_{BE})\left(\frac{R_1}{R_2} + 1\right)$$

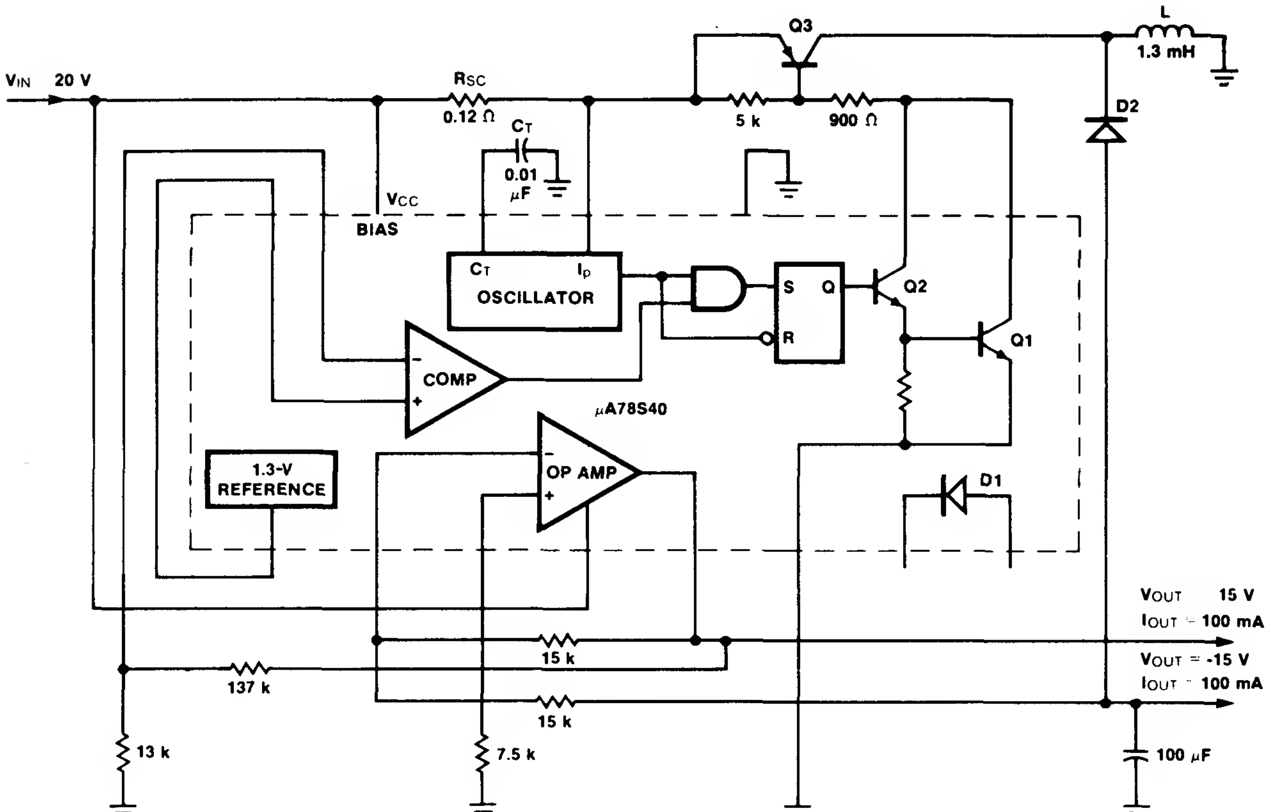
+5 V TO −15 V—Use of switching regulator for voltage conversion permits generation of higher output voltage along with polarity reversal. LM311 operates as free-running MVBR with low duty cycle. Frequency is determined by C_1 and R_5 and duty cycle by divider R_3-R_4. Extra loop function performed by Q_1 and zener operating in conjunction with resistor network modifies oscillator duty cycle until desired output level is obtained. Nominal frequency is 6 kHz, duty cycle is 20% for −15 V output, and maximum load current is 200 mA. Design equations are given.—H. Mortensen, IC Comparator Converts +5 to −15V DC, *EDN Magazine*, Dec. 20, 1973, p 78–79.



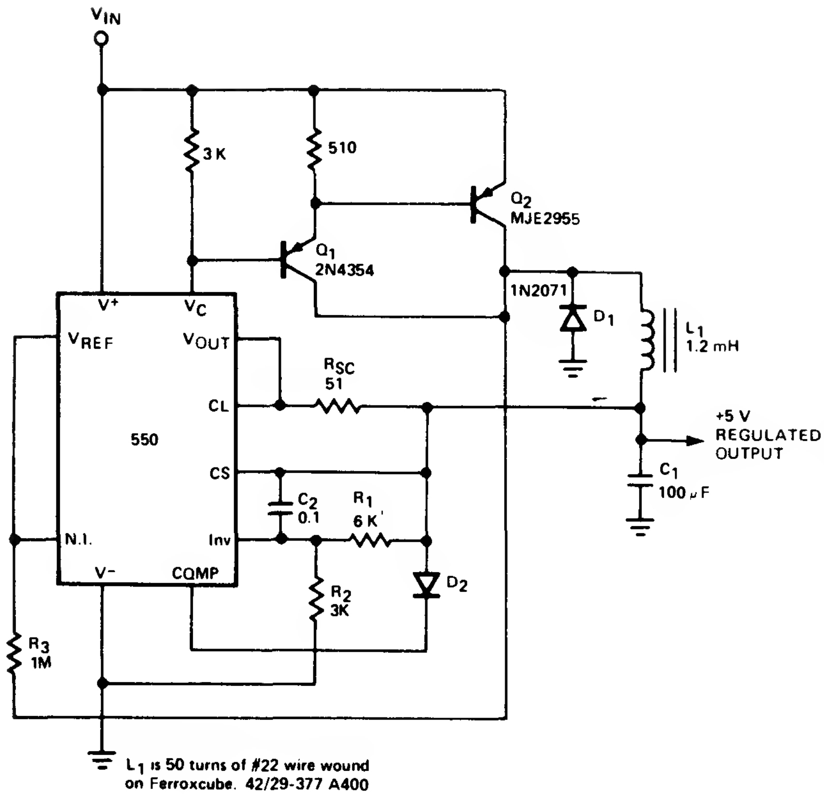
15 V FROM 7.5–30 V—Switching regulator operation is independent of input voltage level. When power is applied, Q_1 conducts and turns on Q_2 and Q_3. When linear rising current of Q_1 exceeds upper threshold as sensed by R_1, IC_1 switches to low output state and turns off all three transistors. Voltage across L_1 reverses, and current flows into C_1 through D_1 and D_2. When this current as sensed by R_2 falls below lower threshold, IC_1 switches back to its high output state. This oscillating action continues until output voltage as sensed by IC_2 rises above desired level, when IC_2 switches to its low output state and holds IC_1 low until output drops back below preset level to complete one cycle of oscillation.—A. Delagrange, Voltage Regulator Can Have Same Input and Output Level, *EDN Magazine*, Aug. 5, 1973, p 87 and 89.



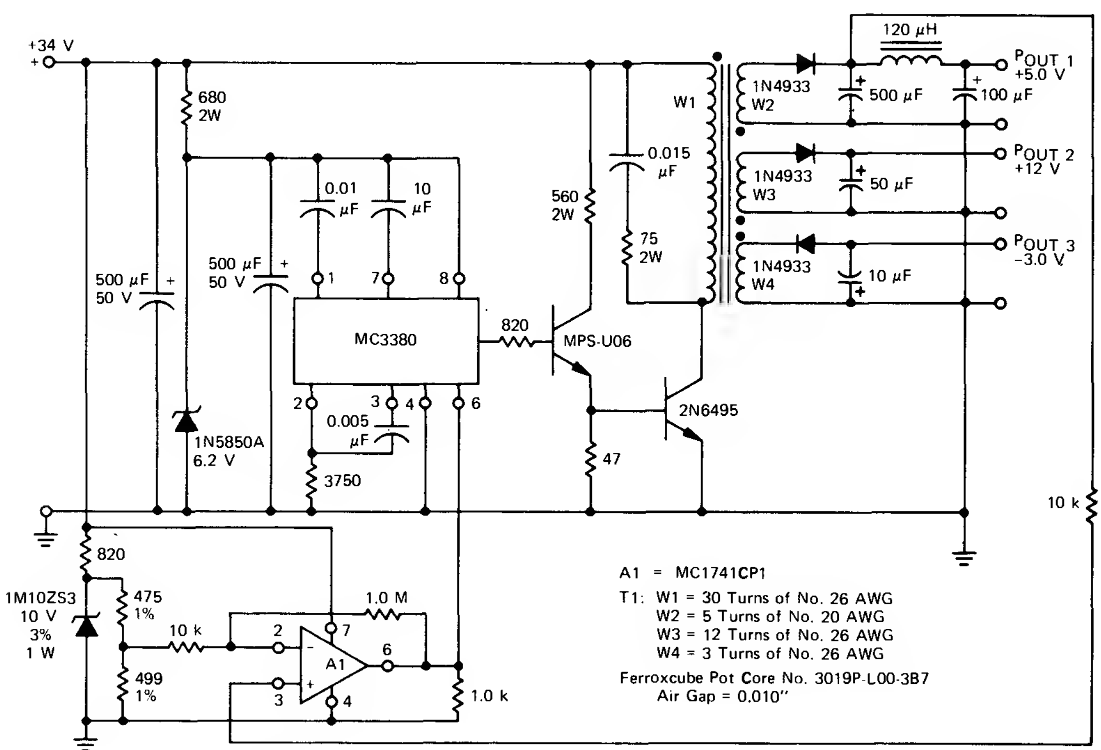
+24 V FROM +12 V AT 2 A—Combination of PIC635 boost switching reguletor end TL497 control circuit accepts DC input voltage end provides reguleted output voltage thet must be greater then input voltage. When transistor switch is turned on, input voltage is applied ecross L. When transistor is tumed off, energy stored in L is trensferred through diode to load where it adds to energy trensferred directly from input to output during diode conduction time. Output voltage is reguleted by controlling duty cycle.—"Flybeck and Boost Switching Raguletor Design Guide," Unitrode, Watertown, MA, 1978, U-76, p 9.



±15 V TRACKING—Dual-tracking connection for Fairchild μA78S40 switching regulator operates from single 20-V input. Efficiency is 75% for +15 V and 85% for −15 V, both at 100 mA. Output ripple is 30 mV.—R. J. Apfel and D. B. Jones, Universal Switching Regulator Diversifies Power Subsystem Applications, *Computer Design*, March 1978, p 103–112.



5-V SWITCHING—Darlington pair Q_1-Q_2 serves as switch for regulator using Signetics 550 as threshold detector. Design equations are given. Exact frequency of self-oscillating switching regulator depends primarily on parasitic components. If frequency is important, as in applications requiring EMI suppression, regulator may be locked to external square-wave drive signal fed to reference terminal.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 661–662.



TYPICAL PERFORMANCE

$P_{OUT\ 1}$ = 4 Watts (V_O = 5 V ±5%)

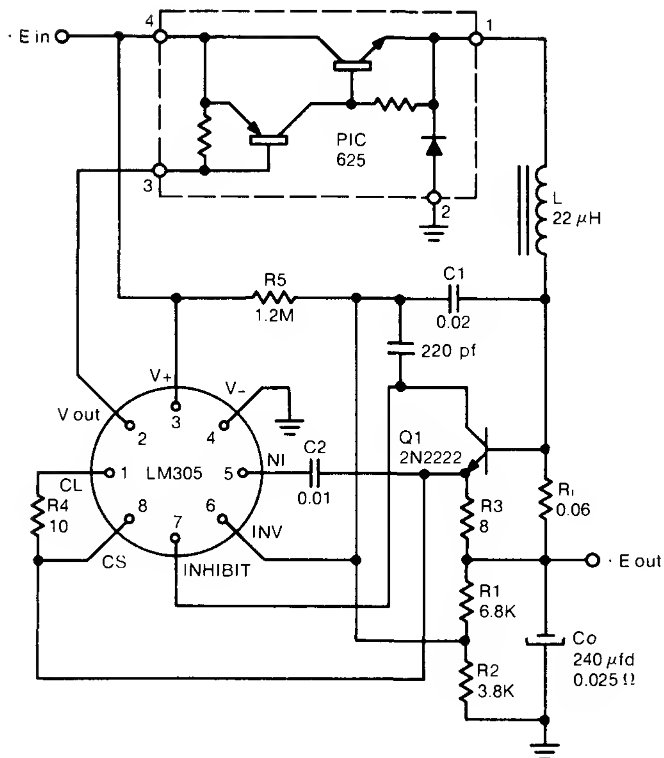
5-V Ripple Component = 50 mV (120 Hz + 20 kHz)

$P_{OUT\ 2}$ = 600 mW (V_O = 12 V ±10%)

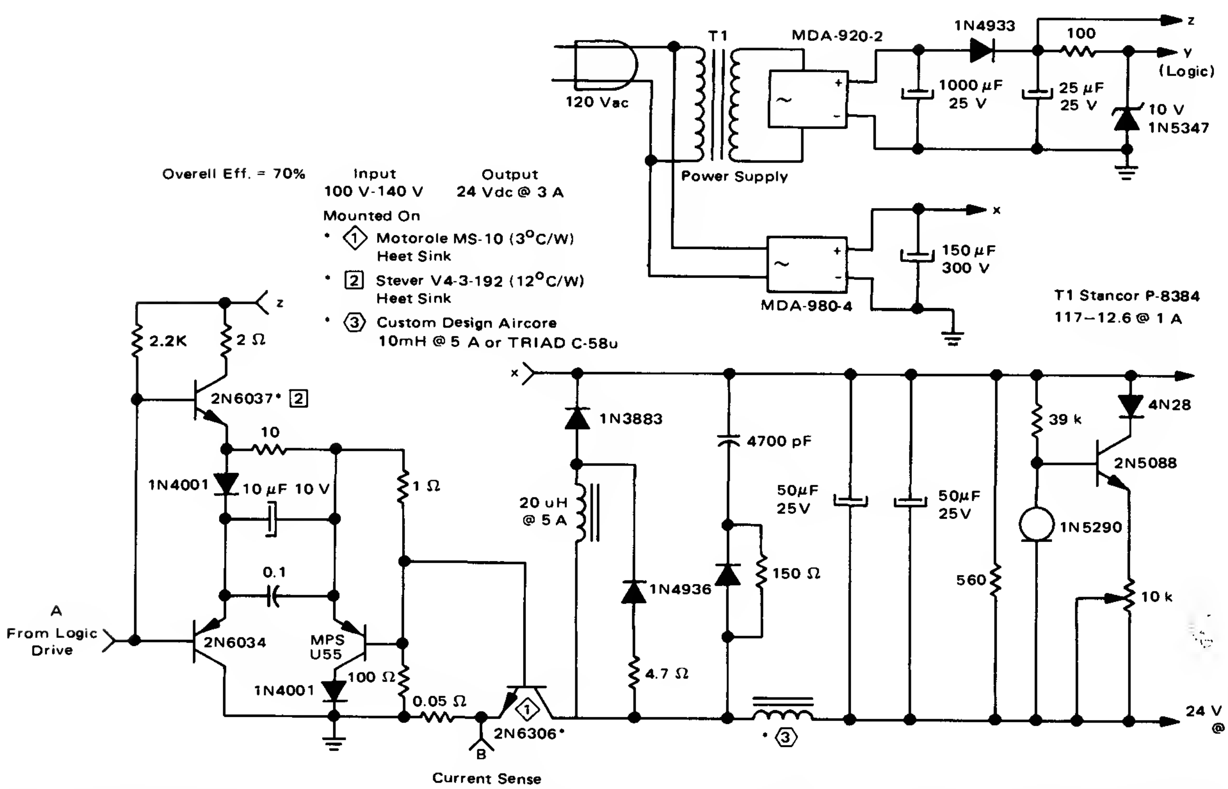
$P_{OUT\ 3}$ = 3 mW (V_O = 3 V ±10%)

Load Regulation, $P_{OUT\ 1}$ = 0.6% ($0 \leqslant I_L \leqslant 800$ mA)

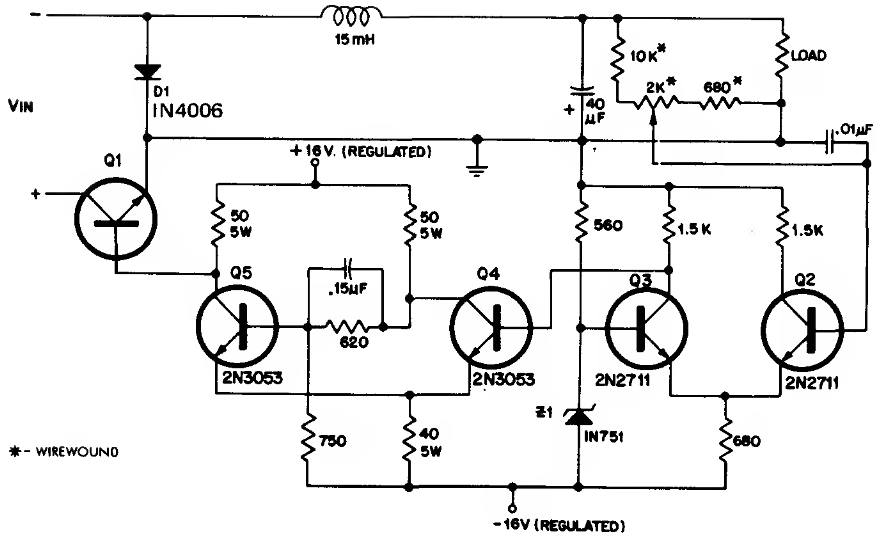
MULTIPLE-OUTPUT SWITCHING REGULATOR—Additional outputs are obtained from switching regulator by adding secondary windings to power transformer. Motorola MC3380 astable MVBR serves as control element. Feedback is achieved by amplifying output error with opamp A1 and applying this voltage to pin 6. Report covers design of transformer and power circuit.—H. Wurzburg, "Control Your Switching Regulator with the MC3380 Astable Multivibrator," Motorola, Phoenix, AZ, 1975, EB-52.



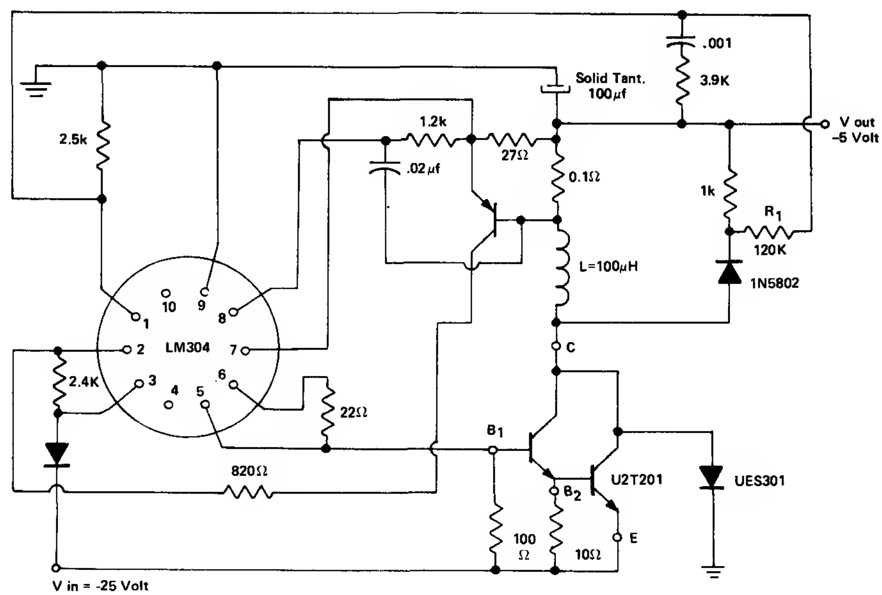
+5 V SWITCHING AT 10 A—Unitrode PIC625 hybrid power switch provides switching action for LM305 regulator at switching speeds up to 100 kHz for input voltage range of 20–40 V. Circuit operates in fixed OFF-time mode that makes output ripple independent of input voltage. Q1 provides current-limiting action.—"Switching Regulator Design Guide," Unitrode, Watertown, MA, 1974, U-68A, p 7.



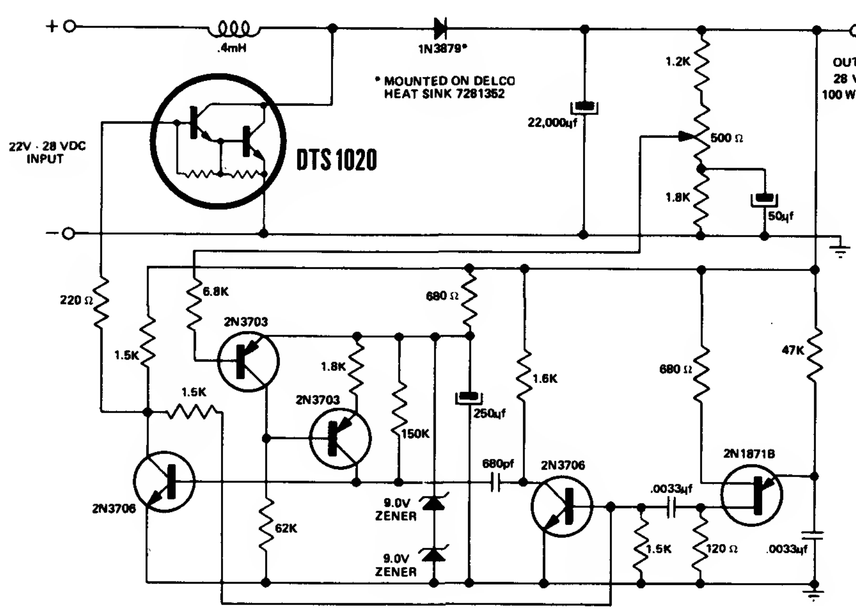
24-V 3-A SWITCHING-MODE—Circuit operates at 20 kHz from AC line with 70% efficiency. Control portion uses quad comparator and optoisolator and provides short-circuit protection. Logic drive uses push-pull transistors to switch 2N6306 power transistor at 20-kHz rate. Load regulation is 0.8% over output range of 1.5 to 3 A with 120-VAC input. Line regulation is 3% at 3 A for input range of 100 to 140 VAC.—R. J. Haver, "A New Approach to Switching Regulators," Motorola, Phoenix, AZ, 1975, AN-719, p 11.



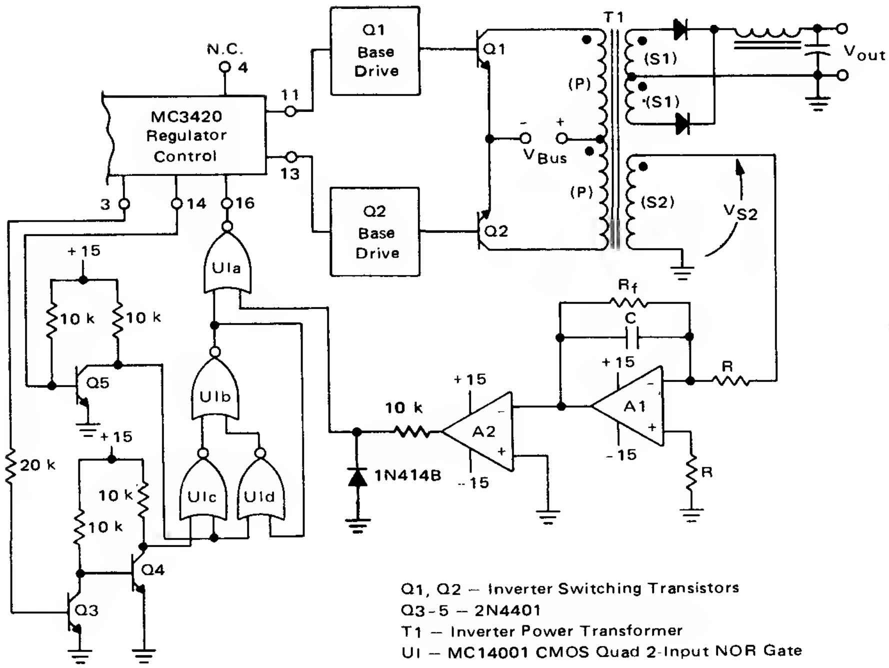
250 V AT 3 A—Single high-voltage silicon power transistor Q1 serves as series element in switching regulator, with regulation obtained by pulse-width modulation. Delco DTS-431 provides output of 250 V for maximum input of 325 V; other Delco transistors in same series give different combinations of output voltage and current in range of 300–750 W maximum output power. Efficiency is 92% at full load. Differential amplifier Q2-Q3 senses output voltage of regulator and feeds Schmitt trigger Q4-Q5 for turning series transistor Q1 on and off. Resulting square wave of voltage is smoothed by LC filter between Q1 and load.—"Pulse Width Modulated Switching Regulator," Delco, Kokomo, IN, 1972, Application Note 39, p 3.



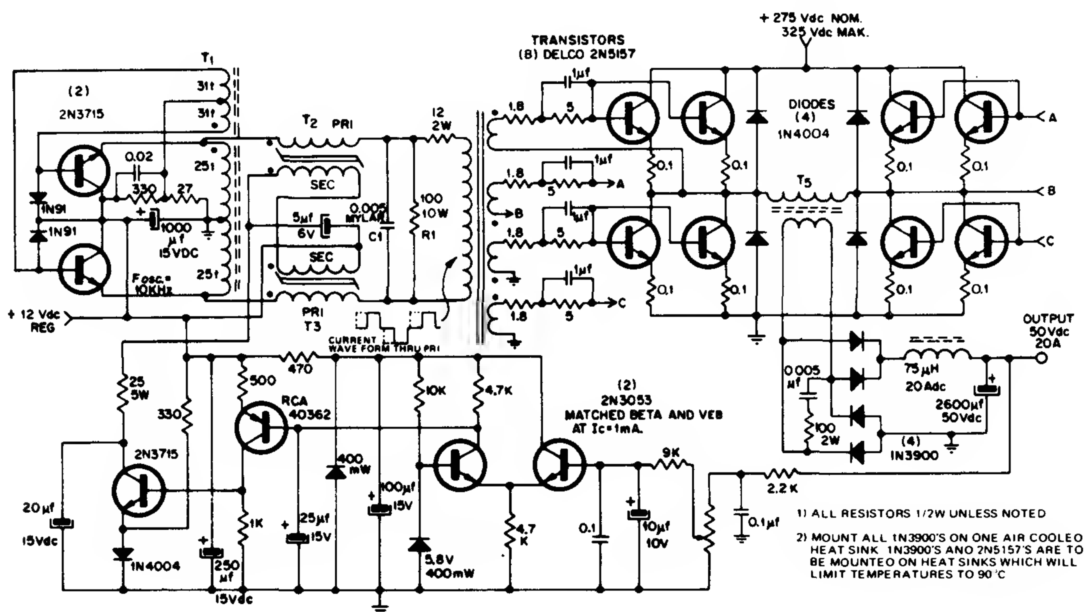
−5 V SWITCHING—Unitrode U2T201 Darlington serves as switching element for LM304 step-down switching regulator operating from input of −25 V. Operating frequency can be about 25 kHz. Darlington will handle peak currents up to 10 A.—"Designer's Guide to Power Darlingtons as Switching Devices," Unitrode, Watertown, MA, 1975, U-70, p 10.



28 V AT 100 W—Circuit using Delco DTS-1020 Darlington silicon power transistor operates over input range of 22–28 V. Switching rate is 9 kHz. Efficiency is about 85% at full load. Output voltage is sensed to control pulse width of mono MVBR which is triggered at 9 kHz by oscillator.—"28 Volt Darlington Switching Regulator," Delco, Kokomo, IN, 1971, Application Note 49, p 4.

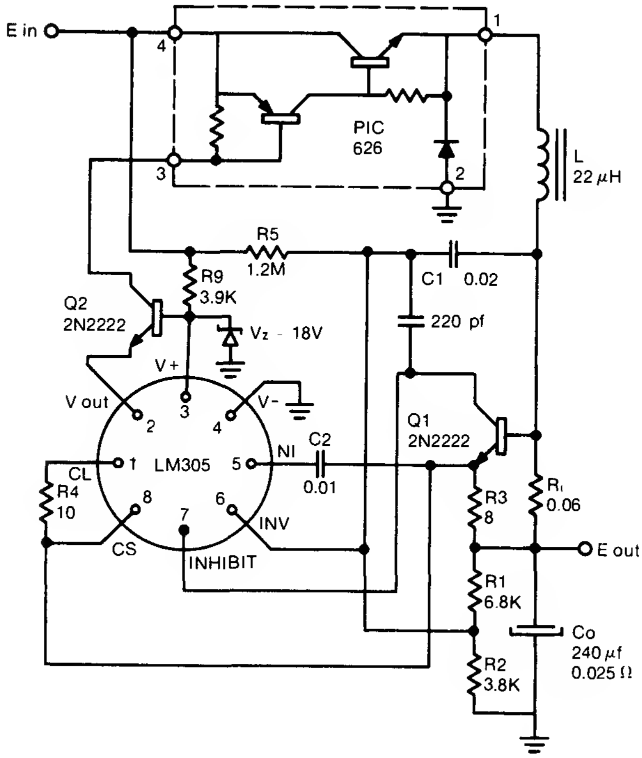


SYMMETRY CORRECTION—Low-cost external correction circuit for MC3420 switching-mode regulator ensures balanced operation of power transformer in push-pull inverter configuration. Circuit senses voltage impressed on primary of T1 through sensing secondary S2, for integration by opamp A1 so voltage on C represents volt-second product applied to T1. During conduction period of Q1, voltage on C ramps up to some positive value and output of A2 is low. Conduction period for output 2 then begins, Q2 turns on, and C ramps down to 0 V. A2 output then goes high, inhibiting output 2 and Q2. Times for C2 to charge and discharge are equal so conduction periods are equal.—H. Wurzburg, "A Symmetry Correcting Circuit for Use with the MC3420," Motorola, Phoenix, AZ, 1977, EB-66.

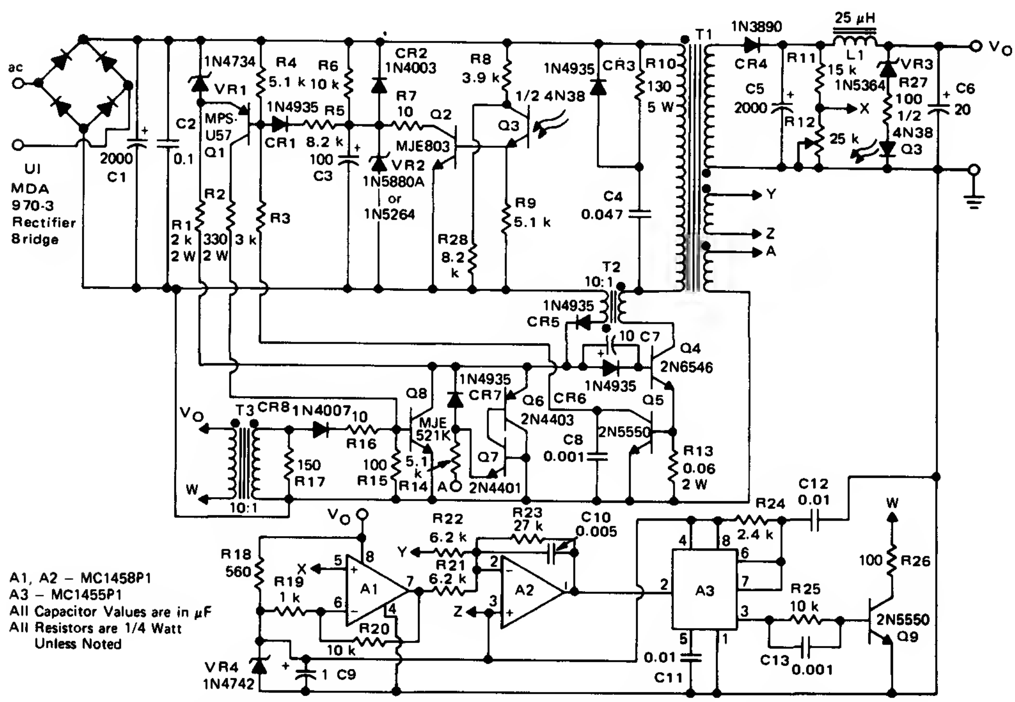


T1 - PRI 50t tap @ 25t #22 AWG SEC 62t tap @ 31t #25 AWG. CORE FERROXCUBE INC 846T250-3E2A	T4 — PRI. 75t #25 ALL SEC'S 12t #25 CORE MAGNETICS INC. 50076-1O	L1 — 70t of 5 Pcs. #16 in PARALLEL CORE. ARNOLD ENG. MOLY PERMALLOY A109156-2
T2, T3 - PRI 150t #29 SEC 150t #29 CORE ARNOLD ENG 4T5515-S500	T5 - PRI 77t #16 SEC 18t of 6 Pcs #16 in PARALLEL CORE USE 2 Pcs. FERROXCUBE 144T500-365	

50 V AT 1 kW—Switching regulator operating at 10 kHz uses pulse-width modulation to give 87% efficiency at full load. Input voltage is 275 VDC. Inverter output drives combination of eight Delco 2N5157 power transistors connected in paralleled pairs in each leg of bridge circuit. Clamp diodes in each bridge leg prevent reverse conduction through collector-base diodes of transistors. Regulator consists of differential amplifier and two-stage DC amplifier controlling direct current through windings of magnetic amplifier.—"One Kilowatt Regulated Power Converter with the 2N5157 Silicon Power Transistor," Delco, Kokomo, IN, 1972, Application Note 44, p 3.



HIGH-VOLTAGE POSITIVE-SWITCHING—Designed for operation from supply voltages above 40-V maximum rating of LM305 regulator. Output is +5 V at up to 10 A. Circuit uses fraction of input voltage as determined by R9 and zener, with Q2 providing voltage isolation between regulator and Unitrode PIC626 hybrid power switch.—"Switching Regulator Design Guide," Unitrode, Watertown, MA, 1974, U-68A, p 9.

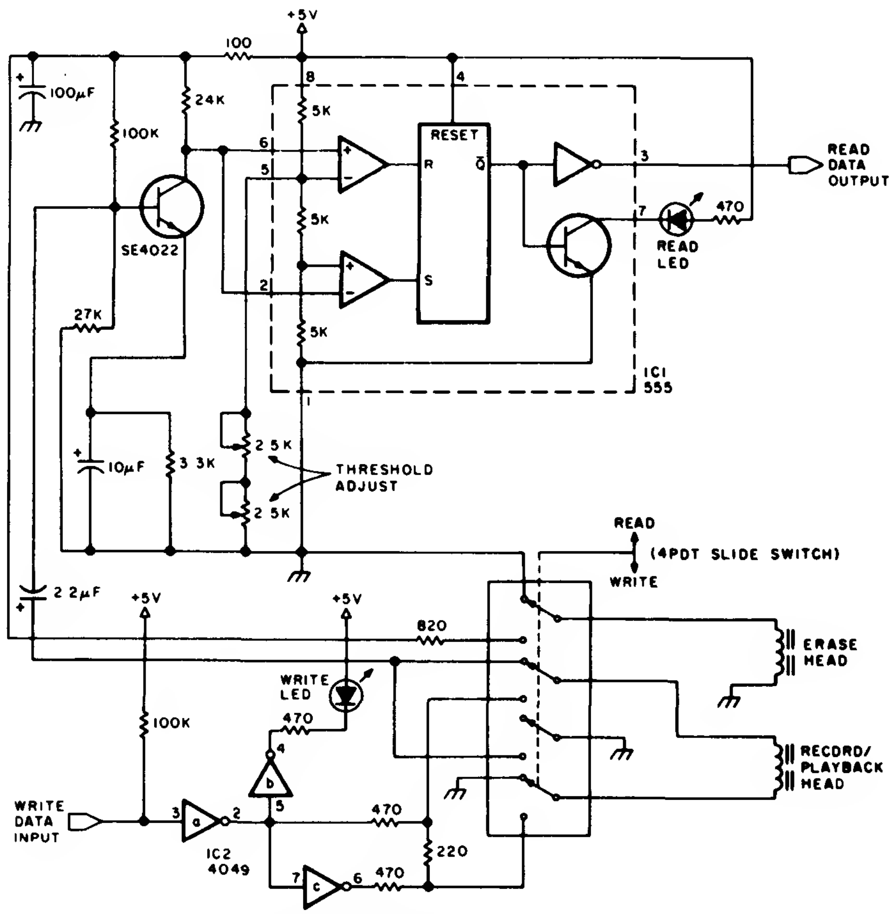


24 V AT 3 A FOR CATV—Switching regulator design meets requirements for cable television systems where small size, low weight, and high efficiency are prime considerations. Circuit operates above 18 kHz either from 40–60 V 60-Hz square-wave source (CATV power line from ferroresonant transformer) or from DC standby source. Control circuit consists of dual opamp and linear IC timer used to vary ON time of 2N6546 power transistor. At start-up, Q4 is saturated and full input voltage is applied to primary of power transformer T1. Current then ramps up linearly until Q4 is switched off by opamps A1 and A2 and timer A3. Power transistor is operated between saturation and OFF state at above 18 kHz, with ON time varied while OFF time is fixed, to maintain constant output voltage as sensed by A1.—J. Nappa and N. Wellenstein, "An 80-Watt Switching Regulator for CATV and Industrial Applications," Motorola, Phoenix, AZ, 1975, AN-752, p 5.

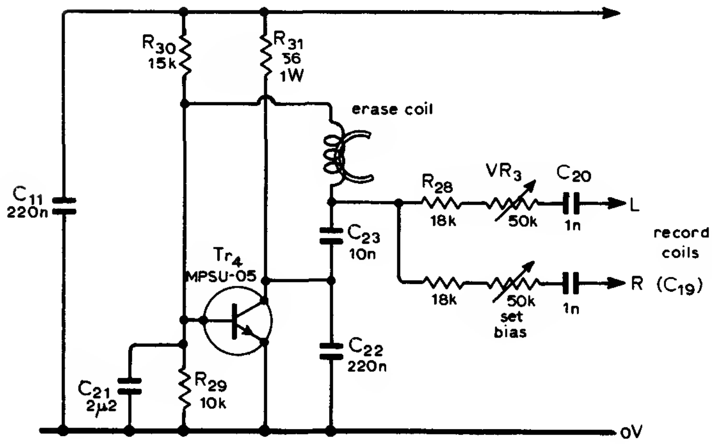
CHAPTER 89

Tape Recorder Circuits

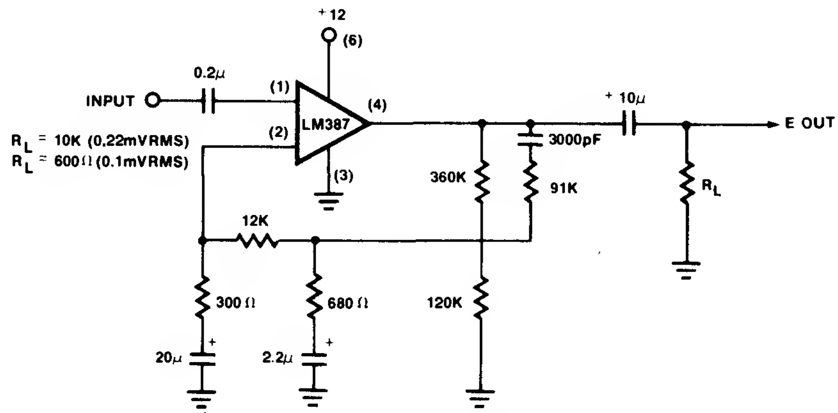
Includes interface circuits for recording and playback of instrumentation and microprocessor data signals, Morse code, and RTTY signals on inexpensive cassette deck, along with NAB-equalized preamps, erase/bias oscillator, AVC, dynamic range expansion, and VOX circuits for all types of mono and stereo tape recorders. Interface for keying CW transmitter with taped message is also given.



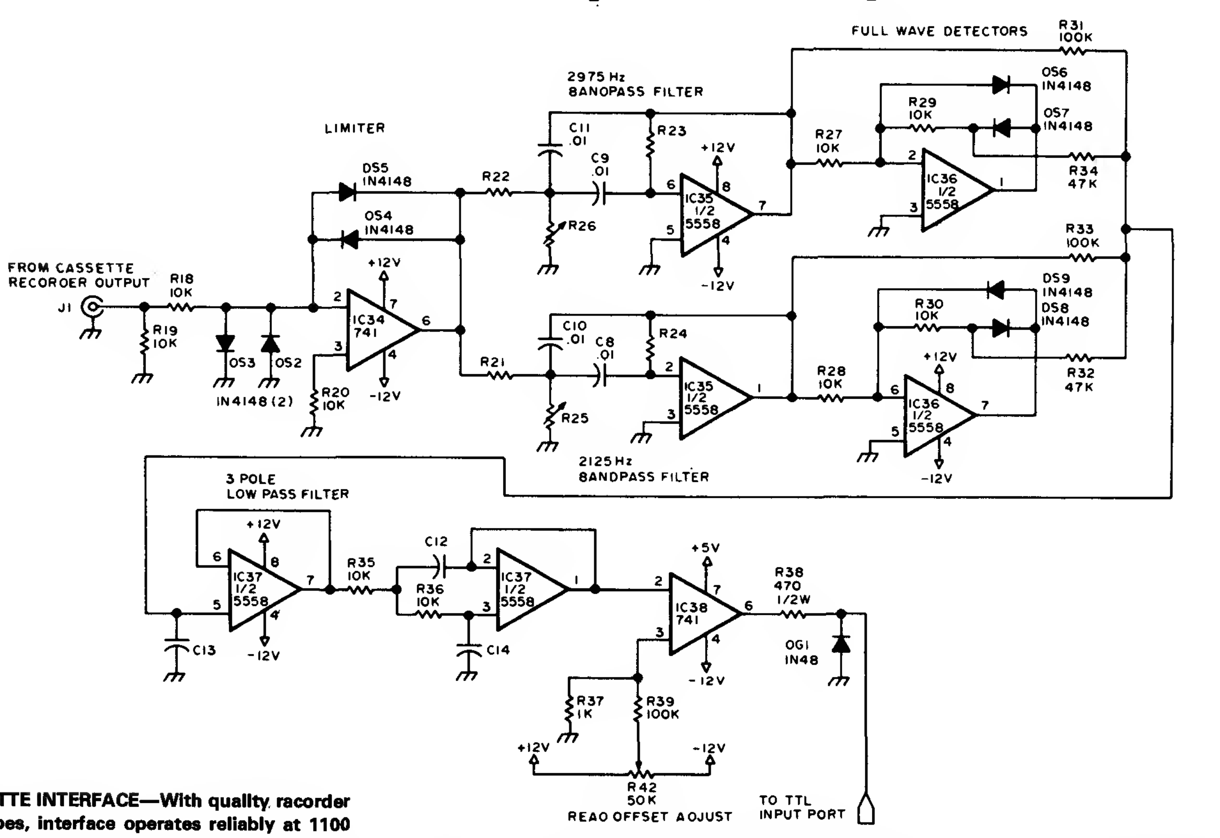
DIGITAL RECORDING WITH CASSETTES—Circuit shows modifications required for standard cassette recorder to bring read level up to about 1 V. Recorder works well over range of 100 to 1200 b/s. During write process, direct current is passed through record head to saturate tape, with polarity depending on direction of current. During read cycle, voltage is induced in head winding only when transition between oppositely polarized zones moves past head. 555 timer is used as combination level detector and flip-flop to recover serial data.—R. W. Burhans, A Simpler Digital Cassette Tape Interface, *BYTE*, Oct. 1978, p 142–143.



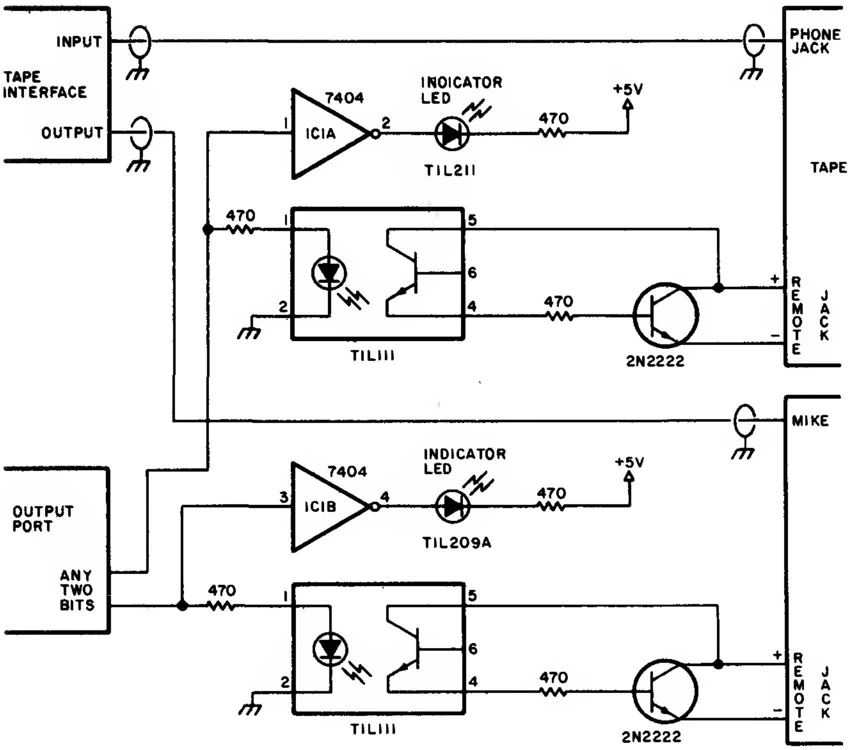
ERASE/BIAS OSCILLATOR—Used in high-quality stereo cassette deck operating from AC line or battery. Provides up to 33 VRMS at 50-kHz erase frequency, as required for completely erasing existing recording on tape when recording over it. Supply voltage should be in range of 12–14 V. Article gives all other circuits of cassette deck and describes operation in detail.—J. L. Linsley Hood, Low-Noise, Low-Cost Cassette Deck, *Wireless World*, Part 1—May 1976, p 36–40 (Part 2—June 1976, p 62–66; Part 3—Aug. 1976, p 55–56).



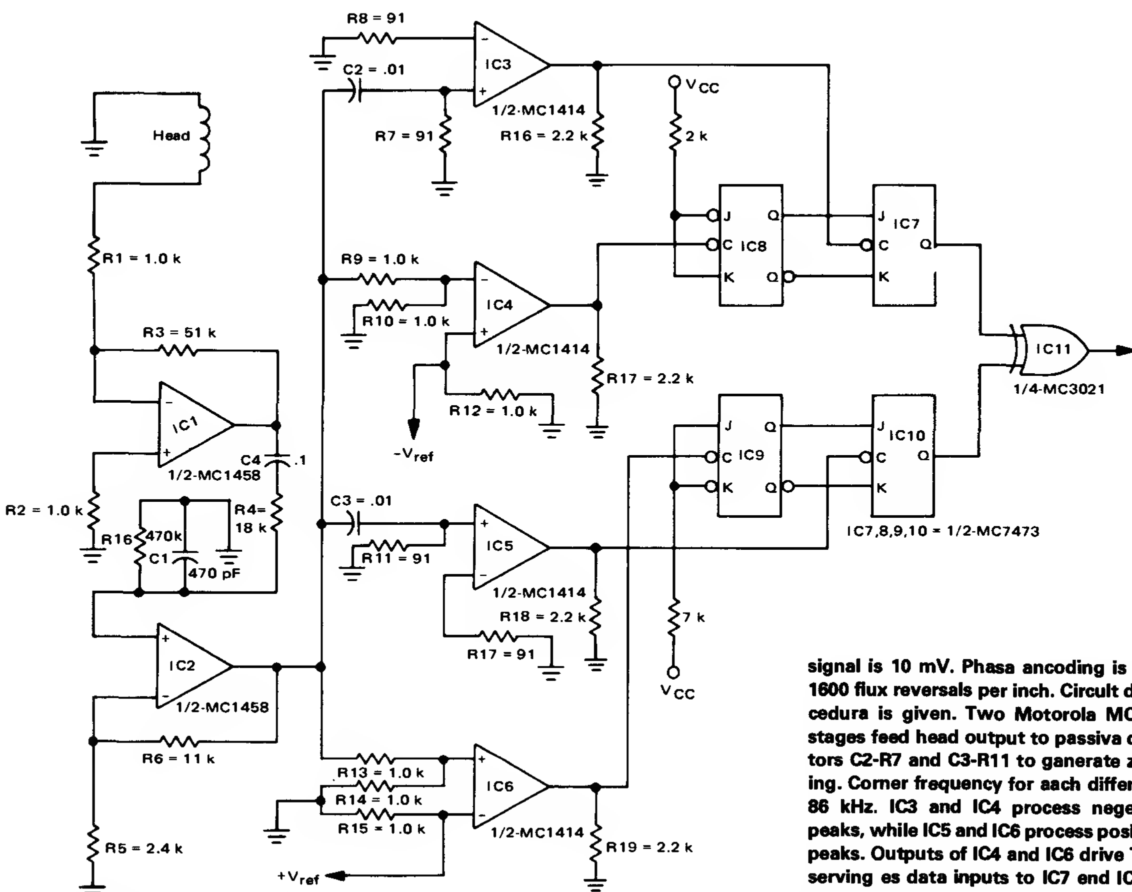
CASSETTE PREAMP—Provides gain of 81 dB and 0.22 mVRMS for 10K load. Gain drops to about 78 dB and output is 0.1 mVRMS for 600-ohm load. Gain values are for 100 Hz, with gain dropping above and below this value.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 782.



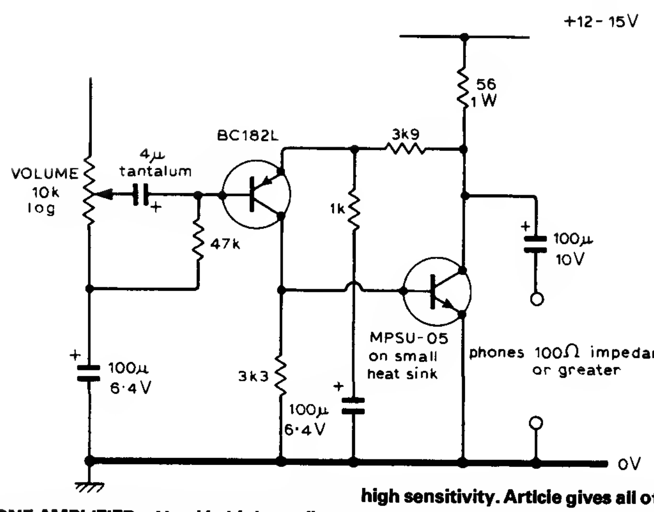
CASSETTE INTERFACE—With quality recorder and tapes, interface operates reliably at 1100 bauds, for loading 24K microprocessor system in 246 s. Cassette output is amplified and clipped by limiting amplifier IC34. Bandpass filters followed by full-wave detectors respond to 2125-Hz mark and 2975-Hz space frequencies and feed their outputs to summing junction at pin 5 of three-pole active low-pass filter IC37. 2975-Hz tones are rectified to positive voltage and 2125-Hz tones to negative voltage, with amplitudes varying from maximum at exact frequencies to sum voltage of 0 V at midfrequency of 2550 Hz. Output opamp IC38 delivers correct TTL level for reading by single-bit input port.—R. Suding, Why Wait? Build a Fast Cassette Interface, *BYTE*, July 1976, p 46–53.



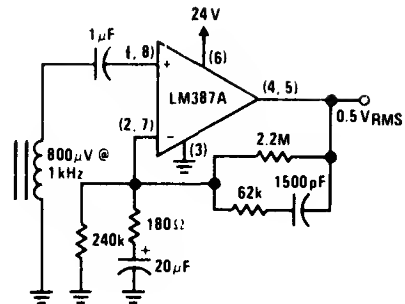
CASSETTE FILE UPDATE—Interface circuit controls two tape decks for updating mailing lists or other sequential files stored on magnetic tape in audio cassettes. Two cassette tape recorders are required, one for input (reading files) and one for output (writing files). Microprocessor tape input and output circuits are connected to appropriate tape unit as shown. Only one cassette operates at any given time. Optocouplers prevent polarity or voltage problems between tape motor and microprocessor. Tape functions are under software control. Software delay of about 1 s allows tape motor to come up to speed before recording starts. Records are in numerical or other logical sequence, so updating requires only one pass. On update, old cassette file is read into microprocessor for deletion, change, or addition of data, and corrected data is written on new cassette. Article covers use for maintaining Christmas card and other mailing lists, payroll records sequenced by Social Security number, and other sequential lists.—W. D. Smith, Fundamentals of Sequential File Processing, *BYTE*, Oct. 1977, p 114–116, 118, 120, 122, 124, and 126–127.



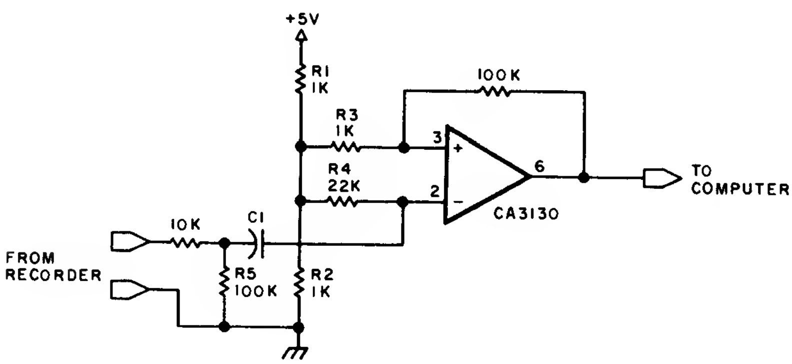
CASSETTE DATA READOUT—Uses separate circuits having threshold provisions for both positive and negative peaks, for reading data stored on cassette tape at 15 in/s. Head output signal is 10 mV. Phase encoding is used with 1600 flux reversals per inch. Circuit design procedure is given. Two Motorola MC1458 gain stages feed head output to passive differentiators C2-R7 and C3-R11 to generate zero crossing. Corner frequency for each differentiator is 86 kHz. IC3 and IC4 process negative-going peaks, while IC5 and IC6 process positive-going peaks. Outputs of IC4 and IC6 drive T flip-flops serving as data inputs to IC7 and IC10.—"The Recovery of Recorded Digital Information in Drum, Disk and Tape Systems," Motorola, Phoenix, AZ, 1974, AN-711, p 9.



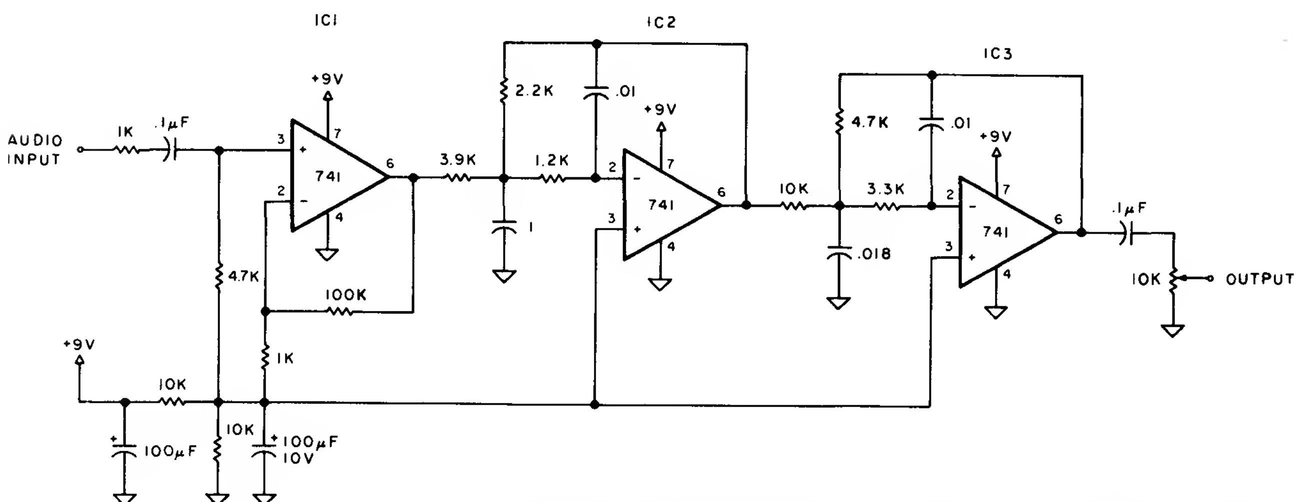
HEADPHONE AMPLIFIER—Usad in high-quality stereo cassetta deck operating from AC line or battary. Provides gain of 5 in class A, for use with low-sensitivity headphones or low-impedance haedphones down to 100 ohms. Replay ampliflar output alona is adequate for haadphones having 2000-ohm load impedance or high sensitivity. Article gives all other circuits of cassette deck and describes oparation in detail. Input to volume control is takan from output of opamp in replay amplifier, nominelly about +5 V.—J. L. Linsley Hood, Low-Noisa, Low-Cost Cassetta Deck, *Wirelass World,* Part 2—June 1976, p 62–66 (Part 1—May 1976, p 36–40; Part 3—Aug. 1976, p 55–56).



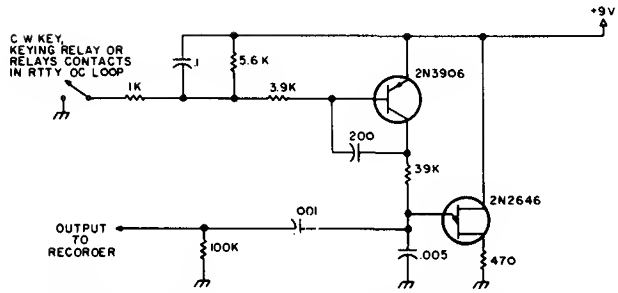
NAB PLAYBACK PREAMP—Provides standard NAB equalization for tapa player requiring 0.5 VRMS from head having sensitivity of 800 μV et 1 kHz, with operating speed of 3¾ in/s. Design procedure is given. Voltaga gain at 1 kHz is 56 dB.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-31–2-37.



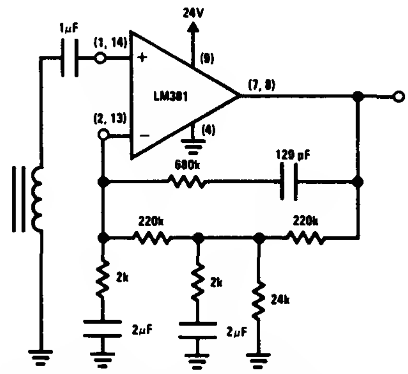
CASSETTE INTERFACE—Usad betwaan recorder end computer for loading data stored in tape cessette. Single divider network R1-R2 drives both opamp inputs and provides stabilized sensitivity. R3 isoletes inputs.—B. E. Rehm, The TDL Syatem Monitor Board, *BYTE,* April 1978, p 10, 12–14, and 16.



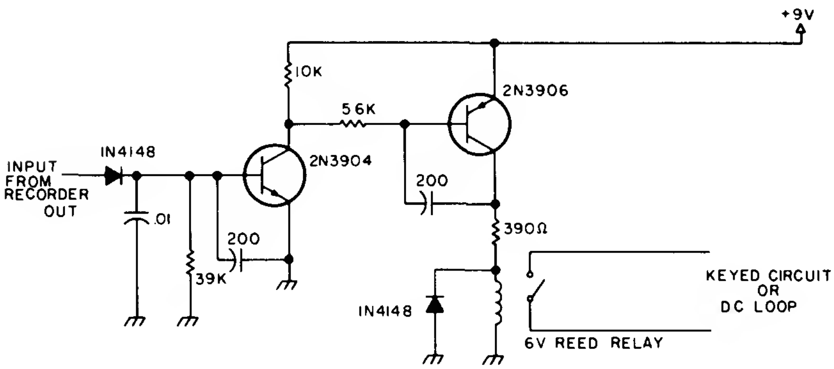
COPYING CASSETTE PROGRAMS—Controller serves for making duplicata copias of microprocessor programs recorded on magnatic tapa, for insurance against accidental damage to master cessetta during usa. Used betwaan audio output of cassetta player and audio input of tape recorder. Opamp IC1 with gain of 100 overloeds so output is constant-amplituda squera wave regardless of input level from tape being copied. If program uses eudio tones for digital date, aight cycles of 2400 Hz represents digitel 1 and four cycles of 1200 Hz represents digital 0. Additionel opamps act as four-pole Buttarworth filter rejecting signals above 3000 Hz. 10K pot is adjusted so output level matches requiramants of recorder.—P. A. Stark, Copying Computer Cassettes, *Kilobaud,* Aug. 1978, p 94–96.



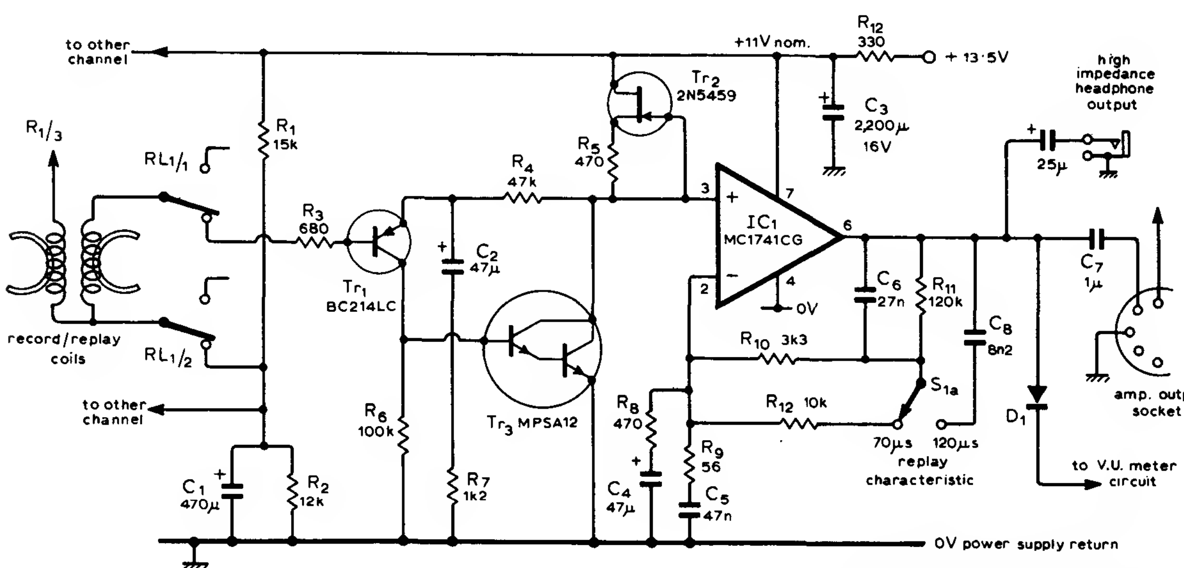
CW AND RTTY ON CASSETTES—Circuit provides conditioning of routina CW calls or RTTY test messages, as required for racording on andless-loop cassette. Kayed signal is filtared to remova contact bounca, then used to tum on 2N3906 which gates 2N2646 sawtooth oscillator operating at about 5 kHz when using 0.005-μF gate capacitor; for lower frequancy, incraasa capacitor to 0.01 μF.—Cassetta-Aided CW and RTTY, *73 Magazina*, Sept. 1977, p 122–123.



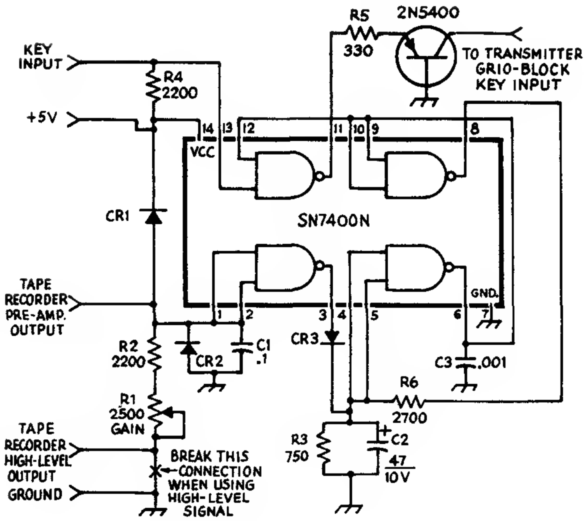
FAST TURN-ON PLAYBACK PREAMP—Turn-on for gain and supply voltaga is only 0.1 s, as compared to 5 s normally required in preamp providing NAB tape playback responsa.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-31–2-37.



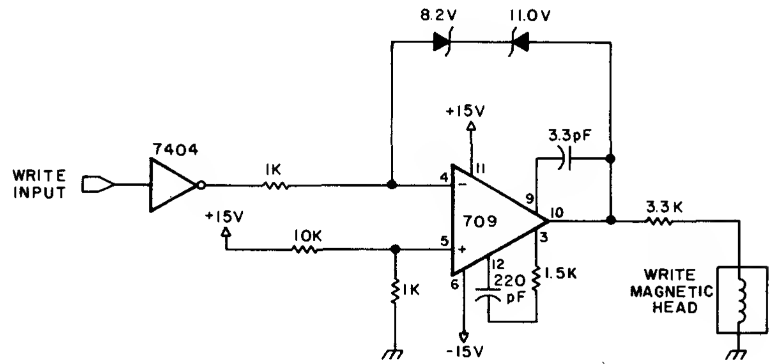
CASSETTE PLAYBACK OF CW AND RTTY—Playback-signal conditioning circuit is used between tape recorder and transmitter when routine CW calls or RTTY test messages are recorded on andless-loop cassette recorder. Recorded tona is rectified by 1N4148 and applied to RC timing circuit. Decay voltage developed across network when tone is removed turns on 2N3904 and 2N3906 stages. Output of 2N3906 drivas raed ralay in transmittar kaying circuit. If resistor is used in placa of ralay, drop across it during key-down period can be used to driva electronic kayar.—Cassette-Aided CW and RTTY, *73 Magazina*, Sapt. 1977, p 122–123.



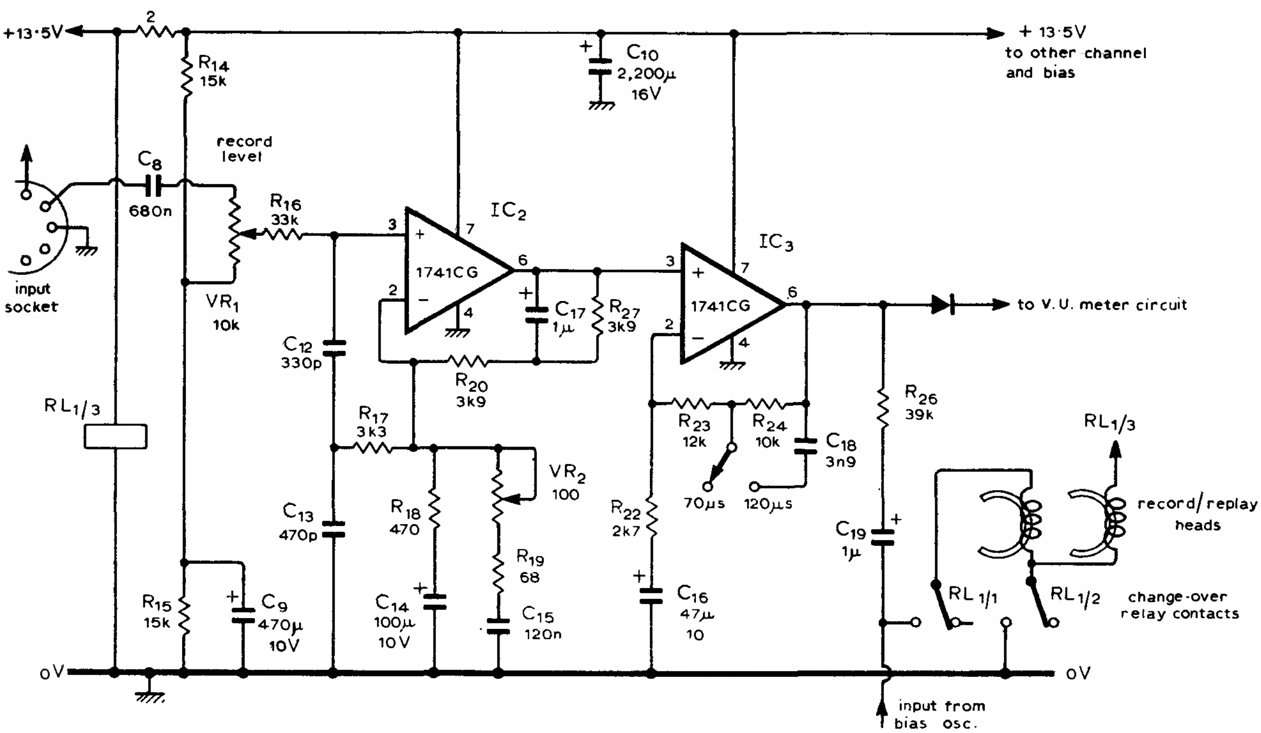
REPLAY AMPLIFIER—Used in high-quality starao cassette dack operating from AC lina or battery. Amplifier design is optimized for minimum noise voltaga by using PNP silicon input transistor operated with lowest possible collector currant (10 μA for Taxas Instrumants transistor specifiad). Motorola IC in second stage, similar to 741 but having 8-pin metal-can encapsulation, provides aqualization required for replay. Output of ampiifiar is about 0.4 VRMS. Article gives all other circuits of cassette deck and describes operation in datail.—J. L. Linslay Hood, Low-Noise, Low-Cost Cassette Dack, *Wireless World*, Part 1—May 1976, p 36–40 (Part 2—June 1976, p 62–66; Part 3—Aug. 1976, p 55–56).



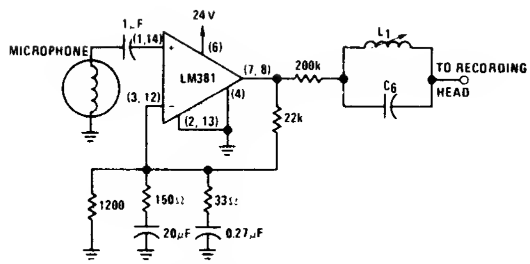
KEYING FROM TAPE—Simple envelope detector and weve-sheping circuit uses quad NAND gate for instant replay of recorded CW transmissions through transmitter. Diodes can be 1N270 or eny othar small-signel switching or ganaral-purposa types. R3, C2, and CR3 provide envelope detection of amplified and clipped audio input from tapa racorder.—A. H. Kilpatrick, Keying e Trensmittar with a Tepe Recorder, *QST*, Jen. 1974, p 45.



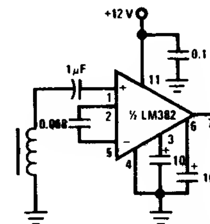
DIGITAL CASSETTE HEAD DRIVE—Provides saturation recording as requlred for digitel date. Back-to-back zenars provide bipolar limiting at ±10 V. TTL-level inputs are applled to writa data input, inverted by 7404, end fed to inverting input of opemp. Noninverting opamp input is referenced to +1.4 V so output will switch polarities when TTL level of input changes.—I. Rampil end J. Breimeir, The Digital Cassette Subsystem: Digital Recording Background and Head Interfaca Electronics, *BYTE*, Feb. 1977, p 24–31.



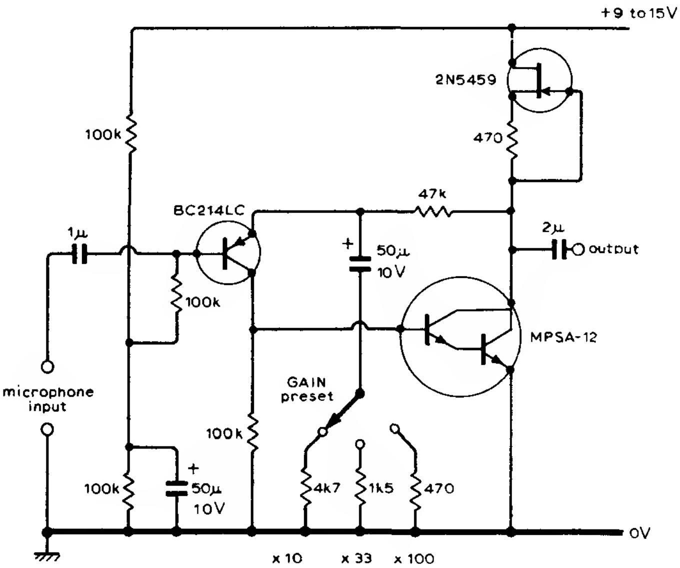
RECORDING AMPLIFIER—Used in high-quality stereo cassette deck operating from AC line or battary. Uses active RC circuit R_{16}-R_{17}-C_{12}-C_{13}-R_{19}-VR_2-C_{15} to provide required high-frequancy recording characteristic for usa with Garrard CT4 recording head; componant values may have to be changed for other heads. C_{18} (3.9 nF) is switched in to change from basic 70-μs racording charactaristic to 120 μs. C_{17} and R_{27} provide new cassette-standard bess preemphesis at 3,180 μs. Recording leval is chosan as 0 VU at 660 Hz. Output feeds VU metar through silicon dioda. Article gives all other circuits of cassetta deck end describes operetion in detail.—J. L. Linsley Hood, Low-Noise, Low-Cost Cassetta Dack, *Wireless World*, Part 1—May 1976, p 36–40 (Part 2—Juna 1976, p 62–66; Part 3—Aug. 1976, p 55–56).



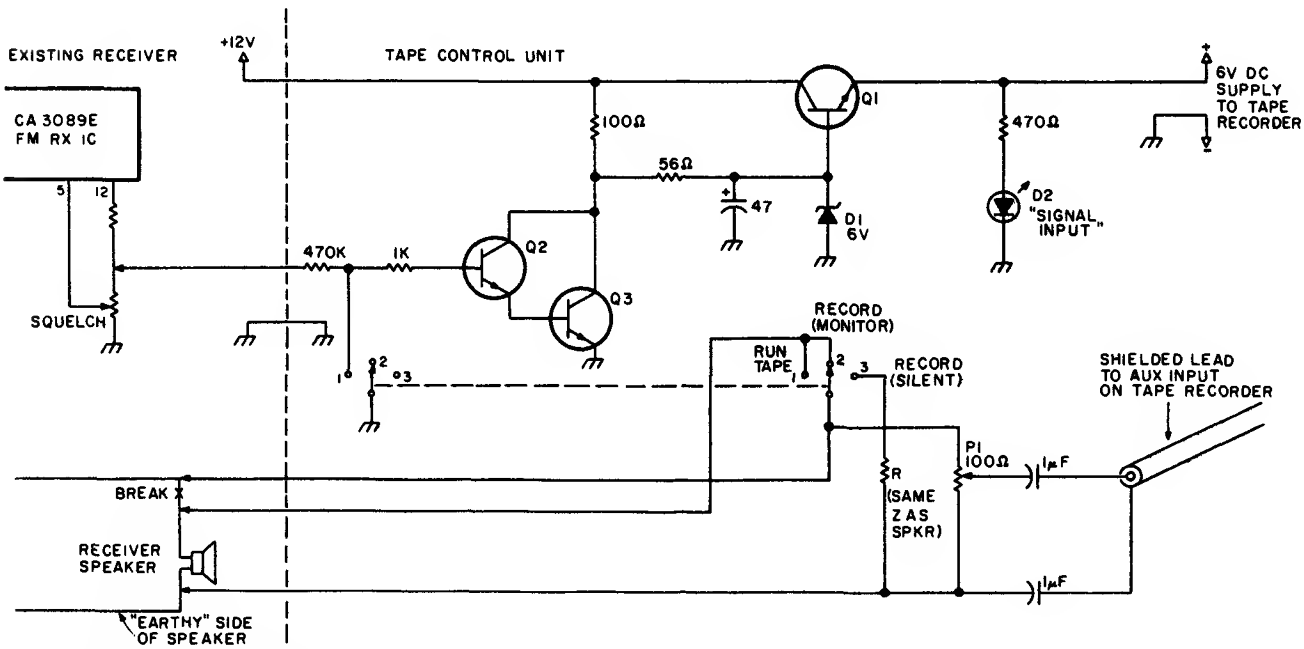
RECORDING AMPLIFIER—Designed for use with microphona having 10-mV peak output and recording heed requlring 30-μA AC drive current. Output swing la 6 VRMS. High-frequency cutoff is 16 kHz, with circuit designed for slope of 6 dB per octava between 4 kHz and 16 kHz to compensate for falling frequency response of recording head starting at 4 kHz.—"Audio Handbook," National Semiconductor, Sante Clera, CA, 1977, p 2-31–2-37.



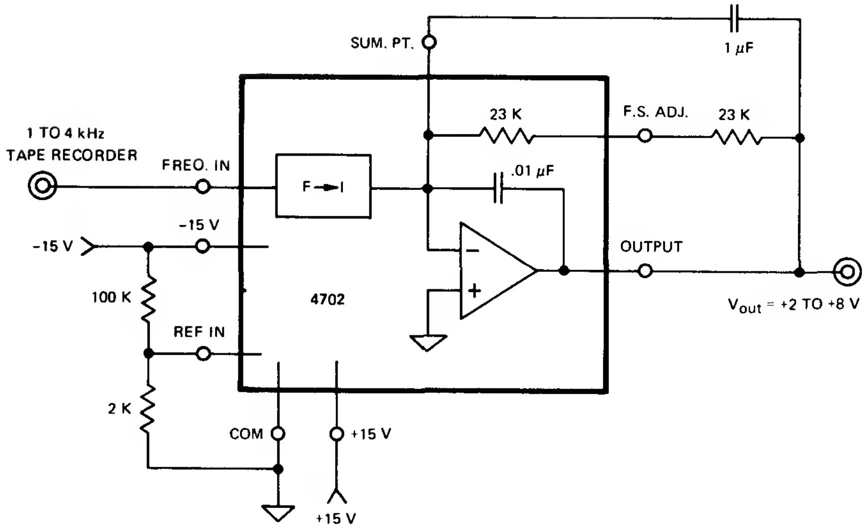
PLAYBACK PREAMP—Circuit is optimized for eutomotive usa at supply of 10–15 V. Wideband 0-dB reference gein is 46 dB. NAB equelization is Included. Tape speeds can be 1⅞ or 3¾ in/s.—"Audio Hendbook," National Semiconductor, Senta Clara, CA, 1977, p 2-31–2-37.



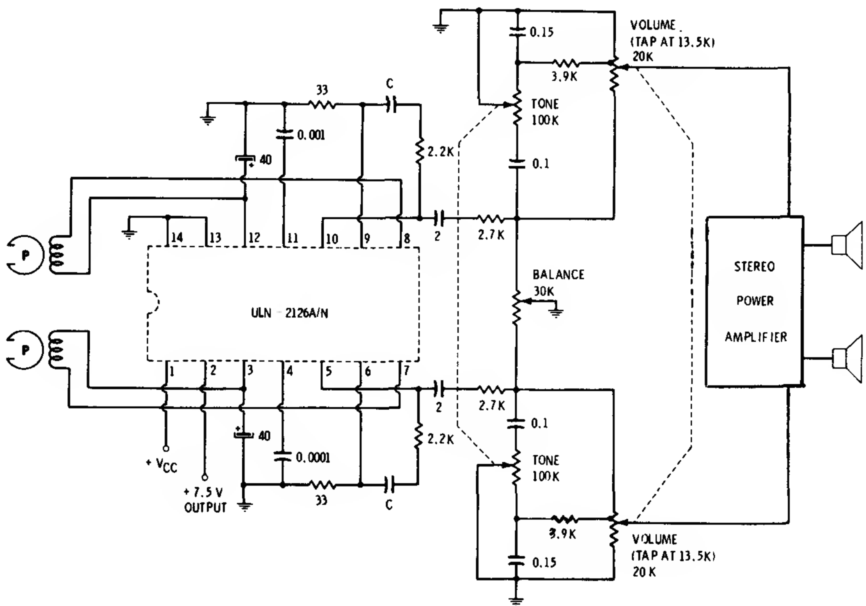
MICROPHONE PREAMP—Used in high-quality stereo cassette deck operating from AC line or battery. Provides three preset gain positions (10, 33, and 100) to meet amplification requirements of precticelly ell types of microphones used with tape recorders. Recording Input of cassette deck providas only enough gain for recording from eudio amplifiar or radio tuner delivering 50–100 mV at feirly low impedence, hence ia not suitebie for microphone input. Article gives eil other circuits of cassette deck and describes operation In detail.—J. L. Linsley Hood, Low-Noisa, Low-Cost Cassette Deck, *Wireless World*, Part 2—June 1976, p 62–66 (Part 1—May 1976, p 36–40; Part 3—Aug. 1976, p 55–56).



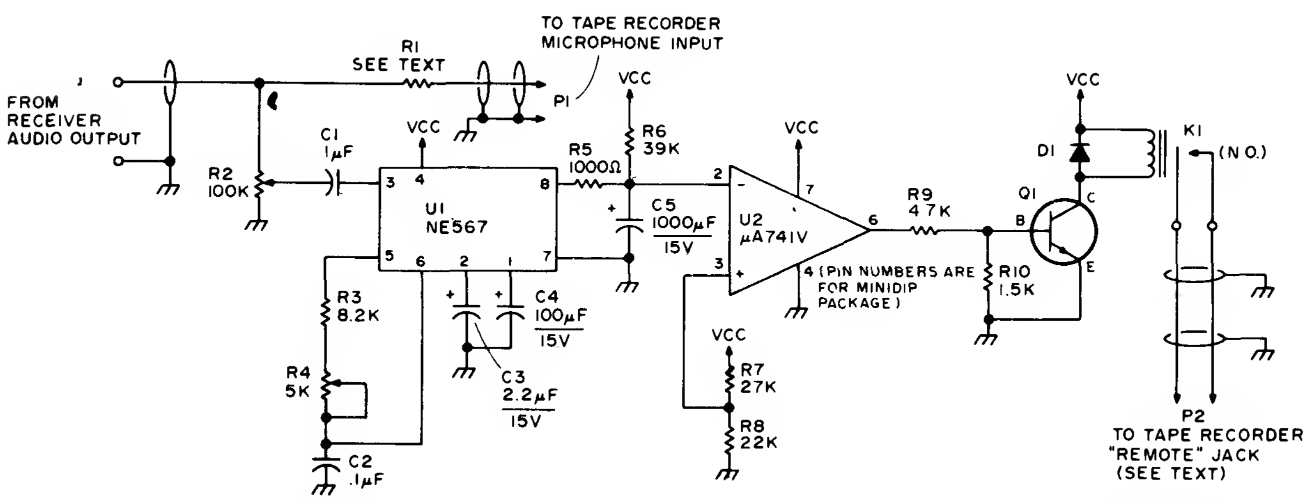
MESSAGE-CONTROLLED RECORDER—Circuit turns on tape recorder whenevar input signal is present In receiver, end turns off recorder when signal goes off. Applications include monitoring locai FM repeatar for daily usage to obtain caii signs of users, or unattended recording of messages left by other amateur stations. Uses cheap cassette tepe recorder with autostop, operating at 6 V obtained from 12-V receiver supply by series regulator Q1 and zener D1. Connection to mute or squelch circuit of receiver is shown for set having CA3089E in IF tail and. Darlington peir Q2-Q3 effectively removes base supply for Q1 to turn recorder off. LED comes on when recorder is on. Q1 Is NPN power trensistor, whila Q2 and Q3 are amall-signal NPN transiators.—F. Johnson, Automatic Taping Unit, *73 Magazine*, May 1977, p 98–99.



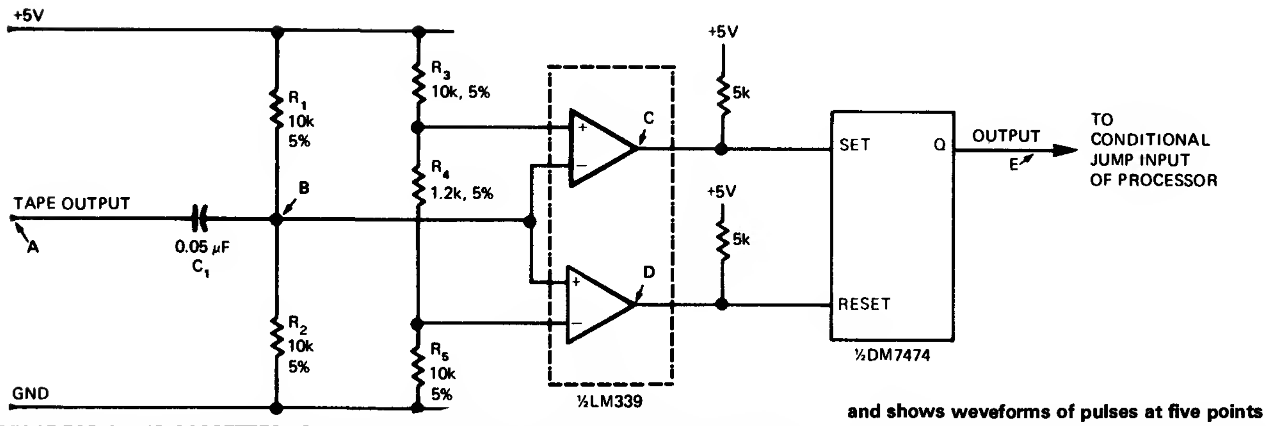
PLAYBACK OF PULSE TRAINS—Taledyne Philbrick 4702 fraquancy-to-voltaga converter circuit provides rippla filter required for converting recordad squere waves In frequancy range of 0.5 to 5 kHz to desired analog output In ranga of 2 to 8 VDC. Report covers problems of recording and playing back pulsa trains.—"V-F's, F-V's, and Audio Tape Recorders," Teledyne Philbrick, Dedham, MA, 1974, AN-11.



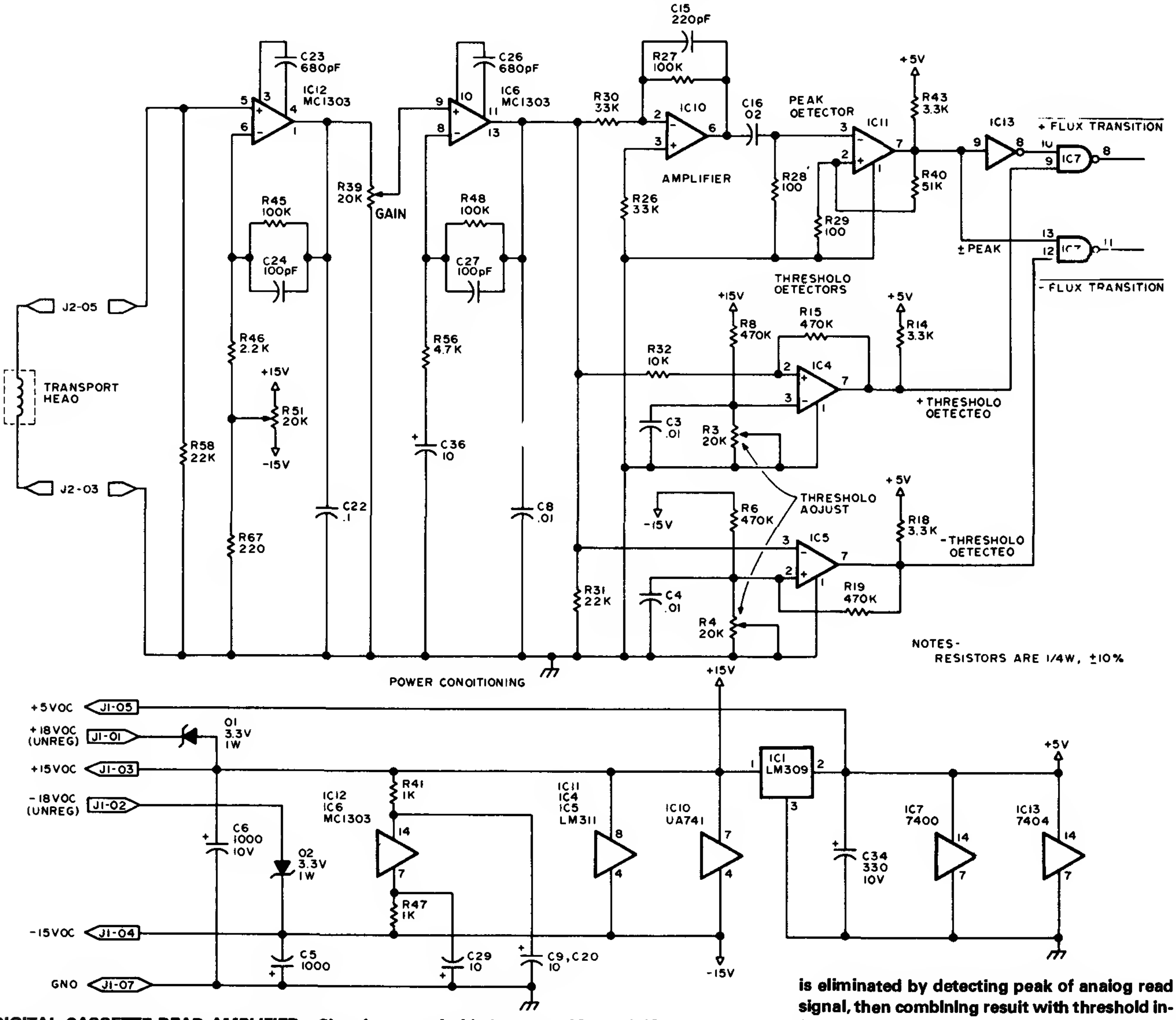
STEREO TAPE PLAYBACK—Singla Spregua ULN-2126A IC provides preamplification for two channels along with 2-W output power for driving stereo powar amplifiar. Values shown giva equalization required for tape playback. Single ganged tone control servas for both treble and bass adjustmant.—E. M. Noll, "Linaar IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 237 and 243.



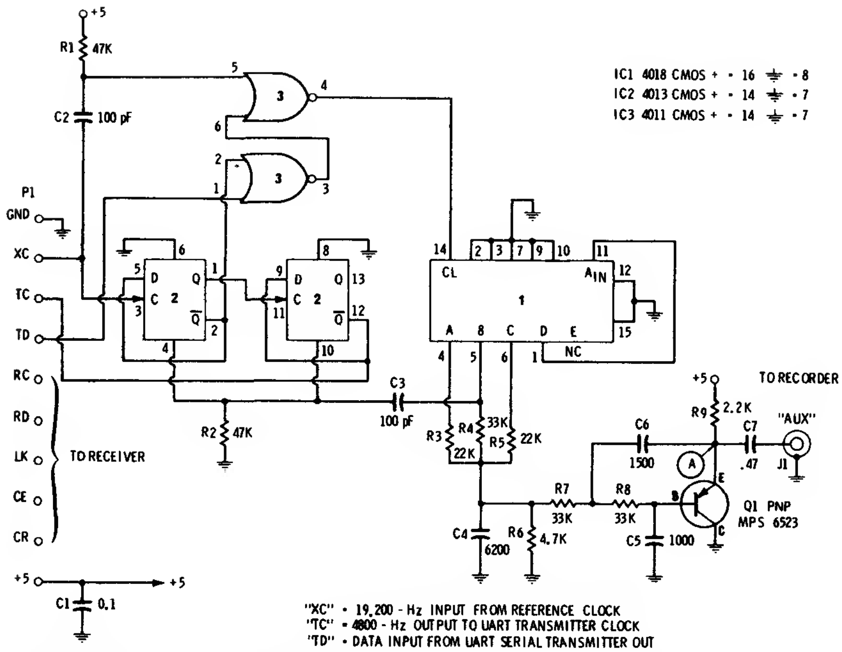
UNATTENDED RECORDER—Uses 567 tona decoder In circuit designed to respond to 1-kHz tona, to turn on recorder for taking message when receivar of amateur station Is unattanded. R6, C5, and 741 opamp U2 form timar that turns on RS-267-2016 translstor and pulls in relay to turn on tape recorder for recording about 30-s messega. Relay then drops out. Usa wall-regulated 5-V supply. All transmittars using this service must hava 1-kHz audio ancodars for producing required control frequency. Articla gives construction and adjustmant details.—R. Parlman, The F.M. "Auto-Start," *73 Magazina*, April 1974, p 21 and 23–24.

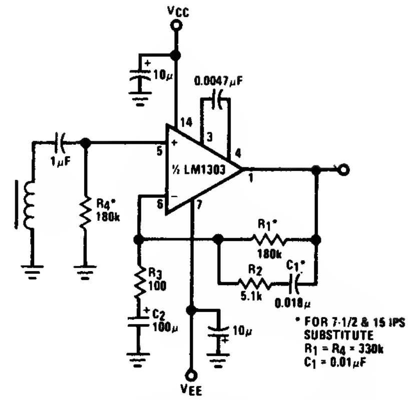


INTERFACE FOR AUDIO CASSETTES—Permits use of ordinary home cassetta racordar to provide high-speed loading of assembiar and sourca program into microprocessor. Data is recorded by using variation of phase encoding, which provides salf-clocking end is indepandent of tape speed verietion. Effective I/O rete is about 500 b/s or 5 times that of iow-speed paper-tapa punch or raadar. Article covers phase-encoding procedure, gives flowchert, and shows weveforms of pulses at five points in circuit. Parity bits provide error correction and detection, using Hamming code.—S. Kim, An Inexpensive Audio Cassette Recorder Interface for µP's, *EDN Magazine*, March 5, 1976, p 83–86.



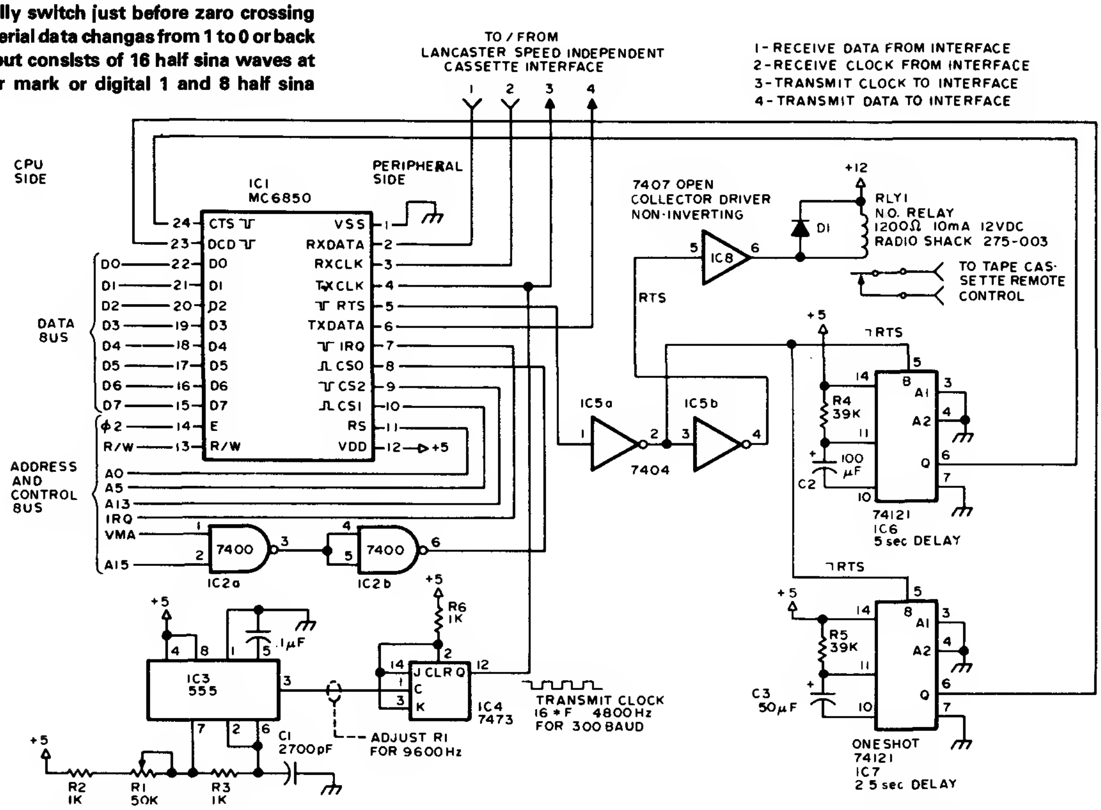
DIGITAL CASSETTE READ AMPLIFIER—Signai from magnetic head of digital tapa cassetta is amplified by two-stage MC1303 ampiifier providing analog output of about 4 V P-P to µA741 opamp IC10 of LM311 peak detector IC11. Signal also goes to LM311 positive and negative threshold detectors IC4 and IC5, which give logic-level output. When input signal is below preset reference level, output of positive threshold detector is low; above reference, output is high. Negative threshoid detector operates similarly for nagative pulses. Time jitter in outputs is eliminated by detecting peak of analog read signal, then combining result with threshold information in peak detector. Circuit is used in Phi-Deck cassette system made by Economy Compeny, Oklehoma City.—I. Rampil and J. Braimeir, The Digitai Cassette Subsystem: Digital Recording Background and Head intarface Electronics, *BYTE*, Feb. 1977, p 24–31.



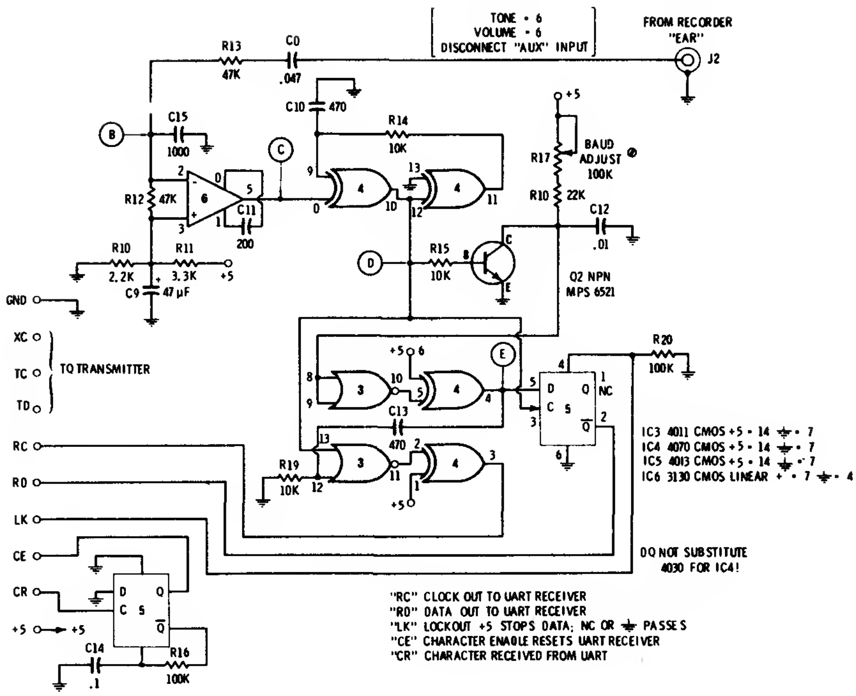


FOUR-SPEED PLAYBACK PREAMP—Provides 0-dB referenca gain of 34 dB. Supply can ba ±4.5 to ±15 V. Veluas shown ere for NAB equelization end 1⅞ or 3¾ in/s; for 7½ end 15 in/s, chenge velues es indicated. Dasign aquations ara given.—"Audio Handbook," National Semiconductor, Sante Clare, CA, 1977, p 2-31–2-37.

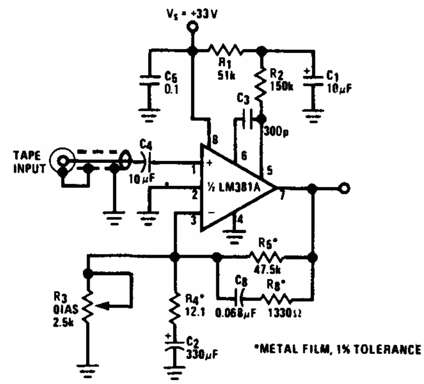
300-BAUD BIT BOFFER TRANSMITTER—Permits recording of sarial data on ordinary low-cost cassette tapa recorders for bulk storega of data to be used latar in microprocessor. Requires 19,200-Hz reference input to terminal XC from external clock. Feedback from sine-weve synthesizar IC1 to divide-by-4 counter IC2 automatically synchronizes system so sina waves automatically switch just before zaro crossing each time serial data changas from 1 to 0 or back agaln. Output consists of 16 half sina waves at 2400 Hz for mark or digital 1 and 8 half sina waves at 1200 Hz for speca or digital 0, for feed to input of cassetta recordar. Circuit aliminates arrors commonly ancountered when attempting to record squere waves on tapa with low-cost recordar.—D. Lancaster, "TV Typawriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 167–171.



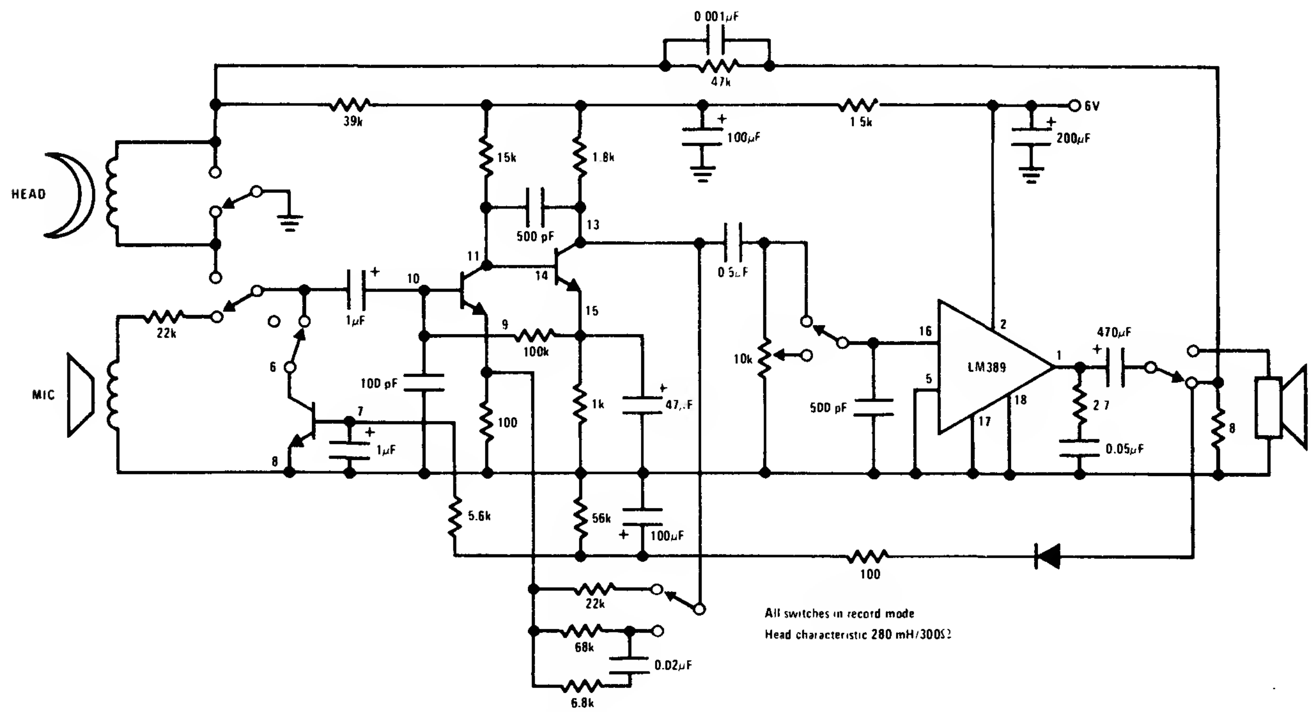
CASSETTE INTERFACE WITH ACIA—Parmits usa of audio pickup for mass storaga in Motorola 6800 microcomputar systam. Uses Motorola MC6850 asynchronous communication interface adapter (ACIA), which is spacialized version of UART. All control, status, and data transfars in ACIA ara mada ovar single 8-bit bidirectional bus. Request-to-sand lina (RTS) controls tapa recordar motor. When RTS is set high, input to IC8 is high and ralay coil is not anargized. IC6 gives 5-s dalay following motor turn-on so long leadar will ba recorded at mark frequency. IC7 gives delay so reeding starts 2.5 s bafore first data byta. Articla covars circuit operation in detail and gives operating subroutines.—J. Hamenwey, The Compleat Tapa Cassetta Intarfaca, *BYTE*, March 1976, p 10–16.



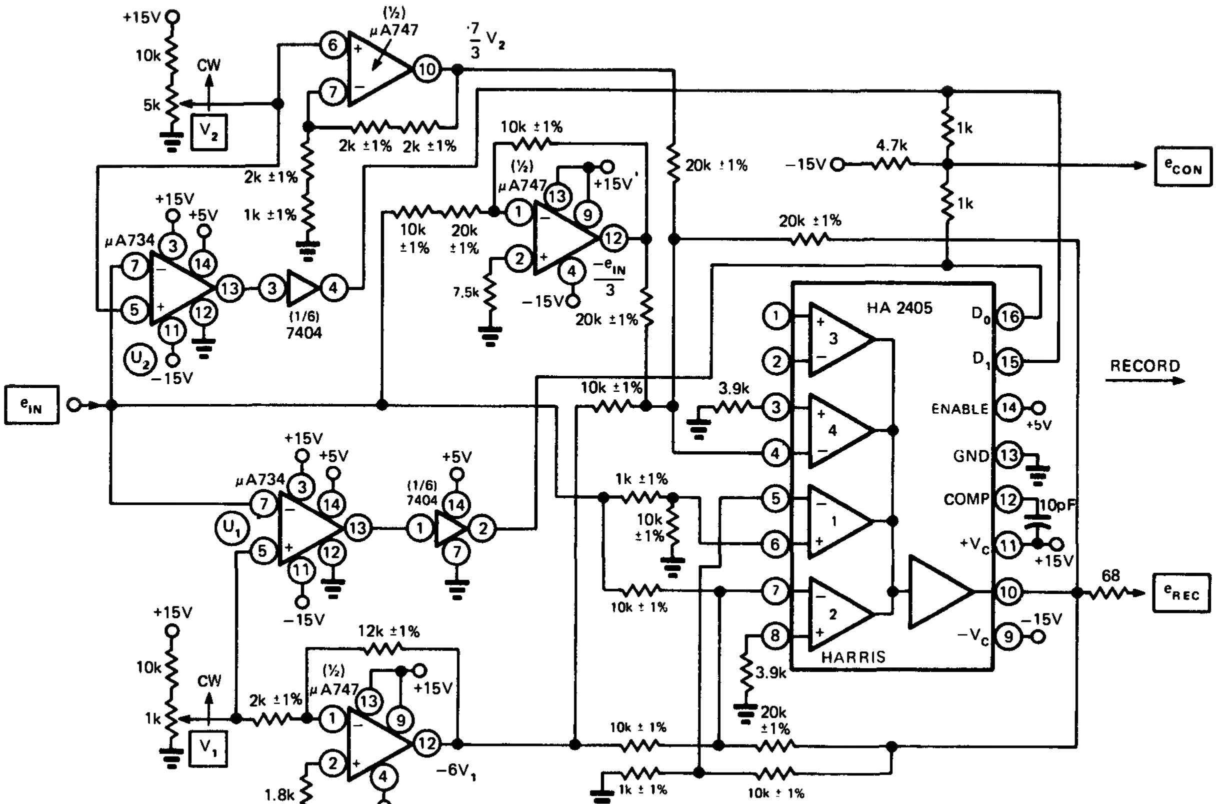
300-BAUD BIT BUFFER RECEIVER—Used with ordinary cassette recorder to convert half sine waves of recorded serial data to corresponding digital 1s and 0s. Output of recorder passes through filter and limiter IC6 to give square wave at point C whose zero crossings correspond to recorded sine wave. Leading and trailing edges of square wave are converted to narrow positive pulses by EXCLUSIVE-OR gate IC4 to give stream of pulses at D, one for each zero crossing. Transistor circuit forms retriggerable mono that is adjusted so point E goes positive three-fourths of way through low-frequency (1200 Hz) half-cycle. Point E then has stream of eight pulses for 0 and no pulses for 1. Final flip-flop provides recovery of data as 1s and 0s. Leading edge of waveform at D is shortened and combined with clock pulses to provide composite UART clock output. Buffer system eliminates errors commonly encountered when attempting to record square waves on tape with low-cost recorder.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 167–171.



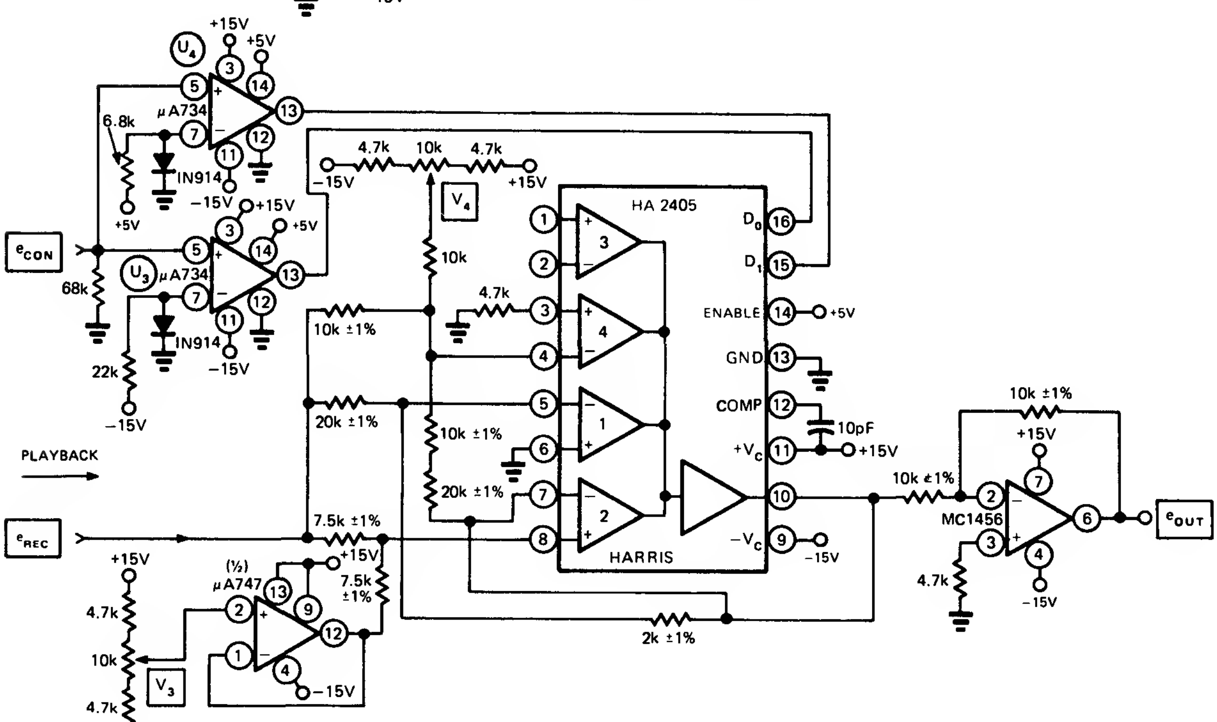
ULTRALOW-NOISE PLAYBACK PREAMP—Provides optimum noise performance at popular tape speeds of 1⅞ and 3¾ in/s. Reference gain for 0 dB is 41 dB, giving output level of 200 mV from head output of 1 mV at 1 kHz. Single-ended biasing and use of metal-film resistors reduce noise.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 2-31–2-37.



CASSETTE RECORD/PLAYBACK—National LM389 power amplifier chip includes three NPN transistors, to provide all circuits needed for complete recording and playback of cassette tapes. Two of internal transistors act as signal amplifiers while third is used for automatic level control when recording. Diode is also on chip.—"Audio Handbook," National Semiconductor, Santa Clara, CA, 1977, p 4-33–4-37.

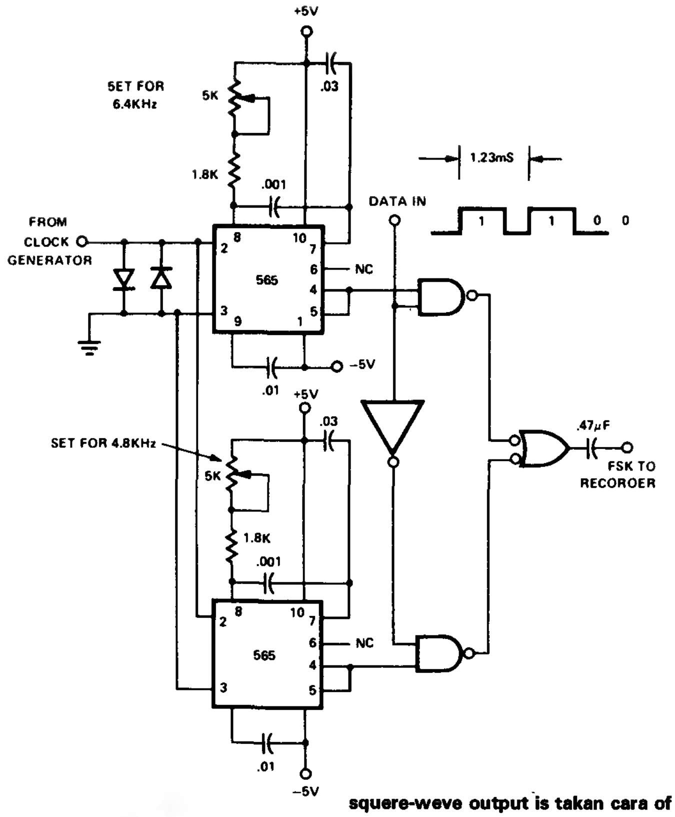


RECORD CIRCUIT

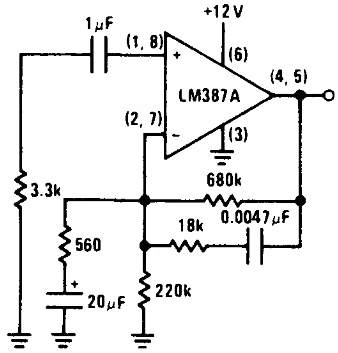


PLAYBACK CIRCUIT

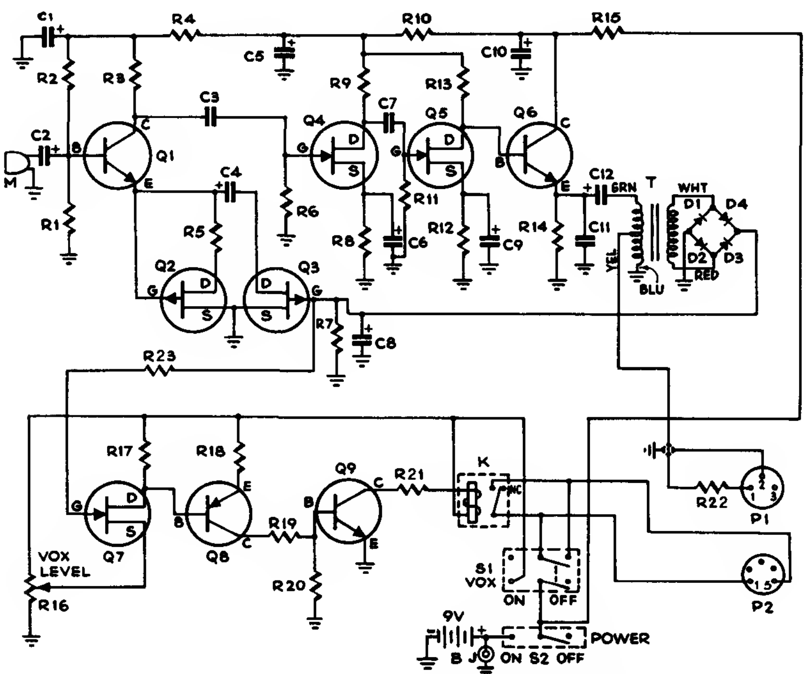
AUTOMATIC RANGE EXPANSION—Instrumentation tape recorder technique folds recorded signal over and reuses same VCO range three times, at three different gains, for increasing dynamic recording range to over 10,000. Two comparators select one of three amplifier gains according to level of input signal and record selected gain on separate control track. During playback, control track signal e_{CON} is used to select corresponding inverse gain for unfolding recorded signal. Level of input signal e_{IN}, in range of 0–10 V, is sensed by comparators whose preset thresholds are determined by pots V_1 and V_2. If input is less than V_1, both comparator outputs are low and section 1 of HA2405 four-channel opamp is selected for recording at 10 times input. If input is greater than V_1 and less then V_2, section 2 having gain of −2 is selected so direction of e_{REC} is reversed. If e_{IN} is greater than V_2, both comparators are high and section 4 is selected for gain of +1/3, so e_{REC} again reverses to cross VCO range for third time. Outputs of comparators are summed to form three-level signal for recording on control track.—J. R. White, Comparator Technique Expands Tape Recorder's Range, *EDN Magazine*, April 5, 1975, p 111, 113, and 115.



FSK GENERATOR FOR CASSETTE DATA—Uses two 565 PLL ICs, locked to 800-Hz system clock but oscillating at 6.4 kHz and 4.8 kHz, to provida FSK signals for recording digital data on ordinsry cassette tape. Hermonic suppression of squere-weve output is takan cara of automatically by high-frequancy rolloff characteristic of tape recorder. Incoming data determines which oscilletor feeds its signal to recorder.—"Signetics Analog Dete Manuel," Signetics, Sunnyvsle, CA, 1977, p 859–860.

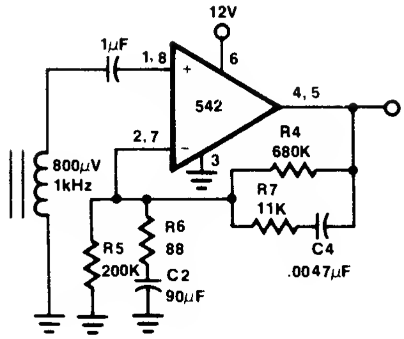


12-V PLAYBACK PREAMP—Provides standard NAB equalization. Gsin is dacreesed gradually from 60 dB et 20 Hz to 32 dB at 20 kHz in eccordence with NAB pleyback curve. Playback heed is represented by 3.3K resistor.—"Audio Handbook," Netional Semiconductor, Santa Clara, CA, 1977, p 2-31–2-37.

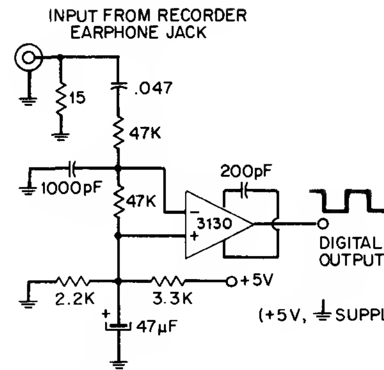


C1, 4, 8, 10, 12—50mfd electrolytic capacitor
C2—2.2mfd electrolytic capacitor
C3, 7, 11—0.1mfd ceramic capacitor
C5—220mfd electrolytic cepacitor
C6, 9—100mfd electrolytic capacitor
R1—120,000-ohm, ¼w resistor
R2—56,000-ohm, ¼w resistor
R3, 9, 13—10,000-ohm, ¼w resistor
R4, 10, 14—1000-ohm, ¼w resistor
R5—15,000-ohm, ¼w resistor
R6, 11—1 megohm, ¼w resistor
R7—120,000-ohm, ¼w resistor
R8, 12—2700-ohm, ¼w resistor
R15—56-ohm, ¼w resistor
R16—50,000-ohm, miniature potentiometer
R17—6800-ohm, ¼w resistor
R18—1500-ohm, ¼w resistor
R19—150-ohm, ¼w resistor
R20—2200-ohm, ¼w resistor
R21—330-ohm, ¼w resistor
R22, 23—560,000-ohm, ¼w resistor
D1, 2, 3, 4—diodes 1N266 or equiv.
Q1-Q6—NPN transistor Motorola HEP 50
Q2, 3—P-chennel FET 2N3820
Q4, 5, 7—N-channel FET Motorola HEP 801
Q8—PNP transistor Motorola HEP 52
Q9—NPN transistor Motorola HEP 53
T—output transformer 1K-200K Radio Shack 273-1376
K—minieture relay Radio Shack 275-004

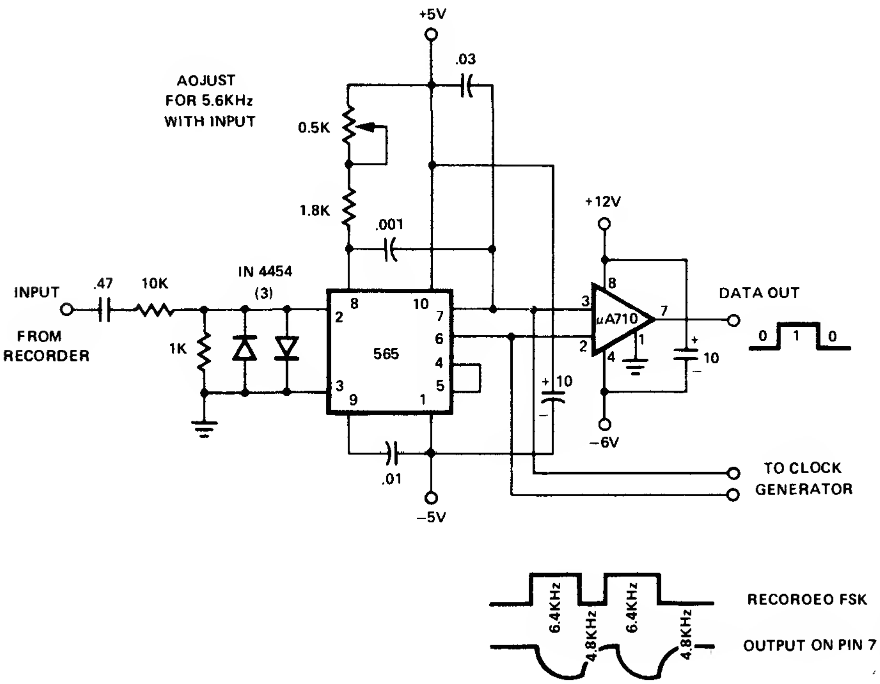
AVC AND VOX—Voice-operated ON/OFF switch uses microphone to sense normel background sound. Anything above beckground threshold preset by R16 energizas reley K for turning on recorder. Circuit provides ebout 2-s deley after subject stops telking, before releasing relay. Automatic volume control circuit keeps recorded signel essentielly conatent despite movements of loudspeaker toward or ewey from microphone.—G. Besrd, Automatic Volume end VOX for Your Tape Racorder, *Popular Science,* Oct. 1973, p 134 end 136.



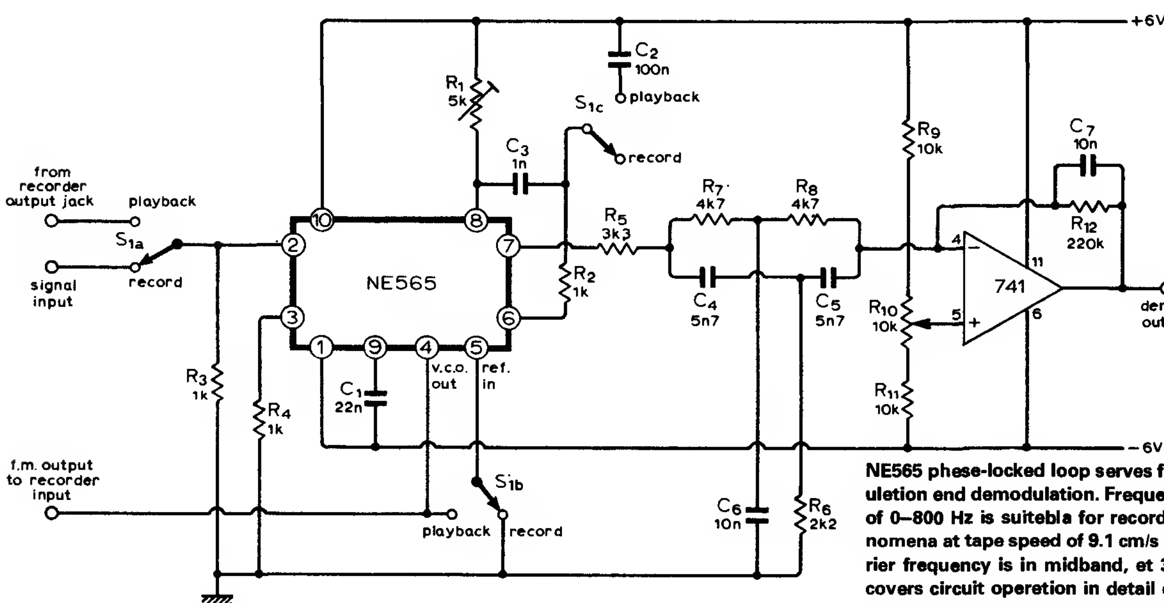
NAB TAPE PREAMP—One section of Signatics NE542 duel noise amplifier is used to provide 100-mV output level et 1 kHz following NAB equalization curve for tepe speed of 7½ in/s.—"Signetics Analog Data Manual," Signatics, Sunnyvale, CA, 1977, p 780.



CASSETTE DATA PLAYBACK—Converts low-level digitel signals from cassette recorder into CMOS-compatible 5-V square waves. Both inputs of 3130 opamp are biased to +2 V for use es open-loop comparator. RC input filter minimizes hum and bias interference.—D. Lancaster, "CMOS Cookbook," Howerd W. Sams, Indianapolis, IN, 1977, p 345.



FSK DETECTOR FOR CASSETTE-RECORDED DATA—Connection shown for 565 PLL provides date output of 1 for 6.4 kHz and 0 for 4.8 kHz from ordinary cassette tape recorder having frequency response to 7 kHz. Report gives circuit of suitable recorder using return-to-zero FSK. System elso requires 800-Hz clock generator for synchronizing to data. Up to seven 0s can occur in succession without making clock go out of sync. Odd perity is used.—"Signetics Analog Dete Manual," Signetics, Sunnyvele, CA, 1977, p 857–859.

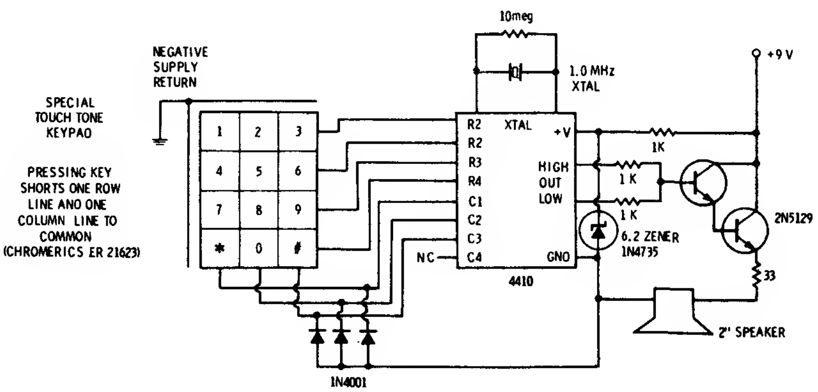


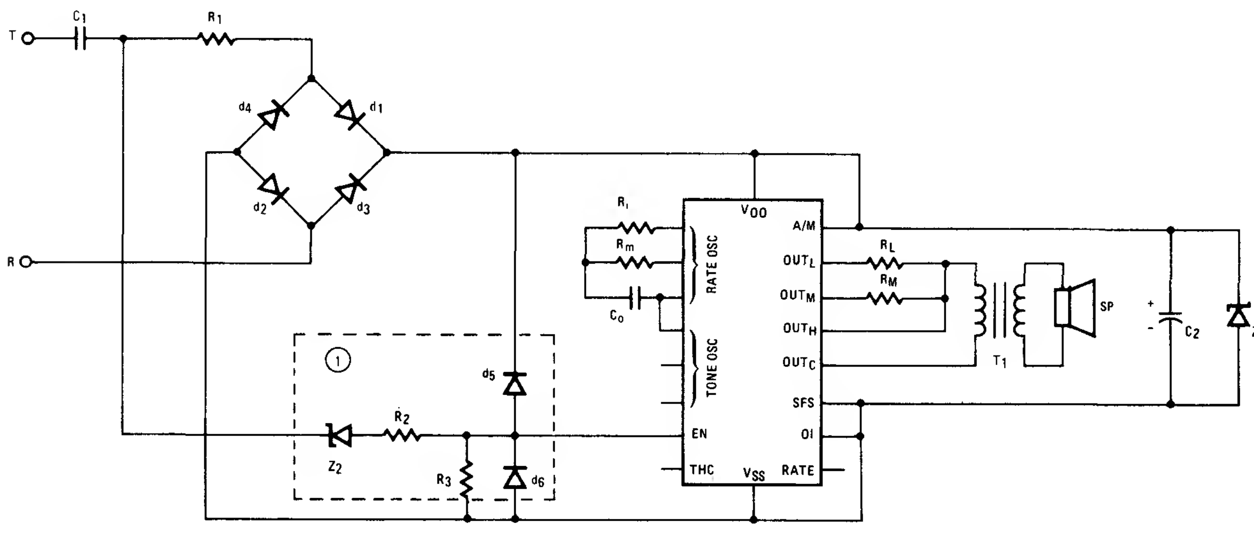
FM FOR INSTRUMENTATION—Frequency modulator-demodulator circuit using single IC and opamp converts ordinary low-cost tape recorder into instrumentation recorder. Signetics NE565 phase-locked loop serves for both modulation end demodulation. Frequency response of 0–800 Hz is suitable for recording VLF phenomena at tape speed of 9.1 cm/s (3.5 in/s). Carrier frequency is in midband, et 3 kHz. Article covers circuit operation in detail end gives design equations.—B. D. Jorden. Simple F.M. Modulator/Demodulator for a Magnetic Tepa Recorder, *Wireless World,* Merch 1974, p 29–30.

CHAPTER 90
Telephone Circuits

Includes coders and decoders for standard Touch-Tone pairs of frequencies and for single-tone remote ON/OFF control, along with repeater autopatch circuits, Touch-Tone to dial converter, phone-call counter, ring detector, ring simulator, and busy-signal generator. See also Repeater chapter.

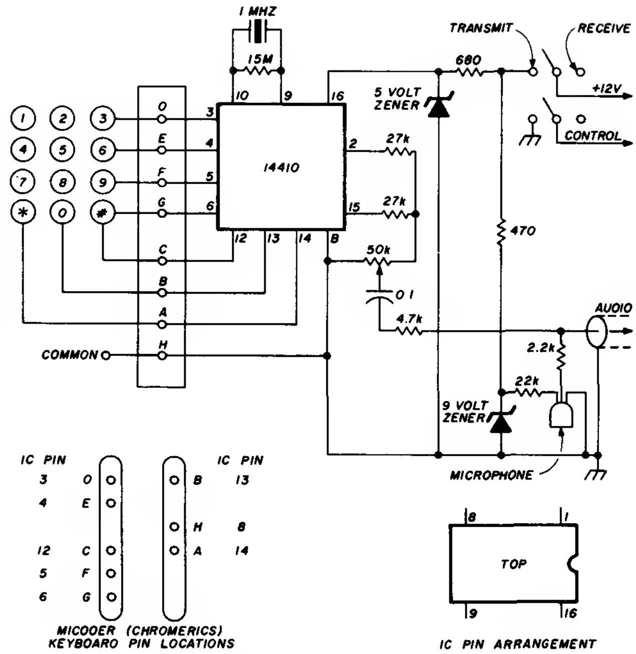
DIAL-TONE GENERATOR—Simultaneous pairs of Touch-Tone frequencies used by telephone company are ganereted by adjustment-free circuit using Motorole Touch-Tone dieler with external 1-MHz crystel. Internel circuits of IC select proper division rates end convert outputs to synthesized sine waves of correct frequencies. Grounding one of row inputs by pressing key gives lower-frequency tone, while grounding one of column inputs gives higher-frequency tone. Speciel Touch-Tone keyboerd provides this grounding ection eutometicelly when single key is pressed.—D. Lencaster, "CMOS Cookbook," Howard W. Sams, Indianepolis, IN, 1977, p 239–240.



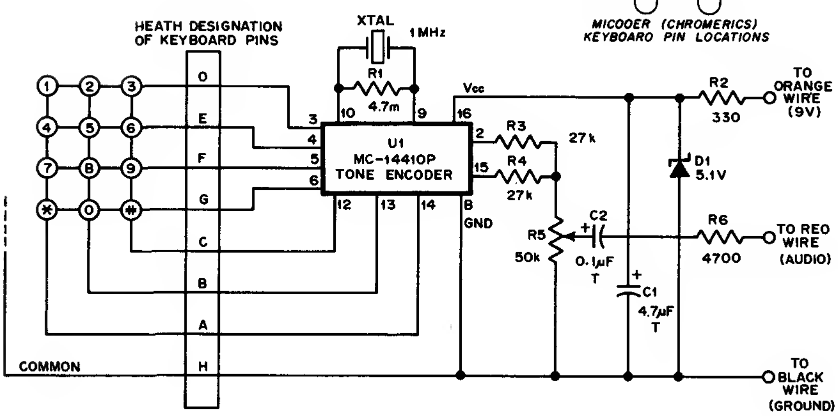


TYPICAL VALUES										
	C_1	1μF/200V	R_m	750kΩ	T_1	2000Ω/8Ω TRANSFORMER	Z2	27V ZENER
	R_1	2kΩ	C_o	330pF	SP	8Ω SPEAKER	R_2	150kΩ
	d_1-d_4	1N 4004	R_L	18kΩ	C_2	47μF/25V	R_3	300kΩ
	R_t	200kΩ	R_M	3.3kΩ	Z_1	12V ZENER 1N4742	d_5, d_6	IN914

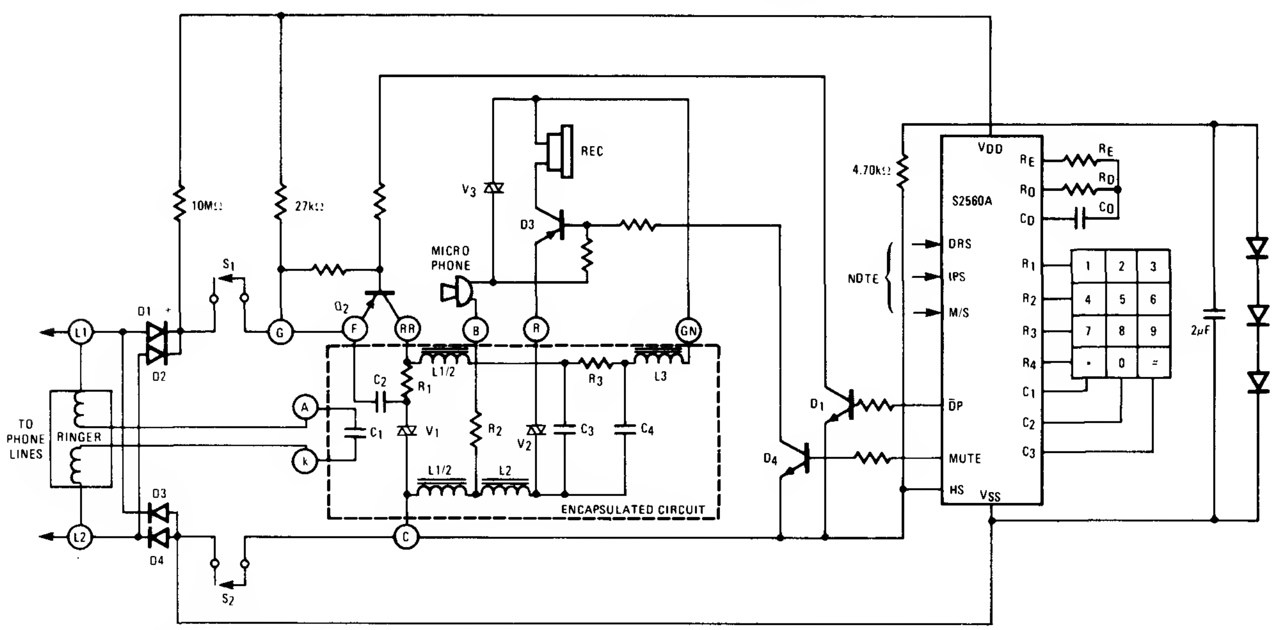
BELL SIMULATOR—Uses AMI S2561 CMOS IC to simulate effects of telephone bell by producing tone signel that shifts between two predetermined frequencies et ebout 16 Hz. In applications where diel pulse rejection is not necessary, network inside deshed lines can be omitted and pins EN and DI connected directly to V_{DD}, which is typically 10 V. Power is derived from telephone lines by diode-bridge supply. Velues shown give tone frequencies of 512 end 640 Hz. Power output to 8-ohm loudspeaker is at least 50 mW, fed through 200:8 ohm transformer.—"Tone Ringer," American Microsystems, Santa Clara, CA, 1977, S2561, p 7.



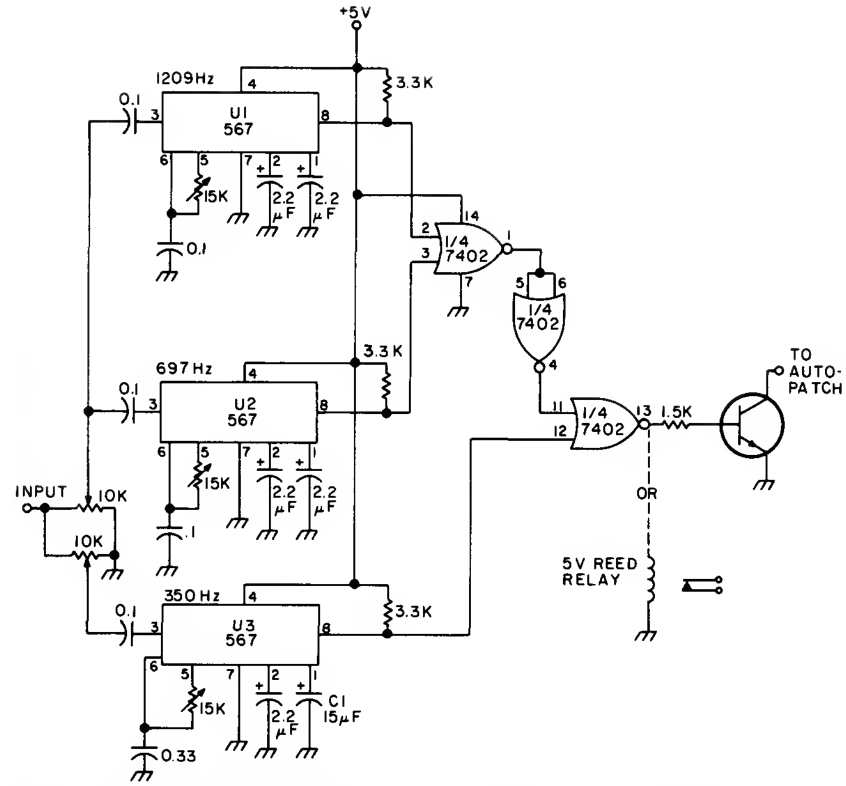
TOUCH-TONE ENCODER—Crystal-controlled encoder using 14410 tone encoder operates from 12-V supply to provide good frequency stability along with correct balance between high end low tones. 50K level adjustment pot can be screwdriver type.—G. A. Wilson, The Micoder: Some Improvements, *Ham Radio*, Nov. 1978, p 42–43.



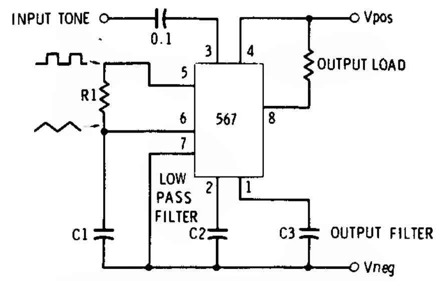
STABLE ENCODER—All tones are frequency-synthesized and held within tolerance of 0.2% by using Motorola MC14410P CMOS tone-encoder chip which is digital synthesizer requiring only 1-MHz reference crystal and nine other external parts. Circuit is redesign of Heath Micoder for triggering autopatch of repeater during mobile operation. Operates from 9-V battery. Audio output matches input for low-impedance microphone. For higher output, increase R3 and R4.—G. K. Fellenbeck, Mycoder, *QST*, April 1978, p 27–29.



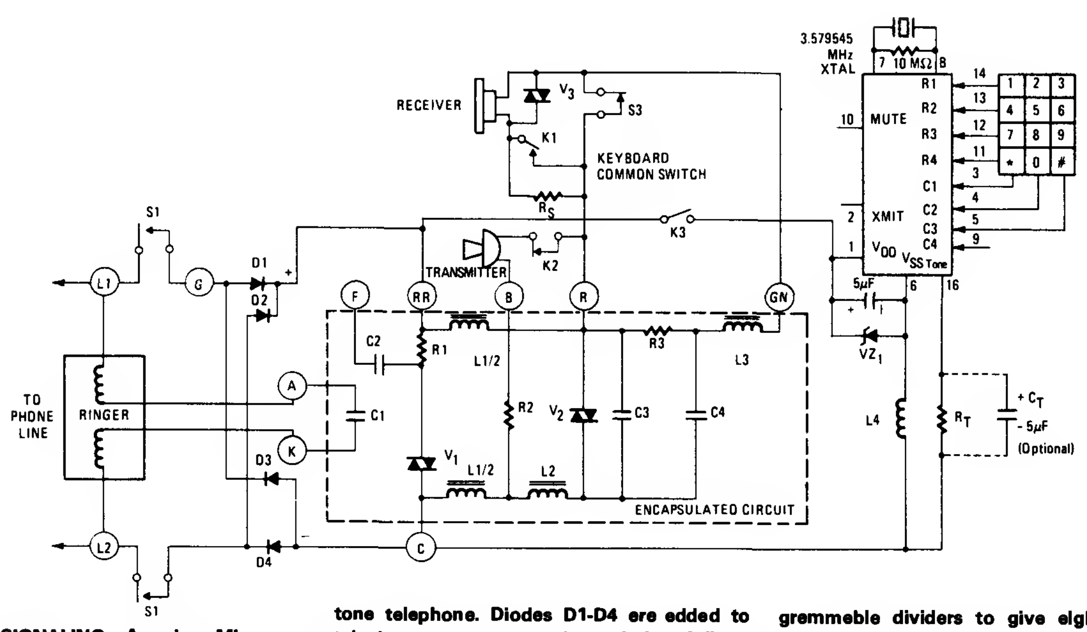
KEY PULSER—American Microsystems S2560A CMOS IC pulser converts pushbutton inputs to series of pulses suitable for telephone dialing, as replacement for mechanical telephone dial. Circuit shows typical connection to dial telephone set using 500-type encapsulated circuit. Dialing rate can be varied by changing dial rate oscillator frequency. IC includes 20-digit memory that makes last dialed number available for redialing until new number is entered. Entered digits are stored sequentially in internal memory, with dial pulsing starting as soon as first digit is entered. Arrangement permits entering digits much faster than output rate. Last number is redialed by going off hook and pressing # key.—"Key Pulser," American Microsystems, Santa Clara, CA, 1977, S2560A/S2560B, p 8.



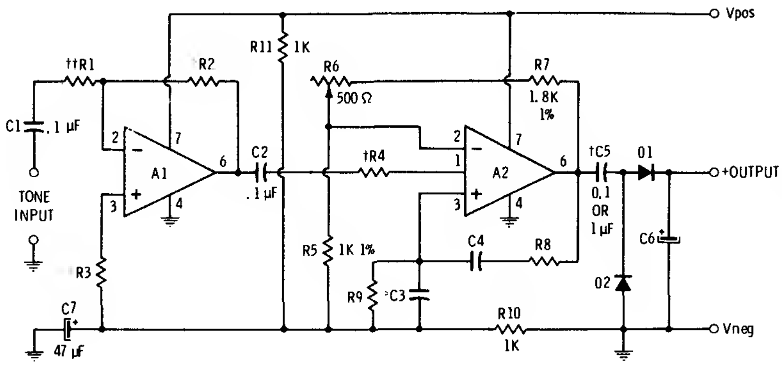
TOLL-CALL KILLER—Prevents unauthorized direct long-distance dialing through repeater autopatch from areas where "1" must be dialed ahead of desired out-of-town phone number. Based on simultaneous detection of 350-Hz component of dial tone and 1209- and 697-Hz tones assigned to "1" in Touch-Tone system. Circuit requires only three 567 tone decoders, 7402 quad gate, and either transistor or relay for controlling autopatch. Article covers installation and operation.—W. J. Hosking, Long Distance Call Eliminator, *73 Magazine*, April 1976, p 44–45.



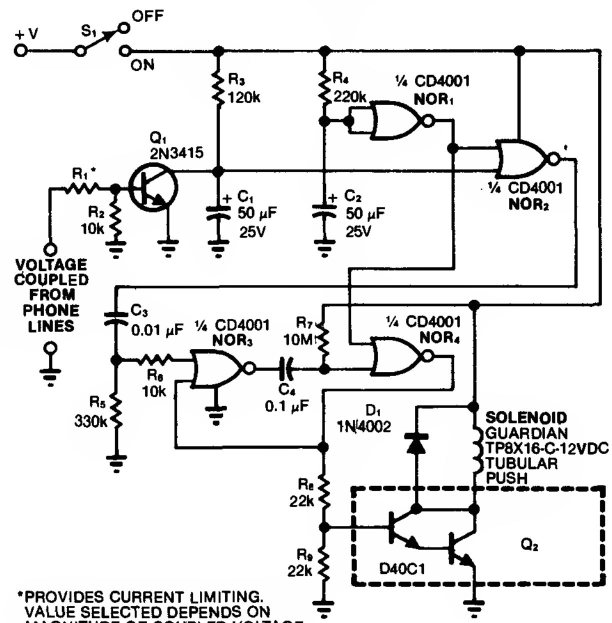
PLL SINGLE-TONE DECODER—Can be used for Touch-Tone decoding as well as for telephone-line and wireless control applications using single audio frequency. Operating center frequency depends on R1 and C1. R1 should be between 2K and 20K. C1 in microfarads is computed from f = 1/R1C1, where R is in megohms and f is in hertz. C2 is low-pass filter in range of 1–22 μF; the larger its value, the narrower its bandwidth. C3 is not critical and can be about twice C2.—C. D. Rakes, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 68–73.



DUAL-TONE SIGNALING—American Microsystems S2559 digital tone generator IC at upper right interfaces directly with encapsulated 500-type telephone set to give pushbutton dual-tone telephone. Diodes D1-D4 are added to telephone set to ensure that polarity of direct voltage across device is unchanged even if connections to phone terminals are reversed. Generator IC requires external crystal feeding programmable dividers to give eight standard audio frequencies with high accuracy for combining in pairs as required for dual-tone signaling.—"Digital Tone Generator," American Microsystems, Santa Clara, CA, 1977, S2559, p 11.

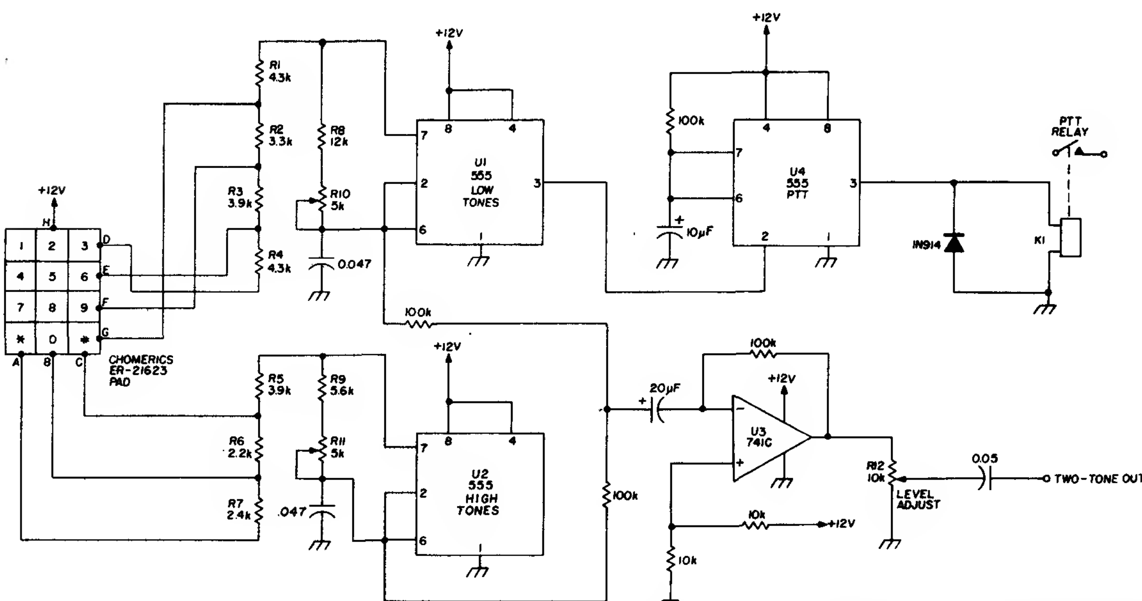


SINGLE-TONE DECODER—Used at receiving end of leased telephona lina in which singla tone frequency servas for alarm and othar purposes. A1 is 741 opamp connected as invarting amplifiar, with R1 and R3 chosen to match Input impedanca and R2 chosen to give gain required for available input signal laval. For 10K input impedance, R1 and R3 ara 10K and R2 in kilohms is 10 times required gain (500K for gain of 50). Actual tone decoding Is parformad by A2, which is elso 741; hera C3, C4, R8, and R9 ara frequency-determining components and R6 Is gain control. R4 is chosan to giva desired bandwidth; usa 470K for 5–10%, 1 magohm for 3–5%, and 2.2 megohms for 1–3%. R8 is same as R2, and R9 equels R3. Diodas ara 1N914.—C. D. Rakes, "Integrated Circuit Projacts," Howard W. Sams, Indianapolis, IN, 1975, p 60–66.

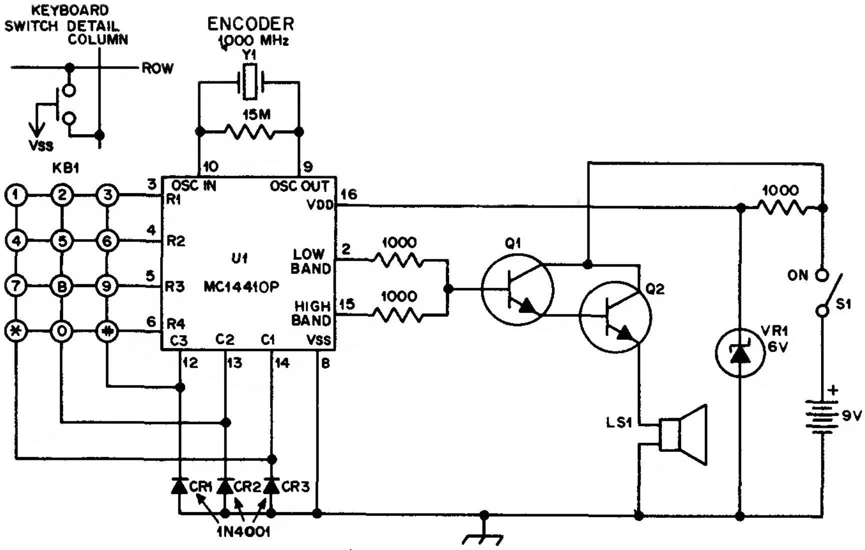


*PROVIDES CURRENT LIMITING. VALUE SELECTED DEPENDS ON MAGNITUDE OF COUPLED VOLTAGE

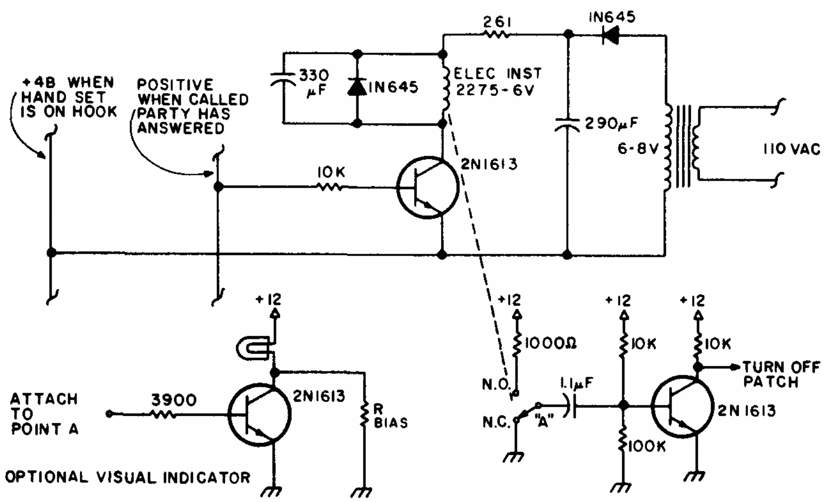
PHONE-CALL COUNTER—Circuit actuates solanoid that depresses R/S counting kay of SR-56 calculator for aach interrogation avant consisting of sequance of pulsa bursts aach corrasponding to ring of phona. Bursts are separated by 4-s pauses, so circuit includes time dalay that pravants actuation of solenoid until lina has remainad quiascant for more than 5 s aftar burst. Articla includes progrem that is Inserted in calculator to total numbar of times R/S key is depressed. Applications includa counting numbar of telephone calls racalved whila away.—M. Bram, Herdwera + Program Mekes SR-56 Event Countar, *EDN Magazina*, Aug. 5, 1978, p 84 and 86.



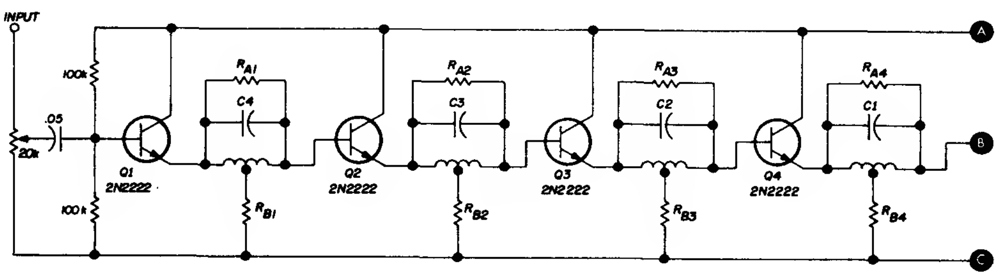
TOUCH-TONE ENCODER—Uses 555 timers to genarata Touch-Tone frequencies in pairs using two of saven possibla frequencies, under control of standard 12-button pad. Adjust R10 so low-group oscillator raeds 941 Hz at pin 3 of U1 whan * kay ie preseed. Frequencies of 852, 770, and 697 Hz will than ba correct within 2% when 7, 4, end 1 ara pressed, if 1% reslstors are used and 0.047-µF capecitors are tantalum or Mylar. Automatic push-to-talk control uses U4 connected es 1-s mono MVBR driving reley K1.—H. M. Barlin, Homabrew Touch-Tone Encoder, *Ham Radio*, Aug. 1977, p 41–43.

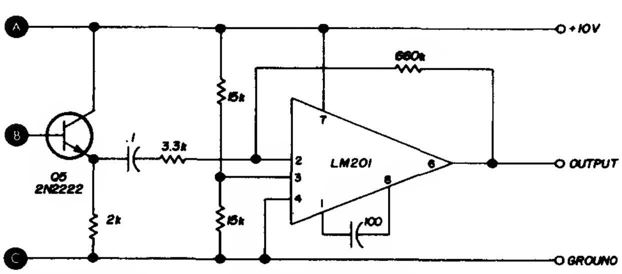


TOUCH-TONE DRIVE FOR LOUDSPEAKER—Encoder is held in front of microphone to access and use autopatch of repeater. Acoustic coupling eliminates need for opening new transceiver to make wire connections, which would void guarantee. Uses Motorola MC14410P IC with KB1 keyboard (Polypaks 92CU3149). Q1 and Q2 are 2N3643 or equivalent. Y1 is 1.000 MHz crystal (Marlann Labs ML18P or Sharold Crystal HC-6). Transistors Q1 and Q2 boost output enough to drive 8-ohm loudspeaker. Total current drain is 35 mA idling and 100 mA with full drive.—C. Gorski, A Low-Cost Touch-Tone Encoder, *QST*, Oct. 1976, p 36–37.



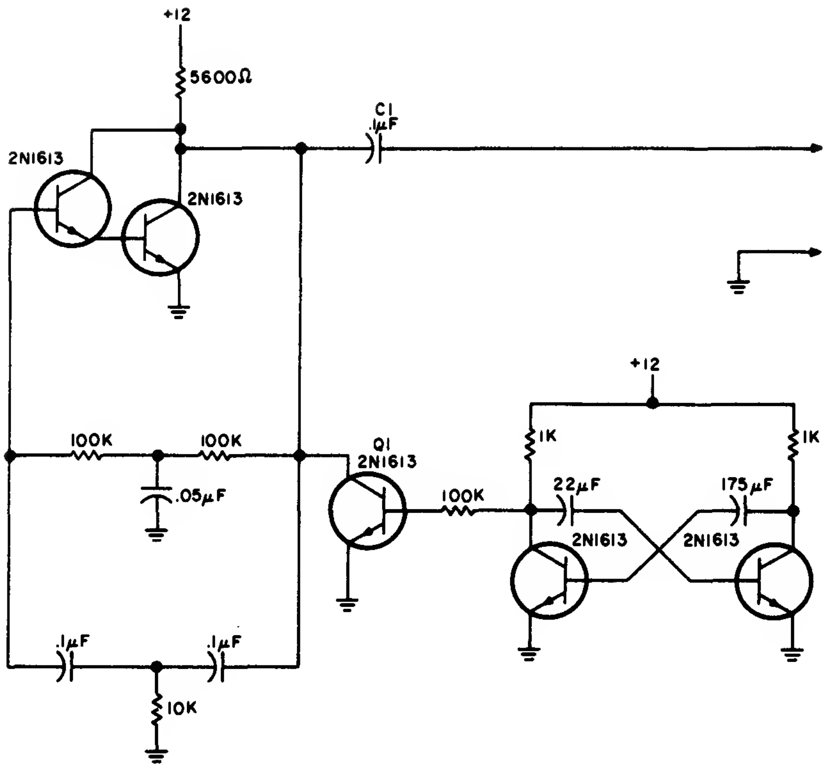
AUTOPATCH RELEASE—Control circuit automatically releases telephone autopatch at receiver when called party hangs up, by generating disconnect signal for patch control logic. Action is based on reversal of polarity of phone line when called party answers, and return of polarity to preanswered condition when called party hangs up. Article describes circuit operation and use.—T. R. Yocom, Automatic Autopatch Release, *73 Magazine*, April 1977, p 52.



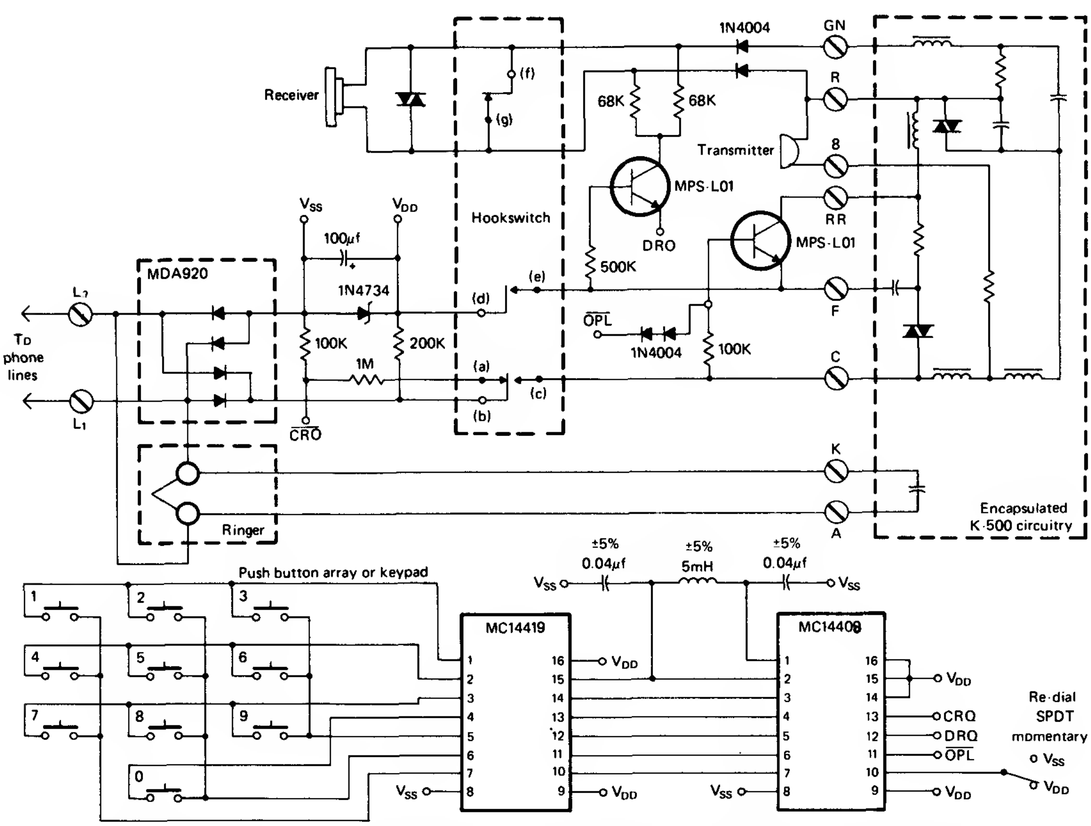


	low group	high group
C1	.68	.22
C2	.5	.18
C3	.39	.15
C4	.33	.1

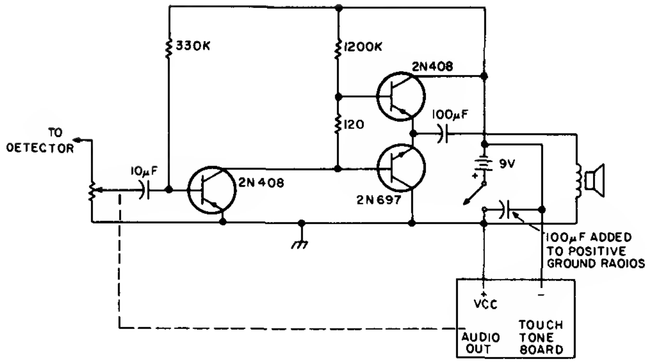
TOUCH-TONE BAND-REJECT FILTER—Cascaded notch filters with active limiter at output provide 20-dB attenuation of either low (697–941 Hz) or high (1209–1633 Hz) groups of tones, as aid to decoding for repeater control functions. All coils are 88-mH toroid. R_A is between 5600 and 22,000 ohms, and R_B is 1000 to 3000 ohms. Article gives tuning procedure for selecting resistor values and adjusting toroids so each stage rejects different tone in its band.—B. Bretz, Multi-Function FM Repeater Decoder, *Ham Radio*, Jan. 1973, p 24–32.



BUSY-SIGNAL GENERATOR—Conventional Bell System busy signal is provided by turning twin-T oscillator at left on and off with low-frequency asymmetrical square wave generated by transistor pair at right. Q1 acts as switch for turning oscillator on and off. Developed for use at repeater in home when autopatch connects to family telephone, to inhibit use of autopatch by mobile station when phone is in use. Article also covers connections to phone line and to repeater.—T. Yocom, An Autopatch Busy Signal, *73 Magazine*, Holiday issue 1976, p 148 and 150.

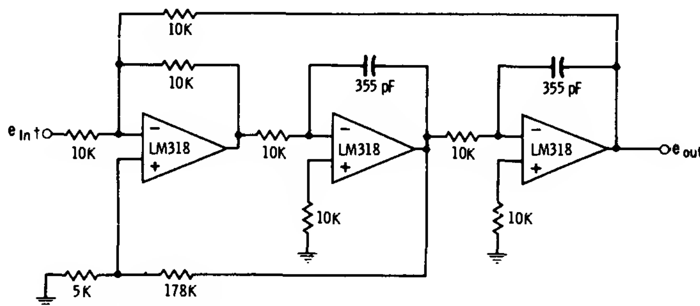


PUSHBUTTON-TO-DIAL CONVERTER—Combination of Motorola MC14419 keypad-to-binary converter and MC14408 BCD-to-dial telephone pulse converter is used with 10-switch pushbutton array to provide correct chain of pulses for dialing number on conventional dial-telephone system. Eleventh SPDT button is used for redial feature; if line called is busy, one press of redial button dials number over again. Number is stored for repeated use until new number is dialed. Check local telephone company regulations before making connections to telephone lines.—I. Math, A Push-Button to Dial Telephone Converter, *CQ*, Sept. 1976, p 36–37.

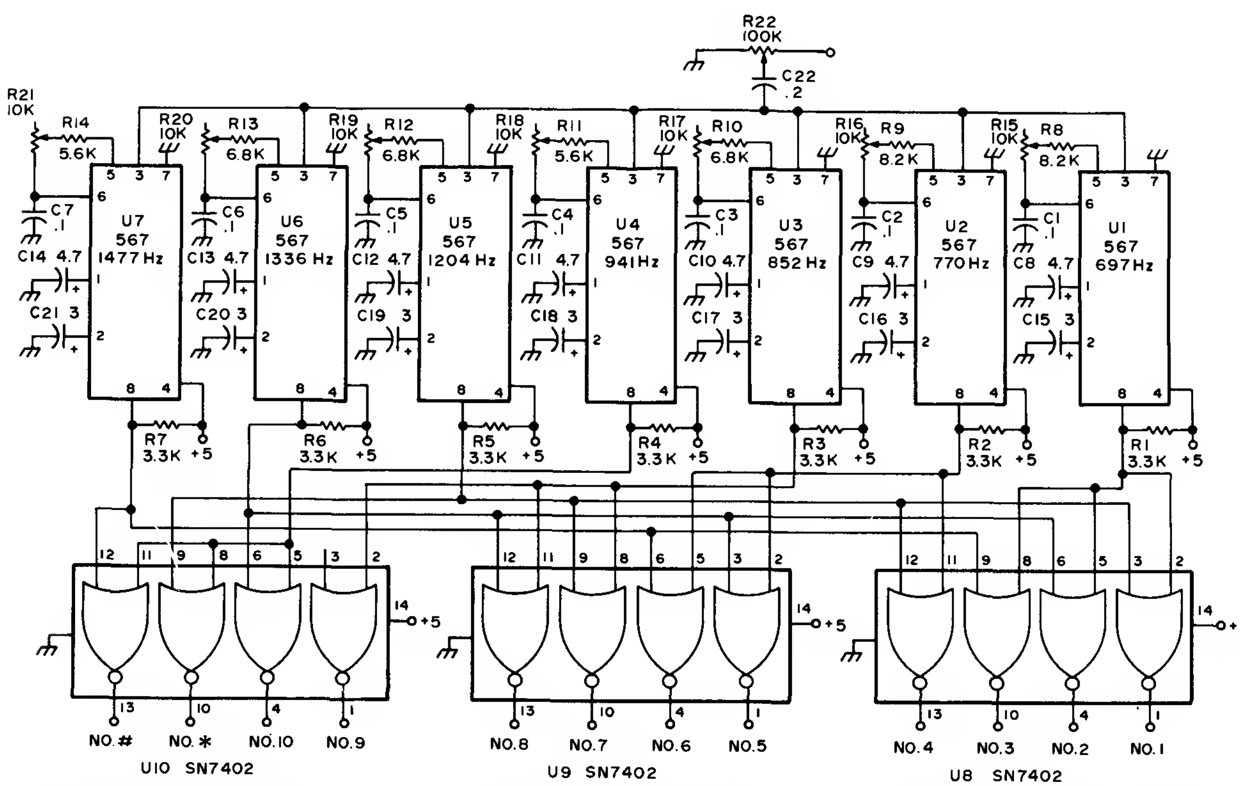


TOUCH-TONE ENCODER—Consists of SME Touch-Tona ganarator and kayboard mada by Date Signal (Albany, GA) mountad on any small translstor redio. Only audio sactlon is used, with output tones from loudspaaker baing fed acoustlcally to microphona of FM amataur station. Articla gives construction deteils.—D. Ingram, Tha Shlrt Pockat Touch-Tona, *73 Magazine*, Nov. 1976, p 58–59.

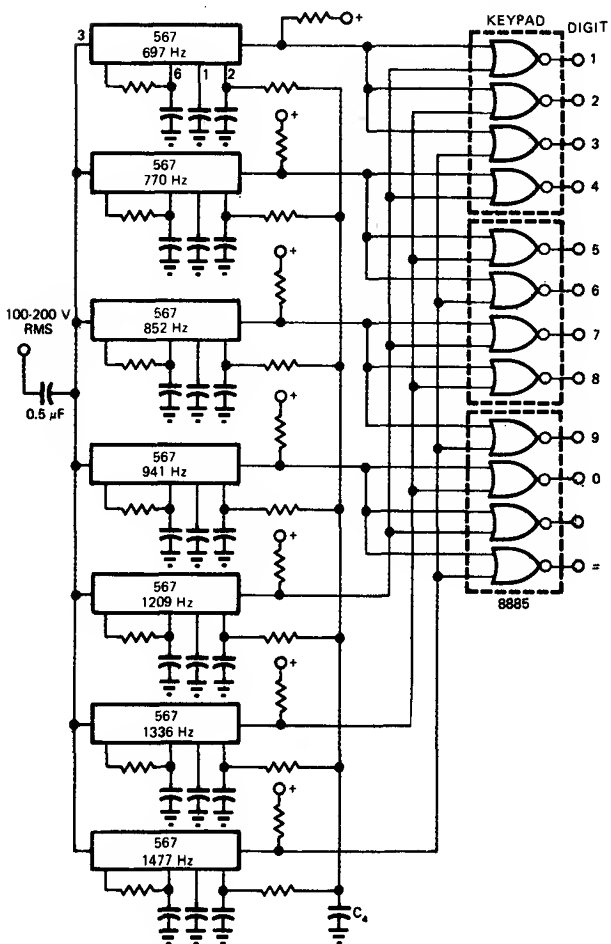
45-kHz LOW-PASS STATE-VARIABLE FILTER—Used in pracision talephone-network active equalizar. Damplng value is 0.082, which raquires 1% components. For high pass, taka output from first opemp; for bandpass, taka output from second opamp.—D. Lancastar, "Activa-Filter Cookbook," Howard W. Sems, Indienapolis, IN, 1975, p 147.



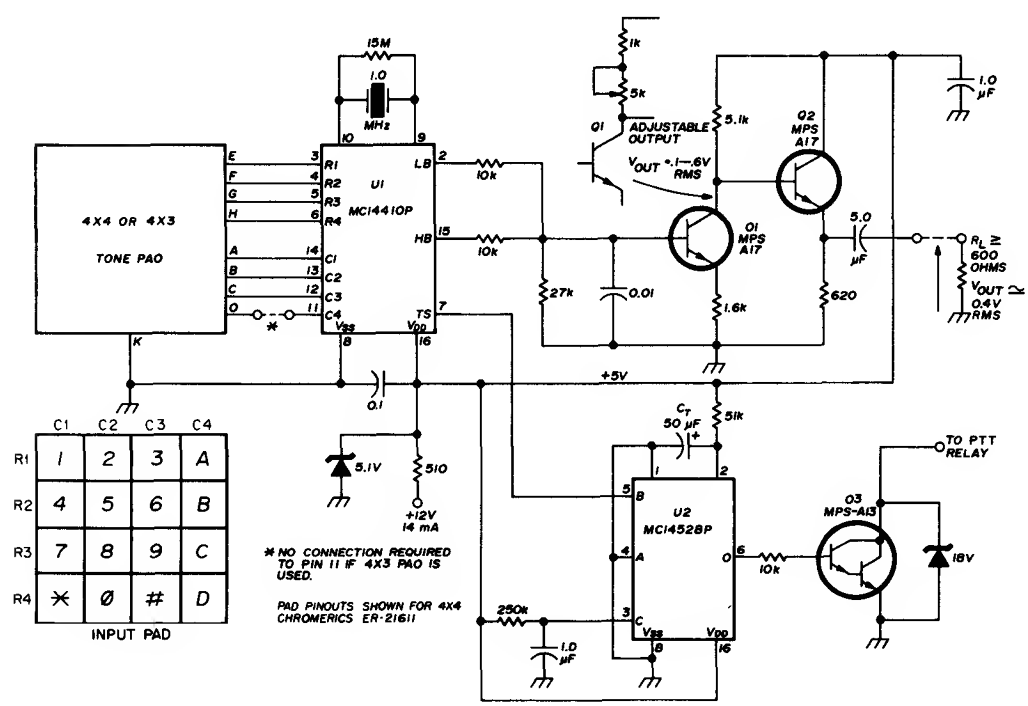
† must return to ground via low-impedance dc path.



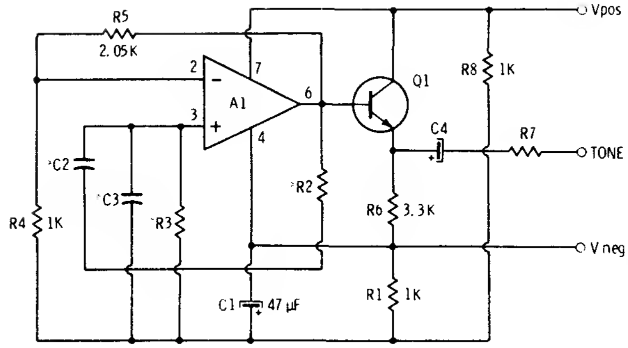
TOUCH-TONE DECODER—Uses savan Netional LM567 phase-locked loop decodars (U1–U7) heving high nolsa rajection, immunity to felse signals, and stabla center frequancy. Each 567 ectlvates propar gata of SN7402, making output of geta go to high or 1 stata for drlving NPN translstor that can tum on LED labeled with corresponding Touch-Tone number. Altametively, gata outputs can drive 12 raleys, with raley contacts golng to LEDs end/or to kayboerd switches of ordinary calculator used as digitel displey. Articla tells how to edjust 10K pot for aach 567 for detection of deslred frequancy.—W. MacDowell, Touch-Tona Decodar, *73 Magazine*, Juna 1976, p 26–27.



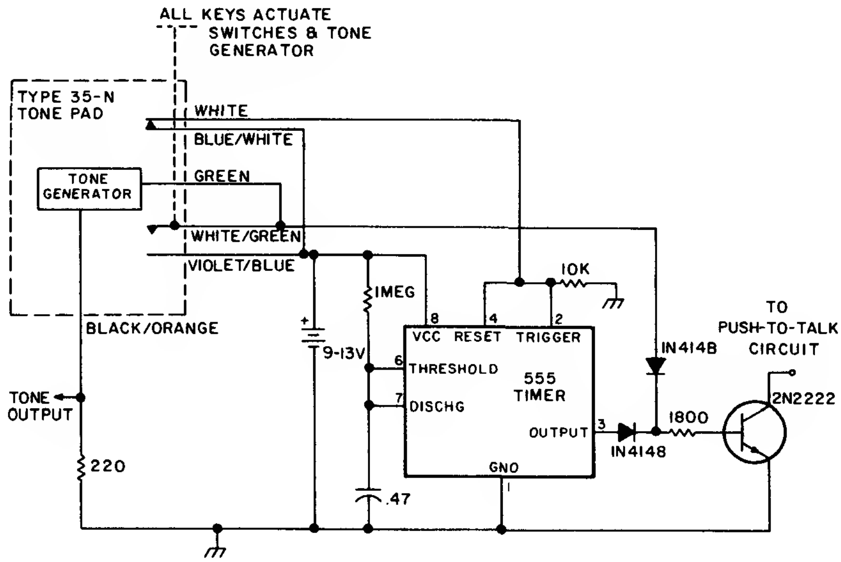
PLL TOUCH-TONE DECODER—Seven 567 PLLs sense presence of selected tones from common 100–200 VRMS input line, while 8885 NOR gates perform necessary decoding logic to generate decimal outputs. Circuit takes advantage of good frequency selectivity provided by lock-and-capture ranges of PLLs, as required for discriminating against many tones.—E. Murthi, Monolithic Phese-Locked Loops—Analogs Do All the Work of Digitals, and Much More, *EDN Magazine*, Sept. 5, 1977, p 59–64.



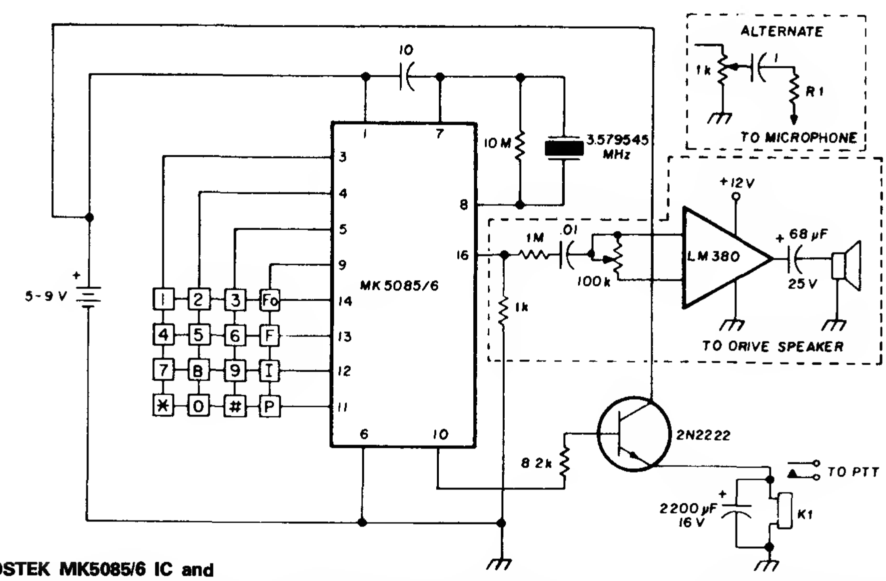
TONE ENCODER—Motorola MC14410 CMOS IC is basis of accurate low-power Touch-Tone encoder system providing full 2-of-8 encoding from basic 1-MHz crystal oscillator. Can be used with 2-of-7 or 2-of-8 keypad switch matrix such as Chromerics ER-21623 or ER-21611. Q1-Q2 form tone-amplifier/emitter-follower line driver. U2 is push-to-talk mono 1-s timer. Supply can be any voltage from 5 to 12 V if zener is used to supply 5 V to ICs. Article covers circuit operation in detail and gives tone-encoder frequency table.—J. DaLaune, Digital Touch-Tone Encoder for VHF FM, *Ham Radio*, April 1975, p 28–31.



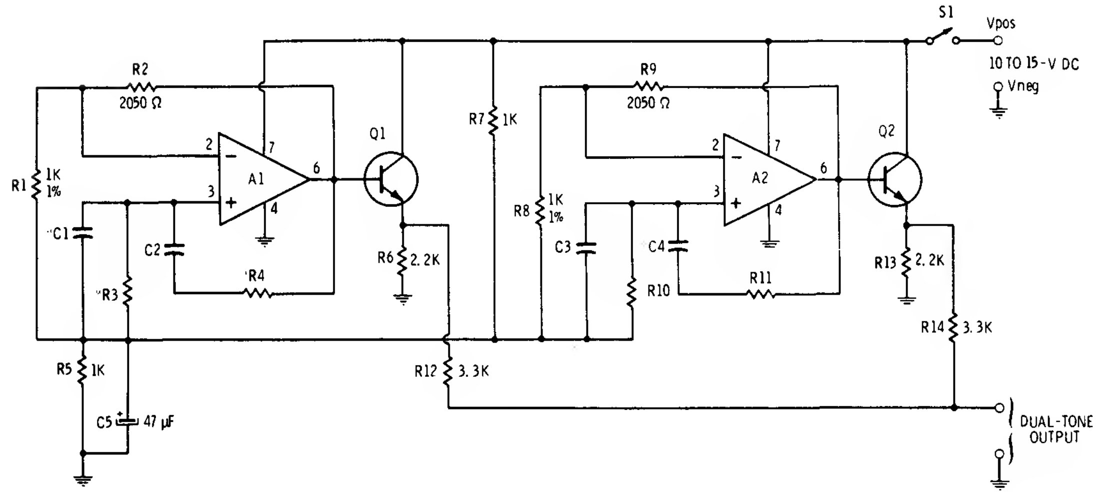
SINGLE-TONE SIGNALING—Wien-bridga oscillator using 741 opemp drives 2N2924 or equivalent NPN transistor to generate steble eudio tone for signeling over telephone lines. Tuning capacitor (C2 end C3 ere equel) and resistor (R2 and R3 ere equal) values range from 0.1 µF and 15.9K for 100 Hz to 0.005 µF and 6.3K for 5000 Hz. For other frequencies, use f = 0.159/R2C2. With 12-V supply, tone output is about 7 V P-P. Select R7 to match impedance of driven circuit.—C. D. Rakes, "Integrated Circuit Projects," Howerd W. Sams, Indienepolis, IN, 1975, p 55–60.



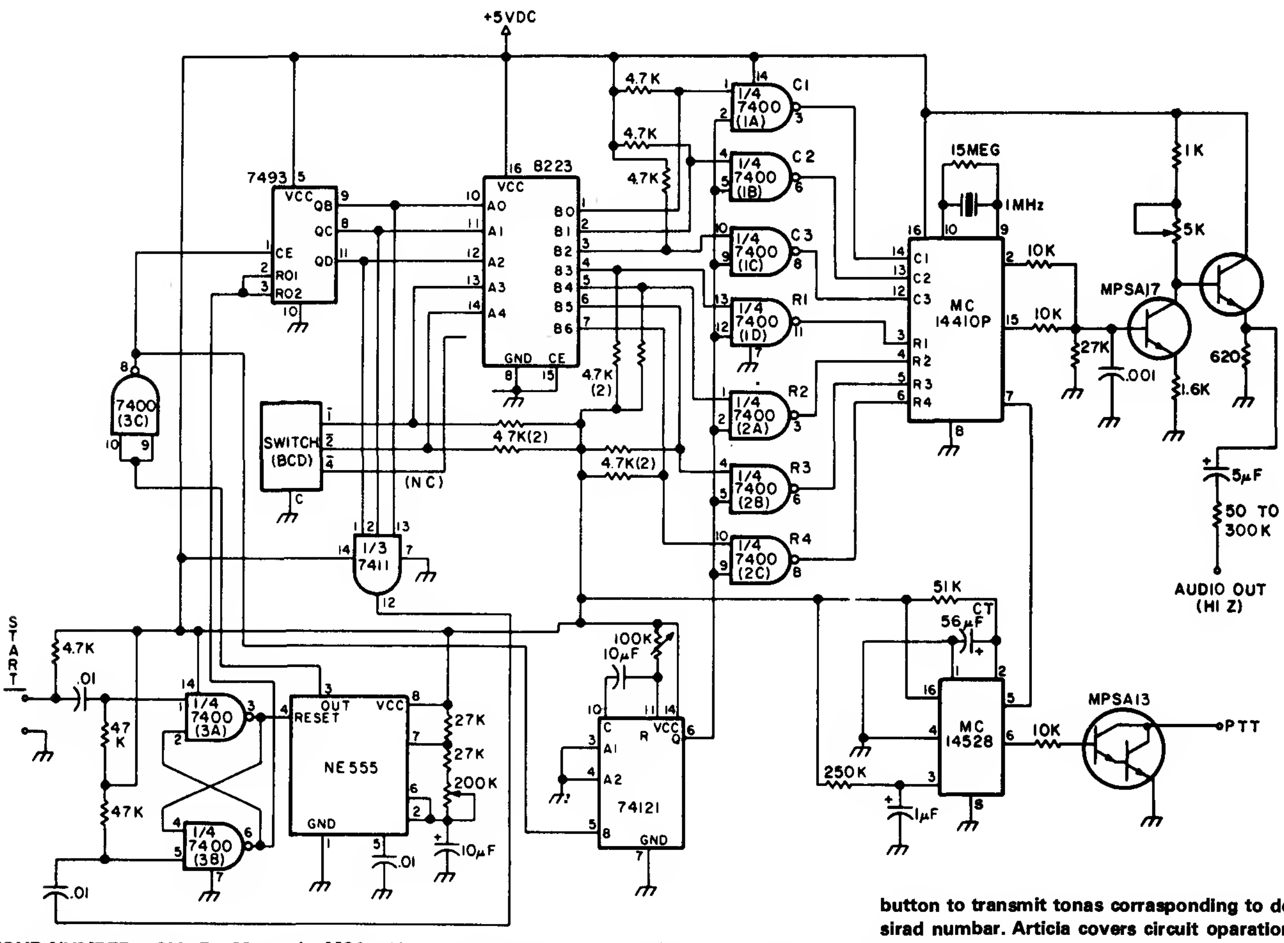
MOBILE AUTOPATCH—Circuit operates push-to-talk of mobile station automatically when eny button on Touch-Tona pad is pushed for dialing telephone number after making autopatch, eliminating naed for engaging microphone before dieling. Circuit remains ective for about 2 s after Touch-Tone button is released.—Circuits, *73 Magazine,* May 1977, p 19.



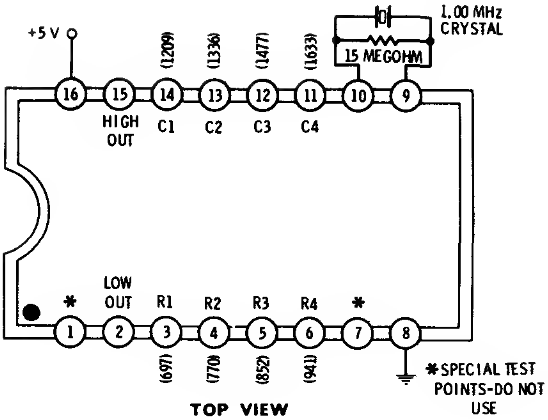
TOUCH-TONE IC—MOSTEK MK5085/6 IC and kayboerd together form inexpensive Touch-Tone generator producing tones within 0.75% of required values. Uses 3.579545-MHz TV color-burst crystal. Pin 15 is grounded to provide dual tones only. Pin 10 provides output when keyboard entry hes been made, for keying push-to-talk (PTT). Loudspeaker can be eliminated if output is fed directly into microphona input of transmitter. Choice of IC depends on type of keyboerd used.—T. Ahrens, Integrated-Circuit Tone Generator, *Ham Radio,* Feb. 1977, p 70.



TWO-TONE ENCODER—741 opamps and 2N2924 transistors are connected as single-tone encoders producing different audio frequencies, with outputs connected together. For 2000-Hz tone, use 0.01 µF for C1 and C2 and use 8K for R3 and R4. Formula for frequency of each encoder is f = 0.159/RC where f is in hertz, R in megohms, and C in microfarads; R = R3 = R4 and C = C1 = C2. Frequencies can be chosen for Touch-Tone signaling.—C. D. Rakes, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 95–97.

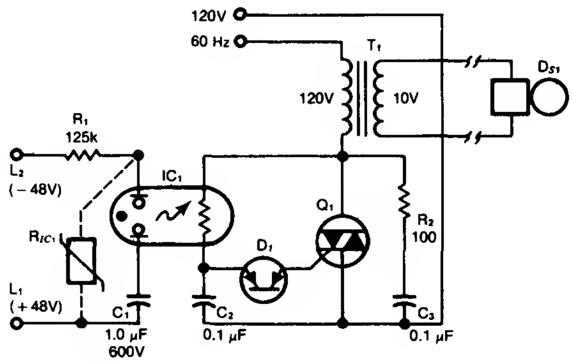


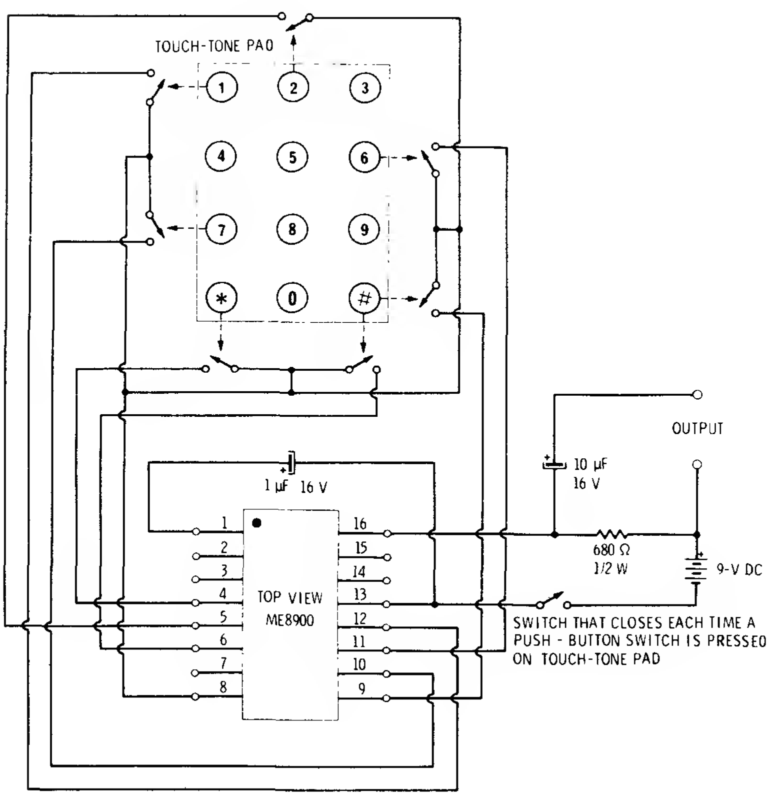
FOUR-NUMBER CALLER—Motorola MC14410 CMOS Touch-Tone generator chip forms basis for automatic dialer using BCD thumbwheel switch to choose telephone number desired. Numbers are stored in 256-bit PROM by conventional programming. Article shows how autopatch access and disconnect switches are added. To make telephone call from car through repeater, select number desired, push access button and, when dial tone is heard, push start button to transmit tones corresponding to desired number. Article covers circuit operation, programming, and coding, and gives additional circuit using 512-bit PROM to provide eight telephone numbers.—W. J. Hosking, Drive More Safely with a Mobile Dialer, *73 Magazine*, Feb. 1977, p 102–104.



TOUCH-TONE DIALER—Single Motorola 4410 chip requires only two external components and 2-of-8 keyboard to generate two sine waves simultaneously for Touch-Tone dialing and telephone modem communication. Each key on keyboard grounds one of C inputs and one of R inputs. As example, when 6 key is pressed, R2 and C3 are grounded to give 770-Hz sine wave on pin 2 and 1477-Hz sine wave on pin 15. Designed for driving 1K load. Output voltage is about 600 mV P-P for low output and 800 mV P-P for high output.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 132.

RING DETECTOR—Optoisolator using neon lamp and light-dependent resistor serves as interface between telephone line and line-operated remote bell. Neon fires reliably from nominal 100-VAC ring signal, while capacitor C_1 provides isolation required to prevent latch-up by sustaining voltages within range of phone-line quiet battery. If optional protective varistor R_{IC1} is added, rating of capacitor can be reduced to 400 V. Triac Q_1 in series with primary of line transformer provides synchronization to 20-Hz ringing frequency of phone system.—W. D. Kraengel, Jr., Ring Detector Optically Interfaces Phone, *EDN Magazine*, Aug. 5, 1978, p 80 and 82.

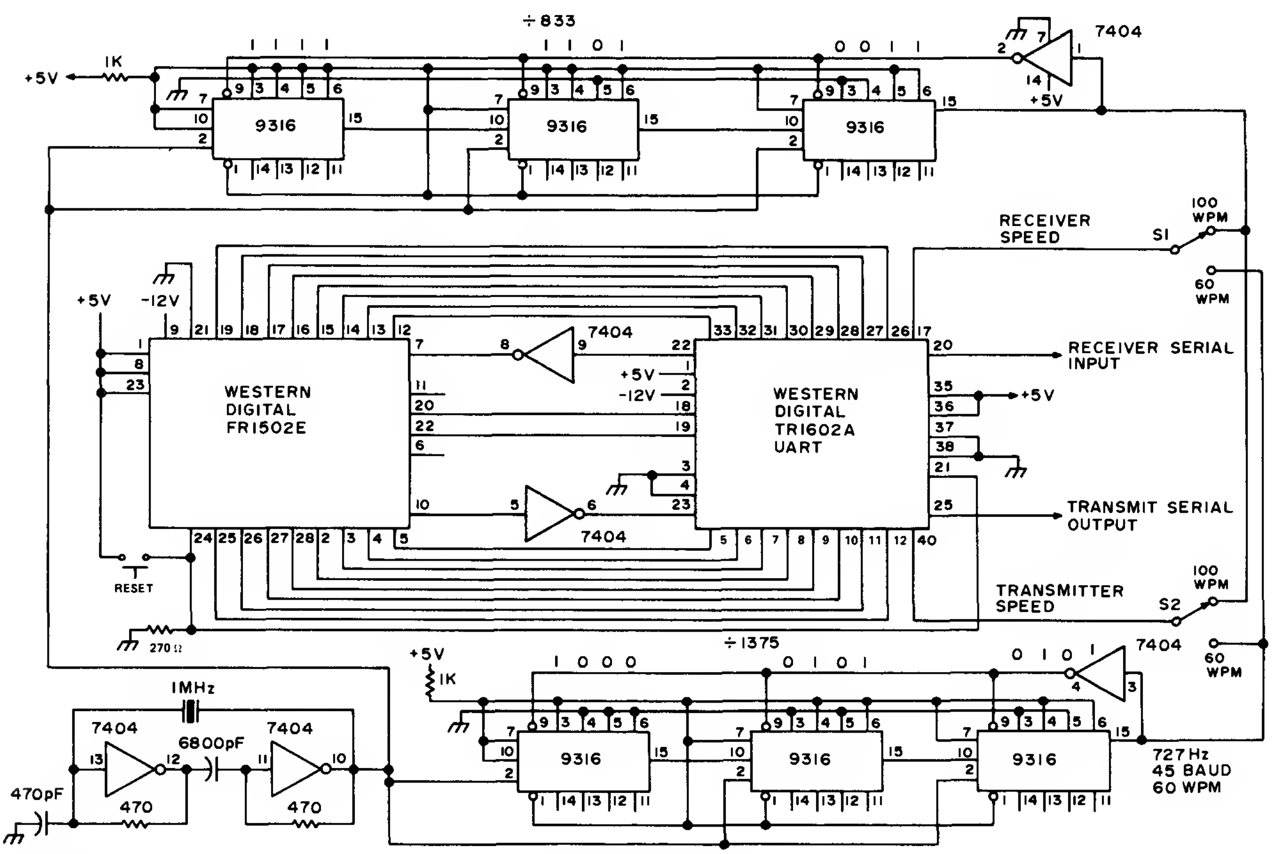




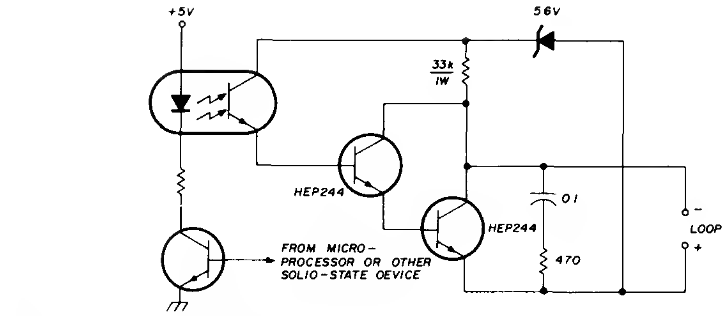
SINGLE-IC TOUCH-TONE ENCODER—Uses ME8900 tone generator made by Microsystems International, Ottawa, Canada, to generate pairs of audio frequencies for telephone signaling. Standard Touch-Tone pad provides column and row switch closures for pins 4, 5, 6, and 8 going to low-frequency parallel-T oscillators of IC and for pins 9, 10, 11, and 12 of high-frequency oscillator.—C. D. Rakes, "Integrated Circuit Projects," Howard W. Sams, Indianapolis, IN, 1975, p 100–101.

CHAPTER 91
Teleprinter Circuits

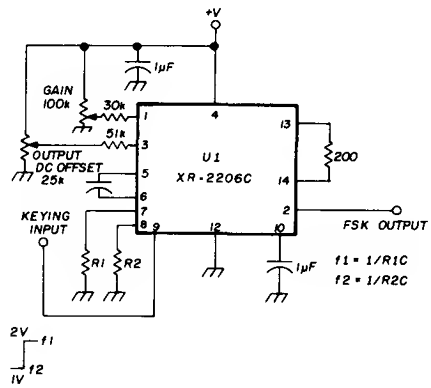
Includes tone generators and demodulators for FSK and AFSK used in wire and video Teletype systems having 170-Hz, 850-Hz, or other frequency shifts, as well as "QUICK BROWN FOX" and other test-character generators, RAM storage for up to 128 RTTY characters, autostart control, RTTY active filters and motor control, microprocessor and UART interfaces, and clock-signal generator for variety of keying speeds.



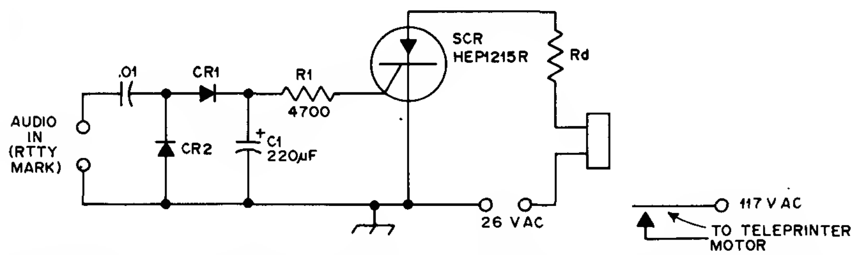
RTTY SPEED CONVERTER—Digitel speed converter for amateur RTTY permits transmitting either ebove or below input speed from keyboard or tape. Uses FR1502E 40-charecter 9-bit FIFO storage chip, TR1602A universal asynchronous receiver-transmitter, and six Feirchlld 9316 programmable dividers. Velues shown give choice of 60 or 100 WPM for receiving end for trensmitting, derived by dividing down from seme 1-MHz clock. Input end output are TTL-compatible.—A. Sperduti, The 60 WPM Conversion, *73 Magazine,* April 1977, p 158–159.



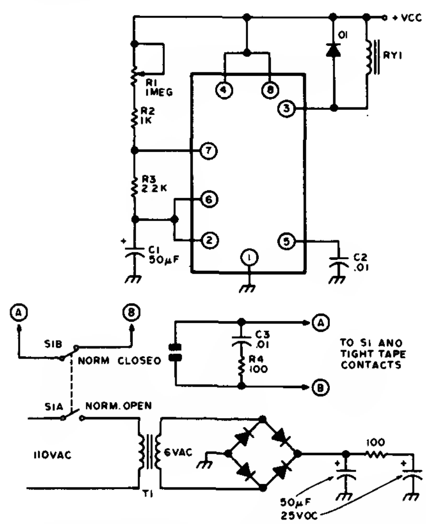
SAFE SWITCHING OF SOLENOIDS—Optoisolator provides protectiva interfaca between teleprinter and 8080A or other microprocessor when switching inductive loads of teleprinter. RC filter across Darlington pair speeds ralease tima of print magnets.—T. C. McDarmott, Switching Inductiva Loads with Solid-Stata Devices, *Ham Radio,* June 1978, p 99–100.



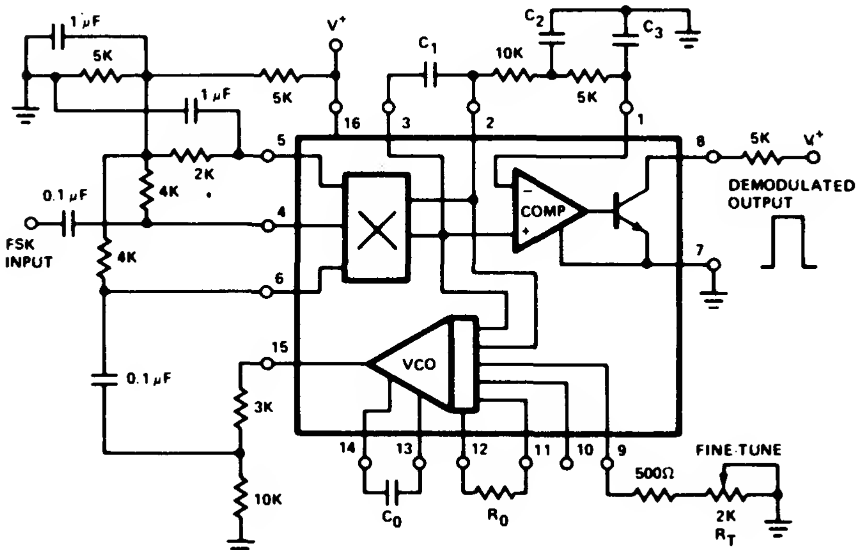
FSK GENERATOR—Simple frequancy-shift kayer usas Exar XR-2206C IC. Kaying input is applied to pin 9. Mark frequancy f1 is 1/R1C and spaca fraquency f2 is 1/R2C, with C connectad between pins 5 and 6.—E. Noll, VHF/UHF Single-Frequency Convarsion, *Ham Radio,* April 1975, p 62–67.



SCR CONTROLS RTTY MOTOR—Singla SCR can replace saveral transistor or tube stages in RTTY, VOX, COR, and othar relay control circuits. Threshold triggering effect of SCR means triggering is automatically suppressed on low-laval noisa and similer intarfarance. Used in RTTY autostart and motor dalay sections of demodulator. Pickup time is 1 s and dropout time is 3 s, determined by values of R1 and C1 and by SCR. Circuit keys only on 2125-Hz mark tone. Diodes are 50-PIV silicon. Rd is appropriata dropping rasistor for ralay, if needed.—D. Weedan, SCR Relay Control for RTTY, VOX, and COR, *QST,* July 1976, p 42.

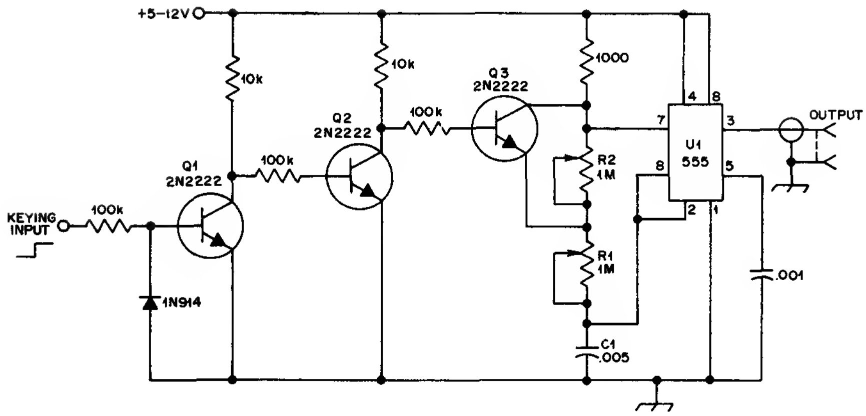


TAPE AS RTTY BUFFER—Davalopad to giva constant-speed amateur radioteletype transmissions despite erratic kayboarding spaeds. Uses NE555 timer chip as free-running MVBR whosa speed can be varied by R1 down to about 1 character avary 15 s or up to full machina speed. Can be used with any automatic send-receive machine. Keep enough slack in punched papar tape to parmit backspacing and correcting arrors before they are sant. With 5-V supply shown, 6-V SPST DC ralay can ba used.—B. Gulledga, Machanical RTTY Buffar, *73 Magazina,* Oct. 1976, p 74.

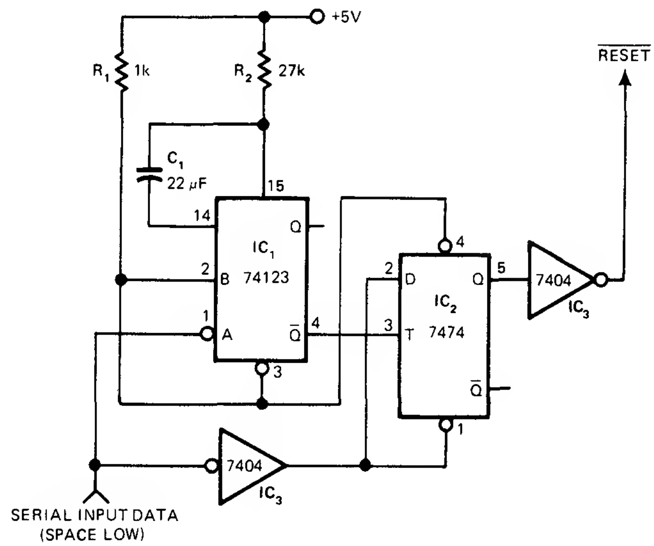


300 Baud		
Low Band:	f_1 = 1070 Hz f_2 = 1270 Hz	R_0 = 5.1 KΩ, C_0 = 0.22 μF C_1 = C_2 = 0.047 μF, C_3 = 0.033 μF
High Band:	f_1 = 2025 Hz f_2 = 2225 Hz	R_0 = 8.2 KΩ, C_0 = 0.1 μF C_1 = C_2 = C_3 = 0.033 μF
1200 Baud	f_1 = 1200 Hz f_2 = 2200 Hz	R_0 = 2 KΩ, C_0 = 0.14 μF C_1 = 0.033 μF, C_3 = 0.02 μF C_2 = 0.01 μF

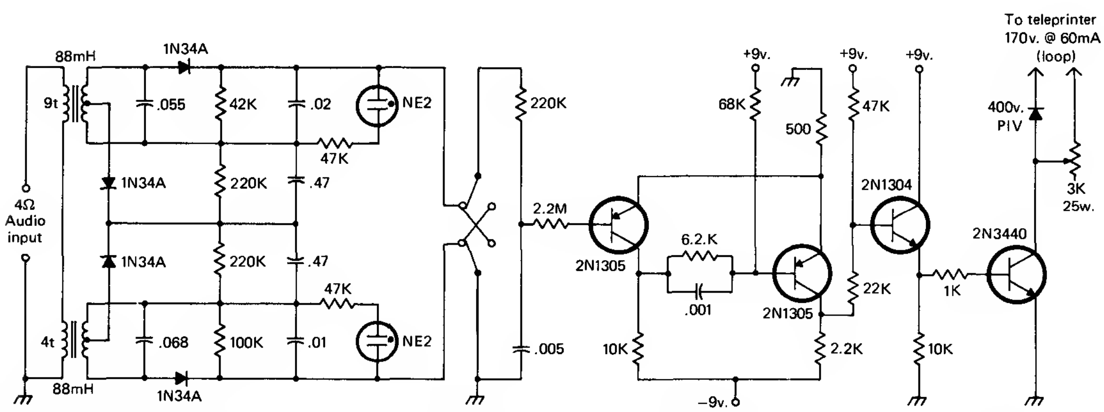
FSK DEMODULATOR—Exar XR-210 FSK modulator-demodulator is connected as PLL system by providing AC coupling betwaan VCO output pin 15 and pin 6. When input frequency is shifted, corresponding to data bit, polarity of DC voltaga across phasa datector output pins 2 and 3 is ravarsed. Voltage comparator and logic driver sections convart this DC laval shift to binary pulse. C_1 sarves as PLL filtar. C_2 and C_3 are postdetection filters. Timing capacitor C_0 and fine-tune adjustment are usad to set VCO midway betwaan mark and space frequencies of input signal. Tabla gives typical values for 300-baud (103-type) and 1200-baud (202-type) modam applications. Supply can be 5–26 V.—"Phase-Locked Loop Data Book," Exar Integratad Systems, Sunnyvala, CA, 1978, p 17–20.



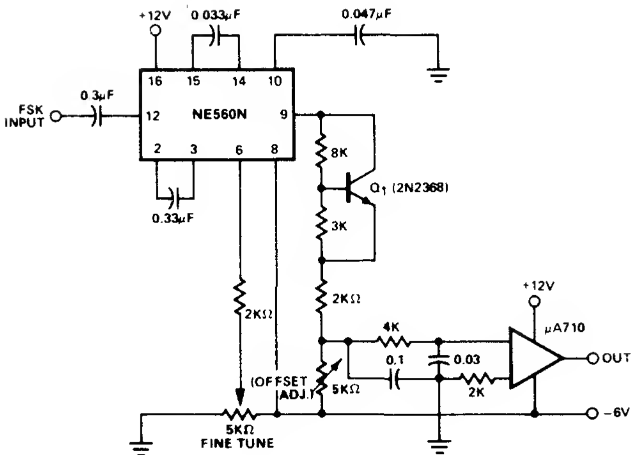
AFSK SHIFTS UP TO 20 kHz—Wide-range generator can be tuned from 50 Hz to 20 kHz, for shifting between two frequencies as much as 20 kHz apart. U1 is 555 timer connected as astable MVBR. When Q3 is biased off, charge/discharge currents for C1 flow chiefly through R1 and R2 to determine lower frequency of oscillation. When Q3 is on, R2 is effectively shorted and frequency is increased. Q1 acts as buffer and inverter so higher voltage at input gives higher tone. Keying occurs when input voltage exceeds 1 V with 5-V supply. If 10K supply resistor for Q1 is reduced to 1000 ohms, keying voltage increases to 3V.—T. M. Whittaker, Wide-Range AFSK Generator, *QST*, May 1977, p 48.



TTY RESETS CPU—Circuit uses break key on TTY as reset button for microprocessor. Retriggerable mono IC_1 monitors data input line from TTY, which goes low for spacing condition. During normal data input, constant spacing pulses in data retrigger mono, keeping IC_2 reset. When break key is depressed, input data goes to steady space and IC_1 times out. IC_2 then transfers high on its data input to its output to produce reset signal for CPU. Values of R_2 and C_1 give 150-ms period for mono, suitable for baud rates of 110 and higher.—C. Sondgeroth, Reset Your CPU from Your TTY's Break Key, *EDN Magazine*, May 5, 1978, p 39.

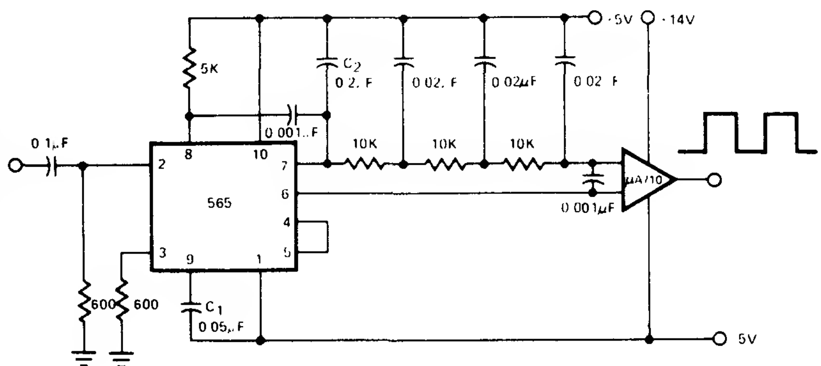


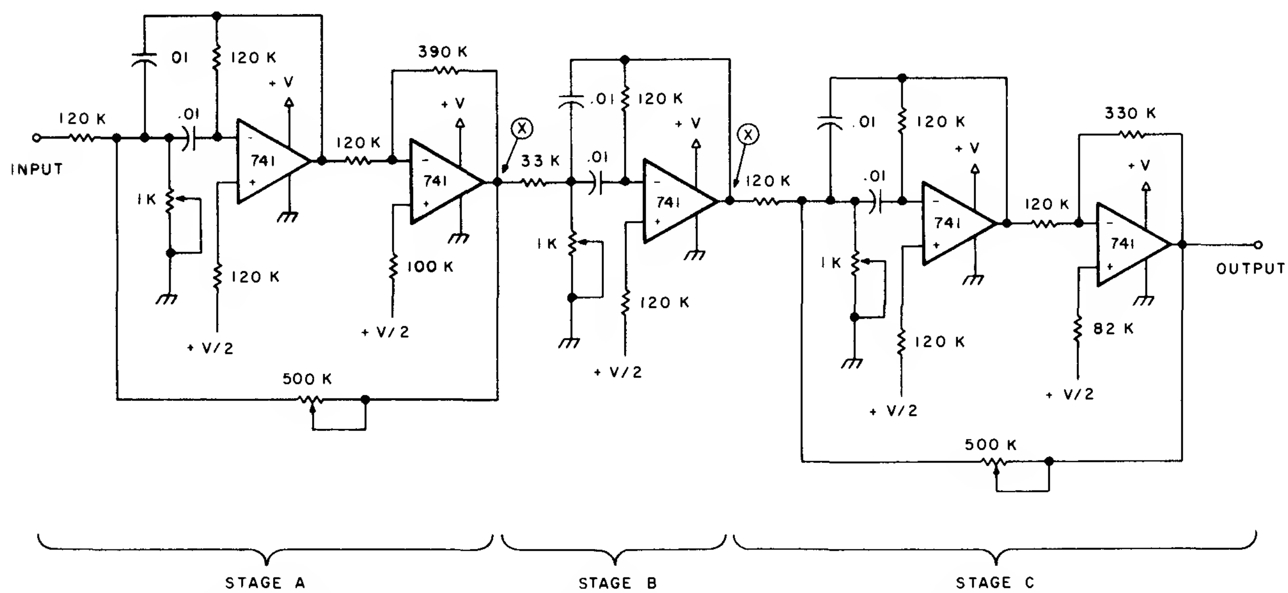
DEMODULATOR FOR 170-Hz SHIFT—Converts RTTY audio tones of 2125 and 2295 Hz to DC pulses required for driving selector magnets of teleprinter. Coupling links are added to standard 88-mH toroids as indicated.—I. Schwartz, An RTTY Primer, *CQ*, Feb. 1978, p 31–36.



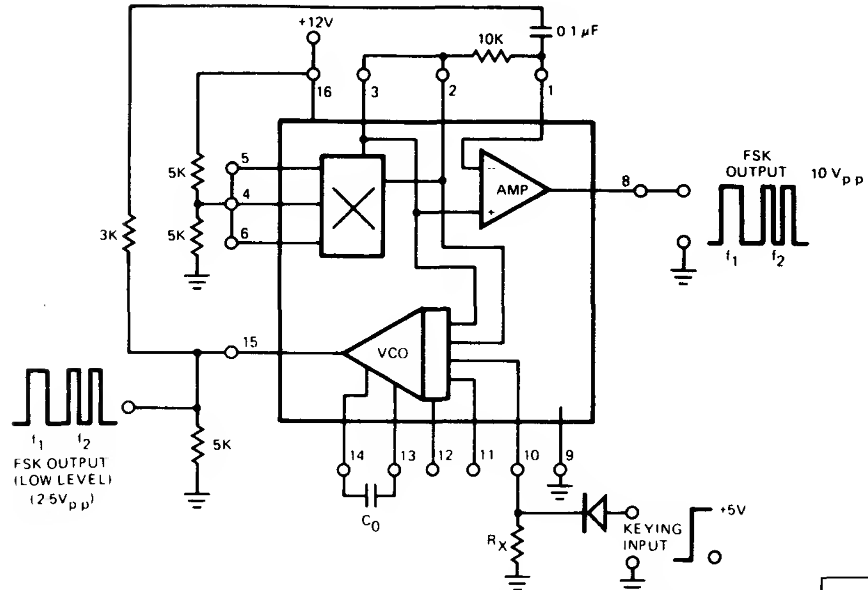
PLL FSK DEMODULATOR—Signetics NE560N phase-locked loop is used as receiving converter for demodulating carrier shifted between two preset frequencies, one corresponding to 0 and other to 1 of binary data signal. PLL provides shifting DC voltage to initiate 1 or 0 (mark or space) code elements. Circuit locks on and tracks output frequency of receiver. Input at pin 12 should be from 30 mV to 2 V P-P square or sine wave. Output of about 60 mVDC at pin 9 is amplified, conditioned, and fed to μA710 comparator to provide proper output voltages for interfacing with printer.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 844–845.

FSK DECODER—Simple circuit for Signetics NE565 PLL locks to input frequency and tracks it between two values used, to produce corresponding DC shift at output. Values shown are for 1070-Hz and 1270-Hz FSK signals. Three-stage RC ladder filter removes sum frequency component. Band edge of filter is chosen to be about halfway between maximum keying rate (150 Hz) and twice input frequency (about 2200 Hz). Output is made logic-compatible by connecting voltage comparator to pin 6.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 845.

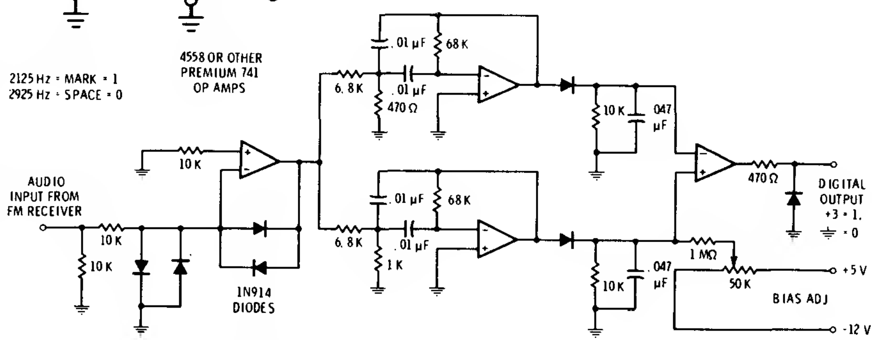




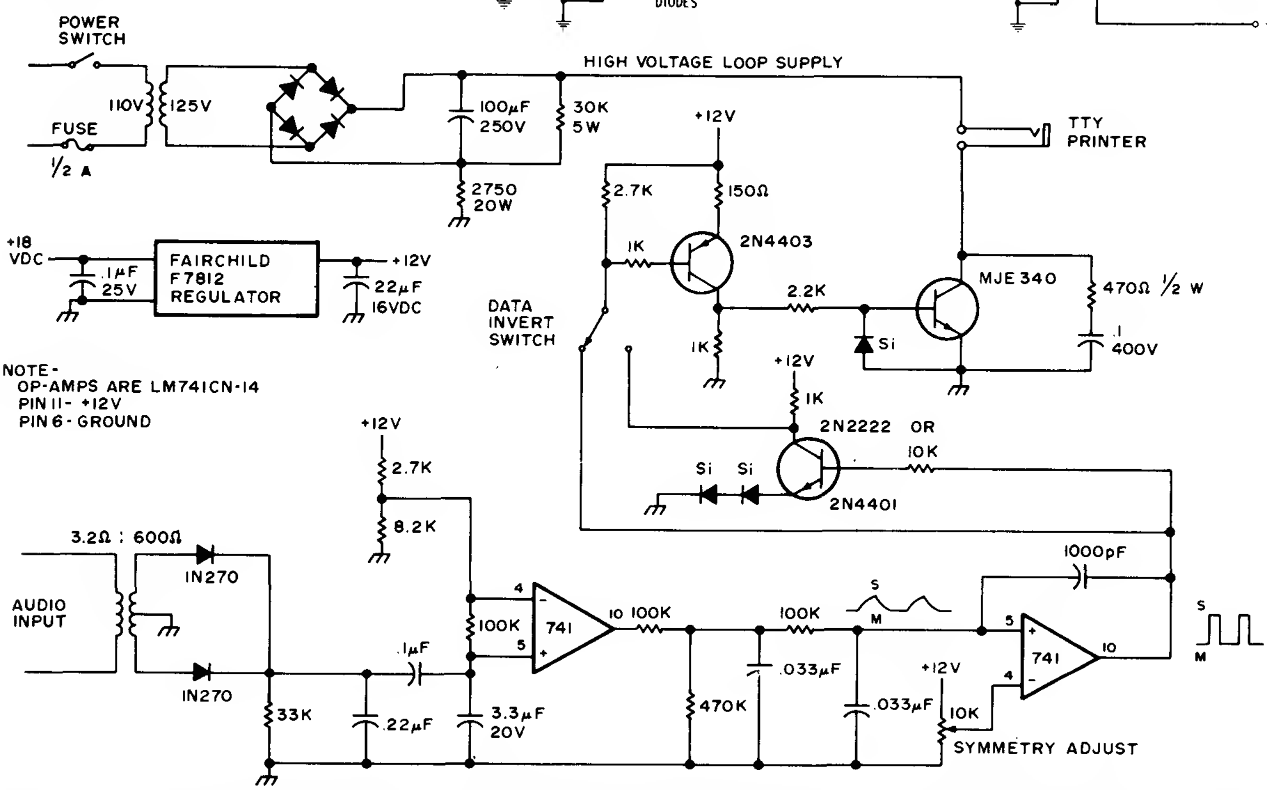
BANDPASS FOR 170-Hz RTTY SHIFT—Three-stage active Butterworth bandpass input filter is used in radioteletype *demodulator* to separate RTTY tones from each other and from noise. Filter is centered on 2200 Hz, and has bandpass of about 260 Hz to allow reception of some of audio sidebands produced by keying and allow for small drift. Five pots serve for trimming center frequency of each stage and Q of end stages. Article gives step-by-step design and alignment procedures. Use two 10K resistors between V and ground to get V/2 for bias when operating from single supply.—P. A. Stark, Design an Active RTTY Filter, *73 Magazine*, Sept. 1977, p 38–43.



FSK GENERATOR—Digital programming capability of Exar XR-215 PLL IC is used to provide shifting of VCO frequency between mark and space frequencies by applying logic pulse to pin 10. Circuit gives 2.5 V P-P output at pin 15 and 10 V P-P output at pin 8. Each output is symmetrical square wave with second harmonic content less than 0.3%.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 21–28.

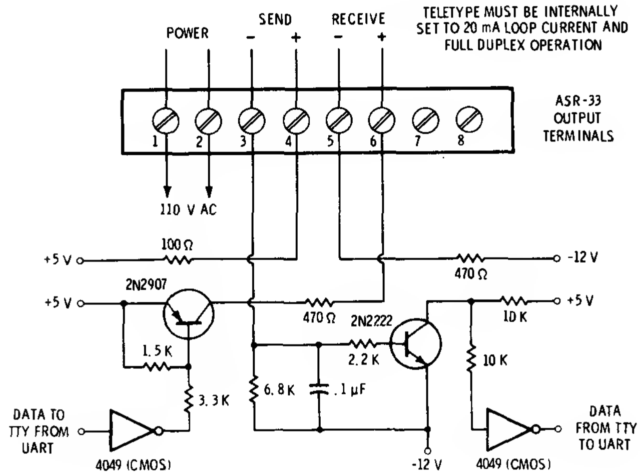


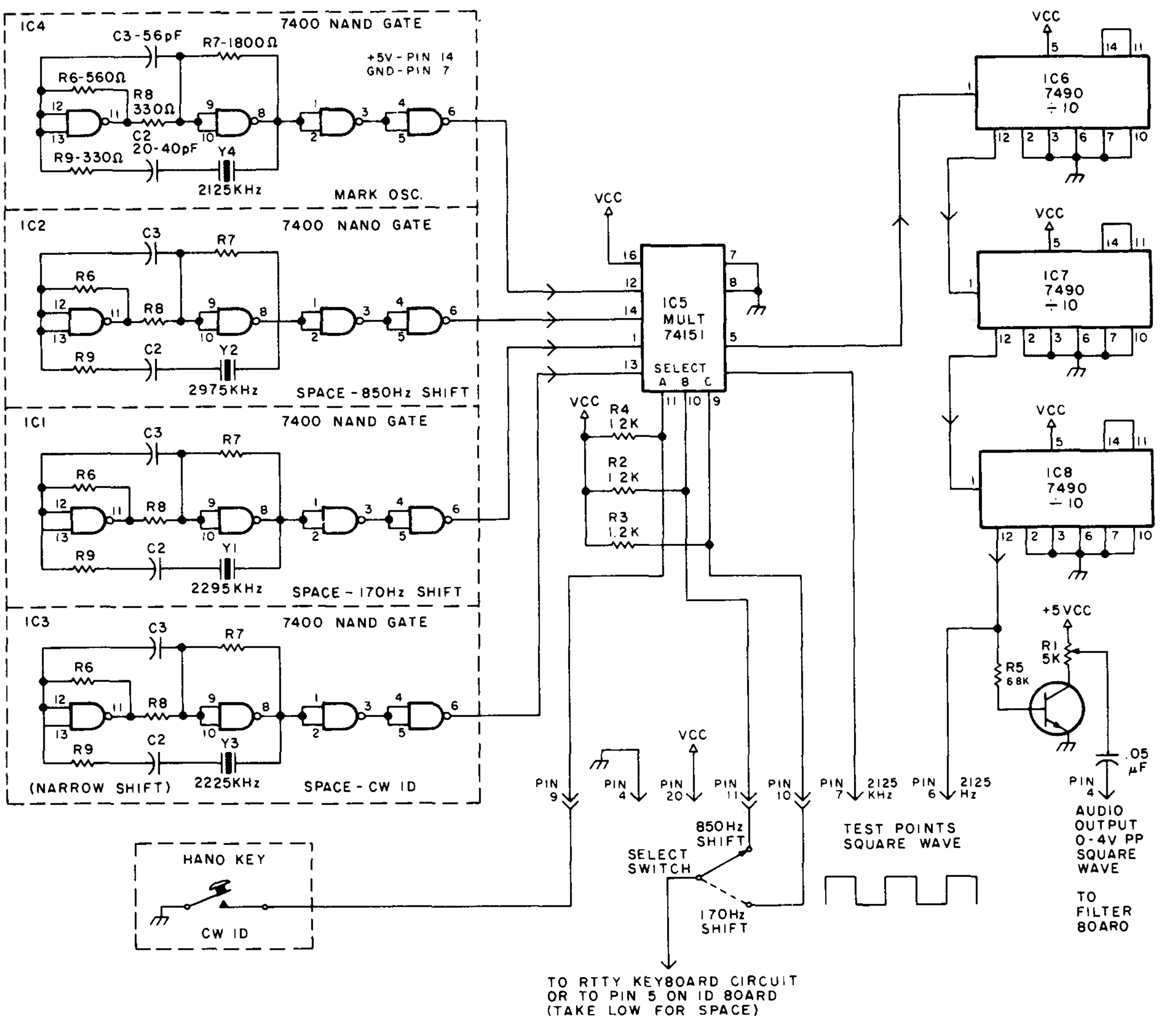
AUDIO PROCESSOR FOR RTTY RECEIVER—Audio tones of 2125 and 2975 Hz, as received and detected by FM receiver, are limited and fed to two active bandpass filters, each set to one of tone frequencies. Outputs are amplitude-detected and compared, to give output of 1 for 2125 Hz and output of 0 for 2975 Hz. Output is suitable for UART providing serial-to-parallel conversion.—D. Lancaster, "TV Typewriter Cookbook," Howard W. Sams, Indianapolis, IN, 1976, p 174–175.



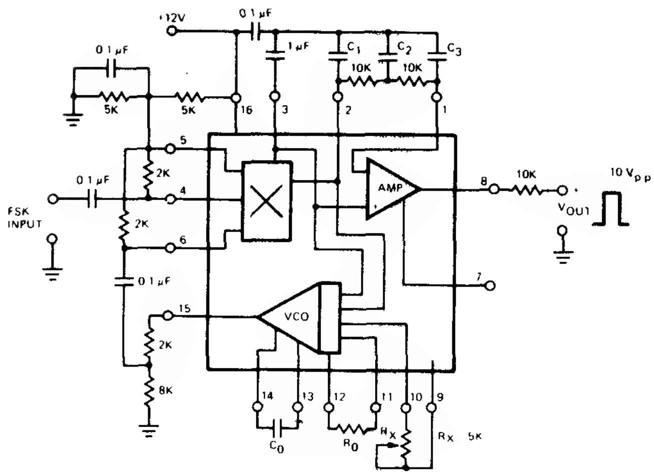
RTTY FROM SATELLITE—Developed for receiving RTTY transmitted from satellite as space-only keying. Receiver can be operated in CW or narrow-filter mode, to increase signal-to-noise ratio. Any receiver having CW filter with 400-Hz bandwidth can be used. Tune for audio output of 1 kHz. Audio is converted to varying DC voltage by envelope detector and amplified by 741 opamp that drives additional filter having high-level output for space and low-level output for mark. Slow rise and fall times of varying voltage are converted to ON/OFF keying signals by 741 used as comparator, for feeding to two-stage driver and high-voltage loop keying circuit of conventional design.—K. O. Learner and W. A. Kotras, Oscar RTTY Converter, *73 Magazine*, July 1975, p 53–54.

UART INTERFACE—Permlts use of universal asynchronous receiver-transmltter with model 33 Teletype so keyboard can eend and printer can receive at eama time. Transmltter interfaca provides 20-mA current for merk or 1 and opan circuit for space or 0. Receiver sanses closed contact for mark or 1 and open contact for epaca or 0. Extra invarters are added to meka codes correspond so 1 from UART is read es 1 by Teletype. Deslgned for 110-baud rate.—*D. Lancaeter, "TV Typewritar Cookbook,"* Howard W. Sams, Indianapolls, IN, 1976, p 162–164.



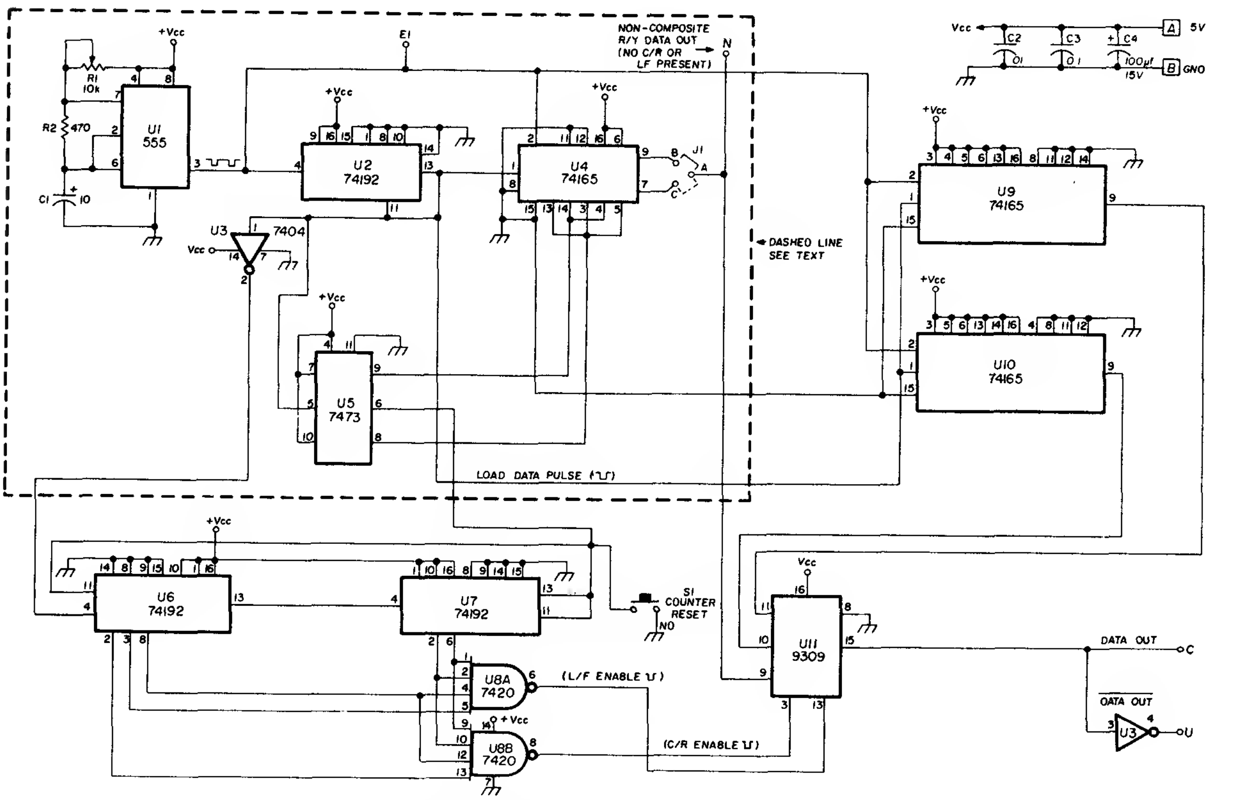


AFSK KEYER—Developed for use wlth 49-MHz FM transmitter to rebroadcest hurricana bulletins and other weather wernlngs to amateur RTTY etations. Crystals assure high precision in genarating RTTY tones for 850-Hz shift, with extra crystals for 170-Hz shift and for narrow-shift CW identification. Frequency tolerance is ±1 Hz and requires no callbratlon. Circuit uses 7400 quad NAND-gata crystal oscillator, which works with elmoet any HC-6/U crystal. Frequency cen be adjusted by changing valua of C2. Outputs feed 74151 multlplexer. When all SELECT inputs ara high (2.8–5 V), mark oscillator frequency appears at multlplexer output. When input B is low (0–0.8 V), multiplexer output changes to space frequency of 2975 kHz. Multiplexer feeds divida-by-1000 chaln faedlng 2125-Hz square wava to buffer translstor. Articla gives circult of low-pass filter that removas harmonics from output to glva pura slne wave for modulating transmitter.—L. J. Fox, Dodga That Hurricanel, *73 Magazine,* Jan. 1978, p 62–69.

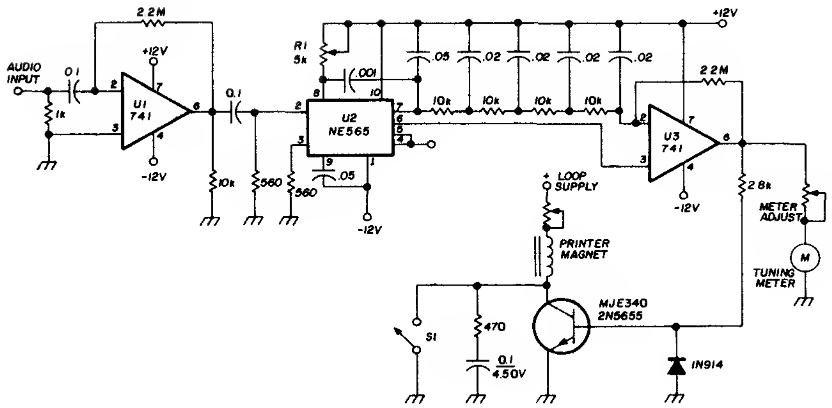


300 Baud	
Low Band: f_1 = 1070 Hz	R_0 = 5 kΩ, C_0 = 0.17 μF
f_2 = 1270 Hz	C_1 = C_2 = 0.047 μF, C_3 = 0.033 μF
High Band: f_1 = 2025 Hz	R_0 = 8 kΩ, C_0 = 0.1 μF
f_2 = 2225 Hz	C_1 = C_2 = C_3 = 0.033 μF
1800 Baud	R_0 = 2 kΩ, C_0 = 0.12 μF
f_1 = 1200 Hz	C_1 = C_3 = 0.003 μF,
f_2 = 2200 Hz	C_2 = 0.01 μF

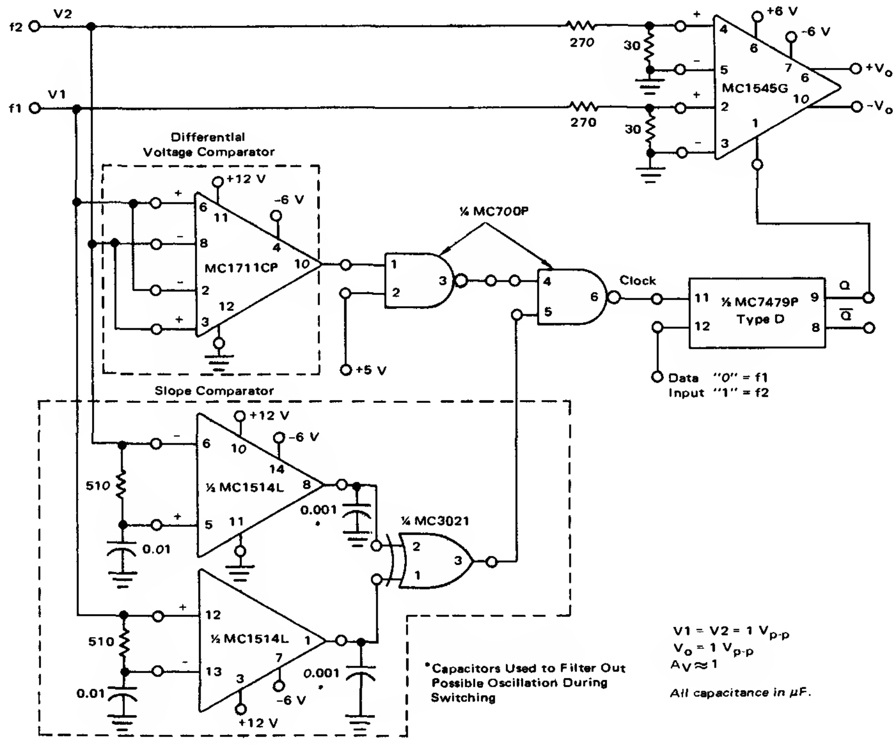
300- AND 1800-BAUD FSK DEMODULATOR— Uses Exar XR-215 PLL IC having frequency range of 0.5 Hz to 35 MHz. When input frequency is shifted by data bit, DC voltage between pins 2 and 3 reverses polarity. Opamp section is connected as comparator for converting DC level shift to binary output pulse. C_1 serves as PLL filter. C_2 and C_3 are postdetection filters. Table gives typical values of components for two transmission speeds.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 21–28.



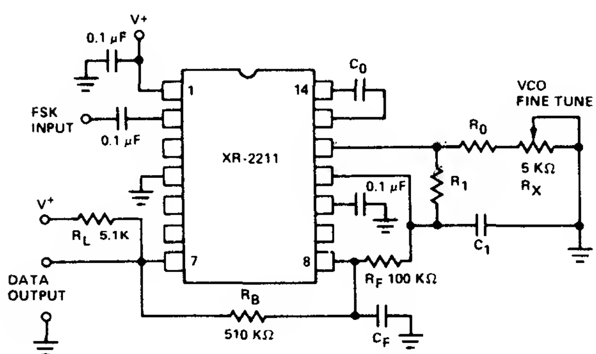
R-Y TEST GENERATOR— Uses ICs rather than PROM for automatic generation of sequence of 64 alternating Rs and Ys, plus Baudot codes for carriage return and line feed, as used for testing radioteletype equipment. Circuit in dashed lines generates codes for printing R and Y continuously without regard for line length. Jumper J1 gives choice of normal or inverted output data for keying transmitter with either mark-high or space-high signal. Operates at slightly less than 60 WPM. Adjust R1 so clock pulse generator U1 runs at 45.45 Hz. Article covers construction and operation.—J. Loughmiller, RTTY Test Generator, *Ham Radio*, Jan. 1978, p 64–66.



PLL RTTY TERMINAL—Uses 741 opamp as limiter, followed by NE565 phase-locked loop, another opamp U3 operating as voltage comparator or slicer, and keying transistor. Terminal requires no filters because incoming signal locks onto VCO whose frequency is placed between those of mark and space tones. As these tones alternate, output of PLL is made to produce plus and minus voltages by connecting voltage comparator to output of NE565. Resulting plus voltage corresponds to mark tone and minus voltage to space tone for use in keying loop circuit of teleprinter. R1 is only adjustment required; article covers adjustment for receiver in SSB mode and in CW mode.—N. Stinnette, Phase-Locked Loop RTTY Terminal Unit, *Ham Radio*, Feb. 1975, p 36–37.



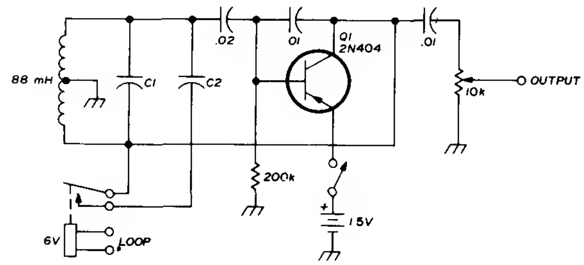
FSK WITH SLOPE AND VOLTAGE DETECTION—Motorola MC1545G gated video amplifier is used with slope and differential voltage comparators to provide switching of output alternately between input signal f1 at 2975 Hz and f2 at 2125 Hz. With gate level on pin 1 of MC1545G high (greater than 1.5 V), signal applied between pins 4 and 5 is passed and signal between pins 2 and 3 is suppressed. With gate low (less than 0.5 V), situation is reversed. To avoid generation of spurious frequencies and noise, gate control voltage is allowed to change only when rate of change of f1 and f2 have same sign and values of f1 and f2 themselves have same sign and equal magnitude within several millivolts. Data rate is about 170 Hz.—"Gated Video Amplifier Applications—the MC1545," Motorola, Phoenix, AZ, 1976, AN-491, p 12.

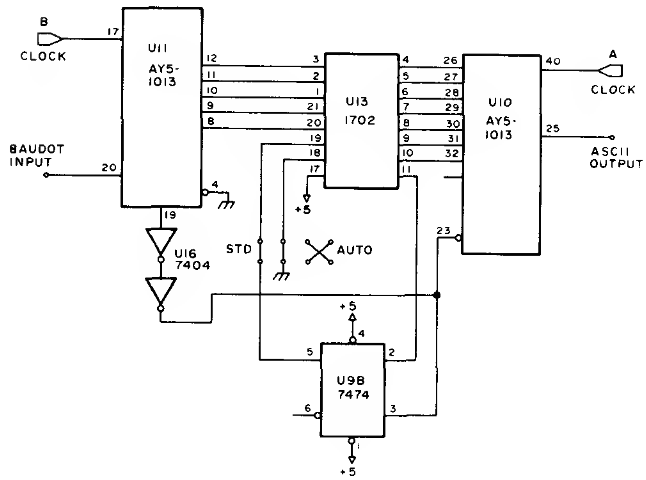


FSK BAND	COMPONENT VALUES
300 Baud f_1 = 1070 Hz f_2 = 1270 Hz	C_0 = 0.039 μF C_F = 0.005 μF C_1 = 0.01 μF R_0 = 18 KΩ R_1 = 100 KΩ
300 Baud f_1 = 2025 Hz f_2 = 2225 Hz	C_0 = 0.022 μF C_F = 0.005 μF C_1 = 0.0047 μF R_0 = 18 KΩ R_1 = 200 KΩ
1200 Baud f_1 = 1200 Hz f_2 = 2200 Hz	C_0 = 0.027 μF C_F = 0.0022 μF C_1 = 0.01 μF R_0 = 18 KΩ R_1 = 30 KΩ

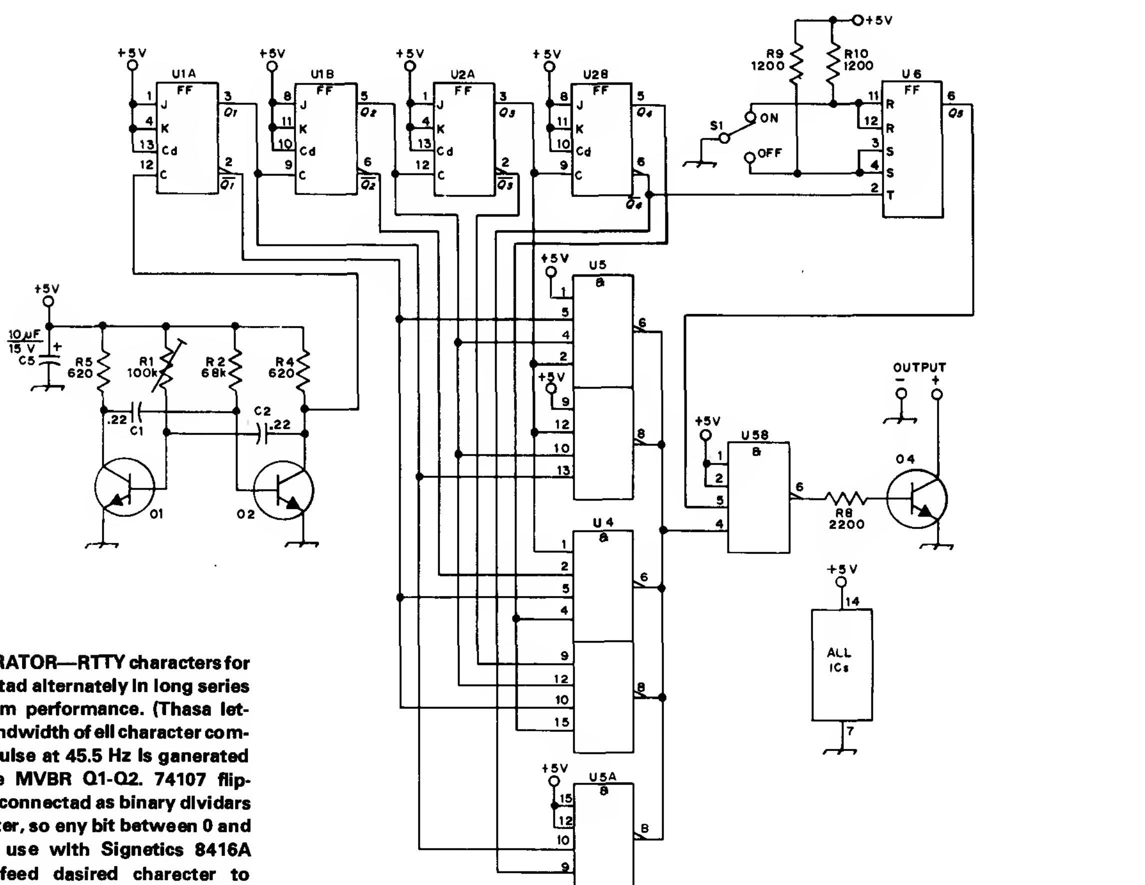
FSK DECODER—R_0 and C_0 set PLL center frequency for Exar XR-2211 FSK demodulator/tone decoder. R_1 sets system bandwidth. C_1 sets loop filter time constant and loop damping factor. C_F and R_F form postdetection filter for FSK data output. Table gives values for most commonly used FSK bands.—"Phase-Locked Loop Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 29–34.

KEYER FOR AFSK—Uses one center-tapped 88-mH toroid tuned to desired RTTY space frequency by suiteble velua of C1 (0.0628 μF for 2295 Hz). When relay is closed, suiteble valua for C2 (0.0156 μF for 2125 Hz) is paralleled with C1 to give desired speca frequency. Output Is perfect sine weva. Plug output into eudio input jack of trensmitter. Plug reley coil directly into 150-V 60-mA loop of telaprinter. Whan loop current is turned on, reley closes end AFSK is on mark. Space frequency occurs when reley is opened by teleprintar keyboard.—J. B. Dillon, Audio-Frequency Shift Keyar, *Ham Radio,* Sept. 1976, p 45.

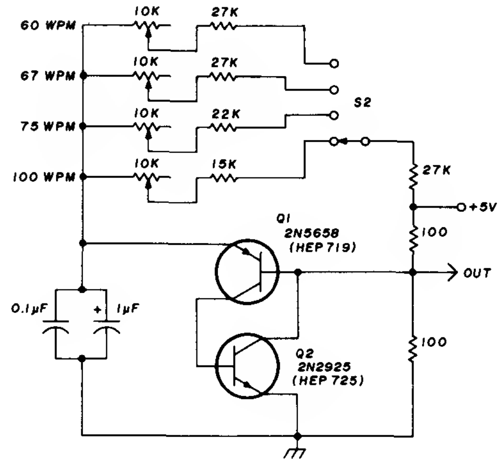




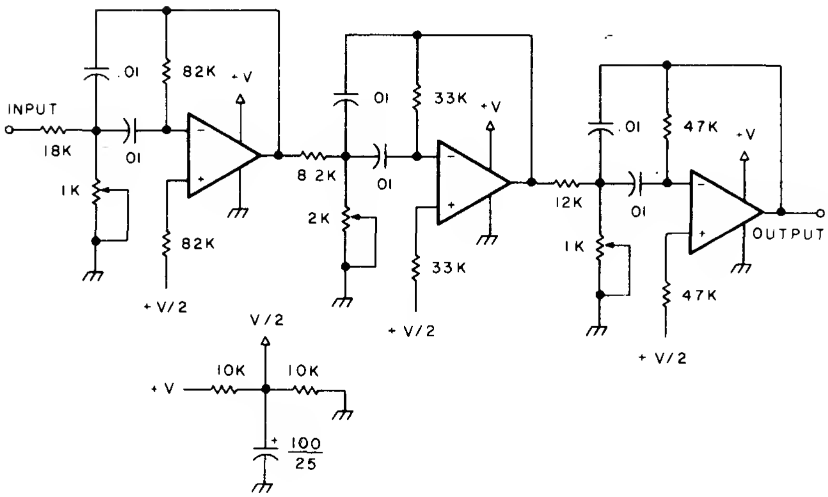
BAUDOT TO ASCII—Used with Baudot RTTY codes on ameteur bands, to drive Teletype machine requlring ASCII code. Separata 555 timers are used as clocks running at 727 Hz and at 1760 Hz. Provides only one-way conversion for receiving capebility, but article gives companion circuit for two-wey code conversion as required for transmission with ASCII Teletype. On U13, pins 12, 13, 15, 22, end 23 ell go to +5 V along with pin 17; only pin 14 is groundad.—J. G. Mills, Baudot to ASCII Converter, *73 Magazine,* Sept. 1977, p 80–85.



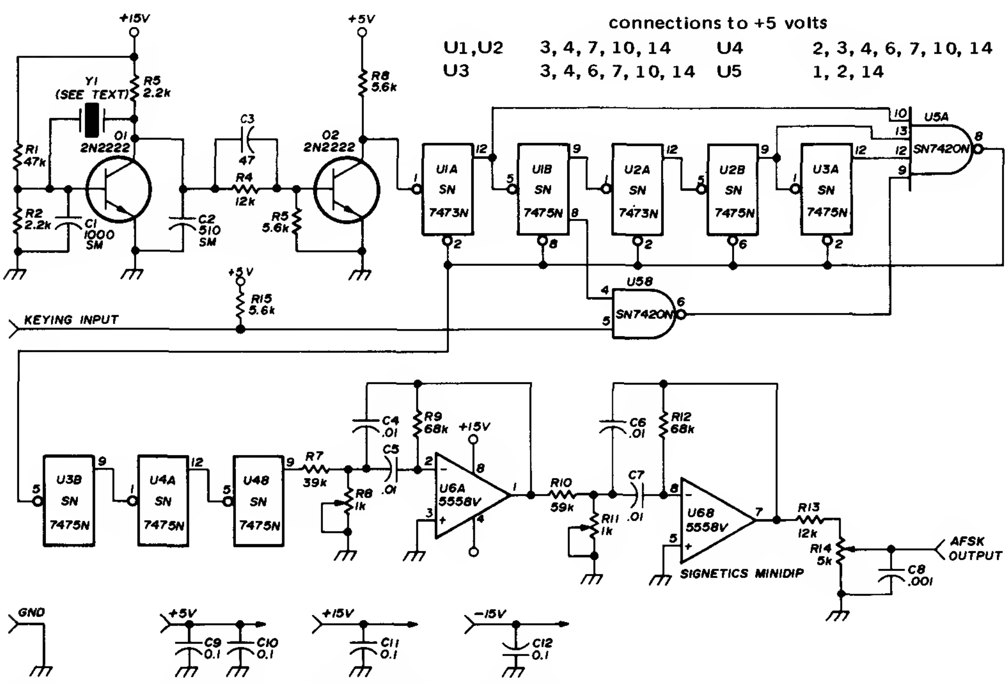
TEST-CODE GENERATOR—RTTY characters for R and Y ara generatad alternately In long series for checking system performance. (Thasa letters give widest bendwidth of ell character combinations.) Clock pulse at 45.5 Hz Is ganerated by 2SC943 astable MVBR Q1-Q2. 74107 flip-flops U1A-U2B are connactad as binary dlvidars for modulo-8 counter, so eny bit between 0 and 7 Is eveileble for use with Signetics 8416A getes U3-U5 to feed dasired charecter to 2SC372 output transistor. Automatic start/stop circuit using Feirchild 9945 clocked flip-flop U6 ansures that sequence elways sterts with R and ends with Y. Q4 conducts on mark end is cut off on space, for feeding frequency-shift keyer.—K. Sekine, A Simple RY Coda Generator for TTY, *QST,* Dec. 1974, p 20–24.



CLOCK FOR TEST MESSAGES—Generates negative-going pulse train at choice of four baud rates, to control RTTY test-message generator at four different speeds.—K. Ebneter and J. Romelfanger, RTTY Test-Message Generator, *Ham Radio*, Nov. 1976, p 30–32.

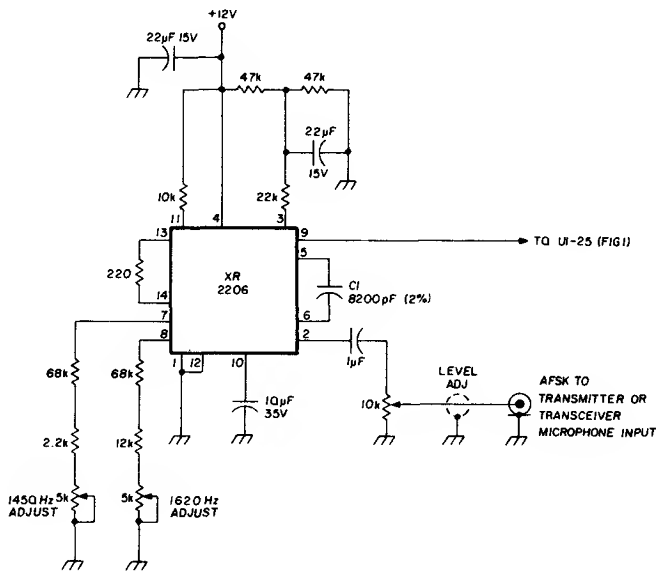


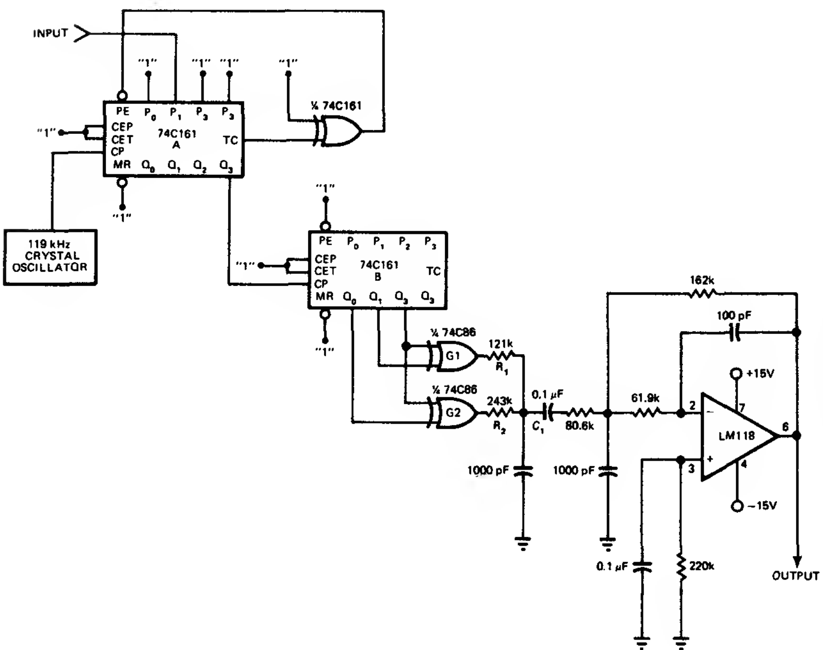
BANDPASS FOR 850-Hz RTTY SHIFT—Three-stage active Butterworth input filter passes 2125- and 2975-Hz tones plus modulation sidebands and allowance for drift in RTTY receiver. Inset shows how 741 opamps are biased when used with single power supply. Article gives step-by-step design and alignment procedures.—P. A. Stark, Design an Active RTTY Filter, *73 Magazine*, Sept. 1977, p 38–43.



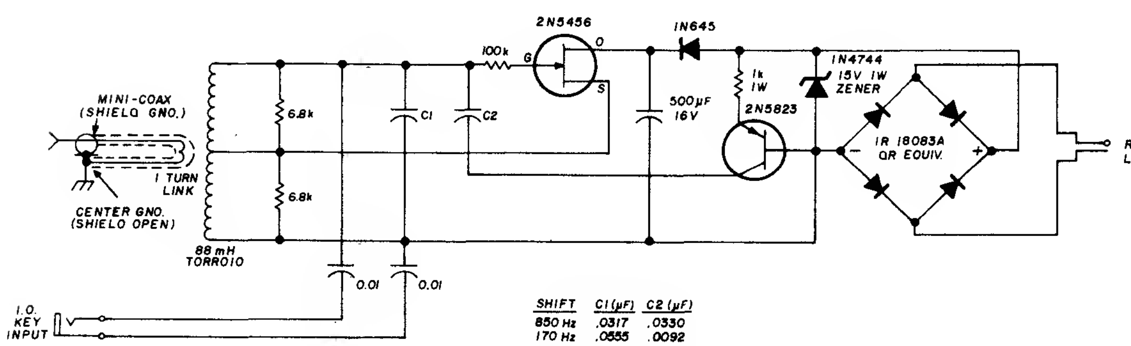
GENERATOR FOR 170-Hz SHIFT—Provides precise 2125- and 2295-Hz audio tones without requiring counter to establish correct frequency. Used for adjusting AFSK oscillator. Crystal can be 459.259 kHz (channel 48), which with appropriate divider chains gives output frequencies accurate within 2 Hz while preserving 170-Hz relative shift within 0.1 Hz. For even greater accuracy, order crystal that has been adjusted to exactly 459.000 kHz. When input is grounded, divide ratio is 25 to give 2295 Hz. When input is high, divide ratio is 27 to give 2125 Hz. Pin 11 of U1-U4 and pin 7 of U5 are grounded.—H. Nurse, Crystal Controlled AFSK Generator, *Ham Radio*, Dec. 1973, p 14–17.

AFSK GENERATOR—Uses phese-continuous frequency shift to prevent out-of-bend trensients while generating radio frequencies of 1450 end 1620 Hz. Second hermonic is outside pessbend of modern SSB equipment. Frequency of sine weve is determined by C1 end total resistence connected to pin 7 or 8 of Exer XR2206.—E. Kirchner, Serlel Converter for 8-Level Teleprinters, *Ham Radio,* Aug. 1977, p 67–73.





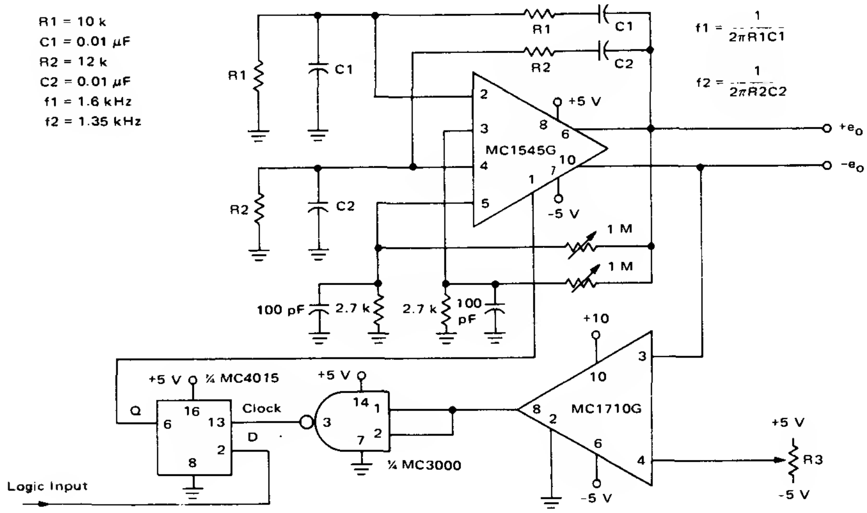
FSK FOR NRZ INPUT—Crystel-controlled frequency-shift keyer accepts nonreturn-to-zero digitel input end generates 5-V P-P FSK output signel heving less then 3% totel hermonic distortion, at standerd 2.125- and 2.975-kHz radio-teletypa frequencies. When input is low, counter A divides by seven; for high or logic 1 input, counter divides by fiva. Counter B divides by eight to produce required output frequencies. EXCLUSIVE-OR getes G_1 end G_2 generate first approximetion to desired sine-wava output, for filtering by three-pole active Butterworth low-pess filter heving 4.75-kHz cutoff.—K. Erickson, Frequency-Shift Kayer Features Rock-Steady Operation, *EDN Magazine,* Jen. 5, 1977, p 44.



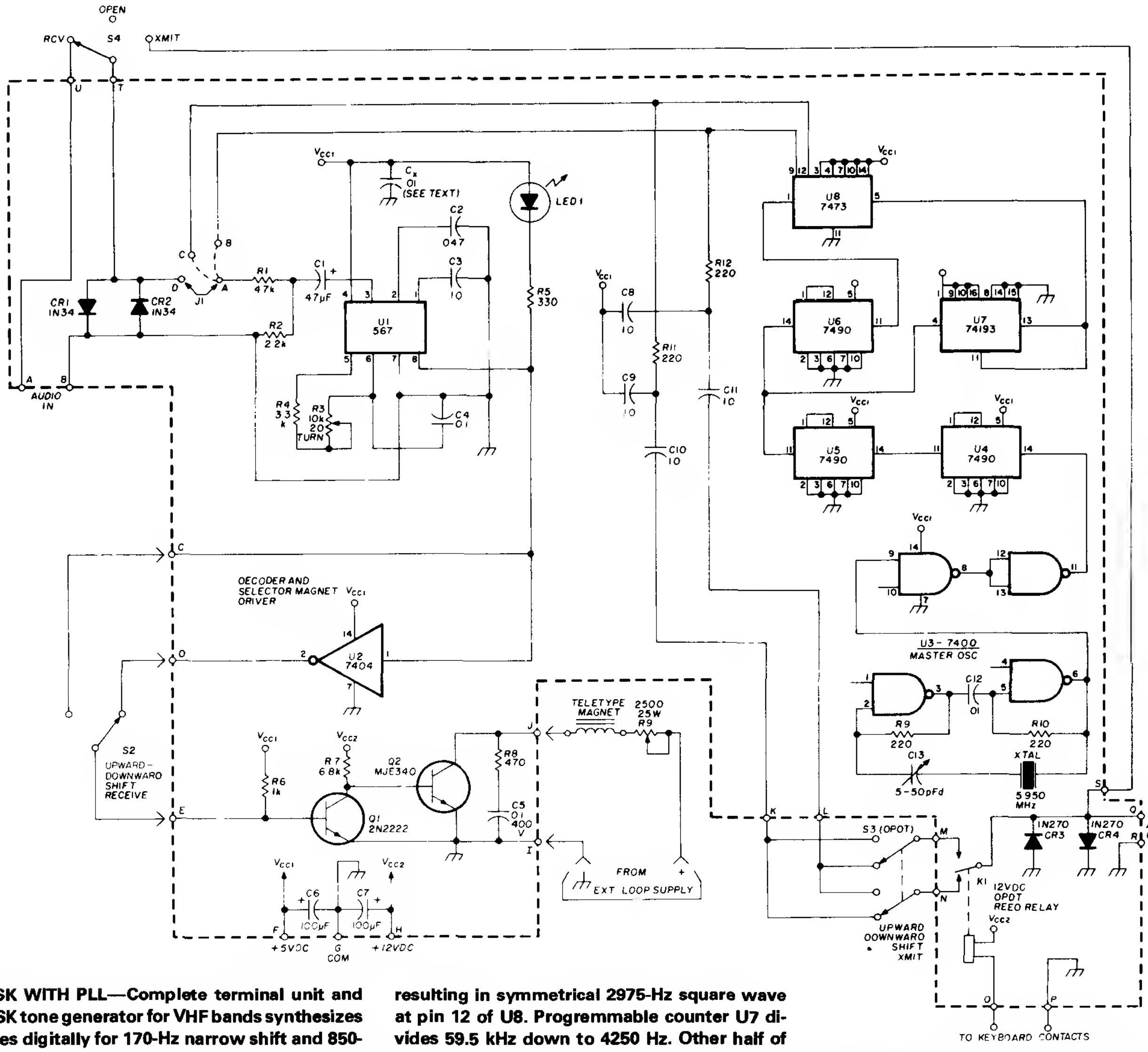
SHIFT	C1 (µF)	C2 (µF)
850 Hz	.0317	.0330
170 Hz	.0555	.0092

(VALUES FOR 86.7 mH)

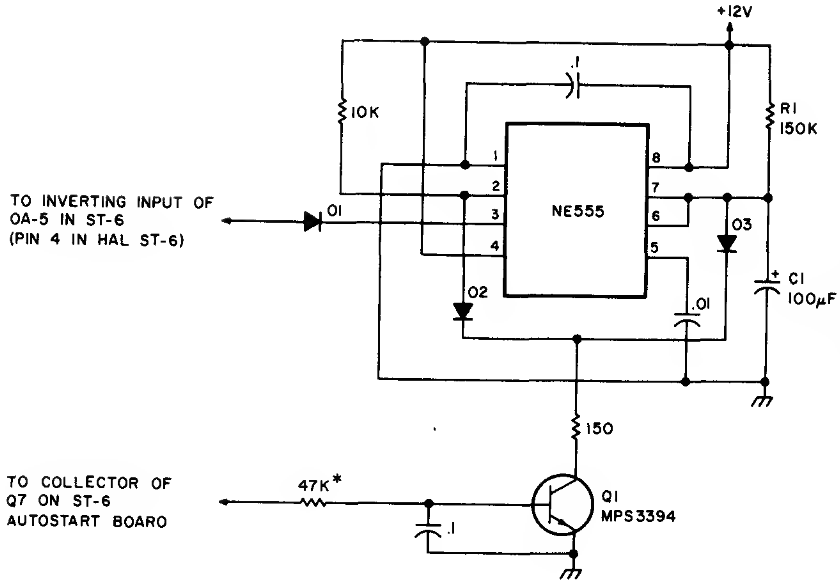
170- OR 850-Hz SHIFT—Simple AF RTTY keyer uses 2N5823 silicon PNP trensistor switch Instead of optical coupler. Short piece of coex servas as 1-turn output link. Outer shield is grounded only at coaxial connector so braid ects as Feredey shield, elimineting capecitive signel end noise pickup from circuit.—E. Noll, Circuits end Techniques, *Ham Radio,* April 1976, p 40–43.



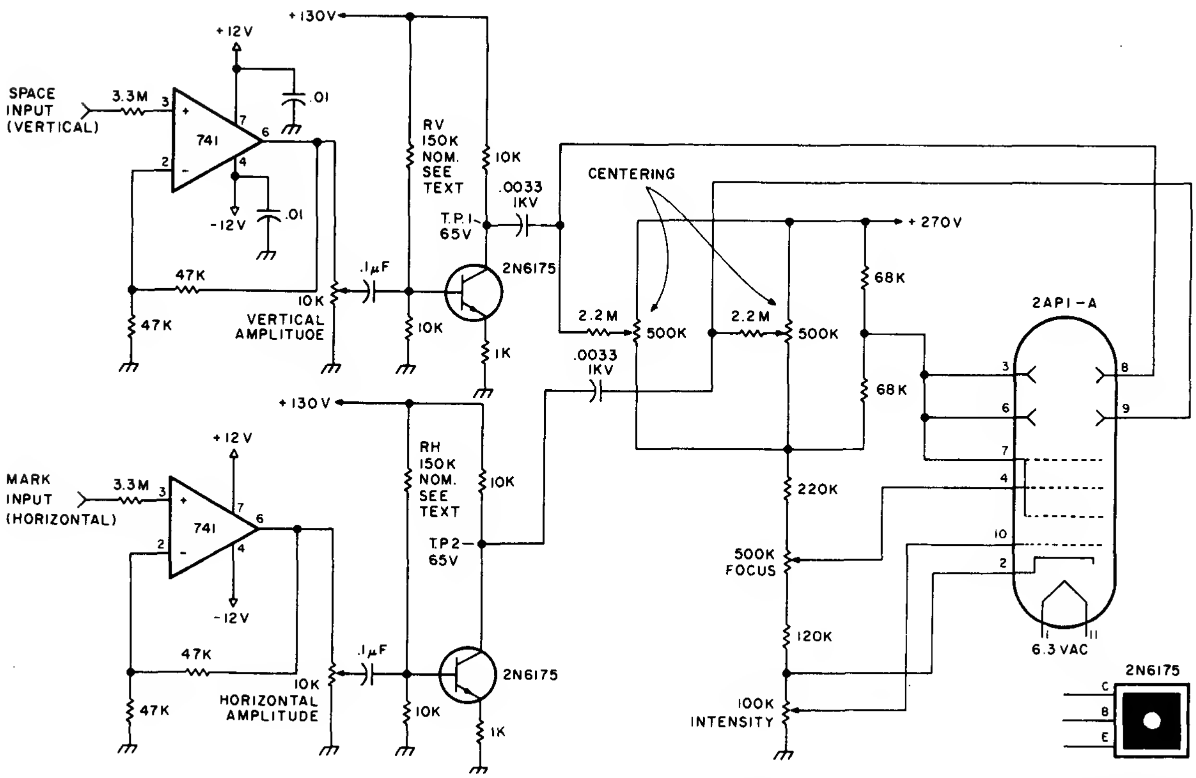
SELF-GENERATING FSK—Dual oscillators in Motorola MC1545G gated video amplifier are used with external frequency-determining components R1C1 and R2C2 to give 1.6 kHz for f1 and 1.35 kHz for f2. Logic switching network compares output to reference and updates gate input with each cycle of output. Circuit gives smaller switching transients than are possible with separate oscillators because one oscillator is driven at frequency of the other while first oscillator is off. R3 sets transition to any level desired.—"Gated Video Amplifier Applications—the MC1545," Motorola, Phoenix, AZ, 1976, AN-491, p 13.



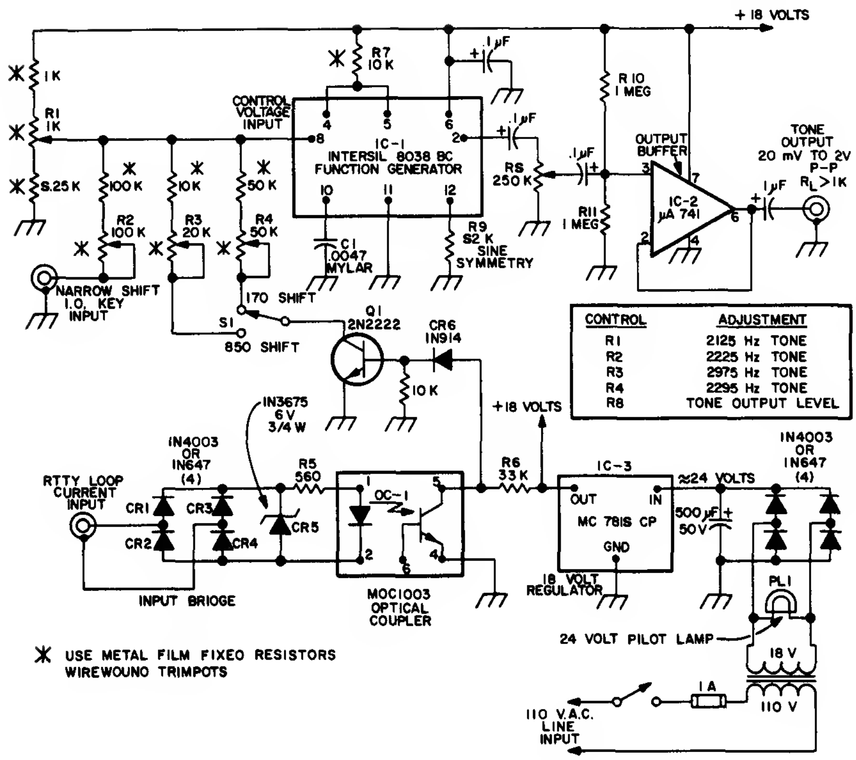
AFSK WITH PLL—Complete terminal unit and AFSK tone generator for VHF bands synthesizes tones digitally for 170-Hz narrow shift and 850-Hz standard shift found in VHF amateur RTTY bands. Additional feature is PLL circuit that follows drifting signal and copies signals from which mark or space information is missing. Precision AFSK generator consists of 5.95-MHz crystal oscillator U3, divide-by-100 ICs U4 and U5, divide-by-10 IC U6, and divide-by-2 IC U8, resulting in symmetrical 2975-Hz square wave at pin 12 of U8. Programmable counter U7 divides 59.5 kHz down to 4250 Hz. Other half of U8 divides this by 2, to give symmetrical 2125-Hz square wave at pin 9 of U8. Square waves are converted to trapezoids, with tops smoothed by CR3 and CR4, to give 1 V P-P quasi-sine waves at output. Demodulator U1 compares incoming frequencies to its internal current-controlled oscillator and generates digital signals when they are identical. Internal oscillator is locked to incoming signal if within detection bandwidth of about 220 Hz for 2125 Hz with 170-Hz shift. At 2975 Hz, detection bandwidth is about ±135 Hz.—J. Loughmiller, Digi-ratt—RTTY AFSK Generator and Demodulator, *Ham Radio*, Sept. 1977, p 26–28.



STOP FOR AUTOSTART—Uses 555 timar IC to make ST-6 autostart turn off motor of tale-printer if copying commercial station that doas not drop its carrier whan no taxt is baing transmitted. Values shown for C1 and R1 giva tima of 15 s which, added to 25 s of ST-6 dalay, givas about 40 s to turn off in presenca of staady mark tone (carrier only). Useful whan copying weather and press reports.—R. Bourgeois, Stop That Autostart, *73 Magazine,* May 1977, p 47.

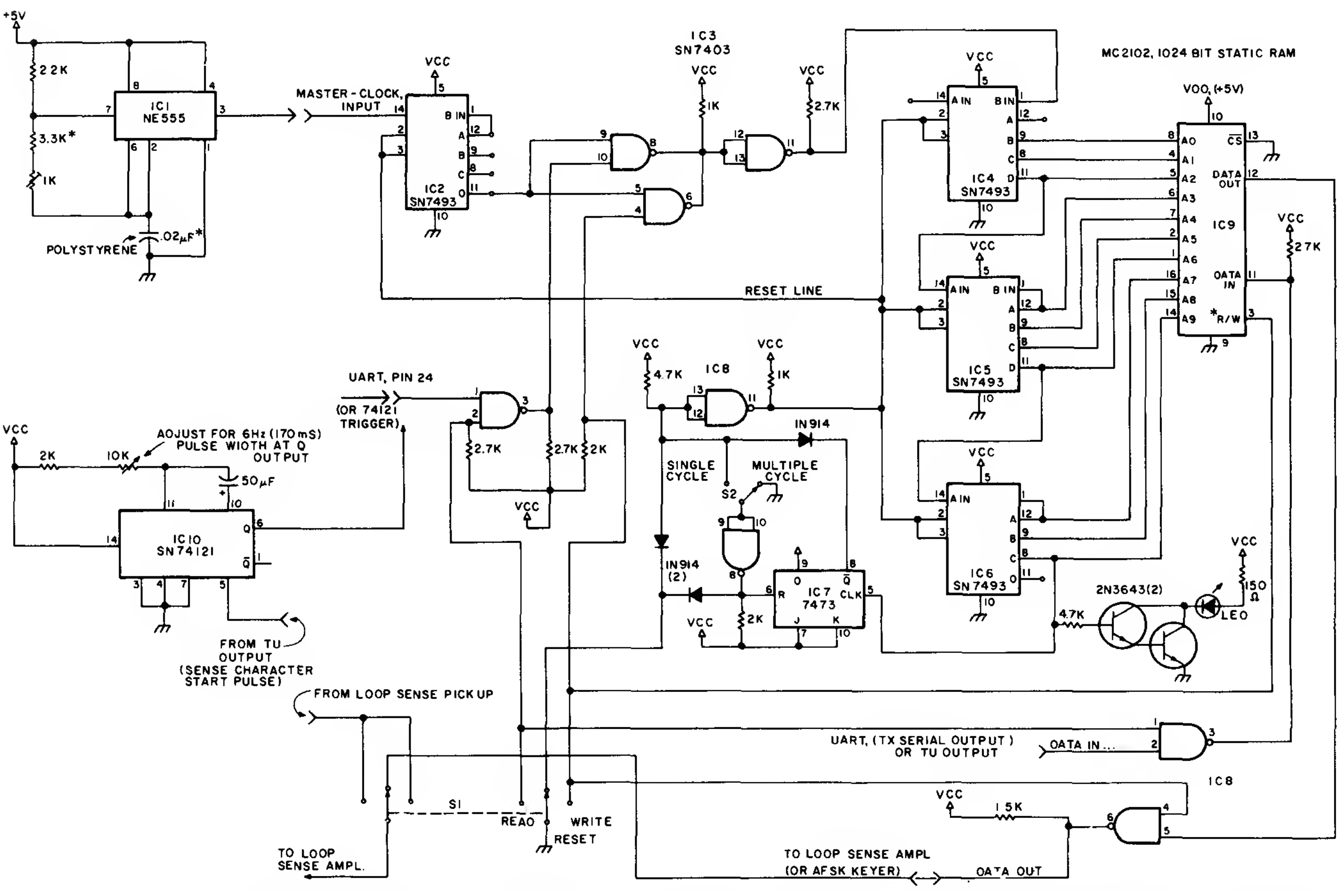


CRT TUNING INDICATOR—Crossed-ellipsa display on CRT aids in tuning receivar to RTTY signal. Display shows at a glanca if station is narrow or wide, or if othar station is transmitting upside-down signals (mark and spaca frequancies ravarsed). Tuned for maximum amplituda of major axis of aach allipsa; if transmitting station is wida or narrow, tuna for aqual amplitudes avan though they ara not maximized. Try diffarant valuas of RV until T.P.1 voltage is 65 V, to canter signal so it can swing aqual amounts on either side. Adjust RH similarly.—R. R. Parry, RTTY CRT Tuning Indicator, *73 Magazine,* Sept. 1977, p 118–120.

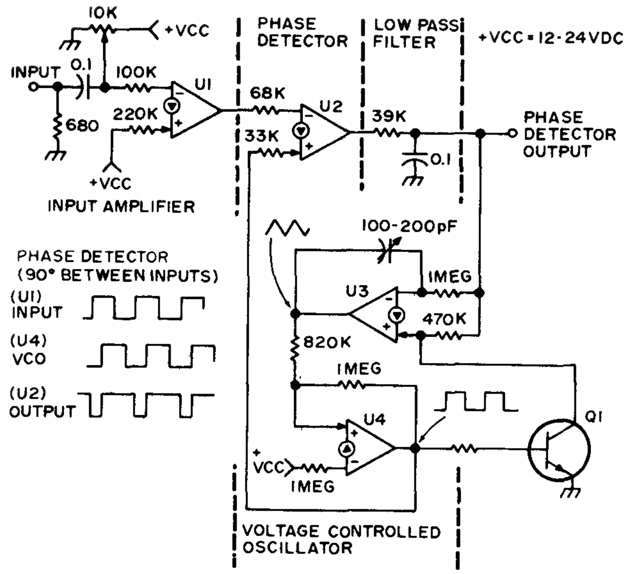


CONTROL	ADJUSTMENT
R1	2125 Hz TONE
R2	2225 Hz TONE
R3	2975 Hz TONE
R4	2295 Hz TONE
R8	TONE OUTPUT LEVEL

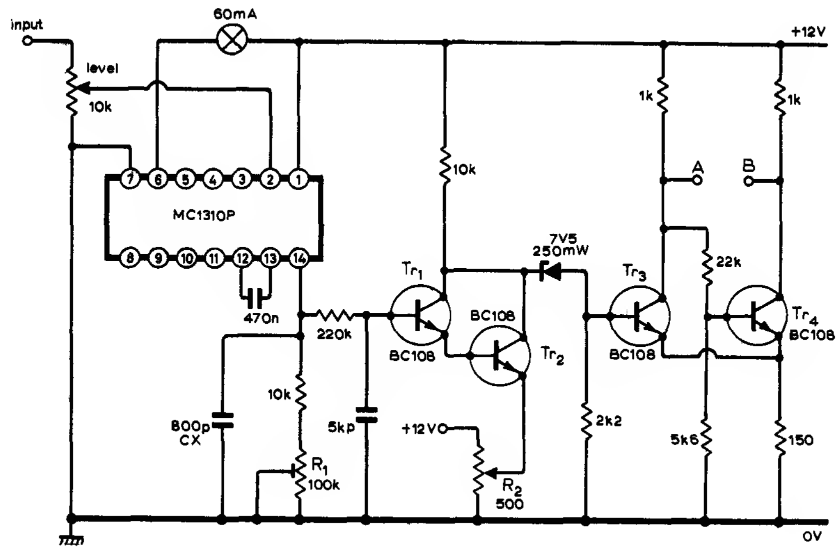
AFSK TONES—Generates tones needed for either 170- or 850-Hz frequency shift in automatic frequency-shift keying of RTTY equipment. Independent adjustments are provided for each tone. Sine-wave output has constant amplitude, with excellent tone frequency stability. Circuit permits plug-in operation in any RTTY loop, independent of loop polarity or grounding. Article covers construction and adjustment.—J. C. Roos, Universal AFSK Generator, *73 Magazine*, July 1974, p 37–40, 42, and 44–46.



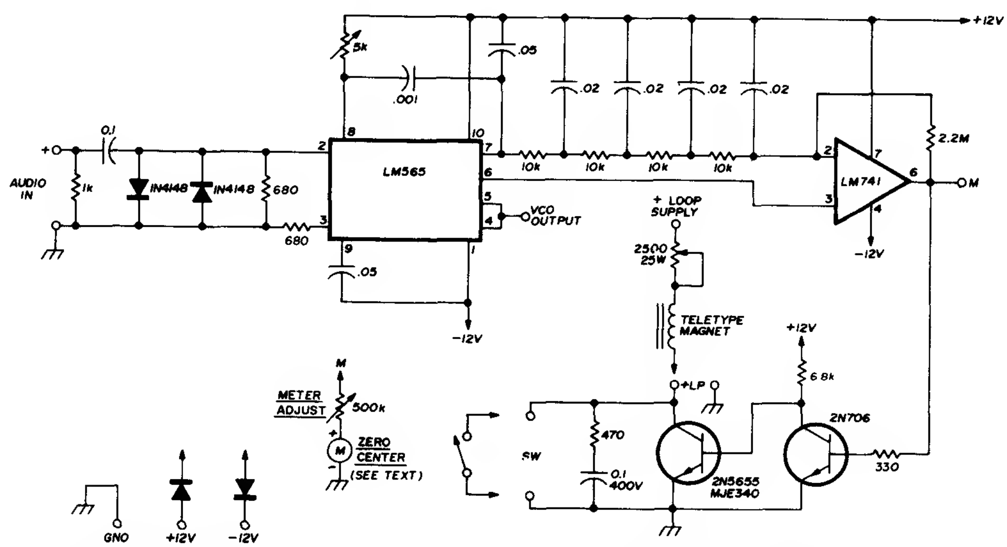
RAM FOR RTTY—Erasable MC2102 1024-bit RAM stores two Teletype lines (128 characters) of Baudot code for readout at machine speed. Can also serve in place of tape loop for frequently used code messages such as CQ calls. Values shown with IC1 timer are for 728-Hz master clock (16 × 45.45 bauds). Stored message is volatile, disappearing when power is turned off. For permanent storage, use ROM in place of RAM.—H. P. Fischer, RTTY Scratchpad Memory, *73 Magazine*, June 1977, p 54–55.



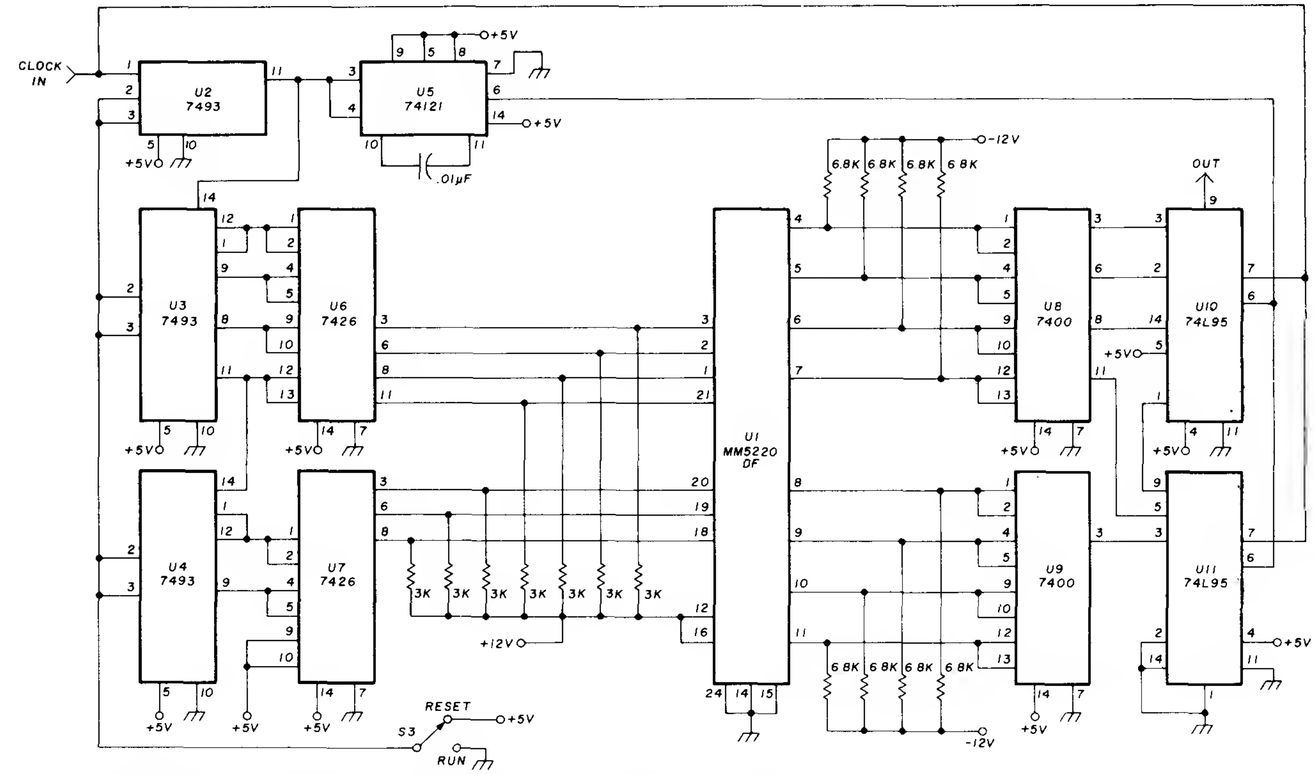
PLL FOR RTTY—Complete phese-locked loop uses all four sections of LM3900 qued lineer opemp. Veriable cepacitor is set to give center fraquency of 2.2 kHz for VCO. Once in lock, loop will meintain lock over renge of 1.55 to 2.9 kHz, to covar tones normally used in RTTY. Additional kaying circuit for TTY selector magnets and more filtering of output completes setup for driving printer. Q1 is 2N706, with 33K resistor in base circuit.—C. Sondgeroth, More PLL Magic, *73 Megazine*, Aug. 1976, p 56–59.



FSK DEMODULATOR—Uses IC originelly daveloped for stereo multiplex decoders, containing phasa-locked loop suitabie for demoduiating teleprinter FSK signals. Circuit shown raquires only smell input signal for phese lock, gives visuai indication with iamp when phase lock has occurred, and requires oniy peir of 2N3055 drive transistors between outputs A-B end taieprinter receiving solenolds. Article also gives this output circuit and setup procedure.—K. S. Beddoe, Teleprintar Tarminal Unit Uses Phese-Locked Loop, *Wireless World*, Dec. 1973, p 605.



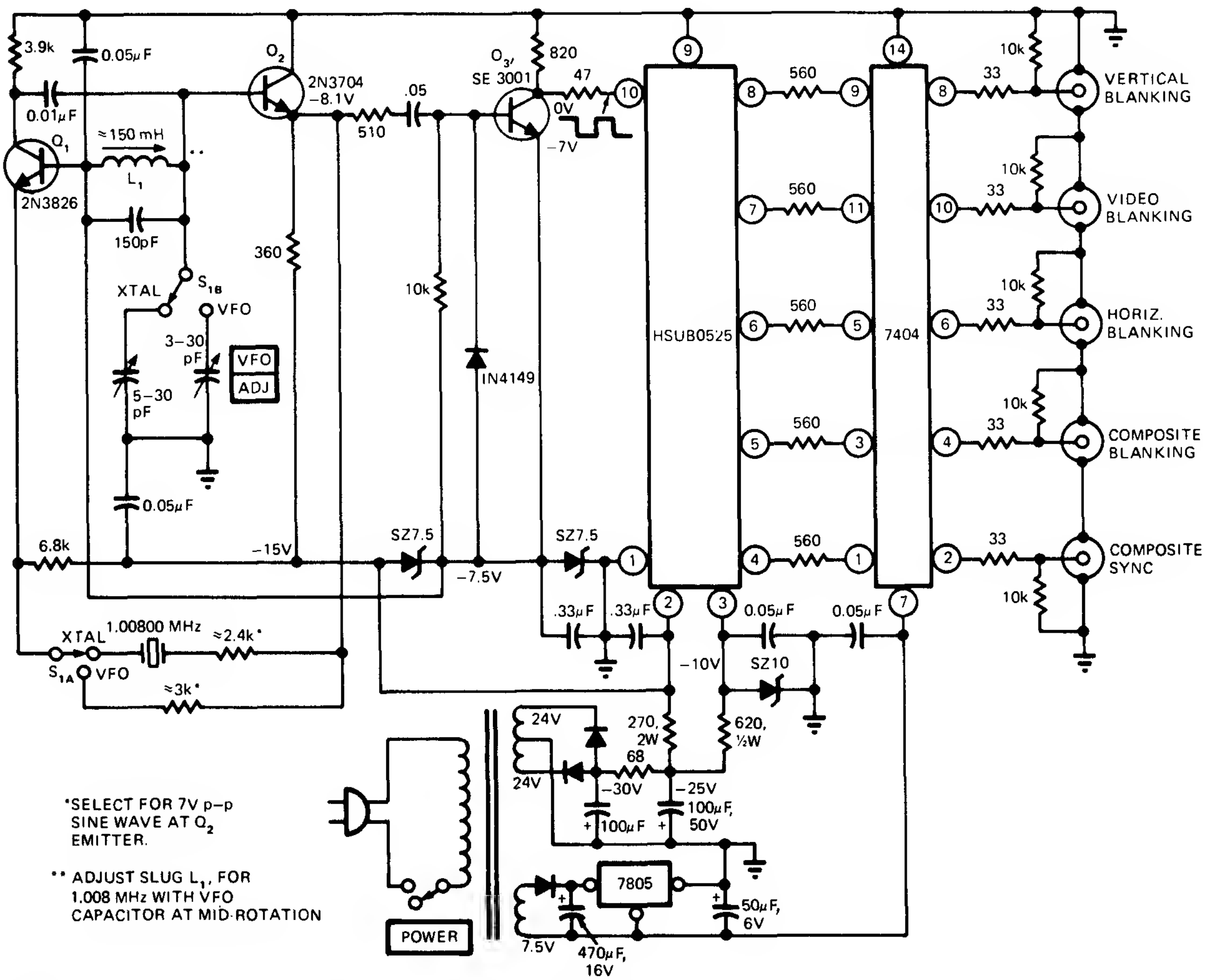
UPWARD-SHIFT RTTY DEMODULATOR—PLL demodulator serves for copying AFSK/FSK upward-shift RTTY signels. 2N706 switches 2N5655 on end off, reversing polarity of voltaga from LM741 comparator on mark/hold es needed for smooth upwerd-shift copy. Works equally weil on wide-shift or narrow-shift signals. Zero-centar tuning meter wiii show full-scale minus (left) reeding on merk/hoid signel. Meter mey not be needed on AFSK.—N. Stinnette, Updete of the Phese-Locked Loop RTTY Demodulator, *Hem Radio*, Aug. 1976, p 16–17.



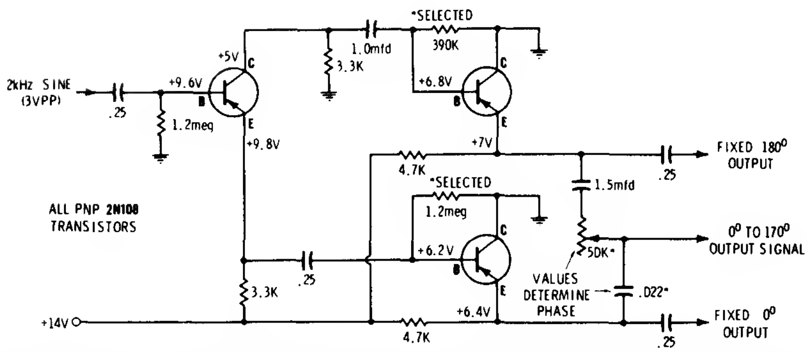
QUICK BROWN FOX GENERATOR—TTL ICs and National MM5220DF preprogrammed MOS read-only memory chip together generate standard RTTY test message: THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 1234567890 DE. Requires external clock providing sharp negative-going pulse train at frequency corresponding to RTTY speeds desired. Requires two supplies, for +5 V and ±12 V.—K. Ebneter and J. Romelfanger, RTTY Test-Message Generator, *Ham Radio*, Nov. 1976, p 30–32.

CHAPTER 92
Television Circuits

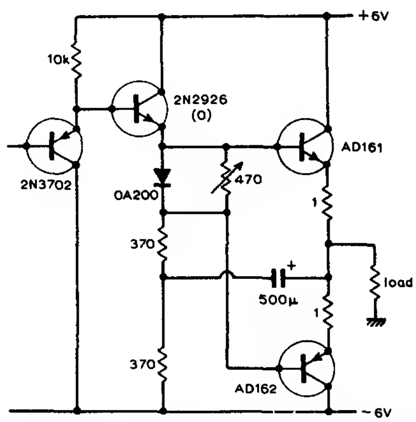
Covers circuits for black-and-white, color, industrial, and slow-scan amateur TV receivers, including infrared remote control, microprocessor interface, and test equipment. See also Cathode-Ray, Game, and Microprocessor chapters.



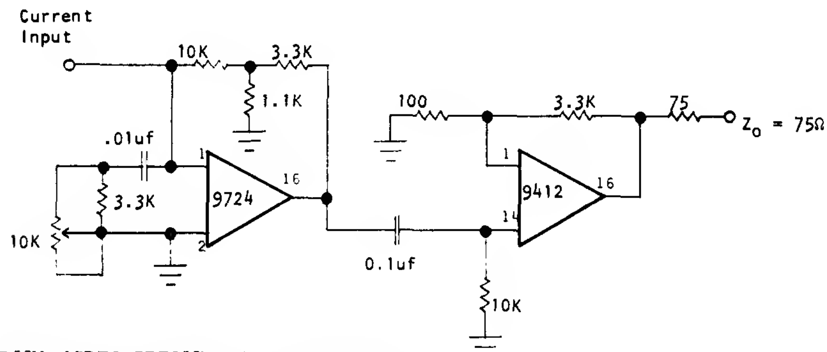
CRYSTAL/VFO SYNC GENERATOR—With crystal, can be used as system sync generator or as drive for staircase generators, custom pattern generators, and special TV test equipment. When VFO-controlled, circuit provides variable-frequency sync needed for determining pull-in range of sweep oscillators in TV sets and VTR decks. Clock-pulse section uses Q_1 and Q_2 as 1.00800-MHz Butler oscillator. On VFO operation, oscillator frequency can be varied ±3.5% from mean. Sine-wave output of Q_2 is converted to square wave by Q_3 for application to clock input of Hughes HSUB0525 sync generator. Each output of sync generator feeds one of inverters in 7404, providing 3.3 V P-P signal into 75-ohm load for each output.—M. J. Salvati, VFO Adds Versatility to TV Sync Generator, *EDN Magazine,* May 20, 1974, p 70 and 72.



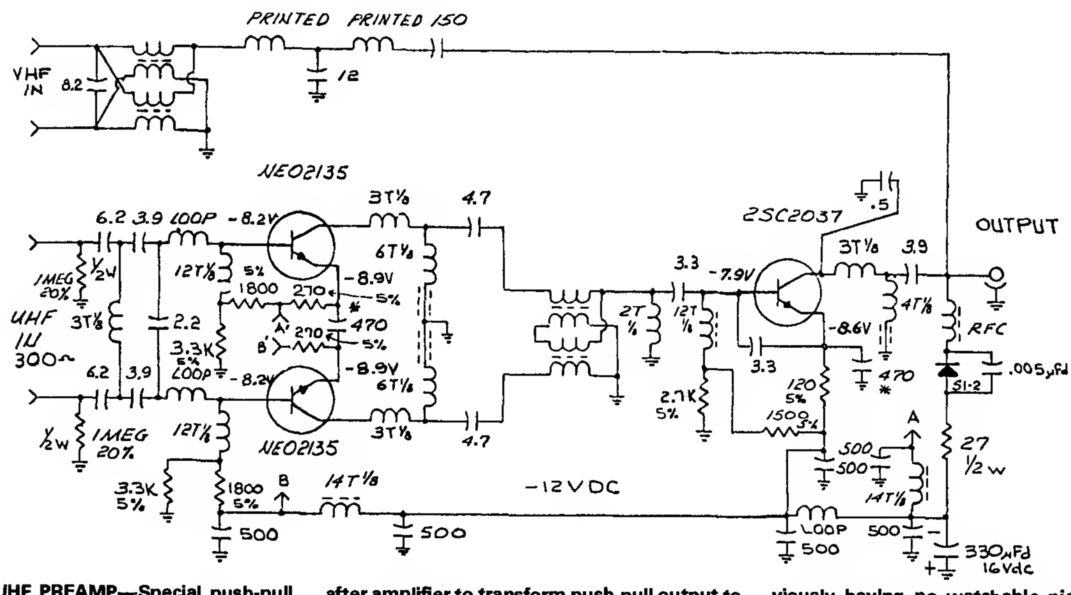
AF PHASE SHIFTER—Developed for testing chroma damodulator in color TV receiver. Audio oscillator is used as source of sine waves. First staga is phase inverter, followed by two amitter-followers. Resulting output signals of opposita phase are combined through e small capacitor (0.022 μF, selected for frequency used) from one channel and 50K variable resistor from other channel. 90° phases ara judged by position of sine waves on screen of CRO; 90° is halfway between 0° and 180°.—C. Babcoke, Waveforms Explain Chroma Demodulators, *Electronic Servicing,* Sapt. 1972, p 22–23, 26–28, and 30.



SSTV DEFLECTION DRIVE—Developed for usa in line tlme-base amplifier of 4-Hz slow-scan TV system. Emitter-follower in driver stage is used with first transistor to match output Impedance of UJT sawtooth oscillator. Will drive deflection coils of 17-inch CRT (coil resistance about 5 ohms).—M. Hadley, Deflectlon Coil Driver for Slow-Scan Telavision, *Wireless World,* March 1974, p. 18.

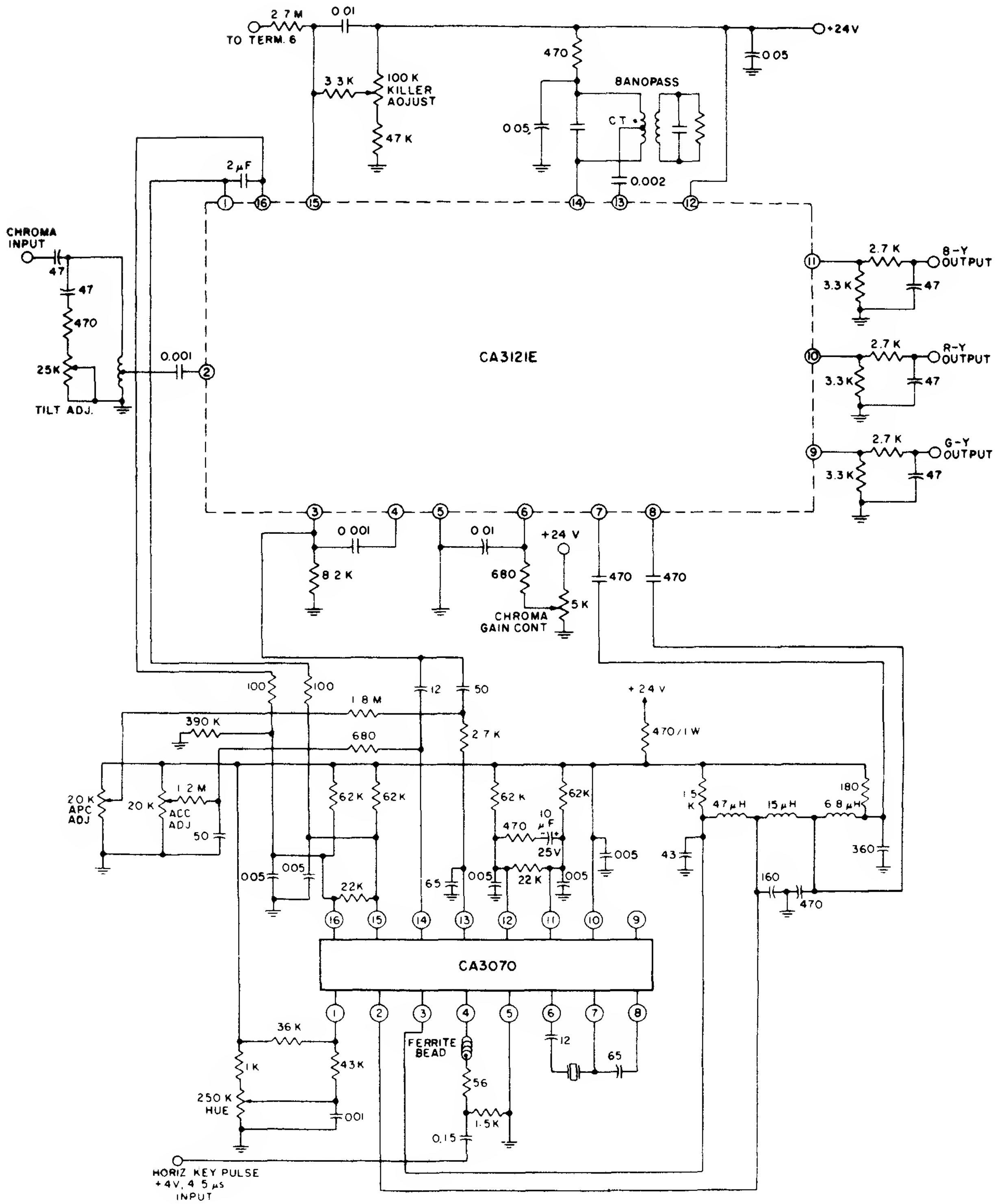


25-MHz VIDEO PREAMP—Uses Optical Electronics 9724 opamp for input stage and 9412 opamp for output stage. Current input can be from vidicon or image orthicon camera tube. Input compensation can be adjusted to provide aperture correction. Feedback network for input opamp minimizes effects of stray capacitanca. Values shown give 1-V output for 1-μA input.—"A 25 MHz Video Preamplifier—Line Driver," Optical Electronics, Tucson, AZ, Application Tip 10195.

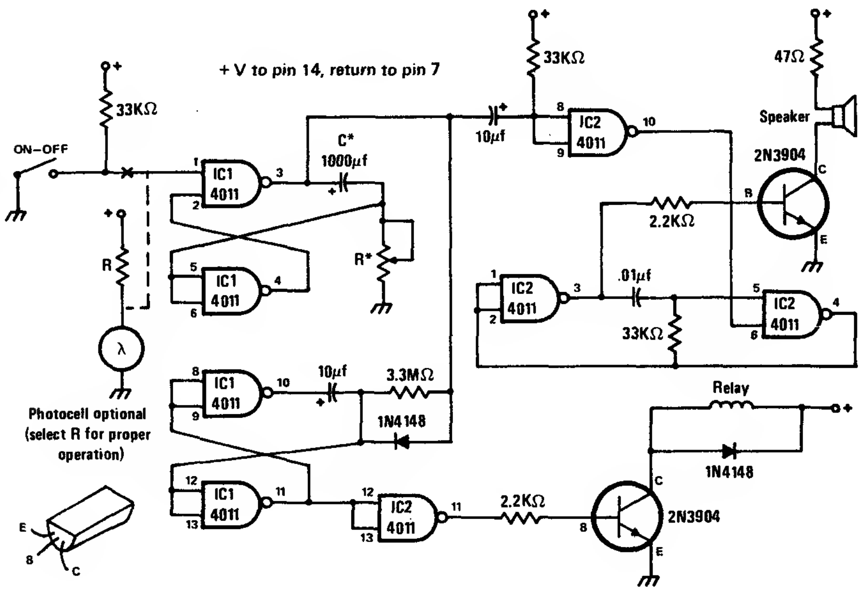


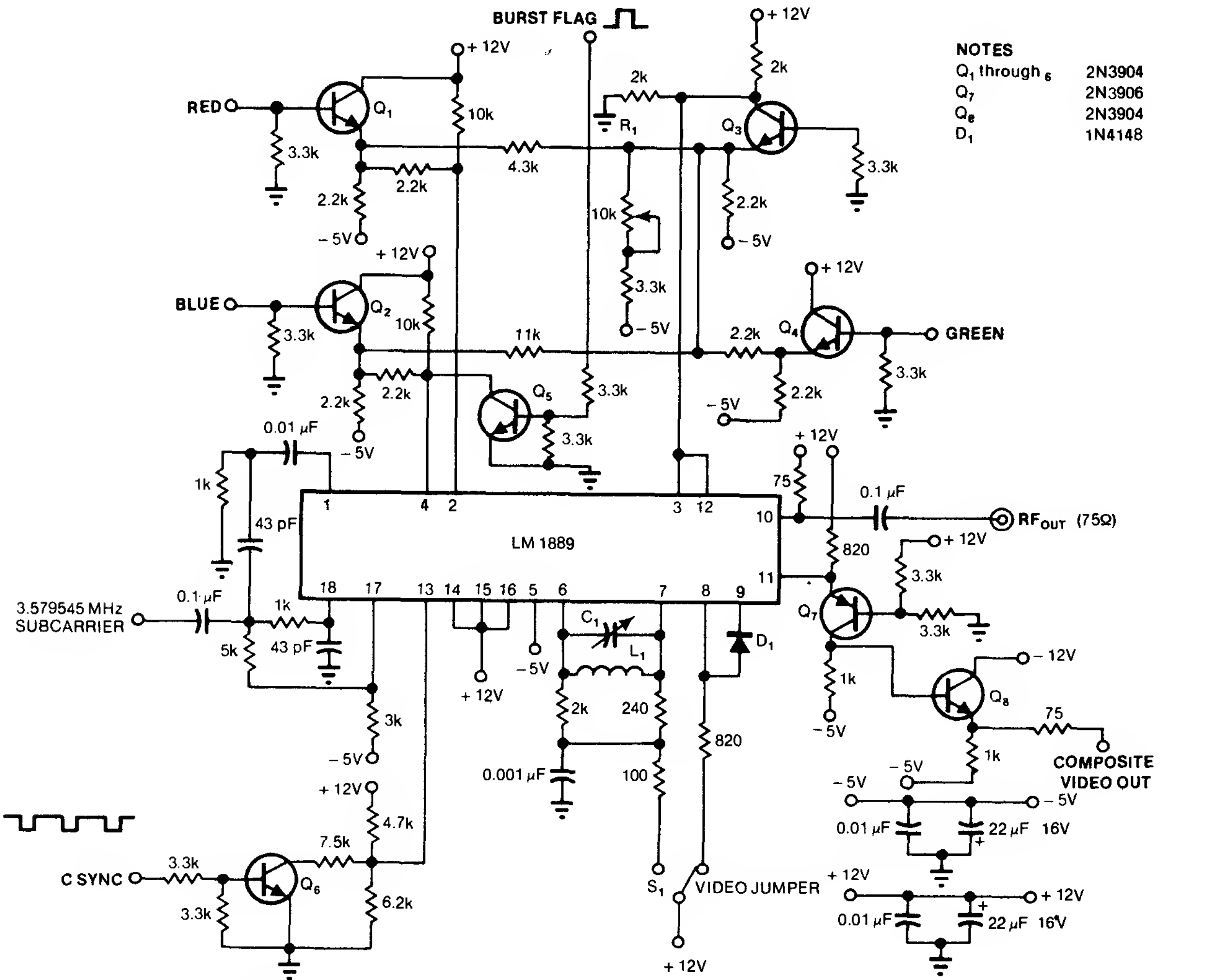
LOW-NOISE UHF PREAMP—Special push-pull input stage using low-noise UHF transistors gives average preamp noise figure as low as 2.2 dB. Can be used with 300-ohm line of broadband UHF antenna without usual balun transformer or differential input stage. Balun is used after amplifier to transform push-pull output to input of single-ended second stage without degrading noise figure. Developed for use with naw deep-fringe-area UHF TV antenna having three flat In-line director elements, for over-the-air reception of UHF TV programs in areas praviously having no watchable picturas.—J. E. Kluge, Advanced Antenna Design and an Ultra-low-Noise Preamplifier Extend UHF Viawing Area, *IEEE Transactions on Broadcasting,* March 1977, p 17–22.

CHROMA PROCESSOR—Combination of RCA CA3121E chroma amplifier/demodulator and CA3070 chroma signal processor provides automatic chroma control and color killer sensing along with other functions required for high-level B − Y, R − Y, and G − Y color difference signals having low impedances for driving high-level R, G, and B output amplifiers.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 359–360.

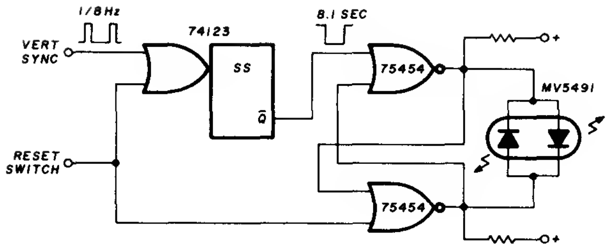


TV TURNOFF WITH WARNING BEEP—Timer providing turnoff delays up to 1 h gives warning beep about 30 s before turnoff to permit resetting if desired for watching remainder of particular program. Can be mounted inside TV set or in small chairside box connected to set by cable. Photocell can be substituted for ON/OFF switch to permit remote control with flashlight while leaving entire circuit in TV set. Can be operated from 9-V battery if this voltage is not available in receiver. Momentary closing of switch turns on TV and initiates timing cycle. With 3.6-megohm pot for R, maximum delay is 1 h. For 30-min delay, use 1.3 megohms. Setting of R determines exact delay.—J. Sandler, 9 Projects under $9, *Modern Electronics,* Sept. 1978, p 35–39.



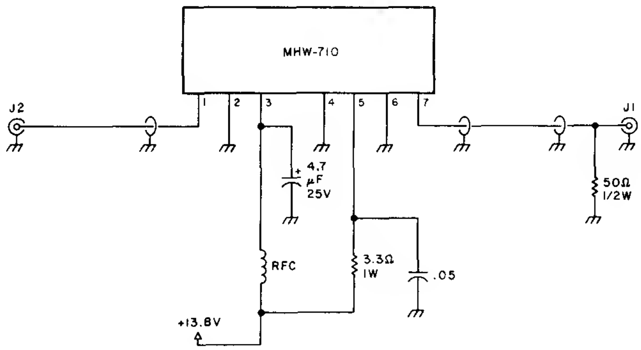


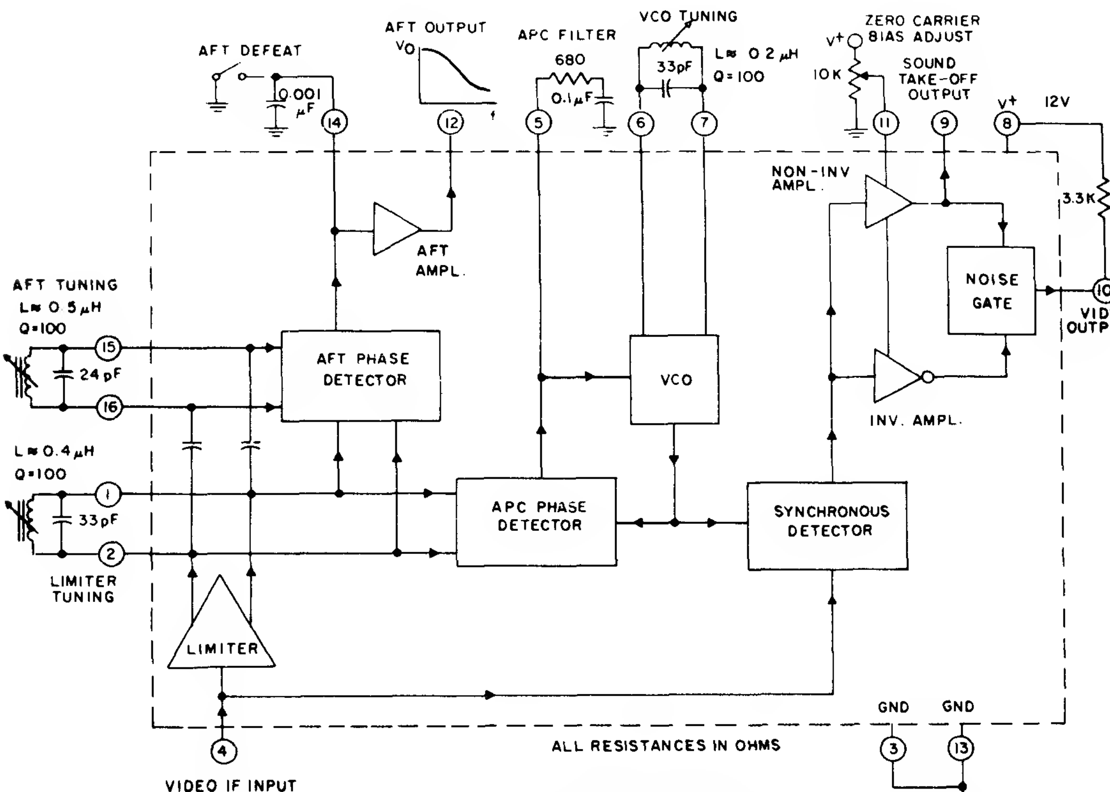
COMPOSITE COLOR SIGNAL GENERATOR—Single LM1889 encoder chip produces standard composite color video signal from separate sync, burst flag, 3.579545-MHz subcarrier, and 0–4 V red, green, and blue inputs. Subcarrier should be 1–5 V P-P. Modulated RF output can go to cable input of TV set through 75-ohm cable. Applications include TV mixing effects and video games.—L. Trottier and B. Matic, Signal Encoder Generates Composite Color, *EDN Magazine,* Aug. 20, 1978, p 148 and 150.



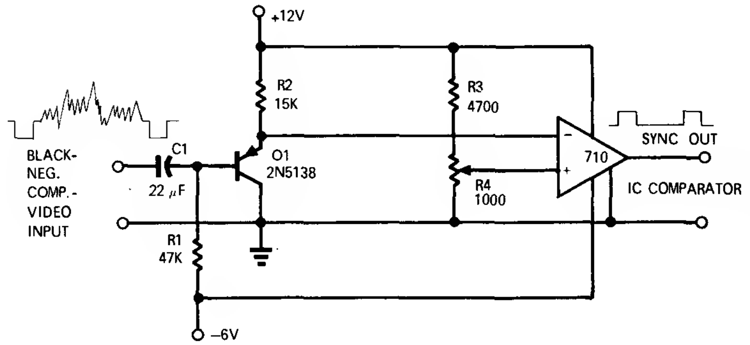
SSTV VERTICAL SYNC INDICATOR—Retriggereble mono MVBR using SN74123 is triggared by 0.125-Hz verticel sync pulse of amataur television system. Absance of pulse allows mono to time out and change state of LED from green to red. Verticel raset switch must then be used to restart vertical sweep end reset LED. Uses Monsanto MV5491 dual red/green LED, with 220 ohms in upper lead to +5 V supply and 100 ohms in lower +5 V lead becausa red and green LEDs in perallel beck-to-back heve different voltage requirements. Drivars for LEDs are SN75454.—K. Powell, Novel Indicator Circuit, *Ham Radio,* April 1977, p 60–63.

LINEAR AMPLIFIER—Motorola MHW-710 power module boosts 1-W output of VHF Engineering TX-432B crystal-controlled solid-state exciter to ebout 10 W for simple ameteur TV transmitter. Interconnections are made wlth short lengths of RG-174 coax. Input jack J1 is connected to excitar by 50 ft of RG-174, end length is gradually reduced until proper drive level is obtained for linaer operation. RFC usas 8 turns No. 22 enemel on 1-megohm 1-W resistor. To cover 400–440 MHz, use MHW-710-1; for 440–470 MHz, use MHW-710-2.—R. E. Taggart, Interested in Television?, *73 Magazine,* Oct. 1977, p 164–174.



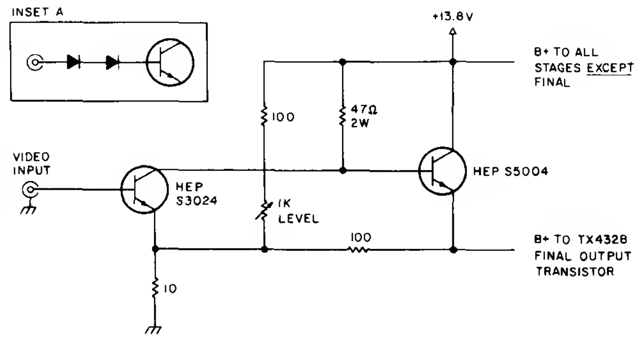


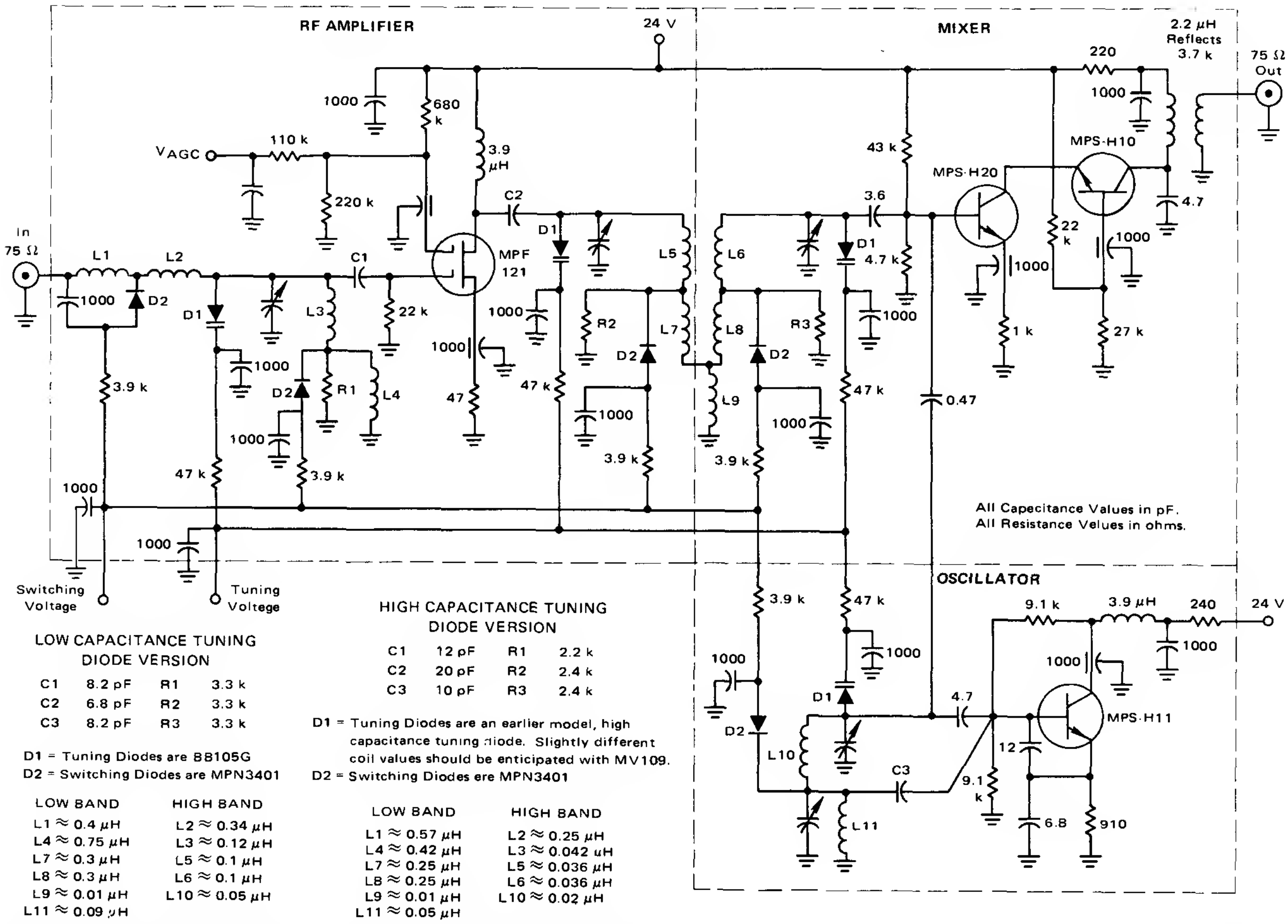
SYNCHRONOUS VIDEO DETECTOR—RCA CA3136E serves as video IF PLL synchronous detector for color TV receivers. Phase-locked oscillator demoduletes 45.75-MHz video IF signels. Circuit features include eutomatic fine tuning voltage (AFT) for DC control of tuner, adjustmant of zero-carrier DC level at video output terminal, amplifier errangement for inverting noisa impulses toward black level, end separate noninverting output terminel for sound IF. Requires singla 12-V supply.—"Linear Integrated Circuits and MOS/FET's," RCA Solid Stete Division, Somerville, NJ, 1977, p 374.



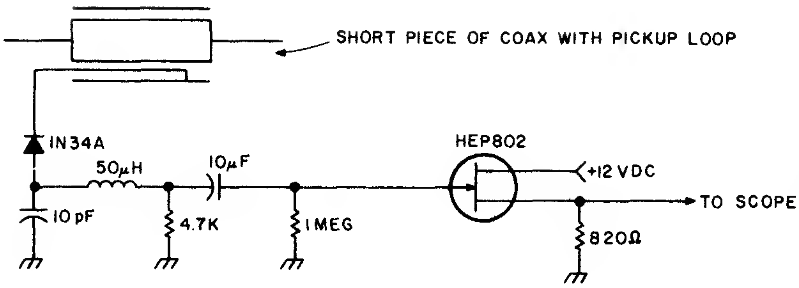
COMPARATOR SEPARATES SYNC PULSES—By setting DC referance input of 710 comparator at 0.15 VDC, only horizontal sync pulses are extracted from composita black-negativa video signal to appaar at comparator output. Setting referance laval at 0.35 VDC gives only blanking pulses at output.—R. G. Groom, IC Comparator Separates Sync Pulses, *EDN Magazina,* Sept. 15, 1970, p 53–54.

VIDEO MODULATOR—Developed for use between solid-state TV camera and VHF Engineering TX-432B crystal-controlled solid-stata axcitar to give simpla amataur TV transmitter. For tube-typa cameras, add 1N914 or other small-signal silicon diodes In series with input until modulator provides propar video swing. Articla givas construction details.—R. E. Taggart, Interested in Television?, *73 Magazine,* Oct. 1977, p 164–174.



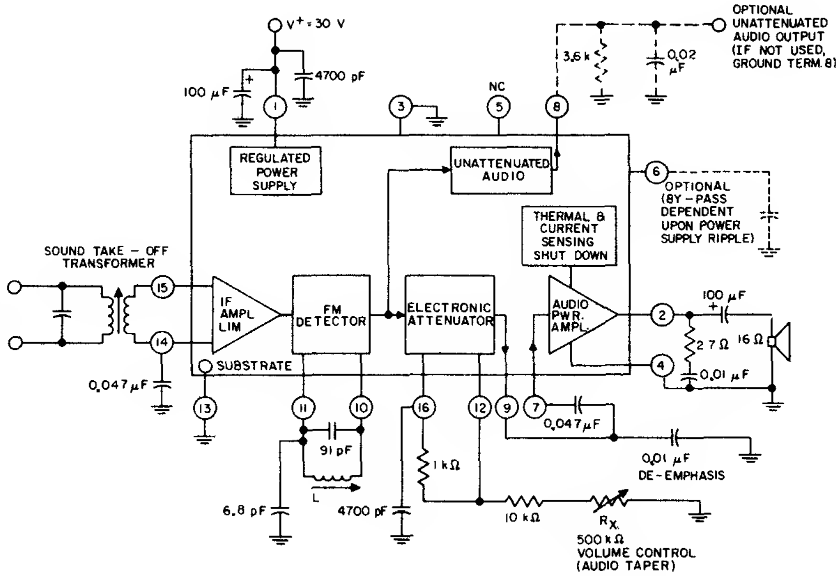


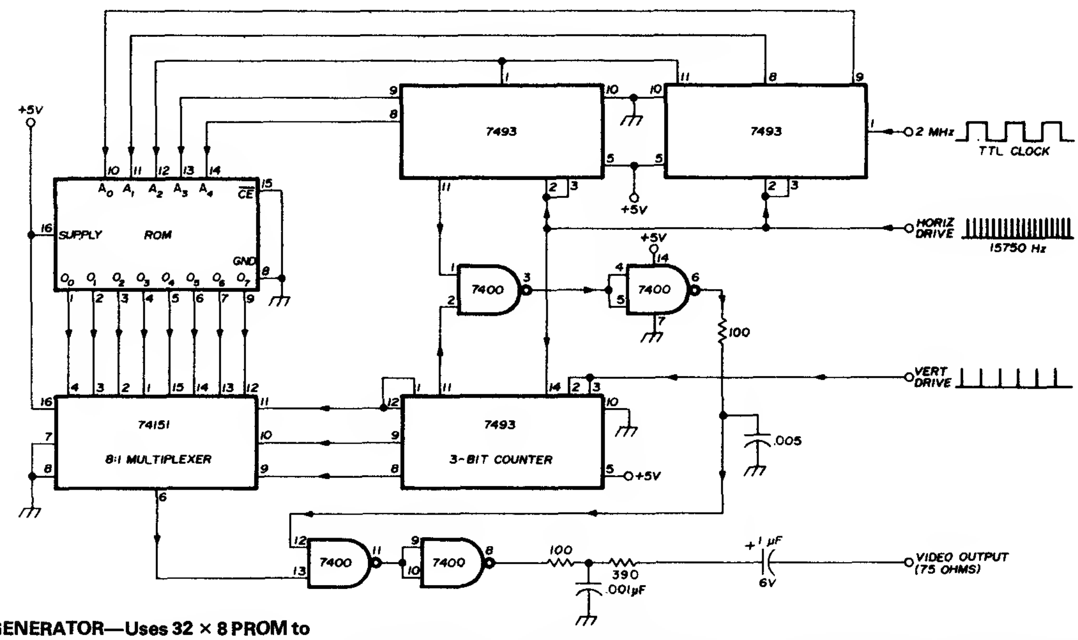
VHF VARACTOR TUNER—DC bias voltages ara used in placa of machanical switches for channel selection. Values for tuned circuits depend on varactor dioda used. With high-capacitanca varactor diode, tuning voltaga ranges from 4.3 V for channel 2 to 23 V for channel 13. Corresponding voltages for low-capacitance varactor ara 2.2 V and 20.4 V. Tunar noisa figure is in range of 4–5 dB.—J. Hopkins, "Printed Circuit VHF TV Tunars Using Tuning Diodes," Motorola, Phoenix, AZ, 1972, AN-544A, p 4.



CRO AS TV MONITOR—Permits monitoring transmitted amateur television signals with oscilloscope, for such applications as checking sync levels and sync-pulse shape. Outgoing signal can be monitored while adjusting modulator.—Circuits, *73 Magazine*, March 1977, p 152.

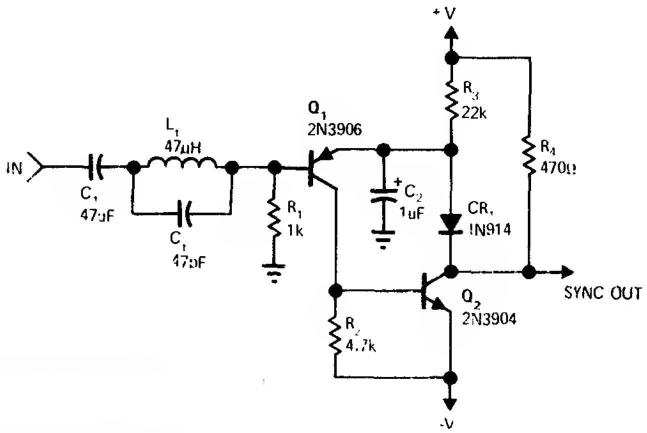
SOUND SUBSYSTEM—RCA CA3134 combines sound IF and audio output stages in single IC for use in TV receivers. Input is taken from sound IF output of receiver. Provides electronic volume control with improved taper. Alternate circuit shown provides unattenuated audio output.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 368.

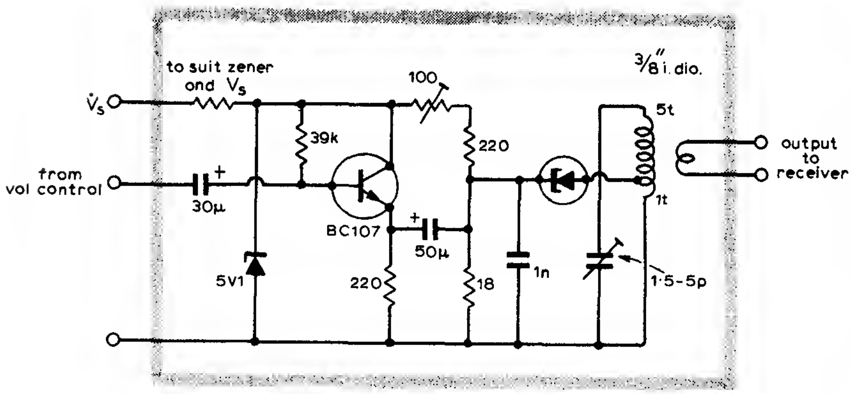




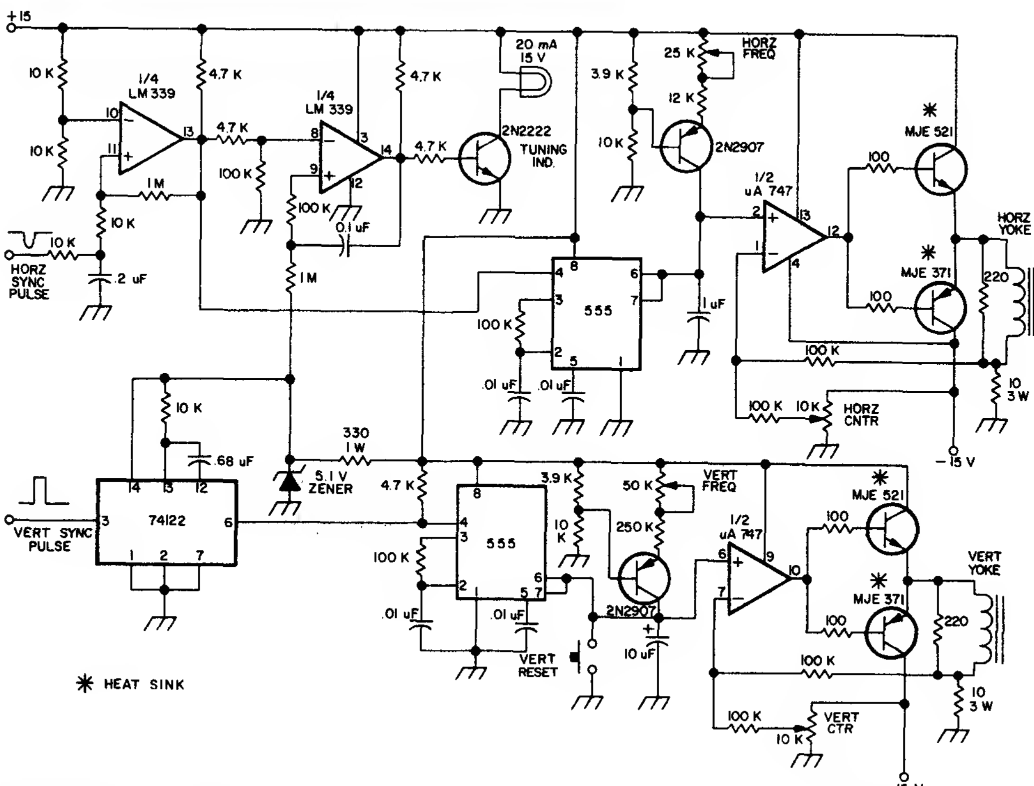
ATV CALL GENERATOR—Uses 32 × 8 PROM to generate up to six characters of amateur call. Squares in matrix are numbered 1–32 horizontally and 1–8 vertically starting from upper left, and black squares forming call letters are programmed as 1s in PROM. Pin connections shown for PROM are valid for AMI 27508/27509, 82S23/82S123, MM5330/MM5331, HPROM 8256, and IM5600/5610. Two 7493 binary counters address all 32 words in ROM, with clock rate (2–3 MHz) determining length of characters on screen. 74151 multiplexer advances to next ROM output once per scan line, under control of 7493 3-bit counter clocked by horizontal drive pulses from sync generator of ATV transmitter. Positive-going horizontal drive pulses reset 5-bit word counters, while positive-going vertical drive pulses reset 3-bit line counters, to make characters appear in same position on screen for all fields.—J. Pulice, Amateur Television Callsign Generator, *Ham Radio*, Feb. 1977, p 34–35.

SYNC SEPARATOR—Input video having negative synchronizing pulses is applied to Q_1 through 3.58-MHz notch filter L_1-C_1 to remove color subcarrier components. Circuit is set up to conduct only on negative peaks, when Q_1, Q_2, and CR_1 are all on, so feedback is 100% at this time. Negative peaks of output then follow input exactly. C_2 acts as memory for negative peaks, storing their level between sync pulses.—W. Jung, An Operational Approach to Sync Separation, *EDN/IEEE Magazine*, July 15, 1971, p 48–49.

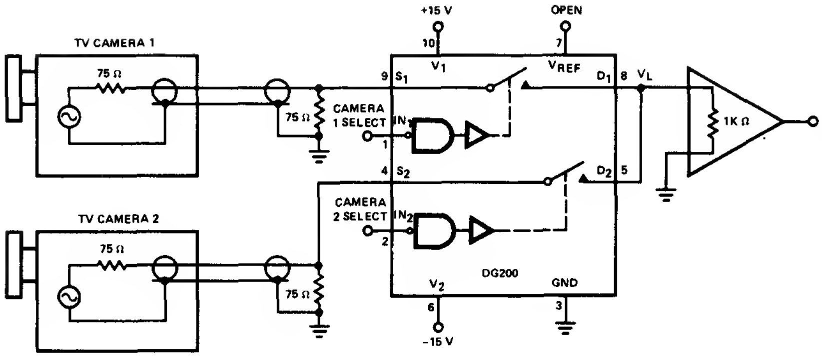




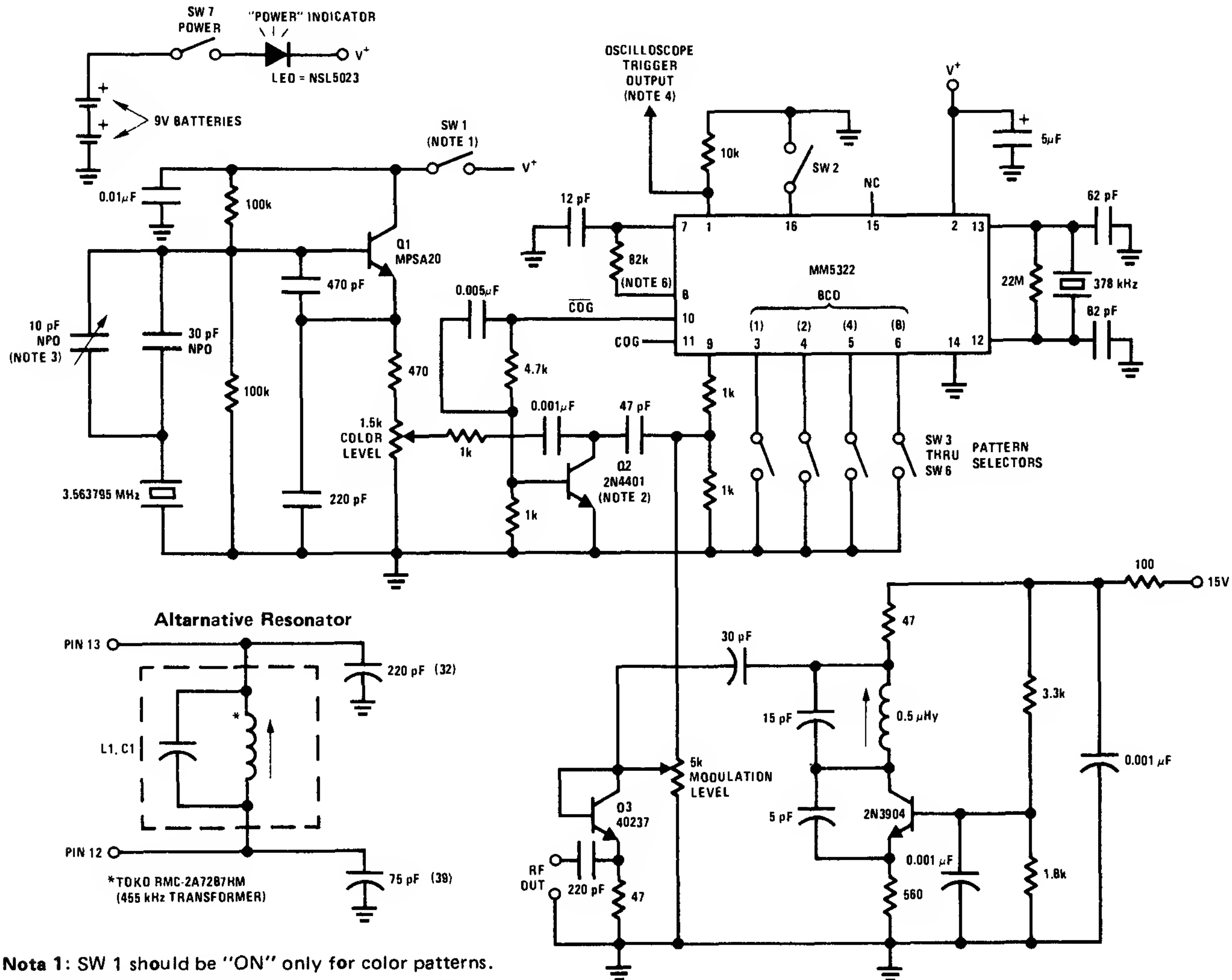
IMPROVING TV SOUND—AF signal from volume control of TV receiver is converted to FM signal by using BC107 transistor to frequency-modulate tunnel-diode oscillator operating within FM broadcast band. Oscillator output is fed through air-core transformer and coaxial line to FM receiver of high-fidelity sound system. Arrangement eliminates most of distortion introduced in power amplifier and loudspeaker of average TV set. Use shielding to keep unwanted FM radiation at minimum.—A. J. Smith, Improving Television Sound, *Wireless World*, Aug. 1973, p 373.



SWEEP FOR SSTV MONITOR—Uses two 555 timers, one as oscillator and other as linear sawtooth generator. Adjust R4 so oscillator period is slightly longer than interval between sync pulses. When sync is lost, oscillator runs very close to correct frequency and locks in again instantly on first good sync pulse. Circuit also has pulse stretcher, along with lamp driver that operates from horizontal sync pulses for use as tuning indicator.—R. L. Anderson, 555 Timer Sweep Circuit for SSTV, *73 Magazine*, May 1976, p 134–136.



GENERAL-PURPOSE VIDEO SWITCH—When used for switching TV cameras, DG200 CMOS analog switch provides 45-dB isolation at 10 MHz betwaan on and off cameras. Insartion loss of switch is 0.5 dB. For graatar isolation, usa additional analog switch in aach camara lina.—"Analog Switches and Thair Applications," Siliconix, Santa Clara, CA, 1976, p 7-70.



Note 1: SW 1 should be "ON" only for color patterns.

Note 2: Do not substitute Q2.

Note 3: Variable cap may be used to trim color crystal to exact frequency.

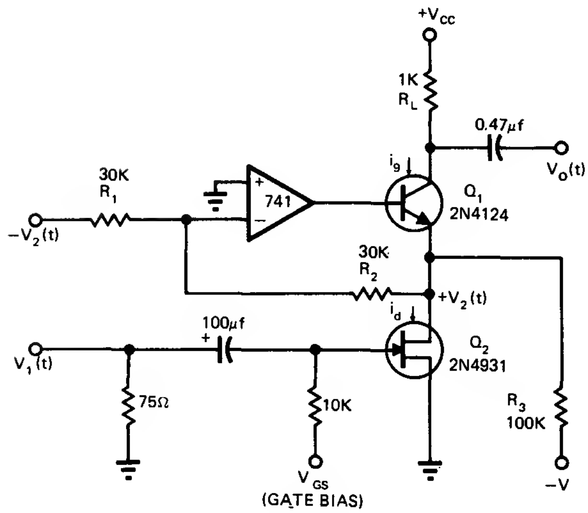
Note 4: SW 2 and 10k resistor on pins 16 and 1 are needed only if scope trigger pulse is desired.

Note 5: SW 2 selects "H" or "V" trigger output pulses.

Note 6: A 27k resistor in series with a 100k trimpot may be used in place of 82k resistor for variable vertical line width.

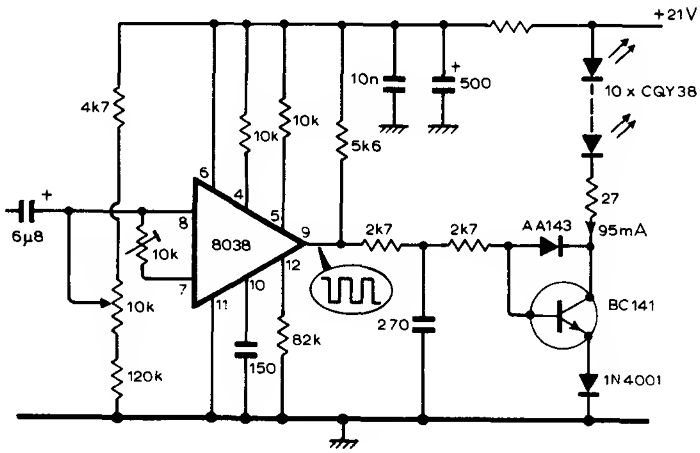
Note 7: Modulation level adjusted for best patterns as viewed on TV screen.

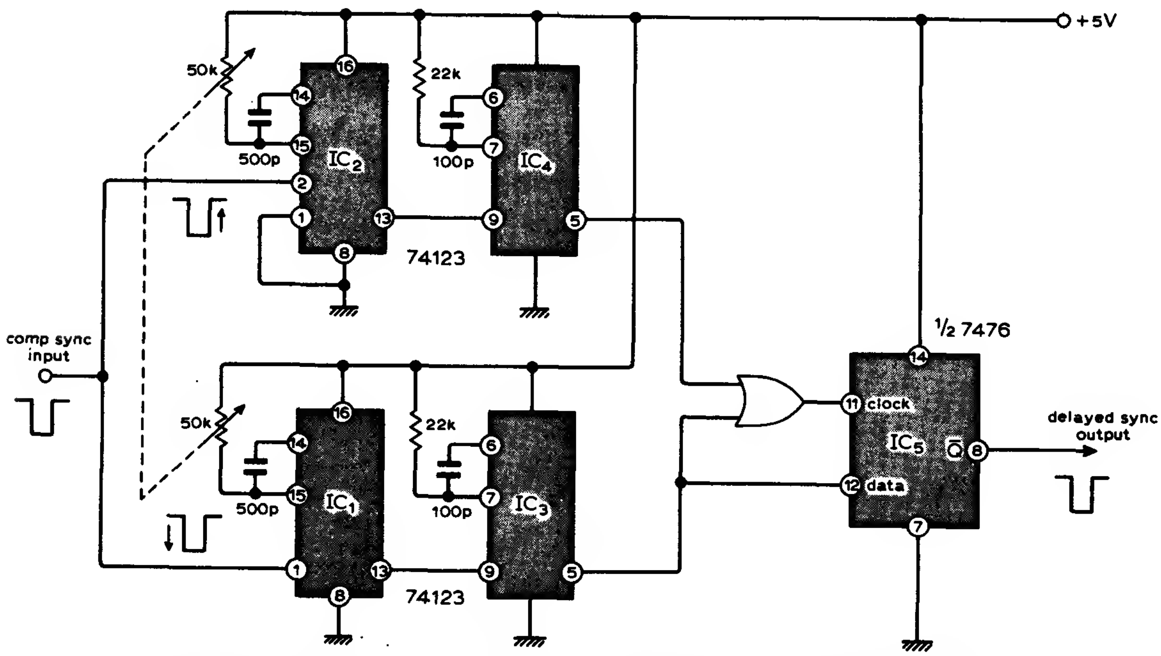
COLOR BAR GENERATOR—National MM5322 chip forms complete dot-bar and color hua ganaration system. Chip divides intarnal crystal-controlled oscillator frequancy to provida timing, sync, and vidao information required for aligning color TV receivars. Composita video output sarves for complete black-and-whita dot-bar oparation to giva variety of scraan pattarns. Separata output is provided for precisa gating of 3.56-MHz color bursts.—"MOS/LSI Databook," National Samiconductor, Santa Clara, CA, 1977, p 4-18–4-22.



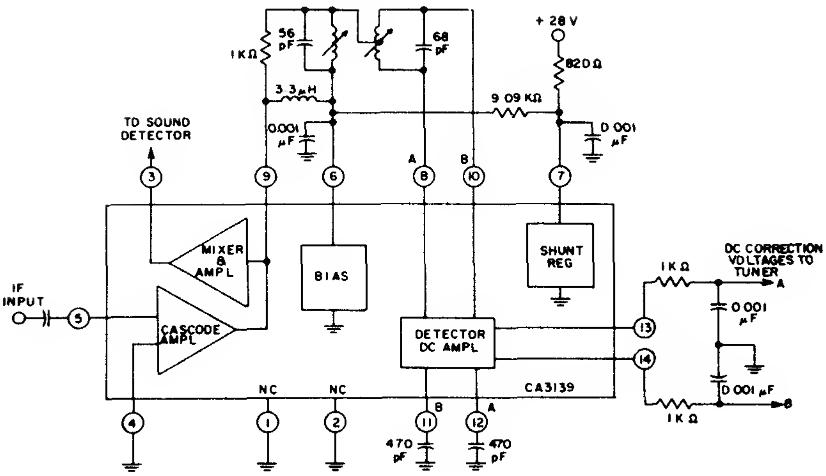
FET LINEAR MODULATOR—Circuit developed for closed-circuit industriel color television system uses linear portion of operating charecteristic for 2N4931 FET to provide lineer response et modulation frequencies from 1 MHz down to near zero. Article gives design equations.—G. R. Shepiro, Anelog Multipliers Offer Solutions to Video Modulation Problems, *EDN Magazine*, Sept. 1, 1972, p 40–41.

IR TRANSMITTER FOR TV SOUND—Mono eudio output of TV receiver is fed to infrered modulator using Intersil 8038 IC and transistor, to provide pulse-frequency-modulated infrared output thet cen ba picked up by compact receiver built into headphones. S/N ratio is 58 dB in daylight in evarage living room having light walls end ceiling, but drops to 40 dB when receiver faces awey from transmitter. Used in German TV receivars displayed et 1975 Berlin Exhibition.—Internationel Radio and Television Exhibition, *Wirelass World*, Nov. 1975, p 521–524 end 539.

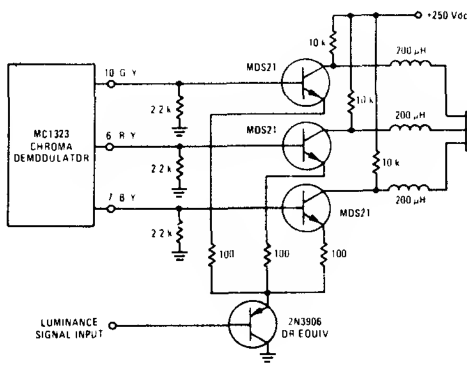




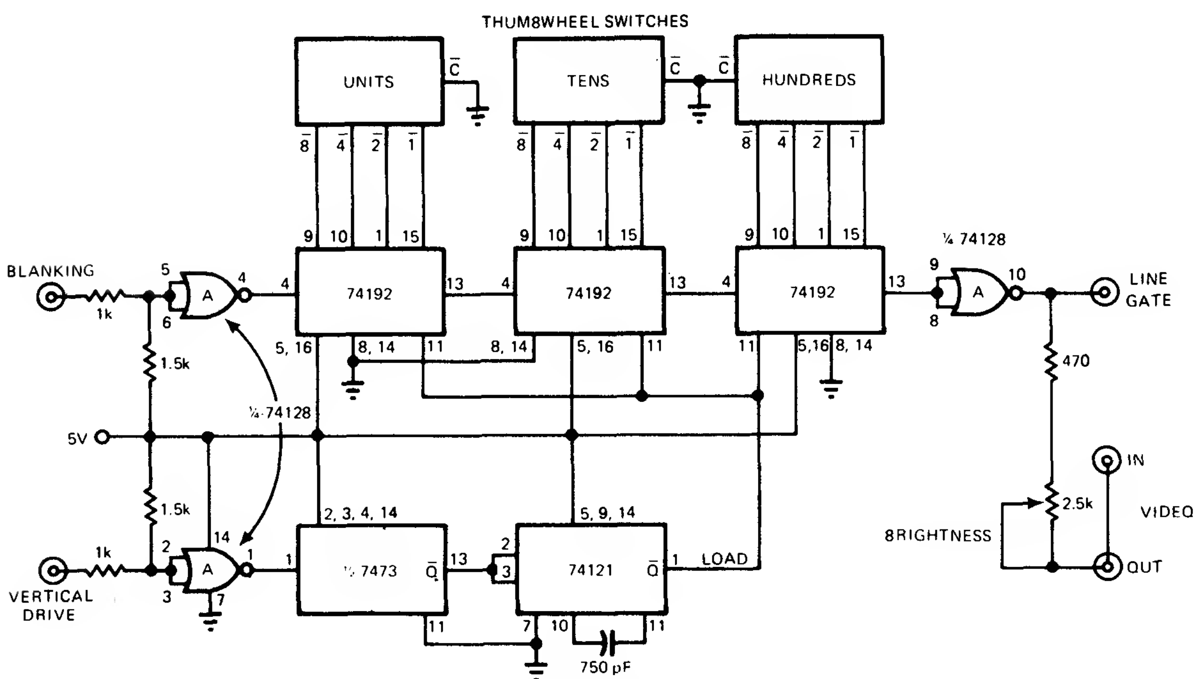
VARIABLE DELAY UP TO 7 μs—Used in television broadcasting when longar dalay is required than can be echieved with passiva alements for composite signal.—C. M. Wong, Sync-Pulse Delay, *Wiraless World*, Feb. 1977, p 46.



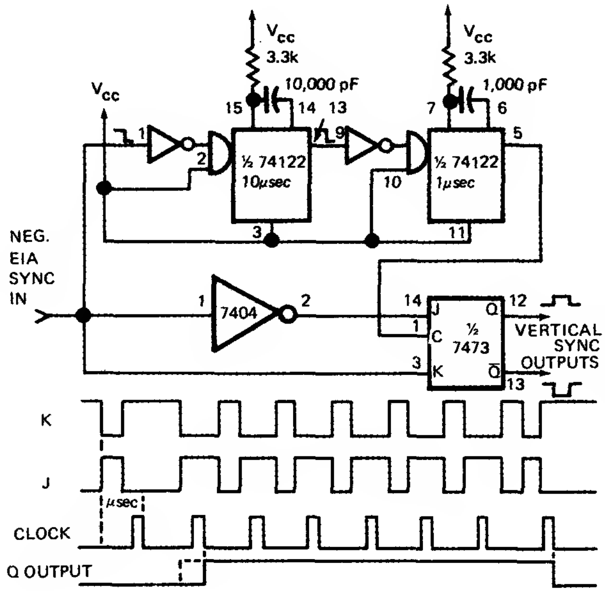
AFT SUBSYSTEM—RCA CA3139 automatic fine tuning IC combined with intercarrier mixer/amplifier for color and monochrome receivers provides AFT voltage for tuner correction and amplified 4.5-MHz intercarrier sound signal for external FM sound detector of receiver. Input is taken from output of IF amplifier in receiver.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 381.



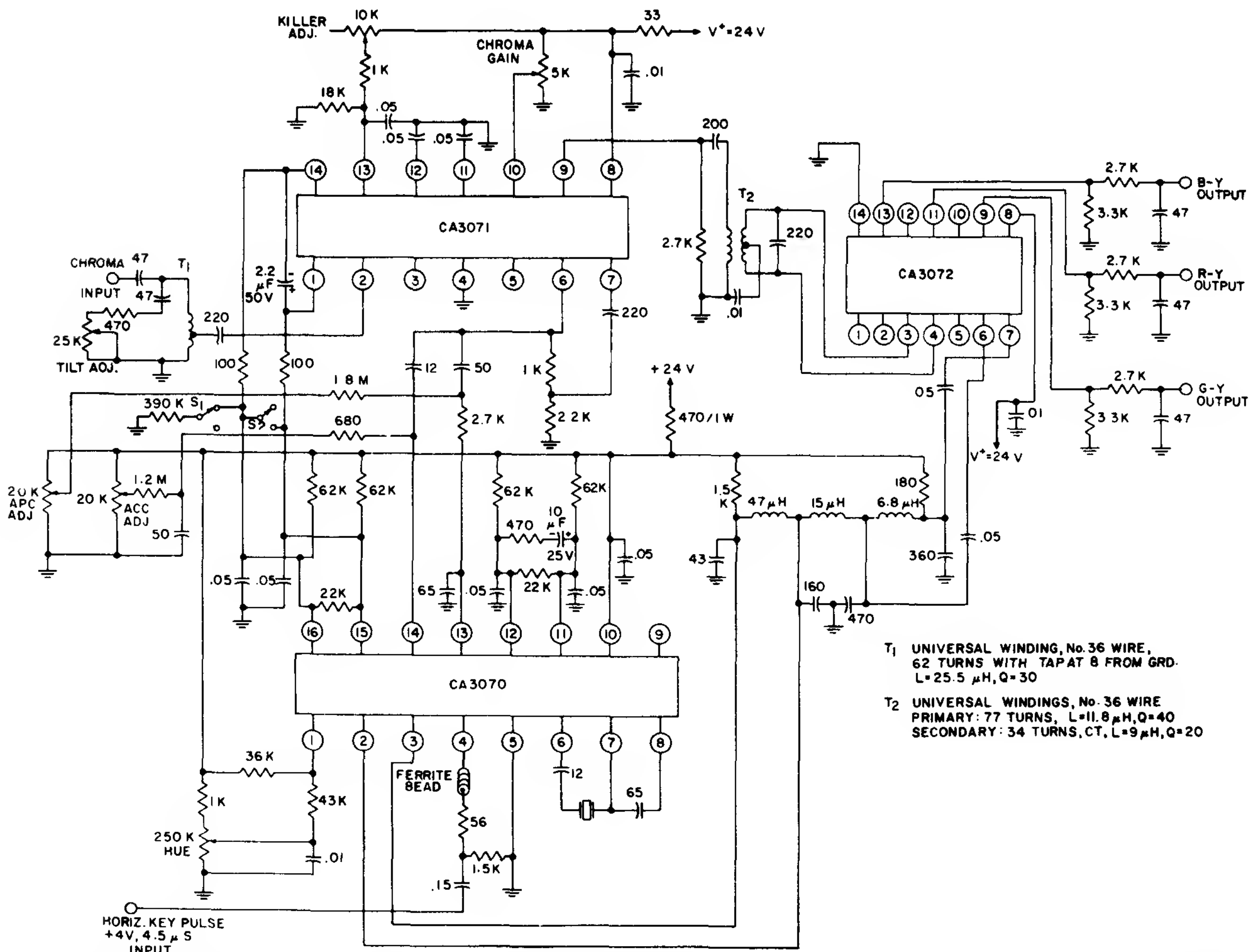
RGB OUTPUT—Motorola MDS21 high-voltage silicon transistors serve as output stages for red, green, and blue channels of color TV receiver, to provide video amplitude requirements for color picture tube. Transistors can be driven directly by most types of chroma demodulators.—"NPN Silicon Annular High Voltage Amplifier Transistors," Motorola, Phoenix, AZ, 1978, DS 3364.



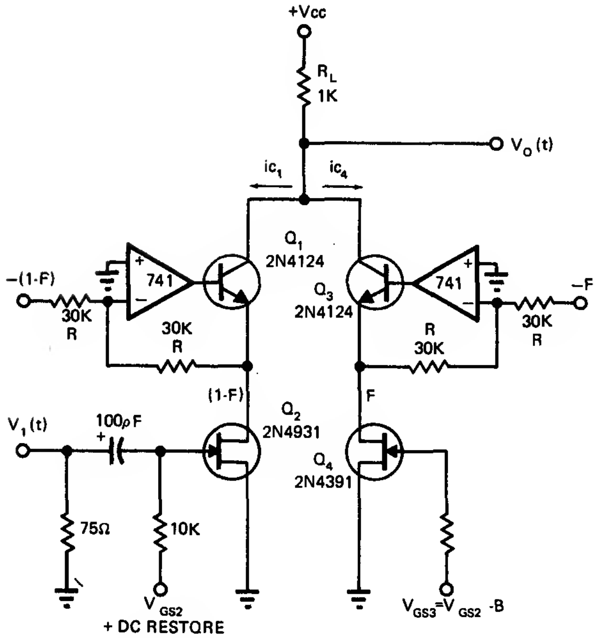
DIGITAL LINE-SELECTING SWITCHES—Three thumbwheel switches connected in binary mode control three 74192 counters, for selection of any desired line up to 999 in television field. Line-gate pulse injects into looped-through video for brightening selected line to make it visible on display. Circuit can also be used to determine exact number of active lines in each television field. Article describes operation in detail.—H. F. Stearns, Build a Thumbwheel-Switched Television Line Selector, *EDN Magazine,* June 20, 1976, p 124.



VERTICAL SYNC SEPARATOR—Arrangement uses controlled clocking sequence of JK flip-flop to detect presence of vertical sync interval in standard EIA television composite sync waveform. Complementary sync waveforms J and K are fed to J and K inputs of 7473 flip-flop, which is clocked by 1-μs pulse that is delayed slightly longer than 10-μs horizontal sync interval. First clock pulse after 11-μs interval changes flip-flop output Q to 1, where it stays for six clock periods before reverting to 0 state after vertical sync interval has passed.—W. G. Jung, Vertical Sync Separator Has No Integrating Network, *EDN Magazine*, Oct. 15, 1972, p 57.

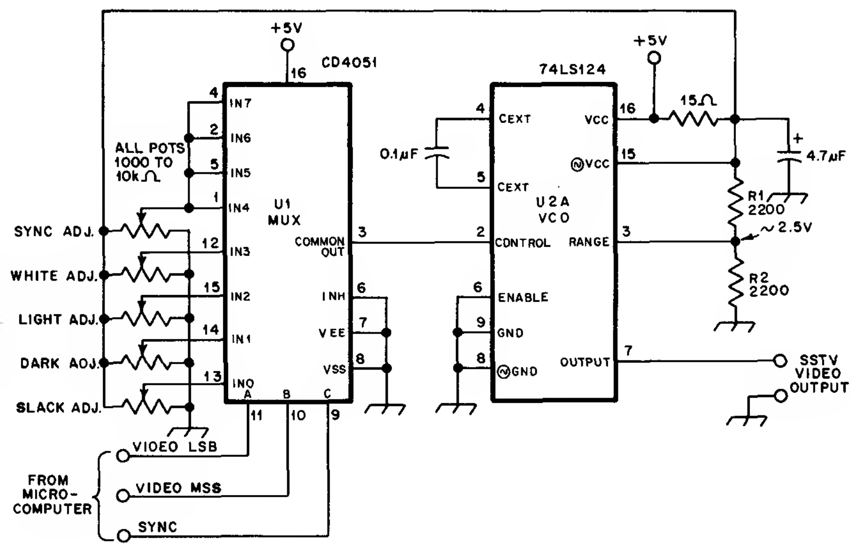


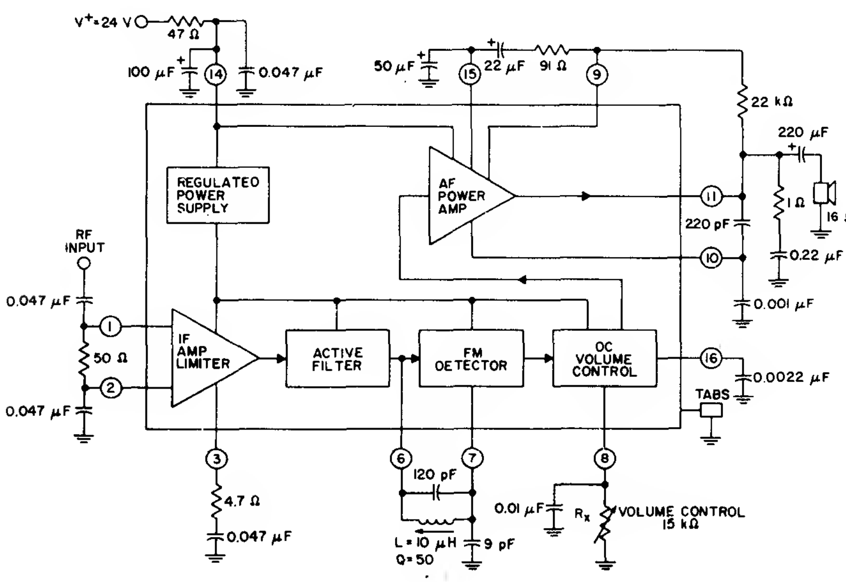
CHROMA SYSTEM—Uses RCA CA3070 as subcarrier regenerator, CA3071 as chroma amplifier, and CA3072 as chroma demodulator. Input can be taken from either first or second video stage of color TV receiver. Outputs from system are color difference signals for driving high-level amplifiers. Operates from single 24-V supply that should be maintained within 3 V. Only other requirement is 4-V 4.5-μs horizontal keying pulse centered on color burst. Crystal oscillator generates 3.579545 MHz.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 345–346.



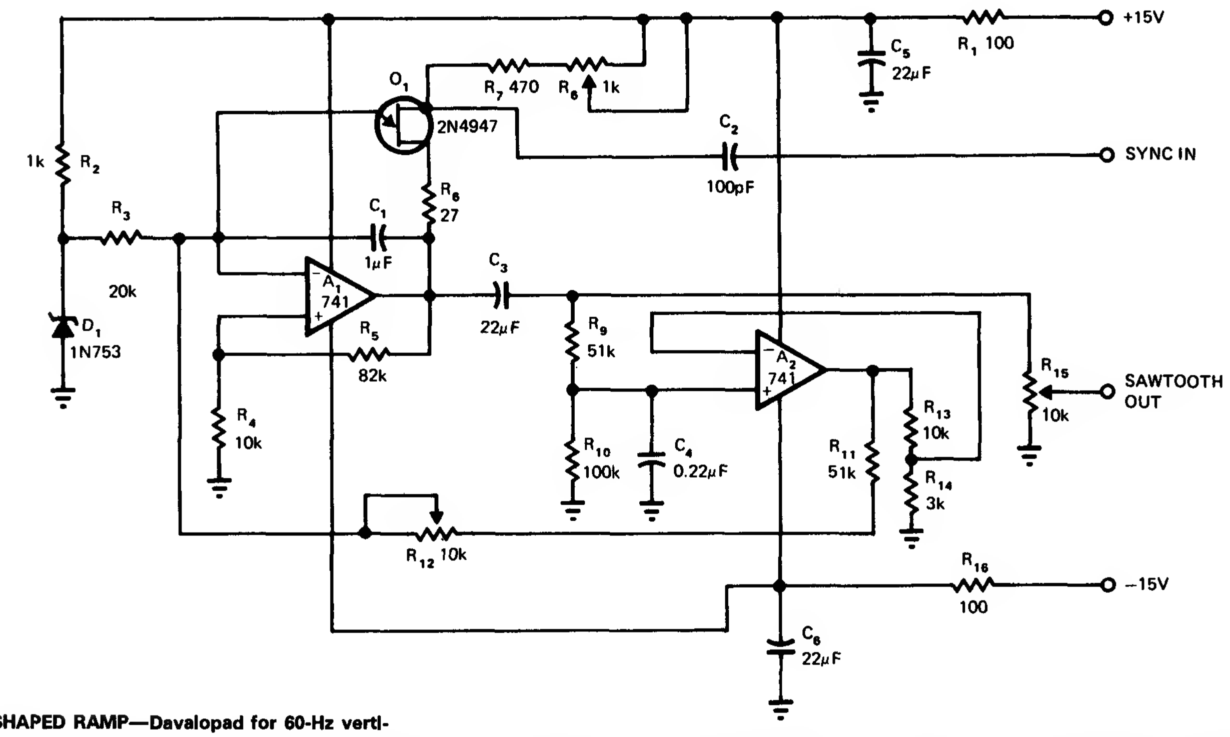
MODULATOR/MULTIPLIER—Belanced direct-coupled FET modulator/multiplier wes developed for dosed-circuit industriel color television system. Opemps hendle moduletion frequencies up to 1 MHz while providing lineer response down to neer zero modulation.—G. R. Shepiro, Anelog Multipliers Offer Solutions to Video Moduletion Problems, *EDN Magazine*, Sept. 1, 1972, p 40–41.

MICROPROCESSOR-SSTV INTERFACE—Digital-to-enelog-to-frequency converter for slow-scan television permite direct generation of simple graphic end elphameric cherecters by microprocessor, without use of camere. U1 is CD4051 CMOS anelog multiplexer, end U2A is one section of 74LS124 TTL duel voltage-controlled oscillator. Picture formet uses 64 different lines, repeated once to give totel of 128 lines, with meximum of 64 different picture elements per horizontal line eech heving one of four shades of gray. Separete pot is provided for eetting each of five different levels so VCO oscillates at proper frequencies: sync—1200 Hz; black—1500 Hz; derk—1767 Hz; light—2033 Hz; white—2300 Hz. Article covers operetion in dateil end gives flow diagrems for microprocessor subroutines required.—B. Senderson, SSTV Pictures from Your Microcomputer, *QST*, Oct. 1978, p 25–29.

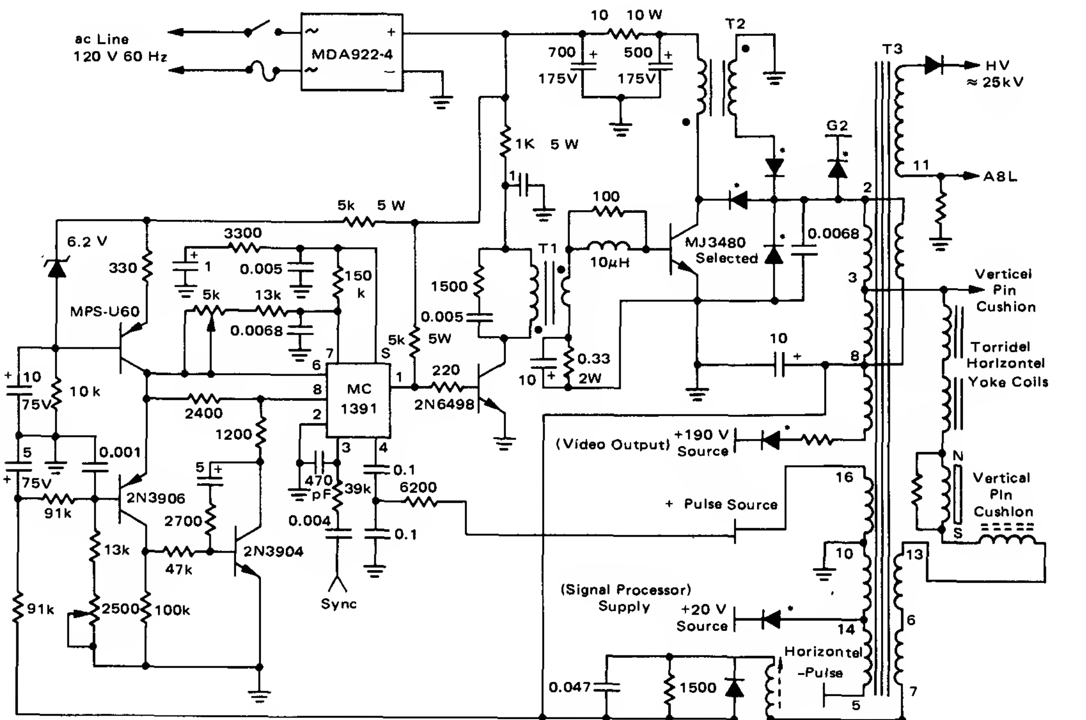




SOUND IF SUBSYSTEM—Single RCA CA1190GQ IC combines sound IF, FM detector, and complete eudio emplifier for driving 8-, 16-, or 32-ohm loudspeeker in TV receiver. Nominal power output is 3 W. Electronic volume control on chip provides improved taper with single 15K wirewound control.—"Lineer Integreted Circuits end MOS/FET's," RCA Solid-Stete Division, Somerville, NJ, 1977, p 301.



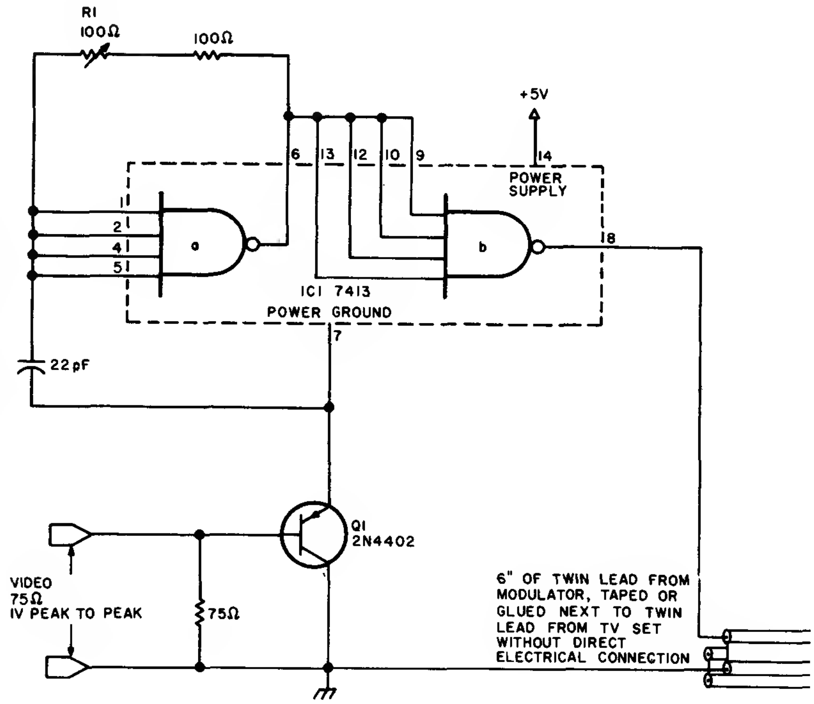
S-SHAPED RAMP—Davalopad for 60-Hz vertical deflaction in high-resolution vldeo display requirlng highly linear remp summad wlth second Integral of ramp to giva S shaplng of deflactlon so swaep is llnear on flat scraan. Opamp A_1 is connacted as integrator that takes Integral of constant voltaga across zenar D_1. Parlod of integretion is limited by UJT Q_1 that rasets Integrating capacitor C_1 whan nagatlva-going sync slgnal is appliad to basa 2 of Q_1. Sawtooth llnaarlty can ba trimmed by adjustlng ratlo of R_4 to R_5. Sync ranga is wlda anough so axtarnal vertlcal hold can ba allmlnatad. Amount of shaping can ba adjusted wlth pot.—L. G. Smains, "S"-Shaped Sawtooth Osclllator, *EDN Magazine*, Fab. 20, 1974, p 83 and 85.



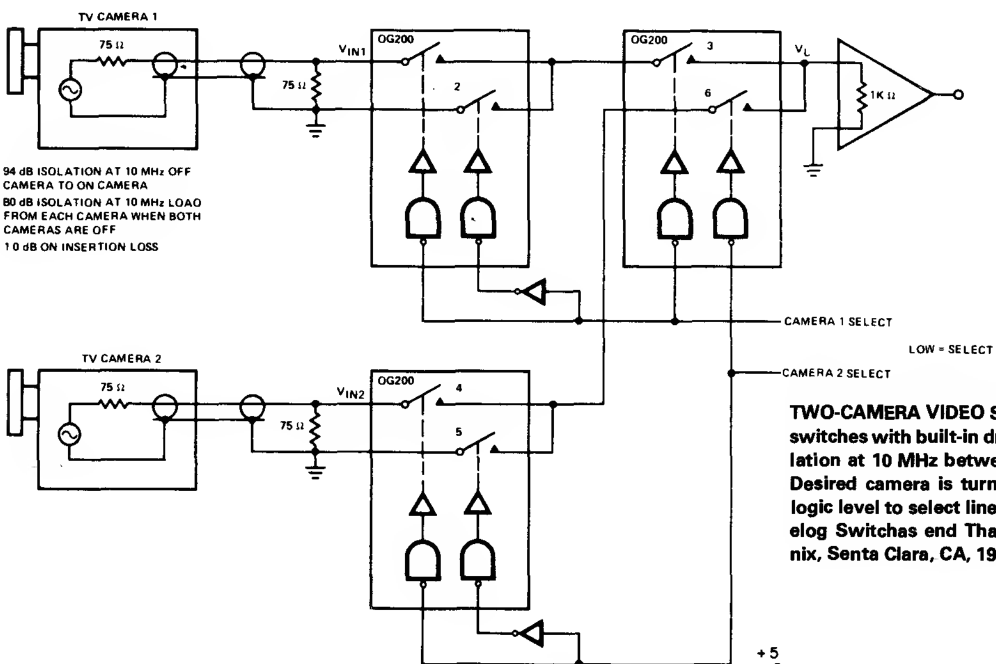
T1 = Driver Transformer (GE # 73C182195-1)
T2 = Input Trensformer 1:1 ≈ 15 mH @ 15 kHz
T3 = Flyback Transformer (Seers #80-164-3)

*MR918 selected to 1400V

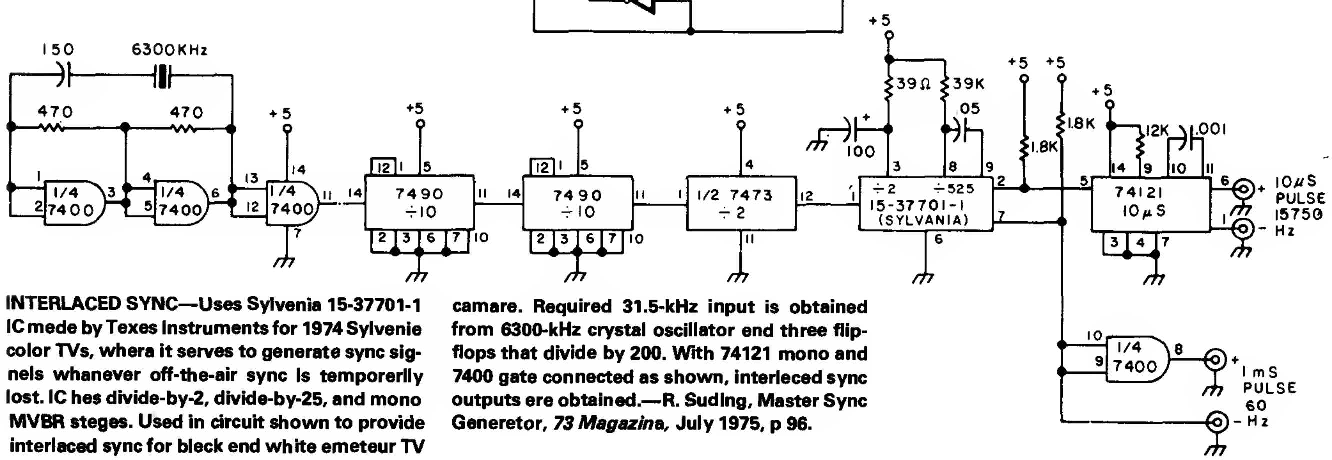
HORIZONTAL SYSTEM FOR 19-INCH COLOR—Salf-regulating scan systam includes short-circuit protection. Provides axcellent high-voltage reguletion et 25 kV. Vertical yoka current is elso stabilized sinca it is powered from auxiliary flyback winding. System consumas 30% less powar than mora convantional circuit using SCR half-wave regulated supply.—R. J. Valentina, "A Self-Regulating Horizontal Scan System," Motorola, Phoanix, AZ, 1975, AN-750, p 7.



RF MODULATOR—First section of free-running 7413 Schmitt-trigger oscillator runs et one-third of desired TV-channel carriar frequency (ebout 20 MHz for chennel 3) end drives buffer section whose output is squere weve at oscillator fundementel. Q1 modulates RF output by varying effective supply voltage to IC. Sinca standard video is 1 V P-P, modulation depth is ebout 20% with 5-V supply. Capecitive connection is made to TV sat, using short lengths of 300-ohm line after removing reguler antenna leeds from set used as experimentel displey terminal for microprocessor. R1 datermines frequency of oscillation; adjust for best reception.—W. Banks, The Waterloo RF Modulator, *BYTE*, Jen. 1978, p 94.



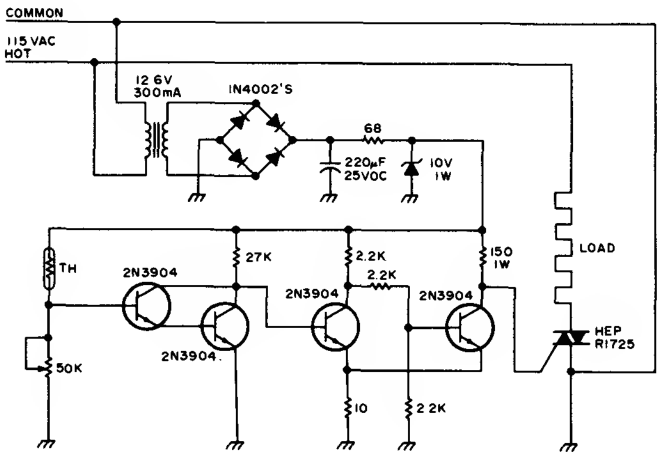
TWO-CAMERA VIDEO SWITCH—DG200 CMOS switches with built-in drivers provide 94-dB isolation at 10 MHz between on and off cemeres. Desired camera is turned on by applying low logic level to select line for thet cemare.—"Anelog Switchas end Their Applications," Sliiconix, Senta Clara, CA, 1976, p 7-26.



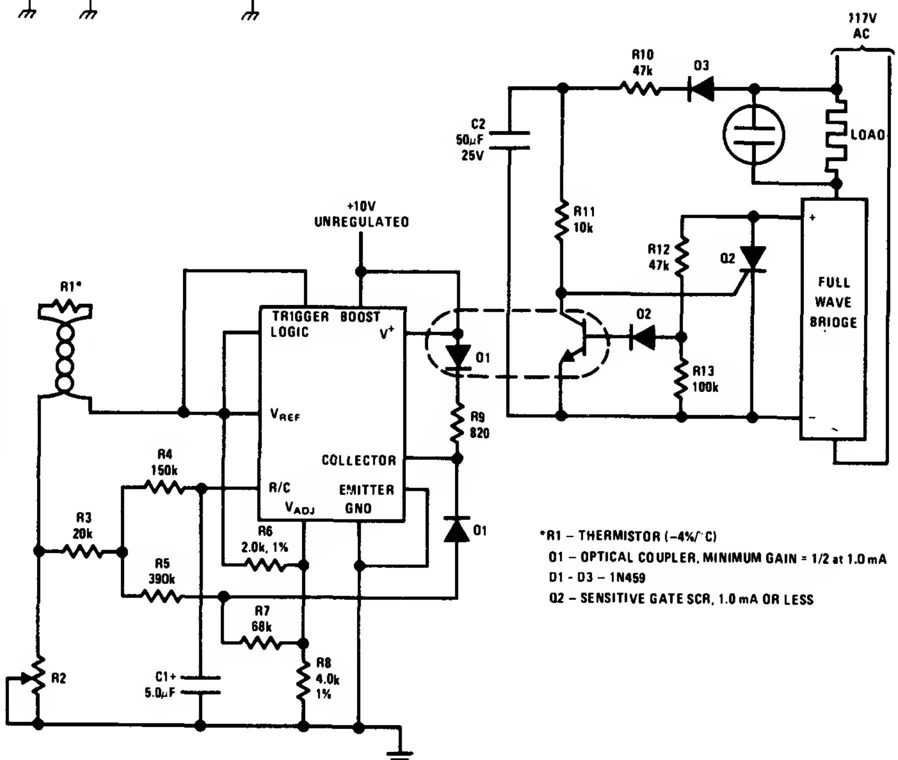
INTERLACED SYNC—Uses Sylvenia 15-37701-1 IC mede by Texes Instruments for 1974 Sylvenie color TVs, wherea it serves to generate sync signels whanever off-the-air sync Is temporerlly lost. IC hes divide-by-2, divide-by-25, and mono MVBR steges. Used in circuit shown to provide interlaced sync for bleck end white emeteur TV camare. Required 31.5-kHz input is obtained from 6300-kHz crystal oscillator end three flip-flops that divide by 200. With 74121 mono and 7400 gate connected as shown, interleced sync outputs ere obtained.—R. Suding, Master Sync Genereter, *73 Magazina*, July 1975, p 96.

CHAPTER 93
Temperature Control Circuits

Variety of circuits maintain temperature at desired preset value to within as little as 0.0000033°C. Special features include overshoot compensation, anticipation control, differential control, and proportioning control. See also Power Control and Temperature Measuring chapters.



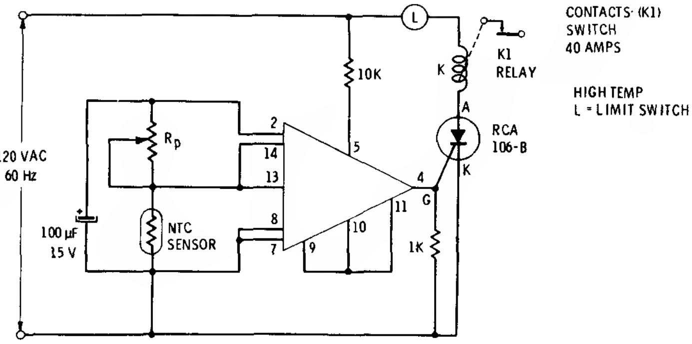
COOKER CONTROL—Uses Model K600A thermistor (Allied Electronics) placed in slow cooker to maintain ideal cooking temperature. Pot can be adjusted to provide triggering for ON/OFF control of heating element for cooker. Use polarized power plug for proper operation.—Circuits, *73 Magazine*, May 1977, p 19.

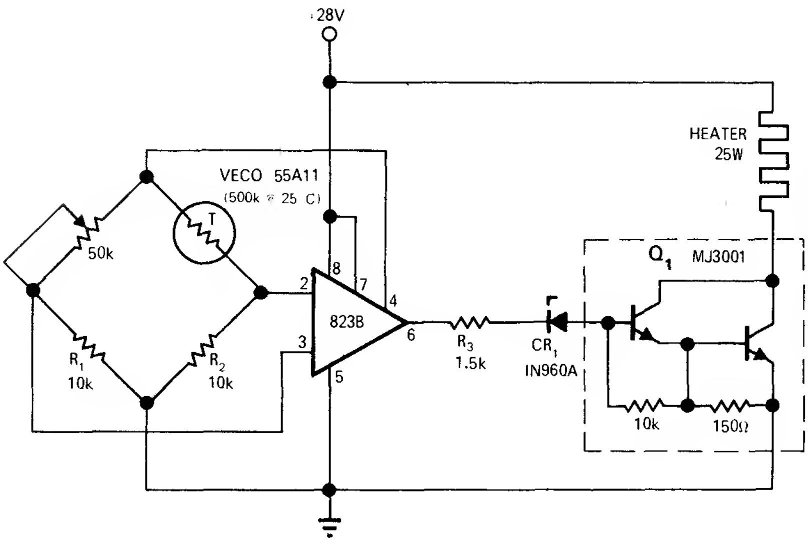


*R1 – THERMISTOR (−4%/°C)
O1 – OPTICAL COUPLER, MINIMUM GAIN = 1/2 at 1.0 mA
D1 - D3 – 1N459
Q2 – SENSITIVE GATE SCR, 1.0 mA OR LESS

PROPORTIONING CONTROLLER—National LM122 timer is used as proportioning temperature controller with optical isolation and synchronized zero-crossing. R2 is used to set temperature to be controlled by thermistor R1. SCR used for Q2 is chosen to handle required load. D3 is rated at 200 V. R12, R13, and D2 implement synchronized zero-crossing feature.—C. Nelson, "Versatile Timer Operates from Microseconds to Hours," National Semiconductor, Santa Clara, CA, 1973, AN-97, p 8.

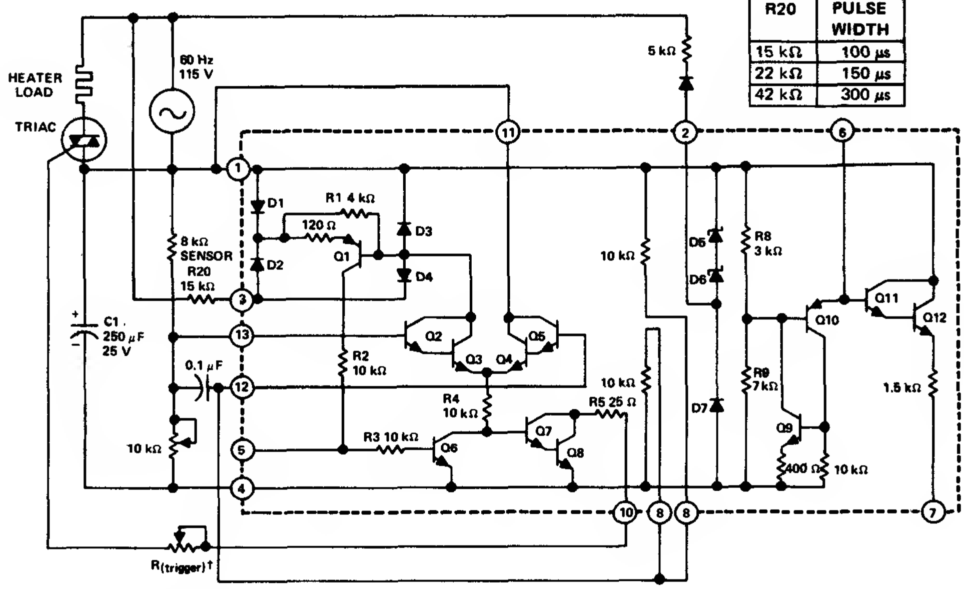
OVEN CONTROL—Simple circuit using RCA CA3059 zero-crossing switch regulates ON and OFF intarvals of low-current SCR thet controls solenoid in electric or gas oven. Sensor resistor hes negative temperature coefficient. R_p is set for desired control temperetura.—E. M. Noll, "Linaer IC Principles, Experimants, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 323.



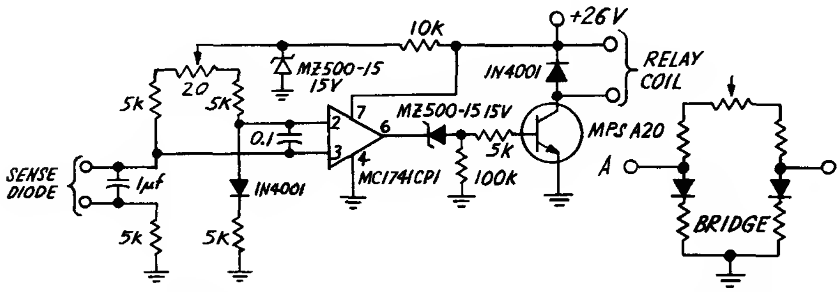


75–250°C OVEN CONTROL—Provides proportional tamperatura control of smell oven to within 1°C over temperatura renge. Uses 823B voltaga regulator operating from same 28-V sourca as oven. Temperature-setting pot should be 10-turn wirewound. Powar transistor Q_1 operates either saturated or almost cut off, so no haatsink is requirad.—R. L. Wilbur, Proportional Ovan-Tamparatura Controllar, *EDN/IEEE Magazine*, Sept. 15, 1971, p 45.

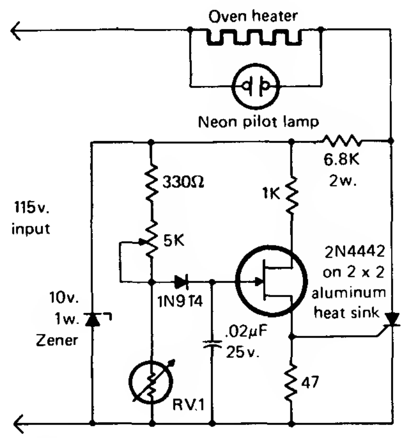
R20	OUTPUT PULSE WIDTH
15 kΩ	100 µs
22 kΩ	150 µs
42 kΩ	300 µs



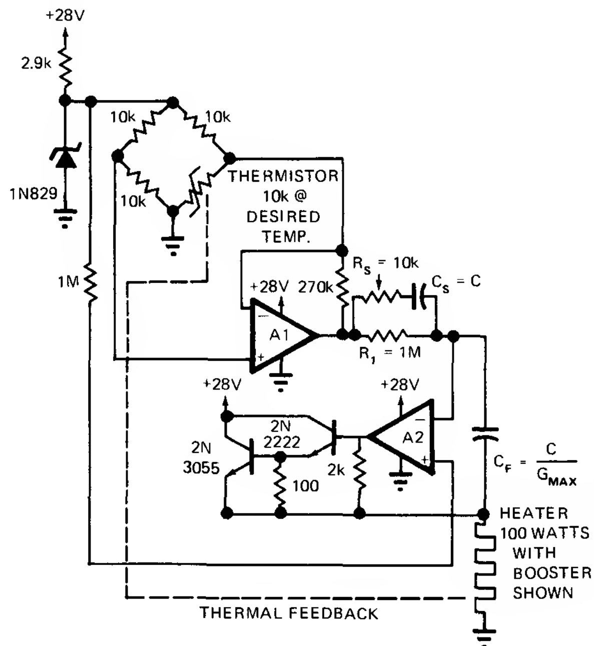
ON/OFF HEATER CONTROL—Uses Texas Instruments SN72440 zaro-voltage switch to trigger triac that turns AC heater on and off in accordance with damands of 8K resistence-typa temparature sansor. Ona output pulsa par zaro crossing of AC line voltage is eithar inhibited or permitted by action of differential amplifiar and rasistance bridga circuit in IC. Width of output pulse at pin 10 is controlled by triggar pot R20 as givan in tabla and should be variad to suit triggering charactaristics of triac usad.—"The Linaar and Interfaca Circuits Data Book for Dasign Enginaers," Taxas Instruments, Dallas, TX, 1973, p 7-37.



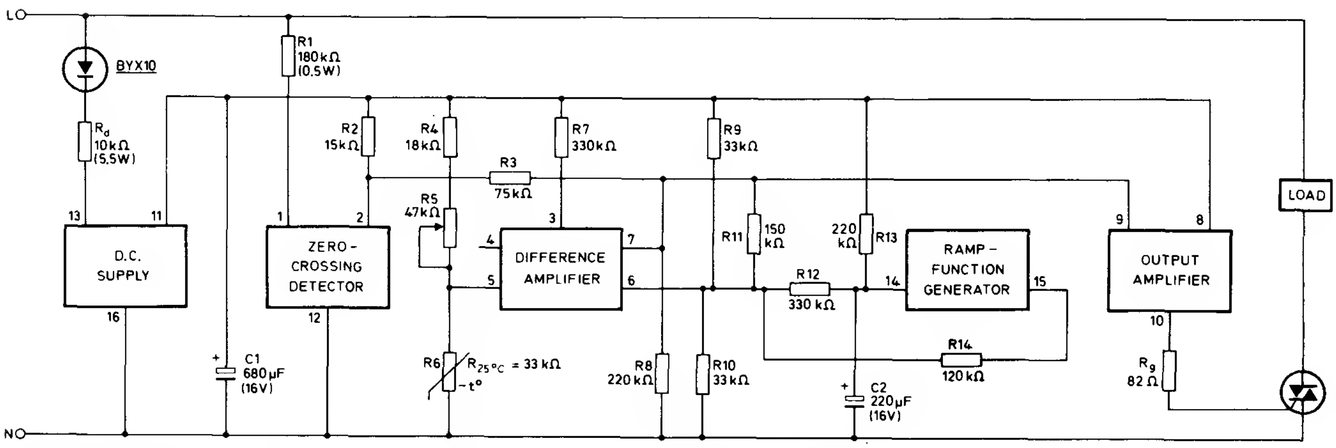
SILICON-DIODE SENSOR—Ordinary silicon diode having temperature coefficient of about −2 mV/°C over wide temperature range serves for sensing temperature differentials up to ±10°F with resolution of about 0.3°F. Two diodes connected in resistor bridge provide voltage proportional to temperature difference at terminals A and B. Pot supplies variable offset current corresponding to presettable temperature offset range. Low output voltage of bridge is amplified by opamp such as Motorola MC1741 which gives output swing of 30 V for input change of 0.3 mV. Buffer transistor is added for handling load such as motor control relay.—"Industrial Control Engineering Bulletin," Motorola, Phoenix, AZ, 1973, EB-4.



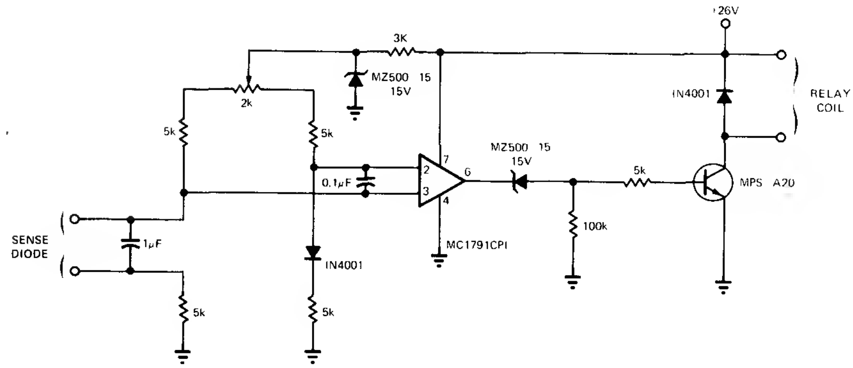
PROPORTIONAL CONTROL FOR OVEN—Thermistor RV1 and resistor-pot combination form voltage divider across 10-V zener, with output applied to UJT. Voltage across capacitor is ramp during positive half-cycles of AC line, slope of which is function of temperature and setting of 5K pot. When ramp reaches firing voltage of UJT, it turns on SCR and applies power to load. Negative half of AC input turns off SCR and cycle repeats. When oven temperature is low, SCR fires early in cycle to give more heat. When preset temperature is reached, SCR fires very late in cycle to compensate for heat lost by oven. Designed for 100°F environmental test chamber.—I. Math, Math's Notes, *CQ*, Sept. 1978, p 63 and 82–83.



0.001°C ACCURACY—Simple design using thermistor bridge and two opamps controls temperature with high precision and has wide dynamic response as required for fast-changing ambient conditions. Circuit will not oscillate about desired temperature. Article covers design and operation of circuit in detail.—L. Accardi, Universal Temperature Controller, *EDN Magazine*, Dec. 1, 1972, p 53 and 55.

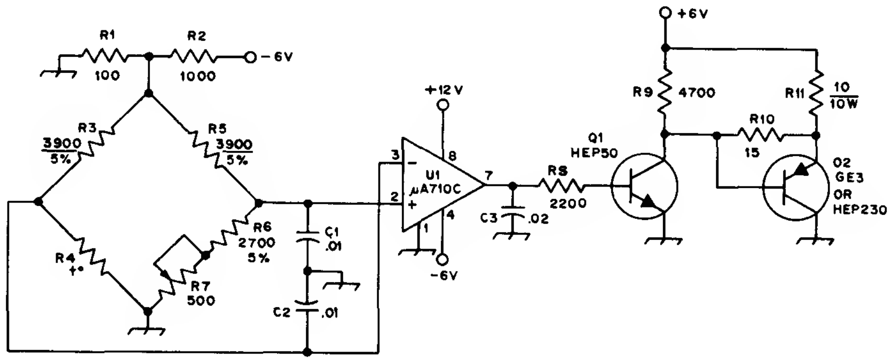


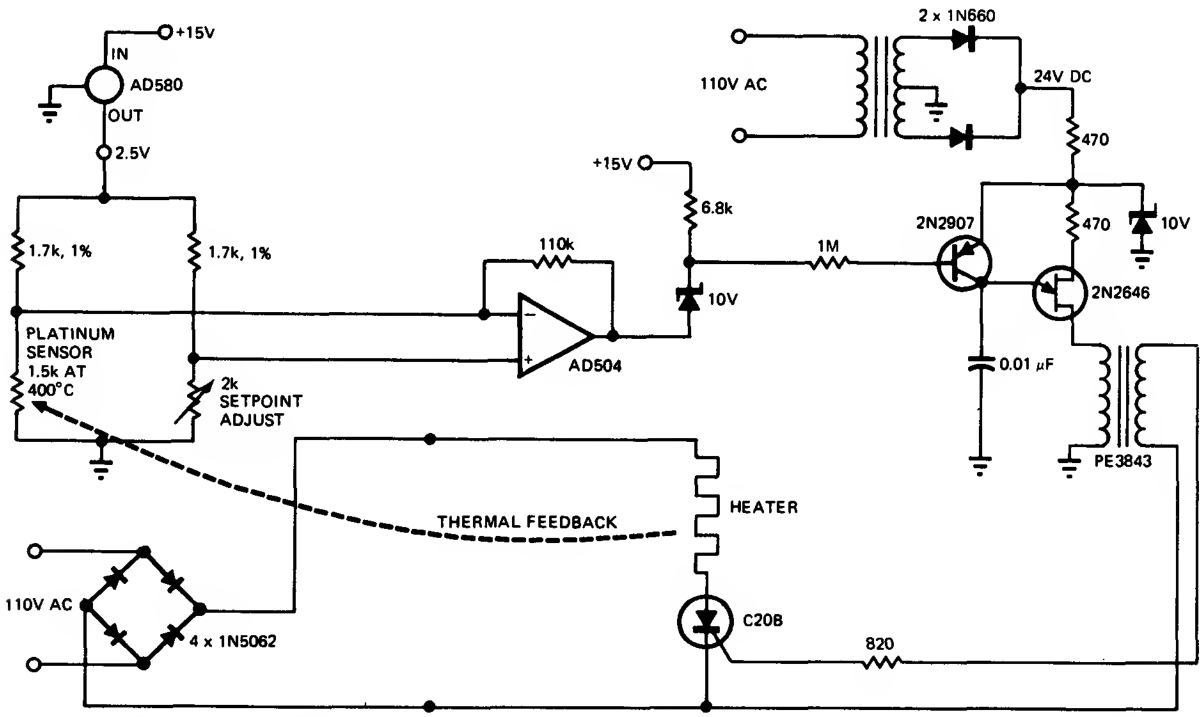
TIME-PROPORTIONAL CONTROL—Provides synchronous ON/OFF switching of resistive load under control of temperature-sensitive bridge formed by R4, R5, and negative temperature coefficient thermistor R6 in one bridge branch, with R9 and R10 in other branch. All required function elements are included in Mullard TCA280A trigger module. Values shown are for triac requiring gate current of 100 mA; for other triacs, values of R_d, R_g, and C_1 may need to be changed. Proportional band can be adjusted by changing value of R12. Triac triggering coincides with zero crossings of AC line voltage. Repetition time of internally generated sawtooth is about 30 s and can be adjusted by changing C2.—"TCA280A Trigger IC for Thyristors and Triacs," Mullard, London, 1975, Technical Note 19, TP1490, p 10.



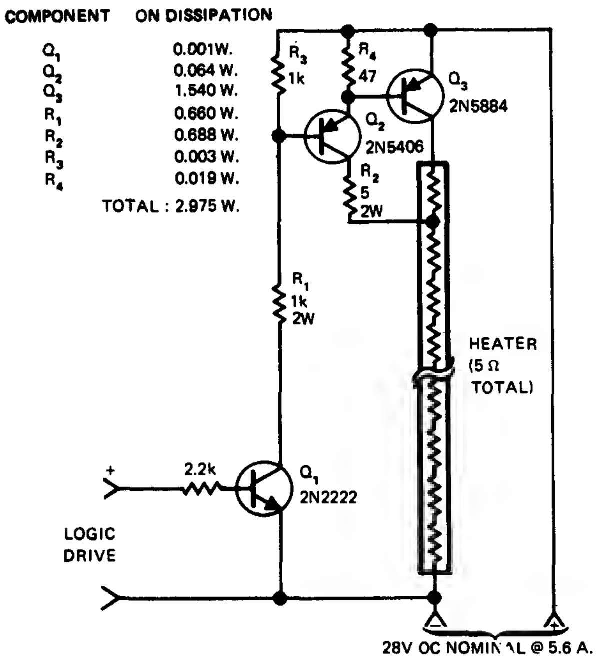
DIFFERENTIAL TO 10°F—Simple circuit senses difference between temperatures of two objects, as required for such control applications as turning on fans, turning off heaters, or operating mixing valves. Inexpensive 1N4001 silicon diode is used as sensor; with two such diodes in resistance bridge as shown, voltage proportional to temperature difference between reference end sensor diodes is applied to pins 4 and 7 of opamp. High-gain opamp is required because bridge output is only about 2 mV/°C of temperature differential. If output requires more than about 10 mA, buffer transistor is needed.—J. Barnes, Differential-Temperature Sensor is Very Inexpensive, *EDN Magazine*, April 5, 1973, p 90–91.

CRYSTAL OVEN CONTROL—Unbalance voltage produced in thermistor bridge when temperature drops below set point is sensed by differential opamp that feeds buffer Q1 and power amplifier Q2. Power dissipated in Q2 and its load R11 heats oven. Thermistor R4 has nominal resistance of 3600 ohms at 50°C (GE 1D53 or National Lead 1D053). Voltage divider R1-R2 reduces U1 input to safe level and makes thermistor operate at low current, minimizing self-heating effects. All arms of thermistor bridge except R7 (vernier temperature adjustment) are in oven.—R. Silberstein, An Experimental Frequency Standard Using ICs, *QST*, Sept. 1974, p 14–21 and 167.



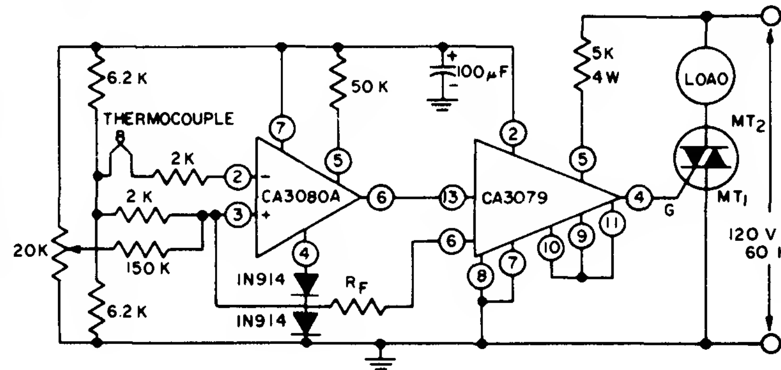


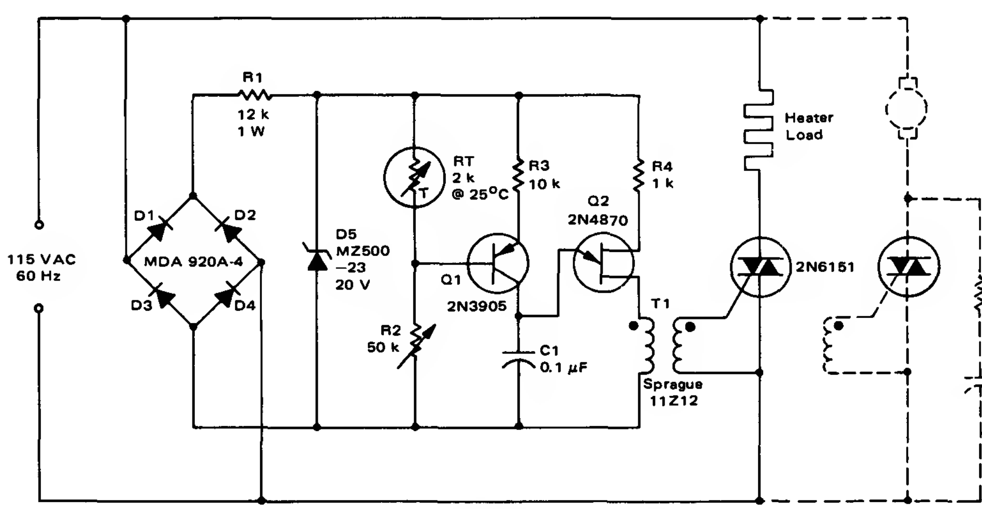
PHASE-FIRED SCR CONTROL—Can provide linear thermal control to 0.001°C at high power with good efficiency. Band-gap voltage reference of AD580 IC temperature transducer furnishes power to bridge circuit, while platinum sensor provides sensing function. AD504 opamp amplifies bridge output for biasing 2N2907 transistor which in turn controls 60-Hz synchronized UJT oscillator that drives gate of SCR through isolation transformer. Biasing action makes SCR fire at different points on AC waveform as required for precise control of oven heater. Possible drawback is RF noise generated because SCR chops in middle of waveform.—J. Williams, Designer's Guide to: Temperature Control, *EDN Magazine*, June 20, 1977, p 87–95.



LOW-DISSIPATION SWITCH—Logic-controlled power switch for 150-W instrument heater uses tep on heating alement to force switch Q_3 and driver Q_2 into saturetion end keep dissipetion low. When input goes positive, Q_1 turns on and drives Q_2 end Q_3 on. Collector current of Q_2 and base drive of Q_3 era determined by R_2. Voltage drop ecross R_2 is proportionel to supply voltage so drive for Q_3 is et optimum level ovar wide voltega renge.—M. Strenga, Increese Electronic Power Switch Efficiency, *EDN Magazine*, Aug. 20, 1975, p 78.

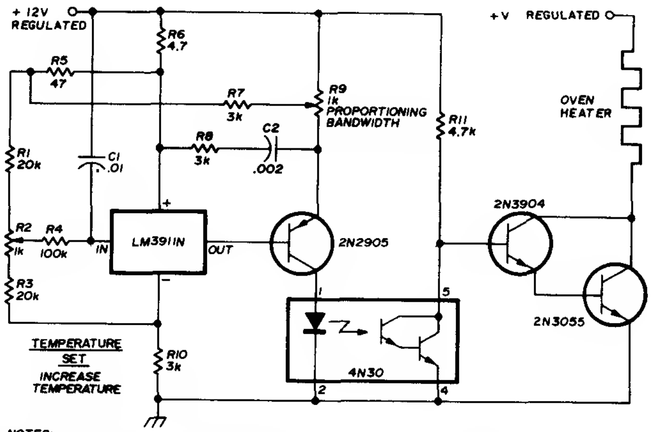
THERMOCOUPLE WITH ZERO-VOLTAGE SWITCH—Differential input connection of RCA CA3080A operationel transconductance emplifier is used with thermocouple to drive CA3079 zaro-voltage switch serving es trigger for triac handling AC loed. Choose triec to match loed being controlled. Supply voltega for opemps is not criticel.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 165–170.



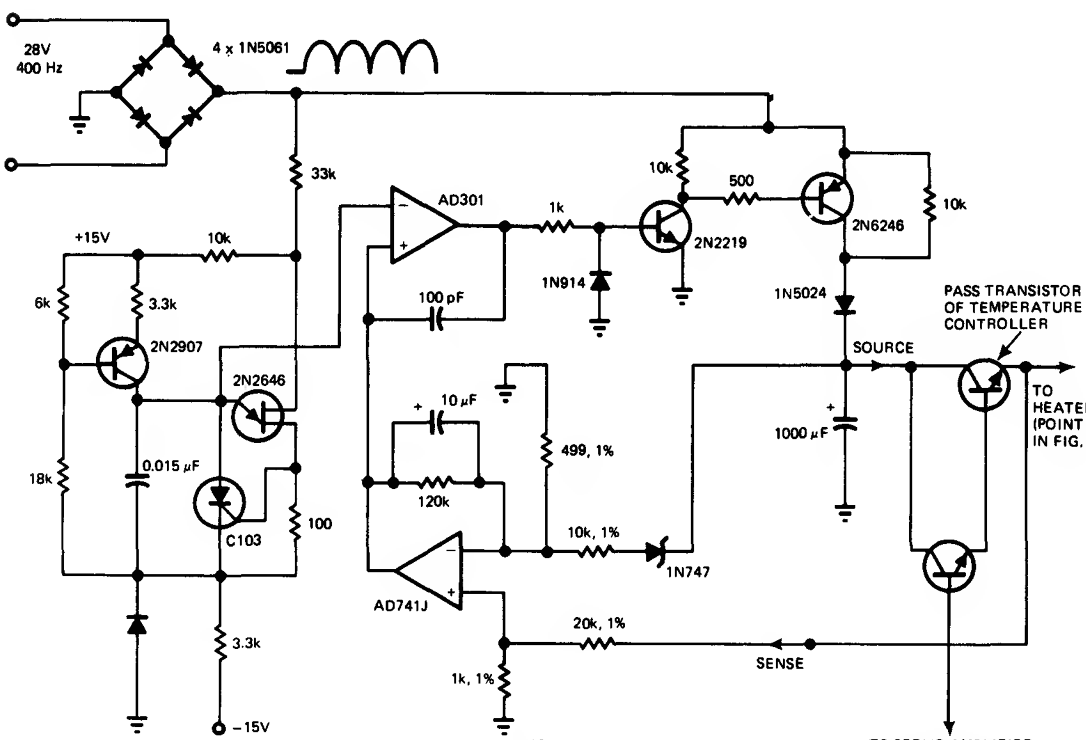


ROOM-HEATER CONTROL—Use of phase control for triac provides graduel reduction in heater load current es desired temparetura is approached, eliminating lerge overshoots. R2 is adjusted so Q1 is off at desired tamparatura, turning Q2 off and prevanting firing of triac. If temperature decreases, resistance of sensor RT increases end trensistors initiate firing of triec. If RT continues to increesa, C1 charges fastar and triec is triggered eerlier in each half-cycle, delivering mora powar to load. Dashed lines indicate eltemate connections for controlling motor with constant load such as blower motor. For cooling applications, interchanga RT and R2.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 9.

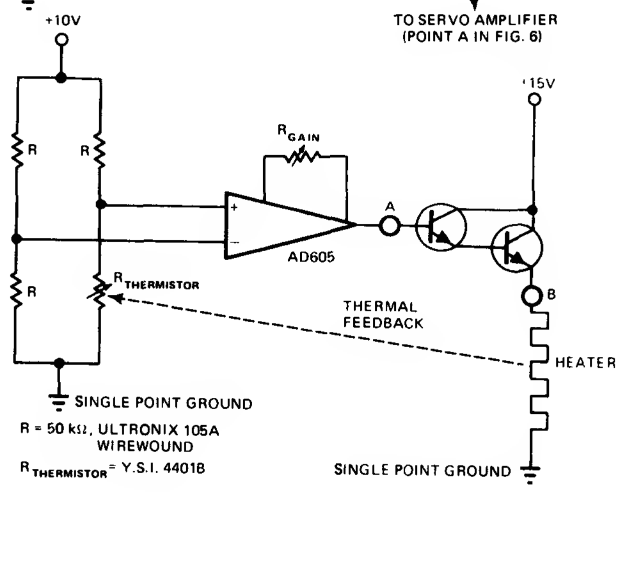
75°C CRYSTAL OVEN—Proportional temparature controller using Netionel LM3911 IC holds crystal oven temperature constent within 0.1°C of 75°C, to improve stebility of oscillator used In frequency synthesizers and digitel counters. Duty cycle of square-wave output of IC (ratio of OFF to ON time) veries with temperature of sensor in IC end with voltage at inverting input terminel. Duty cycle chenge makes average haeter current chenge es requirad to bring temperature beck to desired velue. Squere-weva frequency is determined by R4 end C1. 4N30 optocoupler drives power trensistor heving oven haeter in collector circuit. During ON intervels of squere weve, power trensistor is driven to seturetion, and during OFF intervels is cut off.—F. Schmidt, Precision Temperature Control for Crystal Ovens, *Ham Radio*, Feb. 1978, p 34–37.

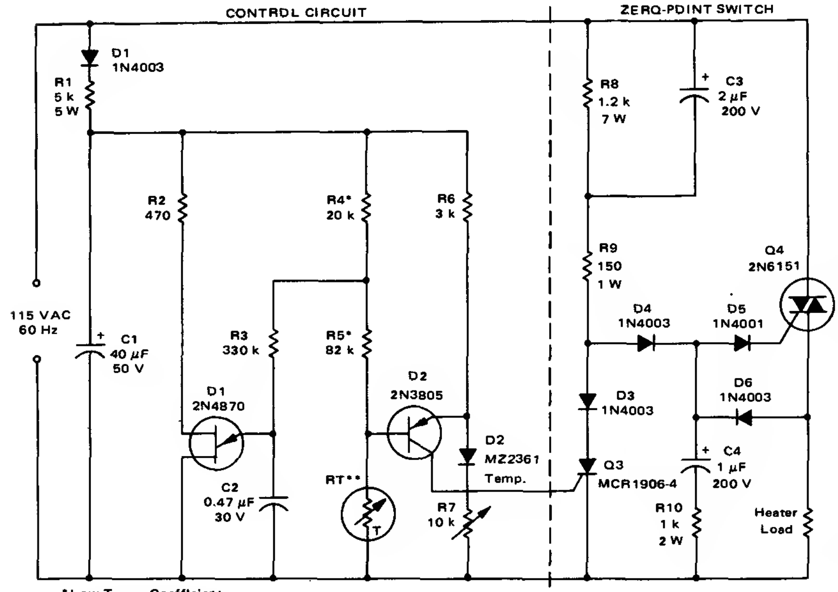


NOTES:
1. ALL RESISTORS 1/2 WATT COMPOSITION, EXCEPT R1 AND R3, WHICH SHOULD BE METAL FILM OR WIREWOUND.
2. VALUES OF R1, R2 AND R3 ARE FOR OVEN TEMPERATURE OF 75C.
3. +V SHOULD BE 5-6 VOLTS FOR 6.3 VOLT SURPLUS OVEN; 9-12 VOLTS FOR HOME BREW OVEN.



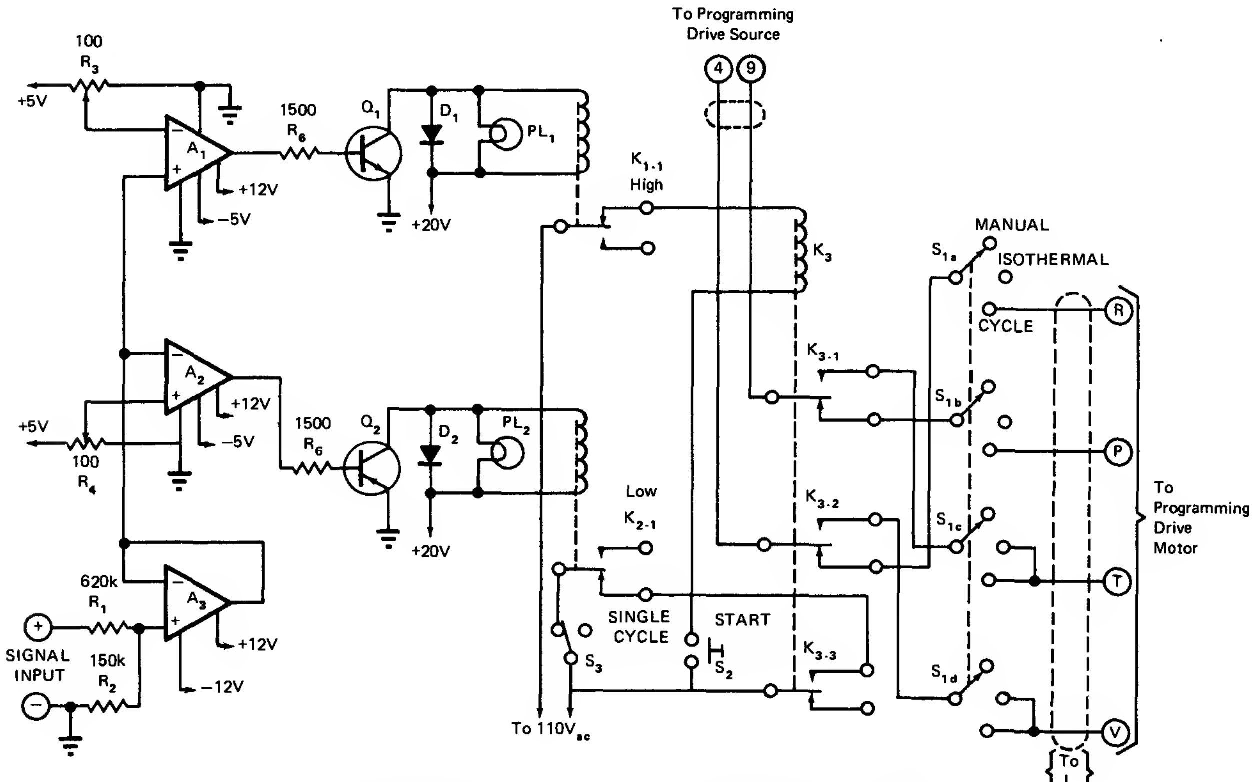
0.000075°C BATH CONTROL—Will hold oven or bath at 37.5°C with high stability. Bridge offset is sensed by AD605 instrumentation opamp heving high common-mode rejection, low drift, and balanced inputs. Opamp drives Darlington pair providing current gain to heater. Pass transistor must dissipete ell power not delivered to heater; to overcome this, large servo circuit is connected between points A end B to maintain constant 3 V across pass transistor regerdless of heater power demands. Output of 741 opemp is compared with 400-Hz line-synchronized ramp by AD301A amplifier serving es pulse-width modulator that drives 2N2219-2N6246 transistor switch. Switch delivers phase-controlled power to 100-μF integreting cepecitor end pass transistor of temperature controller.—J. Williems, Designar's Guide to: Temperetura Control, *EDN Magazine*, June 20, 1977, p 87–95.





*Low Temp. Coefficient
**Fenwall QR51J1 100 k Thermistor

EMI-FREE PHASE CONTROL OF HEATER—Modulated triac zero-point switch eliminates electromagnetic interference generated by phase control while providing proportional ON/OFF switching for accurata temperatura reguiation of heater load. Circuit at right of dashed line is basic zaro-point switch that turns triec on eimost immediataly eftar eech zero crossing betwaen half-cycles. R7 is set so bridge in control circuit is baienced at desired tempereture. When temparature overshoots, thermistor RT decraases in resistenca and Q2 turns on to provida gate drive for SCR Q3. Q3 then turns on end shunts gate signel awey from triec Q4, to remove power from load. When temperatura drops, Q2 end Q3 turn off and fuli-weve power is appiied to loed. Modulation is achieved by superimposing sawtooth voltage from Q1 on one arm of bridga through R3, with sawtooth pariod equel to 12 cycles of iine frequancy. From 1 to 12 of these cycles can be applied to load for modulating power in 8% staps from 0% to 100% duty cycle.—"Circuit Applications for tha Triec," Motorola, Phoenix, AZ, 1971, AN-466, p 13.

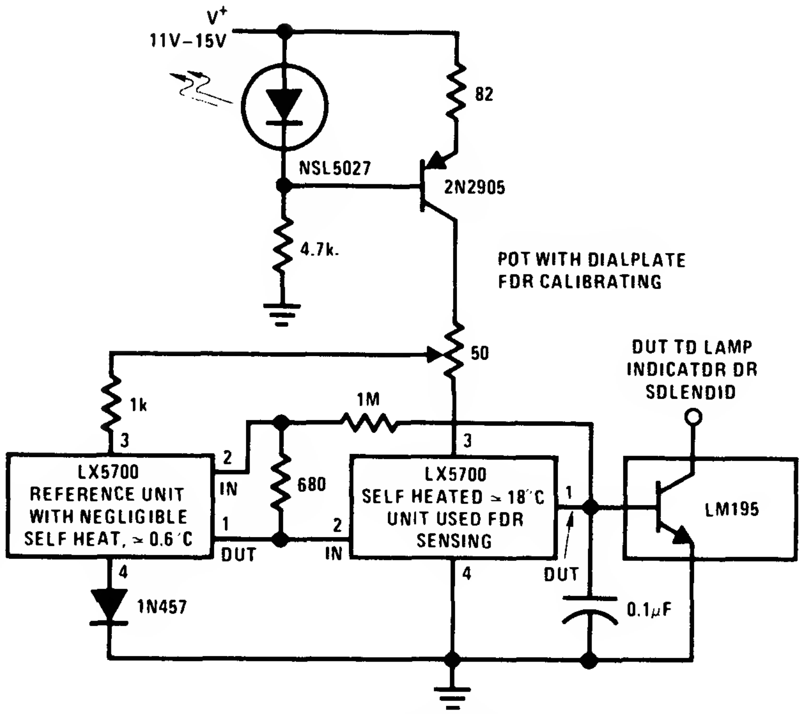


A_1,A_2 - Voltage Comparator, UA710
A_3 - Semiconductor, HA2602
Q_1,Q_2 - NPN Transistor, 2N2222 or Equivalent
D_1,D_2 - Diodes, 1N4148 or Equivalent
K_1,K_2 - DPDT Relays, 24Vdc Coil
K_3 - 3 PDT Relay, 110Vac Coil

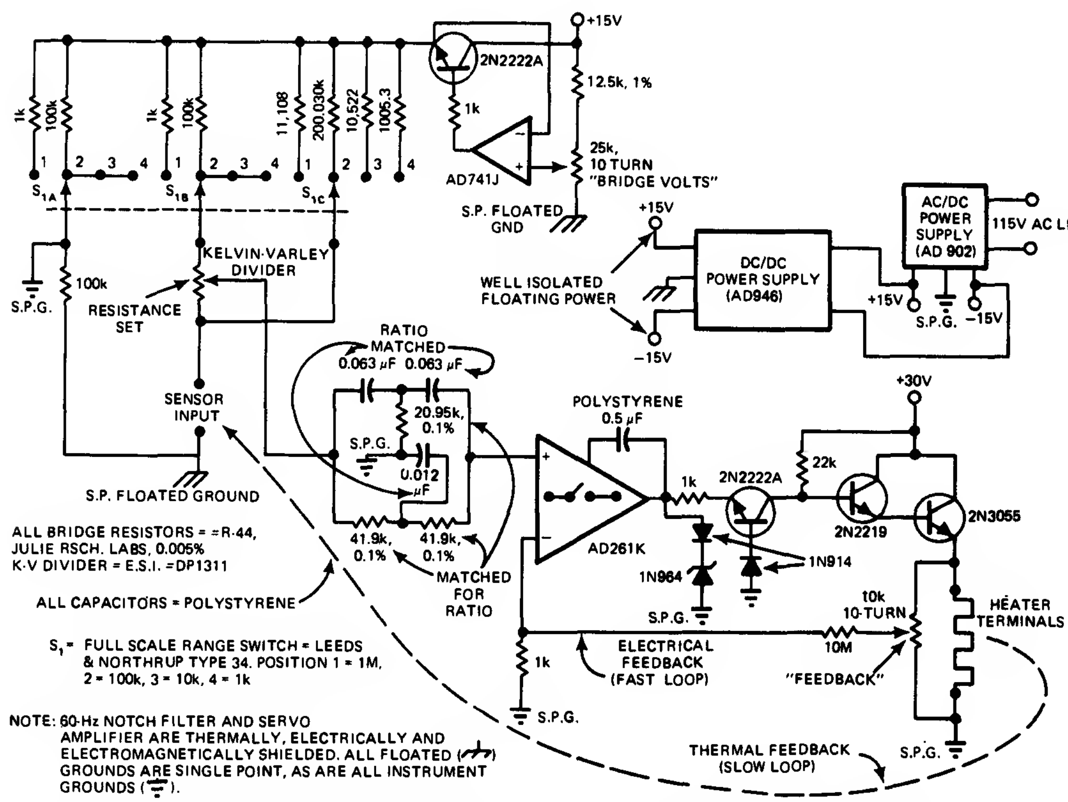
S_1 - 4 Pole - 3 Position Rotary Switch
S_2 - SPST N.O. Momentary Contact Switch
S_3 - SPST Toggle Switch
PL_1,PL_2 - 10V, 14 m Pilot Lights
R_3,R_4 - 100Ω, 10-Turn, Wire-Wound Potentiometers

THERMAL CYCLER—Circuit ellows operator to presalect uppar and lowar temperature limits for controller used in determining effect of continuous thermel cycling on properties of materials. Switching arrangament givas choice of modes renging from manual to fuliy automatic continuous cyciing. Oparation of programming drive motor is controlled by contacts of relay K_3. When relay is energized, motor runs in forward direction to increasa temperature; when deenergized, motor is reversed. Condition of K_3 depends on which of limit ralays K_1 or K_2 wes most recently energized. Control circuit samples output of temperature programmar; this DC input signel is reduced to 5 V maximum by R_1-R_2 and amplified by voltage foiiower A_3. Signal is then compered in A_1 end A_2 to continuously variable reference voltage from 0 to 5 V preselected by 10-turn pots R_3 end R_4. Q_1 is cut off whan input is below reference. When input exceeds reference, Q_1 goes on and energizes upper-limit reley K_1. Article gives initial setup procedura.—W.J. Dobbin, Variable Limit Switch Parmits Hends-Off Equipment Cycling, *EDN Magazine*, Jan. 20, 1973, p 66–67.

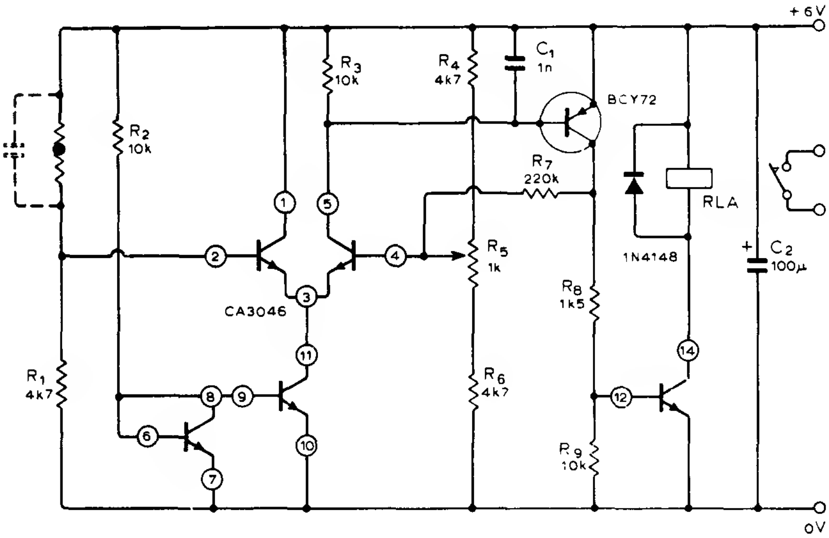
TEMPERATURE-DIFFERENCE DETECTOR—Pair of National LX5700 temperature transducers delivers output voltage proportional to temperature difference between transducers, as required for sensing temperature gradient in chemical processes, detecting failure of cooling fan, detecting movement of cooling oil, and monitoring other heat-absorbing phenomena. With sensing transducer in hot condition (out of liquid or in still air for 2 min), adjust 50-ohm pot to setting that just turns power output off. Next, with transducer in cool condition (in liquid or in moving air for 30 s), find setting that just turns output on. These settings overlap, but final setting between them will provide stable operation.—P. Lefferts, "A New Interfacing Concept; the Monolithic Temperature Transducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 7.



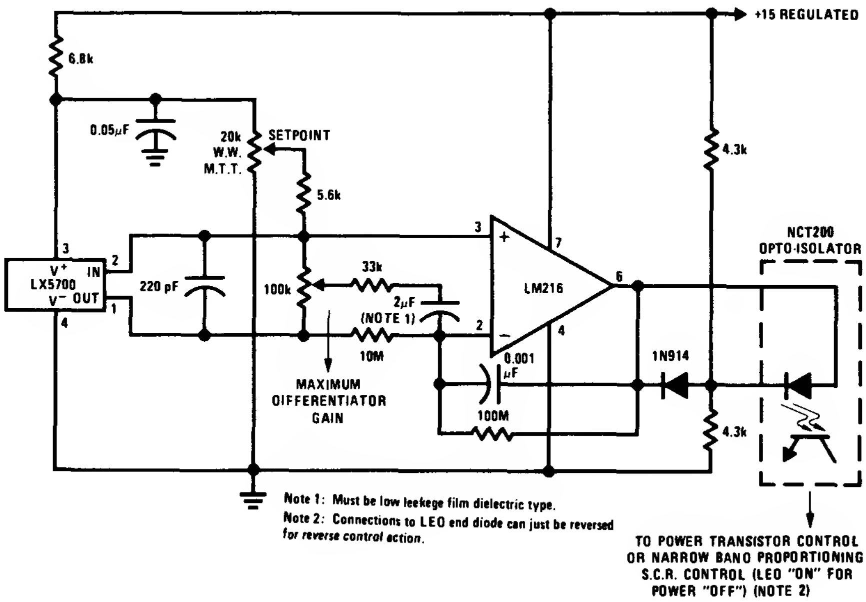
Output "OFF" if sensing unit becomes hot, i.e., out of liquid or airstream.
Reference unit is 1 inch from the sensing unit in airstreams, and below the sensor in liquid sensing systems.



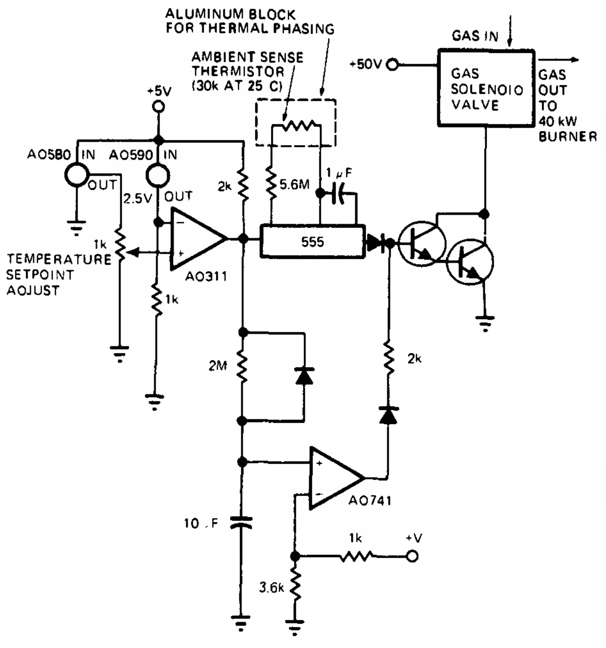
0.0000033°C CHOPPER-STABILIZED OVEN CONTROL—Uses chopper-stabilization techniques to provide ultimate in temperature control for laboratory oven. Multiranging bridge accommodates sensors from 10 ohms to 1 megohm, with Kelvin-Varley divider being used to dial sensor resistance control point directly to five digits. Use of floating power supply for bridge allows single-ended noninverting chopper-stabilized AD741J amplifier to take differential measurement and eliminates common-mode voltage error. Passive 60-Hz notch filter eliminates pickup noise at input of AD261K amplifier which in turn feeds 2N2222A transistor driving Darlington pair that provides up to 30 V across heater of oven. Article also gives circuit of 30-V regulated supply required for output transistors.—J. Williams, Designer's Guide to: Temperature Control, *EDN Magazine*, June 20, 1977, p 87–95.



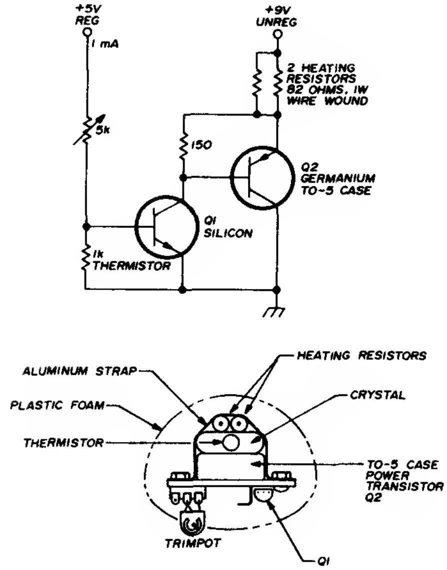
THERMISTOR BRIDGE—Bridge is formad by thermistor with R_1, R_4, R_5, and R_6. Unbalence is sensed by CA3046 IC heving two matched pairs of transistors, with edditional output transistor in IC. Positive feedbeck through R_7 prevents chatter as switching point is epproached. R_5 sets switching temperetura precisaly. Relay comes on when temperature drops balow predetermined point; for opposita function, reverse positions of thermistor and R_1. Value of R_1 is chosen to giva epproximately the deslrad control point.—D. E. Weddington, Thermistor Controlled Thermostat, *Wireless World*, July 1976, p 36.



ANTICIPATING CONTROLLER—Circuit adds selected amount of phese leading signal to normel emplified output of Netionel LX5700 temperature sensor to compensate et least partially for sensing lags. DC gain of LM216 opamp is set et 10 by 10-megohm end 100-megohm resistors to give opamp output of 1 V/°C. Output of opemp energizes optolsolator that feeds conventional tempereture control systam.—P. Lefferts, "A New Interfacing Concept; the Monolithic Temparetura Trensducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 7.

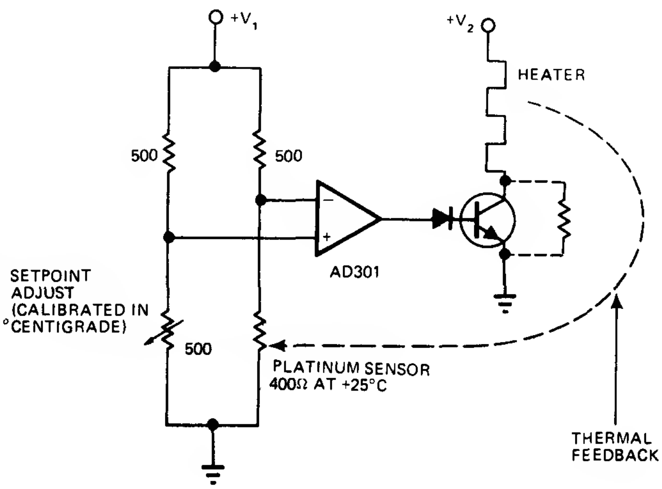


OVERSHOOT COMPENSATION—Used to control temperature of industrial gas-firad heater having vary high thermel capacity. When AD311 opamp comparator trips et set-point temperature, 555 mono mekes trenslstors turn on gas solenoid and light burnar. When mono tlmas out, burner goes off ragardless of opamp output condition. Time constant of 555 compensates for legs In system by turning off heater before AD590 sensor reaches cutoff value. Tharmlstor across 555 mono compensetes for changes In emblent temperature. During start-up, AD741 opamp and associated circuit affactivaly bypasses mono, and also turns on haatar If mono falls to fire for any reason.—J. Willlams, Dasigner's Gulde to: Temperature Control, *EDN Magazine*, June 20, 1977, p 87–95.



CRYSTAL OVEN—All components for proportional temperature control circuit ara mounted on crystal, so total power of 2 W maximum serves for maintaining crystal tamparatura. Thermistor is about 1K at room temperature. Transistor types are not critical but should have low leakage currents. Thermistor current of about 1 mA should be much more than 0.1-mA base currant of Q1. If Q2 is silicon, increase 150-ohm resistor to 680 ohms.—P. H. Mathieson, Simpla Crystal Ovan, *Ham Radio,* April 1976, p 66.

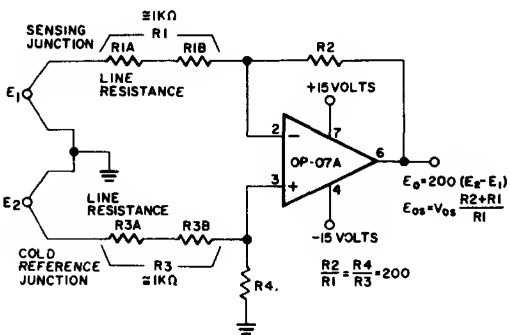
0.01°C CONTROL WITH OPAMP COMPARATOR—Uses platinum sensor in bridge configuration, with opamp connected across bridge differentially. When cold, sensor resistance is less than 500 ohms so opamp saturates to give positive output that turns on power transistor and heatar. As oven warms, sensor resistance increases, bridga balanca shifts, and heater is cut off.—J. Williams, Designar's Guide to: Temperature Control, *EDN Magazine,* June 20, 1977, p 87–95.



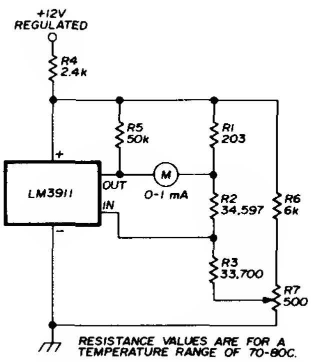
CHAPTER 94

Temperature Measuring Circuits

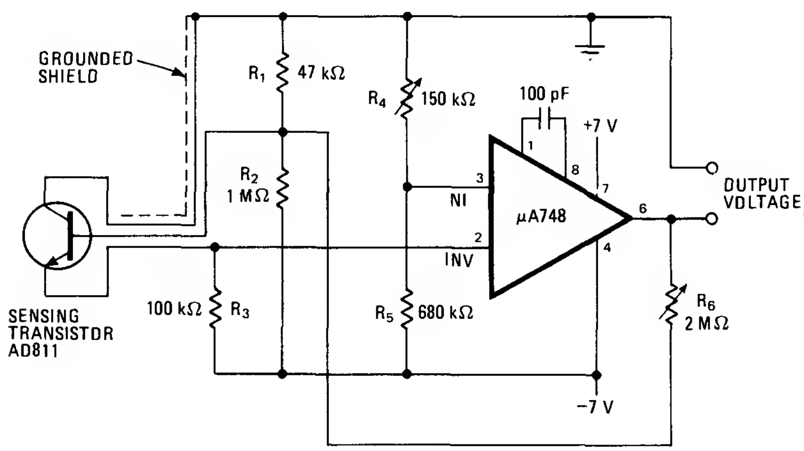
Convert temperature to frequency, voltage, or other parameter for driving meter or digital display that gives temperature value with desired accuracy. Includes wind-chill meter, air-velocity meter, position sensor, thermocouple multiplexer, integrator for soldering-energy pulses, and differential drive for strip-chart recorder.



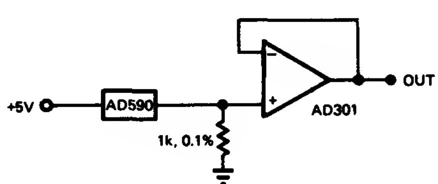
THERMOCOUPLE AMPLIFIER—Precision Monolithics OP-07A opamp has high common-mode rejection ratio and long-term accuracy required for use with thermocouples having full-scale outputs under 50 mV, frequently located in high-noise industrial environments. CMRR is 100 dB over full ±13 V range when ratios R2/R1 and R4/R3 are matched within 0.01%. Circuit is useful in many other applications where small differential signals from low-impedance sources must be accurately amplified in presence of large common-mode voltages.—D. Soderquist and G. Erdi, "The OP-07 Ultra-Low Offset Voltage Op Amp—a Bipolar Op Amp That Challenges Choppers, Eliminates Nulling," Precision Monolithics, Santa Clara, CA, 1975, AN-13, p 11.



70–80°C THERMOMETER—Uses National LM3911 IC having built-in temperature sensor. If no thermometer is available for calibration, set pot R7 to its midpoint. Article gives equations for calculating resistance values for other temperature and meter ranges. Applications include monitoring of temperature in crystal oven. If permanently connected meter is not required, terminals can be provided for checking temperature with multimeter.—F. Schmidt, Precision Temperature Control for Crystal Ovens, *Ham Radio*, Feb. 1978, p 34–37.

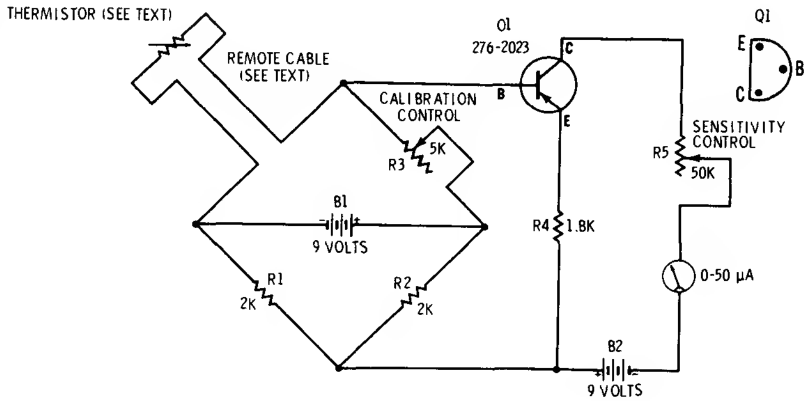


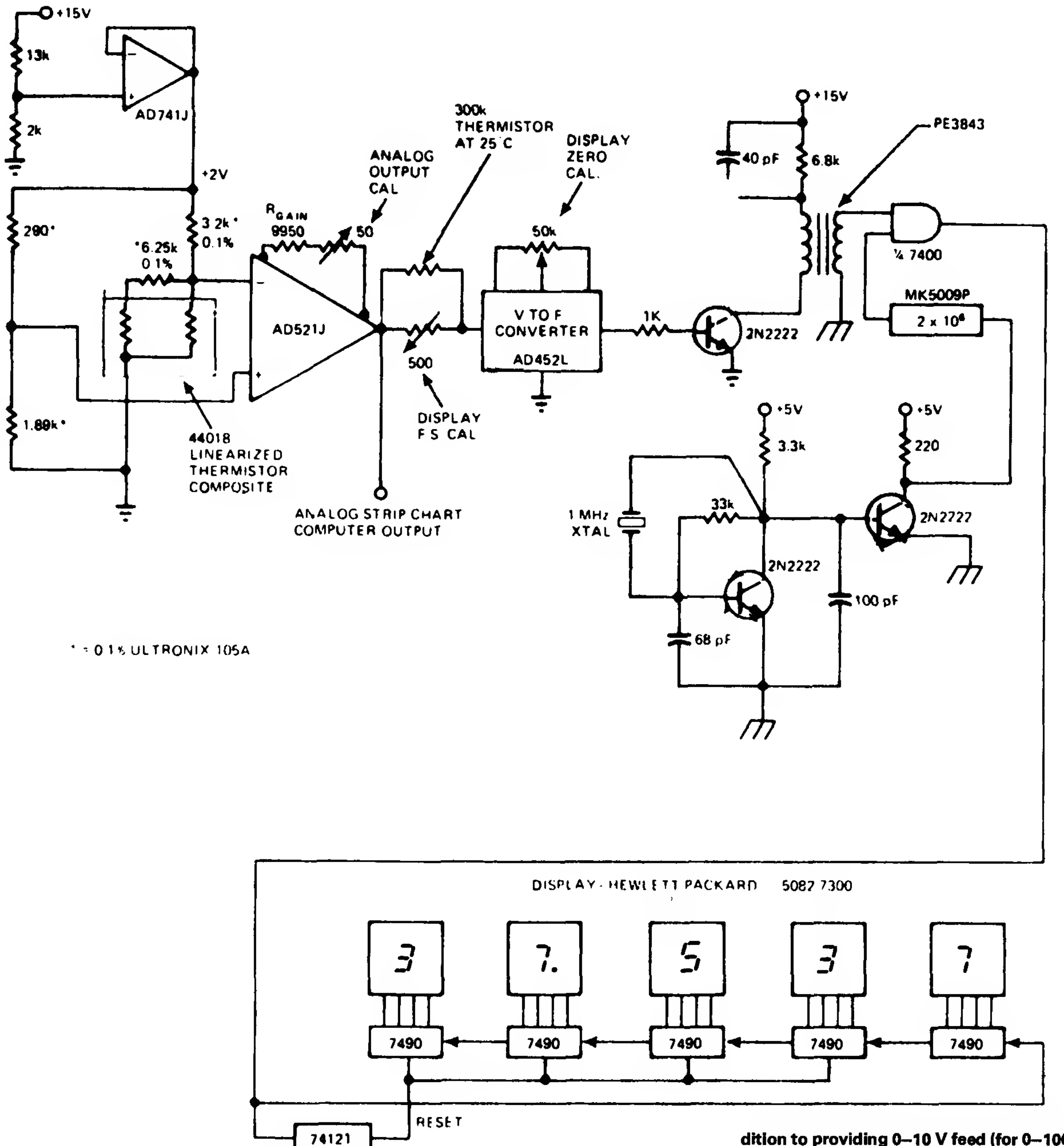
TRANSISTOR SENSOR—Use of bipolar supply for opamp makes electronic thermometer circuit fully linear even at low temperatures. Accuracy is within 0.05°C. Zero point is set by R_4 and gain by R_6.—C. J. Koch, Diode or Transistor Makes Fully Linear Thermometer, *Electronics*, May 13, 1976, p 110–112.



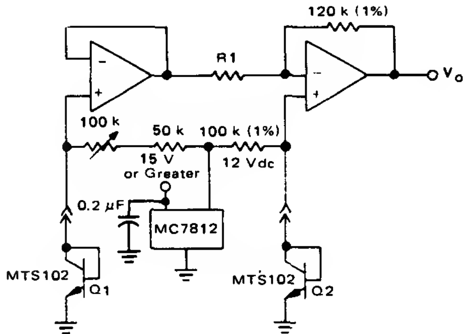
−125 to +200°C WITH 1° ACCURACY—Use of factory-trimmed AD590 IC temperature sensor gives wide temperature range with minimum number of parts. Other temperature scales can be obtained by offsetting AD301 buffer opamp.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.

THERMISTOR THERMOMETER—Thermistor for desired temperature range is one leg of Wheatstone bridge driving microammeter through transistor to provide direct indication of temperature. Can also be used for control purposes if suitable amplifier and relay are used in place of meter. Thermistor cable can be ordinary parallel or twisted wires. To calibrate, immerse thermistor in water at various temperatures and measure water temperature with conventional high-accuracy thermometer. Calibration graph can then be prepared as guide for marking meter scale.—F. M. Mims, "Transistor Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 86–93.

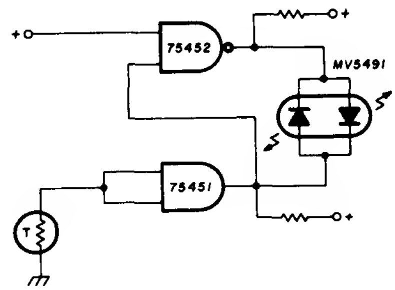




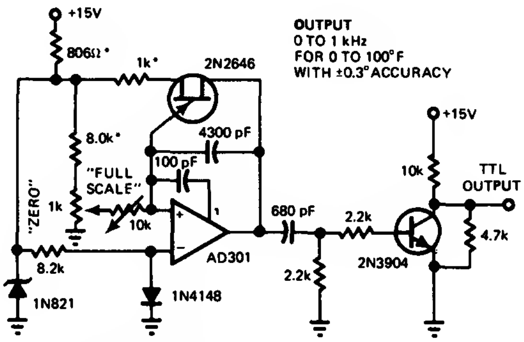
5-DIGIT THERMOMETER—Temperature-to-frequency converter drives digital display providing 0.001°C resolution with 0.15°C absolute accuracy. Linearized thermistor network biases inverting input of AD521J instrumentation amplifier, while noninverting input is driven from same reference. Output can be fed directly to analog strip-chart recorder or computer, in addition to providing 0–10 V feed (for 0–100°C) to voltage-to-frequency circuit that drives display. Readout is updated at 2-s intervals.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.



FOUR-THERMOCOUPLE MULTIPLEXING—Low power dissipation in DG306 analog switches means lower offset voltages added to thermocouple voltages by silicon in contact with aluminum in switches. Thermocouples are switched differentially to instrumentation amplifier driving meter, in order to cancel thermal offsets due to switch.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-87.

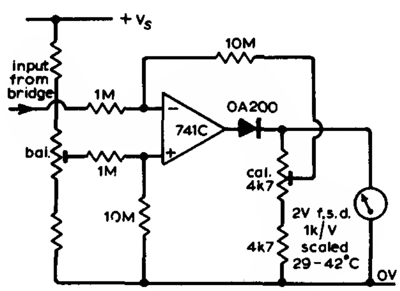


RED/GREEN LED MONITOR—Set points are adjusted by trimming resistor shunted across thermistor, to give one color when desired temperature has been reached and other color when temperature is low. Uses Monsanto MV5491 dual red/green LED, with 220 ohms in upper lead to +5 V supply and 100 ohms in lower +5 V lead because red and green LEDs in parallel back-to-back have different voltage requirements. LED drivers are SN75452 and SN75451.—K. Powell, Novel Indicator Circuit, *Ham Radio*, April 1977, p 60–63.

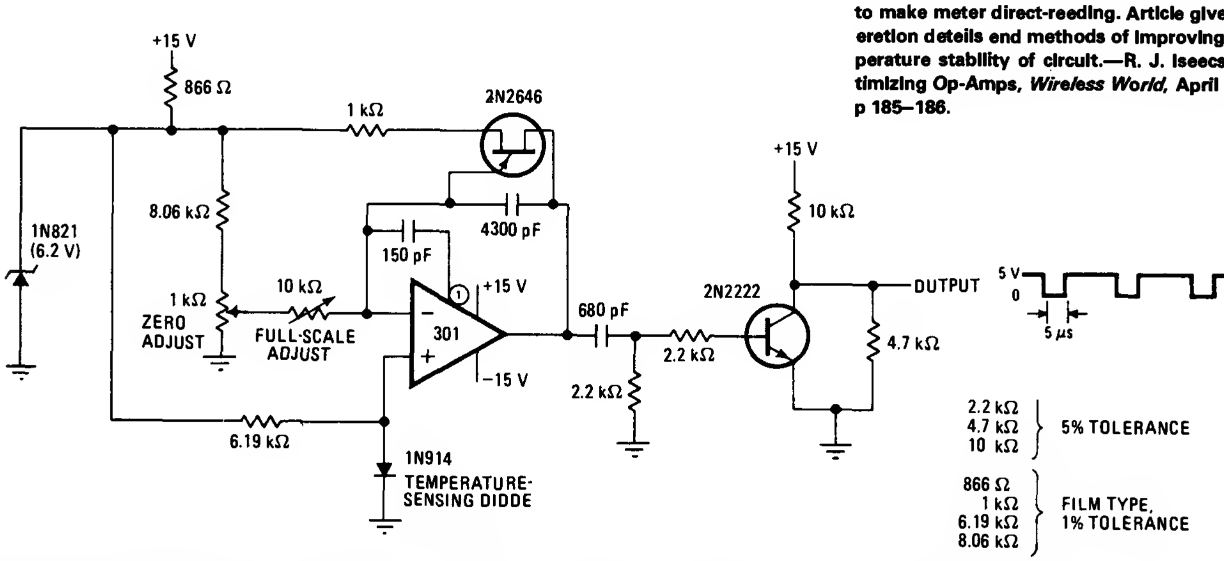


* = RN60C, 1%, METAL FILM

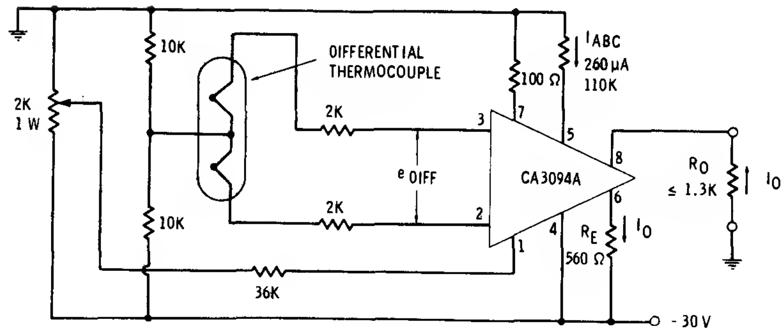
0–100°F GIVES 0–1 kHz OUTPUT—Circuit provides direct temperature-to-frequency conversion at low cost for applications where digital output is desired. Temperature sensor is 1N4148 diode having −2.2 mV/°C temperature shift, controlling AD301 opamp in relaxation oscillator circuit. Compensated 1N821 zener stabilizes against supply changes. Output network using 680 pF and 2.2K differentiates 400-ns reset edge of negative-going output ramp of opamp and drives single-transistor inverter to provide TTL output. Accuracy is within 0.3°F.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.



ZERO SUPPRESSION—Opamp is used in inverting configuration at output of temperature-sensing bridge, so noninverting input of opamp can be used for suppressing meter zero when temperature range for application is 29 to 42°C. Calibration control is set for gain of about 17.2 to make meter direct-reading. Article gives operation details and methods of improving temperature stability of circuit.—R. J. Isaacs, Optimizing Op-Amps, *Wireless World*, April 1973, p 185–186.

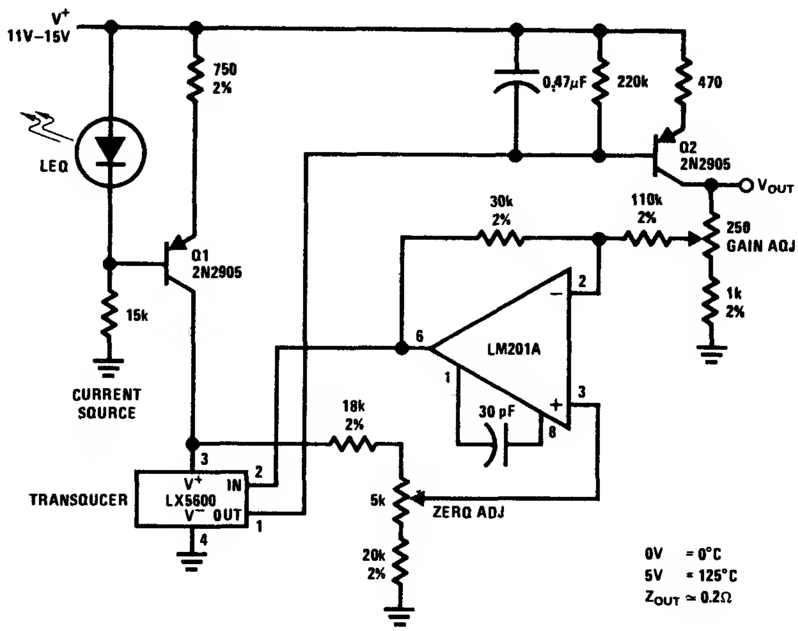


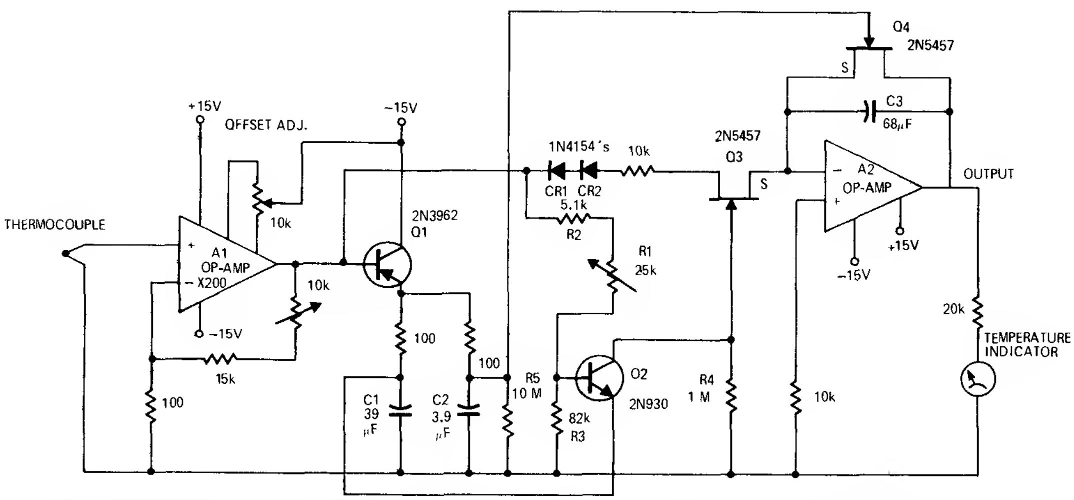
TEMPERATURE-TO-FREQUENCY CONVERTER—Frequency of relaxation oscillator varies linearly with temperature-dependent voltage across 1N914 diode sensor, with range of 0–1000 Hz for 0–100°C. Frequency meter at output shows temperature directly with accuracy of ±0.3°C. Opamp is used as integrator, with 1N821 temperature-compensated diode providing voltage reference that determines firing point of UJT. Circuit functions as voltage-to-frequency converter. Calibrate at 100°C and 0°C, repeating until adjustments cease to interact. Output frequency is than 10 times Celsius temperature.—J. Williams and T. Durgavich, Direct-Reading Converter Yields Temperature, *Electronics*, April 3, 1975, p 101 and 103; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 366.



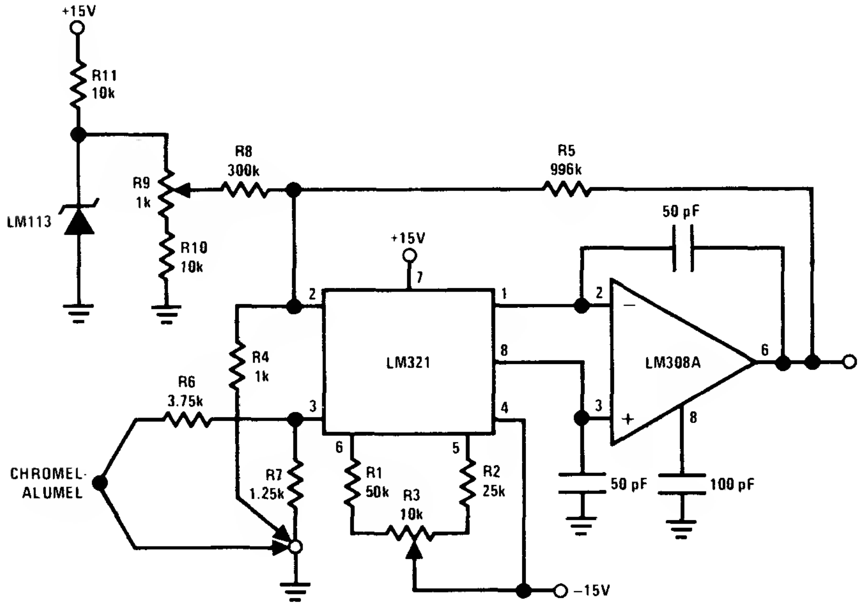
IC FOR DIFFERENTIAL THERMOCOUPLE— Amount of heat sensed by differential thermocouple is proportional to voltage between pins 2 and 3 of CA3094A programmable power switch/amplifier. Input swing of ±26 mV gives single-ended output current range of ±8.35 mA.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 314.

TEMPERATURE TRANSDUCER INTERFACE— Output of National LX5600 temperature-sensing transducer is inverted, level-shifted, and given extra voltage gain of 4 to give required output of 0 to +5 V for telemetry system or instrumentation recorder. Q1 furnishes constant current to thermometer, and Q2 provides inverting function. Resulting output signal is reinverted by LM201A opamp connected through zero-adjust divider to pin 3 which provides voltage reference.—P. Leffarts, "A New Interfacing Concept; the Monolithic Temperature Transducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 3.



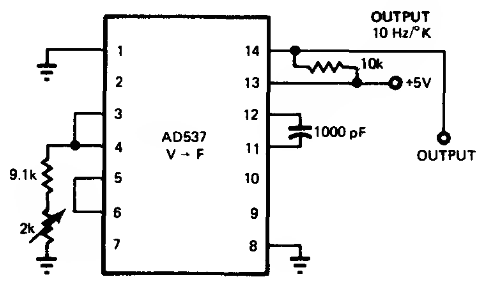


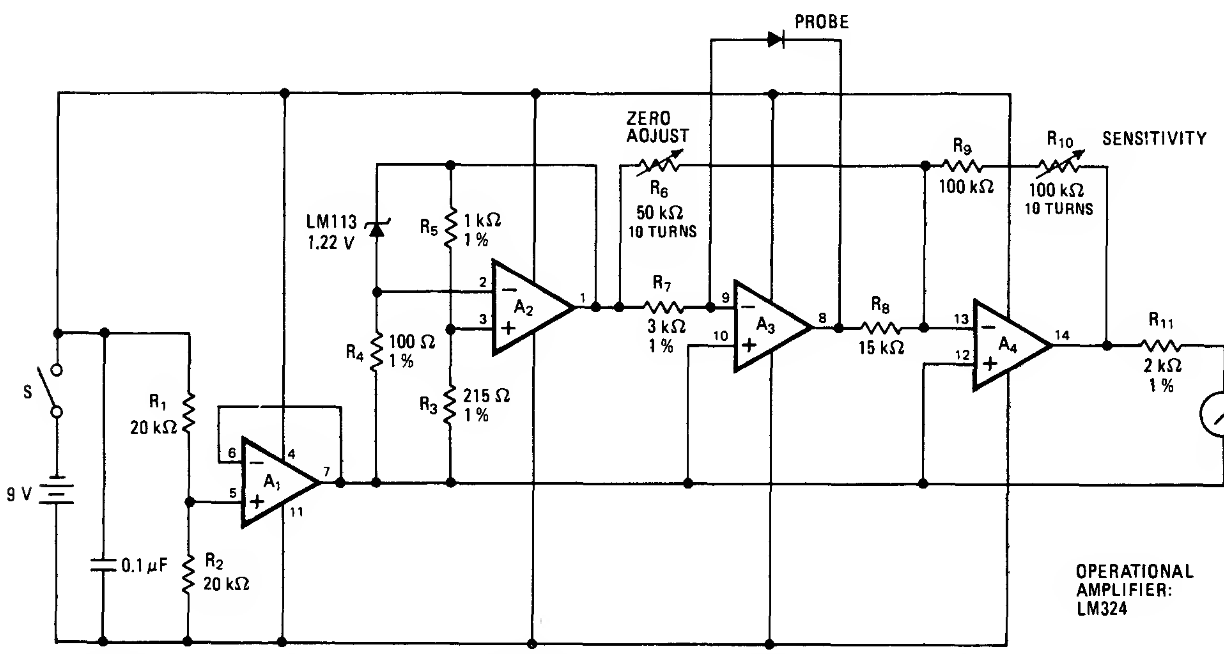
HEAT-ENERGY INTEGRATOR— Pulses of heat energy applied to solder preforms by tips of pulsed soldering machine are metered by integrate/hold-to-indicate circuit using thermocouple as input sensor. Temperature derived from area under time/temperature curve is indicated momentarily on output meter, as guide for operator when size of solder preform is changed. Article describes operation of circuit in detail and gives timing diagram.—C. Brogedo, Heat-Energy Pulse Measured and Displayed, *EDN Magazine*, Sept. 15, 1970, p 61–62.



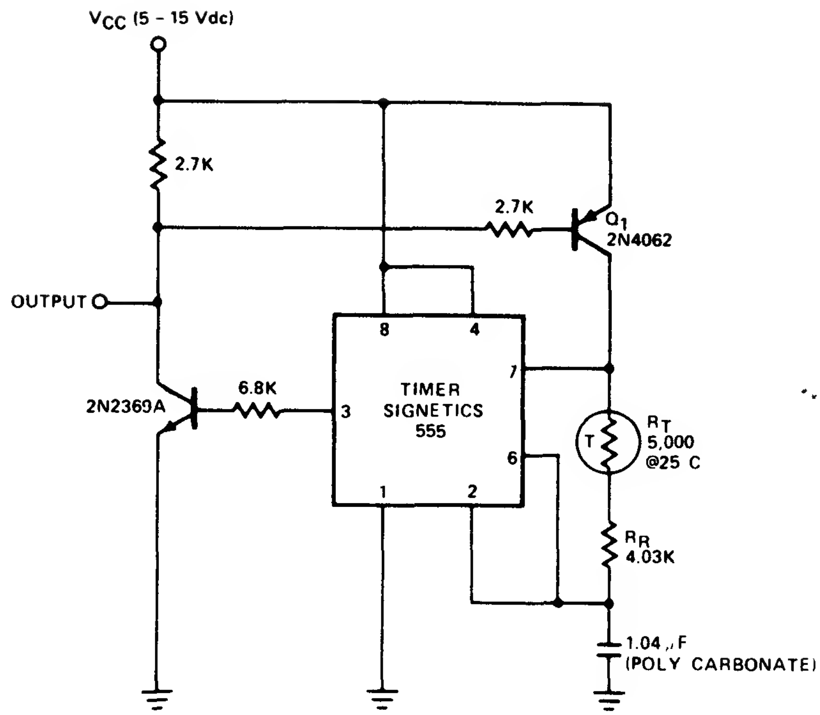
THERMOCOUPLE AMPLIFIER—Combination of LM321 preamp and LM308A opamp forms precision low-drift amplifier that includes compensation for ambient temperature variations. LM113 zener provides temperature-stable reference for offsetting output to read thermocouple temperature directly in degrees C. R4, R6, and R7 should be wirewound.—R. C. Dobkin, "Versatile IC Preamp Makes Thermocouple Amplifier with Cold Junction Compensation," National Semiconductor, Santa Clara, CA, 1973, LB-24.

TEMPERATURE-TO-FREQUENCY CONVERTER—Temperature sensor on chip of AD537 voltage-to-frequency converter IC minimizes number of external parts needed. Output frequency changes 10 Hz for each degree (kelvin or Celsius) change in temperature.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine,* May 20, 1977, p 71–77.

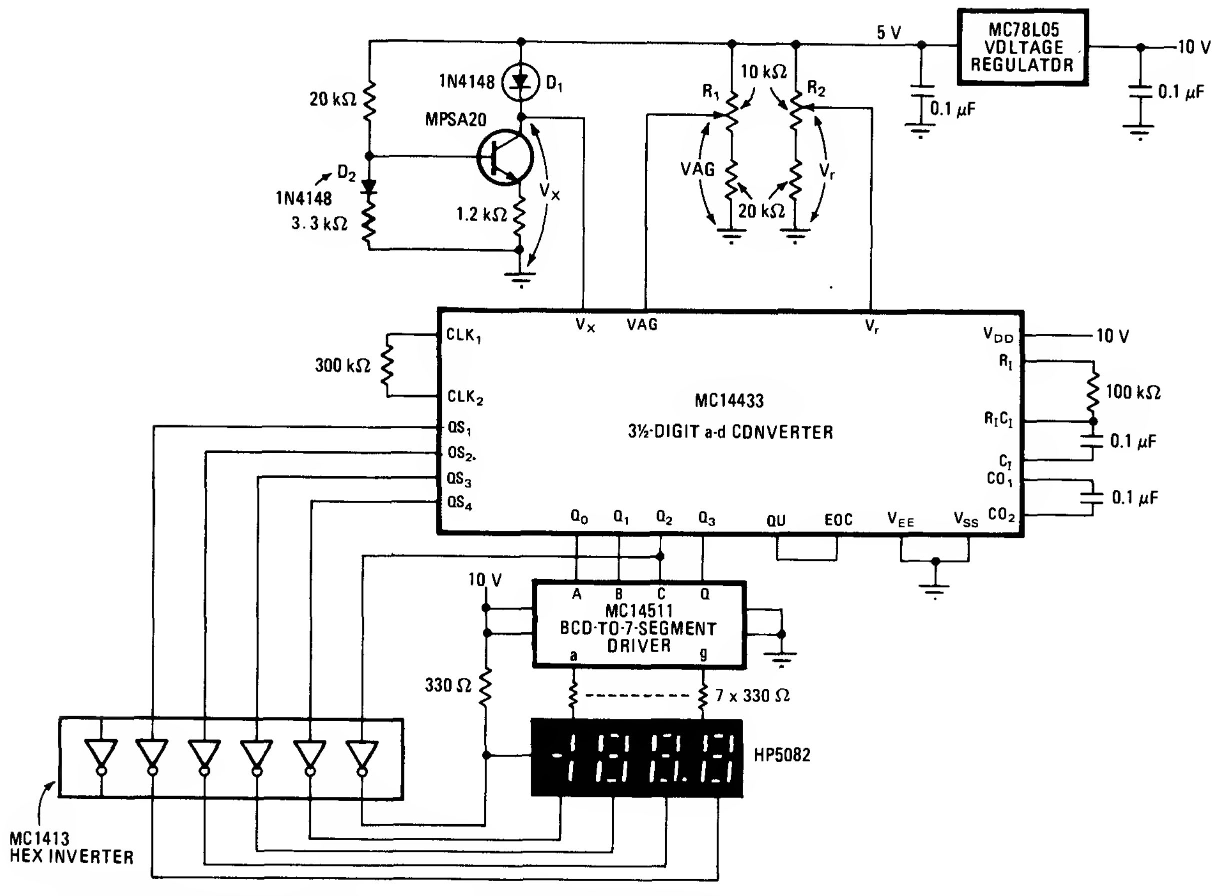




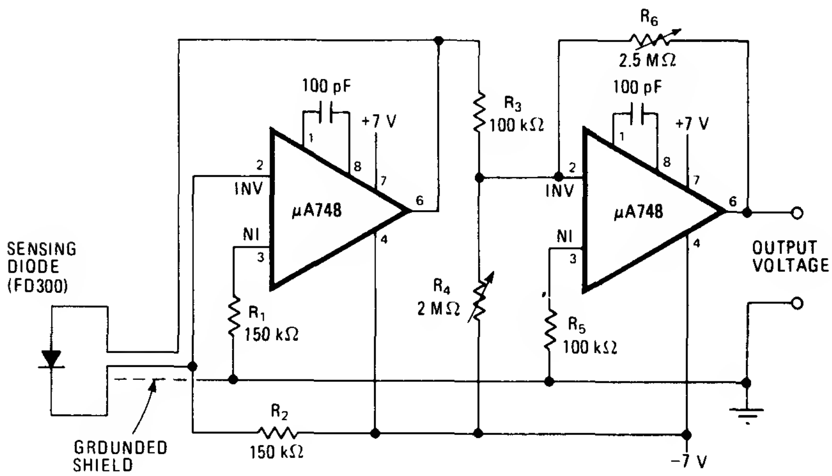
0.1°C PRECISION—Temperature sensor is LM113 diode in probe, with sections A_1 and A_2 of LM324 quad opamp maintaining constant current to diode to ensure that voltage changes across diode are direct result of temperature. 4.5-V output of A_1 is reference point for other opamps. Changes in output voltage of diode are reflected in output of A_4 through buffer A_3. Calibration involves adjusting R_6 for zero output voltage at low end of temperature range, then adjusting R_{10} for full-scale or other convenient reading at desired upper temperature limit. Use 1-mA meter movement.—Y. Nezar, Accurate Thermometer Uses Single Quad Op Amp, *Electronics,* May 26, 1977, p 126.



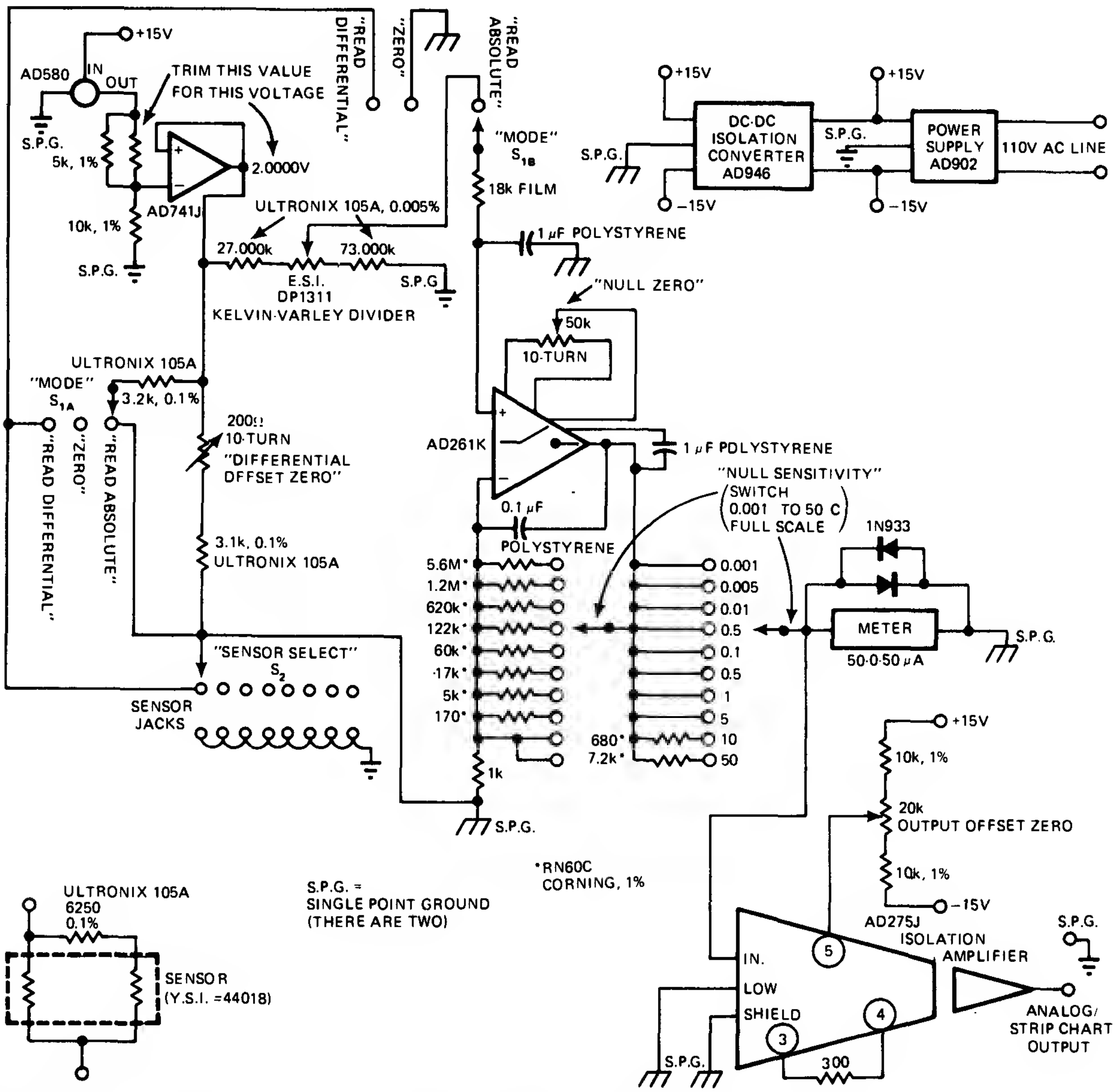
THERMISTOR-CONTROLLED TIMER—Tharmistor and two transistors in cherging network of 555 timer give output frequency that varies with temperature over 78°F range with accuracy of ±1 Hz.—"Signetics Anelog Data Manual," Signetics, Sunnyvale, CA, 1977, p 731.



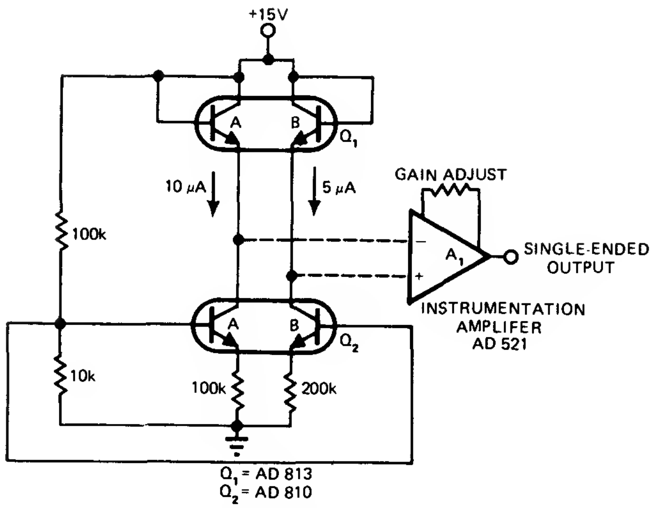
DIGITAL THERMOMETER—Diode D_2 sarves as sensor for driving A/D converter directly, eliminating temperature-drift errors normelly essociated with amplifiers. Can be calibratad ovar temparatura ranga of −199° to 199° in either Fehranheit or Calsius scales. Accuracy is about 1°.—H. Wurzburg end M. Hadley, Digital Thermometer Circumvents Drift, *Electronics*, Jan. 5, 1978, p 176–177.



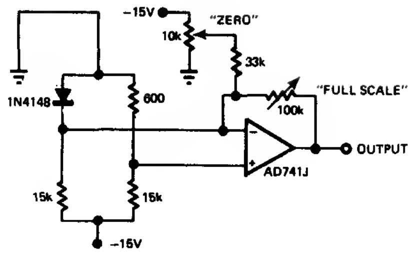
FULLY LINEAR DIODE SENSOR—First opamp acts as constant-current source for temperature-sensing diode, making voltage drop across diode depend only on temperature. Second opamp offsets diode voltage to whatever temperature range is desired and provides gain that is adjustable with R_6. R_4 is used to set output at zero for selected temperature such as 0°C. Circuit can then be adjusted to give 1 V at 50°C.—C. J. Koch, Diode or Transistor Makes Fully Linear Thermometer, *Electronics*, May 13, 1976, p 110–112.



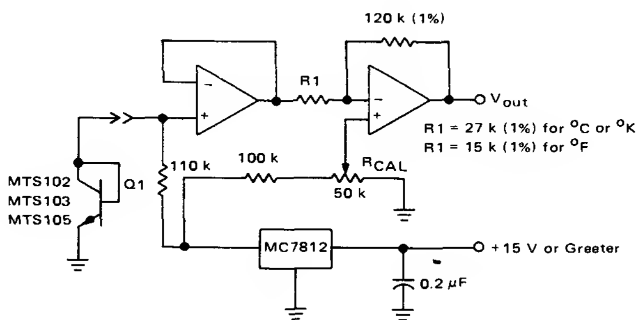
DIFFERENTIAL THERMOMETER—Temperature is directly dialed out on five-decade Kelvin-Varley voltage divider, and differences between dialed temperature and that of YSI 44018 sensor are read directly on meter. Full-scale sensitivity of meter is varied from 0.001 to 50°C by adjusting gain of AD261K chopper-stabilized null detector which drives both meter and AD275J isolation amplifier used to drive strip-chart recorder. Circuit can also be used to measure temperature difference between two sensors with 100-microdegree accuracy. Article describes other measuring modes as well, including techniques for measuring 200-nanodegree temperature shifts.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.



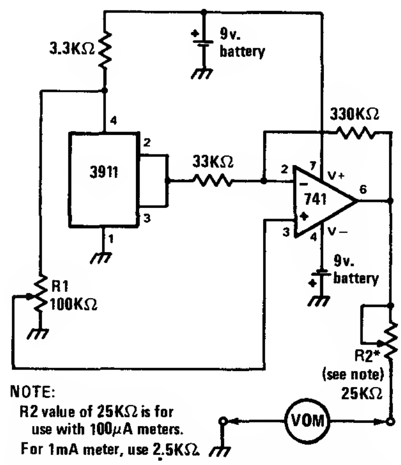
TRANSISTOR SENSOR—Current-ratio differential-pair temperatura sensor uses dual transistor Q_1. Difference between base-emitter voltages of Q_{1A} and Q_{1B} varies linearly with temperature, when dual translstor Q_2 provides 10μA through Q_{1A} and 5μA through Q_{1B}. Instrumentation opamp provides single-endad output with better than 1°C accuracy over 300°C temperature range. Analog Devices AD 590 IC version of differential pair will operate over wire line thousands of feet away from instrumentation opamp, for remote sensing.—J. Williams, Designer's Guide to: Temperature Sensing, *EDN Magezine*, May 5, 1977, p 77–84.



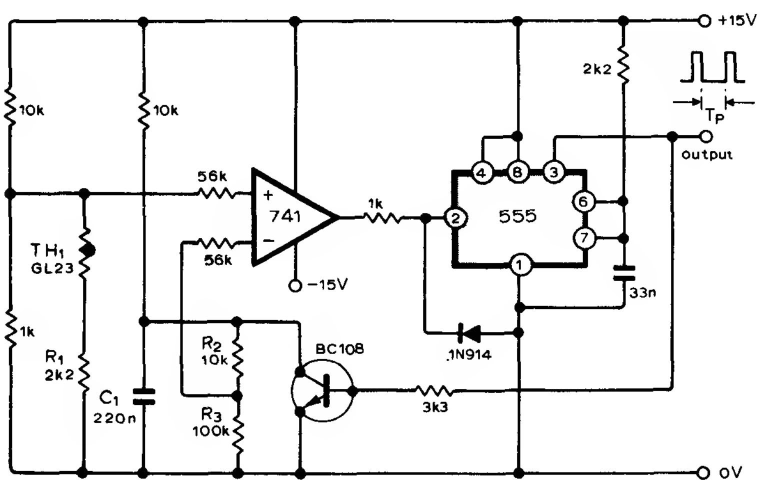
0–100°C WITH 1° ACCURACY—Low-cost diode serves as temperature aensor. To calibrate, place diode in 0°C envlronment and adjust zero pot for 0-V output, then place diode in 100°C environment and adjust full-scale pot for 10-V output. Repeat procedure until interaction between adjustments ceases.—J. Williams, Designer's Gulde to: Temperature Measurement, *EDN Megazine*, May 20, 1977, p 71–77.



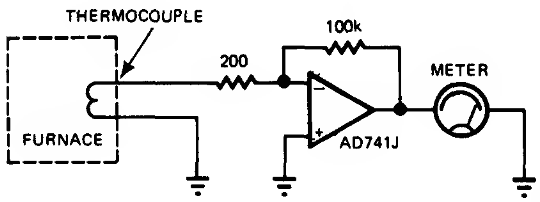
ABSOLUTE-TEMPERATURE SENSING—Silicon temperature senaor (MTS102, MTS103, or MTS105) provides preciae temperature-sensing accuracy over range of −40°C to +150°C. Sensor is essentially a transistor with base and collector leads connected together externally; base-emitter voltage drop then decreases linearly with temperature over operating range. Voltage change ia amplified by two opamps in series, operating from regulated output of MC7812 regulator. Opamp types are not critical. With Q1 at known temperature, adjust 50K pot to give output voltage equal to TEMP × 10 mV. Output voltage is then 10 mV per degree in desired temparature scale.—"Sllicon Temperature Sensors," Motorola, Phoenix, AZ, 1978, DS 2536.



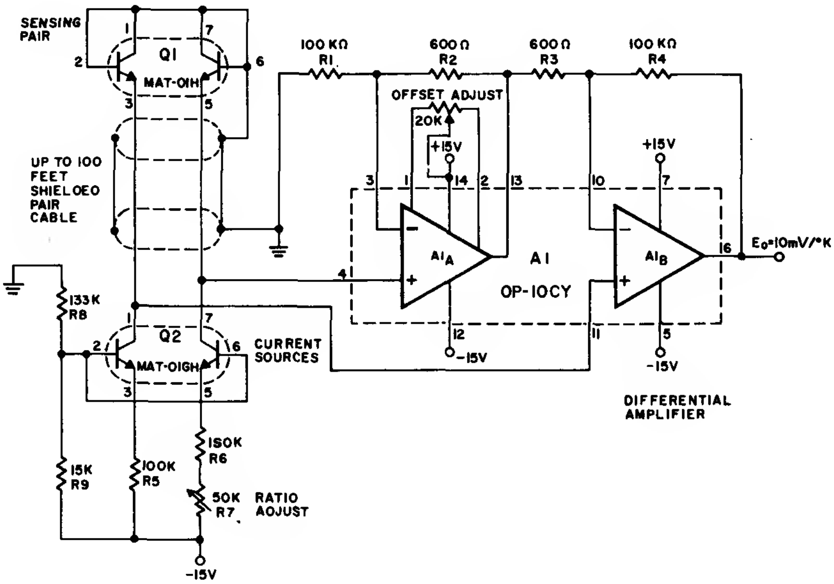
THERMOMETER—Sensor is 3911 IC whose output is 10 mV/K (kelvin temperature scale). At 0°C, output is 2.73 V. Output swing is amplified by 741 opamp to 0.1 V/°C for driving volt-ohm-milliammeter or sensitive milliammeter. R2 adjusts scaling factor, for readout in °C or °F as desired.—J. Sandler, 9 Projecta under $9, *Modern Electronics*, Sept. 1978, p 35–39.



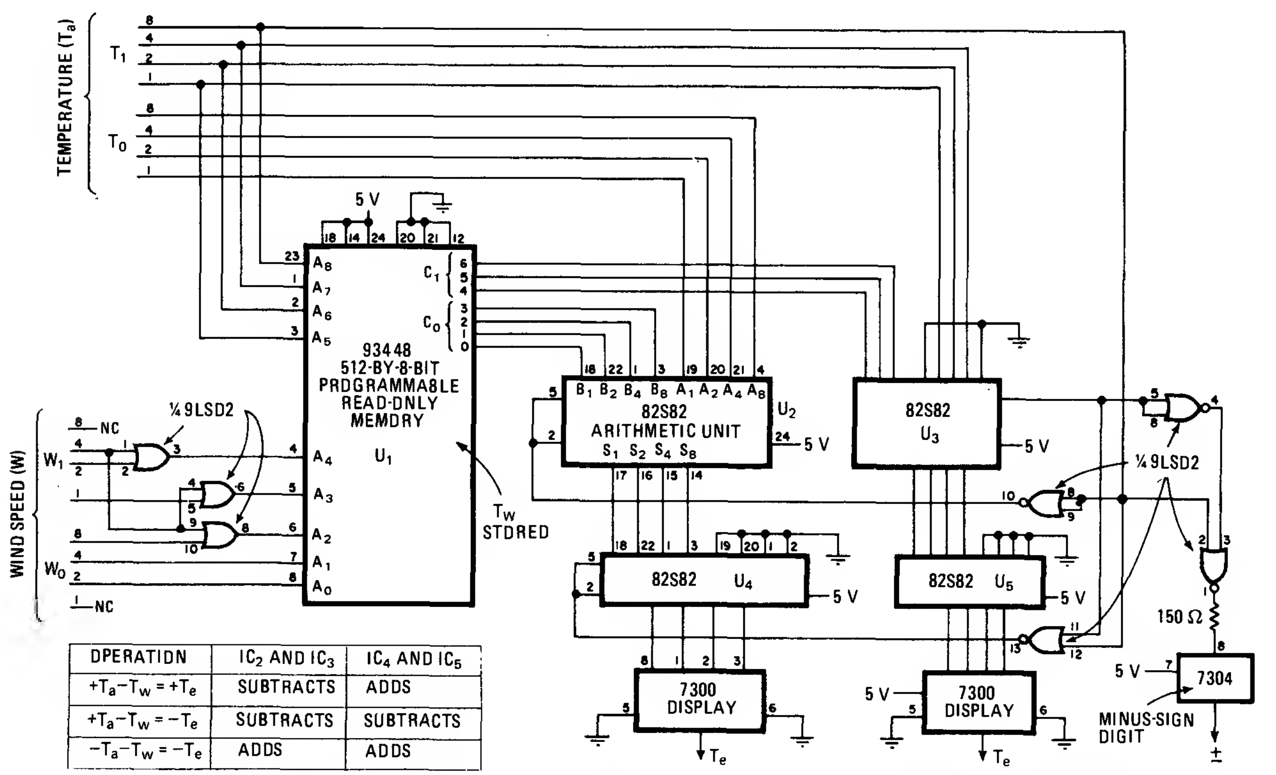
TEMPERATURE TO PULSE WIDTH—Temperature-dependent current through thermistor TH_1 develops voltage across R_1 that is comparad with fraction of increasing voltage across C_1 by 741 opamp. When output of opamp goes negative, it triggers 555 IC connected as mono MVBR, to turn transistor on for about 100 μs and discharge C_1. Circuit is basad on similarity between resistance-temperature curve of thermistor and Inverse function of voltage across capacitor charging through resistor. For values shown, circuit gives 650-μs pulse width at 0°C, increasing 20 μs per degree with accuracy of ±1.2°C up to 60°C. If IC output la used to gate clock oscillator, number of oscillator output pulaes will be directly proportional to temperature.—T. P. Y. Sander, Temperature to Pulse-Length Converter, *Wireless World*, Jan. 1977, p 76.



HOT-COLD METER—Output of unreferenced thermocouple drives meter through opamp that provides required gain, for monitoring temperature inside furnace when exact temperature value is not required. Meter is simply calibrated in terms of hot and cold.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.

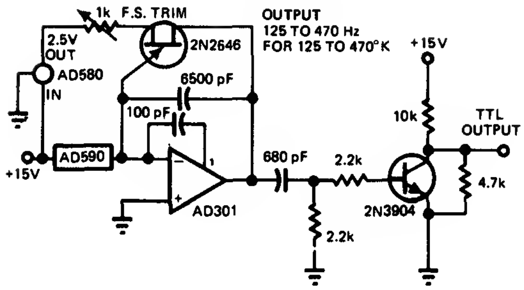


MATCHED-TRANSISTOR SENSOR—Precision Monolithics MAT-01H matched-transistor pair Q1 senses temperature over range of −55°C to +125°C with inherent linearity and long-term stability. Matched transistors Q2 (MAT-01GH) are current sources for sensing transistors. Transistor combination provides differential voltage output that is directly proportional to absolute temperature. Amplifier using OP-10CY changes this voltage difference to single-ended signal that can be used for measurement or control. Circuit will drive 10-V full-scale digital panel meter to give digital thermometer.—J. Simmons and D. Soderquist, "Temperature Measurement Method Based on Matched Transistor Pair Requires No Reference," Precision Monolithics, Santa Clara, CA, 1975, AN-12, p 4.

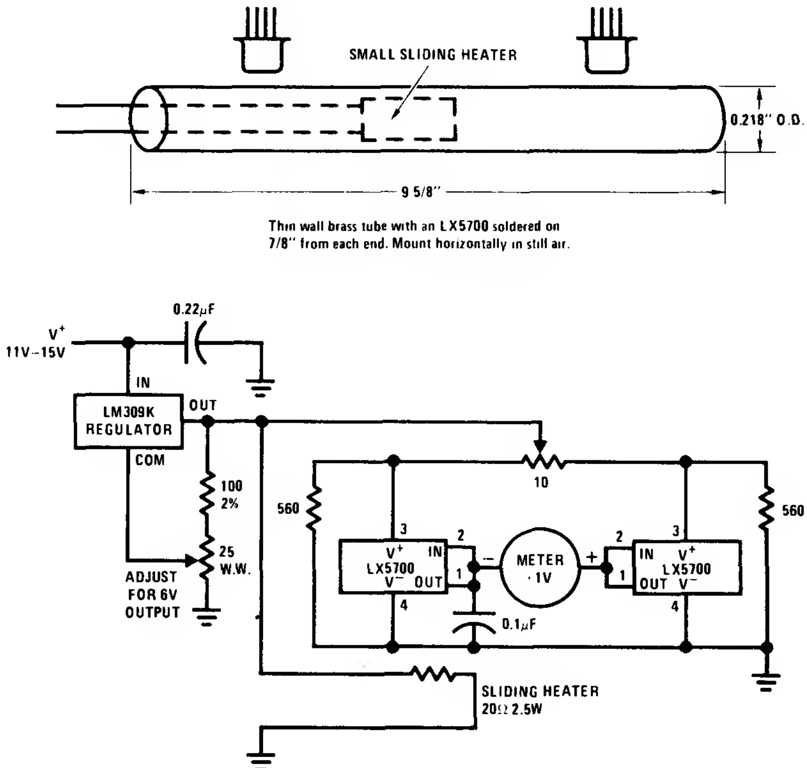


OPERATION	IC_2 AND IC_3	IC_4 AND IC_5
$+T_a-T_W=+T_e$	SUBTRACTS	ADDS
$+T_a-T_W=-T_e$	SUBTRACTS	SUBTRACTS
$-T_a-T_W=-T_e$	ADDS	ADDS

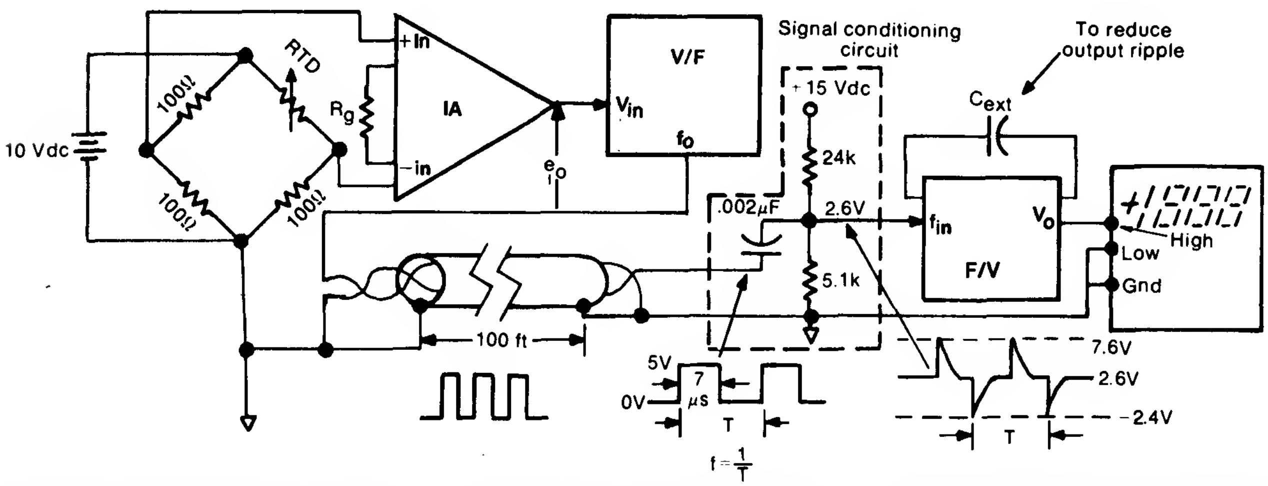
WIND-CHILL METER—Circuit measures and displays wind-chill equivalent temperature by combining air temperature and wind speed data. PROM is programmed to act in combination with arithmetic-logic units to generate output values corresponding to those of wind-chill temperature chart adopted by National Weather Service. Article gives listing of PROM contents.—V. R. Clark, PROM Converts Weather Data for Wind-Chill Index Display, *Electronics*, Jan. 5, 1978, p 158–159.



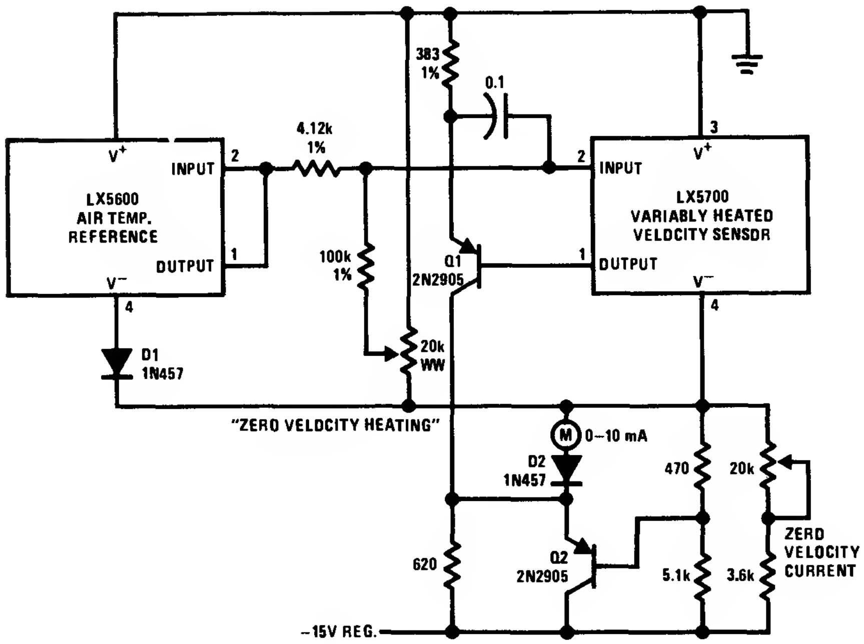
125–470 K GIVES 125–470 Hz—Use of AD590 current-ratioed differential-pair IC temperature transducer gives low parts count for temperature-to-frequency converter. Sensor controls AD301 opamp in relaxation oscillator, with negative-going output ramp being differentiated for driving single-transistor inverter giving TTL output.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine,* May 20, 1977, p 71–77.



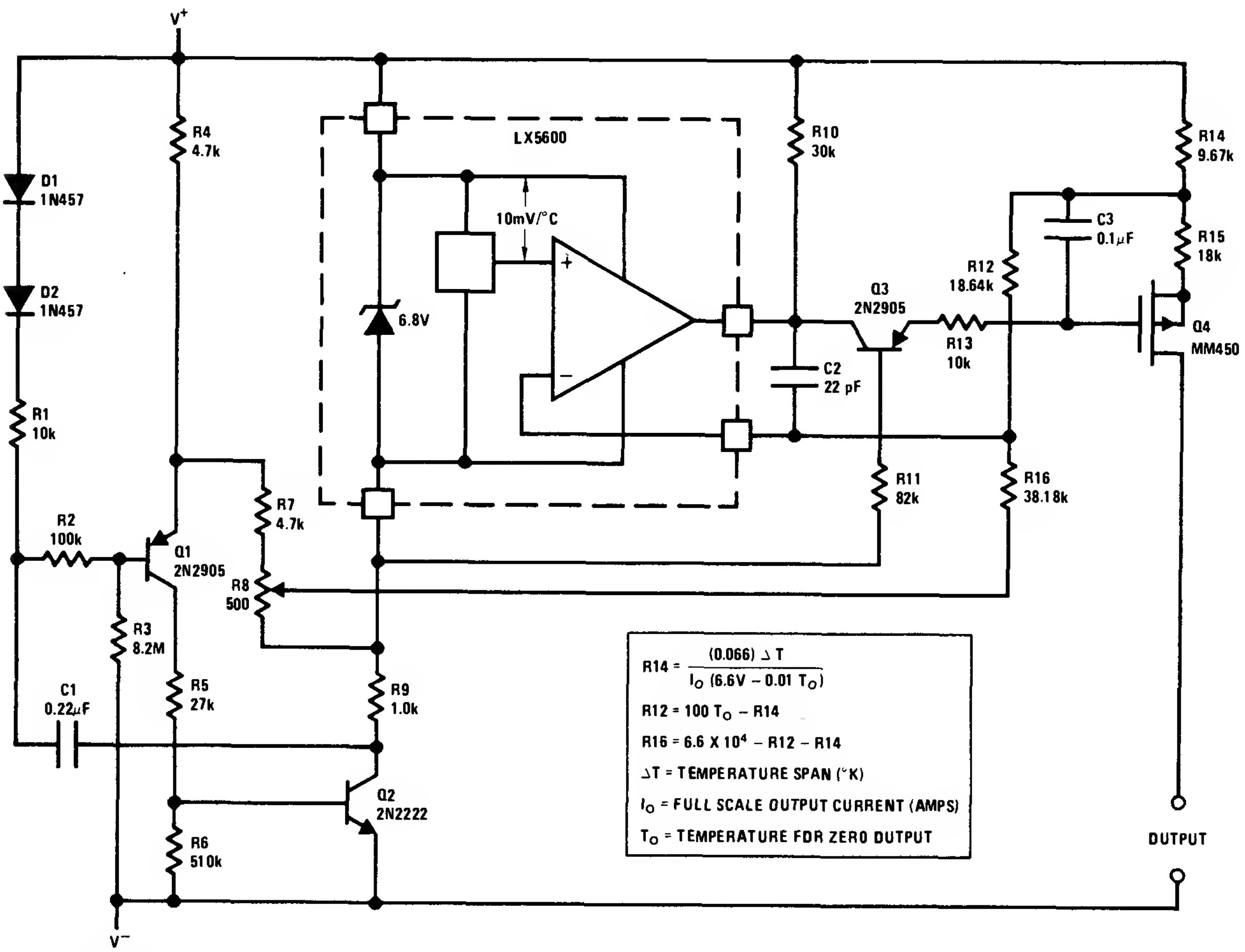
POSITION SENSOR—Position of small heating element sliding inside thin-wall brass tube is sensed by National LX5700 temperature transducer mounted outside of tube. With heater at center, transducers at both ends reach same temperature. With heater at one end of pipe, that transducer is about 50°C above ambient and other is near ambient. As heater moves toward one end, one thermometer becomes more sensitive and the other less. Circuit regulates heater power to keep position "gain" constant. Digital voltmeter gives average position. Applications include measuring average truck spring deflection while moving on rough road.—P. Lefferts, "A New Interfacing Concept; the Monolithic Temperature Transducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 9.



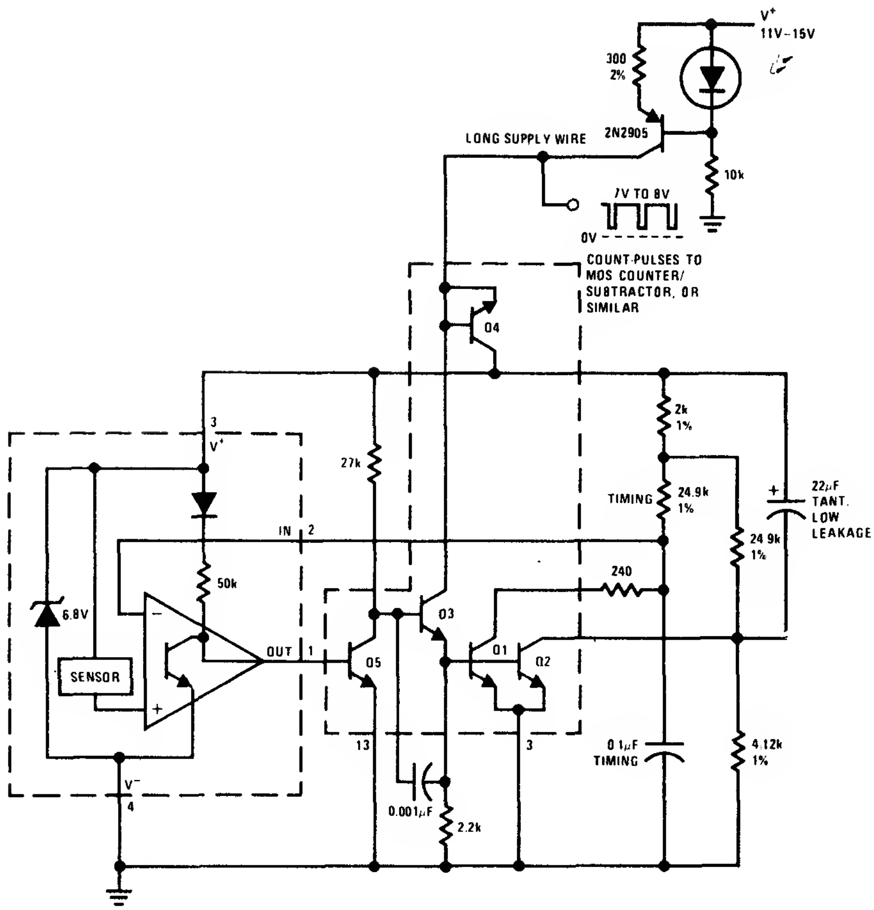
V/F AND F/V CONVERTERS FOR DPM—Signal transmitted as variations in frequency in 0–10 kHz range is converted back to voltage for driving digital panel meter to give indication of temperature value sensed by 100-ohm resistive thermal device (RTD) in bridge. V/F and F/V converters can be almost any commercial models designed for 0–10 V and 0–10 kHz. Instrument amplifier can be Datel AM201 or equivalent.—E. L. Murphy, Sending Transducer Signals over 100 Feet?, *Instruments & Control Systems,* June 1976, p 35–39.



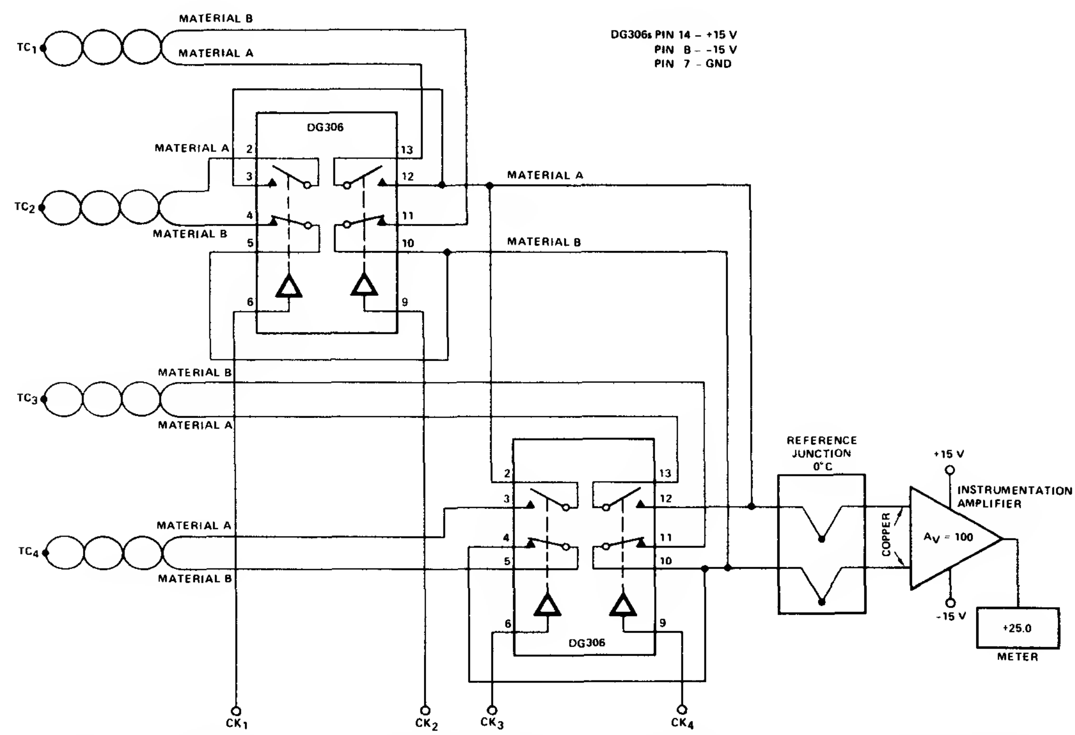
AIR VELOCITY METER—Uses National LX5600 air temperature reference, connected in unity-gain mode, in combination with LX5700 self-heated velocity sensor to convert wind velocity or airspeed to differential between heated and unheated transducers. As wind velocity rises, heating current required to hold velocity sensor predetermined number of degrees above ambient is measured. Calibration curve is drawn to show correlation between current and airspeed.—P. Lefferts, "A New Interfacing Concept; the Monolithic Temperature Transducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 8.



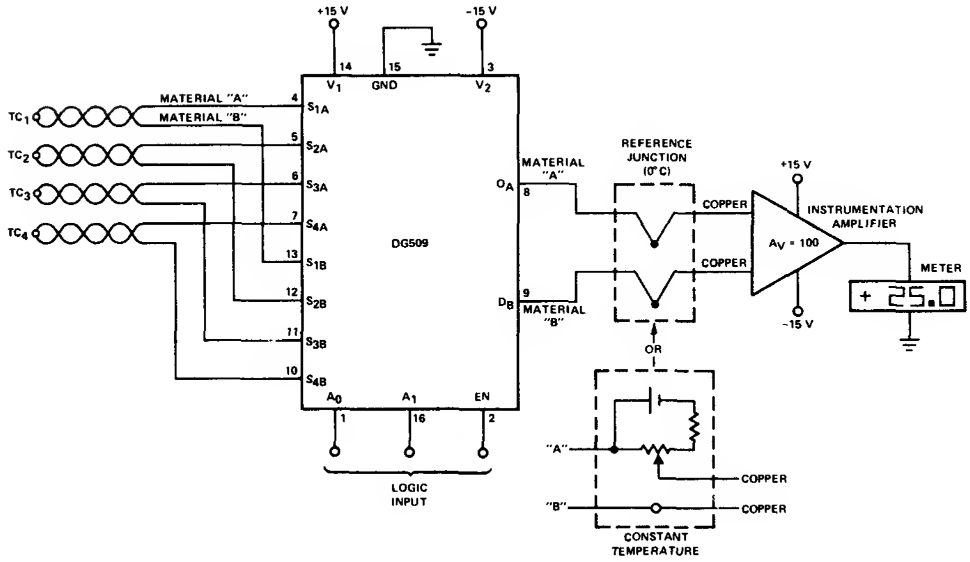
MICROPOWER THERMOMETER—Low power consumption makes circuit attractive for battery-operated equipment. Uses National LX5600 temperature transducer covering −55°C to +125°C, whose output is directly proportional to absolute temperature at 10 mV/K. Both zero and scale factor are independently selectable. Thermometer is pulsed at low duty cycle to reduce power consumption, with sample and hold used to obtain continuous output between pulses. Supply range is 8–12 V; 8.4-V mercury battery will give over 1 year of operational life. Output can be used to drive meter for direct readout. MVBR Q1-Q2 drives LX5600 through R9. C1 and R3 control OFF time, and C1, R1, R4, and R7 control ON time. Q3 is sample transistor. Output is 0–50 μA for 50–100°F temperature change. Formulas in box give values for other ranges.—R. C. Dobkin, "Micropower Thermometer," National Semiconductor, Santa Clara, CA, 1974, LB-27.



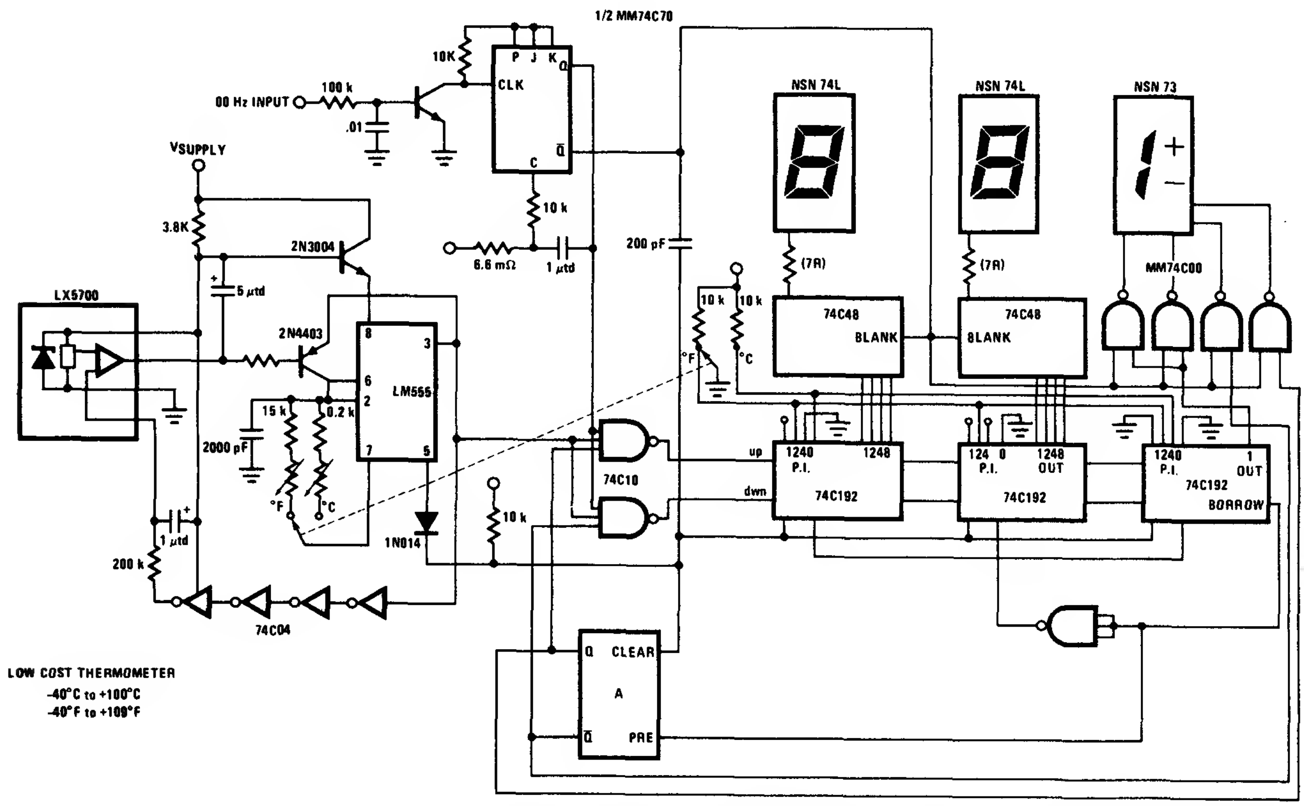
TEMPERATURE-TO-FREQUENCY CONVERTER—Transistors Q1-Q5 in National LM3046 transistor array form oscillator and ramp that together convert varying output voltages of LX5600 temperature transducer to proportional changes in frequancy of square-wave pulses for feed to pulse counter.—P. Lefferts, "A New Interfacing Concept; tha Monolithic Temperatura Trensducer," National Semiconductor, Sante Clara, CA, 1975, AN-132, p 4.



DIFFERENTIAL TEMPERATURE SENSOR—Responds to difference in temperatures of MTS102 ailicon high-precision temperatura sensors heving range of −40°C to +150°C. With both sensors et seme tempereture, 100K pot is edjusted so output voltage is 0.000 V. Opamp types are not criticel. R1 is 27K for maasurements in Celsiua or kelvin end 15K for Fahrenheit measuramants.—"Silicon Temparature Sensors," Motorole, Phoenix, AZ, 1978, DS 2536.

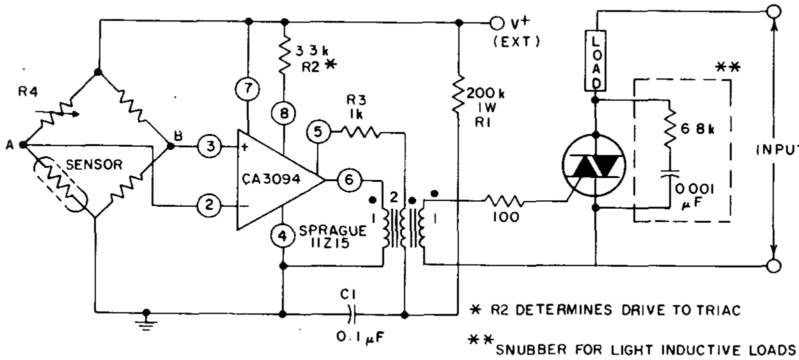


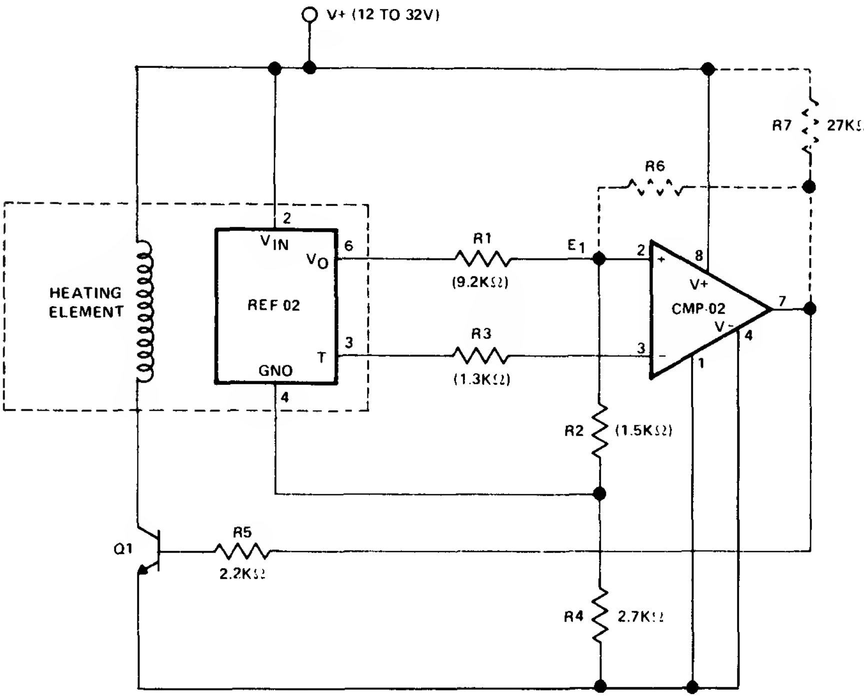
THERMOCOUPLE MULTIPLEXER—Undar control of logic Input, DG509 four-channel differential analog multiplexer connects selected one of four thermocouples to Instrumantation amplifiar driving digital or other readout. To decouple sensors from instrumentation amplifier, reference junction at 0°C can be used as shown. Altematively, bucking voltege can be set et room temperature, but this errangament will be sensitiva to changes In amblent temperature.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 7-77–7-78.



FAHRENHEIT/CENTIGRADE LED THERMOMETER—National LX5700 tampareture transducer provides Input for coda conversion circuit driving 3-digit LED display Indicating temparature range from −40°C to +100°C or −40°F to +199°F under control of ganged switch.—"Linear Applications, Vol. 2," National Semiconductor, Sante Clere, CA, 1976, LB-30.

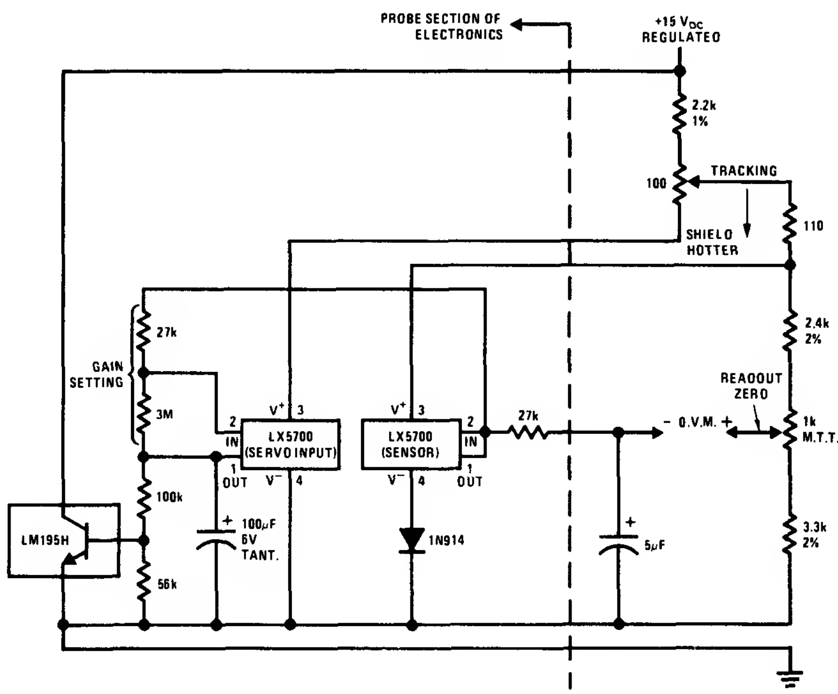
BRIDGE-TYPE SENSOR—CA3094 programmable opamp is connected as level-triggered MVBR at output of bridge, driving triac for temparature monitor or control applications. Sensor can be any temperature-dependent device. Load can be lamp, horn, or bell. For control applications, load is appropriate temperature-controlling device connected in feedback relationship to sensor.—"Circuit ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 10.



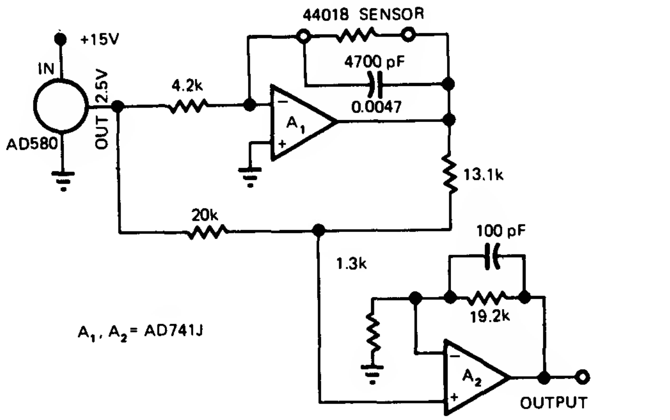


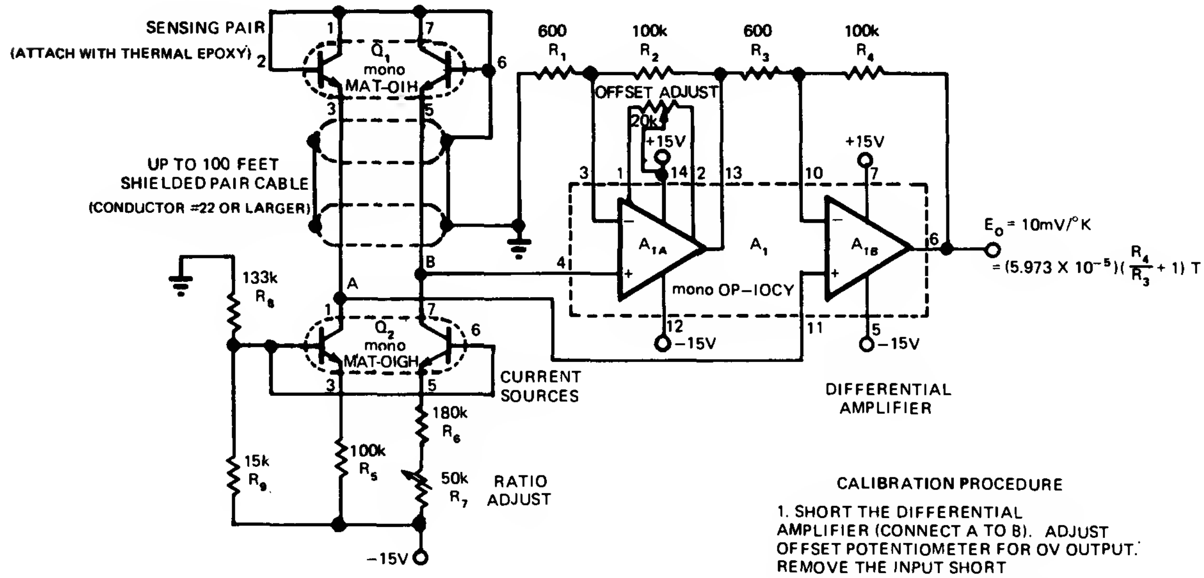
VOLTAGE-REFERENCE THERMOMETER—Precision Monolithics comparator CMP-02 turns on heating-element driver Q1 when temparature drops below set point determined by ratio of R1 to R2, as sensed by +5 V voltage reference REF-02 serving as thermometer. Circuit also provides adjustable hysteresis, determined by R6 and R7, if this feature is desired. Values in parentheses are for 60°C set point. REF-02 should be thermally connected to substance being heated. Design equations are given.—"Linear & Conversion I.C. Products," Precision Monolithics, Santa Clara, CA, 1977–1978, p 15-4.

SERVOED SHIELD FOR PROBE—Used when only part of temperature sensor can touch surface being measured. LM195H power transistor is main power amplifier and at same time serves as 23-W heater that is used to make copper shield track actual temperature of surface to be measured. Uses National LX5700 sensors. Diode in series with ground leg of one sensor permits adjusting pin 3 of that sensor over range of 40–80 mV to make it track with servo thermometer. Digital voltmeter is used to read temperature directly in degrees C.—P. Lefferts, "A New Interfacing Concept; the Monolithic Temperature Transducer," National Semiconductor, Santa Clara, CA, 1975, AN-132, p 6.



0–100°C WITH 0.15° ACCURACY—Low-cost YSI 44018 temperature sensor in feedback loop of 741J opamp gives accuracy approaching that of platinum sensors. Opamp is driven by AD580 band-gap reference. Voltage output of A_1 feeds similar opamp that provides zeroing and sets desired output gain.—J. Williams, Designer's Guide to: Temperature Measurement, *EDN Magazine*, May 20, 1977, p 71–77.



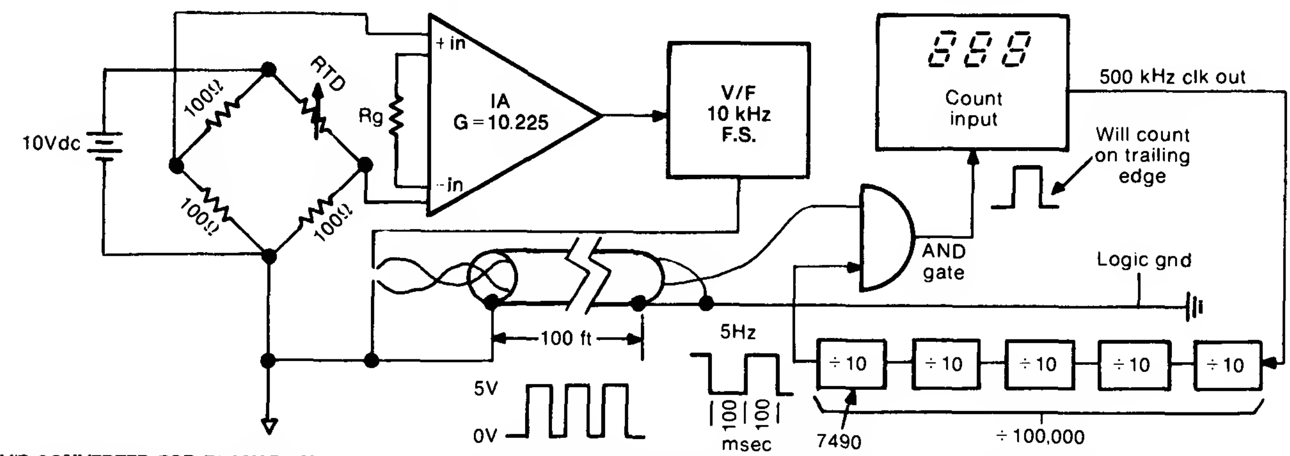


R_1, R_2, R_3, R_4: 0.01%, GENERAL RESISTANCE ECONISTOR
R_5, R_6 : 0.1%, GENERAL RESISTANCE ECONISTOR
R_7, R_{10} : 10%, BOURNS TYPE 3006P
R_8, R_9 : 1%, TYPE RN55C

CALIBRATION PROCEDURE

1. SHORT THE DIFFERENTIAL AMPLIFIER (CONNECT A TO B). ADJUST OFFSET POTENTIOMETER FOR 0V OUTPUT. REMOVE THE INPUT SHORT
2. WITH SENSING PAIR AT KNOWN TEMPERATURE (e.g. ROOM TEMP.), ADJUST RATIO POTENTIOMETER FOR CORRECT OUTPUT READING.

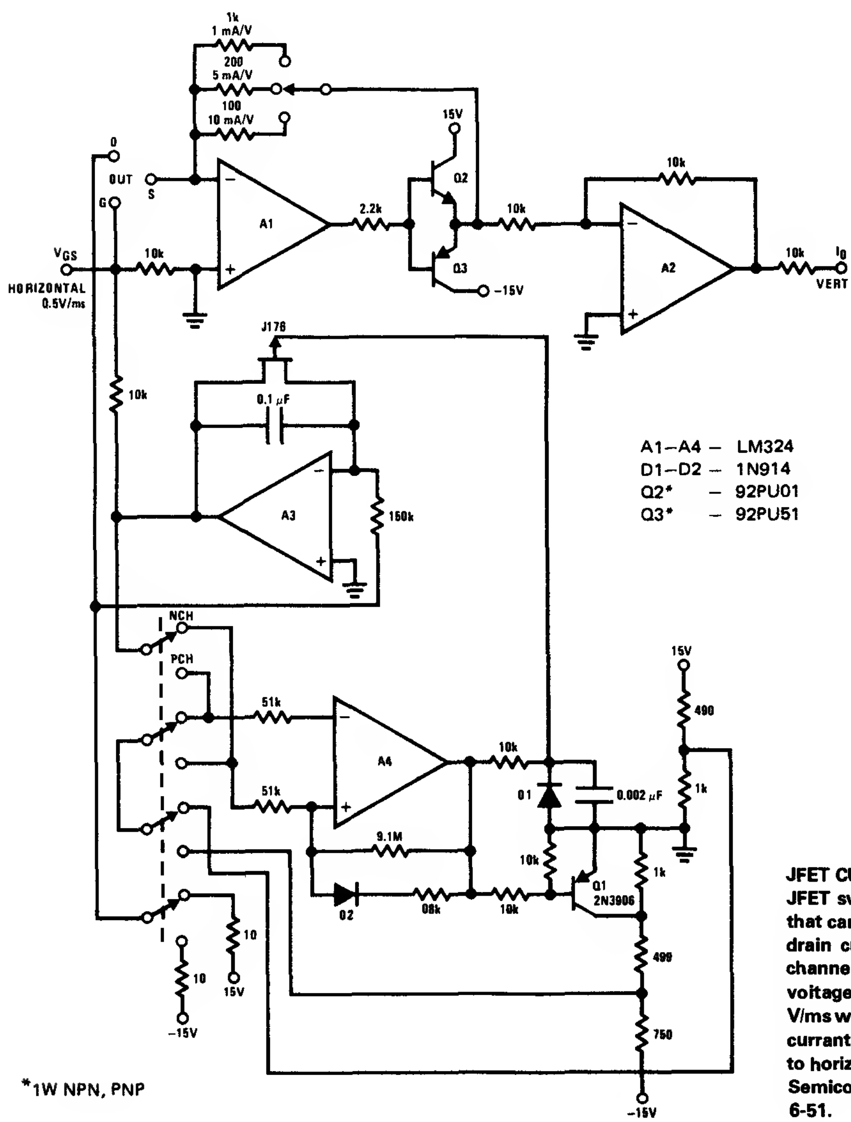
±1 K ACCURACY FOR −55 to +125°C—Matched transistor pairs and opamps give high-accuracy temperature-measuring system that is easy to calibrate, has long-term stability, and can operate with sensor transistor pair up to 100 feet from rest of circuit. Common-mode rejection at amplifier input is greater than 100 dB. Output voltage is +2.18 V at −55°C (218 K), increasing to +3.98 V at +125°C (398 K).—J. Simmons and D. Soderquist, Temperature Measurement Method Requires No Reference, *EDN Magazine*, Aug. 5, 1974, p 78 and 80.



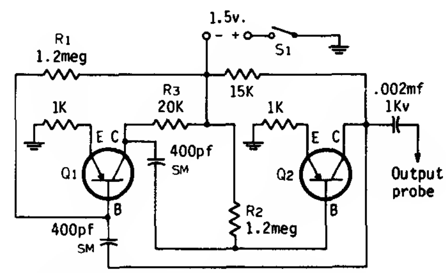
V/F CONVERTER FOR TRANSDUCER—Output of low-level transducer such as temperature bridge can be transmitted reliably over long wires (100 feet or more) in aerial form if changes in 100-ohm resistive thermal device (RTD) are converted to corresponding changes in frequency with almost any commercially available V/F converter. Typical converter has 0–10 V full-scale analog input and 0–10 kHz output. If 5 V is applied to input, output pulse train will have rate of 5 kHz ± 0.5 Hz, which can be counted for 1 s or less and displayed on digital readout to show analog value. Instrument amplifier can be Datel AM201 or equivalent.—E. L. Murphy, Sending Transducer Signals over 100 Feet?, *Instruments & Control Systems*, June 1976, p 35–39.

CHAPTER 95
Test Circuits

Includes variety of circuits for checking diodes, transistors, opamps, ICs, coils, crystals, filters, and power supplies, along with curve tracers, signal injectors, signal tracers, power peak meter, printed-circuit ammeter, and pseudorandom digital generator.

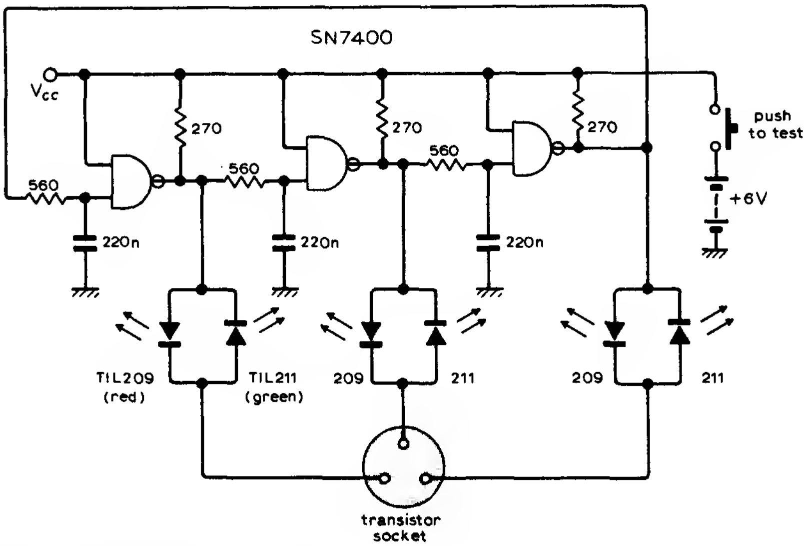


*1W NPN, PNP

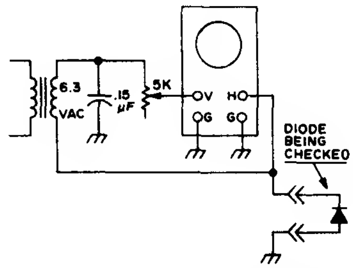


AF SIGNAL INJECTOR—Can be built into penlight housing, using single penlight cell or 1.5-V mercury cell for power. Output probe for feeding signal to audio circuit under test is about 1-inch length of stiff wire, pointed. For more output, run ground lead to equipment under test. Q_1 can be HEP253, 2N519, 2N741A, 2N2929, or equivalent. Q_2 can be HEP3, 2N1280, 2N2273, SK3005, or equivalent. Adjust R_1 and R_2 for good output, and adjust R_3 as required for good tone. To use, touch probe to input of any receiver or high-fidelity audio circuit. Tone should be heard from loudspeaker if circuit is good between probe and loudspeaker.—C. J. Schauers, Transistorized Signal Tracer, *CQ*, Sept. 1973, p 12 and 14.

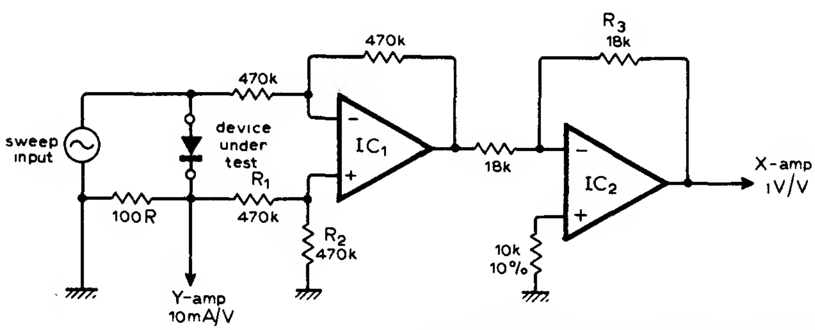
JFET CURVE TRACER—Quad opamp and J176 JFET switch form basis of simple curve tracer that can be used with any CRO. Circuit displays drain current versus gate voltage for both P-channel and N-channel JFETs at constant drain voltage. Sweep time is 10 ms. Sweep rate is 0.5 V/ms with maximum gate voltage of ±5 V. Drain current is fed to vertical input and gate voltage to horizontal input.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-50–6-51.



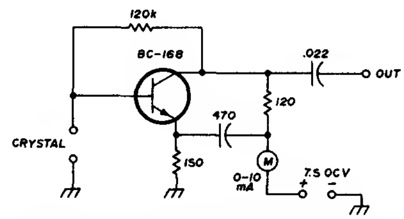
TRANSISTOR/DIODE TESTER—Checks for polarity, shorts, and opens in one measurement, using six LEDs as indicators. Circuit derives three-phase waveform from 2-kHz ring-of-three oscillator for application to device under test through LEDs. Oscillator waveform serves to make each pair of device terminals forward, reverse, and unbiased in turn for one-third of a cycle. Current flowing into device turns on red LED, and current flowing out turns on green LED, to indicate polarity and position of base lead.—N. E. Thomas, Semiconductor Tester, *Wireless World*, March 1977, p 43.



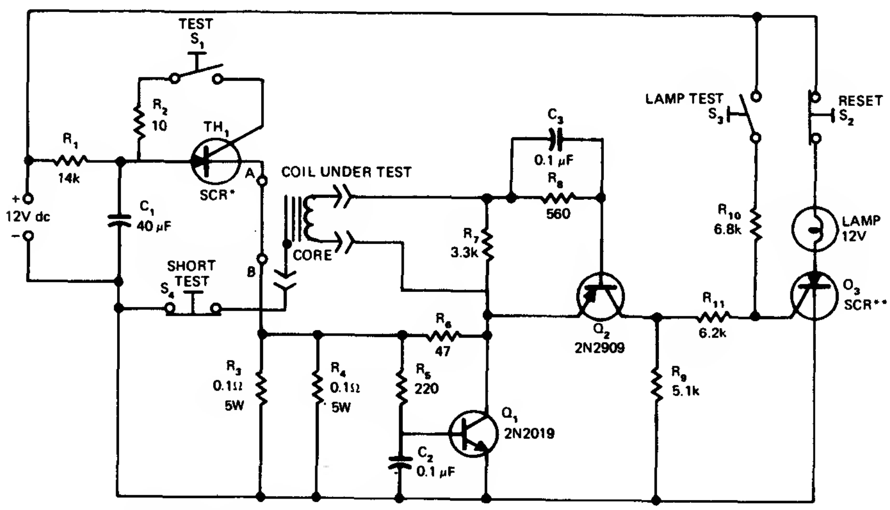
CHECKING DIODES WITH CRO—Simple oscilloscope setup checks and matches diodes. Sort diodes according to type, set pot to give desired trace size for good diode, then note relative sizes of traces obtained for unknown diodes. Reject diodes showing fuzz or ripple on oscilloscope trace.—Novice Q & A, *73 Magazine*, March 1977, p 187.



DIODE CURVE-TRACER—Circuit is designed to produce voltage-current characteristic curve of diode or other two-terminal device on oscilloscope. Sweep input can be any low-voltage AC source, such as 20-V Variac. Three-terminal devices may be traced if suitable external bias is provided. Opamps are 741.—S. Cahill, Diode Curve Tracer for Oscilloscope, *Wireless World*, Feb. 1976, p 76.

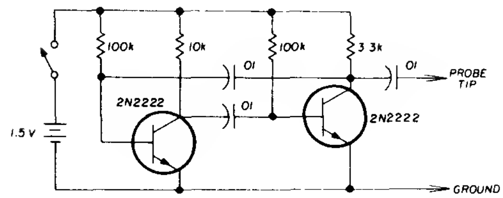


CRYSTAL CHECKER—Simple oscillator circuit checks crystal activity and resonant frequency, as required when choosing matched crystals for filters. For frequency check, signal from oscillator is injected into frequency counter. Values shown are for crystals around 5.5 MHz. For matching purposes, higher accuracy is obtained by reading harmonics of oscillator.—J. Perolo, Practical Considerations in Crystal-Filter Design, *Ham Radio*, Nov. 1976, p 34–38.

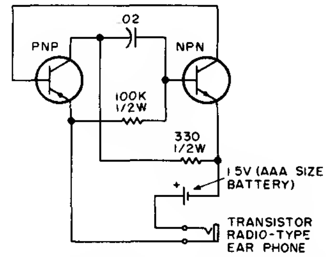


*Motorola-type Silicon Control Rectifier (SCR) or equivalent.
**Any SCR that can handle lamp-current requirements.

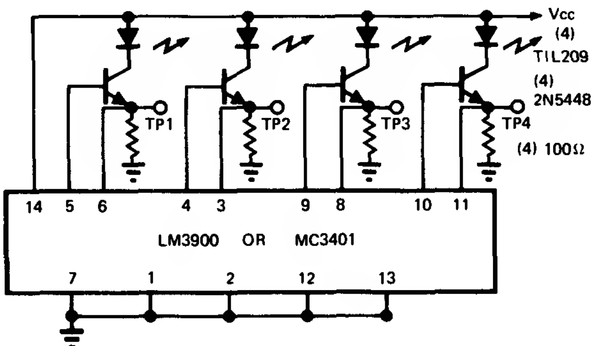
SEALED-COIL TESTER—Permits rapid nondestructive testing of hermetically sealed coils for shorted or open turns, coil-to-core shorts, and reversed polarity of connections. Can be used for simultaneous testing of all coils in recording heads for up to 18 tracks. Circuit develops test pulse having predetermined polarity, amplitude, and duration. Article gives details of circuit operation and test procedures. With multiple-coil units, lamp and detector circuit must be provided for each coil.—D. L. Uhls, Novel Method Nondestructively Tests Sealed Coils, *EDN Magazine*, March 20, 1976, p 102 and 104.



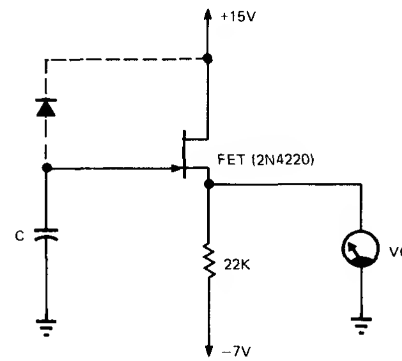
SIGNAL INJECTOR—Circuit is basically 1-kHz MVBR having high harmonic output through 50 MHz. Used with signal tracer for troubleshooting audio equipment. Practically any NPN transistors can be used. Article gives troubleshooting techniques for all types of equipment.—M. James, Basic Troubleshooting, *Ham Radio*, Jan. 1976, p 54–57.



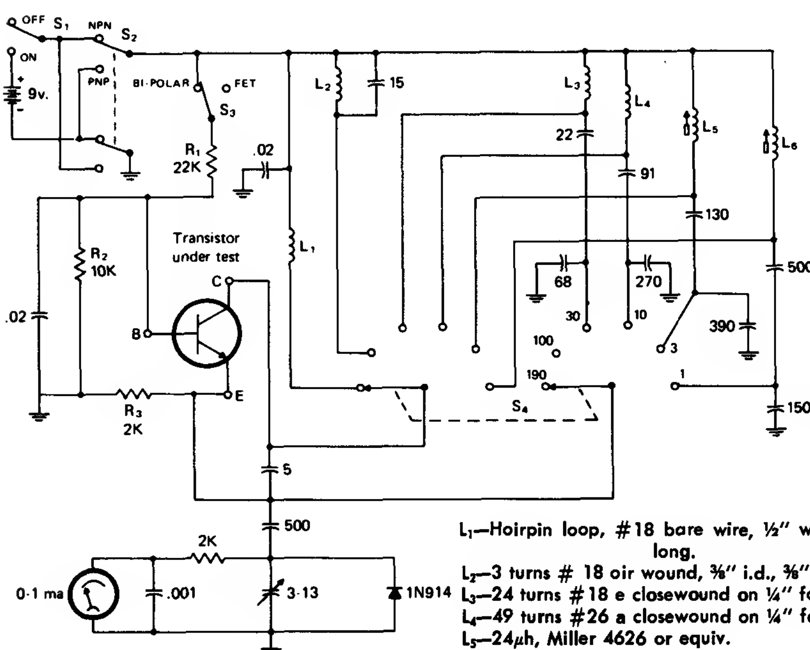
TRANSISTOR-TESTING OSCILLATOR—With any good general-purpose transistor, circuit delivers steady AF tone to earphone. To test another transistor, substitute it in appropriate socket. No tone means it is bad. Low tone or chirp indicates questionable condition. If type (PNP or NPN) is unknown, try in both sockets. If leads of unknown cannot be identified, try all three possible positions in socket.—Circuits, *73 Magazine*, July 1977, p 35.



MATCHING OPAMPS—Simple circuit checks condition of quad Norton opamps (National LM3900 or Motorola MC3401). Can also be used to match or select devices for similar DC characteristics in critical applications. Amplifier under test is plugged into socket connected as shown. Good unit makes all four LEDs glow with about same brightness, and all four test-point voltages will agree within about 2 mV. If one section of amplifier is damaged, associated LED will glow very brightly or not at all. Wide variations between test-point voltages indicate partial damage. For critical applications, select amplifiers by matching average test-point voltages.—R. Tenny, Check Norton Amplifiers Quickly, *EDN Magazine*, March 5, 1974, p 72.

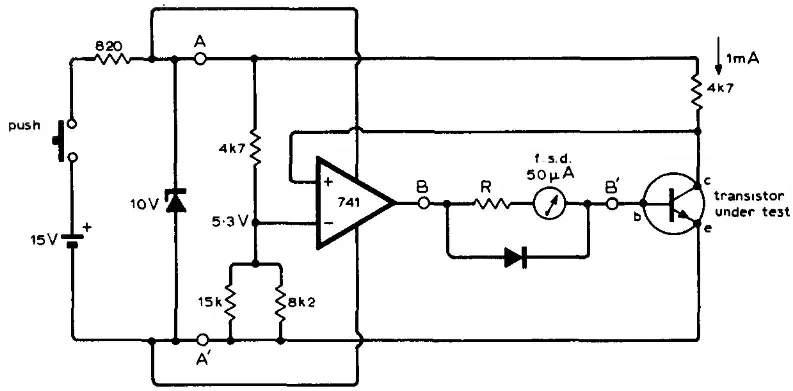


DIODE AND FET LEAKAGE—FET under test is connected with 22K resistor as source follower, with capacitor C across input from gate to ground. Leakage of FET charges capacitor at rate directly proportional to leakage and inversely proportional to capacitance. With 0.01 μF for C, each volt of change across C indicates stored charge of 10^{-8} coulomb. This can be interpreted as current in amperes if time for voltage on capacitor to rise 1 V is measured with stopwatch or timer while watching voltmeter. To test diode, connect as shown by dashed line and use good FET in circuit as shown. Article gives design equations; if voltage across C rises 1 V in 38.7 s, leakage current is 0.258 nA.—D. Diletush, Leakage Testing of Diode and JFETs, *EDN Magazine*, May 5, 1973, p 72–73.

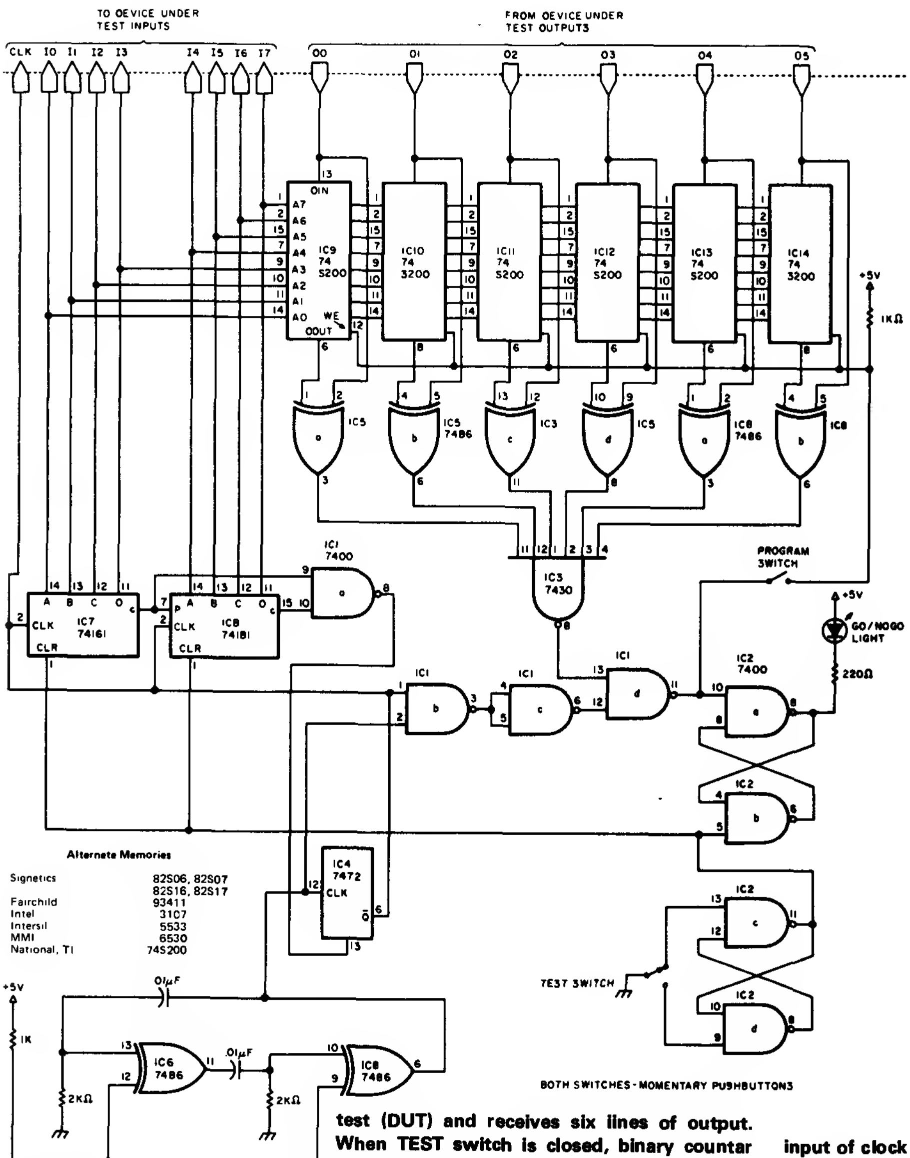


L₁—Hairpin loop, #18 bare wire, ½" wide, 1⅝" long.
L₂—3 turns # 18 air wound, ⅜" i.d., ⅜" long.
L₃—24 turns #18 e closewound on ¼" form.
L₄—49 turns #26 e closewound on ¼" form.
L₅—24 μh, Miller 4626 or equiv.
L₆—62 μh, Miller 4630 or equiv.

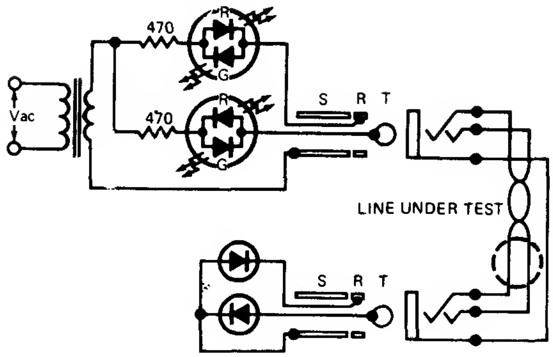
RF TRANSISTOR TESTER—Tells if unknown bipolar or FET transistor is AF, RF, or VHF and whether it is NPN or PNP. Transistor to be tested is placed in frequency-switchable oscillator circuit, and amplitude of oscillation is noted on meter. Highest oscillation frequency corresponds to highest amplification frequency. Six switch positions cover frequency range of 1 to 190 MHz.—F. Brown, An R.F. Transistor Tester, *CQ*, April 1975, p 35–36 and 66.



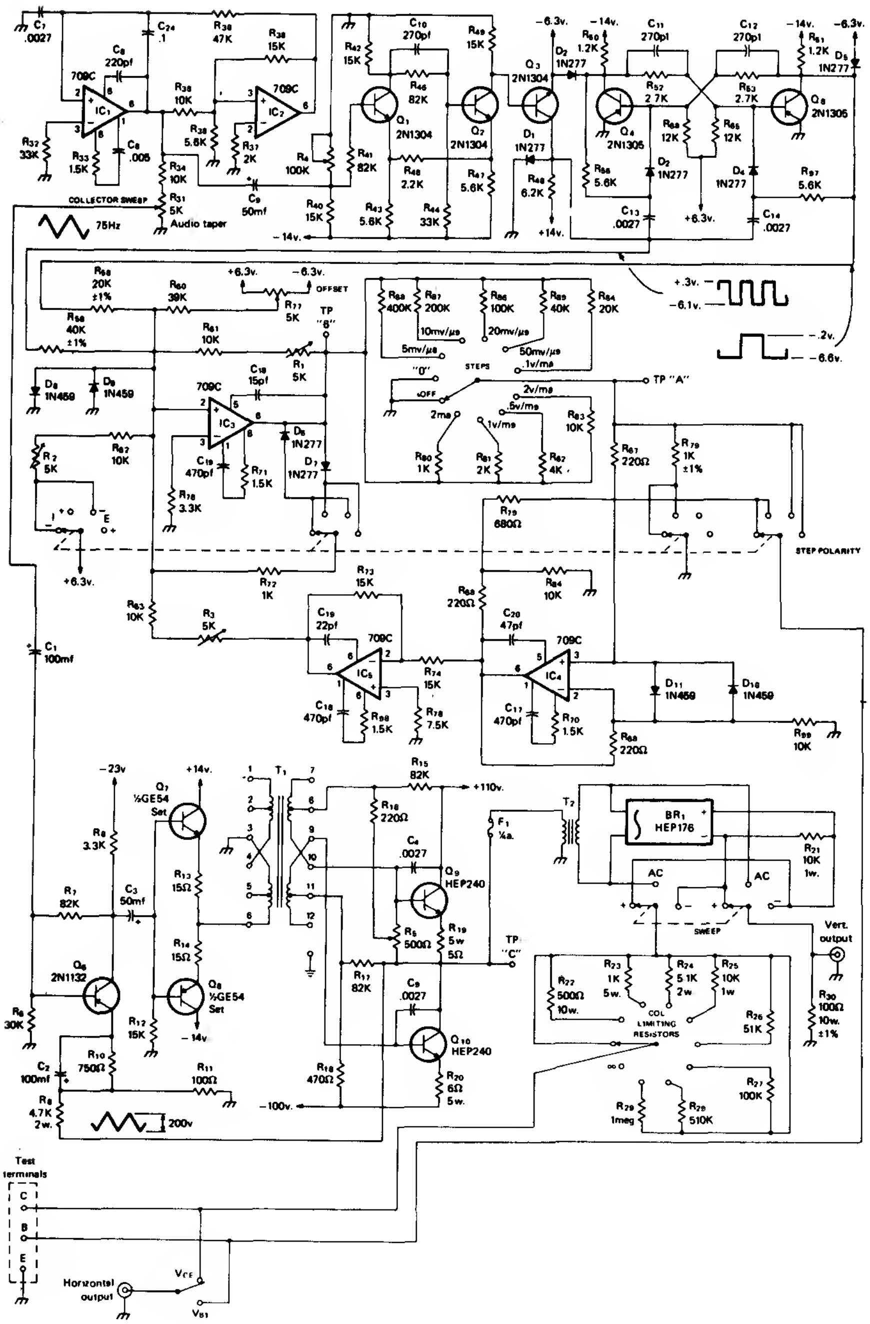
SINGLE-OPAMP TRANSISTOR TESTER—Meter scale is calibrated to read transistor gain directly for NPN devices. Addition of switch for reversing supply and meter polarities permits testing PNP devices as well. When reference voltage of 741 opamp is 5.3 V, circuit passes sufficient base current to make collector current 1 mA. Gain of transistor is then 1 mA divided by base current in microamperes; thus, 50-μA point on meter scale is marked for gain of 20 (1,000 divided by 50). Gain is 400 at 2.5 μA.—A. Rigby, Direct-Reading Transistor Tester, *Wireless World*, Aug. 1976, p 52.



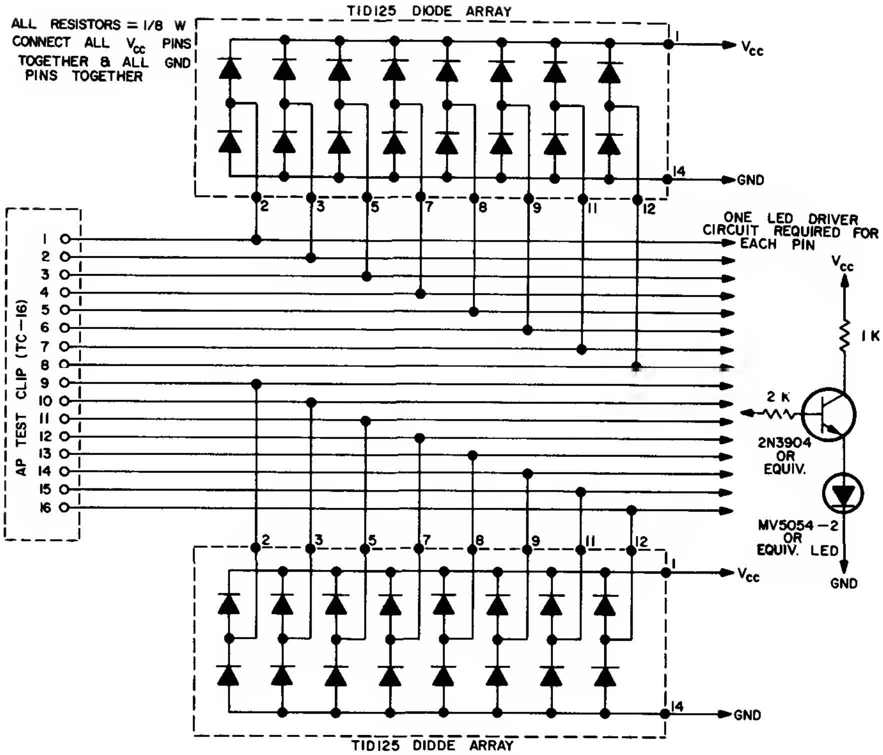
PROGRAMMABLE IC TESTER—Provides automatic, instantaneous, and exhaustive tests of most small-scale integration gates, inverters, flip-flops, etc, and medium-scale integration counters, latches, shift registers, etc. Circuit sends eight lines of input data to device under test (DUT) and receives six lines of output. When TEST switch is closed, binary counter driving DUT input lines is cleared and flip-flop driving GO/NO-GO light is set. Upon release of switch, counter increments through all 256 input conditions. Between counts, data on output lines is compared with data stored in memories IC9-IC14. If mismatch exists, GO/NO-GO flip-flop is cleared at terminal count, CLEAR input of clock oscillator flip-flop is driven low, and further counts are inhibited until TEST button is pushed again. If GO/NO-GO light stays on, component passes test. To program, hold PROGRAM button down while testing known good device. Article gives examples of various applications.—M. Thorson, A Programmable IC Tester, *BYTE*, June 1978, p 28, 30, 32, and 35.



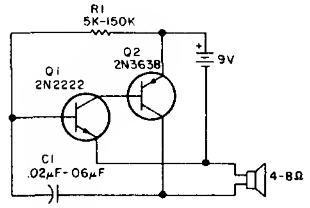
AF LINE TESTER—Gives complete check of shielded twisted-pair cable in one operation, indicating short-circuits between conductors and providing positive continuity check of each conductor. Tester using polarity-sensitive bicolor LEDs is connected to one end of cable under test, and two-diode plug is patched in at other end. If cable is good, only green LEDs come on. If a conductor in cable is open, one or both green LEDs will be off. One or both red LEDs will light for short between any combination of conductors or if cable is wired incorrectly. Signal diode types are not critical.—W. L. Mahood, Tester for Balanced Audio Lines, *EDN Magazine*, April 5, 1974, p 80 and 82.



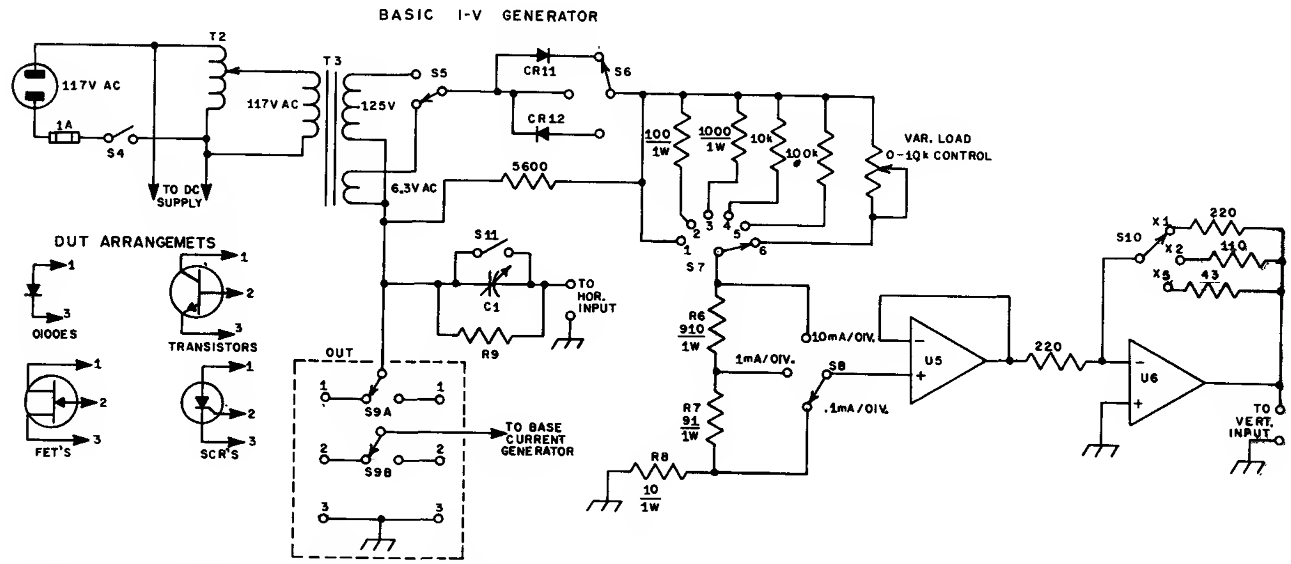
HIGH-ACCURACY CURVE TRACER—Can be used with any calibrated CRO, for matching and testing transistors or diodes by comparing performance curves. All opamps are 709C. Triangle wave generated by IC_1-IC_2 is fed to Schmitt trigger Q_1-Q_2, which generates square wave having transitions at zero voltage crossings of input triangle. Q_3 clamps square wave to 6.3 V P-P. Flip-flop Q_4-Q_5 generates same square wave but at half the frequency of triangle wave. Combining square waves gives three-step staircase voltage having steps precisely in phase with zero signal crossings of triangle wave. T_1 is UTC A-20 audio transformer, and T_2 is Stancor P-6411 15-W 1:1 isolation transformer. Article covers construction, alignment, and use, and gives circuit of suitable regulated supply operating from ±110 and ±6.3 V available in AN/USM-140C military version of Hewlett-Packard 170 CRO.—A. J. Klappenbarger, An Accurate Solid State Component Curve Tracer, *CQ*, July 1974, p 20–24 and 82.



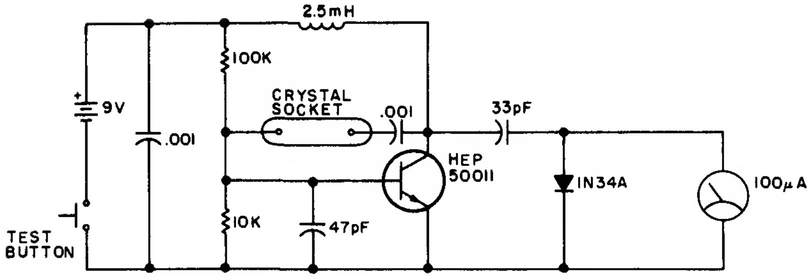
IC TEST CLIP—Provides in-circuit testing for ell types of 16-pin ICs. LED array indicetes logic status of each IC pin. Circuit uses Texas Instruments TID125 diode arrays on test clip to determine pin with highest voltage (V_{CC}) end pin with lowest voltage (GND). These pins ere then used to supply power to LEDs. No batteries ere needed. Position of clip on IC is unimportent. On 14-pin ICs, disregerd LEDs for two unused pins. Circuit can ba expanded for 24- or 40-pin ICs, although adding LEDs makes clip more difficult to usa.—J. Errlco and R. Baker, Powerless IC Test Clip, *BYTE*, Dec. 1975, p 26–27.



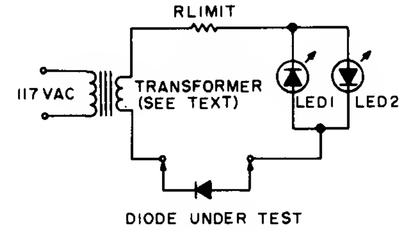
TRANSISTOR PIN-FINDER—Simple eudio oscillator is assembled as shown end veiues of R1 and C1 edjusted for desired tone. General-purpose transistor to be tested is then substituted in circuit (NPN for Q1 or PNP for Q2) end rotated in socket until oscillator works agein; plns then correspond to those of the good transistor. If oscilletor wili not work in any of three possibie positions, transistor under test is bed.—Circuits, *73 Magazine*, July 1977, p 34.



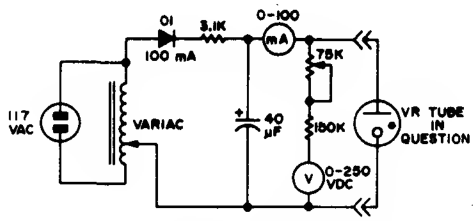
TRANSISTOR CURVE TRACER—When fed with staircase waveform of base-current generator, circuit generates series of current-voltage (I-V) curves as function of basa currant, for transistors and other three-terminel semiconductor devices. Cathode follower U5 and inverting controlled-gein amplifier U6 can be elimineted if correct sense of current indication is not essentiel. S11 switches multiplier R9 in end out; R9 is 18 megohms (about 9 times input resistance of CRO). C1 is 7–13 pF mica trimmer. Diodes are 1N4822. U5 and U6 ere Fairchild 741. T2 is Knight 54A3800 or equivelent variebie autotrensformer rated 1 A. T3 is Knight 54A1410 or equiveient power trensformer with 125-V 15-mA end 6.3-V 0.6-A secondaries.—R. P. Ulrich, A Semiconductor Curve Trecer for the Amateur, *QST*, Aug. 1971, p 24–28.



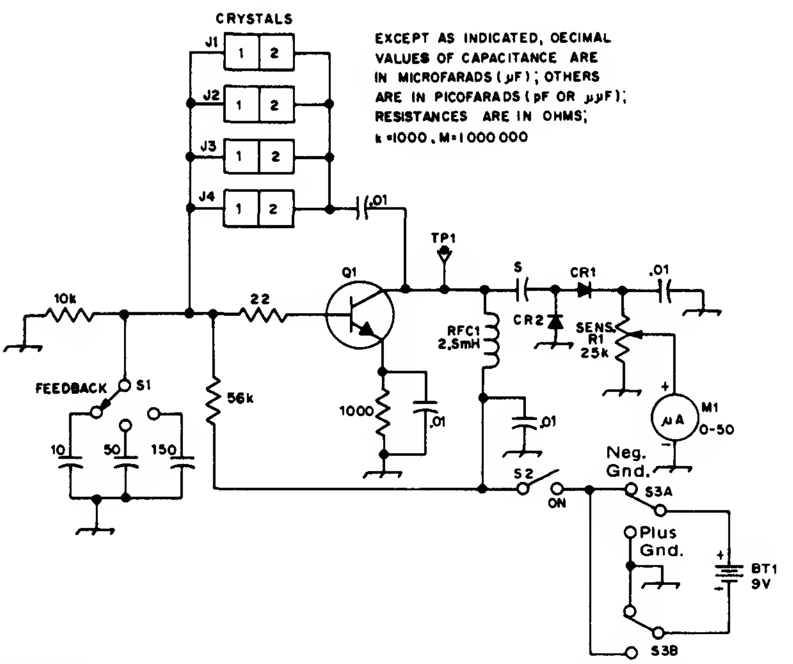
POCKET-SIZE CRYSTAL CHECKER—Provides quick check of condition when shopping for used or surplus crystals. Meter gives steady indication at about half scale when test button is pushed, if crystal is oscillating properly.—Circuits, *73 Magazine*, April 1977, p 164.



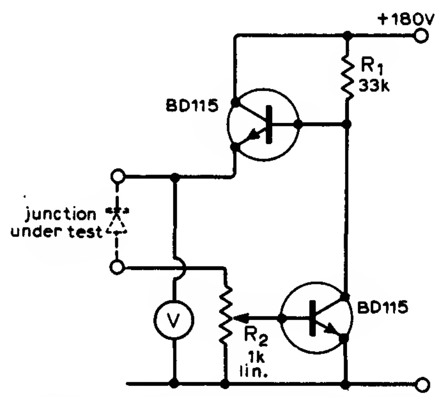
DIODE CHECKER—Requires only one resistor, two LEDs, and any small power transformer providing 3 to 25 VAC. If diode under test is open, neither LED lights. If diode is shorted, LED1 lights on one half-cycle and LED2 on other half-cycle, so both appear lit continuously. If diode is good, LED1 will light if anode of diode is toward transformer, and LED2 will light for other polarity of diode. Choose resistor to limit current through LEDs to about 10 mA.—M. D. Kitchens, Ultra Simple Diode Checker, *73 Magazine*, Oct. 1977, p 44–46.



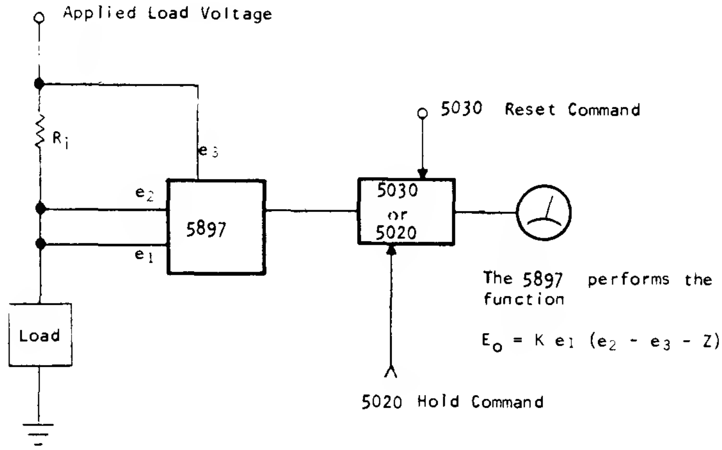
VR TUBE CHECKER—Increase output voltage of Variac gradually until VR tube fires, then read milliammeter and voltmeter. Good tubes will fire at their rated voltage and current values.—Circuits, *73 Magazine*, May 1977, p 31.



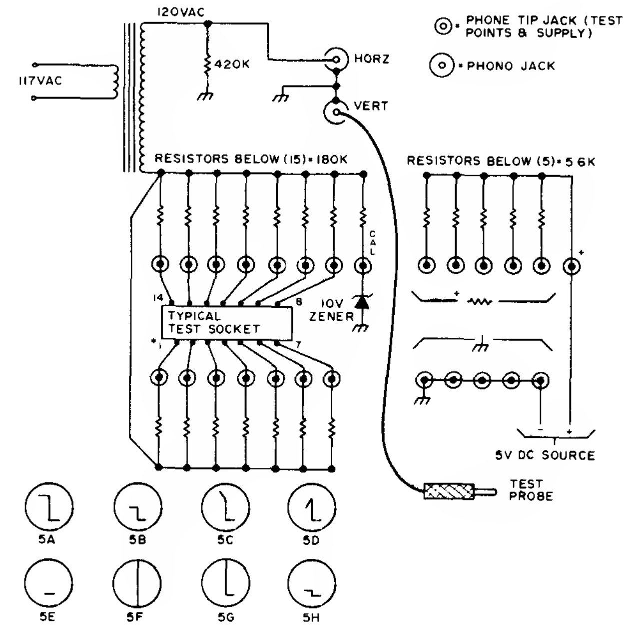
PORTABLE CRYSTAL TESTER—Pierce oscillator using 2N4124, MPS3563, or HEP53 NPN transistor gives indication of crystal activity on M1, from upper HF range down to at least 455 kHz. Increase feedback capacitance with S1 for lower frequency. Choose sockets J1-J4 for types of crystals to be tested. With known good crystal, circuit can also be used for checking bipolar transistors, with S3 providing correct polarity. Diodes are 1N34A germanium or equivalent.—D. DeMaw and C. Greene, A Pair of Handy Testers, *QST*, May 1973, p 24–27.



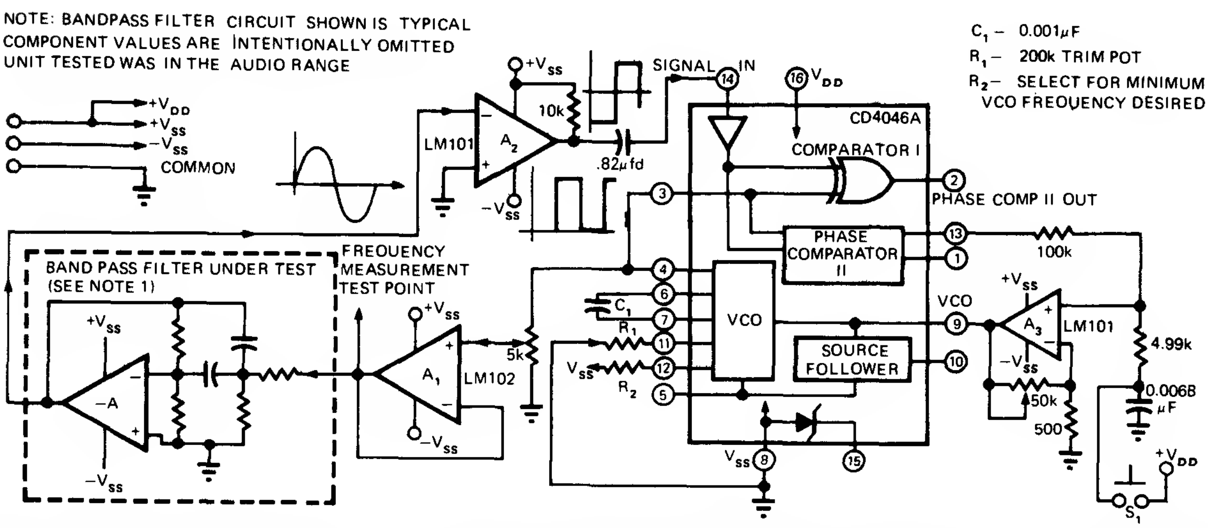
TRANSISTOR BREAKDOWN TESTER—Simple circuit measures breakdown voltages of most types of small-signal and power transistors, reverse breakdown voltages of small power diodes, and zener diode voltages. Two small 90-V batteries in series provide power. R_1 biases upper transistor into conduction. When voltage is applied to diode or transistor junction under test, junction breaks down and current flows through R_2. This makes lower transistor conduct, thereby dropping base voltage of upper transistor. R_2 may be used to set breakdown current over wide range. Voltmeter reads breakdown voltage of junction, since drop across R_2 is negligibly small.—J. W. Brown, Simple Breakdown Voltage Meter, *Wireless World*, July 1973, p 337.



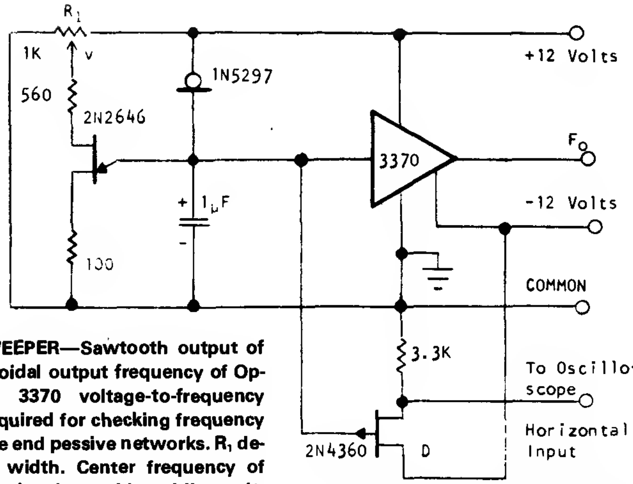
POWER PEAK METER—Optical Electronics 5897 four-quadrant multiplier generetes product of load voltage end loed current, while 5030 peek sense-and-hold module holds peak powar for display on panel metar or other reedout. Applicetions include maesuring peek power applied to transistor, motor, lamp, or squib. If power paek et particular moment is requirad, such es that of trensistor feilure or squib detonation, 5020 sample-end-hold module is used in eddition to or in pleca of 5030. Hold commend can be obtained from flip-flop connected for triggering by ebrupt change in power level.—"A Peak Reading/Sampled Reeding Power Meter," Opticel Electronics, Tucson, AZ, Application Tip 10083.



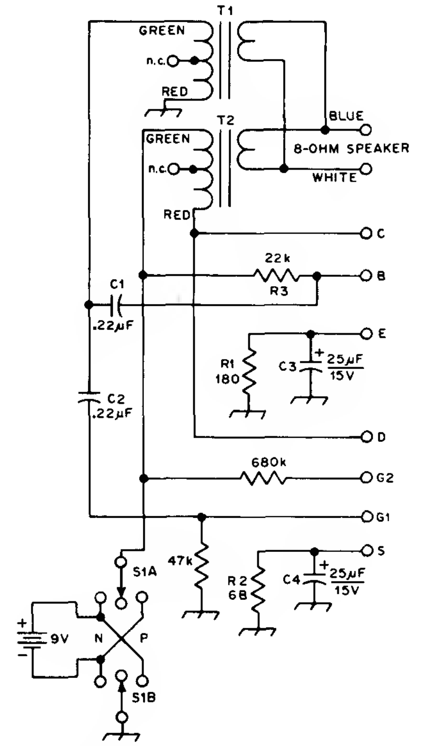
TTL TESTER—Used to chack quality, identify internal sections, end identify terminels of unmerked TTL ICs. Operetes from 5-VDC source, which should heve current-limitad output for fuse protection egeinst shorts. Used with ordinery CRO, for which horizontel end vertical jecks ere shown on diegrem. Article tells how eight different oscilloscope displeys ere interpreted, end gives procedure for identifying terminals of chip one by one as test probe is held on pins.—S. S. Smith, Jr., A TTL Tester, *73 Magazine*, Oct. 1976, p 110–111.



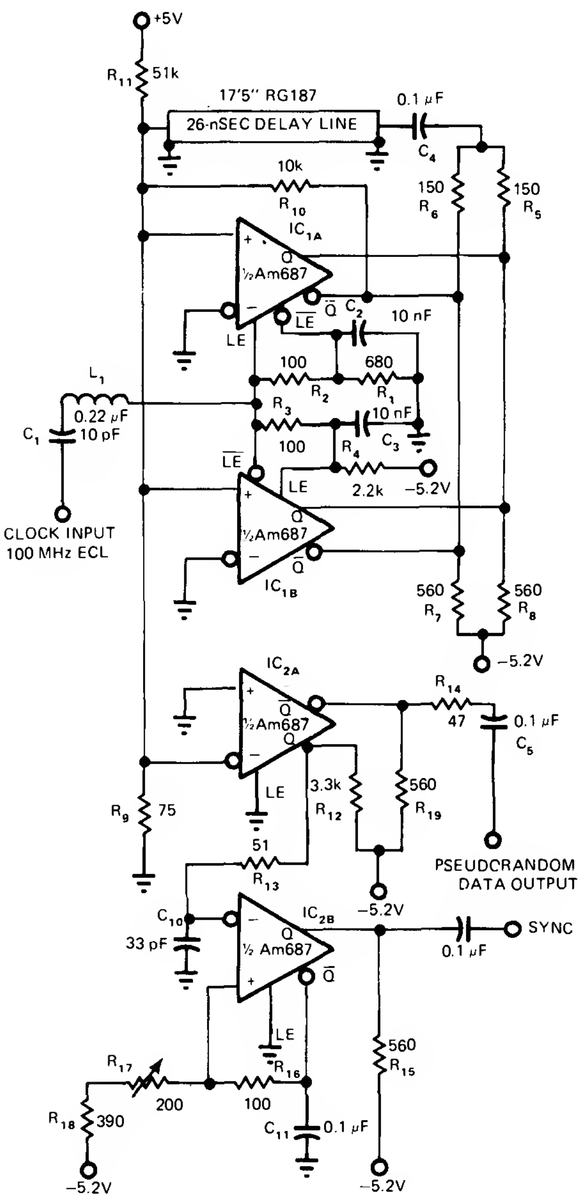
BANDPASS-FILTER TESTER—Meesures center frequency of active bandpess filter by meesuring phase engle es function of frequency. Output of VCO excites bandpass filter undar test. Output of filter serves es input for PLL comparator. When VCO and filter signals are in phase, PLL locks at cantar frequency of filtar, corresponding to 0° phese shift. Accurecy is 1% for measurements in AF range.—M. P. Prongua, Phase-Lock Loops Test Bendpass Filters, *EDN Magezine*, Juna 20, 1974, p 76 and 78.



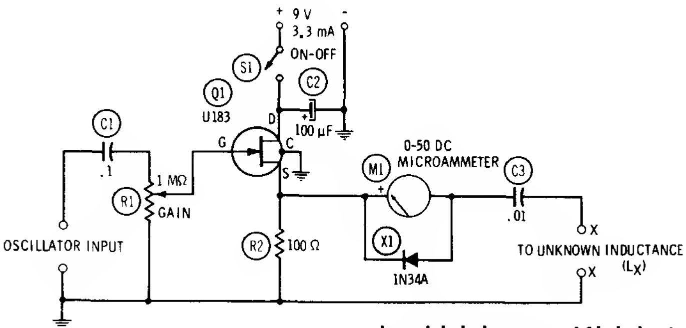
FREQUENCY SWEEPER—Sawtooth output of UJT varies sinusoidal output frequency of Optical Electronics 3370 voltage-to-frequency transducer, as required for checking frequency response of active and passive networks. R_1 determines sweep width. Center frequency of sweep output can be changed by adding voltage to sawtooth or adjusting 3370. Sweep speed can be increased by reducing value of 1-μF tantalum capacitor.—"Sweep Generator Using a Voltage-to-Frequency Transducer," Optical Electronics, Tucson, AZ, Application Tip 10059.



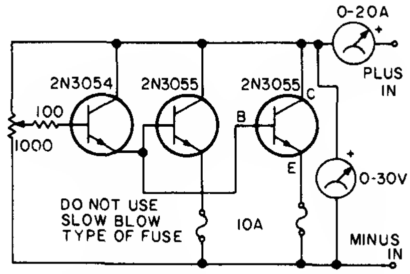
TRANSISTOR TESTER—Will test conventional bipolar transistors, JFETs, MOSFETs, Darlingtons and UJTs. Audible note between 1000 and 5000 Hz from connected loudspeaker indicates that device is functioning as amplifier and gives relative indication of gain and noise figure. Most devices can be tested in-circuit. Among similar JFETs or MOSFETs, those producing lowest tone pitch have lowest noise figure. Among similar devices of any type, those producing loudest tone have highest gain. Tester feeds back audio signal through two transformers to create sustained oscillation when amplifying device is connected to proper terminals. S1 applies positive or negative voltage through audio output transformer T2 to device under test. C3 and C4 must be nonpolarized electrolytics because R1 and R2 may produce either positive or negative voltage depending on device being tested. T1 and T2 have 1200-ohm primary and 8-ohm secondary (Celectro DI-724). Note above 10,000 Hz means device has some gain but does not meet specifications or is connected incorrectly. For MOSFETs, source and substrate are both connected to source terminal.—W. E. Anderson, A Universal Transistor Tester, *QST*, Dec. 1975, p 26–28.



PSEUDORANDOM DIGITAL GENERATOR—Uses two Am687 dual sampling comparators to implement 200-Mb/s pseudorandom digital-sequence generator for checking and measuring performance of high-speed digital communication equipment. Produces sequence length of 127 bits, but delay-line length can be changed to give any desired other sequence length. Circuit accepts from 195 to 203 Mb/s, which is more than adequate for systems using crystal clock having ±0.1% frequency variation. Article describes operation and gives timing diagram.—G. L. Meyer, Sampling Comparators—They Sub for High-Speed Logic and Produce Power, Cost and Space Savings, *EDN Magazine*, Sept. 5, 1977, p 71–74.

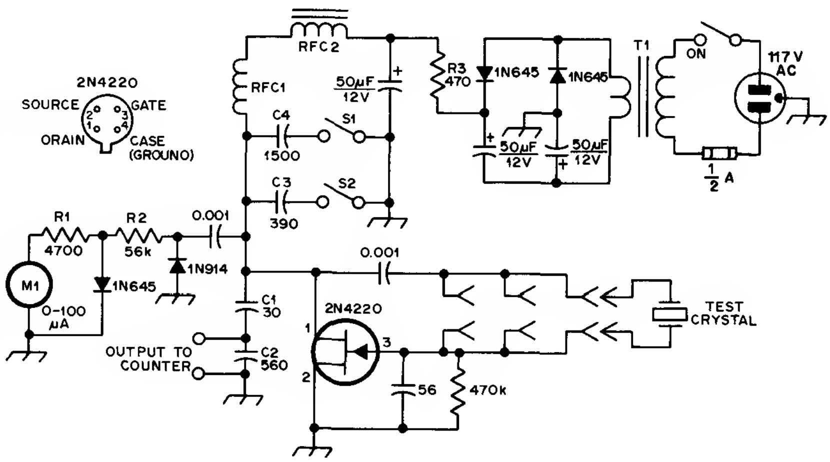


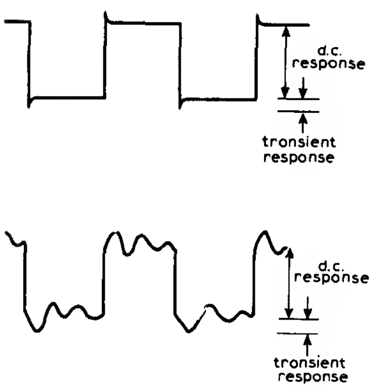
INDUCTANCE METER—When used with variable-frequency audio oscillator, FET circuit checks any inductance between 60 μH and 60,000 H by resonance mathod. With unknown coil connected to terminals XX, external oscillator is tuned for peek deflection of M1. Inductance is then calculated from $L = 1/(395\times10^{-9}f^2)$ where L is in henrys and f is in hertz. If desired, calibration graph can be prepared to eliminate calculations. High input impedance of FET minimizes oscillator loading. Adjust R1 for full-scale deflection of meter at resonance, to give maximum sensitivity.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 138–140.

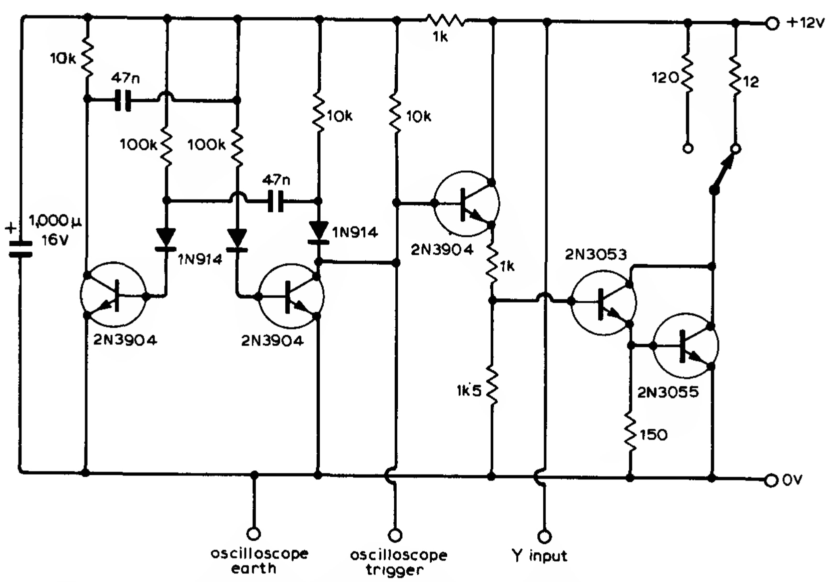


POWER-SUPPLY TESTER—Serves as high-current solid-state resistor load for testing power supplies before use, to datermine voltage and current under load. Darlington configuration of transistors reducas power-dissipating requirements of pot. Use large heatsink for 2N3055s because they must dissipate almost 200 W when power supply ia delivering 15 A at 15 V.—E. Fruitman, The Smoke Tester, *73 Magazine*, Nov. 1976, p 159.

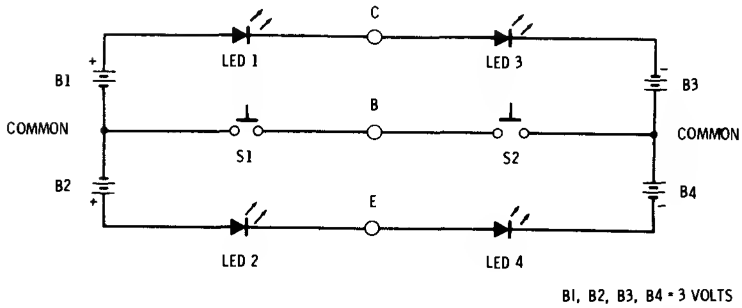
CRYSTAL TESTER—JFET Pierce oscillator will test any crystal from 50 kHz through 25-MHz upper frequency limit of fundamental-mode crystals without tuning, and drive counter for measuring crystal frequency. Will test overtone VHF crystals on their fundamental frequency. T1 is small output transformer from tube-type radio, having about 33:1 turns ratio, or 6.3-V filament transformer if 1N645 rectifiers are used in place of 50-μF filter capacitors to give full-wave voltege doubler providing required 9 V. RFC1 is 2.5 mH, end RFC2 is 150-mH miniature toroid.—F. Brown, A Universal Crystal Oscillator, *QST*, Feb. 1978, p 15–16.





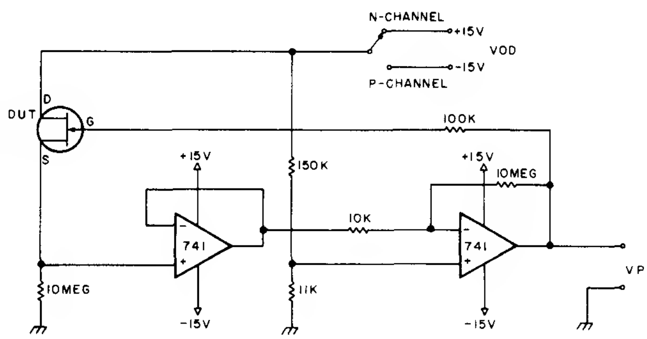


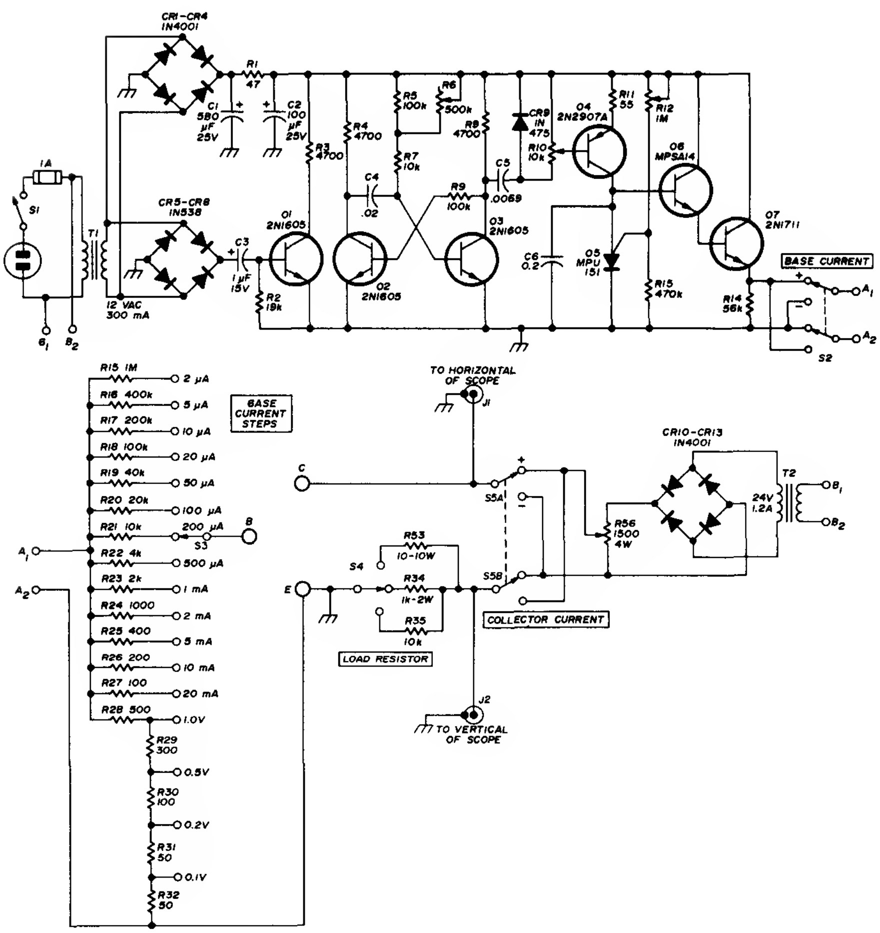
TRANSIENT RESPONSE OF REGULATED SUPPLIES—Developed for testing translent response of 12-V regulated power supply at loading of either 100 mA or 1 A, depending on swltch poaitlon. Load resistors can be changed for other voltegea and currents. Tranaients generated by supply may be observed on AC-coupled oscilloscope. Good translent response will show only small leading-edge peaks, as in upper waveform. Any tendency of power supply toward instablity degrades waveform much more, as in lower diagram. Circuit consists of multivibrator using series diodes in base circuits to protect transistors from excessive voltage swings in switching cycle. Square-wave output is used for oscilloscope trigger and fed to other three tranaistors that provide load for power supply under test.—H. Macdonald, Transient Response Testing, *Wireless World*, July 1973, p 338.



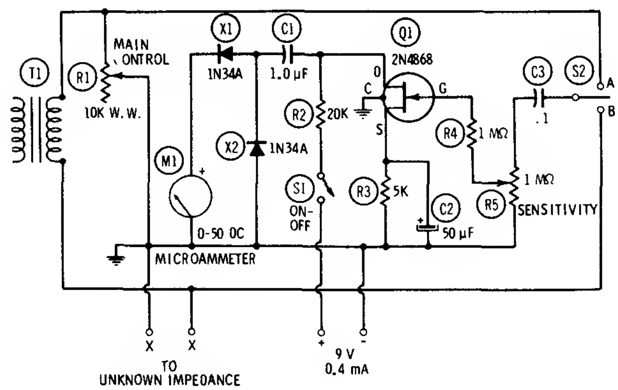
TRANSISTOR AND DIODE TESTER—Four peirs of AA panlight calls provide powar for testing transistors and diodes quickly for opens and shorts. Circuit also distinguishes betwaan PNP and NPN transistors and shows dioda polarity. Leads of dioda ara inserted into basa and collactor jacks (B and C), and switchas are pressed in succession. If LED 1 glows, diode is good and its anode laad is in collector jeck. If LED 3 glows whan S2 is pressed, anode of dioda is in besa jeck. If both LEDs glow, diode is shorted. If neither LED glows, dioda is opan. With transistor in tester, unit is PNP if LED 1 and LED 2 glow. If LED 3 and LED 4 glow, unit is NPN. If one or no LEDs glow, transistor is opan. If three or more LEDs glow, transistor has shortad junction. Any LEDs can be used.—F.M. Mims, "Transistor Projacts, Vol. 3," Radio Shack, Fort Worth, TX, 1975, p 87–93.

FET TESTER—Can ba used for maesuring JFET pinchoff voltega, matching FETs of sama ganaric typa, and maesuring bias renga of FET. Opamps sansa source currant of FET undar test. First 741 is buffar, while sacond is presat to 1 V and its output used to drive davice undar tast (DUT) until sourca current is 100 μA. Polarity of VP is opposita that of VDD.—Circuits, *73 Magazina*, Juna 1977, p 49.



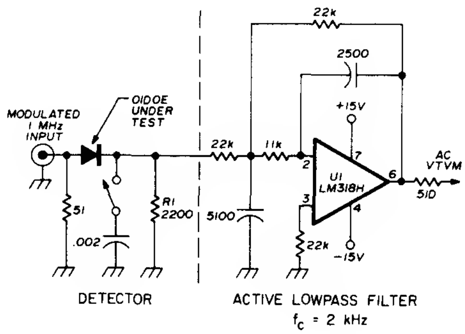


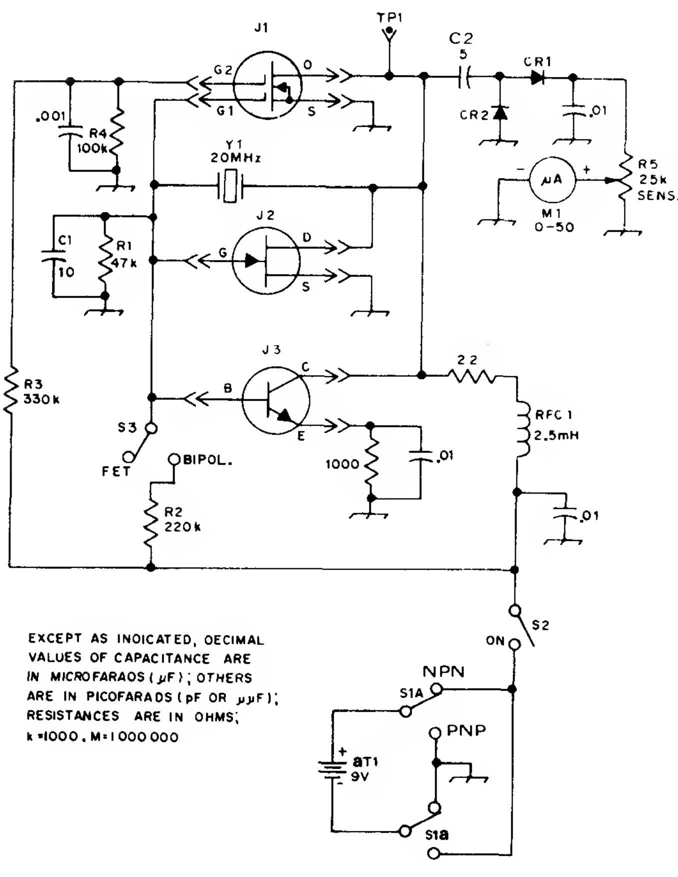
CURVE TRACER—Displeys on CRO a femily of six collector characteristics for transistors end voltage/current characteristics of diodes. Circuit varias besa voltaga in discreta staps whila sweeping collector voltaga from zaro to maximum at each step. Collector voltaga is 120-Hz rectified sine wave from bridga rectifiar CR10-CR13, varied by R36. S5 selacts propar polarity. Base voltaga staps are synchronizad to 120-Hz collector voltaga by adjusting R6 in mono MVBR Q2-Q3 drivan by Q1. R10 adjusts voltaga betwaan staps. Programmable UJT Q5 rasets staircase generator to zaro. R12 adjusts gata voltage. Staircase voltaga is coupled to bias resistors R15-R32 for test transistor by Q6 end Q7, with bies polarity and value selactad by S2 and S3. Connect devica under test to points B, C, and E. Connect points A_1 and A_2 together. R15-R35 should hava 5% accuracy.—D. Wright, Transistor Curve Tracer, *Ham Radio,* July 1973, p 52–55.



IMPEDANCE METER—External AF voltage is applied to unknown impedance through input transformer T1 and calibrated variable resistor R1. Voltage drops across impedence end R1 are checked seperately with electronic voltmeter while R1 is varied. When dropa are equal, unknown impedance is equal to setting of R1, read directly from its calibrated dial. Voltmeter uses FET followed by two-diode rectifier X1-X2 and microammeter M1. With S2 in position A, voltmeter reads drop across R1; in poaition B, voltmeter reads drop across unknown impedence. Adjust R5 so meter deflection is near full scale to increase compariaon accuracy. Common test frequencies used are 400, 500, and 1000 Hz.—R. P. Tumer, "FET Circuits," Howard W. Sams, Indianapolia, IN, 1977, 2nd Ed., p 143–144.

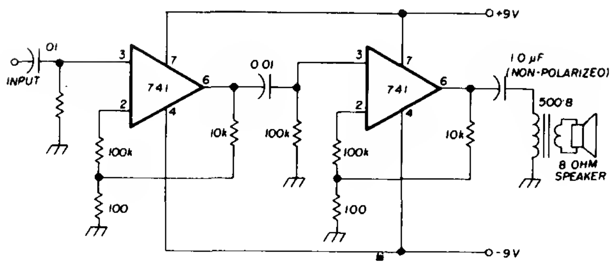
DIODE TESTER—Developed to demonstrate how 0.002-µF shunt capecitor increases efficiency of diode detector. Cen elso be used to compere performence of different diodes. Input terminates AM signal generator. IC with essocIated capacitors and resistors forms low-pass filter heving cutoff et 2 kHz. R1 is detector load. Resistor at output of U1 preventa oscillation of opemp when using coax feed to VTVM. For higher input signal levels, shunt capacitor increases AF output up to 10 dB.—H. Olson, Diode Detectors, *Ham Radio,* Jan. 1976, p 28–34.



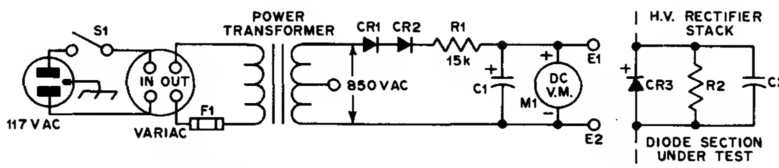


EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k = 1000, M = 1 000 000

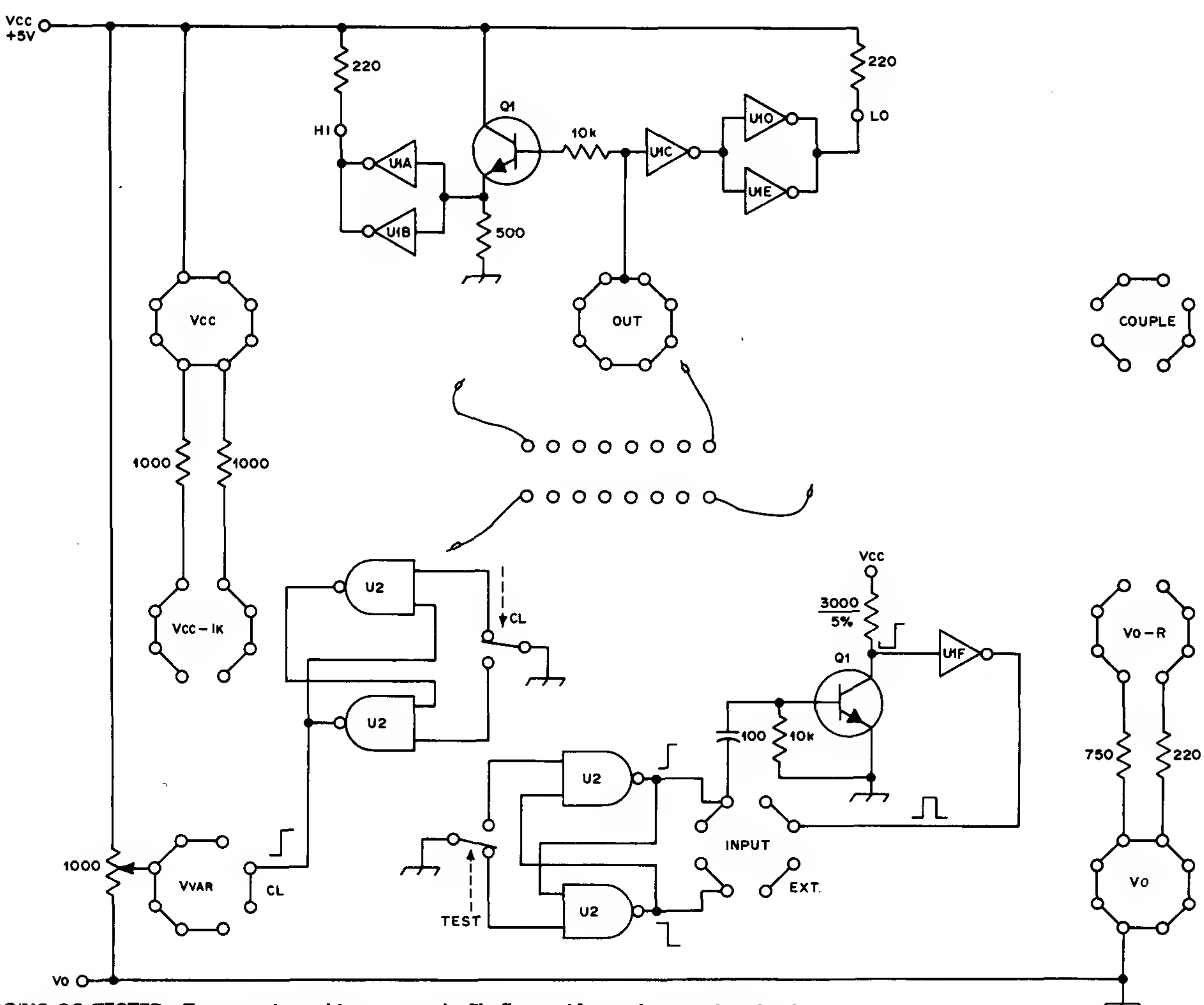
PORTABLE TRANSISTOR TESTER—Go/no-go taster shows relative condition of NPN and PNP transistors, junction FETs, and dual-gate MOSFETs. Not suitable for checking audio or high-power RF transistors. Crystal for upper range of HF spectrum is permanently wired; any HF crystal cut for fundamantal-mode operation can be used. Rectified RF from oscilletor is monitored on M1. S1 selects negetive ground for testing N-channel FETs and NPN bipolars and provides positive ground for P-channal and PNP devices. If device is open, shorted, or extremely leaky, circuit will not oscillete and meter will not deflect. The higher the meter reading, the higher the gain of transistor at operating fraquency. When testing MOSFETs that are not gate-protected, keep transistor leads shorted until device is in socket and replace short before removing device. Diodes are 1N34A or equivalent.—D. DeMaw and C. Greene, A Pair of Handy Testers, *QST,* May 1973, p 24–27.



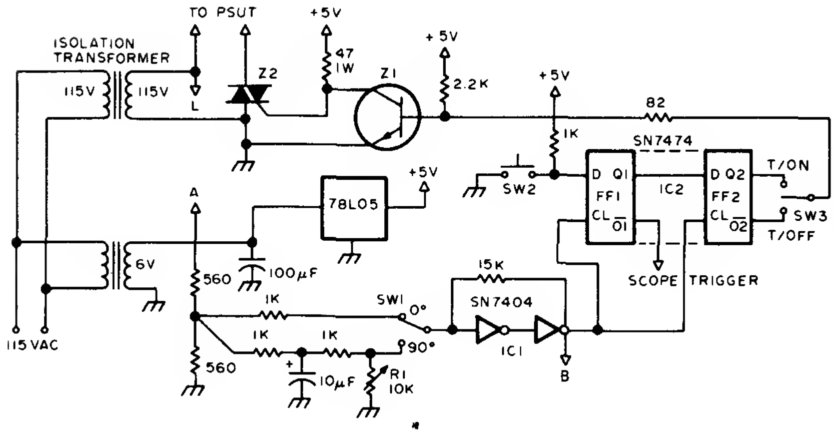
AF SIGNAL TRACER—High-gain audio emplifier with loudspaeker output serves for trouble-shooting AF stagas. With normal input to am-plifiar undar tast, presance of AF signel is tested in each stage in turn. If AF signal appaars et input of stage but not at output, thet stage has e defect. Signal source may also be signel injac-tor having broadbend output from eudio through VHF.—M. Jemas, Basic Troubleshoot-ing, *Ham Radio,* Jen. 1976, p 54–57.



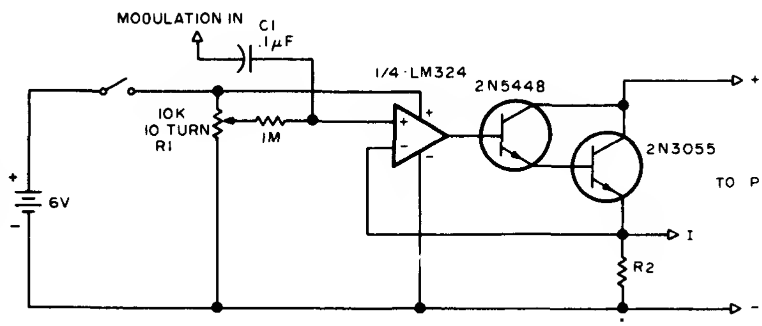
POWER DIODE TESTER—Providas reversa-volt-age test of individuel sections of rectifiar steck et 1000 VDC. With test laads E1 and E2 clipped ecross diode saction under tast, Variac setting is increased from 0 until C1 is cherged to 1000 V as indicated by voltmatar. If diode or capacitor in section under tast is defective, metar will raad low because of extra voltaga loss ecross R1. Initial setup is mada with good dioda sac-tion. Open S1 befora chenging dioda bacausa voltaga is lethal.—R. K. Dya, Testing "Dye-Odes," *QST,* Feb. 1976, p 44.



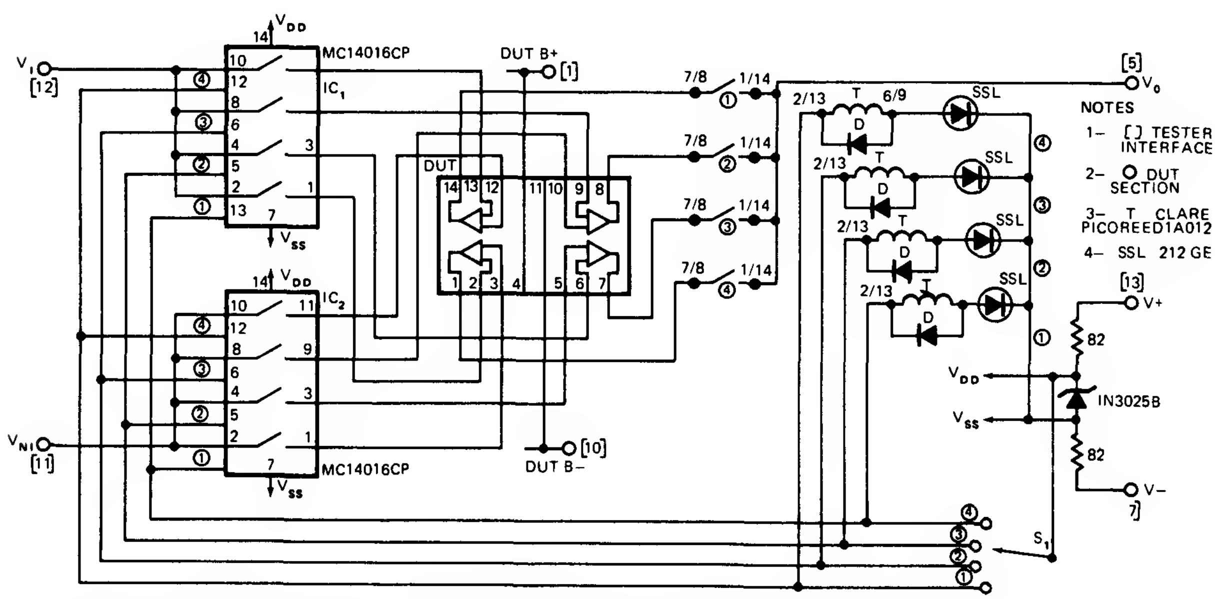
TTL GO/NO-GO TESTER—Tast penel provides fast static test of surplus 7400 series TTL ICs. Each contact of 16-pin DIP socket has laad that can be plugged into array of sevan othar sockets carrying various supply voltagas, loads, etc. Switches provide pulses of input currant for toggling or clocking, counting, and resetting. Leads also sarva for cross-coupling gatas in IC to make flip-flop and for setting up othar simpla circuits. Input voltaga control allows plotting of transfar functions and study of circuit oparation undar diffarent signal-level conditions. External test metar can be connectad whan nacassary. HI end LO indicators ere LEDs thet show laval of tarminal connactad to output socket. Tran-sistors era generel-purpose NPN such as 2N2926. U1 is SN7404 hax invartar, and U2 is SN7400 quad two-input NAND gata. Testar is not suitebla for complamantery MOS devicas requiring protaction from static chargas. Articla givas detailed instructions for testing each typa of TTL device.—J. S. Worthington, A Simple TTL Test Panel, *QST,* Dec. 1976, p 25–27.



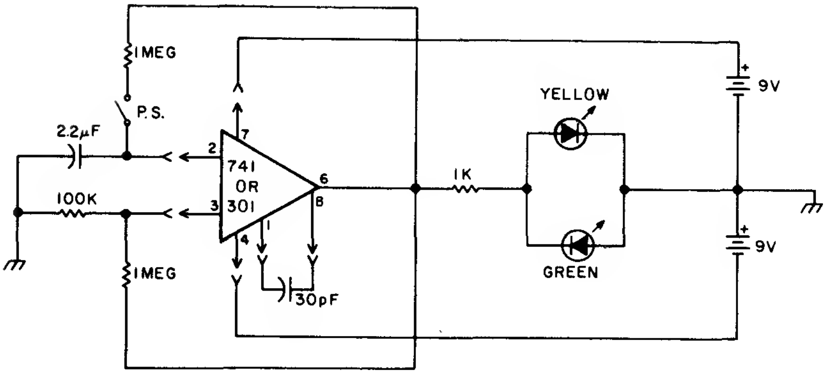
POWER-SUPPLY TESTER—Circuit switches power supply on or off either at peak or zero of line voltage while supply is connected to CRO. Spikes on treca then indicate supply defect. Developed for testing unknown power supplies before being placed in use on home computer systems, to ensure safa end reliable computer oparetion. Article gives dateiled instructions for using circuit to chack for trensiants, DC regulation, heat rise, end output impedence.—R. Tanny, Powar Supply Testing, *73 Magazine*, July 1976, p 112–114 end 116–117.



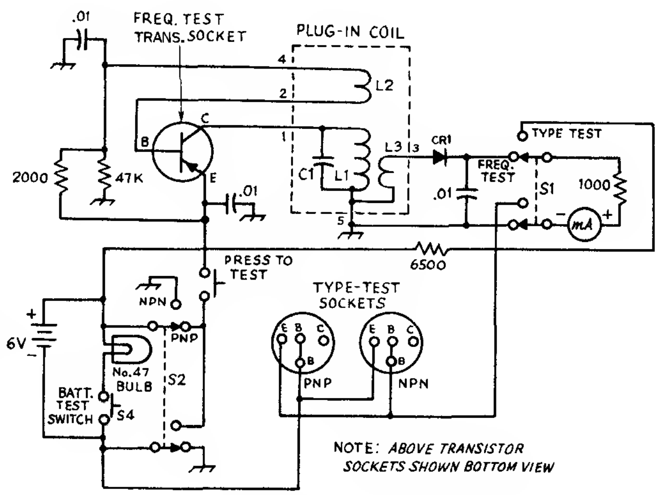
DYNAMIC LOAD—R1 sats load current drawn from powar supply under test to desirad value, after R2 is chosen to give about 1-V output et meximum load current to be drawn from power supply under test (PSUT). Moduletion input to C1 is obtained from externel pulse generator, and serves to meke loed current incraasa and decrease over small ranga.—R. Tenny, Power Supply Testing, *73 Magazine*, July 1976, p 112–114 end 116–117.



QUAD OPAMP TESTER—Intarface circuit shown permits use of single-opamp taster for tasting quads without major modification of tester's original function. Interfaca operates on power evailable from tester, which can be Teladyne/Philbrick 5102 or current Taktronix or ESI tasters. CMOS input transmission gates IC_1 and IC_2 supply input signals to sections of device under test (DUT). Gate control signels are supplied by section salector S_1; switch cen ba eutomated by using two-line BCD salection. Seme switch elso ectivetes reed relay that connects respective amplifiar section to load and output monitoring circuits of taster. LEDs indicate section under test. Interface can be used with LM124, CA124, end MC3503 serias of quad opamps.—A. C. Svoboda, Use a Single Op-Amp Tester for Queds, *EDN Magazine*, Merch 5, 1975, p 76.



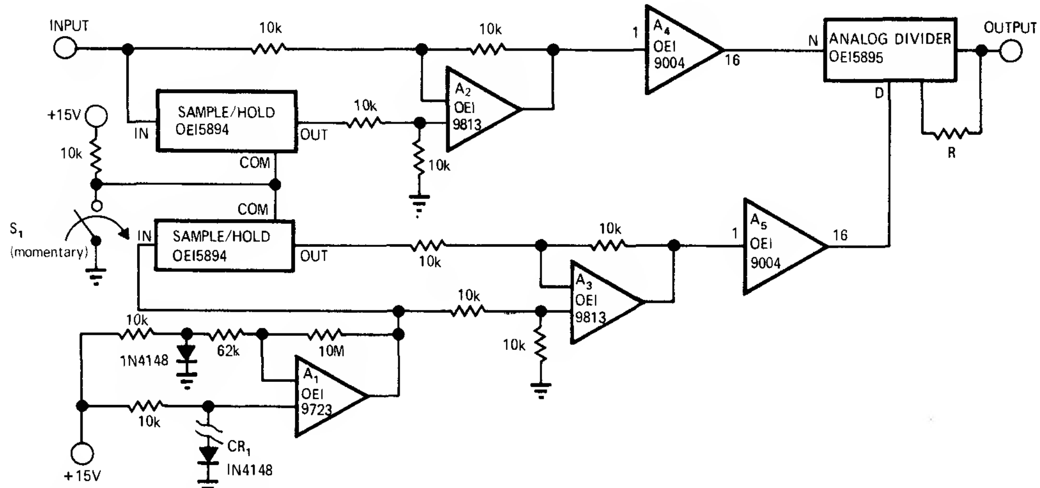
OPAMP TESTER—Developed for quick testing of 741 and 301 opamps. For good opamp, LEDs flash alternately with 1-s period. No flashing and no illumination indicate opamp output fault. If one of LEDs glows continuously, one of inputs is faulty. Asymmetrical blinking indicates leakage in opamp.—Circuits, *73 Magazine*, March 1977, p 152.



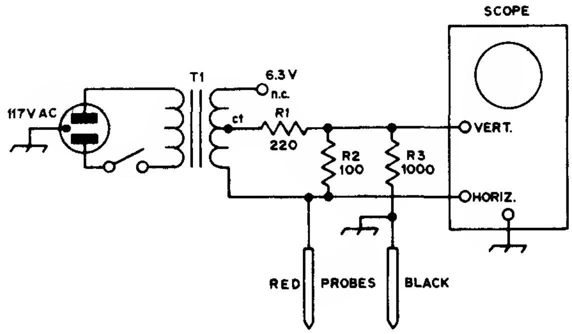
Frequency (MHz)	L1 (Turns)	L2 (Turns)	L3 (Turns)	C1 (PF)
60	3	3	3	25
31	7	6	4	25
12	12	7	6	80
3	22	10	9	270
1	34	20	8	1000

Note: Above coils close-wound, 3/4-inch (19 mm) diameter.

TRANSISTOR TESTER—Determines maximum frequency at which unknown transistor will still maintain reasonable current gain, and tells whether transistor is NPN or PNP. Based on fact that emitter-base junction of transistor is equivalent to crystal diode, conducting in one direction only. Direction depends on transistor type. Setting of S2 which gives meter reading identifies transistor type. Frequency-limit circuit is self-excited oscillator in which frequency depends on plug-in coil. If meter reads when 60-MHz coil is used, transistor is capable of handling 60 MHz; if no reading, change to lower-frequency coils one by one until reading is obtained. To check battery, press S4; lamp should have full brilliance. CR1 is 1N34A.—H. Henson, How High Will It Go?, *QST*, April 1974, p 32–33 and 39.

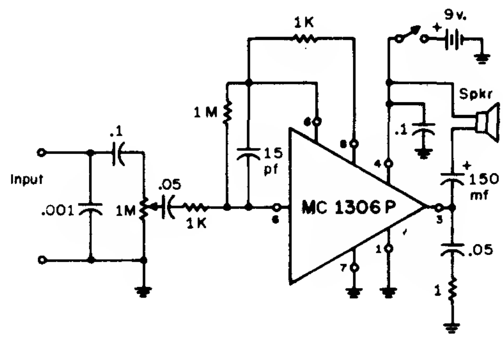


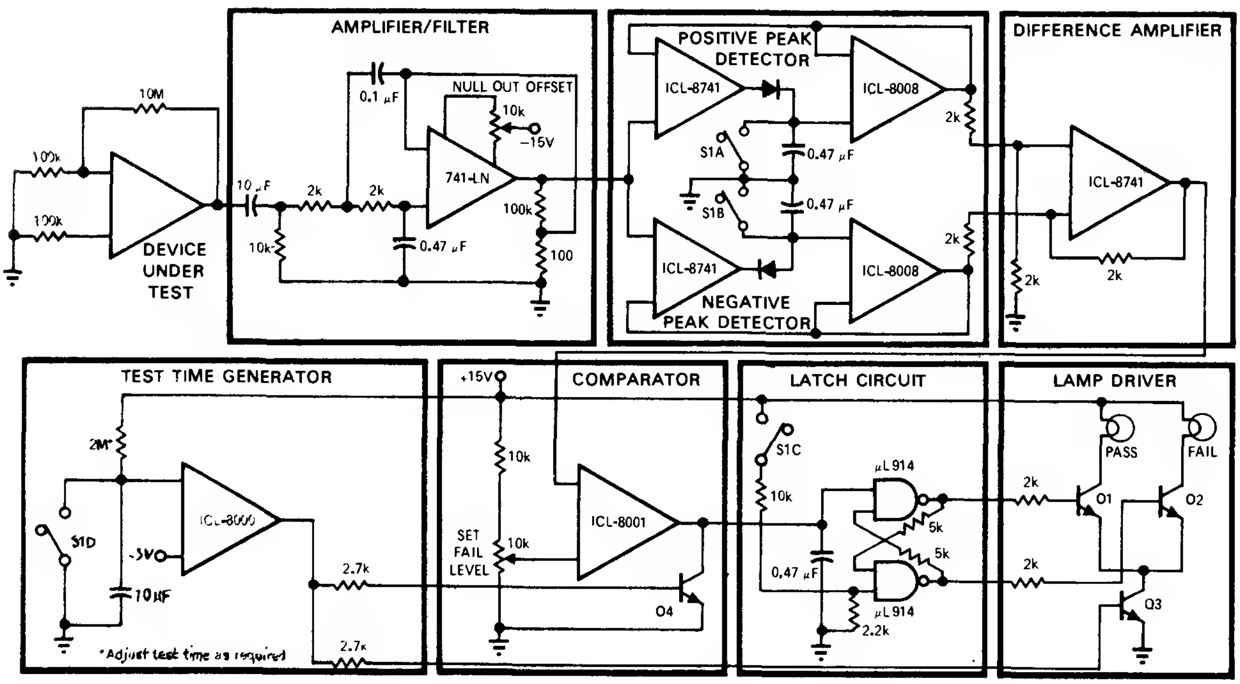
TEMPERATURE-COEFFICIENT COMPUTER—Circuit automatically measures and calculates temperature coefficients of analog circuits or devices. Silicon diode CR_1 is used as temperature probe having forward drop of about 2 mV/°C. R adjusts output scale factor. FET-input opamp A_1 converts forward voltage drop of temperature probe into high-level analog voltage that varies 325 mV/°C from −10 V at +55°C to 10 V at −5°C. Output of A_1 is applied to sample-and-hold circuit, while analog voltage from device under test is applied to second sample-and-hold. Momentary closing of S_1 causes voltage and temperature data to be stored in sample-and-hold circuits at start of test to bias A_2 and A_3. Outputs of these opamps can be positive or negative, but are made positive by unity-gain absolute-value opamps A_4 and A_5. From these outputs, analog divider calculates temperature coefficient.—R. C. Gerdes, Temperature-Coefficient Measuring Circuit, *EDN/EEE Magazine*, Feb. 1, 1972, p 54.



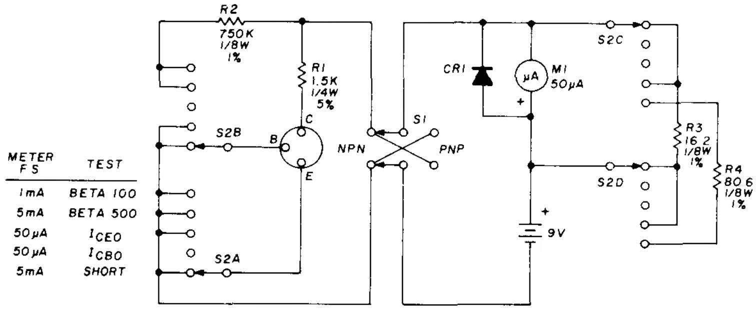
IN-CIRCUIT TESTER—Eliminates need for removing componants one by one for testing. Voltages and currents used are low enough for almost any transistorized circuit. Will test for shorts and opens. Shows forward-reverse ratios on junction transistors and diodes. Lissajous figures and other combination displays on CRO facilitate analysis of circuits having reactive components, transistors, and ICs. Will detect high-resistance solder joint and check continuity of switches, fuses, lamps, and printed wiring. Displays form hends of clock or ovals. Vertical line indicates short, horizontal means open, slant indicates resistance, vertical oval is inductance, horizontal oval is capacitance, diode and highest-merit transistor show 3 o'clock, fair transistor shows 4 o'clock, and poor transistor shows 5 o'clock. For other patterns, compare with those obtained with known good components.—D. L. Ludlow, The Octopus, *QST*, Jan. 1975, p 40–42.

AF SIGNAL TRACER—Motorola MC1306P complementary power amplifier delivers ½ W into loudspeaker for 3-mVRMS input to preamp, for troubleshooting all types of audio equipment. Zaro-signal current drain is only 4 mA with 9-V supply. For RF tracing of modulated AM or SSB signal, use demodulator probe at input.—W. M. Scharer, High-Gain Signal Tracer, *CQ*, July 1972, p 12 and 14.

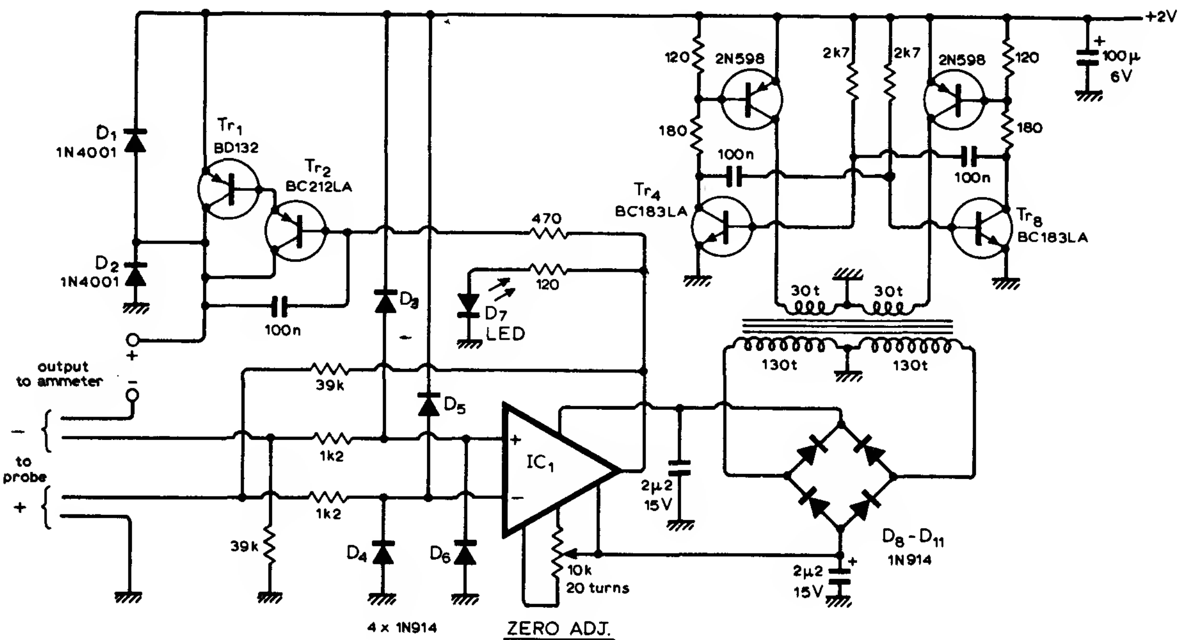




POPCORN NOISE TESTER—Developed at Intarsil to test opamps for erratic low-frequancy jumps between two or more stable states. After start-up switch S is closed, pass/fail lamps are inhibitad by Q3. At end of preselacted test time (typically 5 s), one of lamps will come on. If output from difference amplifier exceeds preset fail laval at inverting input of comparator during test period, fail lamp is turned on by Q2. Q4 prevents triggering of latch by spurious signals after end of test time.—T. P. Rigoli, IC Op Amps, *EDN Magazine*, May 1, 1971, p 23–33.



TRANSISTOR TESTER—Useful for troubla-shooting and for checking small-signal transistors having no markings. Set four-pola five-position rotary switch S2 to SHORT (lowest position) before inserting transistor, then flip S1 back end forth. If meter shows eny raading at all, raject transistor without further tests. If meter stays et zaro, set S2 to I_{CBO} (collactor-base current, emitter open). Discard transistor if raeding is high for either position of S1; modem trensistors pass only nanoamperas, but older types mey give noticeable reading, particulerly if garmanium. Rapaet tast for I_{CEO} (collector-emittar current, basa open), which should be greater than I_{CBO} by factor approximating current gein (beta) of device. Modarn silicon transistors mey give no raading hare. For final beta test, oldar types show 100 or less and modem transistors like 2N3391 have beta reedings between 300 and 400. CR1 is 1N4603.—D. Chanay, Shirt Pocket Transistor Taster, *Ham Radio,* July 1976, p 40–42.

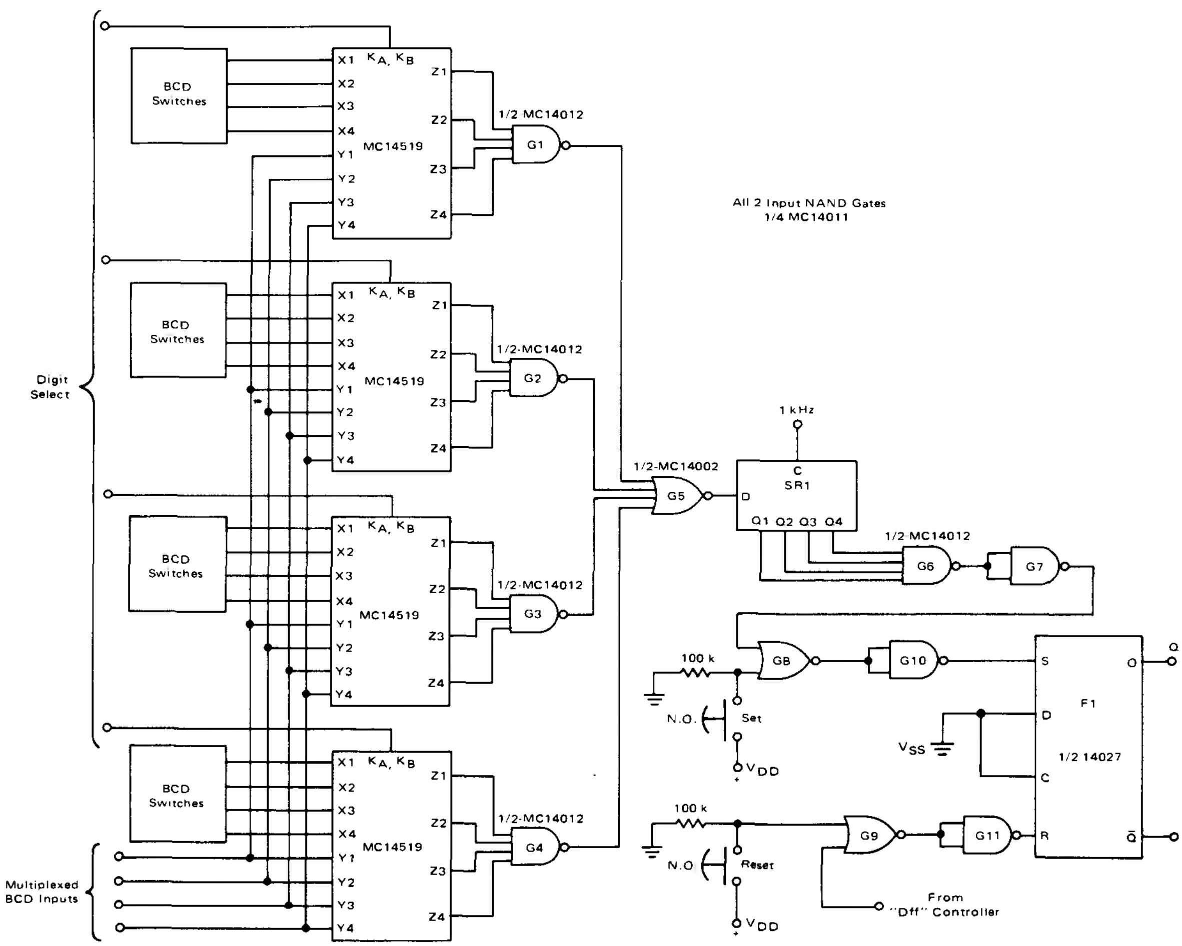


AMMETER FOR PRINTED-CIRCUIT WIRING—Permits measuremant of current in singla conductor on board without cutting it. Article gives design of proba heving four projecting wires that ara pressed on conductor baing maasured, and describes oparetion of circuit in detail. Opamp can be 741, but higher-cost 725C will improve performanca. Whan all four wires of probe make contact, voltaga drop appears at input of differential amplifier. Outar wires of proba carry currant of opposita polarity passing through ammatar; becausa thara is negative feedback loop in conductor, opamp input voltage will return to zaro when outgoing currant is equal to that of unknown current pessing through printed-circuit conductor.—F. Andrews, P.C.B. Ammeter, *Wirelass World,* July 1976, p 34.

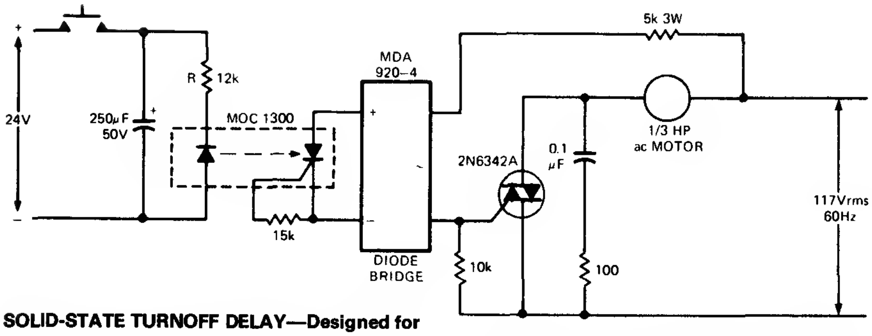
CHAPTER 96

Timer Circuits

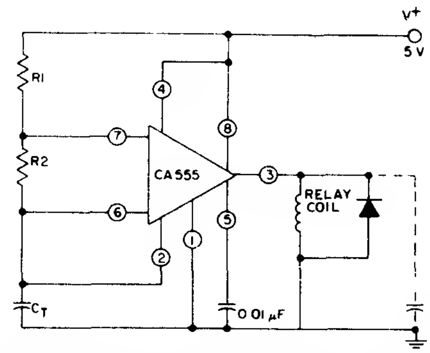
Includes circuits that give elapsed time between two events, produce desired switching action after predetermined adjustable delay, or perform switching actions at preset times. Time-of-day circuits are given in Digital Clock chapter. See also Burglar Alarm and Photography chapters.



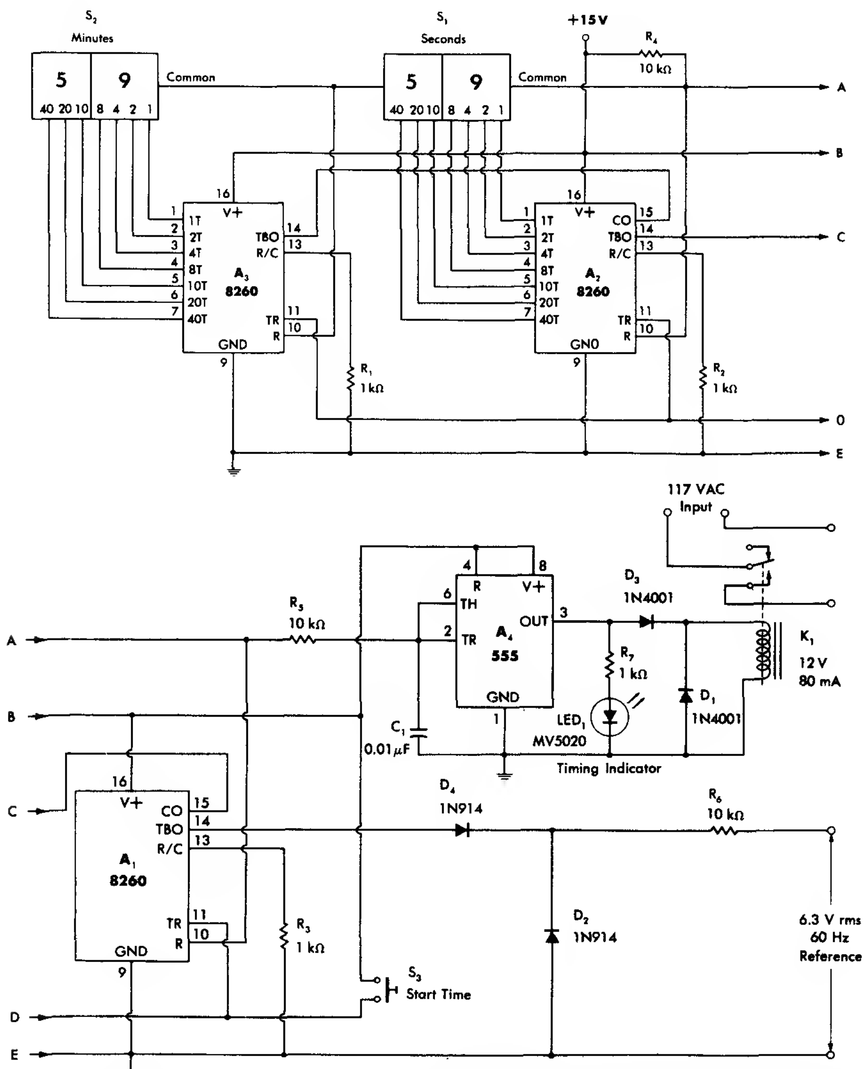
TIME COMPARATOR—Digital circuit compares time thet has been preset on one set of BCD input switches to multiplexed BCD output of besic 24-h industriel clock. When time of dey corresponds to preset time, output circuit of comparetor turns controlled device on for preset period of time. Second set of comparators can be used to turn device off when time of dey equels praset time. Only hour and minute digits ere compered, using Motorola MC14519 4-bit AND/OR select ICs. Q output of F1 cen ba used to control load power through output control circuit driving triac, with optoisolator providing required isolation from AC line. Supply is +5 V.—D. Aldridge end A. Mouton, "Industrial Clock/Timer Feeturing Beck-Up Power Supply Oparetion," Motorole, Phoenix, AZ, 1974, AN-718A, p 6.



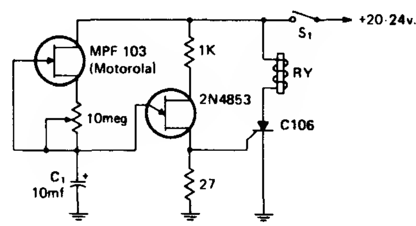
SOLID-STATE TURNOFF DELAY—Designed for applications where machina must remain energized for certain period of time after some other operation has stopped, as whan pump motor must run long enough to clear pipes in chemical plant. When switch is closed, LED of optoisolator ia forward-biased and turned on, meking photo-SCR conduct and provide gate current via MDA920-4 diode bridge for triac. Values shown keep solid-state relay circuit on for about 5 s after pushbutton is raleesed. Resistor end capacitor values cen be changed to obtain different delay.—T. Mezur, Solid-State Relays Offer New Solutiona to Meny Old Problems, *EDN Magazine,* Nov. 20, 1973, p 26–32.



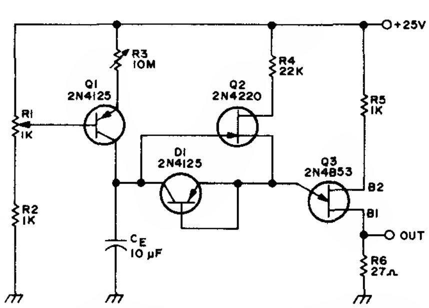
REPEAT-CYCLE—RCA CA555 is connected for estable operation in which total period is aum of individual perids t_1 and t_2, where $t_1 = 0.693(R_1 + R_2)C_T$ and $t_2 = 0.693R_2C_T$. With 5-V supply, output voltege has rectengular pulses with interval t_1 separated by interval t_2. With optionel capacitor connected, voltage across capecitor is sawtooth that rises for intervel t_1 end decays for interval t_2.—"Linear Integrated Circuits end MOS/FET's," RCA Solid Stata Division, Somarville, NJ, 1977, p 56.



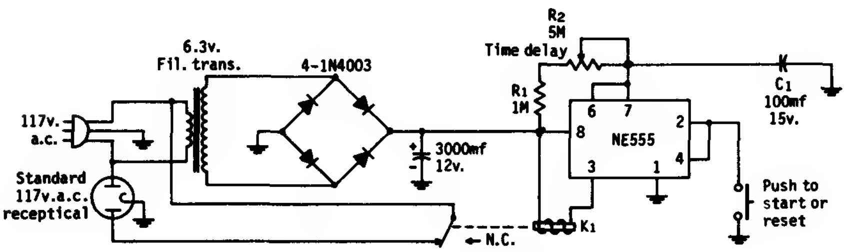
APPLIANCE TIMER—Controls intervals up to 1 h in 1-s incrsmants as progremmad by thumbwheel switches S_1 and S_2. Circuit is basically two-stage programmed counter driven by 1-s clock derived from 60-Hz powar line. A_1 is connected as divide-by-60 counter triggered by 60-Hz signal developed ecross D_2. 1-Hz output from A_1 triggers A_2 which in turn triggers A_3, all programmable timers. When S_3 is closed, R_4 bus goes low to start timing cycle. Ralay driver A_4 holds relay K_1 closad for application of AC powar to device baing controlled and energizing of LED to indicata active timing cycle. Applications include uses as kitchan end darkroom timers.—W. G. Jung, "IC Timar Cookbook," Howerd W. Sams, Indienapolis, IN, 1977, p 214–218.



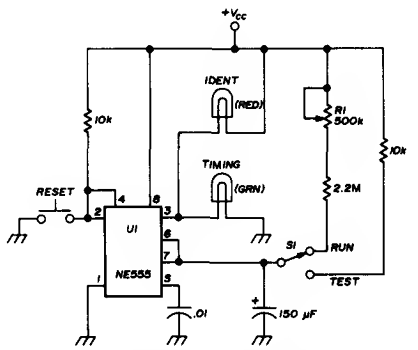
10-min DELAY—MPF103 JFET mekes charging current of C_1 constant regardless of degree of charge, to give longer charging time and longer time delay. After deley determined by setting of 10-megohm pot, UJT conducts and discharges C_1 through 27-ohm resistor, triggering SCR end energizing relay. Open S_1 to reset circuit.—I. Math, Meth's Notes, *CQ,* April 1974, p 64–65 and 91–92.



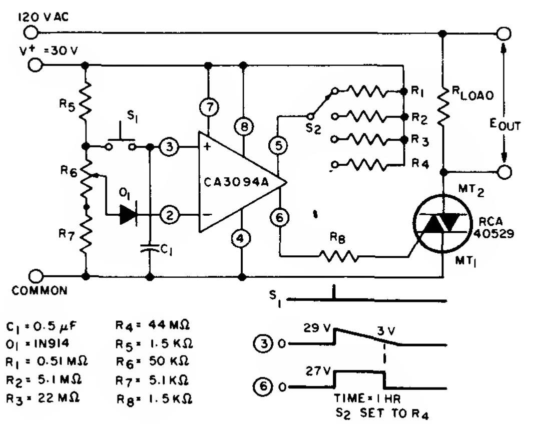
10-h FET—Long duration timer gives adjustable deleys up to 10 hours before turning Q3 on to giva output voltage.—Circuits, *73 Magazine,* Feb. 1974, p 101.



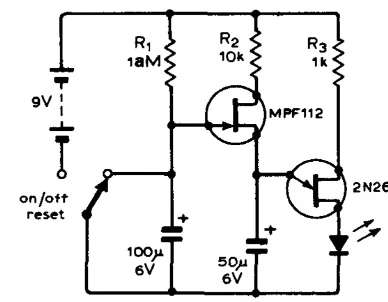
RADIO TURNOFF—Time-delay control R_2 can be set to turn off radio, TV, or other appliance at any desired interval between about 3 and 60 min after start button is pushed. Ideal for those who fall asleep to music. K_1 is 12-V relay drawing 200 mA or less.—P. Walton, An Electronic Timer for Less than $5.00, *CQ*, Aug. 1973, p 42 and 82.



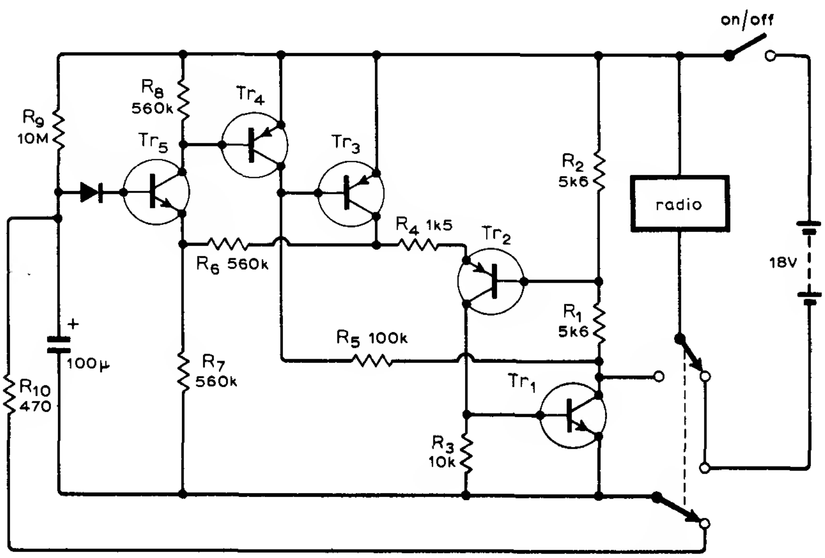
10-min ID TIMER—Red pilot lamp comes on at end of timing period, adjustable with R1 from 7 to 11 min, as reminder for amateur radio operator to make station identification required by FCC every 10 minutes. Green lamp indicates that timer is on and timing. Lamps should draw no more than 100 mA, to avoid overloading NE555 timer. Any 9–12 VDC supply can be used.—D. Backys, Identification Timer, *Ham Radio*, Nov. 1974, p 60–61.



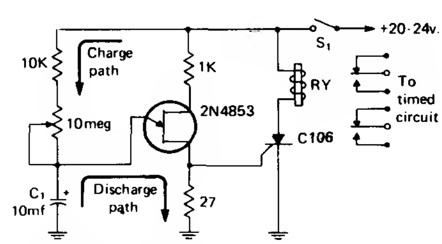
PRESETTABLE ANALOG TIMER—Switch S_2 gives choice of four delay intervals between closing of S_1 and triggering of triac by RCA CA3094A programmable power switch and amplifier. Pot R_6 is required for initial time set.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 192–196.



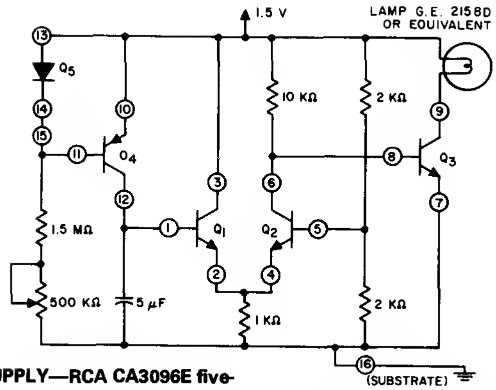
FLASHING-LED EGG TIMER—UJT oscillator controlled by FET timer makes LED flash after time delay determined by value of R_1. When 100-µF capacitor charges to about 1 V after switch is turned on, MPF112 FET switches on and forms part of charging circuit for 2N2646 UJT oscillator which then pulses LED at about 200 mA peak. Although developed as inexpensive egg timer, circuit has many other applications.—J. Jeffrey, Simple Flashing-L.E.D. Timer, *Wireless World*, Oct. 1974, p 381.



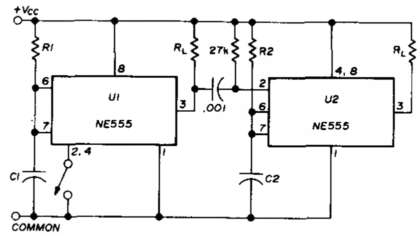
TRANSISTOR RADIO TURNOFF—Circuit switches radio off after delay of about 30 min, if ganged switch is set to other position and radio switch itself is left on. Current drain of timer circuit is negligible in both positions. Article describes timing action of transistors in detail. Tr_1 should have current gain above 25 with collector currents of 10 to 100 mA; 2N3706 can be used here and for Tr_5. Other transistors should have current gain above 50, as in 2N3702. For operation from 4.5 to 9 V, omit diode and cut values of R_4-R_7 in half.—S. Lamb, Delayed Switch Off for Transistor Radios, *Wireless World*, Aug. 1973, p 373.



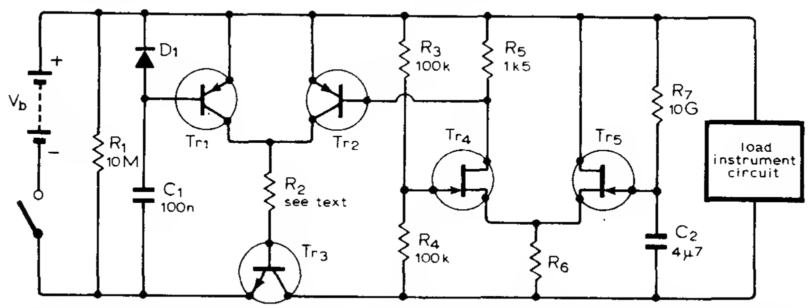
1.5-min DELAY—When S_1 is closed, C_1 begins charging. After delay determined by setting of 10-megohm pot, UJT conducts and makes C_1 discharge through 27-ohm resistor, triggering SCR C106 and energizing relay. Open S_1 to reset circuit.—I. Math, Math's Notes, *CQ*, April 1974, p 64–65 and 91–92.



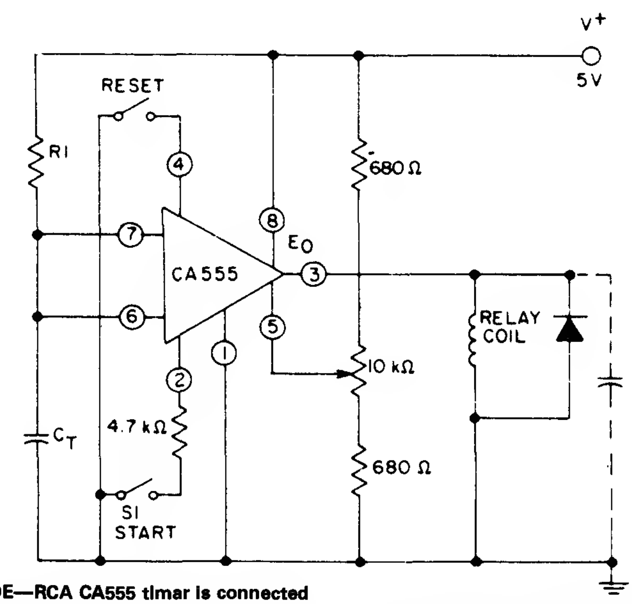
10 s USING 1.5-V SUPPLY—RCA CA3096E five-transistor array drives indicator lamp that comes on at end of timing interval. Q_5 is one of PNP transistors in array connected as diode.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 205–210.



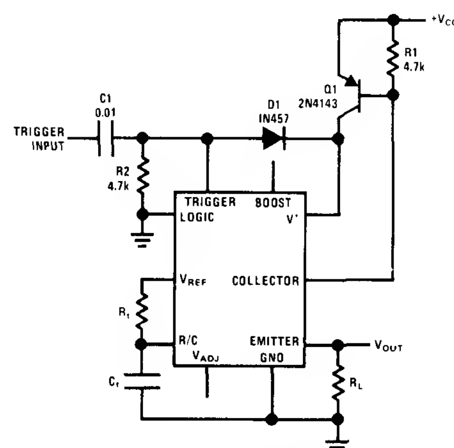
CASCADED TIMER—Two NE555 timers give sequential timing intervals for two separate loads. Time for U1 is set by R1 and C1, and for U2 by R2 and C2. Grounding pin 2 momentarily with switch starts timing. Once started, it cannot be retriggered. With pin 2 connected to reset input 4, both functions are obtained with one push of switch. If reset function is not wanted, connect 4 to 8. When pin 3 of U1 goes low at end of timing interval, negative pulse generated by 0.001-μF capacitor and 27K resistor goes to pin 2 of U2 to trigger second timer. With 15-V supply, each timer can handle 200-mA load.—H. Vordenbaum, Automatic Reset Timer, *Ham Radio*, Oct. 1974, p 50–51.



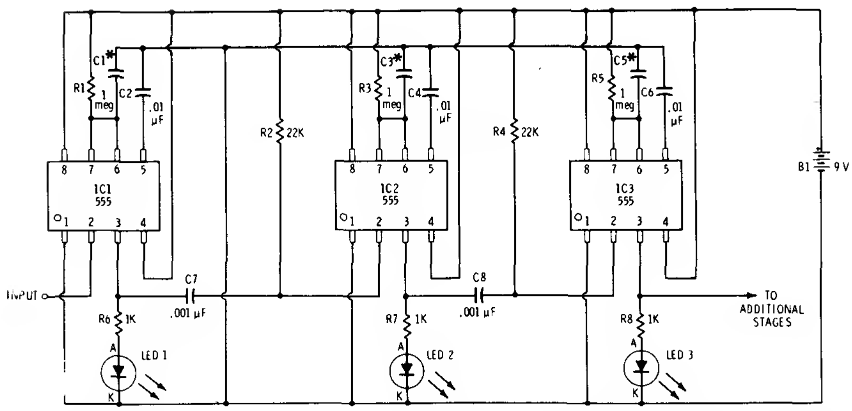
BATTERY SWITCH-OFF—Can be added to any battery-operated device to eliminate unnecessary running down of costly batteries when someone forgets to turn switch off manually. Circuit shown gives operating time of about 10 hours, permitting use of equipment for full working day without interruption. Normal operation can be restored after shut-off by turning manual switch off and then on again. When circuit has switched off, only battery drain is current through 10-megohm resistor R_1 and leakage through transistors. Time of switch-off can be changed by altering C_2 or R_7. Tr_1 and Tr_2 are 2N4061, BC478, or similar PNP silicon; Tr_3 is 2N3053, BC142, or similar medium-power NPN silicon; Tr_4 and Tr_5 are 2N3819; D_1 is any small silicon diode; R_6 is 4.7K for 9-V or 12-V battery, and 10K for 15-V to 27-V battery. R_2 is chosen to suit working current and battery voltage; suitable value is 15 V_b/I_{out}.—D. T. Smith, Automatic Battery Switch-Off Circuit, *Wireless World*, April 1976, p 76.



RESET MODE—RCA CA555 timer is connected so C_T is initially held in discharged state by transistor in IC. When start switch is closed, internal flip-flop clears short across C_T, driving output voltage high and energizing relay. Voltage across capacitor then increases exponentially with time constant R_1C_T. When capacitor voltage equals two-thirds of V+, flip-flop resets and discharges capacitor rapidly, driving output low and releasing relay. Timing interval is relatively independent of supply voltage variations. Applying negative pulse simultaneously to reset pin 4 and trigger pin 2 by closing both switches during timing cycle causes timing cycle to restart. Momentary closing of reset switch only serves to discharge C_T without restarting timer.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somerville, NJ, 1977, p 56.

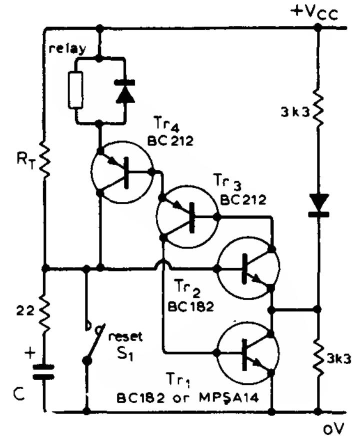


MINIMUM-DRAIN TIMER—National LM122 timer is connected to reduce supply drain to zero between timing cycles. External PNP transistor Q1 serves as latch between V+ terminal of timer and power supply. Between timing periods, Q1 is off and no current is drawn. Arrival of 5-V or larger trigger pulse turns Q1 on for duration of timing period set by R_t and C_t, which can range from microseconds to hours.—C. Nelson, "Versatile Timer Operates from Microseconds to Hours," National Semiconductor, Santa Clara, CA, 1973, AN-97, p 10.

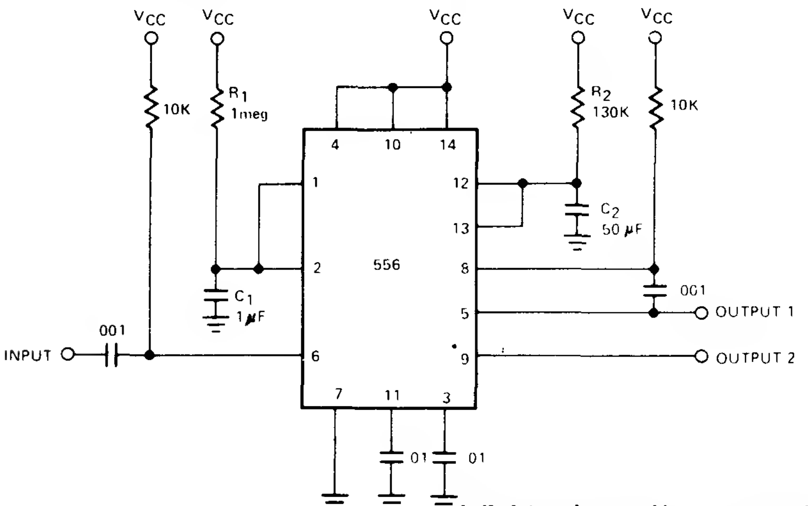


*SEE TEXT

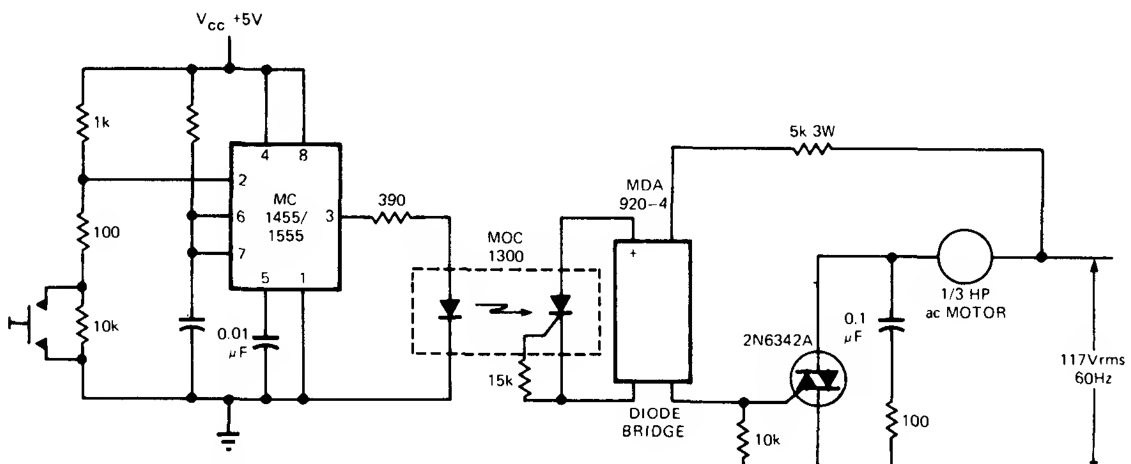
SEQUENCED TIMERS—Cascsding of three 555 timers, each driving LED, gives sequenced flashes with individually adjustable durstions. Times of timers sre determined by vslues used for C1, C3, snd C5. R1, R3, snd R5 velues elso effect time deleys; use pots if 1 μF is used for all three capecitors.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 64–75.



STABLE FOUR-TRANSISTOR TIMER—Circuit hes good immunity to impulse noise because normel state of sll transistors is on. This eliminates spurious timing cycles thst sometimas occur in IC timers. At switch-on, C begins cherging until its voltsge mekes Tr_2 stsrt conducting; this in turn mekes other three transistors switch on. Reganeretion action then discherges C to ebout 0.6 V. Timer is stsrted either by epplying V_{CC} or opening S_1. Timing period depends on velue of V_{CC}.—J. L. Linsley Hood, One-Shot Timer Circuit, *Wireless World,* Nov. 1975, p 520.

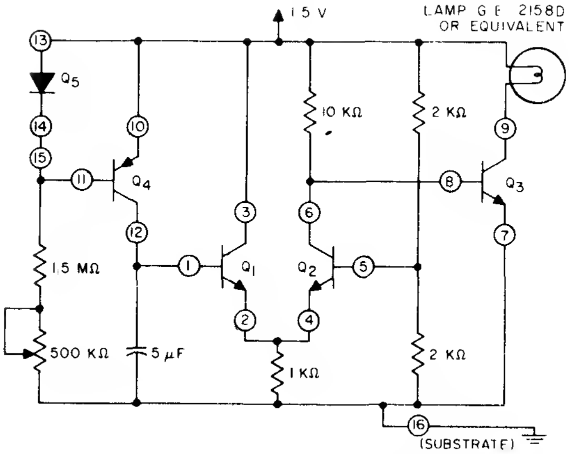


SEQUENTIAL TIMER—Output of first half of 556 dual timer is fed to input of second half through 0.001-μF coupling capscitor to give total deley equal to sum of individual timer delays. First hslf of timer is started by connecting pin 6 momentarily to ground. After interval determined by $1.1R_1C_1$, second timer starts its dalay determined by $1.1R_2C_2$.—"Signetics Analog Data Manual," Signetics, Sunnyvale, CA, 1977, p 724.

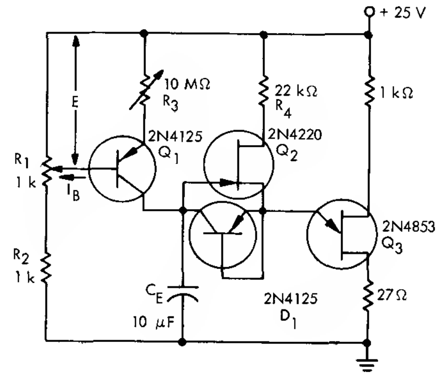


T=1.1RC

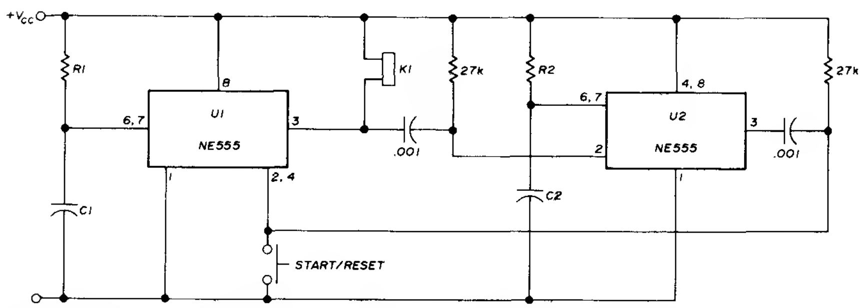
LONG TURNOFF DELAY—Combinetion of timer, optoisolator, snd bridge-triggared triac keeps AC motor or other device energized for up to 1 h sfter control switch is depressed momentarily. Closing of switch drops voltage et pin 2 of timer below ⅓ V_{CC}, meking timer output go high end thus tum LED on. At same time, capecitor st pin 7 begins chsrging. Output remains high until capscitor resches ⅔ V_{CC}, when output is reset to low state and motor thereby tumad off.—T. Mszur, Solid-State Ralays Offer New Solutions to Msny Old Problems, *EDN Magazine,* Nov. 20, 1973, p 26–32.



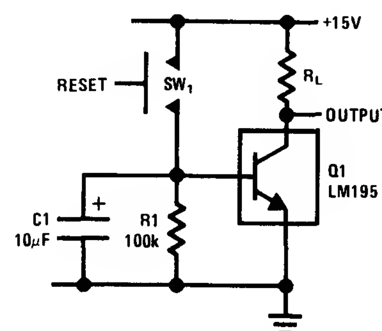
10-s TIMER—CA3096 transistor array provides all needed activa devicas. 5-μF capacitor charges through Q_4 until it turns on bistabla switch Q_1-Q_2, which then triggers Q_3 to delivar current to lamp load to indicata and of timing interval.—"Circuit Idaas for RCA Linear ICs," RCA Solid State Division, Somervilla, NJ, 1977, p 8.



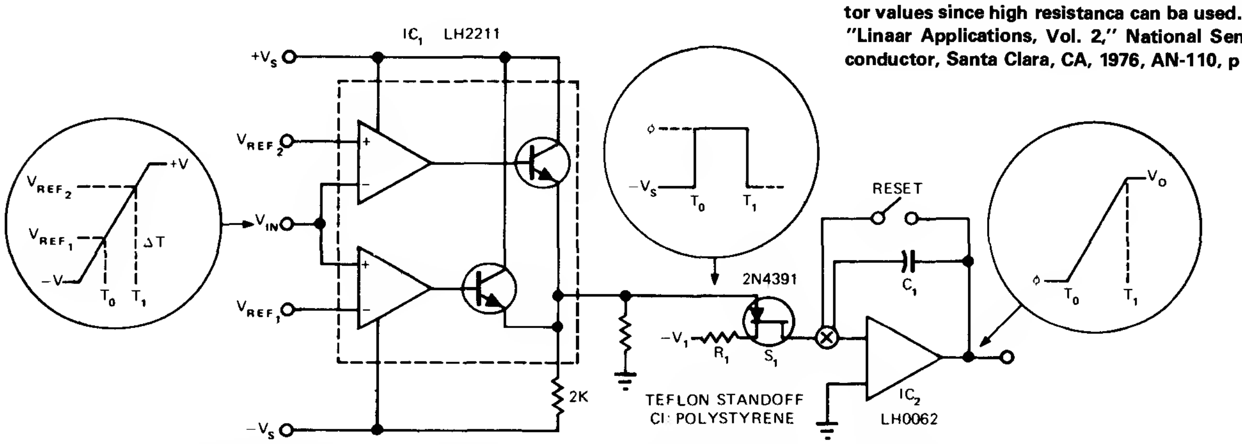
10-h DELAYS—Long duration is achieved by separating paak currant of timer from charging currant. Q_1 and R_1-R_2-R_3 form constant-current source whosa charging currant can be adjustad to as low as several nanoamparas. Q_2 acts as source follower to supply current flowing in emittar laad prior to firlng of UJT Q_3. Diode-connected transistor Q_1 provides low-impedance discharga path for timing capacitor C_E. Dalay time varies linearly with setting of R_3.—"Unijunction Transistor Timers and Oscillators," Motorola, Phoenix, AZ, 1974, AN-294, p 5.



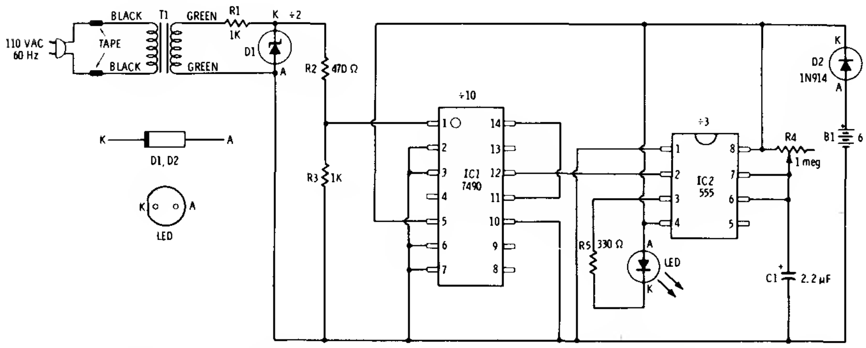
CASCADE WITH AUTOMATIC RETRIGGERING—Two timars, each controlling own load and having own time intervals (determinad by R1C1 and R2C2), recycle automatically whan start switch is closed momantarily. If dasired, second timar can ba set to control ON time of first timer. With 15-V supply, aach timer can handle 200-mA load.—H. Vordenbaum, Automatic Reset Timer, *Ham Radio*, Oct. 1974, p 50–51.



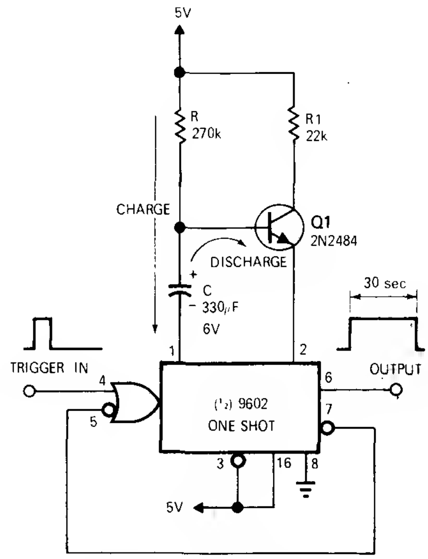
TIME DELAY USES POWER TRANSISTOR IC—Load is energized when switch is closed. C1 charges until voltaga across R1 drops balow 0.8 V, opening LM195 and deenergizing load. Long time delays can be obtained with small capacitor values since high resistanca can ba used.—"Linaar Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-110, p 4.



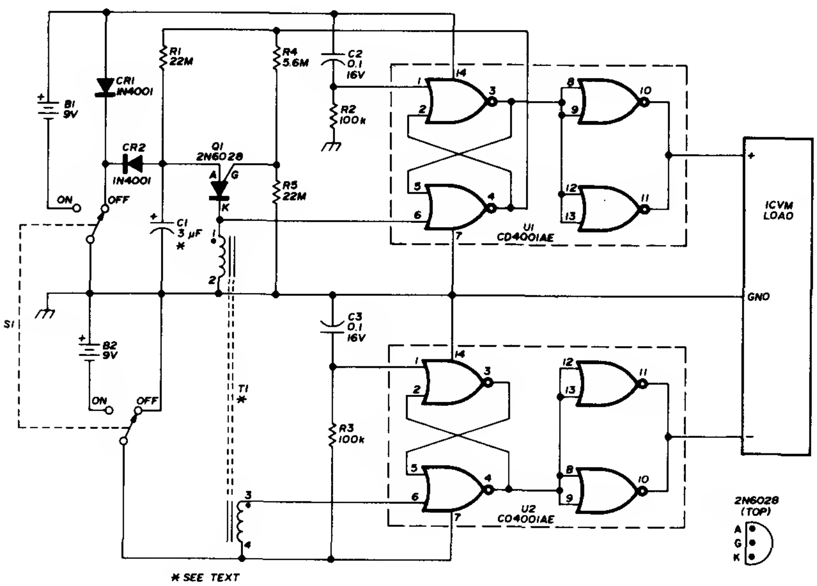
TIME-TO-VOLTAGE CONVERTER—Dual comparator, solid-state switch, and fast FET opamp provide flexibility, range, and accuracy required for using convertar in computer-controlled test system. IC_2 operatas as integrator and sample-and-hold circuit. Reference voltages of IC_1, V_{REF1}, and V_{REF2} allow time maasuraments of signal having eithar positive or negative voltage levels or both. Floating output stagas of comparators provida voltage translation for FET switch S_1. With S_1 closed, IC_2 integrates for tima pariod during which input signal is below referance voltagas. With S_1 open, IC_2 holds final voltage valua. Measurement range is from 1 μs to savaral hours.—C. Wojslaw, Wida Range Tima Measuramants Simplified, *EDN Magazina*, Feb. 5, 1974, p 95–96.



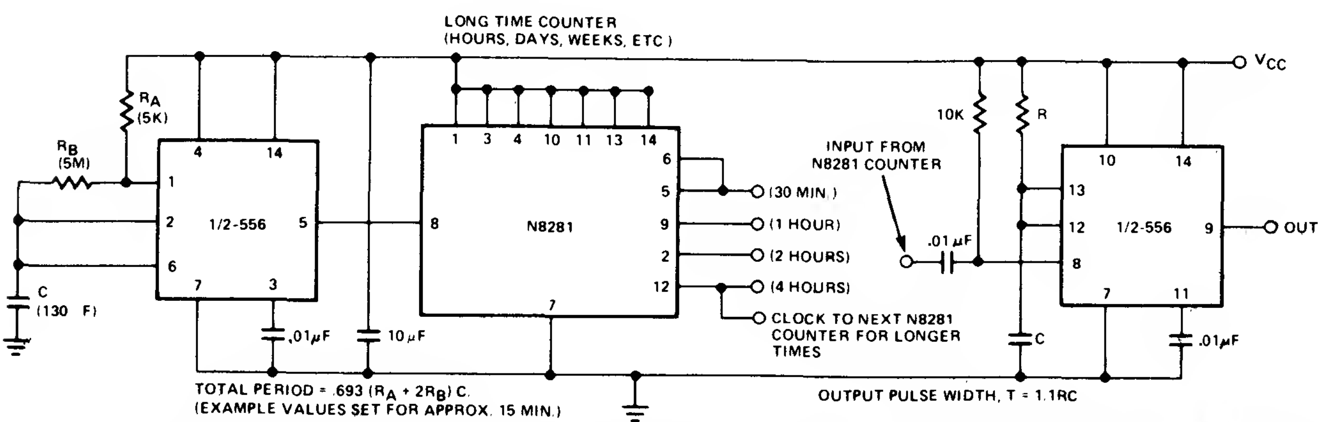
1-s HIGH-PRECISION—Accuracy is comparebla to that of 60-Hz power-lina frequency. After Redio Shack 276-561 6-V zener divides power-lina frequency by 2, 7490 decede counter provides division by 10 to give 3 Hz. 555 timar connactad es mono MVBR is than edjusted with R4 to divide by 3. LED then flashes et precise 1-s intarvels, staying on ebout 100 ms. T1 is 6.3-V filamant transformar.—F. M. Mims, "Integrated Circuit Projects, Vol. 5," Radio Sheck, Fort Worth, TX, 1977, 2nd Ed., p 21–29.



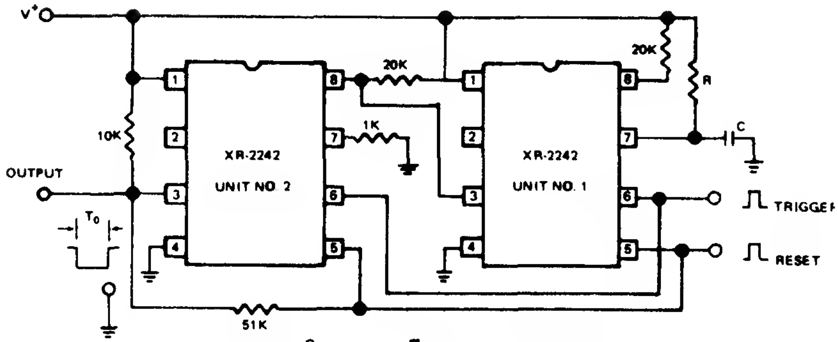
30-s NONRETRIGGERABLE—With values shown, mono IC gives deley pariod of 30 s after triggering by input pulse end ignores other input pulsas during timing period. Dalay time in seconds is RC/3, whera R is in ohms and C in farads. Dalay can be reduced to es littla es 10 ms by reducing R to 30 kilohms end C to 1 μF. Maximum deley is about 1 min, with 560 kilohms for R.—F. R. Shirlay, Thirty-Second Timer Uses IC Ona-Shot, *EDN/EEE Magazine*, Jan. 1, 1972, p 73–74.



BATTERY-SAVER—Turns off battery-powered IC VTVM automatically about 3.5 min after tuming on with S1, to prolong battery life evan though usar forgets to turn off instrumant. Circuit can be retriggared at any time in timing cycle by switching S1 off and then on again. Q1 is programmable UJT that drivas latch using two gates of CD4001AE qued NOR gate U1. With pin 3 high end pin 4 low, timing circuit and loed era both turned off; battery drain by U1 is then only 0.001 μA. Values of R1 and C1 determine tima intarvel. T1 is air-cora pulse transformar heving 600 turns (No. 36 to 40) enamel for primary and sama number wound over primary for secondary.—R. Hardesty, Turn-Off Timar for Portable Equipment, *Ham Radio*, Sapt. 1976, p 42–44.

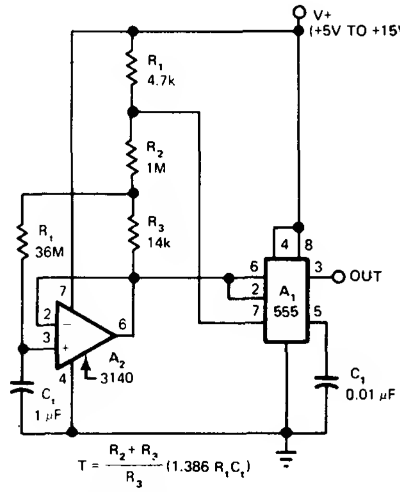


4-h SEQUENTIAL TIMER—Usa of N8281 divider network between sections of 556 dual timer gives extremely long time deleys without costly larga low-leakage capacitors. First section operates es oscillator having period of 1/f. Oscillator output is applied to divide-by-*N* network to give output with pariod of N/f for triggering second half of timer. Connection of dividar to second section determines amount of delay introduced by dividar. Cascading of additional dividers increases maximum delay to days or even weeks.—"Signetics Analog Data Manual," Signetics, Sunnyvela, CA, 1977, p 724.



$$T_0 = (2^8 - 1)(2^7)\ RC = 32.640\ RC$$

1-YEAR TIMER—Casceded operation of Exar XR-2242 long-range timers providas ultrelong time dalays, up to 1 yaar. Cascading of counter sections providas 32,640 clock cycles bafora output pin 3 of unit 2 chengas stata. Common pull-up rasistor makes counter section of unit 2 trigger eech tima output of unit 1 makas positive-going transition. Cascading additional timer with unit 2 extends time dalay to 1.065 × 10⁹ RC. With RC valuas giving 0.1 s, time delay bacomas 3.4 yaars.—"Timer Data Book," Exar Intagratad Systems, Sunnyvale, CA, 1978, p 19–22.

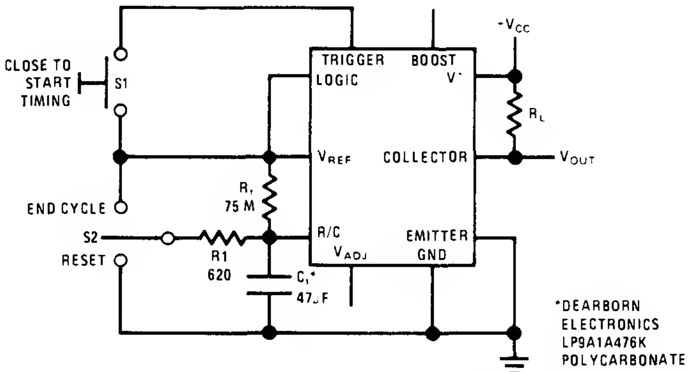


$$T = \frac{R_2 + R_3}{R_3}(1.386\ R_1C_1)$$

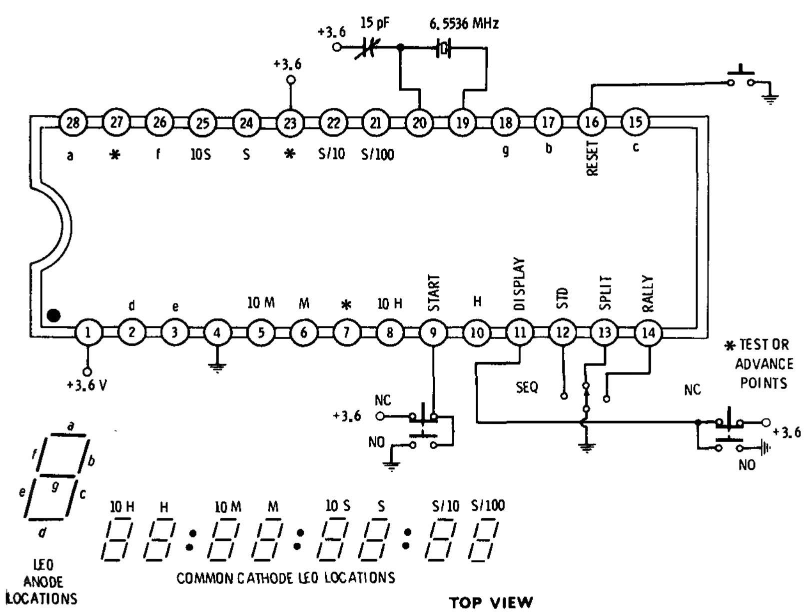
$T = 100\ R_1C_1$

(AS SHOWN T = 1 HR.)

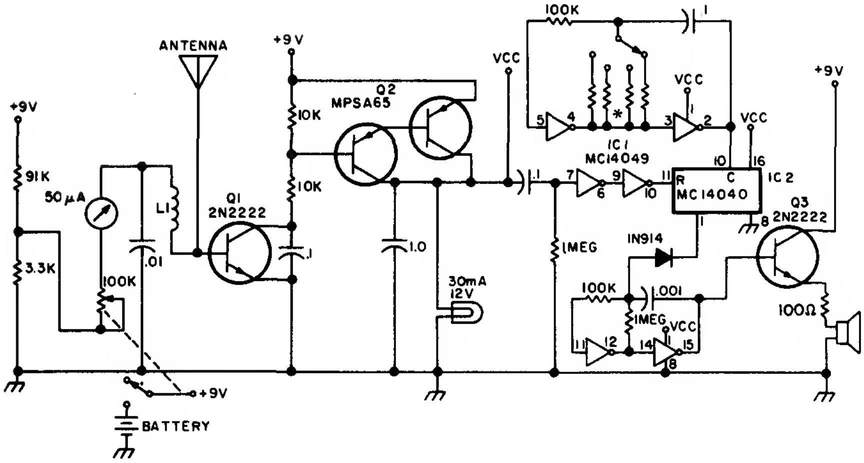
MICROSECONDS TO HOURS—Timing renge of 555 is increesed 100 times by using 3140 FET-input opamp in circuit that effectivaly multiplies values of timing componants end buffers timing natwork. Pin 7 of 555 switches epplied voltage of timing network between V+ and ground. Ratio selected for R_2-R_3 can be varied over wida range to change multiplying retio, provided squara-wave voltage across R_3 is at least 50 mV. Output is essentially pura squere wave. Supply voltege is notcritical.—W. G. Jung, Teke e Fresh Look at New IC Timer Applications, *EDN Magazine*, March 20, 1977, p 127–135.



1 h WITH END-CYCLE SWITCH—Nationel LM122 timar is connected with manual controls for start, raset, and intermediata tarmination of 1-h timing cycle sterted by closing S1. Once timing starts, S1 hes no further affect. Moving S2 up anda cycle prematuraly with appropriata change in output state. Moving S2 down rasats timing capacitor to 0 V without changing output; raleasing S2 starts new timing cycla.—C. Nelson, "Versatile Timar Oparates from Microseconds to Hours," Nationel Semiconductor, Santa Clere, CA, 1973, AN-97, p 9.

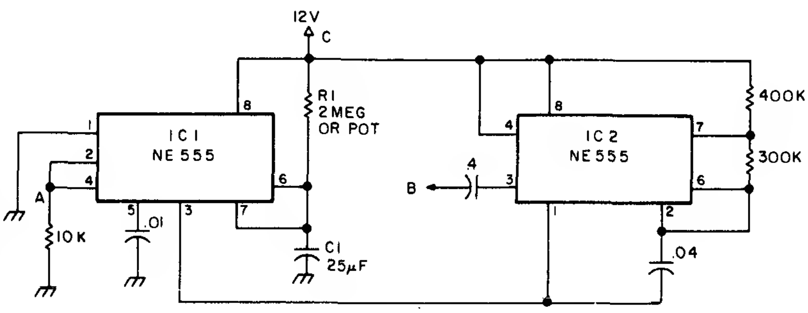


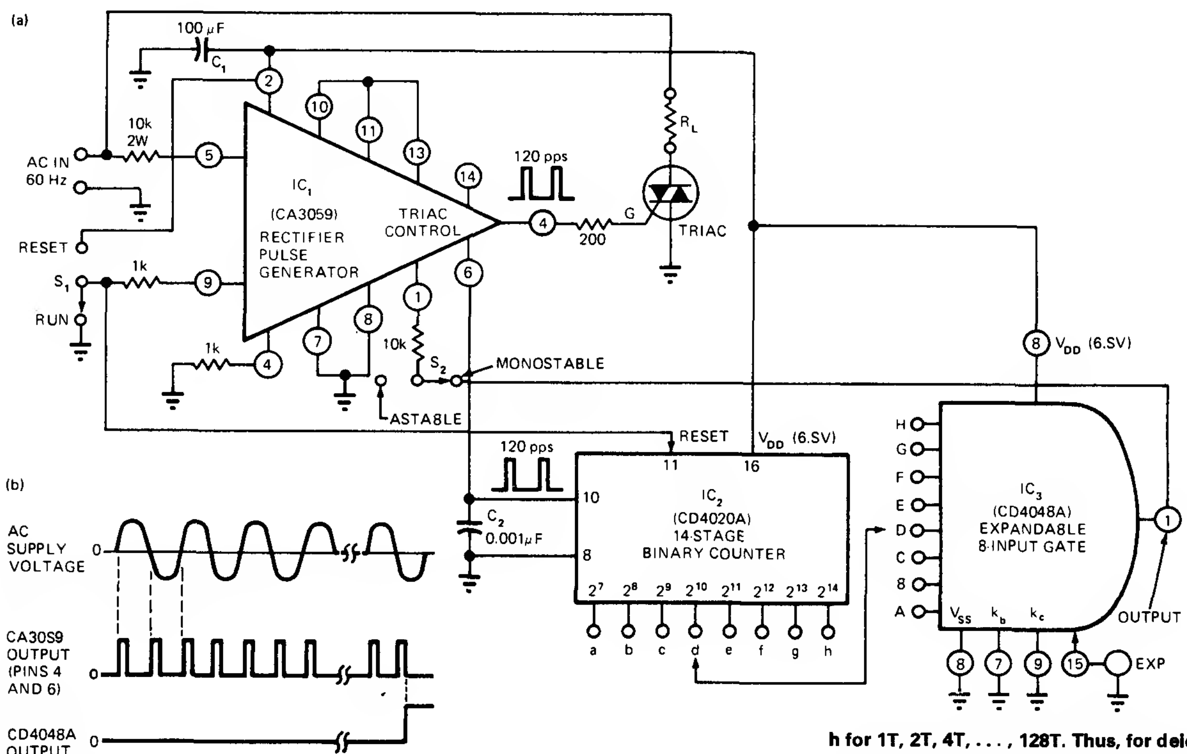
STOPWATCH—Intarsil 7045 IC providas cepebility for driving digital displey of time in hundredths of a sacond up through hours in four different operating modes salected by lowar switchas: saquantial, standard, split, or rally. Grounding pin 9 momentarily with start swltch initiates timing action. Repeated prassinga of swltch activate operating modes aa aalectad. Grounding rasat pin 16 clears stopwetch. IC can be connacted directly to LED display, without drivers or rasistors.—D. Lancastar, "CMOS Cookbook," Howard W. Sama, Indienepolis, IN, 1977, p 159.



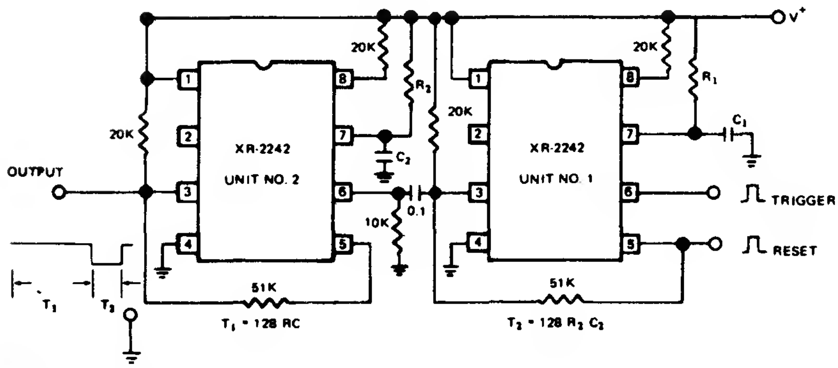
TALK TIMER—Switch givas choica of intervels from 0.5 to 5 min aftar going on eir, before time-out elerm tone sounds. Circuit includes field-strength meter end on-the-eir light. Releesing mika button for about 1 s resets timer, which consists of MC14049 hax inverter end MC14040 12-bit ripple countar. L1 is 3 turns No. 20 wire on 5/16-in form. Timing resistor velues ere 47K for 0.5 min, 100K for 1, 220K for 2, 390K for 3, and 510K for 5 min.—B. Fatta, An FM Gedget, *73 Magazine,* April 1977, p 154–155.

90-s TALKING-LIMIT WARNING—Developed for AM radio transceivers making use of re-peaters, to limit langth of individual transmis-sion so es to avoid baing timed out at repeater. Uses NE-555 connected as timer, with C1 and R1 chosen to set timing at about 90 s. Point A is connected to terminal of TR switch that goes from neutral or ground on receive to 12 V on transmit. Timing cycle begins on transmit; whan IC1 times out, it activates IC2 connected as 1000-Hz astabla oscillator driving transceiver connectad to B. Tone sounds until microphone button is released to raset timar.—S. Kraman, Try the Mini-Timar, *73 Magazina,* June 1977, p 48.

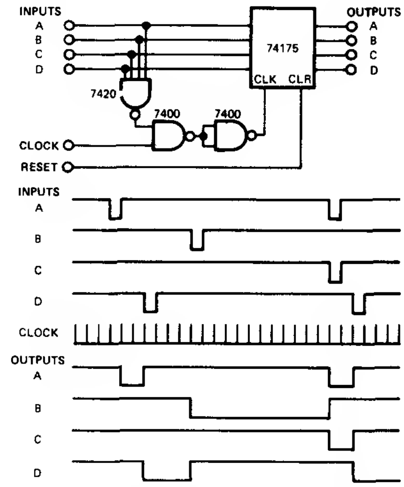




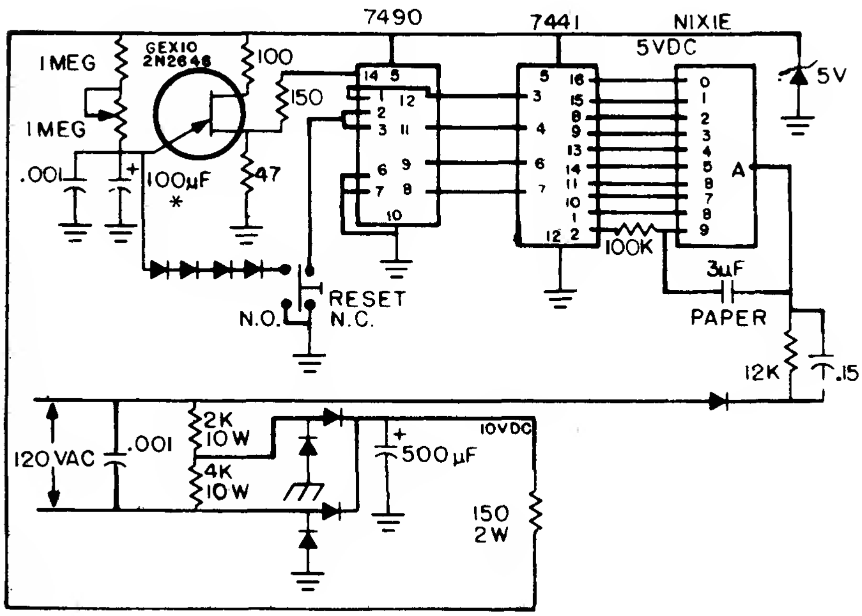
0.5333–136 s WITH LINE-FREQUENCY ACCU-RACY—Providas tima deleys in selected incre-ments of 0.5333 s with accuracy essentially that of AC line frequency. IC_1 develops 120 pulses per second heving 100-μs width at pins 4 and 6 for eech zaro crossing of line. First six stages of IC_2 determine basic timing pariod 1T. These stagas produce pulsa train with pariodicity of 0.5333 s et input of seventh counter stege. Binery-or-dared output signels era evelleble et outputs e-h for 1T, 2T, 4T, . . . , 128T. Thus, for deley of 1 min (ebout 112T), use 64T + 32T, + 16T with AND-gate programming interconnections e-E, f-F, and g-G. Tia all unused AND-gete inputs to V_{DD} bus.—A. C. N. Sheng, Line-Opereted Timar Couples High Accuracies with Long Time De-leys, *EDN Magazina,* Jen. 5, 1978, p 37–40.



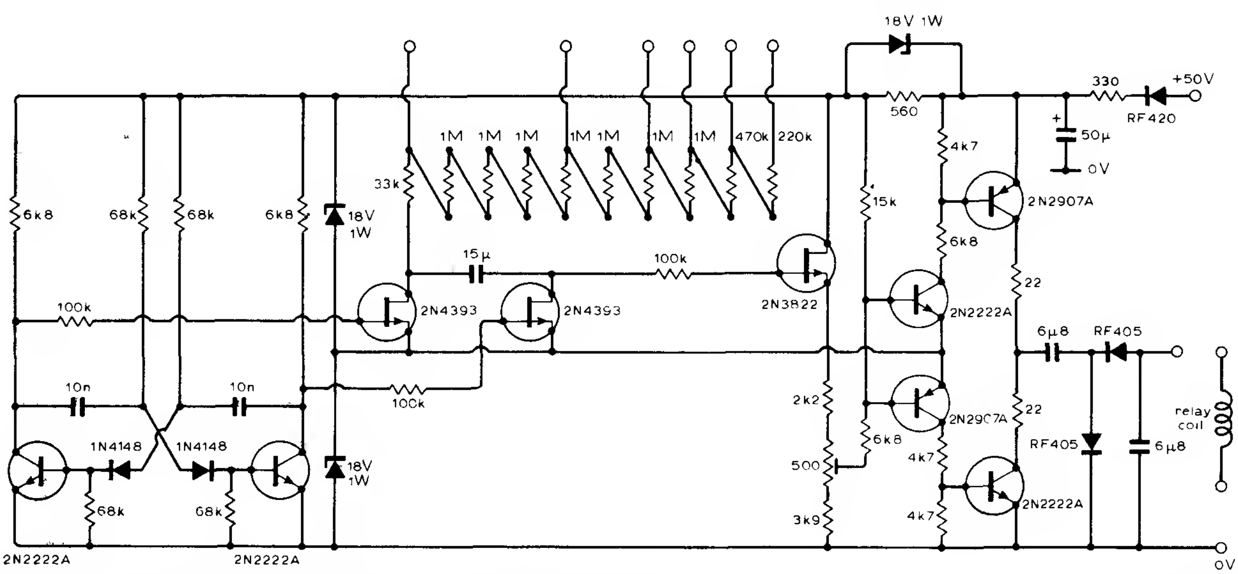
SEQUENTIAL TIMER—Second Exar XR-2242 long-range timer is triggered when first timer completes its cycle, length of which is equal to $128R_1C_1$. Output of second timer thus stays high for $T_1 = 128R_1C_1$ after trigger is applied, then goes low for duration $T_2 = 128R_2C_2$ corresponding to timing interval of unit 2. Circuit then reverts to rest state.—"Timer Data Book," Exar Integrated Systems, Sunnyvale, CA, 1978, p 19–22.



EVENT REGISTER—Inputs from sequential timer provide pulsed output and operate devices which stay on until next timed event. When an input goes low, output of four-input positive-NAND 7420 goes high, enabling the clock for 74175 4-bit D-type register. Since event-timer clock signal is used, outputs of register are coincident with clock. All outputs remain until one or more inputs goes low.—J. Glaab, Time Events with a Pulse Output Controller, *EDN Magazine*, Jan. 5, 1977, p 43.

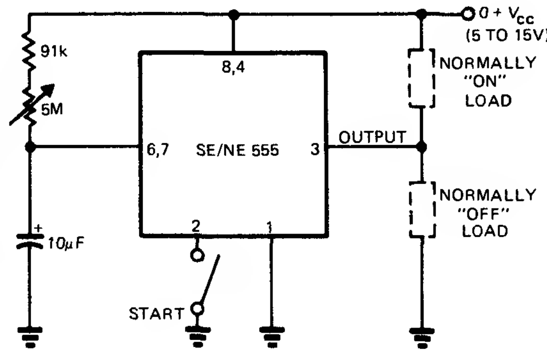


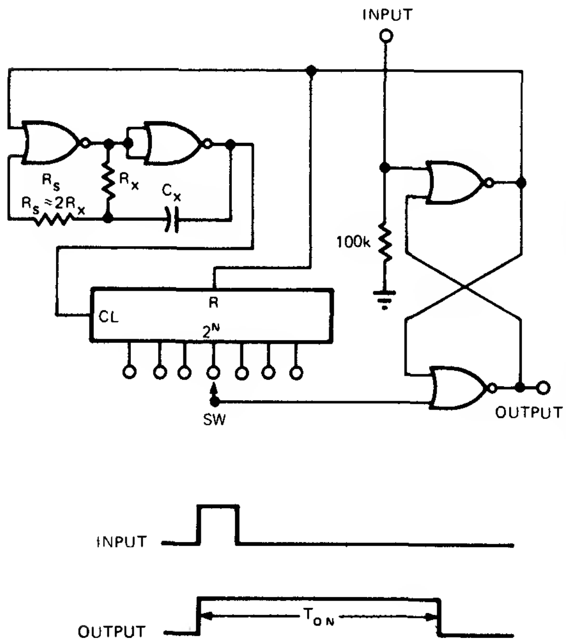
10 min WITH BLINKING—Station-identification timer uses single Nixie display to indicate elepsed time in minutes. After 9 min, numeral 9 blinks for 60 s before resetting to zero as visual reminder that amateur radio station identification should be made. Transistor can be GE X10 or 2N2646. Diodes are 1N4001 or equivalent. Numeral 9 or Nixie is connected as relaxation oscillator, flash rate of which can be changed by changing value of 100K resistor connected to pin 9.—W. Pinner, ID Timer, *73 Magazine*, Aug. 1974, p 95–96.



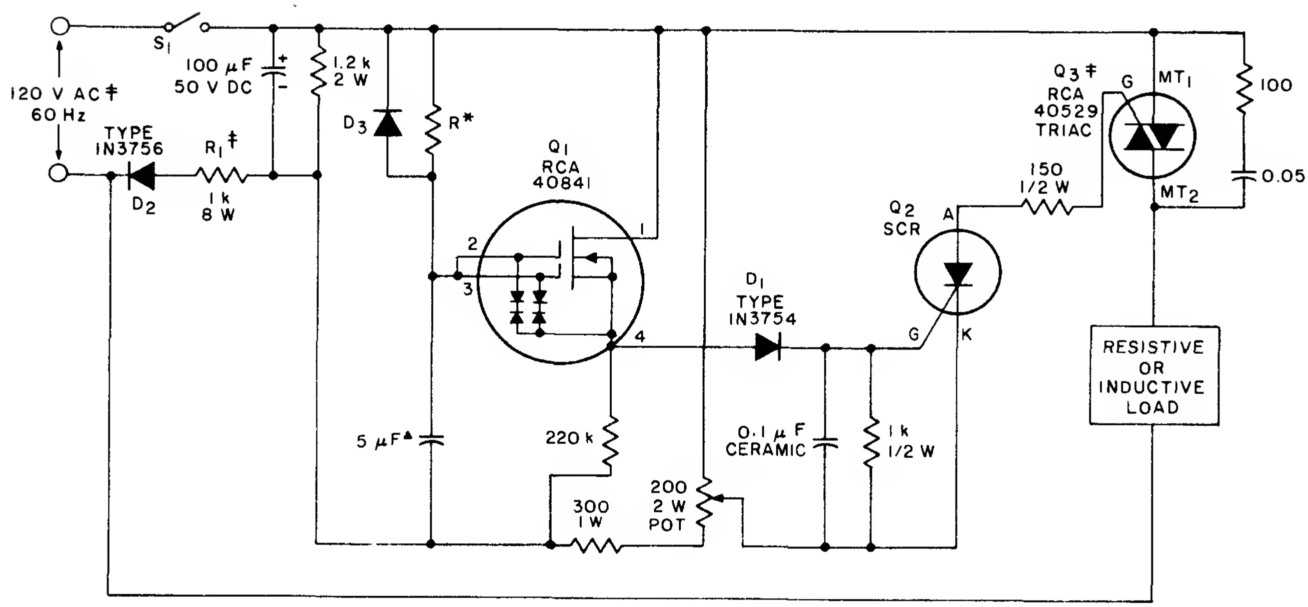
FAIL-SAFE TIMER FOR TRAINS—Provides delays up to 4 min, adjustable in 2-s steps, with accuracy better than 5%. Patented circuit was developed by ML Engineering to provide appropriate automatic braking or other action if engineer on train fails to respond to signal within period of delay.—W. E. Anderton, Computers, Communication and High Speed Railways, *Wireless World*, Aug. 1975, p 348–353.

ON OR OFF CONTROL—Circuit shows two ways of connecting 555 timer IC, for switching load on or switching loed off at end of timing interval determined by setting of 5-megohm pot (1 to 60 s) end initieted by menual start switch. If desired, both loeds can be connected to circuit for simultaneous switching.—E. R. Hnetak, Put tha IC Timer to Work in e Myried of Ways, *EDN Magazine,* March 5, 1973, p 54–58.

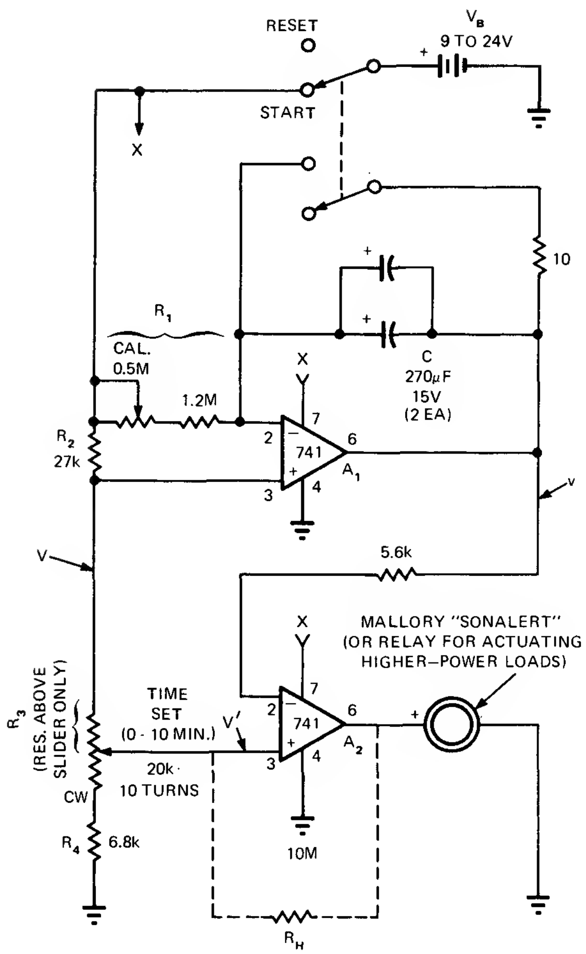




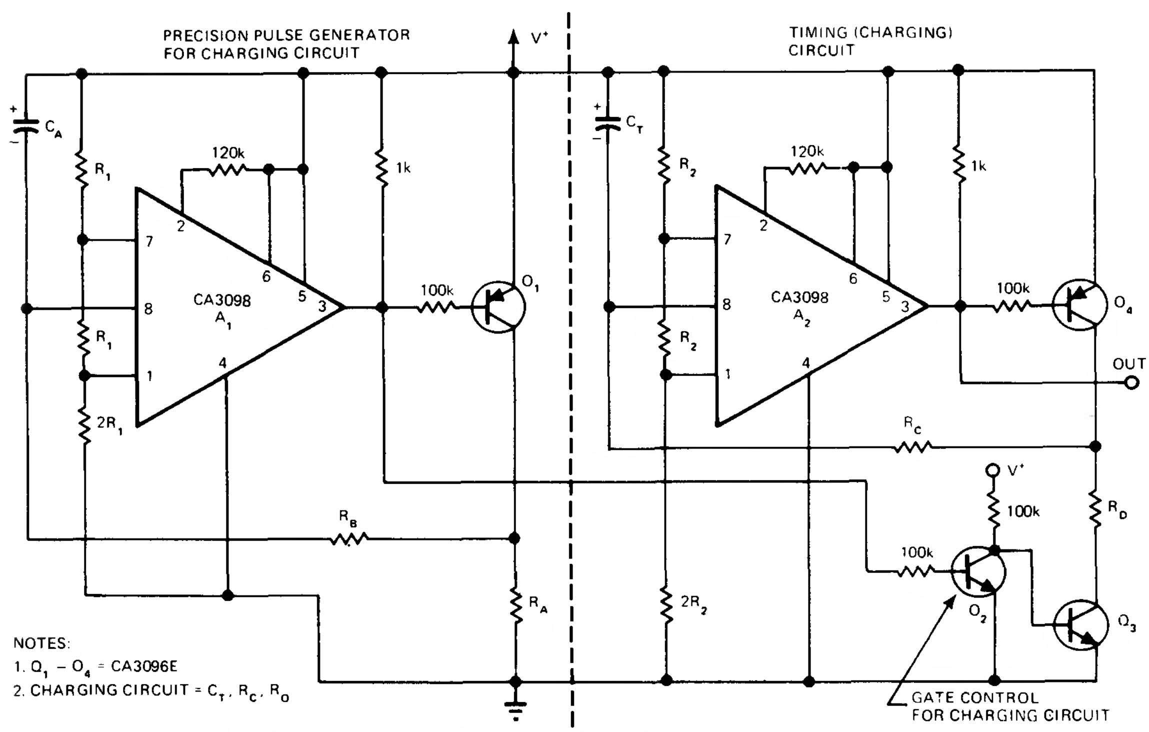
MICROSECONDS TO HOURS—Simpla CMOS circuit serves es time-deley switch and generai-purpose timer. Geted oscillator and letch are obtained from CD4001 quad two-input NOR gate, end 14-stage counter uses CD4020. T_{ON} is function of oscillator frequency es determined by R_XC_X and proper 2^N output from counter. Pulse applied to latch input enables oscillator end counter. Latch output remains high until counter resets latch et end of count selected by switch. Further decoding is required for count or time veriations finer than power of 2.—J. Chin, Low-Power Counter Is Progremmeble over Wida Renge, *EDN Magazine,* March 20, 1974, p 83.



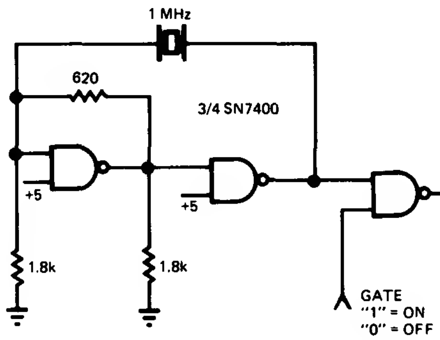
0–5 min DELAY—Value of resistor R controls duretion of time deiey provided by RCA 40841 dual-gate FET in SCR triggar circuit, with SCR in tum serving to trigger triec for hendling high-currant rasistive or inductive AC loads. Maximum delay of 5 min is obtained when R is 60 megohms (IRC typa CGH or equivalant resistor). Timing is accureta within 10% over tempareture renge of −25°C to +60°C. D_3 should be rated 60 V. Use any SCR cepable of handling triac trigger current, rated 60 V.—"Linear Integrated Circuits end MOS/FET's," RCA Solid State Division, Somervilie, NJ, 1977, p 435–437.



0–10 min WITH 1-s ACCURACY—After calibration, accurecy is independent of battery voltage because source voltage affects cherging voltage of C end threshold of comparator A_2 equelly. Time delay t for timer is CR_1R_3/R_2.—M. Strenge, Simple Electronic Timer is Compect end Accurete, *EDN Magazine,* April 20, 1973, p 89 and 91.

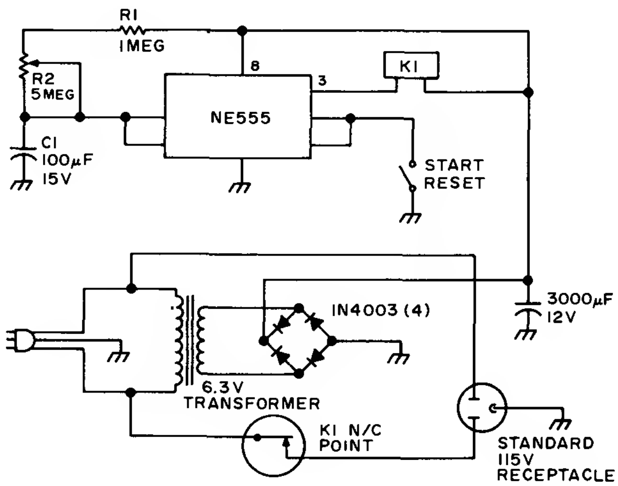


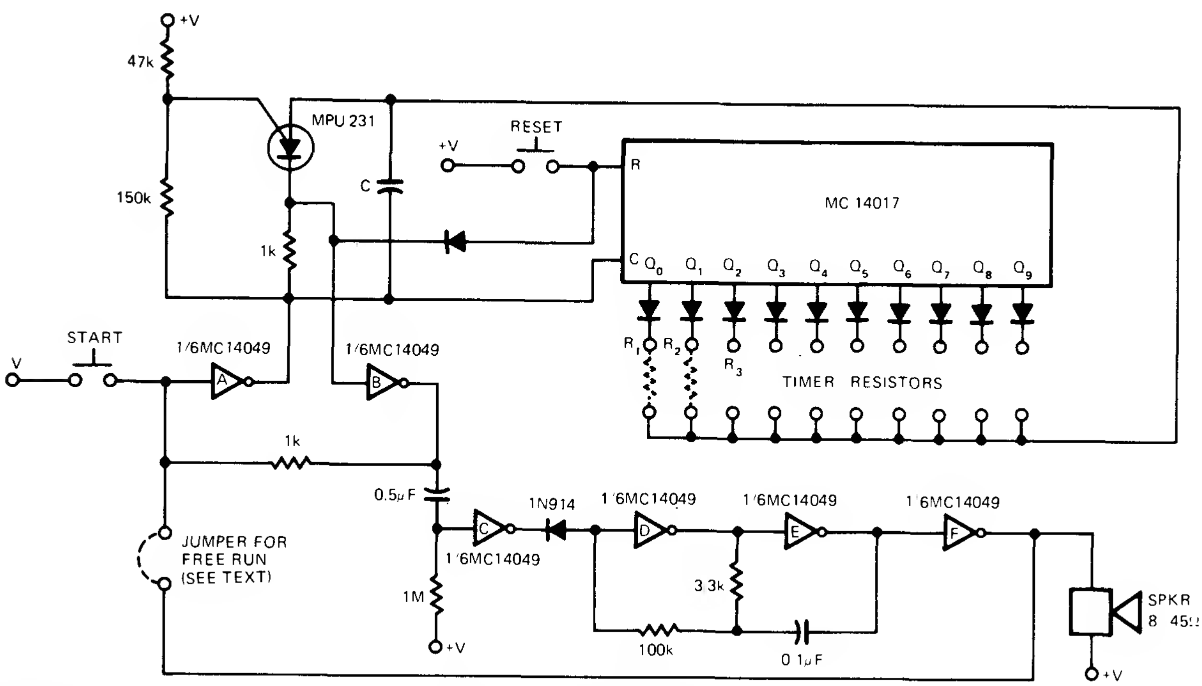
LONG INTERVALS WITH SMALL C—Use of two CA3098 dual-input precision level detectors eliminates naed for expensive high-capacitance low-leakaga timing capacitors when delay intervals of several hours are required. For 4-h timar, C_T is only 16 μF if R_C is 22 megohms and R_D is 100 kilohms. Articla traces circuit operation end gives design equations.—G. J. Granieri, Precision Level Detector IC Simplifies Control Circuit Daslgn, *EDN Magazine,* Oct. 5, 1975, p 69–72.



PROGRAM TIMER—Measures tima between two points in microprocessor program whila progrem is running. Gated 1-MHz crystal oscillator feeds Fluka 1941A counter used in totalize mode. Gate input is connected to unused bit of output port on microprocessor system. Instructions ere than inserted in program under test to gate counter on et beginning of desired step and turn it off et and. Display then shows numbar of microseconds required by microprocessor to executa instructions.—M. M. Dodd, Benchmark Timar Eliminates Need to Total Individual Execution Times, *EDN Magazina*, Oct. 20, 1975, p 91–92.

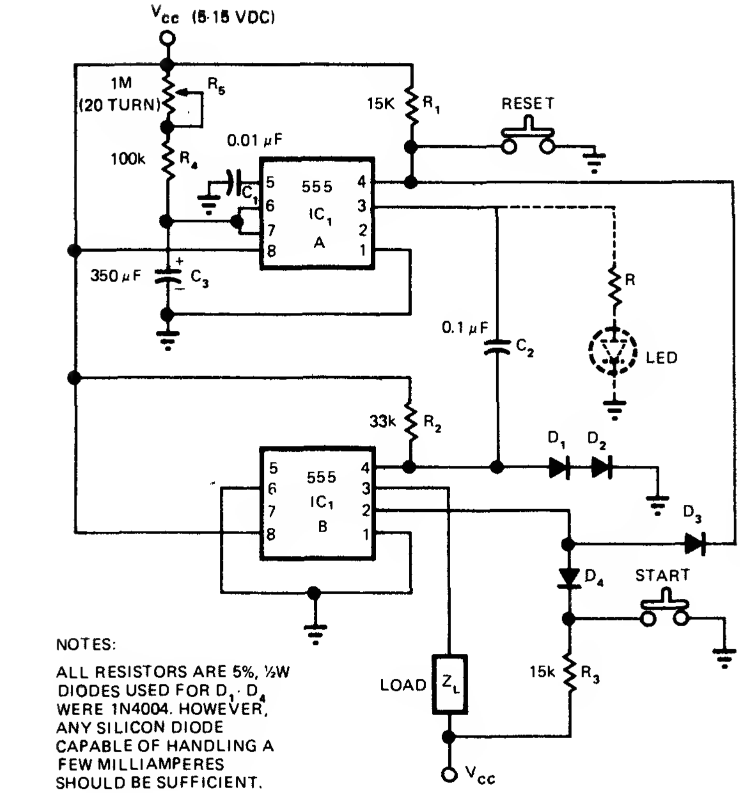
1-h HOUSEHOLD TIMER—NE555 timar circuit turns off television set or othar devica at any desired tima up to about 1 h eftar start switch is closed. Use IRC MR312C relay heving coil resistance of 212 ohms, or other 12-V ralay drawing less then 200 mA. With values shown, R2 givas time delay ranga of 3 to 58 min. For othar ranges, changa values of R2 end C1. Clockwise from top, pins on NE555 are 8, 3, 4, 2, 1, 7, and 6.—P. C. Walton, Build This $5 Timer, *73 Magazine*, Jan. 1976, p 129.



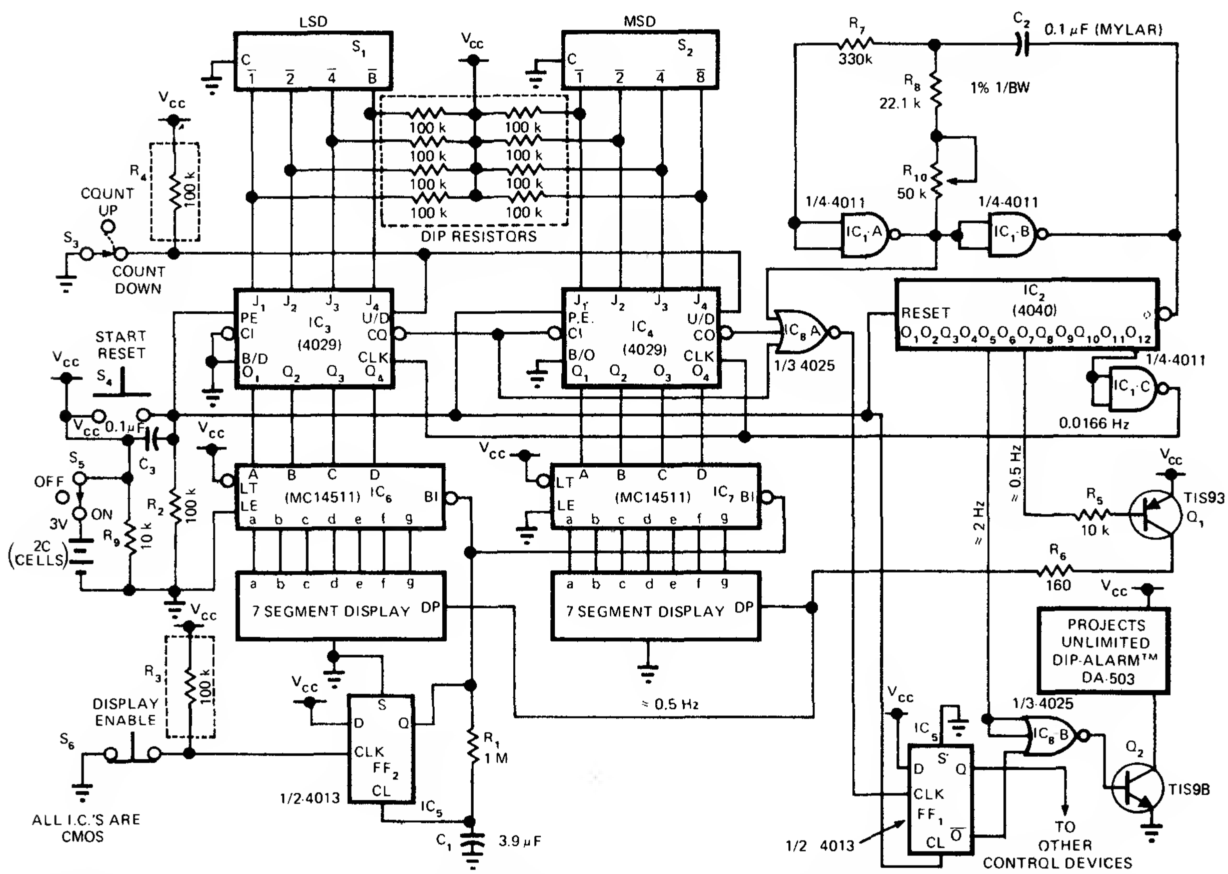


Diode needed only in FREE RUN MODE

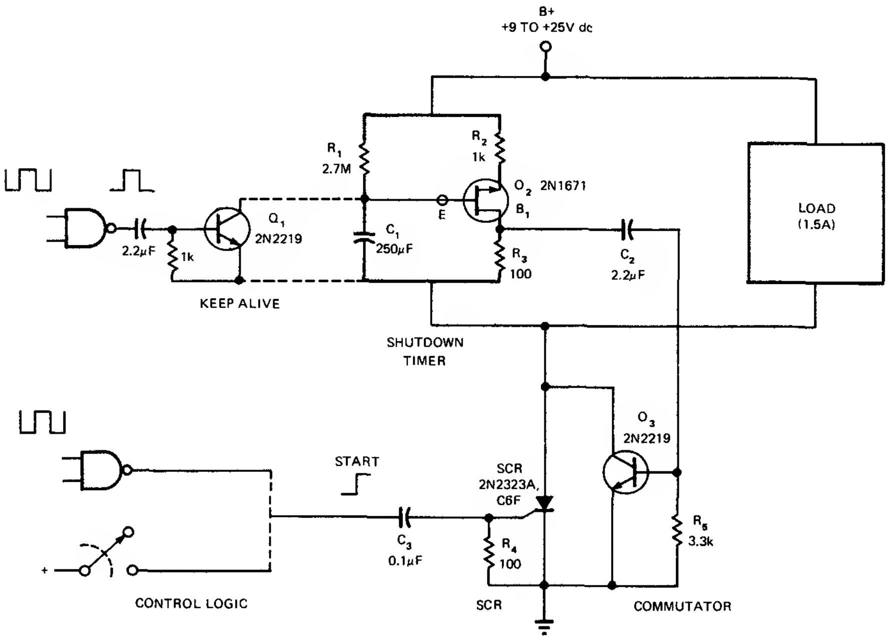
10-INTERVAL TIMER—Ten Independently predeterminad tima intarvals run in sequance, with eudible beep at end of aach interval. Timar holds after eech intarval until stert button is pressed to initiata naxt interval. If jumpar is inserted, succaading intervals start automatically. Values of R_1-R_9 and C determine time intarvals. If sama time is usad for mora than ona step, dioda outputs of those steps may be tied togethar to use sama resistor. Supply can be in ranga of 5 to 18 V. Current drain is less than 100 µA, but increases to 40 mA during baep. Reset button can ba daprassed at any tima, to restart timing at first interval.—T. Henry, Ten Stap Sequential Interval Timer, *EDN Magazina*, March 20, 1974, p 78 and 80.



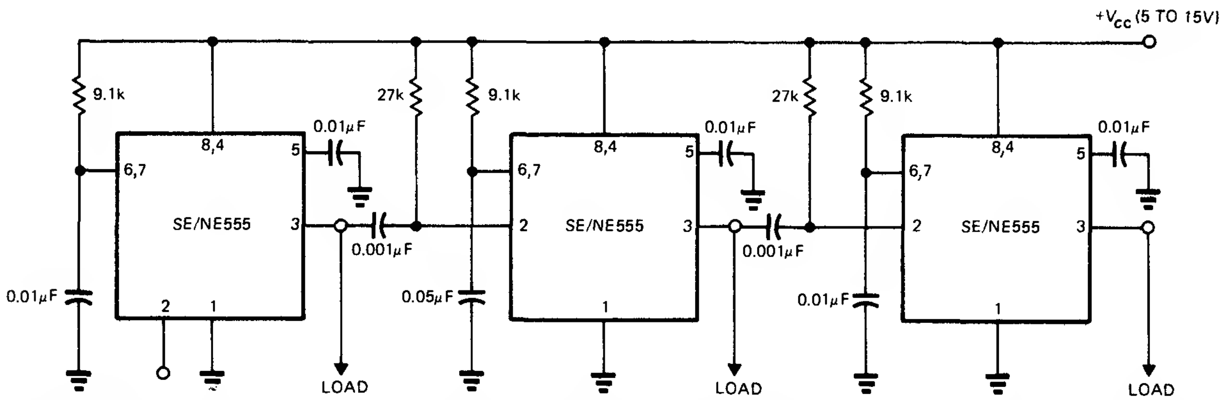
2–5 min STARTING DELAY—Energizing of load is delayed up to 5 min after start button is pushed, as required in some CMOS circuits and digital control systems. Uses pair of 555 timers, with A operating in straightforward timing mode and B connected as set-reset flip-flop. Pushing reset button initializes system, placing A in low state and making pin 3 of B high, leaving load unenergized. When start button is pushed, A goes high and begins timing out. After delay interval, output of B goes low, energizing load until system is reset. LED can be added to indicate that timing is in progress.—J. C. Nichols, Versatile Delay-on-Energize Timer Uses Two 555's, *EDN Magazine*, Oct. 5, 1975, p 76 and 78.



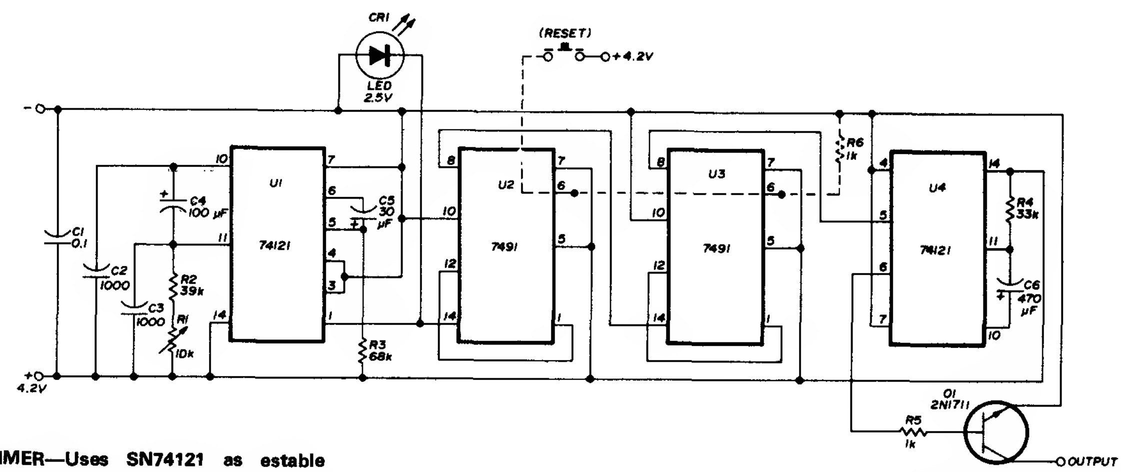
THUMBWHEEL-SET TO 99 min—Developed for timing events and for limiting event to predetermined interval that can be set up with 2-digit BCD-encoded thumbwheel switches. Digital display shows time remaining, as guide for speakers. Audible alarm indicates end of time interval. Flashing decimal point indicates counter is working. Designed for operation from two C cells. To conserve power, display is normally blanked; pressing display-enable switch turns on display for about 4 s. Article describes operation of circuit in detail.—R. A. Fairman, CMOS Lowers Timer Power Consumption, *EDN Magazine*, Oct. 5, 1975, p 78 and 80.



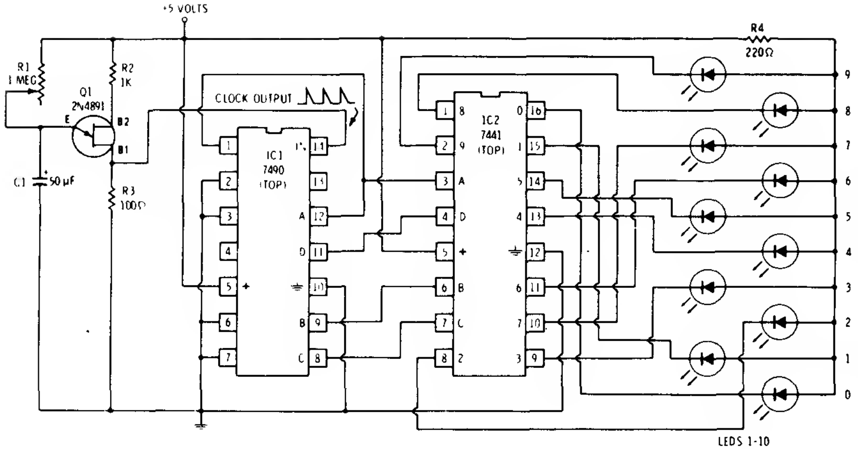
BATTERY-SAVING TIMER—Developed for usa with elarms, remota controls, or unattended electronic equlpment, to turn off battary automaticelly et predetermined intervel after circuit is ectuated by control logic or switch. Turn-on applies positive pulse that triggers SCR on, grounding load and UJT timer Q_2. After delay interval determined by values of C_1 end R_1, Q_2 fires end discherges C_1, producing pulse across R_3 that turns on Q_3. This in turn shunts SCR and commutatas it off. Circuit is thus turned off, efter which only vary smell leakage currents through reverse SCR junction will be drain on bettery.—D. Weigand, Battery Saver Has Automatic Turn-Off, *EDN Magazine*, April 20, 1973, p 91.



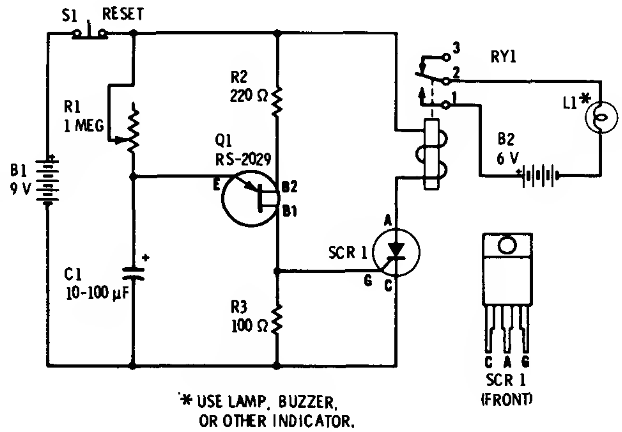
TEST SEQUENCING—Uses 555 timers connected sequentially. With velues shown, first timer runs for 10 ms efter starting with pulse at terminal 2 or by grounding 2. At end of timing cycle, second circuit runs for 50 ms before triggering third circuit having 10-ms delay. Each timer controls its own load, as required for sequencing of eutomatic tester.—E. R. Hnatek, Put the IC Timer to Work in a Myriad of Ways, *EDN Magazine*, March 5, 1973, p 54–58.



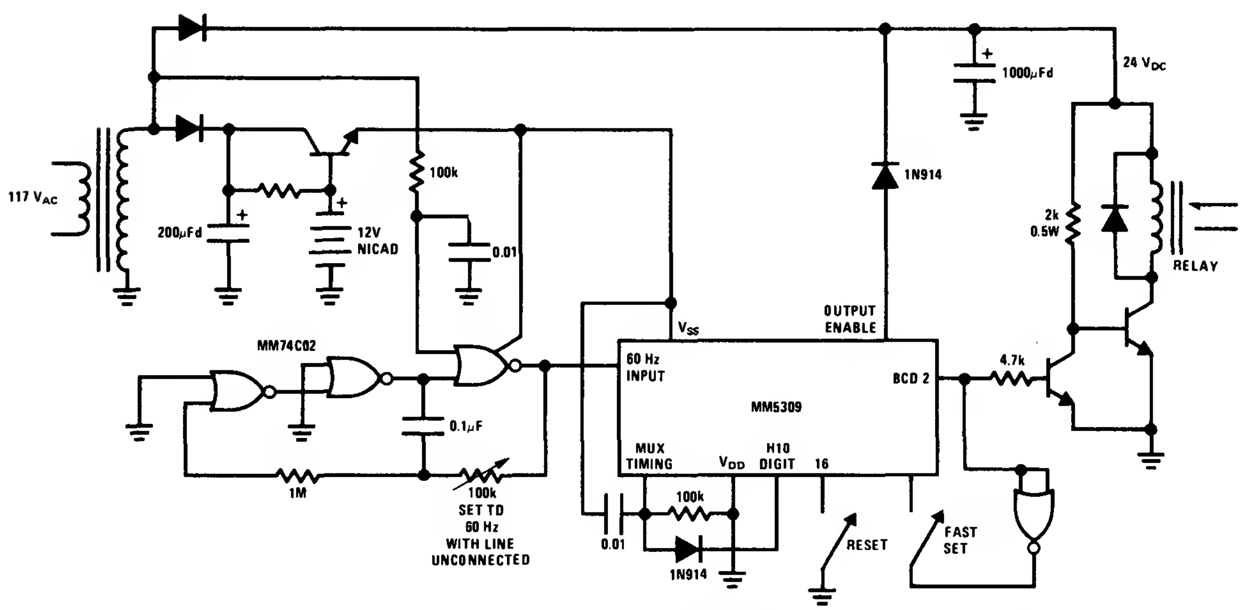
10-min TIMER—Uses SN74121 as estable MVBR generating pulses et 4-s intervals. U2 and U3 divide pulse train by 144 to give period of 576 s. U4 is then turned on, producing positive output pulsa lasting 20 s that turns on Q1 for driving keyer, sidetone oscillator, lamp, or other signelling device as reminder for amateur redio operator to make 10-min stetion identification. R1 adjusts timing.—H. Seeger, Ten-Minute Timer, *Ham Radio*, Nov. 1976, p 66.



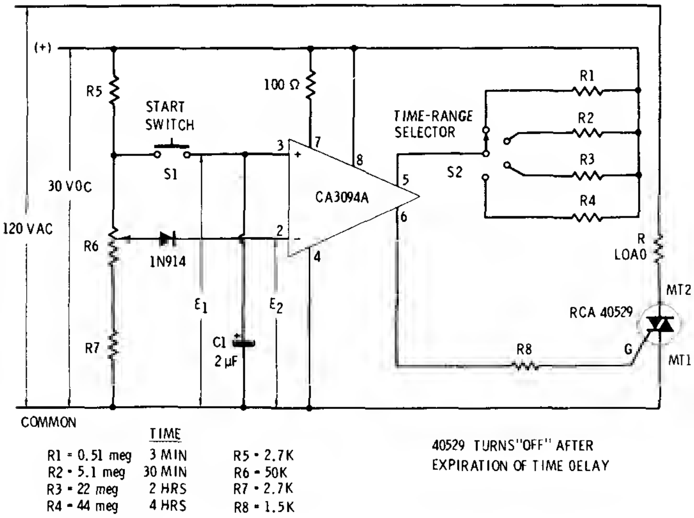
10 s TO 10 min—Array of ten LEDs serves for measuring time intervals up to 10 min, for timing phone calls, photographic exposures, and cooking. Pulse output rate of UJT oscillator Q1 is determined by value of C1 and setting of R1. Pulses are counted by 7490 which gives total count in binary form. 7490 recycles after each 10 counts. 7441 converts binary signals from 7490 to decimal outputs driving LED indicators. Each LED glows in sequence as count advances from 0 through 9 and repeats. For 10-min timer, adjust R1 until first LED stays on for exactly 1 min. For 10-s timer, adjust R1 for blink rate of 1 s per LED.—F. M. Mims, "Optoelectronic Projects, Vol. 1," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 67–78.



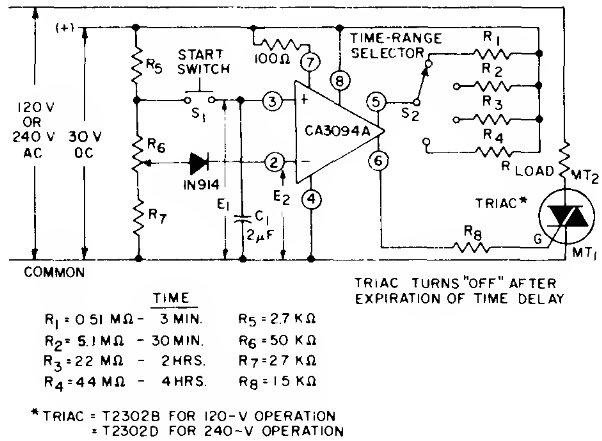
UJT-SCR TIMER—Use of large capacitance for C1 in simple UJT relaxation oscillator provides time delay action for triggering SCR controlling relay. R1 provides convenient adjustment of delay. SCR can be 6-A 50-V Radio Shack 276-1089. Relay is 275-004.—F. M. Mims, "Semiconductor Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1976, p 50–61.



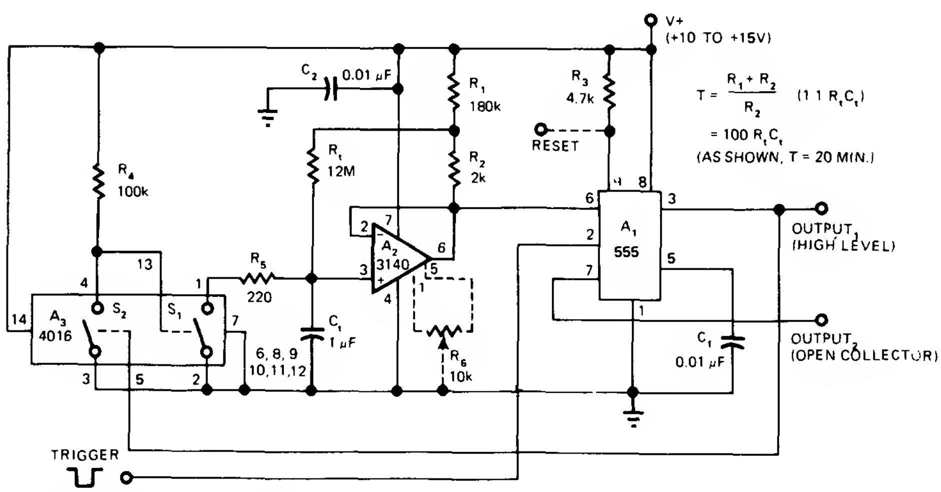
FAIL-SAFE LIGHT TIMER—National MM5309 clock IC is used as timer in circuit that maintains timing with adequate accuracy during periods of power-line failure and returns automatically to 60-Hz line as soon as power is restored. Applications include control of lights in unoccupied home. Timing action turns on lights for 4-h period every 24 h. When power is applied, internal multiplex circuit strobes each digit until digit with connected diode is accessed. This digit stops multiplex scanning, and BCD outputs present data from selected digit as control waveform whose edges determine timer data.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 1-74–1-77.



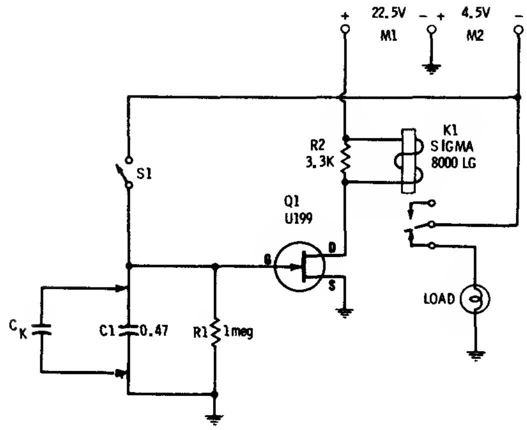
4-h CONTROL FOR TRIAC—Time at which triac is triggered by IC after momentarily pressing start switch is determined by resistor values used. When switch is released, charging capacitor C1 begins its long discharge interval. When voltage E_1 becomes less than E_2, pin 2 draws current and serves to reverse polarity of output at pin 6 for triggering triac. Diode limits maximum differential input voltage.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 316–317.



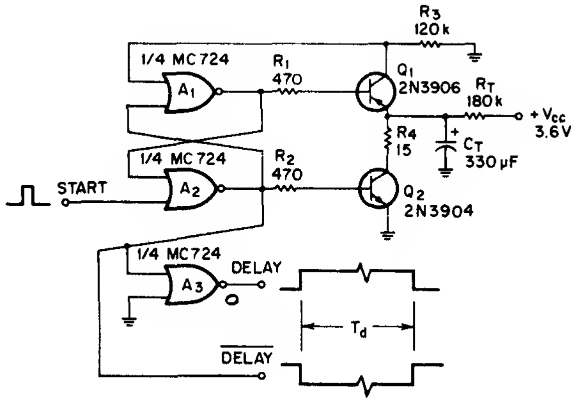
3 min TO 4 h—Presettable analog timer achieves long time intervals by discharging C_1 into input terminal 3 of CA3094 programmable opamp, which provides sufficient output current for driving thyristors and other control devices.—"Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 8.



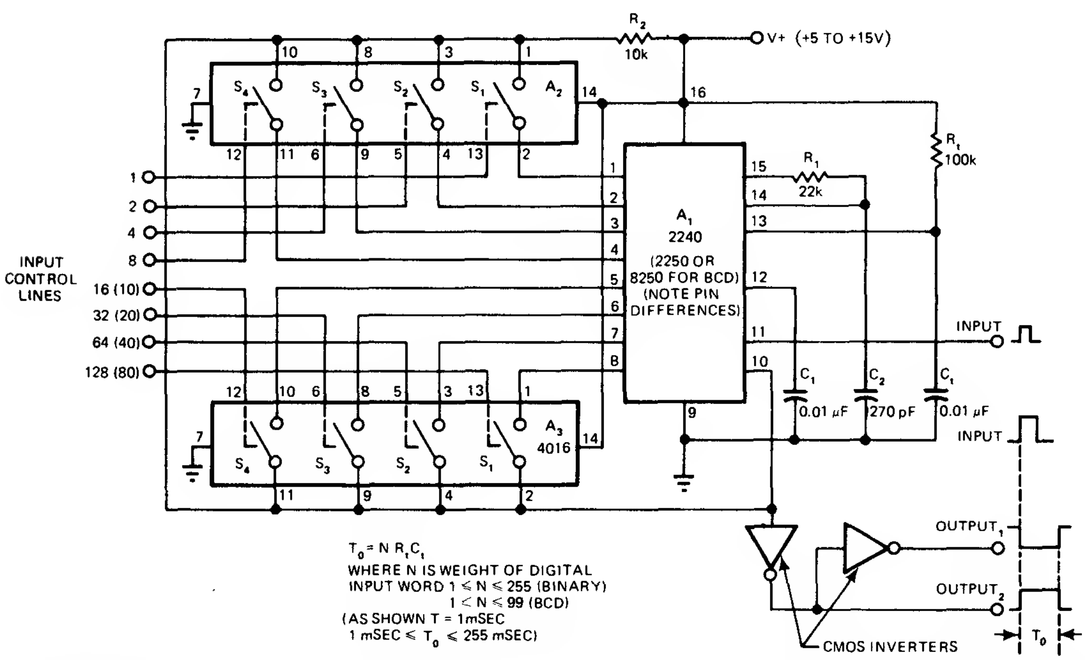
LONG-DELAY 555 MONO—FET-input 3140 opamp is used to multiply effective values of timing components R_t and C_t, eliminating need for high-value precision resistor and large low-leakage capacitor. Combination performs as standard 555 mono except that timing equation is T = 100R_tC_t (for condition wherein division resistors R_1 and R_2 are chosen for 91-to-1 operation). Circuit has uncommitted open-collector output from pin 7 of 555, which can be referred to any voltage from 0 to +15 V. Pin 4 is between pins 6 and 8 on 555.—W. G. Jung, Take a Fresh Look at New IC Timer Applications, *EDN Magazine,* March 20, 1977, p 127–135.



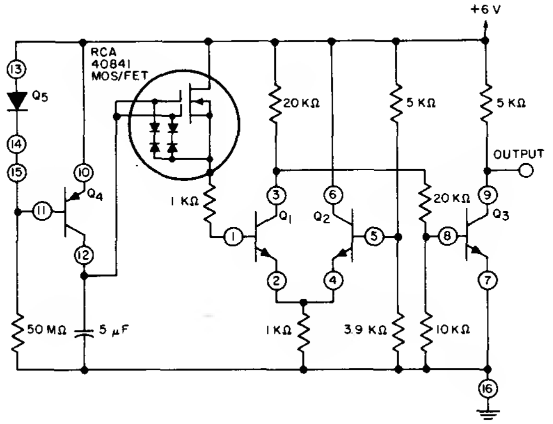
FET TIMER WITH RELAY—With values shown, circuit gives delay of saveral seconds. Increasing C1 by shunting with 20-μF capacitor delays energizing of ralay to ovar 1 min. C1 Is charged to −4.5 V when switch S1 is closed, biesing gata to cutoff and deenergizing relay. When S1 is open, capacitor begins discharging at rate determined by RC time constant of circuit. When voltage across capecitor drops to point at which Q1 conducts, relay is enargized and power is applied to loed.—E. M. Noll, "FET Principles, Expaelmants, and Projects," Howard W. Sams, Indienepolis, IN, 2nd Ed., 1975, p 215–216.



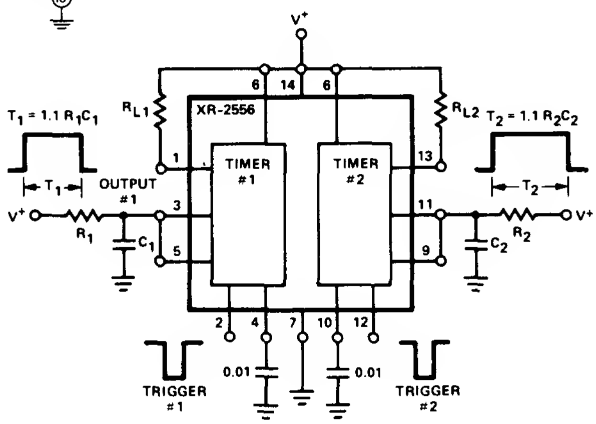
OVER 1 min—Circuit provides dalays well over 1 min even with low opareting voltages of ICs. When start pulse is appliad to RS flip-flop A_1-A_2, Q_2 turns off and allows R_T to provide charging currant for timing capecitor C_T. When voltage ecross C_T gets high enough, Q_1 turns on and resets flip-flop, terminating delay pariod. A_3 provides buffared complementary output.—R. W. Hilsher, Long-Delay Timar, *EEE Magazine*, Aug. 1970, p 79.



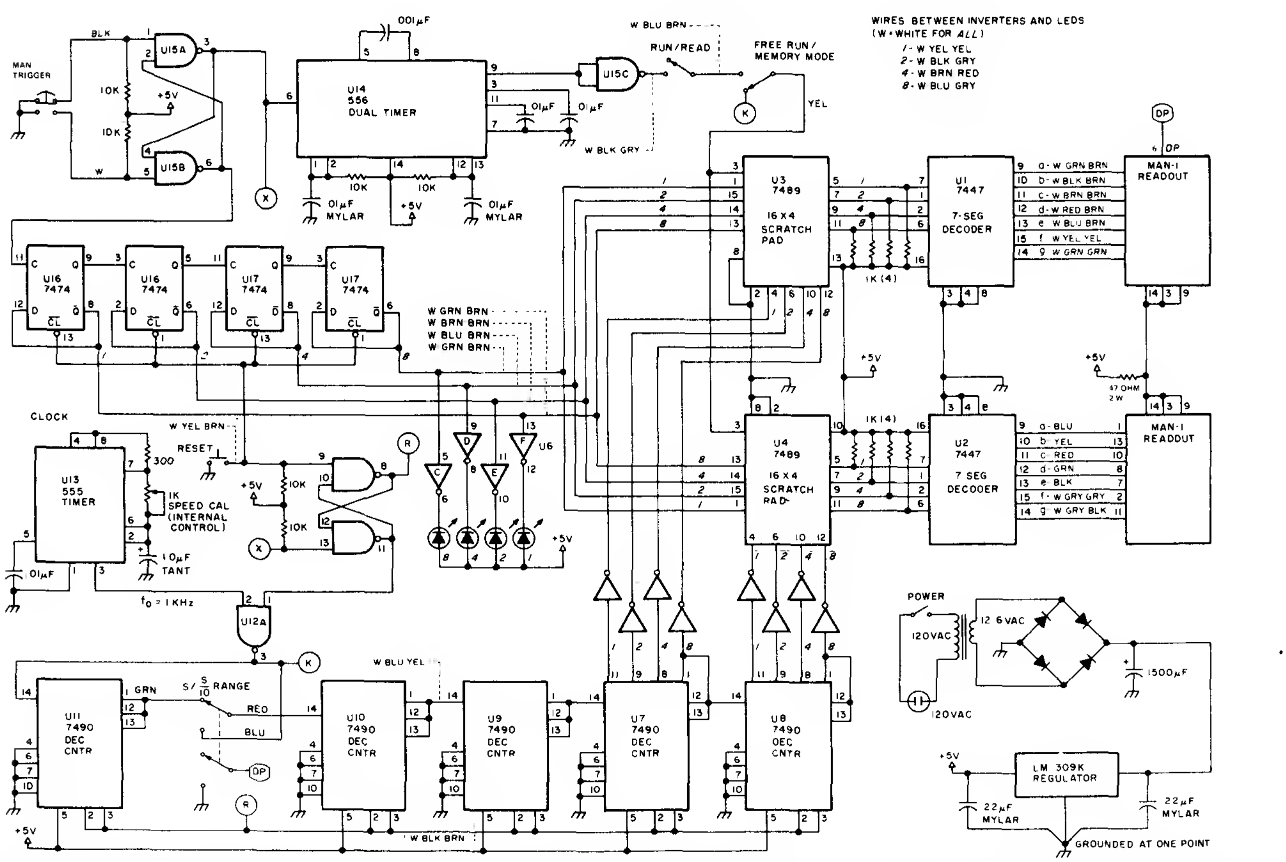
REMOTE DIGITAL PROGRAMMING OF TIMER—Eithar binary or BCD logic can ba used for selecting delay intarvel of monostable timer A_1, with delays baing intagral multiplas of shortest tima. Timing is programmed by peir of 4016 CMOS enalog switches, A_2 and A_3. Given timing tap is activated when corresponding digital input control lina is high and deactivated whan control is low. Programmabla timing ranga is 1 to 255 ms for 2240, and 1 to 99 ms for 2250 or 8250 timer. Besic intarvel can ba changed to suit othar applications. CMOS output buffer stage ensuras valid output logic levels. Although circuit will oparate ovar supply ranga indicated, oparation is optimum for supply of 10 to 15 V.—W. G. Jung, Taka a Fresh Look at New IC Timar Applications, *EDN Magazina*, Merch 20, 1977, p 127–135.



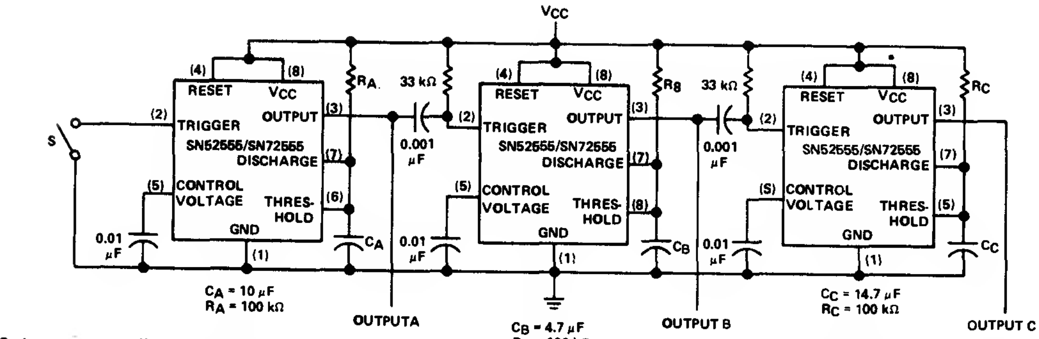
1 min WITH TRANSISTOR ARRAY—Circuit uses RCA CA3096AE five-transistor array in combination with dual-gate MOSFET to provide timing ection that meintains eccurecy within 7% for supply voltage veriations of ±10%. Q_5 is one of PNP transistors connected es diode.—"Linear Integrated Circuits and MOS/FET's," RCA Solid State Division, Somarville, NJ, 1977, p 205–210.



TWO INDEPENDENT DELAYS—Eech timar section of Exar XR-2556 dual timer oparates independently in mono MVBR mode to provide daleys shown ebove output waveforms. Supply voltega range is 4.5 to 16 V.—"Timer Date Book," Exer Integrated Systems, Sunnyvele, CA, 1978, p 23–30.

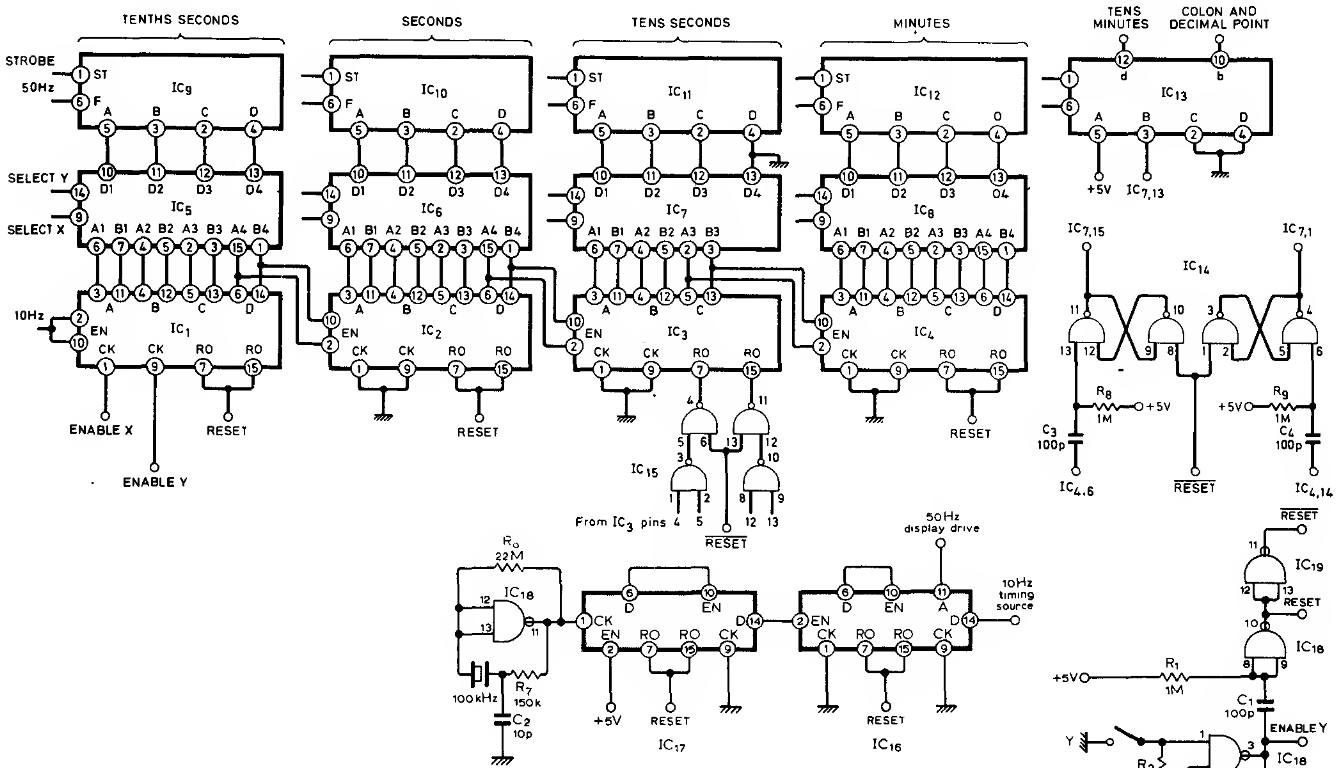


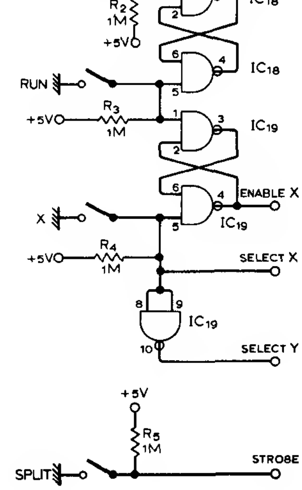
TIMER WITH MEMORY—Time elapsed since initial triggering at start of event is shown on 2-digit MAN-1 displey in seconds or tenths of seconds and written into memory. Up to 16 event times cen be stored for leter readout. Free-running mode counts off seconds or tenths of seconds on display. Article covers construction end operation. Circuit wes Scianca Fair winner. Gata end opemp types are not criticel.—M. Jose, Event Timer with Memory, *73 Magazine*, June 1977, p 72–74.



S closes momantarily at t = 0.

THREE-STEP SEQUENCE TIMER—Provides three different outputs at predetermined time intervals for initializing conditions during stert-up or for activating tast signals in sequance. Uses three Taxas Instruments SN52555 or SN72555 timers which ere interchangeabla with othar 555 timers. Veluas of R and C at output of each timer detarmine daleys (T = 1.1RC). With values shown below timers, output A is 5 V for interval of 1.1 s after switch is closed. At end of this interval, output B goes to 5 V for 0.5 s, efter which output C goes to 5 V for 1.5 s to complete sequence. Supply can be 5–15 V.—"The Lineer and Interface Circuits Deta Book for Design Engineers," Texes Instruments, Dalles, TX, 1973, p 7-53–7-61.

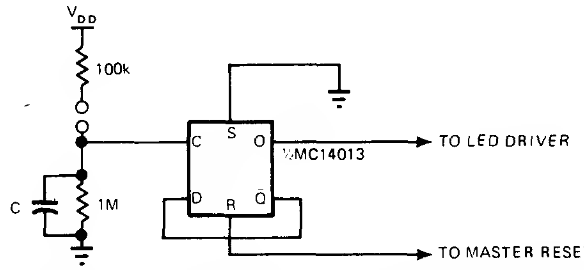




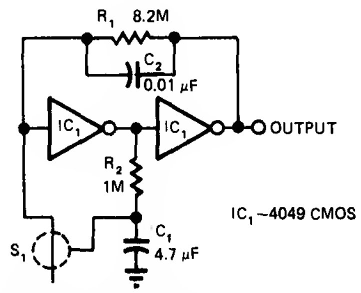
DIGITAL STOPWATCH—Provides 4½-digit liquid crystel display for up to 19 min 59.9 s, efter which tens of minutes steys at 1 and unit digit racycles from 0 to 9. Givas over 600 hours continuous operation from 5-V mercury bettery. Accuracy is determined by 100-kHz crystal oscillator, output of which is divided in two dual decede countars to provide 50-Hz displey drive end 10-Hz timing signal. ICs 1, 2, 3, 4, 16, end 17 era CD4518; 5-8 era CD4019; 9-13 are CD4056; 18 end 19 are CD4011. Article gives construction end operation details.—P. A. Birnie, Digitel EvantTimer, *Wiralass World*, Part 1—Dec. 1976, p 32–34 (Part 2—Jan. 1977, p 65–68).

CHAPTER 97
Touch-Switch Circuits

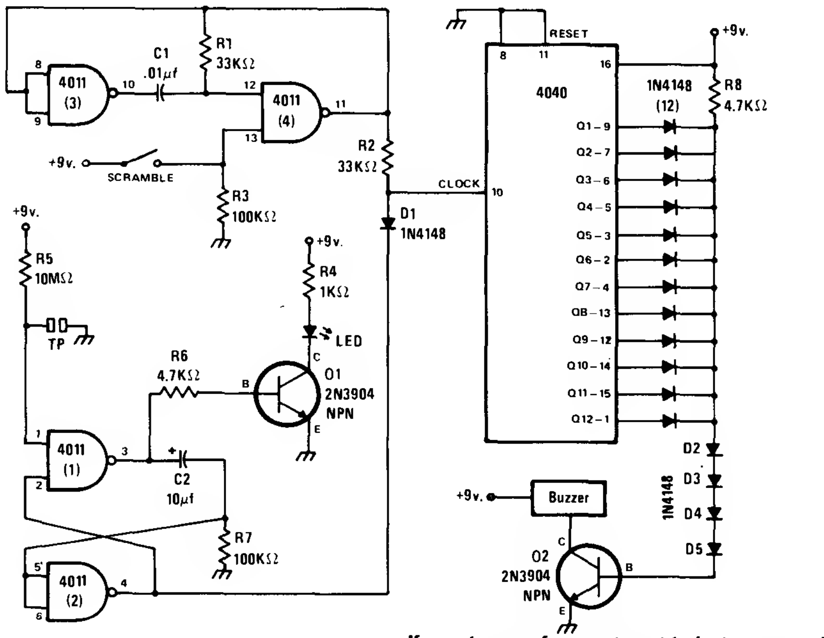
Includes circuits activated by skin resistance between two touch plates, by small AC voltage picked up by body and applied to single touch plate, or by changing of capacitance. Many circuits include debouncing.



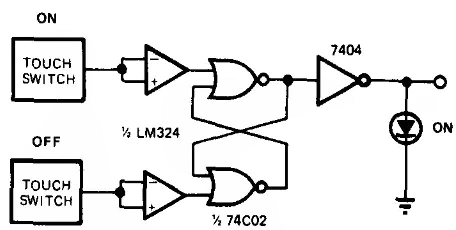
TOGGLING TOUCH SWITCH—Uses half of Motoroia MC14013 as flip-flop that changes state eech time contects are bridged by resistance of finger. For stetus displey, LED driven by 2N3903 trensistor can be edded. Possible drewbeck is bouncing if finger is carelessly epplied.—V. Gregory, CMOS Touch Switches—Convenient, Less $ and Sexy, *EDN Magazine,* Mey 5, 1976, p 112.



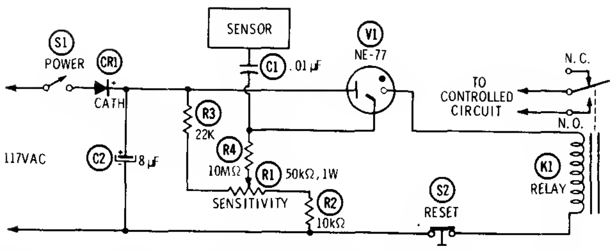
DEBOUNCE FOR TOUCH SWITCH—Two CMOS inverters respond to high-impedance peth between electrodes of touch switch to provide finger-touch sensitivity and positive switching action with minimum components. Lerge time constant of R_1C_1 requires weit of about 4 s before ettempting to retrigger circuit. C_2 prevents oscillation from 60-Hz pickup when electrodes are touched.—H. Maneli, CMOS Inverters Implement Finger-Touch ON-OFF, *EDN Magazine,* Jen. 5, 1978, p 90.



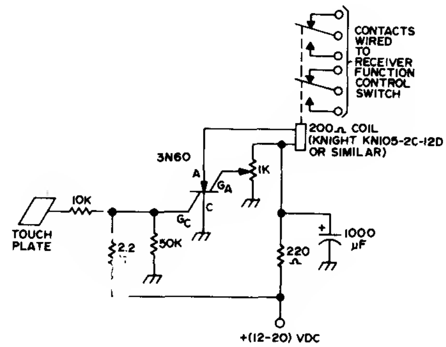
ADJUSTABLE-ODDS LOTTERY—Odds for lottery ere set by diode metrix connected to output of 4040 counter. Range is from 1:2 to 1:1024. To use, close scremble switch for e second or two to meke free-running oscillator drive counter at high rata, then let contestent hit touch plete to trigger flip-flop thet edvences counter one step. If counter wes frozen et next to lest connected diode, next diode is biesed off end Q2 energizes buzzar. For 50-50 odds, connect only diode et output Q1. For odds of 1 in 10, connect diodes only to outputs Q2 end Q4 for binery 1010 or 10. With ell diodes connected as shown, odds ere 1:1024.—J. Sendler, Pley 'Random Chence,' *Modern Electronics,* Oct. 1978, p 42–43 end 88.



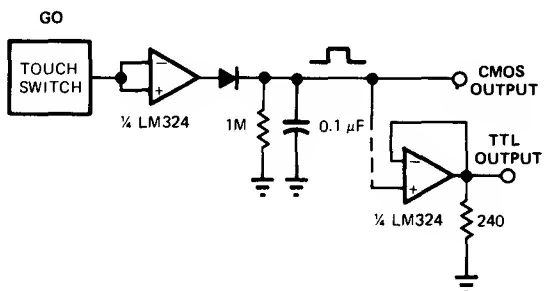
TOGGLE SWITCH—Touching one 0.5-inch-squara coppar-clad pattern on printed-circuit boerd turns switch circuit on by giving high output. Touching other plate turns switch off. LED between output end ground shows status of switch. For proper switching, circuit must connect to line-operated DC power supply.—R. D. Wood, Replece Bulky Mechanical Switches with Touch Controls, *EDN Magazine,* April 20, 1978, p 132–133.



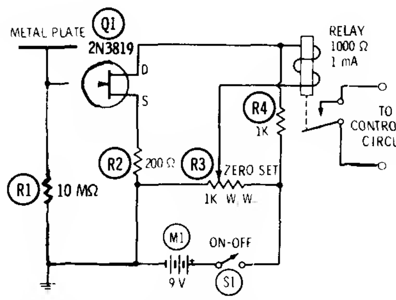
TOUCH SWITCH—Uses NE-77 neon lemp, which is similer to NE-2 but has third electrode for triggering. Whan person touches metel sensor plate of switch, AC voltega picked up by body is applied to triggar electrode of neon, making it fire end anergize 5000-ohm reley K1 (Pottar & Brumfield RS5D or equivalent). Relay rameins energized until S2 is opened to raset circuit. Adjust R1 so voltege applied to center alactrode of V1 is just below trigger point.—J. P. Shields, "How to Build Proximity Detectors & Matel Locators," Howard W. Sems, Indienepolis, IN, 2nd Ed., 1972, p 52–55.



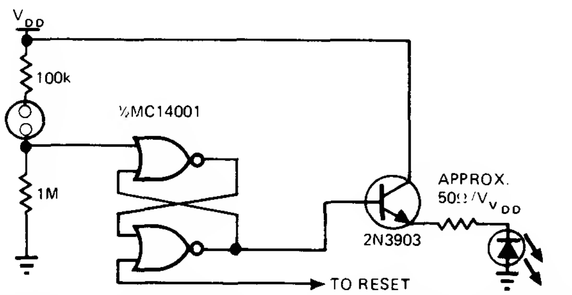
TOUCH SWITCH—Parforms function of switch by means of ralay contacts whan SCR is triggared by placing finger on touch plate. Values shown keep relay energized for 5–10 s after touch. Daveloped as replacamant for switch-type controls on emeteur radio receiver. Onca SCR has fired, it conducts until charge on 1000-μF cepecitor decraases enough to drop SCR currant balow minimum for conduction.—J. J. Schultz, Repid Raceiver Control Switching, *73 Magazine*, Dec. 1973, p 67–69.



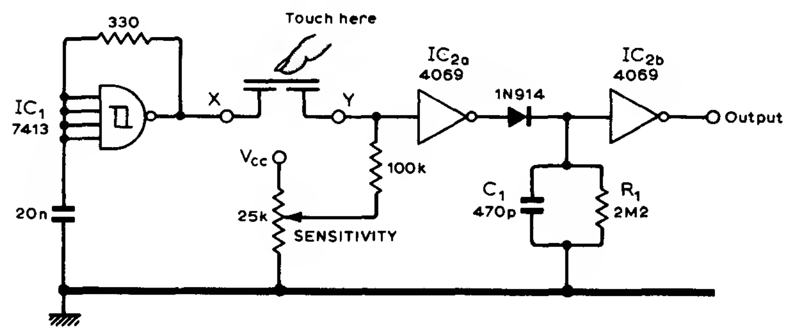
DATA ENTRY—Touch of operator's fingar on input button produces CMOS output. Addition of ona opamp section gives TTL output. Touch button can ba 0.5-inch-squara copper-clad pettarn on printed-circuit board or machine-scraw head having comparable aree. For propar switching, circuit must connect to line-oparatad DC power supply.—R. D. Wood, Replece Bulky Mechenicel Switchas with Touch Controls, *EDN Magazine*, April 20, 1978, p 132–133.



TOUCH-PLATE RELAY—When 2-inch diametar disk of sheet matal or foil is firmly touched with finger, strey noise picked up by body and coupled into 10-megohm geta circuit of FET is sufficient to boost drein currant to ebout 1.7 mA end close relay. Deleyed dropout can ba obteined by placing cepacitor in parellal with ralay coil; dalay is about 0.8 s par 1000 μF of parallel cepecitance.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 104–105.

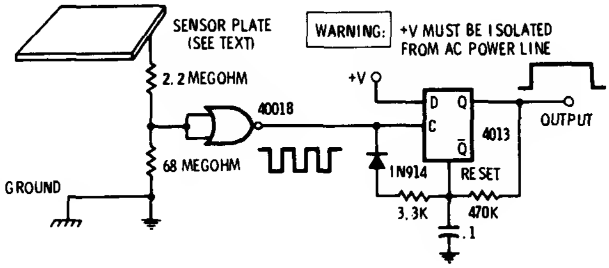


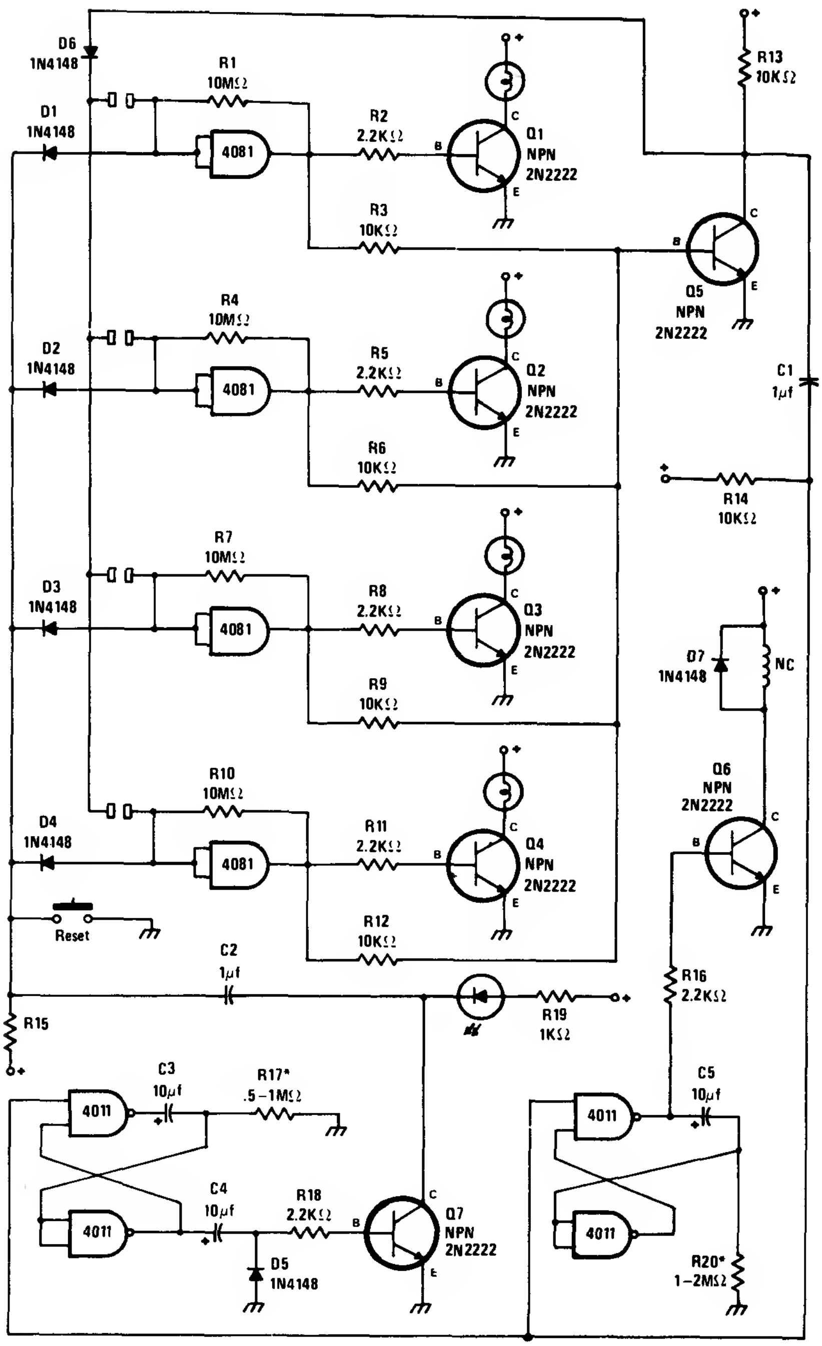
LATCHING TOUCH SWITCH—Uses LED as status display that substitutes for tactila feal of ordinary pushbutton switch. In raset state, LED is off. Whan touch contects ere bridged by resistance of fingar, flip-flop changes state end LED comes on whila output changes to high stata.—V. Gregory, CMOS Touch Switches—Convenient, Less $ and Saxy, *EDN Magazine*, May 5, 1976, p 112.



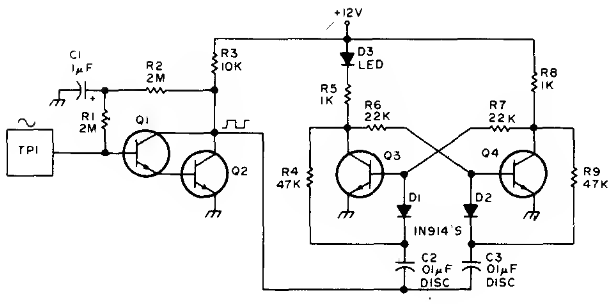
LOGIC SWITCH—Can ba used with battery-powered circuits because CMOS touch switch does not require body pickup of AC lina hum for switching action. Schmitt triggar IC_1 forms 100-kHz oscillator. IC_{2a} emplifies oscillator output end charges C_1 through diode. When sensor is touched, oscillator output is severely ettanuated, making C_1 discharge end thereby changing output stata of level datector IC_{2b}. Sensor is 1-inch-squere of double-sided printed-circuit board with lowar side divided into two equal sections.—N. Sunderland, C.M.O.S. Touch Switch, *Wireless World*, May 1978, p 69.

PROXIMITY SWITCH—Hand brought near sensor plate induces 60-Hz power-line hum in section of quad two-input NOR gate. Hum is squared by gate and used to trip section of 4013 connected as retriggerable mono MVBR. Output of mono is clean from instant of first proximity until several milliseconds after moving hand away. Sensitivity depends on size of metal plate and on number of permissible false alarms from other noise sources nearby.—D. Lancaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 278–282.



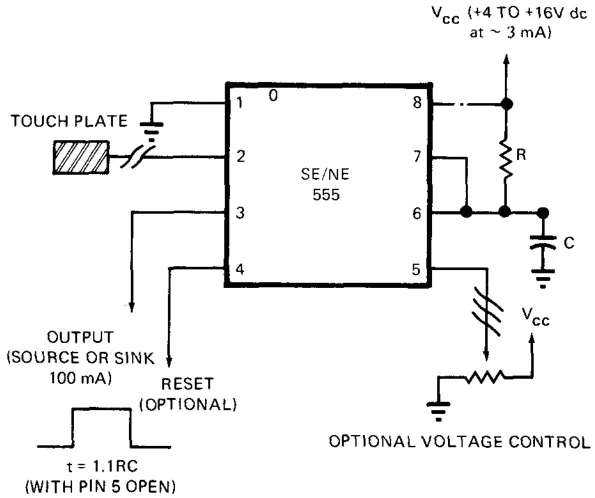


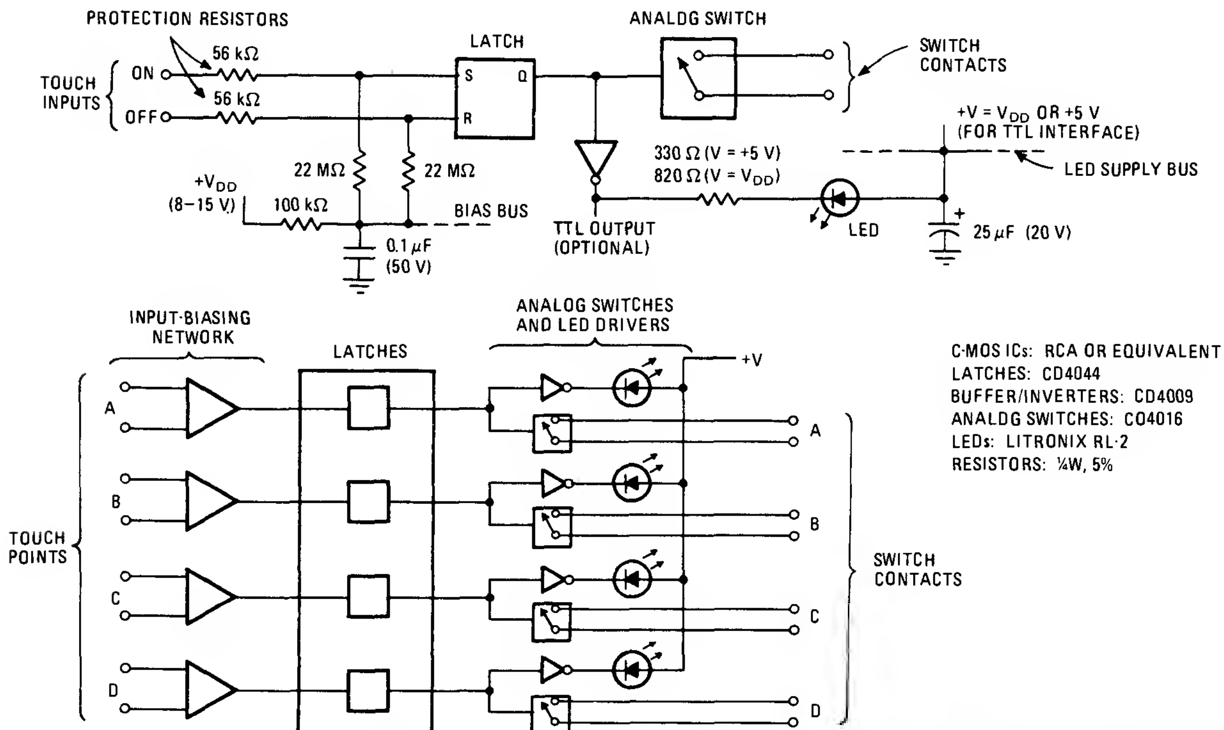
TV GAME CONTROL—Developed for use in game in which first person to recognize musical tune places finger on touch plate to energize his lamp. Action stops cassette player and locks out touch plates of other players. After 5-s delay, lockout is disabled so different player can have try at correct answer if first is wrong. After additional 5-s delay, relay is deenergized and music resumes. Additional reset switch is provided to reactivate all touch plates independently of delay. Supply is 12 V, and lamps are 12 V.—J. Sandler, Name That Tune, *Modern Electronics*, Dec. 1978, p 66 and 69–70.



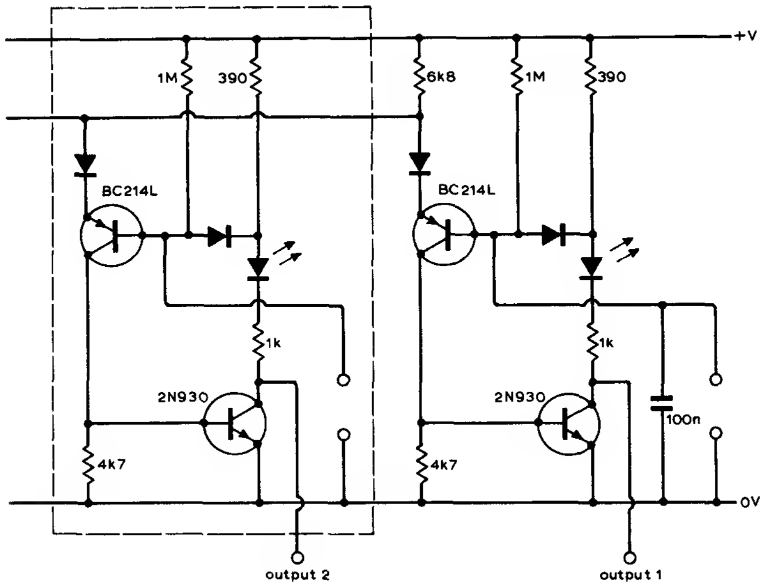
COIN TOSSER—Finger on touch plate TR1 feeds stray 60-Hz sine weve (picked up by body cepacitence) to high-impedance Darlington pair Q1-Q2 for squaring. Output drives flip-flop Q3-Q4. LED conducts only when Q3 is on. Removel of finger leaves LED either on or off with random probebility. Players cen try in turn to metch, play odd-man-buys, or play odd-man-out. For faster results, circuit can be duplicated so eech player has own touch plate. Precticelly any transistor types can be used, es circuit is not critical.—J. H. Everhart, The Coffee Flipper, *73 Magazine*, Nov. 1976, p 162–163.

TOUCH SWITCH USES TIMER—Free-running or mono cepabilities of Signetics 555 timer can be controlled through choice of trigger and reset inputs. Characteristics of output pulses can be adjusted over timing periods ranging from microseconds to hours. With 5-V supply, output is TTL-compatible end current drain of only 3 mA permits bettery operation. Circuit is easily triggered by voltage differentiel between floating (ungrounded) human body and timer itself. Touch plate can be any conducting material, with virtually no size limitation. Once triggered by momentary touch, device cannot be retriggered until it hes timed out. Duration of output pulse depends on RC time constant and on control voltage. Applications include switchless keyboards, burgler alarms, and bounce-free switches.—J. C. Heater, Monolithic Timer Makes Convenient Touch Switch, *EDN Magazine*, Dec. 1, 1972, p 55.



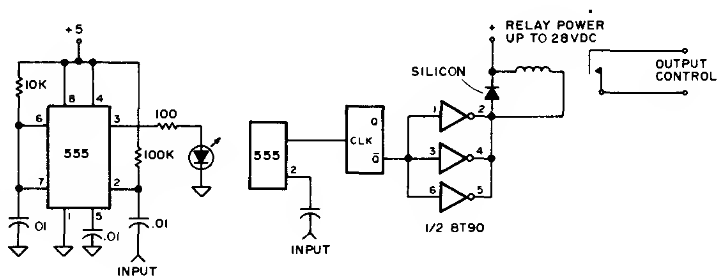


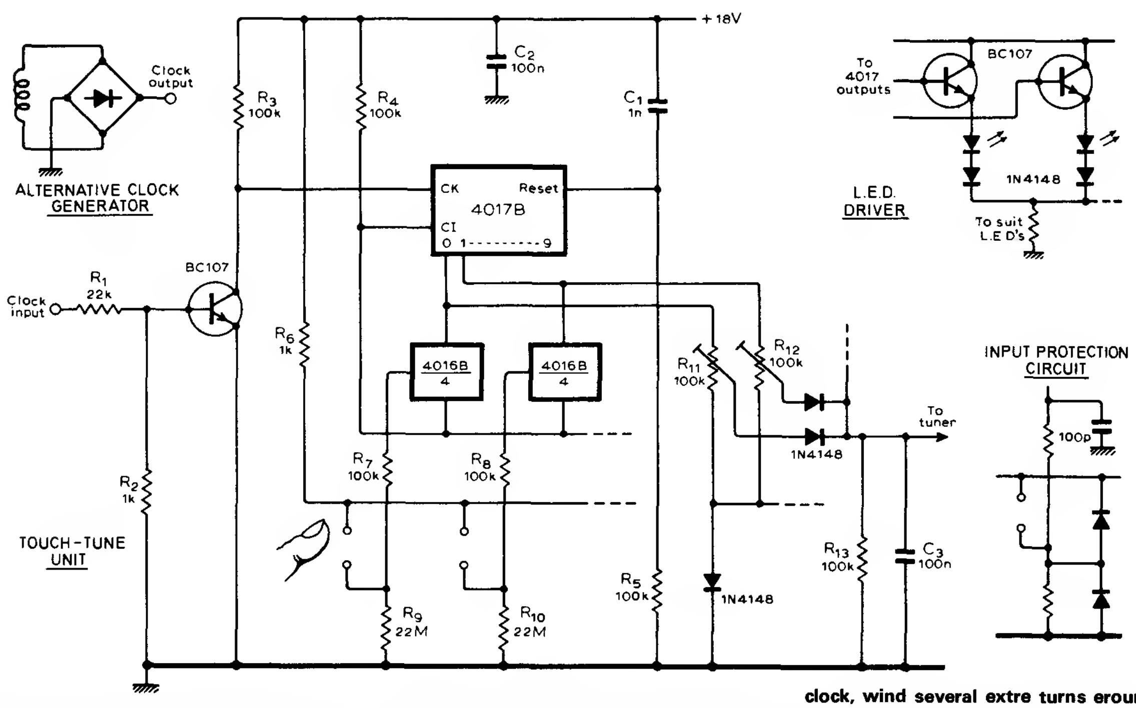
ANALOG SIGNAL CONTROL—CMOS logic gives bounceless operation of CD4016 analog switches by sensing of ambient signels at fingertip of operator. Connections for quadruple touch-switch array are shown below. Touch plates can be metal squeres or disks up to 2 cm wide. If used in remote locations where power lines or other electromagnetic-field sources are not present, it mey be necessary to provide grounded second contact et each sensor so slight conduction between contacts will assure triggering.—M. W. Hauser, C-MOS Touch-Switch Arrey Controls Analog Signals, *Electronics*, March 7, 1974, p 113–114; reprinted in "Circuits for Electronics Engineers," *Electronics*, 1977, p 357–358.



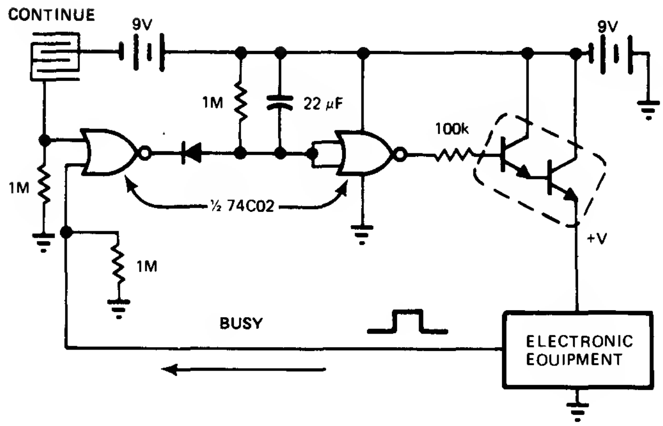
TOUCH BUTTONS—Based on detecting skin resistance betwaen two contacts built into aach touch button. Contact going to 0 V would normelly be matal front panel of control. Any number of sections lika thet in dashed lines can be cascaded to hendla more buttons. A particular button always comes on when power is applied, end is cencaled by next button touched. LED identifies button currently activated; use eny LED rated at 20 mA. Supply can be 20 to 30 V. Outputs may be used to drive FET anelog switches, veractor tuning diodes, or relays.—P. G. Hinch, Self-Cancelling Touch Button Control, *Wiralass World*, Oct. 1974, p 380.

TOUCH-CONTROLLED RELAY—Basic circuit uses Signetics 555 timar to maka LED flesh aach time input is touched with finger. Raplace LED with flip-flop (any typa) end threa sections of 8T90 hax power inverter to driva DC relay. Silicon diode suppresses voltage spikes generated when magnetic fiald of ralay collapses. Usa only as many parellaled sections of invertar as are required to operate raley. Input can be bress or copper plate at least 2 inches square.—G. Young, Voltage, Current, and Powar Supplies, *Kilobaud*, Nov. 1977, p 76–78 end 80–82.

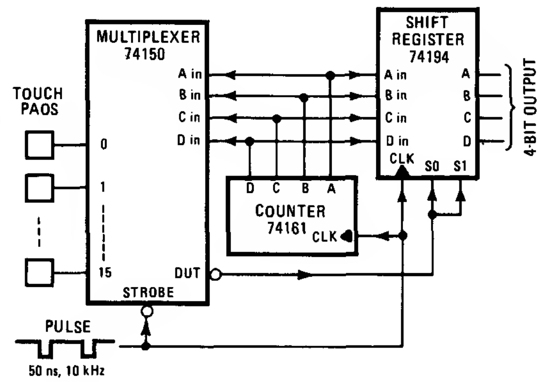




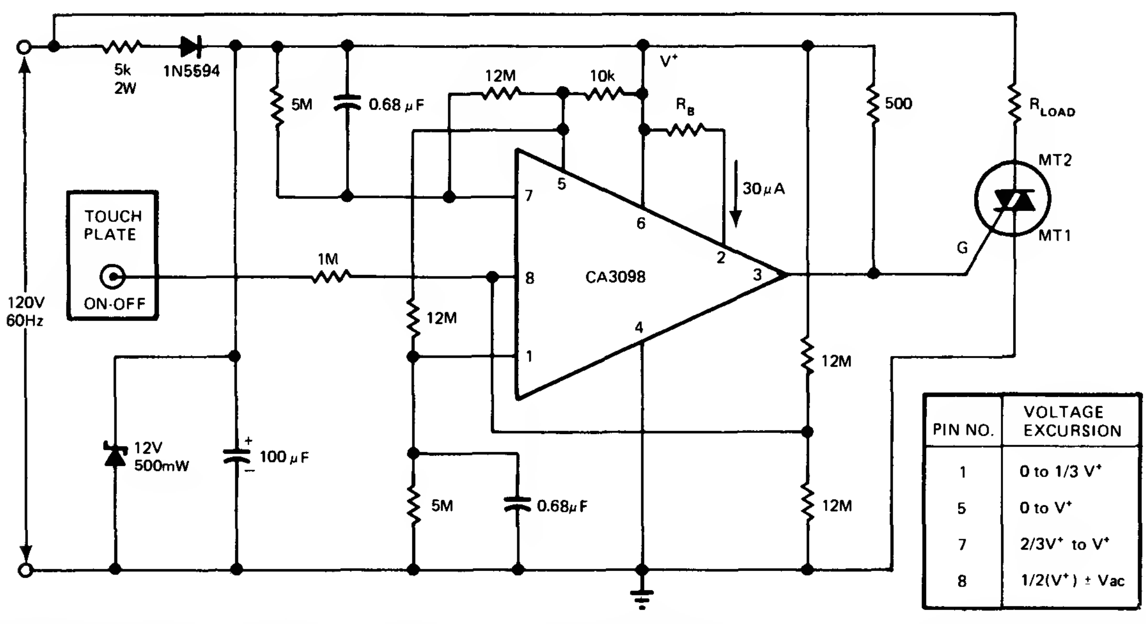
FM TOUCH-TUNE—Up to 10 chennels cen be tuned by turning on appropriate section of 4016 CMOS digitel IC by finger contact thet drives clock inhibit line low. 4017B then counts clock pulses until desired output goes high. C_1 end R_5 ensure that chennel 0 is selected when circuit is turned on. Clock frequency is not critical end cen range from 100 Hz to 19 kHz. For 120-Hz clock, wind several extre turns eround power transformer of receiver and feed this voltage to bridge rectifier.—L. Crampin end R. van der Molen, Touch-Tune for F.M. Receivers, *Wireless World*, Jan. 1978, p 60.



AUTOMATIC TURNOFF—Circuit ramovas bias from power Darlington about 15 s aftar both CONTINUE and BUSY signals go low, to conserve battery lifa in portabla alectronic aquipment. Intarleaved coppar patterns on printed-circuit board form touch switch that must ba reactivated evary 15 s or kapt closed by fingar contact whila equipmant is being used.—R. D. Wood, Replace Bulky Mechanical Switches with Touch Controls, *EDN Magazina*, April 20, 1978, p 132–133.



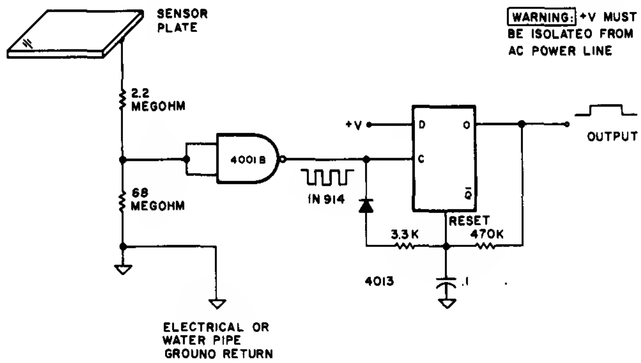
CONTACTLESS KEYBOARD—Touching ona of 16 metal pads at inputs of 74150 multiplexer produces corresponding 4-bit BCD output from 74194 shift registar. During scanning of multiplexar inputs by counter, output la produced only when finger of operator is on corresponding fingertip-siza touch pad. Requires 10-kHz pulse from extemal aource to strobe multiplexar end serve es clock for counter. Duration of clock pulse must be more than 20 ns so untouchad peds charge up to threshold voltage but not long enough to let touched pad charga.—D. Cockarall, TTL IC Sarves as Touch Keyboard, *Electronics*, Fab. 20, 1975, p 108–109.

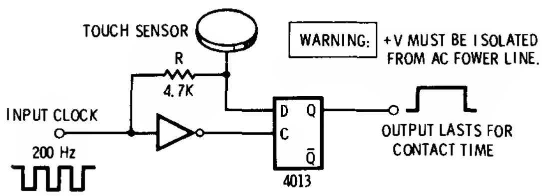


PIN NO.	VOLTAGE EXCURSION
1	0 to 1/3 V+
5	0 to V+
7	2/3V+ to V+
8	1/2(V+) ± Vac

TOUCH SWITCH—Small AC signal momentarily introduced by finger contact on touch plate causes voltage et pin 8 of CA3098 duel-input precision level detactor to be greatar than high reference voltage. This toggles mamory flipflop in IC, making voltaga high at pin 5. Voltaga at pin 7 then incraases exponentially to V+ in ebout 10 s. This 10-s deley is maximum that button can be touched; longer touch makes system oscillate between ON and OFF states until finger is removed. Shortar touch energizes load, placing pin 7 at V+. Next touch of plata tums circuit off.—G. J. Graniari, Precision Laval Detector IC Simplifias Control Circuit Design, *EDN Magazine*, Oct. 5, 1975, p 69–72.

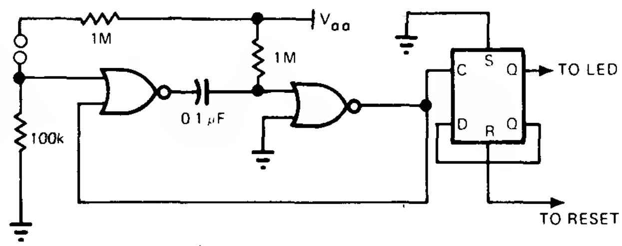
PROXIMITY SWITCH—Based on coupling of humen body to 60-Hz powar lina. Hand hald close to sensor pleta inducas hum into 4001B gate. This is squared and used to trip 4013 retriggerabla mono MVBR. Output is clean from instant of first proximity until several millisaconds eftar relaese. Sensitivity depends on size of pleta.—D. Lancaster, Clocked Logic, *Kilobaud,* May 1977, p 24–30.

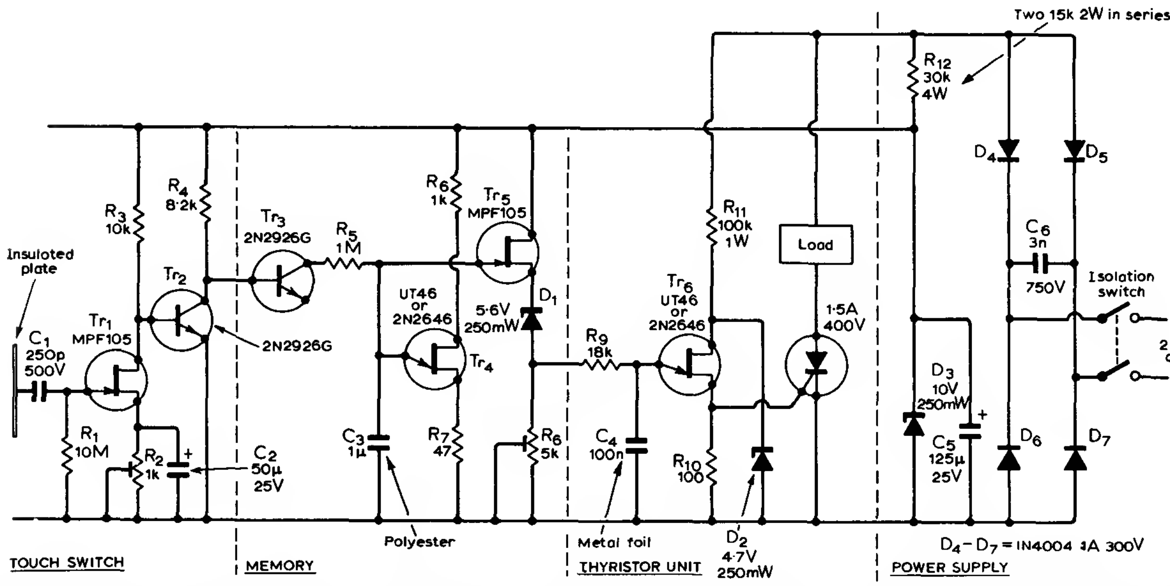




TOUCH SWITCH FOR MUSIC KEYBOARD—Touching metal sensor plate edds about 300 pF of capacitance betwaen pleta and ground, changing RC deley network thet slows down clock waveform reaching D input of 4013 dual D flip-flop, meking flip-flop output high for duration of contact. Circuit is repeated for aech kay in electronic music system.—D. Lencaster, "CMOS Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 278–282.

DEBOUNCING TOUCH SWITCH—Foolproof debouncing for touch switch using toggling flip-flop (helf of Motorola MC14013) is provided by two gatas connected es monostabla pulsa stretchar. Tima constant of pulsa stretcher is selected to match needs of application. For status display, LED driven by 2N3903 transistor can ba connected to Q terminal of flip-flop.—V. Gregory, CMOS Touch Switches—Convanient, Lass $ and Saxy, *EDN Magazine,* May 5, 1976, p 112.



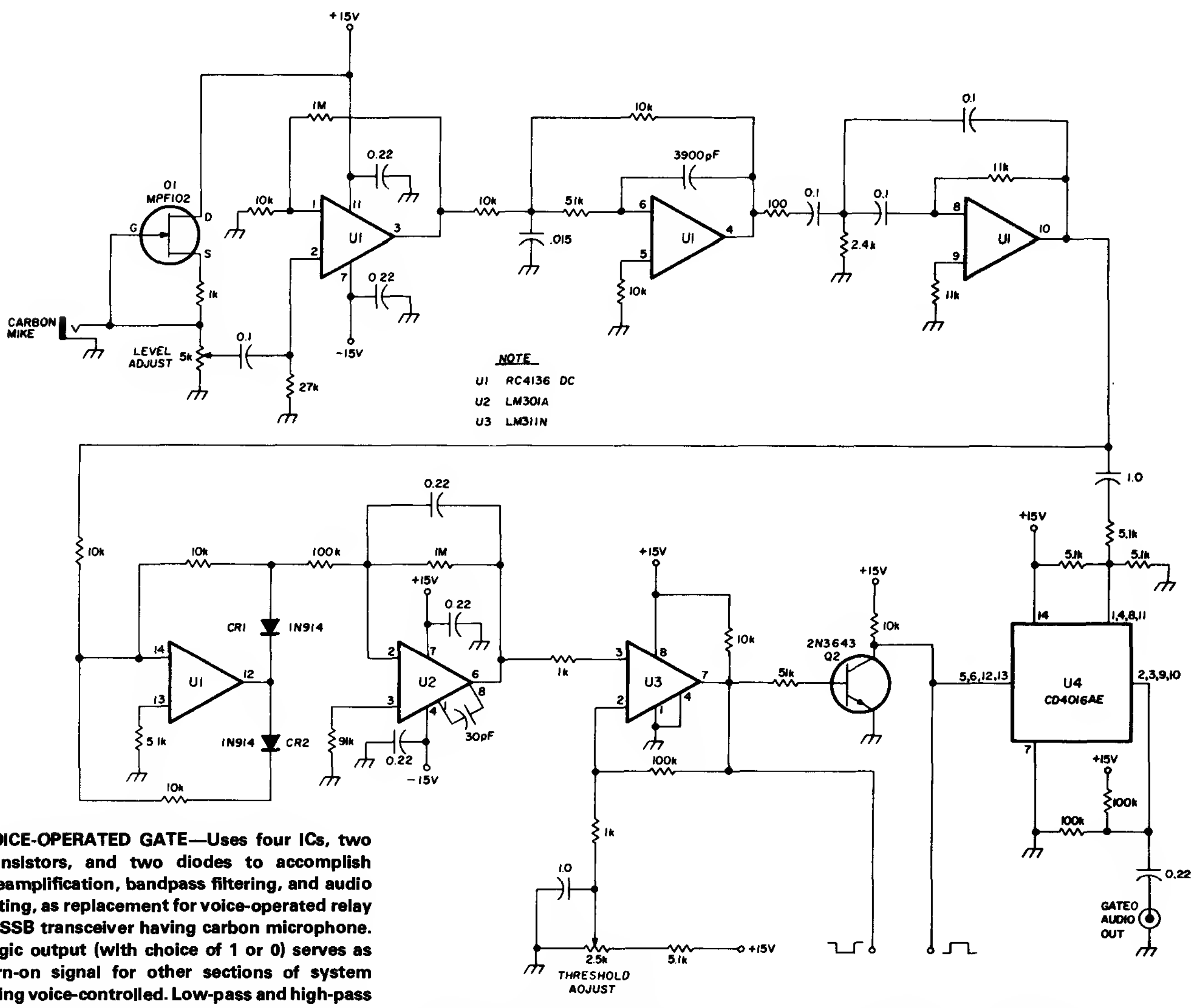


TOUCH SWITCH—Fingar on insulated metal plate applies small AC voltaga (pickad up by body) to FET Tr_1 for amplification, to produce lina-frequency squara wava across R_4 for eppllcation to memory saction Tr_3-Tr_5. Charging of C_3 through Tr_3 and R_5 produces DC output voltaga across R_8 that is fed to UJT Tr_6 for triggering thyristor. C_4 is dischargad at ebout 10-ms intarvals by Tr_6 which oparates from rectified AC lina. For high voitaga across R_8, such es 4 V, thyristor is triggared aerly in AC cycle and maximum power is supplied to load. Diodes D_4-D_7 ensura that control is provided ovar both positive and negative half-cycles of lina. The longer a fingar is hald on touch switch, tha graater is the voltaga ecross R_8 and tha more current there is through load. Ramoving fingar turns off load, which can ba lamps or othar alectric equipmant.—R. Krauzer, Touch-Switch Controller, *Wireless World,* Aug. 1971, p 389.

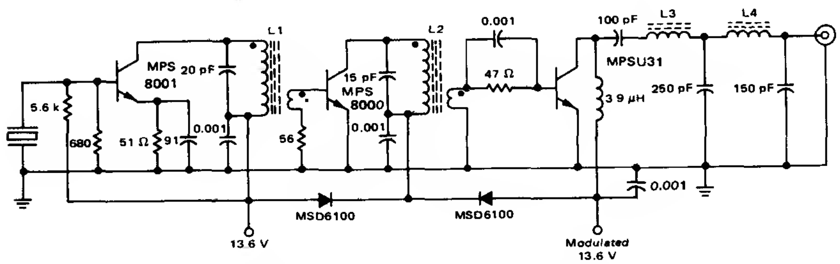
CHAPTER **98**

Transceiver Circuits

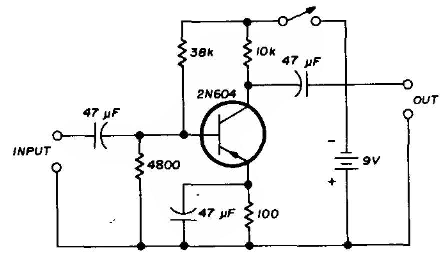
Used in combined transmitters and receivers for amateur, CB, and other two-way communication applications. Includes voice-actuated TR switches, scanners, varactor tuners, and remote tuning systems. See also Antenna, Squelch, Receiver, and Transmitter chapters.



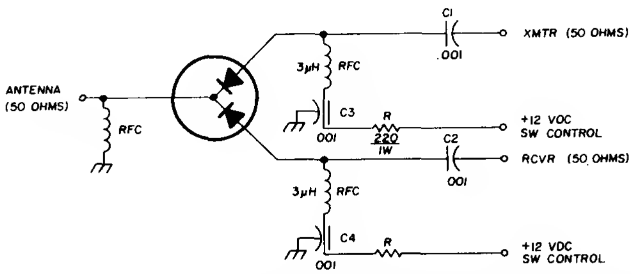
VOICE-OPERATED GATE—Uses four ICs, two transistors, and two diodes to accomplish preamplification, bandpass filtering, and audio gating, as replacement for voice-operated relay in SSB transceiver having carbon microphone. Logic output (with choice of 1 or 0) serves as turn-on signal for other sections of system being voice-controlled. Low-pass and high-pass active filter pair provides equivalent of 300–3000 Hz bandpass filtar with 40 dB rolloff per decade at each edge, to discriminate against ambient noise. Q1 is FET constant-currant source for carbon microphone, feeding preamp U1 that provides voltage gain of about 100 and output of about 3 VRMS. Next two sections of quad opamp U1 are active filters, and last section of U1 is active diode detector in which opamp linaarizes detector CR1-CR2. Rectified audio is averaged by U2 to giva smoothad long positive pulse with duration of audio burst. Schmitt trigger U3 sharpens pulse and makes it compatibla with CMOS logic. Invertar Q2 turns on analog gate U4 when audio signal is present.—H. Olson, Voice-Operated Gate to Replace Voice-Oparated Ralays for Carbon Microphones, *Ham Radio,* Dec. 1977, p 35–37.



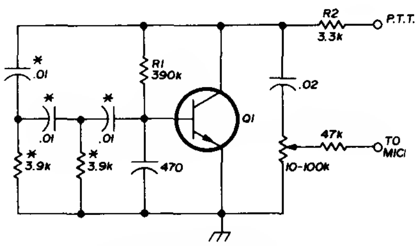
3.5-W TRANSMITTER—Class D circuit using economical plastic transistors operates from 12-V auto battery. 100% amplitude modulation requires about 2.5-W audio input. Modulator uses MSD6100 dual diode in modulated power supply system, with one diode in series with modulated supply voltage to MPS8000 driver to prevent driver from being down-modulated. Other diode maintains drive to final while final is being down-modulated, to make 100% modulation easy to obtain. All coils are wound on ¼-inch coil forms with No. 22 wire, with Carbonyl "J" ¼ × ⅜ inch cores in each. 2-turn secondaries are wound over bottom of primaries. L1 is 12 turns, L2 is 18, L3 is 7, and L4 is 5.—G. Young, "A Class D Citizen's Band Transmitter Using Low-Cost Plastic Transistors," Motorola, Phoenix, AZ, 1975, AN-596.



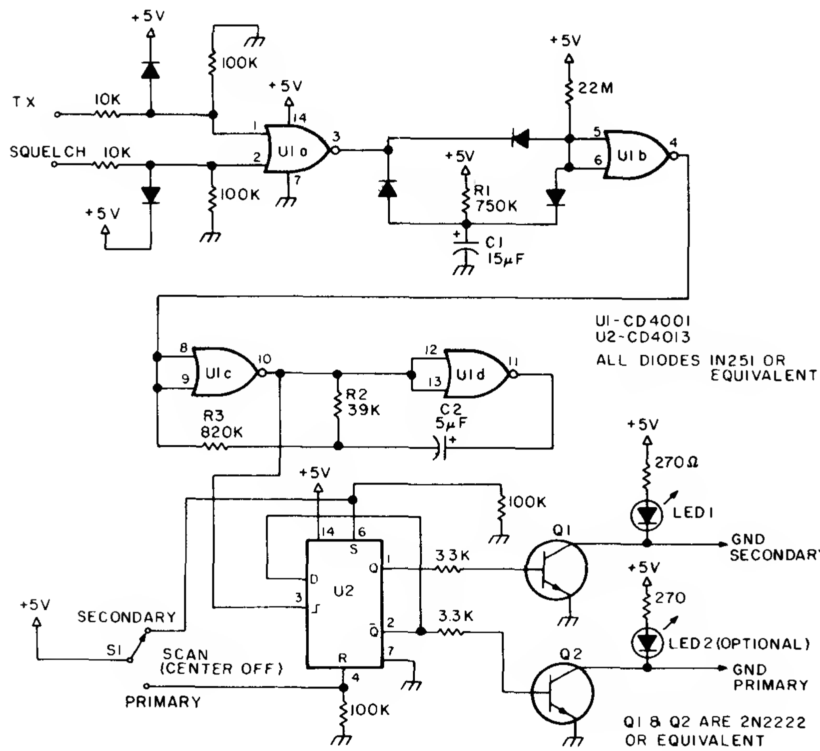
MATCHING LOW-Z MIKE—Single-transistor microphone impedance-matching circuit for low-impedance microphone feeds high-impedance input of amateur SSB transceiver. Circuit also boosts gain enough to meet transmitter input requirements.—C. Drumeller, Active Microphone Impedance Match, *Ham Radio*, Sept. 1973, p 67–68.



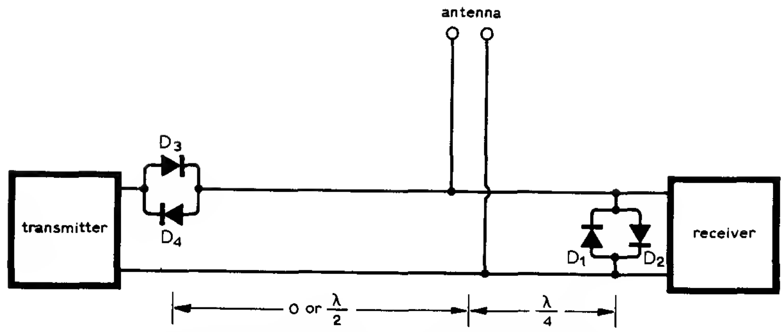
DIODE TR SWITCH—Microwave Associates MA8334 solid-state TR switch replaces conventional relays for switching antenna back and forth between transmitter and receiver. Handles up to 50 W CW at 144 MHz, and can be used at other frequencies up to 1000 MHz by proper choice of circuit constants. Measured insertion loss is 0.25 dB, and SWR is 1.23:1 when operated at 50 ohms.—T. Raddeck, Solid-State VHF-UHF Transmit/Receive Switch, *Ham Radio*, Feb. 1978, p 54.



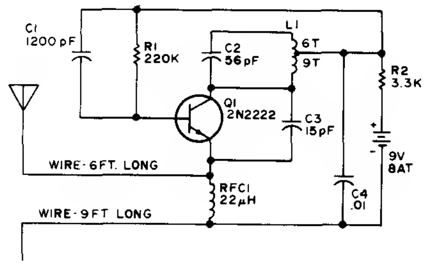
END-OF-TRANSMISSION BEEPER—Release of push-to-talk (PTT) switch at end of radio conversation activates time delay for antenna changeover relay, keeping transmitter on air long enough to transmit 800-Hz tone burst indicating transmission termination. Tone is generated in simple one-transistor phase-shift oscillator powered by voltage present between PTT terminal and ground in receive mode of transceiver, which may be any voltage between 6 and 30 VDC. Transistor can be any small-signal NPN silicon with gain of at least 300 at 1 mA, such as 2N930. Parts marked with asterisk must be matched within 5%.—E. Hornbostel, Automatic Beeper for Station Control, *Ham Radio*, Sept. 1976, p 38–39.



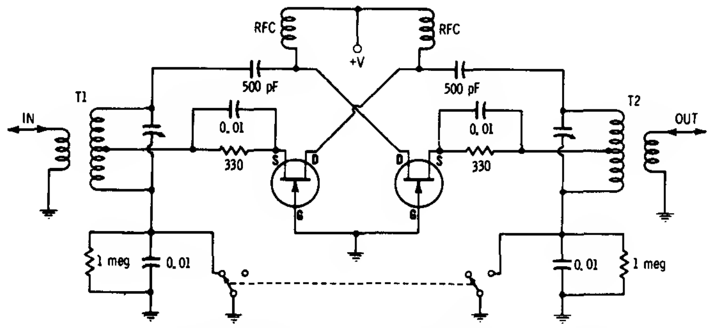
SCANNING ADAPTER—Developed for use with 2-meter transceiver having frequency synthesizer to provide automatic scanning that is disabled when transmitting and when receiver squelch is opened by transmission on one of channels being scanned. Will hang on to channel about 5 s after scanning is disabled, to allow starting of other side of communication. Scan rate is about 250 ms per channel. U1A generates 0 output when squelch is open, producing output of 1 for U1B that disables oscillator U1C-U1D. Oscillator drives D flip-flop that turns on Q1 and Q2 alternately. When Q1 is on, LED1 is lit to indicate that secondary channel is enabled. Article covers method of increasing number of scanned channels.—B. McNair, Add-a-Scanner, *73 Magazine*, Nov. 1978, p 116–119.



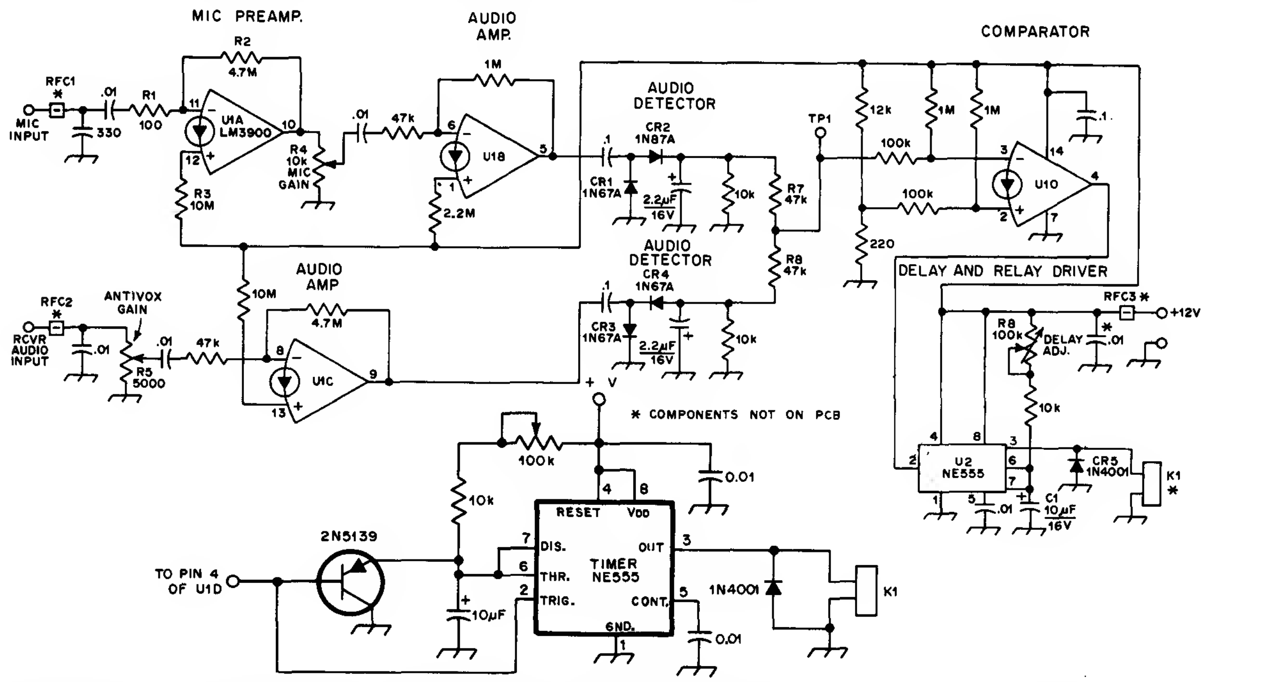
FOUR-DIODE TR SWITCH—Circuit requires only two pairs of high-frequency switching diodes having current ratings appropriate for transmitter power. With diode pairs spaced as shown, impedance at T junction looking toward transmitter is infinite during reception because there is open circuit half a wavelength away created by nonconducting D_3 and D_4. Line is matched in receiver direction so all incoming power from antenna goes into receiver. When transmitter is on, D_3 and D_4 conduct and power flows toward antenna, while D_1 and D_2 also conduct and place short-circuit across receiver input.—A. Lieber, Passive Solid-State Antenna Switch, *Wireless World*, Jan. 1975, p 12.



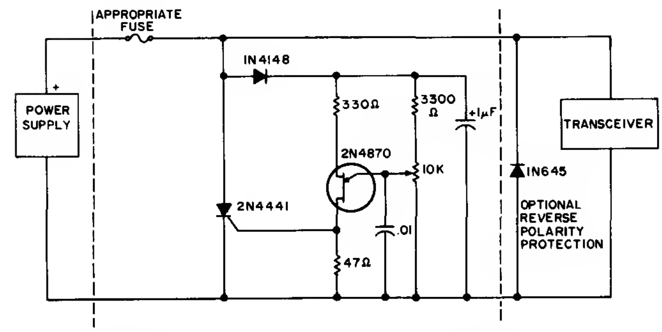
TUNE-UP AID—Superregenerative receiver circuit is modified to bring quenching frequency down into audio range, thereby giving many closely spaced carriers in region of 27 MHz. RF level across frequency range is essentially constant. Signal simplifies tune-up of front ends of CB units. Antenna is 6 feet of wire connected to emitter side of RFC, with 9 feet of wire on battery side of RFC as counterpoise. Combination, with circuit in center, can be hung vertically in tree if means can be provided for turning it off or removing battery when not in use. Drain is about 0.5 mA from 9-V battery.—E. A. Lawrence, Citizens Band Alignment Aid, *73 Magazine*, April 1973, p 87–88.



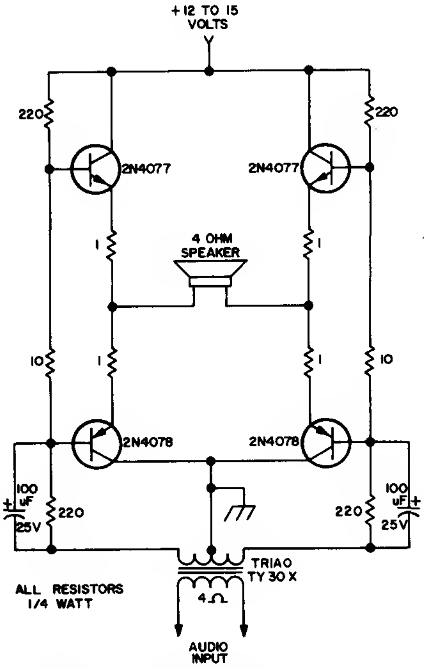
BILATERAL AMPLIFIER—When switch is in position shown, signal entering through T1 is amplified by first transistor and fed from its drain terminal to output through resonant transformer T2. Second transistor is not operational because it now has cutoff bias between gate and source. When switch position is reversed, incoming signal is applied to transistor at right through T2 and removed from left side of circuit to give changeover in signal direction. First transistor is inactive now.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 198–199.



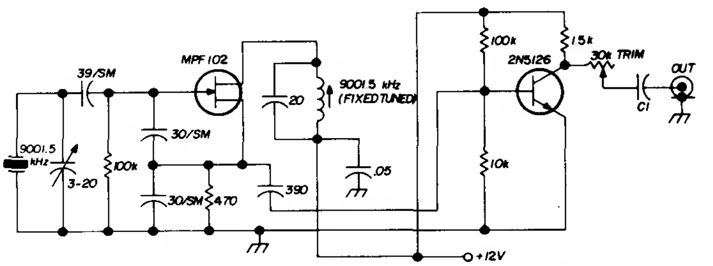
VOX FOR SSB—Uses LM3900 quad Norton opamp and NE555 timer operating from single supply. U1A and U1B amplify microphone signal. U1C amplifies audio sample obtained from station loudspeaker. Outputs of both amplifiers are converted to varying DC voltages by rectifiers in detector stages. Rectifier outputs are summed resistively by R6 and R7 for application to inverting input of voltage comparator U1D. Positive microphone signal drives comparator output low and triggers NE555, which in turn energizes 12-V relay K1 after delay set at about 10 ms by R8 to avoid losing first syllable. Same delay applies to relay dropout, to hold relay closed between words. If K1 drops out for fraction of second at end of timing cycle even though audio is present, add 2N5139 transistor to NE555 input as shown.—D. A. Blakeslee, A VOX for a Very Small Box, *QST*, March 1976, p 24–26.



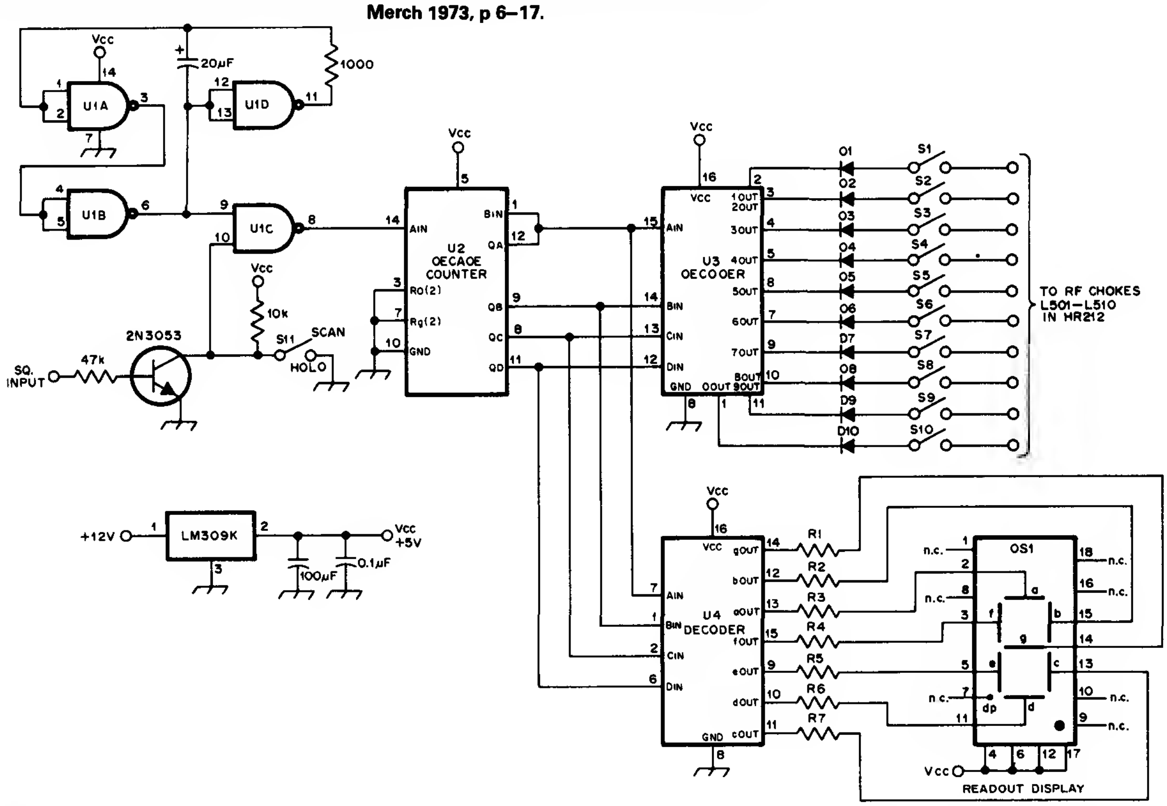
UJT-TRIGGERED CROWBAR—Circuit is used between transceiver end regulated 12-V power supply to protect transceiver from overvoltaga or reverse polerity. UJT permits precise setting of overvoltage level at which 2N4441 SCR crowbar operates. Fuse is blown within microseconds of ovarvoltage. Crowber can be built into transceivar.—Circuits, *73 Magazine*, July 1977, p 35.



15-W ADD-ON—Increeses usual 1-W audio output of transceiver to up to 15 W. Loudspeaker can be 8-ohm unit, but output will be somewhat reduced.—P. Bunnall, More Fun with the IC-230, *73 Magazine*, May 1975, p 45–46 and 48.

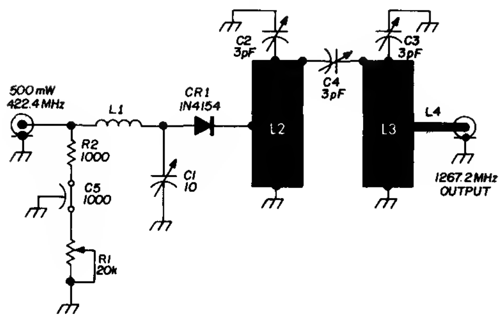


9-MHz CRYSTAL—Usad in trensmitter section of 80-meter 10-W SSB trensceiver. Value of C1 is 50–330 pF, chosan for dasired output range. Cerriar level can ba edjusted with slug-tuned coil or with 30K trimpot.—D. Hambling, Solid-State 80-Meter SSB Transceiver, *Ham Radio*, Merch 1973, p 6–17.



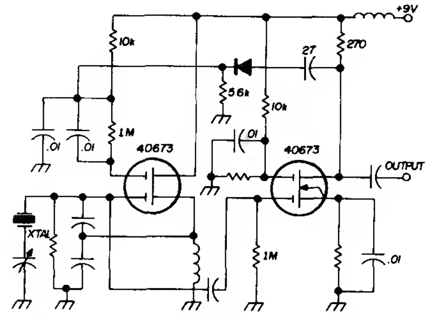
D1-D10 incl. — Silicon switching diodes, type 1N4154.
DS1 — Seven-segment readout display, Litronix type DL-747 or Radio Shack no. 276-056.
R1-R7 incl. — 220 ohm.
S1-S10 incl. — Spst switch.
U1 — Quad 2-input positive NAND gate, TTL type 7400.
U2 — Decade counter, TTL type 7490.
U3 — BCD-to-decimal decoder, TTL type 7445.
U4 — BCD-to-seven segment decoder, TTL type 7446.

10-CHANNEL SCANNER—Designed for Regency HR-212 2-meter trensceivar but can be adapted for other transceivers. Faeturas includa eutomatic stop, stert, end large LED 7-segment raedout. Diodes D1-D10 pravent transceiver voltages from reeching scanner circuit. Squelch voltaga input of 2N3053 is teken from transceivar. S1-S10 are used to switch out channals not monitored. Wires going to chokes in HR-212 should be connected to choke leads going to channel switch.—A. Little, 10-Channel Scanner for the Regency HR-212, *QST*, Feb. 1978, p 37.

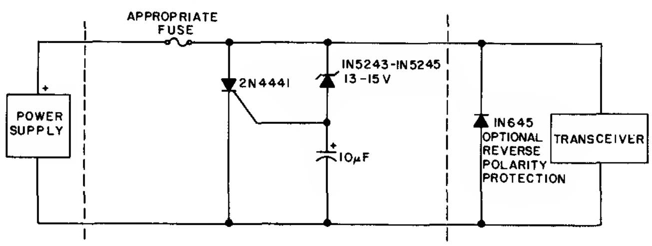


C1	1-10 pF concentric piston trimmer
C2,C3 C4	0.3-3 pF concentric piston trimmer
CR1	1N4154 high-speed switching diode
L1	2 turns no. 20, 0.1" (2.5 mm) diameter, 0.25" (6 mm) long
L2	micro-stripline, 0.3" (7.5 mm) wide, 0.865" (22 mm) long, grounded at bottom, tapped 0.20" (5 mm) from ground end
L3	Same as L2 but tapped 0.25" (6 mm) from ground end
L4	50-ohm micro-stripline, 0.1" (2.5 mm) wide, any length
R1	20k, 10-turn trimpot

TRIPLING TO 1267.2 MHz—Diode triplar and filter combination is designed for double-clad gless epoxy printed-circuit board to simplify construction. Devalopad for usa in 1296-MHz SSB transceivar for emetaur 23-cm bend. RF energy from 422.4-MHz power amplifier is applied to GE 1N4154 high-spaed switching diode through L network. Harmonic comb et output of diode passes only dasired frequency to output terminel going to mixar of transceiver.—H. P. Shuch, Eesy-to-Build SSB Trensceivar for 1296 MHz, *Ham Radio*, Sept. 1974, p 8–23.

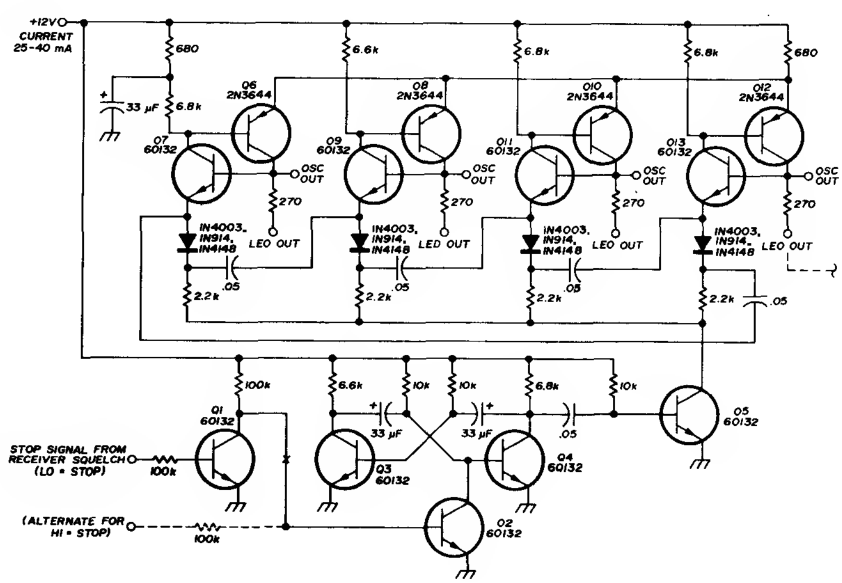


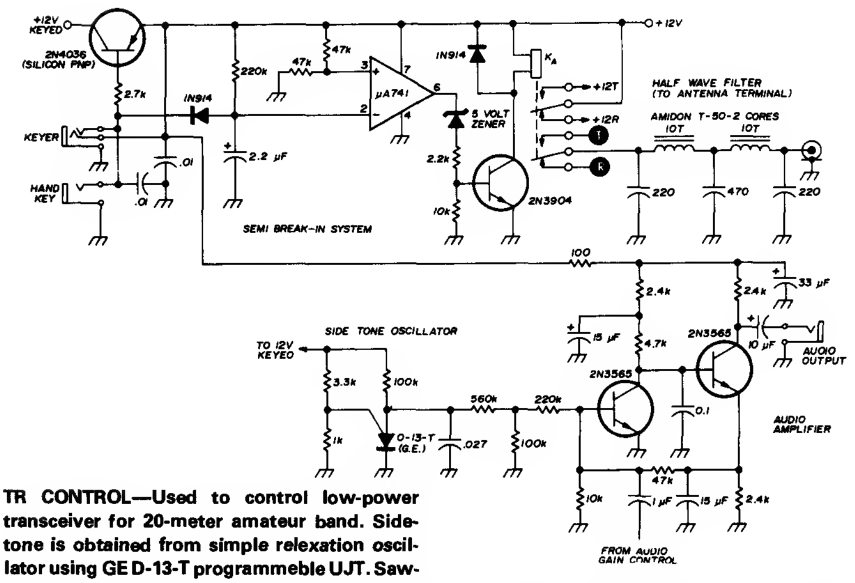
2–23 MHz UNTUNED OSCILLATOR—Two dual-gate MOSFETs operate in untuned Colpitts crystel oscillator. Used In SSB transceiver made by Sidebend Associates for radiomerina communication in 2–23 MHz renge. Oscilletor faads isolating emplifiar. Small capacitor can be used for netting individual crystal to precise assigned frequancy.—E. Noll, MOSFET Circuits, *Ham Radio*, Fab. 1975, p 50–57.



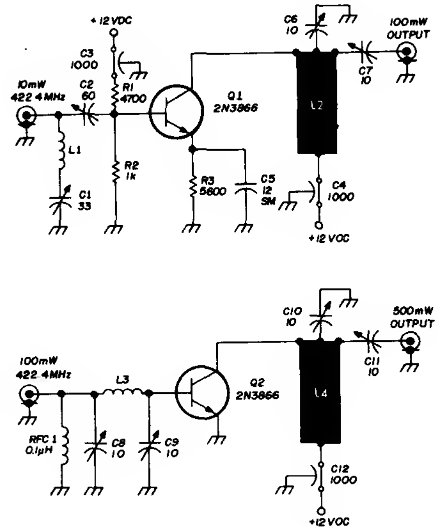
12-V CROWBAR—Uses overvoltaga-sensing zenar to triggar SCR and placa it ecross powar-supply llna, blowing fuse within microseconds to protact transceiver. Optionel diode providas protection from accidental ravarsal of supply polerity.—Circuits, *73 Magazine*, July 1977, p 35.

4-CHANNEL VHF FM SCANNER—Discrete components permit simpler reedout, with any number of chennels end any desired scen reta. Oparates directly from 10–15 V powar supply without regulation, end has low current drain. Can be used with either positive or nagative logic from squelch circuit, so scanning can be stopped with either positive or ground signal. Any voltage from a faw volts up will stop scanning. Q3 and Q4 form estable MVBR operating at about 10 pulses per second. Q2 turns on to stop MVBR whan base of Q2 is high. Invartar Q1 provides propar polerity of signal to operata Q2. Q6-Q13 form 4-staga ring counter. Pulsing by Q5 serves to pass high output from stega to stage in endless ring pattern. When squelch stops pulsing ection, counter stops stepping and output of one counter staga stays high, providing 5-V output for enabling corrasponding oscillator and driving LED for that chennel. Articla gives connections to oscillator for almost any FM transcaivar or racaivar, along with modifications for changing scan speed and number of channals.—J. Vogt, Improved Channel Scanner for VHF FM, *Ham Radio*, Nov. 1974, p 26–31.



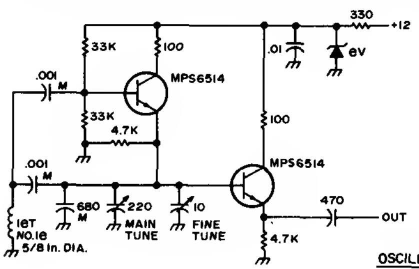


TR CONTROL—Used to control low-power transceiver for 20-meter amateur band. Sidetone is obtained from simple relaxation oscillator using GE D-13-T programmeble UJT. Sawtooth output is attenuated and applied to input of two-trensistor audio amplifier. Tranamitter keying is done with series switch using 2N4036 silicon transistor. Antenna relay applies +12 V appropriately to transceiver stages used during transmit (+12T) and receive (+12R), and provides switching of antenna between tranamitter power chain and receiver RF amplifier. Uae DPDT relay with 800-ohm 12-V coil. Transmit-receive logic uses μA741C opamp as differentiel comparator. When key is cloaed, 2.2-μF capacitor is discharged, making opamp output switch to high state and saturete 2N3904 relay driver, pulling in relay for transmit operation. When kay is released, capacitor begina to charge; at 6-V point (about 0.5 s with 220K timing resistor), opamp changes state again and relay opens for receiving.—W. Hayward, Low-Power Single-Band CW Transceiver, *Ham Radio*, Nov. 1974, p 8–17.

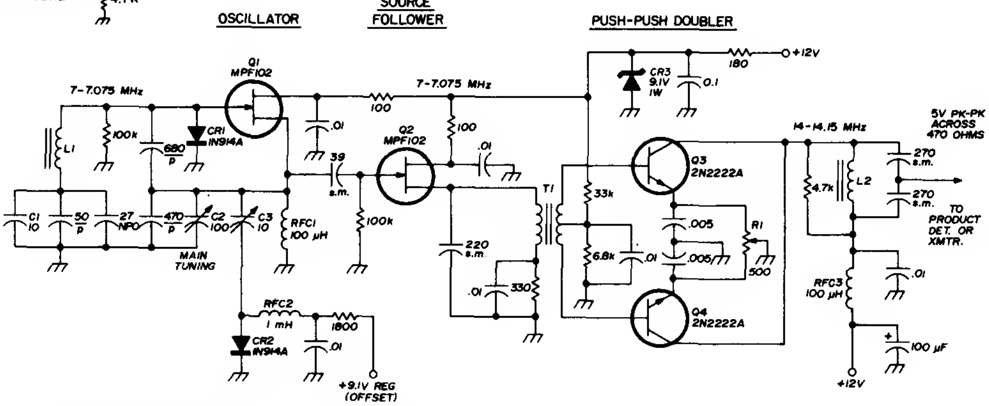


C1	3-35 pF trimmer
C2	8-60 pF trimmer
C6-C11	10-pF concentric piston trimmers
L1	2 turns no. 18, wound on 1/4" (6 mm) mandrel, 1/8" (3 mm) long
L2,L4	brass strip, 0.5" (12.5 mm) wide, 1.5" (38 mm) long, mounted 1/8" (3 mm) above ground plane
L3	2 turns 1/8" (3 mm) wide brass strip, 0.1" (2.5 mm) diameter, 0.5" (12.5 mm) long

422.4-MHz POWER AMPLIFIER—Used in local oscillator chain of 1296-MHz SSB transceiver to boost 10-mW output of chain to 500 mW as required for driving final diode-type tripler stage. Sections are connected together with miniature 50-ohm coax.—H. P. Shuch, Easy-to-Build SSB Transceiver for 1296 MHz, *Ham Radio*, Sept. 1974, p 8–23.

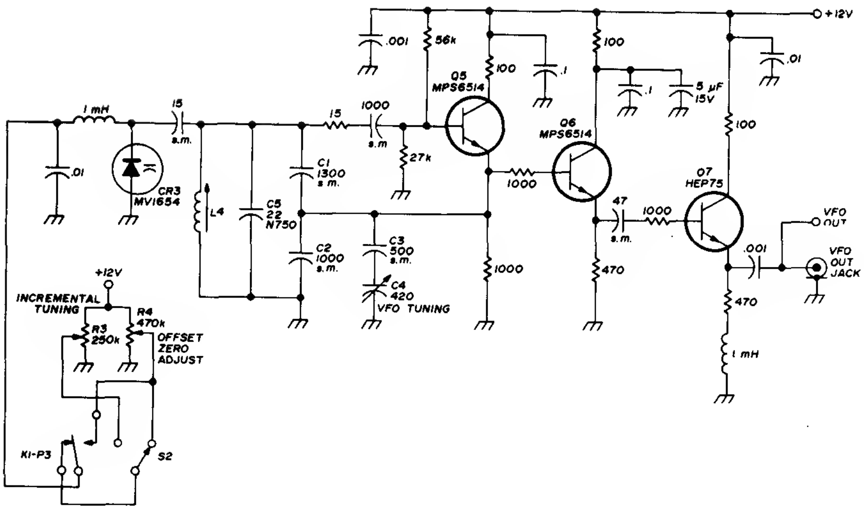


5 MHz ± 500 kHz—Developed for use as separete VFO control for transmitting and receiving frequencies in amateur transceiver. Capacitors marked M should be mica. Fine-tuning control covers ±20 kHz range. Will operate elmost enywhere in HF range with eppropriate change in coil. Output is 4 V P-P.—An Accessory VFO - the Easy Wey, *73 Magazine*, Aug. 1975, p 103 and 106–108.

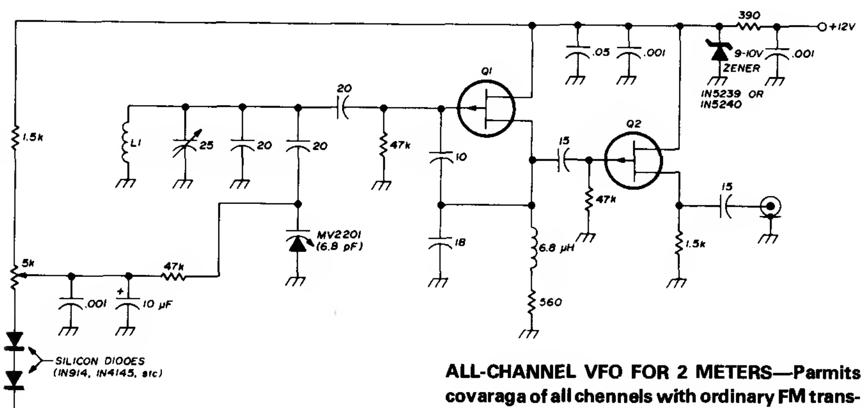


C1,C3	subminiature PC-board-mount air trimmers (Johnson 189-507-5 or T-9-5)
C2	100 pF miniature air variable (large gang of Miller 2109 suitable)
L1	7.6 μH toroidal inductor. 37 turns no. 24 (0.5mm) enamelled wire on Amidon T-68-2 toroidal core (see text)
L2	1 μH toroidal inductor. 14 turns no. 22 (0.6mm) enamelled wire on Amidon T-50-6 toroidal core
R1	500-ohm PC-board-mount control
T1	toroidal transformer. Primary, 2 μH. Use 23 turns no. 24 (0.5mm) enamelled wire on Amidon T-50-6 toroidal core. Secondary is 20 turns no. 24 (0.5mm) enamelled wire (center tapped) over primary winding. Observe same rotation sense when winding
Z1	9.1 volt, 1 watt, zener-diode regulator

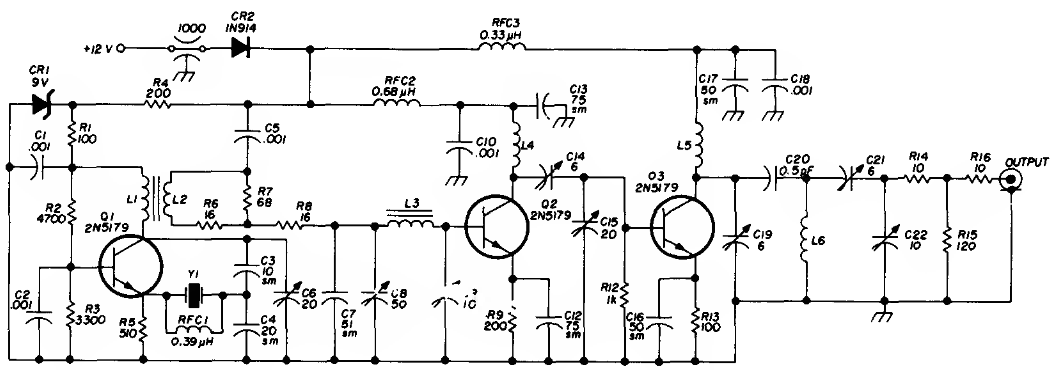
14-MHz VFO USING DOUBLER—Developed for use with 20-meter low-power (QRP) transceiver. Push-push doubler avoids instability problems of 14-MHz oscillator and minimizes chirp during CW transmit periods. Uses low-drift series-tuned Colpitts oscilletor operating at 7 MHz, with source-follower buffer separating it from doubler. Adjust dynamic balance control R1 of doubler for best output waveform purity. Cepacitors merked P ere polystyrene, and SM are ailver mica. Article stresses importance of choosing and using components that minimize drift.—D. DeMaw, VFO Design Techniques for Improved Stabilty, *Ham Radio*, June 1976, p 10–17.



6.545–6.845 MHz VFO—Covers 40-meter amataur band of transcalvar for SSB end CW with stabla incrementel tuning circuit using Motorole MV1654 varactor diode CR3. Tunar permits up to 10-kHz offsat above or below VFO fraquancy. Veractor control voltaga is set by offset tuning control R3. R4 compansates for differences in varectors and adjusts VFO for zaro offsat. Output buffaring is provided by Q6 and Q7, with Q7 also serving as power amplifiar for balancad mixer used in companion axciter of transmitter. S2 activatas recaivar offsat. Ralay K1 automatically tums off offset whan raceivar is in transmit or standby mode. Offset faatura is naeded only if thara is frequancy difference betwaan transmitted and racaived signals. L4 has 5 turns No. 22 on ½-inch slug-tuned caramic form.—W. J. Waisar, Simpla SSB Transmitter and Receiver for 40 Metars, *Ham Radio,* March 1974, p 6–20.

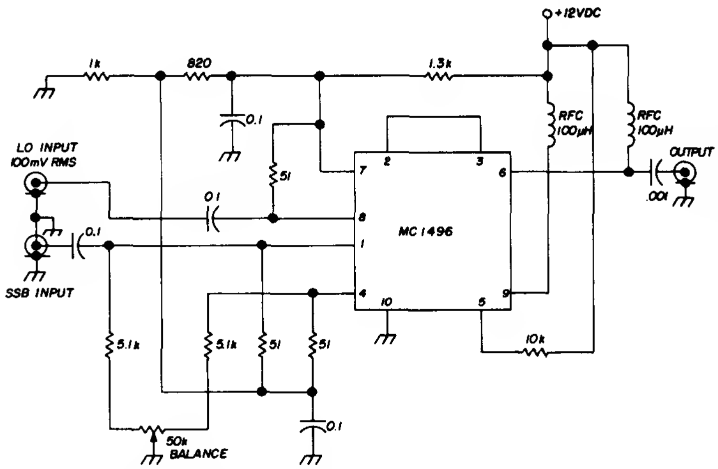


ALL-CHANNEL VFO FOR 2 METERS—Parmits covaraga of all chennels with ordinary FM transcalvar without costly frequancy synthesizar or individuel chennel crystals. Can also ba used for tuning input of rapaatar when mada necessary by malicious or accidental intarferance. Replaces first crystel oscillator in FM trenscaivar and tunes over required ranga, ganarelly onathird of first injaction frequancy. Oparatas at about 45 MHz for most transceivars, but fraquancy can easily ba chenged. Tuning pot (10-turn 5K with digitel dial is best) can ba pleced ramotaly. VFO uses FET oscilletor tunad by tuning diode (elso known as Vericap, varector, or veriable-capacitanca diode). Source-followar output stega buffers oscillator. Supply is regulated by zenar. Q1 end Q2 can ba MPF102 FETs, but 2N5668 or 2N5669 ara bettar. L1 is 4 turns No. 16 ½ inch in diametar. Articla covars construction, testing, and installetion in trenscaivar.—P. Frenson, Simpla Tunabla Receivar Modificetion for VHF FM, *Ham Radio,* Oct. 1974, p 40–43.

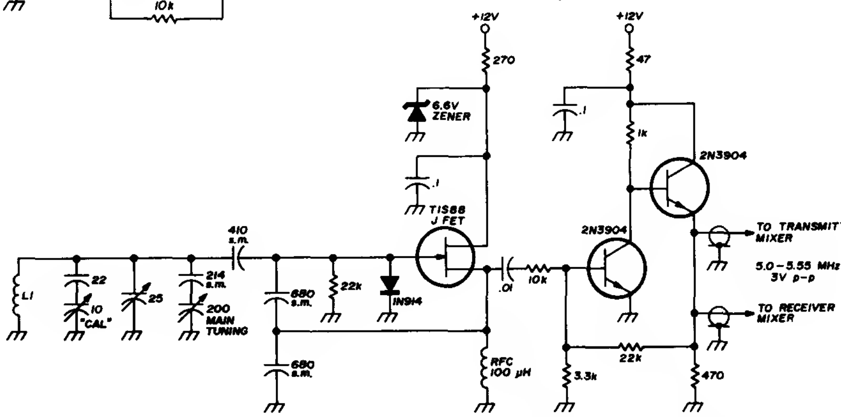


C6,C15	20-pF trimmer (JFD DJV 300)	L3	12 turns no. 28 on Micrometals T-25-13 toroid core
C8	50-pF trimmer (JFD DVJ 305)		
C9,C22	10-pF trimmer (JFD DVJ 302)	L4	6 turns no. 24, close wound on 0.1" (2.5 mm) diameter form
C14,C19, C21	6-pF trimmer (JFD DVJ 301)	L5,L6	1½ turn no. 22, 1/8" (3 mm) diameter, 1/4" (6 mm) long
C20	0.5-pF ceramic (two 1-pF capacitors in series)	RFC1	0.39 µH miniature inductor (Nytronics Deci-Ductor)
L1	10 turns no. 28 on Micrometals T-25-13 toroid core	Y1	5th overtone crystal, series resonant, HC-18/U holder, 105.600 MHz for 28.8-MHz i-f
L2	4 turns no. 28 on cold end of L1		

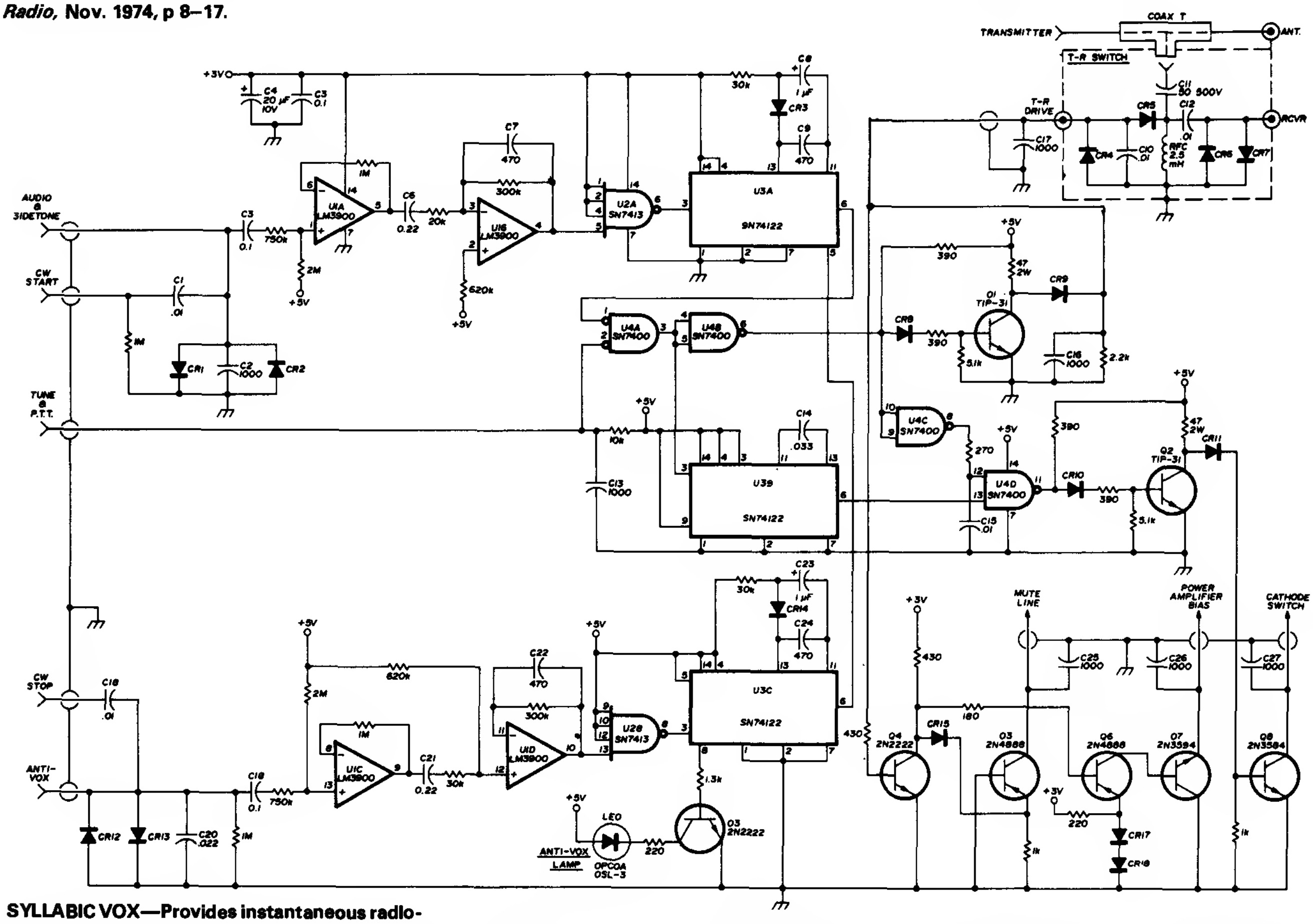
422.4-MHz CRYSTAL OSCILLATOR—Uses 105.6-MHz crystal oscillator followed by fraquancy-doubling stages to giva desired output for driving axtamel diode-typa triplar for which circuit is elso givan in article. Davaloped for usa in 1296-MHz SSB transceiver for 23-cm amataur bend.—H. P. Shuch, Easy-to-Build SSB Transcaivar for 1296 MHz, *Ham Radio,* Sept. 1974, p 8–23.



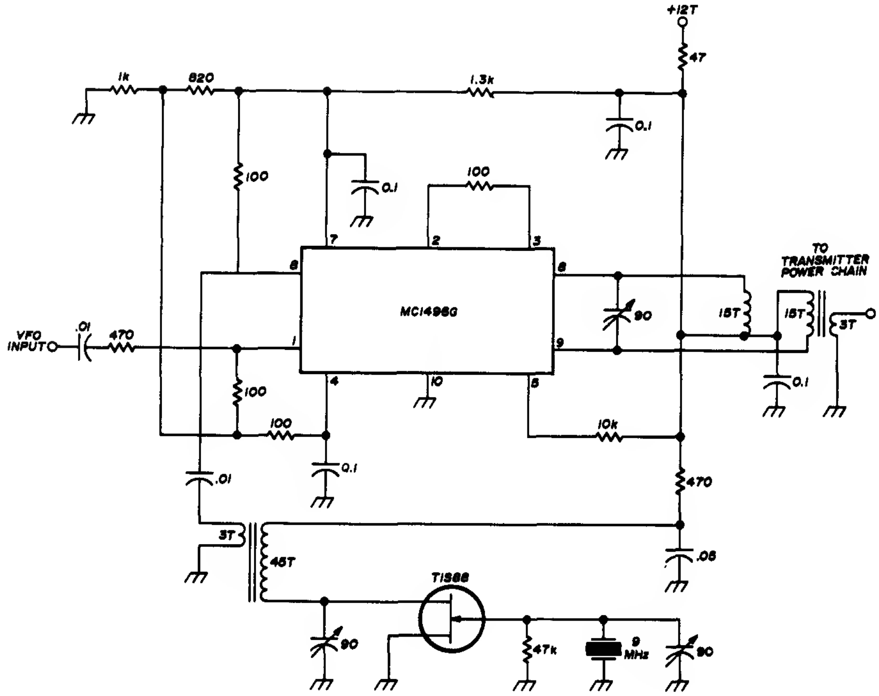
DOUBLE-BALANCED MIXER—Used in 80-meter SSB transceiver on both transmit and receive. Local oscillator input of 5–5.5 MHz is provided by VFO. SSB signal for receive comes from two-stage MOSFET RF amplifier.—D. Hembling, Solid-State 80-Meter SSB Transceiver, *Ham Radio*, March 1973, p 6–17.



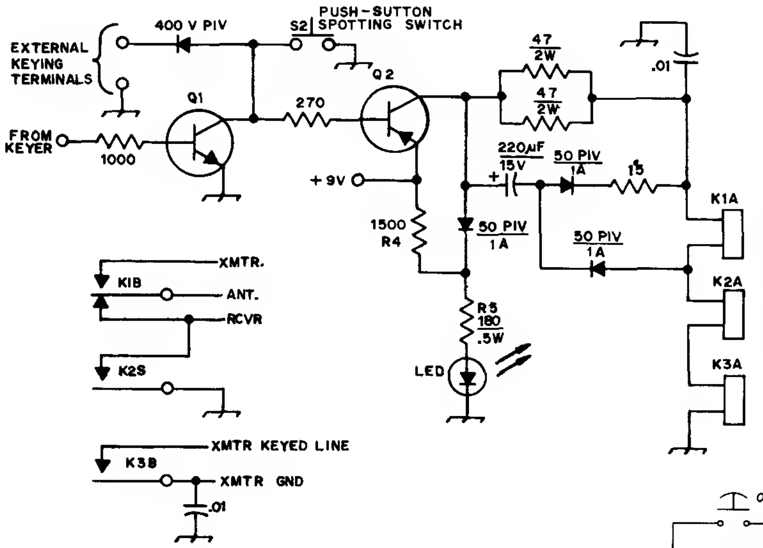
5–5.55 MHz VFO—Controls both receiver and transmitter of low-power transceiver for 20-meter amateur band. L1 is 3.5 μH wound on 6-mm ceramic form without tuning slug. Number of turns is adjusted to obtain exact inductance. JFET can also be 2N4416 or Motorola MPF102. VFO is buffered with single-stage feedback amplifier using pair of 2N3904 transistors (transistor type is not critical). Article also gives other circuits of transceiver.—W. Hayward, Low-Power Single-Band CW Transceiver, *Ham Radio*, Nov. 1974, p 8–17.



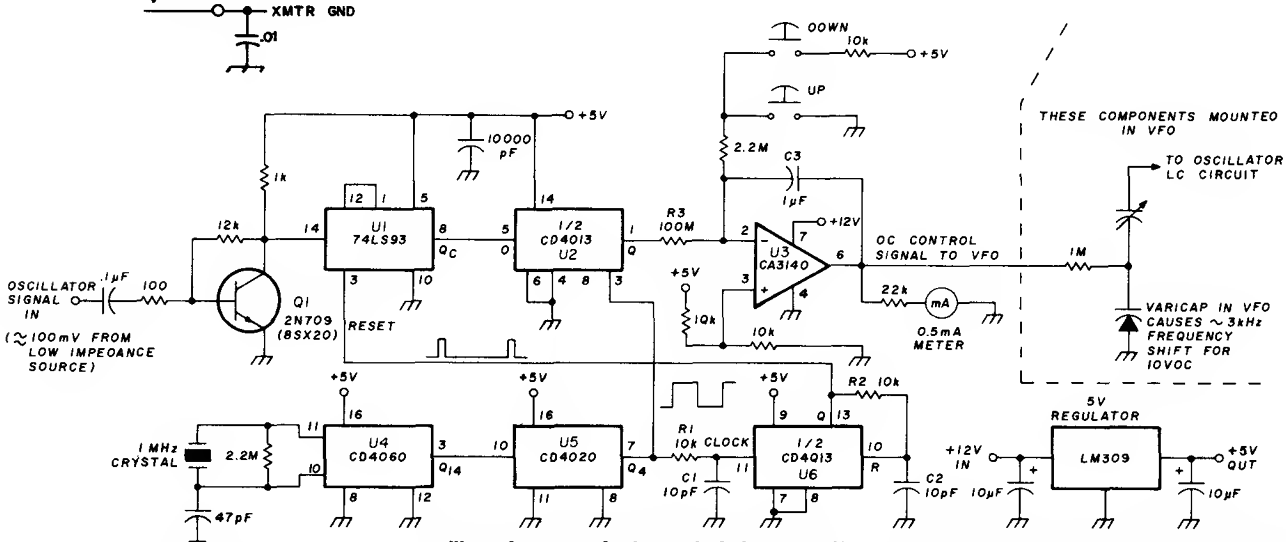
SYLLABIC VOX—Provides instantaneous radiotelephone speech communication without conventional VOX relays. Switching transistors eliminate contact-bounce problems of relays. Designed for use with Drake T-4XB and R-4B transmitter and receiver. Also gives true break-in CW keying. Since only words and syllables of words go on air, there are no VOX RF transients and no extraneous local noise. Operating bias for final amplifier is applied only during transmission; at other times, final amplifier tubes are completely cut off. Diodes CR4-CR7, CR9, and CR11 are 1N4004 or equivalent. All other diodes are 1N914 or equivalent. RF choke is 2.5 mH rated 100 mA. Article describes operation in detail and gives installation and setup procedures.—R. W. Hitchcock, Syllabic VOX System for Drake Equipment, *Ham Radio*, Aug. 1976, p 24–29.



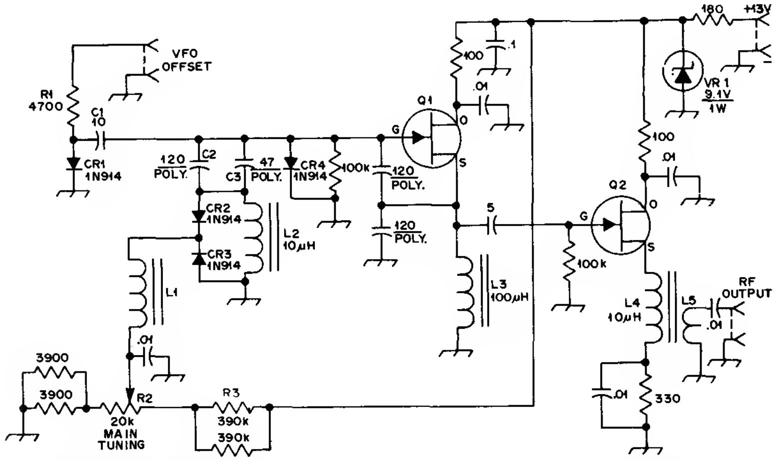
TRANSMIT MIXER—Used in low-power transceiver for 20-meter amateur band. VFO input, tunable from 5 to 5.55 MHz, is combined with 9-MHz output of crystal oscillator in Motorola MC1496G double-balanced modulator to give 14-MHz output for transmitter power chain. Supply voltage (+12 V) is applied only when transmitting. Transformers are wound on Amidon T-50-6 toroids or equivalent. Balance is maintained in mixer with center-tapped tuned circuit in output, made by putting 15-turn bifilar winding on toroid core and tuning series combination. Article gives all other circuits of transceiver.—W. Hayward, Low-Power Single-Band CW Transceiver, *Ham Radio*, Nov. 1974, p 8–17.



TR SWITCH—Consists of driver transistors Q1 and Q2 and reed relays K1-K3. K1 switches antenna from receiver to transmitter, K2 grounds receiver input, and K3 keys transmitter. Coil of K1 has 400 turns No. 32 enamel, while K2 and K3 each have 120 turns. Coils are wound directly on glass of reed relays and covered with epoxy cement. LED normally glows dimly, with brightness increasing when character is keyed.—J. H. Fox, An Integrated Keyer/TR Switch, *QST*, Jan. 1975, p 15–20.



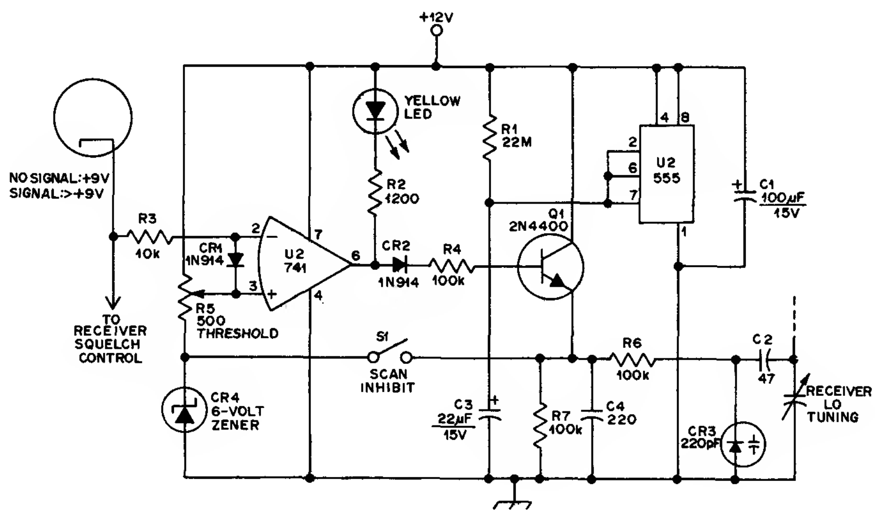
WARM-UP DRIFT COMPENSATOR—Warm-up drift of transceiver VFO is automatically corrected by using binary counter U1 to count oscillator frequency for interval of about 3.81 Hz determined by 1-MHz reference crystal oscillator and divider chain U4-U5. Switches labeled UP and DOWN are used to bring output of integrator R3-C3 into range manually after circuit switch-on.—K. Spaargaren, Drift-Correction Circuit for Free-Running Oscillators, *Ham Radio*, Dec. 1977, p 45–47.

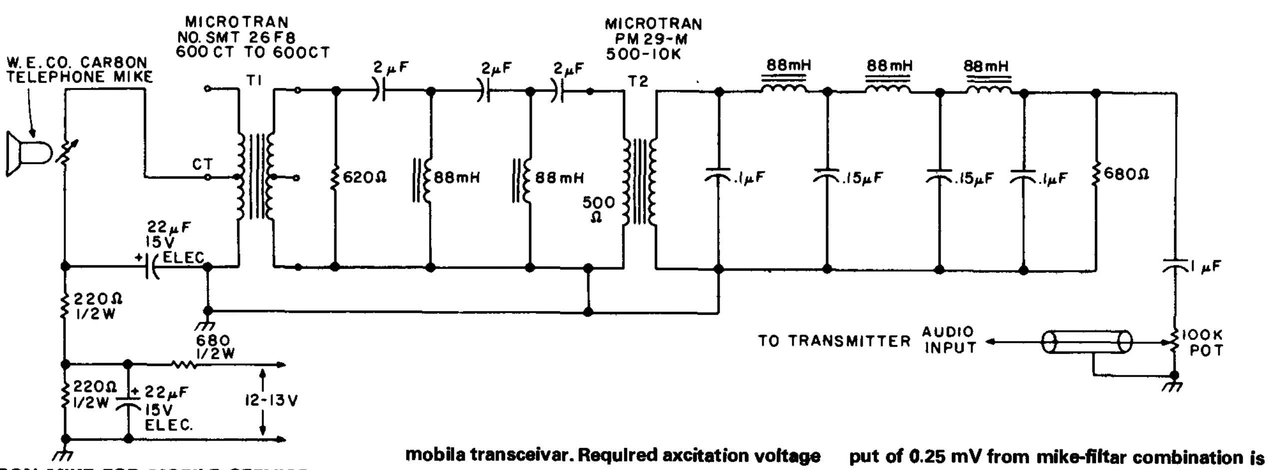


CR1-CR4 — Small-signal silicon diodes, 1N914 or equiv.
J1-J3 — Phono jack.
L1 — Modified rf choke (Radio Shack 273 102). Remove original turns and replace with approximately 100 turns no. 28 enam. wire.
L2, L4 — Rf choke (Radio Shack 273-101).
L3 — Rf choke (Radio Shack 273-102).
L5 — 1 turn no. 28 enam. wire over L4.
Q1, Q2 — JFET (Radio Shack RS 2036 or equiv.).
R2 — Slide potentiometer, 20 kΩ (from Radio Shack 271-1601).
VR1 — Zener diode, 9.1 V, 1 W.

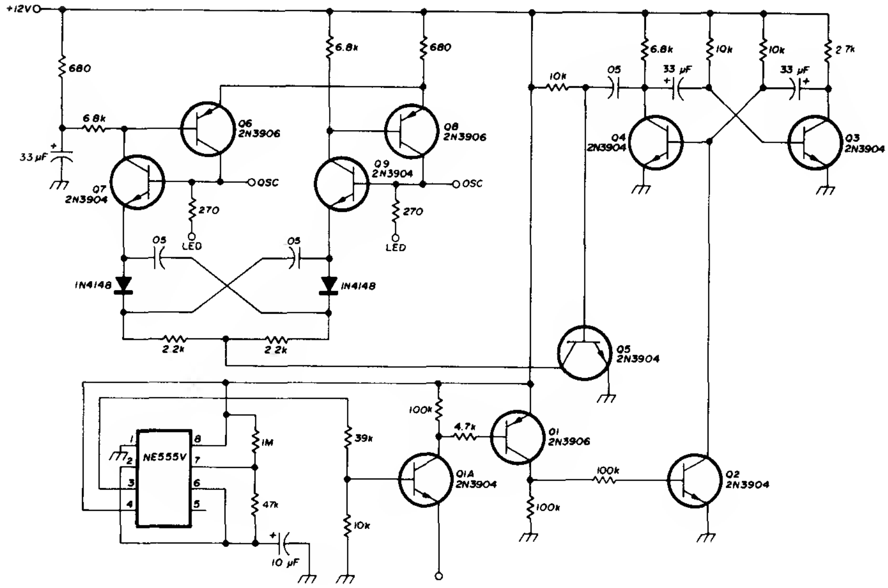
7–7.1 MHz VFO—JFET Q1 serves as oscillator, with frequency determined by C2, L2, CR2, and CR3; diodes operata in raverse-bias regions as voltage-variable capacitors. Amount of revarsa bias applied by R2 detarmines capacitance and frequency. VFO operates on both transmit and racaiva; on transmit, no voltage is applied to VFO offset circuit R1-C1-CR1 so it has little effect on oscillator. On raceive, +12 V applied to R1 makes CR1 conduct and places C1 across frequancy-determining network to shift VFO about 100 kHz away from operating frequancy so recaiver will not be biockad. Q2 is buffar betwaan oscillator and transmittar. VR1 provides regulated 9.1 V for oscillator and buffar. (Project was named aftar chopped beef can in which it was mounted.)—J. Rusgrova, The CB Slidar, *QST*, March 1977, p 15–17.

500-kHz SCAN ON 2 METERS—Circuit added to 2-meter transcaivar sweeps 500-kHz segment of 2-meter band at 2-s intervals. When incoming signal is strong anough to trip recaiver squalch, swaap stops and receiver locks on station. R4 and C3 determine scan rate. Adjust R1 for best lock-on. When signal is sensed, squelch is greater than 9 V on R3, driving output of U2 low, tuming on LED, and removing charging voltaga from R4. Whan signal disappaars, output of U2 goes high and scanning continues.—W. Sward, Add Frequency Scan to a Raceivar for $10, *QST*, March 1977, p 48.

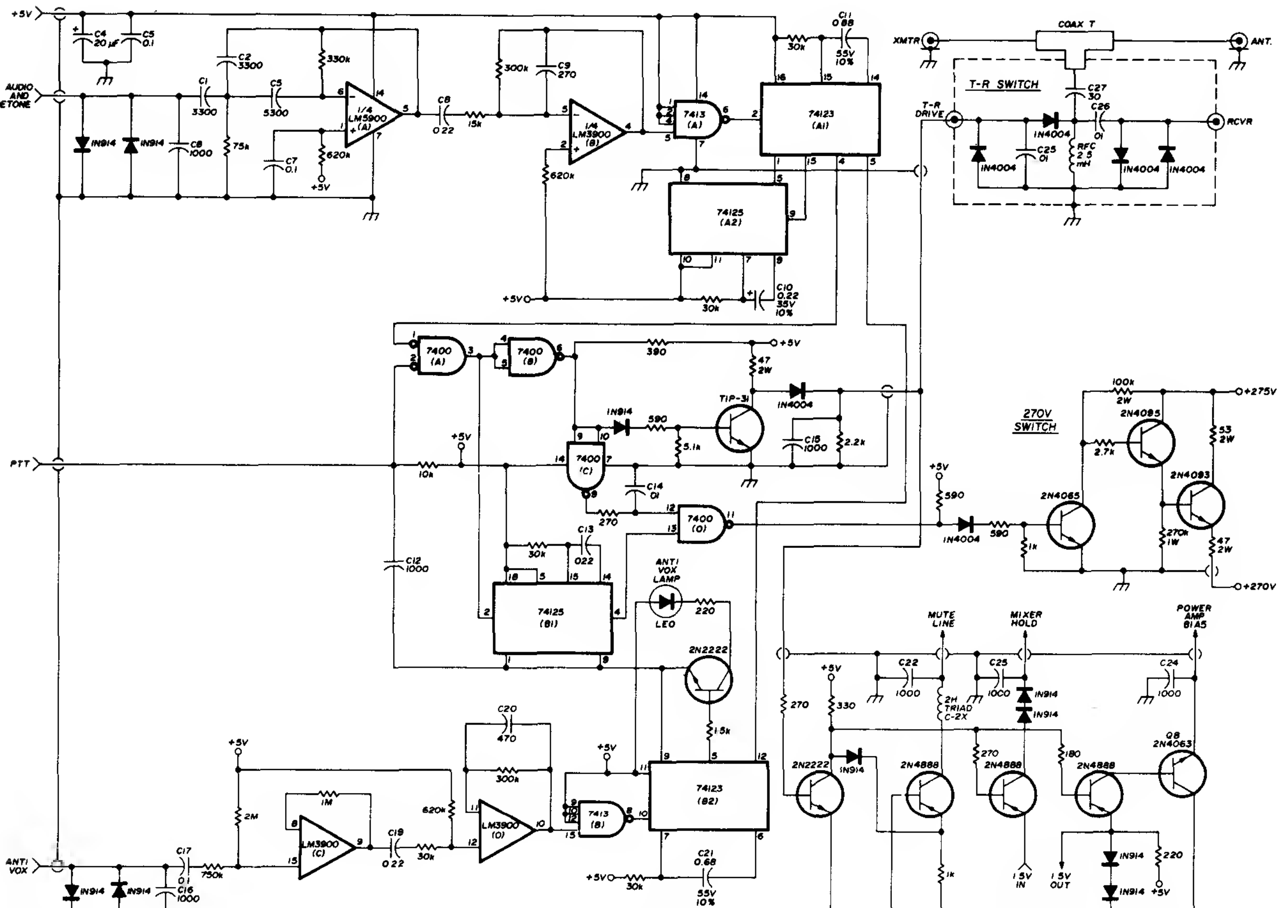




CARBON MIKE FOR MOBILE SERVICE—Filtar anhances desirable charactaristics of ordinary carbon mika taken from telephone, for usa with mobila transceivar. Requlred axcitation voltage of 3.5 V for mika is reduced from 12 V of car battary by resistor network having hash filtar to kaep alternator whine out of audio systam. Output of 0.25 mV from mike-filtar combination is reduced by 100K pot to valua naeded for transmittar.—S. Olberg, Tha Carbon Marvel, *73 Magazina*, April 1977, p 120.

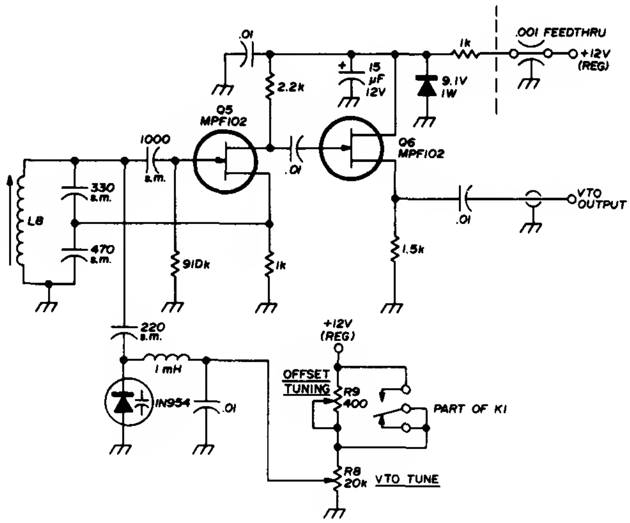


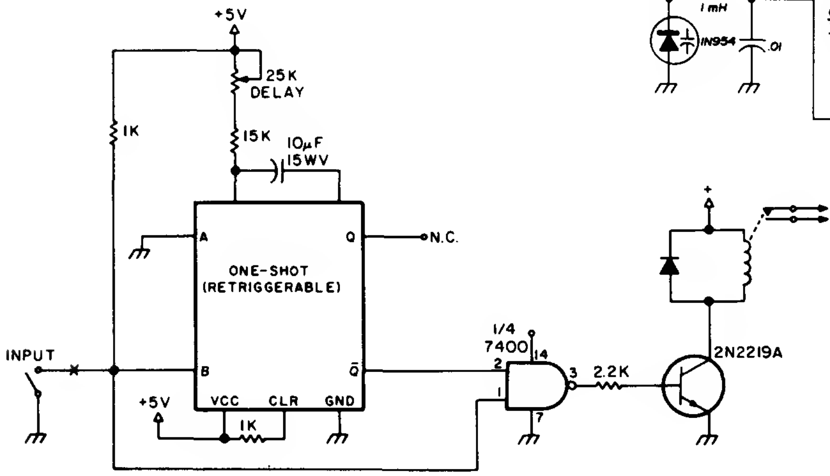
SCANNER WITH SEARCHBACK—Combines scanning between two repeater channels with periodic searchback, to prevent scanner from locking on one of channels during long periods of use. NE555 timer is added to squelch recognition circuit to provide automatic control of scanner so both frequencies are checked at least every 15 s. If scanner is extended to monitor four channels, none are unguarded for more than 1 min. Article shows how receiver section of transceiver is modified for diode switching by scanner of oscillator crystals for individual channels.—P. Shrave, Two-Channel Scanner for Repeater Monitoring, *Ham Radio*, Oct. 1976, p 48–51.



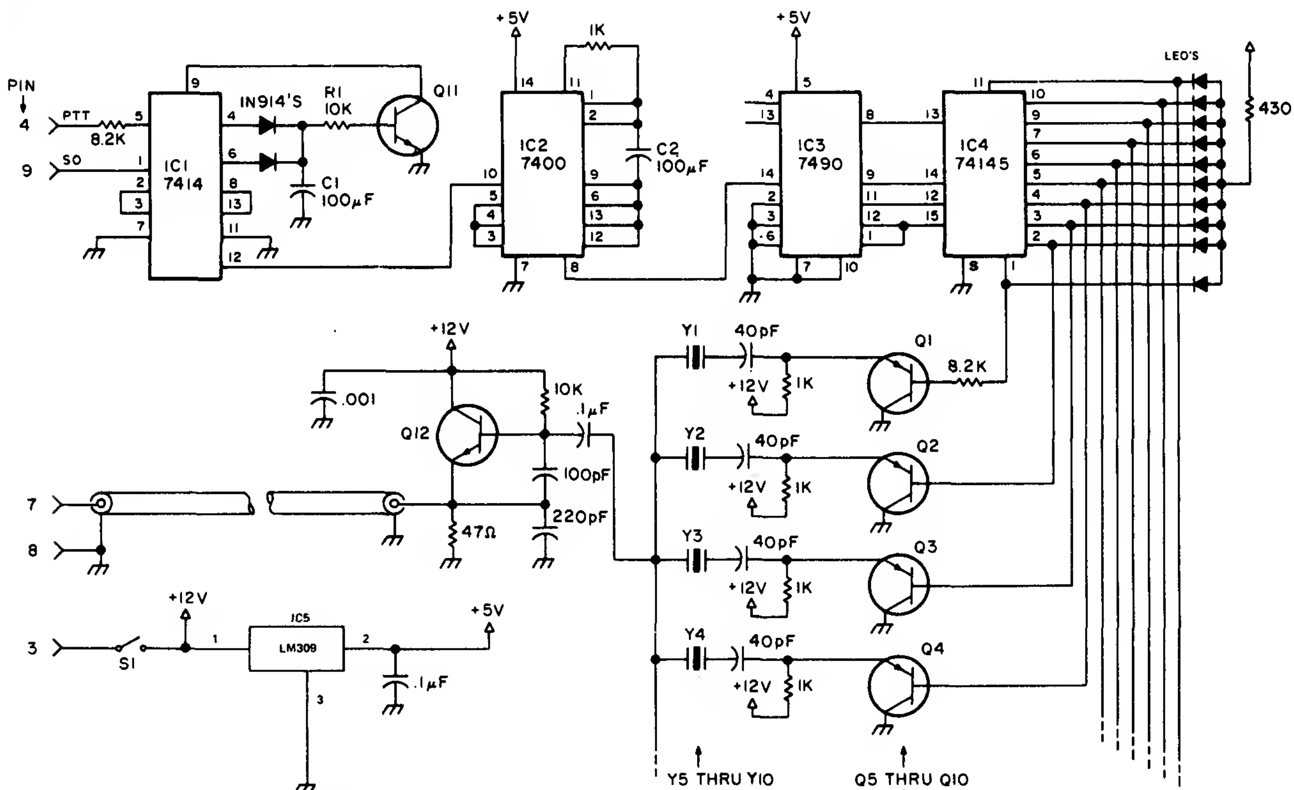
HIGH-SPEED VOX—Use of switching transistors for rapid, silent voice-controlled switching of transmitter-receiver functions improves on-the-air effectiveness of SSB station. Conversation is essentially the same as when using telephone. Each set of contacts that would open or close single circuit in relay-type VOX is replaced by switching transistor. TR switch is diode-biased antenna gate in which actual switching takes place 200 μs before RF appears, being accomplished by forward-biasing diode with DC voltage. Input to LM3900 is through high-pass filter. Operation of similar solid-state VOX circuit is described in detail in earlier article by same author (see author index).—H. R. Hildreth, Syllabic VOX System for the Collins S-Line, *Ham Radio*, Oct. 1977, p 29–33.

3–3.5 kHz VARACTOR TUNER—Variable oscillator for 80-meter SSB transceiver is tuned by 1N594 diode. MPF102 FET serves as source-follower buffer. With values shown, full excursion of R8 tunes oscillator from 3.045 to 3.545 MHz. Use well-regulated 12-V source. R9 allows synchronization of receive and transmit frequencies. K1 is 4PDT relay used for switching supply voltage and antenna from transmit to receive. L8 is 40 turns No. 32 on ¼-in slug-tuned form.—W. J. Waisar, Integrated Circuit SSB Transceiver for 80 Meters, *Ham Radio*, April 1976, p 48–52.

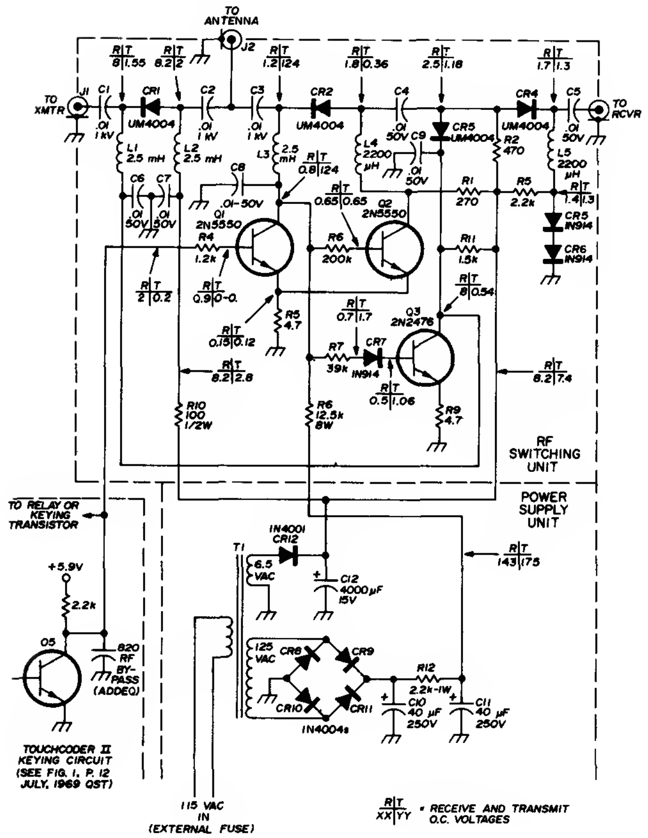




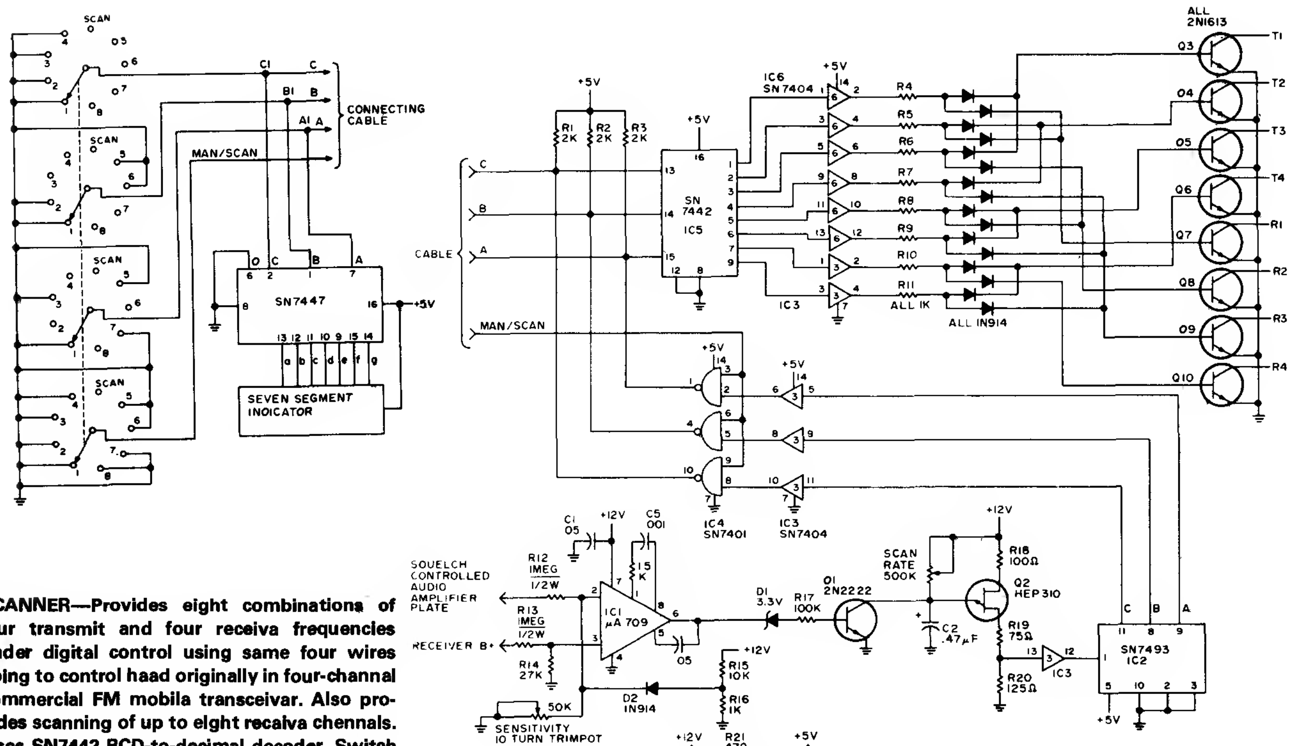
TR SWITCH—Simple transmit-receive switch uses 74122 retriggerable mono MVBR with clear and one NAND gate. When input of gate goes low (during key down or speech), transistor conducts and closes relay. Relay stays closed for period determined by delay pot, to maintain transmit condition between dots or dashes or between other pauses. Switch may be removed and any other TTL-compatible input applied at point X.—B. Voight, The TTL One Shot, *73 Magazine*, Feb. 1977, p 56–58.



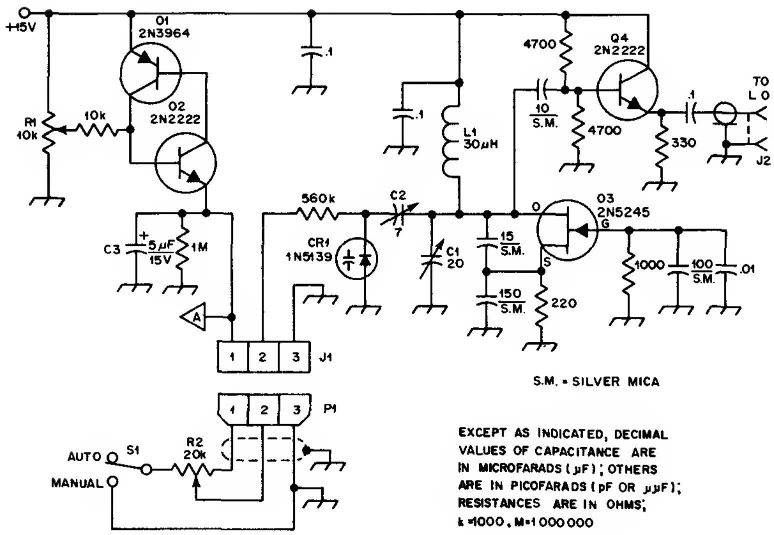
SCANNER FOR 2 METERS—Developed for use with frequency synthesizer to scan transmit and receive frequencies of four receivers plus six other channels in 2-meter amateur band. Pin connections at left go to socket provided on Icom IC-230 synthesizer for connecting external VFO operating between 11.255 and 12.255 MHz. Q1-Q10 can be 2N3638 or equivalent; Q11 is any NPN silicon such as 2N2102; and Q12 is 2N2102. LEDs operate from +12 V. In operation, scanner stops on active channel, and resumes scanning 5 s after channel goes off air. Article covers circuit operation, gives construction details, and tells how to calculate crystal frequency for each channel desired.—C. A. Kollar, Two Meter Scanner, *73 Magazine*, June 1977, p 46–48.



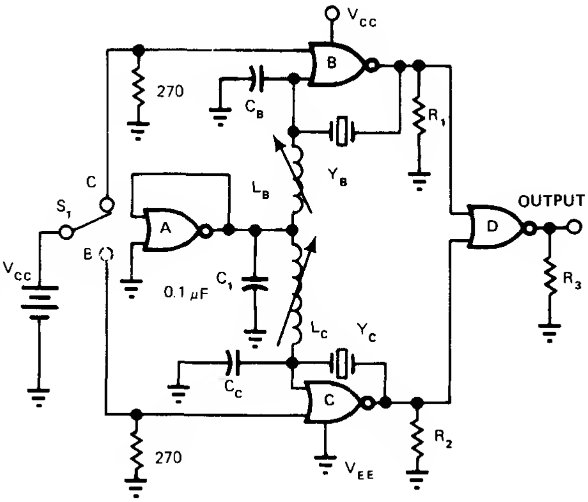
PIN-DIODE TR SWITCH—Solid-state TR switch operates at very high kaying spaeds and handles up to 100 W while transfarring antanna between receiver and transmittar in accordance with transmitter keying demands. Uses Unitroda UM4004 PIN diodes to provide about 0.2-dB insartion loss when forward-biased and about 30-dB isolation when ravarse-biased. CR1 is forward-biased for about 45 mA DC and CR2 is raverse-biased by 124 V during transmlt, for minimum loss in CR1 and maximum isolation in CR2. Circuit is designed to operate from collactor of kaying-circuit transistor in Touchcoder II (in dotted lines at lower left), but any sourca providing raquired T (transmit) and R (receive) DC voltages shown on diagram will kay circuit. Article covers construction in detail.—J. K. Boomar, PIN Diode Transmit/Receive Switch for 80-10 Matars, *Ham Radio,* May 1976, p 10–15.



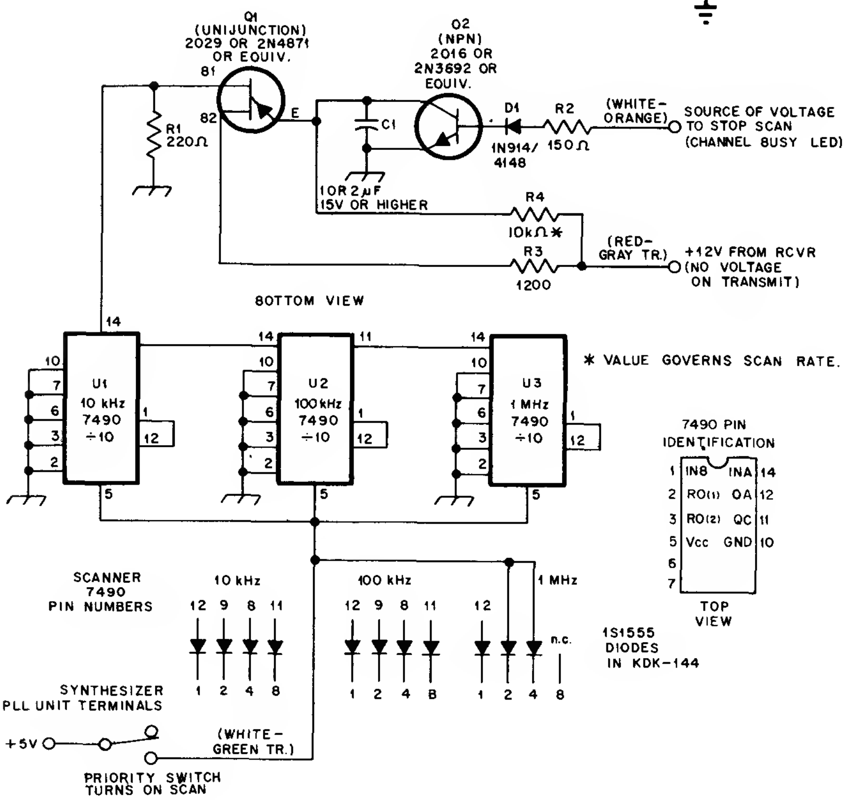
SCANNER—Provides eight combinations of four transmit and four receiva frequencies under digital control using same four wires going to control haad originally in four-channal commercial FM mobila transceivar. Also provides scanning of up to eight recaiva chennals. Uses SN7442 BCD-to-decimal decoder. Switch in original control head is rawired to count in BCD format. Carriar-oparated circuit stops clock when signal is racaived during scanning, and raadout davice displays number of channel being received. Clock is UJT Q2 with 500K pot varying scanning rata. Article covers construction and testing.—C. Durst, Scanning Adaptar for FM Transceivers, *73 Magazine,* April 1973, p 73–78.



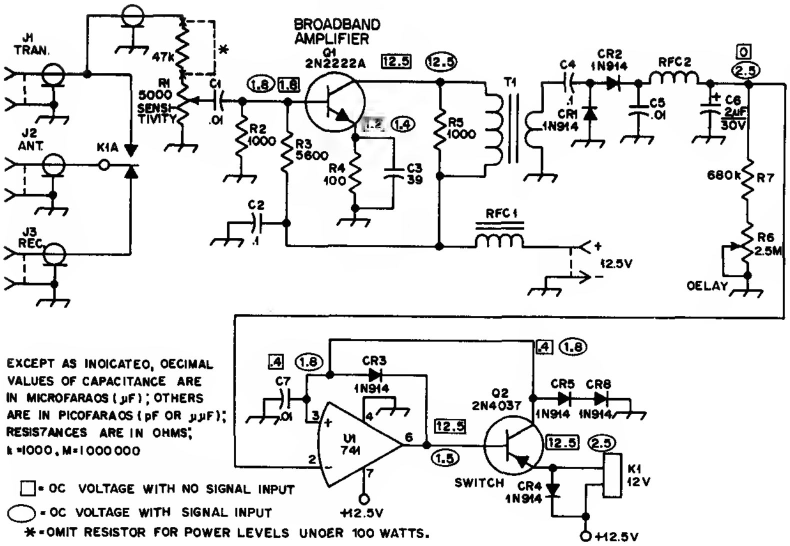
REMOTE TUNING—Simple swaep genarator and 5–5.5 MHz VCO provide remota menual or automatic alectronic tuning of 6-metar transceivar, for quick check of possibla band openings a few kilohartz from frequancy to which recaivar is normelly tuned. To adjust, set S1 on MANUAL and turn R2 fully countarclockwise. If signal at lowast recaivad frequency is epplied to antanna jeck, signal can ba cantared within IF passbend of receivar by adjusting C1. Next, turn R2 fully clockwisa, apply signal et highest frequency to ba raceived, and cantar signal within passband again by adjusting C2. With S1 in AUTO position, R1 detarmines highest fraquancy tuned. If swaep rata is too low, reduce velue of C3. Point A is used to driva CRO through FET buffer staga, for displaying signals presant within sweep ranga as pips on screen.—J. R. Bingham, Sweep 6 Metars and Raally Claan Up! *QST*, April 1977, p 27–28.



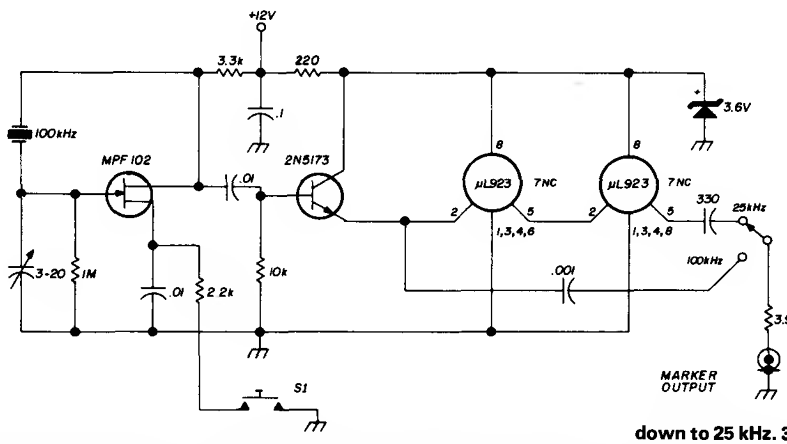
76.25 AND 81.6 MHz—MC10102 ECL quad NOR gata providas conveniant switching between two crystal oscillators, as required for change from racaiva to transmit in transcaivar. Output laval of about 0.8 V P-P can aasily driva 50-ohm loed and is fully buffered from oscillator sections. Gate A provides bies for oscillator gates B and C. Use 270 ohms for R_1-R_3. Crystals ara fifth ovartona; Y_B is 81.6 MHz with 97 nH for L_B and 39 pF for C_B, and Y_C is 76.25 MHz with 104 nH for L_C and 39 pF for C_C.—G. Griasmyar, Clockad CMOS One-Shot Has No RC Time Constant, *EDN Magazina*, May 20, 1978, p 164 and 172.



2-METER SCANNER—Designed for usa with KDK-144 amateur 2-meter transceivar to provida automatic scanning betwaen 146 and 147.990 MHz. When transceiver is switched to priority position, +5 VDC is appliad to 7490 dacada counters U1, U2, and U3 to activate scanner. Scanning stops when signal strong anough to opan squalch turns on Darlington-connected transistors Q1 and Q2, shorting UJT timing capacitor C1 which is 1–2 μF.—R. W. Shoamaker, Jr., A Scanner for KDK, *QST*, Oct. 1978, p 36–37.



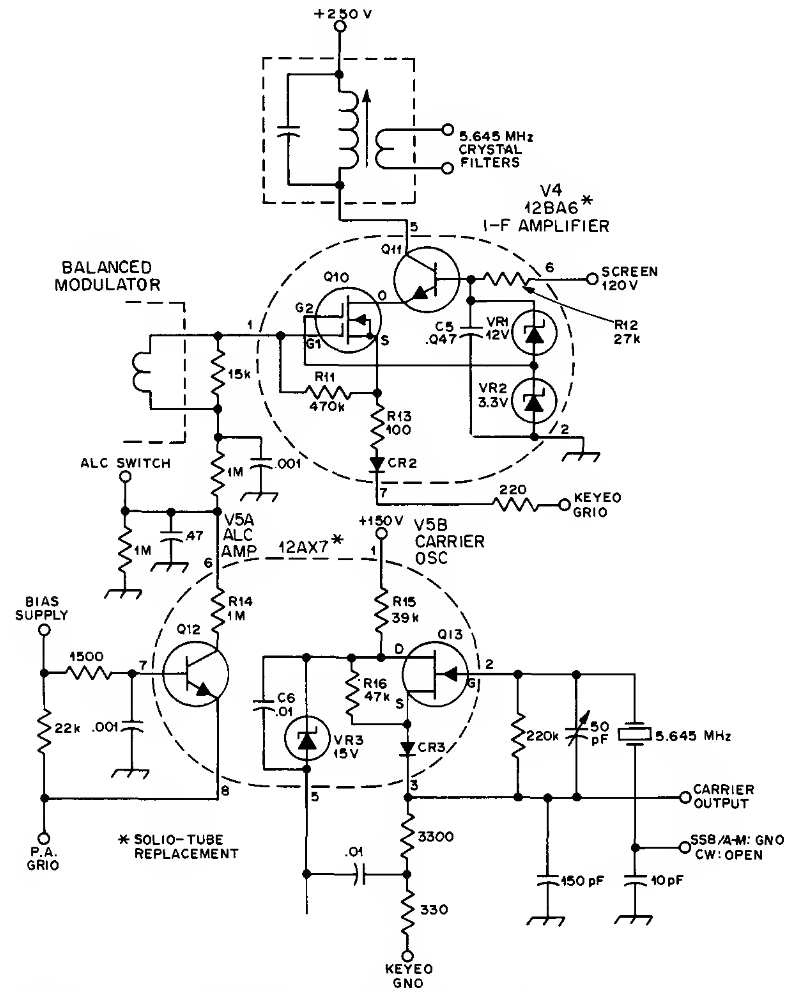
RF-SENSING TR SWITCH—System detects presenca of RF at output of transmittar and changes antenna connection from raceivar to transmitter instantly and automatically. No modifications ara required for transmitter or raceivar. RF voltage divider R1 parmits usa with transmitters of any power. Broadband amplifier Q1 feeds voltage doubler CR1-CR2 through broadband toroidal step-down transformer T1. CR6, R7, and R6 form adjustable timing network thet governs hold-in time of reley K1. Inverting amplifiar U1 turns on Q2 for energizing K1 and switching antenna to transmitter when RF is sensed. Whan no rectified RF reaches U1, Q2 is cut off and antenna is changed over to receiver. RFC1 and RFC2 have 42 turns No. 28 enamel on Amidon FT-50-43 core. T1 uses Amidon FT-50-43 cora, with 25 turns No. 28 enamel for primary and 5 turns No. 28 ovar this for secondary.—D. DeMaw end J. Rusgrova, An RF-Sensed Antenne Changeovar Relay, *QST*, Aug. 1976, p 21–23.



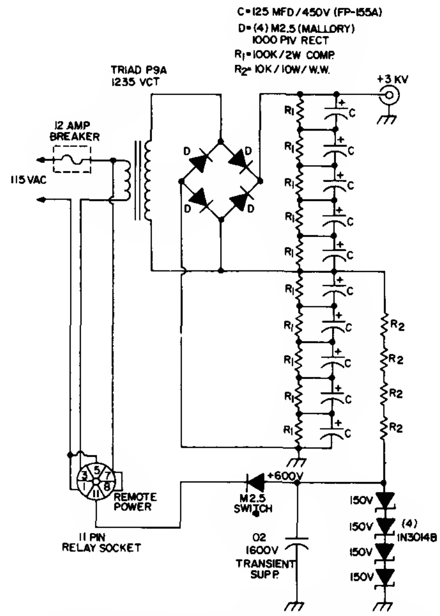
MARKER GENERATOR—Crystal-controlled frequency marker for 80-meter SSB transceiver provides front-panel control of either 25- or 100-kHz markers. S1 activates circuit by complating source circuit of FET momentarily. Two μL923 JK flip-flops divide 100-kHz crystal frequency down to 25 kHz. 3–20 pF trimmer is adjusted to zero-beat crystel ageinst recaivar tuned to WWV.—D. Hambling, Solid-State 80-Meter SSB Transceiver, *Ham Radio*, March 1973, p 6–17.

CHAPTER 99
Transmitter Circuits

Covers circuits specifically developed for use in AM, FM, and CW communication transmitters for amateur, aircraft, marine, satellite relay, long-wave, and other applications. Power ratings range from fractions of watt for QRP low-power CW transmitters up to 2 kW for moonbounce transmitter. Circuits for measuring RF output power are included.

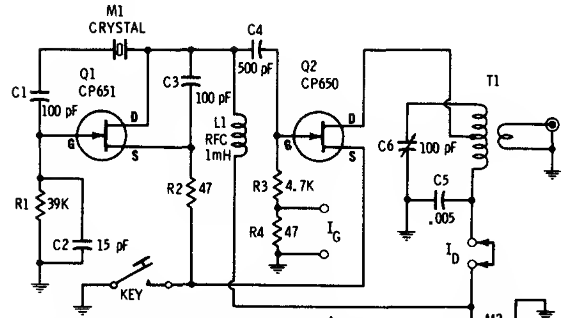


CR2, CR3 — General-purpose silicon diode, 300 PIV, 1N645 or equivalent.
Q10 — N-channel dual-gate MOSFET, 25 $V_{(BR)}$, 3N206 or equiv.
Q11 — Npn transistor, 300 $V_{(BR)}$, Texas Inst., TIS131.
Q12 — Npn transistor, 300 $V_{(BR)}$, Texas Inst., A5T5058.
Q13 — N-channel JFET 30 $V_{(BR)}$, 2N5246 or equiv.
VR1 — Zener diode, 12 V, 400 mW, 1N759.
VR2 — Zener diode, 3.3 V, 1 W, 1N746.
VR3 — Zener diode, 15 V, 400 mW, 1N965.



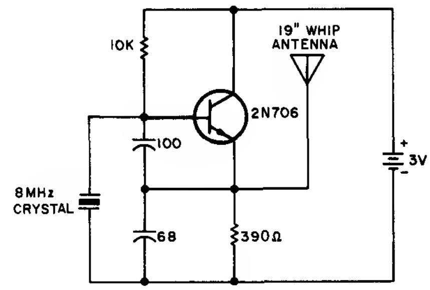
3 kV AT 2 kW—Developed as supply for 1-kW linear amplifier used in 2-meter moonbounce communication. Article covers construction, with emphasis on insulation requirements, and gives circuit of 1-kW amplifier using Eimac 5-500A pentode.—R. W. Campbell, Kilowatt Linear Amplifier for 2 Meters, *73 Magazine*, Dec. 1973, p 29–35.

TRANSISTORS FOR OSCILLATOR AND IF TUBES—Article covers replacement of tubes in Drake T-4XB transmitter with solid-state equivalent circuits mounted in 7-pin and 9-pin miniature plugs. V4 uses dual-cascode MOSFET, with CR2 and zeners providing high-voltage protection from keyed grid. Carrier oscillator V5B uses single low-voltage high-μ JFET with zener voltage regulator in original grounded "plate" oscillator circuit. High keyed-ground voltages are isolated by CR3 and R16. Automatic level control amplifier V5A is single high-voltage transistor. R14 synthesizes 12AX7 plate resistance, to maintain same audio time response.—H. J. Sartori, Solid-Tubes—a New Life for Old Designs, *QST*, April 1977, p 45–50.

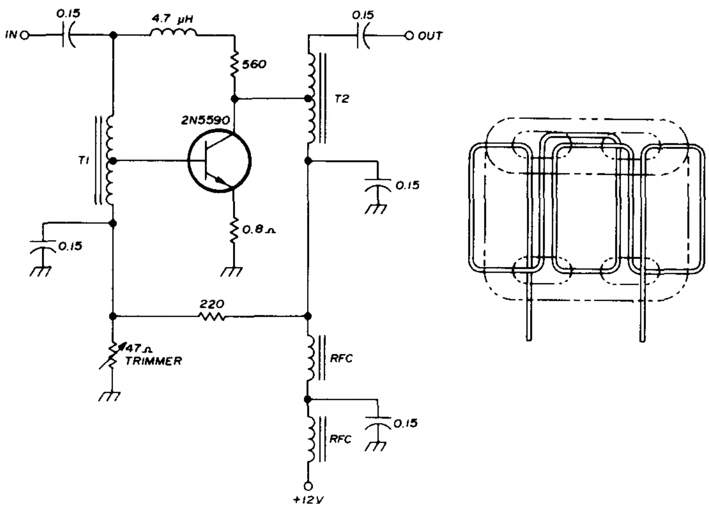


T1 PRIMARY: 25 turns #20 enameled wire, air wound, 1-1/4" diameter, 1-1/2" length, center tapped
T1 SECONDARY: 3 turns #16 enameled wire, over center of primary

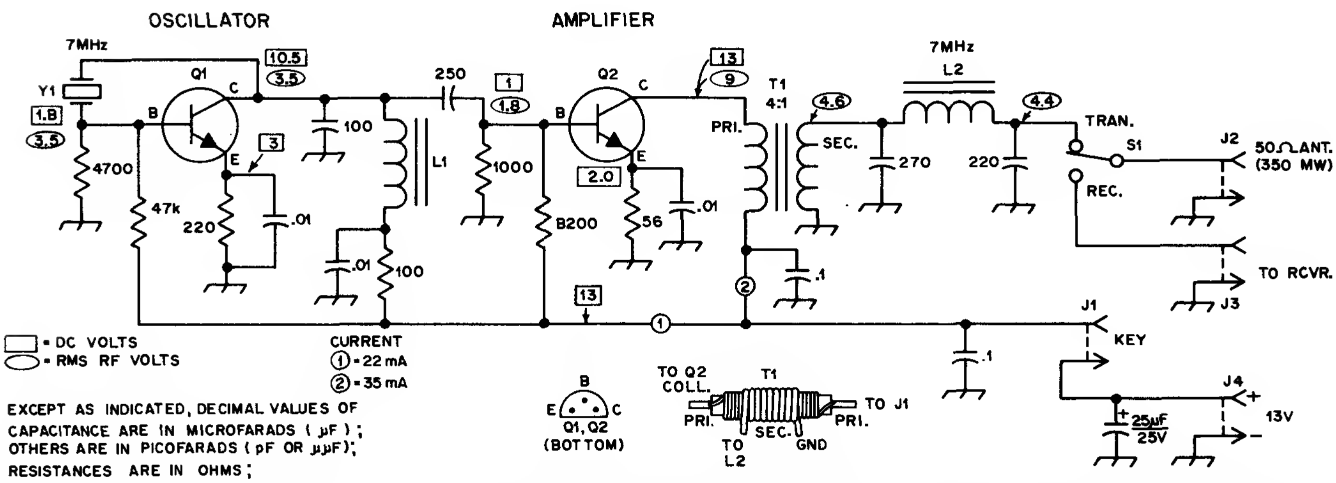
5-W FET TRANSMITTER—Values shown giva oparetion in 40-meter ematuer bend. Drain of power FET Q2 is connected to tep on primary of rasonent tank circuit.—E. M. Noll, "FET Principles, Experiments, end Projects," Howerd W. Sems, Indienepolis, IN, 2nd Ed., 1975, p 188–189.



144-MHz LOW-POWER—Used es weak-signal source for tuning circuits of 2-m receiver or preamp whan no stations ere on air.—C. Sondgeroth, Really Soup Up Your 2m Receiver, *73 Magazine*, Feb. 1976, p 40–42.

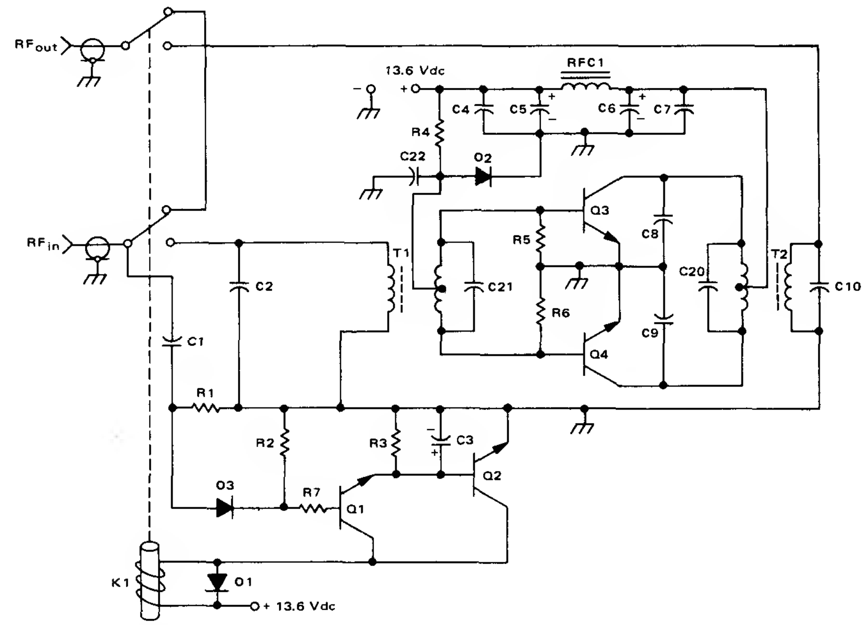


4-W LINEAR—Produces power output of 4 W across high-frequency RF renge from 300 kHz to 30 MHz, for output of low-powar QRP trensmitter or es driver for final amplifiar of higharpower transmittar. Gain is only 3 dB down at frequency limits end is still useful at 6 meters. Amplifiar output mey be shorted or left open indefinitely aven with full drive. Stability end wide frequency reeponse ere echieved by edding considereble nagative feedbeck to otherwise conventional broadband emplifiar. T1 and T2 are wound on two-hole balun cores as found in TV sets, such es Phillips 4322-020-31520. Two lengths of No. 22 enamel are twisted about 3 times per inch end then wound through core as shown. Ona end of ona wire is connected to opposite end of other wire to serve es canter tap for transformer. Transformers are responsible for wide frequency response of amplifier.—J. A. Koehler, Four-Watt Widaband Linaar Amplifier, *Ham Radio*, Jen. 1976, p 42–44.



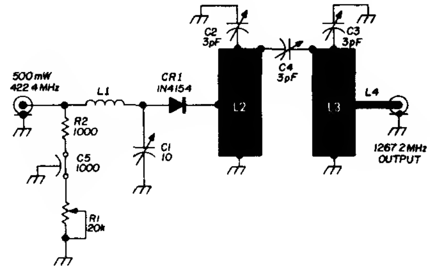
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k = 1 000, M = 1 000 000.

250 mW FOR 40-METER CW—Two-trensistor circuit is aasily essambled on circuler printed-circuit board small enough to fit into tunafish cen, for low-power (QRP) operation. Simpla Pierce crystel oscillator Q1 feeds class C amplifier Q2. L1 is made by unwinding 10-μH Redio Sheck choke 273-101 end filling form with No. 28 or 30 enamel to give 24 μH. Similar choka is unwound so only 11 turns remein (1.36 μH), with turns spaced one wire thickness epart for L2. Adjust spacing of turns for meximum output during finel tune-up with transmitter opereting into 50-ohm loed. For T1, remove ell but 50 turns from 100-μH Radio Shack choke 273-102 and wind 25 turns No. 22 or 24 enamal ovar these. Supply cen be nine Penlite, C, or D calls in series or 12-V or 13-V regulated DC supply. Q1 end Q2 ere 2N2222A or equivelent. Y1 is 7-MHz fundemantel crystel.—D. DeMaw, Build e Tuna-Tin 2, *QST*, Mey 1976, p 14–16.



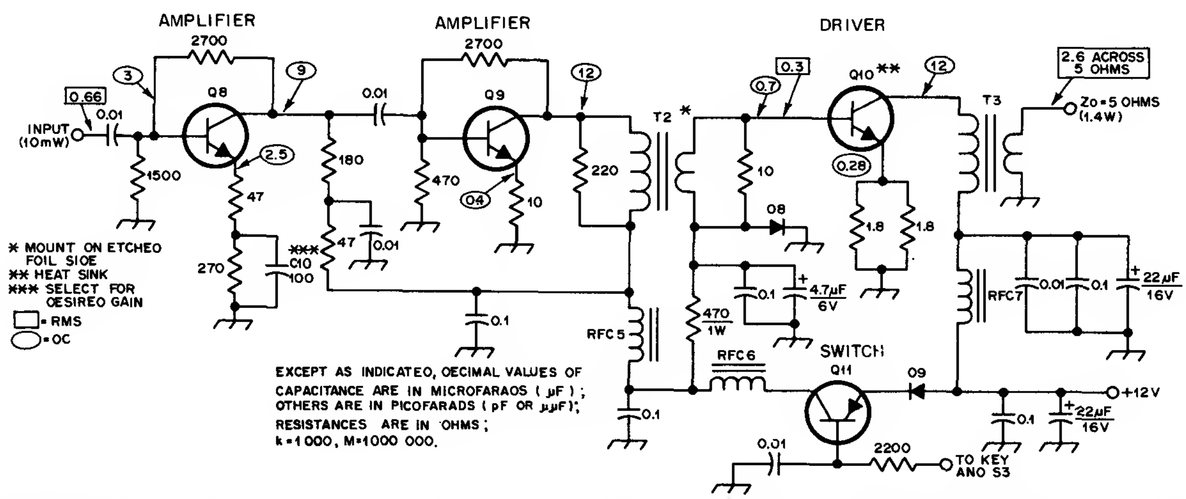
C1	=	33 pF Dipped Mica	R7	=	100 Ω 1/4 W Resistor
C2	=	18 pF Dipped Mica	RFC1	=	9 Ferroxcube Beads on #18 AWG Wire
C3	=	10 µF 35 Vdc for AM operation, 100 µF 35 Vdc for SSB operation.	D1	=	1N4001
			D2	=	1N4997
C4	=	.1 µF Erie	D3	=	1N914
C5	=	10 µF 35 Vdc Electrolytic	Q1, Q2	=	2N4401
C6	=	1 µF Tantalum	Q3, 4	=	MRF454
C7	=	.001 µF Erie Disc	T1,.T2	=	16:1 Transformers
C8, 9	=	330 pF Dipped Mica	C20	=	910 pF Dipped Mica
R1	=	100 kΩ 1/4 W Resistor	C21	=	1100 pF Dipped Mica
R2, 3	=	10 kΩ 1/4 W Resistor	C10	=	24 pF Dipped Mica
R4	=	33 Ω 5 W Wire Wound Resistor	C22	=	500 µF 3 Vdc Electrolytic
R5, 6	=	10 Ω 1/2 W Resistor	K1	=	Potter & Brumfield KT11A 12 Vdc Relay or Equivalent

2–30 MHz 140-W LINEAR—Uses two Motorola MRF454 transistors Q3-Q4 in circuit providing relatively flat gain ovar frequancy band, as required for power amplifiar of amateur SSB transmittar. Bias dioda D2 is mounted on heatsink of Q3-Q4 for tamparature tracking. Circuit Includes carrier-operated relay driven by Q1 and Q2.—T. Bishop, "140W (PEP) Amataur Radio Linear Amplifiar 2-30MHz," Motorola, Phoenix, AZ, 1976, EB-63.

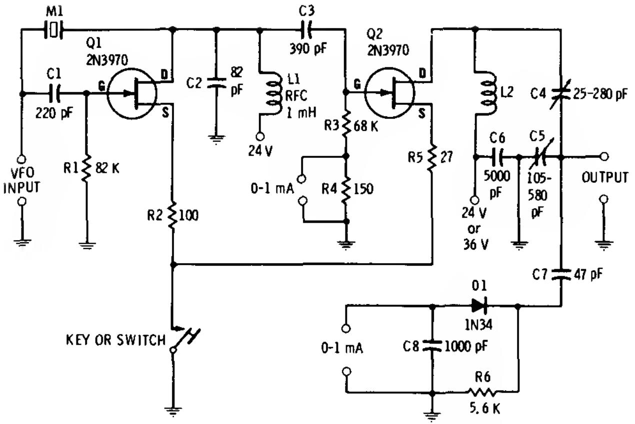


C1	1-10 pF concentric piston trimmer
C2,C3 C4	0.3-3 pF concentric piston trimmer
CR1	1N4154 high-speed switching diode
L1	2 turns no. 20, 0.1" (2.5 mm) diameter, 0.25" (6 mm) long
L2	micro-stripline, 0.3" (7.5 mm) wide, 0.865" (22 mm) long, grounded at bottom, tapped 0.20" (5 mm) from ground end
L3	Same as L2 but tapped 0.25" (6 mm) from ground end
L4	50-ohm micro-stripline, 0.1" (2.5 mm) wide, any length
R1	20k, 10-turn trimpot

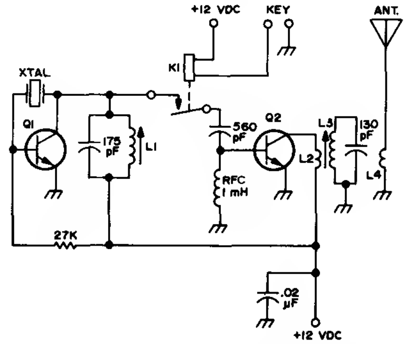
100 W AT 432 MHz—Two-transistor 100-W PEP solid-state linaar amplifiar can ba usad for SSB activity in satallite relay service or for linear, CW, or FM sarvica. Circuit uses Motorola MRF306 28-V 60-W 225–400 MHz power transistors in narrow-band parallel amplifier oparating in class AB linaar moda. Driva level is about 10 W PEP. Article covars construction and tune-up.—R. K. Olsan, 100-Watt Solid-Stata Power Amplifier for 432 MHz, *Ham Radio,* Sapt. 1975, p 36–43.



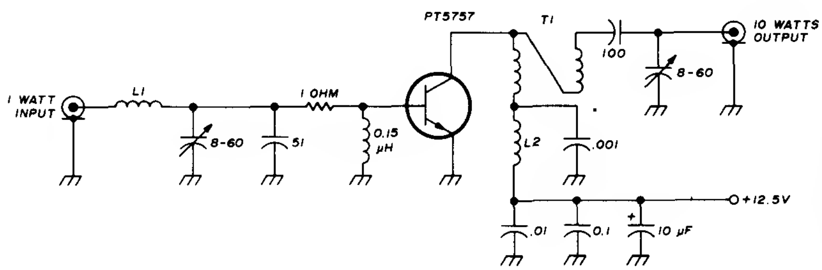
1.4-W BROADBAND LINEAR FOR 7 AND 14 MHz—Requires about 10-mW driving power. Frequency rasponse is essentially flat over 7–14 MHz frequency ranga. Diodes are 1N4003. Q8 is 2N2222A, Q9 is 2N3866, Q10 is 2N2270, and Q11 is 2N4037. RF chokas usa 18 turns No. 28 enamal on FT-37-43 ferrite toroid core. Primary of T2 is 30 tums of No. 28 anamel on FT-50-43 ferrite toroid core, with 4 turns No. 28 wound over cold end for secondary. T3 has 16 turns of No. 28 anamel for primary and 4 turns for secondary looped through BLN-43-302 farrita cora. Artlcla glves test procedure.—D. DaMaw, Transmitter Dasign—Emphasis on Anatomy, *QST,* July 1978, p 23–25.



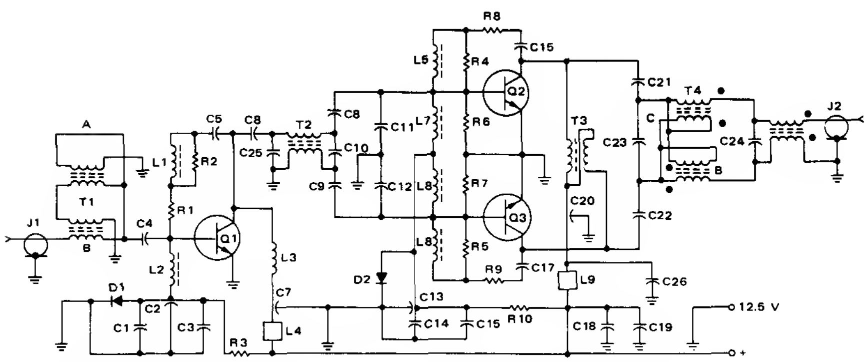
¼-W CW TRANSMITTER—Low-power two-stage FET transmitter for 80-meter ematour band uses Piarce crystal oscillator thet raquires no output resonent circuit. DC milliammeter can be connected ecross 150-ohm resistor in gate circuit of second transistor to indicate strength of oscillator output signal. Rasonent circuit of RF amplifier Q2 uses toroid L2 (56 turns No. 24 enamel on $^{13}/_{16}$-in Permacor 57-1541 core) end two series-connected trimmers. Milliammeter is connectad across C8 when level of RF output voltage is to be measured.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 204–207.



2-METER QRP—Can supply up to 1 W of RF output on CW for portable or low-power (QRP) emateur radio operation. Providas chirpless keying with negligible backweve. Operetes from 12-V car battery or lantern batteries. Oscillator uses 7-MHz fundamantel crystal end 40080 translator Q1, with 40081 In final stege. L1 is 20 tums No. 28 on ¼-inch slug-tuned form. L3 is 28 turns No. 28 on ¼-inch slug-tuned form, with 5 turns No. 24 wound on it for L2 end the seme for L4. Article covars construction and oparation.—C. Klinert, Simple QRP Transmittar, *73 Magazine*, Aug. 1973, p 85–87.



10 W ON 2 METERS—Single TRW PT5757 transistor providas 10-W output when operating from 12.5-V euto battery. L1 is 4 turns No. 20 enemel and L2 is 10 turns No. 20, both with $^{3}/_{32}$-inch inner diemetar. T1 is 4:1 transmission-llna transformar made from 3-inch length of twisted-peir No. 20 enemel.—J. Fisk, Two-Meter Powar Amplifier, *Ham Radio*, Jan. 1974, p 67.



C1, C14, C18 – 0.1 µF ceramic
C2, C7, C13, C20 – 0.001 µF feed through.
C3 – 100 µF/3V.
C4, C6 – 0.033 µF mylar
C5 – 0.0047 µF mylar.
C8, C9 – 0.015 and 0.033 µF mylars in parallel.
C10 – 470 pF mice.
C11, C12 – 560 pF mica.
C15 – 1000 µF/3 V
C16, C17 – 0.015 µF mylar
C19 – 10 pF 15 V
C21, C22 – two 0.068 µF mylars in parallel.
C23 – 330 pF mice
C24 – 39 pF mica
C25 – 680 pF mica
C26 – .01 µF ceramic

R1, R6, R7 – 10 Ω, 1/2 W carbon
R2 – 51 Ω, 1/2 W carbon
R3 – 240 Ω, 1 wire W
R4, R5 – 18 Ω, 1 W carbon
R8, R9 – 27 Ω, 2 W carbon
R10 – 33 Ω, 6 W wire W

L1 – 0.22 µh molded choke
L2, L7, L8 – 10 µh molded choke
L5, L6 – 0.15 µh
L3 – 25 t, #26 wire, wound on a 100 Ω, 2 W resistor. (1.0 µh)
L4, L9 – 3 ferrite beads each.

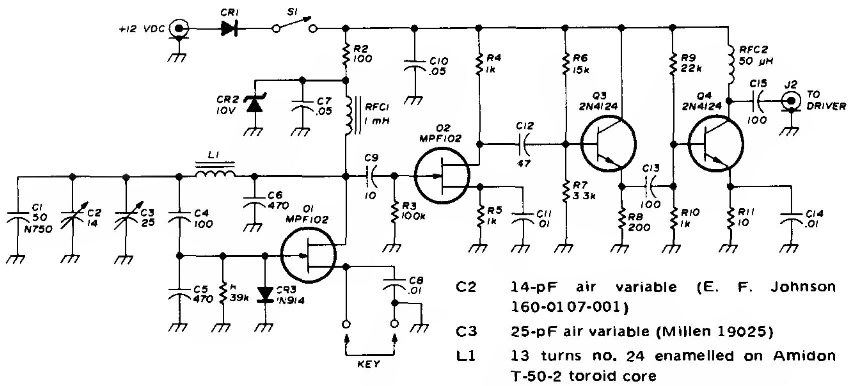
T1 – 2 twisted pairs of #26 wira, 8 twists per inch. A = 4 turns, B = 8 turns. Core - Stackpole 57-9322-11, Indiana General F627-8Q1 or equivalent
T2 – 2 twisted pairs of #24 wire, 8 twists per inch, 6 turns. (Core as above.)
T3 – 2 twisted pairs of #20 wira, 6 twists per inch, 4 turns. (Core as above.)
T4 – A and B = 2 twisted pairs of #24 wira, 8 twists par inch. 5 turns each. C = 1 twisted pair of #24 wire, 8 turns. Core - Stackpole 57-9074-11, Indiana Genaral F624-19Q1 or equivelent.

Q1 – 2N6367
Q2, Q3 – 2N6368

D1 – 1N4001
D2 – 1N4997

J1, J2 – BNC connectors

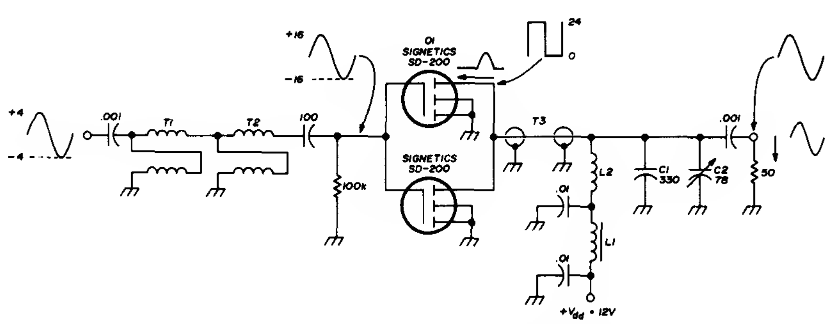
80-W LINEAR FOR MOBILE SSB—Designed for oparation from 12.5-V supply, using driver stage to provida total powar gain of about 30 dB for 3–30 MHz bend. Negative collector-to-base faedback providas gein compensation in both drivar and output stages. Low circuit impedences meke layout end construction mora critical than with highor-voltaga circuits.—H. Granberg, "Broedbend Linaer Power Amplifiers Using Push-Pull Transistors," Motorola, Phoanix, AZ, 1974, AN-593, p 7.



C1 50-pF, N750 temperature coefficient ceramic
C2 14-pF air variable (E. F. Johnson 160-0107-001)
C3 25-pF air variable (Millen 19025)
L1 13 turns no. 24 enamelled on Amidon T-50-2 toroid core
RFC1 1-mH rf choke (Millen J300-1000)
RFC2 50-μH rf choke (Millen 3 00-50)

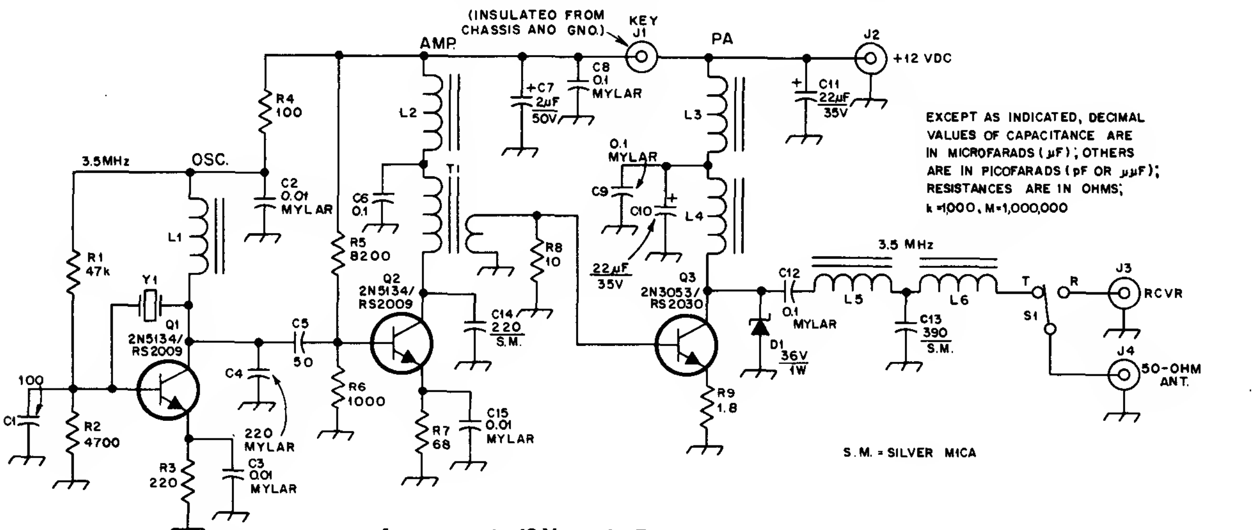
20-METER VFO—Tunes from 14.0 to 14.2 MHz, using stable Vackar design. Protectiva diode CR1 can be any silicon ractifiar. Clamping dioda CR3 improves stability by pravanting conduction in gata of JFET oscillator Q1.—C. E. Galbreath, Low-Powar Solid-Stata VFO Transmitter for 20 Meters, *Ham Radio*, Nov. 1973, p 6–11.

300-mW 25-MHz AMPLIFIER—Uses quartar-wavelength transmission line T3 in place of parallal-tuned traps to pass even-harmonic currant freely whila blocking odd harmonics. Circuit can be edepted to 300-mW walkie-talkie for 6 or 10 metars. At 25 MHz, efficiency is 73%.—F. H. Raab, High-Efficiancy RF Power Amplifiers, *Ham Radio*, Oct. 1974, p 8–29.

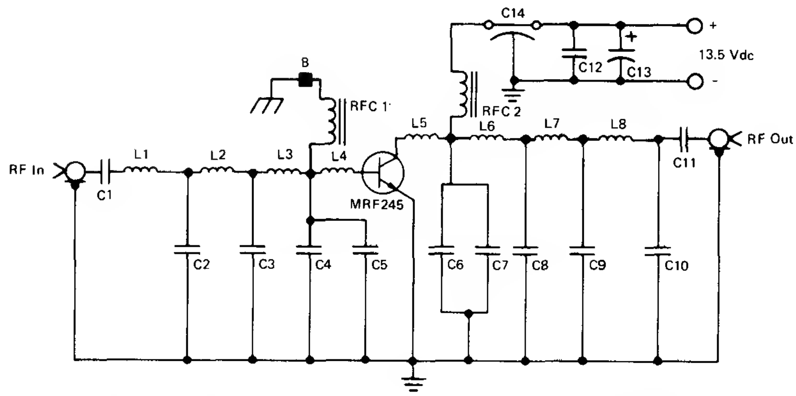


C2 78-pF variable (E.F. Johnson 158-4)
L1 2.2 μH rf choke (Delevan 1025-28)
L2 106 nH (4 turns no. 26 wire on Permacore 57-2656 or Micrometals T30-6 core)
T1,T2 11 turns no. 26 twisted pair on Permacore 57-2656 or Micrometals T30-6 core
T3 piece of 125-ohm coaxial cable (RG-63B/U), 112.2" (2.85 meters) long

D1 — 36-V, 1-W Zener diode.
J1-J4, incl. — Single-hole mount phono jack.
L1 — 100-μH choke (Radio Shack 273-102).
L2-L4, incl. — 10-μH choke (Radio Shack 273-101).
L5 — 12-μH inductor (Radio Shack 273-101 with 4 turns no. 26 enam. wire added).
L6 — 8.9-μH inductor (Radio Shack 273-101 with 3 turns removed).
S1 — Miniature sodt toggle or slide switch.
T1 — Broadband transformer (Radio Shack 273-101 for primary, with 5-turn secondary of no. 26 enam. wire over C6 end of primary).
Y1 — 80-meter fundamental type of crystal (crystal socket optional).



80-METER CW FOR QRP—Low-power transmitter can be mounted on smell can for operation from separate 12-V supply. Zener D1 protects Q3 by clemping on RF voltage peaks in excess of 36 V. Output tenk of Q3 gives satisfectory operation from 3.5 to 3.75 MHz without tuning.—D. DeMaw, Build This "Sardine Sandar," *QST*, Oct. 1978, p 15–17 end 38.

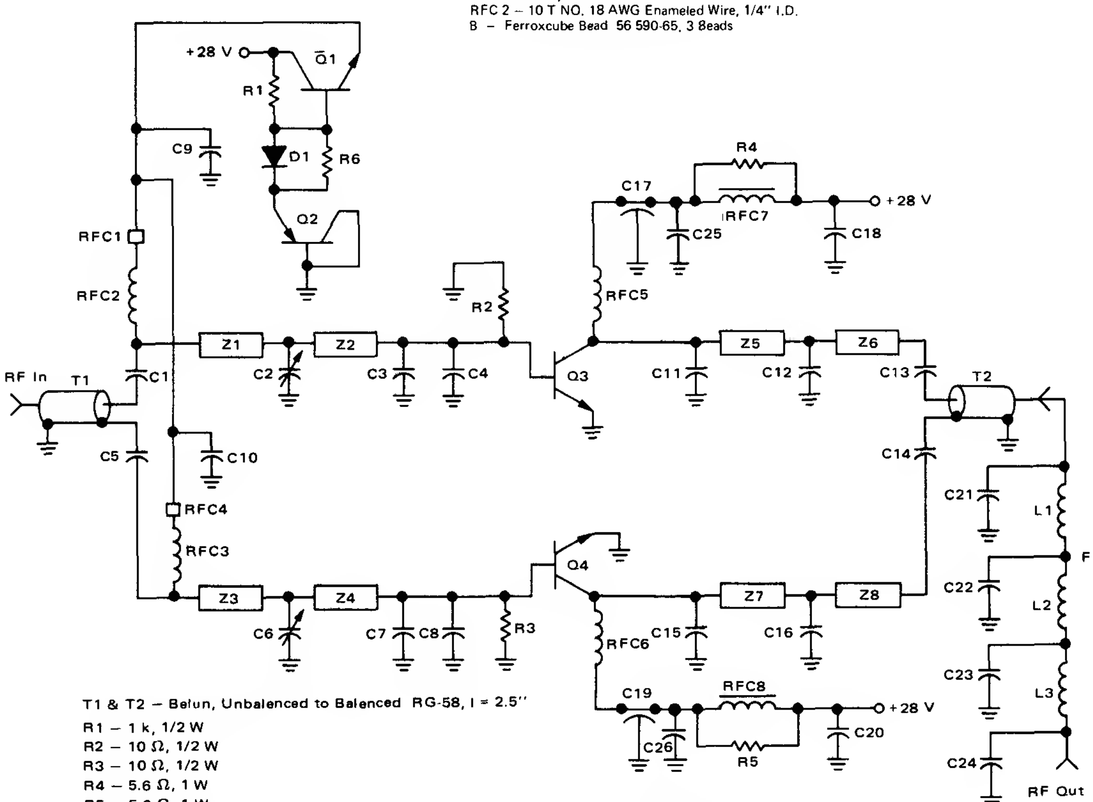


143–156 MHz 80-W AMPLIFIER—Single transistor mounted on haevy heetsink provides about 9.4-dB gain. 8-W driva at 13.5 VDC produces full output power. Series tuning inductors ere printed striplines with ground plane removed benaath them; report givas designs for photomasks. Transistor will withstand 20:1 VSWR at all phase engles.—T. Bishop, "A Single-Device, 80-Watt, 50-Ohm VHF Amplifiar," Motorola, Phoenix, AZ, 1978, EB-46.

C1, 11 – 500 pF Dipped mica
C2, 9 – 10 pF UNELCO
C3 – 60 pF UNELCO
C4, 5 – 250 pF UNELCO
C6, 7 – 250 pF UNELCO
C8 – 80 pF UNELCO
C10 – 40 pF UNELCO
C12 – 0.1 μF Erie Redcap
C13 – 1 μF Tantalum
C14 – 680 pF Allen Bradley Feed Thru

RFC 1 – 0.15 μH Molded choke
RFC 2 – 10 T NO. 18 AWG Enameled Wire, 1/4" I.D.
B – Ferroxcube Bead 56 590-65, 3 Beads

L1 – 1.2 X 0.3 cm Airline Inductor
L2 – 3.5 X 0.3 cm Airline Inductor
L3 – 4.0 X 0.3 cm Airline Inductor
L4, L5 – 0.3 X 0.3 cm Airline Inductor
L6 – 2.7 X 0.3 cm Airline Inductor
L7 – 0.8 X 0.3 cm Airline Inductor
L8 – 3.0 X 0.3 cm Airline Inductor
Board: G10, $\epsilon_r \approx 5$, t = 0.16 cm, 57 gm, Copper-Clad
connectors = BNC

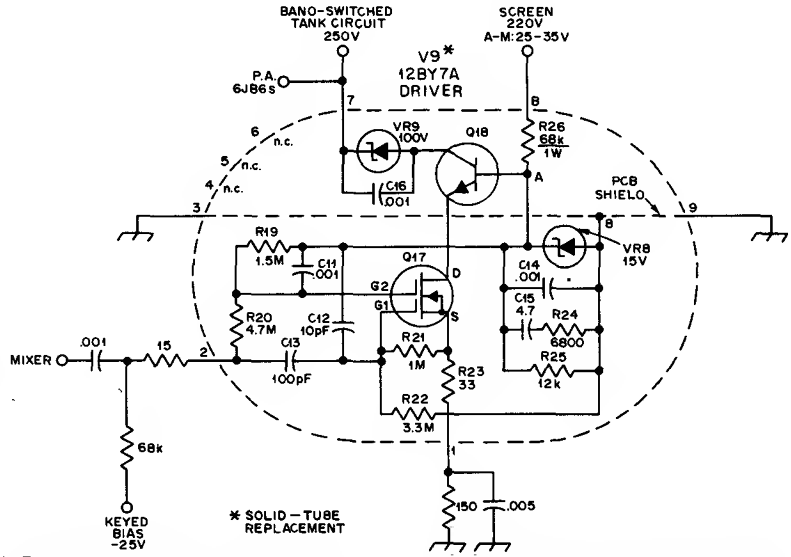


T1 & T2 – Balun, Unbalanced to Balanced RG-58, l = 2.5"
R1 – 1 k, 1/2 W
R2 – 10 Ω, 1/2 W
R3 – 10 Ω, 1/2 W
R4 – 5.6 Ω, 1 W
R5 – 5.6 Ω, 1 W
R6 – 2.7 Ω, 1/4 W
Z1 & Z3 – Microstrip – W = 200 mils, l = 1.8"
Z2 & Z4 – Microstrip – W = 200 mils, l = 300 mils
Z5 & Z6 – Microstrip – W = 150 mils, l = 300 mils
Z6 & Z8 – Microstrip – W = 150 mils, l = 1.4"
RFC1, 4 – Ferroxcube Bead 56-690-65-3B
RFC2,3 – 0.15 μH Cambion Molded Coil
RFC5, 6 – 1 Turn #20 Enameled Wire Wound on 5/16" Bolt
RFC7, 8 – VK200 20/4B
C1,3,4,5,7,8,11,15 – Underwood 40 pF
C12, 16 – Underwood 25 pF
C13, 14, 22, 23 – Underwood 15 pF
C9, 10, 18, 20 – 1 μF Tantalum

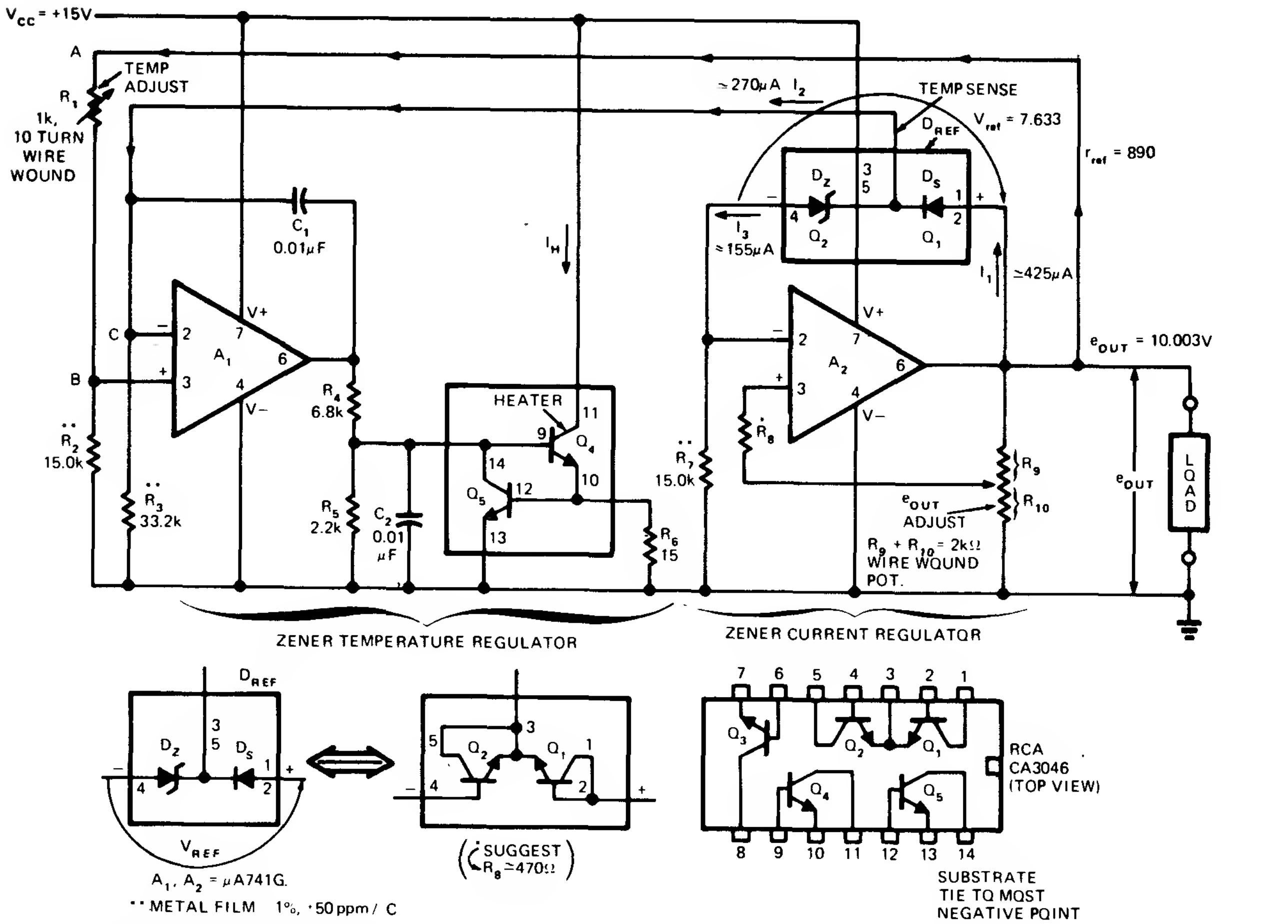
C21, 24 – Underwood 10 pF
C2,6 – Arco 403
C17,19 – Underwood J102, 1000 pF Feed Thru
C25, 26 – 0.1 μF, Erie Red Cap
L1 – 24 nH, #14 Wire, l = 1.2"
L2 – 12 nH, #14 Wire, l = 0.6"
L3 – 24 nH, #14 Wire, l = 1.2"
Board – G10, $\epsilon R \approx 5$, t = 0.062", l = 8.0", W = 4.0"
Q1 – 2N5192
Q2 – 2N5194
Q3 – MRF309
Q4 – MRF309
D1 – 1N4001

420–450 MHz 100-W LINEAR—Two Motorole MRF309 transistors in push-pull require only 16-W drive to daliver 100 W for transmitter applications. Circuit provides 8 dB of powar gain at efficiancy greeter than 40% when operating from 28-V supply. Harmonic suppression inherent in push-pull operetion is anhancad by seven-element low-pass filter at output. Q1 and Q2 ere bias resistors and must be insulated from heetsink with mica washers. T1 end T2 ere transformers constructed from RG58 coax. Use 3-inch lengths end prapare ¼ inch at each end to give total transformer length of 2½ inches.—H. Swenson and B. Tekniepe, "A 100-Wett PEP 420-450 MHz Push-Pull Lineer Amplifier," Motorola, Phoenix, AZ, 1978, EB-67.

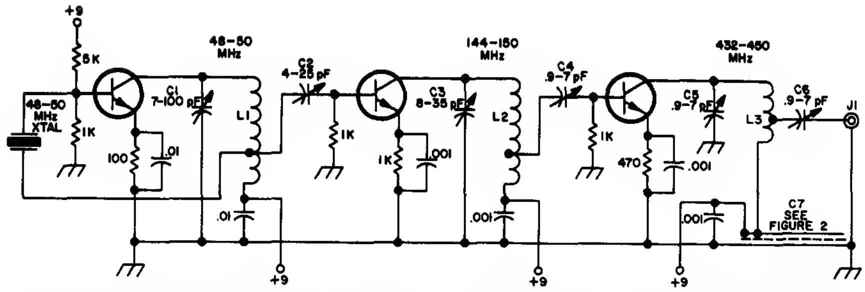
TRANSISTORS FOR DRIVER TUBES—Solid-state replecemant for 12BY7A power emplifier runs much cooler than tuba. Shiald is required between input and output circuits. Gete 2 is biesed very high and geta 1 is close to source voltaga, to parmit maximum signal ranga without chenging perametars. Bypessed zanar VR9 prevents 100-V collector signel swing from exceeding trensistor breekdown voltage. Solid-stata replacamants for othar tube types in Draka T-4XB transmittar are also given in erticla.—H. J. Sartori, Solid-Tubes—a New Life for Old Daslgns, *QST*, Aprll 1977, p 45–50.



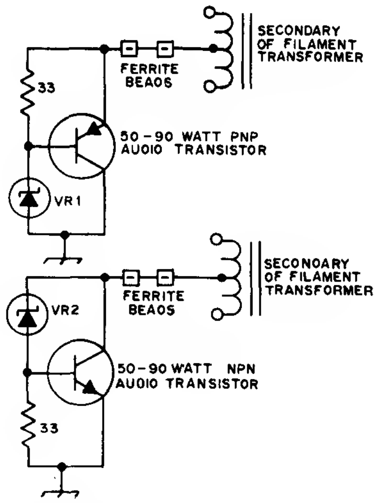
Q17 – N-channel dual-gate MOSFET, 25 $V_{(BR)}$ 3N206.
Q18 – Npn transistor, 300 $V_{(BR)}$, TIS131.
VR8 – Zener diode, 15 V, 400 mW, 1N965.
VR9 – Zener diode, 100 V, 5 W, 1N5378.



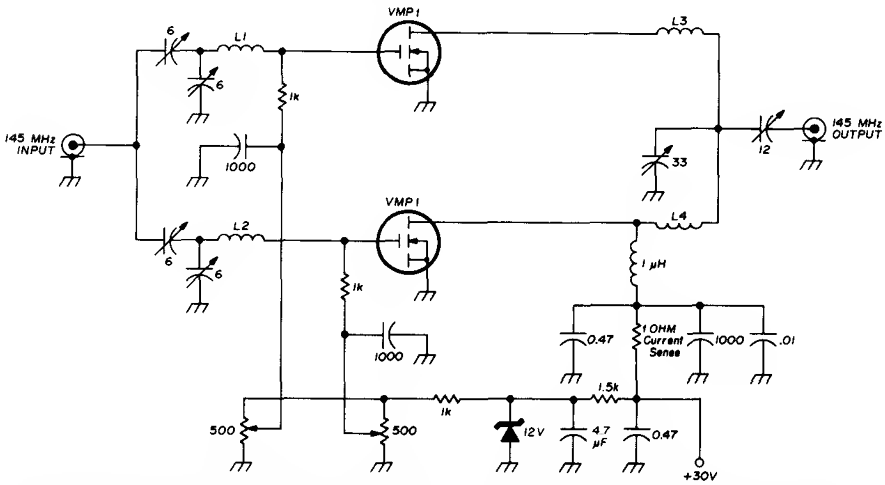
10-V TEMPERATURE-STABILIZED—Self-regulation of substrete temperatura of CA3046 five-trensistor chip allows 10-V referenca output voltage to rise only 0.5 mV when tamperature incraases from 27 to 62°C. Circuit requires only single 15-V supply. Zanar-connected translstor Q_2 and diode-connected trenslstor Q_1 togethar provida tamperature compensation by sensing voltage ecross Q_1 (D_S) end comparing it with temparature-referance voltaga produced across R_1 by μA741G opamp A_1. Opemp drlves Q_5 to control currant through Q_4 which serves as chip haatar. Opamp A_2 (μA741G) and essocieted components (including Q_1-Q_2 in feedback path) act as self-regulating (zanar-current) voltege refarence.—M. J. Shah, A Salf-Regulating Temparature-Stabilized Reference, *EDN Magazine*, Mey 20, 1974, p 74 and 76.



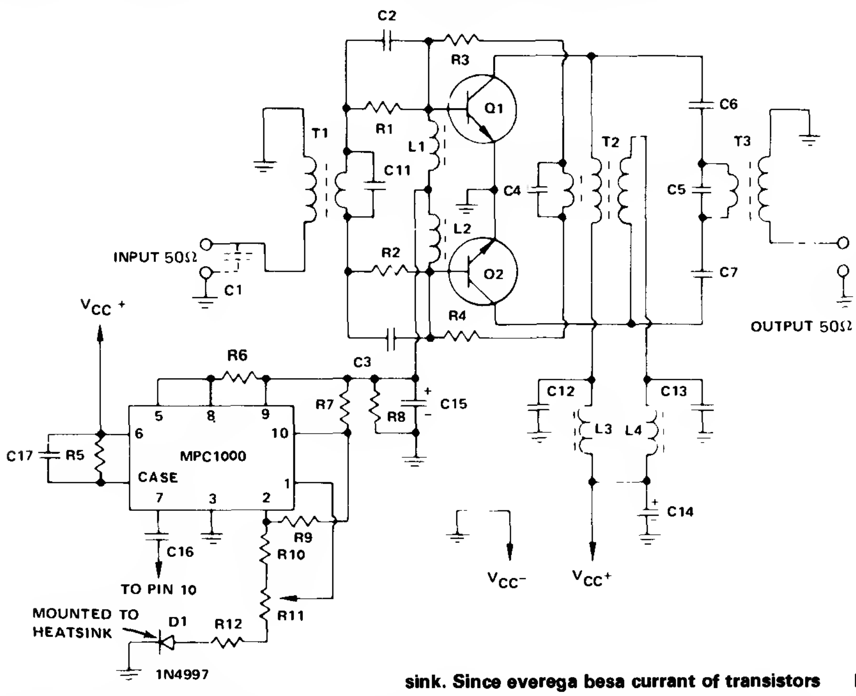
432–450 MHz—Crystal oscillator stage operating at 48–50 MHz puts out enough power to drive pair of triplers. All transistors are HEP-75. L1 is 20 turns No. 24 on 5-mm form, tapped 8 turns from cold end. L2 is 5 turns No. 20 air-wound to 8-mm diameter. L3 is 3 turns No. 20 air-wound to 5-mm diameter, with center tap. Article covers construction, adjustment, and uses.—B. Hoisington, Getting Started on 450 MHz, *73 Magazine*, Nov. 1973, p 21–24.



AMPLIFIED ZENER—Combination of 1-W zener and 50–90 W audio transistor replaces 50-W zener in developing bias for high-power tube-type linear amplifier. Voltage rating of zener should be about 0.3 V less than desired bias voltage if using germanium transistor and about 0.7 V less for silicon transistor. Connections are shown for PNP and NPN transistors. Use chassis as heatsink for transistor, with mica insulating washer for NPN. Ferrite beads discourage parasitic oscillations.—An Alternative to High-Wattage Zener Diodes, *QST*, June 1975, p 45.

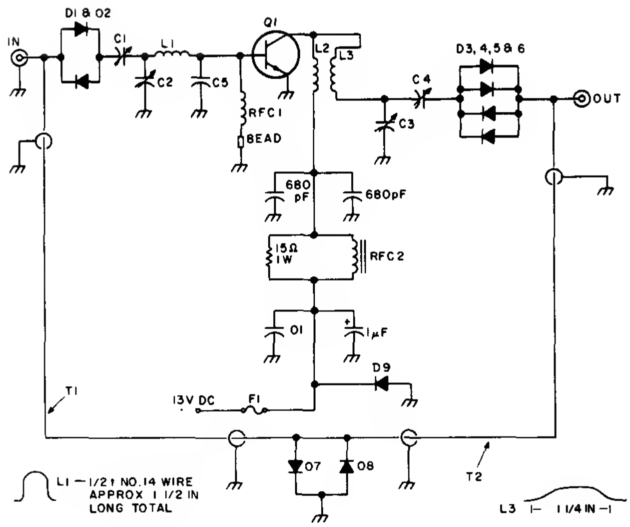


10 W ON 2 METERS—Linear power amplifier for 2-meter transverter delivers 10 W PEP using two Siliconix VMP1 Mospower FETs. L1 and L2 are 8 turns, and L3 and L4 are 5 turns, all close-wound with No. 20 enamel on 3-mm form. Transistor requires heatsink, insulated from chassis with 0.062-in beryllium oxide insulators. Efficiency is about 40%.—L. Leighton, Two-Meter Transverter Using Power FETs, *Ham Radio*, Sept. 1976, p 10–15.

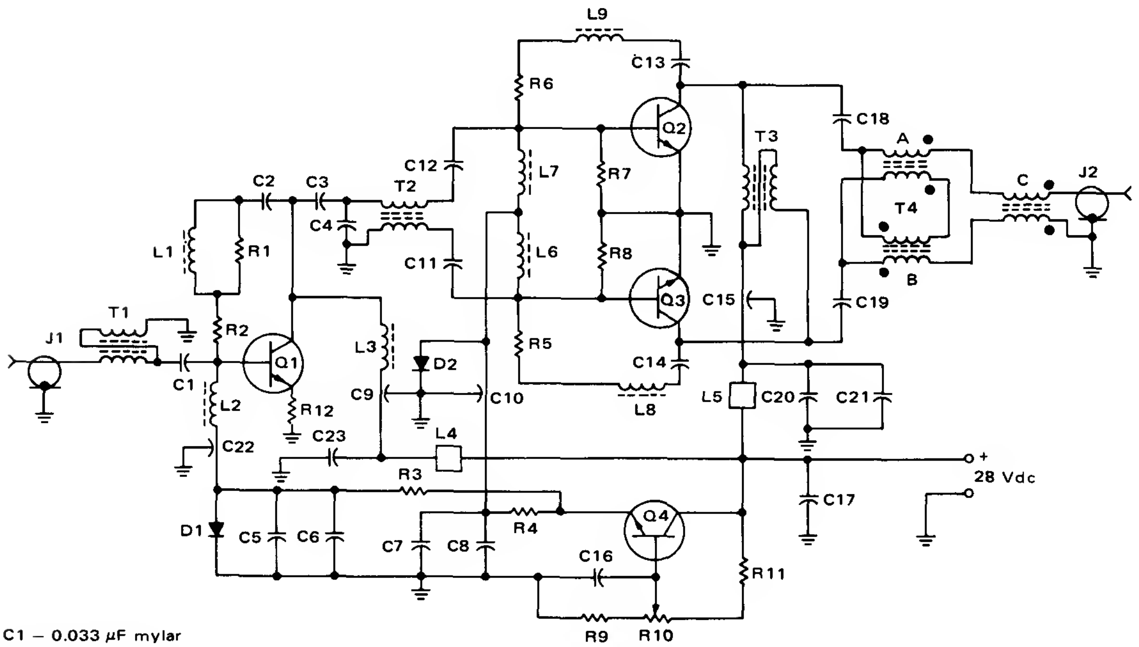


C1 - 100 pF
C2, C3 - 5600 pF
C4, C5 - 680 pF
C6, C7 - .10 µF
C11 - 470 pF
C12, C13 - .33 µF
C14 - 10 µF - 50 V electrolytic
C15 - 500 µF - 3 V electrolytic
C16 - 1000 pF
C17 - .1 µF
R1, R2 - 2 X 3.3Ω, 1/2-W in parallel
R3, R4 - 2 X 3.9Ω, 1/2-W in parallel
R5 - 47Ω, 5 W
R6 - 1.0Ω, 1/2 W
R7 - 1.0 k, 1/4 W
R8 - 100Ω, 1/4 W
R9 - 18 k, 1/4 W
R10 - 8.2 k, 1/4 W
R11 - 1.0 k Trimpot
R12 - 180Ω, 1/4 W
L1, L2 - Ferroxcube VK200 20/4B
L3, L4 – 6 ferrite beads each, Ferroxcube 56590 65/3B

2–30 MHz 300-W LINEAR—Motorola MRF422 high-power transistors connected in push-pull provide 300 W of PEP or CW output power across band. Uses MPC1000 regulator rated for 10 A and dissipation of 100 W with proper heatsink. Since average base current of transistors is less than 500 mA, however, regulator can be used without heatsink. T1 and T3 have 9:1 impedance ratio, obtained with ⅛-inch copper-braid secondary through which 3 turns of No. 22 are wound for primary on Stackpole dual balun ferrite core 57-1845-24B. T2 has 5 turns of two twisted pairs No. 22 enamel wound on Stackpole 57-9322 toroid.—H. Granberg, "Get 300 Watts PEP Linear Across 2 to 30 MHz from This Push-Pull Amplifier," Motorola, Phoenix, AZ, 1978, EB-27.



2-METER POWER AMPLIFIER—Provides 10-dB gain with full 30-W output at 160 MHz and about 0.5-dB more gain at 150 MHz, using Motorola MRF238 transistor. C1-C4 are Arco 463, 464, or 424. RFC1 is 10 turns No. 20 on 270-ohm ½-W resistor. C5 is three 90-pF silver mica in parallel. RFC2 is 6 to 8 turns No. 18 on toroid. L1 is ½ turn No. 14 1½ inch long. L2 is 4 turns No. 14 spaced on ¼ inch diameter. L3 is 1¼-inch curve of No. 14. D1-D8 are 1N4148. T1 and T2 are one quarter-wavelength of RG-174 or similar 50-ohm coax. D9 is 2-A silicon rectifier.—D. J. Lynch, Build a 2m Power Amp, *73 Magazine*, Nov. 1977, p 96–97.



C1 — 0.033 μF mylar
C2, C3 — 0.01 μF mylar
C4 — 620 pF dipped mica
C5, C7, C16 — 0.1 μF ceramic
C6 — 100 μF/15 V electrolytic
C8 — 500 μF/6 V electrolytic
C9, C10, C15, C22 — 1000 pF feed through
C11, C12 — 0.01 μF
C13, C14 — 0.015 μF mylar
C17 — 10 μF/35 V electrolytic
C18, C19, C21 — Two 0.068 μF mylars in parellel
C20 — 0.1 μF disc ceramic
C23 — 0.1 μF disc ceramic
R1 — 220 Ω, 1/4 W carbon
R2 — 47 Ω, 1/2 W carbon
R3 — 820 Ω, 1 W wire W
R4 — 35 Ω, 5 W wire W
R5, R6 — Two 150 Ω, 1/2 W carbon in parellel
R7, R8 — 10 Ω, 1/2 W carbon
R9, R11 — 1 k, 1/2 W carbon
R10 — 1 k, 1/2 W potentiometer
R12 — 0.85 Ω (6 5.1 Ω or 4 3.3 Ω 1/4 W resistors in parallel, divided equally between both emitter leads)

T1 — 4:1 Transformer, 6 turns, 2 twisted pairs of #26 AWG enameled wire (8 twists per inch)

T2 — 1:1 Balun, 6 turns, 2 twisted pairs of #24 AWG enemeled wire (6 twists per inch)

T3 — Collector choke, 4 turns, 2 twisted pairs of #22 AWG enemeled wire (6 twists per inch)

T4 — 1:4 Transformer Balun, A&B — 5 turns, 2 twisted pairs of #24, C — 8 turns, 1 twisted pair of #24 AWG enameled wire (All windings 6 twists per inch). (T4 — Indiana General F624-19Q1, — All others are Indiana General F627-8Q1 ferrite toroids or equivalent.)

PARTS LIST

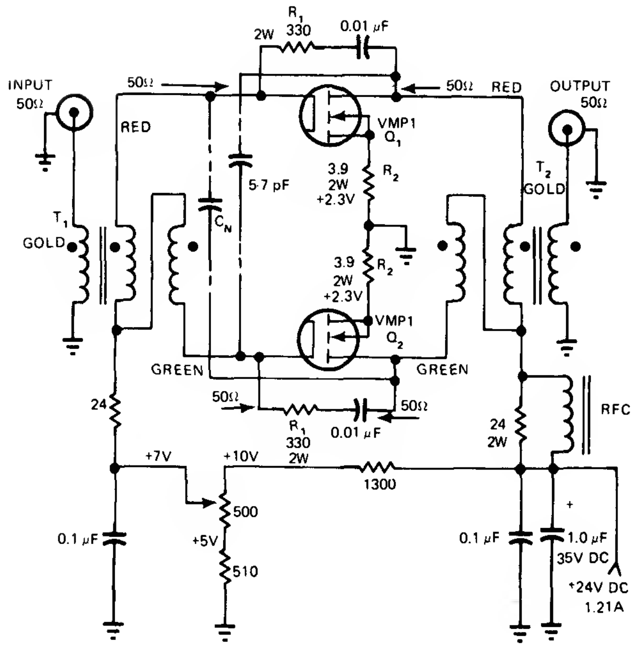
L1 — .33 μH, molded choke
L2, L6, L7 — 10 μH, molded choke
L3 — 1.8 μH (Ohmite 2-144)
L4, L5 — 3 ferrite beads each
L8, L9 — .22 μH, molded choke

Q1 — 2N6370
Q2, Q3 — 2N5942
Q4 — 2N5190

D1 — 1N4001
D2 — 1N4997

J1, J2 — BNC connectors

160-W LINEAR SSB—Designed for operation at fixed land location, using 28-VDC supply. Circuit covers 3–30 MHz band, using driver stage to provide total power gain of about 30 dB. If heat-sinks are used, cooling fans are not normally required because average power for speech operation is about 15 dB below peak levels.—H. Granberg, "Broadband Linear Power Amplifiers Using Push-Pull Transistors," Motorola, Phoenix, AZ, 1974, AN-593, p 3.

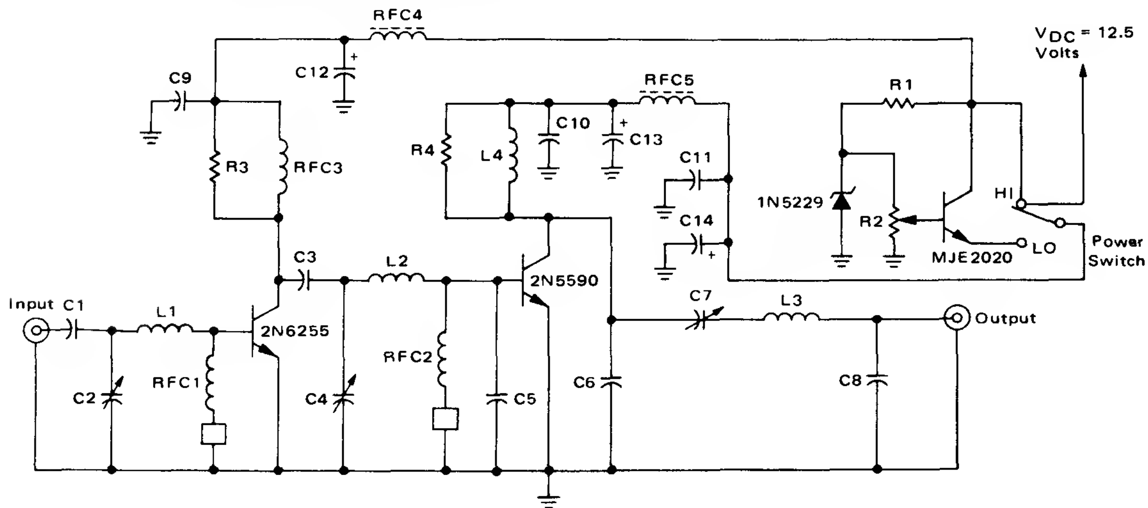


VMOS 8-W BROADBAND—Linear power amplifier provides 15-dB gain over entire range of 2 to 100 MHz. Negative faedback stabilizes gain and gives 50-ohm resistive input and output impedances. VSWR is 2:1 or less over frequency range. Can ba used as low-power amplifiar or driver for amateur radio transmitters, for boosting power level of standard signal generators, and as CB amplifier (with reduced supply voltage). Q_1 and Q_2 (Siliconix VMP1) combina with feedback resistors R_1 and R_2 to form separate broadband amplifiars, each delivering up to 5 W with 15-dB gain.—G. D. Fray, VMOS Power Amplifiers—This Broadband Circuit Outputs 8W with a 15 dB Gain, *EDN Magazine,* Sapt. 5, 1977, p 83–85.

NOTES: T_1 FERROXCUBE 0.375IN O.O 3E2A FERRITE TOROID. WINO SEVEN TURNS TRIFILAR =30, UNWIND ONE TURN FROM EACH ENO OF RED ANO GREEN WINOINGS, CROSS CONNECT "FINISH" RED TO "START" GREEN WIRE FOR CENTER TAP, USE CENTER "GOLD" WINDING FOR 50Ω UNBALANCEO PORT.

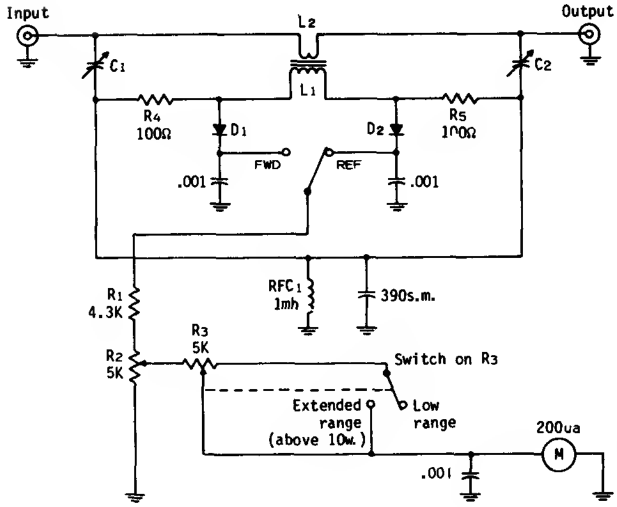
T_2 STACKPOLE 57-9130 SLEEVE BALUN CORE CERAMAG GRADE 11 SIMILAR CONSTRUCTION TO T_1 (COUNT TURNS AS ONE PASS THROUGH BOTH HOLES - ONE TURN)

RFC STACKPOLE 57 9130 5T =30 WIRE (L ≈ 7.0 μH)

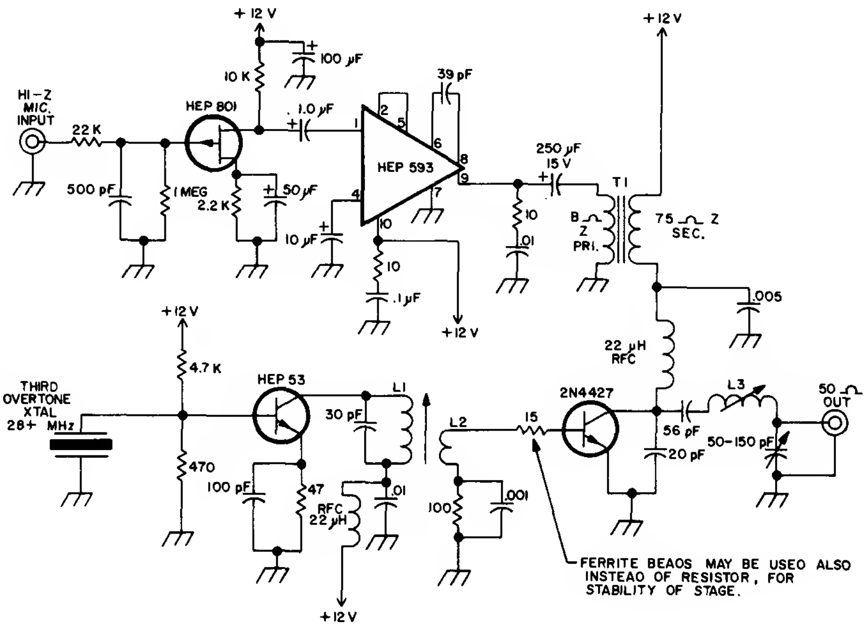


C1, C3	– 10 pF (Dipped Silvered Mica)	L1, L2	– 1-1/2 T, #16 AWG Wire, 0.25" I.D. (30 nH)
C5, C6	– 56 pF (Dipped Silvered Mica)	L3	– 1-1/2 T, #16 AWG Wire, 0.30" I.D. (35 nH)
C8	– 36 pF (Dipped Silvered Mica)	L4	– 3 T, #16 AWG Wire, Wound on 100 Ohm Resistor (45 nH)
C15	– 22 pF (Dipped Silvered Mica)	L5	– #16 AWG Wire, 0.8" Long, "U" Shaped (12 nH)
C19	– 33 pF (Dipped Silvered Mica)	L7	– #16 AWG Wire, 1.1" Long, Formed Around 0.6" Dia. Cyl. (15 nH)
C9, C10	– 0.001 μF Ceramic Disc		
C11	– 0.01 μF Ceramic Disc	RFC1, 2	– 0.15 μH Molded Choke with Ferroxcube 5659065/38 Ferrite Bead on Ground Lead
C12, C13	– 1.0 μF, 35 V, Tantalum		
C14	– 10 μF, 25 V, Aluminum Electrolytic	RFC3	– 7 T, #20 AWG Wire, Wound on R3 (100 nH)
C2, C4, C7	– 8-60 pF Compression Mica Trimmer ARCO #404 or Equivalent	RFC4, 5	– Ferroxcube VK200 19/4B Ferrite Choke
		R1	– 91 Ohm, 2 W, ±5% Carbon Resistor
		R2	– 100 Ohm, 0.25 W, Potentiometer, CTS Type R1018 or Equivalent
		R3	– 560 Ohm, 1 W, ±10% Carbon Resistor
		R4	– 100 Ohm, 1 W, ±10% Carbon Resistor

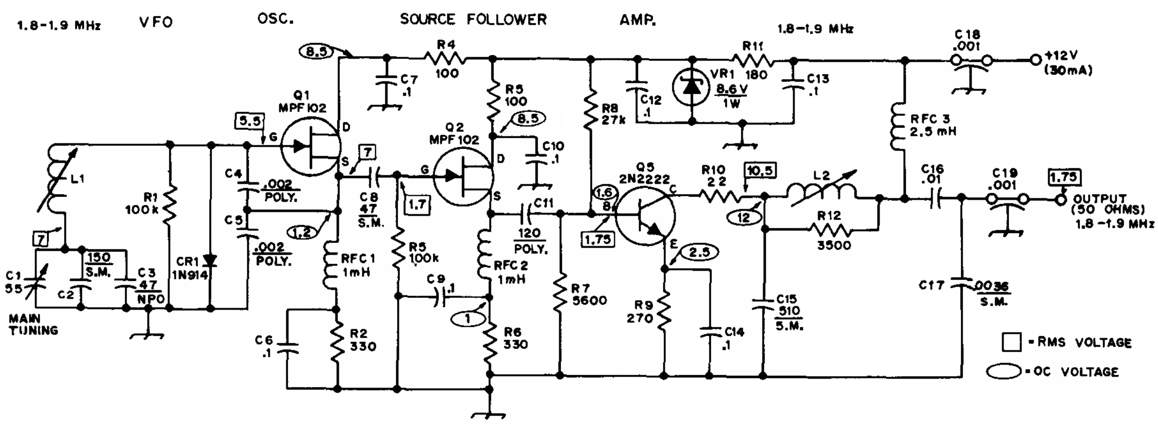
10-W MARINE-BAND—Power amplifier operating in class C from 12.5-VDC supply is designed for 152–162 MHz VHF marine band. Switch permits reducing powar output to 1 W or less. Tuning range of 144–175 MHz makes amplifier suitable for other applications such as amateur 2-meter and land-mobile radio. Power input is 180 mW, power gain is 17.4 dB, and efficiency is 44.5%.—J. Hatchett, "25-Watt and 10-Watt Marine Band Transmitters," Motorola, Phoenix, AZ, 1978, AN-595, p 4.



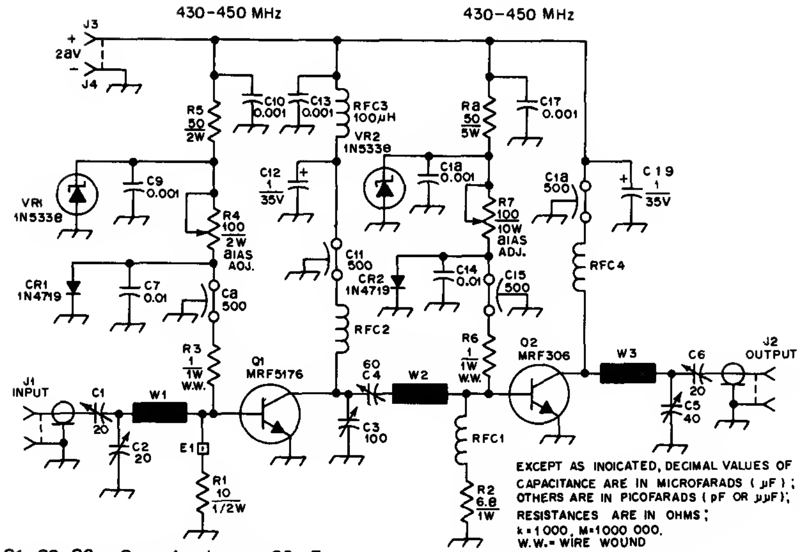
RF WATTMETER—Calibration is accurete on ell HF bends because circuit is not frequency-sensitive. Sensitivity depends on meter movement, number of turns in primery coil, and resistive voltage divider. With velues shown, pots can ba adjusted for full-scale values from 1–14 W. C_1 end C_2 ere 3–20 pF. Diodes ere 1N34A, 1N60, or equivelent. L_1 is 46 tums No. 28 on Amidon T-50-2 toroid, with 2 turns No. 22 between ends of L_1 for L_2. To edjust, connect resistive dummy loed to one coex receptacle and RF power source to other, with R_2 at meximum resistance. Pleca upper switch in position providing highest meter reeding, end meke that the FWD position. Switch to other position, which becomes REF, end adjust C_1 for null reeding. Reverse RF source and loed, leaving switch et FWD, end edjust C_2 for null. Wettmeter can now be calibrated.—A. Weiss, QRP Low-Low Power Opereting, *CQ*, Jan. 1974, p 42–44 and 80.



20-MHz PHONE—Colpitts oscillator using HEP 53 provides excellent stebility with third-overtone crystal. Power amplifier staga uses 2N4427 in class C common-emitter stage moduleted through collector circuit, to develop about 1.25-W output at 28 MHz. HEP 801 FET microphona emplifier provides high-impedence input for crystal microphone end drives HEP 593 IC to give about 1-W AF output. Article covers construction end tune-up.—B. Johnston, Littla Bill, *73 Magazine*, July 1974, p 63–64 end 66–67.

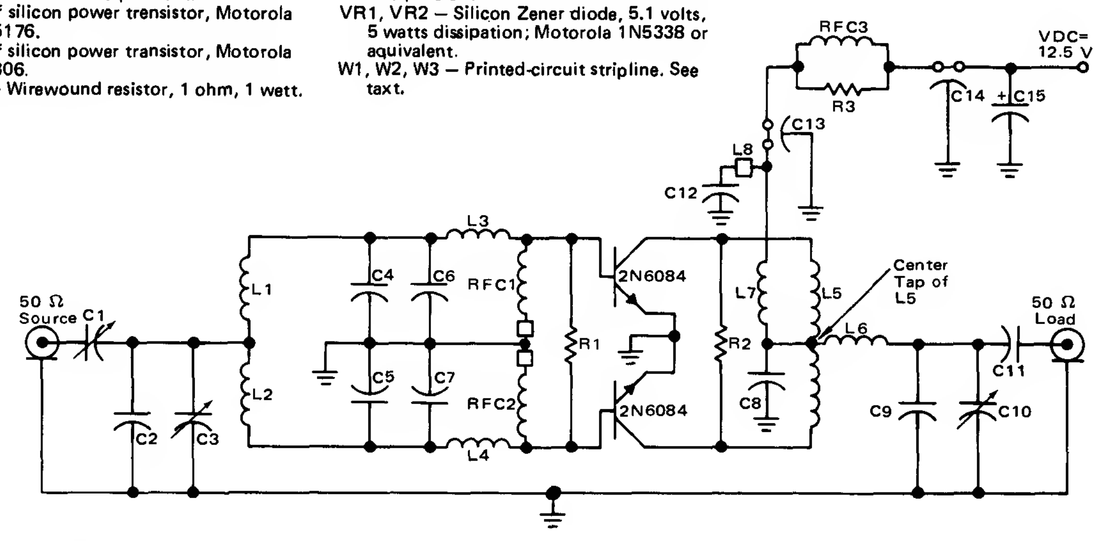


1.8–1.9 MHz VFO—Series-tuned Clapp oscillator using high-impedence JFET Q1 hes good frequency stability. Diode stabilizes bias. Air verieble C1 provides frequency spread of exectly 100 kHz. L1 is 25–58 μH slug-tuned (Miller 43A475CBI). L2 is 10–18.7 μH slug-tuned (Miller 23A155RPC).—D. DeMew, More Besics on Solid-State Transmitter Design, *QST*, Nov. 1974, p 22–26 end 34.



C1, C2, C6 — Ceramic trimmer, 20 pF, Elmenco 402 or equivalent.
C3 — Ceramic trimmer, 100 pF; Elmenco 423 or equivalent.
C4 — Ceramic trimmer, 60 pF; Elmenco 404 or equivalent.
C5 — Ceramic trimmar, 40 pF; Elmenco 422 o or equivalent.
CR1, CR2 — Germanium rectifier, 50 PIV, 1 A; Motorola 1N4719 or equivalent.
E1 — Ferrite bead placed over the lead of R1; Amidon FT-73 or equivalent.
Q1 — Uhf silicon power trensistor, Motorola MRF5176.
Q2 — Uhf silicon power transistor, Motorola MRF306.
R3, R6 — Wirewound resistor, 1 ohm, 1 wett.
R4 — Wirewound or carbon potantiometer, 100 ohms, 2 watts, lineer taper.
R7 — Wirewound potentiometer, 100 ohms, 10 watts.
RFC1 — 4 turns no. 20 anameled wire, close-wound, 1/8-inch diameter.
RFC2, RFC4 — 6 turns no. 20 enameled wire, 1/8-inch diametar.
RFC3 — 100-μH ferrite-core choke, 500 mA. Two J. W. Miller 73F224AF in perallel or equivelent.
VR1, VR2 — Silicon Zener diode, 5.1 volts, 5 watts dissipation; Motorola 1N5338 or aquivalent.
W1, W2, W3 — Printed-circuit stripline. See taxt.

60-W LINEAR FOR 432 MHz—Suitabla for making DX contacts through Oscar satellita, as well as for tropo and local contacts, uaing CW or SSB. Motorola MRF5176 transistor provides drive to MRF306 output stage, glving sufficiant output over ranga of 430–450 MHz. Requires 1–3 W RF input. Microstrip conductors W1-W3, each 0.077 wavalength long, provide widaband matching end high efficiency. Article gives dimensioned layout for printed-circuit boerd and ell construction details.—J. Buscemi, A 60-Watt Solid-Stata UHF Linaar Amplifiar, *QST,* July 1977, p 42–45.

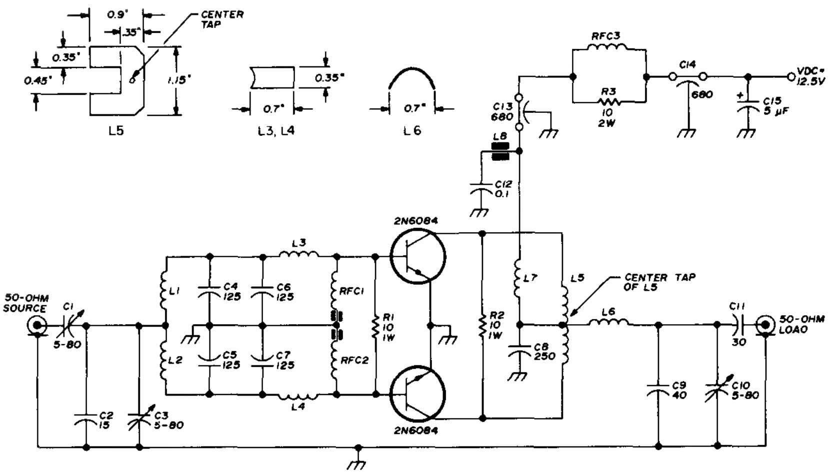


—Amplifier Constructed on 0.062" Single Sided, G10 Circuit Boerd—

L1,L2-2½T, #16 AWG Wire, 0.2" I.D. (60 nH)
L3,L4- Cut From 0.031" Single Sided G10 Circuit Board (5 nH) 0.35" 0.7"
L8- Ferrite Bead, Ferroxcube 5659065/38
L7- 3T, #14 AWG Wire, 0.25" I.D. (50 nH)
L5- Cut From 0.031" Single Sided G10 Circuit Board (8 nH To Center Tap) 0.9" 0.35" 1.15" 0.45" Center Tap

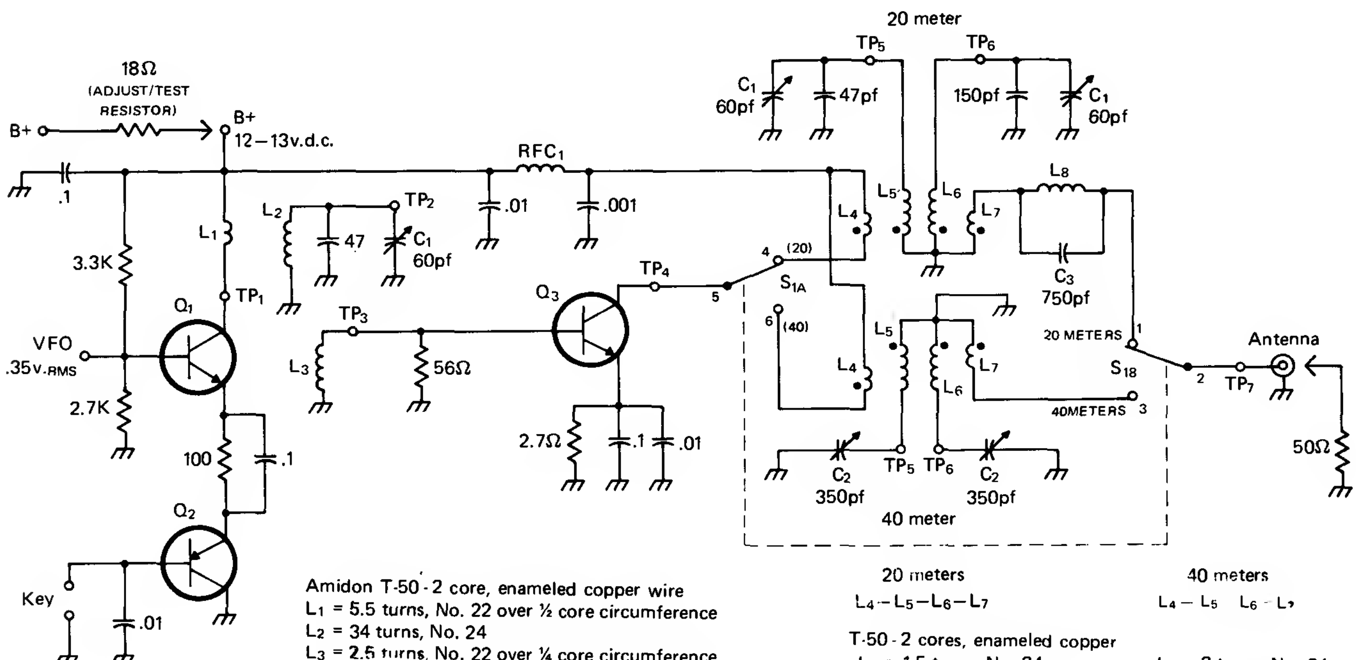
L6- #12 AWG Wire, Approximately 1.1" Long. 0.7" (10 nH)
RFC1,2 0.15 μH Molded Choke with Ferroxcube 5659065/3B Ferrite Bead on Ground Lead
RFC3- 10 T, #14 AWG Wire Wound on R3
R1, R2- 10 Ohm, 1 W, Carbon Resistor
R3- 10 Ohm, 2 W, Carbon Resistor
C1,C3,C10- #462 ARCO Trim Ceps (5-80 pF)
C2- 15 pF
C4,C5,C6,C7 - 125 pF
C8- 250 pF
C9- 40 pF
C11- 30 pF
(C2–C11: Underwood Electric Co. Type J-101)
C12- 0.1 μF, 75 V, Ceramic Disc
C13,C14- 680 pF, Allen Bradley Type FA5C
C15- 5.0 μF Tantalum

144–175 MHz 80-W SINGLE-STAGE FM MOBILE—Provides reted output into 50-ohm load. Can withstand open and shorted loads for ell load phase angles without trenaistor demage. Usea Motorola 2N6084 lend-mobile transistors optimized for 12.5-V FM operation. Trensistors are used in parallel with single-endad input and output, isolated from each other by signal-splitting coils.—J. Hatchett, "VHF Powar Amplifiers Using Peralleled Output Tranaistors," Motorole, Phoenix, AZ, 1972, AN-585, p 2.



C1,C3,C10	5-80 pF trimmers (ARCO 462)	L3,L4	cut from 0.031" single-sided G10 circuit board (5 nH)
C2	15 pF metal clad (Underwood Electric type J-101*)	L5	cut from 0.031" single-sided G10 circuit board (8 nH to center tap)
C4,C5,C6,C7	125 pF metal clad (Underwood Electric type J-101)	L6	number-12 wire, approximately 1.1" long (10 nH)
C8	250 pF metal clad (Underwood Electric type J-101)	L7	3 turns number 14, 0.25" ID (50 nH)
C9	40 pF metal clad (Underwood Electric type J-101)	L8	ferrite bead (Ferroxcube 5659065/3B)
C11	30 pF metal clad (Underwood Electric type J-101)	RFC1,RFC2	0.15 µH molded choke with Ferroxcube 5659065/3B ferrite bead on ground lead
C12	0.1 µF, 75 V ceramic disc	RFC3	10 turns number-14 wire wound around R3
C13,C14	680 pF feedthrough (Allen Bradley type FA5C)		
C15	5.0 µF, 25v, aluminum electrolytic		
L1,L2	2½ turns number-16, 0.2" ID (60 nH)		

80 W ON 2 METERS—Single-stage design using two 2N6084 transistors combined with simple LC components can be tuned from 144 to 175 MHz. Typical input is 20 W for 80-W output at 144 MHz. Article shows how to add 2N6083 driver stage that reduces input drive requirement to 2.5 W. Power gain at 144 MHz is 8 dB. Article covers construction and adjustment.—J. Hatchett, A Solid 80 Watts for Two Meters, *Ham Radio*, Dec. 1973, p 6–12.

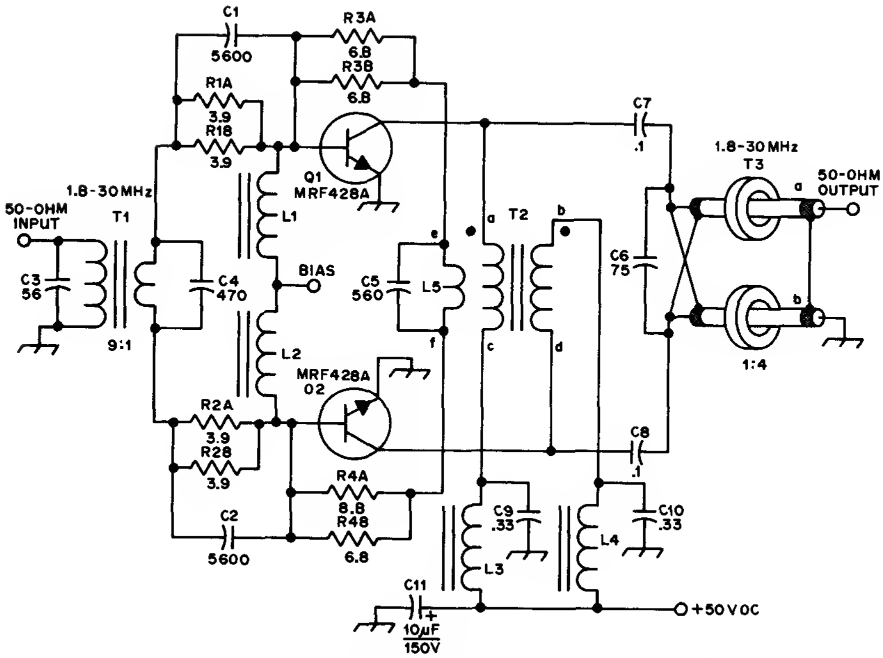


Amidon T-50-2 core, enameled copper wire
L_1 = 5.5 turns, No. 22 over ½ core circumference
L_2 = 34 turns, No. 24
L_3 = 2.5 turns, No. 22 over ¼ core circumference
L_8 = T-50-2 core, 9 turns, No. 22 spaced evenly over circumference of core
RFC_1 = 15 turns, No. 28, Amidon FB-73-B01 jumbo bead

T-50-2 cores, enameled copper

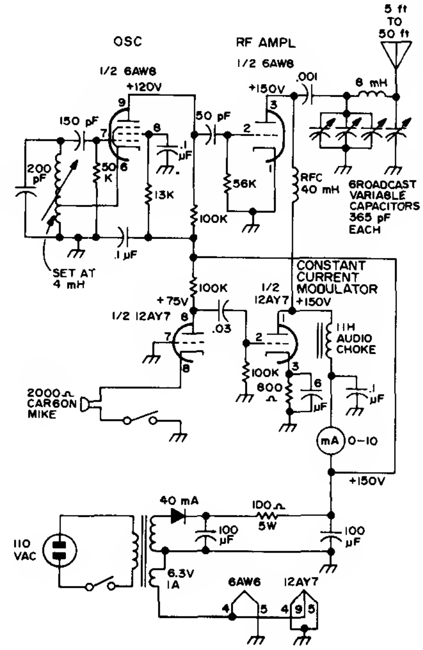
20 meters L_4–L_5–L_6–L_7	40 meters L_4–L_5 L_6–L_7
L_4 = 1.5 turns, No. 24	L_4 = 2 turns, No. 24
L_5 = 10 turns, No. 22	L_5 = 14 turns, No.22
L_6 = 7 turns, No. 22	L_6 = 11 turns, No. 22
L_7 = 2 turns, No. 24	L_7 = 2 turns, No. 24

1-W EXCITER FOR 7 AND 14 MHz—Developed for use in simple solid-state VFO transmitter covering 40 and 20 meters for low-power operation. Adequate drive can be provided by any 7-MHz VFO that develops 0.45 VRMS across 1000-ohm load. Circuit consists of class A buffer/amplifier Q_1 and keying switch Q_2. Q_3 is class C amplifier on 7 MHz (40 m) and frequency doubler on 14 MHz (20 m). Q_1 is MPS6514. Q_2 is 2N3906 or equivalent. Q_3 is MPS-U31. All transformer cores are Amidon T-50-2.—A. Weiss, QRP, *CQ*, Nov. 1977, p 54–58 and 88.

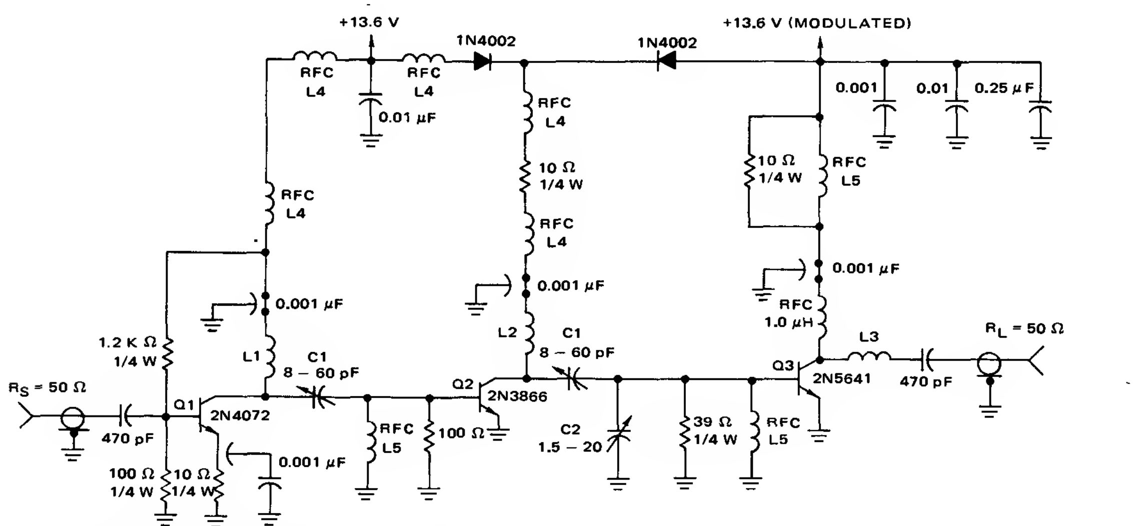


L1, L2 – Rf choke (Ferroxcube VK200-19/4B or equiv.)
L3, L4 – Rf choke (Ferroxcube 56-590-65/3B or equiv.)
T1 – Broadband 9:1 transformer on ferrite core (Stackpole 57-1845-24B or Fair-Rite Prod. 2973000201, or equiv. See text).
T2 – 7 bifilar turns of No. 20 enam wire on Stackpole 57-9322 or Indiana General F627-8Q1 toroid core.
T3 – 14 turns Microdot 260-4118-000 25-ohm submin. coax cable (or equiv.) wound on each of two toroid cores. Cores are Stackpole 57-9074 or Indiana General F624-19Q1, or equiv.

300-W LINEAR SOLID-STATE—Class A circuit using two MRF428A transistors is emittar-ballasted to ensure even current-sharing. Requires separata 0.5–1 V regulated bias voltage source, circuit for which is given in article along with design procedure for amplifier. Second part of article (May 1976, p 28–30) tells how to combine four 300-W amplifiers to get 1-kW output for 1.8–30 MHz.—H. O. Granberg, One KW—Solid-State Style, *QST*, April 1976, p 11–14.

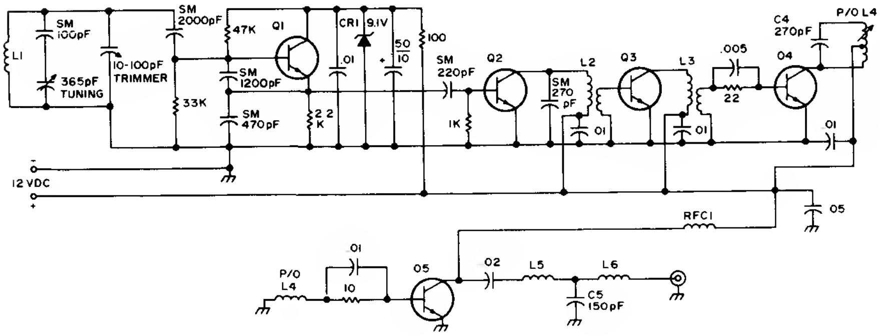


500 mW ON 180 kHz—Maets FCC requirement for amateur radio operation in 160–190 kHz band with 1-W maximum plate input power and antenna up to 50 feet long including lead-in. Working range is about 1 mila. Uses electron-coupled oscillator to minimize frequancy shift during modulation. RF amplifiar Is self-biased. 40-mH choke in amplifier plate circuit is nearly self-resonant to 180 kHz.—C. Landahl, QRP on 180 kHz, *73 Magazine*, May 1973, p 93–95.

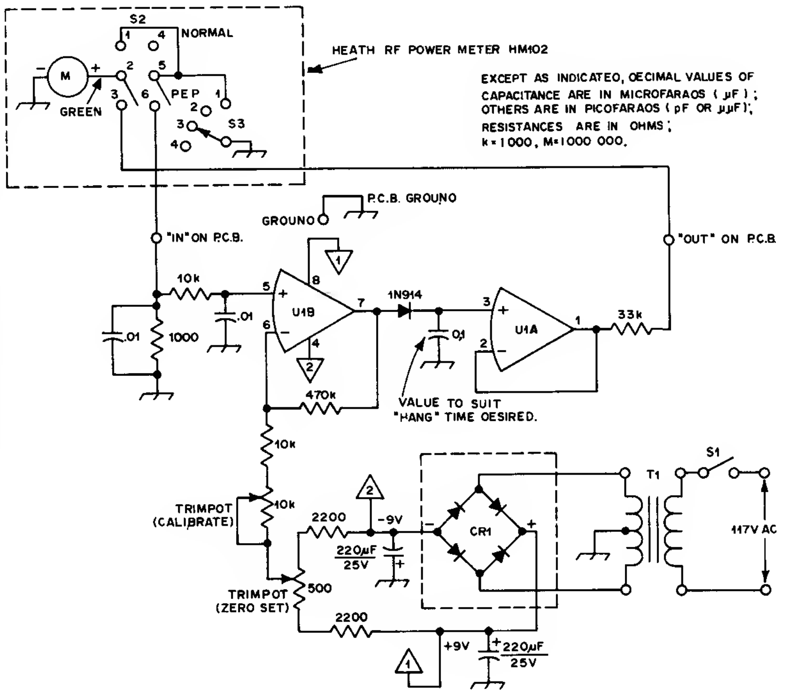


L1 = 6T #26 wire wound on toroid (micrometals T30-13) with 3/32" specing
L2 = 2T #26 wire wound on toroid (see L1) with 1/8" spacing
L3 = 2T #26 wire wound on toroid (see L1) with 5/16" specing
L4 = RF bead (one hole), 1/8"
L5 = Ferrite Choke (Ferroxcube VK-200)
C1 = 8-60 pF (Arco 404)
C2 = 1.5-20 pF (Arco 402)

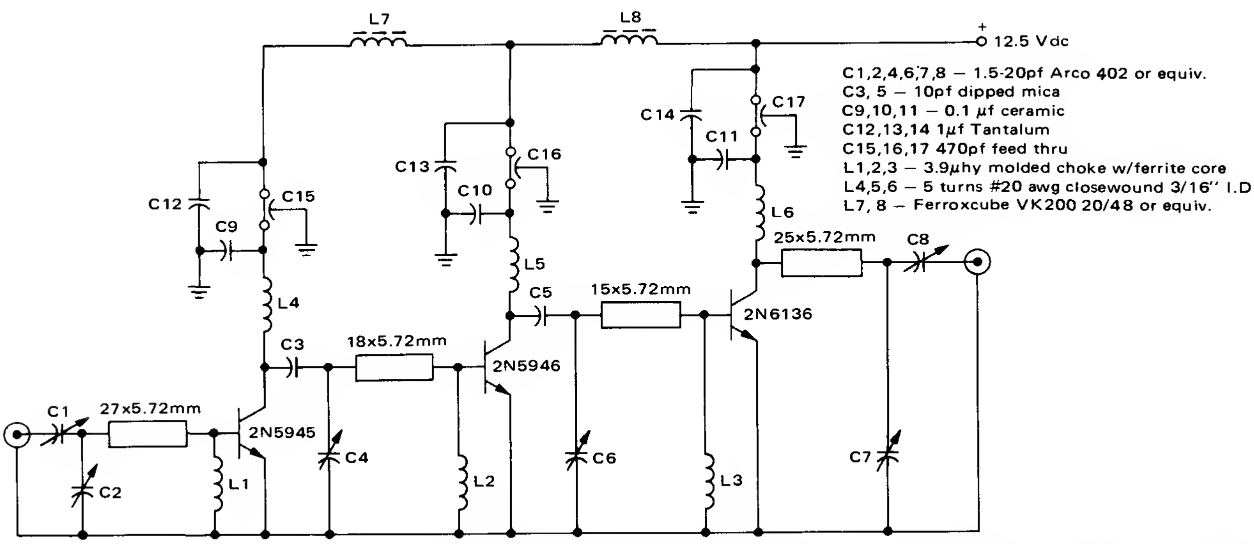
2.5-W AIRCRAFT AM TRANSMITTER—Oparates from 13.6-V supply, covers frequency ranga of 118–136 MHz without tuning, and has 50-ohm input and output terminations. Only thrae transistor stages are required. Diodes limit downward modulation to Q2. Upward modulation is 95%. Supply drain is 345 mA.—"A 13-W Broadband AM Aircraft Transmitter," Motorola, Phoenix, AZ, 1974, AN-507, p 5.



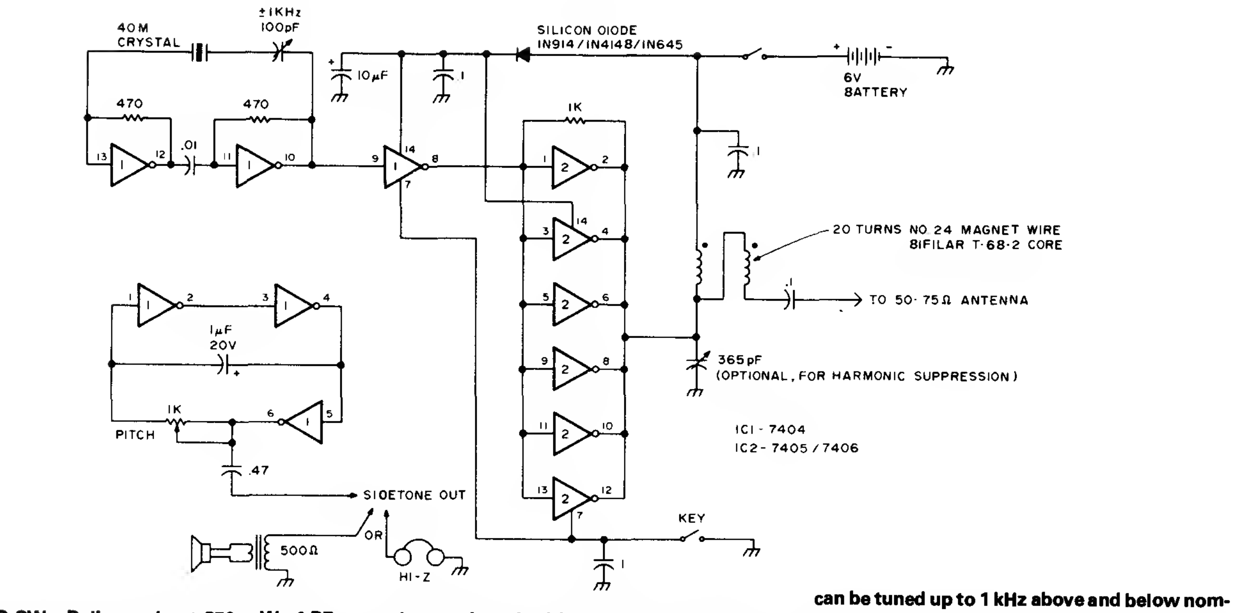
7 W FOR QRP—Operates at 7-W peak power for cutting through interference when operating on low power on any CW band from 80 to 10 meters with typical inefficient antenna systems of portable operation. Q1 is 2N709 VFO feeding 2N697 amplifier Q3 through 2N697 buffer Q2. Q4 is GE63 driver for Motorola HEP53001 final amplifier Q5. Keying can be introduced at Q2, Q3, or Q4. Article gives coil-winding data for all bands and covers construction and operation in detail.—J. Huffman, The Mini-Mite Allband QRP Rig, *73 Magazine*, July 1976, p 30–32 and 34–35.



MEASURING PEAK POWER—Addition of amplifier and rectifier circuits to Heath HM-102 or other similar RF wattmeter permits measurement of transmitter peak power output. DPDT toggle switch S2 is added to wattmeter to give choice of measurement desired. Circuit uses LM1458 or equivalent dual opamp. Current passing through 1N914 diode charges 0.1-μF capacitor at pin 3 of U1A, delaying meter return to zero long enough for reading of peak. When pointer just starts moving downward, next spoken word kicks it back up to peak value. To calibrate, set 10K pot so peak reading (S2 at PEP) is equal to normal reading (S2 at NORMAL) while using CW output of transmitter as test signal. CR1 is 2-A 50-PIV bridge rectifier. T1 has 12.6-V center-tap 100-mA secondary.—G. D. Rice, PEP Wattmeter—a la Heath, *QST*, Dec. 1976, p 30–31.

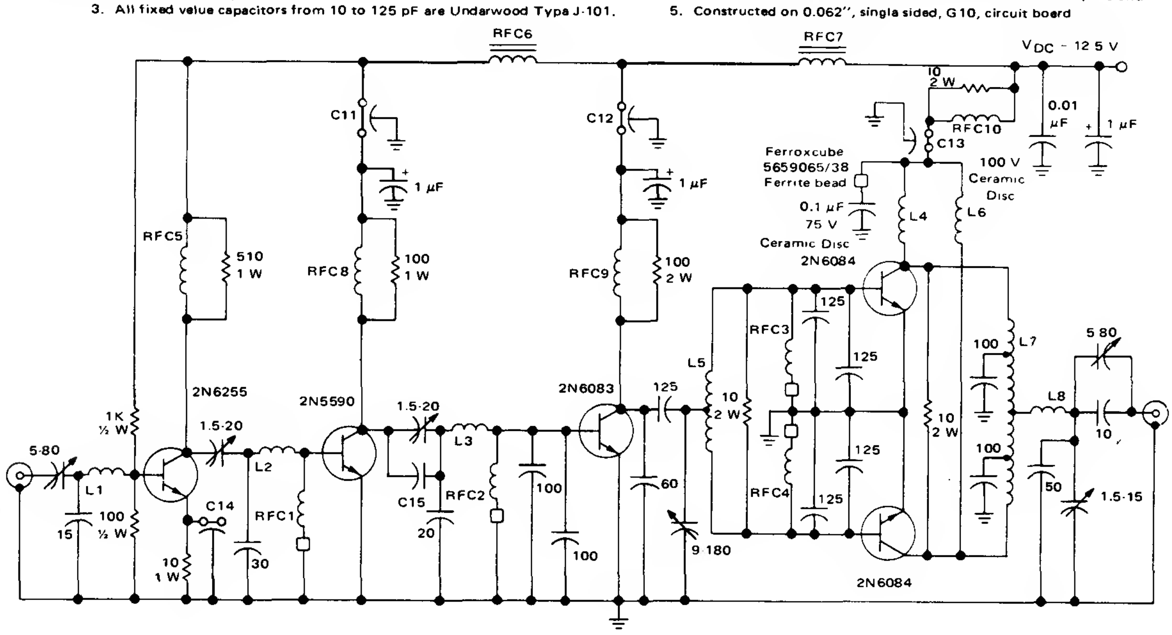


450–470 MHz AT 25 W—Power amplifier for land-mobile 12.5-V transmitter is constructed on double-sided microstrip substrate. Power gain at 470 MHz is 19.5 dB, and overall efficiency is 47%.—G. Young, "UHF Microstrip Amplifiers Utilizing G-10 Epoxy-Glass Laminate," Motorola, Phoenix, AZ, 1976, AN-578, p 4.

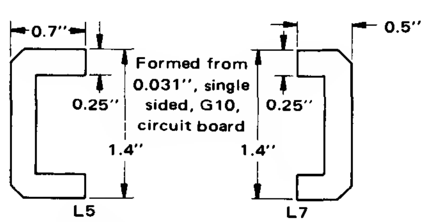


40-METER CW—Delivers about 250 mW of RF output, operating from 6-V battery. Sidetone can be monitored with high-impedance headphones or small loudspeaker. Carrier frequency can be tuned up to 1 kHz above and below nominal frequency of 40-meter crystal.—Circuits, *73 Magazine*, July 1977, p 34.

NOTES
1. All resistors in Ohms
2. All capacitors in pf unless noted otherwise
3. All fixed value capacitors from 10 to 125 pF are Underwood Type J-101.
4. All trimmer capacitors are ARCO compression mica or equivalent.
5. Constructed on 0.062", single sided, G10, circuit board

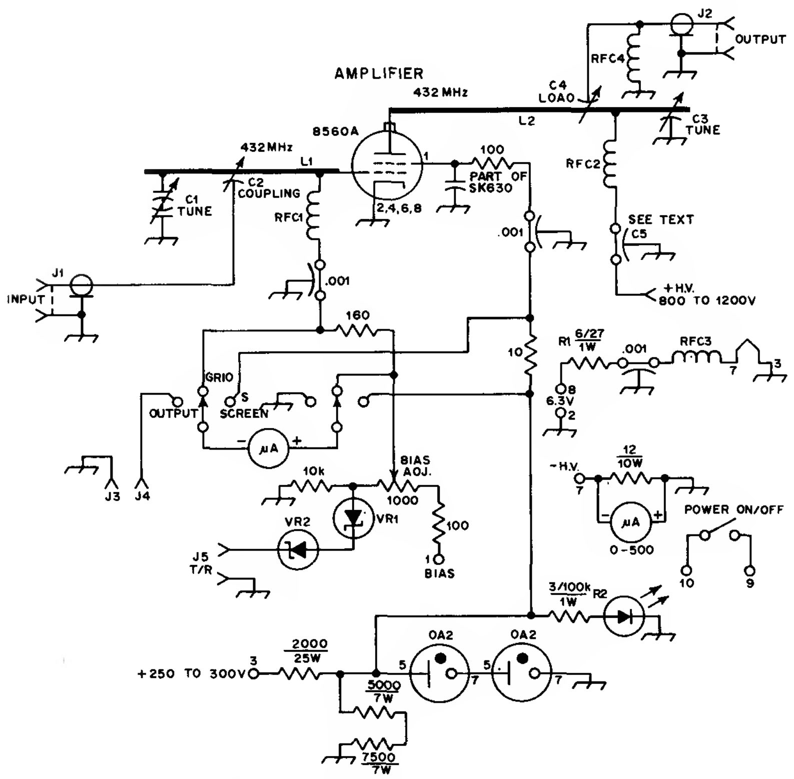


RFC1,2,3,4 — 0.15 µH, molded choke with Ferroxcube 5659065/3B ferrite bead on ground lead
RFC5 — 0.15µH molded choke
RFC6,7 — Ferroxcube VK-200 19/4B ferrite choke
RFC8 — 4T #16 awg wire, wound on 100Ω 1 W resistor (75 nH)
RFC9 — 2T #15 awg wire, wound on 100Ω 2 W resistor (45 nH)
RFC10 — 10T #14 awg wire wound on 10Ω 2 W resistor
L1,2,3 — 1T #18 awg, ¼" dia, ¾" L (25 nH)
L4,6 — 2T #15 awg wire, ¼" dia, ½" L (30 nH)
L5, 7 — See outline diagram.
L8 — #12 awg wire approximately 1" Long (9 nH)
C11,12,13 — 680 pF, Allen Bradley Type FA5C
C14 — 470 pF, Allen Bradley Type SS5D
C15 — 5 pF, Dipped Silvered Mica



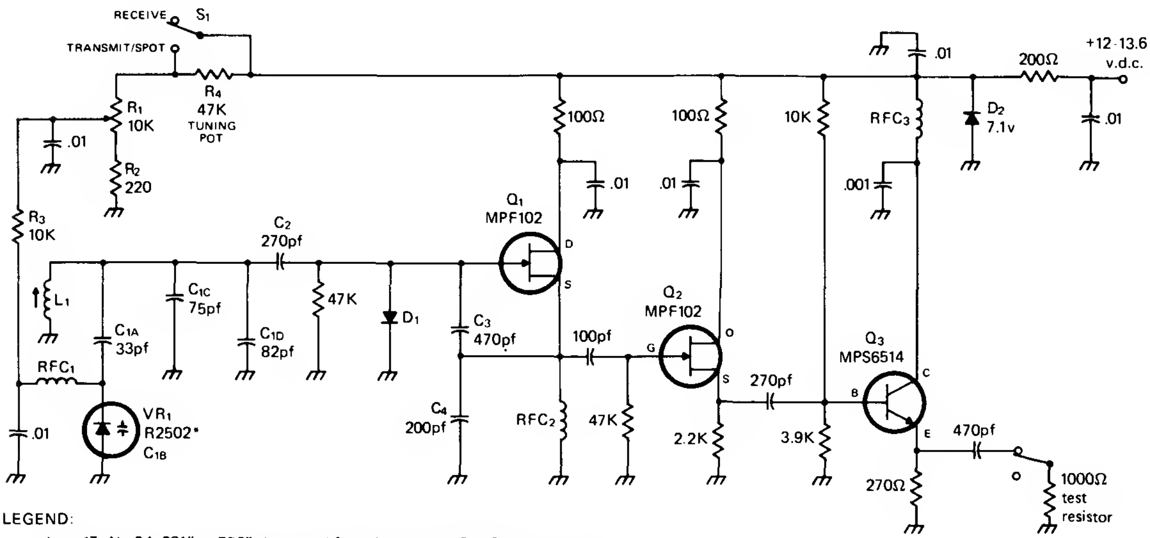
Outline Diagrams for Coils L5 and L7

175-MHz 80-W MOBILE FM—Uses Motorola transistors optimized for 12.5-V FM operation. All stages are class C. Signal-splitting techniques in input and output matching networks of power output stage minimize problems of unequal load sharing and of matching to extremely low impedance levels. Overall gain is 26 dB, and efficiency is 49.5%.—J. Hatchett, "Design Techniques for an 80 Watt, 175 MHz Transmitter for 12.5 Volt Operation," Motorola, Phoenix, AZ, 1972, AN-577, p 2.



L1 — 1-3/4 X 4-inch double-sided pc board, spaced 7/8-inch from chassis.
L2 — 3-1/2 X 6-1/4-inch double-sided pc board or aluminum strip. Length from tip of line to tube center is 7-1/8 inches.
C1 — 1.8- to 5.1-pF air variable, E. F. Johnson 160-0205-001. Mount on phenolic bracket.
C2 — 1/2-inch dia disk on center conductor of coaxial extension.
C3,C4 — Spring-brass flapper type tuning capacitors.
C5 — 2-1/2 X 4-inch pc board, single-sided, with .01-inch thick Teflon sheet for insulation to chassis. Copper-foil side mounted toward the chassis wall.
CR1 — 1/4-inch dia LED.
R1 — 27 ohm, 1-W resistor, 6 in parallel.
R2 — 100-kΩ 1-W resistor 3 in parallel.

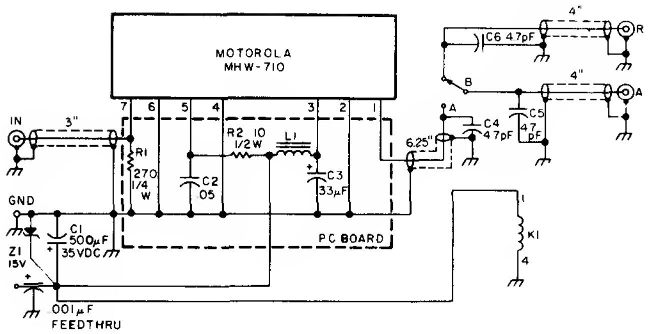
100-W LINEAR FOR 432 MHz—Medium-powered amplifier using 8560A conduction-cooled tetrode provides extra power needed for use of Oscar satellite in mode B on 432.15 MHz, with drive of only 7 W. Half-wave grid is fabricated from double-sided printed-circuit board. Capacitive probe to grid line serves for input coupling. Half-wave plate line is capacitively tuned by movable vanes. Article covers construction in detail.—T. McMullen, A Tramplifier for 432 MHz, *QST*, Jan. 1976, p 11–15.



LEGEND:

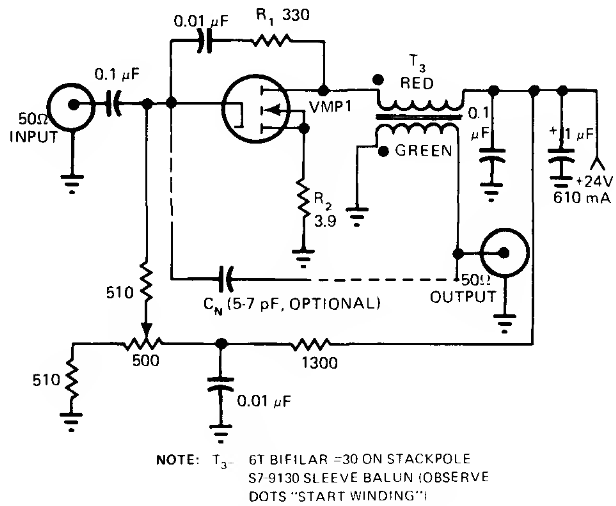
L_1 = 17t No.24,.281" x .750" slug tuned form (J.W. Miller 23A014–3, green dot)
VR_1 = Motorola R2502/MV2105, 15pf varactor diode or HEP R2502
RFC_1 = 25t No. 28, Amidon F8-43-801 "jumbo bead" (or 100μh, Miller 4632-E)
RFC_2 = 14t No. 28, Amidon FB-43-801
RFC_3 = 22t No.28, Amidon F8-43-801
D_1 = 1N456, 1N914 or similar switching diode
D_2 = 6.8/9.1v. Zener, 1N4736/1N4739 or 1N757

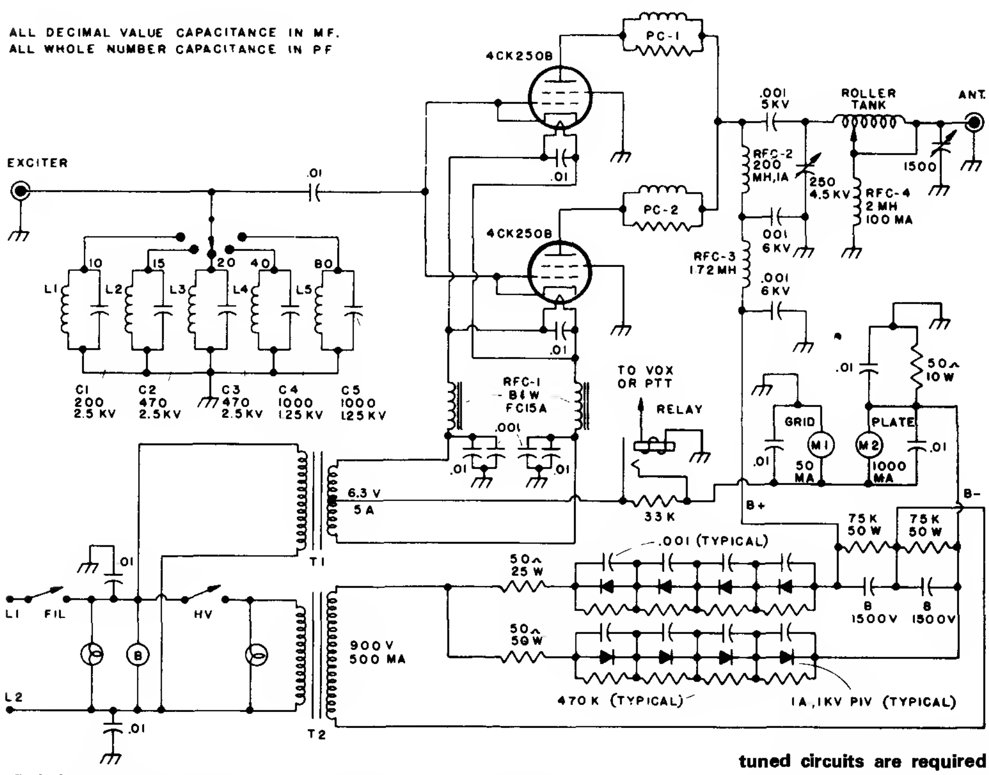
VFO FOR 7 AND 14 MHz—Drift rate of Seiler variable-frequency oscillator can be less than 100 Hz if reasonable care is taken in board design and parts selection. Oscillator Q_1 is followed by buffer stages Q_2 and Q_3. Tuning control R_1 varies DC voltage applied to varactor tuning diode. Developed for use with 1-W exciter as solid-state transmitter for low-power (QRP) operation in 40-meter and 20-meter bands. VFO runs continuously to enhance stability; if oscillator signal leaks through receiver and interferes with desired incoming signal, switching S1 to RECEIVE puts R_4 in circuit to move oscillator from operating frequency. Offset resistor R_4 can also serve for improving bandspread on 20 meters.—A. Weiss, QRP, *CQ*, Dec. 1977, p 88–92 and 112.



10 W AT 450 MHz—Uses Motorola MHW-710 sealed power module drawing 2.7 A on 13.8 VDC. Developed for use with fast-scan amateur TV transmitter having audio on video carrier and TR switching. Relay K1 is Archer (Radio Shack) 275-206. L1 is Ferroxcube VK200-20/4B.—B. J. Brown, Super Simple 450 MHz Rig, *73 Magazine*, Aug. 1976, p 72–75.

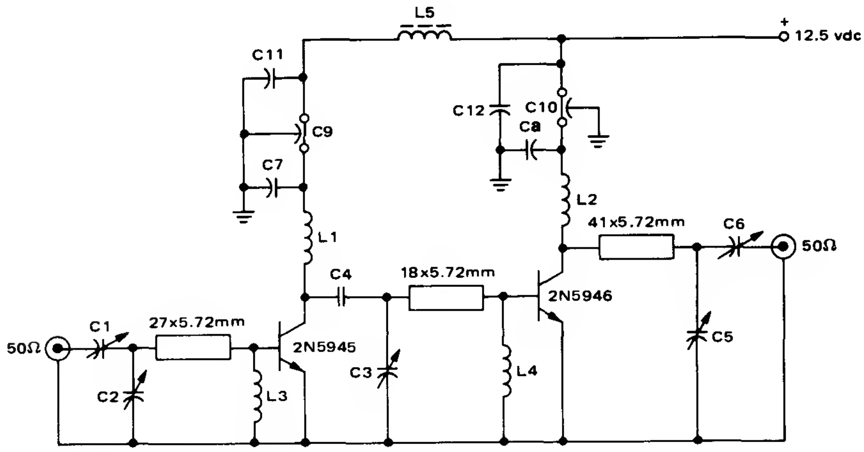
VMOS 5-W BROADBAND—Single-transistor broadband linear amplifier uses Siliconix VMP1 to provide 15-dB gain over entire frequency range of 2 to 100 MHz.—G. D. Frey, VMOS Power Amplifiers—This Broadband Circuit Outputs 8W with a 15 dB Gain, *EDN Magazine*, Sept. 5, 1977, p 83–85.





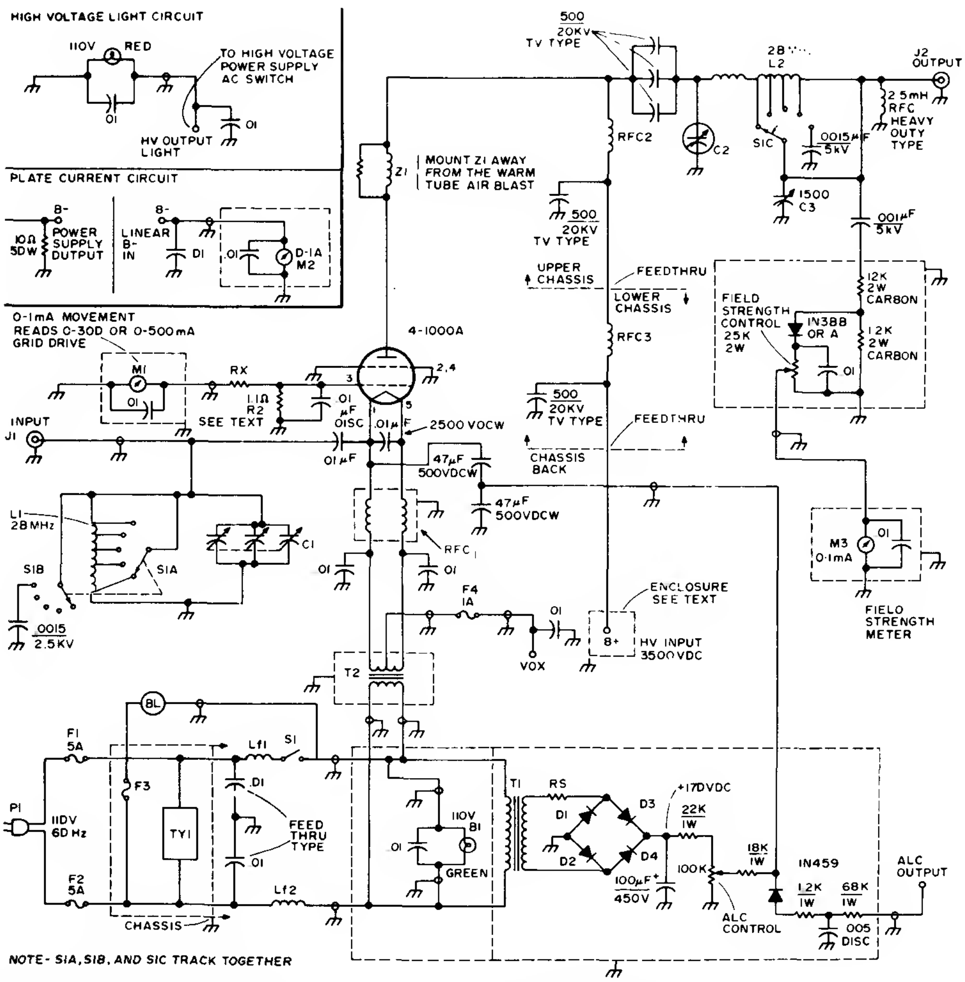
1200-W PEP POWER AMPLIFIER—Ceramic tetrodes are operated as low-mu triodes, with control grids tied to cathodes. Amplifier takes about 200-W drive. Tuned-cathode input circuit presents better load to exciter. Bias is developed through 33K cathode resistor that is shorted out by relay during operation. In standby mode, plate current is virtually zero. Article covers construction and operation, with emphasis on proper cooling of tubes. Separate tuned circuits are required for each amateur band. L1 and L2 are 0.15 μH, L3 and L4 are 0.31 μH, and L5 is 1.3 μH. PC-1 and PC-2 are 3 turns No. 16 enamel wound on 50-ohm 2-W carbon resistor.—S. W. Hochman, The Ample Amplifier, *73 Magazine*, March 1973, p 50–54.

450–470 MHz AT 10 W—Powar amplifiar for land-mobile 12.5-V transmitter is constructed on double-sided microstrip substrate. Powar gein at 470 MHz is 14.5 dB, end ovarall efficiency is 55%.—G. Young, "UHF Microstrip Amplifiers Utilizing G-10 Epoxy-Glass Leminate," Motorola, Phoenix, AZ, 1976, AN-578, p 3.



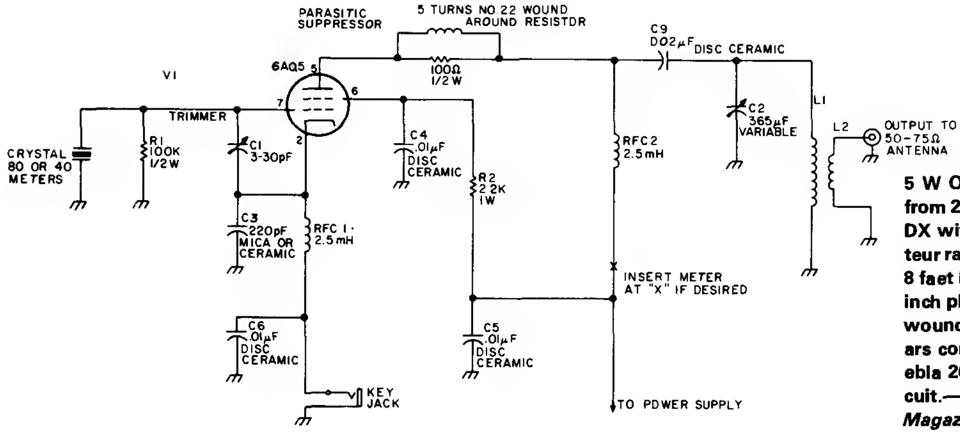
C1,2,3,5,6 — 1.5-20 pF, Arco 402 or equiv.
C4 — 10 pf dipped mica
C7, 8 — 0.1 µF ceramic
C9, 10 — 470 pf Feed thru
C11, 12 — 1 µf Tentelum

L1, 2 — 5 turns #20 AWG Closewound 3/16" I.D.
L3, 4 — 3.9 µhy molded choke w/ferrite core
L5 — Ferroxcube VK200 20/48 or equiv.
Board is 1/16" thick apoxy-glass
"G-10" Dielectric with 1oz copper on both sides

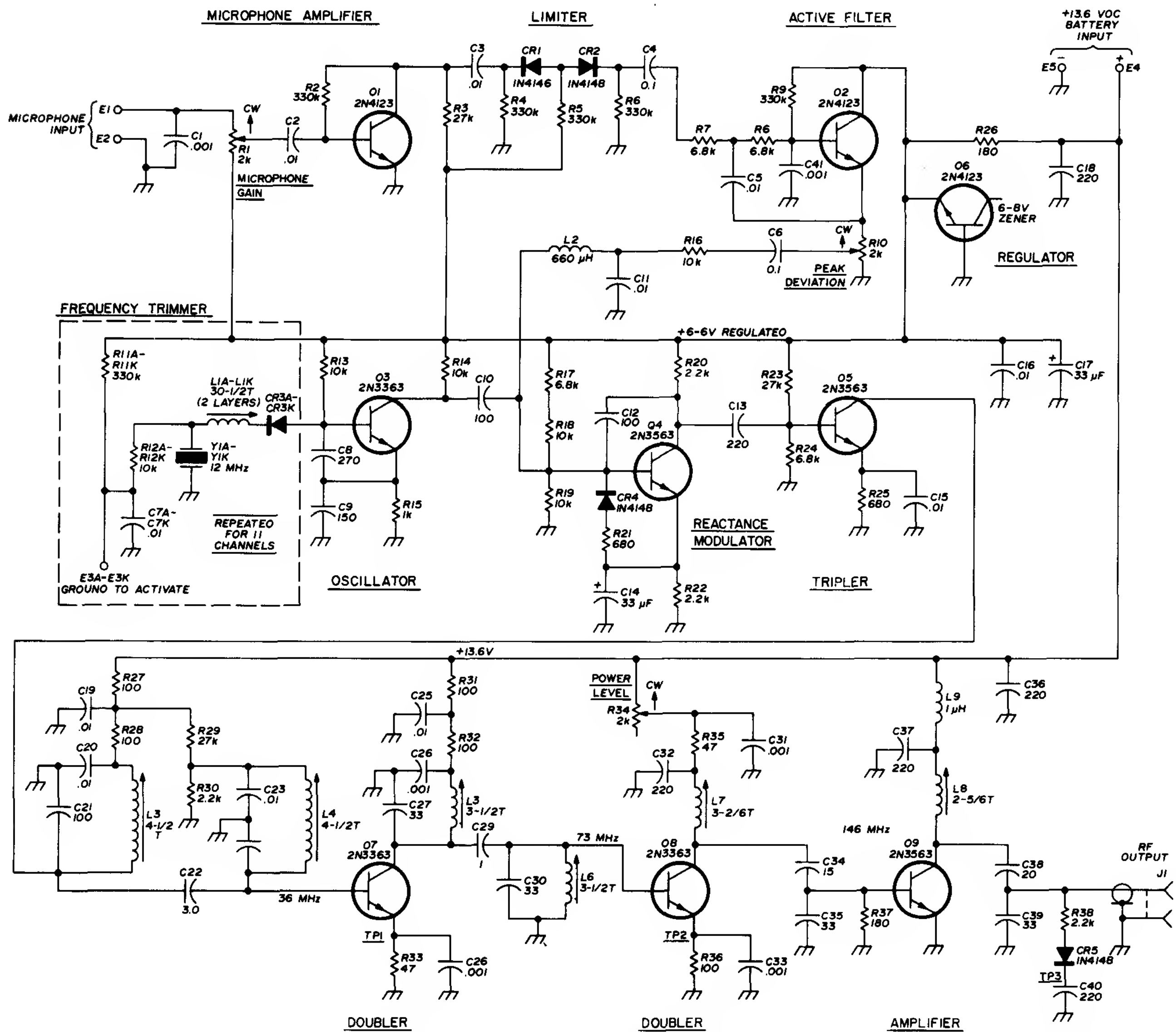


NOTE- S1A, S1B, AND S1C TRACK TOGETHER

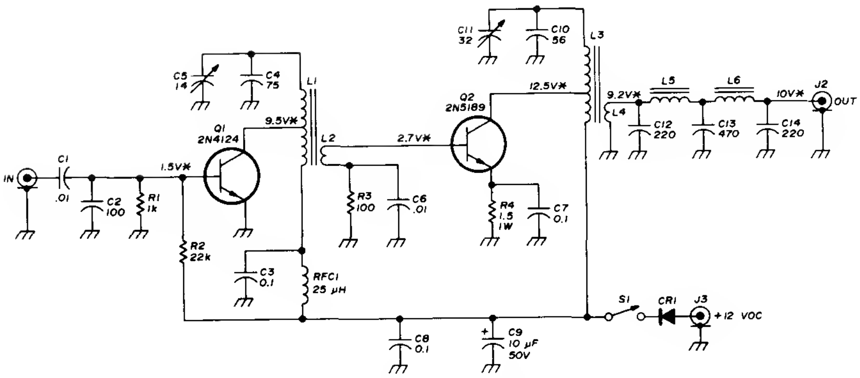
1-kW GROUNDED GRID—Class B lineer emplifiar for amateur transmittar can ba switched to any band from 80 through 10 metars. Do not exceed 200-mA grid drive, and do not apply full excitation without plata voltege. Tuba requiras blower for air coolIng. Articla covers construction end adjustment.—E. Hartz, 4-1000 A Grounded Grid Linaar, *73 Magazine,* July 1974, p 17, 19–20, 22–24, and 26.



5 W ON 80 OR 40 m—Single 6AQ5 operating from 200-V supply can cover all states and some DX with CW on 40 meters as low-power amateur radio station. Antenna can be simple dipole 8 feet high. L1 is 15 turns No. 22 enamel on 1¼-inch plastic form, with 3 turns of insulated wire wound around cold end of L1 for L2. Article covers construction and operation and gives suitable 200-V voltage-doubling power supply circuit.—S. Dunn, QRP Fun on 40 and 80, *73 Magazine*, Oct. 1976, p 44–46.

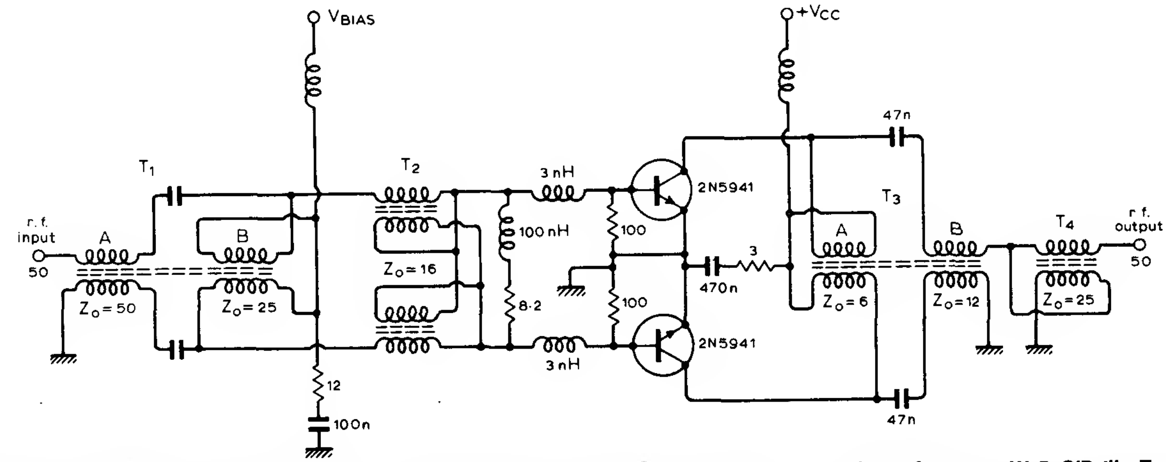


2-METER FM EXCITER—Includes both deviation and microphone gain controls. Low-pass filter following limiter eliminates raspy voice signal. Input takes either carbon or transistor-amplified dynamic microphones. Phase modulation used is suitable for multichannel operation and frequency synthesizers. Oscillator uses 12-MHz series-resonant crystals. Voltage regulator for oscillator, modulator, and audio stages minimizes effects of line-voltage variation and noise. Output power of 150–200 mW is enough to drive new TRW and Motorola RF power modules. Article gives construction and alignment details.—J. Vogt, High-Performance Two-Meter FM Exciter, *Ham Radio*, Aug. 1976, p 10–15.

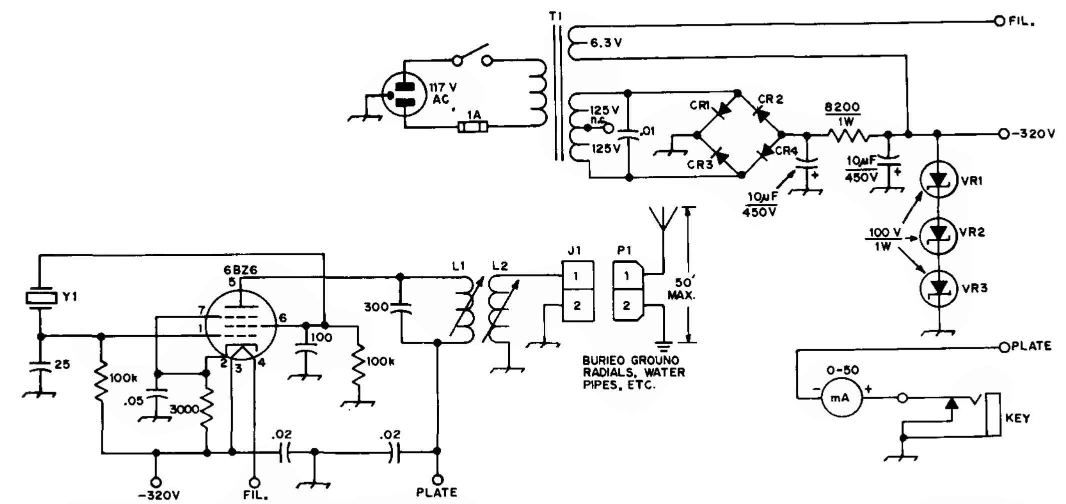


- C5 — 14-pF air variable (E. F. Johnson 160-0107-001)
- C11 — 32-pF air variable (E. F. Johnson 160-0130-001)
- L1 — 16 turns no. 24 enamelled on Amidon T-50-2 toroid core, tapped 6 turns from B+ end
- L2 — 2 turns small insulated wire wound over B+ end of L1
- L3 — 16 turns no. 20 enamelled on Amidon T-68-2 toroid core, tapped 3 turns from B+ end
- L4 — 3 turns small insulated wire wound over B+ end of L3
- L5, L6 — 11 turns no. 20 enamelled on Amidon T-50-2 core
- RFC1 — 25-μH rf choke (Millen J300-25)

2 W FOR 20-METER CW—Motorola 2N4124 drivar operetes as cless B emplifier. With no signal, collector current is neer zaro, mlnimizing current drein when key is up. Tank circuit of RCA 2N5189 final is similar to that of driver. Double-pi network in output assures good harmonic attenuation. RMS values of RF voltages era merked with asterisks. Protectiva diode CR1 Is eny silicon rectifier. For portable usa, supply can be lentarn bettery.—C. E. Galbraeth, Low-Powar Solid-Stata VFO Transmitter for 20 Meters, *Ham Radio*, Nov. 1973, p 6–11.

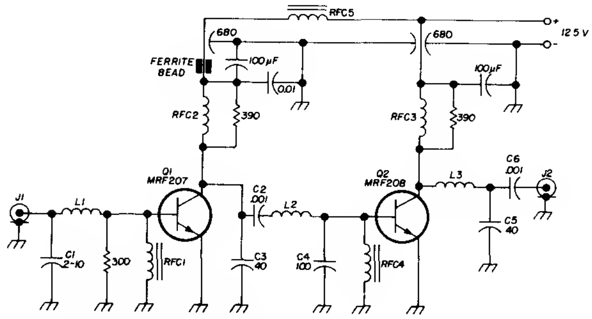


50-W PUSH-PULL—Single RF power amplifier stage usas broadband trensmission-line transformars, operates between 50-ohm source and load Impedances, end producas 50 W peak envelope power from 28-V supply ovar band of 2–30 MHz. Articla glves dasign aquations for toroid transformers.—W. P. O'Rallly, Transmittar Powar Amplifier Deslgn, *Wireless World*, Sept. 1975, p 417–422.



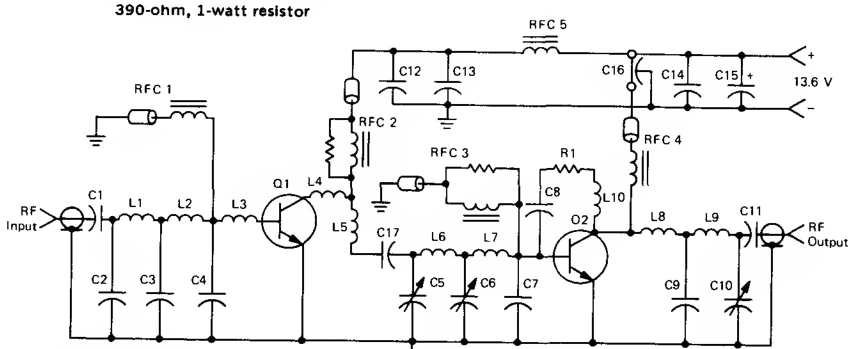
- CR1-CR4, incl. — 400 PRV, 1-A Silicon diode.
- L1 — Slug-tuned inductor, 0.5 to 3 mH (J. W. Miller No. 9003).
- L2 — Slug-tuned inductor, 2 to 8 mH (J. W. Miller No. 9004).
- T1 — Power transformer, 250 V ct and 6.3 V ac (Stancor PS-8416 or equiv.).
- VR1, VR2, VR3 — Zener diode, 100 volt.
- Y1 — 160 to 190 kHz.

1 W ON 175 kHz—Simpla one-tuba circuit with zanar-regulated power supply provides amateur CW oparation in 30-kHz segment of long-wava (VLF) spectrum. Adjust L1 end L2 to resonence with crystal used, then adjust coupling between them until metar betwaan plate and ground raeds correct current for legal limit of 1-W powar input to finel stage. Antenna is vertical mest insulated from ground, with transmitter directly at its base.—J. V. Hagan, A Crystal-Controlled Converter and Simple Transmitter for 1750-Meter Operation, *QST*, Jen. 1974, p 19–22.



C1	20-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA200DO)	L1	1 turn number 24 wire, 1/4" ID
C2,C6	0.001-μF metal-clad mica capacitor (El Menco MCM 01/002/-CA103DO)	L2	copper strap, 0.032" thick, 0.25" wide x 0.75" long
C3,C5	40-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA400DO)	L3	0.8" lead of capacitor C6 (0.001-μF disc)
C6	100-pF metal-clad mica capacitor (El Menco MCM 01/002/-CA102DO)	RFC1,RFC4 RFC5	low-Q rf choke (Ferroxcube VK200-20/4B)
		RFC2	2 turns no. 24 wound around 390-ohm, 1/4-watt resistor
		RFC3	2 turns no. 20 wound around 390-ohm, 1-watt resistor

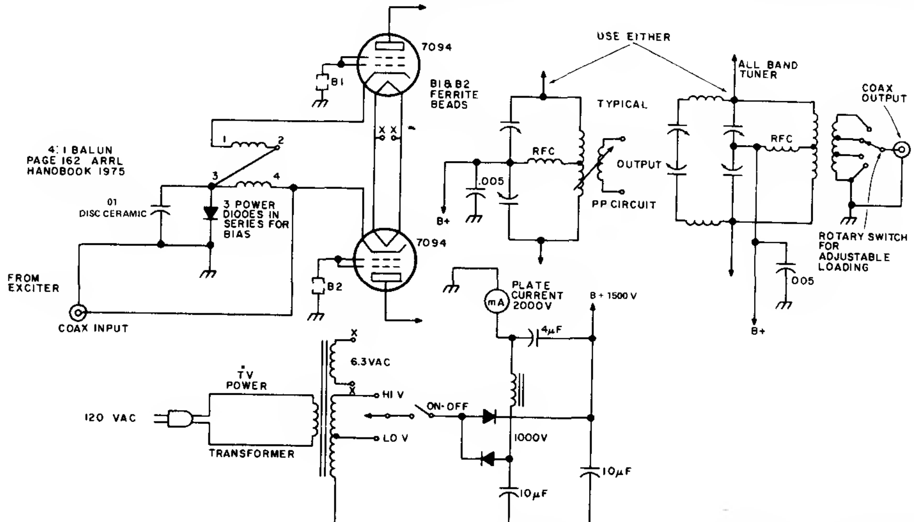
10 W FOR 220 MHz—Class C RF power amplifiar for VHF FM transmittar has stable gain of 20 dB for operating bendwidth of 40 MHz. Article gives design procedure using Smith chert and covers construction and tune-up.—J. DuBois, 220-MHz RF Power Amplifiar for VHF FM, *Ham Radio*, Sept. 1973, p 6–8.



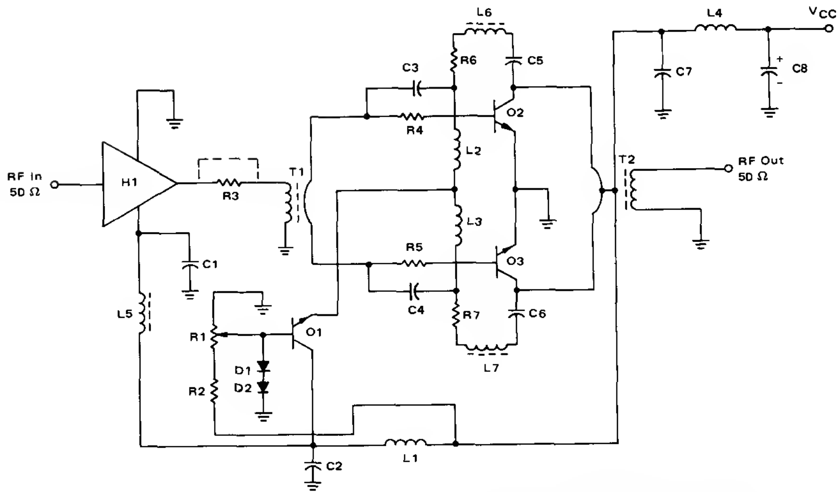
Q1 – MRF237
Q2 – MRF238
C1 – 0.001 μF, 50-V, Erie Disc
C2 – 39 pF Dipped MICA
C3 – 24 pF Dipped MICA
C4 – 91 pF Dipped MICA
C5 – 8.0–60 pF ARCO 404 Trimmer
C6, C10 – 15–115 pF ARCO 406 Trimmer
C7 – 250 pF and 100 pF UNELCO in Parallel
C8, 12, 14 – 0.1 μF, 50 Vdc, Erie Disc
C9 – 82 pF Dipped MICA
C11 – 500 pF Dipped MICA
C13 – 0.018 μF Chip
C15 – 1 μF, 35 Vdc, Tantalum
C16 – 680 pF Allen-Bradley Feedthrough
C17 – 100 pF Dipped MICA
R1 – 150-ohm, 1/2-Watt
RFC 1, 4 – 0.15 μH Molded Choke with Ferrite Bead Ferroxcube 5659065/4B

RFC 2 – 10 turns, No. 20 AWG, Enameled on 470-ohm, 1/2 W Resistor with Ferrite Bead Ferroxcube 5659065/4B
RFC 3 – 10 turns, No. 20 AWG, Enameled on 270-ohm, 1/2 W Resistor with Ferrite Bead Ferroxcube 5659065/4B
RFC 5 – Ferroxcube VK20020/4B
L1 – 1.3" X 0.1" (3.30 X 0.254 cm) Airline Inductor
L2 – 0.6" X 0.1" (1.52 X 0.254 cm) Airline Inductor
L3 – Base Lead Q1
L4 – Collector Lead Q1
L5 – Airline Inductor and 1 turn, No. 18 AWG, 0.25" (0.64 cm) I.D.
L6 – 1.9" X 0.1" (4.83 X 0.254 cm) Airline Inductor
L7 – 0.7" X 0.1" (1.78 X 0.254 cm) Airline Inductor
L8 – 0.9" X 0.1" (2.29 X 0.254 cm) Airline Inductor
L9 – 1.4" X 0.1" (3.56 X 0.254 cm) Airline Inductor
L10 – 10 turns, No. 20 AWG, Enameled Wire 0.62" (0.159 cm) I.D.

140–180 MHz AT 30 W—Two-transistor amplifier provides gain of ovar 20 dB for VHF merina, amateur, and commercial transmitters. Trimmers are tuned for paak output at centar frequency in 10-MHz renga of intarest. Will operate into 30:1 mismetch without demege.—H. Burger and T. Bishop, "Two VHF Highband Gain Blocks Form 20-dB, 30-Watt Amplifier Chain," Motorola, Phoenix, AZ, 1975, EB-53.



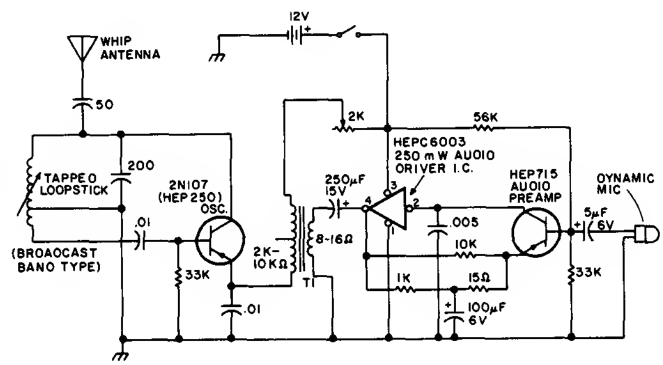
400-W PUSH-PULL—Grounded-grid llnaar push-pull powar amplifiar requires no nautralizing, uses balun for push-pull excitetion, and can feed either one-band or ell-band tuner for amateur radio bends. Belun is 8 turns of 72-ohm twin-line wound on Amidon 2-inch toroid core to giva 4:1 ratio. Article covers construction end adjustment.—B. Beird, Build This Inexpensive 400 Watt Amplifiar, *73 Magazine,* Holiday issue 1976, p 22–23.



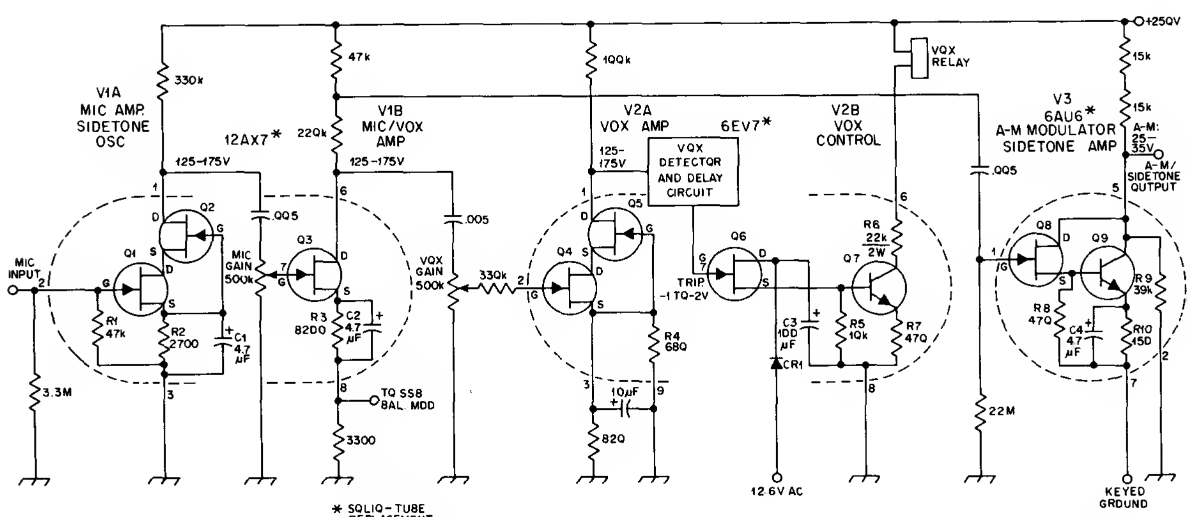
R1 – 1 Ohm Trimpot
R2 – 1 k Ohm, 1/4 W
R3 – Optional
R4, R5 – 5. 6 Ohms, 1/4 W
R6, R7 – 47 Ohms, 1/4 W
C1, C2, C5, C6, C7 – 0.01 µF Chip
C3, C4 – 1800 pF Chip
C8 – 10 µF/35 V Electrolytic

L1, L4, L5 – Ferrite Beeds (Fair-Rite Products Corp. #2643000101 or Ferroxcube #56 590 65/38 or equivalent)
L2, L3 – 10 µH Molded Choke
L6, L7 – 0.1 µH Molded Choke
Q1 – MJE240
Q2, Q3 – MRF433
H1 – MHW591
T1, T2 – 4:1 and 1:4 Impedance Transformers, respectively. (See discussion on transformers.) Ferrite Beeds ere Fair-Rite #2643006301 or equivalent)

1.6–30 MHz 20-W HIGH-GAIN DRIVER—Broadband amplifier operating from 12-V supply uses Motorola MRF433 power transistors for class AB operation and MHW591 as predriver. For class A operation, power transistors should ba MRF426. Q2 does not raquire haatsink because its peak dissipation is undar 1 W. Powar gain is 55 dB wall bayond four-octave band of amplifiar, and input VSWR is under 1.2.—H. O. Granbarg, "Low-Distortion 1.6 to 30 MHz SSB Driver Designs," Motorola, Phoenix, AZ, 1977, AN-779, p 7.

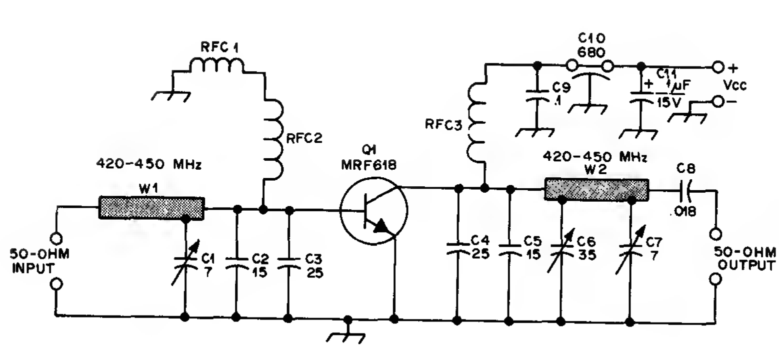


1–2 MHz—Simpla low-power AM transmittar uses low-impedance output transformar in reverse to driva 2N107 oscillator staga for short-range voice transmissions.—Circuits, *73 Magazine*, Juna 1977, p 49.

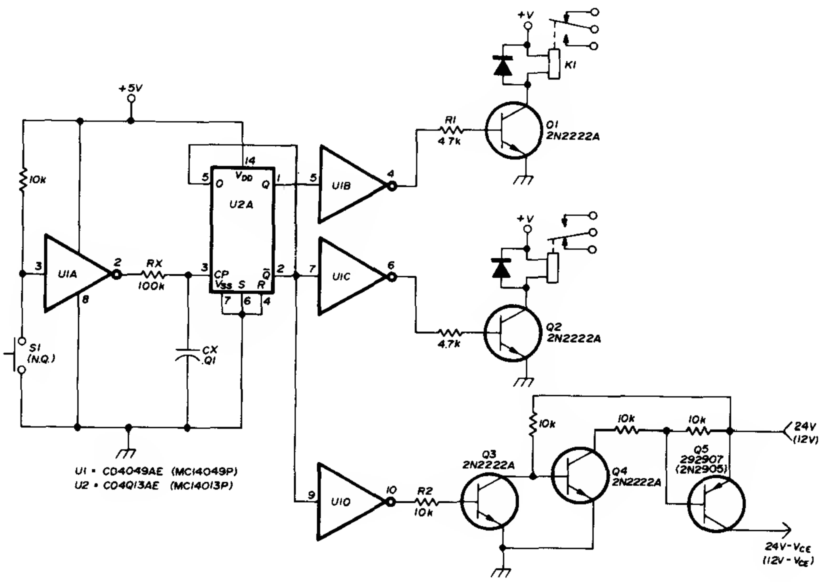


CR1 – General-purpose silicon diode, 300 PIV, 1N645 or equiv.
Q1, Q4 – N-channel JFET, 30 $V_{(BR)}$, 2N5246 or equiv.
Q2, Q3, Q5, Q8 – N-channel JFET, 300 $V_{(BR)}$, Texas Inst., A5T6449.
Q6 – N-channel JFET, 30 $V_{(BR)}$, 2N5950 or equiv.
Q7, Q9 – Npn transistor, 300 $V_{(BR)}$, Texas Inst., A5T5058.

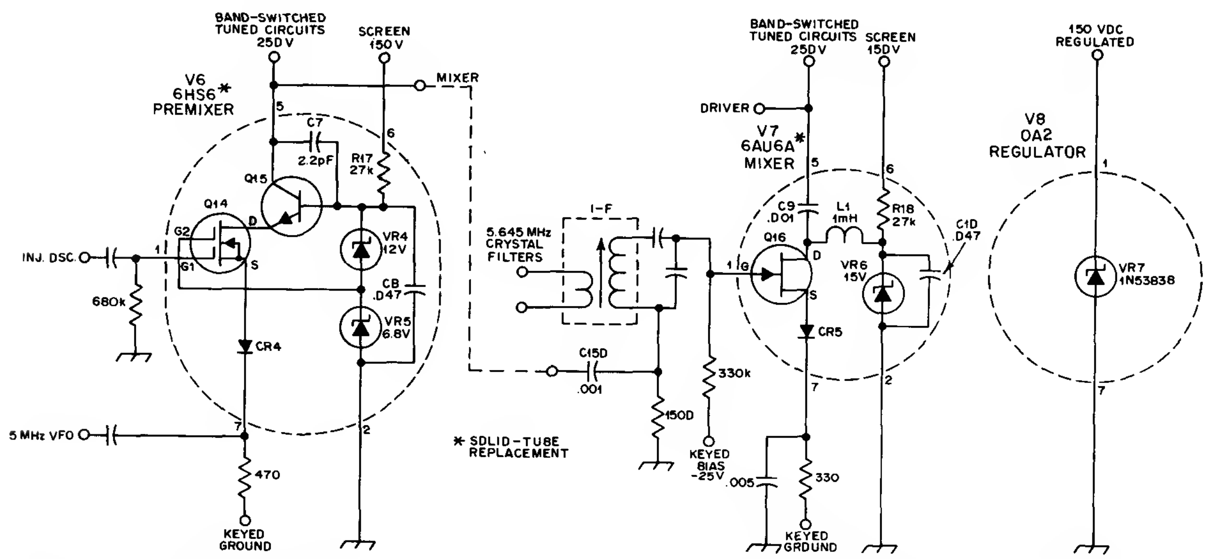
TRANSISTORS FOR AF TUBES—Article covars repiacement of tubas in Drake T-4XB transmittar with solid-stata aquivalant circuits mounted in 7-pin and 9-pin miniatura plugs. Numbers identify original tuba pins. V1A and V2A use dual-cascode JFETs, whiie voice-oparatad transmittar ralay control V2B and AM modulator V3 usa high-voltaga Darlington. Q9 collector voltaga is sat at 150 V during standby by adjusting R9. Circuit includes first and second audio stages. Voltages indicata propar operating points. Source resistors may require adjustmant.—H. J. Sartori, Solid-Tubes—a Naw Lifa for Oid Designs, *QST*, Aprii 1977, p 45–50.



15-W POWER AMPLIFIER FOR 440 MHz—Power gain of 10 dB increases effective range of amateur transmitter. Narrow-band amplifier using Motorola MRF618 internally matched 12.5-V controlled-Q transistor can be tuned from 430 to 450 MHz. Multiple L sections using 50-ohm microstrip line and mica compression variable capacitors provide input-match and collector-load transformations. Article gives printed-circuit board layout for U-shaped 0.112-inch-wide stripline inductors W1 and W2. RFC1 is ferrite bead, RFC2 is 8 turns No. 22 enamel closewound on ⅛-inch form, and RFC3 is 4 turns No. 22 enamel closewound on ⅛-inch form.—R. Olsen, Build This Solid-State PA for 440 MHz, *QST*, Feb. 1977, p 37–38.

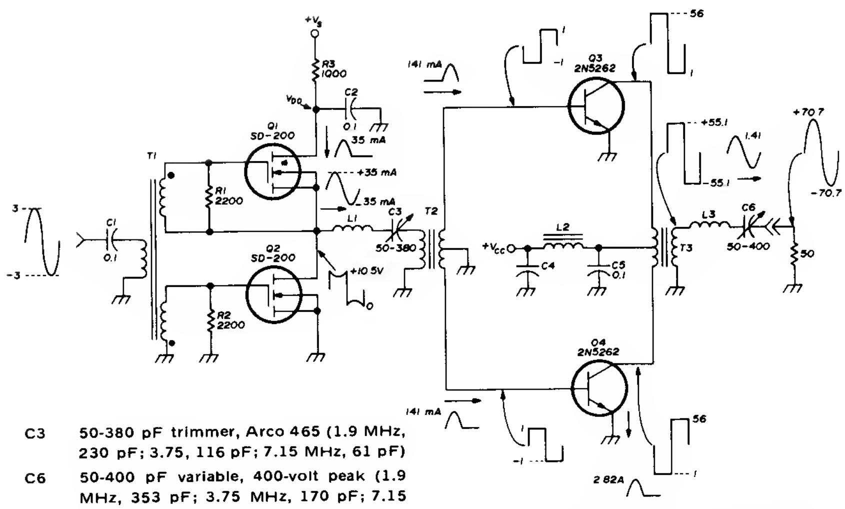


PTT LATCH—Eliminates need for holding down microphone switch continuously while transmitting. U1 is inverting hex buffer, and U2 is dual CMOS D flip-flop. When S1 is depressed, input to U1A goes low and its output goes high, making U2A and U1B together turn on Q2 and energize relay K1. Q3-Q5 serve as optional silent power switch for use when relay noise is objectionable.—B. Lambing, DC Latch Circuit, *Ham Radio*, Aug. 1975, p 42–44.



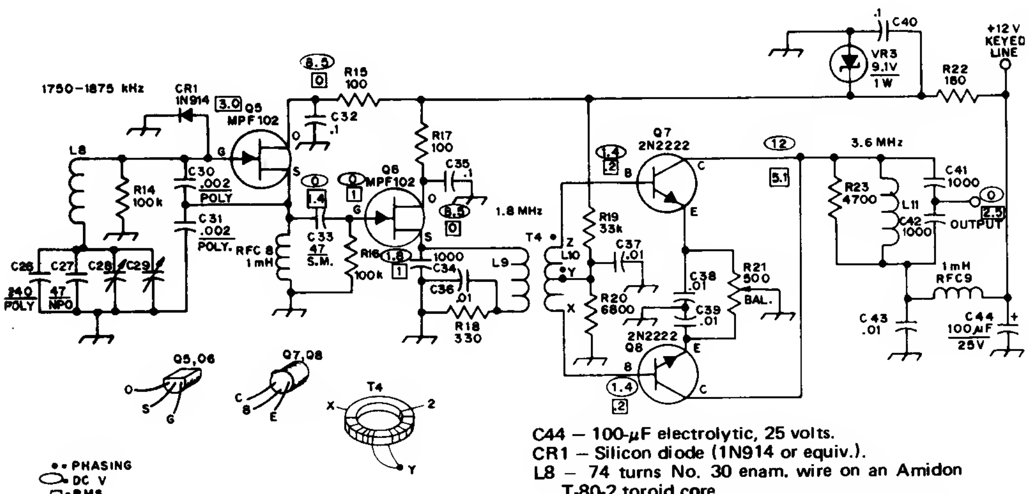
CR4-CR5 — General-purpose silicon diode, 300 PIV (1N645).
Q14 — N-channel dual-gate MOSFET, 25 $V_{(BR)}$ 3N206.
Q15 — Npn transistor 300 $V_{(BR)}$ TIS131.
Q16 — N-channel JFET 30 $V_{(BR)}$ 2N5950.
VR4 — Zener diode, 12 V, 400 mW, 1N759.
VR5 — Zener diode, 6.8 V, 400 mW, 1N754.
VR6 — Zener diode, 15 V, 400 mW, 1N965.
VR7 — Zener diode, 150 V, 5 W, Motorola 1N5383B.

TRANSISTORS FOR MIXER AND VR TUBES—Premixer V6 in Drake T-4XB transmitter is replaced by dual-cascode MOSFETs, with CR4 protecting MOSFET from keyed-ground circuit. High-level mixer V7 operates over large dynamic range of signals coming from IF stage. Output of mixer is low level, about 4 VRMS maximum. Decoupling capacitor C9 and choke L1 isolate JFET from high-voltage tube circuit.—H. J. Sartori, Solid-Tubes—a New Life for Old Designs, *QST*, April 1977, p 45–50.



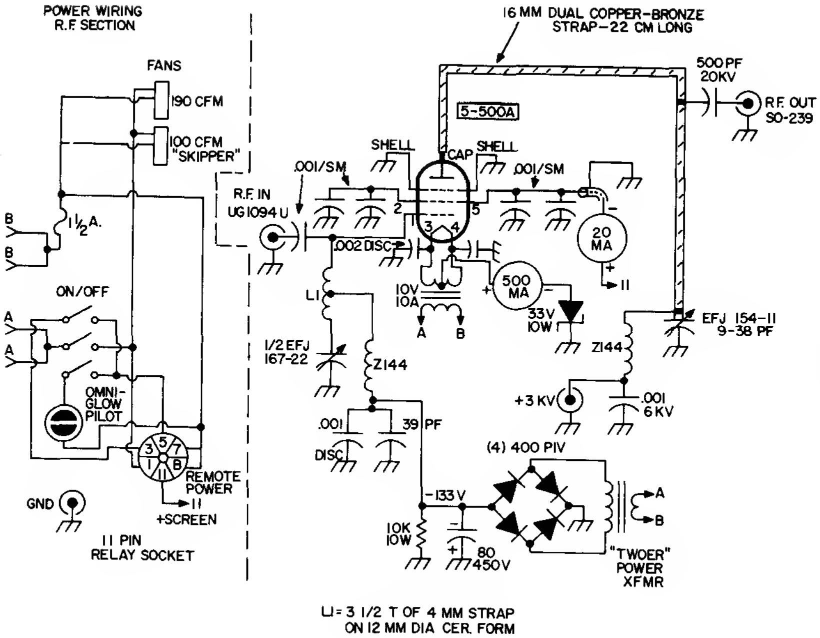
35-W CLASS D ON 40, 80, OR 160 m—Can be used on any of three bands by changing values as set forth in parts table. Article gives circuit design procedure in detail. Power gain is about 27 dB. Almost any type of RF amplifier providing about 100 mW can be used as driver. V_S is 25 V or less, and V_{CC} is 28 V.—F. H. Raab, High-Efficiency RF Power Amplifiers, *Ham Radio*, Oct. 1974, p 8–29.

C3 50-380 pF trimmer, Arco 465 (1.9 MHz, 230 pF; 3.75, 116 pF; 7.15 MHz, 61 pF)
C6 50-400 pF variable, 400-volt peak (1.9 MHz, 353 pF; 3.75 MHz, 170 pF; 7.15 MHz, 89 pF)
L1 160 meters 63 turns no. 30 on Permacore 57-1753 core (30.5 μH)
80 meters 44 turns no. 26 on Permacore 57-1753 core (15.4 μH)
40 meters 36 turns no. 26 on Permacore 57-1677 core (8.1 μH)
L2 16 turns no. 26 on Permacore 56-3596 ferrite core (1.0 μH)
L3 160 meters 52 turns no. 26 on Permacore 57-1753 core (20.9 μH)
80 meters 42 turns no. 26 on Permacore 57-1677 core (10.6 μH)
40 meters 30 turns no. 26 on Permacore 57-1677 core (5.6 μH)
T1 primary is 5 turns no. 26 enamelled on Ferroxcube 226T125-3E2A ferrite core. Secondary windings are each 25 turns no. 26 on same core
T2 primary is 8 turns no. 20 enamelled wire wound through 6 Ceramic Magnetics CN-20 cores (two parallel stacks). Secondary is 4 turns no. 20, center-tapped, through same cores
T3 primary is 4 turns no. 20 enamelled wire, center-tapped to C5, wound through 12 Ceramic Magnetics CN-20 cores (two parallel stacks). Secondary is 4 turns no. 20 through same cores

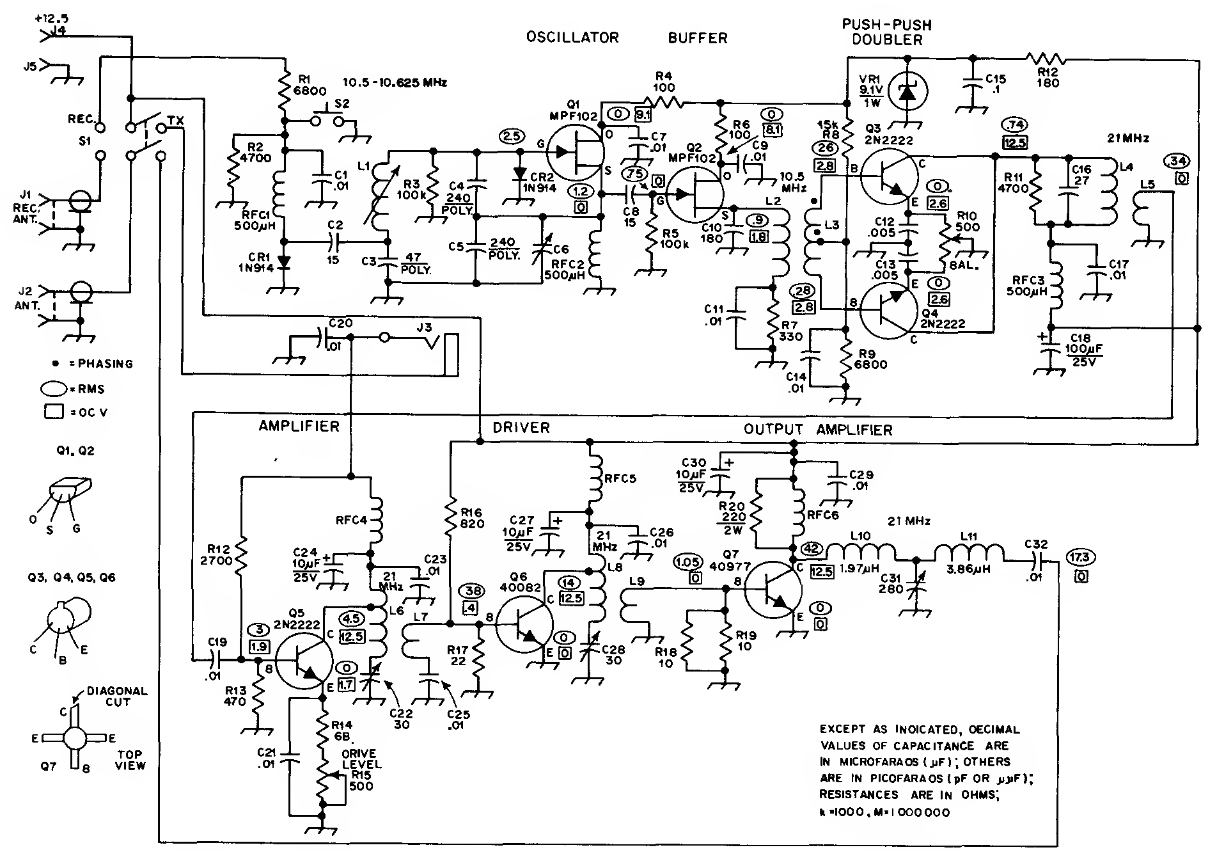


C26 – 240-pF polystyrene.
C27 – 47-pF NPO type.
C28 – 4.5 to 25-pF ceramic trimmar (Centralab 822-CN or equiv.).
C29 – 4 to 53.5-pF variable (Millan 22050 or equiv.).
C30, C31 – .002-μF polystyrene.
C32, C35, C40 – 0.1 μF.
C33 – 47-pF silver mica.
C34, C41, C42 – .001 μF silver mica
C36, C37, C38, C39, C43 – .01 μF.
C44 – 100-μF electrolytic, 25 volts.
CR1 – Silicon diode (1N914 or equiv.).
L8 – 74 turns No. 30 enam. wire on an Amidon T-80-2 toroid core.
L9 – 35 turns No. 24 enam. wire on an Amidon T-80-2 toroid core.
L10 – 12 turns No. 24 enam. wire, center tapped, wound over L9.
L11 – 24 turns No. 24 enam. wire on an Amidon T-80-2 toroid core.
Q5, Q6 – Motorola MPF102 JFET or equiv.
Q7, Q8 – 2N2222 transistor.
R21 – 500-ohm control (Radio Shack 271-226 or equiv.).
RFC8, RFC9 – 1-mH rf choke (Millen J300-1000 or equiv.).
VR3 – Zener diode, 9.1 volt, 1 watt.

80-METER VFO—Used in place of crystal-controlled oscillator in low-power (QRP) amateur transmitter. Tuning range is 1750–1875 kHz in 160-meter band. Colpitts oscillator uses JFET Q5 with series-tuned tank for good stability. Q6 provides isolation between oscillator and push-push class C doubler emplifier stage. Doubling gives desired 80-meter output.—D. DeMaw and J. Rusgrove, Learning to Work with Semiconductors, *QST*, Oct. 1975, p 38–42.

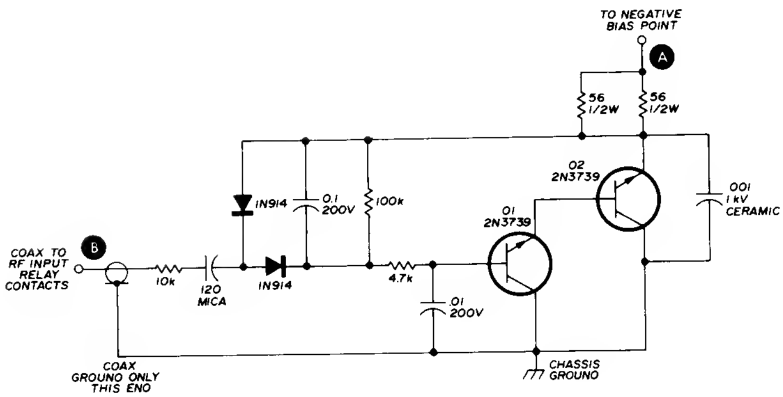


1 kW ON 2 METERS—Developed for moonbounce communicetion. Article covers construction, with emphasis on insulation end cooling, end gives circuit of 3-kV power supply required.—R. W. Campbell, Kilowatt Linear Amplifier for 2 Meters, *73 Magazine*, Dec. 1973, p 29–35.



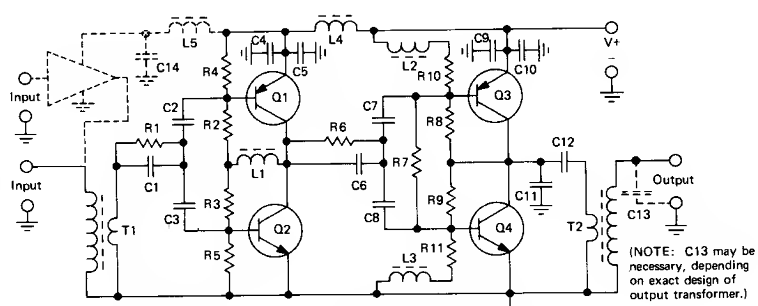
L1 – 6.05- to 12.5-µH adjustable coil (Miller 42A105CBI or equiv.).
L2 – 17 turns No. 28 enam. wire on Amidon T-50-6 core.
L3 – 10 turns No. 28 enam. wire, center tapped, wound over L2.
L4 – 17 turns No. 28 enam. wire on an Amidon T-50-6 core.
L5 – 5 turns No. 28 enam. wire wound over L4.
L6 – 30 turns No. 28 enam. wire on an Amidon T-50-6 core. Tap 10 turns above C23 end.
L7 – 4 turns No. 28 enam. wire wound over L6.
L8 – 30 turns No. 28 enam. wire on an Amidon T-50-6 core. Tap 7 turns above C26 end.
L9 – 3 turns No. 28 enam. wire wound over L8.
L10 – 20 turns No. 22 enam. wire on an Amidon T-68-6 core.
L11 – 29 turns No. 22 enam. wire on an Amidon T-68-6 core.

21–21.25 MHz with VFO—Developed for low-power CW work in 15-meter amateur bend. Colpitts oscillator Q1 runs continuously at 10.5–10.625 MHz during transmit end receive, for good frequency stability, so VFO frequency must be shifted awey from opereting frequency during receive periods. Supply is 12 V et 1.3 A. C6 is 4–53.5 pF. RFC4 is 16 turns No. 28 enamel, RFC5 is 11 turns No. 22, and RFC6 is 6 turns No. 22, each on Amidon FT-50-61 core. Article covers construction end tune-up.—J. Rusgrove, A 15-Meter Goober Whistle, *QST*, Jan. 1976, p 16–19.



BIAS SWITCH—Automatic electronic bias switching improves efficiency of negatively biesed linear cless B RF power amplifier such es Heath SB-200 because no power is dissipated under no-signel conditions. Transistors ere chosen to withstand meximum negative volteges switched, about −150 VDC. Capecitor across collector-bese junction of Q1 can be edjusted to reduce turn-on time of switch. With no RF drive from transmitter, amplifier is biesed to cutoff end plete current is zaro. Switch will operete et RF threshold of about 2 V end epply cless B bies voltaga to amplifier. As RF drive is increased, plete current increases. With transmittar in SSB moda, plate current is zero with no spaech. For speech, plate current increases with RF driving voltage.—F. E. Hinkle, Electronic Bies Switch for Negetively Biased Amplifiers, *Ham Radio*, Nov. 1976, p 27–29.

2–30 MHz SSB DRIVER—Two-stage complementary-symmetry emplifier combines single-ended impedenca metching with high-gein push-pull design to provide up to 25 W PEP for driver epplicetions. Provides good harmonic rejection end low intermodulation distortion. Supply voltage range is 22–30 V. Low-impedance windings of T1 end T2 use 1 turn of copper braid, with 2 turns No. 22 for primary of T1 end 4 turns No. 22 for secondary of T2.—H. Grenberg, "A Complementery Symmetry Amplifier for 2-30 MHz SSB Driver Applications," Motorola, Phoenix, AZ, 1975, EB-32.



C1, C6 – 1000 pF
C2, C3, C7, C8 – 0.1 μF
C4, C9, C14 – 0.15 μF
C5, C10, C12 – 0.68 μF*
C11 – 2000 pF
C13 – 100 pF (Typ.)

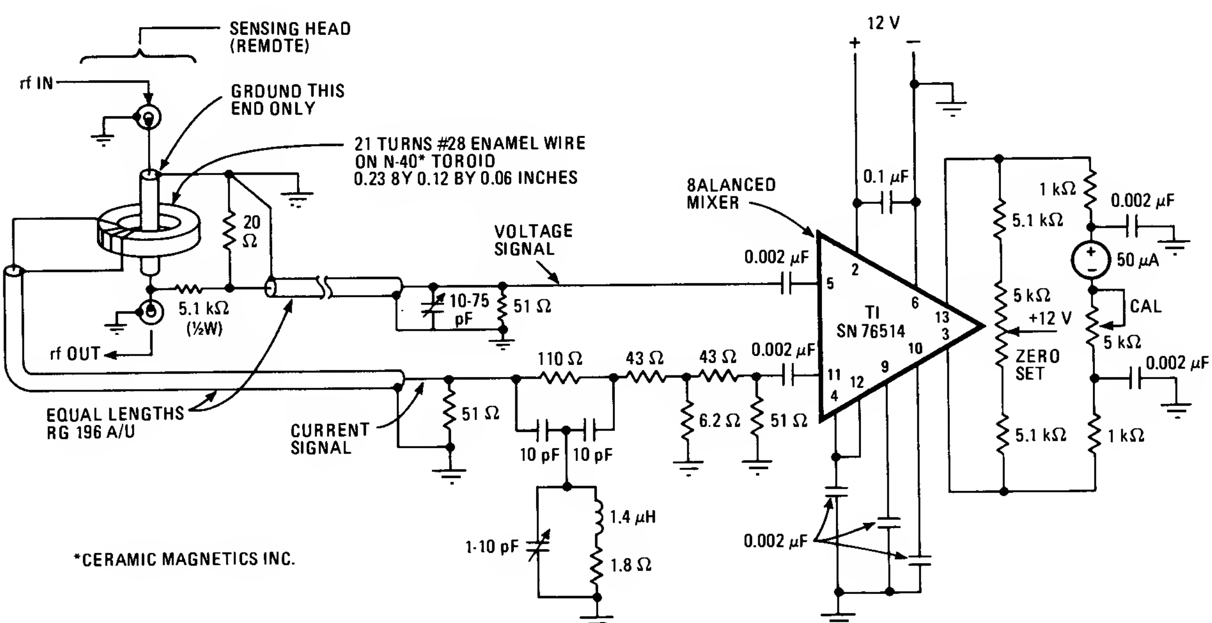
R1, R4, R5 – 22 ohms/1/4 W
R2, R3 – 330 ohms/1/2 W
R6 – 15 ohms/1/4 W
R8, R9 – 220 ohms/1 W
R10, R11 – 6.8 ohms/1/2 W
R7 – 560–680 ohms/2 W

L1 – 0.68 μH molded choke
L2, L3 – 6.8 μH molded choke
L4 – 4 ferrite beads, Ferroxcube 56˙590 65/38

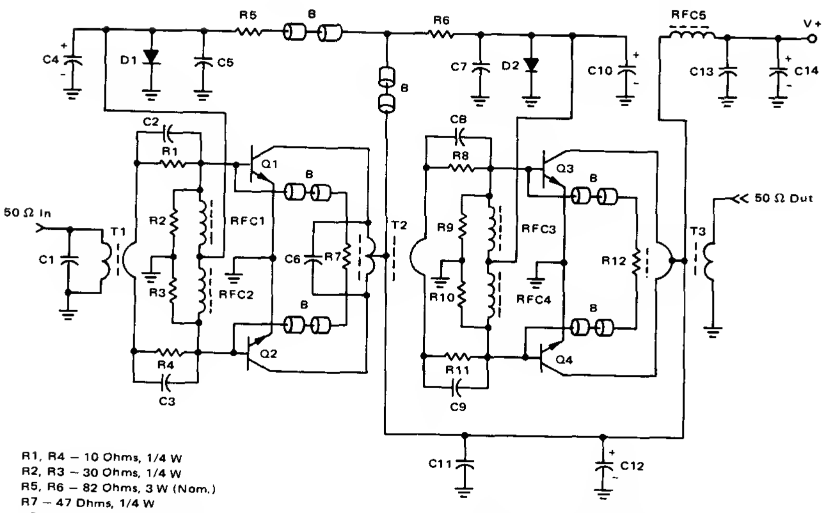
Q1, Q3 – MRF432
Q2, Q4 – MRF433

T1, T2 – See text

All capacitors are ceramic chips, Union Carbide type 1225 or 1813 or Varadyne size 18 or 14 or equivalent.
All resistors are carbon composite.



50-W RF—Direct-reeding RF wattmeter developed for use et 27.12 MHz is eccurate to within 1% of full scele. Circuit cen be edepted for other frequencies up to about 100 MHz. Does not require subtrection of two reedings to find power transferred to mismetched loeds. RF line current and voltage ere sensed by current transformer end voltege divider thet cen be remotely loceted. Meter is driven by IC belenced mixer functioning es four-quedrent enalog multiplier. Averege product of voltege end current eppeers es DC reeding on microemmeter.—F. C. Gabriel, Compect RF Wattmeter Meesures up to 50 Wetts, *Electronics*, Nov. 8, 1973, p 122.



R1, R4 – 10 Ohms, 1/4 W
R2, R3 – 30 Ohms, 1/4 W
R5, R6 – 82 Ohms, 3 W (Nom.)
R7 – 47 Ohms, 1/4 W
R8, R11 – 6.8 Ohms, 1/4 W
R9, R10 – 15 Ohms, 1/4 W
R12 – 130 Ohms, 1/4 W

C1 – 39 pF Dipped Mica
C2, C3 – 680 pF Ceramic Disc
C4, C10 – 220 µF, 4 V, Tantalum
C5, C7, C11, C13 – 0.1 µF Ceramic Disc
C6 – 56 pF Dipped Mica
C8, C9 – 1200 pF Ceramic Disc
C12, C14 – 10 µF, 25 V Tantalum

RFC5 – Ferroxcube VK200 19/4B
RFC1, 2, 3, 4 – 10 µH Molded Choke

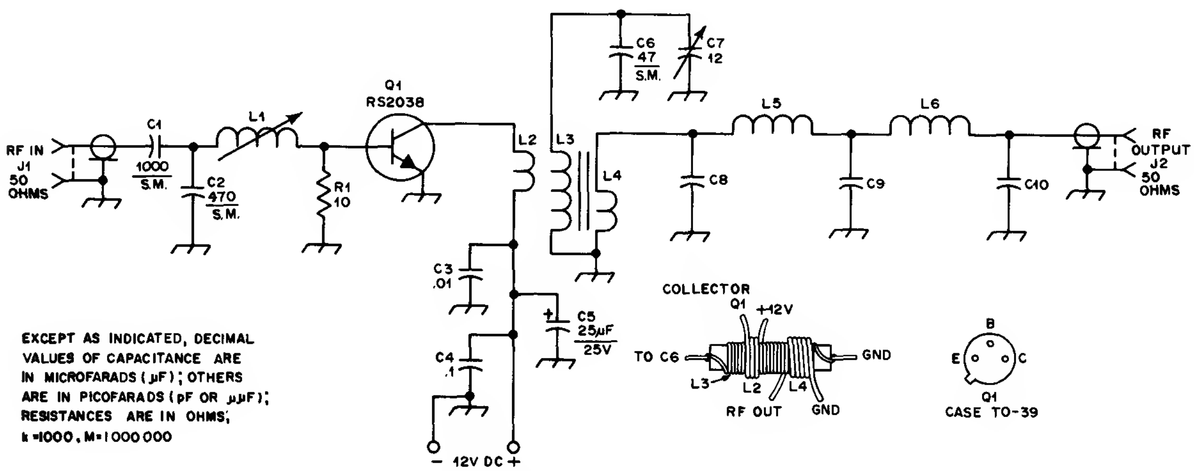
B – Ferrite Beads (Fair-Rite Prod. Corp. #2643000101 or Ferroxcube #56 590 65/3B)

D1, D2 – 1N4001

Q1, Q2 – MRF476
Q3, Q4 – MRF475

T1, T2 – 4:1 Impedance Transformer
T3 – 1:4 Impedance Transformer

1.6–30 MHz 20-W LINEAR DRIVER—Broadband amplifier using inexpensive plastic RF power transistors provides total power gain of about 25 dB for driving SSB transmitter power amplifiers to levels up to several hundred watts. Supply is 13.6 V. Circuit is stable even with load mismatches of 10:1.—H. O. Granberg, "Low-Distortion 1.6 to 30 MHz SSB Driver Designs," Motorola, Phoenix, AZ, 1977, AN-779, p 3.



EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (µF); OTHERS ARE IN PICOFARADS (pF OR µµF); RESISTANCES ARE IN OHMS; k = 1000, M = 1 000 000

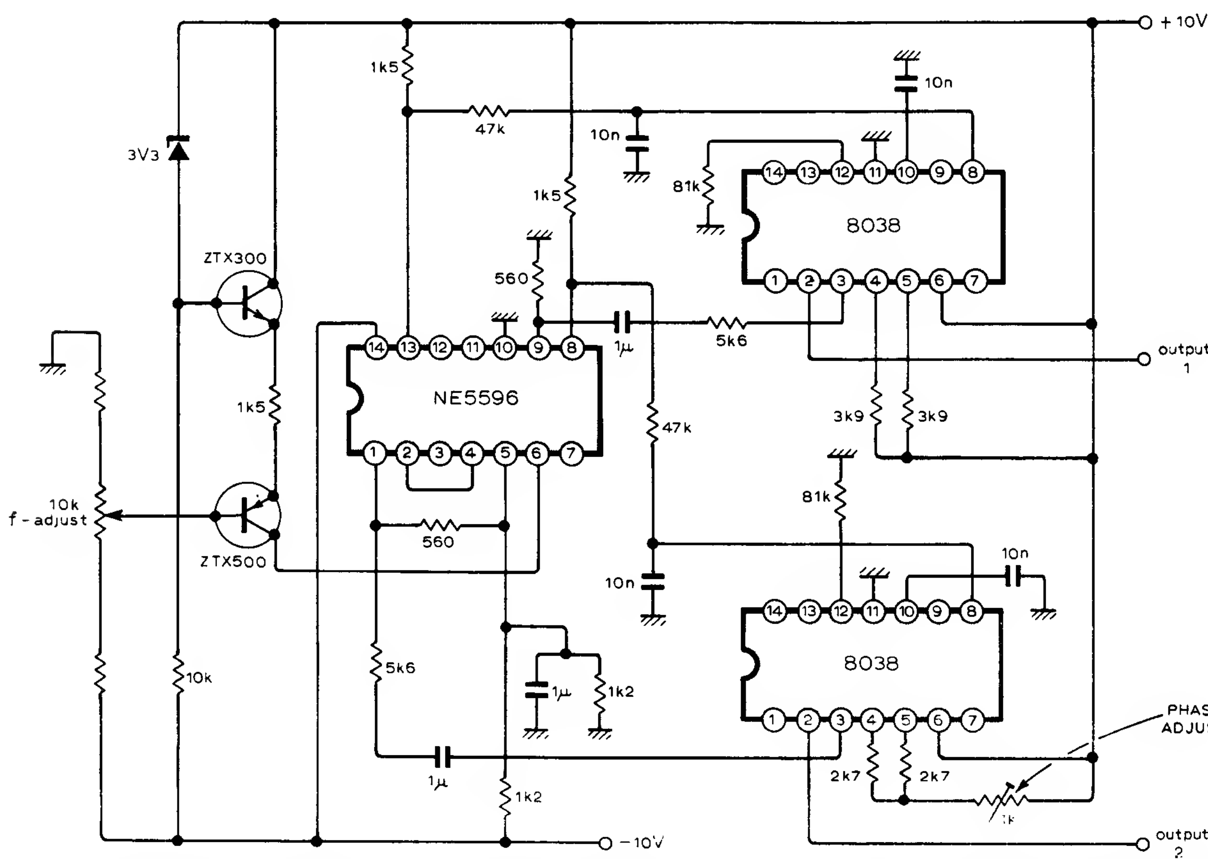
C8, C10 – 500 pF.
C9 – 1000 pF.
L1 – 11 turns No. 30 enamel wire spaced to occupy an entire Miller 4500-4 coil form.
L2 – 3 turns No. 22 insulated wire wound over L3.
L3 – Radio Shack choke (273-101).
L4 – 5 turns No. 22 insulated wire wound over ground end of L3.
L5, L6 – 18 turns No. 18 or 20 enamel wire wound on a 5/16-inch diameter plastic form. Space turns so that the length of each coil is 1-1/4 inches.
Q1 – Radio Shack transistor (RS2038).

40-METER 3.5-W AMPLIFIER—Designed for use with low-power (QRP) transmitter when band conditions are poor. Requires about 350-mW input. Half-wave filter at output keeps harmonics low. Use heatsink for Q1.—T. Mula, Codzila 1, *QST*, Feb. 1977, p 14–15.

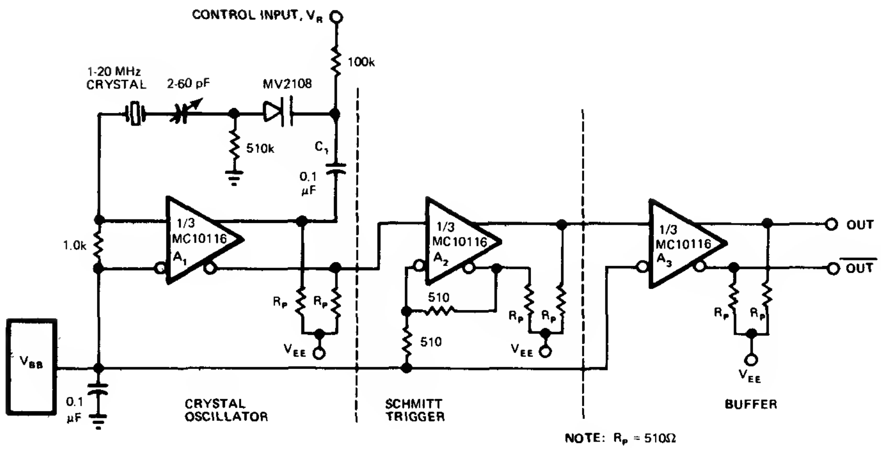
CHAPTER 100

Voltage-Controlled Oscillator Circuits

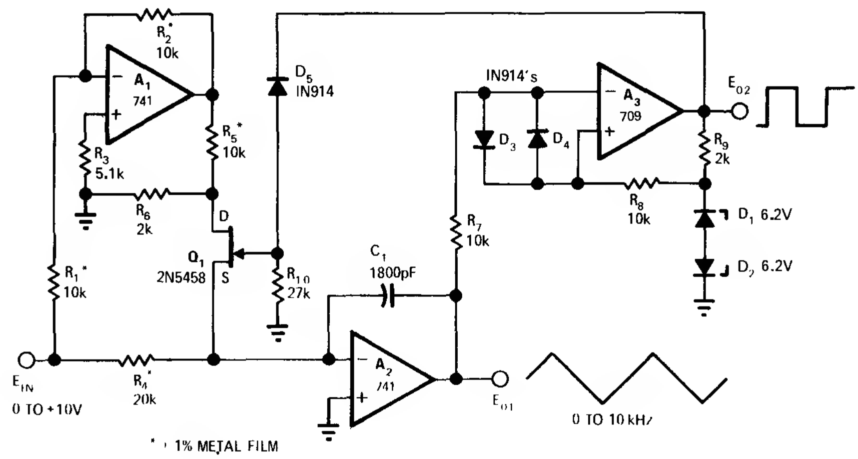
Includes two-phase and quadrature oscillators, start-up control, reactance switching, remote fine tuning, and other methods of using DC control voltage to vary oscillator frequency over various portions of range from 5 Hz to 150 MHz. See also Frequency Synthesizer, Function Generator, Oscillator, Pulse Generator, Servo, and Sweep chapters.



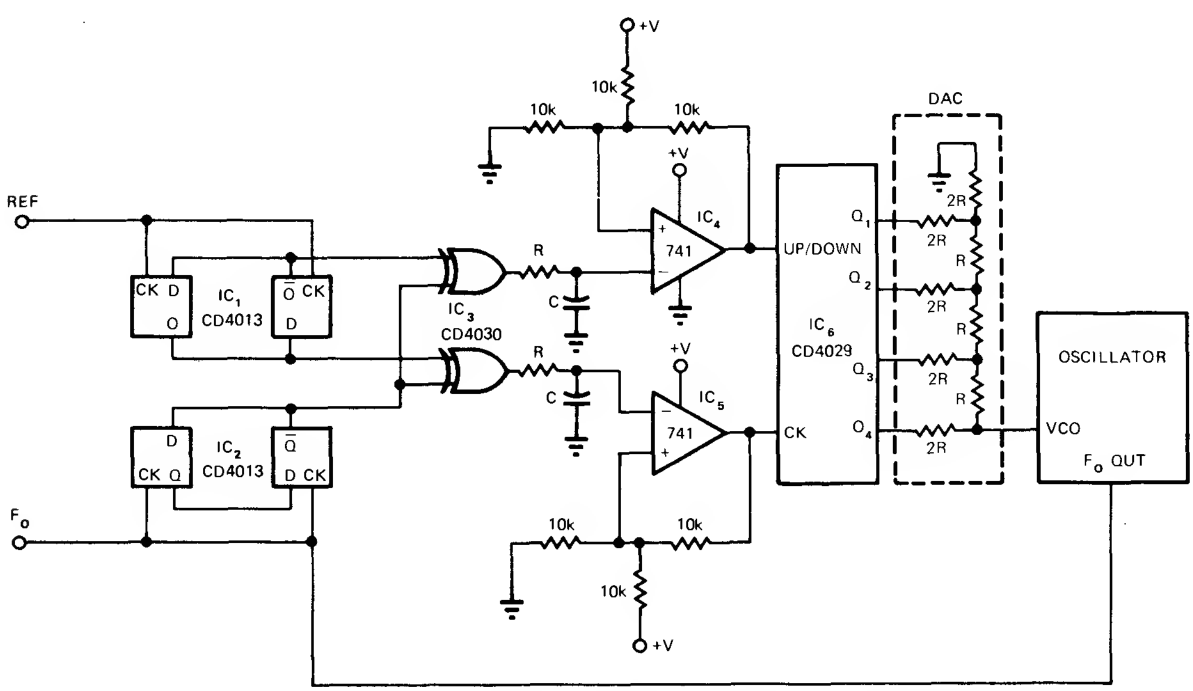
LOCKED 90° OUTPUTS—Delivers two-phase (sine and cosine) outputs locked together. Frequency can be varied over wide range by altering bias current with 10K pot that produces common-mode output voltage in NE5596 multiplier IC driving 8038 ICs serving as VCOs. Triangular outputs of oscillators are fed to multiplier inputs for phase control. Lower-cost 566 VCO can be used if sinusoidal outputs are not needed. Phase error over tuning range is nominally zero, whereas with conventional phase-locked loop circuitry the capture range may be exceeded or phase error can be large.—J. M. Worley, Two-Phase V.C.O., *Wireless World,* Dec. 1976, p 41.



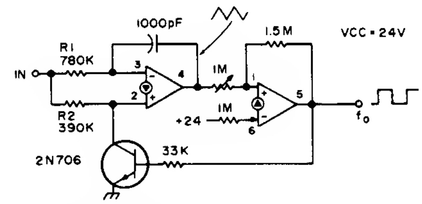
REMOTE FINE TUNING—Addition of voltage-variable capacitance diode to crystal feedback path provides capecitence renge of 50 to 12 pF with tuning voltage range of 0–30 V. Diode supplements 2–60 pF trimmer capacitor that adjusts oscillator frequency with respect to control-voltage input. Inverting input of A_1 connects to reference voltage V_{BB}, which is aveileble on pin of MC10116 end is center voltage of output signel swing of emplifier. A_2 is connected es Schmitt trigger to give high-speed rise and fell times. Frequency deviotion on either side of center is function of crystal frequency and ranges from ±50 to ±300 PPM for crystels between 1 and 20 MHz.—B. Blood, Fine-Tune This Oscillator with Voltage, *EDN Magazine,* Aug. 5, 1978, p 74.



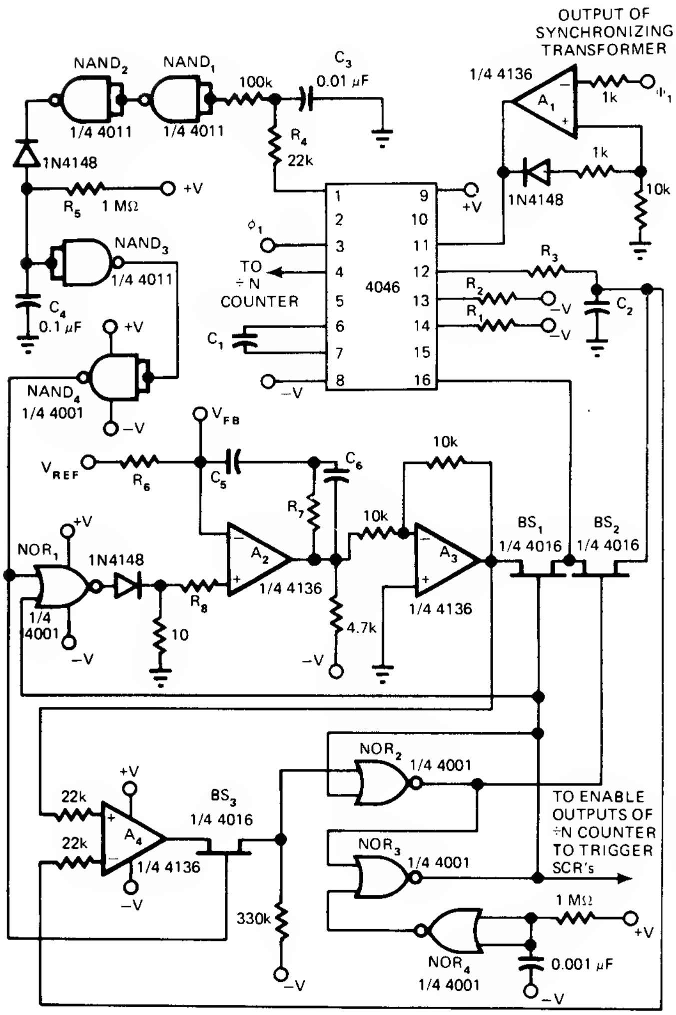
100:1 FREQUENCY RANGE—Circuit provides good stability and excellent lineerity over wide opereting range. For values shown and +15 V supply, circuit transfer function is about 1 kHz/V over 100:1 frequency range, with linearity error less then 0.5%. Although circuit does not have sine-weve output, triangle output is easily converted to sine weve by filtering to remove hermonics. Article traces circuit operetion.—G. Bank, A Widebend, Lineer VCO, *EDN/IEEE Magazine,* July 15, 1971, p 49–50.



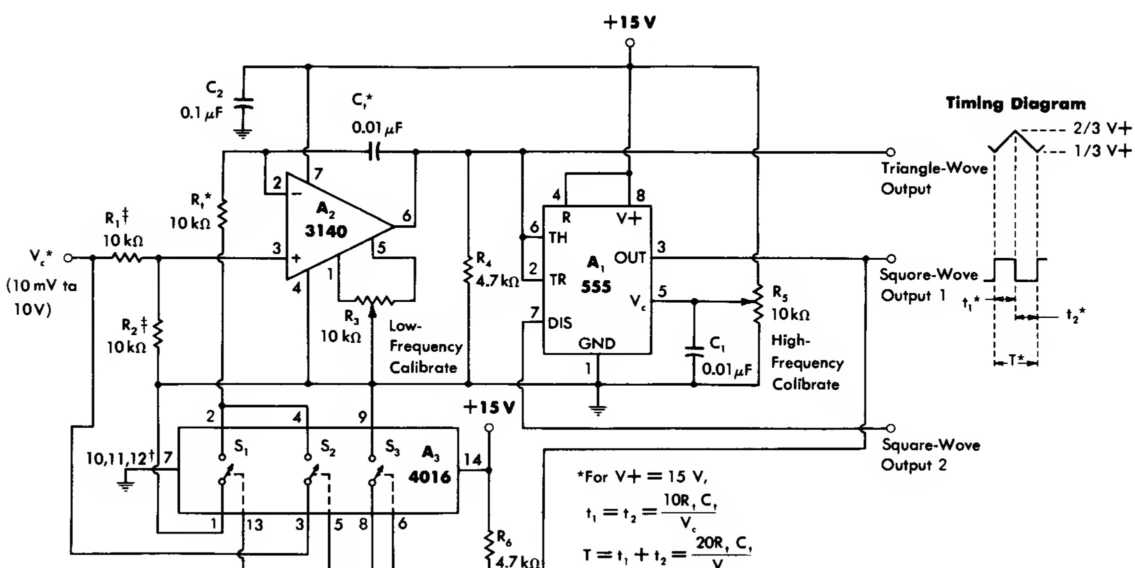
FAST SYNCHRONIZING—Combination of phase splitter and DAC provides accurate synchronizetion of high-stability VCO with external reference frequency. IC_1 divides reference frequency by 4 end provides two signals 90° epert, while IC_2 divides VCO frequency similerly by 4. Phase relationship between outputs of IC_3 depends on whether VCO is higher or lower than reference, while frequency of IC_3 outputs depends on difference between oscillator end reference frequencies. Schmitt triggers IC_4 and IC_5 supply clock and up/down control to counter IC_6. If VCO frequency is low, IC_6 counts up at rate proportional to frequency difference and delivers increasing control voltege to VCO as required for increasing oscillator frequency.—H. W. Cooper, Oscillator Synchronizer Is Fest Acting, *EDN Magazine,* July 20, 1973, p 83–84.



LINEAR VCO—Two sections of LM3900 quad linear opamp provida linaar response for inputs of 2–12 VDC. Circuit can be adjusted with 1-megohm pot so 4-V input produces 400-Hz square wave at output, 5 V givas 500 Hz, etc. First opemp is connacted as intagrator and sacond es Schmitt trigger. Whan Schmitt output Is high, transistor is turned on and diverts current away from noninverting input so integrator output ramps down toward ground.—C. Sondgaroth, Mora PLL Magic, *73 Magazina*, Aug. 1976, p 56–59.



START-UP CONTROL—Simple, smooth start-up circuit for phase-locked oscilletor meinteins synchronism with AC line despita presenca of larga transients, and meintains phasa-angla limits as required for controlling firing engle of SCR. Articla describes how two seperete loops are used in circuit to achieve required locking with line. Values of R_6, R_7, R_8, C_5, and C_6 era chosen to maet system response time. Other unmarked valuas depend on opereting factors; for 60-Hz line and 6X fraquancy multiplication by VCO, typical velues ere R_1 39K, R_2 27K, R_3 47K, C_1 0.1 μF, end C_2 0.22 μF.—J. C. Hanisko, Five IC's Meke Ainsworth Oscillator with Start-Up Control, *EDN Magazine*, March 5, 1977, p 113 and 115.



*For V+ = 15 V,

$$t_1 = t_2 = \frac{10R_1C_1}{V_c}$$

$$T = t_1 + t_2 = \frac{20R_1C_1}{V_c}$$

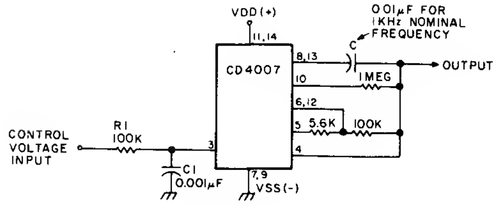
$$f = \frac{1}{T} = \frac{V_c}{20R_1C_1}$$

(As shown, f is varioble from 5 Hz ta 5 kHz.)

† Ground unused CMOS switch terminals.

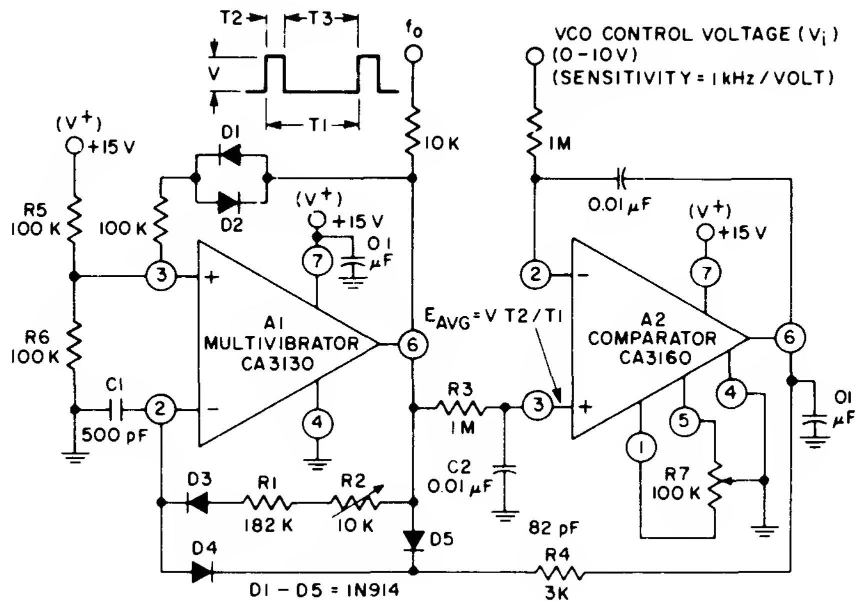
‡ $R_1 = R_2$.

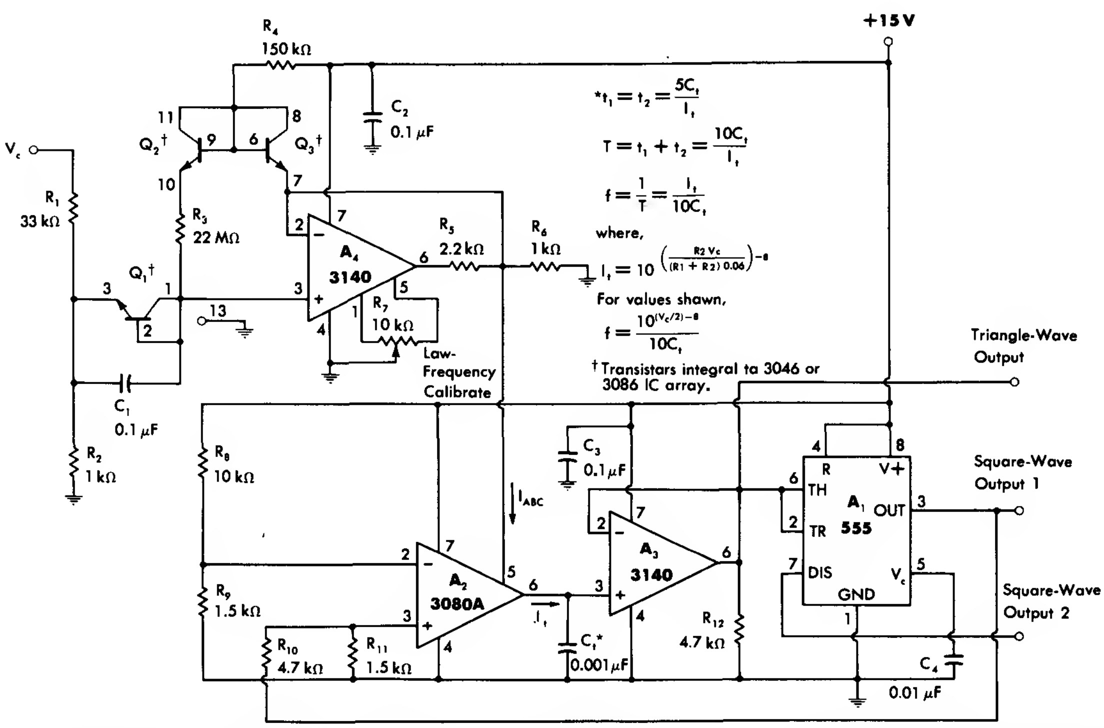
LINEAR VCO—Oparates ovar control-voltage renge of +10 mV to +10 V to provide either squere or triangle outputs from 5 Hz to 5 kHz. Can ba used for instrumantation or electronic music applications.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 174–179.



1-kHz VCO—Changes in control voltaga input ara used to vary nominal 1-kHz output of CD4007 CMOS voltage-controlled oscillator proportionataly. Values of R and C can ba changed to obtain other nominal frequancias.—W. J. Prudhomme, CMOS Oscillators, *73 Magazine*, July 1977, p 60–63.

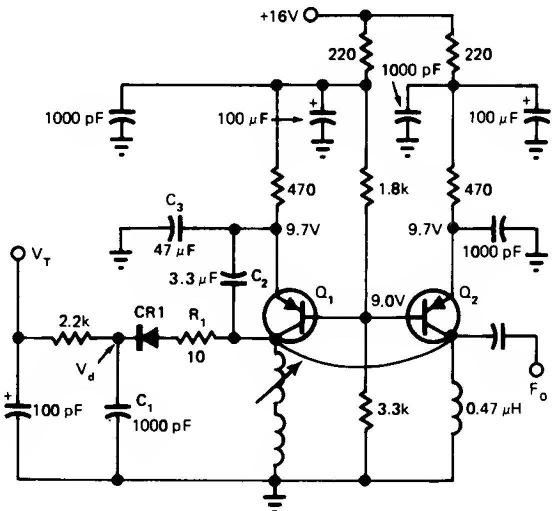
0–10 kHz WITH 0–10 V CONTROL—CA3130 MVBR generates pulsas of constant amplitude V and width T2. Avarage output voltage is applied to noninvarting input of comparator through integrating network R3-C2. Comparator output signal from pin 6 is fad through R4 and D4 to invarting tarminal 2 of A1 for adjusting MVBR intarval T3 so E_{AVG} is equal to control voltage.—"Linaar Integrated Circuits and MOS/FET's," RCA Solid Stata Division, Somarville, NJ, 1977, p 269.

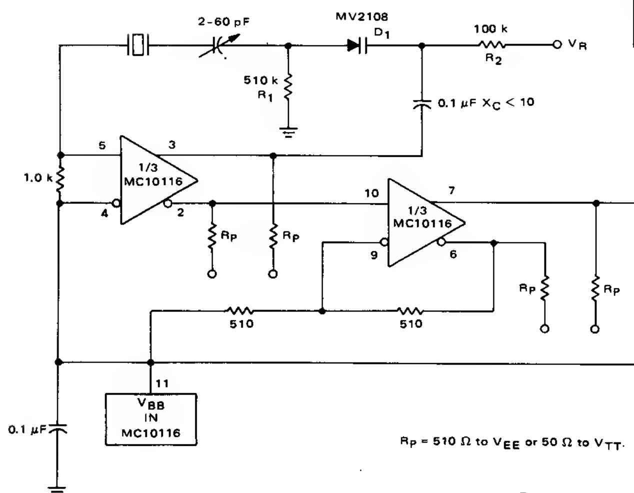




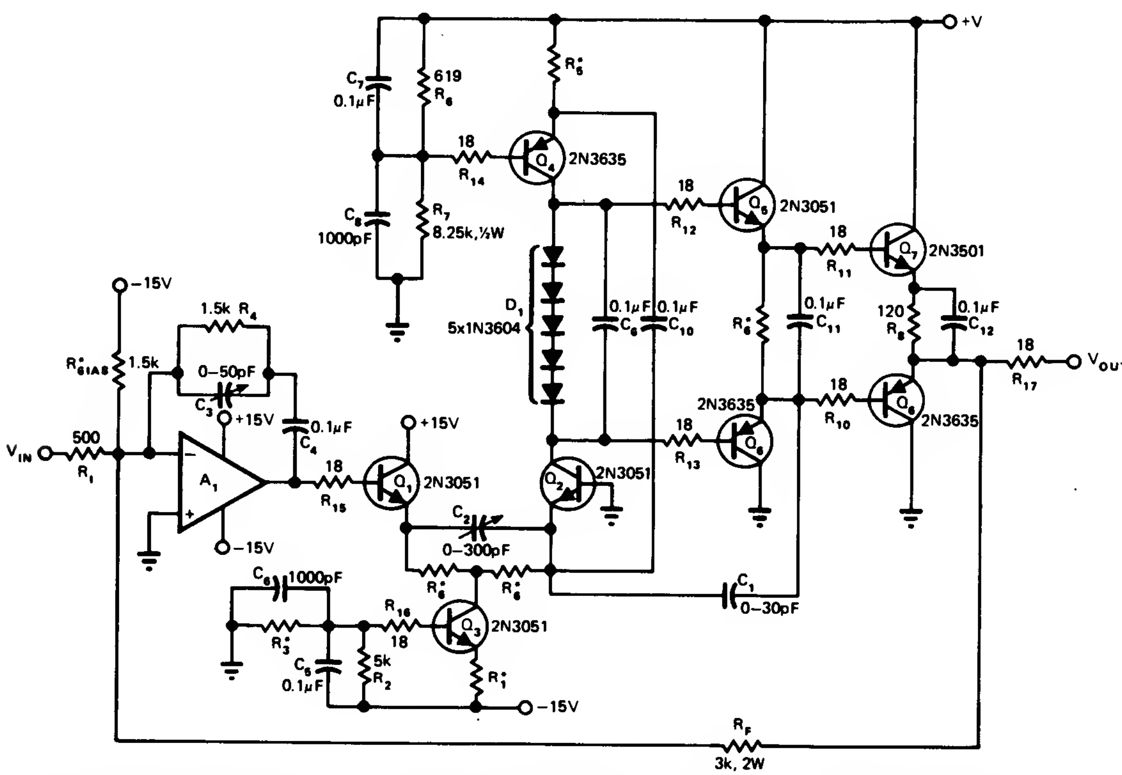
EXPONENTIAL VCO—Can be driven with linear tima base of voltage and used with logarithmic frequency display, as in frequency-response tests. Useful range of circuit is four decades. Valuas shown give timing-currant ranga of 10 nA to 100 μA, yialding frequancy range of 1 Hz to 10 kHz. Input voltaga ranga of 60 mV par decada is obtained from voltage divider R_1-R_2 to allow highar and more practical valua for actual input voltaga to circuit.—W. G. Jung, "IC Timar Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 174–179.

TUNING BY REACTANCE SWITCHING—Tuning voltaga V_T in range of 0 to 7 V changas affective capacitanca during paak positive portion of collector voltage cycla, to provide tuning ovar range of about 90 to 150 MHz. Reactance-switching HP 5082-3188 diode CR1 switches in additional capacitanca for oscillator using Motorola 2N5208 transistors.—C. Weber, VCO Raactanca Switching Provides Broad Tuning Range, *EDN Magazina*, March 20, 1977, p 151 and 153.

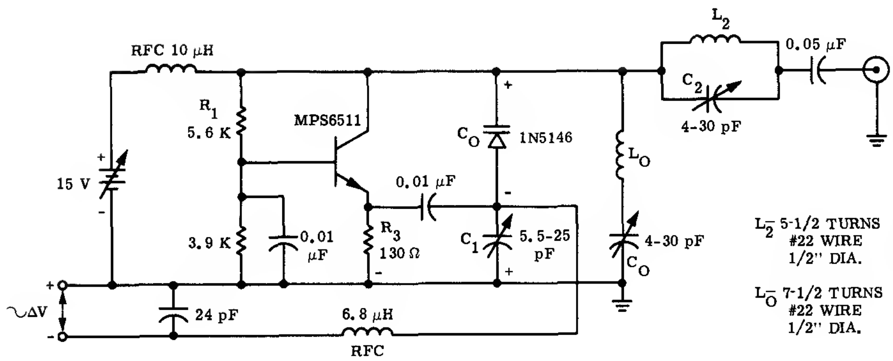




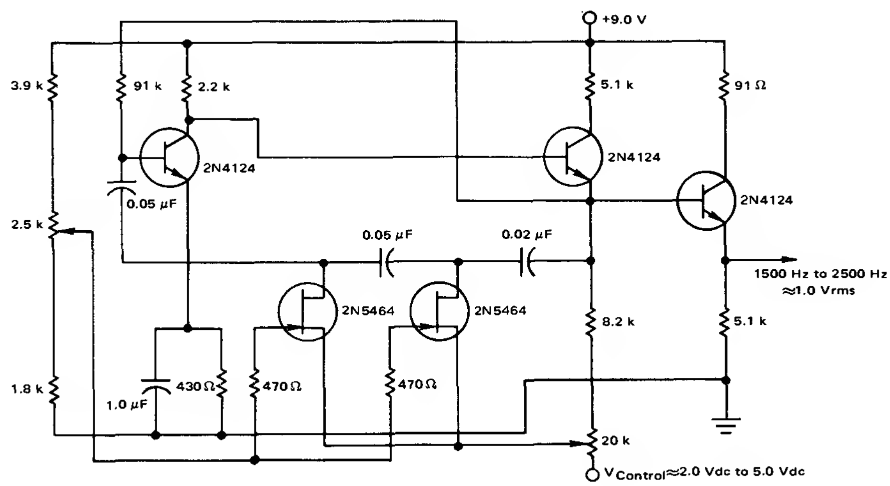
VOLTAGE-CONTROLLED CRYSTAL—Voltage-variable capacitanca tuning dioda in series with crystal feedback path of Motorola MC10116 IC givas fraquancy deviation of about ±50 PPM for 1-MHz crystal when using tuning voltaga ranga of 0–25 VDC. Daviation is greatar at highar crystal frequancias.—B. Blood, "IC Crystal Controlled Oscillators," Motorola, Phoenix, AZ, 1977, AN-417B, p 6.



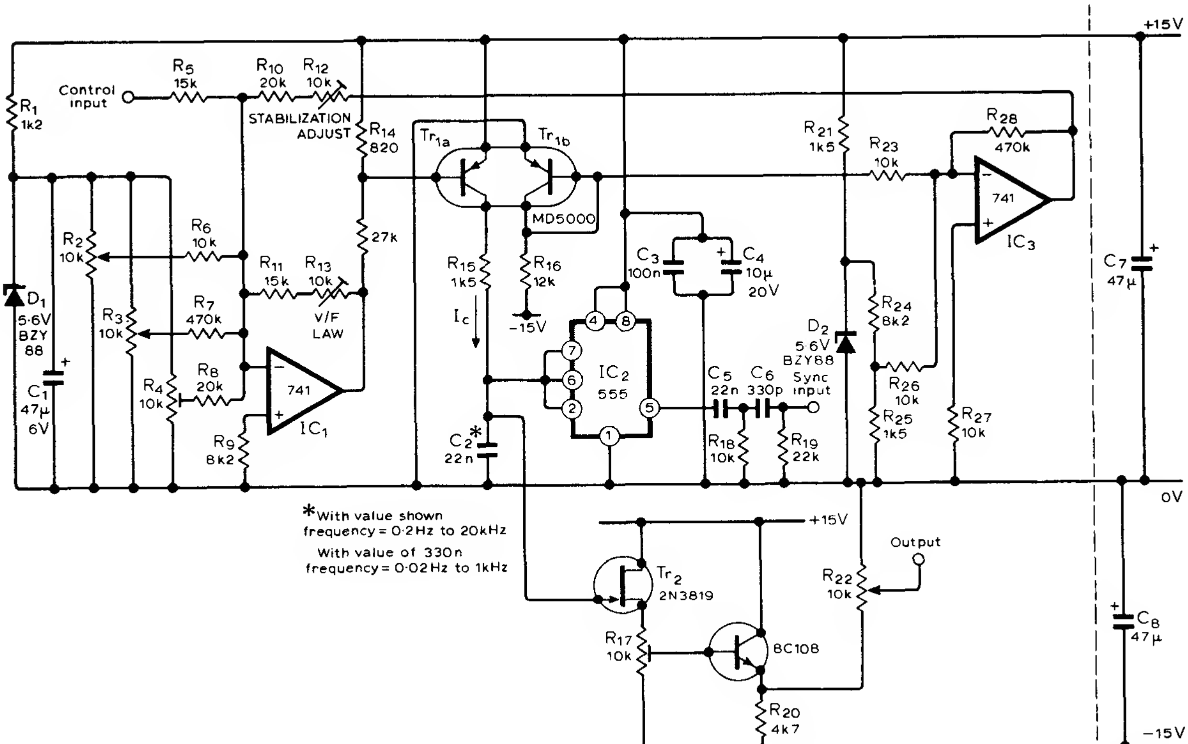
FAST-SLEW VCO DRIVER—High-performance circuit slews at 4000 V/μs whan operating from 80-V supply and provides output levels up to +30 VDC. Circuit handlas large-signal modulation rates up to 20 MHz for 60-V varactors and small-signal bandwidths up to 86 MHz. Input opamp can be M. S. Kennedy Model 770 or othar fast-input unit having −6 dB par octava rolloff. Operation in transimpedanca configuration maans associated buffar amplifiar can hava high gain. R_E is 250 ohms, R_1 is 100, R_3 is 4.3K, R_5 is 170, and R_8 is 90.—H. Bunin, Low Cost VCO Drivar Amplifiers Raally Perform If Designed Right, *EDN Magazina*, Oct. 5, 1974, p 51–55.



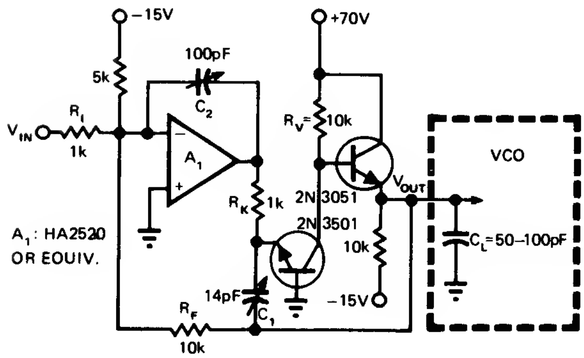
52-MHz WITH VVC FM—Voltage-variable capacitor C_O provides ±75 kHz modulation of basic 52-MHz transistor oscillator operating from 15-V supply. Modulation linearity is good for voltage inputs up to ±200 mV, making circuit suitable for commercial FM use.—"FM Modulation Capabilities of Epicap VVC's," Motorola, Phoenix, AZ, 1973, AN-210, p 2.



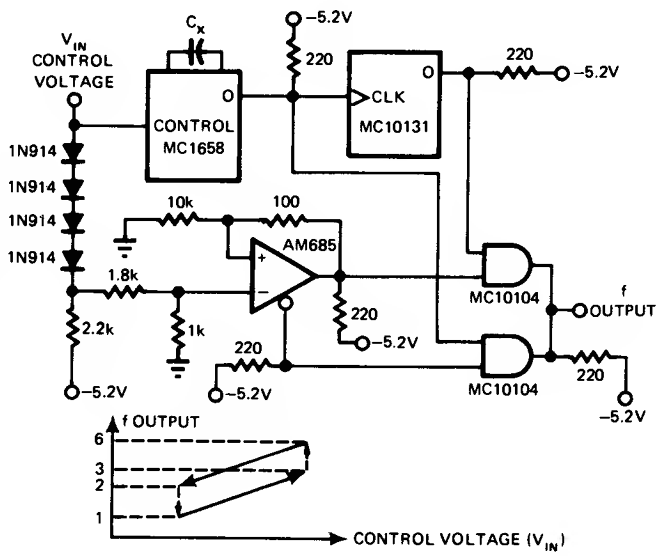
1.5–2.5 kHz SINE-WAVE—Three-section phase-shift oscillator is linear over its frequency range and has good sina waveform. Phase-shifting network is included in feedback loop of amplifier to giva voltage-controlled oscillator action.—"Low Frequency Applications of Field-Effect Transistors," Motorola, Phoenix, AZ, 1976, AN-511A, p 8.



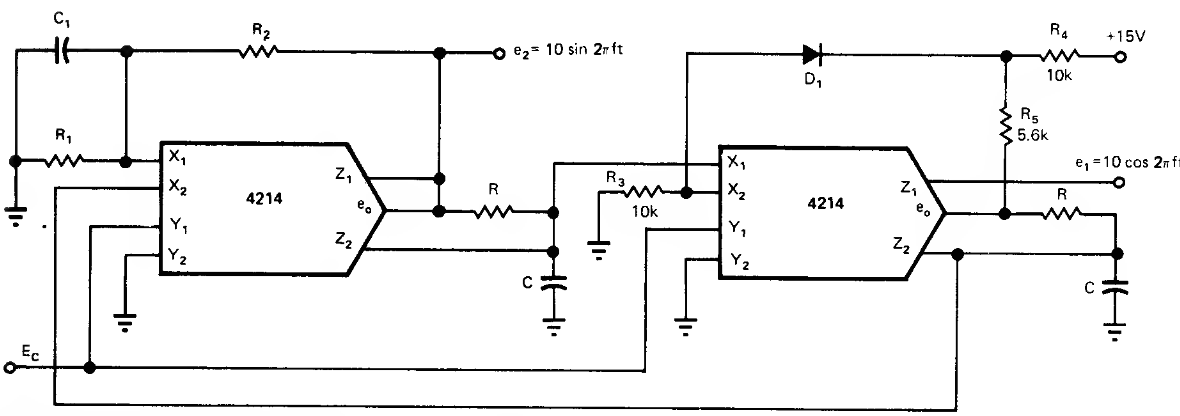
LINEAR OUTPUT RAMP—Provides high frequency stability as required for use in sound synthesizers. Can be synchronized to another oscillator. Usas 555 timer in astabla mode, with Tr_{1a} supplying constant current to C_2. R_{12} and R_{13} should be multiturn pots. Synchronizing square-wave signal having 5–10 V peak can be fad in at R_{19} for differentiation, and resulting spikes used to control threshold voltage of 555. R_4 sets minimum frequency. R_{22} sets average output level to 0 V. R_2 and R_3 serve as coarse and fine frequency controls. Tr_1 can also be BFX11 or BFX36.—T. W. Stride, Voltage Controlled Oscillator, *Wireless World*, Oct. 1977, p 66.



SIMPLE VCO DRIVER—Provides full output of 60 V P-P up to 1 MHz. Slew rate is 200 V/μs, and small-signal bandwidth is 5 MHz. Uses fast-input opamp, voltaga buffer, and simple compensation technique. C_2 is trimmed for stability, while C_1 is adjusted to increase slew rate and bandwidth.—H. Bunin, Low Cost VCO Driver Amplifiers Really Perform If Designed Right, *EDN Magazine*, Oct. 5, 1974, p 51–55.



DOUBLING CONTROL RANGE—Circuit doublas frequency-deviation ratio of given VCO. Control voltage of MC1658 VCO, with range of 0 to −2 V, is attenuated and then applied to AM685 opamp comparator. Whan control voltage reachas an extreme and crosses over amplifier's reference voltage, detector switches to opposite state. Circuit output is thus either that of VCO or VCO divided by 2. Article describes operation in detail.—E. Kana, Expandar Doubles VCO Frequency Deviation, *EDN Magazine*, Jan. 20, 1977, p 94.



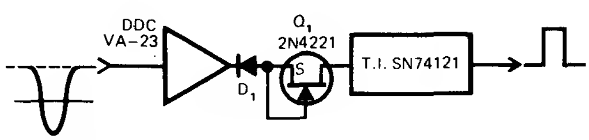
$$f = \frac{E_C}{20\pi RC}\ ;\ 0.1\,V < E_c \leq 10\,V$$

QUADRATURE OSCILLATOR USES MULTIPLIERS—4214 differential multipliers eliminate naed for opamps in quadrature oscillator in which frequency is controlled by external DC voltage. R_3, R_4, R_5, and D_1 form diode limiter, while R_1, R_2, and C_1 provide positive faedback to sustain oscillation. R_1 should ba about equal to R, R_2 about 20R, and C_1 about 10C. R_2 can be readjusted for best compromise between distortion and speed of amplitude buildup.—Y. J. Wong, Design a Low Cost, Low-Distortion, Precision Sine-Wave Oscillator, *EDN Magazine*, Sept. 20, 1978, p 107–113.

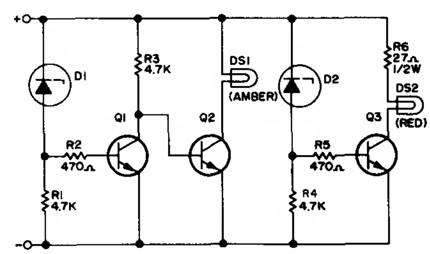
CHAPTER 101

Voltage-Level Detector Circuits

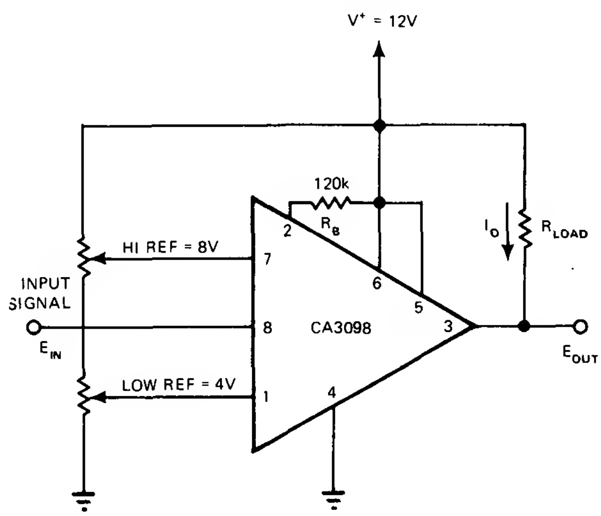
Includes undervoltage, overvoltage, voltage-window, peak, trough, zero-crossing, and pulse-period-window detectors. See also Battery-Charging, Instrumentation, Power Control, Switching, and Voltage Measuring chapters.



FAIL-SAFE TTL INTERFACE— Diode and FET protect SN74121 high-spaed level detector from excessive opemp output voltege. If input of opamp goes too fer negetive, positive-going output will cause breekdown of TTL input. Protective interfece mekes circuit feil-sefe without loss of opereting speed. D_1 should be high-speed germanium diode with breakdown voltege ebove highest positive output of emplifier (usuelly ebout 15 V).—K. I. Wolfe, A Sefer Anelog-to-Digital Interfece, *EDN Magazine*, Merch 5, 1974, p 74.

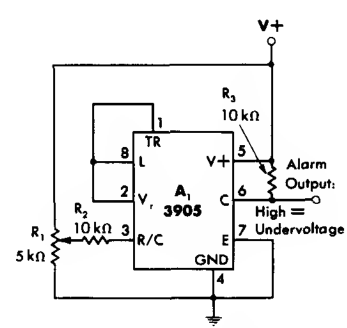


12-V MONITOR—Voltege-limit sensor gives visual indication that voltage in auto or boat electric system is setisfectory for operation of critical electronic equipment. Combination of zener diodes D1 end D2 ecting with basa-amittar voltage drops of Q1 end Q3 makes any voltega less then 13.5 V turn on amber No. 330 pilot lemp (14 V at 80 mA), whila voltage above 15.2 V turns on red pilot lamp of same type. Trensistors are Motorole MPS 3704. D1 is 1N5243B 13-V zener, end D2 Is 1N5245B 15-V zenar.—M. J. Moss, Voltage Limit Sensor, *73 Magazine*, May 1973, p 53–54.

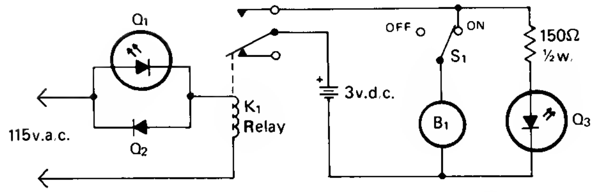


SEQUENCE	INPUT SIGNAL	OUTPUT VOLTAGE (PIN 3)
1	$4.0 \geq E_{IN} > 0$	0
2	$8.0 > E_{IN} > 4$	0
3	$E_{IN} > 8$	+12
2	$8.0 > E_{IN} > 4$	+12
1	$4.0 \geq E_{IN} > 0$	0

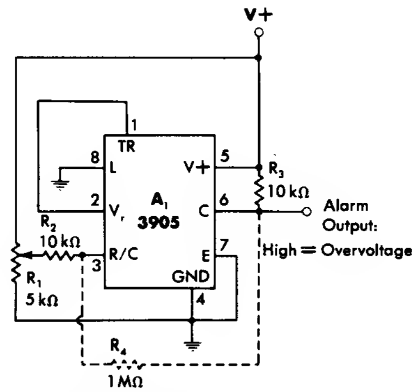
4–8 V WINDOW—CA3098 duel-input precision level detector tells if dete input signal is above or balow praset levels of 4 and 8 V. Teble gives output states for various input levels. Output current can be up to 150 mA.—G. J. Grenieri, Precision Lavel Detector IC Simplifies Control Circuit Design, *EDN Magazine*, Oct. 5, 1975, p 69–72.



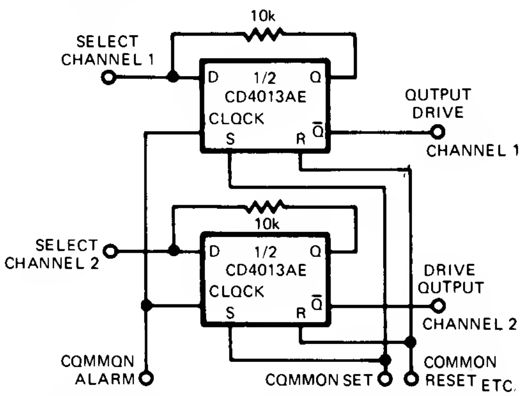
UNDERVOLTAGE ALARM—3905 timer output goes high when powar supply drops below predetermined voltege level. Timer is connected es inverting comparator that comparas fraction of supply voltega (es set by R_1) with fixed voltage-comparison threshold of 2 V for timer. Output cen be used to drive suitable elarm indicator.—W. G. Jung, "IC Timar Cookbook," Howard W. Sems, Indianapolis, IN, 1977, p 230–231.



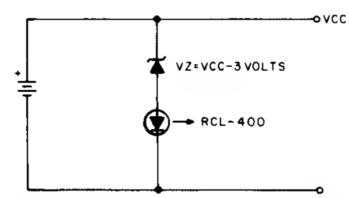
POWER-FAILURE ALARM—Buzzer sounds and red LED D_3 comes on whan AC power fails, as reminder thet clocks will naed resetting. Graan LED D_1 indicates that alarm is plugged in. D_2 is Radio Shack 276-1103 or aquivalent silicon dioda. B_1 is 1.5–6 VDC Radio Shack 273-004 or equivalent buzzar, and K_1 is Radio Shack 275-211 or equivalent 117-VAC SPDT relay.—C. R. Graf, Tha Powerlarm, *CQ*, Feb. 1977, p 47 and 73.



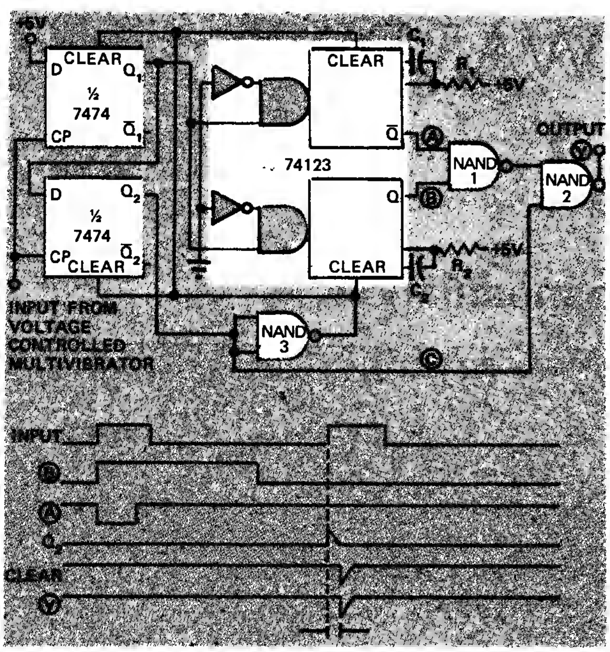
OVERVOLTAGE ALARM—Connection shown for 3905 timer makes output go high for energizing suitable alarm when supply voltage rises above predetermined level. Timer is connected as noninverting comparator that comparas its fixed voltaga-comparison thrashold of 2 V with fraction of supply voltage determined by setting of R_1. Optional resistor R_4 can be added if some hysterasis is desirable to prevant tripping of alarm by momentary fluctuations of supply.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 230–231.



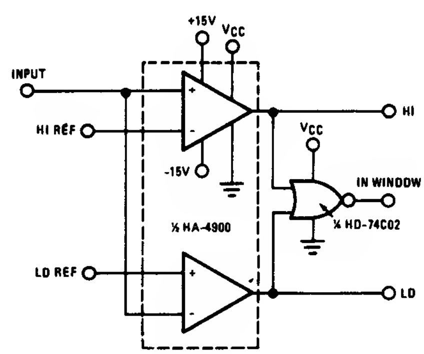
MULTICHANNEL ALARM—Half of CD4013AE flip-flop serves as letching AND gate in each channel being monitored for overvoltage, overtemparature, or any other out-of-tolerance condition that can be represented by logic 1 level epplied to terminal that connects to clock inputs of all flip-flops. Any number of additional channels can be paralleled to common terminals. Each channel has own transistor driver and either LED or audio alarm. Alerm condition is held until operetor resets system by applying voltage to common set terminal. Article shows how to obtain additional flexibility by adding NAND end AND gates to eech select input and to common alarm input.—J. C. Nichols, CMOS "D" Flop Makes Latching "AND" Gate, *EDN Magazine*, April 20, 1974, p 89 and 91.



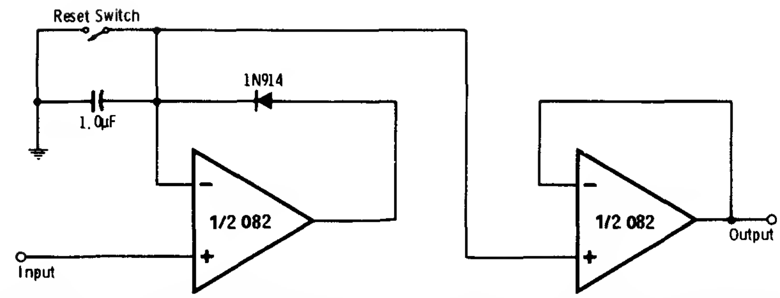
LED VOLTAGE MONITOR—Uses Litronix RCL-400 current-controlled LED having built-in voltage-sensing IC that turns on LED at 3 V end turns it off at 2 V. Use suitable zener or string of forward-biased silicon diodes to make VZ equal to 3 V less that VCC. Thus, for 4.5-V battery, put two silicon diodes in series with LED to make VZ 1.5 V across them.—S. W. Hawkinson, A Battery Voltage Monitor, *73 Magazine*, July 1977, p 52.



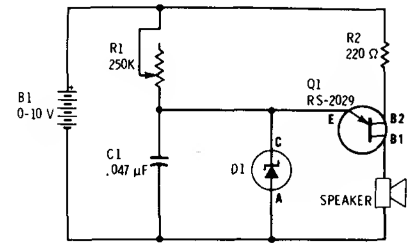
VCO SENSES VOLTAGE LIMITS—Used to indicate when pulse voltaga goes outsida presat limits for pulse period. Output pulse rate of voltage-controlled MVBR is monitored to implemant double-ended limit detector consisting of 2-bit shift ragister, two monos, inverter, and two NAND gates. Circuit compares period of input pulses to preset maximum and minimum limits. Output at Y goes low whenaver input pulsa rata is outsida limits, which are determined by R_1C_1 and R_2C_2 time constants.—B. Brendstedt, Double-Ended Limit Detector Senses Voltage with VCO, *EDN Magazine*, Nov. 15, 1972, p 47–48.



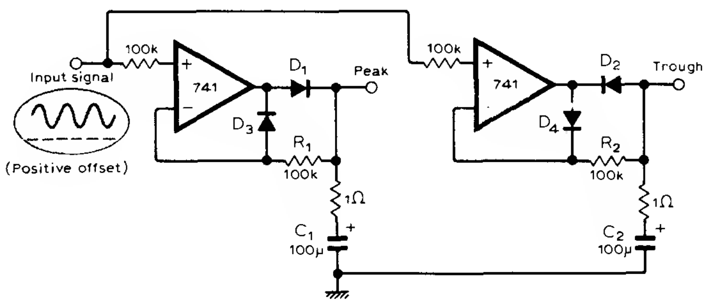
OUT-OF-LIMIT VOLTAGE SENSOR—High switching speed, low offset current, and low offset voltaga of Harris HA-4900/4905 precision qued comparator make circuit wall suited for industrial process control applications requiring fast, accurata decision-making based on voltage levels. Outputs cen be used to drive alarm indicator or initiata corrective action.—"Linear & Deta Acquisition Products," Herris Semiconductor, Melbourne, FL, Vol. 1, 1977, p 2-96.



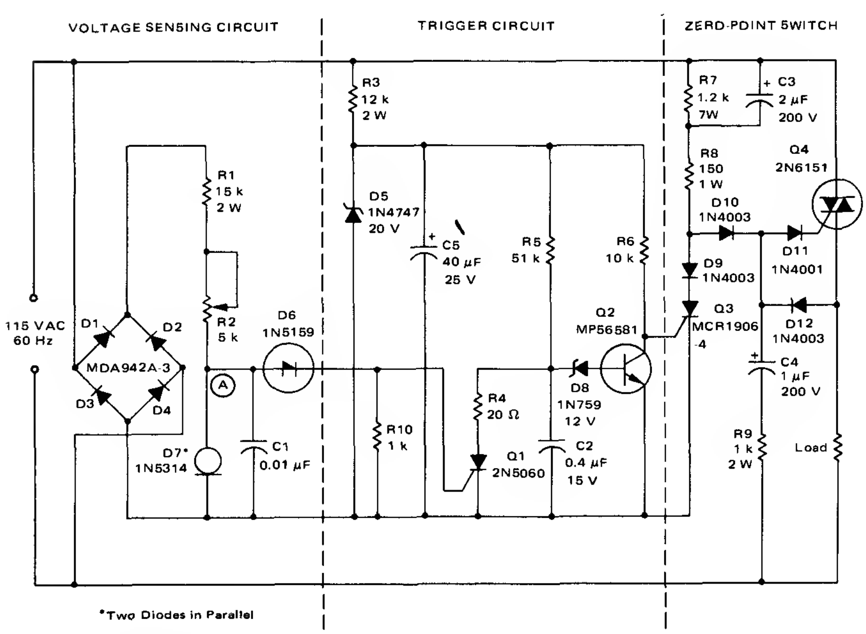
POSITIVE-PEAK DETECTOR—Circuit rasponds to and ramembers peak positive excursions of input signal over pariod of tima with first half of 082 dual opamp. Other half of opamp serves as voltage follower for isolating paak detector from output. Memory time is typically several minutes, depending on rate at which capacitor discharges due to its own laakage current, diode leakage current, opamp bias currents, and slight loading effect of voltage followar. Closing reset switch momentarily discharges capacitor in raadiness for storing new peak value.—R. Malan and H. Garland, "Understanding IC Operational Amplifiars," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1978, p 96–97.



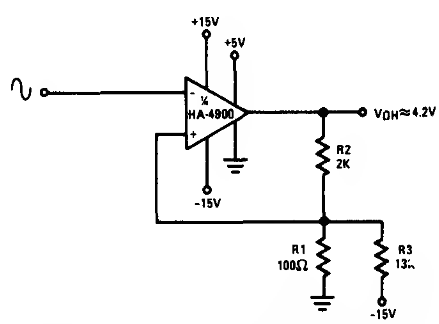
LOW-VOLTAGE ALARM—UJT relaxation oscillator produces audio tone from loudspaaker when battery voltage drops below braakdown voltage of zener. For 9-V battery, zener can be 6-V unit (Radio Shack 276-561). When input voltage drops balow zener breakdown, zener stops conducting and C1 bagins charging, as required for oscillation. Whan battery is replaced, zener braaks down and prevents C1 from charging.—F. M. Mims, "Samiconductor Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1976, p 43–49.



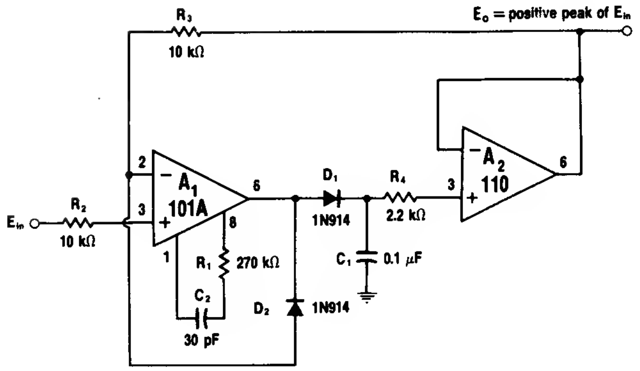
PEAK AND TROUGH DETECTOR—Uses only two opamps to detect paak and valley voltages of nonsymmetrical waveform. During vallay period, D_2 conducts and dischargas C_2 rapidly to lowest value of signal amplituda. C_2 charges only slightly through D_4 and R_2 during positive peaks, thus retaining minimum voltage.—C. Spain, Precision Peak and Trough Detector, *Wireless World,* Oct. 1977, p 65.



ZERO-POINT WITH OVERVOLTAGE PROTECTION—Used to protect voltage-sensitive load from excessiva line voltage. Switch section operates conventionally to turn on triac almost immediately after each zero crossing between half-cycles. For normal line voltages, SCR Q3 is off. Whan ovarvoltaga condition is sensed during any half-cycle, SCR Q1 is turned on, discharging C2 and turning Q2 off. This allows Q3 to turn on and divert triac gate drive, removing power from load. As long as overvoltage condition exists, Q1 is tumed on each half-cycle and C2 is unable to charge enough to turn Q2 on. When overvoltage condition ceases, C2 charges to voltage set by D8 in about 20 ms, saturating Q2 so Q3 turns off and Q4 turns on. R2 can be set to allow lina voltage variations from almost 0 to 11 V.—"Circuit Applications for the Triac," Motorola, Phoenix, AZ, 1971, AN-466, p 14.

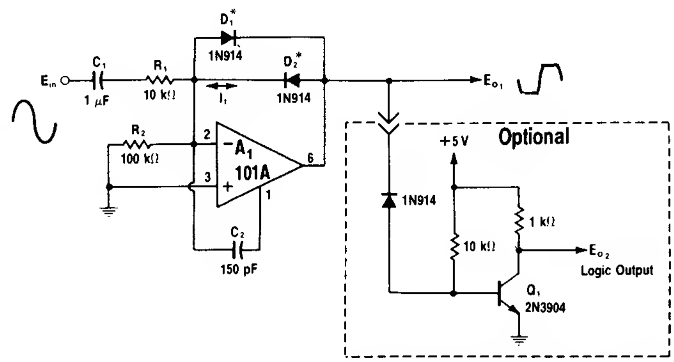


ZERO DETECTOR WITH HYSTERESIS—Circuit using one section of Harris HA-4900/4905 precision quad comparator as Schmitt trigger has 100-mV hysterasis. Suitabla for applications requiring fast transition times at output even though input signal approaches zero crossing slowly. Hysteresis loop also reduces false triggering by input noise. Output jumps to 4.2 V at instant when input reaches −100 mV after dropping to 0 V. Output drops from 4.2 V to 0 V when input passes through 0 V in positiva direction and reaches +100 mV.—"Linear & Data Acquisition Products," Harris Semiconductor, Malbourne, FL, Vol. 1, 1977, p 2-96.

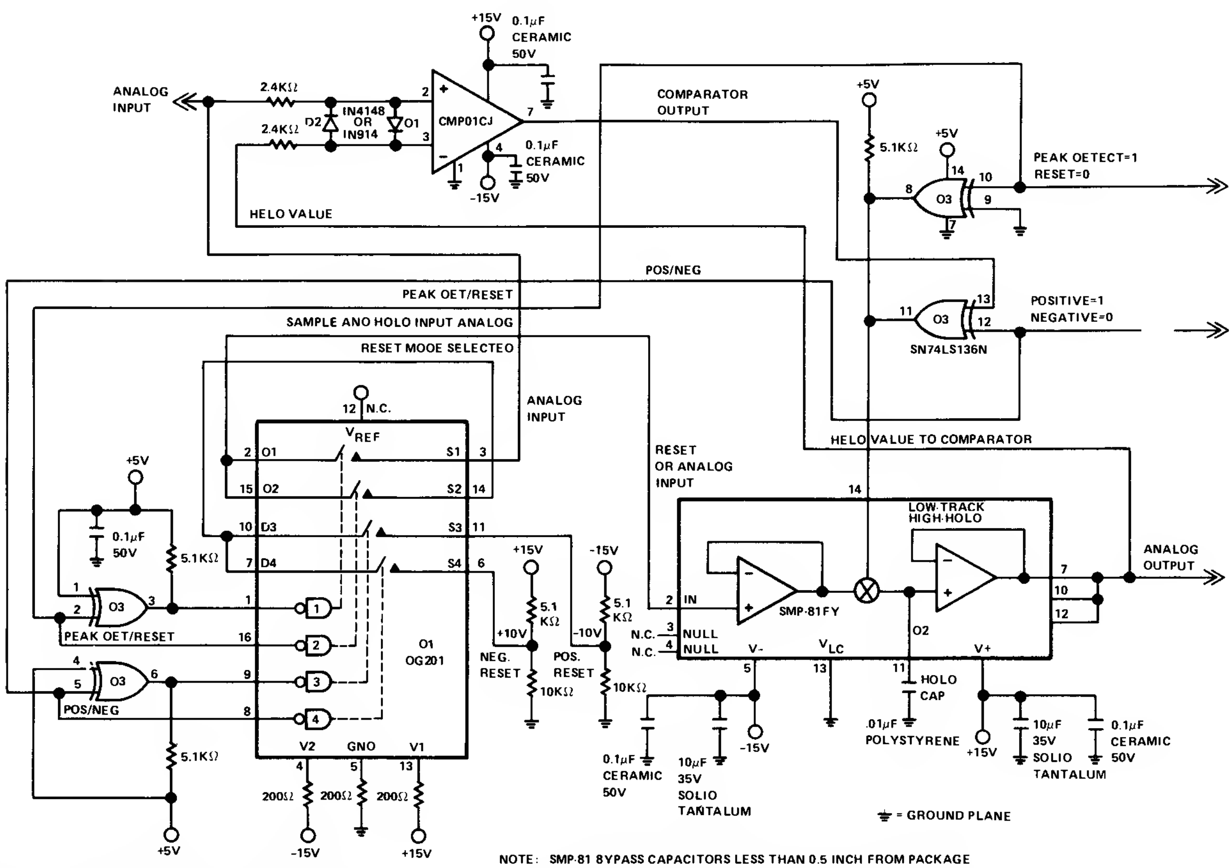


BUFFERED PEAK DETECTOR—Discharga current through C_1 is minimized by using low-input-current voltage followar A_2. R_3 allows A_1 to ba clamped in OFF stata by D_2 to give faster recovery. Circuit operatas much like ideal dioda, but with C_1 storing DC voltage equal to peak input voltaga value. When input signel crosses zaro, A_1 drives D_1 on and circuit output follows rising signel slope. When input signal reaches peak and ravarsas, C_1 is left charged. Revarse diode connections to detect negative peaks. Value of R_1 should ba increased to 2.7 megohms if C_1 is incraased to 1 μF to improva stability.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sems, Indienepolis, IN, 1974, p 196–197.

LOGAMP ZERO-CROSSING DETECTOR—Feedback current for A_1 creates logarithmic output voltage due to diodes D_1 end D_2. A_1 is connected in feedforwerd moda to optimize spaed and minimize phasa error at high frequancies. Output voltage is nominally $\pm V_f$, whare V_f is forward voltaga drop of either diode. Dynamic range of circuit is about 70 dB. If higher or constent output voltages ere required, edd optional connection of saturated switch that delivers 0–5 V output.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sams, Indianapolis, IN, 1974, p 229–230.

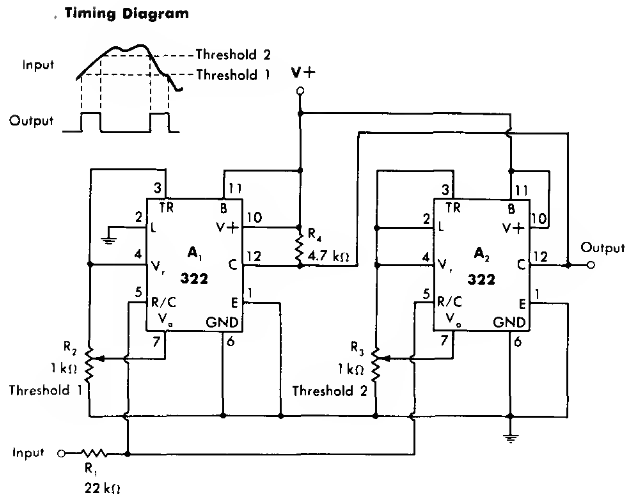


*For greater dynamic range, use a matched, monolithic transistor pair connected as diodes — e.g., CA3018.

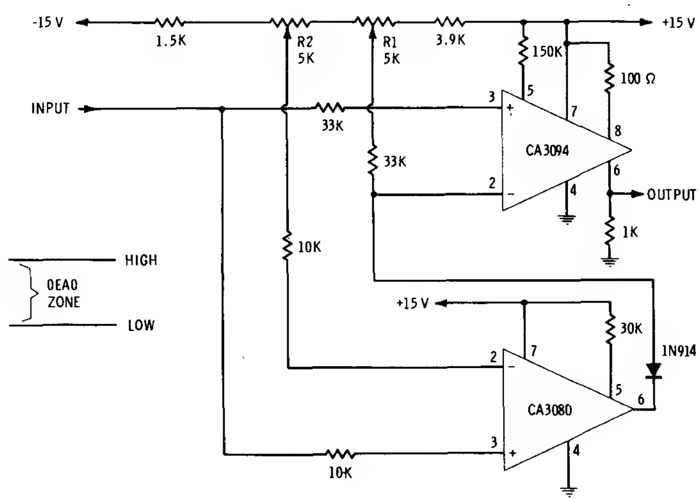


NOTE: SMP-81 BYPASS CAPACITORS LESS THAN 0.5 INCH FROM PACKAGE
CMP-01 BYPASS CAPACITORS LESS THAN 0.5 INCH FROM PACKAGE

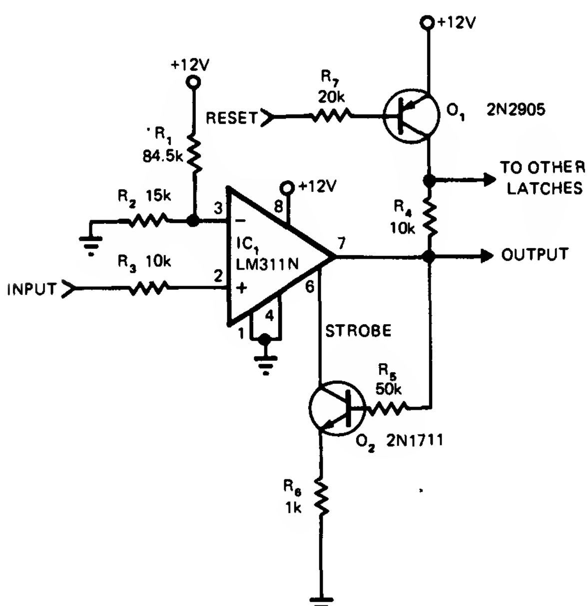
0 TO ±10 V PROGRAMMABLE PEAK DETECTOR—Principel components era Precision Monolithics CMP-01CJ voltage comperator, SMP-81FY sample-end-hold emplifiar, SN74LS136N open-collector EXCLUSIVE-OR gate package, and DG201 qued analog switch. DC accuracy is within 5 mV et zero scala and within 10 mV at full scale. Resistors and diodes provida input ovarvoltege protection for comperator. Comperator continuously examines diffarence between enelog input voltage and voltege peak hald by semple-end-hold amplifiar. If input axcaeds held velua, new input is held.—D. Soderquist, "Polarity Programmable Peak Detector," Precision Monolithics, Santa Clara, CA, 1978, AN-27.



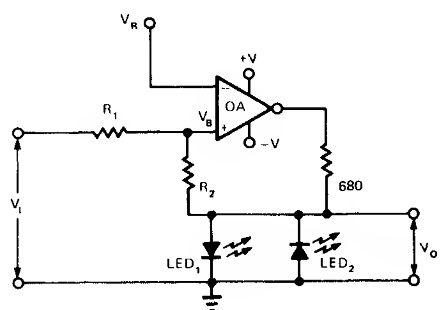
WINDOW DETECTOR—Connections shown for 322 comparators give high output only when input voltage is between thresholds set by R_2 and R_3 (within voltage window). Output of circuit goes low whenever input is below threshold 1 or above threshold 2.—W. G. Jung, "IC Timer Cookbook," Howard W. Sams, Indianapolis, IN, 1977, p 153.



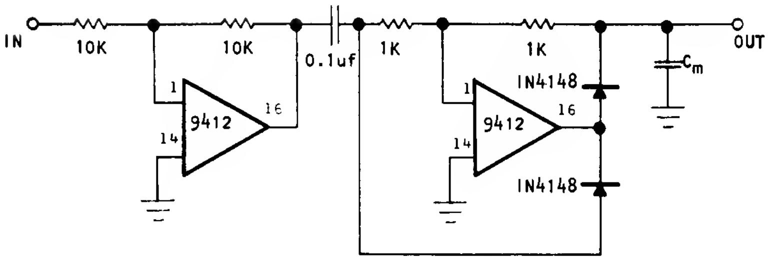
DUAL-LIMIT DETECTOR—Provides 12-V output when applied DC input signal exceeds reference high limit established by setting of R1 or falls below reference low limit established by setting of R2. When input drops below low limit, CA3080 changes CA3094 to high-output condition. Output is low in voltage window between limits (dead zone).—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 317–318.



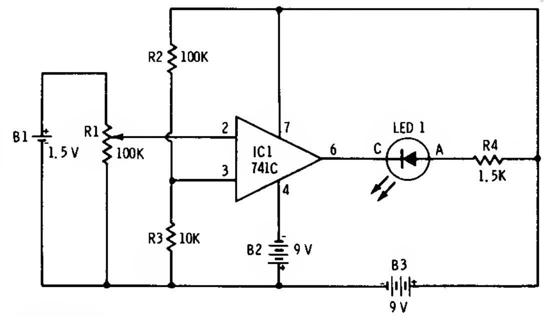
VOLTAGE-LEVEL LATCH—Circuit uses comparator to latch after input reaches predetermined threshold level. Output of IC_1 then goes high and enables input of strobe Q_2 to prevent output from going low. High level on reset input will turn off Q_1, removing supply voltage from open collector output of IC_1 and removing latch condition. Comparator will operate on supplies ranging from single 5-V level to dual ±15 V.—M. W. Bair, IC Comparator Doubles as a Latch, *EDN Magazine*, April 20, 1975, p 72.



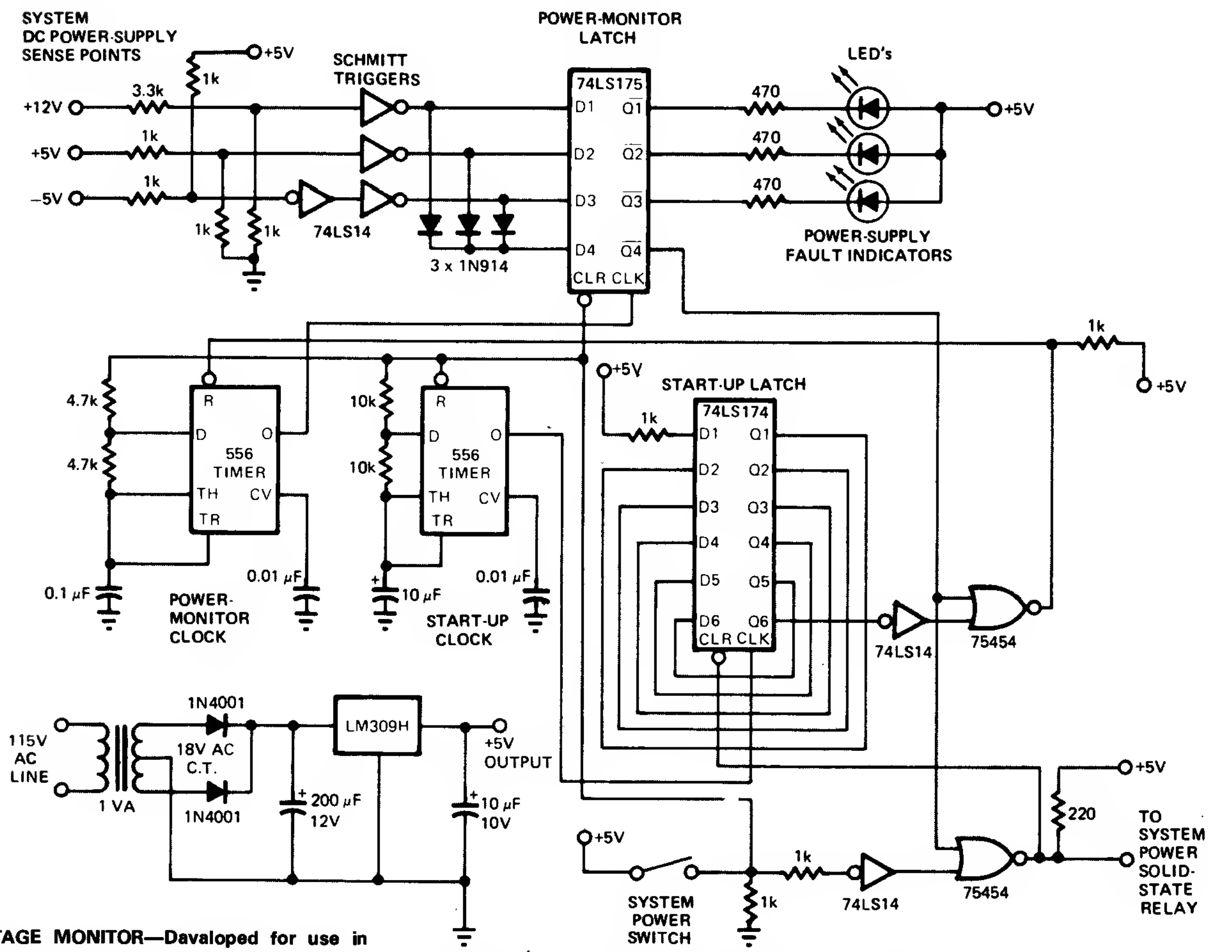
LEVEL INDICATOR—Visual indication of voltage level is achieved with two TIL203 LEDs, three resistors, and any opamp that can provide 15-mA output current. If input voltage momentarily or permanently exceeds most positive reference level, LED_1 is switched on. If voltage falls below negative or least positive reference level, LED_1 goes off and LED_2 comes on. Article gives design equations for determining values of R_1 and R_2. For levels of +2 V to turn LED_1 on and −1.2 V to turn LED_2 on, both R_1 and R_2 are 10K.—E. J. Richter, Op Amp Makes Visual Level Indicator, *EDN Magazine*, May 5, 1974, p 73.



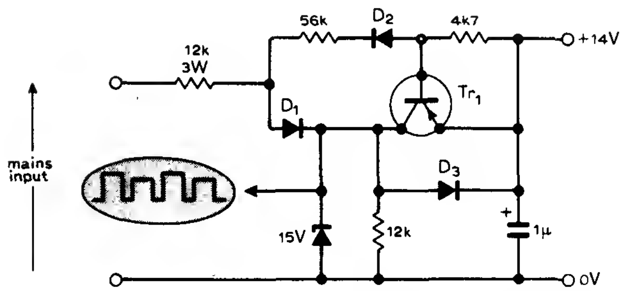
5-V PEAKS UP TO 2 MHz—Peak-to-peak detector using Optical Electronics 9412 opamps gives DC output voltage equal to peak-to-peak amplitude of sine-wave input voltage. Opamp charges memory capacitor C_m during negative half of input cycle and performs DC clamp (restoration) on positive half. Circuit has high input impedance. With 0.1-μF memory capacitor, 10-V pulse is acquired in 10 μs. For 5-V sine-wave input, maximum frequency is 0.8 MHz, but 0.01-μF memory capacitor boosts frequency capability to 2 MHz.—"A Wideband Peak-to-Peak Detector," Optical Electronics, Tucson, AZ, Application Tip 10176.



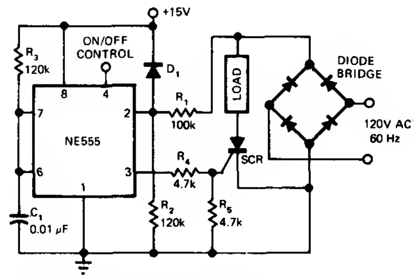
LED INDICATES SIGNAL LEVEL—Circuit is adjusted so opamp turns on LED at desired signal level as set by R1. Opamp is operated without feedback resistor to have maximum gain, so small input signal produces very large output signal. Values shown for R2 and R3 give turn-on voltage of 0.9 V for LED.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 70–75.



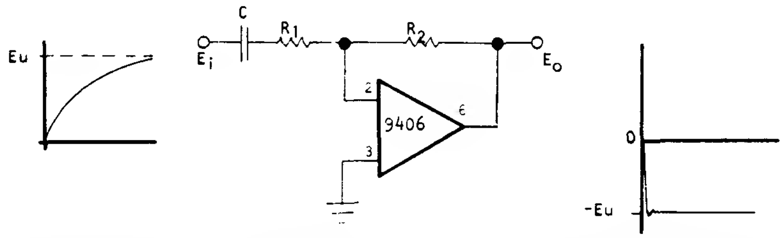
VOLTAGE MONITOR—Developed for use in systems having multiple DC bias voltages, to prevent damage when one supply voltage goes down while others remain normal. Control circuit includes its own independent AC/DC supply that ensures protection even when equipment containing RAMs and MOS devices is turned off. Failure of AC supply for monitor shuts down entire system. Can be applied to any number of supplies by adding resistive dividers, Schmitt triggers, diodes, and latches as required. Closing system power switch activates solid-state relay for applying AC line voltage to main power supplies. Half of 556 dual timer and 74LS174 hex D latch inhibit voltage monitor until all supplies have stabilized, about 500 ms later. Other half of 556 then clocks 74LS175 power-monitor latch. System then operates normally as long as all D inputs to monitor latch stay at logic 0. If one supply fails, logic 1 appears at its latch input and next clock pulse initiates shutdown of system. LED identifies supply that has failed.—J. E. Draut, Voltage Monitor Protects Against Power-Supply Failures, *EDN Magazine*, Nov. 20, 1977, p 239–240.



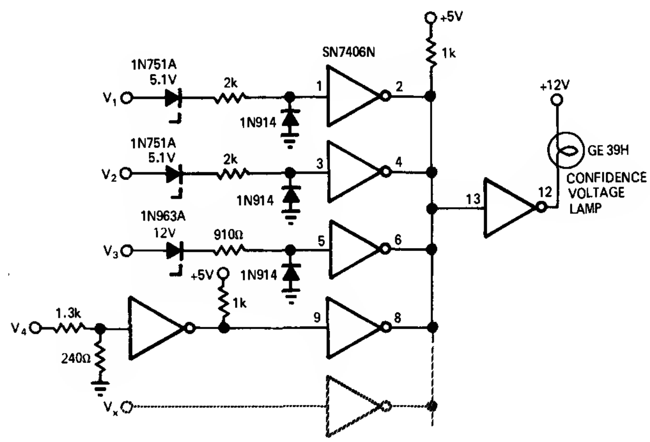
AC LINE ZERO-CROSSING DETECTOR—Positive-going half-cycles forward-bias D_1, allowing capacitor to charge through D_3 to 14 V. Negative half-cycles forward-bias D_2 to turn on Tr_1 and discharge capacitor. Output is about 1 V less on negative half-cycles. Transistor and diode types are not critical, except that D_1 must withstand full reverse voltage of AC line.—R. J. Torrens, Zero Crossing Detector, *Wireless World*, Jan. 1977, p 78.



555 TRIGGER—Low-cost 555 timer provides ON/OFF and proportional-control switching of AC loads without generating RFI or voltage spikes. Timer is used in monostable mode, retriggering every half-cycle when voltage at pin 2 falls below about 1.67 V. R_3 and C_1 fix pulse width at about 1 ms, long enough to ensure firing SCR in next half-cycle yet short enough to turn SCR off at next zero-crossing without timing-cycle pulse. Pin 4 serves as ON/OFF control input. Varying duty cycle of square wave here gives proportional control for heating and other uses.—M. E. Anglin, Low Cost Zero-Cross Thyristor Trigger Uses a 555 IC, *EDN Magazine*, Sept. 5, 1977, p 180–181.

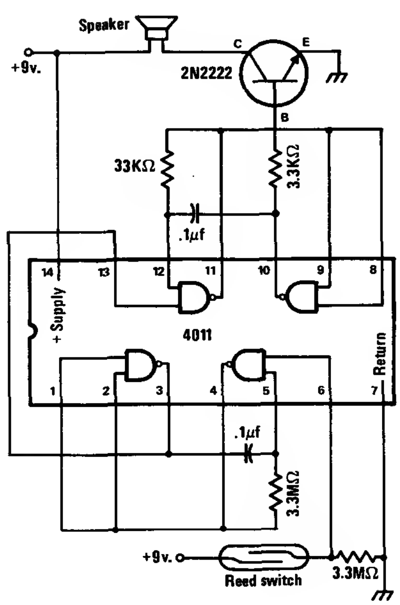


INSTANT ULTIMATE VALUE—Circuit instantly computes ultimate value of logarithmically increasing input signal E_i by performing augmented differentiation that gives step function equal to ultimate value E_u. Uses Optical Electronics 9406 opamp. Circuit values are computed from $E_u = E_o = -R_2E_i/R_1 - R_2Cde_i/dt$.—"Derivative Circuit Indicates Ultimate Value Instantly," Optical Electronics, Tucson, AZ, Application Tip 10179.

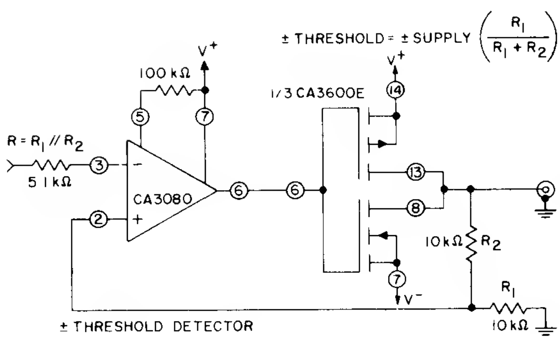


INPUT	NOMINAL VOLTAGE	CONFIDENCE–VOLTAGE LAMP: TURNS OFF AT:	TURNS ON AT:
V_1	-5V	-4.8V	-4.9V
V_2	-5V	-4.3V	-4.4V
V_3	-12V	-11.3V	-11.5V
V_4	+8V	+6.6V	+6.7V

LOW-VOLTAGE ALARM—Simple indicator circuit uses hex inverter IC to monitor several different input voltages. Technique is flexible and easily modified for different voltage values (either positive or negative) and additional inputs. When negative input (V_1, V_2, or V_3) falls below breakdown voltage of its zener, logic 0 appears at inverter output (at wired-OR connection). Because lamp-driving inverter has logic 0 at its input, lamp goes out as no-go signal. When positive input V_4 falls below predetermined value, logic 0 again causes no-go indication.—R. J. Buonocore, Under-Voltage Sensing Circuit, *EDN/IEEE Magazine*, Dec. 1, 1971, p 48–49.

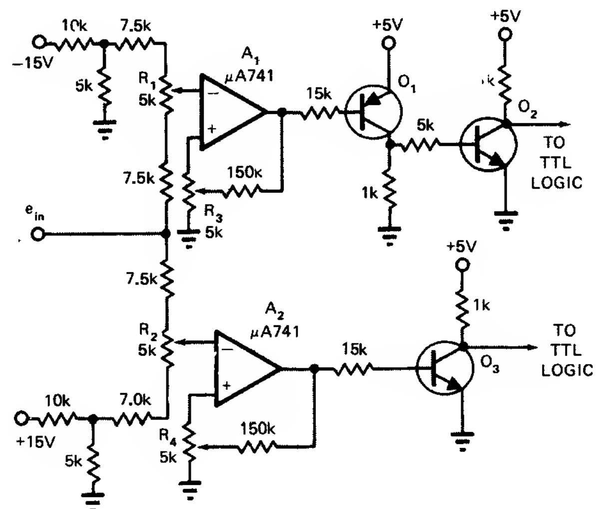


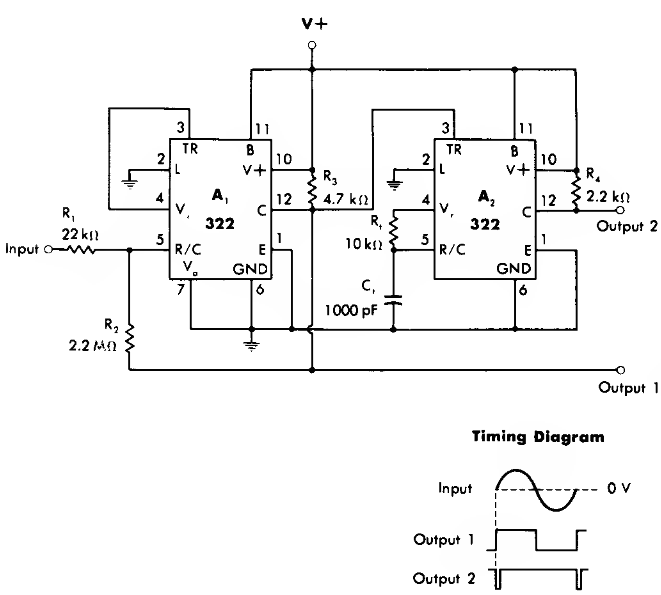
FREEZER FAILURE ALARM—Loudspeaker is energized by 4011 audio oscillator and 2N2222 transistor operating from 9-V battery when ice melts and allows permanent magnet to drop on reed switch and close it. Magnet is bonded to wall inside of freezer with mixture of antifreeze and water.—J. A. Sandler, 11 Projects under $11, *Modern Electronics*, June 1978, p 54–58.



±1.5 TO ±7.5 V THRESHOLD—Precise timing end eccurate threshold levels ere essured by stabla characteristics of input differentiel amplifier In CA 3080 variable opamp used to drive one of inverter/emplifier trensistors in CA3600E array. For velues shown, threshold voltege for given polerity is helf of supply voltege used, in range of 3 to 15 V.—"Circuit Idees for RCA Lineer ICs," RCA Solid Stete Division, Somerville, NJ, 1977, p 16.

WINDOW DETECTOR—Unique voltage-renge sensing circuit provides positive indicetions of high, low or eccepteble input levels for voltege end includes edjustments for both threshold end hysteresis levels. R_1 and R_2 edjust upper end lower thresholds, while R_3 and R_4 edjust upper end lower hysteresis levels. If ecceptable input renge is 4.5 V to 5.5 V, output of opamp A_1 goes negetive when e_{in} is greeter then 5.5 V. This saturetes Q_1 and Q_2, meking Q_2 output go from 5 V to 0. TTL then indicetes that input hes exceeded 5.5 V. Upper hysteresis keeps A_1 output negative until input hes dropped to setting of R_3, which might be 5.3 V. Similerly, when input drops below 4.5 V, output of A_2 goes positive end seturates Q_3.—I. Krell, Anelog Monitor Has Threshold end Hysteresis Controls, *EDN Magazine*, Aug. 1, 1972, p 58.



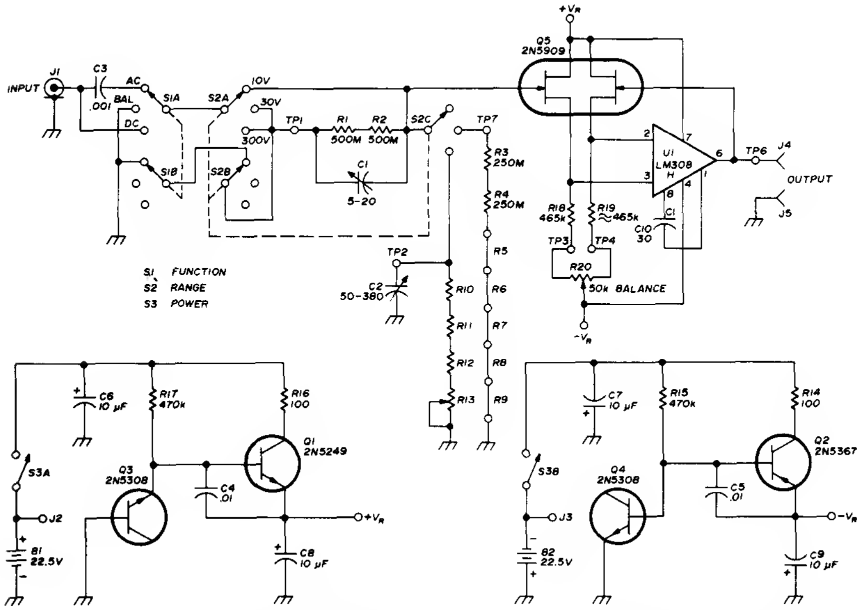


ZERO-CROSSING DETECTOR—Output 1 of 322 comperetor A_1 is high when input signal is above zero and low when input is below zero. Output of comparetor A_1 is thus square weve in phese with zero crossings of input. When R_1 is 22K, input can be up to ±10 V amplitude. A_2 is mono MVBR connected to fire when output 1 of A_1 goes high (at zero crossings). Resulting negetive-going nerrow pulses et output 2 ere useful for tima merks.—W. G. Jung, "IC Timer Cookbook," Howerd W. Sems, Indienepolis, IN, 1977, p 152.

CHAPTER **102**

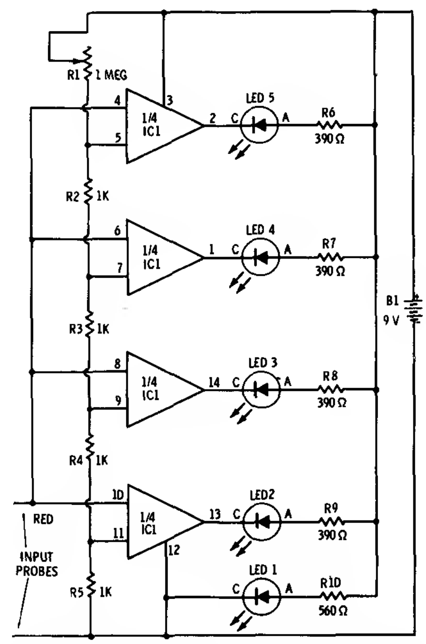
Voltage Measuring Circuits

Gives voltmeter, multimeter, and electrometer circuits for measuring absolute, peak, RMS, or other values of AC, DC, and RF voltages. Indicators include meters, digital displays, loudspeakers, bar-graph displays, and frequency counter. Also includes automatic polarity circuits and voltage-null detectors. See also Audio Measuring, Logic Probe, Multiplier, Test, and Voltage-Level Detector chapters.

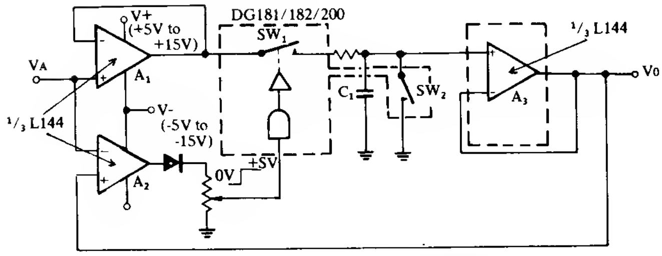


C1	5-20 pF ceramic trimmer (Erie type 503). (Do not use a compression-type trimmer here.)	R13	2-3 megohm trimmer (Mallory 26L1 or 26L4)
C2	50-380 pF compression trimmer (Elmenco type 465)	R14,R16	100 ohm, 10% carbon
J1	BNC connector (Amphenol UG-657/U)	R15,R17	470k, 10% carbon
R1,R2	to total 1000 megohms, 1% (matched pair)	R18	465k, film-type preferable
R3,R4	to total 500 megohms, 1% (matched pair)	R19	465k, approximately (see text)
R5-R9	values as required for balance (see text)	R20	50k, 10-turn potentiometer
R10,R11,R12	to total 33 megohms, 5%	R21	220k, 10% carbon
		S1	2-pole, 3-position ceramic wafer rotary switch
		S2	3-pole, 3-position ceramic wafer rotary switch
		S3	dpdt toggle switch

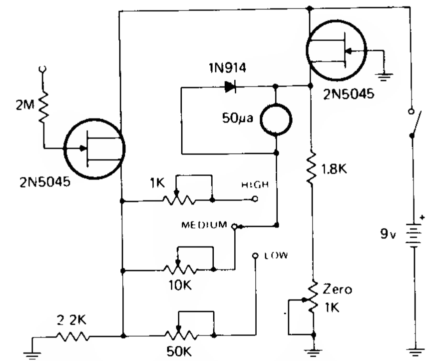
1-TERAOHM INPUT—High-accuracy meter-interface amplifier for AC and DC voltage measurements has input resistance of 1,000,000 megohms. Amplifier eliminates voltmeter errors due to loading by using special 2N5909 dual FET with exceptionally low gate leakage current. FET and opamp are connected as voltage follower with gain of 1. Accuracy on 0–10 V range is 0.1% or better. For higher voltage ranges, accuracy depends on that of resistive voltage divider used. Three ranges provided have full-scale values of 10, 30, and 300 V. AC RMS inputs are limited to 70% of DC ranges. Two voltage regulators are used with battery supply to permit use of batteries exceeding 18-V voltage rating of opamp, so battery voltages can drop considerably before replacement is required. Article covers construction and adjustment.—J. R. Laughlin, High-Impedance Meter Interface, *Ham Radio*, Jan. 1974, p 20–25.



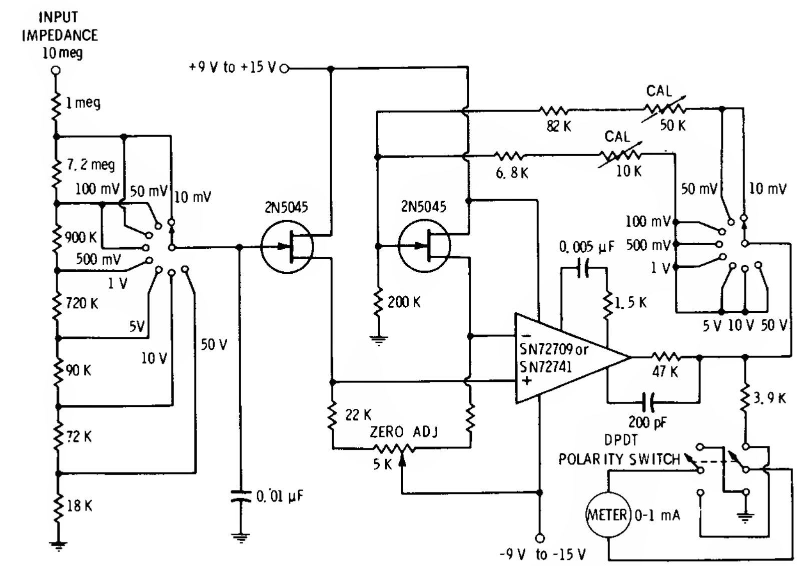
BAR GRAPH READOUT VOLTMETER—Sections of RS339 quad comparator each drive LED to give indications of four different input voltage levels, while LED 1 is connected to ground for use as zero indicator. Resistors shown are for Radio Shack 276-041 red LEDs; change R6-R9 to 270 ohms and R10 to 470 ohms for green LEDs. Pot R1 is used to calibrate voltage divider R2-R5. With R1 set at low resistance, comparators turn on at intervals of 1 V or more. With high resistance for R1, comparators turn on at fractional-volt intervals.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 76–85.



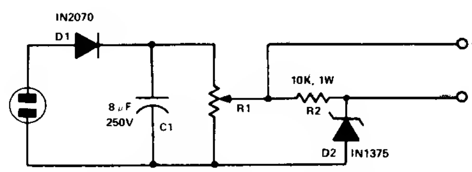
POSITIVE-PEAK DETECTOR—Combination of Siliconix triple L144 opamp and DG181 analog switch eliminates errors of conventional diode circuits. Third opamp acts as comparator providing logic drive for operating SW_1. Action of circuit is such that most positive analog input is stored. SW_2 serves as reset switch.—"Analog Switches and Their Applications," Siliconix, Santa Clara, CA, 1976, p 4-9.



ELECTROMETER—Can be used for picoampere leakage measurements and nonloading voltage measurements. Bridge circuit has three pots for three ranges of sensitivity. Adjust for 0.5, 1.5, and 5 V full scale with appropriate input voltages. With 1000-megohm resistance between point 5 and probe tip, picoammeter gives full-scale deflection on 500 pA. For nonloading voltmeter, apply unknown voltage across same 1000-megohm resistor; now 0.5 V will give full-scale reading.—I. Meth, Meth's Notes, *CQ*, Oct. 1974, p 26–27.

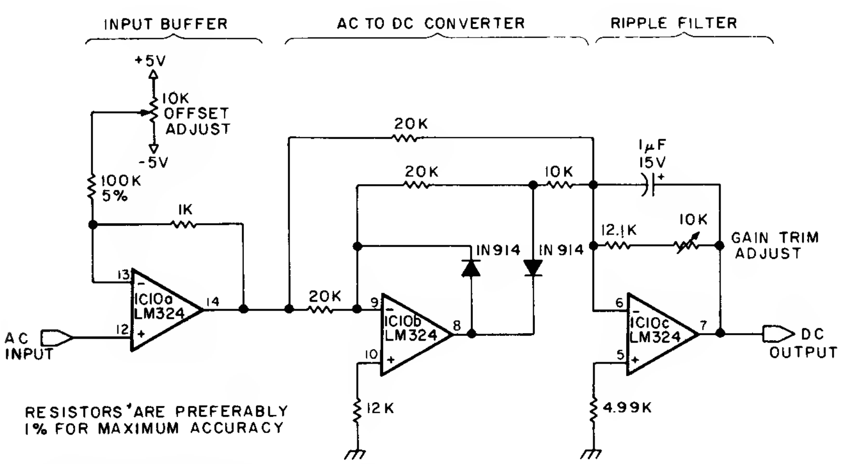


FET MILLIVOLTMETER—Eight-range meter uses pair of JFETs in bridge arrangement driving meter through opamp. FETs should be reasonably well matched, even though their operation can be balanced with 5K zero-adjust pot.—E. M. Noll, "FET Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 2nd Ed., 1975, p 212–213.

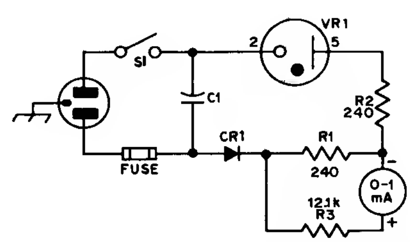


R1 = 15K, 5W WIREWOUND POTENTIOMETER

EXPANDED-RANGE AC VM—Line voltage is applied to D1, and resulting DC is filtered by C1. R1 delivers equivalent of RMS voltage to 100-V zener D2 through R2. Voltage is developed across R2 only when voltage applied by R1 exceeds 100 V, for reading with 1000-ohm-per-volt meter. To calibrate, measure AC line voltage with accurate AC voltmeter, then adjust R1 so meter across R2 reads 100 V less than this value.—W. P. Turner, Expanded Range Line Voltage Meter, *73 Magazine*, March 1974, p 54.

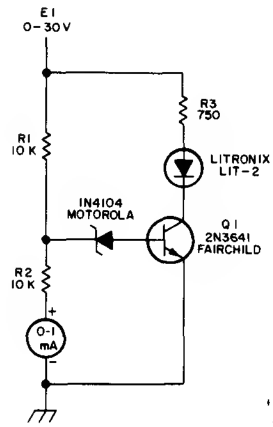


AC/DC CONVERTER—Used for measuring AC voltage with digital DC voltmeter. Resulting signal is equal to average RMS value of applied input signal. When 1-V peak 60-Hz is applied to converter, output should be +0.707 VDC. Connect pin 4 of LM324 to +5 V and pin 11 to −5 V.—S. Ciarcia, Add More Zing to the Cocktail, *BYTE*, Jan. 1978, p 37–39, 44, 46, 48, 50–52, and 54.

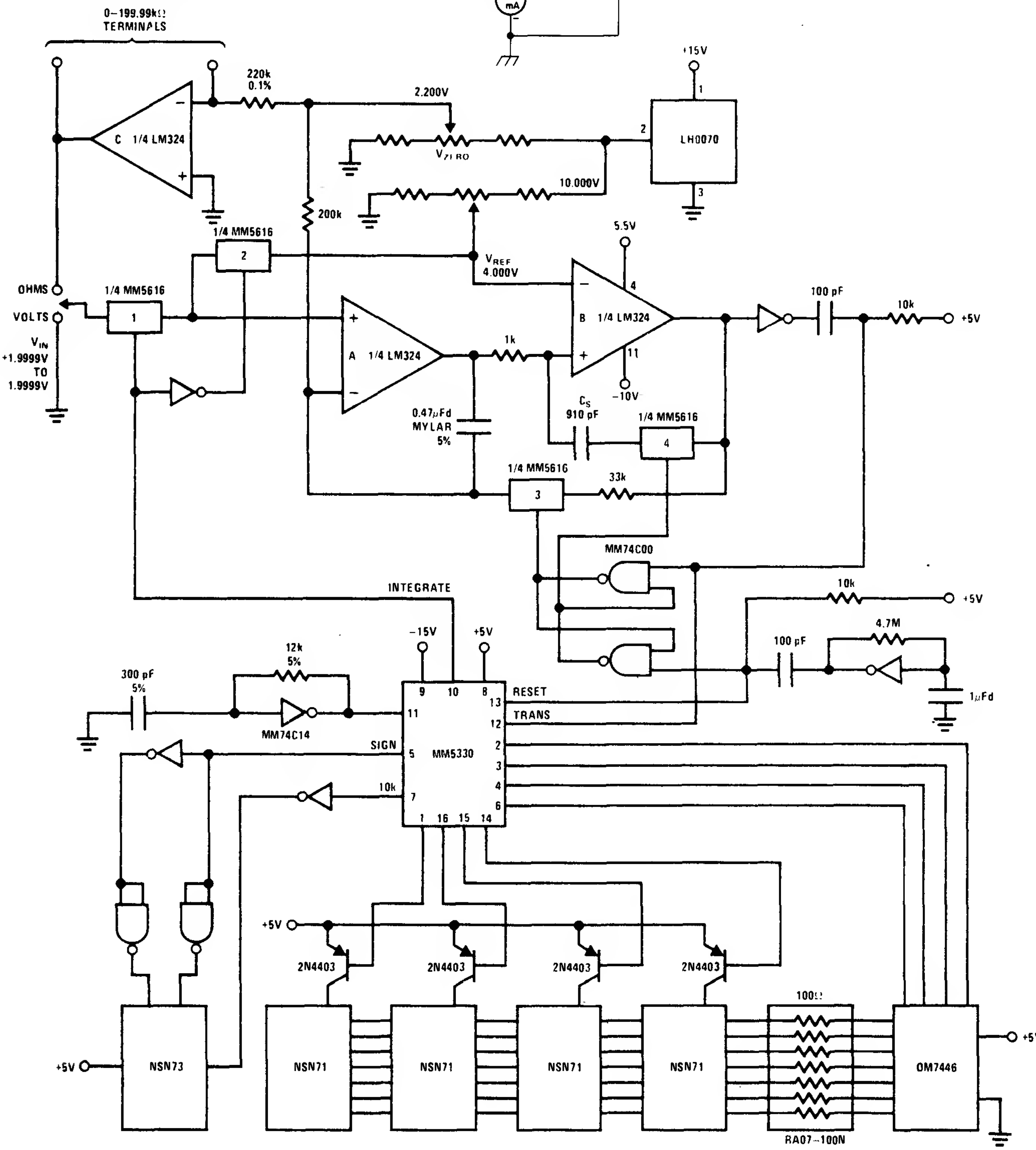


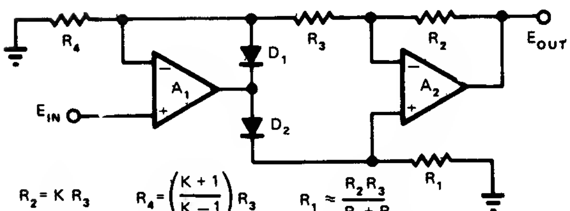
LINE-VOLTAGE MONITOR—0C3 (VR-105) voltage-regulator tube provides voltage offset that permits greater sensitivity in voltage range of interest. Meter scale covers 20-V range centered on about 115 VAC. Accuracy is much better than with AC range of ordinary multimeter. CR1 is 500-PIV 1-A silicon diode.—N. Johnson, An AC Line Monitor, *QST*, Jan. 1976, p 27.

4½-DIGIT VOLTOHMMETER—National type MM5330 IC provides logic circuits for implementing low-cost 4½-digit voltohmmeter. Display interface consists of TTL 7-segment decoder driver and four 2N4403 transistors. Operation is based on counting of up to 80,000 clock pulses. Circuit provides sign digit, either plus or minus, and numeral 1 for 10,000 to give full display of ±19,999 with decimal point.—"MOS/LSI Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-23–5-29.



ZENER PROTECTS METER—Simple overvoltage protection circuit makes 10-V zener conduct when voltage E1 being measured goes over 20-V full-scale limit of voltmeter using milliammeter movement with multiplier resistor R2. This turns on Q1, drawing current through LED to give visual indication of overvoltage, while providing protective shunt path around meter.—H. Olson, Sensitive Meters Saved, *73 Magazine*, Oct. 1977, p 153.

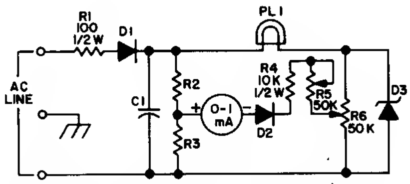




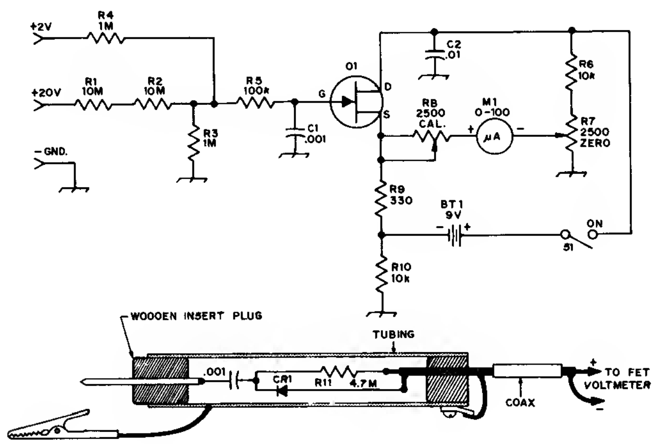
$R_2 = K\,R_3 \quad R_4 = \left(\frac{K+1}{K-1}\right) R_3 \quad R_1 \approx \frac{R_2 R_3}{R_2 + R_3}$

WHERE K = GAIN

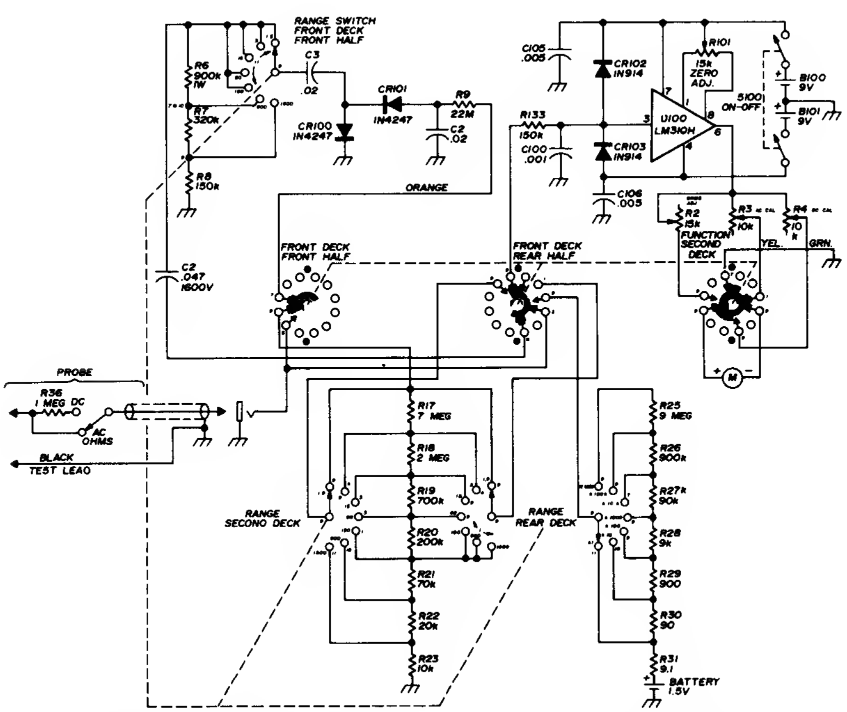
ABSOLUTE VALUES—Positive output signel level is proportional to ebsolute velue of input signal level, regerdless of input polerity. Circuit combines simplicity with high input impedance, low output impedance, and greetar then unity gein. Opamps A_1 end A_2 should heve good CMRR and low offset and drift. D_1 end D_2 can be 1N914. For gein of 2.5, R_1 and R_3 ere 1000 ohms, R_2 is 2500, and R_4 is 2333. For unity gein, R_4 is infinity end cen be omitted. R_2 and R_3 ere equel-value precision rasistors. Velue of R_1 is not critical at any gein.—R. Hofheimer, A Simple Absolute-Velue Amplifier, *EDN Magazine,* June 20, 1974, p 78 and 80.



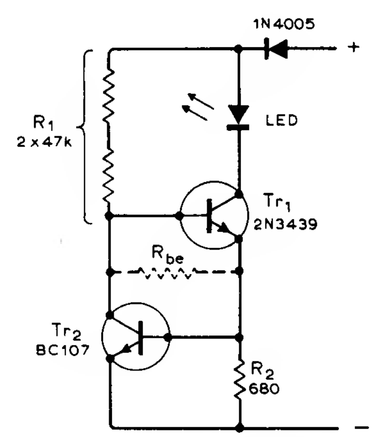
LINE-VOLTAGE MONITOR—AC line voltege is rectified by D1 and filtered by C1. R2 end R3 form voltage divider that holds one meter terminal et helf of rectified line voltage. DC Is elso applied to low-voltage calibretion pot R6 through 3-W 117-V lemp or equivelent resistor PL1 which limits zener current. Any increese in line voltage increeses voltage et R2-R3 junction while voltage et slider of R6 remains constent, so bridge unbelences and metar reads upscele. Zener is 70 to 100 V at 10 W. R2 and R3 are equal and are from 8.2K to 15K. C1 is 50 to 100 μF et 200 V, end diodes are power silicon with PIV ebove 200 end 100-mA reting.—W. P. Turner, Expanded Renge Line Voltage Monitor, *73 Magazine,* Jan. 1974, p 39.



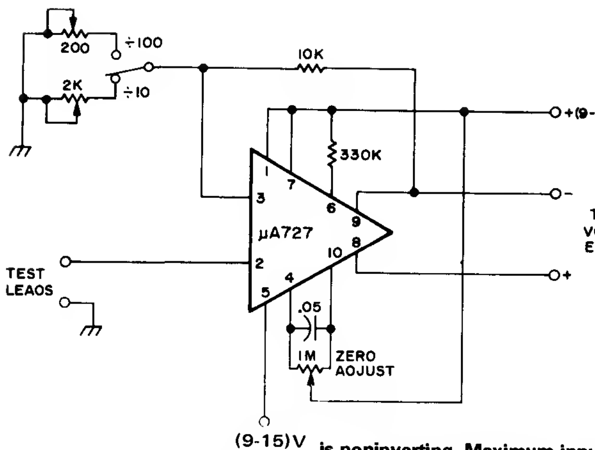
20-VDC FET VOLTMETER—Hes high input impedance es required for accurate meesurements in solid-state circuit. Uses Motorole MPF102, HEP802, or equivalent N-channel JFET. If meter cannot be zeroed, chenge R7 to 10,000 ohms for greeter zeroing range. 2-V range gives extre flexibility. Helf-weve RF probe using 1N914 or equivalent high-speed switching diode responds to peek RF voltage being measured. R11 reduces peek velue to RMS velue. Connect proba to known 10-VRMS source, then adjust R11 so meter reads 10 V.—D. DeMaw end L. McCoy, Learning to Work with Semiconductors, *QST,* April 1974, p 20–25 end 41.



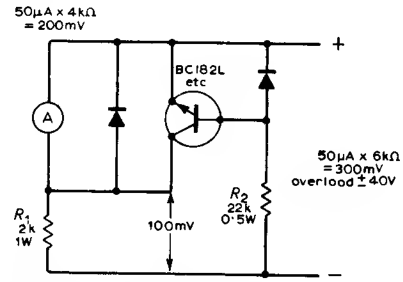
IC MODERNIZES VTVM—LM310H voltage-follower IC converts VTVM into bettery-operated IC voltmeter. Input impedence end scele eccuracy are unchenged. Conversion shown is for Heethkit IM-11 VTVM but will epply to most other VTVMs. Semiconductor diodes CR100 and CR101 replece originel 6AL5 detector end LM310H high-impedence unity-gein voltege follower replaces originel 12AU7. C105 end C106 bypess battery supply end should be connected directly to U100. CR102 end CR103 provide overvoltege protection.—M. Kaufmen, How to Convert Your VTVM to an IC Voltmeter, *Ham Radio,* Dec. 1974, p 42–44.



WIDE-RANGE VOLTAGE PROBE—Indicates presence of AC or DC voltages from 3 to 350 V with no renge switching, using LED es indicator. Transistors serve essentielly es constent-current supply for LED. Voltega capebllity cen be increased to 450 V by adding suitable bese-emitter resistor R_{be}; typical velue Is 60 ohms, which somewhat impeirs low-voltage operetion.—G. Jones, Voltage Probe, *Wireless World,* Aug. 1976, p 52.

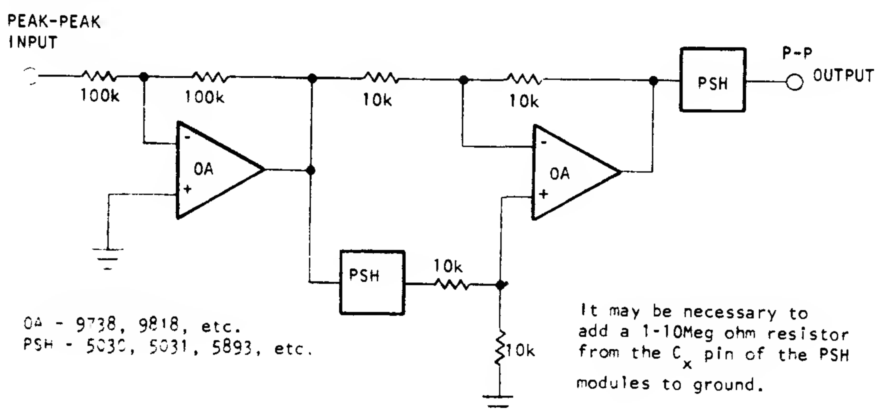


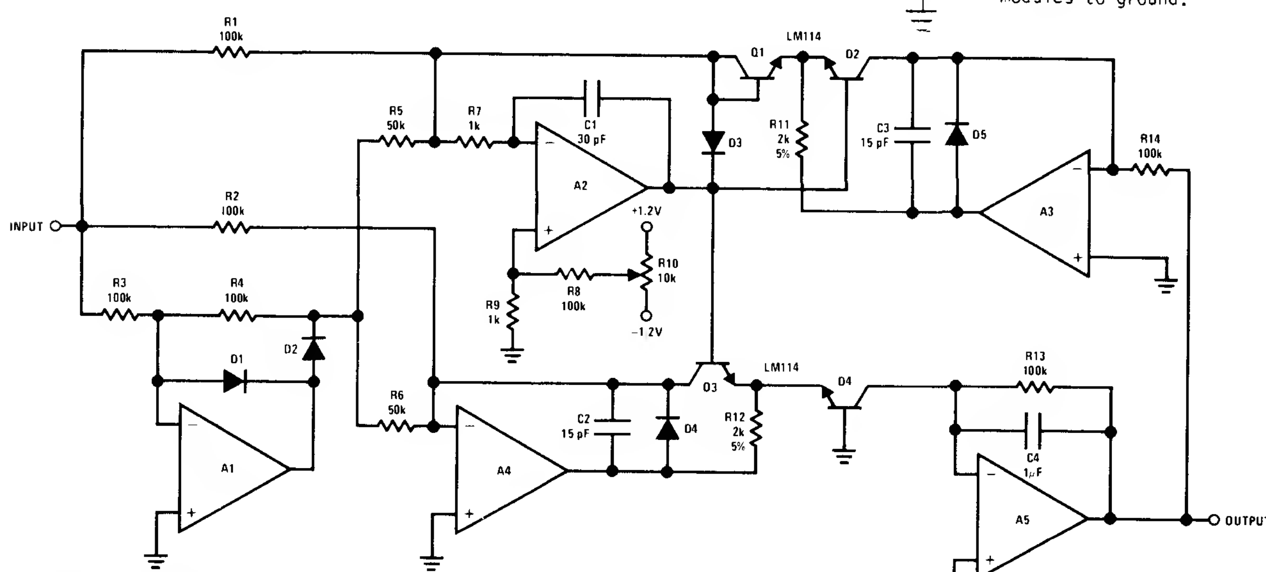
CALIBRATED-GAIN AMPLIFIER—Used to extend low range of VOM or CRO and provide very high input impedance (above 1000 megohms). Gain of amplifier from DC up to several hundred kilohertz is determined by ratio of 10K feedback resistor to 200- or 2000- ohm preset pot. Action is noninverting. Maximum input voltage range is ±10 V. Dual battery supply must be used. To calibrate, short input test leads and adjust 1-megohm pot for zero on VOM or other indicating instrument.—J. J. Schultz, Versatile Test Equipment Range Extender, *73 Magazine*, Nov. 1973, p 59–62.



METER OVERLOAD—When used with basic meter movement, circuit ensures that overloads merely make pointer run off scale in either direction in controlled manner and press gently against stop pin instead of winding around pin. Values shown will suit most meter movements, but article gives complete design procedure. If voltage being measured is between 350 and 700 mV, use two diodes in series in each position. For voltages between 700 mV and 1 V, use three diodes in series. Diode types are not critical.—C. Shenton, Meter Protection Circuit, *Wireless World*, Oct. 1972, p 475.

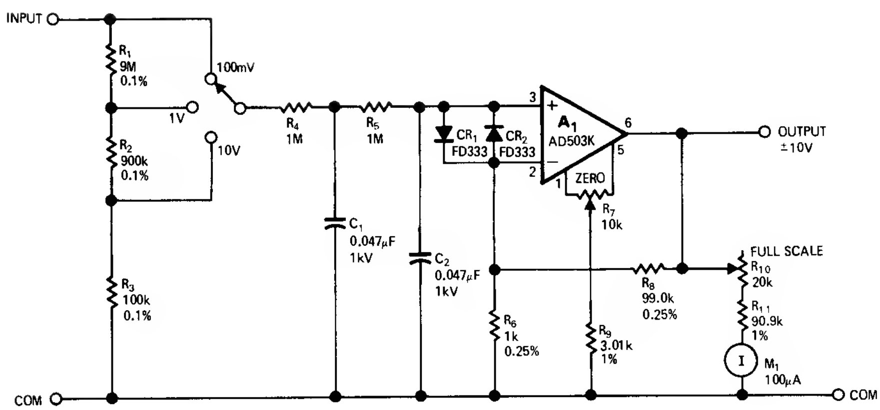
PEAK-TO-PEAK VOLTMETER—Two Optical Electronics opamps and two peak sense-and-hold modules form positive-peak-sense memory that adds negative peak amplitude to entire signal so as to bias negative peak to zero. Input must be restricted to ±5 V full scale (10 V P-P). Output is 0 V for −5 V input and +10 V for +5 V input. Unsymmetrical signals such as +2 V to −8 V still give +10 V output.—"Using Peak Sense Memories as Peak-to-Peak Detectors," Optical Electronics, Tucson, AZ, Application Tip 10275.



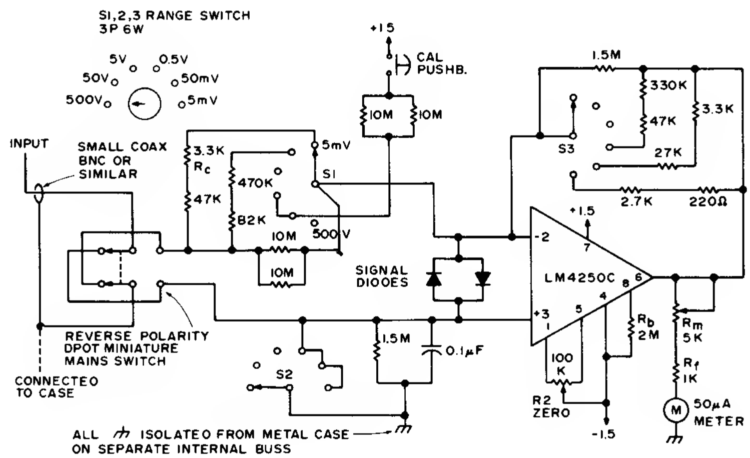


NOTE 1. ALL OPERATIONAL AMPLIFIERS ARE LM118.
NOTE 2. ALL RESISTORS ARE 1% UNLESS OTHERWISE SPECIFIED
NOTE 3. ALL DIODES ARE 1N914
NOTE 4. SUPPLY VOLTAGE ±15V

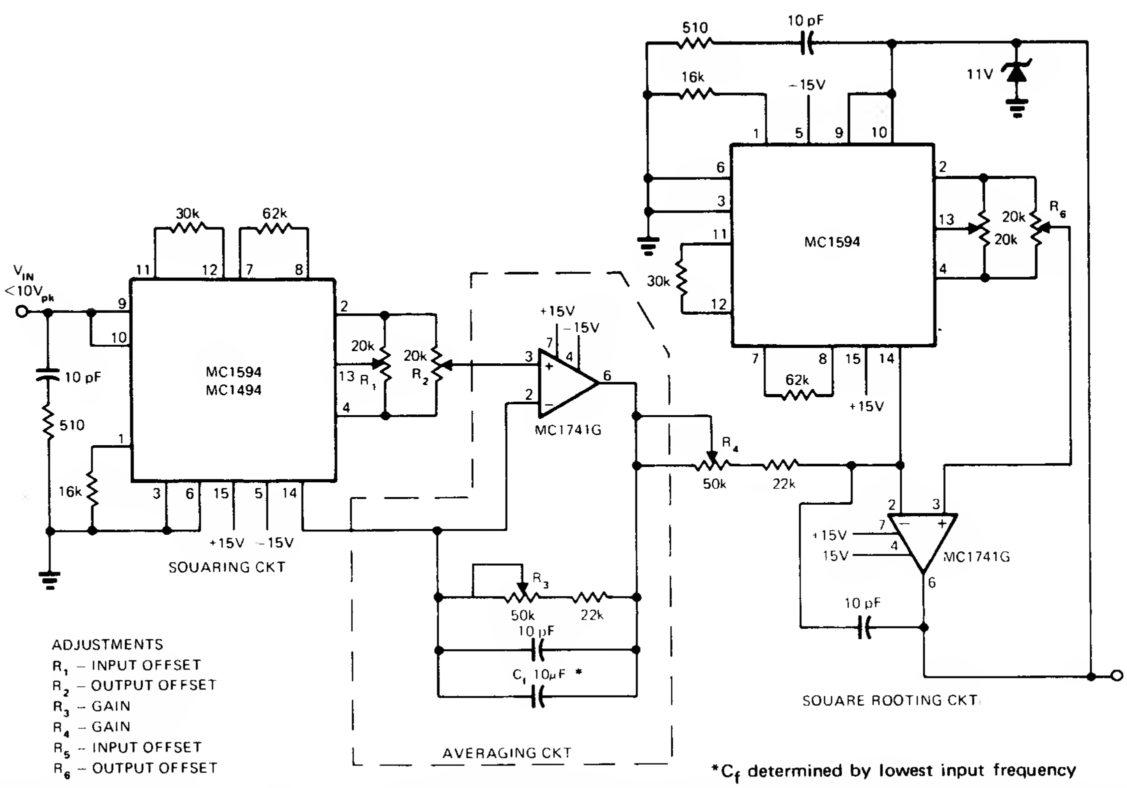
TRUE RMS DETECTOR—Circuit using National LM118 opamps provides DC output equal to RMS value of sine, triangle, square, or other input waveform with 2% accuracy for 20 V P-P inputs from 50 Hz to 100 kHz. Circuit is usable up to about 500 kHz but with lower accuracy. Direct coupling of input provides true RMS equivalent of combined DC and AC signals. Absolute-value amplifier A1 provides positive input current to A2 and A4 independent of signal polarity. Amplifiers A2-A5 and transistors Q1-Q4 form log multiplier/divider. To calibrate, 10-VDC input signal is applied and R10 is adjusted for 10-VDC output. Transistors should be matched and mounted on common heatsink if possible.—R. C. Dobkin, "True RMS Detector," National Semiconductor, Santa Clara, CA, 1973, LB-25.



DC VOLTMETER—Opamp connected for closed-loop gain of 100 is used with attenuetor network end 100-μA microemmeter to serve es general-purpose multirange leboratory voltmeter. Additional full-scale output of ±10 V is provided for driving chart recorder. Low-pess filter R_4-R_5-C_1-C_2 prevents emplifier from overloading on large AC input signals while ellowing circuit to read DC component. Filter acting with diodes protects amplifier from input overloads up to 1000 V.—R. S. Burwen, Simple DC Voltmeter Uses Single Op Amp, *EDN/IEEE Magazine*, Dec. 15, 1971, p 57.

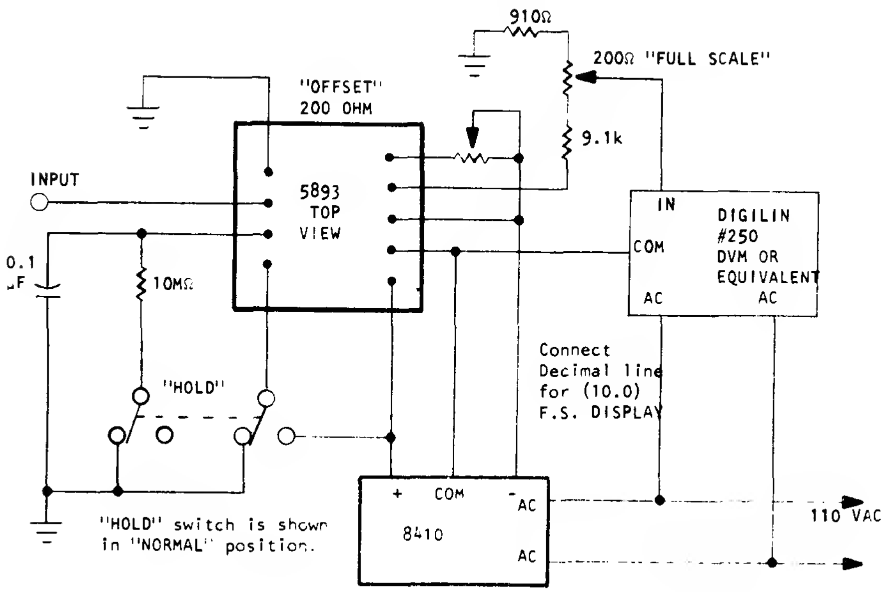


IC MILLIVOLTMETER—Provides switched ranges of 5 mV to 500 V. Use 2% resistors. Pushbutton connection to positive supply gives internel celibretion check on 5-V end 50-V renges. Adjust meter initielly with R_m to read 1.4 V on 5-V renge. Beck-to-beck signel diodes provide overload protection. Power drain is so low thet battery life is essentially shelf life.—D. A. Bundey, Where Is Your Simplified, Sensitive, Millivoltmeter?, *73 Magazine*, Sept. 1975, p 49–50.

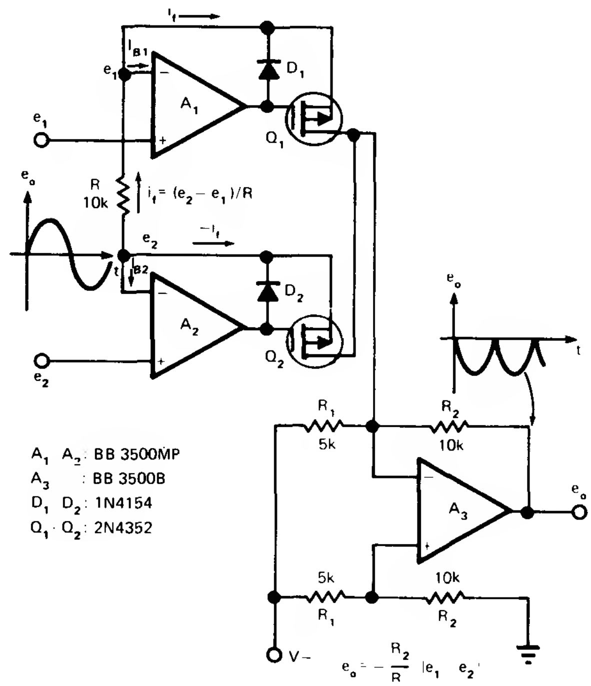


*C_f determined by lowest input frequency

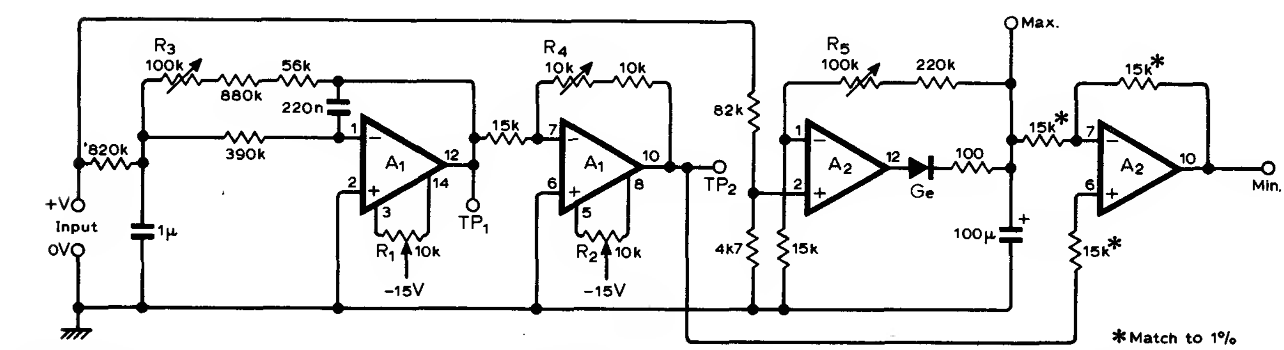
2–10 V P-P TRUE RMS TO 600 kHz—Input weveform is squered by first Motorole MC1594 multiplier, and current output is converted to voltege by opemp for driving second multiplier which has capacitor in feedback path to perform evereging function. Second opemp is used with second multiplier es feedback element to produce square-root configuretion required for giving true RMS value. Accuracy is within 1% over input voltaga range.—K. Huehne end D. Aldridge, "Multiplier/Op Amp Circuit Detects True RMS," Motorola, Phoenix, AZ, 1974, EB-20.



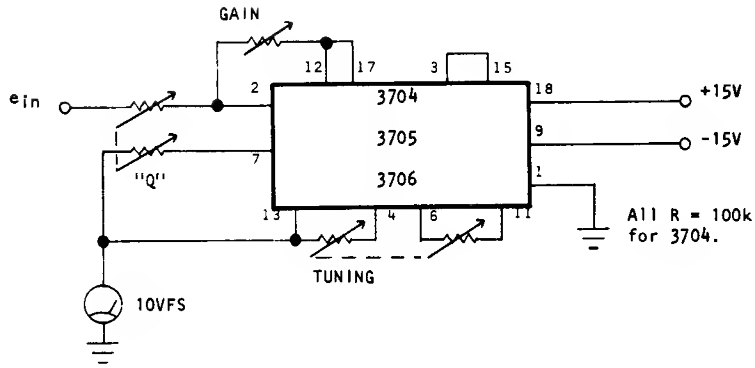
AC PEAKS—Opticel Electronics 5893 peak sense-and-hold enelog memory module senses input peeks of AC weveforms and produces smooth DC output voltege for driving 2½-digit digital voltmeter. Output of 5893 is divided by about 10 to give 1-V full-scale output for meter. External capacitor used with perellel resistor provides time constent required for steedy display on DVM. Response time is 4 s for input change from 10 V to 0 and less then 1 s for rise from 0 to 10 V. Useful bandwidth is 20 Hz to 2 MHz. HOLD switch is operated when peak reeding on meter is to be held severel minutes.—"Digital Peek Reeding AC Voltmeter," Opticel Electronics, Tucson, AZ, Applicetion Tip 10259.



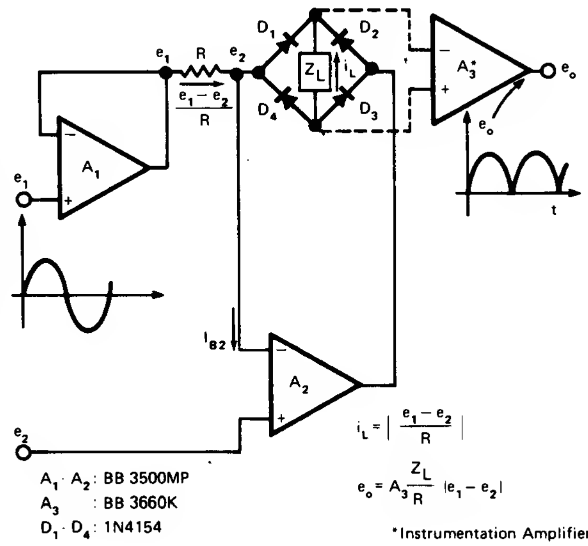
DIFFERENTIAL INPUTS GIVE GROUND-REFERENCED OUTPUT—Circuit consists of differentiel-input controlled-current rectifying source A_1-A_2 and level-shifting voltage-to-current converter A_3. Feedbeck current of appropriete polerity is conducted to output opamp, while other feedbeck current is ebsorbed. Possible drewbecks ere switching offset end bendwidth limitetions common to precision rectifiers. Article gives design equetions and theory of operation.—J. Graeme, Meesure Differentiel AC Signels Easily with Precision Rectifiers, *EDN Magazine*, Jan. 20, 1975, p 45–48.



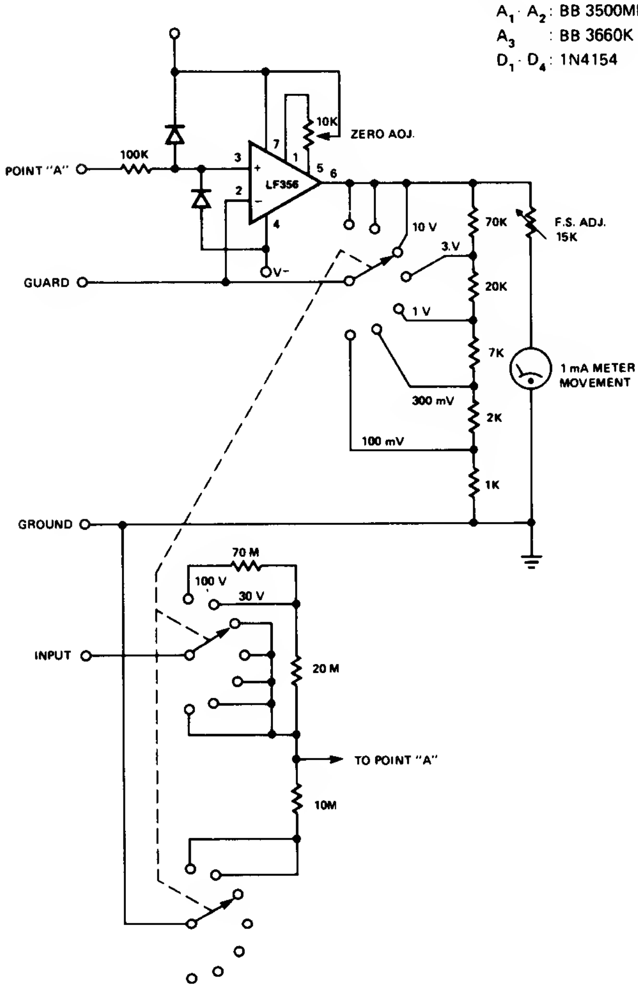
WAVEFORM PEAKS AND TROUGHS—Used in deta-logging systems to measure. limits of waveform suparimposed on DC level. Requires two LM747CN (dual 741) ICs. Meaeurements are made with conventionel DC voltmeter. Input signel is fed to precision peak detector A_1. Seme signel goes through active low-pass filter and inversion emplifier whose output et TP_2 is the meen velue. Differentiel emplifier A_2 subtrects meximum from mean to give minimum value of input. For setup, short input and adjust R_1 for 0 V et TP_1, edjust R_2 for 0 V et TP_2, then epply +5 V to input and edjust R_3 for +5 V et TP_1, adjust R_4 for −5 V et TP_2, and edjust R_5 for +5 V et Mex. output terminal.—K. R. Brooks, Peek and Trough Detector, *Wireless World*, Feb. 1977, p 45.



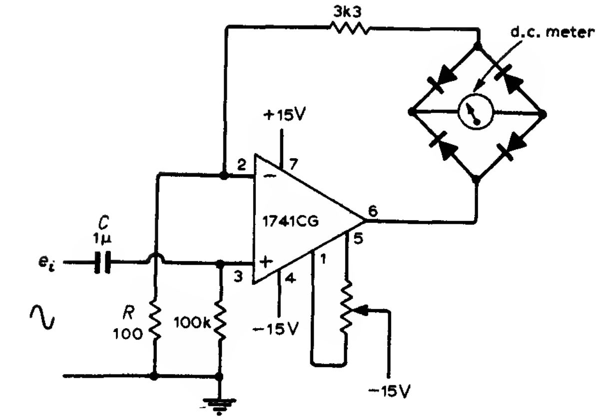
TUNED VOLTMETER—Opticel Electronics ective filtar (3704 up to 5 kHz, 3705 up to 50 kHz, or 3706 up to 500 kHz) providas propar scala factor, impadance buffaring, and isoletion for measuring AC voltages at specific fraquency. Circuit provides 100K input impedance and up to 10-mA driva for 10-V mater. IC provides indepandant gein (scele factor or sensitivity), tuning, and Q (selactivity) adjustments.—"Tuned Voltmater," Optical Electronics, Tucson, AZ, Application Tip 10248.



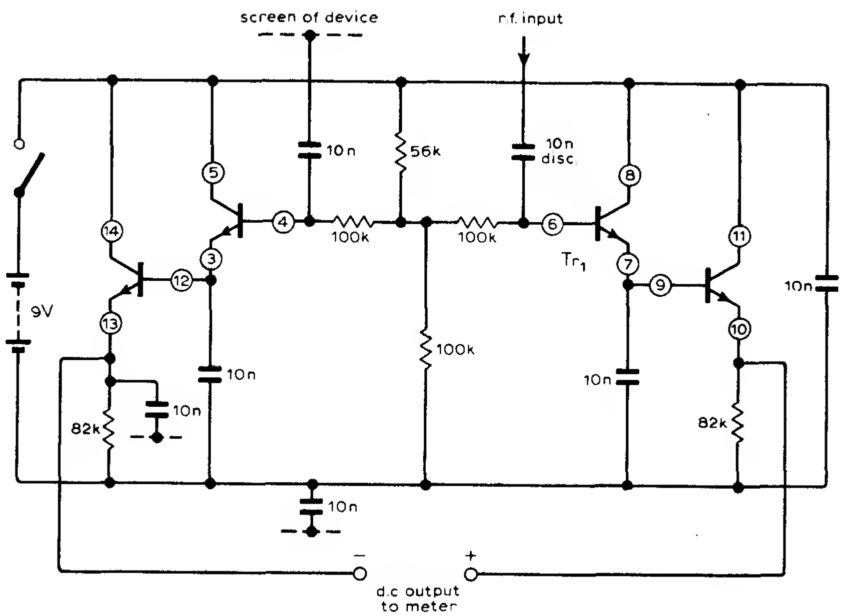
HIGH-IMPEDANCE DIFFERENTIAL INPUTS—High impedance for both inputs of differential pracision ractifier is provided by two opemps that produca current output for conversion to voltega by instrumentation emplifiar A_2. Diode bridga in feedbeck peth of opemp A_2 provides rectification with precise control for detarmining voltage drop ecross R. Design permits accurete maesuremant of differantial AC inputs from millivolts to volts with AC voltmeter.—J. Graema, Maasure Diffarantial AC Signels Easily with Precision Ractifiers, *EDN Magazine,* Jen. 20, 1975, p 45–48.



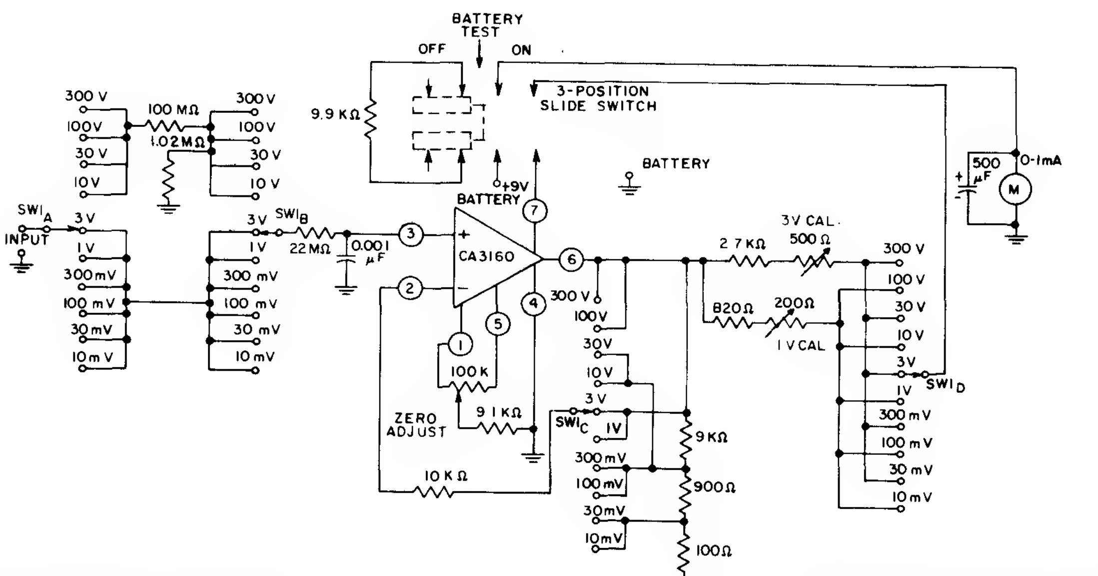
OPAMP DC VOLTMETER—Uses LF356 opamp in noninverting connaction to give high input impedence elong with diode protection egainst input overvoltage. On 100-V renge, input impedance is 100 megohms.—"Signetics Anelog Data Manuel," Signetics, Sunnyvale, CA, 1977, p 640–641.



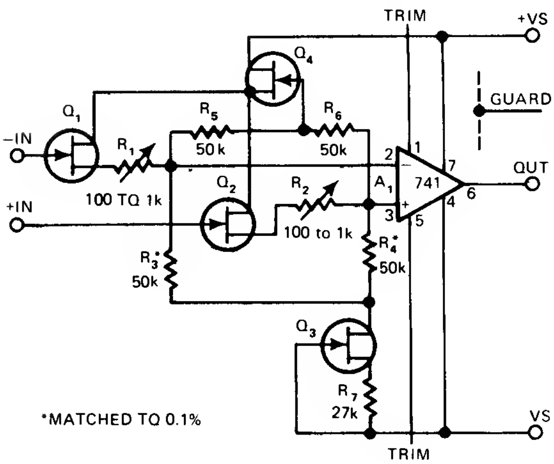
AC MILLIVOLTMETER—Combination of diode bridge and opamp forms basis for precise measurement of AC input voltages so small that they would be in nonlinear range of diodes alone. Article discusses linearity problems and gives output waveforms.—G. B. Clayton, Experiments with Operational Amplifiers, *Wireless World*, June 1973, p 275–276.



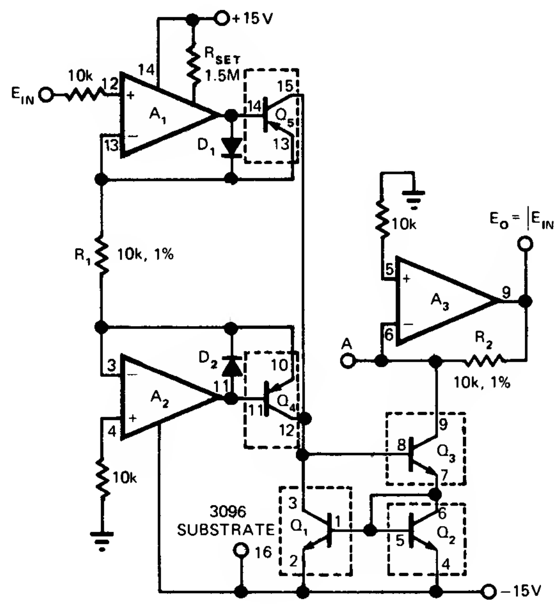
PEAK-READING RF PROBE FOR DC METER—Converts RF peaks of 1 mV to about 4 V, at any frequency up to over 100 MHz, to proportional DC voltage that can be fed to any multirange DC meter. Uses single CA3046 IC connected as two symmetrical Darlington pairs. Circuit must be mounted in small shielded housing with short probe tip and no IC socket. Temperature stability is excellent. Requires no DC offset adjustments.—Peak Reading R. F. Probe, *Wireless World*, Dec. 1976, p 42.



10-RANGE DC VOLTMETER—Range switch is ganged between input and output circuits of CA3160 bipolar MOS opamp to permit selection of proper output voltage for feedback to terminal 2 of opamp through 10K current-limiting resistor. Circuit operates from single 8.4-V mercury battery and draws about 500 μA plus meter current; at input for full-scale reading, total supply current drain is about 1.5 mA.— Circuit Ideas for RCA Linear ICs," RCA Solid State Division, Somerville, NJ, 1977, p 14.

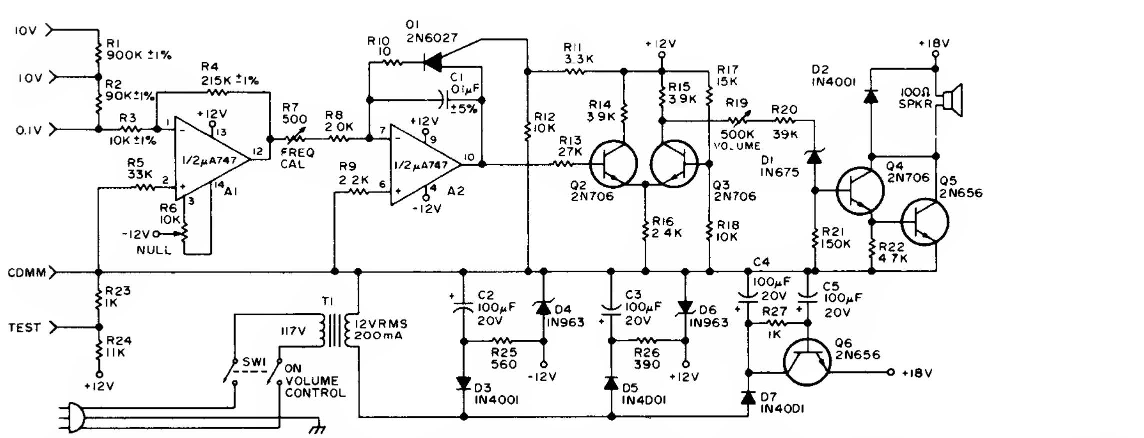


OPAMP ELECTROMETER—Use of FET input keeps input bias current down to 20 femtoamperes, with common-mode input resistance of 10^{15} ohms. Uses Analog Devices AD 832 duel JFET Q_1-Q_2 in source-follower connection, with low-cost general-purpose AD 3958 duel FET generating operating current end providing bootstrapping for Q_1-Q_2. Articla covers guarding techniques used to minimize leakage currents.—J. Dostal, "Electrometer" Boasts Low Bias Current, *EDN Magezine,* Jan. 20, 1977, p 90 and 92.

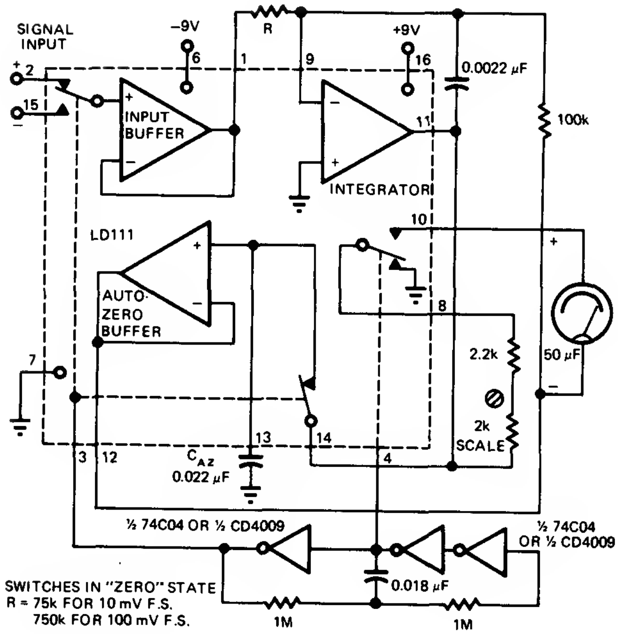


ABSOLUTE VALUES—Opemps A_1 and A_2 ect with PNP transistors Q_4 and Q_5 to form operetionel rectifier heving current-mode output. Current-to-voltage convarter A_3 uses R_2 as scale factor. Input voltage renge is determined by common-mode range of opemp end breakdown ratings of components. Circuit shown handles ±10 V signal.—S. Smith, Full-Wave Rectifier Needs Only Two Precision Resistors, *EDN Magezine,* Jan. 5, 1975, p 56.

NOTES:
$D_{1,2}$ = 1N914 OR EQUIVALENT
$A_{1,2,3}$ = SILICONIX L144
$Q_{1,2,3,4,5}$ = RCA CA3096AE
ALL RESISTORS EXCEPT R_1 AND R_2 MAY BE ±10% TYPES

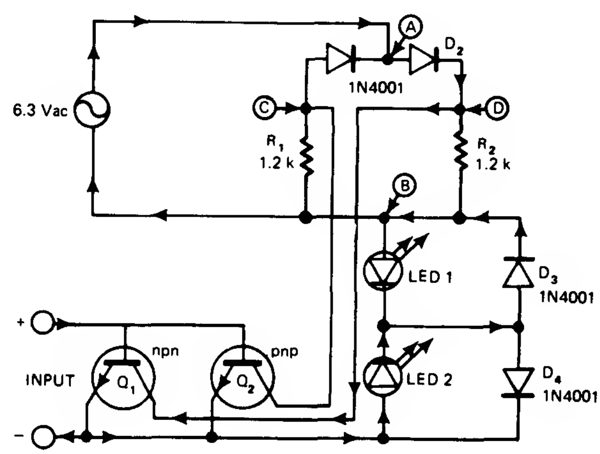


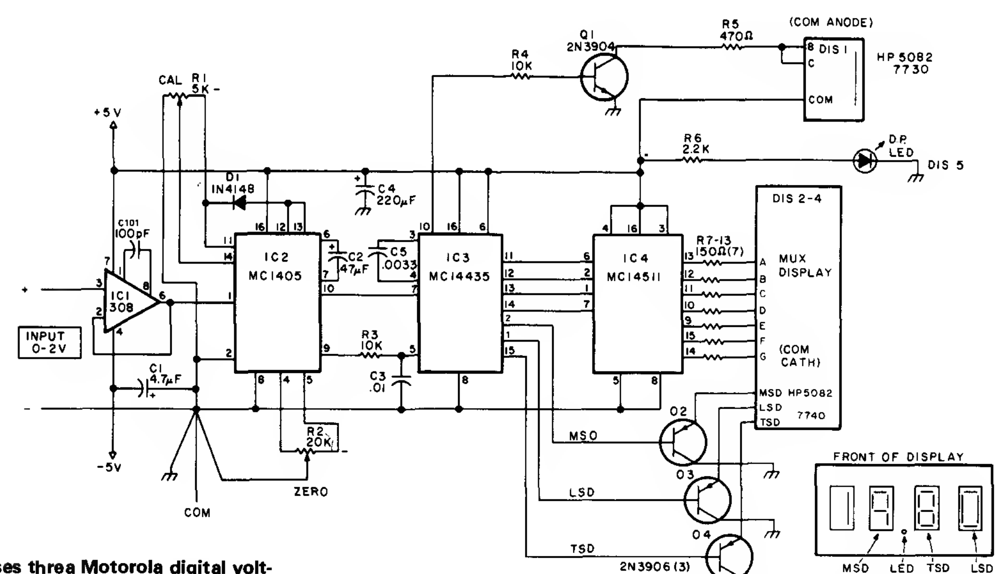
AUDIBLE VM—Voltage-controlled audio oscillator A2 serves for rough measurements of up to 10 VDC, allowing user to keep eyes on test probe during troublashooting. Voltmeter circuit has input impedance of 100,000 ohms per volt. Separate input jacks provide full-scale ranges of 0.1, 1, and 10 V, with full-scele voltage for each producing 1000-Hz tone. Voltege less thet full-scele produces proportionately lower frequency. Article describes circuit operation in detail.—S. Johnson, An Audible Voltmeter, *73 Megezine,* Aug. 1974, p 55 and 57–59.



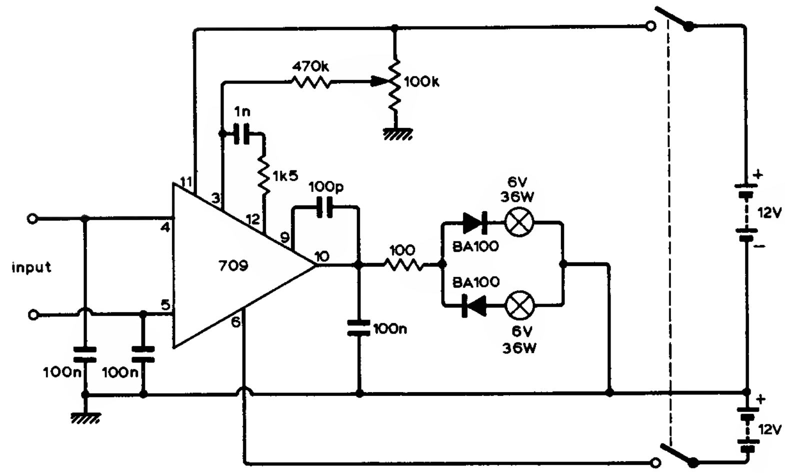
DVM IC DRIVES METER—Uses Siliconix LD111 IC analog processor section of digitel voltmeter IC peir to combine desireble feetures of digital voltmeter with signel-evereging advanteges of ordinary meter. Input range covered is 10 mV to 3 V, with resistive divider being required for lerger input voltege. Differentiel inputs eech heve 1-gigohm input impedence. Circuit requires only two 9-V batteries. Article describes operetion in detail.—B. Hervey, Digitel Voltmeter IC Drives Anelog Meter, *EDN Magazine,* June 20, 1977, p 113.

DVM POLARITY INDICATOR—Designed for usa in low-cost digital voltmetars. With input polarity as indicated, errows on connections indicate direction of current flow. When NPN Q_1 is on, LED 2 will be on; with PNP Q_2 on, LED 1 will be on. Derlingtons Q_1-Q_2 drew very little current, so choica of type is not critical. AC supply is usuelly availabla in lab but can be replaced by intarnel clock of DVM driving smell transformar to giva required floeting AC sourca. A, B, C, and D idantify nodes of bridge.—R. A. Snydar, Polerity Indlcator Mlnimizes Parts Count, *EDN Magazine,* Fab. 20, 1977, p 121.

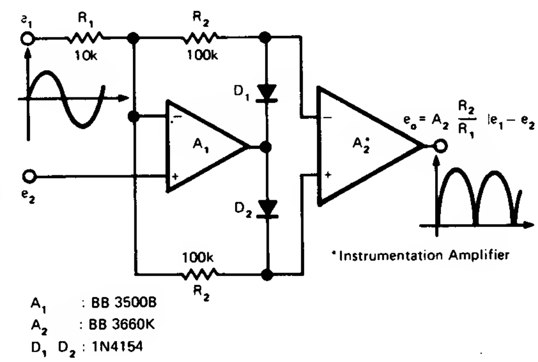




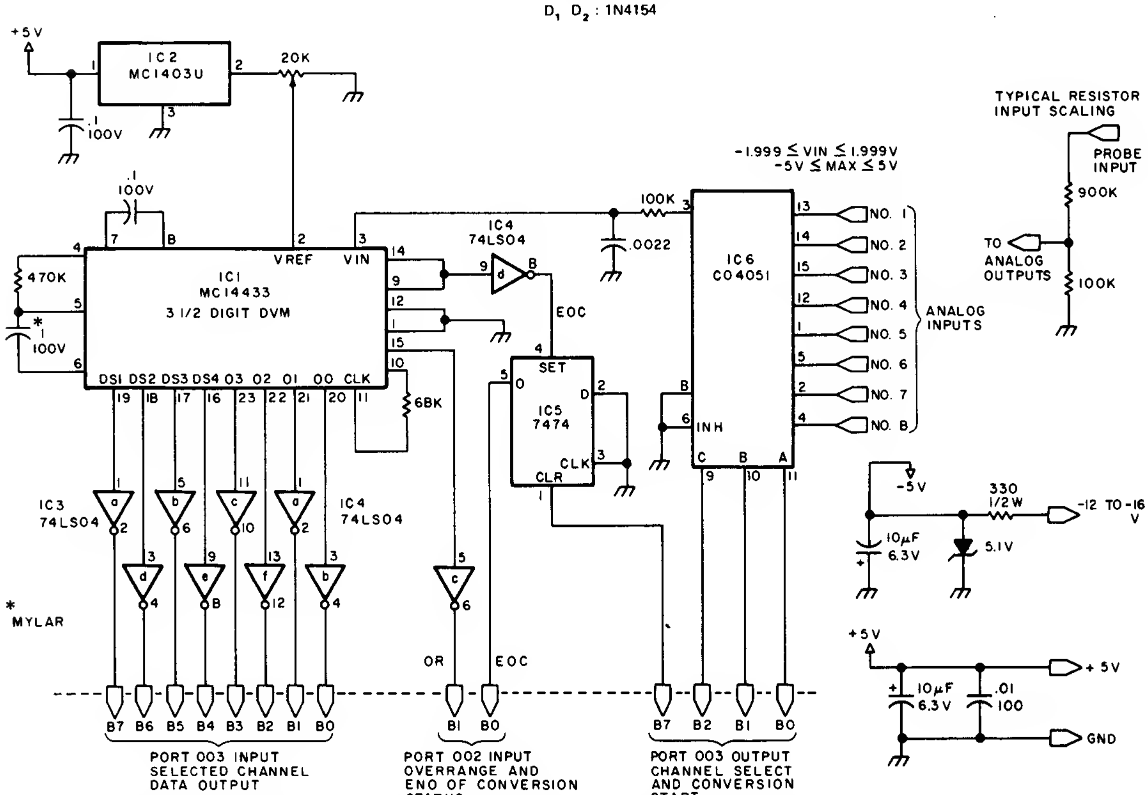
0–2 V DVM—Uses threa Motorola digital voltmater ICs preceded by opemp heving 10-megohm input impedance, driving Hewlett-Peckerd HP5082 multiplexed digital display, with LED serving es decimel point. Input leads must be reversed to reed negetive voltages. Article gives construction end celibretion details. Errate: move C3 upper connection to pin 9 of IC2, end trenspose connections to pins 1 and 2 of IC3.—G. McClellan, DVMs Get Simpler end Simpler, *73 Magazine,* Feb. 1977, p 60–63.



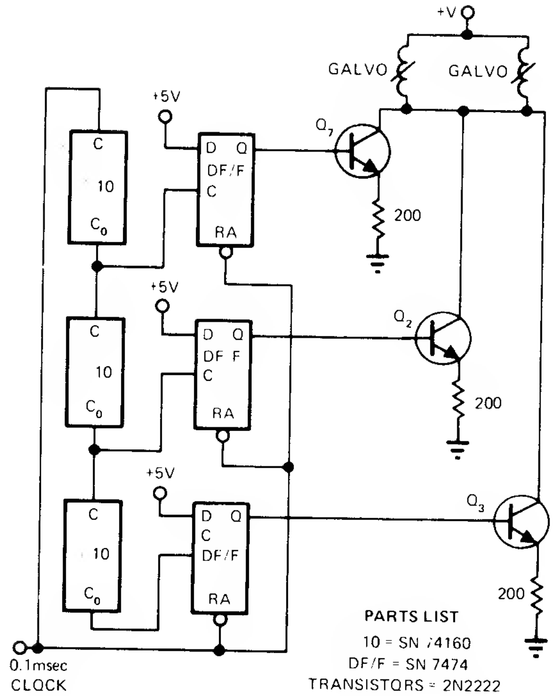
NULL INDICATOR—Opamp is driven open-loop so change of only 1 mV in input voltage makes output switch polarity. This is indicated by one of lamps. Both lamps go out to indicate null. If LEDs are used in place of lamps, diodes are not needed; adjust series resistance as required for full brillience of LEDs.—B. P. Cowan, Miniature Null Indicator, *Wireless World*, June 1973, p 284.



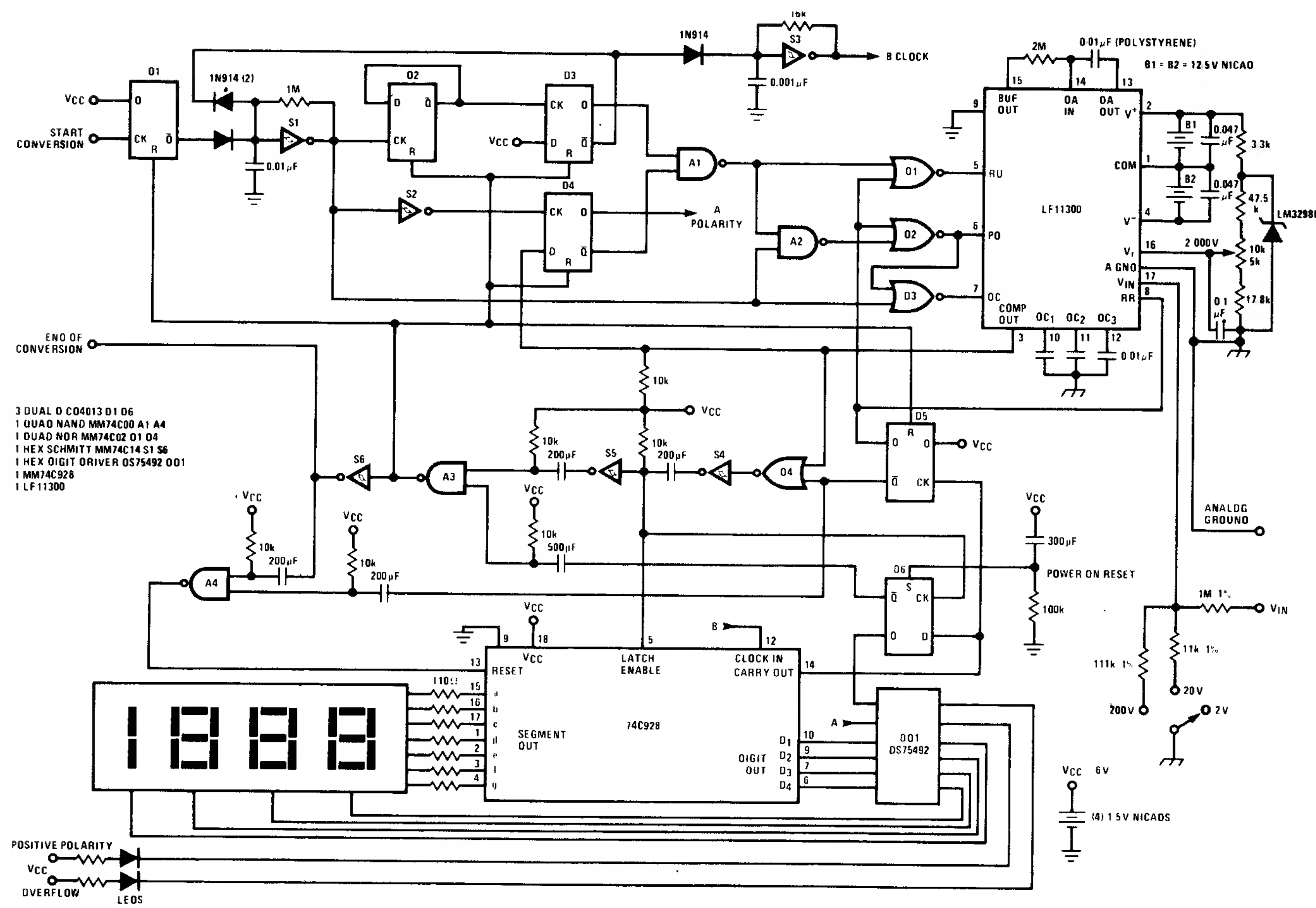
PRECISION SIGNAL RECTIFIER—High input impedance at one of differential inputs of precision rectifier is achieved with opamp A_1 whose output is switched between inputs of instrumentation amplifier A_2 by diodes. This switching reverses polarity of gain provided by A_2 when signal polarity changes, so output signal is always positive.—J. Graeme, Measure Differential AC Signals Easily with Precision Rectifiers, *EDN Magazine*, Jan. 20, 1975, p 45–48.



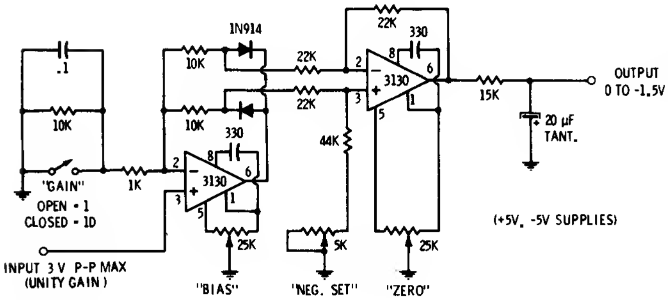
EIGHT-CHANNEL COMPUTERIZED 3½-DIGIT VM—Displays up to eight different DC voltages on CRT terminal of microprocessor under keyboard control, using BASIC commands and BASIC routine given in article. Uses Motorola MC14433 modified duel-lamp integreting analog-to-digital converter. Unknown voltege is applied to integrator having defined integration time constent for predetermined time limit, to give output voltage proportionel to unknown voltage. Computer program substitutes −2.000 V reference from IC2, end circuit keeps track of time for integretor output to move back toward zero. Changing referenca to 0.200 V makes same 1999 count represent 199.9 mV full scale. IC1 performs about 25 conversions per second. IC3 and IC4 are output buffers. IC5 is 7474 used as set-reset flip-flop. IC6 is eight-input CMOS multiplexer input.—S. Ciarcia, Try an 8 Chennel DVM Cocktaill, *BYTE*, Dec. 1977, p 76, 78, 80, 92, 94, 96, and 98–103.



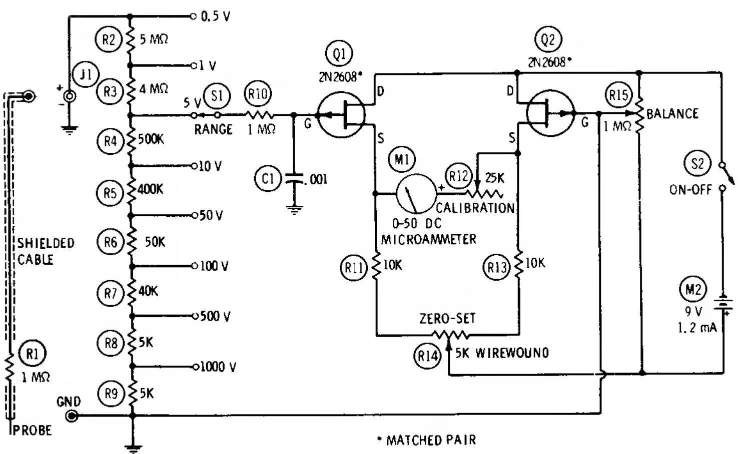
STRIP-CHART TIMING MARKS—Drives two galvanometers for genarating three decades of timing marks in identical pattems on edges of chart. 10-ms marks ara twice as long as 1-ms marks, and 100-ms marks are 3 times length of 1-ms marks. By placing ruler across equivalant marks on edgas, exact tima for any point on racorded pattern is easily and accurately detarmined.—S. Rummel, TTL Circuit Aids Evaluation of Oscillograph Data, *EDN Magazine*, Dec. 5, 1973, p 86.



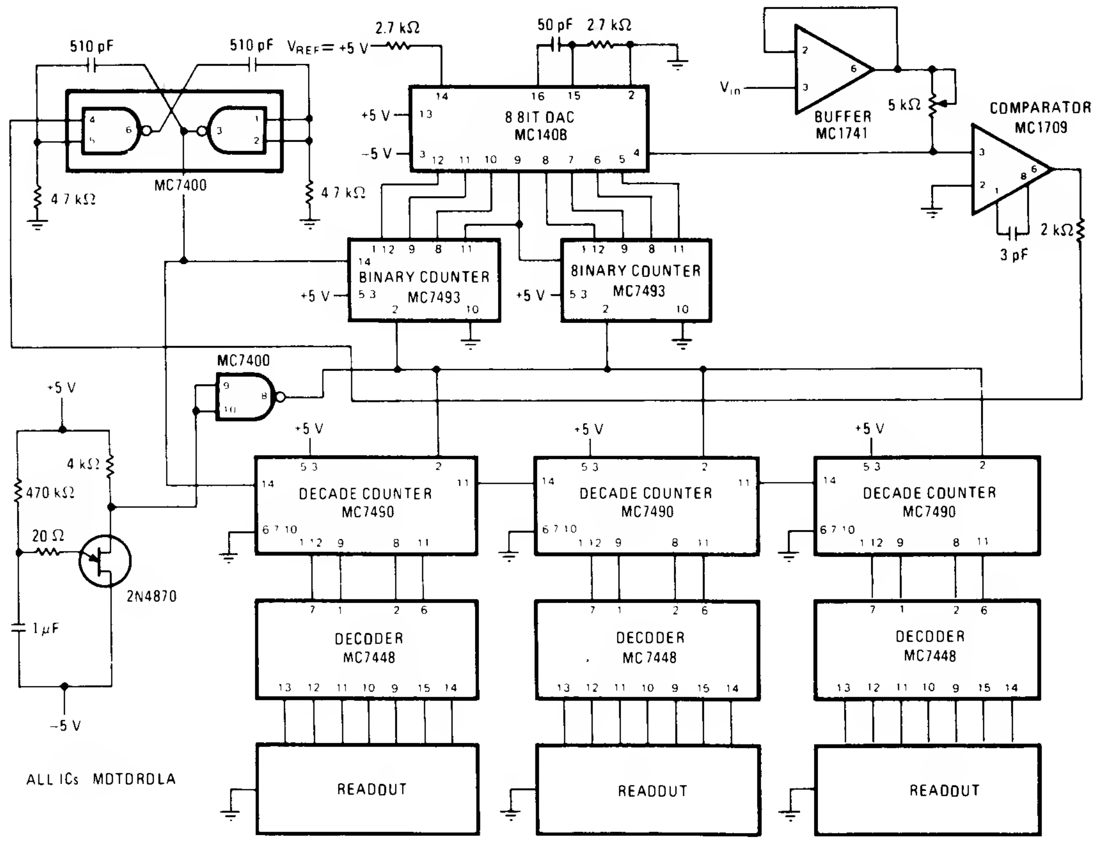
3½-DIGIT DVM—Combination of National LF11300 dual-slope analog building block and MM74C928 CMOS 3½-decade counter with 7-segment outputs gives automatic-zaroing automatic-polarity 3½-digit digital voltmeter. Counter drives LED display with multiplexed 7-sagment information under control of internal frae-running oscillator. Interface circuits provide nonovarlapping control signals to LF11300 for polarity determination and offset correction for avery conversion cycle. Analog circuit draws 1.5 mA from aach 12.5-V battery. Digital circuit draws about 40 mA from 6-V supply.—"CMOS Databook," National Semiconductor, Santa Clara, CA, 1977, p 5-36–5-37.



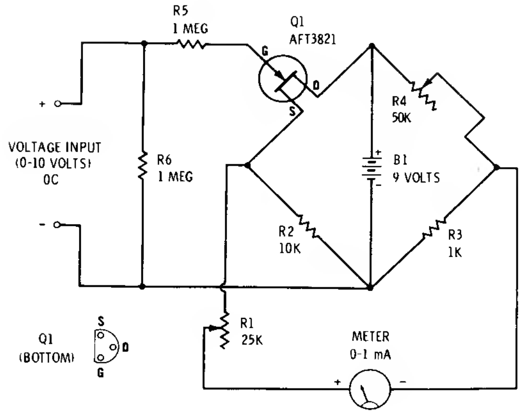
PRECISION RECTIFIER—Used in digitel voltmetars to convart AC waveform to full-wava-rectified DC equivelant. First 3130 opemp is used es polarity separator, with negative-going signals appearing across upper 10K resistor and positive-going signals ecross lower 10K resistor. Output of opemp exceeds thesa voltaga drops by exactly dioda voltaga drop. Sacond opamp staga recombines positiva and nagative peeks. 5K trimming pot is adjusted so both paaks ara equal haight. Output of second opamp is nagetiva-going full-wava replica of input signal. Aftar filtering, output is evaraga DC velua in range from 0 to −1.5 V for 0–3 V P-P input.—D. Lencaster, "CMOS Cookbook," Howard W. Sams, Indienepolis, IN, 1977, p 345–346.



BALANCED-FET DC VOLTMETER—Factory-matched FETs ere connected in resistance bridge that is belanced by R14 to meke metar read zero for 0–V input voltage. Voltage divider provides eight renges, using 1% resistors for accuracy. Soma must be mede up by using two or mora resistors in series. Balanced circuit has very low temperature drift, reducing number of times rebelencing is needed.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianepolis, IN, 1977, 2nd Ed., p 119–122.

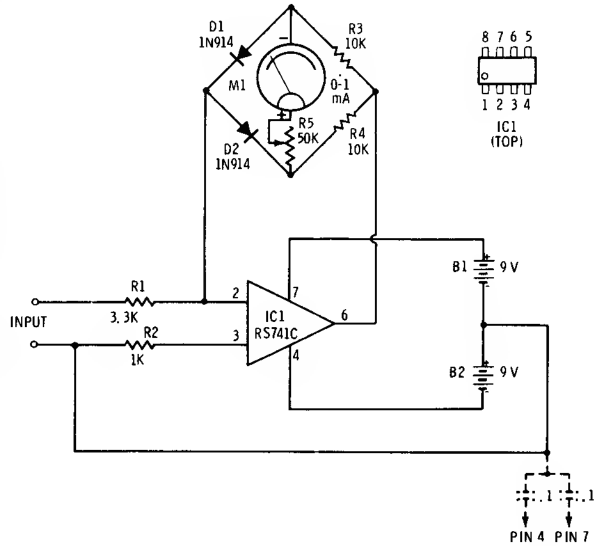


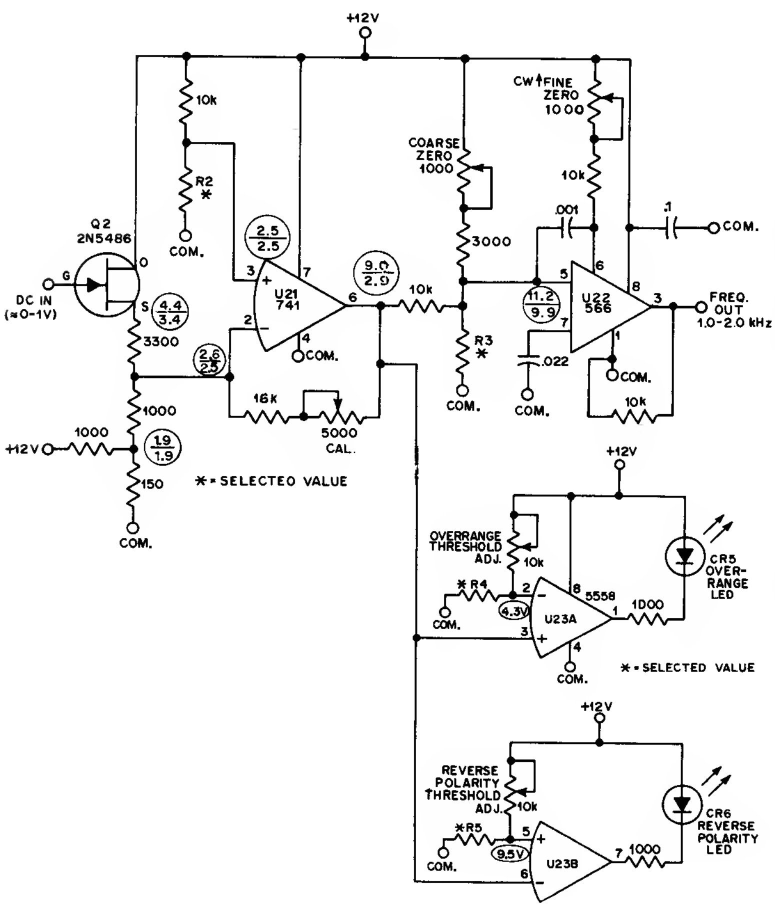
2⅔-DIGIT VOLTMETER—Closed-loop system designed eround Motorole MC1408 8-bit D/A converter uses clocked binery counter feeding converter to produce staircase remp function. Output of convarter is compered to unknown input signal, and clock pulsa is tarmineted whan lavels being compered are equal. Clock pulses ara genereted et 330 kHz by two cross-coupled NAND getes in MC7400. UJT oscillator resets both sets of counters so unknown voltege is re-sampled every 0.5 s. MC7448 BCD to 7-segment dacodars convart outputs of BCD countars to formet for LED displays. With veluas shown, mater cen meesure up to 2.55 V in 10-mV staps. Different full-scale velues cen be obtained by using input voltege dividers or by raplecing unity-gain input buffer with suiteble fixed-gain buffer.—D. Aldridge, "DAC Key to Inexpensive 2⅔ Digit Voltmater," Motorola, Phoenix, AZ, 1975, EB-21.



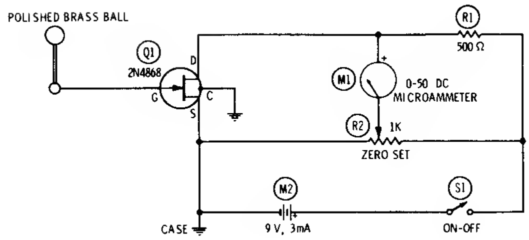
FET VOLTMETER—With FET in one leg of Wheatstone bridge, meter has input impedance of over 1 megohm. With no input voltage, adjust R4 so meter reads zero. With 9-V battery, R1 can be adjusted for full-scale meter reading of 8 V. With 12-V battery, meter range is 0–10 V.—F. M. Mims, "Transistor Projects, Vol. 2," Radio Shack, Fort Worth, TX, 1974, p 59–66.

METER AMPLIFIER—Meter in feedback path of opamp is connected in bridge circuit for measuring both AC and DC voltages. Input voltage is equal to meter current in amperes multiplied by 3 times value of R1 in ohms; with 3.3K and 0.1 mA, input is 0.99 V. Multiplying milliampere reading of meter by 10,000 thus gives input voltage. If long supply leads cause oscillation, connect 0.1-μF capacitors between ground and supply pins 4 and 7 as shown.—F. M. Mims, "Integrated Circuit Projects, Vol. 4," Radio Shack, Fort Worth, TX, 1977, 2nd Ed., p 54–60.



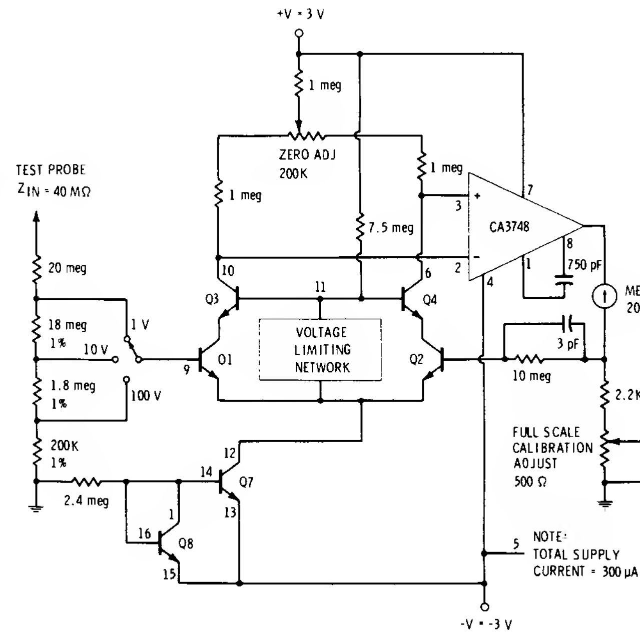


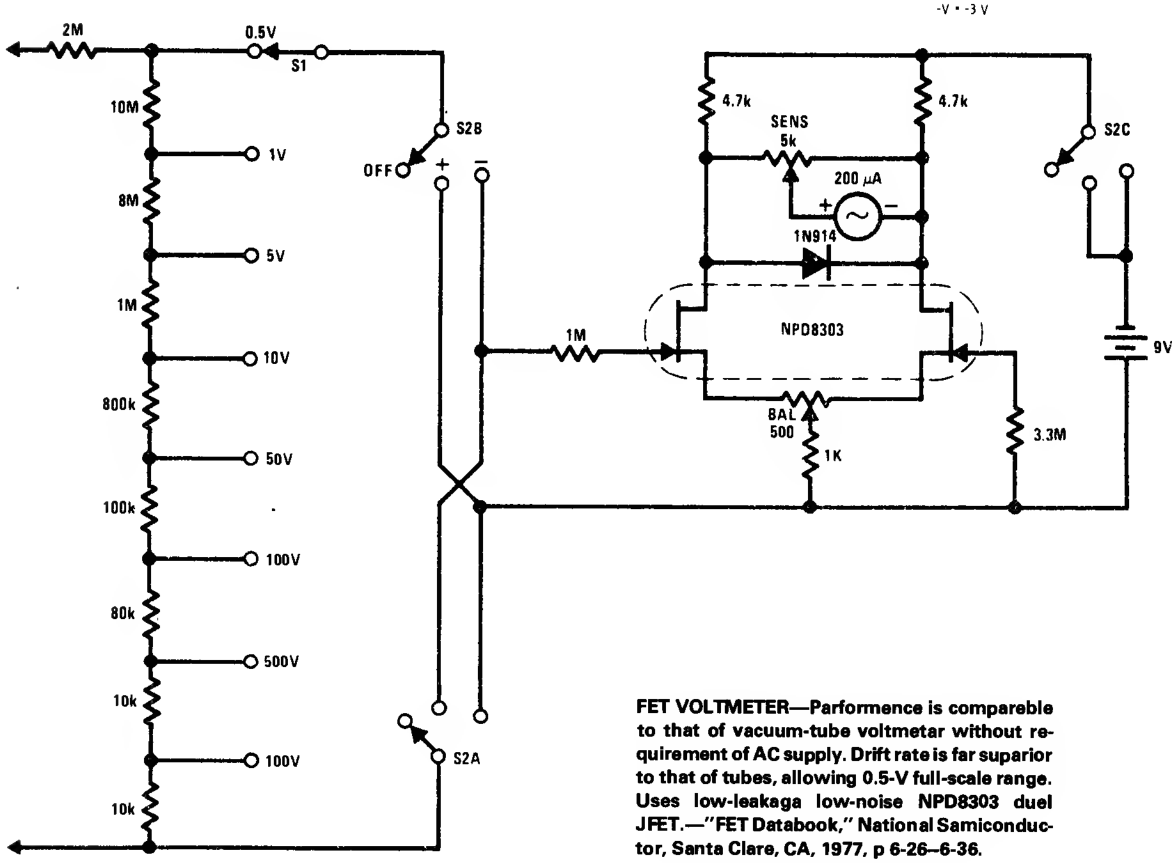
V/F CONVERTER—Can be used with any frequency counter. Only last three digits of display are read for voltage. VCO U22 runs at 1000 Hz when input is grounded and R3 is 56K. Counter is preset to 9000. For 0 V, count starts from 9000 and goes up to 10,000 on display, except that 1 at left overflows so reading is 0 V. If input is +1 V, U22 goes up to 2000 Hz, appearing as 1000 on display. Voltage divider ahead of input is needed to divide full-scale voltages of 10, 100, and 1000 V down to basic 0–1 V range. Range switch is wired to place decimal in appropriate position. Use 2.7K for R2. DC voltages are in circles; upper value is for input probe of electronic voltmeter on +12 V, and lower value for input probe grounded. Terminal A goes to overrange and reverse polarity indicators using 5558 dual opamp U23 and Archer (Radio Shack) 276-041 or equivalent LEDs. R4 and R5 depend on input-signal excursion range and exact value of supply; start with 2700 ohms for R4 and 18K for R5.—J. Hall and C. Watts, Learning to Work with Integrated Circuits, *QST*, June 1976, p 20–24; revised circuit in June 1977, p 20–21.



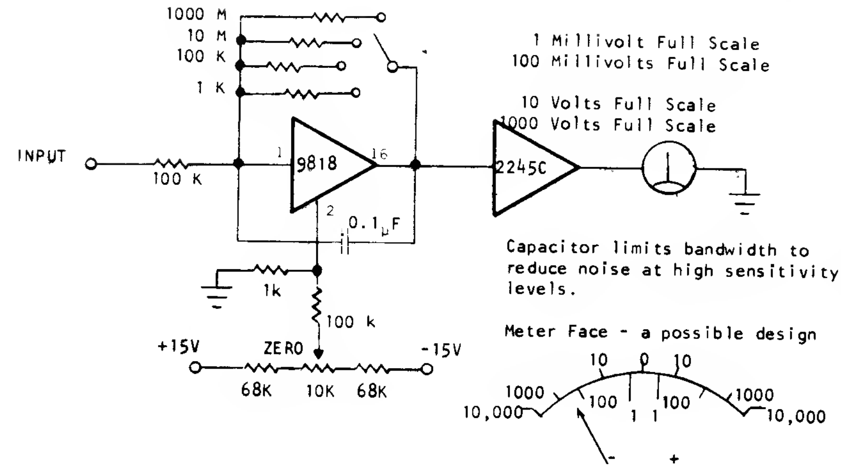
ELECTROSCOPE—Gate of FET floats, being connected only to smooth metal rod tipped with polished brass ball. Rod is insulated from housing with polystyrene washer in large hole. Static drain current of FET is balanced out of meter with R2 when ball is clear of operator's body or other object. Meter deflection then is proportional to intensity of charge on body brought near ball and on separation. Electroscope will respond to vigorously stroked paper or just-used comb.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 153–154.

HIGH INPUT IMPEDANCE—All transistors are on RCA CA3095 transistor array. Q1-Q4 are connected to form bridge, with voltage to be measured applied to base 9. Circuit balance and calibration are achieved by varying DC voltage applied to base of Q2. Q7 and Q8 serve as constant-current source for cascode differential amplifier connection of Q1-Q4. Differential output of bridge is applied to differential input of CA3748 opamp driving meter. Switch gives choice of three voltage ranges.—E. M. Noll, "Linear IC Principles, Experiments, and Projects," Howard W. Sams, Indianapolis, IN, 1974, p 327.

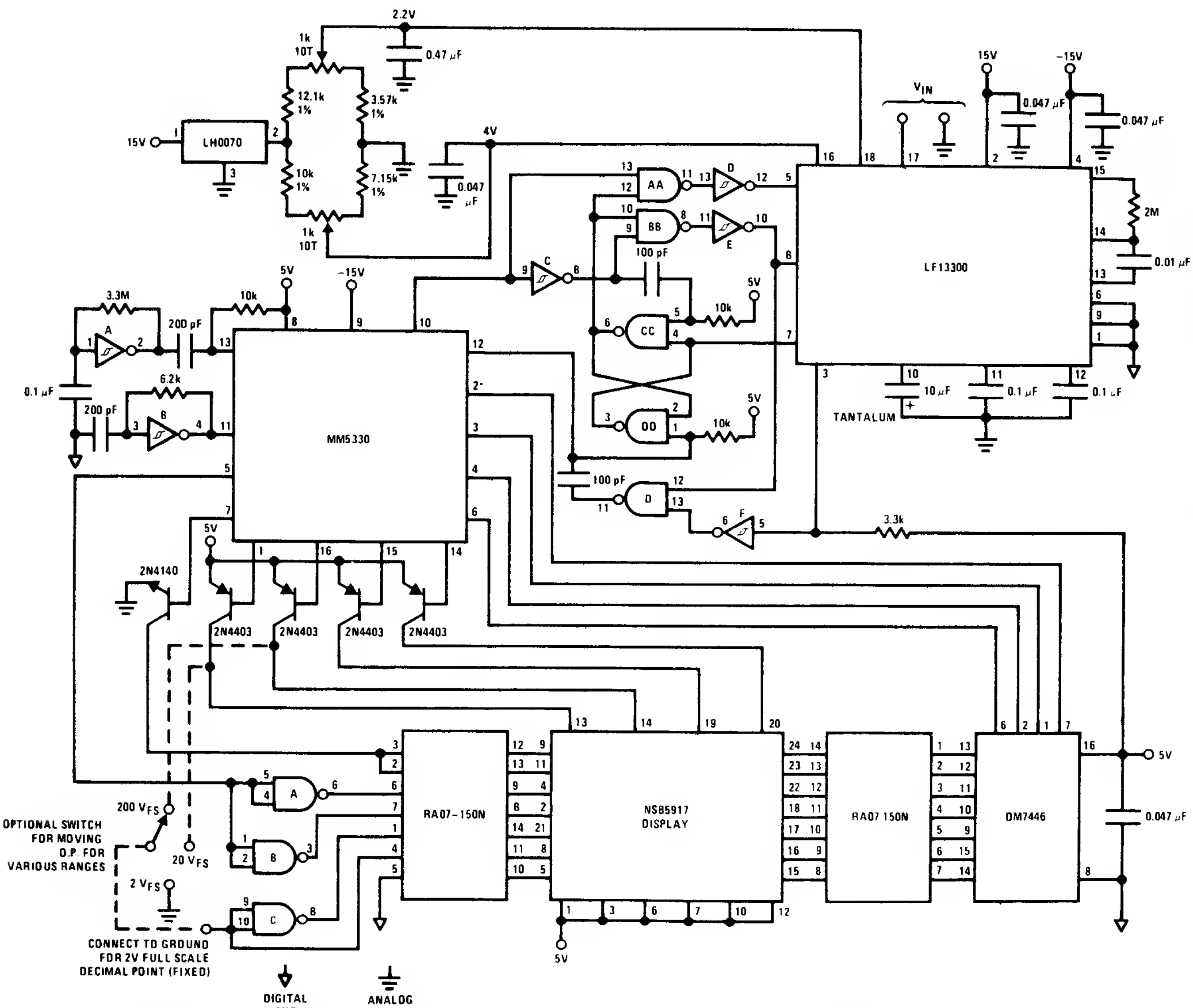




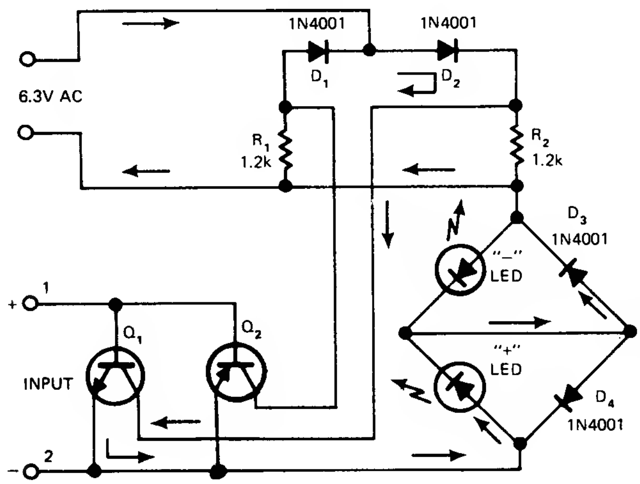
FET VOLTMETER—Performance is comparable to that of vacuum-tube voltmeter without requirement of AC supply. Drift rate is far superior to that of tubes, allowing 0.5-V full-scale range. Uses low-leakage low-noise NPD8303 dual JFET.—"FET Databook," National Semiconductor, Santa Clara, CA, 1977, p 6-26–6-36.



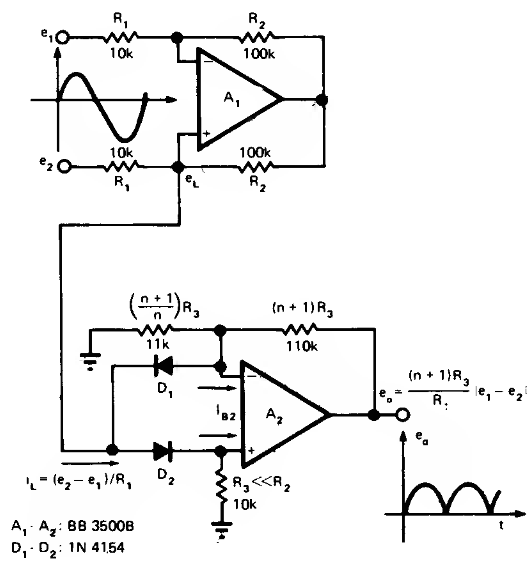
NULL VOLTMETER—Logarithmic voltmeter using Optical Electronics 9818 opamp and 2245C four-decade bipolar logarithmic function can serve as output indicator of Wheatstone bridge, as solid-state galvanometer, or as indicator for differential voltmeter or comparison bridge. Meter scale values are relative; basic sensitivity of circuit corresponds to 1 on scale, representing 100 nV. With this sensitivity, 1 mV gives full-scale reading. Other three positions of range switch give 100 mV, 10 V, and 1000 V for full scale, when using 10–0–10 V meter. Inherent limiting of opamp protects circuit from overvoltage damage.— "A Logarithmic Null-Voltmeter Design," Optical Electronics, Tucson, AZ, Application Tip 10084.



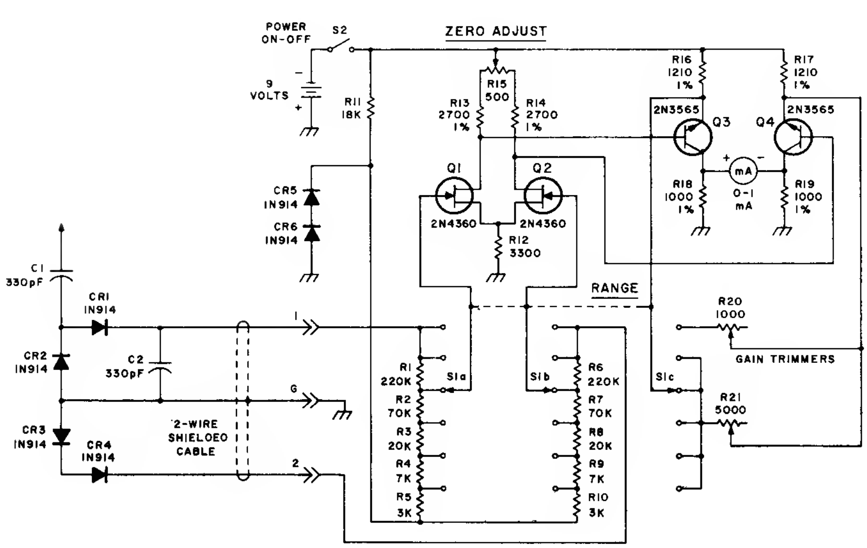
4½-DIGIT METER—National MM5330 BCD building block is used with LF13300 analog section of A/D converter to provide ±19,999 counts on NSB5917 display. Circuit contains counters, latches, and multiplexing system for four full digits of display with one decoder/driver, along with sign bit that is valid during overrange and 10,000-count numeral 1. LF13300 has automatic zeroing of all offset voltages. Operation is based on code conversion of number of counts made by MM5330 before comparator crossing is detected. Switch gives choice of 2-, 20-, and 200-V full-scale ranges. Inverters are MM74C14 hex Schmitt triggers. Two-letter NAND gates are MM74C00 CMOS quad NAND gates. One-letter NAND gates (A, B, etc) are DM7400 TTL quad NAND gates.—"MOS/LSI Datebook," National Semiconductor, Santa Clara, CA, 1977, p 5-2–5-22.



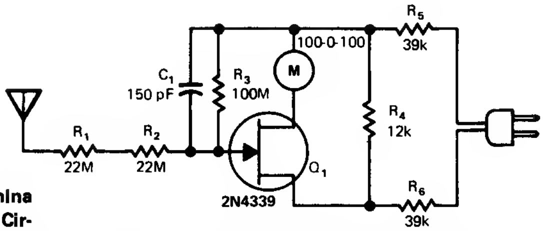
POLARITY INDICATOR—Q_1 and Q_2 at input should ba Darlington transistors to minimiza loading on input signal. With no input, current flows through R_1D_1 and R_2D_2 networks on alternata half-cycles. Positive signal at input 1 turns on Q_1, shunting sum of current through D_3 and lighting positive-indicating LED in diode bridga. Similarly, negativa voltaga on 1 turns on othar LED. Supply raquirament of 6.3 VAC can usually ba obtained from digital multimetar with which indicator is used.—R. A. Snydar, Simpla Polarity Indicator Suits DMM's or DPM's, *EDN Magazine*, Nov. 5, 1977, p 110.



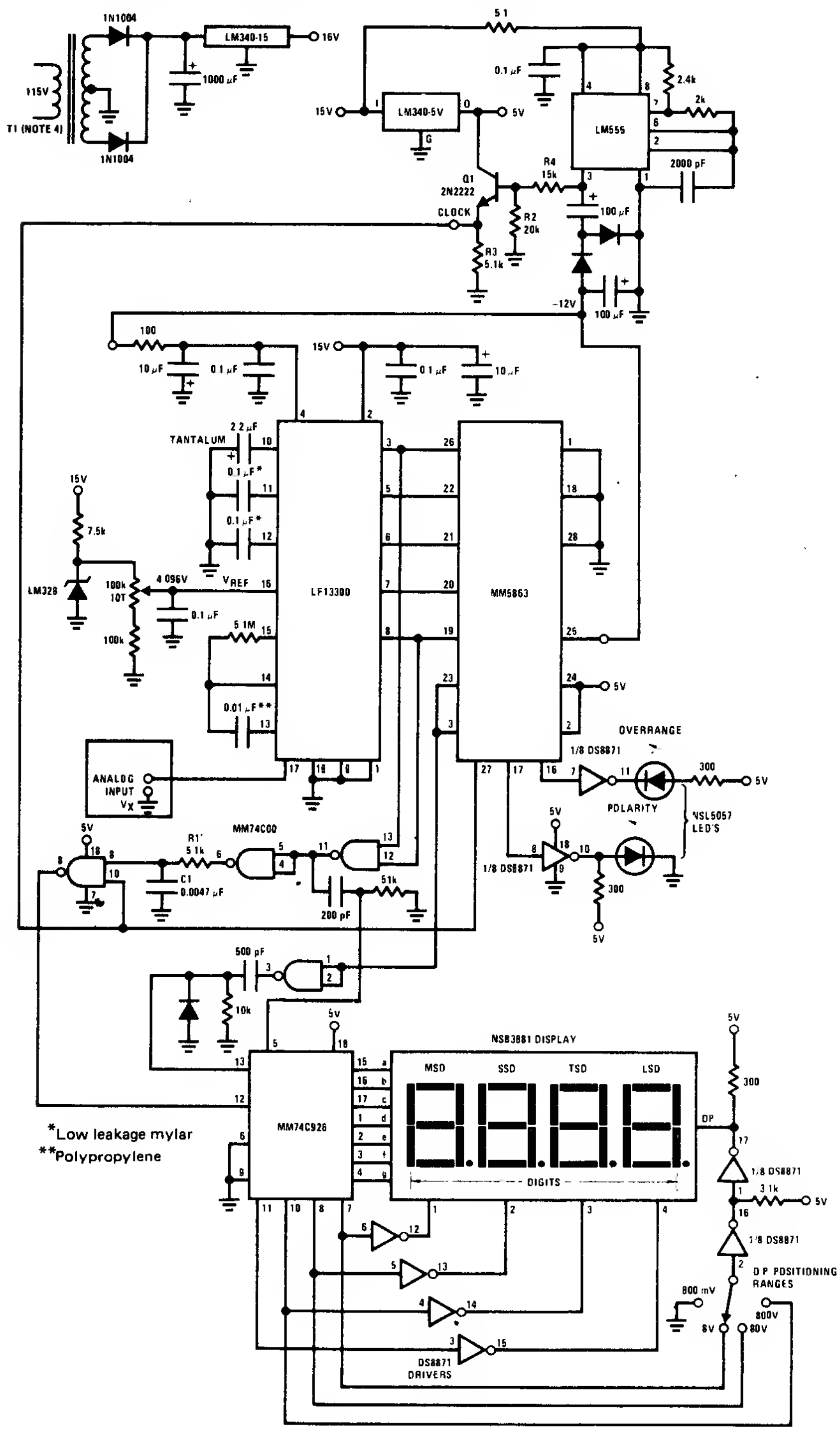
DIFFERENTIAL AC SIGNALS—Precision full-wave ractification of differantial voltaga is achieved by transforming to current for rectification and raconvarsion to output voltaga. One opamp serves as voltage-to-current convarter and the other as rectifying current-to-current convarter. Circuit is suitabla for applications in which lower input impedance and lowar fre-quancy response are accaptabla. Article gives design equations.—J. Graeme, Measura Differential AC Signals Easily with Pracision Rectifiers, *EDN Magazina*, Jan. 20, 1975, p 45–48.

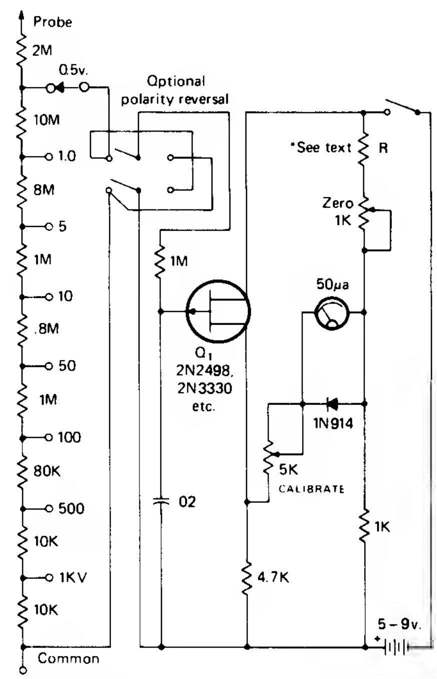


0.4–200 MHz VM—Battery-operated RF voltmeter has full-scale ranges from 0.03 V to 10 V and flat frequancy response from 40 kHz to over 200 MHz. Circuit uses voltage-doubling rectifiar-type probe CR1-CR2 followed by high-gain DC amplifiar driving milliammetar. Article covers construction and calibration in detail.—J. M. Lomasney, Sensitive RF Voltmeter, *73 Magazine*, Dec. 1973, p 53–62.



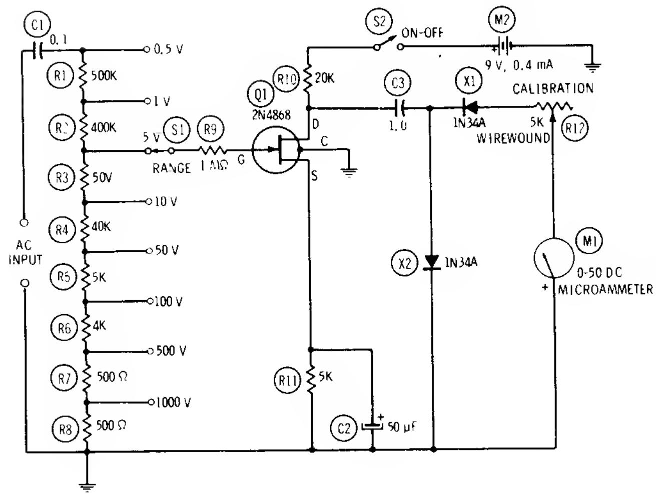
AC LINE POLARITY METER—Used to determina correctness of ground wiring in receptecle. Circuit compares voltege waveform on line conductors with AC potential of 10–40 V at 60 Hz pickad up by antenne which cen be human body. Circuit is synchronous demodulator that conducts on elternate helf-cycles depending on whethar gate voltage of JFET is positive with respect to source or drein. Zero-center DC milliemmeter serves as reedout. If plug is inserted into receptecle having belanced power line, milliemmeter stays et center to indicete leck of ground. With properly grounded receptecle, meter swings full scale in either direction.—T. Gross, Indicator Shows Correct Wiring Polerity, *EDN Magazine,* Oct. 20, 1978, p 150 and 152.





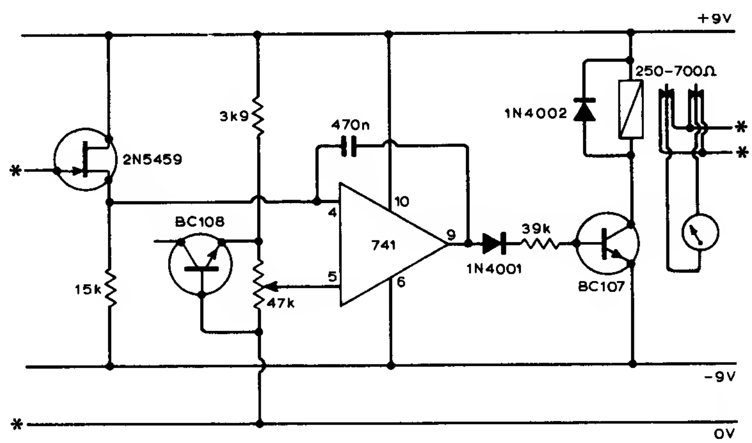
FET VOLTMETER—Voltega dlvider provides 22-megohm resistance for FET version of VTVM. JFET Q_1 is used as source follower. Metar is connected in bridge that is balanced with 1K zero-adjust pot. With proper selection of R, pot can also be used to set zero point of circuit to half scale. Accuracy depends primarily on divider chein. Total current drain rarely exceeds 1 mA, giving long life for elmost any type of bettery.—I. Math, Math's Notes, *CQ,* Oct. 1974, p 26–27.

3¾-DIGIT METER—Netionel MM5883 12-bit binery building block is used with LF13300 anelog section of A/D converter to provide ±8191 counts on NSB3881 display. MM74C928 CMOS counter is connected to count clock pulses during ramp reference cycle of LF13300. Counts ere letched into displey when comperator output trips end goes low. Operetes from single 15-V supply with eid of DC/DC converter. LM555 serves es clock and generates required negetive supply voltages. All diodes are 1N914.—"MOS/LSI Databook," National Semiconductor, Sante Clara, CA, 1977, p 5-2–5-22.



FET AC VOLTMETER—Covers 0–1000 VRMS in eight ranges. Frequency response referred to 1 kHz is down 3.5 dB at 50 Hz and down 2 dB at 50 kHz. Meter deflection is proportional to average value of AC signal voltage, but meter can be calibrated to read RMS voltages on sine-wave basis. Use 1% resistors for voltage divider. Useful for audio and ultrasonic measurements and tests.—R. P. Turner, "FET Circuits," Howard W. Sams, Indianapolis, IN, 1977, 2nd Ed., p 122–124.

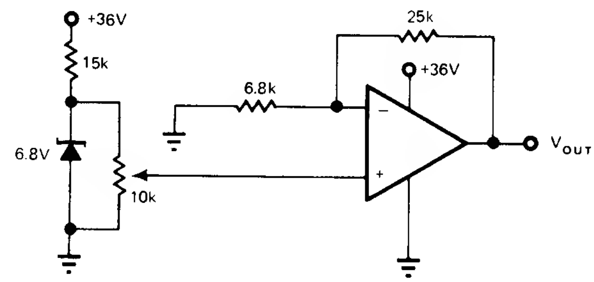
AUTOMATIC POLARITY SWITCHING—Can be added to almost any high-impedance voltmeter to give automatic reversal of polarity as required during measurements. Additional contacts on relay can be used to switch polarity indicators. FET input prevents meter shunting. Feedback is used in opamp comparator to speed switching action.—H. Wedemayer, Auto Polarity Switching for Voltmeters, *Wireless World*, Oct. 1974, p 380.

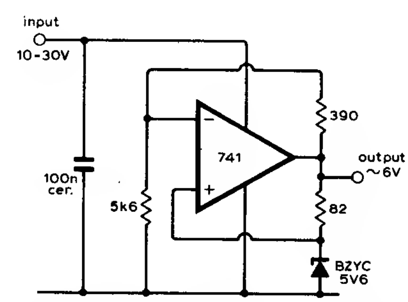


CHAPTER 103
Voltage Reference Circuits

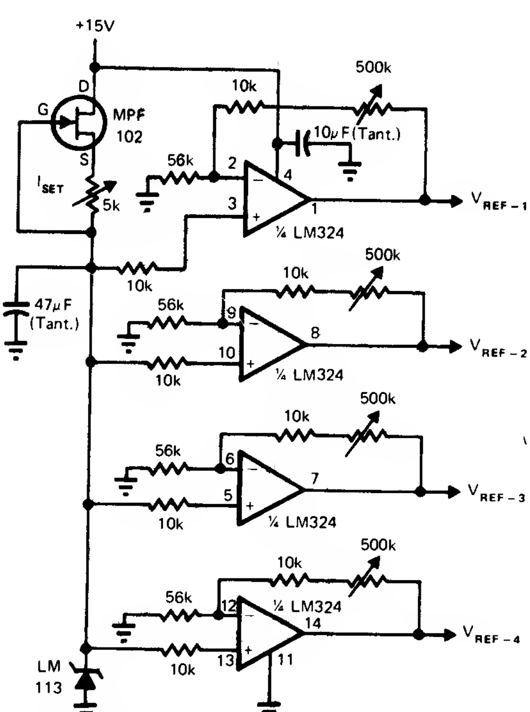
Provides variety of fixed and variable positive and negative voltages up to 30 V for use in regulators and other circuits requiring highly stable reference voltage. Some of circuits can be used as exact replacements for standard cells. See also Regulated Power Supply, Regulator, and Voltage-Level Detector chapters.

VARIABLE REFERENCE—With 759 power opamp used as variable-output voltage regulator, output voltage can be varied over full range from zener maximum down to zero by varying voltage from zener. With 791 opamp, voltage can be adjusted down to 2 V. Since output voltage can be less than zener reting, simple bootstrapping cannot be used. Alternate biesing techniques are then required to improva lina regulation. Arrangement is cepable of supplying severel hundred milliamperes while using only low-drift (5 PPM/°C) zener.—R. J. Apfel, Power Op Amps—Their Innovetlve Circuits and Packeging Provide Designers with Mora Options, *EDN Magazine,* Sept. 5, 1977, p 141–144.

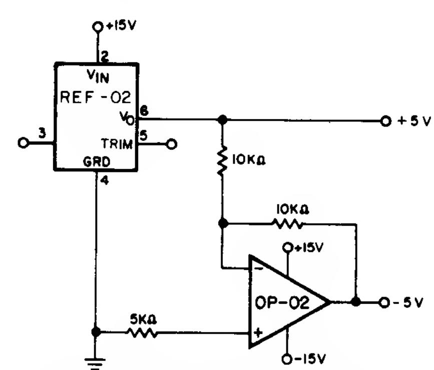




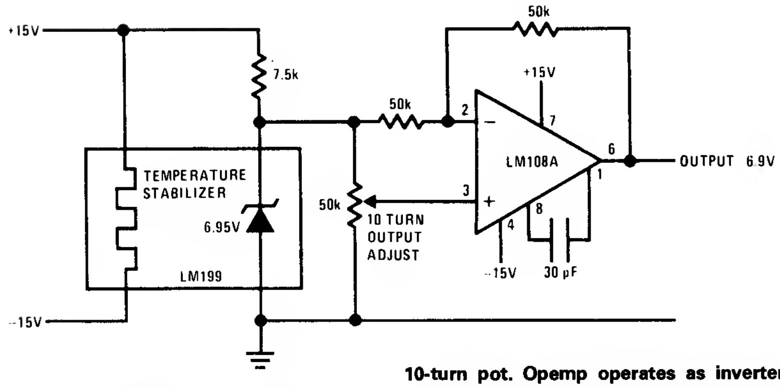
0.005% REGULATION—Simple opemp circuit chenges less than 1 mV at output for input range of 10–30 V. Circuit is easily modified to give othar output voltages, either positive or negative.—M. Walne, High Performanca Reference, *Wireless World,* May 1974, p 123.



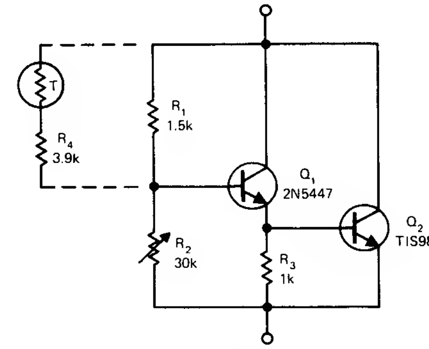
1.5–12 V FOUR-OUTPUT—Single LM113 1.22-V stabla reference is driven by 1-mA FET constent-current source to provide highly stable low-voltage standard driving four adjusteble-gain opemps. Gain of each is set to give desired output reference voltage in range from 1.5 to 12 V. Use cermet trimmers end metal-oxide fixed resistors in opamp feedback circuits to achieve stebilities of severel millivolts over 0 to 70°C renge.—H. Olson, Two IC's and FET Provida Quad Stable Refarence, *EDN Magazine,* Jan. 20, 1974, p 82.



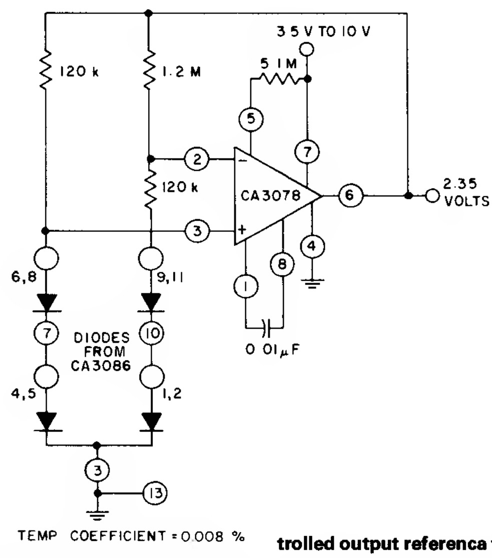
±5 V USING OPAMP—Precision Monolithics REF-02 voltage reference provides +5 V directly, while OP-02 inverting opamp provides −5 V.—"+5 V Precision Voltege Reference/ Thermometer," Precision Monolithics, Santa Clare, CA, 1978, REF-02, p 6.



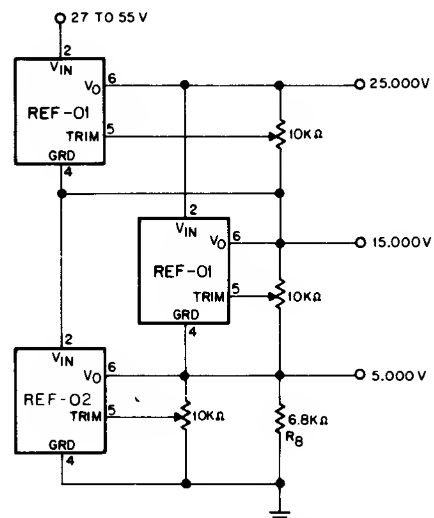
−6.9 V TO +6.9 V VARIABLE—Netionel LM199 temperature-stabilized 6.95-V reference is converted to continuously verieble bipoler output by LM108A opamp. Use precision wirewound 10-turn pot. Opemp operates as inverter for negative outputs but is noninverting for positive outputs.—"Lineer Applications, Vol. 2," Nationel Semiconductor, Sente Clere, CA, 1976, AN-161, p 6.



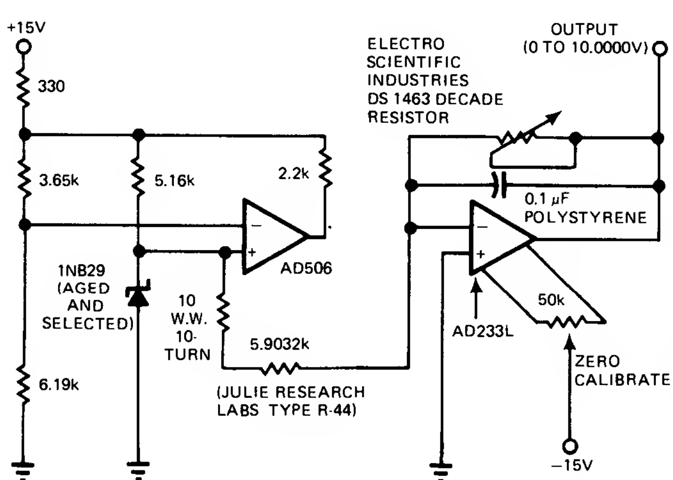
ADJUSTABLE REFERENCE—Two-transistor equivelent of zener is combined with Gulton 35TF1 thermistor to give voltege stability within 0.5% over 0–50°C renge, with output voltage edjusteble from 3.5 to 15.5 V with R_2. Dynemic impedence is only 1 ohm. Developed for reguletor service in bettery-powered MOS instruments.—R. Tenny, Compensated Adjusteble Zener, *EDN Magazine,* Mey 5, 1973, p 72.



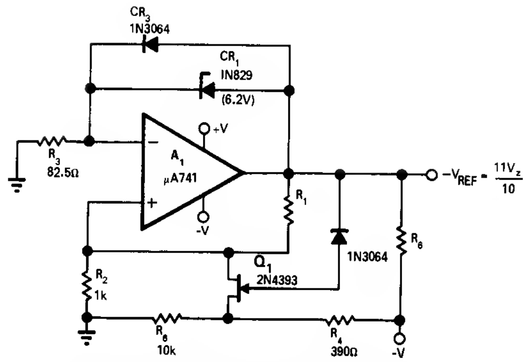
BAND-GAP PRECISION REFERENCE—Uses diodes from CA3086 array end CA3078 micropower opemp to develop 2.35-V precisely controlled output referenca thet is elmost independent of temperature.—"Circuit Ideas for RCA Lineer ICs," RCA Solid State Division, Somerville, NJ, 1977, p 18.



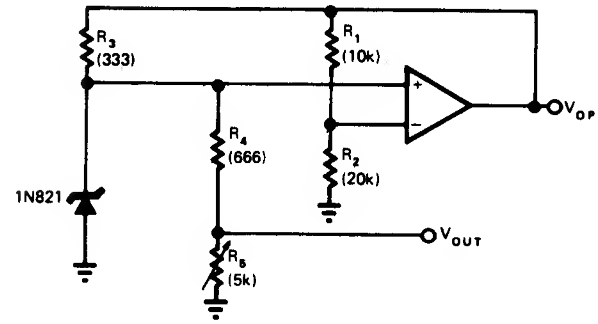
+5, +15, AND +25 V—Stacking of Precision Monolithics REF-02 5-V reference with two REF-01 10-V references gives outputs increesing in steps of 10.000 V from 5.000 V. Any number of edditionel references cen be stecked in seme way up to line-voltege limit of 130 V for references, provided totel loed current does not exceed ebout 21 mA. Input chenge from 27 to 55 V produces output change less then noise voltege of devices in circuit shown.—"+5 V Precision Voltege Reference/Thermometer," Precision Monolithics, Sente Clere, CA, 1978, REF-02, p 7.



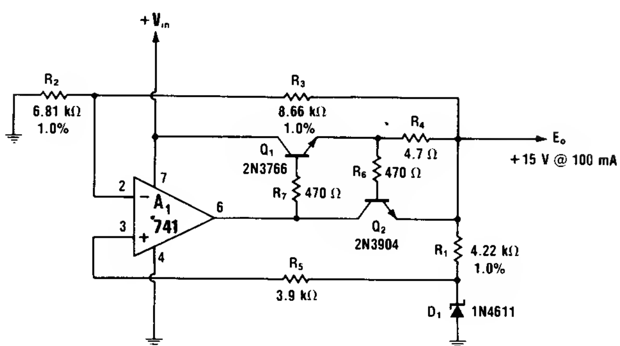
0–10.0000 V IN 100-μV STEPS—Constent current from AD506 opemp drives zener, with 5.16K resistor providing optimum current through zener for tempereture-drift cencelletion. Chopper-stabilized opemp scales output of zener over full renge. Offset-voltege pot serves for zero calibration. Refererce voltage is steble to ebout 11 PPM per yeer.—J. Williems, Don't Bypass the Voltege Reference That Best Suits Your Needs, *EDN Magazine,* Oct. 5, 1977, p 53–57.



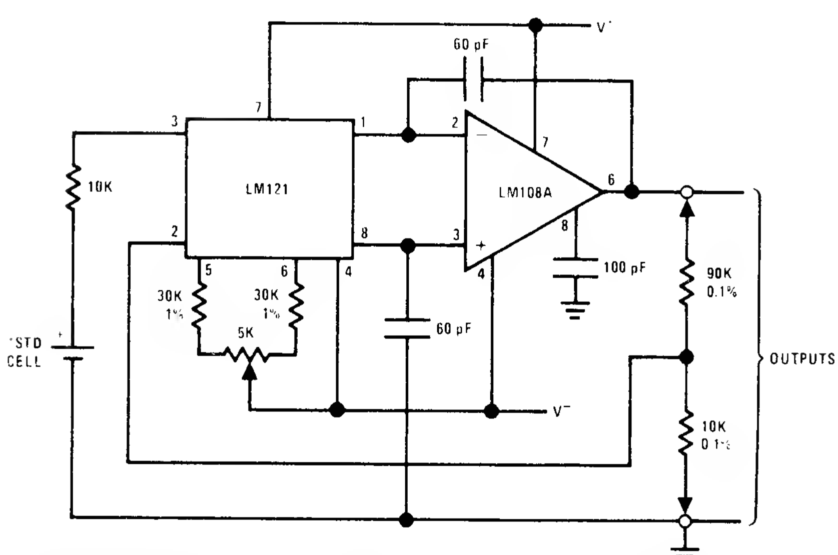
SELF-STABILIZING ZENER—Current through 7.5-mA zener CR_1 is independent of supply voltage, which may be as low as 10 V. Negative reference is 1.1 times zener rating, or −6.8 V for zener shown. Article describes circuit operation and gives design equations.—L. Accardi, Super-Stable Reference-Voltage Source, *EDN/EEE Magazine,* Oct. 1, 1971, p 41–42.



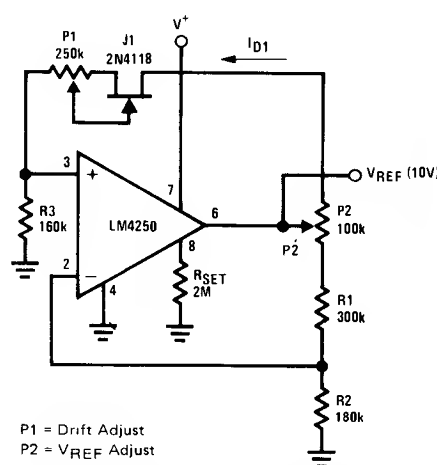
5 V AT 7.5 mA—Circuit uses single pot with standard opamp to adjust output voltage and simultaneously set current of 6.2-V zener at optimum value for temperature stability. With some opamps, emitter-follower may be needed at opamp output to supply necessary zener current. Technique eliminates need for separate zener current adjustment or permits use of lower-cost zener.—K. Henne, Single Control Adjusts Voltage Reference, *EDN Magazine,* June 5, 1976, p 117.



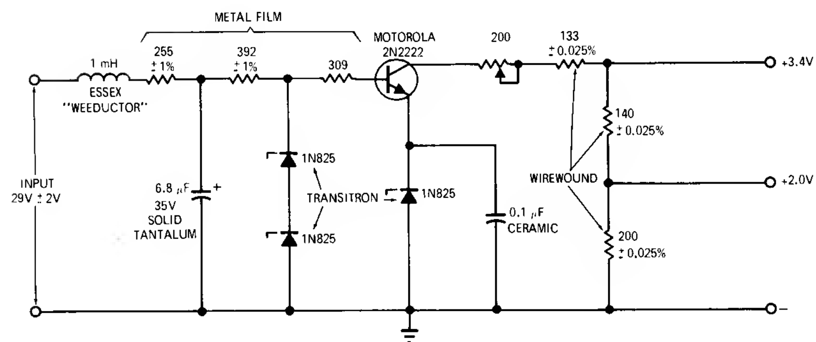
+15 V AT 100 mA—Boost transistor Q_1 is added inside feedback loop to amplify output current of A_1 to 100 mA at scaled-up reference of +15 V from 6.6-V value of zener. R_4 and Q_2 provide protection against load shorts.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 152–155.



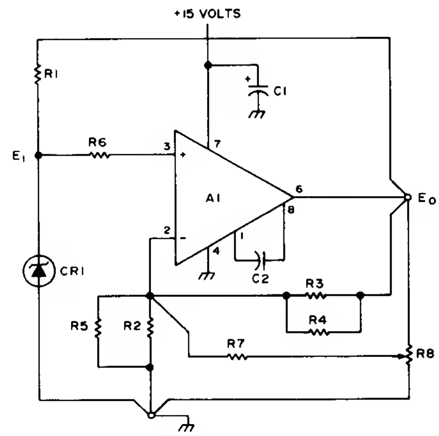
10 V USING STANDARD CELL—Low drift and low input current of National LM121 differential amplifier provide buffering for standard cell with high accuracy. Typical long-term drift for LM121 operating at constant temperature is less than 2 μV per 1000 h. Circuit should be shielded from air currents. When power is not applied, disconnect standard cell to prevent it from discharging through internal protection diodes.—"Linear Applications,Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-79, p 8.



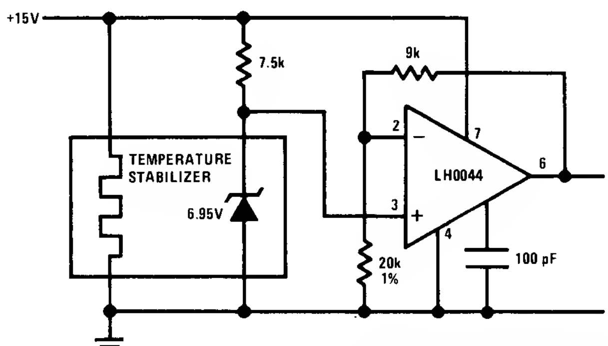
10-V MICROPOWER—Low-drift voltage reference has standby current less than 100 μA, using LM4250 opamp to convert zero-temperature-coefficient current to desired reference voltage output. Adjust P1 for low output temperature coefficient, and adjust P2 for exact reference desired.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, LB-34.



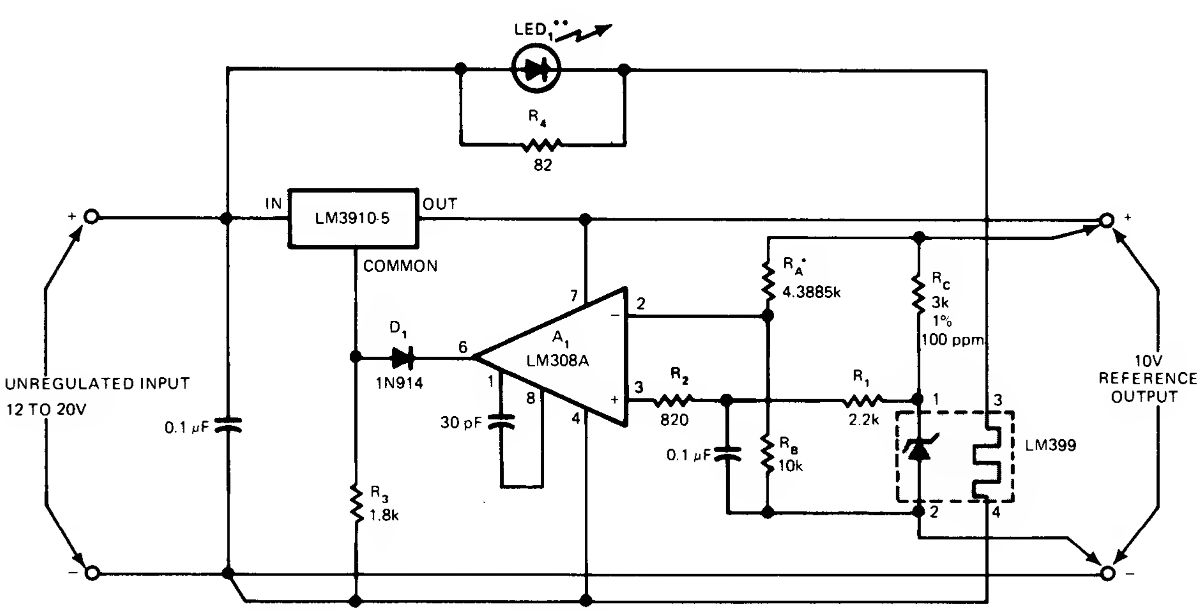
3.4-V RADIATION-HARDENED—Two-stage regulator is combined with special filter design that helps keep output voltage free of gamma-produced transients and RFI. Voltage divider using wirewound resistors provides 2-V output. Gamma radiation of 1,000,000 rads caused only 0.3% change in output voltages. Article covers procedure for designing and testing circuits that are to be operated in high-rediation environment.—A. J. Sofia, Designing a Radiation-Stable Voltage Reference, *EDN Magazine*, Sept. 15, 1970, p 39–41.



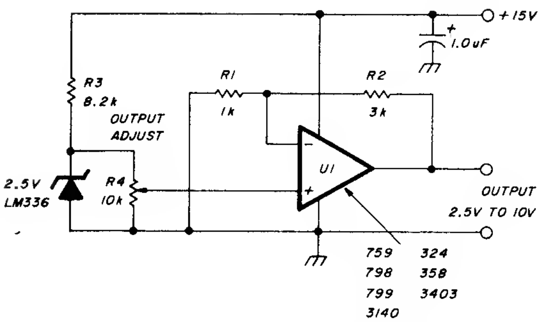
+10.000 V—Uses LM301A opamp with 1N825 6.2-V zener reference diode (not zener regulator diode) to maintain steble DC voltege under severe combinations of temperature, shock, and vibration. Gain resistors R2 end R3 should heve seme 0.01%/°C tempereture coefficients as reference diode. R1 is RN55 511-ohm metel-film resistor, R2 is RN55E 6.04K matel-film resistor, and R3 is RN55E 3.57K metal-film resistor. R4 and R5 ere gain trim resistors. R6 should equal parellel combination of R2 end R5. R8 is 10K cermet pot. with R7 (optional) 100K to 1 megohm. Article tells how to trim circuit for desired output end how to calculate values of resistors end tempereture coefficients for other output voltages.—D. W. Ishmeel, Precision +10.000 V DC Voltege Reference Standard, *73 Magazine*, Sept. 1975, p 124–126.



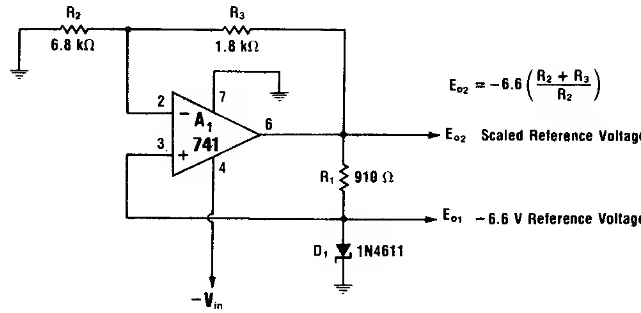
BUFFERED 10 V—Reference voltage developed by Netional LM199 temperature-stabilized IC is 6.95 V with very low tempereture drift and excellent long-term stability. LH0044 precision low-noise opamp is used to scale and buffer reference to give required output of 10 V. Regulation of 15-V supply need be only about 1%.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clare, CA, 1976, AN-161, p 5.



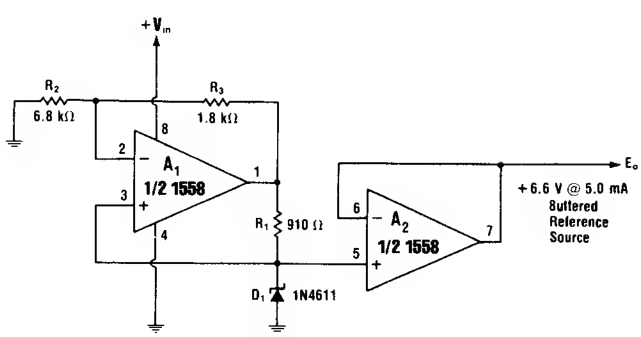
10-V HIGH-PRECISION—Use of LM399 thermally stabilized subsurface zener in state-of-the-art reference circuit keeps temperature error well under 2 PPM/°C over temperature renge of 0 to 70°C. Article gives design equetion end covers procedures for optimizing stability and minimizing power-supply rejection-retio errors.—W. G. Jung, Precision Reference Source Feetures Minimum Errors, *EDN Magazine*, Aug. 5, 1976, p 80 and 82.



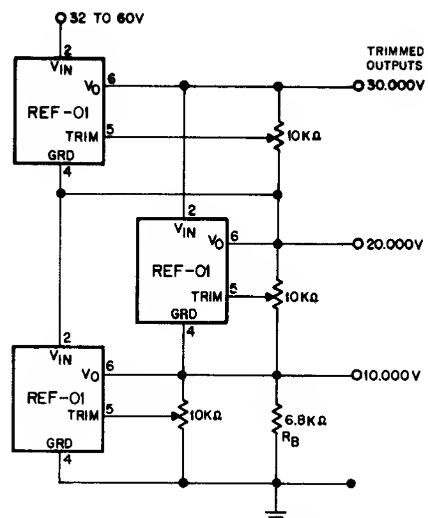
VARIABLE 2.5–10 V—General-purpose opamp end zener, opereting from single 15 V supply, serve es steble buffered voltage reference source that is readily edapted to wide range of output volteges end currents. R4 applies some frection of zener's 2.5 V to opemp, which amplifies it by factor of 4 to give 2.5 to 10 V output. Output current rating depends on opamp and is about 10 mA for generel-purpose types. 759 will handle up to 350 mA, and other devices cen be buffered with NPN emitter-follower stage. For greater output renge, use higher supply voltege end adjust R2 accordingly. R3 should be chosen to meintein about 1 mA in zener.—W. Jung, An IC Op Amp Update, *Ham Radio*, March 1978, p 62–69.



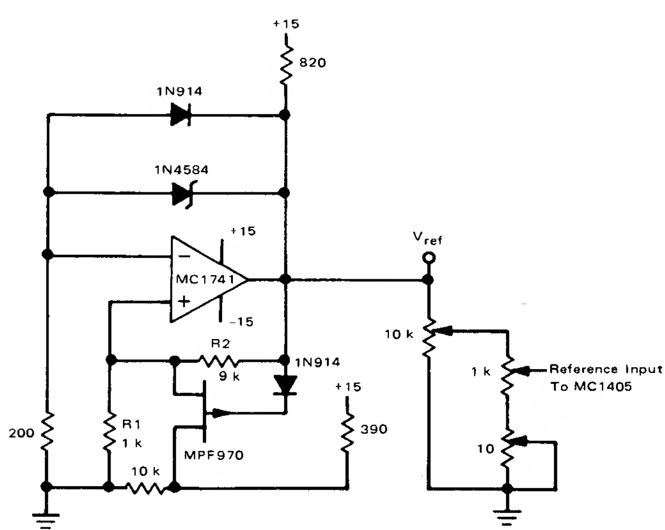
−6.6 V WITH 741 OPAMP—Reference output of −6.6 V, determined by breekdown voltage of zener, is scaled to more negetive level at output of A_1. If 1558 dual opemp is used in plece of 741, other section cen be connected to zener as buffer that raises output current to 5 mA and lowers output impedence.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sems, Indianepolis, IN, 1974, p 151.



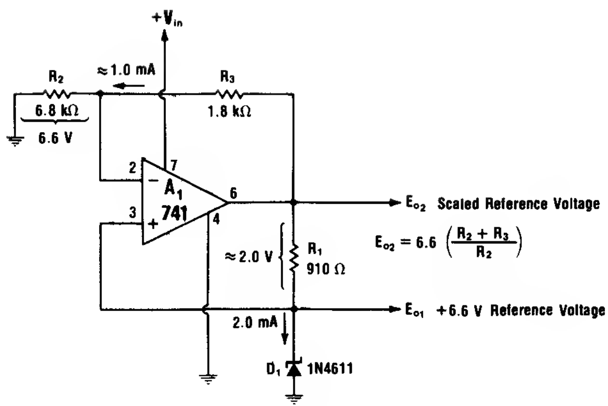
+6.6 V AT 5 mA—Helf of 1558 duel opemp is used as buffer for besic opemp-zener voltage reference to raise output current end lower output impedenca.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sems, Indianapolis, IN, 1974, p 150–151.



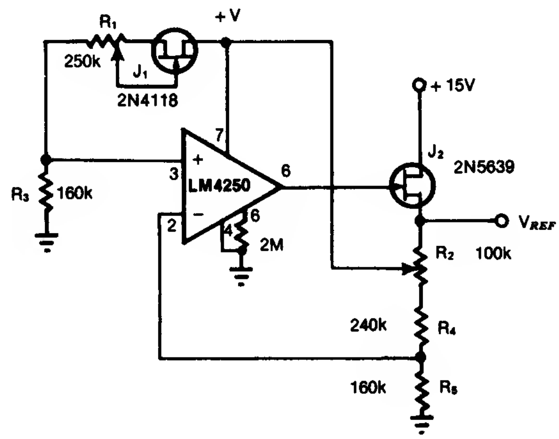
+10, +20, AND +30 V—Simple stacking errengement of Precision Monolithics REF-01 voltage references gives neer-perfect line regulation for inputs of 32 to 60 V, with output chenges less then noise voltage of devices for input extremes. Any number of units can be stacked to obtain edditionel output voltages.—"+10 V Precision Voltage Reference," Precision Monolithics, Sante Clera, CA, 1977, REF-01, p 7.



1-V HIGH-PRECISION—Drift is less then 1 mV over 20°C temperature renge, and voltage divider reduces this to ±0.1 mV for 1.00-V reference required in 4½-digit meter. All three pots should be wirewound. Current of reference zener is regulated by opemp gein end zener voltege.—S. Kelley, "Applications of MC1405/MC14435 in Digital Meters," Motorole, Phoenix, AZ, 1975, AN-748, p 19.

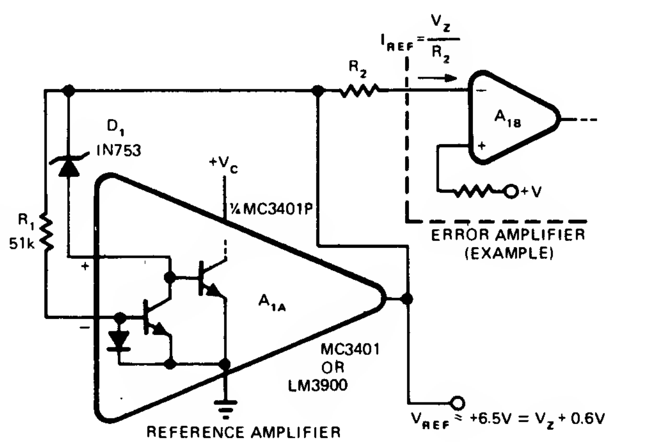


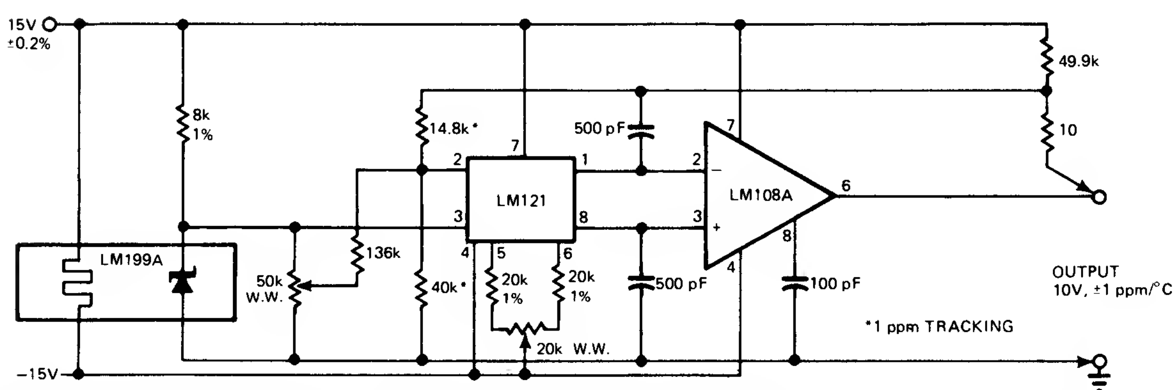
+6.6 V WITH 741 OPAMP—Uses combination of negative and positive feedback to maintain constant current of 2 mA in D_1, independent of veriations in ambiant temperature and unregulated input. Reference voltage of 6.6 V, determined by breekdown voltage of 1N4611 zener, is scaled up to more positive level at output of A_1. Scaled output hes low impedance and can supply eppreciable current without affecting referenca voltege accuracy. Supply must be single-ended for raliable sterting.—W. G. Jung, "IC Op-Amp Cookbook," Howerd W. Sems, Indienapolis, IN, 1974, p 141–143.



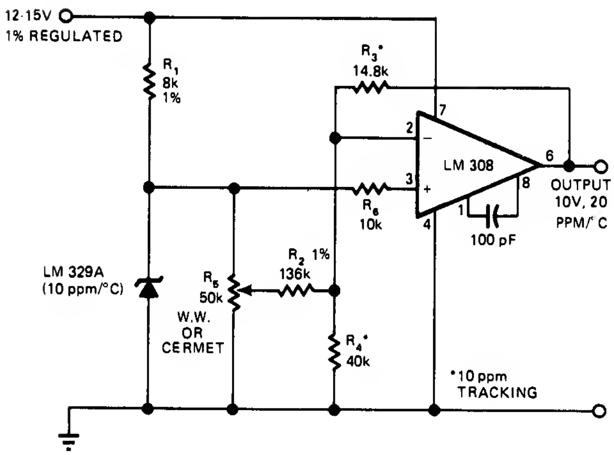
LOW-DRIFT MICROPOWER—Uses JFET biesed slightly below pinchoff in combination with micropower opamp to convert zaro-temperature-coefficiant drein current to correspondingly stabla reference voltage. Additional JFET J_2 makas operation independant of velue of unreguleted input. Output impedance is low. For higher output impedance, refarance voltage cen be teken from wiper of R_2, but buffering could then be required. R_1 is adjusted to compensate for temparetura coefficiant arising from opamp supply current.—N. Sevastopoulos end J. Moyer, Micropower Reference Steys Stable, *EDN Magazina*, Sapt. 5, 1978, p 158.

6.5-V REFERENCE—Referenca amplifier uses mirror characteristic of noninverting input of current-mode opemp to determine zenar current. Resulting voltage drop ecross zener provides, through R_2, current referance for other opamps or companseted voltege reference.—R. W. Fargus, Use Current-Mode Op Amps in Reference Circuits, *EDN Magazine*, June 20, 1974, p 80 and 83.

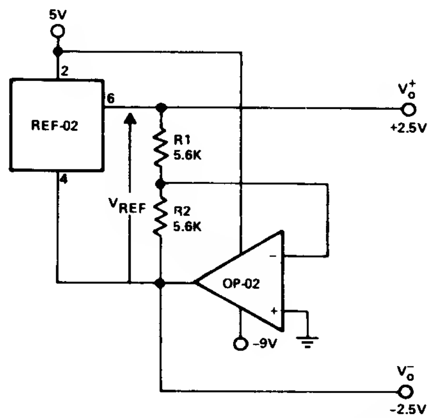




10 V WITH TC TRIMMING—Provides temperature-compensetion trimming to giva lowest possible reference-voltage drift for A/D converter. Reference zener is LM199A havlng 0.5 PPM/°C drift that is independant of operating current. Low-drift combinetion of LM121 end LM108A hes drift predictebly proportional to offset voltage, permitting use of potentiometers for trimming to better than 1 PPM/°C. Article gives details of trimming procedure to be used during temparatura runs.—R. C. Dobkin, Don't Forget Reference Stability When Designing A-to-D Converters, *EDN Magazine*, June 20, 1977, p 105–108.

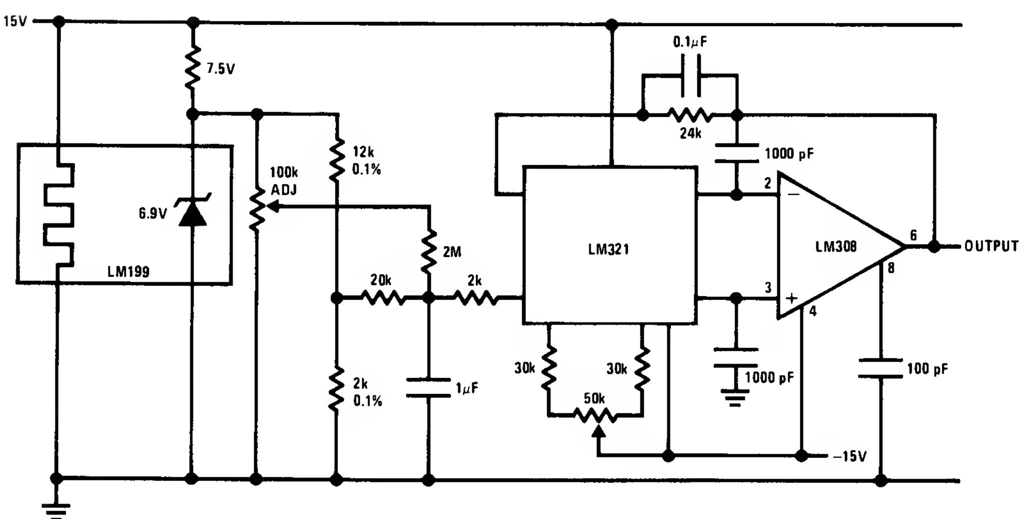


10 V WITH MODERATE DRIFT—Suitabla for A/D convartar applications in which output voltage cen drift as much as 20 PPM/°C. Temparatura-drift error is divided equally between zenar and amplifier, permitting usa of moderataly low-drift components.—R. C. Dobkin, Don't Forget Reference Stebility When Designing A-to-D Converters, *EDN Magazine,* June 20, 1977, p 105–108.

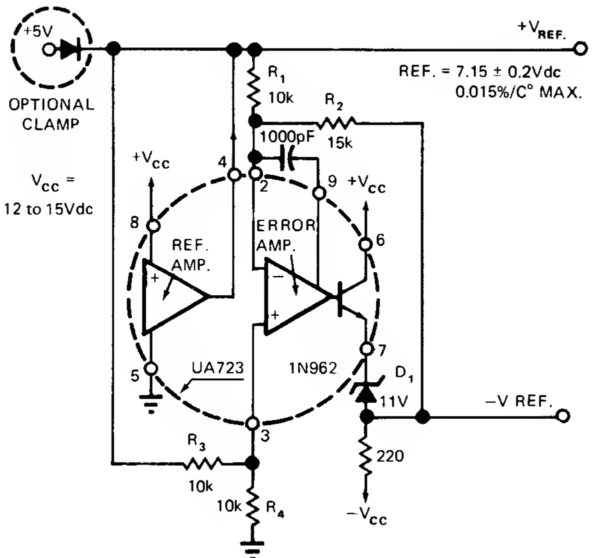


$$V_o^+ = \frac{R_1}{R_1 + R_2}\left(V_{REF}\right) \quad V_o^- = \frac{R_2}{R_1 + R_2}\left(V_{REF}\right)$$

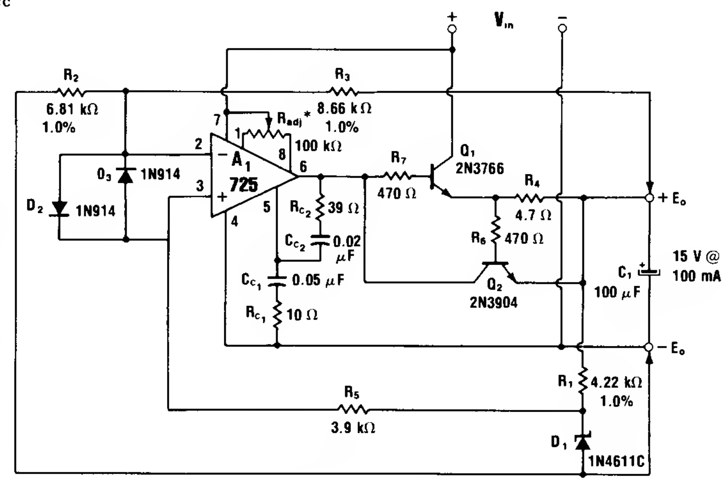
±2.5 V—Precision Monolithics REF-02 voltage refarenca end OP-02 invarting opamp provide desired references whan used with supply voltages shown.—"+5 V Precision Voltega Refarenca/Thermometar," Precision Monolithics, Santa Clara, CA, 1978, REF-02, p 6.



1.01-V STANDARD-CELL REPLACEMENT—National LM199 temparature-stabilizad 6.95-V reference is applied to LM3308 opemp through LM321 preamp to give stendard-call raplecamant thet cen be adjusted to output of exactly 1.01 V. Null offset of opamp befora adjusting for proper output voltaga.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-161, p 5.

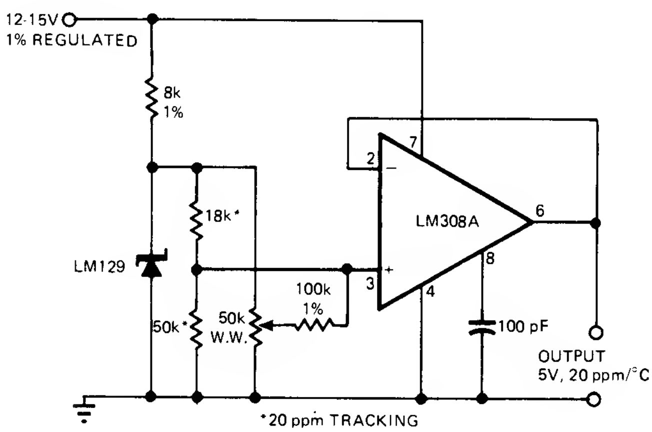


±7 V REFERENCE—Developed for anelog applications requiring dual-polarity references. Both voltages are ganarated from single μA723 IC voltage regulator chip. Chief requirement is kaaping inputs and outputs within dynamic range of amplifiar, which is +2 to +9 V; this is done by shifting output voltaga laval upward with zener D_1 and shifting input arror voltaga with divider R_1-R_2. Changing retio of R_3 to R_4 chengas nagativa refarence velue.—D. Weigand, Dual 7V Referenca Davaloped from a Single μA723, *EDN Magazine*, Nov. 1, 1972, p 47.



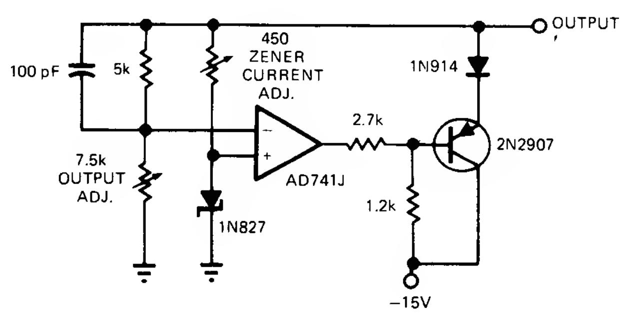
*Adjust for minimum input offset of A_1.

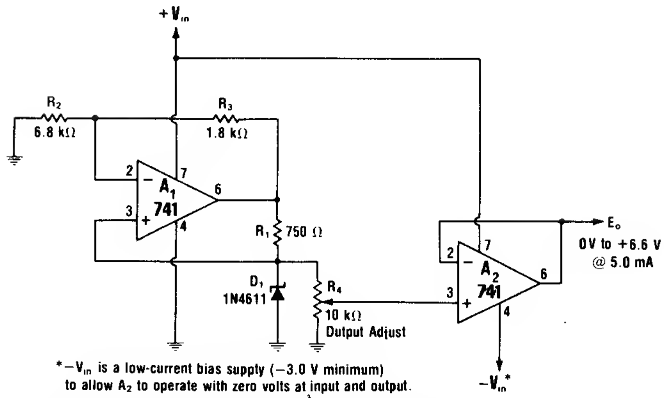
+15 V HIGH-PRECISION—Uses 725 opamp having low offset drift and high common-mode rejection in combination with low-drift version of 1N4611 zener to give highly stabla operetion at output currants up to 100 mA. Closa-tolerance low-temparatura-coefficient film or wirewound resistors ere required for R_1, R_2, and R_3. Remote sensing at load corrects for wiring voltaga drops.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sems, Indianapolis, IN, 1974, p 152-155.



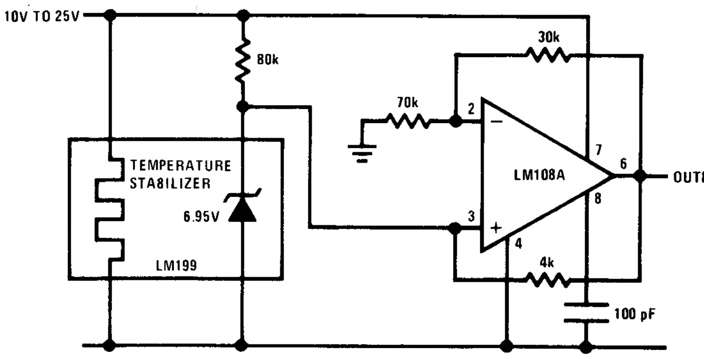
5 V FROM 15 V—Used as refarance for A/D converter whan refarence voltage required is below that of zanar, parmitting simplified circuit design. Zener drift contributes proportionally to output temperatura drift, while opamp offset drift contributes et graatar rata. Opamp is unnecessery if high output impedance can be tolerated.—R. C. Dobkin, Don't Forget Reference Stability When Designing A-to-D Convertars, *EDN Magazina*, June 20, 1977, p 105–108.

10.000 V WITH ZENER—Circuit provides stable current biasing of zenar and adjustabla output voltaga by bootstrapping excitation currant off output voltega. Commercial version of circuit (Analog Davicas AD2700) achiavas tamparature drift of only 3 PPM/°C.—J. Williams, Don't By-pass tha Voltage Reference That Bast Suits Your Needs, *EDN Magazine*, Oct. 5, 1977, p 53–57.

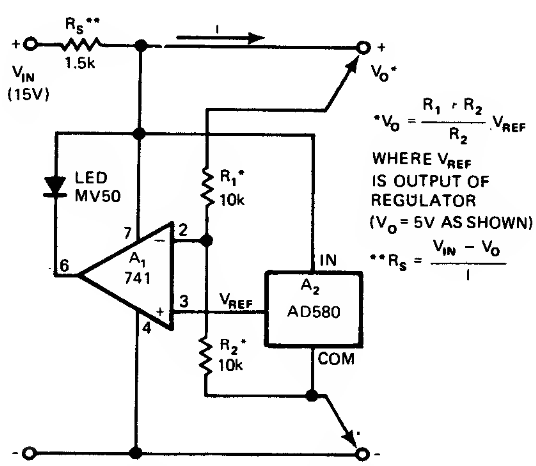




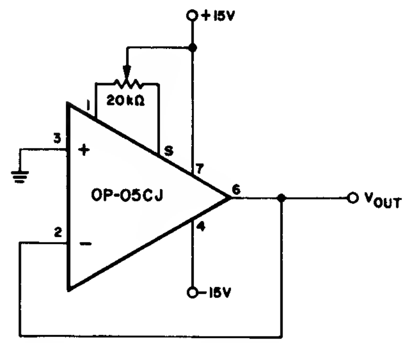
0–6.6 V AT 5 mA—R_4 at input of voltage-follower opamp permits varying reference voltage from 0 up to limit of zener. A_2 compensetes for loeding of zener by R_4. Dual opamp cannot be used because negative supply terminal of A_2 must be slightly more negative than −3 V common to permit linear output operation down to 0 V. If additional load current is required, NPN booster transistor cen be used with A_2.—W. G. Jung, "IC Op-Amp Cookbook," Howard W. Sams, Indianapolis, IN, 1974, p 155–157.



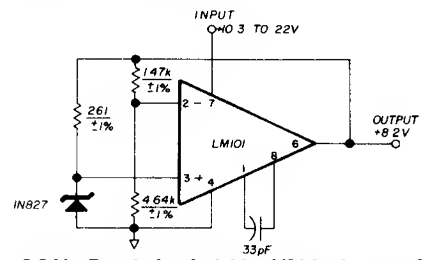
WIDE INPUT VOLTAGE RANGE—Power for LM199 temperature-stabilized voltage reference is obtained from output of LM108A buffer opamp, to permit use with 10–25 V supply. 80K resistor is used in unregulated input to make circuit start properly when power is applied.—"Linear Applications, Vol. 2," National Semiconductor, Santa Clara, CA, 1976, AN-161, p 6.



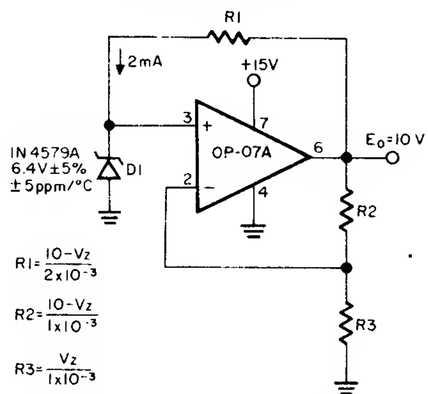
UPWARD SCALING—Output of AD580 three-terminal voltage regulator is multiplied in shunt regulator loop using opamp A_1. Resulting reference voltage V_{REF} is scaled upward by reciprocal of feedback divider R_1/R_2. Resulting reference is immune to input verietions. Reference output range is from 5 V up to voltage limit of opamp used. If desired, reference value can be programmed via R_1. LED lights to show proper operation of circuit.—W. G. Jung, Programmable Voltage Reference Is Stable, yet Simple, *EDN Magazine,* Nov. 5, 1975, p 98 and 100.



OPAMP AS MILLIVOLT REFERENCE—High-performance bipolar-input Precision Monolithics OP-05CJ instrumentation opamp is connected as unity-gain buffer. Output is adjusted to desired reference voltage with pot connected to offset nulling terminels. Reference range is −3.5 mV to +3.5 mV, and long-term drift of zenerless source is less than 3.5 μV per month.—D. Soderquist, "Simple Precision Millivolt Reference Uses No Zeners," Precision Monolithics, Santa Clara, CA, 1975, AN-10.



+8.2 V—Regulation is 0.01 mV/V for inputs of 10.3–22 V, and temperature stability is ±0.05% from −55°C to 125°C. Short-circuit protection for reference is provided internally. Uses National LM101, LM301A, or equivalent opamp.—D. W. Nelson, Introduction to Operational Amplifiers, *Ham Radio,* March 1978, p 48–60.



+10 V WITH BOOTSTRAPPED OPAMP—High-stability Precision Monolithics OP-07A bipolar-input opamp with ultralow offsat voltage provides precise 10 V virtually independent of changes in supply voltage, ambient temperature, end output loading. Choose value of R1 to maintain zener current at exactly 2 mA, using 5 PPM/°C resistor. All resistor values are determined from exact zener voltage V_Z, as given by equations alongside circuit.—D. Soderquist and G. Erdi, "The OP-07 Ultra-Low Offsat Voltage Op Amp—a Bipolar Op Amp That Chellenges Choppers, Eliminates Nulling," Precision Monolithics, Santa Clara, CA, 1975, AN-13, p 8.

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