

Rudolf F. Graf & William Sheets

Encyclopedia of Electronic Circuits

VOLUME 4

OVER 200,000
COMPANION VOLUMES SOLD

Encyclopedia of Electronic Circuits

VOLUME 4

Patent notice

Purchasers and other users of this book are advised that several projects described herein could be proprietary devices covered by letters patent owned or applied for. Their inclusion in this book does not, by implication or otherwise, grant any license under such patents or patent rights for commercial use. No one participating in the preparation or publication of this book assumes responsibility for any liability resulting from unlicensed use of information contained herein.

Encyclopedia of Electronic Circuits

VOLUME 4

Rudolf F. Graf & William Sheets

TAB

TAB BOOKS

Blue Ridge Summit, PA

FIRST EDITION
FIRST PRINTING

© 1992 by **Rudolf F. Graf and William Sheets.**

Published by TAB Books.

TAB Books is a division of McGraw-Hill, Inc.

Printed in the United States of America. All rights reserved. The publisher takes no responsibility for the use of any of the materials or methods described in this book, nor for the products thereof.

Library of Congress Cataloging-in-Publication Data

(Revised for volume 4)

Graf, Rudolf F.

Encyclopedia of electronic circuits.

Vol. 4: By Rudolf F. Graf and William Sheets.

Includes bibliographical references and indexes.

1. Electronic circuits—Encyclopedias. I. Sheets,

William. II. Title.

TK7867.G66 1985 621.3815'.3 84-26772

ISBN 0-8306-0938-5 (v. 1)

ISBN 0-8306-1938-0 (pbk. : v. 1)

ISBN 0-8306-3138-0 (pbk. : v. 2)

ISBN 0-8306-3138-0 (v. 2)

ISBN 0-8306-3348-0 (pbk. : v. 3)

ISBN 0-8306-7348-2 (v. 3)

ISBN 0-8306-3895-4 (pbk. : v. 4)

ISBN 0-8306-3896-2 (v. 4)

TAB Books offers software for sale. For information and a catalog, please contact
TAB Software Department, Blue Ridge Summit, PA 17294-0850.

Acquisitions Editor: Roland S. Phelps
Technical Editor: Andrew Yoder
Director of Production: Katherine G. Brown
Cover Design: Holberg Design, York, PA

TAB1

Contents

	Introduction	ix
1	Active Antennas	1
2	Analog-to-Digital Converter	5
3	Annunciators	7
4	Antenna Circuits	11
5	Audio Effects Circuits	15
6	Audio Scramblers	25
7	Audio Power Amplifiers	28
8	Audio Signal Amplifiers	34
9	Automotive Instrumentation Circuits	43
10	Automotive Security Circuits	49
11	Automotive Light Circuits	57
12	Automotive Electronic Circuits	63
13	Battery Chargers	68
14	Battery Monitors	73

15	Bridge Circuits	81
16	Burglar Alarms	84
17	Buffers	88
18	Carrier-Current Circuits	91
19	Compressor/Expander Circuits	94
20	Computer-Related Circuits	98
21	Converters	110
22	Crystal Oscillators	121
23	Data Circuits	129
24	Detectors	134
25	Direction Finders	146
26	Dividers	150
27	Driver Circuits	157
28	Electronic Locks	161
29	Field-Strength Meters	164
30	Filter Circuits	167
31	Flashers and Blinkers	178
32	Fluid and Moisture Detectors	184
33	Frequency-to-Voltage Converters	192
34	Function Generators	196
35	Games	203
36	Ground-Fault Hall Detector	208
37	Indicators	210
38	Infrared Circuits	219
39	Instrumentation Amplifiers	229
40	Intercom	235
41	Interface Circuits	238
42	Keying Circuits	243
43	Light-Control Circuits	246
44	Limiter	255
45	Mathematical Circuits	258

46	Measuring and Test Circuits	264
47	Measuring and Test Circuits (<i>E</i>, <i>I</i>, and <i>R</i>)	283
48	Measuring and Test Circuits (High-Frequency and RF)	297
49	Measuring and Test Circuits (Sound)	304
50	Metronomes	312
51	Microwave Amplifier Circuits	315
52	Miscellaneous Treasures	320
53	Mixers	330
54	Model and Hobby Circuits	337
55	Motion and Proximity Detectors	341
56	Motor Control Circuits	347
57	Noise-Reduction Circuits	354
58	Operational-Amplifier Circuits	357
59	Optical Circuits	365
60	Oscillators	370
61	Photography-Related Circuits	378
62	Power-Control Circuits	383
63	Power Supplies (Fixed)	390
64	Power Supplies (High-Voltage)	409
65	Power Supplies (Variable)	414
66	Power-Supply Monitors	422
67	Probes	428
68	Pulse Circuits	435
69	Radar Detectors	441
70	Ramp and Staircase Generators	443
71	Receivers	448
72	Receiving Circuits	456
73	Regulator Circuits	462
74	Regulators (Variable)	468
75	Relay Circuits	471
76	RF Amplifiers	476

77	RF Converters	494
78	Sample-and-Hold Circuit	502
79	Sine-Wave Oscillators	504
80	Sirens, Warblers, Wailers, and Whoopers	514
81	Sound Effects	518
82	Sound-Operated Circuits	525
83	Square-Wave Generators	529
84	Switching Circuits	537
85	Tape Recorder Circuits	547
86	Telephone-Related Circuits	549
87	Temperature Circuits	565
88	Temperature Sensors	568
89	Thermometer Circuits	573
90	Timers	578
91	Tone-Control Circuits	587
92	Touch Controls	590
93	Transmitters and Transceivers	595
94	Ultrasonic Circuits	604
95	Video Circuits	607
96	Video-Switching Circuits	618
97	Voice-Operated Circuits	622
98	Voltage-Controlled Oscillators	625
99	Voltage Multiplier Circuits	631
100	Voltage-to-Frequency Converters	638
101	Volume/Level-Control Circuit	643
102	Wave-Shaping Circuits	646
103	Wireless Microphones	652
104	Window Circuits	655
	Sources	660
	Index	683

Introduction

Volume 4 of *Encyclopedia of Electronic Circuits* contains many new, not previously covered circuits, organized into 104 chapters. Circuit titles are listed at the beginning of each chapter, for references. Most of these circuits appeared in publications since 1988 and should be very useful for obtaining new ideas for research and development, or simply to fill a need for a specific circuit idea or application. Those wishing to develop their own circuits will find this book indispensable as a source of ideas, to see how others have solved a problem or approach a design, and to obtain a starting point toward a new design.

A brief explanation accompanies almost every entry. Those that have been omitted are either repetitive, obvious, or too involved to describe in few words. In this case, the reader should consult the original sources (as listed in the back of the book).

We also wish to extend our sincere thanks to Ms. Loretta Gonsalves for her fine work at the word processor. Her skill and cooperation contributed much to the successful completion of this book.

Rudolf Graf and William Sheets

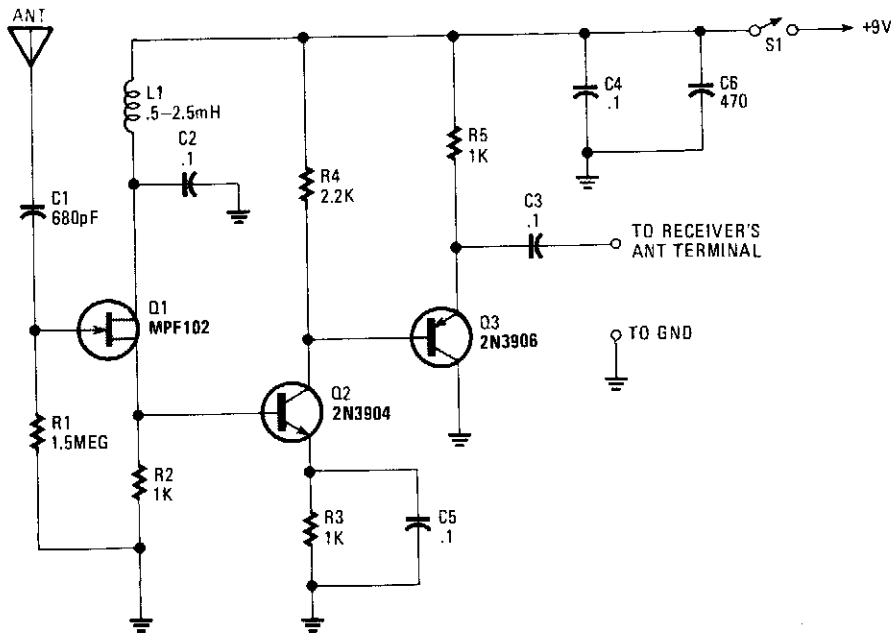
1

Active Antennas

The sources of the following circuits are contained in the Sources section, which begins on page 660. The figure number in the box of each circuit correlates to the entry in the Sources section.

Active Antenna with Gain
Active Antenna I
Active Antenna II
Wideband Active Rod Antenna

ACTIVE ANTENNA WITH GAIN



POPULAR ELECTRONICS

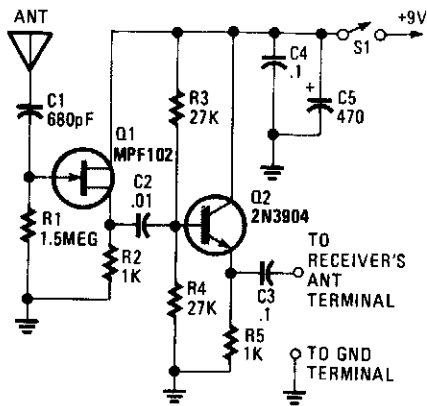
Fig. 1-1

The signal booster, built around a few transistors and support components, offers an RF gain of about 12 to 18 dB (from about 100 kHz to over 30 MHz).

The RF signal is direct-coupled from Q1's source terminal to the base of Q2, which is configured as a voltage amplifier. The output of Q2 is then direct-coupled to the base of Q3 (configured as an emitter-follower amplifier). Transistor Q3 is used to match and isolate the gain stage from the receiver's RF-input circuitry.

Inductor L1 is used to keep any power source noise from reaching the FET (Q1) and any value of RF choke from 0.5 to 2.5 mH will do. The value of R2 sets the Q2 bias at about 2 V. If the voltage is less than 2 V, increase the value of R2 to 1.5 k Ω . To go below 100 kHz (to the bottom of the RF spectrum), increase the value of C1 to 0.002 μ F. The antenna is a short pull-up type (42" to 86" long).

ACTIVE ANTENNA I



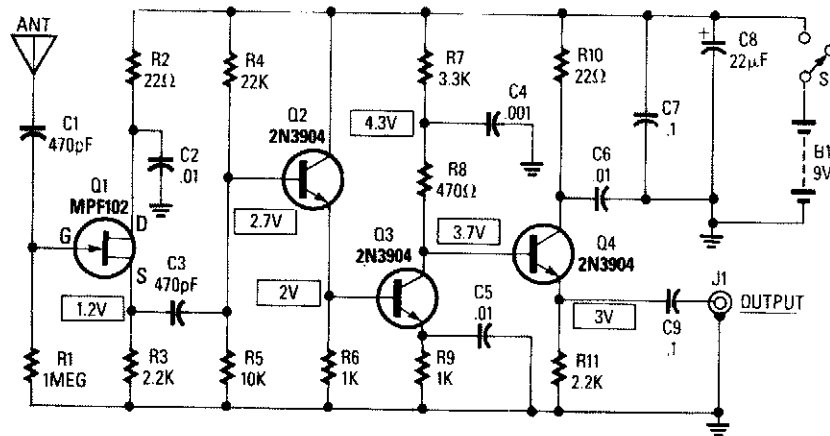
POPULAR ELECTRONICS

Fig. 1-2

This circuit is designed to make a short pull-up antenna perform like a long wire antenna, while offering no voltage gain. The circuit boosts the receiver's performance only if the signal at the antenna is of sufficient level to begin with.

This circuit takes a short pull-up antenna that has a high output impedance and couples it to the receiver's low input impedance through a two-transistor impedance-matching network. Transistor Q1's high input impedance and high-frequency characteristics make it a good match for the short antenna, and Q2's low output impedance is a close match for the receiver's input. This circuit is usable over the range from 100 kHz to 30 MHz.

ACTIVE ANTENNA II

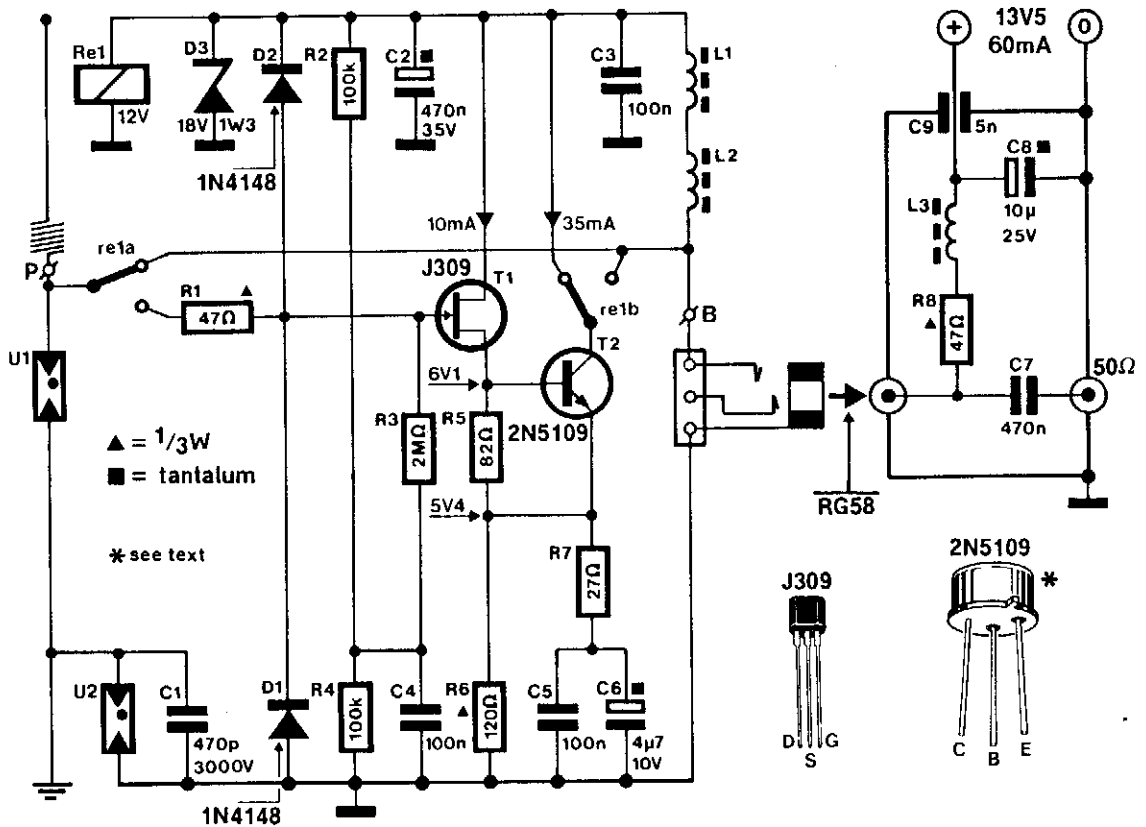


RADIO-ELECTRONICS

Fig. 1-3

This circuit provides 14- to 20-dB gain at frequencies from 10 kHz to 30 MHz. The antenna length can be anything between 5 and 10 feet. A 102-inch CB whip is excellent for this purpose.

WIDEBAND ACTIVE ROD ANTENNA



ELEKTOR ELECTRONICS

Fig. 1-4

A J309 Siliconix FET feeds a 2N5109 in a wideband RF amplifier configuration. A relay is used to bypass the amplifier in the transmit mode (if desired). A 2-m ⁵/₈-wave whip is used as the active antenna element. The amplifier is fed dc via the coax cable, which makes the use of only a single coax lead for both signal and power. U1 is a surge arrester for electrostatic discharge protection.

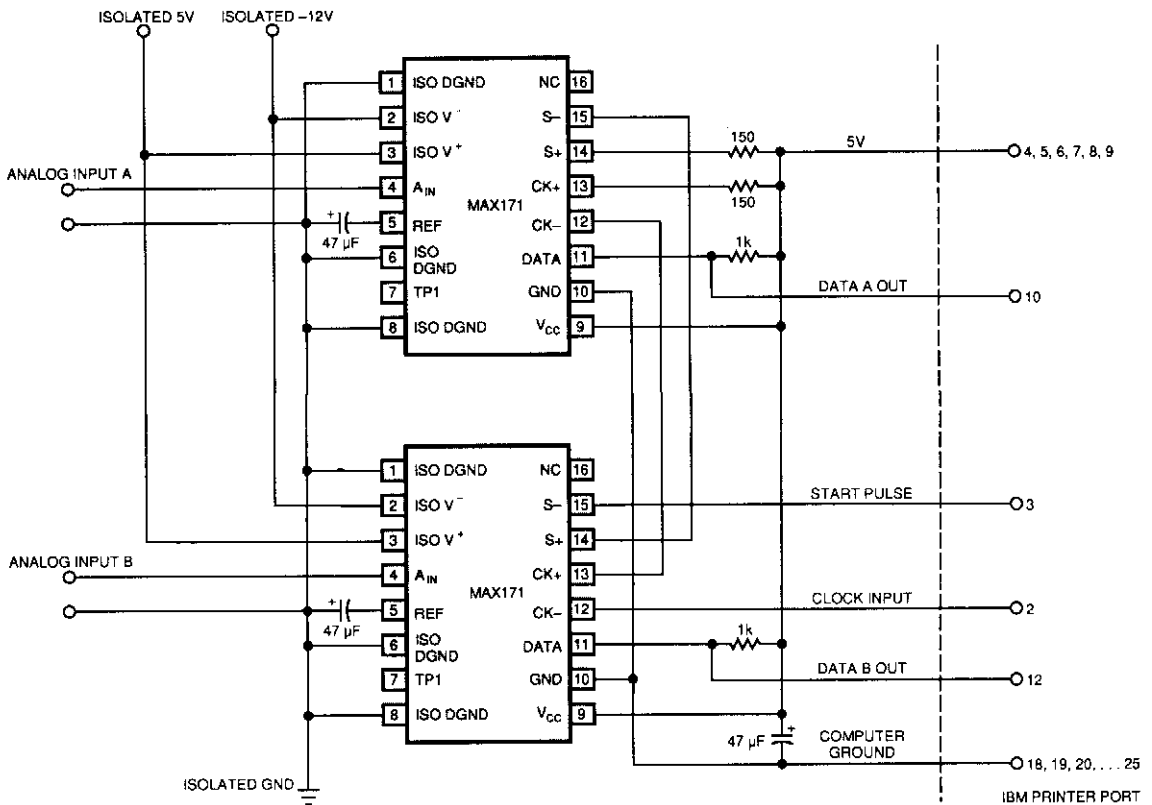
2

Analog-to-Digital Converter

The source of the following circuit is contained in the Sources section, which begins on page 660. The figure number in the box correlates to the entry in the Sources section.

A/D Board

A/D BOARD



EDN

Fig. 2-1

An IBM PC can operate the two 12-bit A/D converters in Fig. 1 via its printer port. The converters' serial outputs use only two of the printer port's eight data lines (DATA A OUT, DATA B OUT). Because the IBM PC's printer port supplies no power, interface software running on the PC programs the six unused data lines high. Busing these data lines provides power for the digital portion of the A/D converters. (The converters have internal optoisolators. Consequently, you must provide isolated supplies for their analog sides.)

Although the converters can execute 12-bit conversions in 6 μs, the slow software-driven approach used in this Design Idea stretches conversion periods out to about 100 μs (depending on your PC's clock speed).

The circuit takes advantage of the converters' optoisolator inputs to put their clock and start inputs in series. Therefore, the converters operate synchronously.

The accompanying software starts the conversions, issues clock pulses, reads the data bits as they become available, and stores them in memory. The listing is too long to reproduce here; you can obtain it from the EDN BBS (617-558-4241, 2400, 8, N, 1).

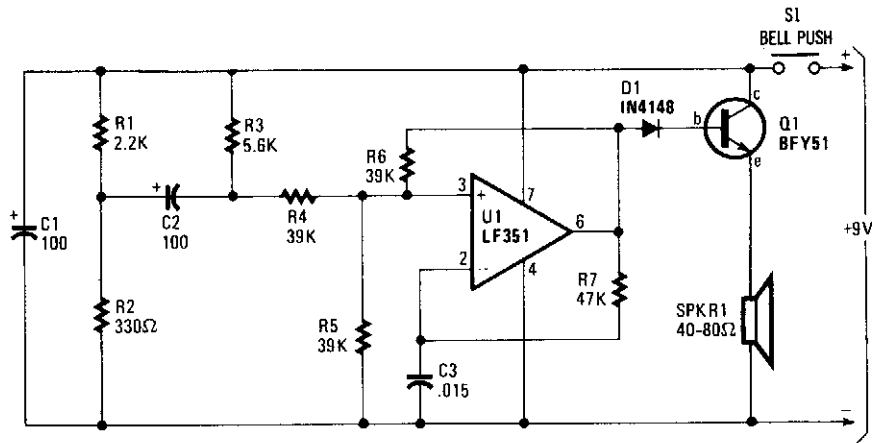
3

Annunciators

The sources of the following circuits are contained in the Sources section, which begins on page 660. The figure number in the box of each circuit correlates to the entry in the Sources section.

Electronic Door Buzzer
Door Buzzer
SCR Circuit with Self-Interrupting Load
Electronic Bell
Two-Door Annunciator

ELECTRONIC DOOR BUZZER

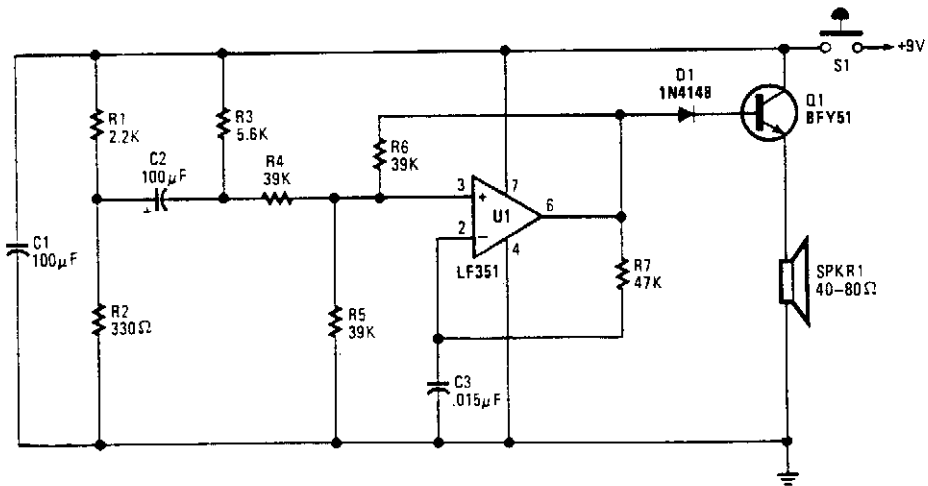


HANDS-ON ELECTRONICS

Fig. 3-1

When S1 is depressed, an initial positive voltage is placed on C2 and the noninverting terminal of U1. The circuit oscillates at a low frequency. As C2 charges up through R3, a rapid increase in frequency of oscillation results, producing (at SPKR1) a rapidly rising pitched sound. This sound is easily recognized over ambient noise.

DOOR BUZZER

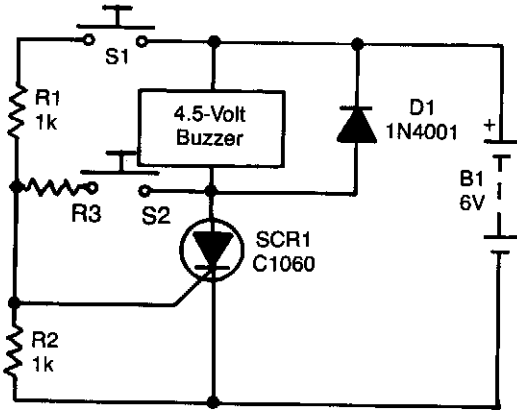


POPULAR ELECTRONICS

Fig. 3-2

An LF357 functions as a swept-tone oscillator, driving Q1 and SPKR1. A 9-Vdc supply is required.

SCR CIRCUIT WITH SELF-INTERRUPTING LOAD



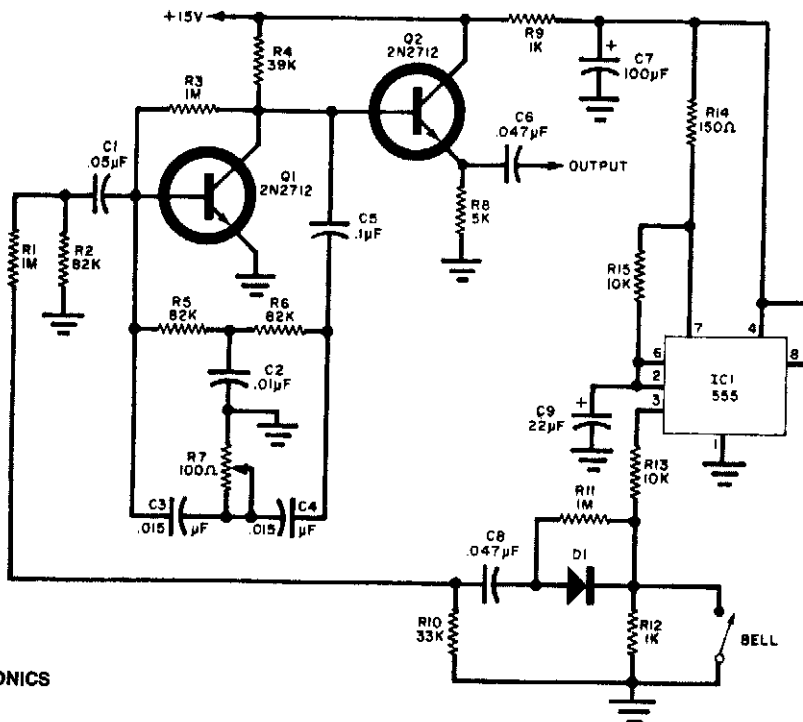
RADIO-ELECTRONICS

Fig. 3-3

A self-interrupting device connected to a voltage source functions as a switch that repeatedly opens and closes; therefore, the circuit does not latch in the normal way, so the alarm operates only as long as S1 is closed. Because of the inductive nature of that type of load, a damping diode (D1) must be wired across it.

The circuit can be modified to provide a self-latching action simply by wiring a 470-Ω resistor in parallel with the alarm. The circuit latches because the anode current of the SCR does not fall to zero when the alarm self-interrupts, but to a value that is determined by the value of the R3. The circuit can be unlatched by pressing S2, thereby enabling the anode current to fall to zero when the alarm self-interrupts.

ELECTRONIC BELL

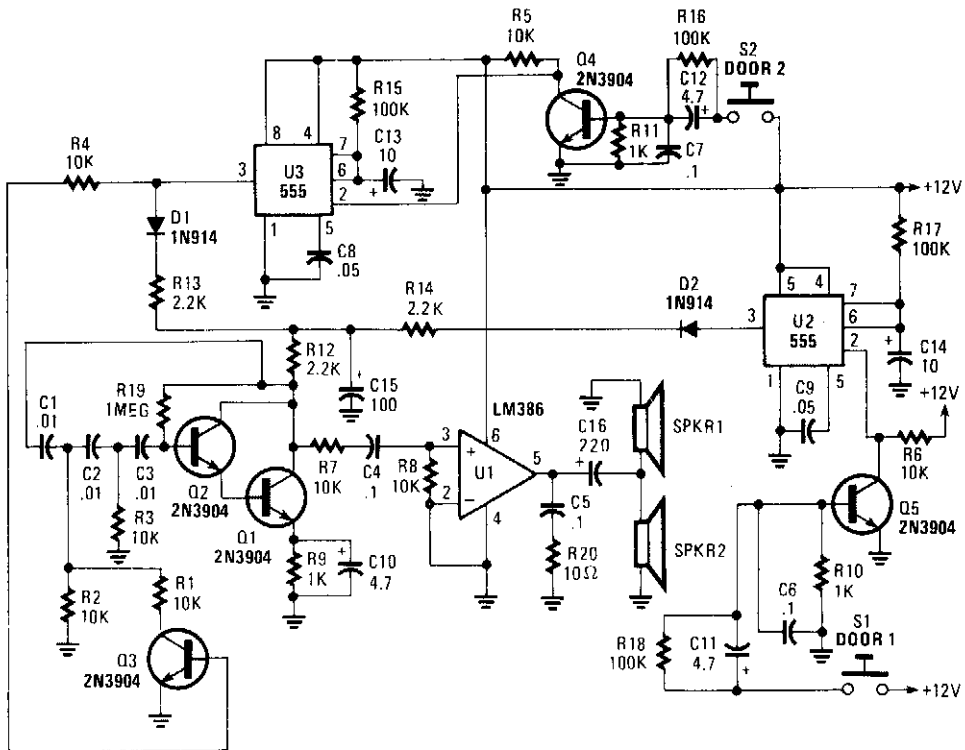


POPULAR ELECTRONICS

Fig. 3-4

A 555 timer pulses twin-T oscillator Q1. Q2 acts as an output buffer. R7 adjusts the frequency of oscillator Q1.

TWO-DOOR ANNUNCIATOR



POPULAR ELECTRONICS

Fig. 3-4

When the pushbuttons at either door are depressed, this circuit generates a different tone for each door. Tones are generated by phase-shift oscillator Q1/Q2. Q3 provides tone frequency change by changing the phase-shift network. U2 and U3 are timers for the tones and Q4/Q5 interface the timers with the pushbuttons.

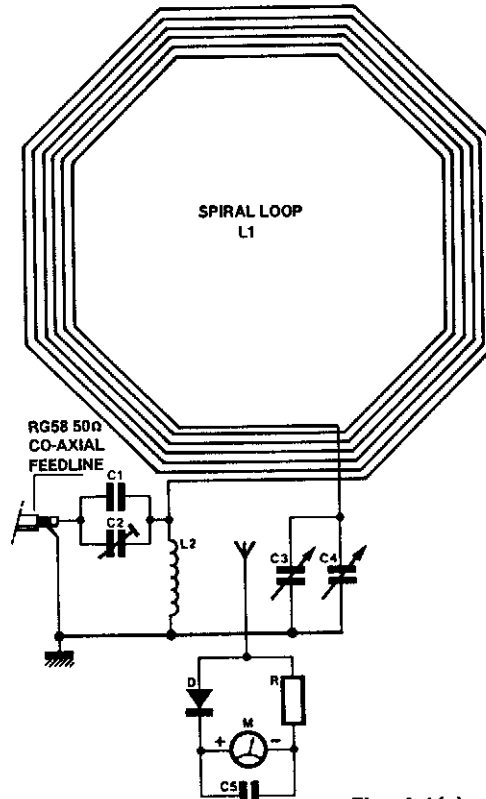
4

Antenna Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 660. The figure number in the box of each circuit correlates to the entry in the Sources section.

Loop Antenna for 3.5 MHz
1-to 30-MHz Antenna Tuner

LOOP ANTENNA FOR 3.5 MHz



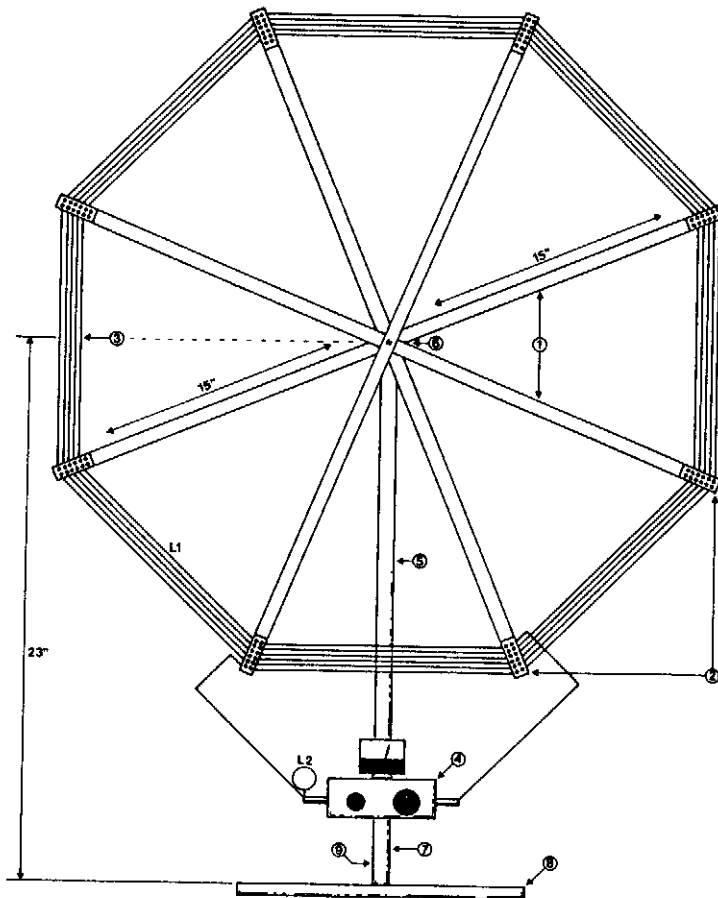
ELEKTOR ELECTRONICS USA

Fig. 4-1(a)

COMPONENTS LIST

- C1 = 3 750 pF 500 V silver-mica capacitor.
- C2 = 100 pF preset capacitor (Jackson C803).
- C3 = 75 pF variable capacitor (Jackson C809), plus knob.
- C4 = 12.7 pF variable capacitor (Jackson C16), plus knob.
- C5 = 22 nF mica capacitor.
- M = 250 μ A f.s.d. 40 x 40 mm moving coil meter (Maplin LB808).
- D = HF silicon diode.
- R = 1 k Ω resistor (see text).
- L1 = 5 $\frac{1}{8}$ turns of PVC covered stranded 7/0.2 mm wire. Outside diameter: 1.2 mm, 1 kV/1.5 A rating (see text).
- L2 = 13 turns 16SWG tinned wire, 1 inch internal diameter.
- Feedline = 48 inch RG58 coaxial cable, plus plug to suit transmitter.
- Box = ABS box type MB3, 118 x 96 x 45 mm. Maplin ref. LH22.
- Terminal blocks = qty. 4 12-way 2 amp terminal block. Maplin ref. FE78.
- Spacers = qty. 3 insulated spacer type M3, 30 mm long, Maplin ref. FS40T.
- Spokes = qty. 4 8-foot lengths of $\frac{5}{8}$ x $\frac{1}{4}$ inch molded hardwood (DIY store).
- Vertical support = 23 x 0.8 x 0.8 inch wood (DIY store).
- Wood base = 12 x 8 x 0.5 inch plywood or similar.
- 2 $\frac{1}{2}$ inch steel support bracket.

LOOP ANTENNA FOR 3.5 MHz (Cont.)



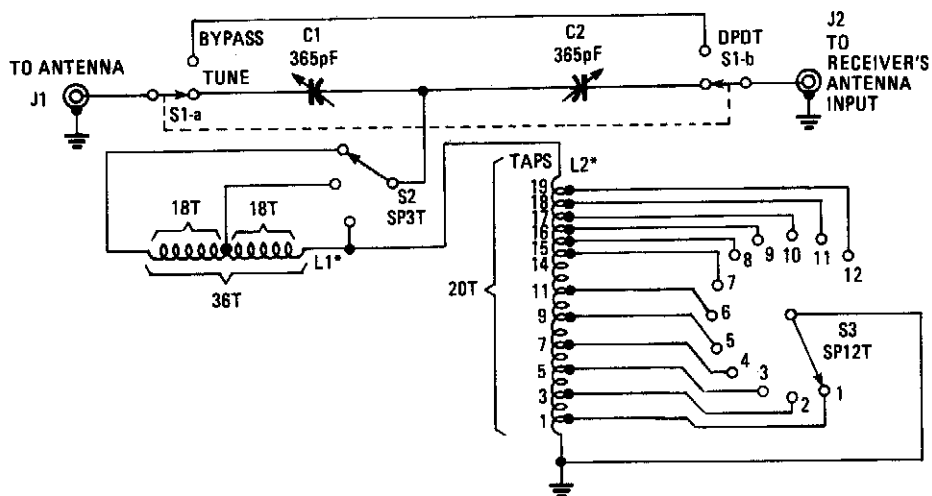
ELEKTOR ELECTRONICS USA

Fig. 4-1(b)

1. 4 lengths molded hardwood 30" \times 5/8" \times 1/4". Varnished. 2BA holes drilled in the centre. Glued and bolted together.
 2. 8 off 6-way 2-amp polythene terminal blocks used as insulated wire spacers.
 3. 5 1/8 turns of PVC stranded wire (for specs see components list).
 4. See Fig. 3.
 5. Wood vertical support 23" \times 0.8" \times 0.8", wood stained.
 6. 2" \times 2BA bolt.
 7. Box front vertical support, 4 1/2" \times 1/2" \times 3/4", wood stained.
 8. Wood base 12" \times 8" \times 1/2" (for similar), wood stained.
 9. 2 1/2 steel support bracket behind wood vertical support.
 10. Drilled and secured with glue and c/s wood screws.
- Note: " = inch = 2.54 cm.

Suitable for receiving or transmitting (10 W or less) on the 80-m band, this loop antenna might be helpful when an outside antenna is not possible.

1-TO 30-MHz ANTENNA TUNER



POPULAR ELECTRONICS

Fig. 4-2

L1 = 36T #18 enamel wire
on 2" PVC SCH 40 pipe.

L2 = 20T #18 enamel (as in L1)
tapped as shown C1/C2.

365-pF variable capacitor,
receiving type.

This tuner will match a random length wire antenna to a receiver or low-power transmitter (≤ 25 W) for optimum signal transfer.

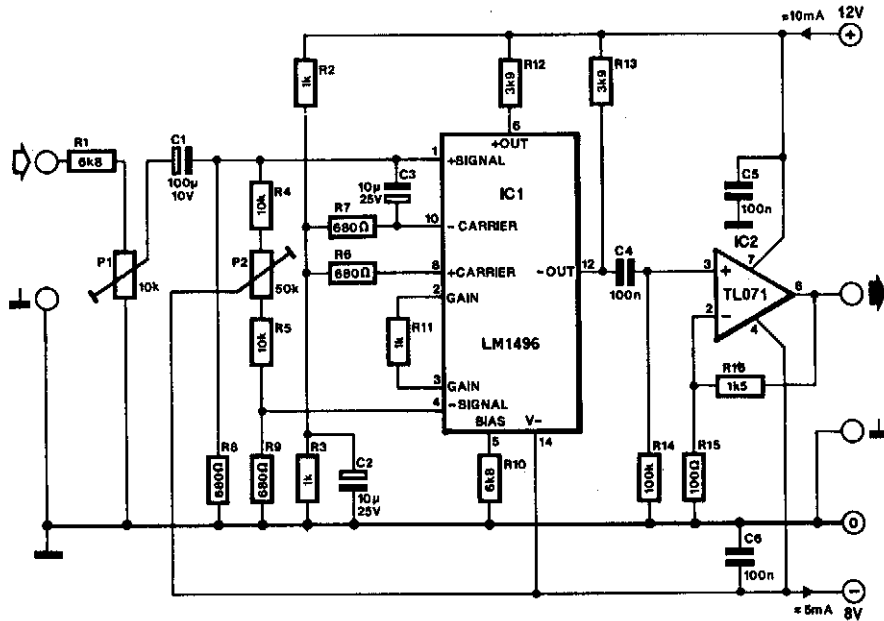
5

Audio Effects Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 660. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio-Frequency Doubler
Audio Fader
Audio Equalizer
Vocal Eliminator
Voltage-Controlled Amplifier
Analog Delay Line (Echo and Reverb)
Musical Envelope Generator and Modulator
Audio Ditherizing Circuit for Digital Audio Use
Derived Center-Channel Stereo System
Low-Distortion Amplifier/Compressor

AUDIO-FREQUENCY DOUBLER



HANDS-ON ELECTRONICS

Often the frequency of a signal must be doubled: modulator/demodulator chip LM1496 is an ideal basis for this.

From trigonometry it is well known that:

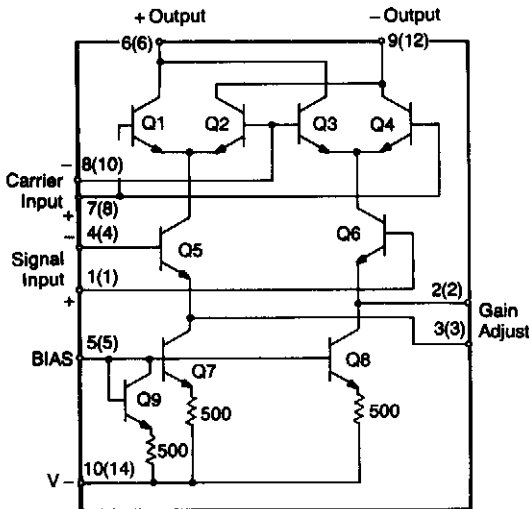
$$2\sin x \cos x = \sin 2x$$

and:

$$\sin^2 = 1 - x \cos 2x.$$

These equations indicate that the product of two pure sinusoidal signals of the same frequency is one signal of double that frequency. The purity of the original signals is important: composite signals would give rise to all sorts of undesired products.

The LM1496 can only process signals that are not greater than 25 mV: above that level, serious distortion will occur. The design is therefore provided with a potential divider at its input. This addition makes it possible, for instance, to arrange for a 500-mV input signal to result in a signal of only 25 mV at the input of the LM1496.



Internal circuit of the LM1496.

ELEKTOR ELECTRONICS

Fig. 5-1

AUDIO-FREQUENCY DOUBLER (Cont.)

To provide a sufficiently high output signal, the output of IC1 is magnified by op amp IC2, which is connected as a noninverting amplifier. Because the output of IC1 contains a dc component of about 8 V, the coupling between the two stages must be via a capacitor, C4.

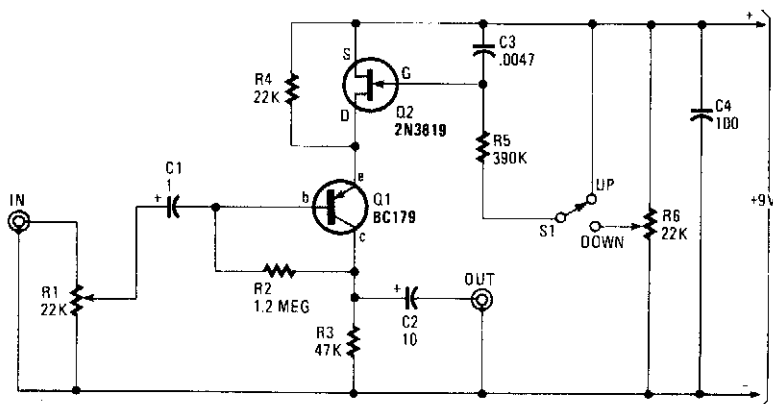
With values of R15 and R16 as shown, IC2 gives an amplification of 16 (24 dB). The overall amplification of the circuit depends on the level of the input signal: with an input of 1.2 V, the amplification is unity; when the input drops to 0.1 V, the amplification is just 0.1. The value of the input resistors has been fixed at 680 Ω : this value gives a reasonable compromise between the requirements for a high input impedance and a low noise level.

To ensure good suppression of the input signal at the output, the voltages at pin 1 and pin 4 of IC1 must be absolutely identical to P4. It is possible, with the aid of a spectrum analyzer, to suppress the fundamental (input) frequency by 60 to 70 dB.

The output signal at pin 12 is distorted easily, because the IC is not really designed for this kind of operation. The distortion depends on the level of the input signal. At a frequency of 1 kHz and an input level of 100 mV, the distortion is about 0.6%; when the input level is raised to 500 mV, the distortion increases to 2.3%, and when the input level is 1 V, the distortion is 6%. The signal-to-noise ratio under these conditions varies between 60 and 80 dB.

The circuit draws a current of 10 mA from the positive supply line and 5 mA from the negative line. The phase shift between the input and output signals is about 45° (output lags). Finally, although the normal output is taken from pin 12, a similar output that is shifted by 180° (with respect to that at pin 12), is available at pin 6.

AUDIO FADER

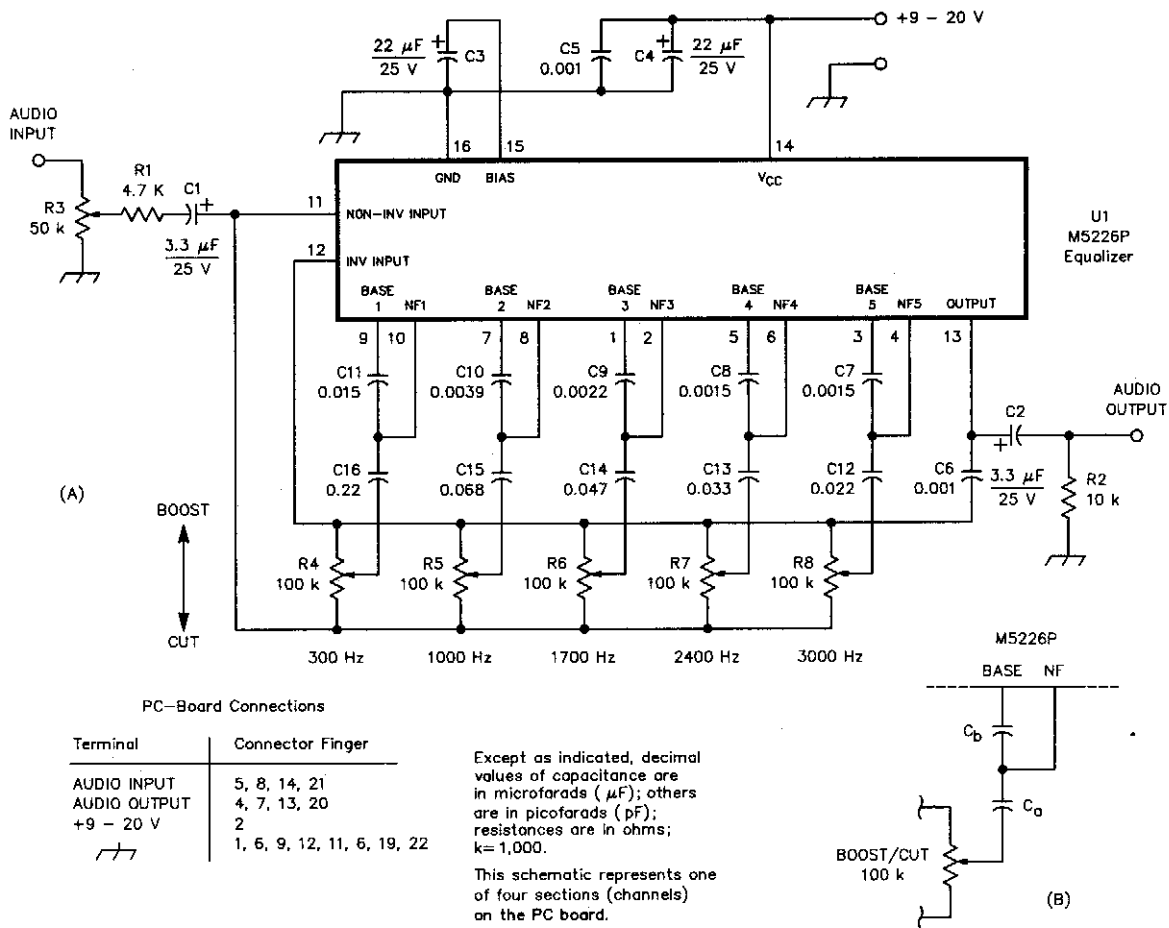


HANDS-ON ELECTRONICS

Fig. 5-2

In this circuit, Q1 is a simple amplifier that has its gain controlled by a variable emitter resistance supplied by FET Q2. In the up position of S1, C3 discharges through R5 and the gain of Q1 decreases because Q2 is driven toward cut-off. In the down position, Q2 conducts more, depending on the setting of R6, which causes a gain increase. By varying R5 or C3, various fade rates can be obtained.

AUDIO EQUALIZER

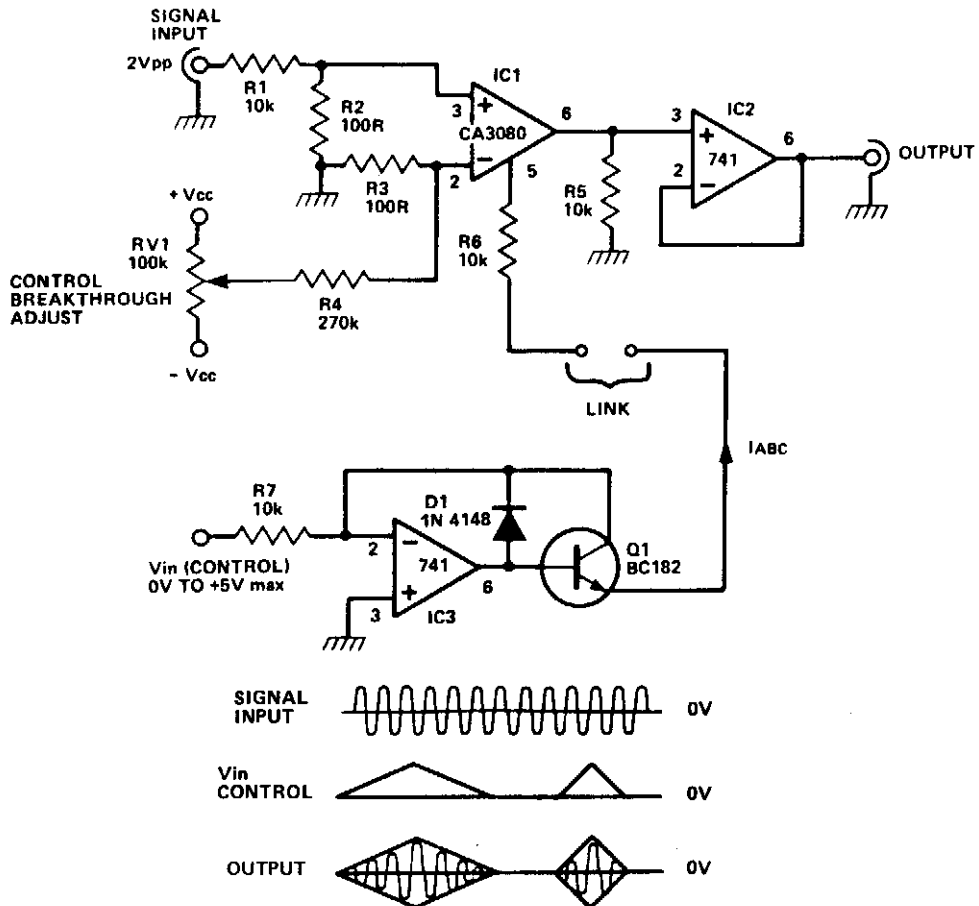


QST

Fig. 5-3

Designed for communications use, this equalizer circuit uses a Mitsubishi M5226P audio equalizer IC to adjust frequency response. It runs from a 9 to 20 V supply. C6 through C16 are polyester film capacitors of $\pm 5\%$ tolerance.

VOLTAGE-CONTROLLED AMPLIFIER



ELECTRONICS TODAY INTERNATIONAL

Fig. 5-5

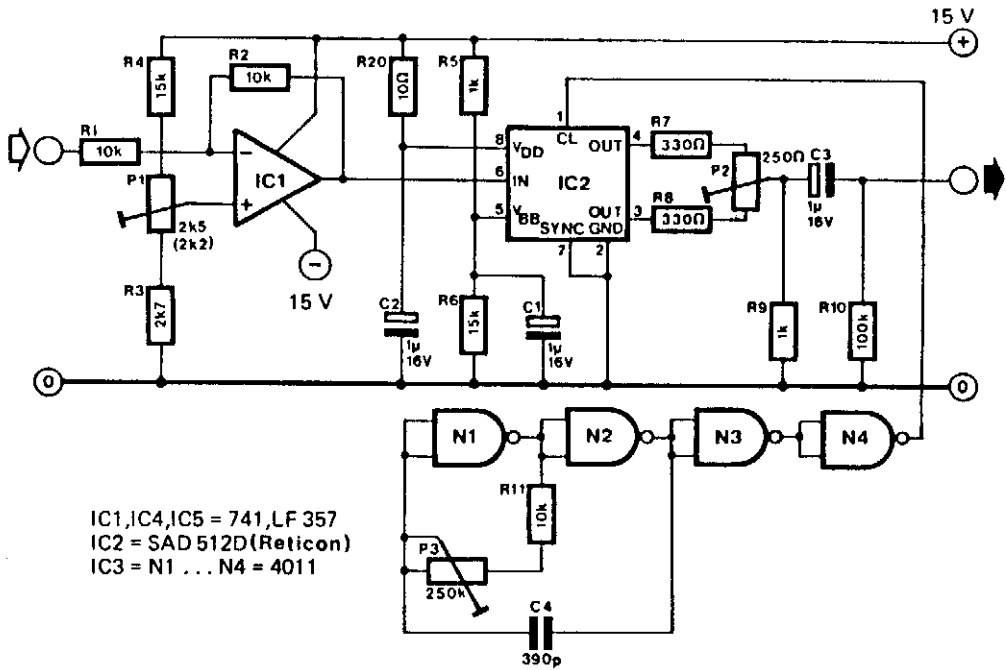
The CA3080 can be used as a gain controlling device. The input signal is attenuated by R1/R2 so that a 20-mVpp signal is applied to the input terminals. If this voltage is much larger, significant distortion will occur at the output. In fact, this distortion is put to good use in the triangle-to-sine wave converter.

The gain of the circuit is controlled by the magnitude of the current IABC. This current flows into the CA3080 at pin 5, which is held at one diode voltage drop above the $-V_{CC}$ rail. The gain of the CA3080 is "linearly" proportional to the magnitude of the IABC current over a range of 0.1 μA to 1 mA. Thus, by controlling IABC, you can control the signal level at the output. The output is a current output, which has to be "dumped" into a resistive load (R5) to produce a voltage output. The output impedance at IC1 pin 6 is 10 k Ω (R5), but this is "unloaded" by the voltage follower (IC2) to produce a low output impedance.

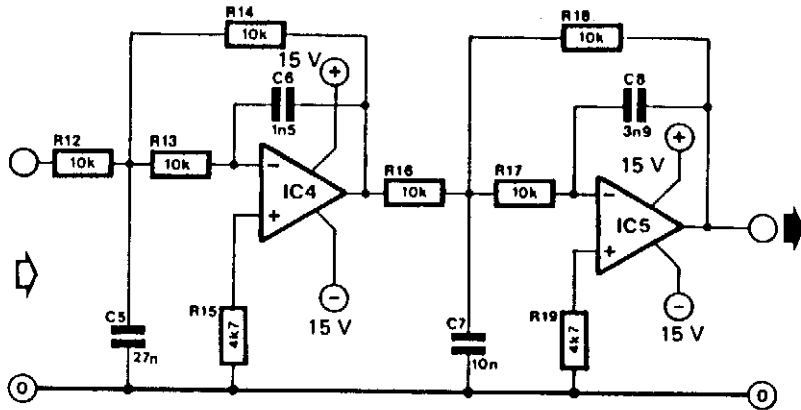
The circuit around IC3 is a precision voltage-to-current converter and this can be used to generate IABC. When V_{in} (control) is positive, it linearly controls the gain of the circuit. When it is negative, IABC is zero and so the gain is zero.

ANALOG DELAY LINE (ECHO AND REVERB)

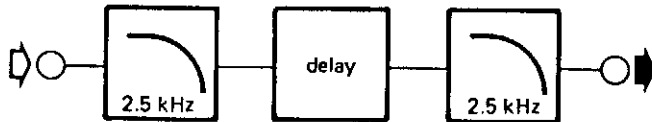
1



2



3

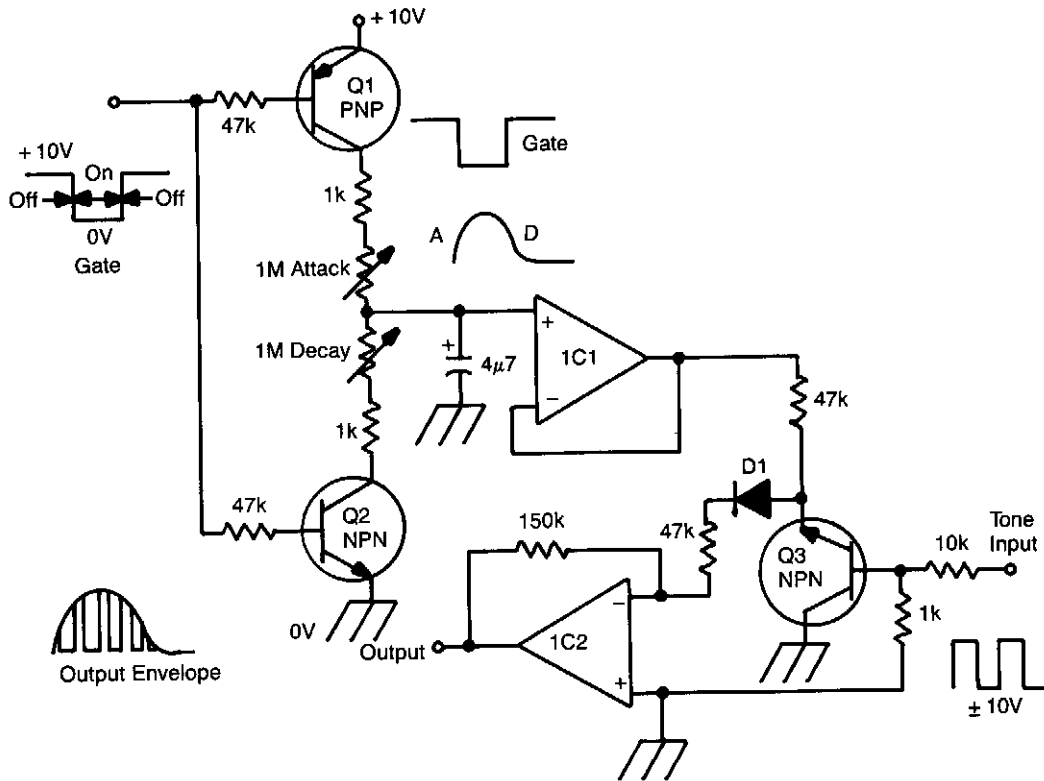


ELEKTOR ELECTRONICS

Fig. 5-6

This circuit uses an SAD 512D (Reticon) chip, which is a 512-stage analog shift register. By varying the clock frequency between 5 and 50 kHz, delay time can be set between 51.2 and 5.12 ms. The clock frequency must be at least twice the highest audio frequency.

MUSICAL ENVELOPE GENERATOR AND MODULATOR



ELECTRONICS TODAY INTERNATIONAL

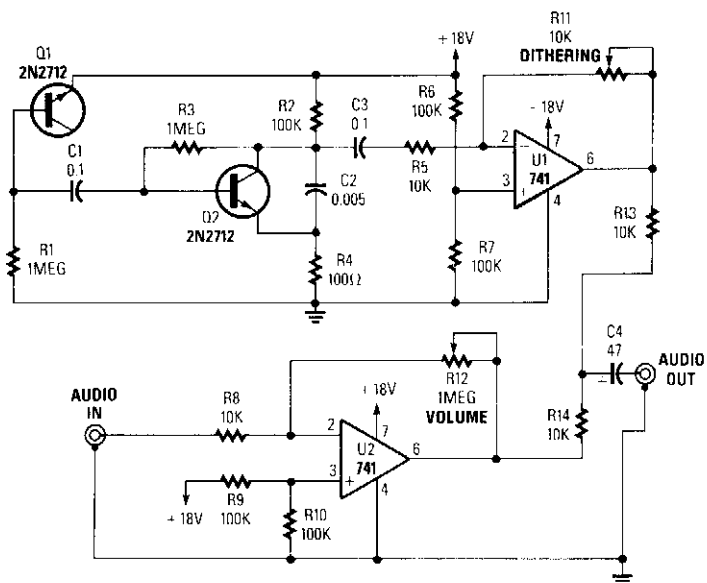
Fig. 5-7

A gate voltage is applied to initiate the proceedings. When the gate voltage is in the ON state, Q1 is turned on, and capacitor C is charged up via the attack pot in series with the 1-k Ω resistor. By varying this pot, the attack time constant can be manipulated. A fast attack gives a percussive sound, a slow attack gives the effect of "backward" sounds. When the gate voltage returns to its OFF state, Q2 is turned on and the capacitor is then discharged via the decay pot and the other 1-k Ω resistor to ground. Thus, the decay time constant of the envelope is also variable.

This envelope is buffered by IC1, a high-impedance voltage follower and is applied to Q3, which is being used as a transistor chopper. A musical tone in the form of a square wave is connected to the base of Q3. This turns the transistor on or off. Thus, the envelope is chopped up at regular intervals, which are determined by the pitch of the square wave.

The resultant waveform has the amplitude of the envelope and the harmonic structure of the square wave. IC2 is used as a virtual earth amplifier to buffer the signal and D1 ensures that the envelope dies away at the end of a note.

AUDIO DITHERING CIRCUIT FOR DIGITAL AUDIO USE



POPULAR ELECTRONICS

Fig. 5-8

By adding a small amount of noise to a signal to be digitized (about 0.7 bit):

$$V_{\text{NOISE}} \approx 0.7 \left(\frac{V_{\text{INPUT P-P}}}{2^N} \right)$$

where: n = # of bits. For example, 8 bits and 2 V p-p would be 0.0055 V.

This circuit uses a transistor (Q1) and an amplifier (Q2 and U1) to generate the noise signal. R11 controls the noise injection and R12 controls the gain of the system.

DERIVED CENTER-CHANNEL STEREO SYSTEM

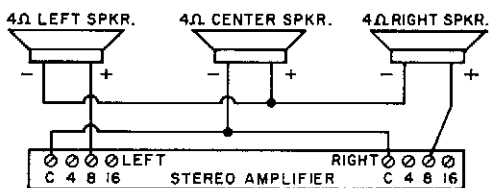


Fig. 5-9(a)

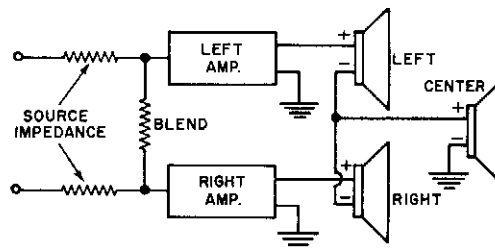
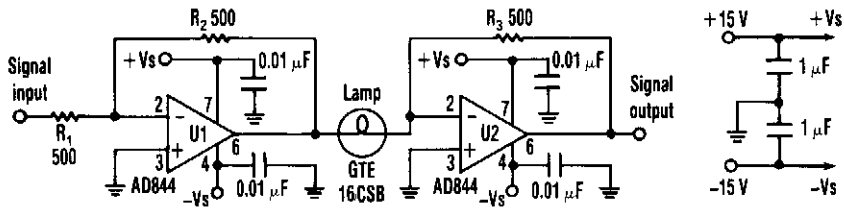


Fig. 5-9(b)

A simple method of deriving a center or third channel without the use of an extra transformer or amplifier. (a) 4- Ω speakers are connected to 8- Ω amplifier taps. 8 and 16- Ω speakers connect to 16- Ω taps. (b) By blending the inputs it is possible to cancel out undesired crosstalk.

LOW-DISTORTION AMPLIFIER/COMPRESSOR



ELECTRONIC DESIGN

Fig. 5-10

Designers can build a 15-dB compressor with a miniature lamp and a current-feedback amplifier. The circuit possesses extremely low distortion at frequencies above the lamp's thermal time constant. This means that distortion is negligible from audio frequencies to beyond 10 MHz. There's also relatively little change in phase versus gain compared to other automatic gain-control circuits. Lastly, the circuit has many instrumentation, audio, and high-frequency applications as a result of its low distortion and small phase change.

The AD844 op amp is a perfect fit for this application because it's a current-feedback amplifier. Each stage of the circuit, U2, lamp, and feedback resistor compresses an ac signal by over 15 dB (see the figure). Cascading a number of stages delivers higher compression ranges.

Op amp U1 operates as a unity-gain buffer to drive the input to the compressor. However, U1 is optional if a low-impedance signal source is used. The lamp's resistance will increase with temperature, which reduces the ratio of resistor R3 to the resistance of the lamp. This ratio reduces the gain of U2. The lamp's cold resistance should be greater than the input resistance of U2 (more than 50 Ω) for proper operation. The lamp's resistance will change slightly for low input levels. Therefore, the ratio of R3 to the resistance of the lamp and the gain of U2 stays high.

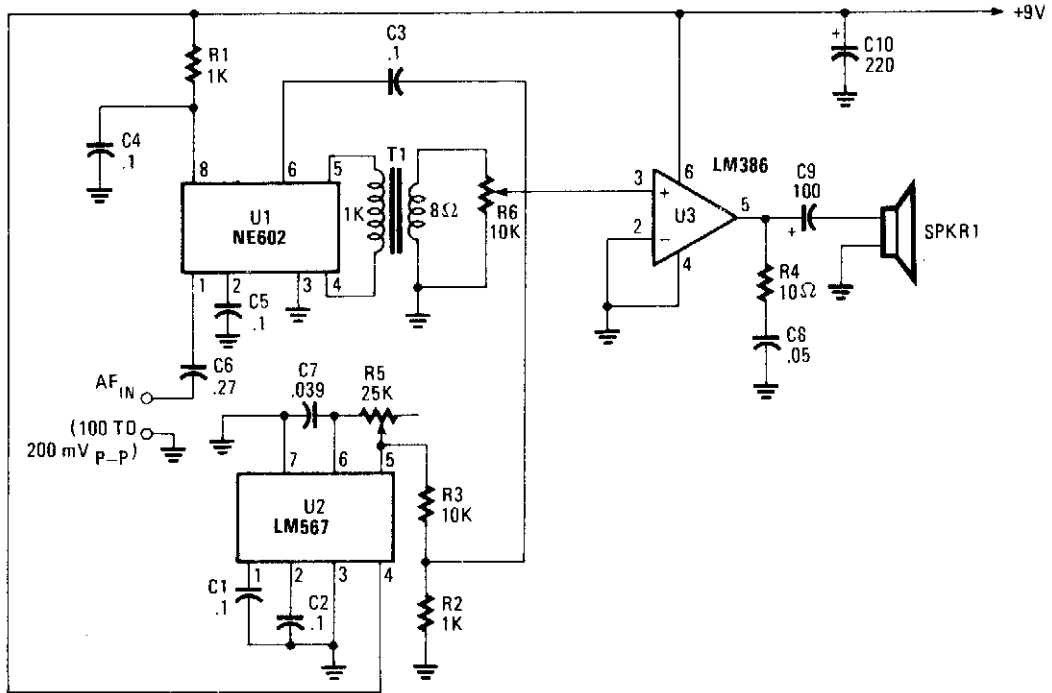
6

Audio Scramblers

The sources of the following circuits are contained in the Sources section, which begins on page 661. The figure number in the box of each circuit correlates to the entry in the Sources section.

Voice Scrambler/Descrambler
Voice Scrambler/Disguiser Circuit

VOICE SCRAMBLER/DESCRAMBLER

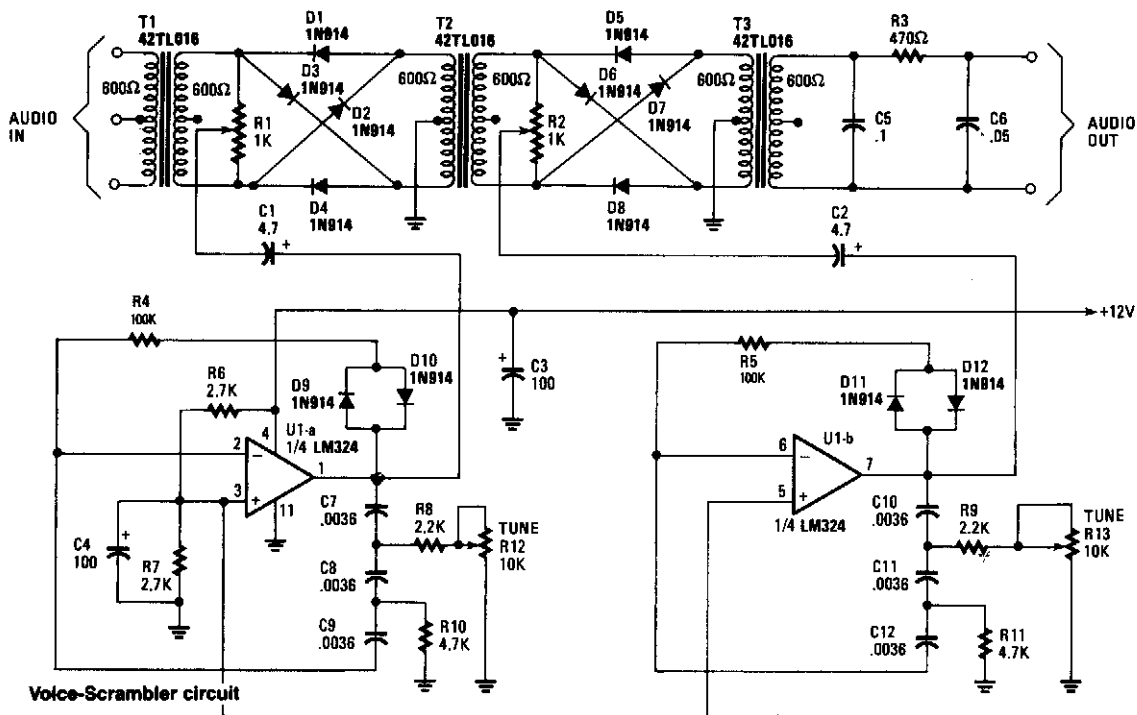


POPULAR ELECTRONICS

Fig. 6-1

This circuit uses an NE602 as an inversion mixer. U2 is set to run at about 2.5 to 3.5 kHz. U3 drives a loudspeaker. Because speech inversion scrambling is its own inverse, the circuit will also descramble.

VOICE SCRAMBLER/DISGUISER CIRCUIT



HANDS-ON ELECTRONICS

Fig. 6-2

This circuit uses two balanced modulators to produce a DSB signal and then reinsert the carrier, except the carrier now has a different frequency. This causes an input signal to be distorted. A voice signal will be recognizable with this circuit, but the original speakers' voice will not be identifiable with correct adjustments.

Two LM324 op amps act as oscillators that are tuneable from 2 to 3.5 kHz. The frequencies are set with R12 and R13. T1, T2, and T3 are 600 Ω CT/600 Ω audio transformers—available from Mouser Electronics, Inc.

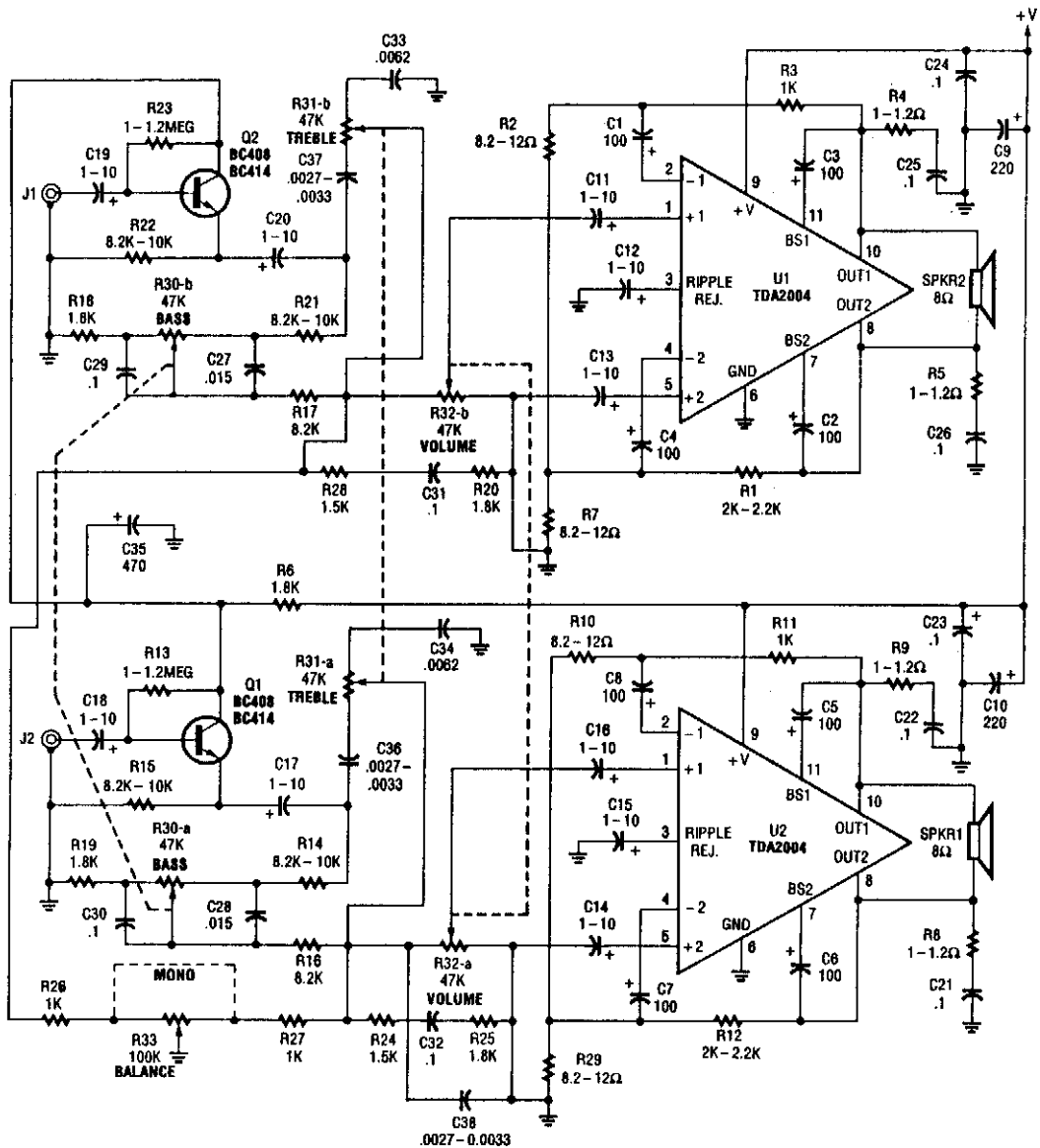
7

Audio Power Amplifiers

The sources of the following circuits are contained in the Sources section, which begins on page 661. The figure number in the box of each circuit correlates to the entry in the Sources section.

12-V/20-W Stereo Amplifier
General-Purpose 5-W Audio Amplifier with ac Power Supply
Bull Horn
Receiver Audio Circuit
Audio Amplifier
8-W Audio Amplifier
Simple Op Amp Audio Amplifier

12-V/20-W STEREO AMPLIFIER

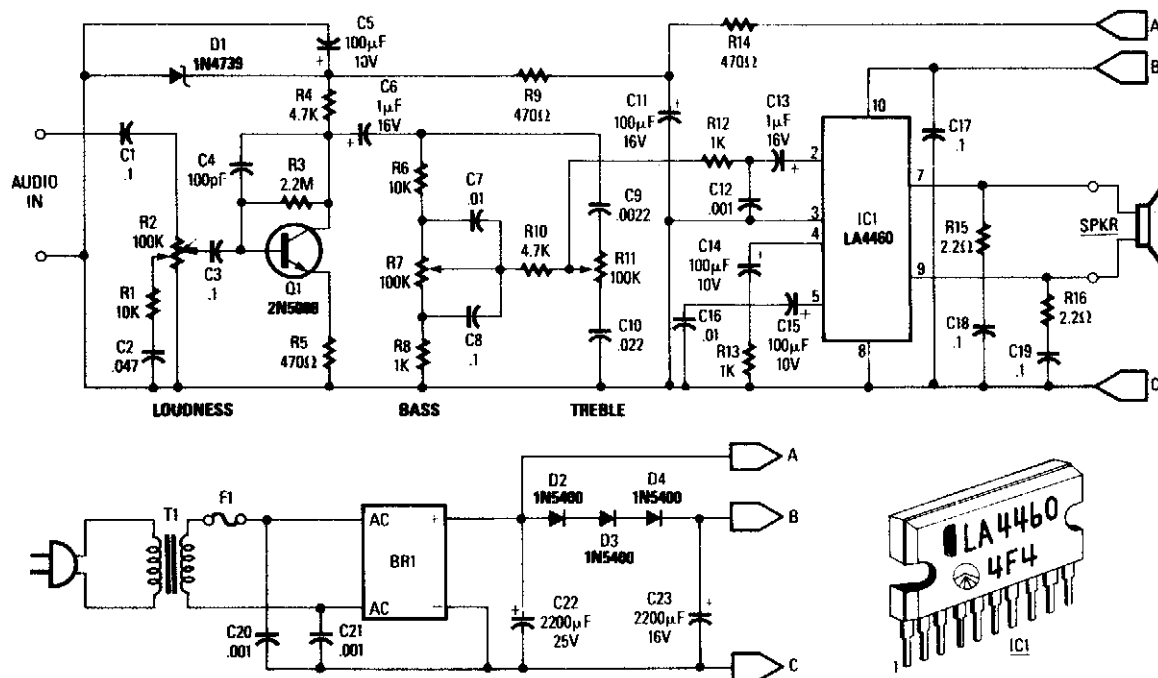


POPULAR ELECTRONICS

Fig. 7-1

This amplifier delivers 20 W per channel. Input sensitivity is about 300 mV into 47 k Ω . Notice that a bridged output is used, so the speakers are operated with both wires above ground. A +12-V supply is used. U1 and U2 must be heatsinked.

GENERAL-PURPOSE 5-W AUDIO AMPLIFIER WITH ac POWER SUPPLY

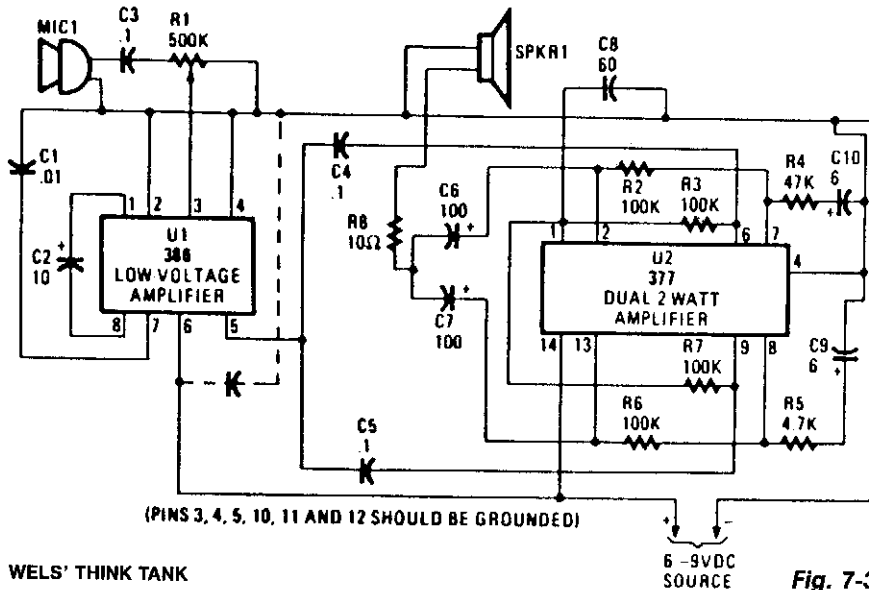


RADIO-ELECTRONICS

Fig. 7-2

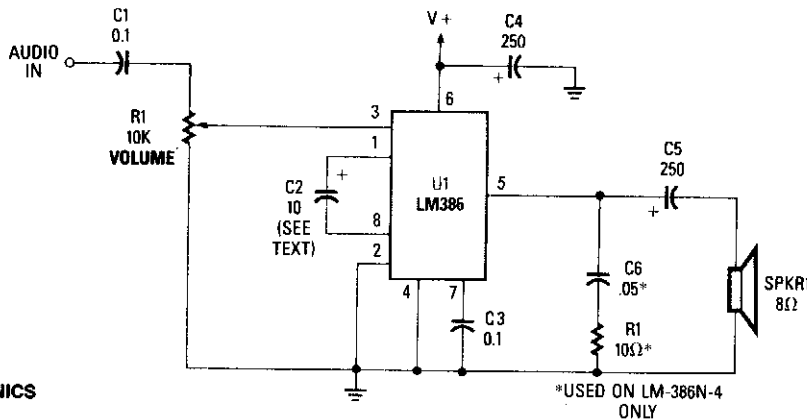
This general-purpose low-power (5 W) audio amplifier is suitable for driving a speaker of approximately 8 to 12 inches. A Sanyo LA4460 IC is used as the audio output IC. The circuit consists of a loudness control, driver amplifier Q1, and bass and treble controls of about ± 10 dB boost/cut. It should be useful in a wide variety of situations. Either the ac supply shown can be used, or a 12 Vdc supply can be connected to points A&B (positive) and C (negative). Two of these circuits, using ganged potentiometers at R2, R7, and R11 can be used for stereo applications. T1 is a 12-V 1-amp plug-in transformer. Notice that IC1 must be heatsinked. Power output is about 5 W. A $4" \times 2" \times 0.050"$ aluminum heatsink should be adequate.

BULL HORN



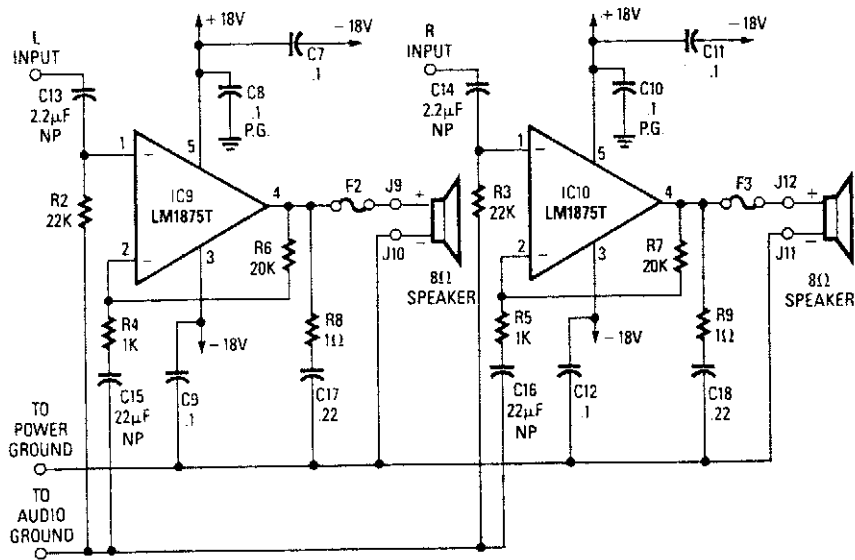
This bull horn uses U1 as a driver stage and U2 as an output driver. U1 is set up for a gain of 200. The microphone should have about 200-mVpp output. The two sections of U2 produce about 4-W of output power. Use shielded cable for all audio leads. Power is a 6-to 9-V battery or other source.

RECEIVER AUDIO CIRCUIT



This simple receiver AF amplifier can supply several hundred milliwatts to an 8-Ω speaker. The gain is about 200X. If high gain is not needed, C2 can be deleted and a gain of 20 will be obtained. R1 and C6 are musts, otherwise ultrasonic (30 to 60 kHz) oscillations might occur. C6 can be 0.1 μF on all LM386N versions for protection against these oscillations. The supply voltage is typically 6 to 12 V. No heatsink is necessary, but good grounding is a must.

AUDIO AMPLIFIER

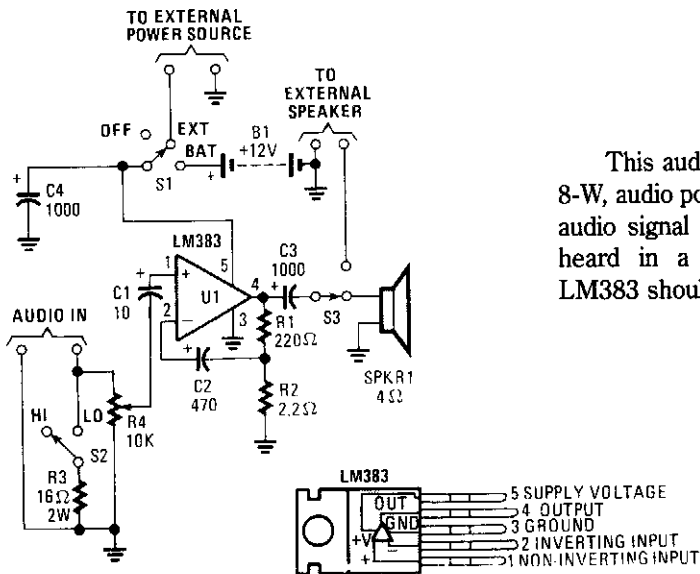


RADIO-ELECTRONICS

Fig. 7-5

This amplifier will deliver around 20 W to an 8-Ω speaker.

8-W AUDIO AMPLIFIER

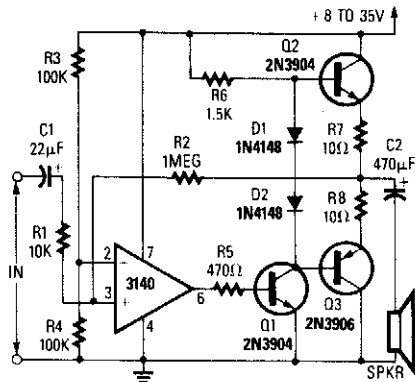


This audio power amp (built around an LM383 8-W, audio power amplifier) can be used to boost an audio signal to a sufficient level so that it can be heard in a high-noise environment. Note that LM383 should be heatsinked.

POPULAR ELECTRONICS

Fig. 7-6

SIMPLE OP AMP AUDIO AMPLIFIER



A CA3140 drives a complementary output stage Q1, Q2, and Q3. Output power depends on supply voltage and limits on dissipations of Q2 and Q3, but it can be 1 or 2 W with a higher impedance speaker and a 30-V supply.

RADIO-ELECTRONICS

Fig. 7-7

8

Audio Signal Amplifiers

The sources of the following circuits are contained in the Sources section, which begins on page 661. The figure number in the box of each circuit correlates to the entry in the Sources section.

Preamplifier for Magnetic Phono Cartridge
Simple Tape Playback Amplifier
Low-Noise Phono Preamp
Simple 40-dB Gain Amplifier
Ultra-Low-Noise Magnetic Phono Preamp
Impedance-Matching Preamp
Low-Noise Amplifier
Low-Noise 1 000 × Preamp
Simple Microphone Preamp
Electric Guitar Matching Amplifier
Universal Audio Line Amplifier
CD4049 Amplifier
Low-Noise Audio Preamp
Low-Impedance Microphone Preamp
Microphone Preamp
General-Purpose Preamp

PREAMPLIFIER FOR MAGNETIC PHONO CARTRIDGES

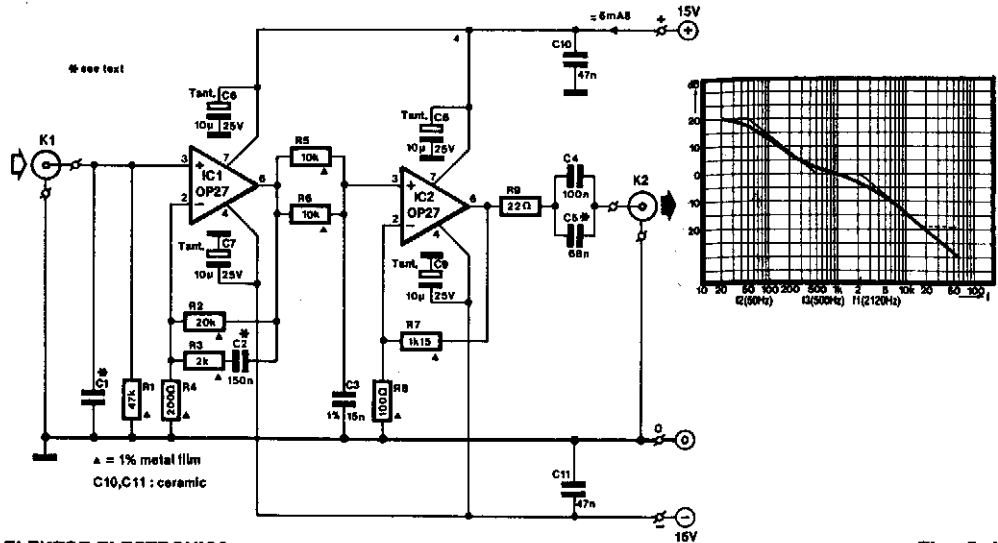


Fig. 8-1

This amplifier is intended to be added to preamplifiers that have no phono input. Such a phono input is required for normal record players with a dynamic pick-up, of which millions are still around. Moreover, the amplifier does not only bring the output of the pick-up to line level, it also adds the correction to the frequency response (according to RIAA requirements).

When recording gramophone records, the frequency characteristic is lifted at the high end. This lift must be countered in the playback (pre)amplifier. The corrections to the frequency response characteristic are according to a norm set by the Record Industries Association of America (RIAA) and also by the IEC.

The corrective curve provided by the amplifier is shown in the graph (bold line). The thin line shows the ideal corrective curve. The sharp bends in this at 50 and 500 Hz are nearly obtained in the practical curve by network R3/C2; just above 2 kHz is approached in practice by filter R5/R6/C3. The arrangement of R3/C2 in the feedback loop of IC1 gives noticeably better results than the usual (passive) filter approach.

Circuit IC1 provides a dc amplification of 40 dB, which drops to about 20 dB when the frequency rises above 500 Hz. To minimize the (resistor) noise and the load of the op amp at higher frequencies, the value of R3 is a compromise. The associated polystyrene capacitor, C2, should have a tolerance of 1 to 2%.

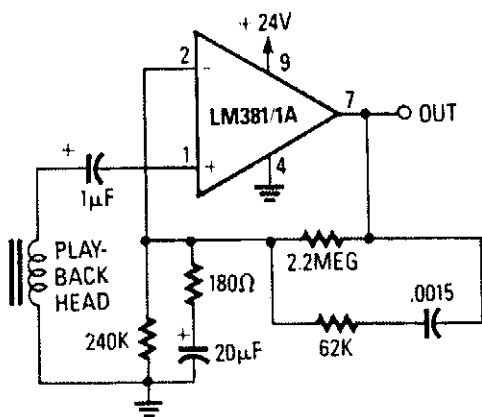
To raise the 2-mV output of the dynamic pick-up to line level at 1 kHz, linear amplifier IC2 has been added. This stage has a gain of 22 dB, so a signal of 250 mV is available at its output.

Capacitors C4/C5 at the output, in conjunction with the input impedance of the following preamplifier, form a high-pass filter with a cut-off frequency of 20 Hz; this serves to suppress any rumble or other low frequency noise. The value of C1 is normally given in the instruction booklet of the dynamic pick-up.

The power supply for the amplifier must be of good quality. Particularly, the transformer should be class A1 with a small stray magnetic field.

When the amplifier is built into the record player (best), the power supply should not be included unless it is very well screened; otherwise, hum is unavoidable.

SIMPLE TAPE PLAYBACK AMPLIFIER

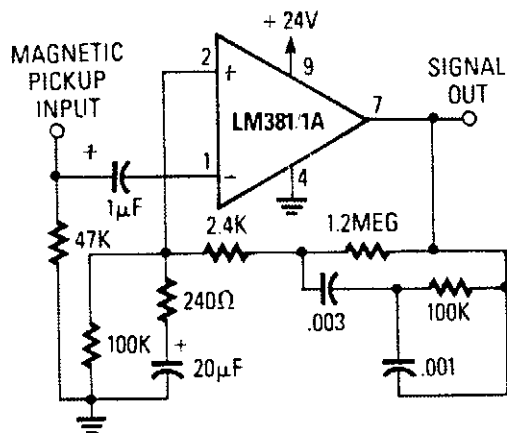


RADIO-ELECTRONICS

Fig. 8-2

This circuit uses an LM381/1A as a tape preamp. The feedback network includes NAB Equalization.

LOW-NOISE PHONO PREAMP

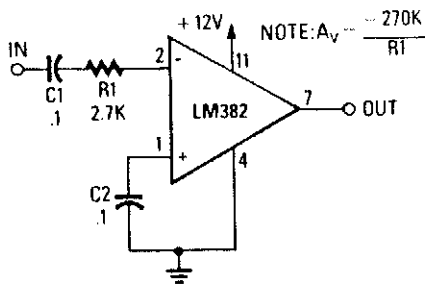


RADIO-ELECTRONICS

Fig. 8-3

This circuit uses an LM381/1A as a low-noise phono preamp. The feedback network provides RIAA compensation.

SIMPLE 40-dB GAIN AMPLIFIER

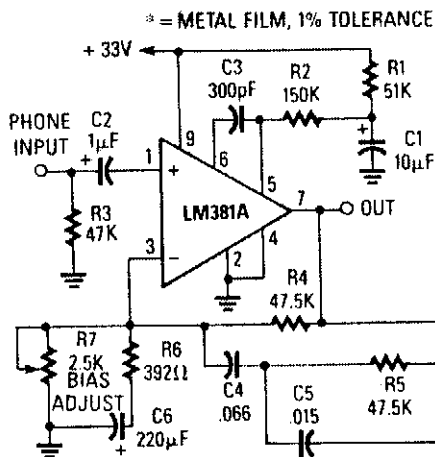


RADIO-ELECTRONICS

Fig. 8-4

An LM382 low-noise preamp is used here to obtain a 40-dB gain amplifier, using only the IC and three peripheral components.

ULTRA-LOW-NOISE MAGNETIC PHONO PREAMP

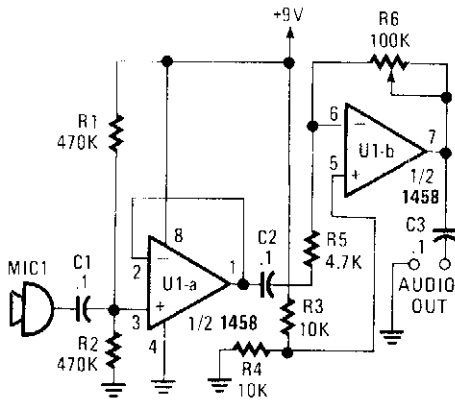


RADIO-ELECTRONICS

Fig. 8-5

This phono preamp uses an LM381/1A in a circuit that includes RIAA equalization. Adjust R7 for a voltage that is equal to half of the supply voltage (≈ 16.5 V).

IMPEDANCE-MATCHING PREAMP

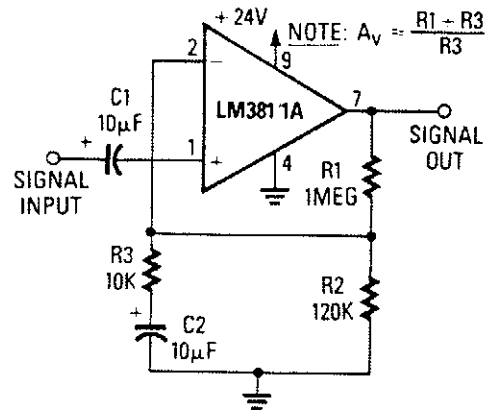


POPULAR ELECTRONICS

Fig. 8-6

This circuit will match a crystal microphone to a device that requires a low-impedance dynamic microphone.

LOW-NOISE AMPLIFIER

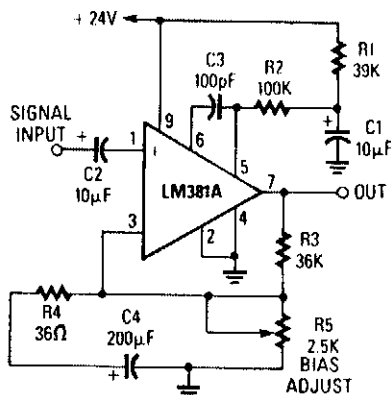


RADIO-ELECTRONICS

Fig. 8-7

This low-noise LM381/1A noninverting amplifier has a gain of 100.

LOW-NOISE 1 000 × PREAMP

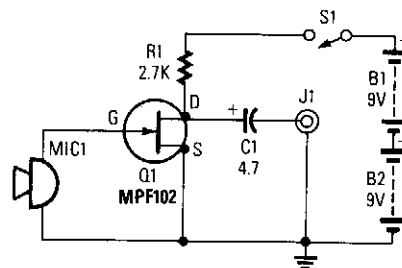


RADIO-ELECTRONICS

Fig. 8-8

An LM381A is used here as a low-noise preamp with a gain of approximately 1 000 ×. Adjust R5 for 12 V at pin 7, assuming a 24-V supply.

SIMPLE MICROPHONE PREAMP

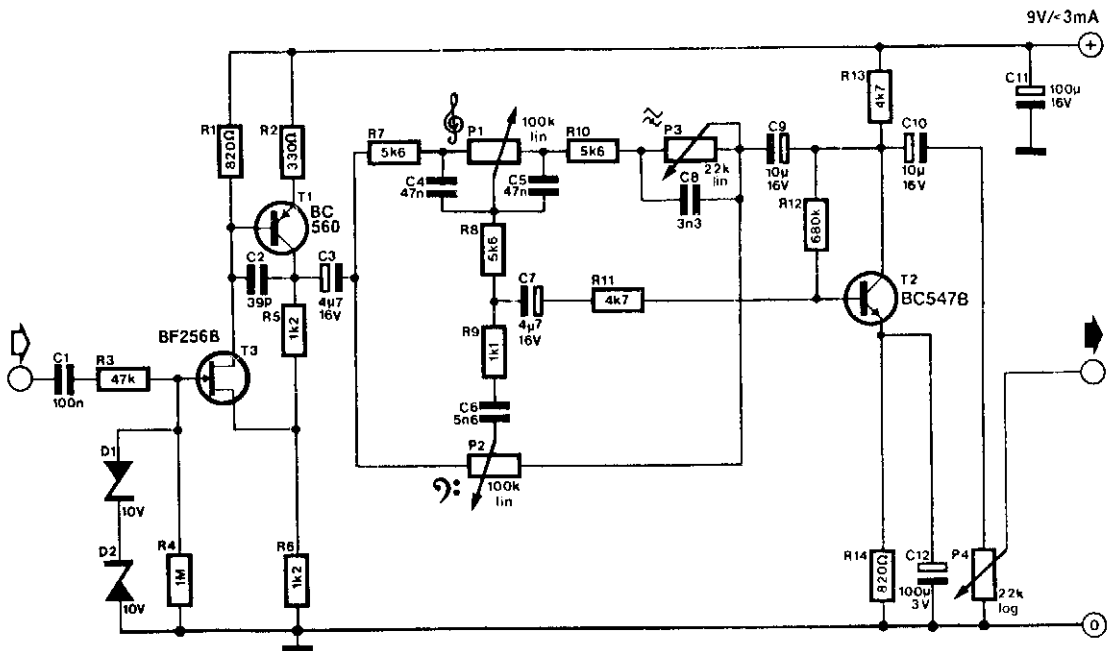


POPULAR ELECTRONICS

Fig. 8-9

This preamp uses a small dynamic microphone coupled to the gate of Q1. R1 is a load resistor. Audio is taken out between the negative side of C1 and ground. Output will be between 10 and 100 mVpp, depending on the microphone.

ELECTRIC GUITAR MATCHING AMPLIFIER



ELEKTOR ELECTRONICS

Fig. 8-10

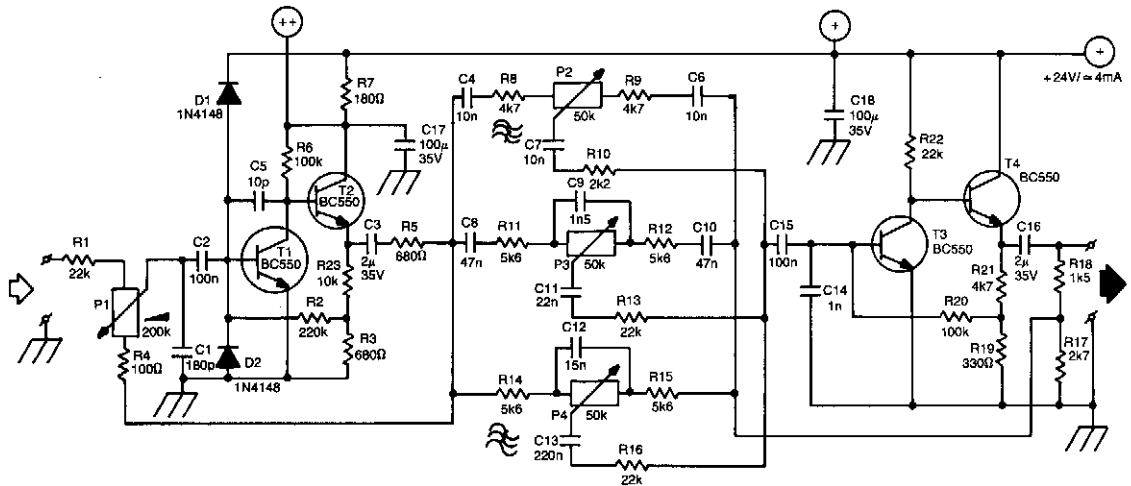
An electric guitar often has to be connected to a mixing panel, a tape deck or a portable studio. As far as cabling is concerned, that is no problem, but matching the high impedance of the guitar element to the low impedance of the line input of the mixing panel or tape deck is a problem. Even the so-called high impedance inputs of those units are not suitable for the guitar output. When the guitar is connected to such an input, hardly any signal is left for the panel or deck to process.

It would be possible to connect the guitar to the (high impedance) microphone input, but it is normally far too sensitive for that purpose; guitar clipping occurs all too readily.

The matching amplifier presented here solves those problems: it has a high-impedance (1 MΩ) input that can withstand voltages of over 200 V. The output impedance is reasonably low. Amplification is $\times 2$ (6 dB). Dual tone control, presence control, and volume control are provided.

The circuit can handle input levels of up to 3 V. Above that level distortion increases, but that is, of course, a good thing with guitar music. Real clipping of the input signal does not occur until much higher levels than are obtainable from a guitar are applied. Power is supplied by a 9-V (PP3) battery from which the circuit draws a current that does not exceed 3 mA.

UNIVERSAL AUDIO LINE AMPLIFIER



ELEKTOR ELECTRONICS

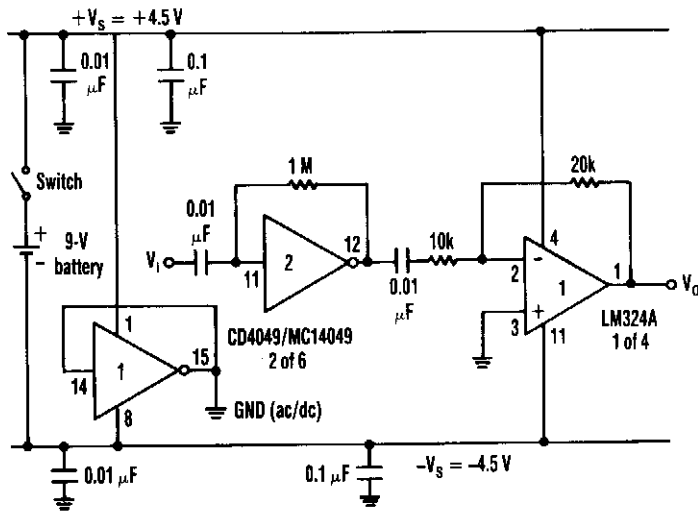
Fig. 8-11

A line amplifier is always a useful unit to have around, whether it is for matching a line signal or raising its level somewhat. This might be needed during a recording session or with a public-address system. Furthermore, a line mixer can be constructed from a number of these amplifiers. The input of the amplifier is high-voltage proof. The output impedance is low.

The circuit is a conventional design: two dc-coupled stages of amplification are separated by a three-fold Baxandall tone control system. The volume control at the input is conspicuous by having its "cold" side connected, not to ground, but to the output of the first amplifier. Because the signal there is out of phase with the input signal, the amplifier obtains negative feedback via P1. The amplification is therefore inversely proportional to the magnitude of the input signal. Thus, it is possible for the amplifier to accept a wide range of input levels. It is quite possible to input a signal taken directly from the loudspeaker terminals of a power amplifier.

The supply voltage is 24 V. At that voltage, the amplifier draws a current of about 4 mA. If several amplifiers are used in conjunction (as, for instance, in a mixer panel), the various supplies (+ and ++ in the diagram) can be interlinked. Capacitors C17 and C18, and resistor R7 don't need to be duplicated in that case.

CD4049 AMPLIFIER



INVERTER CHARACTERISTICS

	V supply	
	9V	13.6V
A_v	30 V/V	40 V/V
$f_{(-3dB)}$	2.5 MHz	3.5 MHz nom.
I_{oh}	-1.25 mA	-3.0 mA min.
I_{ol}	8.0 mA	20.0 mA min.

ELECTRONIC DESIGN

Fig. 8-12

When an inverter is biased with one resistor from its input to output in the range of 100 k Ω to 10 M Ω and is capacitor coupled, it exhibits amplifier characteristics (see the table).

Furthermore, when a split power-supply bus is needed and only one battery is used, the inverter can be configured to supply a pseudo-dc ground of relatively low impedance, coincident with the ac ground (see the figure). Depending on the magnitude of the dc ground return currents, anywhere from one inverter to several in parallel are sufficient. Also, the supply buses must be capacitor bypassed.

The configured input-to-input shorted inverter now acts as a voltage regulator that sinks and sources current. In this configuration, the inverter is forced to operate at the midpoint of its transfer characteristic. This divides the battery potential into two equal parts—as referenced to the defined dc ground by virtue of its internal gain and physical structure. Op amps such as the LM324A, can be powered from one battery while being referenced to the dc ground that is generated by the inverter. This novel technique surpasses the use of discrete resistors for battery potential dividing. It can be employed in other applications where individual component savings and improved design performance are needed.

LOW-NOISE AUDIO PREAMP

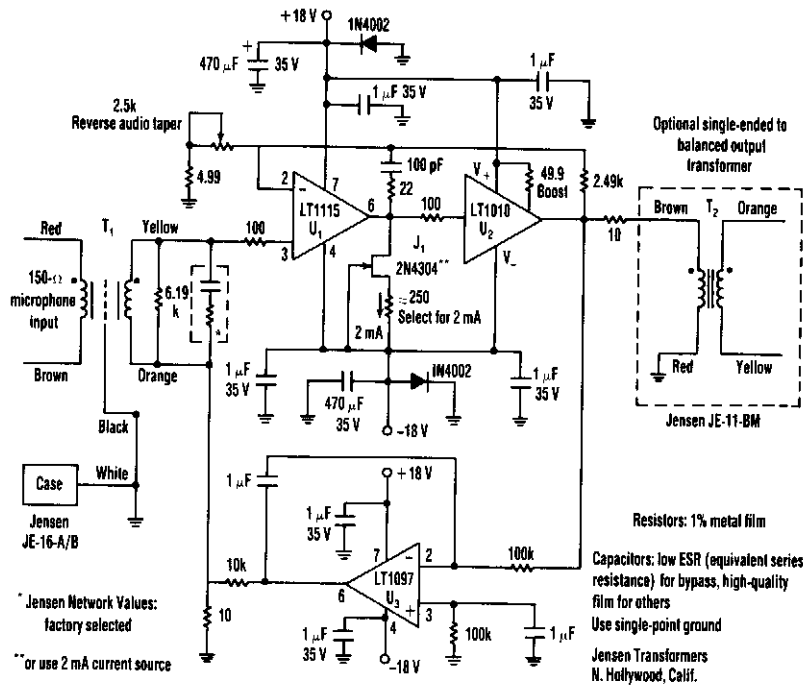
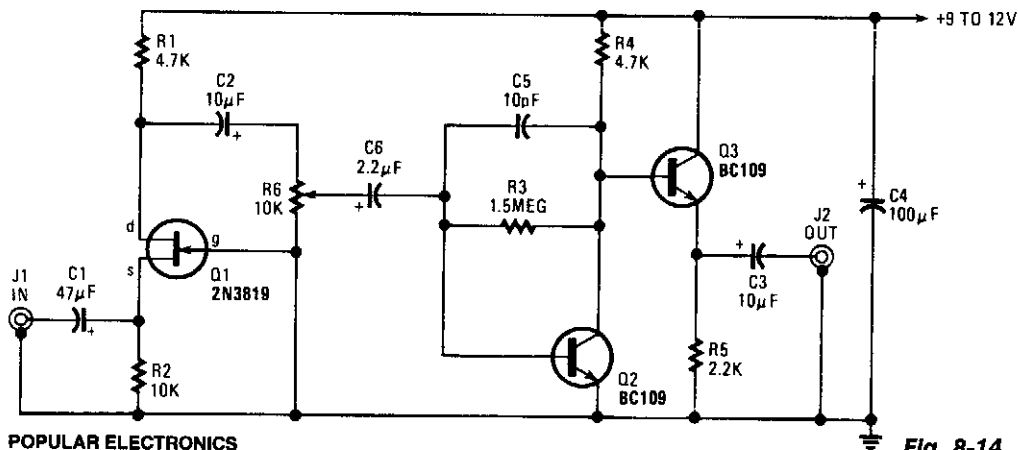


Fig. 8-13

ELECTRONIC DESIGN

A low-noise LT1115 (Linear Technology, Inc.) op amp is coupled to a class-A buffer amplifier to produce a variable gain (12-to-50 dB) microphone preamp. THD is less than 0.01% from 80 Hz to over 20 kHz. The transformers must be properly grounded and shielded.

LOW-IMPEDANCE MICROPHONE PREAMP

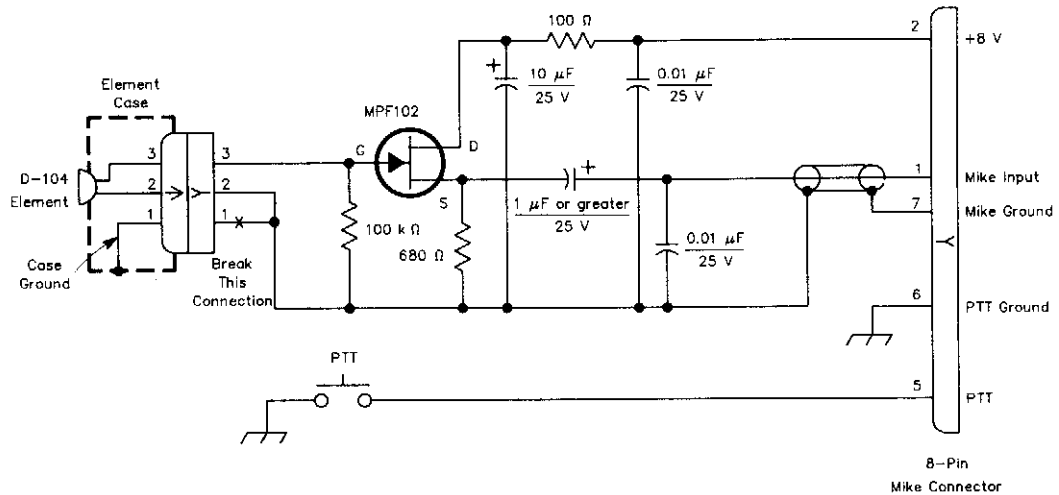


POPULAR ELECTRONICS

Fig. 8-14

This amplifier uses a common-gate FET amplifier to match a low-Z microphone.

MICROPHONE PREAMP

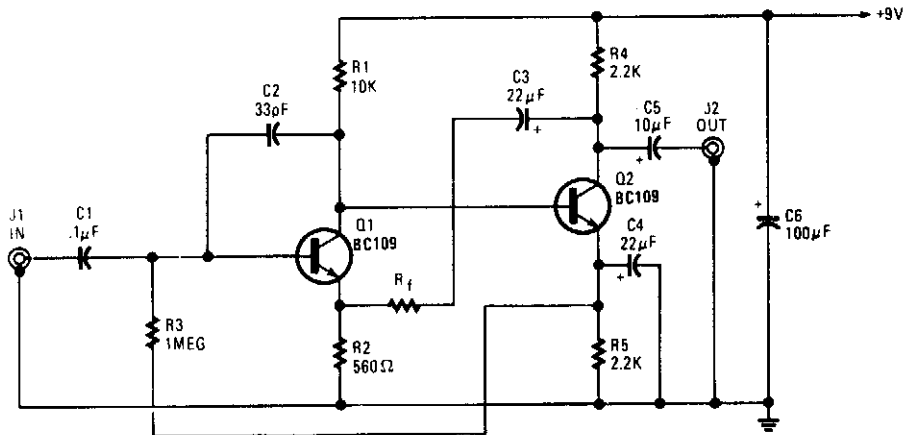


GST

Fig. 8-15

This circuit is used to interface a high-impedance microphone to a radio transceiver that requires a low-impedance microphone. The supply voltage can be either a battery or taken from the transceiver the circuit is used with.

GENERAL-PURPOSE PREAMP



POPULAR ELECTRONICS

Fig. 8-16

This amplifier is useful for audio and video applications. Gain is set by R_f and the voltage gain of this amplifier is approximately $1 + R_f/560$, where R_f is in ohms. Bandwidth depends on gain selected, but typically it is several MHz. $R_f = 5.1 \text{ k}\Omega$, which produces a gain of $10 \times$ (20 dB) voltage.

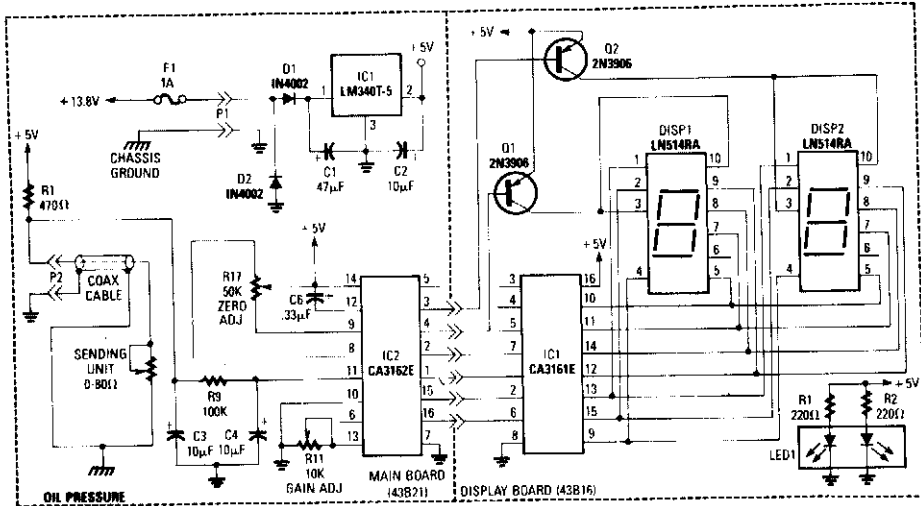
9

Automotive Instrumentation Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 661. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Digital Oil-Pressure Gauge
- Water Temperature Gauge
- Automotive Electrical Tester
- Digital Vacuum Gauge
- Digital Fuel Gauge
- Analog Expanded-Scale Meter for Autos
- Digital Pressure Gauge
- Voltage Gauge
- Digital Miscellaneous Temperature Gauge

DIGITAL OIL-PRESSURE GAUGE

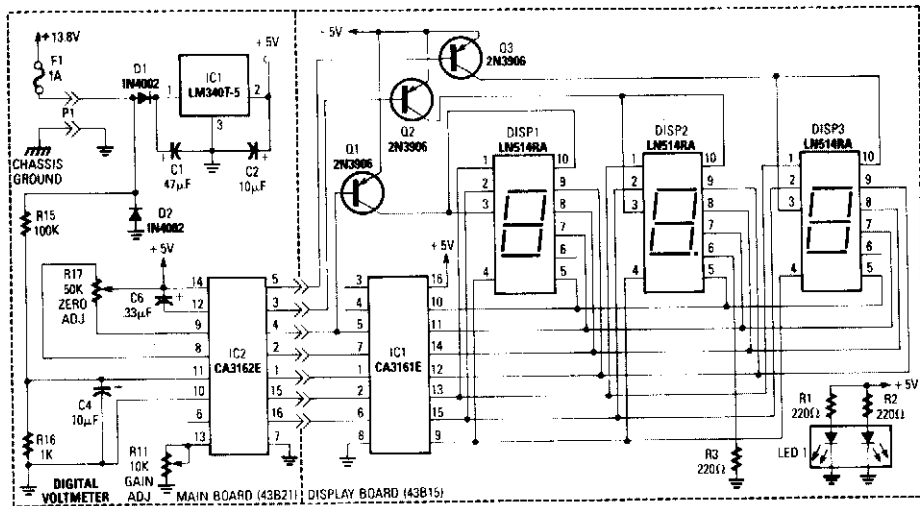


RADIO-ELECTRONICS

Fig. 9-1

This gauge uses a sensor in conjunction with R1 to develop a dc voltage proportional to oil pressure. IC1 and IC2 form a two-digit DVM. Q1 and Q2 are display selectors for the multiplexed display. IC1 provides the necessary +5 V to the circuitry. Calibration is via R11 and zero adjust via R17.

WATER TEMPERATURE GAUGE

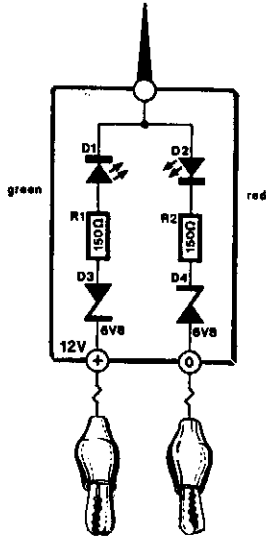


RADIO-ELECTRONICS

Fig. 9-2

This gauge is similar to the miscellaneous temperature gauge, except that a thermostat is used as a sensing element.

AUTOMOTIVE ELECTRICAL TESTER



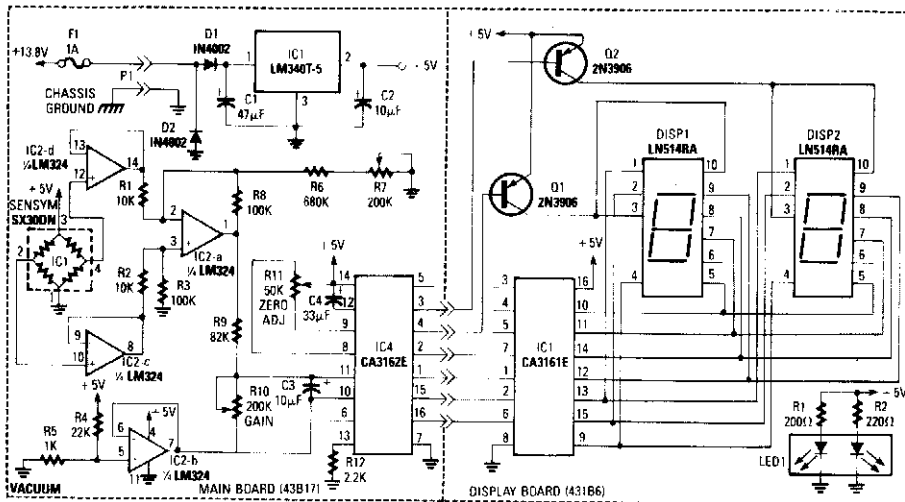
ELEKTOR ELECTRONICS

Fig. 9-3

This little tester is useful for checking vehicle electrical circuits. Two LEDs indicate whether one of the clips is connected to the positive supply line (red) or to ground (green).

The unit is powered by the vehicle battery. It is advisable to terminate the unit into two insulated heavy-duty crocodile clips. These enable connection to be made directly to the battery or to terminals on the fuse box. It is also possible to terminate it into a suitable connector that fits into the cigarette lighter socket. If a sharp needle is soldered to one of the terminals, it is possible to check insulated wiring—but only those that carry 12 V. Although the needle pierces the insulation, it does not damage it.

DIGITAL VACUUM GAUGE



RADIO-ELECTRONICS

Fig. 9-4

A bridge circuit is used to produce a signal from the output of vacuum sensor IC1. IC2b provides about a 0.2 V offset for IC4, the A/D converter. IC2b and d are voltage followers that drive differential amp IC2a. The output of this circuit is used to drive IC4 and IC1, the display drivers.

DIGITAL FUEL GAUGE

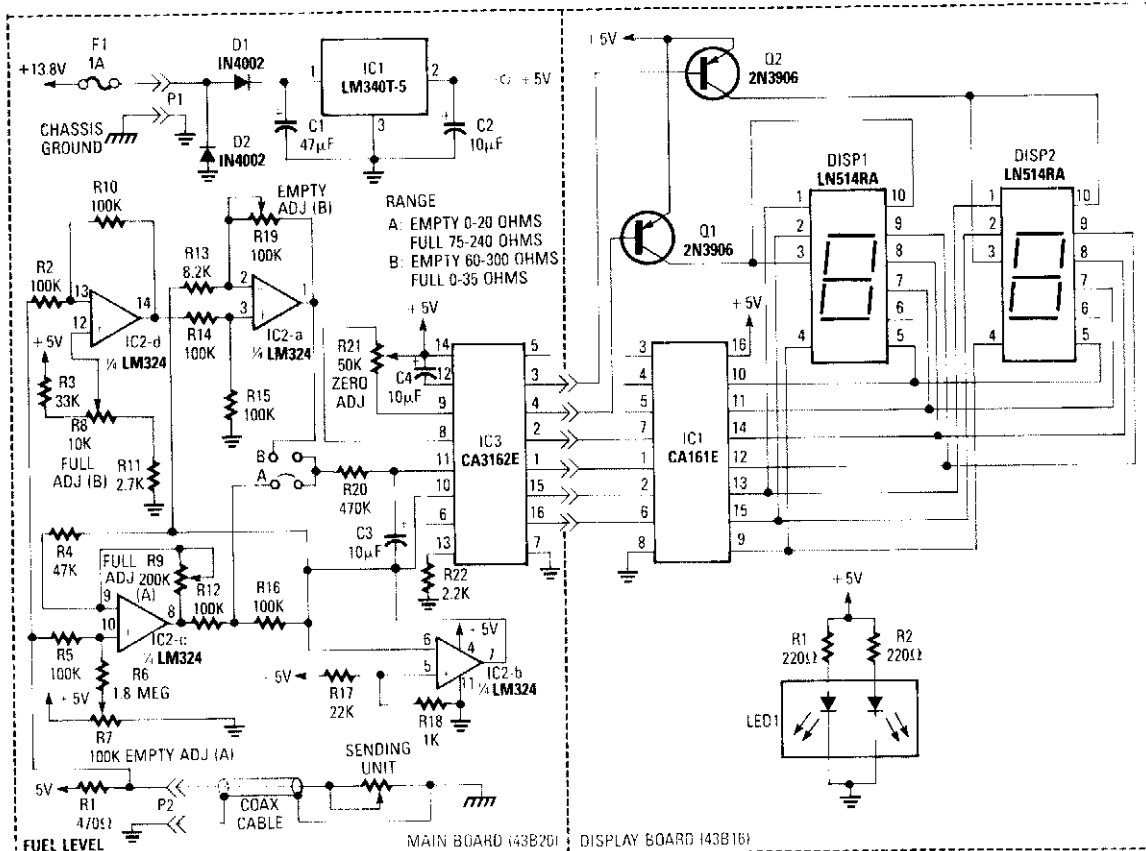
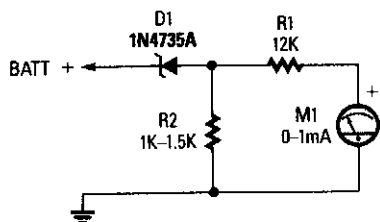


Fig. 9-5

RADIO-ELECTRONICS

This circuit uses a digital voltmeter (formed from IC1 and IC3) to display fuel quantity as a percentage of a full tank. In order to work with two kinds of fuel sensors, low resistance = full. Where higher resistance = full, IC2 forms a dc amplifier that has both inverting (path A) or noninverting (path B) outputs, and calibration adjustments for each path.

ANALOG EXPANDED-SCALE METER FOR AUTOS

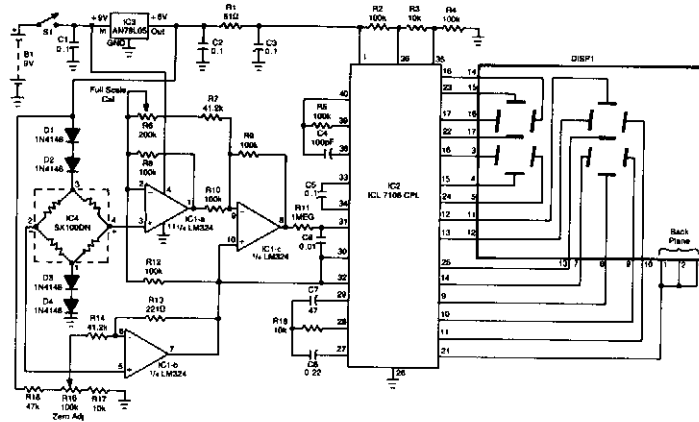


Zener diode D1 is used to suppress the first 6 V of the scale, which gives a meter reading of 6 to 8 V—useful for automotive electrical system monitoring.

POPULAR ELECTRONICS

Fig. 9-6

DIGITAL PRESSURE GAUGE

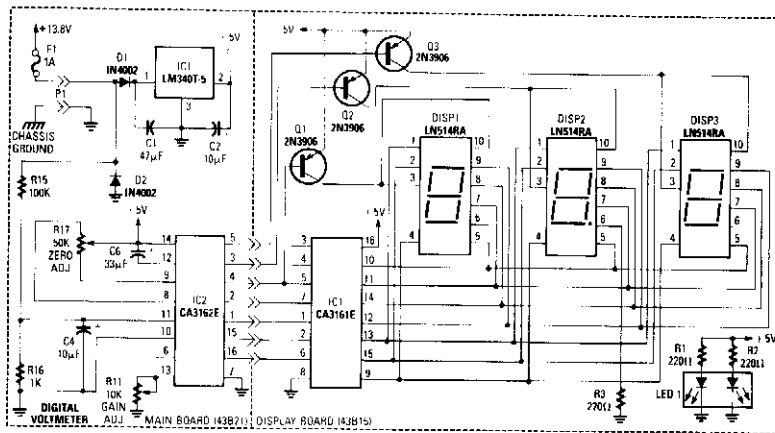


RADIO-ELECTRONICS

Fig. 9-7

Using an intersil ICL 7106 A/D converter chip and an LED display module, this gauge uses a Sensym Corp. pressure transducer SX100pn (100 psi full scale) in a Wheatstone bridge configuration to drive an op amp (IC1a, b, c) translator circuit that supplies a dc voltage to IC2 that is proportional to pressure. R6 sets the gain of IC1A (full-scale sensitivity) and R16 supplies a zero adjustment. IC3 provides regulated +5 V to power the circuit.

VOLTAGE GAUGE

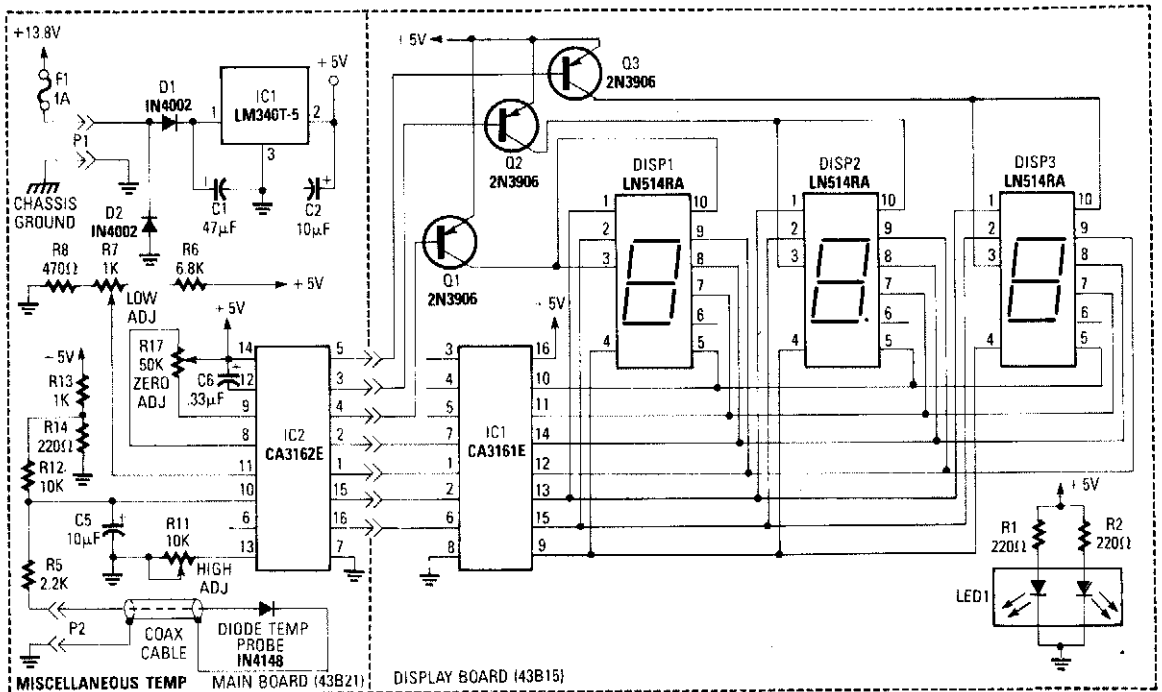


RADIO-ELECTRONICS

Fig. 9-8

This circuit uses an RCA CA3162E (IC2) A/D converter. This converter has 12-bit output (BCD) which is sent to display decoder driver IC1. +5 V is obtained from IC1. R17 adjusts to 0 and R11 should be set to produce correct calibration of gauge unit. Displays are common cathode types. No limiting resistors are necessary because the output drivers are constant current. R15 and R16 sample the applied voltage (usually 8 to 18 V). LED1 is used to illuminate the gauge legend (Volts, Temp, etc.).

DIGITAL MISCELLANEOUS TEMPERATURE GAUGE



RADIO-ELECTRONICS

Fig. 9-9

A diode (IN4148) is used as a temperature sensor. IC2 is an A/D converter with BCD output. A reference voltage set by R7 is applied to the positive input of IC2. As the temperature increases, the voltage across the temperature sensor resistance decreases. This increases the differential input voltage across pins 10 and 11 of IC2. R3 adjusts low calibration. R17 zeros the A/D converter and R7 adjusts high calibration.

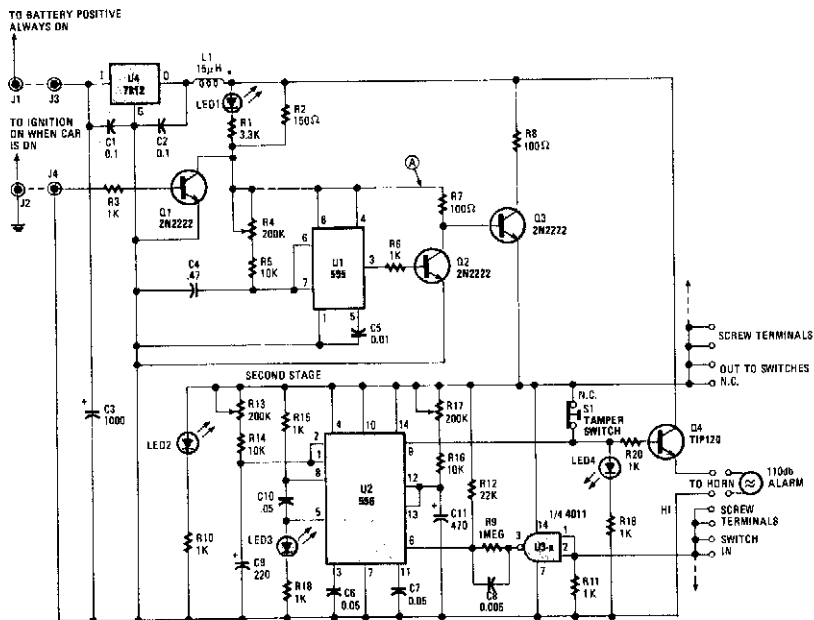
10

Automotive Security Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 662. The figure number in the box of each circuit correlates to the entry in the Sources section.

Automatic Arming Auto Alarm
Backup Beeper
Auto Turn-Off Alarm with 8-Minute Delay
Auto Alarm
Auto Ignition Cut-Off
Car Alarm with Horn as Loudspeaker
Automotic Turn-Off Alarm with Delay
Single-IC Alarm
Low-Current Simple CMOS Alarm
Back-Up Alarm

AUTOMATIC ARMING AUTO ALARM



POPULAR ELECTRONICS

Fig. 10-1

The circuit automatically turns on when the car is turned off. It gives you a variable time to get out and lock up, and also provides a variable time delay to get in and start the car.

The 555 oscillator/timers are always powered down when the car is on. That keeps the alarm from going off while you're driving. As soon as the car is turned off, Q2 switches off and shunts power to U1. When that happens, U1 immediately sends its output high, keeping Q3 on, and thereby prevents power from returning to U2.

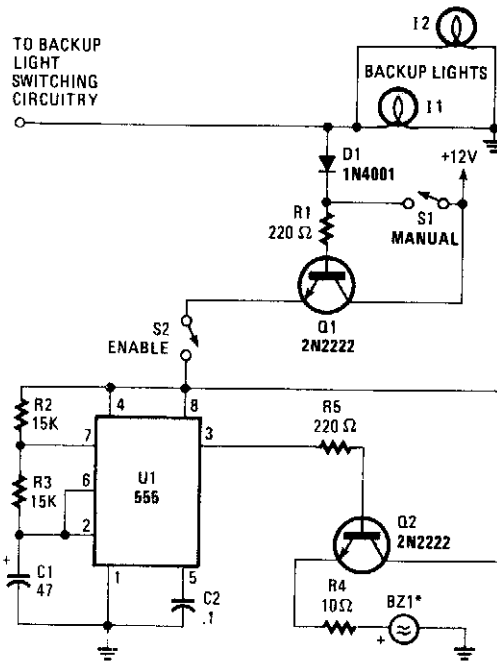
Transistor Q2 also sends power to Q3's collector to be used only when U1 has completed its timing cycle. When U1 has finished, it turns Q3 off, which in turn activates Q4, and sends power to the balance of the circuit. That timing period was the time needed to get out of the car. LED1 indicates that the system is disarmed and LED2 indicates that the system is armed.

At this point, U2 waits for a trigger pulse from the car's door switches or dome light. A positive impulse at the 4011's input sends a negative trigger pulse to the first stages of U2, which is connected as a cascading timer. The first stage's output becomes high for a time to allow the car to be turned on.

If that does not happen, the first stage's output lowers, which sends a low trigger pulse to the second stage. The second stage then sends its output high, turning on Q5, which sounds the alarm for a given time. Once that time has elapsed, the alarm is shut off by a low output to Q5 and the system is reset. If the car door is closed or a second door opened while the alarm is sounding, the first stage retriggers and prepares to extend the ON-time of the alarm.

The cascading or counting action continues until the car is left alone. You can add a switch on the positive supply rail at J3 to override and silence the alarm, if (for example) you plan to work on the car. Switch S1 is a normally closed type that is built into the case of the alarm; S1 is pushed to the open position when the case is mounted flush with a surface. Any attempt to remove the alarm will sound the alarm.

BACKUP BEEPER

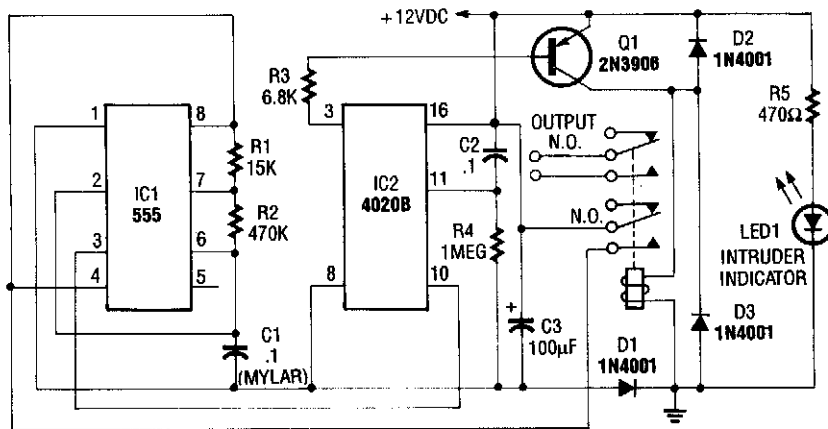


POPULAR ELECTRONICS

Fig. 10-2

When the vehicle's backup lights kick on, or when the manual switch (S1) is closed, a small current is fed to the base of Q1. Transistor Q1 allows current to flow through it and, if the enable switch (S2) is closed, it sends 12 V to U1, a 555 timer. Timer U1 sends high pulses that last 0.977 13 s and low signals that last 0.488 565 s to the base of Q2. When U1 switches Q2 on, it sends 12 V to BZ1, a piezoelectric buzzer. For best results, the buzzer should be mounted under the vehicle—somewhere where people around the car can hear the warning beeps.

AUTO TURN-OFF ALARM WITH 8-MINUTE DELAY

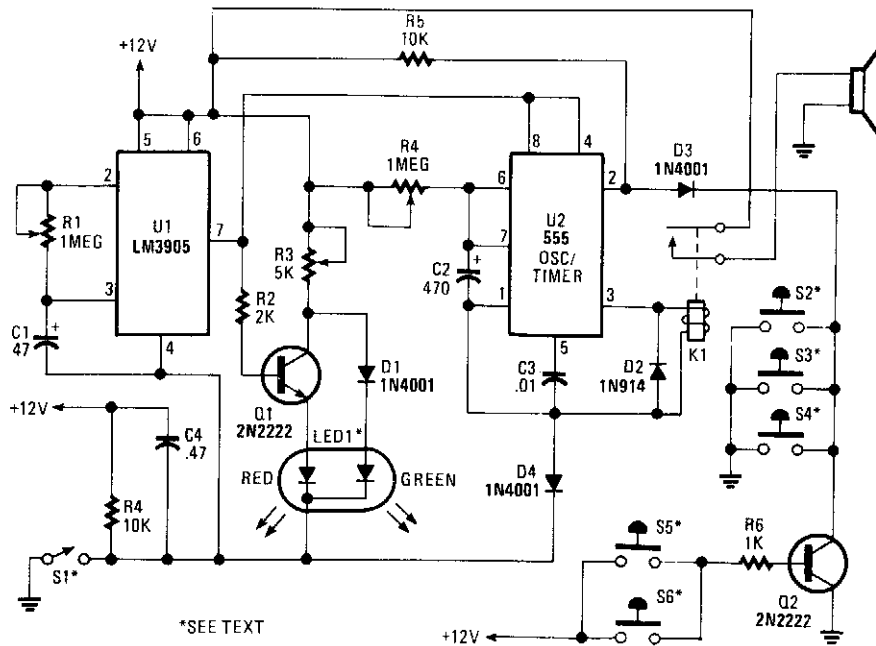


RADIO-ELECTRONICS

Fig. 10-3

This circuit uses a NE555 timer and CD4020B. When +12 Vdc is applied to the circuit, the output of IC2 is set low via C2, which turns on the relay, and IC1, a pulse generator. IC1 pulses counter IC2. After 8192 clocks, IC2 output (pin 3) goes high, cuts off Q2, and completes the cycle.

AUTO ALARM



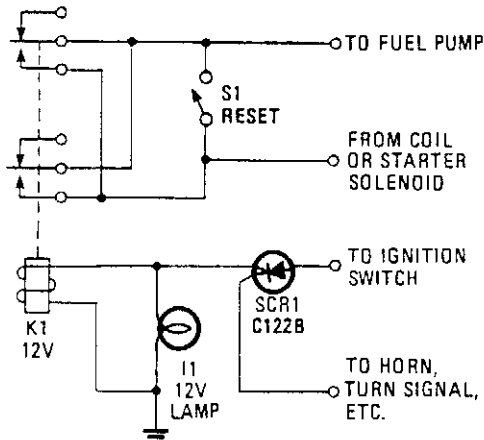
*SEE TEXT

POPULAR ELECTRONICS

Fig. 10-4

S1 is external key switch. The alarm allows a 0- to 45-s delay after S1 is operated before the circuit is armed. During this period, LED1 lights green. After this delay, LED1 lights red, which indicates that the circuit is armed. Then, sensors S2 through S4 -(NO) or S5 through S6 (NO) pull pin 2 of U2 low, which activates K1 and sounds the alarm. The alarm sounds for a duration determined by R4 and C2. After this time, K1 releases and the circuit is again ready. Manual reset is via the key switch, S1.

AUTO IGNITION CUT-OFF

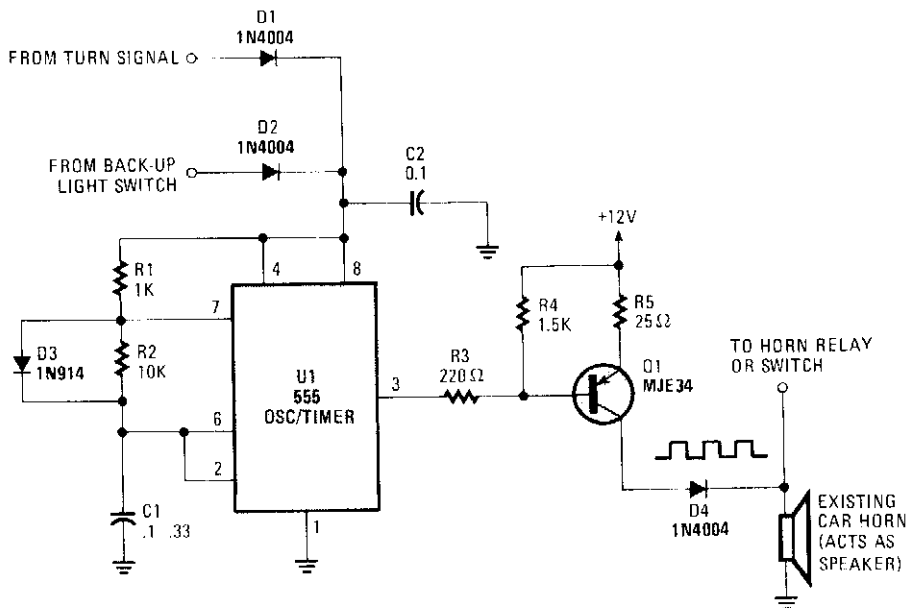


Using an SCR/relay combination, this circuit can be made to cut off ignition, unless a positive voltage is applied to the gate of the SCR. This is useful as an anti-theft device, because depending on hook-up, the car will not start unless a certain accessory or a hidden switch is closed.

POPULAR ELECTRONICS

Fig. 10-5

CAR ALARM WITH HORN AS LOUDSPEAKER

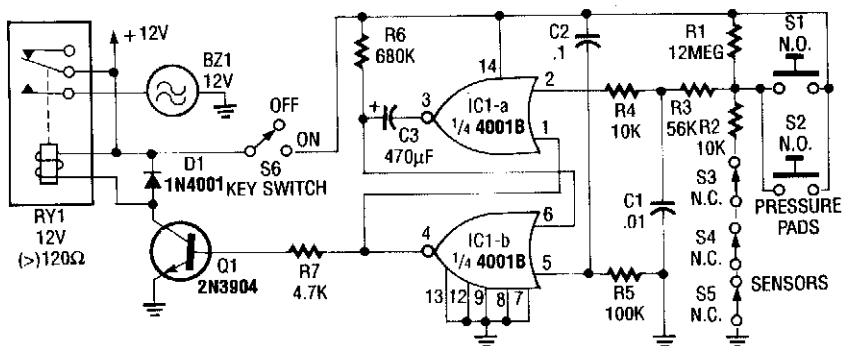


POPULAR ELECTRONICS

Fig. 10-6

An auto horn will work as a speaker of limited audio-frequency range. This circuit uses a 555 timer as an oscillator to drive an MJE34 transistor, which in turn drives the horn. Normal horn operation is ensured by blocking diode D4.

AUTOMATIC TURN-OFF ALARM WITH DELAY

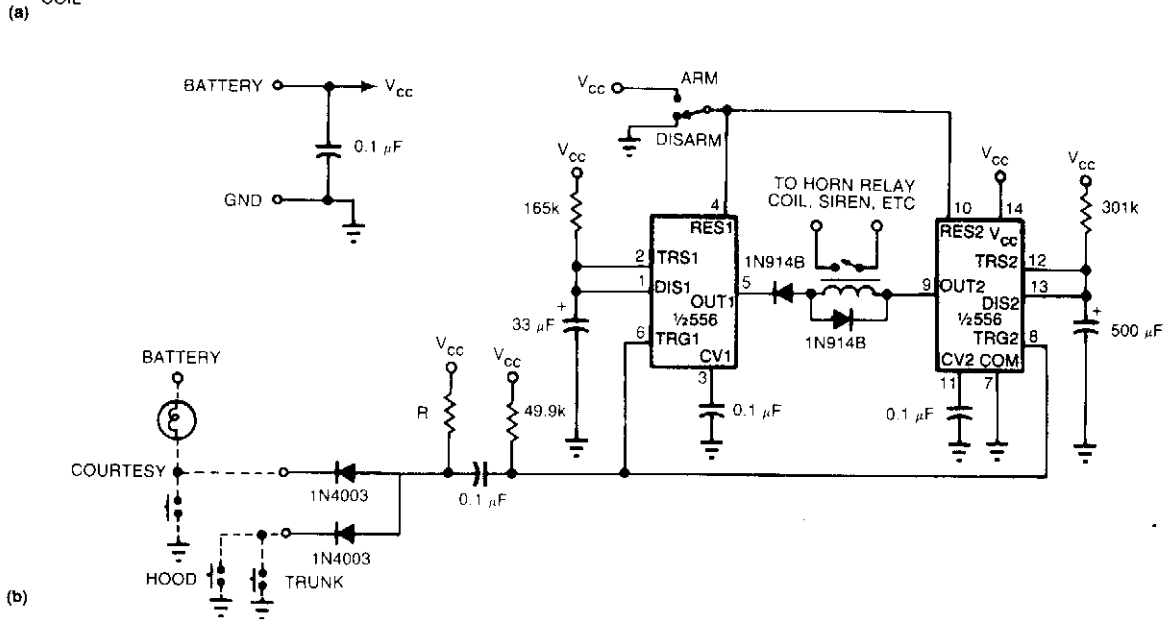
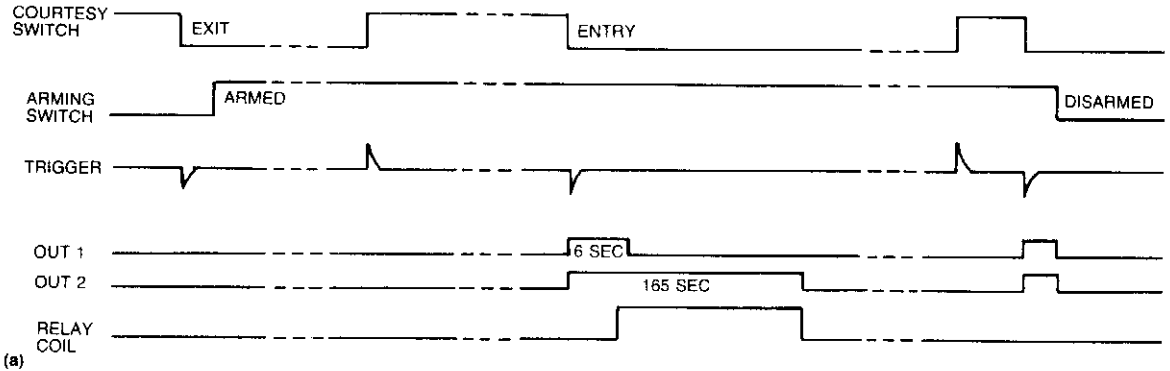


RADIO-ELECTRONICS

Fig. 10-7

In this circuit, IC1A and IC1B act as a monostable multivibrator. Any input from the sensors S1 through S5 forces IC1A to produce logic low, which causes IC1B to turn on Q1 until C3 charges through R6. This action resets the latch formed by IC1A and IC1B.

SINGLE-IC ALARM



EDN

Fig. 10-8

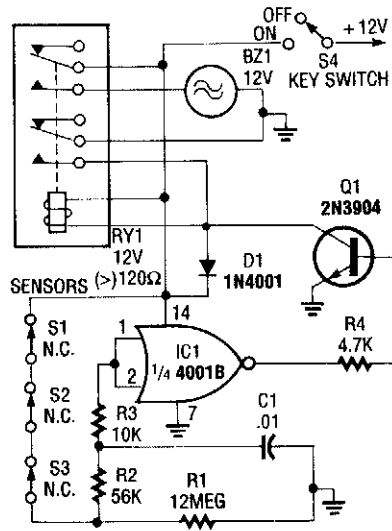
With a single IC, you can build a simple, reliable auto burglar alarm or a similar alarm. See (a) for the timing information for the alarm circuit in (b).

When you leave your vehicle, flip the arming switch and close the door behind you to arm the device. Subsequent opening of an entrance triggers both timers. After the expiration of the entry delay timer, the alarm sounds for a time that is determined by the second timer.

The value of R should be less than $1k\Omega$. If you use an incandescent lamp instead of a resistor, you get an extra function—an open-entrance indicator. By keeping the resistance low, you avoid false tripping should water collect under the hood.

If your door switch connects the courtesy light to 12 V rather than to ground, use a single transistor as an inverter at the input. Although this circuit's simplicity has its drawbacks, you can add more features, such as no-entry delays for the hood and trunk, and retriggering when doors remain open.

LOW-CURRENT SIMPLE CMOS ALARM

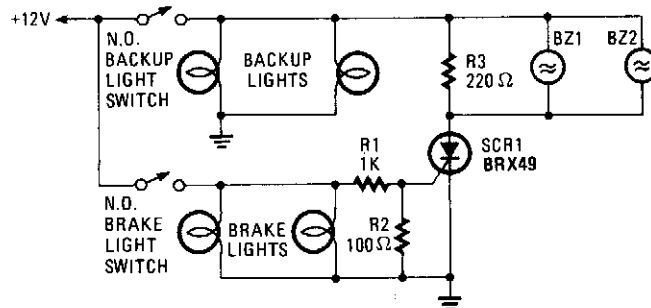


RADIO-ELECTRONICS

Fig. 10-9

This CMOS-aided alarm draws only 1 μ A standby current. An open sensor allows IC1 to bias Q1 on, activating RY1.

BACK-UP ALARM



POPULAR ELECTRONICS

Fig. 10-10

The brake lights of the automobile trigger this circuit on and off. This saves the annoyance of the alarm when it is not needed.

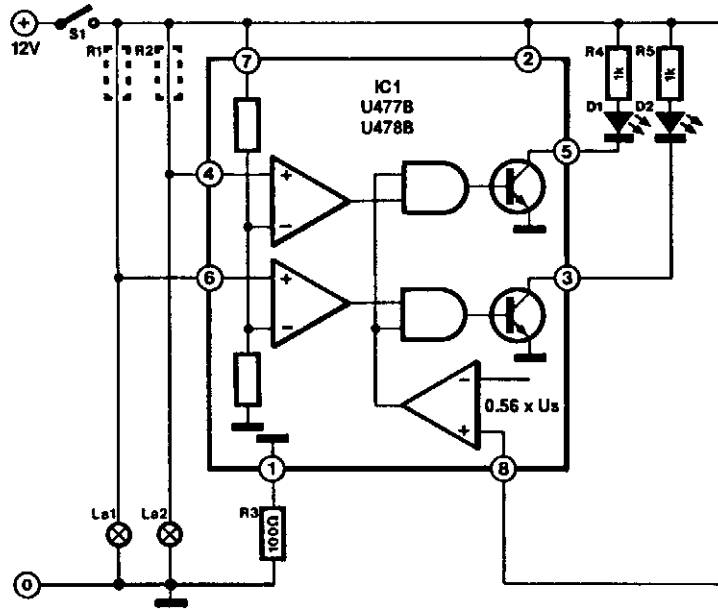
11

Automotive Light Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 662. The figure number in the box of each circuit correlates to the entry in the Sources section.

Car Lights Monitor
Rear Fog Light Controller with Delay
Interior Convenience Light
Third Brake Light
Lights-On Warning
Car Headlight Control
Night Safety Light for Autos
Lights-On Reminder for Autos
Automobile Lights-On Reminder

CAR LIGHTS MONITOR



ELEKTOR ELECTRONICS

Fig. 11-1

This circuit is for the purpose of monitoring automotive lighting. Two special ICs are available from Telefunken that are designed to measure the current through a light bulb. In practice, detecting whether a current flows through a bulb or not is a most suitable way of determining whether the bulb still works.

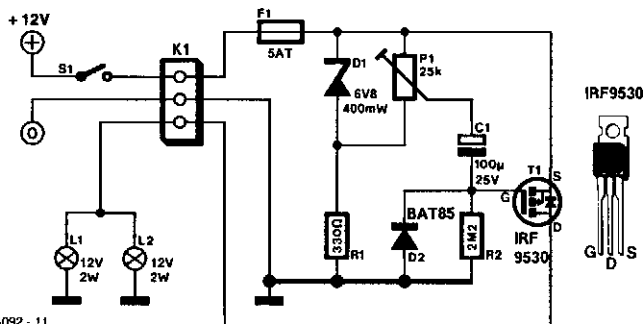
If a small resistance is connected in series with a bulb, a small voltage drop will develop across it when the bulb lights (R_1 and R_2 in the diagram). Each IC can cope with only two bulbs, so three or four ICs are needed per car. The junction of the bulb and resistor is connected to one of the inputs (pin 4 or pin 6) of the IC. The potential across the resistor is compared in the IC with an internal reference voltage. Depending on which of the two ICs is used, the voltage drop must be about 16 mV (U477B) or 100 mV (U478B). This voltage drop is so small that it will not affect the brightness of the relevant bulb.

The value of the series resistor is determined quite easily. If, for instance, it is in series with the brake light (normally 21 W), the current through the bulb, assuming that the vehicle has a 12-V battery, is $21 \div 12 = 1.75$ A. The resistance must then be of $16 \div 1.75 = 9$ m Ω (U477B) or $100 \div 1.75 = 57$ m Ω (U478B).

These resistors can be made from a length of resistance wire (available from most electrical retailers). Failing that, standard circuit wire of 0.7 mm diameter can be used. This has a specific resistance of about 100 m Ω per meter. However, in most cars, the existing wiring will have sufficient resistance to serve as series resistor.

LEDs can be connected to the outputs of the IC (pins 3 and 5). These will only light if the relevant car light fails to work properly.

REAR FOG LIGHT CONTROLLER WITH DELAY



ELEKTOR ELECTRONICS 904092 - 11

Fig. 11-2

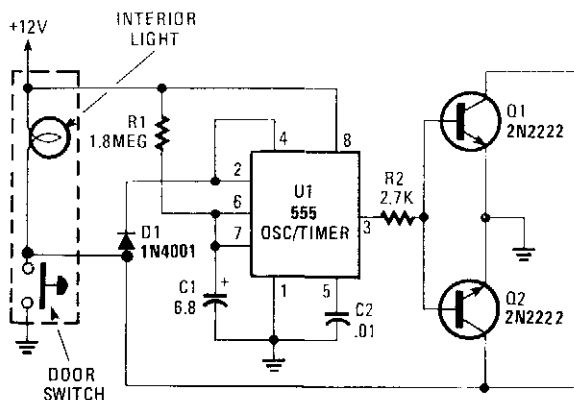
We assume that most of our readers are thoughtful drivers who do not switch on their rear fog lights when closely followed by other traffic. Following drivers (for an instant) will think that you are braking (although they have seen no reason for your doing so) and thus slam on their brakes as well. This could cause a very dangerous situation. Avoid a potentially dangerous action and install the rear fog light delay circuit, presented here.

Switch S1 is the on/off control for rear fog lights L1 and L2. As soon as this switch is closed, the gate-source voltage (V_{gs}) of MOSFET T1 will become more and more negative. Thus, the IC will conduct harder and harder. This in turn causes the brightness of the lights to gradually become brighter. Maximum brightness is reached after a delay of about 20 seconds, which is determined by time constant $R2/C1$.

The gate of T1 can be given a bias by preset P1. This provides compensation for the initial period after the lights are switched on and the lamps do not light, because they need hundreds of milliamperes before they can do so. With P1 set correctly, the lamps will light, albeit weakly, and immediately the control switch is closed. The gate potential is then equal to the voltage at the wiper of P1 (remember that C1 is then still discharged).

Although the dissipation of T1 is a maximum during the transitional period (between switch on and the lamps lighting brightly), the heatsink required is calculated on the basis of the dissipation when the lamps light brightly.

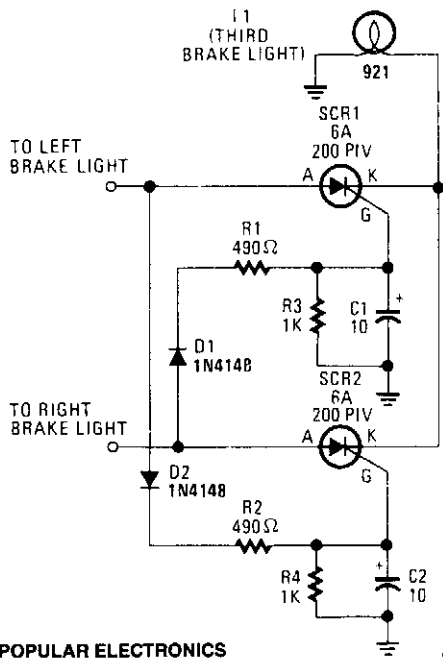
INTERIOR CONVENIENCE LIGHT



POPULAR ELECTRONICS

Fig. 11-3

When the door is closed, this circuit keeps the dome light on for a period determined by $R1/C1$. The time is approximately $(1.1)R1 \times C1$.



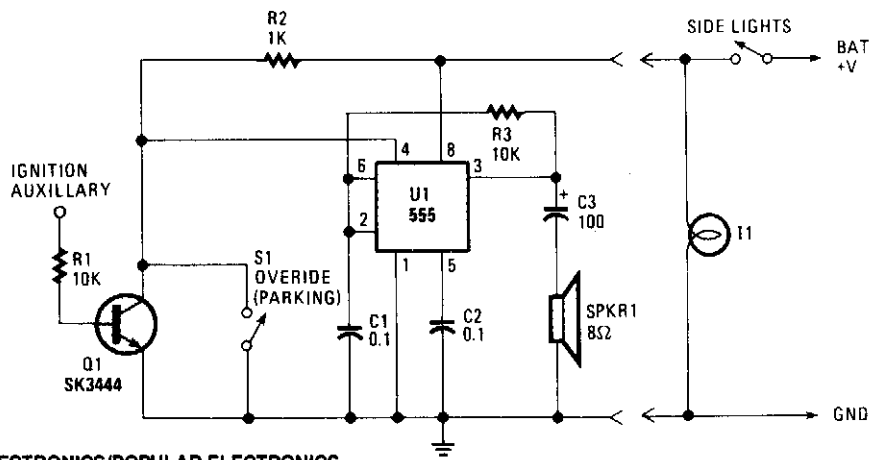
THIRD BRAKE LIGHT

The circuit is designed to light (via SCR1 and SCR2) only when both the left and right brake lights are activated. The circuit operates on 12-V negative-ground systems. When the brake pedal is depressed, 12 V is applied to the left and right brake lights. The gates of the two SCRs are triggered and current flows through the SCRs, which turns on the third brake light.

POPULAR ELECTRONICS

Fig. 11-4

LIGHTS-ON WARNING



HANDS-ON ELECTRONICS/POPULAR ELECTRONICS

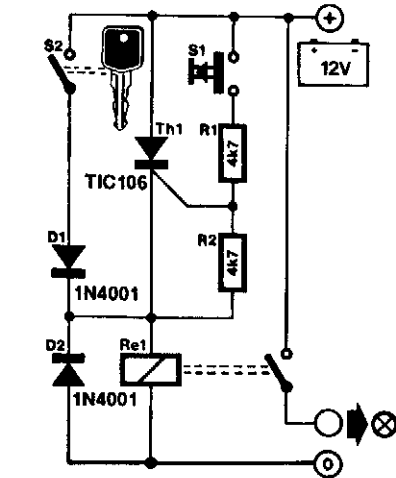
Fig. 11-5

Because power for the circuit is obtained from the car's side lights, the circuit can't oscillate unless the lights are on. The reset pin on the 555 connects to transistor Q1. The base of Q1 is connected through R1 to the ignition auxiliary terminal on the car's fuse box. When the ignition is turned on, power is supplied to the base of Q1, which turns it on. With Q1 turned on, pin 4 of U1 is tied low, which disables the oscillator and inhibits the alarm. If the ignition is turned off while the lights are on, power is applied to the 555 and Q1 is turned off, and the alarm starts. Switch S1 is an optional override.

CAR HEADLIGHT CONTROL

It is annoying to realize that you have left your car headlights on only to find that the battery is flat. One possible way to prevent this is with the present control.

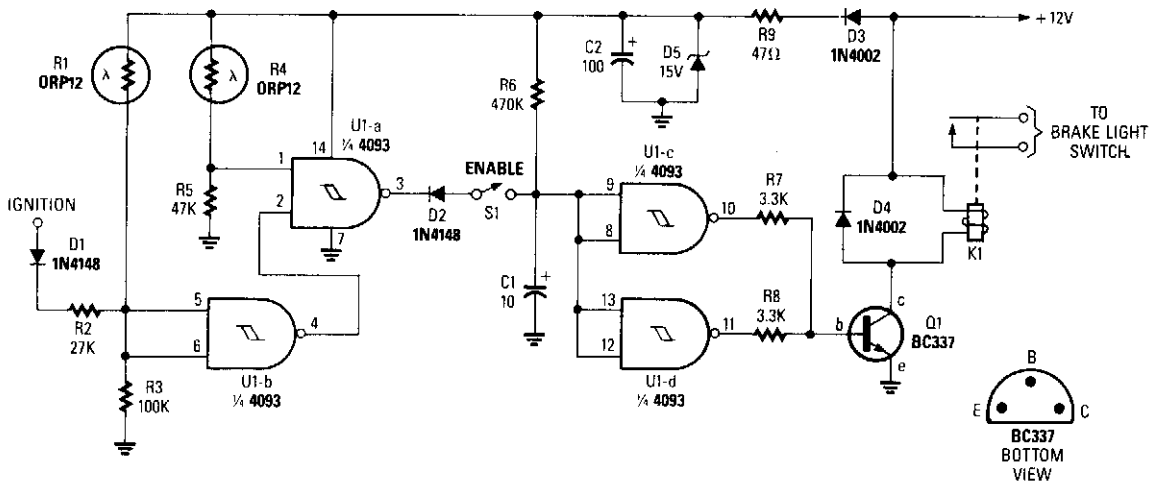
The circuit does not provide a warning, but an action: when you switch off the ignition, relay Re1 is de-energized and the headlights are switched off—unless you deliberately decide otherwise. That decision is made possible by switch S1, which, when operated, triggers silicon-controlled rectifier Th1 so that Re1 is energized. Notice that this is possible only when the ignition switch, S2, is off. Otherwise, the voltage across Th1 is so low, owing to shunt diode D1, that it cannot be triggered. However, the headlights should not normally be switched on when the ignition is off; in most cases S1 will be used only rarely and the switch can then be omitted altogether. The relay should be a standard 12-V car type with contacts that can switch up to 25 A.



ELEKTOR ELECTRONICS

Fig. 11-6

NIGHT SAFETY LIGHT FOR AUTOS

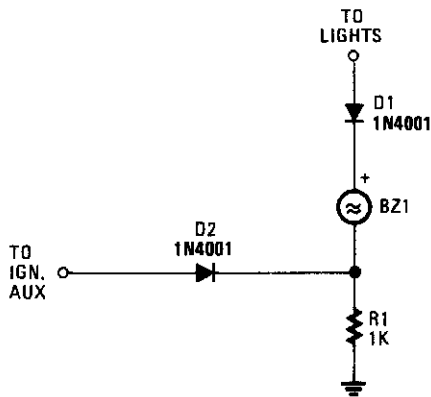


POPULAR ELECTRONICS

Fig. 11-7

This circuit turns on the brake lights of a parked car when the headlights of an oncoming car are detected, warning the driver of the oncoming car about the parked vehicle. LDR4 is the sensor. LDR1 disables the circuit by causing U1 gate input to be pulled high during daylight hours, causing pin 2 of U1a to become low, disabling it and the circuit.

LIGHTS-ON REMINDER FOR AUTOS

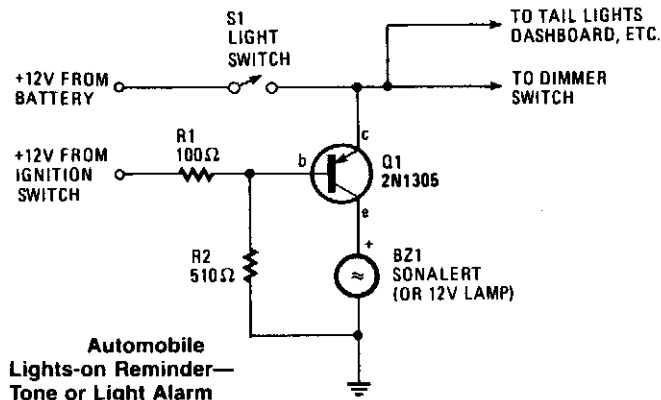


When ignition is off, BZ1 will sound if the headlights are on. With the ignition on, BZ1 receives no voltage.

POPULAR ELECTRONICS

Fig. 11-8

AUTOMOBILE LIGHTS-ON REMINDER



HANDS-ON ELECTRONICS

Fig. 11-9

The circuit can be used to give a visible or an audible warning that the headlights are on. It uses a 2N1305 transistor as a switch to turn on a Sonalert tone generator or a small 12-V lamp. Operating current for the transistor is supplied from the wire that feeds the headlights. When the ignition is on, the transistor is biased off and the alarm is not activated. Turning off the ignition while the lights are on sets off the alarm.

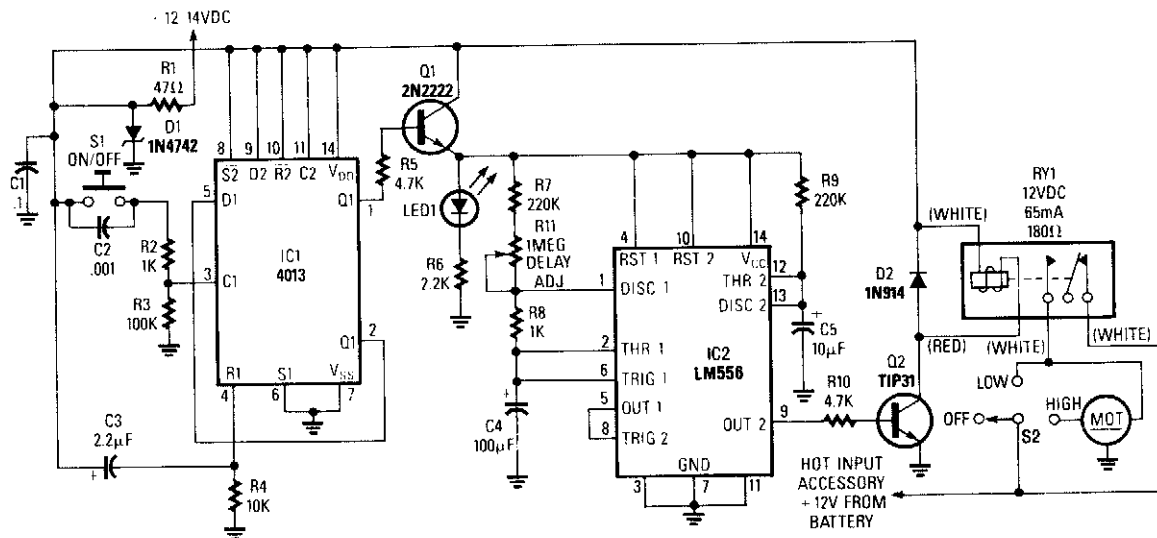
12

Automotive Electronic Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 662. The figure number in the box of each circuit correlates to the entry in the Sources section.

Solid-State Windshield-Wiper Delay
Electronic Ignition
High-Power Car Audio Amplifier
Windshield Wiper Interval Controller
Voltage Regulator for Cars and Motorcycles

SOLID-STATE WINDSHIELD-WIPER DELAY



RADIO-ELECTRONICS

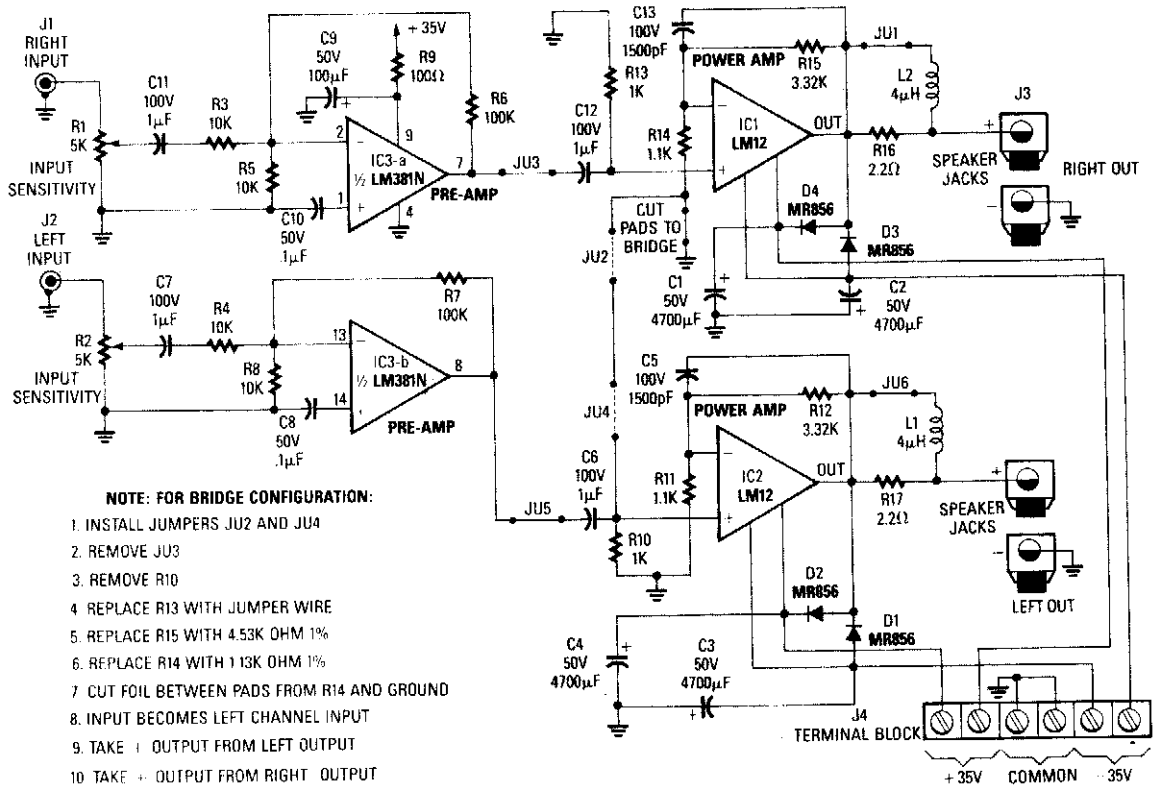
Fig. 12-1

In the wiper-delay schematic shown, with the ignition on, D1 maintains regulated +12 Vdc. When S1 closes, C1 bypasses transients and passes this +12 Vdc to divider R2-R3, producing a TTL high at pin 3 of IC1, a 4013 CMOS dual leading-edge triggered D-type flip-flop. Filter R4/C3 keeps IC1 from triggering erroneously when the ignition is on. When S1 is pressed, output Q1 (pin 1) of IC1 latches high, turning on Q1, which conducts via R5, turning on IC2; LED1 indicates power, and R6 sets the current. Because IC2 depends on Q1 for power, IC2 stays off until Q1 turns on.

The left half of IC2 is an astable, with its delay set by R7, R8, R11, and C4. The right half of IC2 is a monostable, with its pulse duration set by R9 and C5. With the values used, you might expect R11 to vary the delay from about 15 to 84 seconds, with a 2.42-second monostable pulse operating the wiper blades on each cycle. However, the actual delay will range between 2 to 18 s, with a 1-s monostable pulse on each cycle. That discrepancy stems from the fact that IC2 is being fed from the emitter of Q1, rather than directly from the regulated +12-V supply. Transistor Q1 acts as an active current source, charges and discharges C4 faster than it ordinarily would.

The astable output (OUT1, pin 5) is tied to TRIG2 (pin 8). When OUT2 (pin 9) becomes high, Q2 is biased via R10 and current flows through RY1, with D2 dissipating back-emf when RY1 shuts off.

HIGH-POWER CAR AUDIO AMPLIFIER

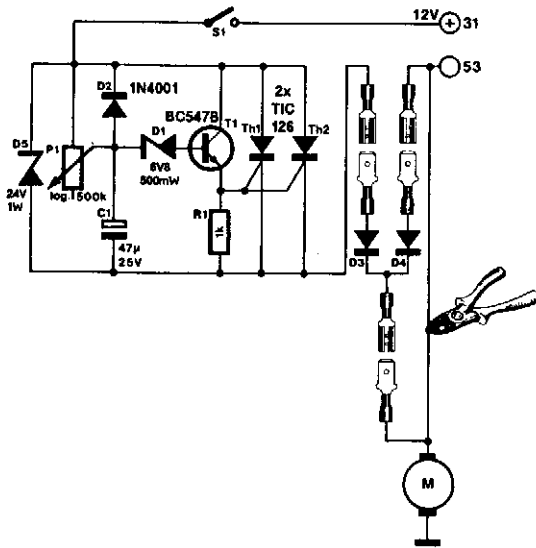


RADIO-ELECTRONICS

Fig. 12-3

This stereo amp will supply 60 W rms into 8 Ω or 100 W rms into 4 Ω. Notice that the LM12C1 line level (about 300 mV) into 5 KΩ. A ±35-V supply is required for full power output. Power can be obtained from a dc-dc converter.

WINDSHIELD WIPER INTERVAL CONTROLLER



ELEKTOR ELECTRONICS

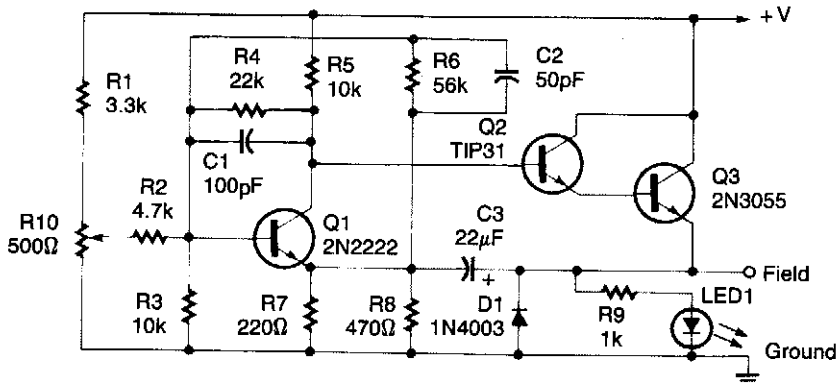
Fig. 12-4

The windshield wiper interval circuit presented here is very compact and is noteworthy for its use of two thyristors, instead of a relay. It has only two connections and operates without any problems—even in conjunction with multistage wiper circuits.

The connecting wire between the wiper motor and terminal 53 is cut and new connections are made (as shown in the diagram). When the interval switch, S1, is closed, capacitor C1 charges via P1 and the wiper motor. After a time set with P1, transistor T1 switches on and triggers the thyristors. The wiper motor is then energized via the thyristors and D3 and sets the wipers into motion. At the same time, C1 discharges via D2 and the thyristors.

After a short time, the wiper stop switch connects terminal 53 to the +12-V line so that the wiper motor is energized via D4. The thyristors are switched off because the voltage drop across D3 plus Th1/Th2 is then greater than that across D4. When the wipers reach the end of their travel again, the stop switch connects terminal 53 to ground and enables C1 to charge again.

VOLTAGE REGULATOR FOR CARS AND MOTORCYCLES



RADIO-ELECTRONICS

Fig. 12-5

This regulator circuit can be used on an alternator that has one field terminal grounded. When +V (input) gets too high, Q1 conducts, and the base of Q2 is driven toward ground, reducing the voltage fed to Q3. This lowers the voltage fed to the field of the alternator.

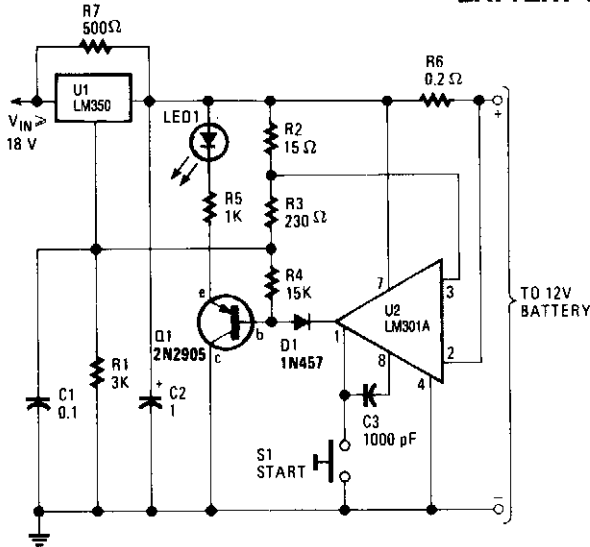
13

Battery Chargers

The sources of the following circuits are contained in the Sources section, which begins on page 662. The figure number in the box of each circuit correlates to the entry in the Sources section.

Portable Nicad Charger
Battery Charger
Current-Limited 6-V Charger
12-V Battery Charger
+ 12-Vdc Mobile Battery Charger
Charger Extends Lead-Acid Battery Life

BATTERY CHARGER

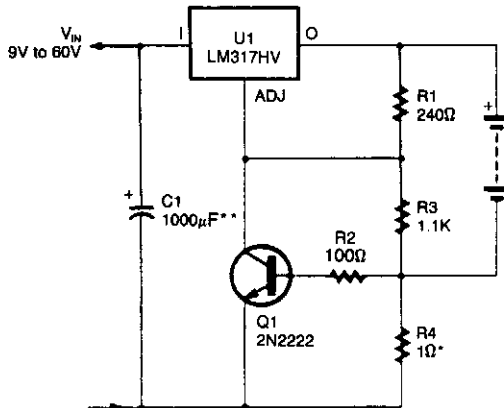


This high-performance charger quickly charges gelled lead-acid batteries, and turns off at full charge. At first, the charge current is held at 2 A, but as battery voltage rises, current decreases. When current falls to 150 mA, the charger automatically switches to a lower float voltage to keep from overcharging. When you hit full charge, transistor Q1 lights the LED to indicate that status.

HANDS-ON ELECTRONICS

Fig. 13-2

CURRENT-LIMITED 6-V CHARGER



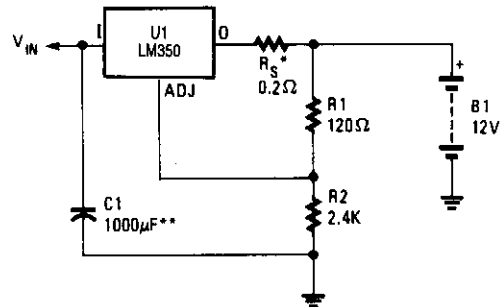
- *Sets Peak Current (0.6A for 1Ω)
- **The 1000μF is Recommended to Filter Out Input Transients.

POPULAR ELECTRONICS

Fig. 13-3

An LM317HV regulator is used as a current-limited charger. If current through R4 exceeds 0.6 A, Q1 is biased on, which pulls the ADJ terminal of the LM317 HV to ground and reduces the battery-charging current.

12-V BATTERY CHARGER



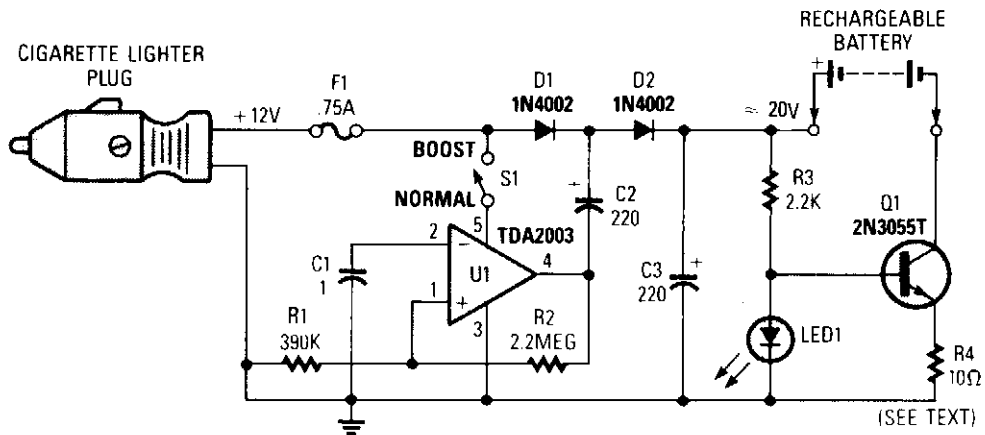
- * R_3 -SETS OUTPUT IMPEDANCE OF CHARGER $Z_{OUT} = R_3 (1 + \frac{R_2}{R_1})$
- USE OF R_3 ALLOWS LOW CHARGING RATES WITH FULLY CHARGED BATTERY.
- **THE 1000μF IS RECOMMENDED TO FILTER OUT INPUT TRANSIENTS.

POPULAR ELECTRONICS

Fig. 13-4

This simple charger uses an LM350 regulator as a battery charger.

+ 12-Vdc MOBILE BATTERY CHARGER



Cell Size	Amp/hr Rate	R4 value (14 hr rate)
N	150 mA	120 ohms @ .25-watt
AA	500 mA	47 ohms @ .5 watt
C	1500 mA	12 ohms @ .5 watt
D	1500 mA	12 ohms @ .5 watt
D (High capacity)	4000 mA	3.3 ohms @ 2 watt

POPULAR ELECTRONICS

Fig. 13-5

This circuit provides up to 20 V output from a 12-V automotive supply, to enable constant current charging of Nicad battery assemblies up to about 18 V total. V1 forms a square-wave oscillator, D1 and D2, coupling this square wave to the 12-V battery supply to obtain over 20 Vdc. If this is not needed, S1 is left open. Q1 forms a current regulator to determine the charging rate of the rechargeable battery. R4 is selected from the table or it can be switched with a rotary selector switch.

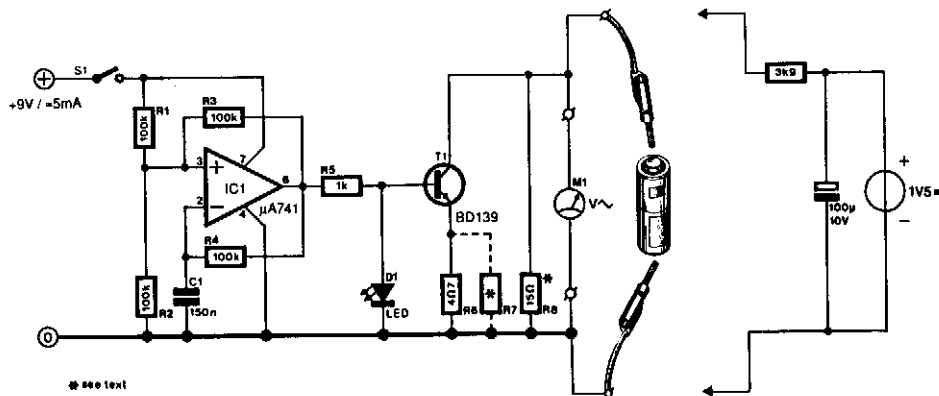
14

Battery Monitors

The sources of the following circuits are contained in the Sources section, which begins on page 662. The figure number in the box of each circuit correlates to the entry in the Sources section.

Internal Resistance Battery Tester
Battery-Saving Disconnect Switch
Low-Battery Detector
Battery-Temperature Sensing Nicad Charger
Battery-Voltage Measuring Regulator
Battery Tester
Nicad Battery Tester
Low-Battery Indicator
Voltage-Level Indicator
Low-Battery Detectors
Voltage Monitor

INTERNAL RESISTANCE BATTERY TESTER



ELEKTOR ELECTRONICS

Fig. 14-1

A designer often needs to know the value of the internal resistance of a battery. Quite a few testers give a relative indication of the value, but this is seldom in ohms. The present tester can, in principle, provide that information.

The basic idea behind it is to load the battery with a varying current, so as to cause an alternating-voltage drop across the internal resistance that can be measured at the battery terminals. Provided that current variations are regular and constant, the voltage drop is directly proportional to the internal resistance.

Choose the variation of the current carefully to read the value of the internal resistance directly on the scale of an ac voltmeter.

The load current is varied with the aid of a current source, T1 in the diagram, which is switched on and off by square-wave generator IC1. The chosen switching frequency of 50 Hz ensures that the ac component at the battery terminals can be measured by a standard ac voltmeter (universal meter).

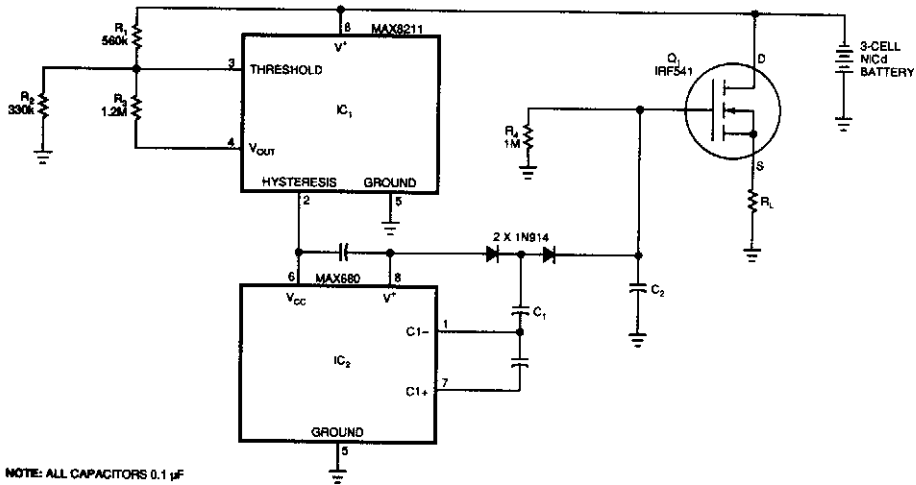
The battery is loaded constantly by R8, which has a value of 1.5 Ω for 1.5-V batteries, shunted by the ac voltmeter. The indicated voltage times 10 is the value of the internal resistance of the battery. When the battery under test is flat or if the supply battery is flat, no current flows and the meter will read zero. It would then appear as if the battery under test is an ideal type—without internal resistance.

A flat supply battery is indicated if D1 does not light. You can ascertain that the battery under test is flat by measuring the direct voltage across its terminals. The load must be left connected, of course, otherwise the emf is measured and this may well be 1.5 V—even if the battery is flat.

The tester is calibrated with the aid of the auxiliary circuit (shown at the extreme right in the circuit diagram). The 1.5-V supply and electrolytic capacitor form a virtually ideal voltage source, of which the 3.9-Ω resistor forms the internal resistance. With this source connected across the output terminals of the tester, a suitable value should be ascertained for R7. That value is found when the ac voltmeter shows 0.39 V. Notice that this procedure is not the same for all measuring instruments: the alternate use of the digital and a moving coil meter, for instance, is not feasible.

The tester is intended for 1.5-V batteries. The load current is fairly high: about 100 mA through R8 and around 170 mA through T1. For 9-V batteries that current is too high: the current should then be reduced by taking greater values for R6 through R8.

BATTERY-SAVING DISCONNECT SWITCH



EDN

Fig. 14-2

At a predetermined level of declining terminal voltage, the circuit disconnects the battery from the load and halts potentially destructive battery discharge. Q1, a high-side, floating-source MOSFET, acts as the switch. The overall circuit draws about 500 μ A when the switch is closed and about 8 μ A when it's open.

The values of R_1 , R_2 , and R_3 set the upper and lower voltage thresholds, V_U and V_L , according to the relationships

$$R_1 = R_2 \left(\frac{V_L}{1.15} \right) - 1$$

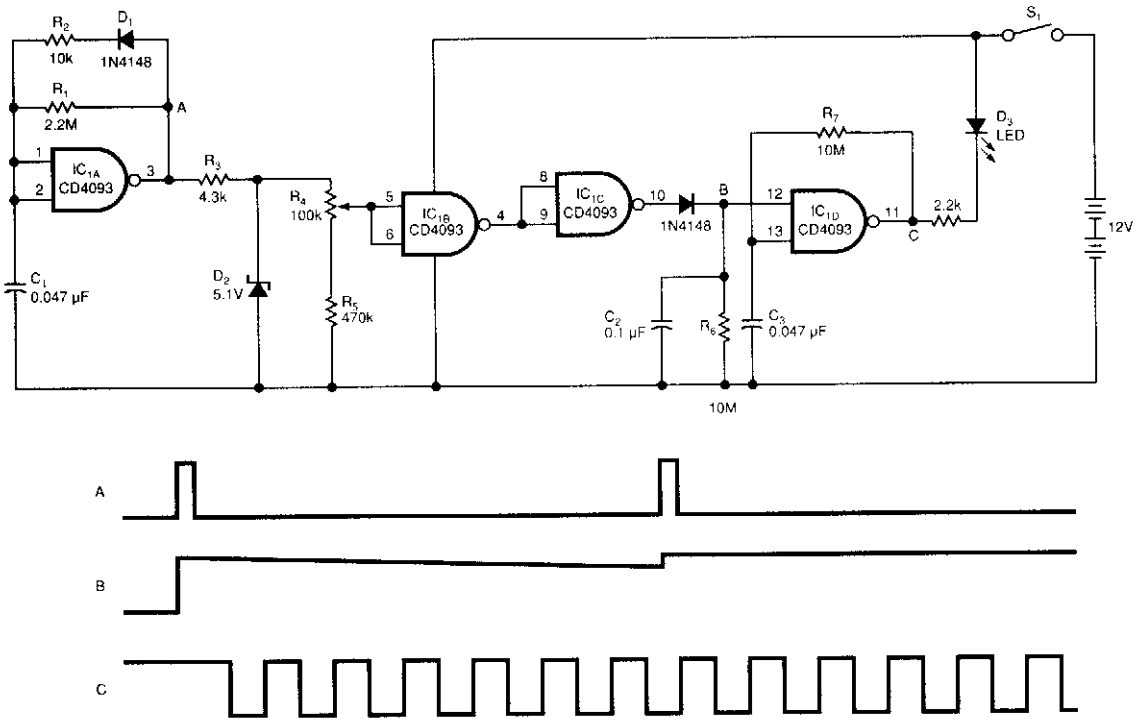
and

$$R_3 = 1.15 \left(\frac{R_1}{V_U - V_L} \right)$$

For the circuit to start, V_+ must exceed V_U . The voltage detector IC1 then powers IC2, but only while V_+ remains above V_L . Otherwise, IC2 loses its power, removes gate drive from Q1, and turns it off. IC2 is a dual charge-pump inverter that normally converts 5 V to ± 10 V. Capacitors C1, C2, and the two associated diodes form a voltage tripler that generates a gate drive for Q1 that is approximately equal to two times the battery voltage.

With the values in the schematic, the circuit disconnects 3-cell Nicad battery from its load when V_+ reaches a V_L of 3.1 V. Approximately 0.5 V of hysteresis prevents the switch from turning on immediately when the circuit removes the load; V_+ must first return to V_U , which is 3.6 V. The gate drive declines as the battery voltage declines, cause the ON-resistance of Q1 to reach a maximum of approximately 0.1 Ω , just before V_+ reaches its 3.1-V threshold. A 300-mA load current at that time will cause a 30-mV drop across the disconnect switch. The drop will be 2 to 3 mV less for higher battery voltages. Resistor R4 ensures that Q1 can adequately turn off by providing a discharge path for C2.

LOW-BATTERY DETECTOR



EDN

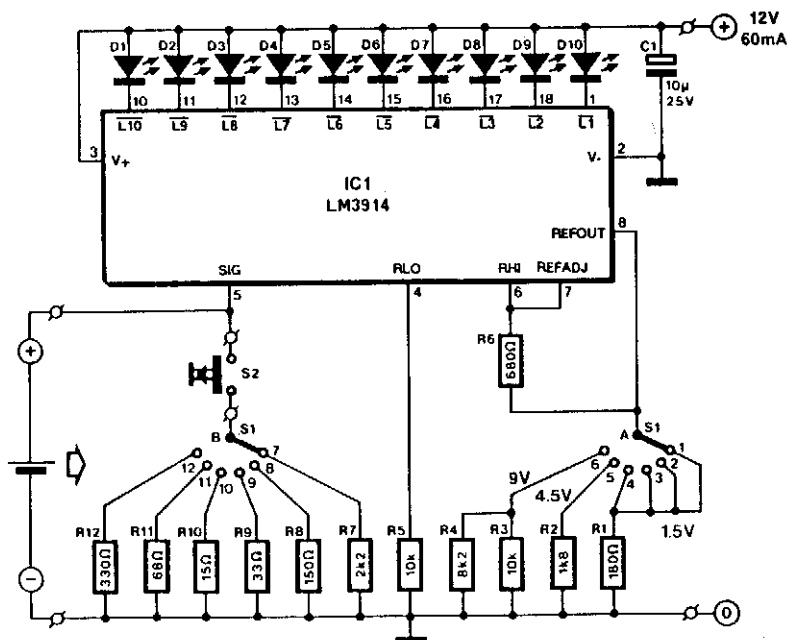
Fig. 14-3

The battery low-voltage detector uses a CD4093 Schmitt trigger and a capacitor that acts as a 1-bit dynamic RAM. The circuit conserves power by using a periodic test method. IC1A, C1, R1, R2, and D1 generate a narrow, positive pulse at point A.

D2, R4, and R5 regulate and divide the signal at A. Thus, the input of IC1B is independent of the power supply. Because the threshold voltage of the Schmitt trigger depends on the power supply, the threshold voltage will drop if the power-supply voltage drops. When the threshold voltage is lower than the input voltage, IC1B will become low, and IC1C's output will become high.

Capacitor C2 stores the results of the periodic test. The time constant C2 and R6 set is 1 s, and the test period is approximately 0.1 s. When point B is high, which implies that the battery is low, IC1D, C3, and R7 generate a square waveform, which lights D3. You can adjust the detected voltage level by adjusting R4. You can test different battery voltages by changing the voltage level of D2.

BATTERY TESTER



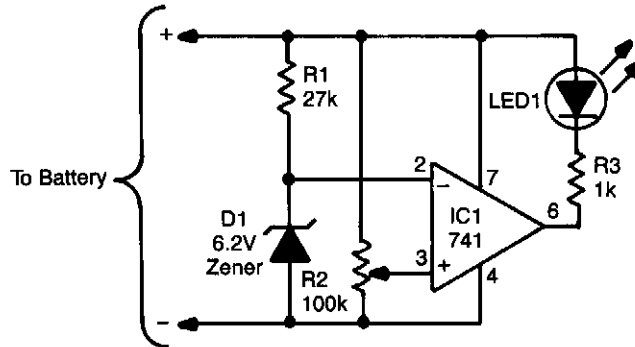
Range	LED									
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
	red	orange		green						
1.5 V	0.86	0.96	1.04	1.13	1.21	1.29	1.38	1.46	1.55	1.63
4.5 V	2.58	2.83	3.05	3.31	3.57	3.82	4.07	4.33	4.57	4.82
9.0 V	5.3	5.8	6.3	6.9	7.4	7.9	8.5	9.0	9.5	10.2

ELEKTOR ELECTRONICS

Fig. 14-6

This battery tester makes use of an LM3914 bar-graph driver IC. S1 selects load on battery under test and programs the voltage range. S2 loads the battery under test. The table gives the calibration factors for the tester. LEDs D1 through D10 are used as indicators.

LOW-BATTERY INDICATOR



42 NEW IDEAS

Fig. 14-8

The sensing circuit consists of a 741 op amp set up as a voltage comparator, using a zener diode as a voltage reference. The op amp is inserted as a bridge between two resistance ladders, one which contains the zener reference, and the other a high-value linear potentiometer. When the voltage at the wiper of the potentiometer drops below the voltage set by the zener, the output of the op amp becomes low; that turns on the LED connected between it and V_{CC} . The circuit can be adapted to work with battery-powered circuits that require between 6 and 18 V; the only changes needed would be a lower-voltage zener and a smaller current-limiting resistor in the case of voltage below 9 V, and a larger resistor for higher voltages.

VOLTAGE-LEVEL INDICATOR

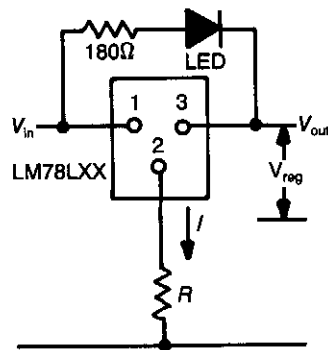


Fig. 14-9(a)

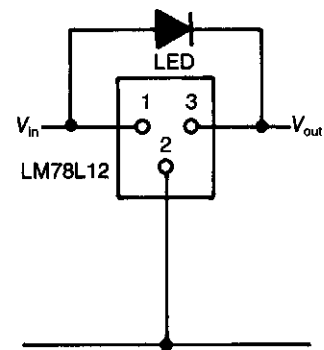


Fig. 14-9(b)

ELECTRONIC ENGINEERING

Three-terminal regulator device (LM78LXX) has $V_{out} = V_{in}$ until the input rises 1.5 to 2 V above the output when the regulated voltage $V_{reg} = XX$ is obtained. A differential of 1.5 V between input and output is necessary to light the LED. Thus, the LED lights when V_{in} rises above $V_{reg} + IR + 1.5$ V, where I is typically 6 mA (a zener diode could be used in place of R). For input voltages much higher than necessary to light the LED, a current-limiting resistor in series might be necessary. A useful automotive application is shown in Fig. 14-9(b). The circuit indicates when battery voltage is above 13.5 V which indicates (in conjunction with an ammeter) whether the alternator/regulator/battery system is operating correctly. With the engine off, the battery voltage drops to 12 V and the LED extinguishes. The circuit requires no calibration.

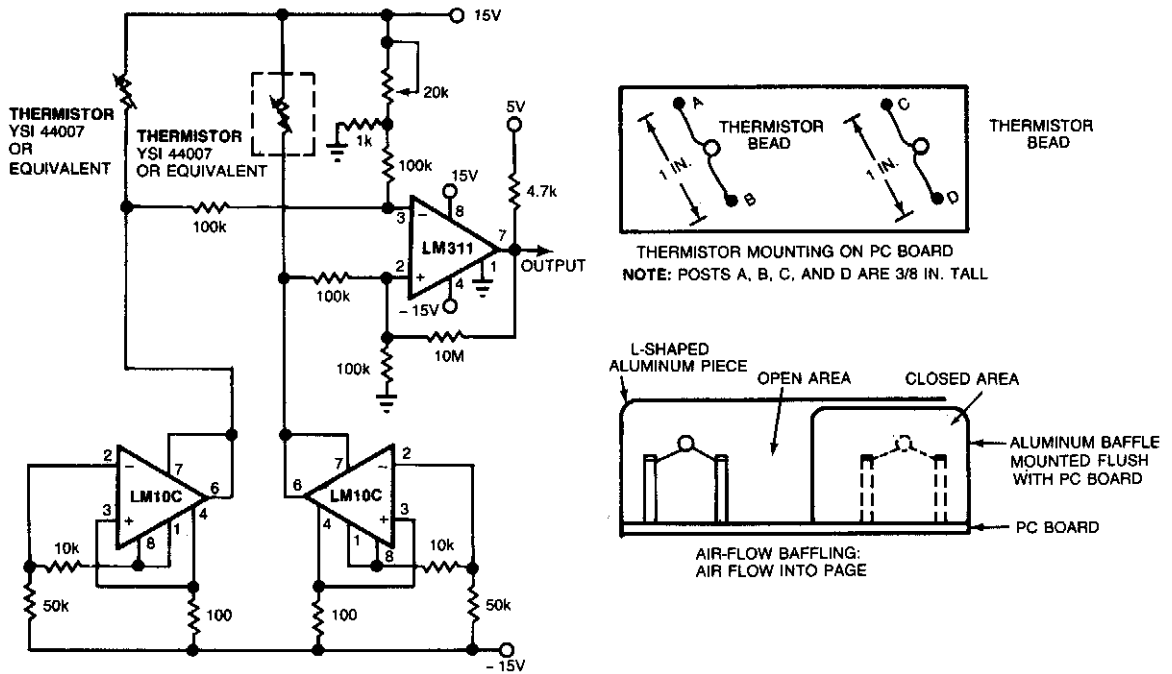
15

Bridge Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Air-Flow Sensing Thermistor Bridge
Bridge Circuit With One Power Supply
Inductance Bridge

AIR-FLOW SENSING THERMISTOR BRIDGE



EDN

Fig. 15-1

Using the thermistor-bridge circuit, you can detect system-cooling air losses caused by filter or inlet blockage or fan failure. One thermistor is mounted directly in the air flow; the other is baffled. The exposed thermistor senses the temperature in the cooling system; the baffled thermistor senses the ambient temperature in still air. As long as the thermistors are at different temperatures, the bridge stays unbalanced and the circuit produces a logical high, indicating that the cooling system is working. If the air flow stops, the exposed thermistor will reach ambient temperature, the bridge will become balanced, and the circuit will indicate ventilation-system failure by producing a logical low.

The bridge circuit's matched thermistors are biased by matched-current sources. Two LM10C operational amplifiers act as constant-current sources, and an LM311 comparator senses the difference between the voltage drops across the thermistors, producing the logical high when the bridge is unbalanced and the logical low when the bridge is balanced. Use a 20-k Ω potentiometer to set the comparator's threshold; this setting determines the minimum air flow that will cause the circuit to produce a logical high.

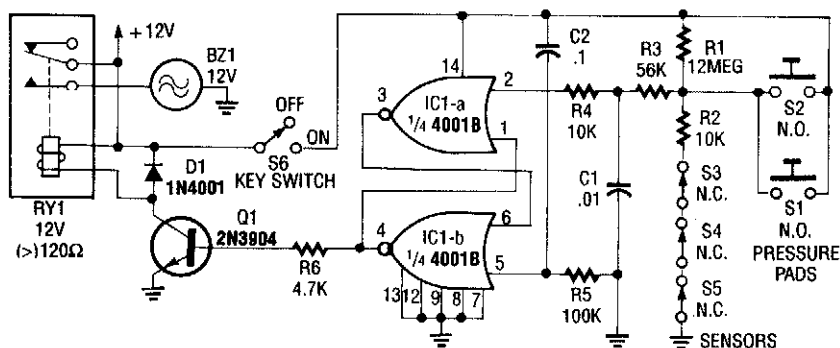
16

Burglar Alarms

The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Self-Latching Burglar Alarm
Burglar Alarm With Timed Shutoff
Simple Burglar Alarm
Simple Burglar Alarm
Home Security System
Simple Burglar Alarm With NC Switches
Burglar Alarm with NC And NO Switches

SELF-LATCHING BURGLAR ALARM



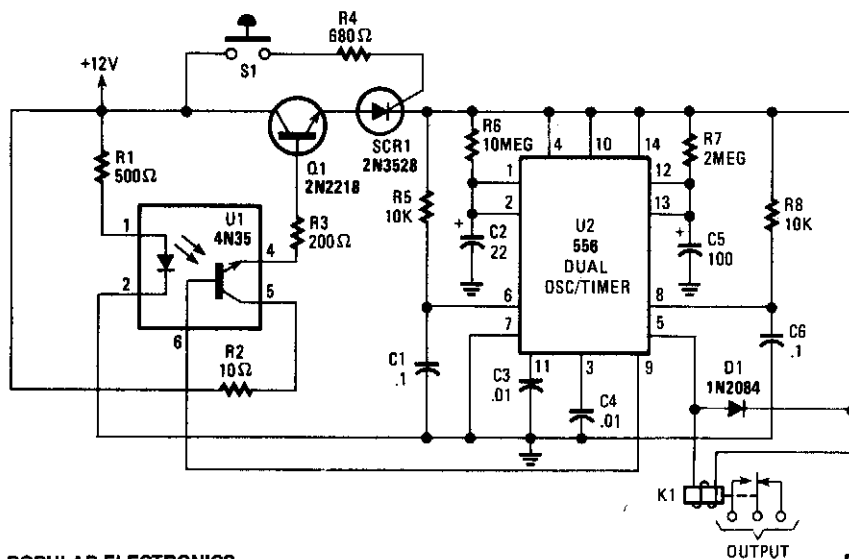
A SIMPLE SELF-LATCHING BURGLAR ALARM.

RADIO-ELECTRONICS

Fig. 16-1

This alarm uses IC1A and IC1B as a latch. When sensors S1 through S5 activate, IC1A turns on and forces IC1B to cut off. Q1 drives RY1.

BURGLAR ALARM WITH TIMED SHUTOFF



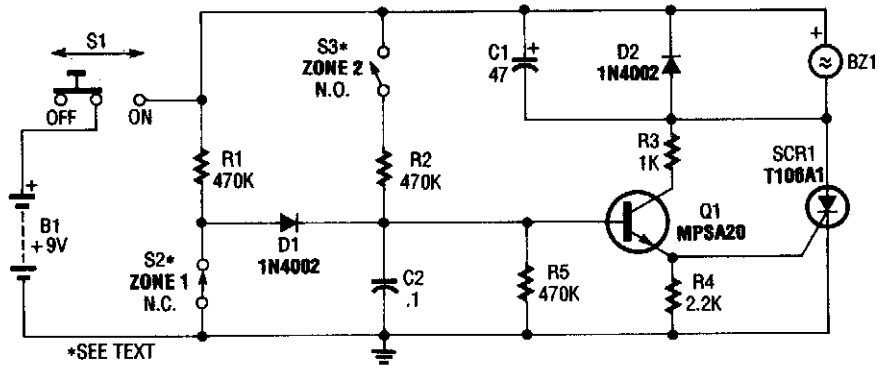
POPULAR ELECTRONICS

Fig. 16-2

When S1 (sensor) is closed, power is applied to U2, a dual timer. After a time determined by C2, C1 is energized after a predetermined time determined by the value of C5, pin 9 of U2 becomes low, switching off the transistor in the optoisolator, cutting anode current of SCR1 and de-energizing K1. The system is now reset. Notice that $(R_6 \times C_2)$ is less than $(R_7 \times C_5)$. The ON time is approximately given by:

$$(R_7 \times C_5) - (R_6 \times C_2) = t_{ON}$$

SIMPLE BURGLAR ALARM

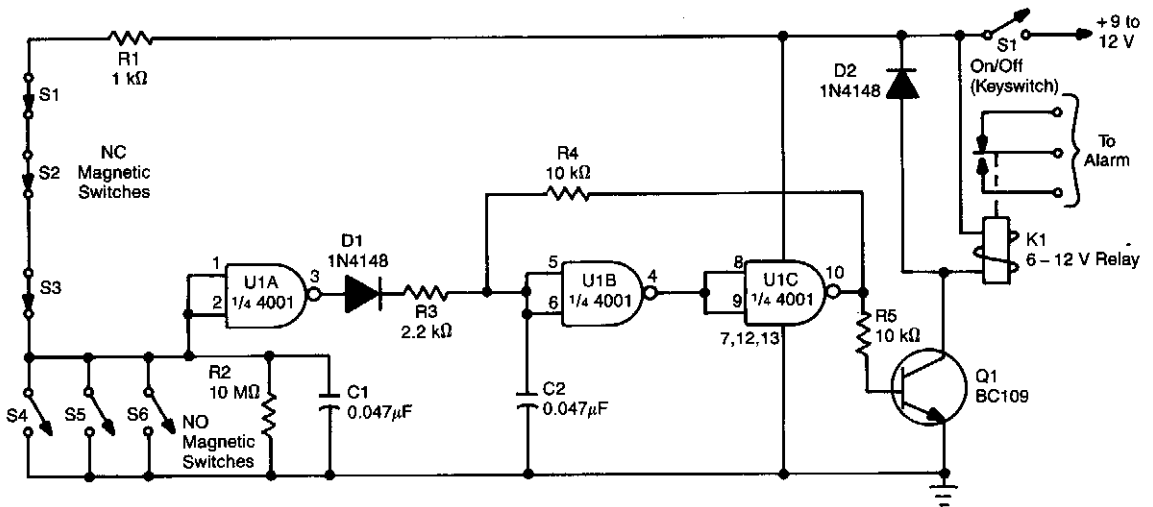


POPULAR ELECTRONICS

Fig. 16-3

A simple circuit using either NO or NC sensors uses an RC delay circuit (R2/C2 or R1/C2) to drive emitter-follower Q1, switching SCR1 and buzzer (or bell) BZ1. S1 is used for activation and reset.

SIMPLE BURGLAR ALARM

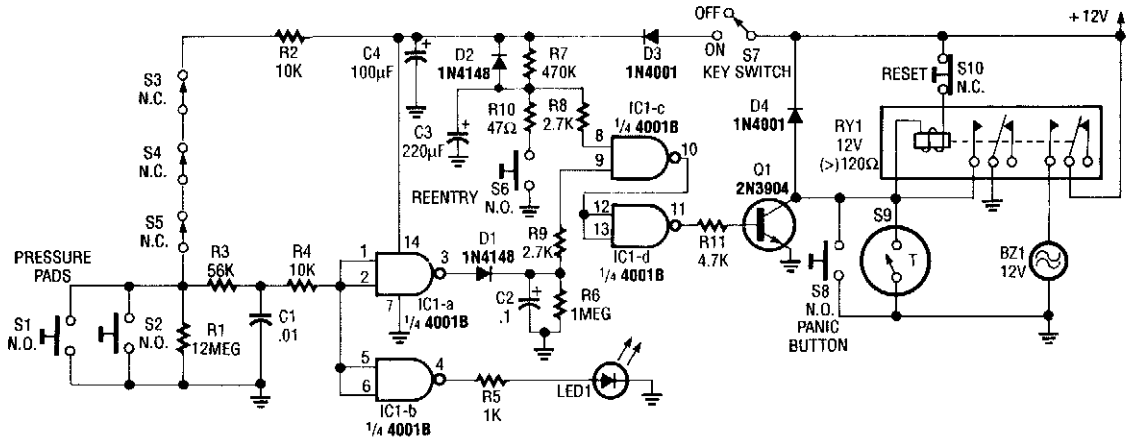


POPULAR ELECTRONICS

Fig. 16-4

Using one IC and a driver transistor, this simple alarm uses either NO or NC sensors. When a sensor operates, the input to U1A goes low, causing U1A to go high, U1B low, and U1C high. This biases Q1 ON and activates relay K1. On/off is via keyswitch S1.

HOME SECURITY SYSTEM

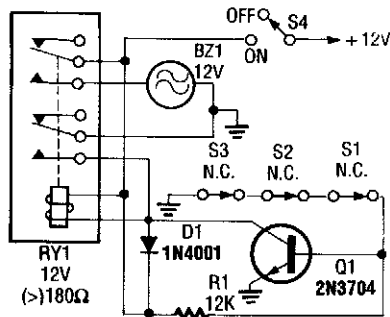


RADIO-ELECTRONICS

Fig. 16-5

This alarm circuit activates when S1 through S5 are activated. This lights LED1 and activates Q1 via IC1C and IC1D. RY1 is wired to self latch. S10 is used to reset. When key switch S1 is activated or when re-entry buttons at S6 are depressed, IC1C is deactivated until RC network R7/C3 charges.

SIMPLE BURGLAR ALARM WITH NC SWITCHES

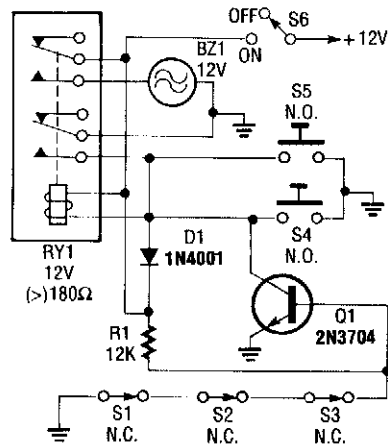


RADIO-ELECTRONICS

Fig. 16-6

This relay draws 1 mA of idling current. Q1 detects open switch and energizes RY1.

BURGLAR ALARM WITH NC AND NO SWITCHES



RADIO-ELECTRONICS

Fig. 16-7

This circuit uses both NC and NO sensors. Series NC sensors allow Q1 to activate RY1. NO sensors directly activate RY1.

17

Buffers

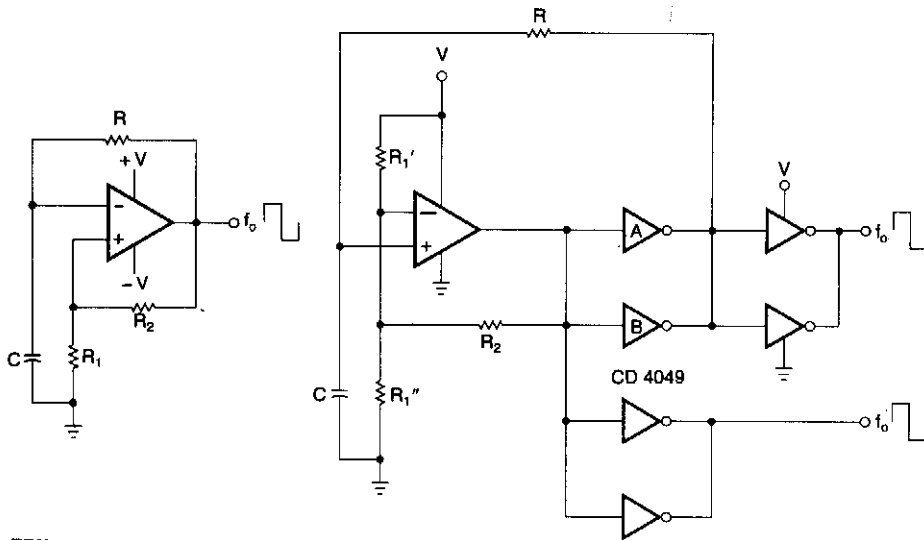
The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Oscillator Buffers

Precision-Increasing Buffer

Inverting Bistable Buffer

OSCILLATOR BUFFERS

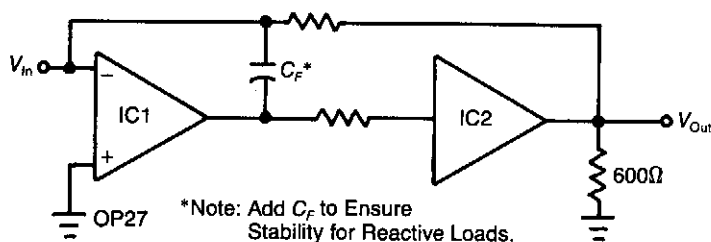


EDN

Fig. 17-1

CMOS buffers added to an op amp oscillator improve performance, largely as a result of nonsymmetry and variability of the op amp's output saturation voltages.

PRECISION-INCREASING BUFFER



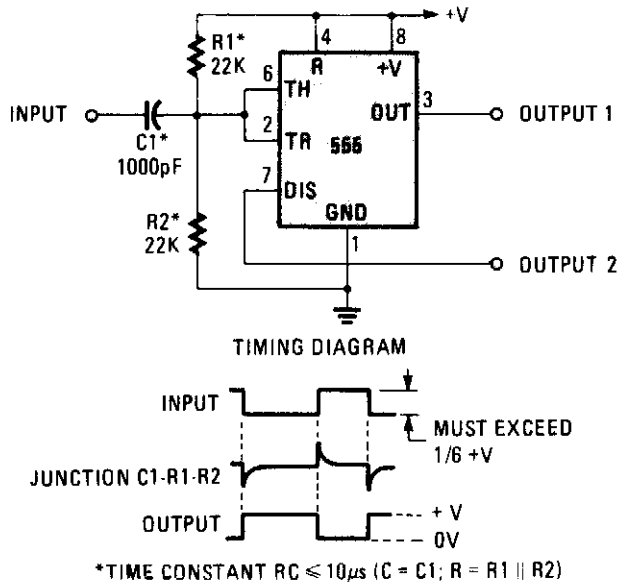
EDN

Fig. 17-2

Adding an unity-gain buffer to your analog circuit can increase its precision. For example, by itself, the op amp IC1 exhibits a maximum dV_{OS}/dT of $1.8 \mu V/^\circ C$ and can drive a $600\text{-}\Omega$ load. Under these conditions, IC1 would dissipate 94 mW incrementally. Thus, the op amp's O_{JA} of $150^\circ C/W$ would change its V_{OS} by $25 \mu V$.

The buffer, IC2, will isolate IC1 from the load and eliminate the change in power dissipation in IC1, thereby achieving IC1's minimum, rated offset-voltage drive. The loop gain of IC1 essentially eliminates the offset of the buffer. Almost any unity-gain buffer will work, provided that it exhibits a 3-dB bandwidth that is at least 5 times the gain-bandwidth product of the op amp.

INVERTING BISTABLE BUFFER



HANDS-ON ELECTRONICS

Fig. 17-3

This circuit uses a 555 timer as a flip-flop bistable buffer.

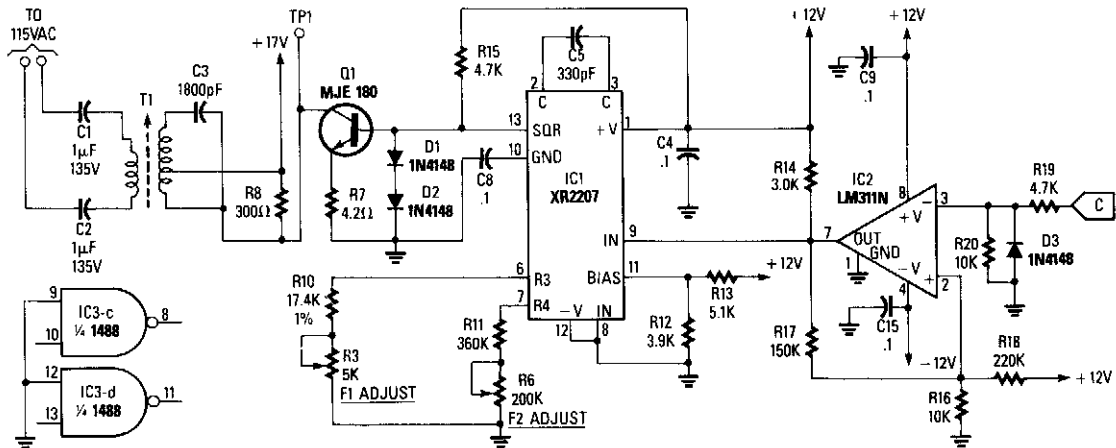
18

Carrier-Current Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Carrier-Current Transmitter for Data Transmission
Carrier-Current Receiver for Data Transmission

CARRIER CURRENT TRANSMITTER FOR DATA TRANSMISSION



RADIO-ELECTRONICS

Fig. 18-1

$$f_1 = \frac{1}{R_3 C_1}$$

$$f_2 = f_1 + \Delta f_1$$

where:

$$\Delta f_1 = \frac{1}{R_4 C_1}$$

In this circuit, data at input C is amplified by IC2 and then fed to modulator IC1. IC1 generates two frequencies, depending on the values of C_5 , R_{10} , R_3 , R_{11} , and R_6 . The frequency f_1 is generated if pin 9 IC1 is low and f_2 if pin 9 IC1 is high. A square wave appears at pin 13 of IC1 and is fed to Q1, an amplifier stage, that is coupled via tuned transformer T, to the ac line via C1 and C2. Notice that, for safety reasons, C1 and C2 must be specifically rated for the ac line voltage.

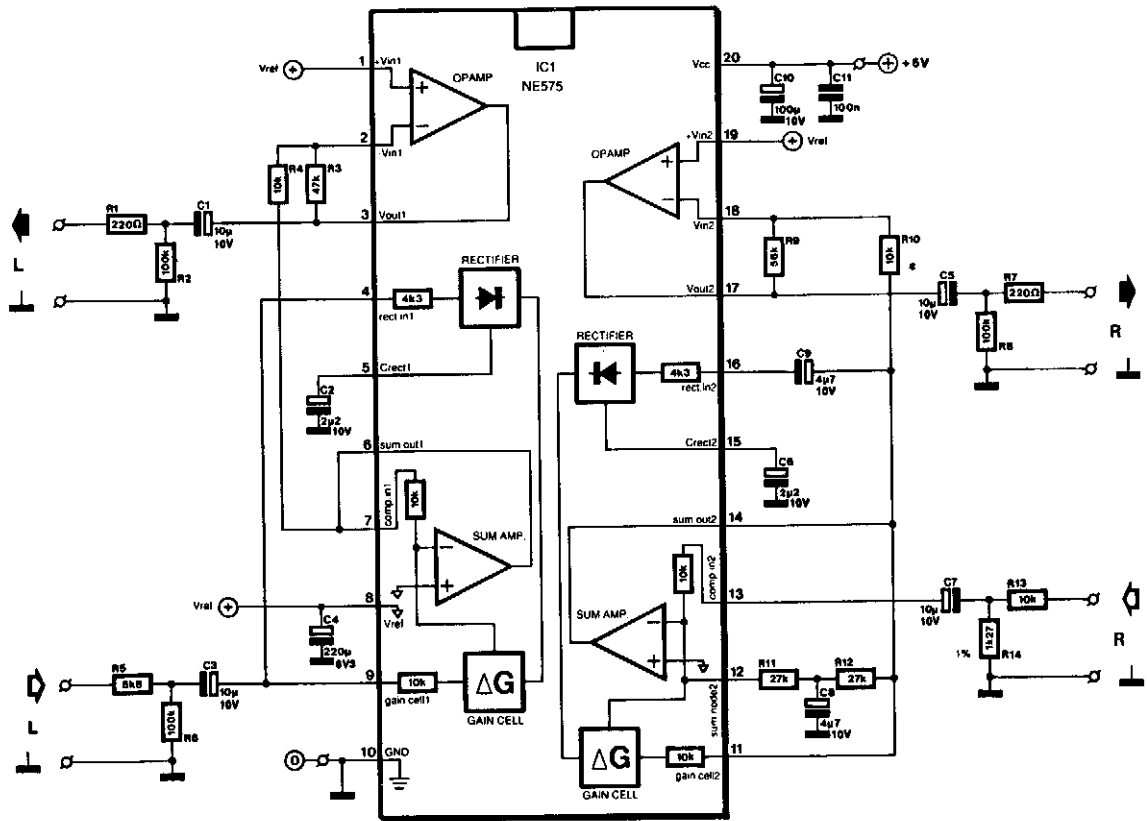
19

Compressor/Expander Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio Compressor/Audio-Band Splitter
Universal Comander

UNIVERSAL COMPANDER



ELEKTOR ELECTRONICS

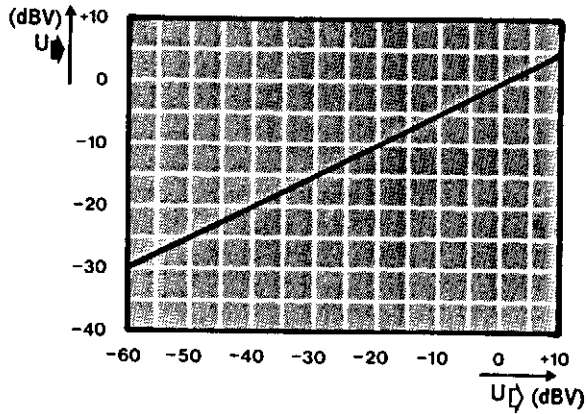
Fig. 19-2(a)

Signetics' type NE575 compander IC is intended primarily for use with battery power supplies of 3 to 7 V (max. 8 V). It draws a current of 3.5 mA at 3 V and 5 mA at 7 V. The compander process (compression at the input, expansion at the output) significantly improves the signal-to-noise ratio in a communications link.

The IC contains two almost identical circuits, of which one (pins 1 to 9) is arranged as an expander. The other (pins 11 to 19) can be used as expander, compressor or automatic load control (ALC), depending on the externally connected circuit. For the compressor function, the inverting output of the internal summing amplifier is brought out to pin 12. This is not the case in the expander section, where a reference voltage is available at pin 8. This pin is interlinked to pins 1 and 19 to enable the setting of the dc operating point of the op amps.

The op amp in the expander section, pins 1 through 3, serves as output buffer in the compressor section, pins 17 through 19 as the input buffer. The IC has a relatively high output sensitivity and is evidently intended for processing small signals (microphone output level). A signal of 100 mV, for instance, is amplified by 1 only. The present circuit caters to larger input signals (line level); its maximum input level is 1.5 Vrms.

UNIVERSAL COMPANDER (Cont.)



ELEKTOR ELECTRONICS

Fig. 19-2(b)

With a 1-V input into R13, a potential of about 500 mV exists between compressor output R7 and expander input R5. The compression characteristic is shown in Fig. 19-2(b). The signal range is reduced by about one half at the output, which is doubled in the expander. Thus, the range after compression and expansion is the same again, but that is not necessarily the case with the input and output level. The compander can be arranged to provide a constant attenuation or amplification. With the circuit values as shown in the diagram, the input and output levels are the same. The prototype had an overall gain of 0.5 dB when the expander input was connected directly to the compressor output.

To allow acceptance of high input levels, R13, R14, and the compressor input resistance form a 10:1 attenuator. At the expander input, R5 and the expander input impedance of about 3 k Ω form a potential divider. If the compander is to be used with smaller signals, the attenuation can be reduced as appropriate. If the input level lies below 100 mV, R5, R13 and R14 can be omitted.

The compander covers the frequency range of 20 Hz to 20 kHz, the overall distortion is less than 1%, and the signal-to-noise ratio is about 80 dB.

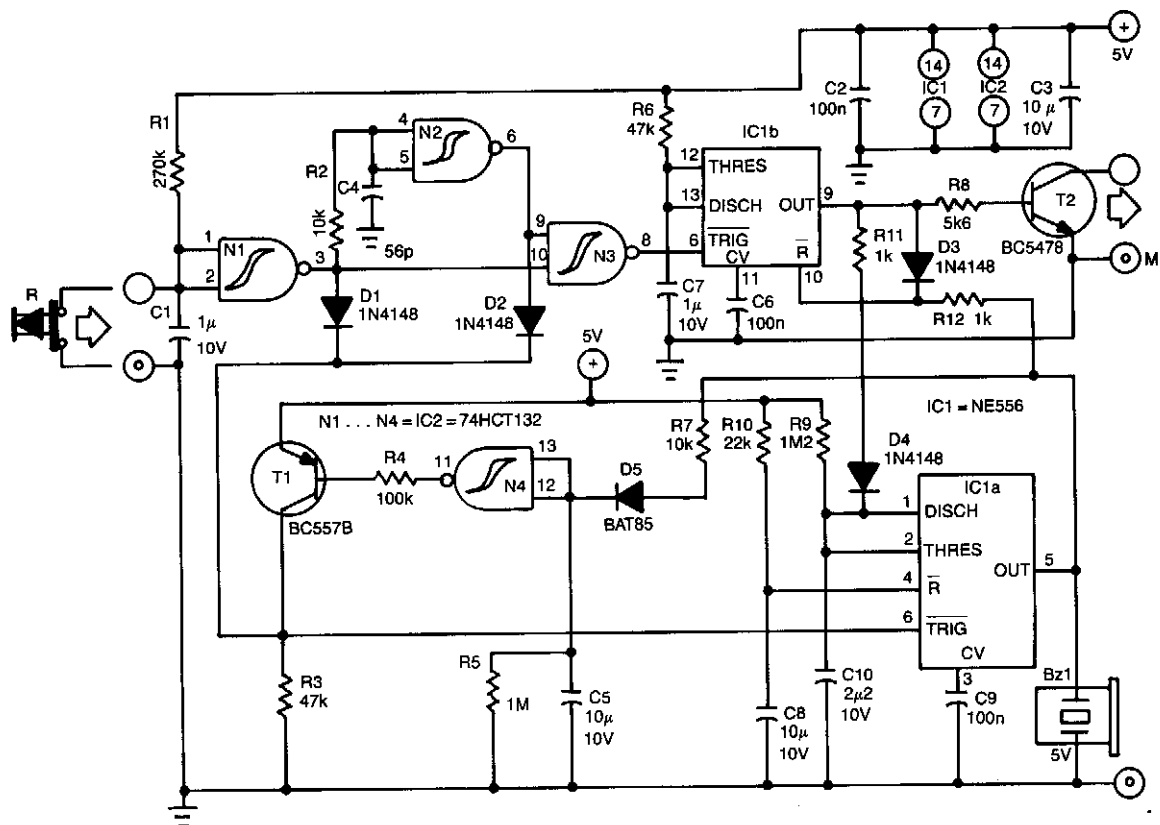
20

Computer-Related Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 663. The figure number in the box of each circuit correlates to the entry in the Sources section.

Dual 8051s Execute In Lock-Step	Switch Debouncer with Auto Repeat
Reset Protection for Computers	Printer Error Alarm
3- μ P I/O Line Protectors	Child-Proof Reset Switch
Data Line Remote Short Sensor	XOR Gate
Z-80 Bus Monitor/Debugger	Flip-Flop Debouncer Switch
RS-232 Line-Driven CMOS Circuits	Digital Levels Scope Displays 2 Logic Signals on 1 Scope
Bit Grabber	Deglitcher
Switch Debouncer	Stalled-Output Detector

RESET PROTECTION FOR COMPUTERS



ELEKTOR ELECTRONICS

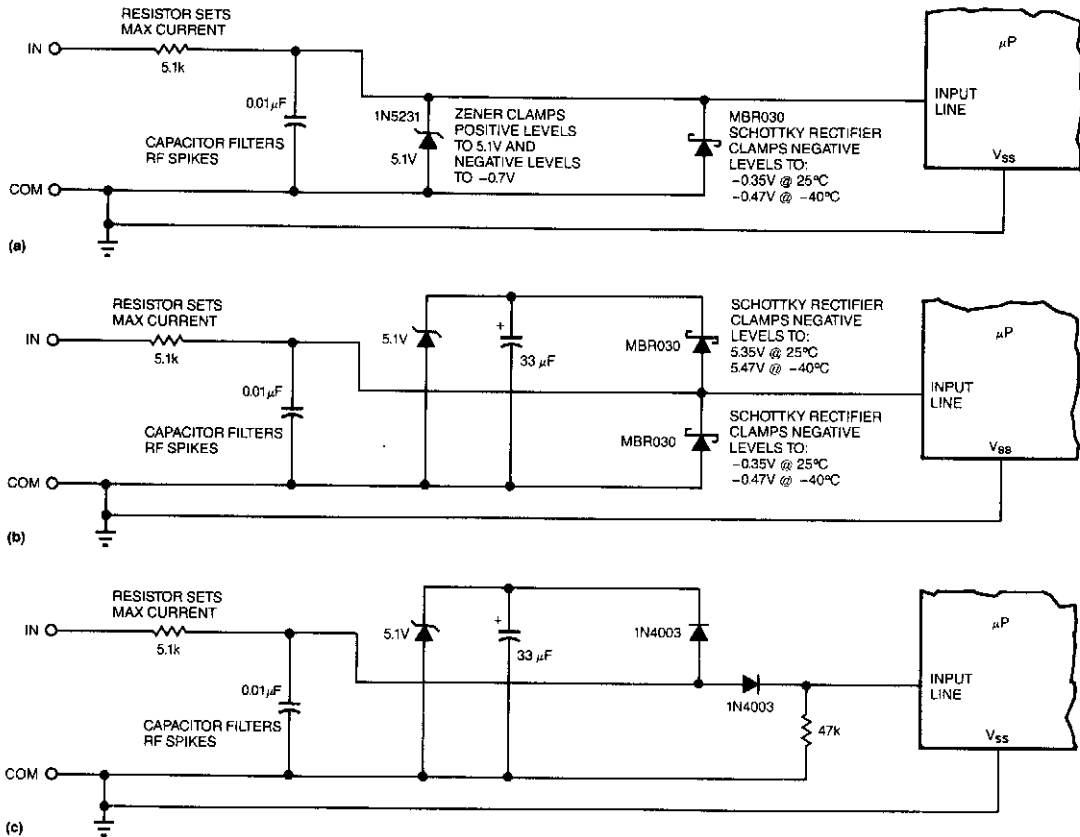
Fig. 20-2

This protection circuit is inserted between the reset switch and the motherboard. The earth connection of the computer must be linked to terminal M of the protection circuit. The protection circuit can draw its power from the computer supply.

When the circuit has been fitted, operation of the reset switch will not immediately restart the computer. Instead, a buzzer will sound to alert you to the reset operation. The buzzer is actuated for 4 s by monostable IC1A, which is triggered by the reset switch. During these 4 s, the output, pin 5, of IC1A ensures that the reset function, pin 10, of IC1B is disabled. When the reset switch is operated again, monostable IC1B will be triggered and this starts the reset procedure. Transistor T2 is then switched on for 0.5 s and the buzzer is deactivated via R11 and D4.

The circuit around T1 and N4 ensures that IC1A can accept trigger pulses again 10 s after the mono time of IC1B has lapsed. This arrangement prevents, for example, children operating the reset switch.

3 μP I/O LINE PROTECTORS



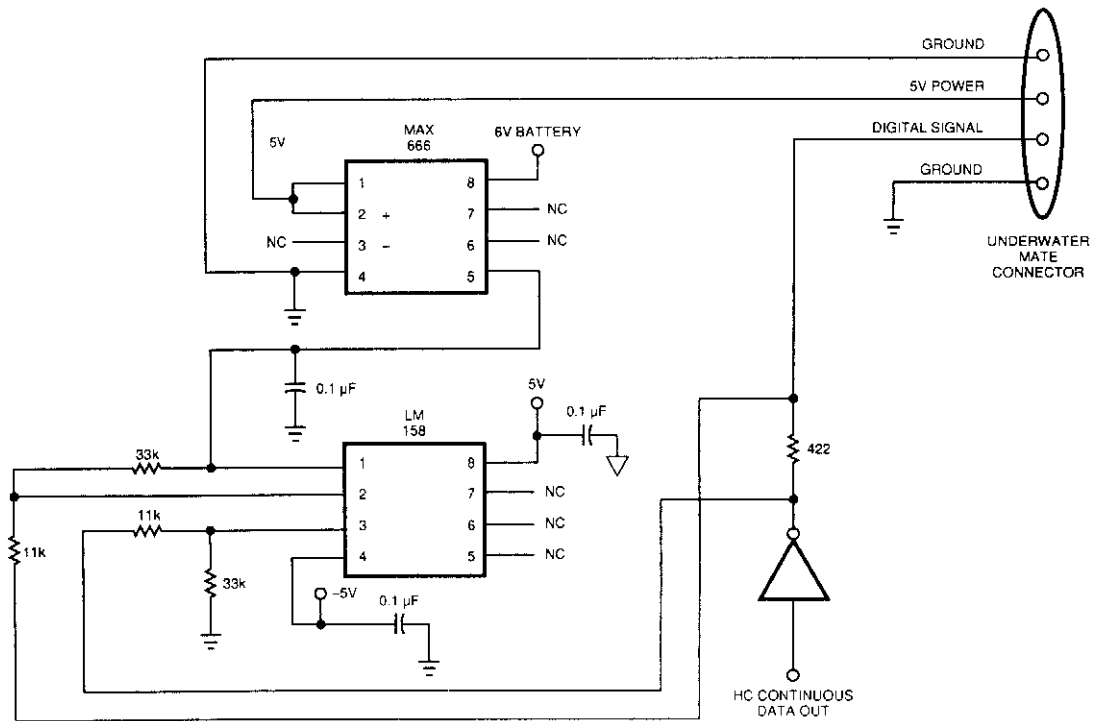
EDN

Fig. 20-3

In Fig. 20-3(a), a 5.1-V zener diode clamps positive-going transients, and a Schottky rectifier clamps negative-going transients. The Schottky rectifier has problems at both ends of the temperature scale. At 125°C (257°F), its leakage current can reach 50 μA when the input line is at 5 V. This leakage is not a big deal unless the input resistor has a value of 100 k Ω or more. More troubling, at temperatures below -40°C (-40°F), the Schottky rectifier's forward voltage rises to about 0.47 V, which is perilously close to the -0.50-V max spec that most HCMOS-type μP 's inputs can tolerate.

The third circuit, Fig. 20-3(c), uses two regular silicon rectifiers. One rectifier is connected in series with the input line, thereby isolating the μP 's inputs from negative-going voltage spikes. The other rectifier is in series with a 5.1-V zener, which clamps positive-going transients.

DATA LINE REMOTE SHORT SENSOR



EDN

Fig. 20-4

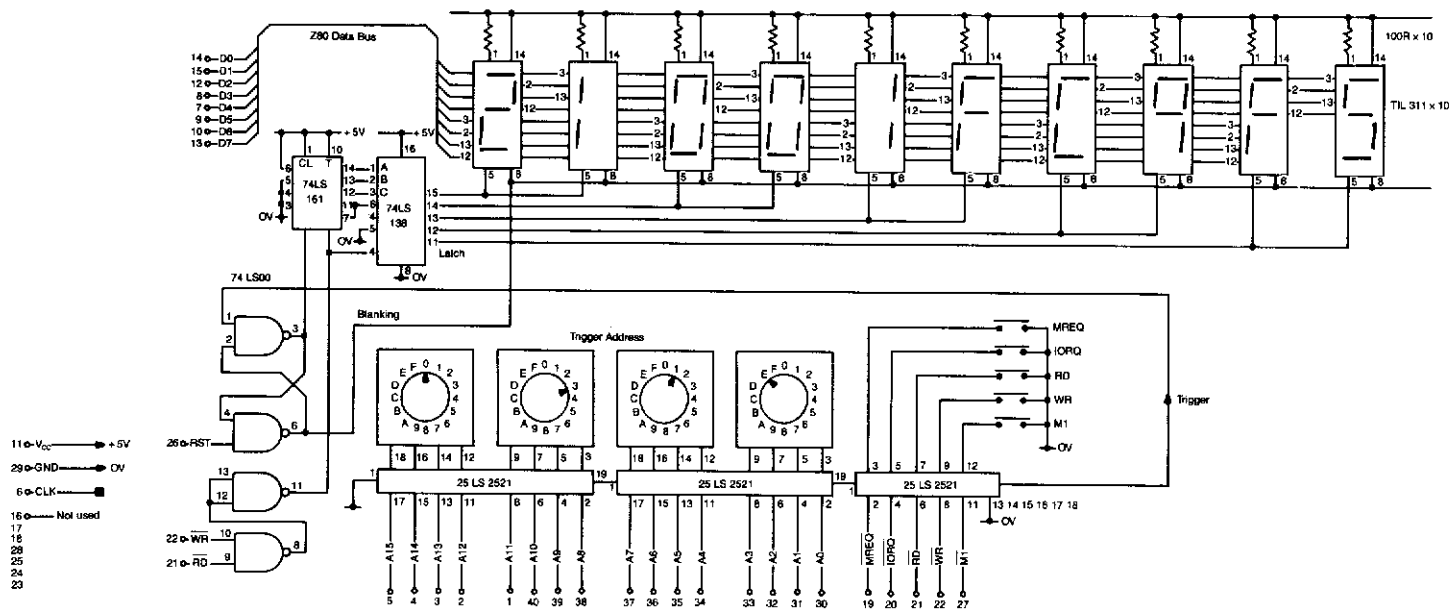
Sensing short circuits in equipment that performs under water is especially critical, but Fig. 20-4's wet-mate connector design also suits other remote short-circuit sensing applications. Because of the limits imposed by the battery and voltage levels, the circuit uses the data line to sense short circuits.

The differential voltage that develops across the 422-Ω resistor in the data line drives a low-bandwidth op amp, which amplifies and filters the differential signal. The resistor values produce a gain of 3. The op amp's output controls the voltage regulator's shutdown pin.

To operate correctly, the circuit must have a continuous stream of digital data. Under normal conditions, and using high-speed CMOS logic, the data source sinks less than 10 μA. This normal operation generates about -3 mV across the sense resistor. The op amp's output will be slightly negative, producing a solid ON signal to the voltage-regulator chip. When a short occurs, the resistor and op amp together produce an average of 2.4 Vdc. This voltage provides a solid OFF to the voltage-regulator chip.

The peak signal-line current is about 12 mA (5-V data divided by 422 Ω), which HCMOS logic can handle. The addition of the resistor and op amp only changes the rise time to about 40 ns and doesn't cause any problems with the 2.5-MHz data rate. When the short is no longer present, the voltage regulator chip turns on again. You can use the same circuit with any TTL on/off-type voltage-regulator IC.

Z-80 BUS MONITOR/DEBUGGER



ELECTRONIC ENGINEERING

Fig. 20-5

Getting microprocessor designs to work is notoriously difficult when both the software and hardware are new. The usual approach is to run test routines that address memory and I/O, but do not rely on their correct functioning. However, miswiring in any part of the circuit usually leads to a misleading jumble of signals that might require a logic analyzer to interpret.

This simple circuit will trace the program execution and help point to the problems. Although the circuit shows connections for a Z-80, the circuit can very easily be adapted for any 8-bit microprocessor or with additional circuitry for CPUs of any bus width.

The circuit consists of a 5-byte hexadecimal display and comparator, which are wired to a 40-pin IC test clip. The test clip sits over the microprocessor (in this case a Z-80), where it gets power and all the required signals. The address bus and control lines are fed to the comparator, where (by means of switches) a trigger condition can be set. Following the trigger, the next 5 occurrences of either RD or WR will latch the contents of the data bus into the 5 hex displays, each in turn.

For example, select address 0000 M1 Rd and reset the CPU. The displays will show the very first instruction fetch, followed by its data and any consequent action. Even details, such as stack writes and subroutine addresses, are included. To trace longer portions of a program the address switches can be incremented to follow the execution path.

RS-232C LINE-DRIVEN CMOS CIRCUITS

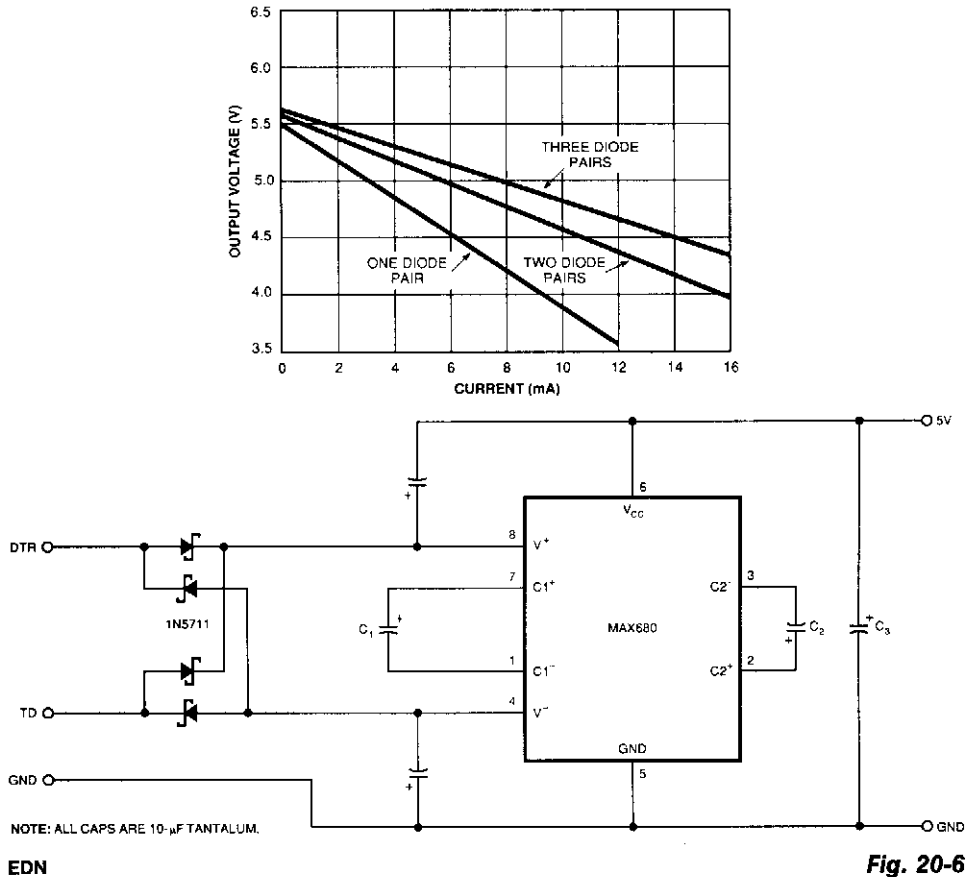
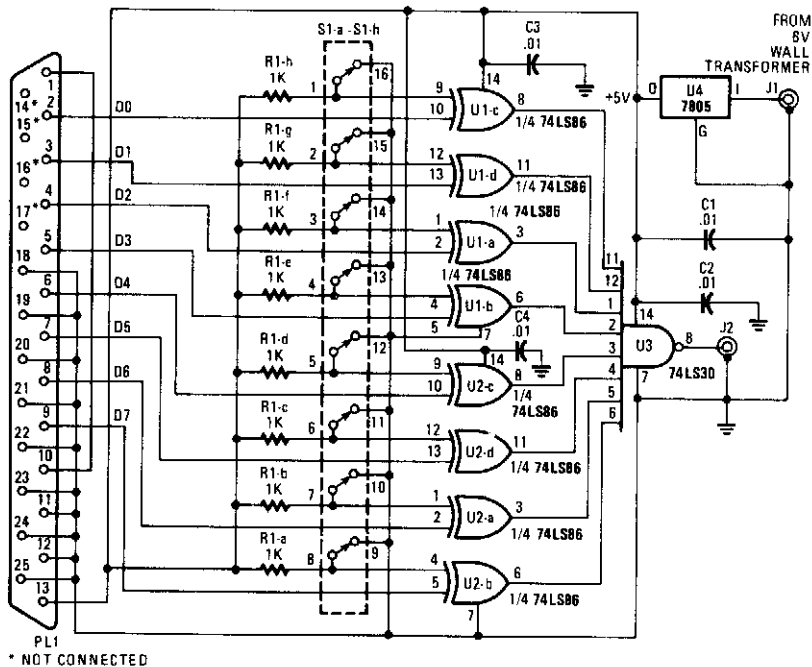


Fig. 20-6

The circuit illustrates a way to power CMOS ICs from RS-232C lines. The MAX680 is normally used to generate a voltage equal to $\pm 2 \times V_{CC}$. This circuit does exactly the opposite. It takes in ± 10.5 to ± 12 V on the DTR and TD lines and puts out a 5.25- to 6-V signal. A pair of Schottky or silicon diodes rectifies each RS-232C line. The resultant energy is stored by the capacitors attached to the IC's V+ and V- pins. C1 or both C1 and C2 then reverse-charge pump the energy stored at the V+ and V- pins to C3. The input source current of the MAX680 is approximately equal to the voltage drop of any one of the diodes that is divided by the series resistance of 160 Ω . When you drive this circuit from a 1488 driver with a ± 12 -V supply, it can deliver 5 V at 3 mA.

To increase the output current, you can use as many as three sets of diodes on each RS-242 line to provide 5 V at 8 mA. The more diodes you use, the lower the source resistance: R_S equals the inversion of the sum of the diodes' conductances. If your circuit requires even more output current, you can place two MAX680s in parallel, tie their V+ and V- capacitors together, and use separate C1 and C2 capacitors for each ship. If you do connect the devices in parallel, make sure not to exceed the power capability of the RS-232C lines.

BIT GRABBER

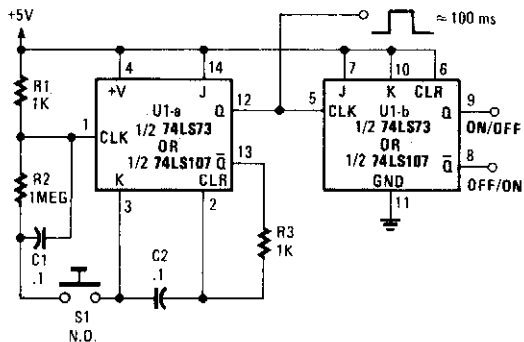


POPULAR ELECTRONICS

Fig. 20-7

When the user set character (D_0 through D_7) from a computer matches the character programmed on S1A through S1H, the output from J2 becomes low. This device can be used as a test aid to check printer cable or as a control circuit for interfacing with a computer.

SWITCH DEBOUNCER

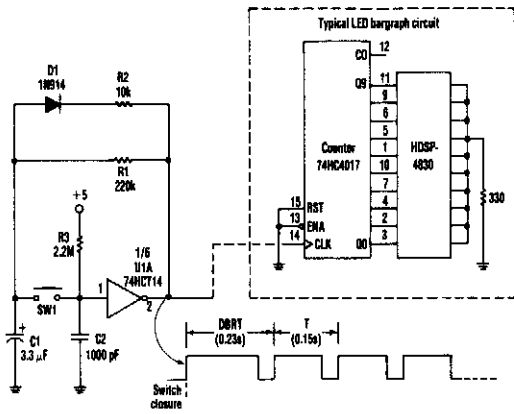


Using a 7473 JK flip-flop U1A connected as a monostable to drive U1B, as a switch debouncer. The circuit is self-clearing during power up. A 100-ms pulse is available at pin 12 U1A.

POPULAR ELECTRONICS

Fig. 20-8

SWITCH DEBOUNCER WITH AUTO REPEAT



ELECTRONIC DESIGN

Fig. 20-9

This circuit produces an output pulse when SW1 (pushbutton) is depressed. It also becomes a hysteresis gate oscillator. D1 and R2 add asymmetry. The DBRT (*delay before repeat time*) is caused by the oscillator start-up conditions: C1 has to change from zero to the upper gate threshold rather than to the lower threshold.

The auto repeat time:

$$t = \frac{(R_1 + R_2)(C_1 + C_2)(\text{Gate Hysteresis})}{V_{\text{SUPPLY}}}$$

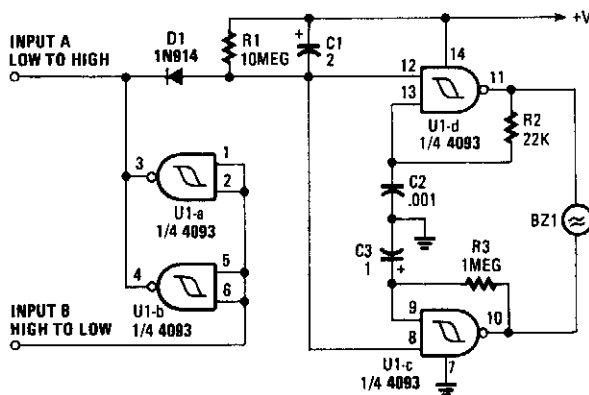
Gate hysteresis ≈ 1 V for 74HCT14 gate

DBRT = 0.7T (upper gate threshold hysteresis)

Upper gate threshold ≈ 2.3 V for HCT14

$$\begin{aligned} R_1 &\ll R_3 \\ R_2 &\ll R_1 \end{aligned}$$

PRINTER ERROR ALARM

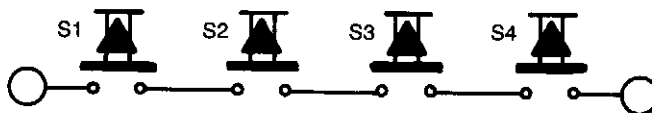


POPULAR ELECTRONICS

Fig. 20-10

When a printer is shut down, this alarm sounds an alarm. The input can be either a high-to-low or low-to-high transition. This can be a logic level that corresponds with the printer being on or off. The oscillator produces an interrupted (on-off) tone.

CHILD-PROOF RESET SWITCH



ELEKTOR ELECTRONICS

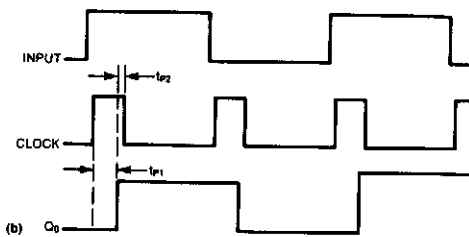
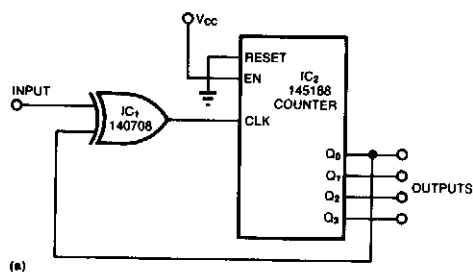
Fig. 20-11

The reset switch on a computer is very important. If an operating instruction threatens to wreck the internal management of a computer, the reset button is often the only way of avoiding a possible disaster. On the other hand, it also could cause a disaster.

It is particularly important that children or pets cannot inadvertently operate the control. The circuit proposed here should put an end to your worries in this respect. Instead of one reset switch, it is necessary to press four switches simultaneously. The chances of this happening via accident, child, or pet are negligible.

The four switches are placed in positions that make it impossible to operate them all with one hand. Instead, two of them can be operated with the fingers of one hand and the other two with the fingers on the other hand. As shown, the four switches are connected in series and are intended to replace the existing switch.

XOR GATE

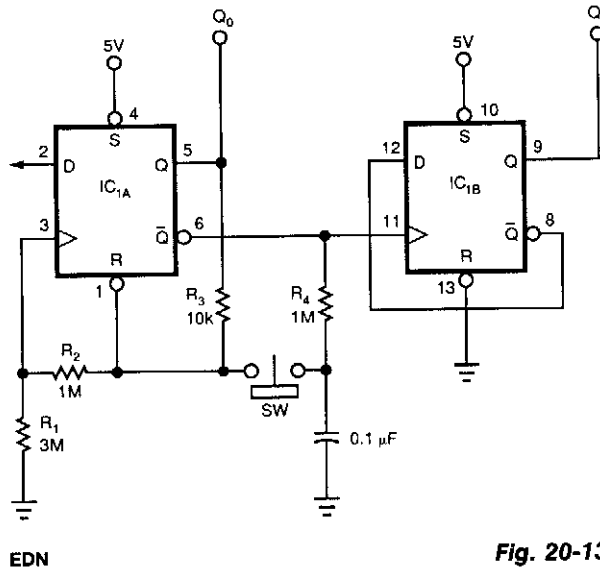


Inverting the negative-going input transactions allows the counter to count both positive- and negative-going edges. The XOR gate transforms the input signal into a series of short pulses whose width is equal to the sum of the counter and gate propagation delays.

EDN

Fig. 20-12

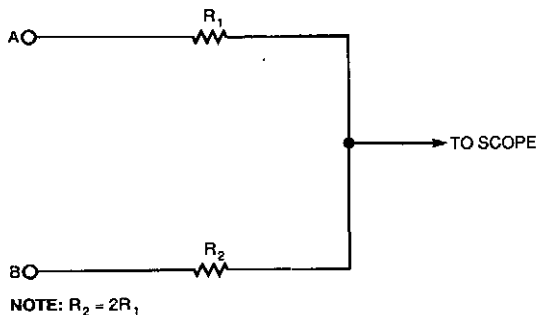
FLIP-FLOP DEBOUNCER SWITCH



Although this circuit uses a 74HC74, any CMOS variant of this flip-flop will work. IC1A acts as a true/complement buffer. R1 and R2 ensure that IC1A comes out of reset before the clock's edge occurs. R3 applies IC1A's logic state to pins 1 and 3. When the switch closes, the next logic state stored on the capacitor transfers to the flip-flop's reset and clock inputs. Releasing the switch lets the capacitor charge to the next state via R4. IC1A's output is the LSB; IC1B's output is the MSB.

Notice that the counter's state advances when the switch is first pressed, rather than when it's released; the latter is the case with many other switch-debouncing schemes. You can replace R1 with a 22-pF capacitor to reduce the circuit's sensitivity to parasitic effects. The addition of this capacitor also lets you lower the magnitude of R2 and R3 by a factor of 10.

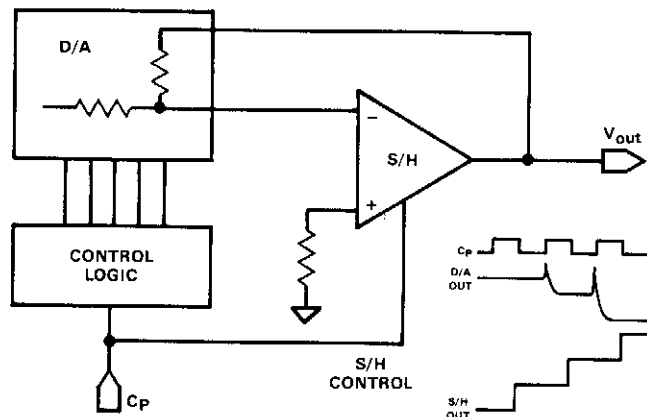
DIGITAL LEVELS SCOPE DISPLAYS 2 LOGIC SIGNALS ON 1 SCOPE



Using this simple resistor circuit, you can trick your oscilloscope into displaying two logic signals on one channel. If you select R_2 to be twice R_1 , the scope trace will show one of four distinct analog levels for each possible combination of the states of inputs A and B.

Of course, the voltage levels that your oscilloscope sees depends heavily on the current-sourcing capability of your digital logic. Because you must use high resistances, this technique has a limited frequency range.

DEGLITCHER



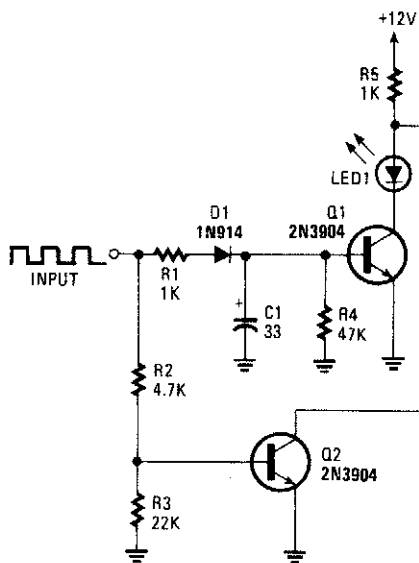
HARRIS

Fig. 20-15

Glitch has been a universal slang expression among electronics people for an unwanted transient condition. In D/A converters, the word has achieved semiofficial status for an output transient, which occurs when the digital input addressed is changed. The sample/hold amplifier does double duty, serving as a buffer amplifier as well as a glitch remover, delaying the output by $1/2$ -clock cycle.

The sample/hold can be used to remove many other types of glitches in a system. If a delayed sample pulse is required, it can be generated using a dual monostable multivibrator IC.

STALLED-OUTPUT DETECTOR



This circuit can be used to detect a stuck output or node in a circuit, or a loss of data or pulses. The pulse train charges C1 and biases Q1 on, which lights the LED. If the input remains high, Q2 extinguishes the LED.

POPULAR ELECTRONICS

Fig. 20-16

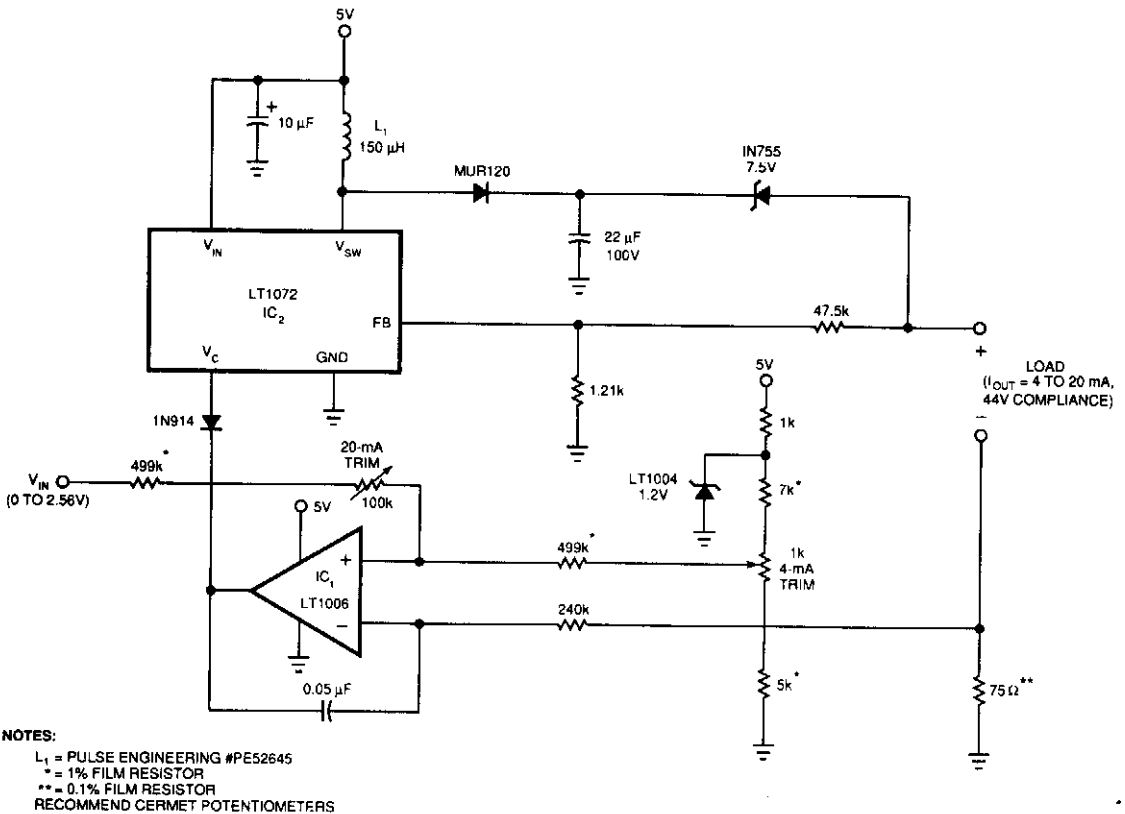
21

Converters

The sources of the following circuits are contained in the Sources section, which begins on page 664. The figure number in the box of each circuit correlates to the entry in the Sources section.

4-to-20-mA Current Loop
Power-Saving Intermittent Converter
Current-to-Frequency Counter
Sawtooth Converter
Period-to-Voltage Converter
Rectangular/Triangular Waveform Converter
 μ P-Controlled Negative Voltage Converter
dc/dc Converter
Voltage-to-Current Converter
1-to-5-V dc/dc Converter
9-to-5-V Converter
+3-V Battery to +5-V dc/dc Converter
Sine-Wave/Square-Wave Converter
Precision Full-Wave ac/dc Converter

4-TO-20-mA CURRENT LOOP



EDN

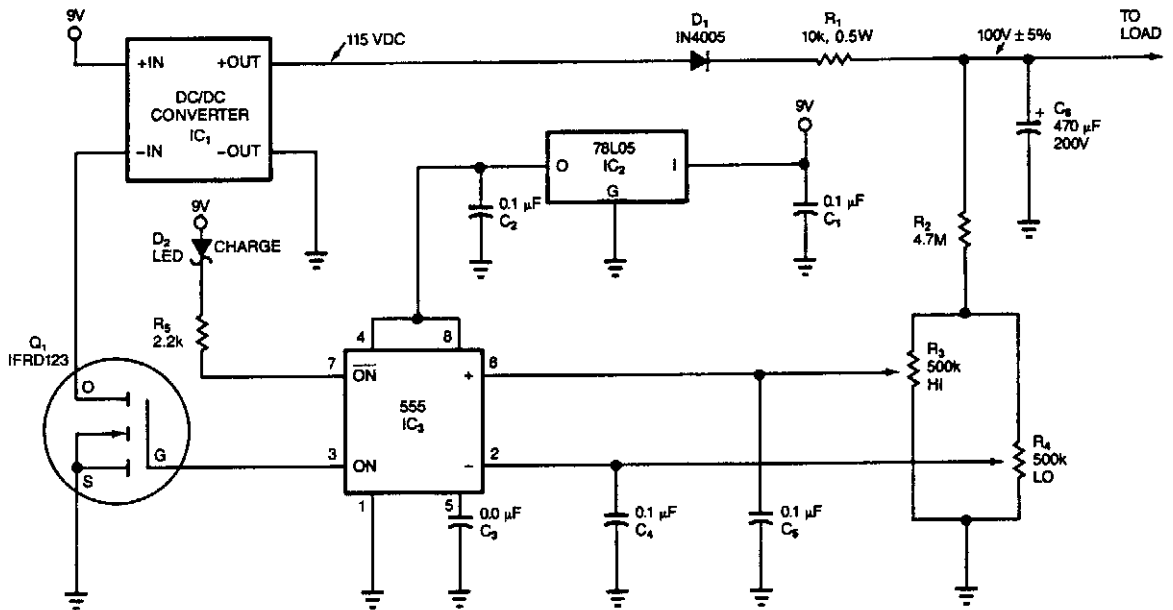
Fig. 21-1

This 5-V circuit utilizes a servo-controlled dc/dc converter to generate the compliance voltage necessary for loop-current requirements. This circuit will drive 4 to 20 mA into loads as high as 2 200 Ω with 44 V of compliance. It is inherently short-circuit protected. A current source by definition limits current regardless of the load.

The circuit's input voltage and the 4-mA trim network determine IC1's positive input voltage. IC1's output biases the LT1072 switching regulator's V_C pin. The resistors connected to the regulator's feedback pin, FB, prevent the circuit output from running away in the event that the load opens up.

Normally, IC1 controls the loop. However, if the load opens, IC1 receives no feedback. Under this condition, the FB pin becomes active when it equals 1.2 V and forces the loop to close locally around the regulator by activating IC2's internal amplifier. Thus, the circuit automatically changes from a current to a voltage regulator, thereby preventing excessive output voltages.

POWER-SAVING INTERMITTENT CONVERTER



EDN

Fig. 21-2

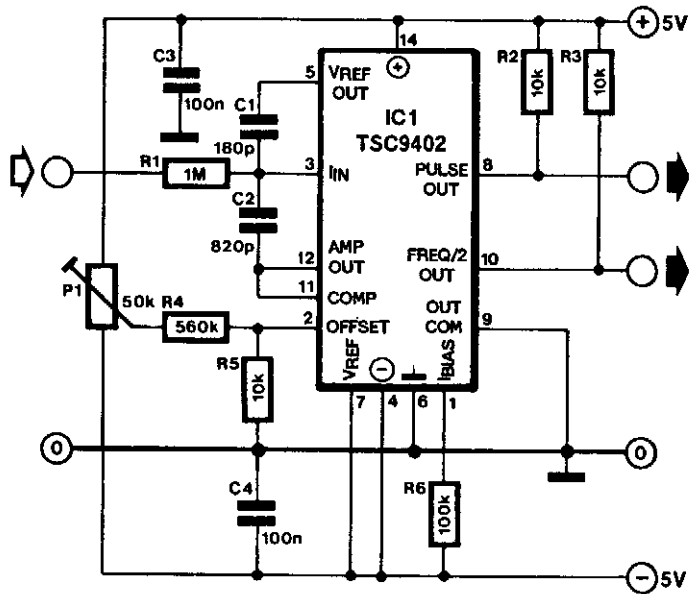
This circuit switches its dc/dc converter, IC1, off whenever the large filter capacitor, C6, has sufficient charge to power the load. This particular circuit uses a dc/dc converter that produces 115 Vdc from a 9-Vdc input; you can tailor the circuit to suit other converters. The heart of the circuit is a 555 timer configured as a dual-limit comparator. Thus, the 555 turns the converter on or off, depending on the voltage across C6. The 555's complementary output lights the charge LED when the FET is on.

Initially, the voltage on C6 is zero, and the 555's output turns on the FET, Q1, in turn, enabling the converter to run, which charges C6. When the voltage on the capacitor reaches the value set by R3, the 555 turns the converter off. Then, C6 slowly discharges into the combined load of the voltage divider (R2, R3, and R4) and the reverse-biased blocking diode, D1.

When the voltage falls below $\frac{1}{3} V_{CC}$, the 555 restarts the dc/dc converter. If this circuit powers a load that periodically goes into a zero-power, shutdown mode, the 555 switches the dc/dc converter on full time whenever the load kicks in.

When the supply voltage falls below 7.5 V, the output of the converter is no longer high enough to charge, the LED doesn't light. The circuit uses 205 mA when the converter is on and 10 mA when the converter is off. The duty cycle comprises a 5-s ON period, a 150-s OFF period, and it represents a 92% power reduction. You can further reduce power consumption by removing the charge LED and using a CMOS 555 and a CMOS 78L05 regulator.

CURRENT-TO-FREQUENCY CONVERTER



ELEKTOR ELECTRONICS

Fig. 21-3

Teledyne Semiconductor's Type TSC9402 IC is eminently suitable as an inexpensive current-to-frequency converter. The maximum input current of the design shown in the diagram is $10\ \mu\text{A}$ (input voltage range is 10 mV to 10 V), while the output frequency range extends from 10 Hz to 10 kHz. The conversion factor is exactly $1\ \text{kHz}/\mu\text{A}$. The factor can be altered by changing the value of R1—as long as the maximum input current of $10\ \mu\text{A}$ is not exceeded.

The circuit has two outputs. That at pin 8 is a short-duration pulse, whose rate is directly proportional to the input current; that at pin 10 is a square wave of half the frequency of the pulse at pin 8.

Calibrating the circuit is fairly simple. Connect a frequency meter to pin 8 (preferably one that can read tenths of a hertz) and connect a voltage of exactly 10 mV to the input (check with an accurate millivoltmeter). Adjust P1 to obtain an output of exactly 10 Hz. Next, connect a signal of exactly 10 V to the input and check that the output signal has a frequency of 10 kHz. If this frequency cannot be attained, shunt C1 with a small trimmer or replace R1 by a resistor of 820 k Ω and a preset of 250 k Ω .

The circuit may be adapted to individual requirements with the aid of:

$$f_{\text{out}} = I_{\text{in}} U_r (C_1 + 12\ \text{pF}) \quad [\text{Hz}]$$

The reference voltage, U_r , here is $-5\ \text{V}$.

SAWTOOTH CONVERTER

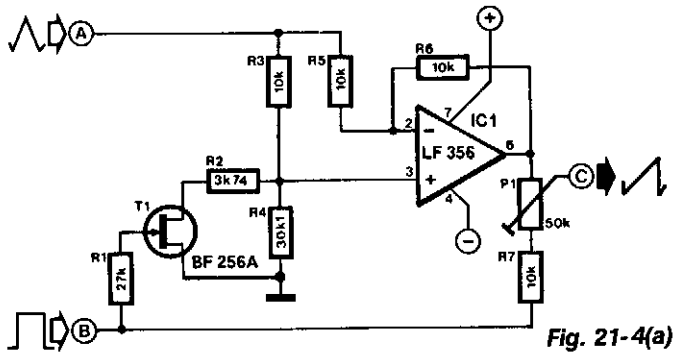


Fig. 21-4(a)

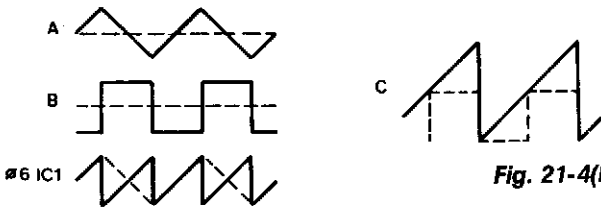


Fig. 21-4(b)

ELEKTOR ELECTRONICS

Simple function generators normally provide sinusoidal, rectangular, and triangular waveforms, but seldom a sawtooth. The circuit in Fig. 21-4(a) derives a sawtooth signal from a rectangular and triangular signal. Its quality depends on the linearity of the triangular signal, the slope of the edges of the rectangular signal and the phase relationship between the rectangular and triangular signals.

The conversion is carried out in IC1. Whether the triangular signal at input A is converted or not by IC1 depends on the state of T1. This FET is controlled by the rectangular signal at input B.

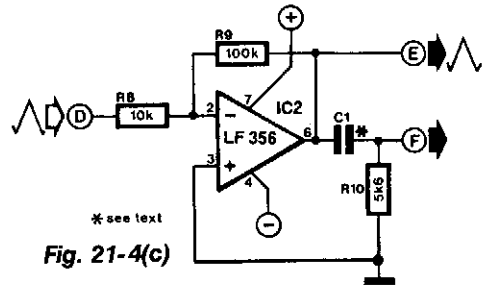
The signal at the output of the op amp is a sawtooth (see Fig. 21-4(b)) whose trailing edge is inverted. The frequency of this signal is double that of the input signals.

If in this state, the dc level of each inverted edge is raised sufficiently to make the lower level of that edge coincide with the higher level of the preceding edge, a sawtooth signal of the same frequency (but double the peak value of the input signals) is obtained. The dc level is raised by adding input B to the output of IC1 via R7 and P1. The preset should preferably be a multiturn type. Resistors R2 and R4 are 1% types.

If a rectangular signal is not available, or if its peak value is too small, the auxiliary circuits (shown in Figs. 21-4(c) and 21-4(d)) will be found useful. Figure 21-4(c) amplifies the triangular input at A by 10. Differentiating network C1/R10 derives rectangular pulses from the amplified triangular signal and these are available at F.

The pulses at F are shaped by the circuit in Fig. 21-4(d) to rectangular signals that have the same peak value as the supply voltage. Capacitor C2 increases the slope of the edge; it can be omitted for low-frequency signals.

The converter provides sawtooth signals over the frequency range of 15 Hz to 15 kHz. If the auxiliary circuits are used, capacitor C1 must be compatible with the frequency of the sawtooth signal (its value lies between 2 nF and 100 pF). The supply for all circuits can be between ± 10 V and ± 15 V. Each op amp draws a current of 4 to 6 mA.



* see text
Fig. 21-4(c)

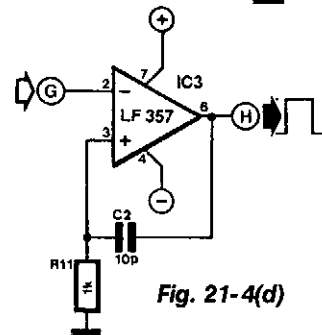
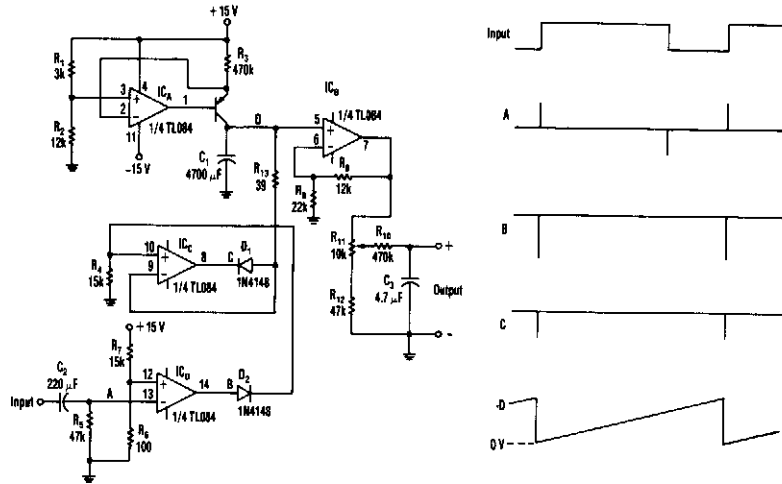


Fig. 21-4(d)

PERIOD-TO-VOLTAGE CONVERTER



ELECTRONIC DESIGN

Fig. 21-5

ICA, R1, R2, R3, and Q1 form a current source. The current that charges C1 is given by:

$$\begin{aligned}
 I &= \frac{V_{Dn} \times R_1}{(R_1 + R_2) \times R_3} \\
 &= \frac{15 \times 3 \text{ k}\Omega}{(3 \text{ k}\Omega + 12 \text{ k}\Omega) \times 470 \text{ k}\Omega} \\
 &= 6.4 \text{ }\mu\text{A}
 \end{aligned}$$

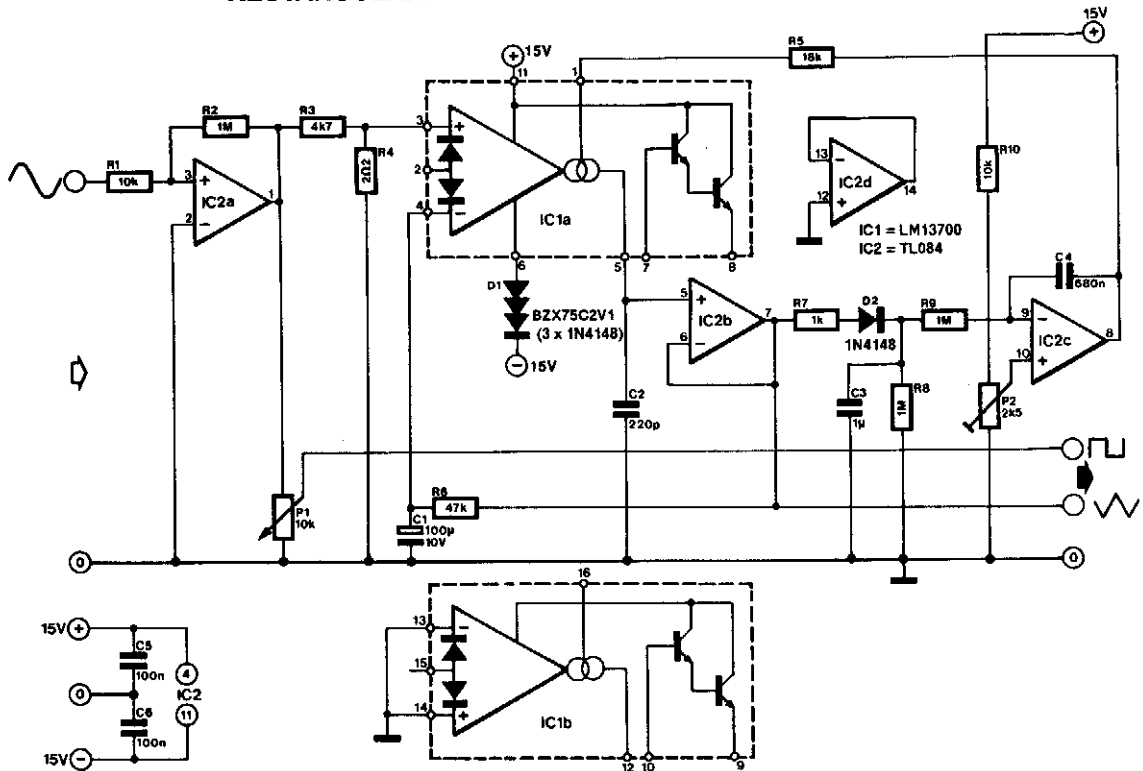
The input signal drives ICD. Because ICD's positive input (V_+) is slightly offset to +0.1 V, its steady state output will be around +13 V. This voltage is sent to ICC through D2, setting ICC's output to +13 V. Therefore, point D is cut off by D1, and C1 is charged by the current source. Assuming the initial voltage on C1 is zero, the maximum voltage ($V_{C_{max}}$) is given by:

$$\begin{aligned}
 V_{C_{max}} &= \frac{I \times T}{C_1} \\
 &= \frac{6.4 \times t}{0.0047} \\
 &= 1362t
 \end{aligned}$$

If $t = 1 \text{ ms}$, then $V_{C_{max}} = 1.362 \text{ V}$.

When the input goes from low to high, a narrow positive pulse is generated at point A. This pulse becomes -13 V at point B, which cuts off D2. ICC's V_+ voltage becomes zero. The charge on C1 will be absorbed by ICC on in a short time. The time constant of C2 and R5 determines the discharge period—about 10 μs . ICB is a buffer whose gain is equal to $(R_8 + R_9) \div R_9 = 1.545$. ICD's average voltage will be $(1362t \times 1.545) \div 2 = 1052t$. R10 and C3 smooth the sawtooth waveform to a dc output.

RECTANGULAR/TRIANGULAR WAVEFORM CONVERTER



ELEKTOR ELECTRONICS

Fig. 21-6

Many function generators are based on a rectangular waveform generator that consists of a Schmitt trigger and integrator. The triangular signal produced by the integrator is then used to form a sinusoidal signal with the aid of a diode network. The converter presented here works the other way around. It converts the output of a good-quality sine-wave oscillator into a rectangular and a triangular signal.

The sinusoidal signal is converted into a rectangular signal by IC2A. Because the output of this gate varies between -15 V and $+15\text{ V}$, it is reduced to a value that is suitable for integration by potential divider R3/R4. It is then integrated by transconductance amplifier IC1A and C2. The amplifier has a current output that is controlled by the current through pin 1. The output therefore behaves as a resistance, with which it is possible to influence the integration time.

The voltage across C2 is available in buffered form at the output of impedance inverter IC2B; this is the triangular signal. The amplitude of this signal is compared with a voltage set by P2 and the difference between these voltages, which is the output of IC2C, is applied to the current source at the output of IC1 via R5. This arrangement ensures that the level of the output voltage is virtually independent of the frequency of the rectangular signal or of the sinusoidal input.

One problem with a precision integration is its being affected by offset voltages and bias currents. Feedback loop R6/C1 ensures that the output follows the potential across R4 accurately. However, tiny deviations might be caused by the bias current in circuit IC1, which is not greater than $8\ \mu\text{A}$ at 70°C .

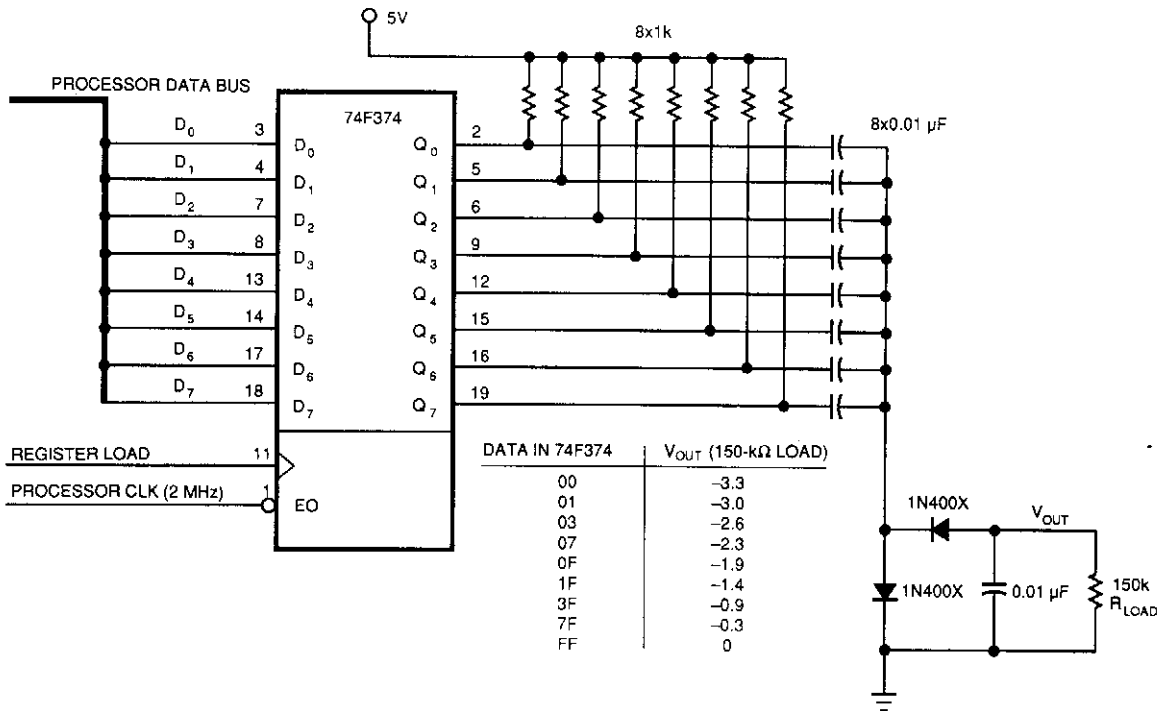
RECTANGULAR/TRIANGULAR WAVEFORM CONVERTER (Cont.)

The time constant $R6/C1$ is large for a purpose: to ensure that the triangular signal, even at low frequencies, cannot affect the waveform of the signal to be integrated—the rectangular shape must be retained. The converter can process signals at frequencies from 6 Hz (where the amplitude is not affected) to 60 kHz (where the amplitude is reached by 10%).

Because of the long time constants, the time taken for the recovery of the amplitude of the triangular signal at frequencies above 1 kHz is rather long. The peak value of this signal should be set to 1 V.

Diode D1 is a so-called *stabistor*—three diodes in one package. It might be replaced by three discrete type 1N4148 diodes. The current drawn by the converter is of the order of 9 mA.

μ P-CONTROLLED NEGATIVE VOLTAGE CONVERTER

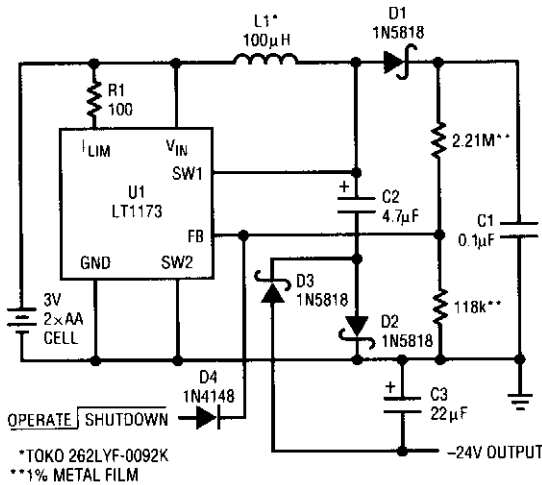


EDN

Fig. 21-7

This circuit was used to produce a variable negative voltage for contrast control of an LCD display. A 74F374 generates a square wave that is ac coupled to a rectifier and load. By using the μ P clock and data from the processor bus, and properly timed load signal, the dc level generated can be controlled by the μ P.

dc/dc CONVERTER

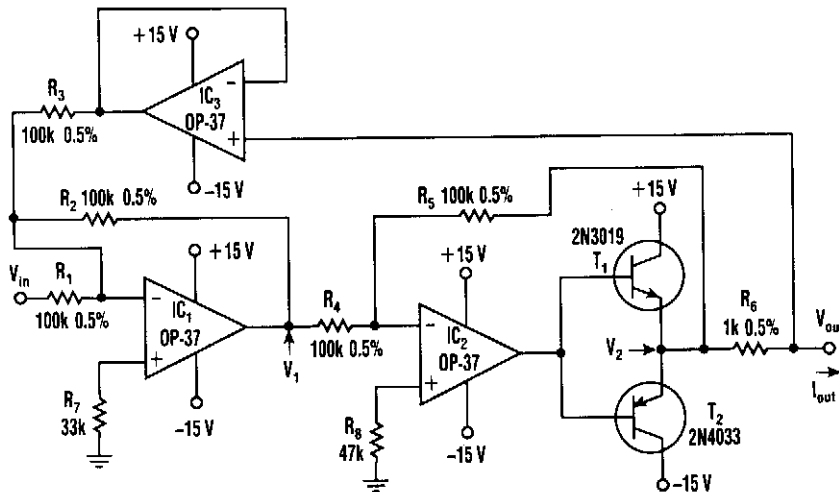


This circuit uses a Linear Technology LT1073 in a -24-V converter. The supply can be two AA cells (3 V) or 5 V. The circuit can deliver 7 mA.

LINEAR TECHNOLOGY

Fig. 21-8

VOLTAGE-TO-CURRENT CONVERTER



ELECTRONIC DESIGN

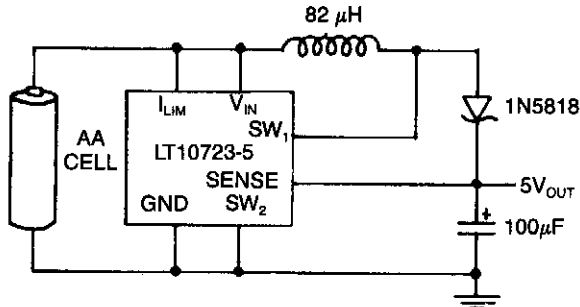
Fig. 21-9

This voltage to current converter uses three op amps to drive a pair of power transistors. The current output is calculated as:

$$I_{OUT} = \frac{V_{in}}{R_6}$$

Output resistance is over 50 M Ω . I_{OUT} can range from 1 mA to the current ratings of T1 and T2.

1-TO-5 V dc/dc CONVERTER

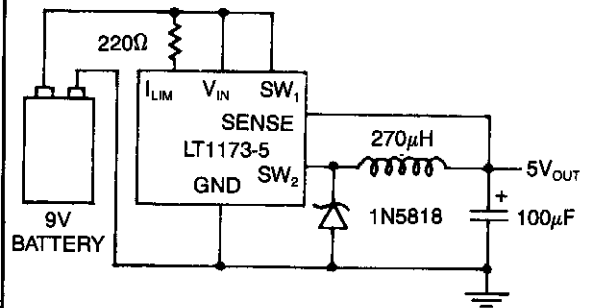


LINEAR TECHNOLOGY

Fig. 21-10

This circuit, using the Linear Technology LT1173, produces 5 V at 40 mA from a 1.5-V AA cell.

9-TO-5-V CONVERTER

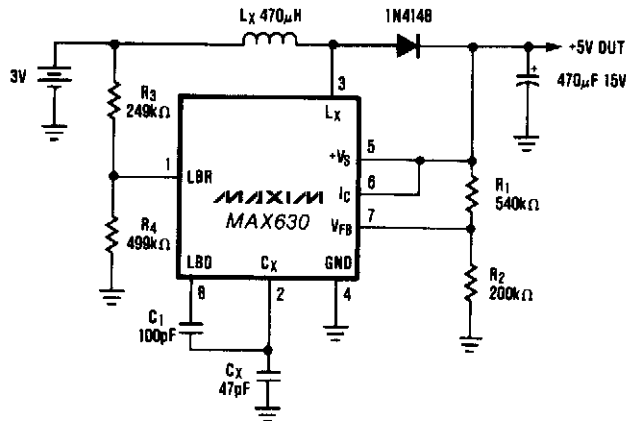


LINEAR TECHNOLOGY

Fig. 21-11

Using a Linear Technology LT1173-5, this converter produces regulated 5 V from a 9-V battery.

+ 3-V BATTERY TO +5-V dc/dc CONVERTER

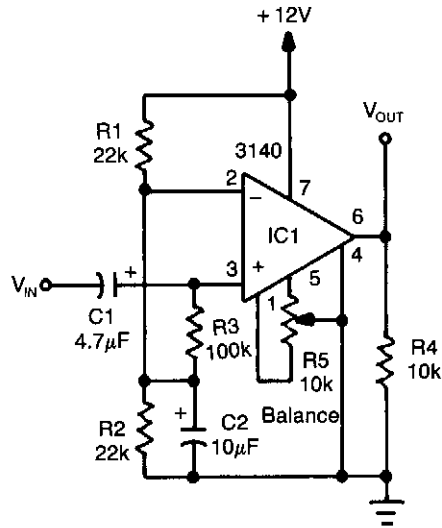


MAXIM

Fig. 21-12

A common power-supply requirement involves converting a 2.4- or 3-V battery voltage to a 5-V logic supply. This circuit converts 3 V to 5 V at 40 mA with 85% efficiency. When I_C (pin 6) is driven low, the output voltage will be the battery voltage minus the drop across diode D1. The optional circuitry that uses C1, R3, and R4 lowers the oscillator frequency when the battery voltage falls to 2.0 V. This lower frequency maintains the output-power capability of the circuit by increasing the peak inductor current, which compensates for the reduced battery voltage.

SINE-WAVE/SQUARE-WAVE CONVERTER

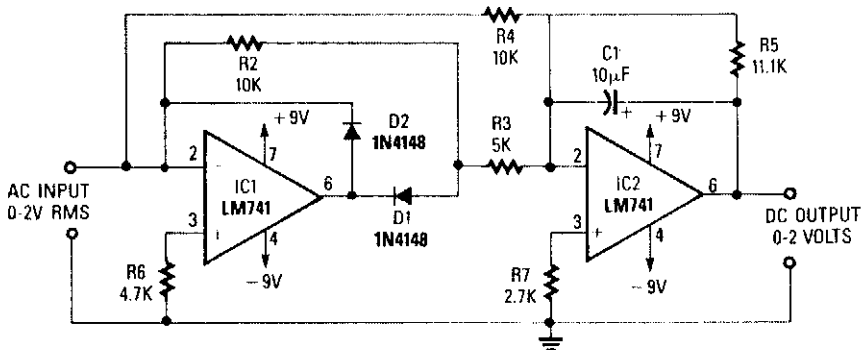


RADIO-ELECTRONICS

Fig. 21-13

An op amp used as a comparator produces a 10-V p-p square-wave output with 100-mV input, to 15 kHz. Adjust R5 for symmetry of square wave at low input levels.

PRECISION FULL-WAVE ac/dc CONVERTER



RADIO-ELECTRONICS

Fig. 21-14

A dc level is produced that corresponds to the ac input rms value (if sine wave). $\frac{R_1}{C_5}$ set the gain of IC2 to 1.11. This factor is the average-to-rms conversion factor. IC1 and IC2 act as a full-wave rectifier circuit, with D1 and D2.

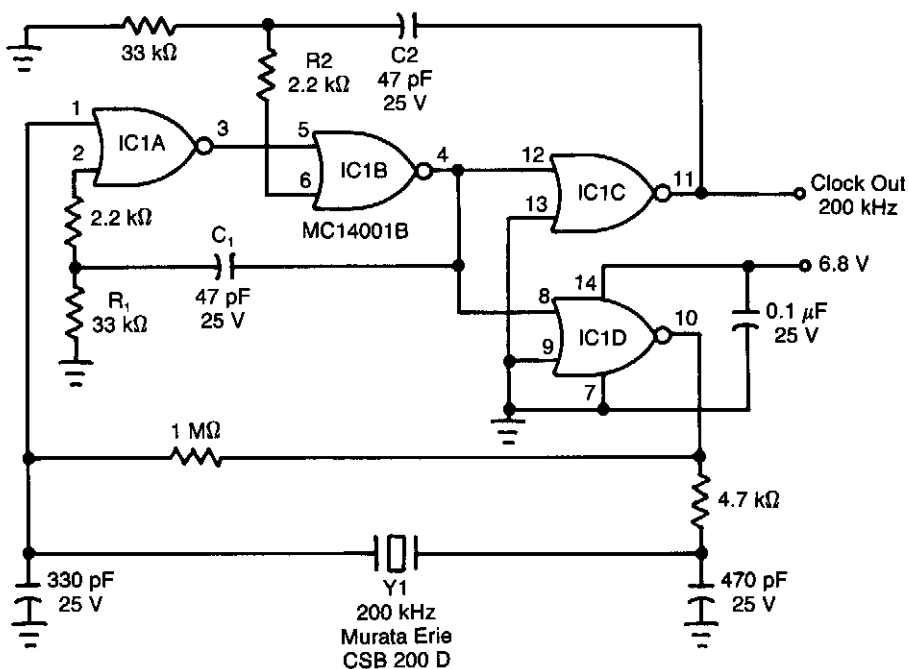
22

Crystal Oscillators

The sources of the following circuits are contained in the Sources section, which begins on page 664. The figure number in the box of each circuit correlates to the entry in the Sources section.

Micropower Clock	10-to 80-MHz Oscillator
Simple Fundamental Crystal Oscillator	1-to 4-MHz CMOS Oscillator
Simple Third-Overtone Oscillator	150-to 30 000-kHz Oscillator
Colpitts 1-to 20-MHz Crystal Oscillator	50-to 150-MHz Oscillator
100-kHz Crystal Calibrator	Two-Frequency Colpitts Oscillator
100-MHz Overtone Oscillator	1-to 20-MHz TTL Oscillator
Voltage-Controlled Crystal Oscillator	Crystal-Controlled Bridge Oscillator
330-MHz Crystal Oscillator	Economical Crystal Time Base
10-to-150 kHz Oscillator	Crystal Oscillator

MICROPOWER CLOCK



EDN

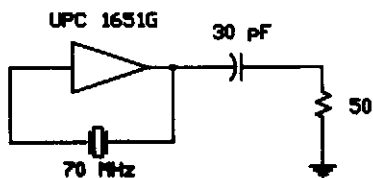
Fig. 22-1

Although ceramic resonators are a good choice for low-power, low-frequency clock sources (if you can stand their 30-ppm temperature coefficient), they have troublesome, spurious-resonance modes. This circuit rejects all but the resonator's fundamental mode. This clock circuit works from -40 to $+80^{\circ}\text{C}$ and consumes only 2.8 mW.

The rising edge of resonator Y1 toggles IC1A low. ac-coupled positive feedback from IC1D via C1 and R1 immediately confirms this state change at IC1B so that Miller loading, harmonic components, or below-minimum rise times at IC1A cannot force IC1C to relapse to its previous state. This tactic also applies to resonator Y1's falling edge because IC1C, via C2 and R2, holds IC1B high.

Choose time constants R_1C_1 , and R_2C_2 to be equal and ranging from 60 to 75% of one-half of the clock's period. Ceramic capacitors (10% tolerance) with X7R dielectric work well. With these time constants, the logic will be locked and unavailable to the ceramic resonator until just before it executes a legitimate transition. IC1D and IC1C are in parallel to isolate the resonator from external loads and, more importantly, from C2.

SIMPLE FUNDAMENTAL CRYSTAL OSCILLATOR

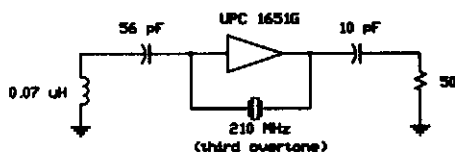


RF DESIGN

Fig. 22-2

This simple fundamental oscillator uses a μ PC1651G IC and two components. The crystal is fundamental.

SIMPLE THIRD-OVERTONE OSCILLATOR

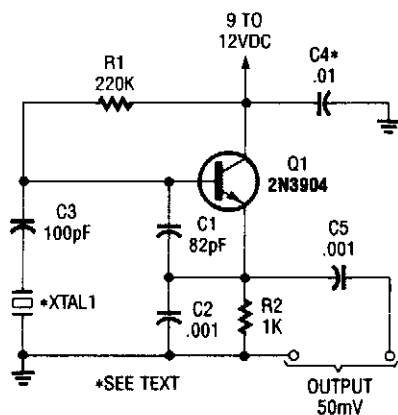


RF DESIGN

Fig. 22-3

Using a 210-MHz third overtone crystal, this circuit operates directly at the crystal frequency, with 210-MHz output and no multiplier stages.

COLPITTS 1-to 20-MHz CRYSTAL OSCILLATOR

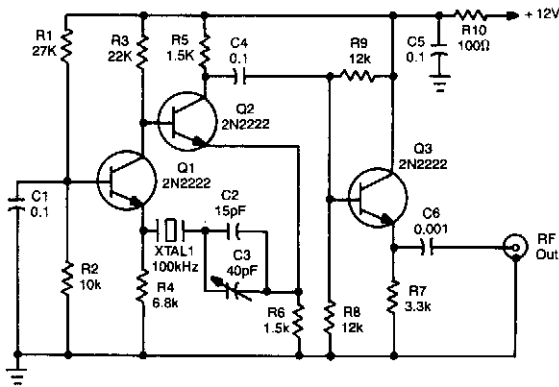


This is a simple Colpitts crystal oscillator for 1 to 20 MHz, can be easily made from junk-box parts (provided that a crystal is handy).

POPULAR ELECTRONICS

Fig. 22-4

100-kHz CRYSTAL CALIBRATOR

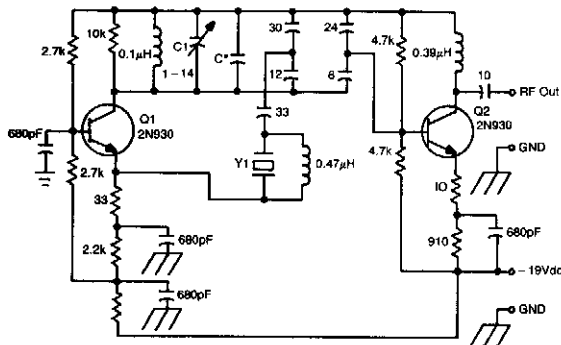


Using a 12-V supply, this crystal calibrator should prove a useful accessory for a SW receiver. Q1 and Q2 form an oscillator and Q3 is a buffer amp.

POPULAR ELECTRONICS

Fig. 22-5

100-MHz OVERTONE OSCILLATOR

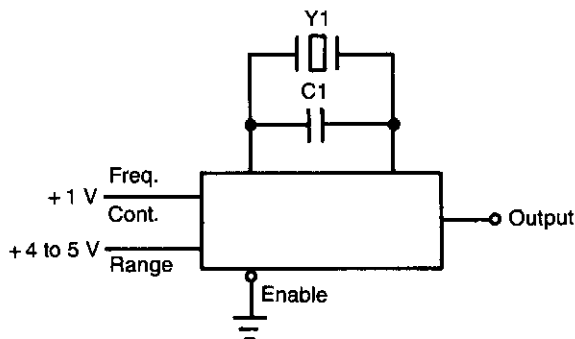


This oscillator circuit uses a 5th overtone crystal in the 85-to-106 MHz range. Y1 is the crystal. The circuit was originally used to frequency control a microwave oscillator.

73 AMATEUR RADIO

Fig. 22-6

VOLTAGE-CONTROLLED CRYSTAL OSCILLATOR



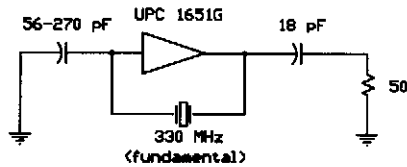
Notes:

1. For frequencies ≤ 1 MHz, $C1 = 5$ to 15 pF.
For frequencies ≥ 1 MHz, $C1$ can be eliminated.
2. IC is SN74S124 for f_{max} of 60 MHz.
IC is SN74LS124 for f_{max} of 35 MHz.

VALPEY-FISHER

Fig. 22-7

330-MHz CRYSTAL OSCILLATOR

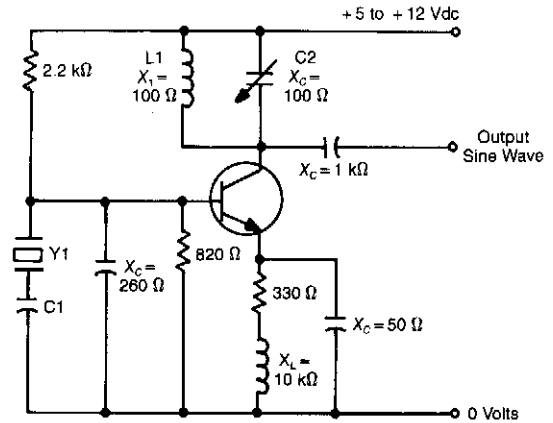


RF DESIGN

Fig. 22-8

A μ PC 1651G IC operates in the fundamental mode with an experimental crystal at 330 MHz. The 56-to-270 pF capacitor is not critical; about +1-dBm RF output is available.

10-to 150-kHz OSCILLATOR



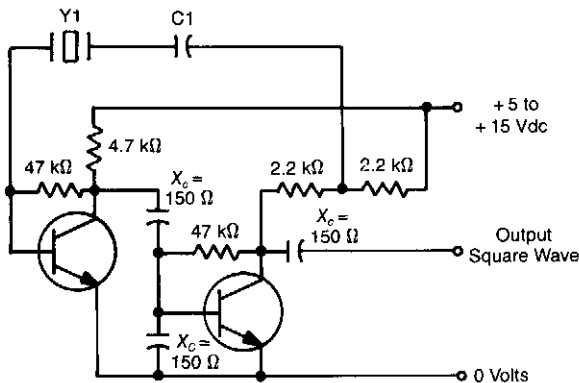
VALPEY-FISHER

Fig. 22-10

Note:

Y1 is 'H', 'NT', or 'E' cut

10-to 80-MHz OSCILLATOR



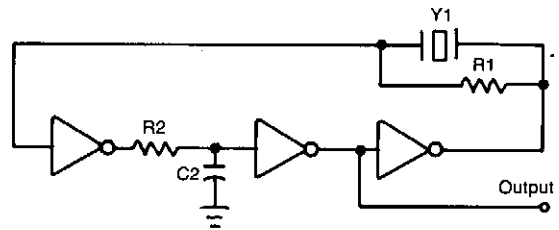
VALPEY-FISHER

Fig. 22-9

Notes:

1. Y1 is 'AT' cut, fundamental, or overtone crystal.
2. Tune L1 and C2 to operating frequency.

1-to 4-MHz CMOS OSCILLATOR



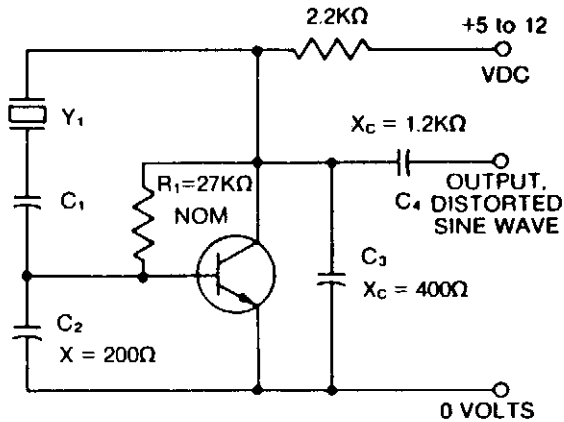
VALPEY-FISHER

Fig. 22-11

Notes:

1. $1 \text{ M}\Omega < R_1 < 5 \text{ M}\Omega$
2. Select R_2 and C_2 to prevent spurious frequency.
3. ICs are 74C04 or equivalent.

150-to 30 000-kHz OSCILLATOR



Notes:

1. Y1 is 'AT', 'CT', 'DT', 'NT', 'SL', or 'E' cut.
2. C1, C2, and C3 in series should equal the load capacity of crystal.
3. Adjust R1 for 1/2 supply voltage at collector of transistor.

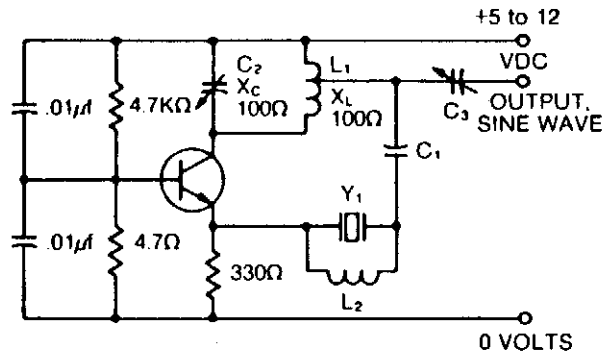
VALPEY-FISHER

Fig. 22-12

C1 capacitor in series with the crystal may be used to adjust the output frequency of the oscillator. The value can range between 20 pF and 0.01 μ F, or it can be a trimmer capacitor.

X values are approximate and can vary for most circuits and frequencies; this is also true for resistance values. Adequate power supply decoupling is required; local decoupling capacitors near the oscillator are recommended.

50-to 150-MHz OSCILLATOR



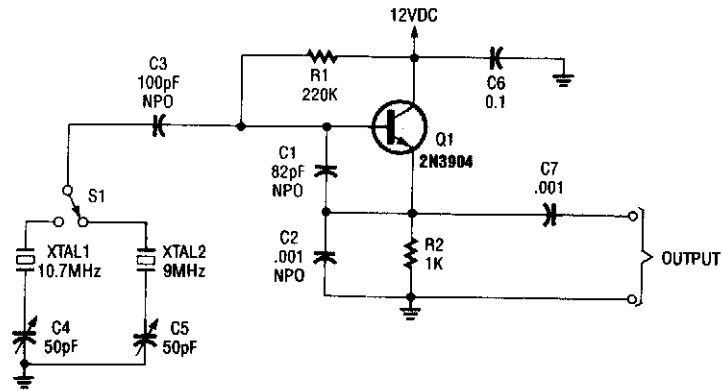
VALPEY-FISHER

Fig. 22-13

Notes:

1. Y1 is 'AT' cut, overtone crystal.
2. Tune L1 and C2 to operating frequency.
3. L2 and shunt capacitance (C0) of crystal (approximately 6 pF) should resonate to the output frequency of the oscillator (L2 = 0.5 μ H at 90 MHz). This is necessary in order to tune out effect of C0 of the crystal.
4. C3 is varied to match output.

TWO-FREQUENCY COLPITTS OSCILLATOR

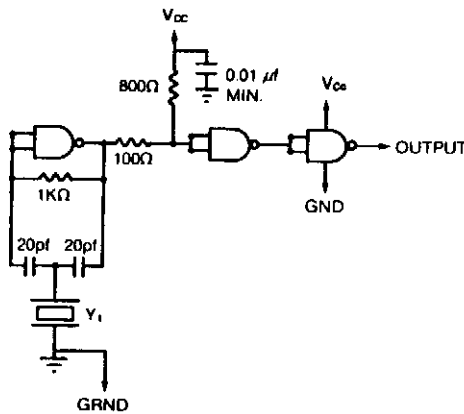


POPULAR ELECTRONICS

Fig. 22-14

Using switched crystals, this oscillator is intended for receiver alignment purposes.

1-to 20-MHz TTL OSCILLATOR



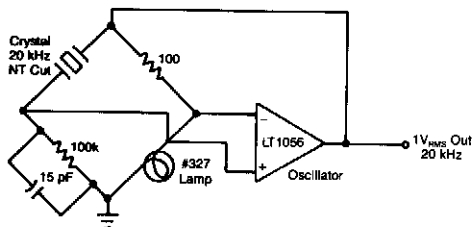
Notes:

1. Y1 is "AT" cut fundamental crystal.
2. ICs are 7400/7404.

VALPEY-FISHER

Fig. 22-15

CRYSTAL-CONTROLLED BRIDGE OSCILLATOR

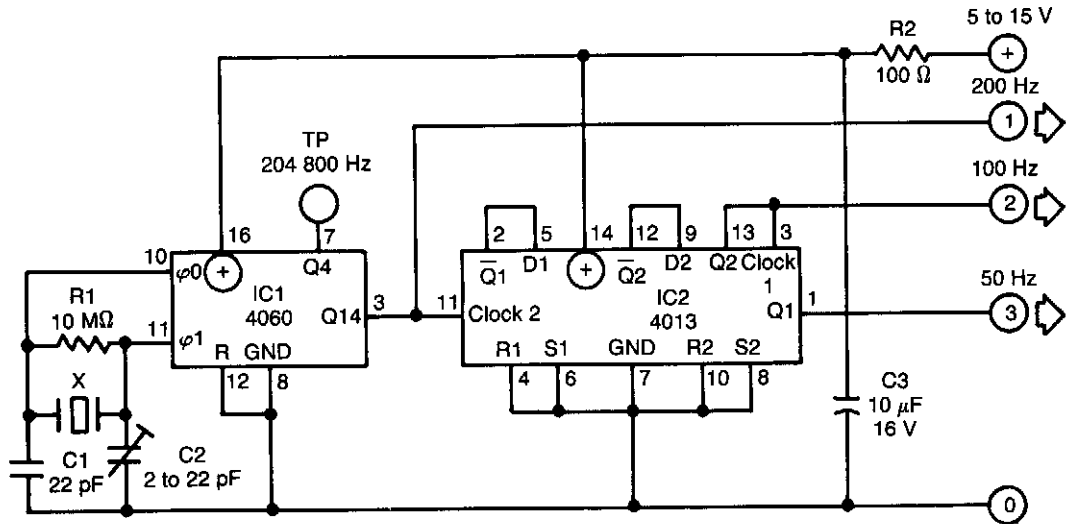


EDN

Fig. 22-16

This crystal-controlled oscillator uses the current variations in a small lamp to stabilize amplitude variations.

ECONOMICAL CRYSTAL TIME BASE

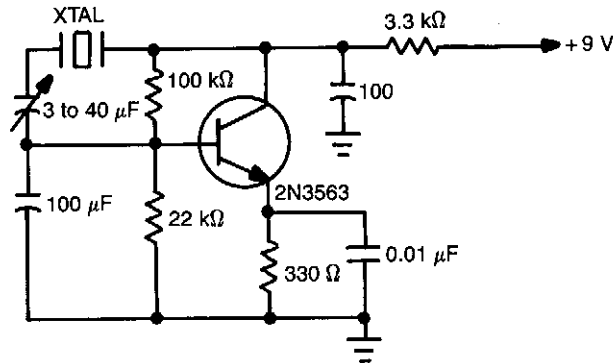


ELEKTOR ELECTRONICS

Fig. 22-17

The above time base circuit will provide 50-, 100-, or 200-Hz signals from an inexpensive crystal cut for 3.276 8 MHz, a common crystal used for microprocessor works. It requires a power supply of 5 to 15 V at 0.05 to 2.5 mA.

CRYSTAL OSCILLATOR



WILLIAM SHEETS

Fig. 22-18

This simple circuit will oscillate with a wide range of crystals. Connect several different types of crystal holders in parallel to improve versatility. The 3-to-40-pF capacitor adjusts crystal frequency over a small range for setting to standard-frequency transmissions when the unit is used as a crystal calibrator.

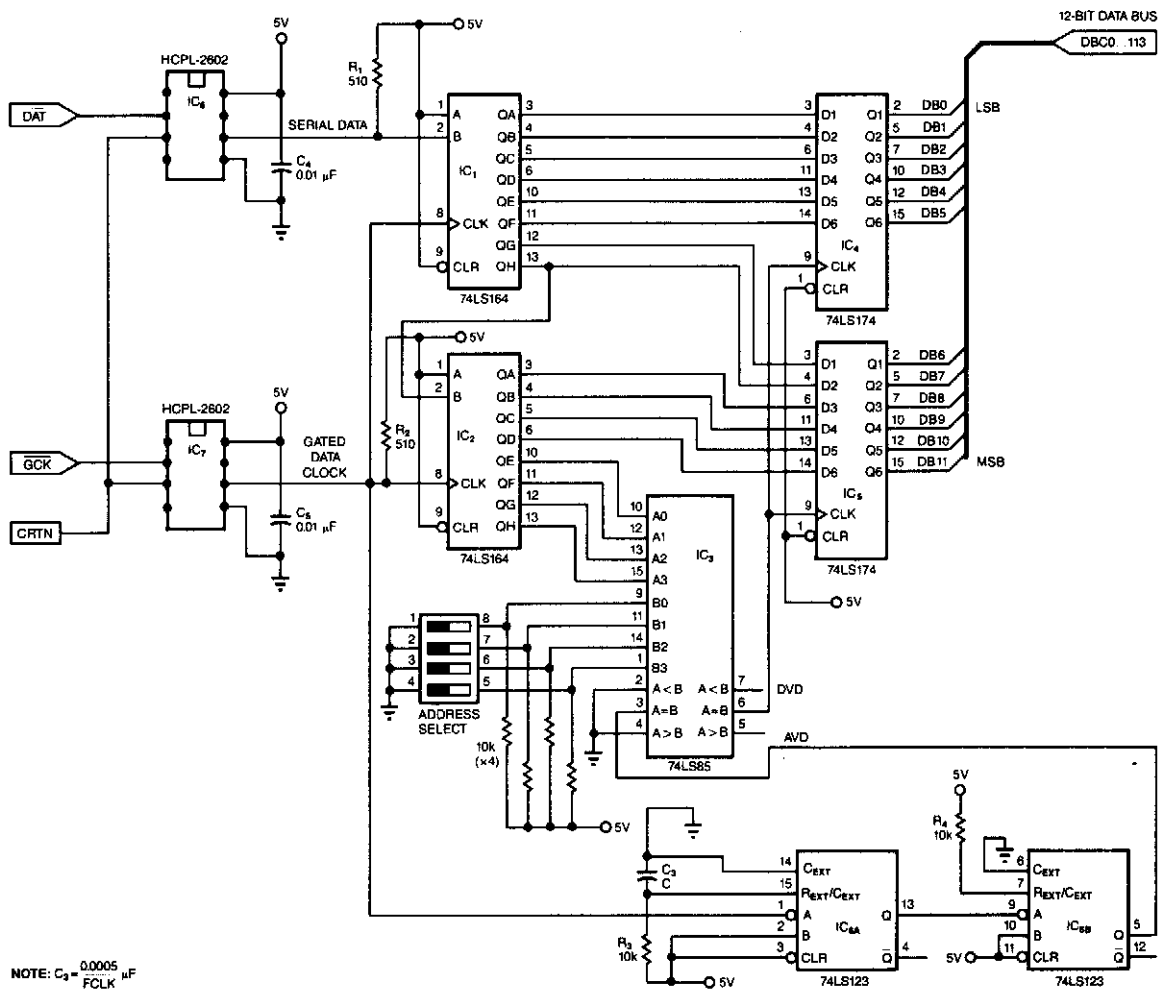
23

Data Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 664. The figure number in the box of each circuit correlates to the entry in the Sources section.

3-Wire Receiver/Message Demuxer
Data Acquisition System I
Data Acquisition System II
Low-Frequency Prescaler
Analog Data-Signal Isolater

3-WIRE RECEIVER/MESSAGE DEMUXER

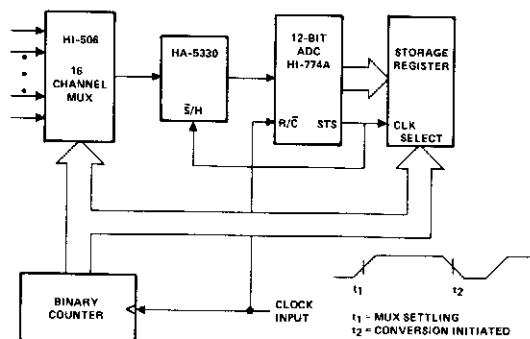


EDN

Fig. 23-1

This 3-wire receiver checks the first four data bits of 16 received bits against a preset address. If the two match, the remaining 12 bits are latched into two 6-bit flip-flop registers. Either CMOS or TTL logic families can be used in the design.

DATA ACQUISITION SYSTEM I



HARRIS

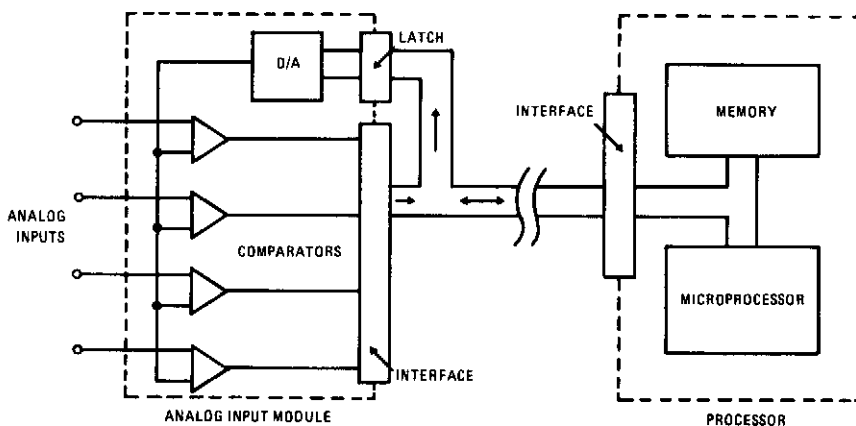
Fig. 23-2

The HI-506 multiplexer is used as an analog input selector, controlled by a binary counter to address the appropriate channel. The HA-5330 is a high-speed sample and hold. The sample/hold con-

trol is tied to the status (STS) output of the HI-774A; whenever a conversion is in process, the S/H is in the hold mode. A conversion is initiated when the clock input becomes low; when the clock becomes high, the mux address changes. The mux will be acquiring the next channel while the ADC is converting the present input, held by the S/H. The clock low time should be between 225 ns and 6.5 μ s, with the period greater than 8.5 μ s.

With this timing, T/C will be high at the end of a conversion, so the output data will be valid \sim 100 ns before STS goes low. This allows STS to clock the data into the storage register. The register address will be offset by one; if this is a problem, a 4-bit latch can be added to the input of the storage register. With a 100-kHz clock rate, each channel will be read every 160 μ s.

DATA ACQUISITION SYSTEM II

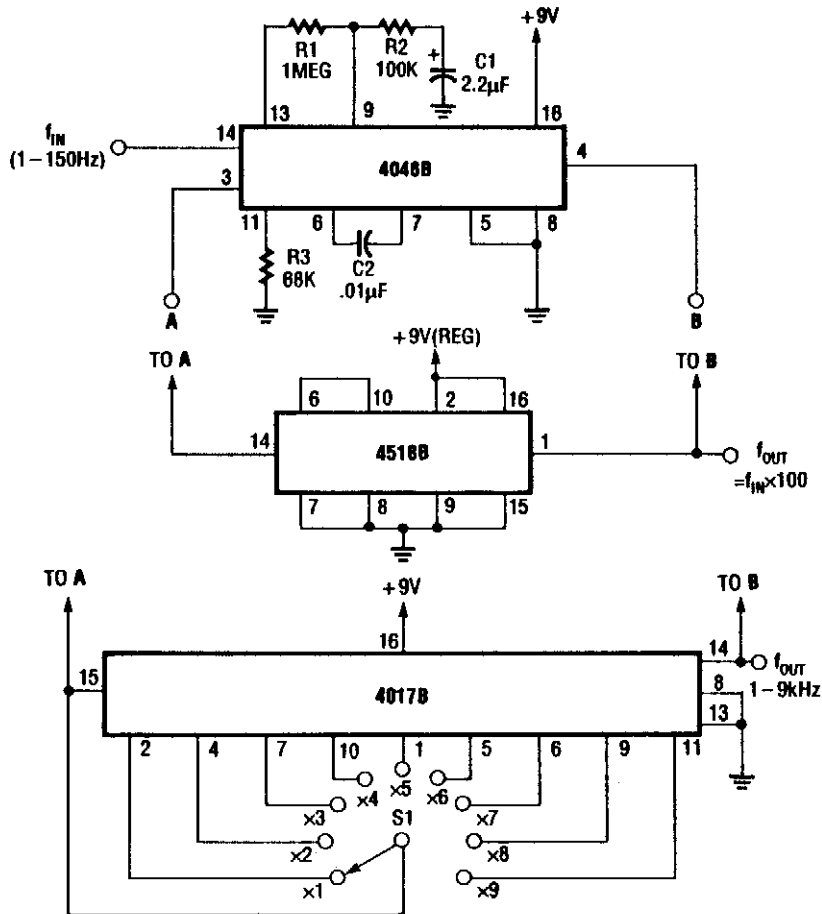


HARRIS

Fig. 23-3

In this circuit, an HA-4900 series comparator is used in conjunction with a D/A converter to form a simple, versatile, multichannel analog input for a data acquisition system. The processor first sends an address to the D/A, then the processor reads the digital word generated by the comparator outputs. To perform a simple comparison, the processor sets the D/A to a given reference level, then examines one or more comparator outputs to determine if the inputs are above or below the reference. A window comparison consists of two such cycles with two reference levels set by the D/A. One way to digitize the inputs would be for the processor to increment the D/A in steps. The D/A address, as each comparator switches, is the digitized level of the input. While stairstepping, the D/A is slower than successive approximation; all channels are digitized during one staircase ramp.

LOW-FREQUENCY PRESCALER



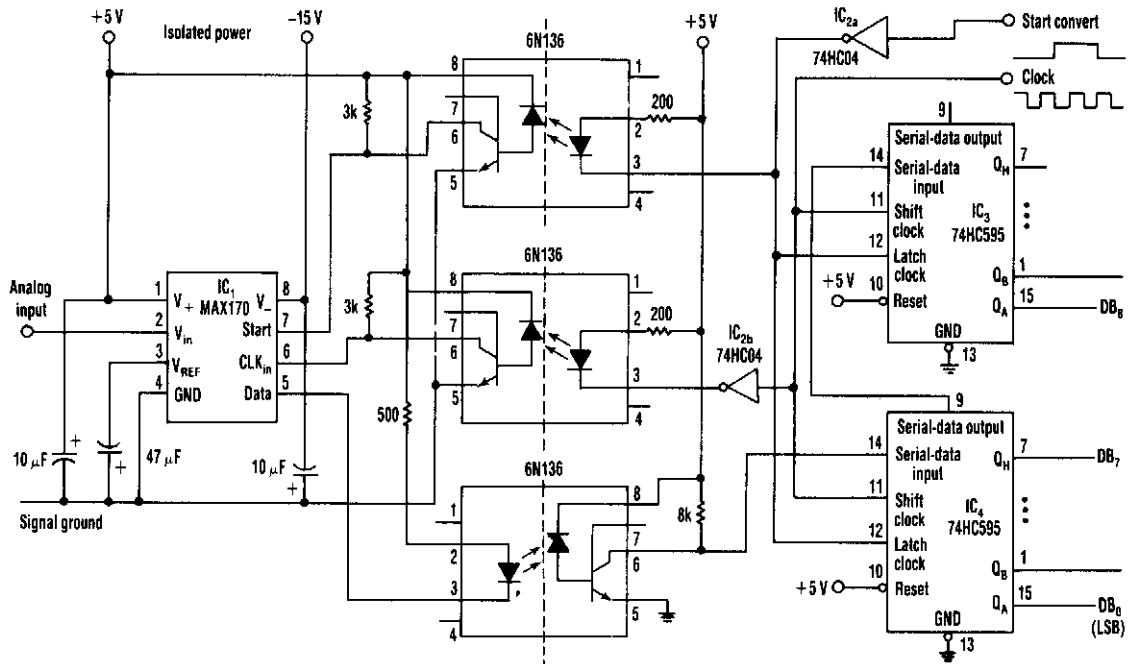
RADIO-ELECTRONICS

Fig. 23-4

For multiplying frequencies in the 1-to 150-Hz range, this circuit uses a 4046B and a $\div 100$ prescaler. The VCO output is phaselocked to the low-frequency input. This simplifies use of a frequency counter to measure LF signal frequencies.

By using a 4017B and a 1-kHz f_{IN} , the circuit can be used as a 1-to 9-kHz frequency synthesizer or as a $\times 10$ frequency multiplier.

ANALOG DATA-SIGNALS ISOLATER



ELECTRONIC DESIGN

Fig. 23-5

By converting analog data to digital and using optocouplers, this circuit can be used to transmit analog signals across barriers, such as voltage levels, different ground systems, etc.

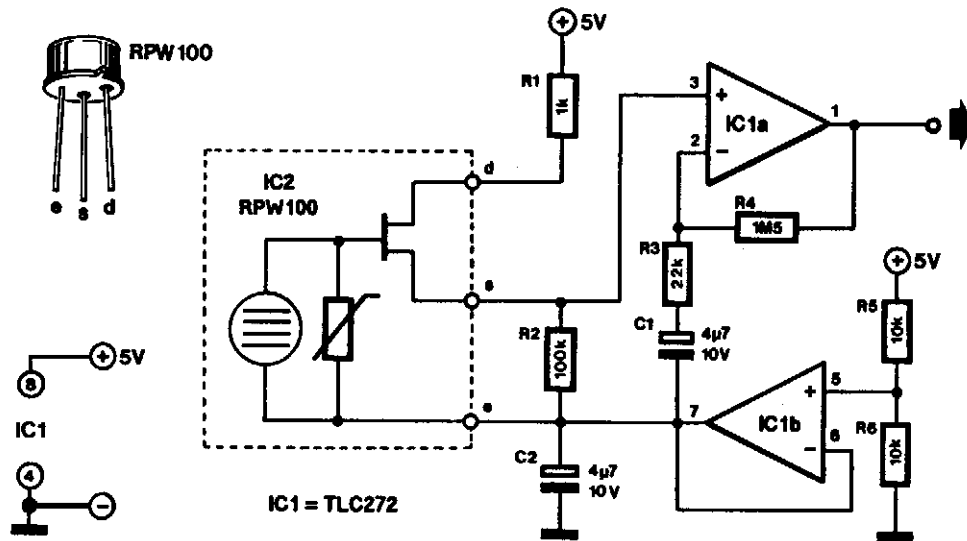
24

Detectors

The sources of the following circuits are contained in the Sources section, which begins on page 664. The figure number in the box of each circuit correlates to the entry in the Sources section.

Thermally Operated Direction Finder	NOAA Weather-Alert Decoder
Two-Sheets Detector	Low-Level Diode Envelope Detector
Metal Detector	Trip-Point Detector and Controller
Metal Detector	AM Envelope Detector
Peak Detector	IC Product Detectors
Undervoltage Detector	Peak Detector
SSB/CW Product Detectors	Air-Pressure Change Detector
RF-Field Detector	Duty-Cycle Detector
Line-Operated Smoke Detector	Op Amp Peak Detector

THERMALLY OPERATED DIRECTION DETECTOR



ELEKTOR ELECTRONICS

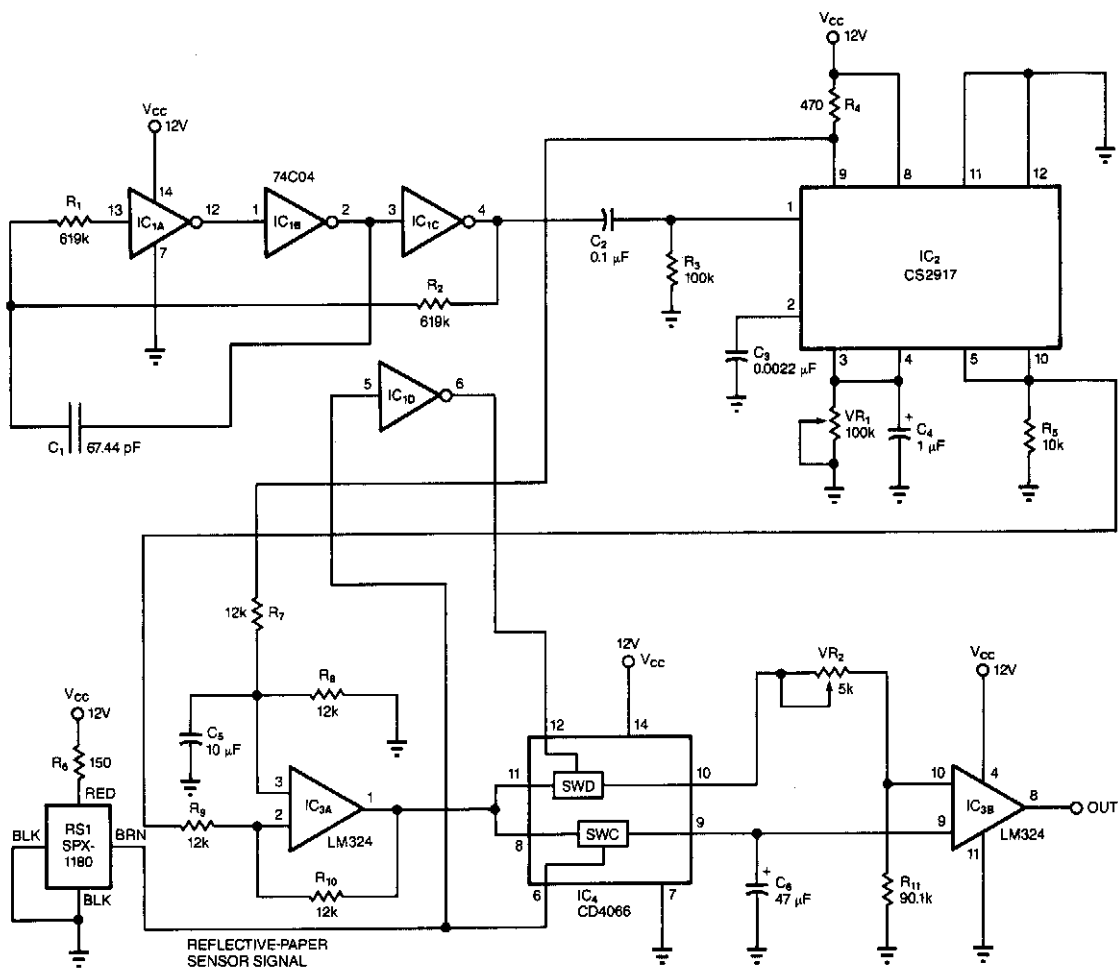
Fig. 24-1

A heat-sensitive sensor can be used to construct a direction detector. Such a sensor reacts to all animal heat. The one used in this design has a sensitive surface that has been divided into two. It, therefore, makes a difference, whether the heat approaches from the left or the right. The indication for cold objects is, of course, exactly the opposite.

Circuit IC1B forms a symmetric supply. Terminal s of the sensor is its output. The signal at s is amplified in IC1A by a factor of about 70 before it is available at the output of the detector.

To obtain good directivity, it is best to place the sensor behind a single narrow slit, rather than behind the usual raster of a multifaceted mirror. The circuit draws a current of only a few mA from a 5-V supply.

TWO-SHEETS DETECTOR

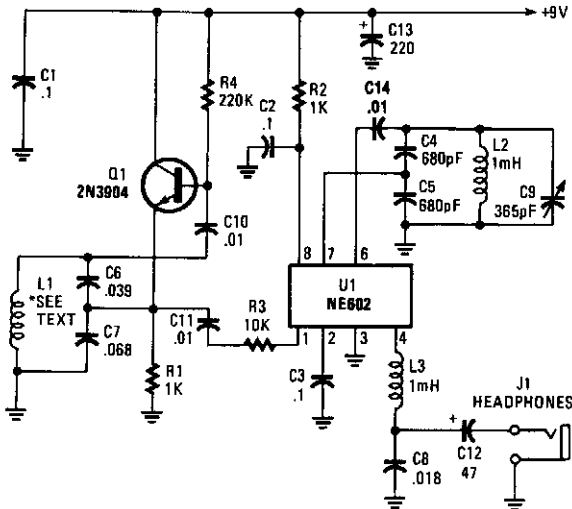


EDN

Fig. 24-2

Using the principle of capacitance between two plates this circuit senses when more than one sheet of paper goes between the sensing electrodes at a time. C1 is the sensing capacitor formed of two plates. It consists of two plates 2" × 15" with 0.1" spacing. A change of capacitance causes a change in oscillator frequency of the IC1 circuit, which is detected by IC2 and IC3.

METAL DETECTOR

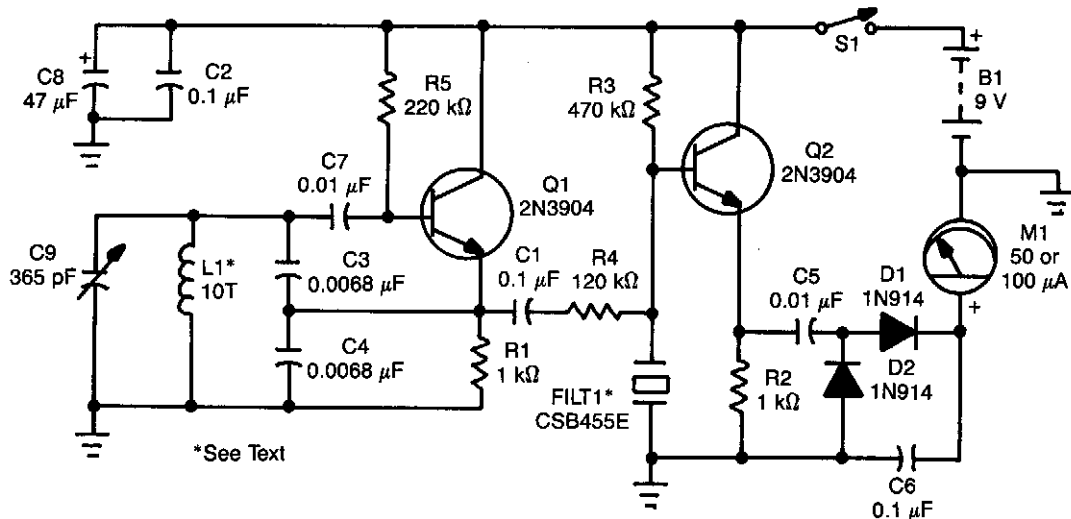


An NE602 acts as a heterodyne detector and Q1 as a sense oscillator. When L1 is brought near metal, it causes a change in loop inductance, shifting the resonant frequency of L1 C6/C7. L1 is 5 turns #20 wire on a 9" diameter wood or plastic form.

POPULAR ELECTRONICS

Fig. 24-3

METAL DETECTOR



POPULAR ELECTRONICS

Fig. 24-4

Using an oscillator running at 455 kHz, the metal-detector circuit produces an indication on the meter M1. When the oscillator frequency changes because of metal in the field of L1, the change will show as an increase or decrease in frequency, which produces a change in the meter reading. The ceramic filter FILT1 produces a selective bandpass that yields this effect. L1 can be a 4" diameter coil wound on a suitable plastic form. About 10 turns of #26 wire are required. Use a frequency counter to adjust L1 and verify that Q1 is operating on or near 455 kHz.

PEAK DETECTOR

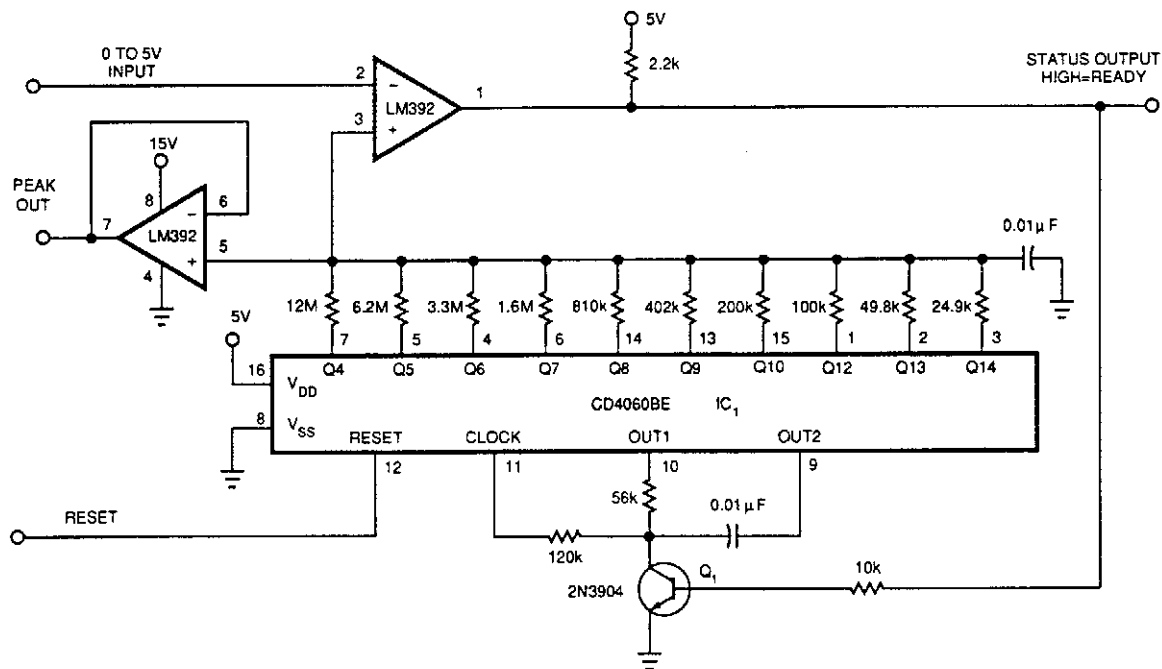
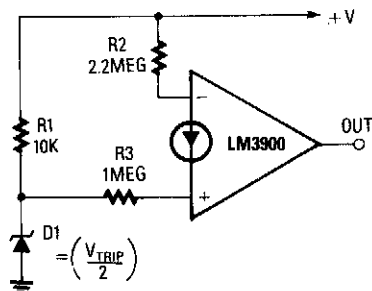


Fig. 24-5

EDN

A 0-to-5 V input drives the negative input of LM392 comparator if reset (pin 12) if DC4060BE is pulled high then low, all outputs of ICF1 are forced low, forcing + input of comparator to go low. Q1 is cut off and IC1's clock oscillator, running at about 775 Hz, starts counting. The Q4 through Q14 outputs connect to a ladder. When the counter reaches a count so that the voltage on pin 3 of the LM392 equals the peak input voltage, the counter stops. This voltage is available at the output of the voltage follower LM392 (pin 7). The maximum time to acquire a peak is 22 seconds. This circuit is slow and was originally intended for battery-charging applications.

UNDERVOLTAGE DETECTOR

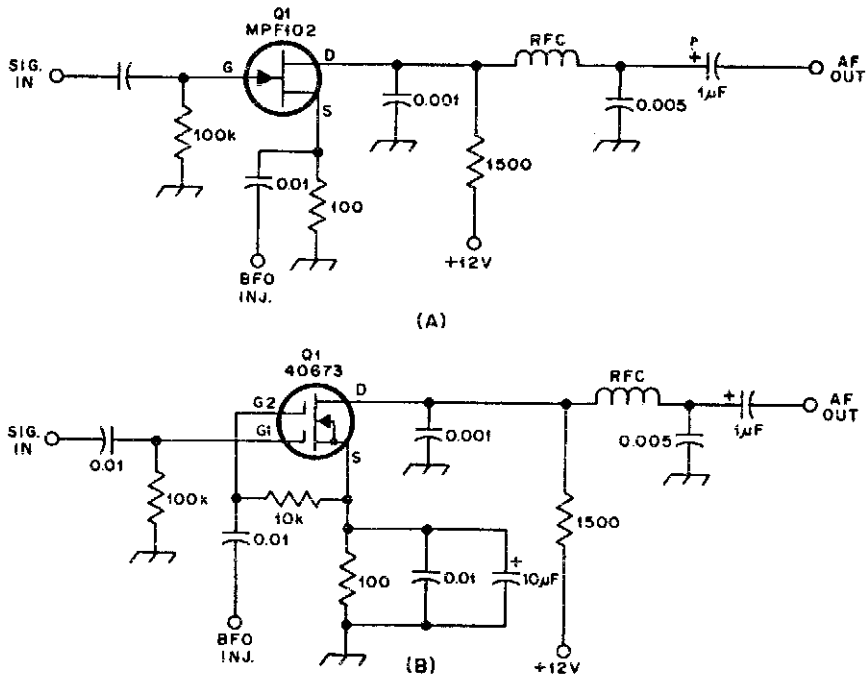


RADIO-ELECTRONICS

Fig. 24-6

The output goes high when the supply falls below a value determined by zener diode D1. If D1 is a 5.6-V zener, the op amp will switch high when the supply voltage falls below approximately 11 V. The precise trip point can be varied by replacing R3 with an 820-kΩ resistor in series with a 470-kΩ potentiometer.

SSB/CW PRODUCT DETECTORS

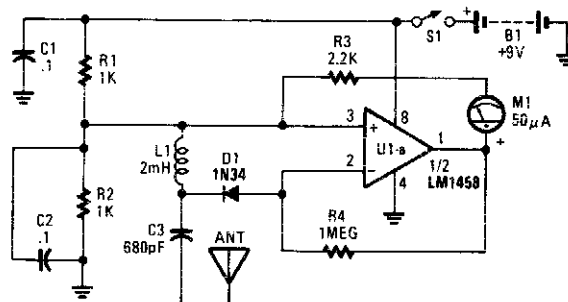


ARRL HANDBOOK

Fig. 24-7

These circuits are used for product detection of single-sideband (SSB) and CW signals. BFO injection is typically 0.5 to 1 V rms for both circuits. Frequencies can be up to 25 MHz or so.

RF-FIELD DETECTOR

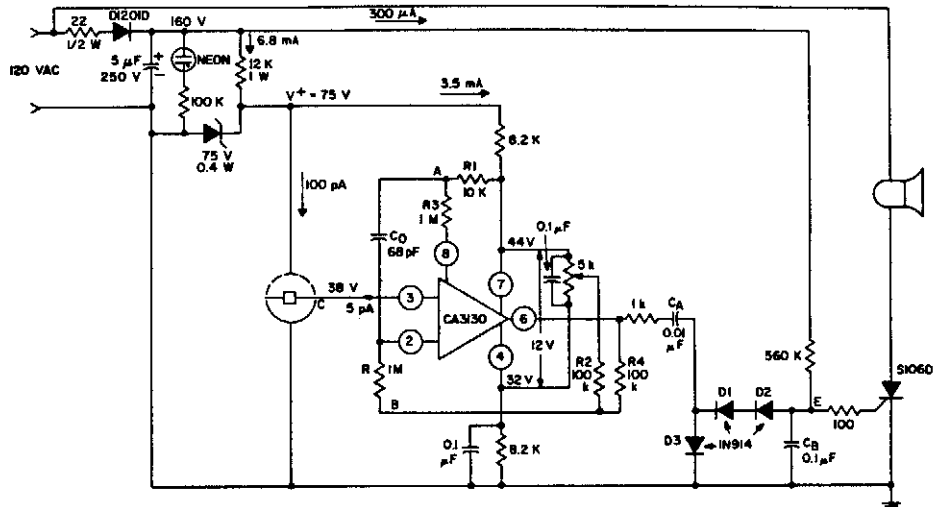


POPULAR ELECTRONICS

Fig. 24-8

This detector is a half-wave rectifier for RF, which then feeds an op amp. U1A acts as an amplifier, driving meter M1. This circuit can detect mW RF levels from below the AM broadcast band to well above the FM broadcast band.

LINE-OPERATED SMOKE DETECTOR

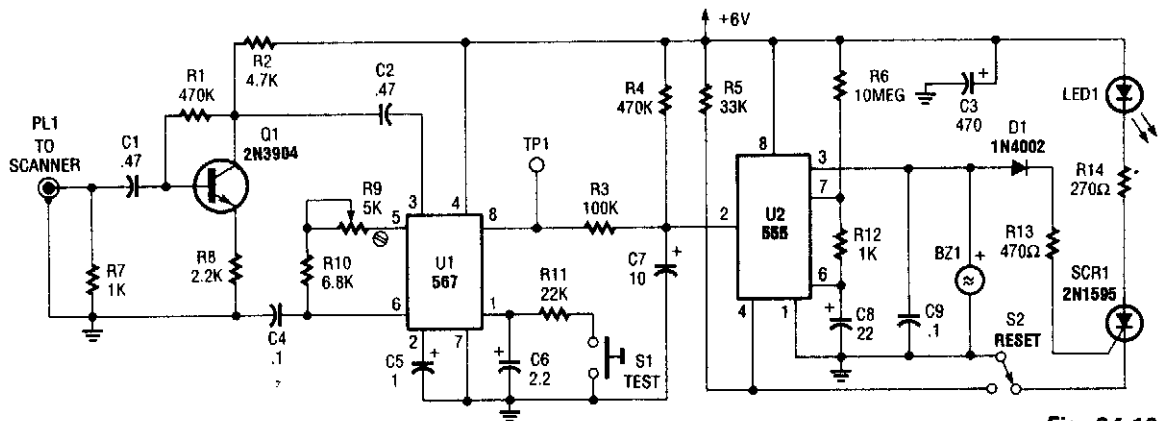


RCA

Fig. 24-9

Using an ionization chamber and a high-impedance (CA3130) op amp, the presence of smoke will cause the CA3130 to stop oscillating, triggering S106D SCR, sounding the alarm.

NOAA WEATHER ALERT DECODER



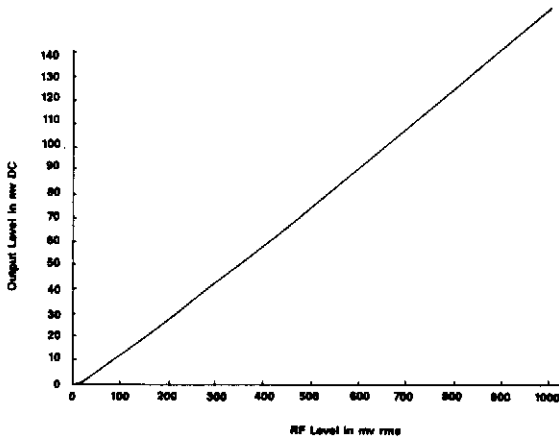
POPULAR ELECTRONICS

Fig. 24-10

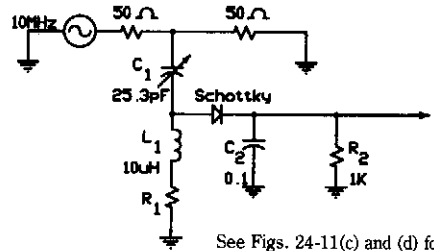
This circuit detects the 1050-Hz tone sent by the NOAA (National Oceanic and Atmospheric Administration) Weather radio stations that operate from 162.40 to 162.55 MHz. This tone lasts for several seconds. Q1 is an amplifier that feeds tone detector U1, an NE567 detects this tone and produces a low on pin 8. This is coupled to a 555 timer (U2), which produces a high on its pin 3, sounds BZ1, triggers SCR1, and lights the LED. S2 is used to rest the circuit.

Audio is taken from the receiver that is used with the device. S1 is used to test the device and it will sound the alarm in two seconds if all is OK.

LOW-LEVEL DIODE ENVELOPE DETECTOR



Envelope detector response.



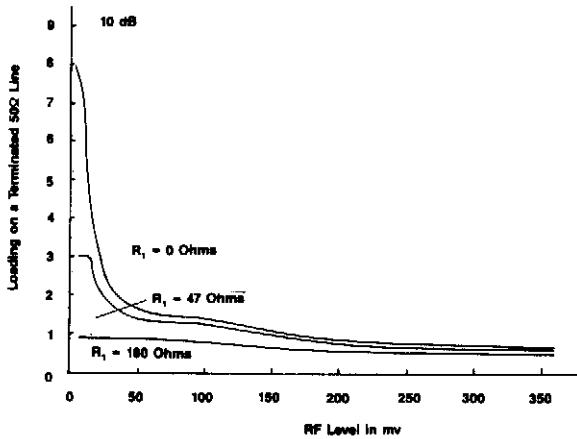
See Figs. 24-11(c) and (d) for values of R_1

Low-level envelope detector with lower L/C ratio to illustrate the effect of R .

Fig. 24-11(c)

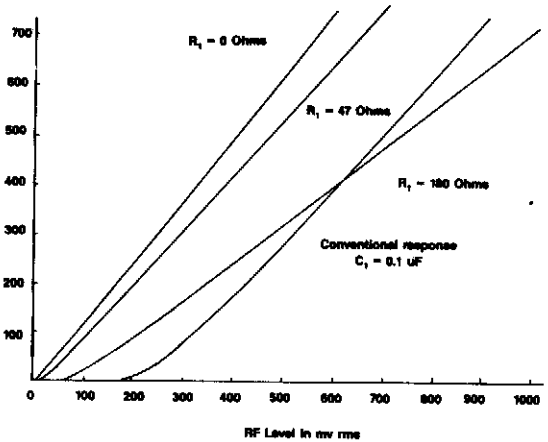
RF DESIGN

Fig. 24-11(a)



Terminated 50-ohm line.

Fig. 24-11(b)



Envelope detector response for 3 values of R .

Fig. 24-11(d)

An approach to low-level RF detection and performance curves is shown here. This design is for 10 MHz, but values can be scaled to other frequencies, if needed.

DETECTOR AND CONTROLLER

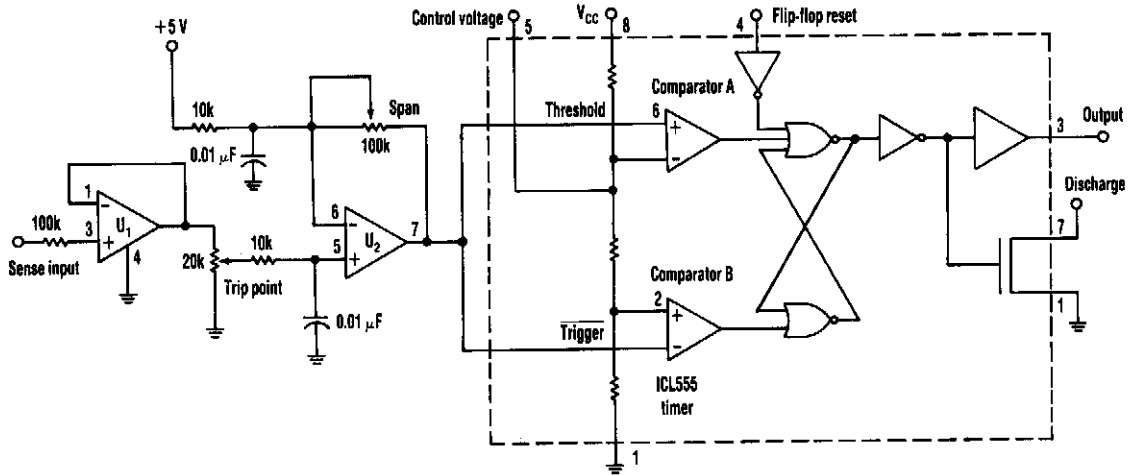


Fig. 24-12

ELECTRONIC DESIGN

Many applications require analog signals to be sensed and digital signals to be controlled. A way to detect these points is by using a 555 timer in an unconventional configuration. This method will also add hysteresis to the circuit and guard against oscillation. The 555 supplies two comparators and a flip-flop eliminates the oscillation. Using this classic timer in the new configuration also reduces the component count.

The circuit shows the 555's trigger and threshold pins tied together. This enables the comparators to set and reset the flip-flop. Op amp U2 supplies both the trip-point setting and a way to adjust the hysteresis for ON and OFF points. One application where this circuit would be useful is in a Nicad battery-charge controller.

AM ENVELOPE DETECTOR

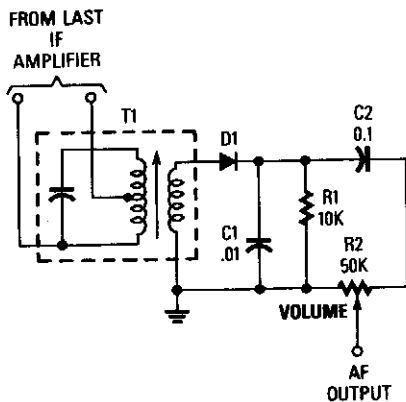
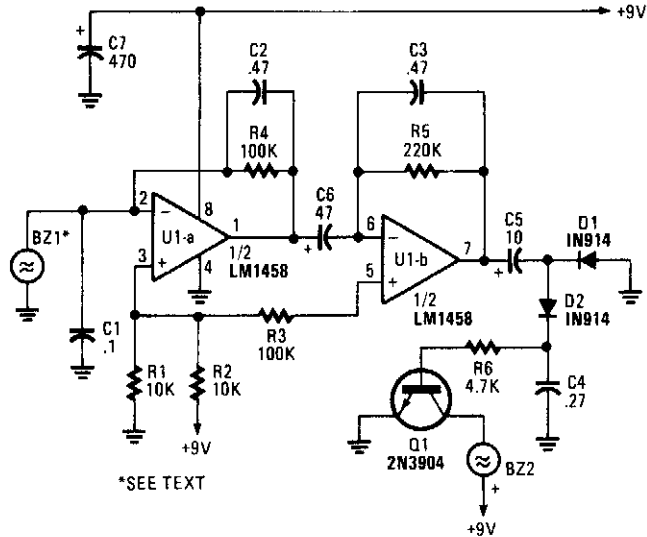


Fig. 24-13

This general-purpose detector for AM envelope detection can be used in many receiver applications. T1 matches the IF amplifier impedance (typically 1 to 10 kΩ) to the 1 kΩ (approximately) detector impedance. D1 can be an IN60, IN82AG, IN270, or a similar type.

AIR-PRESSURE CHANGE DETECTOR

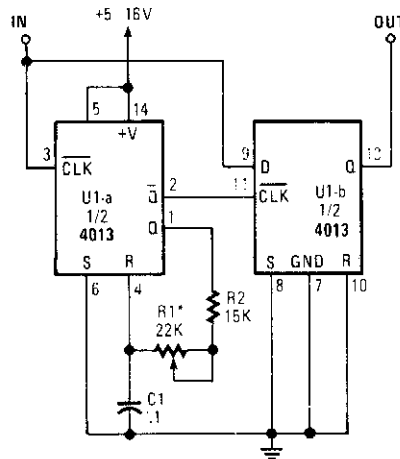


POPULAR ELECTRONICS

Fig. 24-16

A piezoelectric detector (BZ1) is used in this circuit to detect a change in air pressure. BZ1 produces a voltage that is amplified by U1A and U1B. Frequency response is limited to low frequencies. The signal is rectified by D1 and D2 and drives Q1, which activates BZ2, a piezoelectric buzzer.

DUTY-CYCLE DETECTOR

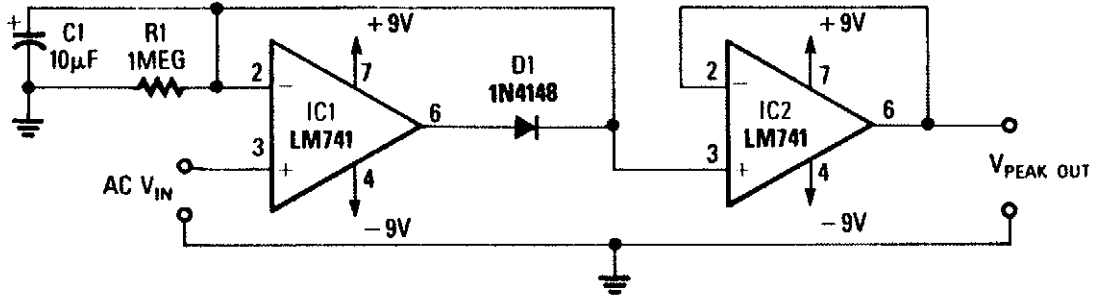


POPULAR ELECTRONICS

Fig. 24-17

This circuit looks at the time an incoming pulse is high. If the incoming pulse is shorter than the adjusted (VAR1) pulse, the output of U1B is high. Values are shown for a 1-to 2- μ s pulse.

OP AMP PEAK DETECTOR



RADIO-ELECTRONICS

Fig. 24-18

The output of this circuit will be a voltage that is equal to the peak of the input. D1 and C1 detect the peak voltage and this is read by the IC2 voltage follower.

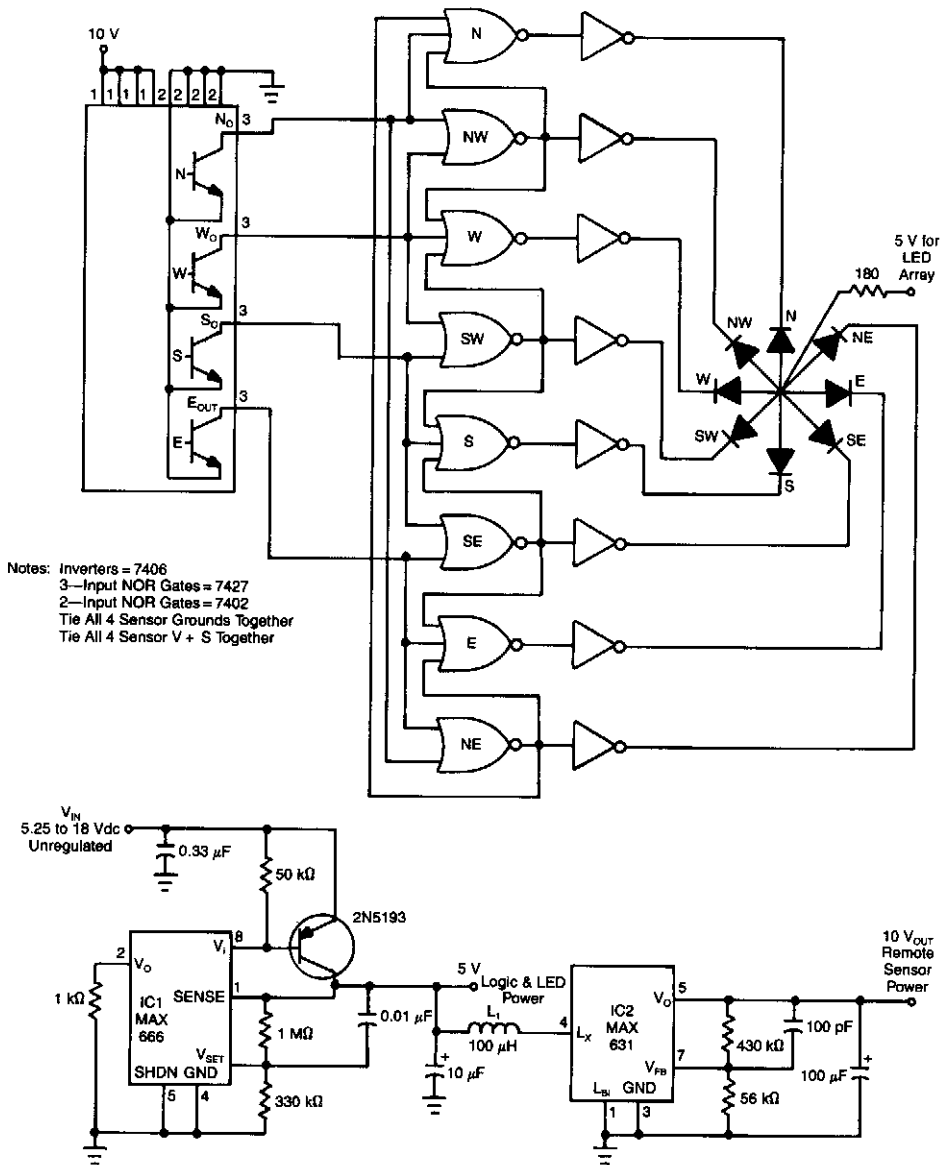
25

Direction Finders

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

Digital Compass
Radio Direction Finder

DIGITAL COMPASS



EDN

Fig. 25-1

A four output Hall sensor combined with a few logic gates produce this digital compass. The NOR gates resolve the four Hall outputs into eight distinct compass directions. LEDs to indicate direction are driven by eight inverters. A power supply for 5.25- to 18-Vdc operation is shown in the figure.

RADIO DIRECTION FINDER

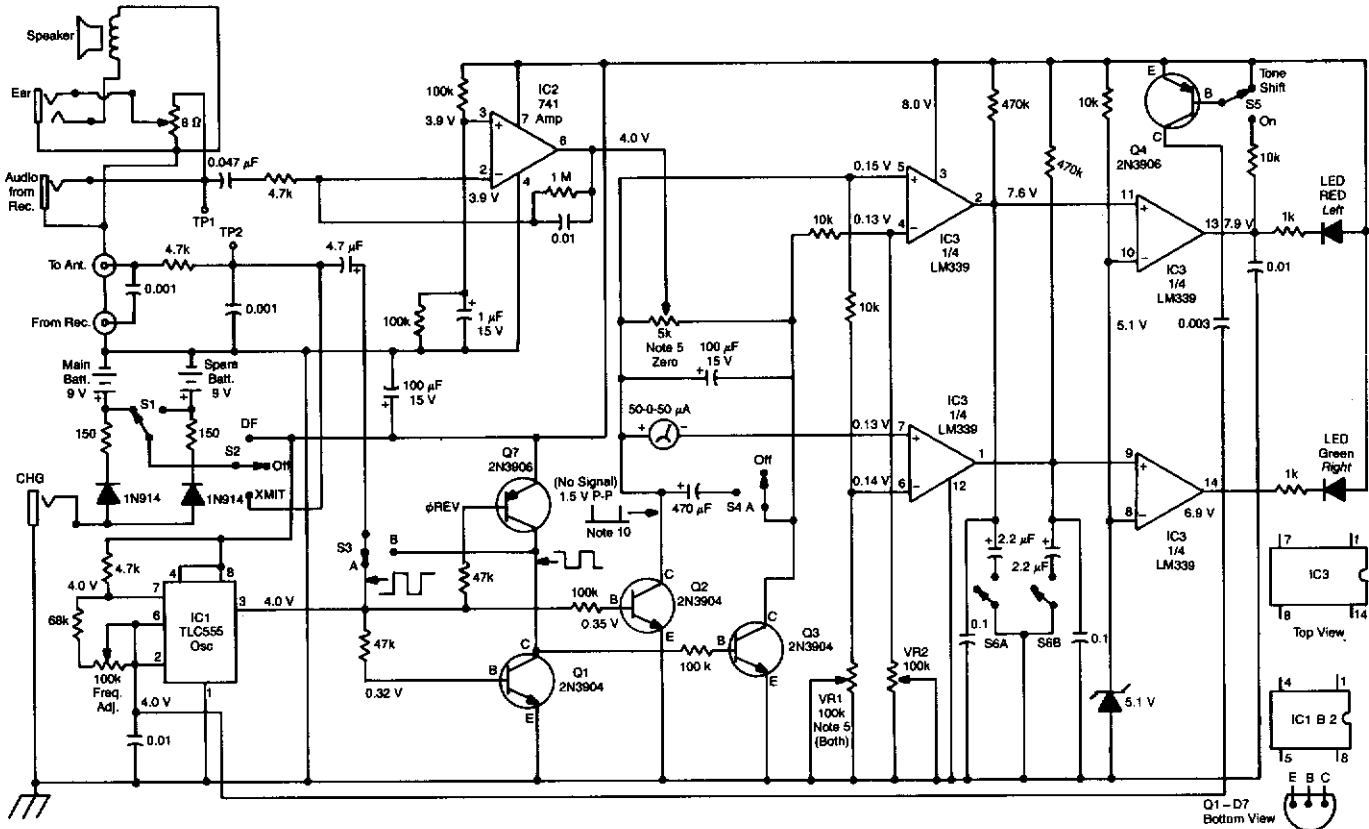
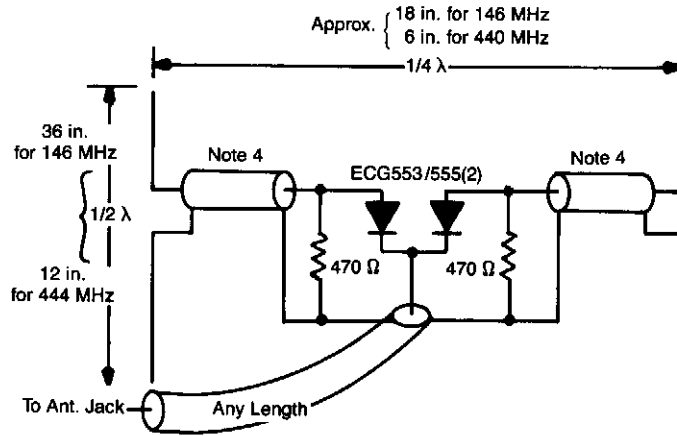
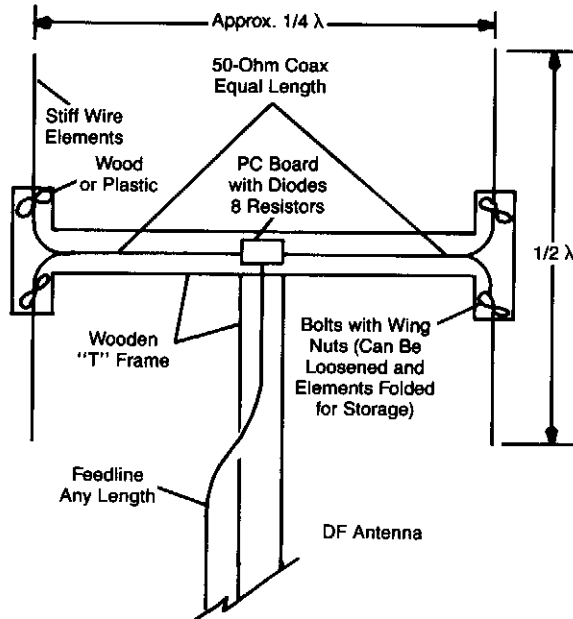


Fig. 25-2

RADIO DIRECTION FINDER (Cont.)



Antenna construction.



Mechanical mounting details.

73 AMATEUR RADIO

Fig. 25-2

This RDF circuit consists of a square-wave oscillator (IC1), which switches two antennas alternately at an audio rate. A phase detector (Q1, 2, 3, 7) is used to compare receiver output amplified by IC2 with the reference phase from IC2 with the reference phase from IC1. A 50- μ A meter is used as a left-right indicator. IC3 is a comparator used to drive indicator LEDs.

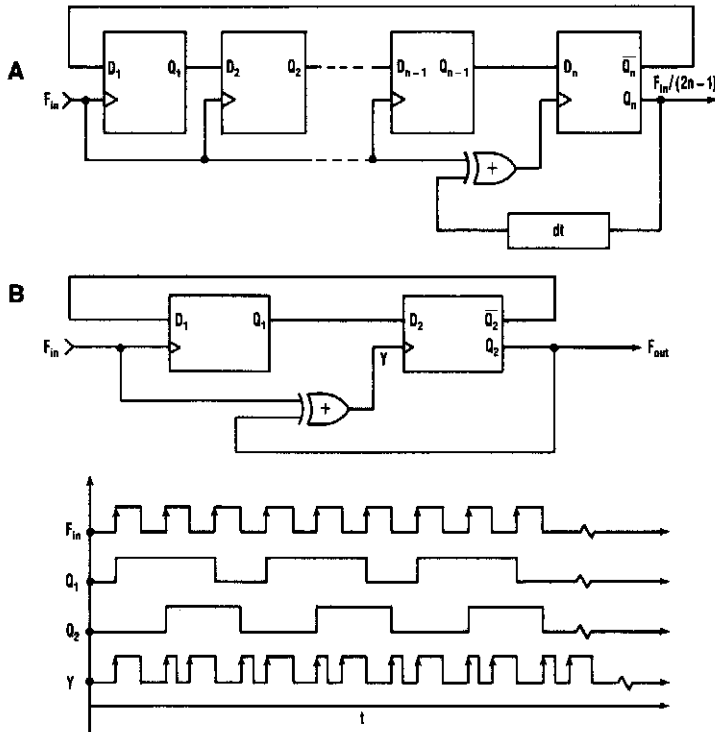
26

Dividers

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

Clock Input Frequency Divider
Programmable Frequency Divider
Divide-by-Odd-Number Counter
7490 ÷ N Circuits
Divide-by-2-or-3 Circuit
1 + -GHz Divide-by- N Counter
Divide-by- $N + 1/2$ Circuit

CLOCK INPUT FREQUENCY DIVIDER



1. THE INPUT CLOCK frequency fed into this circuit is divided by $2n - 1$. The circuit consists of n clocked flip-flops and one exclusive-OR gate. The dt delay is zero in most cases.

2. THIS CIRCUIT CONFIGURATION divides the input frequency by three (a). The circuit's timing diagram verifies the division (b).

ELECTRONIC DESIGN

Fig. 26-1

ICA, R1 through R3, and Q1 form a current source. The current that charges C1 is given by:

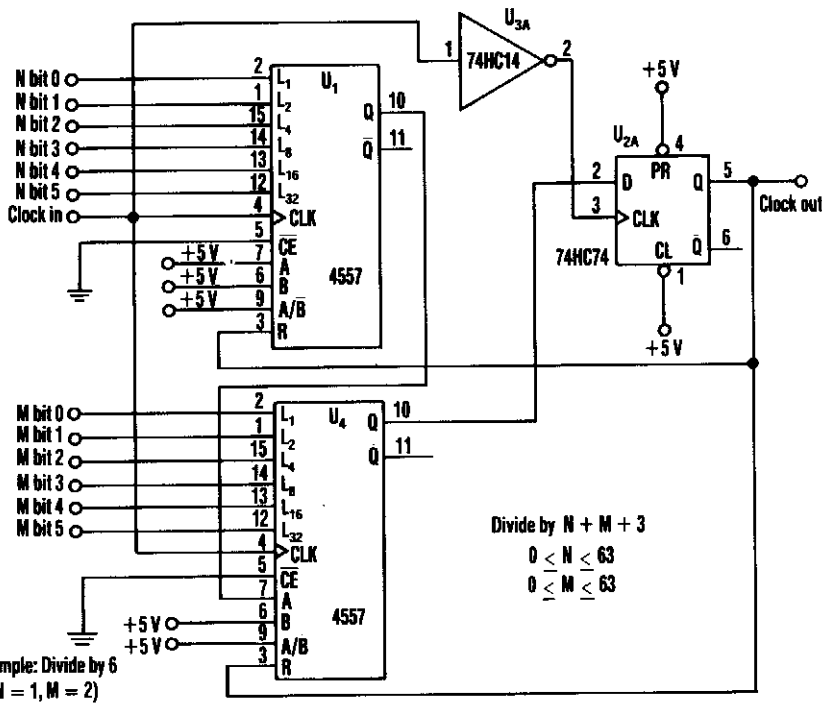
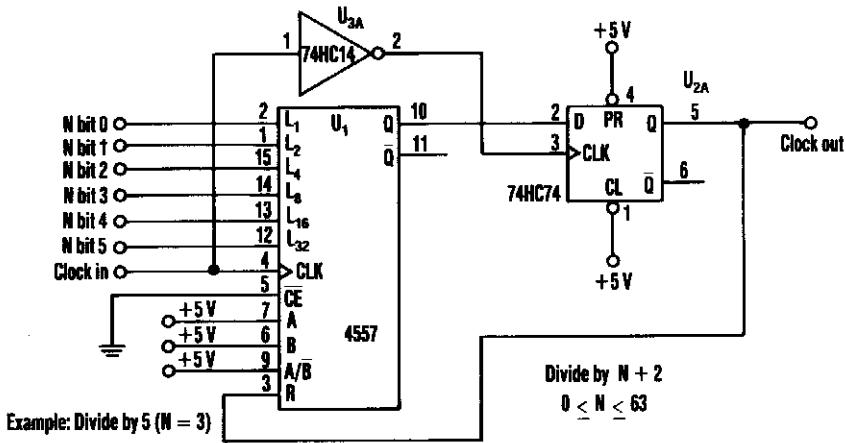
$$\begin{aligned}
 I &= \frac{(V_D \times R_1)}{(R_1 + R_2) \times R_3} \\
 &= \frac{(15 \times 3 \text{ k}\Omega)}{(3 \text{ k}\Omega + 12 \text{ k}\Omega) \times 470 \text{ k}\Omega} \\
 &= 6.4 \mu\text{A}
 \end{aligned}$$

The input signal drives ICD. Because ICD's positive input (V_+) is slightly offset to $+0.1 \text{ V}$, its steady-state output will be near $+13 \text{ V}$. This voltage is sent to ICC through D2, setting ICC's output to $+13 \text{ V}$. Therefore, point D is cut off by D1, and C1 is charged by the current source. Assuming the initial voltage on C1 is zero, the maximum voltage ($V_{C_{\max}}$) is given by:

$$t_{w_{\text{clk}}} > t_{p_{\text{ff}}} + dt + t_{p_{\text{or}}} + t_{w_{\text{ff}}}$$

The right side of the inequality should be the minimum pulse width (either up time or down time) of the input clock. The circuit, when constructed with standard 74F-type parts, operates without any added delay in the exclusive-OR feedback path and with an input frequency of up to 22.5 MHz . The circuit's output signal will have the same duty cycle as the input clock.

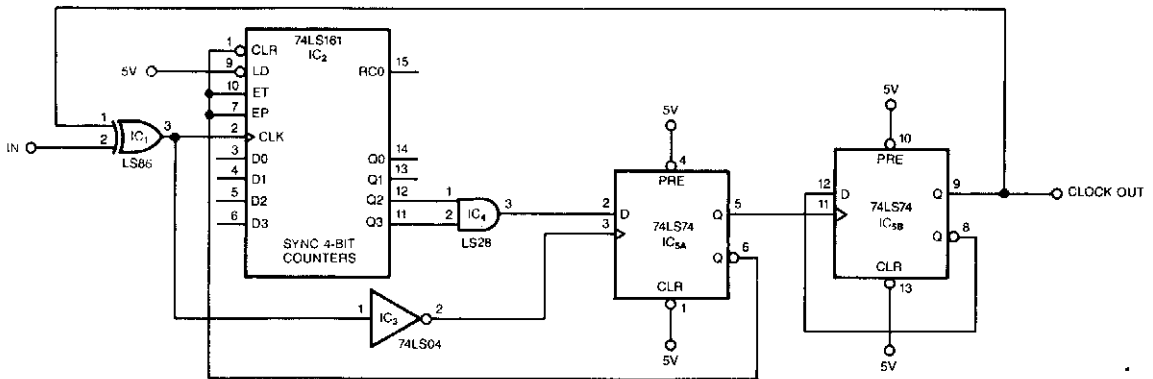
PROGRAMMABLE FREQUENCY DIVIDER



PROGRAMMABLE FREQUENCY DIVIDER (Cont.)

This divider uses a variable-length shift register, a type-D flip-flop, and an inverter. The clock feeds the flip-flop clock input and the output of the shift register feeds the D input of the flip-flop. The FF output is tied back to the reset input of the shift register so that each clock pulse shifts a "1" into the 4557. $N + 1$ cycles after the reset pulse is removed. The first "1" will propagate through the register output. The "1" is latched into the FF on the clock's next falling edge and fed back to the 4557 reset pin, which resets the shift register to zero. When a zero is clocked into the flip-flop on the next falling clock edge, the reset is removed, restarting the process. The divide ratio is $(N + 2)$, where N = the binary number that is programmed into 4557.

DIVIDE-BY-ODD-NUMBER COUNTER



EDN

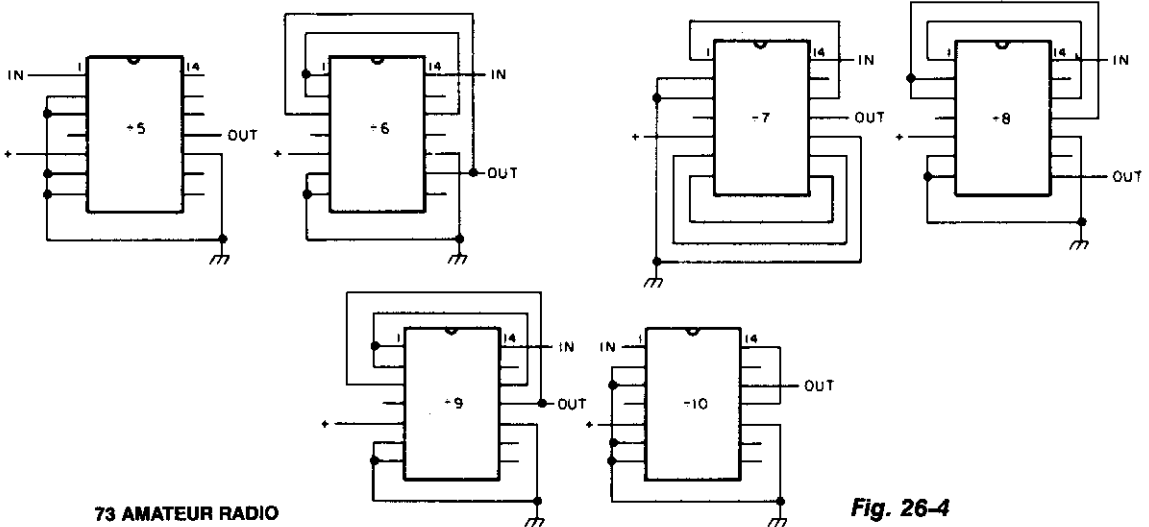
Fig. 26-3

This circuit symmetrically divides an input by virtually any odd number. The circuit contains $n + 1/2$ clocks twice to achieve the desired divisor. By selecting the proper n , which is the decoded output of the 74LS161 counter, you can obtain divisors from 3 to 31. This circuit divides by 25; you can obtain higher divisors by cascading additional LS161 counters.

The counter and IC5A form the $n + 1/2$ counter. Once the counter reaches the decoded counts, n , IC5A ticks off an additional $1/2$ clock, which clears the counter and puts it in hold. Additionally, IC5A clocks IC5B, which changes the clock phasing through the XOR gate, IC1. The next edge of the input clocks IC5A, which reenables the counter to start counting for an additional $n + 1/2$ cycles.

Although the circuit has been tested at 16 MHz, a worst-case timing analysis reveals that the maximum input frequency is between 7 and 8 MHz.

7490 ÷ N CIRCUITS



73 AMATEUR RADIO

Fig. 26-4

A 7490, 74LS90, 74C90, etc., is a decade divider, but it can be configured to divide by any N up to 10. The above figures illustrate the connections necessary to divide by N from 5 to 10.

DIVIDE-BY-2-OR-3 CIRCUIT

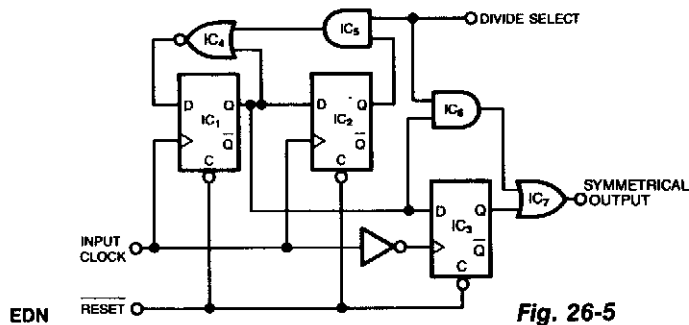


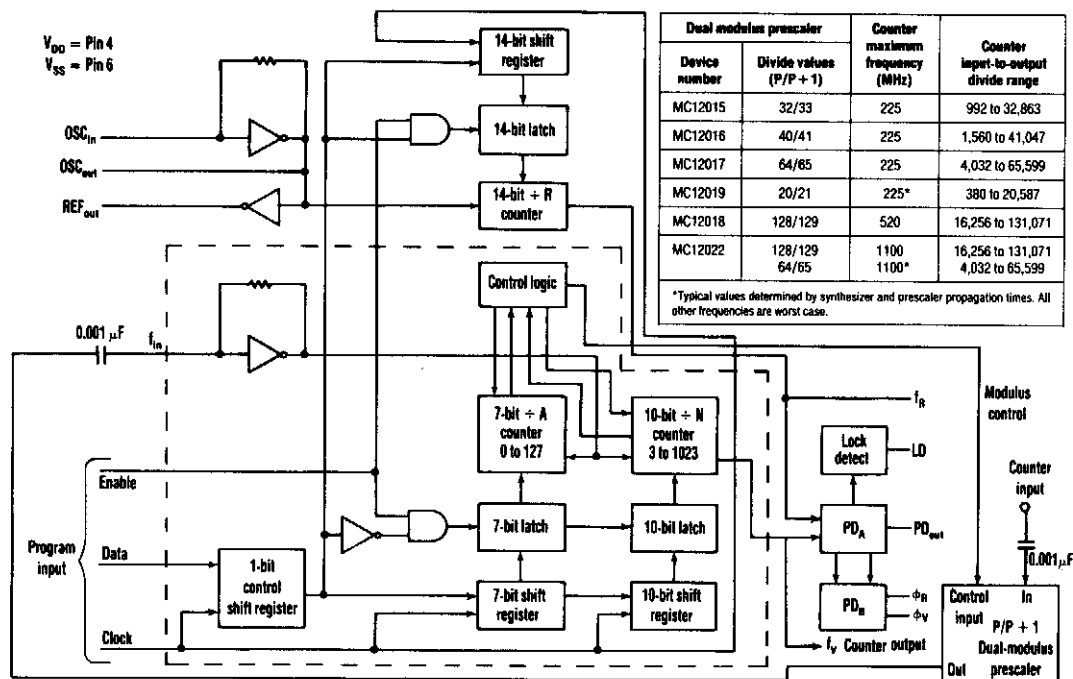
Fig. 26-5

This circuit produces a symmetrical waveform when dividing by either 2 or 3. The Divide Select input controls the division factor. When Divide Select is high, flip-flops IC1 and IC2, along with associated gates, form the classical divide-by-3 circuit.

When divide select is low, however, the output of the AND gate, IC5, goes low. Consequently, the NOR gate, IC4, inverts the feedback signal and passes it to the D input of the flip-flop, IC1. Now, IC1 acts like a toggle flip-flop and produces a divide-by-2 output.

IC3, which is, in effect, a negative-edge-triggered flip-flop, provides symmetrical output signals. When you select division by 2 (Divide Select is low), the output and AND gate IC6 is low, and IC3 simply clocks out the divider's output, delayed by one clock period. When you set Divide Select high, the path to the output through the AND and OR gates, IC6 and IC7, is enabled. This path means that the output goes high on the leading edge of IC3's input (not its output) and produces a symmetrical divide-by-3 output.

1 + -GHz DIVIDE-BY-N COUNTER



ELECTRONIC DESIGN

Fig. 26-6

Counter speeds for CMOS- and TTL-programmable counters are limited to under 100 MHz. ECL-type devices can approach a few hundred MHz, but with significant current requirements. However, coupling the dual-modulus-prescaling technique with the available phase-locked-loop synthesizer chips that control the prescaler circumvents these frequency and power-drain constraints.

With this approach, designers can also choose various counter-programming schemes (serial, parallel, or data bus), in addition to achieving higher frequency capabilities. Low-power drain (less than 75 mW) and low-cost devices can also be selected. Moreover, only two ICs are necessary to achieve divide values above 131 000.

Maximum input frequency and dividing range for the counter are controlled by choosing an appropriate 8-pin dual-modulus prescaler. The counter's output appears at synthesizer pin F_V (see the figure). The total input-to-output divide value is governed by the equation:

$$N_{\text{TOTAL}} = N \times P + A$$

N and A represent the value programmed through the serial port into the divide-by- N and divide-by- A counters. P is the lower dual-modulus value that is established by the synthesizer's modulus-control signal.

Typically, A varies from zero to $P - 1$ to achieve steps within the system's divide range. N must be equal to or greater than A . $N > A$ then sets a lower limit on N_{TOTAL} , which is dictated by $A_{\text{MAX}} = P - 1$.

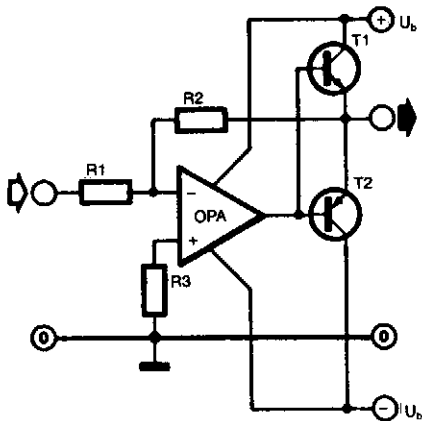
27

Driver Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

Op Amp Power Driver
Emitter/Follower LED Driver
Flip-Flop Independent Lamp Driver

OP AMP POWER DRIVER



ELEKTOR ELECTRONICS

Fig. 27-1(a)

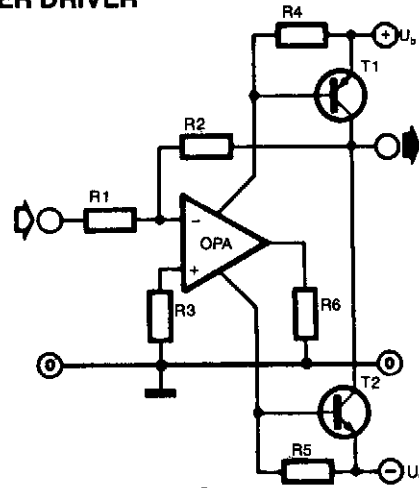


Fig. 27-1(b)

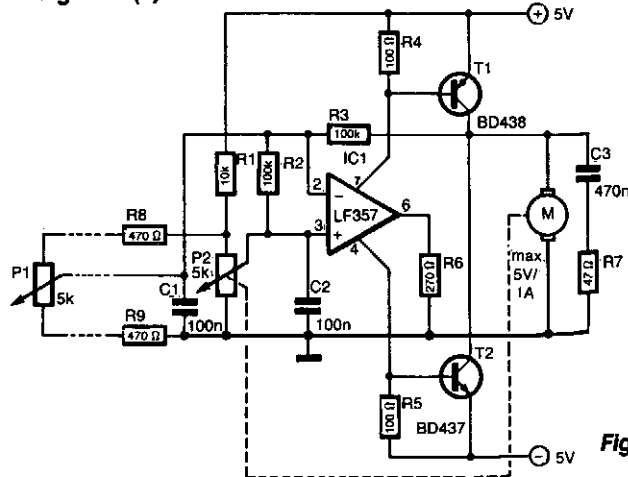


Fig. 27-1(c)

Frequently, the output current of an operational amplifier is inadequate for the application as, for instance, when a small motor or loudspeaker has to be driven. Normally, this is resolved by adding an emitter follower to the circuit as shown in Fig. 27-1(a). Unfortunately, that circuit does not allow the full supply voltage, U_b , to be used, because the output voltage of the op amp must always be 1 to 2 V smaller than $\pm U_b$. To that must be added the drop across the base-emitter junction of transistors T1 and T2.

The circuit shown in Fig. 27-1(b) (principle) and Fig. 27-1(c) (practical) is a more appropriate solution: it was designed specifically for driving small motors. Since the output current of the op amp flows through its supply lines, the driver transistors may also be controlled over these lines.

The value of base-emitter resistors R4 and R5 has been chosen to ensure that in spite of the quiescent current through the op amp, T1 and T2 are switched off. Resistor R6 limits the output current of the op amp. If the op amp is a type with guaranteed short-circuit protection, R6 may be replaced by a jump lead.

The output voltage is only 50 to 100 mV (collector-emitter saturation voltage of the driver transistors) smaller than the supply voltage. When choosing these transistors, it is therefore essential to take into account the saturation voltage (in addition to the maximum current amplification and power rating).

OP AMP POWER DRIVER (Cont.)

The value of the resistors in an inverting circuit is calculated from:

$$\alpha = \frac{R_2}{R_1}$$

and:

$$R_3 \approx \frac{R_2}{R_1}$$

where α is the amplification.

In a noninverting circuit (R_1 between the $-$ input and ground and the input signal connected to the $+$ input of the op amp), the amplification is:

$$\alpha = \frac{R_2}{(R_1 + 1)}$$

and:

$$R_3 < < R_e$$

$$R_4 < \frac{+\alpha}{= U_b}$$

$$R_5 < \frac{-0.5\alpha}{U_b}$$

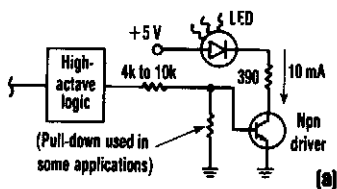
$$R_6 \approx \frac{U_b}{I_{\max}}$$

where R_e is the input impedance of the op amps.

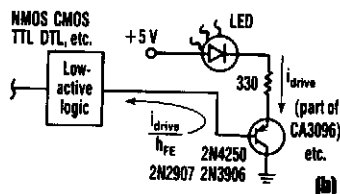
The circuit can be used with discrete (single) op amps only, because double or quadruple types in one package share the supply voltage pins. The setting accuracy of the circuit in Fig. 27-1(c) is better than 1%.

EMITTER/FOLLOWER LED DRIVER

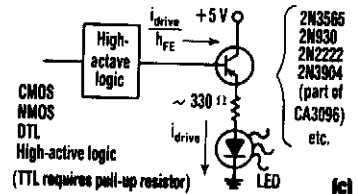
TYPICAL NPN LED DRIVER



PNP EF LED DRIVER



NPN EF DRIVER

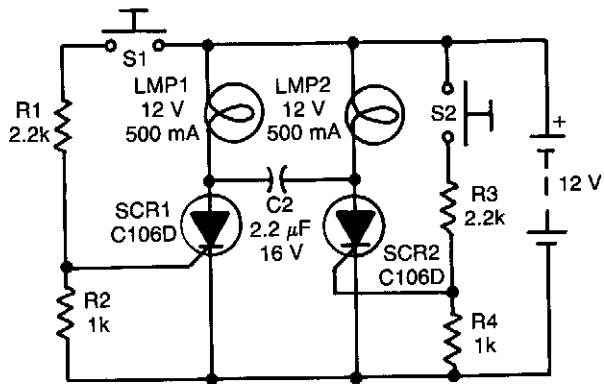


ELECTRONIC DESIGN

Fig. 27-2

Using emitter/followers saves parts and simplifies LED driver circuits and generally produces less loading on logic circuitry.

FLIP-FLOP INDEPENDENT LAMP DRIVER



RADIO-ELECTRONICS

Fig. 27-3

Assume first that SCR1 is on and SCR2 is off so that C1 is fully charged, with its LMP2 end positive. The state of the circuit can be changed by pressing S2. As SCR2 turns on, it turns SCR1 off capacitively via its anode. Capacitor C1 then recharges in the opposite manner (i.e., the left end is now positive). The state of the circuit can be changed again by pressing S1, thus driving SCR1 on by way of its gate, and driving SCR2 off capacitively via its anode.

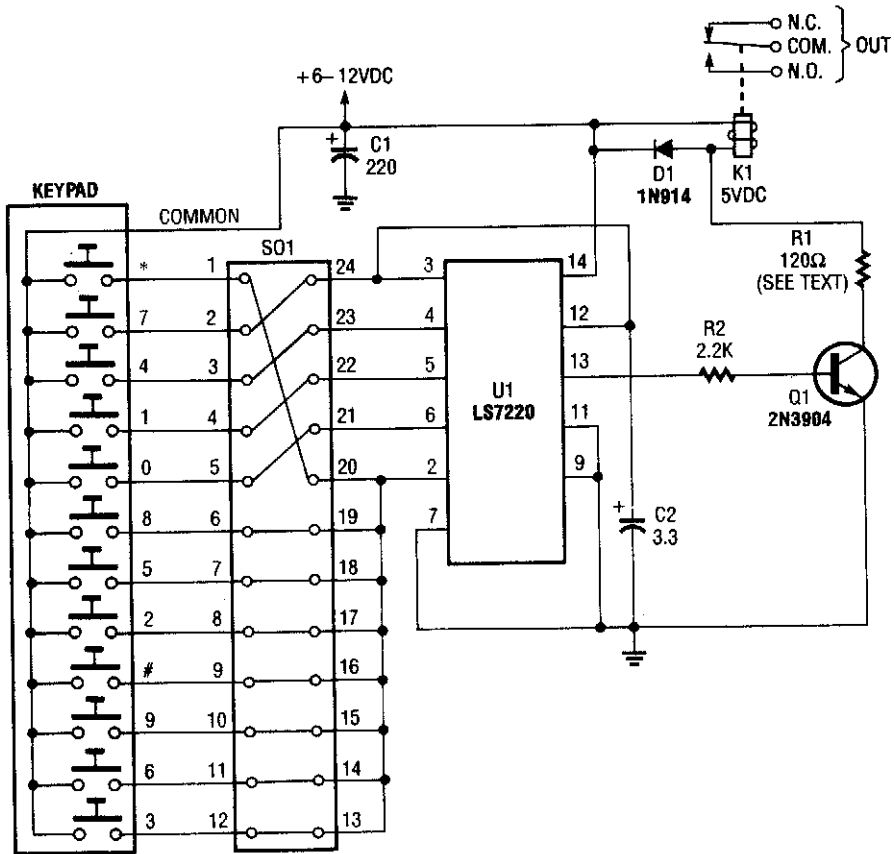
28

Electronic Locks

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

Digital Entry Lock
Keyless Lock

DIGITAL ENTRY LOCK

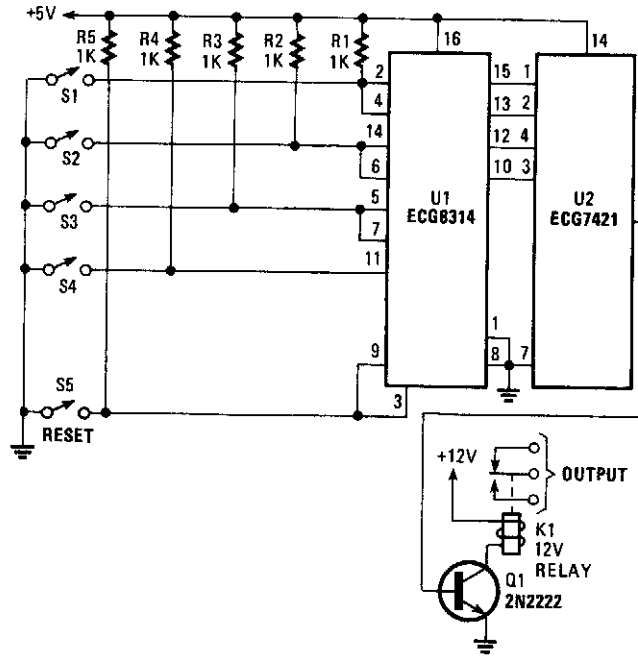


POPULAR ELECTRONICS

Fig. 28-1

A keypad enters a four-digit access code, which is programmed via jumpers on a 24-pin plug-in header and socket. U1 is an LST220, which detects a four-digit sequential data input. When the correct data is entered into the keyboard, pin 13 of U1 goes high, which activates Q1 and K1. K1 drives an external electric lock solenoid, etc.

KEYLESS LOCK



POPULAR ELECTRONICS

Fig. 28-2

The circuit uses a four-bit latch (U1). What makes the circuit sequential is that the set input of the first bit latch is tied to the reset of the second bit latch, and so forth. That ensures that any bit latched will be reset by the previous bit latch. The ECG8314 also has a master reset (pin 9) that is tied to the first bit-latch reset (pin 3), which provides an added measure of security for the lock.

The outputs of U1 are fed to a four-input AND gate (U2), then to Q1 (used as switching transistor), which is used to drive relay K1. The EGC8314 has an enable low (pin) that can be used as a timing circuit, if that is desired.

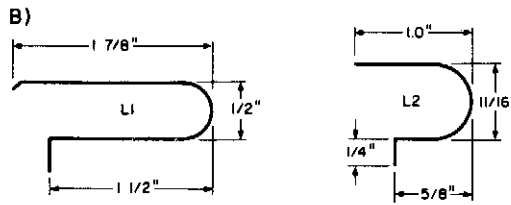
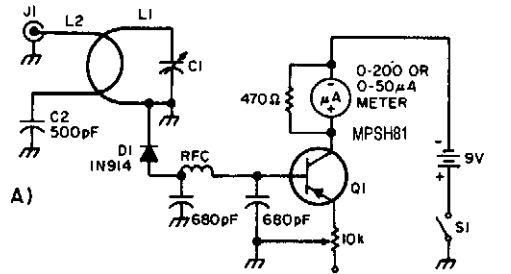
29

Field-Strength Meters

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

UHF Field-Strength Meter
Field-Strength Meter
Signal-Strength Meter

UHF FIELD-STRENGTH METER



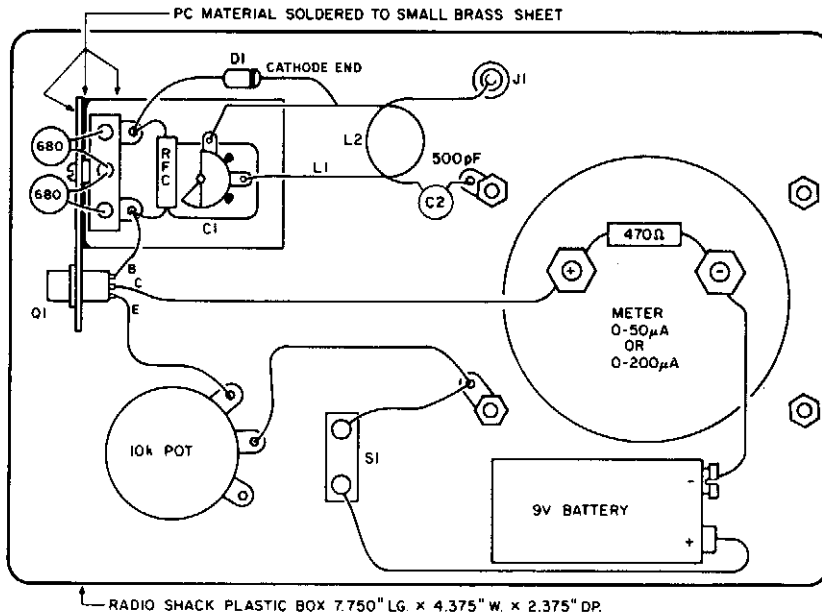
AMATEUR RADIO

3/8" WIDE BRASS

#14 BARE COPPER WIRE

Fig. 29-1(a)

Field strength meter schematic.



AMATEUR RADIO

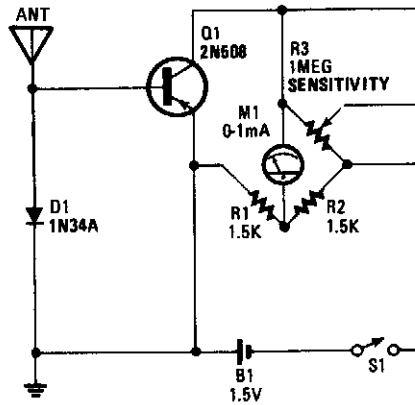
RADIO SHACK PLASTIC BOX 7.750" LG. x 4.375" W. x 2.375" DP.

Fig. 29-1(b)

Parts layout for the field strength meter.

Useful for transmitter or antenna alignment, this meter covers 400 to 500 MHz. An amplifier stage is included for improved sensitivity. Follow the layout in Fig. 29-1(b).

FIELD-STRENGTH METER

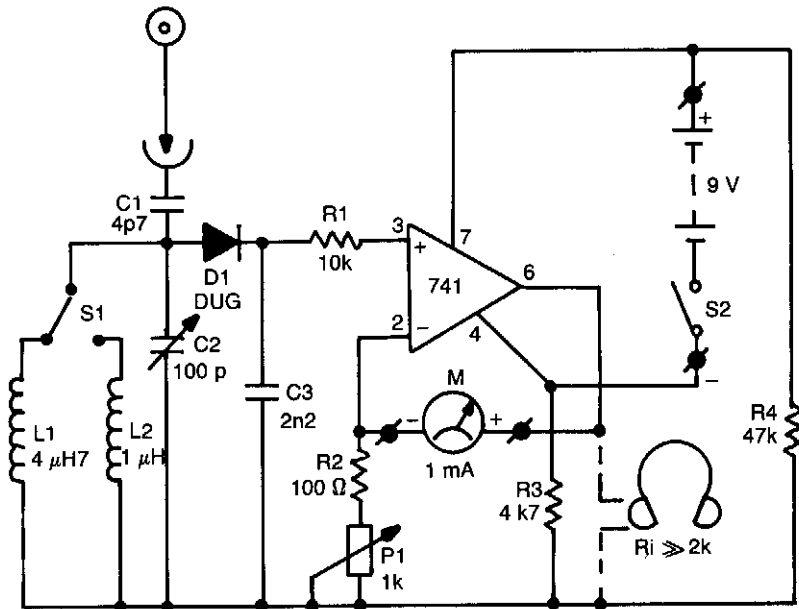


POPULAR ELECTRONICS

Fig. 29-2

This field-strength meter is basically a bridge circuit that is equipped with a 0-to-1-mA meter as a readout.

SIGNAL-STRENGTH METER



ELEKTOR ELECTRONICS

Fig. 29-3

This field-strength meter is useful for antenna testing. It covers 6 to 60 MHz and uses a rugged 0-to-1 mA meter. A 9-V battery supplies power. The unit can be mounted in a small plastic or metal case.

30

Filter Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 665. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Fast-Response (settling) Low-Pass Filter
- Tunable Audio Filter
- Turntable Rumble Filter
- Tunable Bandpass Filter
- Low-Cost Crystal Filters
- Antialiasing and Sync-Compensation Filter
- Two-Section 300-to-3 000 Hz Speech Filter
- 300-to-3 400 Hz Second-Order Speech Filter
- Fourth-Order 100-Hz High-Pass Filter
- Simple Ripple Suppressor
- Second-Order 100-Hz High-Pass Filter
- Scratch Filter
- Simple Rumble Filter
- 1 000:1 Tuning Voltage-Controlled Filter
- Two Sallen-Key Low-Pass Active Filter

FAST-RESPONSE (SETTLING) LOW-PASS FILTER

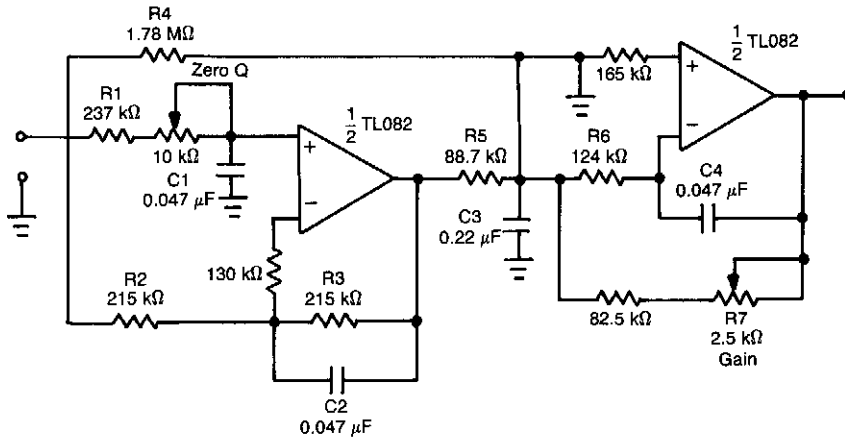


Fig. 30-1(a)

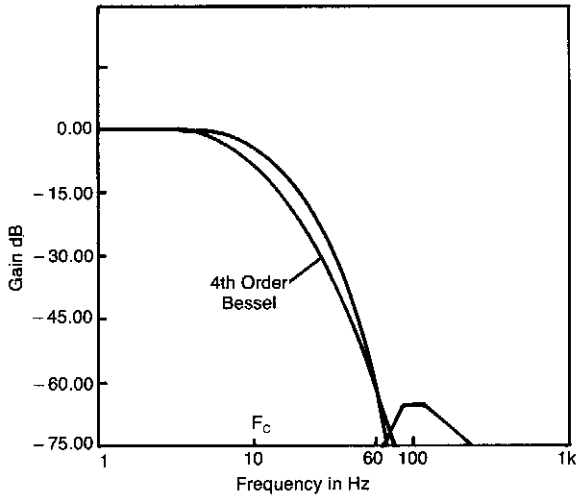


Fig. 30-1(b)

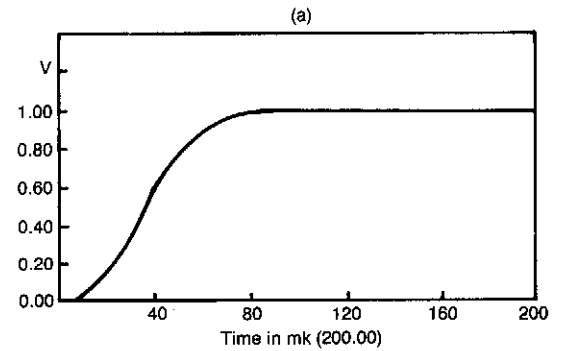


Fig. 30-1(c)

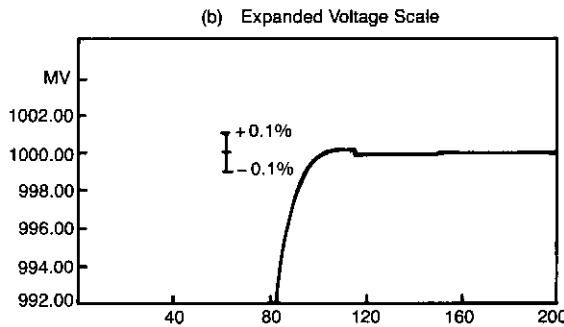


Fig. 30-1(d)

FAST-RESPONSE (SETTLING) LOW-PASS FILTER (Cont.)

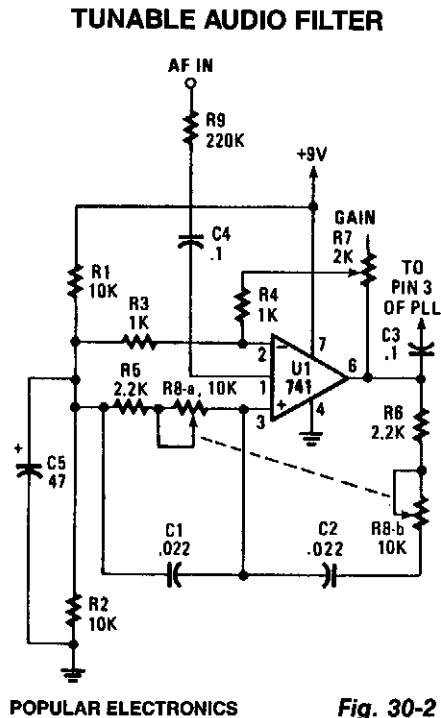
By introducing an extra transmission zero to the stopband of a low-pass filter, a sharp roll-off characteristic can be obtained. The filter design example of Fig. 30-1(a) shows that the time-domain performance of the low-pass section can also be improved. Figure 30-1(b) shows the attenuation characteristic of the proposed circuit. Position of the transmission zero is determined by the passive components around the first op amp. It was chosen to obtain 60 dB of rejection at 60 Hz.

A suitable fourth-order Bessel filter has the frequency response, as shown by the dashed line. Its response to a step input is characterized by settling time to 0.1% of $1.8 \div F_C = 180$ ms.

Figure 30-1(c) and 30-1(d) represent the step response for the filter of Fig. 30-1(a) in both normal and expanded voltage scales. As you can see, settling time to 0.1% is below 100 ms; overshoot and ringing stay below 0.03%.

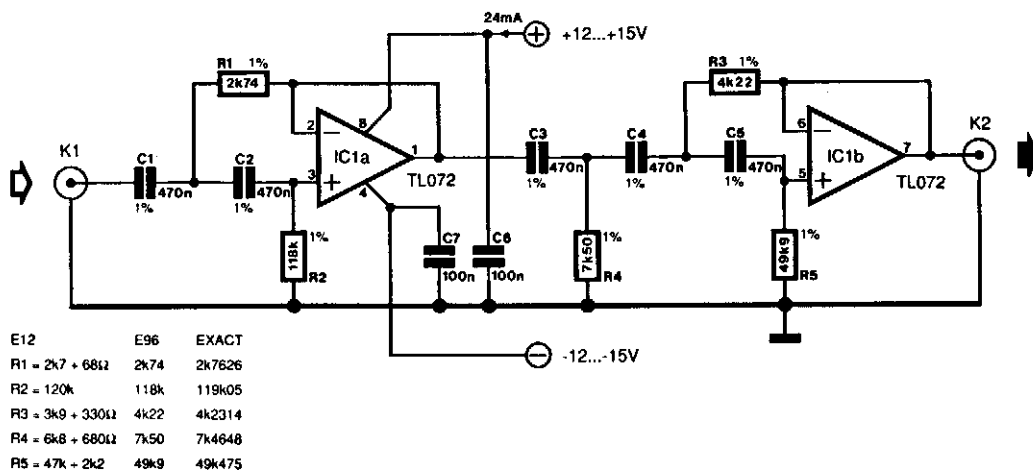
This quite significant speed and accuracy improvement can be a major factor, particularly for low-frequency applications. Averaging filter for low-frequency linear or true rms ac-to-dc converters is an example. Some anti-aliasing applications can also be considered.

For best results, resistance ratios $R_4 \div R_5 = 20$, $R_6 \div R_5 = 1.4$, and capacitance ratios $C_3 \div C_2 = C_3 \div C_4 = 4.7$ should be kept up for any selected F_C .



This circuit uses a Wien Bridge and variable negative feedback. R7 controls the gain and R8A and R8B controls the tuned frequency.

TURNTABLE RUMBLE FILTER



ELEKTOR ELECTRONICS

Fig. 30-3

Many record players unfortunately exhibit two undesired side effects: rumble (noise caused by the motor and the turntable) and other low-frequency spurious signals. The active high-pass Chebyshev filter presented here was designed to suppress those noises. The filter has a 0.1-dB ripple characteristic and a cut-off point of 18 Hz.

The choice of a Chebyshev filter might not seem optimum for audio purposes, but because of its 0.1-dB ripple in the pass band it behaves very much like a Butterworth type. Its advantage is that the response has steeper skirts (which are calculated curves). Frequencies below 10 Hz are attenuated by more than 35 dB. The phase behavior in the pass band shows a gradual shift so that its effect on the reproduced sound is inaudible.

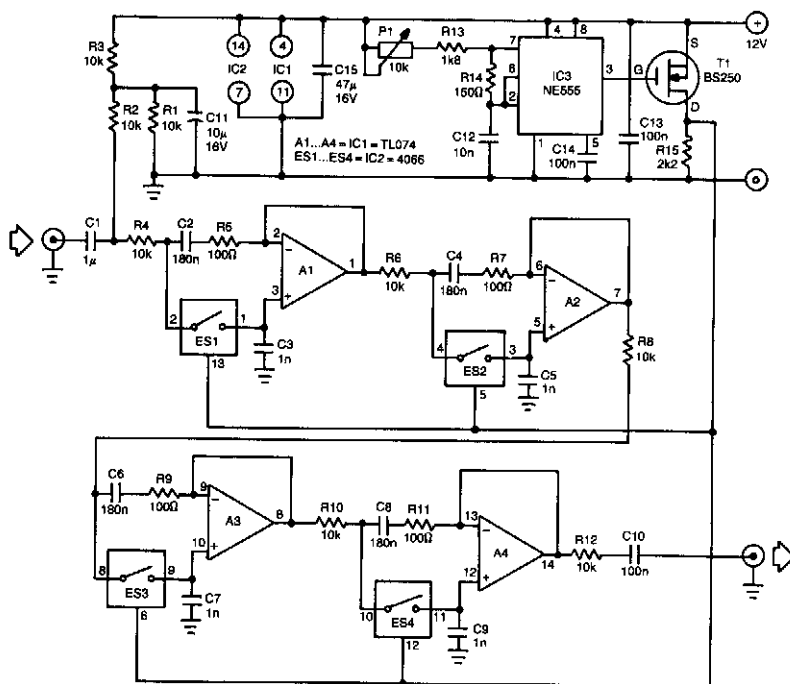
If the filter is used in a stereo installation, the characteristics of both filters must be identical or nearly so. Phase differences between channels can be heard—perhaps not so much at lower frequencies, but certainly in the mid ranges. To ensure identity and also to obtain the desired characteristics, capacitors C1 through C5 must be selected carefully. It does not matter much whether their value is 467 or 473 pF; this difference only causes a slight shift of the cut-off point. However, they must be identical within that 1% tolerance. For symmetry of channels, the capacitors can be paired and then used in either channel at the corresponding position.

The diagram shows theoretical values for the resistors: their practical values are given in the table. The prototype was constructed with 5% metal-film types from the E12 series and these were used without sorting. Their tolerance was perfectly acceptable in practice.

The current drawn by the circuit is purely that through the op amp and it amounts to about 4 mA. The high cut-off point is also determined by the op amp and it lies at about 3 MHz.

The only problem that cannot be foreseen is a possible coupling capacitor in the signal source. That component will be in series with C1 and this might adversely affect the frequency response. However, if its value is greater than 47 μF, it will have little if any effect; if it is below that value, it is best removed; C1 will assume its function.

TUNABLE BANDPASS FILTER



ELEKTOR ELECTRONICS

Fig. 30-4

One of the difficulties in the design of higher-order tunable bandpass filters is achieving correct tracking of the variable resistors in the RC networks. The use of switched capacitor networks can obviate that difficulty, as is shown in this filter.

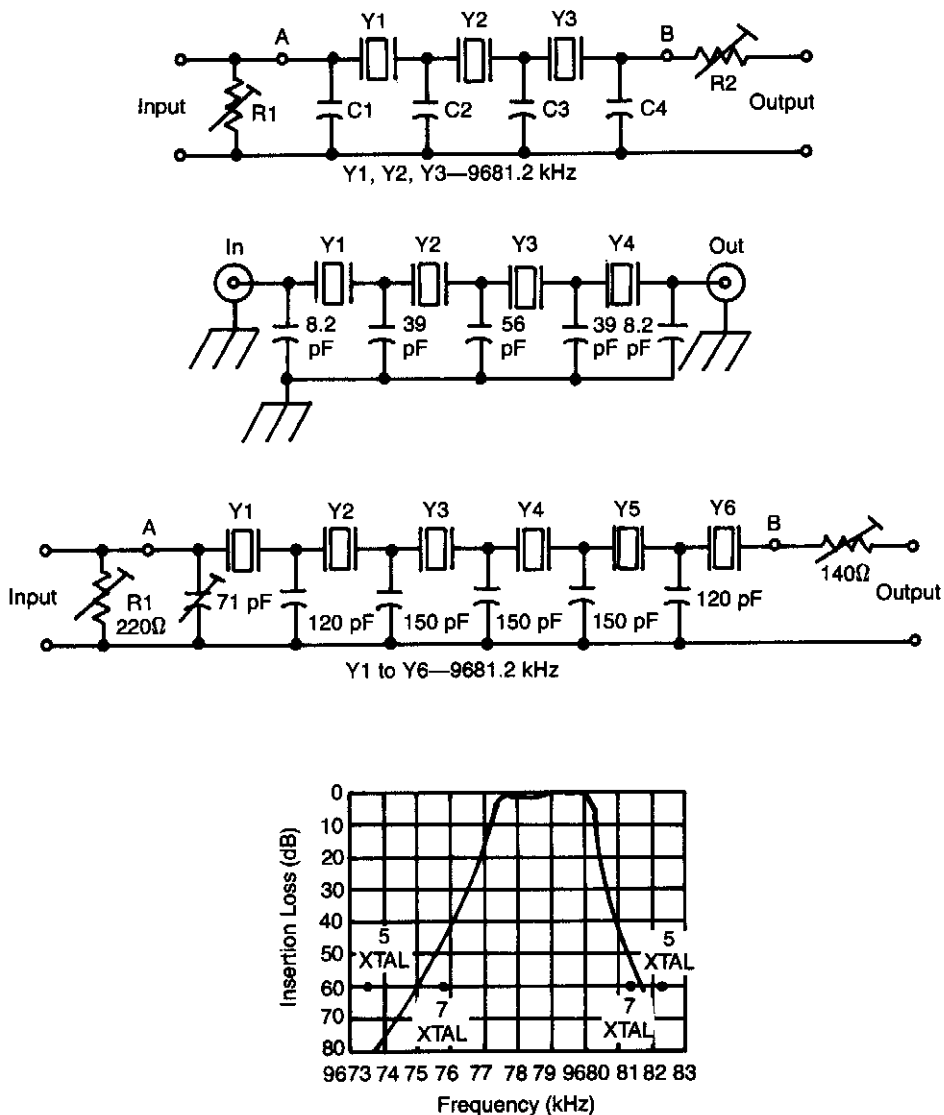
The filter can be divided roughly into two stages: an oscillator that controls the electronic switches and the four phase-shift networks that provide the filtering proper. The oscillator, based on a 555, generates a pulsating signal whose frequency is adjustable over a wide range: the duty factor varies from 1:10 to 100:1.

Electronic switches ES1 through ES4 form the variable resistors whose value is dependent on the frequency of the digital signal. The operation of these switches is fairly simple. When they are closed, their resistance is about 60 Ω ; when they are open, it is virtually infinitely high. If a switch is closed for, say, 25% of the time, its average resistance is therefore 240 Ω . Varying the open:closed ratio of each switch varies the equivalent average resistance. The switching rate of the switches must be much greater than the highest audio frequency to prevent audible interference between the audio and the clock signals.

The input signal causes a given direct voltage across C1, so the op amp can be operated in a quasisymmetric manner, in spite of the single supply voltage. The direct voltage is removed from the output signal by capacitor C10.

The fourth-order filter in the diagram can be used over the entire audio range and it has an amplification of about 40, although this depends to some extent on the clock frequency. The bandwidth depends mainly on the set frequency. The circuit draws a current of not more than 15 mA.

LOW-COST CRYSTAL FILTERS

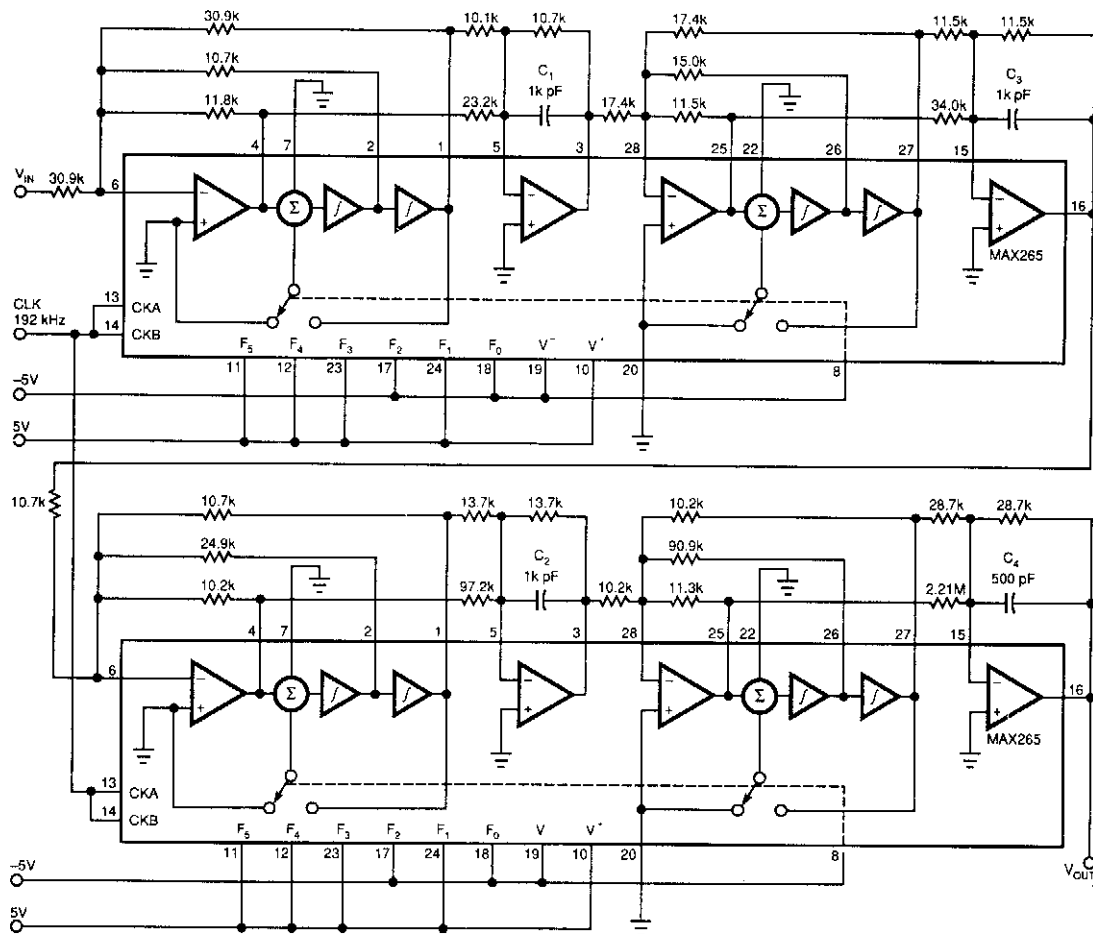


ARRL HANDBOOK

Fig. 30-5

Low-cost CB crystals can be used for these 9-MHz crystal ladder filters. Notice that the 27-MHz crystals (3rd overtone) are used on their fundamental frequencies.

ANTI_ALIASING AND SYNC-COMPENSATION FILTER



EDN

Fig. 30-6

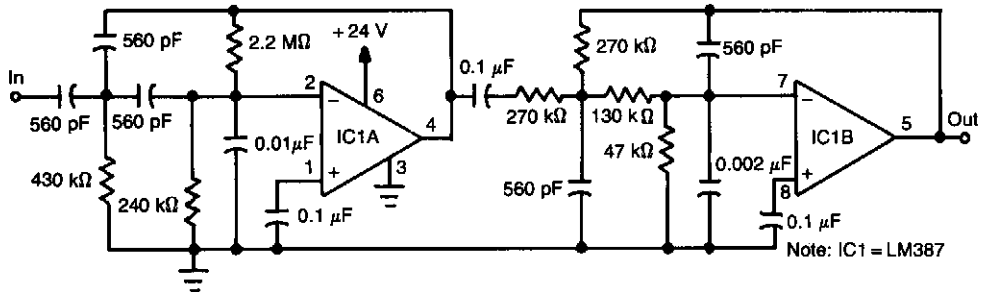
Two dual-biquad filter chips and some external components form a multipurpose filter to reconstruct D/A converter signals. Connected to a converter's output, the filter provides antialiasing, reduces the D/A converter's quantization noise, and compensates for $\sin(\pi x) \div (\pi x)$ —the "sync" function (attenuation).

The circuit incorporates an inverse-sync function that operates to one-third of the converter's sample rate. Beyond one-third, the filter's response shifts to a stopband filter, which provides -70 dB attenuation. This attenuation conforms to the converter's inherent signal-to-noise ratio and quantization error.

To prevent aliasing, the stopband edge must be no higher than the Nyquist frequency ($f_{sn} \div 2$). To achieve 70-dB stopband rejection with this eighth-order filter requires a transition ratio ($f_{STOPBAND} \div f_{PASSBAND}$) of 1.5, which sets the passband's upper limit at $f_s \div 3$.

Notice also that you can apply a simple divide-by-64 circuit to the 192-kHz clock frequency to set the necessary $3 \times$ ratio between the converter's sample rate and the filter's 1-kHz corner frequency. The V^+ , V^- , and the F_0 through F_5 connections program each filter chip for an f_{CLK}/f_0 ratio of 191.64.

TWO-SECTION 300-3 000 Hz SPEECH FILTER

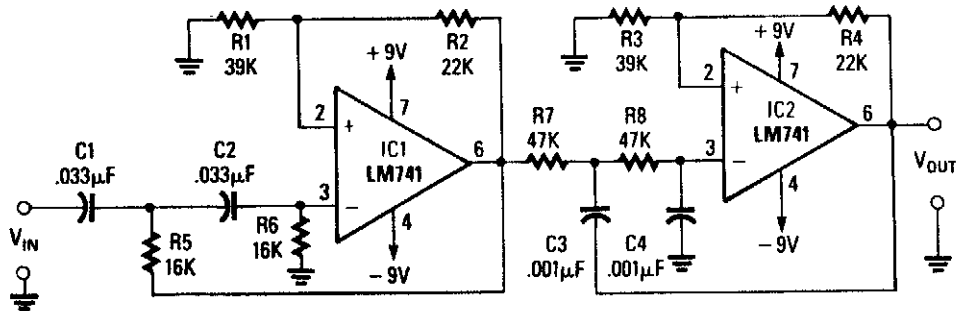


RADIO-ELECTRONICS

Fig. 30-7

An LM387 dual low-noise amplifier is used in an active filter. Both sections are used to produce second-order HP and LP filters, respectively.

300-to-3 400 Hz SECOND-ORDER SPEECH FILTER

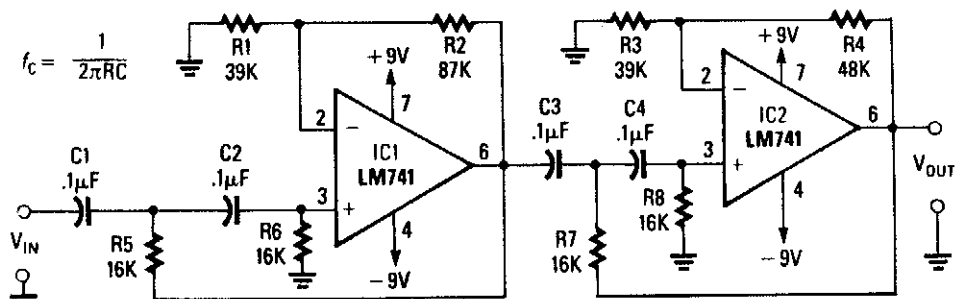


RADIO-ELECTRONICS

Fig. 30-8

Using two op amps, this filter is designed for second-order response. It has a bandpass of 300 to 3 400 Hz, for applications in speech or telephone work.

FOURTH-ORDER 100-Hz HIGH-PASS FILTER

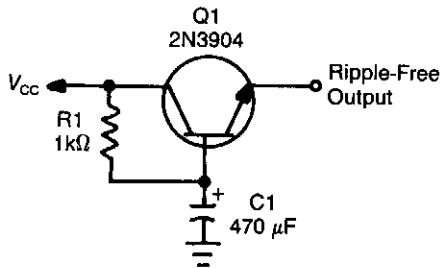


RADIO-ELECTRONICS

Fig. 30-9

This filter, using two sections of LM741, can be scaled in frequency, if desired.

SIMPLE RIPPLE SUPPRESSOR

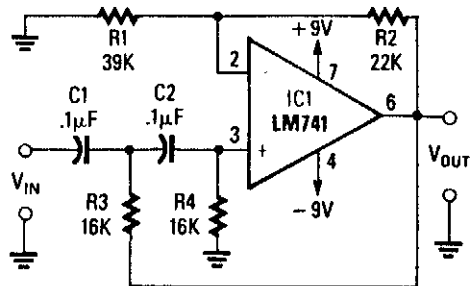


WELS' THINK TANK

Fig. 30-10

This circuit, at times called a *capacitance multiplier*, is useful for suppression of power-supply ripple. C1 provides filtering that is equal to a capacitor of $(B + 1) C_1$, where $B = \text{dc current gain of Q1}$ (typically > 50).

SECOND-ORDER 100-Hz HIGH-PASS FILTER



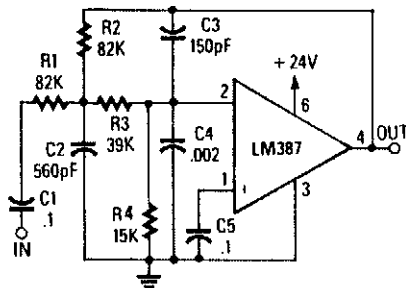
$$f_c = \frac{1}{2\pi RC}$$

RADIO-ELECTRONICS

Fig. 30-11

This second-order filter can be scaled to change the cutoff frequencies.

SCRATCH FILTER

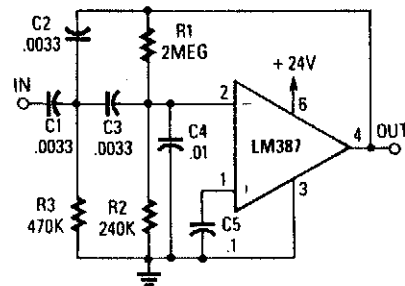


RADIO-ELECTRONICS

Fig. 30-12

Designed to produce 12-dB/octave roll-off above the 10-kHz cutoff frequency, this LP active filter will help reduce needle scratch on records. It uses an LM387 low-noise amplifier IC.

SIMPLE RUMBLE FILTER

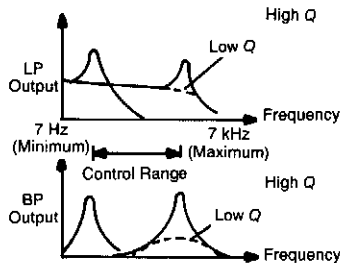
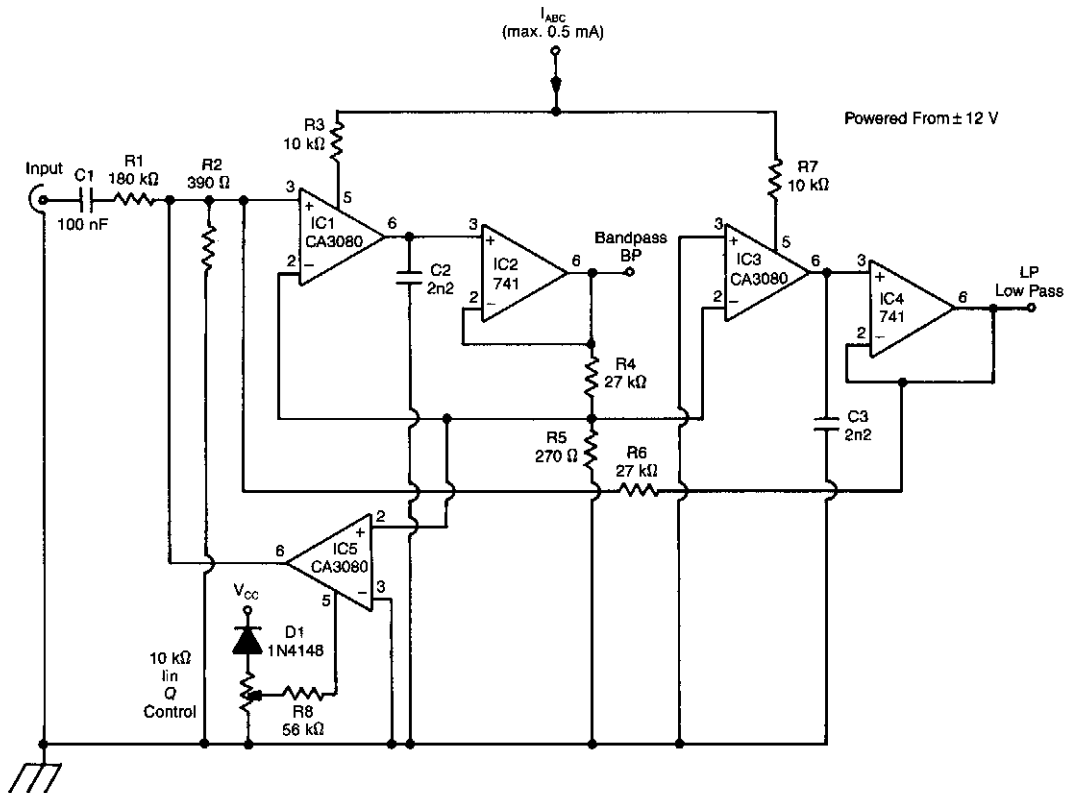


RADIO-ELECTRONICS

Fig. 30-13

This circuit is a two-section active HP filter using an LM387, with a cutoff below 50 Hz at 12-dB per octave. It will help reduce rumble as a result of turntable defects in record systems.

1 000:1 TUNING VOLTAGE-CONTROLLED FILTER

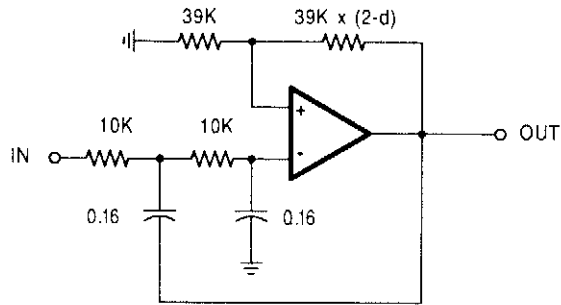


ELECTRONICS TODAY INTERNATIONAL

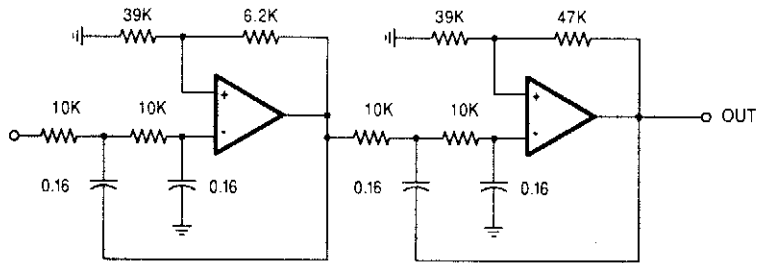
Fig. 30-14

A standard dual integrator filter can be constructed using a few CA3080s. By varying I_{ABC} , the resonant frequency can be swept over a 1 000:1 range. At IC1, three are current-controlled integrators. At IC2, four are voltage followers that serve to buffer the high-impedance outputs of the integrators. A third CA3080 (IC5) is used to control the Q factor of the filter. The resonant frequency of the filter is linearly proportional to I_{ABC} . Hence, this unit is very useful in producing electronic music. Two outputs are produced: a low-pass and a bandpass response.

TWO Sallen-Key Low-Pass Active Filters



(A) SIMPLE SECOND ORDER SALLEN-KEY SECTION



(B) FOURTH ORDER BUTTERWORTH LOW PASS AUDIO FILTER

RADIO-ELECTRONICS

Fig. 30-15

These filters are designed for $10\text{-k}\Omega$ impedance level and 1-kHz cutoff frequency, but the components can be scaled as required for other impedances and cutoff frequencies.

31

Flashers and Blinkers

The sources of the following circuits are contained in the Sources section, which begins on page 666. The figure number in the box of each circuit correlates to the entry in the Sources section.

Pseudorandom Simulated Flicker Sequencer
Xenon Flasher
Strobe Alarm
Sequential Flasher
LED Flasher
Sequential LED Flasher with Reversible Direction
Multivibrator with LEDs
Flashing LED Controller
Flicker Light

PSEUDORANDOM SIMULATED FLICKER SEQUENCER

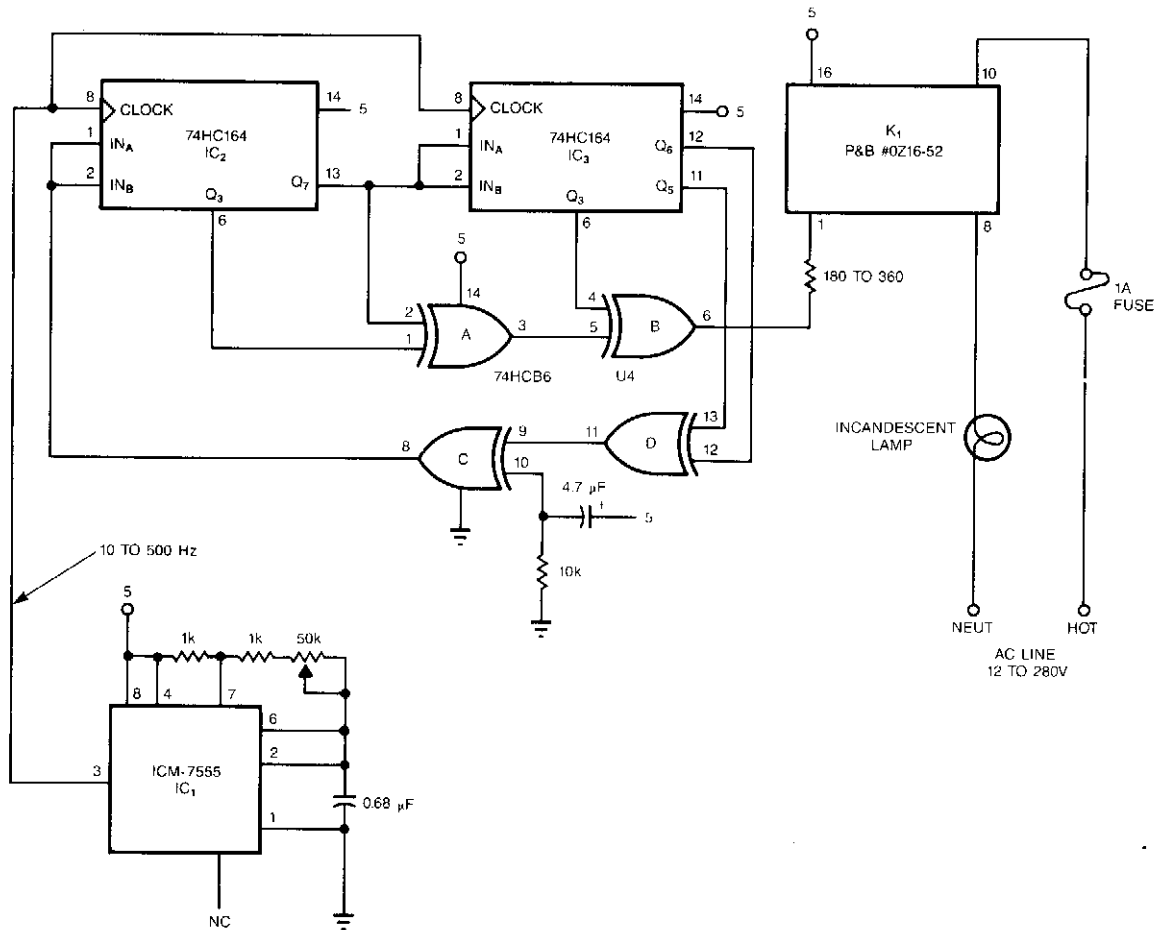


Fig. 31-1

The pseudorandom sequencer drives a solid-state relay. If you power a low-wattage lamp from the relay, the lamp will appear to flicker like a candle's flame in the wind; using higher-wattage lamps allows you to simulate the blaze of a fireplace or campfire. You can enhance the effect by using three or more such circuits to power an array of lamps.

The circuit comprises an oscillator, IC1, and a 15-stage, pseudorandom sequencer, IC2-4. The sequencer produces a serial bit stream that repeats only every 32 767 bits. Feedback from the sequencer's stages 14 and 15 go through IC4D and back to the serial input of IC2. Notice the RC network that feeds IC4C; the network feeds a positive pulse into the sequencer to ensure that it won't get stuck with all zeros at power-up. The leftover XOR gates IC4A and IC4B further scramble the pattern. The serial stream from IC4B drives a solid-state relay that features zero-voltage switching and can handle loads as high as 1 A at 12 to 280 Vac.

XENON FLASHER

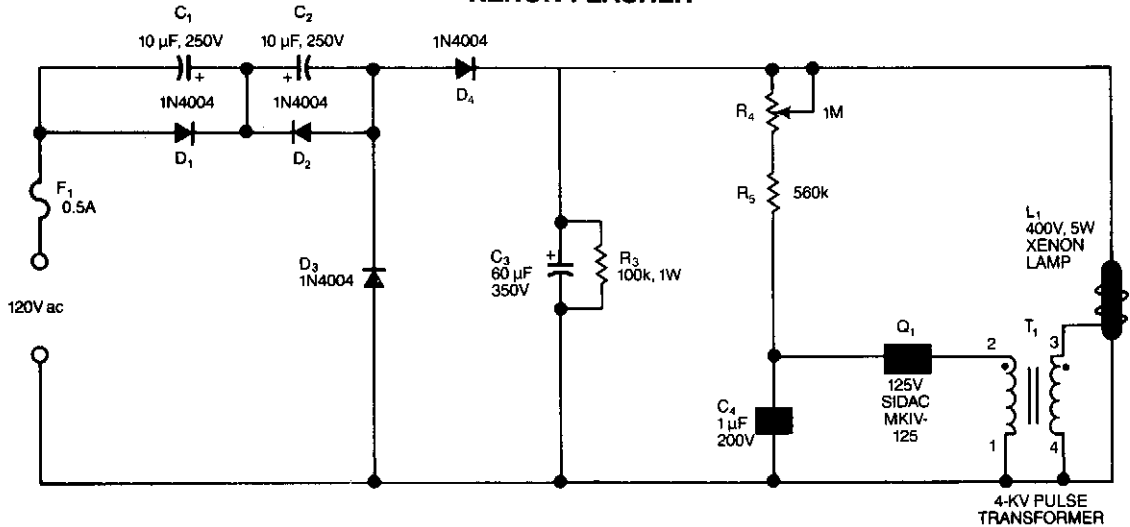


Fig. 31-2

EDN

Using a voltage-doubler supply, this circuit charges a 60- μ F capacitor and discharges it through a Xenon lamp. The SIDAC device is manufactured by Motorola. It is a two-terminal device that breaks over at a specified voltage. R4, R5, and C4 determine the flash rate.

STROBE ALARM

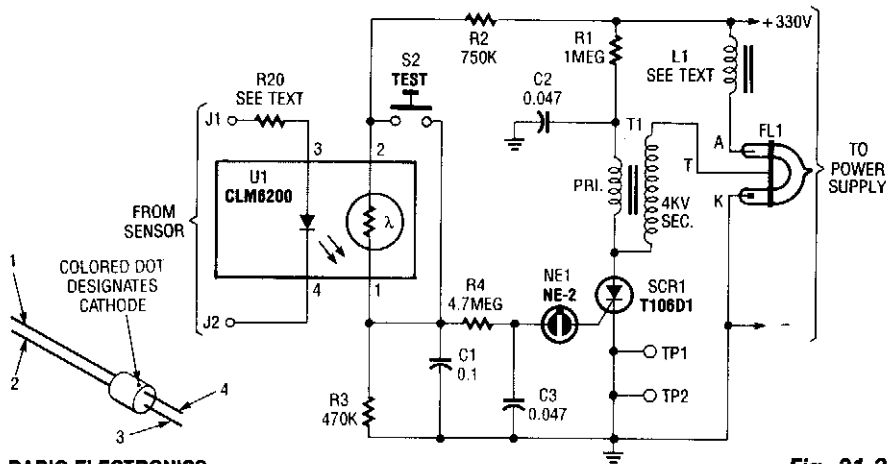
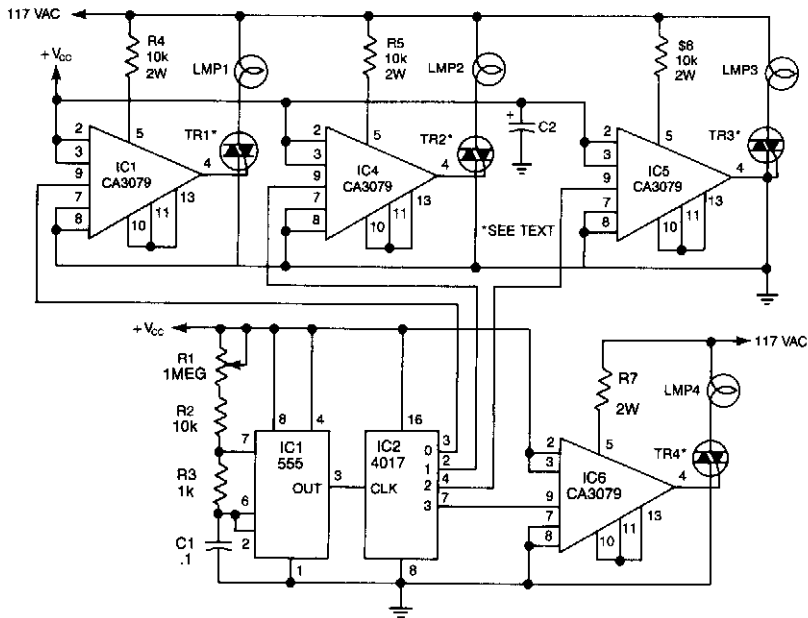


Fig. 31-3

This strobe gives a visual indication of a sensor input. The input signal causes U1, a light dependent resistor, to charge C1 and C3 through R4. When NE1 fires, C3 discharges into SCR1, which triggers it and causes C2 to discharge through trigger transformer T1, which triggers Flashlamp FL1. The 330-V supply should have about 50 to 100 μ F output capacitance. L1 supplies about 25-mH inductance to prolong the flash and the life of FL1.

SEQUENTIAL FLASHER



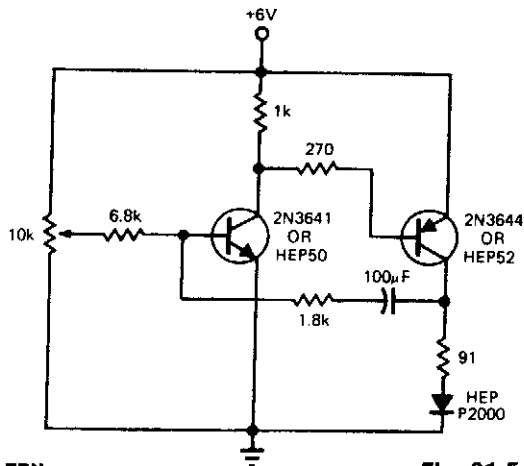
RADIO-ELECTRONICS

Fig. 31-4

Using a 555 timer to drive a CMOS counter, this device uses RCA CA3079 zero-voltage switch to control triacs TR1 through TR4. This circuit can be used to sequence lamp displays, etc.

Caution: The CA3079s are connected to the 117-V line, as is the clock and counter circuit and their power supplies. Use caution, good insulation, and safe construction practices.

LED FLASHER

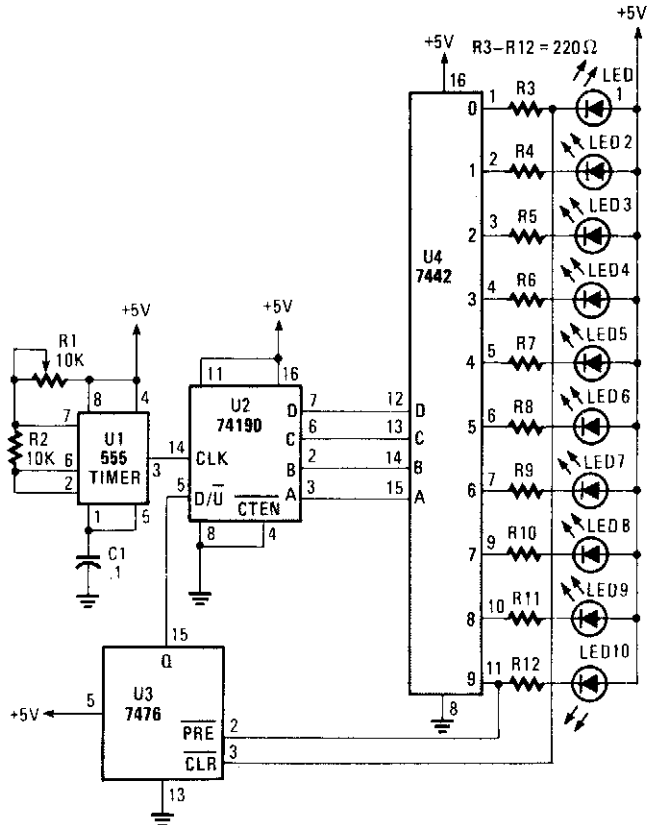


EDN

Fig. 31-5

This circuit is designed to flash an LED. The 100-μF capacitor can be changed to alter the flash rate as desired.

SEQUENTIAL LED FLASHER WITH REVERSIBLE DIRECTION

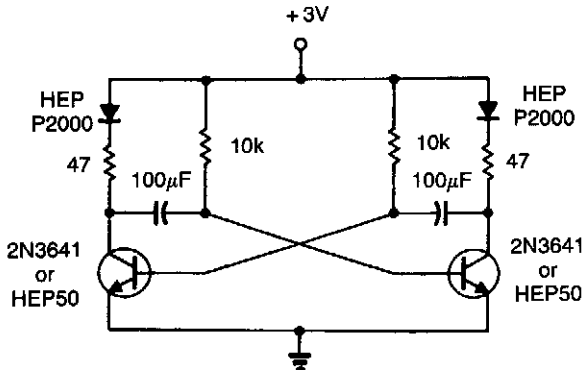


POPULAR ELECTRONICS

Fig.31-6

A 555 timer clocks a 74190 up/down counter. The 74190 drives BCD decoder driver 7442. The 7476 is used to reverse the count on 0 and 9, which results in an up-down-up-down count sequence.

MULTIVIBRATOR WITH LEDs



A simple astable multivibrator is used to alternately flash two LEDs. The approximate time constant is 0.69.

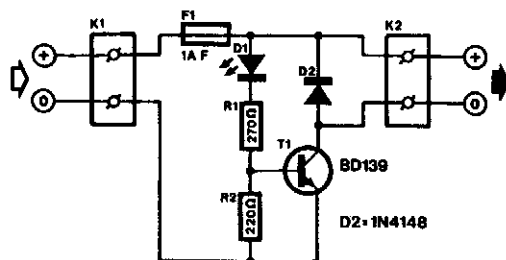
$$(R_1 C_1 + R_2 C_2) \quad R_1 = R_2 = 10 \text{ k}\Omega$$

$$C_1 = C_2 = 100 \text{ }\mu\text{F}$$

EDN

Fig. 31-7

FLASHING LED CONTROLLER



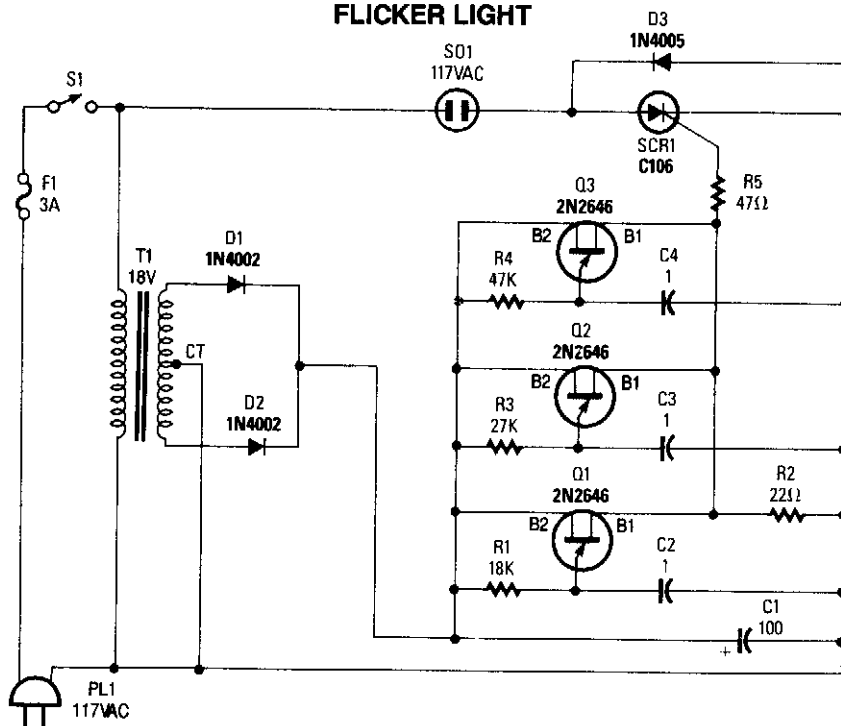
ELEKTOR ELECTRONICS

Fig. 31-8

The LED with integrated flasher is connected in series with the base-emitter junction of transistor T1. Thus, the load connected to K2 is switched on and off in rhythm with the flash rate. This load can be a relay or a lamp.

The maximum collector current of the transistor (of the BD139 = 750 mA) must not be exceeded. If that is not sufficient, a power Darlington can be used, which will give some amperes. The current drawn by the circuit under no-load conditions amounts to 20 mA.

FLICKER LIGHT



POPULAR ELECTRONICS

Fig. 31-9

This circuit will produce a flicker light effect with an ordinary incandescent lamp. Three UJT relaxation oscillators fire the SCR in a pattern.

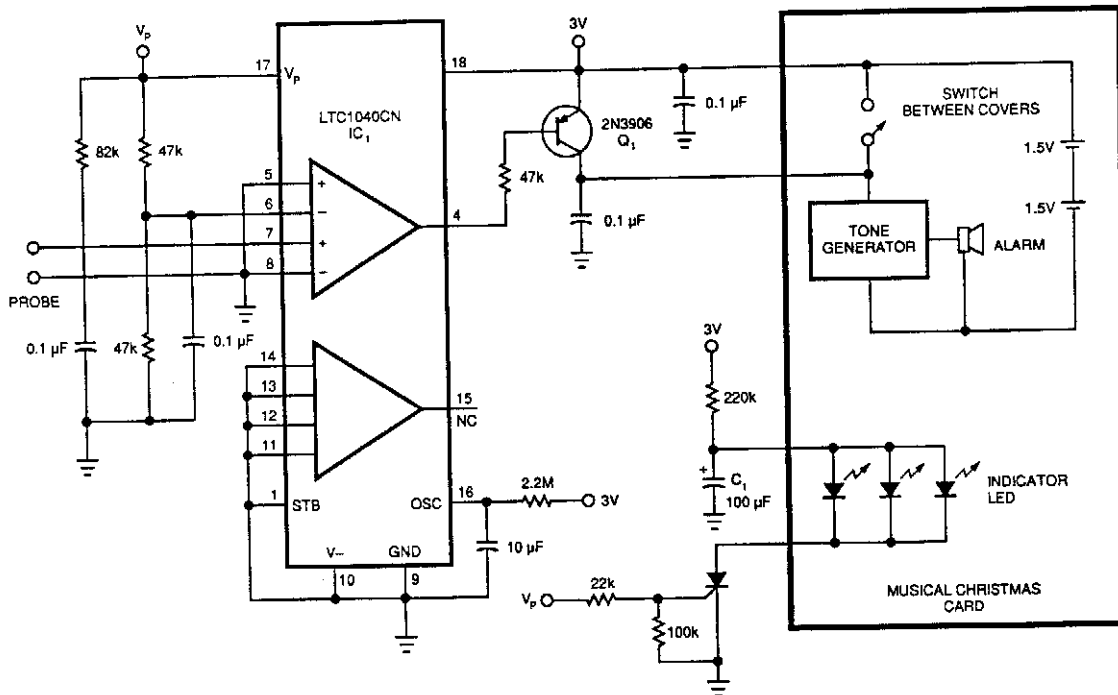
32

Fluid and Moisture Detectors

The sources of the following circuits are contained in the Sources section, which begins on page 666. The figure number in the box of each circuit correlates to the entry in the Sources section.

Water-Level Control	Rain Alarm
3-V Water-Level Detector	Full-Cup Detector for the Blind
Liquid-Level Sensor	Latching Water Sensor
Full Bathtub Indicator	Water-Leak Alarm
Moisture Detector	Water-Level Measurement Circuit
Flood Alarm	

3-V WATER-LEVEL DETECTOR

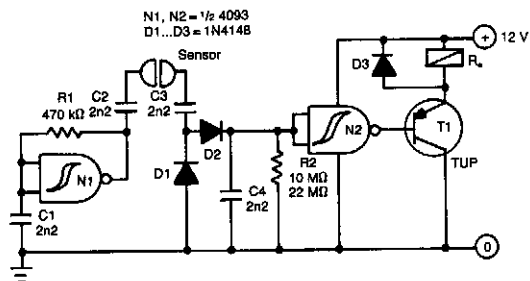


EDN

Fig. 32-2

Originally, this circuit was used to sense a low-water level in a Christmas tree stand, but the circuit can be used as a water-level detector for pump controls, water sensors (for garden and lawn applications), etc. A comparator and probe setup with a Linear Technology LTC1040CN comparator drives a 2N3906, which switches a tone generator. Sampling occurs every 20 seconds, which minimizes current drain. A pair of dry cells will power the circuit for several months.

LIQUID-LEVEL SENSOR

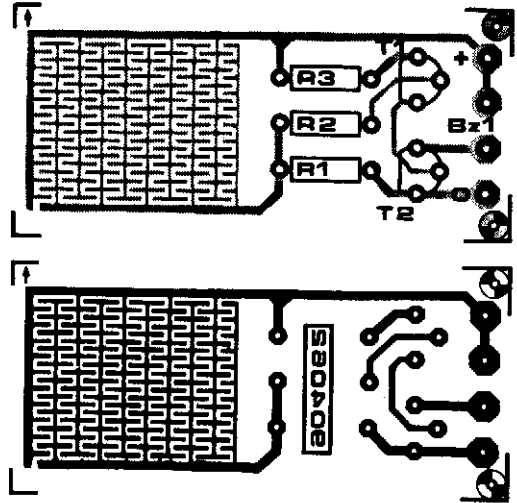
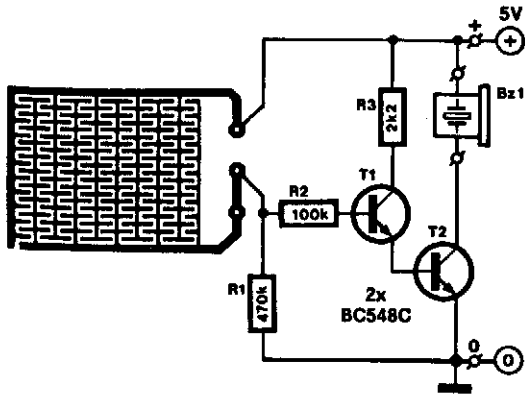


This circuit uses an ac-sensing signal to eliminate electrolytic corrosion. The ac signal is rectified and used to drive a transistor that controls a relay.

ELEKTOR ELECTRONICS

Fig. 32-3

FULL BATHTUB INDICATOR



ELEKTOR ELECTRONICS

Fig. 32-4

Running a bath can end in a minor domestic disaster if you forget to turn off the taps in time. This indicator activates an active buzzer to provide an audible warning when a given water level is reached.

Because the water sensor and the driver circuit for the buzzer are contained on one PC board, the indicator, together with the 9-V battery and the buzzer, can be built into a compact case. Obviously, the sensor, which is etched on the PC-board, must not be fitted in case-iron or steel bath, the indicator is secured to it with the aid of a magnet glued onto the case. To prevent scratching the bath, the magnet can be covered in plastic or rubber. If you have a polypropylene bath, the indicator can be stuck to it with blue tack or double-sided adhesive tape.

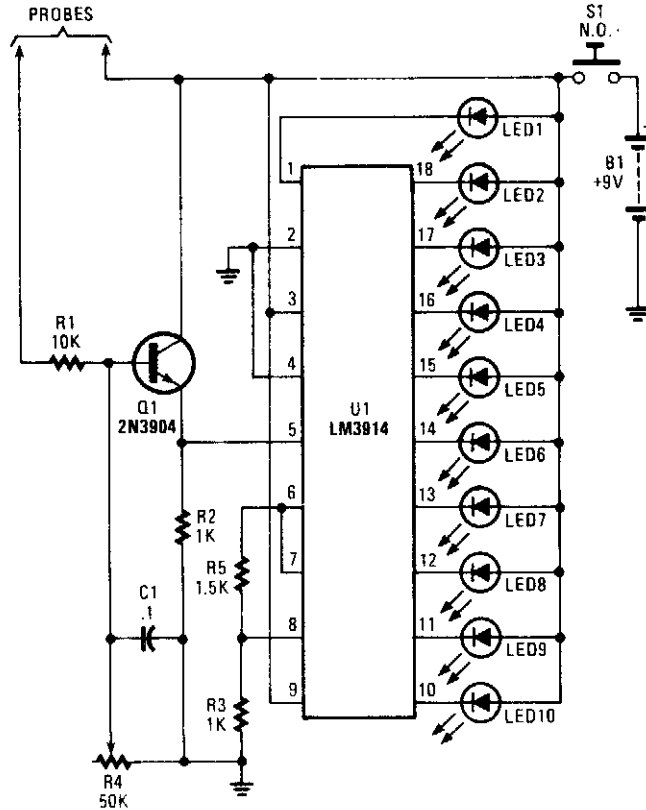
When the water reaches the sensor, the base of T1 is connected to the positive supply line. As a result, T1 and T2 are switched on so that the buzzer BZ1, a self-oscillating type, is activated. The current drawn by the circuit in that condition is about 25 mA.

In case the circuit is actuated by steam, its sensitivity can be reduced by increasing the value of R2. It is best to tin the PC board tracks to prevent corrosion.

T1, T2 = BC548C

BZ1 = active piezo-ceramic resonator

MOISTURE DETECTOR

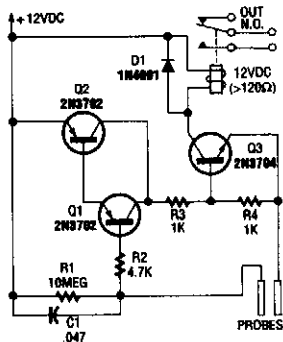


POPULAR ELECTRONICS

Fig. 32-5

A bar-graph LED driver is used to drive 10 LEDs to give a relative indication of moisture. The moisture probes are connected so that electrical conductivity due to moisture tends to forward bias Q1, providing a dc voltage at pin 5 of U1 that is proportional to leakage current. Ideally, the probes should be made of stainless steel.

FLOOD ALARM

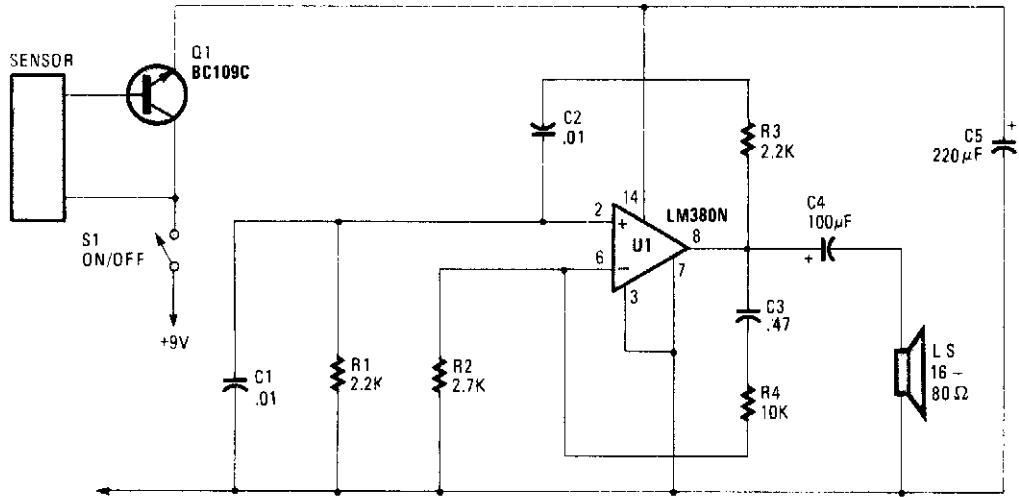


RADIO-ELECTRONICS

Fig. 32-6

Using a few bipolar transistors, this circuit acts as a flood alarm. When liquid touches the probes, leakage current biases Q1, Q2, and Q3 (a dc-coupled amplifier) into conduction, which activates the relay. The contacts can be hooked into the alarm system.

RAIN ALARM

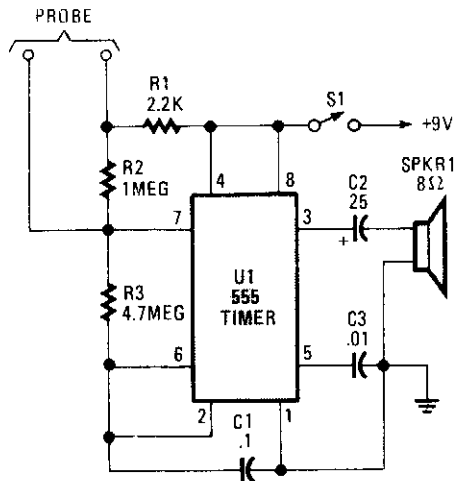


POPULAR ELECTRONICS

Fig. 32-7

This rain sensor causes Q1 to conduct when conductive liquid (rainwater, etc.) applies bias to its base. This bias triggers LM380N oscillator and causes LS to emit a tone.

FULL-CUP DETECTOR FOR THE BLIND



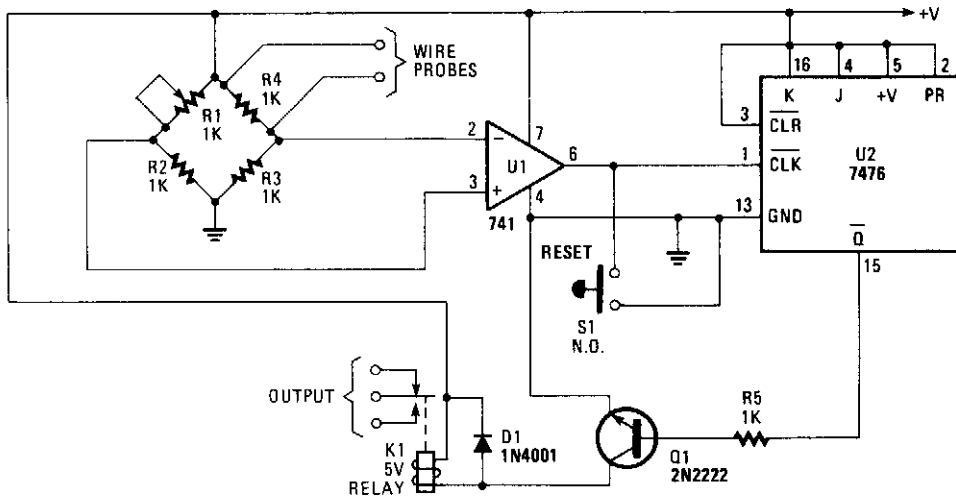
POPULAR ELECTRONICS

Fig. 32-8

At the heart of the Full-Cup Detector is a 555-oscillator/timer configured to produce a 15-Hz click, until its probe contacts are bridged, at which time its output frequency goes to about 500 Hz.

This circuit can be used by the visually handicapped to determine when a cup or bowl is full of liquid (coffee, soup, etc.). U1, an NE555, produces ticks at 15 Hz. A set of probes (wire, etc.) is placed in the container at the desired level. When the liquid level contacts the probes, the frequency of clicks increases to several hundred hertz, depending on its conductivity.

LATCHING WATER SENSOR

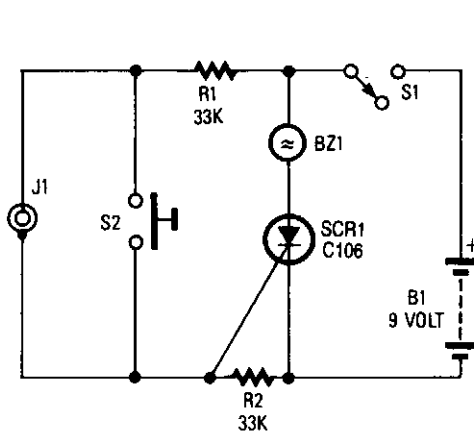


POPULAR ELECTRONICS

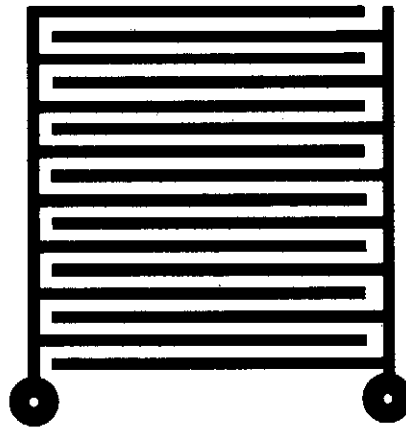
Fig. 32-9

A balanced Wheatstone bridge controls a JK flip-flop that uses an op amp as an interface. This in turn drives a relay circuit. R1 through R4 can be made larger for increased sensitivity.

WATER-LEAK ALARM



POPULAR ELECTRONICS

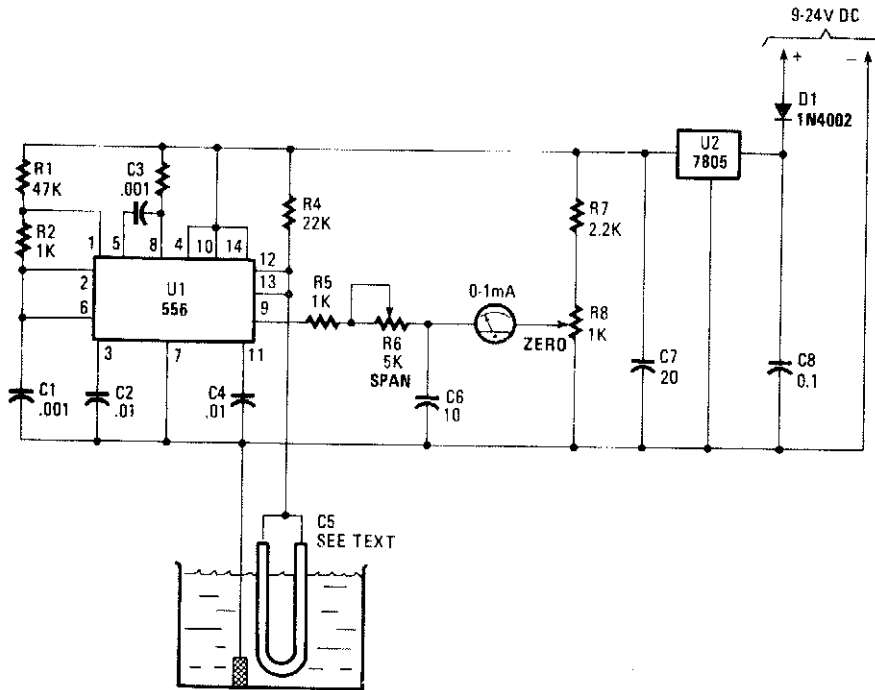


If you choose to make your own moisture sensor, this foil pattern should come in handy.

Fig. 32-10

A sensor connected to J1 causes SCR1 to conduct, which sounds buzzer BZ1. The sensor is a PC-board foil pattern grid. Several sensors can be wired in parallel for increased coverage or to monitor several places simultaneously.

WATER-LEVEL MEASUREMENT CIRCUIT



POPULAR ELECTRONICS

Fig. 32-11

Using a capacitor sensor to detect a water level is a simple method of sensing. This circuit uses C5, which is 10" to 20" of #22 enamelled wire as one electrode. This shifts the oscillator, an NE556 timer, in frequency. The frequency shift depends on the capacitance charge, which in turn varies with water level. A meter connected to pin 9 of the 556 is used as an indicator. C5 can be made larger or smaller to suit the intended application.

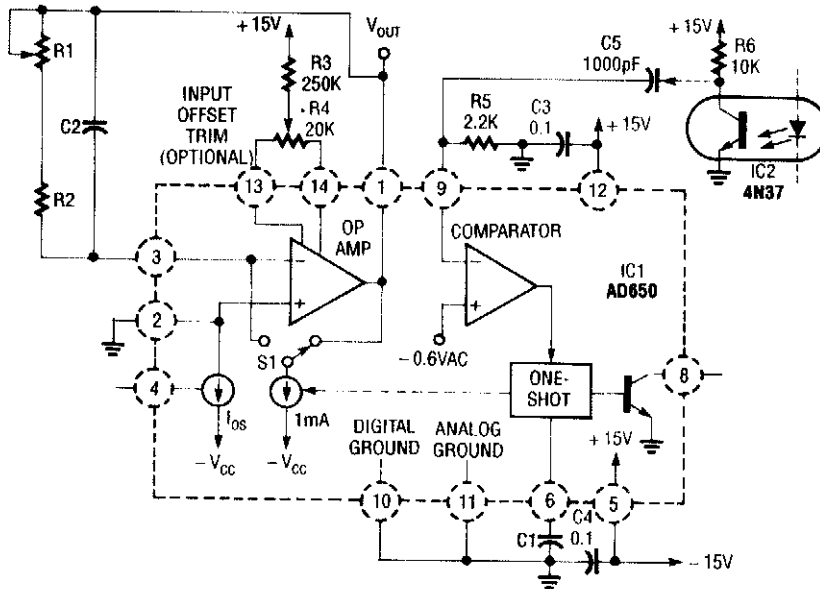
33

Frequency-to-Voltage Converters

The sources of the following circuits are contained in the Sources section, which begins on page 666. The figure number in the box of each circuit correlates to the entry in the Sources section.

Frequency/Voltage Converter
with Optocoupler Input
Frequency/Voltage Converter
with Sample And Hold
Frequency/Voltage Converter
Frequency/Voltage Converter
Single-Supply Frequency/Voltage Converter

FREQUENCY/VOLTAGE CONVERTER WITH OPTOCOUPLER INPUT



CIRCUIT VALUES

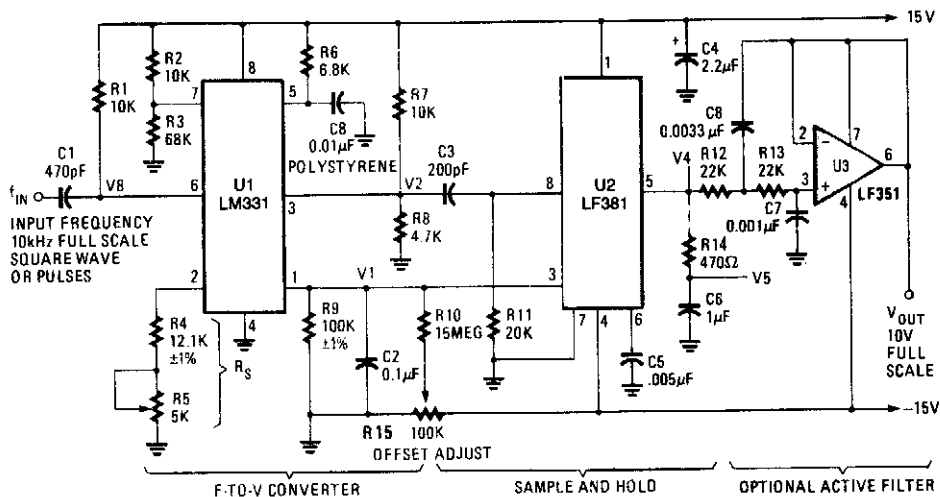
Full-Scale Frequency	Full-Scale Output	C1	C2	R1 (ohms)	R2 (ohms)
10 kHz	1 V	3300 pF	3.3 μ F	1K	3.8K
10 kHz	10 V	3300 pF	0.33 μ F	10K	38.3K
100 kHz	1 V	680 pF	0.33 μ F	500	1.82K
100 kHz	10 V	680 pF	3300 pF	5K	18.2K
1 MHz	1 V	47 pF	3300 pF	500	1.33K
1 MHz	10 V	47 pF	1000 pF	5K	13.3K

RADIO-ELECTRONICS

Fig. 33-1

In this circuit, the input from IC2 optocoupler is fed to the comparator input of the AD650 (Analog Devices or Maxim Electronics) V/F converter. This internally generates a pulse that is fed to the op amp, which outputs a dc voltage that is proportional to frequency. Component values are shown in the figure.

FREQUENCY/VOLTAGE CONVERTER WITH SAMPLE AND HOLD

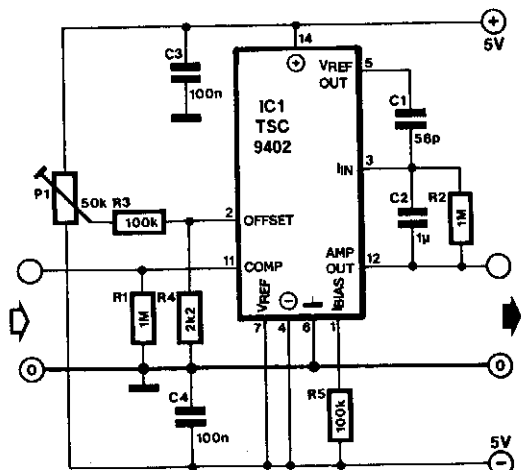


POPULAR ELECTRONICS

Fig. 33-2

U1 is a frequency/voltage converter, feeding sample-and-hold circuit using an LF381. An LF351 provides 10-V full-scale output. The circuit produces 1-V/kHz output.

FREQUENCY/VOLTAGE CONVERTER



ELEKTOR ELECTRONICS

Fig. 33-3

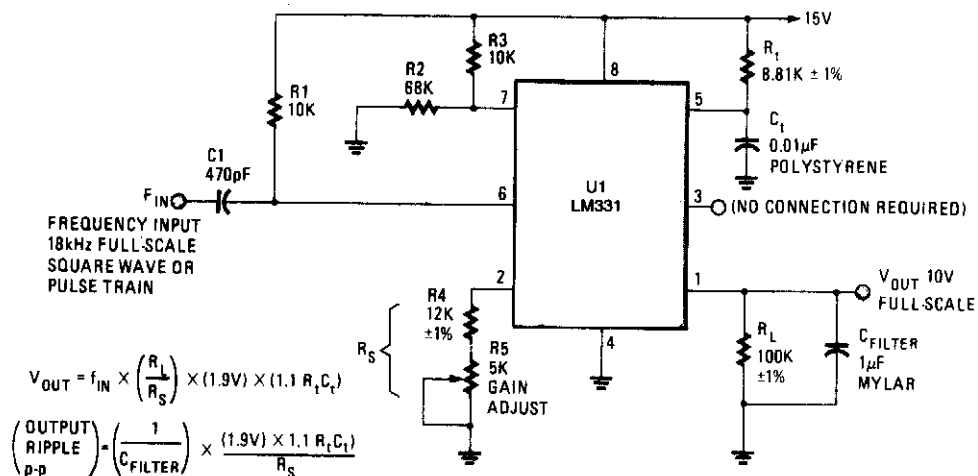
Teledyne Semiconductor's Type TSC9402 is a versatile IC. Not only can it convert voltage into frequency, but also frequency into voltage. It is thus eminently suitable for use in an add-on unit for measuring frequencies with a multimeter. Only a few additional components are required for this.

Just one calibration point sets the center of the measuring range (or of that part of the range that is used most frequently). The frequency-proportional direct voltage at the output (pin 12—AMP OUT) contains interference pulses at levels up to 0.7 V. If these have an adverse effect on the multimeter, they can be suppressed with the aid of a simple RC network. The output voltage, U_o , is calculated by:

$$U_o = U_{ref}(C_1 + 12 \text{ pF}) R_2 f_{in}$$

Because the internal capacitance often has a greater value than the 12 pF taken here, the formula does not yield an absolute value. The circuit has a frequency range of dc to 10 kHz. At 10 kHz, the formula gives a value of 3.4 V. The circuit draws a current of not more than 1 mA.

FREQUENCY/VOLTAGE CONVERTER

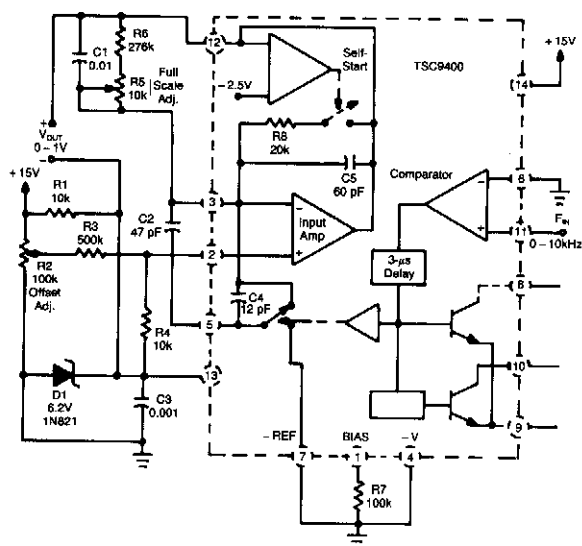


POPULAR ELECTRONICS

Fig. 33-4

A dc output that is proportional to frequency can be derived with this circuit. It is useful for analog frequency meter or tachometer applications.

SINGLE-SUPPLY FREQUENCY/VOLTAGE CONVERTER



RADIO-ELECTRONICS

Fig. 33-5

A Teledyne TSC9400 provides 0-to-1-V output from a 0-to-10-kHz input. A single +15-V supply is used. Linearity is 0.25% to 10 kHz.

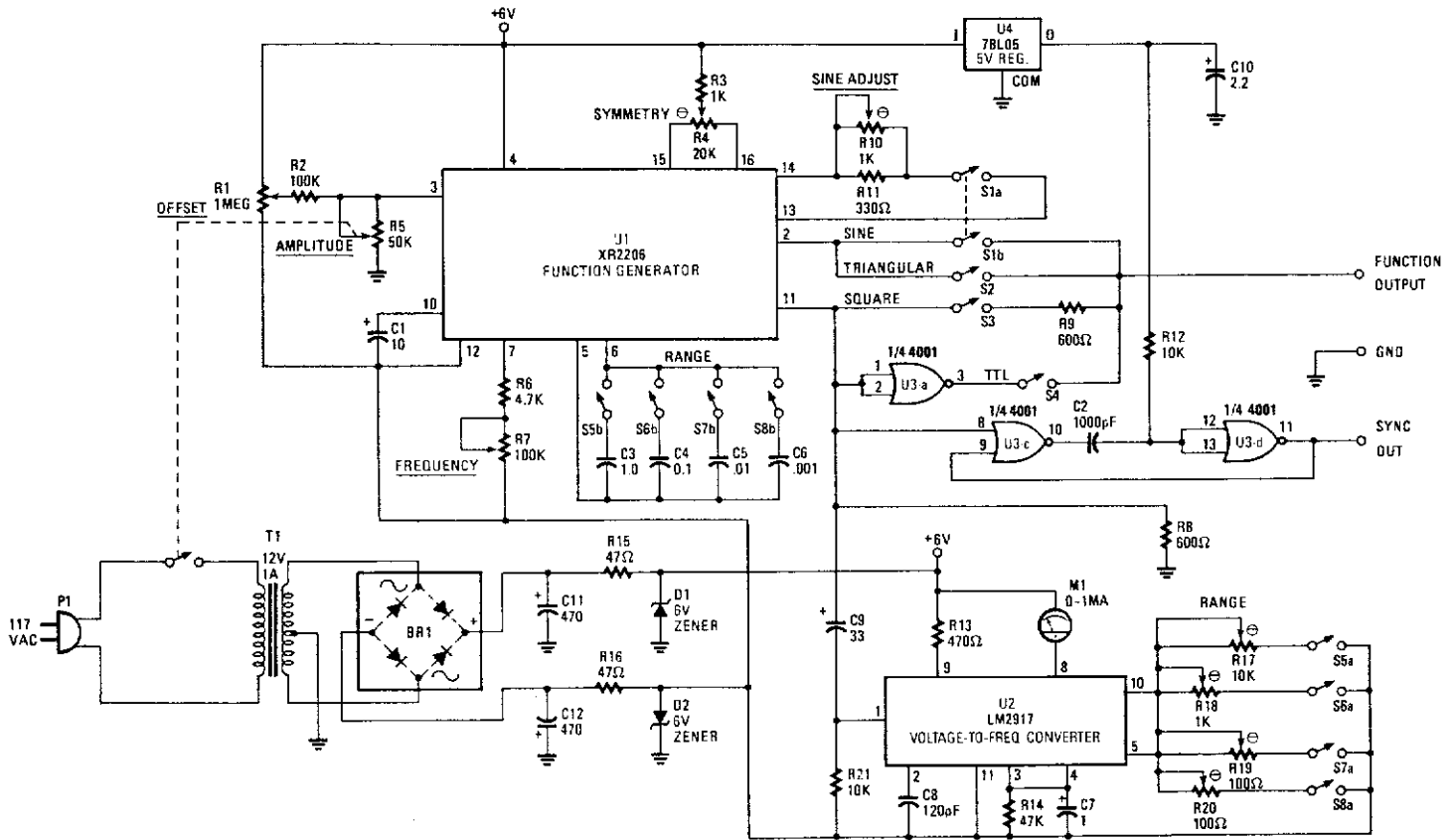
34

Function Generators

The sources of the following circuits are contained in the Sources section, which begins on page 667. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Audio Function Generator
- Nonlinear Potentiometer Outputs
- Function Generator
- Potentiometer-Position V/F Converter
- FM Generator
- 1-Hz Timebase for Readout and Counter
- Applications
- White Noise Generator
- Frequency-Ratio Monitoring Circuit
- Pulse Train

AUDIO FUNCTION GENERATOR

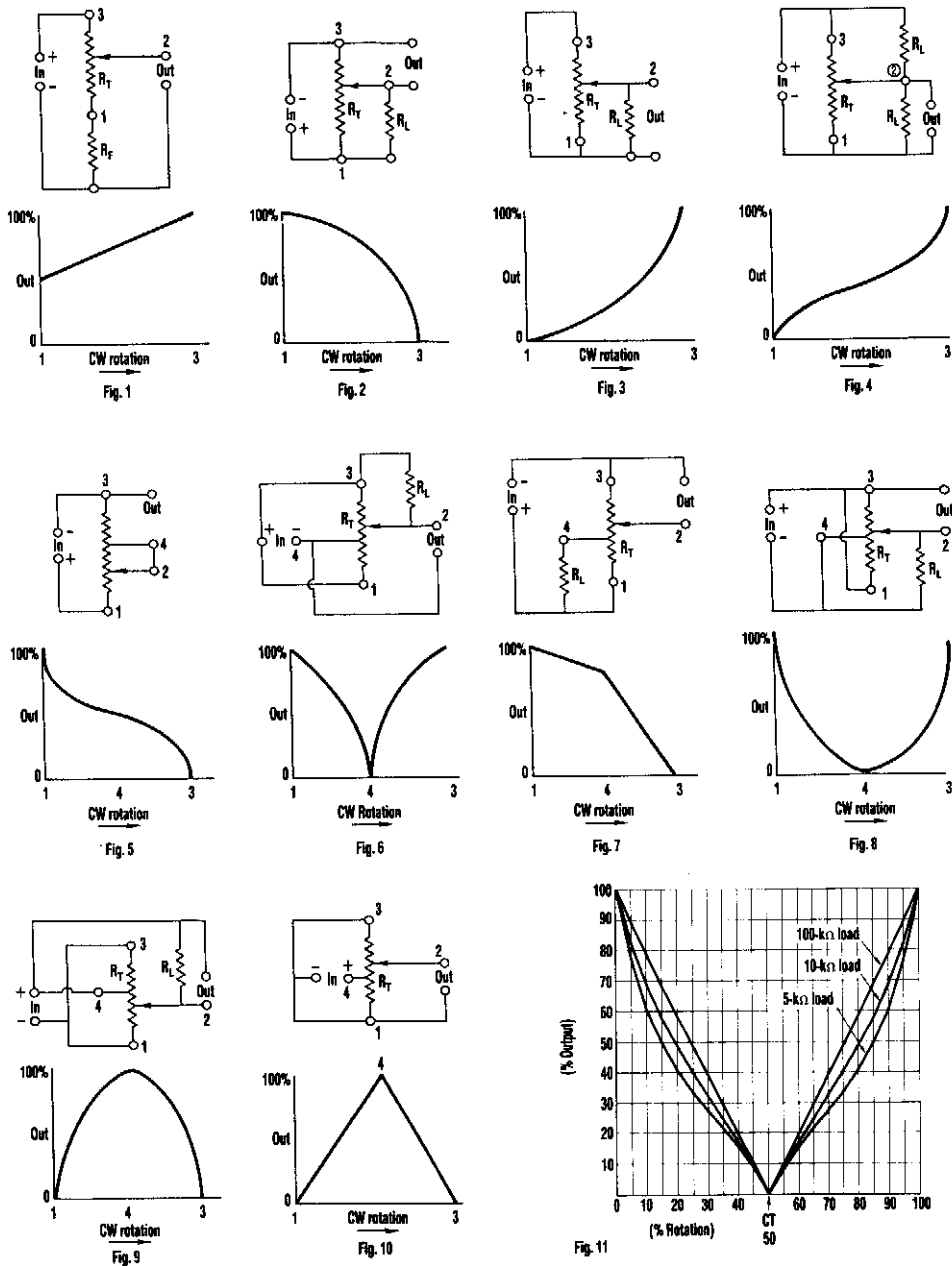


HANDS-ON ELECTRONICS

Fig. 34-1

Using an EXAR XR2206, this generator will produce sine, square, and triangular waves from 10 Hz to 100 kHz. U1 is the XR2206 chip, R7 controls frequency, and S5 through S8 select the frequency range. U3 produces a TTL-compatible square-wave output, while U3C and D produce a sync signal for scope use. U2 is a frequency/voltage converter that is used to drive analog meter M1, which reads the generator frequency.

NONLINEAR POTENTIOMETER OUTPUTS

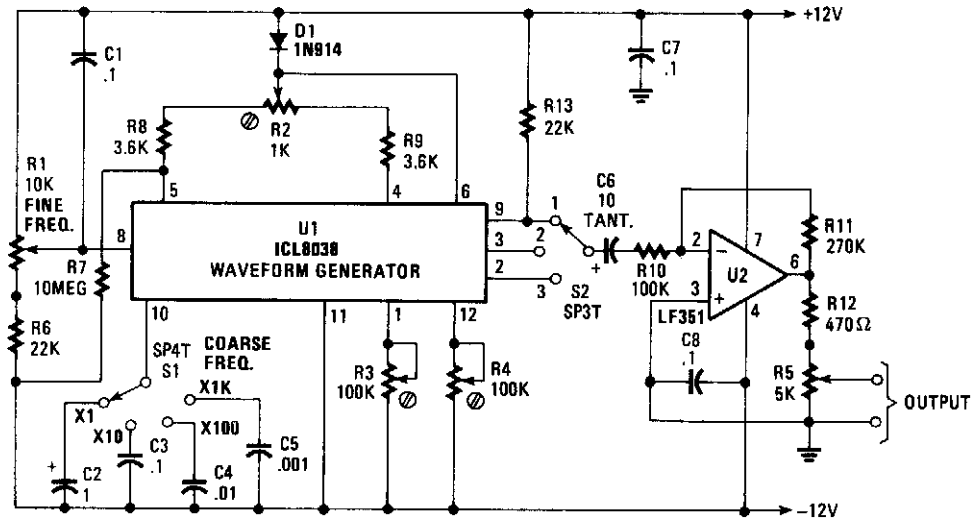


ELECTRONIC DESIGN

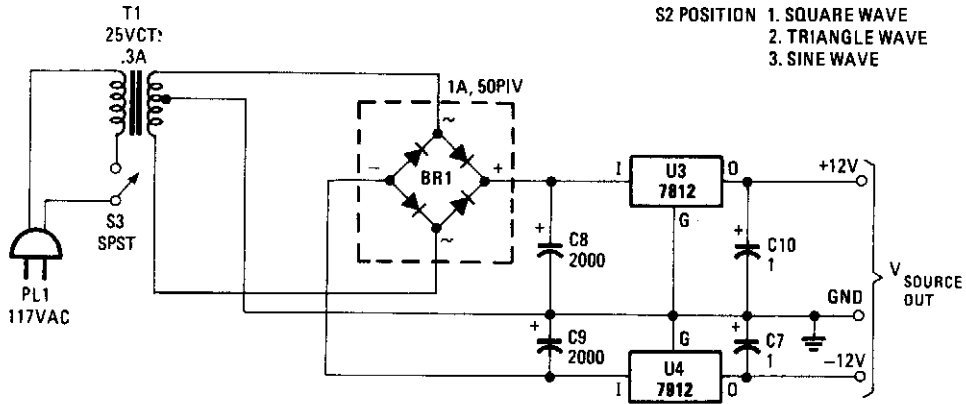
Fig. 34-2

Using these illustrated configurations, various rotation output characteristics can be obtained from potentiometers and one or two resistors.

FUNCTION GENERATOR



S2 POSITION 1. SQUARE WAVE
2. TRIANGLE WAVE
3. SINE WAVE

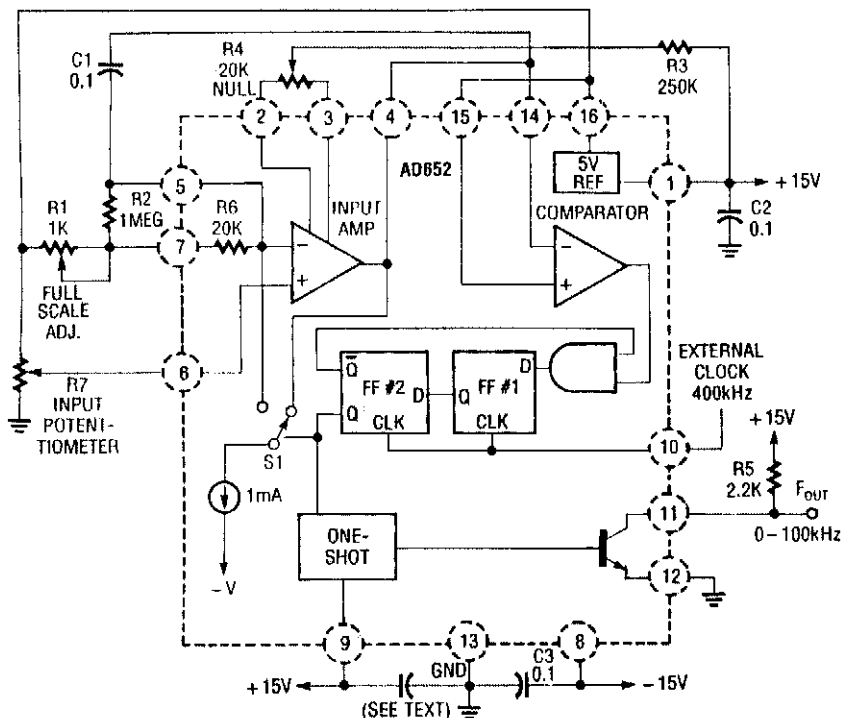


RADIO-ELECTRONICS

Fig. 34-3

Using an Intersil ICL8038, this function generator generates frequencies from 1 Hz to over 80 kHz. R1 is the fine frequency control and S1 is the coarse frequency control range switch. S2 selects square-, triangle-, or sine-wave output. U2 is a buffer amplifier and R5 sets output level. R2 is adjusted for a symmetrical triangle wave. R3 and R4 are adjusted for minimum sine-wave distortion. Power supply is ± 12 V at less than 100 mA.

POTENTIOMETER-POSITION V/F CONVERTER

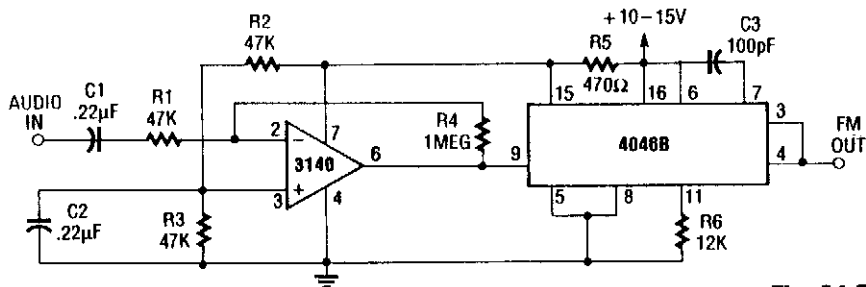


RADIO-ELECTRONICS

Fig. 34-4

In this application, an AD652IC is used in a synchronized V/F converter that derives its input from the position of a potentiometer. This can represent a position of a mechanical component, weight, size, etc., to give a 0-to-100-kHz output versus the 0-to-5-V output from the potentiometer.

FM GENERATOR

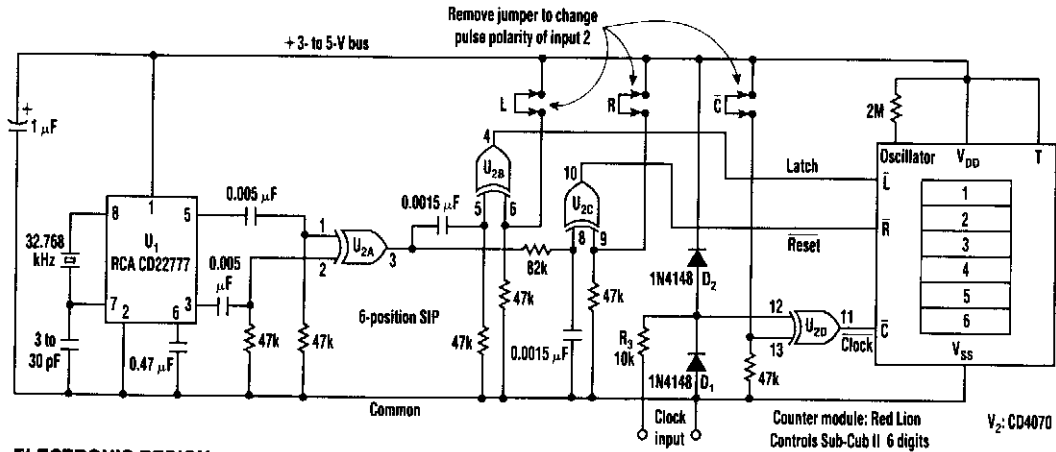


RADIO-ELECTRONICS

Fig. 34-5

The internal zener on pin 15 of the 4046B supplies a stable voltage to the 3140IC op amp. This amplifier modulates the 4046B VCO. The amplifier gain is about $20 \times$ (26 dB voltage). The VCO produces a 220-kHz carrier that is FM modulated. C3 can be changed to vary this frequency.

1-Hz TIMEBASE FOR READOUT AND COUNTER APPLICATIONS



ELECTRONIC DESIGN

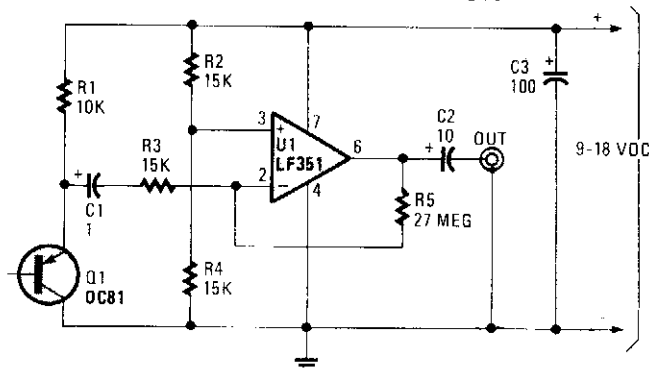
Fig. 34-6

This counter makes direct readout of frequency-generating equipment very easy when a 1-Hz timebase is added to latch, reset, and the count signal is conditioned. This design has the flexibility to select either polarity.

By differentiating, inverting, and ORing the clock pulses in XOR gate U2A, a stream of 1-Hz, positive, 200- μ s pulses is generated. For latching, the 1-Hz stream is again differentiated in U2B, input 1 to supply a 50- μ s pulse. Though U2B's output goes from high to low, it can be reversed, by making input 2 low.

Because the reset pulse must occur after the latch signal, the 1-Hz stream from U2A is delayed 100 μ s at U2C input 1. The output-pulse polarity is determined by making U2C's input 2 either high or low.

WHITE NOISE GENERATOR

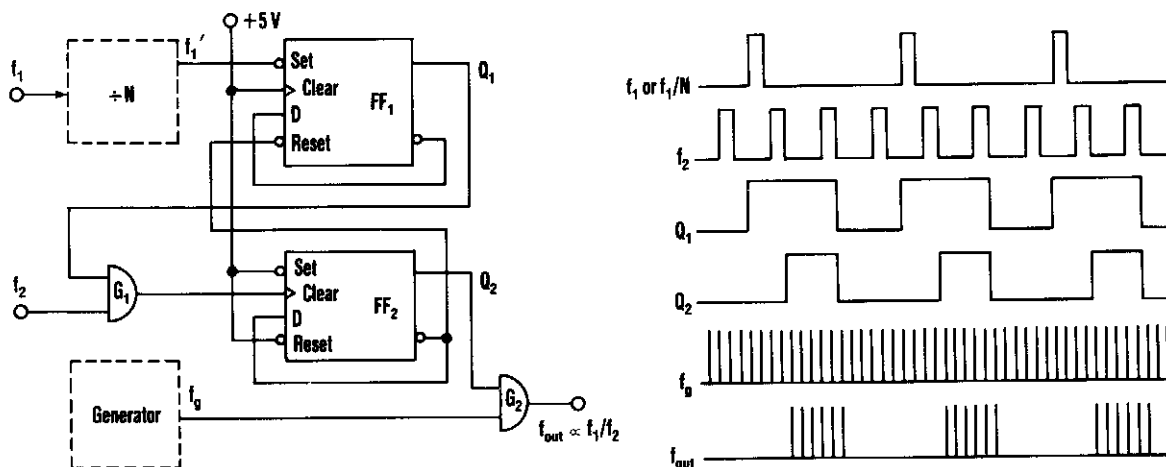


HANDS-ON ELECTRONICS

Fig. 34-7

Germanium transistor Q1 is used as a noise generator in the audio range. U1 acts as a high-gain amplifier. Q1 is not critical; most germanium transistors appear to be satisfactory. A germanium diode can also be substituted. This circuit is mainly used for sound effects and noise experiments. It is not flat over the audio range because of unpredictable effects in Q1, but it should be useful where high precision is not necessary.

FREQUENCY-RATIO MONITORING CIRCUIT

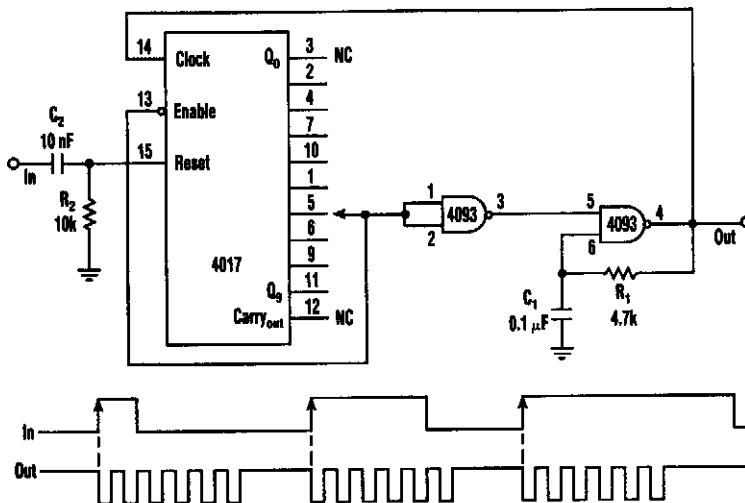


ELECTRONIC DESIGN

Fig. 34-8

This circuit produces an output frequency that is linearly proportional to the ratio of two input frequencies f_1/f_2 . Each pulse of the bias f_1 (or f) will open G_1 for a period $T = 1/f_2$ so that f_g/f_2 pulses pass to the output.

PULSE TRAIN



ELECTRONIC DESIGN

Fig. 34-9

This circuit has a rate multiplier using a 4093 Schmitt trigger as an oscillator, driving a 4017 decade counter. When a pulse present at the input (to C_2) 4017 is reset, output zero goes high, and outputs 1 to 9 go low. The oscillator (4093) starts running and the 4017 counts the pulses until the 4017 output (1 to 9) connected to pin 1 and 2 of the 4093 goes high. The oscillator is inhibited and the output remains high until the next input pulse.

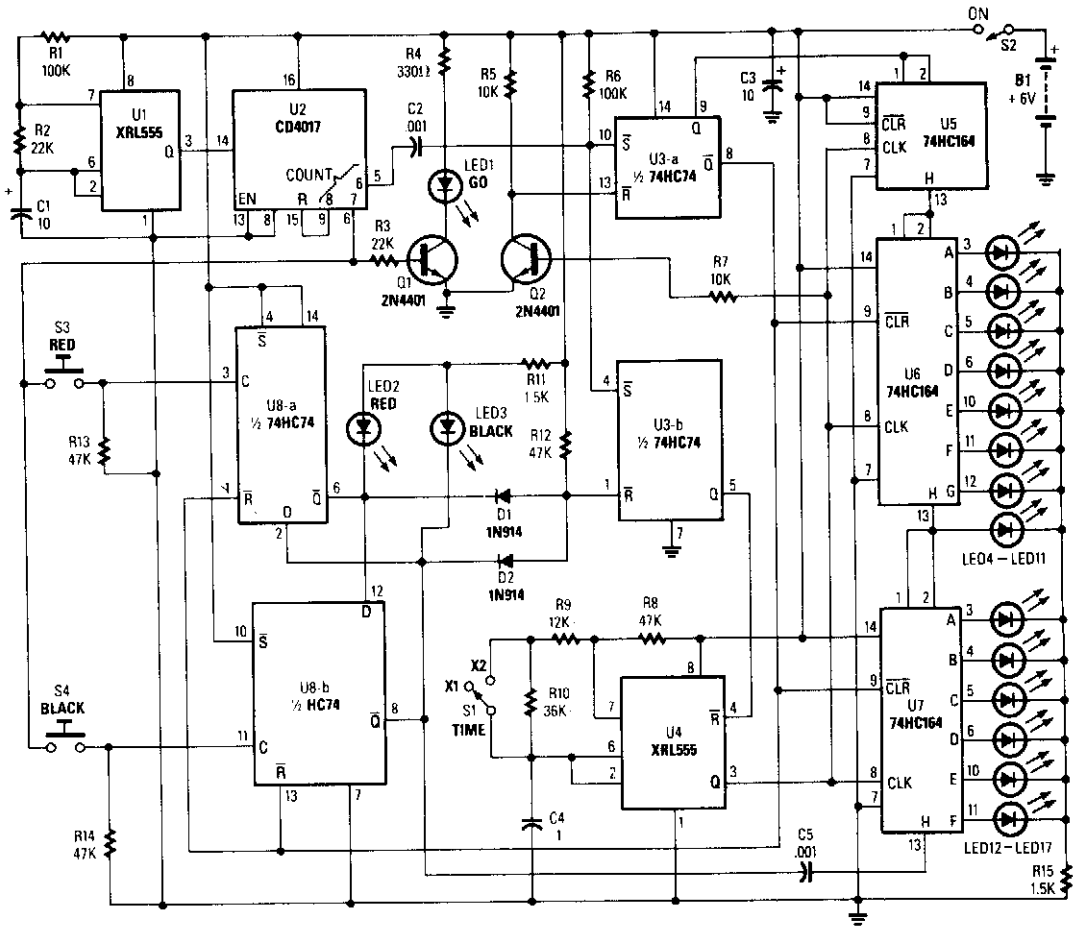
35

Games

The sources of the following circuits are contained in the Sources section, which begins on page 667. The figure number in the box of each circuit correlates to the entry in the Sources section.

Reaction Timer
Electronic Roulette Game
Run-Down Clock/Sound Generator
Wheel of Fortune
Simple Lie Detector
Electronic Dice

REACTION TIMER

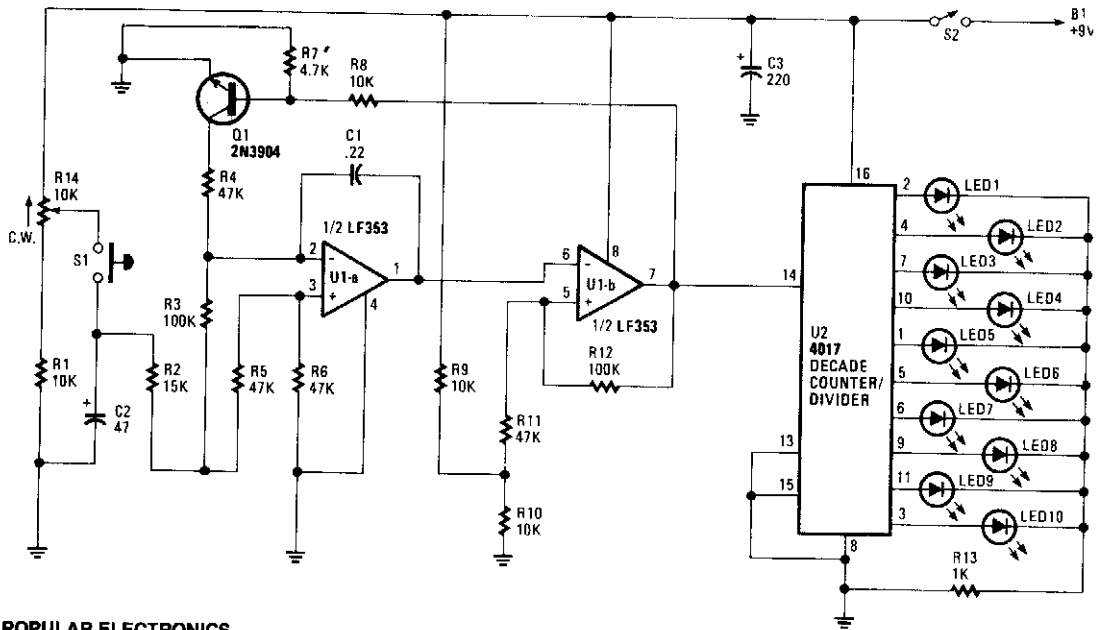


RADIO-ELECTRONICS

Fig. 35-1

This circuit uses a timer to generate pulses at a 5-ms clock rate. The pulses are shifted into the shift register, one at a time, lighting an LED. An auxiliary timer that generates one pulse per second is used to generate timing to activate the "go" LED and start the 5 ms pulses clocking into the registers. At the GO signal each player presses his buttons (S3 or S4). The delay (reaction time) is read out on LED 4 to LED 17; after six seconds, the sequence repeats.

ELECTRONIC ROULETTE GAME

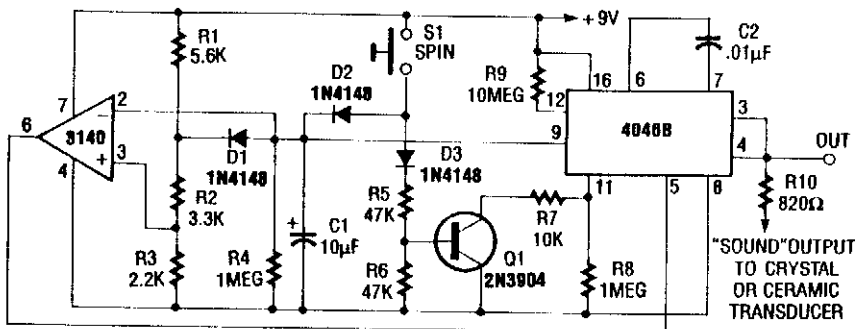


POPULAR ELECTRONICS

Fig. 35-2

R14 is set for an initial "starting" speed of the oscillator U1A and U1B. As C2 charges, oscillation begins slowing down as C2 discharges, giving a roulette-wheel effect on LED S1 through 10. The LED that remains on is the winning number.

RUN-DOWN CLOCK/SOUND GENERATOR

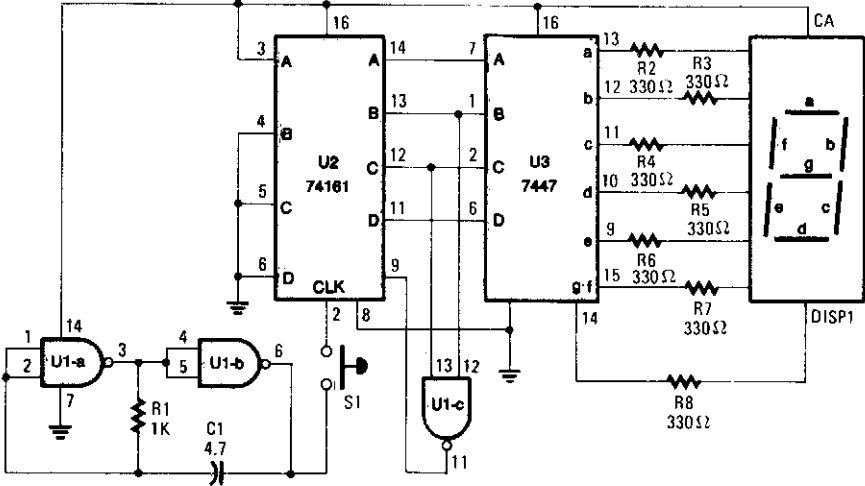


RADIO-ELECTRONICS

Fig. 35-3

Used in electronic roulette or dice games, this circuit produces a clock signal that initially is several tens of kHz (depending on C2) and gradually decreases to zero in about 15 seconds, as C1 discharges through R4.

ELECTRONIC DICE



POPULAR ELECTRONICS

Fig. 35-6

When S1 is pressed, counter U2 is driven by oscillator U1A/U1B and the count (0 through 6) is read on DISP1. R1 and C1 determine the count rate, which should be fast enough to ensure a "random" count.

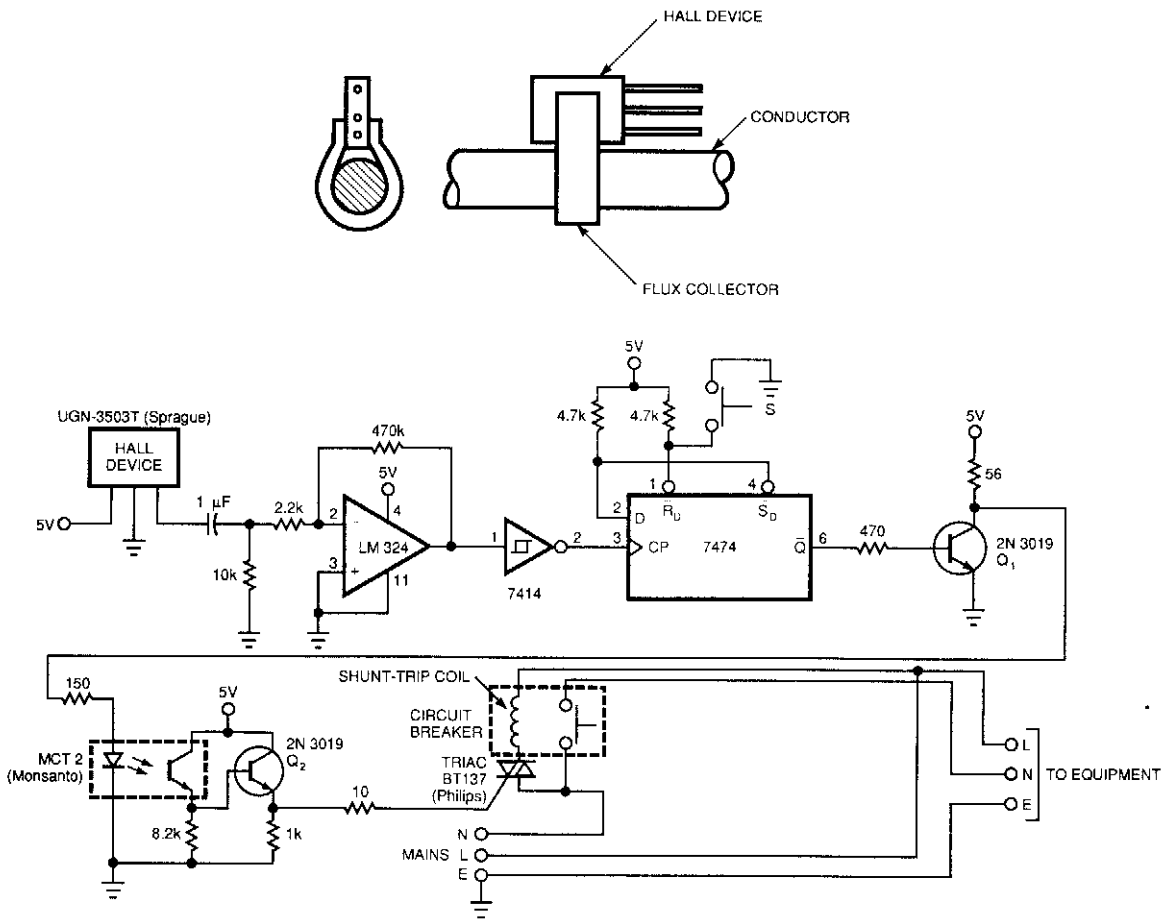
36

Ground-Fault Hall Detector

The source of the following circuit is contained in the Sources section, which begins on page 667. The figure number in the box correlates to the entry in the Sources section.

Ground-Fault Hall Sensor

GROUND-FAULT HALL SENSOR



EDN

Fig. 36-1

No electrical contact exists between the circuit and the conductor. The 7474 flip-flop is triggered by the output from the Hall sensor, op amp, and Schmitt trigger. This triggering activates the optocoupler, turns on the triac, and trips the circuit breaker.

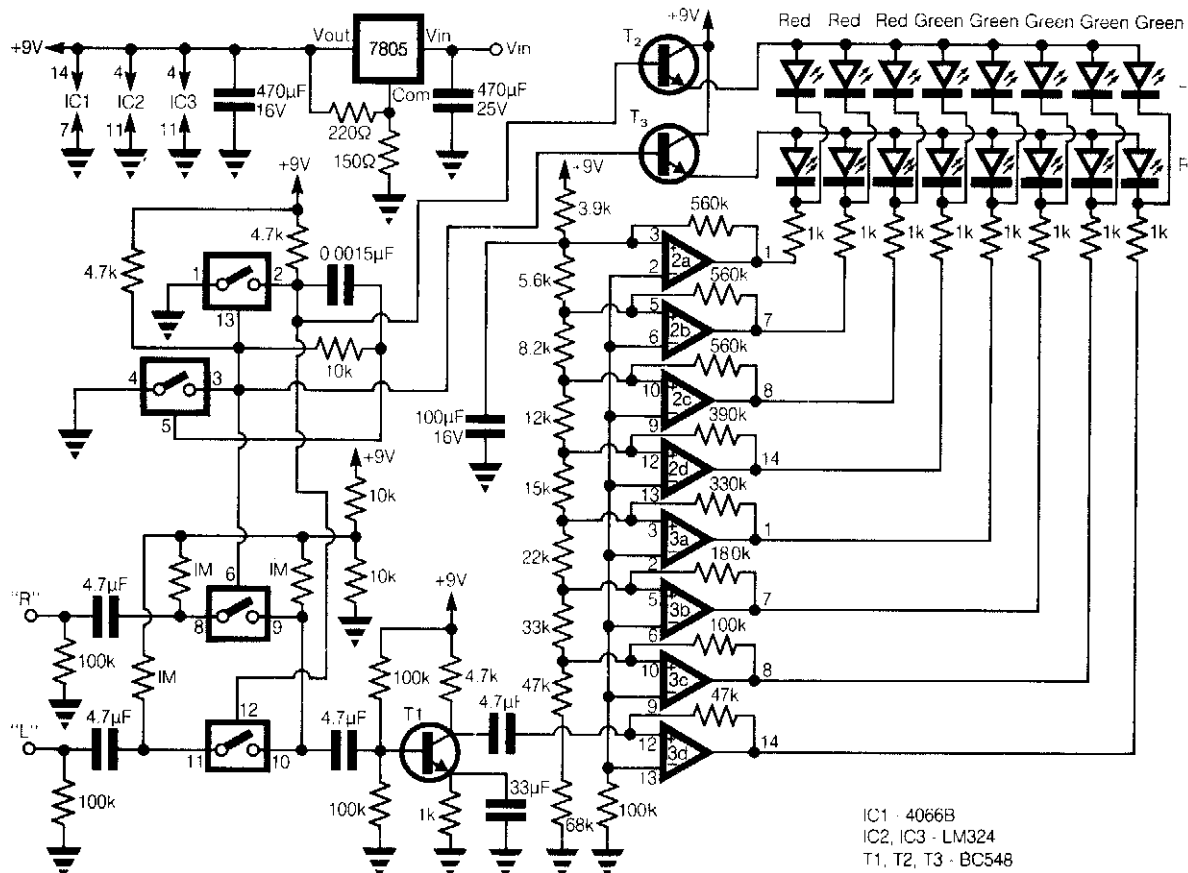
37

Indicators

The sources of the following circuits are contained in the Sources section, which begins on page 667. The figure number in the box of each circuit correlates to the entry in the Sources section.

Stereo LED VU Meter
Audio Amplifier Volume Indicator
Transistorized Bar-Graph Driver
Visual CW Offset Indicator
ac-Circuit LED Power Indicator
ac/dc Indicator
Balance Indicator
Mains Failure Indicator
On Indicator
Sound Sensor
Transmitter Output Indicator

STEREO LED VU METER



ELECTRONIC ENGINEERING

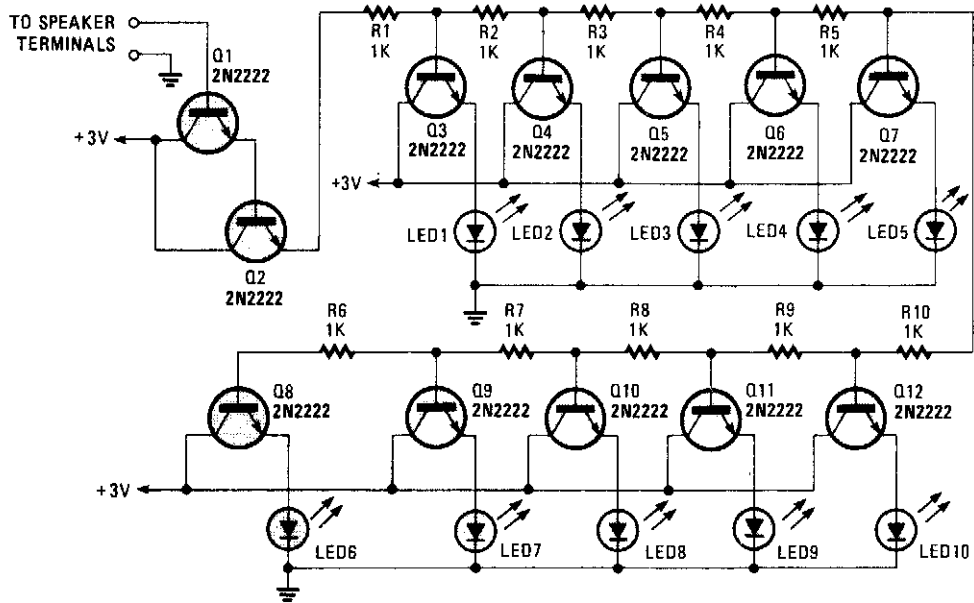
Fig. 37-1

This circuit provides a cheap alternative to the LM3915 series LED displays. The meter relies on a square-wave oscillator built around two CMOS analog switches, which alternatively selects the right and left channels for monitoring and display. The selected signal is amplified by the common-emitter stage T1, and the output is fed into the string comparators which control the display.

These eight comparators are from two LM324 quad op amps, each is connected to a resistor network, which has a 3dB step between each comparator. Each comparator has a positive feedback resistor to increase the hysteresis to provide a longer display, which is switched alternatively at about 10 kHz.

The two CMOS switches in line are biased at half the supply voltage by 1-M Ω resistors from a 100-k Ω divider, which allows them to handle analog signals up to 9 V peak to peak. As the voltage increases above the setpoint of each comparator, the output goes low and the corresponding LED lights, which produces a bar of light in response to the input voltage. For a linear response the resistor-network can be replaced by nine 10-k Ω resistors, giving an equal voltage gap before each LED comes on.

TRANSISTORIZED BAR-GRAPH DRIVER

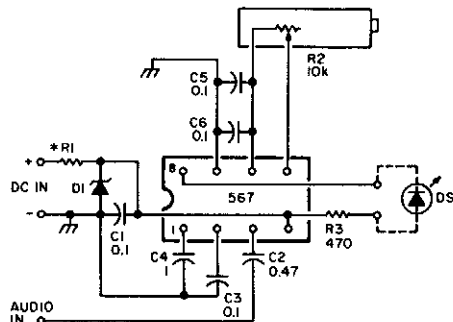


POPULAR ELECTRONICS

Fig. 37-3

A resistor network (R1 through R10) with emitter followers (Q1 and Q2) drives LED drivers (Q3 through Q7). This circuit was used as a "light organ" to provide visual volume indication. It can be hooked to a speaker, to another audio source, etc.

VISUAL CW OFFSET INDICATOR

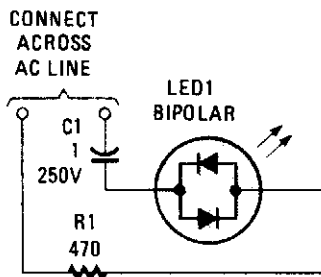


73 AMATEUR RADIO

Fig. 37-4

An NE567 tone decoder, tuned to the transceiver's CW offset frequency, ensures that the transceiver will be transmitting on the same frequency as the received CW signal. Simply tune the transceiver so that the LED lights. Eight to 13 Vdc is required; this can be taken from the transceiver supply or an extra battery. Audio is taken from the speaker or headphone output.

ac CIRCUIT LED POWER INDICATOR



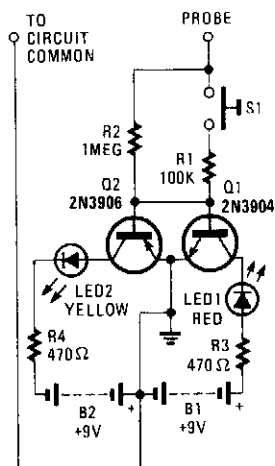
POPULAR ELECTRONICS

Fig. 37-5

Many electronic circuits need an indication that they are under power; for most ac circuits, a neon lamp is the device of choice. A bidirectional tricolor LED can be used if a capacitor is connected in series with the LED to limit the current through the LED. A $1\text{-}\mu\text{F}$, 250-WVdc capacitor, which has a reactance of 2 650 ohms at 60 Hz, is used in series with an LED to limit the current through the unit to 43 mA. The impedance of the LED is low compared to the reactance of the capacitor, so nearly all the impedance will be caused by the capacitor with the added advantage of no energy loss caused by the capacitor.

The power of the LED is $1.175\text{ V} \times 0.043\text{ A} = 50\text{ mW}$ compared to an NE-2H at 250 mW. For 230 V, use a $0.47\text{-}\mu\text{F}$, 400-WVdc capacitor.

ac/dc INDICATOR

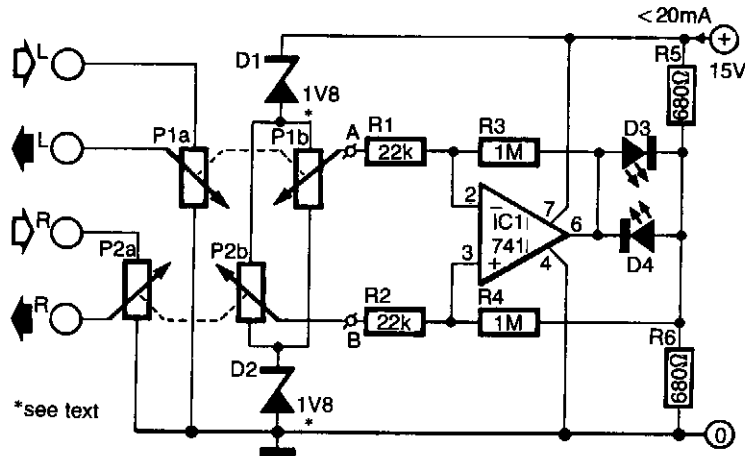


RADIO-ELECTRONICS

Fig. 37-6

By using two switching transistors and two LEDs, this circuit can distinguish low-level ac and dc signals. If the red LED illuminates, the signal is positive dc. If the yellow LED lights, the signal is negative dc. If the signal is ac, both LEDs will light.

BALANCE INDICATOR



ELEKTOR ELECTRONICS

Fig. 37-7

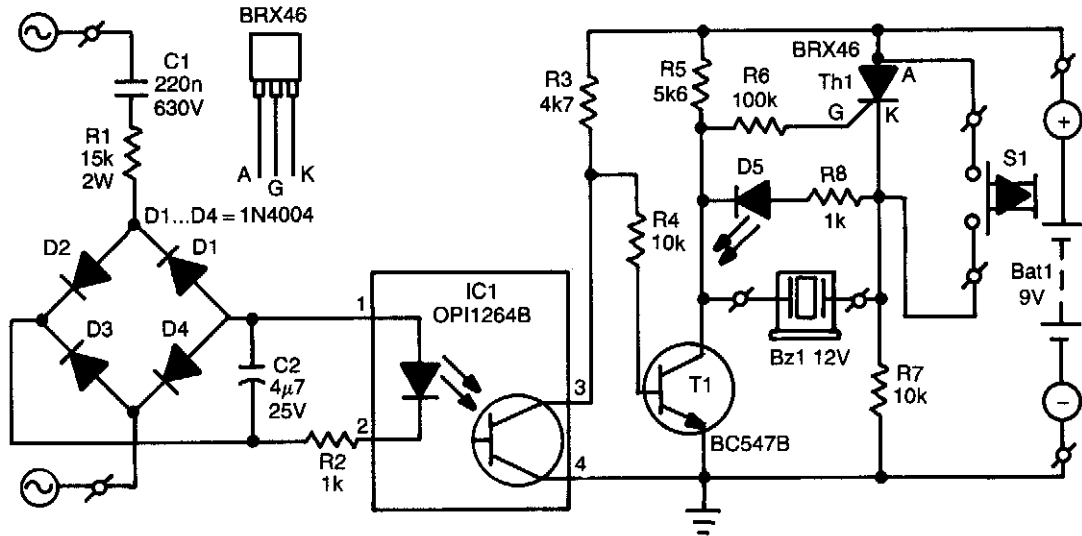
If your amplifier is fitted with two level controls, it actually offers you a balance control and a level control. A drawback of this is that it is quite difficult to set the balance properly. This can be obviated, however, by replacing the two monopotentiometers with stereo versions P1 and P2 in the diagram.

One half of the pair, P1A and P2A, assumes the tasks of the removed components. The other half is connected in a bridge circuit. The voltage between wipers of the potentiometers is then a measure of the balance between the two channels. The lower the potential, the better the balance. If you are interested in knowing the degree of unbalance, connect a center-zero moving coil meter with a bias resistor between A and B. With this arrangement, zener diodes D1 and D2 can be omitted: they are necessary only with the LED indicator shown in the diagram to prevent the input voltage of the op amp from getting too close to the level of the supply voltage.

The circuit around IC1 is a classical differential amplifier. Resistors R5 and R6 provide a virtual earth for the LEDs, which is necessary to ensure that, in spite of the asymmetrical supply voltage, a positive and a negative output is obtained.

Because the LEDs have been included in the feedback loop of the indicator, the circuit is pretty sensitive. At only 40 mV, that is, just $\frac{1}{400}$ of the supply voltage, one of the LEDs begins to light. The maximum current drawn by the LEDs is determined by the values of R5 and R6.

MAINS FAILURE INDICATOR



ELEKTOR ELECTRONICS

Fig. 37-8

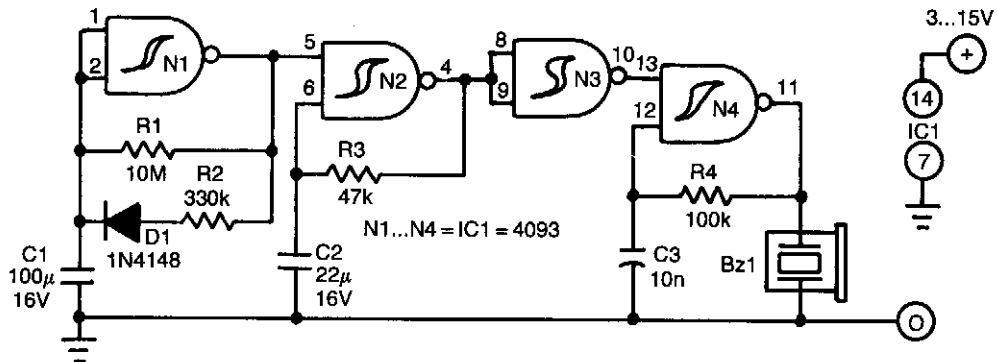
When the mains voltage is present at the input terminals, the transistor in the optocoupler is on, T1 is off, and silicon-controlled rectifier Th1 is in the conducting state. Because both terminals of the piezoelectric buzzer are then at the same potential, the buzzer is inactive. If the mains voltage drops out, transistor T1 conducts and causes one of the terminals of the buzzer to be connected to earth; the thyristor remains in the conducting state. In this situation, a large enough potential difference is across both the buzzer and D5 to cause these elements to indicate the mains failure—both audibly and visibly.

When the mains is restored, the circuit returns to its original state. A touch on the reset button then interrupts the current through the SCR so that the thyristor goes into the blocking state, and the other terminal of the buzzer is connected to ground.

The unit is powered by a 9-V battery and draws a quiescent current of 1.7-2.5 mA. It is important for the enclosure to be well-insulated.

If by accident the circuit to the optocoupler and R2 is broken, electrolytic capacitor C2 might be damaged because it will be charged well above its 25-V rating. Secondly, where a plug is used for the mains connection, it is advisable to solder a 1-M Ω resistor across C1 so that this capacitor does not retain its charge after the plug is removed from the mains socket.

ON INDICATOR



ELEKTOR ELECTRONICS

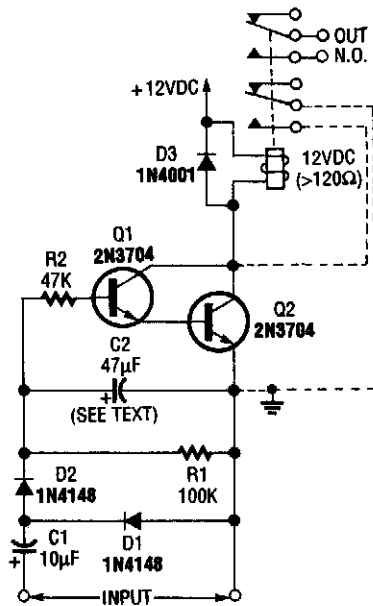
Fig. 37-9

Battery-operated equipment can work on one set of batteries for a long time nowadays. However, if it is left on inadvertently, that "long time" is over very quickly. Moreover, flat (dead) batteries are always found at the wrong moment. The circuit proposed here is a sort of *aide-memoire*. Every two minutes, it emits 5 to 10 pips to indicate that the equipment is still switched on.

Basically, the circuit consists of three rectangle-wave generators and an inverter. The first of the generators is formed by N1 and provides a signal with a period of about two minutes and a pulse duration of around 10 seconds. During those 10 seconds, the second generator starts operating in a one-second rhythm. Thus, N2 outputs 10 pulses every 2 minutes. That output is inverted so that N4, like N2, can only be enabled during the 10-second pulse train from N1. The difference is that during those 10 seconds, N4 is enabled and inhibited 10 times; this is what causes the pips.

Do not take the times and number of pulses too literally, because wide variances are between ICs from different manufacturers. On the other hand, component values are not critical, so it is fairly easy to adapt the circuit to personal taste or requirements. The buzzer can be a standard Toko type or equivalent. The current drawn by the circuit is negligible.

SOUND SENSOR



RADIO-ELECTRONICS

Fig. 37-10(a)

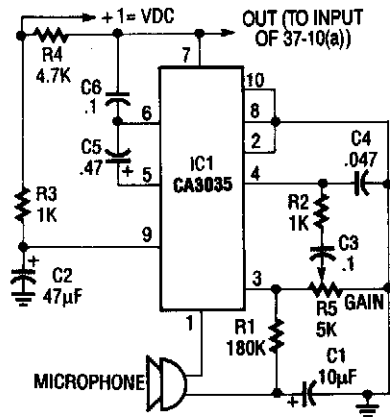
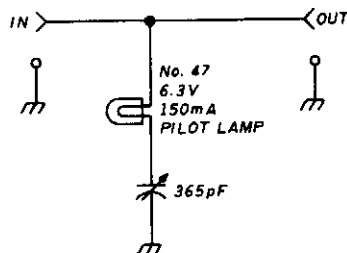


Fig. 37-10(b)

By using a microphone, high-gain amplifier (Fig. 37-10(b)), and detector-relay driver (Fig. 37-10(a)) a sound-detecting alarm system can be constructed. If you want a latching setup, make the dotted connections to the relay shown in Fig. 37-10(a).

TRANSMITTER OUTPUT INDICATOR



HAM RADIO

Fig. 37-11

Relative power can be indicated with this simple circuit. Adjust the 365-pF variable capacitor for desired lamp brightness.

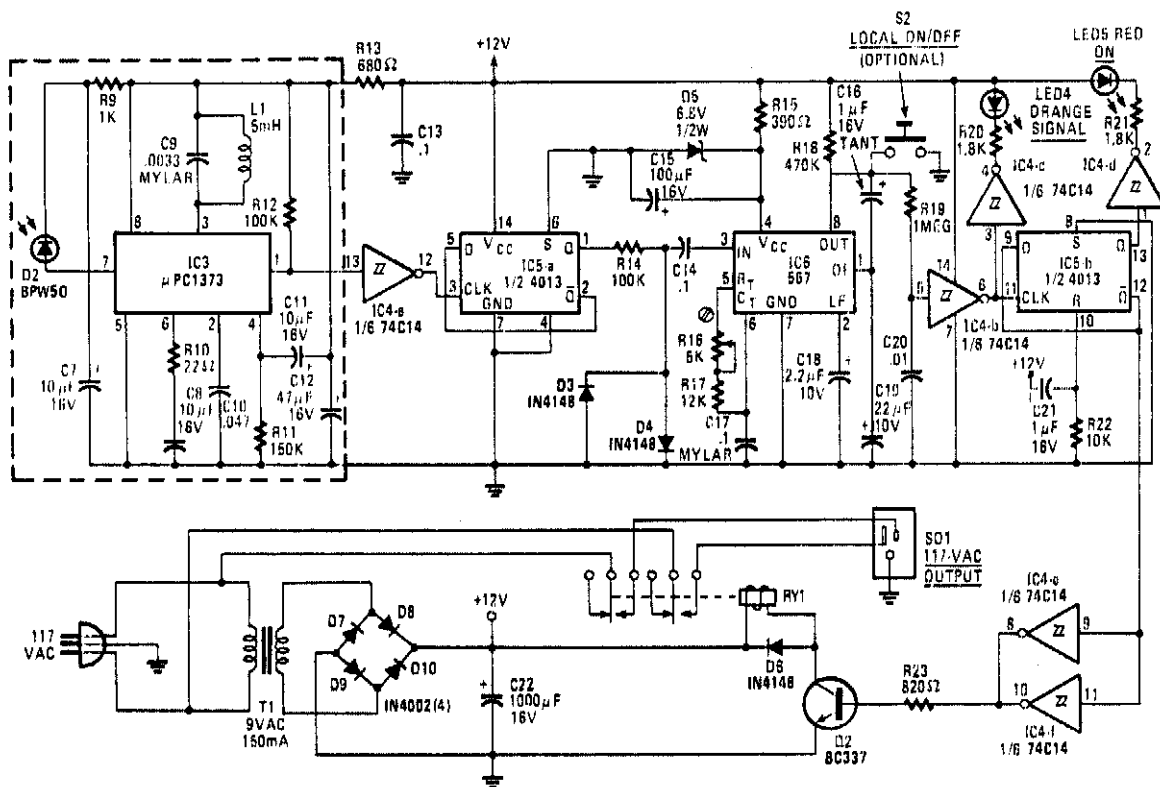
38

Infrared Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 667. The figure number in the box of each circuit correlates to the entry in the Sources section.

- IR Receiver I
- IR Receiver II
- Wireless IR Security System
- IR Detector
- Infrared Remote Controller
- IR-Controlled Soldering Station
- Infrared "People" Detector
- IR Heat-Controlled Kitchen Fan
- Simple IR Transmitter
- IR Transmitter
- IR Remote Extender
- Infrared Remote-Control Tester
- Voice-Modulated Pulse FM IR Transmitter

IR RECEIVER I



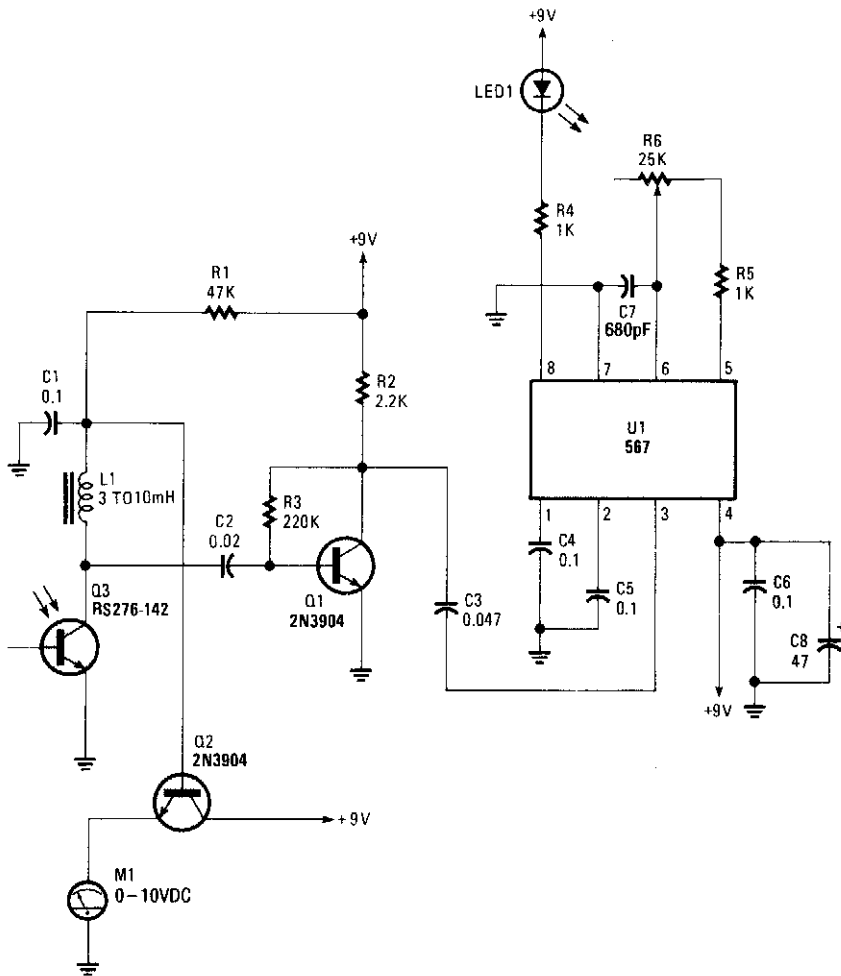
RADIO-ELECTRONICS

Fig. 38-1

This receiver is built around a uPC1373 IR remote-control preamplifier, a sensitive 30-to-40 kHz tuned detector, an automatic gain control, a peak detector, and an output waveshaping buffer. The demodulated signal from the preamp stage is sent to IC4A, a 74C14 Schmitt trigger. The squared-up 1500-Hz signal is then sent to the clock input of IC5A, half of a 4013 dual "D" flip-flop. That 750-Hz signal is clipped to approximately 0.7-V p-p by diodes D3 and D4. The clipped signal is then fed to IC6, a 567 tone decoder. The output of that IC goes low whenever the frequency of the signal fed to it is within the lock range of its internal VCO.

When IC6 detects a signal of the proper frequency, pin 8 goes low. The output signal is fed through another Schmitt trigger (IC4B), which drives another "D" flip-flop, IC5B. Schmitt trigger IC4B also drives IC4C, which in turn drives LED4, SIGNAL, which lights up whenever a signal is received. The Q output of IC5B drives two parallel-connected inverters. IC4C and IC4F turn transistor Q2 on when Q goes low. That transistor energizes the relay; its contacts switch the controlled device on and off.

IR RECEIVER II

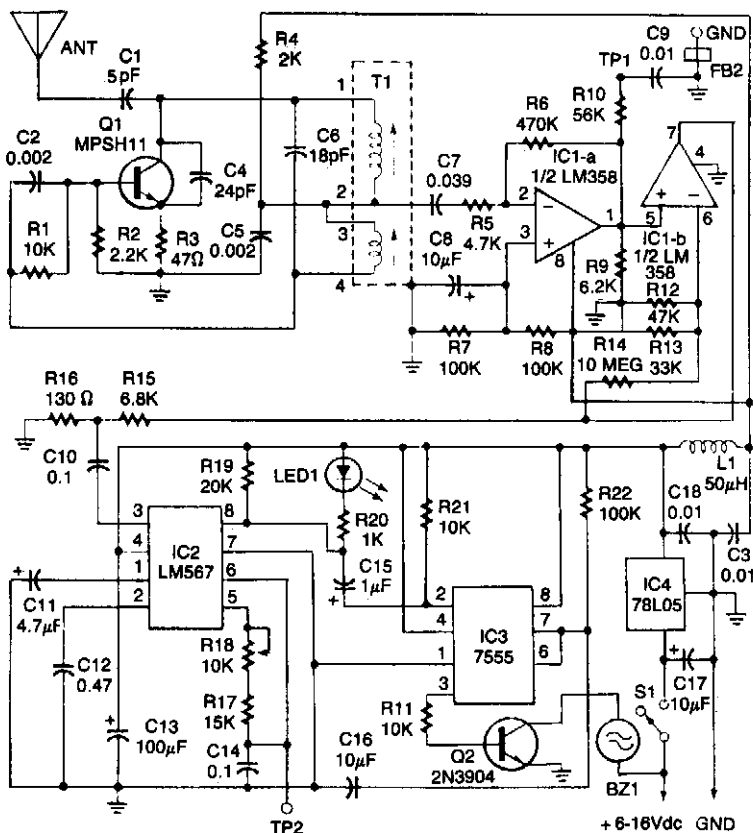


POPULAR ELECTRONICS

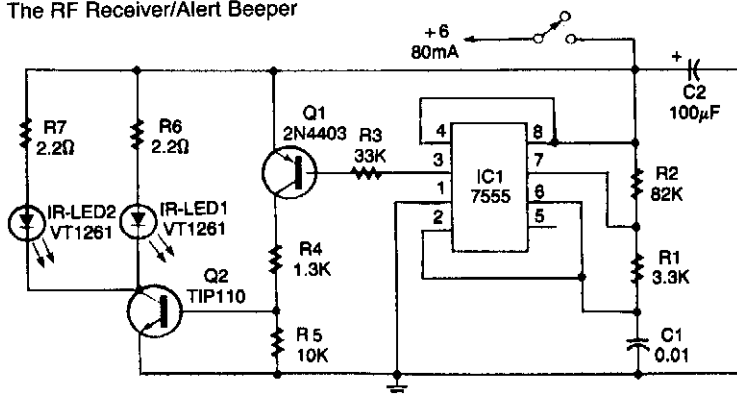
Fig. 38-2

Q3 is an IR phototransistor that responds to a modulated IR beam. Q1 amplifies the ac component of the IR beam. Q2 drives a meter as a relative indication of the strength of the light beam. A strong beam gives a lower meter reading. U1 is a tone decoder that produces a low output on pin 1 during reception for an IR beam that is modulated with the correct tone frequency, determined by R6.

WIRELESS IR SECURITY SYSTEM



The RF Receiver/Alert Beeper



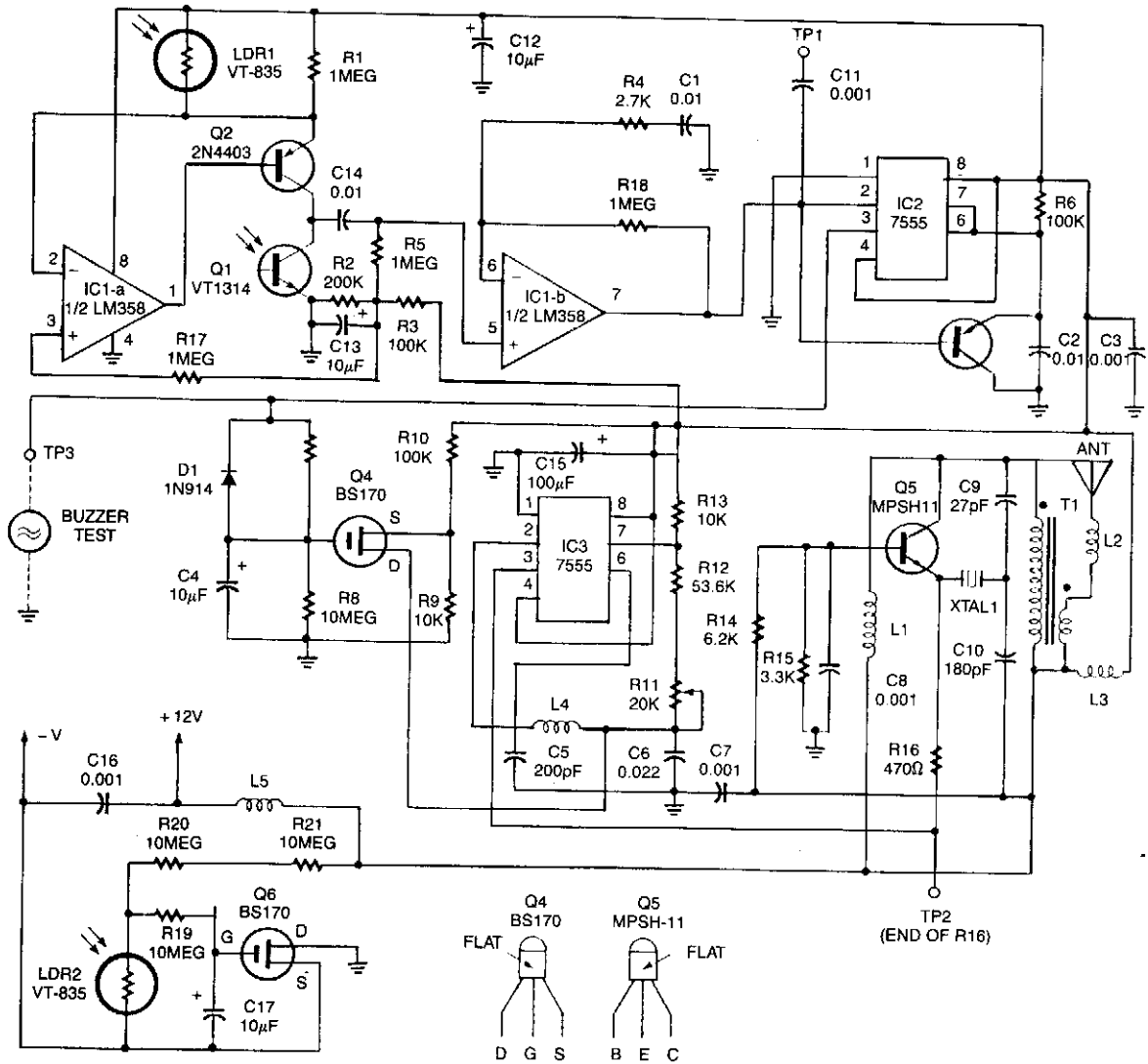
The IR Transmitter

RADIO-ELECTRONICS

Fig. 38-3

This system contains an IR transmitter, an IR receiver/RF transmitter, and an RF receiver/alert beeper. Two IR LEDs in the transmitter transmit a pulsed beam of invisible infrared light to the receiver, which contains an IR phototransistor. The phototransistor detects and amplifies the pulse-modulated IR beam. If the receiver section senses that the IR beam is momentarily interrupted by an object blocking the

WIRELESS IR SECURITY SYSTEM (Cont.)

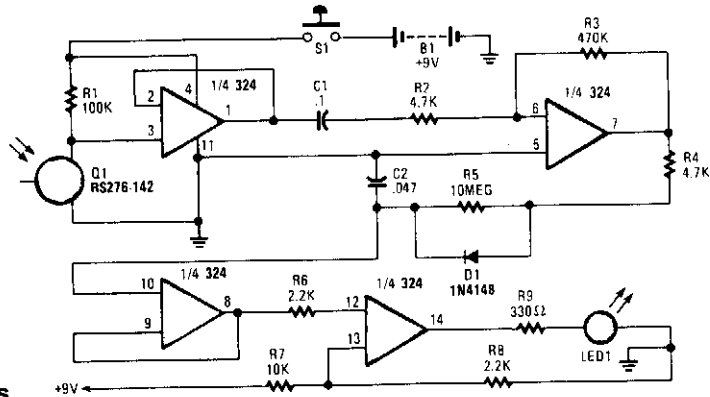


The IR Receiver/RF Transmitter

beam's path, it triggers the transmitter, which outputs a 49.890-MHz carrier that is amplitude-modulated by a 490-Hz tone.

Upon receiving the 490-Hz amplitude-modulated carrier, the RF receiver/beeper unit sounds an alarm that alerts the user to the intrusion. The system is not limited to just one RF transmitter. A single RF receiver/beeper can be used to monitor any number of RF transmitters (or locations). However, the receiver/beeper unit cannot discriminate between different transmitter sites in multiple-transmitter systems.

IR DETECTOR

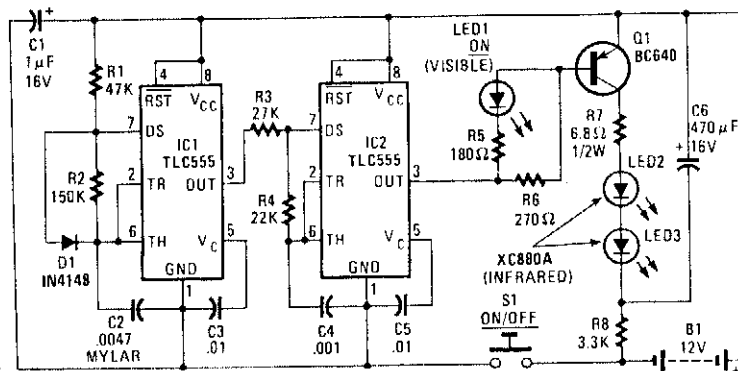


POPULAR ELECTRONICS

Fig. 38-4

Useful for checking TV remote controls, IR-based alarm systems, and IR sources, this circuit causes LED1 to turn on for two seconds in the presence of IR light pulses. U1A acts as a voltage follower for detector Q1. C1 and R2 form a differentiating network and U1B acts as an amplifier for the pulses, which charges C2. Voltage follower U1C samples the voltage on C2 and drives comparator U1D, which switches LED1 on or off.

INFRARED REMOTE CONTROLLER



RADIO-ELECTRONICS

Fig. 38-5

The transmitter is built around two CMOS 555 timer ICs (TLC 555s). The transmitter generates a modulated 35-kHz IR signal. The 35-kHz carrier frequency is generated by IC2, and the 1500-Hz modulating signal is generated by IC1. The output of IC2 drives LED1 through resistor R5; that LED provides visual indication that the transmitter is working. In addition, IC2 drives transistor Q1, which drives the two infrared LEDs (LED 2 and LED3).

To provide the high current needed to drive the two IR LEDs, capacitor C6 is precharged, the charge it contains is dumped when S1 is pressed. When S1 is not pressed, the power to the ICs is cut off. However, C6 is kept charged via R8. Then, when S1 is pressed, the current stored in C6 can be used to drive the LEDs for as much as 1/2 second. That's plenty of time for the receiver to pick up a signal.

IR-CONTROLLED SOLDERING STATION

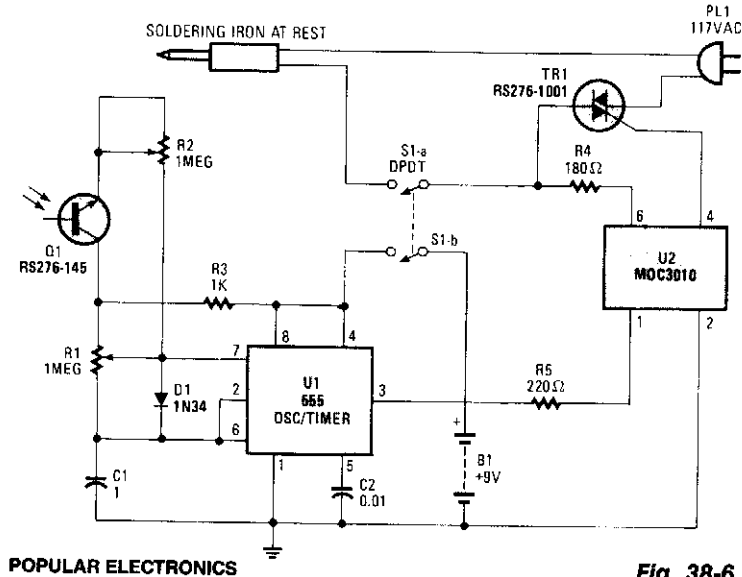
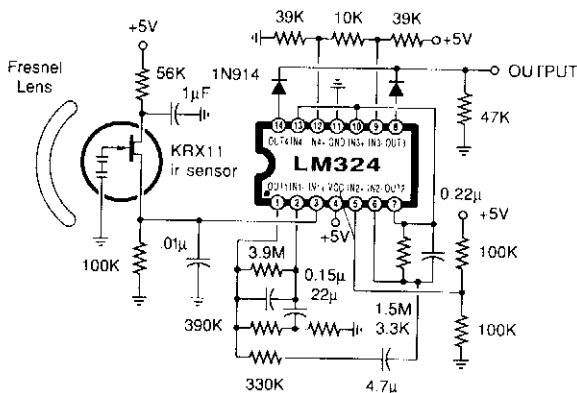


Fig. 38-6

An IR-sensitive phototransistor is used to sense soldering-iron temperature. The phototransistor must see the tip through an opaque tube to avoid stray light, and the phototransistor should preferably be fitted with an IR filter. An old photo negative, dark red plastic, or red or black glass can be used. The iron sits on a holder.

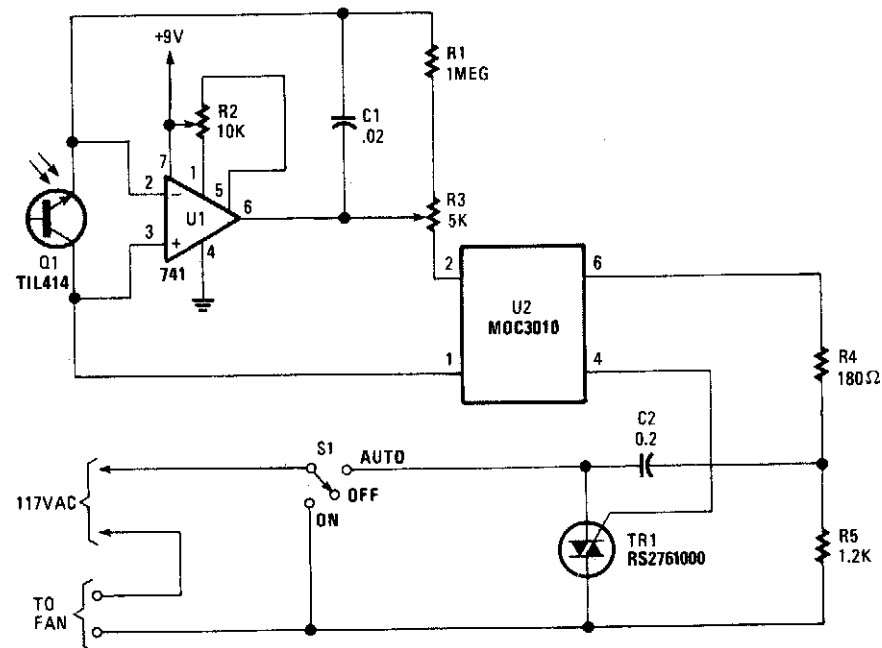
When the iron is removed from the holder, the iron is not being viewed by the detector. The heat will increase, but the circuit has a lag time; if the iron is returned to its holder after each use, overheating should not be a problem.

INFRARED "PEOPLE" DETECTOR



This circuit uses an Amperex pyroelectric IR sensor, an LM324 op amp (configured as a high-gain amplifier in the 0.3-to 5-Hz range), and a window detector. The output will go high on any motion, which will change the infrared signature seen by the sensor.

IR HEAT-CONTROLLED KITCHEN FAN

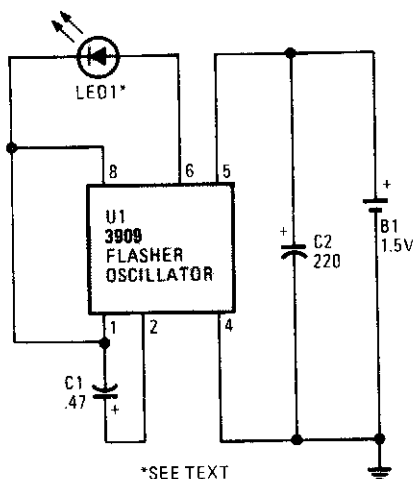


POPULAR ELECTRONICS

Fig. 38-8

Q1 senses IR from heat sources, causes U1 to switch, activates optocoupler U1, and triggers TR1. This controls a fan. The Triac is from Radio Shack, or else a 200-V, 6-A unit (C106B) can be used.

SIMPLE IR TRANSMITTER



*SEE TEXT

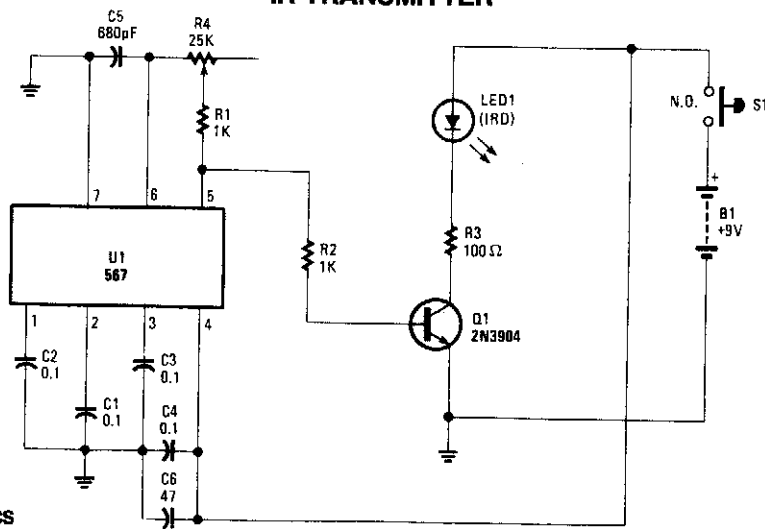
The IR diode's flash rate is determined by the value of C1, a 220- μ F capacitor that sets the rate of oscillation at 1 Hz per second. Reducing C1 will increase the frequency of the circuit, while larger values will decrease the frequency.

Because the circuit only sends out single, narrow pulses of invisible light, the IR receiver only responds with a click for every output pulse.

POPULAR ELECTRONICS

Fig. 38-9

IR TRANSMITTER

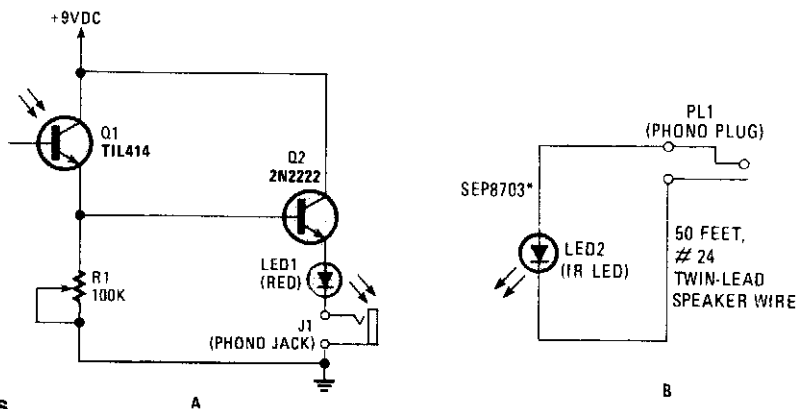


POPULAR ELECTRONICS

Fig. 38-10

Using an NE567 as a tone oscillator, this circuit produces an IR signal from the LED, which is modulated with a square wave. LED1 is an IR-emitting LED. The modulation helps improve performance under high ambient light conditions.

IR REMOTE EXTENDER



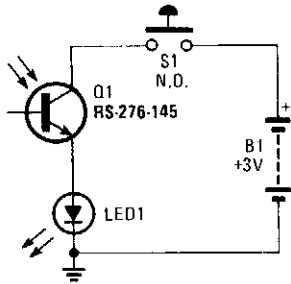
POPULAR ELECTRONICS

Fig. 38-11

This circuit can be used to operate a VCR or CD player from another room. It's really an infrared signal repeater. The signal from the remote is received and then retransmitted over wires to an infrared LED. The beam from the LED is then picked up by the receiving window on the VCR or CD player.

The visible light LED (LED1) in series with the IR unit (LED2) is used to indicate that the transmitted signal has been detected. The 100-kΩ trimmer potentiometer (R1) adjusts the repeater's sensitivity. The resistor that is usually found in series with the LEDs is omitted, because the voltage reading is about 1.0 Vdc as a result of the voltage drop across the lines.

INFRARED REMOTE CONTROL TESTER

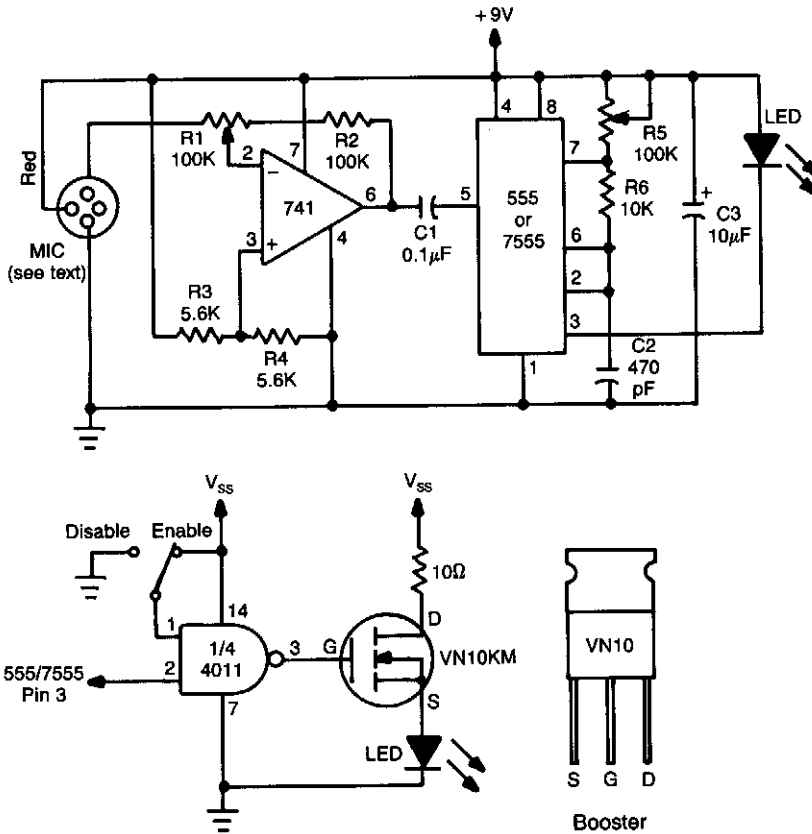


Using a battery, a phototransistor and a visible-light LED, this simple circuit is a "go/no go" tester for IR remote control devices. The illumination of the LED indicates that Q1 is being modulated by IR energy.

POPULAR ELECTRONICS

Fig. 38-12

VOICE-MODULATED PULSE FM IR TRANSMITTER



POPULAR ELECTRONICS

Fig. 38-13

This circuit has a 741 audio amplifier, which is fed by a microphone (use an amplified type), an FM modulator, and a CMOS timer that acts as a VCO. The LED is pulsed with the timer output (the booster circuit can be used for increased range). This yields an FM-modulated, pulsed IR beam.

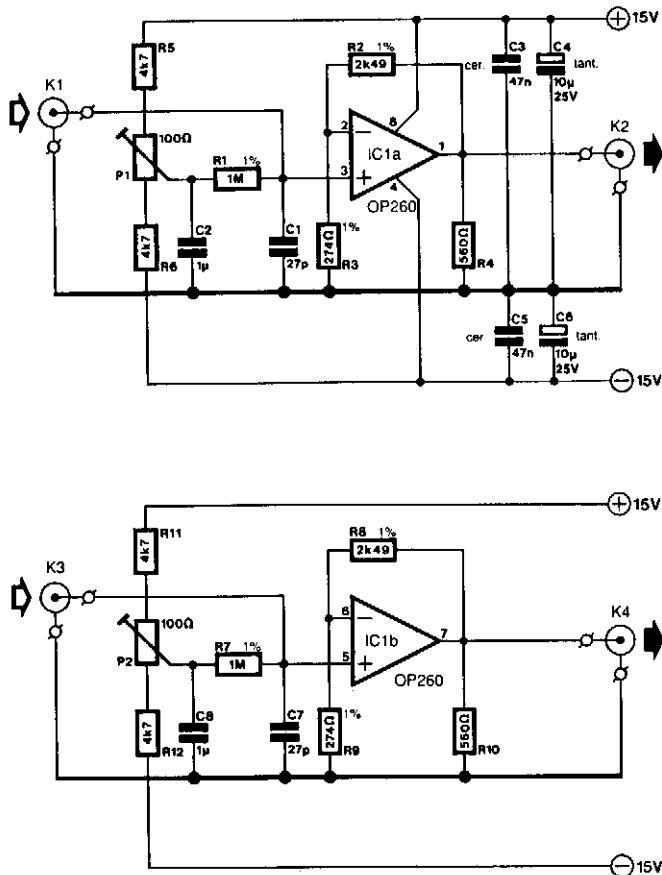
39

Instrumentation Amplifiers

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

Oscilloscope Preamp
Low-Drift/Low-Noise dc Amplifier
Instrumentation Amplifier
Extended Common-Mode Instrument Amplifier

OSCILLOSCOPE PREAMP



ELEKTOR ELECTRONICS

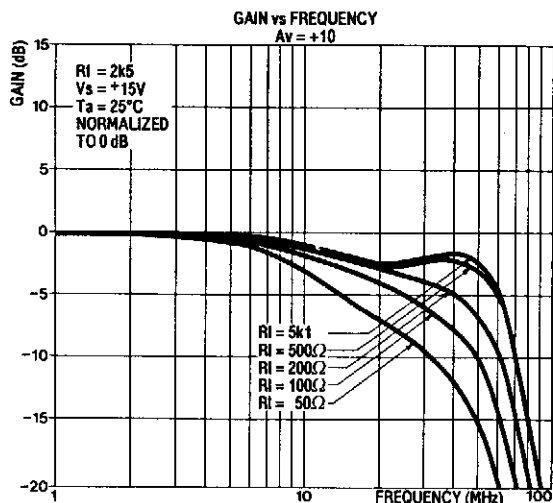
Fig. 39-1(a)

In many oscilloscopes, the most sensitive range is 2 to 5 mV, although it is often possible to improve this to 1 to 2 mV by a variable gain control. To obtain even better sensitivity, the present preamplifier, which has an amplification of about 10 (20 dB), might be useful.

Because most oscilloscopes have a bandwidth of 20 MHz or more, the amplifier must, of course, have a slightly wider bandwidth and that is achieved with a Type OP260 op amp. This has a slew rate of 550 V/ μ s (at an amplification of 10) and a bandwidth of 40 MHz that is virtually independent of the amplification. The gain vs. frequency response is not so good, however: as can be seen from Fig. 39-1(b), where the characteristics are given for a number of loads. The hump in the curves depends on the value of the feedback resistor, whose optimum value appears to be 2.5 k Ω .

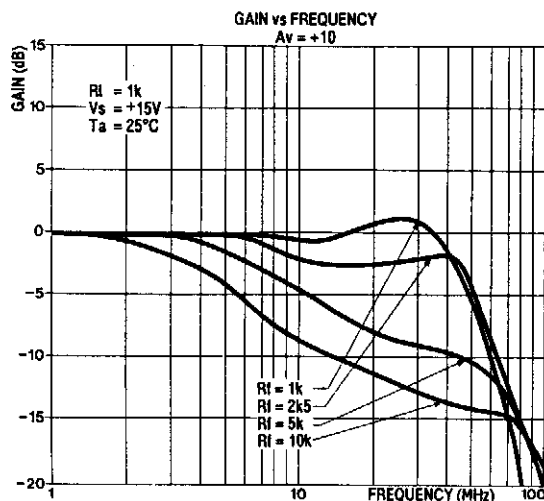
The curves in Fig. 39-1(c) accord with different values of R_2/R_3 for an amplification factor of 10. Some experimentation with the value of R_2/R_3 for different amplification factors can be instructive. Remember, however, that the output impedance increases from 20 to 225 Ω over the frequency range of 10 MHz to 60–70 MHz. It is therefore important to keep all connections on the prototyping board as short as possi-

OSCILLOSCOPE PREAMP (Cont.)



ELEKTOR ELECTRONICS

Fig. 39-1(b)



ELEKTOR ELECTRONICS

Fig. 39-1(c)

ble and to connect all earth points to a common ground via a separate, heavy track. Also, do not use an IC socket.

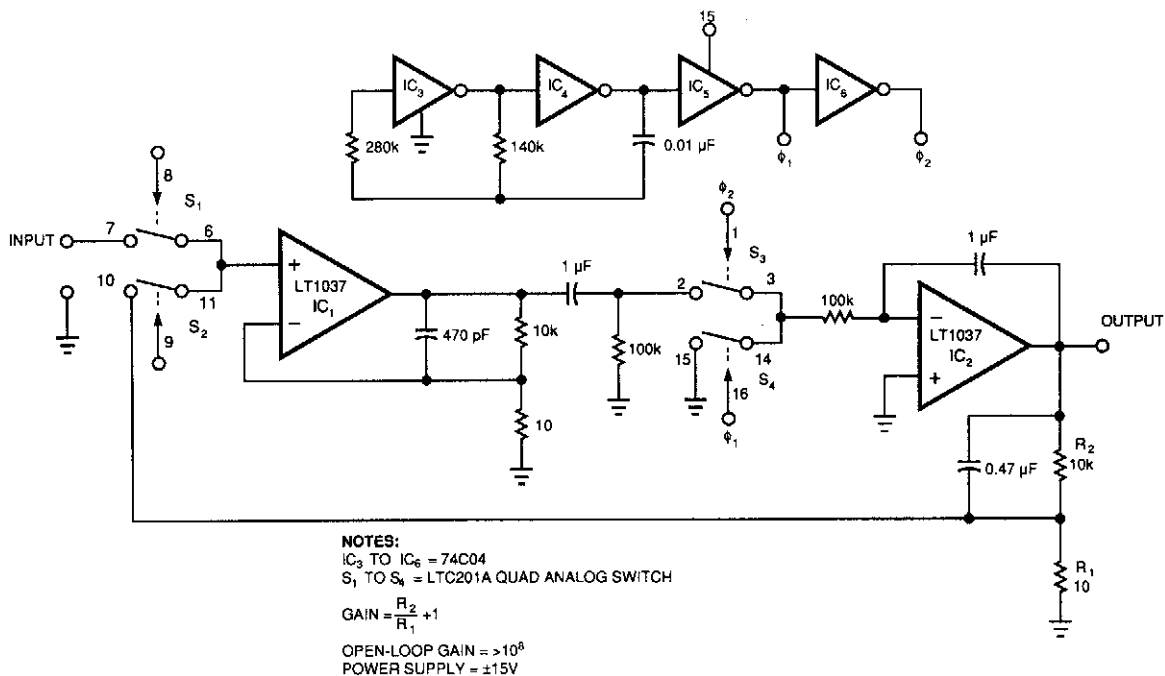
An input impedance of $1\text{ M}\Omega$ was chosen, which results in a fairly high level of noise at the output (with open-circuit input). This value can be reduced, because otherwise the use of a 1:10 probe will be inhibited; it would give constant problems with the noise. However, when the amplifier is connected to a suitable source, the noise reduction is normally more than ample to obtain a good trace on the screen. Presets P1 and P2 provide compensation for the dc offset and input offset, caused by R1 and R7 respectively.

The input bias current for the noninverting input is about 10 times lower than that for the inverting input, which makes the OP260 more suitable for noninverting circuits. The inverting circuit can also give problems because of the low values of R_2 (R_8) and R_3 (R_9). The input bias current is typically $0.2\ \mu\text{A}$, and the input offset is about 3 mV (max. 7 mV).

In this type of circuit, it is important to use a well-regulated power supply. The power-supply suppression up to 10 kHz is roughly 70 dB, and this reduces with increasing frequency. Any noise or tiny ripple on the supply lines would make the application of the circuit as a small-signal amplifier impossible.

The circuit draws a current of about 14 mA. The slew rate, as with most op amps, is asymmetric and might lead to visible distortion of the signal when the drive to the $560\text{-}\Omega$ resistor is high at the higher frequencies.

LOW-DRIFT/LOW-NOISE dc AMPLIFIER



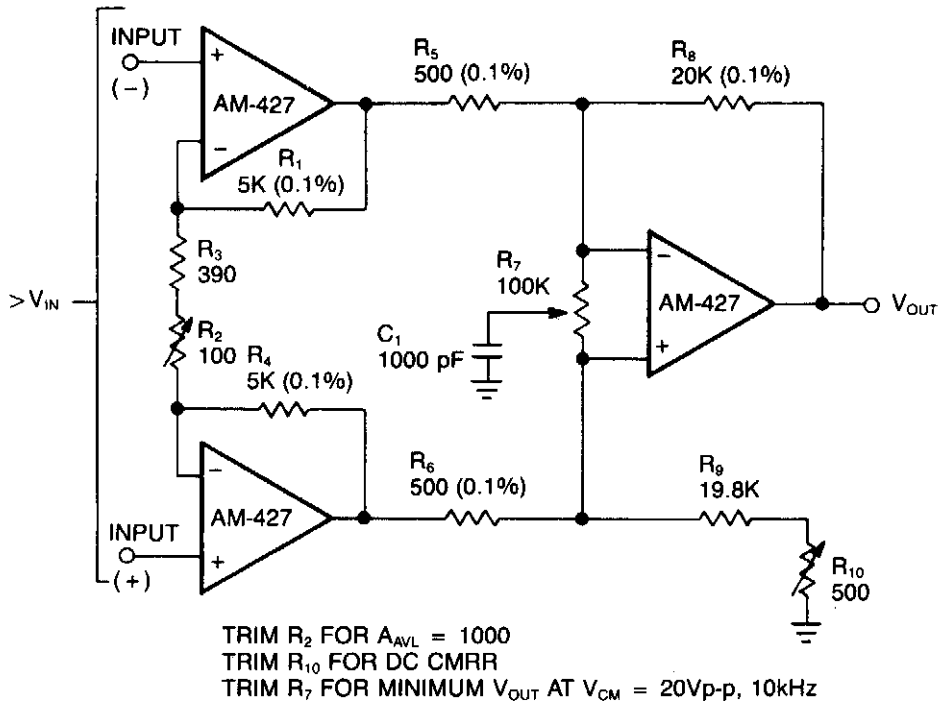
EDN

Fig. 39-2

Figure 39-2's circuit combines a low-noise op amp, IC₁, with a chopper-based carrier-modulation scheme to achieve a low-noise, low-drift dc amplifier whose performance exceeds any currently available monolithic amplifier. The amplifier's offset is less than 1 μV, and its drift is less than 0.05 μV/°C. This circuit has noise within a 10-Hz bandwidth less than 40 nV. The amplifier's bias current, which is set by the bipolar input of IC₁, is about 25 nA.

The 74C04 inverters (IC₃ to IC₆) form a simple 2-phase square-wave clock that runs at about 350 Hz. The complementary oscillator signals (O₁ and O₂) provide drive to S₁ and S₂, respectively, causing a chopped version of the input to appear at IC₁'s input. IC₁ amplifies this ac signal. S₃ and S₄ synchronously demodulate IC₁'s square-wave output. Because S₃ and S₄ switch synchronously with S₁ and S₂, the circuit presents proper amplitude and polarity information to IC₂, the dc output amplifier. This output stage integrates the square wave to provide a dc voltage output. R₁ and R₂ divide the output and feed it back to the input chopper where the divided output serves as a zero signal reference. The ratio of R₁ and R₂ sets the gain, in this case to 1 000.

INSTRUMENTATION AMPLIFIER

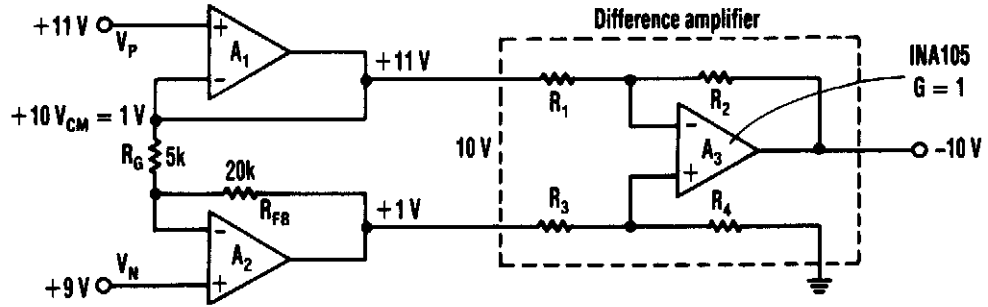


DATEL

Fig. 39-3

In a single difference amplifier configuration, the AM-427 exhibits excellent common-mode rejection and spot noise voltage so low it is dominated by the resistor Johnson noise. The three-amplifier configuration shown avoids the low input-impedance characteristics of difference amplifiers. Because of the additional amplifiers used, the spectral noise voltage will increase from a typical of 3 nV/Hz to approximately 4.9 nV/Hz. The overall gain of the circuit is set at 1000; with balanced source resistors, a CMRR of 100 dB is achieved.

EXTENDED COMMON-MODE INSTRUMENT



ELECTRONIC DESIGN

Fig. 39-4

These circuits allow a larger common-mode range than most instrument amplifier inputs can allow.

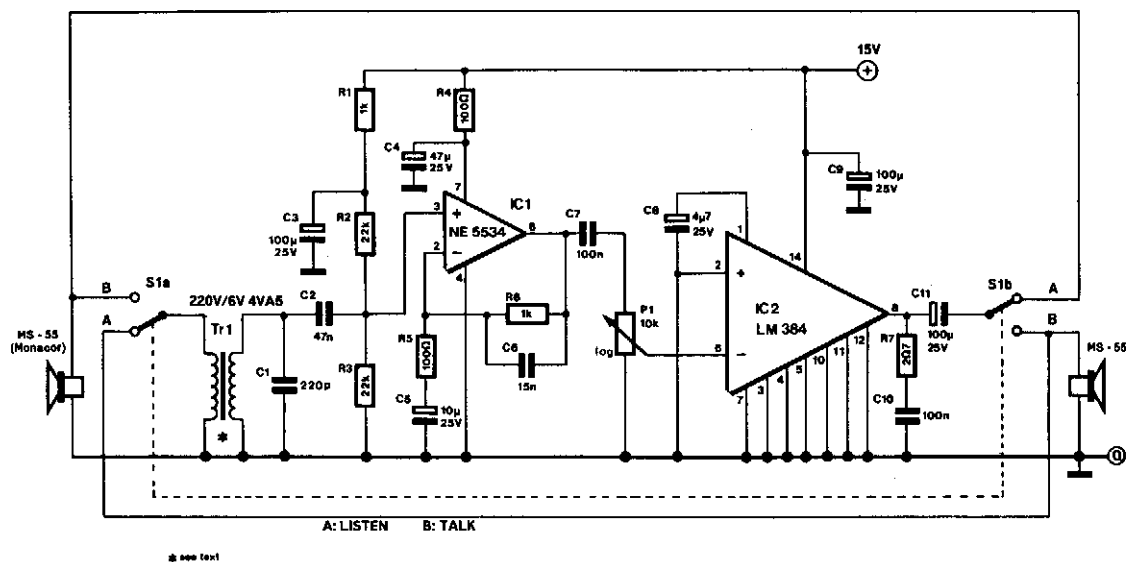
40

Intercom

The source of the following circuit is contained in the Sources section, which begins on page 668. The figure number in the box correlates to the entry in the Sources section.

Two-Wire Intercom

TWO-WIRE INTERCOM



ELEKTOR ELECTRONICS

Fig. 40-1

The design consists of an amplifier, a double-pole changeover switch and two loudspeakers: one for the master station and one for the slave. More than one slave unit can be used, but each requires an additional changeover switch.

The power amplifier is a Type LM384, which can provide almost 2 W output at a supply voltage of 15 V. Pins 3, 4, 5, 10, 11, and 12 are connected to ground and at the same time afford some cooling of the device. Because of that, the IC should not be fitted in a socket, but be soldered direct to the circuit board.

The LM384 processes signals with respect to earth so that an asymmetric supply is sufficient. The amplification has been set internally to $\times 50$ (34 dB). The IC's supply line is decoupled by C9.

To ensure adequate input sensitivity, a preamplifier, IC1, is provided, which has an amplification of 11 (21 dB). Because this stage is intended for speech only, its bandwidth is limited to 160 Hz to 10 kHz. Divider R2/R3 at the input of the op amp is decoupled by C3.

Special loudspeakers that can also serve as microphones are readily available: in the prototype, MS-55 units from Monacor were used, but a number of other makes will do just as well. The bandwidth of the MS-55 (used as loudspeaker) extends from 150 Hz to 20 kHz and (used as a microphone) from 20 Hz to 20 kHz. The MS-55 can handle up to 5-W output. To ensure satisfactory operation, particularly as a microphone, the loudspeaker must be fitted in a closed box.

Although it is advantageous for the "microphone" to have a low internal resistance, it is necessary for a transformer to be used at the input of the circuit. This has, however, the advantage that long cables can be used. The present circuit uses a standard mains transformer instead of a special microphone transformer. For this purpose, the secondary (6 V) winding is connected to the "microphone." The microphone impedance is thereby magnified from about 8 Ω to around 10 k Ω . The power handling of the

TWO-WIRE INTERCOM (Cont.)

transformer is quite high to ensure that signal losses in the primary winding are kept at a minimum. Capacitor C1 suppresses HF interference.

If the mains transformer and the "microphone transformer" are housed in the same enclosure, some trial and error and screening are necessary to eliminate hum. The "microphone transformer" itself might cause hum in the remainder of the circuit. In that case, the preamp stage must also be screened.

In the prototype, the speech bandwidth was limited from 400 Hz to 4 kHz and this proved perfectly acceptable for good speech transfer. Most of the current drawn by the circuit flows through the power amplifier. At worst, this is 210 mA (680 mA peak), when the amplifier delivers 1.8-W output. The LM384 can deliver a power of up to 5 W. The supply voltage should then be raised to 22 V and a heatsink for the device will be necessary.

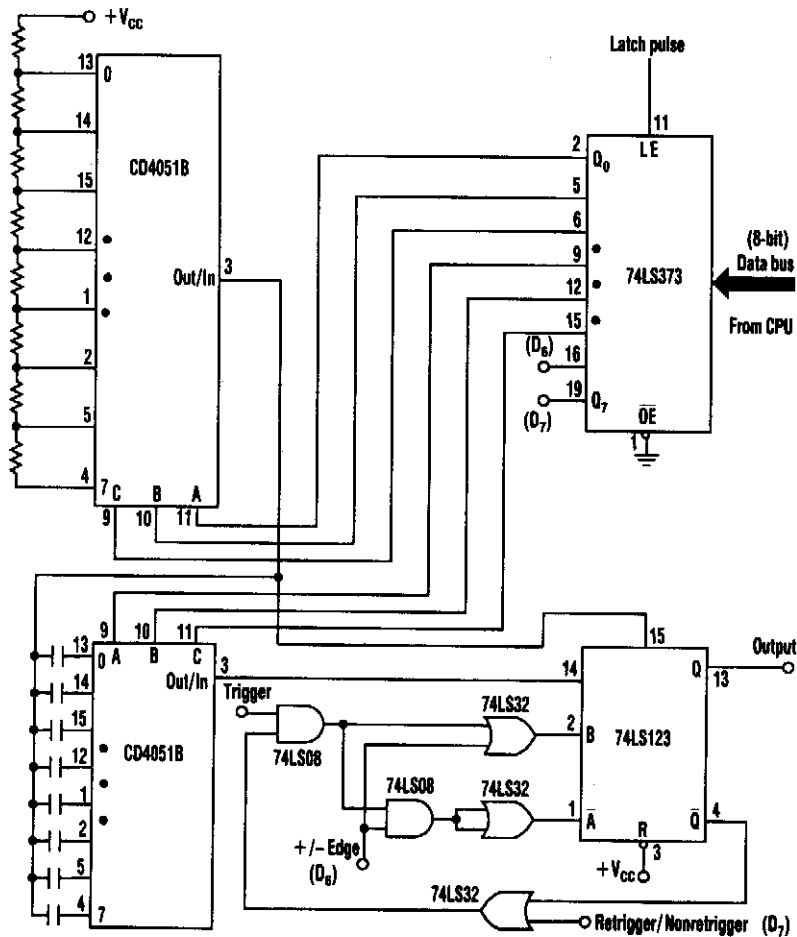
41

Interface Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

Versatile One-Shot CPU Interface
Keyboard Matrix Interface
Low-Level Power FET Driver Method
Logic-Level Translators

VERSATILE ONE-SHOT CPU INTERFACE



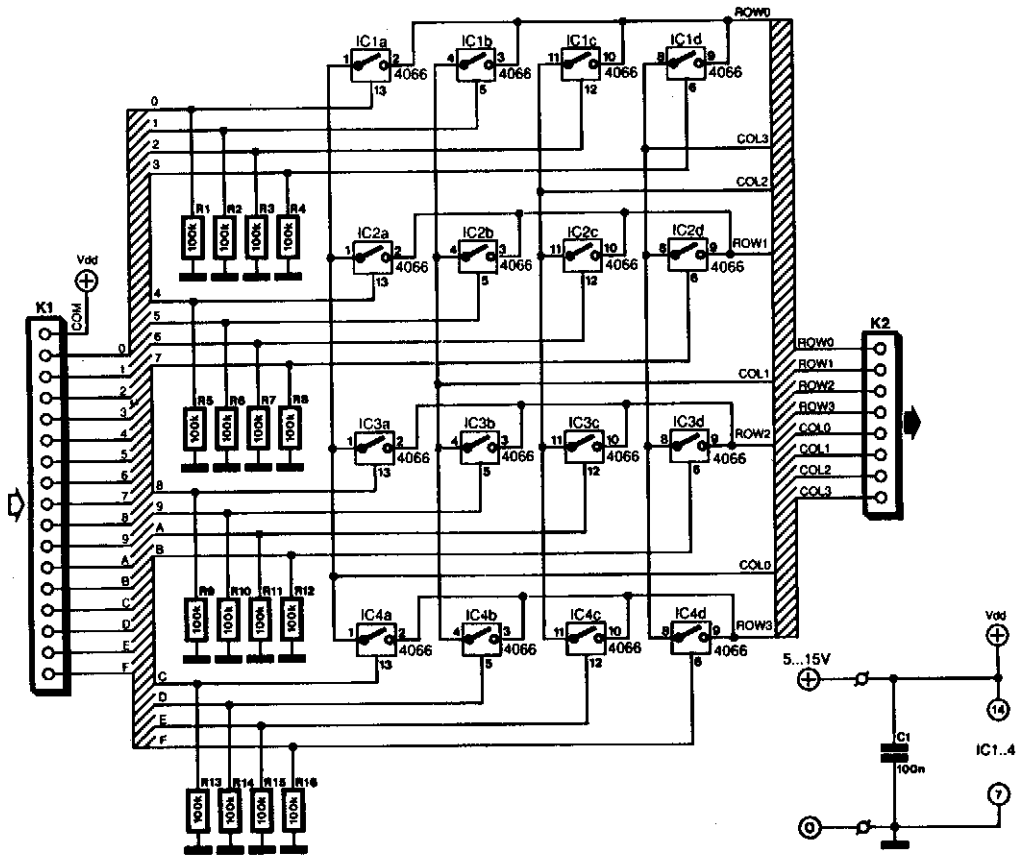
ELECTRONIC DESIGN

Fig. 41-1

Process-control applications often require a monostable multivibrator (one-shot) with a pulse width that can be selected on-the-fly.

This circuit uses two CD4051B analog multiplexers to select the required timing components for the multivibrator, and hence, the pulse width. The multiplexers' address input comes from an 8-bit latch. Bit D6 tells the multivibrator whether to trigger on the leading or trailing edge of the trigger input. Bit D7 determines whether the multivibrator should be in a retriggerable or nonretriggerable mode.

KEYBOARD MATRIX INTERFACE



ELEKTOR ELECTRONICS

Fig. 41-2

Keyboards can be slotted into two categories, at least as far as the manner that the switches are connected is concerned: those with a common connection and those with the switches arranged in a matrix.

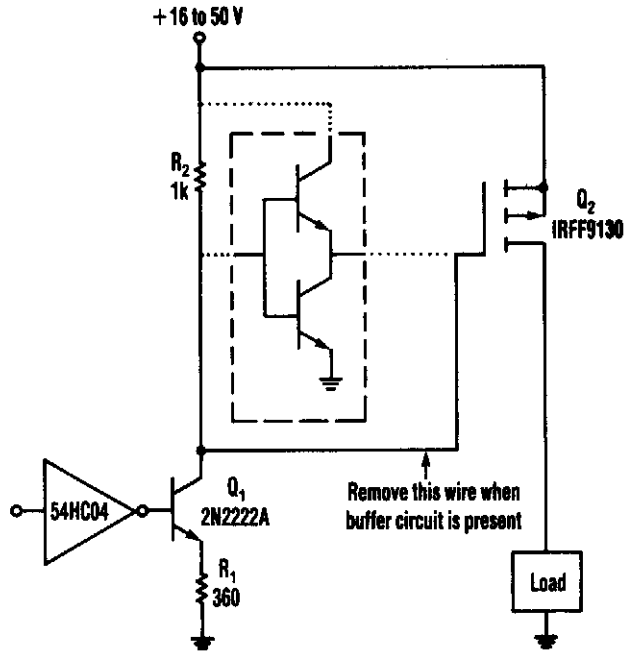
The matrix type has the important advantage that the number of connections is an absolute minimum. Such an arrangement is ideal for ICs; many of these are designed for use with a matrix keyboard.

However, many keyboards are available in job lots, for instance, that apart from a common connection also have a connector for each key. Such keyboards can be connected to ICs that require a matrix type with the aid of a number of electronic switches.

The principle is straightforward: each key of the keyboard controls an electronic switch that is included in a matrix. As an example, the diagram shows a hexadecimal keyboard that is arranged in a 4- x -4 matrix. Each of the electronic switches is held in the open position by a pull-down resistor.

The current drawn by the circuit is very small and is determined mainly by the value of the pull-down resistors and the number of keys being pressed. The CMOS switches draw virtually no current.

LOW-LEVEL POWER FET DRIVER METHOD



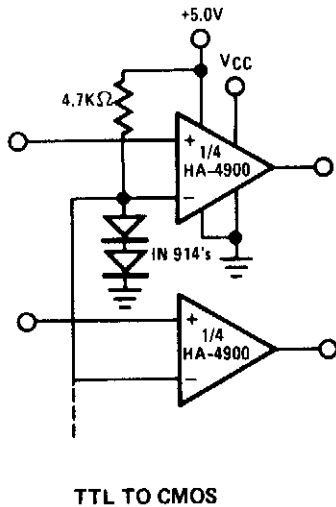
ELECTRONIC DESIGN

Fig. 41-3

This circuit operates from a 16- to 50-V supply. Adding the buffer circuit (within the dashed lines) offers 100-ns switching times. Otherwise, the circuit switches in 1 μ s.

Q1 and R1 form a switched current source of about 12 mA. The current flows through R2, which supplies 12 V to the FET. The circuit works well over a wide range of supply voltages. Furthermore, it switches smoothly in the presence of large ripple and noise on the supply. The switching time (about 1 μ s) can be reduced considerably by lowering the values of R1 and R2 at the expense of higher power dissipations in the resistors and Q1. Alternatively, a buffer circuit can be added to produce switching times of 100 ns without generating significant power dissipation.

LOGIC-LEVEL TRANSLATORS



HARRIS

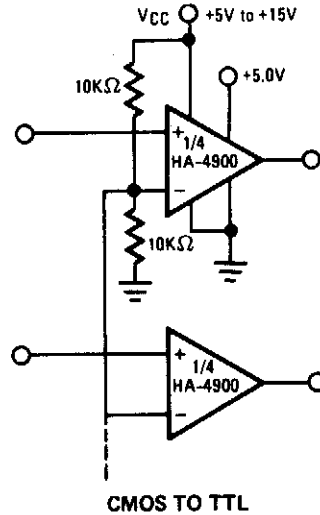


Fig. 41-4

The HA-4900 series comparators can be used as versatile logic interface devices, as shown in these circuits. Negative logic devices can also be interfaced with appropriate supply connections. If separate supplies are used for V_- and $V_{\text{LOGIC}-}$, these logic-level translators will tolerate several volts of ground-line differential noise.

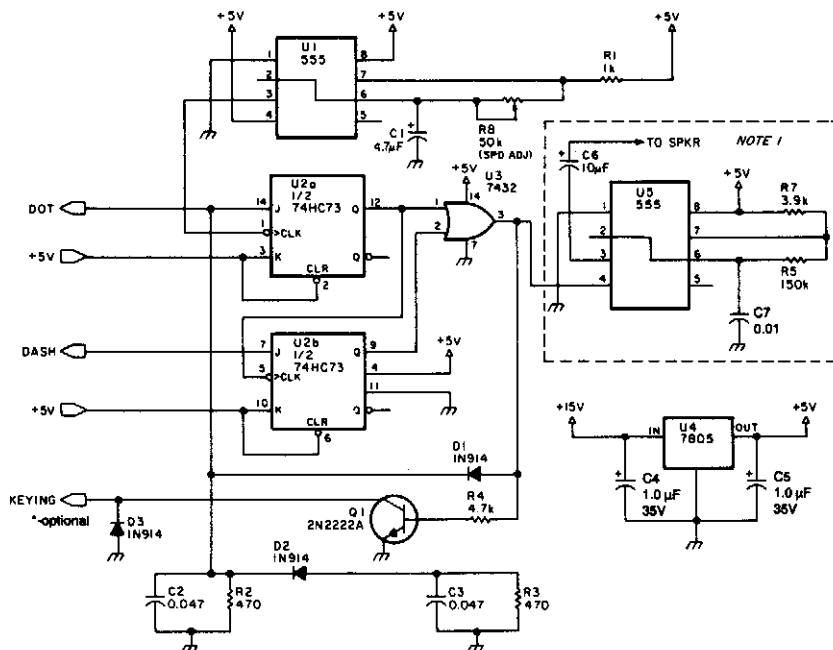
42

Keying Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

CW Keyer
Transmitter Negative Key Line Keyer
Frequency Shift Keyer

CW KEYS

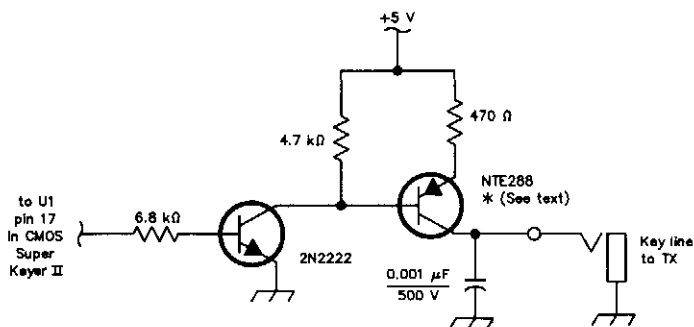


73 AMATEUR RADIO

Fig. 42-1

This electronic keyer uses four ICs (five, if the optional sidetone oscillator is desired) and operates from dc sources of 9 to 15 V. A 2N2222 is used as a keying transistor. If isolators or more power handling ability is desired, a 6-V relay can be keyed with the 2N2222 and the relay in turn can be used to key the transmitter.

TRANSMITTER NEGATIVE KEY LINE KEYS

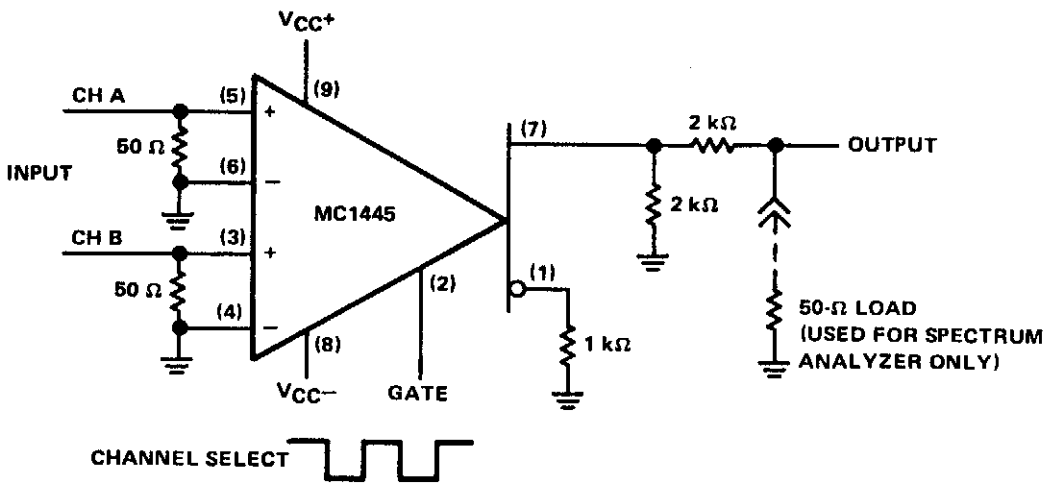


QST

Fig. 42-2

Using an NTE288 (or ECG288, GE223, or SK3434), this circuit can key a negative line up to -300 V maximum. Do not use this circuit to key a vacuum-tube amplifier that draws grid current because the keying transistor might be damaged under these conditions.

FREQUENCY SHIFT KEYS



TEXAS INSTRUMENTS

Fig. 42-3

Apply a signal to each differential amplifier input pair. When the gate voltage is changed from one extreme to the other, the output can be switched alternately between the two input signals. When the gate level is high (1.5 V), a signal applied between pins 5 and 6 (channel A) will be passed and a signal applied between pins 3 and 4 (channel B) will be suppressed. In this manner, a binary-to-frequency conversion is obtained that is directly related to the binary sequence, which is driving the gate input (pin 2).

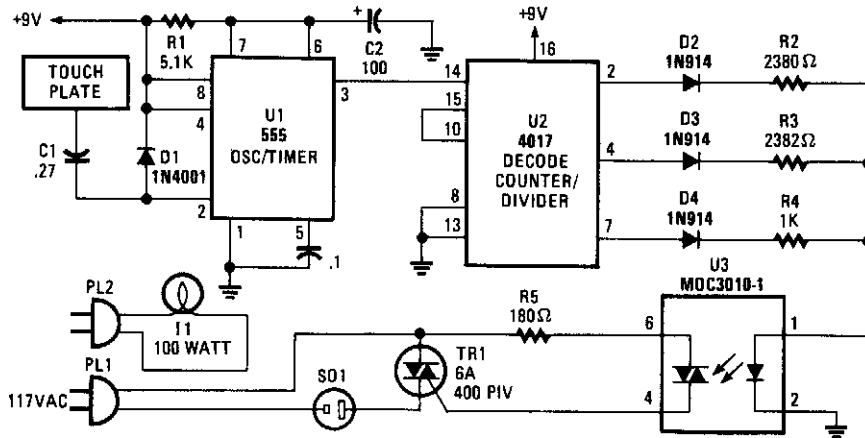
43

Light-Control Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

Three-Way Touch Lamp
Light Dimmer/Speed Control
Four-Quadrant Dimmer
Light Dimmer
Automatic Emergency Lighting Unit
Lights-On Sensor
Light Chaser I
3-Way Light Control
Light Chaser II
Light Controller
“Automatic” Light Bulb Changer
Inductive Load Triac Switch
Christmas Light Driver
SCR Capacitor Turn-Off Circuit

THREE-WAY TOUCH LAMP



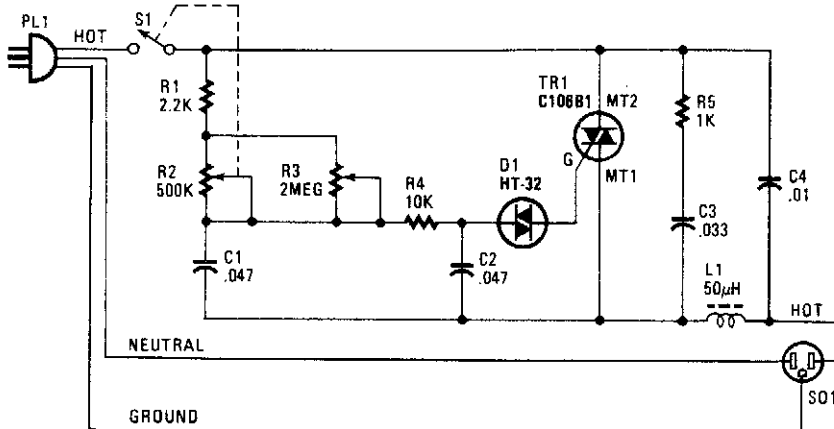
POPULAR ELECTRONICS

Fig. 43-1

A three-way switch to control a lamp (off-dim-bright, etc.) uses an NE555 timer to generate a one-second pulse, triggered by ambient ac fields that are picked up by the human body. C1 and D1 form an input network. U2 is a decode counter/divider and drives one of 10 outputs (three are used). The logic outputs drive various resistors in series with the LED in the optocoupler. The optocoupler controls a triac that is in series with a load (lamp, etc.).

By reconfiguring the outputs of U2, more than three brightness levels can be obtained, up to 10. An IN914 and resistor will be required for each output.

LIGHT DIMMER/SPEED CONTROL

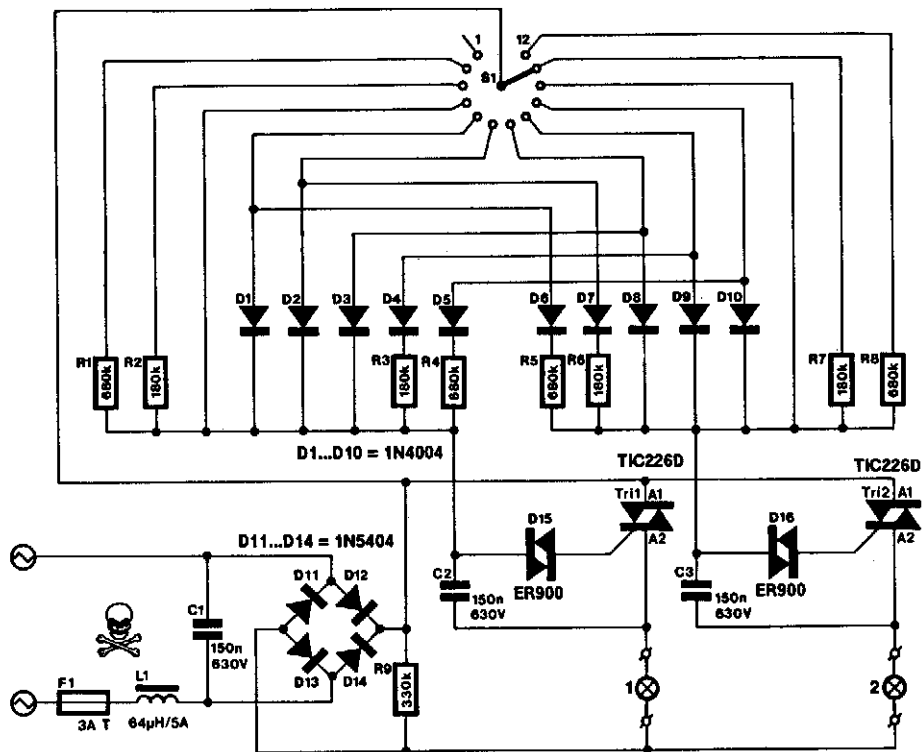


POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 43-2

A phase-controlled triac (HT-32) circuit provides control of effective voltage at load. Do not omit L1 and C4 because they are for RFI suppression. The maximum load is about 500 W. **WARNING:** 120 Vac is present on this circuit—provide adequate insulation and construction techniques.

FOUR-QUADRANT DIMMER



Switch position	Brightness	
	Group A	Group B
1	0	0
2	1/3	0
3	2/3	0
4	1	0
5	1	1/3
6	1	2/3
7	1	1
8	2/3	1
9	1/3	1
10	0	1
11	0	2/3
12	0	1/3

FOUR-QUADRANT DIMMER (Cont.)

This very special mains-operated dimmer for domestic or industrial lights is not available in proprietary form; it enables brightness control of two groups of lights in one operation. The possible combinations of brightness are shown in the table. It will be clear that it is not possible to obtain continuous brightness control in the two groups. Instead, the circuit affords the setting of four states of brightness in either group: full on, fully dimmed, $1/3$ on, and $2/3$ on.

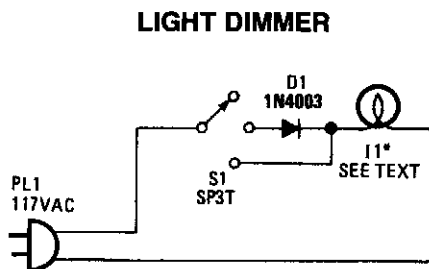
Both sections of the circuit operate on the well-known principle of the triac being switched from the blocking state to the conducting state with the aid of an RC network and a diode. The RC network provides the necessary phase shift and determines when the triac is switched. The rotary switch selects the resistor in a given network, and thus the brightness of the relevant group of lights. No resistor means that the group is off; a short-circuit gives maximum brightness, and resistors of $10\text{ k}\Omega$ and $18\text{ k}\Omega$ produce intermediate brightness. The diodes prevent the groups from affecting one another.

The $64\text{-}\mu\text{H}$ choke (L1) and the 150 nF capacitor across the bridge rectifier prevent the dimmer causing interference in other equipment connected to the mains.

If the triacs are fitted on a heatsink that is rated at 12° K/W , up to 500 W per group can be controlled. It is, of course, essential that the enclosure in which the dimmer is fitted provides ample cooling. A fair number of slots or holes in it are, therefore, essential; these should not permit the circuit elements to be touched.

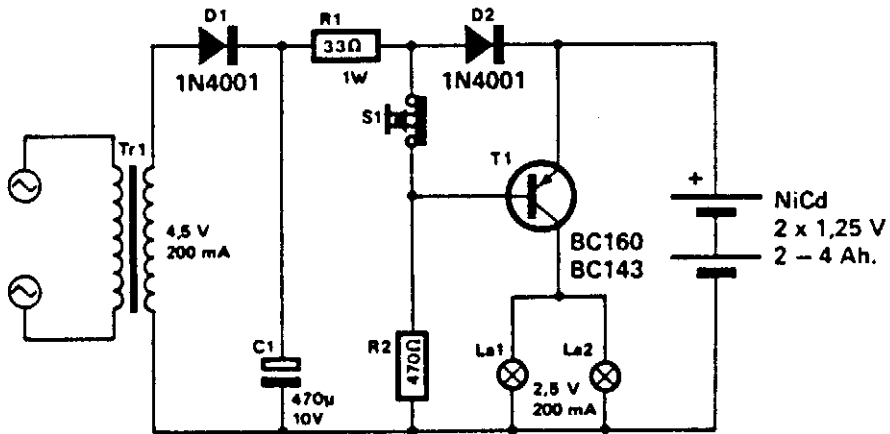
The switch should have a nonmetallic spindle: this is not only safer than a metallic one, but it also enables the easy removal of the end-notch so that the switch can be rotated continuously, instead of having to be returned to the first stop every time it is operated.

The mains on/off switch S2 should be fitted with a built-in ON indicator bulb, which shows at a glance whether the circuit is on, even though S1 might be in the OFF position. Finally, remember that this circuit carries mains voltage in many places: good workmanship and insulation are, therefore, of the utmost importance.



Lamp I1 is a household lamp. When the switch is in the center position, the lamp is operated on half-wave rectified ac; the effective voltage the lamp sees is less, which dims it. I1 can be a lamp up to 200 W or 50 rated at 120 or 240 V , and D1 should be a 200-V PIV or better diode (400 PIV for 240-V operation).

AUTOMATIC EMERGENCY LIGHTING UNIT

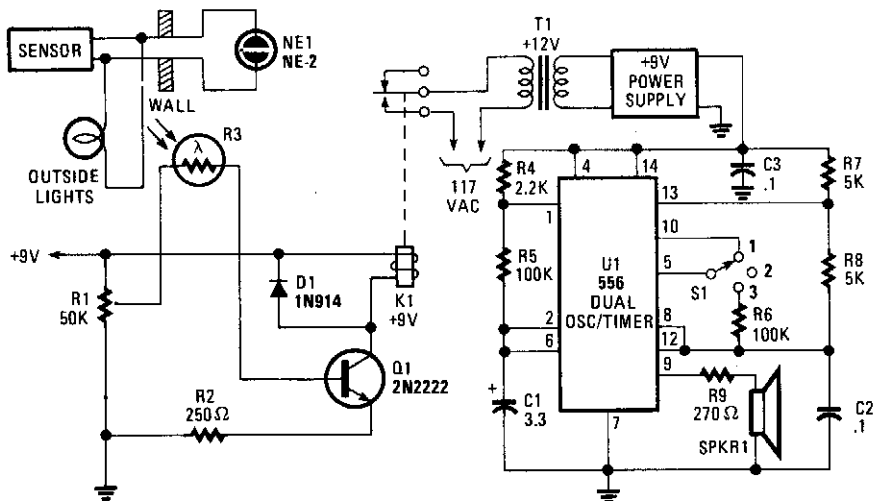


ELEKTOR ELECTRONICS

Fig. 43-5

This unit uses a Nicad battery to provide power to an emergency lighting setup. When power fails, T1 becomes forward biased, which lights L1 and L2. The batteries are normally kept charged. When power is on, T1 is cut off and it keeps the lamps extinguished.

LIGHTS-ON SENSOR

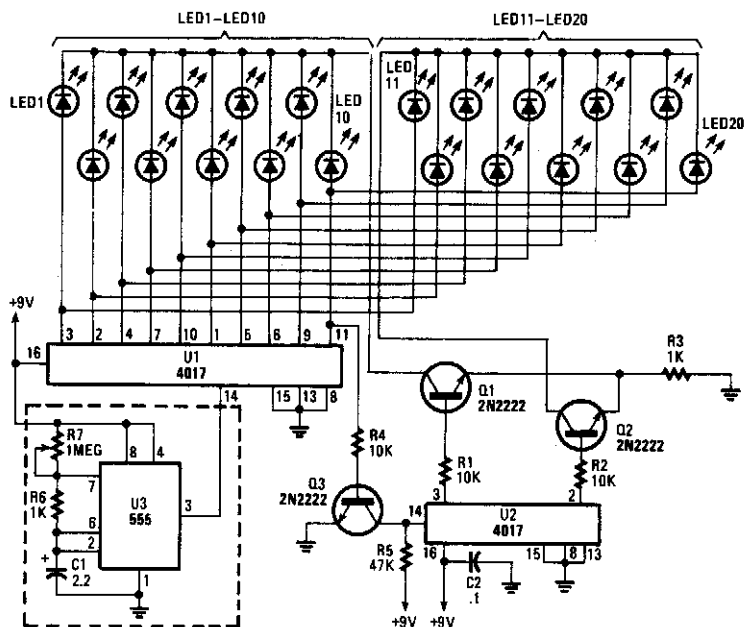


POPULAR ELECTRONICS

Fig. 43-6

Remote monitoring of a light source is possible with this circuit. Photocell R3 activates Q1 and relay K1. U1 is a tone generator that drives a small speaker.

LIGHT CHASER I

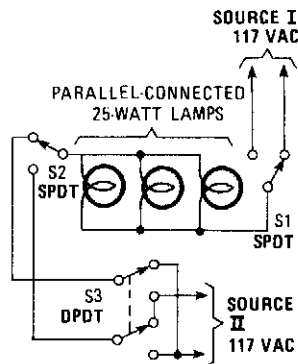


POPULAR ELECTRONICS

Fig. 43-7

Up to 100 lights, LEDs, or optocoupler triac circuits can be sequentially activated by this circuit. One (U1) 4017 decode counter sequences 10 LEDs whose common anode is returned through a second (U2) CD4017, which counts at one-tenth of the rate. The flash rate is controlled by U3, a clock circuit, with a 555 timer.

3-WAY LIGHT CONTROL



POPULAR ELECTRONICS

Fig. 43-8

This hookup is useful in some house wiring situations, where only two wires are available between switches, rather than the usual 3-way setup where 3 wires are required. S1 and S2 are ordinary three-way switches and S3, a DPDT switch, is commonly available as a four-way switch at hardware stores.

LIGHT CHASER II

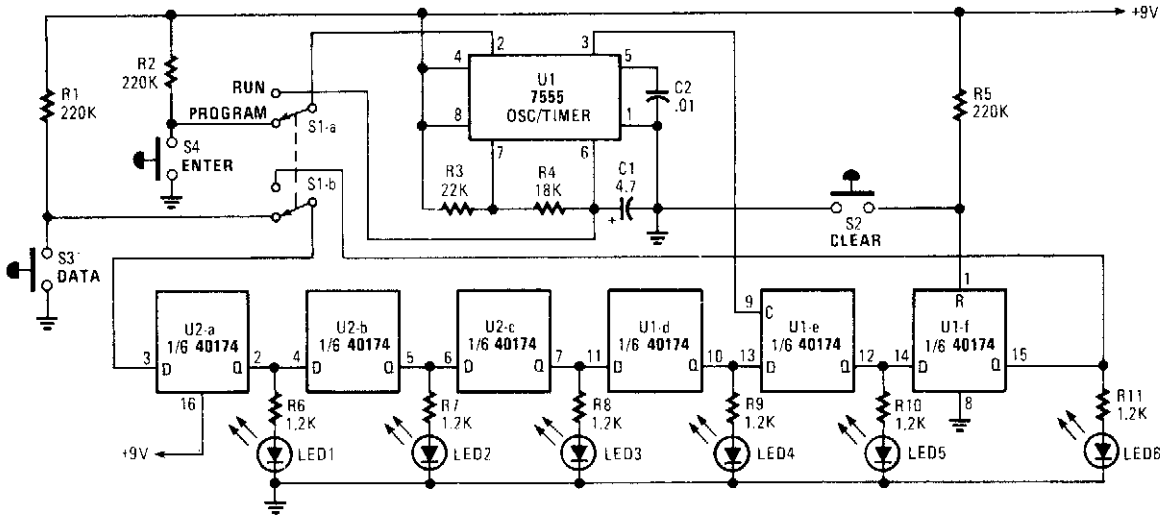
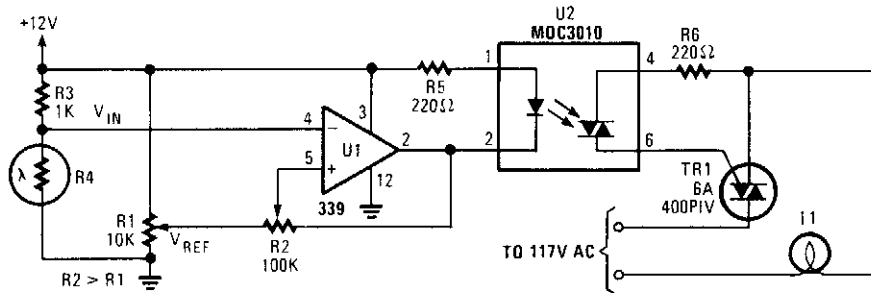


Fig. 43-9

POPULAR ELECTRONICS

Up to six lights can be sequentially flashed using this circuit. LED1 through LED6 can be replaced by photocouplers (MOC3010, etc.) to control 120-Vac loads via triacs. U1 generates pulses that clock the shift register mode up of the six D flip-flops in the CD 40174. By S1A – B, the register can be programmed either ON or OFF (low or high) and then switched to run in the programmed sequence. S2 clears the program.

LIGHT CONTROLLER

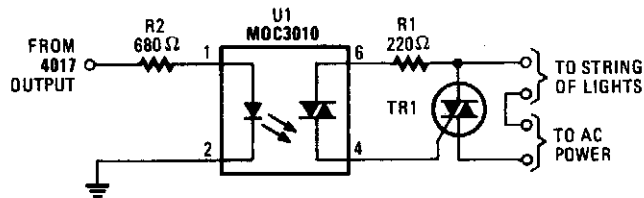


POPULAR ELECTRONICS

Fig. 43-10

A photocell drives U1, a comparator, which controls photocoupler U2. A 6A Triac is used to switch an ac load, such as a lamp, etc.

CHRISTMAS LIGHT DRIVER

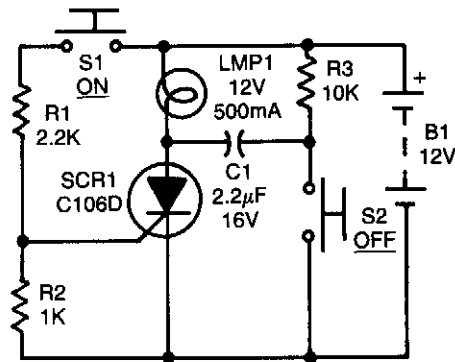


POPULAR ELECTRONICS

Fig. 43-13

This circuit will enable a CMOS logic chip, such as a 4017 decode driver, to control a string of Christmas lights or other lighting. The triac should be rated at 200 V and 3 A or higher. The 4017 should be powered from at least 10 V to ensure adequate drive to the optoisolator.

SCR CAPACITOR TURN-OFF CIRCUIT



RADIO-ELECTRONICS

Fig. 43-14

After the SCR turns on, C1 charges up to almost the full supply voltage via R3 and the anode of the SCR. When S2 is subsequently closed, it clamps the positive end of C1 to ground, and the charge on C1 forces the anode of the SCR to swing negative momentarily, thereby reverse-biasing the SCR and causing it to turn off. The capacitor's charge bleeds away rapidly, but it has to hold the SCR's anode negative for only a few μ s to ensure turn-off. C1 must be a nonpolarized type.

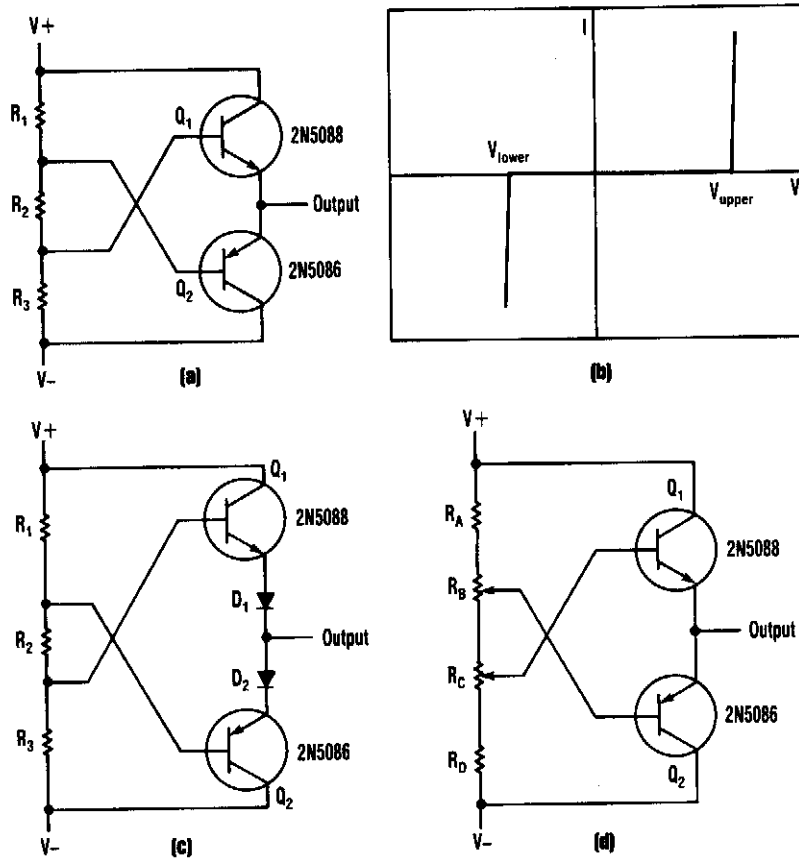
44

Limiter

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

Adjustable Voltage Limiter
One-Zener Precise Limiter

ADJUSTABLE VOLTAGE LIMITER



ELECTRONIC DESIGN

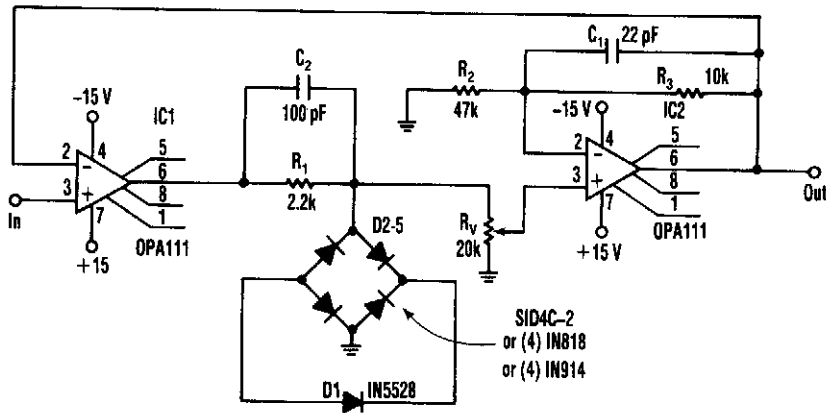
Fig. 44-1

This bipolar voltage clipper can be built with two transistors, two resistors, and two potentiometers. Notice that the maximum p-p range must be $\leq BV_{ebo}$ of the transistors used. The design equations are:

$$V_{upper} = V_- + \frac{(V_+ - V_-)(R_2 + R_3)}{(R_1 + R_2 + R_3)} + V_{be}(Q_2)$$

$$V_{lower} = V_- + \frac{(V_+ - V_-)(R_3)}{(R_1 + R_2 + R_3)} - V_{be}(Q_1)$$

ONE-ZENER PRECISE LIMITER



ELECTRONIC DESIGN

Fig. 44-2

A limiter circuit that requires matched zener diodes can instead use one zener with a full-wave diode bridge. The circuit's two limits are nearly equal when determined by the same zener—only two pairs of forward diodes need to be matched. For best results, an integrated quad of diodes can be used. But, after testing the circuit, four single controlled-drop diodes and four ordinary diodes gave about the same accuracy (better than 0.5%).

Because the limiting level can be adjusted, zener tolerance can be adjusted out. Gain stability can be optimized by connecting the inverting input of the first op amp to the output of the second to make the circuit inherently unity-gain.

The zener voltage must be increased to 8.2 V to compensate for the two diode drops. Placing small capacitors across the resistors in the loop stabilized the circuit adequately and response is orders of magnitude faster than conventional circuits. Moreover, it's limited primarily by the op amp's slew rate.

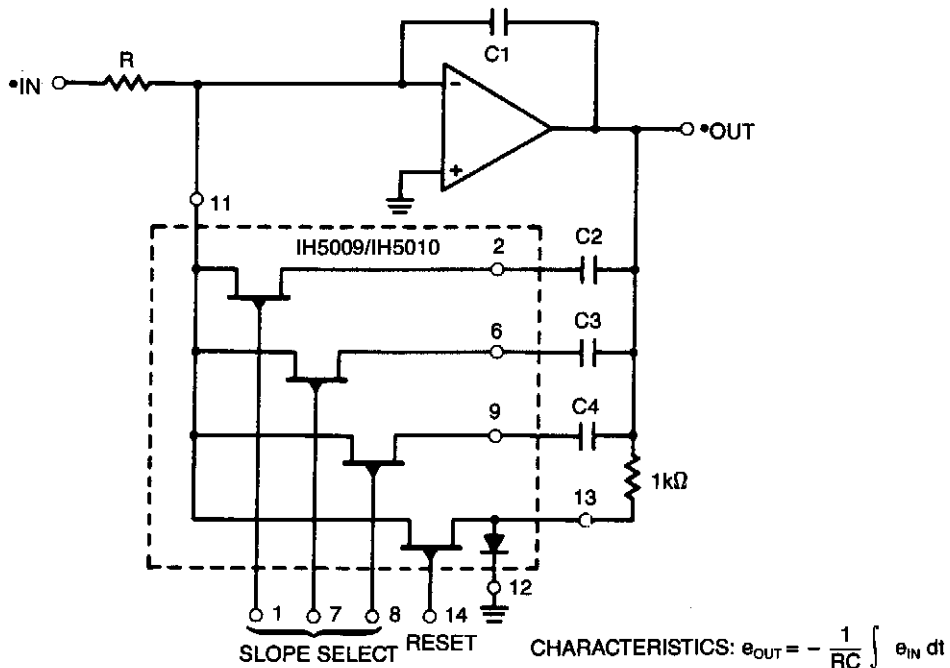
45

Mathematical Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 668. The figure number in the box of each circuit correlates to the entry in the Sources section.

Fast Binary Adding Circuits
Programmable Slope Integrator
Multiplying Precise Commutating Amp

PROGRAMMABLE SLOPE INTEGRATOR



INTERSIL

Fig. 45-1

By using analog switch IH5009/IH5010 to select various capacitors, a variable slope integrator can be had. If $C_3 = 2(C_2)$ and $C_4 = 4(C_2)$, seven different slopes can be obtained if binary information is fed to pins 1, 7, and 8 of the analog switch.

FAST BINARY ADDING CIRCUITS

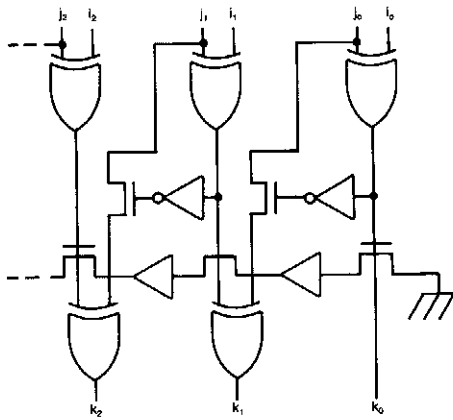


Fig. 45-2(a)

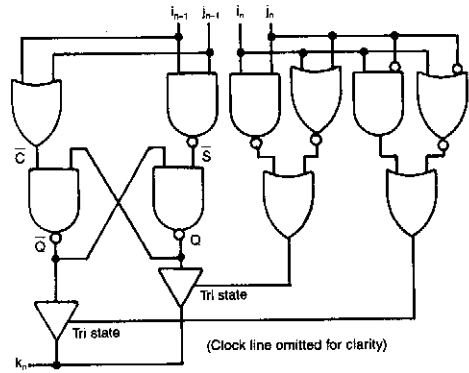
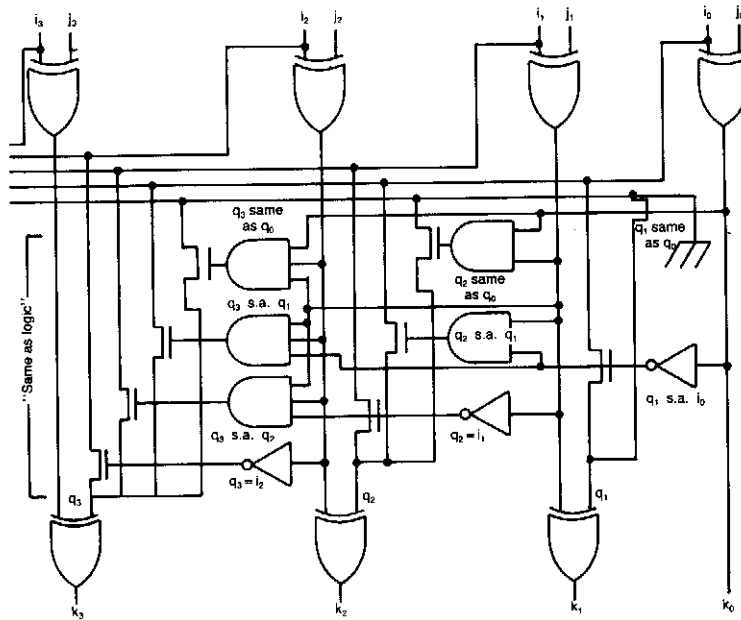


Fig. 45-2(b)



ELECTRONIC ENGINEERING

Fig. 45-2(c)

FAST BINARY ADDING CIRCUITS (Cont.)

Some circuits that add binary numbers have problems with time delay caused by carry propagation. This has been partially solved by the carry look-ahead adder. However, because of the complexity of this scheme, the carry look-ahead logic usually covers no more than 4 bits, and a ripple carry is implemented between the carry look-ahead blocks.

The Daniels Adder avoids these problems by presenting a scheme where carry bits are not used at all in the process of binary addition. It is based on recognition patterns, which exist with the binary addition truth table.

The addition is described by the following two sets of equations:

$$\text{if } i_{n-1} = j_{n-1} \quad q_n = i_{n-1}$$

$$\text{if } i_{n-1} \neq j_{n-1} \quad q_n = q_{n-1}$$

$$\text{if } i_n = j_n \quad k_n = q_n$$

$$\text{if } i_n \neq j_n \quad k_n = q_n$$

with the boundary condition that $q_{-1} = 0$, where i_n , j_n , and k_n are the bit of binary weight 2^n (n^{th} bit) of the addend, summand, and sum respectively, q_n is an intermediate variable and q_n is the inverse of q_n .

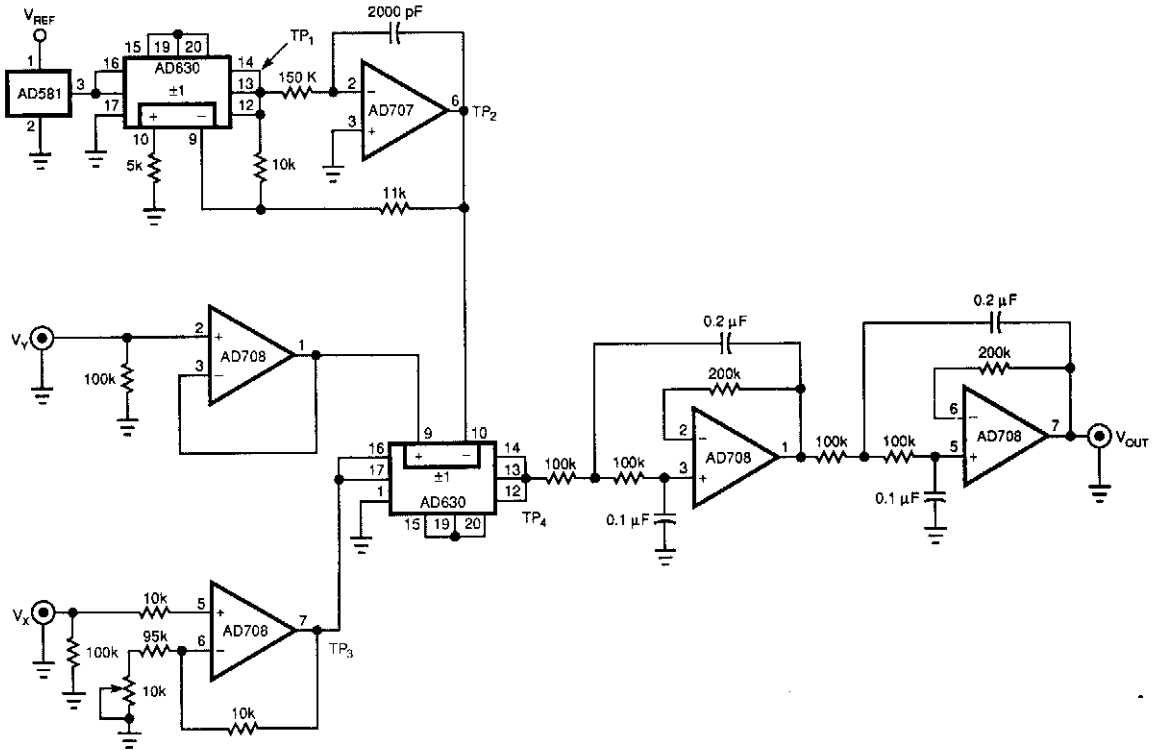
The value of the sum is (depending upon i_n and j_n) either the same as or the inverse of (depending upon i_{n-1} and j_{n-1}) a0, a1, or the inverse of the $(n-1)^{\text{th}}$ bit of the sum. Figure 45-1(a) shows the logic diagram of the ripple through implementation of the adder.

Because each stage calculates whether its value of the intermediate variable q_n is the same as the previous stage's value (q_{n-1}) in parallel, it is possible to devise simple "same as" logic that does not have the complexity drawback of carry look-ahead logic and can be carried over any number of bits (Fig. 45-1(b)). A 32-bit adder built in this way will result in 11-gate delays (no gate having more than 4 inputs).

Especially compact and efficient is the pipelined implementation (Fig. 45-1(c)), which can produce the sum at a rate of 3-gate delays/bit.

The high-speed adder circuits can be used on gate arrays or full-custom ICs to implement fast calculation of addresses or data values. Because of their compact nature, they also use less space on the silicon than conventional adders do.

MULTIPLYING PRECISE COMMUTATING AMP



EDN

Fig. 45-3

By using a pulse-width-height modulation technique, this circuit implements a 0.015%-accurate multiplier. The circuit's output equals $V_X V_Y / 10$. An AD581 voltage reference, an AD630 commutating amplifier, and an integrator comprising an AD707 op amp, 2000-pF capacitor, and 150-kΩ resistor first generate a precision triangle wave. For a given state of the AD630's output ($+V_{REF}$ at TP1, for example) the integrator ramps until its output reaches -11 V. Then, TP1 changes state and the integrator begins ramping toward $+11$ V. The triangle wave's period is $4.4RC$ or 1.32 ms, where R and C are the values of the integrator components.

MULTIPLYING PRECISE COMMUTATING AMP (Cont.)

The circuit uses a second AD630, driven by the variable V_X to compare the triangle waveform at TP₂ to the signal at V_Y . The duty cycle, $T_1 + T_2$, at the output of this second commutating amplifier is:

$$T_1 = \frac{2RC(11 - V_Y)}{10}$$

and

$$T_2 = \frac{2RC(11 + V_Y)}{10}$$

During T_1 , the voltage at TP₄ equals $-1.1V_X$. During the remaining period, T_2 , the pulse height will equal $+1.1V_X$. V_{OUT} is the average, obtained by low-pass filtering, of this T_1 and T_2 combined waveform and equals:

$$V_o = \frac{-1.1V_X T_1 + 1.1V_X T_2}{T_1 + T_2} = \frac{V_X V_Y}{10}$$

You can use a higher bandwidth filter and a higher carrier frequency to build a faster multiplier.

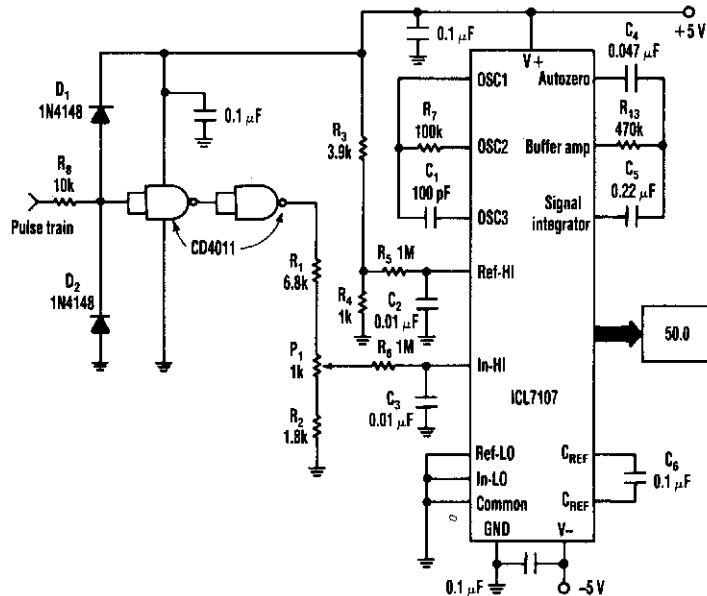
46

Measuring and Test Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 669. The figure number in the box of each circuit correlates to the entry in the Sources section.

Duty-Cycle Measurer	Microfarad Counter
Simple Capacitor Tester	Simple Duty-Cycle Meter
Magnetic Field Meter	Static Detector
Four-Trace Oscilloscope Adapter	Electrolytic Capacitor Reforming Circuit
Digital Tachometer Circuitry	Digital VOM Phase Meter
Sensitive SWR Meter	Simple Electrometer
Meter Tester	Digital Tachometer Counter
Broadband ac Active Rectifier	Capacitor ESR Measurer
Bike Speedometer	Analog Tachometer Readout
B-Field Measurer	Diode Matching Circuit
Low-Cost Barometer	Permanent Magnet Detector
VOR Signal Simulator	Transistor Tester
Simple Diode Curve Tracer	Bike Speedometer
Simple Absolute Value Circuit	Frequency Meter

DUTY-CYCLE MEASURER

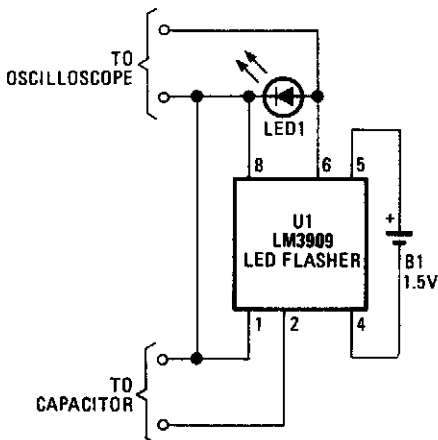


ELECTRONIC DESIGN

Fig. 46-1

An Intersil 7101 3¹/₂-digit A/D converter is used to display the duty cycle of a pulse train as a percentage. The frequency range of this circuit is 100 Hz to 250 kHz. The CMOS gates convert the pulse train to constant amplitude. This amplitude is then compared to a reference of 1 V, derived from R3 and R4. P1 is for calibration.

SIMPLE CAPACITOR TESTER



An LM3909 LED flasher is used as an oscillator, and the capacitor connected to the terminals determines frequency.

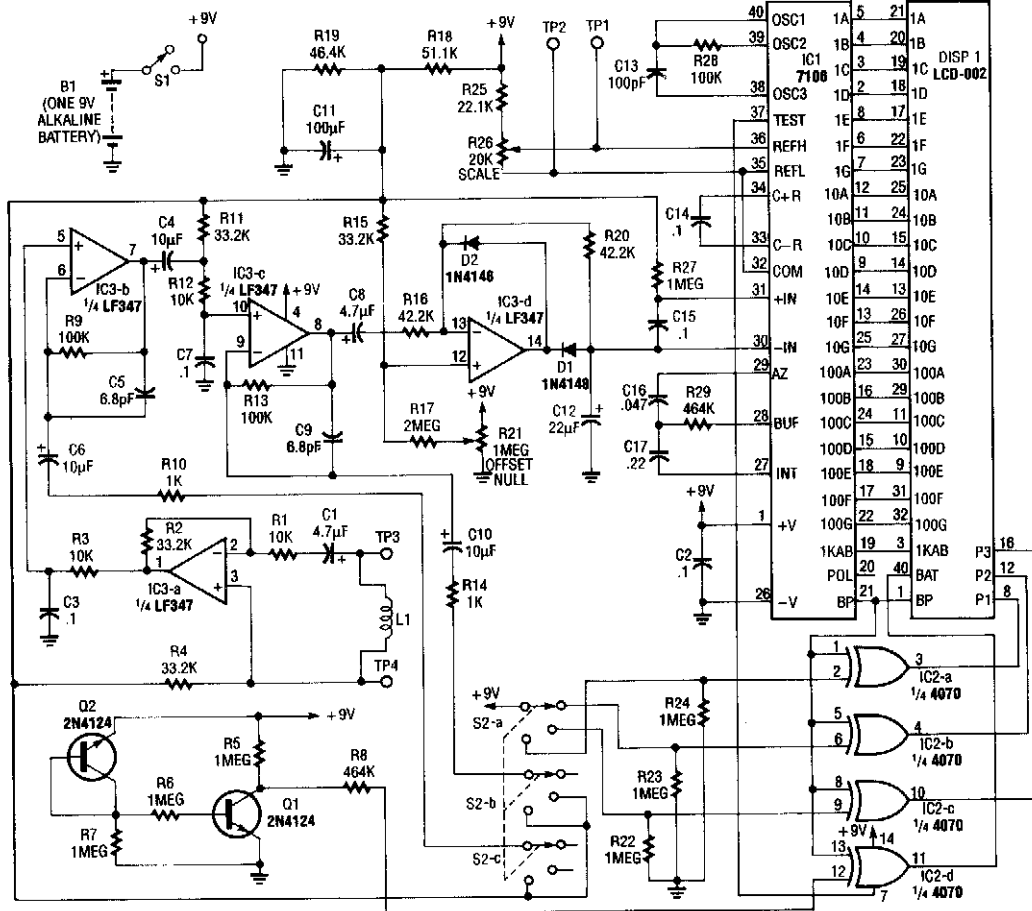
C	f approx
4 700 μ F	0.04 Hz
470 μ F	0.4 Hz
4.7 μ F	4 Hz
0.047 μ F	4 kHz
0.004 7 μ F	25 kHz
47 μ F	660 kHz

The LED can be used to count frequency visually using a stopwatch for large capacitors ($C > 500 \mu$ F).

POPULAR ELECTRONICS

Fig. 46-2

MAGNETIC FIELD METER

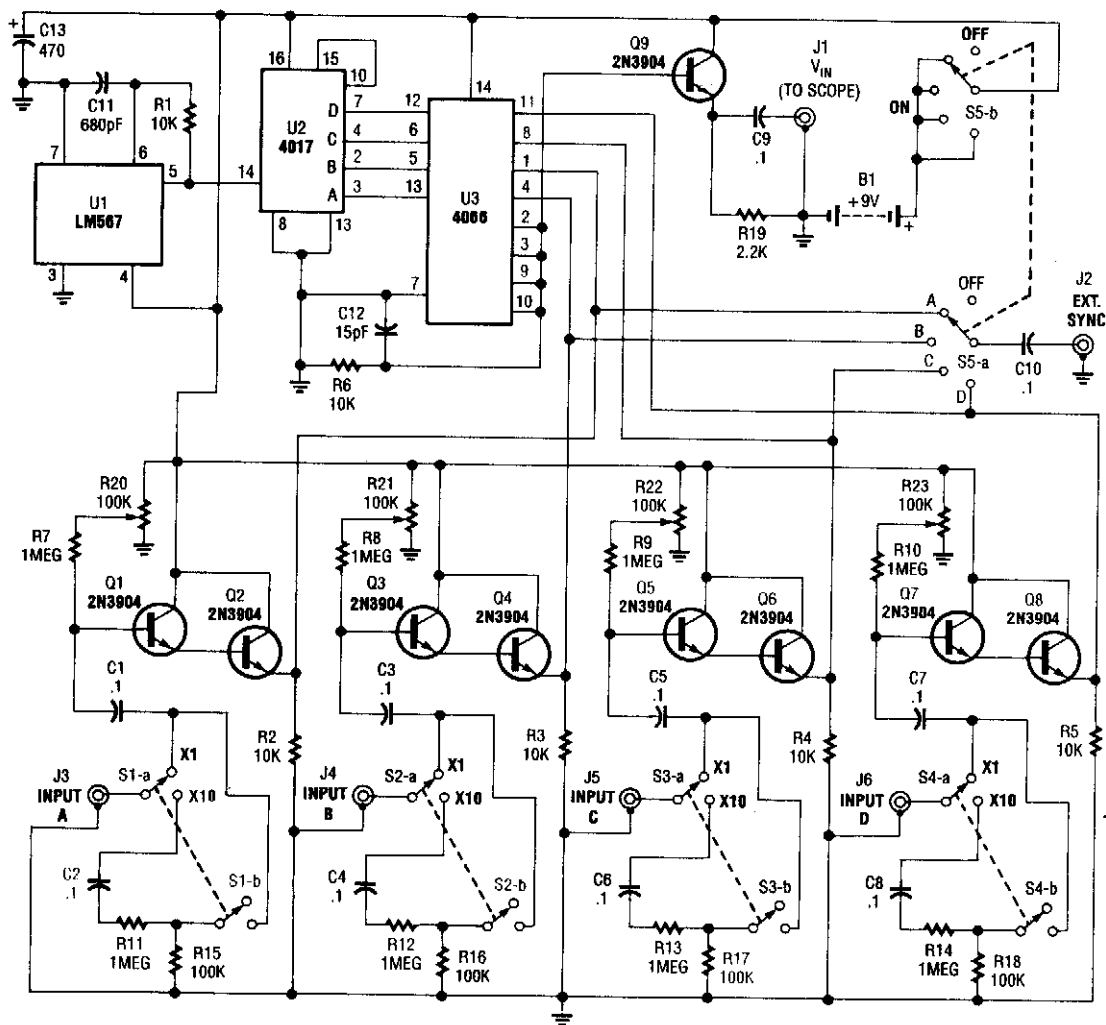


RADIO-ELECTRONICS

Fig. 46-3

Using a pickup coil to drive an amplifier (IC3A-B-C-D), this meter circuit can be directly calibrated in field-intensity units. R3/C3 and R12/C7 establish a frequency roll off that compensates for the pickup-coil sensitivity, and set a 20-kHz cut-off point. S2 is the range-select switch. L1 is an 18-turn 3" diameter coil. The frequency range is 50 Hz to 20 kHz and the range of measurement is 0.1 to 20 000 microTesiers (μT).

FOUR-TRACE OSCILLOSCOPE ADAPTER

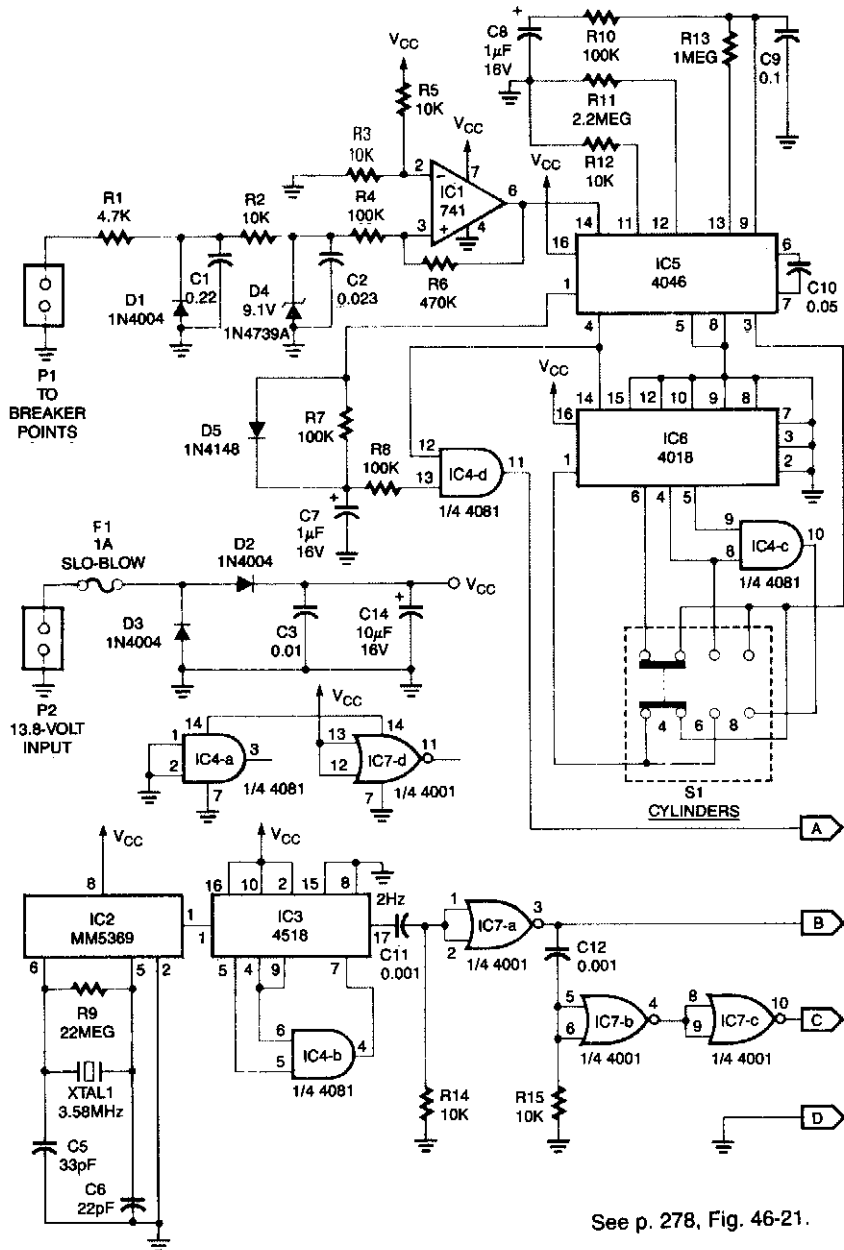


POPULAR ELECTRONICS

Fig. 46-4

This simple adapter uses an oscillator (567) to drive a counter (U2) and switch (U3) that selects the output of one of four scope preamps (Q1/Q2 through Q7/Q8) and feeds it to buffer Q9 and output jack J1. J2 provides sync to the scope. R20 through R23 are posting controls for channels A through D (J3 through J6). S1A-B through S4A-B are switched attenuators, one for each channel. Switching rate is about 125 kHz. This circuit is useful for adding four-trace operation to inexpensive oscilloscopes. Signal levels of 0 to 20 V can be handled.

DIGITAL TACHOMETER CIRCUITRY



See p. 278, Fig. 46-21.

DIGITAL TACHOMETER CIRCUITRY (Cont.)

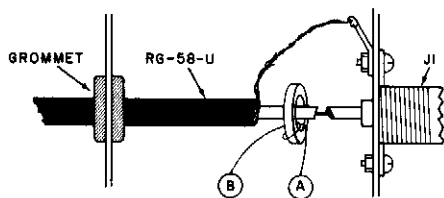
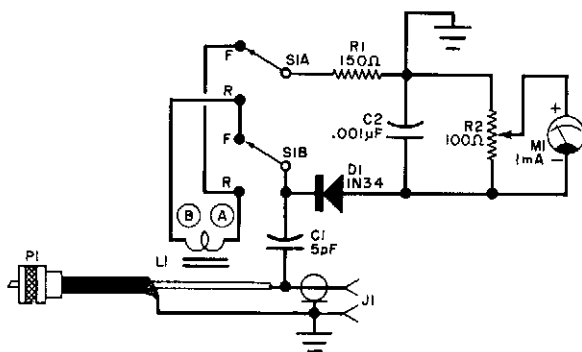
This system can be used with 4-, 6-, or 8-cylinder automobiles. The timebase formed by IC5 is an oscillator that drives counter IC6, which divides by 6, 4, or 3 for 4-, 6-, or 8-cylinder engines, respectively. S1 selects this number. IC5 produces a signal that is phaselocked to this multiple of the ignition system frequency, which in turn depends on engine speed.

$$\text{freq} = \text{rpm} \times \frac{\# \text{ cylinders (4, 6, or 8)}}{120} \text{ Hz}$$

IC1 conditions the ignition input at P1 to feed IC5. The output of IC4D, which is the same frequency as the VCO in IC5, is fed to the frequency display.

IC2 generates a 60-Hz signal using a 3.58-MHz reference. IC3 and IC4B divide this by 30 to produce 2 Hz. IC7B/IC7C and C12/R15 produce a delayed 2-Hz signal. These signals are fed to the counter circuit.

SENSITIVE SWR METER



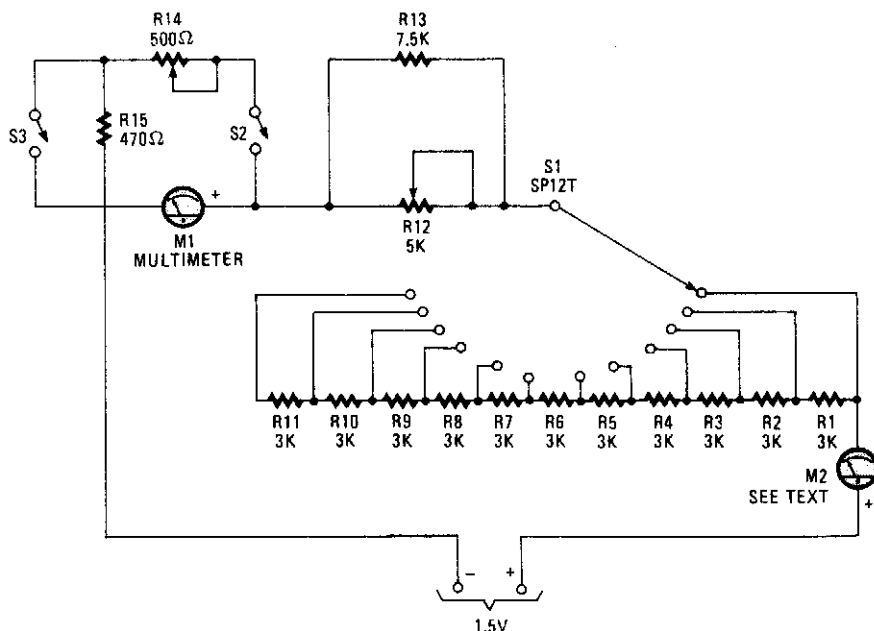
Reflected Meter Reading (% of full scale)	SWR
0	1:1
10	1.22:1
20	1.5:1
30	1.85:1
33.5	2:1
40	2.33:1
50	3:1
60	4:1
66.67	5:1
70	5.66:1
80	9:1
90	19:1
100	∞:1

POPULAR ELECTRONICS

Fig. 46-6

Using a toroidal pickup coil around the center conductor of a coaxial cable, this circuit can be used to measure the SWR of an antenna. L1 is two turns #26 enamelled wire on a Fair-Rite 5963000301 toroidal core.

METER TESTER



POPULAR ELECTRONICS

Fig. 46-7

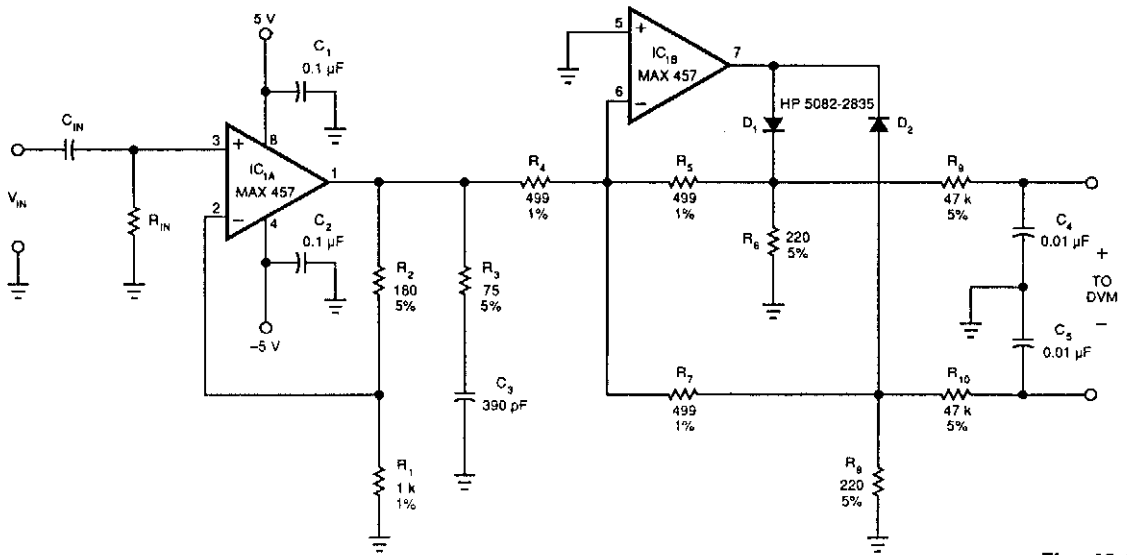
This unit uses switches and resistors to provide a number of current ranges. It allows you to test most of the meters available at surplus outlets, and without damaging the sensitive movements when you have no idea of internal resistance or full-scale current of the unit.

M1 is a multimeter set to measure current, and M2 is the meter-under-test. Starting with S1 set at the maximum resistance and S2 open, decrease the resistance setting of S1, fine tuning with R12, until M2 reads full scale. Then, read M1. It will tell you the full-scale current for the unknown meter. As the meters are connected in series, the same current flows through both.

Now, close S2 and adjust R14 and R15 until M2 reads exactly mid-scale and M1 reads the same current as determined earlier to be the maximum current for M2. Half the current is flowing in M2 and half is going through R14 and R15. The voltage drop is the same across the meter and R14 and R15, because they're in parallel. Thus, the sum of the resistance of R_{14} and R_{15} is the same as the internal resistance of meter M2.

If the internal resistance of M2 is less than 470 Ω , set R14 at maximum resistance and close S3. Readjust R14. Both R14 and R12 should be linear-taper potentiometers.

BROADBAND AC ACTIVE RECTIFIER

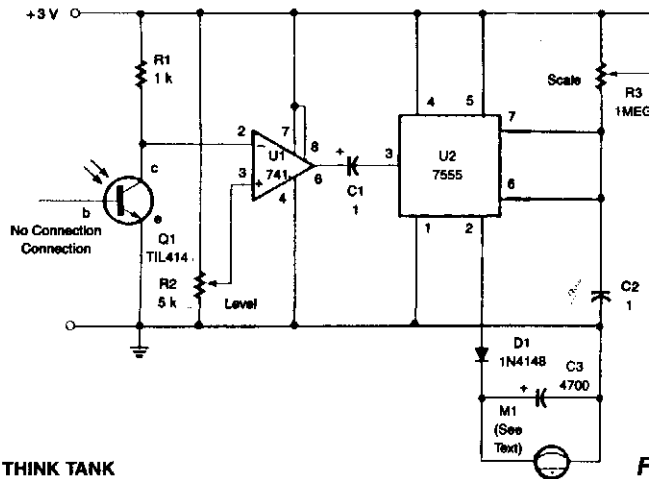


EDN

Fig. 46-8

This circuit converts sine waves of up to 1-V rms into an equivalent dc level. It should prove useful as an ac broadband voltmeter. IC1 is an input amplifier that converts level from rms to an equivalent dc level and feeds IC2. R3 and C3 are stabilizing components. IC2 acts as a full-wave rectifier. R6, R5, and D1 rectify positive levels, R7, R8, and D2 negative-going signals. R9, R10, C4, and C5 are low-pass filters. The output can feed a DVM or another meter.

BIKE SPEEDOMETER

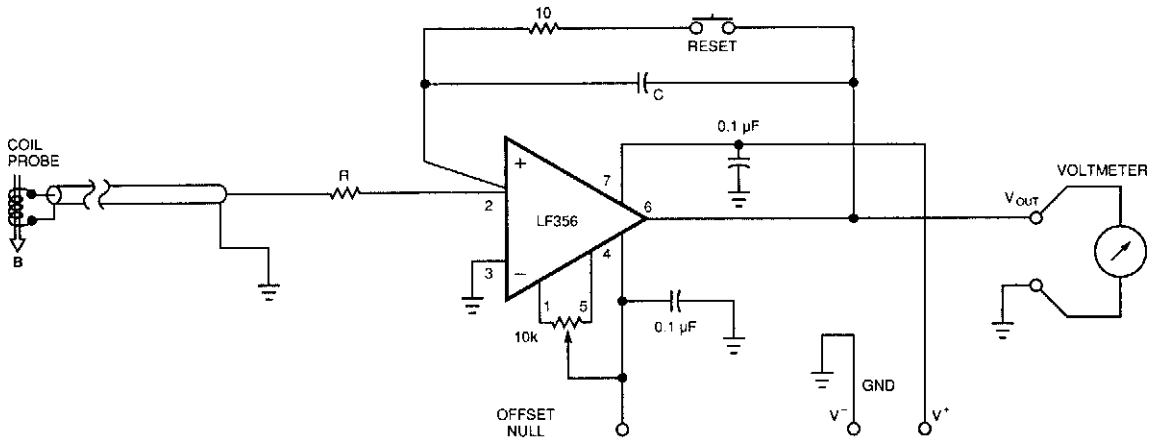


WELS' THINK TANK

Fig. 46-9

A TIL414 photo transistor senses reflection from a spoke-mounted reflector. This generates a pulse and sends it to U1 and U2, a monostable multivibrator, which drives meter M1.

B-FIELD MEASURER



EDN

Fig. 46-10

This circuit develops an output voltage that is proportional to the magnetic induction, B , flowing through its probe's coil. You must size the coil to give a full-scale, 10-V output for your maximum expected magnetic-induction intensity.

For a given value of B (in tesla) and output voltage, V_{OUT} :

$$B = \frac{(R \times C \times V_{OUT})}{A}$$

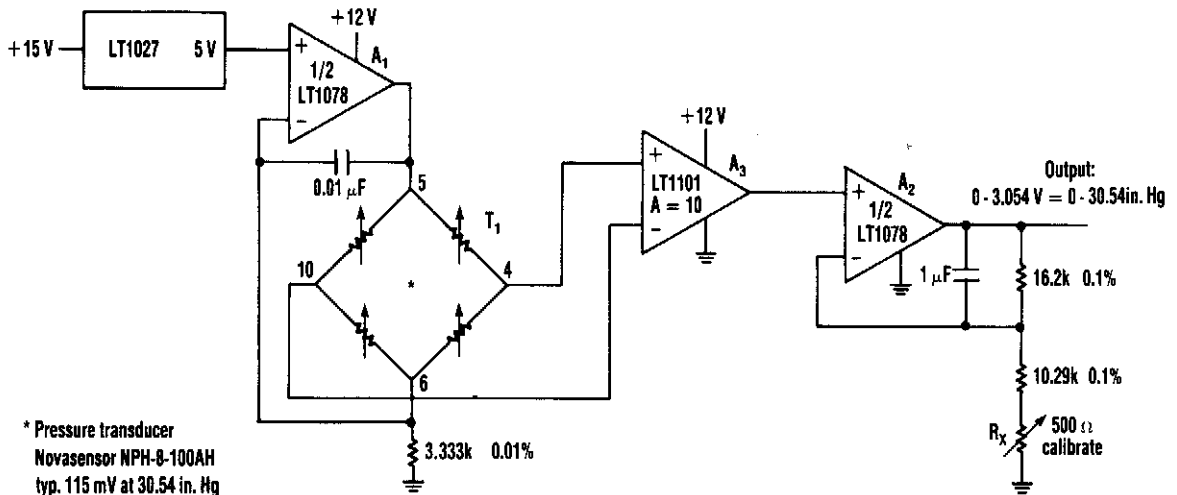
where A is the effective area of your coil in m^2 ($A = \text{number of turns} \times \text{average area of each turn}$), R is the resistance of the coil and the probe, and C is the value of the capacitor. Notice that C should be a low-leakage polypropylene or Teflon device.

For most practical applications that measure a magnetic field in the air, the coil will be either tiny or very thin. If $R = 1 \text{ k}\Omega$, $C = 1 \text{ }\mu\text{F}$, and the coil is 100 turns with a mean area per turn of 1 cm^2 , then the circuit's output will be 1 mV/gauss ($1T = 104G$).

To use the circuit, push the reset button and place the probe in an area that you know is devoid of magnetic fields. Be sure to avoid magnets and iron. Then, put the probe into the field to be measured and read the V_{OUT} with a voltmeter. Finally, calculate the B field's intensity using the equation.

When constructing the instrument, guard the op amp's inputs from undesirable currents at the minus input. For full-scale outputs, use a $\pm 15\text{-V}$ supply for the op amp.

LOW-COST BAROMETER

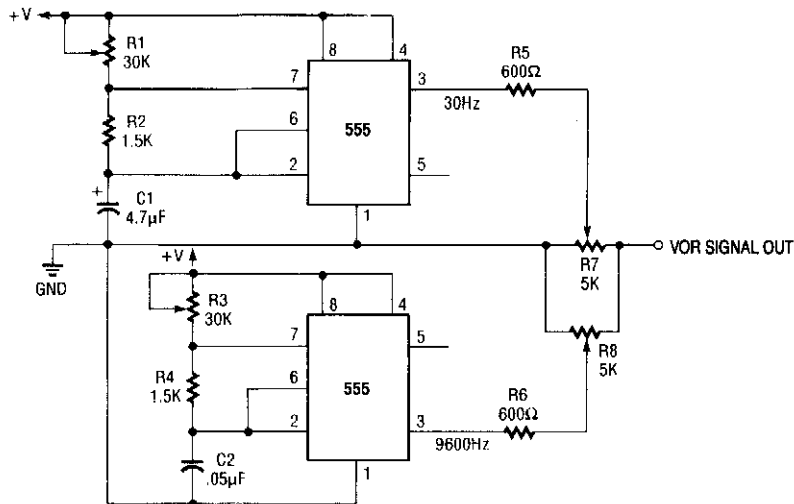


ELECTRONIC DESIGN

Fig. 46-11

Using Linear Technology LT1027 reference and LT1078 op amps, transducer T1 is fed with 1.5 mA. The pressure transducer feeds an amplifier with a gain of 10, then it feeds a voltage follower. Output can either drive an analog meter or a DVM circuit.

VOR SIGNAL SIMULATOR

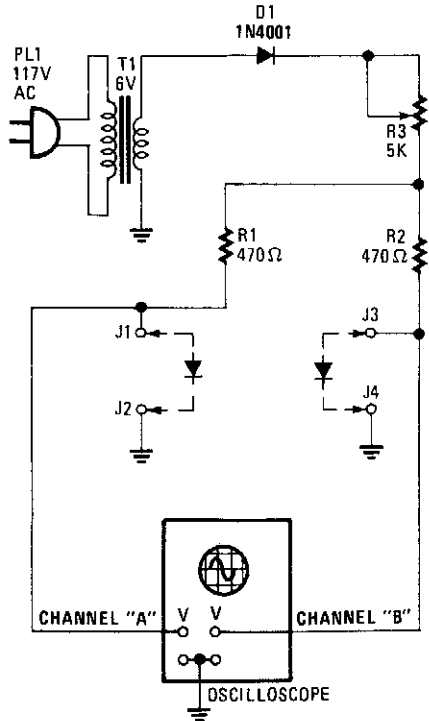


RADIO-ELECTRONICS

Fig. 46-12

An output of 9960 and 30 Hz at 0.5 V_{rms} is produced by this VOR (VHF Omni Range) signal simulator, which uses a pair of 555 timers. Alternatively, a 556 (two timers in one package) could be used.

SIMPLE DIODE CURVE TRACER

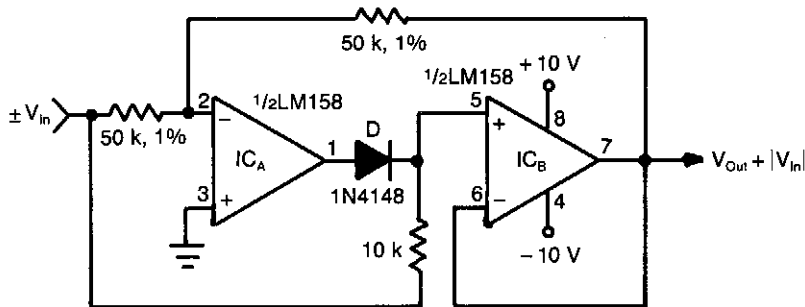


Suitable for matching diodes or examining V/I characteristics of two terminal devices (diodes, etc.), this circuit should be handy for lab use. R_1 and R_2 can be increased in value and a higher voltage transformer can be used for higher voltage test using this principle.

POPULAR ELECTRONICS

Fig. 46-13

SIMPLE ABSOLUTE VALUE CIRCUIT



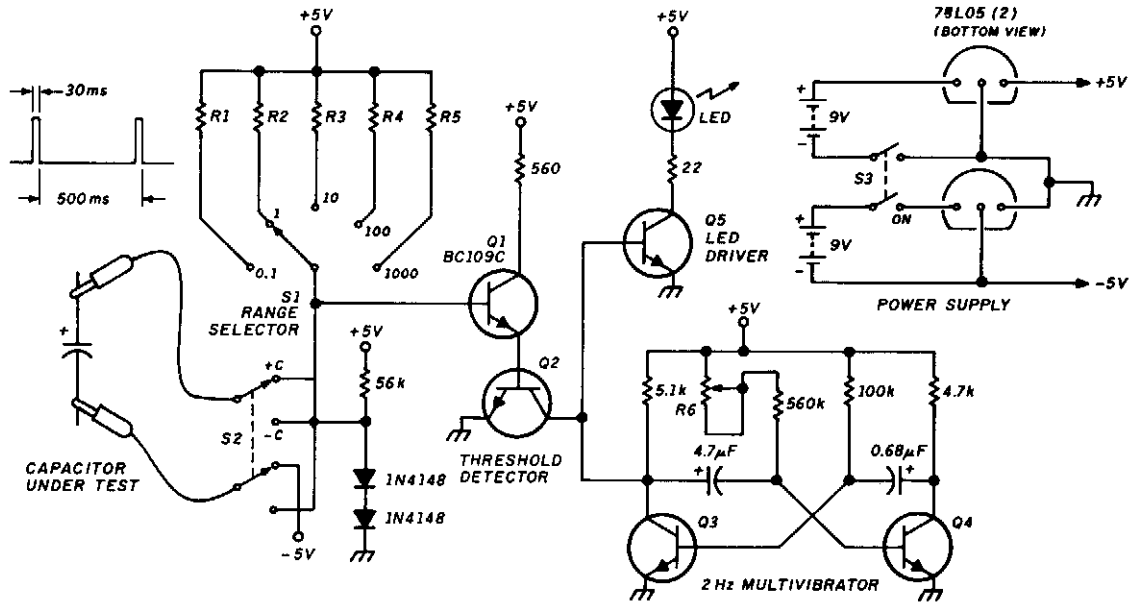
ELECTRONIC DESIGN

Fig. 46-14

When an input voltage is positive, the output of IC_A is negative and diode D does not conduct; hence the output of IC_B is positive. On the other hand, when the input is negative, the output of IC_A is positive. D will conduct and cause the absolute value, expressed as a positive voltage, to appear on the noninverting input of IC_B and on the circuit's output.

The circuit's dynamic range extends from zero to the point at which the op amp saturates. The bandwidth is determined by the characteristics of the diode and the high-frequency performance of the op amp.

MICROFARAD COUNTER

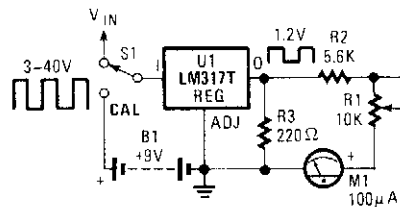


HAM RADIO

Fig. 46-15

This circuit measures capacitance by the time it takes an unknown capacitor to reach 6.32 V ($10\text{ V} \times 63\%$ or 1 RC time constant) when charged through resistor R. The LED used as a timebase is pulsed by Q3, Q4, and Q5. By counting seconds (two flashes per second) until threshold detector Q1/Q2 stops the count, you can directly read the number of microfarads. R_1 , R_2 , R_3 , R_4 , and R_5 can be any convenient values, such as $1\text{ k}\Omega$, $10\text{ k}\Omega$, $100\text{ k}\Omega$, $1\text{ M}\Omega$, $10\text{ M}\Omega$.

SIMPLE DUTY-CYCLE METER

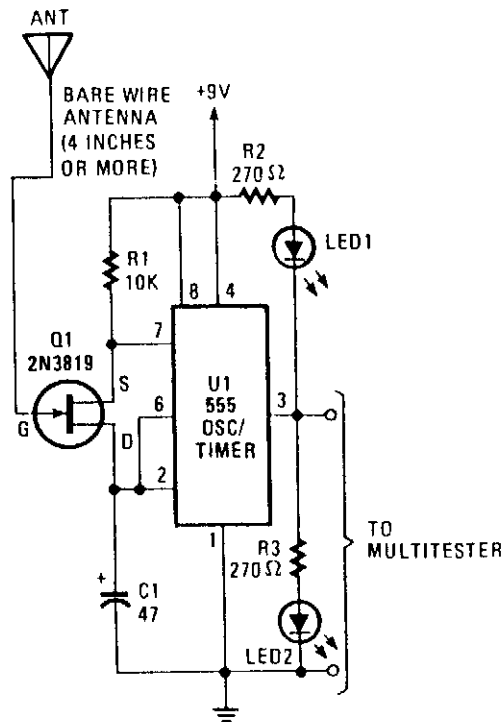


POPULAR ELECTRONICS

Fig. 46-16

Using an LM317T as a precision clipper, this displays the duty cycle of a pulse train from 0 to 100% on a standard 100-mA analog panel meter. This circuit will work up to about 50 kHz.

STATIC DETECTOR

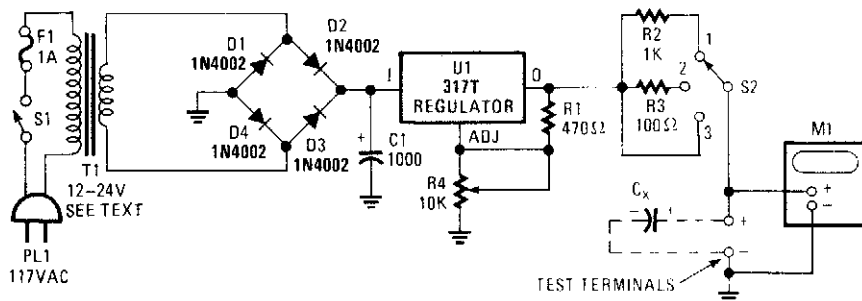


This circuit detects the presence of electrostatic fields by using an FET to alter the flash rate of two LEDs. The FET is installed in the timing circuit and causes a change in the flash rate of the two LEDs.

POPULAR ELECTRONICS

Fig. 46-17

ELECTROLYTIC CAPACITOR REFORMING CIRCUIT

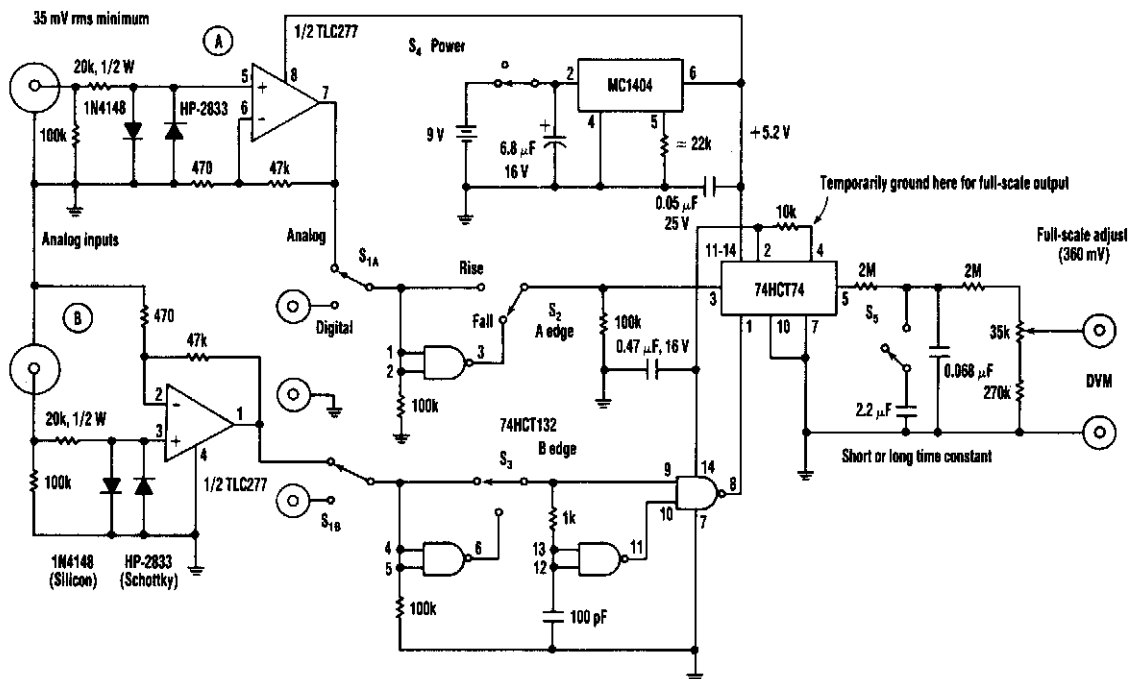


POPULAR ELECTRONICS

Fig. 46-18

Sometimes electrolytic capacitors that are stored for some time will exhibit high leakage currents. Before placing these in service, the capacitors might need to be reformed. This power supply can be used for reforming. Adjust R4 for the capacitor's rated voltage and set S2 in position 1. When M1 indicates the rated voltage, reforming is complete. For large capacitors, use position 2, and then position 3 after reforming starts. T1 can be any transformer with a rating of 12 to 24 Vac at about 1 A.

DIGITAL VOM PHASE METER

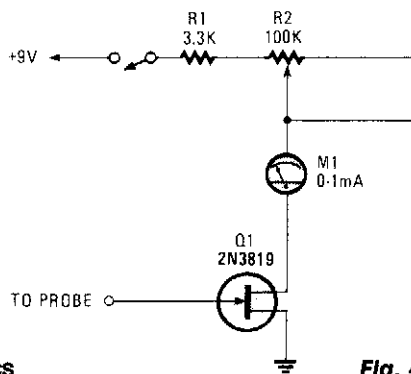


ELECTRONIC DESIGN

Fig. 46-19

The phase-angle meter will work with either analog or digital inputs. A DVM is used as a readout device. The output is 1 mV per degree (360 mV or degrees full-scale). The MC1404 precision regulator maintains calibration with a battery source (9 V).

SIMPLE ELECTROMETER

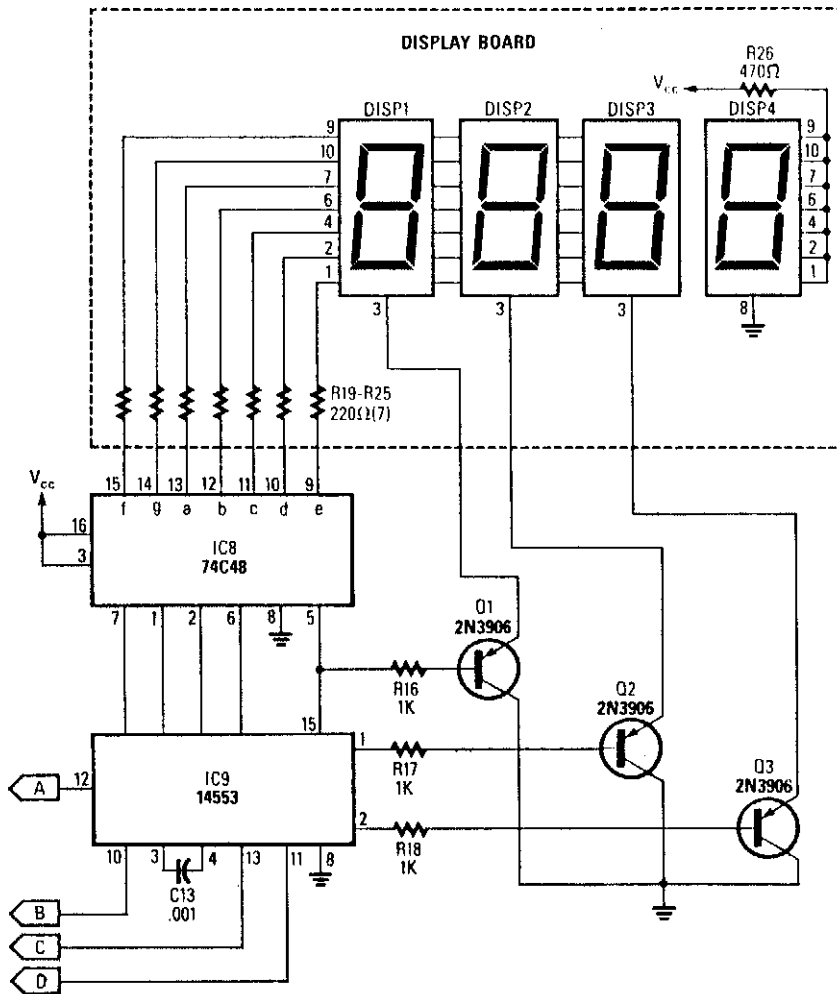


POPULAR ELECTRONICS

Fig. 46-20

This electrometer is useful as a relative indicator of static charges or as an electric field in a charge-free environment. An induced negative charge on the probe will reduce drain current toward zero.

DIGITAL TACHOMETER COUNTER

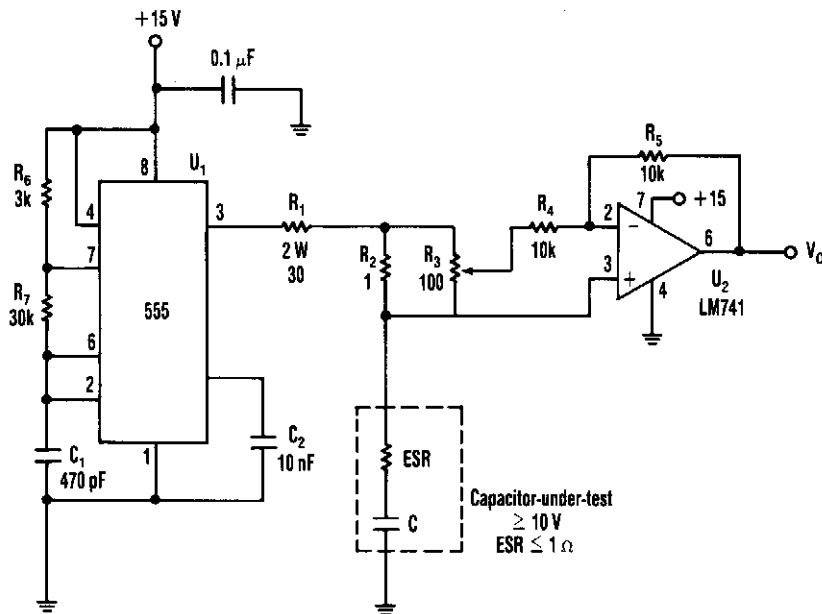


RADIO-ELECTRONICS

Fig. 46-21

This circuit produces a readout for the digital tachometer circuit. IC9 is a 3-digit LED display driver, counter, and latch. IC8 drives the common-cathode LEDs, which are enabled by Q1, Q2, and Q3. See page 268, Fig. 46-5 for the matching project.

CAPACITOR ESR MEASURER



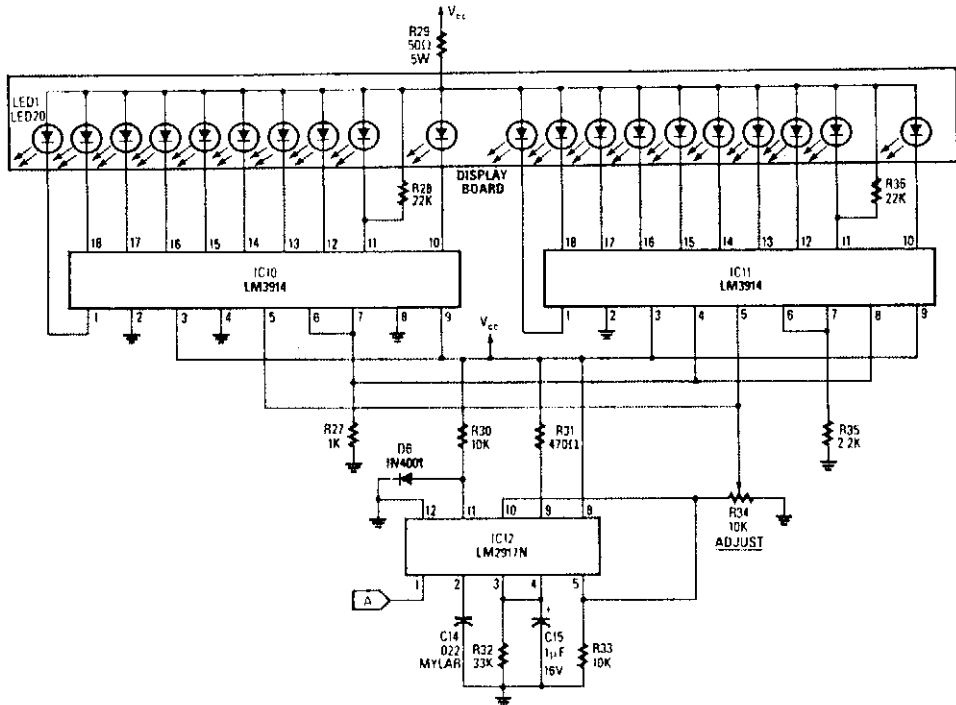
ELECTRONIC DESIGN

Fig. 46-22

The equivalent series resistance (ESR) of a capacitor can be measured using this circuit and an ac voltmeter. U1 functions as a 50-kHz square-wave generator. It drives a current waveform of about ± 180 mA in the capacitor-under-test, through R1 and R2. When R3 is adjusted to the proper value, the voltage drop across the equivalent series resistor is precisely nulled by the inverting amplifier (U2). Thus, V_0 is the pure capacitor voltage which is the minimum voltage that can be produced at V_0 .

To make an ac voltage measurement, adjust R3 until V_0 is minimized. Then, note the position of the potentiometer and multiply it by the value of R2, 1 Ω in this case. That product equals the capacitor's ESR. The capacitor is biased at about 7.5 V. Lower-voltage capacitors won't work with this circuit. By changing the value of R2, other ranges of ESR can be measured. However, for small R2 values, the current level should be increased to keep a reasonable voltage across R2. This requires some sort of buffer. The circuit is intended for capacitors greater than 100 μ F. The ripple voltage gets large for smaller values and accuracy decreases.

ANALOG TACHOMETER READOUT

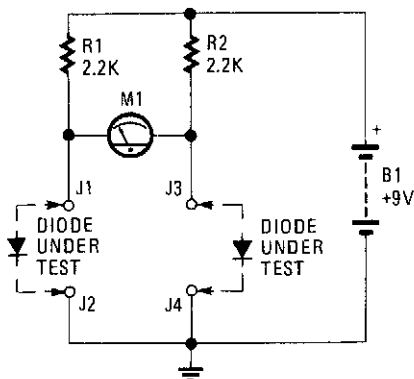


RADIO-ELECTRONICS

Fig. 46-23

The analog display consists of a frequency/voltage converter (IC12) and bar-graph segment drivers IC10 and IC11. R34 is the calibration adjustment and is set so that an engine rpm of 5 000 to 7 000 rpm lights the first LED (redline value).

DIODE MATCHING CIRCUIT

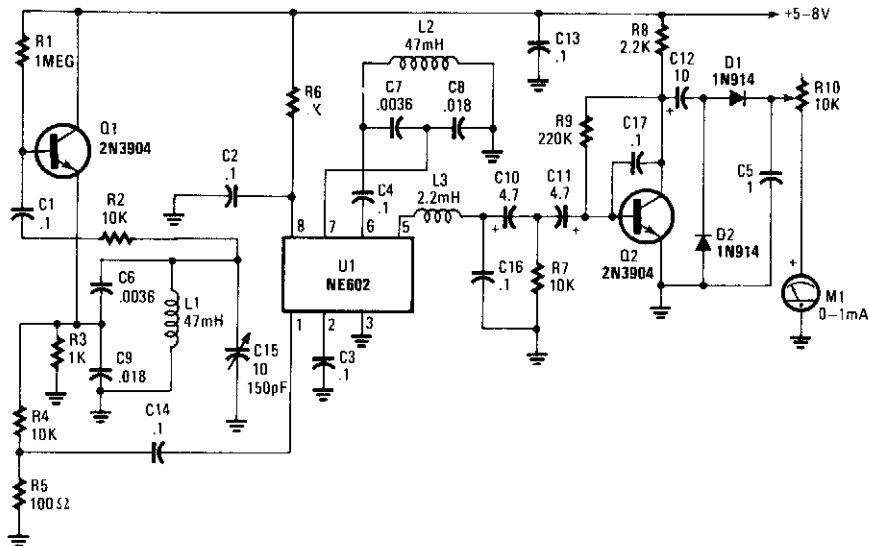


POPULAR ELECTRONICS

Fig. 46-24

This circuit can be used to match diodes for use in circuits where such a balance is necessary (a balanced modulator, for instance). The diode matching circuit will indicate the forward-voltage drop of the two diodes in millivolts.

PERMANENT MAGNET DETECTOR

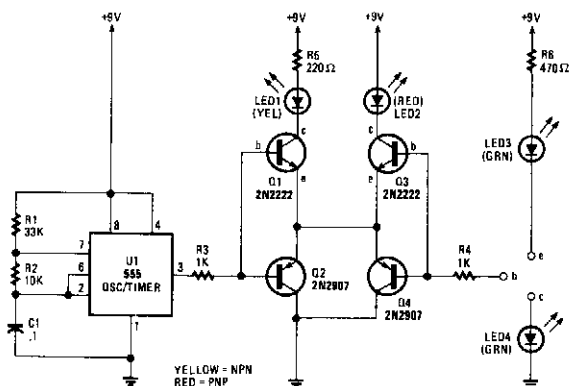


POPULAR ELECTRONICS

Fig. 46-25

In this circuit, oscillator Q1 runs at about 15 kHz and feeds mixer U1. U1 has an internal oscillator that runs at around 15 kHz. C15 is used to zero-beat both oscillators. When a magnet is brought near L1 or L2, the magnetic field shifts the permeability of their respective cases. This changes the oscillator frequency, and the audio note is passed through filter L3, C16, and C10/R7 to amplifier Q2. There the audio is amplified and drives meter M1 via rectifiers D1 and D2.

TRANSISTOR TESTER

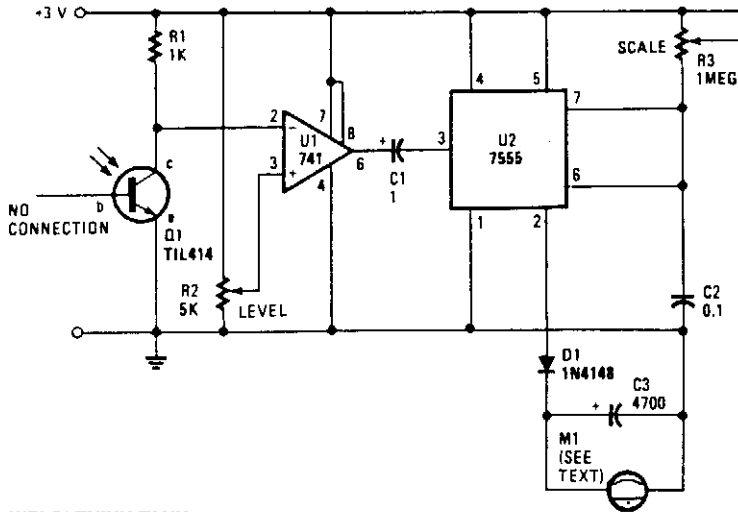


A 555 timer drives Q1 through Q4 with a square wave. LED1 and LED2 light when an npn or pnp transistor respectively, are connected to the test terminals. If LED3 and LED4 light equally as LED1 and LED2, the transistor is functional. If LED3 and LED4 are brighter than LED1 or LED2, the transistor is shorted.

POPULAR ELECTRONICS

Fig. 46-26

BIKE SPEEDOMETER

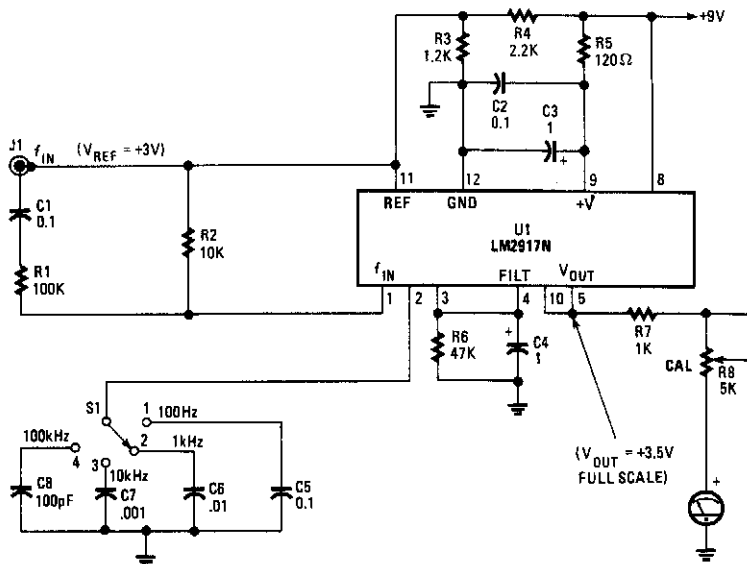


WELS' THINK TANK

Fig. 46-27

A TIL414 photo transistor senses reflection from a spoke-mounted reflector, generates a pulse, and sends it to U1 and U2, a monostable multivibrator, which drives meter M1.

FREQUENCY METER



POPULAR ELECTRONICS

Fig. 46-28

Using an LM2917N, this F/V converter-based circuit indicates the frequency on a meter. S1 selects full-scale range (up to 100 kHz). R8 is recommended to obtain the battery source.

47

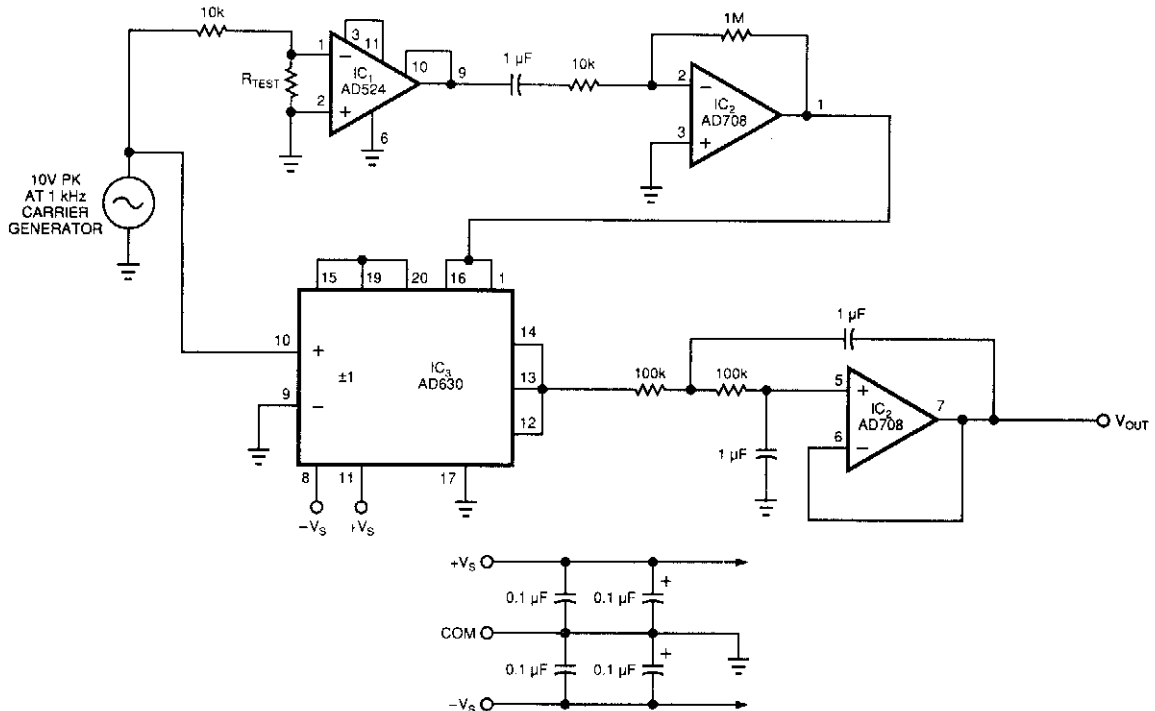
Measuring and Test Circuits (*E*, *I*, and *R*)

The sources of the following circuits are contained in the Sources section, which begins on page 669. The figure number in the box of each circuit correlates to the entry in the Sources section.

Hall-Sensor Current Monitor
Synchronous System
Digital LED Voltmeter
Continuity Checker
Quick Multiconductor Cable Tester
Continuity Tester
4-Range ac Millivoltmeter
Low-Ohms Adapter
ac Current Indicator
5-Range Linear-Scale Ohmmeter

High-Resistance-Measuring DMM
High-Gain Current Sensor
Sensitive Continuity Checker
4-Range dc Microammeter
Multimeter Shunt
Continuity Tester
LED Millivoltmeter
Latching Continuity Tester
dc Millivoltmeter
Continuity Tester

SYNCHRONOUS SYSTEM



EDN

Fig. 47-2

The circuit uses a synchronous-detection scheme to measure low-level resistances. Other low-resistance-measuring circuits sometimes inject unacceptable large currents into the system-under-test. This circuit synchronously demodulates the voltage drop across the system-under-test and can hence use extremely low currents while measuring resistance.

The 10-V (pk), 1-kHz carrier generator injects a 1-mA reference current into unknown resistor, R_{TEST} . Instrument amplifier IC1 and precision op amp IC2A amplify the voltage across R_{TEST} by a gain of 100 000. Synchronous detector IC3 demodulates this voltage, then op amp IC2B acts a low-pass filter on the demodulated voltage. The low-pass filtering will attenuate all uncorrelated disturbances (such as noise, drift, or offsets), while passing a dc voltage that is proportional to the unknown resistance.

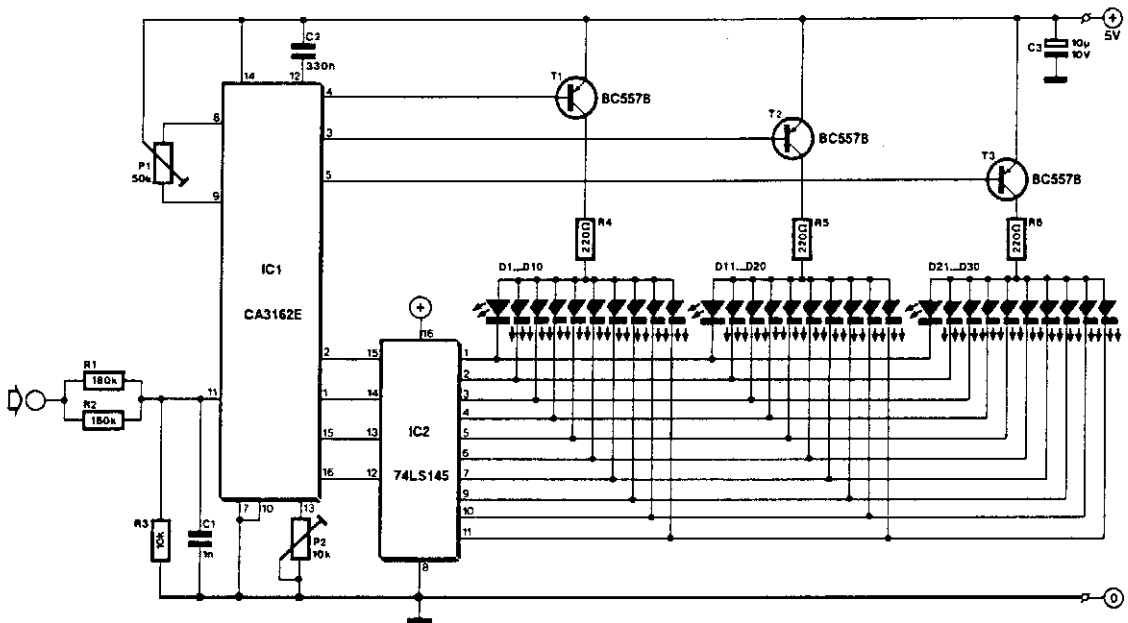
The relationship between the output voltage and the unknown resistance is:

$$V_{OUT} = 10 \times \left(\frac{2 \text{ V}}{\pi} \right) \times R_{TEST} \times \frac{10_5}{10 \text{ k}\Omega}, \text{ or}$$

$$R = 0.0157 \times V_{OUT},$$

which is $\frac{15.7 \text{ m}\Omega}{\text{V}}$ at the circuit's output.

DIGITAL LED VOLTMETER



ELEKTOR ELECTRONICS

Fig. 47-3

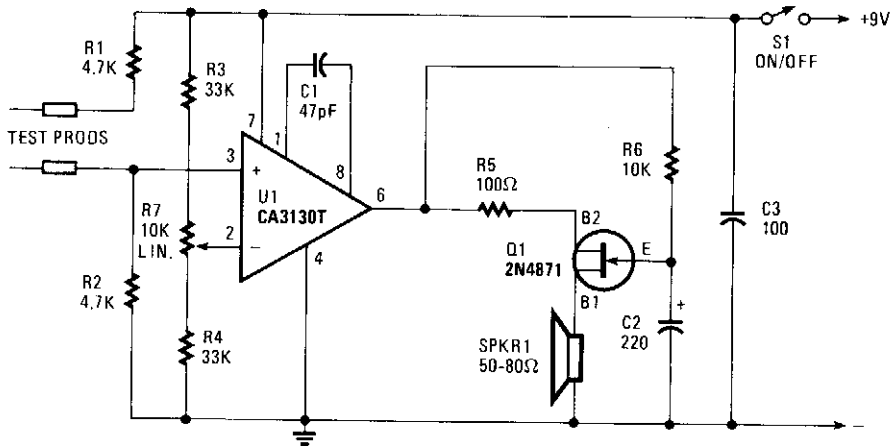
The voltage to be measured is digitized in an analog-to-digital (A/D) converter and then displayed in three decimal digits. The display consists of three groups of 10 LEDs. The meter can only be used for measuring direct voltages.

The A/D converter is based on CA3162, which can process direct voltage up to 999 mV (1-V full-scale deflection—FSD). The FSD is extended to 10 V with the aid of potential divider R1/R2/R3. Other ranges are possible by altering the values of the resistors.

The measured value is read from three bars of LEDs: the first one of these, D1 through D10, shows units; the second, D11 through D20 tens; and the third, D21 through D30, hundreds.

The circuit is nulled with P1 when the input is open. Zero here means that diodes D1, D11, and D21, light. Diodes D10, D20, and D30, represent the figure 9. Next, a known voltage is applied to the input and P2 is adjusted until the LEDs read the correct value. When the input voltage is too high, the display goes out. When the input is negative, the unit LEDs do not light. Notice that variations in the supply voltage affect the measurement adversely.

CONTINUITY CHECKER

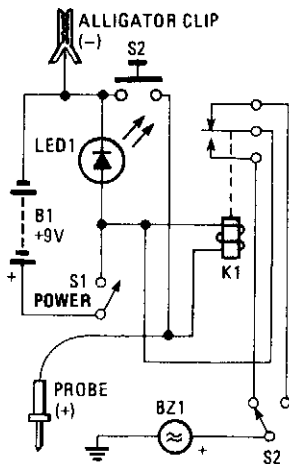


HANDS-ON ELECTRONICS

Fig. 47-4

U1 is an op amp used as a comparator. When the test probes are shorted together, resistors R1 and R2 bias the noninverting input to half the supply voltage. The inverting input is biased by a voltage divider that consists of R3, R7, and R4. Resistor R7 is adjusted so that the voltage to the inverting input is lower than that to the noninverting input when the probes are shorted together. With continuity across the probes, U1's output goes high and supplies power to Q1, which is configured as a relaxation oscillator. The output of Q1 is fed to a high-impedance loudspeaker for an audio tone. When the probe is open, the noninverting input goes to the negative supply rail via R2. This action forces U1's output low, which results in no output from the oscillator.

CONTINUITY TESTER

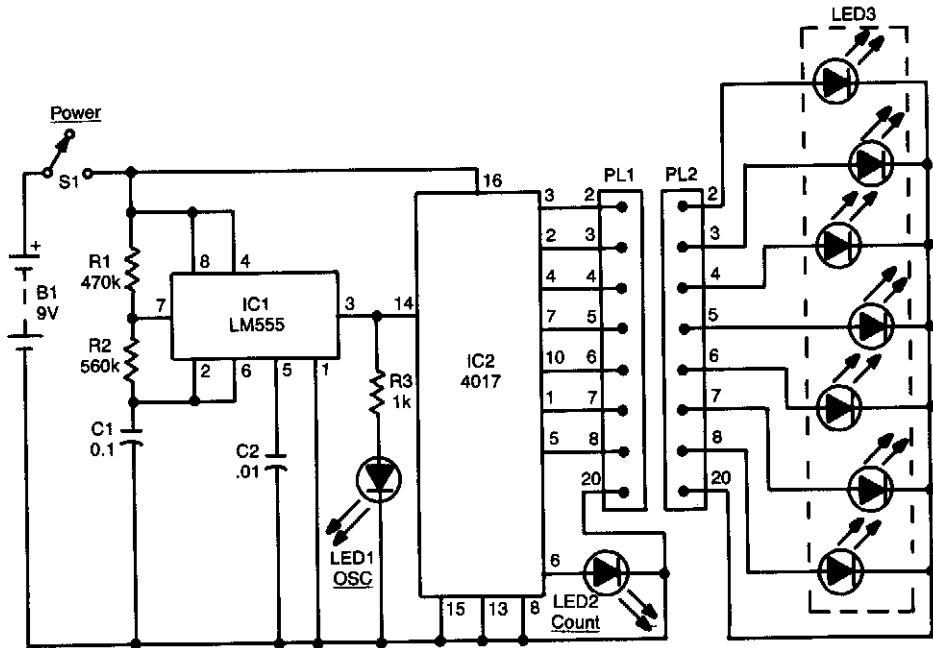


Using an LED and an audible indicator, relay K1 actuates buzzer BZ1. S2 is a buzzer/battery test switch for testing the battery in both NO and NC mode.

POPULAR ELECTRONICS

Fig. 47-5

QUICK MULTICONDUCTOR CABLE TESTER

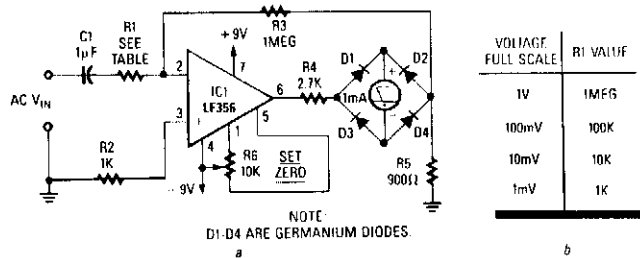


RADIO-ELECTRONICS

Fig. 47-6

This circuit can be used to check up to an eight-conductor cable. IC1, a 555 timer, drives decade counter IC2, a 4017. Each LED should light in sequence. The cable to be tested is connected between PL1 and PL2. If the cable is miswired, the LEDs will light out of sequence. If it is shorted or open, some LEDs will not light.

4-RANGE ac MILLIVOLTMETER

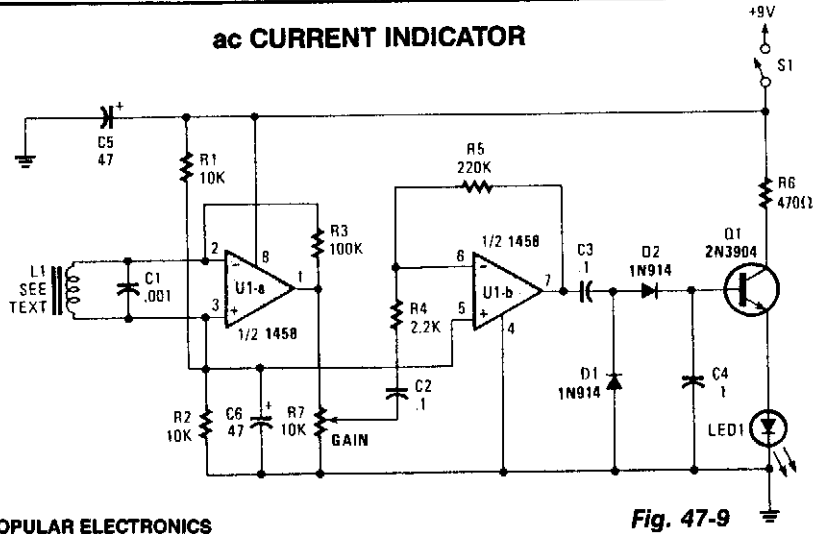


RADIO-ELECTRONICS

Fig. 47-7

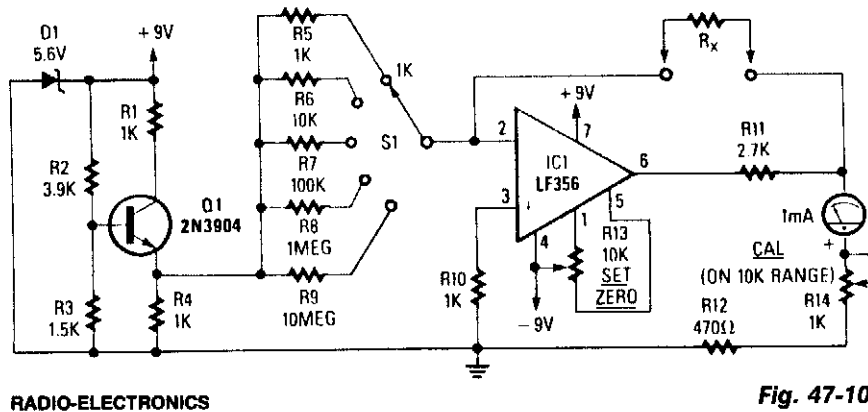
By placing the rectifier in the op amp feedback path, nonlinearity is greatly reduced to insignificant levels. The meter will read the full-wave rectified average (absolute value) of the input signal. Frequency response is a few Hz to about 50 kHz.

ac CURRENT INDICATOR



Using a dual op amp driving a rectifier and emitter-follower, this circuit indicates ac current on an LED. L1 is an audio transformer winding using a pick-up coil, or 100 to 200 turns of #28 gauge wire 2" in diameter, etc. The circuit can trace ac lines behind walls, etc. or detect ac current flow.

5-RANGE LINEAR-SCALE OHMMETER



R_x is inserted in the feedback path of IC1. A known reference current is selected from reference voltage generator Q1, D1, and R5 through R9. A meter reading will be produced:

$$I = \frac{R_x}{R_5} \times 1 \text{ mA}$$

where $R_5 = R_5$ through R_9 , as selected. This corresponds linearly to the value of R_x .

HIGH-RESISTANCE-MEASURING DMM

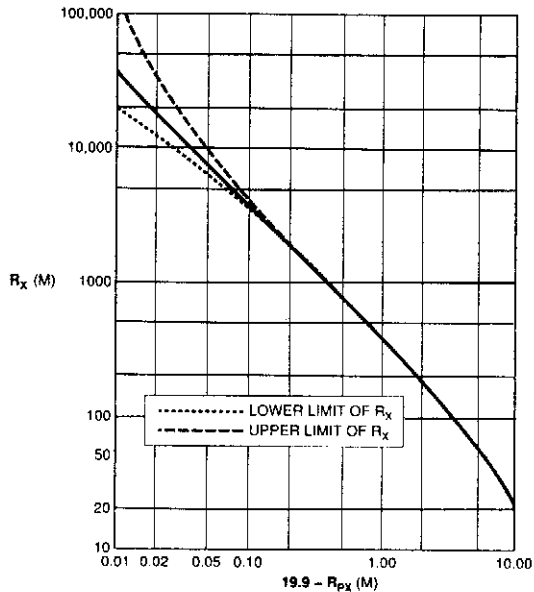


Fig. 47-11

Using a simple technique, you can extend the resistance-measurement range of your $3^{1/2}$ -digit DMM from the usual 19.99 MΩ to 40 GΩ. You could measure, for example, the leakage resistances of transformers, motor windings, and capacitors.

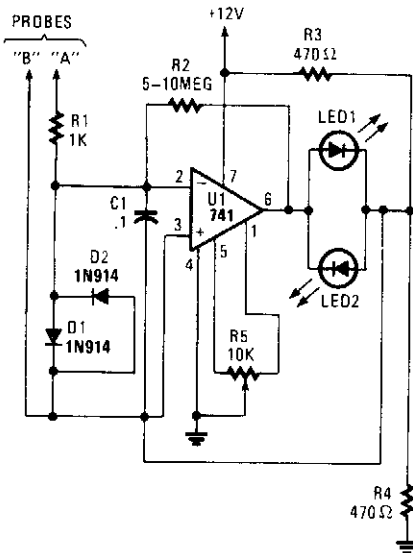
For a 19.99-MΩ DMM range, select a stable 20-MΩ resistor whose value is slightly below nominal, 19.99 MΩ for example. An unknown high resistance, R_X , is:

$$R_X = \frac{(R_P \times R_{PX})}{(R_P - R_{PX})}$$

where R_P is the high-value parallel resistor and R_{PX} is the measured value of R_P in parallel with R_X . An even easier way to determine the value of R_X is to use the graph.

EDN

HIGH-GAIN CURRENT SENSOR

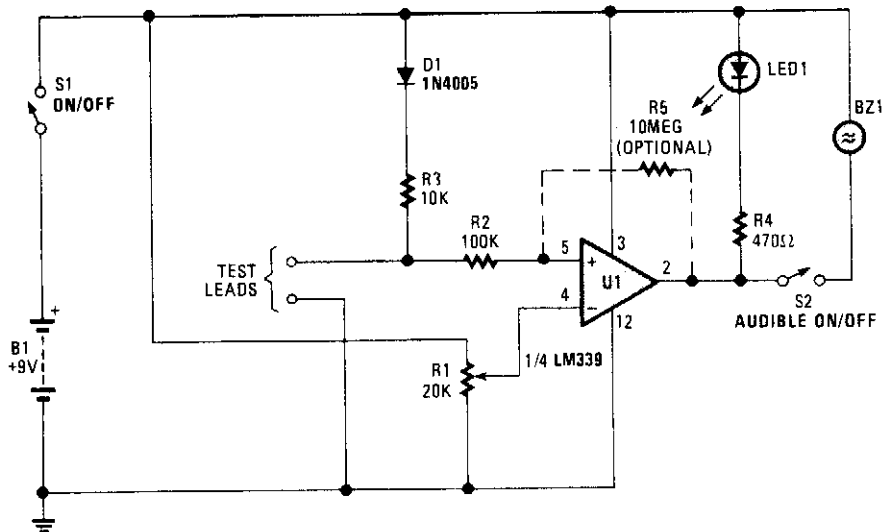


A high-gain amplifier using a UA741 is used to sense relative voltage drop in a conductor, and therefore current in the conductor. R_2 can be increased to 10 MΩ for increased sensitivity. LED1 and LED2 provide polarity indication. This circuit can be used to detect current flowing in a PC board trace, and also for locating shorts and opens.

POPULAR ELECTRONICS

Fig. 47-12

SENSITIVE CONTINUITY CHECKER



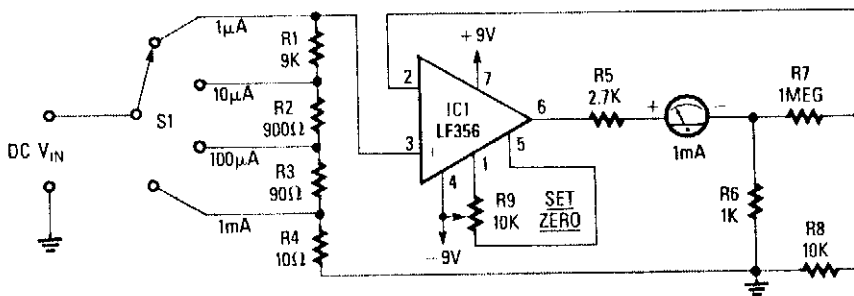
POPULAR ELECTRONICS

Fig. 47-13

This continuity checker (built around an LM339 quad comparator with open-collector outputs) eliminates false readings because of coils or low-resistance devices in a circuit.

U1 is a comparator that acts as a sensing amplifier for the bridge circuit (R1 and D1, R3 and the unknown resistance, R_x , that is connected across the test leads. When R_x is less than this predetermined value (by the setting of R1), the LED lights and BZ1 sounds.

4-RANGE dc MICROAMMETER

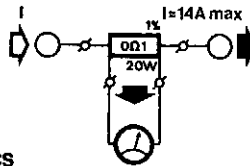
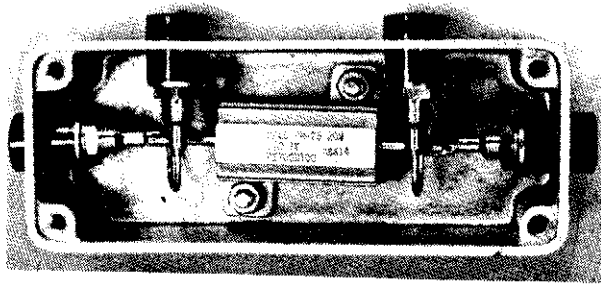


RADIO-ELECTRONICS

Fig. 47-14

IC1 produces a full-scale reading on M1 when pin 3 has a 10 mVdc level on it, as determined by R7 and R8. R1 through R4 are shunts that produce a 10-mV drop for the desired full-scale range. R9 zeros the meter.

MULTIMETER SHUNT



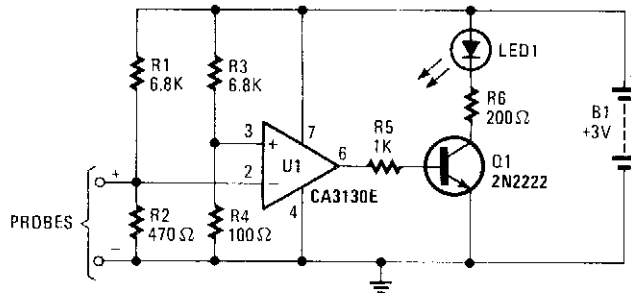
ELEKTOR ELECTRONICS

Fig. 47-15

The current range in multimeters, particularly the more inexpensive ones, is restricted by the load limits of the internal shunts to 1 to 2 A. The figure shows how easily a precision heavy-duty resistor from Dale or RCL (0.1Ω ; 20 W; 1%) can be used as an external shunt. These resistors were not designed for this purpose, but they are much cheaper than custom-made shunt resistors. The 20-W rating applies only, by the way, if a heatsink is used: without that its rating is only 8 W.

The maximum current through the device on a heatsink is about 14 A; the larger versions draw up to 17.5 A. When mounting the shunt, make sure that the test terminals (as well as the device terminals) are soldered properly, otherwise the resistance of the terminals is added to the shunt.

CONTINUITY TESTER

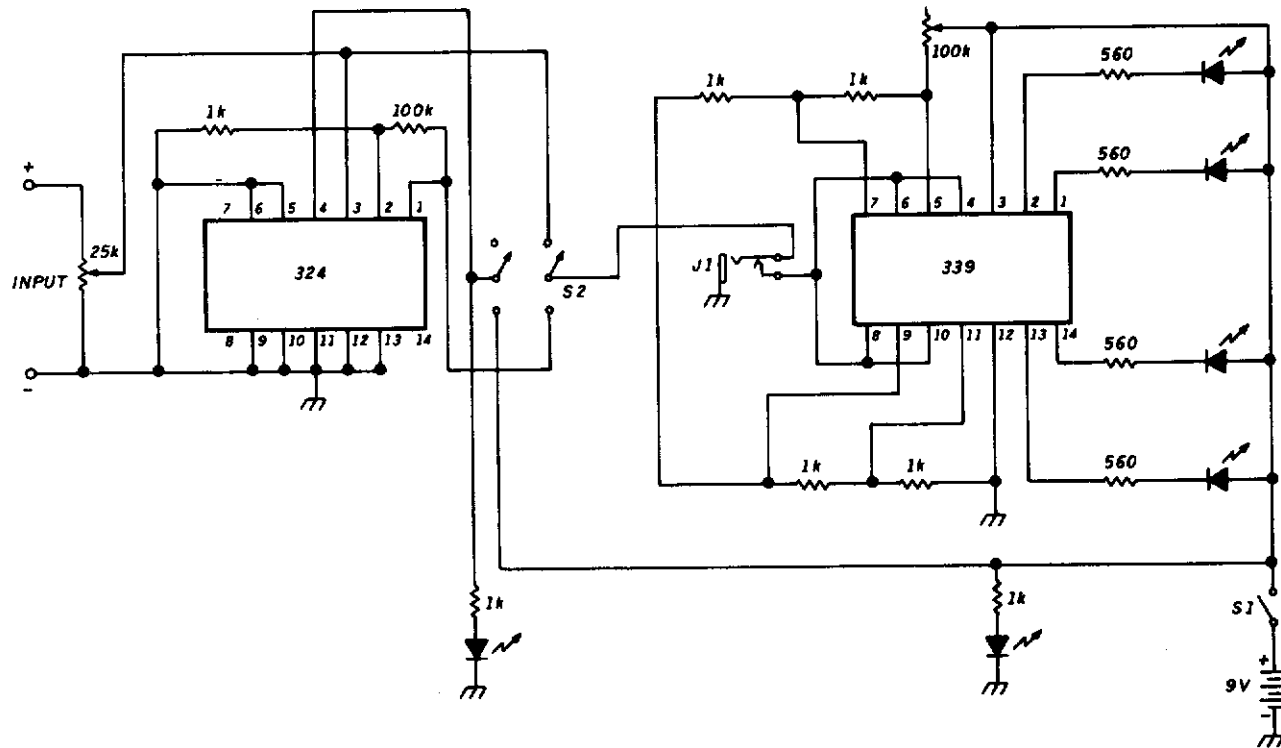


POPULAR ELECTRONICS

Fig. 47-16

Using a comparator, this continuity tester applies only about 300 mV to the circuit to be tested. This avoids false readings in semiconductor circuits.

LED MILLIVOLTMETER

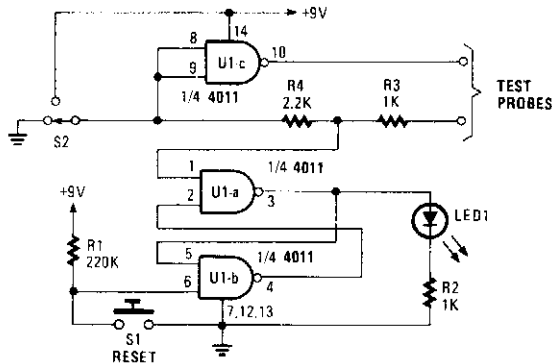


HAM RADIO

Fig. 47-17

This circuit uses a dc amplifier (324) in a bar-graph circuit that uses an LM339 Quad comparator IC to sense dc levels. The LEDs will light every 100 mV. The 324 op amp is configured to provide a gain of $100\times$ to increase this sensitivity to 1 mV. Two auxiliary LEDs indicate "power on" and " $\times 100$ " gain setting.

LATCHING CONTINUITY CHECKER

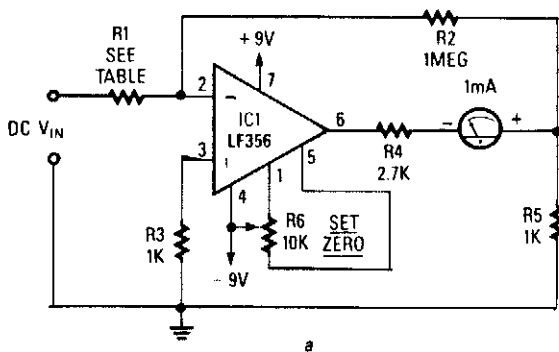


POPULAR ELECTRONICS

Fig. 47-18

This circuit detects brief shorts or opens. When S2 is in the up position, the circuit indicates if there is or was continuity by lighting LED1. U1A and U1B are connected as an R-S flip-flop. S1 resets the tester. When S2 is in the down position, a momentary interruption in continuity will light LED1. This tester is good for detecting intermittent shorts or opens.

dc MILLIVOLTMETER



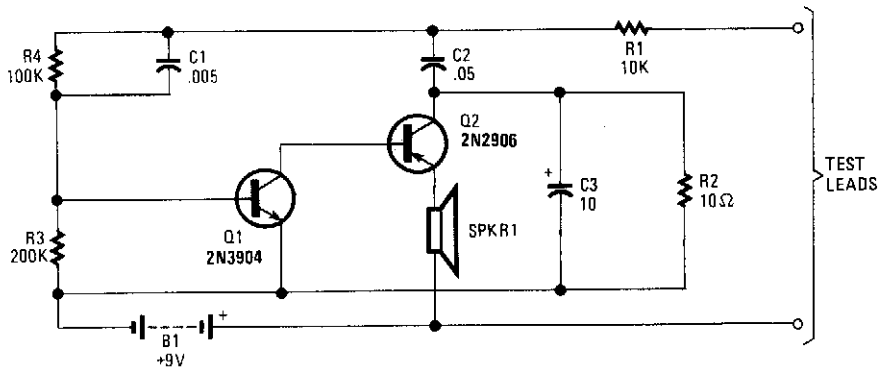
VOLTAGE FULL SCALE	R1
1V	1MEG
100mV	100K
10mV	10K
1mV	1K

RADIO-ELECTRONICS

Fig. 47-19

An LF356 op amp is used as a gain amplifier with the output taken across R5. When a full-scale current of 1 mA is flowing through the meter, exactly 1 V appears across R5 (should be 1% tolerance or better). This is fed back to R2 to the summing junction of IC1 (a full-scale produces $1\mu\text{A}$). This offsets the current through R1. R1 has a value of $1\text{ M}\Omega/\text{V}$ which is used to zero the meter. R4 provides some overcurrent protection for the meter.

CONTINUITY TESTER



POPULAR ELECTRONICS

Fig. 47-20

A continuity tester that has an audible indicator can be more useful in some cases than a visual indicator, because you need not take your eyes from the job at hand. Q1 and Q2 form an audio oscillator. When the test leads are connected to a continuous circuit, the oscillator operates, and sounds a tone from the speaker.

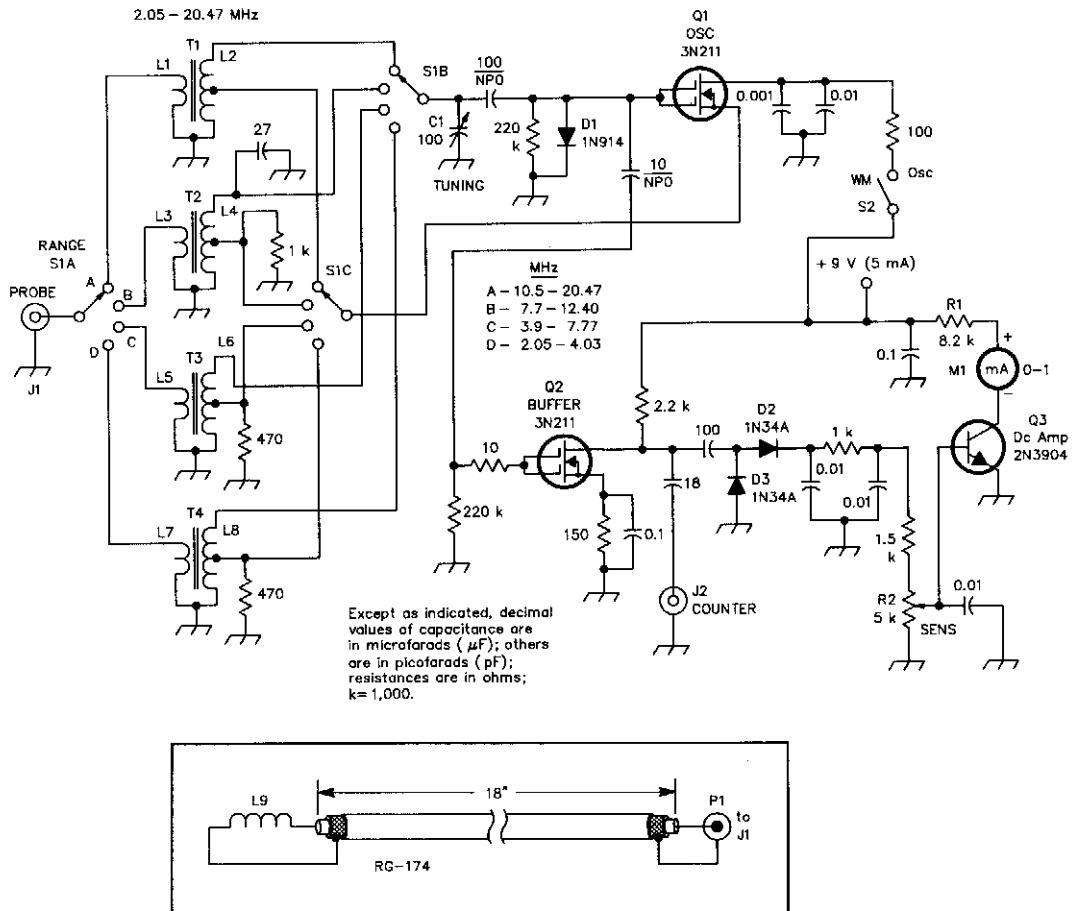
48

Measuring and Test Circuits (High-Frequency and RF)

The sources of the following circuits are contained in the Sources section, which begins on page 670. The figure number in the box of each circuit correlates to the entry in the Sources section.

Bandswitched Grid-Dip Meter
UHF "Source" Dipper
Modulation Monitor
Frequency Counter
455-kHz AM IF Signal Generator
Precision Crystal Frequency Checker
Tuned RF Wavemeter
AM Broadcast Band Signal Generator
Wideband Test Amplifier
Deviation Meter

BANDSWITCHED GRID DIP METER

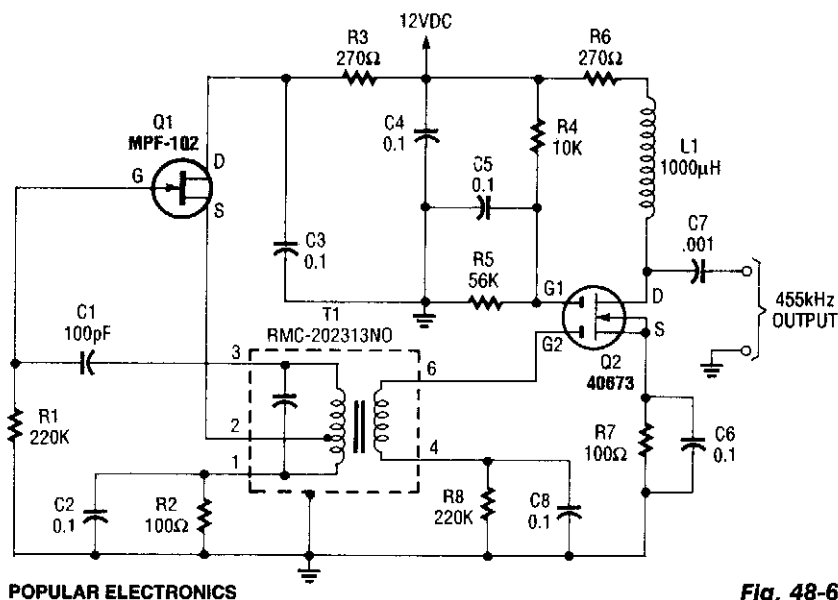


QST

Fig. 48-1

For checking resonances, tuned circuits, antennas, etc., this circuit covers the 2-to 20-MHz range. Q1 serves as an oscillator tunable over this range via C1 and bandswitched coils L1 through L8. When the probe is coupled to a circuit resonant at the oscillation frequency, some RF power will be absorbed and the oscillator output will drop. Q2, D2, D3, and Q3 form an RF detector and dc amplifier to drive meter M1, which will show the drop in Rf level, indicating resonance. R2 is a sensitivity control.

455-KHz AM IF SIGNAL GENERATOR

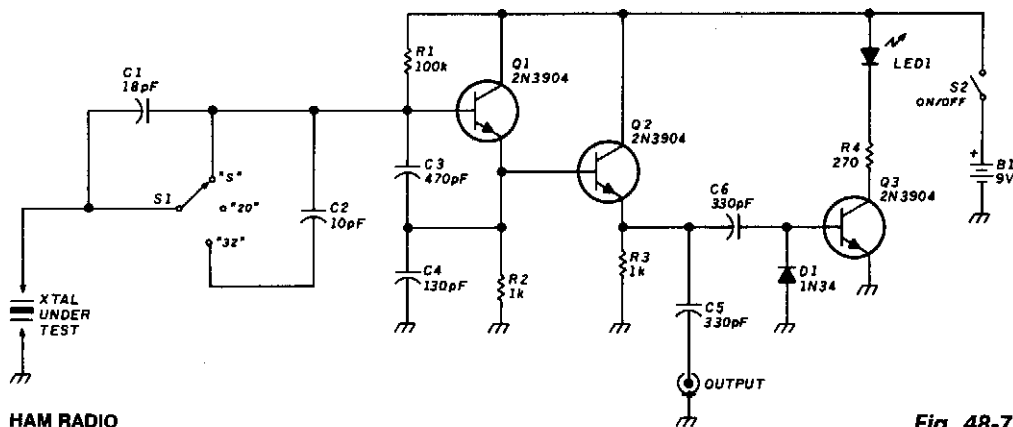


POPULAR ELECTRONICS

Fig. 48-6

An MPF102 FET oscillator drives a dual-gate MOSFET buffer. The MPF102 is configured as a Hartley oscillator. If desired, an audio voltage can be coupled to the junction of R4, R5, and C5 with an extra coupling capacitor ($\approx 1\mu\text{F}$) to AM modulate the signal. T1 = Toko P/N RMC-202313NO.

PRECISION CRYSTAL FREQUENCY CHECKER

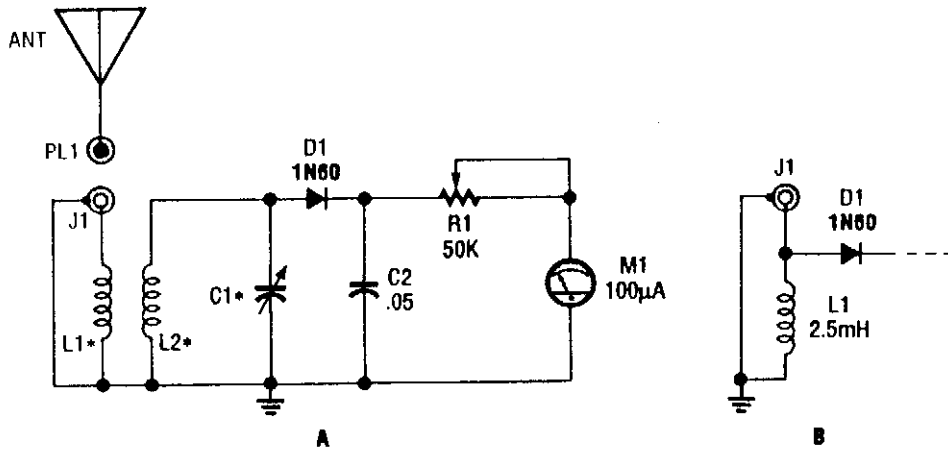


HAM RADIO

Fig. 48-7

This circuit uses a Colpitts oscillator (Q1) with a buffer amplifier (Q2) to test crystals. S1 selects three load conditions—series (S), 20 pF, and 32 pF. Leads to S1 and the crystal should be kept short. The circuit should be useful over 2- to 20-MHz.

TUNED RF WAVEMETER

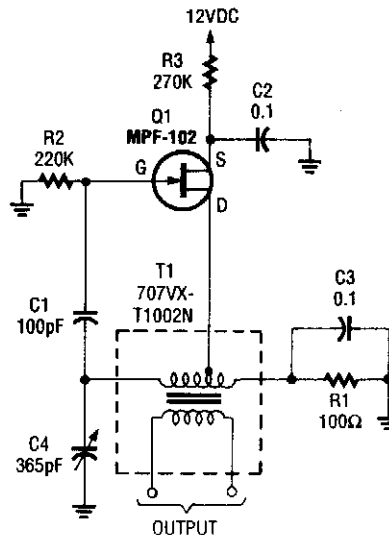


POPULAR ELECTRONICS

Fig. 48-8

L1 and L2 form a tuned transformer. About a 1:3 turns ratio is optimum. L2 and C1 tune to the desired frequency. The frequency range can be 10 kHz to over 200 MHz, depending on the value of C1. For HF use, C1 can be a 140-pF variable. For VHF, use about 25 pF. Use of a 2.5 μ H RF choke will yield an untuned wavemeter.

AM BROADCAST-BAND SIGNAL GENERATOR

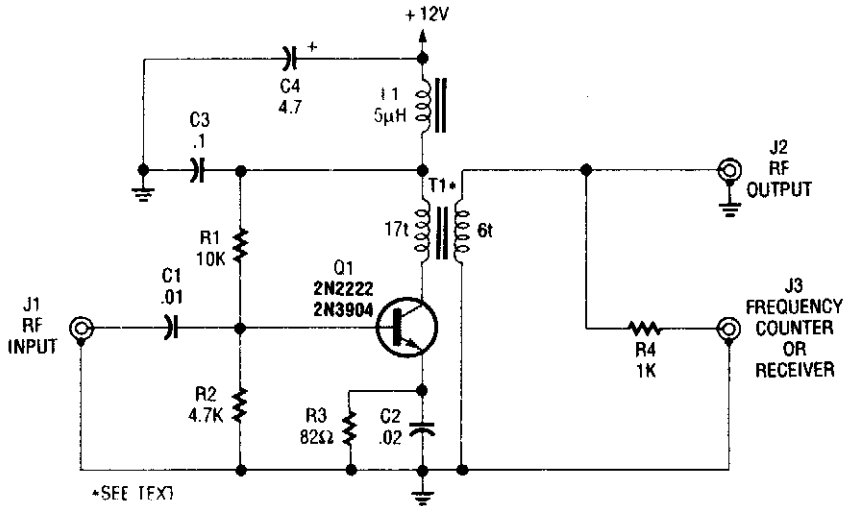


POPULAR ELECTRONICS

Fig. 48-9

A Hartley oscillator using an MPF102 covers the band from 530 to 1 600 kHz. T1 is a Toko P/N T1-707VXT1002N 217 μ hy transformer.

WIDEBAND TEST AMPLIFIER

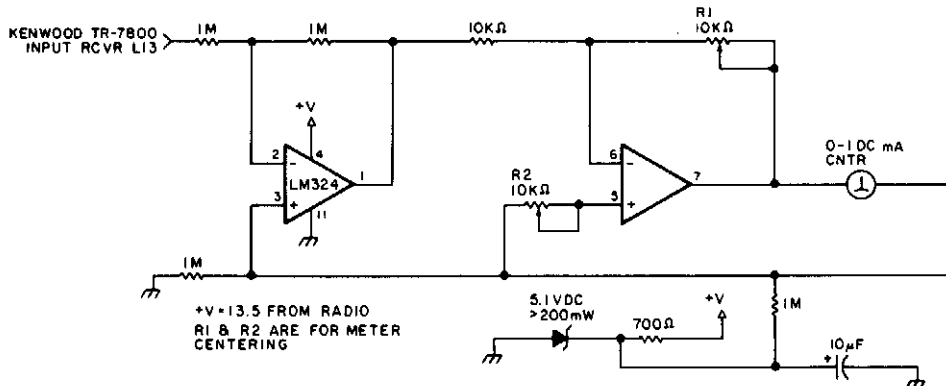


POPULAR ELECTRONICS

Fig. 48-10

This single-stage amplifier (using a 2N2222 or 2N3904 general-purpose transistor) is useful for interfacing test instruments. T1 is an Amidon Associates FT-23-43 core wound with 17 and 6 turns of #26 wire. J3 is a lower-level output for a monitoring device (such as a receiver frequency counter or spectrum analyzer).

DEVIATION METER



73 AMATEUR RADIO

Fig. 48-11

You can use this circuit in most FM VHF receivers; the hookup is off the FM discriminator. Because every signal transmitted has its own deviation signature, this can be a real plus in hunting jammers.

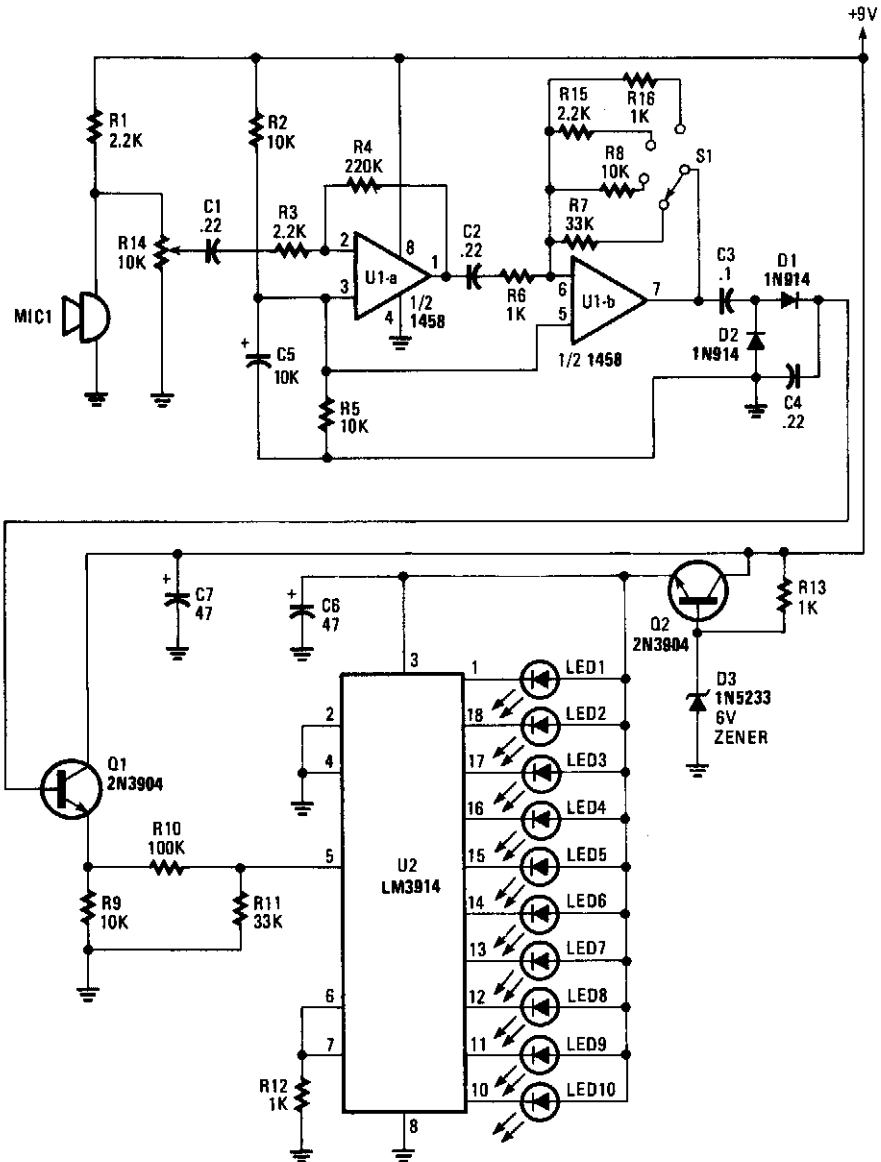
49

Measuring and Test Circuits (Sound)

The sources of the following circuits are contained in the Sources section, which begins on page 670. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sound-Level Meter
Stereo Audio Power Meter
Sound-Level Meter
Noise Generator
Audio Filter Analyzer
Stereo Audio-Level Meter
Mono Audio-Level Meter
Acoustic Sound Transmitter
Acoustic Sound Receiver

SOUND-LEVEL METER

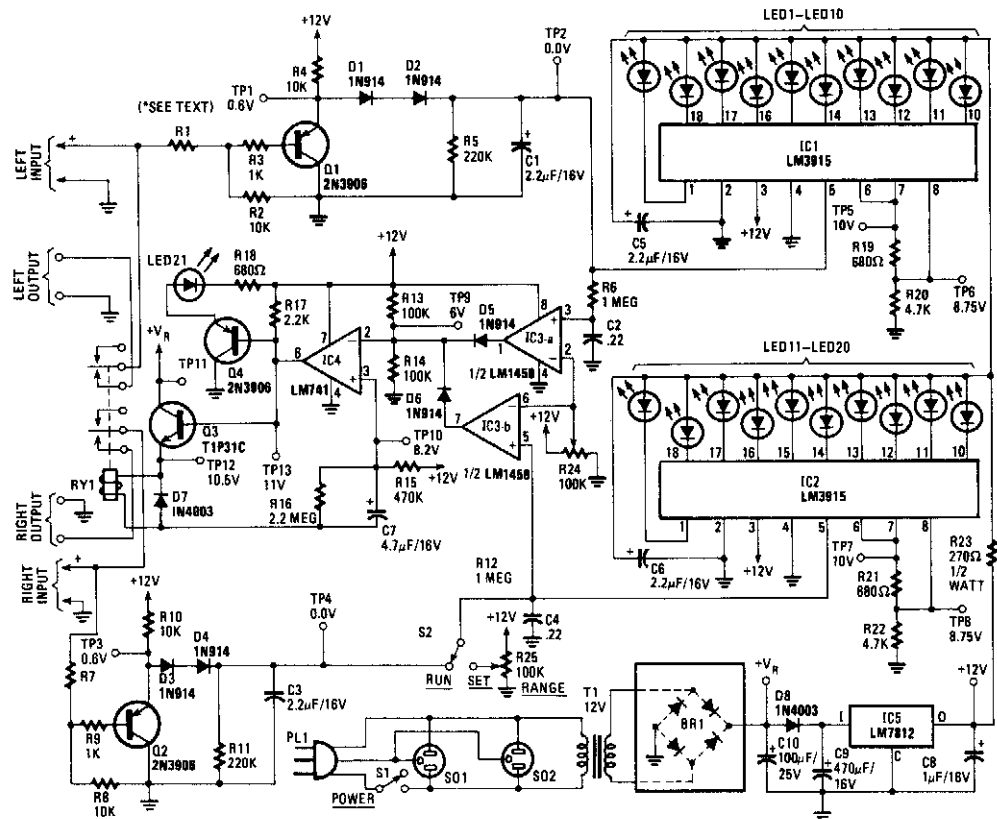


POPULAR ELECTRONICS

Fig. 49-1

An electret microphone feeds an audio amplifier/rectifier combination. The amplifier has switchable gain. The rectifier output drives an LM3914 bar-graph generator. R14 provides fine gain control.

STEREO AUDIO POWER METER



RADIO-ELECTRONICS

Fig. 49-2

Attenuation Resistor Values

Speaker Impedance	50 W	100 W	200 W	400 W	800 W
2 Ω	*	3.9K	10K	18K	30K
4 Ω	3.9K	10K	18K	30K	47K
8 Ω	10K	18K	30K	47K	68K
16 Ω	18K	30K	47K	68K	100K

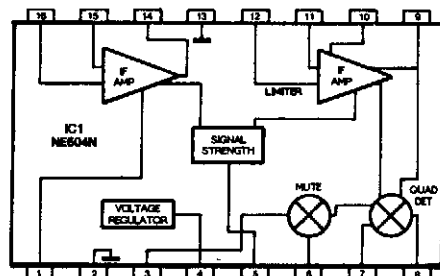
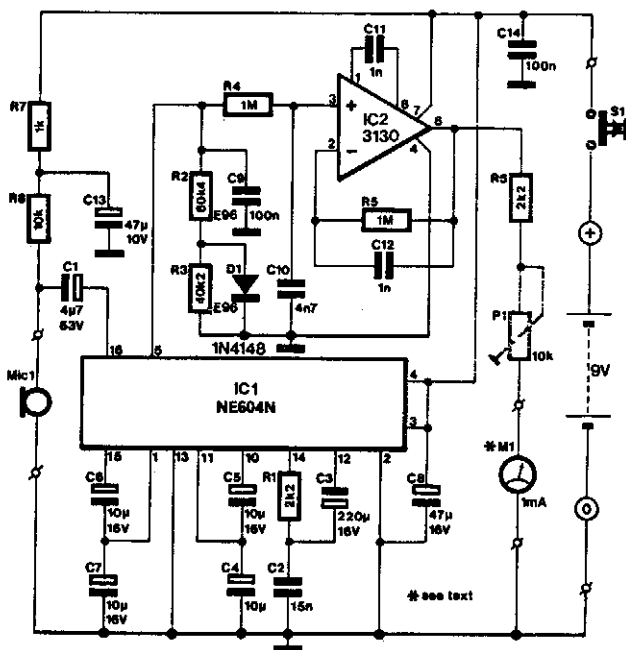
(*To read a maximum power level of 50 W into 2 Ω, R1 and R7 should be replaced by a piece of wire between the appropriate printed circuit board pads.)

Peak Power Displayed

LED	50 W	100 W	200 W	400 W	800 W
1,11	0.1	0.2	0.4	0.8	1.5
2,12	0.2	0.4	0.8	1.5	3
3,13	0.4	0.8	1.5	3	6
4,14	0.8	1.5	3	6	13
5,15	1.5	3	6	13	25
6,16	3	6	13	25	50
7,17	6	13	25	50	100
8,18	13	25	50	100	200
9,19	25	50	100	200	400
10,20	50	100	200	400	800

This circuit is used to meter the audio power output of an amplifier feeding a speaker. RY1 is actuated if excess power is fed to the speaker. Two channels are included for stereo applications. R1 and R2 and R3 form an attenuator. When a signal level is reached that produces a voltage across C1, comparator IC3A goes high, and IC4 and Q4 produce enough drive to Q3 to trip relay 1, which cuts off the speakers. LED21 will light as well. In addition, IC1 reads the voltage across C1. IC1 is a bar-graph driver, which lights bar-graph display LED1 through LED10.

SOUND-LEVEL METER



ELEKTOR ELECTRONICS

Fig. 49-3

The NE604's signal-strength indicator section is used, based on an internal logarithmic converter. This enables a linear decibel scale so that the moving-coil meter (shown in the diagram) can be replaced by a digital instrument.

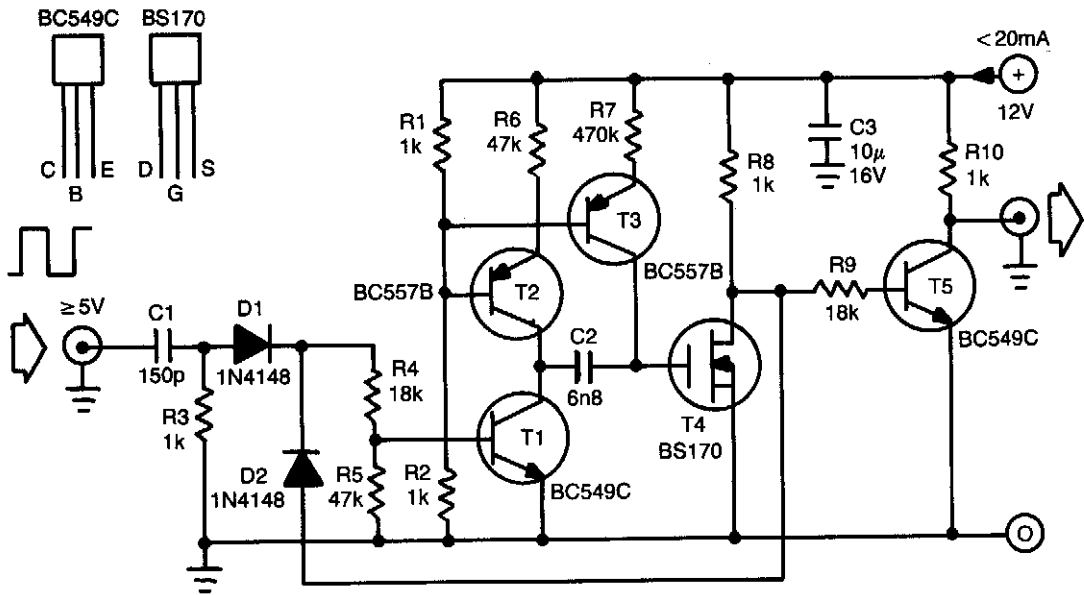
The signal source is assumed to be an electret microphone that converts ambient noise into an electrical signal. Because this type of microphone normally contains a buffer stage, R7, R8, and C13 have been included to provide the supply voltage for this stage.

The NE604 delivers an output current (at pin 5) of 0 to 50 μA , which causes a potential difference across R2 + R3 of 0 to 5 V. The input and output signal range is equivalent to a sound range of 70 dB. To compensate for the effects of temperature changes, the required resistance of 100 k Ω is formed by two resistors (R2 and R3) and a diode (D1).

Any ripple remaining on the output voltage is removed by R4/C9/C10 before the output is buffered by IC2. The indicating instrument, here a moving-coil meter, is connected to the output (pin 6) of IC2 via a series resistance, R₅ + P₁. The preset is adjusted to give full-scale deflection (FSD) for an output voltage of 4 V.

Calibrating the meter is a little tricky, unless you have access to an already calibrated instrument. Otherwise, if you know the efficiency of your loudspeaker, that is, how many decibels for 1 W at 1 m, you can use that as reference. The scale of the meter can then be marked with the (approximate) value. In any case, the meter deflection must at all times be seen as an indication, not as an absolute value: it was not thought to be worthwhile to add a filter to the circuit to enable absolute measurements to be made.

NOISE GENERATOR



ELEKTOR ELECTRONICS

Fig. 49-4

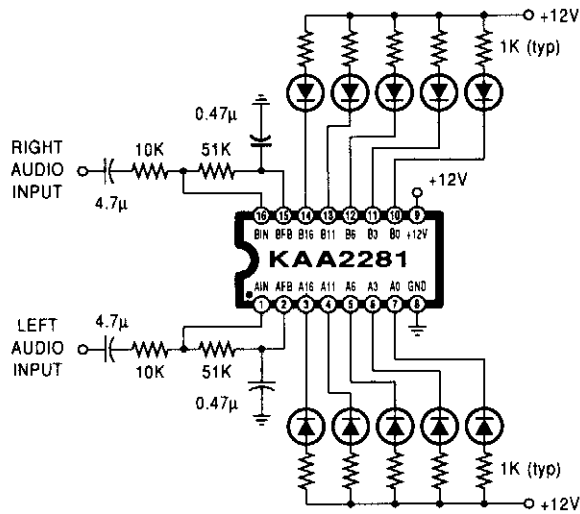
This noise generator provides constant noise energy over its bandwidth, which results from the non-linear behavior of its switching components, more particularly $T4$. It is very useful for measurements where limited noise bands are required. Varying the ratio $R_6:R_7$ and the clock frequency enables the generated noise to be adapted to specific requirements.

Transistors $T2$ and $T3$ are current sources. The current through $T2$ is about 10 times the level of that through $T3$. Assuming that $T4$ is on and that the clock input is low, $T1$ is off, and $C2$ discharges. The capacitor is pulled to about half of the supply voltage by the two current sources. When that state is reached, stability ensues because the potential then present at the gate of $T4$ keeps the FET switched on.

When the clock goes high, $T1$ is switched on so that $C2$ is connected between the gate of $T4$ and the earth. Because $C2$ is only partly charged, the FET is switched off. Transistor $T1$ is kept switched on by OR gate $D1/D2$ so that the clock pulses are blocked. Capacitor $C2$ then charges via $T3$ until the potential across it becomes high enough to switch on $T4$. Transistor $T1$ is then switched off and the circuit is ready to receive another clock pulse (or rather a leading edge of one).

Because it is not known when the clock pulse arrives, it is not known to what potential $C2$ will be discharged by $T2$ (and countered by $T3$). It is therefore also not known when the next clock pulse will arrive. In other words, the pulse width of the output signal is varying constantly, which is characteristic of a noise signal.

STEREO AUDIO-LEVEL METER

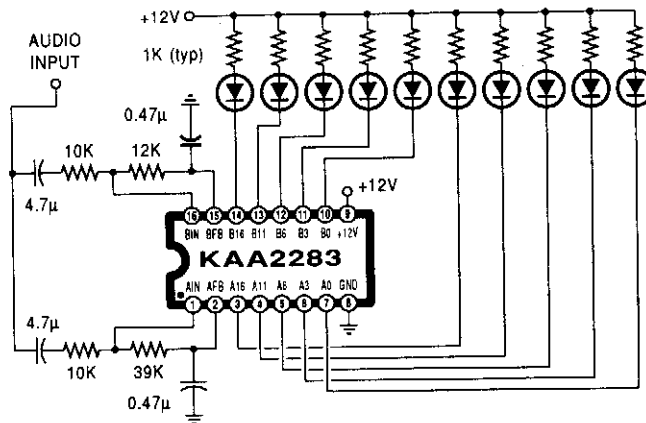


RADIO-ELECTRONICS

Fig. 49-6

A Samsung KAA2281 and a few LEDs make up a simple stereo indicator. Levels displayed are -16 , -11 , -6 , -3 , and 0 dB. Input sensitivity is 1 mV. LEDs can be any suitable types or a bar-graph display.

MONO AUDIO-LEVEL METER



RADIO-ELECTRONICS

Fig. 49-7

This mono indicator uses both halves of a Samsung KAA2283. Levels displayed are -18 to 0 dB in 2 -dB steps. Sensitivity is 0.1 to 0.9 mV.

ACOUSTIC SOUND TRANSMITTER

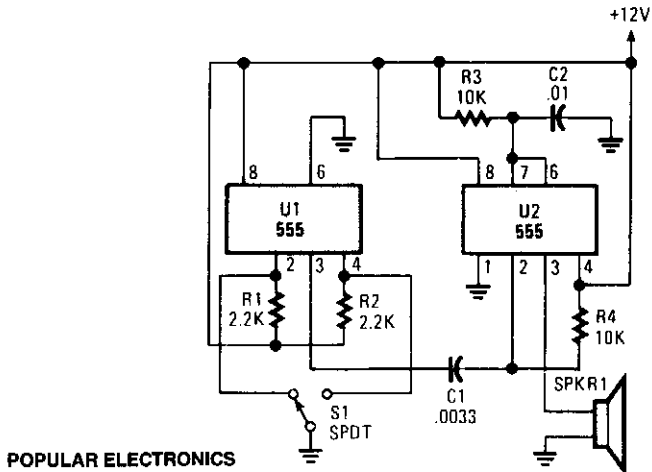


Fig. 49-8

Pulsed sound is produced by this circuit. U1 is used as a bistable multivibrator, which acts as a contact "debouncer" for S1. C1 feeds a trigger pulse to U2, which feeds a pulse to SPKR1, to piezo transducer. Values are shown for a pulse width of 110 μ s.

ACOUSTIC SOUND RECEIVER

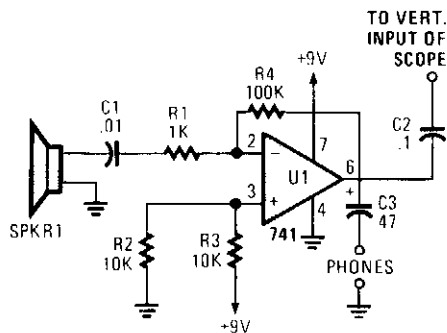


Fig. 49-9

The receiver is an audio amplifier fed by SPKR1, a piezo speaker that is used as a microphone. A scope or headphones can be used as a detector. The scope can be triggered horizontally by the transmitted acoustic pulse; the vertical display can be used to drive the delay time, and hence the distance.

$$\text{distance (feet)} = \frac{\text{delay time (ms)}}{1100}$$

(at 25°C air temperature)

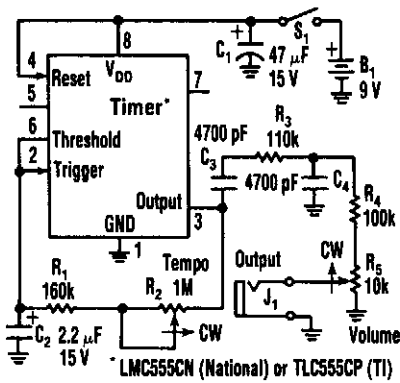
50

Metronomes

The sources of the following circuits are contained in the Sources section, which begins on page 670. The figure number in the box of each circuit correlates to the entry in the Sources section.

Low-Power Metronome
Metronome I
Simple Electronic Metronome
Metronome II
Novel Metronome

LOW-POWER METRONOME

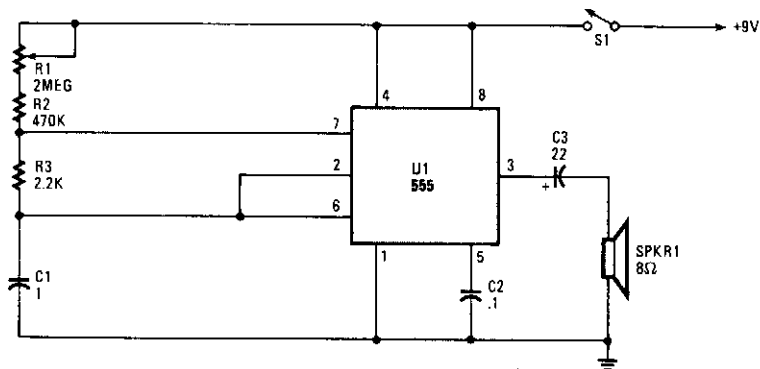


ELECTRONIC DESIGN

Fig. 50-1

Using only 0.25 mA, this metronome is ideal for battery operation. The tempo range is 34 to 246 beats per minute. Use a CMOS timer, such as an LM555 CN or TLC555CP.

METRONOME I

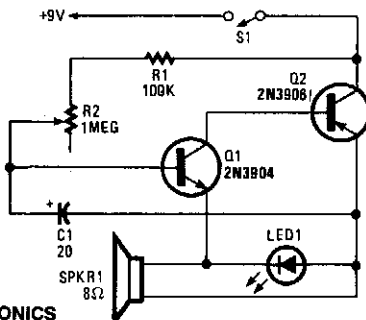


POPULAR ELECTRONICS

Fig. 50-2 .

This simple metronome circuit offers a range of speeds from *largo* to *prestissimo*! The parts values are set so that the repetition rate adjusted by R1 runs from nearly 45 to 184 per minute.

SIMPLE ELECTRONIC METRONOME

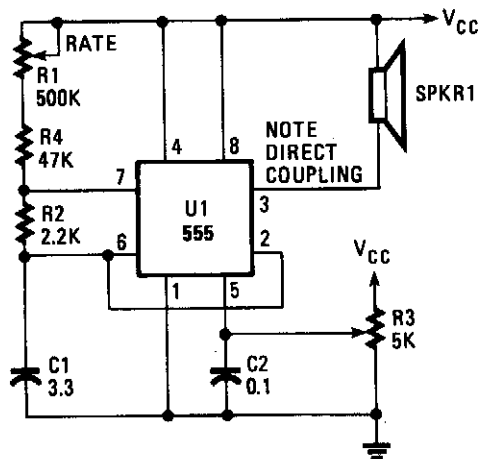


POPULAR ELECTRONICS

Fig. 50-3

Two complementary transistors form a simple oscillator whose frequency range is from about 0.5 to several Hz. This circuit is useful as a metronome, timer, or pacer for exercise equipment.

METRONOME II

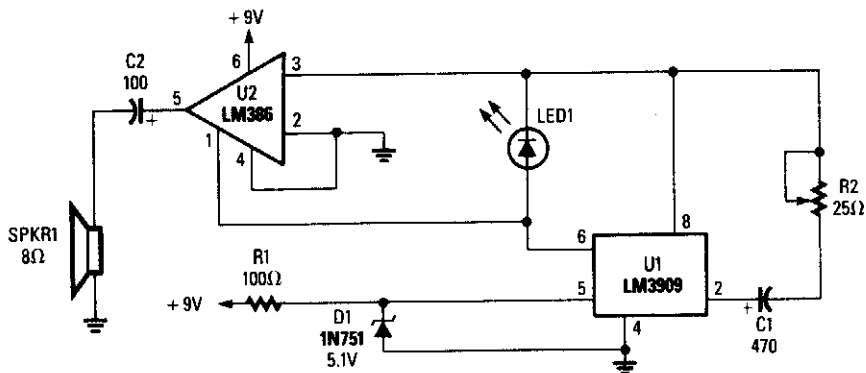


POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 50-4

This electronic metronome, using a 555 oscillator/timer, provides 10 to 40 beats per minute. The frequency is controlled by R3.

NOVEL METRONOME



POPULAR ELECTRONICS

Fig. 50-5

The LM3909 is configured so that the frequency of oscillation is dependent on a single RC timing circuit, which consists of C1 and R2. LED1 discharges capacitor C1 and the resultant pulse is directed into pin 3 as well as pin 1 of the LM386 audio amplifier to externally control that unit, thereby providing adequate volume. The circuit, as it is configured, provides frequency ranges from 57 to 204 beats per minute, and plenty of volume.

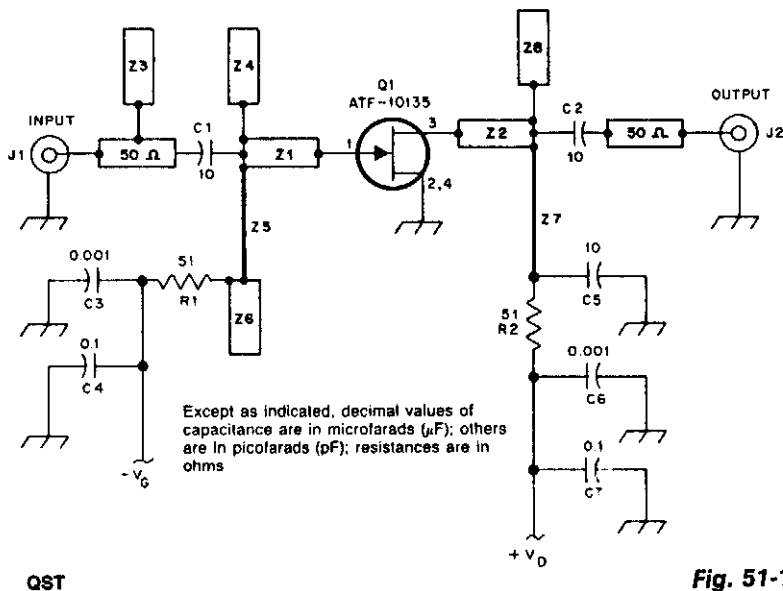
51

Microwave Amplifier Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 671. The figure number in the box of each circuit correlates to the entry in the Sources section.

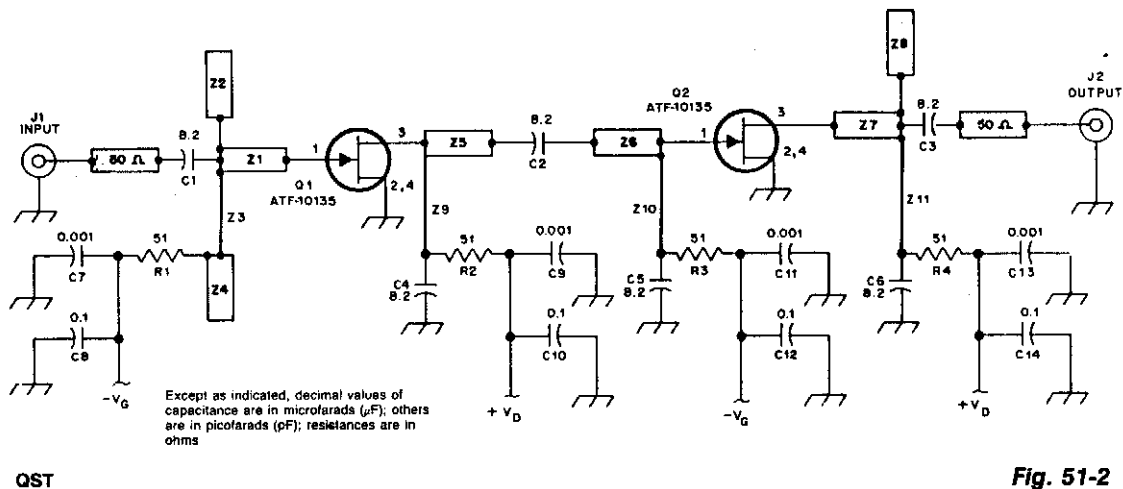
2.3-GHz Microwave Preamp
3.4-GHz Microwave Preamp
5.7-GHz Microwave Preamp
10-GHz Single-Stage Preamp
Bias Supply for Microwave Preamps
10-GHz 2-Stage Preamp

2.3-GHz MICROWAVE PREAMP



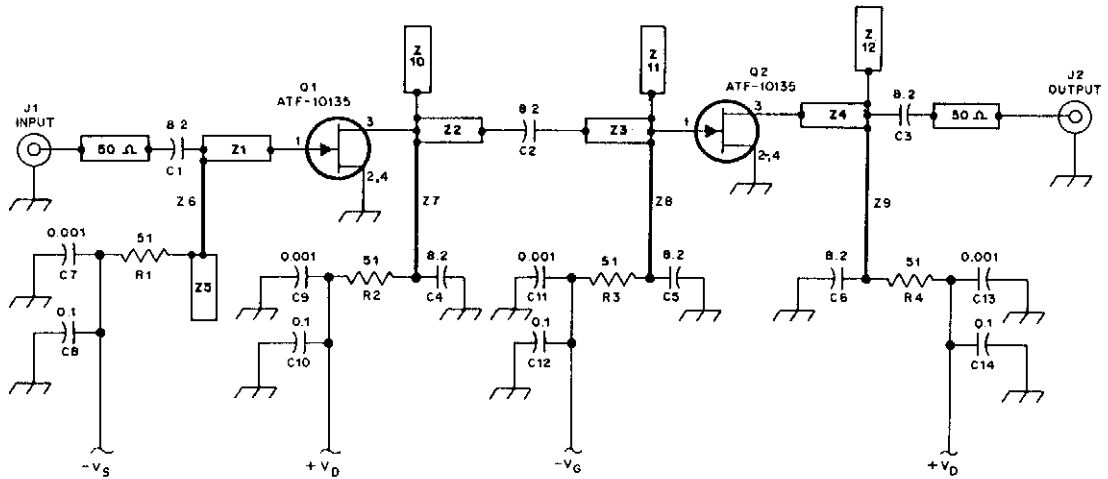
This low-noise amplifier requires no tuning, has a gain of 13 dB, and a typical NF of 0.6 dB at 2.3 GHz.

3.4-GHz MICROWAVE PREAMP



At 3.45 GHz, this 2-stage preamp has a gain of 23 dB (typical) and less than 1 dB NF.

5.7-GHz MICROWAVE AMPLIFIER



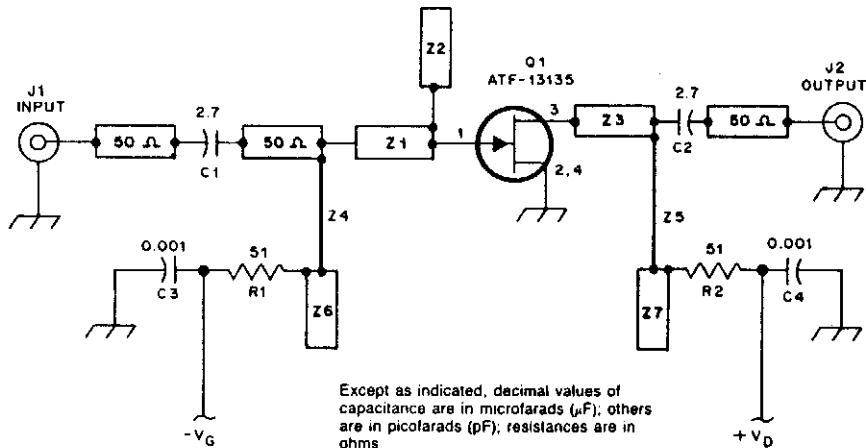
Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.

QST

Fig. 51-3

This preamplifier has a typical gain of 17 dB and $\text{NF} = 1.2$ dB or better. If a 0.031" PC board (with a dielectric constant of 2.2) is used, the reverse side is unetched.

10-GHz SINGLE-STAGE PREAMP



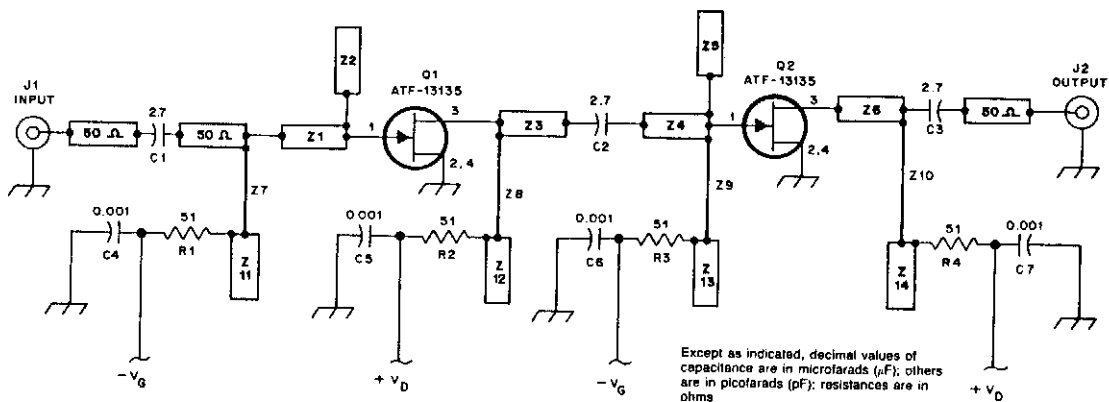
Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.

QST

Fig. 51-4

Using a single Avantek ATF 13135 GASFET, this preamplifier has 8-dB gain (typically) and 1.7-dB noise figure. The PC board is 0.031", doublesided, with $E = 2.2$.

10-GHz 2-STAGE PREAMP



QST

Fig. 51-6

This preamp uses two ATF 13135 stages for typically 17-dB gain and less than 2 dB NF.

52

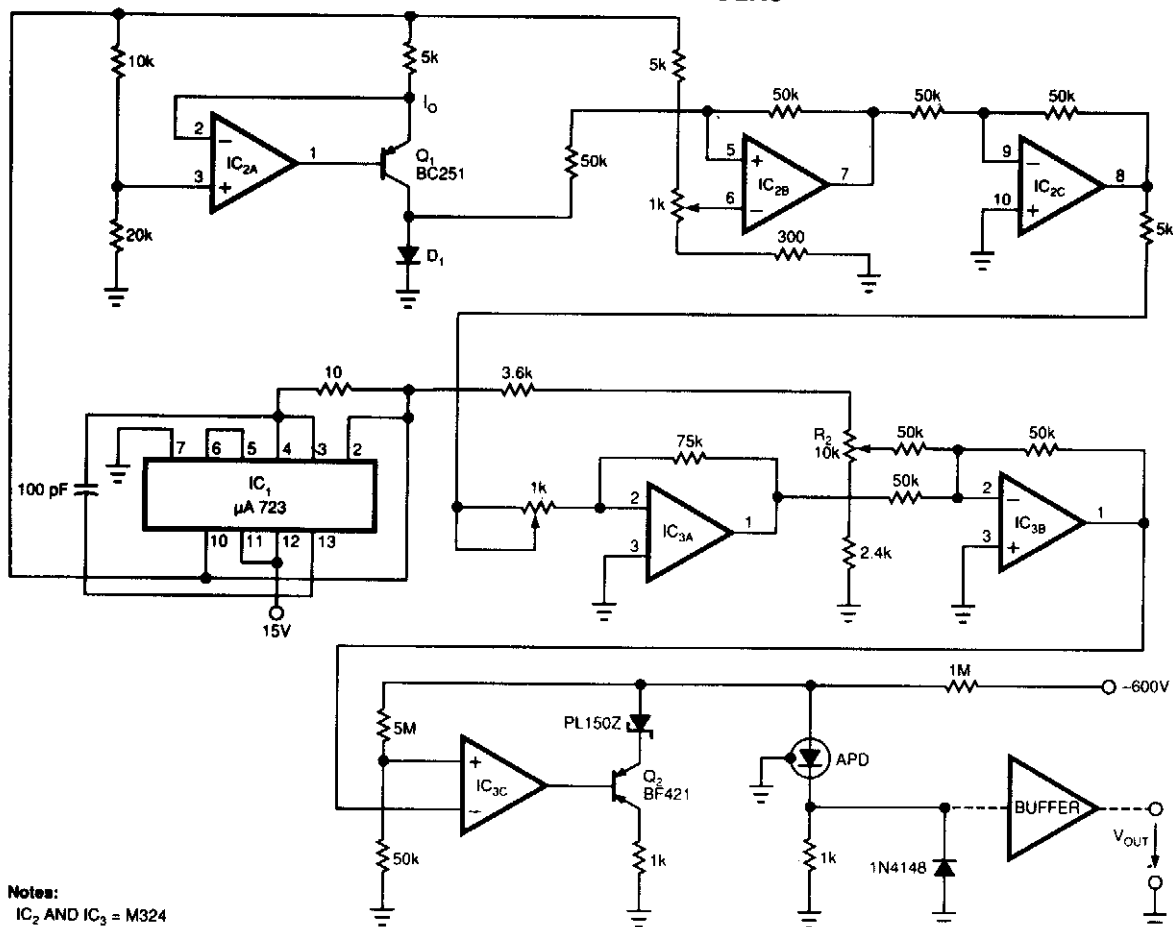
Miscellaneous Treasures

The sources of the following circuits are contained in the Sources section, which begins on page 671. The figure number in the box of each circuit correlates to the entry in the Sources section.

Diode Sensor for Lasers
RF Attenuator
SSB Generators
Sonic Defender
GASFET Frequency Doubler
Low-Frequency Multiplier
Precision Half-Wave Rectifier
Pulse-Width Modulator

Programmable Identifier
Variable-Voltage Reference Source
0-to 200-nA Current Source
Long-Line *IR* Drop-Voltage Recovery
Precision Full-Wave Rectifier
Fast Symmetrical Zener Clipper
Electronic Level

DIODE SENSOR FOR LASERS



Notes:
 IC₂ AND IC₃ = M324

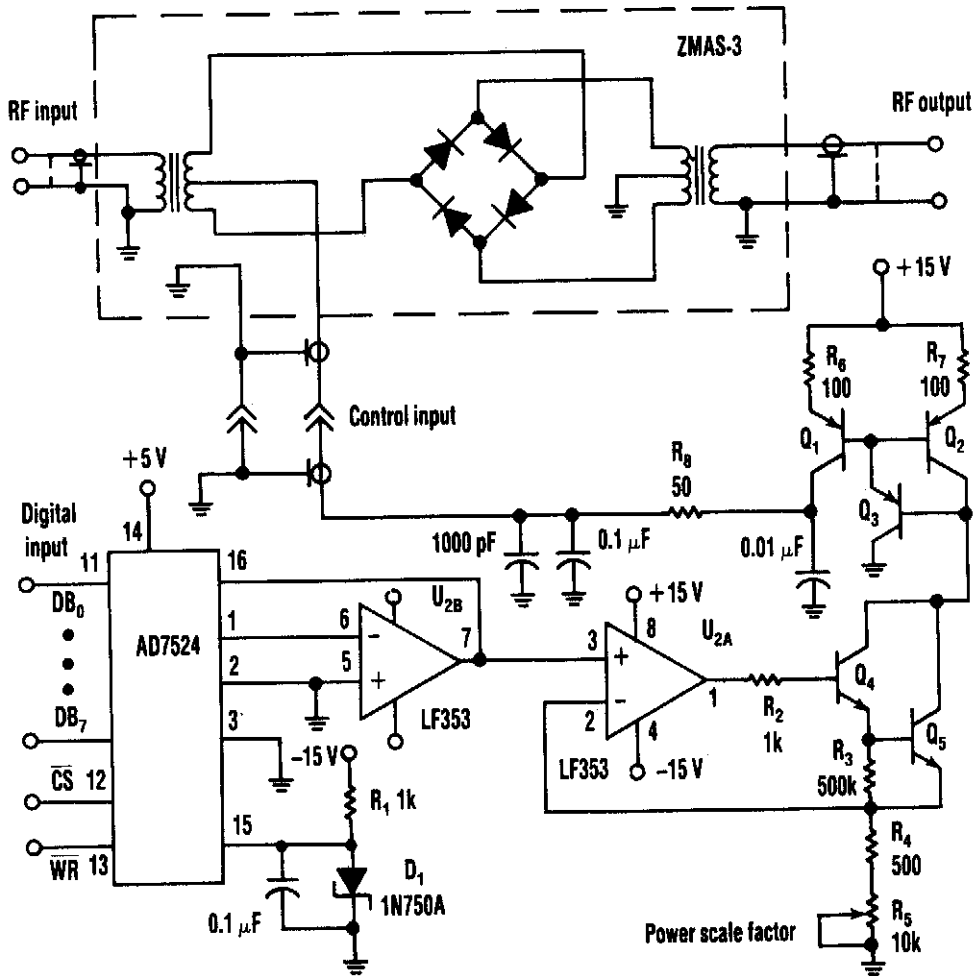
EDN

Fig. 52-1

Laser-receiver circuits must bias their avalanche photo diodes (APD) to achieve optimal gain. Unfortunately, an APD's gain depends on the operating temperature. The circuit controls the operating voltage of an APD over a large temperature range to maintain the gain at the optimal value. The circuit uses D1 as a temperature sensor, thermally matched with the APD.

A voltage regulator, IC1, supplies the necessary reference voltage to the circuit. IC2A and Q1 bias D1 at a constant current. IC2B, IC2C, IC3A/IC3B, and IC3C amplify D1's varying voltage and set Q2 to the optimal-gain corresponding value. Potentiometer R1 controls the amplification over a range of 5 to 15. R2 controls the voltage level, which corresponds to the optimal gain of the APD at 22°C (the temperature is specific to the type of APD). The circuit shown was tested with an RCA C 30954E APD. The tests covered -40 to +70°C and used a semiconductor laser. The laser radiation was transmuted on the APD's active surface in the climatic room via fiberoptic cable. The gain varied by, at most, ±0.2 dB over the entire temperature range.

RF ATTENUATOR

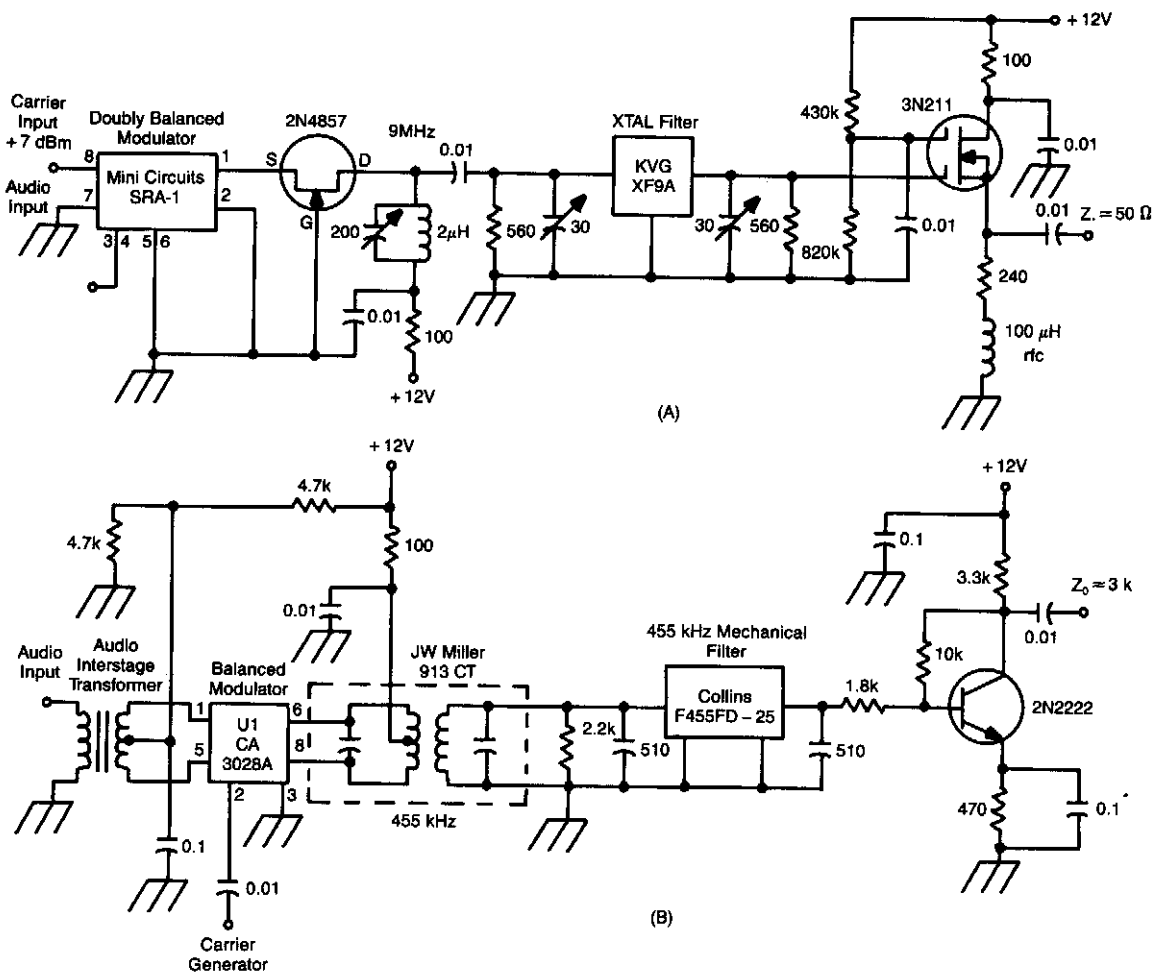


ELECTRONIC DESIGN

Fig. 52-2

A balanced mixer is used as a control element in this circuit. An Analog Devices AD7524 D/A converter drives a voltage-controlled current source using two LF353s and several transistors to control the balanced mixer, a Mini Circuits Lab Z MAS-3.

SSB GENERATORS

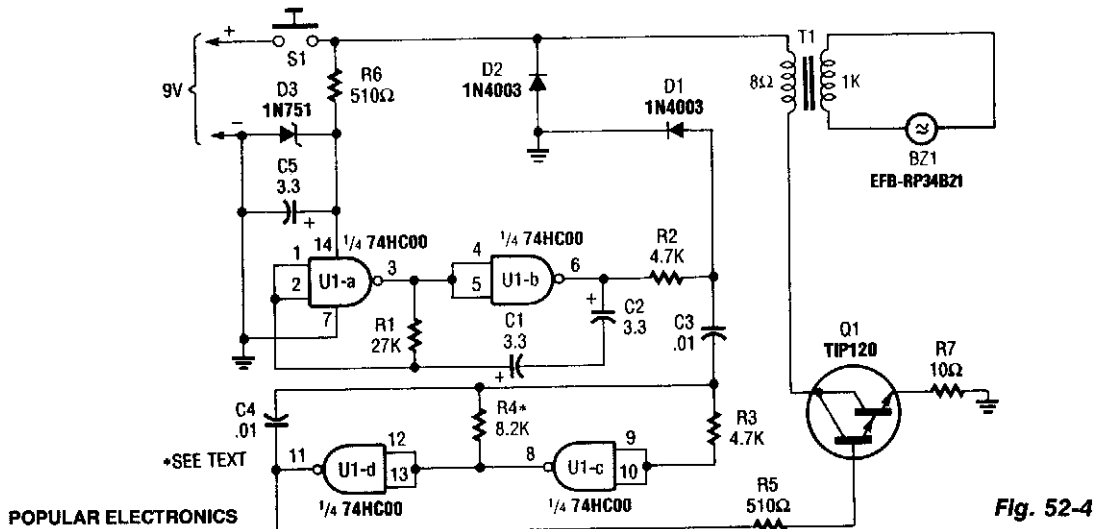


ARRL HANDBOOK

Fig. 52-3

These two circuits are SSB generators. One uses a crystal filter by KVG Electronics at 9 MHz, the other uses a 455-kHz mechanical filter. By feeding the outputs into a mixer, the frequency of the SSB generator can be converted to other frequencies. Keep signal levels low enough so that distortion does not occur.

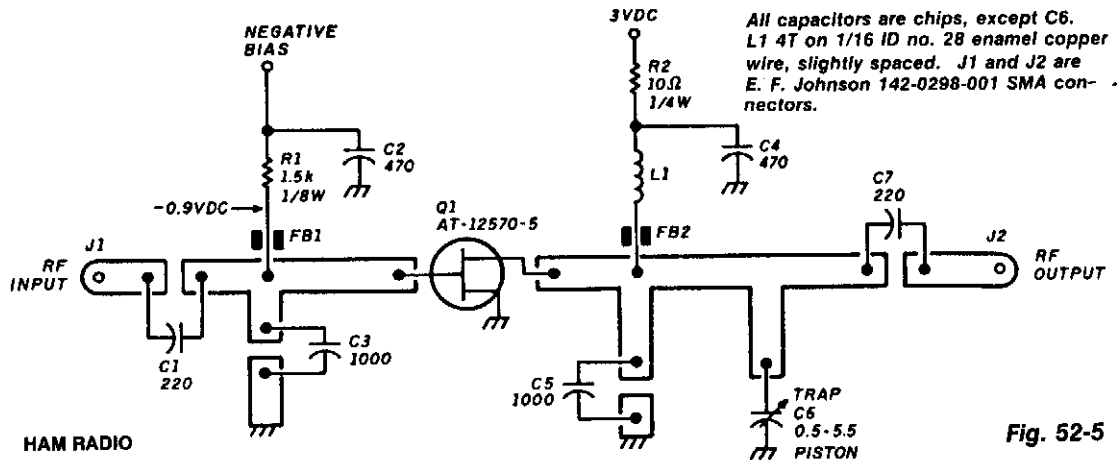
SONIC DEFENDER



This oscillator-driver produces a deafening sound of about 3 kHz, modulated with a 10-Hz warble. BZ1 is a Matsushita EFB-RP34BZ. U1A and B generate the 10-Hz waveform that modulates the 3-kHz tone that is generated by U1C and D. Q1 drives the transducer through a 8-Ω:1-kΩ transformer. R4 might require slight changes (± 1 kΩ) to optimize sound intensity.

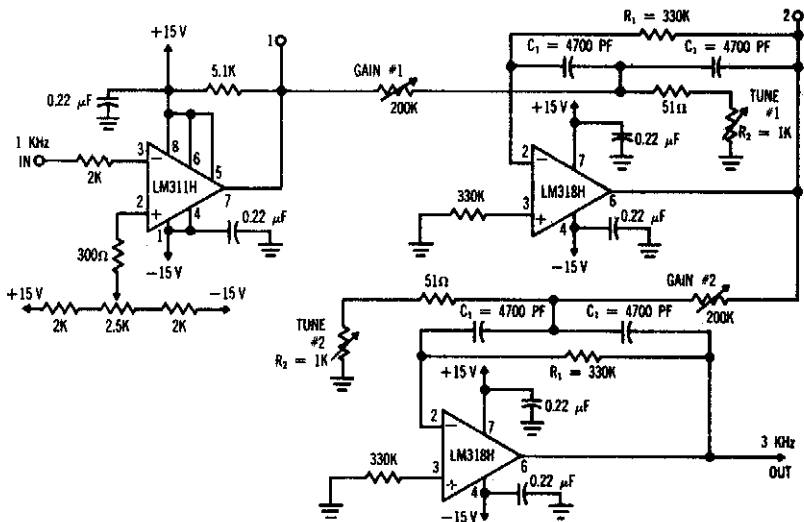
Warning: Could cause hearing loss if improperly used.

GASFET FREQUENCY DOUBLER



This circuit will produce over +10 dBm in the 1 800-3 000-MHz range. Drive power is 7 dBm in the 900-to-1 500-MHz range. The PC board is G-10 Epoxy doublesided. Artwork is shown above, as well as parts placement connectors suitable for these frequencies (such as SMA) should be used. A negative bias supply of 0 to 3 V is required.

LOW-FREQUENCY MULTIPLIER

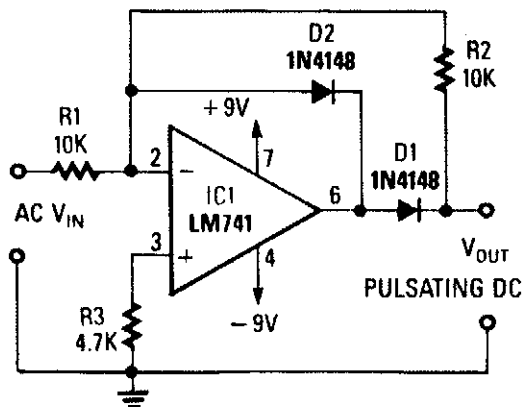


ELECTRONIC DESIGN

Fig. 52-6

This circuit uses a comparator as a Schmitt trigger (311H) and two active bandpass filters (LM318H). 3-kHz output is obtained. Higher harmonics (preferably odd) can be obtained by tuning the active filters to the desired frequency. N can be 1, 3, 5, 7, 9, etc. Even harmonics can be produced by substituting a full-wave rectifier or absolute-value circuit for the Schmitt-trigger comparator.

PRECISION HALF-WAVE RECTIFIER

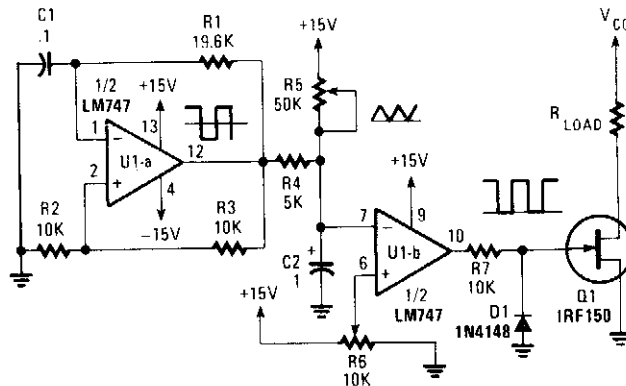


RADIO-ELECTRONICS

Fig. 52-7

An ac input voltage will cause an output that is a half-wave rectified version of the input voltage.

PULSE-WIDTH MODULATOR



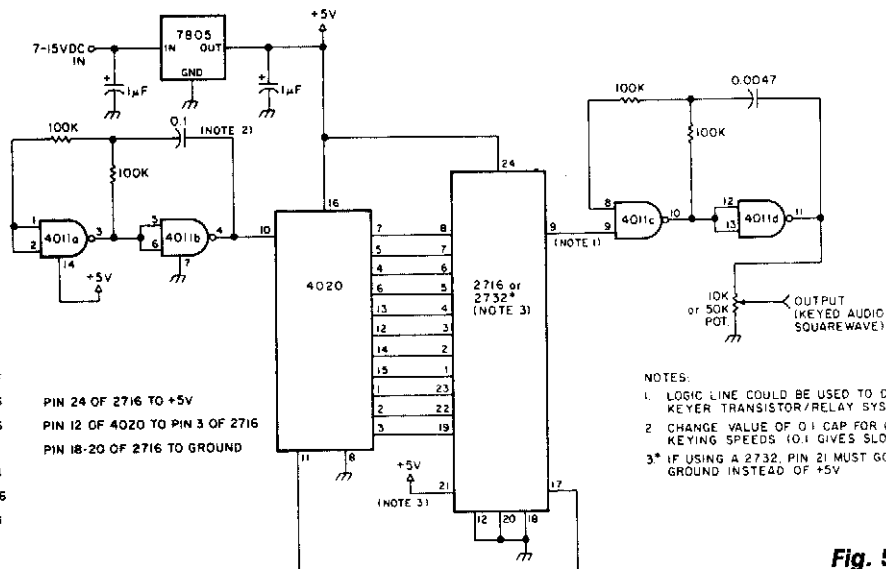
POPULAR ELECTRONICS

Fig. 52-8

This circuit allows the effective power in a load to be controlled by varying the duty cycle of the on/off ratio of load current. No power is dissipated in the switching circuit.

U1A generates a bipolar square wave that is integrated into a triangle by R4 and C2. Reference voltage from R6 is fed to a comparator. The triangle wave on C2 goes to the comparator as well. By varying the reference voltage (R6), the output waveform is a variable width pulse, that drives Q1. R6 controls on/off ratio and therefore load power. R5 sets the offset of the triangle wave across C2.

PROGRAMMABLE IDENTIFIER



FOLLOWING JUMPERS REQUIRED:

- PIN 4 OF 4020 TO PIN 6 OF 2716
- PIN 5 OF 4020 TO PIN 7 OF 2716
- PIN 7 OF 4020 TO GROUND
- PIN 10 OF 4020 TO PIN 4 OF 4011
- PIN 11 OF 4020 TO PIN 17 OF 2716
- PIN 9 OF 2716 TO PIN 9 OF 4011

- PIN 24 OF 2716 TO +5V
- PIN 12 OF 4020 TO PIN 3 OF 2716
- PIN 18-20 OF 2716 TO GROUND

NOTES:

1. LOGIC LINE COULD BE USED TO DRIVER KEYS TRANSISTOR/RELAY SYSTEM.
2. CHANGE VALUE OF 0.1 CAP FOR OTHER KEYING SPEEDS (0.1 GIVES SLOW CW)
- 3* IF USING A 2732, PIN 21 MUST GO TO GROUND INSTEAD OF +5V

73 AMATEUR RADIO

Fig. 52-9

Used on an amateur or experimental radio beacon, the above ID circuit will generate any callsign or message programmed into the EPROM. A CD4020 CMOS counter is driven by an RC clock circuit. This addresses the EPROM, and serial data is available at pin 9.

VARIABLE-VOLTAGE REFERENCE SOURCE

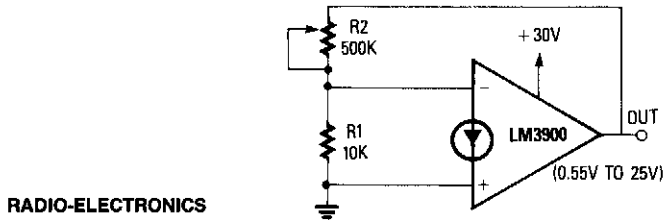


Fig. 52-10

The noninverting terminal of the op amp is grounded, and the circuit uses the voltage at the inverting terminal as a reference. Its voltage gain is determined by the R_2/R_1 ratio. When R_2 is set at zero, the circuit has unity gain and a 0.55-V output. When R_2 is set to the maximum value, the circuit has a gain of 50 and an output of about 25 V. The circuit provides good regulation and can supply output currents of several milliamps. The output voltage however, is not temperature compensated.

0-TO-200-nA CURRENT SOURCE

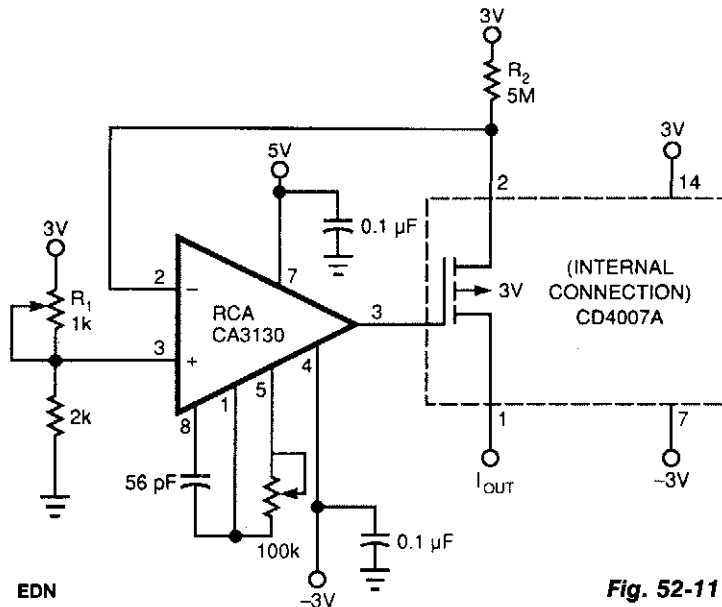


Fig. 52-11

This circuit uses readily available parts to implement a 0-to-200-nA current source. The circuit borrows a PMOS transistor from the input stage of a DC4007A, which is easier to obtain than a discrete PMOS transistor. The CA3130 op amp operates as a follower so that its positive input sets the current that flows through R_2 . The MOSFET input stage of this op amp exhibits low-input current. The op amp must be able to produce an output voltage high enough to turn the CD4007A's internal FET off. Thus, the op amp requires a positive supply voltage of 5 V. The circuit presents an output voltage from 0 to 3 V, and R_1 controls the amount of output current.

LONG-LINE I_R DROP-VOLTAGE RECOVERY

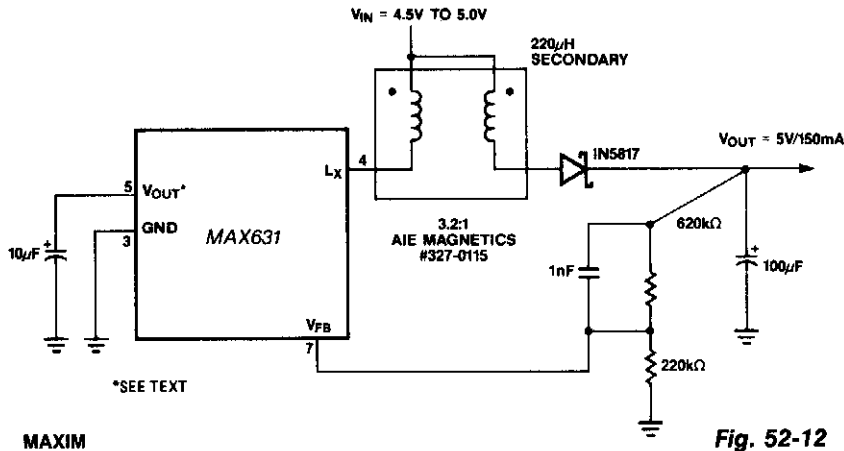


Fig. 52-12

This circuit provides a unique solution to a common system-level power distribution problem: When the supply voltage to a remote board must traverse a long cable, the voltage at the end of the line sometimes drops to unacceptable levels. This +5-V/+5-V converter addresses this by taking the reduced voltage at the end of the supply line and boosting it back to +5 V. This can be especially useful in remote display devices, such as some point-of-sale (POS) terminals, where several meters of cable could separate the terminal from the readout.

PRECISION FULL-WAVE RECTIFIER

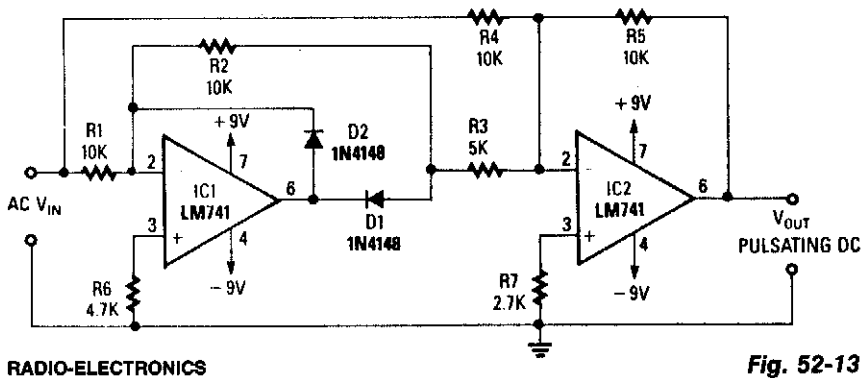
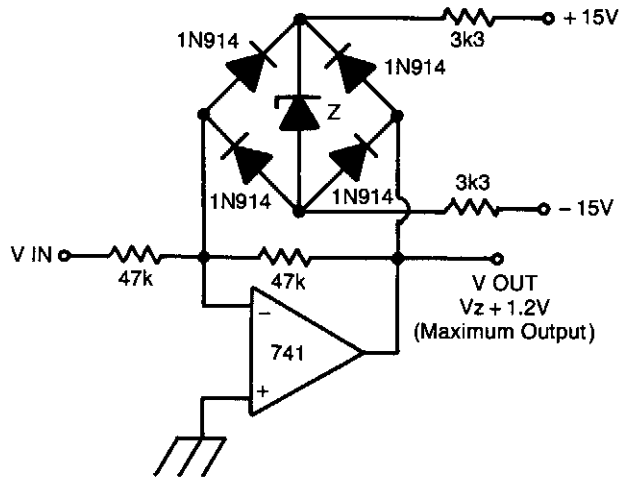


Fig. 52-13

Using two op amps, this circuit produces a full-wave rectified version of the input signal. Op amp IC1 inverts the negative-going signal, but because of D2, it stays near zero. IC2 produces a positive-going signal. For positive-going signals, IC1 produces a negative output through D1 to IC2, where it is combined with positive V_{IN} from R4/R5. At the summing junction of IC2, the negative output of IC1 is doubled and inverted via IC2, R3, and R5 to produce $+V_{OUT}$. This is summed with negative output of IC1 to produce $+V_{OUT}$.

FAST SYMMETRICAL ZENER CLIPPER



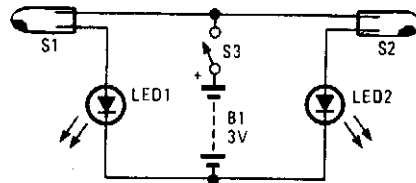
ELECTRONICS TODAY INTERNATIONAL

Fig. 52-14

The problem with using two zeners back to back in series to get symmetrical clamping is that the knee of the zener characteristics is rather sloppy. Also, charge storage in the zeners causes speed problems and the zeners will have slightly different knee voltages, so the symmetry will not be all that good. This circuit overcomes these problems.

By putting the zener inside a diode bridge, the same zener voltage is always experienced. The voltage errors caused by the diodes are much smaller than those caused by the zener. Also, the charge storage of the bridge is much less. By biasing the zener ON all the time, the knee appears to be much sharper.

ELECTRONIC LEVEL



POPULAR ELECTRONICS

Fig. 52-15

An electronic level can be constructed using two mercury switches mounted on an absolutely flat board, along with the LEDs. If one LED lights, the surface is not level. If both light, the surface is level.

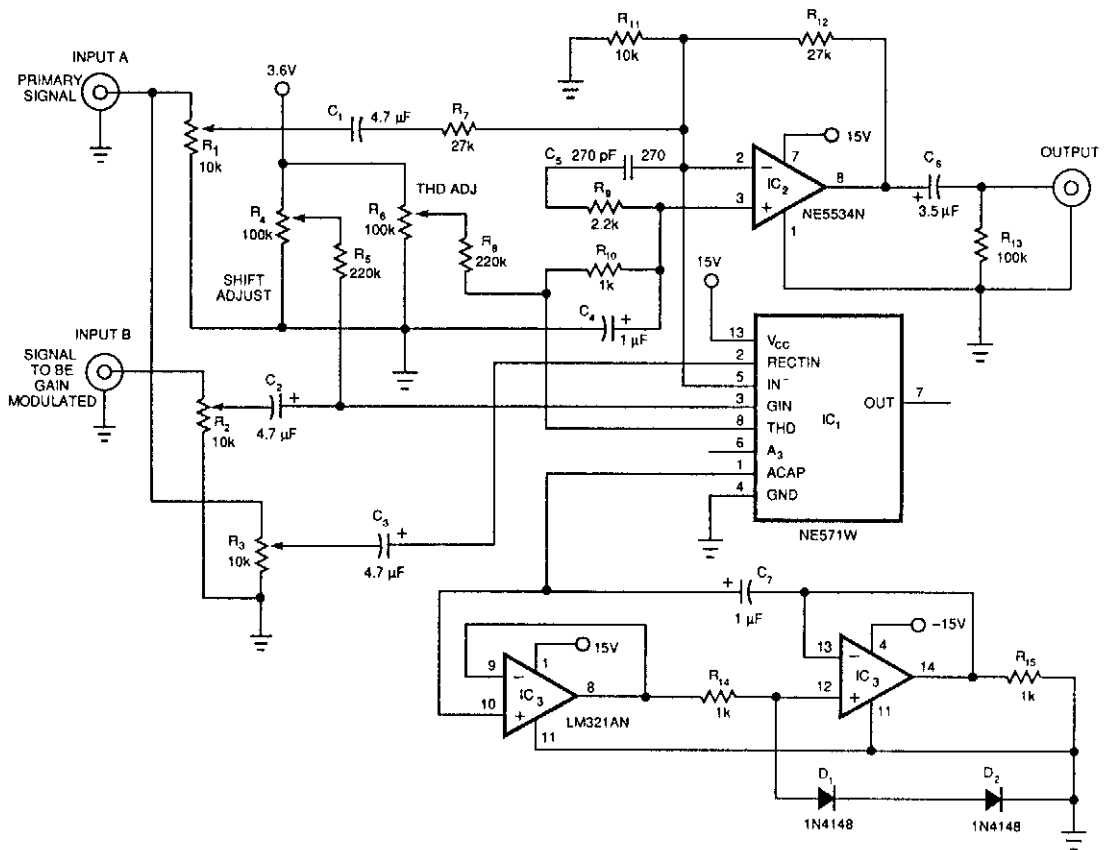
53

Mixers

The sources of the following circuits are contained in the Sources section, which begins on page 671. The figure number in the box of each circuit correlates to the entry in the Sources section.

Dynamic Audio Mixer
Stereo Mixer with Pan Controls
4-Channel Mixer
Digital Mixer
4-Input Unity-Gain Mixer
Audio Mixer
Mixer Diplexer
Simple Utility Mixer

DYNAMIC AUDIO MIXER



EDN

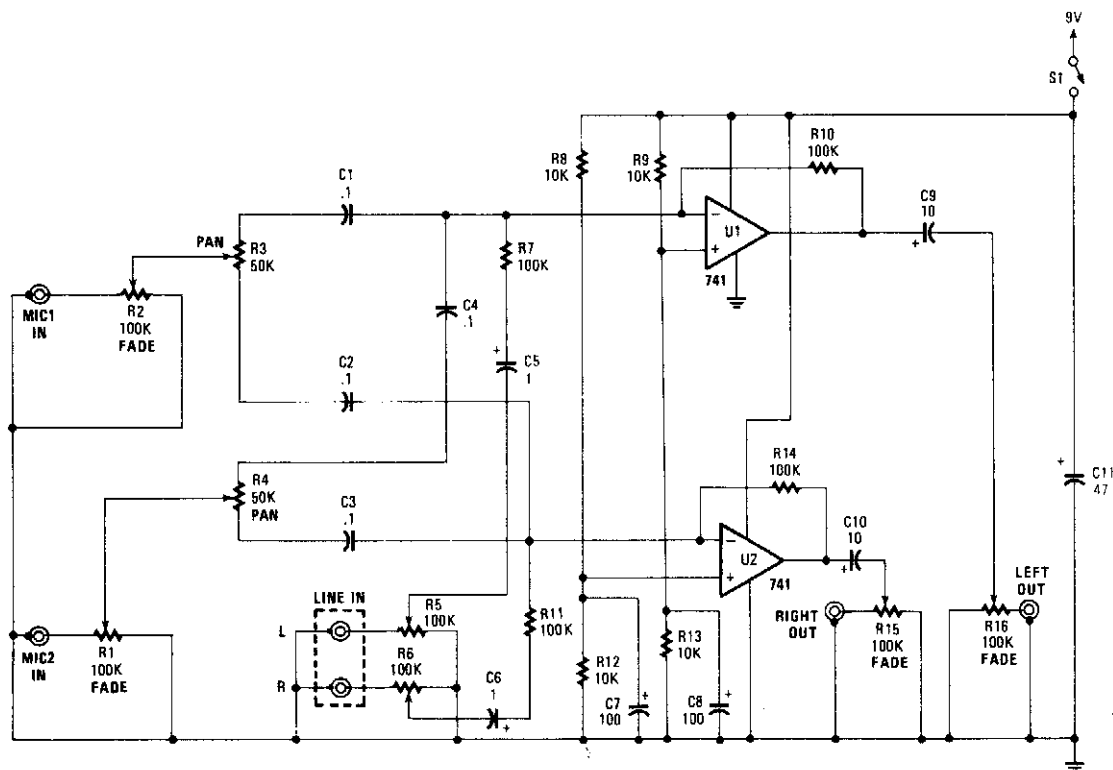
Fig. 53-1

The dynamic mixer combines two audio inputs by adding the primary signal, Input A, to a gain-controlled signal, Input B. The unusual aspect of this circuit is that the average voltage level of Input A controls the gain of Input B.

IC1 has the averaging function and many of the specialized gain blocks that the circuit requires. R1 sets the level of the primary input, Input A, to be passed to the output. R2 governs Input B's level to the modulator, while R3 sets the level of the modulating signal. IC1 can be either an NE571N or an NE570N. The average ac signal at pin 2 controls the amount of signal that shows up at IC1's output, pin 3.

The primary signal gets to IC2, an NE5534N low-noise op amp, via C1 and R7; the gain-modulated secondary signal arrives via pin 5 of IC1. IC2 sums the two signals. Potentiometers R4 and R6 make dc-offset and distortion adjustments, respectively. IC3, C7, R14, R15, D1, and D2 form a filter for IC1.

STEREO MIXER WITH PAN CONTROLS

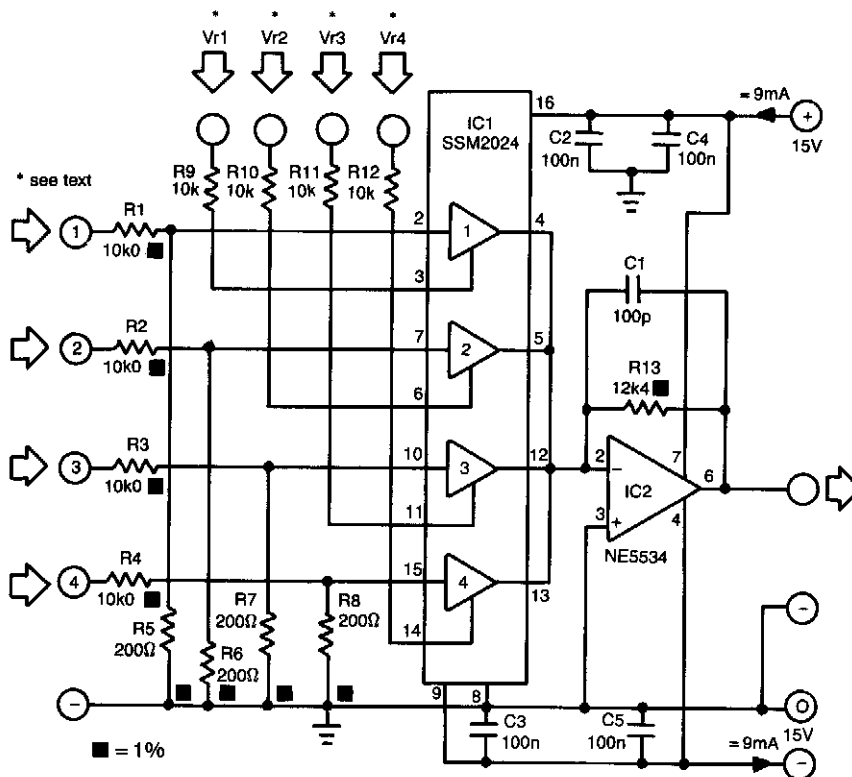


POPULAR ELECTRONICS

Fig. 53-2

This stereo mixer has two mono mixers and a modification to the microphone inputs. When a microphone is in use, the microphone's output is fed to the microphone input of the circuit. The signal is then run into R1 and R2 (which are used as faders). The signal is then split into two different paths by resistors R3 and R4, with which it is possible to change the place of the microphone inputs within the stereo panorama. The stereo line inputs are for that purpose. Joining the microphone inputs with the output of some other source (such as a tape deck, turntable, etc.), all the signals are fed to the inverting input of an op amp. The output reaches the master-fade potentiometers, which control output level.

4-CHANNEL MIXER



ELEKTOR ELECTRONICS

Fig. 53-3

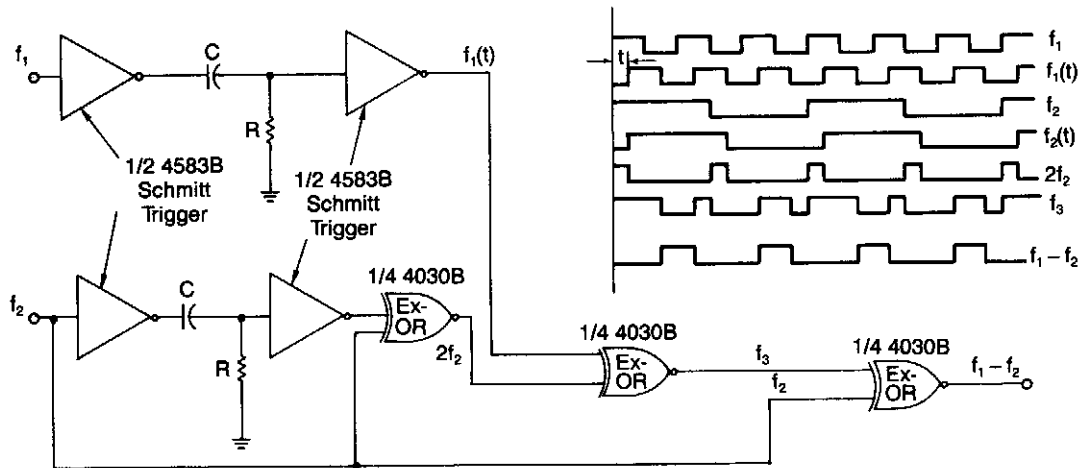
The proposed mixer is designed around four current-driven transconductance amplifiers contained in an SSM2024 from Precision Monolithics. To obtain a low offset and high control rejection, the four inputs should have an impedance to earth of about $200\ \Omega$. These impedances are obtained from resistors R5 through R8, which also form part of a potential divider at each input.

With the values in the diagram, the nominal input signal is $1\ \text{V}$ (0 dBV). Distortion at that level is about 1%; at lower levels, it is not more than 0.3%.

The amplification of the current-driven amplifiers (CDAs) is determined by the current fed into the control inputs. These inputs form a virtual earth so that calculating the values of the bias resistors (to transform the inputs into voltage-driven inputs) is fairly simple.

The output currents of the amplifier are summed by simply linking the output pins. The current-to-voltage converter, IC2, translates the combined output currents into an output voltage. The value of R13 ensures that the amplification of IC2 is unity.

DIGITAL MIXER



ELECTRONIC DESIGN

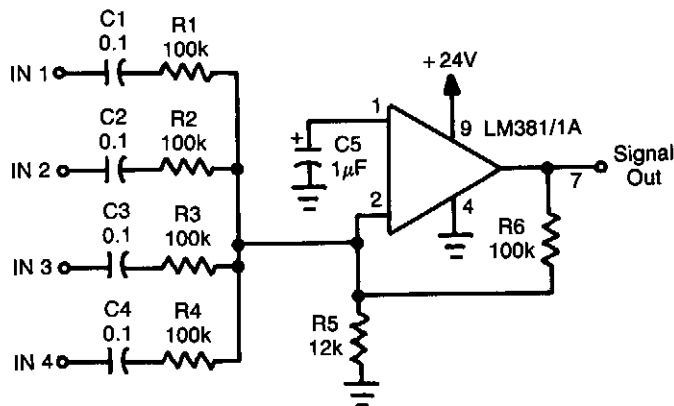
Fig. 53-4

A simple digital mixer, based on two dual-Schmitt triggers (4583B) and three exclusive-OR gates, uses an RC time-delay circuit to permit easy adjustment of the output-signal pulse width. The exclusive-OR gates can also be used separately as a symmetrical frequency doubler.

As shown, a signal passing through the Schmitt triggers is delayed by t , a value equal to $RC \ln(V_{tp}/V_{tn})$, where V_{tp} and V_{tn} are the positive and negative threshold voltages of the triggers.

To function properly, the same time delay must be introduced to signals f_1 and f_2 . Also, the time delay must be less than 50% of the period of f_1 . Provided that f_1 is more than twice the value of f_2 , the output of the circuit will equal the difference of the two signals (i.e., $f_1 - f_2$).

4-INPUT UNITY-GAIN MIXER

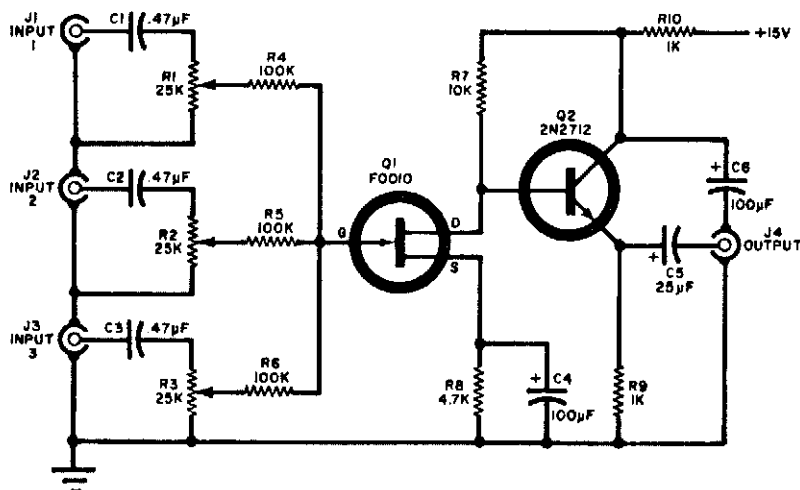


RADIO-ELECTRONICS

Fig. 53-5

An LM381/1A is used as a four-input unity-gain audio mixer. Gain can be increased by decreasing R_1 through R_4 or increasing R_6 .

AUDIO MIXER

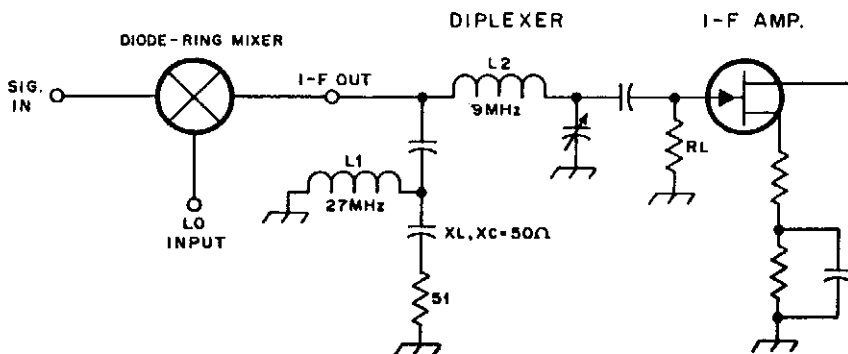


POPULAR ELECTRONICS

Fig. 53-6

Three audio circuits are combined in the circuit shown. Each input is coupled to its own level potentiometer (R1, R2, or R3) and they are combined at the gate of FET Q1. The output of Q1 is coupled to the external audio amplifier through emitter-follower Q2 and capacitor C6.

MIXER DIPLEXER

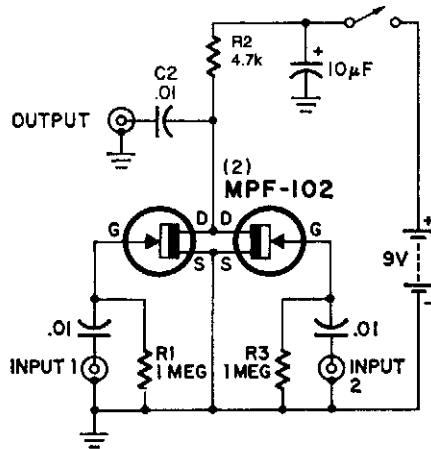


ARRL HANDBOOK

Fig. 53-7

By inserting a high-pass filter section in the IF lead, this mixer is terminated at all frequencies, besides the IF, for other mixer products, which results in improved IMD. In this example, high-pass filter section L1 and capacitors cut off below 28 MHz. Above this frequency, the mixer is terminated.

SIMPLE UTILITY MIXER



RADIO-ELECTRONICS

Fig. 53-8

Here's an interesting mixer circuit. With it you can effectively combine signals from audio to high-frequency RF. Also, as a special bonus, this circuit will provide some gain at a low noise figure. The inputs can be of almost any level or impedance, and the output (low-Z) will drive most tuned circuits or transistors.

Basically, the device consists of two similar FET amplifier stages with a common load resistor (R₂). Each FET develops a signal across this resistor, a form of cancellation occurs, and a difference signal results.

If you want less gain, try reducing R₂ to 2 200-Ω. This modification will not affect the mixing ability.

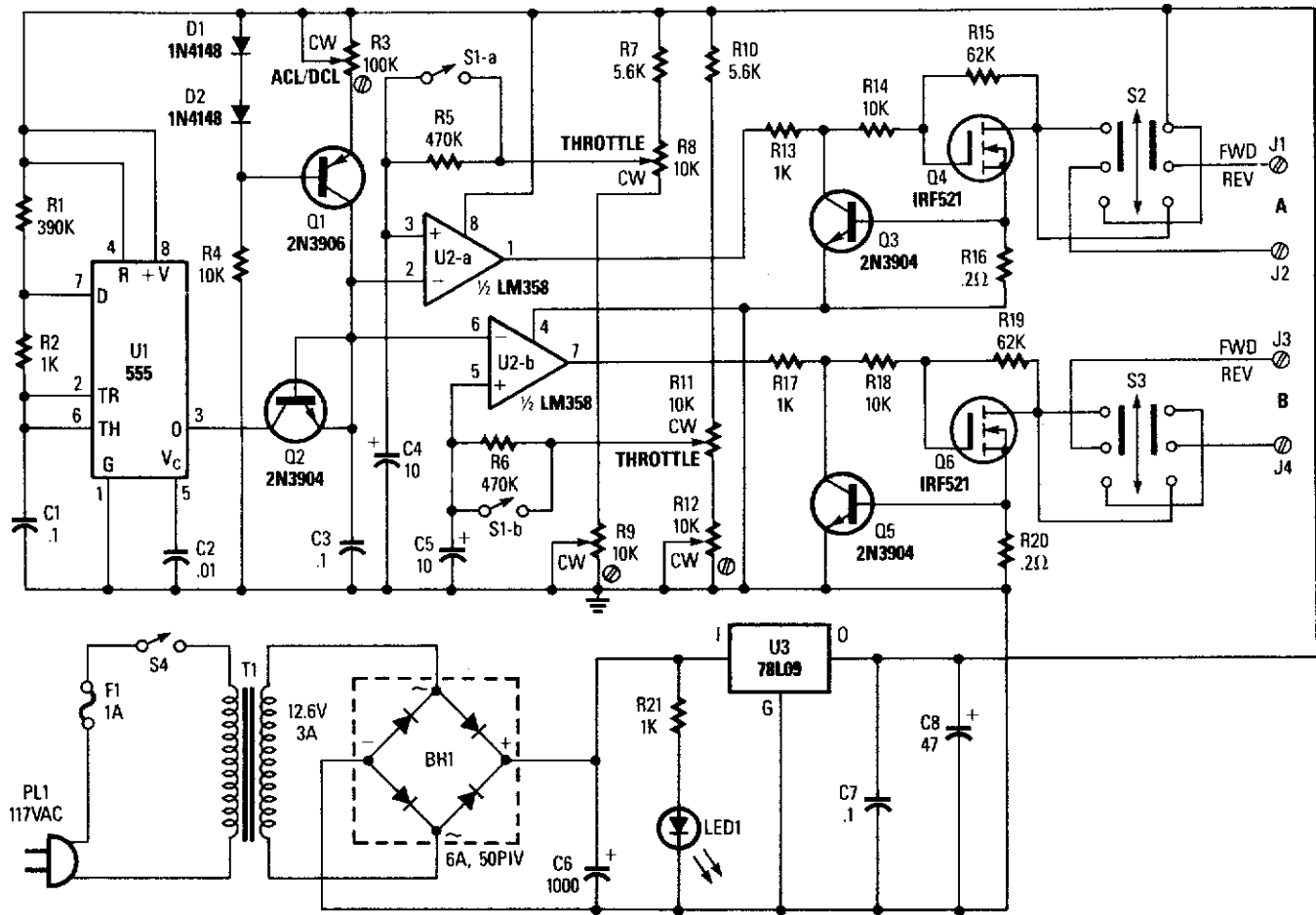
54

Model and Hobby Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 671. The figure number in the box of each circuit correlates to the entry in the Sources section.

Model Train and Slot-Car Controller
Model Train Throttle Control

MODEL TRAIN AND SLOT-CAR CONTROLLER



As shown, a 555 timer (U1) is configured as an astable multivibrator (oscillator) with a 400:1 duty cycle and a frequency of 40 Hz.

When power is applied to the circuit, capacitor C1 (connected to pin 6 of U1) is discharged and the output of the 555 (which is used to sink current) is low. Capacitor C1 begins to charge via R1 and R2 toward the positive supply rail. When the charge on C1 reaches about 66% of +V, the output of U1 at pin 3 goes high.

At that point, C1 begins to discharge through R2. When the charge on C1 decreases to about 33% of the supply voltage, the output of U1 returns to the low state, and the cycle is repeated until power is removed from the circuit.

When the output of U1 is low, C3 is discharged into U1 via transistor Q2. When U1 pin 3 goes high, C3 charges through a current source that consists of D1, D2, R3, R4, and Q1. The charge/discharge cycling of C3 produces a stream of pulses that are fed to the inverting inputs of U2A and U2B (an LM358 dual op amp). Two voltage-divider networks (R7, R8, R9, and R10, R11, R12) set the reference voltage that is applied to the noninverting inputs of U1A and U1B at pins 3 and 5.

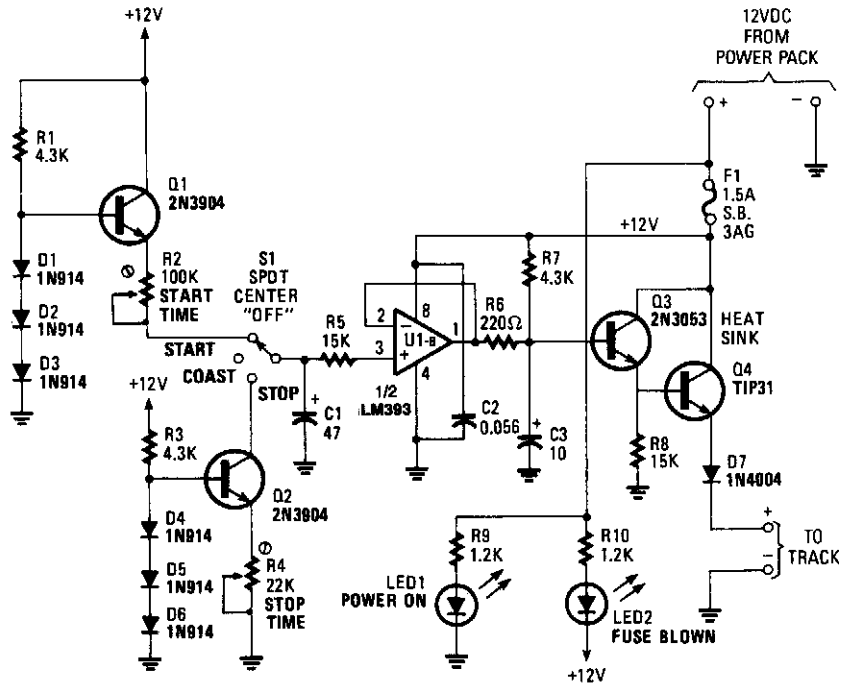
Potentiometers R9 and R12 set the low-level duty cycle (5 to 10%) of U1A and U1B. They are adjusted so that the train headlights glow, but the motor hums only slightly. Potentiometer R3 adjusts the ramp rate of C3 for 100% duty cycle at the full throttle setting. A double-pole, single-throw switch (S1A and S1B) is used to place R3/C4 and R4/C5 in the circuit.

The R5/C4 and R6/C5 combinations cause the reference voltages presented to the noninverting inputs to U2A and U2B to change very slowly when the throttle is turned up and down. When the ACL/DCL switch is turned off, the resistance of the throttle-divider networks are much smaller than those of R5 and R6, so the reference voltages on C4/C5 change "instantly" to the new throttle setting.

The output drivers consist of resistors R13 and R15, and transistors Q3 and Q4 for output "A"; and resistors R17 to R20, and transistors Q5 and Q6 for output "B." Components R13/R16/Q3 and R17/R20/Q5 limit the output drive currents of Q4 and Q6 to about 3 A each. Resistors R14/R15 and R18/R19 turn on Q4 and Q5, respectively, before the breakover voltage is reached to prevent damage to the output drivers and dissipate the energy that is stored in an inductive field (such as in a motor).

The power supply delivers 18 V to the track. Voltage regulator U3 (a 78L09 9-V, 100-mA voltage regulator) supplies power to the control circuits.

MODEL TRAIN THROTTLE CONTROL



POPULAR ELECTRONICS

Fig. 54-2

What makes this control unique is its momentum feature, which adds a degree of realism. The circuit will operate well for trains that draw up to 1 A at 15 V. None of the components are critical.

In the start mode, current source Q1 charges capacitor C1. The charge current and start-up time are adjusted by resistor R2. In the stop mode, current-sink Q2 discharges capacitor C1. The discharge current and stop time are set by resistor R4. In the coast mode, op amp U1 draws very little current from C1, so the speed will remain nearly constant for some time, and then gradually decrease. Transistors Q3 and Q4 form a Darlington emitter-follower to amplify the output of U1. Diode D7 reduces the output by about 0.8 V. Another diode could be added in series to decrease the output to 0 in the stop mode.

55

Motion and Proximity Detectors

The sources of the following circuits are contained in the Sources section, which begins on page 671. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sensitive Low-Current-Drain Motion Detector
Acoustic Doppler Motion Detector
UHF Motion Detector
IR Reflection Proximity Switch
Relay Output Proximity Sensor
Proximity Detector

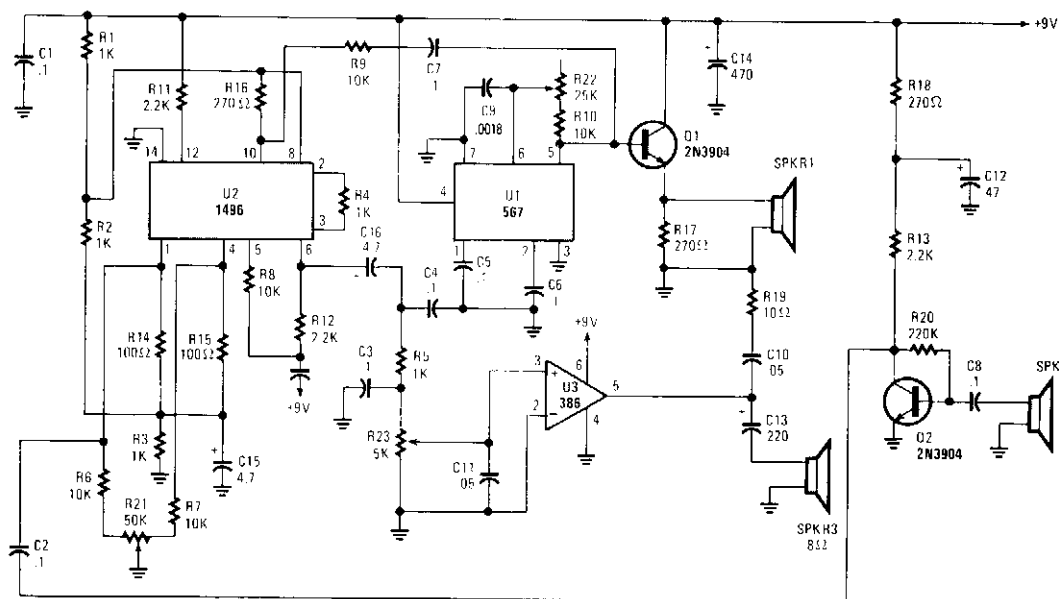
SENSITIVE LOW-CURRENT-DRAIN MOTION DETECTOR (Cont.)

fier, passed on by C4, reach a level of 0.6 V. Saturating T4 leads to the instant charging of C5. This capacitor will discharge partly via R10 and R11 to the base of T5 when T4 switches off again. When C5 discharges, T5 is on, which will make T6 conduct. This in turn will actuate a load, for instance, a buzzer, in the collector circuit of T6.

The sensitivity of the detector depends to a large extent on the distance between the magnet and relay and the length of the "pendulum."

If the circuit is powered by a battery, there is a little problem: batteries have large internal resistances. Thus, a supply voltage can vary by some tenths of a volt if a sudden, large current is drawn. If the buzzer has stopped after a detection, such a situation can retrigger the circuit and cause undesired oscillations. To prevent this happening, the supply of the amplifier stage is decoupled by R3 and C6.

ACOUSTIC DOPPLER MOTION DETECTOR

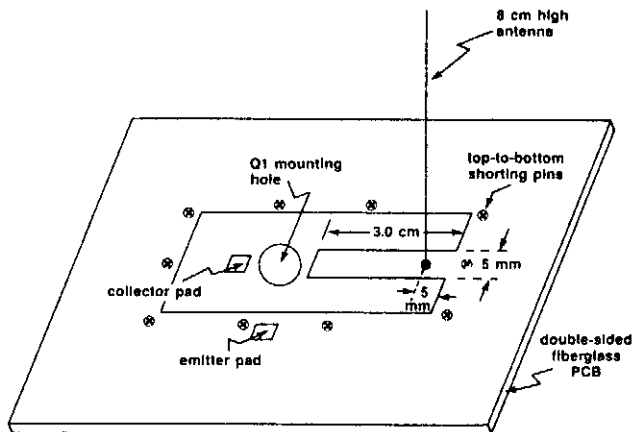


POPULAR ELECTRONICS

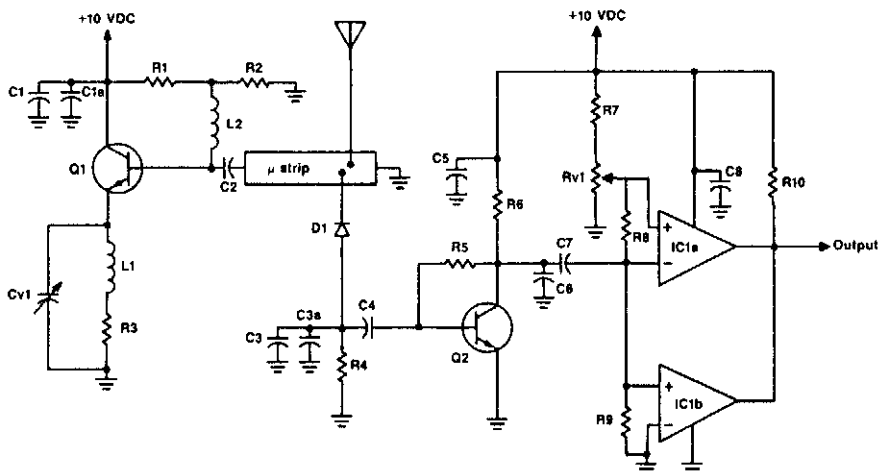
Fig. 55-2

A high-frequency audio signal (15 to 25 kHz) generated by U1 is fed to buffer Q1 and SPKR1. A portion is fed to balanced mixer U2. Received audio picked up by SPKR2 (used as a microphone) is amplified by Q2 and fed to U2. When sound is reflected from a moving object, the Doppler effect will cause an apparent shift in frequency. U2 produces a signal equal to the frequency difference. This is coupled via C16 and gain control R23 to amplifier U3, where the beat note is heard in SPKR3.

UHF MOTION DETECTOR



Construction layout.



Parts List

R1	39 k
R2, 4	1 k
R3	100
R5	2.2 M
R6	68 k
R7	100 k
R8, 9, 10	22 k
Rv1	1 k

C1	1 nF
C1a	470 uF
C2	47 nF
C3a	1 uF
C4	22 uF
C5, 8	100 uF
C6	100 nF
C7	10 uF

D1	ISS97 or other Schottky type
Q1	MRF961
Q2	BC546
Cv1	2-7 pF miniature
IC1	LM339 comparator
L1	5 turns 0.86 mm wire on 3.5 mm core
L2	4 turns 0.86 mm wire on 3.6 mm core

RF DESIGN

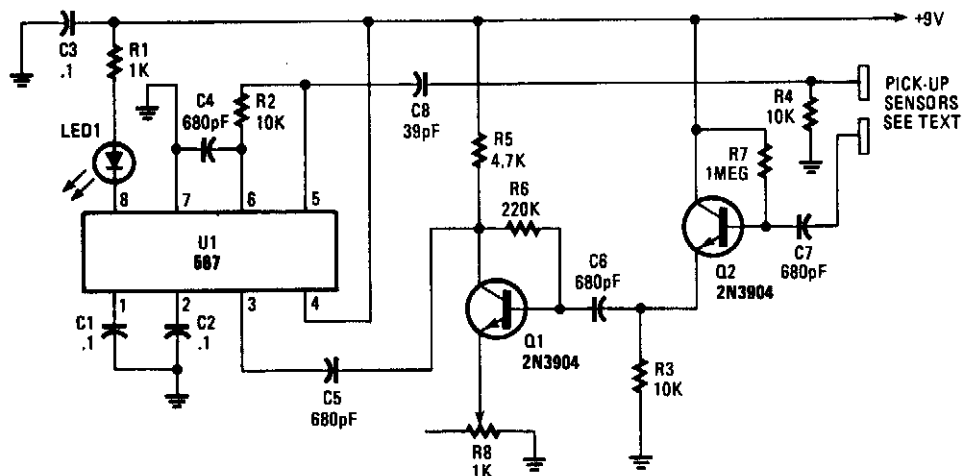
Circuit diagram.

Fig. 55-3

The UHF motion detector operates on the Doppler radar principle. Q1 is an oscillator that creates a radiated signal. An object in the radiated field reflects some of this energy back to the detector. If the object is moving, the reflected signal will have a different frequency because of Doppler shift.

Q1 is an oscillator coupled to a small (8-cm) antenna. This antenna also receives the reflected signal. D1 acts as a mixer and produces a beat note of frequency that is equal to the difference in reflected and radiated signal. Q2 amplifies this signal and couples it to comparator/detector IC1A and IC1B. The output can continue on to an alarm, relay, lamp, etc.

PROXIMITY DETECTOR



POPULAR ELECTRONICS

Fig. 55-6

In this proximity detector an NE567 tone decoder provides a signal of about 100 kHz that is fed to one sensor. The sensors are copper or aluminum wires or plates, or any other suitable conductive material. When another object is near the sensors, it causes an increase in capacitance between the sensors. Q1 and Q2 amplify the signal and feed it to U1. Notice that C8 and R4 phase shift the VCO signal from the NE567 so that U1 can detect its own output signal.

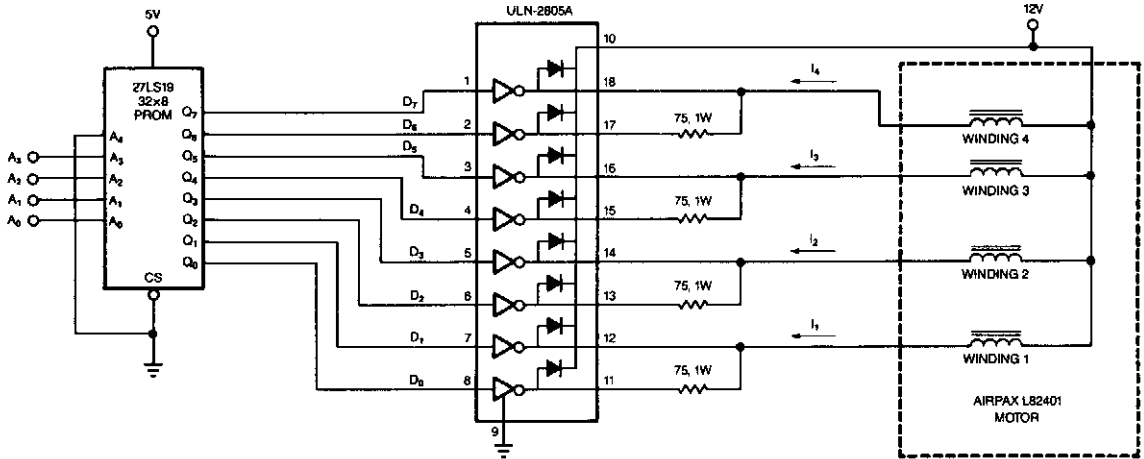
56

Motor Control Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Mini-Drill Control
- Tachometerless Motor Speed Control
- Half-Step Drive Stepper Motor
- Quarter-Step Stepper Motor Driver
- Stepper Motor Speed and Direction Controller
- Compressor Protector
- dc Motor-Speed Control
- Cassette Motor Speed Calibrator

QUARTER-STEP STEPPER MOTOR DRIVER

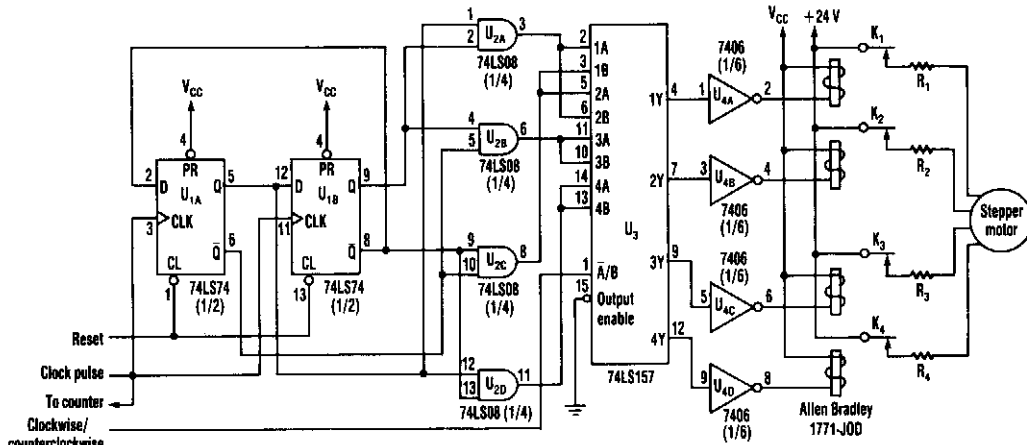


EDN

Fig. 56-4

Using a counter and a PROM, this circuit drives the stepper windings with two levels of current.

STEPPER MOTOR SPEED AND DIRECTION CONTROLLER

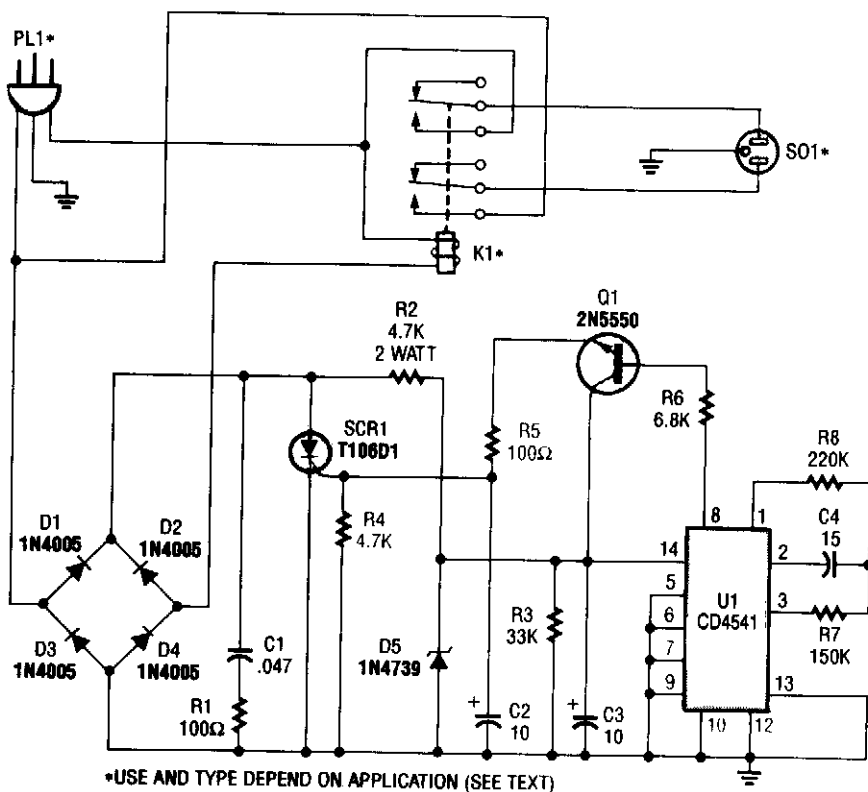


EDN

Fig. 56-5

This new circuit uses four chips, with an option of using just three (the flip-flops and AND gates can be combined). The rate of clock pulses determines the motor's rpm. Switching transistors can replace the relays to increase the circuit's efficiency. This circuit drives a stepper motor whose speed depends on clock rate. Standard SS1 LSTTL chips are used. Switching transistors can be used in place of the solid-state relays to improve the circuit's efficiency.

COMPRESSOR PROTECTOR



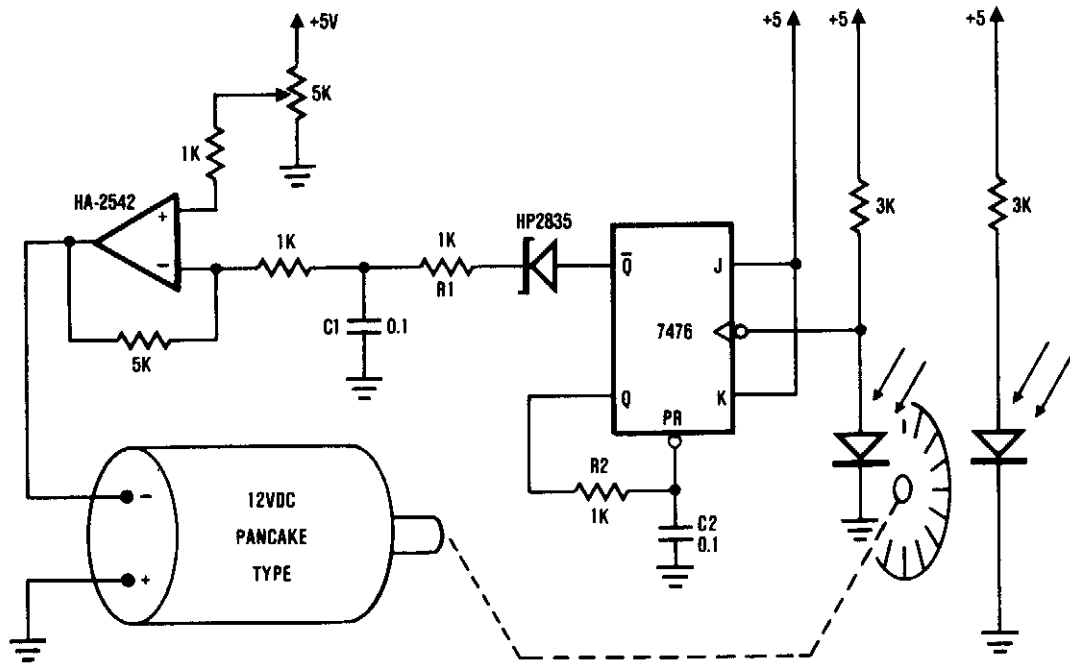
POPULAR ELECTRONICS

Fig. 56-6

This circuit monitors the power-line (ac) voltage. When a power failure occurs, on restoration of power, the circuit adds a five-minute delay before energizing K1, which protects the compressor against limited low voltage.

U1 is a 16-stage counter with an integral oscillator that is set to divide by 8192. R7, R8, and C4 set the oscillator frequency to about 25 Hz, which produces a total count interval of 300 seconds (5 minutes). After this time, pin 8 U1 goes high, which forward biases Q1, triggers SCR1, and activates K1. Up to 30 A can be switched.

dc MOTOR-SPEED CONTROL

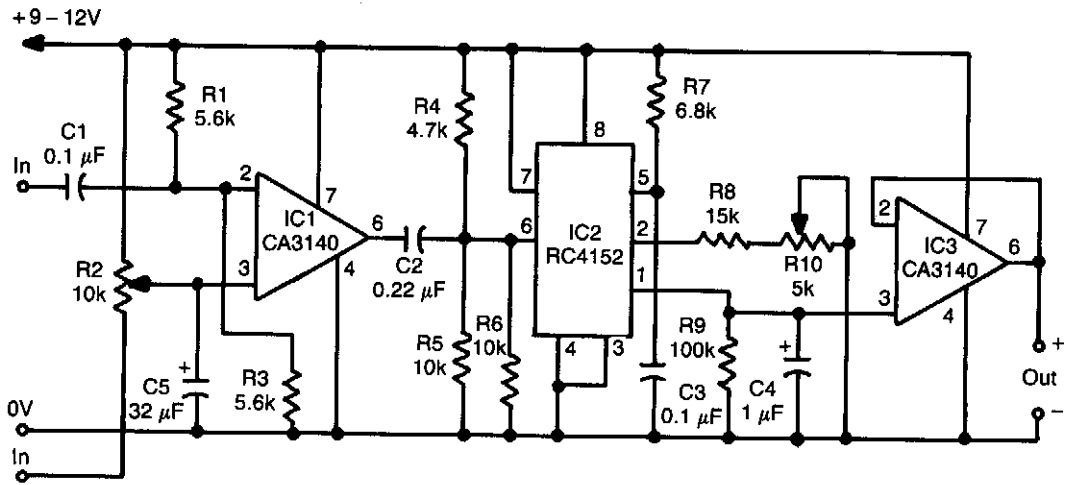


HARRIS

Fig. 56-7

The system shown consists of the HA-2542, a small 12-Vdc motor, and a position encoder. During operation, the encoder causes a series of "constant-width" pulses to charge C1. The integrated pulses develop a reference voltage, which is proportional to motor speed and is applied to the inverting input of HA-2542. The noninverting input is held at a constant voltage, which represents the desired motor speed. A difference between these two inputs will send a corrected drive signal to the motor, which completes the speed control system loop.

CASSETTE MOTOR SPEED CALIBRATOR



RADIO-ELECTRONICS

Fig. 56-8

This frequency/voltage converter enables calibrations of cassette-deck speed. It records a steady 1-kHz tone on the cassette deck, and monitors the frequency on the converter. Then, play the tone back and adjust the motor speed until you get the same frequency reading on the converter. The frequency/voltage converter can drive an analog meter to indicate small variations in tape speed.

57

Noise-Reduction Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio Shunt Noise Limiter
Simple Audio Clipper/Limiter
Noise Blanker

AUDIO SHUNT NOISE LIMITER

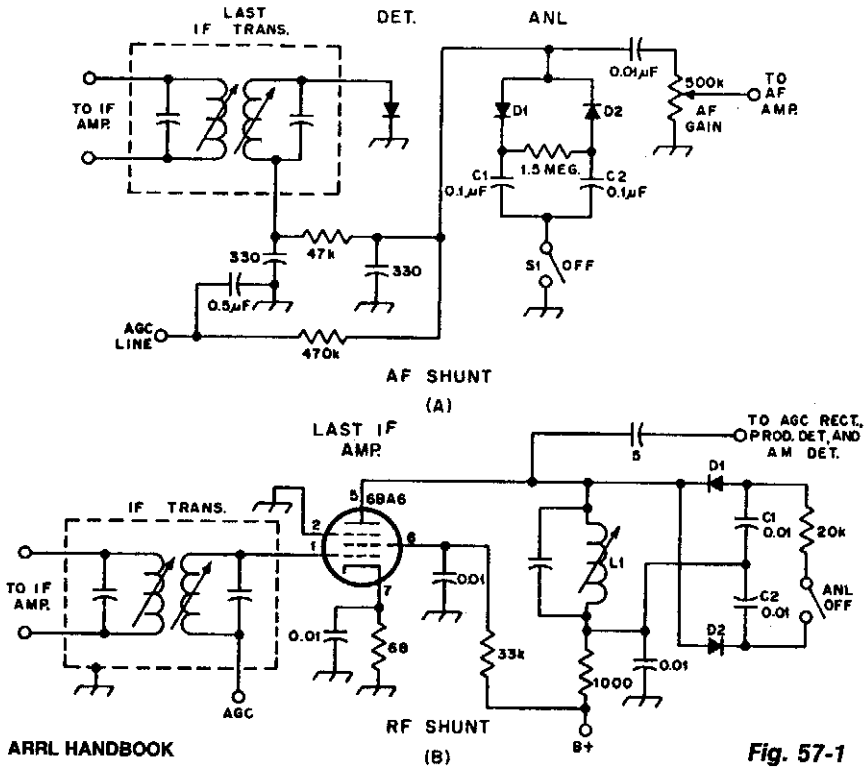
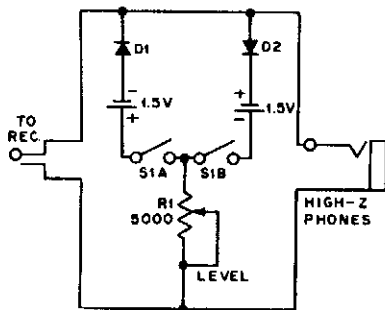


Fig. 57-1

Examples of RF and audio ANL circuits. Positive and negative clipping occurs in both circuits. The circuit at A is self-adjusting. This noise limiter operates at the IF output. It is self-adjusting. Adequate gain is needed at the IF frequency so that several volts p-p of audio is available.

SIMPLE AUDIO CLIPPER/LIMITER

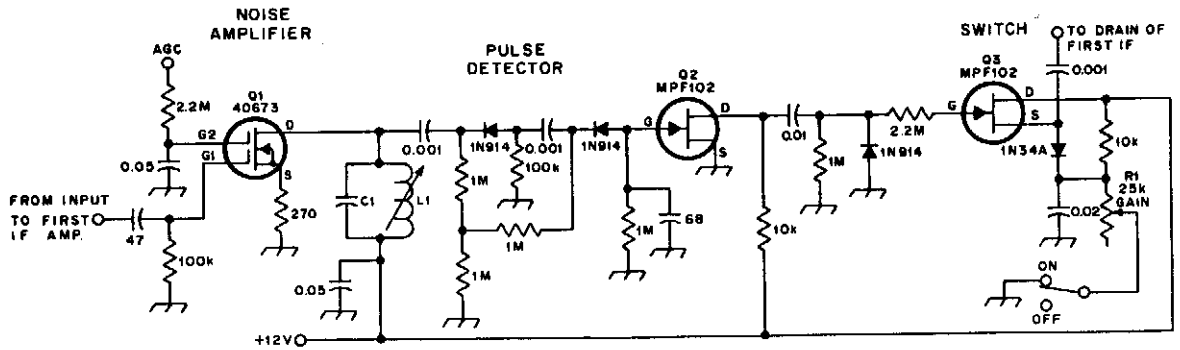


ARRL HANDBOOK

Fig. 57-2

For use with headphones, this circuit sets the audio clipping level via a 5-k Ω pot. This type of noise clipper works best for pulse-type noise of low duty cycle, such as ignition noise. R1 sets the bias on the diodes for the desired limiting level.

NOISE BLANKER



ARRL HANDBOOK

Fig. 57-3

This noise blander takes a sample of IF input voltage, amplifies it, and drives a switch. The switch (when activated by a noise pulse) adds a heavy load to the first IF stage and kills the gain for the pulse duration.

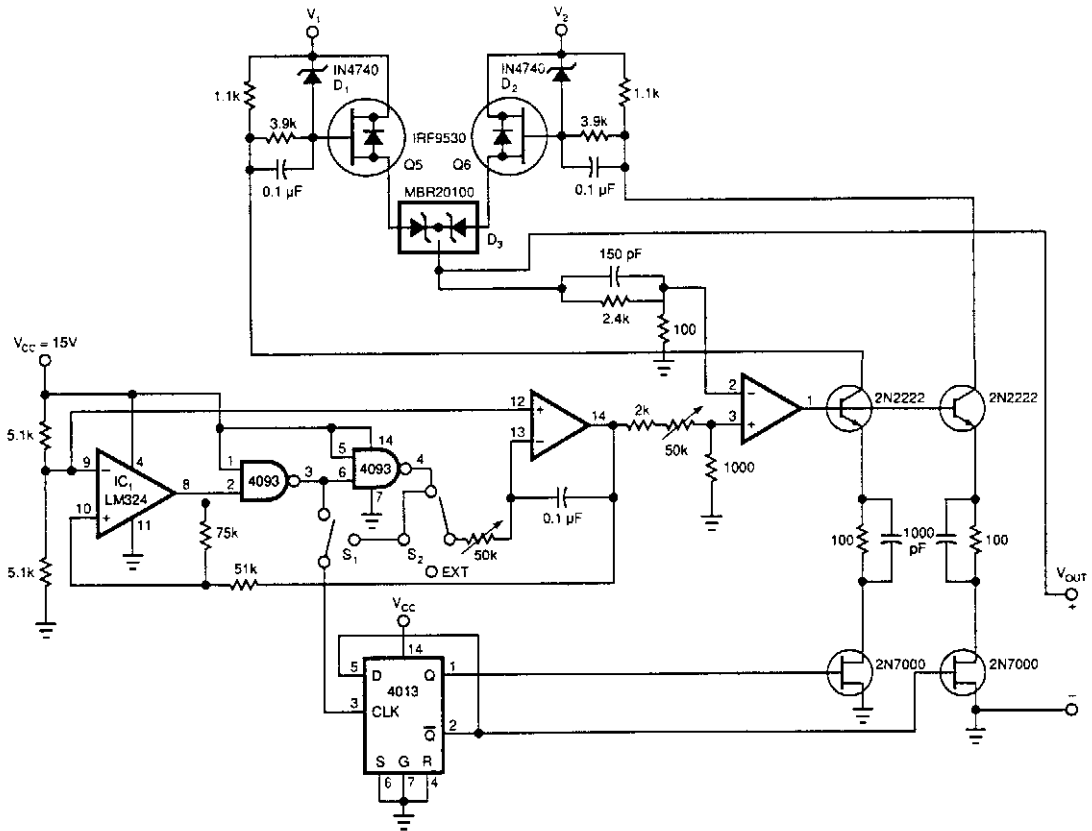
58

Operational-Amplifier Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Efficient Power Booster
- Op Amp Regulator
- Increased Feedback-Stabilized Amplifier
- Gain-Controlled Op Amp
- Bidirectional Compound Op Amp
- Compound Op Amp VCO Driver
- Make LM324 Op Amp Swing Rail-to-Rail
- 3-Input AND Gate Comparator
- Programmable Inverter/Rectifier
- Compound Op Amp

EFFICIENT POWER BOOSTER



EDN

Fig. 58-1

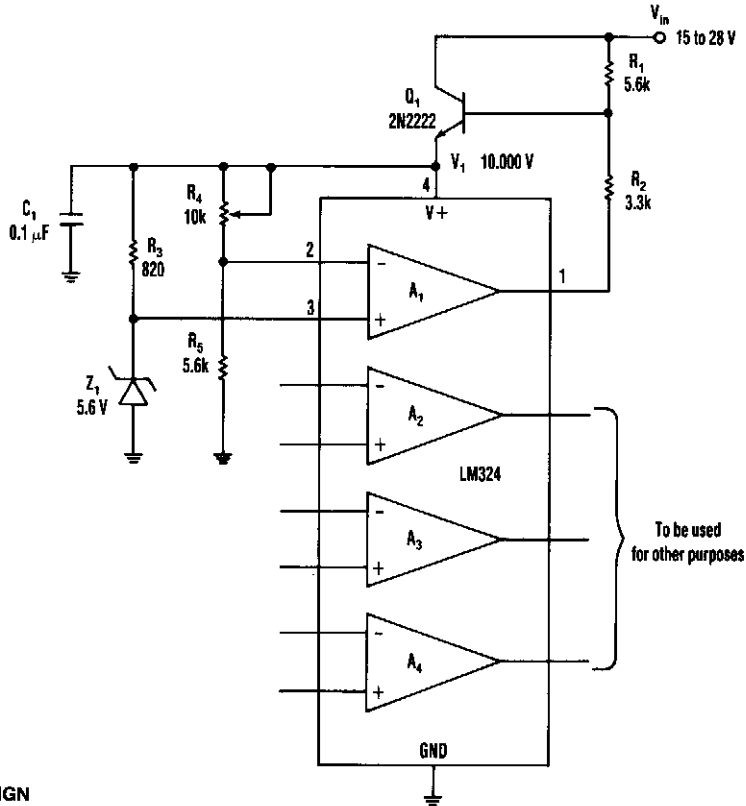
This power booster functions as a high-efficiency “power multiplexer” or, if you supply an external signal-source, as a high-power linear amplifier.

If you want to drive a load with a high-power square wave, the circuit simply draws power from two external power sources, V1 and V2, alternately. In this mode, the circuit’s power-handling devices function as switches, dissipating minimal power. The RC time constant of the integrator, IC1, determines the circuit’s oscillation period.

If you supply an external drive waveform, the circuit functions as a linear amplifier, and, consequently, inherently dissipates varying portions of that power. The power amplifier is stable for gains ≥ 15 .

Diodes D1 and D2 limit the FET’s gate-voltage swing to less than 15 V. D3 is a dual Schottky diode that protects the FETs from short circuits between the two supplies, V1 and V2, through a FET’s parasitic diode. With D3 in place, you can choose either power channel for the higher voltage input. To drive the FETs, Q5 and Q6, at switching frequencies greater than 1 kHz, you will have to use gate drivers for them.

OP AMP REGULATOR



ELECTRONIC DESIGN

Fig. 58-2

This op amp offers a straightforward method of developing a single-polarity stable voltage source (see the figure). Transistor Q1 gets a base drive through resistor R1, and conducts to develop a voltage (V_1) across the IC's supply pins. Amp A1, R2, and Q1 form a positive-feedback closed loop, along with R3 and the zener diode. A1, R2, and Q1 also form a negative-feedback closed loop with R4 and R5.

The effect of positive feedback is predominant as the noninverting input receives V_1 while the inverting input receives only:

$$V_1 \times \frac{R_5}{R_4 + R_5}$$

This happens until the zener comes into play. When the voltage at the inverting input exceeds the voltage at the noninverting input, A1's output takes away Q1's base current through R2, which reduces V_1 . Hence, an equilibrium condition is reached. Now:

$$V_1 = \frac{V_Z(R_4 + R_5)}{R_5}$$

This circuit can source more than 30 mA.

INCREASED FEEDBACK-STABILIZED AMPLIFIER

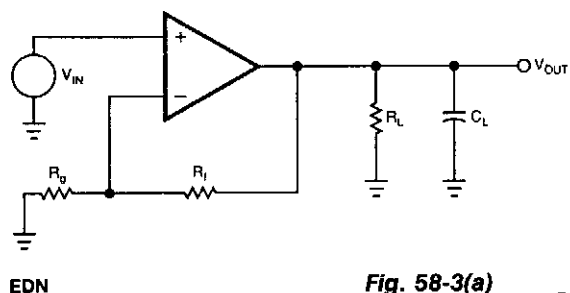


Fig. 58-3(a)

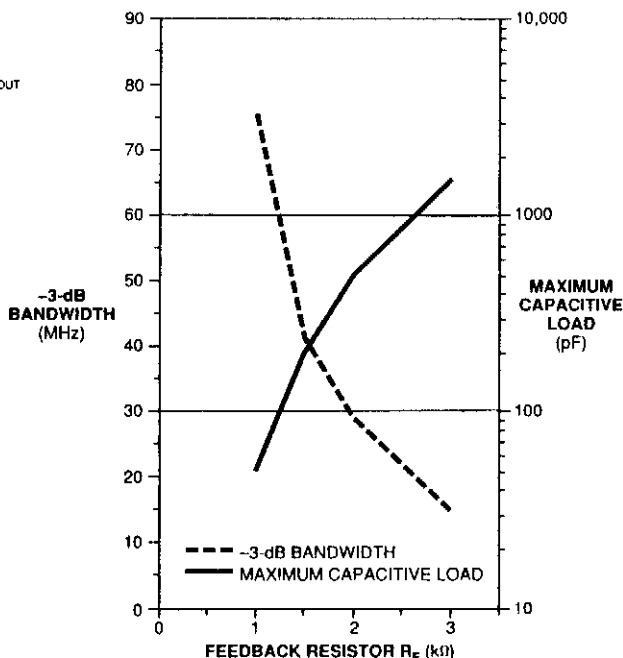


Fig. 58-3(b)

The usual method for using a current-feedback amplifier to drive a capacitive load isolates the load with a resistor in series with the amplifier's output.

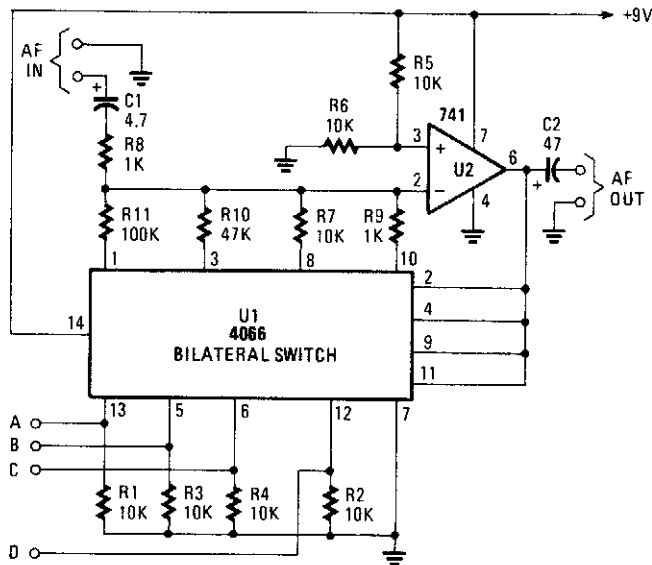
A better solution involves only the amplifier's feedback resistors (Fig. 58-3(a)). Because the feedback resistors determine the amplifier's compensation, you can select the optimal value for these feedback resistors for almost any capacitive load.

Feedback resistance R_F sets the amplifier's bandwidth. Increasing R_F reduces the amplifier's bandwidth, which significantly improves the amplifier's ability to drive capacitive loads. Feedback resistor R_G sets the amplifier's gain.

You cannot get the data necessary to calculate alternate values for R_F from most data sheets. However, a few minutes at the bench with a network analyzer will generate the data to make a graph of the value of the feedback resistor vs. the amount of capacitive load the amplifier can drive (Fig. 58-3(b)).

Start with the recommended data-sheet value for feedback resistor R_F and measure the amplifier's frequency response without any capacitive load. Note the bandwidth, then add capacitive loading until the response peaks by about 5 dB. Record this value of capacitance; it is the maximum amount for that feedback resistor. Then, increase the value of the feedback resistor and repeat the procedure until you develop a graph like the one in Fig. 58-3(b).

GAIN-CONTROLLED OP AMP

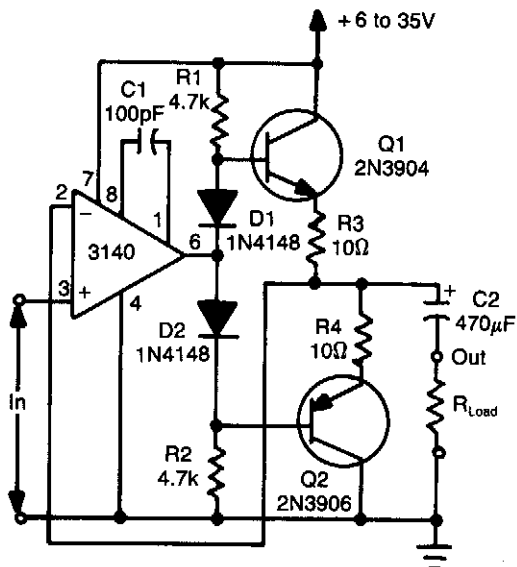


POPULAR ELECTRONICS

Fig. 58-4

The gain controller uses a 4066 quad bilateral switch to electronically select a feedback resistor for the 741 op amp. One or more switches can be turned on at the same time to produce a stepped, variable-gain range from less than 1 to 100.

BIDIRECTIONAL COMPOUND OP AMP

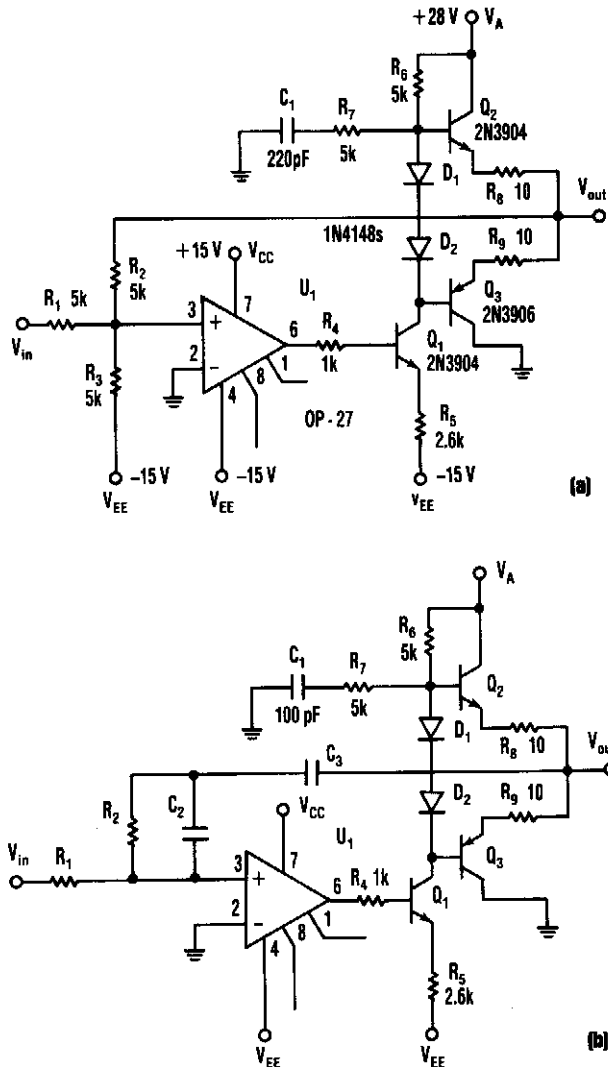


RADIO-ELECTRONICS

Fig. 58-5

Using two transistors (Q1 and Q2), a bidirectional op amp can source or sink up to 50 mA. D1 and D2 provide bias for Q1 to eliminate "dead-zone" effects.

COMPOUND OP AMP VCO DRIVER

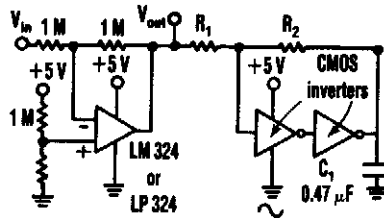


ELECTRONIC DESIGN

Fig. 58-6

This circuit produces 5- to 25-V output to drive a VCO from a standard ±15-V supply system. R₇ and C₁ supply frequency compensation. Q₁ through Q₃ form an inverting amplifier with a gain of two. Negative feedback through R₂ closes the loop. This circuit can act as an active load-log filter and directly drive a voltage-controlled oscillator.

MAKE LM324 OP AMP SWING RAIL-TO-RAIL



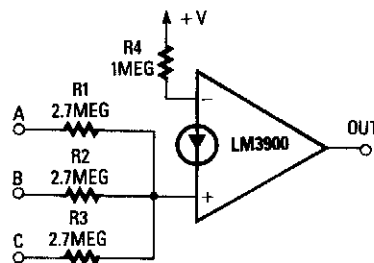
		TYPICAL OUTPUT SWING				
Op Amp	$R_1 =$	Open circuit	2.2 k	1 k	330 Ω	150 Ω
	$R_2 =$	Don't care	15 k	4.7 k	1.5 k	470 Ω
LM324	$V_{out\ Hi} =$	3.71 V	4.30 V	4.73 V	4.89 V	4.94 V
	$V_{out\ Lo} =$	0.04 V	0.023 V	0.015 V	0.010 V	0.003 V
LP324	$V_{out\ Hi} =$	4.16 V	4.91 V	4.965 V	4.982 V	4.987 V
	$V_{out\ Lo} =$	0.53 V	0.064 V	0.022 V	0.007 V	0.003 V

ELECTRONIC DESIGN

Fig. 58-7

By using two CMOS inverters, the output for an LM324 op amp can be increased from 3.5 V_{pp} to 4.9 V_{pp}. This circuit is only recommended for light loads (< 30 mA) and for relatively slow op amps. Any CMOS inverter (74COO, 74CO2, 74C14, CD4001, CD4011, etc.) can be used.

3-INPUT AND GATE COMPARATOR

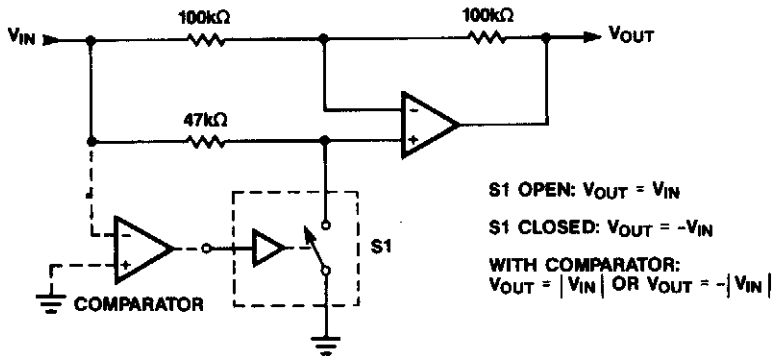


RADIO-ELECTRONICS

Fig. 58-8

This circuit has high output only when all three inputs are high. The noninverting-input current, when all three inputs are high, must exceed that of the inverting input, as determined by R4. The circuit can be converted to a NAND gate by transposing the two inputs of the op amp.

PROGRAMMABLE INVERTER/RECTIFIER

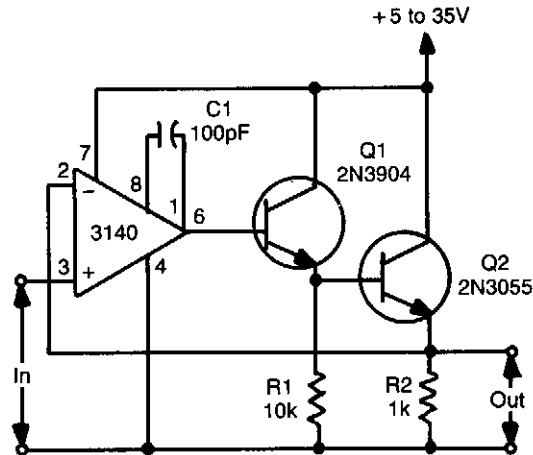


MAXIM

Fig. 58-9

The op amp is alternately an inverter or buffer, under control of the switch polarity. As a buffer, the gain is always 1, but as an inverter, the gain is set by the ratio of the input and feedback resistors. By adding a comparator, the function can be synchronously switched as the input polarity changes, which effectively rectifies the output. The output polarity is determined by the switch logic (normally open or normally closed) and the comparator input polarity.

COMPOUND OP AMP



RADIO-ELECTRONICS

Fig. 58-10

By using an emitter-follower or a Darlington pair, a voltage-follower op amp configuration can source higher currents than the op amp otherwise could.

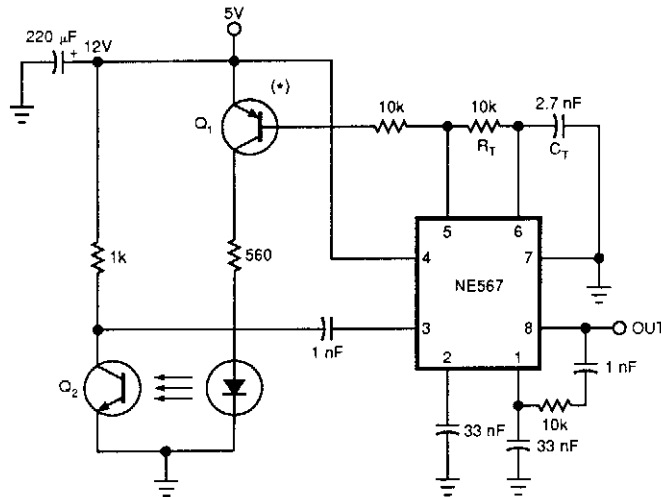
59

Optical Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Optical Interruption Sensor
- Light Receiver
- Optical Receiver
- Light Transmitter
- Optical/Laser Receiver
- Light Detector
- Light Probe
- Simple Photoelectric Light Controller

OPTICAL INTERRUPTION SENSOR



Source	Detector	Manufacturer	Notes
TIL 32	TIL 78	Texas Instruments	IR LED and phototransistor
TIL 38	TIL 414	Texas Instruments	IR LED and phototransistor
CQY58A	BPW22A	Philips	IR LED and phototransistor
CQY89A	BPW 50	Philips	IR LED and pin photodiode
TIL 139		Texas Instruments	Transmissive source and detector assembly
TIL 149		Texas Instruments	Reflective source and detector assembly

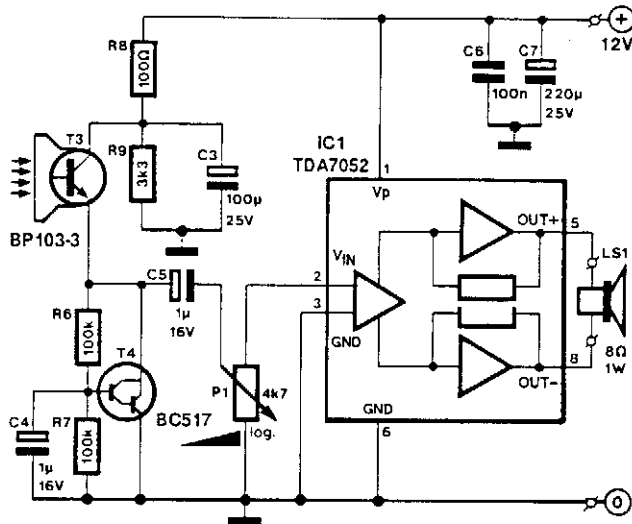
EDN

Fig. 59-1

Using only an 8-pin IC and a few discrete components, you can build the infrared optical interrupter. The NE567 tone decoder has all the necessary circuit elements: a local oscillator, a PLL decoder, and a 100-mA output-drive capability. The local oscillator, which is tuned to 40 kHz by R_T and C_T , drives Q_1 , a universal low-power silicon pnp transistor (such as a 2N3906, BC559, or ZTX500). Q_1 drives the IR-emitting diode. The receiving part of the circuit surrounds the IC's internal PLL input at pin 3. When the photodetector, Q_2 , detects the oscillating IR light beam, the 40-kHz signal appears at pin 3 of the IC. Under this condition, the circuit locks and the IC's output is high. When something opaque comes between the LED and Q_2 , the 40-kHz signal doesn't reach the PLL input, and the IC's output goes low.

The feedback network between pins 1 and 8 prevents the output from chattering. If you connect this circuit to a high-inertia load (such as a mechanical relay), the output doesn't tend to oscillate and you can eliminate these feedback components. The circuit works with virtually any LED-photodetector pair, but matched pairs allow for longer distances between the emitter and receiver. The table lists some of the best choices.

LIGHT RECEIVER

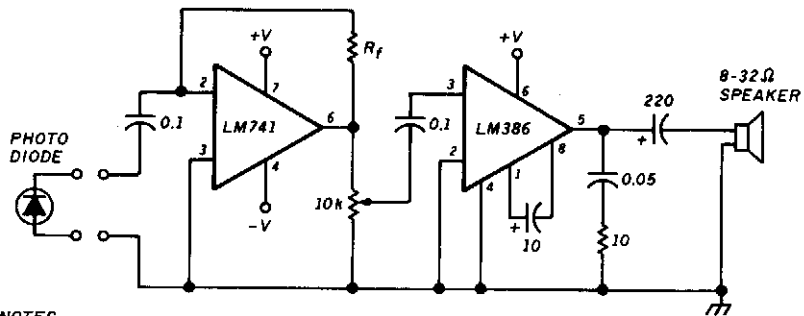


ELEKTOR ELECTRONICS

Fig. 59-2

T3 is a photocell or phototransistor. T4 controls the emitter voltage of T3. IC1 is an audio amplifier to provide amplification of the signal from the photocell.

OPTICAL RECEIVER



NOTES

+V = +9V TO +12V

-V = -9V TO -12V

$R_f = 100k - 1M$ THIS RESISTOR DETERMINES THE GAIN OF THE FIRST AMPLIFIER STAGE

A LOW NOISE OP-AMP MAY BE SUBSTITUTED FOR THE LM741 FOR IMPROVED PERFORMANCE

HAM RADIO

Fig. 59-3

An optical receiver for light-wave communications, this circuit works with AM-type light signals.

LIGHT TRANSMITTER

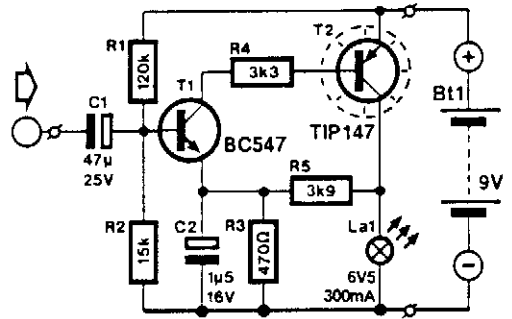
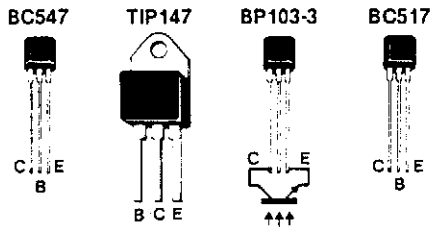


Fig. 59-4

ELEKTOR ELECTRONICS

This circuit modulates the current through a lamp filament. Use a low-voltage lamp with a thin, straight filament. They have a fast response to filament voltage variations. dc is applied to "bias" the filament that is on, and the audio is superimposed. A BC547 drives a TIP147, which modulates the filament current.

OPTICAL/LASER RECEIVER

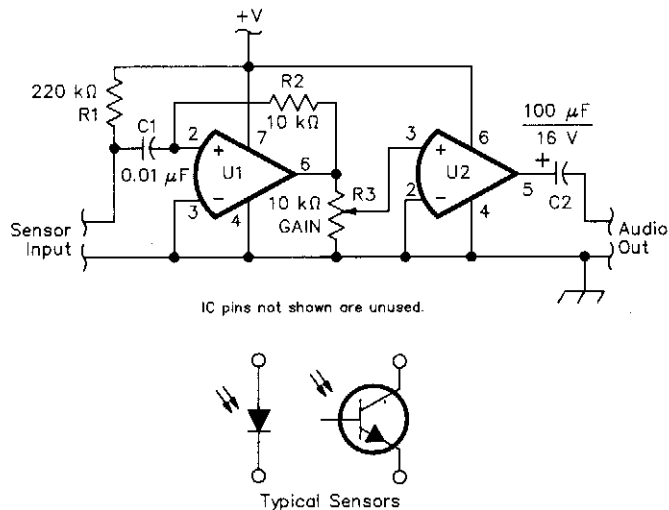
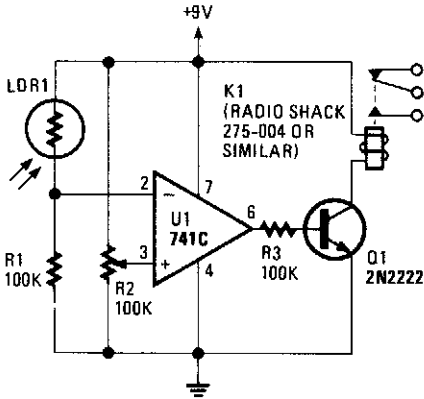


Fig. 59-5

Using a single 741 op amp, a photodiode sensor, and an LM386, this simple receiver operates from a 9-V battery. The circuit will drive a pair of earphones or a small speaker.

LIGHT DETECTOR

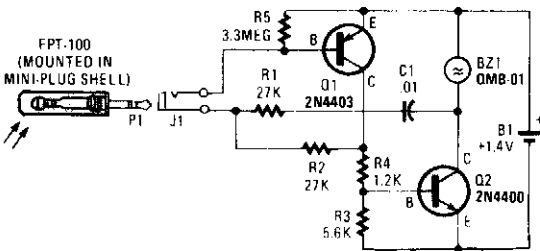


HANDS-ON ELECTRONICS

Fig. 59-6

The circuit's threshold is set by resistor R2. When the intensity of the light falling on the LDR is lowered, resistance of that unit increases, and lowers the voltage applied to the inverting input of the 741. The reference voltage at the noninverting input of the 741 is set (via R2) so that the comparator switches from low to high when the light falling on the LDR is reduced. That high activates transistor Q1, which causes the relay contacts to close.

LIGHT PROBE

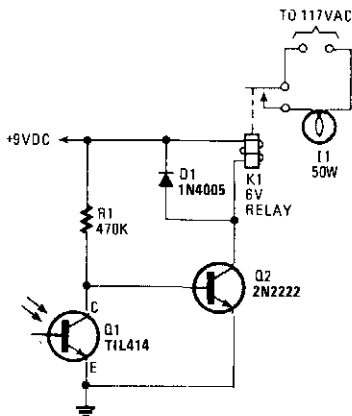


POPULAR ELECTRONICS

Fig. 59-7

Originally designed as an aid for blind people, this probe was used as a light detector in order to tell if a device or room lights are on or off.

SIMPLE PHOTOELECTRIC LIGHT CONTROLLER



POPULAR ELECTRONICS Fig. 59-8

A phototransistor senses daylight. At dusk, it ceases to conduct and R1 biases Q2, activates K1, and switches on the light. At dawn, Q1 starts to conduct, and Q2 is cut off. K1 drops out and the light goes out.

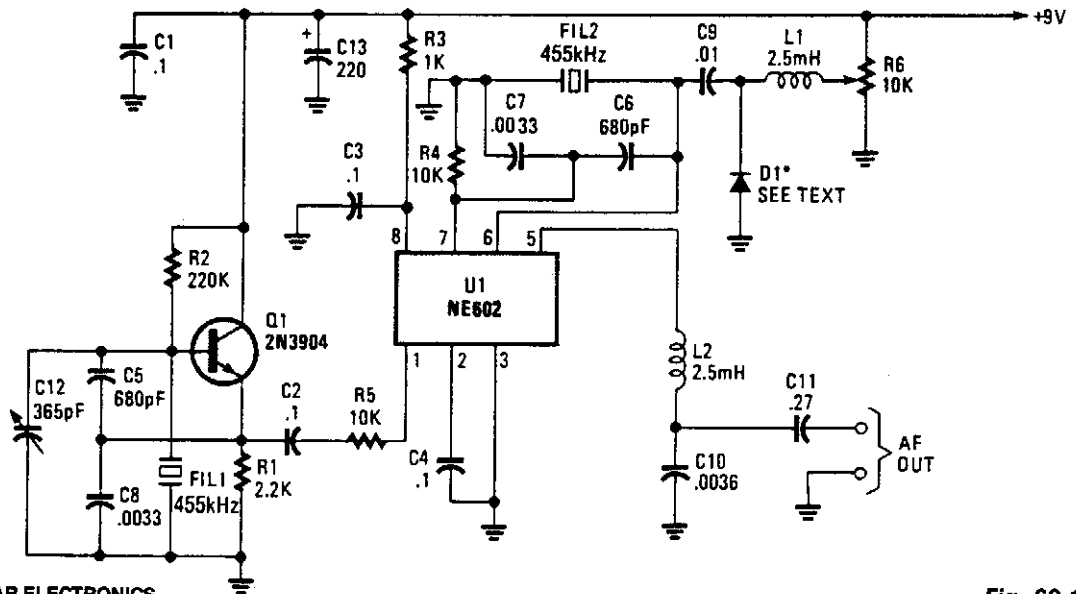
60

Oscillators

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

Beat-Frequency Audio Generator
Simple Wien-Bridge Oscillator
Stable VFO
Code-Practice Oscillator I
Phase-Locked 20-MHz Oscillator
Audio Oscillator
Code-Practice Oscillator II
Audio Oscillator II
Code-Practice Oscillator III
Relaxation Oscillator
Wien-Bridge Oscillator

BEAT-FREQUENCY AUDIO GENERATOR

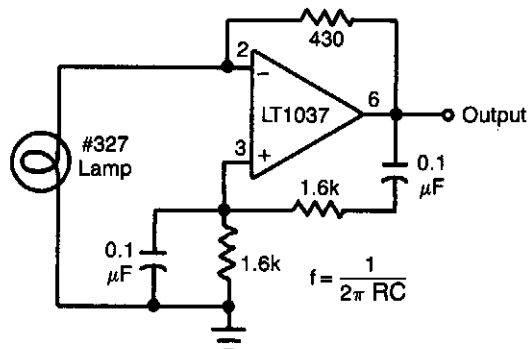


POPULAR ELECTRONICS

Fig. 60-1

Q1 is a fixed oscillator operating at 455 kHz. U1 is a mixer, with its own internal oscillator running at 455 kHz. FIL1 and FIL2 are Murata CSB455E filters or equivalent. D1 is a varactor diode (an IN4002 used as a varactor works well here). R6 controls the bias on D1. When R6 is varied, the oscillator frequency varies a few kHz. Audio beat note is taken, through RF filter L2 and C10, from pin 5 of U1.

SIMPLE WIEN-BRIDGE OSCILLATOR

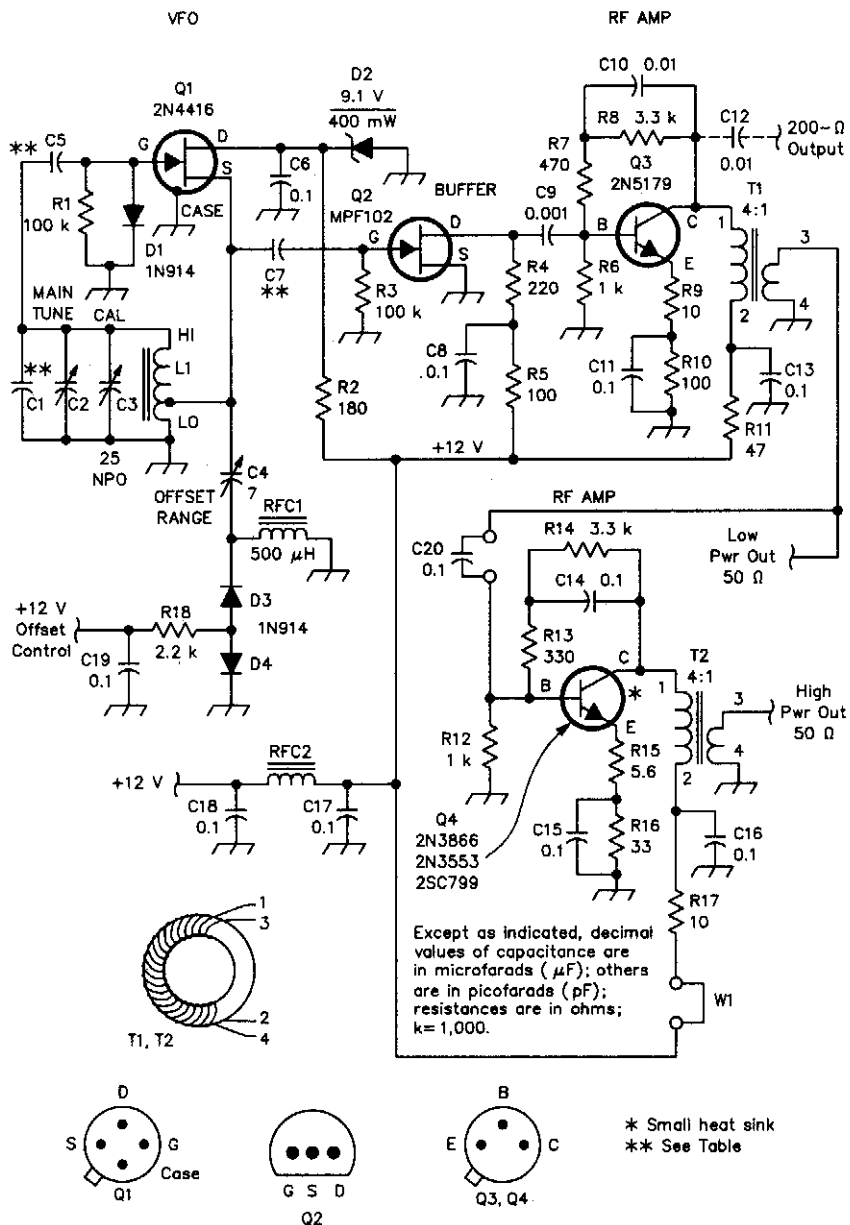


EDN

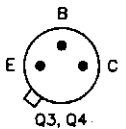
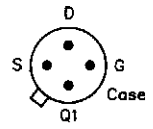
Output Frequency = 1,000 kHz
For Values Given

Fig. 60-2

In this circuit, the Wien-bridge network provides phase shift, and the lamp regulates the amplitude of the oscillations. The smooth, limiting nature of the lamp's operation, in combination with its simplicity, gives good results. Harmonic distortion is below 0.3%.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms; k=1,000.



* Small heat sink
** See Table

Bottom Views

QST

Fig. 60-3

PHASE-LOCKED 20-MHz OSCILLATOR

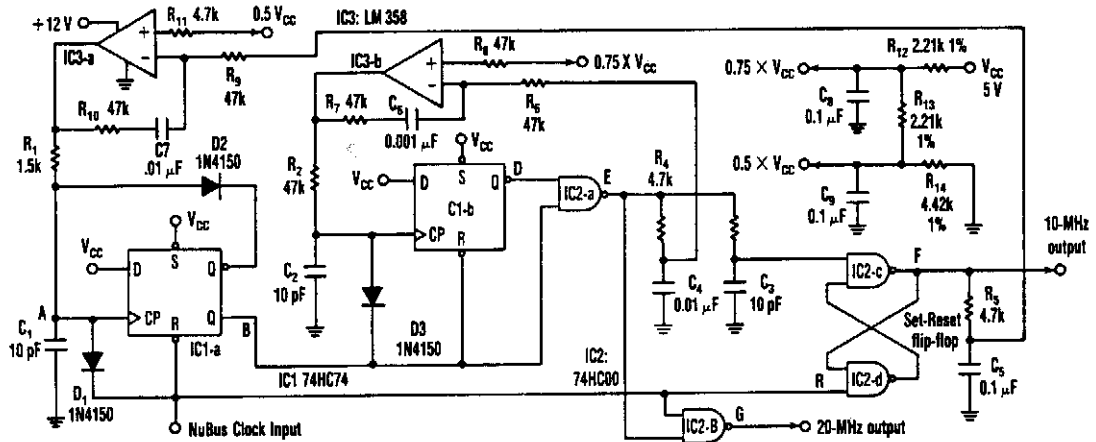
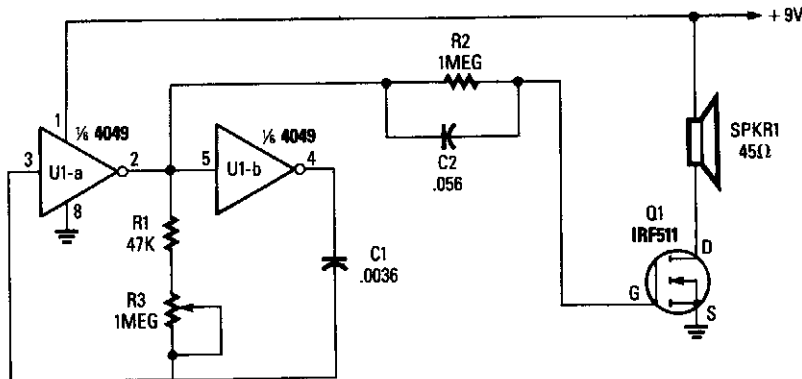


Fig. 60-5

ELECTRONIC DESIGN

This circuit produces a 20-MHz clock phase locked to a 10-MHz clock present in the Apple MAC II. To generate the 20-MHz signal, the circuit produces a 25 ns negative-going pulse delayed 50 ns from the falling edge of the 10-MHz Nubus clock input at point E. NORing that pulse with the Nubus clock produces the 20-MHz clock at point G. Applying the 25-ms pulse to the set input of an S/R flip-flop and the Nubus clock to the reset input results in a 10-MHz square wave at F.

AUDIO OSCILLATOR



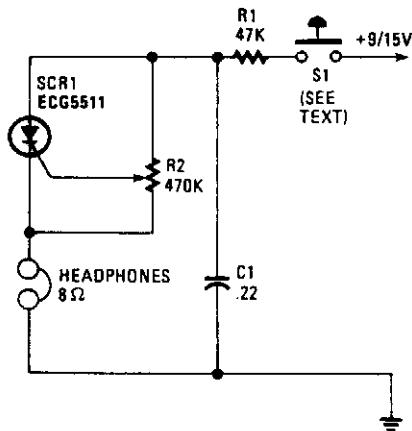
POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 60-6

Two gates, U1A and U1B ($1/3$ of a 4049 hex inverter), are connected in a VFO circuit. Components R1, R3, and C1 set the frequency range of the VFO. With the values given, the circuit's output can range from a few hundred hertz to over several thousand hertz by adjusting R3.

The simplest way to change the frequency range of the oscillator is to use different capacitance values for C1. A rotary switch, teamed up with a number of capacitors, can be used to select the desired frequency range.

CODE-PRACTICE OSCILLATOR II

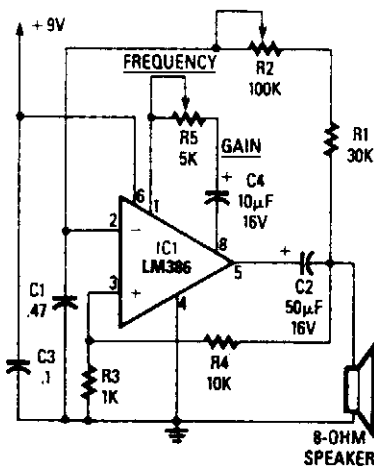


Capacitor C1 charges through resistor R1, and when the gate level established by potentiometer R2 is high enough, the SCR is triggered. Current flows through the SCR and earphones, discharging C1. The anode voltage and current drop to a low level, so the SCR stops conducting and the cycle is repeated. Resistor R2 lets the gate potential across C1 be adjusted, which changes the frequency or tone. Use a pair of 8-Ω headphones. The telegraph key goes right into the B+ line, 9-V battery.

HANDS-ON ELECTRONICS/POPULAR ELECTRONICS

Fig. 60-7

AUDIO OSCILLATOR II



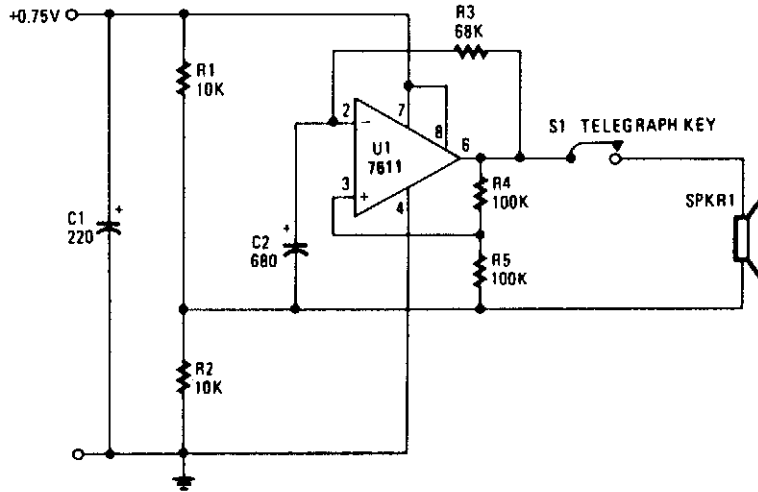
The circuit's frequency oscillation is $f = 2.8 / [C_1 \times (R_1 + R_2)]$. Using the values shown, the output frequency can be varied from 60 Hz to 20 kHz by rotating potentiometer R2.

A portion of IC1's output voltage is fed to its noninverting input at pin 3. The voltage serves as a reference for capacitor C1, which is connected to the noninverting input at pin 2 of the IC. That capacitor continually charges and discharges around the reference voltage, and the result is a square-wave output. Capacitor C2 decouples the output.

WELS' THINK TANK

Fig. 60-8

CODE-PRACTICE OSCILLATOR III

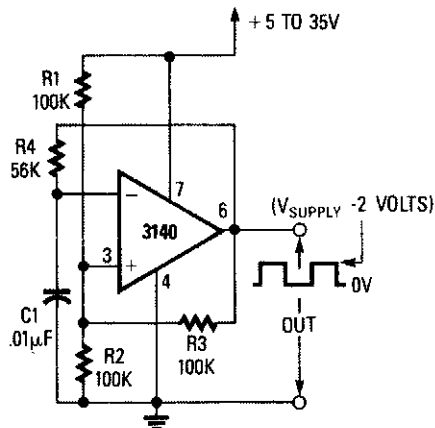


WELS' THINK TANK

Fig. 60-9

U1 is used as an oscillator; the frequency is determined by C2 and R3. Use an 80 Ω or similar high-impedance speaker, and a 1.5-V battery for a power source.

RELAXATION OSCILLATOR

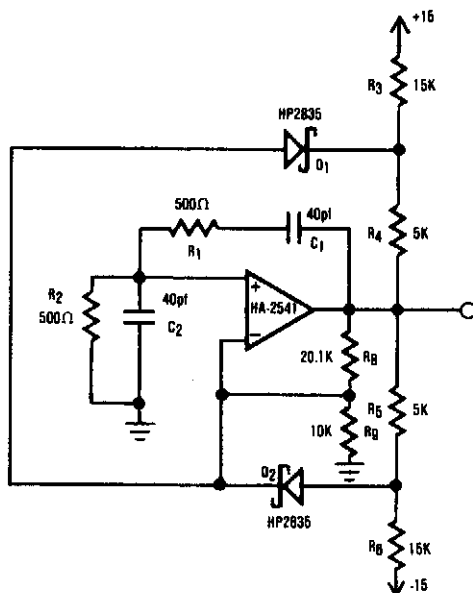


RADIO-ELECTRONICS

Fig. 60-10

This oscillator runs at about 150 Hz, but C1 and/or R4 can be proportionately changed to alter this frequency. Rise and fall times are 12 and 7 μ s, respectively.

WIEN-BRIDGE OSCILLATOR



HARRIS

Fig. 60-11

The HA2541 is well-suited for use as the heart of an oscillator. In spite of the rudimentary diode limiting that is provided by R3 through R7 and D1 and D2, a good-quality sine wave of 40 MHz is readily attainable with an upper limit of 50 MHz, which exceeds the unity-gain bandwidth of HA-2541.

R1/C1 and R2/C2 provide the required regenerative feedback needed for adequate frequency stability. In theory, the feedback network requires a gain of three to sustain oscillation. However, the practical gain needed is just over three and is provided by R8 and R9.

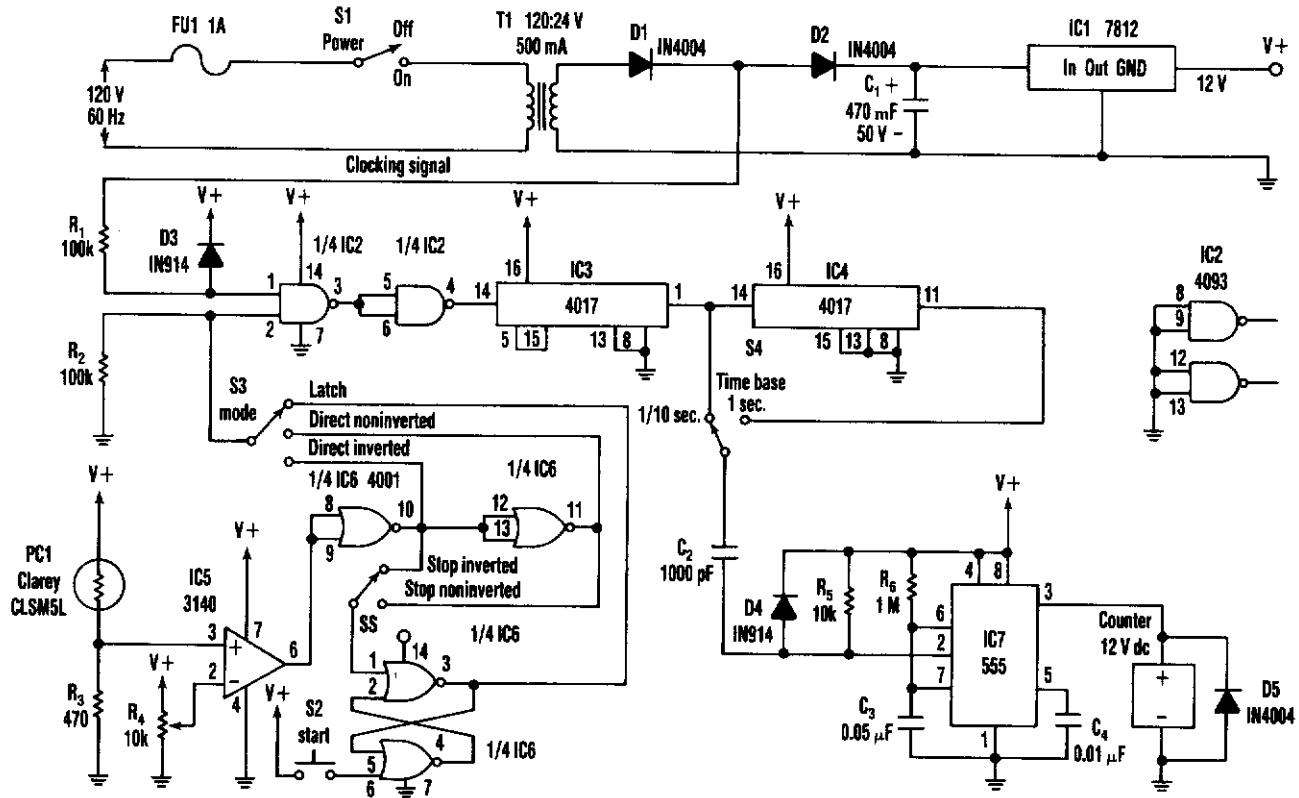
61

Photography-Related Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 673. The figure number in the box of each circuit correlates to the entry in the Sources section.

Photo-Event Timer
SCR Slave Flash
Time-Delay Photo-Flash Trigger
Camera Trip Circuit
Slide Projector Auto Advance
Sound-Trigger Flash
Slave Flash Trigger

PHOTO-EVENT TIMER



ELECTRONIC DESIGN

Fig. 61-1

S2 is used to initiate timing. A light-to-dark or dark-to-light transition stops this timer, depending on the setting of S5. S3 offers a direct operating mode, rather than through the latch. IC3 and IC4 supply 0.1- or 1-second timing pulses. IC7 drives a time display counter, a 12-Vdc unit that draws less than 200 mA.

SCR SLAVE FLASH

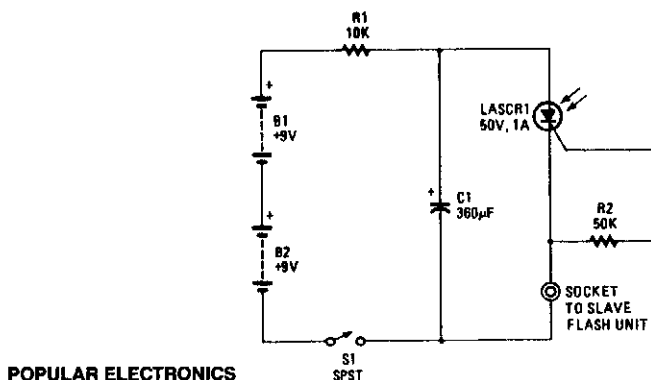
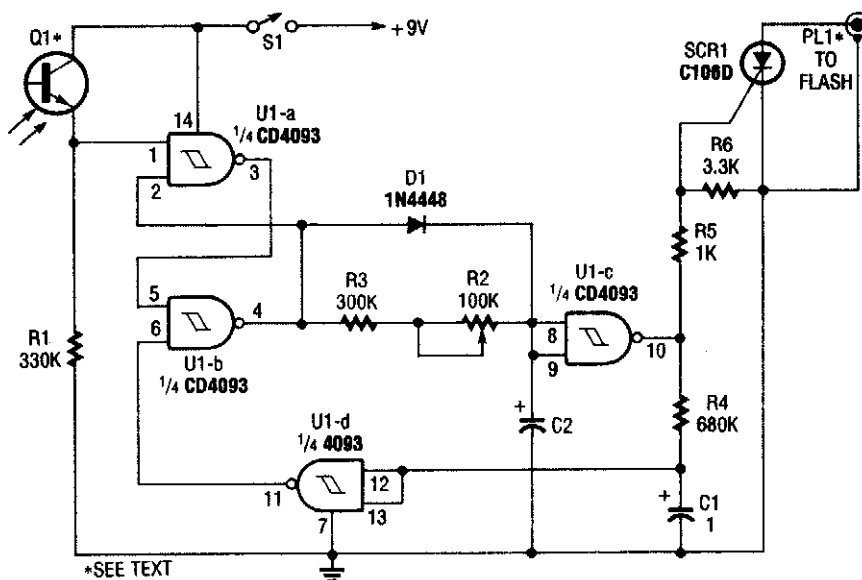


Fig. 61-2

Using a light-activated SCR, this circuit can trigger a slave-flash unit.

TIME-DELAY PHOTO-FLASH TRIGGER



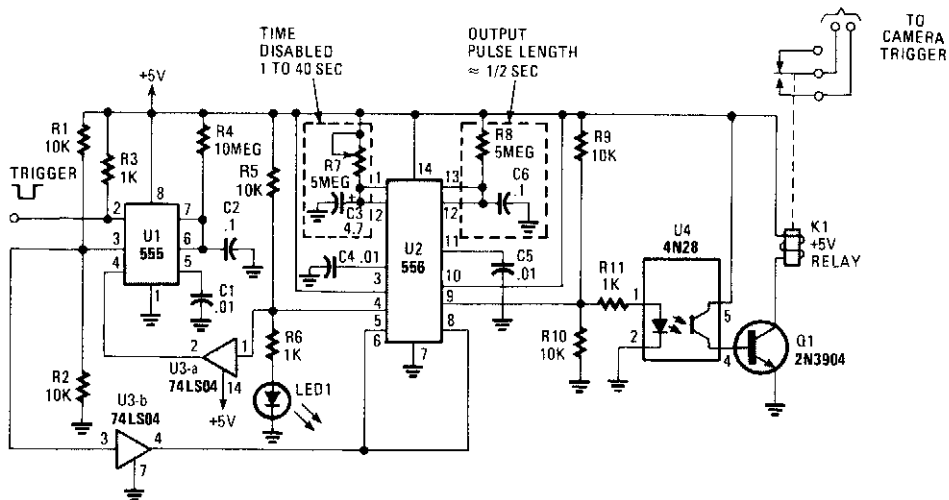
*SEE TEXT

POPULAR ELECTRONICS

Fig. 61-3

Q1 is a phototransistor that is normally illuminated by a beam of light. When the beam is interrupted, pin 1 of U1A goes high, and forces pin 4 U2B low. Then, C2 discharges through R2 and R3. After a certain time delay, pin 10 U1C goes high, triggers SCR1, and sets off the flash. R4/C1 charges, causes U1D output to go low after about 1/2 second, and resets U1A and U1B to the initial state. This delay prevents accidental double flash exposure.

CAMERA TRIP CIRCUIT

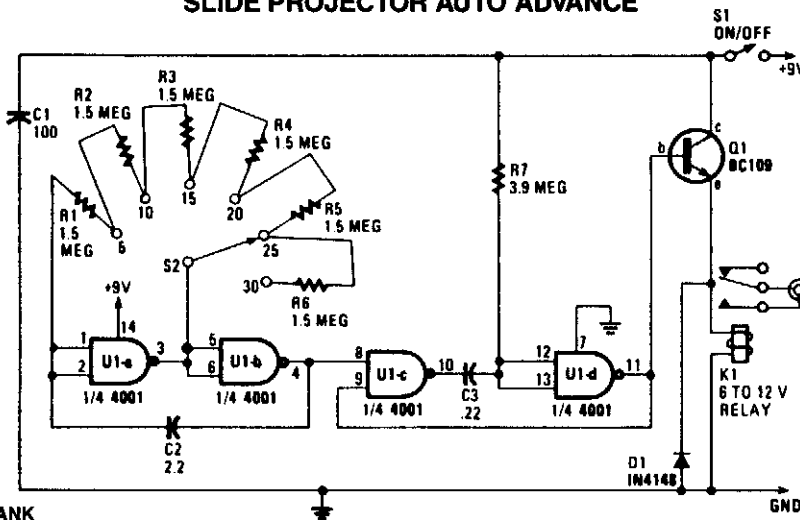


POPULAR ELECTRONICS

Fig. 61-4

This circuit was used to trip a camera shutter. Grounding pin 2 of U1 makes pin 4 of U1 go high. This triggers both timers of dual timer U1. One output holds reset (pin 4) of U1 low to keep U1 from accepting another trigger, depending on the time constant of R7 and C3. This prevents camera film waste. The other timer is used to generate a 1/2-second pulse to drive U4 and Q1, the relay driver. K1 triggers the camera.

SLIDE PROJECTOR AUTO ADVANCE

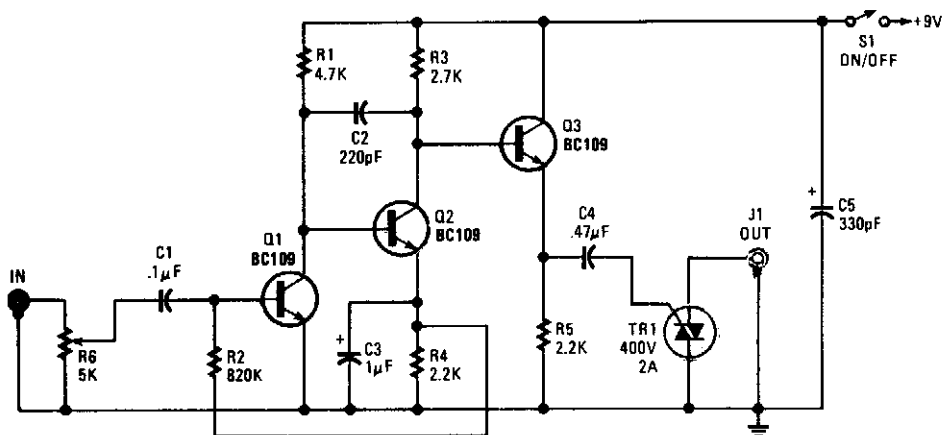


WELS' THINK TANK

Fig. 61-5

A 4001 CMOS Quad NORgate is set up as an astable multivibrator, which drives a simple differentiator and relay driver. Depending on the setting of S2, a delay of 5 to 30 seconds is generated. S2 and R1 through R6 can be replaced by a single 10-MΩ pot, if desired.

SOUND-TRIGGERED FLASH

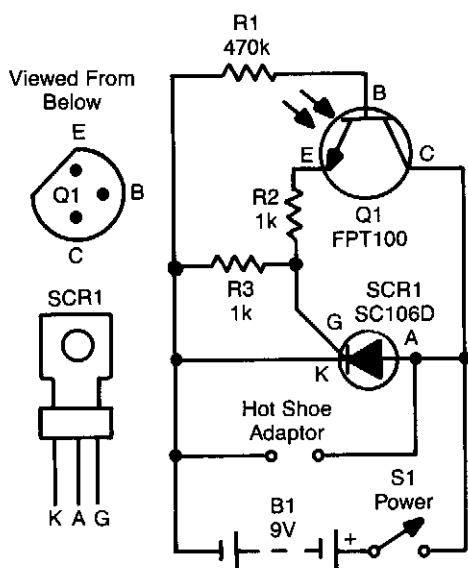


POPULAR ELECTRONICS

Fig. 61-6

Audio input from a microphone drives amplifier Q1/Q2/Q3 to produce an ac voltage across R5. C4 couples this to TR1, causing it to conduct, triggering photoflash or other device that is connected to J1.

SLAVE FLASH TRIGGER



POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 61-7

The SCR is wired across the trigger circuit of the flash gun. Normally, the SCR is off, so the flash gun is able to charge to its trigger voltage. Photo transistor Q1 is used to monitor the light level. When a high-intensity flash occurs, Q1 briefly conducts and supplies gate current to the SCR. That causes the SCR to turn on, which then triggers the slave flash gun via the hot-shoe adapter terminals.

Once the flash gun has triggered, the SCR quickly turns off again. That happens because the current in circuit quickly falls below the SCR's holding current. The resistor at the base of Q1 (R1) determines the sensitivity of the circuit. If you wish, you can reduce the sensitivity, simply by reducing the value of the resistor from that shown. The 1-k Ω resistor between the gate and cathode of the SCR (R3) prevents the SCR from false triggering if high voltages are applied between the anode and the cathode. Q1 can also be a GEL14G2.

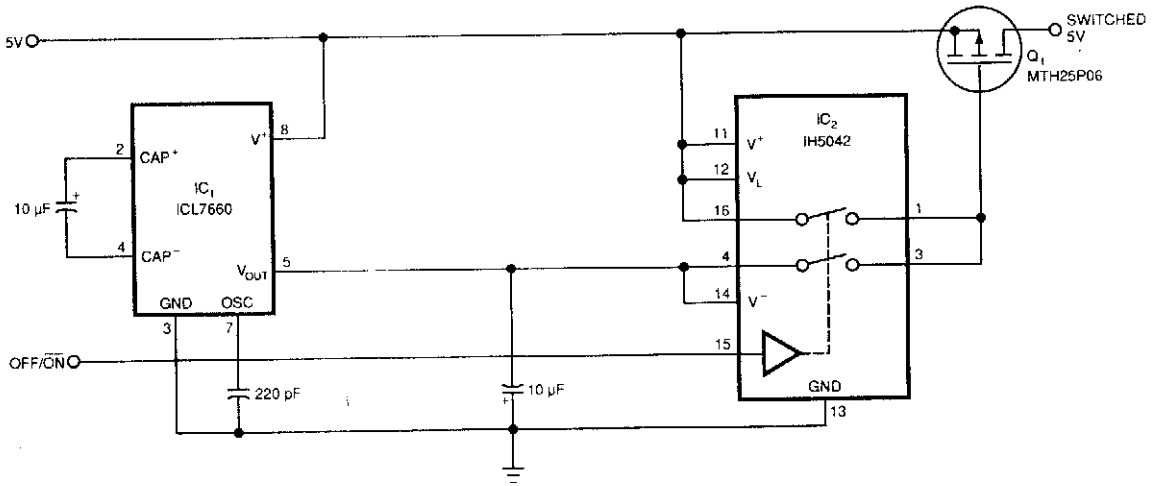
62

Power-Control Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 672. The figure number in the box of each circuit correlates to the entry in the Sources section.

- 5-V Supply High-Side Switcher
- SCR Power Monitor
- Power MOSFET Switch
- Current-Loop SCR Control
- Battery-Triggered ac Switch
- Universal Power Controller
- Pushbutton-Controlled Power Switch
- Bang-Bang Controllers
- SCR Overvoltage Protectors

5-V SUPPLY HIGH-SIDE SWITCHER



EDN

Fig. 62-1(a)

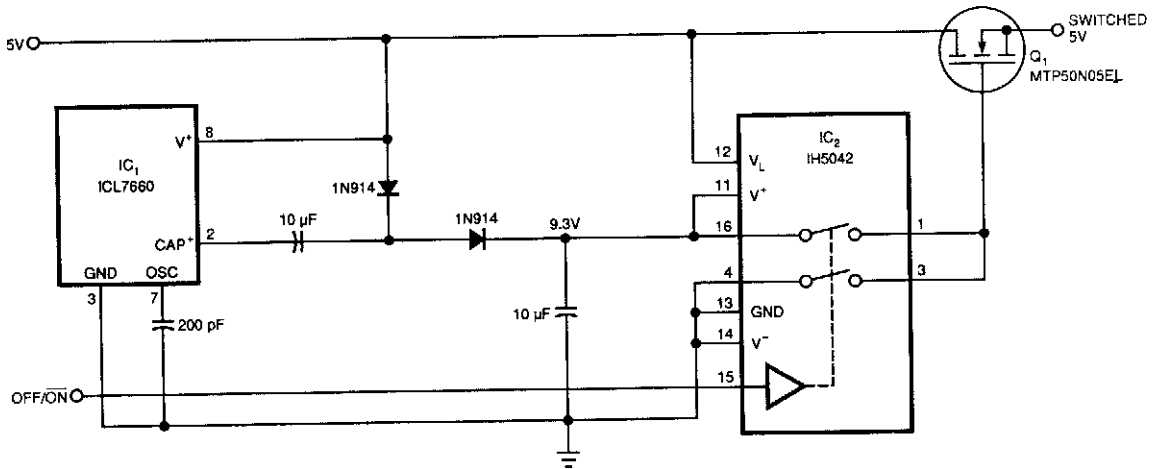


Fig. 62-1(b)

5-V SUPPLY HIGH-SIDE SWITCHER (Cont.)

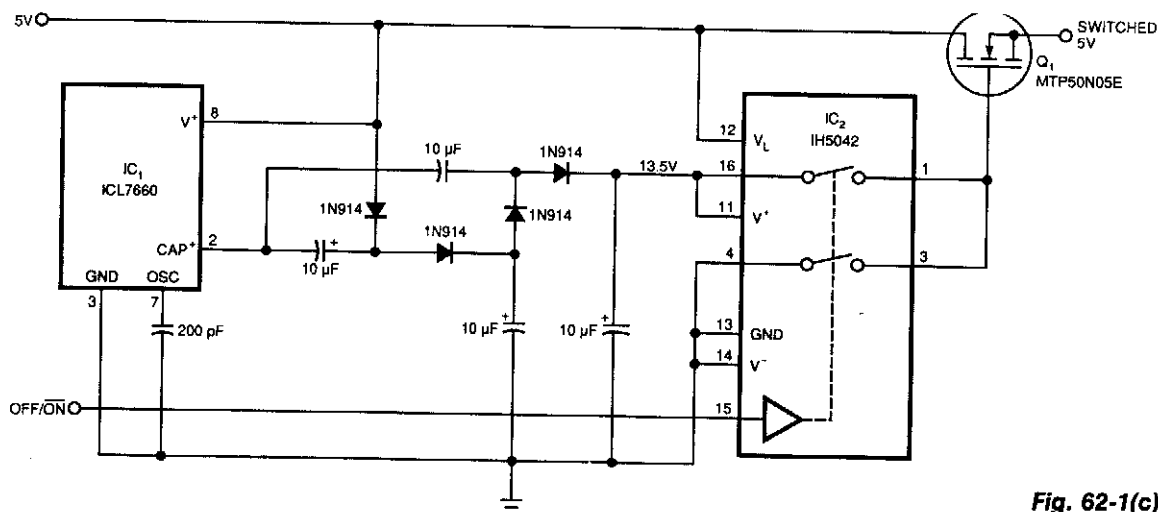


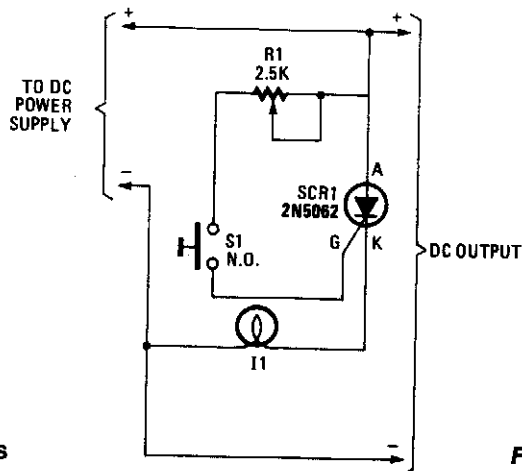
Fig. 62-1(c)

Requiring only $10 \mu\text{A}$ of quiescent current, the circuit of (Fig. 62-1(a)) produces only $0.1\text{-}\Omega$ ON-resistance. IC1 is a charge pump voltage converter to produce a -5-V level, so analog switch IC2 can provide a 10-V swing to MOSFET Q1.

This circuit uses a voltage converter to enable the analog switch to apply a 4.3-V swing to logic level NMOS power transistor Q1. ON resistance is 0.03Ω typical.

This circuit uses additional stages in the voltage-multiplying circuit to provide a higher gate voltage swing. This would enable the use of a converter for an NMOS switching transistor.

SCR POWER MONITOR

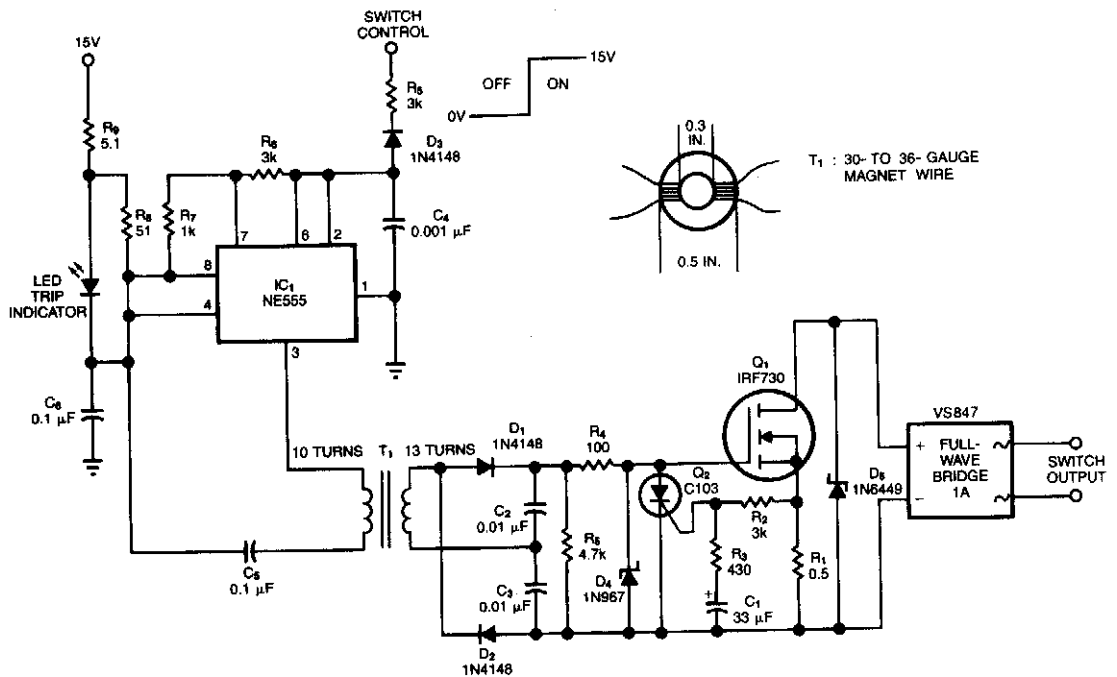


HANDS-ON ELECTRONICS

Fig. 62-2

Pressing R1 lights I1, which will extinguish if there has been a power failure.

POWER MOSFET SWITCH



- NOTES:
 1. ALL RESISTORS EXCEPT R₁ ARE 1/4W CARBON.
 2. T₁ IS A FERROXCUBE 204XT250-3E2A.

EDN

Fig. 62-3

This solid-state switch senses and interrupts an overcurrent condition within 2 μ s. It allows the circuit to float. IC1 runs at 150 kHz and full-wave doubler D1/D2 provides 15 V to the gate of Q1. An overcurrent sensed across R1 triggers Q3, removes gate bias from Q1, and opens the circuit formed by the full-wave bridge and Q1. C1 and R3 allow the circuit to handle surges.

CURRENT-LOOP SCR CONTROL

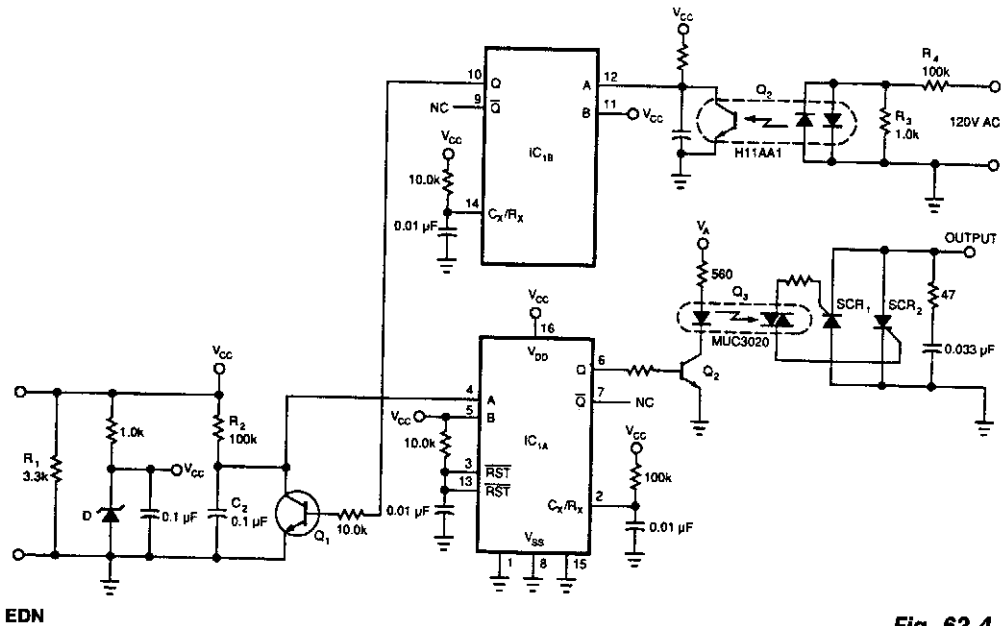
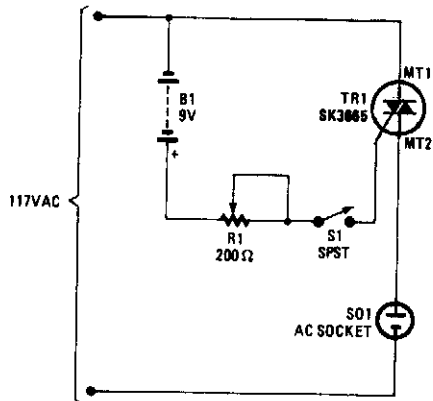


Fig. 62-4

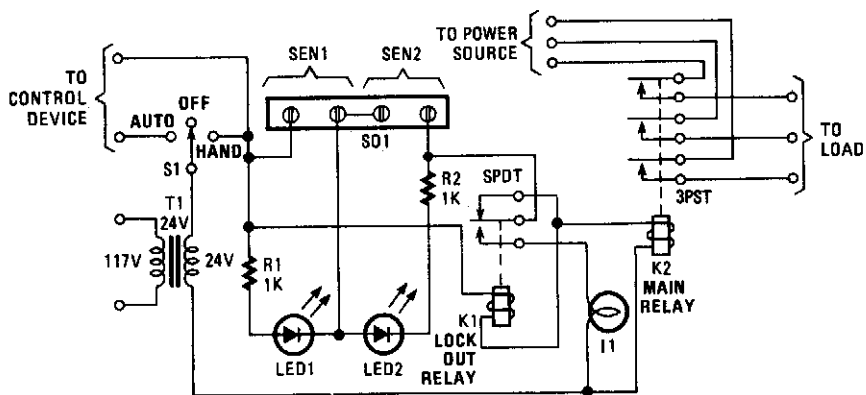
This circuit allows a 4-to 20-mA current loop to control an isolated SCR drive. IC1A and B are one-shots. Q2 detects zero crossings of the 120 Vac line, which triggers one-shot IC1B. IC1A causes Q1 to discharge C2. When C2 recharges through R2, it triggers IC1A, and the optoisolator and SCR1/SCR2. Triggering of SCR1 and SCR2 is a function of input current, which can control motor speed, light intensity, etc.

BATTERY-TRIGGERED ac SWITCH



Using this method, a small switch (S1) can control a large ac load. R1 is adjusted for reliable triggering and should be as large as possible.

UNIVERSAL POWER CONTROLLER

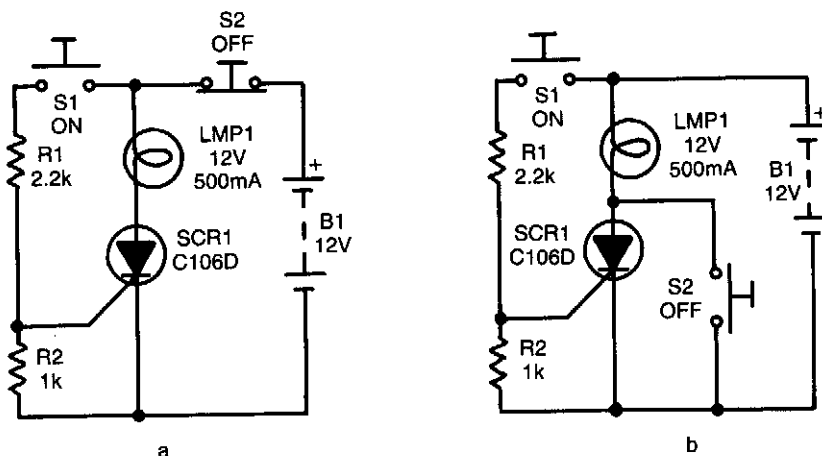


POPULAR ELECTRONICS

Fig. 62-6

Relay K1 has a low-impedance coil and K2 has a high-impedance coil. When a sensor opens, current is routed through the coil of K1. K1 activates, opens its contacts, and prevents a sensor contact reclosure from affecting the circuit. When K1 contacts open, current to the main relay K2 is limited by the impedance of K1. K2 controls power to a load (air conditioner, furnace blower, etc.).

PUSHBUTTON-CONTROLLED POWER SWITCH



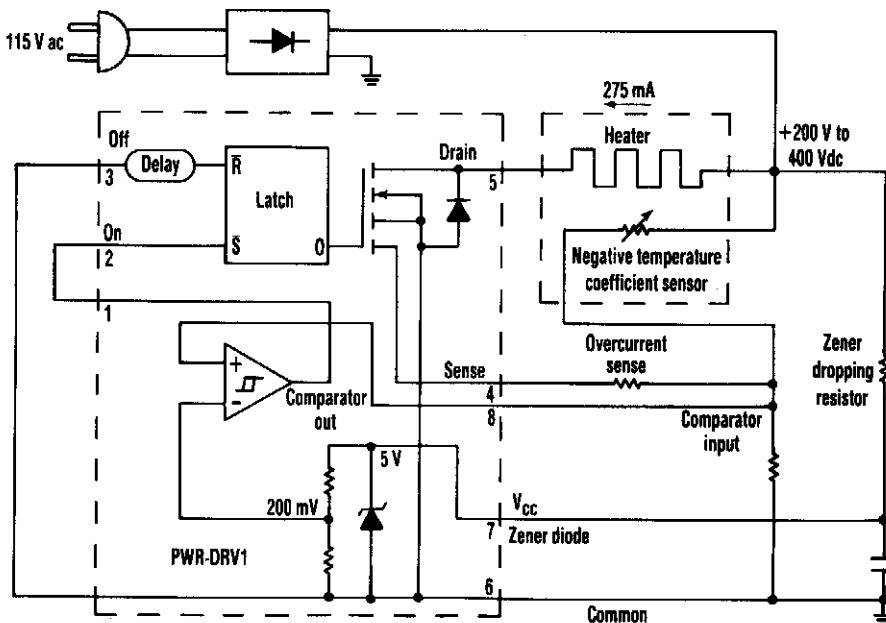
RADIO-ELECTRONICS

Fig. 62-7

In both circuits, the SCR (and thereby the lamp) can be latched on by momentarily closing S1, thereby feeding gate drive to the SC via R1. In both circuits, the gate is tied to the cathode via R2 to improve circuit stability.

Of course, after the SCR turns on, it can be turned off again only by momentarily reducing anode current below the device's I_H value. The SCR is turned off by momentarily opening S2, by using S2 to short the anode and cathode terminals of the SCR momentarily.

BANG-BANG CONTROLLERS

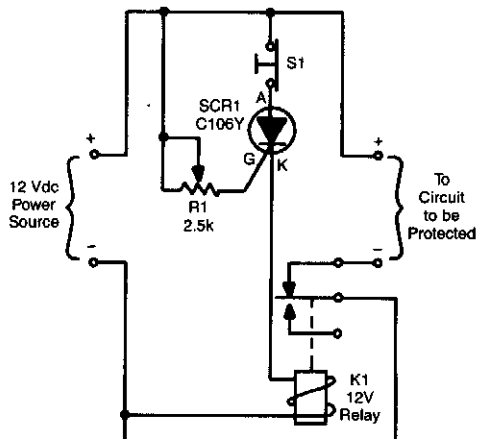


ELECTRONIC DESIGN

Fig. 62-8

Just one chip, the PWR-DRV1 from Power Integrations, builds a “bang-bang” controller that switches 275 mA and runs off the rectified 115-Vac mains. An on-chip zener diode powers the chip from high voltage through a dropping resistor.

SCR OVERVOLTAGE PROTECTOR



HANDS-ON ELECTRONICS

Fig. 62-9

Depending on the setting of R1, when the voltage exceeds a certain amount, SCR1 triggers, which activates K1 and opens the circuit. S1 resets the SCR.

63

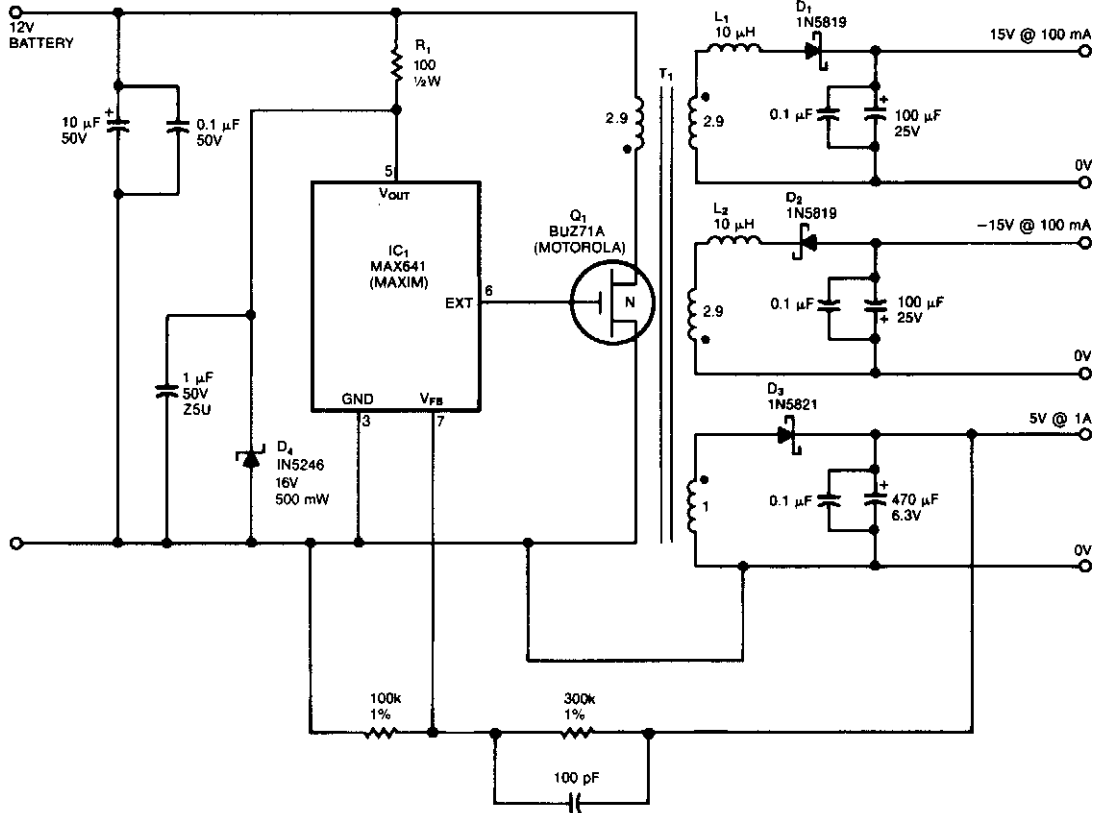
Power Supplies (Fixed)

The sources of the following circuits are contained in the Sources section, which begins on page 673. The figure number in the box of each circuit correlates to the entry in the Sources section.

±15- and 5-V Car Battery Supply
Simple LCD Display Power Supply
Output Stabilizer
Auxiliary Supply
ac-to-dc Converter
12-V Input Simple Inverter
Regulated Charge Pump
Simple Ripple Suppressor
3-V Power Supply for Portable Radios
Negative Voltage from a Positive Supply
Bridge Rectifier
±35-V Supply for Audio Amplifiers
Precise Low-Current Source
3- to 15-V dc/dc Converter
Current Supply for RTTY Machines
+24-V 1.5-A Supply from a +12-V Source
Negative Supply from a +12-V Source

1-A 12-V Regulated Supply
Positive and Negative Voltage Power Supply
1-mA Current Sink
Positive and Negative Voltage Switching Supply
LCD Display Contrast Control Power Supply
5- and ±12-V ac-Powered Switching Supply
Auxiliary Negative dc Supply for Bias or Reference
Applications
GASFET Power Supply
Fast Differential Input Current Source
Bootstrapped Amp Current Source
Diode CMOS Stabilizer
Mobile ±35-V 5-A Audio Amplifier Supply
Isolated 15-V to 2 500-V Supply
Get Negative Rail With CMOS Gates
3-A Switching Regulator

± 15-V AND 5-V CAR BATTERY SUPPLY



EDN

Fig. 63-1

IC1 is a switching regulator that generates a 45-kHz signal that drives the gate of MOSFET Q1. D1, D2, and D3 are Schottky diodes. The 5-V output is sensed as a reference; feedback to the chip turns off the gate signal to Q1 if the voltage rises above 5 V.

T1 has Trifilar windings that assume about 2% regulation for a 10-to 100-mA load change on the ± 15-V supplies. R1/D4 provide overvoltage protection. T1 has a primary inductance of about 21 μ H. Core size should allow 4-A peak currents. The turn ratios are 11 $\frac{1}{2}$ turns each for the 15-V supplies, 11 $\frac{1}{2}$ turns for the primary, and four turns for the 5-V secondary. The efficiency is about 75%.

SIMPLE LCD DISPLAY POWER SUPPLY

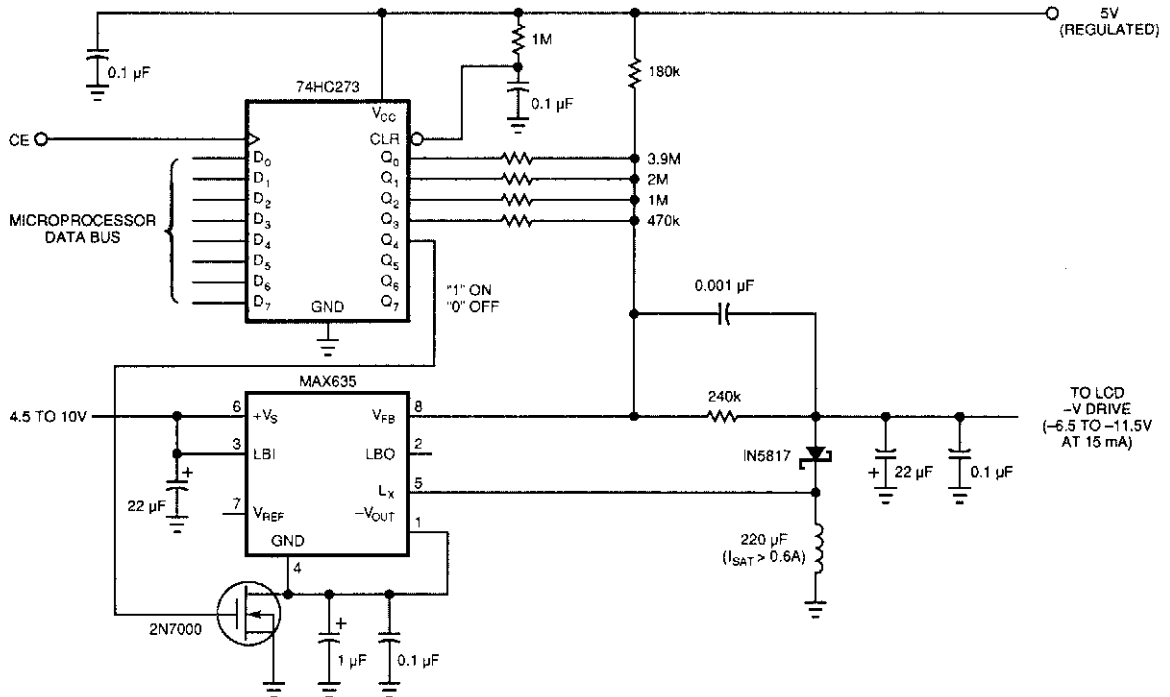


Fig. 63-2

EDN

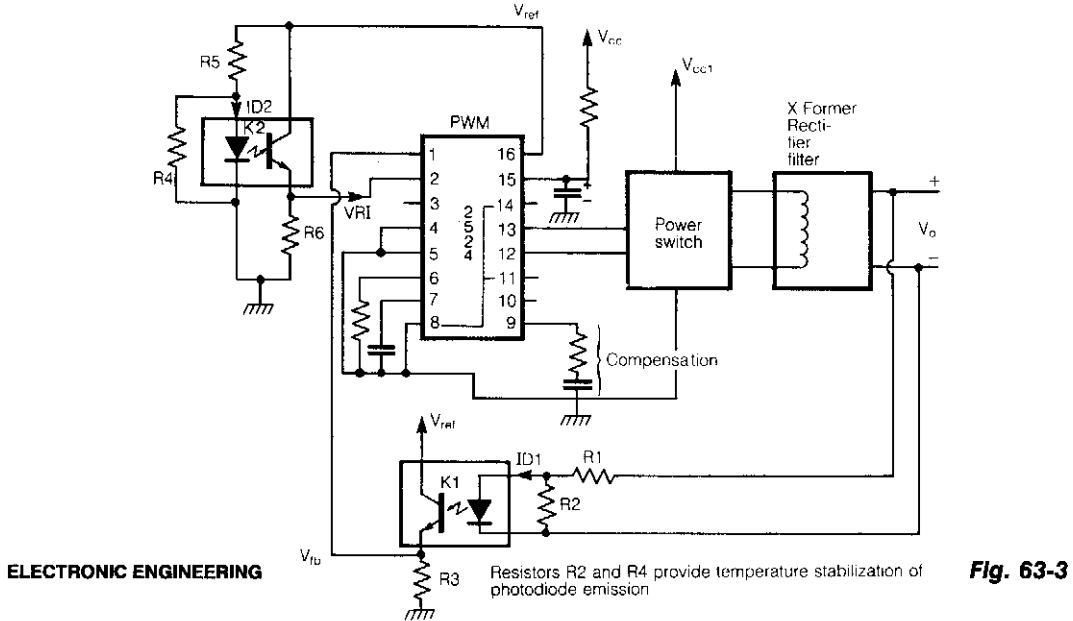
Laptop computers often use large-screen LCDs, which require a variable and a negative supply to ensure maximum contrast. This circuit operates from the system's positive battery supply and generates a digitally variable negative voltage to drive the display.

This figure's switching regulator creates a negative voltage from the battery supply. The microprocessor data bus drives a 4-bit DAC, which in turn varies the actual regulator output from -6.5 to -11.5 V. This arrangement allows a staircase of 16 possible voltages between these limits. The circuit implements the DAC by using the rail-to-rail output-drive capability of a 74 HC-series CMOS gate. A resistor divider network formed by the $240\text{-k}\Omega$ resistor, connected to the $-V$ filter capacitor and the resistors, is referenced to the 5-V supply control (the MAX635 regulator).

When the voltage at the V_{FB} pin is greater than ground, the switching regulator turns on. The inductor dumps this energy into the $-V$ filter capacitor. When the voltage at V_{FB} is less than ground, the regulator skips a cycle. The MAX635 regulates the voltage at the junction of the resistor divider to 0 V. Thus, any resistor that the DAC connects to ground (logic 0) will not contribute any current to the ladder. Only the resistors that are at 5 V (logic 1) will be part of the voltage-divider equation.

The entire switching-regulator supply draws less than $150\ \mu\text{A}$. You can place the circuit in an even lower power mode by interrupting the ground pin. The high-current path is from the battery input through the internal power PMOSFET to the external inductor. Disconnecting the ground connection simply disables the gate drive to the FET and turns off the internal oscillator.

OUTPUT STABILIZER



Optically isolated SMPS and dc-to-dc converters face the variance of output voltage owing to the change of transmission characteristics of an optoisolator with (a) temperature and (b) aging. The photo diode emission decays with temperature and time, and causes the output voltage to change. The problem is solved using a homoeopathic principle. An additional optical isolator is used to derive the $+V_e$ input voltage, instead of a conventional potential divider from internally stabilized reference. A scheme is shown using IC2524 as PWM element:

$$1) V_{R1} = K_2 \times I_{D2} \times R_6 = K_2 \left(\frac{V_{Ref} - V_D}{R_5} - \frac{V_D}{R_4} \right) \times R_6$$

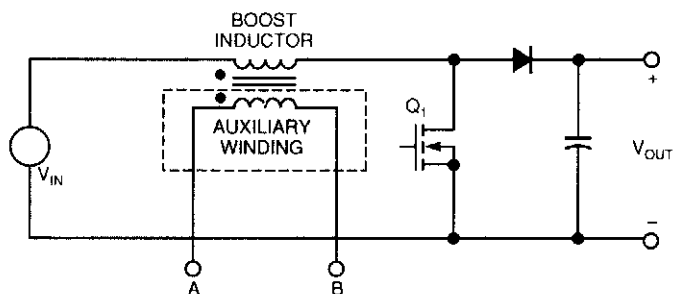
$$2) V_{fb} = K_1 \times I_{D1} \times R_3 = K_1 \left(\frac{V_o - V_D}{R_1} - \frac{V_D}{R_2} \right) \times R_3$$

where V_D = forward drop of a photo diode. In equations 1 and 2, the terms:

$$\frac{V_D}{R_4} \text{ and } \frac{V_D}{R_2}$$

decrease with temperature. Thanks to $-V_e$ temperature coefficient of V_D any changes in K_1 and K_2 as a result of temperature and aging, track each other to maintain the output voltage constant. With proper selection of R_2 and R_4 , the output voltages are found to vary by less than $0.01\%/^{\circ}\text{C}$ over a wide temperature range.

AUXILIARY SUPPLY



EDN

Fig. 63-4(a)

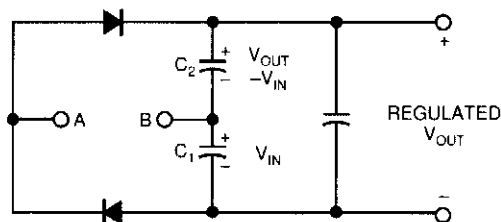


Fig. 63-4(b)

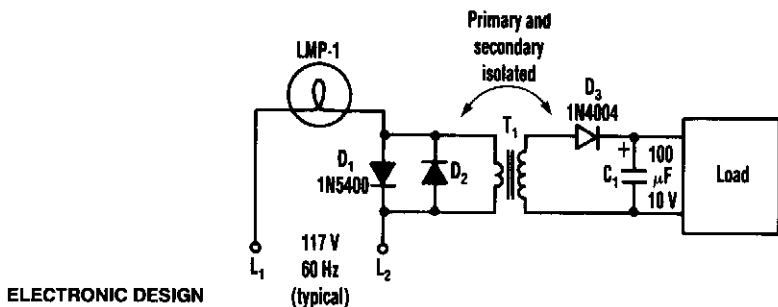
Many power-factor-correction circuits use a boost converter to generate a regulated dc output voltage from the ac line input while forcing the load to draw sinusoidal current, which maximizes the power factor.

This circuit's full-wave rectifier the auxiliary winding's output to completely cancel out line variations and provide a regulated output voltage. The circuit essentially sums the two phases of the boost inductor's voltage to eliminate the 120-Hz components. The regulated output tracks the power-factor-controlled pre-regulator output voltage and it can be used in the corrected output voltage's feedback loop.

An isolated auxiliary winding consists of the desired number of turns wound on the boost inductor. You can vary the exact value of the auxiliary supply's output voltage by adjusting or scaling the auxiliary winding's number of turns. Figure 63-4(b)'s rectifier develops two separate, but individually unregulated voltages, across capacitors C1 and C2. Each of these voltages varies in amplitude at twice the ac-line frequency. When switch Q1 is on, the boost inductor connects directly across the input supply, and a voltage proportional to the instantaneous input voltage develops across capacitor C1.

Once the switch turns off, the inductor voltage reverses and clamps to a voltage equal to $V_{OUT} - V_{IN}$. During this interval, a voltage proportional to $V_{OUT} - V_{IN}$ develops across C2. The sum of these two capacitor voltages produces a regulated auxiliary voltage that is proportional to V_{OUT} . The voltage across the output capacitor equals $V_{IN} + (V_{OUT} - V_{IN})$, which cancels the input-line variations.

ac-TO-dc CONVERTER



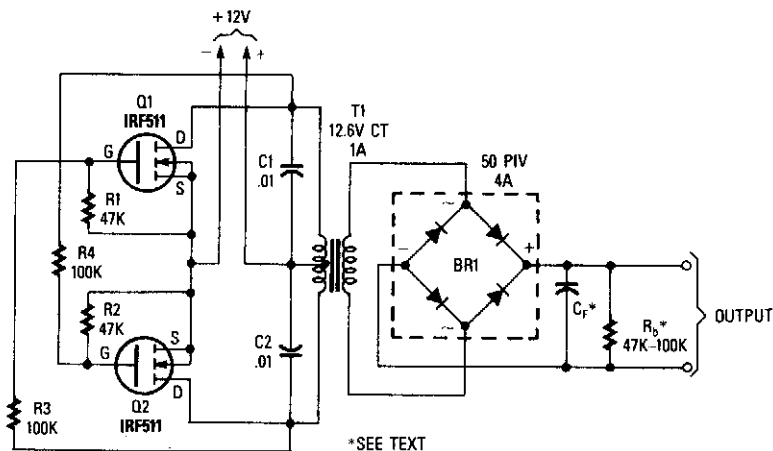
ELECTRONIC DESIGN

Fig. 63-5

By coupling two back-to-back diodes in series with an ac power circuit, a voltage of about 1.4 Vpp can be obtained. This voltage is useful for exciting the primary coil of a small transformer. The voltage induced in the secondary coil can then be rectified and used to power solid-state control circuits. The forward-voltage drop of the diodes is inherently constant and stable over a wide range of ac-circuit power variations. The resulting voltage developed across the transformer windings is also free from variation that might be caused by changes in the circuit's current or voltage.

In the circuit, a lamp (LMP-1) is connected to the primary ac input line (L1 and L2) through a pair of inverse-parallel-connected power diodes (D1 and D2). As power flows to the lamp, a drop of about 0.7 V is alternatively developed across each of the diodes. This voltage feeds the primary of a small transformer (T1). T1 can be a small 8-Ω to 500-Ω transistor radio output, etc. This will deliver about 11 Vpp across its secondary winding. LMP1 can be a small 120-V lamp of 5 to 25 W, etc.

12-V INPUT SIMPLE INVERTER

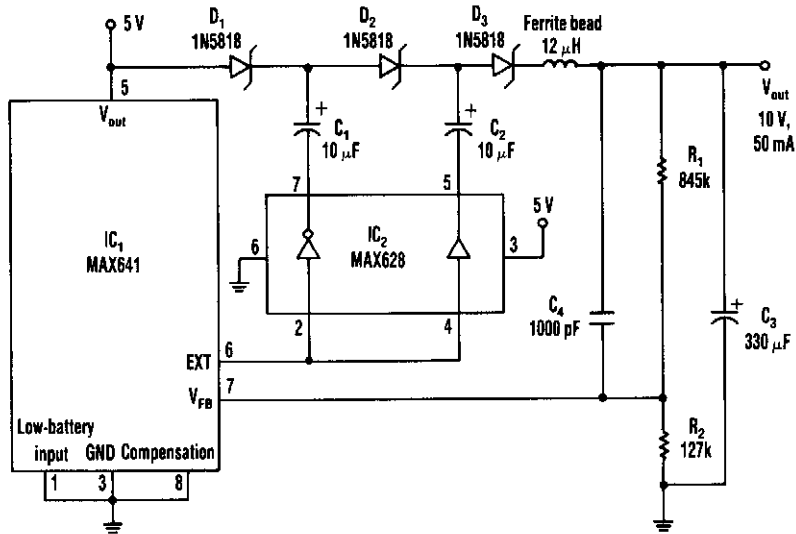


POPULAR ELECTRONICS

Fig. 63-6

Using two power MOSFETs, this inverter can deliver ac or dc up to several hundred volts. T1 is a 12.6-V CT to 120-, 240-, or 480-V transformer for 60-Hz application.

REGULATED CHARGE PUMP



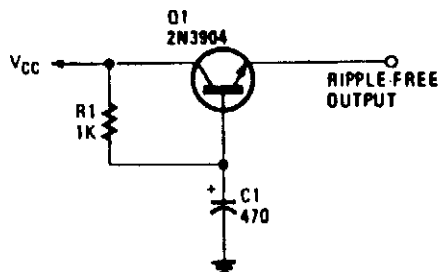
ELECTRONIC DESIGN

Fig. 63-7

The dc-dc converter substitutes a voltage tripler in place of the external inductor and the diode that's typically associated with the switching regulator, IC1. Inverting and noninverting amplifiers in the MOS-FET-driver (IC2) activate a diode-capacitor tripling network (D1 through D3, C1 through C3).

A 50-kHz oscillator residing within IC1 produces the EXT signal (pin 6). IC2 converts this signal into drive signals (180° out of phase) for the tripler. The resulting charge-discharge action in the capacitors recharges C3 toward 10 V every $20 \mu\text{s}$. The ferrite bead limits output ripple to about 20-mVpp for a 50-mA load. Conversion efficiency is about 70% for the 5-V input, 10-V output configuration.

SIMPLE RIPPLE SUPPRESSOR

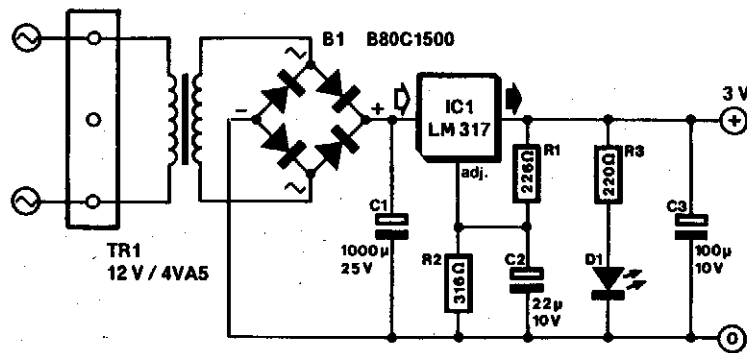


WELS' THINK TANK

Fig. 63-8

This circuit, at times called a *capacitance multiplier*, is useful for suppressing power-supply ripple. C1 provides filtering equal to a capacitor of $(B + 1) C_1$, where $B = \text{dc current gain of } Q1$ (typically > 50).

3-V POWER SUPPLY FOR PORTABLE RADIOS



ELEKTOR ELECTRONICS

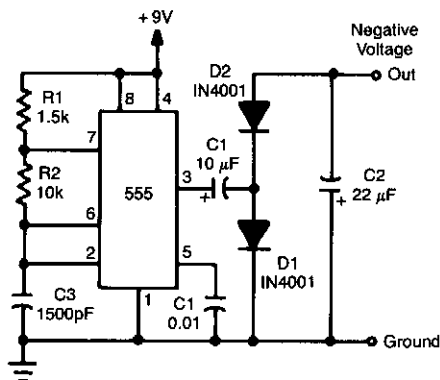
Fig. 63-9

Most small portable radios require a 3-V supply, which is normally provided by two AA or AAA batteries. Because rechargeable batteries are an option with many of these radios, most of them are fitted with a charger socket. When such radios are used in a stationary condition (e.g., in the kitchen or in the office), it is useful (and economical) to use the mains-operated supply described here.

The supply is small enough to be fitted inside the radio or in a mains adapter case (less than transformer). Voltage regulator IC1 is adjusted for an output of 3 V by resistors R1 and R2, which are decoupled by C2. Capacitor C3 provides additional filtering. Diode D1 indicates whether the unit has been connected to the mains. The diode also provides the load necessary for the regulator to function properly; in its absence, the secondary voltage of the transformer might become too high when the unit is not loaded.

The transformer should be a short-circuit-proof miniature type, which is rated at 12 V and 4.5 VA. The secondary voltage is slightly higher than needed for a radio, but this reserve is useful when the unit is used with a cassette or CD player. It is advisable to check the output voltage of the unit when it is switched on for the first time before connecting it to a radio or cassette player.

NEGATIVE VOLTAGE FROM A POSITIVE SUPPLY

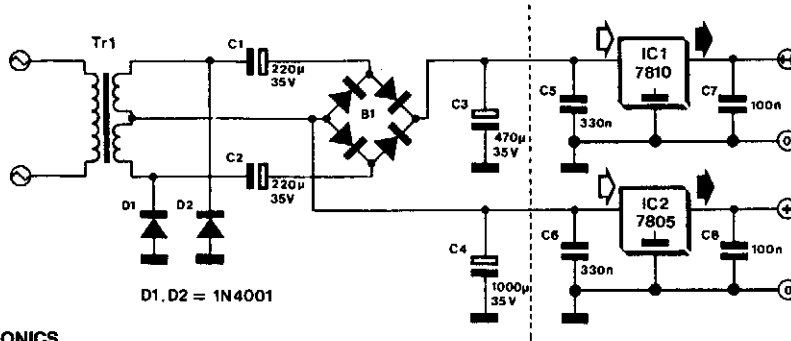


RADIO-ELECTRONICS

Fig. 63-10

By using a 555 timer to generate a square wave and voltage-doubling the output, a negative voltage that is almost equal to the positive supply can be obtained. The current available is up to 20 to 30 mA or so, depending on the regulation and voltage needed.

BRIDGE RECTIFIER



ELEKTOR ELECTRONICS

Fig. 63-11

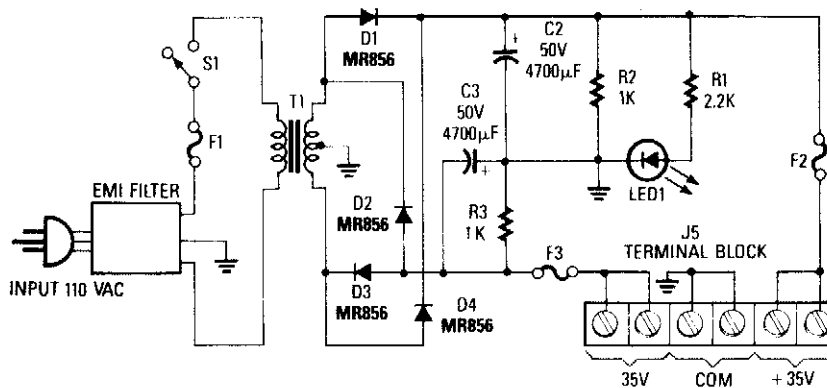
This bridge circuit is intended for those cases where two unequal supply voltages are required. The lower voltage is obtained with the aid of a transformer with symmetric windings and half-wave rectification of the potential across one winding.

For the higher voltage, the potential across both windings is rectified. To that end, the output of the transformer is linked to the bridge rectifier via two electrolytic capacitors that provide isolation of the two direct voltages.

A bonus with this type of circuit is that although the two supplies can be loaded unequally, the currents through the two transformer windings are the same. Thus, the transformer is loaded symmetrically so that its full capacity can be used. Moreover, no unnecessary dissipation is in the voltage regulators.

The load on the lower voltage supply depends primarily on the rating of the transformer. The load on the higher voltage supply is limited by the reactance of C_1 and C_2 ($= 1/2 \pi 50 C$) and the required minimum output voltage.

± 35-V SUPPLY FOR AUDIO AMPLIFIERS

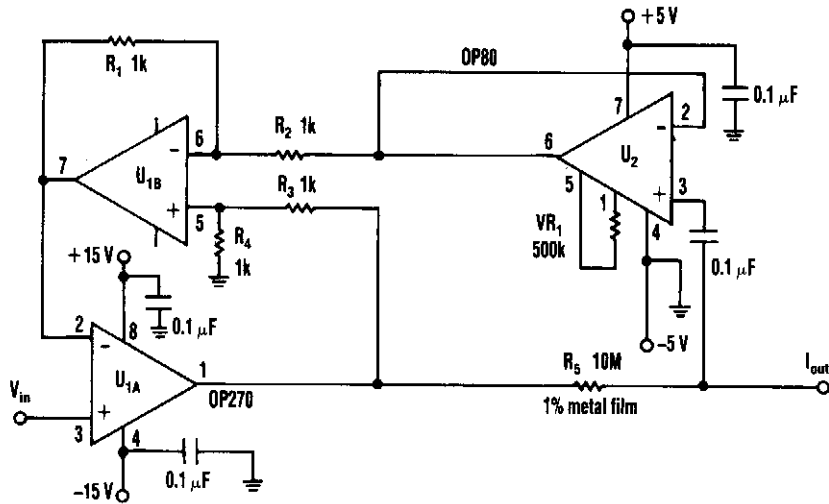


RADIO-ELECTRONICS

Fig. 63-12

This supply will be found useful for operating various transistor AF power amplifiers in the 50- to 100-W output range. T1 = 120 V: 70 V CT at 5 A.

PRECISE LOW-CURRENT SOURCE



ELECTRONIC DESIGN

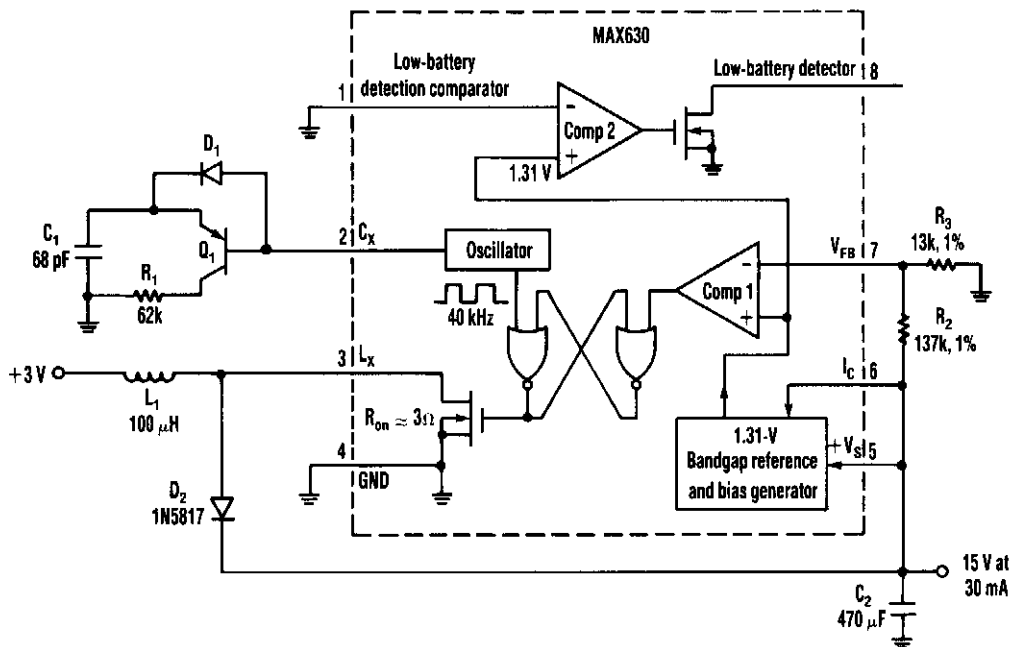
Fig. 63-13

A current source that attains a resolution as low as 10 pA is useful in applications where a precise, low-value current is needed. When the circuit forces current into ground, the output remains within 2% of the ideal current over the $\pm 100\text{-nA}$ range. Over the -4- to $+3.5\text{-V}$ compliance range, the error that appears is less than 5%. This accuracy results from using an OP80 op amp from Precision Monolithics in the feedback loop. The OP80 has an I_B of 200 μA typical.

For a given voltage (V_{in}), amp U1A generates an output voltage so that the current through R5 equals V_{in} divided by R_5 (10 M Ω). This current causes a voltage drop across R5, which is sensed by the unity-gain differential amp (U1B and U2). That amp's output is connected to the inverting input of U1A, completing the feedback loop.

The noise in the circuit is of particular concern, especially that produced by resistor R5. The circuit is limited to low-frequency and dc applications as a result of its 400-nV/kHz noise. For applications that don't require the circuit's 10-pA output, lower values of R_5 can be substituted. This will increase the bandwidth.

3- TO 15-V dc-dc CONVERTER

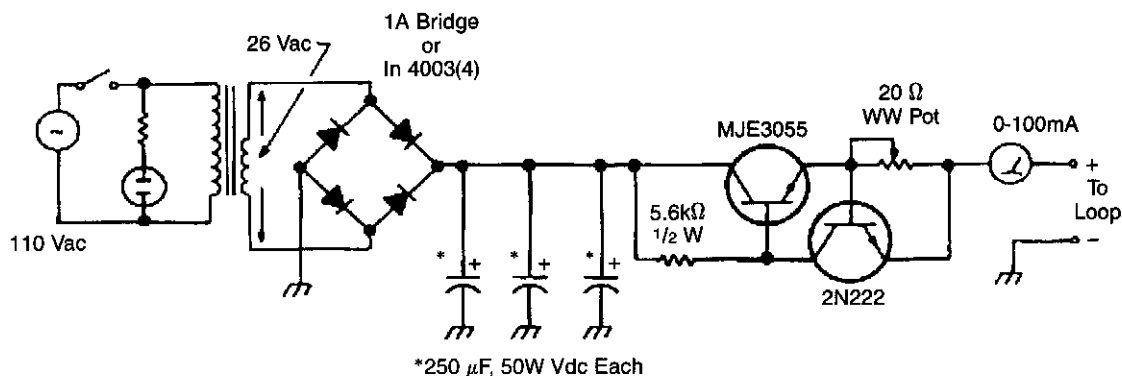


ELECTRONIC DESIGN

Fig. 63-14

This circuit supplies 15 V at 30 mA from a 3-V source. The MAX630 IC is dc-dc converter, Q1 and D1 modify the duty cycle from 50% to 80% to optimize the output power.

CURRENT SUPPLY FOR RTTY MACHINES

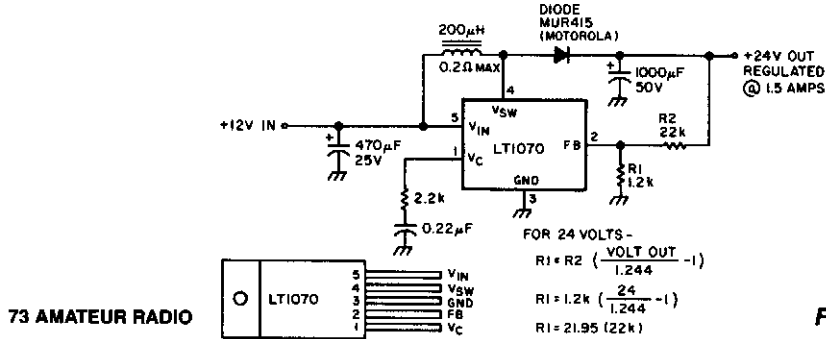


AMATEUR RADIO

Fig. 63-15

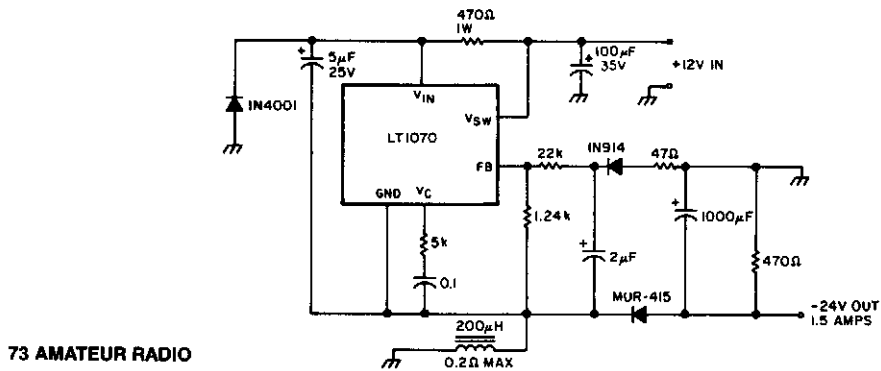
Suitable for powering an old Model 15 Teleprinter, this simple power supply uses few parts and is simple to construct. The 20-Ω pot adjusts loop current.

+24-V 1.5-A SUPPLY FROM A +12-V SOURCE



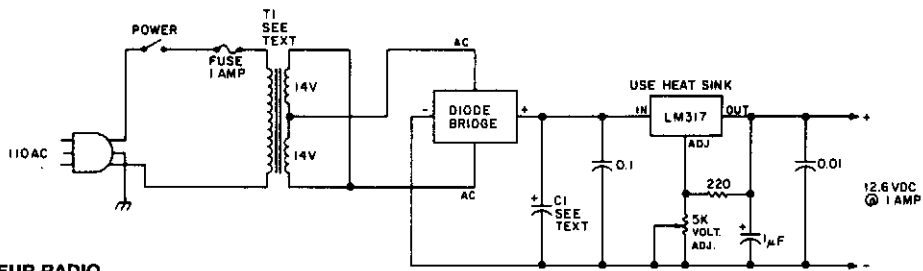
This switching regulator will produce 1.5 A at 24 V from a 12-V auto battery. It operates as a boost-switching supply using an LT 1070. The diode should be a fast-switching type because this regulator operates above 10 kHz.

NEGATIVE SUPPLY FROM A +12-V SOURCE



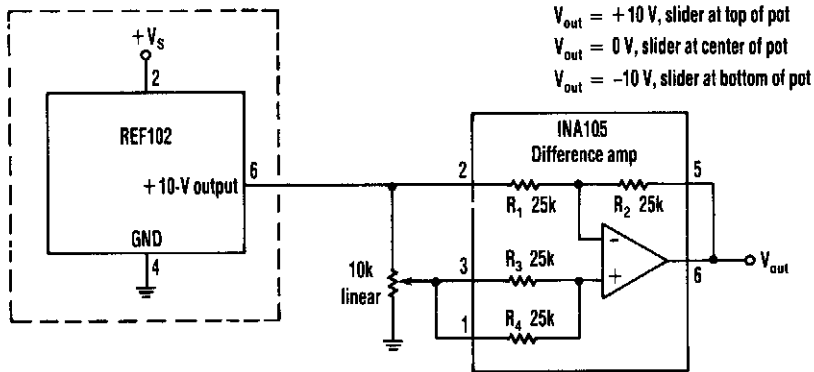
This switching regulator will produce a -24-V/1.5-A source from a +12-V supply, for applications where a positive-grounded source is necessary.

1-A 12-V REGULATED SUPPLY



Using a junked VCR power transformer, this circuit supplies 12 V at 1 A.

POSITIVE AND NEGATIVE VOLTAGE POWER SUPPLY



ELECTRONIC DESIGN

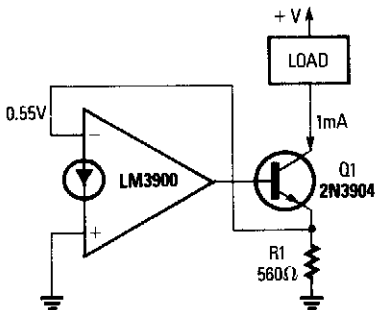
Fig. 63-19

This circuit provides a precision voltage source that can be adjusted through zero to positive and negative voltages, which eliminates reversing connections on the power supply. Also, it is possible to get exactly 0 V, without some offset.

As to how this circuit works, first consider the -1 V/V to $+1\text{ V/V}$ linear gain-control amp (see the figure). A Burr-Brown INA105 difference amp is used in a unity-gain inverting amp configuration. A potentiometer is connected between the input and ground.

The pot's slider is connected to the noninverting input of the unity-gain amp; this input is typically connected to ground. With the slider at the bottom of the pot, the circuit is a normal-precision unity-gain inverting amp with a gain of $-1.0\text{ V/V} \pm 0.01\%$ maximum. With the slider at the top of the pot, the circuit is a normal-precision voltage follower with a gain of $\pm 1.0\text{ V/V} \pm 0.001\%$ maximum. With the slider in the center, there's equal positive and negative gain for a net gain of 0 V/V. The accuracy between the top and the bottom will usually be limited by the accuracy of the pot.

1-mA CURRENT SINK

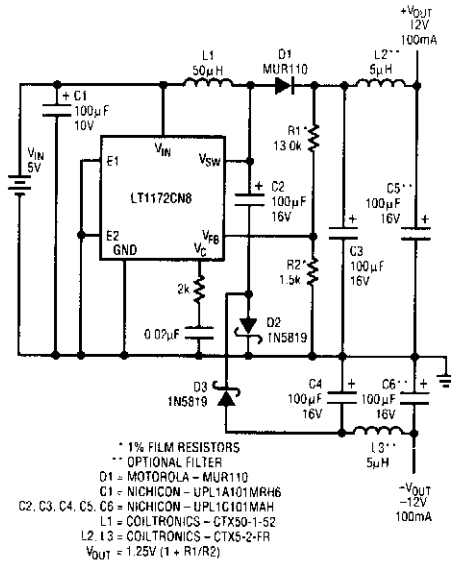


RADIO-ELECTRONICS

Fig. 63-20

A fixed current flows through any load that is connected between the positive supply and Q1's collector. The noninverting terminal of the op amp is grounded, and negative feedback flows between the output of the circuit (Q1's emitter) and the inverting terminal. The voltage across R1 is thus equal to the voltage at the inverting terminal (approximately 0.55 V), so a fixed current of about 1 mA flows through the load, Q1's emitter, and R1.

POSITIVE AND NEGATIVE VOLTAGE SWITCHING SUPPLY

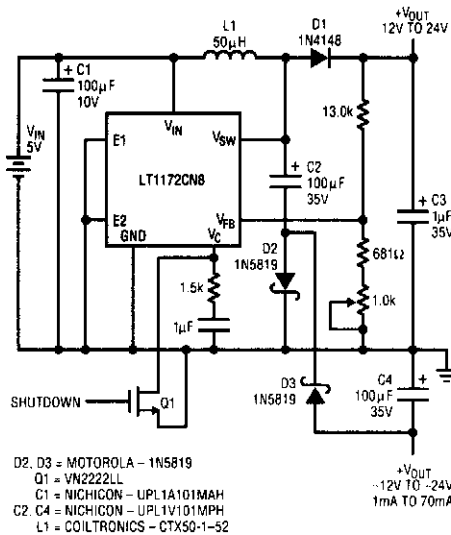


An LT1172 generates positive and negative voltages from a 5-V input. The LT1172 is configured as a step-up converter. To generate the negative output, a charge pump is used. C2 is charged by the inductor when D2 is forward-biased and discharges into C4 when LT1172's power switch pulls the positive side of C2 to ground.

LINEAR TECHNOLOGY

Fig. 63-21

LCD DISPLAY CONTRAST CONTROL POWER SUPPLY

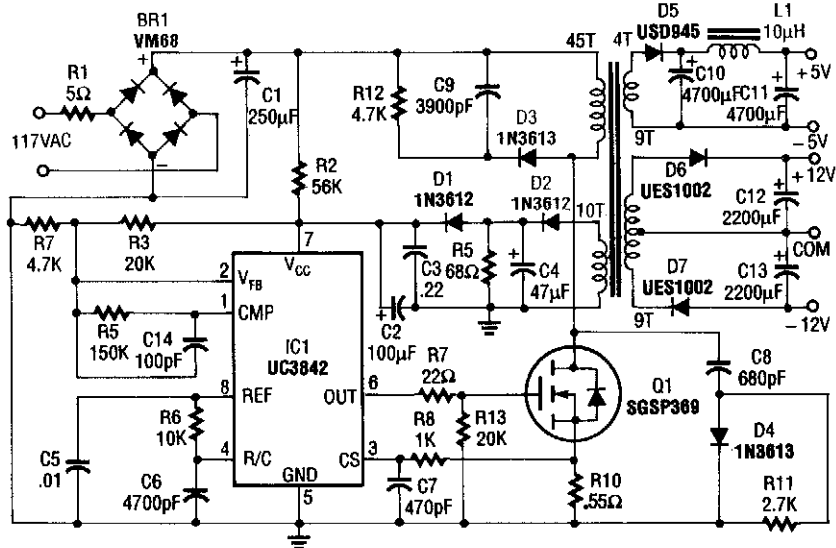


The LT1172 is configured as a step-up converter. C2 is charged by L1 and discharges into C4 when the LT1172's power switch goes to ground. Resistor R3 adjusts the output voltage between -12 and -24 V.

LINEAR TECHNOLOGY

Fig. 63-22

5- AND ± 12 -V ac-POWERED SWITCHING SUPPLY

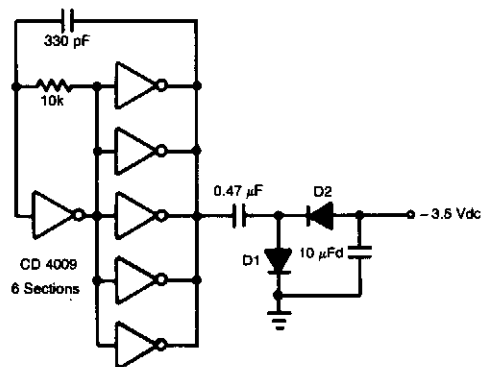


RADIO-ELECTRONICS

Fig. 63-23

This supply uses an SGS-Thomson UC3842 IC in an off-line flyback regulator, providing +5 V at 4 A and ± 12 V at 300 mA. This enables a small high-frequency (50 kHz) transformer, to handle large amounts of power that are normally handled by a 60-Hz transformer. Q1 is a 5-A 500-V MOSFET, and the diodes are fast-recovery types. T1 has a 45-turn primary winding of #26 wire. The 12-V windings are each 9 turns of #30 wire, bifilar wound. The 5-V winding is 4 turns of four bifilar #26 wires. The control (feedback) winding is two bifilar, parallel 10-turn, #30 windings. The core is Ferroxcube EC35-3C8 with a $3/8$ " center leg.

AUXILIARY NEGATIVE dc SUPPLY FOR BIAS OR REFERENCE APPLICATIONS

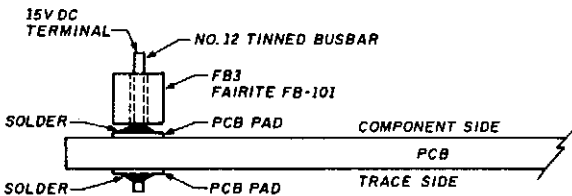
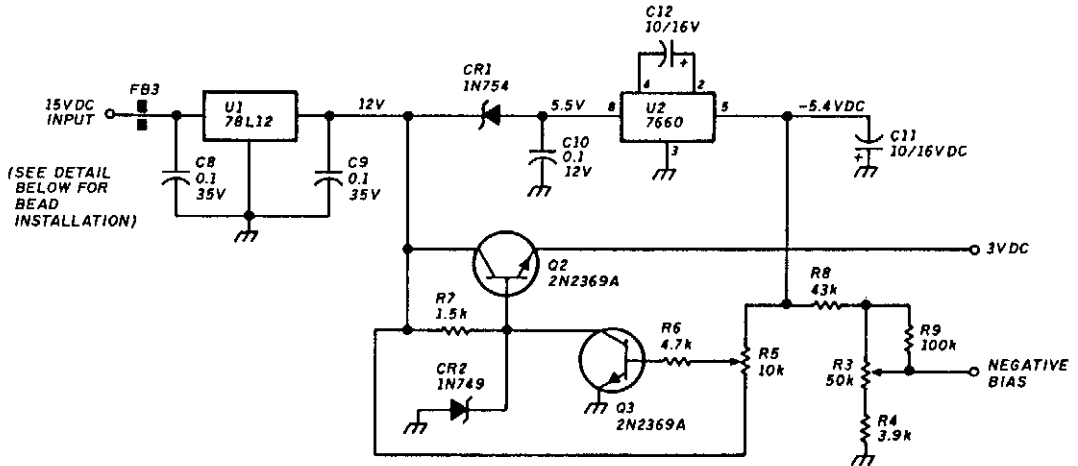


ELEKTOR ELECTRONICS

Fig. 63-24

In this circuit, IC1 (CD4009) is used as a square-wave oscillator at approximately 25 kHz. C1 and R1 set this frequency. C2, D1, D2, and C3 form a p-p rectifier, which outputs about -3.5 Vdc. This circuit should be useful where a small negative dc supply is required, but only positive dc voltages are available.

GASFET POWER SUPPLY

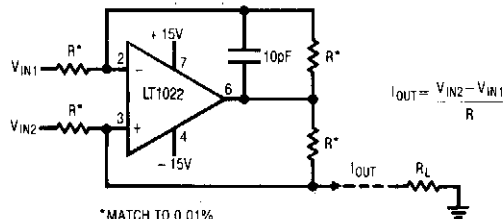


HAM RADIO

Fig. 63-25

Suitable for use with the GASFET doubler in this text, and other similar applications, this supply delivers +3 Vdc and 0 to -3 Vdc bias.

FAST DIFFERENTIAL INPUT CURRENT SOURCE



*MATCH TO 0.01%
 FULL-SCALE POWER BANDWIDTH
 = 1MHz FOR $I_{OUT}R = 8V_{p-p}$
 = 400kHz FOR $I_{OUT}R = 20V_{p-p}$
 MAXIMUM $I_{OUT} = 10mA_{p-p}$

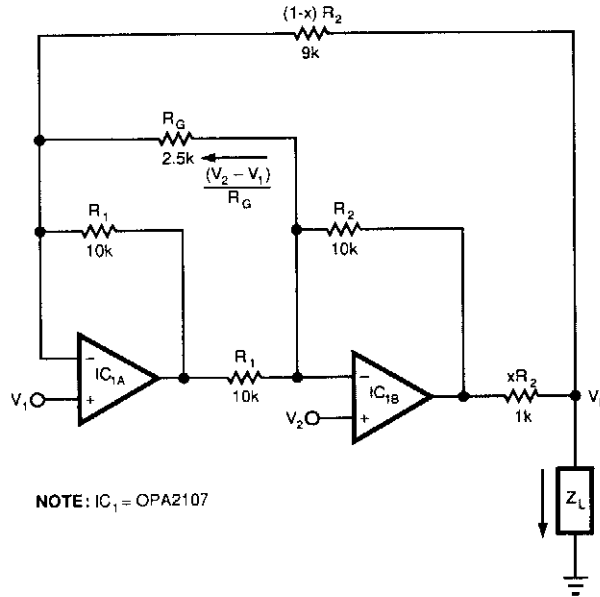
COMMON-MODE VOLTAGE AT LT1022 INPUT = $\frac{I_{OUT} \times R_L}{2}$

LINEAR TECHNOLOGY

Fig. 63-26

An LT1022 op amp used in this configuration can provide a rapidly switched current source. Use the equations in the figure to select component values.

BOOTSTRAPPED AMP CURRENT SOURCE

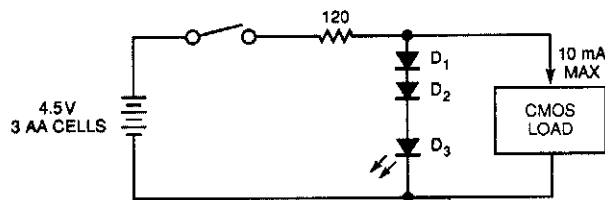


EDN

Fig. 63-27

This circuit responds to the difference between V_1 and V_2 . R_G sets gain. Resistors xR_2 and $(1-x)R_2$ produce the bootstrap effect. These two resistors convert the circuit's output voltage to a current. IC1 and IC2 are Burr-Brown OPA2107 or equal.

DIODE CMOS STABILIZER



Voltage regulation

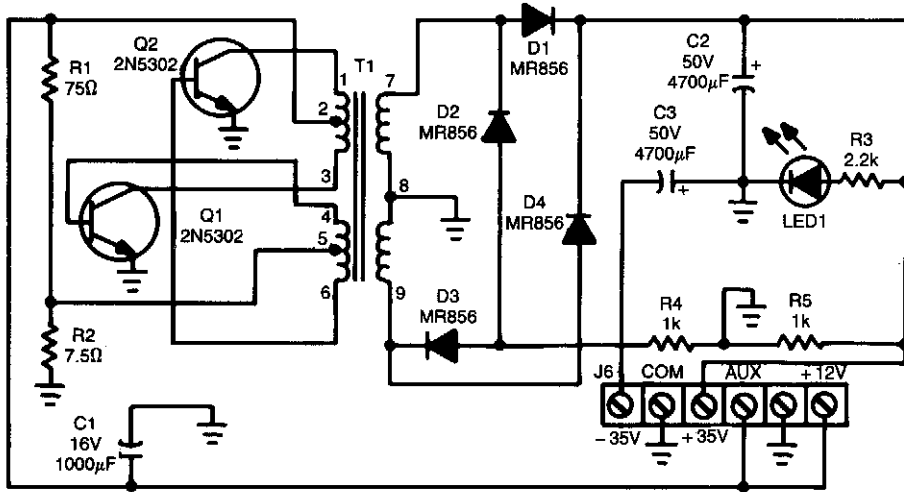
Input	4.5 V	4 V	3.5 V	3.2 V	3 V	2.8 V
Output	3.28 V	3.21 V	3.14 V	3.05 V	2.94 V	2.8 V
LED	on	on	on	on	on	off

EDN

Fig. 63-28

The simple diode network can stabilize the voltage supplied to CMOS circuitry from a battery. D1 and D2 must have a combined forward-voltage drop of about 1.5 V. And D3 is an LED with a forward-voltage drop of about 1.7 V. The table shows the network's output voltage as the battery's voltage declines.

MOBILE ± 35 -V 5-A AUDIO AMPLIFIER SUPPLY



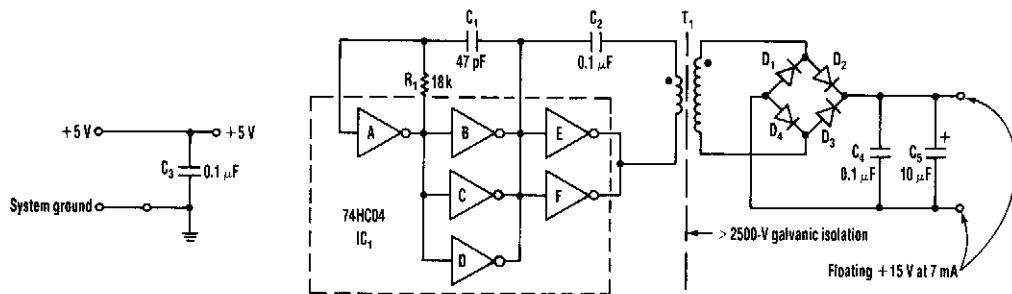
RADIO-ELECTRONICS

Fig. 63-29

This ± 35 -V supply uses a two-transistor multivibrator with a toroidal transformer. The transformer core is obtainable from Magnetics, Inc. Specifications for T1 are:

Core	1 mil tape wound Magnetics, Inc.	1.460" \times 0.915" \times 0.345" P/N 50029 ID
Primary	14T CT	#12 AWG
Base Drive	7T CT	#18 AWG
Secondary	19T CT	#12 AWG

ISOLATED 15-V TO 2 500-V SUPPLY

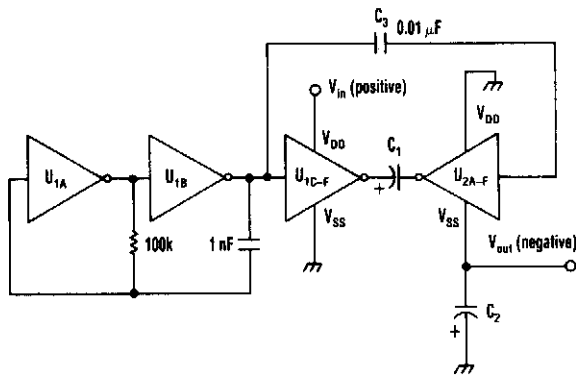


ELECTRONIC DESIGN

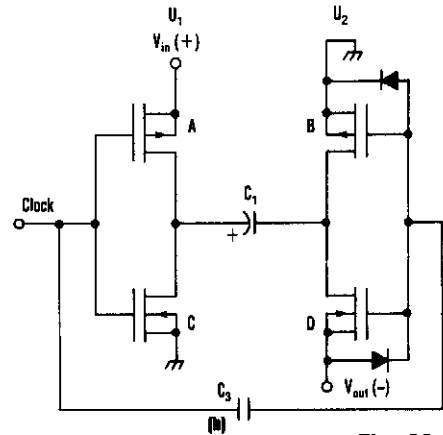
Fig. 63-30

A dc-dc converter using a 74HC04 drives T1. T1 is a ferrite-core transformer using a Fair-Rite, Inc. P/N 5975000201 ($\mu_o + 5000$) and has a 7-turn primary and a 25-turn secondary. Kynar, #30 wirewrap wire is used. With T1, the circuit isolation is good to 2 500 V.

GET NEGATIVE RAIL WITH CMOS GATES



(a)



(b)

Fig. 63-31

ELECTRONIC DESIGN

Using a charge pump and oscillator, this circuit uses a 7-kHz oscillator. When the clock is high, C and D are on, grounding the positive side of C1 and making negative voltage available at the V_{SS} terminal of U2. With $C = C_1 + C_2$, the p-p output ripple is:

$$V_{pp} \text{ ripple} = \frac{V_{in}}{2RFC}$$

Converter output impedance is about 100 Ω and maximum current is 10 mA dc.

3-A SWITCHING REGULATOR

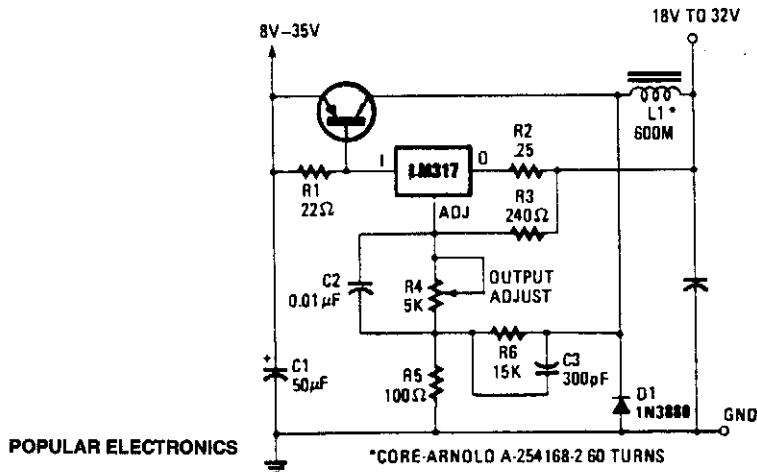


Fig. 63-32

This switching regulator uses an LM317 and a pnp switching transistor of 3- to 5-A rating. L1 is wound on a commercially available core.

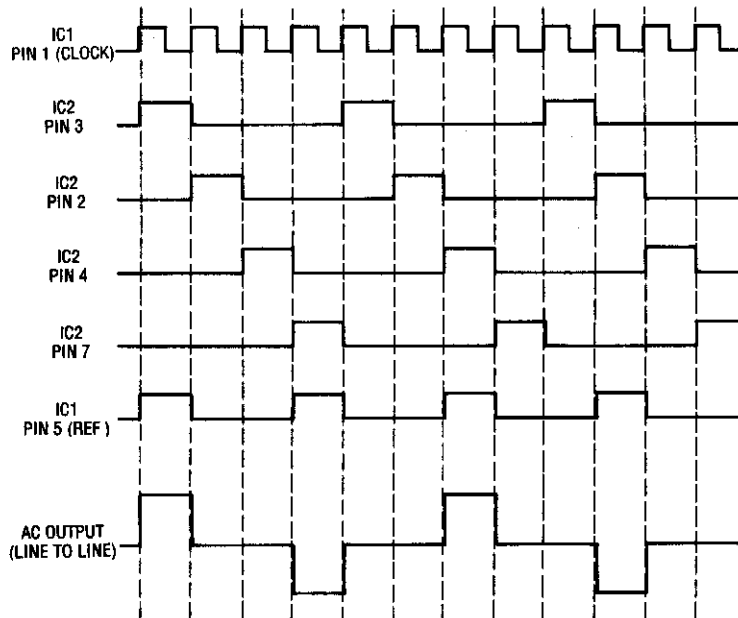
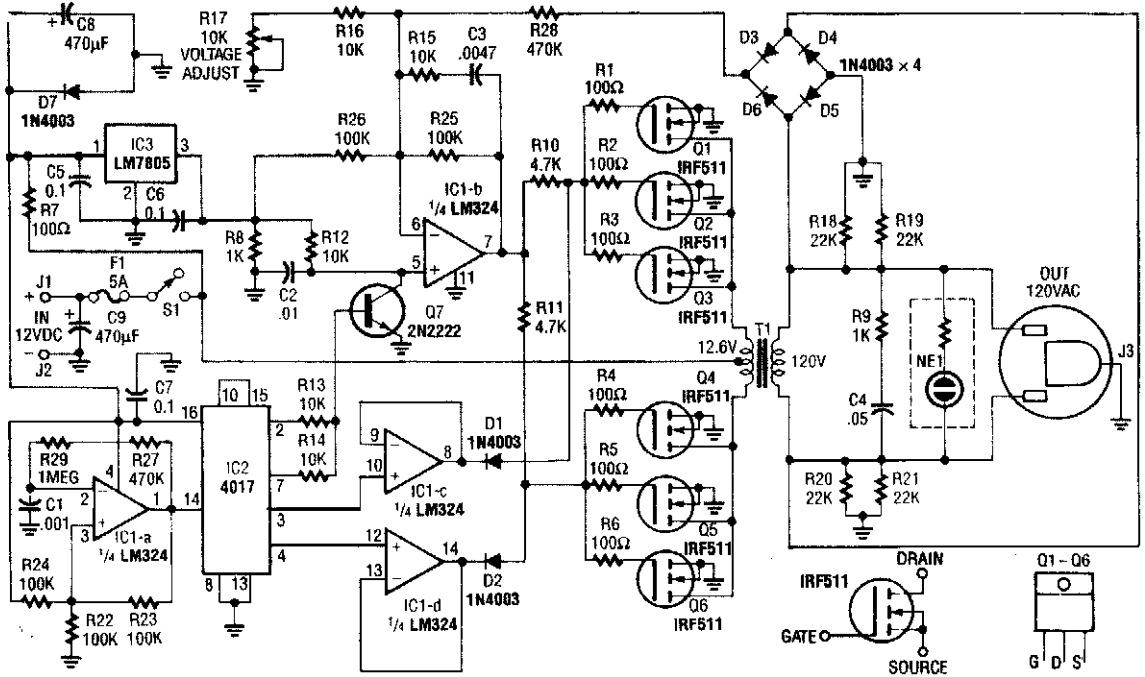
64

Power Supplies (High-Voltage)

The sources of the following circuits are contained in the Sources section, which begins on page 674. The figure number in the box of each circuit correlates to the entry in the Sources section.

40-W 120-Vac Inverter
Cold-Cathode Fluorescent-Lamp Supply
High-Voltage Pulse Supply
High-Voltage Generator
Strobe Power Supply

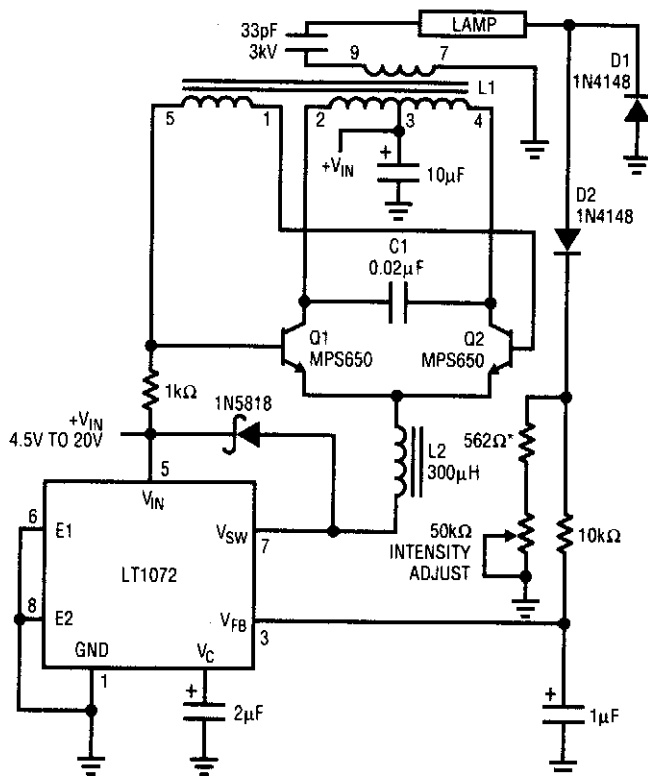
40-W 120-Vac INVERTER



40-W 120-Vac INVERTER (Cont.)

This inverter uses a 12.6-V to 120-V transformer to deliver a quasi-sine wave that has the same rms and peak voltage as a pure sine wave. Q1 to Q6 must be heatsinked. A 1.5" x 4" aluminum heatsink was used on the prototype. The transformer should be a 3-A unit. The circuit uses feedback to help regulate the output voltage to 120 Vac. Notice that the output frequency is 75 Hz to avoid saturating the core of T1.

COLD-CATHODE FLUORESCENT-LAMP SUPPLY



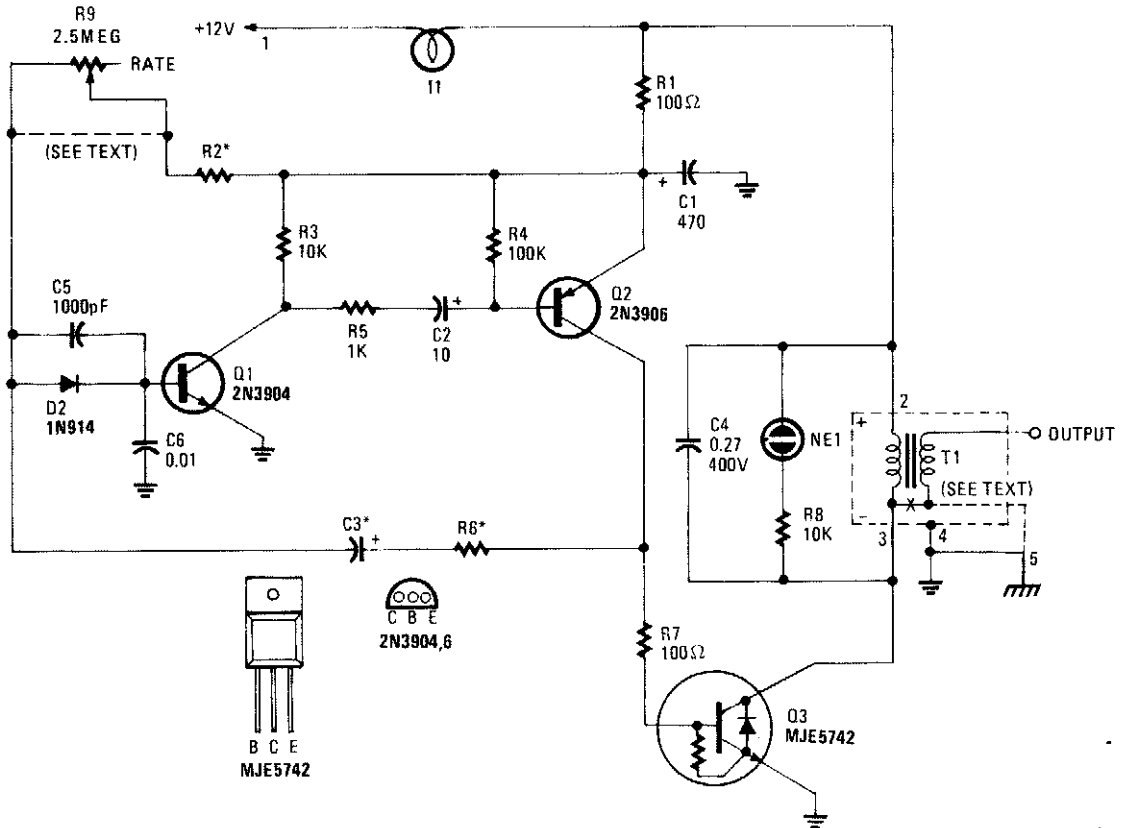
- C1 = MUST BE A LOW LOSS CAPACITOR.
METALIZED POLYCARB
WIMA FPK 2 (GERMAN) RECOMMENDED.
- L1 = SUMIDA 6345-020 OR COILTRONIX CTX110092-1.
PIN NUMBERS SHOWN FOR COILTRONIX UNIT
- L2 = COILTRONIX CTX300-4
- * = 1% FILM RESISTOR
- DO NOT SUBSTITUTE COMPONENTS

LINEAR TECHNOLOGY

Fig. 64-2

For back-lit LCD displays, this supply will drive a lamp. LT1072 drives Q1 and Q2, and a sine wave appears across C1. L1 is a transformer that steps up this voltage to about 1400 V. D1 and D2 detect lamp current and form a feedback loop to the LT1072 to control lamp brightness.

HIGH-VOLTAGE PULSE SUPPLY



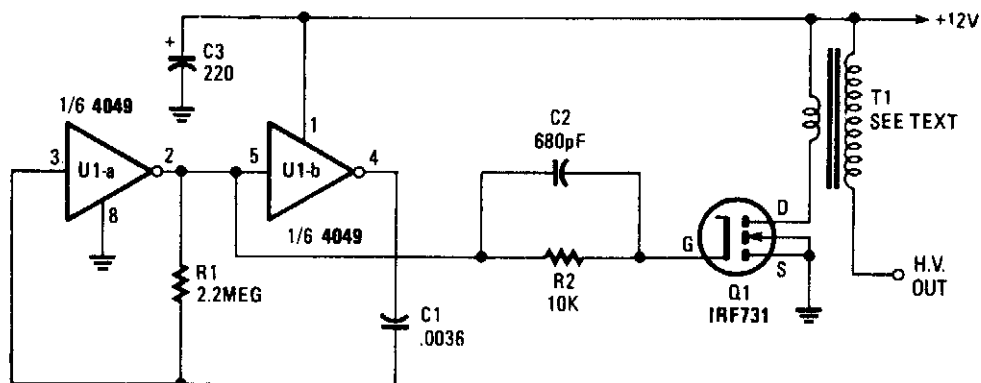
RADIO-ELECTRONICS

Fig. 64-3

This high-voltage pulse supply will generate pulses up to 30 kV. Q1 and Q2 form a multivibrator in conjunction with peripheral components R1 through R6 and C1, C2, C3, C5, C6, and D2. R9 adjusts the pulse repetition rate. R2 should be selected to limit the maximum repetition rate to 20 Hz. I1 is a type 1156 lamp used as a current limiter. R9 can be left out and R2 selected to produce a fixed rate, if desired. Try about 1 MΩ as a start.

Q3 serves as a power amplifier and switch to drive T1 (an automotive ignition coil). NE1 is used as a pulse indicator and indicates circuit operation. Because this circuit can develop up to 30 kV, suitable construction techniques and safety precautions should be observed.

HIGH-VOLTAGE GENERATOR

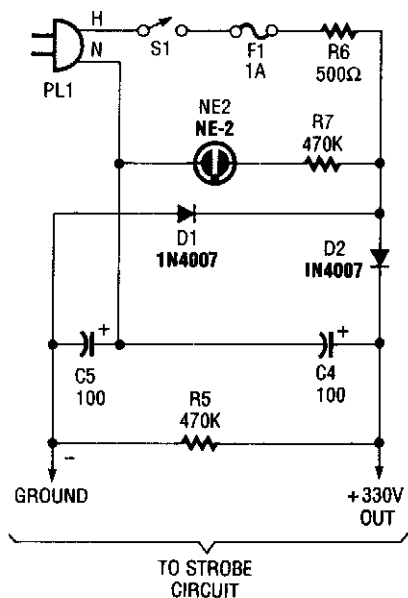


POPULAR ELECTRONICS

Fig. 64-4

A 4049 Hex inverter drives an IRF731 hex FET. The 4049 is configured as an oscillator. Q1 should be heatsinked. T1 is an auto ignition coil.

STROBE POWER SUPPLY



RADIO-ELECTRONICS

Fig. 64-5

This 330-V power supply is a simple voltage doubler which provides 330 Vdc for a strobe circuit. This supply is not isolated from the power lines and extreme caution is advised.

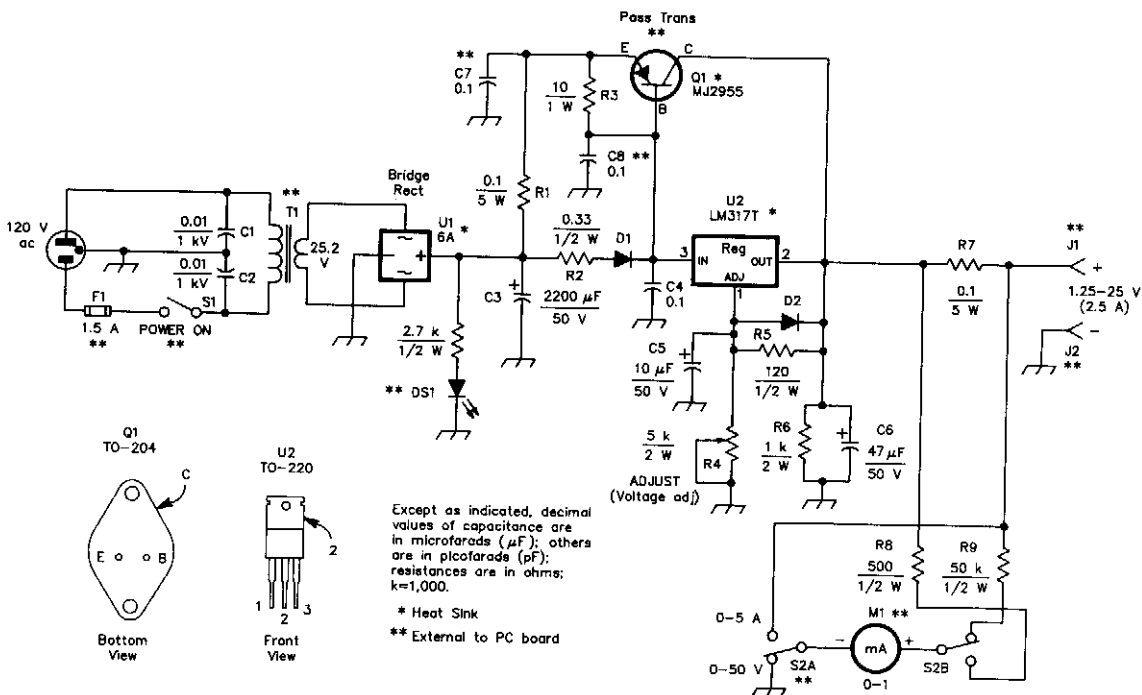
65

Power Supplies (Variable)

The sources of the following circuits are contained in the Sources section, which begins on page 674. The figure number in the box of each circuit correlates to the entry in the Sources section.

2.5-A/1.25-to 25-V Regulated Power Supply
Dual 0-to 50-V/5-A Universal Power Supply
Step Variable dc Supply
SCR Variable dc Power Supply
Switch-Selected Fixed-Voltage Power Supply
Transformerless Power Supply
Voltage-Programmable Current Source
Simple Darlington Regulator
0-to 50-V Variable Regulator

2.5-A/1.25-to 25-V REGULATED POWER SUPPLY



D1, D2—1-A, 100-PIV rectifier diode.

DS1—Red LED.

F1—1.5-A, 3AG fuse in chassis-mount holder.

J1, J2—Standard five-way binding post, one red, one black.

M1—Milliammeter, 0-1 mA dc.

Q1—NPN power transistor MJ2955 (Radio Shack) or equiv device with a +70-V, 10-A, 150-W rating in a TO-204 case.

R1, R2, R7—5-W wire-wound resistor. See Notes 3 and 4 for source. or, use 17 inches of no. 28 enam wire, single-layer wound, on a 10-k Ω , 1-W carbon-composition resistor for R1 and R7. For R2, use 36 inches of no. 30 enam wire on a 10-k Ω , 1-W carbon composition resistor (scramble wound).

R4—Panel-mount, 5-k Ω , 2-W or 5-W potentiometer, carbon or wire wound (See Note 8).

R8, R9—See text.

S1—SPST toggle switch.

S2—DPDT toggle or rotary wafer switch.

T1—25.2-V, 2.75-A power transformer (see text).

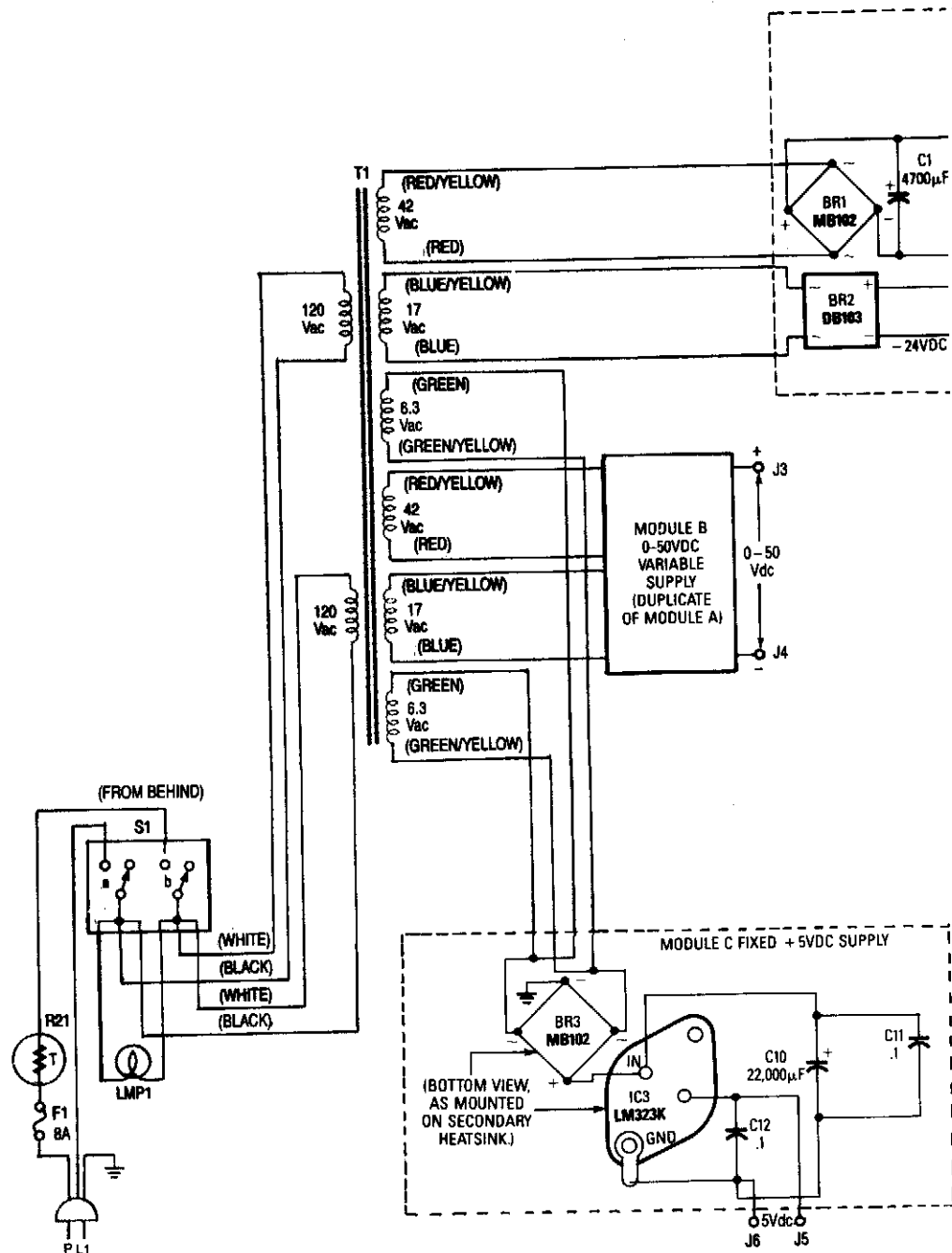
U1—6-A, 200 PIV bridge rectifier with heat sink. See text.

U2—LM317T + 1.25- to 30-V, 1.5-A TO-220 regulator. Use an LM317HVK (TO-204 case) for dc output voltage greater than 40. See text.

Fig. 65-1

This power supply uses an LM317J adjustable regulator and an MJ2955 pass transistor. Q1 and U2 as well as U1 should be heatsinked. A suitable heatsink would typically be 4" \times 4" \times 1" fins, extruded type, because up to 65 W dissipation can occur. R8 and R9 should be 1% types or selected from 5% film types with an accurate ohmmeter. Capacitors are disc ceramic except for those with polarity marked, which are electrolytic.

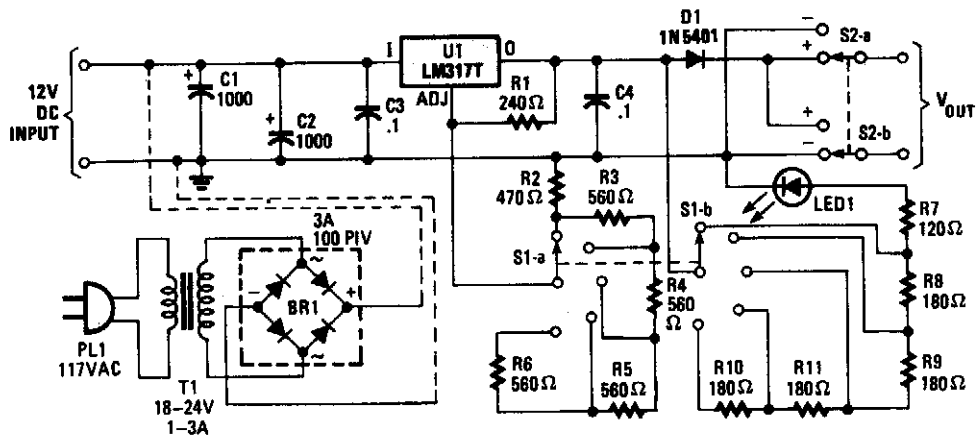
DUAL 0-to 50-V/5-A UNIVERSAL POWER SUPPLY



RADIO-ELECTRONICS

Fig. 65-2

STEP VARIABLE dc SUPPLY

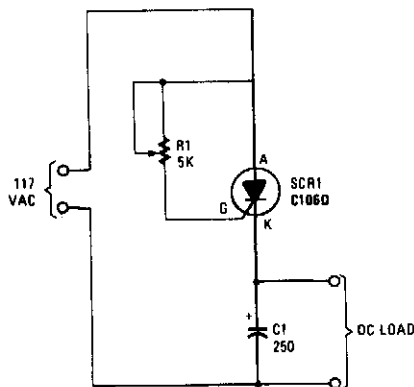


POPULAR ELECTRONICS

Fig. 65-3

Intended as a replacement for generally poorly regulated "wall-type" ac/dc adapters, this circuit offers superior performance to simple, unregulated adapters. Voltages of 3, 6, 9, and 12 V are available. The DPDT switch serves as a polarity-reversal switch. R2 through R6 can be replaced with a 2.5-k Ω pot for a variable voltage of 1 to 12 V. R7 through R10 can be replaced by a fixed resistor of about 1 k Ω if the LED1 brightness variation with output voltage is not a problem.

SCR VARIABLE dc POWER SUPPLY

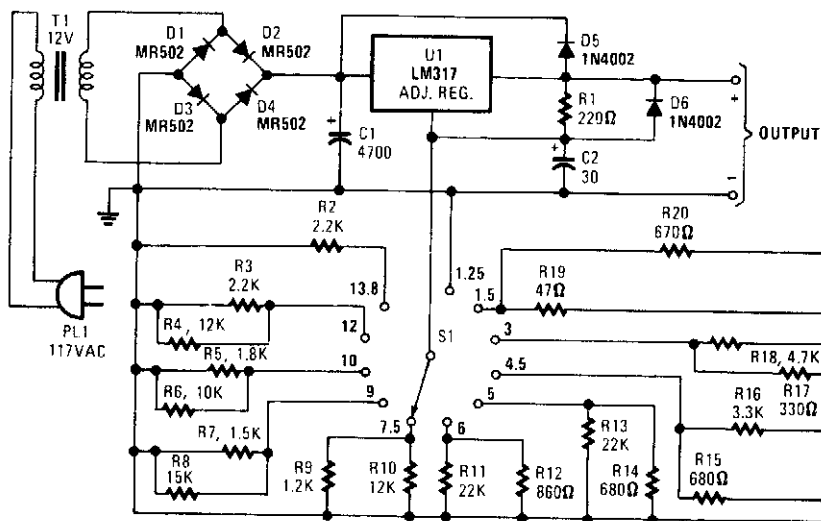


HANDS-ON ELECTRONICS

Fig. 65-4

By adjusting the SCR trigger point, a form of phase control can be obtained from an SCR, which produces a dc output, depending on the conduction angle.

SWITCH-SELECTED FIXED-VOLTAGE POWER SUPPLY



POPULAR ELECTRONICS

Fig. 65-5

This supply can serve as a battery eliminator for various devices (such as tape recorders, small radios, clocks, etc.).

S1 selects a resistance that is predetermined to provide a preselected output voltage. In this circuit, various commonly used supply voltages produced by batteries were chosen, but any voltages up to the rating of T1 (approximately) can be produced by choosing an appropriate resistor.

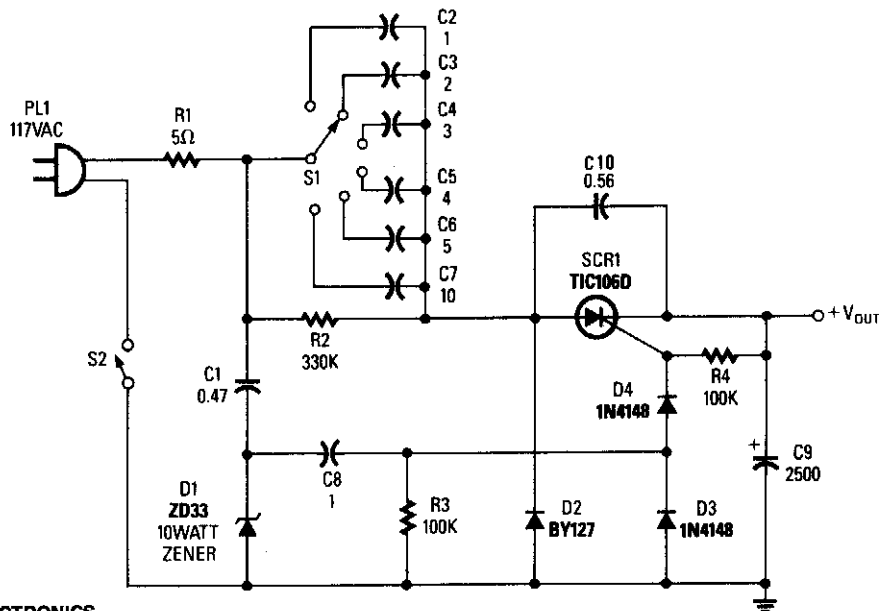
The resistor value is given by:

$$R_x = R_1 \left(\frac{V_{OUT}}{1.25} - 1 \right)$$

$$R_1 = 220 \Omega$$

Remember to provide adequate heatsinking for U1.

TRANSFORMERLESS POWER SUPPLY



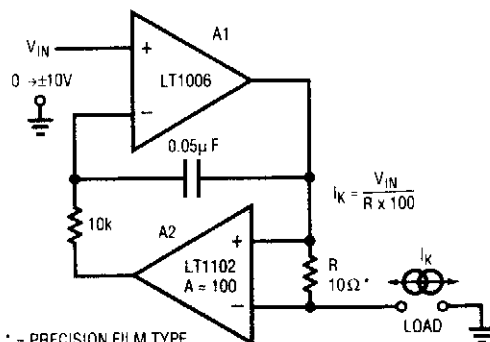
POPULAR ELECTRONICS

Fig. 65-6

By selecting capacitors, various voltages can be obtained from this supply. Notice that C2 through C7 must be nonpolarized capacitors, such as oil-filled or foil types (Mylar) rated for at least 250 Vac.

Warning: This supply is not isolated from the ac mains and presents a serious safety hazard if body contact is made anywhere to this circuit or anything that is powered by it. Use only for applications where contact is avoided or impossible.

VOLTAGE-PROGRAMMABLE CURRENT SOURCE

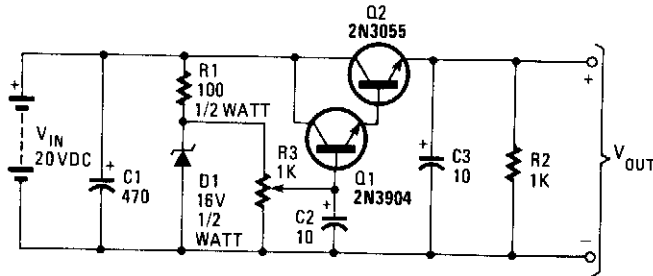


LINEAR TECHNOLOGY * = PRECISION FILM TYPE

Fig. 65-7

This circuit is a programmable current source in which op amp LT1102 (Linear Technology Corp.) is used in conjunction with LT1006 op amp. A1, biased by V_{in} , drives current through R (10 Ω) and the load. A2 senses this current and controls A1. The 10-kΩ resistor and 0.05-μF capacitor sets the frequency response of the circuit.

SIMPLE DARLINGTON REGULATOR

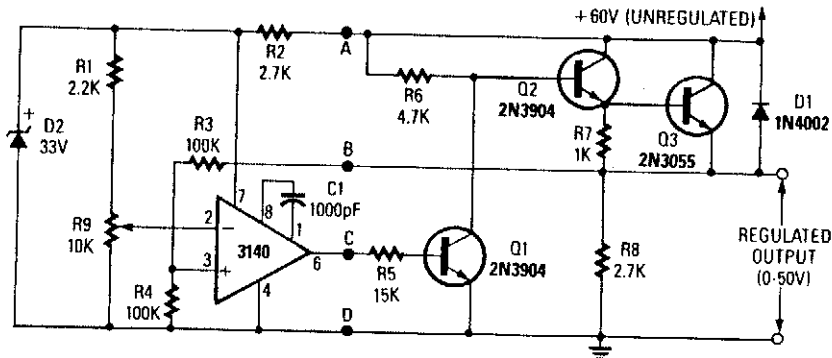


POPULAR ELECTRONICS

Fig. 65-8

A Darlington pair is used as an emitter-follower that produces about 1.2 V less than the wiper voltage of R3. Output voltage for this circuit will range from close to zero to about 14.5 V.

0-TO-50-V VARIABLE REGULATOR



RADIO-ELECTRONICS

Fig. 65-9

A CA3140 op amp compares the regulator output to a reference voltage, depending on the setting of R9. The output voltage will be nominally twice the voltage between the plus input of the CA3140 and ground. R1 and R9 allow 0 to 50 V.

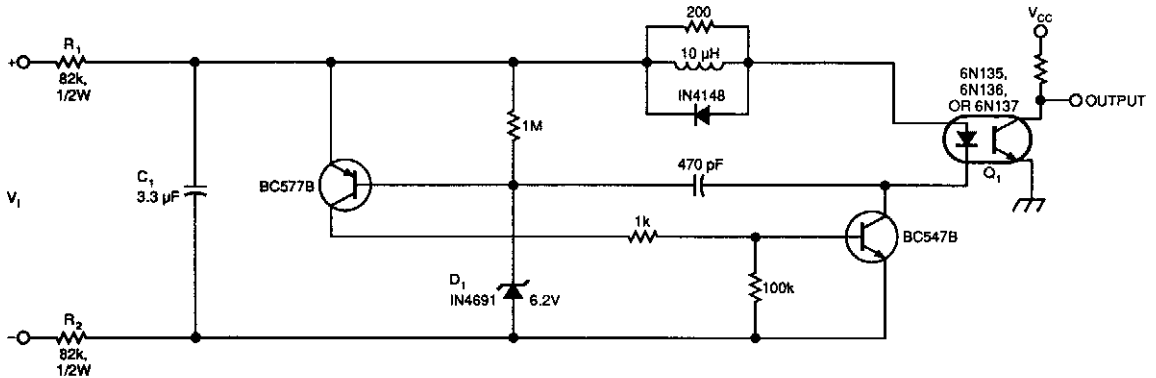
66

Power-Supply Monitors

The sources of the following circuits are contained in the Sources section, which begins on page 674. The figure number in the box of each circuit correlates to the entry in the Sources section.

Isolated Voltage Sensor
Circuit Breaker Tripper
Backup Supply Activates by Drop-In Main Supply
Constant-Current Test Load
Power Buffer Boosts Reference Current
Power Supply Monitor/Memory Protector
Tube Amplifier Isolates High Voltages
Triac ac-Voltage Control
Polarity-Protection Relay

ISOLATED VOLTAGE SENSOR



EDN

Fig. 66-1

A simple voltage-controlled oscillator (VCO), coupled to your instrumentation by an optoisolator, allows you to measure high voltages. The component values suit a 0- to 600-V input range (power dissipation in R1 and R2 set a limit on the input-voltage range). The circuit's linearity is not an issue, because you can linearize its output in software.

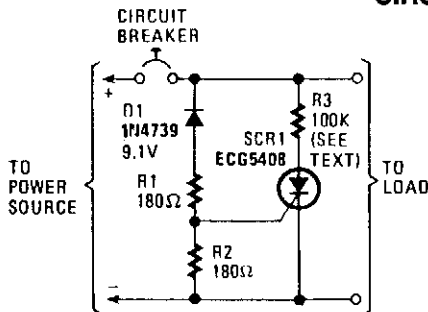
The input voltage (V_1), charges capacitor C1 until zener diode D1 conducts. Then, the zener diode triggers an "avalanche" circuit that discharges C1 into optocoupler Q1. After C1 discharges, the charging cycle repeats. C1 also averages the sensed-voltage level, which thereby provides noise immunity.

The optocoupler's output is a pulse train whose frequency increases with increasing input voltage. To develop a linearizing equation for the circuit, measure its output at two convenient, widely spaced input voltages. Then plug the resulting periods into this second-order polynomial approximation and solve the two simultaneous equations for the two constants, k_1 and k_2 :

$$V_1 = [k_1/T^2 + (k_2/T) + V_z]$$

V_z is the zener voltage of D1.

CIRCUIT BREAKER TRIPPER

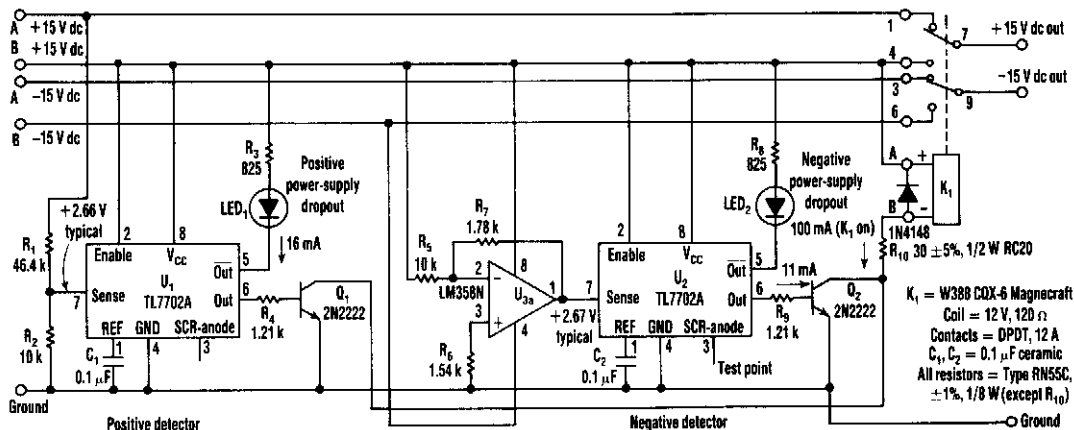


POPULAR ELECTRONICS

Fig. 66-2

This tripper is designed to protect against overvoltages. D1 conducts over 9.1 V and triggers SCR1. R3 is chosen to draw enough current to trip the breaker.

BACKUP SUPPLY ACTIVATES BY DROP-IN MAIN SUPPLY

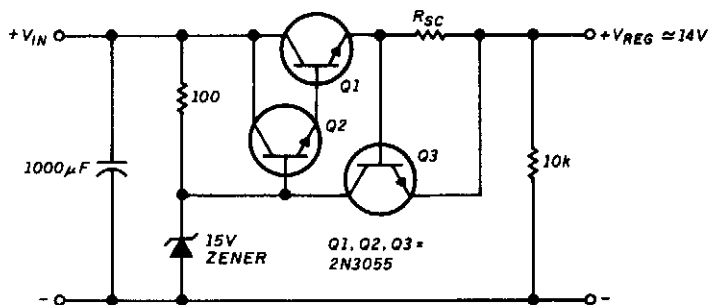


ELECTRONIC DESIGN

Fig. 66-3

A supply monitor using two TL7702A chips monitors the $\pm 15\text{-V}$ supplies and activates the backup supply in case of a voltage drop. Although the chips are intended for use as reset controllers in microprocessor systems, they work well in this application.

CONSTANT-CURRENT TEST LOAD

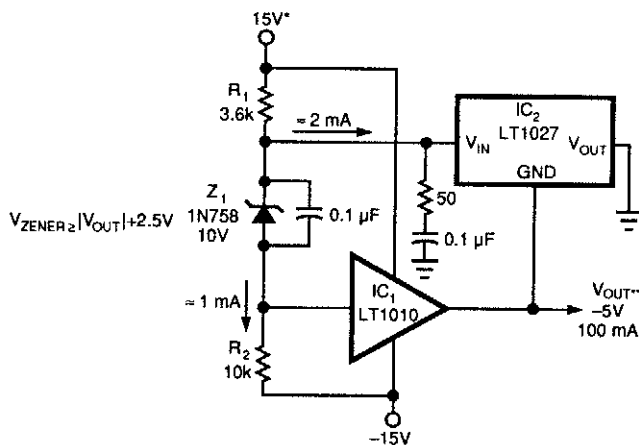


HAM RADIO

Fig. 66-4

This circuit will supply a constant load of 500 mA to 1.5 A. R4 controls the current while R3 provides fine adjustment.

POWER BUFFER BOOSTS REFERENCE CURRENT



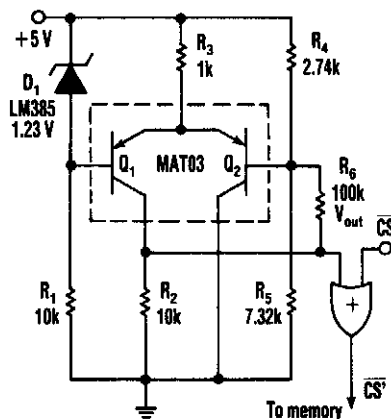
NOTES:
 * = BYPASS SUPPLIES WITH 10 μ F AND 0.1 μ F CAPACITORS
 ** = OUTPUT WILL OSCILLATE WITH LOW ESR CAPACITORS

EDN

Fig. 66-5

A method of boosting the output current of a reference and also protecting against overloads is shown in Fig. 66-5. IC1 acts as a power buffer. The LT1027 forces the output of V_{OUT} and ground to be 5 V. The RC damper (50 Ω and 0.1 μ F) provides loop stability. The output might oscillate if low ESR capacitors are connected to it, so use aluminum electrolytic or tantalum capacitors instead of ceramic or mylar.

POWER SUPPLY MONITOR/MEMORY PROTECTOR



ELECTRONIC DESIGN

Fig. 66-6

This circuit detects low-voltage supply conditions, down to 0.6 V. D1 sets the trip point of the circuit. The circuit is useful to protect memory circuits from accidental writes in the event of power-supply low-voltage conditions, which cause other circuits to turn off, etc. Response time is about 700 ns. R6 provides some hysteresis to ensure clean transitions.

TUBE AMPLIFIER ISOLATES HIGH VOLTAGES

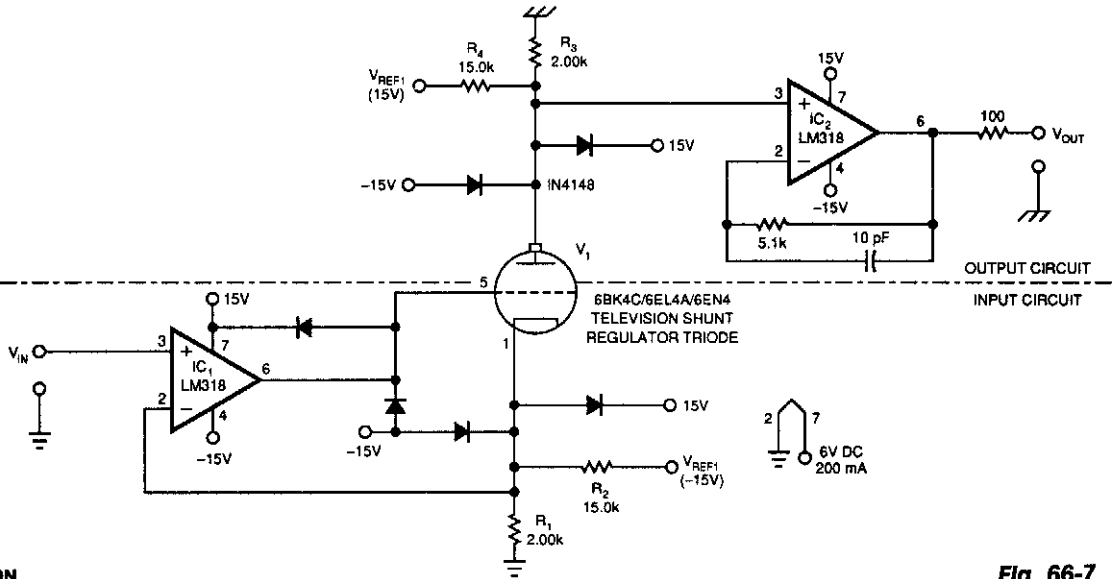


Fig. 66-7

This amplifier can transfer dc-to 5-MHz signals across a potential difference of 25 000 V. This circuit can be used in CRT displays, high-voltage applications, etc. Notice that the tube must be shielded because the tube will generate X-rays. Typically, about 0.1"-thick sheet metal would be used.

TRIAC ac-VOLTAGE CONTROL

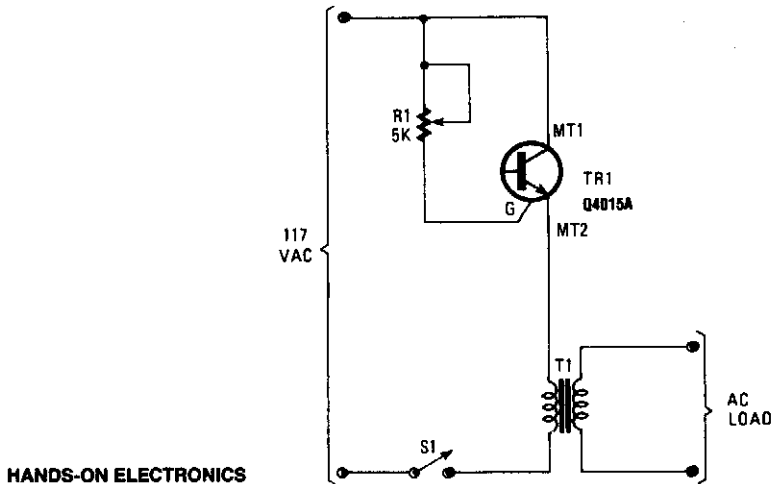
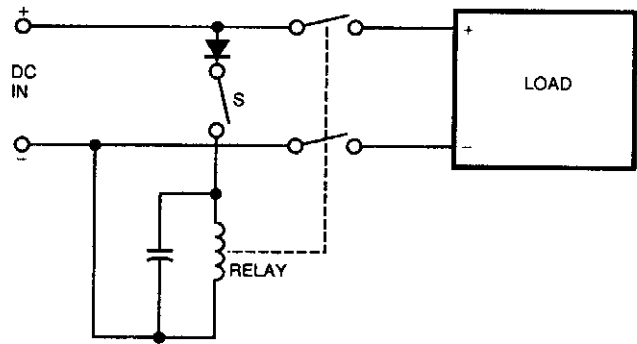


Fig. 66-8

By using a variable resistor in the gate of TR1, variable conduction angles can be achieved via R1.

POLARITY-PROTECTION RELAY



EDN

Fig. 66-9

A diode prevents the relay from applying power if polarity is reversed.

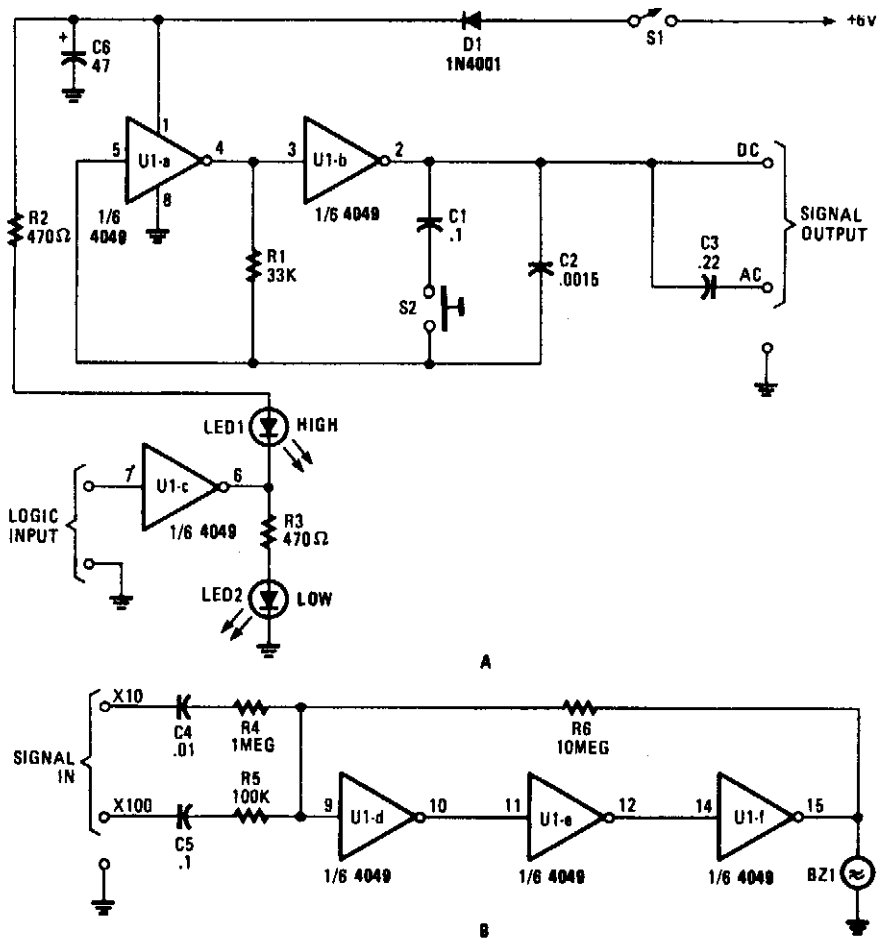
67

Probes

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- 3-In-1 Test Set (Logic Probe, Signal Tracer, and Injector)
- Logic Tester
- Universal Test Probe
- 4-Way Logic Probe
- Active RF Detector Probe
- Single-IC Logic Probe
- Logic Probe
- Logic Probe

3-IN-1 TEST SET (LOGIC PROBE, SIGNAL TRACER, AND INJECTOR)

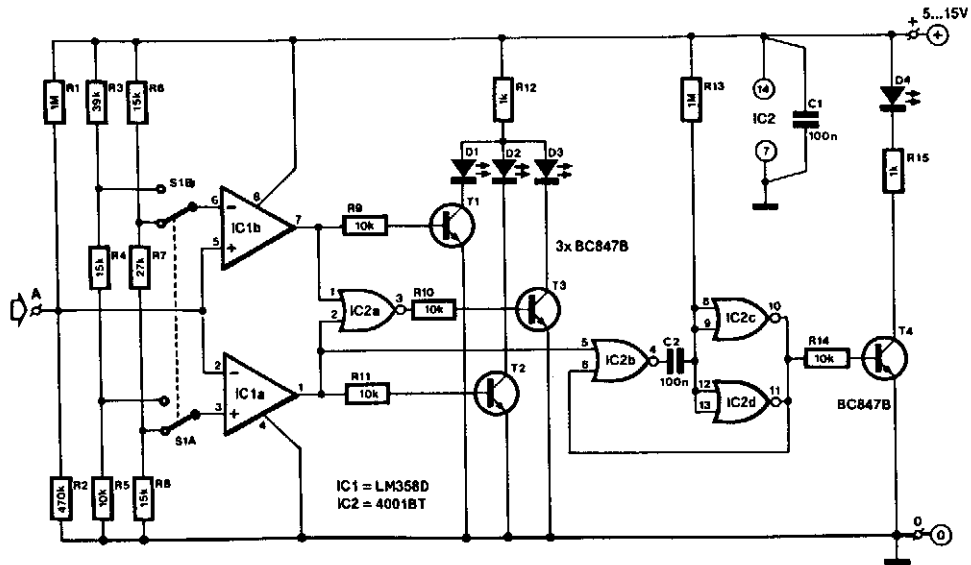


POPULAR ELECTRONICS

Fig. 67-1

This circuit for a test set contains a signal injector (U1A/U1B) and associated components, a logic probe (U1C) and an audio amplifier. S1 selects either 10-kHz or 100-Hz output. U1D, U1E, and U1F form an audio amplifier that drives a piezo sounder element without an internal driver so that it functions as a piezoelectric speaker.

LOGIC TESTER



Parts list

Resistors:

R1, R13 = 1 M Ω
 R2 = 470 k Ω
 R3 = 39 k Ω
 R4, R6, R8 = 15 k Ω
 R5, R9, R10, R11, R14 = 10 k Ω
 R7 = 27 k Ω
 R12, R15 = 1 k Ω

Capacitors:

C1, C2 = 100 nF

Semiconductors:

D1, D2 = LED, 3 mm, green
 D3 = LED, 3 mm, red
 D4 = LED, 3 mm, yellow
 T1, T2, T3, T4 = BC847
 IC1 = LM358
 IC2 = 4001

Miscellaneous:

S1 = sub-miniature switch, 2 make-before-break contacts

ELEKTOR ELECTRONICS

Fig. 67-2

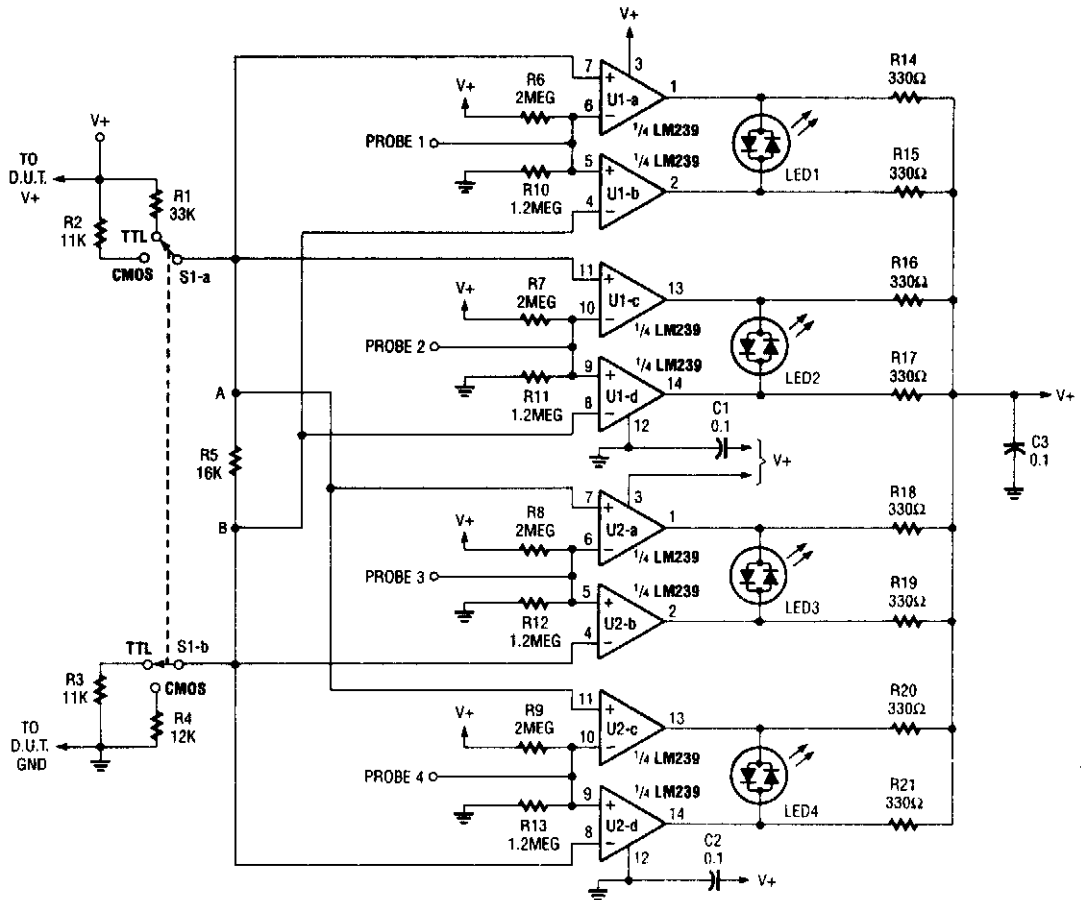
The input consists of two comparators that operate with different reference voltages supplied by separate potential dividers. Divider R3/R4/R5 provides a voltage of about 40% of the supply voltage, U_{CC} , to pin 6 of IC1B and one of about 16% of U_{CC} to pin 3 of IC1A. When $U_{CC} = 5$ V, these voltages are exactly the thresholds (0.8 and 2.0 V) of the TTL comparators.

Similarly, divider R6/R7/R8 provides voltages of 23% of U_{CC} and 73% of U_{CC} to pin 3 of IC1A and pin 6 of IC1B respectively; these levels correspond to the standard threshold for CMOS comparators.

The voltage to be measured U_a , is applied to pin 5 of IC1B and pin 2 of IC1A and compared with the respective reference. The output of comparator IC1B goes high when U_a exceeds the reference, whereas the output of IC1A goes high when U_a lies below the voltage at pin 3.

The comparators are followed by driver stages, T1 and T2, for the LED display (D1 for "high" and D2 for "low") and also NOR gate IC2A that switches on T3 when the output of both comparators is low, that is, when it is undefined. This state is indicated by D3.

4-WAY LOGIC PROBE

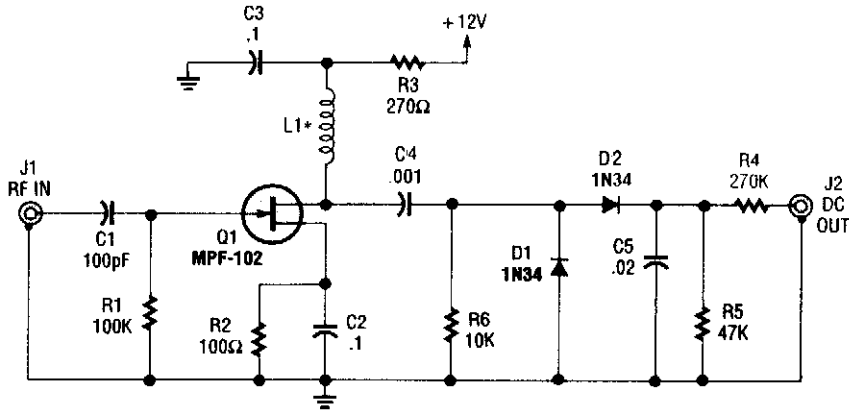


POPULAR ELECTRONICS

Fig. 67-4

This logic probe has four channels and uses two IF quad comparators to drive four bicolor LEDs. S1 and S1B program the comparator trip levels for TTL and CMOS. R6 through R13 bias the probe inputs to prevent the probe from indicating a HIGH for an open circuit. An open circuit will produce an OFF indication on the LED. The LEDs will indicate one color for high, the other color for low, and intermediate colors for pulsing (assuming a duty cycle between 30 and 70%). The color that corresponds to HIGH or LOW depends on how you connect the LEDs.

ACTIVE RF DETECTOR PROBE

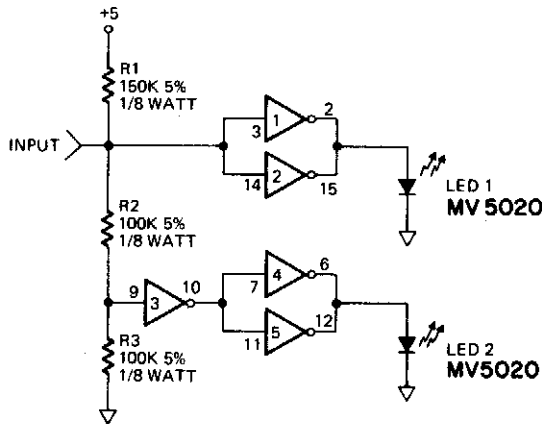


POPULAR ELECTRONICS

Fig. 67-5

An MFP102 FET is used as a wideband amplifier. L1 can be 100 μ H for 30 to 100 MHz or 1 000 μ H for 2 to 30 MHz. For LF, (less than 3 MHz), use a 2.5- μ H RF choke. This probe will work as a relative indicator device, but it can be calibrated over a frequency range, if needed.

SINGLE-IC LOGIC PROBE

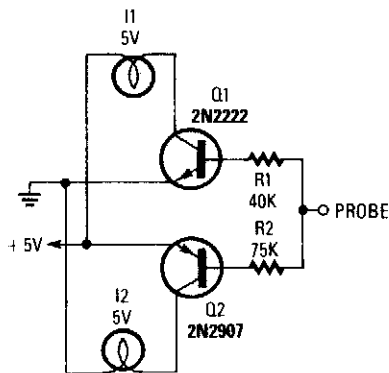


RADIO-ELECTRONICS

Fig. 67-6

This logic probe uses a CD4009 CMOS hex inverter. The characteristic high-input impedance of CMOS gives the advantage of not loading the circuit being tested. Because the output of the inverters is not specified at either a high or low level with a floating input, an input-bias network produces lows at both input inverter pairs if the input is open or at less than 2 V. Resistor R3 holds the input of inverter 3 low which makes the output of inverters 4 and 5 low and will not permit LED 2 to light. At the same time, R1 holds the inputs of inverters 1 and 2 high so that their output is low and LED 1 will not light. If the probe input is touched to a logic low, the output of inverter 3 is held high by R3 and inverter 1 and 2 are brought low, which causes their outputs to go high and turns on LED 1. With no input, both LEDs should be off.

LOGIC PROBE



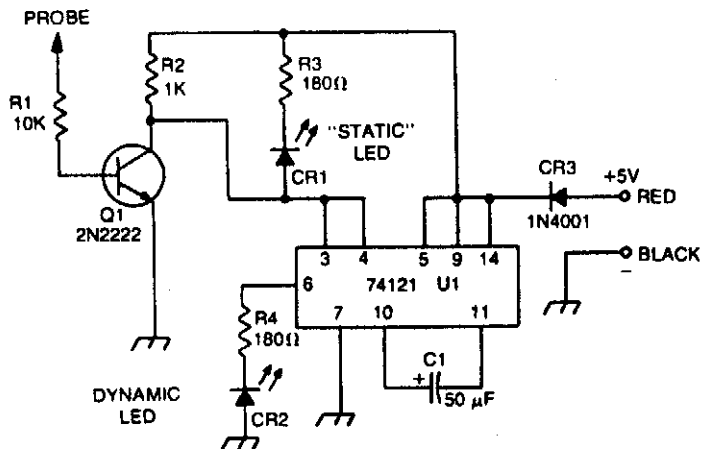
POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 67-7

By connecting this circuit to a logic device that's under power, you can get an indication as to its status. If the circuit is open, neither of the test lamps will light. If the circuit is grounded, the low (or zero) lamp will light. If 3 to 6 V are present, the high-voltage lamp will light.

Other than its application in logic testing, the probe is also convenient for checking supply voltages and grounds. You can select resistors to turn the lamps on at any desired threshold voltage within the component limits.

LOGIC PROBE



POPULAR ELECTRONICS/HANDS-ON ELECTRONICS

Fig. 67-8

The "static" LED indicates a logic level of 1 when lit. The "dynamic" LED indicates a logic 1 *pulse*. A 4-V, 100-ns pulse will be stretched to about 50 ms so that it can be easily seen.

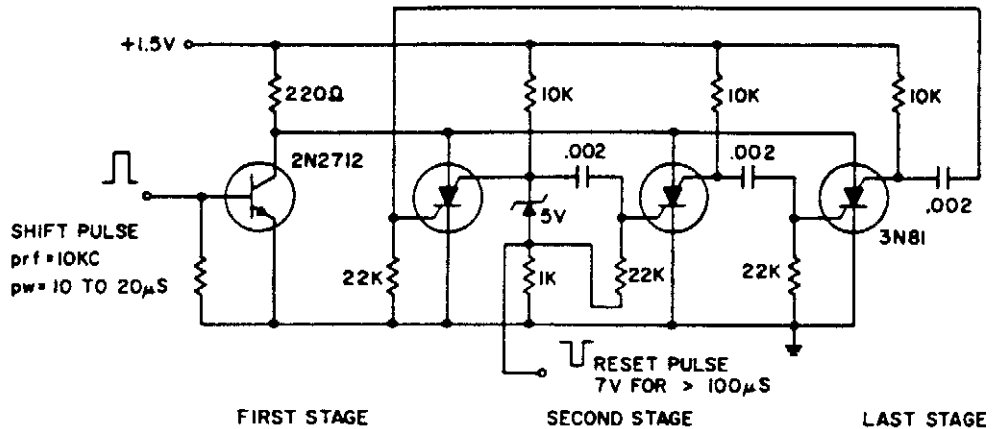
68

Pulse Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Inexpensive Pulse Generator for Logic Troubleshooting
- Negative Pulse Stretcher
- Low-Power Ring Counter (less than 6 mW)
- Transistor Pulse Generator
- Free-Running Pulse Generator
- Stable Start-Stop Oscillator
- Positive Pulse Pulse Stretcher
- 555 Pulse Generator
- Fast Low Duty-Cycle Pulse Oscillator
- Simple Pulse Stretcher
- Delayed Pulse Generator

LOW-POWER RING COUNTER (LESS THAN 6 mW)

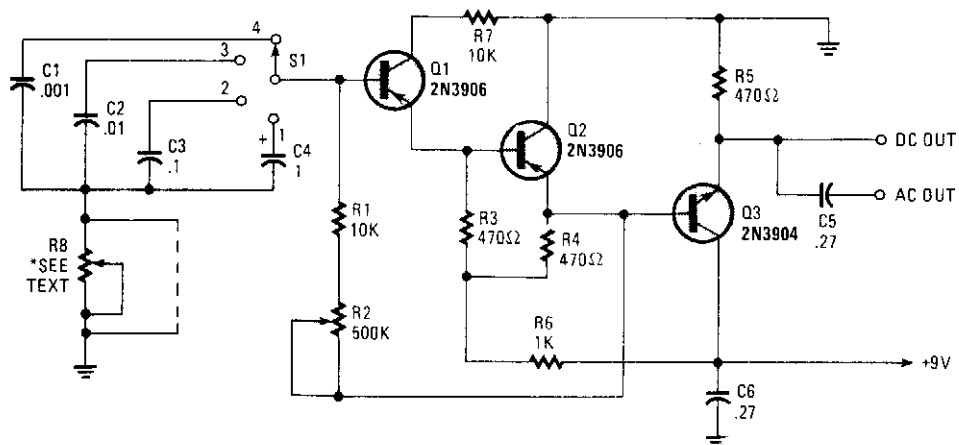


GE

Fig. 68-3

The ring counter operates from 1.0 to 6.0 V and requires only 6 mW at 1.5 V. The reset pulse turns on the first stage with its trailing edge. The maximum shift pulse width increases with voltage and approaches 70 μs for a 6.0-V supply. Minimum pulse width is 10 μs.

TRANSISTOR PULSE GENERATOR

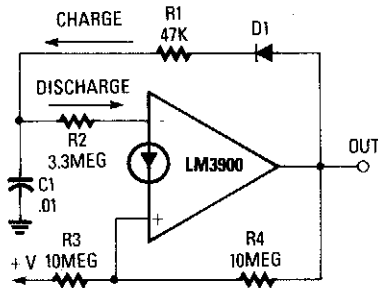


POPULAR ELECTRONICS

Fig. 68-4

Seven-V narrow pulses from 2 Hz to 50 kHz are produced by this circuit. C1 through C4 provide frequency ranges in decode steps. R1 and R2 control the charging time of C1 through C4. R2 is a potentiometer used to set the frequency. R8 controls pulse width. Pulse width varies from 7 μs to 10 ms. Depending on the frequency, R8 can be deleted if it is not needed.

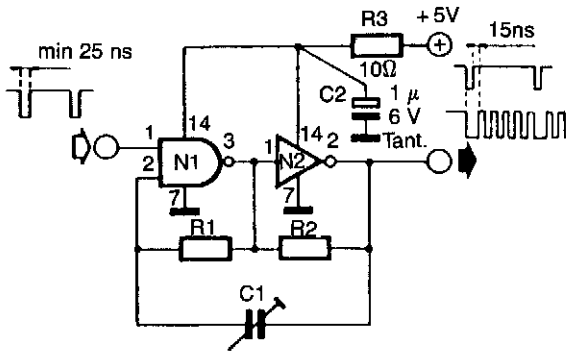
FREE-RUNNING PULSE GENERATOR



C1 alternately charges via R1/D1 and discharges via R2, which produces a duty cycle of about 1:60.

RADIO-ELECTRONICS *Fig. 68-5*

STABLE START-STOP OSCILLATOR



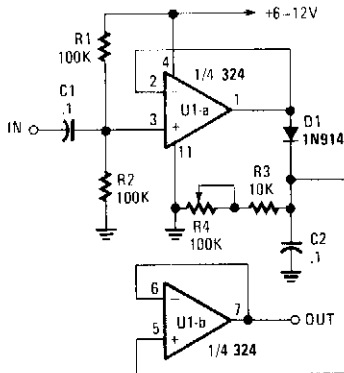
Oscillators that generate a predetermined number of pulses are often required in applications such as video work. This oscillator starts 13 ms after the control signal goes high and stops immediately when the input signal goes low.

N1 = 1/4 74LS00 R1, R2 = 560 Ω ... 4k7
N2 = 1/4 74LS04 C1 = 20 ... 80 p

ELEKTOR ELECTRONICS

Fig. 68-6

POSITIVE PULSE PULSE STRETCHER

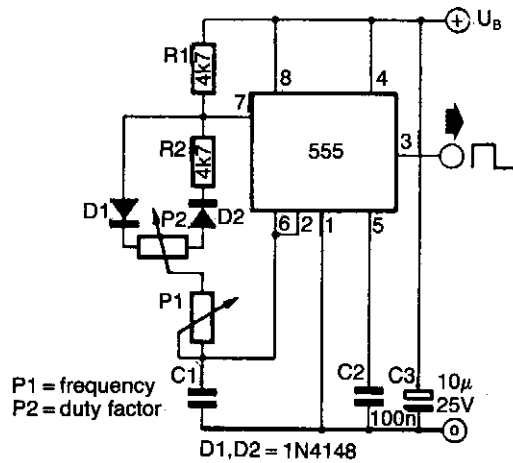


A simple pulse stretcher built with two sections of an op amp uses voltage follower U1A to drive D1 and C2. C2 charges to the peak value of pulse voltage. R3 and R4 determine the discharge time of C2 and therefore the pulse stretching. U1B acts as a voltage follower. Typically this circuit can stretch a pulse by a factor of 50. C2 can be charged to accommodate different pulse rates.

POPULAR ELECTRONICS

Fig. 68-7

555 PULSE GENERATOR

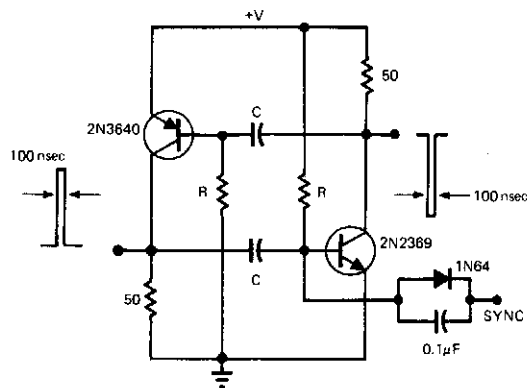


ELEKTOR ELECTRONICS

Fig. 68-8

This approach to using a NEC555 timer uses two diodes to set the charge and discharge timer of capacitor, which gives the circuit a variable duty factor.

FAST LOW DUTY-CYCLE PULSE OSCILLATOR



This simple and symmetrical free-running generator has a 50-Ω output impedance, a pulse width of 100 ns and complementary outputs that swing essentially from ground to the power-supply voltage. Moreover, it functions with a power supply range from <math><1</math> to >15 V and maintains a low voltage and temperature drift while consuming little power.

For oscillation to occur, each transistor must have a gain greater than unity. This restricts the value of R to a range of 1 kΩ to 1 MΩ, because the gain will be less than unity when the transistor is saturated or when beta is low as a result of small collector currents. The two RC timing networks do not have to match because the RC with the longest time constant will determine the frequency of oscillation.

SIMPLE PULSE STRETCHER

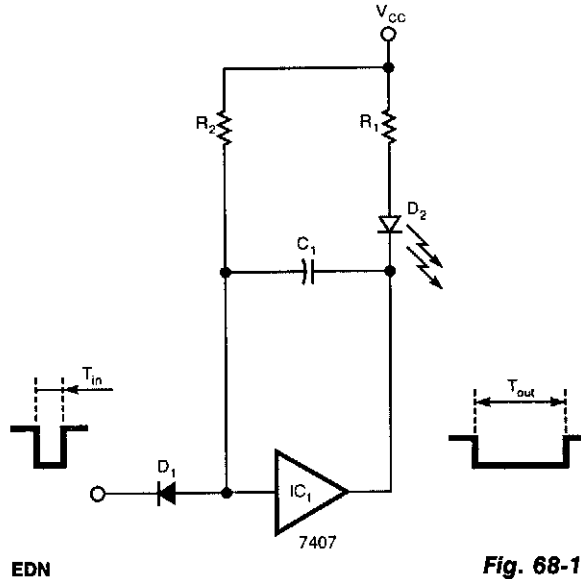
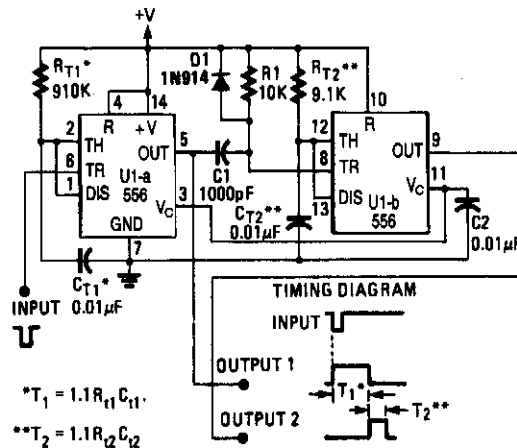


Fig. 68-10

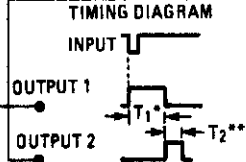
A single gate (open collector, noninverting) produces a simple one-shot to produce a pulse that stretches equal to the pulse duration, plus the R_1C_1 time constant. R_2 is a pull-up resistor to keep the gate's input high while waiting for a pulse.

DELAYED PULSE GENERATOR



$$*T_1 = 1.1R_1C_1$$

$$**T_2 = 1.1R_2C_2$$



HANDS-ON ELECTRONICS (AS SHOWN, $T_1 = 10 \text{ MS}$; $T_2 = 100 \mu\text{S}$)

Fig. 68-11

This circuit produces a delayed pulse width of $1.1(R_2C_2)$. The delay is given by $T = 1.1(R_1C_1)$. A 556 dual timer can be used.

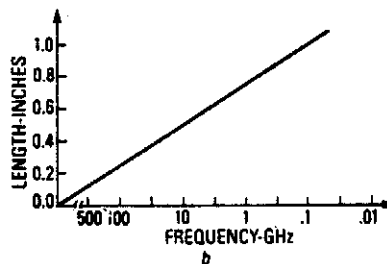
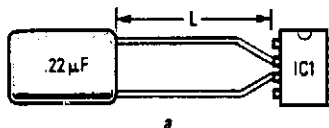
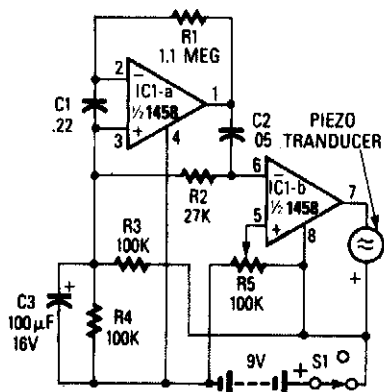
69

Radar Detectors

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Radar Detector
Deluxe Radar Detector

RADAR DETECTOR

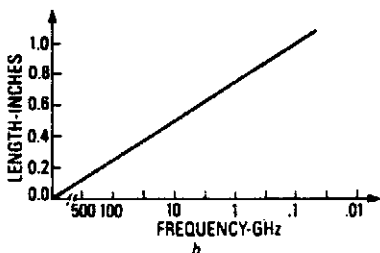
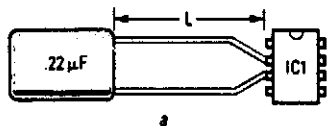
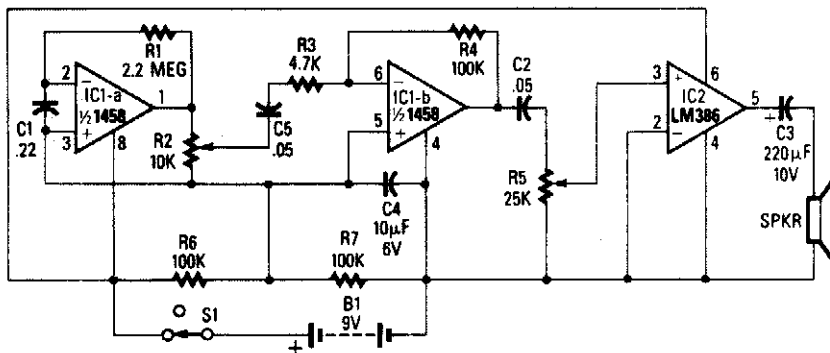


RADIO-ELECTRONICS

Fig. 69-1

A simple detector of radar signals uses the junctions of the input transistors of an LM1458 op amp as RF detectors. The leads of C1 act as an antenna and should be about 0.4" long measured from the IC package. Detected audio components are further amplified by IC1A and IC1B, and drive a piezo transducer. Mount the circuit so that incident RF energy will not be blocked.

DELUXE RADAR DETECTOR



This simple radar detector includes an audio amplifier for driving a loud speaker. As in Fig. 69-1, it uses an op amp as a detector of microwave signals.

RADIO-ELECTRONICS

Fig. 69-2

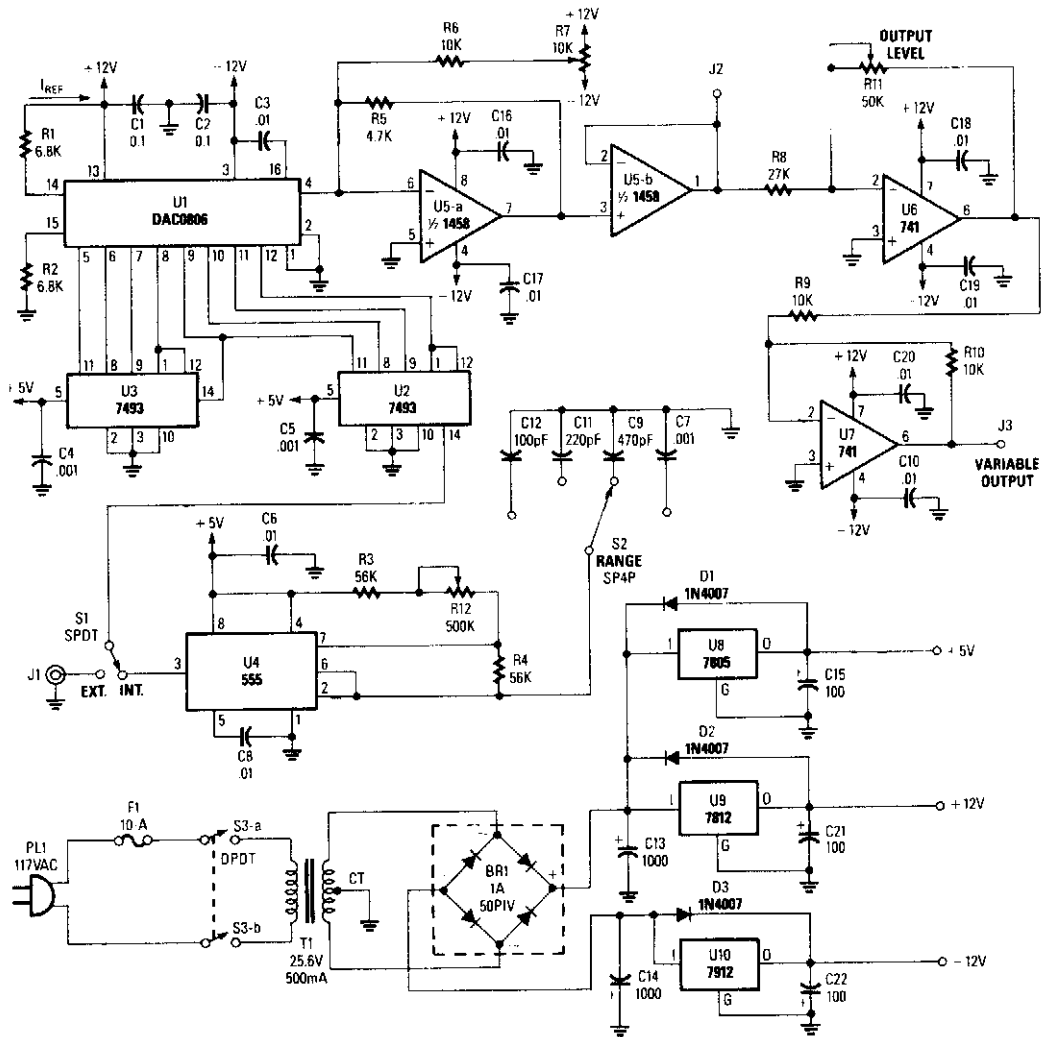
70

Ramp and Staircase Generators

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Digital Sawtooth Generator
Simple Staircase Generator
Ramp Generator
Sawtooth Generator for Sweep Generators
Stepped Waveform Generator

DIGITAL SAWTOOTH GENERATOR

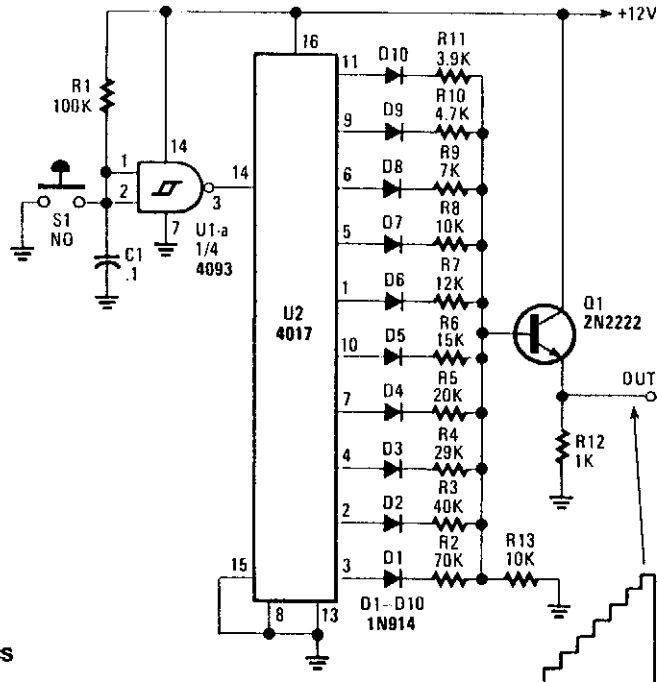


POPULAR ELECTRONICS

Fig. 70-1

This straightforward circuit uses an NE555 timer as an oscillator, a 7493 counter chain and a DAC0806 D/A converter. The counter output feeds the DAC, producing a linearly increasing voltage, which drives an op amp and a dc-level insertion circuit. The clock frequency must be 256 times the desired sawtooth output frequency.

SIMPLE STAIRCASE GENERATOR

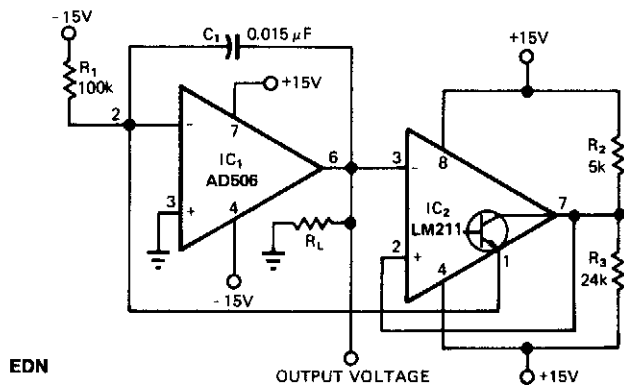


RADIO-ELECTRONICS

Fig. 70-2

U2 is a decade counter /divider. U1 is used as a switch debouncer. For a self-generating system, connect a resistor between pins 2 and 3 of a U1 value that should be between 10 kΩ and several MΩ, depending on desired frequency. C1 can also be varied to change frequency. Also, S1 can be omitted in the self-generating version.

RAMP GENERATOR

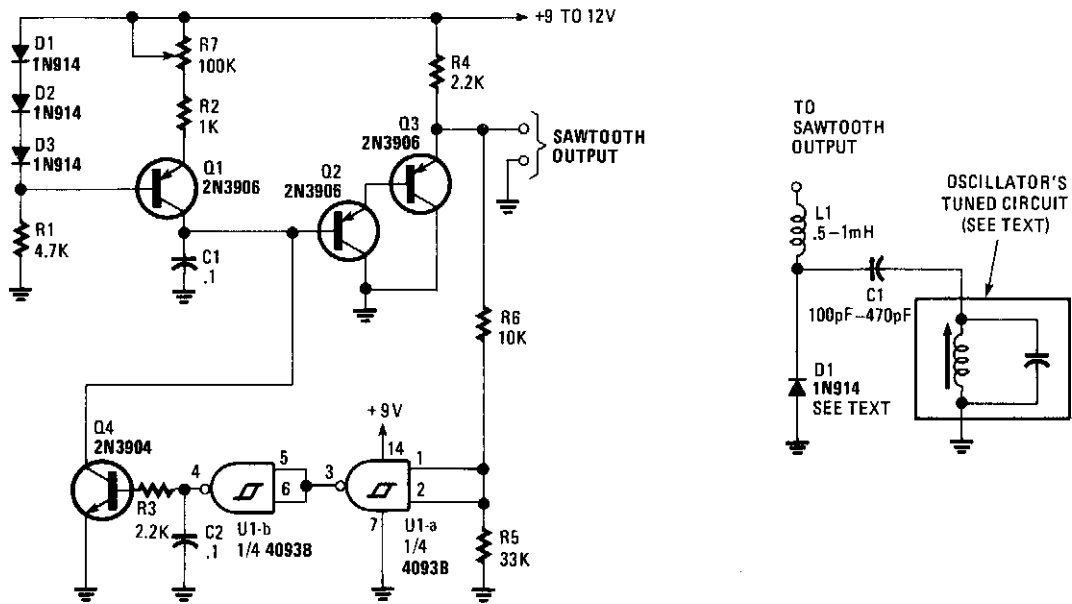


EDN

Fig. 70-3

Providing a 0-to 10-V excursion from 0.4 Hz to 100 kHz, this circuit offers both simplicity and small size. The negative current through R1 produces the ramp's positive slope and causes the output of IC1 to increase linearly toward the +15-V rail.

SAWTOOTH GENERATOR FOR SWEEP GENERATORS

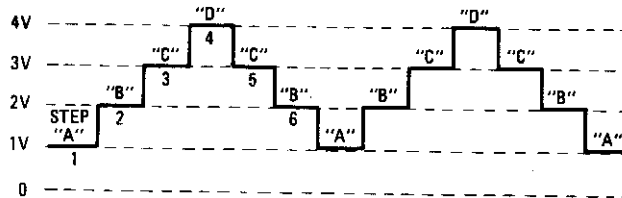
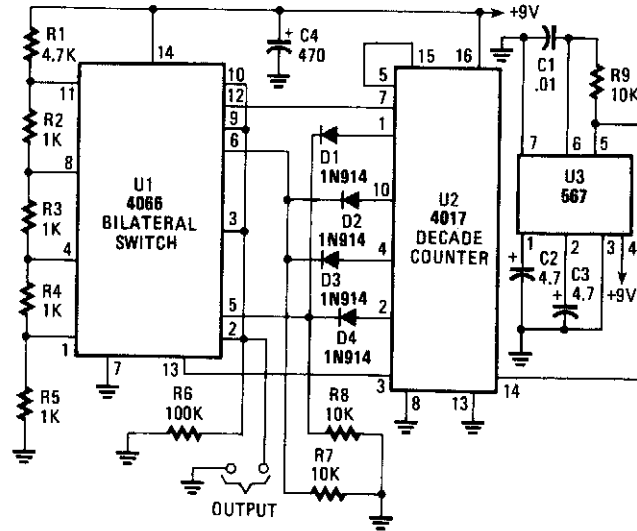


RADIO-ELECTRONICS

Fig. 70-4

This circuit will generate a linear sawtooth between 30 Hz and 3 000 Hz. Q1 is a constant-current source that charges C1 until the output level at Q3 emitter triggers U1A and U1B, which turns on Q4 and discharges C1. The frequency range can be varied by changing the value of C1. This circuit should be good to several tens of kHz.

STEPPED WAVEFORM GENERATOR



The output of the stepped waveform generator is made up of 3-up and 3-down steps in 1-volt increments (much like the output of a digital-to-analog converter). Switch triggering for the 4066 is controlled by a 4017 decade counter/divider (U2), which is clocked by a square-wave generator built around a 567 PLL (phase-locked loop).

POPULAR ELECTRONICS

Fig. 70-5

A decade counter (U2) is used to perform sequential switching via a CD 4066. Analog switch is to generate a waveform. The clock is a 567 PLL or other VCO chip.

71

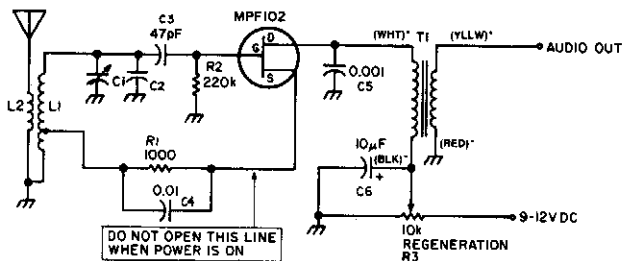
Receivers

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- 1-Transistor Regenerative Receiver
- 3.5- to 10-MHz Simple Superheterodyne Receiver
- Simple Low-Frequency Receiver
- Reflex Radio Receiver
- TRF Radio
- Old-Time Radio
- Pulse-Frequency Modulated Receiver
- Shortwave Receiver
- Simple AM Radio

1-TRANSISTOR REGENERATIVE RECEIVER

RECEIVER



T1 = ANY AUDIO TRANSFORMER AS LONG AS PRIMARY IS GREATER THAN 1kΩ

T50-2 $N = 100 \sqrt{L/50}$
 $N =$ NUMBER OF TURNS
 $L =$ INDUCTANCE IN μH

*COLOR CODED CONNECTIONS FOR 1:1 AUDIO TRANSFORMER

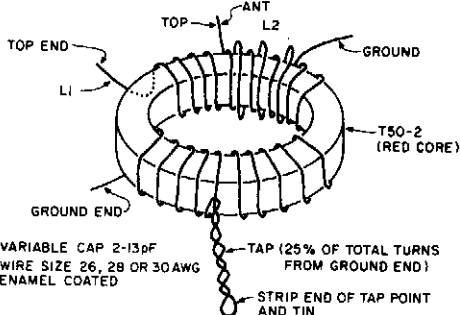
$L1C1 =$ RESONANT FREQUENCY USE FORMULA

$$f = \frac{10^6}{2\pi \sqrt{LC}}$$

TAP 25% FROM COLD END

L2 = 3 TURNS AROUND L1

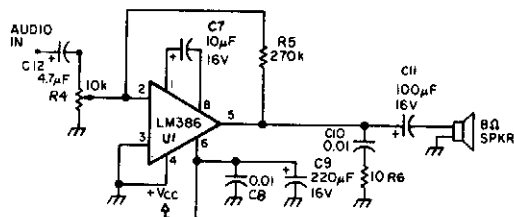
COIL FORM CAN BE ANYTHING EVEN T50-2 TOROID



VARIABLE CAP 2-13pF
 WIRE SIZE 26, 28 OR 30 AWG
 ENAMEL COATED

$$f = \frac{10^6}{2\pi \sqrt{LC}} \quad L = \frac{10^6}{39.5 \cdot f^2 \cdot C} \quad C = \frac{10^6}{39.5 \cdot f^2 \cdot L}$$

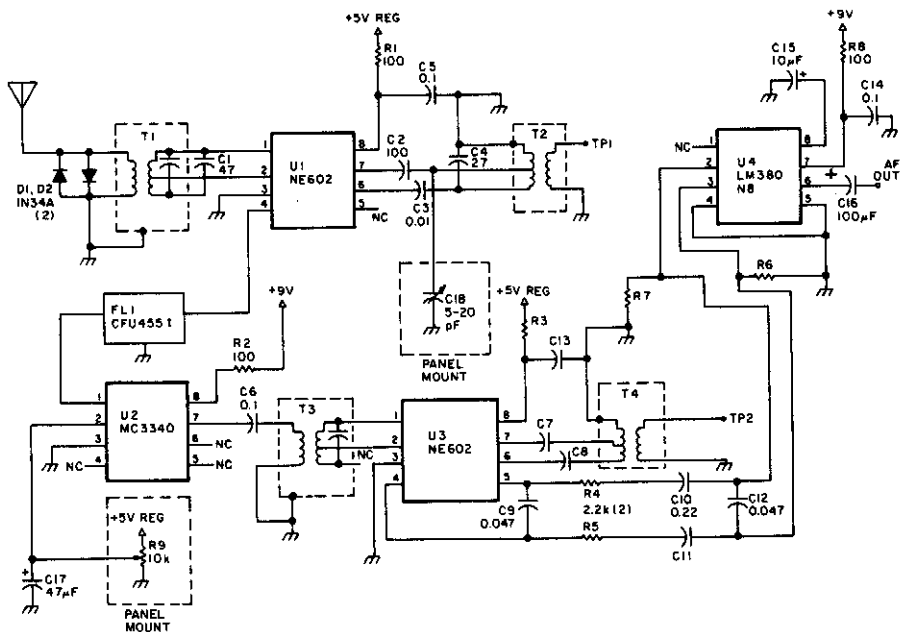
f = FREQUENCY IN MHz
 L = INDUCTANCE IN μH
 C = CAPACITANCE IN pF



Using an MPF102 FET, this one-transistor radio receiver is suitable for experimental use. It can tune 4 to 26 MHz. For speaker operation, a simple IC amplifier can be used.

Frequency (MHz)	C2 (pF)	C18, C19 (pF)	C23 (pF)	L1, L2 (Ant) (# of turns on T37-2 core)	L3 (Osc)
5	100	120	68	5, 41	45
6	100	120	68	4, 30	34
7	82	100	47	4, 26	29
8	82	100	47	3, 22	24
10	82	100	47	3, 17	19
12	82	100	47	2, 15	17
14	68	82	33	2, 14	15
15	68	82	33	2, 13	14

3.5- TO 10-MHZ SIMPLE SUPERHETERODYNE RECEIVER



SuperRX Parts List

Part	Value	Type
C1	47 pF	silver-mica or polystyrene
C2	100 pF	silver-mica or polystyrene
C3	0.01μF	polystyrene or monolithic
C4	27 pF	silver-mica or polystyrene
C5	0.1μF	ceramic disc or monolithic
C6	0.1μF	polystyrene or monolithic
C7	0.022μF	polystyrene or monolithic
C8	0.1μF	polystyrene or monolithic
C9	0.047μF	monolithic
C10	0.22μF	monolithic
C11	0.15μF*	(alternate)
	0.22μF	monolithic
	0.15μF*	(alternate)
C12	0.047μF	monolithic
C13, C14	0.1μF	ceramic disc or monolithic
C15	10μF	electrolytic, 16V
C16	100μF	electrolytic, 16V
C17	47μF	electrolytic, 16V
C18	5-20 pF	panel mounted tuning capacitor
C19, C20	220μF	electrolytic, 16V
D1, D2	1N34A	germanium diode or equivalent
R1, R2, R3, R8	100 ohm, ¼W	carbon composition
R4, R5	2.2 k, ¼W	carbon composition.
	1.5k	(alternate)

3.5- TO 10-MHz SIMPLE SUPERHETERODYNE RECEIVER (Cont.)

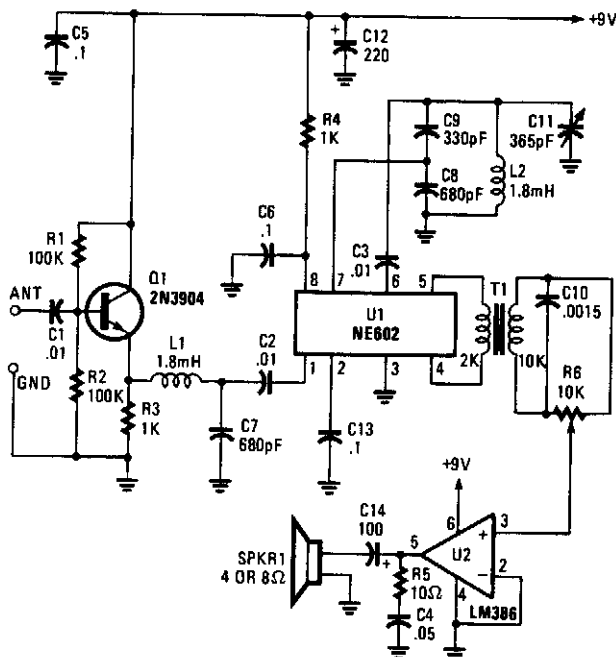
R6, R7	10k, ¼W	carbon composition	
R9	10k	potentiometer	
T1, T2	10.7 MHz	microminiature (7mm)	Mouser PN 42IF223
		IF transformer, green core	
T3, T4	455 kHz	microminiature (7mm)	Mouser PN 42IF203
		IF transformer, black core	
U1, U3	NE602	double-balanced mixer	
U2	MC3340	variable attenuator	
U4	LM380N-8	audio amplifier	
U5	78L05	100 mA miniature +5V regulator	

* C10 and C11 can range from 0.1 to 0.22µf. Values greater than 0.33 cause distortion.

Other: Printed stripboard, DSE PN H5614 or equivalent, cabinet, plastic stick-on feet, 4-40 hardware, etc.

In this circuit, U1 is a frequency converter that feeds the 455-kHz IF stage U2 and detector U3. U4 is the audio output stage. R9 is a gain control that varies the gain of U2. Coil data is given in the part list.

SIMPLE LOW-FREQUENCY RECEIVER

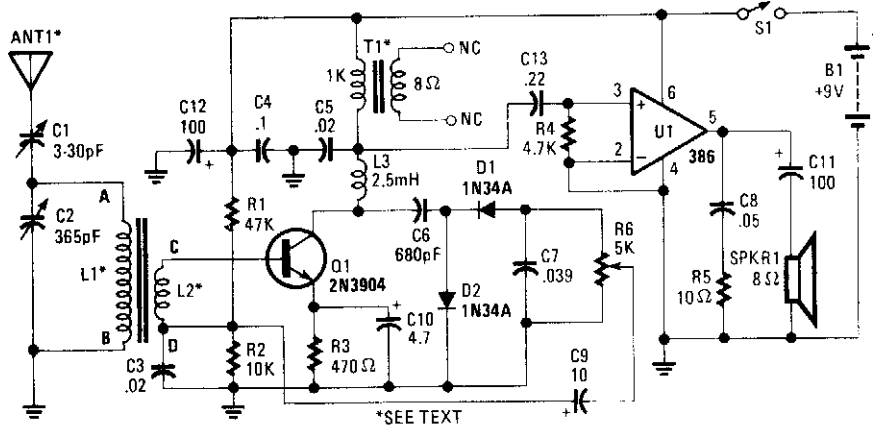


POPULAR ELECTRONICS

Fig. 71-3

Using an NE602 heterodyne detector and U1 as an RF amplifier, this receiver tunes the middle portion of the low-frequency spectrum from 150 to 250 kHz. U2 is a loudspeaker amplifier.

REFLEX RADIO RECEIVER



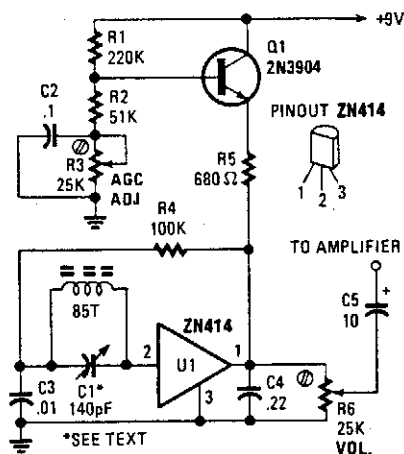
POPULAR ELECTRONICS

Fig. 71-4

The RF signal is passed from the antenna through C1 to the tuned circuit made up of L1 and C2. One end of L2 feeds the RF signal to the base of Q1 for amplification and the other end ties to the junction of R1 and R2 to supply bias to the transistor. A 0.02- μ F capacitor, C3, places the "D" end of L1 at RF ground.

The amplified RF signal is fed through C6 to a two-diode doubler/rectifier circuit and then on to the volume control, R6. The wiper of R6 feeds the detected audio signal through C9 to the junction of R1, R2, and the "D" end of L2. The "D" end of L2 is at RF ground, but not AF ground, allowing the AF signal to be passed through L2 to the base of Q1 for amplification. The junction of the 2.5-mH choke and T1 is placed at RF ground through C5. The amplified audio is fed from this junction to the input of the 386 audio amplifier, U1, to drive the 4" 8- Ω speaker. The single transistor has performed a dual duty by amplifying the RF and AM signals at the same time.

TRF RADIO

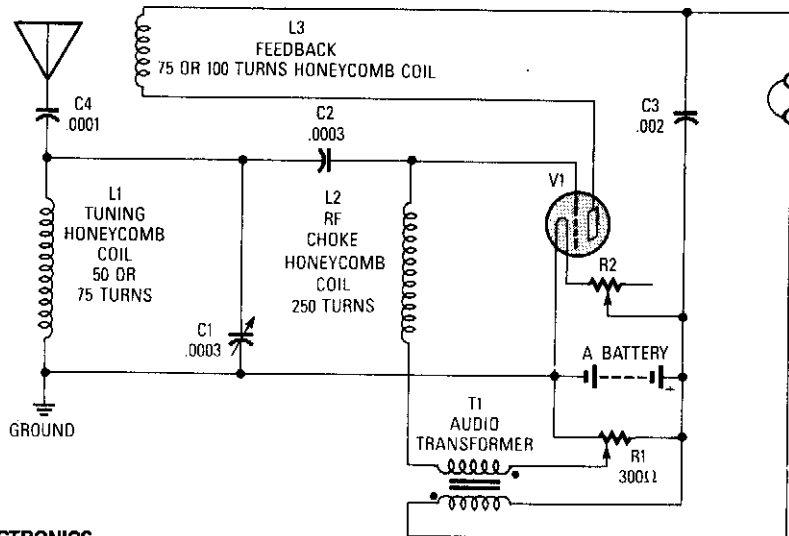


POPULAR ELECTRONICS

Fig. 71-5

This simple AM radio uses a Ferranti ZN414 IC and runs from a 9-V supply. A $\frac{5}{16}$ "-diameter ferrite rod serves as an antenna, and uses about 85 turns of #28 enamelled wire.

OLD-TIME RADIO

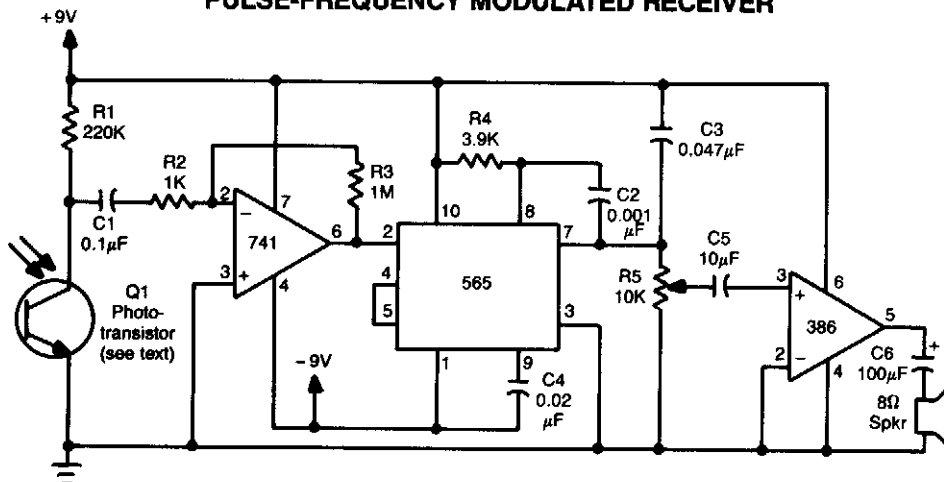


POPULAR ELECTRONICS

Fig. 71-6

This circuit was used in the early days of radio to receive signals. Almost any battery-operated triode, such as a type 30, can be used. "A" battery is 3 V, R2 is a 100-Ω rheostat. Coils are typically 2" to 3" diameter honeycomb wound.

PULSE-FREQUENCY MODULATED RECEIVER

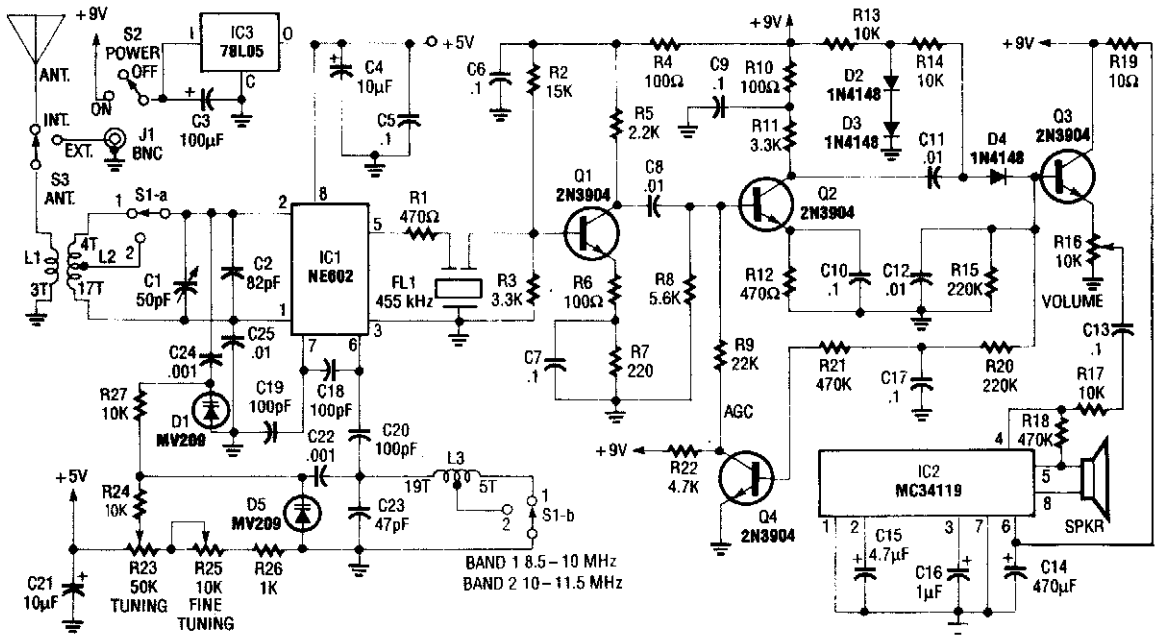


POPULAR ELECTRONICS

Fig. 71-7

This receiver uses an IR-sensitive phototransistor (Clairex, HP, etc.) mounted in a light-tight enclosure with an aperture for the incoming IR beam. An optical system can be used with this receiver for increased range. A 741 amplifies the pulsed IR signal and a 565 PLL FM demodulator recovers the audio, which drives an LM386 audio amplifier and speaker.

SHORT WAVE RECEIVER

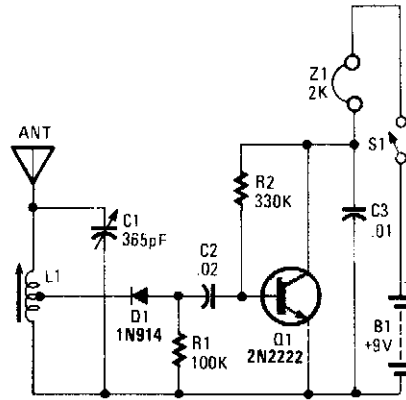


TABLE

Frequency (MHz)	C2 (pF)	C18, C19 (pF)	C23 (pF)	L1, L2 (Ant) (# of turns on T-37-2 core)	L3 (Osc)
5	100	120	68	5, 41	45
6	100	120	68	4, 30	34
7	82	100	47	4, 26	29
8	82	100	47	3, 22	24
10	82	100	47	3, 17	19
12	82	100	47	2, 15	17
14	68	82	33	2, 14	15
15	68	82	33	2, 13	14

Using a Signetics NE602 in a varactor-tuned front end, the circuit of a shortwave receiver can be very simple and yet give high performance. This circuit also uses a ceramic filter as a sensitivity-determining device, two IF stages, AGC, and an audio amplifier. It has a sensitivity of under $1\mu\text{V}$. The table shows coil data for the frequencies from 5 to 16 MHz. The values C_{18} , C_{19} , and C_{23} depend on the frequency range chosen.

SIMPLE AM RADIO



POPULAR ELECTRONICS

Fig. 71-9

An AM radio can be built of a simple diode detector and an audio amplifier. A random length of wire always serves as an antenna. L1 is an adjustable ferrite loopstick of the type used in transistor radios.

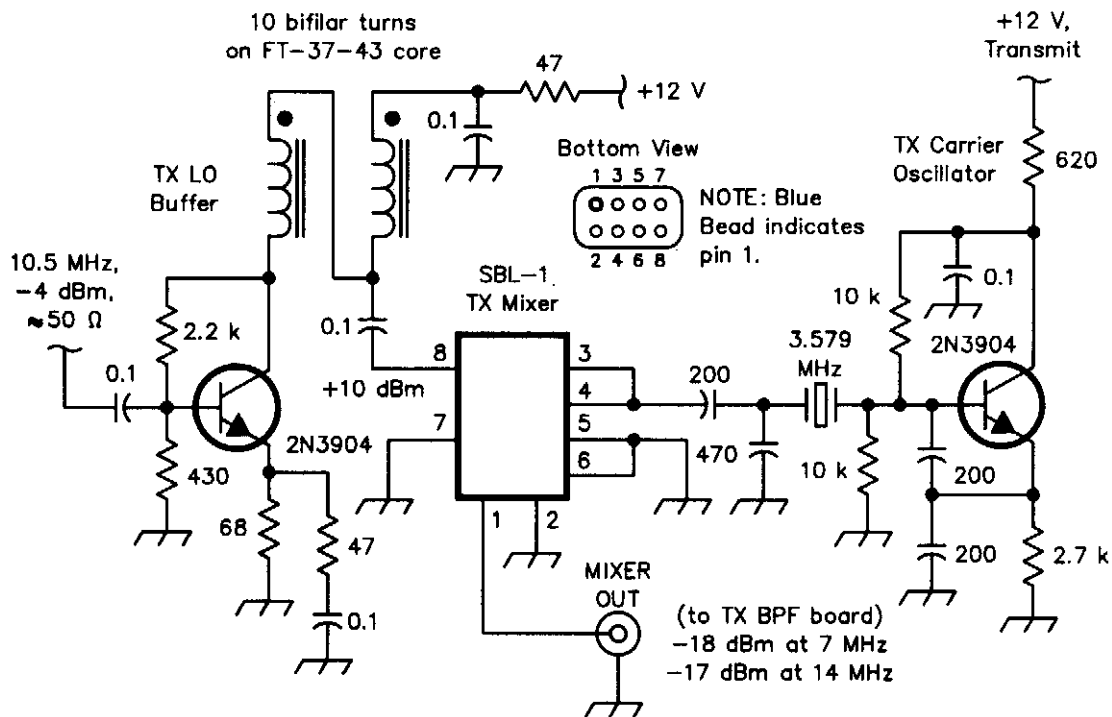
72

Receiving Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 676. The figure number in the box of each circuit correlates to the entry in the Sources section.

HF Transceiver Mixer
AGC System For CA3028 IF Amplifier
Receiver IF Amplifier
30-MHz IF Preamp
Carrier-Operated Relay

HF TRANSCEIVER MIXER

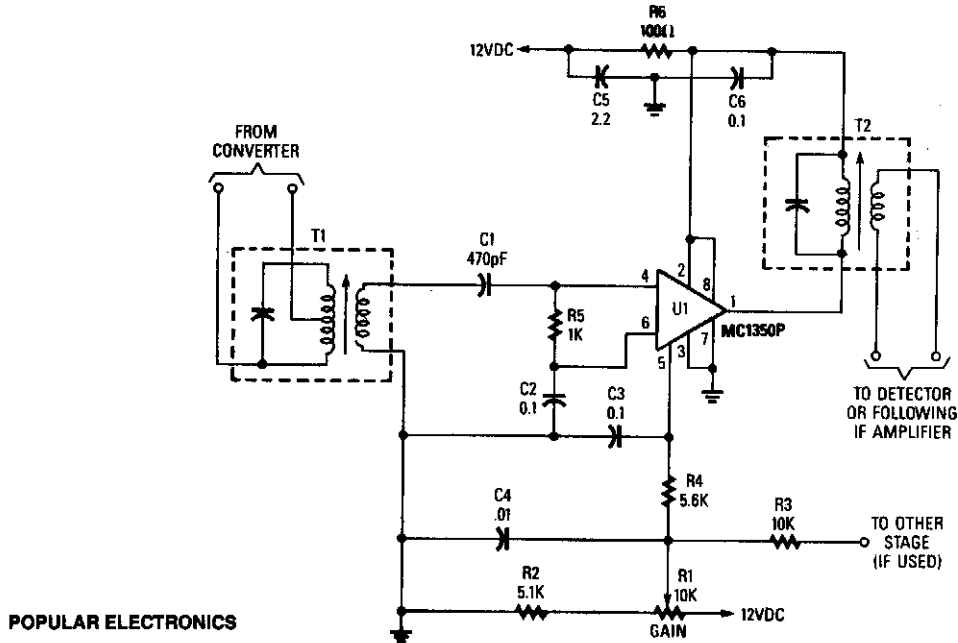


QST

Fig. 72-1

The transceiver mixer and carrier oscillator in the band-imaging (7- and 14-MHz) CW transceiver. Careful selection of drive levels, and use of a spectrally clean carrier oscillator, assure low spurious-signal content in the transmitter output. This transceiver mixer should prove useful in HF and VHF CW or SSB applications. A Mini-Circuits SBL1 low-cost mixer is used with a 3.579-MHz crystal oscillator that uses a low-cost TV color-burst crystal. By paying careful attention to drive leads, good performance and low spurious content can be obtained.

RECEIVER IF AMPLIFIER

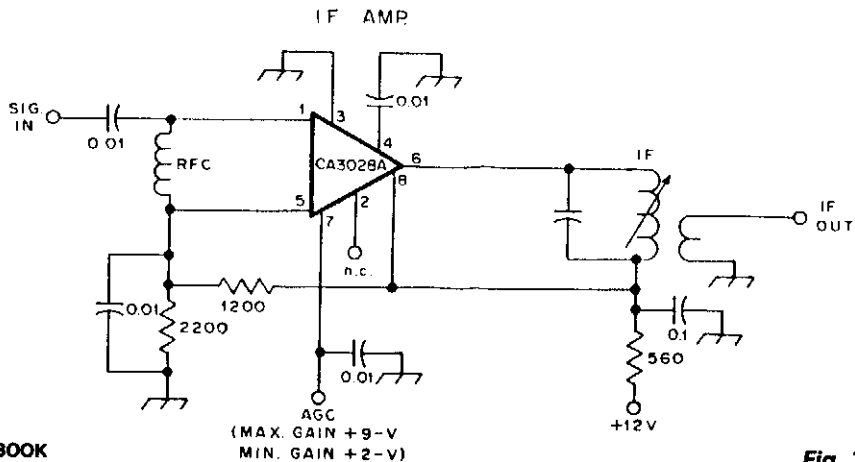


POPULAR ELECTRONICS

Fig. 72-3

T1 is tuned to converter-output frequency U1 to provide 45-to-50-dB gain, depending on the design of T1 and T2. C2, C3, C4, C5, and C6 are bypass capacitors. R5 is a bias resistor. Gain is set by R1, which controls the voltage on pin 5 of U1. T1 and T2 should provide source and load impedance of 1-kΩ and 3- to 10-kΩ, respectively. R3 supplies dc bias to other stages, if required.

IF AMPLIFIER

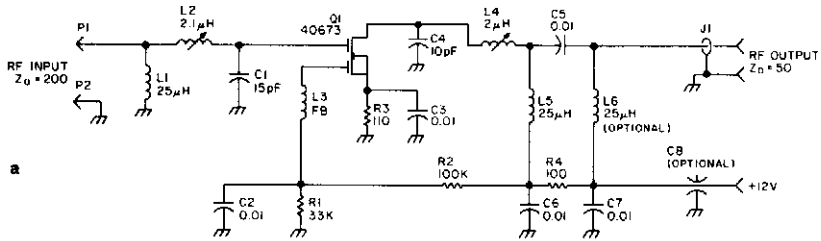


ARRL HANDBOOK

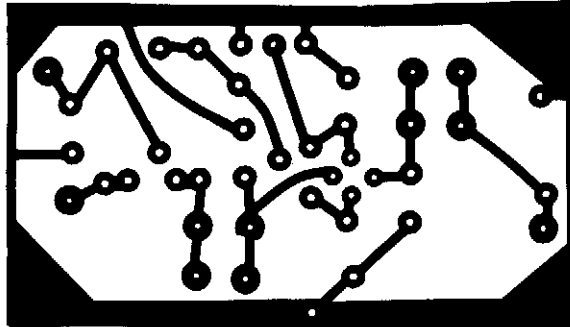
Fig. 72-4

Using a CA3028A, this circuit is useful up to about 15 or 20 MHz.

30-MHz IF PREAMP

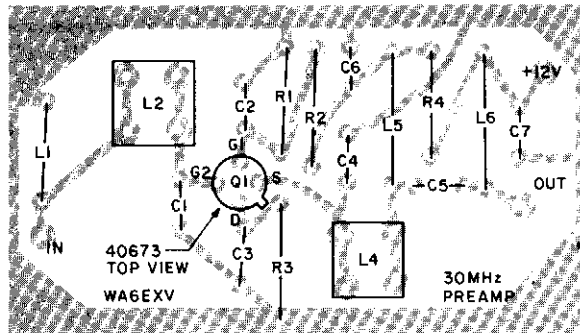


a



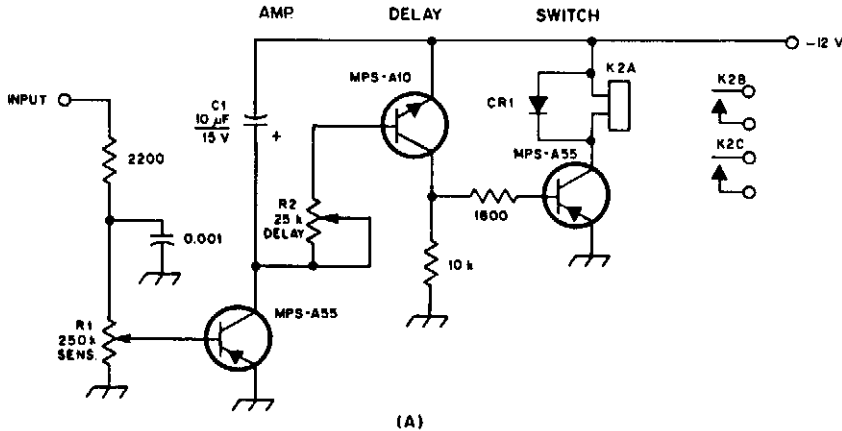
b

c

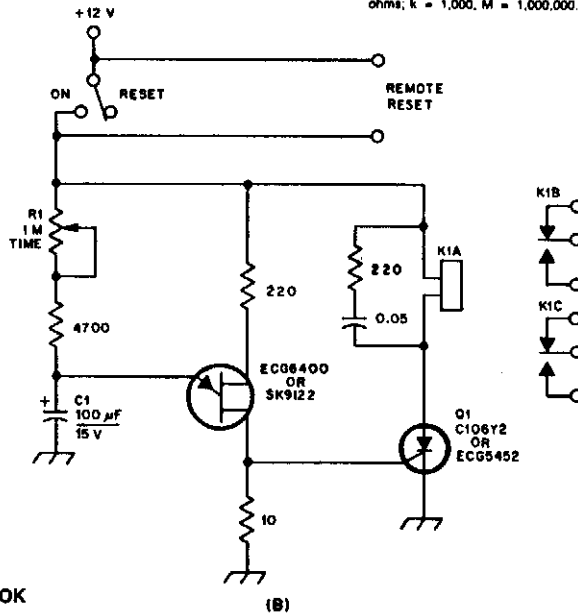


This preamp for 30 MHz is useful for IF applications used in microwave work, etc. A 40673 MOSFET is used and typically the gain at 30 MHz will be 20 to 25 dB.

CARRIER-OPERATED RELAY



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms; k = 1,000, M = 1,000,000.



ARRL HANDBOOK

Fig. 72-6

A shows a COR/CAS circuit for repeater use. CR1 is a silicon diode. K2 may be any relay with a 12-V coil (a long-life reed relay is best). R2 sets the length of time that K2 remains closed after the input voltage disappears (hang time). B shows a timer circuit. Values shown for R1 and C1 should provide timing up to four minutes or so. C1 should be a low-leakage capacitor; Q1 is a silicon-controlled rectifier, ECG-5452 or equivalent. K1 may be any miniature relay with a 12-volt coil. The timer is reset when the supply voltage is momentarily interrupted. The switch must be in the RESET position for the remote reset to work. This circuit operates from the detector output of a receiver. A delay circuit is included so that the relay stays closed for a time period after the carrier output from the receiver disappears.

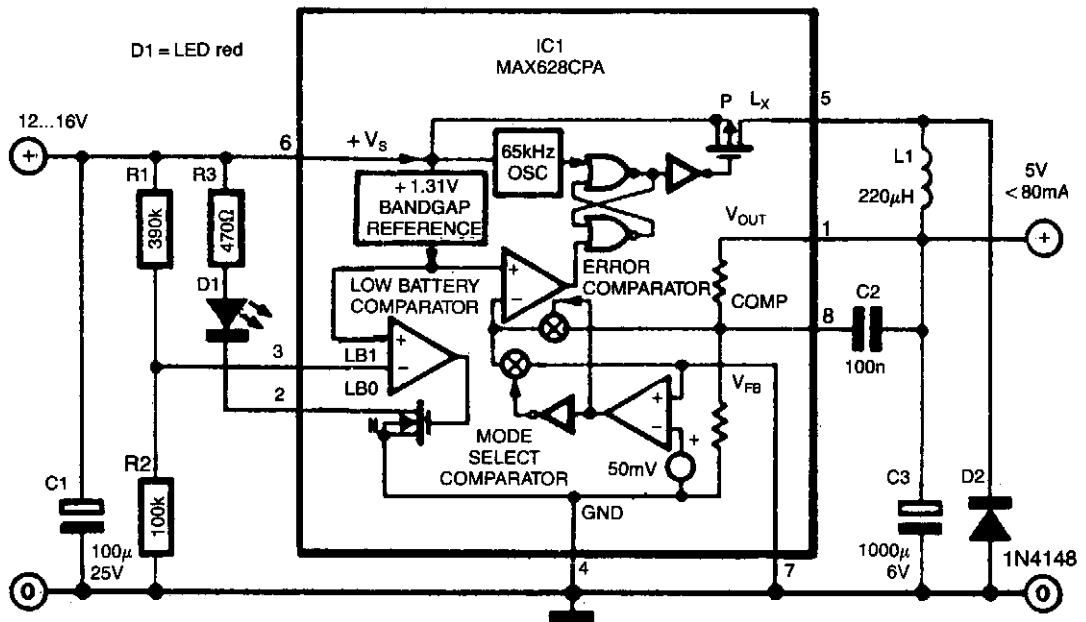
73

Regulators (Fixed)

The sources of the following circuits are contained in the Sources section, which begins on page 676. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Switch-Mode Voltage Regulator
- Switching Improves Regulator Efficiency
- Efficient Negative Voltage Regulation
- High- or Low-Input Regulator
- LM317 Regulator Sensing
- Common Hot-Lead Regulator
- Fixed-Current Regulator

SWITCH-MODE VOLTAGE REGULATOR



ELEKTOR ELECTRONICS

Fig. 73-1

Switch-mode power supplies offer the benefit of a much greater efficiency than obtainable with a traditional power supply. The switch-mode regulator presented here has an efficiency of around 85%.

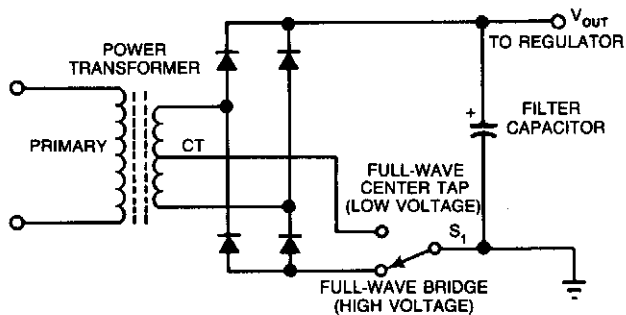
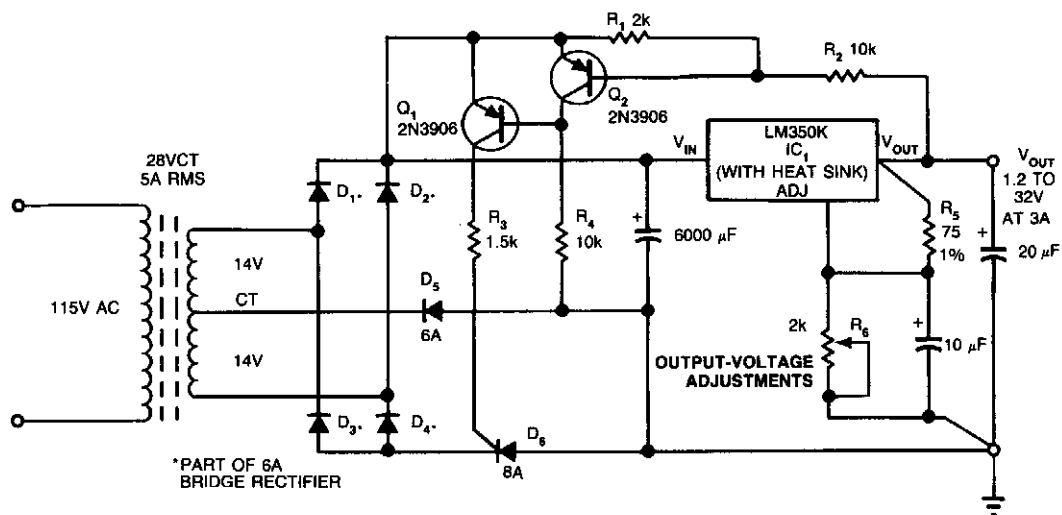
An input voltage of 12 to 16 Vdc is converted into a direct voltage of exactly 5 V. The use of a MAX638CPA enables the design and construction of the regulator to be kept fairly simple: only nine additional components are needed to complete the circuit.

Resistors R1 and R2 are used to indicate when the battery voltage becomes low: as soon as the voltage on pin 3 becomes lower than 1.3 V, D1 lights. With values as shown for the potential divider, this corresponds to the supply voltage getting lower than about 6.5 V. The output of the IC is shunted by a simple LC filter formed by L1, C3 and D2.

The oscillator on board the IC generates a clock frequency of around 65 kHz and drives the output transistor via two NOR gates. The built-in error detector, the "battery low" indicator or the voltage comparator can block the clock frequency, which causes the transistor to switch off.

The IC compares the output voltage of 5 V with a built-in reference (FET). Depending on the load, the FET will be switched on for longer or shorter periods. The maximum current through the FET is 375 mA, which corresponds with a maximum output current of 80 mA.

SWITCHING IMPROVES REGULATOR EFFICIENCY

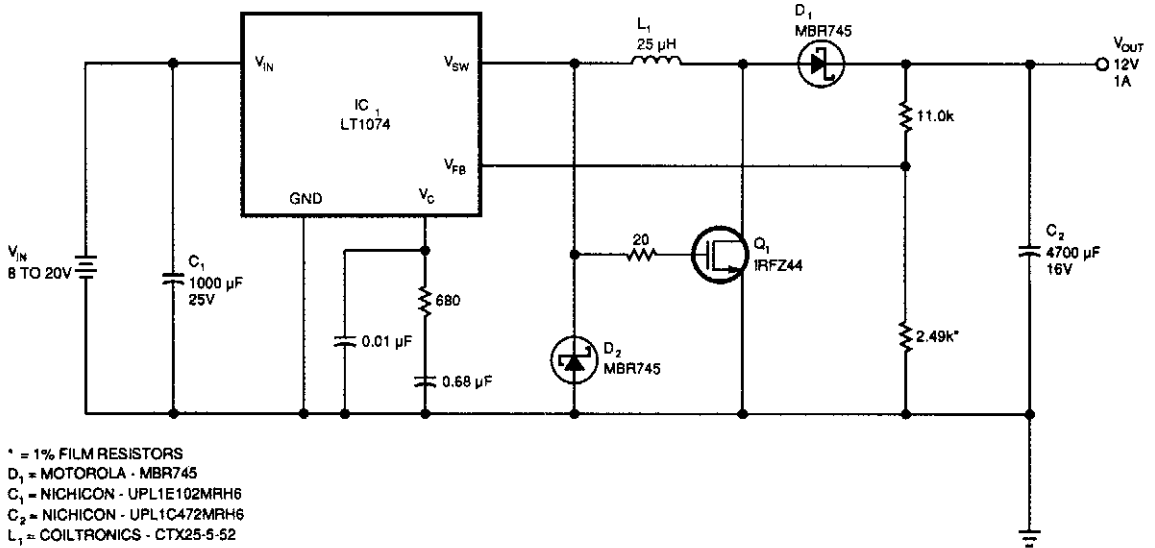


EDN

Fig. 73-2

In this circuit, a full-wave bridge is switched to a full-wave center tap to reduce regulator dissipation. SCR D6 switches between configurations. When D6 is off, the circuit is an FWCT rectifier using D1, D2, and D5. It applies 17 V plus ripple to the regulator input. The drop across the regulator supplies base drive to Q2. If Q2 is on, Q1 is off, and D6 is off. If the regulator voltage drops below about 3 V, Q2 turns off, and turns Q1 on, which turns on D6. This changes the circuit to an FW bridge using D1 through D4.

HIGH- OR LOW-INPUT REGULATOR



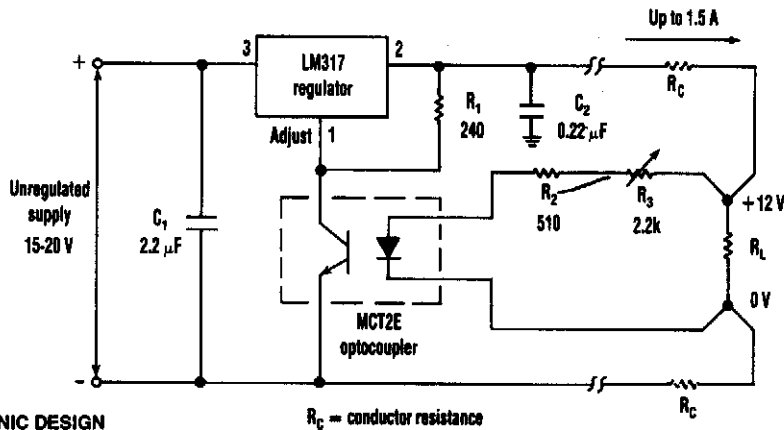
EDN

Fig. 73-4

This regulator provides 12 V at 1 A out with an input voltage of 8 to 20 V. Output voltage can be changed by charging the 11-k Ω and 2.49-k Ω resistors to provide 2.21 V at the V_{FB} pin of IC1, if desired. If you need to handle a higher input voltage, make sure to clamp the gate of Q1 below its 20-V max. rating.

Efficiency can exceed 70% for output currents greater than 0.5 A; above 15-V input voltage, more than 2 A of output current can be obtained.

LM317 REGULATOR SENSING

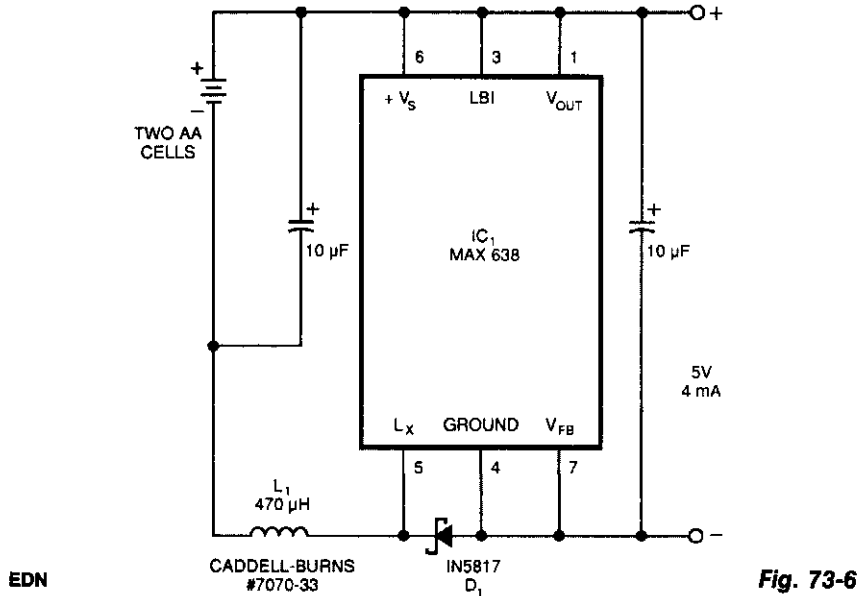


ELECTRONIC DESIGN

Fig. 73-5

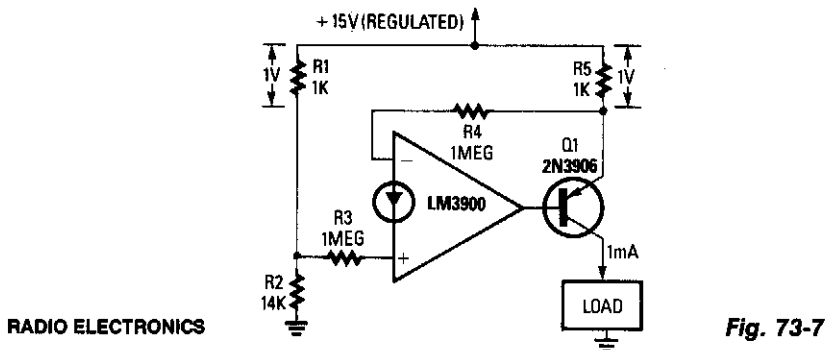
The optocoupler (as shown) provides load sensing for a 3-terminal regulator, such as the LM317 series. R1 sets a current of 5 mA through the optocoupler transistor and R3 is adjusted for 12 V across the load.

COMMON HOT-LEAD REGULATOR



This circuit derives 5 Vdc from 2-AA cells—even at their end-life voltages of 1.05 V, and is approximately 80% efficient, providing 5 V at 4 mA from 2.1 V at 11 mA. IC1 is manufactured by Maxim Integrated Products, Inc.

FIXED-CURRENT REGULATOR



This fixed 1-mA current source delivers a fixed current to a load connected between Q1's collector and ground; the load can be anywhere in the range from 0 Ω to 14 Ω . The circuit is powered from a regulated 15-V supply, and the R1/R2 voltage divider applies a 14-V reference to R3. The op amp's output automatically adjusts to provide an identical voltage at the junction of R4 and R5. That produces 1 V across R5, resulting in an R5 current of 1 mA. Because that current is derived from Q1's emitter, and the emitter and collector currents of a transistor are almost identical, the circuit provides a fixed-current source. The output current can be doubled by halving the value of R5.

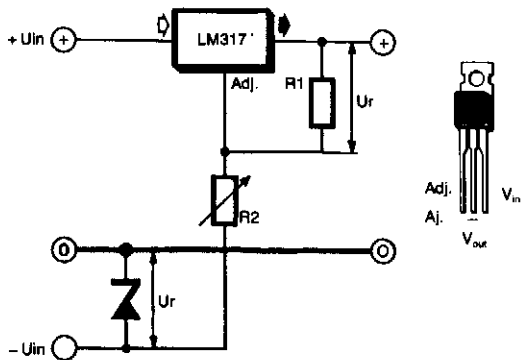
74

Regulators (Variable)

The sources of the following circuits are contained in the Sources section, which begins on page 676. The figure number in the box of each circuit correlates to the entry in the Sources section.

Regulator Circuit
Programmable Zener
Variable Voltage Regulator

REGULATOR CIRCUIT



ELEKTOR ELECTRONICS

Fig. 74-1(a)

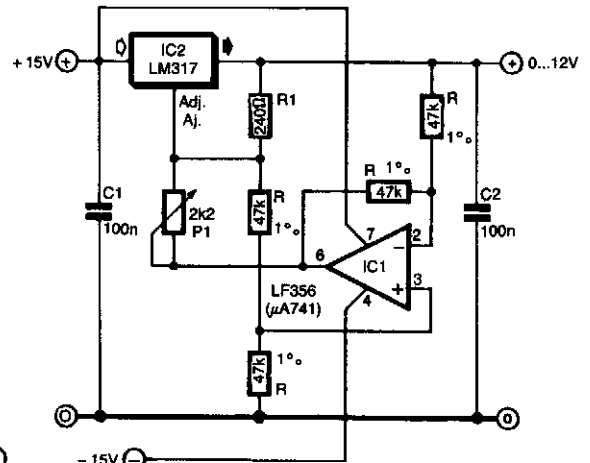


Fig. 74-1(c)

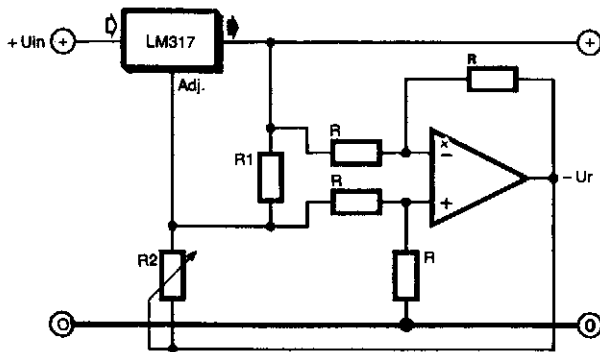


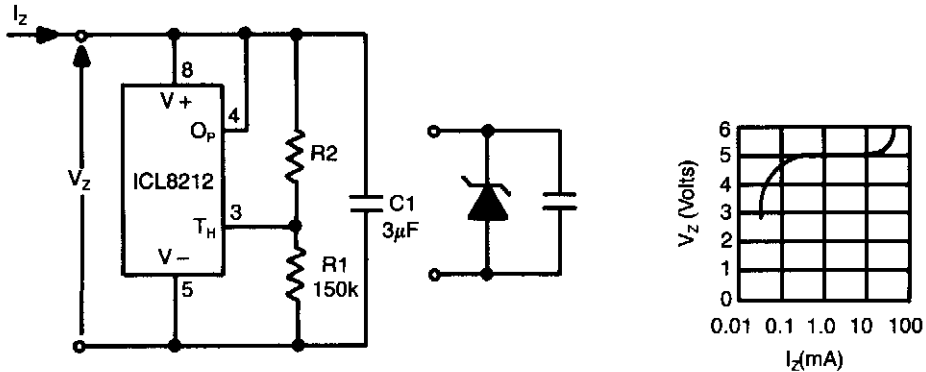
Fig. 74-1(b)

The special characteristic of this regulator is that the output voltage can be adjusted down to 0 V. The regulation is provided by an integrated regulator Type LM317. As is normal in supplies that can be adjusted to 0 V, this IC is used in conjunction with a zener diode. This diode provides a reference voltage that is equal, but of opposite sign, to the reference voltage (U_r) of the regulator, as shown in Fig. 74-1(a). Potential divider $R1/R2$ enables the output voltage to be adjusted.

In this circuit, the negative reference voltage is derived in a different manner: from the regulator with the aid of an op amp (Fig. 74-1(b)). The op amp is connected as a differential amplifier that measures the voltage across $R1$ and inverts this voltage to U_r . An additional advantage of this method is that at low-output voltages, a change in the reference voltage has less effect on the output voltage than the circuit in Fig. 74-1(a). The prototype, constructed as shown in Fig. 74-1(c), gave very satisfactory results.

The op amp need not meet any special requirements: a $\mu A741$ works fine, although an LF356 gives a slightly better performance. The negative supply for the op amp can be obtained with the aid of a center-tapped mains transformer.

PROGRAMMABLE ZENER



INTERSIL

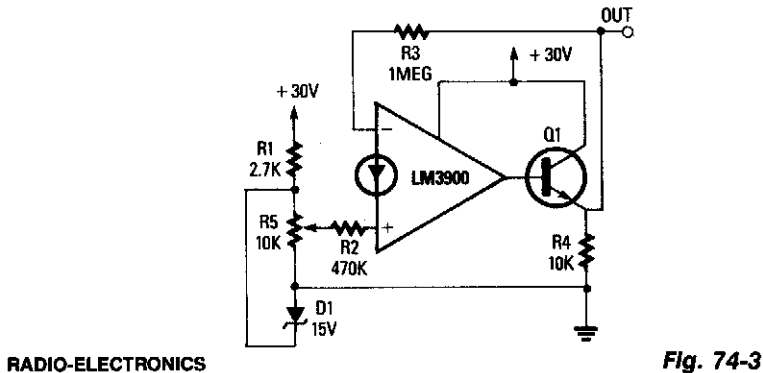
Fig. 74-2

The ICL8212 is connected as a programmable zener diode. Zener voltages from 2 V up to 30 V can be programmed by suitably selecting R2. The zener voltage is:

$$V_Z = 1.15 \times \frac{R_1 + R_2}{R_1}$$

Because of the absence of internal compensation in the ICL8212, C1 is necessary to ensure stability. Two points worthy of note are the extremely low-knee current (less than 300 μ A) and the low dynamic impedance (typically 4 to 7 ohms) over the operating current range of 300 μ A to 12 mA.

VARIABLE VOLTAGE REGULATOR



RADIO-ELECTRONICS

Fig. 74-3

The op amp is wired as a $\times 2$ noninverting dc amplifier with a gain that is determined by the R3/R2 ratio. The input voltage to the op amp is variable between 0 and 15 V via R5. The output voltage is therefore variable over the approximate range from 0.5 to 30 V. The available output current has been boosted by adding transistor Q1 to the output.

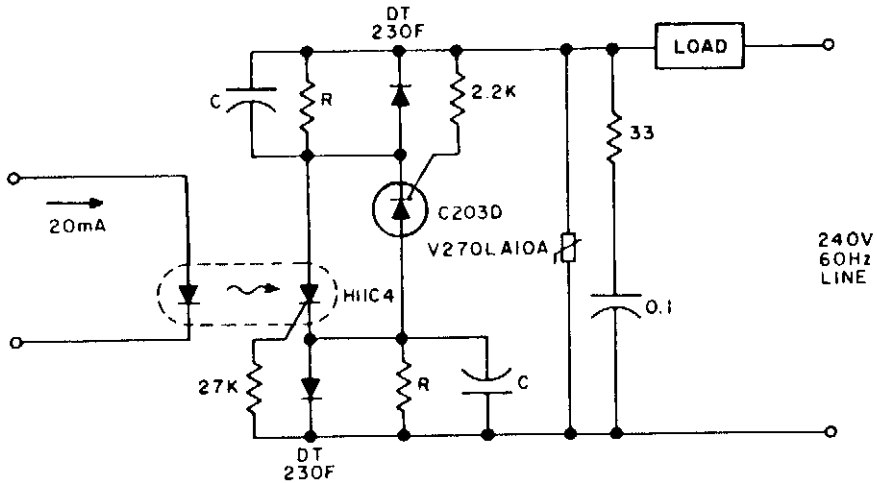
75

Relay Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 676. The figure number in the box of each circuit correlates to the entry in the Sources section.

Latching ac Solid-State Relay
Bidirectional Switch
Low-Consumption Monostable Relay
Delay-Off Relay Circuit
Solid-State Relay
Optoisolator

LATCHING ac SOLID-STATE RELAY

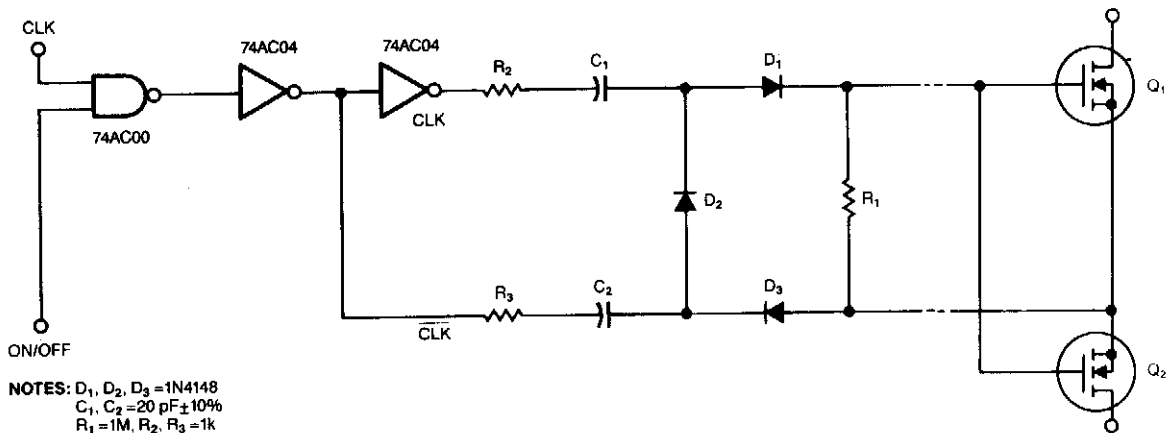


GE

Fig. 75-1

Latching is obtained by storing the gate trigger energy from the preceding half cycle in the capacitors. Power must be interrupted for more than one full cycle of the line to ensure turn-off. Resistor R and capacitor C are chosen to minimize dissipation, while assuring triggering of the respective SCRs for each cycle. A pulse of current, over 10 ms duration into the H11C4 IRED, ensures triggering the latching relay into conduction.

BIDIRECTIONAL SWITCH



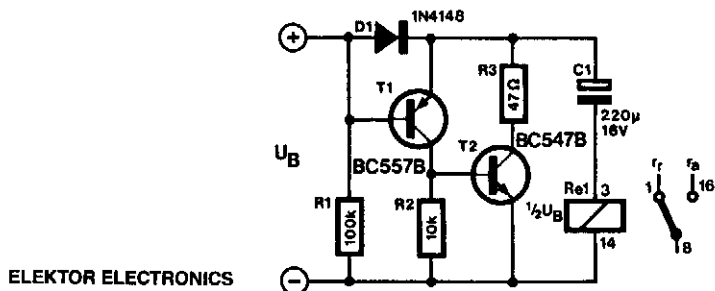
NOTES: $D_1, D_2, D_3 = 1N4148$
 $C_1, C_2 = 20 \text{ pF} \pm 10\%$
 $R_1 = 1M, R_2, R_3 = 1k$

EDN

Fig. 75-2

Using voltage doublers, this simple switch circuit uses a clock signal and a control signal to switch MOSFETs.

LOW-CONSUMPTION MONOSTABLE RELAY



ELEKTOR ELECTRONICS

Fig. 75-3

A monostable relay has two states: *operative* when a large enough current flows through its coil and *quiescent* when no current flows. A relay contact that assumes a certain position after the supply voltage has been switched on is required in many applications. Of course, many relays operate in that manner.

However, most of these relays require an energizing current of 50 mA or more and that normally precludes a battery supply. The circuit presented here, which uses a bistable relay, can solve that problem.

The contact of a bistable relay normally remains in the position it is in after the supply is switched off. This circuit, however, makes the bistable relay behave like a monostable type, at a modest current.

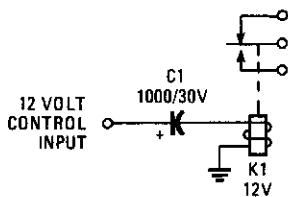
When the supply voltage is switched on, C1 charges via D1 and the relay coil. The current then flowing through the coil causes the relay contact to assume one of two positions. The forward drop across D1 ensures that the base of T1 (in this condition) is more positive than its emitter so that T1, and thus T2, is switched off.

When the supply voltage is switched off, the emitter of T1 is connected to the positive terminal of C1, while the base is connected to the negative terminal of the capacitor via R1 and the relay coil. This results in T1, and thus T2, switching on so that C1 discharges via T4 and the relay. The current flows through the relay coil, then flows in an opposite direction and this causes the contact to change over.

The bistable relay thus behaves exactly as a monostable with the advantage, however, that the operational current is determined by R1, which amounts to only 130 μ A.

To ensure reliable operation, the rating of the relay coil should be 65 to 75% of the supply voltage. In the prototype, a 9-V relay was used with a battery supply voltage of 12 V.

DELAY-OFF RELAY CIRCUIT



POPULAR ELECTRONICS

Fig. 75-4

When voltage is applied to the capacitor, it charges. While it's charging, the relay remains latched. When the charging current falls below the level needed to hold the relay down, the relay unlatches. The higher the value of the capacitor, the longer the relay will remain latched.

SOLID-STATE RELAY

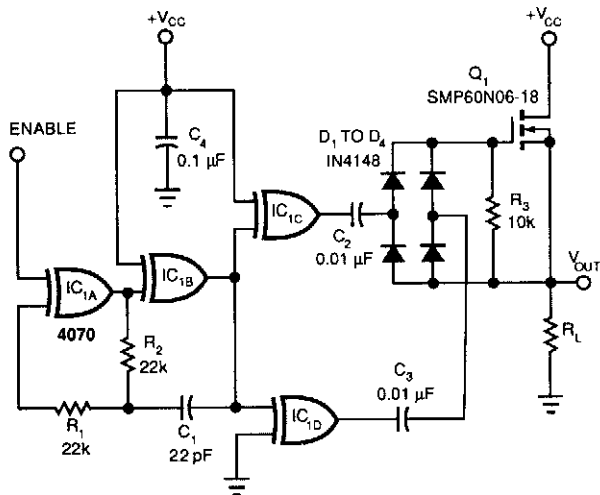


Fig. 75-5(a)

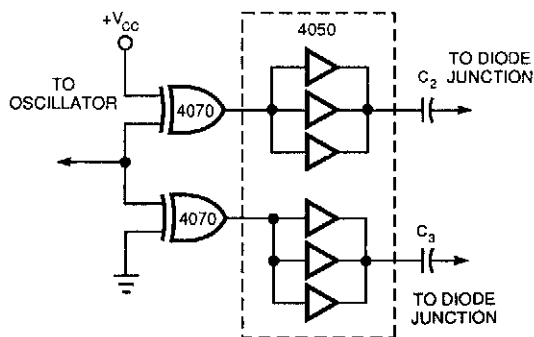


Fig. 75-5(b)

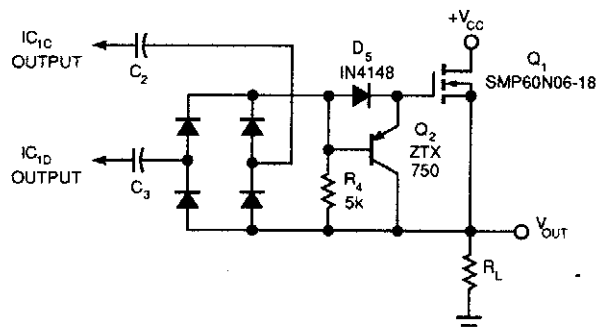


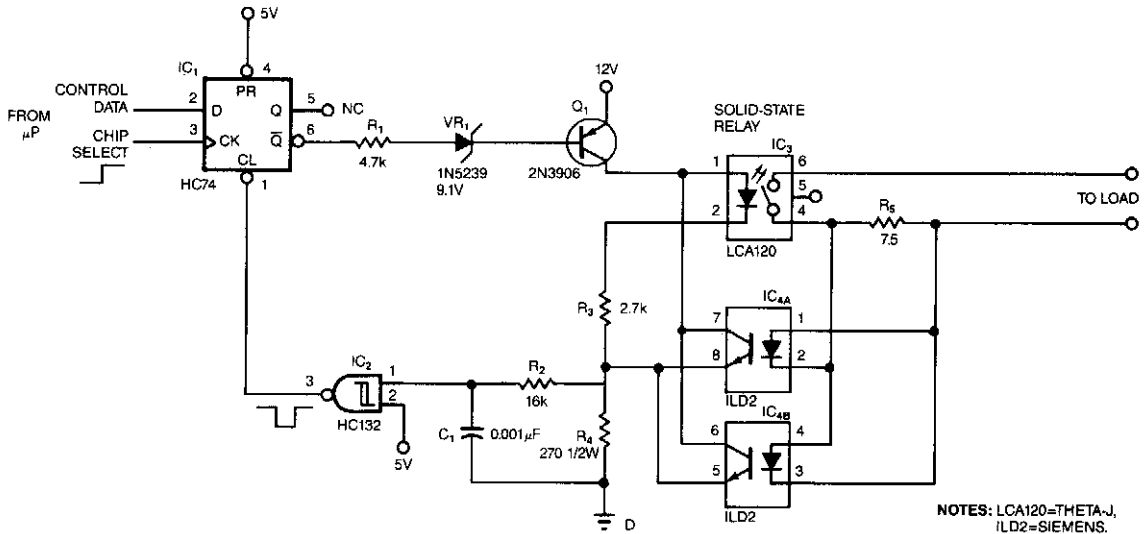
Fig. 75-5(c)

A power MOSFET and a quad exclusive-OR oscillator makes an effective solid-state relay. Figure 75-5(a)'s capacitively isolated drive circuit provides gate drive to turn on the n-channel device. This consists of a gated oscillator (IC1A and IC1B running at 500 kHz, set by R1, R2, and C1).

The diode bridge (D1 through D4) rectifies the charge transferred through C2 and C3. When you disable the oscillator, R3 discharges the stored gate charge, thereby turning off the MOSFET. R3 needs to allow fast turn-off times without loading the gate's enhancement voltage. A value of 10-k Ω is sufficient to produce a turn-off time of 800 μ s with an 18-m Ω SMP60N06-18 MOSFET. The measured turn-on time is 150 μ s.

You can reduce the turn-off time to 100 μ s by using a pnp transistor as a diode-steering emitter-follower in the MOSFET gate circuit (Fig. 75-5(b)). Adding a hex buffer to Fig. 75-5A's circuit increases the drive capability of the complementary outputs (Fig. 75-5(c)).

OPTOISOLATOR



EDN

Fig. 75-6

The circuit protects a solid-state relay from overloads. The circuit limits current, automatically disconnects the load after detecting a short circuit, and develops a fault-condition output signal.

In normal operation, the controlling μP sets the flip-flop, IC1, which turns on transistor Q1. When Q1 turns on, current flows through the solid-state relay's input, thus activating the relay.

If an overcurrent or fault condition occurs, the excessive load current flowing through the relay develops enough potential across sense resistor R5 to turn on one of the optoisolators, IC4A or IC4B. The optoisolator's output transistor diverts current around the solid-state relay's input, which limits the current that the relay's output can pass.

If the overload is severe enough, the optoisolator pulls the input of the Schmitt trigger above its threshold, thus clearing the flip-flop and turning off the solid-state relay. R2 has two functions: It keeps the input of the Schmitt trigger below 5 V max. to prevent latchup, and it forms an RC filter in conjunction with C1. The RC filter prevents spurious triggering of the Schmitt trigger. You can use the output of the flip-flop to signal overload conditions to the controlling μP .

76

RF Amplifiers

The sources of the following circuits are contained in the Sources section, which begins on page 676. The figure number in the box of each circuit correlates to the entry in the Sources section.

4-W Amplifier for 900 MHz	Varactor-Tuned Preselector
1 500-W RF Amplifier	Cascode RF Amplifier
Wideband RF Amplifier	Dual-Gate MOSFET RF-Amp Stage
6-m 100-W Linear Amplifier	Wideband Amplifier-Buffer Amplifier with
10- to 15-W ATV Linear Amplifier	Modulator
UHF TV-Line Amplifier	Wideband Amplifier
Double-Tuned JFET Preselector	Buffer Amplifier with Modulator
903-MHz Linear Amplifiers	Two CA3100 Wideband Operational Amplifiers
Simple JFET Preselector	HF Wideband Amplifier
1 296-MHz RF Amplifier	MOSFET Wideband Amplifier
Broadcast Band Booster	JFET Wideband Amplifier

4-W AMPLIFIER FOR 900 MHz

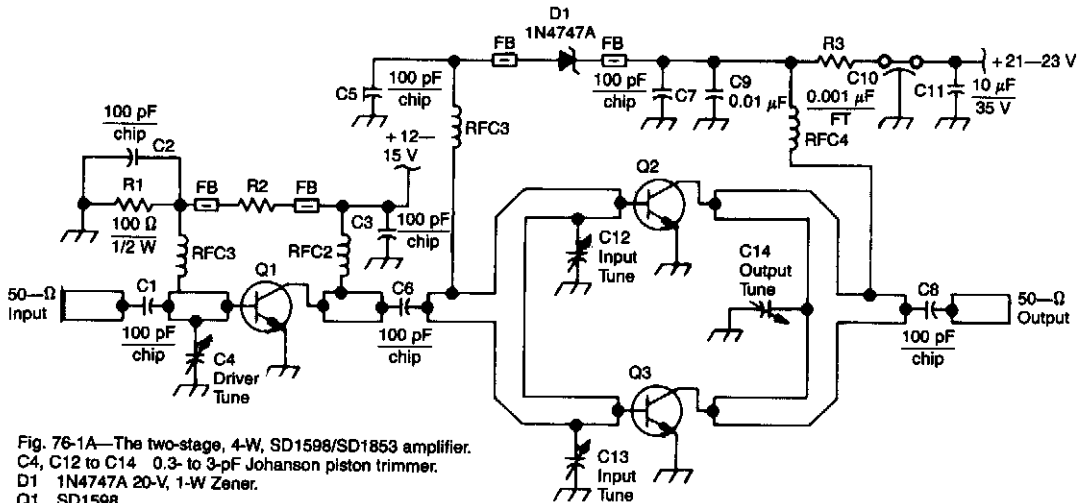
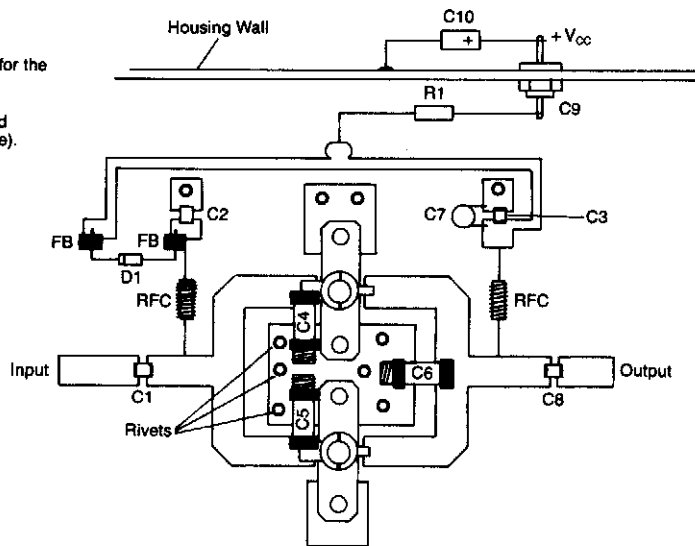


Fig. 76-1A—The two-stage, 4-W, SD1598/SD1853 amplifier.
 C4, C12 to C14 0.3- to 3-pF Johanson piston trimmer.
 D1 1N4747A 20-V, 1-W Zener.
 Q1 SD1598.
 Q2, Q3 SD1853.
 R2 1.5 to 1.7 k Ω , 1/2 W. See text, Part 1, June 1990 QST, p 24.
 R3 1 to 2 Ω , 2 W.
 RFC1 to RFC4 8 turns of #26 enam. wire, closewound, 0.1" ID.

Fig. 76-1B—Parts-placement diagram for the 2 \times SD1853 amplifier. The PC-board edges are not shown. All components mount to the trace side of the PC board (except those mounted to the enclosure).



QST

Fig. 76-1

Using Wilkinson power dividers in the base and collector circuits of Q2 and Q3, two SD1853 devices are paralleled for twice the power output of the 2-W amplifier.

1500-W RF AMPLIFIER (Cont.)

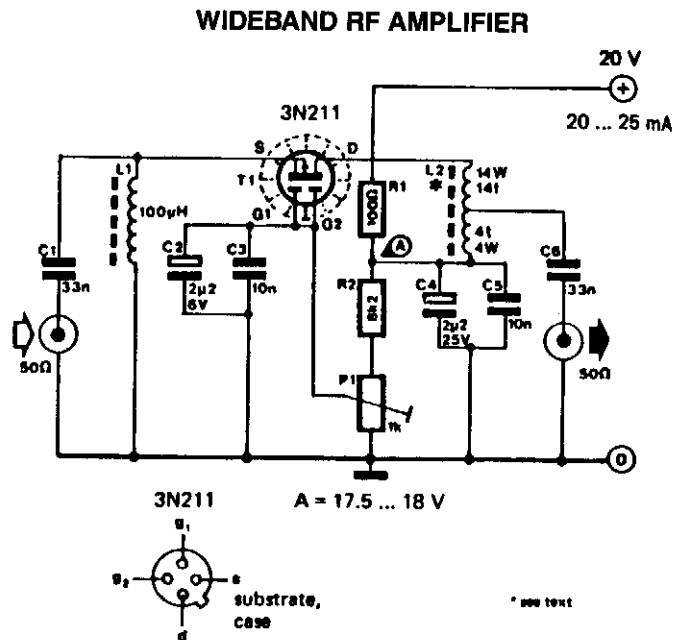
R7—10,000 ohm, 2 watt carbon composition
 RFC1—28 turns no. 18 wire solenoid wound
 on 0.5 inch OD by 2.5 inch ceramic form
 (plate choke)
 RFC2—Plate choke, surplus part (suggest
 B&W 801)
 RFC3—74 turns no. 20 wire solenoid wound
 on 0.75 OD by 3 inch ceramic form
 RFC4—9 μ H 15 A RF choke, surplus part
 (suggest Dale no. 1H15, HF no. 18-105)

RFC5—1.0 mH RF choke
 RFC6—10 H, 1 A RF choke
 RT1—Surgistor, GC 25-933-S
 S1—Air flow switch, Rotron 2A-1350
 SK1—Eimac socket, Sk-810B; chimney
 SK-806 (BY)
 T1—Transformer, 6.3 volts AC at 10 A sec-
 ond—ary, Thordarson 21F12, AL 704-2019
 Z1—Zener diode, 6.2 volts, 1N473

CQ

Fig. 76-2

The frequency range of this amplifier is 1.8 to 54 MHz. The amount of RF drive required for full output is about 30 W. The grid compartment (R1, R2, RFC4, RFC5) should be shielded from the other circuitry—especially the output circuitry.

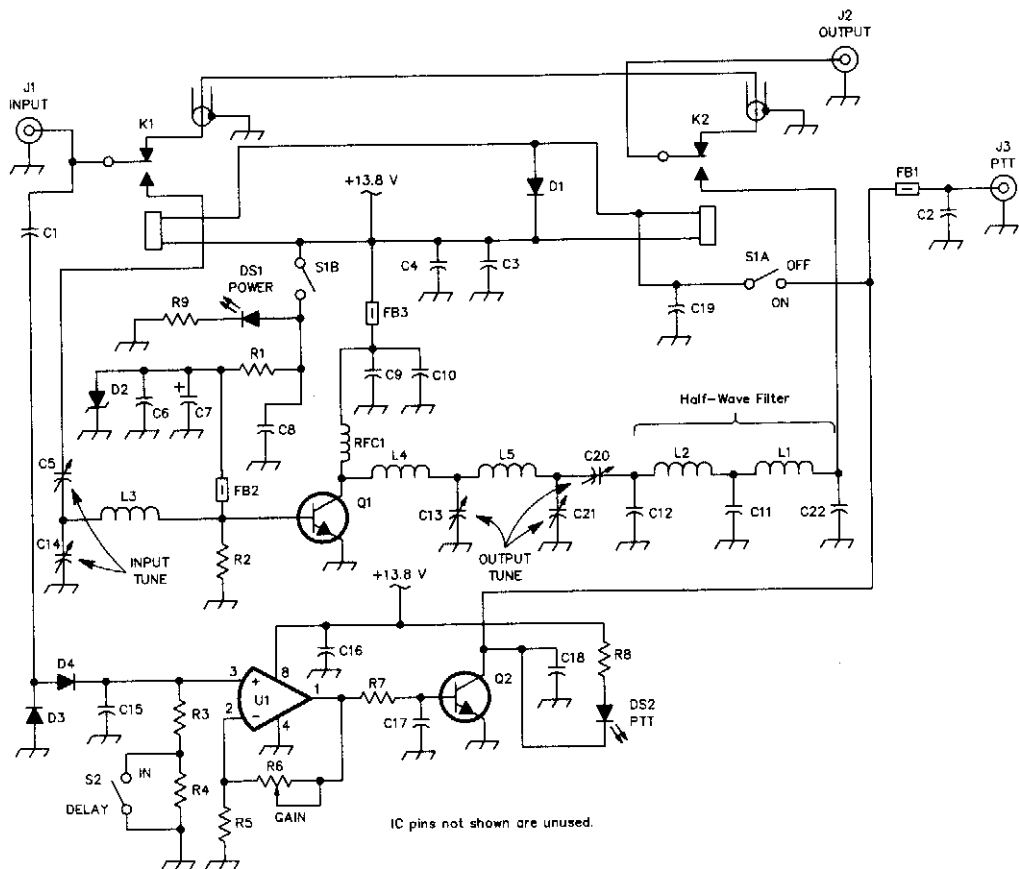


ELEKTOR ELECTRONICS

Fig. 76-3

This RF amplifier has wide bandwidth and dynamic range. It has a gain of 10 dB, noise figure less than 5 dB, and the third-order 1 MD is -40 dB at +22 dBm/tonne output. The bandwidth is 4 to 55 MHz.

6-m 100-W LINEAR AMPLIFIER



C1—10 pF, ceramic disc.
 C2—0.01 μ F, polyester film.
 C3, C10—0.001 μ F, ceramic disc.
 C4, C6, C8, C9, C15-C19—0.1 μ F, polyester film.
 C5—9- to 180-pF mica compression trimmer, Arco no. 463.
 C7—1000 μ F, 6.3 V, aluminum electrolytic.
 C11—120 pF, 100 V, silver mica.
 C12, C22—62 pF, 100 V, silver mica.
 C13, C14, C20—50- to 380-pF mica compression trimmer, Arco no. 465.
 C21—25- to 280-pF mica compression trimmer, Arco no. 464.
 D1—1N4002.
 D2—1N1200 stud-mount diode.
 D3, D4—1N4148.
 DS1—Green LED.
 DS2—Red LED.

FB1, FB3—Ferrite bead, Amidon no. FB43-901 or similar.
 FB2—VK-200 wide-band choke, 2½ turns no. 24 solid wire on Amidon no. FB43-S111 ferrite core.

J1, J2—Female RF connector (UHF, BNC, N, etc).

J3—Phono jack.

K1, K2—SPDT relay, 12-V dc coil, Omron no. G5L112P-PS-DC12. Available from Digi-Key.

L1, L2—4 turns no. 14 enam wire, 7/16 in. diam, 3/8 in. long.

L3—2 turns no. 14 enam wire, 3/8 in. diam, ½ in. long.

L4—no. 14 U-shaped wire loop, 3/8 in. diam, 9/16 in. finished length.

Q1—MRF492.

Q2—2N2222A.

R1—5-W bias resistor (see text).

R2—10 Ω , ½ W, carbon comp.

R3, R5—10 k Ω , ¼ W, carbon comp.

R4—1 M Ω , ¼ W, carbon comp.

R6—100-k Ω PC-board potentiometer.

R7-R9—1 k Ω , ¼ W, carbon comp.

S1—DPDT miniature toggle.

S2—SPST miniature toggle.

U1—LM358.

QST

Fig. 76-4

6-m 100-W LINEAR AMPLIFIER (Cont.)

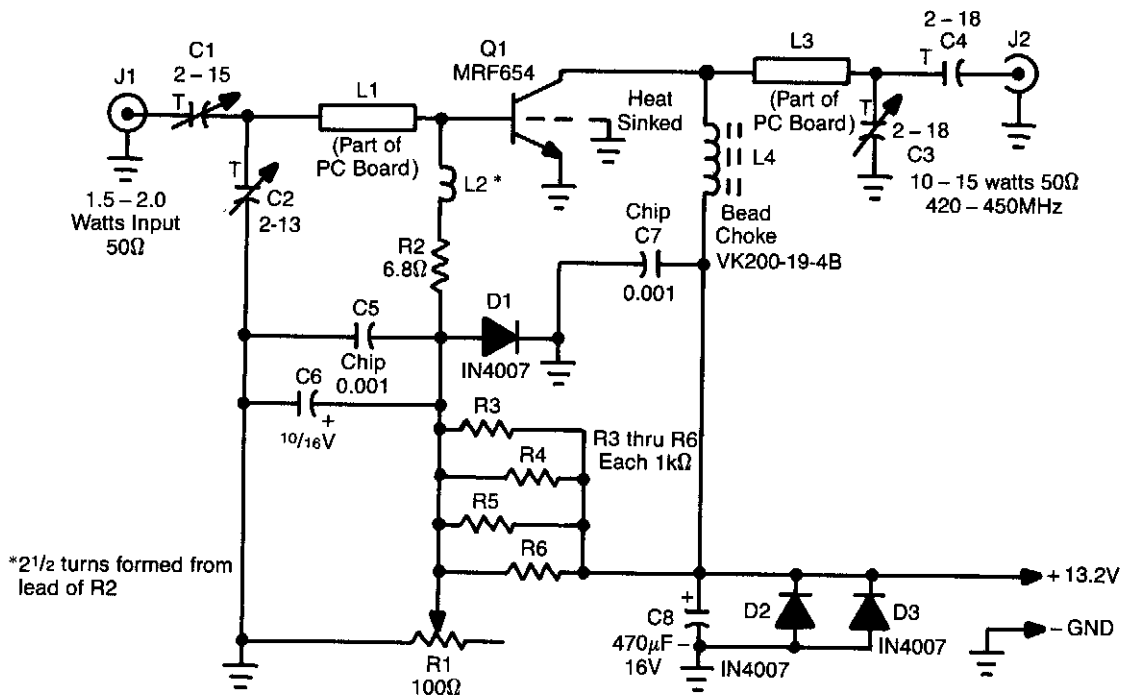
Miscellaneous

Suitable die-cast-aluminum enclosure and heat sink.
Pair of binding posts or other suitable dc-supply connector.

Two 1- × 3-in. strips of double-sided foam tape.
Two LED holders.
Seven no. 4-40 × ¼ in. machine screws.

100 W output at 50 MHz is available from this circuit. U1 and Q2 form a T-R relay driver, switching the amplifier on when RF input at J1 is sensed. During receive periods, J1 and J2 are directly connected. A 13.8-V supply is required for this amplifier.

10- to 15-W ATV LINEAR AMPLIFIER

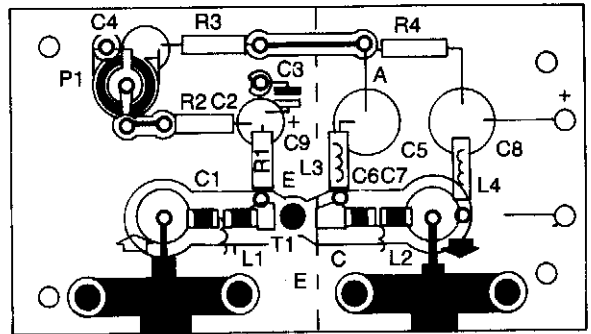
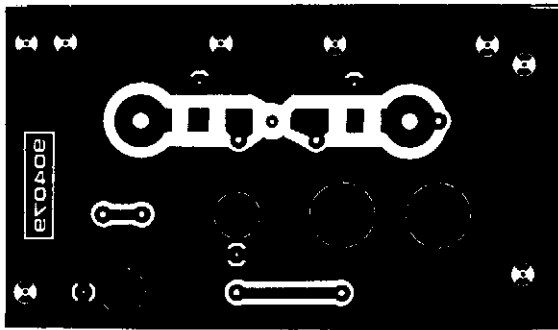
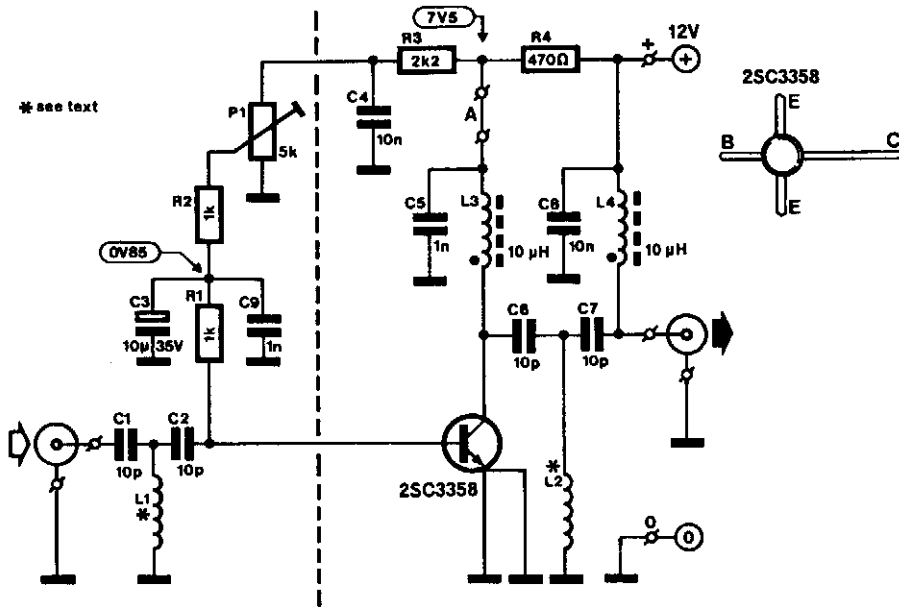


NORTH COUNTRY RADIO

Fig. 76-5

This amplifier is useful for applications where a 10- to 15-W peak-envelope-power (PEP) signal is needed in the 420- to 520-MHz range. C1, C2, and L1 form a matching network for amplifier Q1. L3, C3, and C4 form an output matching network for a 50-Ω load. L2, R2, D1, and R3 through R6 (with bias adjust R1) form a biasing network for Q1. D2 and D3 provide polarity protection for Q1, which must be heat-sinked. A kit of all parts including case and PC board is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804.

UHF TV-LINE AMPLIFIER



ELEKTOR ELECTRONICS

Fig. 76-6

This circuit offers 10- to 15-dB gain from 400 to 850 MHz and is therefore eminently suitable for situations where the television signal is weak. Moreover, the filters can be adapted to the individual needs of users. Construction is simplicity itself if the ready-made PC board shown on the next page is used. The tracks should be tinned or silvered for optimum performance and long life.

The opening at the center of the board is intended to accommodate the transistor. This device has two emitter pins, both of which should be connected to ground. The drawings show that the board is divided into two by a small piece of tin plate, which should have a small cut-out for the transistor.

The input and output terminals are made from small cable clamps and M3 nuts and bolts. One side of disc capacitors C4, C5, C8, and C9 is soldered direct to the board.

Input and output capacitors, C1/C2 and C6/C7 respectively are surface-mount types. C1/C2/L1 form an input filter and C6/C7/L2 form an output filter. The value of the capacitors might have to be lowered to

UHF TV-LINE AMPLIFIER (Cont.)

3.9 pF to obtain the correct frequency range. The amplifier can be housed in a watertight case and then mounted near the antenna at the top of the mast (if used).

The power is obtained from a simple stabilized 12-V supply: a mains adapter with a 78L12 will do nicely. This can be kept indoors, of course. The amplifier can be powered via the coaxial feeder cable, for which purpose a 10- to 100- μ H choke is inserted in the supply line. Calibrating the amplifier is straightforward: set P1 to the center of its travel and then adjust it for optimum picture quality.

In practice, the collector current of the transistor is then 5 to 15 mA. This may be checked by temporarily replacing jump lead A by one suitable meter.

PARTS LIST

R1, R2 = 1 k Ω

R3 = 2 k Ω

R4 = 470 Ω

P1 = 5 k Ω preset potentiometer

C1, C2, C6, C7 = 10 pF surface mount

C3 = 10 μ F; 35 V

C4, C8 = 1 nF disc

C5, C9 = 1 nF disc

L1, L2 = air core, 2 turns of 3mm diameter enamelled copper wire

L3, L4 = 10- μ H choke or 10 turns of 0.2 mm diameter enamelled copper wire on a ferrite bead.

T1 = 2SC3358

DOUBLE-TUNED JFET PRESELECTOR

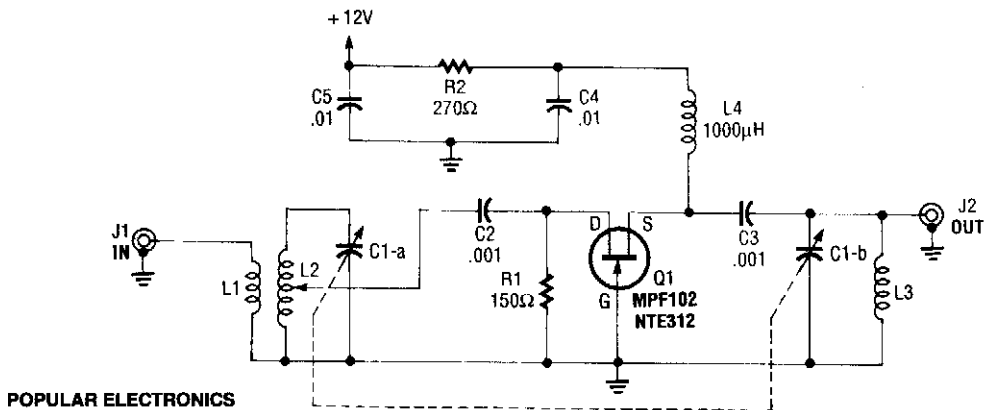


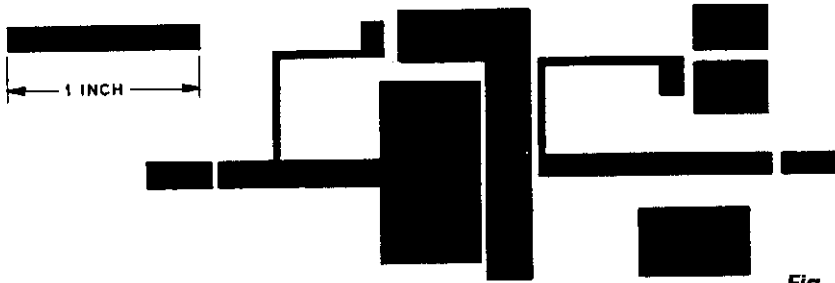
Fig. 76-7

This circuit uses an MPF102 JFET and a double-tuned common-gate amplifier. Gain is typically 10 to 15 dB:

$$L_2 \text{ and } L_3 = \frac{1}{(2\pi f)^2 C_1}$$

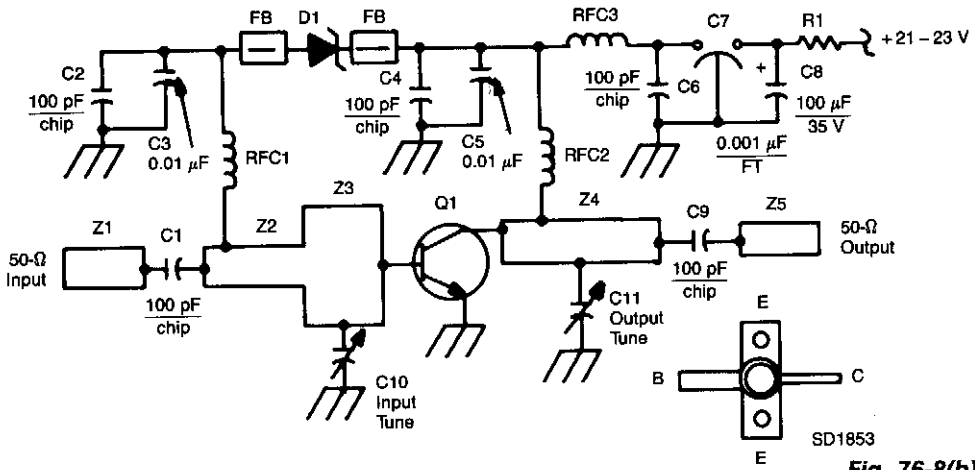
L1 \approx 10% turns on L2 or 1 turn (larger of these two).

903-MHz LINEAR AMPLIFIERS



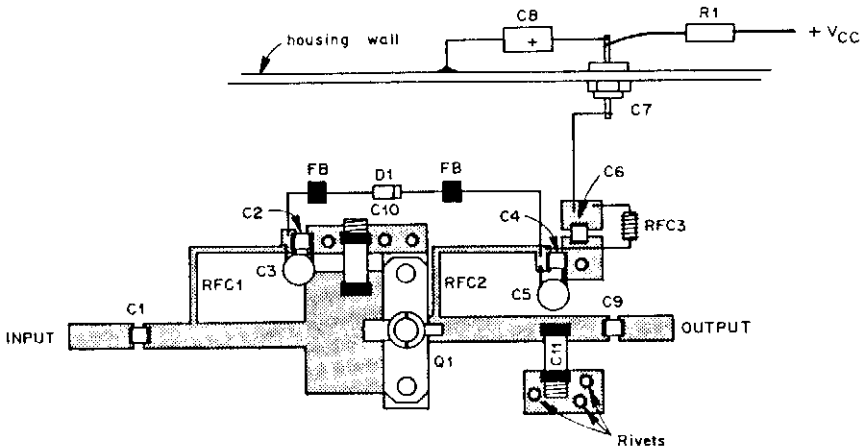
QST

Fig. 76-8(a)



QST

Fig. 76-8(b)



QST

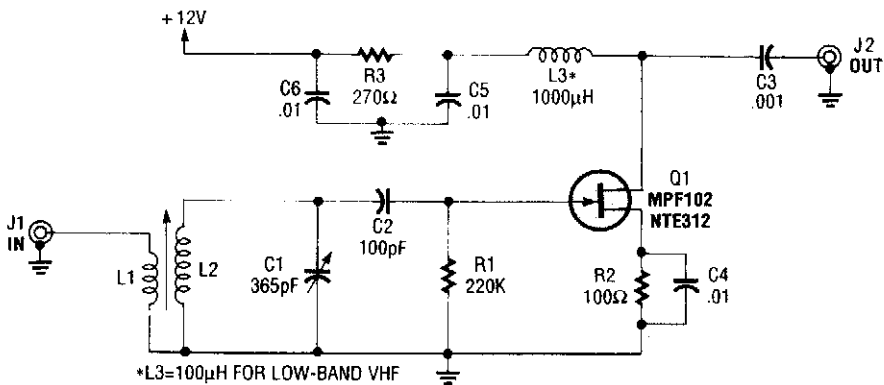
Fig. 76-8(c)

903-MHz LINEAR AMPLIFIERS (Cont.)

The 2-W SD1853 amplifier. RFC1 and RFC2 are implemented as PC-board traces.
 C10,C11 0.3- to 3-pF Johanson piston trimmer.
 D1 1N4747A 20-V, 1-W Zener.
 Q1 SD1853.
 R1 2-3 Ω, 1 W.
 RFC3 8 turns of #26 enam wire, closewound, 0.1" ID.
 Z1-Z5 Microstriplines. See text and Fig. 18.

Two W output can be produced by this circuit designed for the 902- to 928-MHz amateur band. As shown in the figures, much of the circuitry is in the form of PC board traces.

SIMPLE JFET PRESELECTOR



POPULAR ELECTRONICS

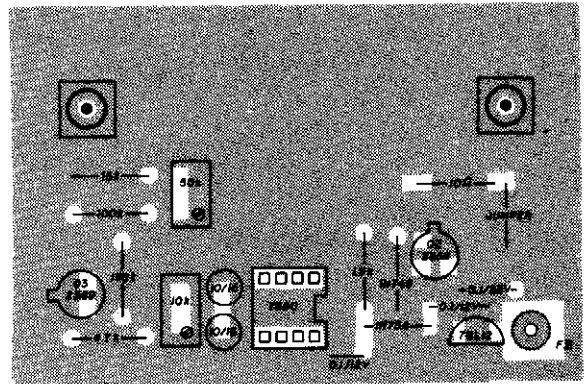
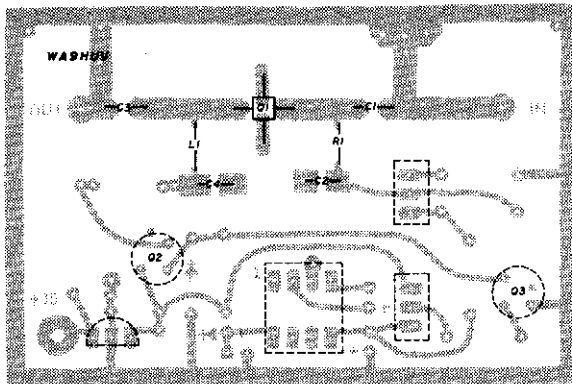
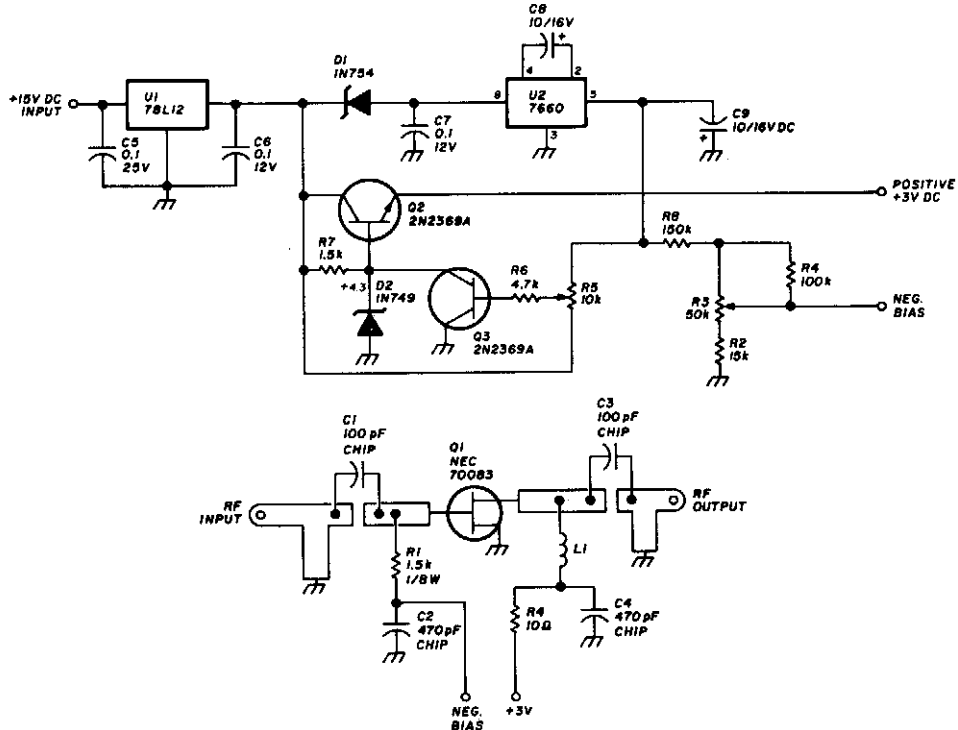
Fig. 76-9

This preselector will improve the performance of simple shortwave receivers. L2 is tuned with Q1. The inductance of L2 is:

$$L_2 = \frac{1}{(2\pi f)^2 C_1}$$

and L1 is found around the cold end of L2. Typically, L1 has 10% of the turns in L2, or one turn, whichever is larger.

1296-MHz RF AMPLIFIER



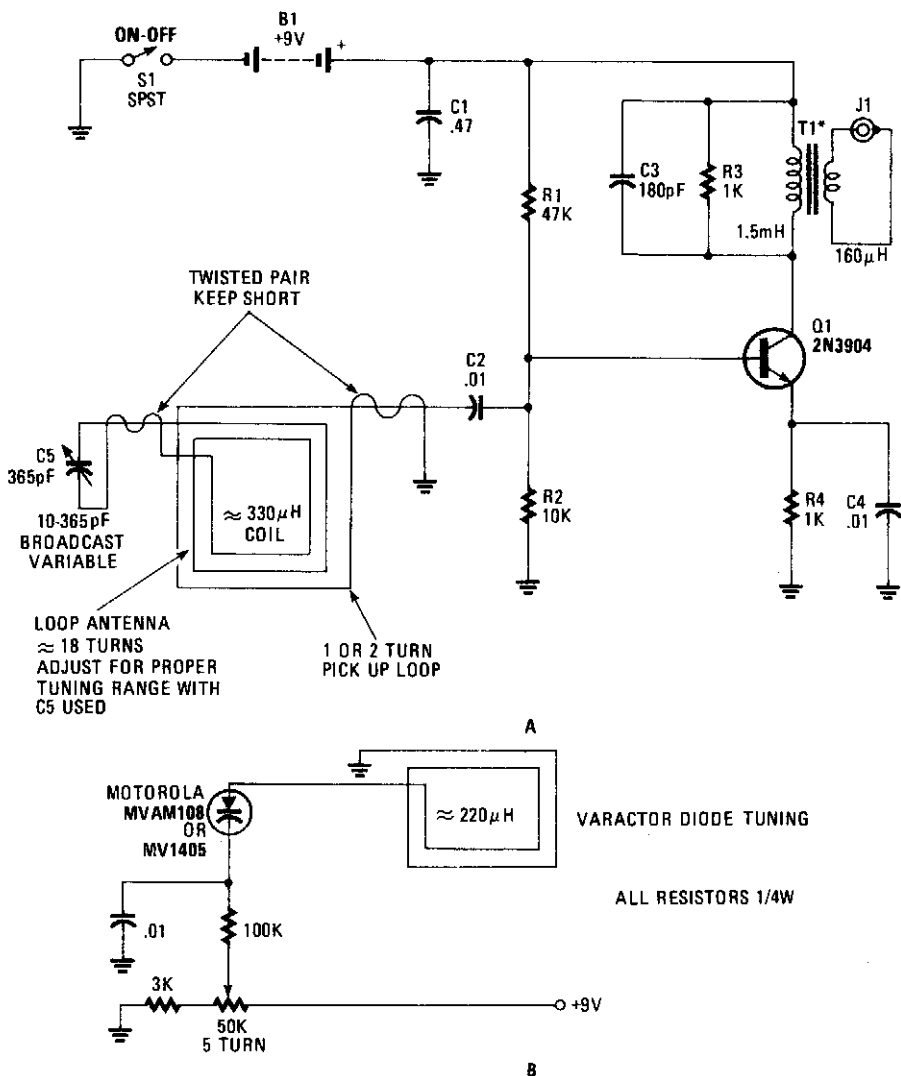
HAM RADIO

Fig. 76-10

Using an NEC70083, this 1296-MHz amplifier delivers about 17-dB gain and around 1- to 1.5-dB noise. It is constructed on a G-10 epoxy fiberglass PC board. Use the layout shown because this is important for correct performance.

The power supply/regulator delivers the regulated 3-Vdc for the drain circuit and U2 produces a negative bias for the gate circuit. R5 sets the drain voltage to +3 V and R3 sets the gate bias. Typically, the drain current is about 10 mA.

BROADCAST BAND BOOSTER

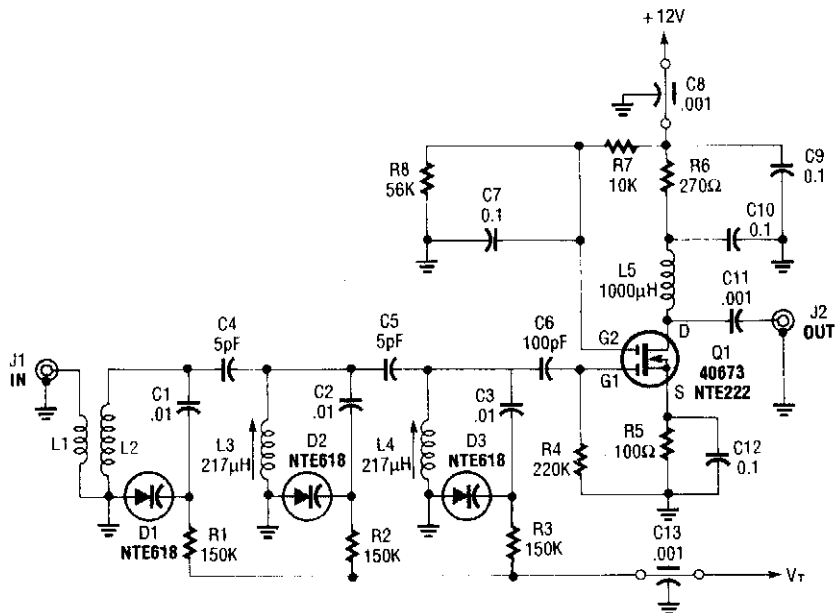


POPULAR ELECTRONICS

Fig. 76-11

The use of a loop antenna of large size (12×18") provides a large signal pickup at AM broadcast frequencies. It has about 18 turns. T1 is a toroidal transformer of about 3:1 turns ratio (not critical). The primary winding should have about 1.5 mH inductance. By using the circuit at (B), a varactor diode can be used in place of the 10- to 365-pF variable capacitor.

VARACTOR-TUNED PRESELECTOR

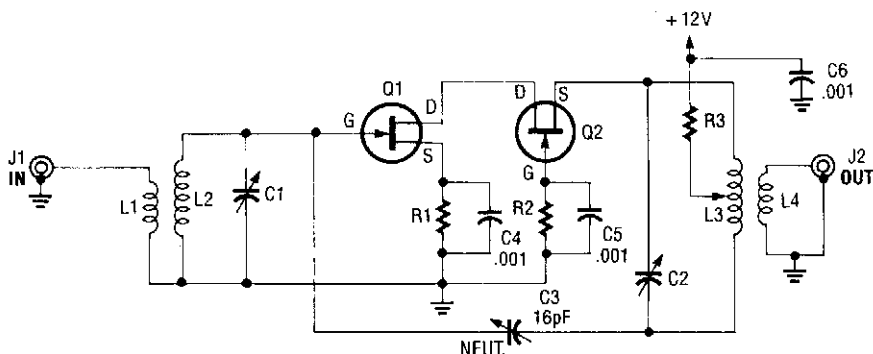


POPULAR ELECTRONICS

Fig. 76-12

Varactor diodes replace the conventional 365-pF tuning capacitors, which reduces size and weight when used as a turned RF stage for AM broadcast applications. Selectivity is good enough for use as a TRF receiver if a detector is connected to J2.

CASCODE RF AMPLIFIER

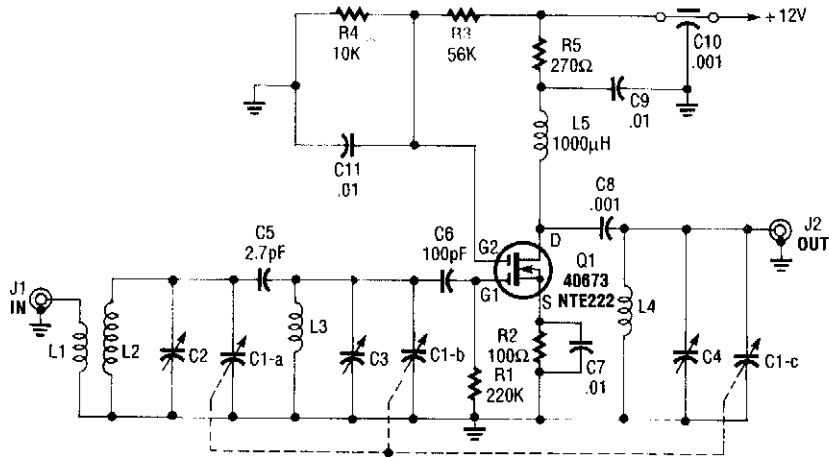


POPULAR ELECTRONICS

Fig. 76-13

A cascode amplifier using two MOSFETs is shown in the diagram. L2C1 and L3C2 resonate to the frequency in use. The circuit has the advantage of good gain, low NF, and excellent linearity. Q1 and Q2 can be MPF102 or 2N4416.

DUAL-GATE MOSFET RF-AMP STAGE

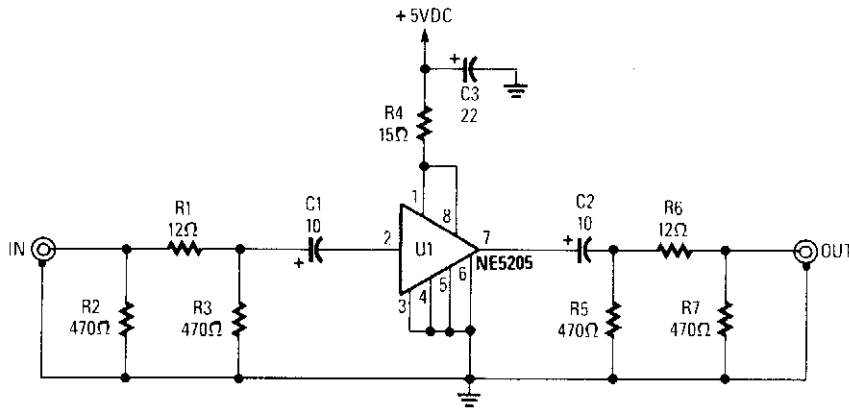


POPULAR ELECTRONICS

Fig. 76-14

The use of a double-tuned input and a single-tuned output yield superior RF selectivity to that of equivalent single-tuned designs. AGC, if required, can be added to gate 2 of Q1, and should drive gate 2 negative for decreased gain.

WIDEBAND AMPLIFIER

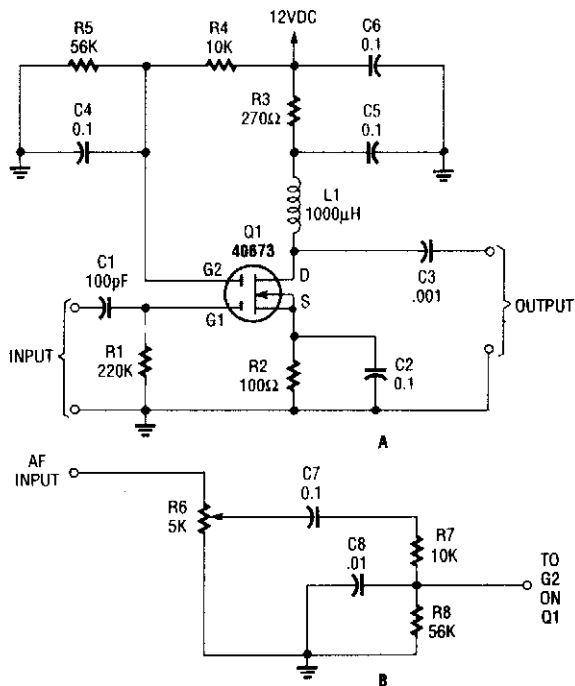


POPULAR ELECTRONICS

Fig. 76-15

Using a Signetics NE5205, this circuit gives about +16-dB gain from LF to 600 MHz. The π minimizes load impedance and source-impedance variations and aids stability.

BUFFER AMPLIFIER WITH MODULATOR

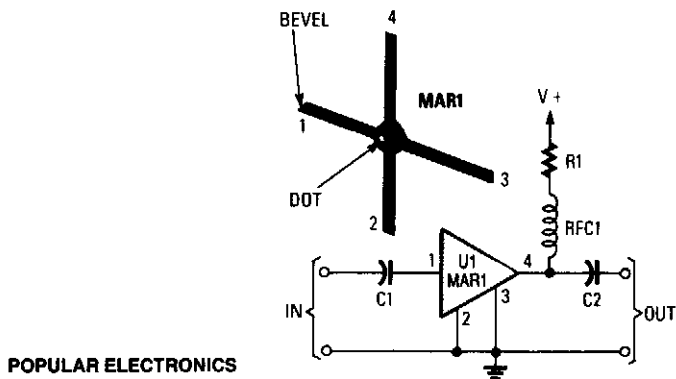


POPULAR ELECTRONICS

Fig. 76-16

A 40673 MOSFET is used as a wideband buffer amplifier (to 20 MHz). If desired, the amplifier can be modulated, considering that the gate 2 voltage of a MOSFET can be used to vary the gain of the stage.

WIDEBAND AMPLIFIER

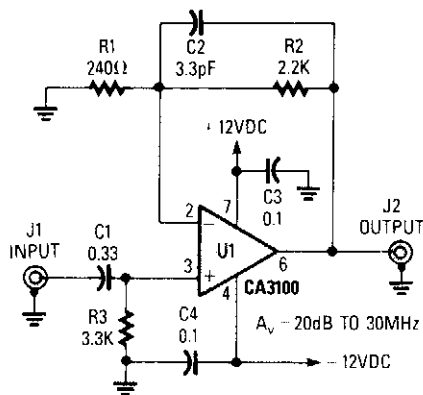


POPULAR ELECTRONICS

Fig. 76-17

This wideband amplifier uses a MAR1 IC, which is a gain block. The device is manufactured by Mini-Circuits Lab and offers +13-dB gain from dc to 1 000 MHz. R_1 is selected to provide 17-mA current to U1 at +5 V. For 12-V supply $R_1 = 470 \Omega$. RFC1 is typically 1 to 5 μH .

TWO CA3100 WIDEBAND OPERATIONAL AMPLIFIERS



POPULAR ELECTRONICS **Fig. 76-18(a)**

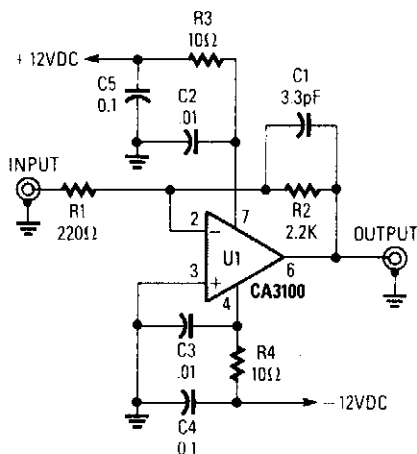


Fig. 76-18(b)

These circuits use the RCA CA3100 wideband amplifier IC. The gain is:

$$A_v = 1 + \frac{R_2}{R_1}$$

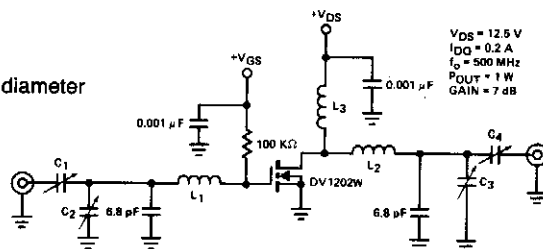
These circuits are useful for video applications to 10 MHz. The 3.3-pF capacitors are compensation capacitors. Capacitors on pins 7 and 4 are bypass capacitors to prevent self-oscillations. Figure 76-18(a) is noninverting and Fig. 76-18(b) is an inverting configuration.

500-MHz AMPLIFIER

C1, C2, C3, C4, ARCO #400, 1→7pF

L1, L2, 1/2" length #12 wire

L3, 4 turns #22 enameled wire close wound on 1/4" diameter

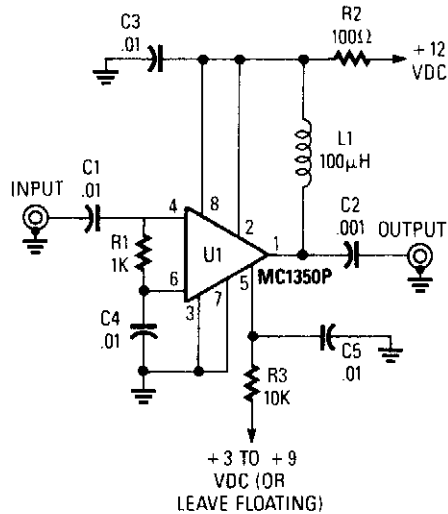


MOTOROLA

Fig. 76-19

This amplifier provides 1-W output at 500 MHz with a DV1202W FET. About 6- to 8-dB power gain can be expected.

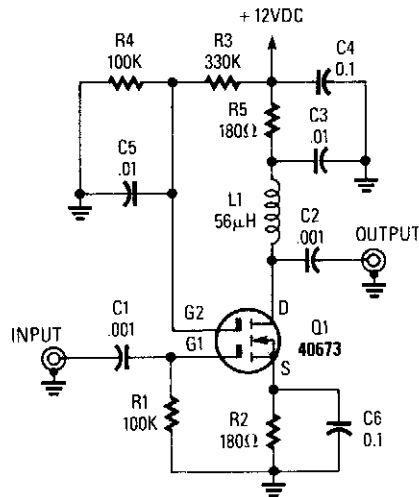
HF WIDEBAND AMPLIFIER



POPULAR ELECTRONICS **Fig. 76-20**

About 20-dB gain can be obtained using this IC. The gain can be controlled by varying the voltage applied to R3.

MOSFET WIDEBAND AMPLIFIER

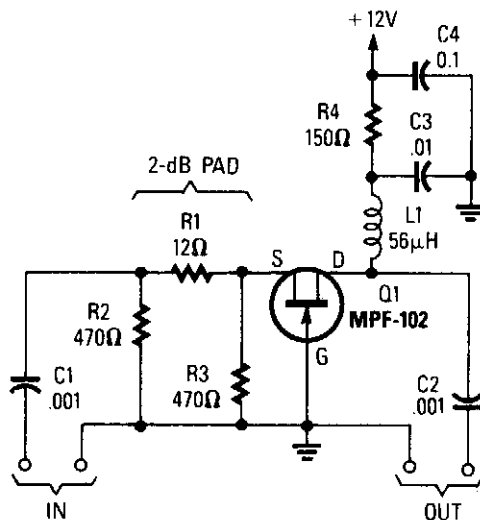


POPULAR ELECTRONICS

Fig. 76-21

For high-impedance ($7500\ \Omega$) applications, this amplifier will provide a voltage gain of approximately $-gm/Z_L$ where Z_L is the load impedance in ohms and gm is $\approx 12 \times 10^{-3}$ for the 40673 FET. The G2 voltage can be used to control the gain.

JFET WIDEBAND AMPLIFIER



POPULAR ELECTRONICS

Fig. 76-22

Using an MPF102 JFET, this circuit has a 50-Ω input impedance. Load impedance should be about 470 Ω. A 3:1 matching transformer can be used to get the impedance back to 50 Ω. This circuit will show about 6- to 8-dB gain at VHF frequencies.

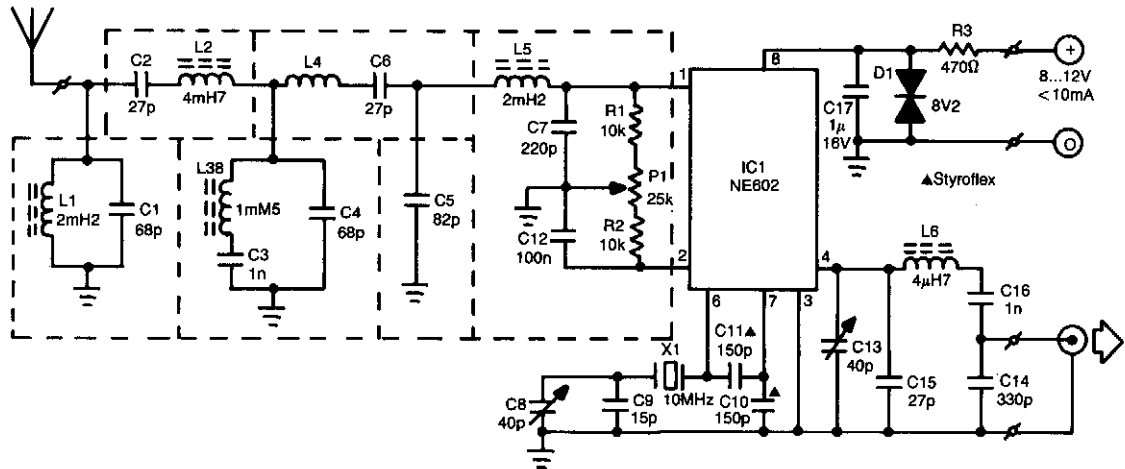
77

RF Converters

The sources of the following circuits are contained in the Sources section, which begins on page 677. The figure number in the box of each circuit correlates to the entry in the Sources section.

Radio Beacon
Low-Noise 420-MHz ATV Receiver/Converter
VLF Converter
2-Meter Converter
Receiver Frequency-Converter Stage
10-MHz WWV to 80-Meter SW Converter
Shortwave Converter for AM Car Radios
220-MHz Receiving Converter
RF Upconverter For TVRO Subcarrier Reception

RADIO BEACON CONVERTER



ELEKTOR ELECTRONICS

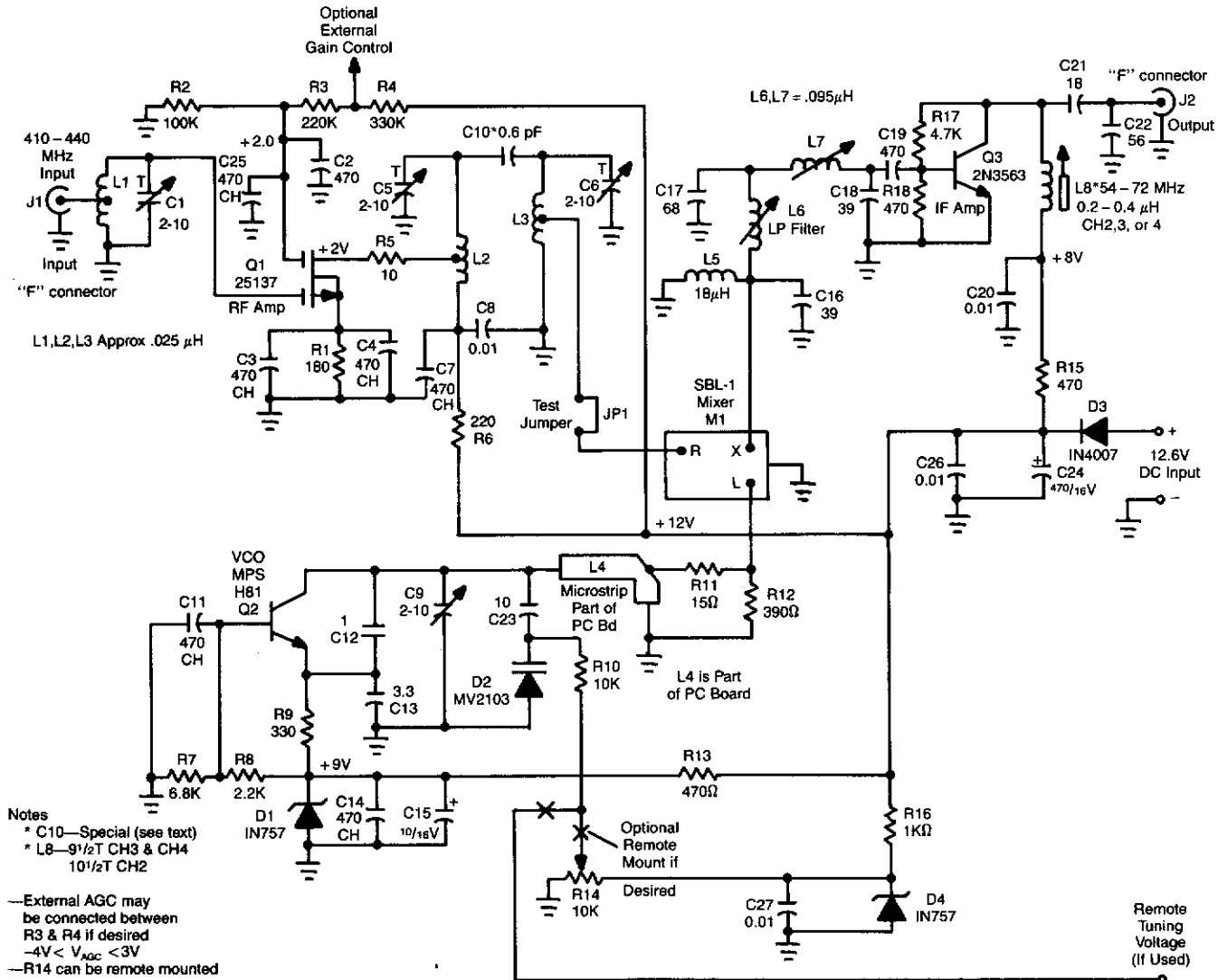
Fig. 77-1

The radio beacon band extends from 280 to 516 kHz. Each beacon has its own characteristic AM-modulated morse-coded callsign that is transmitted on a specific frequency. To be able to receive distant beacons, the aerial signal is passed through a band-pass filter that effectively suppresses longwave and mediumwave signals. The filter also converts the aerial impedance, Z_{in} , from about 10 k Ω to the input impedance of mixer IC1, which is about 1 k Ω .

The mixer adds or subtracts the received signal to/from the local oscillator signal so that the beacon signal can be received on a normal shortwave receiver. The resulting frequencies are from 9.72 to 9.48 MHz or from 10.280 to 10.516 MHz. In the construction of the converter, some components must be surrounded by a metal shield, as indicated by dashed lines on the PC board layout.

The circuit is aligned with the aid of an SSB receiver, to which the output of the converter is connected. Tune the receiver to 10 MHz and adjust the oscillator frequency of the converter with C8 for zero beat. Next, detune the receiver slightly until you hear a pleasant whistle, which is adjusted for minimum level with the aid of P1. Finally, tune to a beacon transmitting at or about 300 kHz and adjust C13 for maximum sound output.

LOW-NOISE 420-MHz ATV RECEIVER/CONVERTER



Notes

- * C10—Special (see text)
- * L8— $9\frac{1}{2}$ T CH3 & CH4
 $10\frac{1}{2}$ T CH2
- External AGC may be connected between R3 & R4 if desired
- $-4V < V_{AGC} < 3V$
- R14 can be remote mounted

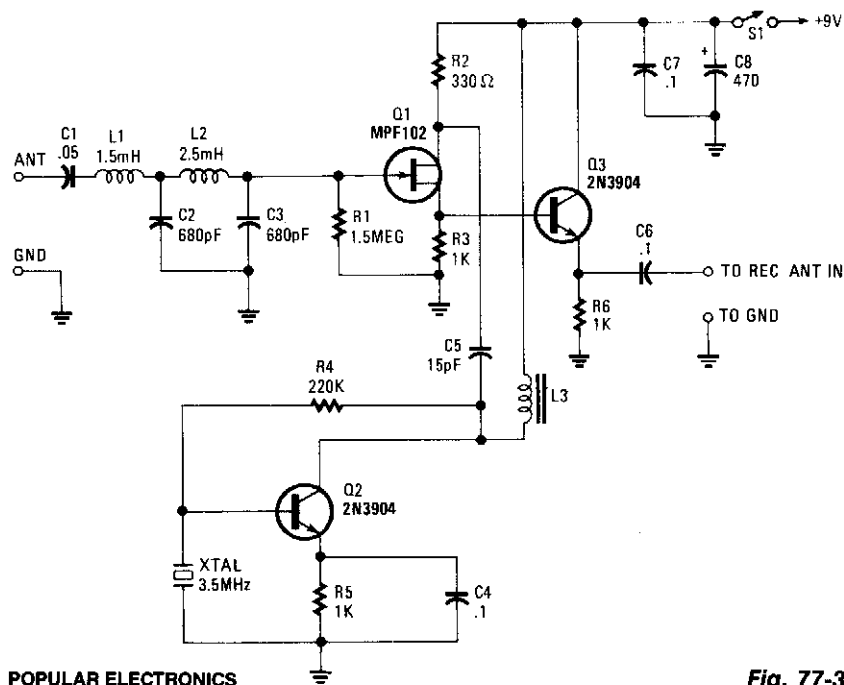
NORTH COUNTRY RADIO

Fig. 77-2

LOW-NOISE 420-MHz ATV RECEIVER/CONVERTER (Cont.)

L1, Q1, L2, and L3 compose an RF amplifier stage that feeds M1, a doubly balanced mixer. Q4 is a local oscillator stage in the 375-MHz range. Signals in the 420- to 450-MHz range from Q1 are mixed in M1 and fed through filter L6/L7/C17, where only the 60- to 70-MHz (CH3/CH4) signals pass. The IF signal is passed to Q3, an IF amplifier. The overall gain is 25 dB and the noise figure less than 2 dB. A kit of all parts, including the PC board, is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804.

VLF CONVERTER



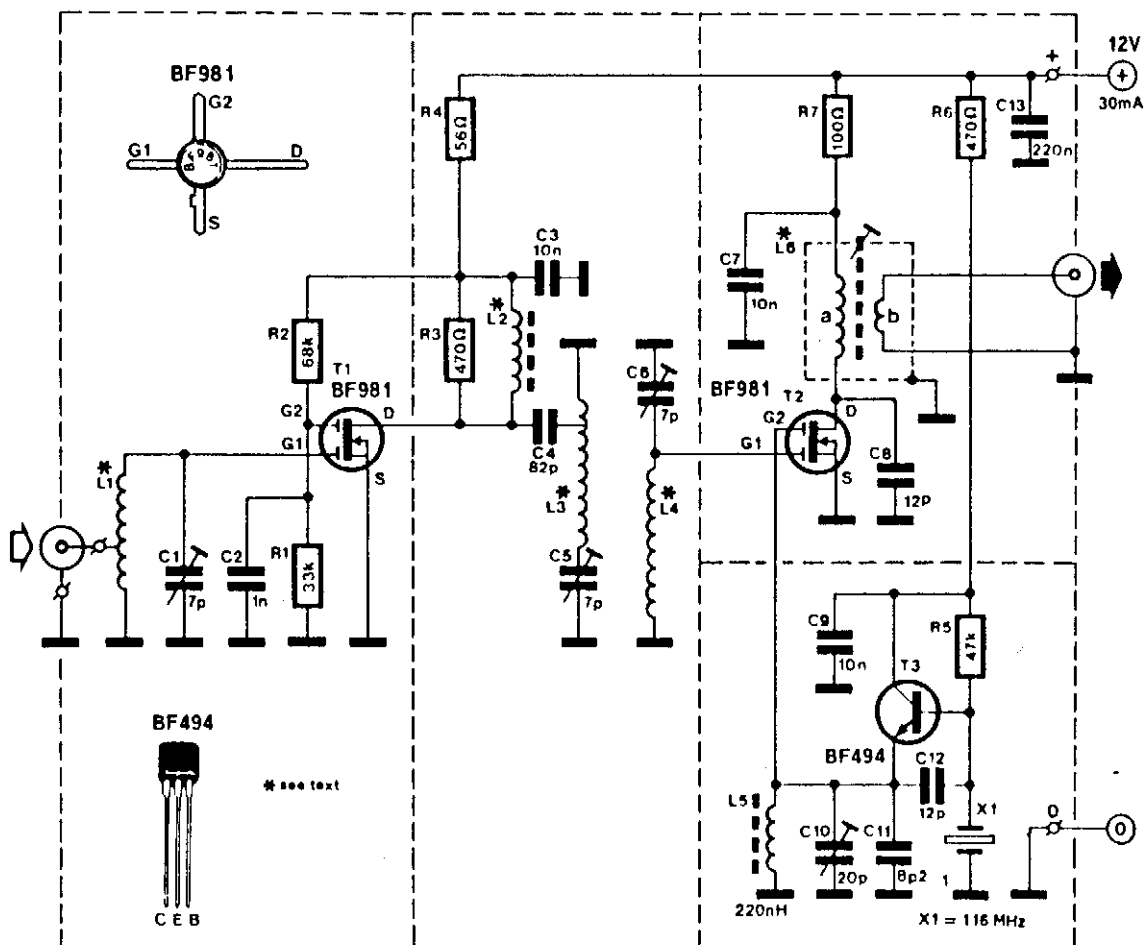
POPULAR ELECTRONICS

Fig. 77-3

The VLF Converter can be used to pick up signals for the general coverage of shortwave receivers. A number of unusual signals can be heard on frequencies below 15 kHz.

This converter will convert frequencies from 0 to 250 kHz to 3 500 to 3 750 kHz so that the LF- and VLF-band segments can be received on an amateur or shortwave receiver that covers 3 500 to 4 000 kHz. Signals from a short whip antenna (8 to 10 feet) are coupled through low-pass filter L1/L2/C2/C3 to RF amp Q1. Q3 mixes these signals with a 3.5-MHz signal from Q2 and associated components C4, R5, R4, and 3.5-MHz XTAL. L3 is an RF choke that presents an inductive load to Q3. It should be resonant somewhat above 3.5 MHz when placed in the circuit. An adjustable coil of about 30 to 100 μ H should be sufficient. The converter output is taken from the emitter of Q3 through C6.

2-METER CONVERTER

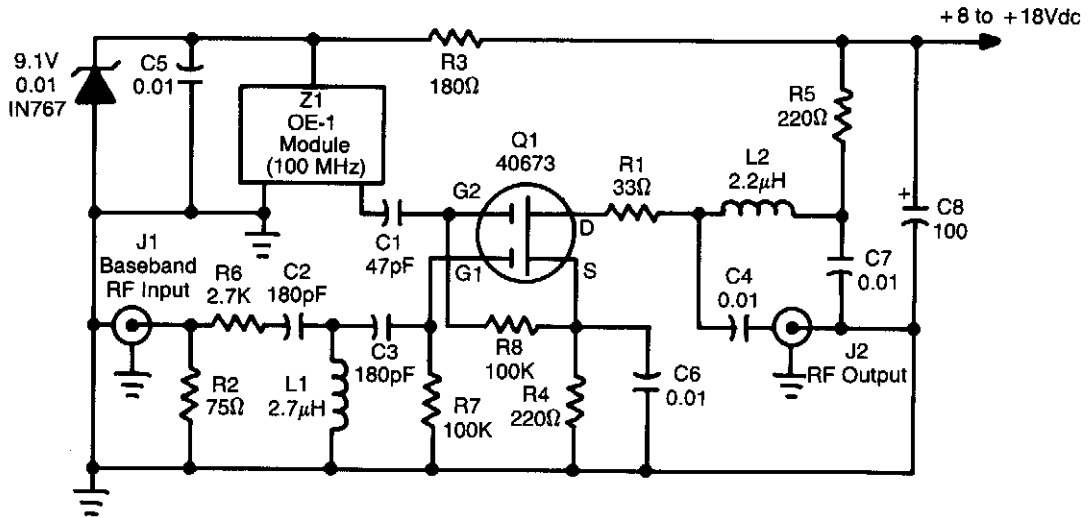


ELEKTOR ELECTRONICS

Fig. 77-4

This converter enables a receiver that tunes 28 to 32 MHz to receive the 144- to 148-MHz amateur band. A BF981 dual-gate MOSFET provides RF gain and feeds mixer T2, another BF981. T3 is a 116-MHz crystal oscillator used to provide L.O. injection to T2. Coils are wound on a 6-mm form. L1, L3, and L4 are 8 turns of 1-mm diameter silver-plated copper wire. L2 is 4 turns of 0.2-mm wire through a ferrite lead. L6 has 19 turns on the primary and 3 turns on the secondary.

RF UPCONVERTER FOR TVRO SUBCARRIER RECEPTION



RADIO-ELECTRONICS

Fig. 77-9

This converter uses a 40673 MOSFET to heterodyne the 5.5- to 8-MHz TVRO subcarriers to the FM broadcast band, where a stereo receiver can be used for high-fidelity stereo reception of TV sound subcarriers. Z1 is a prepackaged 100-MHz oscillator module, which is available from International Crystal Corporation, Oklahoma City, OK.

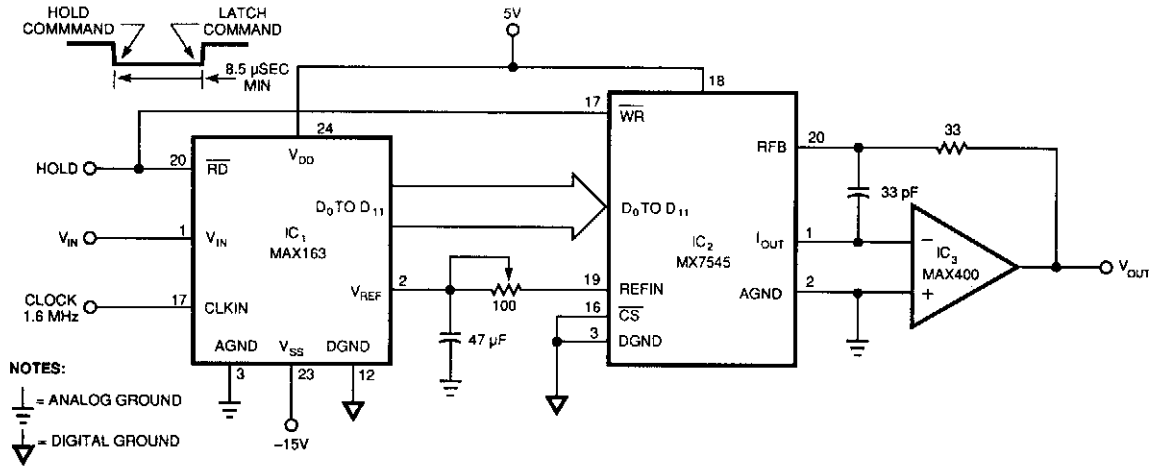
78

Sample-and-Hold Circuit

The source of the following circuit is contained in the Sources section, which begins on page 677. The figure number in the box correlates to the entry in the Sources section.

Sample and Hold

SAMPLE AND HOLD



EDN

Fig. 78-1

By using the ADC and DAC, this circuit uses a negative pulse to latch data into the ADC. The hold pulse width should be at least 8.5 μs. This circuit has zero drop and infinite hold time.

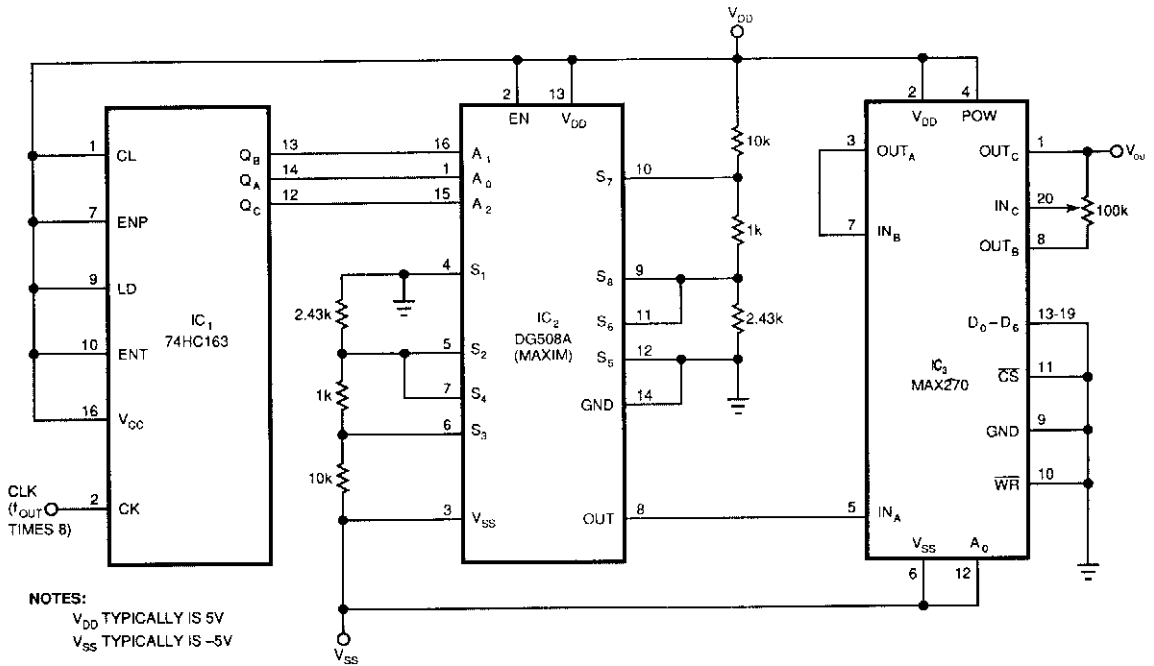
79

Sine-Wave Oscillators

The sources of the following circuits are contained in the Sources section, which begins on page 677. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sine-Wave Generator	Three-Decade 15-Hz to 15-kHz Wien-Bridge Oscillator
Pure Sine-Wave Generator	Phase-Shift Oscillator for Audio Range
LC Sine-Wave Generator	Wien-Bridge Oscillator
60-Hz Sine-Wave Generator	Low-Frequency Sine-Wave Generator
Two-Transistor Sine-Wave Oscillator	Sine- and Square-Wave TTL Oscillator
VLF Audio Tone Generator	Wien-Bridge-Based Oscillator with Very Low Distortion
Very Low Distortion Oscillator	
Low-Frequency LC Oscillator	

PURE SINE-WAVE GENERATOR



EDN

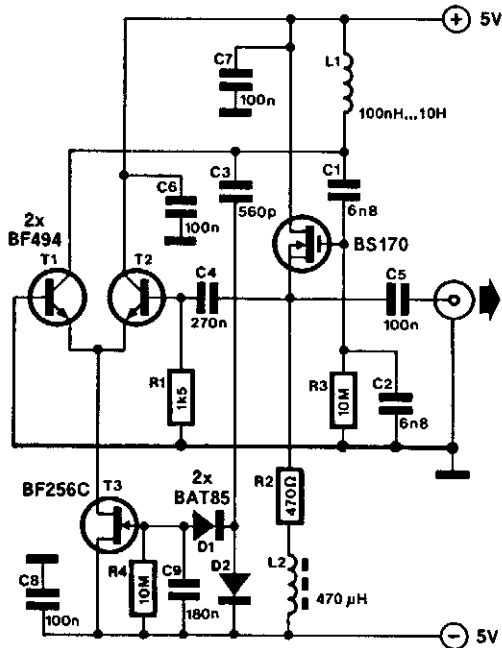
Fig. 79-2

This circuit produces a pure, -80 -dB THD sine wave with a frequency that is equal to the f_c of IC3's filter. A TTL counter, an 8-channel analog multiplexer, and a fourth-order low-pass filter can generate 1- to 25-kHz sine waves with a THD of better than -80 dB. The circuit cascades the two second-order, continuous-time Sallen-Key filters within IC3 to implement the fourth-order low-pass filter. Two resistive dividers connected from ground to V_{DD} and ground to V_{SS} provide bipolar dc inputs to the multiplexer.

To operate the circuit, you first must choose the filter's cutoff frequency, f_c , by tying IC3's D_0 through D_6 inputs to 5 V or ground. The cutoff frequency can be at 128 possible levels between 1 and 25 kHz, depending on those 7 digital input levels. Because this figure ties D_0 through D_6 to ground, f_c equals 1 kHz. The 100-kHz potentiometer adjusts the output level anywhere from 1.5 V below V_{DD} to 1.5 V above V_{SS} .

The clock input frequency must be 8 times higher than the filter's f_c . The multiplexer then produces an $8\times$ oversampled staircase approximation of a sine wave. $8\times$ oversampling greatly simplifies the smoothing requirements of the low-pass filter by pushing the first significant harmonic out to $7\times$ the fundamental. All higher-order harmonics are removed by IC3, which includes an uncommitted amplifier for setting the output level.

LC SINE-WAVE GENERATOR



ELEKTOR ELECTRONICS

Fig. 79-3

This compact LC oscillator offers a frequency range of about 1 kHz to almost 9 MHz and a low-distortion sine-wave output. The heart of the circuit is series-resonant circuit L1/C2/C3 in the feedback loop of amplifiers T1/T2. Transistor T2, which is connected as an emitter follower, serves as impedance converter, whereas T1, connected to a common base circuit, is a voltage amplifier whose

amplification is determined by the impedance of L1 in its collector circuit and the emitter current.

The feedback loop runs from the collector of T1 via the junction of capacitive divider C1/C2, source-follower BS170, and the input impedance is formed by R1/C4. The whole is strongly reminiscent of a Colpitts circuit. The signal is also taken to the output terminal via C5.

Of particular interest is the amplitude control by the current source. The signal is rectified by two Schottky diodes, smoothed by C9, then used to control the current through T3. The gain of amplifier T1 is therefore higher at low input levels than at higher ones. This arrangement ensures very low distortion, because the amplifier cannot be over-driven.

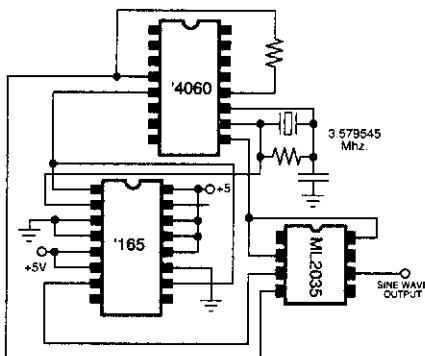
The resonant frequency can be calculated from:

$$f = \frac{1}{2\pi} \sqrt{\frac{L_1 C_1 C_2}{C_1 + C_2}}$$

With values as shown, it extends from 863 Hz ($L_1 = 10$ H) to 8.630 MHz ($L_1 = 100$ H).

The unit can be used to measure the Q of inductors. To that end, a potentiometer is connected in parallel with L1 and adjusted so that the current through the amplifier is doubled. The Q is then calculated from:

$$Q = \frac{R_p}{2\pi f L}$$



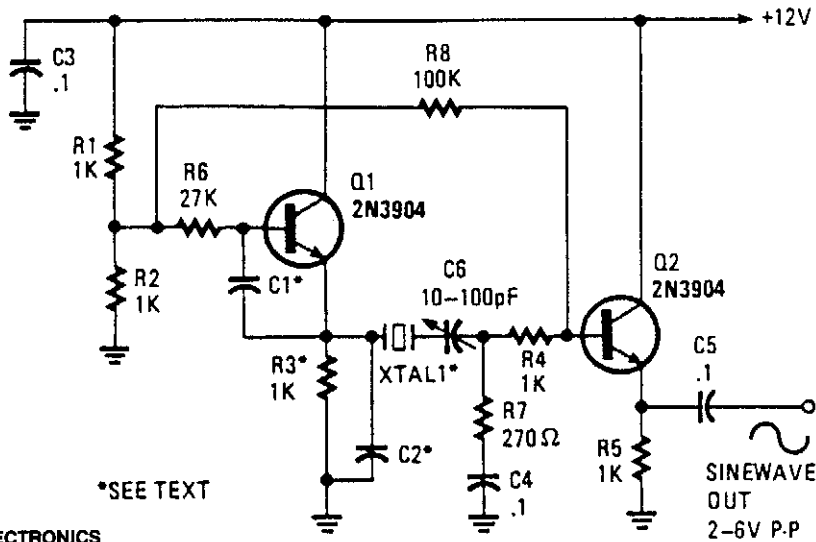
60-Hz SINE-WAVE GENERATOR

A chip by Micro Linear and two CMOS (40165 and 4060) chips generate sine waves at 60 Hz.

MICRO LINEAR

Fig. 79-4

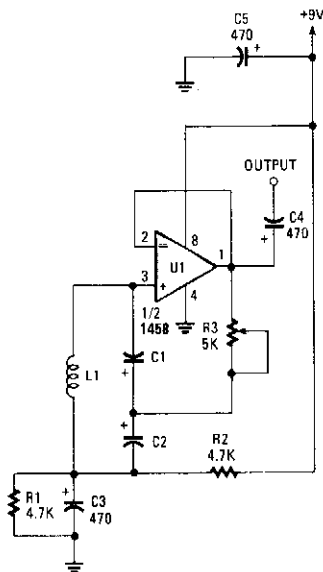
TWO-TRANSISTOR SINE-WAVE OSCILLATOR



POPULAR ELECTRONICS

Fig. 79-5

This oscillator uses two transistors and operates the crystal in the fundamental mode. C_1 and C_2 should be about 2 700 pF for 1 MHz, 680 pF for 5 MHz, and 330 pF for 10 MHz. 150 pF can be used for up to 20 MHz. The output is a near perfect sine wave. Try varying C_1 and C_2 for best waveform. About 2 to 6 Vpp is available.



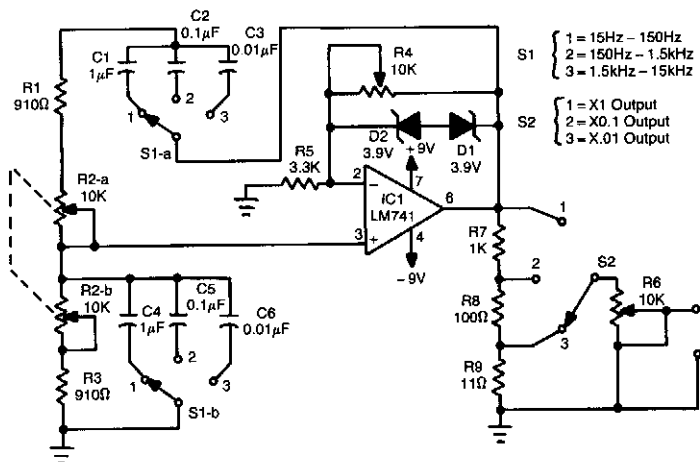
VLF AUDIO TONE GENERATOR

Using an LC-tuned circuit, this oscillator can produce frequencies of less than 10 Hz. C_1 and C_2 can be as large as 1 000 μ F.

POPULAR ELECTRONICS

Fig. 79-6

THREE-DECADE 15-Hz TO 15-kHz WIEN-BRIDGE OSCILLATOR

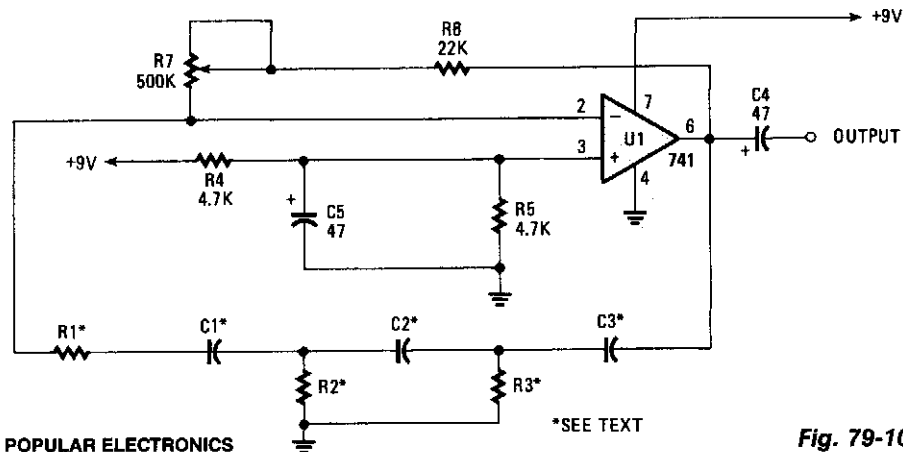


RADIO-ELECTRONICS

Fig. 79-9

In this circuit, an LM741 op amp drives a Wien-bridge network using two zener diodes as an amplitude limiter. Range selection is done by switch selecting the capacitors (C1 through C6) and tuning is done via a ganged pot. The output is about 8 V_{pp} max., depending on the setting of S2 and R6. R4 is set for maximum distortion consistent with stable output.

PHASE-SHIFT OSCILLATOR FOR AUDIO RANGE



POPULAR ELECTRONICS

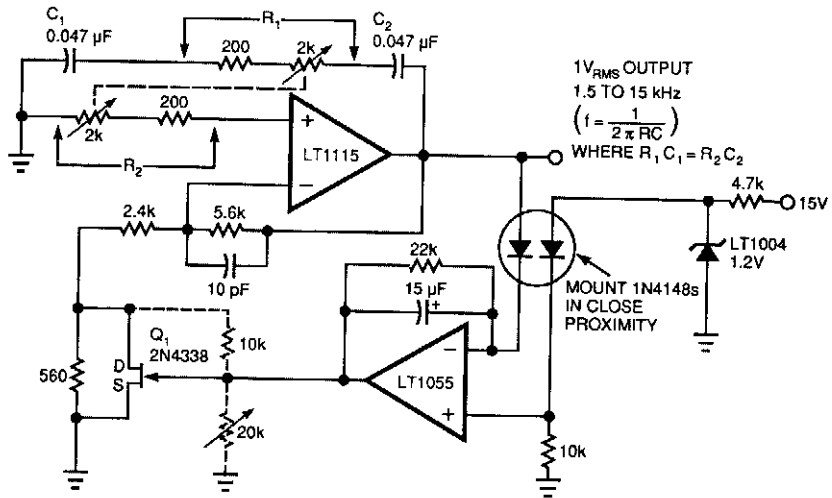
Fig. 79-10

This phase-shift oscillator is useful for audio oscillator applications. Adjust R7 for a good sine wave. An amplifier gain of 29 is required for oscillation. If $C = C_1 = C_2 = C_3$ and $R = R_1 = R_2 = R_3$:

$$f = \frac{1}{2\pi\sqrt{6RC}}$$

Typically, R will be 1 to 100 kΩ and C will be 0.1 μF down to 100 pF, in most practical circuits. As a start, choose $R = 10$ kΩ and $C = 0.0068$ μF (for ≈ 1-kHz range).

WIEN-BRIDGE OSCILLATOR

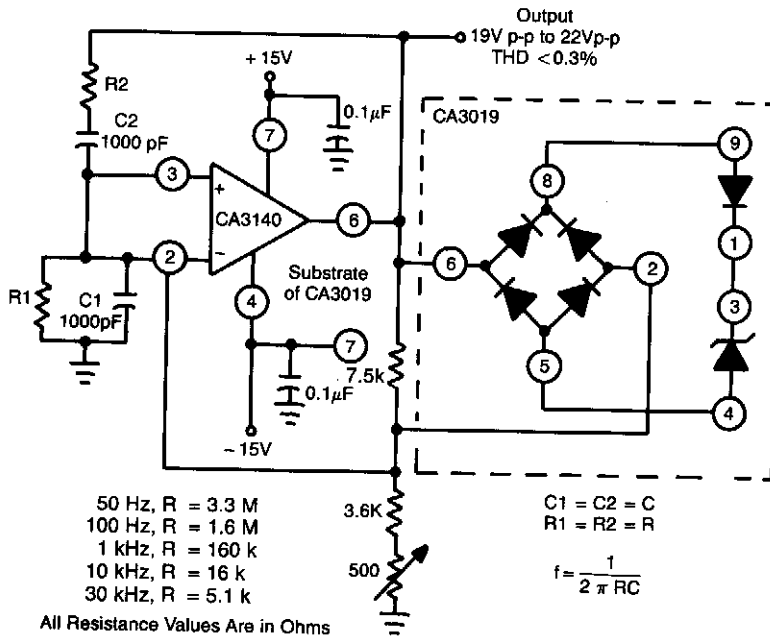


EDN

Fig. 79-11

This complex oscillator circuit uses a photocell and common-mode-suppression circuitry to achieve distortion of 0.0003%.

WIEN-BRIDGE OSCILLATOR

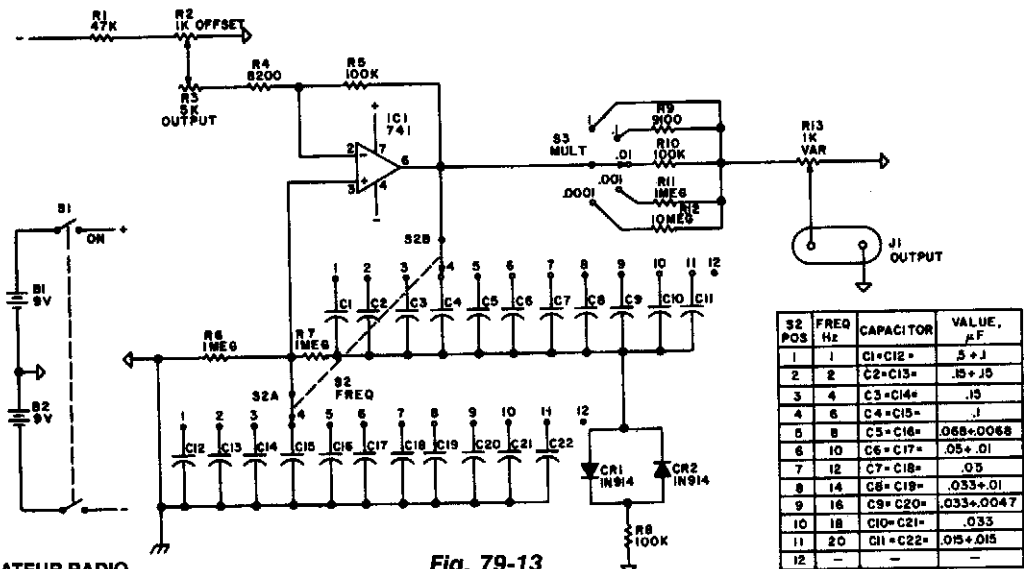


GE/RCA

Fig. 79-12

This circuit makes excellent use of high input impedance, high slew rate, and high-voltage qualities of CA3140 BiMOS op amp, in combination with CA3019 diode array.

LOW-FREQUENCY SINE-WAVE GENERATOR

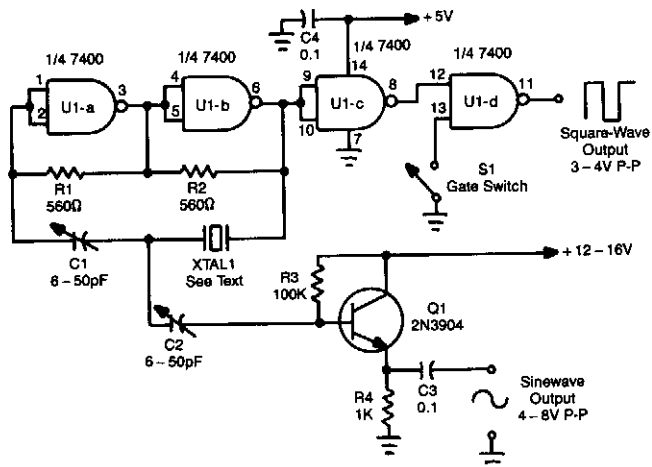


73 AMATEUR RADIO

Fig. 79-13

Using a Wien-bridge oscillator, this circuit generates switch-selected frequencies from 1 to 20 Hz. A 741 op amp is used as the active element.

SINE- AND SQUARE-WAVE TTL OSCILLATOR

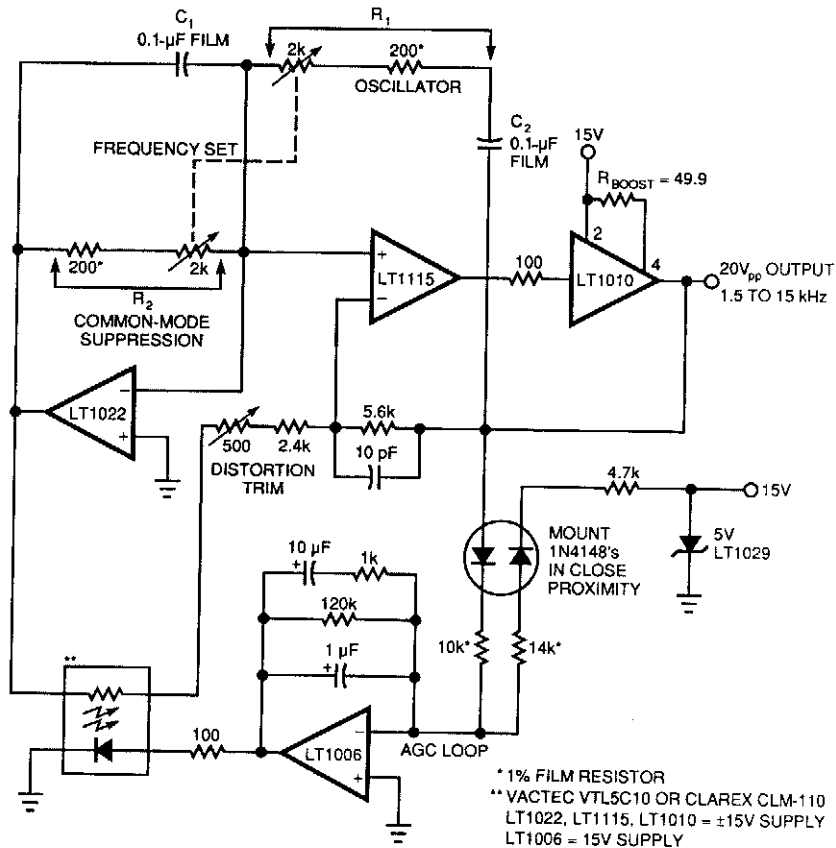


POPULAR ELECTRONICS

Fig. 79-14

Using a Quad NAND Gate, the TTL oscillator can use fundamental crystals between 1 and 10 MHz. The sine-wave output is taken directly from the crystal, which acts as its own filter, and yields a fairly clean sine wave. Adjust C1 and C2 for the best sine wave and also to set the crystal frequency. TTL square wave can be taken from U1D. The gate switch can be replaced with a logic gate to electronically control the output.

WIEN-BRIDGE-BASED OSCILLATOR WITH VERY LOW DISTORTION



EDN

Fig. 79-15

This complex oscillator circuit uses a photocell and common-mode-suppression circuitry to achieve distortion of 0.0003%. This oscillator circuit replaces the lamp in the traditional Wien bridge with an electronic equivalent.

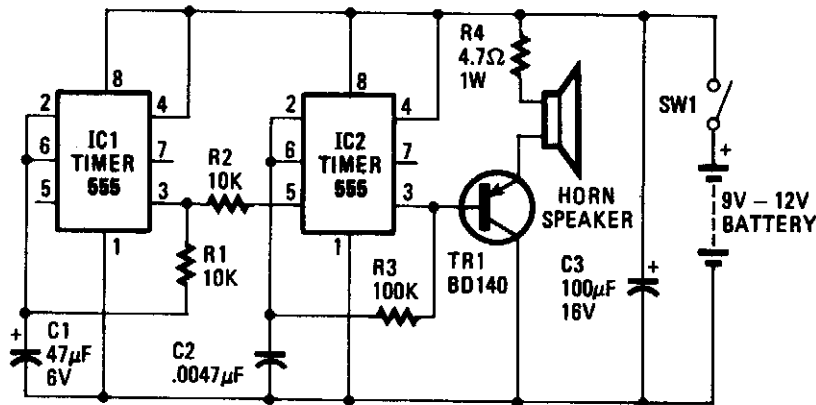
80

Sirens, Warblers, Wailers, and Whoopers

The sources of the following circuits are contained in the Sources section, which begins on page 677. The figure number in the box of each circuit correlates to the entry in the Sources section.

'Hee-Haw' Electronic Siren
Alternate Warble-Tone Siren
6-W Warble-Tone Siren
Low-Cost Siren
Whooper
Electronic Siren

“HEE-HAW” ELECTRONIC SIREN



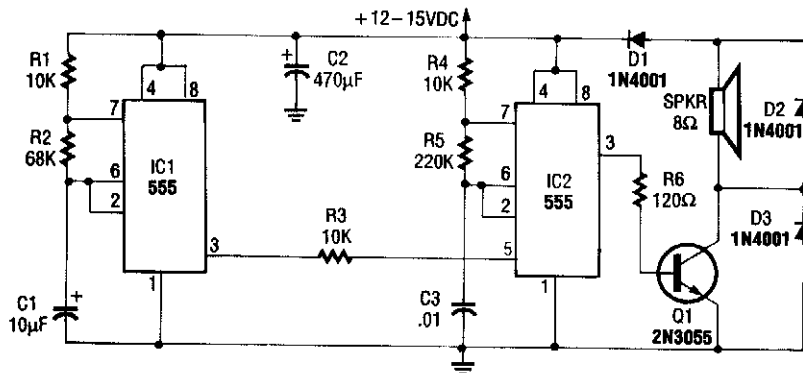
HANDS-ON ELECTRONICS

Fig. 80-1

The oscillator based on IC2 is responsible for producing the sound. Its output is connected to the base of TR1, which amplifies it to drive the speaker. Resistor R4 is included in the circuit to limit the current through TR1 to a safe and reasonable level. The oscillation frequency of IC2 is partially dependent on the values of R_3 and C_2 . Another factor that governs the frequency of oscillation is the magnitude of voltage fed to pin 5 of IC2. If a voltage of varying magnitude is fed to pin 5, the internal circuitry of the IC is forced to reset at a different rate, which changes the frequency.

IC1 is also connected as an oscillator, but it runs much slower than IC2: around 1 Hz. Each time the IC triggers, the voltage at pin 3 goes high. As pin 3 is connected to pin 5 of IC2, this forces IC2 to change its note. That produces the “hee-haw” sound of the siren.

ALTERNATE WARBLE-TONE SIREN

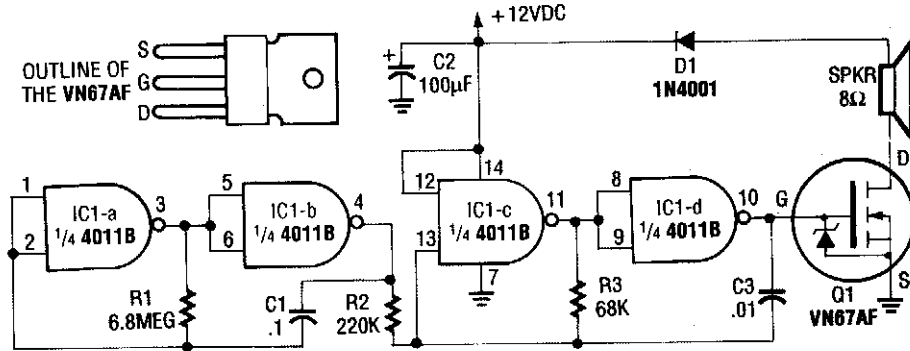


RADIO-ELECTRONICS

Fig. 80-2

This circuit uses two NE555 timers to generate a warble tone. IC1 frequency shifts IC2 by feeding a square wave to pin 5, the modulation input of IC2. IC1 runs at about 1 Hz.

6-W WARBLE-TONE SIREN

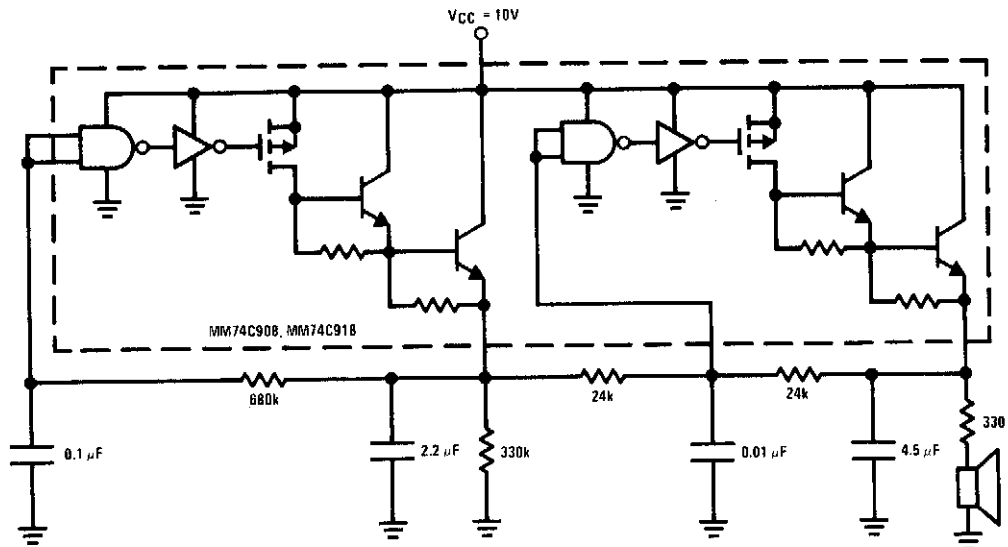


RADIO-ELECTRONICS

Fig. 80-3

This circuit uses a CMOS chip and a VMOS FET amplifier for 6 W of audio output. 18 W of audio can be generated using a +24-Vdc supply. IC1A and IC1B are used as a 1-Hz oscillator. IC1C and IC1D form a 1-kHz multivibrator that is gated by the 1-Hz signal from IC1A and IC1B.

LOW-COST SIREN

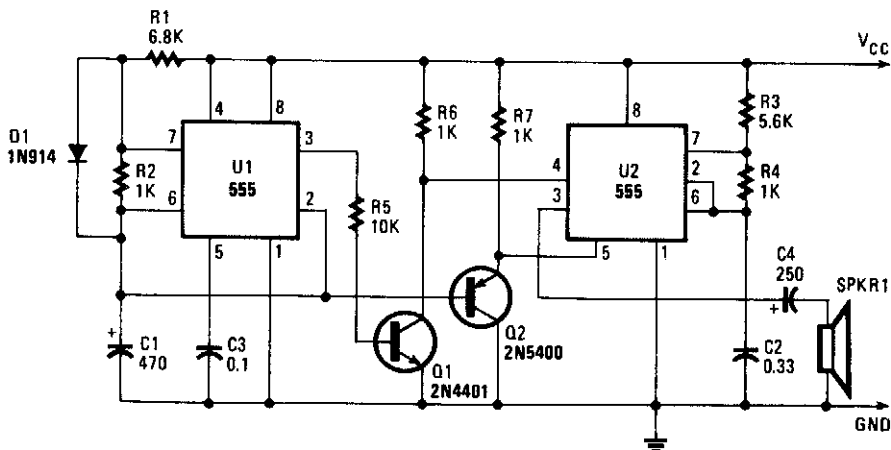


NATIONAL SEMICONDUCTOR

Fig. 80-4

This low-cost 1-package siren has one VCO, and the other oscillator generates the voltage ramp to vary the frequency at the VCO output. All components within the dotted line are part of the IC.

WHOOOPER



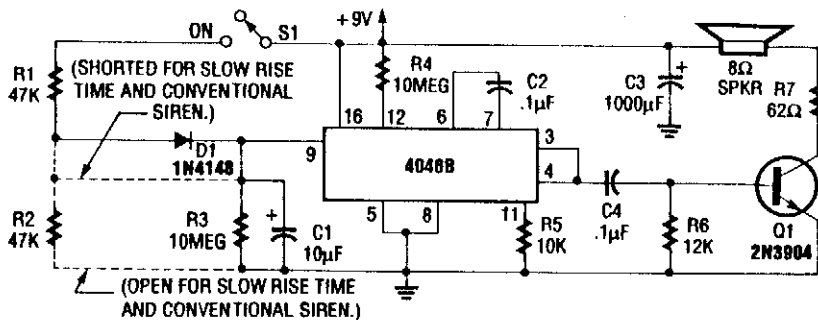
POPULAR ELECTRONICS

Fig. 80-5

Integrated circuit U1 is connected as a low-frequency asymmetrical oscillator. Its output is inverted by Q1 and fed to the reset terminal of U2 at pin 5. Integrated circuit U2 is configured as an audio oscillator and is enabled when the output of U1 is low. With the voltage at pin 5 of U2 constant, the circuit just "bleeps."

The voltage across capacitor C1 is fed to the base of Q2, which turns it on and grounds pin 5 of U2. When the frequency of the reset signal on pin 4 falls, the output frequency of U2 rises. The output then becomes a whoop, starting low in frequency and ending high. Resistor R1 sets the repetition rate and R2 determines the time duration of the whoop. Resistors R3 and R4 set the center-operating frequency.

ELECTRONIC SIREN



RADIO-ELECTRONICS

Fig. 80-6

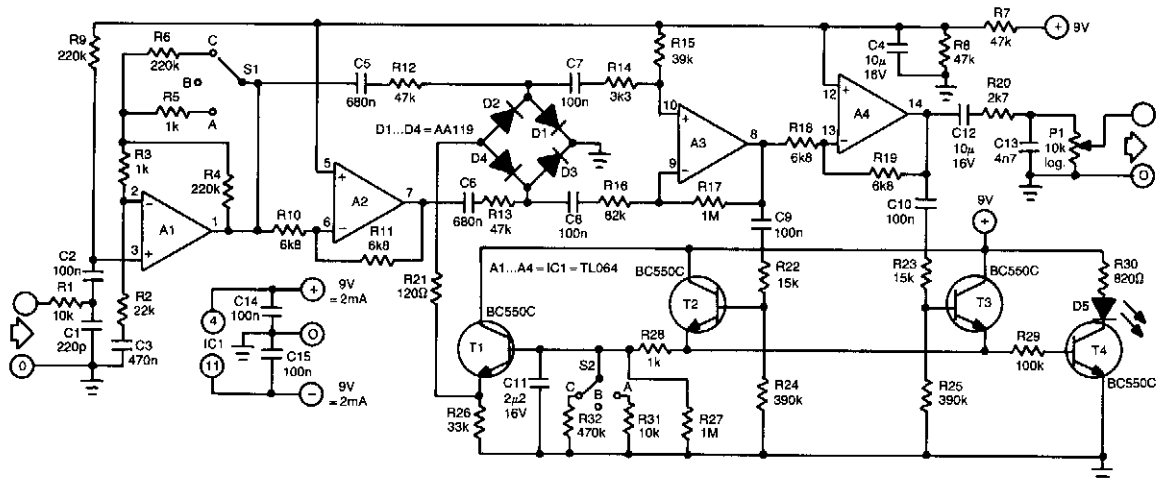
For normal wailing tone, short D1 and open R2. For fast rise and slow fall in frequency, include D1 and R2. Use of a CD4046B with a diode-RC network as shown produces a siren tone, using a VCO.

81

Sound Effects

The sources of the following circuits are contained in the Sources section, which begins on page 677. The figure number in the box of each circuit correlates to the entry in the Sources section.

Guitar Compressor
Single-Chip Melody Generator
Electronic Bagpipe
Electronic Music Maker
Musical Doorbell
Octave Shifter for Musical Effects
Phasor Sound Generator
Single-Chip Chime



ELEKTOR ELECTRONICS

Fig. 81-1

The control of this compressor is based on the dependence of the dynamic resistance of a diode on the current flowing through it. The heart of the present circuit is the diode bridge (D1 through D4), which behaves as a variable resistance controlled by the current flowing in T1.

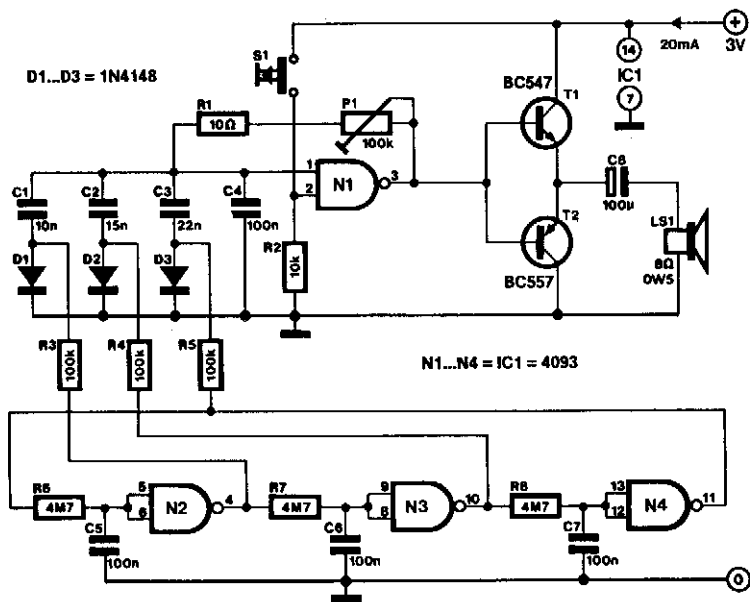
The input signal is applied to preamplifier stage A1 via low-pass filter R1/C1 that removes any HF noise from the input.

Switch S1 in the feedback loop of A1 sets the amplification to 1 (position A), 6 (C) or 11 (B). The amplified signal is applied directly to the diode bridge via R12 and C5, and inverted via inverter A2, capacitor C6 and resistor R13.

The two signals are summed by the bridge, amplified (in A3), then split again into two, one of which is inverted by A4. The positive half cycles of the two signals are used to switch on T2 and T3, respectively. Capacitor C11 is then charged via R12. When the potential across this capacitor reaches a certain level, T1 is also switched on, after which a control current flows through the bridge via R21. This current lowers the resistance of the bridge so that the signal is attenuated (compressed). At the same time, the LED lights to indicate that the signal is being compressed. Capacitor C12 prevents any dc voltage from reaching the output.

The output signal is taken from the wiper of P1. Low-pass section R20/C13 limits its bandwidth to 12 kHz. Switch S2 enables the selection of various decay times from C11. The values shown in the diagram are the most useful. Nevertheless, these values are subjective and can be altered to personal taste and requirements.

SINGLE-CHIP MELODY GENERATOR



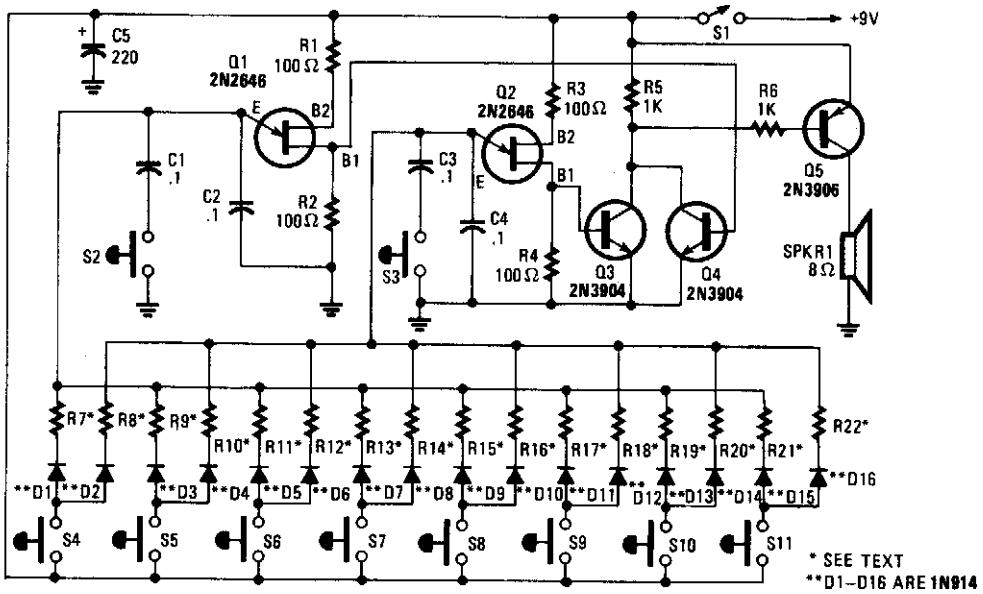
ELEKTOR ELECTRONICS

Fig. 81-2

This melody generator, based on a 4093 CMOS Schmitt trigger, can be used in alarms, doorbells, and cars (audible reverse gear or lights-on indicator).

Three of the four NAND gates in the 4093 are connected in series by RC networks. Oscillation is affected by feedback of the output signal of N4 to the input of N2. The logic-high levels produced by the cascaded gates in the oscillator circuit are used to bias one of associated diodes D1, D2, or D3). The relevant diode connects one of the frequency-determining capacitors (C1 through C3) to tone oscillator N1. The audio signal available when S1 is pressed is applied to complementary transistor pair (T1/T2) that drives the loudspeaker. The frequency of the emitted tone can be adjusted to individual taste with preset P1.

ELECTRONIC BAGPIPE

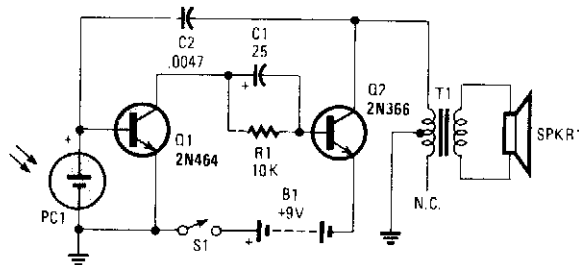


POPULAR ELECTRONICS

Fig. 81-3

The electronic bagpipe mimics the sound of real instruments. This circuit uses two UJT oscillators and an amplifier (Q3, Q4, and Q5). R7 through R22 are selected for tonal range desired (typically 3 300 Ω). Each key selects resistors for the two oscillator circuits Q1 and Q2. S2 and S3 vary the tonal range of S4 through S11.

ELECTRONIC MUSIC MAKER



POPULAR ELECTRONICS

Fig. 81-4

This electronic music maker uses an astable oscillator circuit that is controlled by a photocell. The light falling on the photo cell controls the tone. By mounting the circuit in a box, you can control light-reading PC1 with your hand.

OCTAVE SHIFTER FOR MUSICAL EFFECTS

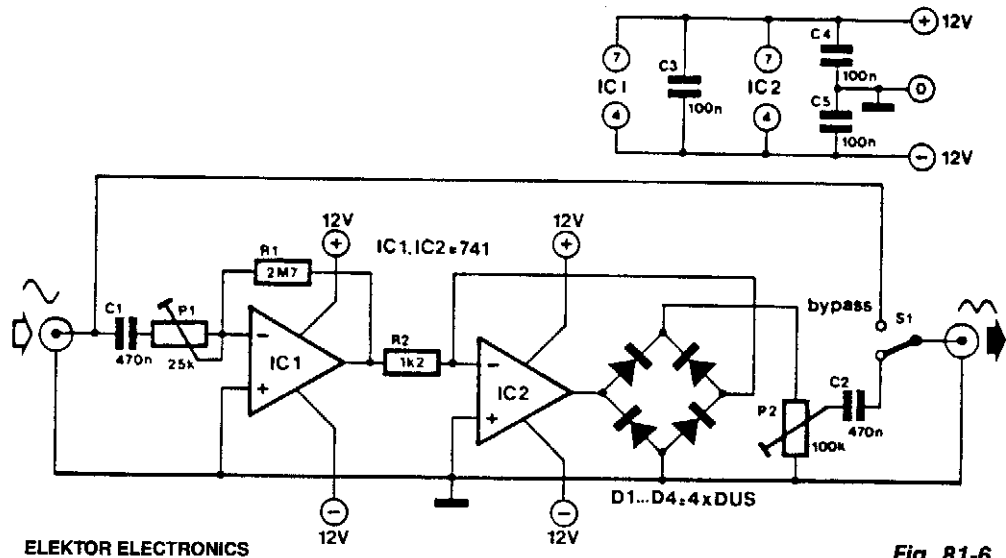


Fig. 81-6

This musical special-effect device is basically a frequency doubler. The input audio is amplified and doubled by using a full-wave rectifier, which has a dc output plus a twice the ac frequency component. The 2× frequency component is fed to the output.

PHASOR SOUND GENERATOR

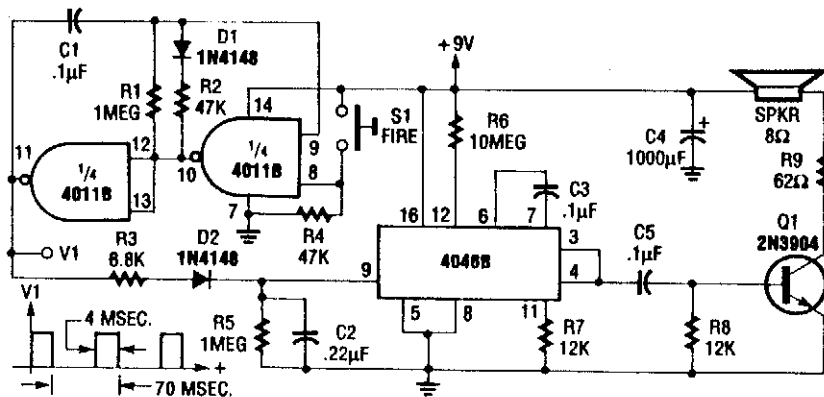
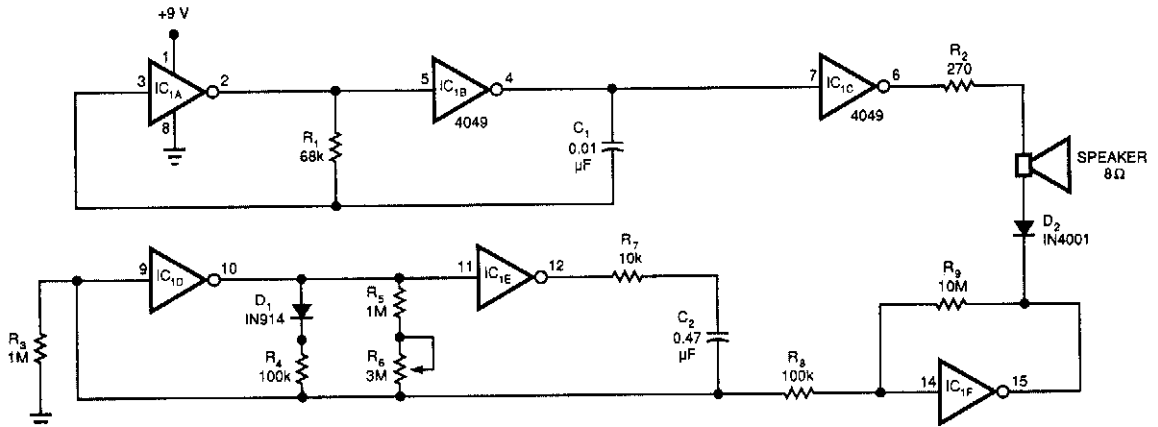


Fig. 81-7

The 4011B astable is gated by S1 to produce 4-ms pulses at 70-ms intervals. Each pulse charges C2 via D2, producing a high tone that decays slowly as C2 discharges through R5. The process repeats for each pulse.

SINGLE-CHIP CHIME



- NOTES:** 1. IC₁ = 4049.
 2. ALL RESISTORS ARE 1/4 W, 10%.
 3. ALL CAPACITORS ARE 25 VOC, 20%.

EDN

Fig. 81-8

This circuit uses only one IC, produces a pleasant tone, and sports a single control for adjusting the tone's chiming rate. IC1A and IC1B form an astable multivibrator, which produces the circuit's basic tone. The multivibrator's frequency is:

$$f = \frac{1}{2.2 \times R_1 \times C_1}$$

The component values produce a 668-Hz tone. IC1C buffers the multivibrator's output to the 8-Ω speaker. Current-limiting resistor R₂, determines the speaker's volume. R₂ minimum value is 220 Ω. IC1D and IC1E form an asymmetric, astable multivibrator, which adds a chime effect to the circuit's basic tone. The chime effect's frequency is:

$$t_{L0} = 1.1C_2(R_4 \parallel (R_5 + R_6))$$

$$t_{HI} = 1.1C_2(R_5 + R_6)$$

R₇ gives this rate multivibrator a slowly varying output signal to produce a pleasant decay for the chime effect. IC1F is an inverting amplifier for the chime multivibrator.

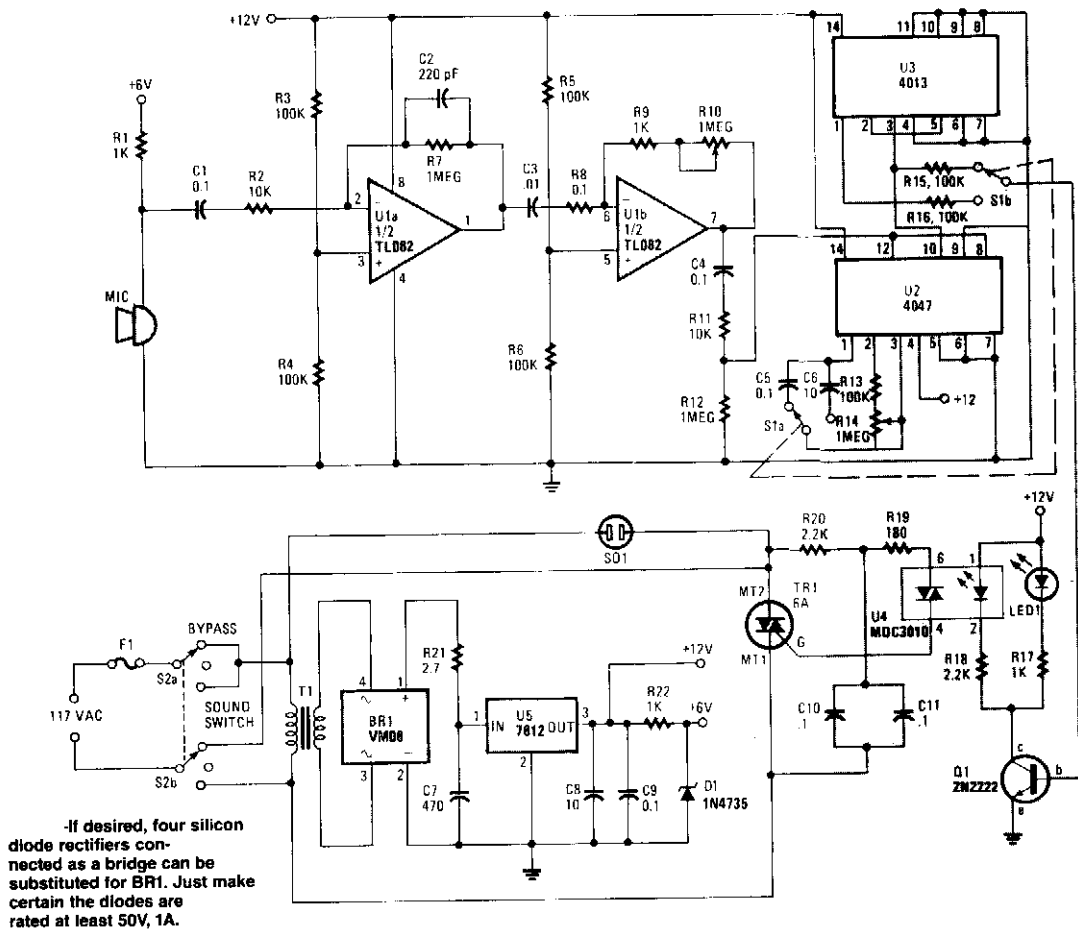
82

Sound Operated Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 678. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sound-Activated Switch
Sound-Operated Switch
Microphone-Controlled Voice-Activated Switch
Gain-Controlled Amplifier

SOUND-ACTIVATED SWITCH

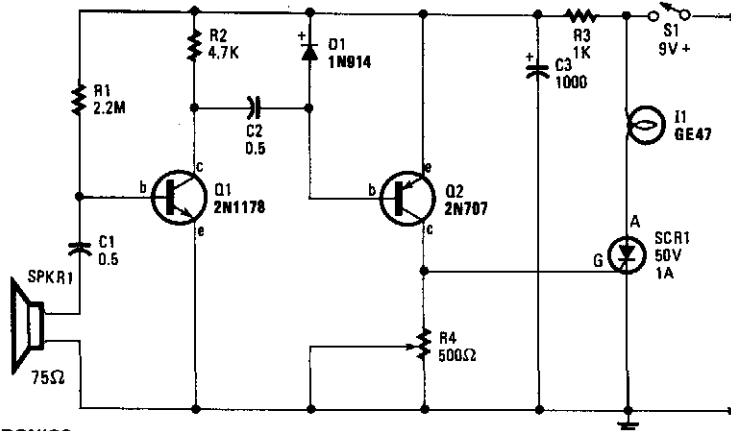


RADIO-ELECTRONICS

Fig. 82-1

This circuit provides either latched switching or timed switching. U1A and U1B provide audio amplification from the microphone. U2 is a retriggerable monostable multivibrator. S1A and S1B select either U3, a flip-flop, or U2. R13 and R14 allow a 6- to 60-second timer delay after the sound ceases, in the timed mode. BR1, U5, and associated components form a power supply. Q1 drives optocoupler U4 and triggers triac TR1.

SOUND-OPERATED SWITCH



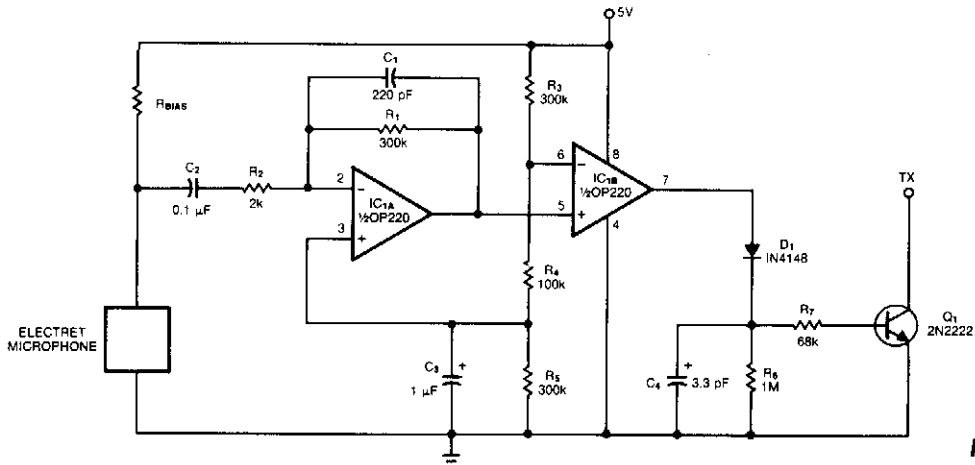
HANDS-ON ELECTRONICS

Fig. 82-2

This sound-operated switch will sense the ring of the phone and translate this to a lamp that will go on and off. The amplified signal across R2 reaches D1 through capacitor C2. The rectified audio signals provide a negative bias for Q2, a pnp transistor. This causes Q2 to conduct so the current that triggers SCR1 is provided at the gate. Potentiometer R4 sets the sensitivity. R3 and C3 delay the operating voltage for Q1 so that the circuit will not be triggered on by the sound of the on/off switch, S1 or by the current surge.

Set the lamp atop a TV receiver, turn it on and set the potentiometer so that a finger snap at two feet will trigger the lamp on. Place the speaker close to the telephone and give it a try.

MICROPHONE-CONTROLLED VOICE-ACTIVATED SWITCH

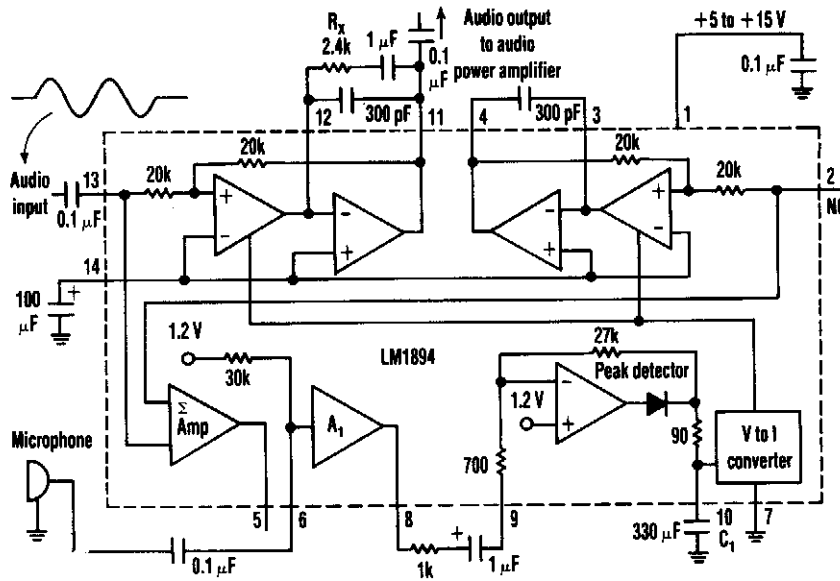


EDN

Fig. 82-3

An electret microphone feeds a bandpass filter circuit (IC1A), then feeds a comparator, which in turn drives Q1. Q1 is a switch that conducts when audio from IC1B causes D1, C4, R6, and R7 to bias it ON.

GAIN-CONTROLLED AMPLIFIER



ELECTRONIC DESIGN

Fig. 82-4

This single-chip circuit adjusts its audio gain according to the ambient noise picked up by the microphone. When operating in a quiet environment, the audio output is quiet, while a noisy environment results in a louder audio output. Audio to pin 13 is amplified by the variable-gain amplifier within the LM1894 IC. Audio from the microphone connected through 0.1-μF capacitor to pin 6 controls the audio gain of the variable-gain amplifier. The output appears on pin 11 and is taken off through an 0.1-μF capacitor.

83

Square-Wave Generators

The sources of the following circuits are contained in the Sources section, which begins on page 678. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple TTL, LSTTL, CMOS, Square-Wave
Generators

Simple Square-Wave Oscillator

Square-Wave Oscillator

Variable Duty-Cycle Square-Wave
Generator

Square-Wave Generator

Square-Wave Astable Circuit

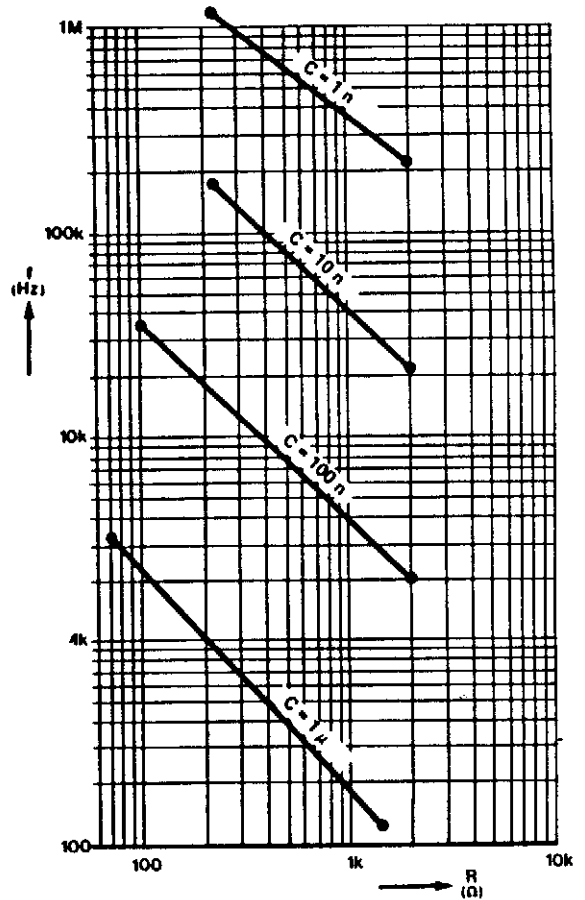
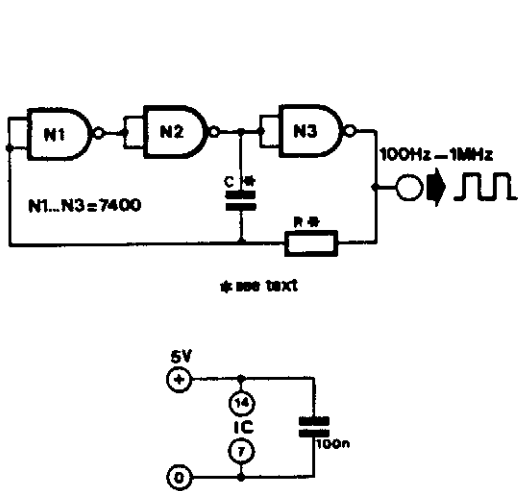
4-Decade Square-Wave Generator

Simple Variable-Frequency Square-Wave Generator

Basic Multivibrator

1-kHz Square-Wave Generator

SIMPLE TTL, LSTTL, CMOS, SQUARE-WAVE GENERATORS

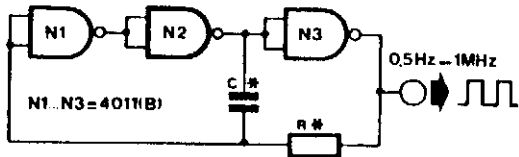


ELEKTOR ELECTRONICS

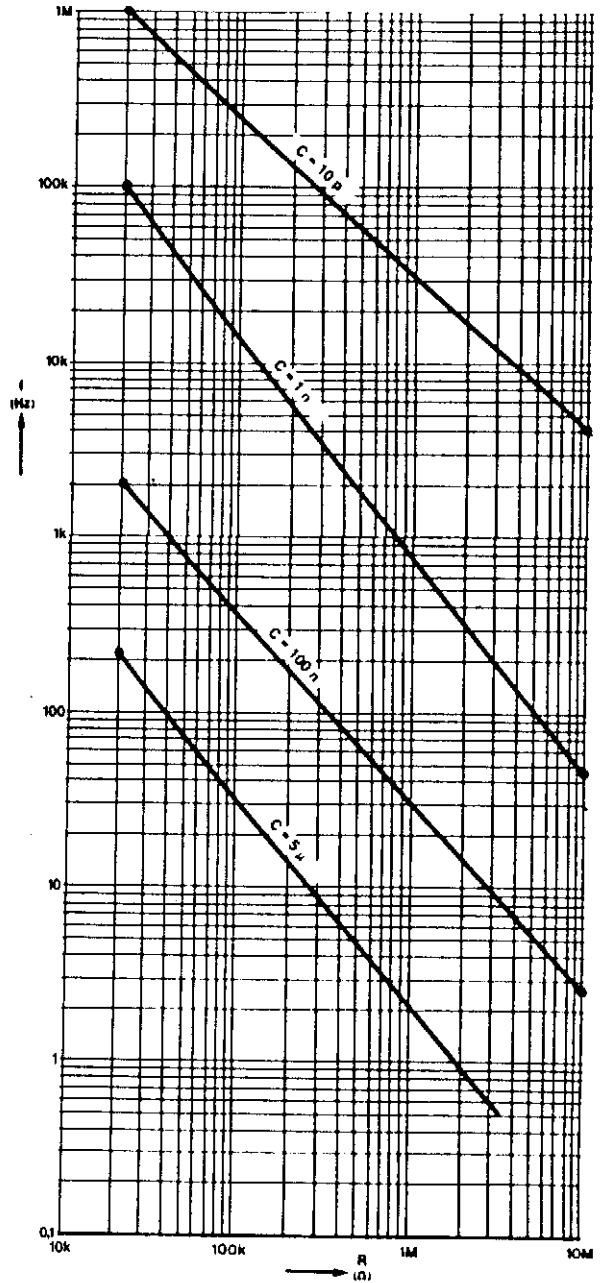
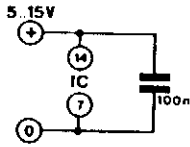
Fig. 83-1(a)

These three circuits for TTL, LSTTL, and CMOS logic use three gates each, and one or two resistors and capacitor as a square-wave oscillator. The circuits are useful for clock oscillators, etc. R and C are determined from the nomographs.

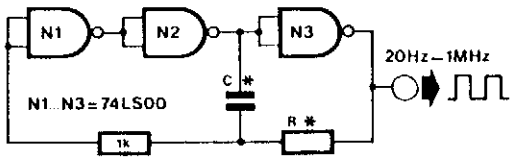
SIMPLE TTL, LSTTL, CMOS, SQUARE-WAVE GENERATORS (Cont.)



* see text



SIMPLE TTL, LSTTL, CMOS, SQUARE-WAVE GENERATORS (Cont.)



* see text

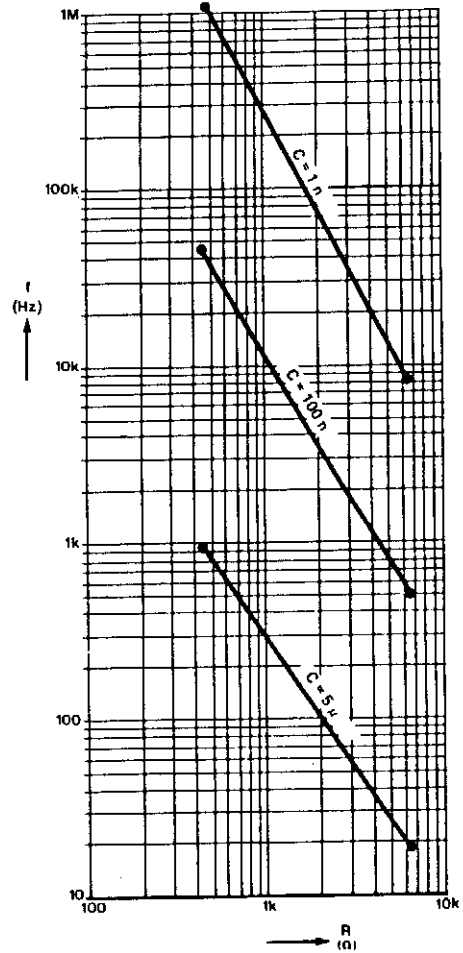
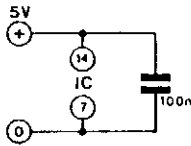
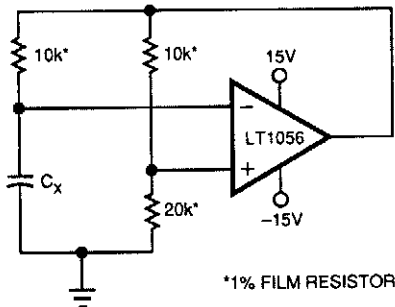


Fig. 83-1(c)

ELEKTOR ELECTRONICS

SIMPLE SQUARE-WAVE OSCILLATOR



*1% FILM RESISTOR

Using only four components, this circuit generates a square wave. Oscillation frequency is $\approx 1/RC_X$ Hz, $R = M\Omega$, $C_X = \mu F$ (in this case, $R = 10 k\Omega$).

EDN

Fig. 83-2

SQUARE-WAVE OSCILLATOR

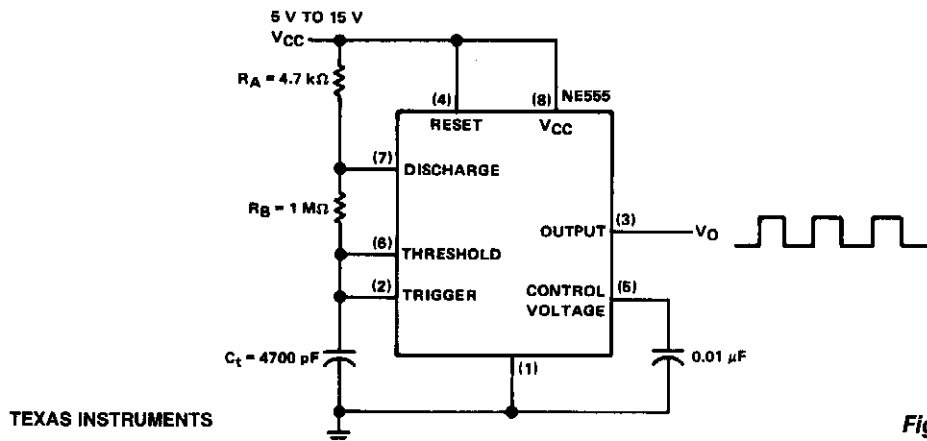
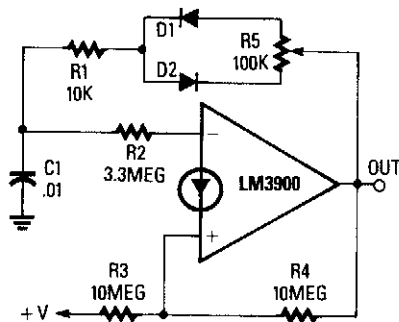


Fig. 83-3

The NE555 is connected in the astable mode and uses only three timing components (R_A , R_B , and C_t). A $0.01\text{-}\mu\text{F}$ bypass capacitor is used on pin 5 for noise immunity. The operating restrictions of the astable mode are few. The upper frequency limit is about 100 kHz for reliable operation, as a result of internal storage times. Theoretically, it has no lower frequency limit, only that which is imposed by R_t and C_t limitations. The frequency for the circuit can be calculated as:

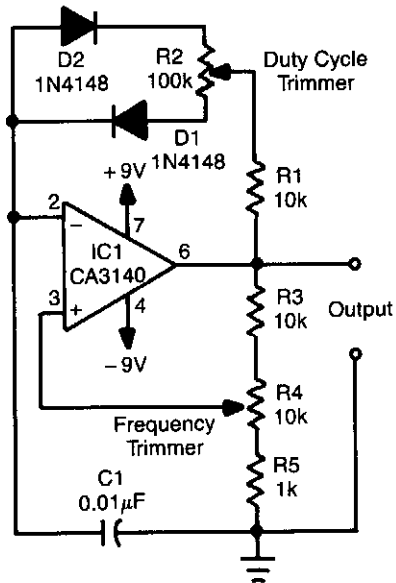
$$\begin{aligned}
 f &= \frac{1.44}{(R_A + 2R_B)C_t} \\
 &= \frac{1.44}{(4.7\text{ k}\Omega + 2\text{ M}\Omega)(0.0047\text{ }\mu\text{F})} \\
 &= \frac{1.44}{9.42209 \times 10^{-3}} \\
 f &= 152.8\text{ Hz}
 \end{aligned}$$

VARIABLE DUTY-CYCLE SQUARE-WAVE GENERATOR



C_1 alternately charges via R_1/D_1 and the upper half of R_5 , and discharges via R_1/D_2 and the lower half of R_5 . The duty cycle can be varied over the range from 1:10 to 10:1 via R_5 .

SQUARE-WAVE GENERATOR

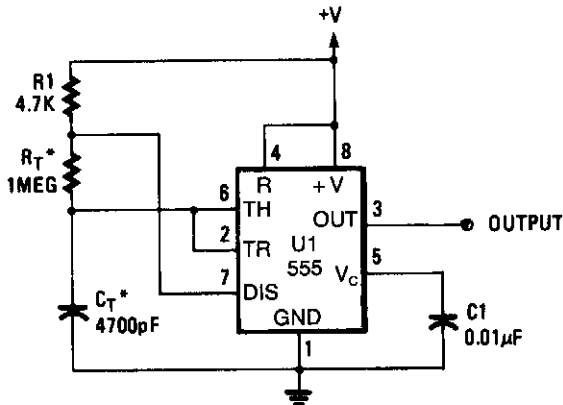


RADIO-ELECTRONICS

Fig. 83-5

This relaxation oscillator circuit uses diodes to produce charge and discharge paths for C1. The duty cycle is set via R2 and the frequency via R4. C1 can be varied to vary the frequency range, which, for this circuit is approximately 300 to 3 000 Hz.

SQUARE-WAVE ASTABLE CIRCUIT



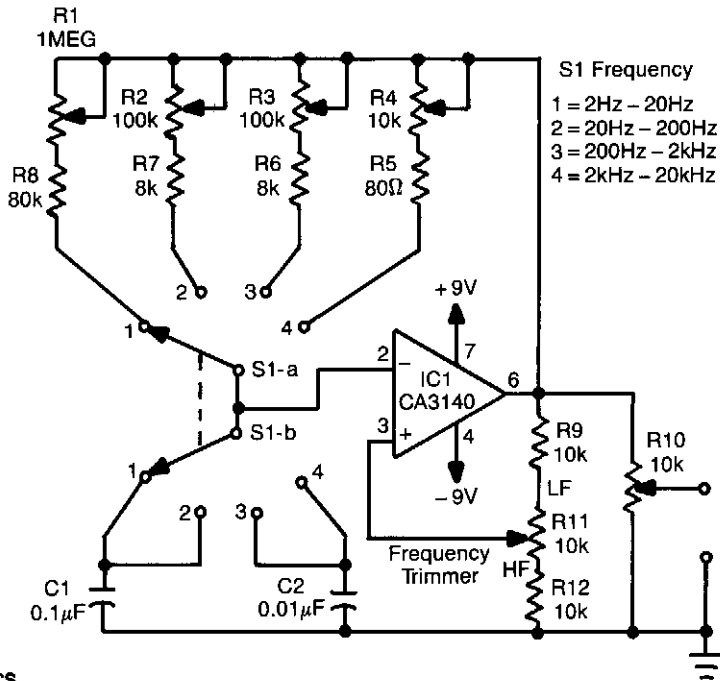
POPULAR ELECTRONICS

*WITH $R_1 < R_T$
 $T = 1.368 R_T C_T$
 $f_o = \frac{0.722}{R_T C_T}$
 (AS SHOWN, $f_o \cong 158 \text{ Hz}$)

Fig. 83-6

This 555 circuit produces a square wave. The frequency depends on the values of R_T and C_T , as per the design equations.

4-DECADE SQUARE-WAVE GENERATOR

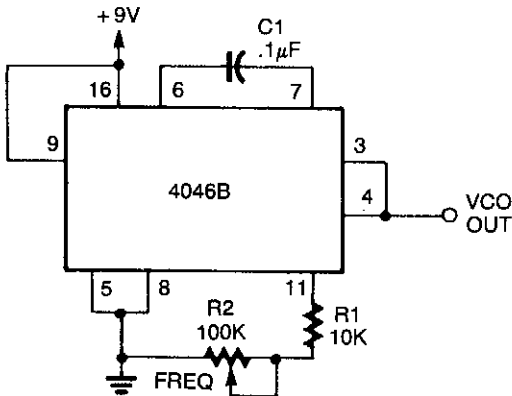


RADIO-ELECTRONICS

Fig 83-7

This circuit will generate a square wave of 2 Hz to 20 kHz. The circuit uses an op amp in a relaxation-oscillator configuration. The output is about 15 V_{pp}. R1 through R4 are calibration controls for each of the four frequency ranges, as selected by S1-a and S1-b. R10 adjusts the output level.

SIMPLE VARIABLE-FREQUENCY SQUARE-WAVE GENERATOR

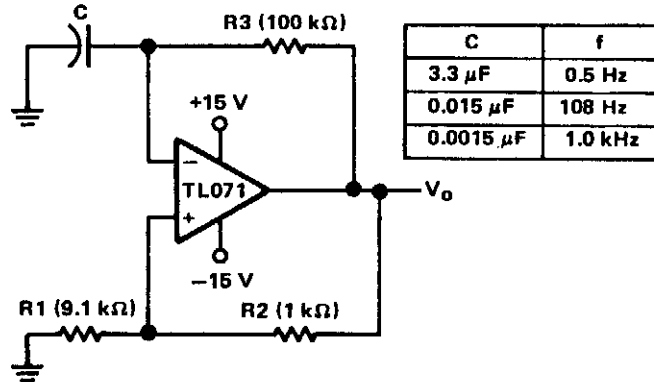


A CD4046B PLL is used as a simple generator. The range is 200 Hz to 2 kHz, but it can be changed by changing C1.

RADIO-ELECTRONICS

Fig. 83-8

BASIC MULTIVIBRATOR



TEXAS INSTRUMENTS

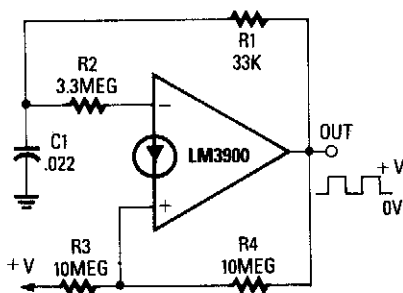
Fig. 83-9

When this circuit is turned on, the natural offset of the devices serves as an automatic starting voltage. Assume that output voltage V_o goes positive and the positive feedback through R_2 and R_1 forces the output to saturate. The high-voltage level at V_o , then charges C through R_3 , until the voltage at the inverting input exceeds that at the noninverting input.

As the inverting input exceeds the noninverting input level, the output switches to the negative saturation voltage. This action starts the capacitor discharging toward the new noninverting input level. When the capacitor reaches that level, the op amp switches back to the positive saturation voltage, and the process starts again. With the TL071, the positive and negative output levels are nearly equal, which results in a 50% duty cycle. The total time period of one cycle will be:

$$t_T = 2 (R_3) C \ln \left(\frac{1 + 2R_1}{R_2} \right)$$

1-KHz SQUARE-WAVE GENERATOR



RADIO-ELECTRONICS

Fig. 83-10

When the output is high, R_3 and R_4 are in parallel, and C_1 charges via R_1 until the current in R_2 equals that at the noninverting terminal. This action occurs when C_1 's voltage rises to $2/3$ of the supply

voltage. At that point, the circuit switches regeneratively. The output switches low and C_1 starts to discharge via R_1 .

Now, R_4 is effectively disabled and the current to the noninverting terminal is determined solely by R_3 , so C_1 discharges until the current through R_2 falls slightly below that of R_3 .

This happens when the voltage across C_1 falls to about $1/3$ of the supply voltage. At that point, the circuit again switches regeneratively, and the output again goes high.

This circuit is useful for generating symmetrical square waves with maximum frequencies of only a few kHz. Because of the poor slew-rate characteristics of the LM3900 ($0.5 \text{ V}/\mu\text{s}$), the output waveforms have rather slow rise and fall times.

84

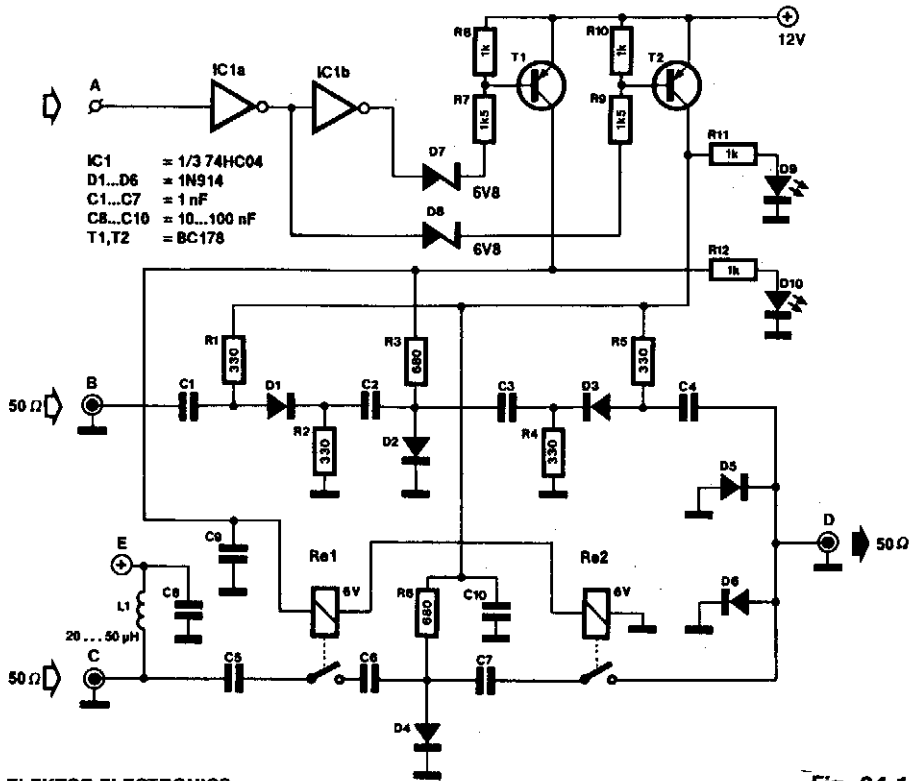
Switching Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 678. The figure number in the box of each circuit correlates to the entry in the Sources section.

Electronic Antenna Selector
($N+1$) Wires Connect N Hall-Effect Switches
Audio/Video Switcher
Precision Narrow-Band Tone Switch
Diode RF Switch
Satellite TV Audio Switcher

On/Off Switch
Switching Circuit
Inexpensive VHF/UHF Diode RF Switch
Mechanically Controlled Bistable
Bounce-Free Auto-Repeat Switch
Transistor Turns Op Amp On or Off

ELECTRONIC ANTENNA SELECTOR



ELEKTOR ELECTRONICS

Fig. 84-1

The electronic antenna selector is intended to switch between two FM antennas via a logic signal. Gates IC1A and IC1B ensure a clean switching action and at the same time form the interface between the 5-V logic level (probably available from the receiver) and the 12-V supply voltage for the selector. Depending on the type of gate used, a digital TTL or CMOS control signal is available in direct and inverted form at the outputs of IC1.

When input A is logic high, the output of IC1A is low and that of IC1B is high. The current then flows from the positive supply line to IC1A via T2, R9, and D8. T2 is switched on and D9 lights.

Because direct currents flow through R1/D1/R2 and R5/D3/R4, diodes D1 and D3 conduct and pass the VHF signal from input A to output D. At the same time, a direct current flows through R6/D4 so that D4 conducts. This arrangement ensures that any VHF signal at input C cannot reach the output via the parasitic capacitances of the relay contacts and the wiring.

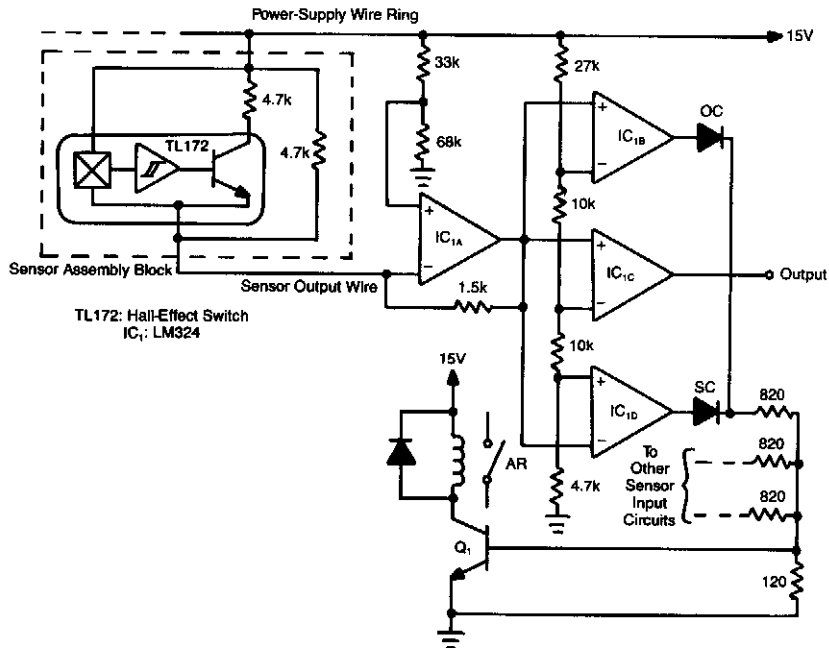
When A is logic low, and IC1B is therefore low, the current flows from the positive supply line to IC1B via T1, R7, and D17. T1 is then switched on and D10 lights. At the same time, the two series-connected relays, Re1 and Re2, are energized, their contacts close, and the VHF signal at input C is fed to output D. Moreover, a direct current flows through R3/D2 so that D2 conducts. Any signal at input B is then shorted to ground via D2.

ELECTRONIC ANTENNA SELECTOR (Cont.)

All resistors should be carbon-film types because these have a higher parasitic series inductance than metal-film resistors. Thus, the attenuation of the VHF signal caused by them is reduced to a minimum.

The attenuation losses caused by the diode junctions (5-10 dB) are somewhat larger than those caused by the relays. It is thus advisable to connect the antenna that provides the weaker signal (normally the domestic one) to input C. If the domestic antenna is equipped with an antenna amplifier, it can be supplied via terminal E. Diodes D5 and D6 protect the circuit against high-voltage spikes that occur during the on and off switching. The selector draws a current of approximately 65 mA.

(N + 1) WIRES CONNECT N HALL-EFFECT SWITCHES



EDN

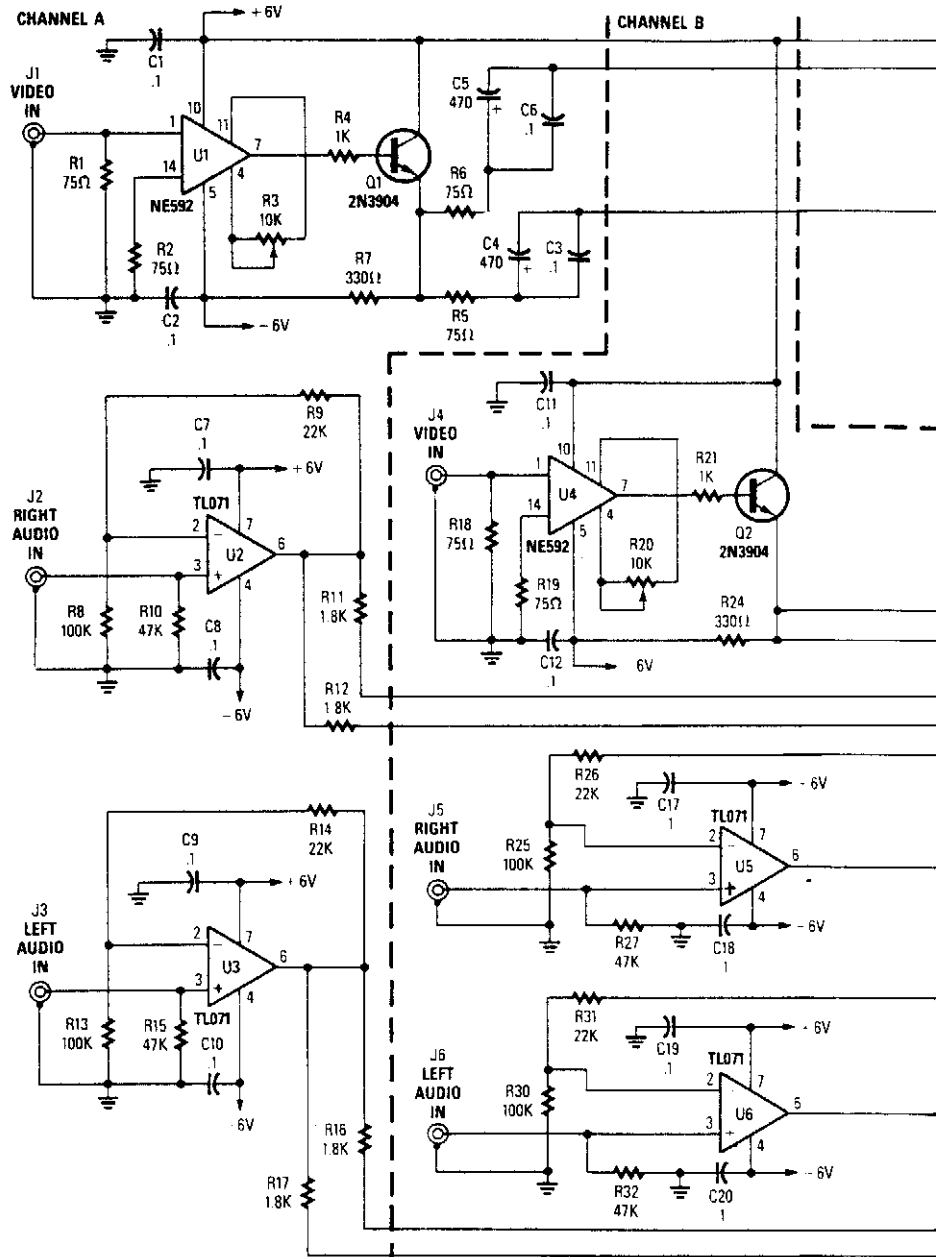
Fig. 84-2

Hall-effect switches have several advantages over mechanically and optically coupled switches. Their major drawback is that they require three wires per device. This circuit, however, reduces this wire count to $N + 1$ wires for N devices.

Amplifier IC1A is configured as a current-to-voltage converter. It senses the sensor assembly's output current. When the Hall-effect switch is actuated, the sensor's output current increases to twice its quiescent value. Amplifier IC1B, configured as a comparator, detects this increase. The comparator's output goes low when the Hall-effect switch turns on.

The circuit also contains a fault-detection function. If any sensor output wire is open, its corresponding LED will turn on. If the power-supply line opens, several LEDs will turn on. A short circuit will also turn an LED on. Every time an LED turns on, Q1 turns on and the alarm relay is actuated.

AUDIO/VIDEO SWITCHER



POPULAR ELECTRONICS

This circuit is a two-channel baseband video switcher. Buffer amps U1/Q1, U4/Q4, and associated components produce a buffered 75-Ω video signal, which is routed to switching network K1/K2/K3. Relay K1 selects either of these two video amplifiers and feeds J7. K2 also routes the output of either video amplifier to K3, which passes the selected video channel to J8 or connects J9 to J8.

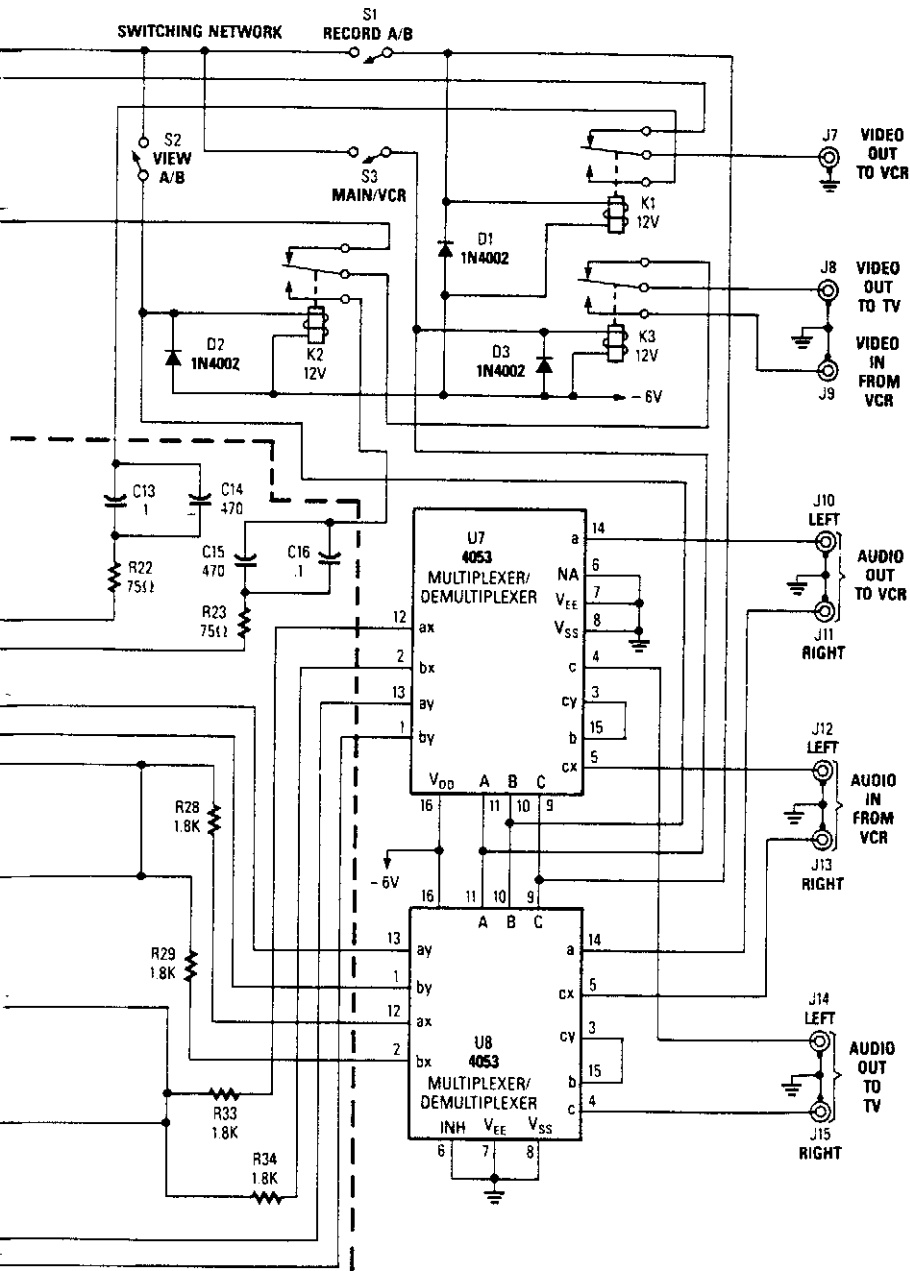
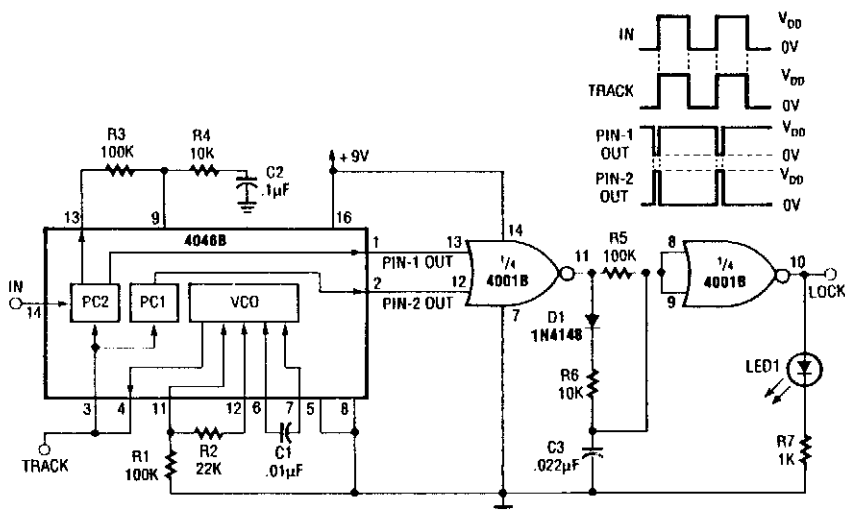


Fig. 84-3

U2 and U3 are audio amplifiers, which drive U7 and U8 (CD4053 analog switches) to route audio from J1 and J2 to either J14/J15, or J10/J11. Also, audio from J12/J13 can be routed to these jacks.

PRECISION NARROW-BAND TONE SWITCH



RADIO-ELECTRONICS

Fig. 84-4

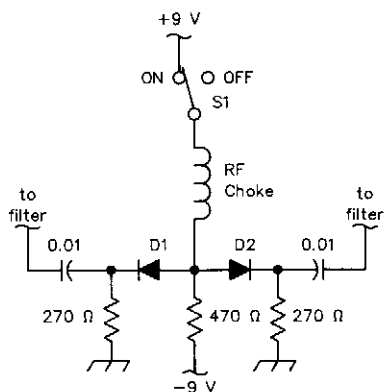
This signal tracker and lock detector combine to make a precision tone switch. Filter R3/R4/C2 determines signal capture and tracking range, as well as settling time.

Max. VCO frequency: $R_1 C_1$

Min. VCO frequency: $(R_1 + R_2) C_2$

Pin 9 voltage affects both. The minimum at pin 9 is 0 V and the maximum at pin 9 is V_{DD} . In the lock detector, the PC (phase comparator) outputs are pulses whose width is proportional to the phase difference between the two PC inputs. At lock up, the two PC outputs are almost mirror images. The output of IC1A remains low and IC1B is high. This lights LED1. If the loop is unlocked, the LED will not light.

DIODE RF SWITCH

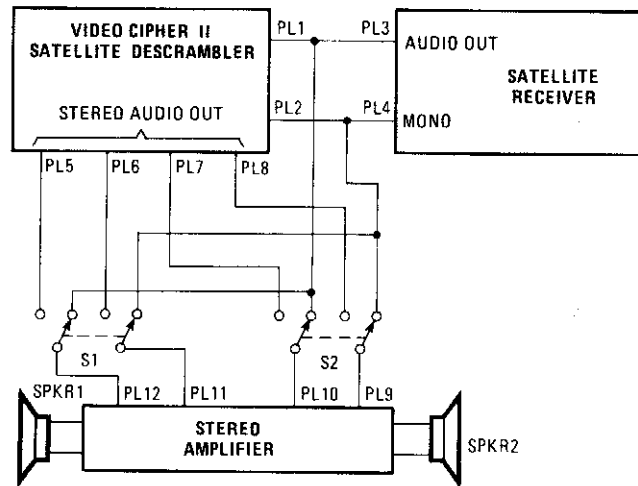


QST

Fig. 84-5

D1 and D2 can be IN914B- or HP2800-series diodes (for UHF). The loss is over 60 dB in the OFF state, and less than 3 dB at 3.5 to 30 MHz (using common IN914B diodes).

SATELLITE TV AUDIO SWITCHER



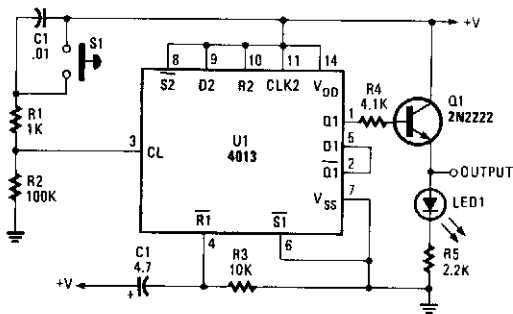
POPULAR ELECTRONICS

Fig. 84-6

Some channels offer a separate audio mode (SAP) in a second language. It is usually transmitted on 6.8 MHz, which is the frequency used for unscrambled channels. The audio in the scrambled channels is transmitted along with the picture, so when the descrambler descrambles the signal, it also descrambles the audio in stereo. When the channel offers SAP, you'll find it on 6.8 MHz.

The switches are a pair of DPDT switches that have the toggle handles tied together. In one position, you hear the audio in stereo and in the other position, you hear the SAP. Just turn down the volume level on the TV and you can connect it to a stereo amplifier and a pair of speakers.

ON/OFF SWITCH

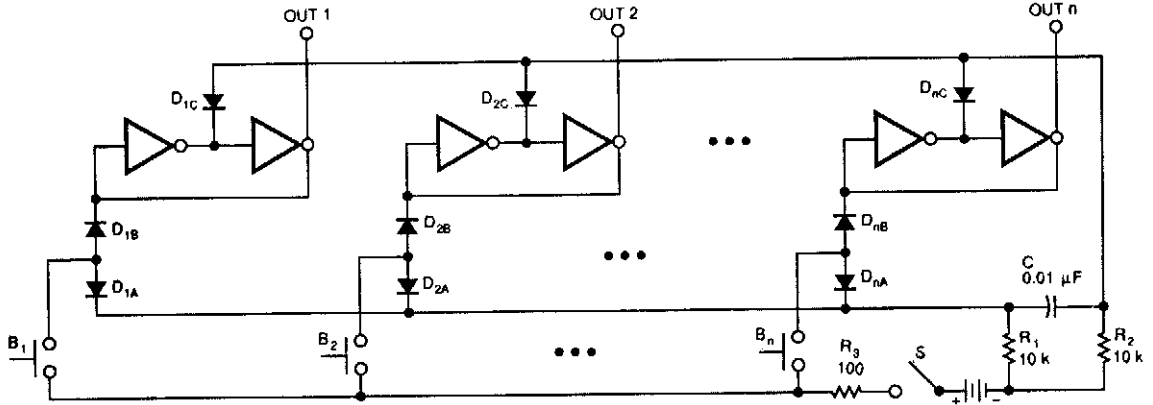


POPULAR ELECTRONICS

Fig. 84-7

A CD 4013 dual-D flip-flop is used to drive an emitter-follower. This circuit can be used where a simple pushbutton on/off is desired.

SWITCHING CIRCUIT



EDN

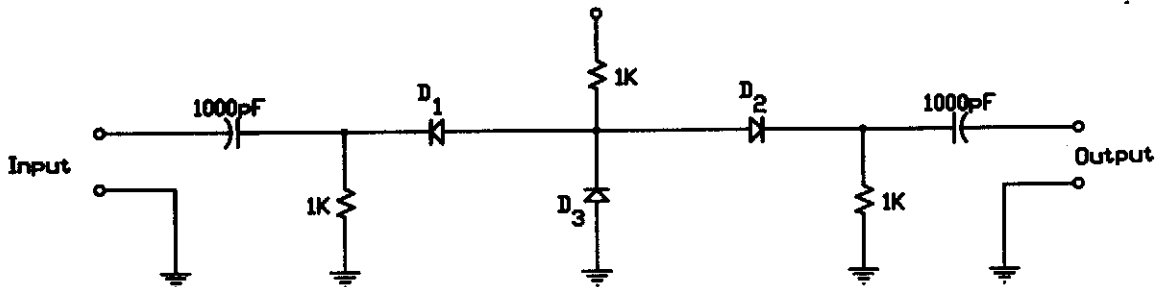
Fig. 84-8

This switching circuit acts like a bank of interlocked mechanical switches; pushing one of the buttons latches its corresponding output and unlatches a previously selected output. A pair of inverters forms a latch for each output.

Pressing button B1, for example, applies a positive pulse, via resistor diode D1B, to the input of the first output's, OUT1, latch. This positive pulse will set OUT1 high. Feedback locks OUT1's pair of converters in this HIGH state. Meanwhile, the pulse will also pass through diode D1A to the differentiator that is formed by C and R2. The differentiator will shorten the pulse.

The shortened pulse goes to all the latches and resets all of them, except the latch that sees the longer setting pulse. Obviously, if you press more than one button at once, more than one output will latch at once.

INEXPENSIVE VHF/UHF DIODE RF SWITCH



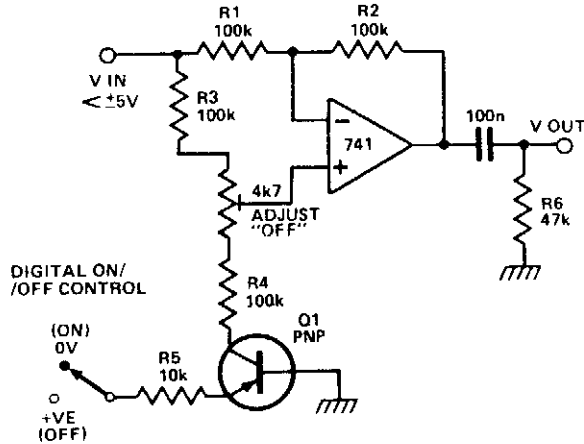
Diodes are 1N4148

RF DESIGN

Fig. 84-9

This circuit uses low-cost IN4148 diodes and exhibits about 1.5 dB insertion loss from 10 to 1000 MHz with a few volts of negative bias. D3 conducts and D1/D2 are cut off, which results in 30 to 50 dB isolation. When a few volts of positive bias are applied, D1 and D2 are biased on and D3 is cut off. This circuit should be useful in applications where a low-cost RF switch is necessary.

TRANSISTOR TURNS OP AMP ON OR OFF



ELECTRONICS TODAY INTERNATIONAL

Fig. 84-12

When transistor $Q1$ is switched off, the circuit behaves as a voltage follower. By applying a positive voltage to the emitter of $Q1$ via a 10 k Ω resistor, the transistor is made to turn on and go into saturation. Thus, the lower end of $R4$ is connected to ground. The circuit has not changed into that of a differential amplifier, except that the voltage difference is always 0 V. As long as the resistor ratios in the two branches around the op amp are in the same ratio, the output should be zero. A 47-k Ω resistor is used to null out any ratio errors so that the OFF attenuation is more than 60 dB. The high common-mode rejection ratio of a 741 enables this large attenuation to be obtained.

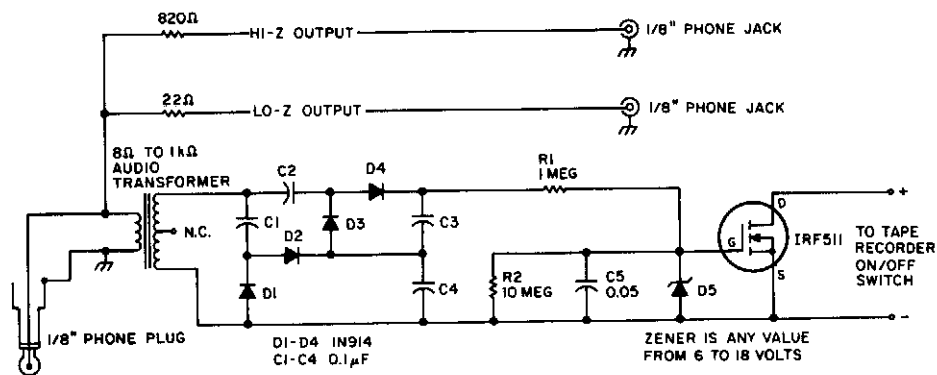
85

Tape Recorder Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 678. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio-Powered Tape Recorder Controller
12-V Auto-Powered Circuit For Cassette Recorders

AUDIO-POWERED TAPE RECORDER CONTROLLER

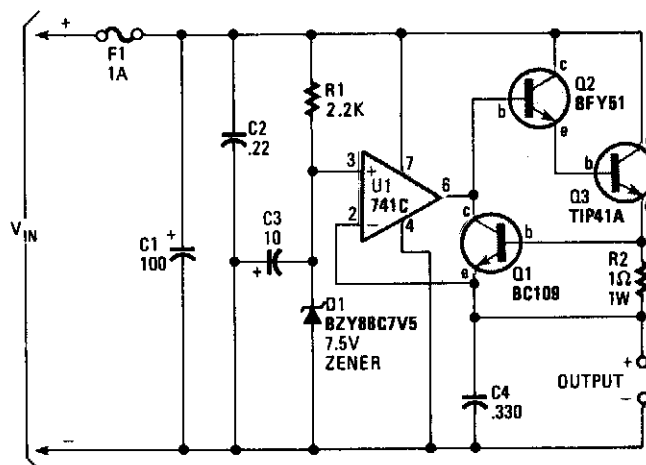


73 AMATEUR RADIO

Fig. 85-1

A tape recorder can be controlled by rectifying the audio input and driving an IRF511 power MOSFET to switch a tape recorder on when audio is present. This circuit was used with a communications receiver to record intermittent transmissions (such as aircraft, repeater output, etc.).

12-V AUTO-POWERED CIRCUIT FOR CASSETTE RECORDERS



HANDS-ON ELECTRONICS

Fig. 85-2

A regulator allows you to power a 7.5-V cassette recorder or other device from a 12-Vdc auto system. About 600 mA is available from the circuit. Q3 should be heatsinked because it dissipates up to 4 W. F1 should be a slow-blow fuse so that the surge caused by C1 does not cause unnecessary fuse failures.

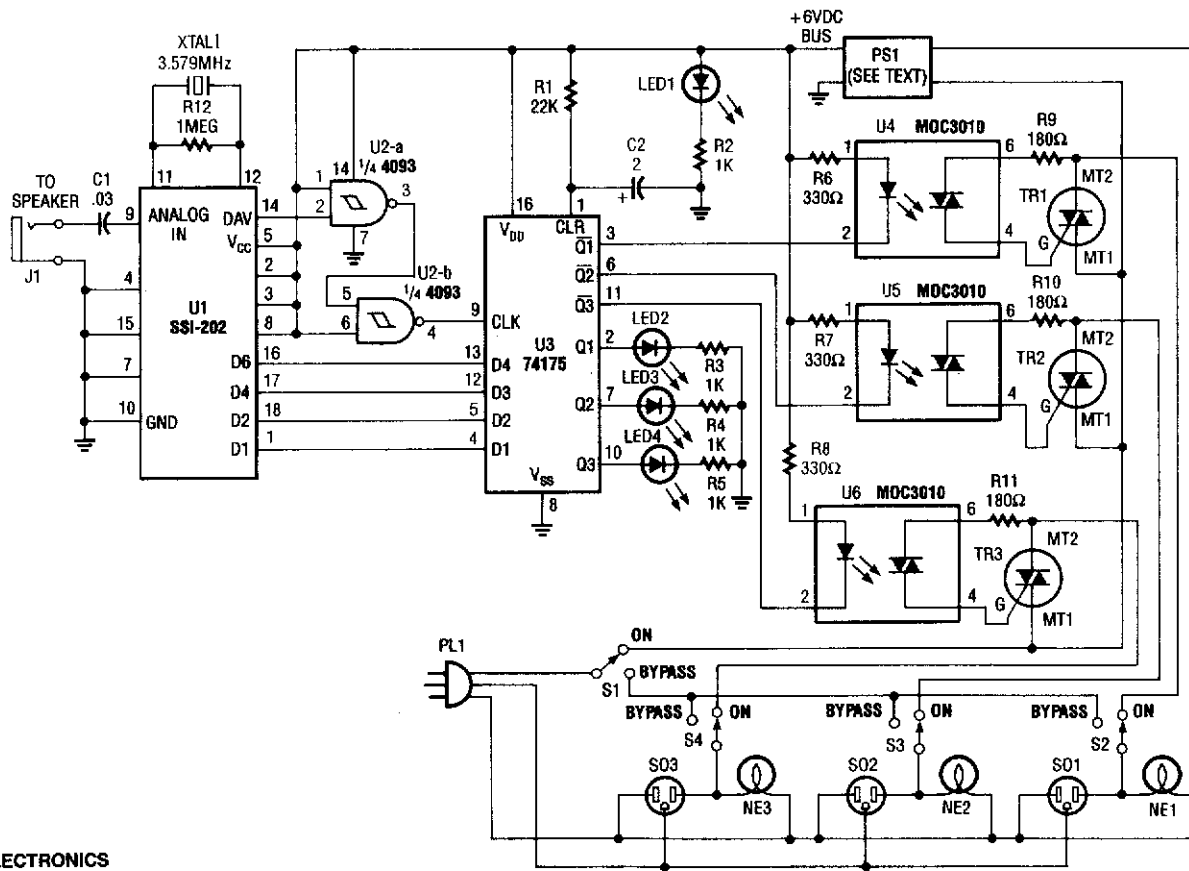
86

Telephone-Related Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 678. The figure number in the box of each circuit correlates to the entry in the Sources section.

Telephone-Operated ac Power Switch	Tell-A-Bell
Telephone Toll Totalizer	Answering Machine Beeper
Remote-Controlled Telephone/Fax Machine Switch	Telephone Visual Ring Indicator
Telemonitor for Recording Phone Calls	Phone-In-Use Indicator
Duplex Audio Link	Telephone Amplifier
Low-Power Touch-Tone Decoder	Extension Phone Ringer
Telephone Speaker Amplifier	Telephone Visual Ring Indicator
Telephone Ringer	Call Tone Generator
Phone Message Flasher	Remote Ringer
Telephone Silencer	Telephone Message Taker
Telephone Intercom	Telephone Line-In-Use Indicator
Telephone Auto Record	Simple Ring Detector

TELEPHONE-OPERATED ac POWER SWITCH



POPULAR ELECTRONICS

Fig. 86-1

Tones (from the DTMF) on the telephone line are detected by U1. When a valid tone is received, pin 14 (DAV) of U1 produces a positive pulse that is used to drive NAND gates U2A and U2B and then to latch binary data from U1 into Quad-D flip-flop U3 (U1 could be decoded into 16 bits, if required). The Q outputs of U3 drive optoisolators that control triacs TR1, TR2, and TR3. PS1 is a 6-V 150-mA dc adapter that operates from 120 Vac.

TELEPHONE TOLL TOTALIZER

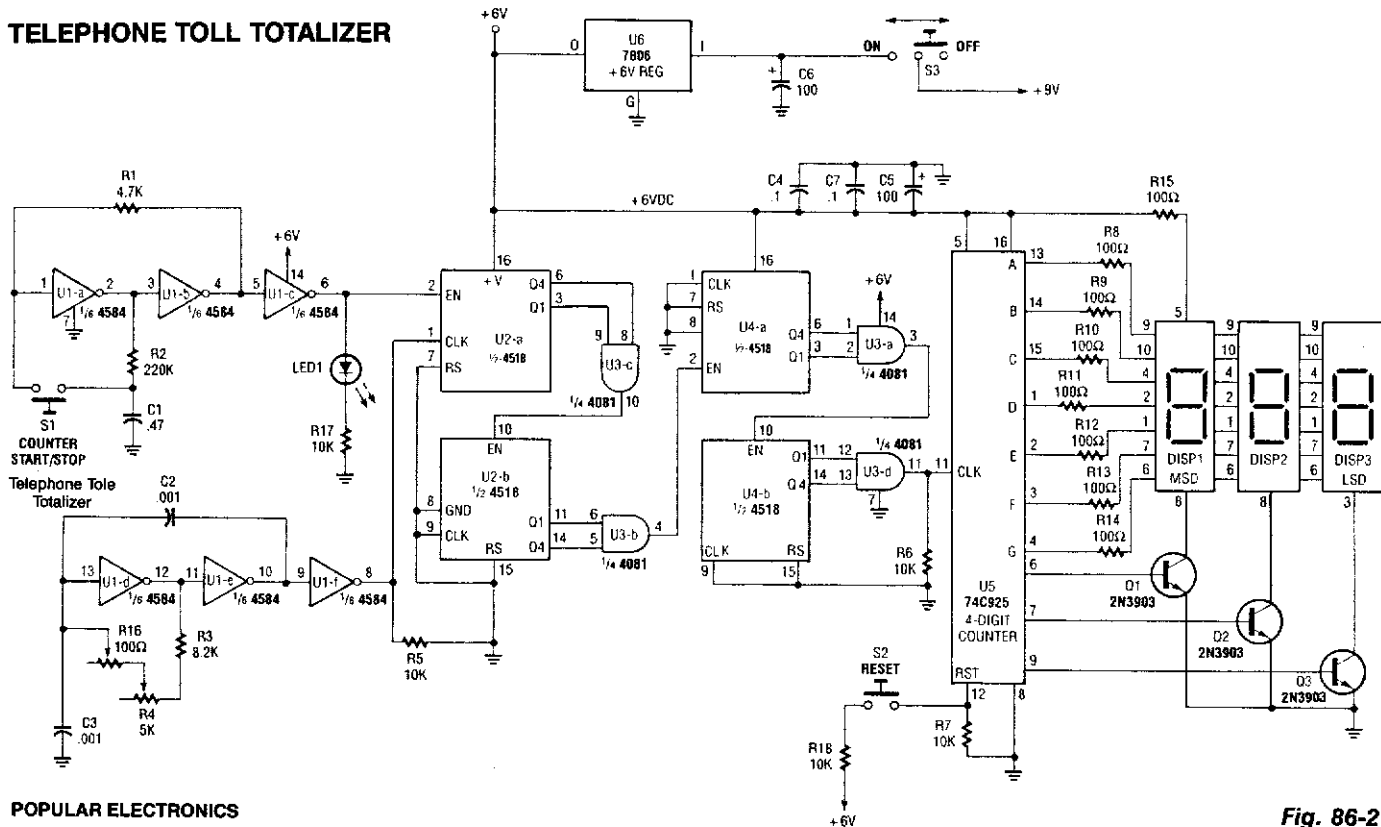


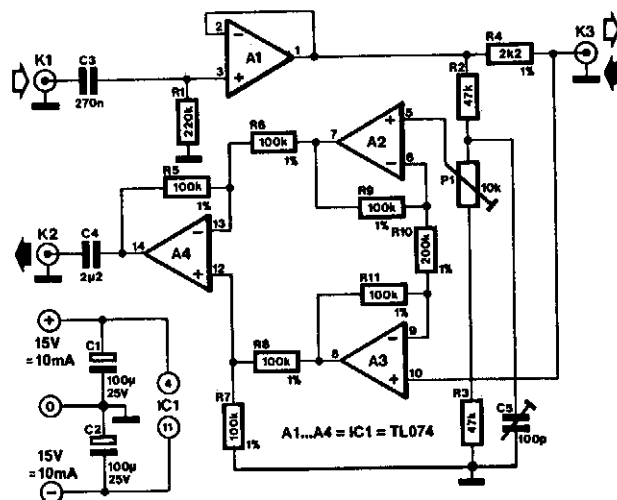
Fig. 86-2

The Telephone Toll Totalizer—built around two 4518 dual synchronous up counters, a 74C925 4-digit counter, a 4584 hex inverting buffer, and a 4081 quad 2-input AND gate—is fairly simple.

Approximate toll charges can be calculated with this counter. It is started when dialing and stopped (manually) on hang-up. It is actually a counter that measures the time you are on the telephone. By calibrating it to the average cost/second of calls (get this from calculations you have done on your monthly phone bill), you can closely estimate your phone bill.

The circuit consists of an oscillator running at the $100\,000 \times$ frequency into the main counter (74C925). Typically, cost of telephone calls is 15 to 25 cents/minute so that the clock frequency (U1) is in the 25- to 40-kHz range. U2 and U4 with gates U3 form a $\div 100\,000$ counter. The approximate cost in dollars and cents is read out on the multiplexed display, DISP 1, 2, 3. S2 resets the counter to zero after each use.

DUPLEX AUDIO LINK



ELEKTOR ELECTRONICS

Fig. 86-5

Duplex communication is, of course, not a new technique: it has been used, for instance, in telephone systems for many years. Those systems, however, use transformers to achieve duplex—this circuit does it with the aid of electronics.

The principle is fairly simple. Two senders impose signals (U_1 and U_2 , respectively) on to the audio cable. The voltage across the cable is then $(U_1 + U_2)/2$. The receivers at both sides of the cable deduct their side's sender signal from the cable signal: the result is that the signal is sent from the other end of the cable. This principle is the basis of the circuit shown. Notice that a similar circuit is required at either end of the link.

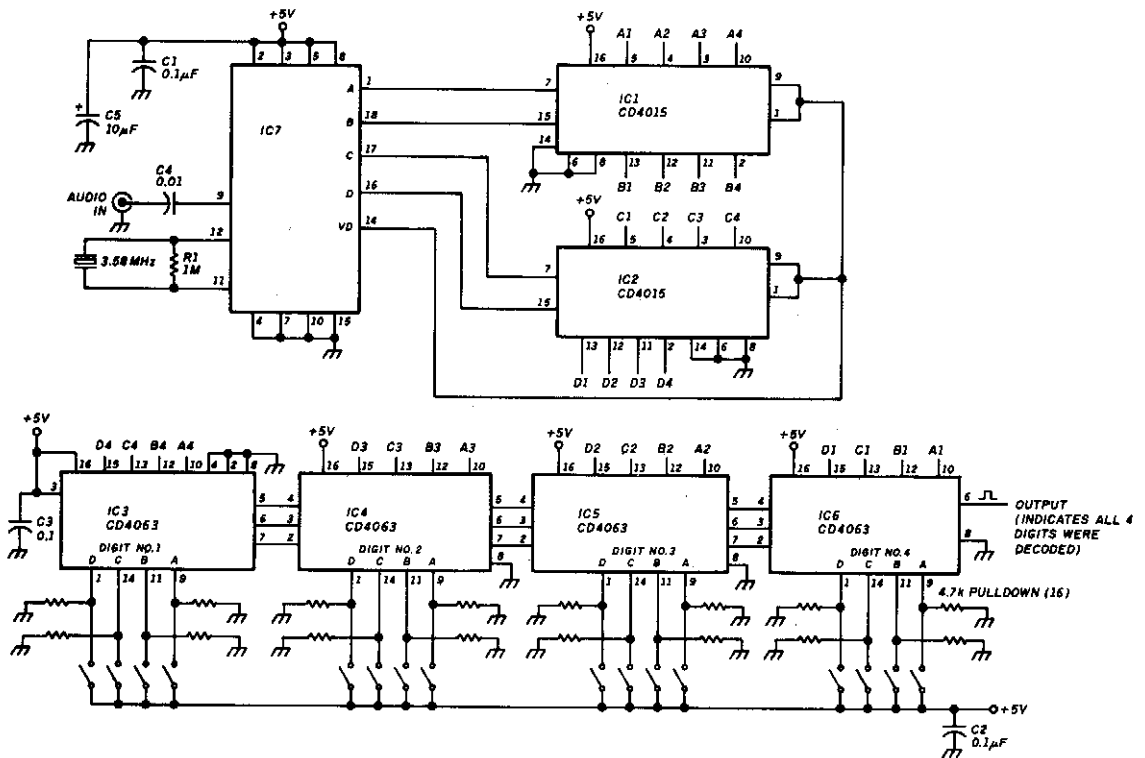
Op amp A1 is connected as a buffer amplifier and serves as sender. The send signal is imposed on the cable via R4. Terminating the cable by R4 results in the voltage across the cable being only half the voltage output of A1. This does not detract from the operation of the circuit, however. At the same time, R4 ensures that signals emanating from the other end of the link cannot get to the output of A1; if they could, they would be short-circuited by the output.

The receiver is a differential amplifier consisting of op amps A2 through A4. The quality of the differential amplifier depends largely on the resistors used with the op amps; 1% types are, therefore, essential.

The cable signal, $(U_1 + U_2)/2$, is applied to one input of the differential amplifier and the (halved) output signal of A1 to the other. Because the differential amplifier has a gain of 6 dB, the received signal applied to K2 has the same level as the original signal.

The circuit is calibrated by connecting the cable to it and to its twin circuit, then injecting a 1-kHz sinusoidal signal and a 5-Vrms level to its input. The input bus of the other circuit must be short-circuited during the calibration. Adjust P2 for minimum signal at K2. Next, increase the frequency of the input signal to 10 kHz and adjust C5 for a minimum signal at K2. Repeat the procedure with the other circuit. The signal suppression at 1 kHz is of the order of 80 dB; at 20 kHz, it is approximately 60 dB.

LOW-POWER TOUCH-TONE DECODER

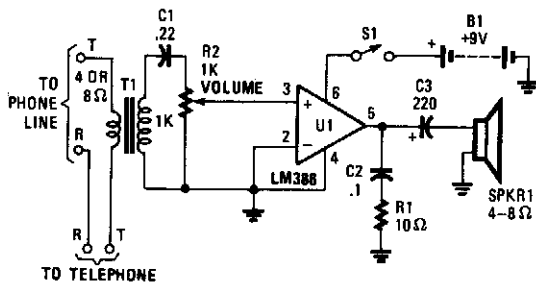


HAM RADIO

Fig. 86-6

This decoder will respond to a preselected 4-digit DTMF number. IC7 is a Radio Shack IC device (part #276-1303). The logic is all CMOS. The digits are selected by SW1 and SW2, a pair of 8-position DIP switches.

TELEPHONE SPEAKER AMPLIFIER

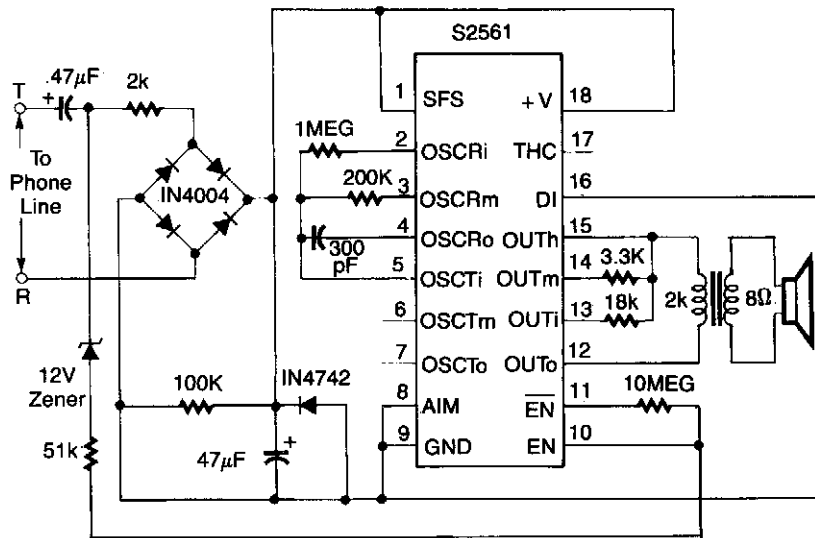


This simple telephone amplifier (which can be switched off for privacy) allows everyone in the room to listen to your telephone conversations.

POPULAR ELECTRONICS

Fig. 86-7

TELEPHONE RINGER

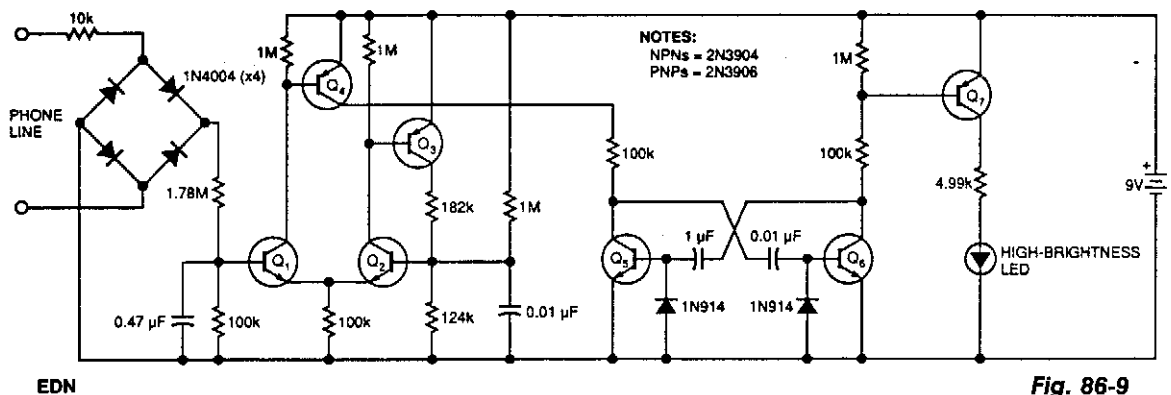


RADIO-ELECTRONICS

Fig. 86-8

Using an AMI P/N S2561 IC, the circuit shown can be either powered by a battery or the telephone line in use. Output is about 50 mW.

PHONE MESSAGE FLASHER

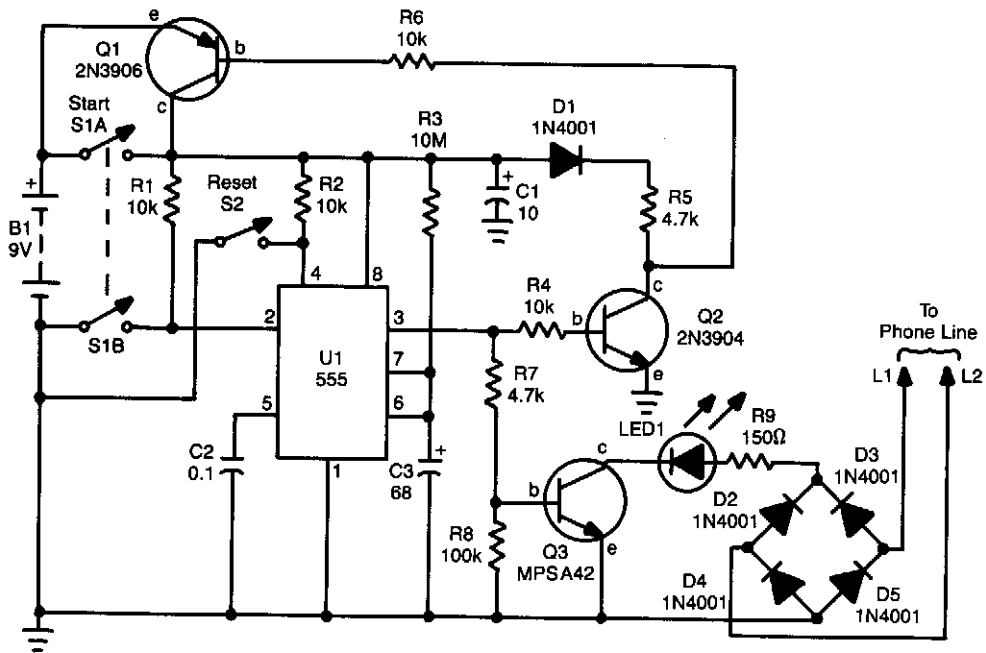


EDN

Fig. 86-9

This circuit flashes an LED to indicate that your phone rang during your absence. A differential amplifier with hysteresis (Q1, Q2, and Q3) detects high line voltage (ringing), which turns on Q4, multivibrator Q5/Q6, and flashes the LED via Q7. Q1 and Q2 remain on until the phone-line voltage drops to less than 9 V, which indicates an off-hook condition.

TELEPHONE SILENCER

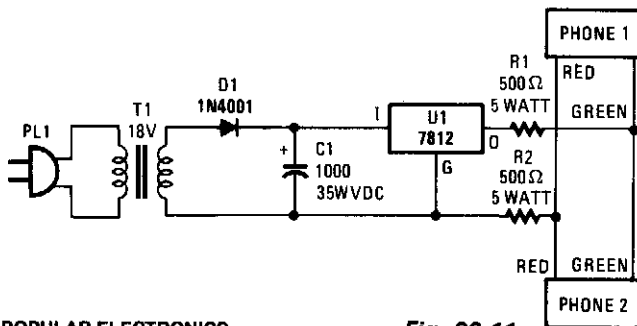


WELS' THINK TANK

Fig. 86-10

If you are busy and cannot answer or do not wish to answer your phone, this circuit will give a busy signal without you having to leave the phone off the hook. After a predetermined time, the circuit is deactivated. U1 forms an astable multivibrator that can be set for a time up to 10 minutes by values of R3 and C3. When S1A is depressed, U1 starts, and Q1 latches, which powers the circuit. At the end of a time interval determined by R3 and C3, Q2 and Q3 cut off and remove power from the circuit. During the operation, S3 throws a 150-Ω resistor across the phone line, which simulates an off-hook condition.

TELEPHONE INTERCOM

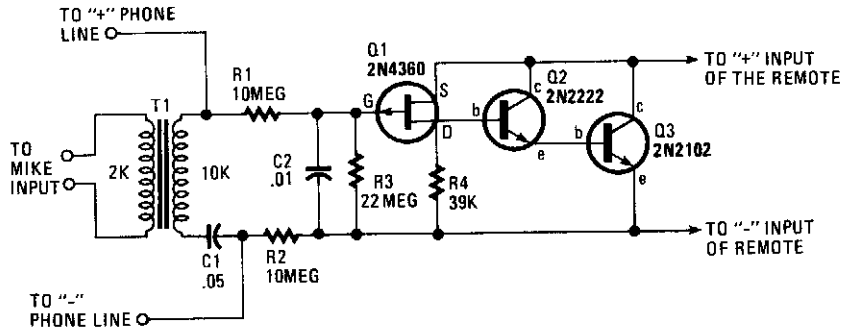


Two telephones can be used as an intercom setup with this simple power-supply arrangement. The 500-Ω resistors maintain line balance.

POPULAR ELECTRONICS

Fig. 86-11

TELEPHONE AUTO RECORD

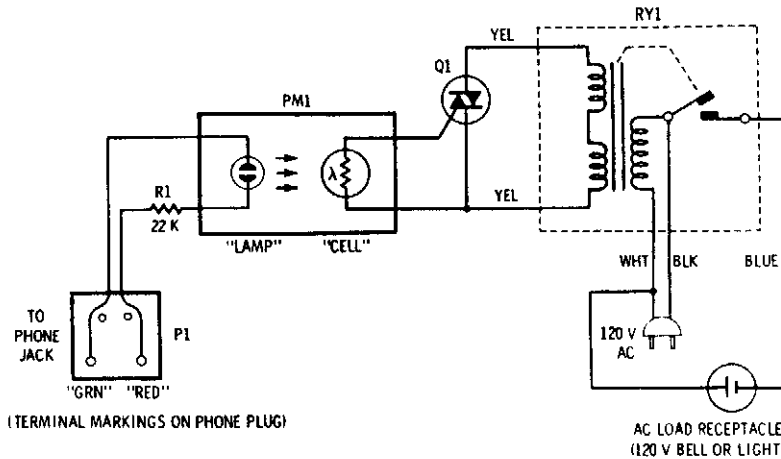


HANDS-ON ELECTRONICS

Fig. 86-12

The circuit requires neither a battery nor an ac supply to make it work. Set the recorder to the record position and when the telephone is taken off the hook, the recorder starts to record everything. When the phone is on the hook, the voltage across the phone lines is about 48 Vdc. When it is taken off the hook, the line voltage drops below 10 V. When the line voltage is near 48 V, the FET is biased off and no current can flow through Q2 and Q3. When the receiver is off the hook, the voltage drops, and allows Q1 to conduct. This action turns on Q2, Q3, and the cassette recorder.

TELL-A-BELL

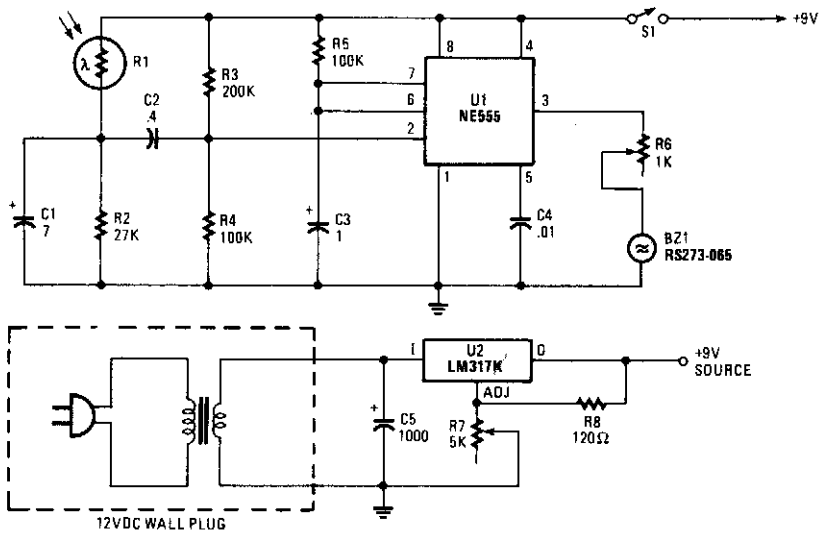


TAB BOOKS

Fig. 86-13

This accessory connects to phone and will activate an attention-getting 120-V bell whenever a ringing voltage appears on the phone line. The four-terminal transducer has a neon bulb close to a photocell, which are both enclosed in a light-tight tube. When the lamp is off, the cell is dark and its resistance is very high. When a ringing voltage appears on the phone line, the neon bulb glows brightly and illuminates the photocell whose resistance then drops to about 1000 Ω . The photocell is in the gate circuit of a triac that will turn on whenever the cell resistance drops. The triac is connected across the switching terminals of the isolation relay. Thus, the relay closes and applies 120 V to the output socket whenever the triac is on.

ANSWERING MACHINE BEEPER

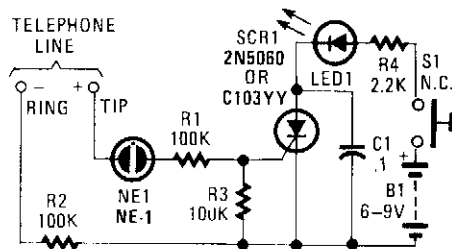


POPULAR ELECTRONICS

Fig. 86-14

When the light on the answering machine blinks, the resistance of photoresistor R1 changes, triggers the timer (U1), and generates 0.2-s pulse that activates BZ1. R1 is optically coupled to the LED on the answering machine and is properly light shielded.

TELEPHONE VISUAL RING INDICATOR

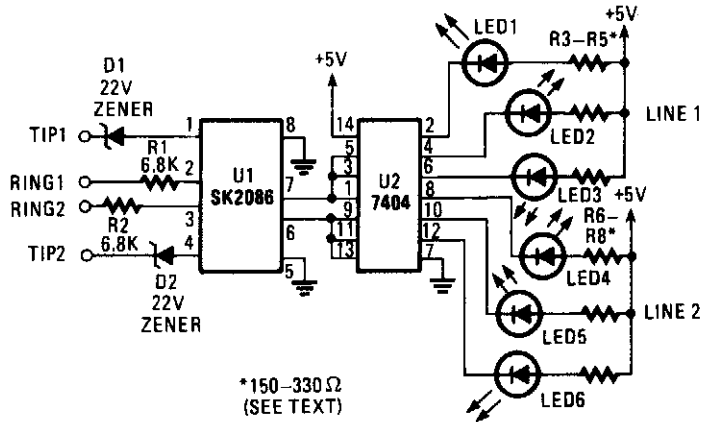


POPULAR ELECTRONICS

Fig. 86-15

This circuit will indicate the receipt of a call. When the telephone rings, a 100- to 120-V ring signal breaks over NE1, and causes SCR1 to trigger. This causes LED1 to light until the SCR1 is turned off by depressing S1.

PHONE-IN-USE INDICATOR

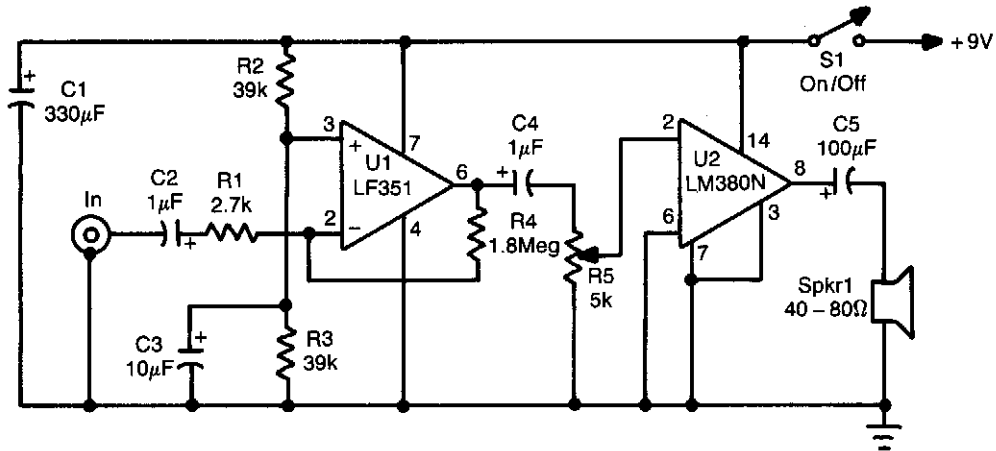


POPULAR ELECTRONICS

Fig. 86-16

The circuit receives its power from a 15-V wall adapter (not shown). The circuit takes advantage of the fact that the phone line voltage drops from 48 to 10 V when an extension is taken off the hook. When the voltage on a line drops, the optoisolator/coupler is turned off so that the inputs to the line-1 hexinverters (U2 pins 1, 3, and 5) float high. The corresponding outputs (U2 pins 2, 4, and 6) go low and light the line-1 LEDs.

TELEPHONE AMPLIFIER

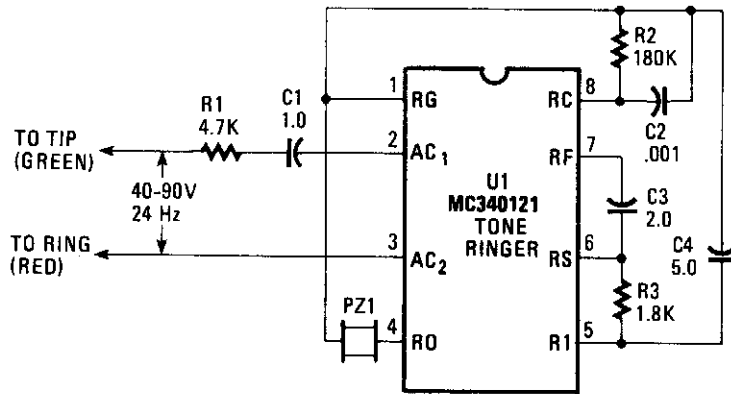


POPULAR ELECTRONICS

Fig. 86-17

This amplifier can be used in telephone work or where a simple speech amplifier is required. The frequency response can be varied by the value of C_2 , C_4 , and addition of a capacitor across R_4 (≈ 33 pF for voice band) to limit the HF response.

EXTENSION PHONE RINGER

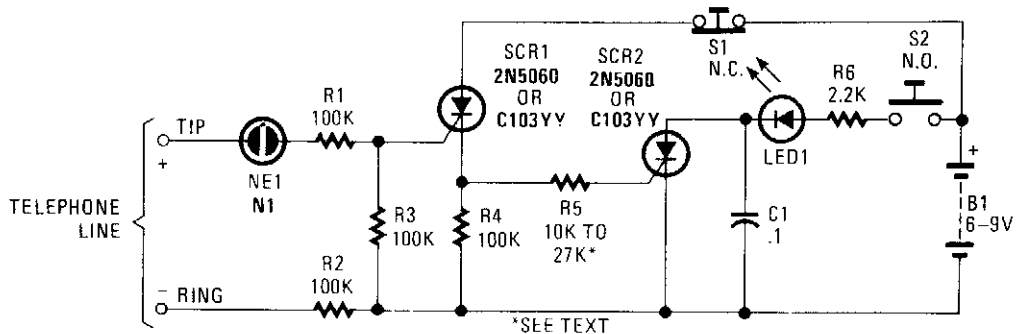


HANDS-ON ELECTRONICS

Fig. 86-18

The ac ringing voltage (typically 40 to 90 V at 26 Hz) is rectified by U1, the tone-ringer IC, and is used to drive that IC's internal tone-generator circuitry. The tone-generator IC includes a relaxation oscillator (with a base frequency of 500, 1 000, or 2 000 Hz) and frequency dividers that produce the high- and low-frequency tones, as well as the tone-warble frequency. An on-board amplifier feeds a 20-V_{pp} signal to the transducer.

TELEPHONE VISUAL RING INDICATOR

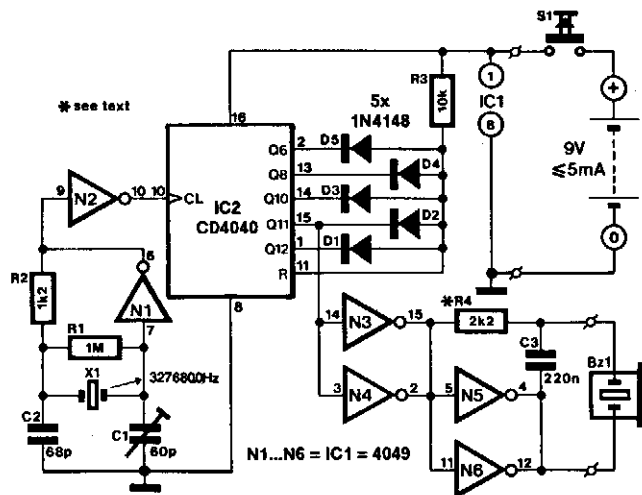


POPULAR ELECTRONICS

Fig. 86-19

In this circuit, the ringing voltage on a telephone line causes NE-1 to break over, triggering SCR1, which in turn triggers SCR2. If a call has been received, depressing S2 will cause LED1 to light. Depressing S1 resets the circuit. This circuit has the advantage of lower battery drain because LED1 is not left on continuously after a ring signal, but only when S2 is depressed.

CALL TONE GENERATOR



ELEKTOR ELECTRONICS

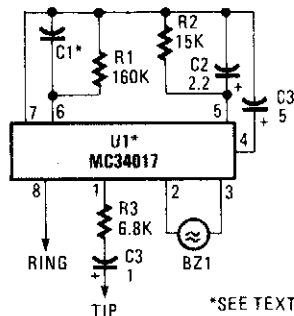
Fig. 86-20

Amateur VHF relay stations are normally actuated by a 1750-Hz call tone. This might give problems if the relevant sending equipment has no internal call-tone generator, if it does not have sufficiently accurate frequencies, or if the tone duration is not long enough to securely energize the relevant relay.

These problems can be overcome by the stand-alone generator described here. Simply placed in front of the microphone, it makes absolutely certain that the relay station is actuated. The generator consists of a quartz oscillator, a frequency counter and a buffer-amplifier—all contained in just two CMOS ICs. It is powered by a 9-V (p-p) battery, from which it draws a current of around 5 mA.

Gates N1 and N2 form an oscillator that is controlled by a 3.27680-MHz crystal and provides clock pulses to IC2, which is connected as a programmable scaler. Diodes D1 through D5 determine the divide factor of 1872. Counter output Q1 provides the wanted 1750-Hz signal, which is buffered by N3 through N6 before being applied to a piezoelectric buzzer. Capacitor C3 suppresses any harmonics, while R4 determines the volume of the output signal.

REMOTE RINGER



*SEE TEXT

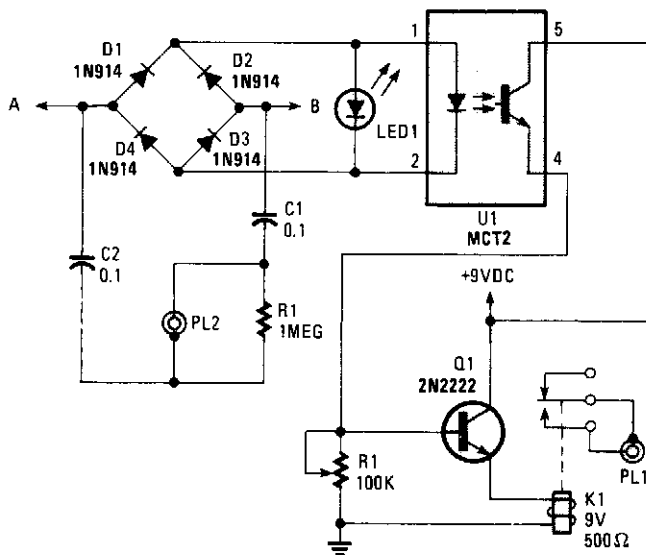
Fig. 86-21

A telephone bell circuit using a Motorola MC34017 can be built from a few components. C1 and U1 depend on the type of ring required.

U1	C1	Ring
MC34017-1	1000 pF	1 kHz
MC34017-2	500 pF	2 kHz
MC34017-3	2000 pF	500 Hz

Select the version of MC34017 and C1 from this table.

TELEPHONE MESSAGE TAKER

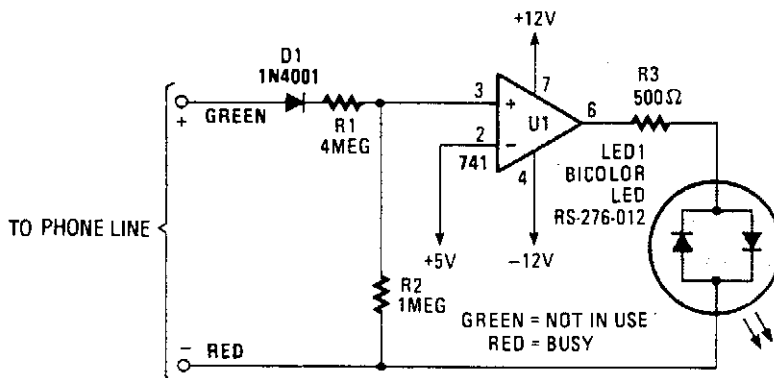


POPULAR ELECTRONICS

Fig. 86-22

This circuit operates on the ringing voltage of the telephone to trigger a tape recorder to record messages. K1 can be made to latch using extra contacts if the tape recorder requires a constant-contact closure.

TELEPHONE LINE-IN-USE INDICATOR

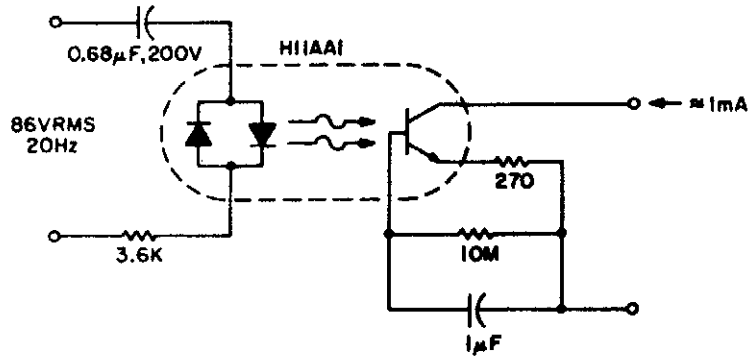


POPULAR ELECTRONICS

Fig. 86-23

When a telephone line is not in use, about 48 V appears across the line, which drops to about 10 V or less when the line is in use. This circuit switches a bicolor LED as an indicator.

SIMPLE RING DETECTOR



GE

Fig. 86-24

This circuit detects the 20-Hz approximately 86-Vrms ring signal on telephone lines and initiates action in an electrically isolated circuit. Typical applications include automatic answering equipment, interconnect/interface and key systems. The detector is the simplest and provides about a 1-mA signal for a 7-mA line, which loads for 0.1 s after the start of the ring signal. The time-delay capacitor provides a degree of dial-tap and click suppression, and filters out the zero crossing of the 20-Hz wave.

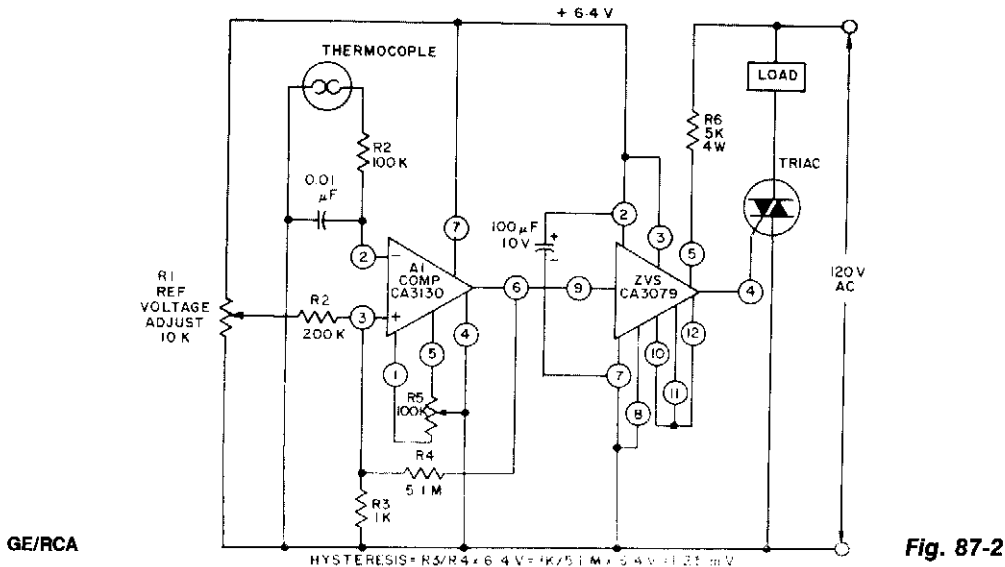
87

Temperature Controls

The sources of the following circuits are contained in the Sources section, which begins on page 679. The figure number in the box of each circuit correlates to the entry in the Sources section.

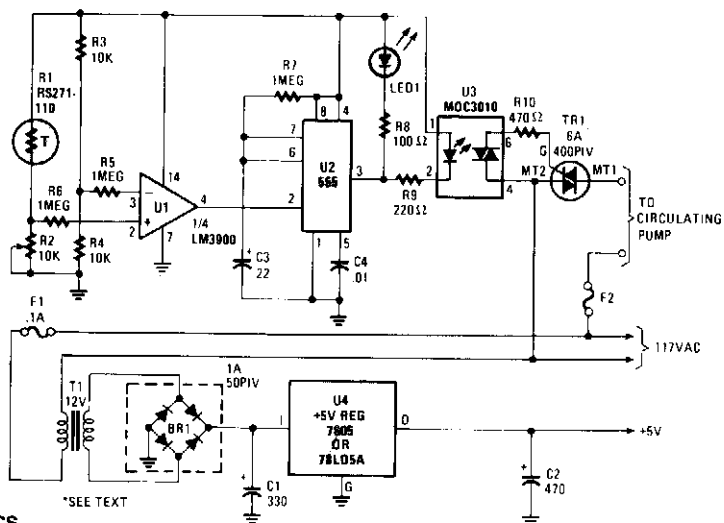
Temperature Controller with Defrost Cycle
Thermocouple Temperature Control
Temperature Controller

THERMOCOUPLE TEMPERATURE CONTROL



This control, with zero-voltage load switching, uses a CA3130 BiMOS op amp and a CA3079 zero-voltage switch. The CA3130, used as a comparator, is ideal because it can “compare” the low voltages generated by the thermocouple to the adjustable reference voltage over the range of 0 to 20 mV.

TEMPERATURE CONTROLLER



POPULAR ELECTRONICS

A thermistor (R1) is compared with a reference (R2) in a Wheatstone-bridge circuit. Comparator U1's output goes high, which triggers U2. U2 is a delay of about 25 s. After 15 s, LED1 lights, U3 actuates, triac TR1 triggers, and turns on a hot water pump. This system was used with a hot-water heater.

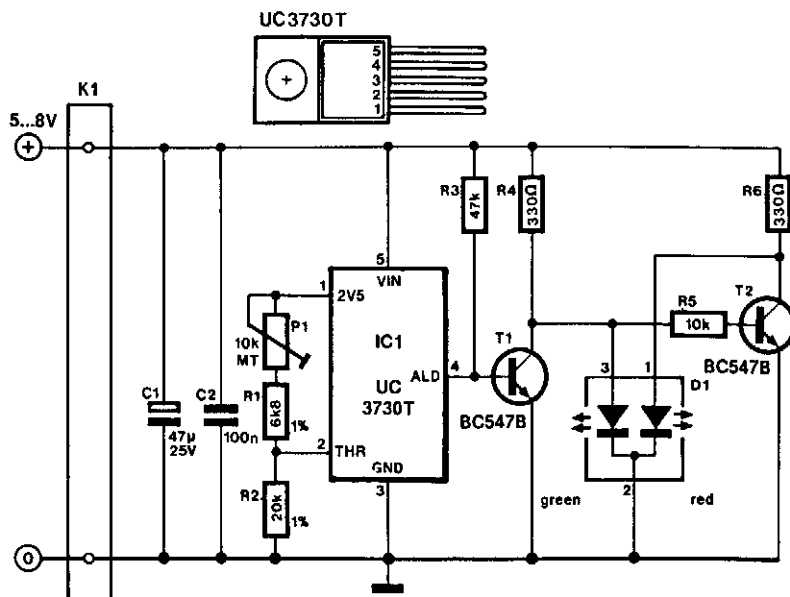
88

Temperature Sensors

The sources of the following circuits are contained in the Sources section, which begins on page 679. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Thermal Monitor
- Simple Temperature Indicator
- Under-Temperature Switch
- Temperature Sensor
- Over-Temperature Switch
- Transistor Sensor Temperature Measurer

THERMAL MONITOR



ELEKTOR ELECTRONICS

Fig. 88-1

Unitrode's UC1730 family of integrated circuits is designed for use in a number of thermal monitoring applications. Each IC combines a temperature transducer, a precision reference, and a temperature comparator to allow the device to respond with a logic output if temperatures exceed a predetermined level.

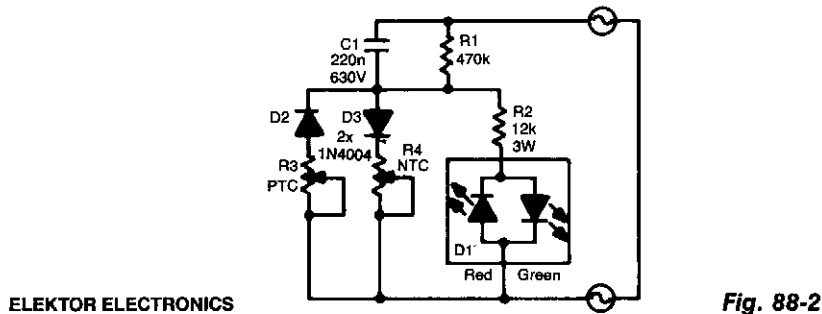
The monitor presented here is based on a UC3730T and it is intended to be fitted to a heatsink. Although the supply to the device can be as high as 40 V, 5- to 8-V is chosen here, because it is normally readily available in the equipment where the monitor will be used (power amplifiers, power supplies, etc.).

The threshold temperature, T_t , in $^{\circ}\text{C}$, is determined by:

$$T_t = \frac{2.5R_2}{0.005(R_1 + R_2 + P_1) - 273.15}$$

The temperature can be preset with $P1$ to values between -1°C and $+100^{\circ}\text{C}$. The indicator is formed by a bicolor LED and controlled by transistors $T1$ and $T2$. Resistors $R4$ and $R5$ limit the current through the LED. When the temperature of the heatsink is below the threshold temperature, the ALD (alarm delay) output, pin 4, is logic low so that $T1$ is switched off and the green LED lights.

SIMPLE TEMPERATURE INDICATOR



ELEKTOR ELECTRONICS

Fig. 88-2

For the absolute measurement of temperatures, a thermometer is indispensable. However, in many situations, an absolute value is not needed and a relative indication is sufficient. It would be a further advantage if a green light would indicate that all is well as far as temperature is concerned. As the temperature rises, the light should change color slowly to indicate that the equipment is getting too hot.

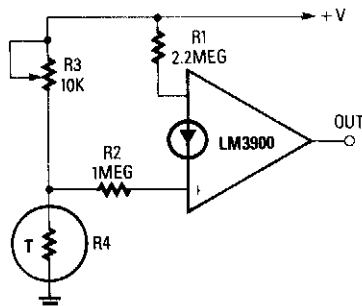
This circuit does this and works directly from the mains. The indicator proper is a two-color LED (D1), while the sensor is a combination of a negative-temperature coefficient (NTC) and a positive-temperature coefficient (PTC) resistor (R4 and R3, respectively).

At a relatively low temperature, the value of R_3 is low and that of R_4 is high. During the positive half cycle of the mains voltage, a voltage will exist across R_3/D_2 that is sufficiently high to cause the green section of D1 to light. The value of R_3 has been chosen to ensure that during the negative half cycle of the mains voltage, the potential across it is too low to cause the red section of D1 to light.

If the temperature rises, the value of R_4 diminishes and that of R_3 rises. Slowly, but surely, the green section will light with lesser and lesser brightness. At the same time, the red section lights with greater and greater brightness until ultimately only the red section will light.

Resistor R2 and capacitor C1 ensure that the current drawn by the LEDs does not become too large. This arrangement keeps the dissipation relatively low. Both R3 and R4 should be of reasonable dimensions—approximately 6 mm in diameter, not less. At 25°C, the NTC must be 22 to 25 k Ω and the PTC must be 25 to 33 Ω . The circuit should be treated with great care because it carries the full mains voltage.

UNDER-TEMPERATURE SWITCH

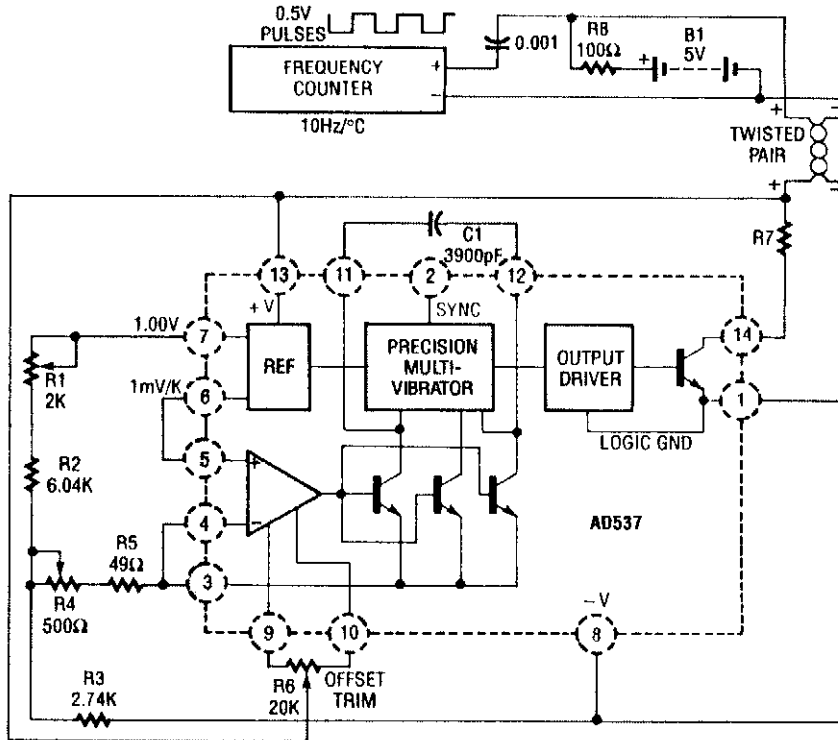


RADIO-ELECTRONICS

Fig. 88-3

The reference current is fed from the supply voltage via R1, to the inverting terminal, and the variable (noninverting) current is supplied from the junction of R3 and R4. Because the value of R_1 is approximately double that of R_2 , and generates a current that is proportional to the supply voltage, the trip temperature (preset via R3) is independent of the supply voltage.

TEMPERATURE SENSOR

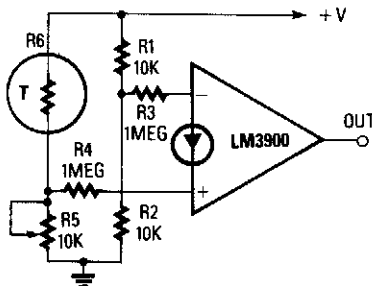


RADIO-ELECTRONICS

Fig. 88-4

The AD537 uses its two reference outputs—one fixed at 1 V, the other of which varies with temperature (1 mV per °K). At 0°C, the 1-V reference multiplied by 0.273 will balance this voltage and produce a zero output. The scale in this circuit is 10 Hz/°C. Output from, as well as power to, the circuit, is fed via a two-wire twisted pair. A frequency counter is used as a readout.

OVER-TEMPERATURE SWITCH

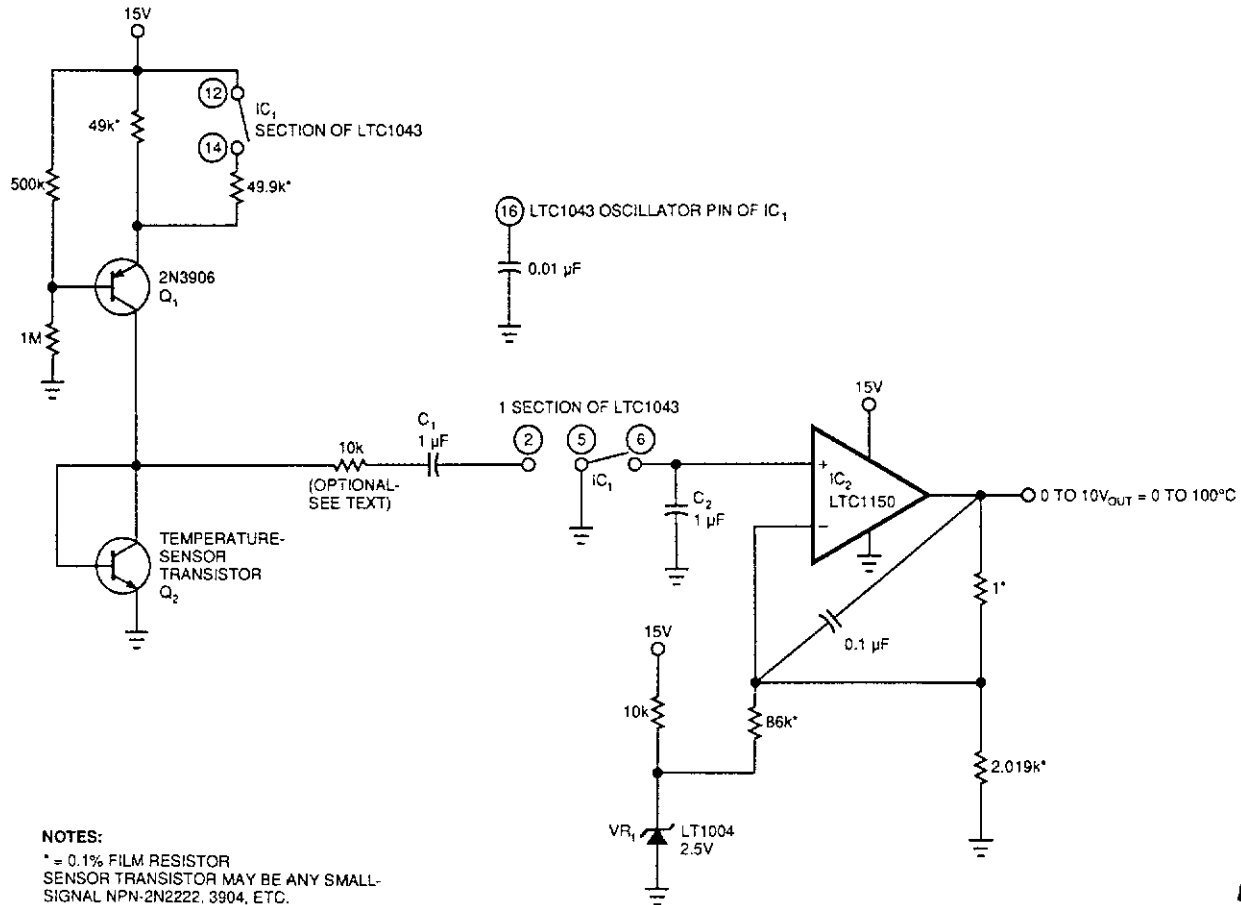


RADIO-ELECTRONICS

Fig. 88-5

The output goes high when a preset temperature is exceeded. A fixed half-supply reference voltage feeds a reference current to the inverting input, and a variable current is fed to the noninverting input. Resistor R6 is a negative-temperature-coefficient (NTC) thermistor, so the potential at the junction of R5 and R6 rises with temperature. The op amp will switch high when that voltage exceeds the half-supply value. The trip temperature can be preset via R5.

TRANSISTOR SENSOR TEMPERATURE MEASURER



EDN

Fig. 88-6

Using the fact that the V_{BE} of a transistor shifts 59.16 mV per decade of current at 25°C. This constant is 0.33%/°C. This V_{BE} -vs.-current relationship holds true regardless of the V_{BE} absolute value. IC₁, an LT1043, acts as an oscillator and switches a current source (Q₁) at a 10:1 ratio. The stepped 10:1 current drive is translated to temperature by IC₂, Q₂, and the associated components. Accuracy is ±1%. No compensation is needed if Q₂ is changed.

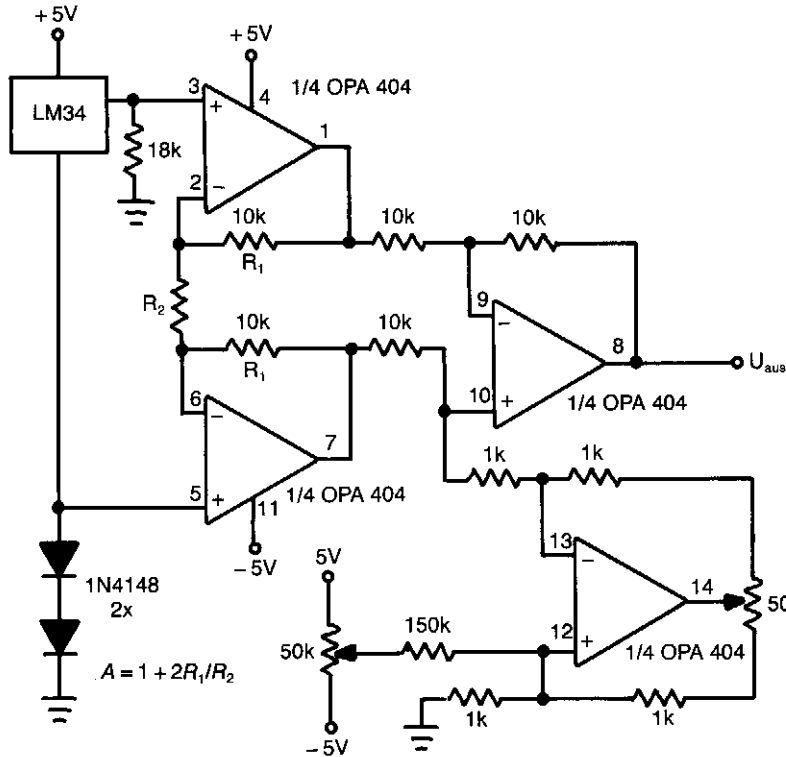
89

Thermometer Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 679. The figure number in the box of each circuit correlates to the entry in the Sources section.

Inexpensive Linear Thermometer
Electronic Thermometer
Single-dc Supply Thermometer
Electronic Thermometer
High-Accuracy Thermometer

INEXPENSIVE LINEAR THERMOMETER



ELECTRONIC ENGINEERING

Fig. 89-1

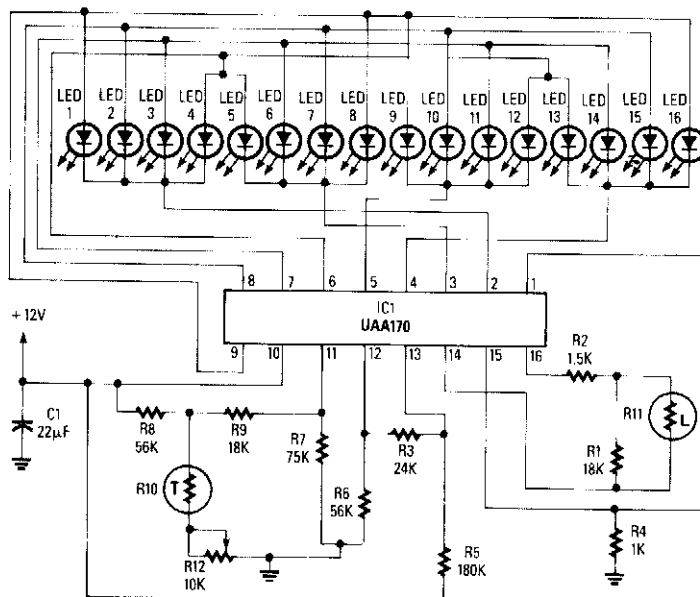
As a sensor in the design of this linear thermometer, the LM34 is used. The output is the difference between two base-emitter voltages ΔV_{EB} of two transistors operated at different collector-current densities. The voltage difference (ΔV_{EB}) is:

$$\begin{aligned}\Delta V_{EB} &= V_{EB1} - V_{EB2} \\ &= \frac{kT}{q} \ln (I_{C1}/I_{C2})\end{aligned}$$

where the current densities are I_{C1} and I_{C2} , k is Boltzmann's constant, and q is the electron charge. Because all factors, including the ratio I_{C1}/I_{C2} are constant, the output of the LM34 (National Semiconductor) is a linear function of T in the range over -50° to 300°F , which provides the output voltage of $10\text{ mV}/^\circ\text{F}$ with a max. nonlinearity of $\pm 0.35^\circ\text{F}$.

The output of the LM34 is amplified by a three-op-amp instrumentation amplifier. The fourth op amp gives the possibility to control the offset voltage of the amplifier. The gain A of the instrumentation amplifier can be set to any desired value by the choice of the resistance R_2 only.

ELECTRONIC THERMOMETER

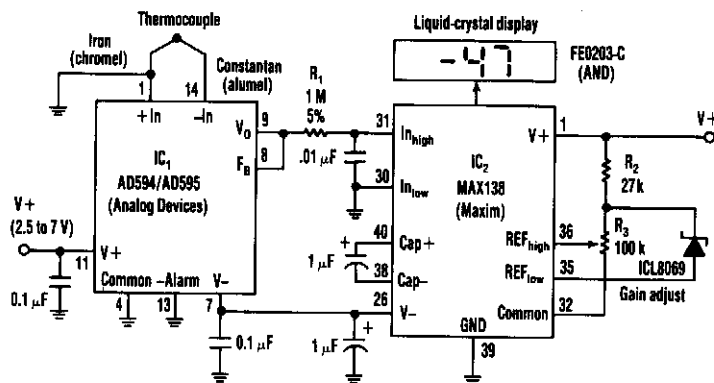


RADIO-ELECTRONICS

Fig. 89-2

This thermometer uses an NTC thermistor (R10) to produce a dc voltage that decreases with temperature, to drive an IC that lights one of the 16 LEDs as a function of this voltage. R11 is a light-dependent resistor that adjusts the LED brightness as a function of ambient light.

SINGLE-dc SUPPLY THERMOMETER

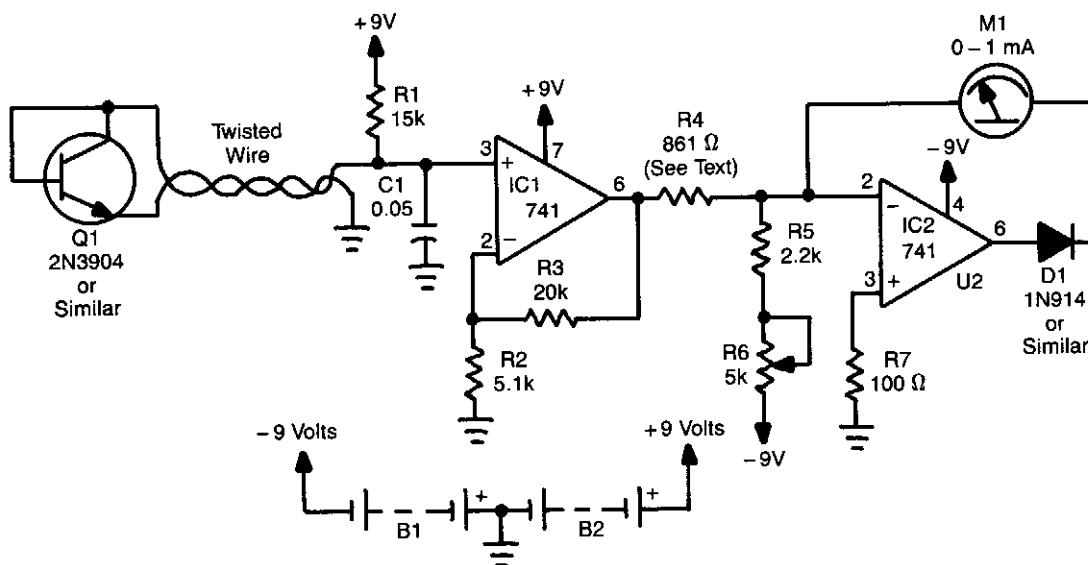


ELECTRONIC DESIGN

Fig. 89-3

Using a J-type thermocouple, this circuit can indicate temperatures from -350° to 400° with a 6-V supply or -50 to $+100^{\circ}$ with a 3-V lithium battery. The AD954 produces 10 mV/ $^{\circ}$ C output to the MAX 138 digital voltmeter chip, which drives the LCD display.

ELECTRONIC THERMOMETER



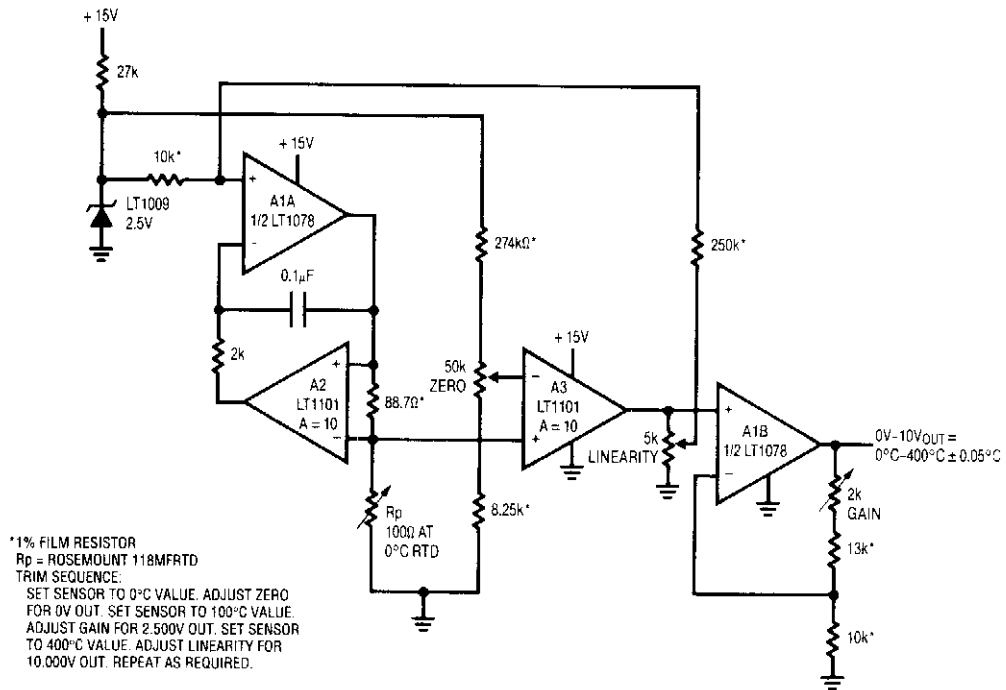
GERNSBACK PUBLICATIONS

Fig. 89-4

This thermometer is capable of measuring temperatures from -30 to $+120^{\circ}\text{F}$. A diode-connected 2N3904 transistor forms a voltage divider with R1. The transistor is used as the temperature sensor and, for best results, it should be connected to the rest of the circuit with twisted wire, as shown. As temperature increases, the voltage drop across the transistor changes by approximately $-1.166 \text{ mV}/^{\circ}\text{F}$. As a result, the current at pin 3 of IC1, a 741 op amp with a gain of 5, decreases as the temperature measured by the sensor increases. A second 741 op amp, IC2, is configured as an inverting amplifier.

Resistors R5 and R6 are used to calibrate the current. At a temperature of about -30°F , the current through R4 (formed by connecting a 910- and a 1600- Ω resistor in parallel) should equal the current through R5 and R6. A temperature of -30°F will result in a meter reading of 0 mA, while a temperature of 120°F will result in a meter reading of 1 mA. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. If you divide it into 150 equal segments, for instance, each division will equal one degree. Calibration is completed by placing the sensor in an environment with a known temperature, such as in an ice-point bath. The freezing point of water is approximately 32°F . Verify that the temperature is indeed 32°F using another thermometer that is known to be accurate. Then, simply place the sensor in the bath and adjust R6 until you get the correct meter reading.

HIGH-ACCURACY THERMOMETER



LINEAR TECHNOLOGY

Fig. 89-5

This circuit combines a current source and a platinum RTD bridge to form a complete high-accuracy thermometer. The ground-referred RTD sits in a bridge that is composed of the current drive and the LT1009 biased resistor string. The current drive allows the voltage across the RTD to vary directly with its temperature-induced resistance shift. The difference between this potential and that of the opposing bridge leg forms the bridge output. The RTD's constant drive forces the voltage across it to vary with its resistance, which has a nearly linear positive temperature coefficient. The nonlinearity could cause several degrees of error over the circuit's 0°C – 400°C operating range.

The bridge's output is fed to instrumentation amplifier A3, which provides differential gain, while simultaneously supplying nonlinearity correction. The correction is implemented by feeding a portion of A3's output back to A1's input via the 10- to 250-kΩ divider. This causes the current supplied to R_p to slightly shift with its operating point, compensating sensor nonlinearity to within $\pm 0.05^\circ\text{C}$. A1B, providing additional scaled gain, furnishes the circuit output. To calibrate this circuit, follow the procedure given in the diagram.

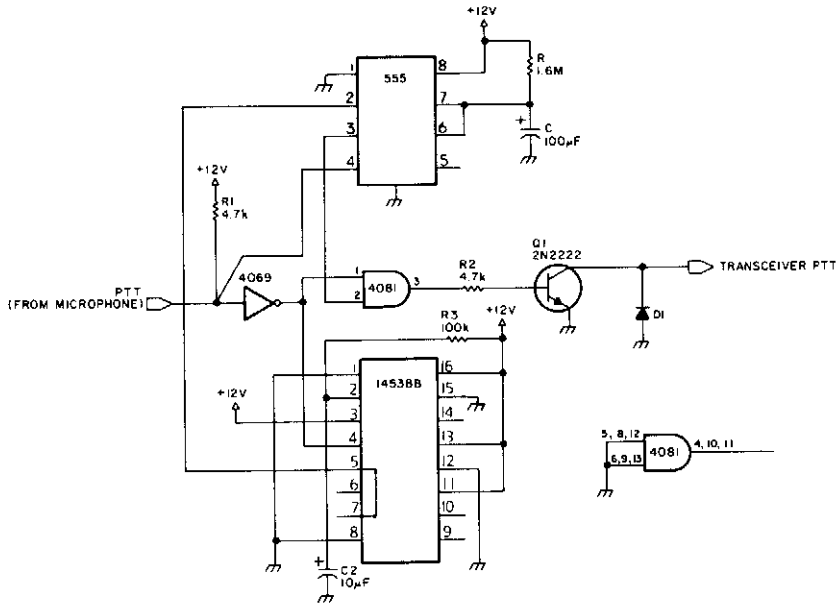
90

Timers

The sources of the following circuits are contained in the Sources section, which begins on page 679. The figure number in the box of each circuit correlates to the entry in the Sources section.

Mains-Powered Timer
Transmit Time Limiter
Long-Interval Programmable Timer
Programmable Timer for Long Intervals
Appliance Cutoff Timer
SCR Timer
Watchdog Timer/Alarm
10-Minute ID Timer
Adjustable Timer
Long-Duration Time Delay
Time-Out Circuit

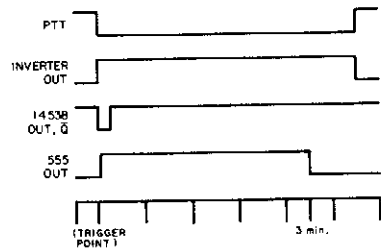
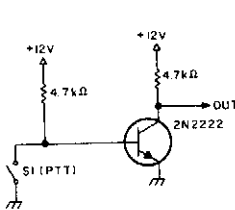
TRANSMIT TIME LIMITER



Values for Diverse Duty Cycles

$T = 1.1RC$		
T_s	R_a	C_f
180	1.6M	100µF
150	1.3M	100µF
120	1.1M	100µF
90	818.2k	100µF

180s = 3 min. C > 100µF TYPICALLY
 150s = 2 1/2 min. REQUIRES MORE
 120s = 2 min. EXPENSIVE LOW-
 90s = 1 1/2 min. LEAKAGE
 (FOR 555 TIMER) CAPACITORS.

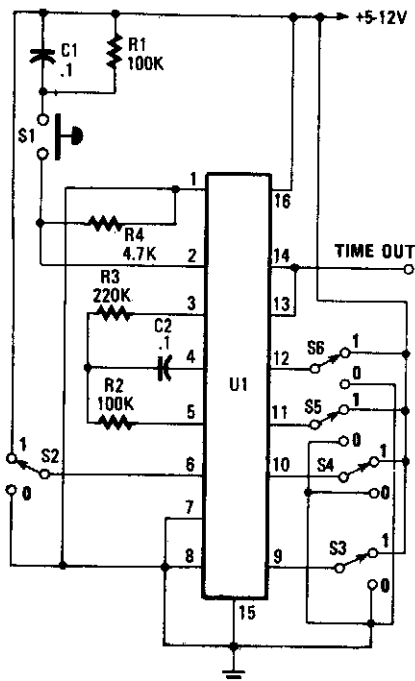


73 AMATEUR RADIO

Fig. 90-2

This circuit prevents making transmissions that are too long, which “time out” repeaters and/or tie up a communications channel too long. On transmit, the PTT (push to talk line) from the microphone is at ground. This causes one input of the AND gate (4081) to go high. The 555 is held in the reset mode. An MC1453B monostable multivibrator generates a pulse to the 555 and causes it to produce a gate of length approximately $1.1RC$, where R is selected for desired time delay and C is $100\ \mu\text{F}$. The output of pin 3 of the 555 causes the 4081 gate to go high, turns on Q1, and keys the transmitter. At the end of the cycle ($1.1RC$), the AND gate will lose one input, which turns off Q1 and unkeys the transmitter.

LONG-INTERVAL PROGRAMMABLE TIMER



These truth tables can be used to set the desired output frequency. Refer to the text for details.

BINARY CODE INPUT					SELECTED STAGE FOR OUTPUT
8 BYPASS PIN 6	D PIN 12	C PIN 11	B PIN 10	A PIN 9	
0	0	0	0	0	9
0	0	0	0	1	10
0	0	0	1	0	11
0	0	0	1	1	12
0	0	1	0	0	13
0	0	1	0	1	14
0	0	1	1	0	15
0	0	1	1	1	16
0	1	0	0	0	17
0	1	0	0	1	18
0	1	0	1	0	19
0	1	0	1	1	20
0	1	1	0	0	21
0	1	1	0	1	22
0	1	1	1	0	23
0	1	1	1	1	24

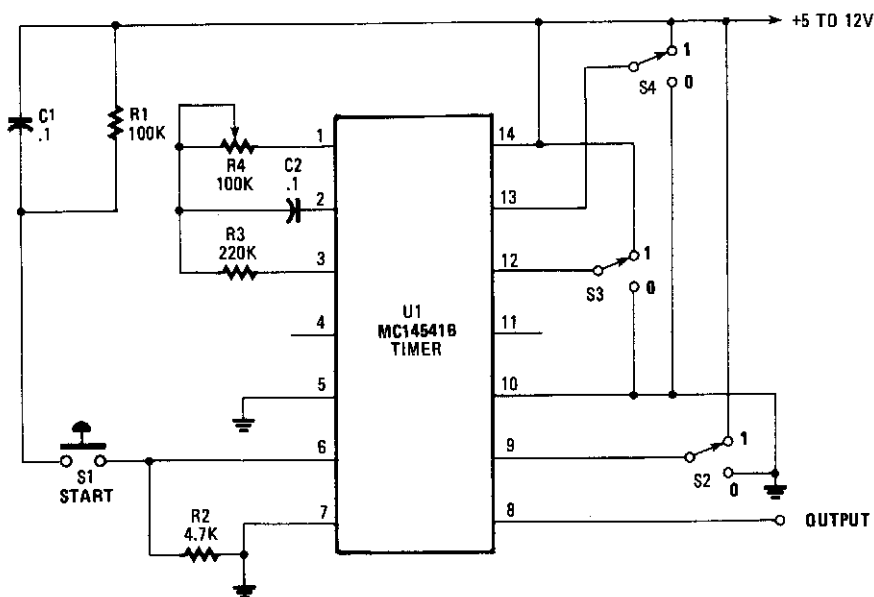
A

BINARY CODE INPUT					SELECTED STAGE FOR OUTPUT
8 BYPASS PIN 6	D PIN 12	C PIN 11	B PIN 10	A PIN 9	
1	0	0	0	0	1
1	0	0	0	1	2
1	0	0	1	0	3
1	0	0	1	1	4
1	0	1	0	0	5
1	0	1	0	1	6
1	0	1	1	0	7
1	0	1	1	1	8
1	1	0	0	0	9
1	1	0	0	1	10
1	1	0	1	0	11
1	1	0	1	1	12
1	1	1	0	0	13
1	1	1	0	1	14
1	1	1	1	0	15
1	1	1	1	1	16

B

Using an RC oscillator, an up to 24-stage ripple counter (\div) 16777216 or 2^{24} , and a 0.1-Hz count-rate with $R_2 = 39 \text{ k}\Omega$, $C_2 = 0.001 \mu\text{F}$, and $R_4 = 220 \text{ k}\Omega$ for example, the count cycle would take about 654 s. This example shows the capabilities of this time circuit, using the Motorola MC14536 timer. A low-frequency oscillator can be used for longer time periods.

PROGRAMMABLE TIMER FOR LONG INTERVALS



COUNTER SELECTOR CHART

PIN 12	PIN 13	NUMBER OF COUNTER STAGES (N)	COUNT 2^N
0	0	13	8192
0	1	10	1024
1	0	8	256
1	1	16	65536

The inputs at pins 12 and 13 of the MC14415 programmable counter determine the number of counter stages selected, and therefore the count.

POPULAR ELECTRONICS

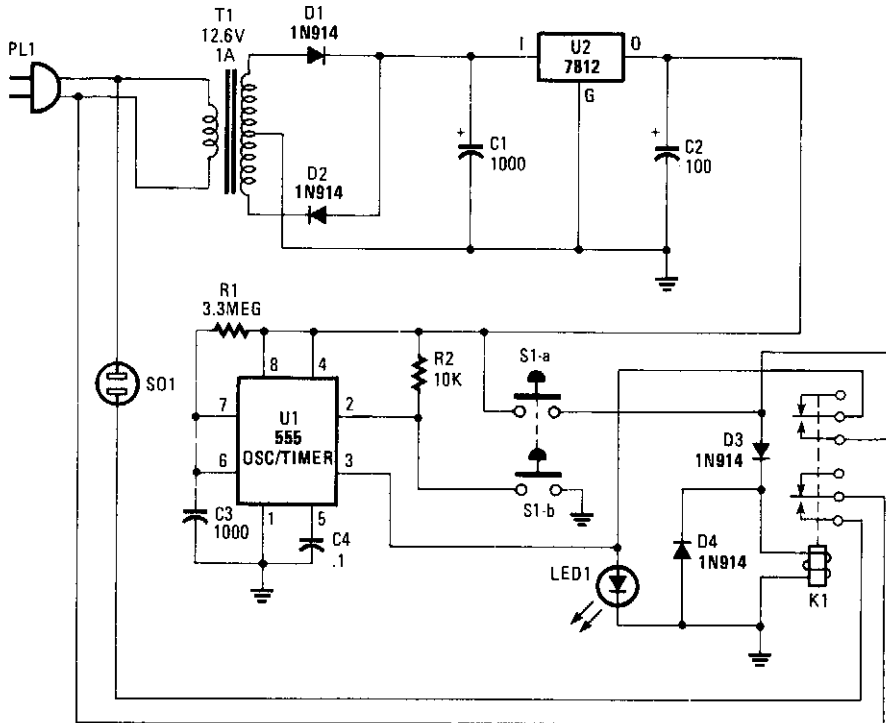
Fig. 90-4

By using an RC oscillator and a programmable divider, this counter can run for hours. An interval oscillator runs at a frequency given by (see figure schematic):

$$f = \frac{1}{2.3 R_4 C_2} \text{ and } R_3 \approx 2R_2$$

By using, for example, $R_4 = 390 \text{ k}\Omega$ and $C_2 = 10 \mu\text{F}$ and R_2 , the oscillator can run at 0.1 Hz. Divided by 65536, this is a cycle of approximately 655 000 s (182 hours, slightly more than a week).

APPLIANCE CUTOFF TIMER

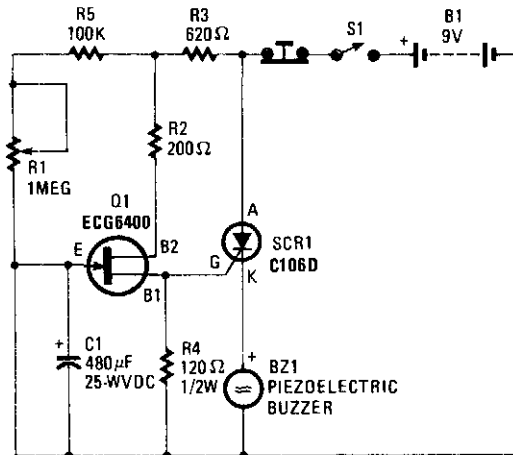


POPULAR ELECTRONICS

Fig. 90-5

Suitable for cutting off an appliance or other ac load, this timer will cut the ac power after a period determined by R1/C3, as shown, for about 40 minutes. K1 is a relay that should handle about 10 A. S1A and S1B is a momentary switch that starts the timer cycle.

SCR TIMER

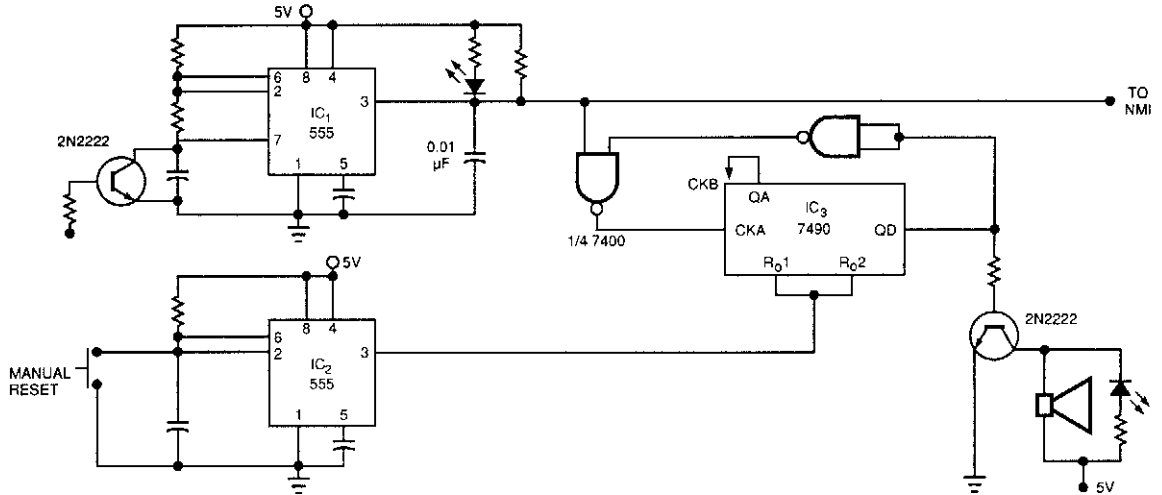


HANDS-ON ELECTRONICS

Fig. 90-6

Depending on the R1 (adjustable) C1 time constant, when C1 charges up to a certain level, Q1 conducts, triggers SCR1, and sounds BZ1. A push-button resets the circuit.

WATCHDOG TIMER/ALARM



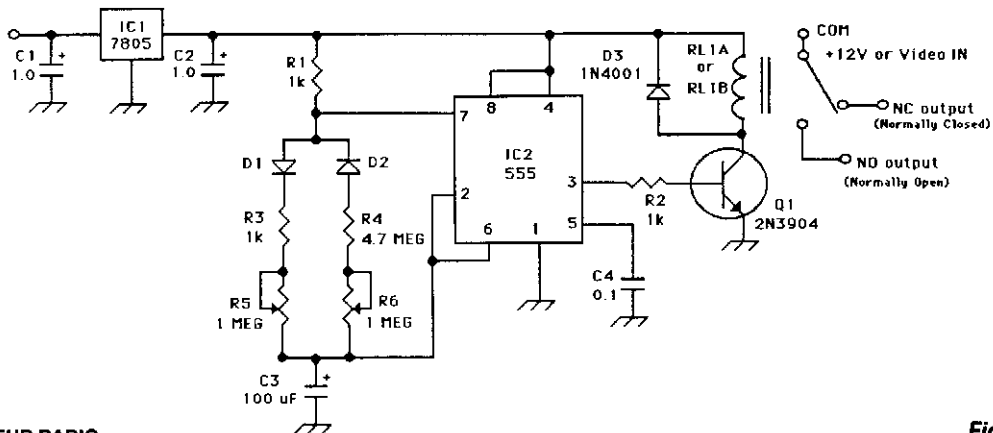
EDN

Fig. 90-7

The watchdog timer contains a counter, IC3, in addition to the usual retriggerable 555 timer, IC1. The counter will sound an audible alarm if the watchdog timer tries to reset the μ P a certain number of times (8, in the case of the counter). The alarm indicates that despite numerous resets, the system μ P has failed to restart successfully, and the system is truly dead.

A second 555 timer, IC2, resets the counter, IC3, for the duration of the manual system restart. The design could be modified so that system μ P resets the counter.

10-MINUTE ID TIMER

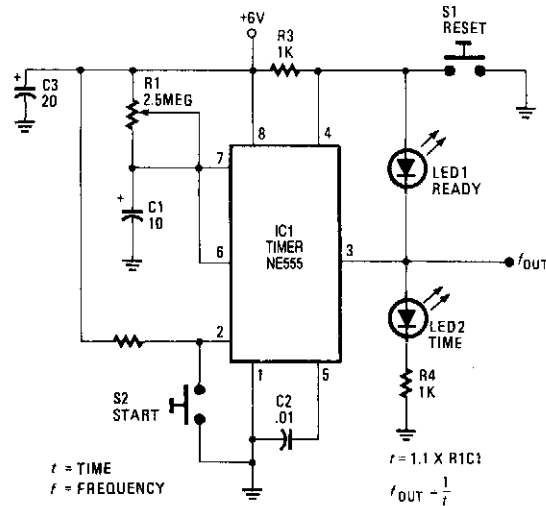


73 AMATEUR RADIO

Fig. 90-8

Designed to automatically identify a transmitter every 10 minutes, this 555 circuit has adjustable charge and discharge paths. The IC should be a standard 555 type, not a CMOS type. C3 should be tantalum. The relay is a small 5-V reed type.

ADJUSTABLE TIMER

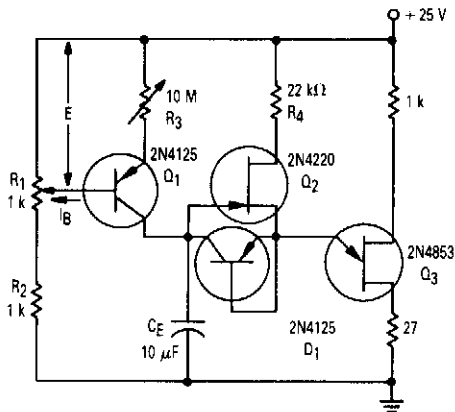


HANDS-ON ELECTRONICS

Fig. 90-9

LEDs indicate at a glance what the status of the circuit is at any given moment. Once the reset switch, S1, makes contact, the timer remains in that state until the start switch, S2, is pressed. When either switch is activated, LED1 (ready) and the time indicator, LED2, keep track of the situation. Although not necessary, the two LEDs should be of different colors (for example, red for “ready” and green for “time”).

LONG-DURATION TIME DELAY



MOTOROLA

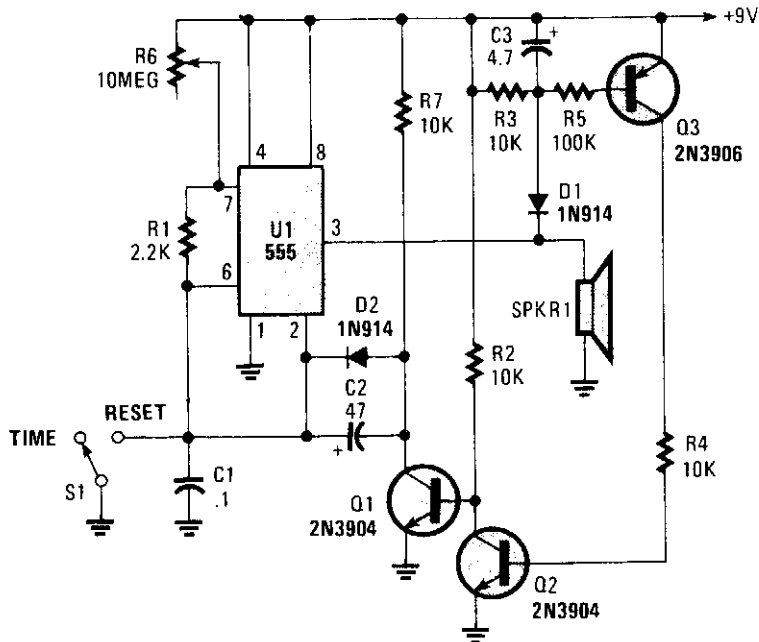
Fig. 90-10

Transistor Q1 and resistors R1, R2, and R3 form a constant current source and the charge current might be adjusted to be as low as a few

nanoamperes. This current would, of course, not be sufficient to fire the UJT where $I_p = 0.2 \mu A$, unless the peak current was supplied from another source. Field-effect transistor Q2, acting as a source follower, supplies the current flowing into the emitter lead prior to firing and diode D1 provides a low-impedance discharge path for C_E . D1 must be selected to have a leakage that is much lower than the charge current.

Because I_B is small, the delay time will vary linearly with R3. The voltage (E), applied across R3 and the base-emitter junction of Q1, is set by the variable resistor R1. Time delays up to 10 hours are possible with this circuit. Resistor R4, in series with the FET drain terminal, must be large enough not to allow currents in excess of I_V to flow when the UJT is on. Otherwise, the UJT will not turn off and the circuit will latch up.

TIME-OUT CIRCUIT



POPULAR ELECTRONICS

Fig. 90-11

This circuit operates in the astable mode and at the end of the first period (up to several minutes), it produces a tone. When S1 is placed in the time position, Q3 is cut off because pin 3 of U1 is high and D1 holds Q3 in cutoff. Q2 is off, and Q1 is on, which grounds the negative end of D2 and C2. Therefore, C1 and C2 are returned to ground.

After a time of about $1.1 R_6 (C_1 + C_2)$, the timer cycle completes and pin 3 U1 goes low. This turns on Q3 and Q2, cuts off Q1, and effectively disconnects C2. Now, the circuit oscillates with a period determined by R7 and C1, because D2 is forward-biased. A tone is then generated and can be heard from SPKR1. Closing S2 resets the circuit.

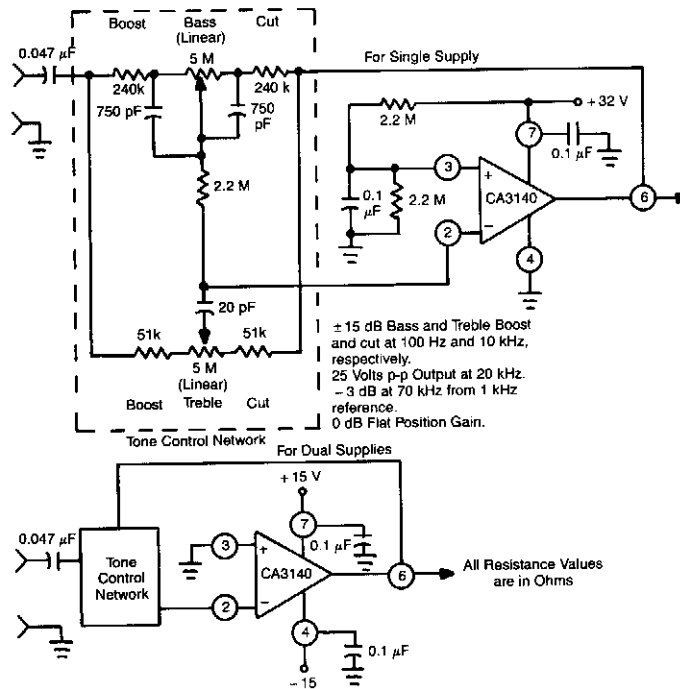
91

Tone-Control Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

Baxandall Tone-Control Audio Amplifier
Active Tone Control
Tremolo Circuit

BAXANDALL TONE-CONTROL AUDIO AMPLIFIER

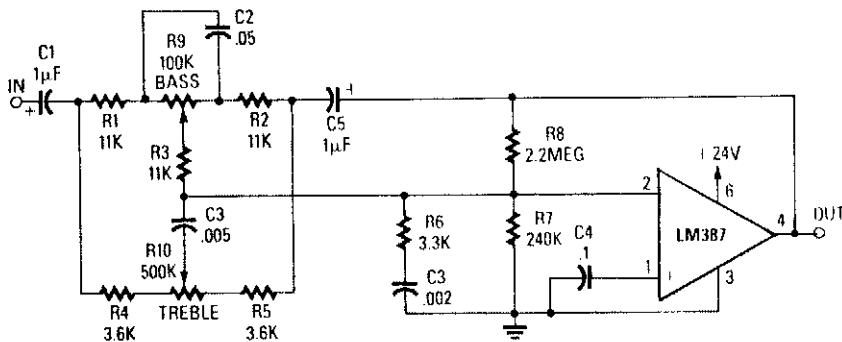


GE/RCA

Fig. 91-1

This circuit exploits the high slew rate, high input impedance, and high output-voltage capability of CA3140 BiMOS op amp. It also provides mid-band unity gain with standard linear potentiometers.

ACTIVE TONE CONTROL

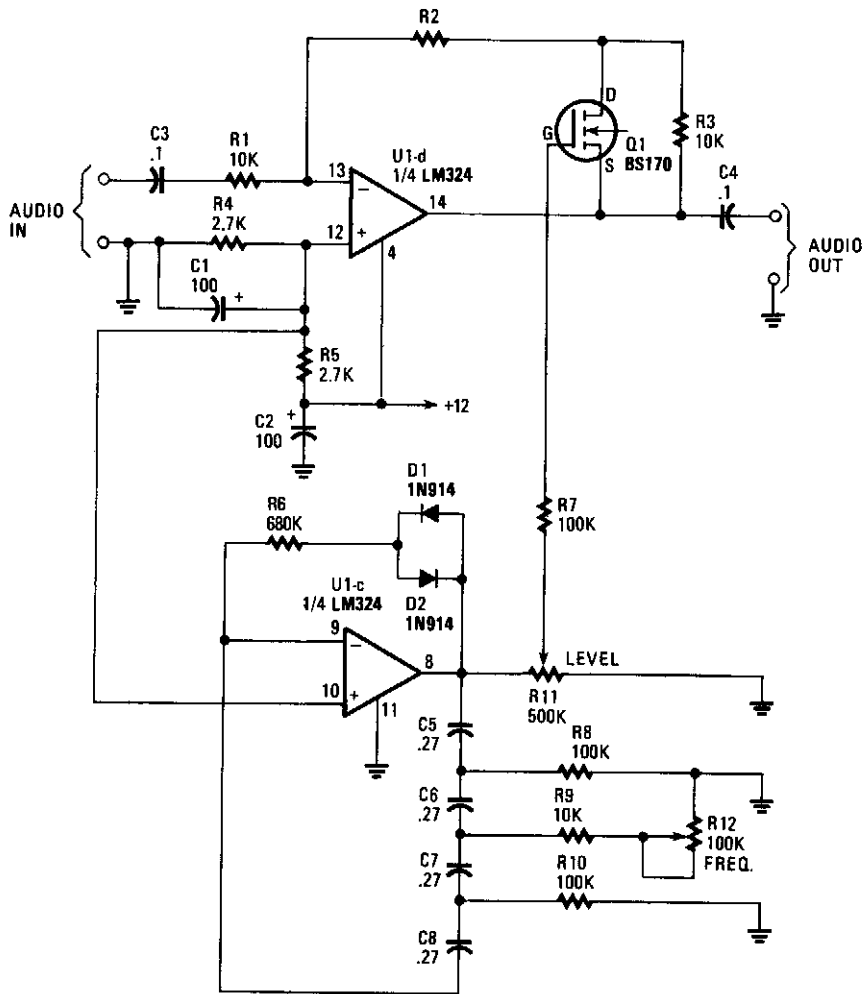


RADIO-ELECTRONICS

Fig. 91-2

The use of a low noise LM387 in a feedback circuit provides 20-dB boost or rejection of treble and bass. The supply voltage is +24 V.

TREMOLO CIRCUIT



HANDS-ON ELECTRONICS

Fig. 91-3

This circuit adds a VLF AM component to an audio signal. This effect is widely used in musical instruments. U1C, a phase-shift oscillator operating at a few Hz applies a signal to Q1, which modulates the gain of U1D. R11 varies the level of the effect, while R12 varies the frequency.

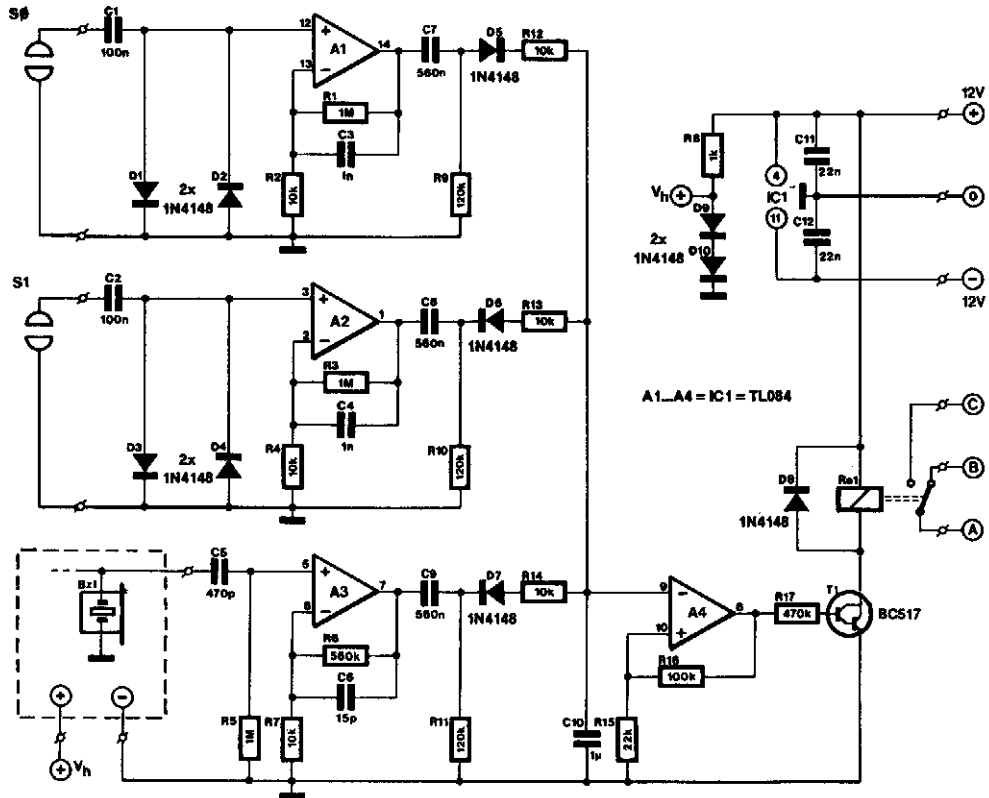
92

Touch Controls

The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sensor Switch and Clock
Touch Switch I
On/Off Touch Switch
Touch Switch II
Hum-Detecting Touch Sensor
Time-On Touch Switch

SENSOR SWITCH AND CLOCK



ELEKTOR ELECTRONICS

Fig. 92-1

One TL084 IC and an old quartz watch enable the construction of a deluxe on/off switch. Two of the four op amps contained in the TL084 (A1 and A2) are used to amplify the input signals from the sensors by one hundredfold (with the component values as shown in the diagram). Just touching the sensors with a finger causes a good 50-Hz input signal (hum). Notice that the amplification drops rapidly with rising frequency.

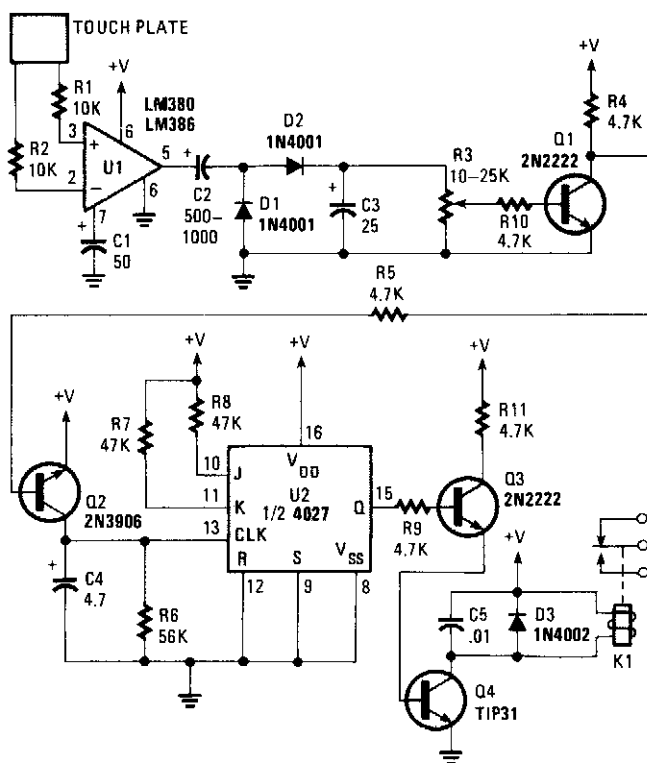
Diodes D5 and D6 rectify (single-phase) the 50-Hz signal. Because the diodes are connected in anti-phase, touching the "off" sensor causes a positive potential across C10, whereas touching the "on" sensor produces a negative potential across C10.

Op amp A4 is connected as an inverting bistable so that a negative potential across C10 causes relay Re1 to be energized. Because of feedback resistor R16, this state is maintained until the other sensor is touched.

The relay can also be energized at a predetermined time with the aid of a quartz watch. The 1.2-V supply for the watch is derived from the voltage drop across diodes D9 and D10; it can be increased to 1.8 V by adding a third diode.

The piezo buzzer in the watch is connected to the input of A3 via C5. As soon as the alarm goes off (the hour signal must be off), the voltage across C10 becomes negative, the relay is energized, and the load is switched on. The circuit, excluding the relay, draws a current of about 20 mA.

TOUCH SWITCH I



POPULAR ELECTRONICS

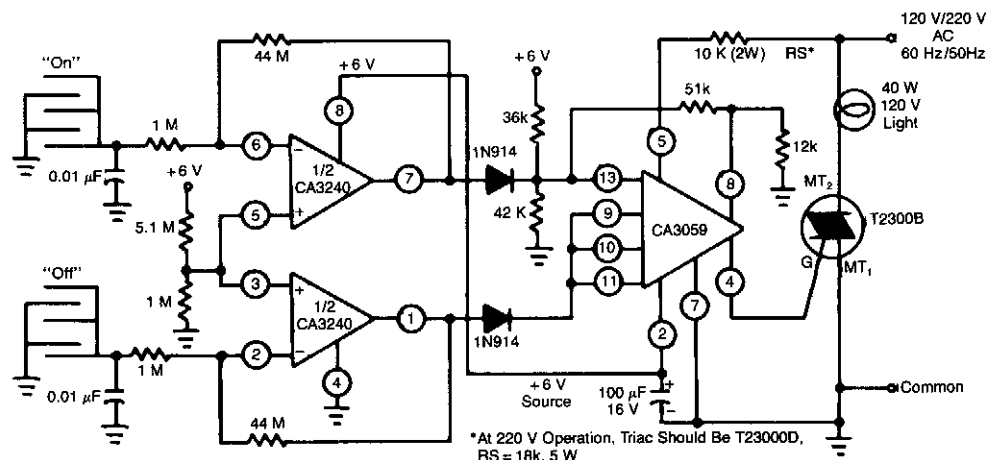
Fig. 92-2

This switch reacts to the touch of a finger to turn lights and/or appliances on or off. The device uses the human body as an antenna to pick up 60-Hz hum, which is applied to a metal plate by your finger. The signal is fed to the input of U1, an LM380 audio-power amplifier. An LM386 should work as well.

The 60-Hz output from the amplifier is rectified by D1 and D2, then filtered by C3. Potentiometer R3 sets the trigger voltage used to saturate Q1. When Q1 turns on, the collector end of R4 goes almost to ground and provides the needed voltage to turn on Q2. Transistor Q2 turns on and clocks. The flip-flop is configured for toggle-mode operation, so its output switches states with each clock pulse.

The 4027 (U2) is wired to toggle by tying the J and K inputs high and the set and resets low. Transistor Q3 is connected to the Q output through the 4.7-k Ω resistor. Transistor Q3 drives Q4, the relay driver. Be sure that the load does not exceed the relay ratings.

ON/OFF TOUCH SWITCH

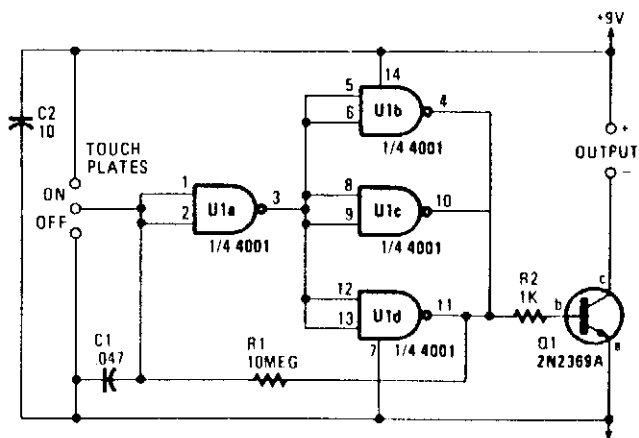


GE/RCA

Fig. 92-3

This circuit uses a CA3240 dual BiMOS op amp to sense small currents flowing between the contact points on a touch plate. The high input impedance of the CA3240 allows the use of 1-M Ω resistors in series with the touch plates to ensure user safety. A positive output on either pin 7 (ON) or pin 1 (OFF) of the CA3240 actuates the CA3059 zero-voltage switch, which then latches the triac on or turns it off. The internal power supply of the CA3059 powers the CA3240.

TOUCH SWITCH II

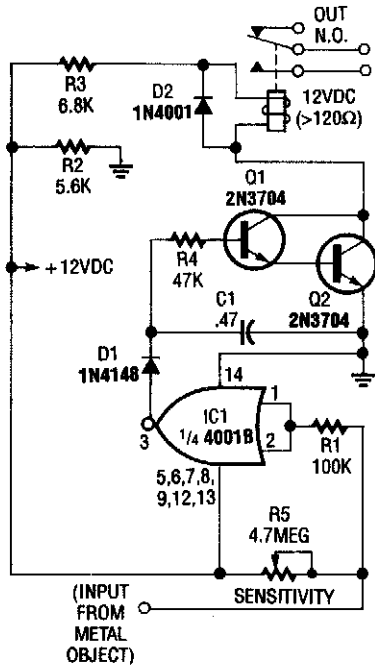


WELLS' THINK TANK

Fig. 92-4

U1A and U1B/U1C/U1D form a bistable multivibrator that drives Q1, which switches the load. Touching the two upper contacts makes Q1 conduct; the two lower contacts cause Q1 to cut off.

HUM-DETECTING TOUCH SENSOR

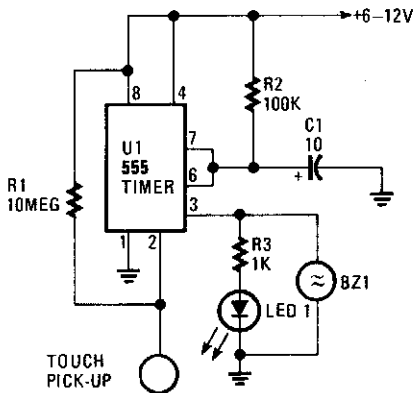


RADIO-ELECTRONICS

Fig. 92-5

This touch sensor uses the 60-Hz hum pickup by the human body to drive a detector and relay drivers, Q1 and Q2. R5 controls sensitivity of the circuit.

TIME-ON TOUCH SWITCH



HANDS-ON ELECTRONICS

Fig. 92-6

The circuit is built around a 555 oscillator (U1), which is turned on when a trigger is applied by touching the touch terminal to pin 2 of U1. When activated, LED1 and BZ1 (a piezoelectric buzzer) turn on for the time period set by the values of R_2 and C_1 . The ON-time of the touch circuit can be altered by changing the values of C_1 and R_2 .

This touch switch can be powered from batteries so that it need not be near a 60-Hz power source for triggering. The extremely small amount of current supplied to the trigger input through the 10-M Ω resistor, R1, makes the input circuitry very sensitive to any external loading, and it is easily triggered by touching the pickup.

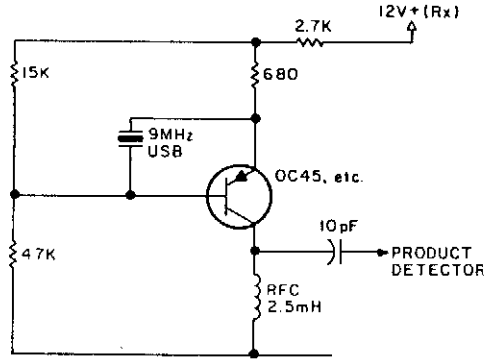
93

Transmitters and Transceivers

The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

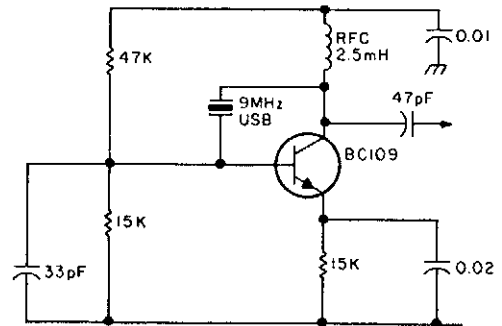
20-m CW Transceiver
Low-Power HF Transmitter
Amateur Television Transmitter
2-m Transmitter
HF Low-Power CW Transmitter
5-W 80-m CW Transceiver
Low-Cost Beacon Transmitter

20-m CW TRANSCEIVER (Cont.)



73 AMATEUR RADIO

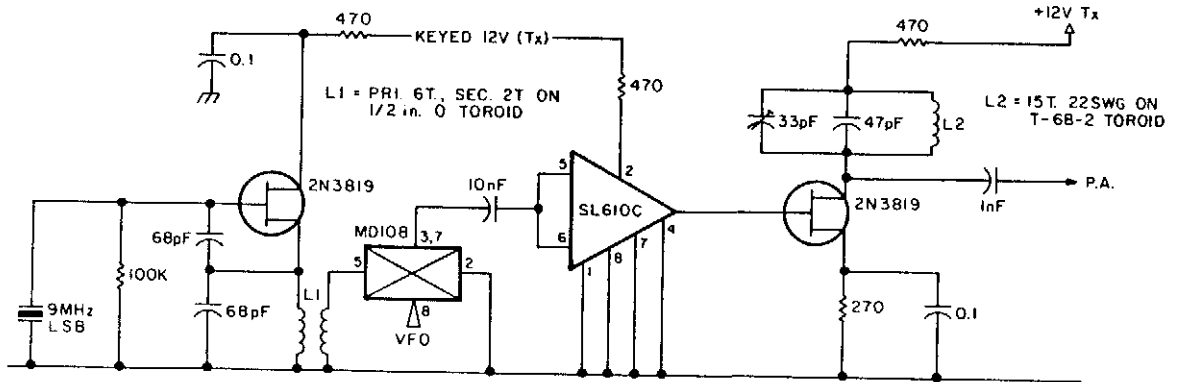
Fig. 93-1(d)



73 AMATEUR RADIO

Fig. 93-1(e)

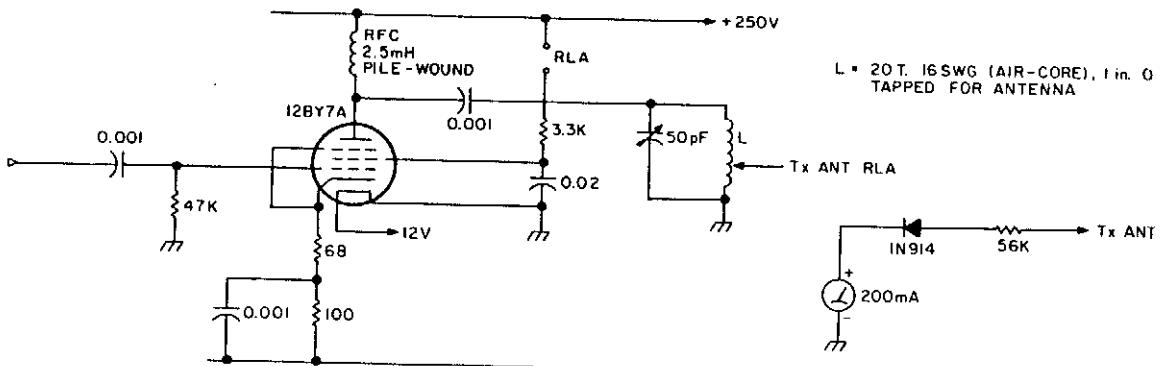
What's in the junk-box? Pick between two receive carrier circuits.



73 AMATEUR RADIO

Fig. 93-1(f)

Transmit mixer and predriver.

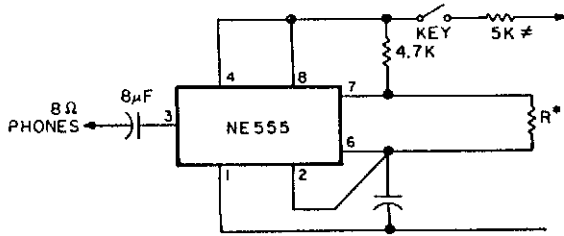


73 AMATEUR RADIO

Fig. 93-1(g)

A simple diode/meter circuit to measure relative power output.

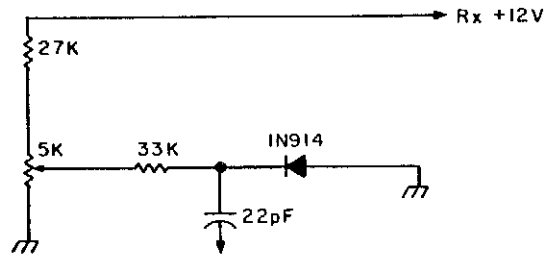
20-m CW TRANSCEIVER (Cont.)



R* : SELECT FOR DESIRED TONE (10 < 50K)
 R* : VARY INPUT RES. FOR REQUIRED OUTPUT.

73 AMATEUR RADIO

Fig. 93-1(h)



73 AMATEUR RADIO

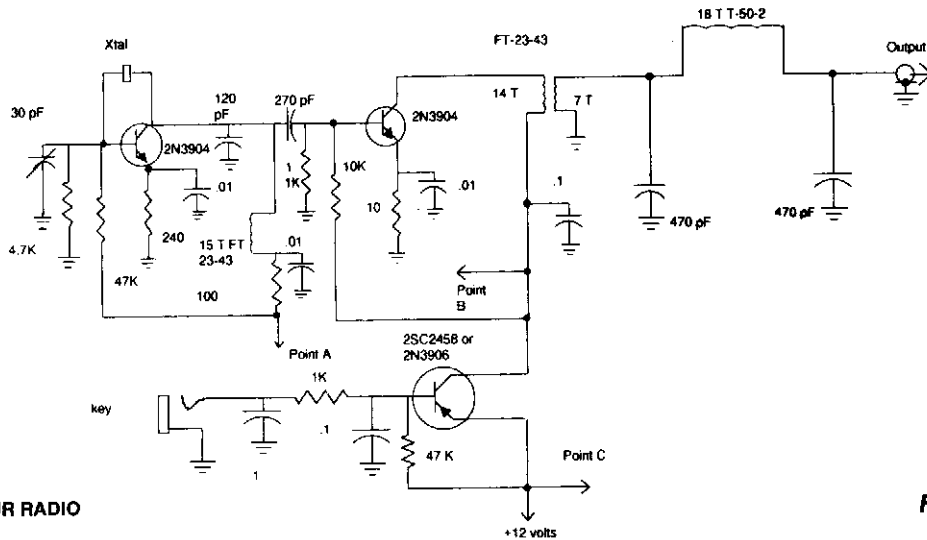
Fig. 93-1(i)

The Colpitts VFO circuit (Fig. 93-1(a)) has gate clamping to improve stability. It is followed by two buffers; the second provides individual outputs to the transmitter and receiver. An RIT circuit operates on receive. The front end uses 40673 dual-gate MOSFETs (Fig. 93-1(b)). The tuned circuits are peaked to the center of the CW band with the trimmer. The mixer output is link-coupled to a KVG 9-MHz SSB filter whose output is amplified by an SL612 IF amplifier IC (Fig. 93-1(c)).

The product detector uses two BC 107 transistors. Carrier reinjection is from a crystal oscillator using the USB crystal supplied with the KVG filter. Figure 93-1(d) and 93-1(e) contain: an FET oscillator and a npn bipolar oscillator. Use either or alter the circuit polarities to suit an npn transistor. The transmitter mixer is an MD108 (Fig. 93-1(f)), fed from the VFO and the LSB carrier-injection oscillator.

A simple diode/meter circuit measures the relative power output (Fig. 93-1(g)). Sidetone is provided by an NE555 circuit (Fig. 93-1(h)).

LOW-POWER HF TRANSMITTER

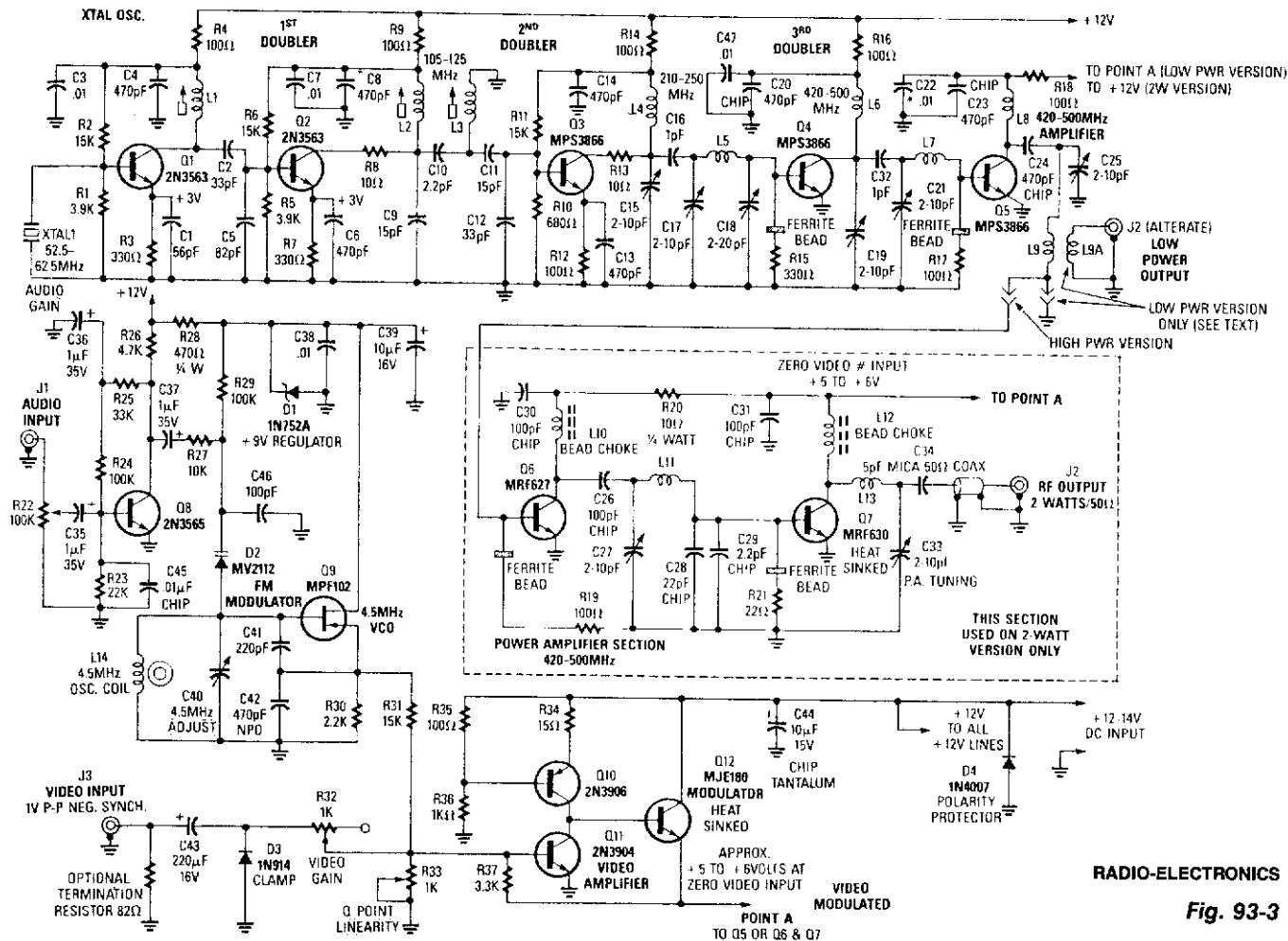


73 AMATEUR RADIO

Fig. 93-2

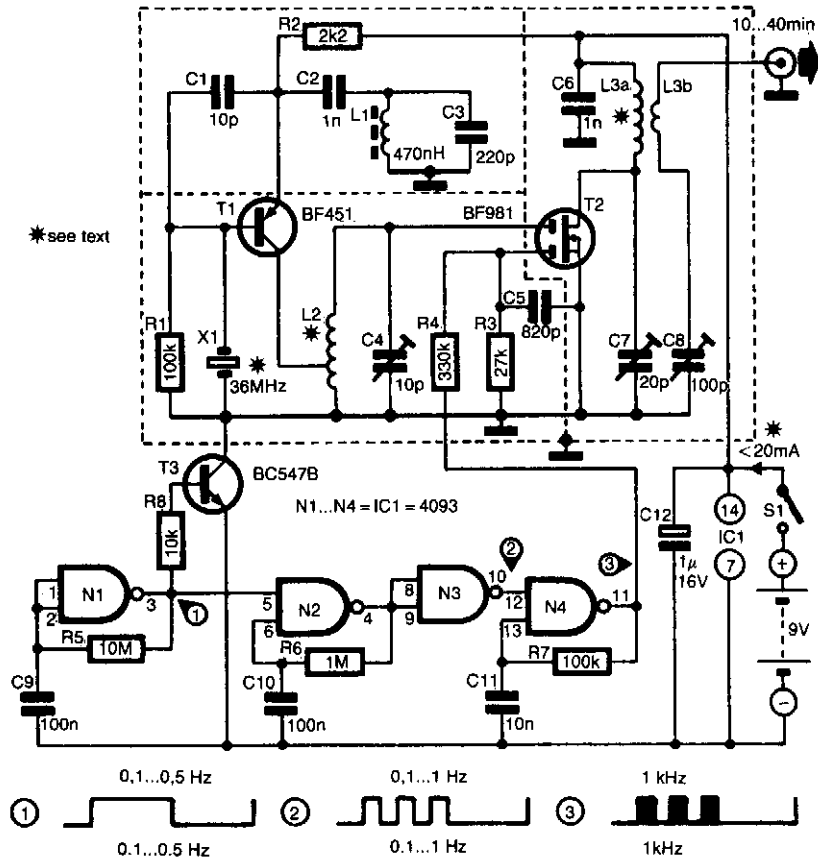
This transmitter runs up to 1/2 W on the 40-m amateur band. Coils are wound on T25 and FT23 toroids, respectively. Point A is connected to point B to key the oscillator, along with the final (point C) to leave the oscillator running constantly. Use 1/10-W resistors and VERY small components.

AMATEUR TELEVISION TRANSMITTER



Although the unit was designed for 2 W operation, Q6 and Q7 stages and associated components can be omitted and about 1 to 30 mW of RF can be obtained by link coupling to L9. A complete set of parts, including PC board is available from North Country Radio, P.O.Box 53, Wykagyl Station, New Rochelle, NY 10804.

2-m TRANSMITTER



ELEKTOR ELECTRONICS

Fig. 93-4

The transmitter was designed specifically for use by radio amateurs as a radio beacon. As such, it provides a good-quality signal that is free of unwanted harmonics.

Transistor T1, in association with crystal X1, operates as a 36-MHz oscillator. Filter L1/C3 obviates any tendency of the circuit to oscillate at 12 MHz (the fundamental frequency of the crystal).

Circuit L2/C4 is tuned to the fourth harmonic of the oscillator signal (144 MHz). This signal is fed to the aerial via a buffer stage that consists of T2, a double-gated FET. The (amplitude) modulating signal is applied to the second gate of the buffer. The output power of the transmitter has been kept low, about 10 to 40 mW.

The modulating signal is generated by N1, an oscillator that switches the transmitter on and off via transistor T3. The switching rate lies between 0.1 and 0.5 Hz. When the output of N1 is low, T3 is switched off, and the transmitter is inoperative because the supply is disabled. When the output of N1 is high, T3 is on and the transmitter operates normally.

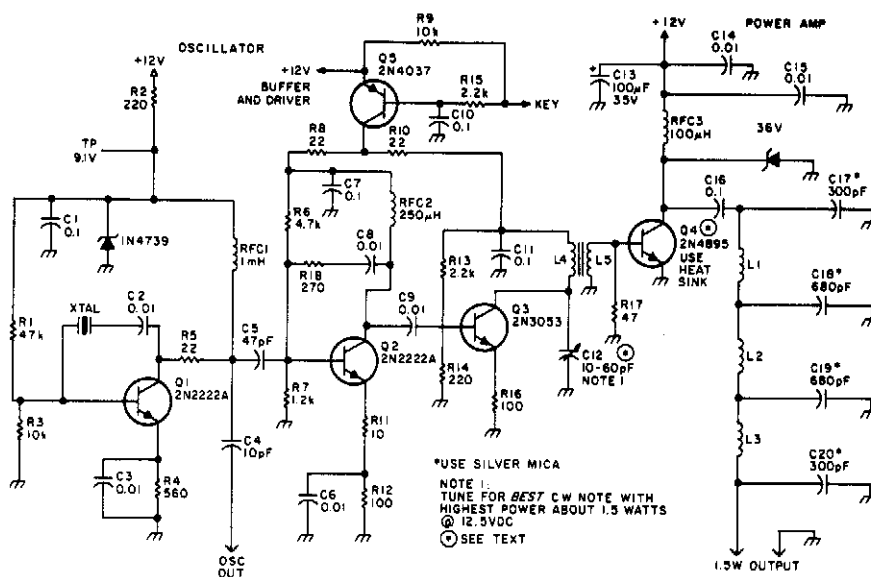
2-m TRANSMITTER (Cont.)

The digital pattern at the gate of T2 shapes the modulating signal. Gate N2 generates a square wave at a frequency of 0.1 to 1 Hz. As long as the output of T3 is high, N4 oscillates at a frequency of about 1 kHz. At the relevant gate of N2, there is, therefore, a periodic burst-signal at 1 kHz, and this signal is used to modulate the transmitter.

The digital pattern at the relevant gate of T2 can be varied to individual requirements by altering the values of the feedback resistors in the digital chain. The transmitter is calibrated by setting trimmers C4, C7, and C8 for maximum output power.

Inductors L2 and L3 are wound from 0.8-mm diameter enamelled copper wire: L2 = 5 turns with a tap of 1 turn from ground; L3A = 3 turns and L3B = 2 turns. The coupling between L3A and L3B should be arranged for maximum output power. The circuit draws a current of only 20 mA, which enables the transmitter to be operated from a 9-V battery for several hours.

HF LOW-POWER CW TRANSMITTER

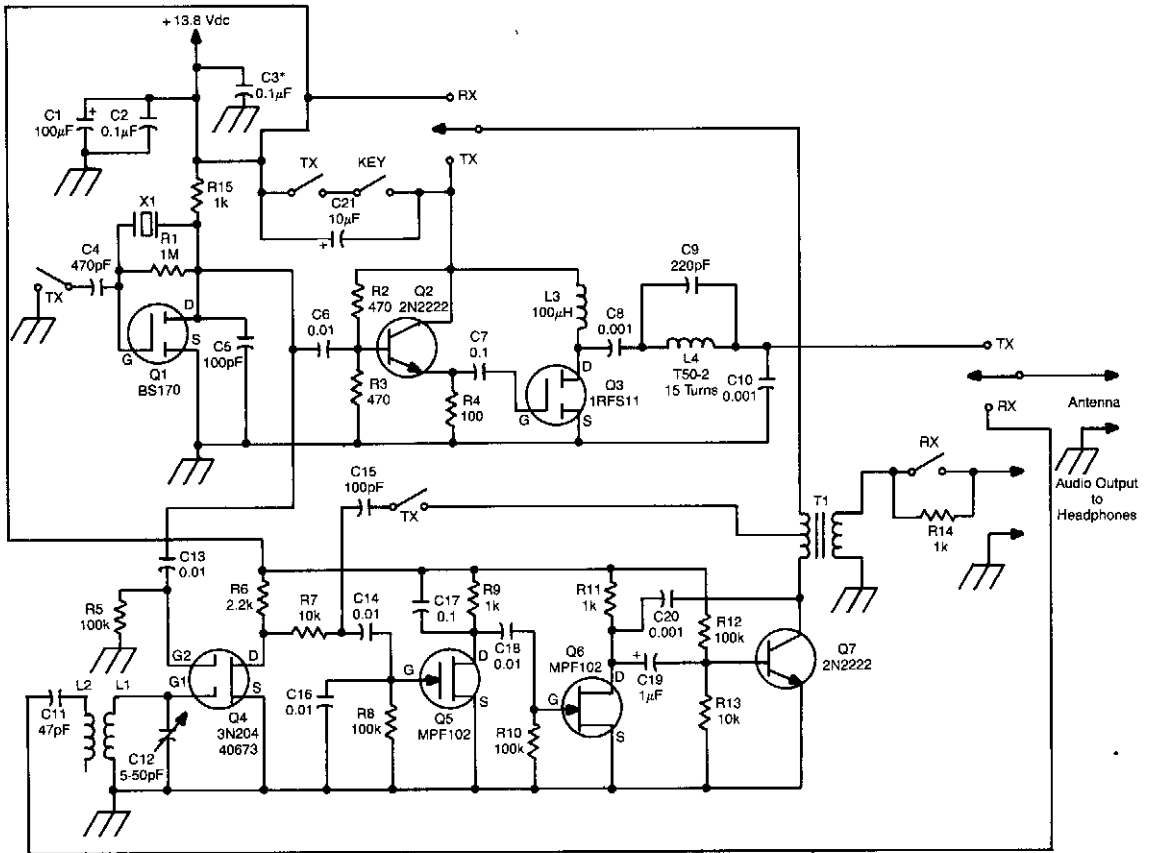


73 AMATEUR RADIO

Fig. 93-5

Suitable for amateur use, this 1.5-W transmitter runs on a 12-V supply. Q1 is an oscillator using a surplus FT243 crystal. Q2 is a buffer driver and is keyed via keying transistor Q5. Q3 acts as a driver for Q4 (which should be heatsinked). Q4 develops about 1.5-W output. Coil data is given in the parts list. C12 is adjusted for best power output.

5-W 80-m CW TRANSCEIVER

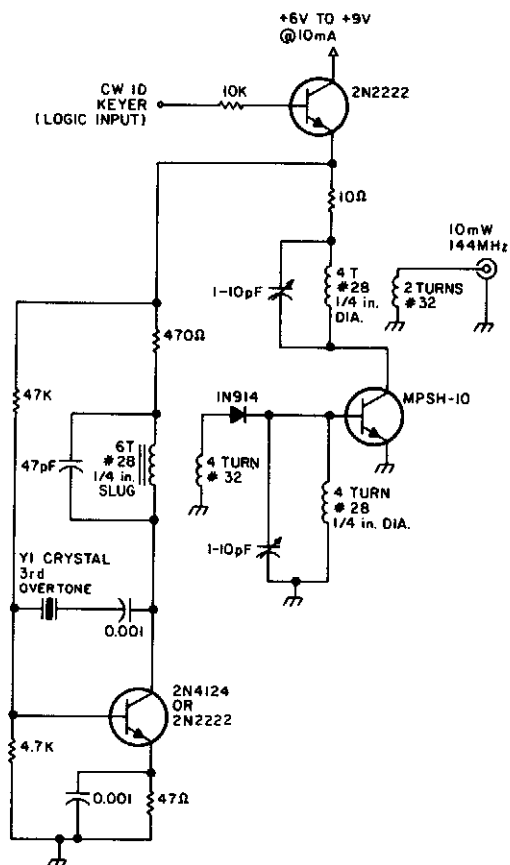


73 AMATEUR RADIO

Fig. 93-6

This transceiver has a 3-stage transmitter and a direct-conversion receiver. Q1 is the transmitter's oscillator, and the frequency is controlled by X1, which also serves as the receiver local oscillator. Buffer Q2 drives final amplifier Q3 to about 5 W output. The B+ lead to these stages is keyed. The receiver consists of mixer Q4 followed by high gain amplifiers Q5/Q6/Q7. The audio signal appears at the secondary of Q7. In the transmit mode, Q5/Q6/Q7 serve as a sidetone oscillator. A 6PDT switch is required for the T/R switching.

LOW-COST BEACON TRANSMITTER



73 AMATEUR RADIO

Fig. 93-7

This transmitter uses a 48-MHz crystal oscillator to drive a diode tripler to the 144-MHz amplifier. The output is 5 to 10 mW.

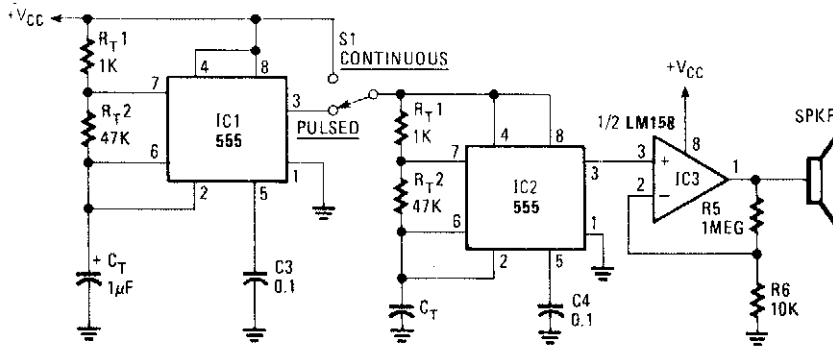
94

Ultrasonic Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

Ultrasonic Sound Source
Ultrasonic Pest Repeller I
Ultrasonic Pest Repeller II

ULTRASONIC SOUND SOURCE



RADIO-ELECTRONICS

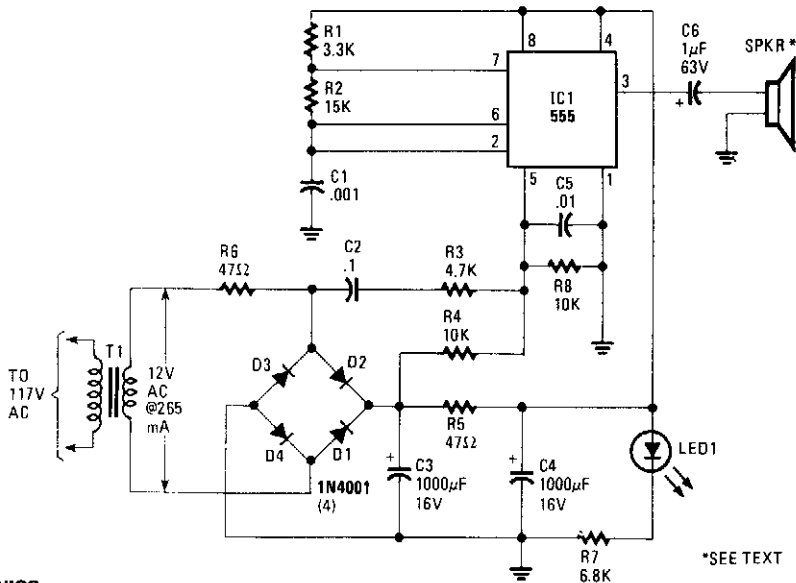
Fig. 94-1

Using two NE555 timer IC devices, this circuit generates either pulsed or continuous ultrasonic signals. The sound frequency is:

$$f = \frac{1.44}{C_T(R_{T1} + R_{T2})}$$

The values of \$C_T\$ for both pulse rate and ultrasonic frequencies can be calculated this way. SPKR is a small hi-fi tweeter.

ULTRASONIC PEST REPELLER I

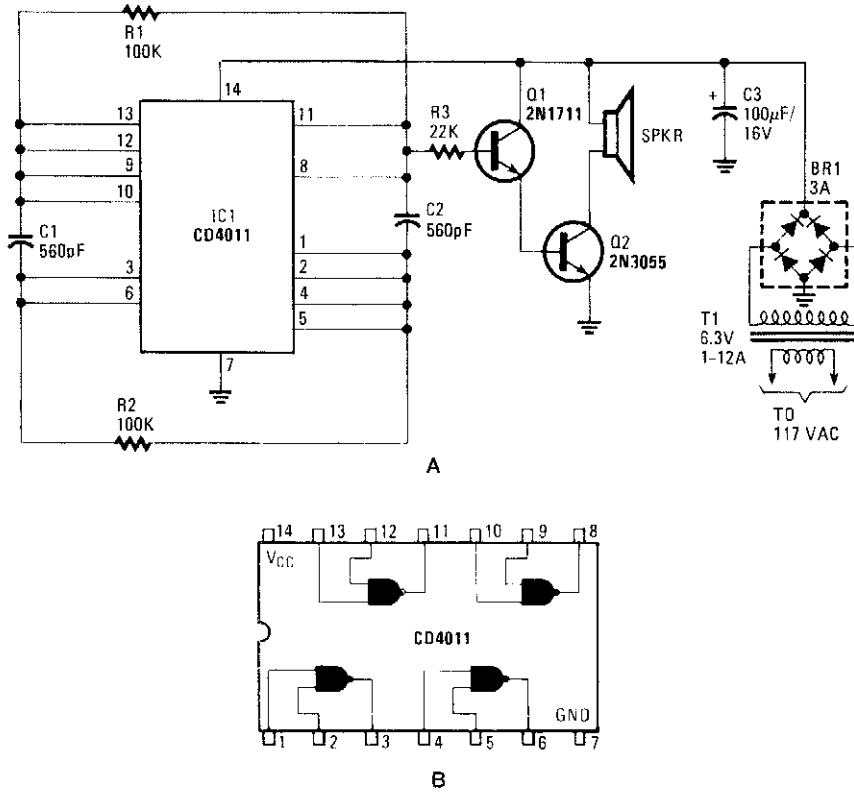


RADIO-ELECTRONICS

Fig. 94-2

An NE555 timer is used to generate an ultrasonic signal in the 20- to 65-kHz range. The speaker is a small piezoelectric tweeter with response above 20 kHz. These frequencies are said to be annoying to rats, mice, and insects.

ULTRASONIC PEST REPELLER II



RADIO-ELECTRONICS

Fig. 94-3

A CD4011 Quad NAND gate acts as an oscillator, operating around 40 kHz. The small amount of filtering used modulates this with 120-Hz hum. The speaker is a small tweeter for hi-fi applications.

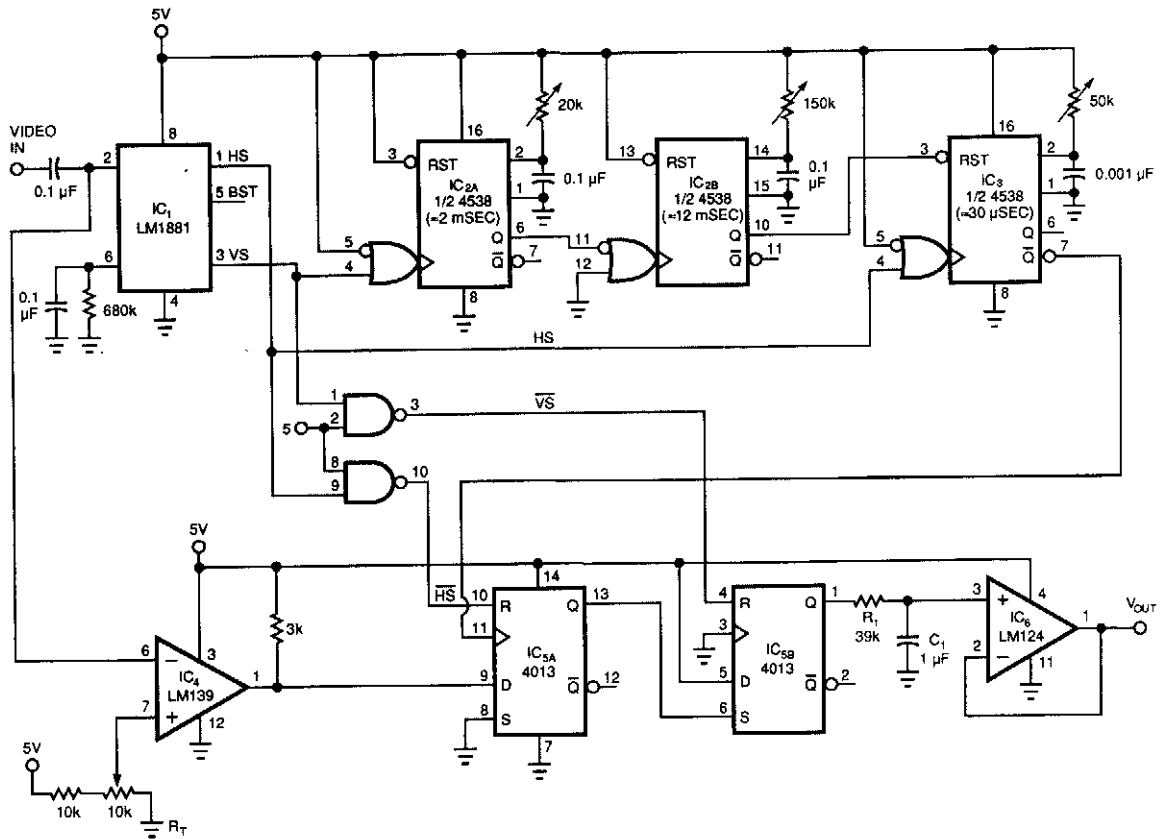
95

Video Circuits

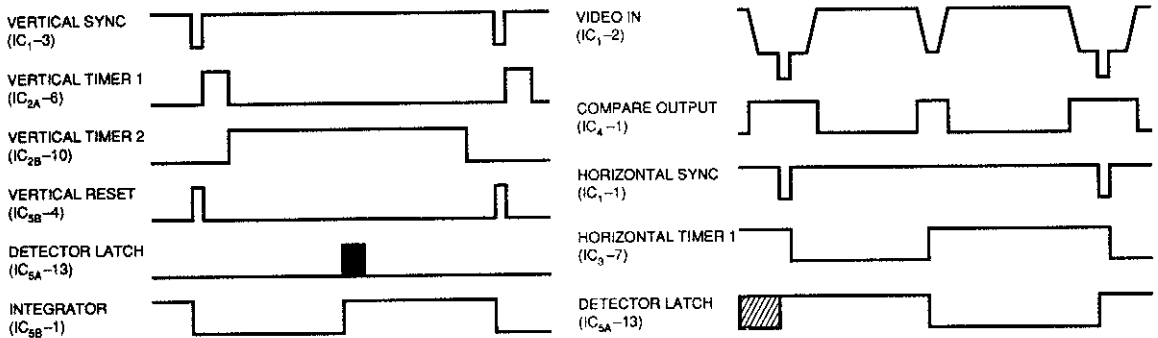
The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

Analog Voltage Camera-Image Tracker	Color-Bar Generator
High-Performance Video Mixer	Video Op Amp Circuits
Video A/D--D/A Converter	Video Loop-Thru Amplifier
RGB/NTSC Converter	Sync Separator
TV Line Pulse Extractor	Simple Monochrome TV-Pattern Generator
NTSC/RGB Video Decoder	

ANALOG VOLTAGE CAMERA-IMAGE TRACKER



VERTICAL TIMING (VERTICAL_{sync} = 60 Hz)

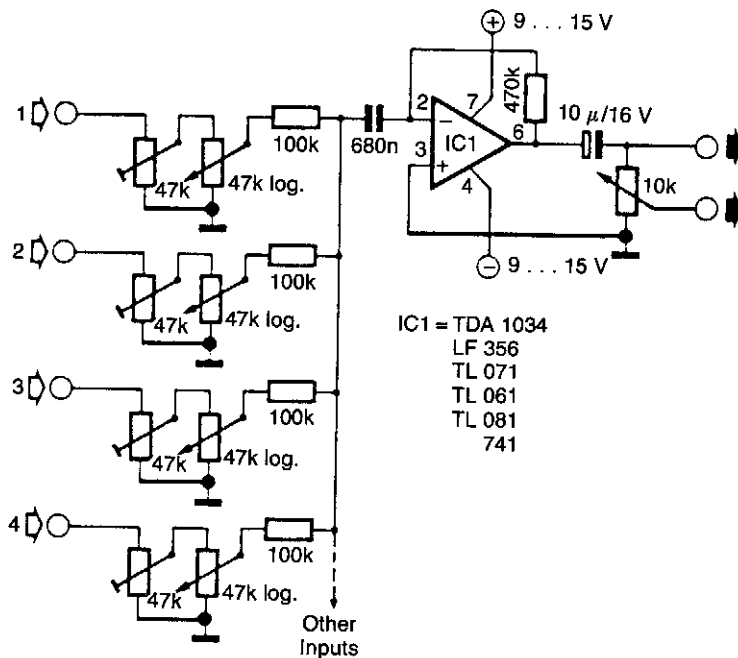


NOTE: ASSUME TARGET IS IN MIDDLE OF SCREEN

ANALOG VOLTAGE CAMERA-IMAGE TRACKER (Cont.)

By using a low-cost RS-170 camera and this circuit, a voltage that trades the position of an object in the field of view of a camera is generated. IC2A and IC2B form a valid video gate that holds IC3 in reset during the internal vertical blanking to prevent false interpretation of the UBI as black video. IC4 is a black level detector. The circuit tests for a black object in the middle of each video line. IC5 latches the comparator's output and produces a square wave whose duty cycle depends on where the black level is detected in the video field. R1, C1, and IC6 integrate and buffer the analog output voltage.

HIGH-PERFORMANCE VIDEO MIXER

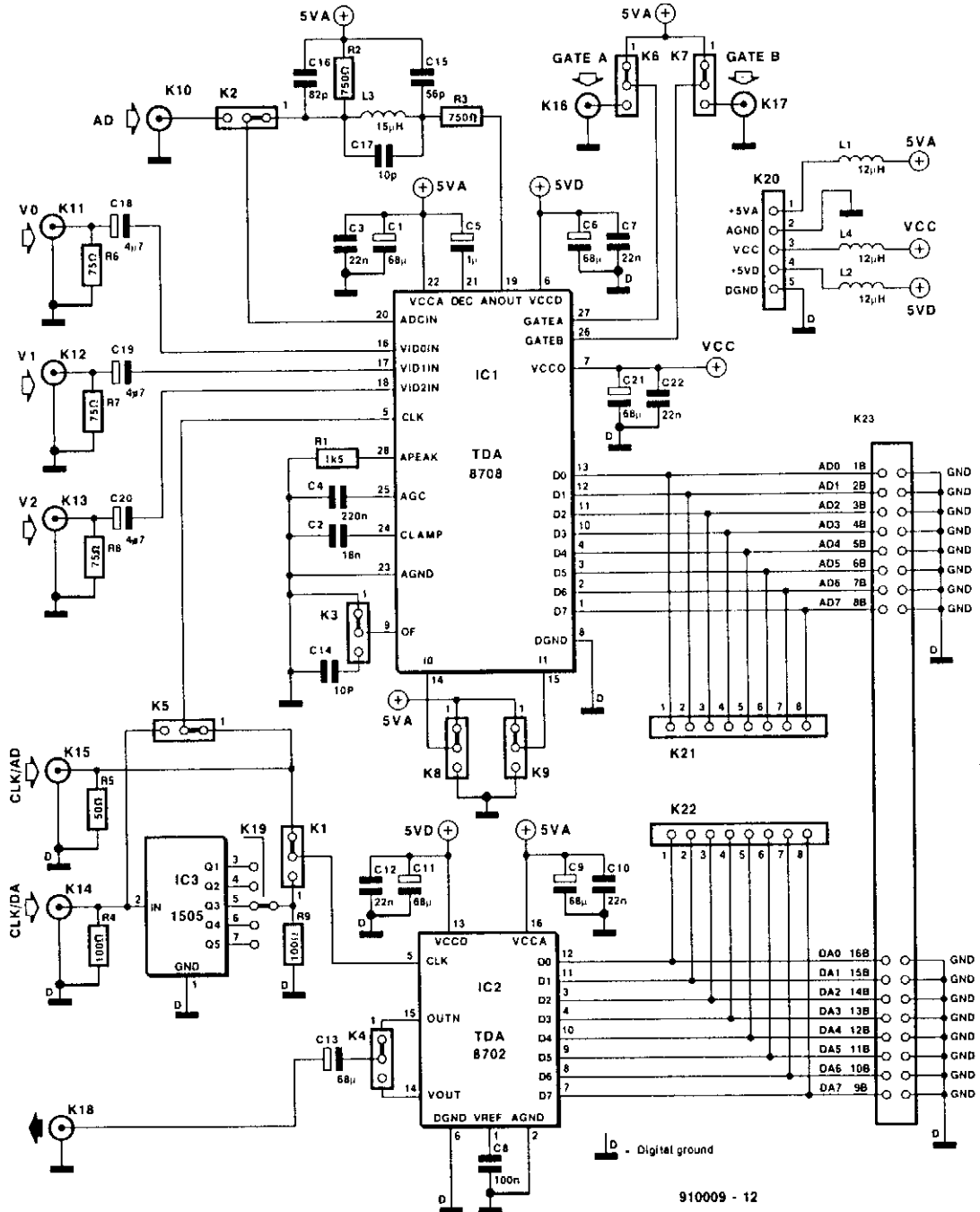


ELEKTOR ELECTRONICS

Fig. 95-2

This circuit mixes H sync, V sync, and actual video. T2 mixes the sync, while T1 serves as an emitter-follower. Bandwidths of up to 25 MHz are typical for this circuit.

VIDEO A/D—D/A CONVERTER

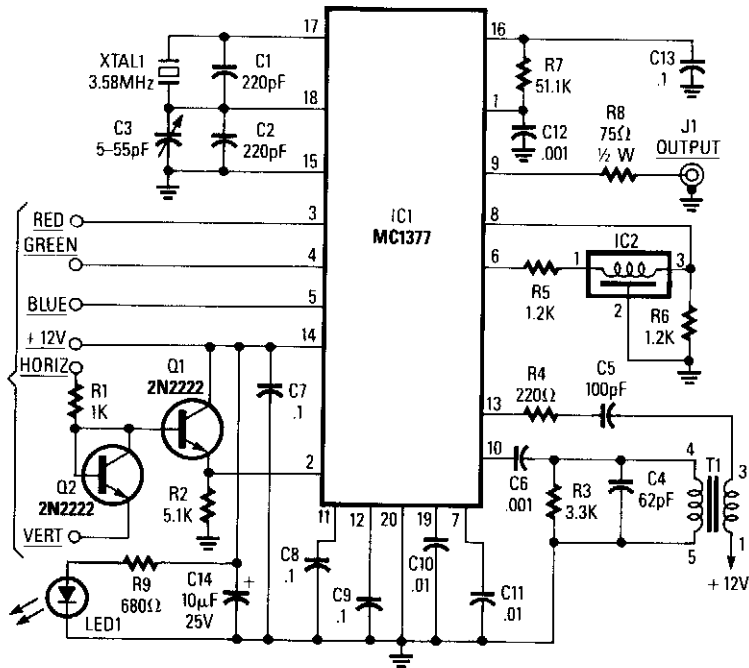


910009 - 12

VIDEO A/D—D/A CONVERTER (Cont.)

This circuit is useful for digital video experiments and for interfacing video with a computer that has a TDA8708 (Philips). The A/D converter provides 8-bit digitized video to k23 socket and k21 socket. A TDA8702 (Philips) D/A converter recovers analog video. IC3 is a 1- to 5-ms delay line (1505) to delay clock pulses in 1-ms steps to the D/A converter. Clock speeds can be up to 30 MHz. Three video inputs are provided for three analog channels (e.g., R, G, B video).

RGB/NTSC CONVERTER

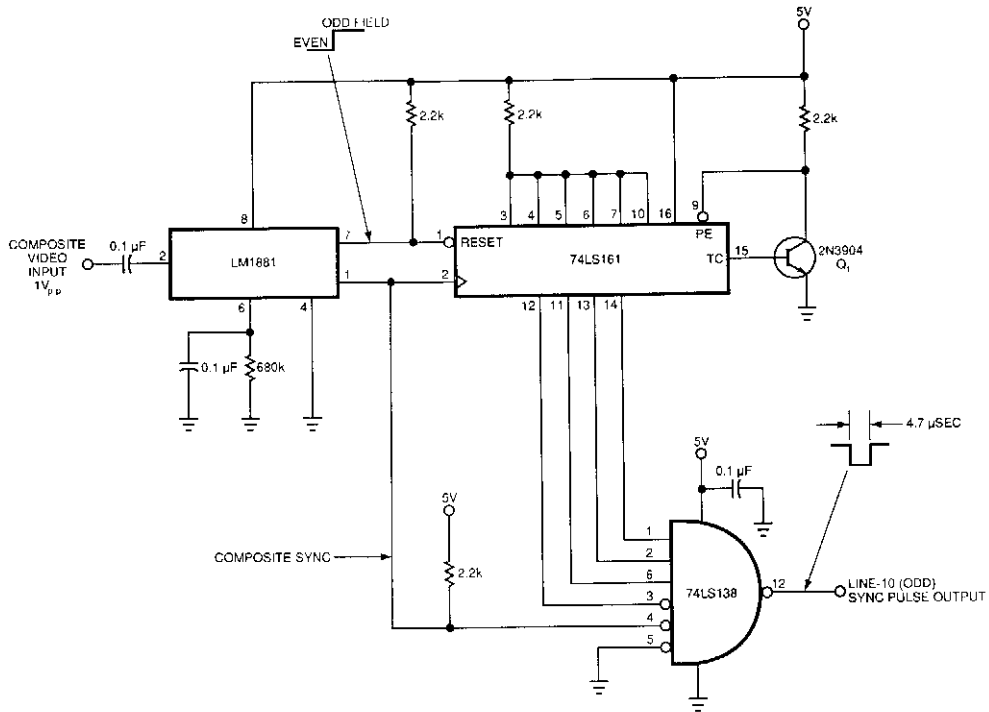


RADIO-ELECTRONICS

Fig. 95-4

Using a Motorola MC1377, this circuit produces NTSC video from an RGB source. Components are not critical, except for R7 and CB, which should be 1% and 2% tolerance, respectively.

TV LINE PULSE EXTRACTOR



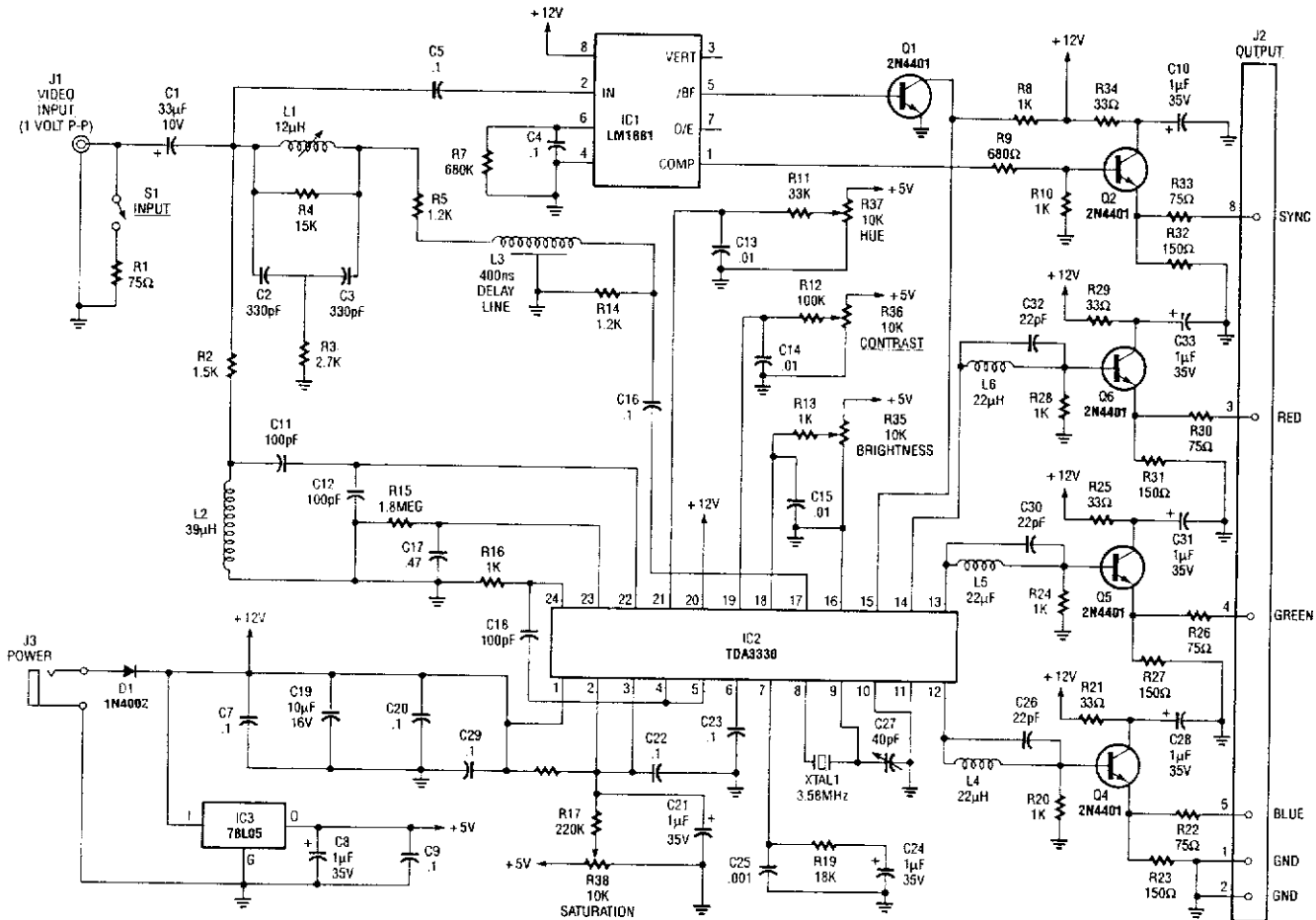
EDN

Fig. 95-5

This circuit uses a sync-generator chip, a counter, and a decoder to detect the horizontal sync pulse that occurs at the beginning of line 10 in field 1 of an NTSC television picture. You can use this circuit to compare the time delay between sync signals at various locations, and to determine and correct for any drift between the two master clocks.

The output of the LM1881 sync separator is the key to detecting line 10; the odd/even line goes high on the leading edge of the first equalizing pulse in the middle of line 4. Thus, you can use this knowledge to find virtually any other line in the field. This particular circuit locates line 10 of field one. The circuit resets the 74LS161 counter until the odd/even line goes high. Then, 74LS161 counts the positive transitions of the sync signal. After 11 positive transitions, the sync pulse drives pin 4 of the 74LS138 decoder low, and the line-10 sync pulse appears at pin 12 of the decoder. (The circuit counts to 11, as opposed to the 6 you might expect—because the composite sync signal contains more than 1 pulse per line). The counter remains in its maximum-count state until the sync separator causes a reset because Q1 feeds the inverted terminal-count output back to the parallel-enable input.

NTSC/RGB VIDEO DECODER

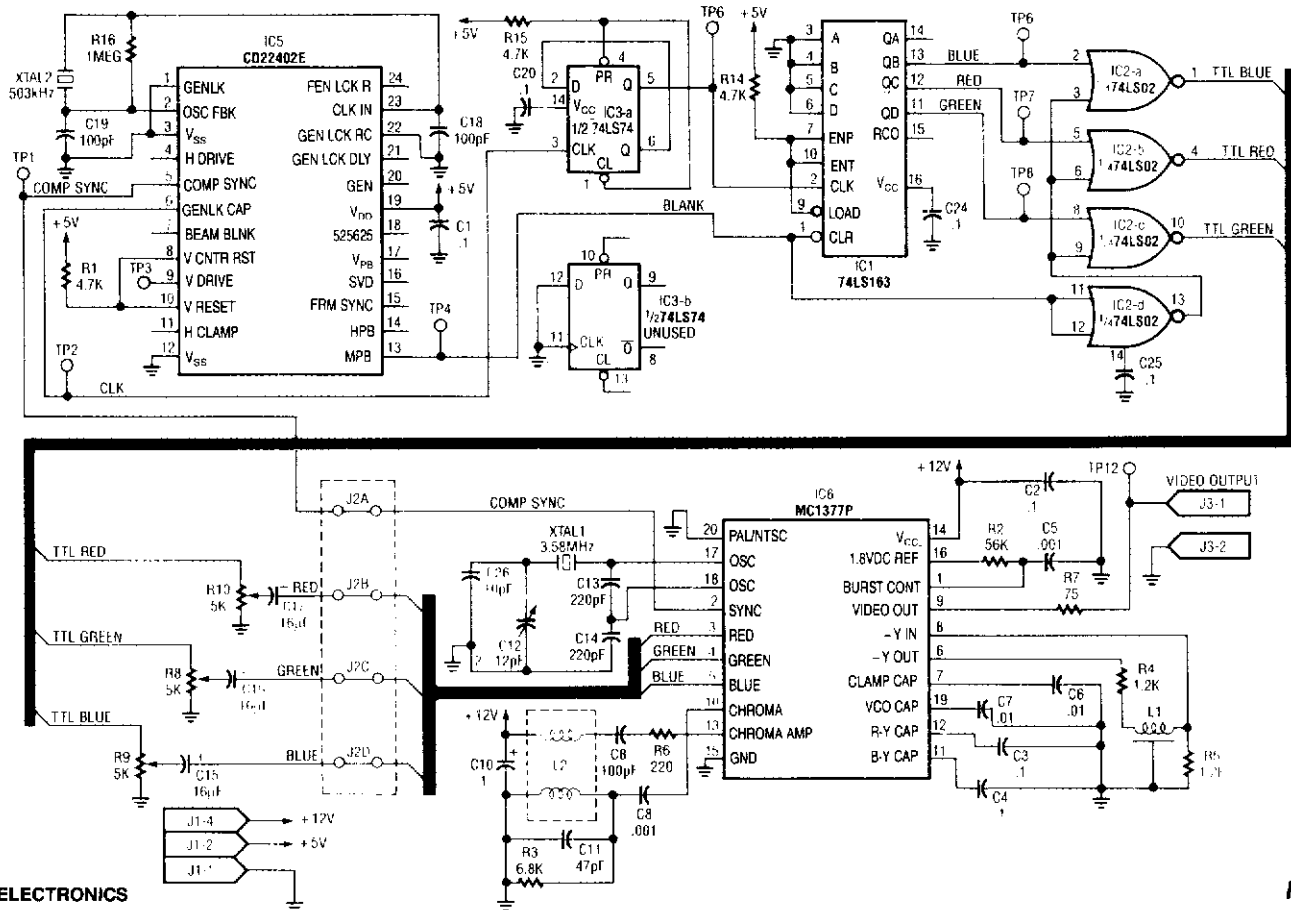


RADIO-ELECTRONICS

Fig. 95-6

An NTSC/RGB decoder is shown here. Using a TDA3330, 1-V input video is broken down into its R, G, B components, and composite synch. U1 is an integrated synch separator (LM1881). This circuit should be useful for interfacing RGB monitors to NTSC video systems.

COLOR-BAR GENERATOR

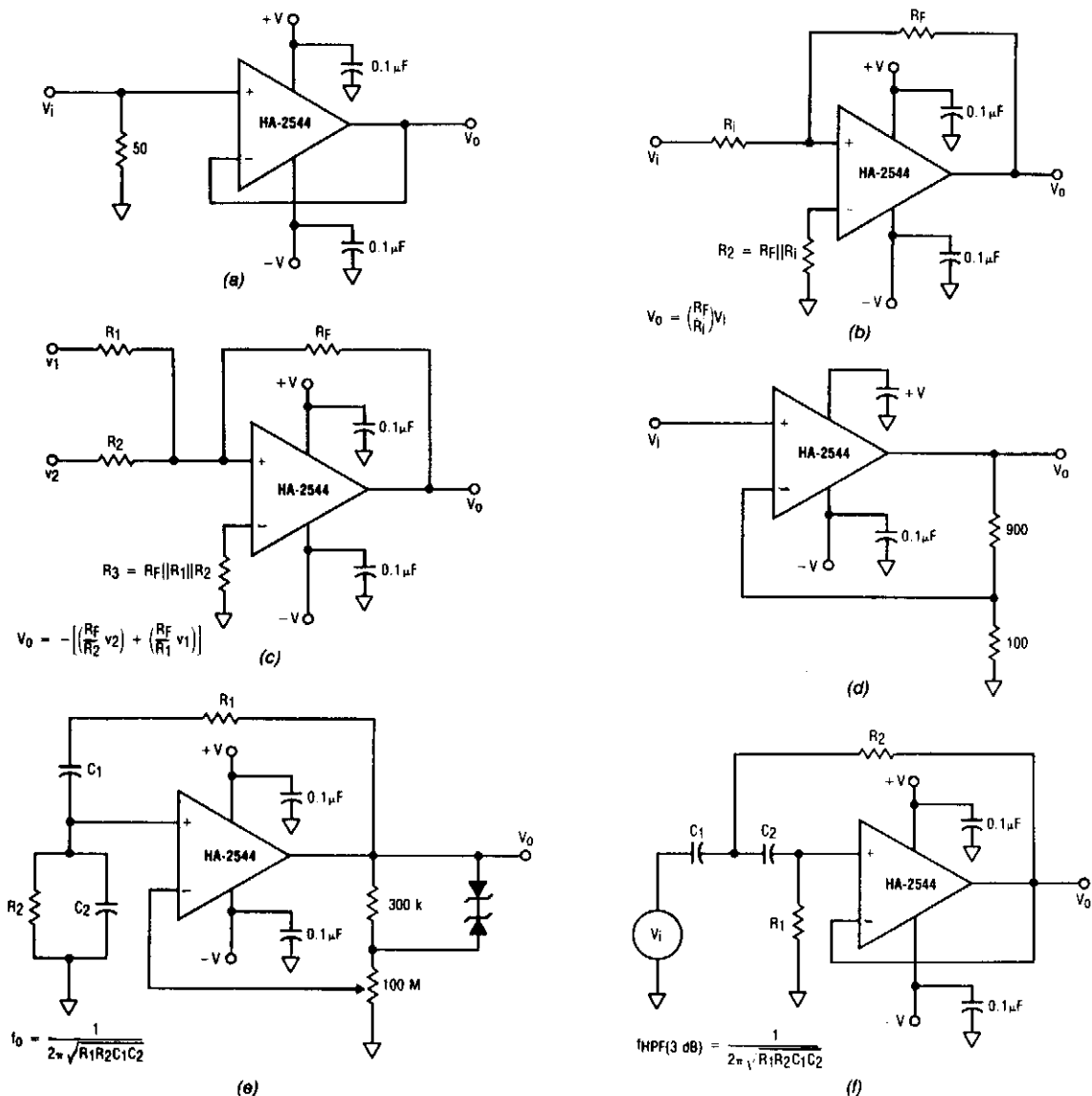


RADIO-ELECTRONICS

Fig. 95-7

IC5 generates RS-170 NTSC synch. IC1, IC2, and IC3 make up the red, green, and blue video signals that drive the video encoder section of IC6 to make up the color bars. IC3 is an $a \div 2$ counter that drives 4-bit counter IC1. Gates IC2a through IC2b form the R, B, and G, video signals. IC6 encodes these, plus synch, to form an NTSC video output signal, which appears at TP12.

VIDEO OP AMP CIRCUITS



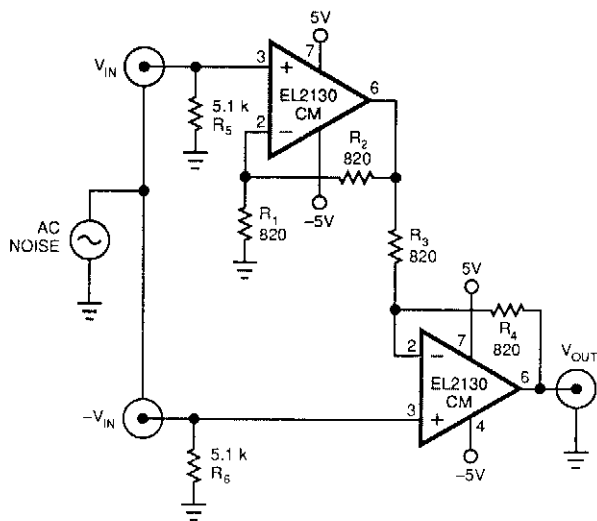
ELECTRONIC PRODUCTS

Fig. 95-8

These 6 circuits use the Harris HA2544 op amp. Component values are obtained by using the equations in the figure.

The HA-2544 can be used in any number of standard op amp configurations, including a voltage follower (a), an inverting amplifier (b), an inverting summer (c), a buffer amplifier with a gain of 10 (d), a Wien-bridge oscillator with zener diode adaptive feedback (e), and a second-order, high-pass active filter (f).

VIDEO LOOP-THRU AMPLIFIER



This video bandwidth amplifier rejects common-mode noise, such as 60- and 120-Hz hum. Bandwidth is typically 60 MHz for a differential gain of 2. The common-mode rejection is typically 45 dB.

The design equations are:

$$A_{DIFF} \geq 1,$$

$$R_2 = R_4 \text{ (select both for optimum bandwidth)}$$

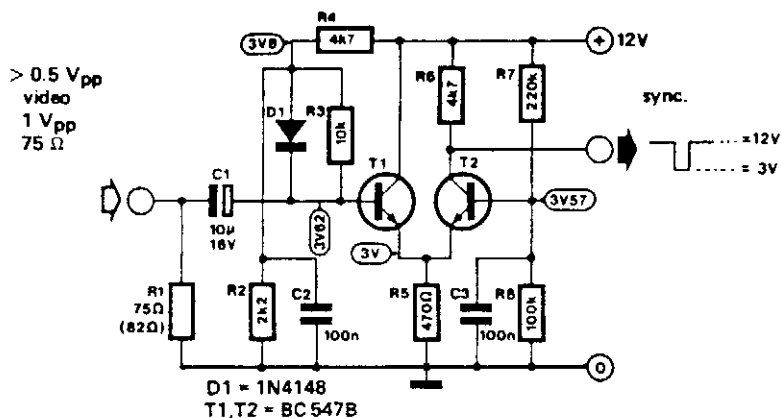
$$R_1 = R_2 (A_{DIFF} - 1)$$

$$R_3 = R_4 (A_{DIFF} - 1)$$

EDN

Fig. 95-9

SYNC SEPARATOR



ELEKTOR ELECTRONICS

Fig. 95-10

This circuit separates the sync from the composite video signal. It uses a two-transistor comparator. Output is 9 Vpp with a 0.5-Vpp (minimum) video input signal.

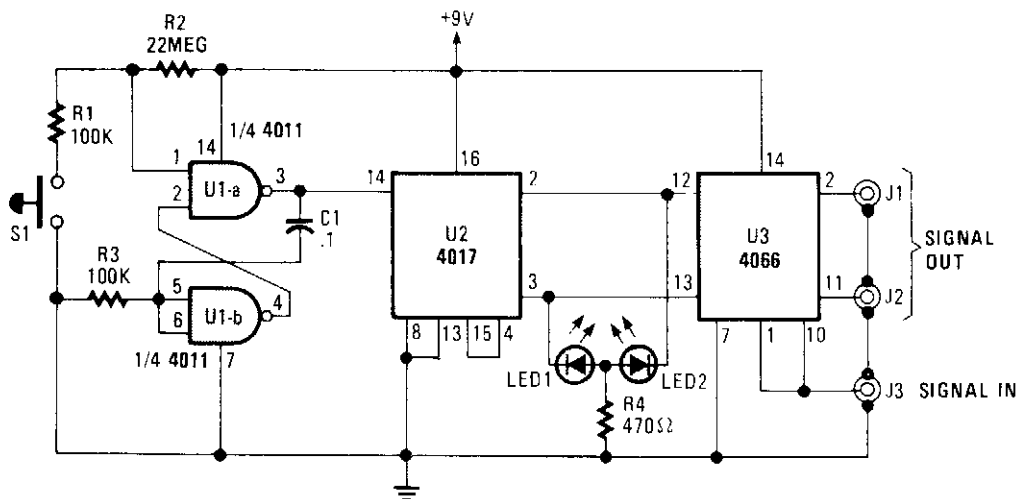
96

Video-Switching Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 680. The figure number in the box of each circuit correlates to the entry in the Sources section.

Remote-Selection Video Switch
Remote-Controlled Switcher

REMOTE SELECTION VIDEO SWITCH



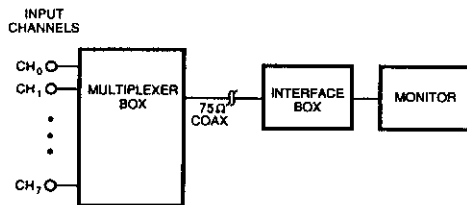
POPULAR ELECTRONICS

Fig. 96-1

The A/B Switch circuit consists of three ICs and a handful of resistors. Two gates from a 4011 quad 2-input NAND gate (U1A and U1B) are configured as a monostable multivibrator that, when switch S1 is pressed, triggers a 4017 decade counter/divider, which has been set to recycle after a count of two. The outputs of U2 at pins 2 and 3 are fed to the control inputs of U3 (a 4066 quad bilateral switch) at pins 12 and 13. Depending on which control input is high, either the J1 or J2 output is selected.

With a little modification, the switch could be set to trigger at a set rate (automatically). With the addition of another 4066, it could have as many as 8 channels. One possible application would be in a security surveillance system.

REMOTE-CONTROLLED SWITCHER

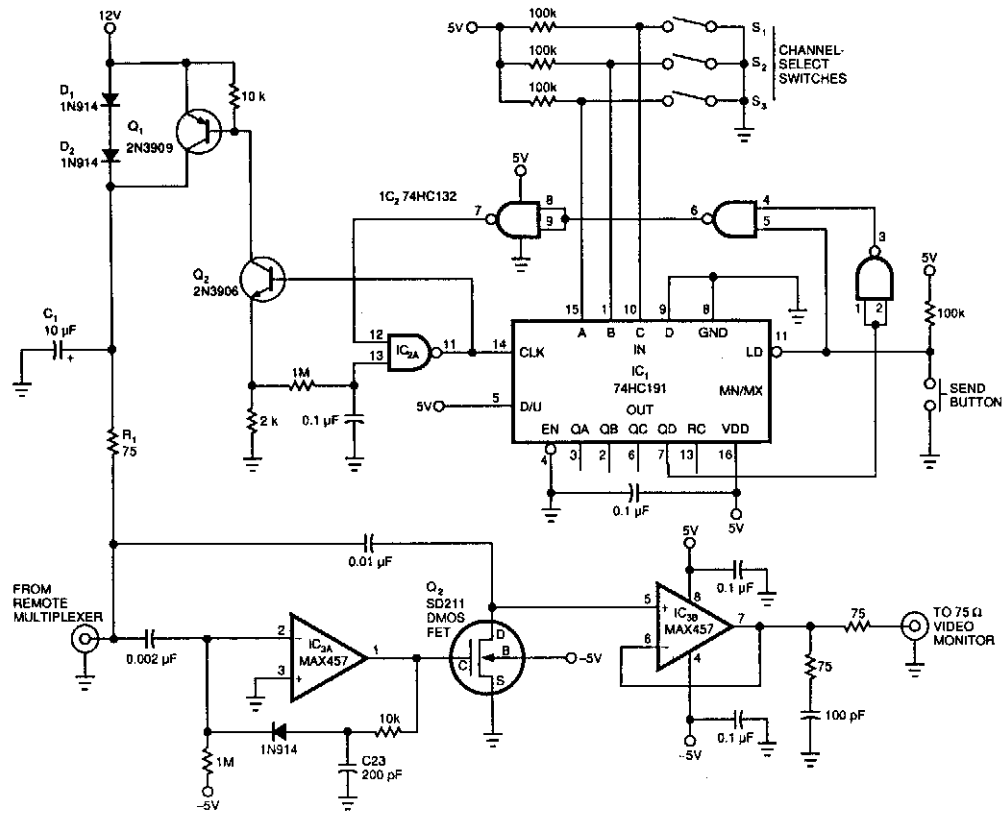


This 1-cable system carries composite video (NTSC, PAL, or SECAM), power, and channel-select signals.

EDN

Fig. 96-2(a)

REMOTE-CONTROLLED SWITCHER (Cont.)



EDN

Fig. 96-2(b)

The interface end of Fig. 96-2(a)'s circuit deliver 10 V down the cable, pulses the supply voltage to transmit channel-change commands, and buffers the received video signal.

The multiplexer circuit in Fig. 96-2(a) receives power and control signals over the coaxial cable, while driving the cable with the currently selected video signal.

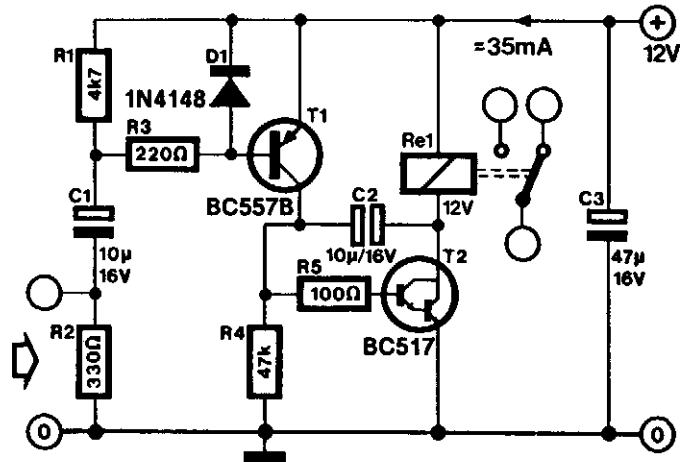
97

Voice-Operated Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 681. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple VOX
Scanner Voice Squelch

SIMPLE VOX



ELEKTOR ELECTRONICS

Fig. 97-1

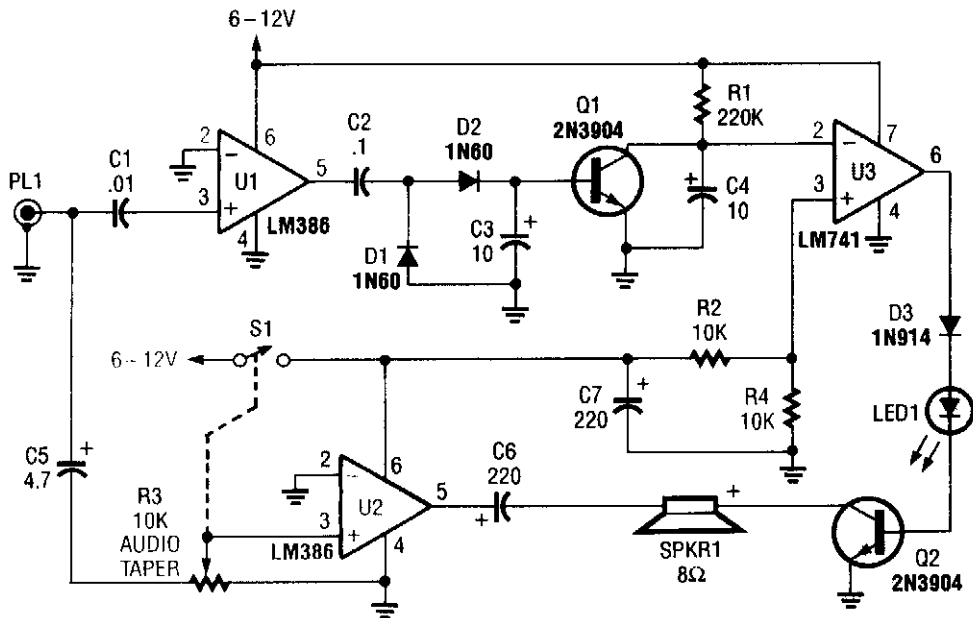
A *VOX* is a voice-operated switch that is often used as a substitute for the press-to-talk switch on a microphone. This *VOX* can be connected to almost any audio equipment that has a socket for an external loudspeaker. The actuation threshold is set by the volume control on the AF amplifier that drives the *VOX*.

The (loudspeaker) signal across R2 is capacitively fed to the base of T1. Resistor R3 limits the base current of this transistor when the input voltage exceeds 600 mV. Diode D1 blocks the positive excursions of the input signal, so that V_{eb} cannot become more negative than about 0.6 V.

The output relay is driven by Darlington T2. Resistor R4 keeps the relay disabled when T1 is off. The value of bipolar capacitor C2 allows it to serve as a ripple filter in conjunction with T2. Resistor R5 limits the base current of T2 to a safe level.

The switching threshold of the *VOX* is about 600 mV across R2. The maximum input voltage is determined by the maximum permissible dissipation of R2 and R3. As a general rule, the input voltage should not exceed 40 Vpp. The current drawn by the *VOX* is mainly the sum of the currents through the relay coil and through R5. The resistor can carry up to 100 mA when the *VOX* is overdriven.

SCANNER VOICE SQUELCH



POPULAR ELECTRONICS

Fig. 97-2

This circuit detects the presence of audio (voice) on the output of a scanner. If the scanner stops on a "dead carrier" or noise, the circuit mutes the speaker to avoid annoying noise.

U1 amplifies speech and drives rectifier D1/D2 and switch Q1. Comparator U3 drives speaker switch Q1 and indicator LED1. Q2 completes the speaker path to ground. U2 is an audio amplifier to drive the speaker. R3 is a volume control. PL1 connects to the scanner speaker or to the headphone jack.

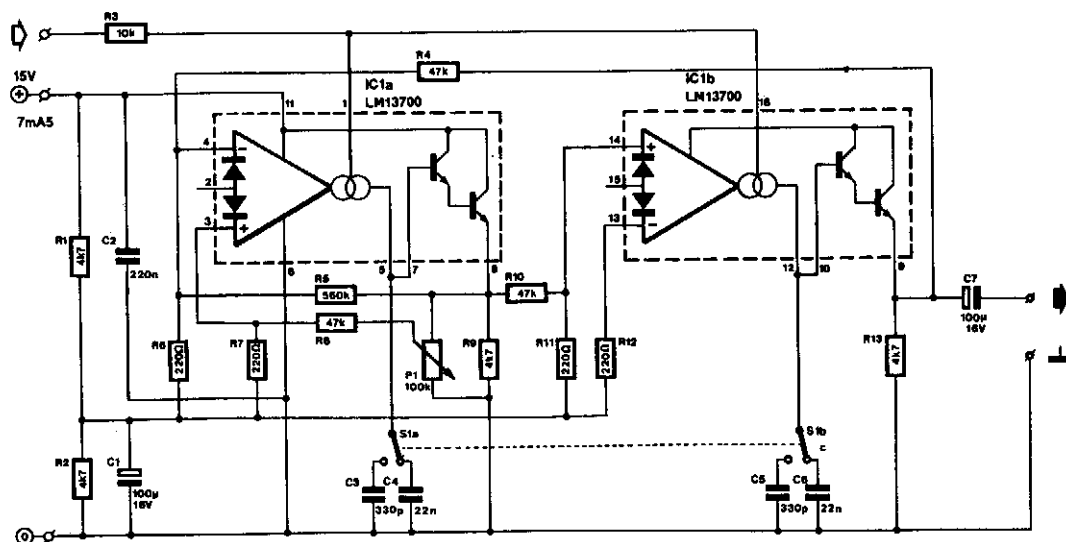
98

Voltage-Controlled Oscillators

The sources of the following circuits are contained in the Sources section, which begins on page 681. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple Audio-Frequency VCO	Voltage-Controlled Current Sink
Gated Wide-Range VCO	Biphase Wide-Range VCO
Simple 555 VCO	Wide-Range VCO
Restricted-Range VCO	Varactorless VCO
Linear VCO	VCO
Voltage-Tuned UHF Oscillator	

SIMPLE AUDIO-FREQUENCY VCO



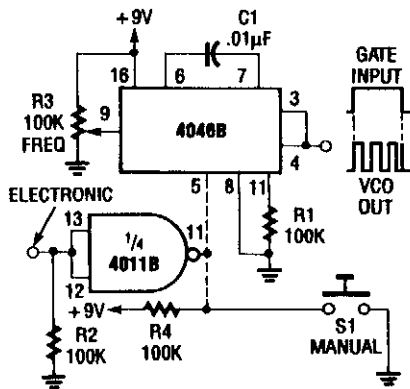
ELEKTOR ELECTRONICS

Fig. 98-1

The frequency of this sine-wave oscillator is determined by a direct voltage, U_c , of 0 to 15 V. The distortion on output signals of up to 10 V_{pp} is not greater than 1%. When the output is reduced with the aid of P1 to 1 V_{pp}, the distortion drops to below 0.1%. It is not recommended to use output signals below 1 V_{pp}, because the oscillator then becomes unstable and temperature-dependent.

The oscillator consists of two operational transconductance amplifiers (OTAs) contained in one package. Their Amp-bias inputs, pins 1 and 16, are connected in parallel. These inputs can drive the output currents at pins 5 and 12 to a peak value of up to 0.75 mA.

Switch S1 enables the oscillator output to be set to two ranges: 6.7 to 400 Hz and 400 Hz to 23.8 kHz. The overall range needs a control voltage that varies from 1.34 to 15 V. When the frequency is changed by a variation of U_c and the setting of P1 is not altered, the output signal might be distorted. In other words, the amplitude of the signal must be adapted to the frequency.

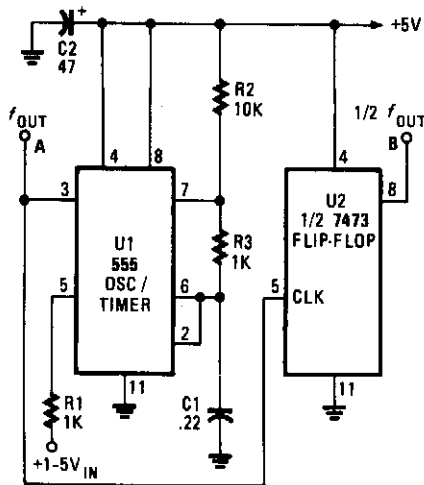


GATED WIDE-RANGE VCO

A CD4046 can be gated either with a switch or electronically, as shown in the figure. Frequency range of this circuit is to 1.5 kHz; use another C_1 for higher frequencies.

RADIO-ELECTRONICS

Fig. 98-2

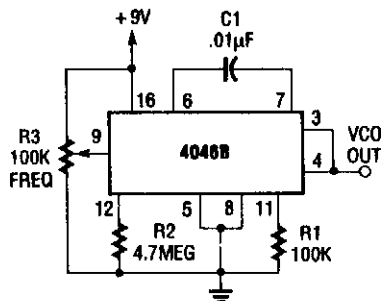


SIMPLE 555 VCO

The VCO has an output frequency that ranges from 1 500 Hz at $V_{in}=1$ V to 300 Hz at $V_{in}=5$ V. R_1 or C_1 can be varied to change this range. U2 provides a symmetrical square-wave output of half the timer frequency.

POPULAR ELECTRONICS

Fig. 98-3



RESTRICTED-RANGE VCO

This VCO is adjustable from 60 Hz to 1.4 kHz. C_1 can be changed for other ranges.

RADIO-ELECTRONICS

Fig. 98-4

VOLTAGE-CONTROLLED CURRENT SINK

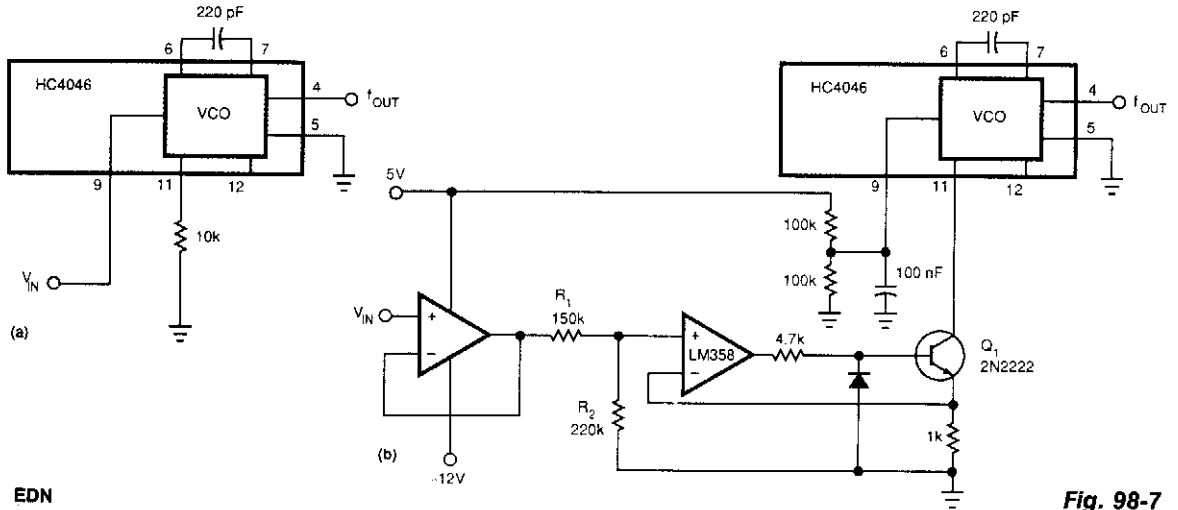
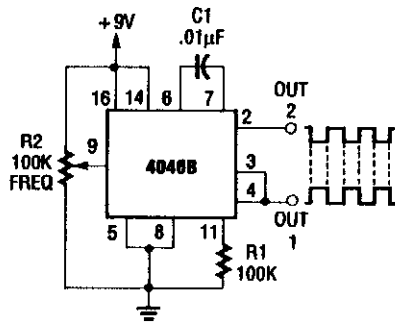


Fig. 98-7

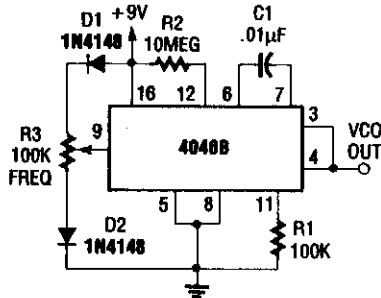
This circuit widens the linear frequency span of an HC4046 from one decade to nearly three decades. An LM358 is used as a constant-current sink to replace the frequency-determining resistor (10 k Ω) from pin 9 to ground. Pin 9 is held at a fixed 2.5 V for this application.



BIPHASE WIDE-RANGE VCO

Using a CD4046B, this circuit generates a biphas signal. The frequency range is below 100 Hz to about 1.5 kHz.

RADIO-ELECTRONICS **Fig. 98-8**

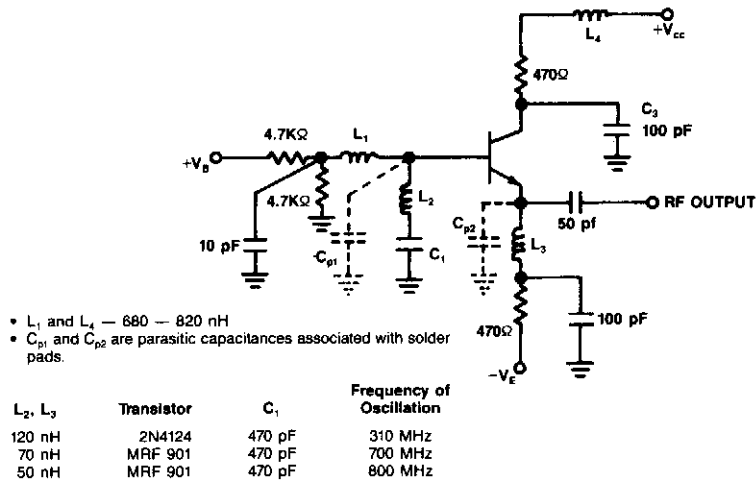


WIDE-RANGE VCO

This circuit covers 0 to 1.4 kHz. C_1 can be changed to cover other ranges, as desired.

RADIO-ELECTRONICS **Fig. 98-9**

VARACTORLESS VCO

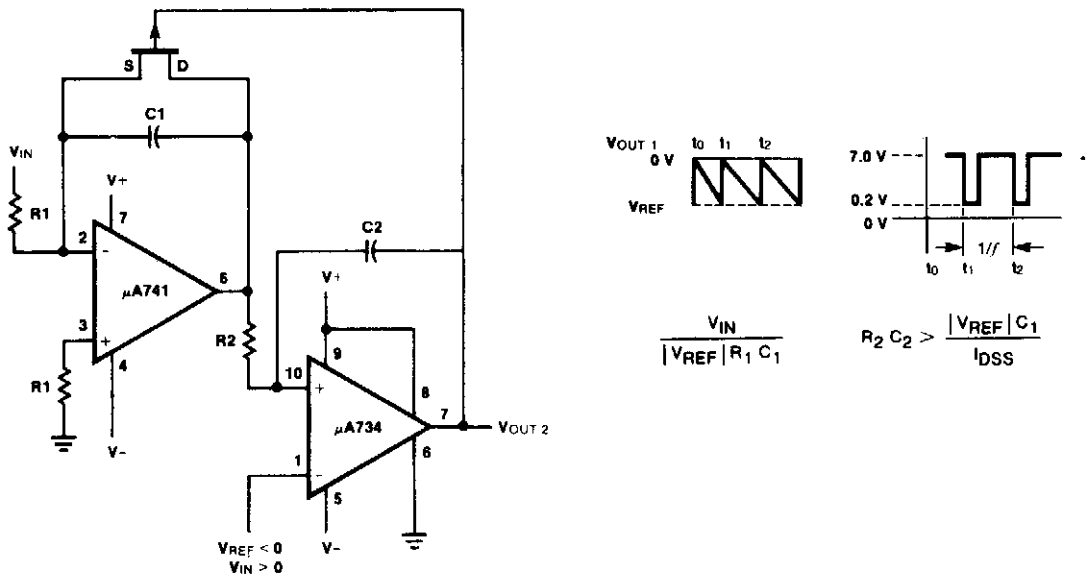


RF DESIGN

Fig. 98-10

The varactorless VCO utilizes a modified Clapp-oscillator configuration, together with some data on the type of transistor, circuit values, and operating frequencies.

VCO



FAIRCHILD CAMERA

Fig. 98-11

Q1, an FET, is used as a variable resistance to control frequency of oscillator.

99

Voltage Multiplier Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 681. The figure number in the box of each circuit correlates to the entry in the Sources section.

Voltage Multiplier
Corona Wind Generator
10 000-Vdc Supply
High-Voltage Negative-Ion Generator
Voltage Doublers
Cockcroft-Walton Cascaded Voltage Doubler
2 000-V Low-Current/Power Supply
Low-Current Voltage Tripler

VOLTAGE MULTIPLIER

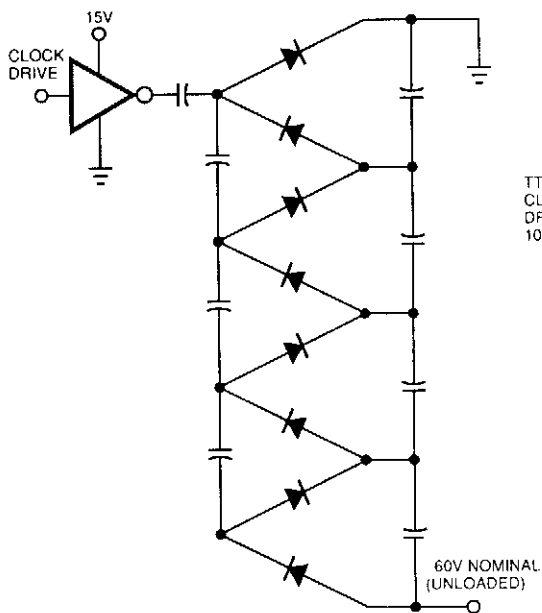


Fig. 99-1(a) EDN

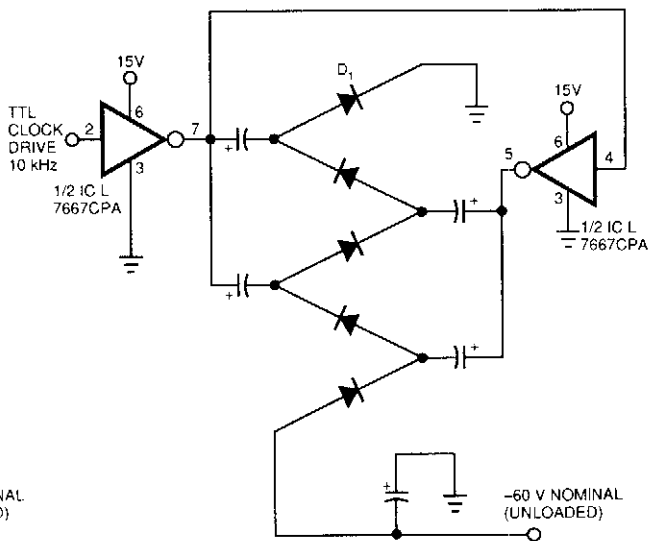


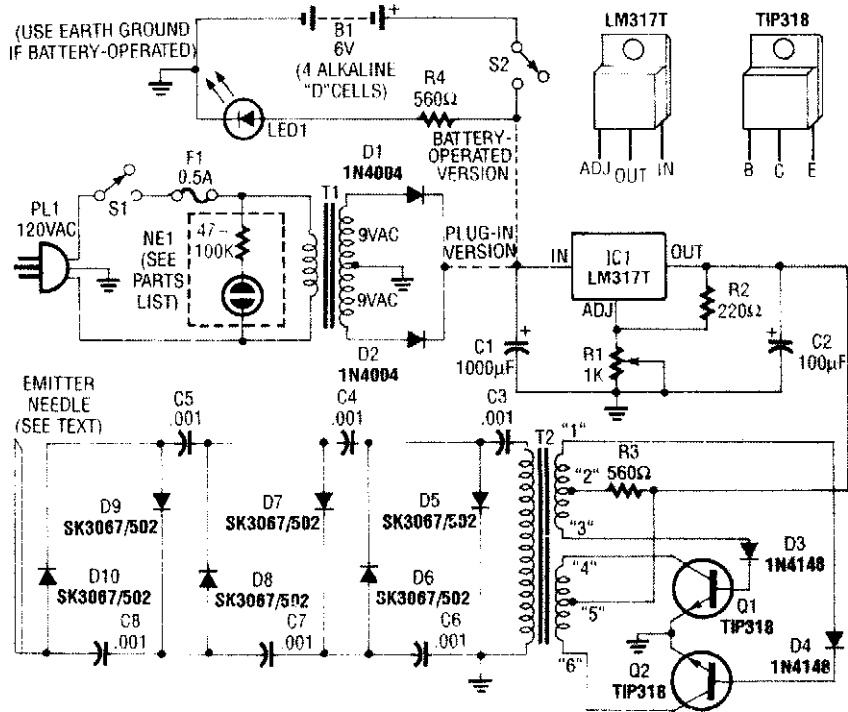
Fig. 99-1(b)

Figure 99-1(a)'s circuit exhibits a high-output impedance as a result of the small effective capacitance of the series-connected capacitors, and it exhibits considerable voltage loss due to all of the diode drops. Further, this circuit requires $2n$ diodes and $2n$ capacitors to produce a dc output voltage approximately n times the rail voltage.

Figure 99-1(b)'s circuit multiplies more effectively using fewer diodes and capacitors. The parallel arrangement of the capacitors lets you use smaller capacitors than those required in Fig. 99-1(a). Alternatively, when using the same capacitor values of Fig. 99-1(a), the output impedance will be lower.

Whereas the clock source directly drives only one of the two strings of capacitors in Fig. 99-1(a), Fig. 99-1(b)'s clock drives both strings with opposite phases. This drive scheme doubles the voltage per stage of two diodes. A final diode is necessary to pick off the dc output voltage because both strings of capacitors now carry the p-p ac input-voltage waveform. The ICL7667 dual-FET driver accepts a TTL drive swing and provides a low-impedance push-pull drive to the diode string. This low impedance is particularly helpful when using a long string to raise output voltage to more than 100 V, starting from a low rail voltage.

HIGH-VOLTAGE NEGATIVE-ION GENERATOR



RADIO-ELECTRONICS

Fig. 99-4

A modified B/W TV flyback transformer is used in this circuit with a voltage multiplier to produce 9- to 14-kV negative voltage. This is connected to a discharge needle to produce negative ions.

VOLTAGE DOUBLERS

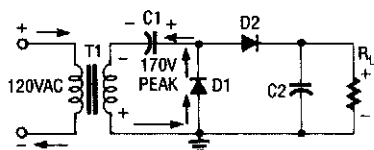


Fig. 99-5(a)

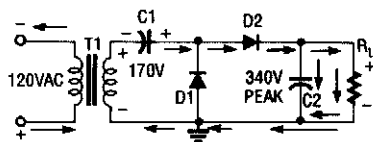


Fig. 99-5(b)

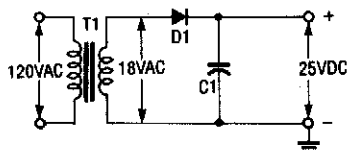


Fig. 99-5(c)

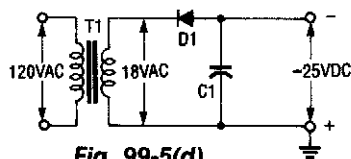


Fig. 99-5(d)

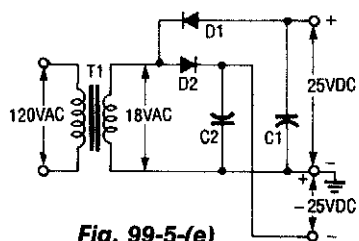
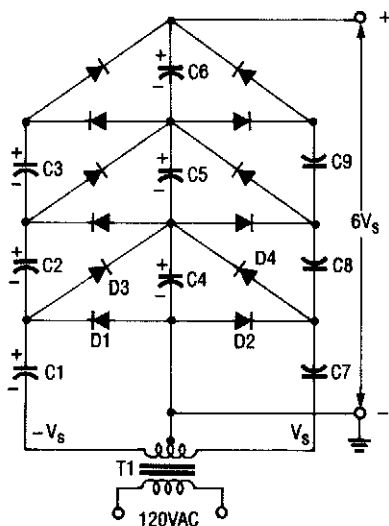


Fig. 99-5(e)

RADIO-ELECTRONICS

Fig. 99-5

During the first half-cycle (Fig. 99-5(a)), D1 conducts, D2 cuts off, C1 charges to 170 V peak, and C2 discharges through R_L . For the second half-cycle (Fig. 99-5(b)), the input polarity is reversed, and both the input and C1 are in series, which produces 340 V (peak). Now, D1 cuts off, while D2 conducts, and the current divides between C2 and R_L ; the cycle then repeats. Two Half-Wave Rectifiers, one with a positive output (Fig. 99-5(c)) and one negative (Fig. 99-5(d)), combine to make a full-wave voltage doubler (Fig. 99-5(e)).



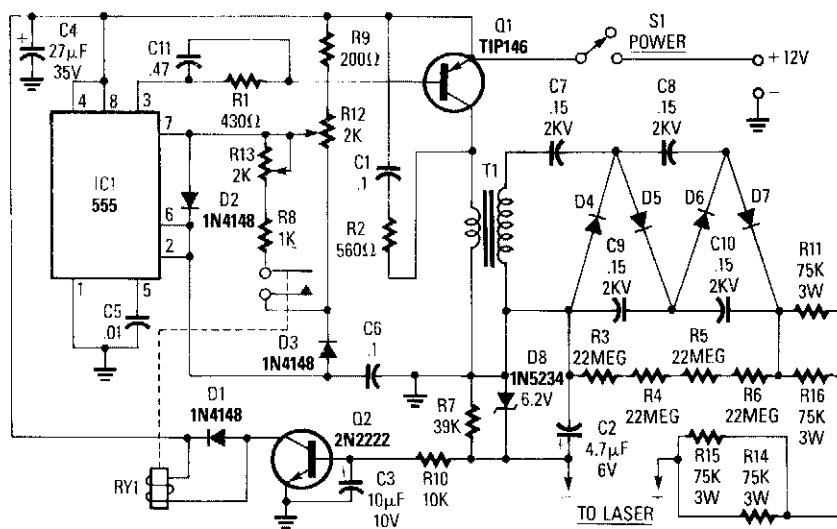
COCKCROFT-WALTON CASCADED VOLTAGE DOUBLER

A center-tapped transformer of secondary voltage. Two V_s can be used to power a voltage multiplier. For higher voltages, simply add more sections.

RADIO-ELECTRONICS

Fig. 99-6

LASER POWER SUPPLY

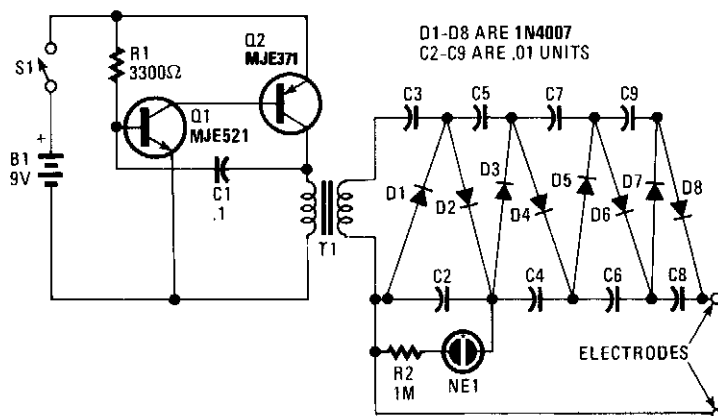


RADIO-ELECTRONICS

Fig. 99-7

IC1 is a 555 timer running at about 16 kHz. This IC drives Q1, a TIP146, which produces a 12-V square wave across T1 primary. This produces between 800 and 2,000 V across the secondary, which is doubled to 3 to 5 kV. When the load (laser) on the power supply increases, current Q2 is turned on, which energizes RY1. This changes the duty cycle of the 555 timer. To adjust this supply, set R12 and R13 at the center. Adjust R12 until the laser tube triggers, and make sure that the relay pulls in. If the relay chatters, adjust R12. If the full-clockwise adjustment of R12 fails to ignite the tube, adjust R13.

2,000-V LOW-CURRENT POWER SUPPLY



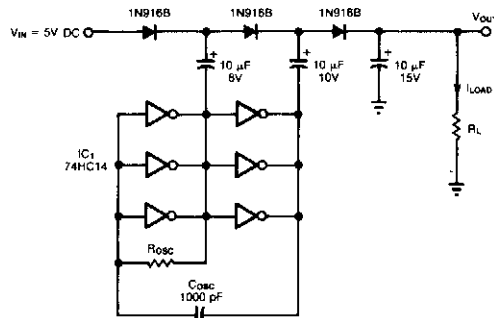
RADIO-ELECTRONICS

Fig. 99-8

2,000-V LOW-CURRENT POWER SUPPLY (Cont.)

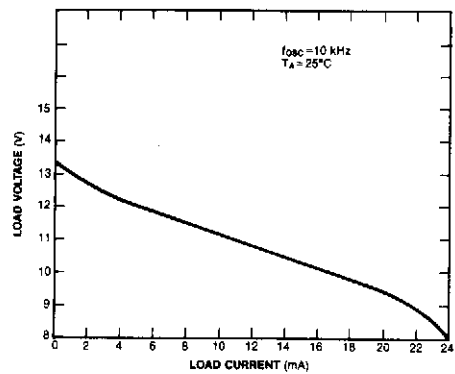
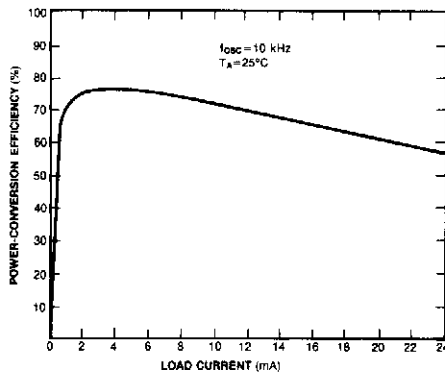
In this circuit Q1, Q2, R1, and C1 form a multivibrator. The square wave that results from the oscillation of this circuit (20 to 30 Vpp) is stepped up by T1 (an audio transformer of the type used in radios or small TVs). An 8- to 1,200- Ω impedance ratio equates to a turn ratio of 12:1. The ac from the secondary of T1 is applied to the multiplier circuit (D1 to D8 and C2 to C9). NE1/R2 are used as an operating indicator. The circuit will supply about 2,000 V. C2 to C9 should have a 400-V or higher voltage rating.

LOW-CURRENT VOLTAGE TRIPLER



This circuit generates a 15V output by tripling V_{IN} .

(a)



These curves show Fig. 99-9(a)'s power-conversion efficiency and load voltage (b) vs load current.

(b)

(c)

EDN

Fig. 99-9

Using a 74HC14 operating at 350 kHz, this voltage tripler delivers approximately 12 V from a 5-V supply.

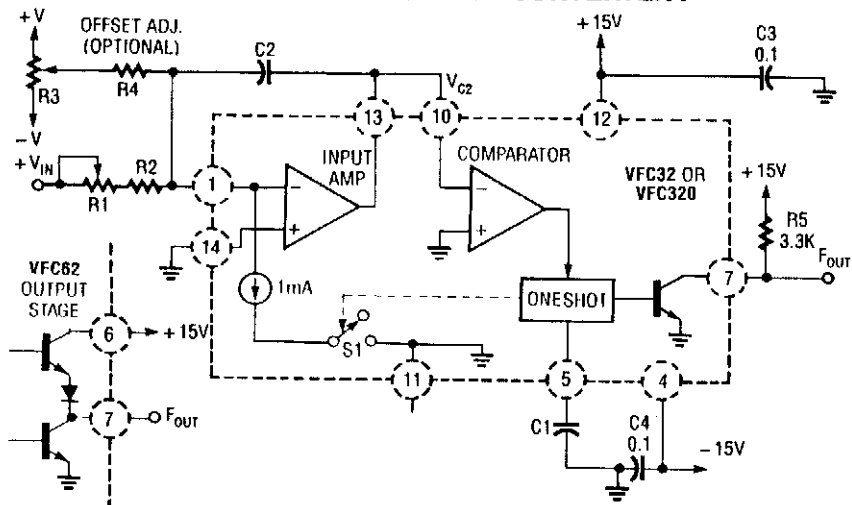
100

Voltage-To-Frequency Converters

The sources of the following circuits are contained in the Sources section, which begins on page 681. The figure number in the box of each circuit correlates to the entry in the Sources section.

Voltage-To-Frequency Converter I
Voltage-To-Frequency Converter II
Simple Low-Frequency V/F Converter
Voltage-To-Frequency Converter with Optocoupler

VOLTAGE-TO-FREQUENCY CONVERTER I



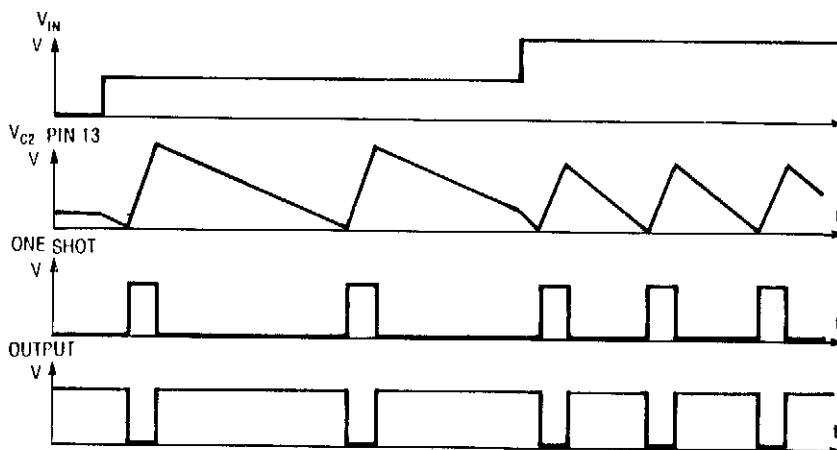
CIRCUIT VALUES

Full-Scale Input	Full-Scale Frequency	C1	C2	R1 (ohms)	R2 (ohms)
1 V	10 kHz	3300 pF	0.01 μ F	1K	3K
10 V	10 kHz	3300 pF	0.01 μ F	10K	30K
1 V	100 kHz	300 pF	0.001 μ F	1K	3K
10 V	100 kHz	300 pF	0.001 μ F	10K	30K

RADIO-ELECTRONICS

Fig. 100-1

(a)

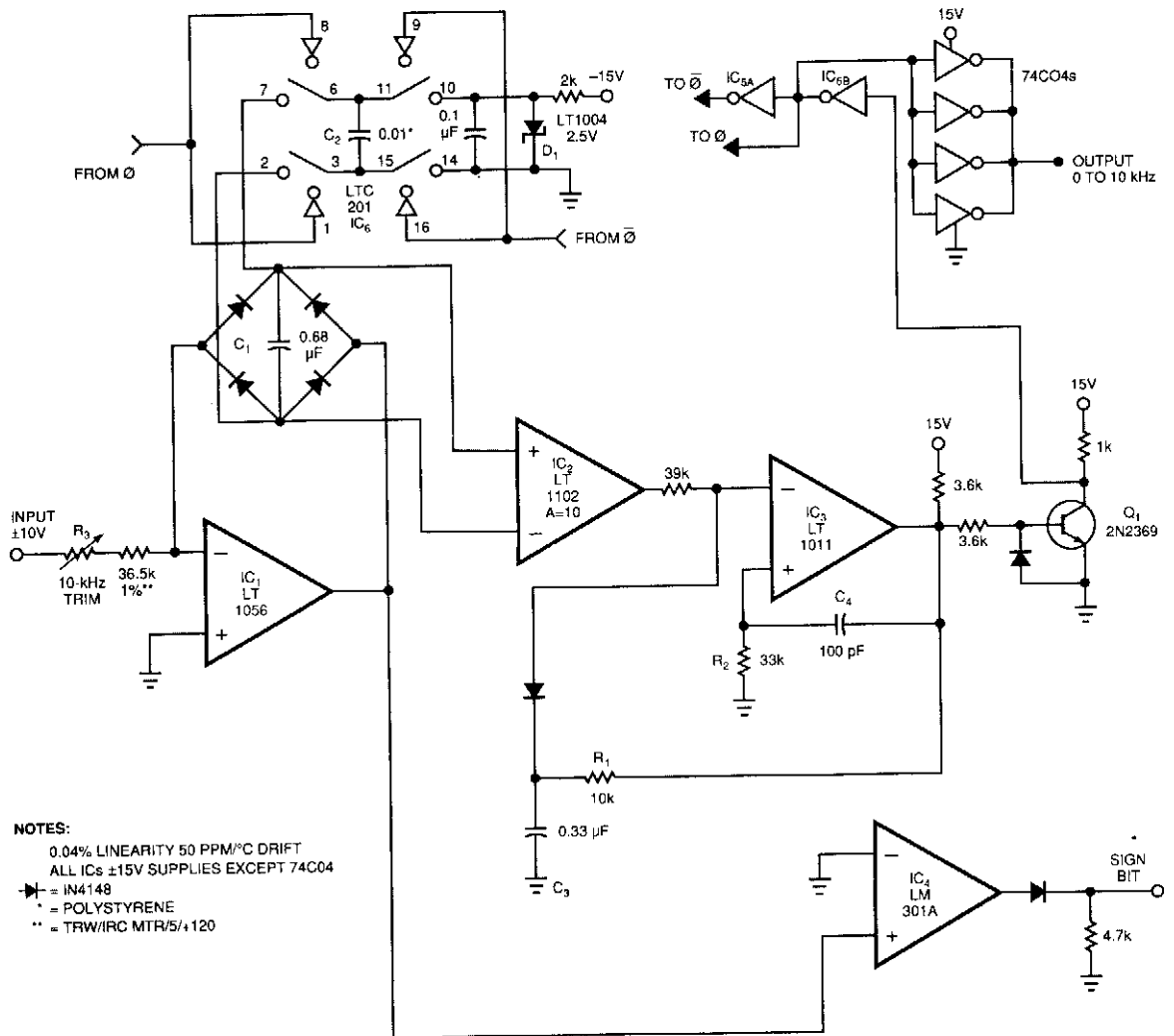


(b)

Using a Burr-Brown VFC 32 IC, this voltage-to-frequency converter uses few components. The circuit values are shown in the figure.

This charge-balanced V/F converter uses a VFC32 or a VFC320 IC. The positive charge from the 1-mA balances the negative charge from the input. V/F converter waveforms are shown in Fig. 100-1(b).

VOLTAGE-TO-FREQUENCY CONVERTER II



NOTES:

- 0.04% LINEARITY 50 PPM/°C DRIFT
- ALL ICs ±15V SUPPLIES EXCEPT 74CO4
- ▶ = IN4148
- * = POLYSTYRENE
- ** = TRW/IRC MTR/5/120

Fig. 100-2

EDN

This voltage-to-frequency converter (VFC) accepts the bipolar-ac inputs. For -10- to +10-V inputs, the converter produces a proportional 0- to 10-kHz output. Linearity is 0.04%, and temperature coefficient (TC) measures about 50 ppm/°C.

To understand the circuit, assume that its input sees a bipolar square wave. During the input's positive phase, IC1's output swings negative and drives current through C1 via the full-wave diode bridge. IC1's current causes C1's voltage to ramp up linearly. Instrumentation amplifier IC2 operates at a gain of 10 and measures the differential voltage across C1.

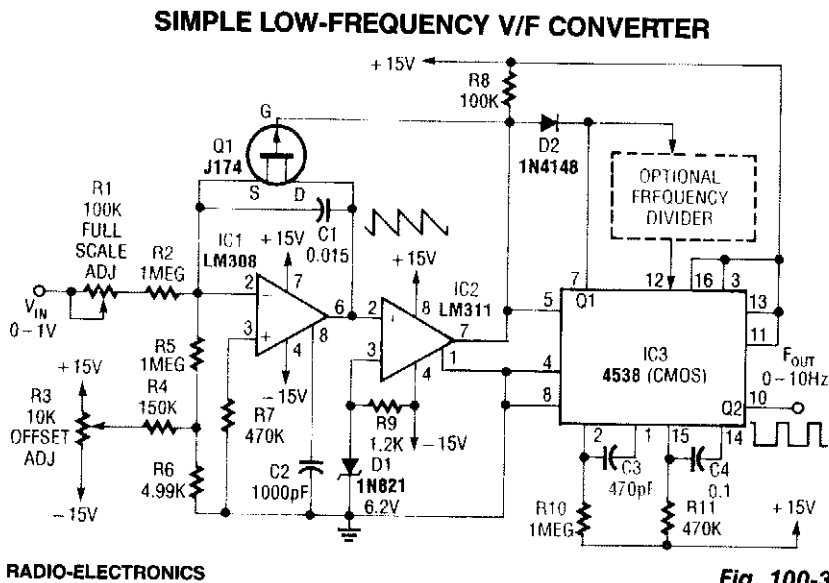
VOLTAGE-TO-FREQUENCY CONVERTER II (Cont.)

IC2's output biases comparator IC3's negative input. When IC2's output crosses zero, IC3 fires and provides positive feedback to IC3's positive input and hangs up IC3's output for about 20 μ s. The Q1 level shifter drives ground-referred inverters IC5A and IC5B to deliver biphasic drive to LT1004 switch IC6.

IC6, configured as a charge pump, places C2 across C1 each time the inverters switch, which resets C1 to a lower voltage. The LT1004 reference (D1), along with C2's value, determines how much charge the charge pump removes from C1 each time the charge pump cycles. Thus, each time IC2's output tries to cross zero, the charge pump switches C2 across C1, which resets C1 to a small negative voltage and forces IC1 to begin recharging C1.

The frequency of this oscillatory behavior is directly proportional to the input-derived current into IC1. During the time that C1 is ramping toward zero, IC6 places C2 across the reference diode (D1), and prepares C2 for the next discharge cycle.

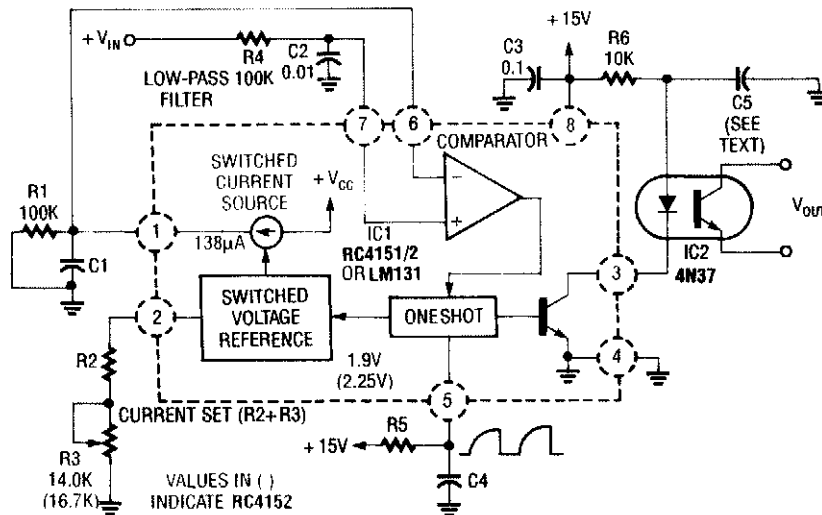
The action is the same for negative-input excursions, except that IC1's output phasing is reversed. IC2, looking differentially across IC1's diode bridge, sees the same signal as it does for positive inputs; therefore, the circuit's action is identical. IC4, detecting IC1's output polarity, provides a signal bid output.



In this circuit, C1 is charged to a fixed reference level, then discharged. Integrator IC1 circuit charges C1 until IC1 has -6.2-V output, when comparator IC2 outputs a low. FET Q1, triggers one-section monostable multivibrator IC3, pulls pin 3 low for 470 μ s, ensuring that Q1 completely discharges C1. The other section of IC3 produces a longer pulse of about 47 ms.

Full scale of this circuit is 10 Hz. For lower output pulse rates, a counter circuit can be inserted between the sections of IC3. Notice that because C1 does not integrate while Q1 is biased on, this circuit has an error in the output period, which must be as short as possible. Therefore, the circuit's use is limited to low frequencies.

VOLTAGE-TO-FREQUENCY CONVERTER WITH OPTOCOUPLER



CIRCUIT VALUES

Full-Scale Input	Full-Scale Frequency	C1	C4	R5 (ohms)
10 V	1 kHz	10 μF	0.1 μF	6.8K
10 V	10 kHz	1 μF	0.01 μF	6.8K
10 V	100 kHz	0.1 μF	0.001 μF	6.8K

RADIO-ELECTRONICS

Fig. 100-4

In this circuit, a Raytheon RC4151 or National LM131 is used in conjunction with an optocoupler for applications where input-to-output isolation is desirable. Circuit values are shown in the figure for various applications.

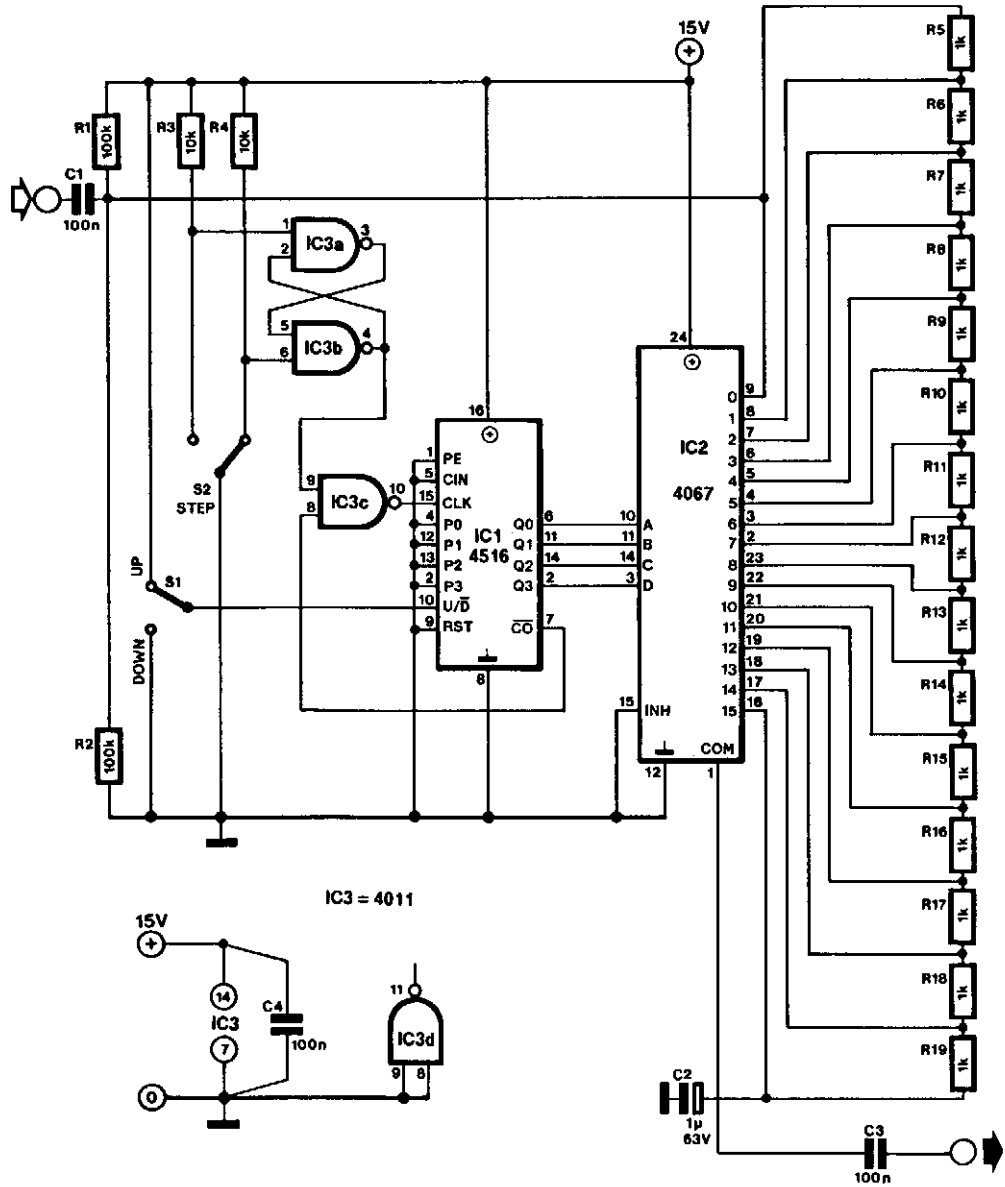
101

Volume/Level-Control Circuit

The source of the following circuit is contained in the Sources section, which begins on page 681. The figure number in the box correlates to the entry in the Sources section.

Digital Volume Control

DIGITAL VOLUME CONTROL



DIGITAL VOLUME CONTROL (Cont.)

The heart of the digitally operated volume control is IC2, a 4067 16-channel analog multiplexer. Depending on the logic state on pins A, B, C, and D of the multiplexer, one of its 16 inputs or outputs is connected to pin 1, which is the "wiper" of the control.

Because a 1-k Ω resistor has been connected between each input and output, the multiplexer can be considered a linear potentiometer with 16 fixed steps. Its overall resistance is 15 k Ω . It is, of course, possible to use a different value for each of the resistors to obtain a different characteristic.

The setting of the potentiometer is controlled by counter IC1. Dependent on the position of switch S1, the counter moves one step up or down when switch S1 is changed over. Circuits IC3A and IC3B debounce S2.

A jump from 0000 to 1111 or the other way around is not possible, because further count pulses are suppressed with the aid of the \overline{CO} line. This line is logic low when both the counter state and signal U/\overline{D} are 0.

When U/\overline{D} is high and the counter state is 15, \overline{CO} again becomes logic low. It is then necessary to reverse the logic state at U/\overline{D} , and thus the direction of counting. The volume control draws a current of around 1 mA.

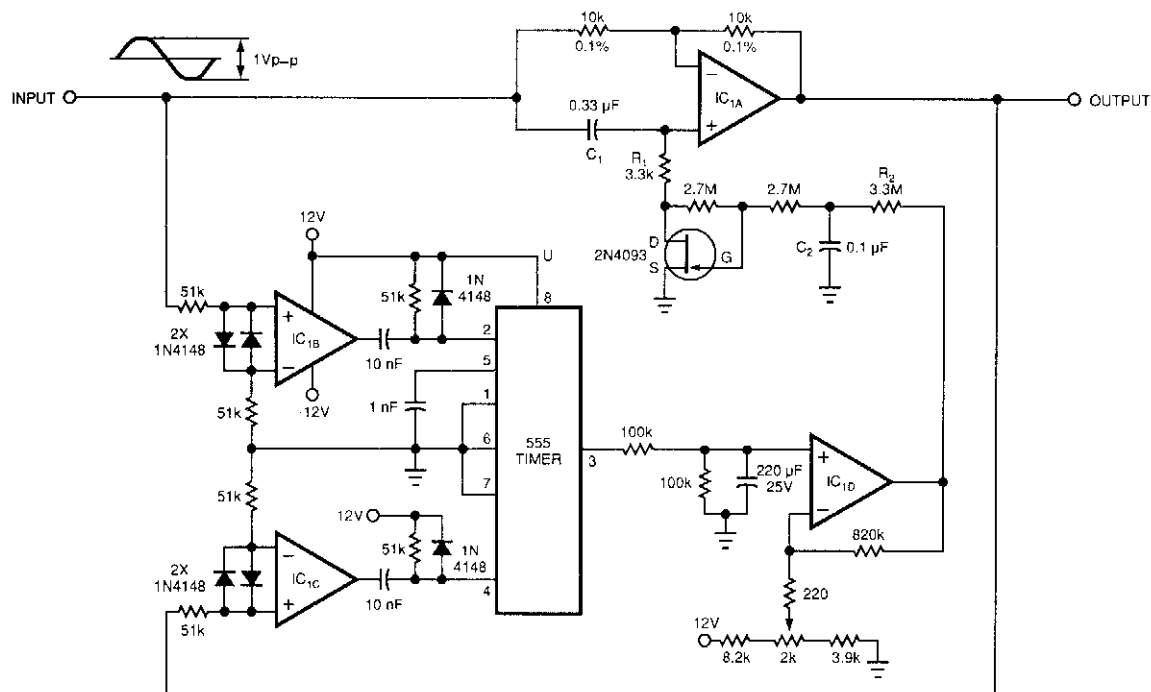
102

Wave-Shaping Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 681. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Phase Shifter
- Glitch-Free Clipper
- Signal Conditioner
- Harmonic Generator
- Full-Wave Rectifier (to 10 MHz)
- Capacitor Allows Higher Slew Rates
- S/R Flip-Flop

PHASE SHIFTER



EDN

Fig. 102-1

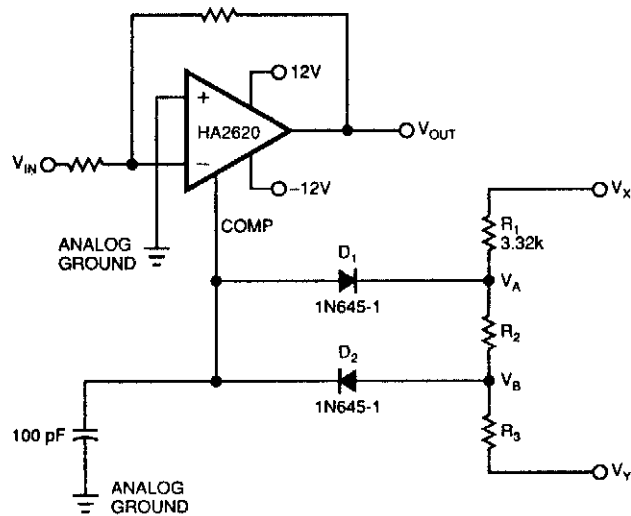
This circuit adds 120 degrees of phase shift to a 50- or 60-Hz input, regardless of the frequency and amplitude fluctuations of that input. The circuit configures a 2N4093 JFET as a voltage-controlled resistor whose value is proportional to the phase difference between the input and the output. The values of C_1 , R_1 , and r_{DS} determine the amount of phase shift (120° this case.)

A 555 timer implements a phase detector whose two inputs are related to the input and output. The input and output, respectively, drive IC1B and IC1C, which operate as zero-crossing detectors. D1 and D2 limit the positive-going pulses at the 555 inputs. Thus, the falling edges of IC1B and IC1C's outputs control the 555 timer. The timer's output signal stays low for a time that is proportional to the phase shift between the circuit's input and output.

The average value of the timer's output and an offsetting voltage drive IC1D. R2 and C2 filter IC1D's output. The resultant signal controls the JFET. The potentiometer sets the control at a value for which the phase shift between input and output is equal to 120 degrees when the input signal frequency is 50 or 60 Hz. Any differences between the input and output changes the 555 output's average value, thus ultimately modifying the control voltage and the JFET's resistance.

To calibrate the circuit, apply a 50-Hz sine wave with an amplitude of less than 1 Vpp to the input and adjust the potentiometer until the phase shift reads 120° on a digital phase meter. For input frequency variations between 40 and 60 Hz, the phase shift changed by a maximum of $\pm 0.17\%$ (equivalent to an offset of only $0.02^\circ/\text{Hz}$). The average value at IC1D's noninverting input is 3.864 V.

GLITCH-FREE CLIPPER



EDN

Fig. 102-2

Adding a simple clamping circuit to a Harris 2620 high-speed op amp produces a glitch-free amplifier/clipper. The op amp pin that controls the device's bandwidth is a high-impedance, isolated input. This pin also tracks the device's output voltage.

Therefore, D1, D2, R1, R2, and R3 will clamp the amplifier's output voltage only when the amplifier's input voltage exceeds your clamping-voltage limits. V_D is the diode drop of D1 or D2. The two clamp voltages, $V_A + V_D$ and $V_B - V_D$, are:

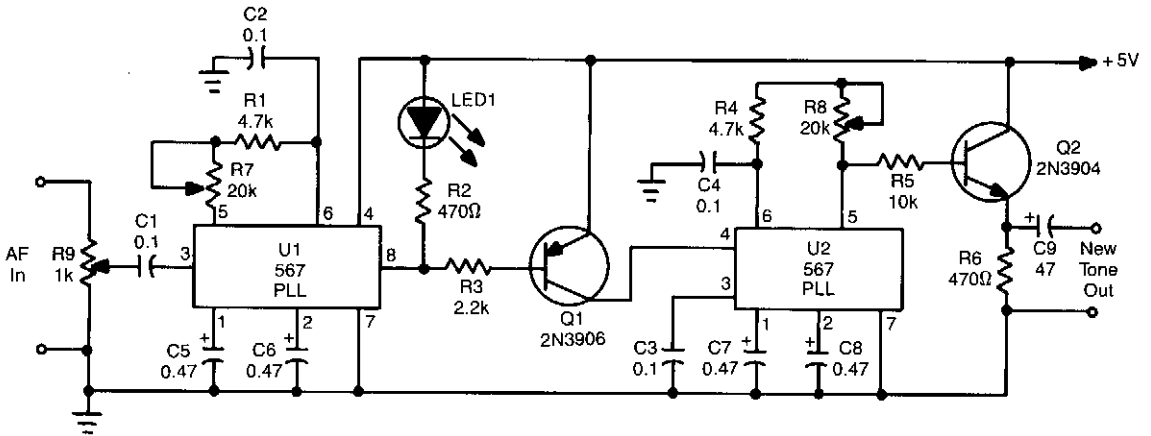
$$V_A = V_X \left(\frac{R_2 + R_3}{R_1 + R_2 + R_3} \right) + V_Y \left(\frac{R_1}{R_1 + R_2 + R_3} \right)$$

$$V_B = V_X \left(\frac{R_3}{R_1 + R_2 + R_3} \right) + V_Y \left(\frac{R_1 + R_2}{R_1 + R_2 + R_3} \right)$$

where V_X and V_Y are the clamping circuit's bias voltages. Choosing R_1 lets you determine the values of R_2 and R_3 . Try a value for R_1 around 3 k Ω .

One example of this circuit had clamping voltages of ± 3.7 V and exhibited THD below -75 dB for a sinusoidal, 30-kHz input signal. When the input signal increased beyond the ± 3.7 -V clamping voltage, the clipper symmetrically clamped the output voltage with no glitches in the waveform.

SIGNAL CONDITIONER

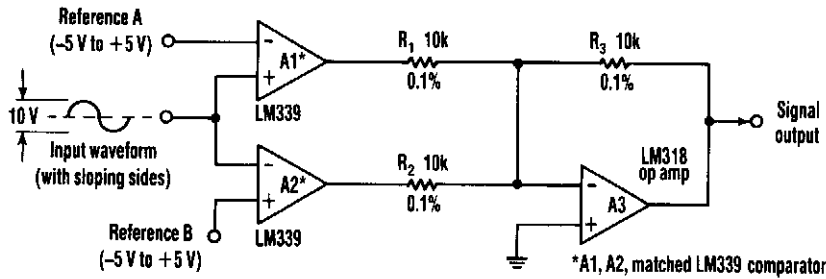


POPULAR ELECTRONICS

Fig. 102-3

This circuit takes audio from a receiver that might have a weak CW or tone signal and uses a PLL (U1) to recover the weak signal. U1 produces a low on receipt of a tone or note of frequency, determined by R1, R7, and C2. The output of U1 (pin 8) goes low, keys tone generator U2, and produces a new tone. The circuit is useful in cleaning up CW reception in static, noise, etc.

HARMONIC GENERATOR



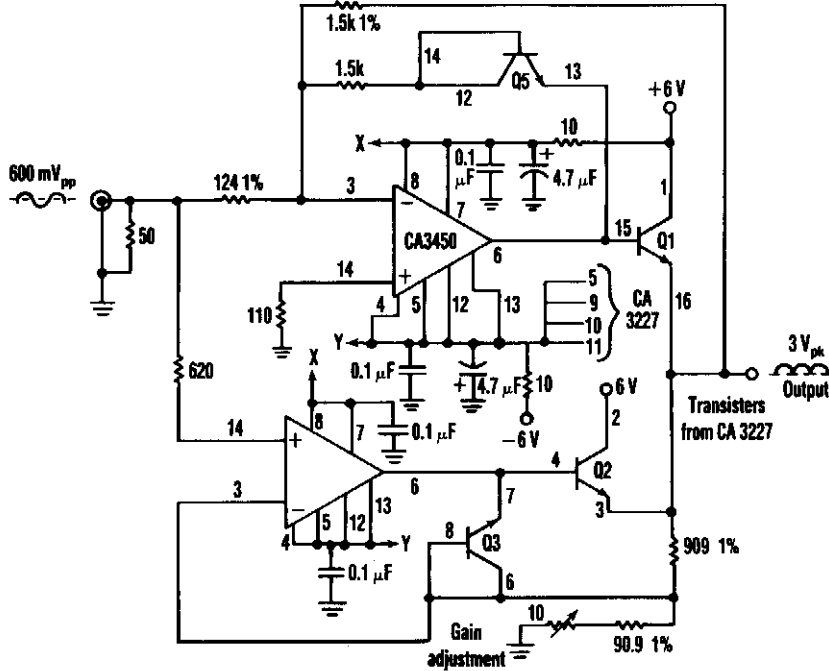
ELECTRONIC DESIGN

Fig. 102-4

This circuit can extract harmonics from various waveforms. With a sloped input waveform, the comparator produces a pulse width that is proportional to a reference plus input amplitude. As the pulse width changes, the harmonics spectrum changes. Combining the two comparator outputs eliminates some harmonics, depending on the duty cycle. Adjusting the references can create virtually any harmonic.

A1 and A2 should be matched, R1 and R2 should be equal to 0.1%, and A3 should have good common-mode rejection and high slew rate.

FULL-WAVE RECTIFIER (TO 10 MHz)

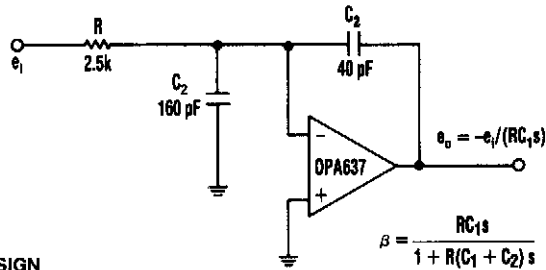


ELECTRONIC DESIGN

Fig. 102-5

Using two CA3450 op amps and a CA3227 transistor array, this circuit will accurately full-wave rectify signals to 10 MHz. Two of the CA3227 transistors drive the output, two are in the feedback circuits. Two transistors serve as clamping diodes, limit the negative-going signals of each amplifier, and keep both amplifiers active during the end cycle. The maximum output is determined by the slew rate of $300 \text{ V}/\mu\text{s}$ at highest frequencies. This output equals $300 \text{ V/ms} \div 6\pi \text{ V peak}$.

CAPACITOR ALLOWS HIGHER SLEW RATES

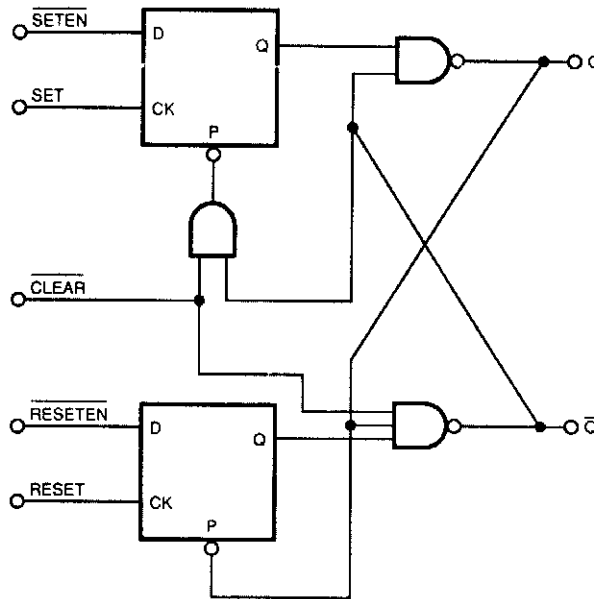


ELECTRONIC DESIGN

Fig. 102-6

In this circuit, a Burr-Brown op amp supplies a slew rate of $135 \text{ V}/\mu\text{s}$. The addition of C_2 charges the high-frequency feedback factor to less than unity, and allows higher slew-rate amplifiers to be compensated for greater-than-unity gain.

S/R FLIP-FLOP



EDN

Fig. 102-7

This circuit combines the characteristics of an asynchronous S/R flip-flop and an edge-triggered JK flip-flop. It changes state on the leading edges of its inputs, and ignores the levels at all other times.

In operation, outputs of both D flip-flops are normally high, going low for brief periods after seeing an edge at their respective clock inputs.

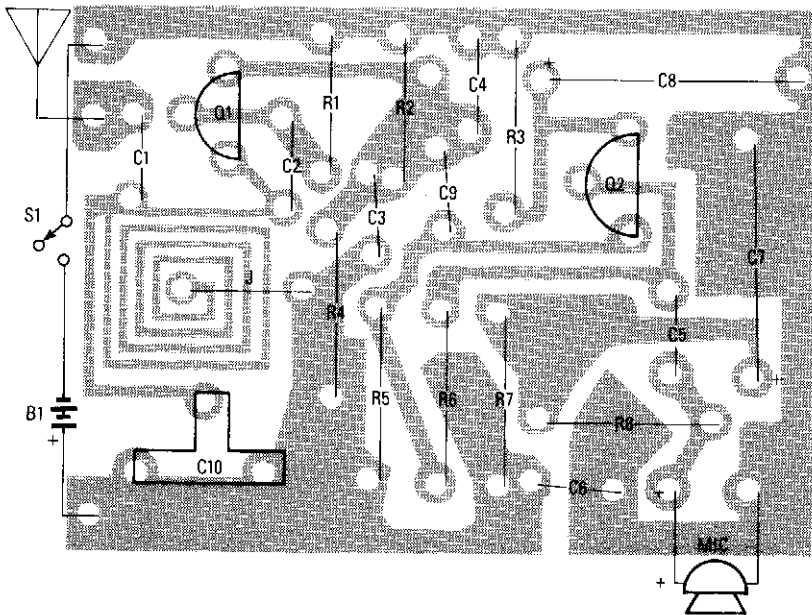
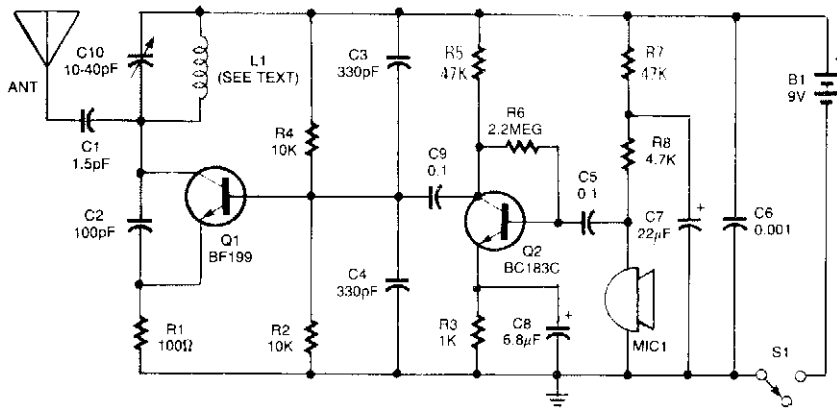
103

Wireless Microphones

The sources of the following circuits are contained in the Sources section, which begins on page 682. The figure number in the box of each circuit correlates to the entry in the Sources section.

Wireless FM Microphone
Wireless Microphone

WIRELESS FM MICROPHONE

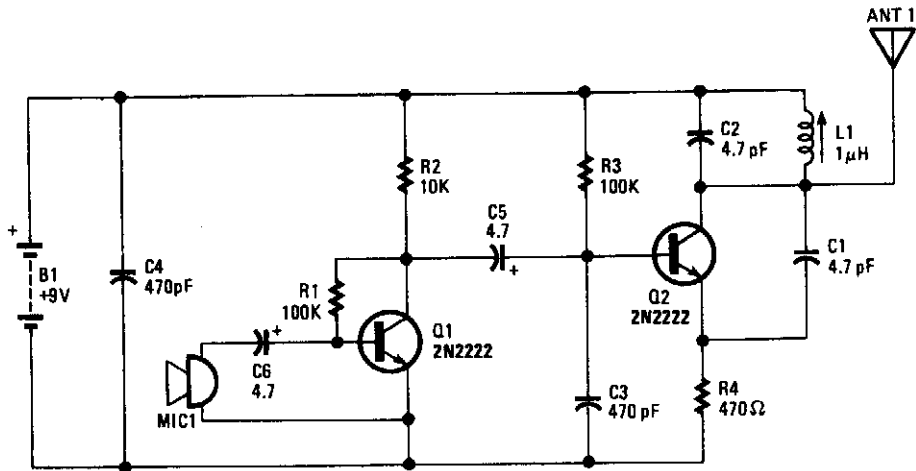


RADIO-ELECTRONICS

Fig. 103-1

A simple FM wireless microphone uses a single BC183C transistor as an audio amplifier. A 2N3565 can be substituted. Q1 is an oscillator that is FM modulated by the signal from Q1. Other transistors can be substituted, but the modulation characteristics should be checked.

WIRELESS MICROPHONE



POPULAR ELECTRONICS

Fig. 103-2

Q1 amplifies the output from an electret microphone MIC1. Audio is fed into oscillator Q2, which modulates the signal. L1C1 is a tank circuit for operation in the 88-MHz region. The antenna is a 6- to 8-inch piece of wire. L1 is a variable inductor in the 1- μ H range.

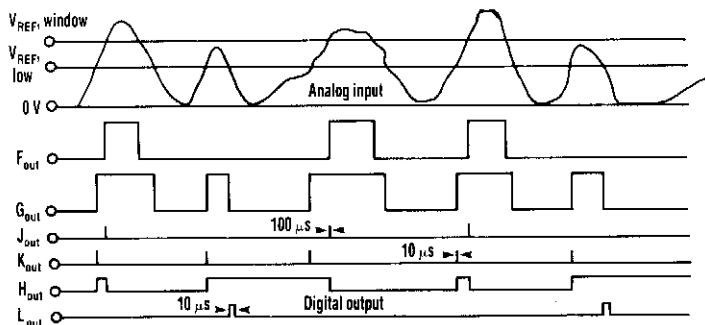
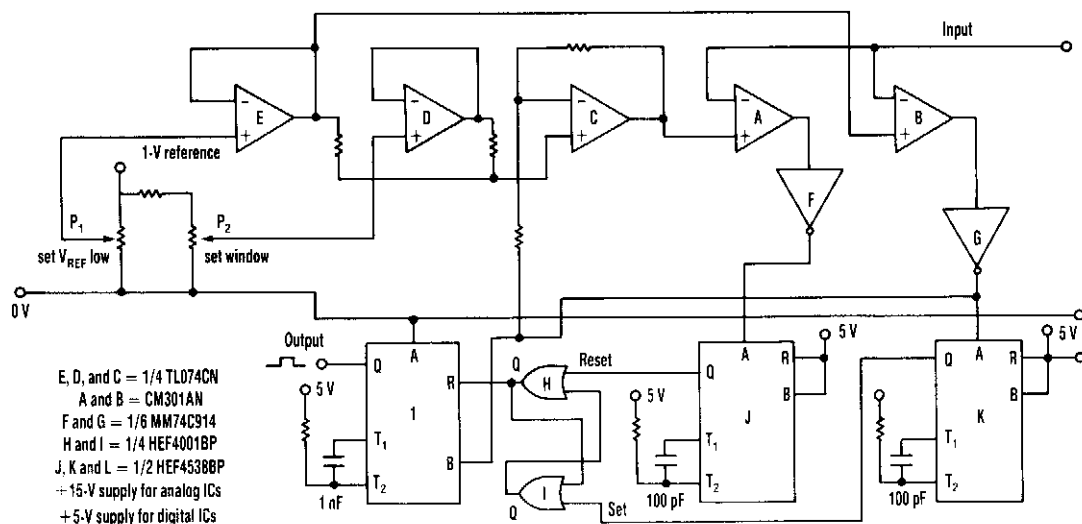
104

Window Circuits

The sources of the following circuits are contained in the Sources section, which begins on page 682. The figure number in the box of each circuit correlates to the entry in the Sources section.

Low-Cost Window Comparator
Window Generator
Window Comparators
Window Detector
Voltage Comparators

LOW-COST WINDOW COMPARATOR



ELECTRONIC DESIGN

Fig. 104-1

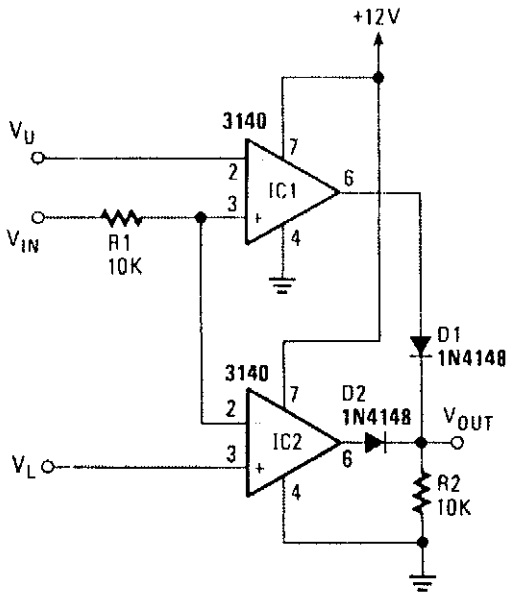
This circuit outputs a TTL-compatible 100- μ s pulse whenever the signal falls within the limits set by potentiometers and can be varied to suit the application.

Op amps, E, D, and C are used with the two potentiometers to supply reference voltages, derived from a 1-V precision source, for two other op amps (A and B) configured as voltage comparators. The input signal is taken to the negative inputs of both these comparators. C is wired as a noninverting summing amp, used to derive the higher reference voltage. Consequently, the acceptance window is set. Because the voltage across potentiometer P2 is 0.5 V, the window can be set between 0 and 0.5 V above the value chosen for the lower reference value. The lower value is set by P1.

The outputs from the comparators are sent to the inputs of inverting Schmitt triggers F and G. Although these triggers operate from a 5-V supply, they have an extended input-voltage range and are capable of handling the comparator's output voltage swings.

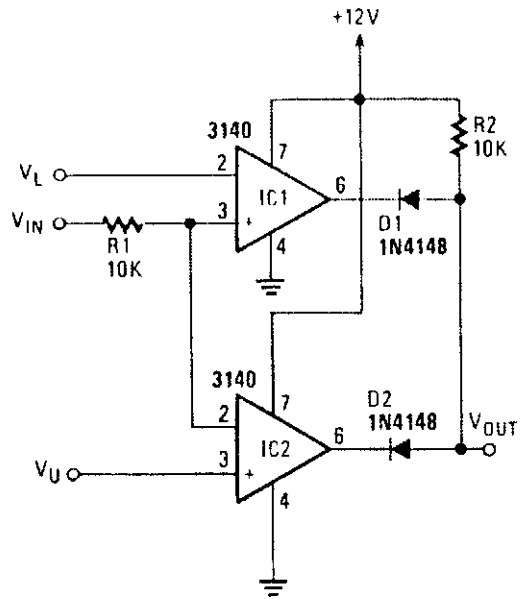
The two monostables, J and K, are triggered on the rising edge of the Schmitt outputs. J and K set and reset the bistable latch formed by two NOR gates. Latch output Q controls the reset of output

WINDOW COMPARATORS



RADIO-ELECTRONICS

Fig. 104-3(a)

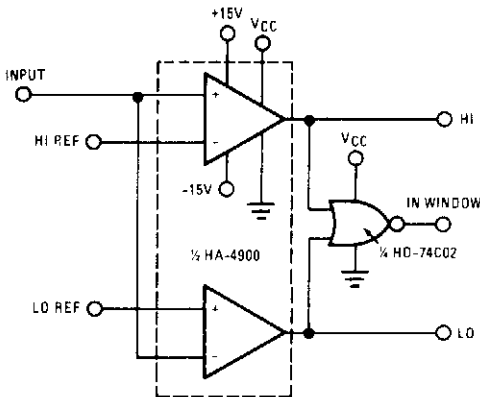


RADIO-ELECTRONICS

Fig. 104-3(b)

In Fig. 104-3(a), when V_{IN} is between reference voltages V_L and V_U , output V_{OUT} goes low. If $V_{IN} > V_L$, IC2 produces a low. Because IC1 outputs low, if $V_{IN} > V_U$, both outputs are low and V_{OUT} is low. If $V_{IN} < V_L$, both IC1 and IC2 are low. Figure 104-3(b) operates the reverse of this; it produces a high when $V_L < V_{IN} < V_U$.

WINDOW DETECTOR

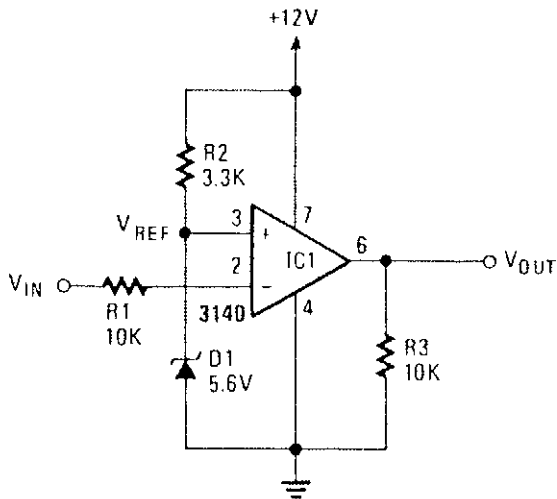


HARRIS

Fig. 104-4

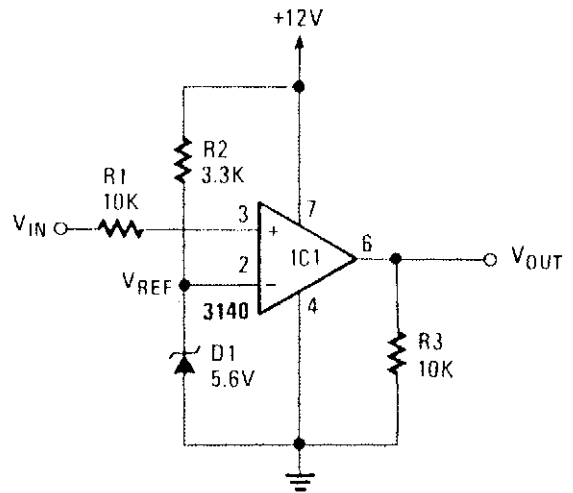
The high switching speed, low offset current and low offset voltage of the HA-4900 series make this window detector extremely well-suited for applications that require fast, accurate decision-making. This circuit is ideal for industrial-process system-feedback controllers, or "out-of-limit" alarm indicators.

VOLTAGE COMPARATORS



RADIO-ELECTRONICS

Fig. 104-5(a)



RADIO-ELECTRONICS

Fig. 104-5(b)

These two comparators are over- and under-voltage comparators. In Fig. 104-5(a), if V_{IN} exceeds the reference voltage, the output of IC1 goes low. In Fig. 104-5(b), if the V_{IN} exceeds the reference, V_{OUT} goes high.

Sources

Chapter 1

- Fig. 1-1. Reprinted with permission from Popular Electronics, 11/90, p. 85. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 1-2. Reprinted with permission from Popular Electronics, 11/90, © Copyright Gernsback Publications, Inc., 1990.
- Fig. 1-3. Elektor Electronics USA, 5/91, p. 51–53.
- Fig. 1-4. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 88. © Copyright Gernsback Publications, Inc., 1990.

Chapter 2

- Fig. 2-1. Reprinted from EDN, 2/91, p. 184. © 1991 Cahners Publishing Co., a division of Reed Publishing USA.

Chapter 3

- Fig. 3-1. Hands-On Electronics, 8/87, p. 94.
- Fig. 3-2. Reprinted with permission from Popular Electronics Fact Card No. 185. © Copyright Gernsback Publications, Inc.
- Fig. 3-3. Reprinted with permission from Radio-Electronics, 9/87, p. 65. © Copyright Gernsback Publications, Inc., 1987.

- Fig. 3-4. Reprinted with permission from Popular Electronics, 12/77, p. 82–83. © Copyright Gernsback Publications, Inc., 1977.
- Fig. 3-5. Reprinted with permission from Popular Electronics, 1/91, p. 81. © Copyright Gernsback Publications, Inc., 1991.

Chapter 4

- Fig. 4-1. Elektor Electronics USA, 6/91, p. 42.
- Fig. 4-2. Reprinted with permission from Popular Electronics, 7/90, p. 80–81. © Copyright Gernsback Publications, Inc., 1990.

Chapter 5

- Fig. 5-1. Elektor Electronics, 12/90, p. 523–524.
- Fig. 5-2. Hands-On Electronics, 8/87, p. 93.
- Fig. 5-3. QST, 5/90, p. 22–24.
- Fig. 5-4. Elektor Electronics, 7/89 Supplement, p. 5–6.
- Fig. 5-5. Electronics Today International, 4/79, p. 70.
- Fig. 5-6. Elektor Electronics, 301 Circuits, p. 30–31.
- Fig. 5-7. Electronics Today International, 4/78, p. 31.
- Fig. 5-8. Reprinted with permission from Popular Electronics, 4/90, p.37–38. © Copyright Gernsback Publications, Inc., 1990.

- Fig. 5-9. Electronics World, 4/66.
Fig. 5-10. Reprinted with permission from Electronic Design, 12/89, p. 71–72. Copyright 1989 Penton Publishing.

Chapter 6

- Fig. 6-1. Reprinted with permission from Popular Electronics, 7/91, p. 70–71. © Copyright Gernsback Publications, Inc., 1991.
Fig. 6-2. Hands-On Electronics, 8/87, p. 90.

Chapter 7

- Fig. 7-1. Reprinted with permission from Popular Electronics, 7/91, p. 40–42. © Copyright Gernsback Publications, Inc., 1991.
Fig. 7-2. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 90. © Copyright Gernsback Publications, Inc., 1990.
Fig. 7-3. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 23.
Fig. 7-4. Reprinted with permission from Popular Electronics, 3/90. © Copyright Gernsback Publications, Inc., 1990.
Fig. 7-5. Reprinted with permission from Radio-Electronics, 1/90, p. 40. © Copyright Gernsback Publications, Inc., 1990.
Fig. 7-6. Reprinted with permission from Popular Electronics, 10/90, p. 90. © Copyright Gernsback Publications, Inc., 1990.
Fig. 7-7. Reprinted with permission from Radio-Electronics, 9/89, p. 41. © Copyright Gernsback Publications, Inc., 1989.
Fig. 7-8. Reprinted with permission from Radio-Electronics, 1/89, p. 71. © Copyright Gernsback Publications, Inc., 1989.

Chapter 8

- Fig. 8-1. Elektor Electronics, 12/90 Supplement, p. 36–37.
Fig. 8-2. Reprinted with permission from Radio-Electronics, 2/90, p. 56. © Copyright Gernsback Publications, Inc., 1990.
Fig. 8-3. Reprinted with permission from Radio-Electronics, 2/90, p. 56. © Copyright Gernsback Publications, Inc., 1990.
Fig. 8-4. Reprinted with permission from Radio-Electronics, 2/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.
Fig. 8-5. Reprinted with permission from Radio-Electronics, 2/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.

Fig. 8-6. Reprinted with permission from Popular Electronics, 8/90, p. 82. © Copyright Gernsback Publications, Inc., 1990.

Fig. 8-7. Reprinted with permission from Radio-Electronics, 2/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.

Fig. 8-8. Reprinted with permission from Radio-Electronics, 2/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.

Fig. 8-9. Reprinted with permission from Popular Electronics, 3/90, p. 72. © Copyright Gernsback Publications, Inc., 1990.

Fig. 8-10. Elektor Electronics, 12/90, p. 514.

Fig. 8-11. Elektor Electronics, 12/90, p. 511.

Fig. 8-12. Reprinted with permission from Electronic Design, 7/91, p. 139. Copyright 1991, Penton Publishing.

Fig. 8-13. Reprinted with permission from Electronic Design, 9/90, p. 90. Copyright 1990, Penton Publishing.

Fig. 8-14. Reprinted with permission from Popular Electronics, Fact Card No. 173. © Copyright Gernsback Publications, Inc.

Fig. 8-15. QST, 10/90, p. 41.

Fig. 8-16. Reprinted with permission from Popular Electronics, Fact Card No. 185. © Copyright Gernsback Publications, Inc.

Chapter 9

Fig. 9-1. Reprinted with permission from Radio-Electronics, 7/90, p. 33. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-2. Reprinted with permission from Radio-Electronics, 7/90, p. 36. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-3. Elektor Electronics, 12/90 Supplement, p. 43.

Fig. 9-4. Reprinted with permission from Radio-Electronics, 7/90, p. 36. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-5. Reprinted with permission from Radio-Electronics, 7/90, p. 35–36. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-6. Reprinted with permission from Popular Electronics, 6/89, p. 23. © Copyright Gernsback Publications, Inc., 1989.

Fig. 9-7. Reprinted with permission from Radio-Electronics, 8/90, p. 42. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-8. Reprinted with permission from Radio-Electronics, 7/90, p. 32. © Copyright Gernsback Publications, Inc., 1990.

Fig. 9-9. Reprinted with permission from Radio-Electronics, 7/90, p. 36. © Copyright Gernsback Publications, Inc., 1990.

Chapter 10

Fig. 10-1. Reprinted with permission from Popular Electronics, 2/90, p. 24–26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-2. Reprinted with permission from Popular Electronics, 2/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-3. Reprinted with permission from Radio-Electronics, 7/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-4. Reprinted with permission from Popular Electronics, 8/89, p. 24. © Copyright Gernsback Publications, Inc., 1989.

Fig. 10-5. Reprinted with permission from Popular Electronics, 12/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-6. Reprinted with permission from Popular Electronics, 1/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-7. Reprinted with permission from Radio-Electronics, 5/90, p. 65. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-8. Reprinted from EDN, 9/84, p. 290. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 10-9. Reprinted with permission from Radio-Electronics, 5/90, p. 64. © Copyright Gernsback Publications, Inc., 1990.

Fig. 10-10. Reprinted with permission from Popular Electronics, 11/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Chapter 11

Fig. 11-1. Elektor Electronics, 7/89 Supplement, p. 15.

Fig. 11-2. Elektor Electronics, 12/90, p. 527–528.

Fig. 11-3. Reprinted with permission from Popular Electronics, 12/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Fig. 11-4. Reprinted with permission from Popular Electronics, 9/89, p. 22. © Copyright Gernsback Publications, Inc., 1989.

Fig. 11-5. Reprinted with permission from Hands-On Electronics/Popular Electronics, 12/88, p. 24. © Copyright Gernsback Publications, Inc., 1988.

Fig. 11-6. Elektor Electronics, 7/89, p. S41.

Fig. 11-7. Reprinted with permission from Popular Electronics, 7/89, p. 76–77. © Copyright Gernsback Publications, Inc., 1989.

Fig. 11-8. Reprinted with permission from Popular Electronics, 8/89, p. 23. © Copyright Gernsback Publications, Inc., 1989.

Fig. 11-9. Hands-On Electronics, 9–10/86, p. 26.

Fig. 11-10. Reprinted with permission from Popular Electronics, 12/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Chapter 12

Fig. 12-1. Reprinted with permission from Radio-Electronics, 4/90, p. 47. © Copyright Gernsback Publications, Inc., 1990.

Fig. 12-2. Elektor Electronics, 12/90, p. 57.

Fig. 12-3. Reprinted with permission from Radio-Electronics, 3/89, p. 51–52. © Copyright Gernsback Publications, Inc., 1989.

Fig. 12-4. Elektor Electronics, 12/90, p. 526.

Fig. 12-5. Reprinted with permission from Radio-Electronics, 8/91, p. 8. © Copyright Gernsback Publications, Inc., 1991.

Chapter 13

Fig. 13-1. Elektor Electronics, 12/90, p. 522.

Fig. 13-2. Hands-On Electronics, 11/87, p. 92.

Fig. 13-3. Reprinted with permission from Popular Electronics, Fact Card No. 134. © Copyright Gernsback Publications, Inc.

Fig. 13-4. Reprinted with permission from Popular Electronics, Fact Card No. 95. © Copyright Gernsback Publications, Inc.

Fig. 13-5. Reprinted with permission from Popular Electronics, 3/90, p. 38. © Copyright Gernsback Publications, Inc., 1990.

Fig. 13-6. Reprinted from EDN, 2/7/85, p. 243. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 14

Fig. 14-1. Elektor Electronics, 12/90, p. 519.

Fig. 14-2. Reprinted from EDN, 5/91, p. 165. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 14-3. Reprinted from EDN, 6/91, p. 168. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 14-4. Reprinted from EDN, 5/90, p. 148. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 14-5. Reprinted from EDN, 2/91, p. 108. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 14-6. Elektor Electronics, 5/91, p. 33.

Fig. 14-7. Reprinted with permission from Popular Electronics, 8/90, p. 40–41. © Copyright Gernsback Publications, Inc., 1990.

Fig. 14-8. 42 New Ideas, 1984, p. 14, Gernsback Publications, Inc.

Fig. 14-9. Electronic Engineering, 11/78, p. 24.

Fig. 14-10. Maxim, Seminar Applications Book, 1988/89, p. 35.

Fig. 14-11. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 19.

Chapter 15

Fig. 15-1. Reprinted from EDN, Design Ideas Special Issue, Vol. III, 2/89, p. 47. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 15-2. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 26. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 15-3. 73 Amateur Radio, 4/91, p. 11–12.

Chapter 16

Fig. 16-1. Reprinted with permission from Radio-Electronics, 5/90, p. 64. © Copyright Gernsback Publications, Inc., 1990.

Fig. 16-2. Reprinted with permission from Popular Electronics, 8/90, p. 92. © Copyright Gernsback Publications, Inc., 1990.

Fig. 16-3. Reprinted with permission from Popular Electronics, 12/90, p. 41–42. © Copyright Gernsback Publications, Inc., 1990.

Fig. 16-4. Reprinted with permission from Popular Electronics, Fact Card No. 173. © Copyright Gernsback Publications, Inc.

Fig. 16-5. Reprinted with permission from Radio-Electronics, 5/90, p. 65. © Copyright Gernsback Publications, Inc., 1990.

Fig. 16-6. Reprinted with permission from Radio-Elec-

tronics, 5/90, p. 62. © Copyright Gernsback Publications, Inc., 1990.

Fig. 16-7. Reprinted with permission from Radio-Electronics, 5/90, p. 62. © Copyright Gernsback Publications, Inc., 1990.

Chapter 17

Fig. 17-1. Reprinted from EDN, 2/91, p. 105. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 17-2. Reprinted from EDN, 11/90, p. 282. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 17-3. Hands-On Electronics, Fact Card No. 89.

Chapter 18

Fig. 18-1. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 158. © Copyright Gernsback Publications, Inc., 1990.

Fig. 18-2. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 162. © Copyright Gernsback Publications, Inc., 1990.

Chapter 19

Fig. 19-1. Reprinted from EDN, 1/91, p. 160–161. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 19-2. Elektor Electronics, 12/90, p. 534–535.

Chapter 20

Fig. 20-1. Reprinted from EDN, 3/91, p. 161. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-2. Elektor Electronics, 6/89, p. S42.

Fig. 20-3. Reprinted from EDN, 9/89, p. 168. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-4. Reprinted from EDN, 5/91, p. 166. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-5. Electronic Engineering, 2/90, p. 29.

Fig. 20-6. Reprinted from EDN, 2/90, p. 135. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-7. Reprinted with permission from Popular Electronics, 8/91, p. 20. © Copyright Gernsback Publications, Inc., 1991.

Fig. 20-8. Reprinted with permission from Popular Electronics, 1/91, p. 23–24. © Copyright Gernsback Publications, Inc., 1991.

Fig. 20-9. Reprinted with permission from Electronic Design, 9/89, p. 93. Copyright 1989, Penton Publishing.

Fig. 20-10. Reprinted with permission from Popular Electronics, 12/90, p. 23. © Copyright Gernsback Publications, Inc., 1990.

Fig. 20-11. Elektor Electronics, 7/89, p. S36.

Fig. 20-12. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 29. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-13. Reprinted from EDN, 1/90, p. 140. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-14. Reprinted from EDN, 11/90, p. 22. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 20-15. Harris, Analog Product Data Book, 1988, p.10–23.

Fig. 20-16. Reprinted with permission from Popular Electronics, 1/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Chapter 21

Fig. 21-1. Reprinted from EDN, 7/90, p. 192. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 21-2. Reprinted from EDN, 7/89, p. 151. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 21-3. Elektor Electronics, 12/90, p. 513–514.

Fig. 21-4. Elektor Electronics, 12/90, p. 56.

Fig. 21-5. Reprinted with permission from Electronic Design, 6/91, p. 110. Copyright 1991, Penton Publishing.

Fig. 21-6. Elektor Electronics, 12/90, p. 530–531.

Fig. 21-7. Reprinted from EDN, 3/90, p. 140. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 21-8. Linear Technology, Design Note No. 2.

Fig. 21-9. Reprinted with permission from Electronic Design, 9/90, p. 93.

Fig. 21-10. Linear Technology, 6/27/91, Advertisement.

Fig. 21-11. Linear Technology, 6/27/91, Advertisement.

Fig. 21-12. Maxim, 1986 Power Supply Circuits, p. 26.

Fig. 21-13. Reprinted with permission from Radio-Electronics, 6/86, p. 59. © Copyright Gernsback Publications, Inc., 1986.

Fig. 21-14. Reprinted with permission from Radio-Electronics, 9/89, p. 60. © Copyright Gernsback Publications, Inc., 1989.

Chapter 22

Fig. 22-1. Reprinted from EDN, 10/90, p. 132. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 22-2. RF Design, 7/90, p. 63.

Fig. 22-3. RF Design, 7/90, p. 63.

Fig. 22-4. Reprinted with permission from Popular Electronics, 11/91, p. 68. © Copyright Gernsback Publications, Inc., 1991.

Fig. 22-5. Reprinted with permission from Popular Electronics, 7/91, p. 58. © Copyright Gernsback Publications, Inc., 1991.

Fig. 22-6. 73 Amateur Radio, 10/90, p. 65.

Fig. 22-7. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-8. RF Design, 7/90, p. 64.

Fig. 22-9. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-10. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-11. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-12. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-13. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-14. Reprinted with permission from Popular Electronics, 11/90, p. 69. © Copyright Gernsback Publications, Inc., 1990.

Fig. 22-15. Valpey-Fisher Corp., A User's Guide to Quartz Crystal Oscillators.

Fig. 22-16. Reprinted from EDN, 11/90, p. 234. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 22-17. Elektor Electronics, 302 Circuits, p. 128–129.

Fig. 22-18. William Sheets.

Chapter 23

Fig. 23-1. Reprinted from EDN, 12/89, p. 262. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 23-2. Harris, Analog Product Data Book, 1988, p. 10–49.

Fig. 23-3. Harris, Analog Product Data Book, 1988, p. 2–105.

Fig. 23-4. Reprinted with permission from Radio-Electronics, 12/89, p. 58. © Copyright Gernsback Publications, Inc., 1989.

Fig. 23-5. Reprinted with permission from Electronic Design, 6/90, p. 102–103. Copyright 1991, Penton Publishing.

Chapter 24

Fig. 24-1. Elektor Electronics, 12/90, p. 520.

Fig. 24-2. Reprinted from EDN, 12/89, p. 260–261. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 24-3. Reprinted with permission from Popular Electronics, 8/91, p. 73. © Copyright Gernsback Publications, Inc., 1991.

Fig. 24-4. Reprinted with permission from Popular Electronics, 3/91, p. 92. © Copyright Gernsback Publications, Inc., 1991.

Fig. 24-5. Reprinted from EDN, 5/90, p. 173. Copyright 1991, Penton Publishing.

Fig. 24-6. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Fig. 24-7. ARRL Handbook, 1991, p. 18–13.

Fig. 24-8. Reprinted with permission from Popular Electronics, 9/91, p. 75. © Copyright Gernsback Publications, Inc., 1991.

Fig. 24-9. RCA, ICAN #6629, Design Guide for Fire Detection Systems, p. 6.

Fig. 24-10. Reprinted with permission from Popular Electronics, 5/91, p. 63. © Copyright Gernsback Publications, Inc., 1991.

Fig. 24-11. RF Design, 4/90, p. 35–36.

Fig. 24-12. Reprinted with permission from Electronic Design, 12/90, p. 61. Copyright 1991, Penton Publishing.

Fig. 24-13. Reprinted with permission from Popular Electronics, 3/90, p. 46. © Copyright Gernsback Publications, Inc., 1990.

Fig. 24-14. ARRL Handbook, 1991, p. 18–14.

Fig. 24-15. Harris, Analog Product Data Book, 1988, p. 10–84.

Fig. 24-16. Reprinted with permission from Popular Electronics, 9/91, p. 74. © Copyright Gernsback Publications, Inc., 1991.

Fig. 24-17. Reprinted with permission from Popular Electronics, 9/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Fig. 24-18. Reprinted with permission from Radio-Electronics, 9/89, p. 59. © Copyright Gernsback Publications, Inc., 1989.

Chapter 25

Fig. 25-1. Reprinted from EDN, 12/90, p. 228–230. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 25-2. 73 Amateur Radio, 7/90, p. 9–11.

Chapter 26

Fig. 26-1. Reprinted with permission from Electronic Design, 6/91, p. 109–114. Copyright 1991, Penton Publishing.

Fig. 26-2. Reprinted with permission from Electronic Design, 3/91, p. 87–88. Copyright 1991, Penton Publishing.

Fig. 26-3. Reprinted from EDN, 6/89, p. 207. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 26-4. 73 Amateur Radio, 3/91, p. 74.

Fig. 26-5. Reprinted with permission from Electronic Design, 11/89, p. 111. Copyright 1989, Penton Publishing.

Fig. 26-6. Reprinted from EDN, 6/91, p. 174. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 27

Fig. 27-1. Elektor Electronics, 12/90, p. 526–527.

Fig. 27-2. Reprinted with permission from Electronic Design, 12/88, p. 104. Copyright 1991, Penton Publishing.

Fig. 27-3. Reprinted with permission from Radio-Electronics, 9/87, p. 65. © Copyright Gernsback Publications, Inc., 1987.

Chapter 28

Fig. 28-1. Reprinted with permission from Popular Electronics, 11/90, p. 61–62. © Copyright Gernsback Publications, Inc., 1990

Fig. 28-2. Reprinted with permission from Popular Electronics, 12/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Chapter 29

Fig. 29-1. 73 Amateur Radio, 2/91, p. 24.

Fig. 29-2. Reprinted with permission from Popular Electronics, 10/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.

Fig. 29-3. Elektor Electronics, 302 Circuits, p. 134.

Chapter 30

- Fig. 30-1. *Electronic Engineering*, 2/90, p. 30.
- Fig. 30-2. Reprinted with permission from *Popular Electronics*, 11/89, p. 101. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 30-3. *Elektor Electronics*, 12/90, p. 530.
- Fig. 30-4. *Elektor Electronics*, 7/89, p. S37.
- Fig. 30-5. *ARRL Handbook*, 1991, p. 16–6.
- Fig. 30-6. Reprinted from *EDN*, 2/91, p. 186–188. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 30-7. Reprinted with permission from *Radio-Electronics*, 2/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 30-8. Reprinted with permission from *Radio-Electronics*, 5/89, p. 58. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 30-9. Reprinted with permission from *Radio-Electronics*, 5/89, p. 58. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 30-10. Reprinted with permission from *Wels' Think Tank*, Gernsback Publications Inc., p. 52.
- Fig. 30-11. Reprinted with permission from *Radio-Electronics*, 5/89, p. 58. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 30-12. Reprinted with permission from *Radio-Electronics*, 2/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 30-13. Reprinted with permission from *Radio-Electronics*, 2/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 30-14. *Electronics Today International*, 4/79, p. 76.
- Fig. 30-15. Reprinted with permission from *Radio-Electronics*, 10/90, p. 78. © Copyright Gernsback Publications, Inc., 1990.

Chapter 31

- Fig. 31-1. Reprinted from *EDN*, 10/88, p. 327. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 31-2. Reprinted from *EDN*, 6/84, p. 242. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 31-3. Reprinted with permission from *Radio-Electronics*, 2/91, p. 33–34. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 31-4. Reprinted with permission from *Radio-Electronics*, 2/87, p. 36. © Copyright Gernsback Publications, Inc., 1987.

- Fig. 31-5. Reprinted from *EDN*, 7/73, p. 87. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 31-6. Reprinted with permission from *Popular Electronics*, 1/91, p. 25. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 31-7. Reprinted from *EDN*, 7/73, p. 87. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 31-8. *Elektor Electronics*, 12/90 Supplement, p. 43.
- Fig. 31-9. Reprinted with permission from *Popular Electronics*, 6/89, p. 22. © Copyright Gernsback Publications, Inc., 1989.

Chapter 32

- Fig. 32-1. Reprinted with permission from *Popular Electronics*, 3/91, p. 24. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 32-2. Reprinted from *EDN*, 12/90, p. 217. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 32-3. *Elektor Electronics*, 301 Circuits, p. 131.
- Fig. 32-4. *Elektor Electronics*, 12/90, p. 55–56.
- Fig. 32-5. Reprinted with permission from *Popular Electronics*, 9/91, p. 76. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 32-6. Reprinted with permission from *Radio-Electronics*, 7/90, p. 59. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 32-7. Reprinted with permission from *Popular Electronics*, Fact Card No. 107. © Copyright Gernsback Publications, Inc.
- Fig. 32-8. Reprinted with permission from *Popular Electronics*, 3/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 32-9. Reprinted with permission from *Popular Electronics*, 11/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 32-10. Reprinted with permission from *Popular Electronics*, 1/90, p. 43. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 32-11. Reprinted with permission from *Popular Electronics*, 1/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Chapter 33

- Fig. 33-1. Reprinted with permission from *Radio-Electronics*, 6/91, p. 56. © Copyright Gernsback Publications, Inc., 1991.

Fig. 33-2. Reprinted with permission from Popular Electronics, Fact Card No. 134. © Copyright Gernsback Publications, Inc.

Fig. 33-3. Elektor Electronics, 12/90, p. 510–511.

Fig. 33-4. Reprinted with permission from Popular Electronics, Fact Card No. 98. © Copyright Gernsback Publications, Inc.

Fig. 33-5. Reprinted with permission from Radio-Electronics, 6/91, p. 58–59. © Copyright Gernsback Publications, Inc., 1991.

Chapter 34

Fig. 34-1. Hands-On Electronics, 11/86, p. 33.

Fig. 34-2. Reprinted with permission from Electronic Design, 5/91, p. 95. Copyright 1991, Penton Publishing.

Fig. 34-3. Reprinted with permission from Radio-Electronics, 2/91, p. 23. © Copyright Gernsback Publications, Inc., 1991.

Fig. 34-4. Reprinted with permission from Radio-Electronics, 6/91, p. 56–57. © Copyright Gernsback Publications, Inc., 1991.

Fig. 34-5. Reprinted with permission from Radio-Electronics, 12/89, p. 57. © Copyright Gernsback Publications, Inc., 1989.

Fig. 34-6. Reprinted with permission from Electronic Design, 8/90, p. 94–96. Copyright 1991, Penton Publishing.

Fig. 34-7. Hands-On Electronics, 8/87, p. 93.

Fig. 34-8. Reprinted with permission from Electronic Design, 6/90, p. 100. Copyright 1991, Penton Publishing.

Fig. 34-9. Reprinted with permission from Electronic Design, 9/90, p. 89. Copyright 1991, Penton Publishing.

Chapter 35

Fig. 35-1. Reprinted with permission from Radio-Electronics, 4/90, p. 33–36. © Copyright Gernsback Publications, Inc., 1990.

Fig. 35-2. Reprinted with permission from Popular Electronics, 6/89, p. 90. © Copyright Gernsback Publications, Inc., 1989.

Fig. 35-3. Reprinted with permission from Radio-Electronics, 12/89, p. 57. © Copyright Gernsback Publications, Inc., 1989.

Fig. 35-4. Reprinted with permission from Popular Electronics, 10/77, p. 82. © Copyright Gernsback Publications, Inc., 1977.

Fig. 35-5. Reprinted with permission from Popular Electronics, 1/90, p. 70. © Copyright Gernsback Publications, Inc., 1990.

Fig. 35-6. Reprinted with permission from Popular Electronics, 12/89, p. 24–25. © Copyright Gernsback Publications, Inc., 1989.

Chapter 36

Fig. 36-1. Reprinted from EDN, 10/90, p. 235. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 37

Fig. 37-1. Electronic Engineering, 4/90, p. 42.

Fig. 37-2. Elektor Electronics, 12/90, p. 532–533.

Fig. 37-3. Reprinted with permission from Popular Electronics, 9/91, p. 22. © Copyright Gernsback Publications, Inc., 1991.

Fig. 37-4. 73 Amateur Radio, 10/90, p. 46.

Fig. 37-5. Reprinted with permission from Popular Electronics, 3/91, p. 25. © Copyright Gernsback Publications, Inc., 1991.

Fig. 37-6. Reprinted with permission from Radio-Electronics, 2/91, p. 83. © Copyright Gernsback Publications, Inc., 1991.

Fig. 37-7. Elektor Electronics, 7/89, p. S44.

Fig. 37-8. Elektor Electronics, 7/89, p. 40–41.

Fig. 37-9. Elektor Electronics, 7/89, p. S41.

Fig. 37-10. Reprinted with permission from Radio-Electronics, 7/90, p. 59. © Copyright Gernsback Publications, Inc., 1990.

Fig. 37-11. Ham Radio, 4/90, p. 66.

Chapter 38

Fig. 38-1. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 59. © Copyright Gernsback Publications, Inc., 1987.

Fig. 38-2. Reprinted with permission from Popular Electronics, 4/90, p. 91. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-3. Reprinted with permission from Radio-Electronics, 4/89, p. 47. © Copyright Gernsback Publications, Inc., 1989.

Fig. 38-4. Reprinted with permission from Popular Electronics, 9/90, p. 23. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-5. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 59. © Copyright Gernsback Publications, Inc., 1987.

Fig. 38-6. Reprinted with permission from Popular Electronics, 1/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-7. Reprinted with permission from Radio-Electronics, 4/91, p. 73. © Copyright Gernsback Publications, Inc., 1991.

Fig. 38-8. Reprinted with permission from Popular Electronics, 2/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-9. Reprinted with permission from Popular Electronics/Hands-On Electronics, 4/89, p. 83. © Copyright Gernsback Publications, Inc., 1989.

Fig. 38-10. Reprinted with permission from Popular Electronics, 4/90, p. 90–91. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-11. Reprinted with permission from Popular Electronics, 3/90, p. 28. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-12. Reprinted with permission from Popular Electronics, 12/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 38-13. Reprinted with permission from Popular Electronics, 2/82, p. 99. © Copyright Gernsback Publications, Inc., 1982.

Chapter 39

Fig. 39-1. Elektor Electronics, 12/90, p. 529.

Fig. 39-2. Reprinted from EDN, 2/91, p. 105. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 39-3. DATEL, Data Conversion Components, p. 4–17.

Fig. 39-4. Reprinted with permission from Electronic Design, 12/88, p. 67. Copyright 1988, Penton Publishing.

Chapter 40

Fig. 40-1. Elektor Electronics, 12/90, p. 515–516.

Chapter 41

Fig. 41-1. Reprinted with permission from Electronic Design, 8/90, p. 94. Copyright 1990, Penton Publishing.

Fig. 41-2. Elektor Electronics, 12/90, p. 512.

Fig. 41-3. Reprinted with permission from Electronic Design, 4/91, p. 102. Copyright 1991, Penton Publishing.

Fig. 41-4. Harris, Analog Product Data Book, 1988, p. 2–105.

Chapter 42

Fig. 42-1. 73 Amateur Radio, 5/91, p. 14–15.

Fig. 42-2. QST, 6/91, p. 45.

Fig. 42-3. Reprinted by permission of Texas Instruments, Linear and Interface Circuits Applications, 1985, Vol. 1, p. 4–3.

Chapter 43

Fig. 43-1. Reprinted with permission from Popular Electronics, 8/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-2. Reprinted with permission from Popular Electronics/Hands-On Electronics, 1/89, p. 44. © Copyright Gernsback Publications, Inc., 1989.

Fig. 43-3. Elektor Electronics, 7/89, p. 38.

Fig. 43-4. Reprinted with permission from Popular Electronics, 8/89, p. 23. © Copyright Gernsback Publications, Inc., 1989.

Fig. 43-5. Elektor Electronics, 301 Circuits, p. 8.

Fig. 43-6. Reprinted with permission from Popular Electronics, 8/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-7. Reprinted with permission from Popular Electronics, 8/90, p. 23. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-8. Reprinted with permission from Popular Electronics, 11/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-9. Reprinted with permission from Popular Electronics, 9/90, p. 26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-10. Reprinted with permission from Popular Electronics, 9/90, p. 26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 43-11. Elektor Electronics, 12/90, p. 58–59.

Fig. 43-12. Reprinted with permission from Popular Electronics, 9/91, p. 19. © Copyright Gernsback Publications, Inc., 1991.

Fig. 43-13. Reprinted with permission from Popular Electronics, 9/91, p. 18. © Copyright Gernsback Publications, Inc., 1991.

Fig. 43-14. Reprinted with permission from Radio-Electronics, 9/87, p. 65. © Copyright Gernsback Publications, Inc., 1987.

Chapter 44

Fig. 44-1. Reprinted with permission from Electronic Design, 5/91, p. 117. Copyright 1991, Penton Publishing.

Fig. 44-2. Reprinted with permission from Electronic Design, 12/89, p. 71. Copyright 1991, Penton Publishing.

Chapter 45

Fig. 45-1. Intersil, Applications Handbook, 1988, p. 5-8.

Fig. 45-2. Electronic Engineering, 4/90, p. 27.

Fig. 45-3. Reprinted from EDN, 10/25/90, p. 79. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 46

Fig. 46-1. Reprinted with permission from Electronic Design, 2/91, p. 81. Copyright 1991, Penton Publishing.

Fig. 46-2. Reprinted with permission from Popular Electronics, 8/89, p. 26-27. © Copyright Gernsback Publications, Inc., 1989.

Fig. 46-3. Reprinted with permission from Radio-Electronics, 4/91, p. 33-42. © Copyright Gernsback Publications, Inc., 1991.

Fig. 46-4. Reprinted with permission from Popular Electronics, 7/91, p. 59-61. © Copyright Gernsback Publications, Inc., 1991.

Fig. 46-5. Reprinted with permission from R-E Experimenter's Handbook, 1989, p. 45. © Copyright Gernsback Publications, Inc., 1989.

Fig. 46-6. Reprinted with permission from Popular Electronics, 10/77, p. 61. © Copyright Gernsback Publications, Inc., 1977.

Fig. 46-7. Reprinted with permission from Popular Electronics, 4/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-8. Reprinted from EDN, 9/3/90, p. 171. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 46-9. Reprinted with permission from Wels' Think Tank, Gernsback Publishing Inc., p. 1.

Fig. 46-10. Reprinted from EDN, 9/90, p. 94. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 46-11. Reprinted with permission from Electronic Design, 5/91, p. 120. Copyright 1991, Penton Publishing.

Fig. 46-12. Reprinted with permission from Radio-Electronics, 8/90, p. 13. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-13. Reprinted with permission from Popular

Electronics, 2/90, p. 86. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-14. Reprinted with permission from Electronic Design, 11/82, p. 184. Copyright 1982, Penton Publishing.

Fig. 46-15. Ham Radio, 5/89, p. 85-87.

Fig. 46-16. Reprinted with permission from Popular Electronics, 10/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-17. Reprinted with permission from Popular Electronics, 2/90, p. 23. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-18. Reprinted with permission from Popular Electronics, 8/90, p. 82. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-19. Reprinted with permission from Electronic Design, 4/91, p. 102. Copyright 1991, Penton Publishing.

Fig. 46-20. Reprinted with permission from Popular Electronics, 1/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-21. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 46. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-22. Reprinted with permission from Electronic Design, 6/91, p. 101. Copyright 1991, Penton Publishing.

Fig. 46-23. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 43-47. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-24. Reprinted with permission from Popular Electronics, 2/90, p. 86. © Copyright Gernsback Publications, Inc., 1990.

Fig. 46-25. Reprinted with permission from Popular Electronics, 7/91, p. 71. © Copyright Gernsback Publications, Inc., 1991.

Fig. 46-26. Reprinted with permission from Popular Electronics, 8/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.

Fig. 46-27. Reprinted with permission from Wels' Think Tank, Gernsback Publishing Inc., p. 1.

Fig. 46-28. Reprinted with permission from Popular Electronics, 10/90, p. 23-24. © Copyright Gernsback Publications, Inc., 1990.

Chapter 47

Fig. 47-1. Reprinted from EDN, Special Ideas Issue, Vol. I, 7/88, p. 39. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 47-2. Reprinted from EDN, 5/91, p. 175. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 47-3. Elektor Electronics, 7-8/91, p. 47.

Fig. 47-4. Hands-On Electronics, 9/87, p. 97.

Fig. 47-5. Reprinted with permission from Popular Electronics, 2/91, p. 25. © Copyright Gernsback Publications, Inc., 1991.

Fig. 47-6. Reprinted with permission from Radio-Electronics, 3/89, p. 73. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-7. Reprinted with permission from Radio-Electronics, 9/89, p. 62. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-8. Reprinted with permission from Popular Electronics/Hands-On Electronics, 2/89, p. 36. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-9. Reprinted with permission from Popular Electronics, 11/91, p. 85. © Copyright Gernsback Publications, Inc., 1991.

Fig. 47-10. Reprinted with permission from Radio-Electronics, 9/89, p. 62. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-11. Reprinted from EDN, 7/91, p. 165. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 47-12. Reprinted with permission from Popular Electronics, 11/91, p. 84. © Copyright Gernsback Publications, Inc., 1991.

Fig. 47-13. Reprinted with permission from Popular Electronics, 3/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-14. Reprinted with permission from Radio-Electronics, 9/89, p. 62. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-15. Elektor Electronics, 7/89, p. 542.

Fig. 47-16. Reprinted with permission from Popular Electronics, 12/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Fig. 47-17. Ham Radio, 3/90, p. 82–83.

Fig. 47-18. Reprinted with permission from Popular Electronics, 1/91, p. 25. © Copyright Gernsback Publications, Inc., 1991.

Fig. 47-19. Reprinted with permission from Radio-Electronics, 9/89, p. 61. © Copyright Gernsback Publications, Inc., 1989.

Fig. 47-20. Reprinted with permission from Popular Electronics, 9/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.

Chapter 48

Fig. 48-1. QST, 7/90, p. 18–19.

Fig. 48-2. 73 Amateur Radio, 2/91, p. 20.

Fig. 48-3. Reprinted with permission from Popular Electronics, 10/89, p. 23. © Copyright Gernsback Publications, Inc., 1989.

Fig. 48-4. Reprinted with permission from Popular Electronics, 7/91, p. 56. © Copyright Gernsback Publications, Inc., 1991.

Fig. 48-5. Reprinted with permission from Radio-Electronics, 12/90, p. 35. © Copyright Gernsback Publications, Inc., 1990.

Fig. 48-6. Reprinted with permission from Popular Electronics, 11/90, p. 70. © Copyright Gernsback Publications, Inc., 1990.

Fig. 48-7. Ham Radio, 6/90, p. 44–47.

Fig. 48-8. Reprinted with permission from Popular Electronics, 7/91, p. 58. © Copyright Gernsback Publications, Inc., 1991.

Fig. 48-9. Reprinted with permission from Popular Electronics, 11/90, p. 70. © Copyright Gernsback Publications, Inc., 1990.

Fig. 48-10. Reprinted with permission from Popular Electronics, 7/91, p. 57. © Copyright Gernsback Publications, Inc., 1991.

Fig. 48-11. 73 Amateur Radio, 3/89, p. 66.

Chapter 49

Fig. 49-1. Reprinted with permission from Popular Electronics, 10/89, p. 84. © Copyright Gernsback Publications, Inc., 1989.

Fig. 49-2. Reprinted with permission from Radio-Electronics, 5/85, p. 73–77. © Copyright Gernsback Publications, Inc., 1985.

Fig. 49-3. Elektor Electronics, 7/89, p. S35.

Fig. 49-4. Elektor Electronics, 7/89, p. S32.

Fig. 49-5. Reprinted with permission from Popular Electronics, 10/90, p. 26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 49-6. Reprinted with permission from Radio-Electronics, 1/91, p. 71. © Copyright Gernsback Publications, Inc., 1991.

Fig. 49-7. Reprinted with permission from Radio-Electronics, 1/91, p. 71. © Copyright Gernsback Publications, Inc., 1991.

Fig. 49-8. Reprinted with permission from Popular Electronics, 9/90, p. 82. © Copyright Gernsback Publications, Inc., 1990.

Fig. 49-9. Reprinted with permission from Popular Elec-

tronics, 9/90, p. 83. © Copyright Gernsback Publications, Inc., 1990.

Chapter 50

Fig. 50-1. Reprinted with permission from Electronic Design, 11/88, p. 144. Copyright 1988, Penton Publishing.

Fig. 50-2. Reprinted with permission from Popular Electronics, 7/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.

Fig. 50-3. Reprinted with permission from Popular Electronics, 9/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.

Fig. 50-4. Reprinted with permission from Popular Electronics/Hands-On Electronics, 12/88, p. 103. © Copyright Gernsback Publications, Inc., 1988.

Fig. 50-5. Reprinted with permission from Popular Electronics, 7/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.

Chapter 51

Fig. 51-1. QST, 5/89, p. 31.

Fig. 51-2. QST, 5/89, p. 31.

Fig. 51-3. QST, 5/89, p. 32.

Fig. 51-4. QST, 5/89, p. 32.

Fig. 51-5. QST, 5/89, p. 33.

Fig. 51-6. QST, 5/89, p. 32.

Chapter 52

Fig. 52-1. Reprinted from EDN, 6/91, p. 161. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 52-2. Reprinted with permission from Electronic Design, 2/91, p. 102. Copyright 1991, Penton Publishing.

Fig. 52-3. ARRL Handbook, 1991, p. 18-7.

Fig. 52-4. Reprinted with permission from Popular Electronics, 5/91, p. 25-26. © Copyright Gernsback Publications, Inc., 1991.

Fig. 52-5. Ham Radio, 4/89, p. 65.

Fig. 52-6. Reprinted with permission from Electronic Design, 11/90, p. 136. Copyright 1990, Penton Publishing.

Fig. 52-7. Reprinted with permission from Radio-Electronics, 9/89, p. 59. © Copyright Gernsback Publications, Inc., 1989.

Fig. 52-8. Reprinted with permission from Popular Electronics, 2/91, p. 28. © Copyright Gernsback Publications, Inc., 1991.

Fig. 52-9. 73 Amateur Radio, 7/90, p. 70.

Fig. 52-10. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Fig. 52-11. Reprinted from EDN, 6/91, p. 182. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 52-12. Maxim, Seminar Applications Book, 1988/89, p. 79.

Fig. 52-13. Reprinted with permission from Radio-Electronics, 9/89, p. 60. © Copyright Gernsback Publications, Inc., 1989.

Fig. 52-14. Electronics Today International, 4/78, p. 31.

Fig. 52-15. Reprinted with permission from Popular Electronics, 9/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.

Chapter 53

Fig. 53-1. Reprinted from EDN, 9/90, p. 172. © 1990 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 53-2. Reprinted with permission from Popular Electronics, 3/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.

Fig. 53-3. Elektor Electronics, 7/89, p. S38.

Fig. 53-4. Reprinted with permission from Electronic Design, 7/82, p. 194. Copyright 1991, Penton Publishing.

Fig. 53-5. Reprinted with permission from Radio-Electronics, 2/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.

Fig. 53-6. Reprinted with permission from Popular Electronics, 12/77, p. 83. © Copyright Gernsback Publications, Inc., 1977.

Fig. 53-7. ARRL Handbook, 1991, p. 12-17.

Fig. 53-8. Reprinted with permission from Radio-Electronics, 4/70, p. 29. © Copyright Gernsback Publications, Inc., 1970.

Chapter 54

Fig. 54-1. Reprinted with permission from Popular Electronics, 12/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.

Fig. 54-2. Reprinted with permission from Popular Electronics, 3/90, p. 70. © Copyright Gernsback Publications, Inc., 1990.

Fig. 54-3. Elektor Electronics, 7/89 Supplement, 545.

Chapter 55

Fig. 55-1. Elektor Electronics, 12/90, p. 54.

Fig. 55-2. Reprinted with permission from Popular Elec-

tronics, 9/90, p. 84. © Copyright Gernsback Publications, Inc., 1990.

Fig. 55-3. RF Design, 7/88, p. 43.

Fig. 55-4. Reprinted with permission from Popular Electronics, 11/90, p. 75. © Copyright Gernsback Publications, Inc., 1990.

Fig. 55-5. Reprinted with permission from Radio-Electronics, 7/90, p. 59. © Copyright Gernsback Publications, Inc., 1990.

Fig. 55-6. Reprinted with permission from Popular Electronics, 5/91, p. 76. © Copyright Gernsback Publications, Inc., 1991.

Chapter 56

Fig. 56-1. Elektor Electronics, 7/89 Supplement, p. 39–40.

Fig. 56-2. Reprinted from EDN, Design Ideas Special Issue, 7/20/89, Vol. IV, p. 36. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 56-3. Reprinted from EDN, 12/89, p. 260. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 56-4. Reprinted from EDN, 12/89, p. 257. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 56-5. Reprinted from EDN, 5/91, p. 121. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 56-6. Reprinted with permission from Popular Electronics, 8/91, p. 35–36. © Copyright Gernsback Publications, Inc., 1991.

Fig. 56-7. Harris, Analog Product Data Book, 1988, p. 10–162.

Fig. 56-8. Reprinted with permission from Radio-Electronics, 1/91, p. 9–10. © Copyright Gernsback Publications, Inc., 1991.

Chapter 57

Fig. 57-1. ARRL Handbook, 1991, p. 12–31.

Fig. 57-2. ARRL Handbook, 1991, p. 12–31.

Fig. 57-3. ARRL Handbook, 1991, p. 12–31.

Chapter 58

Fig. 58-1. Reprinted from EDN, 2/91, p. 183. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 58-2. Reprinted with permission from Electronic Design, 12/90, p. 63. Copyright 1990, Penton Publishing.

Fig. 58-3. Reprinted from EDN, 7/91, p. 165. © 1991

Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 58-4. Reprinted with permission from Popular Electronics, 11/90, p. 76. © Copyright Gernsback Publications, Inc., 1990.

Fig. 58-5. Reprinted with permission from Radio-Electronics, 1/89, p. 69. © Copyright Gernsback Publications, Inc., 1989.

Fig. 58-6. Reprinted with permission from Electronic Design, 5/91, p. 121. Copyright 1991, Penton Publishing.

Fig. 58-7. Reprinted with permission from Electronic Design, 12/88, p. 69. Copyright 1988, Penton Publishing.

Fig. 58-8. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Fig. 58-9. Maxim, Seminar Applications Book, 1988/89, p. 58.

Fig. 58-10. Reprinted with permission from Radio-Electronics, 1/89, p. 69. © Copyright Gernsback Publications, Inc., 1989.

Chapter 59

Fig. 59-1. Reprinted from EDN, 1/90, p. 138. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 59-2. Elektor Electronics, 6/91, p. 43–45.

Fig. 59-3. Ham Radio, 4/90, p. 169.

Fig. 59-4. Elektor Electronics, 6/91, p. 43–45.

Fig. 59-5. QST, 10/90, p. 25.

Fig. 59-6. Hands-On Electronics, 11/87, p. 93.

Fig. 59-7. Reprinted with permission from Popular Electronics, 1/91, p. 27. © Copyright Gernsback Publications, Inc., 1991.

Fig. 59-8. Reprinted with permission from Popular Electronics, 10/89, p. 22. © Copyright Gernsback Publications, Inc., 1989.

Chapter 60

Fig. 60-1. Reprinted with permission from Popular Electronics, 7/91, p. 71–72. © Copyright Gernsback Publications, Inc., 1991.

Fig. 60-2. Reprinted from EDN, 11/90, p. 234. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 60-3. QST, 6/91, p. 27–29.

Fig. 60-4. Reprinted with permission from Wels' Think Tank, Gernsback Publishing Inc., p. 37.

Fig. 60-5. Reprinted with permission from Electronic

Design, 12/88, p. 103. Copyright 1988, Penton Publishing.

Fig. 60-6. Reprinted with permission from Popular Electronics/Hands-On Electronics, 5/89, p. 86. © Copyright Gernsback Publications, Inc., 1989.

Fig. 60-7. Reprinted with permission from Hands-On Electronics/Popular Electronics, 1/89, p. 26.

Fig. 60-8. Reprinted with permission from Radio-Electronics, 8/86, p. 83. © Copyright Gernsback Publications, Inc., 1986.

Fig. 60-9. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 2.

Fig. 60-10. Reprinted with permission from Radio-Electronics, 1/89, p. 71. © Copyright Gernsback Publications, Inc., 1989.

Fig. 60-11. Harris, Analog Product Data Book, 1988, p. 10-147.

Chapter 61

Fig. 61-1. Reprinted with permission from Electronic Design, 9/89, p. 93-94. Copyright 1989, Penton Publishing.

Fig. 61-2. Reprinted with permission from Popular Electronics, Fact Card No. 65. © Copyright Gernsback Publications, Inc.

Fig. 61-3. Reprinted with permission from Popular Electronics, 3/91, p. 40-42. © Copyright Gernsback Publications, Inc., 1991.

Fig. 61-4. Reprinted with permission from Popular Electronics, 1/91, p. 28-29. © Copyright Gernsback Publications, Inc., 1991.

Fig. 61-5. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 39.

Fig. 61-6. Reprinted with permission from Popular Electronics, Fact Card No. 170. © Copyright Gernsback Publications, Inc.

Fig. 61-7. Reprinted with permission from Popular Electronics/Hands-On Electronics, 12/88, p. 58. © Copyright Gernsback Publications, Inc., 1988.

Chapter 62

Fig. 62-1. Reprinted from EDN, 1/91, p. 154-156. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 62-2. Hands-On Electronics, Fact Card No. 57.

Fig. 62-3. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 12. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 62-4. Reprinted from EDN, 2/91, p. 106. © 1991

Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 62-5. Reprinted with permission from Popular Electronics, Fact Card No. 65. © Copyright Gernsback Publications, Inc.

Fig. 62-6. Reprinted with permission from Popular Electronics, 8/90, p. 20. © Copyright Gernsback Publications, Inc., 1990.

Fig. 62-7. Reprinted with permission from Radio-Electronics, 9/87, p. 64. © Copyright Gernsback Publications, Inc., 1987.

Fig. 62-8. Reprinted with permission from Electronic Design, 6/22/89, p. 105. Copyright 1989, Penton Publishing.

Fig. 62-9. Hands-On Electronics, Fact Card No. 40.

Chapter 63

Fig. 63-1. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 14. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 63-2. Reprinted from EDN, 1/90, p. 218. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 63-3. Electronic Engineering, 9/88, p. 31.

Fig. 63-4. Reprinted from EDN, 6/91, p. 162. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 63-5. Reprinted with permission from Electronic Design, 11/90, p. 136. Copyright 1990, Penton Publishing.

Fig. 63-6. Reprinted with permission from Popular Electronics, 6/89, p. 25. © Copyright Gernsback Publications, Inc., 1989.

Fig. 63-7. Reprinted with permission from Electronic Design, 4/91, p. 104. Copyright 1991, Penton Publishing.

Fig. 63-8. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 52.

Fig. 63-9. Elektor Electronics, 12/90 Supplement, p. 41.

Fig. 63-10. Reprinted with permission from Radio-Electronics, 10/90, p. 14. © Copyright Gernsback Publications, Inc., 1990.

Fig. 63-11. Elektor Electronics, 12/90 Supplement, p. 536.

Fig. 63-12. Reprinted with permission from Radio-Electronics, 3/89, p. 53. © Copyright Gernsback Publications, Inc., 1989.

Fig. 63-13. Reprinted with permission from Electronic Design, 2/91, p. 104. Copyright 1991, Penton Publishing.

- Fig. 63-14. Reprinted with permission from Electronic Design, 3/91, p. 86. Copyright 1991, Penton Publishing.
- Fig. 63-15. 73 Amateur Radio, 11/90, p. 67.
- Fig. 63-16. 73 Amateur Radio, 7/90, p. 68.
- Fig. 63-17. 73 Amateur Radio, 7/90, p. 69.
- Fig. 63-18. 73 Amateur Radio, 7/90, p. 77.
- Fig. 63-19. Reprinted with permission from Electronic Design, 12/90, p. 77. Copyright 1990, Penton Publishing.
- Fig. 63-20. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.
- Fig. 63-21. Linear Technology, Design Note #47.
- Fig. 63-22. Linear Technology, Design Note #47.
- Fig. 63-23. Reprinted with permission from Radio-Electronics, 5/91, p. 49–55. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 63-24. Elektor Electronics, 7-8/89, p. 28.
- Fig. 63-25. Ham Radio, 4/89, p. 67.
- Fig. 63-26. Linear Technology, Linear Databook, 1986, p. 2–112.
- Fig. 63-27. Reprinted from EDN, 1/91, p. 152. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 63-28. Reprinted from EDN, 8/2/90, p. 96. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 63-29. Reprinted with permission from Radio-Electronics, 3/89, p. 54–55. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 63-30. Reprinted with permission from Electronic Design, 6/91, p. 109. Copyright 1991, Penton Publishing.
- Fig. 63-31. Reprinted with permission from Electronic Design, 3/91, p. 117. Copyright 1991, Penton Publishing.
- Fig. 63-32. Reprinted with permission from Popular Electronics, Fact Card No. 134. © Copyright Gernsback Publications, Inc.

Chapter 64

- Fig. 64-1. Reprinted with permission from Radio-Electronics, 8/91, p. 42. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 64-2. Linear Technology, Application Note 45.
- Fig. 64-3. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 61. © Copyright Gernsback Publications, Inc., 1990.

- Fig. 64-4. Reprinted with permission from Popular Electronics, 6/89, p. 88. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 64-5. Reprinted with permission from Radio-Electronics, 2/91, p. 34. © Copyright Gernsback Publications, Inc., 1991.

Chapter 65

- Fig. 65-1. QST, 9/89, p. 23.
- Fig. 65-2. Reprinted with permission from Radio-Electronics, 3/90, p. 31–34. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 65-3. Reprinted with permission from Popular Electronics, 12/90, p. 22. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 65-4. Hands-On Electronics, Fact Card No. 40.
- Fig. 65-5. Reprinted with permission from Popular Electronics, 9/90, p. 27. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 65-6. Reprinted with permission from Popular Electronics, 4/90, p. 45–46. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 65-7. Linear Technology, 10/90, Design Notes #40.
- Fig. 65-8. Reprinted with permission from Popular Electronics, 11/90, p. 24. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 65-9. Reprinted with permission from Radio-Electronics, 1/89, p. 70. © Copyright Gernsback Publications, Inc., 1989.

Chapter 66

- Fig. 66-1. Reprinted from EDN, 11/90, p. 292. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 66-2. Reprinted with permission from Popular Electronics, 6/89, p. 26. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 66-3. Reprinted with permission from Electronic Design, 5/90, p. 80. Copyright 1990, Penton Publishing.
- Fig. 66-4. Ham Radio, 4/90, p. 73–78.
- Fig. 66-5. Reprinted from EDN, 1/91, p. 170. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 66-6. Reprinted with permission from Electronic Design, 12/90, p. 22.
- Fig. 66-8. Hands-On Electronics, Fact Card No. 37.
- Fig. 66-9. Reprinted from EDN, 4/91, p. 188. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Design, 9/89, p. 94–95. Copyright 1989, Penton Publishing.

Fig. 66-7. Reprinted from EDN, 12/90, p. 218. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 67

Fig. 67-1. Reprinted with permission from Popular Electronics, 10/89, p. 104. © Copyright Gernsback Publications, Inc., 1989.

Fig. 67-2. Elektor Electronics, 12/90 Supplement, p. 42.

Fig. 67-3. Elektor Electronics, 7-8/89, p. 67.

Fig. 67-4. Reprinted with permission from Popular Electronics, 3/91, p. 55–57. © Copyright Gernsback Publications, Inc., 1991.

Fig. 67-5. Reprinted with permission from Popular Electronics, 7/91, p. 57. © Copyright Gernsback Publications, Inc., 1991.

Fig. 67-6. Reprinted with permission from Radio-Electronics, 12/75, p. 42. © Copyright Gernsback Publications, Inc., 1975.

Fig. 67-7. Reprinted with permission from Popular Electronics/Hands-On Electronics, 5/89, p. 28. © Copyright Gernsback Publications, Inc., 1989.

Fig. 67-8. TAB Books, Third Book of Electronic Projects, p. 39.

Chapter 68

Fig. 68-1. Reprinted with permission from Radio-Electronics, 5/91, p. 40–42. © Copyright Gernsback Publications, Inc., 1991.

Fig. 68-2. Reprinted with permission from Popular Electronics, 8/90, p. 80. © Copyright Gernsback Publications, Inc., 1990.

Fig. 68-3. GE, Application Note 90.16, p. 29.

Fig. 68-4. Reprinted with permission from Popular Electronics, 5/91, p. 74. © Copyright Gernsback Publications, Inc., 1991.

Fig. 68-5. Reprinted with permission from Radio-Electronics, 12/88, p. 76. © Copyright Gernsback Publications, Inc., 1988.

Fig. 68-6. Elektor Electronics, 302 Circuits, p. 203.

Fig. 68-7. Reprinted with permission from Popular Electronics, 8/90, p. 80. © Copyright Gernsback Publications, Inc., 1990.

Fig. 68-8. Elektor Electronics, 302 Circuits, p. 165–166.

Fig. 68-9. Reprinted from EDN, 3/75, p. 73. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 68-10. Reprinted from EDN, 10/90, p. 238. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 68-11. Hands-On Electronics, Fact Card No. 86.

Chapter 69

Fig. 69-1. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 122. © Copyright Gernsback Publications, Inc., 1987.

Fig. 69-2. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 122. © Copyright Gernsback Publications, Inc., 1987.

Chapter 70

Fig. 70-1. Reprinted with permission from Popular Electronics, 6/89, p. 59–62. © Copyright Gernsback Publications, Inc., 1989.

Fig. 70-2. Reprinted with permission from Radio-Electronics, 12/90, p. 81. © Copyright Gernsback Publications, Inc., 1990.

Fig. 70-3. Reprinted from EDN, 3/79, p. 130. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 70-4. Reprinted with permission from Radio-Electronics, 12/90, p. 82. © Copyright Gernsback Publications, Inc., 1990.

Fig. 70-5. Reprinted with permission from Popular Electronics, 11/90, p. 77. © Copyright Gernsback Publications, Inc., 1990.

Chapter 71

Fig. 71-1. 73 Amateur Radio, 11/90, p. 34.

Fig. 71-2. 73 Amateur Radio, 4/91, p. 26.

Fig. 71-3. Reprinted with permission from Popular Electronics, 8/91, p. 72. © Copyright Gernsback Publications, Inc., 1991.

Fig. 71-4. Reprinted with permission from Popular Electronics, 5/90, p. 85 and 96. © Copyright Gernsback Publications, Inc., 1990.

Fig. 71-5. Reprinted with permission from Popular Electronics, 10/89, p. 24. © Copyright Gernsback Publications, Inc., 1989.

Fig. 71-6. Reprinted with permission from Popular Electronics, 3/90, p. 96. © Copyright Gernsback Publications, Inc., 1990.

Fig. 71-7. Reprinted with permission from Popular Electronics, 2/82, p. 99. © Copyright Gernsback Publications, Inc., 1982.

Fig. 71-8. Reprinted with permission from Radio-Elec-

tronics, 1/91, p. 56. © Copyright Gernsback Publications, Inc., 1991.

Fig. 71-9. Reprinted with permission from Popular Electronics, 10/89, p. 22. © Copyright Gernsback Publications, Inc., 1989.

Chapter 72

Fig. 72-1. QST, 8/90, p. 59.

Fig. 72-2. ARRL Handbook, 1991, p. 12–30.

Fig. 72-3. Reprinted with permission from Popular Electronics, 3/90, p. 48. © Copyright Gernsback Publications, Inc., 1990.

Fig. 72-4. ARRL Handbook, 1991, p. 12–26.

Fig. 72-5. 73 Amateur Radio, 3/90, p. 13.

Fig. 72-6. ARRL Handbook, 1991, p. 14–6.

Chapter 73

Fig. 73-1. Elektor Electronics, 7/89 Supplement, p. S33.

Fig. 73-2. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 28–29. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 73-3. Reprinted with permission from Electronic Design, 12/88, p. 105. Copyright 1988, Penton Publishing.

Fig. 73-4. Reprinted from EDN, 4/91, p. 179. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 73-5. Reprinted with permission from Electronic Design, 2/91, p. 104. Copyright 1991, Penton Publishing.

Fig. 73-6. Reprinted from EDN, 6/90, p. 266. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 73-7. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Chapter 74

Fig. 74-1. Elektor Electronics, 12/90, p. 512–513.

Fig. 74-2. Intersil, Applications Handbook, 1988, p. 6–20.

Fig. 74-3. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Chapter 75

Fig. 75-1. GE, Optoelectronics, Third Edition, p. 139.

Fig. 75-2. Reprinted from EDN, 12/89, p. 258. © 1991

Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 75-3. Elektor Electronics, 12/90, p. 525.

Fig. 75-4. Reprinted with permission from Popular Electronics, 5/91, p. 86. © Copyright Gernsback Publications, Inc., 1991.

Fig. 75-5. Reprinted from EDN, 7/90, p. 185. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 75-6. Reprinted from EDN, 9/89, p. 170. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 76

Fig. 76-1. QST, 7/90, p. 29–31.

Fig. 76-2. CQ, 7/90, p. 61–65.

Fig. 76-3. Elektor Electronics, 301 Circuits, p. 38–39.

Fig. 76-4. QST, 10/90, p. 18–21.

Fig. 76-5. North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804.

Fig. 76-6. Elektor Electronics, 12/90, p. 57–58.

Fig. 76-7. Reprinted with permission from Popular Electronics, 1/91, p. 58. © Copyright Gernsback Publications, Inc., 1991.

Fig. 76-8. QST, 7/90, p. 28–30.

Fig. 76-9. Reprinted with permission from Popular Electronics, 1/91, p. 58. © Copyright Gernsback Publications, Inc., 1991.

Fig. 76-10. Ham Radio, 11/88, p. 60–62.

Fig. 76-11. Reprinted with permission from Popular Electronics, 12/89, p. 23. © Copyright Gernsback Publications, Inc., 1989.

Fig. 76-12. Reprinted with permission from Popular Electronics, 1/91, p. 59. © Copyright Gernsback Publications, Inc., 1991.

Fig. 76-13. Reprinted with permission from Popular Electronics, 1/91, p. 59. © Copyright Gernsback Publications, Inc., 1991.

Fig. 76-14. Reprinted with permission from Popular Electronics, 1/91, p. 59. © Copyright Gernsback Publications, Inc., 1991.

Fig. 76-15. Reprinted with permission from Popular Electronics, 1/90, p. 98. © Copyright Gernsback Publications, Inc., 1990.

Fig. 76-16. Reprinted with permission from Popular Electronics, 11/90, p. 69. © Copyright Gernsback Publications, Inc., 1990.

Fig. 76-17. Reprinted with permission from Popular Electronics, 1/90, p. 98. © Copyright Gernsback Publications, Inc., 1990.

- Fig. 76-18. Reprinted with permission from Popular Electronics, 1/90, p. 74. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 76-19. Copyright of Motorola, MOSPOWER Design Catalog, 1/83, p. 5–6. Used by permission.
- Fig. 76-20. Reprinted with permission from Popular Electronics, 1/90, p. 74. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 76-21. Reprinted with permission from Popular Electronics, 1/90, p. 74. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 76-22. Reprinted with permission from Popular Electronics, 1/90, p. 74. © Copyright Gernsback Publications, Inc., 1990.

Chapter 77

- Fig. 77-1. Elektor Electronics, 7/89, p. S31.
- Fig. 77-2. North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804.
- Fig. 77-3. Reprinted with permission from Popular Electronics, 11/90, p. 85. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 77-4. Elektor Electronics, 3/91, p. 37–41.
- Fig. 77-5. Reprinted with permission from Popular Electronics, 3/90, p. 48. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 77-6. Reprinted with permission from Popular Electronics, 8/90, p. 88. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 77-7. Reprinted with permission from Radio-Electronics, 10/89, p. 43. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 77-8. Ham Radio, 4/90, p. 21.
- Fig. 77-9. Reprinted with permission from Radio-Electronics, 11/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.

Chapter 78

- Fig. 78-1. Reprinted from EDN, 12/90, p. 153. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 79

- Fig. 79-1. Elektor Electronics, 12/90, p. 523.
- Fig. 79-2. Reprinted from EDN, 10/90, p. 206. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 79-3. Elektor Electronics, 7/89, p. 542.

- Fig. 79-4. Micro Linear Advertisement
- Fig. 79-5. Reprinted with permission from Popular Electronics, 3/91, p. 92. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 79-6. Reprinted with permission from Popular Electronics, 1/90, p. 85. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 79-7. Reprinted with permission from Electronic Design, 4/91, p. 99. Copyright 1991, Penton Publishing.
- Fig. 79-8. Reprinted with permission from Popular Electronics, 1/90, p. 84. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 79-9. Reprinted with permission from Radio-Electronics, 7/89, p. 52. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 79-10. Reprinted with permission from Popular Electronics, 1/90, p. 101. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 79-11. Reprinted from EDN, 11/90, p. 236. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 79-12. GE/RCA, BiMOS Operational Amplifier Circuit Ideas, 1987, p. 7.
- Fig. 79-13. 73 Amateur Radio, 12/76, p. 97–99.
- Fig. 79-14. Reprinted with permission from Popular Electronics, 3/91, p. 88. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 79-15. Reprinted from EDN, 11/90, p. 23. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 80

- Fig. 80-1. Hands-On Electronics, 1-2/86, p. 67.
- Fig. 80-2. Reprinted with permission from Radio-Electronics, 7/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 80-3. Reprinted with permission from Radio-Electronics, 7/90, p. 57. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 80-4. Reprinted with permission from National Semiconductor Corp., CMOS Databook, 1981, p. 8–46.
- Fig. 80-5. Reprinted with permission from Popular Electronics, 7/89, p. 22. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 80-6. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.

Chapter 81

- Fig. 81-1. Elektor Electronics, 7/89 Supplement, p. 41–42.
- Fig. 81-2. Elektor Electronics, 7/89, p. 537.
- Fig. 81-3. Reprinted with permission from Popular Electronics, 10/89, p. 85. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 81-4. Reprinted with permission from Popular Electronics, 1/91, p. 27. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 81-5. Reprinted with permission from Popular Electronics, 9/90, p. 63–66. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 81-6. Elektor Electronics, 301 Circuits, p. 130.
- Fig. 81-7. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 81-8. Reprinted from EDN, 8/2/91, p. 112. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 82

- Fig. 82-1. Reprinted with permission from Radio-Electronics, 4/87, p. 30. © Copyright Gernsback Publications, Inc., 1987.
- Fig. 82-2. Hands-On Electronics, 11/86, p. 32.
- Fig. 82-3. Reprinted from EDN, 6/88, p. 175. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 82-4. Reprinted with permission from Electronic Design, 10/89, p. 85. Copyright 1991, Penton Publishing.

Chapter 83

- Fig. 83-1. Elektor Electronics, 301 Circuits, p. 32–35.
- Fig. 83-2. Reprinted from EDN, 11/90, p. 232. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 83-3. Reprinted by permission of Texas Instruments, Linear and Interface Circuit Applications, 1985, p. 7–15.
- Fig. 83-4. Reprinted with permission from Radio-Electronics, 12/88, p. 76. © Copyright Gernsback Publications, Inc., 1988.
- Fig. 83-5. Reprinted with permission from Radio-Electronics, 7/89, p. 53. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 83-6. Reprinted with permission from Popular Electronics, Fact Card No. 98. © Copyright Gernsback Publications, Inc.

- Fig. 83-7. Reprinted with permission from Radio-Electronics, 7/89, p. 53. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 83-8. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 83-9. Reprinted by permission of Texas Instruments, Linear and Interface Circuit Applications, 1985, Vol. 1, p. 3–16.
- Fig. 83-10. Reprinted with permission from Radio-Electronics, 12/88, p. 76. © Copyright Gernsback Publications, Inc., 1988.

Chapter 84

- Fig. 84-1. Elektor Electronics, 12/90, p. 531–532.
- Fig. 84-2. Reprinted from EDN, 7/85, p. 282. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 84-3. Reprinted with permission from Popular Electronics, 12/89, p. 29–34. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 84-4. Reprinted with permission from Radio-Electronics, 12/89, p. 58. © Copyright Gernsback Publications, Inc., 1989.
- Fig. 84-5. QST, 6/91, p. 45.
- Fig. 84-6. Reprinted with permission from Popular Electronics, 11/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 84-7. Reprinted with permission from Popular Electronics, 11/90, p. 25. © Copyright Gernsback Publications, Inc., 1990.
- Fig. 84-8. Reprinted from EDN, 10/90, p. 132. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
- Fig. 84-9. RF Design, 9/90, p. 76.
- Fig. 84-10. Elektor Electronics, 12/90, p. 532.
- Fig. 84-11. Elektor Electronics, 12/90 Supplement, p. 43.
- Fig. 84-12. Electronics Today International, 4/78, p. 31.

Chapter 85

- Fig. 85-1. 73 Amateur Radio, 12/90, p. 54.
- Fig. 85-2. Hands-On Electronics, 8/87, p. 92.

Chapter 86

- Fig. 86-1. Reprinted with permission from Popular Electronics, 6/91, p. 53–57. © Copyright Gernsback Publications, Inc., 1991.
- Fig. 86-2. Reprinted with permission from Popular Elec-

tronics, 8/90, p. 33–36. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-3. Reprinted with permission from Popular Electronics, 8/90, p. 29–32. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-4. Reprinted with permission from Popular Electronics, 6/89, p. 33. © Copyright Gernsback Publications, Inc., 1989.

Fig. 86-5. Elektor Electronics, 7/89 Supplement, p. 526.

Fig. 86-6. Ham Radio, 12/89, p. 32.

Fig. 86-7. Reprinted with permission from Popular Electronics, 1/91, p. 81. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-8. Reprinted with permission from Radio-Electronics, 7/90, p. 8. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-9. Reprinted from EDN, 12/90, p. 153–154. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 86-10. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 48.

Fig. 86-11. Reprinted with permission from Popular Electronics, 9/91, p. 21. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-12. Hands-On Electronics, 11/87, p. 85.

Fig. 86-13. TAB Books, The Build-It Book of Electronic Projects, p. 24.

Fig. 86-14. Reprinted with permission from Popular Electronics, 5/91, p. 86. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-15. Reprinted with permission from Popular Electronics, 8/90, p. 80. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-16. Reprinted with permission from Popular Electronics, 7/91, p. 22. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-17. Reprinted with permission from Popular Electronics, Fact Card No. 170. © Copyright Gernsback Publications, Inc.

Fig. 86-18. Hands-On Electronics, Winter 1985, p. 65.

Fig. 86-19. Reprinted with permission from Popular Electronics, 8/90, p. 81. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-20. Elektor Electronics, 7/89, p. 540.

Fig. 86-21. Reprinted with permission from Popular Electronics, 9/91, p. 22. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-22. Reprinted with permission from Popular Electronics, 2/91, p. 25–26. © Copyright Gernsback Publications, Inc., 1991.

Fig. 86-23. Reprinted with permission from Popular Electronics, 11/90, p. 26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 86-24. Reprinted with permission from General Electric Semiconductor Department, Optoelectronics, Second Edition, p. 118.

Chapter 87

Fig. 87-1. Reprinted from EDN, 9/89, p. 152. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 87-2. GE/RCA, BiMOS Operational Amplifiers Circuit Ideas, 1987, p. 25.

Fig. 87-3. Reprinted with permission from Popular Electronics, 1/91, p. 22. © Copyright Gernsback Publications, Inc., 1991.

Chapter 88

Fig. 88-1. Elektor Electronics, 12/90, p. 533.

Fig. 88-2. Elektor Electronics, 7/89, p. 528.

Fig. 88-3. Reprinted with permission from Radio-Electronics, 12/88, p. 72. © Copyright Gernsback Publications, Inc., 1988.

Fig. 88-4. Reprinted with permission from Radio-Electronics, 6/91, p. 58. © Copyright Gernsback Publications, Inc., 1991.

Fig. 88-5. Reprinted with permission from Radio-Electronics, 12/88, p. 71. © Copyright Gernsback Publications, Inc., 1988.

Fig. 88-6. Reprinted from EDN, 4/91, p. 180. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 89

Fig. 89-1. Electronic Engineering, 12/90, p. 28.

Fig. 89-2. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 22–23. © Copyright Gernsback Publications, Inc., 1990.

Fig. 89-3. Reprinted with permission from Electronic Design, 4/90, p. 85–88. Copyright 1991, Penton Publishing.

Fig. 89-4. 42 New Ideas, Gernsback Publications Inc., 1984, p. 13.

Fig. 89-5. Linear Technology, 10/90, Design Notes #40.

Chapter 90

Fig. 90-1. Elektor Electronics, 7/89, p. 536–537.

Fig. 90-2. 73 Amateur Radio, 8/90, p. 82.

Fig. 90-3. Reprinted with permission from Popular Electronics, 12/89, p. 82–83. © Copyright Gernsback Publications, Inc., 1989.

Fig. 90-4. Reprinted with permission from Popular Electronics, 12/89, p. 82. © Copyright Gernsback Publications, Inc., 1989.

Fig. 90-5. Reprinted with permission from Popular Electronics, 12/89, p. 27. © Copyright Gernsback Publications, Inc., 1989.

Fig. 90-6. Hands-On Electronics, Fact Card No. 49.

Fig. 90-7. Reprinted from EDN, 8/2/90, p. 86. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 90-8. 73 Amateur Radio, 2/91, p. 78.

Fig. 90-9. Hands-On Electronics, 1-2/86, p. 52.

Fig. 90-10. Copyright of Motorola, Thyristor Device Data, Series A 1985, p. 1-6-51. Used by permission.

Fig. 90-11. Reprinted with permission from Popular Electronics, 1/91, p. 80. © Copyright Gernsback Publications, Inc., 1991.

Chapter 91

Fig. 91-1. GE/RCA, BiMOS Operational Amplifier Circuit Ideas, 1987, p. 22.

Fig. 91-2. Reprinted with permission from Radio-Electronics, 2/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.

Fig. 91-3. Hands-On Electronics, 8/87, p. 91.

Chapter 92

Fig. 92-1. Elektor Electronics, 7/89, p. 538-539.

Fig. 92-2. Reprinted with permission from Popular Electronics, 2/91, p. 23-24. © Copyright Gernsback Publications, Inc., 1991.

Fig. 92-3. GE/RCA, BiMOS Operational Amplifier Circuit Ideas, 1987, p. 28.

Fig. 92-4. Reprinted with permission from Wels' Think Tank, Gernsback Publications Inc., p. 39.

Fig. 92-5. Reprinted with permission from Radio-Electronics, 7/90, p. 58. © Copyright Gernsback Publications, Inc., 1990.

Fig. 92-6. Hands-On Electronics, 9/87, p. 89.

Chapter 93

Fig. 93-1. 73 Amateur Radio, 6/89, p. 65.

Fig. 93-2. 73 Amateur Radio, 11/90, p. 78.

Fig. 93-3. Reprinted with permission from Radio-Electronics, 6-7/89, p. 45-50. © Copyright Gernsback Publications, Inc., 1989.

Fig. 93-4. Elektor Electronics, 7/89, p. 521.

Fig. 93-5. 73 Amateur Radio, 4/91, p. 76.

Fig. 93-6. 73 Amateur Radio, 4/90, p. 46-47.

Fig. 93-7. 73 Amateur Radio, 7/90, p. 16.

Chapter 94

Fig. 94-1. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 93-94. © Copyright Gernsback Publications, Inc., 1987.

Fig. 94-2. Reprinted with permission from Radio-Electronics, 7/85, p. 61. © Copyright Gernsback Publications, Inc., 1985.

Fig. 94-3. Reprinted with permission from R-E Experimenter's Handbook, 1987, p. 93. © Copyright Gernsback Publications, Inc., 1987.

Chapter 95

Fig. 95-1. Reprinted from EDN, 12/90, p. 224-226. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 95-2. Elektor Electronics, 302 Circuits, p. 180.

Fig. 95-3. Elektor Electronics, 6/91, p. 29.

Fig. 95-4. Reprinted with permission from Radio-Electronics, 12/89, p. 81. © Copyright Gernsback Publications, Inc., 1989.

Fig. 95-5. Reprinted from EDN, 2/90, p. 185. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 95-6. Reprinted with permission from Radio-Electronics, 10/90, p. 59-60. © Copyright Gernsback Publications, Inc., 1990.

Fig. 95-7. Reprinted with permission from Radio-Electronics, 7/89, p. 41. © Copyright Gernsback Publications, Inc., 1989.

Fig. 95-8. Electronic Products, 4/88, p. 36.

Fig. 95-9. Reprinted from EDN, 12/90, p. 222. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Fig. 95-10. Elektor Electronics, 302 Circuits, p. 78-79.

Fig. 95-11. Reprinted with permission from Radio-Electronics, 7/91, p. 73. © Copyright Gernsback Publications, Inc., 1991.

Chapter 96

Fig. 96-1. Reprinted with permission from Popular Electronics, 3/90, p. 28. © Copyright Gernsback Publications, Inc., 1990.

Fig. 96-2. Reprinted from EDN, 3/91, p. 137-138. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 97

- Fig. 97-1. Elektor Electronics, 7/89 Supplement, p. 34.
Fig. 97-2. Reprinted with permission from Popular Electronics, 6/91, p. 39–40. © Copyright Gernsback Publications, Inc., 1991.

Chapter 98

- Fig. 98-1. Elektor Electronics, 12/90 Supplement, p. 41–42.
Fig. 98-2. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
Fig. 98-3. Reprinted with permission from Popular Electronics, 10/89, p. 105. © Copyright Gernsback Publications, Inc., 1989.
Fig. 98-4. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
Fig. 98-5. Reprinted from EDN, 10/90, p. 222. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 98-6. Reprinted with permission from Popular Electronics, 11/90, p. 102. © Copyright Gernsback Publications, Inc., 1990.
Fig. 98-7. Reprinted from EDN, 5/90, p. 174. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 98-8. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
Fig. 98-9. Reprinted with permission from Radio-Electronics, 12/89, p. 56. © Copyright Gernsback Publications, Inc., 1989.
Fig. 98-10. RF Design, 4/86, p. 41.
Fig. 98-11. Fairchild Camera and Instrument Corp., Linear Databook, 1982, p. 5–24.

Chapter 99

- Fig. 99-1. Reprinted from EDN, 6/91, p. 173. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 99-2. Reprinted with permission from Radio-Electronics, 8/91, p. 63. © Copyright Gernsback Publications, Inc., 1991.
Fig. 99-3. Reprinted with permission from Popular Electronics, 10/89, p. 37–38. © Copyright Gernsback Publications, Inc., 1989.
Fig. 99-4. Reprinted with permission from Radio-Elec-

tronics, 1/91, p. 41–43. © Copyright Gernsback Publications, Inc., 1991.

- Fig. 99-5. Reprinted with permission from Radio-Electronics, 8/91, p. 62. © Copyright Gernsback Publications, Inc., 1991.
Fig. 99-6. Reprinted with permission from Radio-Electronics, 8/91, p. 63. © Copyright Gernsback Publications, Inc., 1991.
Fig. 99-7. Reprinted with permission from Radio-Electronics, 3/89, p. 33–37. © Copyright Gernsback Publications, Inc., 1989.
Fig. 99-8. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 45. © Copyright Gernsback Publications, Inc., 1990.
Fig. 99-9. Reprinted from EDN, Design Ideas Special Issue, Vol. IV, 7/20/89, p. 16. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 100

- Fig. 100-1. Reprinted with permission from Radio-Electronics, 6/91, p. 55. © Copyright Gernsback Publications, Inc., 1991.
Fig. 100-2. Reprinted from EDN, 5/91, p. 178. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 100-3. Reprinted with permission from Radio-Electronics, 6/91, p. 59–60. © Copyright Gernsback Publications, Inc., 1991.
Fig. 100-4. Reprinted with permission from Radio-Electronics, 6/91, p. 56. © Copyright Gernsback Publications, Inc., 1991.

Chapter 101

- Fig. 101-1. Elektor Electronics, 12/90 Supplement, p. 40.

Chapter 102

- Fig. 102-1. Reprinted from EDN, 6/91, p. 184. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 102-2. Reprinted from EDN, 7/91, p. 166–168. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.
Fig. 102-3. Reprinted with permission from Popular Electronics, 11/89, p. 85. © Copyright Gernsback Publications, Inc., 1989.
Fig. 102-4. Reprinted with permission from Electronic Design, 4/89, p. 77. Copyright 1989, Penton Publishing.

Fig. 102-5. Reprinted with permission from Electronic Design, 11/88, p. 78. Copyright 1988, Penton Publishing.

Fig. 102-6. Reprinted with permission from Electronic Design, 3/91, p. 119–120. Copyright 1991, Penton Publishing.

Fig. 102-7. Reprinted from EDN, 1/91, p. 168. © 1991 Cahners Publishing Company, a division of Reed Publishing USA.

Chapter 103

Fig. 103-1. Reprinted with permission from R-E Experimenter's Handbook, 1990, p. 155. © Copyright Gernsback Publications, Inc., 1990.

Fig. 103-2. Reprinted with permission from Popular Electronics, 8/89, p. 27. © Copyright Gernsback Publications, Inc., 1989.

Chapter 104

Fig. 104-1. Reprinted with permission from Electronic Design, 7/91, p. 136. Copyright 1991, Penton Publishing.

Fig. 104-2. Reprinted with permission from Popular Electronics, 1/90, p. 26. © Copyright Gernsback Publications, Inc., 1990.

Fig. 104-3. Reprinted with permission from Radio-Electronics, 6/86, p. 60. © Copyright Gernsback Publications, Inc., 1986.

Fig. 104-4. Harris, Analog Product Data Book, 1988, p. 2–106.

Fig. 104-5. Reprinted with permission from Radio-Electronics, 6/86, p. 58. © Copyright Gernsback Publications, Inc., 1986.

Index

Numbers preceded by a "I," "II," "III," or "IV" are from *Encyclopedia of Electronic Circuits* Vol. I, II, III, or IV, respectively.

A

- absolute-value amplifier, I-31
- absolute-value circuit, I-37, IV-274
- absolute-value full wave rectifier, II-528
- absolute-value Norton amplifier, III-11
- ac bridge circuit, II-81
- ac flasher, III-196
- ac linear coupler, analog, II-412
- ac motor
 - control for, II-375
 - three-phase driver, II-383
 - two-phase driver, II-382
- ac sequential flasher, II-238
- ac switcher, high-voltage optically coupled, III-408
- ac timer, .2 to 10 seconds, adjustable, II-681
- ac-coupled amplifiers, dynamic, III-17
- ac/dc indicator, IV-214
- ac-to-dc converter, I-165
 - fixed power supplies, IV-395
 - full-wave, IV-120
 - high-impedance precision rectifier, I-164
- acid rain monitor, II-245, III-361
- acoustic-sound receiver/transmitter, IV-311
- active antennas, III-1-2, IV-1-4
 - basic designs, IV-3
 - wideband rod, IV-4
 - with gain, IV-2
- active clamp-limiting amplifiers, III-15
- active crossover networks, I-172-173
- active filters (*see also* filter circuits)
 - band reject, II-401
 - bandpass, II-221, II-223, III-190
 - digitally tuned low power, II-218
 - five pole, I-279
 - high-pass, second-order, I-297
 - low-pass, digitally selected break frequency, II-216
 - low-power, digitally selectable center frequency, III-186
 - low-power, digitally tuned, I-279
 - programmable, III-185
 - RC, up to 150 kHz, I-294
 - state-variable, III-189
 - ten-band graphic equalizer using, II-684
 - three-amplifier, I-289
 - tunable, I-294
 - universal, II-214
 - variable bandwidth bandpass, I-286
- active integrator, inverting buffer, II-299
- adapters
 - dc transceiver, hand-held, III-461
 - program, second-audio, III-142
 - traveller's shaver, I-495
- adder, III-327
- AGC, II-17
- AGC amplifiers
 - AGC system for CA3028 IF amplifier, IV-458
 - rf, wideband adjustable, III-545
 - squelch control, III-33
 - wideband, III-15
- air conditioner, auto, smart clutch for, III-46
- air flow detector, I-235, II-242, III-364
- air flow meter (*see* anemometer)
- air-pressure change detector, IV-144
- air-motion detector, III-364
- airplane propeller sound effect, II-592
- alarms (*see also* detectors; indicators; monitors; sensors; sirens), III-3-9, IV-84-87

alarms (*cont.*)

auto burglar, II-2, I-3, III-4, I-7, I-10, IV-53
auto burglar, CMOS low-current design, IV-56
auto burglar, horn as loudspeaker, IV-54
auto burglar, single-IC design, IV-55
auto burglar, single-IC, III-7
auto-arming automotive alarm, IV-50
automatic turn-off after 8-minute delay, automotive, IV-52
automatic turn-off with delay, IV-54
blown fuse, I-10
boat, I-9
burglar, III-8, III-9, IV-86
burglar, latching circuit, I-8, I-12
burglar, NC and NO switches, IV-87
burglar, NC switches, IV-87
burglar, one-chip, III-5
burglar, self-latching, IV-85
burglar, timed shutoff, IV-85
camera triggered, III-444
capacitive sensor, III-515
current monitor and, III-338
differential voltage or current, II-3
digital clock circuit with, III-84
door-ajar, II-284
door-ajar, Hall-effect circuit, III-256
doorbell, rain, I-443
fail-safe, semiconductor, III-6
field disturbance, II-507
flasher, bar display, I-252
flood, III-206, I-390, IV-188
freezer meltdown, I-13
headlights-on, III-52
high/low limit, I-151
home-security system, IV-87
ice formation, II-58
infrared wireless security system, IV-222-223
low-battery disconnect and, III-65
low-battery warning, III-59
low volts, II-493
mains-failure indicator, IV-216
motion-actuated car, I-9
motion-actuated motorcycle, I-9
multiple circuit for, II-2
one-chip, III-5
photoelectric, II-4, II-319
piezoelectric, I-12
power failure, III-511, I-581, I-582
printer-error, IV-106
proximity, II-506, III-517
pulsed-tone, I-11
purse-snatcher, capacitance operated, I-134
rain, I-442, I-443, IV-189
road ice, II-57

security, I-4
self-arming, I-2
shutoff, automatic, I-4
signal-reception, receivers, III-270
smoke, photoelectric, line-operated, I-596
smoke, SCR, III-251
solar powered, I-13
sonic defenders, IV-324
speed, I-95
Star Trek red alert, II-577
strobe flasher alarm, IV-180
tamperproof burglar, I-8
temperature, II-643
temperature, light, radiation sensitive, II-4
timer, II-674
trouble tone alert, II-3
varying-frequency warning, II-579
wailing, II-572
warbling, II-573
watchdog timer/alarm, IV-584
water-leakage, IV-190
water level, I-389
allophone generator, III-733
alternators
 battery-alternator monitor, automotive, III-63
AM demodulator, II-160
AM microphone, wireless, I-679
AM radio, I-544
AM radio
 AM car-radio to short-wave radio converter, IV-500
 broadcast-band signal generator, IV-302
 envelope detector, IV-142
 modulation monitor, IV-299
 power amplifier for, I-77
 receivers, III-529, IV-455
 receivers, carrier-current, III-81
 receivers, integrated, III-535
AM/FM
 clock radio, II-543, III-1
 squelch circuit for, II-547, III-1
amateur radio
 linear amp, 2-30 MHz 140-W, III-260
 receiver, III-534
 signal-identifier, programmable, IV-326
 transmitter, 80-M, III-675
ambience amplifier, rear speaker, II-458
ammeter, I-201
 nano, I-202
 pico, II-154, I-202
 pico, circuit for, II-157
 pico, guarded input circuit, II-156
 six decade range, II-153, II-156

amplifiers, II-5-22, III-10-21
 1 watt/2.3 GHz, II-540
 2 to 6 W, with preamp, II-451
 25-watt, II-452
 30 MHz, I-567
 40 dB gain design, IV-36
 60 MHz, I-567
 135-175 MHz, I-564
 absolute value, I-31
 ac servo, bridge type, III-387
 AGC, II-17
 AGC, squelch control, III-33
 AGC, wide-band, III-15
 adjustable-gain, noninverting, I-91
 ambience, rear speaker, II-458
 amateur radio, linear, 2-30 MHz, 140W, I-555
 AM radio power, I-77
 attenuator, digitally controlled, I-53
 audio (*see* audio amplifiers)
 audio converter, two-wire to four-wire, II-14
 audio limiter, low-distortion, II-15
 audio power amplifiers, IV-28-33
 audio signal amplifiers, IV-34-42
 auto fade circuit for, II-42
 automatic level control for, II-20
 automotive audio amplifier, IV-66
 balance, II-46
 balance, loudness control, II-47, II-395
 balancing circuit, inverting, I-33
 bass tone control, stereo phonograph, I-670
 bridge, I-74
 bridge, 4W, I-79
 bridge, 16 W, I-82
 bridge, ac servo, I-458
 bridge, audio power, I-81
 bridge, high-impedance, I-353
 bridge transducer, III-71, II-84, I-351
 broadband, low-noise, I-562
 broadband, PEP, 160W, I-556
 broadband/linear, PEP, 80W, I-557
 buffer, 10x, I-128
 buffer, 100x, I-128
 buffer, ac, single-supply, I-126
 buffer, battery-powered, standard cell, I-351
 buffer, rf amplifiers with modulator, IV-490
 buffer, sinewave output, I-126
 buffer, unity-gain, stable design, II-6
 cascade, III-13
 cascade, 80 MHz, I-567
 cascade, rf amplifiers, IV-488
 CD4049 audio signal amplifiers, IV-40
 chopper, \pm 15V, III-12
 chopper channel, I-350

chopper stabilized, II-7
 clamp-limiting, active, III-15
 color video, I-34, III-724
 common-source, 450 MHz, I-568
 common-source, low power, II-84
 complementary-symmetry, I-78
 composite, II-8, III-13
 compressor/amplifier, low-distortion, IV-24
 constant-bandwidth, III-21
 current-shunt, III-21
 current collector head, II-11, II-295
 current-to-voltage, high-speed, I-35
 dc servo, I-457
 dc-stabilized, fast action, III-18
 dc-to-video log, I-38
 detector, MC1330/MC1352, television IF, I-688
 differential, III-14, I-38
 differential, high-impedance, I-27, I-354
 differential, high-input high-impedance, II-19
 differential, instrumentation, I-347, III-283
 differential, instrumentation, biomedical, III-282
 differential, programmable gain, III-507
 differential, two op amp bridge type, II-83
 dynamic, ac-coupled, III-17
 electrometer, overload protected, II-155
 FET input, II-7
 flat response, I-92, III-673
 forward-current booster, III-17
 four-quadrant photo-conductive detector, I-359
 gain, 10-dB, III-543
 gain-controlled, III-34
 gate, I-36
 guitars, matching audio signal amplifiers, IV-38
 hi-fi compander, II-12
 hi-fi expander, II-13
 high-frequency, III-259-265
 high-impedance/high gain/high-frequency, I-41
 high-impedance/low capacitance, I-691
 IF (*see* IF amplifiers)
 input/output buffer for analog multiplexers, III-11
 instrumentation, I-346, I-348, I-349, I-352, I-354, III-278-284, IV-229-234
 instrumentation, differential, high-gain, I-353
 instrumentation, high-impedance, low-drift, I-355
 instrumentation, high-speed, I-354
 instrumentation, low-signal/high-impedance, I-350
 instrumentation, precision FET input, I-355
 instrumentation, triple op-amp design, I-347
 instrumentation, variable gain, differential input, I-349
 instrumentation, very high-impedance, I-354
 inverting, I-42, II-41, III-14
 inverting, ac, high-gain, I-92
 inverting, gain of 2, lag-lead compensation, UHF, I-566
 inverting, power, I-79
 inverting, unity gain, I-80
 isolation, capacitive load, I-34
 isolation, level-shifting, I-348
 isolation, medical telemetry, I-352
 isolation, rf, II-547
 JFET bipolar cascade video, I-692
 line amplifier, universal design, IV-39
 linear, CMOS inverter in, II-11
 line-operated, III-37
 line-type, duplex, telephone, III-616
 load line protected, 75W audio, I-73
 logarithmic, II-8
 logic (*see* logic amplifier)
 log ratio, I-42
 loudness control, II-46
 low-noise design, IV-37
 low-level video detector circuit, I-687
 medical telemetry, isolation, I-352
 meter-driver, rf, 1-MHz, III-545
 micro-powered, high-input/high-impedance, 20 dB, II-44
 micro-sized, III-36
 microphone, III-34, I-87
 microphone, electronically balanced input, I-86
 microwave, IV-315-319
 monostable, II-268
 neutralized common source, 100 MHz/400MHz, I-565
 neutralized common source, 200 MHz, I-568
 noninverting, I-32, I-33, I-41, III-14
 noninverting, ac power, I-79
 noninverting, single-supply, I-75
 noninverting, split-supply, I-75
 Norton, absolute value, III-11
 op amp (*see also* operational amplifiers)
 op amp, x10, I-37
 op amp, x100, I-37
 op amp, clamping circuit, II-22
 op amp, intrinsically safe-protected, III-12
 oscilloscope sensitivity, III-436
 output, four-channel D/A, III-165
 phono, I-80, I-81
 phono, magnetic pickup, I-89
 photodiode, I-361, II-324, III-672
 photodiode, low-noise, III-19
 playback, tape, III-672
 polarity-reversing low-power, III-16
 power (*see also* power amps), II-46, II-451, III-450-456
 power, 10-W, I-76
 power, 12-W, low distortion, I-76
 power, 90-W, safe area protection, II-459
 power, GaAsFET with single supply, II-10
 power, rf power, 600 W, I-559
 pre-amps (*see* pre-amplifiers)
 precision, I-40
 programmable, III-334, III-504-508
 programmable gain, weighted resistors, II-9
 pulse-width proportional controller circuit, II-21
 push-pull, PEP, 100W, 420-450 MHz, I-554
 PWM servo, III-379
 reference voltage, I-36
 remote, I-91
 rf (*see* rf amplifiers)
 sample and hold, high-speed, I-587
 sample and hold, infinite range, II-558
 selectable input, programmable gain, I-32
 servo, 400 Hz, II-386
 servo motor, I-452
 servo motor drive, II-384
 signal distribution, I-39
 sound-activated, gain-controlled amp, IV-528
 sound mixer, II-37
 speaker, hand-held transceivers, III-39
 speaker, overload protector for, II-16
 speech compressor, II-15
 standard cell, saturated, II-296
 stereo, Av/200, I-77
 stereo, gain control, II-9
 summing, I-37, III-16
 summing, fast action, I-36
 summing, precision design, I-36
 switching power, I-33
 tape playback, I-92, IV-36
 tape recording, I-90
 telephone, III-621, IV-555, IV-560

- amplifiers (*cont.*)
- thermocouple, I-654, III-14
 - thermocouple, cold junction compensation, II-649
 - thermocouple, high-stability, I-355
 - transducer, I-86, III-669-673
 - transformerless, 6W 8-ohm output, I-75
 - transistorized, basic design, I-85
 - transistorized, headphone, II-43
 - tremolo circuit, voltage-controlled, I-598
 - tube amplifier, high-voltage isolation, IV-426
 - TV audio, III-39
 - two-meter, 5W output, I-567
 - two-meter, 10W power, I-562
 - UHF, I-565
 - UHF, wideband, high-performance FET, I-560
 - unity gain, I-27
 - unity gain, ultra-high Z, ac, II-7
 - VHF, single-device, 80W/50-ohm, I-558
 - video, I-692, III-708-712
 - video, FET cascade, I-691
 - video, loop-through amplifier, IV-616
 - voice activated switch, I-608
 - voltage, differential-to-single-ended, III-670
 - voltage-controlled, IV-20
 - voltage-follower, signal-supply operation, III-20
 - voltage-controlled (*see* voltage-controlled amplifiers)
 - volume, II-46
 - walkman, II-456
 - weighted-resistor programmable gain, precision design, II-9
 - wideband (*see* wideband amplifiers)
 - wide frequency range, III-262
 - write, III-18
 - amplitude modulator, low distortion low level, II-370
 - analog counter circuit, II-137
 - analog delay line, echo and reverb effects, IV-21
 - analog multiplexers
 - buffered input/output, III-396
 - single-trace to four-trace scope converter, II-431
 - analog multiplier, II-392
 - 0/01 percent, II-392
 - analog-to-digital buffer, high-speed 6-bit, I-127
 - analog-to-digital converters, II-23-31, III-22-26, IV-5-6
 - 3-bit, high-speed, I-50
 - 8-bit, I-44, I-46
 - 8-bit successive approximation, I-47
 - 10-bit, II-28
 - 10-bit serial output, II-27
 - 12-bit, high-speed, II-29
 - 16-bit, II-26
 - board design, IV-6
 - capacitance meter, 3^{1/2} digit, III-76
 - cyclic, II-30
 - differential input system, II-31
 - fast precision, I-49
 - four-digit (10,000 count), II-25
 - half-flash, III-26
 - IC, low cost, I-50
 - LCD 3.5-digit display, I-49
 - logarithmic, three-decade, I-48
 - precision design, I-49
 - successive approximation, I-45, II-24, II-30
 - switched-capacitor, III-23
 - three-IC, low-cost, I-50
 - tracking, III-24
 - video converter, IV-610-611
 - analyzer, gas, II-281
 - AND gate, I-395
 - large fan-in, I-395
 - anemometers
 - hot-wire, III-342
 - thermally based, II-241
 - angle-of-rotation detector, II-283
 - annunciators, II-32-34, III-27-28, IV-710
 - ac line-voltage, III-730
 - bell, electronic, IV-9
 - chime circuit, low-cost, II-33
 - door buzzer, IV-8
 - door buzzer, electronic, IV-8
 - electronic bell, II-33
 - large fan-in, I-395
 - SCR circuit, self-interrupting load, IV-9
 - sliding tone doorbell, II-34
 - two-door annunciator, IV-10
 - answering machines, beeper, IV-559
 - antennas, IV-11-14
 - active, III-1-2
 - active antenna, wideband rod, IV-4
 - active antenna, with gain, IV-2
 - active antennas, IV-1-4
 - loop, 3.5 MHz, IV-12-13
 - selector switch, IV-538-539
 - tuner, 1-to-30 MHz, IV-14
 - antitheft device, I-7
 - arc lamp, 25W, power supply for, II-476
 - arc welding inverter, ultrasonic, 20 KHz, III-700
 - arc-jet power supply, starting circuit, III-479
 - astable flip-flop with starter, II-239
 - astable multivibrators, II-269, II-510, III-196, III-233, III-238
 - op amp, III-224
 - programmable-frequency, III-237
 - square wave generation with, II-597
 - attendance counter, II-138
 - attenuators, III-29-31
 - analog signals, microprocessor-controlled, III-101
 - digitally programmable, III-30
 - digitally selectable, precision design, I-52
 - programmable, I-53, III-30
 - programmable (1 to 0.00001), I-53
 - rf, IV-322
 - variable, I-52
 - voltage-controlled, II-18, III-31
 - audio amplifiers, III-32-39
 - AGC, squelch control, III-33
 - automotive stereo systems, high-power, IV-66
 - balance indicator, IV-215
 - Baxandall tone-control, IV-588
 - booster, 20 dB, III-35
 - circuit bridge load drive, III-35
 - complementary-symmetry, I-78
 - distribution, I-39, II-39
 - fixed power supplies, \pm 35 V ac, IV-398
 - fixed power supplies, \pm 35 V, 5 A, mobile, IV-407
 - high-slew rate power op amp, I-82
 - gain-controlled, stereo, III-34
 - line-operated, III-37
 - load line protection, 75W, I-73
 - low-power, II-454
 - micro-sized, III-36
 - microphone, III-34
 - mini-stereo, III-38
 - pre-amp, NAB tape playback, professional, III-38
 - pre-amp, phono, magnetic, III-37
 - pre-amp, RIAA, III-38
 - Q-multiplier, II-20
 - signal, II-41-47
 - speaker, hand-held transceivers, III-39
 - television type, III-39
 - tone control, II-686
 - ultra-high gain, I-87
 - volume indicator, IV-212
 - audio circuits
 - audio-rf signal tracer probe, I-527
 - automatic gain control, II-17
 - booster, II-455, III-35
 - biquad filter, III-185
 - bridge load drive, III-35
 - carrier-current transmitter, III-79
 - clipper, precise, II-394
 - compressor, II-44

- continuity tester, I-550
- converter, two-wire to four-wire, II-14
- distribution amplifier, II-39, I-39
- filters (*see* audio filters)
- frequency meter, I-311
- generators (*see* sound generators)
- LED bar peak program meter display, I-254
- limiter, low distortion, II-15
- millivoltmeter, III-767, III-769
- mixers (*see* mixers)
- notch filter, II-400
- power meter, I-488
- Q multiplier, II-20
- sine wave generator, II-564
- squelch, II-394
- switching/mixing, silent, I-59
- waveform generators, precision, III-230
- audio effects circuits (*see* sound generators)
- audio equalizer, IV-18
- audio fader, IV-17
- audio filters
 - analyzer circuit, IV-309
 - biquad filter, III-185
 - notch filter, II-400
 - tunable, IV-169
- audio generators (*see* sound generators)
- audio-operated circuits (*see* sound-operated circuits)
- audio oscillators, I-64, II-24, III-427, IV-374, IV-375
 - 20Hz to 20kHz, variable, I-727
 - light-sensitive, III-315
 - sine wave, II-562
- audio power amplifier, II-451, III-454, IV-28-33
 - 20-W, III-456
 - 50-W, III-451
 - 6-W, with preamp, III-454
 - audio amplifier, IV-32
 - audio amplifier, 8-W, IV-32
 - bridge, I-81
 - bull horn, IV-31
 - general-purpose, 5 W, ac power supply, IV-30
 - op amp, simple design, IV-33
 - receiver audio circuit, IV-31
 - stereo amp, 12-V/20-W, IV-29
- audio scramblers, IV-25-27
 - voice scrambler/descrambler, IV-26
 - voice scrambler/disguiser, IV-27
- audio signal amplifiers, II-41-47, IV-34-42
 - 40 dB gain design, IV-36
 - audio compressor, II-44
 - auto fade, II-42
 - balance, II-46
 - balance and loudness amplifier, II-47
 - CD4049 design, IV-40
 - electric guitar, matching amplifier, IV-38
 - line amplifier, universal design, IV-39
 - loudness, II-46
 - low-noise design, IV-37
 - microphone preamp, II-45
 - micropower high-input-impedance 20-dB amplifier, II-44
 - power, II-46
 - preamplifier, 1000x, low-noise design, IV-37
 - preamplifier, general-purpose design, IV-42
 - preamplifier, impedance-matching, IV-37
 - preamplifier, low-noise, IV-41
 - preamplifier, magnetic phono cartridges, IV-35
 - preamplifier, microphone, IV-37, IV-42
 - preamplifier, microphone, low-impedance, IV-41
 - preamplifier, phono, low-noise, IV-36
 - preamplifier, phono, magnetic, ultra-low-noise, IV-36
 - stereo preamplifier, II-43, II-45
 - tape playback amplifiers, IV-36
 - transistor headphone amplifier, II-43
 - volume, II-46
- audio-frequency doubler, IV-16-17
- audio/video switcher circuit, IV-540-541
- auto-advance projector, II-444
- autodrum sound effect, II-591
- auto-fade circuit, II-42
- auto-flasher, I-299
- auto-zeroing scale bridge circuits, III-69
- automotive circuits, II-48-63, III-40-52, IV-43-67
 - alarms, automatic-arming, IV-50
 - alarms, automatic turn-off after 8-minute delay, IV-52
 - alarms, automatic turn-off with delay, IV-54
 - alarms, CMOS design, low-current, IV-56
 - alarms, horn as loudspeaker, IV-54
 - alarm, motion actuated, I-9
 - alarms, single-IC design, IV-55
 - air conditioner smart clutch, III-46
 - AM-radio to short-wave radio converter, IV-500
 - analog expanded-scale meter, IV-46
 - audio-amplifier, high-power, IV-66
 - automatic headlight dimmer, II-63
 - automobile locator, III-43
 - automotive exhaust emissions analyzer, II-51
 - back-up beeper, III-49, IV-51, IV-56
 - bar-graph voltmeter, II-54
 - battery charger, ni-cad, I-115
 - battery condition checker, I-108
 - battery current analyzer, I-104
 - battery monitor, I-106
 - battery supply circuit, ± 15 V and 5 V, IV-391
 - battery-alternator monitor, III-63
 - brake lights, delayed extra, III-44
 - brake lights, flashing third, III-51
 - brake light, night-safety light for parked cars, IV-61
 - brake light, third brake light, IV-60
 - burglar alarm, I-3, I-7, I-10, II-2, III-4, III-7, IV-53
 - cassette-recorder power circuit, IV-548
 - courtesy light delay switch, III-42
 - courtesy light extender, III-50
 - delayed-action windshield wiper control, II-55
 - digi-tach, II-61
 - directional signals monitor, III-48
 - door ajar monitor, III-46
 - electric vehicles, battery saver, III-67
 - electrical tester, IV-45
 - electronic circuits, IV-63-67
 - fog light controller with delay, IV-59
 - fuel gauge, digital readout, IV-46
 - exhaust-gas emissions analyzer, II-51
 - garage stop light, II-53
 - glow plug driver, II-52
 - headlight alarm, I-109, III-52
 - headlight automatic-off controller, IV-61
 - headlight delay circuit, II-59, III-49
 - headlight dimmer, II-57
 - high-speed warning device, I-101
 - horn, III-50
 - ice formation alarm, II-58
 - ignition circuit, electronic ignition, IV-65
 - ignition cut-off, IV-53
 - ignition substitute, III-41
 - ignition timing light, II-60
 - immobilizer, II-50
 - intermittent windshield wiper with dynamic braking, II-49
 - light circuits, IV-57-62
 - lights-on warning, II-55, III-42, IV-58, IV-60, IV-62
 - night-safety light for parked cars, IV-61
 - oil-pressure gauge, digital readout, IV-44, IV-47

automotive circuits (*cont.*)

PTC thermistor automotive temperature indicator, II-56
radio, receiver for, II-525
read-head pre-amplifier, III-44
road ice alarm, II-57
security system, I-5, IV-49-56
tachometer, set point, III-47
tachometer/dwell meter, III-45
temperature gauge, digital readout, IV-48
temperature indicator, PTC thermistor, II-56
turn signals, sequential flasher, II-109, III-1
vacuum gauge, digital readout, IV-45
voltage gauge, IV-47
voltage regulator, III-48, IV-67
voltmeter, bargraph, I-99
water-temperature gauge, IV-44
wiper control, II-55, II-62
wiper delay, solid-state, IV-64
wiper interval controller, IV-67

B

B-field measurer, IV-272
back-biased GaAs LED light sensor, II-321
back-EMF PM motor speed control, II-379
backup-light beeper, automotive, IV-51, IV-56
bagpipe sound effect, IV-521
balance indicator, audio amplifiers, IV-215
balancer, stereo, I-619
barricade flasher, I-299
battery charge/discharge indicator, I-122
battery charger, automatic shut-off, II-113
balance amplifiers, III-46
loudness control, II-47, II-395
balance indicator, bridge circuit, II-82
bandpass filters (*see also* filter circuits), II-222
0.1 to 10 Hz bandpass, I-296
160 Hz, I-296
active, II-221, II-223, III-190
active, with 60dB gain, I-284
active, 1 kHz, I-284
active, 20 kHz, I-297
active, variable bandwidth, I-286
biquad, RC active, I-285
biquad, second-order, III-188
Chebyshev, fourth-order, III-191
high Q, I-287
MFB, multichannel tone decoder, I-288
multiple feedback, I-285, II-224
multiple feedback, 1.0 kHz, I-297
notch, II-223
Sallen-Key, 500 Hz, I-291
second-order biquad, III-188
state variable, I-290
tunable, IV-171
band reject filters, active (*see also* filter circuits), II-401
bang-bang power controllers, IV-389
bar-code scanner, III-363
bar-expanded scale meter, II-186
bar graphs
ac signal indicator, II-187
voltmeter, II-54
voltmeter, automotive, I-99
barometer, IV-273
bass tuners, II-362
12 V, I-111
200 mA-hour, 12V ni-cad, I-114
automatic shutoff for, I-113
batteries
fixed power supply, 12-VDC/120-VAC, III-464
high-voltage generator, III-482
zapper, simple ni-cad, I-116
battery chargers, I-113, II-64, II-69, III-53-59, IV-68-72
12-V charger, IV-70
battery-life extender, lead-acid batteries, IV-72
constant-voltage, current limited charger, I-115
control for 12V, I-112
current limited 6V, I-118, IV-70
gel cell, II-66
lead/acid, III-55
lithium, II-67
low-battery detector, lead-acid, III-56
low-battery warning, III-59
low-cost trickle for 12V storage, I-117
mobile battery charger, +12-Vdc, IV-71
ni-cad, I-118
ni-cad, portable, III-57, IV-69
ni-cad, temperature-sensing charger, IV-77
ni-cad, zapper, II-66
power supply and, 14V, III-4A, II-73
PUT, III-54
regulator, I-117
simpli-cad, I-112
solar cell, II-71
thermally controlled ni-cad, II-68
UJT, III-56
universal, III-56, III-58
versatile design, II-72
voltage detector relay, II-76

wind powered, II-70
zapper, simple ni-cad, I-116
battery monitors, I-106, II-74-79, III-60-67, IV-73-80
analyzer, ni-cad batteries, III-64
automatic shutoff, battery-powered projects, III-61
battery saver, electric vehicles, III-67
battery-life extender, 9 V, III-62
battery life-extender, disconnect switch, IV-75
capacity tester, III-66
condition checker, I-108, I-121
converter, dc-to-dc +3-to-+5 V, IV-119
disconnect switch, life-extender circuit, IV-75
dynamic, constant current load fuel cell/battery tester, II-75
internal resistance tester, IV-74
level indicator, II-124
lithium battery, state of charge indicator, II-78
low-battery detector, III-63, IV-76
low-battery indicator, I-124, II-77, IV-80
low-battery protector, III-65
low-battery warning/disconnect, III-65
protection circuit, ni-cad batteries, III-62
sensor, quick-deactivating, III-61
splitter, III-66
status indicator, II-77
step-up switching regulator for 6V, II-78
temperature-sensing battery charger, ni-cad batteries, IV-77
test circuit, IV-78
test circuit, ni-cad batteries, IV-79
threshold indicator, I-124
undervoltage indicator for, I-123
voltage, II-79
voltage detector relay in, II-76
voltage gauge, automotive battery, IV-47
voltage indicator, solid-state, I-120
voltage measuring regulator, IV-77
voltage monitor, II-79
voltage monitor, HTS, I-122
voltage-level indicator, IV-80
battery-life extender, 9 V, III-62, IV-75
battery-operated equipment
ac power control switch, battery-triggered, IV-387
automatic shutoff, III-61
automotive battery supply, ± 15 V and 5 V, IV-391
automotive cassette-deck power

- circuit, IV-548
- bipolar power supply for, II-475
- buffer amplifier for standard cell, I-351
- fence charger, II-202
- flasher, high powered, II-229
- lantern circuit, I-380
- light, capacitance operated, I-131
- On indicator, IV-217
- undervoltage indicator for, I-123
- warning light, II-320
- Baxandall tone-control audio amplifier, IV-588
- BCD-to-analog converter, I-160
- BCD-to-parallel converter, multiplexed, I-169
- beacon transmitter, III-683
- beep transformer, III-555, III-566
- beepers
 - back-up, automotive circuits, III-49
 - repeater, I-19
- bells
 - electronic, II-33, IV-9
 - electronic phone, I-636
- benchtop power supply, II-472
- bicycle speedometer, IV-271, IV-282
- bilateral current source, III-469
- binary counter, II-135
- biomedical instrumentation differential amplifier, III-282
- bipolar dc-dc converter with no inductor, II-132
- bipolar power supply, II-475
- bipolar voltage reference source, III-774
- biquad audio filter, I-292-293, III-185
 - second-order bandpass, III-188
 - RC active bandpass, I-285
- bird-chirp sound effect, II-588, III-577
- bistable multivibrator, touch-triggered, I-133
- bit grabber, computer circuits, IV-105
- blinkers (*see* flashers and blinkers)
- blown-fuse alarm, I-10
- boiler control, I-638
- bongos, electronic, II-587
- boosters
 - 12ns, II-97
 - audio, III-35, II-455
 - booster/buffer for reference current boost, IV-425
 - electronic, high-speed, II-96
 - forward-current, III-17
 - LED, I-307
 - power booster, op-amp design, IV-358
 - rf amplifiers, broadcast band booster, IV-487
 - shortwave FET, I-561
- bootstrapping, cable, I-34
- brake lights
 - extra, delayed, III-44
 - flashing, extra, III-51
- brake, PWM speed control/energy recovering, III-380
- breakers
 - 12ns, II-97
 - high-speed electronic, II-96
- breaker power dwell meter, I-102
- breakout box, buffer, II-120
- breath alert alcohol tester, III-359
- breath monitor, III-350
- bridge balance indicator, II-82
- bridge circuits, I-552, II-80-85, III-68-71, IV-81-83
 - ac, II-81
 - ac servo amplifier with, III-387
 - accurate null/variable gain circuit, III-69
 - air-flow sensing thermistor bridge, IV-82
 - auto-zeroing scale, III-69
 - balance indicator, II-82
 - bridge transducer amplifier, III-71
 - crystal-controlled bridge oscillator, IV-127
 - differential amplifier, two op-amp, II-83
 - inductance bridge, IV-83
 - load driver, audio circuits, III-35
 - low power common source amplifier, II-84
 - one-power supply design, IV-83
 - QRP SWR, III-336
 - rectifier, fixed power supplies, IV-398
 - remote sensor loop transmitter, III-70
 - strain gauge signal conditioner, II-85, III-71
 - transducer, amplifier for, II-84
 - Wien bridge, variable oscillator, III-424
 - Wien-bridge filter, III-659
 - Wien-bridge oscillator, III-429
 - Wien-bridge oscillator, low-distortion, thermally stable, III-557
 - Wien-bridge oscillator, low-voltage, III-432
 - Wien-bridge oscillator, single-supply, III-558
- brightness controls, III-308
- LED, I-250
 - low loss, I-377
- broadband communications
 - ac active rectifier, IV-271
- broadcast-band rf amplifier, II-546, III-264
- buck converter, 5V/0.5A, I-494
- buck/boost converter, III-113
- bucking regulator, high-voltages, III-481
- buffers, IV-88-90
 - ac, single-supply, high-speed, I-127-128
 - ADC input, high-resolution, I-127
 - A/D, 6-bit, high-speed, I-127
 - booster/buffer for reference current boost, IV-425
 - capacitance, stabilized low-input, III-502
 - input/output, for analog multiplexers, III-11
 - inverting bistable buffer, IV-90
 - oscillator buffers, IV-89
 - precision-increasing design, IV-89
 - rf amplifiers, buffer amplifier with modulator, IV-490
 - stable, high-impedance, I-128
 - unity gain, stable, good speed and high-input impedance, II-6
 - video, low-distortion, III-712
 - wideband, high-impedance/low-capacitance I-127
- buffer amplifiers
 - 10x, I-128
 - 100x, I-128
 - ac, single-supply, I-126
 - battery-powered, standard cell, I-351
 - sinewave output, I-126
 - unity-gain, stable design, II-6
- buffered breakout box, II-120
- bug detector, III-365
- bug tracer, III-358
- bull horn, II-453, IV-31
- burglar alarms (*see* alarms)
- burst generators (*see also* function generators; sound generators; waveform generators), II-86-90, III-72-74
 - multi-, square waveform, II-88
 - rf, portable, III-73
 - single timer IC square wave, II-89
 - single-tone, II-87
 - strobe-tone, I-725, II-90
 - tone, II-90
 - tone burst, European repeaters, III-74
- burst power control, III-362
- bus interface, eight bit uP, II-114
- Butler oscillators
 - aperiodic, I-196
 - common base, I-191
 - emitter follower, II-190-191, II-194
- Butterworth filter, high-pass, fourth-order, I-280
- buzzers
 - door buzzer, IV-8

buzzers (*cont.*)

- continuous tone 2kHz, I-11
- gated 2kHz, I-12

C

- cable bootstrapping, I-34
 - cable tester, III-539
 - calibrated circuit, DVM auto, I-714
 - calibrated tachometer, III-598
 - calibration standard, precision, I-406
 - calibrators
 - crystal, 100 kHz, I-185
 - electrolytic-capacitor reforming circuit, IV-276
 - ESR measurer, IV-279
 - oscilloscope, II-433, III-436
 - portable, I-644
 - square-wave, 5 V, I-423
 - tester, IV-265
 - wave-shaping circuits, high slew rates, IV-650
- cameras (*see* photography-related circuits; television-related circuits; video circuits)
- canceller, central image, III-358
- capacitance buffers
 - low-input, III-498
 - low-input, stabilized, III-502
- capacitance meters, I-400, II-91-94, III-75-77
- A/D, three-and-a-half digit, III-76
- capacitance-to-voltage, II-92
- digital, II-94
- capacitance multiplier, I-416, II-200
- capacitance relay, I-130
- capacitance switched light, I-132
- capacitance-to-pulse width converter, II-126
- capacitance-to-voltage meter, II-92
- capacitor discharge
 - high-voltage generator, III-485
 - ignition system, II-103
- capacity tester, battery, III-66
- car port, automatic light controller, II-308
- cars (*see* automotive circuits)
- carrier-current circuits, III-78-82, IV-91-93
- AM receiver, III-81
 - audio transmitter, III-79
 - data receiver, IV-93
 - data transmitter, IV-92
 - FM receiver, III-80
 - intercom, I-146
 - power-line modem, III-82
 - receiver, I-143
 - receiver, single transistor, I-145
 - receiver, IC, I-146
 - remote control, I-146
 - transmitter, I-144
 - transmitter, integrated circuit, I-145
- carrier-operated relay (COR), IV-461
- carrier system receiver, I-141
- carrier transmitter with on/off 200kHz line, I-142
- cascaded amplifier, III-13
- cassette bias oscillator, II-426
- cassette interface, telephone, III-618
- cassette-recorders (*see* tape-recorder circuits)
- centigrade thermometer, I-655, II-648, II-662
- central image canceller, III-358
- charge pool power supply, III-469
- charge pumps
 - positive input/negative output, I-418, III-360
 - regulated for fixed power supplies, IV-396
- chargers (*see* battery charger)
- chase circuit, I-326, III-197
- Chebyshev filters (*see also* filter circuits)
 - bandpass, fourth-order, III-191
 - fifth-order multiple feedback low-pass, II-219
 - high-pass, fourth-order, III-191
- chime circuit, low-cost, II-33
- chopper amplifier, I-350, II-7, III-12
- checkers
 - buzz box continuity and coil, I-551
 - car battery condition, I-108
 - crystal, I-178, I-186
 - zener diode, I-406
- chroma demodulator with RGB matrix, III-716
- chug-chug sound generator, III-576
- circuit breakers (*see also* protection circuits)
 - 12ns, II-97
 - ac, III-512
 - high-speed electronic, II-96
 - trip circuit, IV-423
- circuit protection (*see* protection circuits)
- clamp-on-current probe compensator, II-501
- clamp-limiting amplifiers, active, III-15
- clamping circuits
 - video signal, III-726
 - video summing amplifier and, III-710
- class-D power amplifier, III-453
- clippers, II-394, IV-648
 - audio-powered noise, II-396
 - audio clipper/limiter, IV-355
 - zener-design, fast and symmetrical, IV-329
- clock circuits, II-100-102, III-83-85
- 60Hz clock pulse generator, II-102
- adjustable TTL, I-614
- comparator, I-156
- crystal oscillators, micropower design, IV-122
- digital, with alarm, III-84
- gas discharge displays, 12-hour, I-253
- oscillator/clock generator, III-85
- phase lock, 20-Mhz to Nubus, III-105
- run-down clock for games, IV-205
- sensor touch switch and clock, IV-591
- single op amp, III-85
- source, clock source, I-729
- three-phase from reference, II-101
- TTL, wide-frequency, III-85
- Z80 computer, II-121
- clock generators
 - oscillator, I-615, III-85
 - precision, I-193
 - pulse generator, 60 Hz, II-102
- clock radio, I-542
- AM/FM, I-543
- CMOS circuits
 - 555 astable true rail to rail square wave generator, II-596
 - 9-bit, III-167
 - coupler, optical, III-414
 - crystal oscillator, III-134
 - data acquisition system, II-117
 - flasher, III-199
 - inverter, linear amplifier from, II-11
 - mixer, I-57
 - optical coupler, III-414
 - oscillator, III-429, III-430
 - short-pulse generator, III-523
 - timer, programmable, precision, III-652
 - touch switch, I-137
 - universal logic probe, III-499
- coaxial cable, five-transistor pulse booster, II-191
- Cockcroft-Walton cascaded voltage doubler, IV-635
- code-practice oscillator, I-15, I-20, I-22, II-428-431, IV-373, IV-375, IV-376
- coil drivers, current-limiting, III-173
- coin flipper circuit, III-244
- color amplifier, video, III-724
- color-bar generator, IV-614
- color organ, II-583, II-584
- color video amplifier, I-34
- Colpitts crystal oscillator, I-194, I-572, II-147
- 1-to-20 MHz, IV-123
- frequency checker, IV-301

- harmonic, I-189-190
- two-frequency, IV-127
- combination locks
 - electronic, II-196
 - electronic, three-dial, II-195
- commutator, four-channel, II-364
- comparers (*see* compressor/expander circuits)
- comparators, I-157, II-103-112, III-86-90
 - demonstration circuit, II-109
 - diode feedback, I-150
 - display and, II-105
 - double-ended limit, I-156, II-105
 - dual limit, I-151
 - four-channel, III-90
 - frequency, II-109
 - frequency-detecting, III-88
 - high-impedance, I-157
 - high-input impedance window comparator, II-108
 - high-low level comparator with one op amp, II-108
 - latch and, III-88
 - LED frequency, II-110
 - limit, II-104, I-156
 - low-power, less than 10uV hysteresis, II-104
 - microvolt, dual limit, III-89
 - microvolt, with hysteresis, III-88
 - monostable using, II-268
 - opposite polarity input voltage, I-155
 - oscillator, tunable signal, I-69
 - power supply overvoltage, glitch detection with, II-107
 - precision, balanced input/variable offset, III-89
 - precision, photodiode, I-360, I-384
 - time-out, I-153
 - TTL-compatible Schmitt trigger, II-111
 - three-input and gate comparator, op-amp design, IV-363
 - variable hysteresis, I-149
 - voltage comparator, IV-659
 - voltage monitor, II-104
 - window, I-152, I-154, II-106, III-87, III-90, III-776-781, IV-656-658
 - with hysteresis, I-157
 - with hysteresis, inverting, I-154
 - with hysteresis, noninverting, I-153
- compass
 - digital design, IV-147
 - Hall-effect, III-258
- compensator, clamp-on-current probe, II-501
- composite amplifier, II-8, III-13
- composite-video signal text adder, III-716
- compressor/expander circuits, III-91-95, IV-94-97
 - amplifier/compressor, low-distortion, IV-24
 - audio, II-44
 - audio compressor/audio-band splitter, IV-95
 - clock circuit, I-156
 - guitar, sound-effect circuit, IV-519
 - hi-fi, II-12, II-13
 - hi-fi, de-emphasis, III-95
 - hi-fi, pre-emphasis, III-93
 - low-voltage, III-92
 - protector circuit, IV-351
 - speech, II-2
 - universal design, IV-96-97
 - variable slope, III-94
- computalarm, I-2
- computer circuits (*see also* interfaces), II-113-122, III-96-108, IV-98-109
 - analog signal attenuator, III-101
 - alarm, I-2
 - ASCII triplex LCD, 8048/IM80C48 8-char/16-seg, II-116
 - bit grabber, IV-105
 - buffered breakout box, II-120
 - bus interface, 8-bit uP, II-114
 - clock phase lock, 20-Mhz-to-Nubus, III-105
 - CMOS data acquisition system, II-117
 - CPU interface, one-shot design, IV-239
 - data separator for floppy disks, II-122
 - deglitcher, IV-109
 - display, eight-digit, III-106
 - dual 8051s execute in lock-step circuit, IV-99
 - EEPROM pulse generator, 5V-powered, III-99
 - eight-channel mux/demux system, II-115
 - eight-digit microprocessor display, III-106
 - flip-flop inverter, spare, III-103
 - high-speed data acquisition system, II-118
 - interface, 680x, 650x, 8080 families, III-98
 - interval timer, programmable, II-678
 - keyboard matrix interface, IV-240
 - line protectors, 3 uP I/O, IV-101
 - logic-level translators, IV-242
 - logic line monitor, III-108
 - long delay line, logic signals, III-107
 - memory/protector power supply monitor, IV-425
 - memory saving power supply for, II-486
- microprocessor selected pulse width control, II-116
- multiple inputs detector, III-102
- one-of-eight channel transmission system, III-100
- oscilloscope digital-levels, IV-108
- power supply watchdog, II-494
- pulse width control, II-116
- printer-error alarm, IV-106
- reset protection, IV-100
- reset switch, child-proof, IV-107
- RGB blue box, III-99
- RS-232 datsaselector, automatic, III-97
- RS-232C line-driven CMOS circuits, IV-104
- RS-232-to-CMOS line receiver, III-102
- RS-232C LED circuit, III-103
- short-circuit sensor, remote data lines, IV-102
- signal attenuator, analog, microprocessor-controlled, III-101
- socket debugger, coprocessor, III-104
- speech synthesizer, III-732
- stalled-output detector, IV-109
- switch debouncer, IV-105
- switch debouncer, auto-repeat, IV-106
- triac array driver, II-410
- uninterruptible power supply, II-462
- Vpp generator for EPROMs, II-114
- XOR gate, IV-107
- XOR gate up/down counter, III-105
- Z-80 bus monitor/debugger, IV-103
- Z80 clock, II-121
- contact switch, I-136
- continuity testers, II-533, II-535, III-345, III-538-540, IV-287, IV-289, IV-296
 - audible, adjustable, II-536
 - cable tester, III-539
 - latching design, IV-295
 - PCB, II-342, II-535
- contrast meters, II-447
 - automatic, I-472
- control circuits (*see also* alarms; detectors; indicators; monitors; motor control circuits; sensors), III-378-390
 - ac servo amplifier, bridge-type, III-387
 - boiler, I-638
 - brightness, low-loss, I-377
 - fan speed, III-382
 - feedback speed, I-447
 - floodlamp power, I-373
 - fluid level, I-387

- control circuits (*cont.*)
 full-wave SCR, I-375
 heater, I-639
 hi-fi tone, high-Z input, I-676
 high-power, sensitive contacts for, I-371
 LED brightness, I-250
 light-level, I-380
 light-level, 860 W limited-range low-cost, I-376
 light-level, brightness, low-loss, I-377
 liquid level, I-388
 model train and/or car, I-453, I-455
 motor controllers (*see* motor control circuits)
 on/off, I-665
 phase control, hysteresis-free, I-373
 power tool torque, I-458
 sensitive contact, high power, I-371
 servo system, III-384
 single-setpoint temperature, I-641
 speed control (*see* speed controllers)
 switching, III-383
 temperature, I-641-643
 temperature-sensitive heater, I-640
 three-phase power-factor, II-388
 tone control (*see* tone controls)
 voltage-control, pulse generator and, III-524
 water-level sensing, I-389
 windshield wiper, I-105
- conversion and converters, I-503, II-123-132, III-109-122, IV-110-120
 3-5 V regulated output, III-739
 4-18 MHz, III-114
 4-to-20-mA current loop, IV-111
 5V-to-isolated 5V at 20MA, III-474
 5V/0.5A buck, I-494
 9-to-5 V converter, IV-119
 12 V- to 9-, 7.5-, or 6-V, I-508
 12-to-16 V, III-747
 + 50V feed forward switch mode, I-495
 + 50 V push-pull switched mode, I-494
 100 MHz, II-130
 100 V/10.25 A switch mode, I-501
 ac-to-dc, I-165
 ac-to-dc, high-impedance precision rectifier, I-164
 analog-to-digital (*see* analog-to-digital conversion)
 ATV rf receiver/converter, IV-420 MHz, low-noise, IV-496, IV-497
 BCD-to-analog, I-160
 BCD-to-parallel, multiplexed, I-169
 buck/boost, III-113
 calculator-to-stopwatch, I-153
 capacitance-to-pulse width, II-126
 current-to-frequency, IV-113
 current-to-frequency, wide-range, I-164
 current-to-voltage, I-162, I-165
 current-to-voltage, grounded bias and sensor, II-126
 current-to-voltage, photodiode, II-128
 dc-dc, 3-25 V, III-744, IV-118
 dc-to-dc, + 3-to- + 5 V battery, IV-119
 dc-to-dc, 1-to-5 V, IV-119
 dc-to-dc, bipolar, no inductor, II-132
 dc-to-dc, fixed 3- to 15-V supplies, IV-400
 dc-to-dc, isolated +15V., III-115
 dc-to-dc, push-pull, 400 V, 60 W, I-210
 dc-to-dc, regulating, I-210, I-211, II-125, III-121
 dc-to-dc, step up-step down, III-118
 digital-to-analog (*see* digital-to-analog conversion)
 fixed power supply, III-470
 flyback, I-211
 flyback, self oscillating, I-170, II-128
 flyback, voltage, high-efficiency, III-744
 frequency, I-159
 frequency-to-voltage (*see* frequency-to-voltage conversion)
 high-to-low impedance, I-41
 intermittent converter, power-saving design, IV-112
 light intensity-to-frequency, I-167
 logarithmic, fast-action, I-169
 low-frequency, III-111
 ohms-to-volts, I-168
 oscilloscope, I-471
 period-to-voltage, IV-115
 pico-ampere, 70 voltage with gain, I-170
 PIN photodiode-to-frequency, III-120
 polarity, I-166
 positive-to-negative, III-112, III-113
 peak-to-peak, ac-dc, precision, II-127
 pulse height-to-width, III-119
 pulse train-to-sinusoid, III-122
 pulse width-to-voltage, III-117
 radio beacon converter, IV-495
 rectangular-to-triangular waveform, IV-116-117
 regulated 15-Vout 6-V driven, III-745
 resistance-to-voltage, I-161-162
 RGB-composite video signals, III-714
 RMS-to-dc, II-129, I-167
 RMS-to-dc, 50-MHz thermal, III-117
 RGB-to-NTSC, IV-611
 sawtooth wave converter, IV-114
 shortwave, III-114
 simple LF, I-546
 sine-to-square wave, I-170, IV-120
 square-to-sine wave, III-118
 square-to-triangle wave, TTL, II-125
 temperature-to-frequency, I-168
 temperature-to-time, III-632-633
 triangle-to-sine wave, II-127
 TTL-to-MOS logic, II-125, I-170
 two-wire to four-wire audio, II-14
 unipolar-to-dual voltage supply, III-743
 video, a/d and d/a, IV-610-611
 video, RGB-to-NTSC, IV-611
 VLF, I-547
 VLF, rf converter, IV-497
 voltage ratio-to-frequency, III-116
 voltage, III-742-748, III-742
 voltage, negative voltage, uP-controlled, IV-117
 voltage, offline, 1.5-W, III-746
 voltage-to-current, I-166, II-124, III-110, IV-118
 voltage-to-current, power, I-163
 voltage-to-current, zero IB error, III-120
 voltage-to-frequency (*see* voltage-to-frequency conversion)
 voltage-to-pulse duration, II-124
 WWV-to-SW rf converter, IV-499
 coprocessor socket debugger, III-104
 countdown timer, II-680
 counters, II-133-139, III-123-130
 analog circuit, II-137
 attendance, II-138
 binary, II-135
 divide-by-N, CMOS programmable, I-257
 divide-by- n , 1+ GHz, IV-155
 divide-by-odd-number, IV-153
 frequency, III-340, III-768, IV-300
 frequency, 1.2 GHz, III-129
 frequency, 10-MHz, III-126
 frequency, 100 MHz, periodic, II-136
 frequency, low-cost, III-124
 frequency, preamp, III-128
 frequency, tachometer and, I-310
 geiger, I-536-537
 microfarad counter, IV-275
 odd-number divider and, III-217
 preamplifier, oscilloscope, III-438
 precision frequency, I-253
 programmable, low-power wide-range, III-126
 ring, 20 kHz, II-135
 ring, incandescent lamp, I-301
 ring, low cost, I-301
 ring, low-power pulse circuit, IV-437

- ring, SCR, III-195
- ring, variable timing, II-134
- time base, function generators, I-104, IV-201
- universal, 10 MHz, I-255, II-139
- universal, 40-MHz, III-127
- up/down, 8-digit, II-134
- up/down, extreme count freezer, III-125
- up/down, XOR gate, III-105
- couplers
 - linear, ac analog, II-412
 - linear, analog, II-413
 - linear, dc, II-411
 - optical, CMOS design, III-414
 - optical, TTL design, III-416
 - photon, II-412
 - transmitter oscilloscope for CB signals, I-473
- courtesy light delay/extender, I-98, III-42, III-50
- CRO doubler, III-439
- cross-fader, II-312
- cross-hatch generator, color TV, III-724
- crossover networks, II-35
 - 5V, I-518
 - ac/dc lines, electronic, I-515
 - active, I-172
 - active, asymmetrical third order Butterworth, I-173
 - electronic circuit for, II-36
- crowbars, I-516
 - electric, III-510
 - electronic, II-99
 - SCR, II-496
- crystal oscillators (*see also* oscillators),
 - I-180, I-183-185, I-195, I-198, III-140-151, III-131-140, IV-121-128
 - 1-to-20 MHz, TTL design, IV-127
 - 1-to-4 MHz, CMOS design, IV-125
 - 10 MHz, II-141
 - 10-to-150 kHz, IV-125
 - 10-to-80 MHz, IV-125
 - 50-to-150 MHz, IV-126
 - 96 MHz, I-179
 - 150-to-30,000 kHz, IV-126
 - 330 MHz, IV-125
 - aperiodic, parallel-mode, I-196
 - bridge, crystal-controlled, IV-127
 - Butler oscillator, I-182
 - calibrator, 100 kHz, I-185, IV-124
 - ceramic, 10 MHz, varactor tuned, II-141
 - clock, micropower design, IV-122
 - CMOS, I-187, III-134
 - CMOS, 1-to-4 MHz, IV-125
 - Colpitts, II-147
 - Colpitts, 1-to-20 MHz, IV-123
 - Colpitts, frequency checker, IV-301
 - Colpitts, two-frequency, IV-127
 - crystal-controlled oscillator as, II-147
 - crystal-stabilized IC timer for subharmonic frequencies, II-151
 - crystal tester, I-178, I-186, II-151
 - doubler and, I-184
 - easy start-up, III-132
 - FET, 1 MHz, II-144
 - fundamental-frequency, III-132
 - high-frequency, I-175, II-148
 - high-frequency signal generator as, II-150
 - IC-compatible, II-145
 - LO for SSB transmitter controlled by, II-142
 - low-frequency, I-184, II-146
 - low-frequency, 10 kHz to 150 kHz, II-146
 - low-noise, II-145
 - OF-1 HI oscillator, international, I-197
 - OF-1 LO oscillator, international, I-189
 - overtone, I-176, I-180, I-183, II-146
 - overtone, 100 MHz, IV-124
 - marker generator, III-138
 - mercury cell crystal-controlled oscillator as, II-149
 - overtone, I-176, I-177, I-180, I-186, III-146
 - Pierce, II-144
 - Pierce, 1-MHz, III-134
 - Pierce, JFET, I-198
 - Pierce, low-frequency, III-133
 - quartz, two-gate, III-136
 - reflection oscillator, crystal-controlled, III-136
 - Schmitt trigger, I-181
 - signal source controlled by, II-143
 - sine-wave oscillator, I-198
 - stable low frequency, I-198
 - standard, 1 MHz, I-197
 - temperature-compensated, I-187, III-137
 - temperature-compensated, 5V driven, low-power, II-142
 - third-overtone, I-186, IV-123
 - time base, economical design, IV-128
 - TTL design, I-179
 - TTL design, 1-to-20 MHz, IV-127
 - TTL-compatible, I-197
 - transistorized, I-188
 - tube-type, I-192
 - VHF, 20-MHz, III-138
 - VHF, 50-MHz, III-140
 - VHF, 100-MHz, III-139
 - voltage-controlled, III-135, IV-124
 - crystal switching, overtone oscillator with, I-183
 - current analyzer, auto battery, I-104
 - current booster, I-30, I-35
 - current collector head amplifier, II-11, II-295
 - current loop, 4-to-20-mA converter, IV-111
 - current meters and monitors, I-203, II-152-157, III-338
 - ac current indicator, IV-290
 - current sensing in supply rails, II-153
 - electrometer amplifier with overload protection, II-155
 - Hall-effect circuit, III-255
 - Hall-sensor, IV-284
 - high-gain current sensor, IV-291
 - pico ammeter, II-154, II-157
 - pico ammeter, guarded input, II-156
 - range ammeter, six-decade, II-153, II-156
 - current readout, rf, I-22
 - current sensing, supply rails, II-153
 - current sink, I-206
 - 1 mA for fixed power supplies, IV-402
 - voltage-controlled, IV-629
 - current sources, I-205, I-697
 - 0-to-200-nA, IV-327
 - bilateral, III-469, I-694-695
 - bipolar, inverting, I-697
 - bipolar, noninverting, I-695
 - constant, I-697, III-472
 - fixed power supplies, bootstrapped amp, IV-406
 - fixed power supplies, differential-input, fast-acting, IV-405
 - low-current source, fixed power supplies, IV-399
 - precision, I-205
 - precision, 1mA to 1mA, I-206
 - regulator, variable power supply, III-490
 - variable power supplies, voltage-programmable, IV-420
 - voltage-controlled, grounded source/load, III-468
 - current-loop controller, SCR design, IV-387
 - current-shunt amplifiers, III-21
 - current-to-frequency converter, IV-113
 - wide range, I-164
 - current-to-voltage amplifier, high-speed, I-35
 - current-to-voltage converter, I-162, I-165
 - grounded bias and sensor in, II-126
 - photodiode, II-128
 - curve tracer
 - diodes, IV-274
 - FET, I-397
 - CW radio communications

CW radio communications (*cont.*)

filter, razor sharp, II-219
keying circuits, IV-244
offset indicator, IV-213
SSB/CW product detector, IV-139
transceiver, 5 W, 80-meter, IV-602
transmitter, 1-W, III-678
transmitter, 40-M, III-684
transmitter, 902-MHz, III-686
transmitter, HF low-power, IV-601
transmitter, QRP, III-690

cyclic A/D converter, II-30

D

darkroom equipment (*see* photography-related circuits)

Darlington regulator, variable power supplies, IV-421

data-manipulation circuits, IV-129-133
acquisition circuits, CMOS system, II-117

acquisition circuits, four-channel, I-421

acquisition circuits, high-speed system, II-118

analog-signal transmission isolator, IV-133

data-acquisition systems, IV-131
link, IR type, I-341

prescaler, low-frequency, IV-132
read-type circuit, 5 MHz, phase-

encoded, II-365
receiver/message demuxer, three-wire, IV-130

selector, RS-232, III-97

separator, floppy disk, II-122

data transmission

receiver, carrier-current circuit design, IV-93

transmitter, carrier-current circuit design, IV-92

dc adapter/transceiver, hand-held, III-461

dc generators, high-voltage, III-481

dc restorer, video, III-723

dc servo drive, bipolar control input, II-385

dc static switch, II-367

dc-to-dc converters, IV-118

1-to-5 V, IV-119

3-25 V, III-744

bipolar, no inductor, II-132

dual output \pm 12-15 V, III-746

fixed power supplies, 3-to-15 V, IV-400

isolated +15 V, III-115

push-pull, 400 V, 60 W, I-210

regulated, I-210, I-211, II-125, III-121

step up/step down, III-118

dc-to-dc SMPS variable power supply, II-480

debouncer, III-592, IV-105

auto-repeat, IV-106

flip-flop, IV-108

debugger, coprocessor sockets, III-104

decibel level detector, audio, with meter driver, III-154

decoders, II-162, III-141-145

10.8 MHz FSK, I-214

24-percent bandwidth tone, I-215

direction detector, III-144

dual-tone, I-215

encoder and, III-144

frequency division multiplex stereo, II-169

PAL/NTSC, with RGB input, III-717

radio control receiver, I-574

SCA, I-214, III-166, III-170

second-audio program adapter, III-142

sound-activated, III-145

stereo TV, II-167

time division multiplex stereo, II-168

tone alert, I-213

tone dial, I-631

tone dial sequence, I-630

tone, I-231, III-143

tone, dual time constant, II-166

tone, relay output, I-213

video, NTSC-to-RGB, IV-613
weather-alert detector/decoder, IV-140

degitcher circuit, computer circuits, IV-109

delay circuits/ delay units, III-146-148

adjustable, III-148

door chimes, I-218

headlights, I-107, II-59

leading-edge, III-147

long duration time, I-217, I-220

precision solid state, I-664

pulse, dual-edge trigger, III-147

time delay, constant-current charging, II-668

time delay, simple design, I-668, II-220

windshield wiper delay, I-97, II-55

delay line, analog, echo and reverb effects, IV-21

delayed pulse generator, II-509

delay relay, ultra-precise long time, II-211

demodulators, II-158-160, III-149-150
5V FM, I-233

12V FM, I-233

565 SCA, III-150

AM, II-160

chroma, with RGB matrix, III-716

FM, II-161

FM, narrow-band, carrier detect, II-159

linear variable differential transformer driver, I-403

LVDT circuit, III-323-324, III-323

LVDT driver, II-337

stereo, II-159

telemetry, I-229

demonstration comparator circuit, II-109

demultiplexer, III-394

descramblers, II-162

gated pulse, II-165

outband, II-164

sine wave, II-163

derived center-channel stereo system, IV-23

detect-and-hold circuit, peak, I-585

detection switch, adjustable light, I-362

detectors (*see also* alarms; control circuits; indicators; monitors; sensors), II-171-178, III-151-162, IV-134-145

air flow, I-235, II-240-242

air motion, I-222, III-364

air-pressure change, IV-144

amplifier, four quadrant photoconductive, I-359

angle of rotation, II-283

bug, III-365

controller circuit, IV-142

decibel level, audio, with meter driver, III-154

direction detector, thermally operated, IV-135

double-ended limit, I-230, I-233

duty-cycle, IV-144

edge, III-157, I-226

electrostatic, III-337

envelope detector, III-155

envelope detector, AM signals, IV-142

envelope detector, low-level diodes, IV-141

flame, III-313

flow, III-202-203

flow, low-rate thermal, III-203

fluid and moisture, II-243, II-248, III-204-210, IV-184-191

frequency limit, II-177

frequency window, III-777

frequency, digital, III-158

frequency-boundary, III-156

gas, II-278, III-246-253
 gas and smoke, I-332
 gas and vapor, II-279
 ground-fault Hall detector, IV-208-209
 high-frequency peak, II-175
 high-speed peak, I-232
 IC product detector, IV-143
 infrared, II-289, III-276, IV-224
 IR, long-range objects, III-273
 level, II-174
 level, with hysteresis, I-235
 lie detector, IV-206
 light detector, IV-369
 light interruption, I-364
 light level, III-316
 light level, level drop, III-313
 line-current, optically coupled, III-414
 liquid level, I-388, I-390
 low-level video, video IF amplifier, I-687-689
 low-line loading ring, I-634
 low-voltage, I-224
 magnet, permanent-magnet detector, IV-281
 magnetic transducer, I-233
 MC1330/MC1352 television IF amplifier, I-688
 metal, II-350-352, IV-137
 missing pulse, I-232, III-159
 moisture, I-442
 motion, IV-341-346
 motion, UHF, III-516
 multiple-input, computer circuit, III-102
 negative peak, I-234
 nuclear particle, I-537
 null, I-148, III-162
 peak program, III-771
 peak, II-174, II-175, IV-138, IV-143
 peak, analog, with digital hold, III-153
 peak, digital, III-160
 peak, high-bandwidth, III-161
 peak, low-drift, III-156
 peak, negative, I-225
 peak, op amp, IV-145
 peak, positive, III-169
 peak, wide-bandwidth, III-162
 peak, wide-range, III-152
 peak voltage, precision, I-226
 people-detector, infrared-activated, IV-225
 pH level, probe and, III-501
 phase, III-440-442
 phase, 10-bit accuracy, II-176
 photodiode level, precision, I-365
 positive peak, I-225, I-235
 power loss, II-175
 product, I-223, I-861
 proximity, I-344, II-135, II-136, IV-341-346
 pulse coincidence, II-178
 pulse sequence, II-172
 pulse-width, out-of-bounds, III-158
 radar (*see* radar detector)
 radiation (*see* radiation detector)
 resistance ratio, II-342
 rf, II-500, IV-139
 rf detector probe, IV-433
 Schmitt trigger, III-153
 smoke, II-278, III-246-253, IV-140
 smoke, ionization chamber, I-332-333
 smoke, operated ionization type, I-596
 smoke, photoelectric, I-595
 speech activity on phone lines, II-617, III-615
 SSB/CW product detectors, IV-139
 stalled computer-output detector, IV-109
 static detector, IV-276
 telephone ring, III-619, IV-564
 telephone ring, optically interfaced, III-611
 threshold, precision, III-157
 tone, 500-Hz, III-154
 toxic gas, II-280
 true rms, I-228
 TV sound IF/FM IF amplifier with quadrature, I-690
 two-sheets in printer detector, IV-136
 ultra-low drift peak, I-227
 undervoltage detector, IV-138
 video, low-level video IF amplifier, I-687-689
 voltage level, I-8, II-172
 weather-alert decoder, IV-140
 window, I-235, III-776-781, IV-658
 zero crossing, I-732, I-733, II-173
 zero crossing, with temperature sensor, I-733
 deviation meter, IV-303
 dial pulse indicator, telephone, III-613
 dialers, telephone
 pulse-dialing telephone, III-610
 pulse/tone, single-chip, III-603
 telephone-line powered repertory, I-633
 tone-dialing telephone, III-607
 dice, electronic, I-325, III-245, IV-207
 differential amplifiers, I-38, III-14
 high-impedance, I-27, I-354
 high-input high-impedance, II-19
 instrumentation, I-347, III-283
 instrumentation, biomedical, III-282
 programmable gain, III-507
 two op amp bridge type, II-83
 differential analog switch, I-622
 differential capacitance measurement circuit, II-665
 differential hold, I-589, II-365
 differential multiplexers
 demultiplexer/, I-425
 wide band, I-428
 differential thermometer, II-661, III-638
 differential voltage or current alarm, II-3
 differentiators, I-423
 negative-edge, I-419
 positive-edge, I-420
 digital-capacitance meter, II-94
 digital-IC, tone probe for testing, II-504
 digital-frequency meter, III-344
 digital-logic probe, III-497
 digital audio tape (DAT)
 ditherizing circuit, IV-23
 digital multimeter (DMM)
 high-resistance-measuring, IV-291
 digital oscillator, resistance controlled, II-426
 digital transmission isolator, II-414
 digital voltmeters (DVM)
 3.5-digit, common anode display, I-713
 3.5-digit, full-scale, four-decade, III-761
 3.75-digit, I-711
 4.5-digit, III-760
 4.5-digit, LCD display, I-717
 auto-calibrate circuit, I-714
 automatic nulling, I-712
 interface and temperature sensor, II-647
 digital-to-analog converters, I-241, II-179-181, III-163-169
 0-to -5V output, resistor terminated, I-239
 3-digit, BCD, I-239
 8-bit, I-240-241
 8-bit, high-speed, I-240
 8-bit, output current to voltage, I-243
 8-bit to 12-bit, two, II-180
 9-bit, CMOS, III-167
 10-bit, I-238
 10-bit, 4-quad, offset binary coding, multiplying, I-241
 +10V full scale bipolar, I-242
 +10V full scale unipolar, I-244
 12-bit, binary two's complement, III-166

- digital-to-analog converters (*cont.*)
 - 12-bit, precision, I-242
 - 12-bit, variable step size, II-181
 - 14-bit binary, I-237
 - 16-bit binary, I-243
 - fast voltage output, I-238
 - high-speed voltage output, I-244
 - multiplying, III-168
 - output amplifier, four-channel, III-165
 - video converter, IV-610-611
- digitizer, tilt meter, III-644-646
- dimmers (*see* lights/light-activated and controlled circuits)
- diode emitter driver, pulsed infrared, II-292
- diode tester, II-343, III-402
 - go/no-go, I-401
 - zener diodes, I-406
- diode-matching circuit, IV-280
- dip meters, I-247, II-182-183
 - basic grid, I-247
 - dual gate IGFET, I-246
 - little dipper, II-183
 - varicap tuned FET, I-246
- diplexer/mixer, IV-335
- direction detector, thermally operated, IV-135
- direction detector decoder, III-144
- direction finders, IV-146-149
 - compass, digital design, IV-147
 - radio-signal direction finder, IV-148-149
- direction-of-rotation circuit, III-335
- directional-signals monitor, auto, III-48
- disco strobe light, II-610
- discrete current booster, II-30
- discrete sequence oscillator, III-421
- discriminators
 - multiple-aperture, window, III-781
 - pulse amplitude, III-356
 - pulse width, II-227
 - window, III-776-781
- display circuits, II-184-188, III-170-171
 - 3¹/₂ digit DVM common anode, II-713
 - 60 dB dot mode, II-252
 - audio, LED bar peak program meter, II-254
 - bar-graph indicator, ac signals, II-187
 - brightness control, III-316
 - comparator and, II-105
 - exclamation point, II-254
 - expanded scale meter, dot or bar, II-186
 - LED bar graph driver, II-188
 - LED matrix, two-variable, III-171
 - oscilloscope, eight-channel voltage, III-435
- dissolver, lamp, solid-state, III-304
- distribution circuits, II-35
- distribution amplifiers
 - audio, I-39, II-39
 - signal, I-39
- dividers, IV-150-156
 - 1 + GHz divide-by-*n* counter, IV-155
 - 7490-divided-by-*n* circuits, IV-154
 - binary chain, I-258
 - counter, divide-by-odd-number, IV-153
 - divide-by-2-or-3 circuit, IV-154
 - divide-by-*n* + 1/2 circuit, IV-156
 - frequency, I-258, II-254, III-213-218
 - frequency divider, clock input, IV-151
 - frequency, decade, I-259
 - frequency, divide-by-1¹/₂, III-216
 - frequency, low frequency, II-253
 - frequency divider, programmable, IV-152-153
 - mathematical, one trim, III-326
 - odd-number counter and, III-217
 - pulse, non-integer programmable, II-511, III-226
- Dolby noise reduction circuits, III-399
- decode mode, III-401
- encode mode, III-400
- door bells/chimes, I-218, I-443, IV-8
 - buzzer, two-door, IV-10
 - musical-tone, IV-522
 - rain alarm, I-443
 - single-chip design, IV-524
 - sliding tone, II-34
- door-open alarm, II-284, III-46
 - Hall-effect circuit, III-256
- door opener, III-366
- dot-expanded scale meter, II-186
- double-sideband suppressed-carrier modulator, III-377
- double-sideband suppressed-carrier rf, II-366
- doublers
 - 0 to 1MHz, II-252
 - 150 to 300 MHz, I-314
 - audio-frequency doubler, IV-16-17
 - broadband frequency, I-313
 - CRO, oscilloscope, III-439
 - crystal oscillator, I-184
 - frequency, I-313, III-215
 - frequency, digital, III-216
 - frequency, GASFET design, IV-324
 - frequency, single-chip, III-218
 - low-frequency, I-314
 - voltage, III-459
 - voltage, triac-controlled, III-468
- downbeat-emphasized metronome, III-353-354
- drivers and drive circuits, I-260, II-189-193, III-172-175, IV-157-160
 - 50 ohm, I-262
- bar-graph driver, transistorized, IV-213
- BIFET cable, I-264
- bridge loads, audio circuits, III-35
- capacitive load, I-263
- coaxial cable, I-266, I-560
- coaxial cable, five-transistor pulse boost, II-191
- coil, current-limiting, III-173
- CRT deflection yoke, I-265
- demodulator, linear variable differential transformer, I-403
- fiber optic, 50-Mb/s, III-178
- flash slave, I-483
- glow plug, II-52
- high-impedance meter, I-265
- instrumentation meter, II-296
- lamp, I-380
 - flip-flop independent, IV-160
 - lamp, low-frequency flasher/relay, I-300
 - lamp, optically coupled, III-413
 - lamp, short-circuit proof, II-310
- laser diode, high-speed, I-263
- LED, bar graph, II-188
- LED, emitter/follower, IV-159
- line signals, 600-ohm balanced, II-192
- line, I-262
- line, 50-ohm transmission, II-192
- line, full rail excursions in, II-190
- line-synchronized, III-174
- load, timing threshold, III-648
- LVDT demodulator and, II-337, III-323-324
- meter-driver rf amplifier, 1-MHz, III-545
- microprocessor triac array, II-410
- motor drivers (*see* motor control, drivers)
 - multiplexer, high-speed line, I-264
- neon lamp, I-379
- op amp power driver, IV-158-159
- optoisolated, high-voltage, III-482
- power driver, op amp, IV-158-159
- pulsed infrared diode emitter, II-292
- relay, I-264
 - relay, delay and controls closure time, II-530
 - relay, with strobe, I-266
- RS-232C, low-power, III-175
- shift register, I-418
- solenoid, I-265, III-571-573
- SSB, low distortion 1.6 to 30MH, II-538
- stepping motor, II-376
- totem-pole, with bootstrapping, III-175
- two-phase motor, I-456

VCO driver, op-amp design, IV-362
 drop-voltage recovery for long-line systems, IV-328
 drum sound effect, II-591
 dual-tone decoding, II-620
 dual-tracking regulator, III-462
 duplex line amplifier, III-616
 duty-cycle detector, IV-144
 duty-cycle meter, IV-275
 duty-cycle monitor, III-329
 duty-cycle multivibrator, 50-percent, III-584
 duty-cycle oscillators
 50-percent, III-426
 variable, fixed-frequency, III-422
 dwell meters
 breaker point, I-102
 digital, III-45

E

eavesdropper, telephone, wireless, III-620
 echo effect, analog delay line, IV-21
 edge detector, I-266, III-157
 EEPROM pulse generator, 5V-powered, III-99
 EKG simulator, three-chip, III-350
 elapsed-time timer, II-680
 electric-fence charger, II-202
 electric-vehicle battery saver, III-67
 electrolytic-capacitor reforming circuit, IV-276
 electrometer, IV-277
 electrometer amplifier, overload protected, II-155
 electronic dice, IV-207
 electronic locks, II-194-197, IV-161-163
 combination, I-583, II-196
 digital entry lock, IV-162
 keyless design, IV-163
 three-dial combination, II-195
 electronic music, III-360
 electronic roulette, II-276, IV-205
 electronic ship siren, II-576
 electronic switch, push on/off, II-359
 electronic theremin, II-655
 electronic thermometer, II-660
 electronic wake-up call, II-324
 electrostatic detector, III-337
 emergency lantern/flasher, I-308
 emergency light, I-378, IV-250
 emissions analyzer, automotive exhaust, II-51
 emulators, II-198-200
 capacitance multiplier, II-200
 JFET ac coupled integrator, II-200
 resistor multiplier, II-199
 simulated inductor, II-199

encoders
 decoder and, III-14
 telephone handset tone dial, I-634, III-613
 tone, I-67, I-629
 tone, two-wire, II-364
 engine tachometer, I-94
 enlarger timer, II-446, III-445
 envelope detectors, III-155
 AM signals, IV-142
 low-level diodes, IV-141
 envelope generator/modulator, musical, IV-22
 EPROM, Vpp generator for, II-114
 equalizers, I-671, IV-18
 ten-band, graphic, active filter in, II-684
 ten-band, octave, III-658
 equipment-on reminder, I-121
 exhaust emissions analyzer, II-51
 expanded-scale meters
 analog, III-774
 dot or bar, II-186
 expander circuits (*see* compressor/expander circuits)
 extended-play circuit, tape-recorders, III-600
 extractor, square-wave pulse, III-584

F

555 timer
 astable, low duty cycle, II-267
 beep transformer, III-566
 integrator to multiply, II-669
 RC audio oscillator from, II-567
 square wave generator using, II-595
 fader, audio fader, IV-17
 fail-safe semiconductor alarm, III-6
 fans
 infrared heat-controlled fan, IV-226
 speed controller, automatic, III-382
 Fahrenheit thermometer, I-658
 fault monitor, single-supply, III-495
 fax/telephone switch, remote-controlled, IV-552-553
 feedback oscillator, I-67
 fence charger, II-201-203
 battery-powered, II-202
 electric, II-202
 solid-state, II-203
 FET circuits
 dual-trace scope switch, II-432
 input amplifier, II-7
 probe, III-501
 voltmeter, III-765, III-770
 fiber optics, II-204-207, III-176-181
 driver, LED, 50-Mb/s, III-178
 interface for, II-207
 link, I-268, I-269, I-270, III-179

motor control, dc, II-206
 receiver, 10 MHz, II-205
 receiver, 50-Mb/s, III-181
 receiver, digital, III-178
 receiver, high-sensitivity, 30nW, I-270
 receiver, low-cost, 100-M baud rate, III-180
 receiver, low-sensitivity, 300nW, I-271
 receiver, very-high sensitivity, low speed, 3nW, I-269
 repeater, I-270
 speed control, II-206
 transmitter, III-177

field disturbance sensor/alarm, II-507
 field-strength meters, II-208-212, III-182-183, IV-164-166
 1.5-150 MHz, I-275
 adjustable sensitivity indicator, I-274
 high-sensitivity, II-211
 LF or HF, II-212
 microwave, low-cost, I-273
 rf sniffer, II-210
 sensitive, I-274, III-183
 signal-strength meter, IV-166
 transmission indicator, II-211
 tuned, I-276
 UHF fields, IV-165
 untuned, I-276

filter circuits, II-213-224, III-184-192, IV-167-177
 active (*see* active filters)
 antialiasing/sync-compensation, IV-173
 audio, biquad, III-185
 audio, tunable, IV-169
 bandpass (*see* bandpass filters)
 band-reject, active, II-401
 biquad, I-292-293
 biquad, audio, III-185
 biquad, RC active bandpass, I-285
 bridge filter, twin-T, programmable, II-221
 Butterworth, high-pass, fourth-order, I-280
 Chebyshev (*see* Chebyshev filters)
 CW, razor-sharp, II-219
 full wave rectifier and averaging, I-229
 high-pass (*see* high-pass filters)
 low-pass (*see* low-pass filters)
 networks of, I-291
 noise, dynamic, III-190
 noisy signals, III-188
 notch (*see* notch filters)
 programmable, twin-T bridge, II-221
 rejection, I-283
 ripple suppressor, IV-175

- filter circuits (*cont.*)
 - rumble, III-192, IV-175
 - rumble, LM387 in, I-297
 - rumble filter, turntable, IV-170
 - rumble/scratch, III-660
 - Sallen-Key, 500 Hz bandpass, I-291
 - Sallen-key, low-pass, active, IV-177
 - Sallen-Key, low-pass, equal component, I-292
 - Sallen-Key, low-pass, second order, I-289
 - scratch, III-189, IV-175
 - scratch, LM287 in, I-297
 - speech, bandpass, 300 Hz 3kHz, I-295
 - speech filter, second-order, 300-to-3,400 Hz, IV-174
 - speech filter, two-section, 300-to-3,000 Hz, IV-174
 - state-variable, II-215
 - state-variable, multiple outputs, III-190
 - state-variable, second-order, 1kHz, Q/10, I-293
 - state-variable, universal, I-290
 - turbo, glitch free, III-186
 - twin-T bridge filter, II-221
 - Wien-bridge, III-659
 - voltage-controlled, III-187
 - voltage-controlled, 1,000:1 tuning, IV-176
- fixed power supplies, III-457-477, IV-390-408
- 12-VDC battery-operated 120-VAC, III-464
- +24 V, 1.5 A supply from +12 V source, IV-401
- 15 V isolated to 2,500 V supply, IV-407
- audio amplifier supply, ± 35 V ac, IV-398
- audio amplifier supply, ± 35 V, 5 A, mobile, IV-407
- automotive battery supply, ± 15 V and 5 V, IV-391
- auxiliary supply, IV-394
- bias/reference applications, auxiliary negative dc supply, IV-404
- bilateral current source, III-469
- bridge rectifier, IV-398
- charge pool, III-469
- charge pump, regulated, IV-396
- constant-current source, safe, III-472
- converter, III-470
- converter, 5V-to-isolated 5V at 20mA, III-474
- converter, ac-to-dc, IV-395
- converter, dc-to-dc, 3-to-15 V, IV-400
- current sink, 1 mA, IV-402
- current source, bootstrapped amp, IV-406
- current source, differential-input, fast-acting, IV-405
- dc adapter/transceiver, hand-held, III-461
- dual-tracking regulator, III-462
- GASFET power supply, IV-405
- general-purpose, III-465
- inverter, 12 V input, IV-395
- isolated feedback, III-460
- LCD display power supply, IV-392, IV-403
- linear regulator, low cost, low dropout, III-459
- low-current source, IV-399
- low-power inverter, III-466
- negative rail, GET, with CMOS gates, IV-408
- negative supply from +12 V source, IV-401
- negative voltage from positive supply, IV-397
- output stabilizer, IV-393
- portable-radio 3 V power supply, IV-397
- positive and negative voltage power supplies, IV-402
- pnp regulator, zener increases voltage output, II-484
- programmable, III-467
- rectifier, bridge rectifier, IV-398
- rectifier, low forward-drop, III-471
- regulated 1 A, 12 V, IV-401
- regulated +15V 1-A, III-462
- regulated -15V 1-A, III-463
- regulator, 15V slow turn-on, III-477
- regulator, positive with PNP boost, III-471
- regulator, positive, with NPN/PNP boost, III-475
- regulator, switching, 3-A, III-472
- regulator, switching, high-current inductorless, III-476
- ripple suppressor, IV-396
- RTTY machine current supply, IV-400
- stabilizer, CMOS diode network, IV-406
- switching, III-458
- switching, 5- and ± 12 V, ac-powered, IV-404
- switching, 50-W off-line, III-473
- switching, positive and negative voltage, IV-403
- switching regulator, 3 A, IV-408
- three-rail, III-466
- uninterruptible +5V, III-477
- voltage doubler, III-459
- voltage doubler, triac-controlled, III-468
- voltage regulator, 10V, high stability, III-468
- voltage regulator, 5-V low-dropout, III-461
- voltage regulator, ac, III-477
- voltage regulator, negative, III-474
- voltage-controlled current source/grounded source/load, III-468
- fixed-frequency generator, III-231
- flame ignitor, III-362
- flame monitor, III-313
- flash/flashbulb circuits (*see* photography-related circuits)
- flashers and blinkers (*see also* photography-related circuits), I-304, II-225, III-193-210, IV-178-183
- 1.5 V, minimum power, I-308
- 1 kW flip-flop, II-234
- 1A lamp, I-306
- 2 kW, photoelectric control in, II-232
- 3V, I-306
- ac, III-196
- alternating, I-307, II-227
- astable multivibrator, III-196
- auto, I-299
- automatic safety, I-302
- automotive turn signal, sequential, I-109
- bar display with alarm, I-252
- barricade, I-299
- boat, I-299
- CMOS, III-199
- dc, adjustable on/off timer, I-305
- dual LED CMOS, I-302
- electronic, II-228
- emergency lantern, I-308
- fast-action, I-306
- flash light, 60-W, III-200
- flicker light, IV-183
- flip-flop, I-299
- four-parallel LED, I-307
- high efficiency parallel circuit, I-308
- high-voltage, safe, I-307
- high-power battery operated, II-229
- incandescent bulb, III-198, I-306
- LED, IV-181
- LED, alternating, III-198, III-200
- LED, control circuit, IV-183
- LED, multivibrator design, IV-182
- LED, PUT used in, II-239
- LED, ring-around, III-194
- LED flasher, sequential, reversible-direction, IV-182
- LED, three-year, III-194
- LED, UJT used in, II-231
- low-current consumption, II-231

low-voltage, I-305, II-226
 miniature transistorized, II-227
 minimum-component, III-201
 neon, I-303
 neon, five-lamp, III-198
 neon, two-state oscillator, III-200
 neon, tube, I-304
 oscillator and, high drive, II-235
 oscillator and, low frequency, II-234
 photographic slave-flash trigger, SCR design, IV-380, IV-382
 photographic time-delay flash trigger, IV-380
 relay driver, low-frequency lamp, I-300
 SCR design, II-230, III-197
 SCR chaser, III-197
 SCR relaxation, II-230
 SCR ring counter, III-195
 sequential, II-233, IV-181
 sequential, ac, II-238
 sequencer, pseudorandom simulated, IV-179
 single-lamp, III-196
 strobe alarm, IV-180
 telephone, II-629, IV-558, IV-559, IV-561
 telephone-message flasher, IV-556
 transistorized, III-200, I-303
 transistorized, table of, II-236
 variable, I-308
 xenon light, IV-180
 flashlight finder, I-300
 flip-flops
 astable, with starter, II-239
 debouncer switch, IV-108
 flasher circuit, 1 kW, use of, II-234
 inverter, III-103
 SCR, II-367
 wave-shaping circuits, S/R, IV-651
 flood alarm, I-390, III-206, IV-188
 flow detectors, II-240-242, III-202-203
 air, II-242
 low-rate thermal, III-203
 thermally based anemometer, II-241
 flowmeter, liquid, II-248
 fluid and moisture detectors, I-388, I-390, I-442, II-243-248, III-204-210, IV-184-191
 acid rain monitor, II-245
 checker, III-209
 control, I-388, III-206
 cryogenic fluid-level sensor, I-386
 dual, III-207
 flood alarm, III-206, IV-188
 fluid-level control, III-205
 full-bathtub indicator, IV-187
 full-cup detector for the blind, IV-189
 indicator, II-244
 liquid flow meter, II-248
 liquid-level checker, III-209
 liquid-level monitor, III-210
 liquid-level sensor, IV-186
 liquid-level, dual, III-207
 moisture detector, IV-188
 monitor, III-210
 plant water, II-245, II-248
 pump controller, single-chip, II-247
 rain alarm, IV-189
 rain warning bleeper, II-244
 sensor and control, II-246
 soil moisture, III-208
 temperature monitor, II-643, III-206
 water-leak alarm, IV-190
 water-level, III-206, IV-186, IV-191
 water-level, indicator, II-244
 water-level, sensing and control, II-246, IV-190
 windshield-washer level, I-107
 fluid-level controller, I-387, III-205
 fluorescent display, vacuum, II-185
 fluorescent lamps
 high-voltage power supplies, cold-cathode design, IV-411
 inverter, 8-W, III-306
 flyback converters, I-211
 self oscillating, I-170, II-128, III-748
 voltage, high-efficiency, III-744
 flyback regulator, off-line, II-481
 FM transmissions
 5 V, I-233
 12 V, I-233
 clock radio, AM/FM, I-543
 demodulators, I-544, II-161
 IF amplifier with quadrature detector, TV sound IF, I-690
 generators, low-frequency, III-228
 radio, I-545
 receivers, carrier-current circuit, III-80
 receivers, MPX/SCA receiver, III-530
 receivers, narrow-band, III-532
 receivers optical receiver/transmitter, 50 kHz, I-361
 receivers, zero center indicator, I-338
 snooper, III-680
 speakers, remote, carrier-current system, I-140
 squelch circuit for AM, I-547
 stereo demodulation system, I-544
 transmitters, I-681
 transmitters, infrared, voice-modulated pulse, IV-228
 transmitters, multiplex, III-688
 transmitters, one-transistor, III-687
 transmitters, optical, 50 kHz center frequency, II-417
 transmitters, optical receiver/transmitter, 50 kHz, I-361
 transmitters, optical (PRM), I-367
 transmitters, voice, III-678
 tuner, I-231, III-529
 wireless microphone, III-682, III-685, III-691
 FM/AM clock radio, I-543
 fog-light controller, automotive, IV-59
 foldback current, HV regulator limiting, II-478
 followers, III-211-212
 inverting, high-frequency, III-212
 noninverting, high-frequency, III-212
 source, photodiode, III-419
 unity gain, I-27
 voltage, III-212
 forward-current booster, III-17
 free-running multivibrators
 100 kHz, I-465
 programmable-frequency, III-235
 free-running oscillators, I-531
 square wave, I-615
 freezer, voltage, III-763
 freezer-meltdown alarm, I-13
 frequency comparators, II-109
 LED, II-110
 frequency control, telephone, II-623
 frequency converter, I-159
 frequency counters, III-340, III-768, IV-300
 1.2 GHz, III-129
 10-MHz, III-126
 100 MHz, period and, II-136
 low-cost, III-124
 preamp, III-128
 precision, I-253
 tachometer and, I-310
 frequency detectors, II-177, III-158
 boundary detector, III-156
 comparator, III-88
 frequency dividers, I-258, II-251, II-254
 clock input, IV-151
 decade, I-259
 low, II-253
 programmable, IV-152-153
 staircase generator and, I-730
 frequency-division multiplex stereo decoder, II-169
 frequency doublers, I-313
 broadband, I-313
 GASFET design, IV-324
 frequency generators, fixed-frequency, III-231
 frequency indicators, beat, I-336
 frequency inverters, variable frequency, complementary output, III-297

- frequency meters, II-249-250, IV-282
 - audio, I-311
 - linear, I-310
 - low cost, II-250
 - power, II-250
 - power-line, I-311
 - frequency multipliers/dividers, II-251, III-213-218
 - counter, odd-number, III-217
 - divide-by- $1\frac{1}{2}$, III-216
 - doubler, III-215
 - doubler, digital, III-216
 - doubler, to 1MHz, II-252
 - doubler, single-chip, III-218
 - nonselective tripler, II-252
 - pulse-width, III-214
 - frequency-boundary detector, III-156
 - frequency-detecting comparator, III-88
 - frequency oscillator, tunable, II-425
 - frequency-ratio monitoring circuit, IV-202
 - frequency-shift key (FSK) communications
 - data receiver, III-533
 - decoder, 10.8 MHz, I-214
 - generator, low-cost design, III-227
 - keying circuits, IV-245
 - frequency synthesizer, programmable
 - voltage controlled, II-265
 - frequency-to-voltage converter, I-318, II-255-257, III-219-220
 - dc, 10kHz, I-316
 - digital meter, I-317
 - optocoupler input, IV-193
 - sample-and-hold circuit, IV-194
 - single-supply design, IV-195
 - zener regulated, I-317
 - fuel gauge, automotive, IV-46
 - full-wave rectifiers, IV-328, IV-650
 - absolute value, II-528
 - precision, I-234, III-537
 - function generators (*see also* burst generators; sound generators; waveform generators), I-729, II-271, III-221-242, III-258-274, IV-196-202
 - 555 astable, low duty cycle, II-267
 - astable multivibrator, II-269, III-233, III-238
 - astable multivibrator, op amp, III-224
 - astable multivibrator, programmable-frequency, III-237
 - audio function generator, IV-197
 - clock generator, I-193
 - clock generator/oscillator, I-615
 - complementary signals, XOR gate, III-226
 - DAC controlled, I-722
 - emitter-coupled RC oscillator, II-266
 - fixed-frequency, III-231
 - FM, low-frequency, III-228
 - free-running multivibrator, programmable-frequency, III-235
 - frequency-ratio monitoring circuit, IV-202
 - frequency synthesizer, programmable
 - voltage controlled, II-265
 - FSK, low-cost, III-227
 - harmonics, III-228
 - linear ramp, II-270
 - linear triangle/square wave VCO, II-263
 - monostable operation, III-235
 - monostable multivibrator, III-230
 - monostable multivibrator, linear-ramp, III-237
 - monostable multivibrator, positive-triggered, III-229
 - monostable multivibrator, video amplifier and comparator, II-268
 - multiplying pulse width circuit, II-264
 - multivibrator, low-frequency, III-237
 - multivibrator, single-supply, III-232
 - nonlinear potentiometer outputs, IV-198
 - one-shot, precision, III-222
 - one-shot, retriggerable, III-238
 - oscillator/amplifier, wide frequency range, II-262
 - potentiometer-position V/F converter, IV-200
 - precise wave, II-274
 - programmed, I-724
 - pulse divider, noninteger, programmable, III-226
 - pulse train, IV-202
 - pulse, 2-ohm, III-231
 - quad op amp, four simultaneous synchronized waveform, II-259
 - ramp, variable reset level, II-267
 - sawtooth and pulse, III-241
 - signal, two-function, III-234
 - sine/cosine (0.1-10 kHz), II-260
 - single supply, II-273
 - sine-wave/square-wave oscillator, tunable, III-232
 - single-control, III-238
 - timebase, 1 Hz, for readout and counter applications, IV-201
 - time-delay generator, I-217-218
 - triangle-square wave, programmable, III-225
 - triangle-wave, III-234
 - triangle-wave timer, linear, III-222
 - triangle-wave/square-wave, III-239
 - triangle-wave/square-wave, precision, III-242
 - triangle-wave/square-wave, wide-range, III-242
 - tunable, wide-range, III-241
 - UJT monostable circuit insensitive to changing bias voltage, II-268
 - variable duty cycle timer output, III-240
 - voltage controlled high-speed one shot, II-266
 - waveform, II-269, II-272
 - waveform, four-output, III-223
 - white noise generator, IV-201
 - funk box, II-593
 - furnace exhaust gas/smoke detector, temp monitor/low supply detection, III-248
 - fuzz box, III-575
 - fuzz sound effect, II-590
- ## G
- GaAsFET amplifier, power, with single supply, II-10
 - gain block, video, III-712
 - gain control, automatic, audio, II-17
 - gain-controlled stereo amplifier, II-9, III-34
 - game feeder controller, II-360
 - game roller, I-326
 - games, II-275-277, III-243-245, IV-203-207
 - coin flipper, III-244
 - electronic dice, III-245, IV-207
 - electronic roulette, II-276, IV-205
 - lie detector, II-277, IV-206
 - reaction timer, IV-204
 - run-down clock/sound generator, IV-205
 - Wheel-of-Fortune, IV-206
 - who's first, III-244
 - garage stop light, II-53
 - gas analyzer, II-281
 - gas/smoke detectors (*see also* smoke alarms and detectors), II-278-279, III-246-253, III-246
 - analyzer and, II-281
 - furnace exhaust, temp monitor/low-supply detection, III-248
 - methane concentration, linearized output, III-250
 - toxic, II-280
 - SCR, III-251
 - smoke/gas/vapor detector, III-250
 - GASFET fixed power supplies, IV-405
 - gated oscillator, last-cycle completing, III-427
 - gated-pulse descrambler, II-165
 - gates
 - programmable, I-394
 - XOR gate, IV-107

geiger counters, I-536-537
 high-voltage supply, II-489
 pocket-sized, II-514
 gel cell charger, II-66
 generators, electric-power
 corona-wind generator, IV-633
 high-voltage generator, IV-413
 high-voltage generator, battery-powered, III-482
 high-voltage generator, capacitor-discharge, III-485
 high-voltage generator, dc voltage, III-481
 high-voltage generator, negative-ions, IV-634
 high-voltage generator, ultra-high voltages, II-488
 glitch-detector, comparator, II-107
 glow plug driver, II-52
 graphic equalizer, ten-band, active filter in, II-684
 grid-dip meter, bandswitched, IV-298
 ground tester, II-345
 ground-fault Hall detector, IV-208-209
 ground-noise probe, battery-powered, III-500
 guitars
 compressor, sound-effect circuit, IV-519
 matching audio signal amplifiers, IV-38
 treble boost for, II-683
 tuner, II-362
 gun, laser, visible red and continuous, III-310

H

half-duplex information transmission link, III-679
 half-flash analog-to-digital converters, III-26
 half-wave ac phase controlled circuit, I-377
 half-wave rectifiers, I-230, III-528, IV-325
 fast, I-228
 Hall-effect circuits, II-282-284, III-254-258
 angle of rotation detector, II-283
 compass, III-258
 current monitor, III-255, IV-284
 door open alarm, II-284
 ground-fault detector, IV-208-209
 security door-ajar alarm, III-256
 switches using, III-257, IV-539
 halogen lamps, dimmer for, III-300
 handtalkies, I-19
 two-meter preamplifier for, I-19

hands-free telephone, III-605
 hands-off intercom, III-291
 handset encoder, telephone, III-613
 harmonic generators, I-24, III-228, IV-649
 Hartley oscillator, I-571
 HC-based oscillators, III-423
 HCU/HTC-based oscillator, III-426
 headlight alarm, III-52
 headlight delay unit, I-107, III-49
 headlight dimmer, II-63
 headphones, amplifier for, II-43
 heart rate monitor, II-348, II-349
 heat sniffer, electronic, III-627
 heater, induction, ultrasonic, 120-KHz 500-W, III-704
 heater controls, I-639
 element controller, II-642
 protector circuit, servo-sensed, III-624
 temperature sensitive, I-640
 hee-haw siren, II-578, III-565
 hi-fi circuits
 compander, II-12
 compressor, pre-emphasis and, III-93
 expander, II-13
 expander, de-emphasis, III-95
 tone control circuit, high Z input, I-676
 high-frequency amplifiers, III-259-265
 hi-fi circuits
 29-MHz, III-262
 3-30 MHz, 80-W, 12.5-13.6 V, III-261
 amateur radio, linear, 2-30 MHz 140-W, III-260
 noninverting, 28-dB, III-263
 RF, broadcast band, III-264
 UHF, wideband with high-performance FETs, III-264
 wideband, hybrid, 500 kHz-1GHz, III-265
 wideband, miniature, III-265
 high-frequency oscillator, III-426
 crystal, I-175, II-148
 high-frequency peak detector, II-175
 high-frequency signal generator, II-150
 high-input-high-impedance amplifiers, II-19, II-44
 high-pass filters, I-296
 active, I-296
 active, second-order, I-297
 Butterworth, fourth-order, I-280
 Chebyshev, fourth-order, III-191
 fourth-order, 100-Hz, IV-174
 second-order, 100-Hz, IV-175
 sixth-order elliptical, III-191
 wideband two-pole, II-215
 high-voltage power supplies (*see also* generators, electrical power), II-

487-490, III-486, IV-409-413
 10,000 V dc supply, IV-633
 arc-jet power supply, starting circuit, III-479
 battery-powered generator, III-482
 buckling regulator, III-481
 dc generator, III-481
 fluorescent-lamp supply, cold-cathode design, IV-411
 geiger counter supply, II-489
 generators (*see* generators, electrical power)
 inverter, III-484
 inverter, 40 W, 120 V ac, IV-410-411
 negative-ion generator, IV-634
 optoisolated driver, III-482
 preregulated, III-480
 pulse supply, IV-412
 regulator, III-485
 regulator, foldback-current limiting, II-478
 solid-state, remote adjustable, III-486
 strobe power supply, IV-413
 tube amplifier, high-volt isolation, IV-426
 ultra high-voltage generator, II-488
 hobby circuits (*see* model and hobby circuits)
 hold button, telephone, 612, II-628
 home security systems, IV-87
 lights-on warning, IV-250
 monitor, I-6
 horn, auto, electronic, III-50
 hot-wire anemometer, III-342
 hour/time delay sampling circuit, II-668
 Howland current pump, II-648
 humidity sensor, II-285-287, III-266-267
 HV regulator, foldback current limiting, II-478
 hybrid power amplifier, III-455

IC product detectors, IV-143
 IC timer, crystal-stabilized, subharmonic frequencies for, II-151
 ice alarm, automotive, II-57
 ice formation alarm, II-58
 ice warning and lights reminder, I-106
 ICOM IC-2A battery charger, II-65
 IF amplifiers, I-690, IV-459
 AGC system, IV-458
 AGC system, CA3028-amplifiers, IV-458
 preamp, IV-460
 preamp, 30-MHz, IV-460
 receiver, IV-459
 two-stage, 60 MHz, I-563

ignition circuit, electronic, automotive, IV-65
 ignition cut-off circuit, automotive, IV-53
 ignition substitute, automotive, III-41
 ignition system, capacitor discharger, I-103
 ignition timing light, II-60
 ignitor, III-362
 illumination stabilizer, machine vision, II-306
 image canceller, III-358
 immobilizer, II-50
 impedance converter, high to low, I-41
 incandescent light flasher, III-198
 indicators (*see also* alarms; control circuits; detectors; monitors; sensors), III-268-270, IV-210-218
 ac-current indicator, IV-290
 ac-power indicator, LED display, IV-214
 ac/dc indicator, IV-214
 alarm and, I-337
 automotive-temperature indicator, PTC thermistor, II-56
 balance indicator, IV-215
 bar-graph driver, transistorized, IV-213
 battery charge/discharge, I-122
 battery condition, I-121
 battery level, I-124
 battery threshold, I-124
 battery voltage, solid-state, I-120
 beat frequency, I-336
 CW offset indicator, IV-213
 dial pulse, III-613
 field-strength (*see* field-strength meters)
 in-use indicator, telephone, II-629
 infrared detector, low-noise, II-289
 lamp driver, optically coupled, III-413
 level, three-step, I-336
 low-battery, I-124
 low-voltage, III-769
 mains-failure indicator, IV-216
 On indicator, IV-217
 on-the-air, III-270
 overspeed, I-108
 overvoltage/undervoltage, I-150
 peak level, I-402
 phase sequence, I-476
 receiver-signal alarm, III-270
 rf output, IV-299
 rf-actuated relay, III-270
 simulated, I-417
 sound sensor, IV-218
 stereo-reception, III-269
 SWR warning, I-22
 telephone, in-use indicator, II-629, IV-560, IV-563
 telephone, off-hook, I-633
 temperature indicator, IV-570
 transmitter-output indicator, IV-218
 undervoltage, battery operated equipment, I-123
 visual modulation, I-430
 visual level, III-269
 voltage, III-758-772
 voltage, visible, I-338, III-772
 voltage-level, I-718, III-759
 voltage-level, five step, I-337
 voltage-level, ten-step, I-335
 volume indicator, audio amplifier, IV-212
 VU meter, LED display, IV-211
 zero center, FM receivers, I-338
 in-use indicator, telephone, II-629
 induction heater, ultrasonic, 120-KHz 500-W, III-704
 inductors
 active, I-417
 simulated, II-199
 infrared circuits, II-288-292, III-271-277, IV-219-228
 data link, I-341
 detector, III-276, IV-224
 detector, low-noise, II-289
 emitter drive, pulsed, II-292
 fan controller, IV-226
 laser rifle, invisible pulsed, II-291
 loudspeaker link, remote, I-343
 low-noise detector for, II-289
 object detector, long-range, III-273
 people-detector, IV-225
 proximity switch, infrared-activated, IV-345
 receivers, I-342, II-292, III-274, IV-220-221
 receivers, remote-control, I-342
 remote controller, IV-224
 remote-control tester, IV-228
 remote-extender, IV-227
 transmitter, I-343, II-289, II-290, III-274, III-276, III-277, IV-226-227
 transmitter, digital, III-275
 transmitter, remote-control, I-342
 transmitter, voice-modulated pulse FM, IV-228
 wireless speaker system, III-272
 injectors
 three-in-one set: logic probe, signal tracer, injector, IV-429
 injector-tracers, I-522
 single, II-500
 signal, I-521
 input selectors, audio, low distortion, II-38
 input/output buffer, analog multiplexers, III-11
 instrumentation amplifiers, I-346, I-348, I-349, I-352, II-293-295, III-278-284, IV-229-234
 ± 100 V common mode range, III-294
 current collector head amplifier, II-295
 differential, I-347, I-354, III-283
 differential, biomedical, III-282
 differential, high-gain, I-353
 differential, input, I-354
 differential, variable gain, I-349
 extended common-mode design, IV-234
 high-impedance low drift, I-355
 high-speed, I-354
 low-drift/low-noise dc amplifier, IV-232
 low-signal level/high-impedance, I-350
 low-power, III-284
 meter driver, II-296
 preamp, oscilloscope, IV-230-231
 re-amp, thermocouple, III-283
 precision FET input, I-355
 saturated standard cell amplifier, II-296
 strain gauge, III-280
 triple op amp, I-347
 ultra-precision, III-279
 variable gain, differential input, I-349
 very high-impedance, I-354
 wideband, III-281
 instrumentation meter driver, II-296
 integrators, II-297-300, III-285-286
 active, inverting buffer, II-299
 JFET ac coupled, II-200
 gamma ray pulse, I-536
 long time, II-300
 low drift, I-423
 noninverting, improved, II-298
 photocurrent, II-326
 programmable reset level, III-286
 ramp generator, initial condition reset, III-327
 resettable, III-286
 intercoms, I-415, II-301-303, III-287-292
 bidirectional, III-290
 carrier current, I-146
 hands-off, III-291
 party-line, II-303
 pocket pager, III-288
 telephone-intercoms, IV-557
 two-way, III-292
 two-wire design, IV-235-237
 interfaces (*see also* computer circuits), IV-238-242
 680x, 650x, 8080 families, III-98

- cassette-to-telephone, III-618
 - CPU interface, one-shot design, IV-239
 - DVM, temperature sensor and, II-647
 - FET driver, low-level power FET, IV-241
 - fiber optic, II-207
 - keyboard matrix interface, IV-240
 - logic-level translators, IV-242
 - optical sensor-to-TTL, III-314
 - process control, precision, I-30
 - tape recorder, II-614
 - interrupter, ground fault, I-580
 - interval timer, low-power, microprocessor programmable, II-678
 - inverters, III-293-298
 - dc-to-dc/ac, I-208
 - fast, I-422
 - fixed power supplies, 12 V input, IV-395
 - flip-flop, III-103
 - fluorescent lamp, 8-W, III-306
 - high-voltage, III-484
 - high-voltage power supplies, 40 W, 120 V ac, IV-410-411
 - low-power, fixed power supplies, III-466
 - on/off switch, III-594
 - picture, video circuits, III-722
 - power, III-298
 - power, 12 VDC-to-117 VAC at 60 Hz, III-294
 - power, medium, III-296
 - power, MOSFET, III-295
 - rectifier/inverter, programmable op-amp design, IV-364
 - ultrasonic, arc welding, 20 KHz, III-700
 - variable frequency, complementary output, III-297
 - voltage, precision, III-298
 - inverting amplifiers, I-41-42, III-14
 - balancing circuit in, I-33
 - low power, digitally selectable gain, II-333
 - power amplifier, I-79
 - programmable-gain, III-505
 - unity gain amplifier, I-80
 - wideband unity gain, I-35
 - inverting buffers, active integrator using, II-299
 - inverting comparators, hysteresis in, I-154
 - inverting followers, high-frequency, III-212
 - isolated feedback power supply, III-460
 - isolation amplifiers
 - capacitive load, I-34
 - level shifter, I-348
 - medical telemetry, I-352
 - rf, II-547
 - isolation and zero voltage switching logic, II-415
 - isolators
 - analog data-signal transmission, IV-133
 - digital transmission, II-414
 - stimulus, III-351
- J**
- JFET ac coupled integrator, III-200
- K**
- Kelvin thermometer, I-655
 - zero adjust, III-661
 - keying circuits, IV-243-245
 - automatic operation, II-15
 - automatic TTL morse code, I-25
 - CW keyer, IV-244
 - electronic, I-20
 - frequency-shift keyer, IV-245
 - negative key line keyer, IV-244
- L**
- lamp-control circuits (*see* lights/light-activated and controlled circuits)
 - laser circuits (*see also* lights/light-activated and controlled circuits; optical circuits), II-313-317, III-309-311
 - diode sensor, IV-321
 - discharge current stabilizer, II-316
 - gun, visible red, III-310
 - light detector, II-314
 - power supply, IV-636
 - pulsers, laser diode, III-311, I-416
 - receiver, IV-368
 - rifle, invisible IR pulsed, II-291
 - latches
 - 12-V, solenoid driver, III-572
 - comparator and, III-88
 - latching relays, dc, optically coupled, III-417
 - latching switches
 - double touchbutton, I-138
 - SCR-replacing, III-593
 - LCD display, fixed power supply, IV-392, IV-403
 - lead-acid batteries
 - battery chargers, III-55
 - life-extender and charger, IV-72
 - low-battery detector, III-56
 - leading-edge delay circuit, III-147
 - LED circuits
 - ac-power indicator, IV-214
 - alternating flasher, III-198, III-200
 - bar graph driver, II-188
 - driver, emitter/follower, IV-159
 - flasher, IV-181
 - flasher, control circuit, IV-183
 - flasher, multivibrator design, IV-182
 - flasher, PUT, II-239
 - flasher, sequential, reversible-direction, IV-182
 - flasher, UJT, II-231
 - frequency comparator, II-110
 - matrix display, two-variable, III-171
 - millivoltmeter readout, IV-294
 - multiplexed common-cathode display ADC, III-764
 - panel meter, III-347
 - peakmeter, III-333
 - ring-around flasher, III-194
 - RS-232C, computer circuit, III-103
 - three-year flasher, III-194
 - voltmeter, IV-286
 - VU meter, IV-211
 - level, electronic, II-666, IV-329
 - level controllers/indicators/monitors, II-174
 - alarm, water, I-389
 - audio, automatic, II-20
 - cryogenic fluid, I-386
 - fluid, I-387
 - hysteresis in, I-235
 - liquid, I-388, I-389, I-390
 - meter, LED bar/dot, I-251
 - peak, I-402
 - sound, I-403
 - three-step, I-336
 - visual, III-269
 - warning, audio output, low, I-391
 - warning, high-level, I-387
 - water, I-389
 - level shifter, negative-to-positive supply, I-394
 - LF or HF field strength meter, II-212
 - LF receiver, IV-451
 - lie detector, II-277, IV-206
 - lights/light-activated and controlled circuits (*see also* laser circuits; optical circuits), II-304-312, II-318-331, III-312-319
 - 860 W limited-range light control, I-376
 - ambient-light cancellation circuit, II-328
 - audio oscillator, light-sensitive, III-315
 - battery-powered light, capacitance operated, I-131
 - brightness control, lighted displays, III-316
 - carport light, automatic, II-308

- lights/light-activated and controlled circuits (*cont.*)
- chaser lights, sequential activation, IV-251, IV-252
- Christmas light driver, IV-254
- complementary, I-372
- controller, IV-252
- cross fader, II-312
- detectors, detection switch, adjustable, I-362
- dimmer, I-369, II-309, IV-247, IV-249
- dimmer, 800 W, II-309
- dimmer, dc lamp, II-307
- dimmer, four-quadrant, IV-248-249
- dimmer, halogen lamps, III-300
- dimmer, headlight, II-57, II-63
- dimmer, low-cost, I-373
- dimmer, soft-start, 800-W, I-376, III-304
- dimmer, tandem, II-312
- dimmer, triac, I-375, II-310, III-303
- dissolver, solid-state, III-304
- drivers, I-380
- drivers, flip-flop independent design, IV-160
- drivers, indicator-lamps, optical coupling, III-413
- drivers, neon lamps, I-379
- drivers, short-circuit-proof, II-310
- emergency light, I-378, I-581, II-320, III-317, III-415, IV-250
- flame monitor, III-313
- fluorescent-lamp high-voltage power supplies, cold-cathode design, IV-411
- indicator-lamp driver, optically coupled, III-413
- interruption detector, I-364
- inverter, fluorescent, 8-W, III-306
- level controller, I-380
- level detector, I-367, III-316
- level detector, low-light level drop detector, III-313
- life-extender for lightbulbs, III-302
- light-bulb changer, "automatic" design, IV-253
- lights-on warning, IV-58, IV-62, IV-250
- light-seeking robot, II-325
- logic circuit, I-393
- machine vision illumination stabilizer, II-306
- marker light, III-317
- meters, light-meters, I-382, I-383
- modulator, III-302
- monostable photocell, self-adjust trigger, II-329
- mooring light, automatic, II-323
- night light, automatic, I-360, III-306
- night light, telephone-controlled, III-604
- on/off relay, I-366
- on/off reminder, automotive lights, I-109
- on/off reminder, with ice alarm, I-106
- one-shot timer, III-317
- phase control, II-303, II-305
- photo alarm, II-319
- photocell, monostable, self-adjust trigger, II-329
- photocurrent integrator, II-326
- photodiode sensor amplifier, II-324
- photoelectric controller, IV-369
- photoelectric switches, II-321, II-326, III-319
- projector-lamp voltage regulator, II-305
- power outage light, line-operated, III-415
- pulse-generation interruption, I-357
- relay, on/off, I-366
- remote-controller, I-370
- robot, eyes, II-327
- robot, light-seeking robot, II-325
- sensor, ambient-light ignoring, III-413
- sensor, back-biased GaAs LED, II-321
- sensor, logarithmic, I-366
- sensor, optical sensor-to-TTL interface, III-314
- sequencer, pseudorandom, III-301
- short-circuit proof lamp driver, II-310
- signal conditioner, photodiode design, II-330
- sound-controlled lights, I-609
- speed controller, IV-247
- strobe, high-voltage power supplies, IV-413
- strobe, variable, III-589-590
- sun tracker, III-318
- switch, II-320, III-314
- switch, capacitance switch, I-132
- switch, light-controlled, II-320, III-314
- switch, photoelectric, II-321, II-326, III-319
- switch, solar triggered, III-318
- switch, zero-point triac, II-311
- tarry light, I-579
- telephone in-use light, II-625
- three-way light control, IV-251
- touch lamp, three-way, IV-247
- triac switch, inductive load, IV-253
- turn-off circuit, SCR capacitor design, IV-254
- twilight-triggered circuit, II-322
- voltage regulator for projection lamp, II-305
- wake-up call light, II-324
- warning lights, II-320, III-317
- light-seeking robot, II-325
- lights-on warning, automotive, II-55, III-42
- limit alarm, high/low, I-151
- limit comparator, I-156, III-106
 - double ended, I-156, II-105
- limit detectors
 - double ended, I-230, I-233
 - micropower double ended, I-155
- limiters, III-320-322, IV-255-257
 - audio, low distortion, II-15
 - audio clipper/limiter, IV-355
 - dynamic noise reduction circuit, III-321
 - hold-current, solenoid driver, III-573
 - noise, III-321, II-395
 - one-zener design, IV-257
 - output, III-322
 - power-consumption, III-572
 - transmit-time limiter/timer, IV-580
 - voltage limiter, adjustable, IV-256
- line amplifier
 - duplex, telephone, III-616
 - universal design, IV-39
- line drivers
 - 50-ohm transmission, II-192
 - 600-ohm balanced, II-192
 - full rail excursions, II-190
 - high output 600-ohm, II-193
 - video amplifier, III-710
- line-dropout detector, II-98
- line-frequency square wave generator, II-599
- line receivers
 - digital data, III-534
 - low-cost, III-532
- line-sync, noise immune 60 Hz, II-367
- line-current detector, optically coupled, III-414
- line-current monitor, III-341
- line-hum touch switch, III-664
- line-synchronized driver circuit, III-174
- line-voltage announcer, ac, III-730
- line-voltage monitor, III-511
- linear amplifiers
 - 2-30MHz, 140W PEP amateur radio, I-555
 - 100 W PEP 420-450 MHz push-pull, I-554
 - 160 W PEP broadband, I-556
 - amateur radio, 2-30 MHz 140-W, III-260
 - CMOS inverter, II-11
 - rf amplifiers, 6-m, 100 W, IV-480-481
 - rf amplifiers, 903 MHz, IV-484-485
 - rf amplifiers, ATV, 10-to-15 W, IV-481

- linear couplers
 - analog, II-413
 - analog ac, II-412
 - dc, II-411
 - linear IC siren, III-564
 - linear optocoupler, instrumentation, II-417
 - linear ramp generator, II-270
 - linear regulators
 - fixed power supply, low dropout low cost, III-459
 - radiation-hardened 125A, II-468
 - link, fiber optic, III-179
 - liquid flowmeter, II-248
 - liquid-level detectors (*see* fluid and moisture detectors)
 - lithium batteries
 - charger for, II-67
 - state of charge indicator for, II-78
 - little dipper dip meter, II-183
 - locator, lo-parts treasure, I-409
 - locks, electronic, II-194-197, IV-161-163
 - combination, I-583, II-196
 - digital entry lock, IV-162
 - keyless design, IV-163
 - three-dial combination, II-195
 - locomotive whistle, II-589
 - logarithmic amplifiers, I-29, I-35, II-8
 - dc to video, I-38
 - log-ratio amplifier, I-42
 - logarithmic converter, fast, I-169
 - logarithmic light sensor, I-366
 - logarithmic sweep VCO, III-738
 - logic/logic circuits
 - audible pulses, II-345
 - four-state, single LED indicator, II-361
 - isolation and zero voltage switching, II-415
 - light-activated, I-393
 - line monitor, III-108
 - overvoltage protection, I-517
 - probes (*see* logic probes)
 - pulse generator for logic-trouble-shooting, IV-436
 - pulsar, III-520
 - signals, long delay line for, III-107
 - tester, audible, III-343
 - tester, TTL, I-527
 - translators, logic-level translators, IV-242
 - logic amplifiers, II-332-335
 - low power binary, to 10n gain low frequency, II-333
 - low power inverting, digitally selectable gain, II-333
 - low power noninverting, digitally selectable input and gain, II-334
 - precision, digitally programmable input and gain, II-335
 - programmable amplifier, II-334
 - logic converter, TTL to MOS, I-170
 - logic level shifter, negative-to-positive supply, I-394
 - logic probes, I-520, I-525, I-526, IV-430-431, IV-434
 - CMOS, I-523, I-526, III-499
 - digital, III-497
 - four-way operation, IV-432
 - memory-tester, installed, I-525
 - single-IC design, IV-433
 - three-in-one test set: probe, signal tracer, injector, IV-429
 - long-duration timer, PUT, II-675
 - long-range object detector, III-273
 - long-term electronic timer, II-672
 - long-time integrator, II-300
 - long-time timer, III-653
 - loop antenna, 3.5 MHz, IV-12-13
 - loop transmitter, remote sensors, III-70
 - loop-thru video amplifier, IV-616
 - loudness amplifier, II-46
 - loudness control, balance amplifier with, II-395
 - loudspeaker coupling circuit, I-78
 - low-current measurement system, III-345
 - low-distortion audio limiter, II-15
 - low-distortion input selector for audio use, II-38
 - low-distortion low level amplitude modulator, II-370
 - low-distortion sine wave oscillator, II-561
 - low-frequency oscillators, III-428
 - crystal, I-184, II-146
 - oscillator/flasher, II-234
 - Pierce oscillator, III-133
 - TTL oscillator, II-595
 - low-pass filters, I-287
 - active, digitally selected break frequency, II-216
 - Chebyshev, fifth-order, multi-feed-back, II-219
 - pole-active, I-295
 - fast-response, fast settling, IV-168-169
 - fast-settling, precision, II-220
 - precision, fast settling, II-220
 - Sallen-Key, 10 kHz, I-279
 - Sallen-key, active, IV-177
 - Sallen-Key, equal component, I-292
 - low-voltage alarm/indicator, II-493, III-769
 - low-voltage power disconnecter, II-97
 - LVDT circuits, II-336-339, III-323-324
 - driver demodulator, II-337
 - signal conditioner, II-338
- M**
- machine vision, illumination stabilizer for, II-306
 - magnetic current low-power sensor, III-341
 - magnetic phono preamplifier, I-91
 - magnetic pickup phone preamplifier, I-89
 - magnetometer, II-341
 - magnets, permanent-magnet detector, IV-281
 - mains-failure indicator, IV-216
 - marker generator, III-138
 - marker light, III-317
 - mathematical circuits, III-325-327, IV-258-263
 - adder, III-327
 - adder, binary, fast-action, IV-260-261
 - divide/multiply, one trim, III-326
 - multiplier, precise commutating amp, IV-262-263
 - slope integrator, programmable, IV-259
 - subtractor, III-327
 - measurement/test circuits (*see also* detectors; indicators; meters), II-340, III-328-348, IV-264-311
 - 3-in-1 test set, III-330
 - absolute-value circuit, IV-274
 - acoustic-sound receiver, IV-311
 - acoustic-sound transmitter, IV-311
 - anemometer/, hot-wire, III-342
 - audible logic tester, III-343
 - automotive electrical tester, IV-45
 - B-field measurer, IV-272
 - barometer, IV-273
 - battery internal-resistance, IV-74
 - battery tester, IV-78
 - battery tester, ni-cad batteries, IV-79
 - breath alert alcohol tester, III-359
 - broadband ac active rectifier, IV-271
 - cable tester, III-539
 - capacitor tester, IV-265
 - capacitor-ESR measurer, IV-279
 - continuity tester, I-550, I-551, II-342, III-345, III-540, IV-287, IV-289, IV-296
 - continuity tester, latching, IV-295
 - crystal tester, II-151
 - current indicator, ac current, IV-290
 - current monitor, Hall-sensor, IV-284
 - current monitor/alarm, III-338
 - current sensor, high-gain, IV-291
 - deviation meter, IV-303
 - digital frequency meter, III-344

measurement/test circuits (*cont.*)
 digital multimeter (DMM), high-resistance measuring, IV-291
 diode, I-402, II-343
 direction-of-rotation circuit, III-335
 diode-curve tracer, IV-274
 diode-matching circuit, IV-280
 duty-cycle measurer, IV-265
 duty-cycle meter, IV-275
 duty-cycle monitor, III-329
 E, T, and R measurement/test circuits, IV-283-296
 electrolytic-capacitor reforming circuit, IV-276
 electrometer, IV-277
 electrostatic detector, III-337
 filter analyzer, audio filters, IV-309
 frequency checker, crystal oscillator, precision design, IV-301
 frequency counter, III-340, IV-300
 frequency meter, IV-282
 frequency shift keyer tone generator, I-723
 go/no-go, diode, I-401
 go/no-go, dual-limit, I-157
 grid-dip meter, bandswitched, IV-298
 ground, I-580, II-345
 injectors, IV-429
 high-frequency and rf, IV-297-303
 LC checker, III-334
 LED panel meter, III-347
 line-current monitor, III-341
 logic probes (*see* logic probes)
 logic-pulses, slow pulse test, II-345
 low-current measurement, III-345
 low-ohms adapter, IV-290
 magnet, permanent-magnet detector, IV-281
 magnetic current sensor, low-power, III-341
 magnetic-field meter, IV-266
 magnetometer, II-341
 measuring gauge, linear variable differential transformer, I-404
 meter tester, IV-270
 microammeter, dc, four-range, IV-292
 microfarad counter, IV-275
 millivoltmeter, dc, IV-295
 millivoltmeter, four-range, IV-289
 millivoltmeter, LED readout, IV-294
 modulation monitor, IV-299
 mono audio-level meter, IV-310
 motion sensor, unidirectional, II-346
 motor hour, III-340
 multiconductor-cable tester, IV-288
 multimeter shunt, IV-293
 noise generator, IV-308
 ohmmeter, linear, III-540
 ohmmeter, linear-scale, five-range, IV-290
 oscilloscope adapter, four-trace, IV-267
 paper sheet discriminator, copying machines, III-339
 peak-dB meter, III-348
 peakmeter, LED, III-333
 phase difference from 0 to 180 degrees, II-344
 phase meter, digital VOM, IV-277
 picoammeter, III-338
 power gain, 60 MHz, I-489
 power supply test load, constant-current, IV-424
 probes, 4-to-220 V, III-499
 pulse-width, very short, III-336
 QRP SWR bridge, III-336
 remote-control infrared device, IV-228
 resistance measurement, synchronous system, IV-285
 resistance ratio detector, II-342
 resistance/continuity meters, III-538-540
 rf output indicator, IV-299
 rf power, wide-range, III-332
 SCR tester, III-344
 shutter, I-485
 signal generator, AM broadcast-band, IV-302
 signal generator, AM/IF, 455 kHz, IV-301
 signal strength (S), III-342
 signal tracer, IV-429
 sound-level meter, III-346, IV-305, IV-307
 sound-test circuits (*see also* sound generators), IV-304
 speedometer, bike, IV-271, IV-282
 static detector, IV-276
 stereo audio-level meter, IV-310
 stereo audio-power meter, IV-306
 stereo power meter, III-331
 stud finder, III-339
 SWR meter, IV-269
 tachometer, III-335, III-340
 tachometer, optical pick-up, III-347
 tachometer, analog readout, IV-280
 tachometer, digital readout, IV-278
 tachometer, digital, IV-268-269
 temperature measurement, transistorized, IV-572
 test probe, 4-220 V, III-499
 thermometers, III-637-643
 three-in-one set, logic probe, signal tracer, injector, IV-429
 three-phase tester, II-440
 transistor, I-401, IV-281
 TTL logic, I-527
 universal test probe, IV-431
 UHF source dipper, IV-299
 voltmeter, digital LED readout, IV-286
 VOM, phase meter, digital readout, IV-277
 VOR signal simulator, IV-273
 water-level measurement circuit, IV-191
 wavemeter, tuned RF, IV-302
 wideband test amplifier, IV-303
 wire tracer, II-343
 zener, I-400
 medical electronic circuits, II-347-349, III-349-352
 biomedical instrumentation differential amp, III-282
 breath monitor, III-350
 EKG simulator, three-chip, III-350
 heart rate monitor, II-348, II-349
 preamplifier for, II-349
 stimulator, constant-current, III-352
 stimulus isolator, III-351
 thermometer, implantable/ingestible, III-641
 melody generator, single-chip design, IV-520
 memory-related circuits
 EEPROM pulse generator, 5V-powered, III-99
 memory protector/power supply monitor, IV-425
 memory-saving power supply, II-486
 metal detectors, II-350-352, IV-137
 micropower, I-408
 meters (*see also* measurement/test circuits)
 ac voltmeters, III-765
 analog, expanded-scale, IV-46
 analog, expanded-scale, voltage reference, III-774
 anemometer/, hot-wire, III-342
 audio frequency, I-311
 audio millivolt, III-767, III-769
 audio power, I-488
 automatic contrast, I-479
 basic grid dip, I-247
 breaker point dwell, I-102
 capacitance, I-400
 dc voltmeter, III-763
 dc voltmeter, high-input resistance, III-762
 deviation meter, IV-303
 digital frequency, III-344
 digital multimeter (DMM), high-resistance measuring, IV-291
 dip, I-247
 dip, dual-gate IGFET in, I-246

dosage rate, I-534
 duty-cycle meter, IV-275
 electrometer, IV-277
 extended range VU, I-715, III-487
 FET voltmeter, III-765, III-770
 field-strength meters (*see* field-strength meters)
 flash exposure, I-484, III-446
 frequency meter, IV-282
 grid-dip meter, bandswitched, IV-298
 LED bar/dot level, I-251
 LED panel, III-347
 light, I-383
 linear frequency, I-310
 linear light, I-382
 logarithmic light, I-382
 magnetic-field meter, IV-266
 meter-driver rf amplifier, 1-MHz, III-545
 microammeter, dc, four-range, IV-292
 microwave field strength, I-273
 millivoltmeter, dc, IV-295
 millivoltmeter, four-range, IV-289
 millivoltmeter, LED readout, IV-294
 mono audio-level meter, IV-310
 motor hour, III-340
 multimeter shunt, IV-293
 ohmmeter, linear, III-540
 ohmmeters, linear-scale, five-range, IV-290
 peak decibels, III-348
 peak, LED, III-333
 pH, I-399
 phase, I-406
 picoammeter, III-338
 power line frequency, I-311
 power, I-489
 resistance/continuity, III-538-540
 rf power, I-16
 rf power, wide-range, III-332
 rf voltmeter, III-766
 signal strength (S), III-342, IV-166
 soil moisture, III-208
 sound-level meter, IV-305, IV-307
 sound level, telephone, III-614
 sound level, III-346
 speedometer, bicycle, IV-271, IV-282
 stereo audio-level meter, IV-310
 stereo audio-power meter, IV-306
 stereo balance, I-618-619
 stereo power, III-331
 suppressed zero, I-716
 SWR power, I-16, IV-269
 tachometer, III-335, III-340, III-347
 tachometer, analog readout, IV-280
 tachometer, digital readout, IV-278
 temperature, I-647
 tester, IV-270
 thermometers, III-637-643
 tilt meter, III-644-646
 varicap tuned FET DIP, I-246
 vibration, I-404
 voltage, III-758-77
 voltmeters, ac wide-range, III-772
 voltmeters, digital, 3.5-digit, full-scale four-decade, III-761
 voltmeters, digital, 4.5-digit, III-760
 voltmeters, high-input resistance, III-768
 VOM field strength, I-276
 VOM/phase meter, digital readout, IV-277
 wavemeter, tuned RF, IV-302
 methane concentration detector, linearized output, III-250
 metronomes, I-413, II-353-355, III-353-354, IV-312-314
 ac-line operated unijunction, II-355
 accentuated beat, I-411
 downbeat-emphasized, III-353-354
 electronic, IV-313
 low-power design, IV-313
 novel design, IV-314
 sight and sound, I-412
 simple, II-354
 version II, II-355
 microammeter, dc, four-range, IV-292
 microcontroller, musical organ, preprogrammed single-chip, I-600
 micro-sized amplifiers, III-36
 microphone circuits
 amplifiers for, I-87, III-34
 amplifiers for, electronic balanced input, I-86
 FM wireless, III-682, III-685, III-691
 mixer, II-37
 preamp for, II-45, IV-37, IV-42
 preamp, low-impedance design, IV-41
 preamp for, low-noise transformerless balanced, I-88
 preamp for, tone control in, I-675, II-687
 wireless, IV-652-654
 wireless AM, I-679
 microprocessors (*see* computer circuits)
 microvolt comparators
 dual limit, III-89
 hysteresis-including, III-88
 microvolt probe, II-499
 microwave amplifier circuits, IV-315-319
 5.7 GHz, IV-317
 bias supply for preamp, IV-318
 preamplifier, 2.3 GHz, IV-316
 preamplifier, 3.4 GHz, IV-316
 preamplifier, single-stage, 10 GHz, IV-317
 preamplifiers, bias supply, IV-318
 preamplifiers, two-stage, 10 GHz, IV-319
 Miller oscillator, I-193
 millivoltmeters (*see also* meters; voltmeters)
 ac, I-716
 audio, III-767, III-769
 high-input impedance, I-715
 mini-stereo audio amplifiers, III-38
 mixers, III-367-370, IV-330-336
 1-MHz, I-427
 audio, I-23, II-35, IV-335
 audio, one-transistor design, I-59
 CMOS, I-57
 common-source, I-427
 digital mixer, IV-334
 diplexer, IV-335
 doubly balanced, I-427
 dynamic audio mixer, IV-331
 four-channel, I-60, III-369, IV-333
 four-channel, four-track, II-40
 four-channel, high level, I-56
 four-input, stereo, I-55
 four-input, unity-gain, IV-334
 HF transceiver/mixer, IV-457
 hybrid, I-60
 input-buffered, III-369
 microphone, II-37
 multiplexer, I-427
 one-transistor design, I-59
 passive, I-58
 preamplifier with tone control, I-58
 signal combiner, III-368
 silent audio switching, I-59
 sound amplifier and, II-37
 stereo mixer, pan controls, IV-332
 unity-gain, four-input, IV-334
 utility-design mixer, IV-336
 universal stage, III-370
 video, high-performance operation, IV-609
 mobile equipment, 8-amp regulated power supply, II-461
 model and hobby circuits, IV-337-340
 controller, model-train and/or slot-car, IV-338-340
 model rocket launcher, II-358
 modems, power-line, carrier-current circuit, III-82
 modulated light beam circuit, ambient light effect cancellization with, II-328
 modulated readback systems, disc/tape phase, I-89
 modulation indicator/monitor, I-430
 CB, I-431

modulators, I-437, II-368-372, III-371-377
 + 12V dc single supply, balanced, I-437
 AM, I-438
 amplitude, low-distortion low level, II-370
 balanced, III-376
 balanced, phase detector-selector/sync rectifier, III-441
 double-sideband suppressed-carrier, III-377
 linear pulse-width, I-437
 monitor for, III-375
 musical envelope generator, I-601
 pulse-position, I-435, III-375
 pulse-width, I-435, I-436, I-438-440, III-376, IV-326
 rf, I-436, III-372, III-374
 rf, double sideband, suppressed carrier, II-369
 saw oscillator, III-373
 TTL oscillator for television display, II-372
 TV, I-439, II-433, II-434
 VHF, I-440, III-684
 video, I-437, II-371, II-372
 moisture detector (*see* fluid and moisture detectors)
 monitors (*see also* alarms; control circuits; detectors; indicators; sensors), III-378-390
 acid rain, III-361
 battery, III-60-67
 battery-alternator, automotive, III-63
 blinking phone light, II-624
 breath monitor, III-350
 current, alarm and, III-338
 directional signals, auto, III-48
 door-ajar, automotive circuits, III-46
 duty cycle, III-329
 flames, III-313
 home security system, I-6
 line-current, III-341
 line-voltage, III-511
 logic line, III-108
 modulation, III-375
 overvoltage, III-762
 power monitor, SCR design, IV-385
 power-supply monitors (*see* power-supply monitors)
 power-line connections, ac, III-510
 precision battery voltage, HTS, I-122
 receiver, II-526
 sound level, telephone, III-614
 telephone status, optoisolator in, I-625
 telephone, remote, II-626
 thermal monitor, IV-569
 undervoltage, III-762
 voltage, III-767
 voltage, III-758-772
 monostable circuit, I-464, II-460
 monostable multivibrators, I-465, III-230, III-235
 input lockout, I-464
 linear-ramp, III-237
 positive-triggered, III-229
 monostable photocell, self-adjust trigger, II-329
 monostable TTL, I-464
 monostable UJT, I-463
 mooring light, automatic, II-323
 MOSFETs
 power control switch, IV-386
 power inverter, III-295
 mosquito repelling circuit, I-684
 motion sensors
 acoustic Doppler motion detector, IV-343
 auto alarm, I-9
 low-current-drain design, IV-342-343
 motorcycle alarm, I-9
 UHF, III-516, IV-344
 unidirectional, II-346
 motor control circuits, IV-347-353
 400 Hz servo amplifier, II-386
 ac motors, II-375
 bidirectional proportional, II-374
 compressor protector, IV-351
 direction control, dc motors, I-452
 direction control, series-wound motors, I-448
 direction control, shunt-wound motors, I-456
 direction control, stepper motor, IV-350
 driver control, ac, three-phase, II-383
 driver control, ac, two-phase, II-382
 driver control, constant-speed, III-386
 driver control, dc, fixed speed, III-387
 driver control, dc, servo, bipolar control input, II-385
 driver control, dc, speed-controlled reversible, III-388
 driver control, N-phase motor, II-382
 driver control, reversing, dc control signals, II-381
 driver control, servo motor amplifier, I-452, II-384
 driver control, stepper motors, III-390
 driver control, stepper motor, half-step, IV-349
 driver control, stepper motor, quar-
 ter-step, IV-350
 driver control, two-phase, II-456
 fiber-optic, dc, variable, II-206
 hours-in-use meter, III-340
 induction motor, I-454
 load-dependent, universal motor, I-451
 mini-drill control, IV-348
 power brake, ac, II-451
 power-factor controller, three-phase, II-388
 PWM motor controller, III-389
 PWM servo amplifier, III-379
 PWM speed control, II-376
 PWM speed control/energy-recovering brake, III-380
 self-timing control, built-in, universal motor, I-451
 servo motor amplifier, I-452, II-384
 speed control (*see* speed controllers)
 start-and-run motor circuit, III-382
 stepper motors, half-step, IV-349
 stepper motors, quarter-step, IV-350
 stepper motors, speed and direction, IV-350
 tachometer feedback control, II-378
 tachometer feedback control, closed loop, II-390
 motorcycle alarm, motion actuated, II-9
 multiburst generator, square waveform, II-88
 multimeters, shunt, IV-293
 multiple-input detector, III-102
 multiplexed common-cathode LED-display ADC, III-764
 multiplexers, III-391-397
 1-of-8 channel transmission system, III-395
 analog, II-392
 analog, 0/01-percent, II-392
 analog, buffered input and output, III-396
 analog, input/output buffer for, III-11
 analog, single- to four-trace converter, II-431
 capacitance, II-200, II-416
 de-, III-394
 four-channel, low-cost, III-394
 frequency, III-213-218
 mathematical, one trim, III-326
 oscilloscopes, add-on, III-437
 pulse-width, III-214
 resistor, II-199
 sample-and-hold, three-channel, III-396
 two-level, III-392
 video, 1-of-15 cascaded, III-393
 wideband differential, II-428
 multipliers, low-frequency multiplier, IV-325

multiplying D/A converter, III-168
 multiplying pulse width circuit, II-264
 multivibrators
 100 kHz free running, II-485
 astable, I-461, II-269, II-510, III-196, III-224, III-233, III-238
 astable, digital-control, II-462
 astable, dual, II-463
 astable, programmable-frequency, III-237
 bistable, II-465
 bistable, touch-triggered, I-133
 car battery, II-106
 CB modulation, II-431
 current, II-203
 duty-cycle, 50-percent, III-584
 free-running, programmable-frequency, III-235
 low-frequency, III-237
 low-voltage, II-123
 modulation, II-430
 monostable, II-465, III-229, III-230, III-235, III-237
 monostable, input lock-out, II-464
 one-shot, II-465
 oscilloscope, II-474
 single-supply, III-232
 sound level, II-403
 square-wave generators, IV-536
 telephone line, II-628
 wideband radiation, II-535
 music circuits (*see* sound generators)
 musical envelope generator/modulator, IV-22
 mux/demux systems
 differential, I-425
 eight-channel, I-426, II-115

N

N-phase motor drive, III-382
 NAB preamps
 record, III-673
 two-pole, III-673
 NAB tape playback pre-amp, III-38
 nano ammeter, I-202
 narrow-band FM demodulator, carrier detect in, II-159
 negative-ion generator, IV-634
 neon flashers
 five-lamp, III-198
 two-state oscillator, III-200
 networks
 filter, I-291
 speech, telephone, II-633
 ni-cad batteries
 analyzer for, III-64
 charger, I-112, I-116, III-57
 charger, 12 v, 200 mA per hour, I-114

 charger, current and voltage limiting, I-114
 charger, fast-acting, I-118
 charger, portable, IV-69
 charger, temperature-sensing, IV-77
 charger, thermally controlled, II-68
 packs, automotive charger for, I-115
 protection circuit, III-62
 test circuit, IV-79
 zappers, I-6, II-68
 night lights (*see* lights/light-activated and controlled circuits)
 noise generators (*see* sound generators)
 noise reduction circuits, II-393-396, III-398-401, IV-354-356
 audio clipper/limiter, IV-355
 audio shunt noise limiter, IV-355
 audio squelch, II-394
 balance amplifier with loudness control, II-395
 blanker, IV-356
 clipper, II-394
 clipper, audio-powered, III-396
 Dolby B, decode mode, III-401
 Dolby B, encode mode, III-400
 Dolby B/C, III-399
 dynamic noise reduction, III-321
 filter, III-188
 filter, dynamic filter, III-190
 limiter, II-395, III-321
 noninverting amplifiers, I-41, III-14
 adjustable gain, I-91
 comparator with hysteresis in, I-153
 high-frequency, 28-dB, III-263
 hysteresis in, I-153
 low power, digitally selectable input and gain, II-334
 power, I-79
 programmable-gain, III-505
 single supply, I-74
 split supply, I-75
 noninverting integrator, improved design, II-298
 noninverting voltage followers, I-33
 high-frequency, III-212
 nonselective frequency tripler, transistor saturation, II-252
 Norton amplifier, absolute value, III-11
 notch filters (*see also* filter circuits), I-283, II-397-403, III-402-404
 4.5 MHz, I-282
 550 Hz, II-399
 1800 Hz, II-398
 active band reject, II-401
 adjustable Q, II-398
 audio, II-400
 bandpass and, II-223
 high-Q, III-404
 selectable bandwidth, I-281

 three-amplifier design, I-281
 tunable, II-399, II-402
 tunable, passive-bridged differentiator, II-403
 tunable, hum-suppressing, I-280
 tunable, op amp, II-400
 twin-T, III-403
 Wien bridge, II-402
 NTSC-to-RGB video decoder, IV-613
 null circuit, variable gain, accurate, III-69
 null detector, I-148, III-162

O

ohmmeters, I-549
 linear, III-540
 linear scale, I-549
 linear-scale, five-range, IV-290
 ohms-to-volts converter, I-168
 oil-pressure gauge, automotive, IV-44, IV-47
 on/off inverter, III-594
 on/off touch switches, II-691, III-663
 one-of-eight channel transmission system, III-100
 one-shot function generators, I-465
 digitally controlled, I-720
 precision, III-222
 retriggerable, III-238
 one-shot timers, III-654
 light-controlled, III-317
 voltage-controlled high-speed, II-266
 op amps, II-404-406, III-405-406, IV-357-364
 x10, I-37
 x100, I-37
 astable multivibrator, III-224
 audio amplifier, IV-33
 bidirectional compound op amp, IV-361
 clamping for, II-22
 clock circuit using, III-85
 comparator, three-input and gate comparator, IV-363
 compound op-amp, IV-364
 feedback-stabilized amplifier, IV-360
 gain-controlled op amp, IV-361
 intrinsically safe protected, III-12
 inverter/rectifier, programmable, IV-364
 on/off switch, transistorized, IV-546
 power booster, IV-358
 power driver circuit, IV-158-159
 quad, simultaneous waveform generator using, II-259
 single potentiometer to adjust gain over bipolar range, II-406
 swing rail-ray, LM324, IV-363

- op amps (*cont.*)
 - tunable notch filter with, II-400
 - variable gain and sign, II-405
 - VCO driver, IV-362
 - video op amp circuits, IV-615
- optical circuits (*see also* lasers; lights/light-activated and controlled circuits), II-407-419, IV-365-369
 - 50 kHz center frequency FM transmitter, II-417
 - ac relay, III-418
 - ac relay using two photon couplers, II-412
 - ac switcher, high-voltage, III-408
 - ambient light ignoring optical sensor, III-413
 - CMOS coupler, III-414
 - communication system, II-416
 - dc linear coupler, II-411
 - dc latching relay, III-417
 - digital transmission isolator, II-414
 - high-sensitivity, NO, two-terminal zero voltage switch, II-414
 - indicator lamp driver, III-413
 - integrated solid state relay, II-408
 - interruption sensor, IV-366
 - isolation and zero voltage switching logic, II-415
 - light-detector, IV-369
 - line-current detector, III-414
 - linear ac analog coupler, II-412
 - linear analog coupler, II-413
 - linear optocoupler for instrumentation, II-417
 - microprocessor triac array driver, II-410
 - optoisolator relay circuit, IV-475
 - paper tape reader, II-414
 - photoelectric light controller, IV-369
 - power outage light, line-operated, III-415
 - probe, IV-369
 - receiver, 50 kHz FM optical transmitter, II-418
 - receiver, light receiver, IV-367
 - receiver, optical or laser light, IV-368
 - relays, dc solid-state, open/closed, III-412
 - source follower, photodiode, III-419
 - stable optocoupler, II-409
 - telephone ring detector, III-611
 - transmitter, light transmitter, IV-368
 - triggering SCR series, III-411
 - TTL coupler, optical, III-416
 - zero-voltage switching, closed half-wave, III-412
 - zero-voltage switching, solid-state, III-410
 - zero-voltage switching, solid-state relay, III-416
- optical communication system, I-358, II-416
 - optical pyrometer, I-654
 - optical receiver, I-364, II-418
 - optical Schmitt trigger, I-362
 - optical sensor, ambient light ignoring, III-413
 - optical sensor-to-TTL interface, III-314
 - optical transmitters, I-363
 - FM (PRM), I-367
- optocouplers
 - linear, instrumentation, II-417
 - stable, II-409
- optoisolators, IV-475
 - driver, high-voltage, III-482
 - telephone status monitor using, I-626
- OR gate, I-395
- organ, musical, I-415
 - preprogrammed single chip microcontroller for, I-600
- stylus, I-420
- oscillators, II-420-429, III-420-432, IV-370-377
 - 1 kHz, II-427
 - 1.0 MHz, I-571
 - 2MHz, II-571
 - 5-V, III-432
 - 50 kHz, I-727
 - 400 MHz, I-571
 - 500 MHz, I-570
 - 800 Hz, I-68
 - adjustable over 10:1 range, II-423
 - astable, I-462
 - audio, I-245, III-427, IV-374, IV-375
 - audio, light-sensitive, III-315
 - beat-frequency audio generator, IV-371
 - buffer circuits, IV-89
 - Butler, aperiodic, I-196
 - Butler, common base, I-191
 - Butler, emitter follower, II-190-191, II-194
 - cassette bias, II-426
 - clock generator, I-615, III-85
 - CMOS, I-615
 - CMOS, 1 MHz to 4MHz, I-199
 - CMOS, crystal, I-187
 - code practice, I-15, I-20, I-22, II-428, III-431, IV-373, IV-375, IV-376
 - Colpitts, I-194, I-572, II-147
 - Colpitts, harmonic, I-189-190
 - crystal (*see* crystal oscillators)
 - double frequency output, I-314
 - discrete sequence, III-421
 - duty-cycle, 50-percent, III-426
 - emitter-coupled, big loop, II-422
 - emitter-coupled, RC, II-266
 - exponential digitally controlled, I-728
 - feedback, I-67
 - flasher and, high drive, II-235
 - flasher and, low frequency, II-234
 - free-running, I-531
 - free-running, square wave, I-615
 - frequency doubled output from, II-596
 - gated, I-728
 - gated, last-cycle completing, III-427
 - Hartley, I-571
 - hc-based, III-423
 - HCU/HCT-based, III-426
 - high-current, square-wave generator, III-585
 - high-frequency, III-426
 - high-frequency, crystal, I-175, II-148
 - load-switching, 100 mA, I-730
 - low-distortion, I-570
 - low-duty-cycle pulse circuit, IV-439
 - low-frequency, III-428
 - low-frequency, crystal, I-184, II-146
 - low-frequency, TTL, II-595
 - low-noise crystal, II-145
 - Miller, I-193
 - neon flasher, two-state, III-200
 - one-second, 1 kHz, II-423
 - one-shot, voltage-controlled high-speed, II-266
 - overtone, 50 MHz to 100 MHz, I-181
 - overtone, crystal, I-176, I-180, II-146, IV-123
 - overtone, crystal switching, I-183
 - overtone, fifth overtone, I-182
 - phase-locked, 20-MHz, IV-374
 - Pierce, I-195
 - Pierce, crystal, II-144
 - Pierce, harmonic, I-199, II-192
 - quadrature, III-428
 - quadrature-output, I-729
 - quadrature-output, square-wave generator, III-585
 - R/C, I-612
 - reflection, crystal-controlled, III-136
 - relaxation, IV-376
 - relaxation, SCR, III-430
 - resistance-controlled digital, II-426
 - rf (*see also* rf oscillator), II-550, I-572
 - rf-genie, II-421
 - rf-powered sidetone, I-24
 - RLC, III-423
 - sawtooth wave, modulator, III-373
 - Schmitt trigger crystal, I-181
 - sine-wave (*see* sine-wave oscillators)
 - sine-wave/square wave, easily tuned, I-65
 - sine-wave/square-wave, tunable, III-232
 - single op amp, I-529
 - square-wave, II-597, I-613-614, II-

616, IV-532, IV-533
square-wave, 0.5 Hz, I-616
square-wave, 1kHz, I-612
start-stop oscillator pulse circuit, IV-438
switching, 20 ns, I-729
temperature-compensated, low power 5v-driven, II-142
temperature-stable, II-427
temperature-compensated crystal, I-187
timer, 500 timer, I-531
tone-burst, decoder and, I-726
transmitter and, 27 MHz and 49 MHz rf, I-680
triangle/square wave, I-616, II-422
TTL, I-179, I-613
TTL, 1MHz to 10MHz, I-178
TTL, television display using, II-372
TTL-compatible crystal, I-197
tube type crystal, I-192
tunable frequency, II-425
tunable single comparator, I-69
varactor tuned 10 MHz ceramic resonator, II-141
variable, II-421
variable, audio, 20Hz to 20kHz, II-727
variable, four-decade, single control for, II-424
variable, wide range, II-429
variable-duty cycle, fixed-frequency, III-422
voltage-controlled (*see* voltage-controlled oscillators)
wide-frequency range, II-262
wide-range, I-69, III-425
wide-range, variable, I-730
Wien-bridge (*see* Wien-bridge oscillators)
XOR-gate, III-429
yelp, II-577
oscilloscopes, II-430-433, III-433-439
analog multiplexer, single- to four-trace scope converter, II-431
beam splitter, I-474
calibrator, II-433, III-436
converter, I-471
CRO doubler, III-439
eight-channel voltage display, III-435
extender, III-434
FET dual-trace switch for, II-432
four-trace oscilloscope adapter, IV-267
monitor, I-474
multiplexer, add-on, III-437
preamplifier, III-437
preamplifier, counter, III-438
preamplifier, instrumentation amplifiers, IV-230-231

sensitivity amplifier, III-436
triggered sweep, III-438
voltage-level dual readout, IV-108
outband descrambler, II-164
out-of-bounds pulse-width detector, III-158
output limiter, III-322
output-gating circuit, photomultiplier, II-516
output-stage booster, III-452
over/under temperature monitor, dual output, II-646
overload protector, speaker, II-16
overspeed indicator, I-108
overtone crystal oscillators, II-146
50 MHz to 100 MHz, I-181
100 MHz, IV-124
crystal, I-176, I-180, II-146
crystal switching, I-183
fifth overtone, I-182
third-overtone oscillator, IV-123
overvoltage detection and protection, IV-389
comparator to detect, II-107
monitor for, III-762
protection circuit, II-96, II-496, III-513
undervoltage and, indicator, I-150

P

pager, pocket-size, III-288
PAL/NTSC decoder, RGB input, III-717
palette, video, III-720
panning circuit, two-channel, I-57
paper-sheet discriminator, copying machines, III-339
paper-tape reader, II-414
parallel connections, telephone, III-611
party-line intercom, II-303
passive bridge, differentiator tunable notch filter, II-403
passive mixer, II-58
PCB continuity tester, II-342
peak decibel meter, III-348
peak detectors, II-174, II-175, II-434-436, IV-138, IV-143
analog, with digital hold, III-153
digital, III-160
high-bandwidth, III-161
high-frequency, II-175
high-speed, I-232
low-drift, III-156
negative, I-225, I-234
op amp, IV-145
positive, I-225, I-235, II-435, III-169
ultra-low drift, I-227
voltage, precision, I-226
wide-bandwidth, III-162
wide-range, III-152
peak meter, LED, III-333
peak program detector, III-771
peak-to-peak converter, precision ac/dc, II-127
people-detector, infrared-activated, IV-225
period counter, 100 MHz, frequency and, II-136
period-to-voltage converter, IV-115
pest-repeller, ultrasonic, III-699, III-706, III-707, IV-605-606
pH meter, I-399
pH probe, I-399, III-501
phase detectors, III-440-442
10-bit accuracy, II-176
phase selector/sync rectifier/balanced modulator, III-441
phase sequence, III-441
phase difference, 0- to 180-degree, II-344
phase indicator, II-439
phase meter, I-406
digital VOM, IV-277
phase selector, detector/sync rectifier/balanced modulator, III-441
phase sequence circuits, II-437-442
detector, II-439, II-441, II-442, III-441
indicator, I-476, II-439
rc circuit, phase sequence reversal detection, II-438
reversal, rc circuit to detect, II-438
three-phase tester, II-440
phase shifters, IV-647
0-180 degree, I-477
0-360 degree, I-477
single transistor, I-476
phase splitter, precision, III-582
phase tracking, three-phase square wave generator, II-598
phasor gun, I-606, IV-523
phono amplifiers, I-80-81
magnetic pickup, I-89
stereo, bass tone control, I-670
phono preamps, I-91
equalized, III-671
LM382, I-90
low-noise design, IV-36
magnetic, I-91, III-37
magnetic, ultra-low-noise, IV-36
photo-conductive detector amplifier, four quadrant, I-359
photo memory switch for ac power control, I-363
photo stop action, I-481
photocell, monostable, self-adjust trigger, II-329
photocurrent integrator, II-326
photodiode circuits
amplifier, III-672

- photodiode circuits amplifier (*cont.*)
 - amplifier, low-noise, III-19
 - current-to-voltage converter, II-128
 - sensor amplifier, II-324
 - amplifier, I-361
 - comparator, precision, I-360
 - level detector, precision, I-365
- PIN, thermally stabilized signal conditioner with, II-330
- PIN-to-frequency converters, III-120
- source follower, III-419
- photoelectric circuits
 - ac power switch, III-319
 - alarm system, II-4
 - controlled flasher, II-232
 - light controller, IV-369
 - smoke alarm, line operated, I-596
 - smoke detector, I-595
 - switch, II-321
 - switch, synchronous, II-326
- photoflash, electronic, III-449
- photography-related circuits, II-443-449, III-443-449, IV-378-382
 - auto-advance projector, II-444
 - camera alarm trigger, III-444
 - camera trip circuit, IV-381
 - contrast meter, II-447
 - darkroom enlarger timer, III-445
 - electronic flash trigger, II-448
 - enlarger timer, II-446
 - exposure meter, I-484
 - flash meter, III-446
 - flash slave driver, I-483
 - flash trigger, electronic, II-448
 - flash trigger, remote, I-484
 - flash trigger, sound-triggered, II-449
 - flash trigger, xenon flash, III-447
 - photo-event timer, IV-379
 - photoflash, electronic, III-449
 - shutter speed tester, II-445
 - slave-flash unit trigger, SCR design, IV-380, IV-382
 - slide projector auto advance, IV-381
 - slide timer, III-448
 - slide-show timer, III-444
 - sound trigger for flash unit, II-449, IV-382
 - time-delay flash trigger, IV-380
 - timer, I-485
 - xenon flash trigger, slave, III-447
- photomultiplier output-gating circuit, II-516
- picoammeters, I-202, II-154, III-338
 - circuit for, II-157
 - guarded input circuit, II-156
- picture fixer/inverter, III-722
- Pierce crystal oscillator, I-195, II-144
 - 1-MHz, III-134
 - harmonic, I-199, II-192
 - low-frequency, III-133
- piezoelectric alarm, I-12
- piezoelectric fan-based temperature controller, III-627
- PIN photodiode-to-frequency converters, III-120
- pink noise generator, I-468
- plant watering gauge, II-248
- plant watering monitor, II-245
- plant waterer, I-443
- playback amplifier, tape, I-77
- PLL/BC receiver, II-526
- pocket pager, III-288
- polarity converter, I-166
- polarity-protection relay, IV-427
- polarity-reversing amplifiers, low-power, III-16
- portable-radio 3 V fixed power supplies, IV-397
- position indicator/controller, tape recorder, II-615
- positive input/negative output charge pump, III-360
- positive peak detector, II-435
- positive regulator, NPN/PNP boost, III-475
- power amps, II-450-459, III-450-456
 - 2- to 6-watt audio amplifier with preamp, II-451
 - 10 W, I-76
 - 12 W low distortion, I-76
 - 25 W, II-452
 - 90 W, safe area protection, II-459
 - am radio, I-77
 - audio, II-451, III-454, IV-28-33
 - audio, 20-W, III-456
 - audio, 50-W, III-451
 - audio, 6-W, with preamp, III-454
 - audio, booster, II-455
 - bridge audio, I-81
 - bull horn, II-453
 - class-D, III-453
 - hybrid, III-455
 - inverting, I-79
 - low-distortion, 12 W, I-76
 - low-power audio, II-454
 - noninverting, I-79
 - noninverting, ac, I-79
 - output-stage booster, III-452
 - portable, III-452
 - rear speaker ambience amplifier, II-458
 - rf, 1296-MHz solid state, III-542
 - rf, 5W, II-542
 - switching, I-33
 - two-meter 10 W, I-562
 - walkman amplifier, II-456
- power booster, I-28, I-33
- power control, burst, III-362
- power disconnecter, low-voltage, II-97
- power factor controller, three-phase, II-388
- power failure alarm, I-581-582
- power gain test circuit, 60 MHz, I-489
- power inverters, III-298
 - 12 VDC-to-117 VAC at 60 Hz, III-294
 - medium, III-296
 - MOSFET, III-295
- power loss detector, II-175
- power meters, I-489
 - audio, I-488
 - frequency and, II-250
 - rf, I-16
 - SWR, I-16
- power op amp/audio amp, high slew rate, I-82
- power outage light, line-operated, III-415
- power pack for battery operated devices, I-509
- power protection circuit, I-515
- power reference, 0-to-20 V, I-694
- power supplies, II-460-486, III-464
 - 5V including momentary backup, II-464
 - 5V, 0.5A, I-491
 - 8-amp regulated, mobile equipment operation, II-461
 - 10 A regulator, current and thermal protection, II-474
 - 12-14 V regulated 3A, II-480
 - 90 V rms voltage regulator with PUT, II-479
 - 500 kHz switching inverter for 12V, II-474
 - 2,000 V low-current supply, IV-636-637
 - adjustable current limit and output voltage, I-505
 - arc lamp, 25W, II-476
 - arc-jet, starting circuit, III-479
 - backup supply, drop-in main-actuated, IV-424
 - balance indicator, III-494
 - battery charger and, 14V, 4A, II-73
 - bench top, II-472
 - benchtop, dual output, I-505
 - bipolar, battery instruments, II-475
 - charge pool, III-469
 - dc-to-dc SMPS variable 18V to 30 V out at 0.2A, II-480
 - dual polarity, I-497
 - fault monitor, single-supply, III-495
 - fixed power supplies (*see fixed power supplies*)
 - general-purpose, III-465
 - glitches in, comparator to detect, II-107

- high-voltage (*see* high-voltage power supplies)
- increasing zener diode power rating, II-485
- isolated feedback, III-460
- laser power supply, voltage multiplier circuits, IV-636
- low-ripple, I-500
- low-volts alarm, II-493
- memory save on power-down, II-486
- micropower bandgap reference, II-470
- microprocessor power supply watchdog, II-494
- monitors (*see* power-supply monitors)
- off-line flyback regulator, II-481
- overvoltage protection circuit, II-496
- overvoltages in, comparator to detect, II-107
- power-switching circuit, II-466
- programmable, III-467
- protection circuit, II-497
- protection circuit, fast acting, I-518
- push-pull, 400V/60W, II-473
- radiation-hardened 125A linear regulator, II-468
- regulated, +15V 1-A, III-462
- regulated, -15V 1-A, III-463
- regulated, split, I-492
- SCR preregulator for, II-482
- single supply voltage regulator, II-471
- split, I-512
- stand-by, non-volatile CMOS RAMs, II-477
- switching, II-470, III-458
- switching, 50-W off-line, III-473
- switching, variable, 100-KHz multiple-output, III-488
- three-rail, III-466
- uninterruptible, +5V, III-477
- uninterruptible, personal computer, II-462
- variable (*see* variable power supplies)
- voltage regulator, II-484
- power-consumption limiters, III-572
- power-control circuits, IV-383-389
 - ac switch, battery-triggered, IV-387
 - bang-bang controllers, IV-389
 - current-loop control, SCR design, IV-387
 - high-side switches, 5 V supplies, IV-384, IV-385
 - monitor, SCR design, IV-385
 - MOSFET switch, IV-386
 - overvoltage protector, IV-389
 - power controller, universal design, IV-388
 - pushbutton switch, IV-388
- power-down protection
 - alarm, III-511
 - memory save power supply for, II-486
 - protection circuit, II-98
- power-line connections monitor, ac, III-510
- power-line modem, III-82
- power-on reset, II-366
- power-supply monitors, II-491-497, III-493-495, IV-422-427
 - backup supply, drop-in main-activated, IV-424
 - balance monitor, III-494
 - booster/buffer, boosts reference current, IV-425
 - circuit breaker, trip circuit, IV-423
 - fault monitor, single-supply, III-495
 - memory protector/supply monitor, IV-425
 - polarity-protection relay, IV-427
 - test load, constant-current, IV-424
 - triac for ac-voltage control, IV-426
 - tube amplifier, high-voltage isolation, IV-426
 - voltage sensor, IV-423
- power-switching circuit, II-466
 - complementary ac, I-379
- power/frequency meter, II-250
- preamplifiers, I-41
 - 6-meter, 20 dB gain and low NF, II-543
 - 1000x, low-noise design, IV-37
 - audio amplifier, 2- to 6-watt, II-451
 - audio amplifier, 6-W and, III-454
 - equalized, for magnetic phono cartridges, III-671
 - frequency counter, III-128
 - general purpose, I-84
 - general-purpose design, audio signal amplifiers, IV-42
 - handitalkies, two-meter, I-19
 - IF, 30 MHz, IV-460
 - impedance-matching, IV-37
 - LM382 phono, I-91
 - low-noise, IV-41
 - low-noise 30MHz, I-561
 - low-noise transformerless balanced microphone, I-88
 - magnetic phono, I-91, III-673, IV-35
 - medical instrument, II-349
 - microphone, II-45, IV-37, IV-42
 - microphone, low-impedance, IV-41
 - microphone, tone control for, II-687
 - microphone, transformerless, unbalanced input, I-88
 - microwave, 2.3 GHz, IV-316
 - microwave, 3.4 GHz, IV-316
 - microwave, bias supply, IV-318
 - microwave, single-stage, 10 GHz, IV-317
 - microwave, two-stage, 10 GHz, IV-319
- NAB, tape playback, professional, III-38
- NAB, record, III-673
- NAB, two-pole, III-673
- oscilloscope, III-437
- oscilloscope, instrumentation amplifiers, IV-230-231
- oscilloscope/counter, III-438
- phono, I-91
- phono, low-noise, IV-36
- phono, magnetic, ultra-low-noise, IV-36
- phono, magnetic, III-37
- read-head, automotive circuits, III-44
- RIAA, III-38
- RIAA/NAB compensation, I-92
- stereo, II-43, II-45
- tape, I-90
- thermocouple instrumentation amplifier, III-283
- tone control, I-675
- tone control, high-level, II-688
- tone control, IC, I-673, III-657
- tone control, mixer, I-58
- UHF-TV, III-546
- ultra-low leakage, I-38, II-7
- VHF, I-560
- precision amplifier, I-40
 - digitally programmable input and gain, II-335
- preregulators
 - high-voltage power supplies, III-480
 - tracking, III-492
- prescaler, data circuits, low-frequency, IV-132
- prescaler probe, amplifying, 650 MHz, II-502
- preselectors
 - rf amplifiers, JFET, IV-485
 - rf amplifiers, JFET, double-tuned, IV-483
 - rf amplifiers, varactor-tuned, IV-488
- printer-error alarm, computer circuits, IV-106
- printers
 - printer-error alarm, IV-106
 - two-sheets in printer detector, IV-136
- probes, II-498-504, III-496-503, IV-428-434
 - 100 K megaohm dc, I-524
 - ac hot wire, I-581
 - audible TTL, I-524
 - audio-rf signal tracer, I-527
 - capacitance buffer, low-input, III-498
 - capacitance buffer, stabilized low-input, III-502

- probes (*cont.*)
- clamp-on-current compensator, II-501
 - CMOS logic, I-523
 - FET, III-501
 - general purpose rf detector, II-500
 - ground-noise, battery-powered, III-500
 - logic probes (*see* logic probes)
 - microvolt, II-499
 - optical light probe, IV-369
 - pH, I-399, III-501
 - prescaler, 650 MHz amplifying, II-502
 - rf, I-523, III-498, III-502, IV-433
 - single injector-tracer, II-500
 - test, 4-220V, III-499
 - three-in-one test set: logic probe, signal tracer, injector, IV-429
 - tone, digital IC testing, II-504
 - universal test probe, IV-431
 - process control interface, I-30
 - processor, CW signal, I-18
 - product detector, I-223
 - programmable amplifiers, II-334, III-504-508
 - differential-input, programmable gain, III-507
 - inverting, programmable-gain, III-505
 - noninverting, programmable-gain, III-505
 - precision, digital control, III-506
 - precision, digitally programmable, III-506
 - programmable-gain, selectable input, I-32
 - variable-gain, wide-range digital control, III-506
 - projectors (*see* photography-related circuits)
 - proportional temperature controller, III-626
 - protection circuits, II-95-99, III-509-513
 - 12ns circuit breaker, II-97
 - automatic power down, II-98
 - circuit breaker, ac, III-512
 - circuit breaker, electronic, high-speed, II-96
 - compressor protector, IV-351
 - crowbars, electronic, II-99, III-510
 - heater protector, servo-sensed, III-624
 - line protectors, computer I/O, 3 uP, IV-101
 - line dropout detector, II-98
 - line-voltage monitor, III-511
 - low-voltage power disconnecter, II-97
 - overvoltage, II-96, IV-389
 - overvoltage, fast, III-513
 - overvoltage, logic, I-517
 - polarity-protection relay for power supplies, IV-427
 - power-down, II-98
 - power-failure alarm, III-511
 - power-line connections monitor, ac, III-510
 - power supply, II-497, I-518
 - reset-protection for computers, IV-100
 - proximity sensors, I-135-136, I-344, II-505-507, III-514-518, IV-341-346
 - alarm for, II-506
 - capacitive, III-515
 - field disturbance sensor/alarm, II-507
 - infrared-reflection switch, IV-345
 - relay-output, IV-345
 - SCR alarm, III-517
 - self-biased, changing field, I-135
 - switch, III-517
 - UHF movement detector, III-516
 - pseudorandom sequencer, III-301
 - pulse circuits, IV-435-440
 - amplitude discriminator, III-356
 - coincidence detector, II-178
 - counter, ring counter, low-power, IV-437
 - delay, dual-edge trigger, III-147
 - detector, missing-pulse, III-159
 - divider, non-integer programmable, III-226, II-511
 - extractor, square-wave, III-584
 - generator, 555-circuit, IV-439
 - generator, delayed-pulse generator, IV-440
 - generator, free-running, IV-438
 - generator, logic troubleshooting applications, IV-436
 - generator, transistorized design, IV-437
 - height-to-width converters, III-119
 - oscillator, fast, low duty-cycle, IV-439
 - oscillator, start-stop, stable design, IV-438
 - pulse train-to-sinusoid converters, III-122
 - sequence detector, II-172
 - stretcher, IV-440
 - stretcher, negative pulse stretcher, IV-436
 - stretcher, positive pulse stretcher, IV-438
 - pulse generators, II-508-511
 - 2-ohm, III-231
 - 300-V, III-521
 - astable multivibrator, II-510
 - clock, 60Hz, II-102
 - CMOS short-pulse, III-523
 - delayed, II-509
 - EEPROM, 5V-powered, III-99
 - interrupting pulse-generation, I-357
 - logic, III-520
 - programmable, I-529
 - sawtooth-wave generator and, III-241
 - single, II-175
 - two-phase pulse, I-532
 - unijunction transistor design, I-530
 - very low duty-cycle, III-521
 - voltage-controller and, III-524
 - wide-ranging, III-522
 - pulse supply, high-voltage power supplies, IV-412
 - pulse-dialing telephone, III-610
 - pulse-position modulator, III-375
 - pulse-width-to-voltage converters, III-117
 - pulse-width modulators (PWM), IV-326
 - brightness controller, III-307
 - control, microprocessor selected, II-116
 - modulator, III-376
 - motor speed control, II-376, III-389
 - multiplier circuit, II-264, III-214
 - out-of-bounds detector, III-158
 - proportional-controller circuit, II-21
 - servo amplifier, III-379
 - speed control/energy-recovering brake, III-380
 - very short, measurement circuit, III-336
 - pulse/tone dialer, single-chip, III-603
 - pulsers, laser diode, III-311
 - pump circuits
 - controller, single chip, II-247
 - positive input/negative output charge, I-418
 - push switch, on/off, electronic, II-359
 - push-pull power supply, 400V/60W, II-473
 - pushbutton power control switch, IV-388
 - PUT battery chargers, III-54
 - PUT long-duration timer, II-675
 - pyrometer, optical, I-654
- ## Q
- Q-multipliers
 - audio, II-20
 - transistorized, I-566
 - QRP CW transmitter, III-690
 - QRP SWR bridge, III-336
 - quad op amp, simultaneous waveform generator using, II-259
 - quadrature oscillators, III-428
 - square-wave generator, III-585
 - quartz crystal oscillator, two-gate, III-136

quick-deactivating battery sensor, III-61

R

- race-car motor/crash sound generator, III-578
 - radar detectors, II-518-520, IV-441-442
 - one-chip, II-519
 - radiation detectors, II-512-517
 - alarm, II-4
 - micropower, II-513
 - monitor, wideband, I-535
 - photomultiplier output-gating circuit, II-516
 - pocket-sized Geiger counter, II-514
 - radiation-hardened 125A linear regulator, II-468
 - radio
 - AM car-radio to short-wave radio converter, IV-500
 - AM demodulator, II-160
 - AM radio, power amplifier, I-77
 - AM radio, receivers, III-81, III-529, III-535
 - AM/FM, clock radio, I-543
 - AM/FM, squelch circuit, II-547, III-1
 - amateur radio, III-260, III-534, III-675
 - automotive, receiver for, II-525
 - clock, I-542
 - direction finder, radio signals, IV-148-149
 - FM (*see* FM transmissions)
 - portable-radio 3 V fixed power supplies, IV-397
 - radio beacon converter, IV-495
 - receiver, AM radio, IV-455
 - receiver, old-time design, IV-453
 - receiver, reflex radio receiver, IV-452
 - receiver, short-wave receiver, IV-454
 - receiver, TRF radio receiver, IV-452
 - radio beacon converter, IV-495
 - radio-control circuits
 - audio oscillator, II-567, III-555
 - motor speed controller, I-576
 - phase sequence reversal by, II-438
 - oscillator, emitter-coupled, II-266
 - receiver/decoder, I-574
 - single-SCR design, II-361
 - radioactivity (*see* radiation detectors)
 - rain warning beeper, II-244, IV-189
 - RAM, non-volatile CMOS, stand-by power supply, II-477
 - ramp generators, I-540, II-521-523, III-525-527, IV-443-447
 - accurate, III-526
 - integrator, initial condition reset, III-527
 - linear, II-270
 - variable reset level, II-267
 - voltage-controlled, II-523
 - ranging system, ultrasonic, III-697
 - reaction timer, IV-204
 - read-head pre-amplifier, automotive circuits, III-44
 - readback system, disc/tape phase modulated, I-89
 - readout, rf current, I-22
 - receiver audio circuit, IV-31
 - receivers and receiving circuits (*see also* transceivers; transmitters), II-524-526, III-528-535, IV-448-461
 - 50kHz FM optical transmitter, I-361
 - acoustic-sound receiver, IV-311
 - AGC system for CA3028 IF amplifier, IV-458
 - AM, III-529, IV-455
 - AM, carrier-current circuit, III-81
 - AM, integrated, III-535
 - analog, I-545
 - ATV rf receiver/converter, 420 MHz, low-noise, IV-496, IV-497
 - car radio, capacitive diode tuning/ electronic MW/LW switching, II-525
 - carrier current, I-143, I-146
 - carrier current, single transistor, I-145
 - carrier system, I-141
 - carrier-operated relay (COR), IV-461
 - CMOS line, I-546
 - data receiver/message demuxer, three-wire design, IV-130
 - fiber optic, 10 MHz, II-205
 - fiber optic, 50-Mb/s, III-181
 - fiber optic, digital, III-178
 - fiber optic, high-sensitivity, 30nW, I-270
 - fiber optic, low-cost, 100-M baud rate, III-180
 - fiber optic, low-sensitivity, 300nW, I-271
 - fiber optic, very high-sensitivity, low speed 3nW, I-269
 - FM, carrier-current circuit, III-80
 - FM, MPX/SCA, III-530
 - FM, narrow-band, III-532
 - FM, tuner, III-529
 - FM, zero center indicator, I-338
 - FSK data, III-533
 - ham-band, III-534
 - IF amplifier, IV-459
 - IF amplifier, preamp, 30 MHz, IV-460
 - IF amplifier/receiver, IV-459
 - infrared, I-342, II-292, III-274, IV-220-221
 - laser, IV-368
 - LF receiver, IV-451
 - line-type, digital data, III-534
 - line-type, low-cost, III-532
 - monitor for, II-526
 - optical, I-364, II-418
 - optical light receiver, IV-367, IV-368
 - PLL/BC, II-526
 - pulse-frequency modulated, IV-453
 - radio control, decoder and, I-574
 - radio receiver, AM, IV-455
 - radio receiver, old-time design, IV-453
 - radio receiver, reflex, IV-452
 - radio receiver, TRF, IV-452
 - regenerative receiver, one-transistor design, IV-449
 - RS-232 to CMOS, III-102
 - short-wave receiver, IV-454
 - signal-reception alarm, III-270
 - superheterodyne receiver, 3.5-to-10 MHz, IV-450-451
 - tracer, III-357
 - transceiver/mixer, HF, IV-457
 - ultrasonic, III-698, III-705
 - zero center indicator for FM, I-338
- recording amplifier, I-90
 - recording devices (*see* tape-recorder circuits)
 - rectangular-to-triangular waveform converter, IV-116-117
 - rectifiers, II-527-528, III-536-537
 - absolute value, ideal full wave, II-528
 - averaging filter, I-229
 - bridge rectifier, fixed power supplies, IV-398
 - broadband ac active, IV-271
 - diodeless, precision, III-537
 - full-wave, I-234, III-537, IV-328, IV-650
 - half-wave, I-230, II-528, IV-325
 - half-wave, fast, I-228
 - high-impedance precision, for ac/dc converter, I-164
 - inverter/rectifier, programmable op-amp design, IV-364
 - low forward-drop, III-471
 - precision, I-422
 - synchronous, phase detector-selector/balanced modulator, III-441
 - redial, electronic telephone set with, III-606
 - reference voltages, I-695, III-773-775
 - $\pm 10V$, I-696
 - $\pm 3V$, I-696
 - $\pm 5V$, I-696
 - 0- to 20 V power, I-694, I-699
 - amplifier, I-36
 - bipolar output, precision, I-698

- reference voltages (*cont.*)
 - dual tracking voltage, precision, I-698
 - high-stability, I-696
 - low-noise buffered, precision, I-698
 - low-power regulator, I-695
 - micropower 10 V, precision, I-697
 - square wave voltage, precision, I-696
 - standard cell replacement, precision, I-699
 - variable-voltage reference source, IV-327
- reference clock, three phase clock
 - from, II-101
- reference supply, low-voltage adjustable, I-695
- reflection oscillator, crystal-controlled, III-136
- reflectometer, I-16
- regenerative receiver, one-transistor design, IV-449
- registers, shift, I-380, II-366
 - driver, I-418
- regulated power supplies
 - 8-amp, II-461
 - 12 to 14V at 3 A, II-480
 - +15V 1-A, III-462
 - 15V 1-A, III-463
 - split power supplies, I-492
- regulators (*see* voltage regulators)
- rejection filter, I-283
- relaxation oscillator, III-430, IV-376
- relays, II-529-532, IV-471-475
 - ac, optically coupled, III-418
 - ac, photon coupler in, II-412
 - ac, solid-state latching, IV-472
 - audio operated, I-608
 - bidirectional switch, IV-472
 - capacitance, I-130
 - carrier operated, I-575
 - carrier-operated relay (COR), IV-461
 - dc latching, optically coupled, III-417
 - delay-off circuit, IV-473
 - driver, delay and controls closure time, II-530
 - light-beam operated on/off, I-366
 - monostable relay, low-consumption design, IV-473
 - optically coupled, ac, III-418
 - optically coupled, dc latching, III-417
 - optoisolator, IV-475
 - polarity-protection for power supplies, IV-427
 - rf-actuated, II-270
 - ringer, telephone, III-606
 - solid-state, III-569-570, IV-474
 - solid-state, 10 A 25 Vdc, I-623
 - solid-state, ac, III-570
 - solid-state, ac, latching, IV-472
- solid-state, dc, normally open/closed, III-412
- solid-state, integrated, II-408
- solid-state, light-isolated, I-365
- solid-state, ZVS, antiparallel SCR output, III-416
- sound actuated, I-576, I-610
- telephone, I-631
 - time delayed, I-663
 - time delayed, ultra-precise, I-219
 - tone actuated, I-576
 - TR circuit, II-532
 - triac, contact protection, II-531
- remote control devices
 - amplifier, I-99
 - carrier, current, I-146
 - drop-voltage recovery for long-line systems, IV-328
 - extender, infrared, IV-227
 - fax/telephone switch, IV-552-553
 - infrared circuit, IV-224
 - lamp or appliance, I-370
 - loudspeaker via IR link, I-343
 - on/off switch, I-577
 - ringer, telephone, III-614
 - sensor, temperature transducer, I-649
 - servo system, I-575
 - telephone monitor, II-626
 - temperature sensor, II-654
 - tester, infrared, IV-228
 - thermometer, II-659
 - transmitter/receiver, IR, I-342
 - video switch, IV-619-621
- repeaters
 - European-type, tone burst generator for, III-74
 - fiber optic link, I-270
 - telephone, III-607
- repeater beeper, I-19
- reset buttons
 - child-proof computer reset, IV-107
 - power-on, II-366
 - protection circuit for computer, IV-100
- resistance/continuity meters, II-533, III-538-540
 - cable tester, III-539
 - continuity tester, III-540
 - ohmmeter, linear, III-540
 - resistance-ratio detector, II-342
 - single chip checker, II-534
- resistance measurement, low parts count ratiometric, I-550
- resistance-to-voltage converter, I-161-162
- resistor multiplier, II-199
- resonator oscillator, varactor tuned 10 MHz ceramic, II-141
- restorer, video dc, III-723
- reverb effect, analog delay line, IV-21
- reverb system, stereo, I-602, I-606
- reversing motor drive, dc control signal, II-381
- rf amplifiers, II-537-549, III-542-547, IV-476-493
 - 1 W, 2.3 GHz, II-540
 - 10 W, 225-400 MHz, II-548
 - 10 dB-gain, III-543
 - 2- to 30 MHz, III-544
 - 4 W amp for 900 MHz, IV-477
 - 5 W 150-MHz, III-546
 - 5 W power, II-542
 - 6-meter kilowatt, II-545
 - 6-meter preamp, 20dB gain and low NF, II-543
 - 60 W 225-400 MHz, III-547
 - 125 W, 150 MHz, II-544
 - 500 MHz, IV-491
 - 1,296 MHz, IV-486
 - 1,500 W, IV-478-479
 - AGC, wideband adjustable, III-545
 - broadcast-band, III-264, II-546
 - broadcast-band booster, IV-487
 - buffer amplifier with modulator, IV-490
 - cascode amplifier, IV-488
 - common-gate, 450-MHz, III-544
 - isolation amplifier, II-547
 - linear amplifier, 903 MHz, IV-484-485
 - linear amplifier, 6-m, 100 W, IV-480-481
 - linear amplifier, ATV, 10-to-15 W, IV-481
 - low distortion 1.6 to 30MHz SSB driver, II-538
 - meter-driver, 1-MHz, III-545
 - MOSFET rf-amp stage, dual-gate, IV-489
 - power, 600 W, I-559
 - power amp, 1296-MHz solid-state, III-542
 - preselector, JFET, IV-485
 - preselector, JFET, double-tuned, IV-483
 - preselector, varactor-tuned, IV-488
 - UHF-TV preamp, III-546
 - UHF TV-line amplifier, IV-482, IV-483
 - wideband amplifier, IV-479, IV-489, IV-490
 - wideband amplifier, HF, IV-492
 - wideband amplifier, JFET, IV-493
 - wideband amplifier, MOSFET, IV-492
 - wideband amplifier, two-CA3100 op

- amp design, IV-491
 - rf circuits
 - attenuator, IV-322
 - burst generators, portable, III-73
 - converters, IV-494-501
 - converters, ATV receiver/converter, 420 MHz, low-noise, IV-496, IV-497
 - converters, radio beacon converter, IV-495
 - converters, receiver frequency-converter stage, IV-499
 - converters, SW converter for AM car radio, IV-500
 - converters, two-meter, IV-498
 - converters, up-converter, TVRO subcarrier reception, IV-501
 - converters, VLF converter, IV-497
 - converters, WWV-to-SW converter, IV-499
 - converters, receiving converter, 220 MHz, IV-500
 - current readout, I-22
 - detector, II-500
 - detector probe, IV-433
 - genie, II-421
 - measurement/test circuits, IV-297-303
 - modulators, I-436, III-372, III-374
 - modulators, double sideband suppressed carrier, II-369
 - oscillators, I-550-551, I-572
 - oscillators, 5 MHz VFO, II-551
 - oscillators, transmitter and, 27MHz and 49MHz, I-680
 - output indicator, IV-299
 - power meter, I-16
 - power meter, sidetone oscillator, I-24
 - power meter, switch, III-592
 - power meter, wide-range, III-332
 - probe, I-523, III-498, III-502
 - signal tracer probe, audio, I-527
 - sniffer, II-210
 - switch, low-cost, III-361
 - VHF/UHF diode switch, IV-544
 - voltmeter, I-405, III-766
 - RGB video amplifier, III-709
 - RGB-composite video signal converter, III-714
 - RGB-to-NTSC converter, IV-611
 - ring counters
 - 20 kHz, II-135
 - incandescent lamps, I-301
 - low cost, I-301
 - pulse circuit, low-power, IV-437
 - SCR, III-195
 - variable timing, II-134
 - ring detectors
 - low line loading, I-634
 - telephone, II-623, III-619
 - telephone, auto-answer, I-635
 - telephone, optically interfaced, III-611
 - ring-around flasher, LED, III-194
 - ringers, telephone, I-628, IV-556
 - extension-phone ringer, IV-561
 - high isolation, II-625
 - multi-tone, remote programmable, II-634
 - musical, II-619
 - piezoelectric, I-636
 - plug-in, remote, II-627
 - relay, III-606
 - remote, II-627, III-614, IV-562
 - silencer, IV-557
 - tone, I-627, I-628, II-630, II-631
 - ripple suppressor, IV-175
 - fixed power supplies, IV-396
 - RLC oscillator, III-423
 - rms-to-dc converter, I-167, II-129
 - thermal, 50-MHz, III-117
 - road ice alarm, II-57
 - robots
 - eyes for, II-327
 - light-seeking, II-325
 - rocket launcher, II-358
 - rotation detector, II-283
 - roulette, electronic, II-276, IV-205
 - RS-232 interface
 - CMOS-to, line receiver, III-102
 - datasector, automatic, III-97
 - drive circuit, low-power, III-175
 - LED circuit, III-103
 - line-driven CMOS circuits, IV-104
 - RS flip-flop, I-395
 - RTD signal conditioners
 - 5V powered linearized platinum, II-650
 - precision, linearized platinum, II-639
 - RTTY machines, fixed current supply, IV-400
 - rumble filters, I-297, III-192, III-660, IV-170, IV-175
- S**
- S meter, III-342
 - safe area protection, power amplifier with, III-459
 - safety flare, II-608
 - Sallen-Key filters
 - 500 Hz bandpass, I-291
 - low-pass, active, IV-177
 - low-pass, equal component, I-292
 - low-pass, second order, I-289
 - sample-and-hold circuits, I-590, II-552-559, III-548-553, IV-502-503
 - x 1000, I-589
 - charge-compensated, II-559
 - fast and precise, II-556
 - filtered, III-550
 - frequency-to-voltage conversion, IV-194
 - high-accuracy, I-590
 - high-performance, II-557
 - high-speed amplifier, I-587
 - high-speed, I-587-588, I-590, III-550
 - infinite, II-558
 - inverting, III-552
 - JFET, I-586
 - low-drift, I-586
 - offset adjustment for, I-588
 - three-channel multiplexer with, III-396
 - track-and-hold, III-552
 - track-and-hold, basic, III-549
 - sampling circuit, hour time delay, II-668
 - saturated standard cell amplifier, II-296
 - sawtooth waves
 - converter, IV-114
 - generator, digital design, IV-444, IV-446
 - oscillator modulator, III-373
 - pulse generator and, III-241
 - SCA decoder, I-214, II-166, II-170
 - SCA demodulator, II-150, III-565
 - scale, digital weight, I-398
 - scalar, inverse, I-422
 - scanner, bar codes, III-363
 - Schmitt triggers, I-593, III-153
 - crystal oscillator, I-181
 - programmable hysteresis, I-592
 - TTL-compatible, II-111
 - without hysteresis, I-592
 - SCR circuits
 - annunciator, self-interrupting load, IV-9
 - chaser, III-197
 - crowbar, II-496
 - flasher, III-197
 - flip-flop, II-367
 - gas/smoke detector, III-251
 - preregulator, II-482
 - proximity alarm, III-517
 - radio control using, II-361
 - relaxation flasher, II-230
 - relaxation oscillator, III-430
 - ring counter, III-195
 - tester, III-344
 - time delay circuit with, II-670
 - triggering series, optically coupled, III-411
 - scramblers, audio (*see also* sound generators; voice-activated circuits), IV-25-27

- scramblers, audio (*cont.*)
 - telephone, II-618
 - voice scrambler/descrambler, IV-26
 - voice scrambler/disguiser, IV-27
- scratch filters, III-189, IV-175
 - LM287 in, I-297
- second-audio program adapter, III-142
- security circuits, I-4, III-3-9
 - automotive security system, I-5, IV-49-56
 - home system, I-6, IV-87
 - infrared, wireless, IV-222-223
- sense-of-slope tilt meter, II-664
- sensors (*see also* alarms; control circuits; detectors; indicators; monitors)
 - 0-50 C, four-channel temperature, I-648
 - air-flow sensor, thermistor bridge, IV-82
 - ambient light ignoring optical, III-413
 - capacitive, alarm for, III-515
 - cryogenic fluid level, I-386
 - differential temperature, I-655
 - humidity, II-285-287, III-266-267
 - IC temperature, I-649
 - isolated temperature, I-651
 - light level, I-367
 - light, back-biased GaAs LED, II-321
 - logarithmic light, I-366
 - magnetic current, low-power, III-341
 - motion, IV-341-346
 - motion, unidirectional, II-346
 - nanoampere, 100 megohm input impedance, I-203
 - optical interruption sensor, IV-366
 - photodiode amplifier for, II-324
 - precision temperature transducer with remote, I-649
 - proximity, II-505, III-514-518, IV-341-346
 - remote, loop transmitter for, III-70
 - remote temperature, I-654
 - self-biased proximity, detected changing field, I-135
 - short-circuit sensor, computer remote data lines, IV-102
 - simple differential temperature, I-654
 - temperature (*see also* temperature sensor), II-645, I-648, I-657
 - temperature, III-629-631, III-629
 - voltage regulators, LM317 design, IV-466
 - voltage sensor, power supplies, IV-423
 - voltage-level, III-770
 - water level, I-389
 - zero crossing detector with temperature, I-733
- sequence indicator, phase, I-476
- sequencer, pseudorandom, III-301
- sequential flasher, II-233
 - ac, II-238
 - automotive turn signals, I-109
- sequential timer, III-651
- series connectors, telephone, III-609
- servo amplifiers
 - 400 Hz, II-386
 - bridge type ac, I-458
 - dc, I-457
- servo motor drive amplifier, II-384
- servo systems
 - controller, III-384
 - remote control, I-575
- shaper, sine wave, II-561
- shift registers, I-380, II-366
 - driver for, I-418
- shifter, phase (*see* phase shifter)
- ship siren, electronic, II-576
- short-circuit proof lamp driver, II-310
- shortwave transmissions
 - converters, III-114
 - converter, AM car radio, IV-500
 - FET booster, I-561
 - receiver, IV-454
- short-circuit sensor, computer remote data lines, IV-102
- shunt, multimeter shunt, IV-293
- shutoff, automatic, battery-powered projects, III-61
- shutter speed tester, II-445
- sidetone oscillator, rf-powered, I-24
- signal amplifiers, audio, IV-34-42
- signal attenuator, analog, microprocessor-controlled, III-101
- signal combiner, III-368
- signal conditioners, IV-649
 - 5V powered linearized platinum RTD, II-650
 - bridge circuit, strain gauge, II-85
 - linearized RTD, precision design, II-639
 - LVDT, II-338
 - thermally stabilized PIN photodiode, II-330
- signal distribution amplifier, I-39
- signal generators (*see also* function generators; sound generators; waveform generators)
 - AM broadcast-band, IV-302
 - AM/IF, 455 kHz, IV-301
 - high-frequency, II-150
 - square-wave, III-583-585
 - staircase, III-586-588
 - two-function, III-234
- signal injectors, III-554-555
- signal sources, crystal-controlled, II-143
- signal tracer, three-in-one set: logic probe, signal tracer, injector, IV-429
- signal-strength meters, III-342, IV-166
- signal-supply, voltage-follower amplifiers, III-20
- simulated inductor, II-199
- simulators
 - EKG, three-chip, III-350
 - VOR signals, IV-273
- sine-to-square wave converter, IV-120
- sine-wave descrambler, II-163
- sine-wave generators, square-wave and, tunable oscillator, III-232
- sine-wave oscillators, I-65, II-560-570, III-556-559, III-560, IV-504-513
 - 555 used as RC audio oscillator, II-567
 - adjustable, II-568
 - audio, II-562
 - audio, generator, III-559
 - audio, simple generator for, II-564
 - generator, IV-505
 - generator, LC sine-wave, IV-507
 - generator, LF, IV-512
 - generator, pure sine-wave, IV-506
 - generator, VLF audio tone, IV-508
 - generators, 60 Hz, IV-507
 - LC oscillator, low-frequency, IV-509
 - low distortion, II-561
 - one-IC audio generator, II-569
 - phase-shift, audio ranging, IV-510
 - programmable-frequency, III-424
 - relaxation, modified UJT for clean audio sinusoids, II-566
 - sine wave shaper, II-561
 - sine/square wave TTL oscillator, IV-512
 - two-tone generator, II-570
 - two-transistor design, IV-508
 - variable, super low-distortion, III-558
 - very-low distortion design, IV-509
 - Wien bridge, I-66, I-70, II-566, IV-511
 - Wien bridge, CMOS chip in, II-568
 - Wien-bridge, low-distortion, thermal stable, III-557
 - Wien-bridge, single-supply, III-558
 - Wien-bridge, three-decade 15 Hz to 15 kHz, IV-510
 - Wien-bridge, very-low distortion, IV-513
- sine-wave output buffer amplifier, I-126
- sine-wave to square-wave converter, I-170
- sine/cosine generator, 0.1 to 10 kHz, II-260
- sine/square wave oscillators, I-65
 - easily tuned, I-65
 - TTL design, IV-512

tunable, III-232

single-pulse generator, II-175

single-sideband (SSB) communications
 CW/SSB product detector, IV-139
 driver, low distortion 1.6 to 30MHz,
 II-538
 generators, IV-323
 transmitter, crystal-controlled LO for,
 II-142

sirens (*see also* alarms; sound genera-
 tors), I-606, II-571, III-560-568
 alarm using, II-572, II-573, IV-514-
 517
 7400, II-575
 adjustable-rate programmable-fre-
 quency, III-563
 electronic, III-566, IV-515, IV-517
 generator for, II-572
 hee-haw, III-565, II-578
 high power, II-578
 linear IC, III-564
 low-cost design, IV-516
 multifunction system for, II-574
 ship, electronic, II-576
 sonic defender, IV-324
 Star Trek red alert, II-577
 tone generator, II-573
 toy, II-575
 TTL gates in, II-576
 two-state, III-567
 two-tone, III-562
 varying frequency warning alarm, II-
 579
 wailing, III-563
 warble-tone siren, 6 W, IV-516
 warble-tone siren, alternate tone, IV-
 515
 whooper, IV-517
 yelp oscillator, II-577, III-562

slave-flash trigger, IV-380, IV-382

slide timer, III-448

slide-show timer, III-444

sliding tone doorbell, II-34

smart clutch, auto air conditioner, III-
 46

smoke alarms and detectors, II-278,
 III-246-253
 gas, I-332
 ionization chamber, I-332-333
 line-operated, IV-140
 operated ionization type, I-596
 photoelectric, I-595, I-596

sniffers (*see also* detectors; monitors)
 heat, electronic, III-627
 rf, II-210

snooper, FM, III-680

socket debugger, coprocessor, III-104

soldering station, IR-controlled, IV-225

soil moisture meter, III-208

solar-powered battery charger, II-71

solar-triggered switch, III-318

solenoid drivers, III-571-573
 12-V latch, III-572
 hold-current limiter, III-573
 power-consumption limiter, III-572

solid-state devices
 ac relay, III-570
 electric fence charger, II-203
 high-voltage supply, remote adjusta-
 ble, III-486
 relays, III-569-570
 stepping switch, II-612
 switch, line-activated, telephone, III-
 617

sonic defender, IV-324

sound-activated circuits (*see* sound-
 operated circuits)

sound generators (*see also* burst gener-
 ators; function generators; sirens;
 waveform generators), I-605, II-
 585-593, III-559-568, III-575, IV-
 15-24, IV-518-524
 amplifier, voltage-controlled, IV-20
 amplifier/compressor, low-distortion,
 IV-24
 allophone, III-733
 audio tone generator, VLF, IV-508
 autodrum, II-591
 bagpipes, electronic, III-561, IV-521
 beat-frequency, IV-371
 bird chirp, I-605, II-588, III-577
 bongos, II-587
 chime generator, II-604
 chime generator, single-chip design,
 IV-524
 chug-chug, III-576
 dial tone, I-629, III-609
 ditherizing circuit, digital audio use,
 IV-23
 doorbell, musical tones, IV-522
 doubler, audio-frequency doubler, IV-
 16-17
 echo and reverb, analog delay line,
 IV-21
 electronic, III-360
 envelope generator/modulator, II-601
 equalizer, IV-18
 fader, IV-17
 frequency-shift keyer, tone-generator
 test circuit, I-723
 funk box, II-593
 fuzz box, III-575
 guitar compressor, IV-519
 harmonic generator, I-24, IV-649
 high-frequency signal, III-150
 hold for telephone, II-623
 melody generator, single-chip design,
 IV-520

music maker circuit, IV-521

musical chimes, I-640

musical envelope, modulator, I-601,
 IV-22

noise generators, I-467, I-468, I-469,
 IV-308

octave-shifter for musical effects, IV-
 523

one-IC design, II-569

phasor sound generator, IV-523

pink noise, I-468

portable, I-625

race-car motor/crash, III-578

run-down clock for games, IV-205

sound effects, III-574-578

steam locomotive whistle, II-589, III-
 568

steam train/prop plane, II-592

stereo system, derived center-
 channel, IV-23

super, III-564

synthesizer, II-599

telephone call-tone generator, IV-562

telephone ringer, II-619

tone generator, burst, I-604

tone generator, portable design, I-
 625

Touchtone dial-tone, telephone, III-
 609

train chuffer, II-588

tremolo circuits, III-692-695, IV-589

twang-twang, II-592

two-tone, II-570

ultrasonic sound source, IV-605

unusual fuzz, II-590

warbling tone, II-573

white noise, IV-201

very-low frequency, I-64

vocal eliminator, IV-19

voice circuits, III-729-734

waa-waa circuit, II-590

white noise, IV-201

sound-level meters, III-346, IV-305,
 IV-307
 meter/monitor, telephone, III-614

sound-operated circuits (*see also* ultra-
 sonic circuits; voice-operated
 circuits), II-580-584, III-579-580,
 IV-525-528
 amplifier, gain-controlled, IV-528
 color organ, II-583, II-584
 decoder, III-145
 flash triggers, I-481, II-449, IV-382
 lights, I-609
 noise clipper, I-396
 relay, I-608, I-610
 switch, II-581, III-580, III-600, III-
 601, IV-526-527
 switch, ac, II-581

- sound-operated circuits (*cont.*)
 - switch, two-way, I-610
 - switch, voice-operated, III-580
 - switch, voice-activated, microphone-controlled, IV-527
 - speech activity detector, telephone, III-615
 - voice-operated switch, III-580
 - vox box, II-582
- sources (*see* current sources; voltage sources)
- source follower, photodiode, III-419
- SPDT switch, ac-static, II-612
- space war, I-606
- speaker systems
 - FM carrier current remote, I-140
 - hand-held transceiver amplifiers, III-39
 - overload protector for, II-16
 - wireless, IR, III-272
- speakerphone, II-611, III-608
- speech-activity detector, II-617, III-619
- speech compressor, II-15
- speech filter
 - 300 Hz-3kHz bandpass, I-295
 - second-order, 300-to-3,400 Hz, IV-174
 - two-section, 300-to-3,000 Hz, IV-174
- speech network, II-633
- speed alarm, I-95
- speed controllers, I-450, I-453, II-378, II-379, II-455
 - back EMF PM, II-379
 - cassette-deck motor speed calibrator, IV-353
 - closed-loop, III-385
 - fans, automatic, III-382
 - dc motors, I-452, I-454, III-377, III-380
 - dc motor, direction control and, I-452
 - dc variable, fiber optic, II-206
 - feedback, I-447
 - fixed, III-387
 - high-efficiency, III-390
 - high-torque motor, I-449
 - light-activated/controlled, IV-247
 - load-dependent, I-451
 - model trains and/or cars, I-455, IV-338-340
 - motor, I-450, I-453
 - motor, dc, reversible, driver and, III-388
 - motor, high-efficiency, III-390
 - PWM, II-376
 - PWM, energy-recovering brake, III-380
 - radio-controlled, I-576
 - series-wound motors, I-448, II-456
 - shunt-wound motors, II-456
 - stepper motors, direction and speed control, IV-350
 - switched-mode, III-384
 - tachless, III-386
 - tachometer, II-378, II-389
 - tachometerless, IV-349
 - tools and appliances, I-446
 - universal motors, I-457
 - universal motors, load-dependent, II-451
- speed warning device, I-96, I-101
- speedometers, bicycle, IV-271, IV-282
- splitters, III-581-582
 - battery, III-66
 - phase, precision, III-582
 - precision phase, I-477
 - voltage, III-738, III-743
 - wideband, III-582
- squarer, precision, I-615
- square-wave generators, II-594-600, III-583-585, IV-529-536
 - 1 kHz, IV-536
 - 2 MHz using two TTL gates, II-598
 - 555 timer, II-595
 - astable circuit, IV-534
 - astable multivibrator, II-597
 - CMOS 555 astable, true rail-to-rail, II-596
 - duty-cycle multivibrator, III-50-percent, III-584
 - four-decade design, IV-535
 - high-current oscillator, III-585
 - line frequency, II-599
 - low-frequency TTL oscillator, II-595
 - multiburst generator, II-88
 - multivibrator, IV-536
 - oscillator, II-597, IV-532, IV-533
 - oscillator, with frequency doubled output, II-596
 - phase-tracking, three-phase, II-598
 - pulse extractor, III-584
 - quadrature-outputs oscillator, III-585
 - sine-wave, tunable oscillator, III-232
 - three-phase, II-600
 - tone-burst generator, single timer IC, II-89
 - triangle-wave, III-239
 - triangle-wave, precision, III-242
 - triangle-wave, programmable, III-225
 - triangle-wave, wide-range, III-242
 - TTL, LSTTL, CMOS designs, IV-530-532
 - variable duty-cycle, IV-533
 - variable-frequency, IV-535
- square-wave oscillators, I-613-614, II-597, II-616, IV-532, IV-533
 - 0.5 Hz, I-616
 - 1kHz, I-612
- square-to-sine wave converters, III-118
- squelch circuits, II-394
 - AM/FM, I-547
 - voice-activated circuits, IV-624
- squib firing circuits, II-357
- stabilizer
 - fixed power supplies, CMOS diode network, IV-406
 - fixed power supplies, output stabilizer, IV-393
- staircase generators, (*see also* waveform generators), II-601-602, III-586-588, IV-443-447
 - UA2240, III-587
- stand-by power supply, non-volatile CMOS RAMs, II-477
- standard, precision calibration, I-406
- standard-cell amplifier, saturated, II-296
- standing wave ratio (SWR)
 - meter, IV-269
 - power meter, I-16
 - QRP bridge, III-336
 - warning indicator, I-22
- Star Trek red alert siren, II-577
- start-and-run motor circuit, III-382
- state-of-charge indicator, lithium battery, II-78
- state-variable filters, II-215, III-189
 - multiple outputs, III-190
 - second-order, 1kHz, Q/10, I-293
 - universal, I-290
 - steam locomotive sound effects, II-589, II-592, III-568
- static detector, IV-276
- step-up switching regulator, 6V battery, II-78
- step-up/step-down dc-dc converters, III-118
- stepping motor driver, II-376, III-390
- stepping switch, solid state, II-612
- stereo circuits
 - amplifier, 12-V/20-W, IV-29
 - amplifier, Av/200, I-77
 - amplifier, bass tone control, I-670
 - audio-level meter, IV-310
 - audio-power meter, IV-306
 - balance circuit, II-603-605
 - balance meter, II-605, I-618-619
 - balance tester, II-604
 - decoder, frequency division multiplex, II-169
 - decoder, time division multiplex, II-18
 - decoder, TV-stereo, II-167
 - demodulator, II-159
 - demodulator, FM, I-544
 - derived center-channel system, IV-23
 - mixer, four-input, I-55
 - power meter, III-331

preamplifier, II-43, II-45
 reception indicator, III-269
 reverb systems, I-602, I-606
 reverb systems, gain control in, II-9
 TV-stereo decoder, II-167
 stimulator, constant-current, III-352
 stimulus isolator, III-351
 stop light, garage, II-53
 strain gauges
 bridge excitation, III-71
 bridge signal conditioner, II-85
 instrumentation amplifier, III-280
 strobe circuits, II-606-610
 disco-, II-610
 high-voltage power supplies, IV-413
 safety flare, II-608
 simple, II-607
 tone burst generator, II-90
 trip switch, sound activated, I-483
 variable strobe, III-589-590
 stud finder, III-339
 subharmonic frequencies, crystal-stabilized IC timer, II-151
 subtractor circuit, III-327
 successive-approximation A/D converter, II-24, II-30
 summing amplifiers, III-16
 precision design, I-36
 video, clamping circuit and, III-710
 sun tracker, III-318
 superheterodyne receiver, 3.5-to-10 MHz, IV-450-451
 supply rails, current sensing in, II-153
 suppressed-carrier, double-sideband, modulator, III-377
 sweep generators
 10.7 MHz, I-472
 add-on triggered, I-472
 oscilloscope-triggered, III-438
 switches and switching circuits, II-611-612, III-591-594, IV-537
 ac switch, battery-triggered, IV-387
 analog, buffered, DTL-TTL-controlled, I-621
 analog, differential, I-622
 analog, high-toggle/high-frequency, I-621
 analog, one MOSPOWER FET, III-593
 antenna selector, electronic, IV-538-539
 audio/video switcher circuit, IV-540-541
 auto-repeat switch, bounce-free, IV-545
 bidirectional relay switch, IV-472
 bistable switch, mechanically controlled, IV-545
 contact, I-136
 dc static, II-367
 debouncer, III-592
 debouncer, computer switches, IV-105
 debouncer, computer switches, auto-repeat, IV-106
 debouncer, computer switches, flip-flop, IV-108
 delay, auto courtesy light, III-42
 DTL-TTL controlled buffered analog, I-621
 fax/telephone switch, IV-552-553
 FET dual-trace (oscilloscope), II-432
 Hall-effect, III-257, IV-539
 high-frequency, I-622
 high-side power control switch, 5 V supply, IV-384, IV-385
 infrared-activated, IV-345
 latching, SCR-replacing, III-593
 light-operated, II-320, III-314
 light-operated, adjustable, I-362
 MOSFET power control switch, IV-386
 on/off inverter, III-594
 on/off switch, IV-543
 on/off switch, transistorized op-amp on/off switch, IV-546
 optically coupled, high-voltage ac, III-408
 optically coupled, zero-voltage, solid-state, III-410
 over-temperature switch, IV-571
 photocell memory, ac power control, I-363
 photoelectric, II-321
 photoelectric, ac power, II-326
 photoelectric, synchronous, II-326
 proximity, III-517
 push on/off, II-359
 pushbutton power control switch, IV-388
 remote, on/off, I-577
 remote, ring extender, I-630
 rf, low-cost, III-361
 rf, power switch, III-592
 satellite TV audio switcher, IV-543
 solar-triggered, III-318
 solid-state stepping, II-612
 sonar transducer/, III-703
 sound-activated, II-581, III-580, III-600, III-601, IV-526-527
 sound-activated, two-way, I-610
 speed, I-104
 SPDT, ac-static, II-612
 switching controller, III-383
 temperature control, low-power, zero-voltage, II-640
 tone switch, narrowband, IV-542
 touch switches (*see* touch switches)
 touchomatic, II-693
 triac, inductive load, IV-253
 triac, zero point, II-311
 triac, zero voltage, I-623
 two-channel, I-623
 ultrasonic, I-683
 under-temperature switch, IV-570
 VHF/UHF diode rf switch, IV-544
 video, IV-618-621
 video, automatic, III-727
 video, general purpose, III-725
 video, high-performance, III-728
 video, very-high off isolation, III-719
 voice-operated, I-608, III-580
 voice-operated, microphone-controlled, IV-527
 zero crossing, I-732
 zero point, I-373, II-311
 zero-voltage switching, closed contact half-wave, III-412
 zero-voltage switching, solid-state, optically coupled, III-410
 zero-voltage switching, triac design, I-623
 switched-mode power supplies, II-470, III-458
 50 W, off-line, III-473
 100 kHz, multiple-output, III-488
 converter, +50V push pull, I-494
 switched light, capacitance, I-132
 switching inverter, 500 kHz, 12 V systems, II-474
 switching power amplifier, I-33
 switching regulators
 3 A, III-472
 5 V, 6 A, 25 uHz, separate ultrastable reference, I-497
 6 A variable output, I-513
 200 kHz, I-491
 application circuit, 3W, I-492
 fixed power supplies, 3 A, IV-408
 high-current inductorless, III-476
 low-power, III-490
 multiple output MPU, I-513
 positive, I-498
 step-down, I-493
 step-up, 6V battery, II-78
 switching/mixing, silent audio, I-59
 sync separators
 single-supply wide-range, III-715
 video circuits, IV-616
 synthesizers
 four-channel, I-603
 frequency, programmable voltage-controlled, II-265
 music, I-599

T
 tachometers, I-100, I-102, II-175, III-335, III-340, III-595-598

tachometers (*cont.*)
 analog readout, IV-280
 calibrated, III-598
 closed-loop, feedback control, II-390
 digital, II-61, III-45, IV-268-269, IV-278
 frequency counter, I-310
 gasoline engine, I-94
 low-frequency, III-596
 minimum component, I-405
 motor speed control, II-378, II-389
 optical pick-up, III-347
 set point, III-47

tandem dimmer, II-312

tap, telephone, III-622

tape-recorder circuits, I-21, I-419, III-599-601, IV-547-548
 amplifier, I-90
 amplifier, playback mode, IV-36
 audio-powered controller, IV-548
 automatic tape-recording switch, I-21, II-21
 automotive-battery power circuit, IV-548
 cassette-deck motor speed calibrator, IV-353
 extended-play circuit, III-600
 flat-response amplifier, III-673
 interface for, II-614
 playback amplifier, III-672, IV-36
 position indicator/controller, II-615
 preamplifier, I-90
 sound-activated switch, III-600, III-601
 starter switch, telephone-activated, I-632
 telephone-activated starter switch, I-632, II-622, III-616
 telephone-to-cassette interface, III-618

telemetry demodulator, I-229

telephone-related circuits, II-616-635, III-602-622, IV-549-564
 amplifier, III-621, IV-560
 answering machine beeper, IV-559
 auto answer and ring indicator, I-635
 automatic recording device, II-622
 blinking phone light monitor, II-624, II-629
 call-tone generator, IV-562
 cassette interface, III-618
 decoder, touch-tone, IV-555
 dial pulse indicator, III-613
 dialed-phone number vocalizer, III-731
 dialer, pulse/tone, single-chip, III-603
 dual tone decoding, II-620
 duplex audio link, IV-554
 duplex line amplifier, III-616

eavesdropper, wireless, III-620

fax-machine switch, remote-controlled, IV-552-553

flasher, phone-message, IV-556

flasher, tell-a-bell, IV-558

flasher, visual ring indicator, IV-559, IV-561

frequency and volume controller, II-623

hands-free telephone, III-605

handset encoder, I-634, III-613

hold button, II-628, III-612

in-use indicator, II-629, IV-560, IV-563

intercom, IV-557

light for, II-625

line interface, autopatch, I-635

line monitor, I-628

message-taker, IV-563

musical hold, II-623

musical ringer, II-619

night light, telephone controlled, III-604

off-hook indicator, I-633

optoisolator status monitor, I-626

parallel connection, III-611

piezoelectric ringer, I-636

power switch, ac, IV-550

pulse-dialing, III-610

recording calls, I-632, III-616

recording calls, auto-record switch, IV-558

recording calls, telemonitor, IV-553

redial, III-606

relay, I-631

remote monitor for, II-626

repeater, III-607

repertory dialer, line powered, I-633

ring detector, II-623, III-619, IV-564

ring detector, optically interfaced, III-611

ringers, IV-556

ringers, extension-phone ringer, IV-561

ringers, high isolation, II-625

ringers, multi-tone, remote programmable, II-634

ringers, musical, II-619

ringers, piezoelectric, I-636

ringers, plug-in, remote, II-627

ringers, relay, III-606

ringers, remote, II-627, III-614, IV-562

ringers, tone, I-627, I-628, II-630, II-631

scrambler, II-618

series connection, III-609

silencer, IV-557

sound level meter monitor, III-614

speaker amplifier, IV-555

speakerphone, II-632, III-608

speech activity detector, II-617, III-615

speech network, II-633

status monitor using optoisolator, I-626

switch, solid-state, line-activated, III-617

tap, III-622

tape-recorder starter controlled by, I-632

toll-totalizer, IV-551

tone-dialing, III-607

tone ringers, I-627, I-628, II-630, II-631

Touchtone generator, III-609

touch-tone decoder, IV-555

vocalizer, dialed-phone number, III-731

television-related circuits (*see also* video circuits)
 amplifier, audio, III-39
 amplifier, IF detector, MC130/MC1352, I-688
 amplifier, IF/FM IF, quadrature, I-690
 amplifier, RF, UHF TV-line amplifier, IV-482, IV-483
 audio/video switcher circuit, IV-540-541
 automatic turn-off, I-577
 cross-hatch generator, III-724
 data interface, TTL oscillator, II-372
 decoder, stereo TV, II-167
 IF detector, amplifier, MC130/MC1352, I-688
 modulators, I-439, II-433, II-434
 preamplifier, UHF, III-546
 rf up-converter for TVRO subcarrier reception, IV-501
 satellite TV audio switcher, IV-543
 stereo-sound decoder, II-167
 transmitter, III-676
 transmitter, amateur TV, IV-599

temperature-related circuits (*see also* thermometers), IV-565-572
 alarms, II-4, II-643
 alarms, adjustable threshold, II-644
 automotive temperature indicator, II-56, IV-48
 automotive water-temperature gauge, IV-44
 Centigrade thermometer, II-648
 control circuits, I-641-643, II-636-644, III-623-628, IV-567
 control circuits, defrost cycle, IV-566
 control circuits, heater element, II-642

control circuits, heater protector, servo-sensed, III-624

control circuits, heat sniffer, electronic, III-627

control circuits, liquid-level monitor, II-643

control circuits, low-power, zero-voltage switch, II-640

control circuits, piezoelectric fan-based, III-627

control circuits, proportional, III-626

control circuits, signal conditioners, II-639

control circuits, single setpoint, I-641

control circuits, thermocoupled, IV-567

control circuits, zero-point switching, III-624

converters, temperature-to-frequency, I-646, I-168, I-656, II-651-653

converters, temperature-to-time, III-632-633

defrost cycle and control, IV-566

heater control, I-640, II-642, III-624

heat sniffer, III-627

hi/lo sensor, II-650

indicator, IV-570

indicator, automotive temperature, PTC thermistor, II-56

measuring circuit, digital, II-653

measuring sensor, transistorized, IV-572

meter, I-647

monitor, III-206

monitor, thermal monitor, IV-569

oscillators, crystal, temperature-compensated, I-187

oscillators, temperature-stable, II-427

over-temperature switch, IV-571

over/under sensor, dual output, II-646

remote sensors, I-649, I-654

sensors, I-648, I-657, II-645-650, III-629-631, IV-568-572

sensors, 0-50-degree C four channel, I-648

sensors, 0-63 degrees C, III-631

sensors, 5 V powered linearized platinum RTD signal conditioner, II-650

sensors, automotive-temperature indicator, PTC thermistor, II-56

sensors, Centigrade thermometer, II-648

sensors, coefficient resistor, positive, I-657

sensors, differential, I-654, I-655

sensors, over/under, dual output, II-646

sensors, DVM interface, II-647

sensors, hi/lo, II-650

sensors, integrated circuit, I-649

sensors, isolated, I-651, III-631

sensors, remote, I-654

sensors, thermal monitor, IV-569

sensors, thermocouple amplifier, cold junction compensation, II-649

sensors, thermocouple multiplex system, III-630

sensors, zero-crossing detector, I-733

signal conditioners, II-639

thermocouple amplifier, cold junction compensation, II-649

thermocouple control, IV-567

thermocouple multiplex system, III-630

transducer, temperature-to-frequency, linear, I-646

transducer, temperature-transducer with remote sensor, I-649

under-temperature switch, IV-570

zero-crossing detector, I-733

temperature-to-frequency converter, I-168, I-656, II-651-653

temperature-to-frequency transducer, linear, I-646

temperature-to-time converters, III-632-633

ten-band graphic equalizer, active filter, II-684

Tesla coils, III-634-636

test circuits (*see* measurement/test circuits)

text adder, composite-video signal, III-716

theremins, II-654-656

digital, II-656

electronic, II-655

thermal flowmeter, low-rate flow, III-203

thermocouple circuits

digital thermometer using, II-658

multiplex, temperature sensor system, III-630

pre-amp using, III-283

thermometer, centigrade calibrated, I-650

thermocouple amplifiers, I-654, II-14

cold junction compensation, II-649

high stability, I-355

thermometers, II-657-662, III-637-643, IV-573-577

0-50 degree F, I-656

0-100 degree C, I-656

adapter, III-642

add-on for DMM digital voltmeter, III-640

centigrade, I-655, II-648, II-662

centigrade, calibrated, I-650

centigrade, ground-referred, I-657

differential, I-652, II-661, III-638

digital, I-651, I-658

digital, temperature-reporting, III-638

digital, thermocouple, II-658

digital, uP controlled, I-650

electronic, II-660, III-639, IV-575, IV-576

Fahrenheit, I-658

Fahrenheit, ground-referred, I-656

high-accuracy design, IV-577

implantable/ingestible, III-641

kelvin, zero adjust, I-653, II-661

kelvin, ground-referred, I-655

linear, III-642, IV-574

low-power, I-655

meter, trimmed output, I-655

remote, II-659

single-dc supply, IV-575

variable offset, I-652

thermostats

electronic, remote ac, two-wire, I-639

electronic, three-wire, I-640

three-in-one test set, III-330

three-minute timer, III-654

three-rail power supply, III-466

threshold detectors, precision, III-157

tilt meter, II-663-666, III-644-646

differential capacitance measurement circuit, II-665

sense-of-slope, II-664

ultra-simple level, II-666

time base

crystal oscillator, III-133, IV-128

function generators, 1 Hz, for read-out and counter applications, IV-201

time delays, I-668, II-220, II-667-670, III-647-649

circuit, precision solid state, I-664

constant current charging, II-668

electronic, III-648

generator, I-218

hour sampling circuit, II-668

integrator to multiply 555 timers, low-cost, II-669

long-duration, I-220

relay, I-663

relay, ultra precise long, I-219

timing threshold and load driver, III-648

two-SCR design, II-670

time division multiplex stereo decoder, II-168

timers, I-666, I-668, II-671-681, III-650-655, IV-578-586
 0.1 to 90 second, I-663
 741 timer, I-667
 adjustable, IV-585
 adjustable ac .2 to 10 seconds, II-681
 alarm, II-674
 appliance-cutoff timer, IV-583
 CMOS, programmable precision, III-652
 circuit, II-675
 darkroom, I-480
 elapsed time/counter timer, II-680
 electronic egg, I-665
 IC, crystal-stabilized, II-151
 interval, programmable, II-678
 interval, programmable, thumbwheel, I-660
 long-delay, PUT, I-219
 long-duration, PUT, II-675
 long-duration, time delay, IV-585
 long-interval, programmable, IV-581, IV-582
 long-interval, RC, I-667
 long-term electronic, II-672
 long-time, III-653
 mains-powered, IV-579
 one-shot, III-654
 photographic, I-485
 photographic, darkroom enlarger, III-445
 photographic, photo-event timer, IV-379
 reaction timer, game circuit, IV-204
 SCR design, IV-583
 sequential, I-661-662, I-663, III-651
 sequential UJT, I-662
 slide-show, III-444
 slides, photographic, III-448
 solid-state, industrial applications, I-664
 ten-minute ID timer, IV-584
 three-minute, III-654
 thumbwheel-type, programmable interval, I-660
 time-out circuit, IV-586
 transmit-time limiter, IV-580
 triangle-wave generator, linear, III-222
 variable duty-cycle output, III-240
 voltage-controlled, programmable, III-676
 washer, I-668
 watchdog timer/alarm, IV-584
 timing light, ignition, II-60
 timing threshold and load driver, III-648
 tone alert decoder, I-213
 tone annunciator, transformerless, III-27-28
 tone burst generators, I-604, II-90
 European repeaters, III-74
 tone controls (*see also* sound generators), I-677, II-682-689, III-656-660, IV-587-589
 active bass and treble, with buffer, I-674
 active control, IV-588
 audio amplifier, II-686
 Baxandall tone-control audio amplifier, IV-588
 equalizer, ten-band octave, III-658
 equalizer, ten-band graphic, active filter, II-684
 guitar treble booster, II-683
 high-quality, I-675
 high-z input, hi fi, I-676
 microphone preamp, I-675, II-687
 mixer preamp, I-58
 passive circuit, II-689
 preamplifier, high-level, II-688
 preamplifier, IC, I-673, III-657
 preamplifier, microphone, I-675, II-687
 preamplifier, mixer, I-58
 rumble/scratch filter, III-660
 three-band active, I-676, III-658
 three-channel, I-672
 tremolo circuit, IV-589
 Wien-bridge filter, III-659
 tone decoders, I-231, III-143
 dual time constant, II-166
 24 percent bandwidth, I-215
 relay output, I-213
 tone-dial decoder, I-631
 tone detectors, 500-Hz, III-154
 tone-dial decoder, I-630, I-631
 tone-dial encoder, I-629
 tone-dial generator, I-629
 tone-dialing telephone, III-607
 tone encoder, I-67
 subaudible, I-23
 tone-dial encoder, I-629
 two-wire, II-364
 tone generators (*see* sound generators)
 tone probe, digital IC testing with, II-504
 tone ringer, telephone, II-630, II-631
 totem-pole driver, bootstrapping, III-175
 touch circuit, I-137
 touch switches, I-131, I-135-136, II-690-693, III-661-665, IV-590-594
 CMOS, I-137
 bistable multivibrator, touch-triggered, I-133
 double-button latching, I-138
 hum-detecting touch sensor, IV-594
 lamp control, three-way, IV-247
 low-current, I-132
 On/Off, II-691, III-663, IV-593
 line-hum, III-664
 momentary operation, I-133
 negative-triggered, III-662
 positive-triggered, III-662
 sensor switch and clock, IV-591
 time-on touch switch, IV-594
 touchomatic, II-693
 two-terminal, III-663
 Touchtone generator, telephone, III-609
 toxic gas detector, II-280
 toy siren, II-575
 TR circuit, II-532
 tracers
 audio reference signal, probe, I-527
 bug, III-358
 closed-loop, III-356
 receiver, III-357
 track-and-hold circuits, III-667
 sample-and-hold circuit, III-549, III-552
 signal, III-668
 tracking circuits, III-666-668
 positive/negative voltage reference, III-667
 preregulator, III-492
 track-and-hold, III-667
 track-and-hold, signal, III-668
 train chuffer sound effect, II-588
 transceivers (*see also* receivers; transmitters), IV-595-603
 CE, 20-m, IV-596-598
 CW, 5 W, 80-meter, IV-602
 hand-held, dc adapter, III-461
 hand-held, speaker amplifiers, III-39
 HF transceiver/mixer, IV-457
 ultrasonic, III-702, III-704
 transducer amplifiers, III-669-673
 flat-response, tape, III-673
 NAB preamp, record, III-673
 NAB preamp, two-pole, III-673
 photodiode amplifier, III-672
 preamp, magnetic phono, III-671, III-673
 tape playback, III-672
 voltage, differential-to-single-ended, III-670
 transducers, I-86
 bridge type, amplifier, II-84, III-71
 detector, magnetic transducer, I-233
 sonar, switch and, III-703
 temperature, remote sensor, I-649
 transistors and transistorized circuits
 flashers, II-236, III-200
 frequency tripler, nonselective, saturated, II-252
 headphone amplifier, II-43

- on/off switch for op amp, IV-546
 - pulse generator, IV-437
 - sorter, I-401
 - tester, I-401, IV-281
 - transmission indicator, II-211
 - transmitters (*see also* receivers; transceivers), III-674-691, IV-595-603
 - 2-meter, IV-600-601
 - acoustic-sound transmitter, IV-311
 - amateur radio, 80-M, III-675
 - amateur TV, IV-599
 - beacon, III-683, IV-603
 - broadcast, 1-to-2 MHz, I-680
 - carrier current, I-144, I-145, III-79
 - computer circuit, 1-of-8 channel, III-100
 - CW, 1 W, III-678
 - CW, 10 W, one-tube, I-681
 - CW, 40 M, III-684
 - CW, 902 MHz, III-686
 - CW, HF low-power, IV-601
 - CW, QRP, III-690
 - fiber optic, III-177
 - FM, I-681
 - FM, infrared, voice-modulated pulse, IV-228
 - FM, multiplex, III-688
 - FM, one-transistor, III-687
 - FM, (PRM) optical, I-367
 - FM, snooper, III-680
 - FM, voice, III-678
 - FM, wireless microphone, III-682, III-685, III-691
 - half-duplex information transmission link, low-cost, III-679
 - HF, low-power, IV-598
 - infrared, I-343, II-289, II-290, III-277, IV-226-227
 - infrared, digital, III-275
 - infrared, FM, voice-modulated pulse, IV-228
 - infrared, remote control with receiver, I-342
 - line-carrier, with on/off, 200 kHz, I-142
 - low-frequency, III-682
 - multiplexed, 1-of-8 channel, III-395
 - negative key-line keyer, IV-244
 - optical, I-363, IV-368
 - optical, FM, 50 kHz center frequency, II-417
 - optical, receiver for, II-418
 - oscillator and, 27 and 49 MHz, I-680
 - output indicator, IV-218
 - remote sensors, loop-type, III-70
 - television, III-676
 - ultrasonic, 40 kHz, I-685
 - VHF, modulator, III-684
 - VHF, tone, III-681
 - treasure locator, lo-parts, I-409
 - treble booster, guitar, II-683
 - tremolo circuits, I-59, III-692-695, IV-589
 - voltage-controlled amplifier, I-598
 - triac circuits
 - ac-voltage controller, IV-426
 - contact protection, II-531
 - dimmer switch, II-310, III-303
 - dimmer switch, 800W, I-375
 - drive interface, direct dc, I-266
 - microprocessor array, II-410
 - relay-contact protection with, II-531
 - switch, inductive load, IV-253
 - trigger, I-421
 - voltage doubler, III-468
 - zero point switch, II-311
 - zero voltage, I-623
 - triangle-to-sine converter, II-127
 - triangle/square wave oscillator, II-422
 - triangle-wave generators, III-234
 - square-wave, III-225, III-239
 - square-wave, precision, III-242
 - square-wave, wide-range, III-242
 - timer, linear, III-222
 - trickle charger, 12 V battery, I-117
 - triggers
 - 50-MHz, III-364
 - camera alarm, III-444
 - flash, photography, xenon flash, III-447
 - optical Schmitt, I-362
 - oscilloscope-triggered sweep, III-438
 - remote flash, I-484
 - SCR series, optically coupled, III-411
 - sound/light flash, I-482
 - triac, I-421
 - triggered sweep, add-on, I-472
 - tripler, nonselective, transistor saturation, II-252
 - trouble tone alert, II-3
 - TTL circuits
 - clock, wide-frequency, III-85
 - coupler, optical, III-416
 - gates, siren using, II-576
 - Morse code keyer, II-25
 - square wave to triangle wave converter, II-125
 - TTL to MOS logic converter, II-125
 - TTL oscillators, I-179, I-613
 - 1MHz to 10MHz, I-178
 - television display using, II-372
 - crystal, I-197
 - sine/square wave oscillator, IV-512
 - tube amplifier, high-voltage isolation, IV-426
 - tuners
 - antenna tuner, 1-to-30 MHz, IV-14
 - FM, I-231
 - guitar and bass, II-362
 - turbo circuits, glitch free, III-186
 - twang-twang circuit, II-592
 - twilight-triggered circuit, II-322
 - twin-T notch filters, III-403
 - two-state siren, III-567
 - two-tone generator, II-570
 - two-tone siren, III-562
 - two-way intercom, III-292
 - two's complement, D/A conversion system, binary, 12-bit, III-166
- ## U
- UA2240 staircase generator, III-587
 - UHF transmissions
 - field-strength meters, IV-165
 - rf amplifiers, UHF TV-line amplifier, IV-482, IV-483
 - source dipper, IV-299
 - TV preamplifier, III-546
 - VHF/UHF rf diode switch, IV-544
 - wideband amplifier, high performance FETs, III-264
 - UJT circuits
 - battery chargers, III-56
 - metronome, II-355
 - monostable circuit, bias voltage change insensitive, II-268
 - ultrasonic circuits (*see also* sound-operated circuits), III-696-707, IV-604-606
 - arc welding inverter, 20 KHz, III-700
 - induction heater, 120-KHz 500-W, III-704
 - pest-controller, III-706, III-707
 - pest-repeller, I-684, II-685, III-699, IV-605-606
 - ranging system, III-697
 - receiver, III-698, III-705
 - sonar transducer/switch, III-703
 - sound source, IV-605
 - switch, I-683
 - transceiver, III-702, III-704
 - transmitter, I-685
 - undervoltage detector, IV-138
 - undervoltage monitor, III-762
 - uninterruptible power supply, II-462 + 5V, III-477
 - unity-gain amplifiers
 - inverting, I-80
 - inverting, wideband, I-35
 - ultra high Z, ac, II-7
 - unity-gain buffer
 - stable, with good speed and high-input impedance, II-6
 - unity-gain follower, I-27
 - universal counters
 - 10 MHz, II-139

universal counters (*cont.*)

40-MHz, III-127

universal mixer stage, III-370

universal power supply, 3-30V, III-489

up/down counter, extreme count freezer, III-125

V

vacuum fluorescent display circuit, II-185

vacuum gauge, automotive, IV-45

vapor detector, II-279

varactor-tuned 10 MHz ceramic resonator oscillator, II-141

variable current source, 100 mA to 2A, II-471

variable duty-cycle oscillator, fixed-frequency, III-422

variable-frequency inverter, complementary output, III-297

variable-gain amplifier, voltage-controlled, I-28-29

variable-gain and sign op amp, II-405

variable-gain circuit, accurate null and, III-69

variable oscillators, II-421

audio, 20Hz to 20kHz, II-727

four-decade, single control for, II-424

sine-wave oscillator, super low-distortion, III-558

wide range, II-429

variable power supplies, III-487-492, IV-414-421

adjustable 10-A regulator, III-492

current source, voltage-programmable, IV-420

dc supply, SCR variable, IV-418

dc supply, step variable, IV-418

dual universal supply, 0-to-50 V, 5 A, IV-416-417

regulated supply, 2.5 A, 1.25-to-25 V

regulator, Darlington, IV-421

regulator, variable, 0-to-50 V, IV-421

regulator/current source, III-490

switch-selected fixed-voltage supply, IV-419

switching regulator, low-power, III-490

switching, 100-KHz multiple-output, III-488

tracking preregulator, III-492

transformerless supply, IV-420

universal 3-30V, III-489

variable current source, 100mA to 2A, II-471

voltage regulator, III-491

vehicles (*see* automotive circuits)

VFO, 5 MHz, II-551

VHF transmissions

crystal oscillator, 20-MHz, III-138

crystal oscillator, 50-MHz, III-140

crystal oscillator, 100-MHz, III-139

modulator, I-440, III-684

tone transmitter, III-681

VHF/UHF diode rf switch, IV-544

video amplifiers, III-708-712

75-ohm video pulse, III-711

buffer, low-distortion, III-712

color, I-34, III-724

dc gain-control, III-711

FET cascade, I-691

gain block, III-712

IF, low-level video detector circuit, I-689, II-687

JFET bipolar cascade, I-692

line driving, III-710

log amplifier, I-38

RGB, III-709

summing, clamping circuit and, III-710

video circuits (*see also* television-related circuits), III-713-728, IV-607-621

audio/video switcher circuit, IV-540-541

camera-image tracker, analog voltage, IV-608-609

camera link, wireless, III-718

chroma demodulator with RGB matrix, III-716

color amplifier, III-724

color-bar generator, IV-614

composite-video signal text adder, III-716

converter, RGB-to-NTSC, IV-611

converter, video a/d and d/a, IV-610-611

cross-hatch generator, color TV, III-724

dc restorer, III-723

decoder, NTSC-to-RGB, IV-613

high-performance video switch, III-728

line pulse extractor, IV-612

loop-thru amplifier, IV-616

mixer, high-performance video mixer, IV-609

modulators, I-437, II-371, II-372

monitors, RGB, blue box, III-99

monochrome-pattern generator, IV-617

multiplexer, cascaded, 1-of-15, III-393

PAL/NTSC decoder with RGB input, III-717

palette, III-720

picture fixer/inverter, III-722

RGB-composite converter, III-714

signal clamp, III-726

switching circuits, IV-618-621

switching circuits, remote selection switch, IV-619

switching circuits, remote-controlled switch, IV-619-621

sync separator, IV-616

sync separator, single-supply wide-range, III-715

video op amp circuits, IV-615

video switch, automatic, III-727

video switch, general purpose, III-725

video switch, very-high off isolation, III-719

wireless camera link, III-71

vocal eliminator, IV-19

voice scrambler/descrambler, IV-26

voice scrambler/disguiser, IV-27

voice substitute, electronic, III-734

voice-activated circuits (*see also* sound-operated circuits), III-729-734, IV-622-624

ac line-voltage announcer, III-730

allophone generator, III-733

amplifier/switch, I-608

computer speech synthesizer, III-732

dialed phone number vocalizer, III-731

scanner voice squelch, IV-624

switch, III-580

switch, microphone-controlled, IV-527

switch/amplifier, I-608

voice substitute, electronic, III-734

VOX circuit, IV-623

voltage amplifiers

differential-to-single-ended, III-670

reference, I-36

voltage-controlled amplifier, I-31, I-598

attenuator for, II-18

tremolo circuit, I-598

variable gain, I-28-29

voltage-controlled filter, III-187

1,000:1 tuning, IV-176

voltage-controlled high-speed one shot, II-266

voltage-controlled ramp generator, II-523

voltage-controlled resistor, I-422

voltage-controlled timer, programmable, II-676

voltage-controlled amplifier, IV-20

tremolo circuit or, I-598

voltage-controlled oscillators, I-702-

704, II-702, III-735, IV-625-630

3-5 V regulated output converter, III-739

10Hz to 10kHz, I-701, III-735-741

555-VCO, IV-627
 audio-frequency VCO, IV-626
 crystal oscillator, III-135, IV-124
 current sink, voltage-controlled, IV-629
 driver, op-amp design, IV-362
 linear, I-701, IV-628
 linear triangle/square wave, II-263
 logarithmic sweep, III-738
 precision, I-702, III-431
 restricted-range, IV-627
 stable, IV-372-373
 supply voltage splitter, III-738
 three-decade, I-703
 TMOS, balanced, III-736
 two-decade, high-frequency, I-704
 varactorless, IV-630
 variable-capacitance diode-sparked, III-737
 VHF oscillator, voltage-tuned, IV-628
 waveform generator, III-737
 wide-range, IV-629
 wide-range, biphasic, IV-629
 wide-range, gate, IV-627
 voltage-controller, pulse generator, III-524
 voltage converters, III-742-748
 12-to-16 V, III-747
 dc-to-dc, 3-25 V, III-744
 dc-to-dc, dual output \pm 12-15 V, III-746
 flyback, high-efficiency, III-744
 flyback-switching, self-oscillating, III-748
 negative voltage, μ P-controlled, IV-117
 offline, 1.5-W, III-746
 regulated 15-Vout 6-V driven, III-745
 splitter, III-743
 unipolar-to-dual supply, III-743
 voltage detector relay, battery charger, II-76
 voltage followers, I-40, III-212
 fast, I-34
 noninverting, I-33
 signal-supply operation, amplifier, III-20
 voltage inverters, precision, III-298
 voltage meters/monitors/indicators, III-758-772
 ac voltmeter, III-765
 ac voltmeter, wide-range, III-772
 audio millivoltmeter, III-767, III-769
 automotive battery voltage gauge, IV-47
 battery-voltage measuring regulator, IV-77
 comparator and, II-104
 dc voltmeter, III-763
 dc voltmeter, resistance, high-input, III-762
 DVM, 3.5-digit, full-scale 4-decade, III-761
 DVM, 4.5-digit, III-760
 FET voltmeter, III-765, III-770
 five-step level detector, I-337
 frequency counter, III-768
 high-input resistance voltmeter, III-768
 HTS, precision, I-122
 level detectors, I-338, II-172, III-759, III-770
 low-voltage indicator, III-769
 multiplexed common-cathode LED ADC, III-764
 over/under monitor, III-762
 peak program detector, III-771
 rf voltmeter, III-766
 solid-state battery, I-120
 ten-step level detector, I-335
 visible, I-338, III-772
 voltage freezer, III-763
 voltage multipliers, IV-631-637
 2,000 V low-current supply, IV-636-637
 10,000 V dc supply, IV-633
 corona wind generator, IV-633
 doublers, III-459, IV-635
 doubler, cascaded, Cockcroft-Walton, IV-635
 doublers, triac-controlled, III-468
 laser power supply, IV-636
 negative-ion generator, high-voltage, IV-634
 tripler, low-current, IV-637
 voltage ratio-to-frequency converter, III-116
 voltage references, III-773-775
 bipolar source, III-774
 digitally controlled, III-775
 expanded-scale analog meter, III-774
 positive/negative, tracker for, III-667
 variable-voltage reference source, IV-327
 voltage regulators, I-501, I-511, II-484
 0- to 10-V at 3A, adjustable, I-511
 0- to 22-V, I-510
 0- to 30-V, I-510
 5 V, low-dropout, III-461
 5 V, 1 A, I-500
 6 A, variable output switching, I-513
 10 A, I-510
 10 A, adjustable, III-492
 10 V, high stability, III-468
 15 V, 1 A, remote sense, I-499
 15 V, slow turn-on, III-477
 -15 V negative, I-499
 45 V, 1 A switching, I-499
 100 Vrms, I-496
 ac, III-477
 adjustable output, I-506, I-512
 automotive circuits, III-48, IV-67
 battery charging, I-117
 bucking, high-voltage, III-481
 common hot-lead regulator, IV-467
 constant voltage/constant current, I-508
 current and thermal protection, 10 amp, II-474
 dual-tracking, III-462
 efficiency-improving switching, IV-464
 fixed pnp, zener diode increases output, II-484
 fixed-current regulator, IV-467
 fixed-voltages, IV-462-467
 flyback, off-line, II-481
 high- or low-input regulator, IV-466
 high-stability, I-499
 high-stability, 1 A, I-502
 high-stability, 10 V, III-468
 high-voltage, III-485
 high-voltage, foldback-current limiting, II-478
 high-voltage, precision, I-509
 low-dropout, 5-V, III-461
 low-voltage, I-502, I-511
 linear, low-dropout, III-459
 linear, radiation-hardened 125 A, II-468
 mobile, I-498
 negative, III-474, IV-465
 negative, -15 V, I-499
 negative, floating, I-498
 negative, switching, I-498
 negative, voltage, I-499
 positive, floating, I-498
 positive, switching, I-498
 positive, with NPN/PNP boost, III-475
 positive, with PNP boost, III-471
 pre-, SCR, II-482
 pre-, tracking, III-492
 projection lamp, II-305
 PUT, 90 V rms, II-479
 remote shutdown, I-510
 negative, IV-465
 sensor, LM317 regulator sensing, IV-466
 short-circuit protection, low-voltage, I-502
 single-ended, I-493
 single-supply, II-471
 slow turn-on 15 V, I-499
 switch-mode, IV-463
 switching, 3-A, III-472
 switching, 3 W, application circuit, I-492

- voltage regulators (*cont.*)
 - switching, 5 V, 6 A 25kHz, separate ultrastable reference, I-497
 - switching, 6 A, variable output, I-513
 - switching, 200 kHz, I-491
 - switching, multiple output, for use with MPU, I-513
 - switching, step down, I-493
 - switching, high-current inductorless, III-476
 - switching, low-power, III-490
 - variable, III-491, IV-468-470
 - variable, current source, III-490
 - zener design, programmable, IV-470
 - voltage sources
 - millivolt, zenerless, I-696
 - programmable, I-694
 - voltage splitter, III-738
 - voltage-to-current converter, I-166, II-124, III-110, IV-118
 - power, I-163
 - zero IB error, III-120
 - voltage-to-frequency converters, I-707, III-749-757, IV-638-642
 - 1 Hz-to-10MHz, III-754
 - 1 Hz-to-30 MHz, III-750
 - 1Hz-to-1.25 MHz, III-755
 - 5 KHz-to-2MHz, III-752
 - 10Hz to 10 kHz, I-706, III-110
 - accurate, III-756
 - differential-input, III-750
 - function generators, potentiometer-position, IV-200
 - low-cost, III-751
 - low-frequency converter, IV-641
 - negative input, I-708
 - optocoupler, IV-642
 - positive input, I-707
 - precision, II-131
 - preserved input, III-753
 - ultraprecision, I-708
 - wide-range, III-751, III-752
 - voltage-to-pulse duration converter, II-124
 - voltmeters
 - 3 $\frac{1}{2}$ digit, I-710
 - 3 $\frac{1}{2}$ digital true rms ac, I-713
 - 5-digit, III-760
 - ac, III-765
 - ac, wide-range, III-772
 - add-on thermometer for, III-640
 - bar-graph, I-99, II-54
 - dc, III-763
 - dc, high-input resistance, III-762
 - digital, III-4
 - digital, 3.5-digit, full-scale, four-decade, III-761
 - digital, LED readout, IV-286
 - FET, I-714, III-765, III-770
 - high-input resistance, III-768
 - millivoltmeters (*see* millivoltmeters)
 - rf, I-405, III-766
 - wide-band ac, I-716
 - voltohmmeter, phase meter, digital readout, IV-277
 - volume amplifier, II-46
 - volume control circuits, IV-643-645
 - telephone, II-623
 - volume indicator, audio amplifier, IV-212
 - VOR signal simulator, IV-273
 - vox box, II-582, IV-623
 - Vpp generator, EPROM, II-114
 - VU meters
 - extended range, II-487, I-715
 - LED display, IV-211
- ## W
- waa-waa circuit, II-590
 - wailers (*see* alarms; sirens)
 - wake-up call, electronic, II-324
 - walkman amplifier, II-456
 - warblers (*see* alarms; sirens)
 - warning devices
 - auto lights-on warning, II-55
 - high-level, I-387
 - high-speed, I-101
 - light, III-317
 - light, battery-powered, II-320
 - low-level, audio output, I-391
 - speed, I-96
 - varying-frequency alarm, II-579
 - water-level sensors (*see* fluid and moisture detectors)
 - water-temperature gauge, automotive, IV-44
 - wattmeter, I-17
 - wave-shaping circuits (*see also* waveform generators), IV-646-651
 - capacitor for high slew rates, IV-650
 - clipper, glitch-free, IV-648
 - flip-flop, S/R, IV-651
 - harmonic generator, IV-649
 - phase shifter, IV-647
 - rectifier, full-wave, IV-650
 - signal conditioner, IV-649
 - waveform generators (*see also* burst generators; function generators; sound generators; square-wave generators; wave-shaping circuits), II-269, II-272
 - audio, precision, III-230
 - four-output, III-223
 - harmonic generator, IV-649
 - high-speed generator, I-723
 - precise, II-274
 - ramp generators, IV-443-447
 - sawtooth generator, digital, IV-444, IV-446
 - sine-wave, IV-505, IV-506
 - sine-wave, 60 Hz, IV-507
 - sine-wave, audio, II-564
 - sine-wave, LC, IV-507
 - sine-wave, LF, IV-512
 - sine-wave oscillator, audio, III-559
 - staircase generators, IV-443-447
 - staircase generator/frequency divider, I-730
 - stepped waveforms, IV-447
 - triangle and square waveform, I-726
 - VCO and, III-737
 - wavemeter, tuned RF, IV-302
 - weather-alert decoder, IV-140
 - weight scale, digital, II-398
 - Wheel-of-Fortune game, IV-206
 - whistle, steam locomotive, II-589, III-568
 - who's first game circuit, III-244
 - wide-range oscillators, I-69, III-425
 - variable, I-730
 - wide-range peak detectors, III-152
 - hybrid, 500 kHz-1 GHz, III-265
 - instrumentation, III-281
 - miniature, III-265
 - UHF amplifiers, high-performance FETs, III-264
 - wideband amplifiers
 - low-noise/low drift, I-38
 - two-stage, I-689
 - rf, IV-489, IV-490, IV-491
 - rf, HF, IV-492
 - rf, JFET, IV-493
 - rf, MOSFET, IV-492
 - rf, two-CA3100 op amp design, IV-491
 - unity gain inverting, I-35
 - wideband signal splitter, III-582
 - wideband two-pole high pass filter, II-215
 - Wien-bridge filter, III-659
 - notch filter, II-402
 - Wien-bridge oscillators, I-62-63, I-70, III-429, IV-371, IV-377, IV-511
 - CMOS chip in, II-568
 - low-distortion, thermally stable, III-557
 - low-voltage, III-432
 - sine wave, I-66, I-70, II-566
 - sine-wave, three-decade, IV-510
 - sine-wave, very-low distortion, IV-513
 - single-supply, III-558
 - variable, III-424
 - wind-powered battery charger, II-70
 - windicator, I-330
 - window circuits, II-106, III-90, III-776-

781, IV-655-659
comparator, IV-658
comparator, low-cost design, IV-656-657
comparator, voltage comparator, IV-659
detector, IV-658
digital frequency window, III-777
discriminator, multiple-aperture, III-781
generator, IV-657
high-input-impedance, II-108
windshield wiper circuits
control circuit, I-103, I-105, II-62
delay circuit, II-55
delay circuit, solid-state, IV-64
hesitation control unit, I-105
intermittent, dynamic braking, II-49
interval controller, IV-67
slow-sweep control, II-55
windshield washer fluid watcher, I-107
wire tracer, II-343

wireless microphones (*see* micro-phones), IV-652
wireless speaker system, IR, III-272
write amplifiers, III-18

X

xenon flash trigger, slave, III-447
XOR gates, IV-107
complementary signals generator, III-226
oscillator, III-429
up/down counter, III-105

Y

yelp oscillator/siren, II-577, III-562

Z

Z80 clock, II-121

zappers, battery, II-64
ni-cad battery, II-66
ni-cad battery, version II, II-68
zener diodes
clipper, fast and symmetrical, IV-329
increasing power rating, I-496, II-485
limiter using one-zener design, IV-257
tester, I-400
variable, I-507
voltage regulator, programmable, IV-470
zero-crossing detector, II-173
zero meter, suppressed, I-716
zero-point switches
temperature control, III-624
triac, II-311
zero-voltage switches
closed contact half-wave, III-412
solid-state, optically coupled, III-410
solid-state, relay, antiparallel SCR output, III-416

Other Bestsellers of Related Interest

ENCYCLOPEDIA OF ELECTRONIC CIRCUITS

Vol. 1—Rudolf F. Graf

"... schematics that encompass virtually the entire spectrum of electronics technology . . . This is a well worthwhile book to have handy." —**Modern Electronics**

Discover hundreds of the most versatile electronic and integrated circuit designs, all available at the turn of a page. You'll find circuit diagrams and schematics for a wide variety of practical applications. Many entries also include clear, concise explanations of the circuit configurations and functions. 768 pages, 1,762 illustrations. Book No. 1938, \$29.95 paperback, \$60.00 hardcover

THE ILLUSTRATED DICTIONARY OF ELECTRONICS—5th Edition

—Rufus P. Turner and Stan Gibilisco

This completely revised and updated edition defines more than 27,000 practical electronics terms, acronyms, and abbreviations. Find up-to-date information on basic electronics, computers, mathematics, electricity, communications, and state-of-the-art applications—all discussed in a nontechnical style. The author also includes 360 new definitions and 125 illustrations and diagrams. 736 pages, 650 illustrations. Book No. 3345, \$26.95 paperback, \$39.95 hardcover

ELECTRONIC CONVERSIONS: Symbols and Formulas—2nd Edition

—Rufus P. Turner and Stan Gibilisco

This revised and updated edition supplies all the formulas, symbols, tables, and conversion factors commonly used in electronics. Exceptionally easy to use, the material is organized by subject matter. Its format is ideal and you can save time by directly accessing specific information. Topics cover only the most-needed facts about the most often used conversions, symbols, formulas, and tables. 280 pages, 94 illustrations. Book No. 2865, \$14.95 paperback only

ELECTRONIC DATABOOK—4th Edition

—Rudolf F. Graf

If it's electronic, it's here—current, detailed, and comprehensive! Use this book to broaden your electronics information base. Revised and expanded to include all up-to-date information, this fourth edition makes any electronic job easier and less time-consuming. You'll find information that will aid in the design of local area networks, computer interfacing structure, and more! 528 pages, 131 illustrations. Book No. 2958, \$24.95 paperback only

BUILD YOUR OWN TEST EQUIPMENT

—Homer L. Davidson

Build more than 30 common electronic testing devices, ranging from simple continuity and polarity testers to signal injectors and power supplies. Also learn how test instruments work, how they are used, and how to save money. Each project includes a complete parts list with exact part numbers. 300 pages, 324 illustrations. Book No. 3475, \$17.95 paperback, \$27.95 hardcover

ELECTRONIC SIGNALS AND SYSTEMS:

Television, Stereo, Satellite TV, and Automotive—Stan Prentiss

Study signal analysis as it applies to the operation and signal-generating capabilities of today's most advanced electronic devices with this handbook. It explains the composition and use of a wide variety of test instruments, transmission media, satellite systems, stereo broadcast and reception facilities, antennas, television equipment, and even automotive electrical systems. You'll find coverage of C- and Ku-band video, satellite master TV systems, high-definition television, C-QUAM® AM stereo transmission and reception, and more. 328 pages, 186 illustrations. Book No. 3557, \$19.95 paperback, \$29.95 hardcover

MASTERING ELECTRONICS MATH

—2nd Edition—R. Jesse Phagan

A self-paced text for hobbyists and a practical toolbox reference for technicians, this book guides you through the practical calculations needed to design and troubleshoot circuits and electronics components. Clear explanations and sample problems illustrate each concept, including how each is used in common electronics applications. If you want to gain a strong understanding of electronics math and stay on top of your profession, this book will be a valuable tool for you! 344 pages, 270 illustrations. Book No. 3589, \$17.95 paperback, \$27.95 hardcover

BOB GROSSBLATT'S GUIDE TO CREATIVE CIRCUIT DESIGN

—Robert Grossblatt

Robert Grossblatt, *Radio Electronics'* popular columnist brings his unique circuit design philosophy and style to this hands-on guide. Emphasizing the importance of scientific method over technical knowledge, it walks you through the circuit design process—from brainwork to paperwork to boardwork—and suggests ways for making your bench time as efficient as possible. 248 pages, 129 illustrations. Book No. 3610, \$17.95 paperback, \$28.95 hardcover

SECRETS OF RF CIRCUIT DESIGN

—Joseph J. Carr

This book explains in clear, nontechnical language what RF is, how it works, and how it differs from other electromagnetic frequencies. You'll learn the basics of receiver operation, the proper use and repair components in RF circuits, and principles of radio signal propagation from low frequencies to microwave. You'll enjoy experiments that explore such problems as electromagnetic interface. 416 pages, 411 illustrations. Book No. 3710, \$19.95 paperback, \$32.95 hardcover

INTERNATIONAL ENCYCLOPEDIA OF INTEGRATED CIRCUITS—2nd Edition

—Stan Gibilisco

The most thorough coverage of foreign and domestic integrated circuits is available today in this giant resource. Seven separate sections detail thousands of ICs and their applications, including all relevant information, charts, and tables. This second edition of a unique all-in-one reference tells what each IC is, what it does, how it does it, and what its relationship is to other ICs and their applications. 1,168 pages, 4,605 illustrations. Book No. 3802, \$84.95 hardcover only

ELECTRONIC POWER CONTROL: Circuits, Devices & Techniques

—Irving M. Gottlieb

This guide focuses on the specific digital circuits used in electronic power applications. It presents state-of-the-art approaches to analysis, troubleshooting, and implementation of new solid-state devices. Gottlieb shows you how to adapt various power-control techniques to your individual needs. He uses descriptive analysis and real-world applications wherever possible, employing mathematical theory only when relevant. 272 pages, 197 illustrations. Book No. 3837, \$17.95 paperback, \$27.95 hardcover

ENCYCLOPEDIA OF ELECTRONICS

—2nd Edition—Stan Gibilisco and

Neil Sclater, Co-Editors-in-Chief

Praise for the first edition:

"... a fine one-volume source of detailed information for the whole breadth of electronics."

—*Modern Electronics*

The second edition brings you more than 950 pages of listings and cover virtually every electronics concept and component imaginable. From basic electronics terms to state-of-the-art applications, this is the most complete and comprehensive electronics reference available! 976 pages, 1,400 illustrations. Book No. 3389, \$69.50 hardcover only

MASTER HANDBOOK OF ELECTRONIC TABLES AND FORMULAS—5th Edition

—Martin Clifford

"... a source of quick, accurate, and easy-to-use solutions to electronics problems... to be used as a reference book for hobbyists as well as professionals."

Electronics for You, on a previous edition

It's a completely revised and updated edition of the classic reference used by thousands of hobbyists, technicians, and engineers. Reflecting the latest developments in the field, you'll never again have to stop and make pencil and paper calculations, hunt up your calculator for simple conversions, or search through reference books trying to find a specific formula. Everything you need is right here—logically organized and fully indexed. Martin Clifford includes the most current information on everything from resistance formulas, sine waves, capacitance, impedance vectors, decibels, and more. 544 pages, 490 illustrations. Book No. 3739, \$22.95 paperback, \$39.95 hardcover

Prices Subject to Change Without Notice.

Look for These and Other TAB Books at Your Local Bookstore

To Order Call Toll Free 1-800-822-8158

(in PA, AK, and Canada call 717-794-2191)

or write to TAB Books, Blue Ridge Summit, PA 17294-0840.

Title	Product No.	Quantity	Price
-------	-------------	----------	-------

Check or money order made payable to TAB Books

Subtotal \$ _____

Charge my VISA MasterCard American Express

Postage and Handling
(\$3.00 in U.S., \$5.00 outside U.S.) \$ _____

Acct. No. _____ Exp. _____

Add applicable state and local
sales tax \$ _____

Signature: _____

TOTAL \$ _____

Name: _____

Address: _____

TAB Books catalog free with purchase; otherwise send \$1.00 in check
or money order and receive \$1.00 credit on your next purchase.

City: _____

Orders outside U.S. must pay with international money in U.S. dollars

State: _____ Zip: _____

**TAB Guarantee: If for any reason you are not satisfied with the
book(s) you order, simply return it (them) within 15 days and receive
a full refund.**

BC