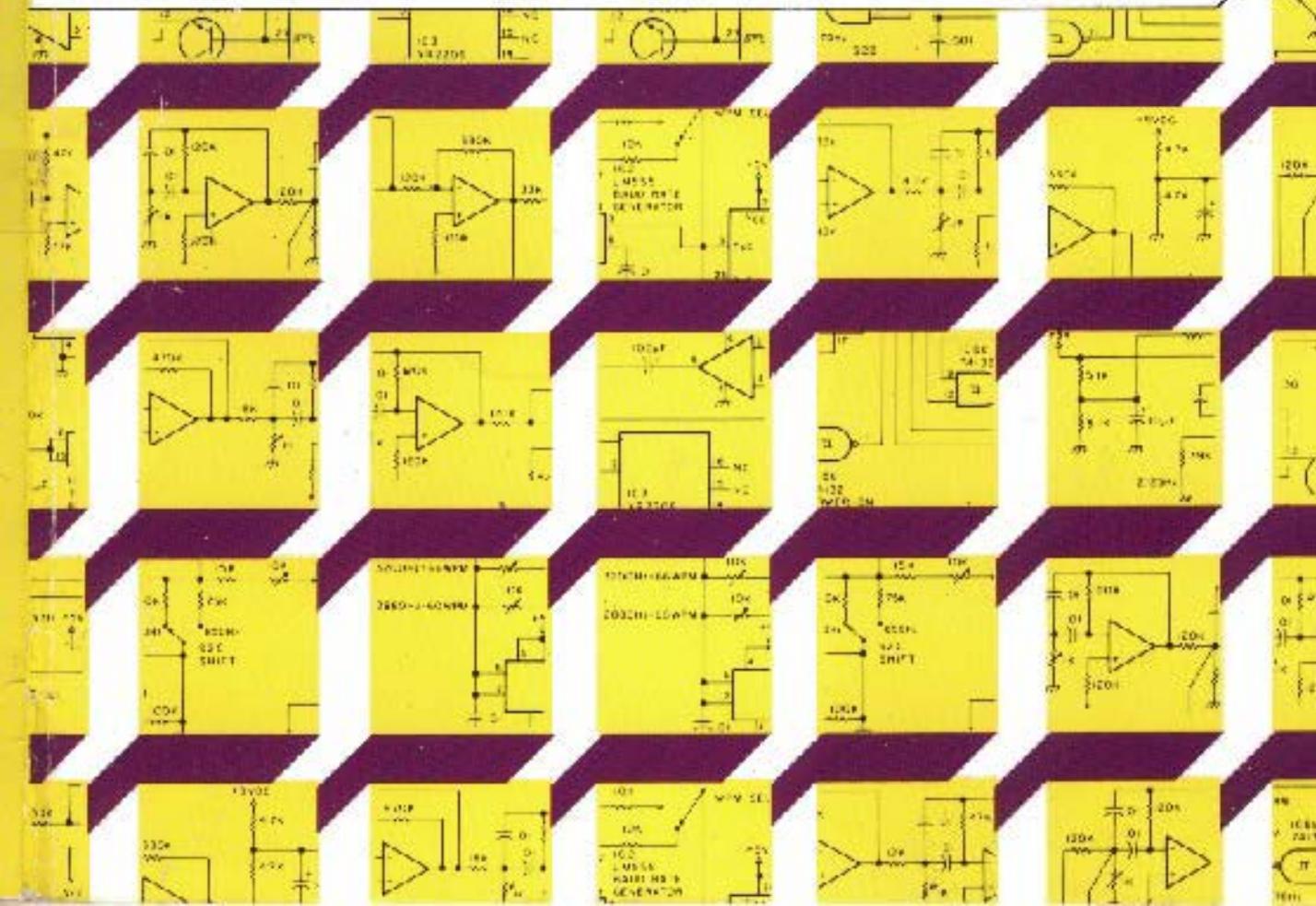


1938

ENCYCLOPEDIA OF ELECTRONIC CIRCUITS

VOLUME 1
RUDOLF F. GRAF



Contents

	Acknowledgments	vi
	Introduction	vii
	Common Schematic Symbols	viii
1	Alarms	1
2	Amateur Radio	14
3	Amplifiers	26
4	Analog-to-Digital Converters	43
5	Attenuators	51
6	Audio Mixers	54
7	Audio Oscillators	61
8	Audio Power Amplifiers	71
9	Audio Signal Amplifiers	83
10	Automotive	93
11	Battery Chargers	110
12	Battery Monitors	119
13	Buffers	125
14	Capacitance (Touch) Operated Circuits	129
15	Carrier Current Circuits	139
16	Comparators	147
17	Converters	158
18	Crossover Networks	171
19	Crystal Oscillators	174
20	Current Measuring Circuits	200
21	Current Sources and Sinks	204

22	Dc/dc and dc/ac Converters	207
23	Decoders	212
24	Delay Circuits	216
25	Detectors	221
26	Digital-to-Analog Converters	236
27	Dip Meters	245
28	Displays	249
29	Dividers	256
30	Drivers	260
31	Fiber Optic Circuits	267
32	Field Strength Meters	272
33	Filters	277
34	Flashers and Blinkers	298
35	Frequency Measuring Circuits	309
36	Frequency Multipliers	312
37	Frequency-to-Voltage Converters	315
38	Fuzz Circuits	319
39	Games	323
40	Gas/Vapor Detectors	331
41	Indicators	334
42	Infrared Circuits	340
43	Instrumentation Amplifiers	345
44	Light Activated Circuits	356
45	Light Controls	368
46	Light Measuring Circuits	381
47	Liquid Level Detectors	385
48	Logic Circuits	392
49	Measuring Circuits	396
50	Metal Detectors	407
51	Metronomes	410
52	Miscellaneous Circuits	414
53	Mixers and Multiplexers	424
54	Modulation Monitors	429
55	Modulators	432
56	Moisture and Rain Detectors	441
57	Motor Controls	444
58	Multivibrators	459
59	Noise Generators	466
60	Oscilloscope Circuits	470
61	Phase Sequence and Phase Shift Circuits	475

62	Photography Related Circuits	478
63	Power Measuring Circuits	486
64	Power Supplies (Fixed)	490
65	Power Supplies (Variable)	504
66	Power Supply Protection Circuits	514
67	Probes	519
68	Pulse Generators	528
69	Radiation Detectors	533
70	Ramp Generators	538
71	Receivers	541
72	Resistance and Continuity Measuring Circuits	548
73	RF Amplifiers	553
74	RF Oscillators	569
75	Remote Control Circuits	573
76	Safety and Security Circuits	578
77	Sample and Hold Circuits	584
78	Schmitt Triggers	591
79	Smoke and Flame Detectors	594
80	Sound Effect Circuits	597
81	Sound (Audio) Operated Circuits	607
82	Square Wave Oscillators	611
83	Stereo Balance Circuits	617
84	Switches	620
85	Telephone Related Circuits	624
86	Temperature Controls	637
87	Temperature Sensors	645
88	Timers	659
89	Tone Control Circuits	669
90	Transmitters	678
91	Ultrasonic Circuits	682
92	Video Amplifiers	686
93	Voltage and Current Sources and Reference Circuits	693
94	Voltage-Controlled Oscillators	700
95	Voltage-to-Frequency Converters	705
96	Voltmeters	709
97	Waveform and Function Generators	717
98	Zero Crossing Detectors	727
	Sources	730
	Index	749

Introduction

This volume of timely and practical circuits highlights the creative work of many people. Featured here are many circuits that appeared only briefly in some of our finer periodicals or limited-circulation publications. Also included are other useful and unique circuits from more readily available sources.

The source for each circuit is given in the sources section at the back of the book. The bold figure number that appears inside the box of each circuit is the key to the source. For example, the High Stability Voltage Reference circuit shown below is Fig. 93-10. If you turn to the Sources section and look for Fig. 93-10 you will find that Precision Monolithics supplied this circuit from p. 6-142 of their Full Line Catalog.

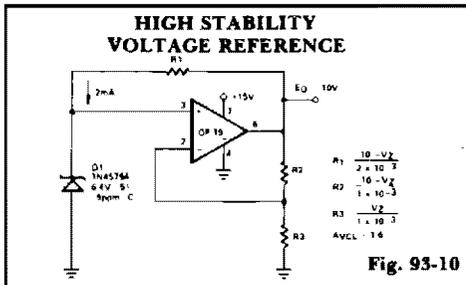


Fig. 93-9: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-25.

Fig. 93-10: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-142.

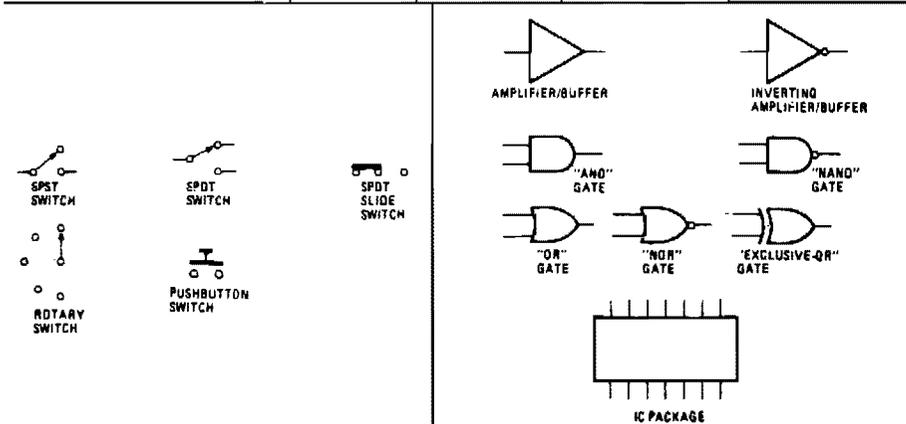
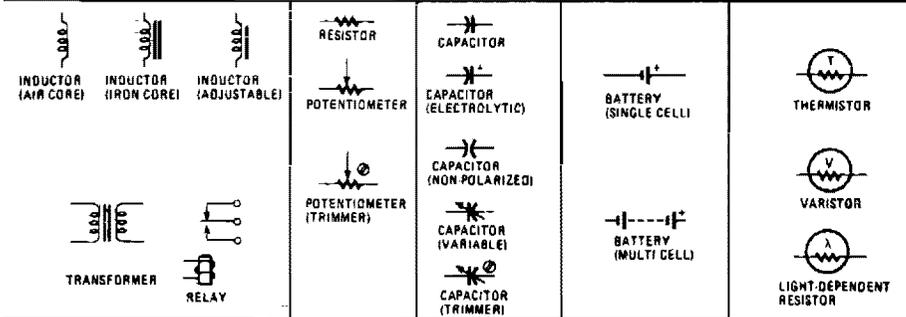
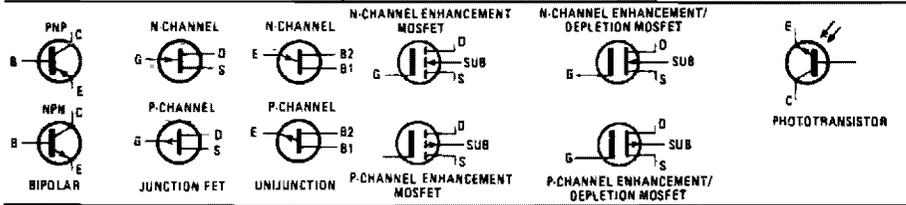
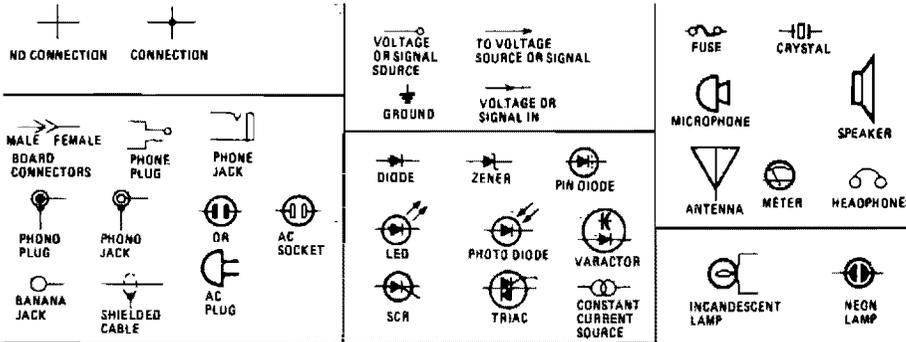
Fig. 93-11: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-18.

Many circuits are accompanied by a brief explanatory text. Those that do not have text can be readily understood from similar circuits in that chapter, or else they may be too complex to be explained briefly. The sparseness of text is deliberate so as to allow for more circuits which, after all, is what this book is all about.

The Index and Contents will be a time saver for the reader who knows exactly what he is looking for. The first page of each chapter lists the circuits in the order that they appear. The browser will surely discover many ideas and circuits that may well turn out to be most rewarding and great fun to put together.

The Common Schematic Symbols chart will help you identify circuit components.

Common Schematic Symbols



1

Alarms

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Computalarm	Blown Fuse Alarm
Automotive Burglar Alarm	Auto Burglar Alarm
Security Alarm	Continuous-Tone 2 kHz Buzzer with Bridge Drive, Gated on by a Logic 0
Vehicle Security System	Pulsed-Tone Alarm, Gated by a High Input, with Direct-Drive Output
Home Security Monitor System	Piezoelectric Alarm
Antitheft Device	Gated 2 kHz Buzzer
Auto Burglar Alarm	Burglar Alarm
Tamper-Proof Burglar Alarm	Latching Burglar Alarm
Latching Burglar Alarm	Sun -Powered Alarm
Motion-Activated Motorcycle or Car Alarm	
Boat Alarm	
	Freezer Meltdown Alarm

COMPUTALARM

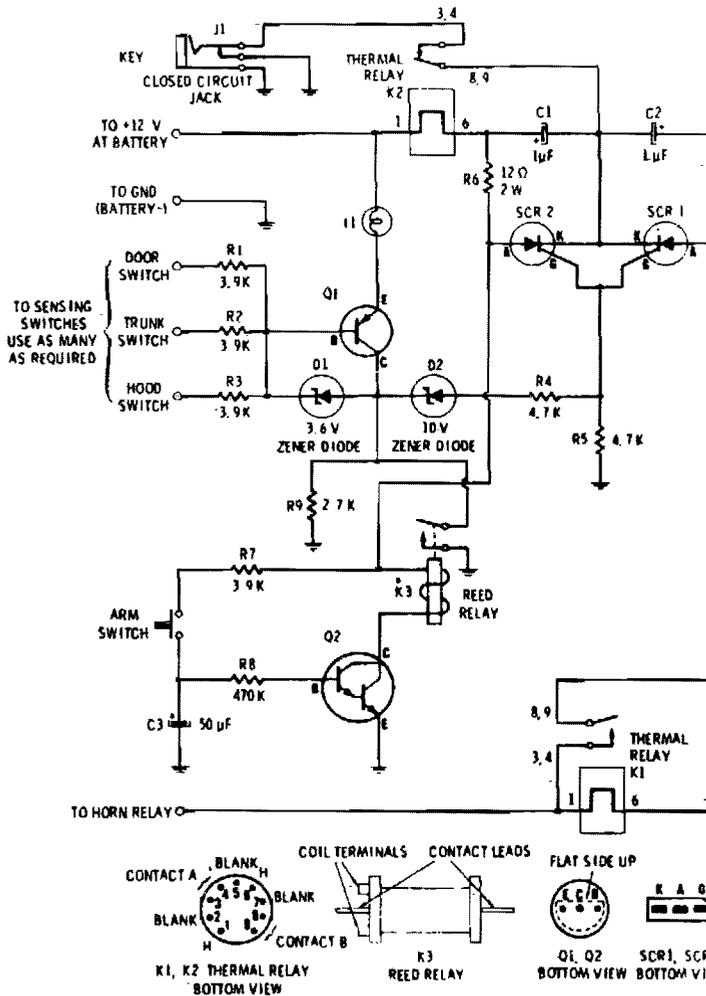


Fig. 1-1

Circuit Notes

The circuit has a built-in, self-arming feature. The driver turns off the ignition, presses the arm button on the Computalarm, and leaves the car. Within 20 seconds, the alarm arms itself—all automatically! The circuit will then detect the opening of any monitored door, the trunk lid, or the hood on the car. Once activated, the circuit remains dormant for 10 seconds. When the 10-second time delay has run out, the circuit will close the car's horn relay and sound the horn in periodic blasts (approx-

mately 1 to 2 seconds apart) for a period of one minute. Then the Computalarm automatically shuts itself off (to save your battery) and re-arms. If a door, the trunk lid, or the hood remains ajar, the alarm circuit retriggers and another period of horn blasts occurs. The Computalarm has a "key" switch by which the driver can disarm the alarm circuit within a 10-second period after he enters the door. The key switch consists of a closed circuit jack, J1, and a mating miniature plug.

SECURITY ALARM

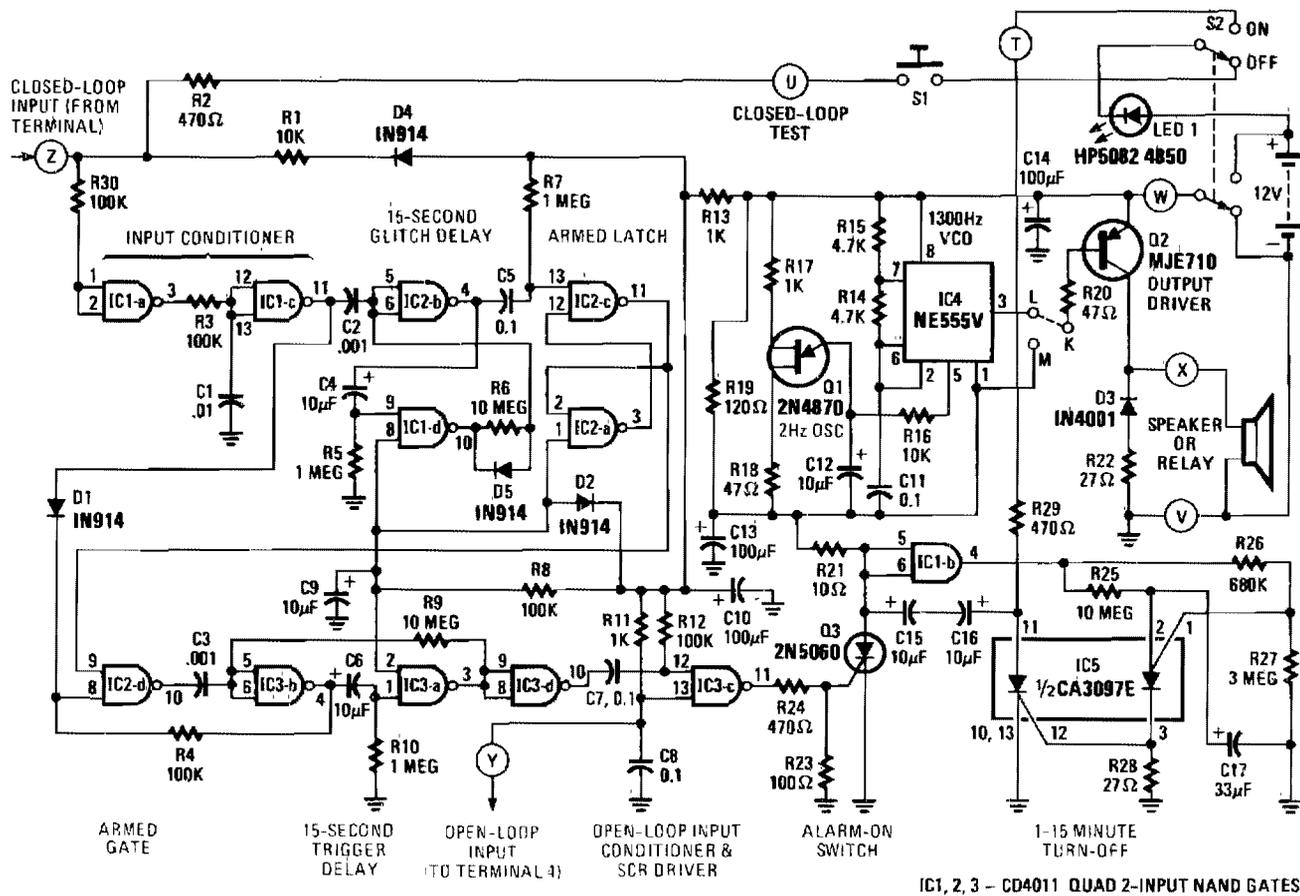


Fig. 1-3

Circuit Notes

This alarm features open- and closed-loop detector and automatic alarm shutoff. Offers 15 second exit/entrance delay. Alarm on time can be adjusted from 1 to 15 minutes.

VEHICLE SECURITY SYSTEM

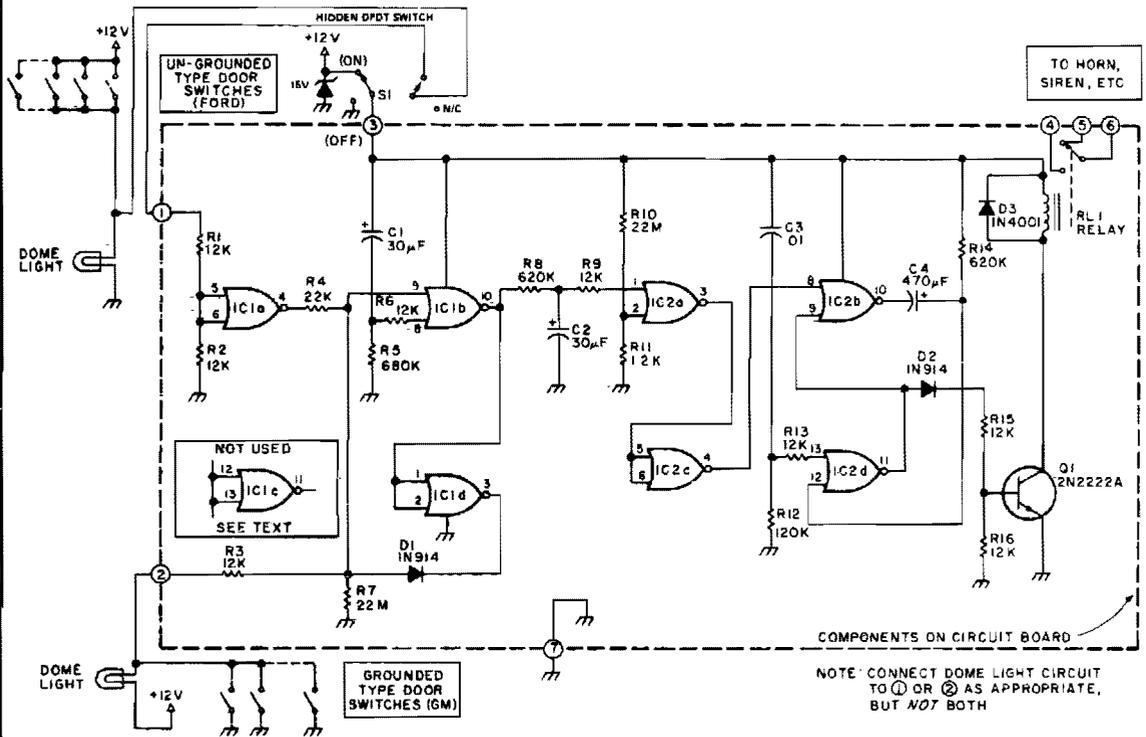


Fig. 1-4

Circuit Notes

This alarm gives a 15-20 second exit and entrance delay. After being triggered, the alarm sounds for five minutes and then shuts off. Once triggered, the sequence is automatic and is not affected by subsequent opening or closing of doors.

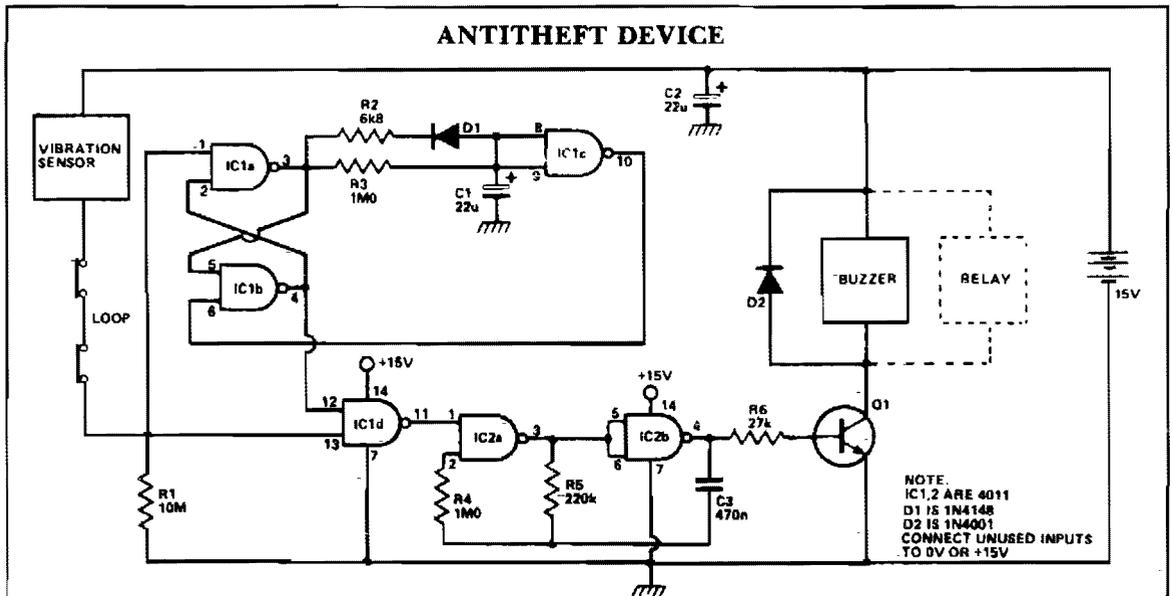


Fig. 1-6

Circuit Notes

Any momentary break in the protective loop or tripping of the normally closed vibration sensor, causes alarm to sound for 20 seconds. If the circuit is open all the time, the alarm will sound continuously.

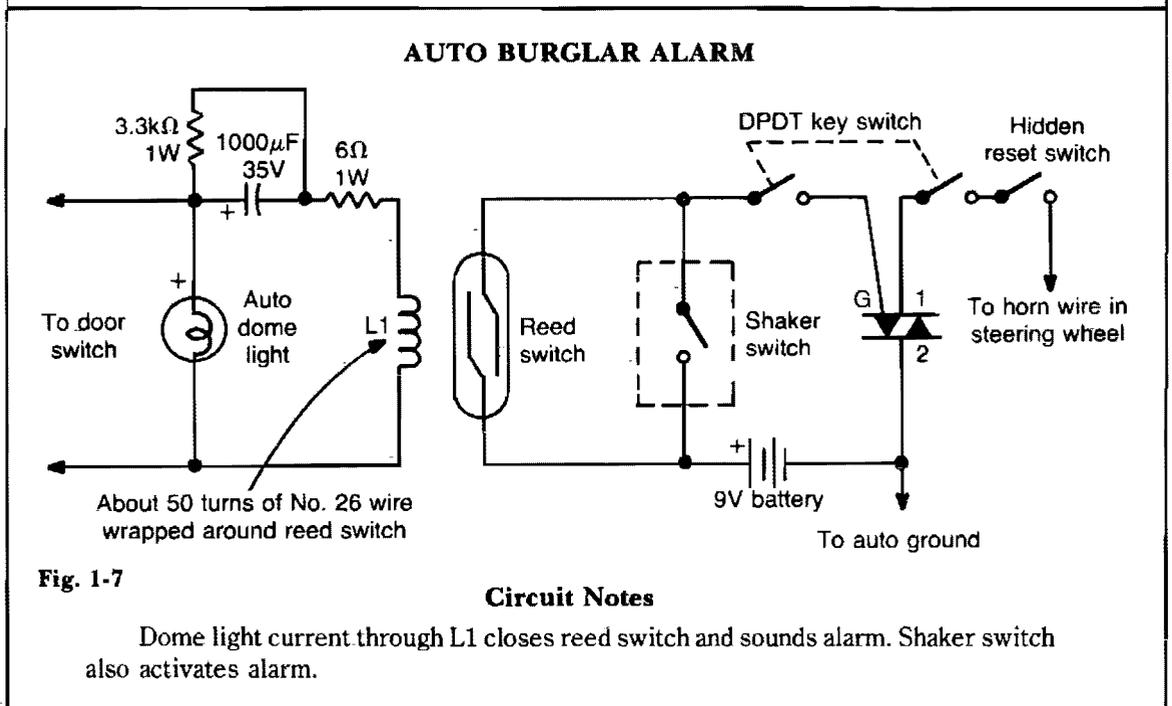


Fig. 1-7

Circuit Notes

Dome light current through L1 closes reed switch and sounds alarm. Shaker switch also activates alarm.

TAMPER-PROOF BURGLAR ALARM

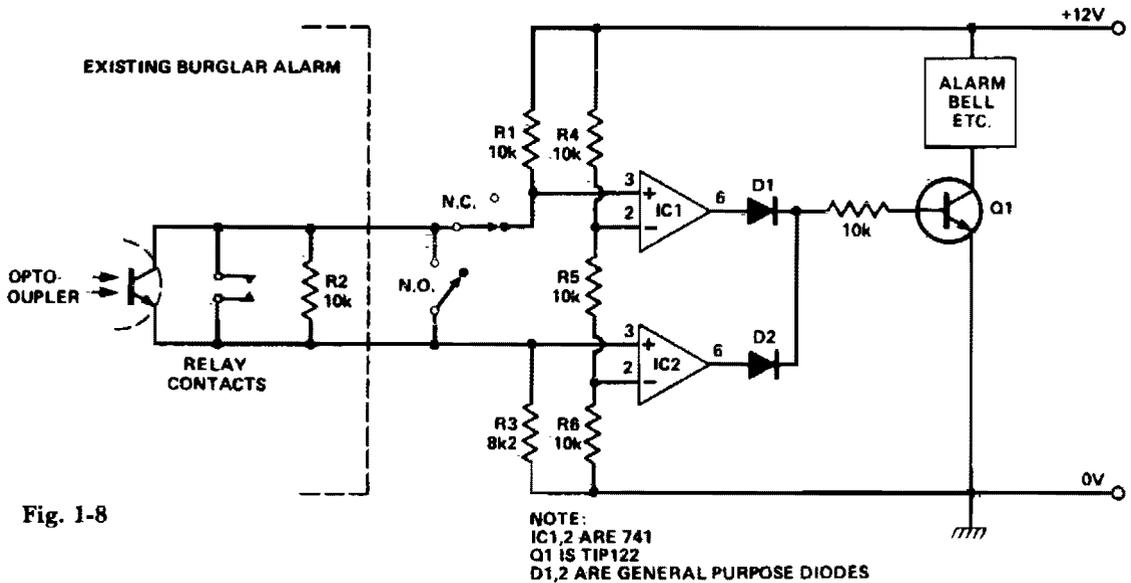


Fig. 1-8

Circuit Notes

If R2 is opened or shorted, the alarm sounds.

LATCHING BURGLAR ALARM

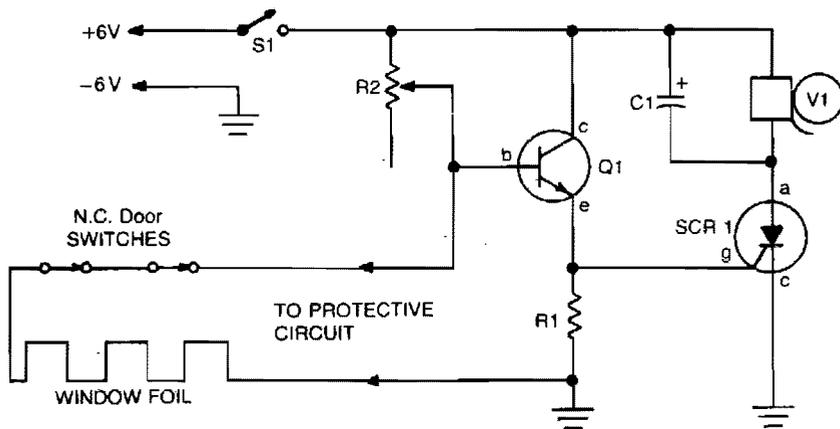


Fig. 1-9

Circuit Notes

When the protective circuit is interrupted (opened), the alarm sounds. To set the circuit, adjust R2 (with protective circuit open) for 1 V across R1.

MOTION-ACTIVATED MOTORCYCLE OR CAR ALARM

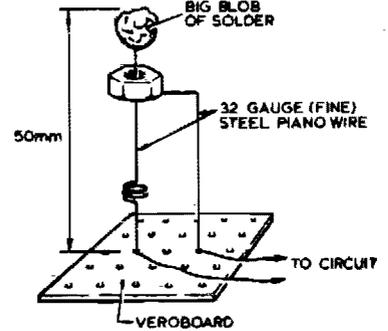
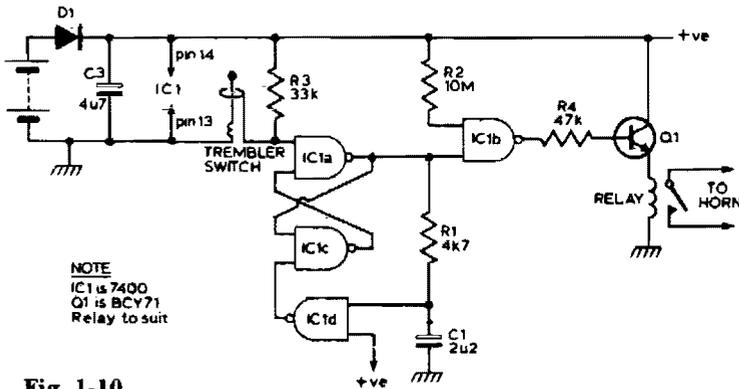


Fig. 1-10

Circuit Notes

Trembler (motion activated) switch sounds the alarm for 5 seconds. Then it goes off. Circuit is timed out for 10 seconds to allow the trembler switch to settle.

BOAT ALARM

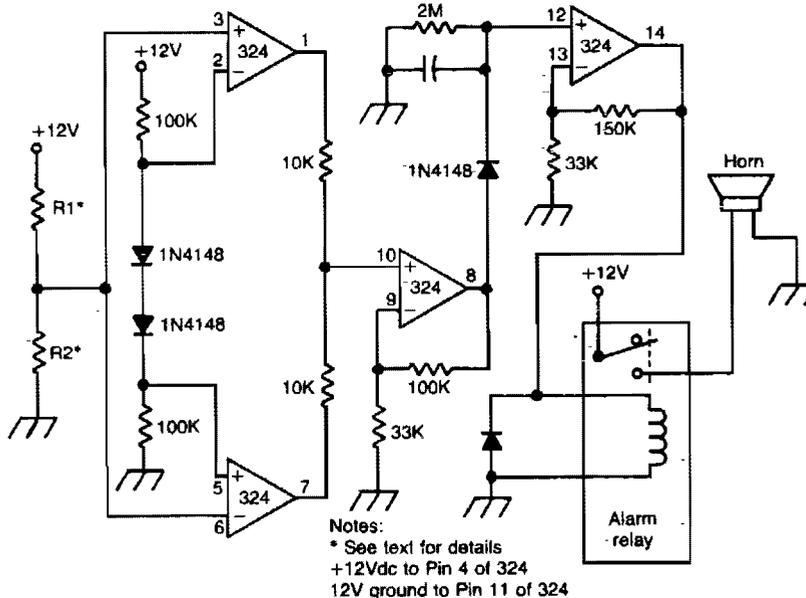


Fig. 1-11

Circuit Notes

Removing R1 or R2 from the circuit (i.e., the potential thief breaks a hidden wire that connects R1 to +12 V and R2 to ground) activates the alarm for about five minutes.

BLOWN-FUSE ALARM

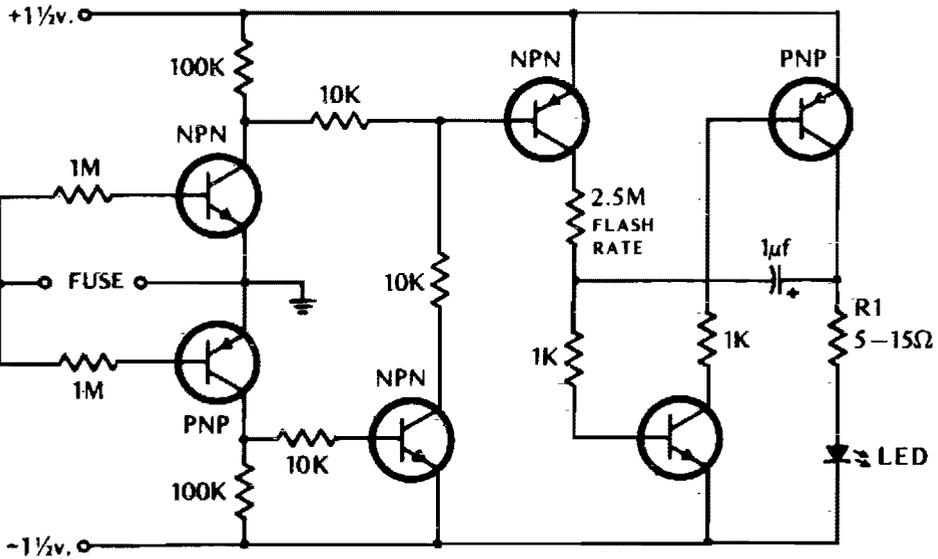


Fig. 1-12

Circuit Notes

If the fuse blows, the LED indicator starts to blink.

AUTO BURGLAR ALARM

SHORT DURATION TIMERS ARE NEEDED
TO ALLOW ENTRY AND EXIT

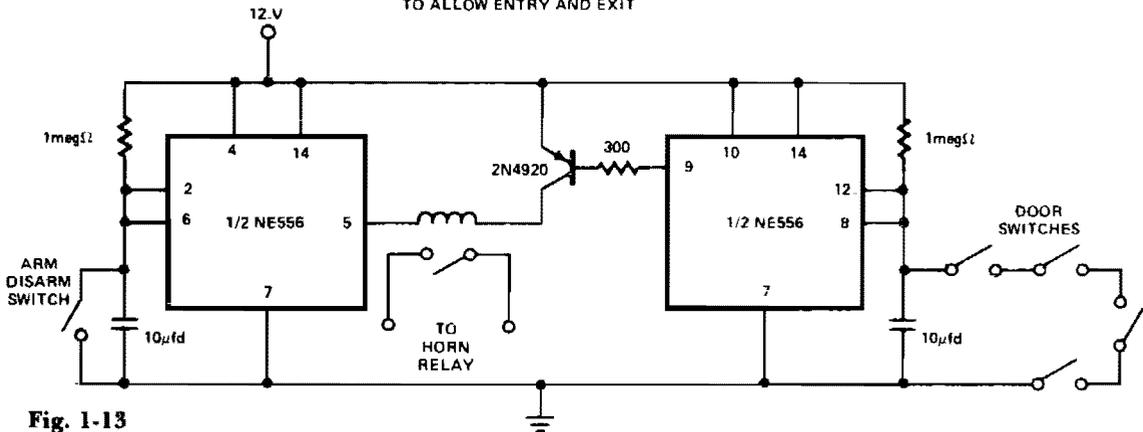
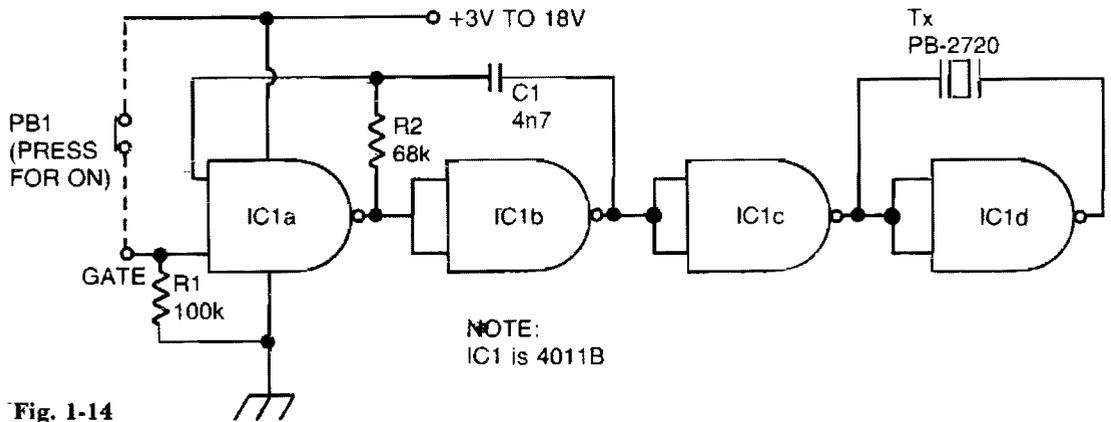
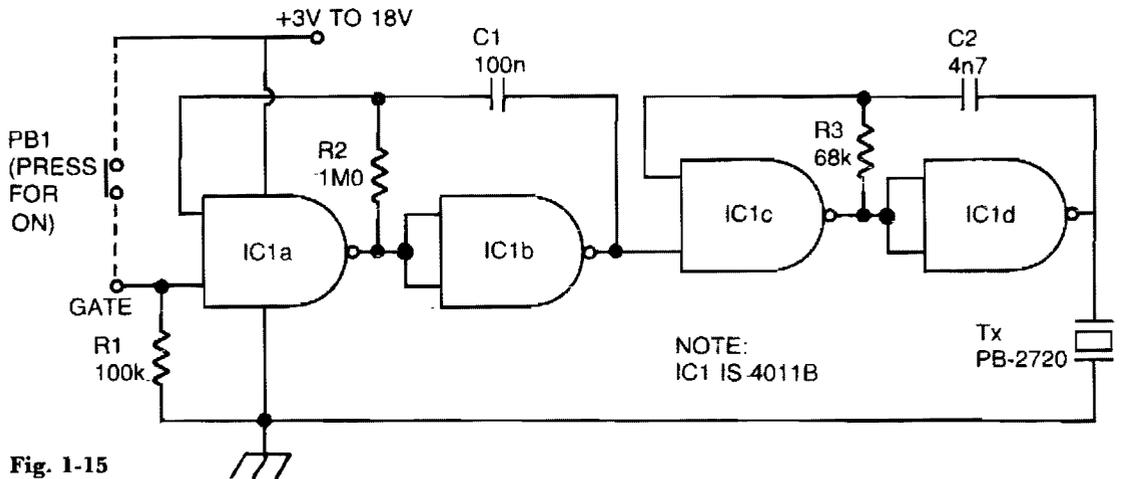


Fig. 1-13

**CONTINUOUS-TONE 2 kHz BUZZER
WITH BRIDGE DRIVE, GATED ON BY A LOGIC 0**



**PULSED-TONE ALARM,
GATED BY A HIGH INPUT,
WITH DIRECT-DRIVE OUTPUT**



SUN-POWERED ALARM

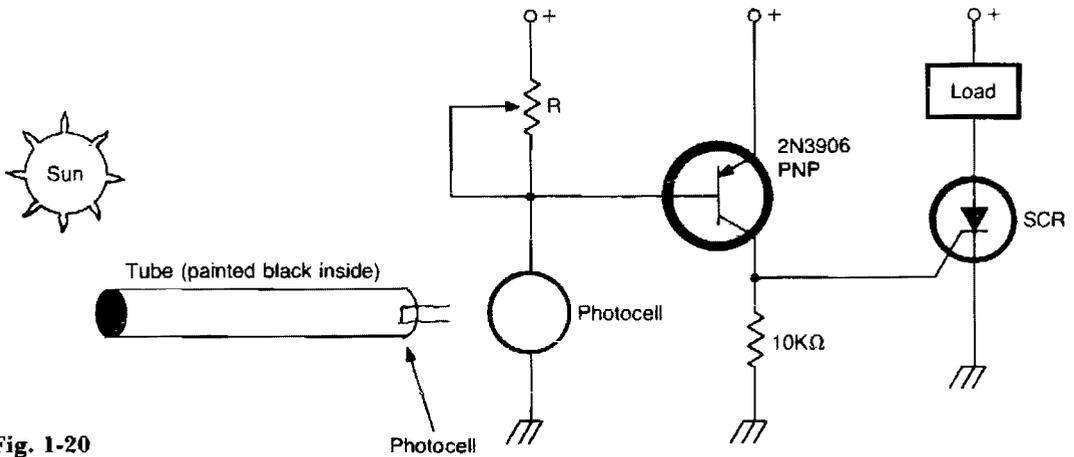


Fig. 1-20

Circuit Notes

Circuit turns on when light (sunlight) strikes photocell. Potentiometer R sets light level at which the alarm sounds. Painted tube (black on inside) may be used on photocell to aim at the sun.

FREEZER MELTDOWN ALARM

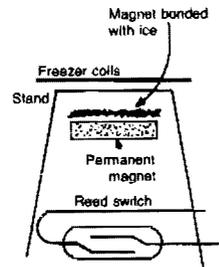
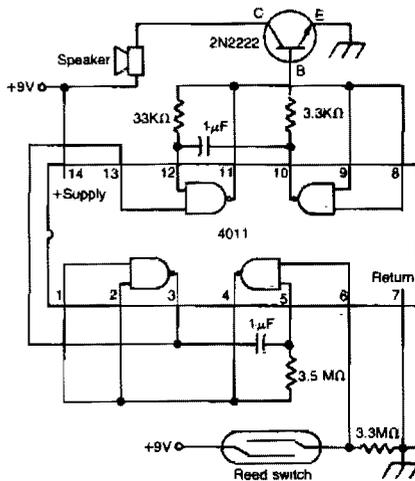


Fig. 1-21

Circuit Notes

The meltdown is a magnet held to a small stand by ice. A reed switch is below the magnet. When the ice melts, the magnet falls on the switch, closing it, and completing the alarm circuit.

2

Amateur Radio

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Code Practice Oscillator Produces Automatic
Dits and Dahs

Rf Power Meter

In-Line Wattmeter

CW Signal Processor

Two-Meter Preamplifier for Handitalkies

Repeater Beeper

Electronic Keyer

Code Practice Oscillator

Automatic Tape Recording

Self-Powered CW Monitor

Remote Rf Current Readout

Code Practice Oscillator

SWR Warning Indicator

Subaudible Tone Encoder

Audio Mixers

Rf Powered Sidetone Oscillator

Harmonic Generator

Automatic TTL Morse-Code Keyer

Remote Rf Current Readout

CODE-PRACTICE OSCILLATOR PRODUCES AUTOMATIC DITS AND DAHS

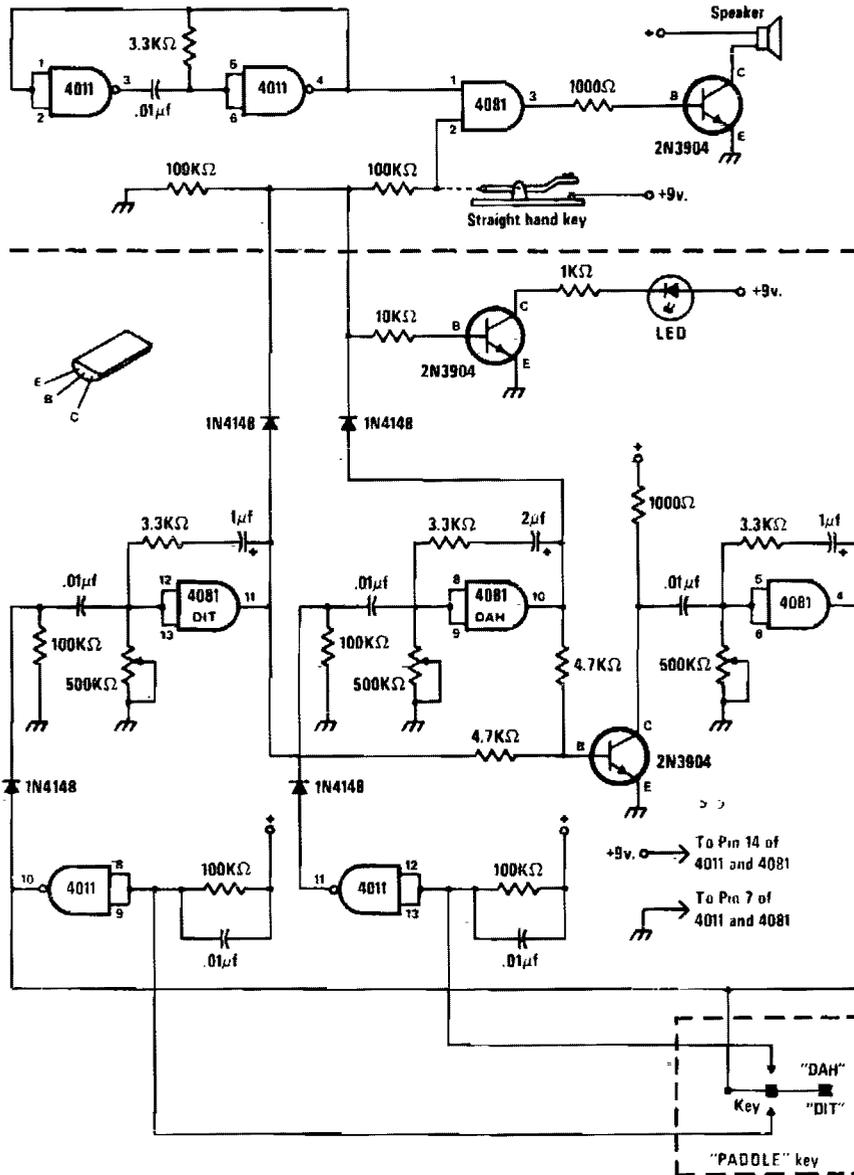


Fig. 2-1

Circuit Notes

The circuit consists of a basic oscillator (above dashed line) and an automatic keyer (below dashed line). The unit can be used with a straight hand key or a paddle key for automatic operation.

RF POWER METER

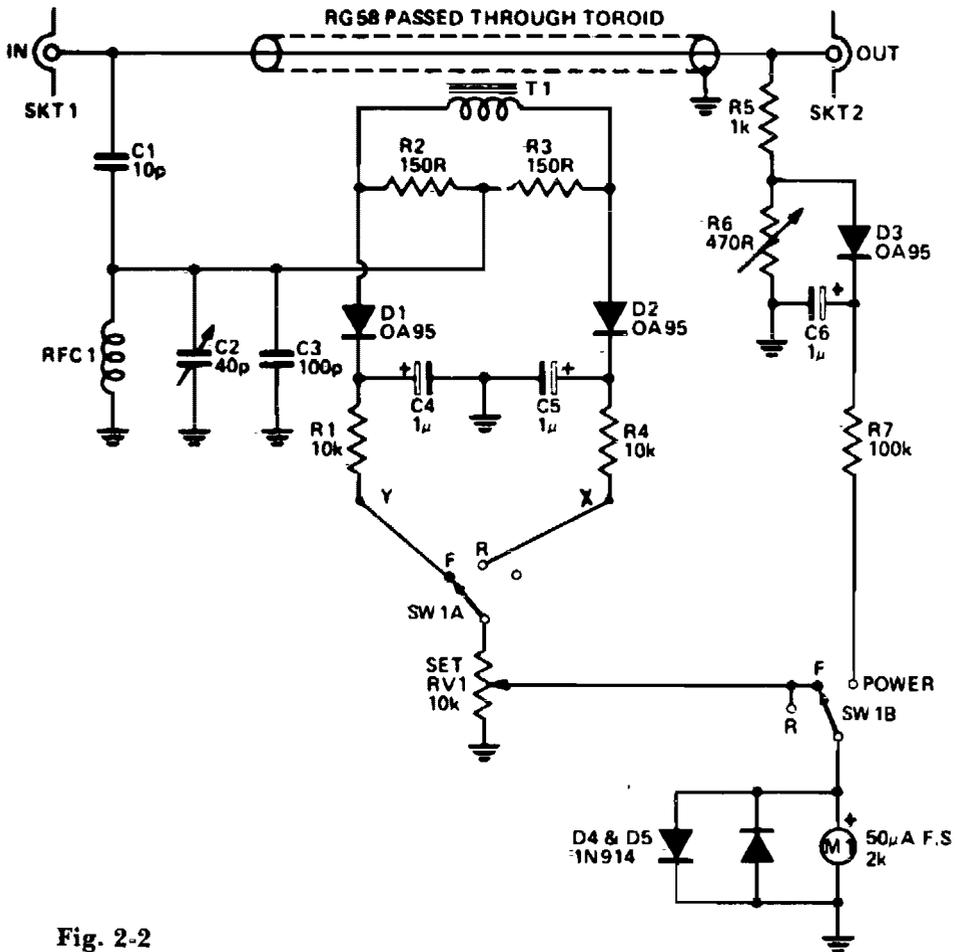


Fig. 2-2

Circuit Notes

Reflectometer (SWR Power Meter) covers three decades—from 100 kHz to 100 MHz. It can be constructed for rf powers as low as 500 mW or up to 500 watts.

IN-LINE WATTMETER

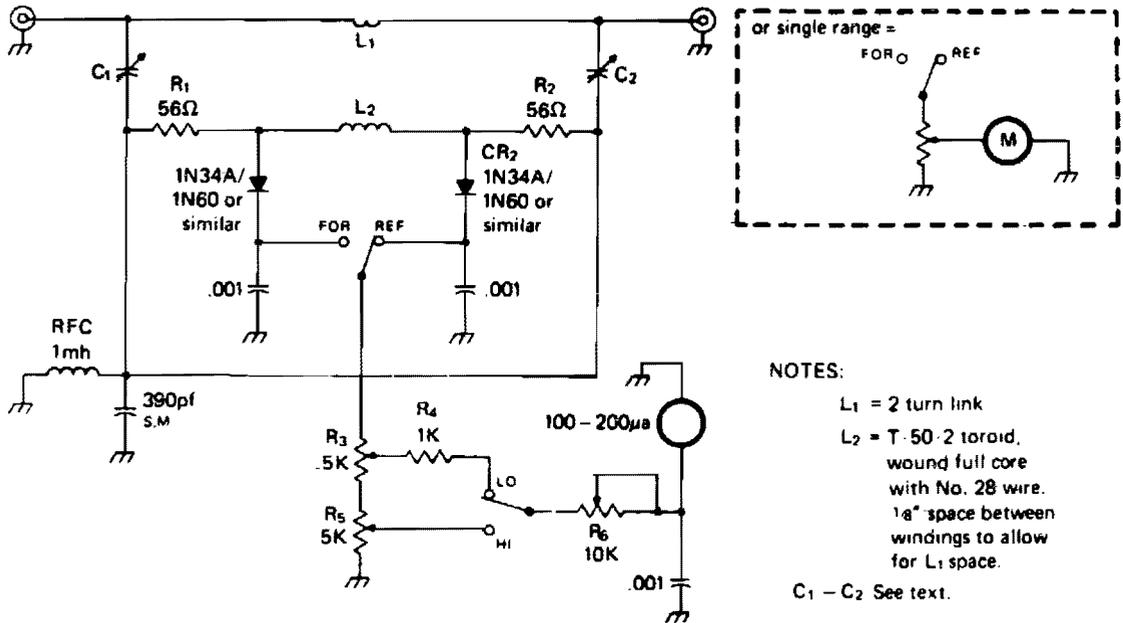


Fig. 2-3

Circuit Notes

The circuit is not frequency sensitive. Its calibration will be accurate over a wide frequency spectrum, such as the entire amateur hf spectrum, if the values of L₂, the voltage divider capacitors C₁₋₂ and C₃, and the resistances of R₁₋₂ are chosen properly. R₁₋₂ and CR₁₋₂ should be matched for best results. Generally, R₁₋₂ must be small compared to the

reactance of L₂ so as to avoid any significant effect on the L₂ current which is induced by the transmission line current flowing through L₁. The lower frequency limit of the bridge is set by the R₁₋₂/L_s ratio, and the cutoff is at the point where the value of R₁₋₂ becomes significant with reference to the reactance of L₂ at that frequency point.

CW SIGNAL PROCESSOR

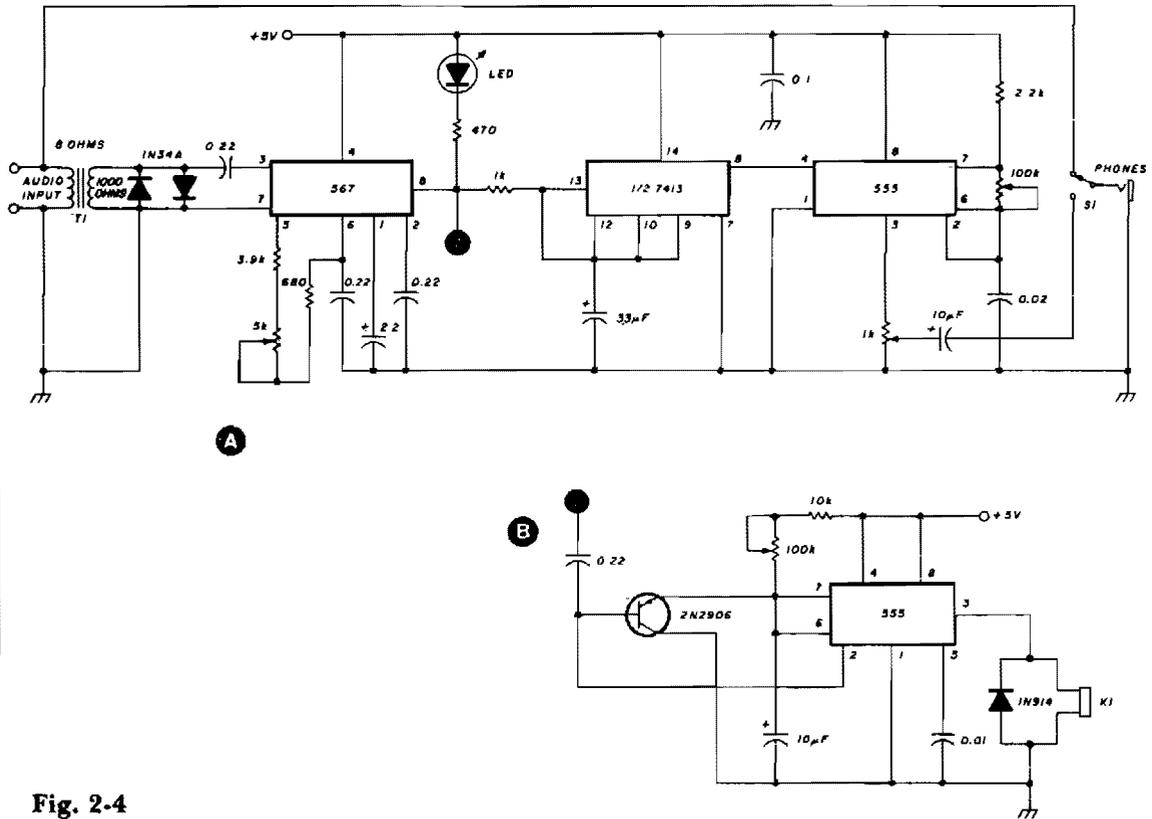


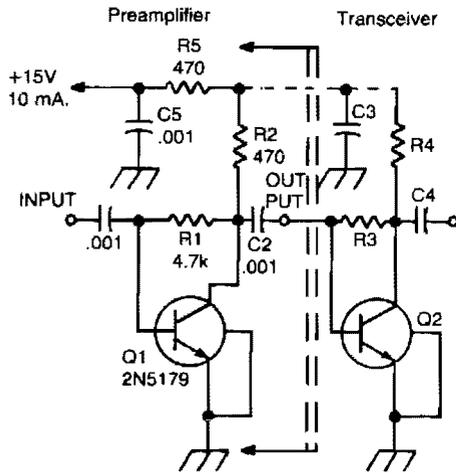
Fig. 2-4

Circuit Notes

This circuit provides interference rejection for the CW operator. The 567 phase-locked loop is configured to respond to tones from 500 to 1100 Hz. The Schmitt trigger reduces the weighting effect caused by the output of the PLL remaining low after removal of the audio signal. Ten to 15 millivolts of audio acti-

vate the circuit. For periods of loss of signal, circuit B will automatically switch back to live receiver audio after a suitable delay. (If a relay with a 5-volt coil is not available, the circuit can also be powered from +12 volts.) When circuit B is used, the contacts on relay K1 replace S1.

TWO-METER PREAMPLIFIER FOR HANDITALKIES



Circuit Notes

This simple, inexpensive, wideband rf amplifier provides 14 dB gain on two meters without the use of tuned circuits.

Fig. 2-5

REPEATER BEEPER

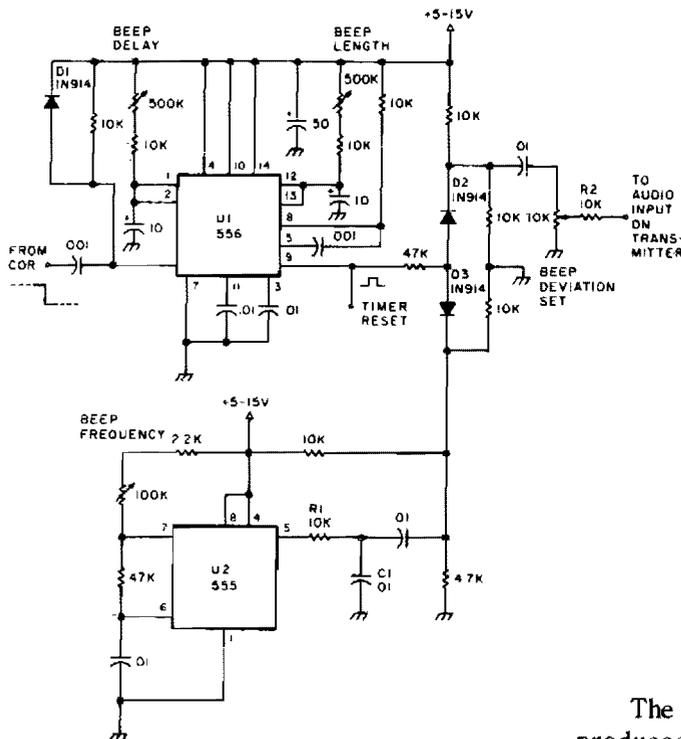


Fig. 2-6

Circuit Notes

The signal from COR triggers U1 which produces a beep-gate pulse that enables the analog gate consisting of D2 and D3 to pass the beep tone generated by U2.

DELAY RANGE 0.15 TO 5 SECONDS
 BURST RANGE 0.15 TO 5 SECONDS
 TONE RANGE 500 TO 1400HZ

ELECTRONIC KEYS

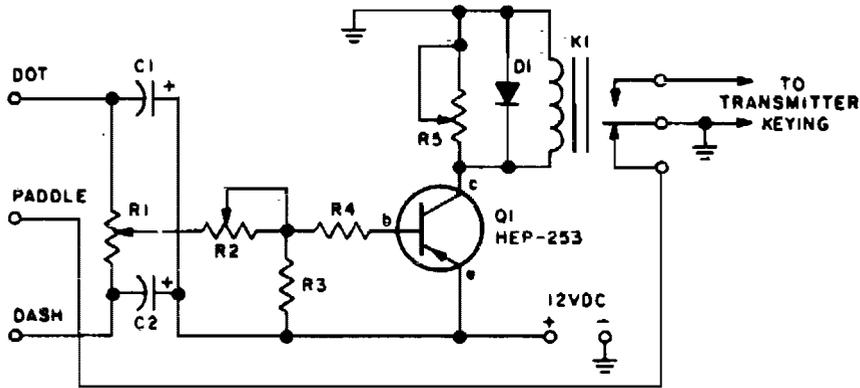


Fig. 2-7

PARTS LIST FOR HAM'S KEYS
C1—3- μ F, 6-VDC electrolytic capacitor
C2—10- μ F, 6-VDC electrolytic capacitor
D1—1N60 diode
K1—12-VDC relay

Q1—HEP-253 pnp transistor
R1—10,000-ohm linear potentiometer
R2—50,000-ohm potentiometer
R3—1,200-ohm, 1/2-watt resistor
R4—560-ohm, 1/2-watt resistor
R5—5,000-ohm potentiometer

Circuit Notes

This circuit automatically produces Morse code dots and dashes set by time constants involving C1 and C2. R1 sets dot/dash ratio and R2 sets the speed. R5 sets the relay drop-out point.

CODE PRACTICE OSCILLATOR

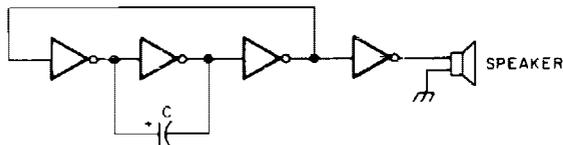
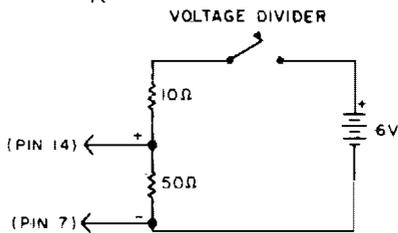
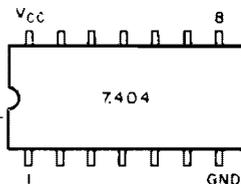


Fig. 2-8



Circuit Notes

This simple cpo uses the 7404 low-power Schottky hex inverter. C is a 5- to 30- μ F electrolytic selected for the desired pitch. The speaker is a 2-inch, 8-ohm unit.



AUTOMATIC TAPE RECORDING

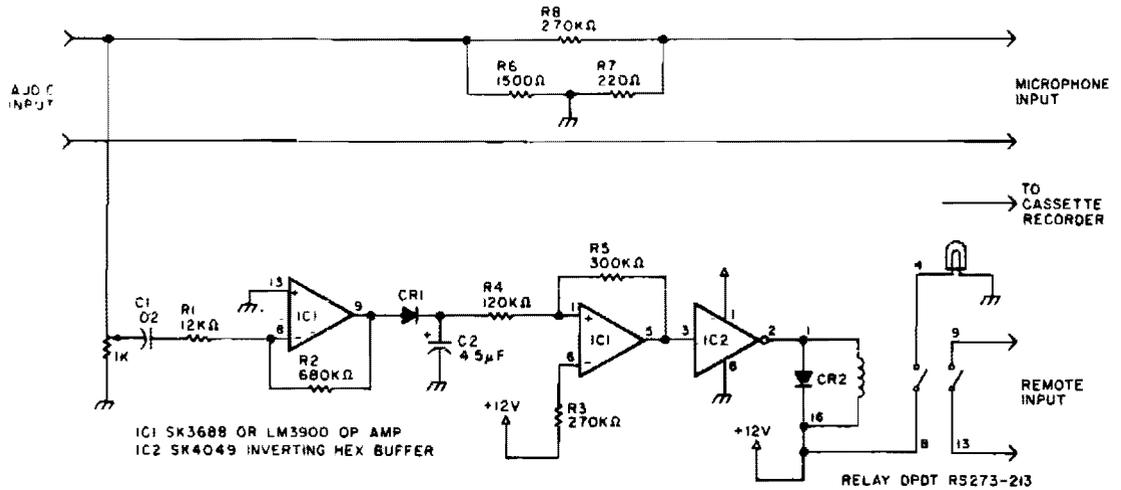


Fig. 2-9

Circuit Notes

Amateurs don't have to miss the action while away from the rig. This circuit turns on a tape recorder whenever the receiver's squelch is broken. After signal loss, the recorder will shut off following a slight delay.

SELF-POWERED CW MONITOR

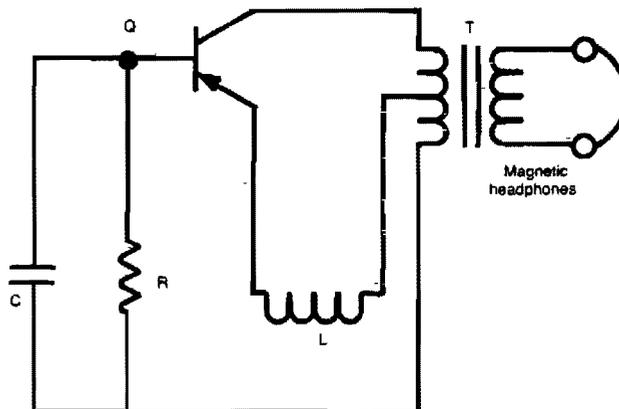


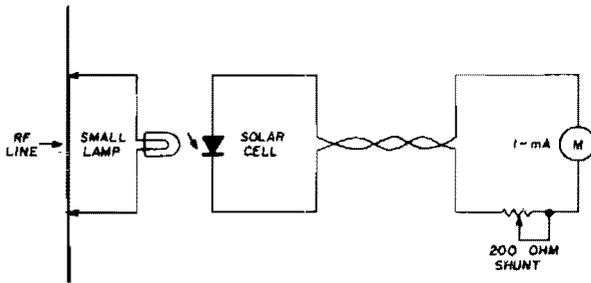
Fig. 2-10

Circuit Notes

Position L near the transmitter output tank to hear the key-down tone. Then tape the coil in place. C = .047 μ F, R = 8.2 K, Q = HEP 253 (or equal), T = 500: 500 ohm center tapped transformer. L = 2 to 6 turns on $\frac{1}{2}$ " coil form.

REMOTE RF CURRENT READOUT

Circuit Notes

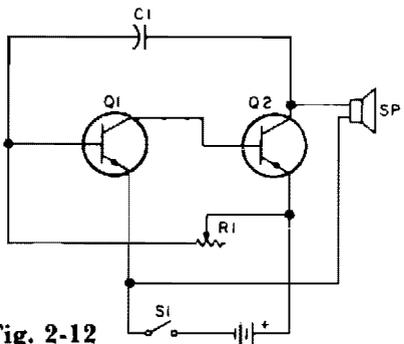


A suitable pilot lamp is illuminated by a small sample of rf and energizes an inexpensive solar cell; the dc current generated by the cell is a measure of relative rf power, and may be routed to a low-current meter located at any convenient point. A sensitive, low-current pilot lamp is desirable to cause minimum disturbance to normal rf circuit conditions. The number 48 or 49, 60 mA lamp is suitable for use with transmitters above 1-watt output.

Fig. 2-11

CODE PRACTICE OSCILLATOR

Circuit Notes

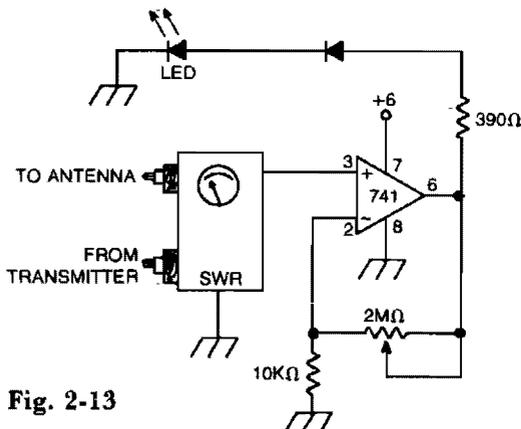


Oscillator, works with 2 to 12Vdc (but 9 to 12 volts gives best volume and clean keying). R1 can be replaced with a 500 K pot and the circuit will sweep the entire audio frequency range.

Fig. 2-12

SWR WARNING INDICATOR

Circuit Notes



Op amp with dc input from SWR meter can be adjusted to preset the SWR reading at which the LED lights.

Fig. 2-13

SUBAUDIBLE TONE ENCODER

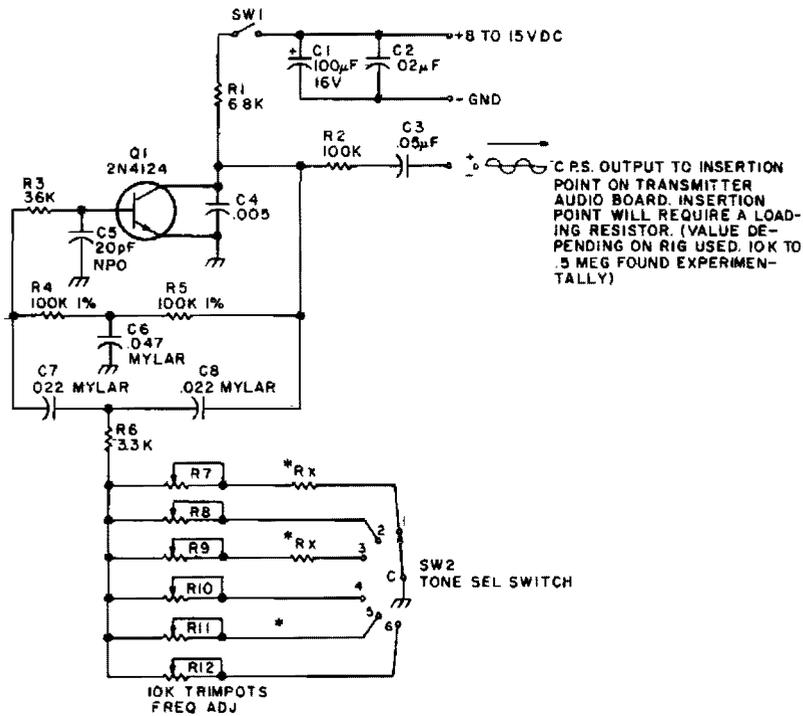


Fig. 2-14

Circuit Notes

This twin-T oscillator produces six preset subaudible tones from 93 to 170 Hz in three ranges.

AUDIO MIXER

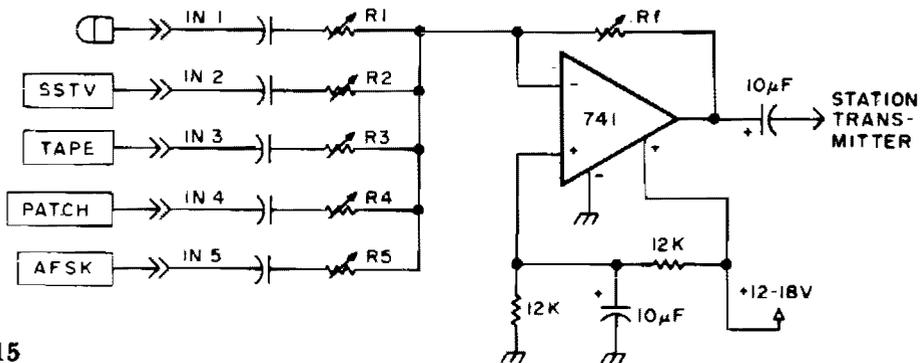


Fig. 2-15

Circuit Notes

The 741 op amp is used as a summing amplifier to combine several audio inputs. Overall gain is set by R_f .

RF-POWERED SIDETONE OSCILLATOR

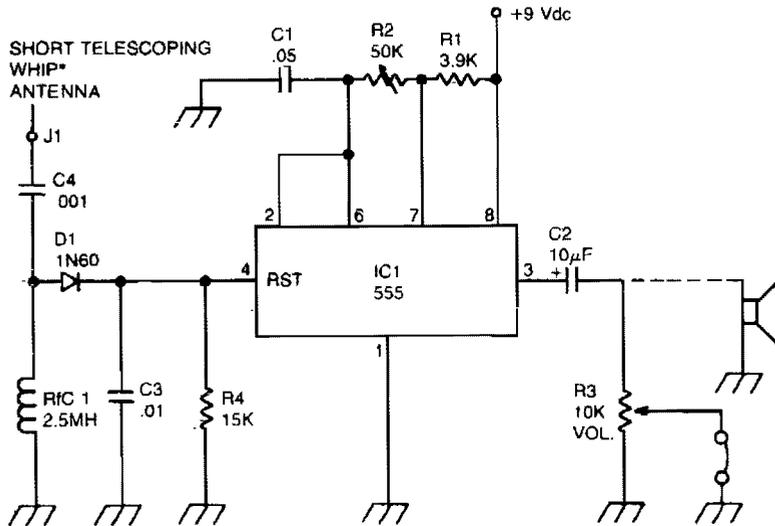


Fig. 2-16

*PORTABLE RADIO REPLACEMENT TYPE

Circuit Notes

A sidetone oscillator is a special audio oscillator that is turned on and off with the transmitter. The oscillator is rf-driven and battery operated. It uses a 555 IC timer as an

astable multivibrator. Keying is accomplished by applying a positive dc potential, developed from the rf signal, to the reset terminal of the 555.

HARMONIC GENERATOR

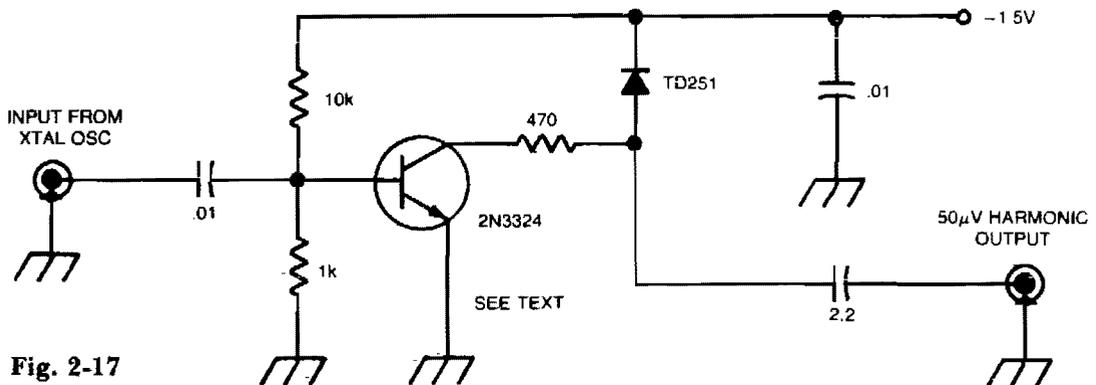


Fig. 2-17

Circuit Notes

This circuit will produce $50 \mu\text{V}$ harmonics through 1296 MHz with an input of 0.15-1 V from a 100 or 1000 kHz crystal oscillator. With a germanium diode instead of a tunnel diode, harmonics can be heard up to about 147 MHz.

AUTOMATIC TTL MORSE-CODE KEY

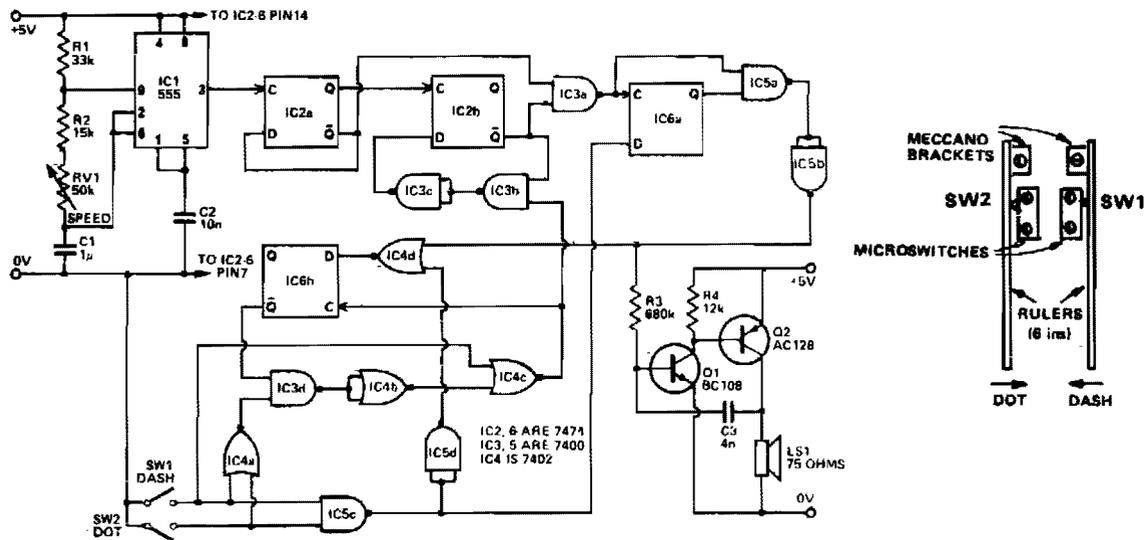


Fig. 2-18

Circuit Notes

Automatically generated dits and dahs are produced over a speed range of 11 to 39 wpm. The upper limit can be raised by decreasing R2. SW1 and SW2 can be a "home-brew" paddle operated key.

3

Amplifiers

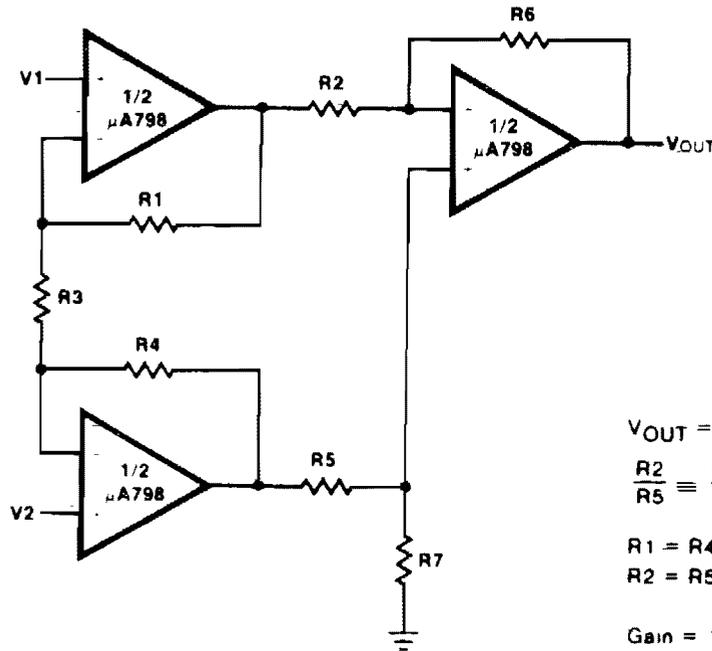
The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

High Impedance Differential Amplifier
Unity Gain Follower
Voltage Controlled Variable Gain Amplifier
Power Booster
Logarithmic Amplifier
Voltage Controlled Variable Gain Amplifier
Discrete Current Booster
Precision Process Control Interface
Voltage Controlled Amplifier
Absolute Value Amplifier
Programmable Gain Noninverting Amplifier
with Selectable Inputs
× 1000 Amplifier Circuit
Inverting Amplifier with Balancing Circuit
Switching Power Amplifier
Precision Power Booster
Noninverting Voltage Follower
Color Video Amplifier
Fast Voltage Follower
Isolation Amplifier for Capacitive Loads
Cable Bootstrapping
Current Booster
Wideband Unity Gain Inverting Amplifier
in a 75 Ohm System
High-Speed Current to Voltage Output
Amplifier

Gated Amplifier
Reference Voltage Amplifier
Fast Summing Amplifier
Adjustment-Free Precision Summing Amplifier
Summing Amplifier with Low Input Current
× 10 Operational Amplifier Using L161
× 100 Operational Amplifier Using L161
Precision Absolute Value Circuit
Ultra-Low-Leakage Preamp
Dc to Video Log Amplifier
±100 V Common Mode Range Differential
Amplifier
Wide Bandwidth, Low Noise, Low Drift
Amplifier
Signal Distribution Amplifier
Audio Distribution Amplifier
High Input Impedance, High Output Current
Voltage Follower
Precision Amplifier
Preamplifier and High-to-Low Impedance
Converter
Noninverting Amplifier
High Impedance, High Gain, High Fre-
quency Inverting Amp
Log-Ratio Amplifier
Inverting Amplifier

Logarithmic Amplifier

HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER



$$V_{OUT} = C (1 + a + b)(V_2 - V_1)$$

$$\frac{R_2}{R_5} \equiv \frac{R_6}{R_7} \text{ for best CMRR}$$

$$R_1 = R_4$$

$$R_2 = R_5$$

$$\text{Gain} = \frac{R_6}{R_2} \left(1 + \frac{2R_1}{R_3} \right) = C (1 + a + b)$$

Fig. 3-1

UNITY GAIN FOLLOWER

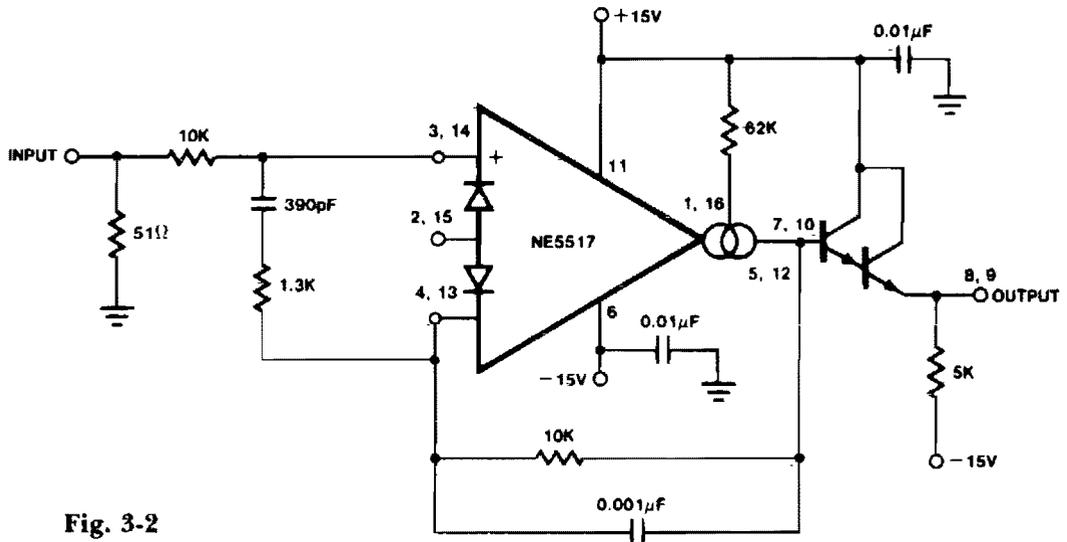


Fig. 3-2

VOLTAGE CONTROLLED VARIABLE GAIN AMPLIFIER

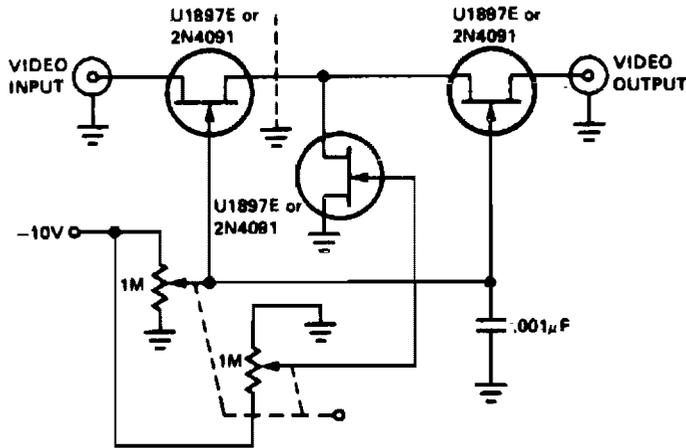
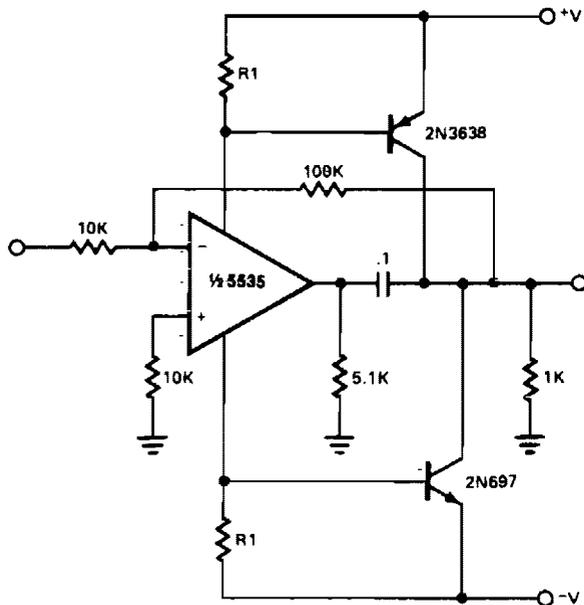


Fig. 3-3

Circuit Notes

The tee attenuator provides for optimum dynamic linear range attenuation up to 100 dB, even at $f = 10.7$ MHz with proper layout.

POWER BOOSTER



Circuit Notes

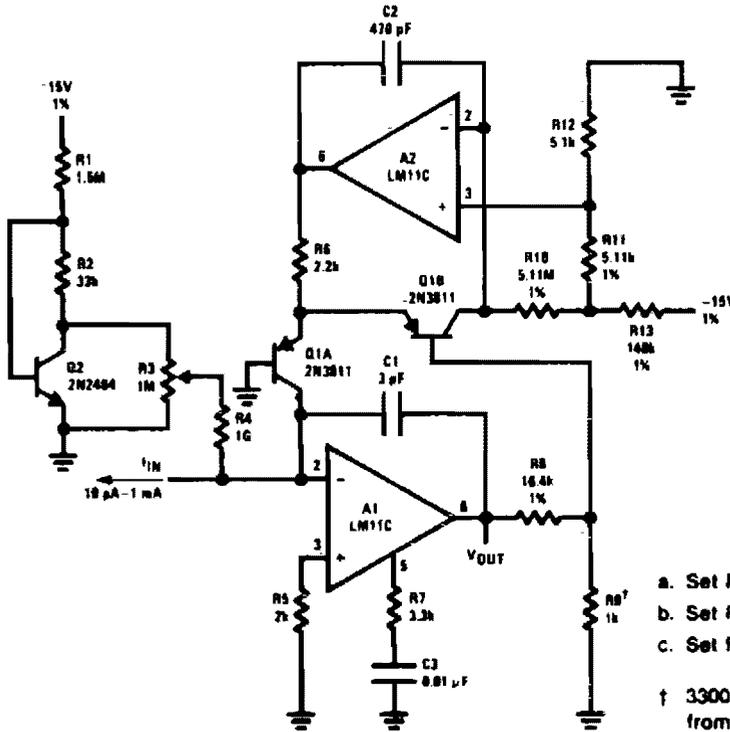
Power booster is capable of driving moderate loads. The circuit as shown uses a NE5535 device. Other amplifiers may be substituted only if $R1$ values are changed because of the I_{cc} current required by the amplifier. $R1$ should be calculated from the following expression:

$$R1 = \frac{600 \text{ mW}}{I_{cc}}$$

All resistor values are in ohms.

Fig. 3-4

LOGARITHMIC AMPLIFIER

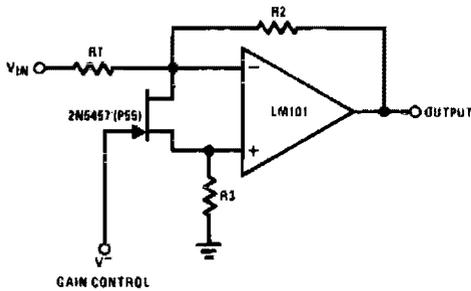


- a. Set R11 for $V_{OUT} = 0$ at $I_{IN} = 100 \mu A$
 - b. Set R8 for $V_{OUT} = 3V$ at $I_{IN} = 100 \mu A$
 - c. Set R3 for $V_{OUT} = -4V$ at $I_{IN} = 10 \text{ pA}$
- † 3300 ppM/°C. Type Q209 available from Tel Labs, Inc., Manchester, N.H.

Circuit Notes

Unusual frequency compensation gives this logarithmic converter a 100 μs time constant from 1 mA down to 100 μA , increasing from 200 μs to 200 ms from 10 nA to 10 pA. Optional bias current compensation can give 10 pA resolution from -55 °C to 100 °C. Scale factor is 1 V/decade and temperature compensated.

VOLTAGE CONTROLLED VARIABLE GAIN AMPLIFIER



Circuit Notes

The 2N5457 acts as a voltage variable resistor with an $R_{ds(on)}$ of 800 ohms max. Since the differential voltage on the LM101 is in the low mV range, the 2N5457 JFET will have linear resistance over several decades of resistance providing an excellent electronic gain control.

Fig. 3-6

DISCRETE CURRENT BOOSTER

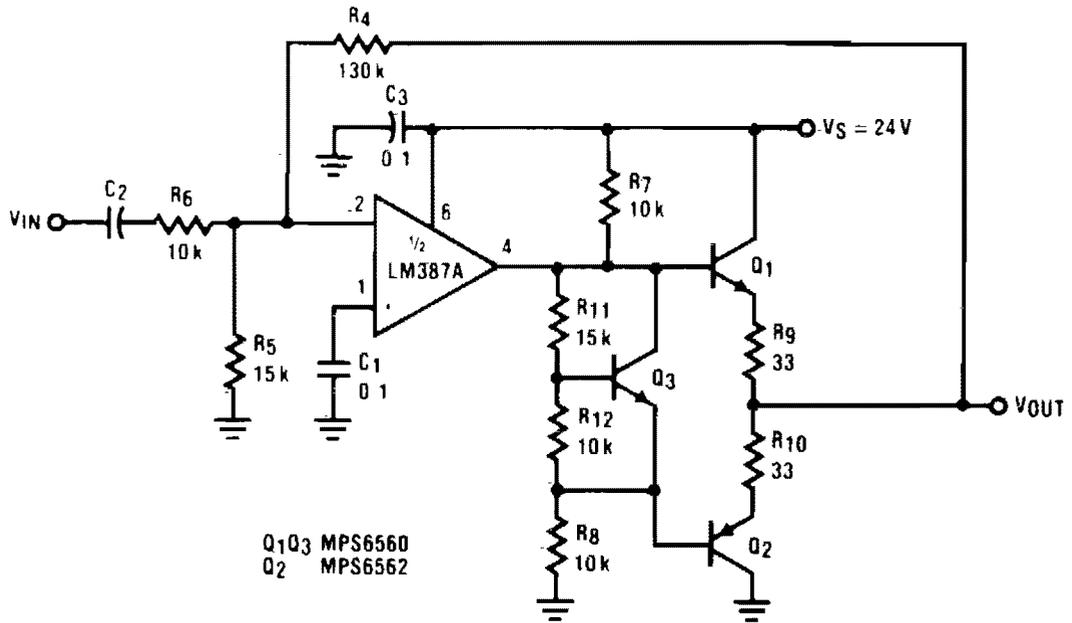


Fig. 3-7

PRECISION PROCESS CONTROL INTERFACE

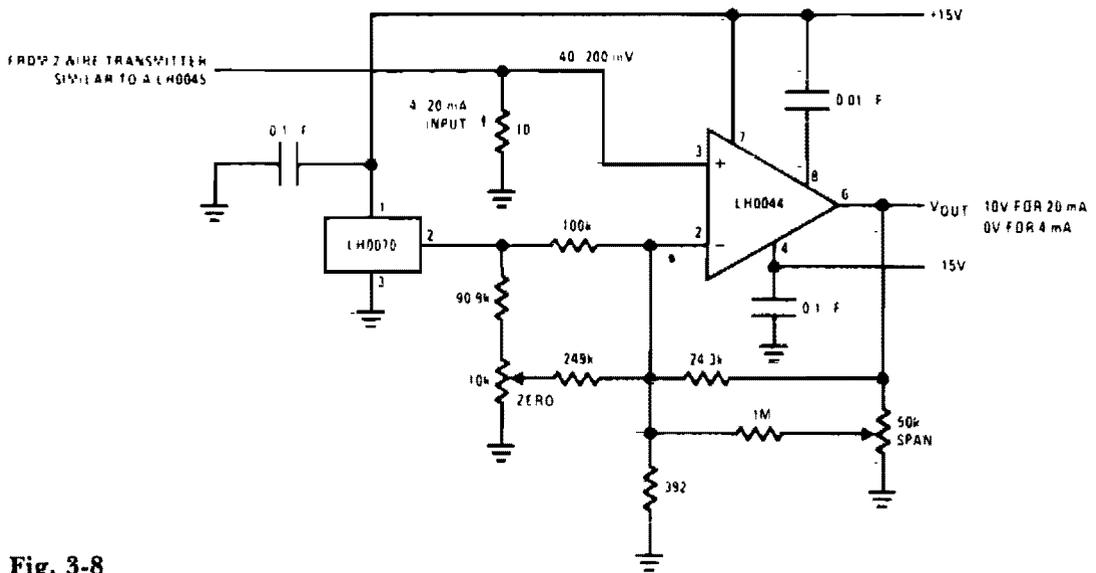


Fig. 3-8

VOLTAGE CONTROLLED AMPLIFIER

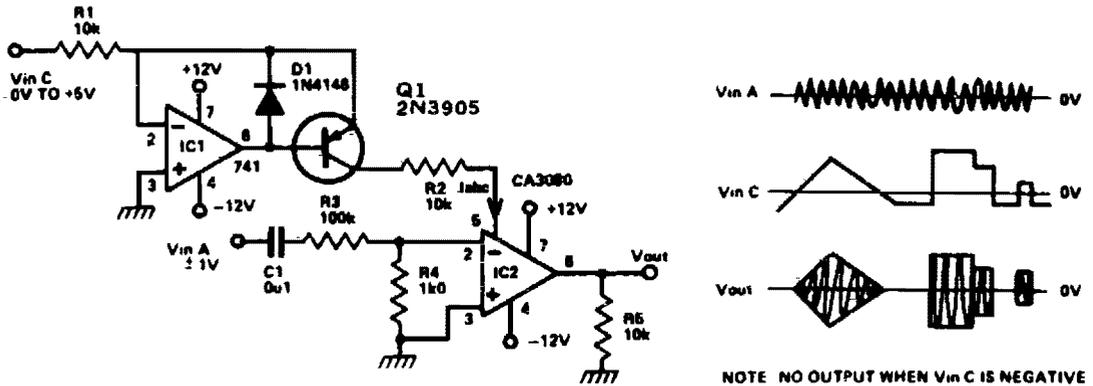


Fig. 3-9

Circuit Notes

This circuit is basically an op amp with an extra input at pin 5. A current I_{ABC} is injected into this input and this controls the gain of the device linearly. Thus by inserting an audio sig-

nal (± 10 mV) between pin 2 and 3 and by controlling the current on pin 5, the level of the signal output (pin 6) is controlled.

ABSOLUTE VALUE AMPLIFIER

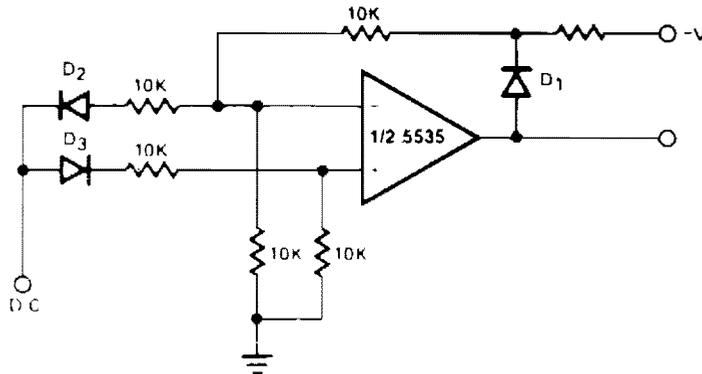


Fig. 3-10

Circuit Notes

The circuit generates a positive output voltage for either polarity of input. For positive signals, it acts as a noninverting amplifier and for negative signals, as an inverting amplifier.

The accuracy is poor for input voltages under 1 V, but for less stringent applications, it can be effective.

PROGRAMMABLE GAIN NONINVERTING AMPLIFIER WITH SELECTABLE INPUTS

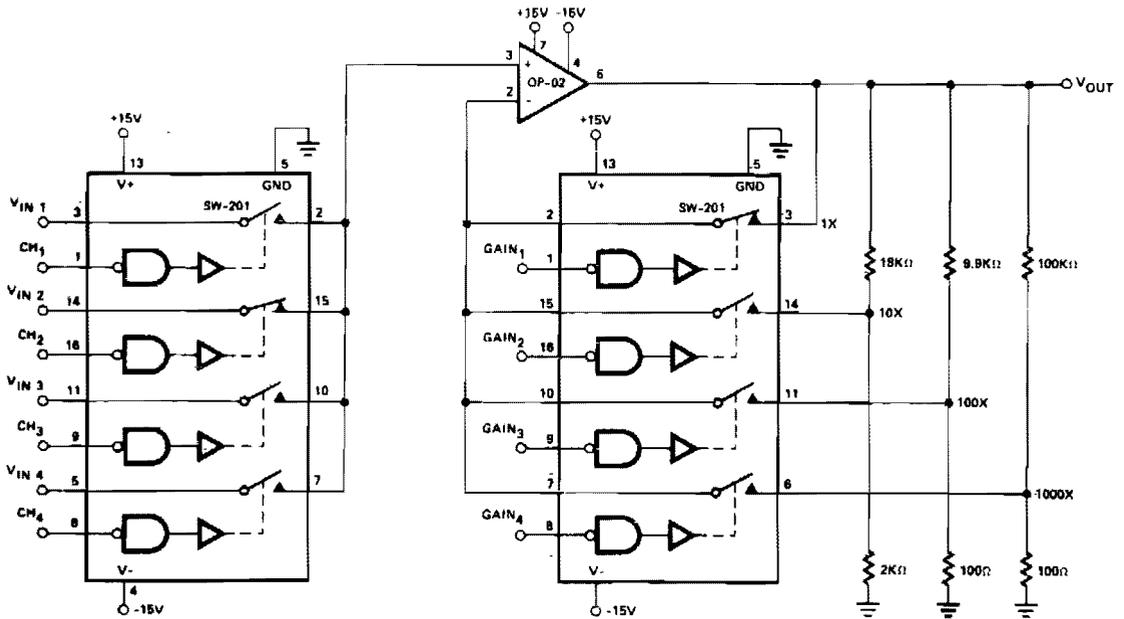


Fig. 3-11

× 1000 AMPLIFIER CIRCUIT

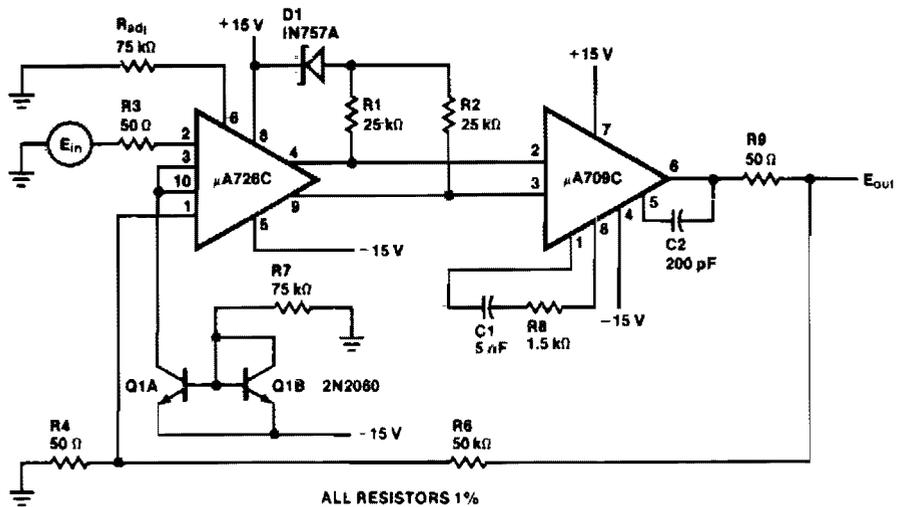


Fig. 3-12

INVERTING AMPLIFIER WITH BALANCING CIRCUIT

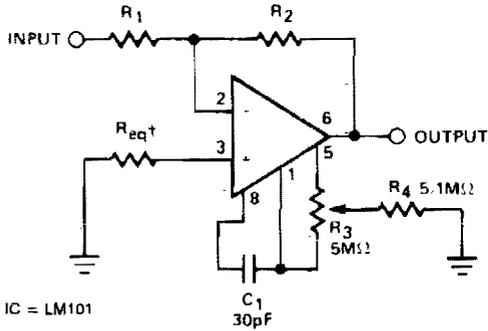


Fig. 3-13

Circuit Notes

R_{eq} may be zero or equal to the parallel combination of R_1 and R_2 for minimum offset.

PRECISION POWER BOOSTER

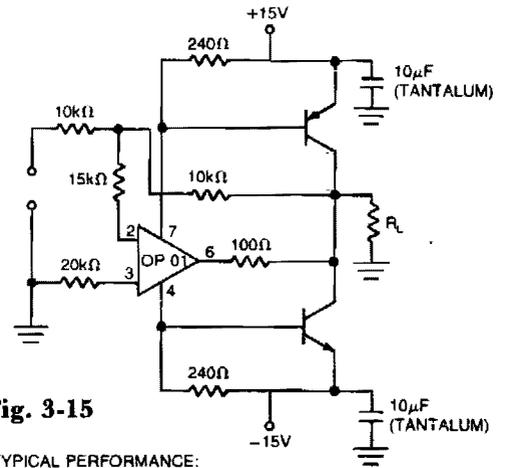


Fig. 3-15

TYPICAL PERFORMANCE:
 SLEW RATE..... $\approx 18V/\mu SEC$
 0.1% SETTling..... $4\mu SEC$ ($R_L = 500$)
 QUIESCENT SUPPLY CURRENT... $1.5mA$

SWITCHING POWER AMPLIFIER

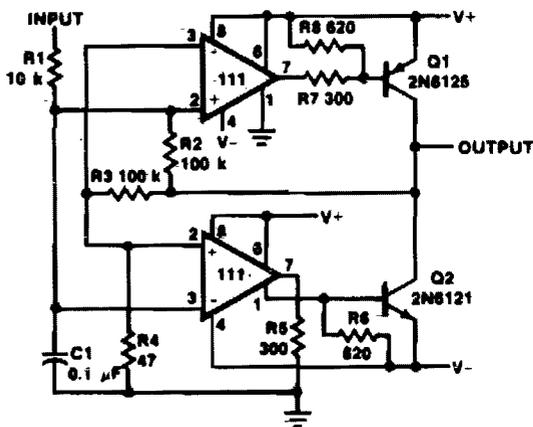


Fig. 3-14

NONINVERTING VOLTAGE FOLLOWER

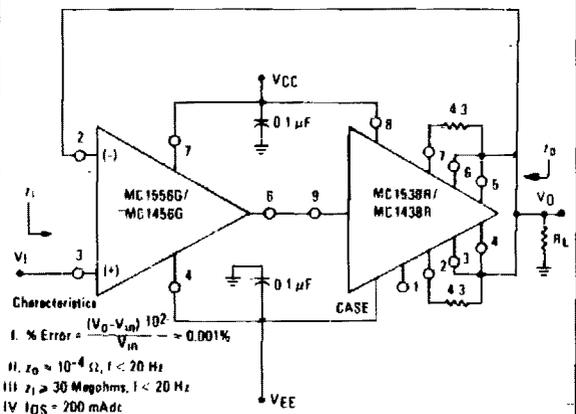
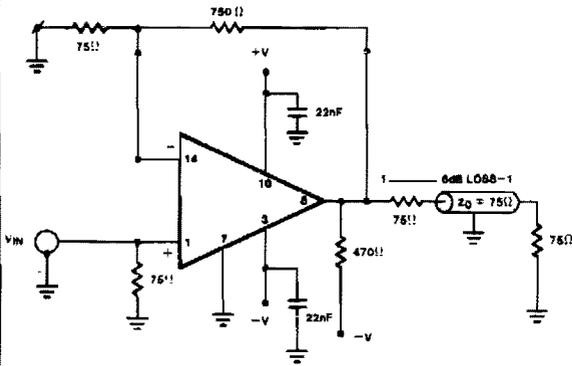


Fig. 3-16

Characteristics
 I. % Error = $\frac{(V_O - V_{in})}{V_{in}} \cdot 10^2 \approx 0.001\%$
 II. $Z_o \approx 10^{-4} \Omega, f < 20 \text{ Hz}$
 III. $Z_i \approx 30 \text{ Megohms}, f < 20 \text{ Hz}$
 IV. $I_{QS} = 200 \text{ mAdc}$

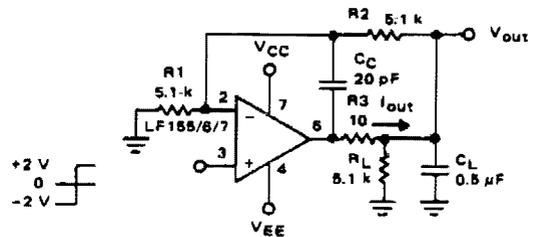
COLOR VIDEO AMPLIFIER



IC = NE5539

Fig. 3-17

ISOLATION AMPLIFIER FOR CAPACITIVE LOADS



- Overshoot 5%
- $t_s = 10 \mu s$
- When driving large C_L , the V_{OUT} slew rate is determined by C_L and $I_{out(max)}$:

$$\frac{\Delta V_{out}}{\Delta t} = \frac{I_{out}}{C_L} \approx \frac{0.02}{0.5} \text{ V}/\mu s = 0.04 \text{ V}/\mu s \text{ (with } C_L \text{ shown)}$$

Fig. 3-19

FAST VOLTAGE FOLLOWER

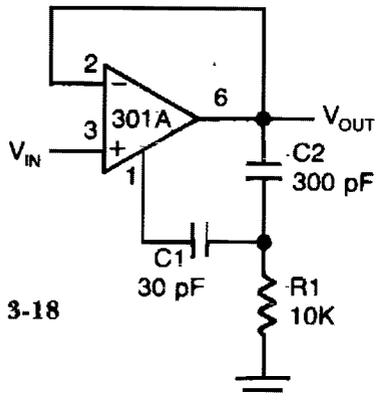


Fig. 3-18

Power Bandwidth: 15 kHz
Slew Rate: 1V/ μs

CABLE BOOTSTRAPPING

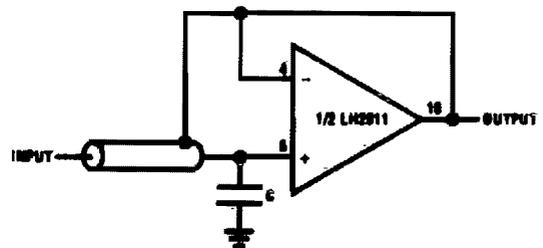
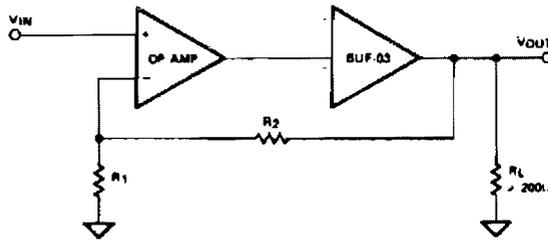


Fig. 3-20

Circuit Notes

Bootstrapping input shield for a follower reduces cable capacitance, leakage, and spurious voltages from cable flexing. Instability can be avoided with small capacitor on input.

CURRENT BOOSTER



GAIN = $\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_2}{R_1}$
 MAXIMUM LOAD CURRENT = (80mA (10V ÷ 200Ω))

Fig. 3-21

HIGH-SPEED CURRENT TO VOLTAGE OUTPUT AMPLIFIER

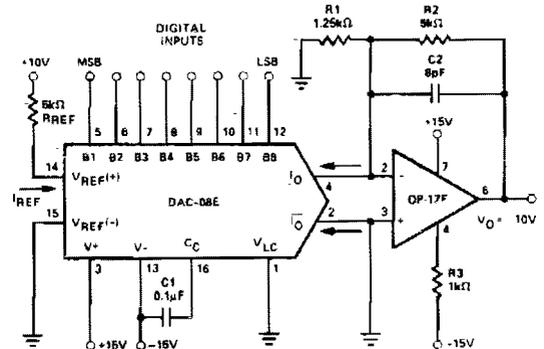


Fig. 3-23

WIDEBAND UNITY GAIN INVERTING AMPLIFIER IN A 75 OHM SYSTEM

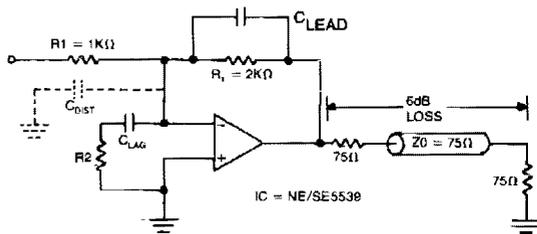


Fig. 3-22

LOGARITHMIC AMPLIFIER

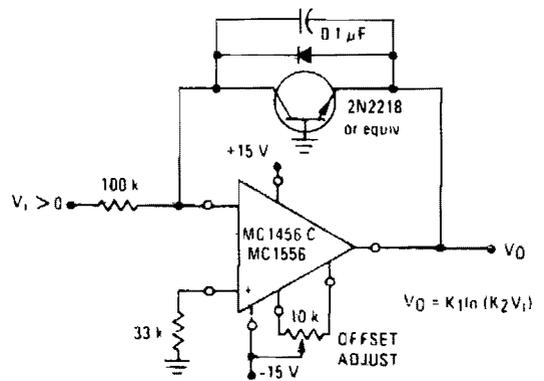


Fig. 3-24

GATED AMPLIFIER

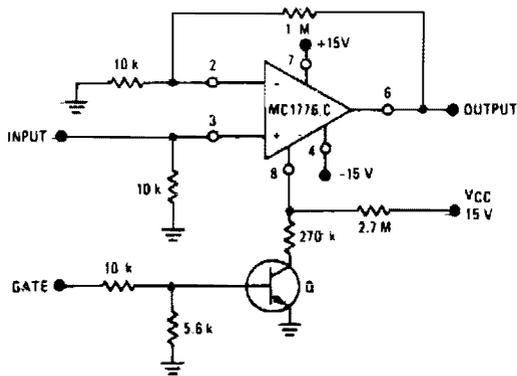
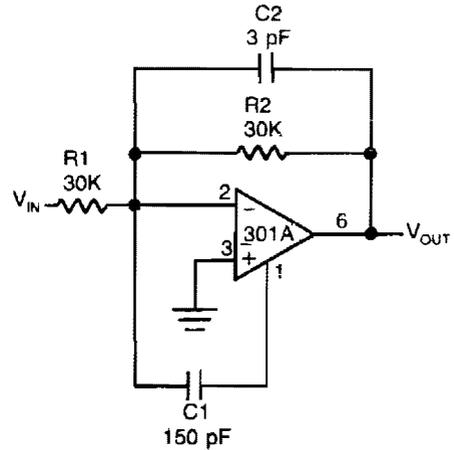


Fig. 3-25

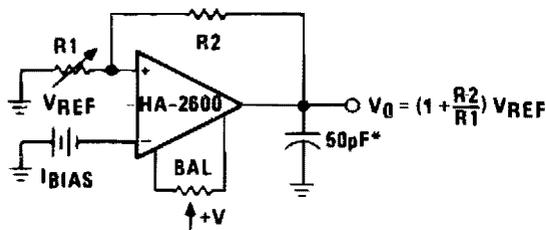
FAST SUMMING AMPLIFIER



Power Bandwidth: 250 kHz
 Small Signal Bandwidth: 3.5 MHz
 Slew Rate: 10V/ μ s

Fig. 3-27

REFERENCE VOLTAGE AMPLIFIER



FEATURES

- 1 MINIMUM BIAS CURRENT IN REFERENCE CELL
- 2 SHORT CIRCUIT PROTECTION

IC = HA-OP07

Fig. 3-26

ADJUSTMENT-FREE PRECISION SUMMING AMPLIFIER

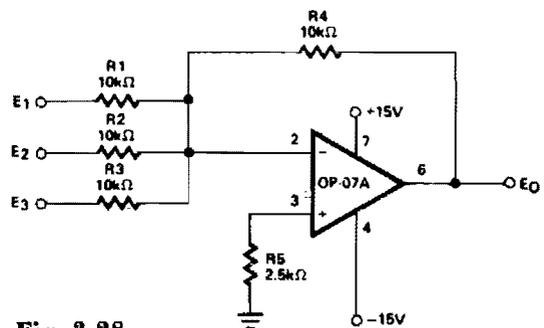
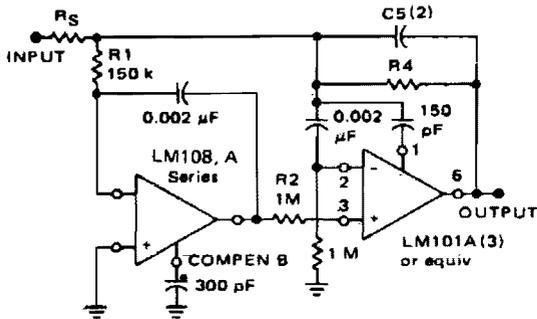


Fig. 3-28

Circuit Notes

This circuit produces continuous outputs that are a function of multiple input variables.

SUMMING AMPLIFIER WITH LOW INPUT CURRENT



- (1) Power Bandwidth: 250 kHz
 Small Signal Bandwidth: 3.5 MHz
 Slew Rate: 10 V/μs
 (2) $C5 = \frac{6 \times 10^{-8}}{R1}$
- (3) In addition to increasing speed, the LM101A raises high and low frequency gain, increases output drive capability and eliminates thermal feedback.

Fig. 3-29

× 100 OPERATIONAL AMPLIFIER USING L161

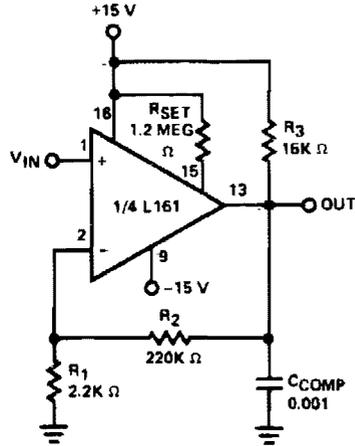


Fig. 3-31

Circuit Notes

Amplifier has gain-bandwidth product of 20 MHz with slew rate of 0.3V/μ sec.

× 10 OPERATIONAL AMPLIFIER USING L161

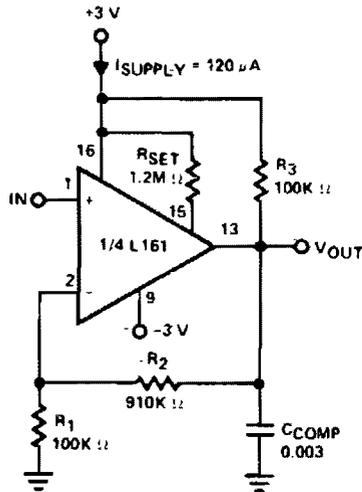
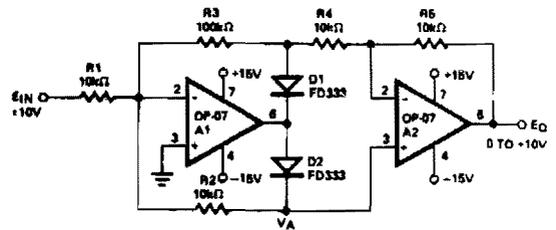


Fig. 3-30

Circuit Notes

Amplifier is 3 dB down at 100 kHz and has a slew rate of 0.02V/μ sec.

PRECISION ABSOLUTE VALUE CIRCUIT



POSITIVE INPUT

1. $V_A = 0, D2 \text{ OFF}, D1 \text{ ON}$
2. $E_O = \left(\frac{-E_{IN} R_2}{R_1} \right) \left(\frac{-R_5}{R_3} \right) + E_{IN} \frac{R_3 R_5}{R_1 R_4}$
3. WITH $R_1 = R_3 = R_4 = R_5: E_O = E_{IN}$
4. $V_{OS} \text{ ERROR INCLUDED. } E_O = E_{IN} + 2V_{OS2}$
5. $E_O = V_A \left(1 + \frac{R_5}{R_3 + R_4} \right)$
6. WITH $R_3 = R_4 = R_5: E_O = 1.5V_A$
7. $E_O = -\frac{(R_2)(R_3 + R_4)(1.5) E_{IN}}{R_1(R_2 + R_3 + R_4)}$
8. WITH $R_1 = R_2 = R_3 = R_4: E_O = -E_{IN}$
9. $V_{OS} \text{ ERROR INCLUDED. } E_O = -E_{IN} + 1.5V_{OS2} - 0.5V_{OS1}$
10. FOR BOTH INPUTS $E_O = \pm E_{IN}$

NEGATIVE INPUT

1. $D1 \text{ OFF}, D2 \text{ ON}$
2. $\frac{-E_{IN}}{R_1} + \frac{V_A}{R_2} + \frac{V_A}{R_3 + R_4}$

Fig. 3-32

ULTRA-LOW-LEAKAGE PREAMP

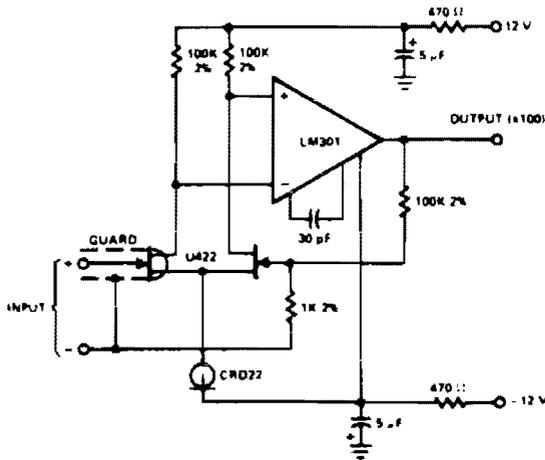
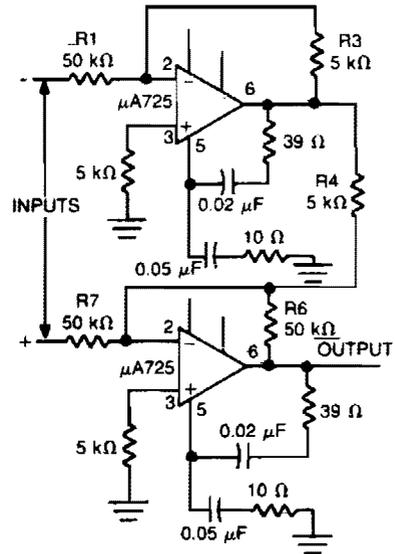


Fig. 3-33

Circuit Notes

Input leakage—2 pA at 75 °C.

±100 V COMMON MODE RANGE DIFFERENTIAL AMPLIFIER



Pin numbers are shown for metal package only.

Fig. 3-35

DC TO VIDEO LOG AMPLIFIER

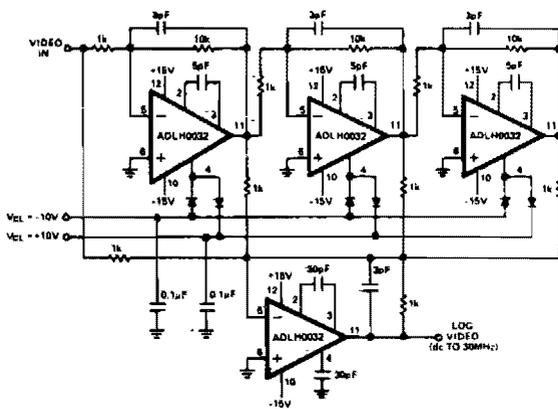
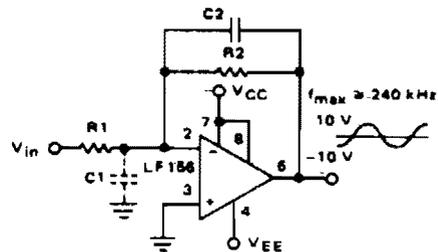


Fig. 3-34

WIDE BANDWIDTH, LOW NOISE, LOW DRIFT AMPLIFIER



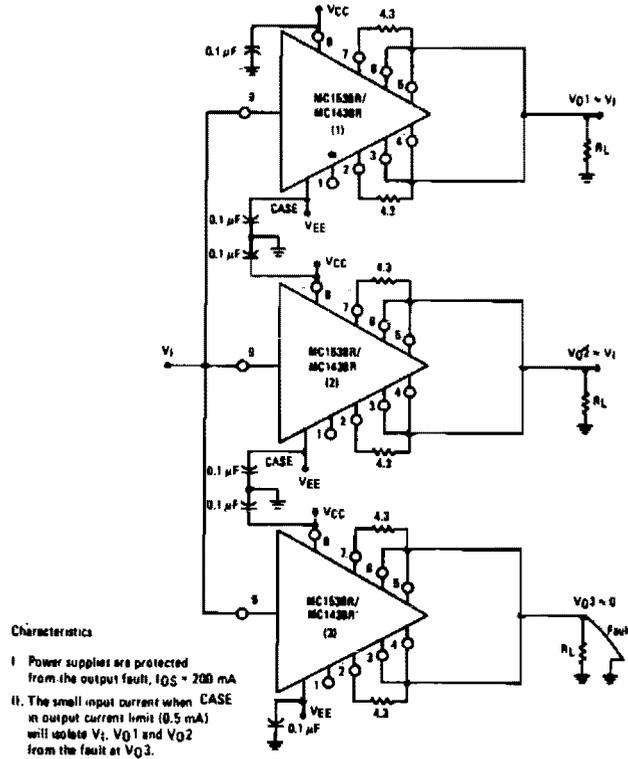
• Power BW: $f_{max} = \frac{S_f}{2\pi V_p} \approx 240 \text{ kHz}$

- Parasitic input capacitance ($C \approx 3 \text{ pF}$ for LF155, LF156, and LF157 plus any additional layout capacitance) interacts with feedback elements and creates undesirable high frequency pole. To compensate add C2 such that: $R_2 C_2 \approx R_1 C_1$.

Fig. 3-36

SIGNAL DISTRIBUTION AMPLIFIER

Fig. 3-37



AUDIO DISTRIBUTION AMPLIFIER

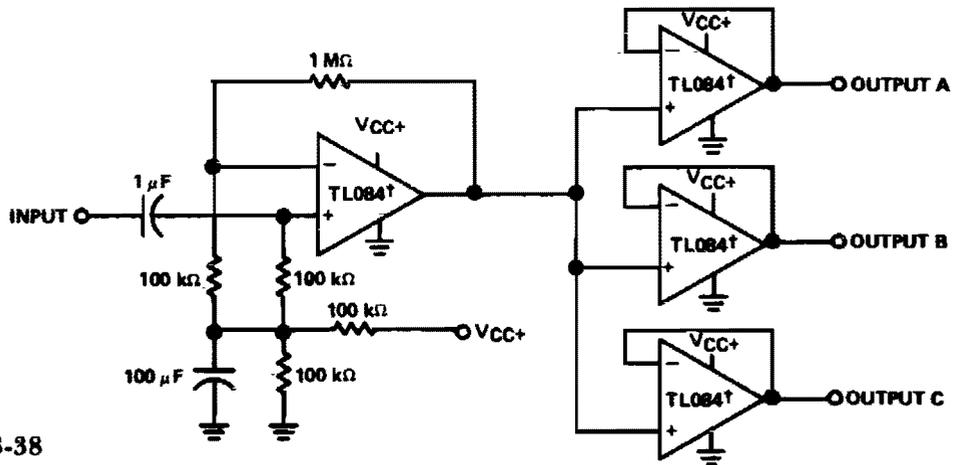


Fig. 3-38

HIGH INPUT IMPEDANCE, HIGH OUTPUT CURRENT VOLTAGE FOLLOWER

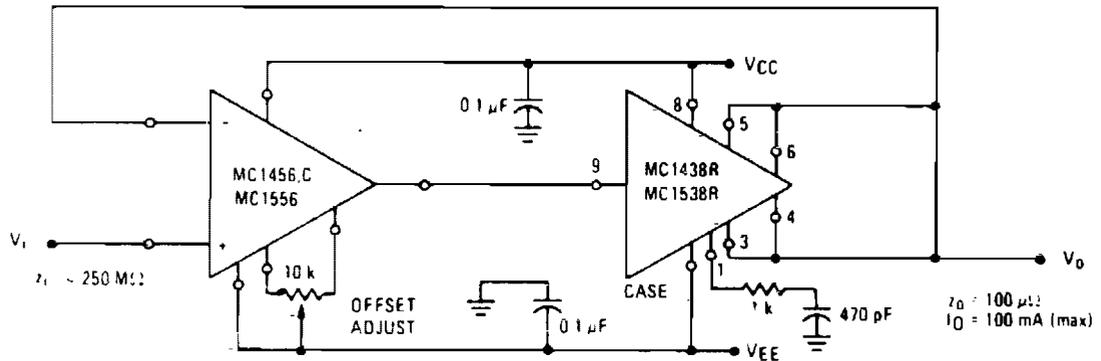
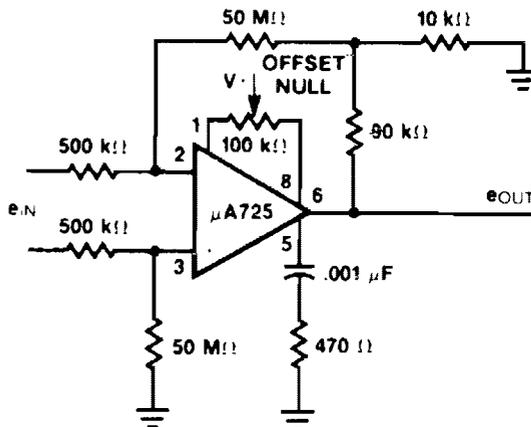


Fig. 3-39

PRECISION AMPLIFIER



Pin numbers are shown for metal package only.

Characteristics

$A_V = 1000 = 60 \text{ dB}$

DC Gain Error = 0.05%

Bandwidth = 1 kHz for -0.05% error

Diff. Input Res. = $1 \text{ M}\Omega$

Typical amplifying capability

$e_{IN} = 10 \mu\text{V}$ on $V_{CM1} = 1.0 \text{ V}$

Caution: Minimize Stray Capacitance

$A_{VCL} = 1000$

Fig. 3-40

PREAMPLIFIER AND HIGH-TO-LOW IMPEDANCE CONVERTER

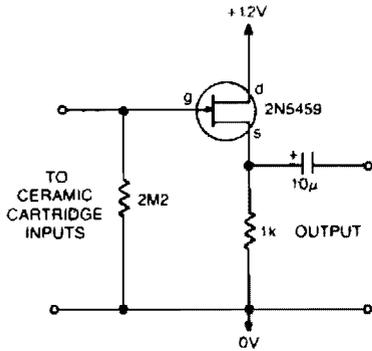


Fig. 3-41

Circuit Notes

This circuit matches the very high impedance of ceramic cartridges, unity gain, and low impedance output. By "loading" the cartridge with a 2M Ω input resistance, the cartridge

characteristics are such as to quite closely compensate for the RIAA recording curve. The output from this preamp may be fed to a level pot for mixing.

NONINVERTING AMPLIFIER

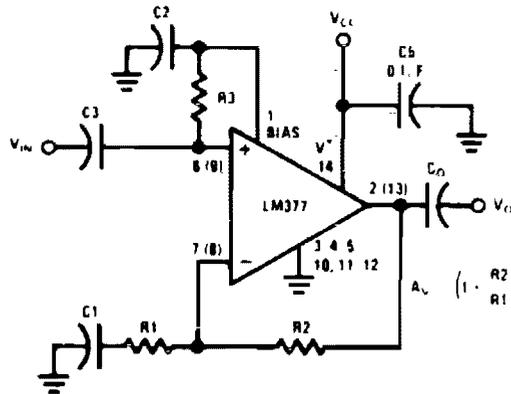


Fig. 3-42

HIGH IMPEDANCE, HIGH GAIN, HIGH FREQUENCY INVERTING AMP

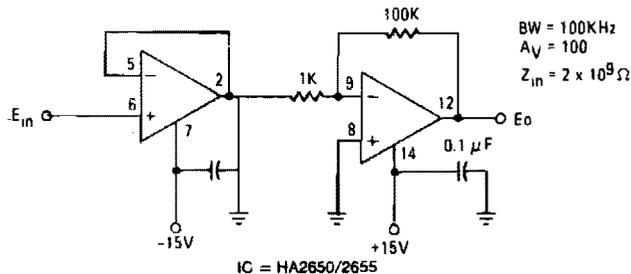


Fig. 3-43

LOG-RATIO AMPLIFIER

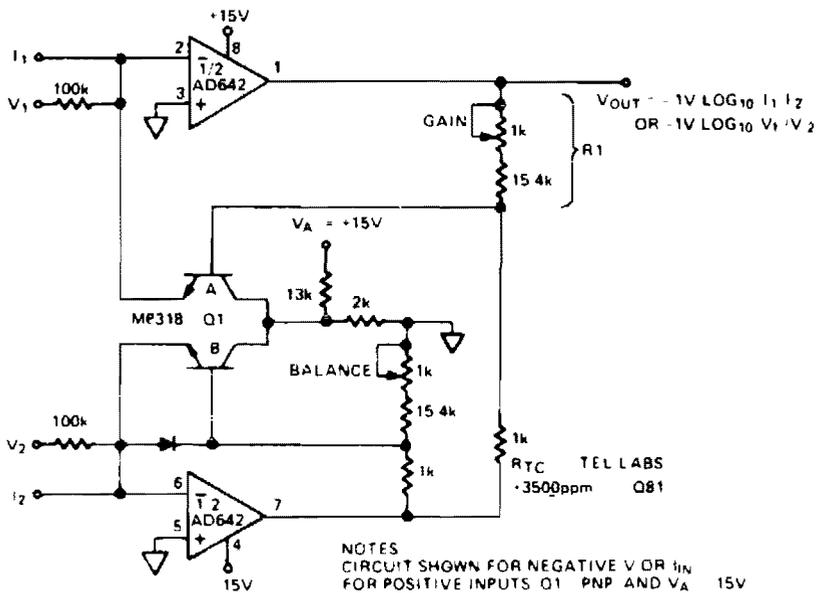


Fig. 3-44

INVERTING AMPLIFIER

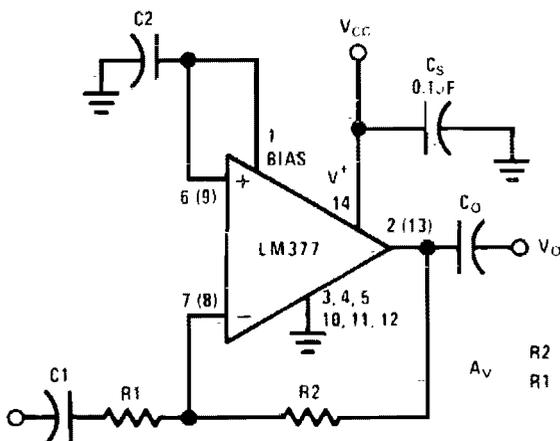


Fig. 3-45

4

Analog-to-Digital Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

8-Bit A/D Converter
Successive Approximation A/D Converter
8-Bit A/D Converter
8-Bit Tracking A/D Converter
8-Bit Successive Approximation A/D Converter
Four Channel Digitally Multiplexed Ramp

A/D Converter
Three Decade Logarithmic A/D Converter
Tracking (Servo Type) A/D Converter
3½ Digit A/D Converter with LCD Display
Fast Precision A/D Converter
High Speed 3-Bit A/D Converter
Three IC Low Cost A/D Converter

SUCCESSIVE APPROXIMATION A/D CONVERTER

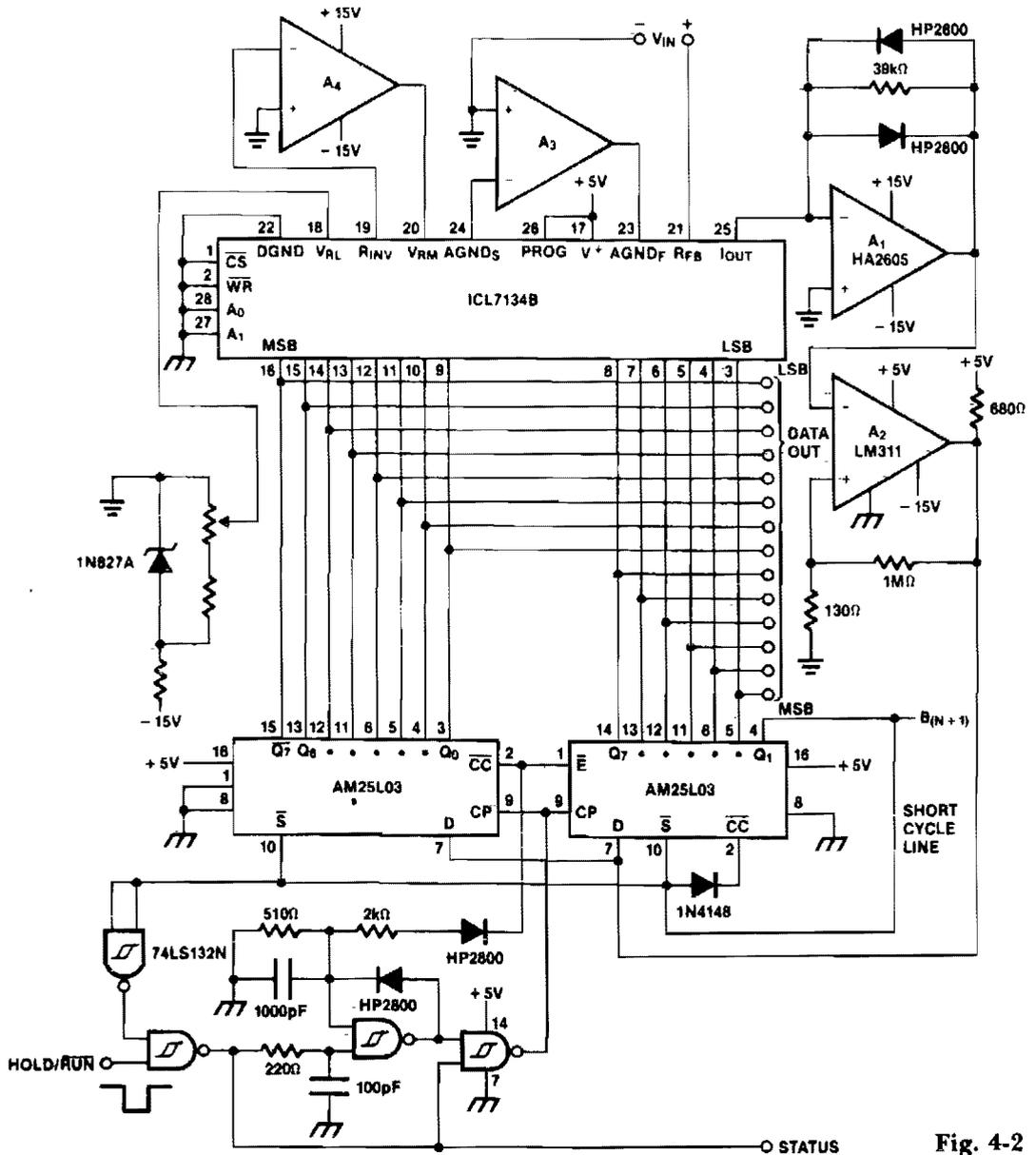


Fig. 4-2

Circuit Notes

A bipolar input, high speed A/D converter uses two AM25L03s to form a 14-bit successive approximation register. The comparator is a two-stage circuit with an HA2605 front-end amplifier used to reduce settling time problems at the summing node. Careful offset-nulling of this amplifier is needed.

8-BIT SUCCESSIVE APPROXIMATION A/D CONVERTER

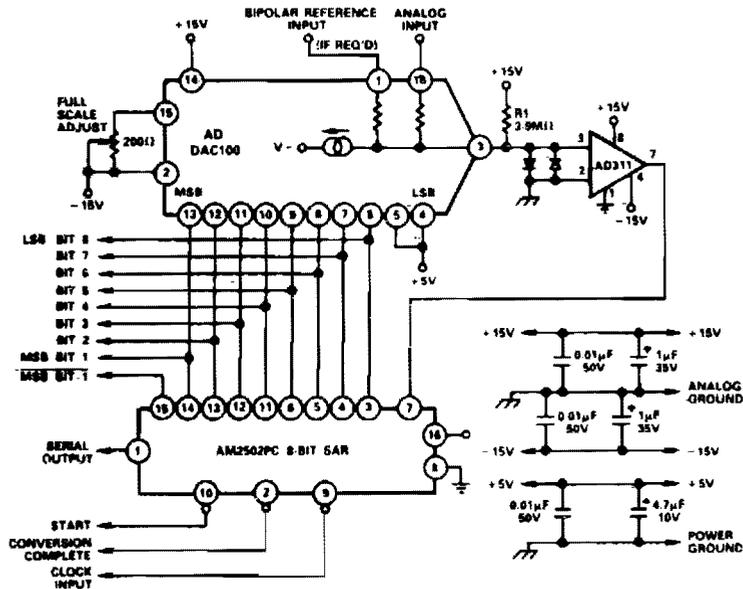


Fig. 4-5

FOUR CHANNEL DIGITALLY MULTIPLEXED RAMP A/D CONVERTER

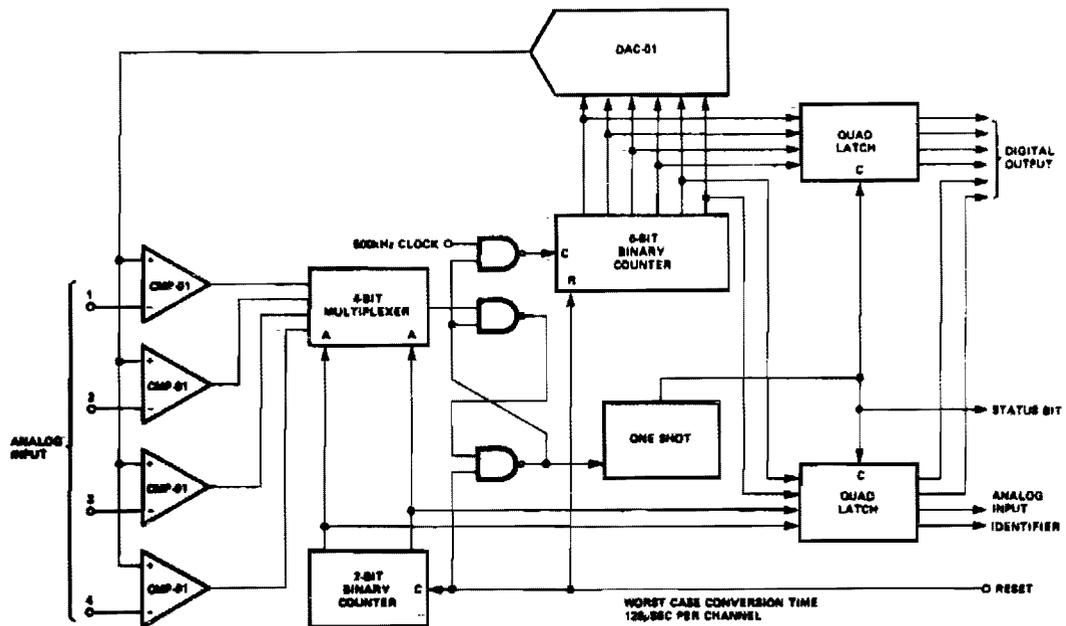


Fig. 4-6

3½ DIGIT A/D CONVERTER WITH LCD DISPLAY

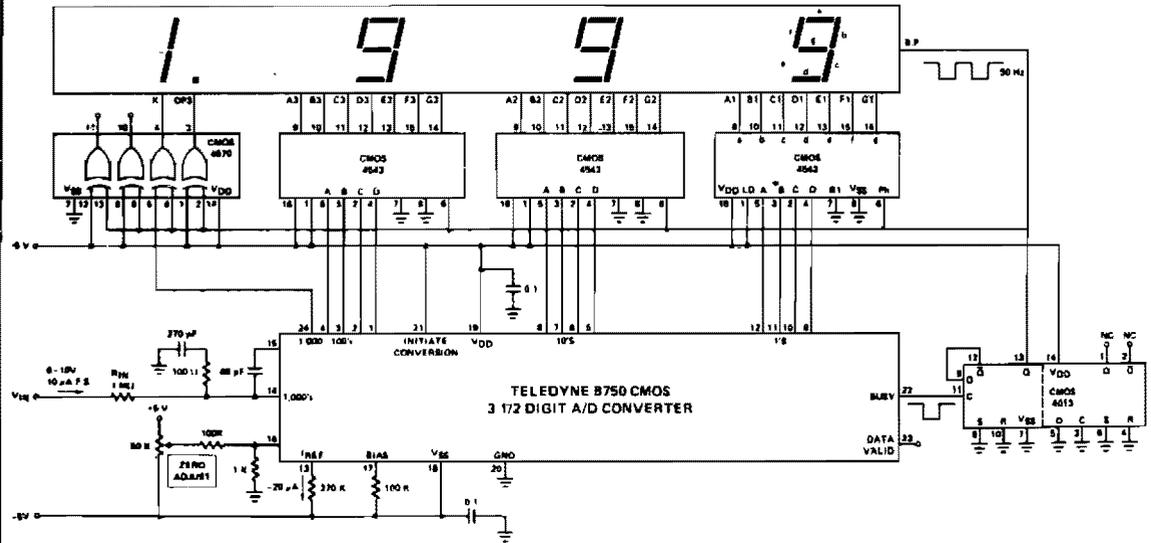


Fig. 4-9

FAST PRECISION A/D CONVERTER

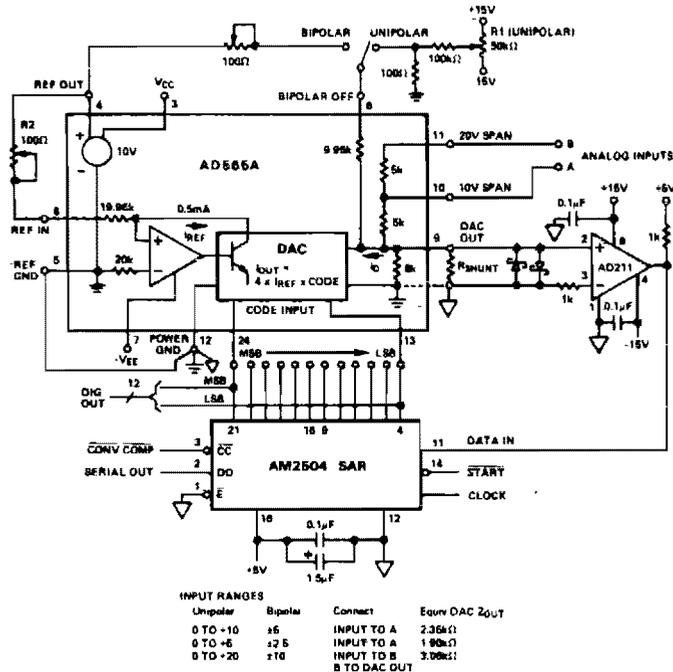


Fig. 4-10

HIGH SPEED 3-BIT A/D CONVERTER

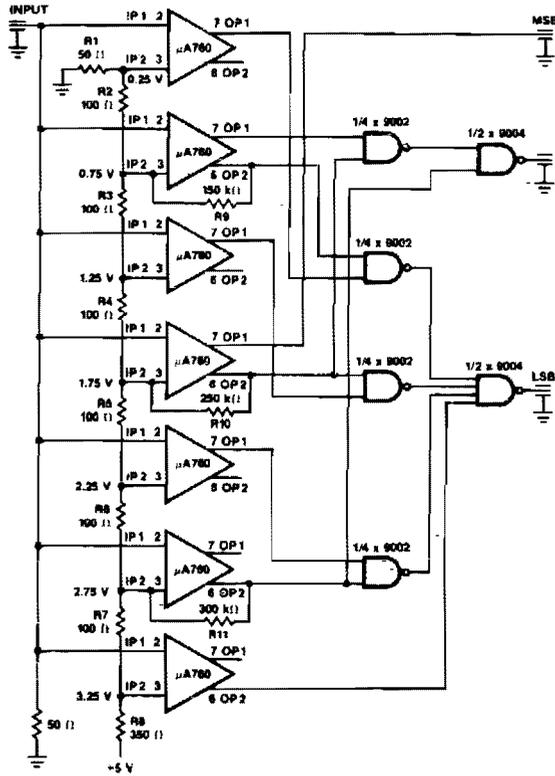


Fig. 4-11

Input voltage range: -3.5 V
 Typical conversion speed: 30 ns

THREE IC LOW COST A/D CONVERTER

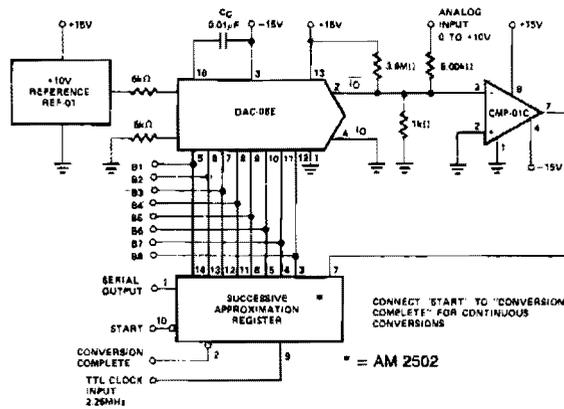


Fig. 4-12

5

Attenuators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Digitally Selectable Precision Attenuator
Variable Attenuator

Digitally Controlled Amplifier/Attenuator
Programmable Attenuator (1 to 0.0001)

DIGITALLY SELECTABLE PRECISION ATTENUATOR

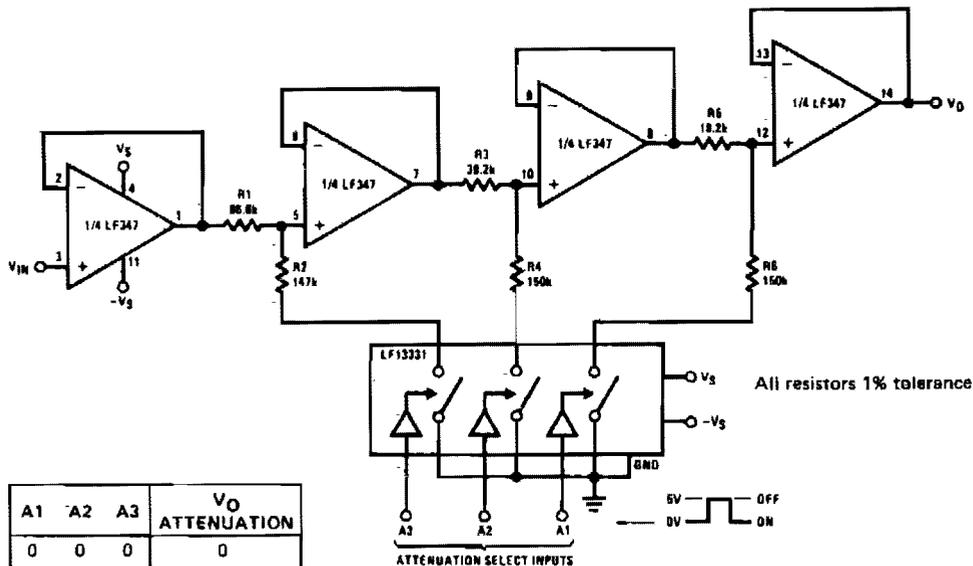
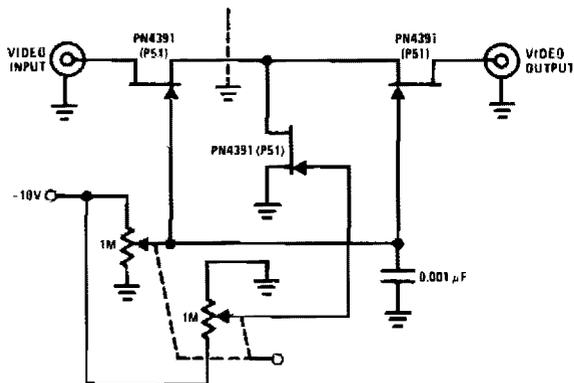


Fig. 5-1

A1	A2	A3	V _O ATTENUATION
0	0	0	0
0	0	1	-1 dB
0	1	0	-2 dB
0	1	1	-3 dB
1	0	0	-4 dB
1	0	1	-5 dB
1	1	0	-6 dB
1	1	1	-7 dB

- Accuracy of better than 0.4% with standard 1% value resistors
- No offset adjustment necessary
- Expandable to any number of stages
- Very high input impedance

VARIABLE ATTENUATOR

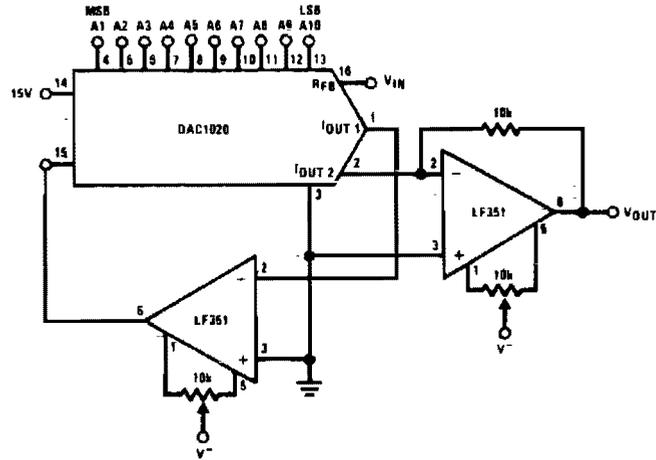


Circuit Notes

The PN4391 provides a low $R_{ds(on)}$ (less than 30 ohms). The tee attenuator provides for optimum dynamic linear range for attenuation and if complete turn-off is desired, attenuation of greater than 100 dB can be obtained at 10 MHz providing proper rf construction techniques are employed.

Fig. 5-2

DIGITALLY CONTROLLED AMPLIFIER/ATTENUATOR



$$V_{OUT} = V_{REF} \left[\frac{\overline{A1}}{2} + \frac{\overline{A2}}{4} + \dots + \frac{A10}{1024} \right] \text{ or } V_{OUT} = V_{REF} \left(\frac{1023 - N}{N} \right)$$

where $0 \leq N \leq 1023$
 $N = 0$ for $A_N =$ all zeros
 $N = 1$ for $A10 = 1, A1-A9 = 0$

$N = 1023$ for $A_N =$ all 1's

Fig. 5-3

PROGRAMMABLE ATTENUATOR (1 TO 0.0001)

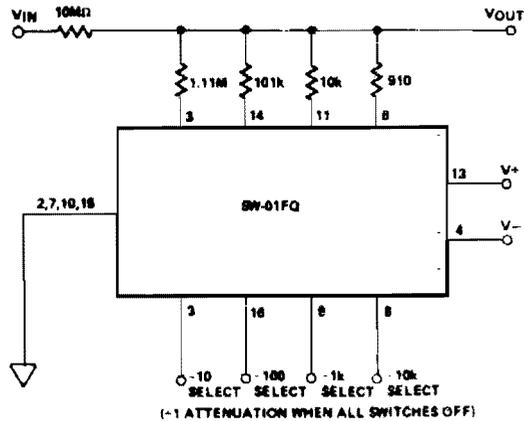


Fig. 5-4

6

Audio Mixers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Four Input Stereo Mixer
High-Level Four-Channel Mixer
Two Channel Panning Circuit
CMOS Mixer
Mixer Preamplifier with Tone Control

Passive Mixer
One Transistor Audio Mixer
Silent Audio Switching/Mixing
Hybrid Mixer
Four Channel Mixer

FOUR-INPUT STEREO MIXER

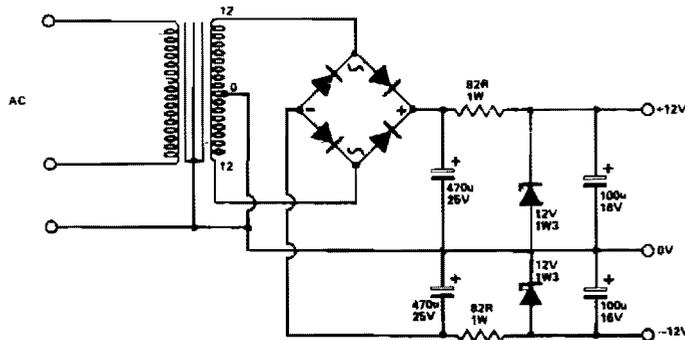
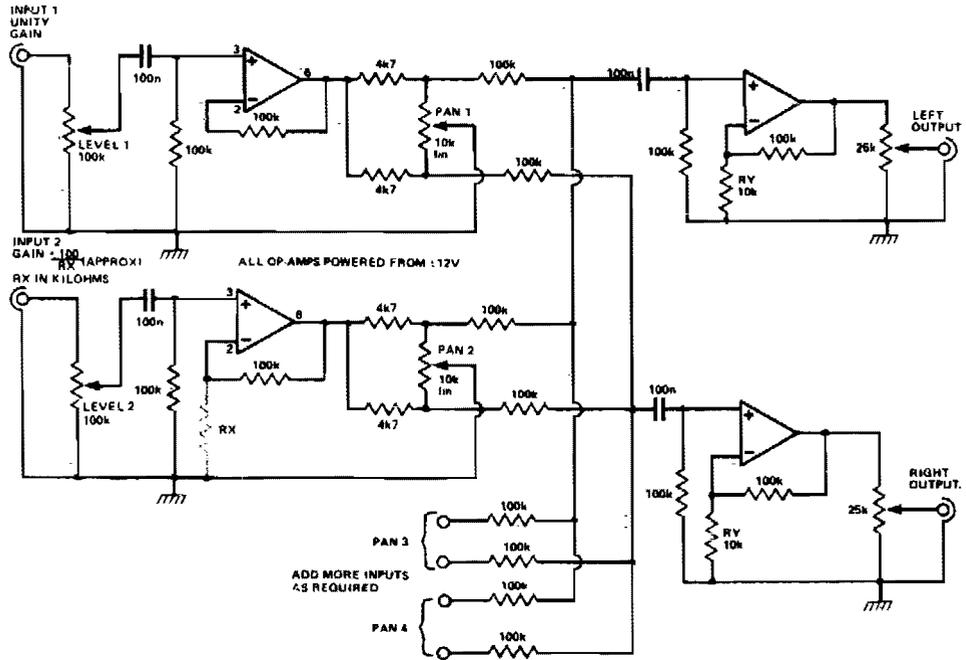


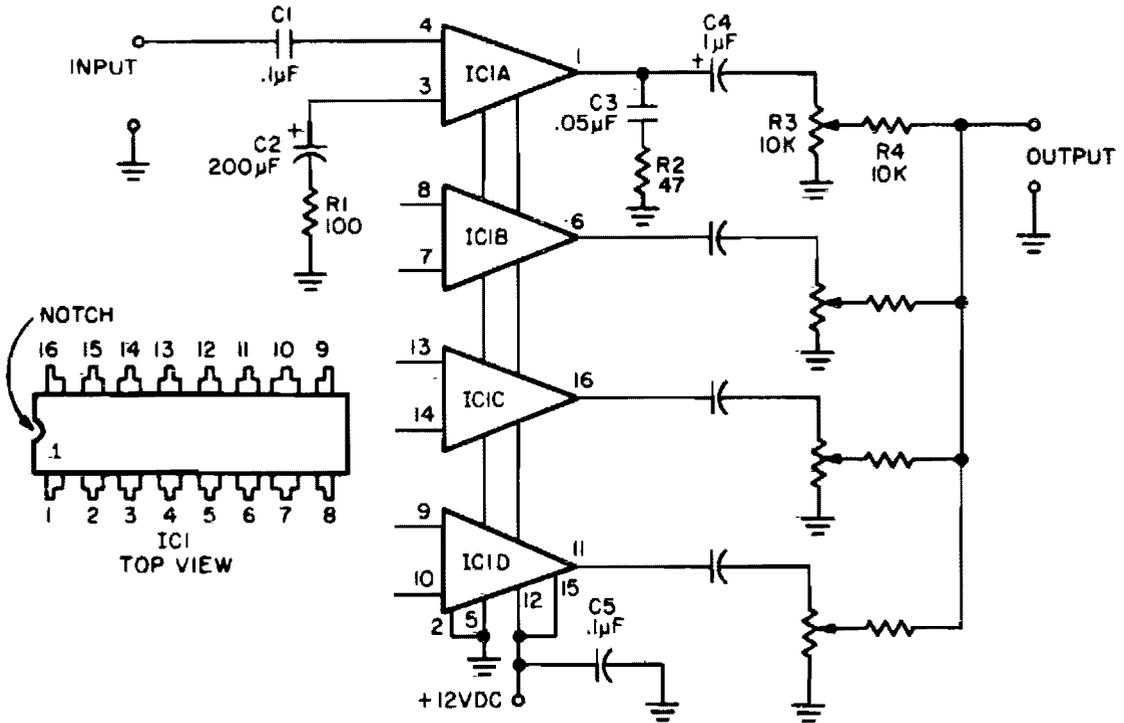
Fig. 6-1

Circuit Notes

Four (or more) inputs can be mixed and produce stereo output. Gain of each stage can be boosted by adding RX, but it should be kept below 50 (RX above 2.2 K) to avoid poor frequency response. If more than four stages are

used, decrease RX to 6.8 K for six inputs, or 4.7 K for eight inputs. The op amps are 741 or other lower noise types. The power supply circuit is also given.

HIGH-LEVEL FOUR-CHANNEL MIXER



PARTS LIST FOR HI-LEVEL MIXER

- C1—0.1-μF, 3 VDC capacitor
- C2—200-μF, 3 VDC capacitor
- C3—0.05-μF, 75 VDC disc capacitor
- C4—1-μF, 15 VDC capacitor
- C5—0.1-μF, 15 VDC capacitor

IC1—RCA CA 3052

- R1—100-ohms, ½-watt resistor
- R2—47-ohms, ½-watt resistor
- R3—Potentiometer, 10,000-ohms audio taper
- R4—10,000-ohms, ½-watt resistor

Fig. 6-2

Circuit Notes

To provide good signal-to-noise ratio, this four channel mixer amplifier controls the signal levels after the amplifiers, and then mixes them to offer a combined output. The circuit works with any 50 ohm to 50 K dynamic mi-

crophone but not with crystal or ceramic mikes because the IC input impedance is low. Note that all four circuits are identical but that only one is shown complete.

TWO CHANNEL PANNING CIRCUIT

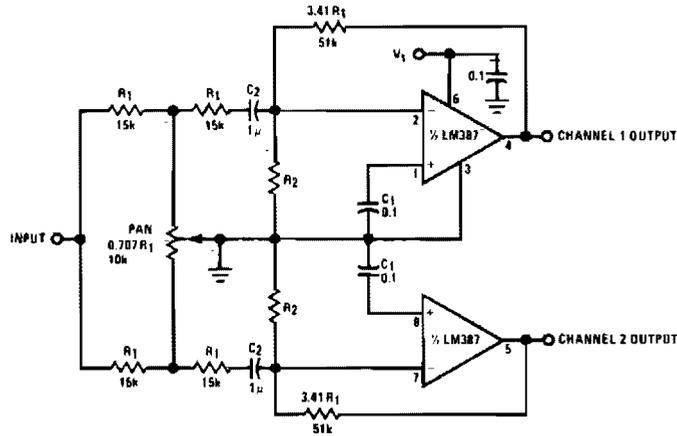


Fig. 6-3

Circuit Notes

This panning circuit (short for panoramic control circuit) provides the ability to move the apparent position of one microphone's input between two output channels. This effect is often required in recording studio mixing con-

soles. Panning is how recording engineers manage to pick up your favorite pianist and "float" the sound over to the other side of the stage and back again.

CMOS MIXER

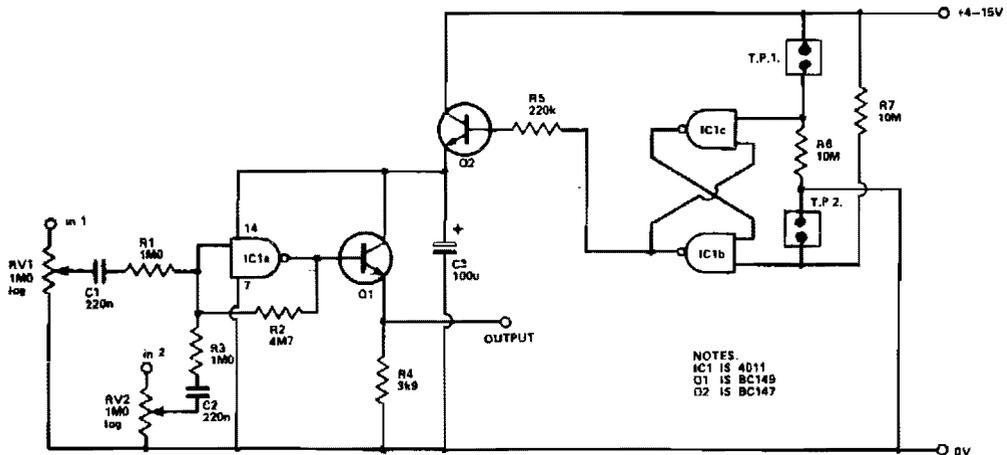


Fig. 6-4

Circuit Notes

Four inputs can be mixed by duplicating the circuit to the left of C3 and using the fourth gate of IC1. Two gates are used in a touch-operated switching circuit that controls the

voltage on the base of switching transistor Q2. Touching TP1 and TP2 alternately turns the circuit on and off.

NOTES:
IC1 IS 4011
Q1 IS BC149
Q2 IS BC147

MIXER PREAMPLIFIER WITH TONE CONTROL

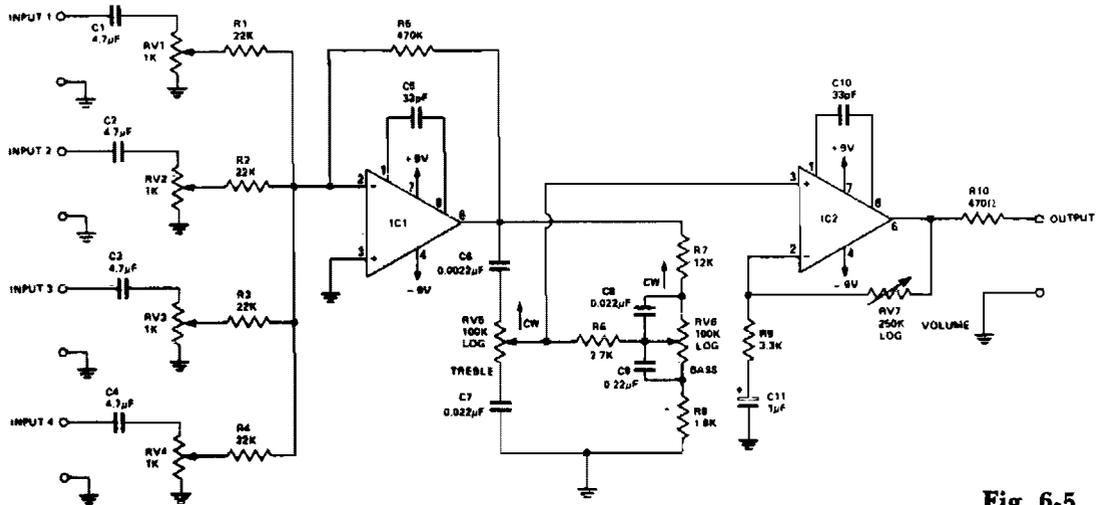


Fig. 6-5

Circuit Notes

General purpose preamplifier/mixer accepts up to four inputs, has a gain of 1600, and provides bass and treble controls that can be varied ± 10 dB at 100 Hz and 10 kHz respectively. IC1 and IC2 = LM301A.

PASSIVE MIXER

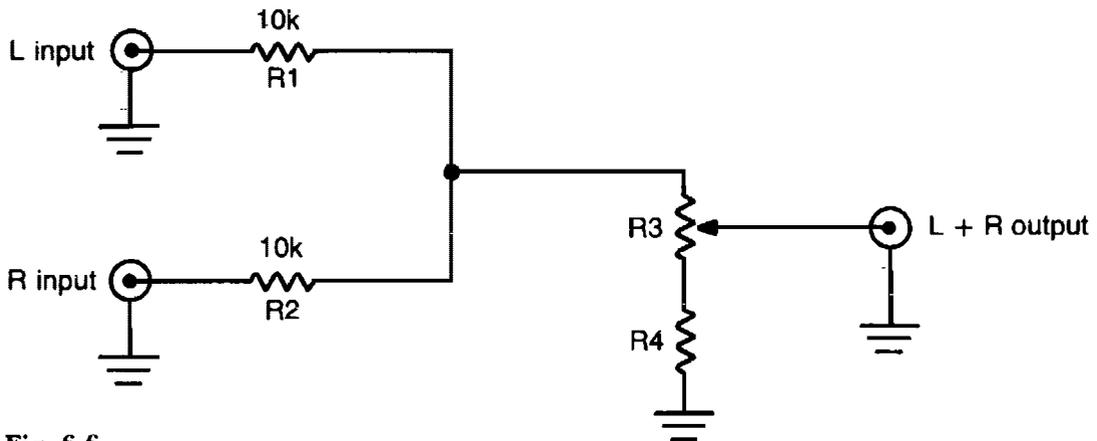


Fig. 6-6

Circuit Notes

This simple circuit can be used to combine stereo signals to produce a monaural output. R1 and R2 isolate both circuits and R3 controls the level of the combined output signal.

ONE TRANSISTOR AUDIO MIXER

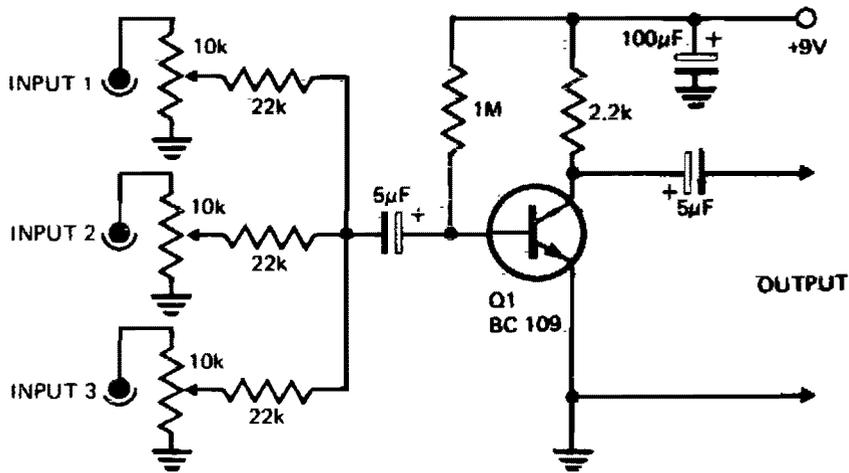


Fig. 6-7

Circuit Notes

Three or more inputs with individual level controls feed into the base of Q1 that provides a voltage gain of 20.

SILENT AUDIO SWITCHING/MIXING

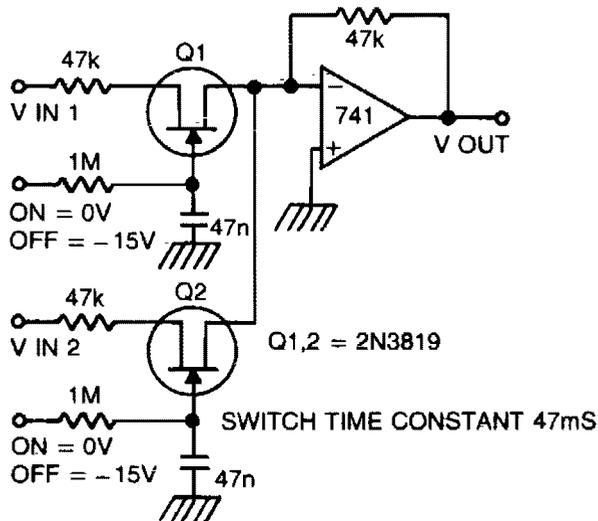


Fig. 6-8

Circuit Notes

Two or more signals can be switched and/or mixed without annoying clicks by using FETs and a low input-impedance op amp circuit.

HYBRID MIXER

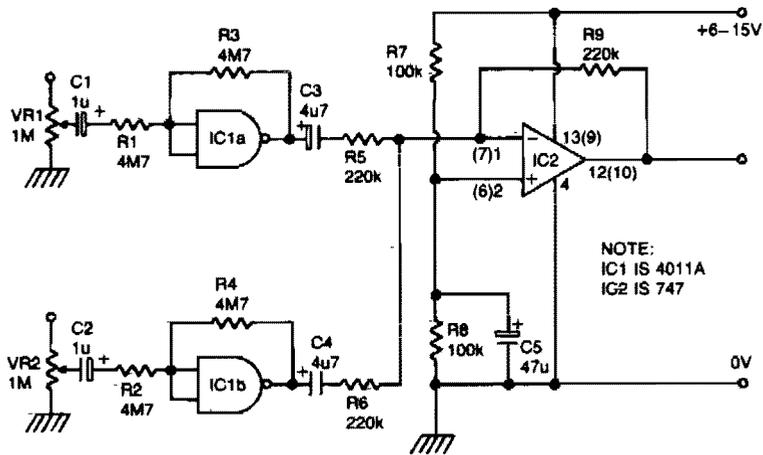


Fig. 6-9

NOTE:
IC1 IS 4011A
IC2 IS 747

Circuit Notes

IC1a and b are biased into the linear regions by R3 and R4. (IC1 must be 4011A). Outputs from gates are combined by op amp IC2, which provides low impedance output.

FOUR CHANNEL MIXER

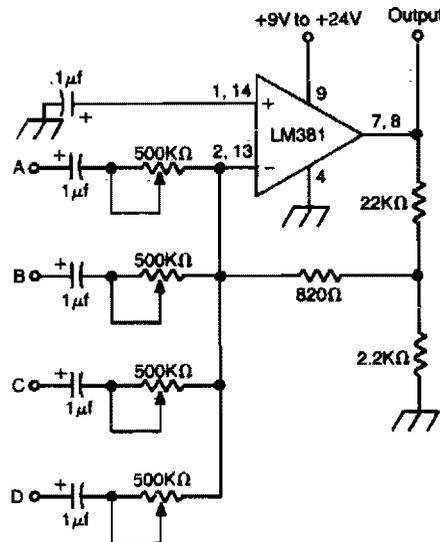


Fig. 6-10

Circuit Notes

High gain op amp combines up to four individually controlled input signals. The dc power source should be well filtered (battery is ideal), and the circuit should be well shielded to prevent hum pickup.

7

Audio Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Wien Bridge Oscillator	Tone Encoder
Wien Bridge Oscillator	Feedback Oscillator
Wien Bridge Oscillator	Phase Shift Oscillator
Very Low Frequency Generator	800 Hz Oscillator
Audio Oscillator	Tunable Single Comparator Oscillator
Sine Wave Oscillator	Wide Range Oscillator (Frequency Range of 500 to 1)
Easily Tuned Sine/Square Wave Oscillators	Wien Bridge Oscillator
Wien Bridge Sine Wave Oscillator	Wien Bridge Sine Wave Oscillator
Phase Shift Oscillator	

WIEN BRIDGE OSCILLATOR

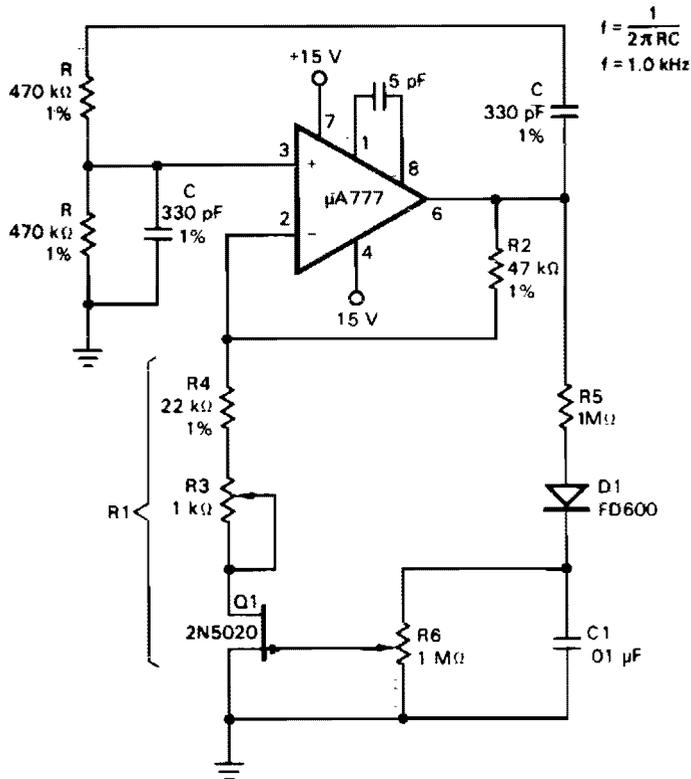


Fig. 7-1

Circuit Notes

Field effect transistor, Q1, operates in the linear resistive region to provide automatic gain control. Because the attenuation of the RC network is one-third at the zero phase-shift oscillation frequency, the amplifier gain determined by resistor R2 and equivalent resistor R1 must be just equal to three to make up the unity gain positive feedback requirement needed for stable oscillation. Resistors R3 and R4 are set to approximately 1000 ohm less than

the required R1 resistance. The FET dynamically provides the trimming resistance needed to make R1 one-half of the resistance of R2. The circuit composed of R5, D1, and C1 isolates, rectifies, and filters the output sine wave, converting it into a dc potential to control the gate of the FET. For the low drain-to-source voltages used, the FET provides a symmetrical linear resistance for a given gate-to-source voltage.

VERY LOW FREQUENCY GENERATOR

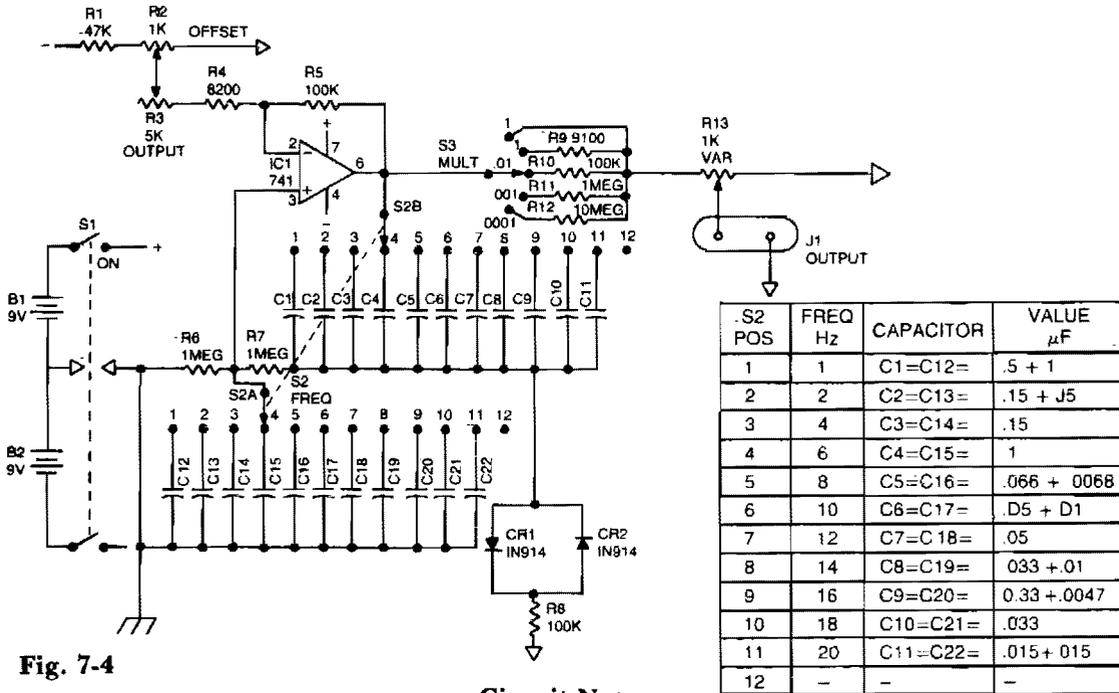


Fig. 7-4

Circuit Notes

Wien bridge oscillator generates frequencies of 1 Hz and 2 to 20 Hz in 2 Hz steps. Maximum output amplitude is 3 volts rms of 8.5 volts peak-to-peak. A pot-and-switch at-

tenuator allows the output level to be set with a fair degree of precision to any value within a range of 5 decades.

AUDIO OSCILLATOR

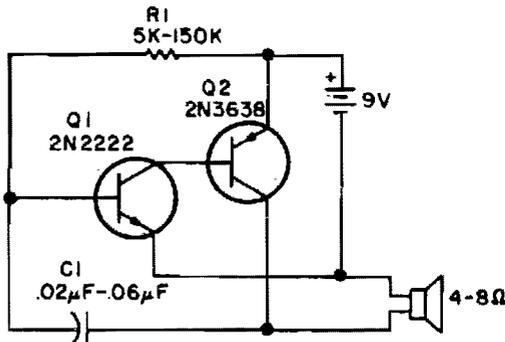


Fig. 7-5

Circuit Notes

Almost any transistor will work. R1 and C1 will vary the tone.

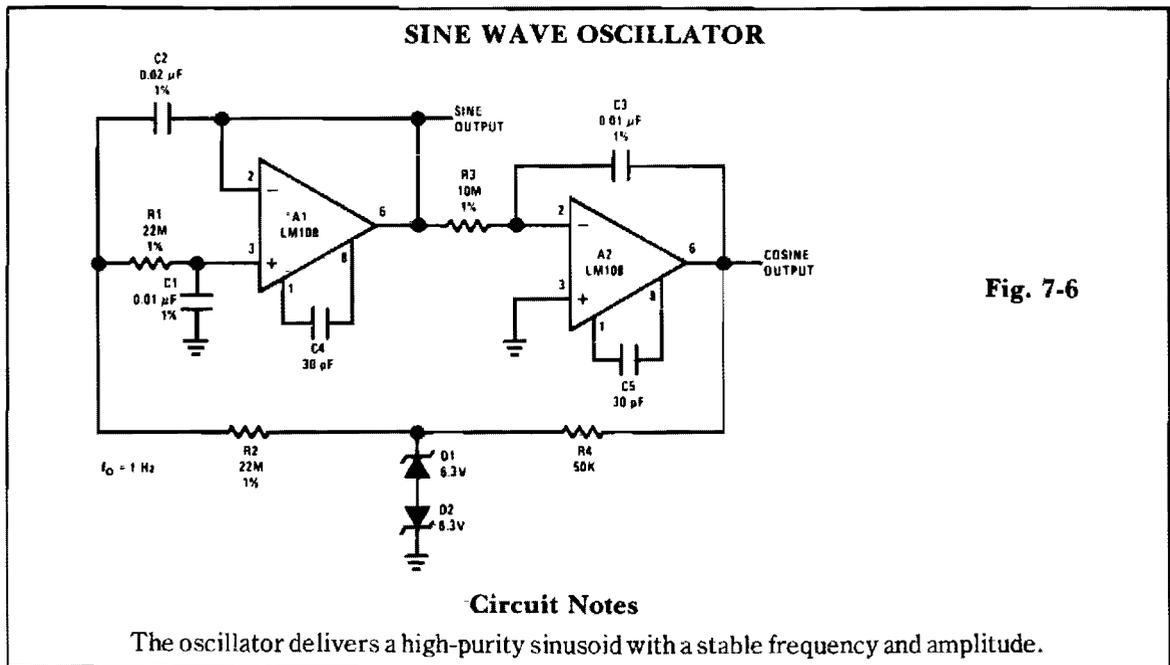


Fig. 7-6

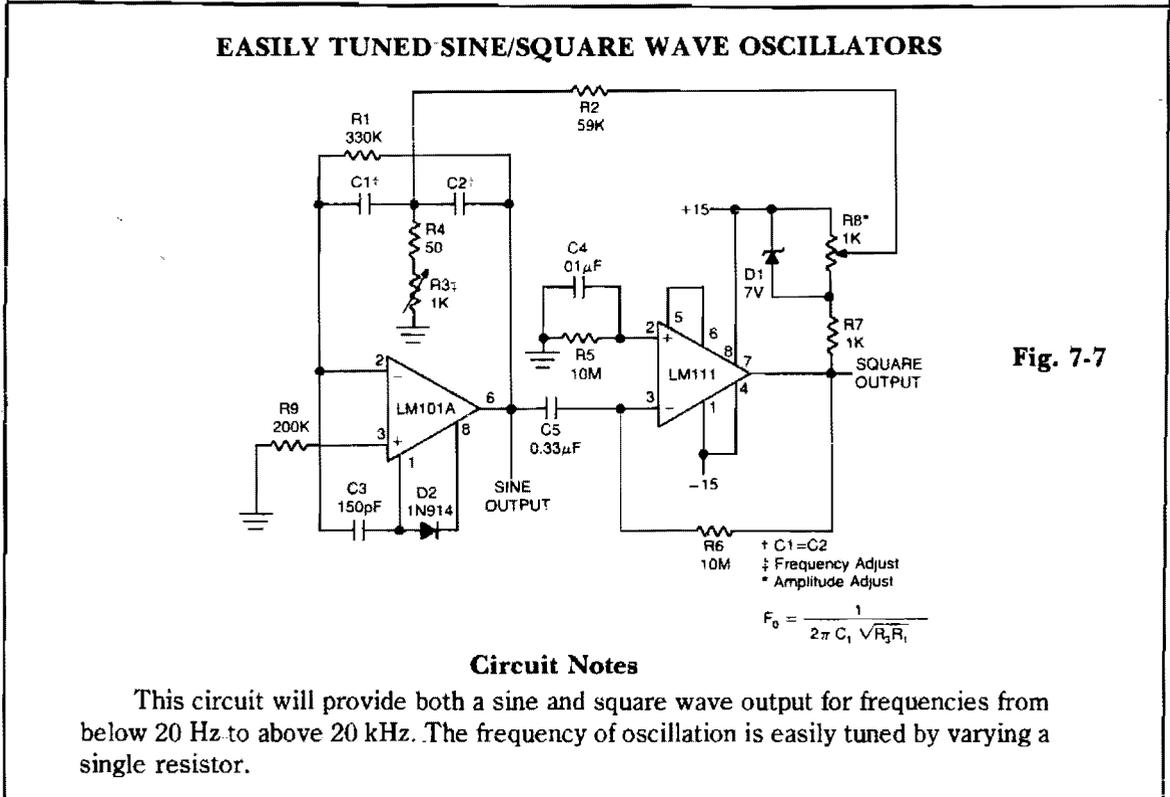
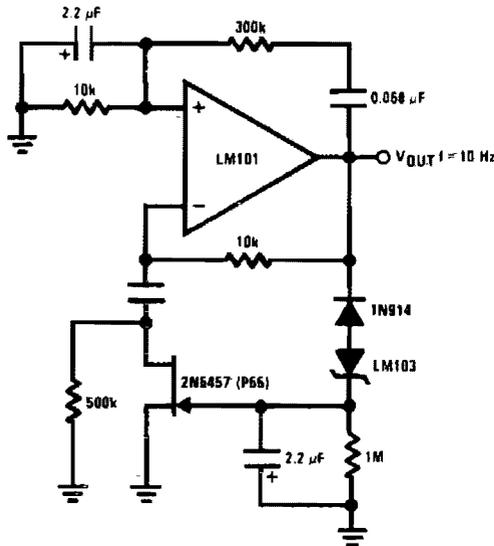


Fig. 7-7

WIEN BRIDGE SINE WAVE OSCILLATOR



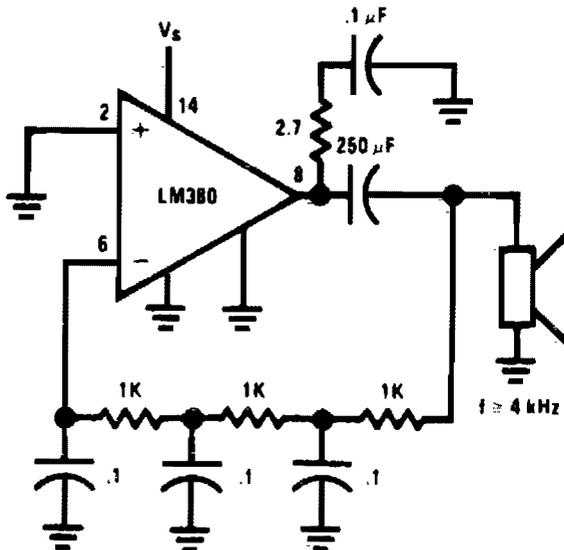
Circuit Notes

Using the 2N5457 JFET as a voltage variable resistor in the amplifier feedback loop, produces a low distortion, constant amplitude sine wave getting the amplifier loop gain just right. The LM103 zener diode provides the voltage reference for the peak sine wave amplitude.

Peak output voltage
 $V_p \approx V_z + 1V$

Fig. 7-8

PHASE-SHIFT OSCILLATOR



Circuit Notes

Circuit uses a simple RC network to produce an exceptionally shrill tone from a miniature speaker. With the parts values shown, the circuit oscillates at a frequency of 3.6 kHz and drives a miniature 2½" speaker with ear-piercing volume. The output waveform is a square wave with a width of 150 μs, sloping rise and fall times, and a peak-to-peak amplitude of 4.2 volts (when powered by 9 volts). Current drain of the oscillator is 90 mA at 9 volts, and total power dissipation at this voltage is 0.81 watt, which is well below the 1.25 watts the 14-pin version will absorb (at room temperature) before shutting down.

Fig. 7-9

TONE ENCODER

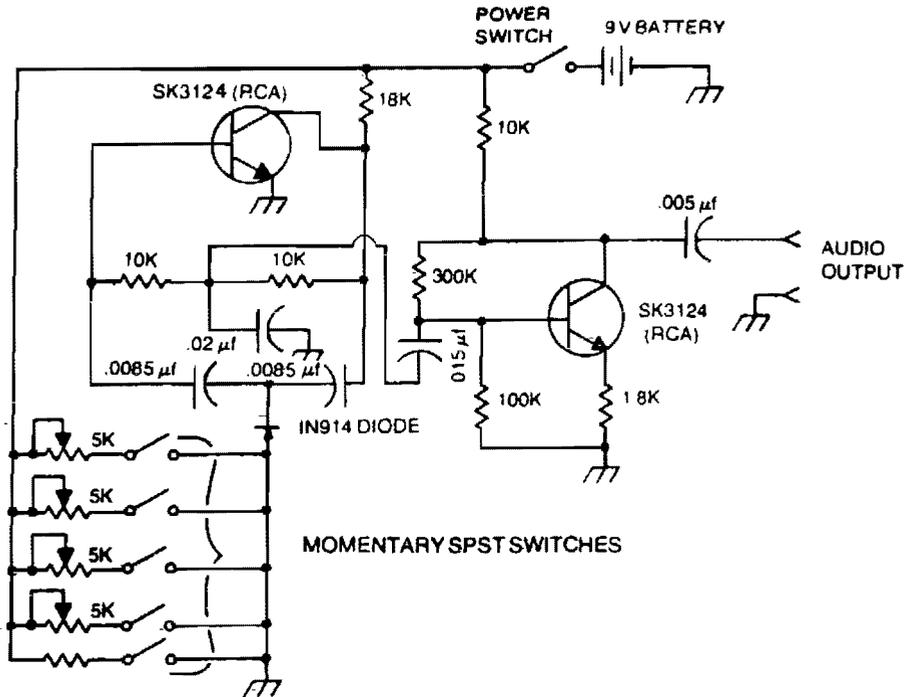
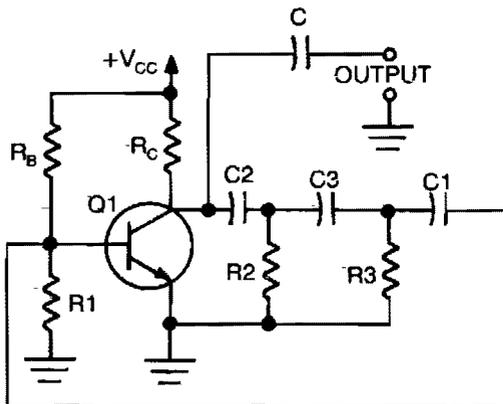


Fig. 7-10

Circuit Notes

A basic twin-T circuit uses resistors for accurately setting the frequency of the output tones, selected by pushbutton. Momentary switches produce a tone only when the button is depressed.

FEEDBACK OSCILLATOR



Circuit Notes

Circuit oscillates because the transistor shifts the phase of the signal 180° from the base to the collector. Each of the RC networks in the circuit is designed to shift the phase 60° at the frequency of oscillation for a total of 180° . The appropriate values of R and C for each network is found from $f = 1/2\sqrt{3\pi RC}$; that equation allows for the 60° phase shift required by the design.

Fig. 7-11

PHASE SHIFT OSCILLATOR

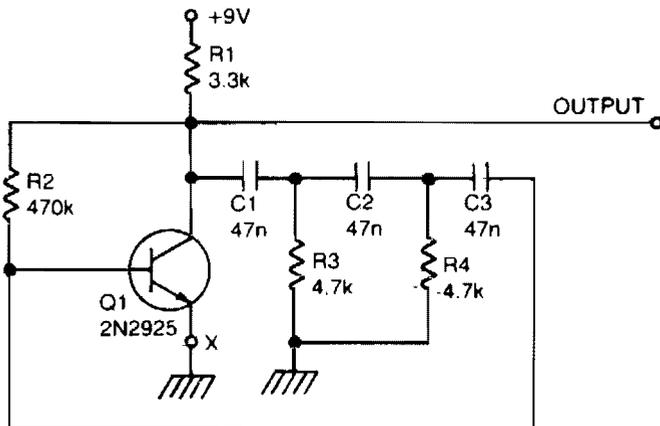


Fig. 7-12

Circuit Notes

A single transistor makes a simple phase shift oscillator. The output is a sine wave with distortion of about 10%. The sine wave purity can be increased by putting a variable resistor (25 ohms) in the emitter lead of Q1 (x). The resistor is adjusted so the circuit is only just oscillating, then the sine wave is relatively pure. Operating frequency may be varied by

putting a 10 K variable resistor in series with R3, or by changing C1, C2, and C3. Making C1, 2, 3 equal to 100 nF will halve the operating frequency. Operating frequency can also be voltage controlled by a FET in series with R3, or optically controlled by an LDR in series with R3.

800 Hz OSCILLATOR

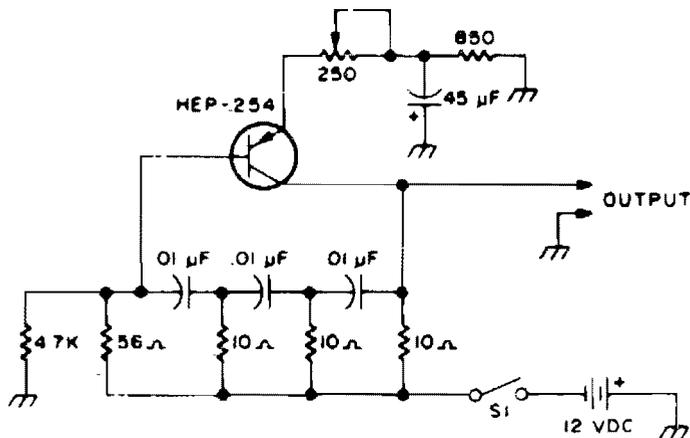


Fig. 7-13

Circuit Notes

The following transistors may be used: HEP-254, O.C-2, SK-3004, AT30H. To increase the frequency, decrease the value of the capacitors in the ladder network.

TUNABLE SINGLE COMPARATOR OSCILLATOR

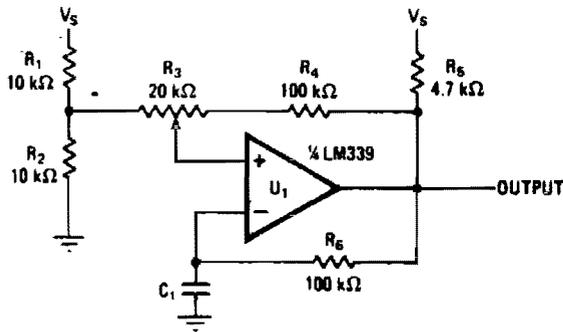


Fig. 7-14

Circuit Notes

Varying the amount of this comparator circuit's hysteresis makes it possible to vary output frequencies in the 740-Hz to 2.7-kHz range smoothly. The amount of hysteresis together with time constant R_6C_1 determines how much time it takes for C_1 to charge or discharge to the new threshold after the output voltage switches.

WIDE RANGE OSCILLATOR (FREQUENCY RANGE OF 5000 TO 1)

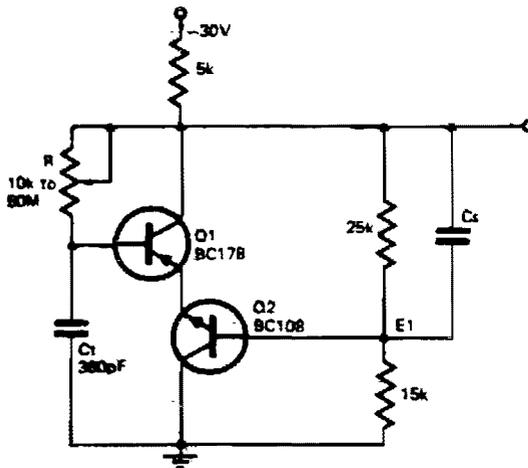


Fig. 7-15

Circuit Notes

Timing resistor R may be adjusted to any value between 10 K and 50 M to obtain a frequency range from 400 kHz to 100 Hz. Returning the timing resistor to the collector of Q_1 ensures that Q_1 draws its base current only from the timing capacitor C_t . The timing capacitor recharges when the transistors are off, to a voltage equal to the base emitter voltage of Q_2 plus the base emitter drops of Q_1 and Q_2 . The transistors then start into conduction. Capacitor C_s is used to speed up the transition. A suitable value would be in the region of 100 pF.

WIEN BRIDGE OSCILLATOR

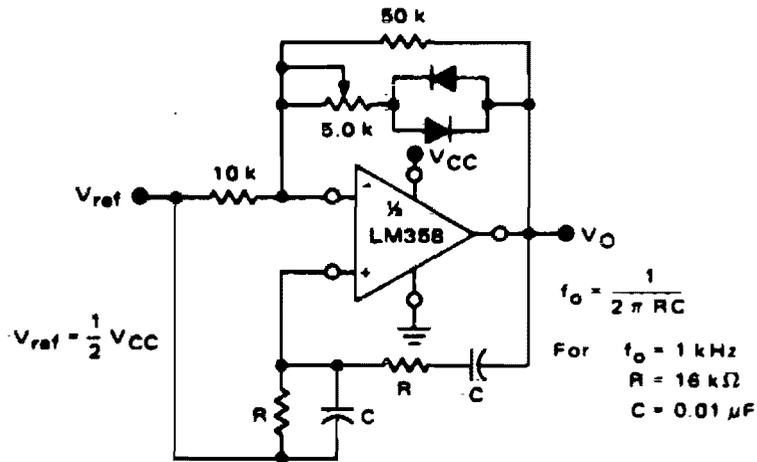


Fig. 7-16

WIEN BRIDGE SINE WAVE OSCILLATOR

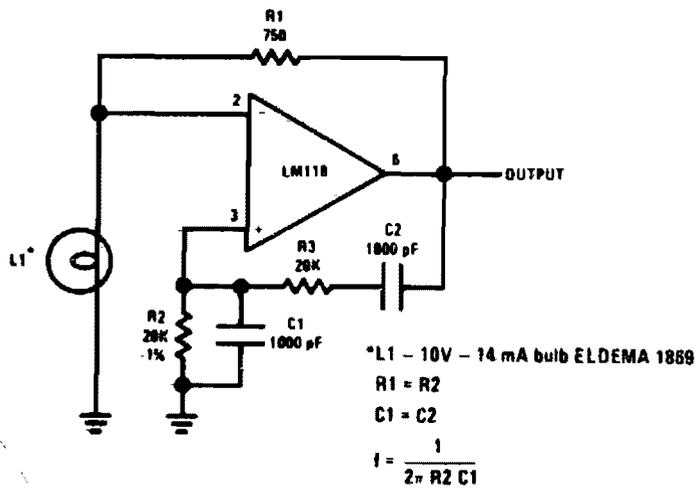


Fig. 7-17

LOW COST 20 W AUDIO AMPLIFIER

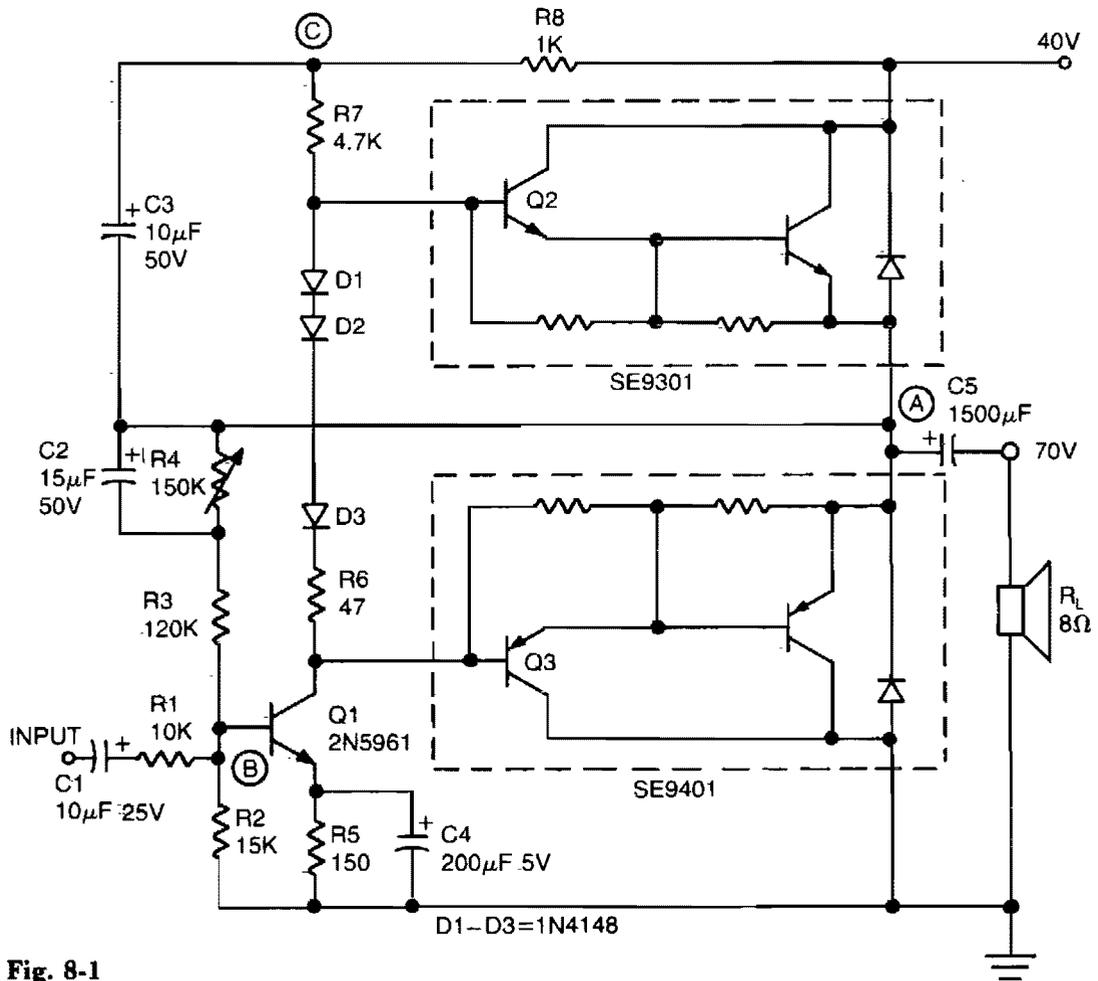


Fig. 8-1

Circuit Notes

This simple inexpensive audio amplifier can be constructed using a couple of TO-220 monolithic Darlington transistors for the push-pull output stage. Frequency response is flat within 1 dB from 30 Hz to 200 kHz with typical harmonic distortion below 0.2%. The amplifier requires only 1.2 V_{rms} for a full 20-W output into an 8 ohm load. Only one other transistor is needed, the TO-92 low-noise high-gain 2N5961 (Q1), to provide voltage gain for driving the output Darlings. Its base

(point B) is the tie point for ac and dc feedback as well as for the signal input. Input resistance is 10 K. The center voltage at point A is set by adjusting resistor R4. A bootstrap circuit boosts the collector supply voltage of Q1 (point C) to ensure sufficient drive voltage for Q2. This also provides constant voltage across R7, which therefore acts as a current source and, together with diodes D1-D3, reduces low-signal crossover distortion.

75 WATT AUDIO AMPLIFIER WITH LOAD LINE PROTECTION

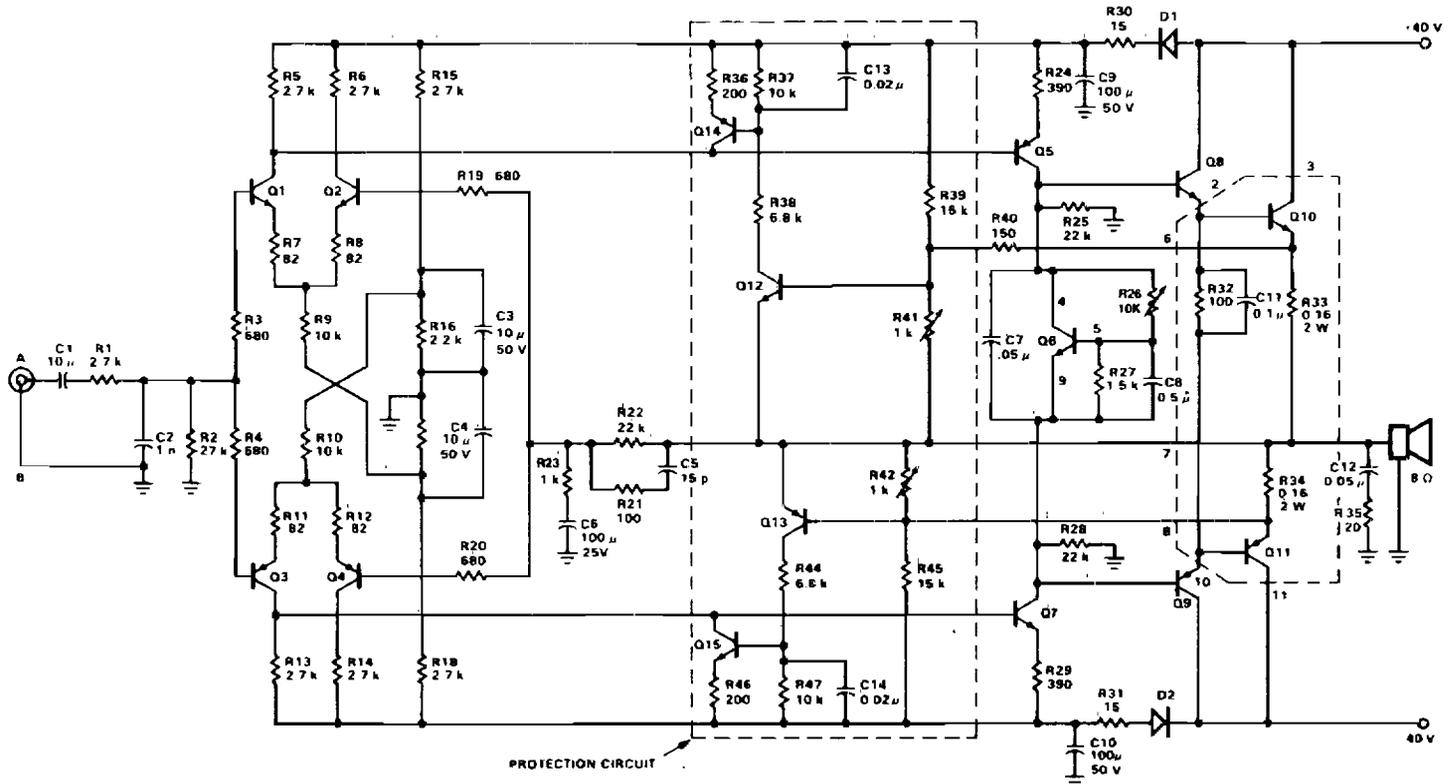
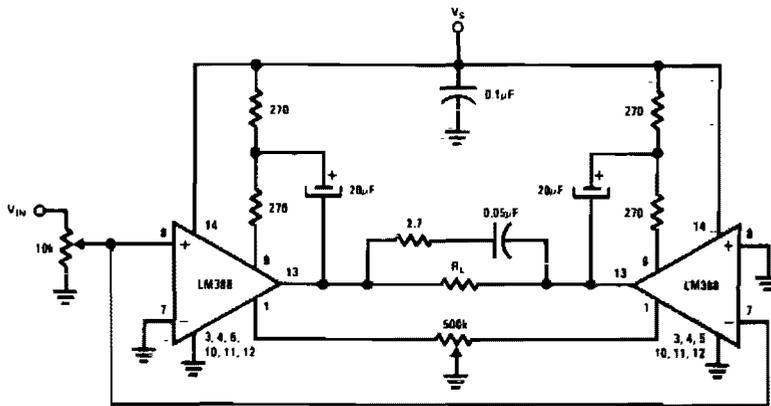


Fig. 8-2

BRIDGE AMPLIFIER



$V_s = 6V \quad R_L = 4\Omega \quad P_o = 1.0W$
 $V_s = 12V \quad R_L = 8\Omega \quad P_o = 3.5W$

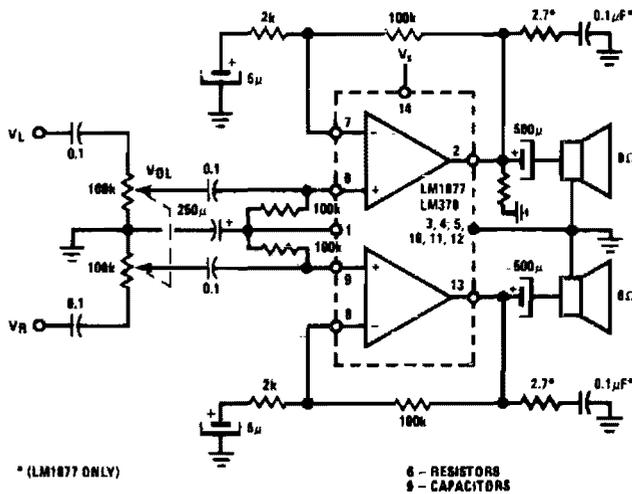
Fig. 8-3

Circuit Notes

This circuit is for low voltage applications requiring high power outputs. Output power levels of 1.0 W into 4 ohm from 6 V and 3.5 W into 8 ohm from 12 V are typical. Coupling capacitors are not necessary since the output

dc levels will be within a few tenths of a volt of each other. Where critical matching is required the 500 K potentiometer is added and adjusted for zero dc current flow through the load.

NONINVERTING AMPLIFIER USING SINGLE SUPPLY



* (LM1877 ONLY)

6 - RESISTORS
9 - CAPACITORS

Fig. 8-4

NONINVERTING AMPLIFIER USING SPLIT SUPPLY

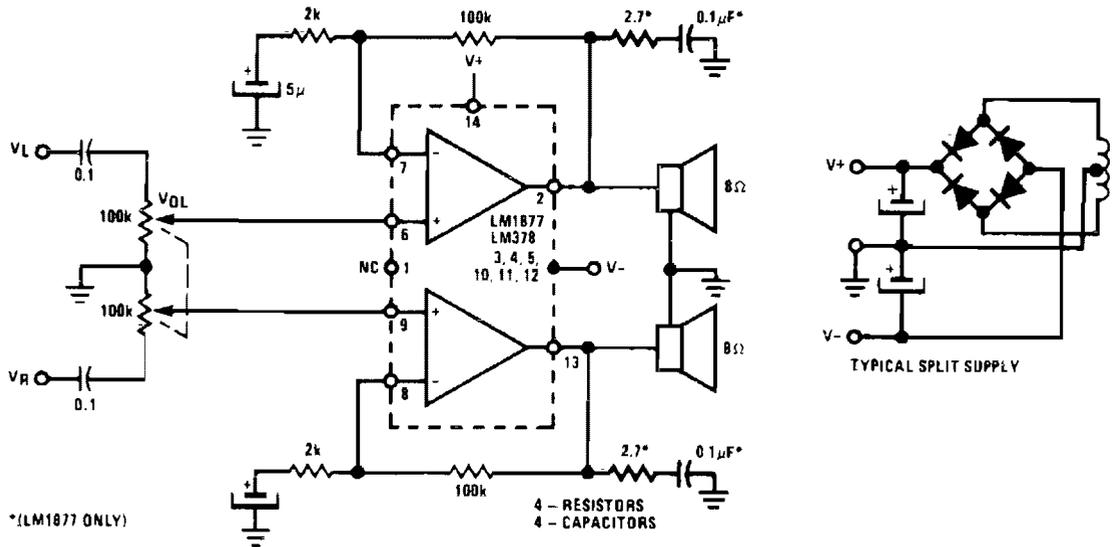


Fig. 8-5

6 W, 8'OHM OUTPUT TRANSFORMERLESS AMPLIFIER

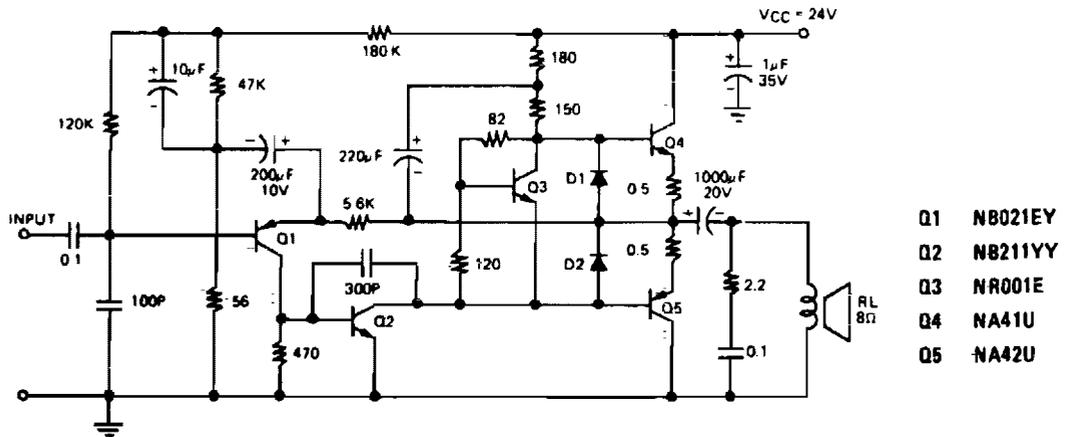
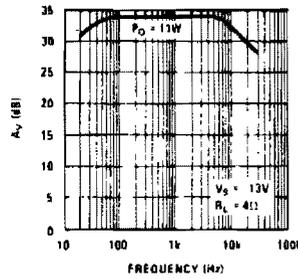
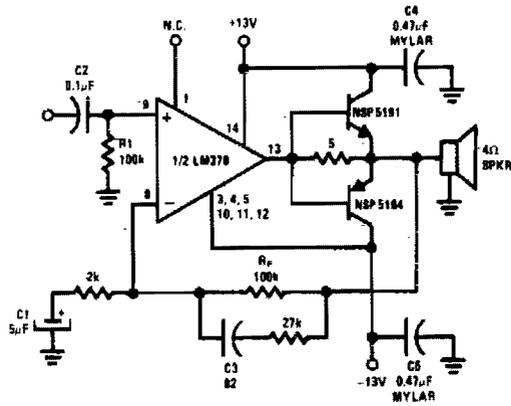
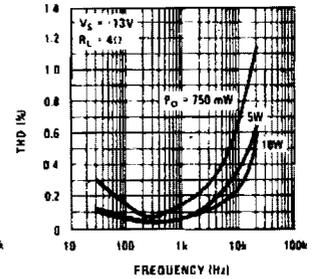


Fig. 8-6

12 W LOW-DISTORTION POWER AMPLIFIER



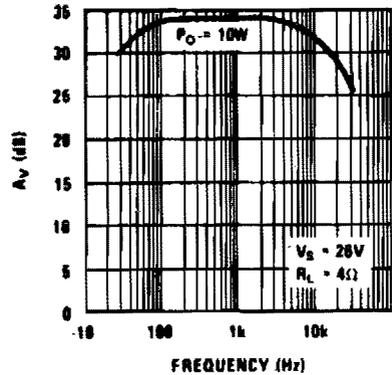
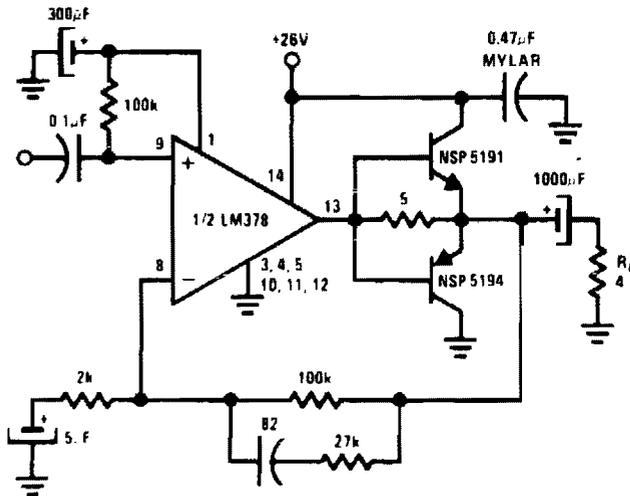
Response for Amplifier



Distortion for Amplifier

Fig. 8-7

10 W POWER AMPLIFIER



Frequency Response

Fig. 8-8

STEREO AMPLIFIER WITH $A_v = 200$

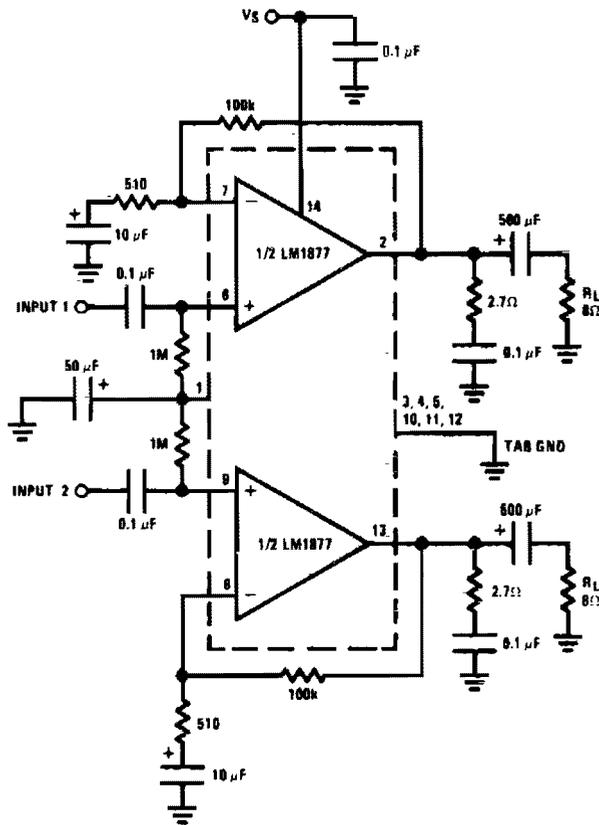
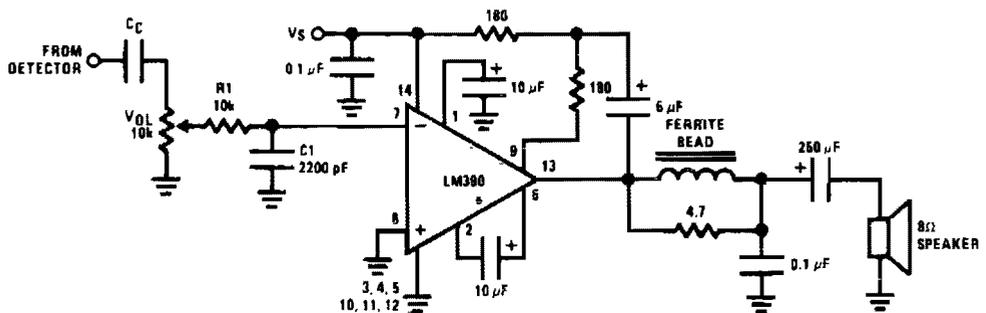


Fig. 8-9

AM RADIO POWER AMPLIFIER



Note 1: Twist supply lead and supply ground very tightly.

Note 2: Twist speaker lead and ground very tightly.

Note 3: Ferrite bead is Ferroxcube K5-001-001/3B with 3 turns of wire.

Note 4: R_1C_1 band limits input signals.

Note 5: All components must be spaced very close to IC.

Fig. 8-10

470 mW COMPLEMENTARY-SYMMETRY AUDIO AMPLIFIER

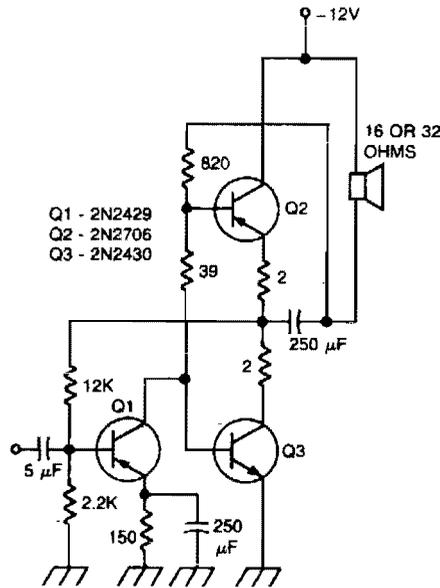


Fig. 8-11

Circuit Notes

This circuit has less than 2% distortion and is flat within 3 dB from 15 Hz to 130 kHz.

NOVEL LOUDSPEAKER COUPLING CIRCUIT

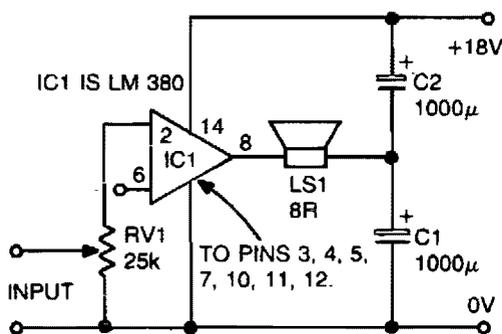


Fig. 8-12

Circuit Notes

The ground side of the speaker is connected to the junction of two equal high value capacitors (1000 μF is typical) across the supply. The amplifier output voltage will be $V_s/2$, and so will the voltage across C1 (if C1 and C2 are equal); so as the supply voltage builds up, the dc voltage across the speaker will remain zero, eliminating the switch-on surge. C1 and C2 will also provide supply smoothing. The circuit is shown with the LM380, but could be applied to any amplifier circuit, providing that the dc voltage at the output is half the supply voltage.

NONINVERTING AC POWER AMPLIFIER

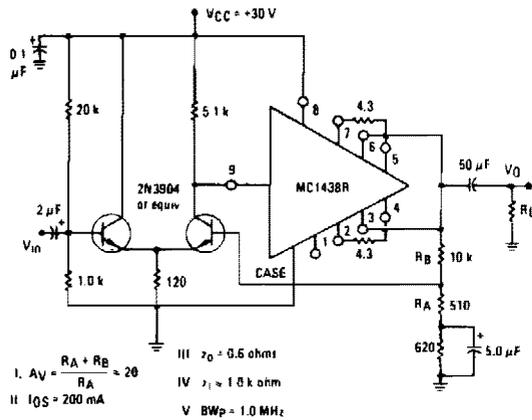


Fig. 8-13

NONINVERTING POWER AMPLIFIER

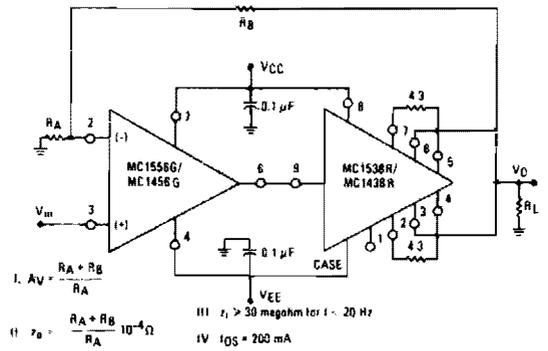


Fig. 8-15

INVERTING POWER AMPLIFIER

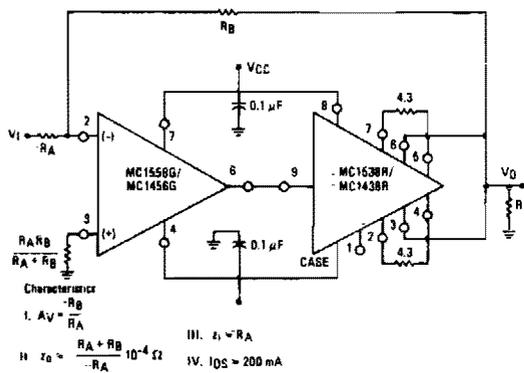


Fig. 8-14

4 W BRIDGE AMPLIFIER

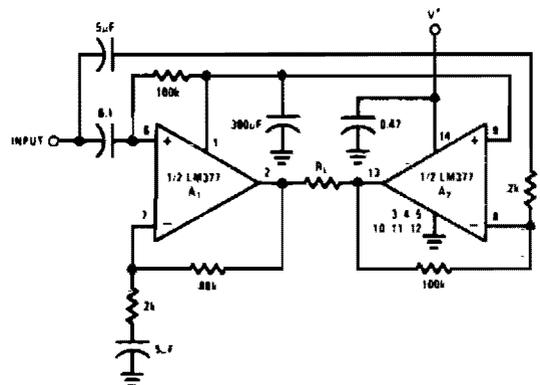


Fig. 8-16

PHONO AMPLIFIER WITH "COMMON MODE" VOLUME AND TONE CONTROL

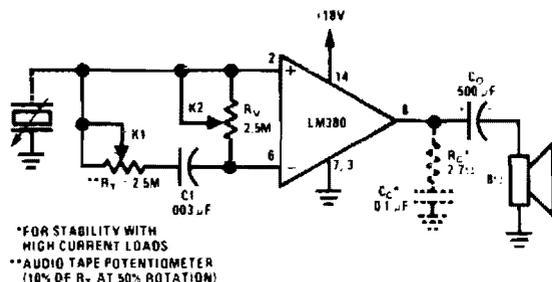


Fig. 8-17

PHONOGRAPH AMPLIFIER (CERAMIC CARTRIDGE)

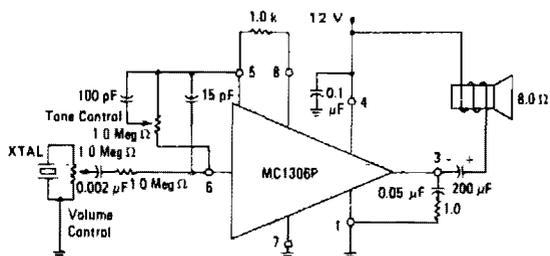


Fig. 8-19

PHONO AMPLIFIER

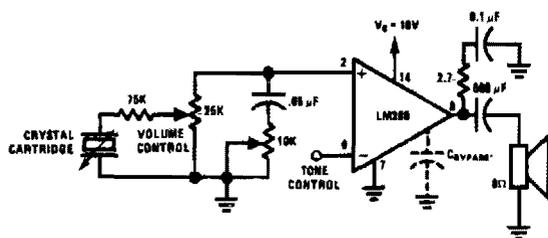


Fig. 8-18

INVERTING UNITY GAIN AMPLIFIER

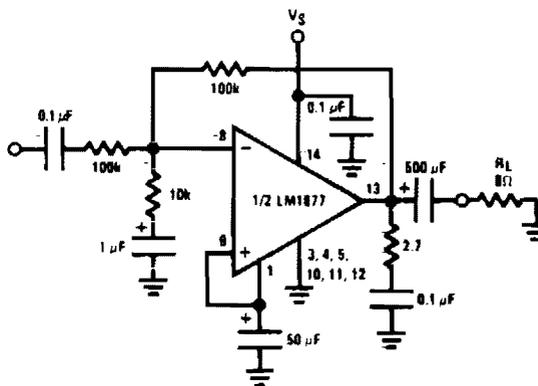
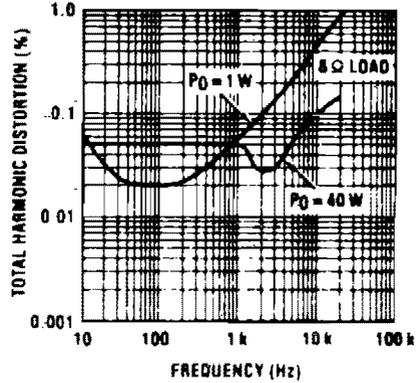
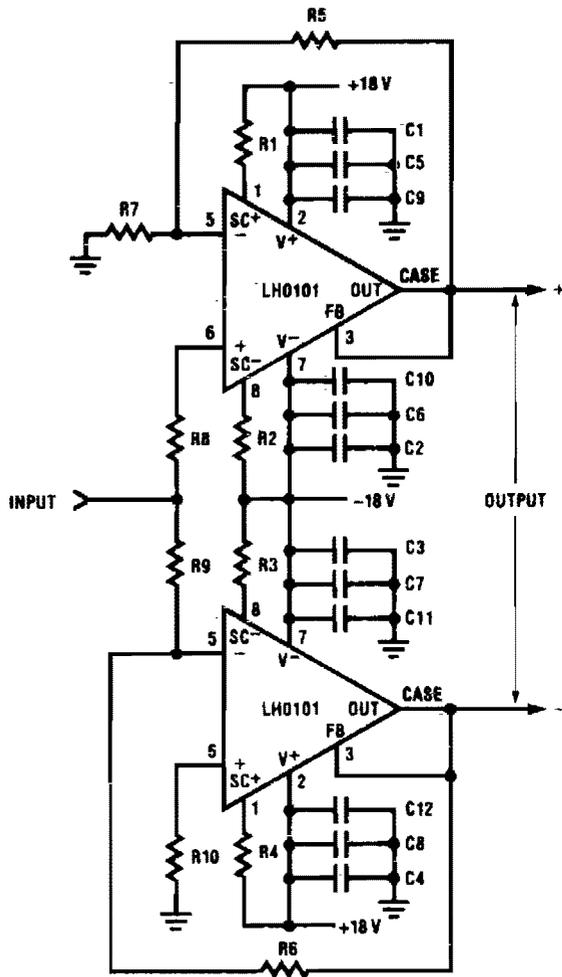


Fig. 8-20

BRIDGE AUDIO POWER AMPLIFIER

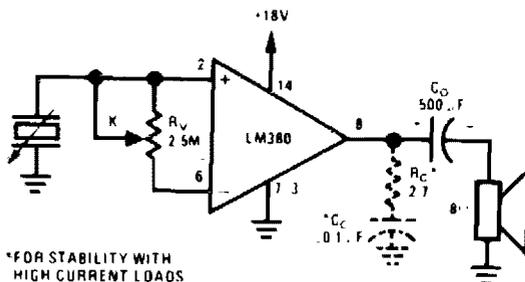


Total Harmonic Distortion vs.
Frequency of Bridge Power
Amplifier

- | | | |
|--------|------------------------|------------------------------|
| R1-R4 | CURRENT LIMIT RESISTOR | 0.15 Ω 2 W |
| R5 | FEEDBACK RESISTOR | 5 k Ω |
| R6 | FEEDBACK RESISTOR | 15 k Ω |
| R7-R10 | INPUT RESISTORS | 10 k Ω |
| C1-C4 | BYPASS CAPACITORS | 47 μ F 25 V ELECTROLYTIC |
| C5-C8 | BYPASS CAPACITORS | 10 μ F 25 V TANTALUM |
| C9-C12 | BYPASS CAPACITORS | 0.1 μ F 25 V CERAMIC |

Fig. 8-21

PHONO AMPLIFIER



*FOR STABILITY WITH
HIGH CURRENT LOADS

Circuit Notes

Used when maximum input impedance is
required or the signal attenuation of the voltage
divider volume control is undesirable.

Fig. 8-22

9

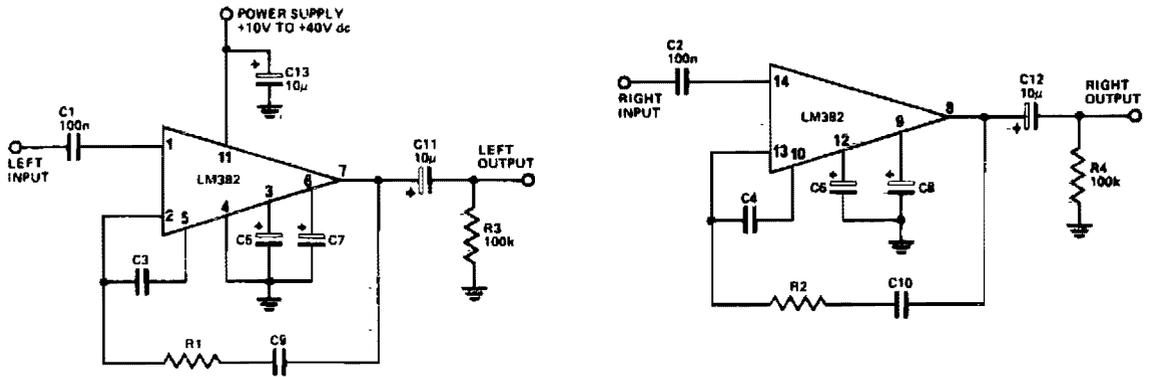
Audio Signal Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

General Purpose Preamplifier
Basic Transistor Amplifier Circuits
Microphone Amplifier
Transducer Amplifier
Ultra-High Gain Audio Amplifier
Transformerless Microphone Preamp (Balanced Inputs)
Transformerless Microphone Preamp (Unbalanced Inputs)
Magnetic Pickup Phone Preamplifier
Disc/Tape Phase Modulated Readback Systems

Two-Pole Fast Turn-On NAB Tape Preamplifier
Tape Preamplifier (NAB Equation)
LM382 Phono Preamplifier
Tape Recording Amplifier
Magnetic Phono Preamplifier
Phono Preamp
Remote Amplifier
Adjustable Gain Noninverting Amplifier
High Gain Inverting AC Amplifier
Flat Response Amplifier
Preamplifier with RIAA/NAB Compensation
Tape Playback Amplifier

GENERAL PURPOSE PREAMPLIFIER



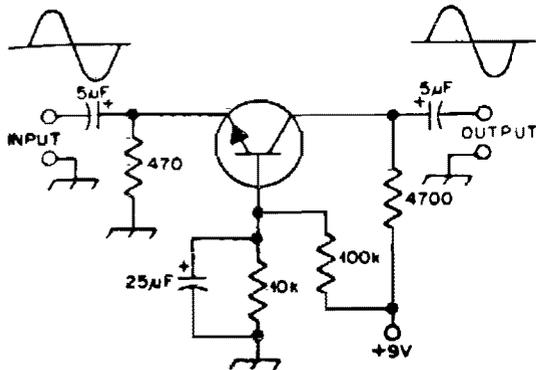
FUNCTION	C3, 4	C5, 6	C7, 8	C9, 10	R1, 2
Phono preamp (RIAA)	330n	10µF	10µF	1n5	1k
Tape preamp (NAB)	68n	10µF	10µF	—	—
Flat 40dB gain	—	—	10µF	—	—
Flat 55dB gain	—	10µF	—	—	—
Flat 80dB gain	—	10µF	10µF	—	—

Fig. 9-1

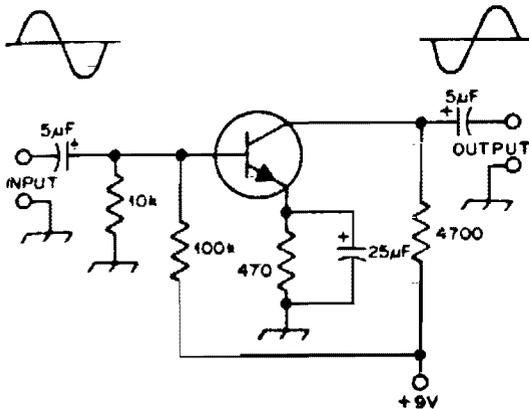
Circuit Notes

Not much can be said about how the LM382 works as most of the circuitry is contained within the IC. Most of the frequency-determining components are on the chip—only the capacitors are mounted externally. The LM382 has the convenient characteristic of rejecting ripple on the supply line by about 100 dB, thus greatly reducing the quality requirement for the power supply.

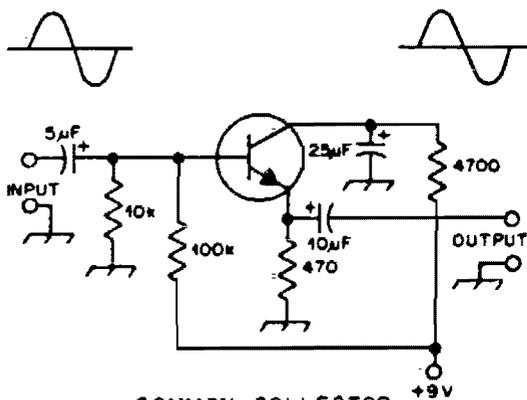
BASIC TRANSISTOR AMPLIFIER CIRCUITS



COMMON BASE



COMMON EMITTER



COMMON COLLECTOR

Circuit Notes

Typical component values are given for use at audio frequencies, where these circuits are used most often. The input and output phase relationships are shown.

Fig. 9-2

ELECTRONIC BALANCED INPUT MICROPHONE AMPLIFIER

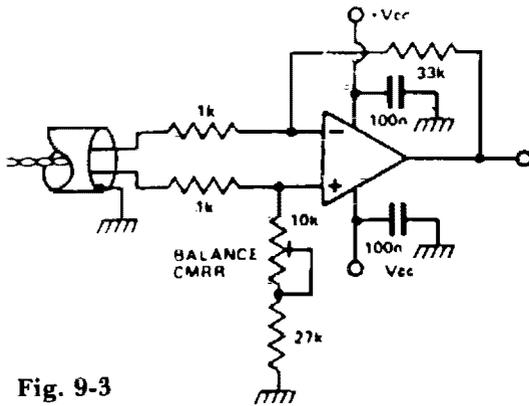


Fig. 9-3

Circuit Notes

It is possible to simulate the balanced performance of a transformer electronically with a different amplifier. By adjusting the presets, the resistor ratio can be balanced so that the best CMRR is obtained. It is possible to get a better CMRR than from a transformer. Use a RC4136 which is a quad low noise op amp.

TRANSDUCER AMPLIFIER

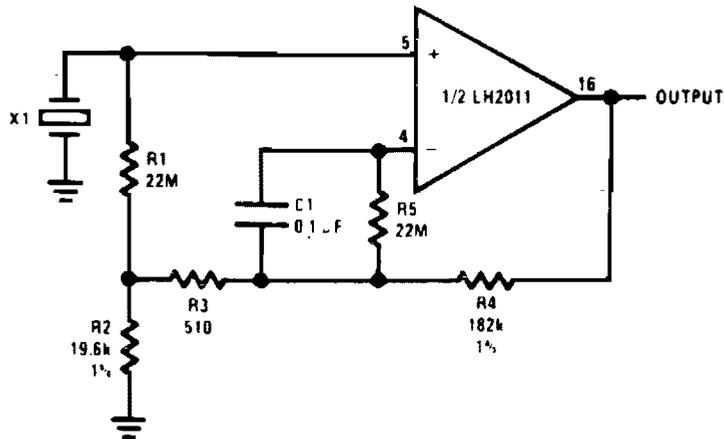


Fig. 9-4

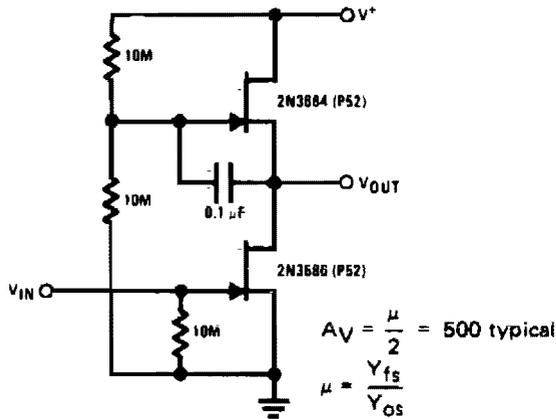
$$R_{IN} = R1 \left(1 + \frac{R2}{R3} \right) A_v = \frac{R2 + R3 + R4}{R2 \cdot R3}$$

Circuit Notes

This circuit is high-input-impedance ac amplifier for a piezoelectric transducer. Input

resistance is 880 M, and a gain of 10 is obtained.

ULTRA-HIGH GAIN AUDIO AMPLIFIER

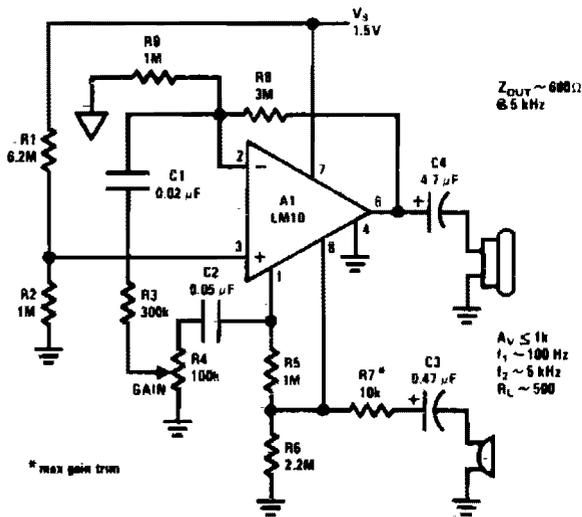


Circuit Notes

Sometimes called the JFET μ -amp, this circuit provides a very low power, high gain amplifying function. Since μ of a JFET increases as drain current decreases, the lower drain current is, the more gain you get. Input dynamic range is sacrificed with increasing gain, however.

Fig. 9-5

MICROPHONE AMPLIFIER



Circuit Notes

This circuit operates from a 1.5 Vdc source.

Fig. 9-6

TRANSFORMERLESS (BALANCE INPUTS) MICROPHONE PREAMP

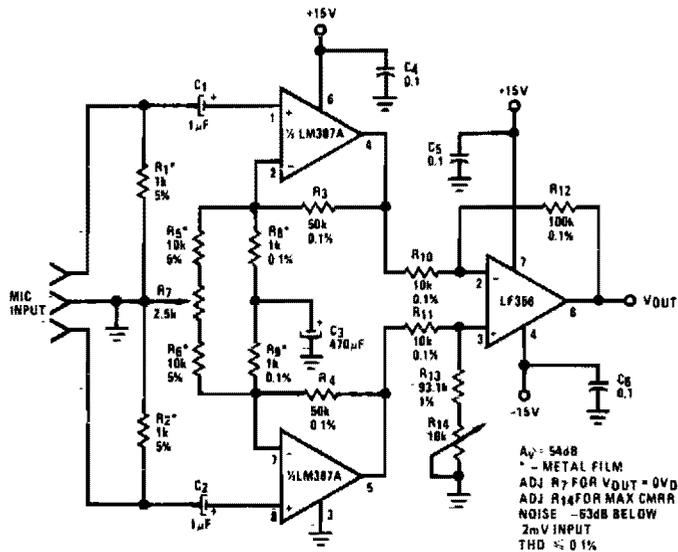


Fig. 9-7

TRANSFORMERLESS MICROPHONE PREAMPS (UNBALANCED INPUTS)

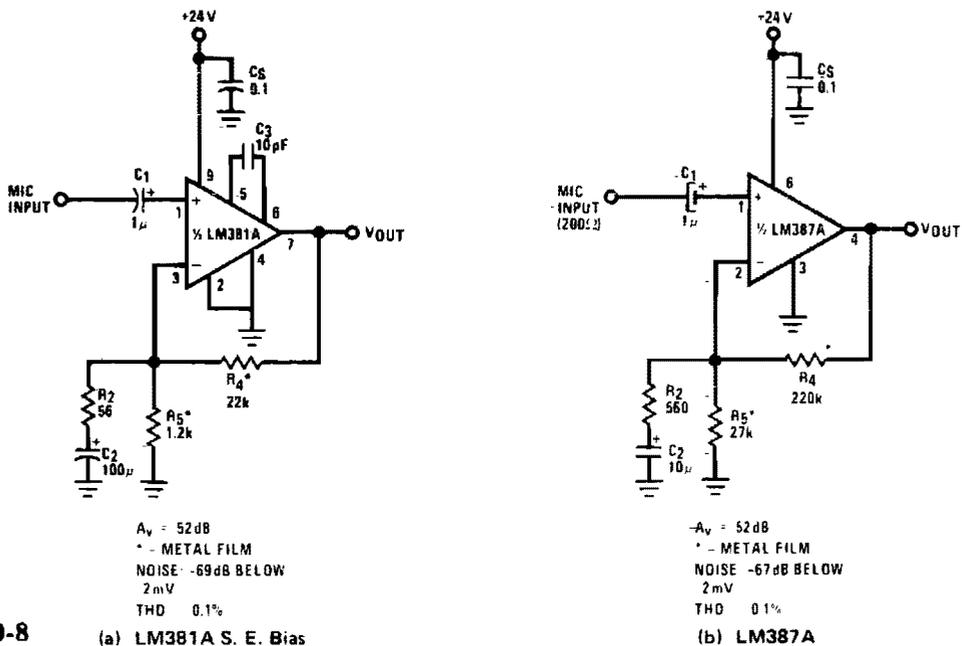


Fig. 9-8

MAGNETIC PICKUP PHONO PREAMPLIFIER

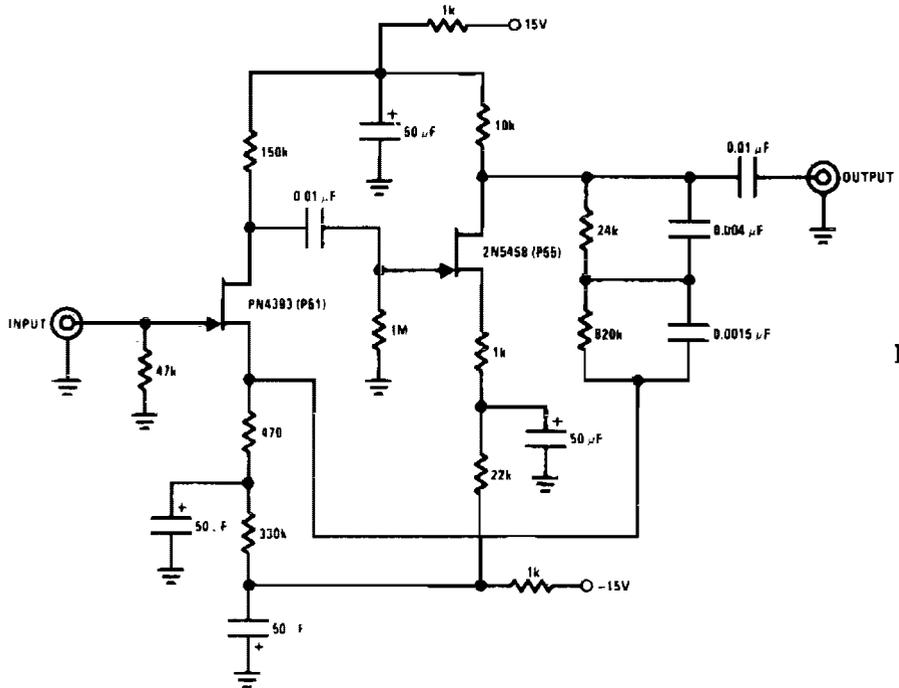


Fig. 9-9

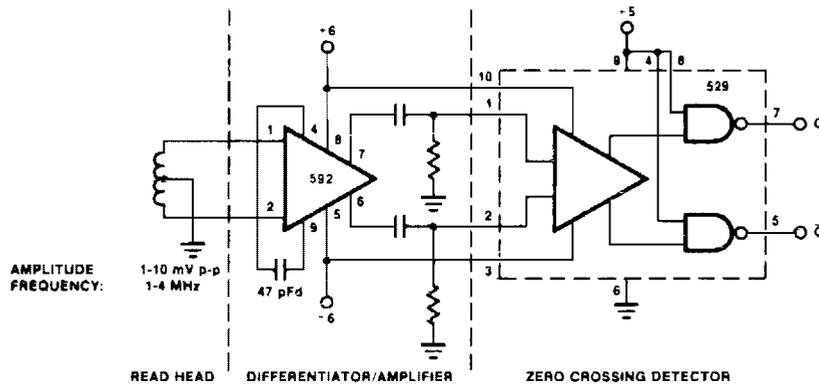
Circuit Notes

This preamplifier provides proper loading to a reluctance phono cartridge. It provides approximately 35 dB of gain at 1 kHz (2.2 mV input for 100 mV output). It features $(S + N)/N$

ratio of better than -70 dB (referenced to 10 mV input at 1 kHz) and has a dynamic range of 84 dB (referenced to 1 kHz). The feedback provides for RIAA equalization.

DISC/TAPE PHASE MODULATED READBACK SYSTEMS

Fig. 9-10



TWO-POLE FAST TURN-ON NAB TAPE PREAMPLIFIER

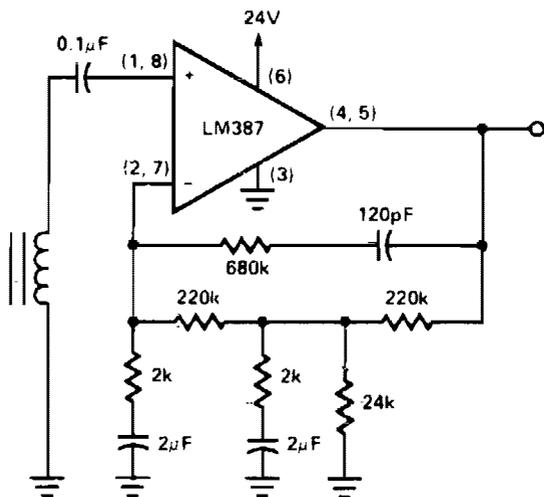


Fig. 9-11

LM382 PHONO PREAMPLIFIER (RIAA)

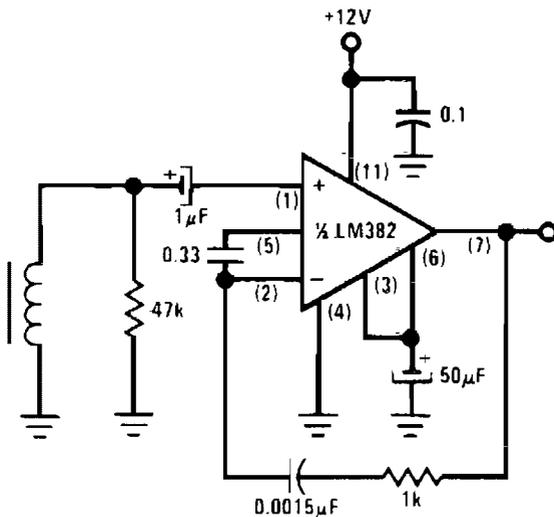


Fig. 9-13

TAPE PREAMPLIFIER (NAB EQUALIZATION)

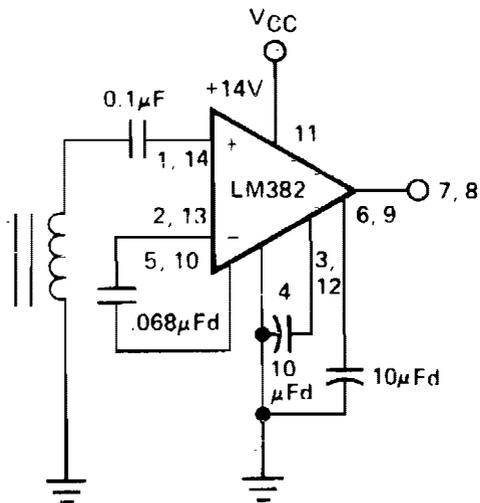


Fig. 9-12

TAPE RECORDING AMPLIFIER

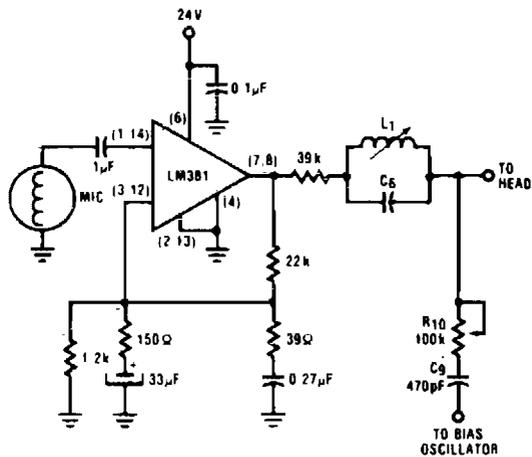


Fig. 9-14

MAGNETIC PHONO PREAMPLIFIER

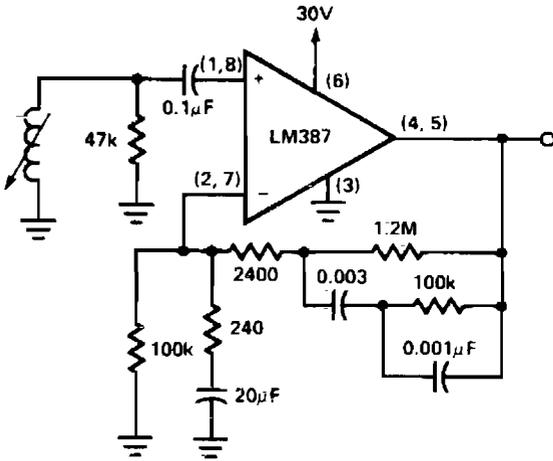


Fig. 9-15

REMOTE AMPLIFIER

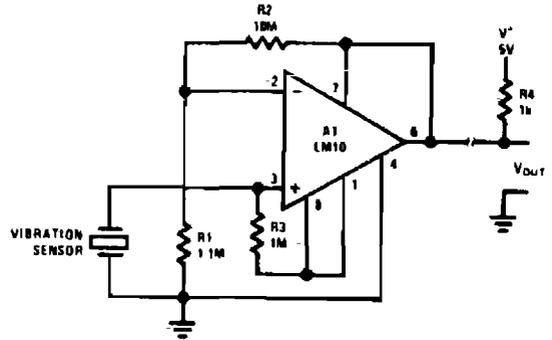
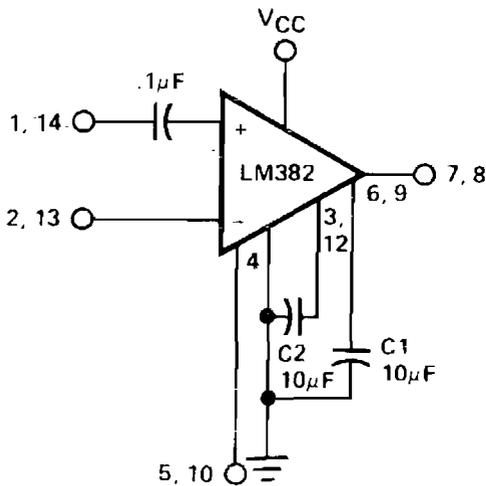


Fig. 9-17

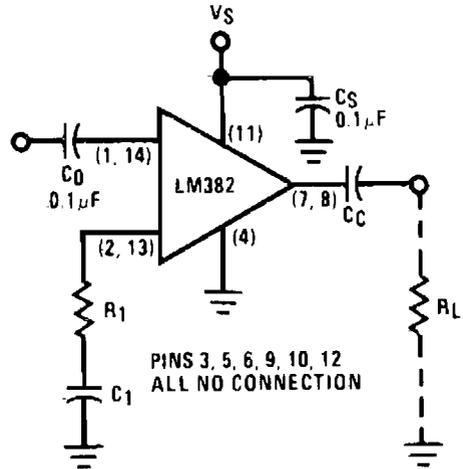
PHONO PREAMP (RIAA EQUALIZATION)



CAPACITOR	GAIN
C1 Only	40dB
C2 Only	55dB
C1 & C2	80dB

Fig. 9-16

ADJUSTABLE GAIN NONINVERTING AMPLIFIER



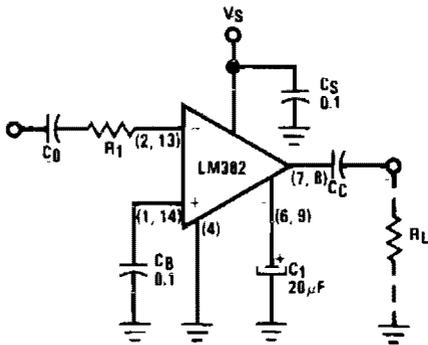
$$\text{GAIN} = 1 + \frac{267k}{R_1}$$

$$C_1 = \frac{1}{2\pi f_0 R_1}$$

f_0 = LOW FREQUENCY -3dB CORNER

Fig. 9-18

HIGH GAIN INVERTING AC AMPLIFIER



$$\text{GAIN} = -\frac{5.1 \times 10^6}{R_1}$$

$$C_0 = \frac{1}{2 \cdot f_0 \cdot R_1}$$

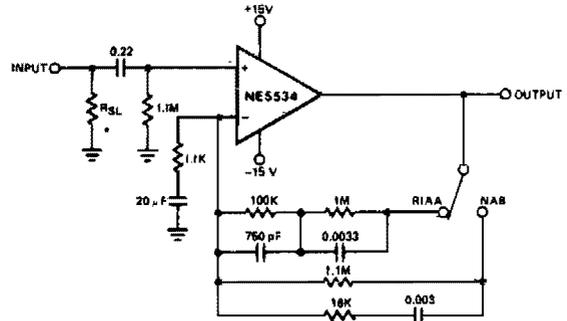
f_0 = LOW FREQUENCY -3dB CORNER ($C_L R_L \gg C_0 R_1$)

INPUT IMPEDANCE = R_1

PINS 3, 5, 16, 12 NOT USED

Fig. 9-19

PREAMPLIFIER WITH RIAA/NAB COMPENSATION



*Select to provide specified transducer loading.
Output Noise \approx 0.8 mV rms (with input shorted)

All resistor values are in ohms.

Fig. 9-21

FLAT RESPONSE AMPLIFIER (FIXED GAIN CONFIGURATION)

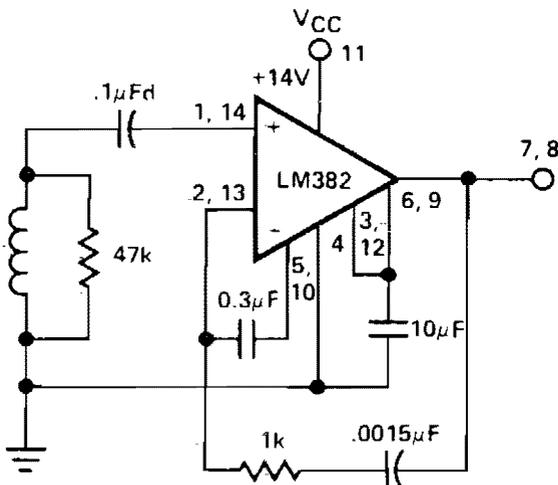


Fig. 9-20

TAPE PLAYBACK AMPLIFIER

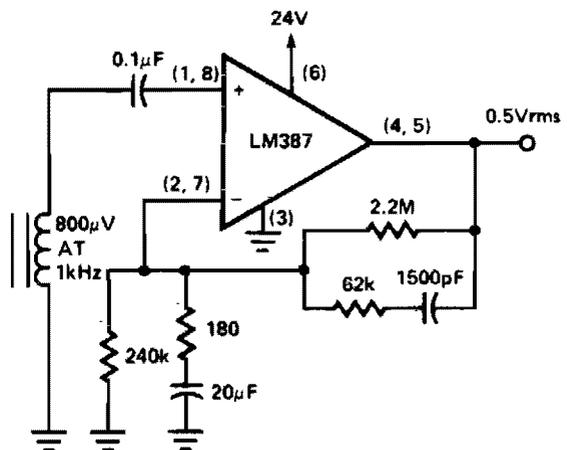


Fig. 9-22

10

Automotive Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Gasoline Engine Tachometer
Speed Alarm
Speed Warning Device
Universal Wiper Delay
Courtesy Light Extender
Bargraph Car Voltmeter
Tachometer
High Speed Warning Device
Breaker Point Dwell Meter
Tachometer
Capacitor Discharge Ignition System
Windshield Wiper Control

Auto Battery Current Analyzer
Speed Switch
Windshield Wiper Controller
Windshield Wiper Hesitation Control Unit
Ice Warning and Lights Reminder
Car Battery Monitor
Headlight Delay Unit
Windshield Washer Fluid Watcher
Car Battery Condition Checker
Overspeed Indicator
Sequential Flasher for Auto Turn Signals
Auto Lights-On Reminder

GASOLINE ENGINE TACHOMETER

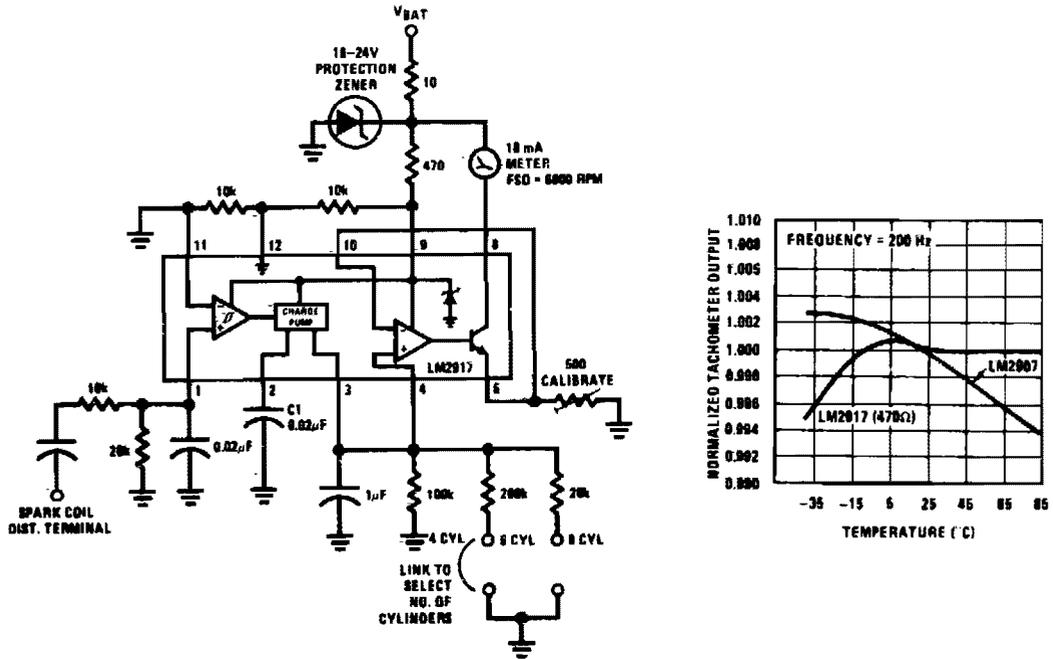


Fig. 10-1

Circuit Notes

This tachometer can be set up for any number of cylinders by linking the appropriate timing resistor as illustrated. A 500 ohm trim resistor can be used to set up final calibration.

A protection circuit composed of a 10 ohm resistor and a zener diode is also shown as a safety precaution against the transients which are to be found in automobiles.

SPEED ALARM

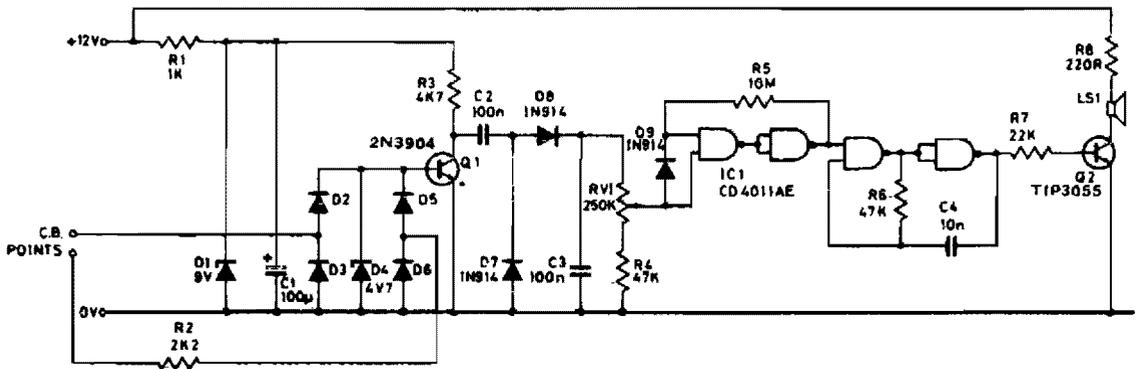


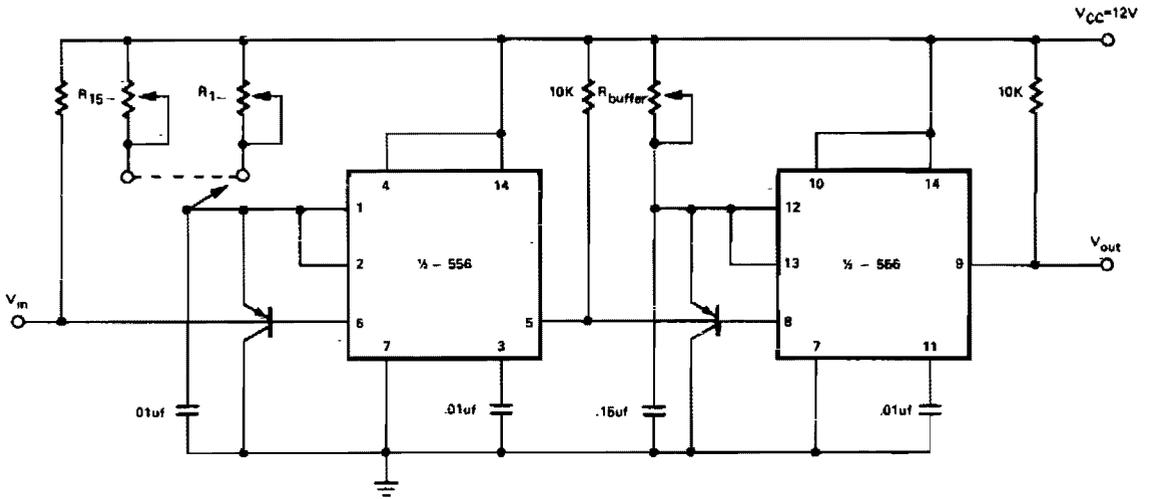
Fig. 10-2

Circuit Notes

Pulses from the distributor points are passed through a current limiting resistor, rectified, and clipped at 4.7 volts. Via Q1 and the diode pump, a dc voltage proportional to engine rpm is presented to RV1; the sharp transfer characteristic of a CMOS gate, assisted by

feedback, is used to enable the oscillator formed by the remaining half of the 4011. At the pre-set speed, a nonignorable tone emits from the speaker, and disappears as soon as the speed drops by three or four mph.

SPEED WARNING DEVICE



OPERATING WAVEFORMS

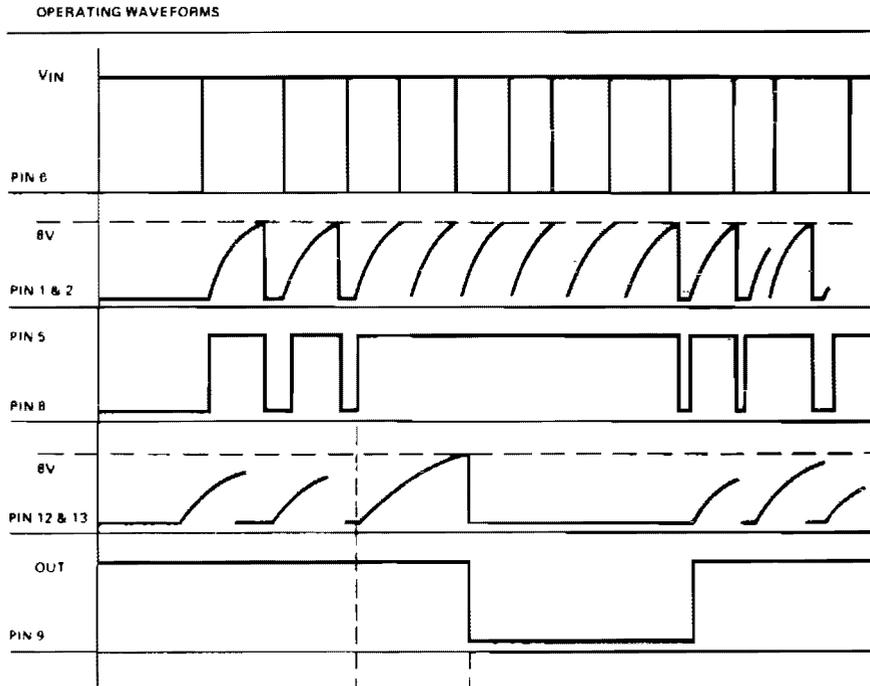


Fig. 10-3

UNIVERSAL WIPER DELAY

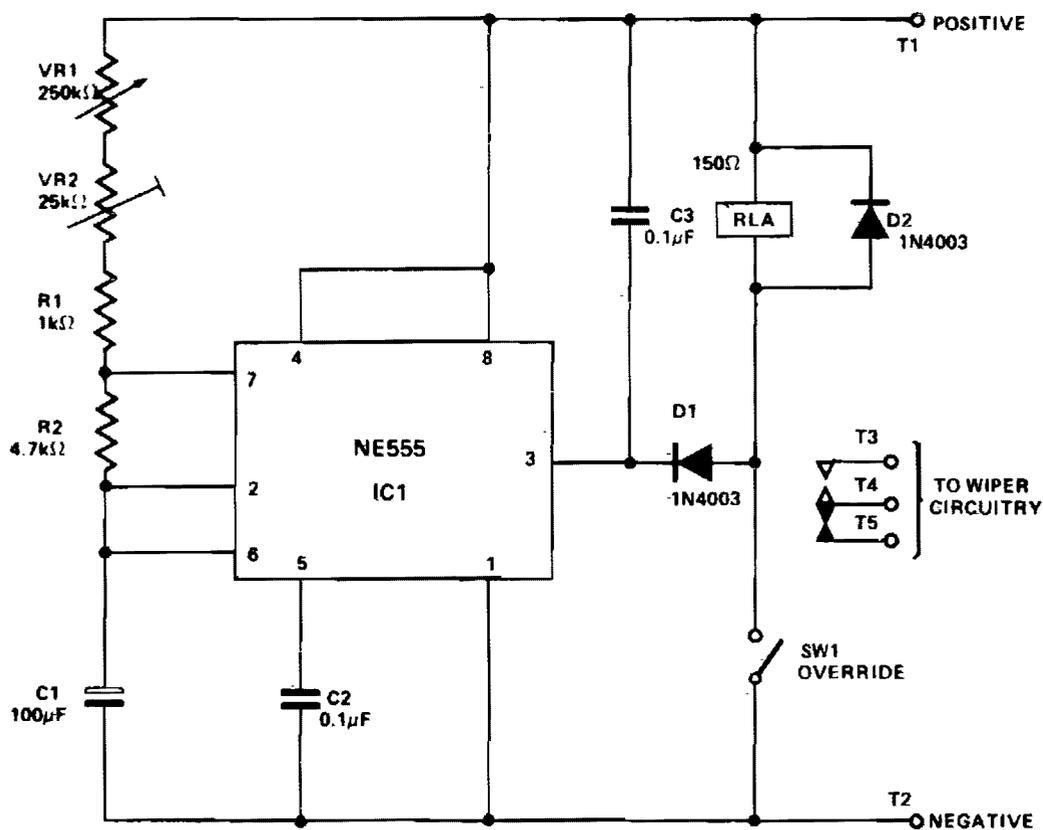


Fig. 10-4

Circuit Notes

IC1 is connected in the astable mode, driving RLA. C3, D1, and D2 prevent spikes from the relay coil and the wiper motor from triggering IC1. VR2 is adjusted to give the minimum delay time required. VR1 is the main delay control and provides a range of from

about 1 second to 20 seconds. SW1 is an override switch to hold RLA permanently on (for normal wiper operation). The relay should have a resistance of at least 150 ohms and have heavy duty contacts. The suppression circuit may be needed for the protection of IC1.

COURTESY LIGHT EXTENDER

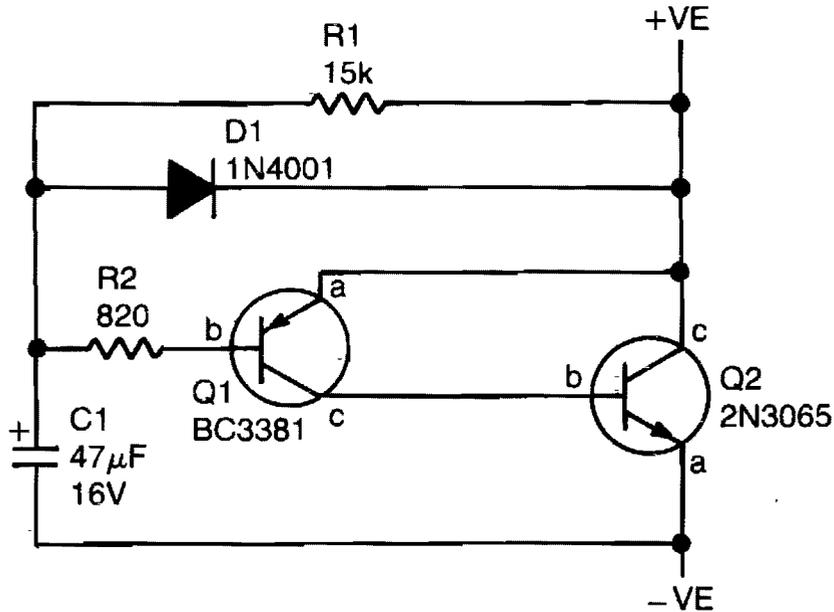


Fig. 10-5

Circuit Notes

Most car door switches are simply single-pole switches, with one side grounded. When the door is opened the switch grounds the other line thus completing the light circuit. In a car where the negative terminal of the battery is connected to the chassis, the negative wire of the unit (emitter of Q2) is connected to chassis the positive wire (case of 2N3055) is connected to the wire going to the switch. In a car having a positive ground system this connection sequence is reversed. When the switch closes (door open), C1 is discharged via D1 to zero volts, and when the switch opens, C1 charges up via R1 and R2.

Transistors Q1 and Q2 are connected as an emitter follower (Q2 just buffers Q1) therefore the voltage across Q2 increases slowly as C1 charges. Hence Q2 acts like a low resistance in parallel with the switch and keeps the lights on. The value of C1 is chosen such that a useful light level is obtained for about four seconds; therefore the light decreases until in about 10 seconds it is out completely. With different transistor gains and with variation in current drain due to a particular type of car, the timing may vary but may be simply adjusted by selecting C1.

TACHOMETER

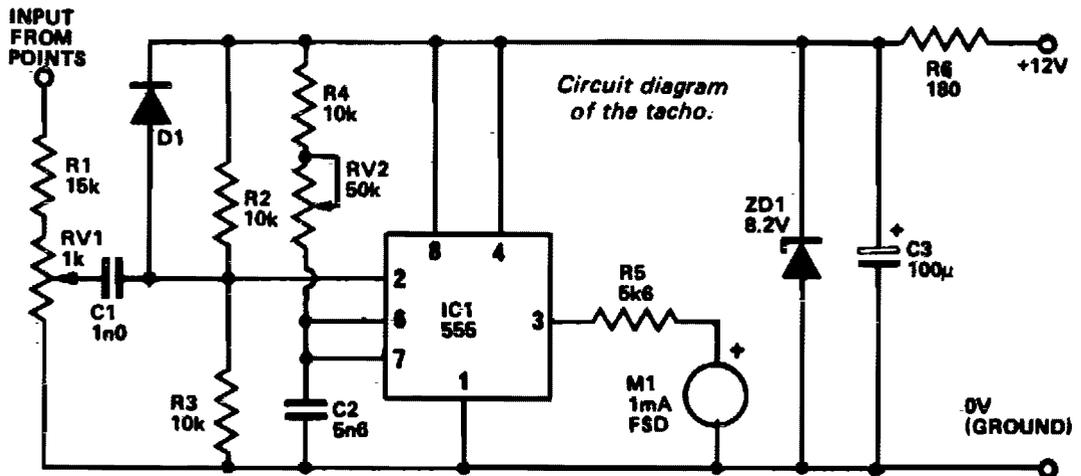


Fig. 10-7

Circuit Notes

An electrical signal taken from the low tension side of the distributor is converted into a voltage proportional to engine rpm and this voltage is displayed on a meter calibrated accordingly. The 555 timer IC is used as a monostable which, in effect, converts the signal pulse from the breaker points to a single positive pulse the width of which is determined by the value of $R4 + RV2$ and $C2$. Resistors $R2$

and $R3$ set a voltage of about 4 volts at pin 2 of IC1. The IC is triggered if this voltage is reduced to less than approximately 2.7 volts ($\frac{1}{2}$ of supply voltage), and this occurs due to the voltage swing when the breaker points open. An adjustment potentiometer $RV1$ enables the input level to be set to avoid false triggering. Zener diode $ZD1$ and the 180 ohm resistor stabilize the unit against voltage variations.

HIGH SPEED WARNING DEVICE

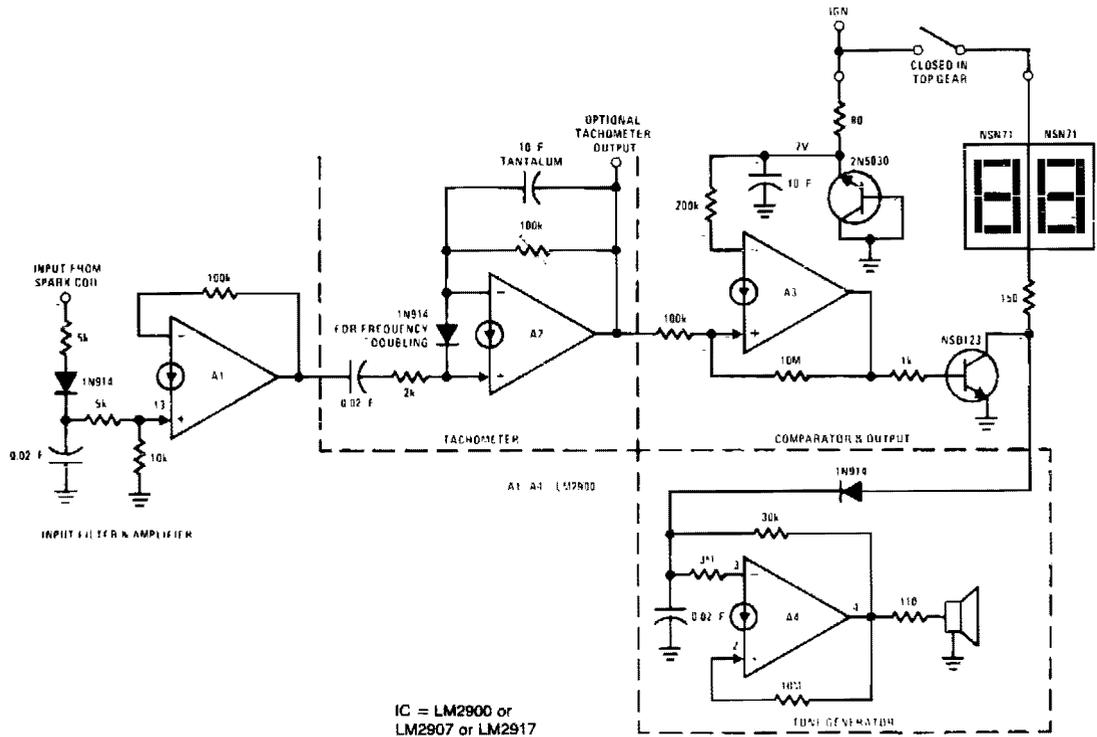


Fig. 10-8

Circuit Notes

A1 amplifies and regulates the signal from the spark coil. A2 converts frequency to voltage so that its output is a voltage proportional to engine rpm. A3 compares the tachometer

voltage with the reference voltage and turns on the output transistor at the set speed. Amplifier A4 is used to generate an audible tone whenever the set speed is exceeded.

BREAKER POINT DWELL METER

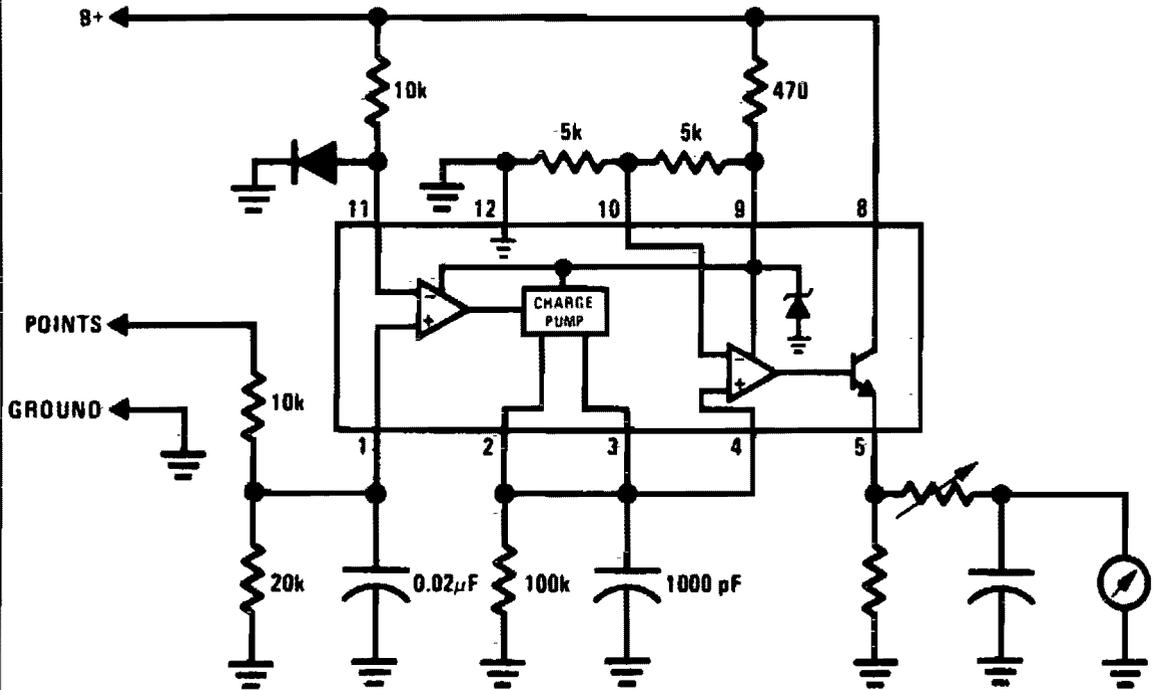


Fig. 10-9

TACHOMETER

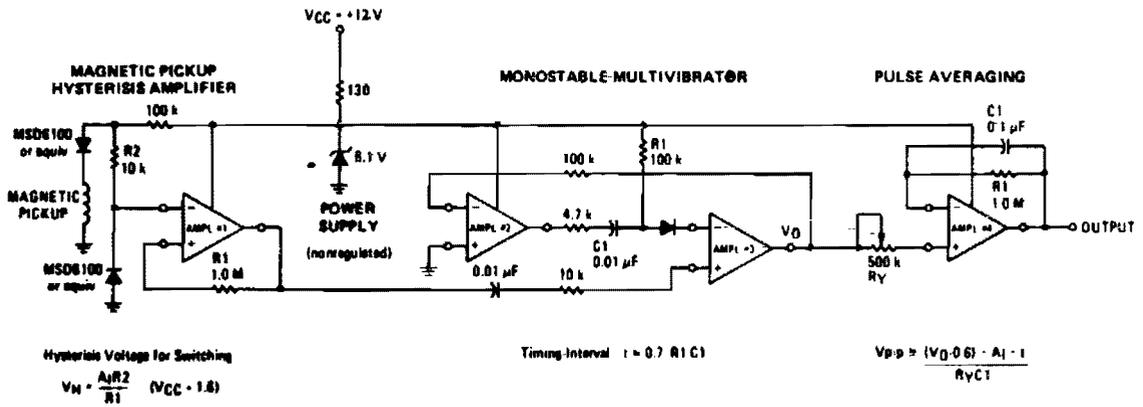


Fig. 10-10

CAPACITOR DISCHARGE IGNITION SYSTEM

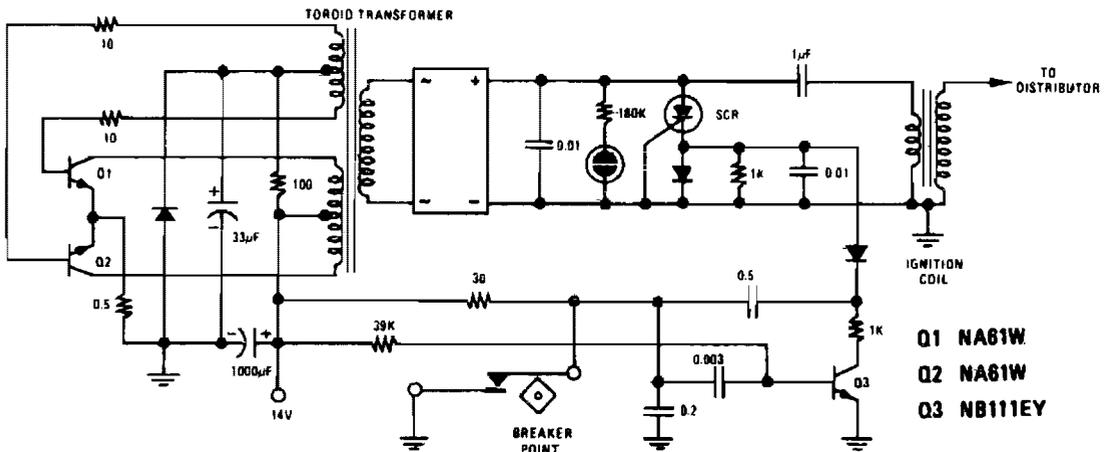


Fig. 10-11

WINDSHIELD WIPER CONTROL

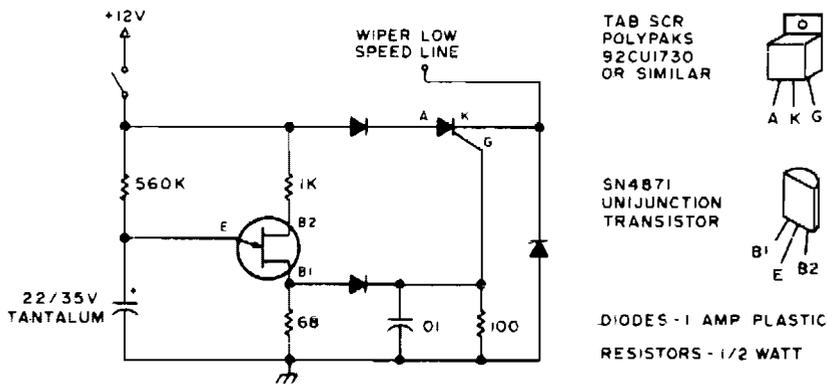


Fig. 10-12

Circuit Notes

Here's a good way to set windshield wipers on an interval circuit. Only two connections to the car's wiper control, plus ground, are required. Variable control can be accomplished by substituting a 500 K pot in series with a 100 K fixed resistor in place of the 560 K.

AUTO BATTERY CURRENT ANALYZER

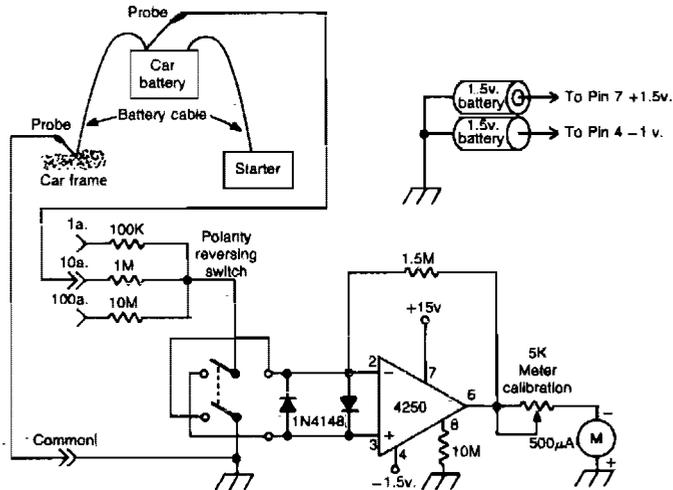


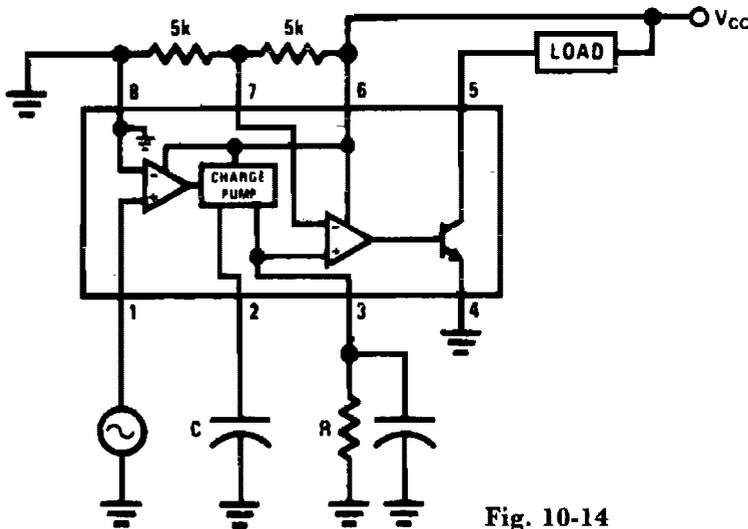
Fig. 10-13

Circuit Notes

This op-amp analyzer can measure the current drawn by any device in a car. The analyzer works by measuring the very small voltage that develops across the battery cables

when current flows. To calibrate the unit, measure the current flow somewhere in the car with an accurate ammeter, then adjust the analyzer for that current reading.

SPEED SWITCH



Circuit Notes

Load is energized when

$$f_{in} \approx \frac{1}{2RC}$$

Fig. 10-14

WINDSHIELD WIPER CONTROLLER

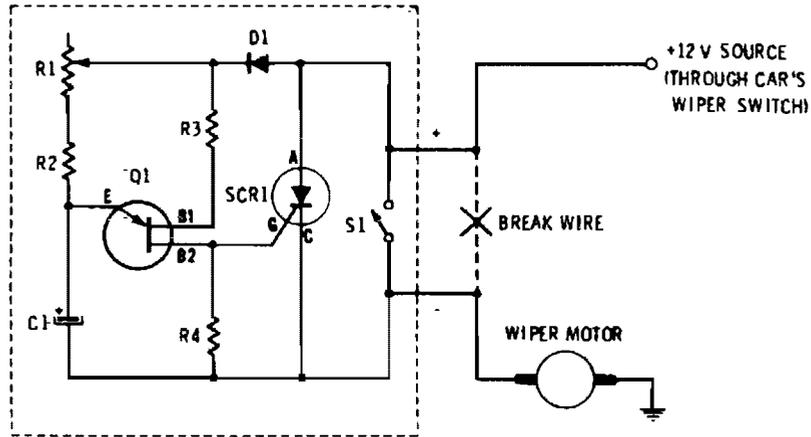


Fig. 10-15

Circuit Notes

This circuit provides complete speed control over car's windshield wipers. They can be slowed down to any rate even down to four sweeps per minute. The controller has two

principal circuits: The rate-determining circuit—a unijunction transistor connected as a freerunning oscillator, and the silicon-controlled rectifier which is the actuator.

WINDSHIELD WIPER HESITATION CONTROL UNIT

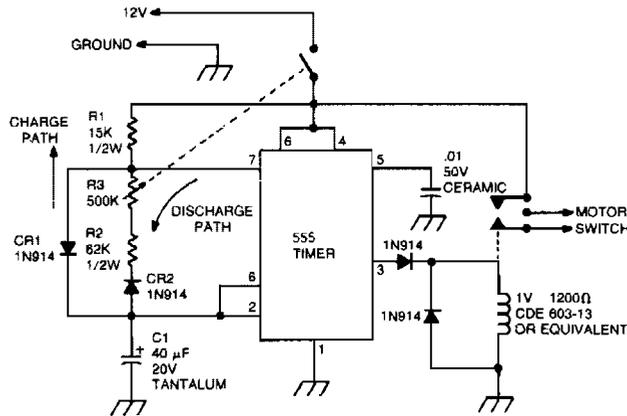


Fig. 10-16

Circuit Notes

This circuit uses the 555 timer in the astable or oscillatory mode. The length of time the timer is off is a function of the values of C1, R2, and R3. The potentiometer which controls the

amount of "hesitation". (Approximately 2 to 15 seconds.) R2 provides a minimum time delay when R3 is at its zero ohms position.

ICE WARNING AND LIGHTS REMINDER

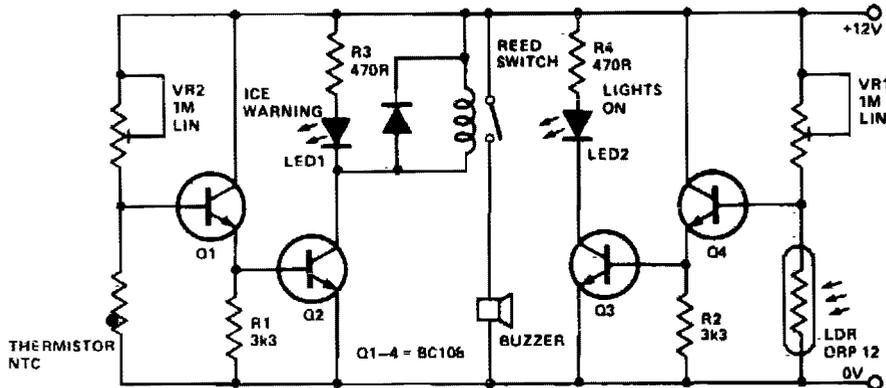


Fig. 10-17

Circuit Notes

This device will tell a driver if his lights for temperature, VR2 for light. Both thermistor and LDR should be well protected. Most high gain NPN transistors will work.

and sounding a buzzer. VR1 adjusts sensitivity

CAR BATTERY MONITOR

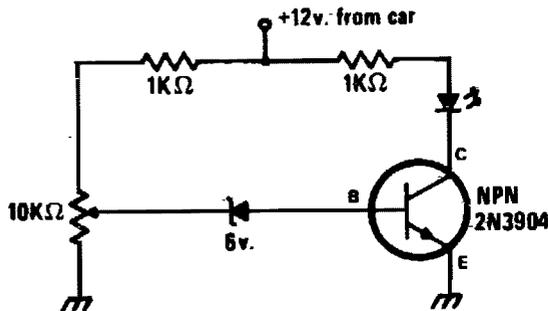


Fig. 10-18

Circuit Notes

Warning light (LED) indicates when battery voltage falls below level set by 10 K pot. Can indicate that battery is defective or needs charging if cranking drops battery voltage below preset "safe" limit.

HEADLIGHT DELAY UNIT

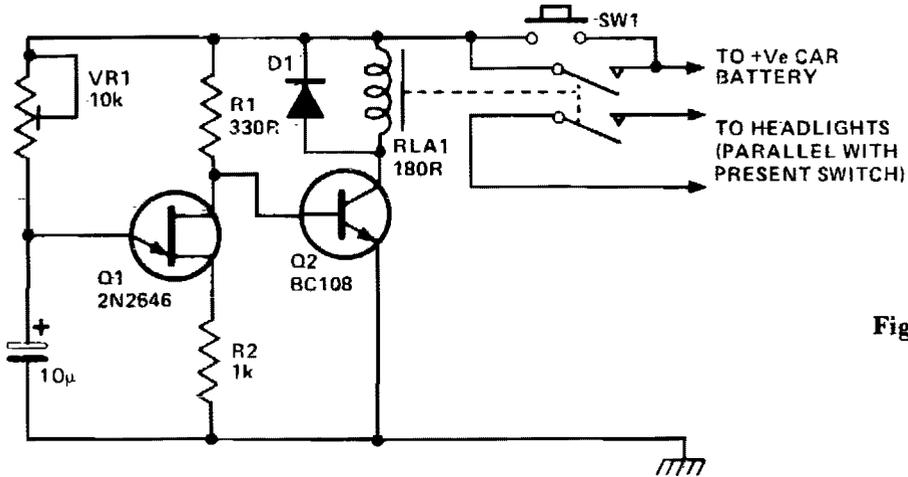


Fig. 10-19

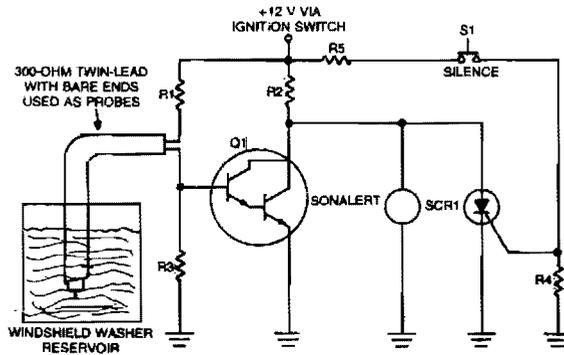
Circuit Notes

This circuit will operate a car's headlights for a predetermined time to light up the driveway or path after the driver has left the car. SQ1 is pushed and Q2 is turned on closing the relay and turning on the car's headlights. C1

begins to charge through VR1 until Q1 turns on, turning Q2 off. The relay will then open switching off both the lights and the unit. The delay is governed by the time taken for the capacitor to charge, which is about one minute.

WINDSHIELD WASHER FLUID WATCHER

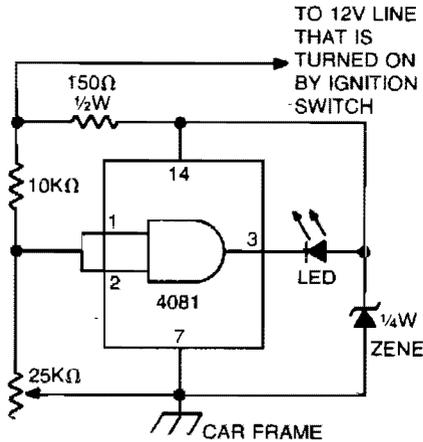
Fig. 10-20



Circuit Notes

This circuit relies upon the minute current between two conductive probes suspended in a washer fluid reservoir. When the level is below the probes, Q1 turns on and the Sonalert sounds.

CAR BATTERY CONDITION CHECKER

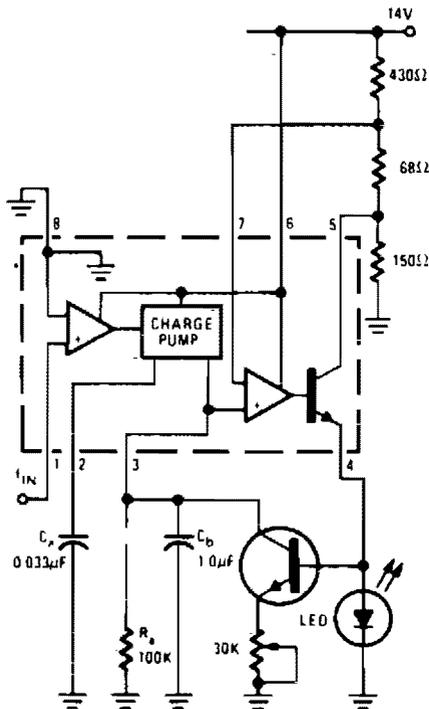


Circuit Notes

This circuit uses an LED and 4081 CMOS integrated circuit. The variable resistor sets the voltage at which the LED turns on. Set the control so that the LED lights when the voltage from the car's ignition switch drops below 13.8 volts. The LED normally will light every now and then for a short period of time. But, if it stays on for very long, your electrical system is in trouble.

Fig. 10-21

OVERSPEED INDICATOR



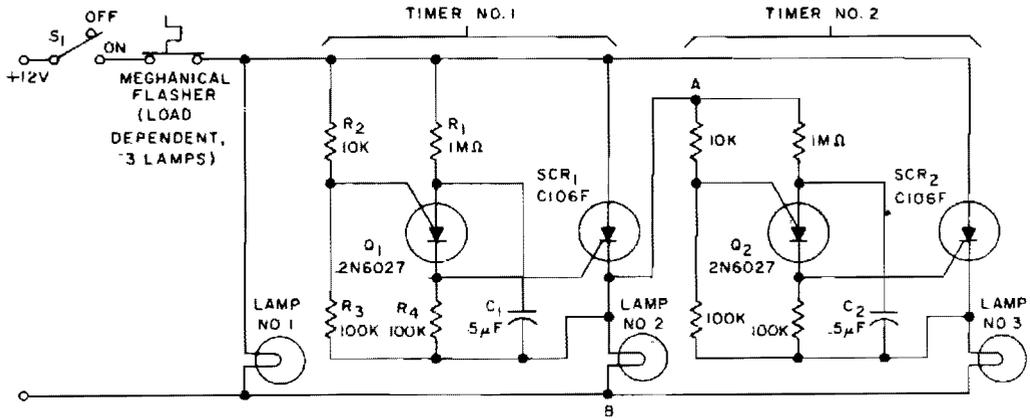
FLASHING BEGINS WHEN $f_{IN} = 100$ Hz
FLASH RATE INCREASES WITH INPUT FREQUENCY
INCREASE BEYOND TRIP POINT

Circuit Notes

An op-amp comparator is used to compare the converter output with a dc threshold voltage. The circuit flashes the LED when the input frequency exceeds 100 Hz. Increases in frequency raise the average current out of terminal 3 so that frequencies above 100 Hz reduce the charge time of C2, increasing the LED flashing rate. IC = LM2907 or LM2917

Fig. 10-22

SEQUENTIAL FLASHER FOR AUTOMOTIVE TURN SIGNALS



Circuit Notes

When the turn signal switch S_1 is closed, lamp #1 will be activated and capacitor C_1 will charge to the triggered voltage of Q_1 . As soon as the anode voltage on Q_1 exceeds its gate voltage by 0.5 V, Q_1 will switch into the low resistance mode, thereby triggering SCR_1 to activate lamp #2 and the second timing circuit.

After Q_2 switches into the low resistance state, SCR_2 will be triggered to activate lamp #3. When the thermal flasher interrupts the current to all three lamps, SCR_1 and SCR_2 are commutated and the circuit is ready for another cycle.

Fig. 10-23

AUTO LIGHTS-ON REMINDER

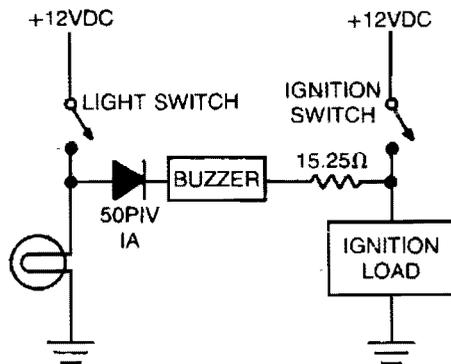


Fig. 10-24

Circuit Notes

The alarm is composed of a diode, buzzer, and limiting resistor. The diode serves as a switch which allows the buzzer to sound off only when the light switch is closed and the ignition is turned off.

11

Battery Chargers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

12 V Battery Charger

Simple Ni-Cad Battery Charger

12 V Battery Charger Control (20 Amps Rms
Max.)

Battery Charger

Automatic Shutoff Battery Charger

200 mA-Hour, 12 V Ni-Cad Battery Charger

Ni-Cad Charger with Current and Voltage
Limiting

Automotive Charger for Ni-Cad Battery Packs

Constant Voltage, Current-Limited Charger

Ni-Cad Charger

Simple Ni-Cad Battery Zapper

Battery Charging Regulator

Low-Cost Trickle Charger for 12V Storage
Battery

Fast Charger for Ni-Cad Batteries

Current Limited 6 V Charger

12 V BATTERY CHARGER

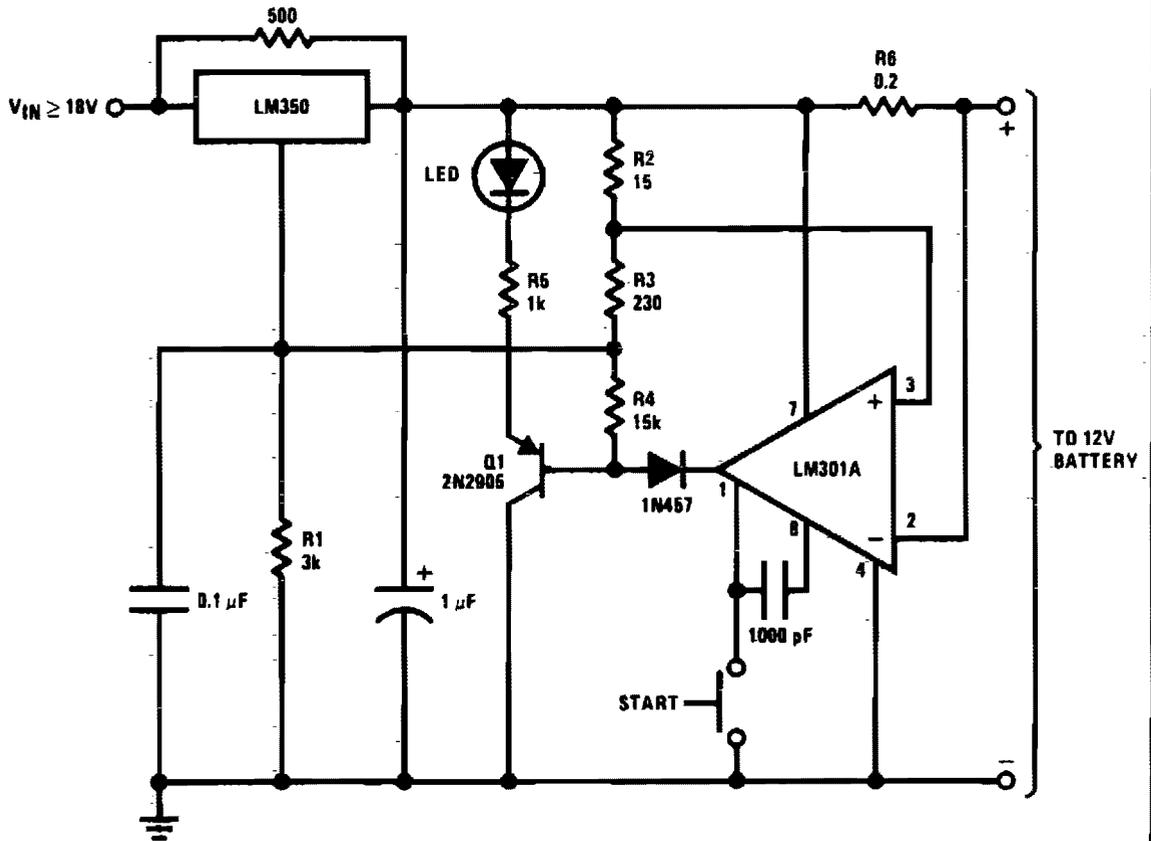


Fig. 11-1

Circuit Notes

This circuit is a high performance charger for gelled electrolyte lead-acid batteries. Charger quickly recharges battery and shuts off at full charge. Initially, charging current is limited to 2A. As the battery voltage rises, current to the battery decreases, and when the current has decreased to 150 mA, the charger switches to a lower float voltage preventing

overcharge. When the start switch is pushed, the output of the charger goes to 14.5 V. As the battery approaches full charge, the charging current decreases and the output voltage is reduced from 14.5 V to about 12.5 V terminating the charging. Transistor Q1 then lights the LED as a visual indication of full charge.

SIMPLE NI-CAD BATTERY CHARGER

PARTS LIST FOR NICAD BATTERY CHARGER

- C1—100- μ F, 50-V electrolytic capacitor
- D1—1-A, 400 PIV-silicon rectifier
- Q1—40-W, pnp power transistor
- R1—2000-ohm potentiometer
- T1—24-Vac, 117-Vac primary filament transformer

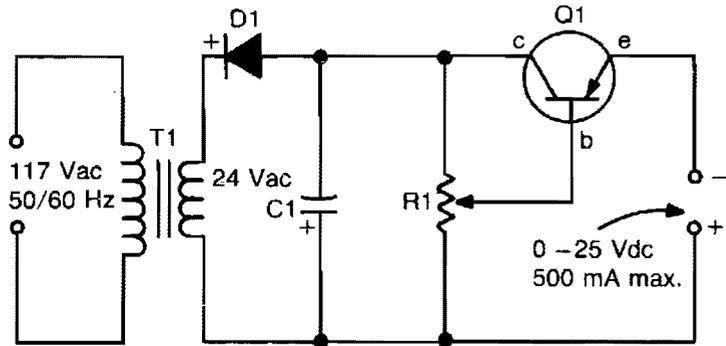
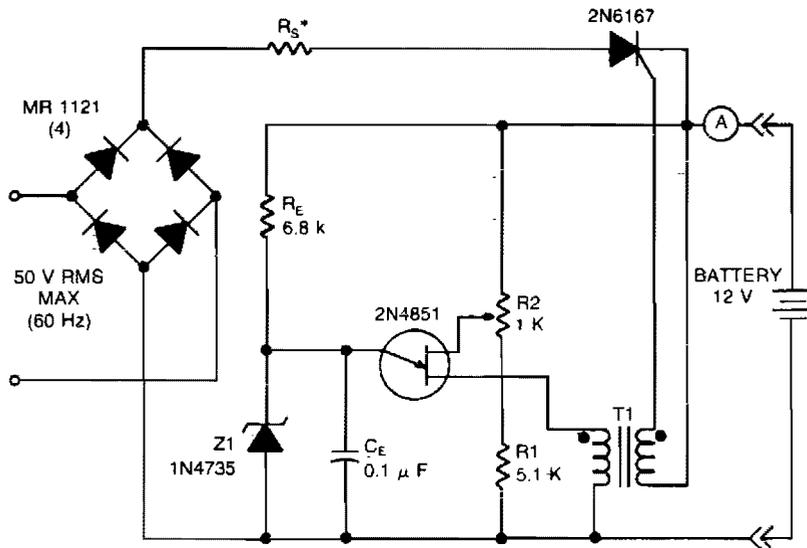


Fig. 11-2

Circuit Notes

This circuit provides an adjustable output voltage up to 35 Vdc and maximum output current of 50 mA. Transistor Q1 dissipates quite a bit of heat and must be mounted on a heatsink.

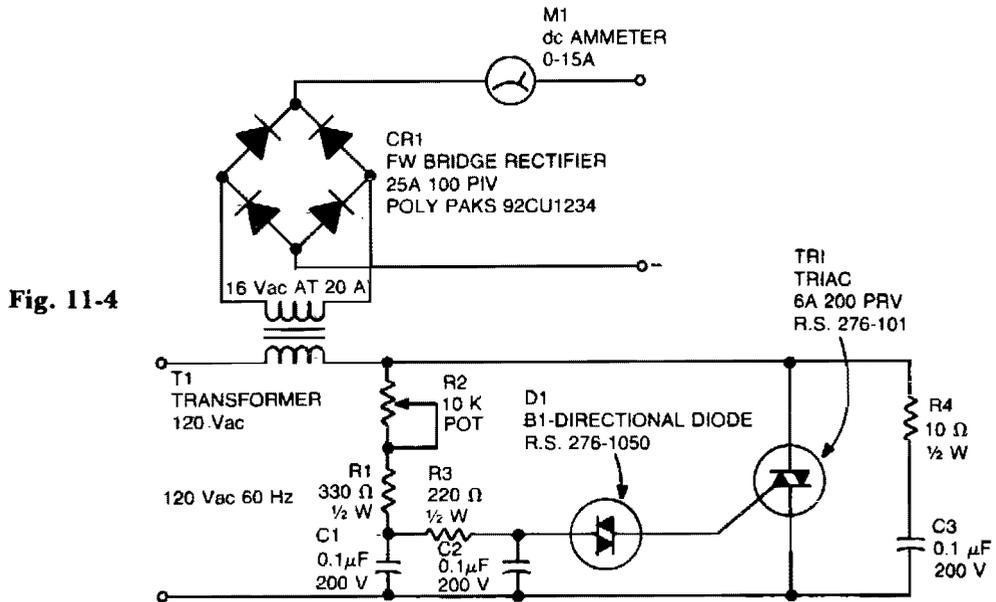
12 V BATTERY CHARGER CONTROL (20 AMPS RMS MAX.)



- T1 - PRIMARY = 30 TURNS #22
SECONDARY = 45 TURNS #22
CORE = FERROXCUBE 203 F 181-3C3
- R_s - SERIES RESISTANCE TO LIMIT CURRENT THROUGH SCR
2N6167 IS RATED AT 20 AMPS RMS

Fig. 11-3

BATTERY CHARGER

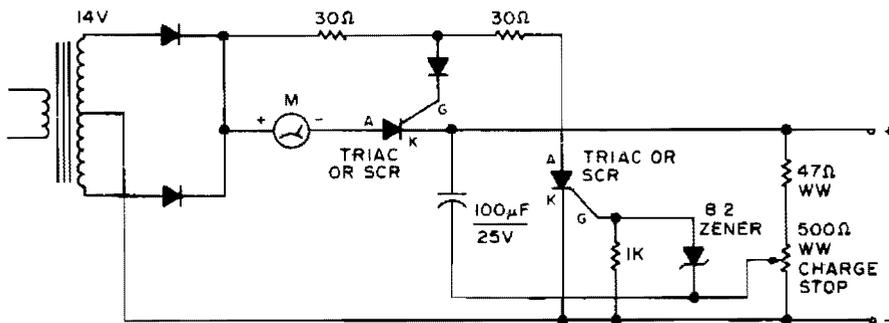


Circuit Notes

A diac is used in the gate circuit to provide a threshold level for firing the triac. C3 and R4 provide a transient suppression network. R1, R2, R3, C1, and C2 provide a phase-shift net-

work for the signal being applied to the gate. R1 is selected to limit the maximum charging current at full rotation of R2.

AUTOMATIC SHUTOFF BATTERY CHARGER



Circuit Notes

Adjust by setting the 500 ohm resistor while attached to a fully charged battery.

200 mA-HOUR, 12 V NI-CAD BATTERY CHARGER

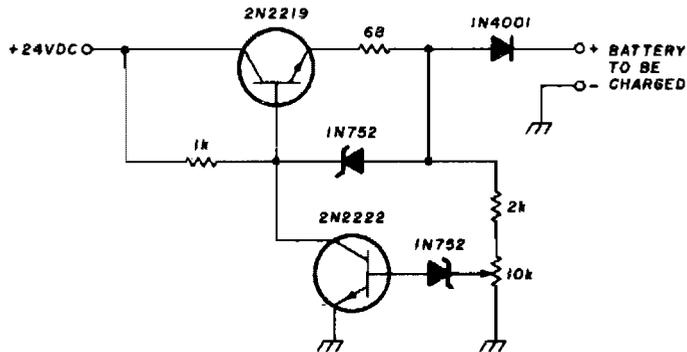


Fig. 11-6

Circuit Notes

This circuit charges the battery at 75 mA until the battery is charged, then it reduces the current to a trickle rate. It will completely recharge a dead battery in four hours and the

battery can be left in the charger indefinitely. To set the shut-off point, connect a 270-ohm, 2-watt resistor across the charge terminals and adjust the pot for 15.5 volts across the resistor.

NI-CAD CHARGER WITH CURRENT AND VOLTAGE LIMITING

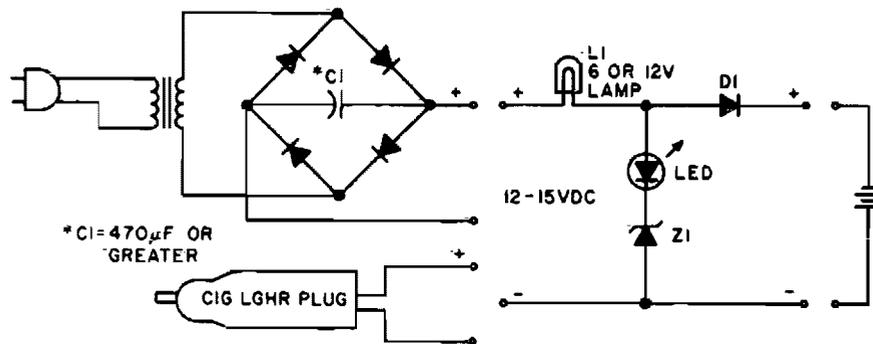


Fig. 11-7

Circuit Notes

Lamp L1 will glow brightly and the LED will be out when the battery is low and being charged, but the LED will be bright and the light bulb dim when the battery is almost ready. L1 should be a light bulb rated for the current you want (usually the battery capacity divided

by 10). Diode D1 should be at least 1 A, and Z1 is a 1 W zener diode with a voltage determined by the full-charge battery voltage minus 1.5 V. After the battery is fully charged, the circuit will float it at about battery capacity divided by 100 mA.

AUTOMOTIVE CHARGER FOR NI-CAD BATTERY PACKS

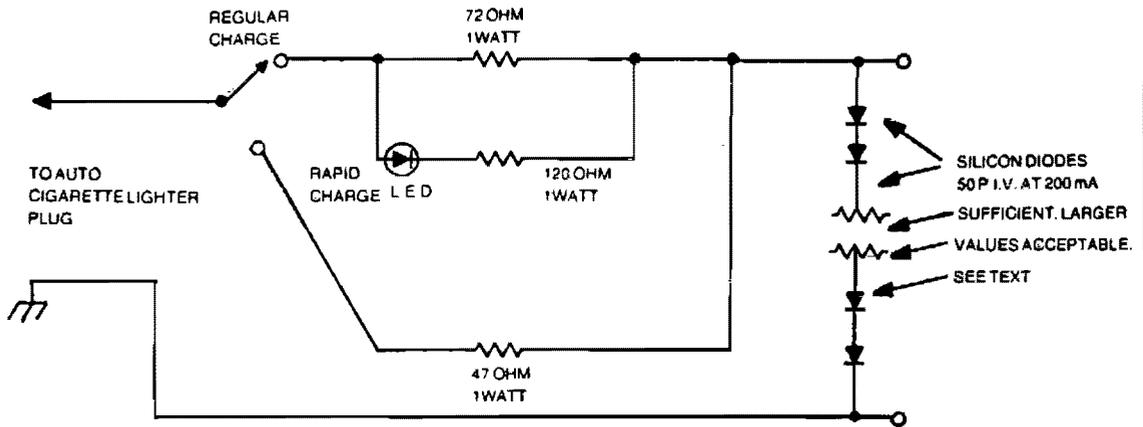


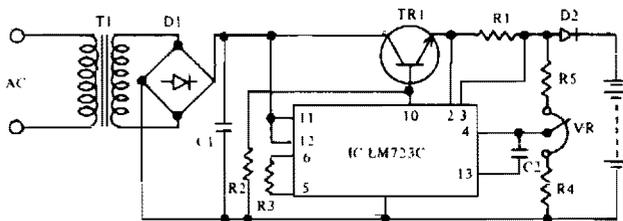
Fig. 11-8

Circuit Notes

The number of silicon diodes across the output is determined by the voltage of the battery pack. Figure each diode at 0.7 volt. For example, a 10.9- volt pack would require $10.9/0.7 = 15.57$, or 16 diodes.

CONSTANT-VOLTAGE, CURRENT-LIMITED CHARGER

IC LM723C VOLTAGE REGULATOR (FOR 12V dc
OUTPUT 0.42A MAX.)



- T1 TRANSFORMER, DC 13V (RMS), 1-3A (RMS)
- D1, D2 100V 1A DIODE
- C1 50V, 470μF ELECTROLYTIC CONDENSER
- TR1 MJ2840 10A 60V 150W (MOTOROLA)
- IC LM723C (NATIONAL SEMICONDUCTOR)
- R1 4.7 OHM 1/2W 3P
- R2 5.1K OHM 1/4W
- R3 3.3K OHM 1/4W
- R4 7.5K OHM 1/4W
- R5 8.2K OHM 1/4W
- VR 2K OHM
- C2 50V 1000PF

Circuit Notes

For 12 V sealed lead-acid batteries.

Fig. 11-9

NI-CAD CHARGER

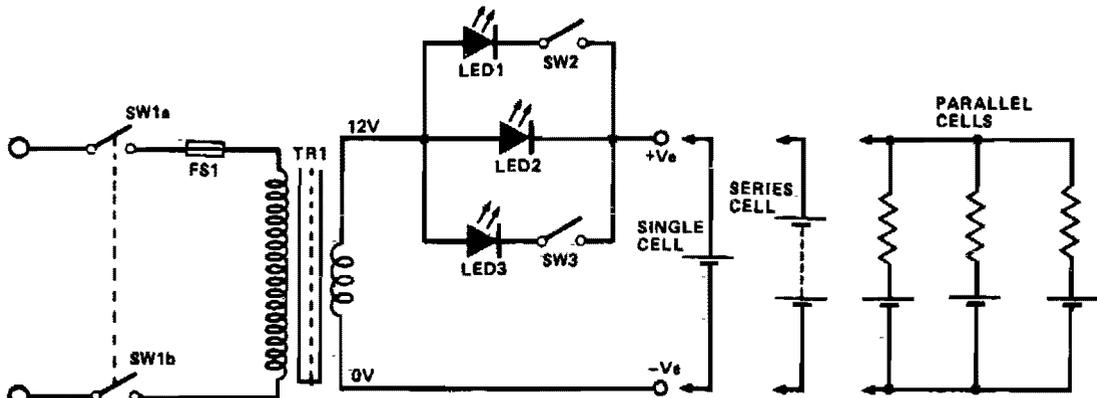


Fig. 11-10

Circuit Notes

This circuit uses constant current LEDs to adjust charging current. It makes use of LEDs that pass a constant current of about 15 mA for an applied voltage range of 2-18 V. They can be paralleled to give any multiple of 15 mA

and they light up when current is flowing. The circuit will charge a single cell at 15, 30 or 45 mA or cells in series up to the rated supply voltage limit (about 14 V).

SIMPLE NI-CAD BATTERY ZAPPER

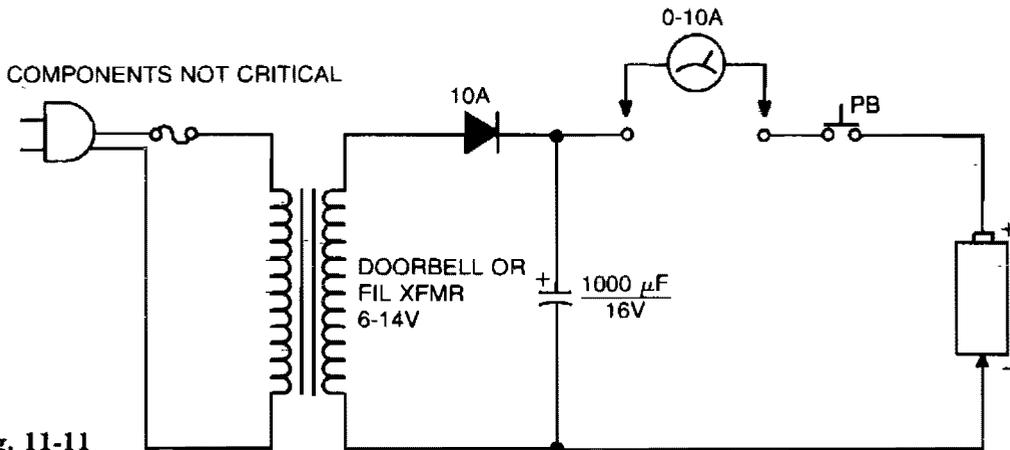


Fig. 11-11

Circuit Notes

This circuit is used to clear internal shorts in nickel cadmium batteries. To operate, connect ni-cad to output and press the pushbutton for three seconds.

BATTERY CHARGING REGULATOR

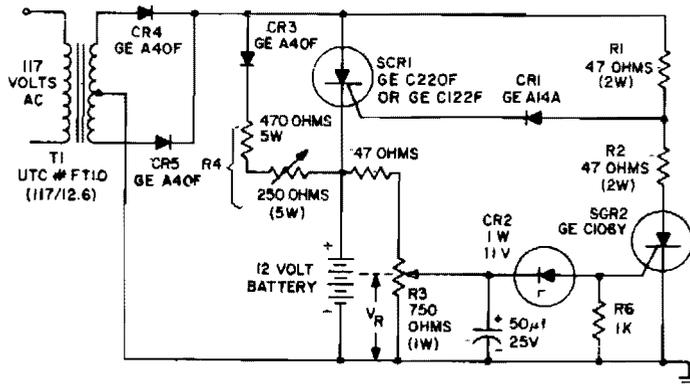


Fig. 11-12

ALL RESISTORS 1/2 WATT EXCEPT AS NOTED

Circuit Notes

The circuit is capable of charging a 12 volt battery at up to a six ampere rate. Other voltages and currents, from 6 to 600 volts and up to 300 amperes, can be accommodated by suitable

component selection. When the battery voltage reaches its fully charged level, the charging SCR shuts off, and a trickle charge as determined by the value of R4 continues to flow.

LOW-COST TRICKLE CHARGER FOR 12 V STORAGE BATTERY

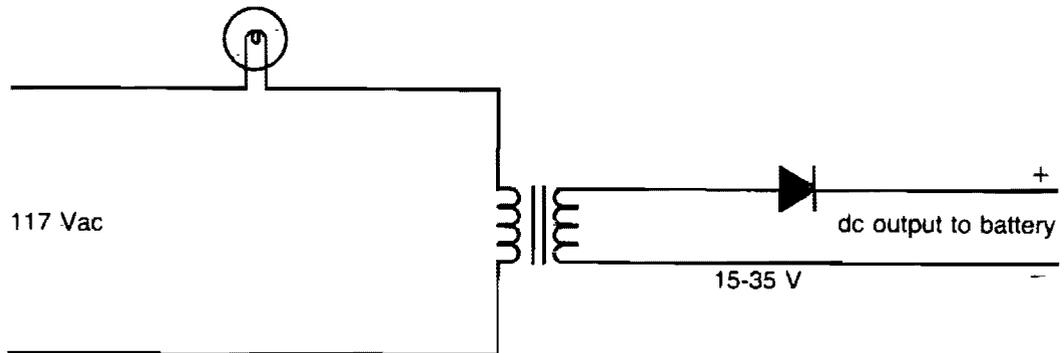


Fig. 11-13

Circuit Notes

Charge rate can be varied and is based on the size of bulb.

12

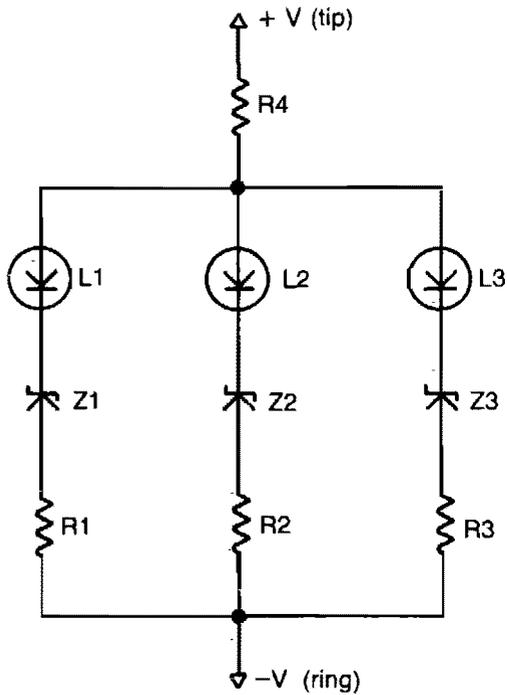
Battery Monitors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Solid-State Battery Voltage Indicator
Ni-Cad Discharge Limiter
Battery Condition Indicator
Equipment on Reminder
Battery Charge/Discharge Indicator
Precision Battery Voltage Monitor for HT's

Low Voltage Monitor
Undervoltage indicator for Battery Oper-
ated Equipment
Low Battery Indicator
Battery-Level Indicator
Battery-Threshold Indicator

SOLID-STATE BATTERY VOLTAGE INDICATOR

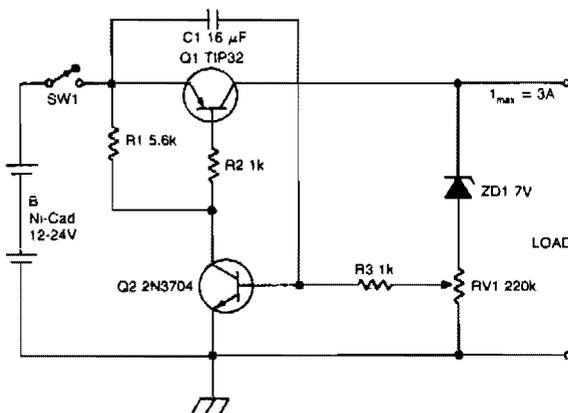


$R1, R2, R3 = 47 \Omega$
 $R4 = 39 \Omega$
 $Z1 = 9.8$ volt zener diode
 $Z2 = 11.1$ volt zener diode
 $Z3 = 11.5$ volt zener diode
 $L1 - L3 =$ light emitting diodes

Two lights on - OK ($L1 + L2$)
 One light on - low voltage ($L1$ only)
 Three lights on - overvoltage ($L1 + L2 + L3$)

Fig. 12-1

NI-CAD DISCHARGE LIMITER



Circuit Notes

The circuit disconnects the battery from the load when output voltage falls below a preset level. C1 charges through R1 and turns on Q2. Collector current flows through R2 turning Q1 on and battery is connected to the load. When the output voltage falls below a point set by RV1, Q2 turns off, Q1 turns off and further discharge of the battery is prevented.

Fig. 12-2

BATTERY CONDITION INDICATOR

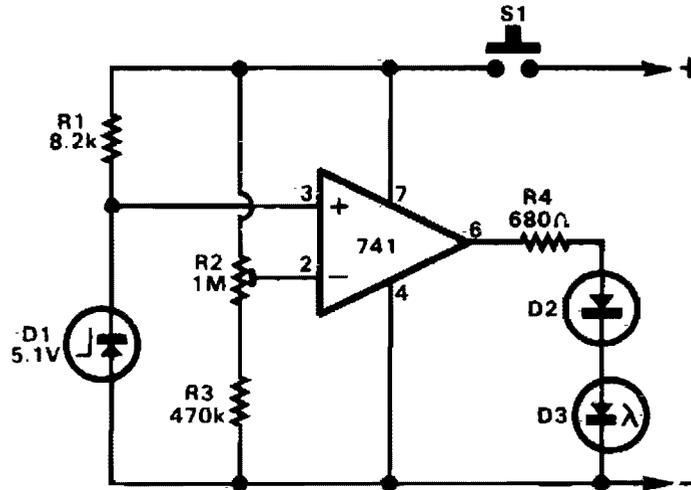


Fig. 12-3

Circuit Notes

A 741 op amp is employed as a voltage comparator. The noninverting input is connected to zener reference source. Reference voltage is 5.1V. R2 is adjusted so that the voltage at the inverting input is half the supply voltage. When supply is higher than 10.2V, the LED will not light. When the supply falls just

fractionally below the 10.2V level, the IC inverting input will be slightly negative of the noninverting input, and the output will swing fully positive. The LED will light, indicating that the supply voltage has fallen to the preset threshold level. The LED can be made to light at other voltages by adjusting R2.

EQUIPMENT ON REMINDER

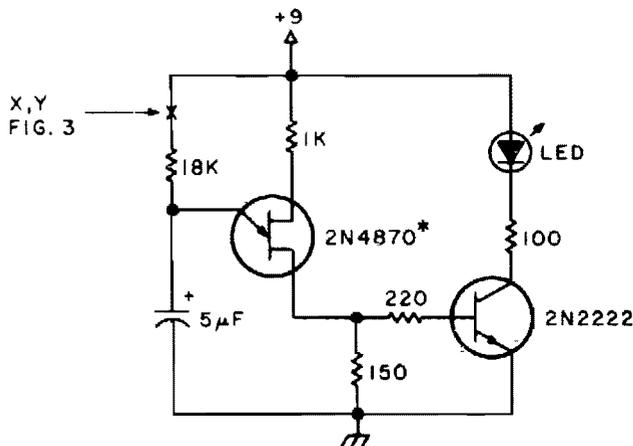


Fig. 12-4

*RADIO SHACK
RS 276-2029
OR ANY TYPE UJT

Circuit Notes

Due to the low duty cycle of flashing LED, the average current drain is 1 mA or less.

BATTERY CHARGE/DISCHARGE INDICATOR

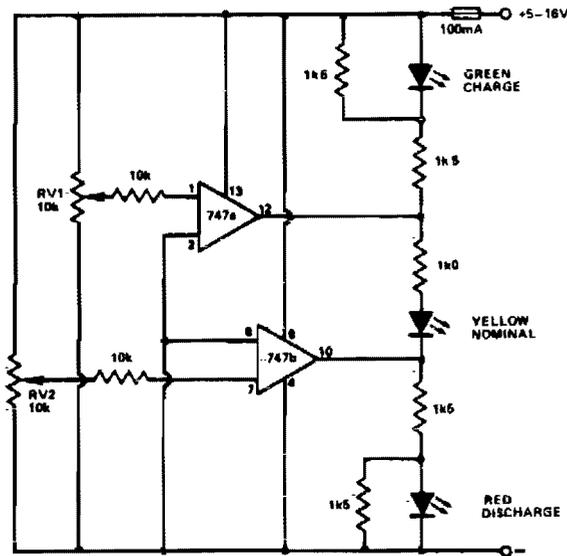


Fig. 12-5

Circuit Notes

This circuit monitors car battery voltage. It provides an indication of nominal supply voltage as well as low or high voltage. RV1 and RV2 adjust the point at which the red/yellow

and yellow/green LEDs are on or off. For example the red LED comes on at 11V, and the green LED at 12V. The yellow LED is on between these values.

PRECISION BATTERY VOLTAGE MONITOR FOR HTS

Circuit Notes

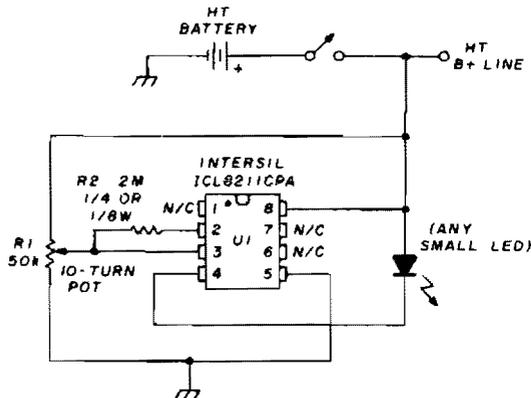


Fig. 12-6

The precision voltage-monitor chip contains a temperature-compensated voltage reference. R1 divides down the battery voltage to match the built-in reference voltage of IC1 (1.15 volts). When the voltage at pin 3 falls below 1.15 volts, pin 4 supplies a constant current of 7 mA to drive a small LED. About 0.2 volt of hysteresis is added with R2. Without hysteresis, the LED could flicker on and off when the monitored voltage varies around the set point, as might be the case on voice peaks during receive.

LOW-VOLTAGE MONITOR

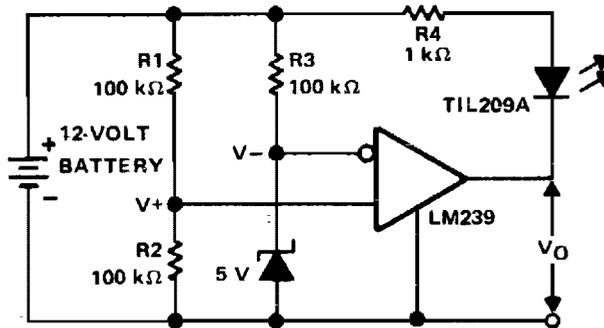


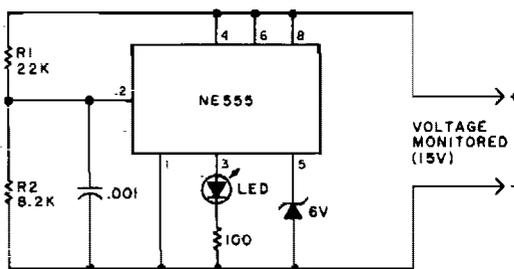
Fig. 12-7

a. SCHEMATIC OF CIRCUIT FOR LOW-VOLTAGE INDICATOR

Circuit Notes

This circuit monitors the voltage of a battery and warns the operator when the battery voltage is below a preset level by turning on an LED. The values are set for a 12V automobile battery. The preset value is 10 volts.

UNDERVOLTAGE INDICATOR FOR BATTERY OPERATED EQUIPMENT

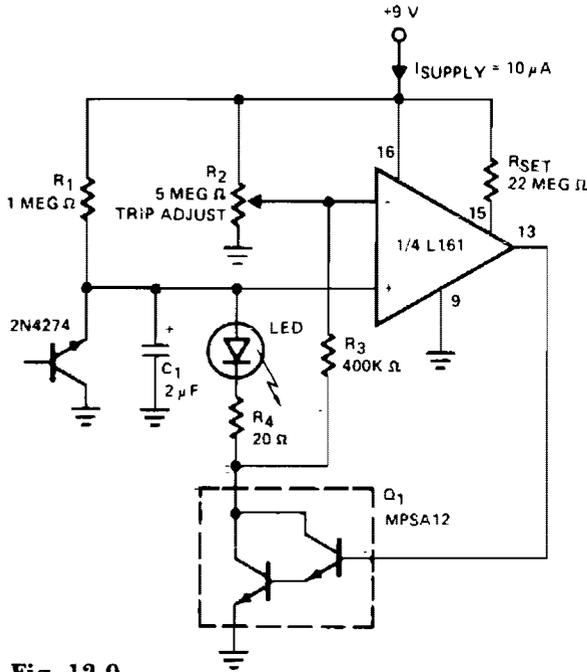


Circuit Notes

Due to the low duty cycle of flashing LED, the average current drain is 1 mA or less. The NE555 will trigger the LED on when the monitored voltage falls to 12 volts. The ratio of R1 to R2 only needs to be changed if it is desired to change the voltage point at which the LED is triggered.

Fig. 12-8

LOW BATTERY INDICATOR



Circuit Notes

The indicator flashes an LED when the battery voltage drops below a certain threshold. 2N4274 emitter-base junction serves as a zener which establishes about 6V on the L161's positive input. As the battery drops, the L161 output goes high. This turns on the Darlington, which discharges C1 through the LED. The interval between flashes is roughly two seconds and gives a low battery warning with only 10 μ A average power drain.

Fig. 12-9

BATTERY-LEVEL INDICATOR

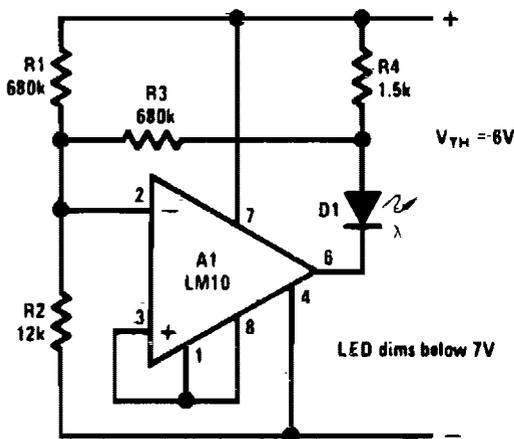


Fig. 12-10

BATTERY-THRESHOLD INDICATOR

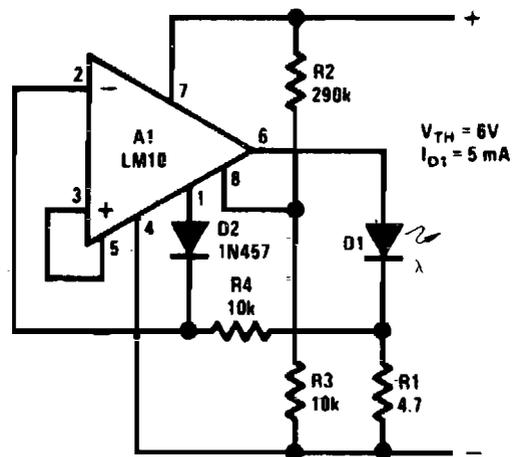


Fig. 12-11

13

Buffers

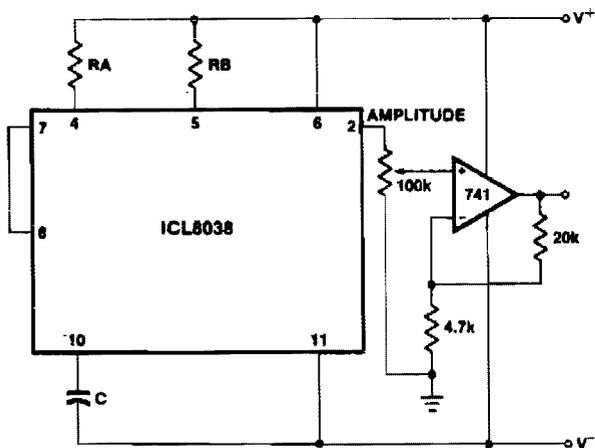
The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Sine Wave Output Buffer Amplifier
Single-Supply AC Buffer Amplifier
Single-Supply AC Buffer
High-Speed 6-Bit A/D Buffer
High Impedance, Low Capacitance

Wideband Buffer
High Resolution ADC Input Buffer
100 × Buffer Amplifier
10 × Buffer Amplifier
Stable High Impedance Buffer

High-Speed Single Supply AC Buffer

SINE WAVE OUTPUT BUFFER AMPLIFIER

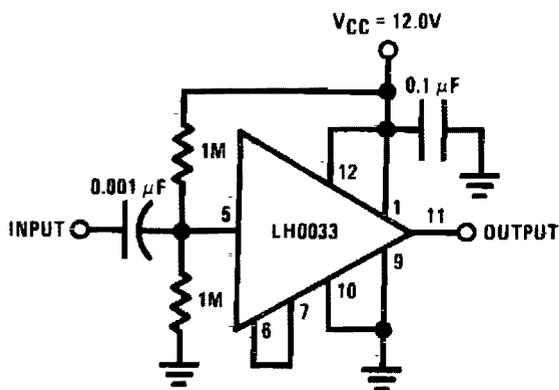


Circuit Notes

The sine wave output has a relatively high output impedance (1K typ). The circuit provides buffering, gain, and amplitude adjustment. A simple op amp follower could also be used.

Fig. 13-1

SINGLE SUPPLY AC BUFFER AMPLIFIER

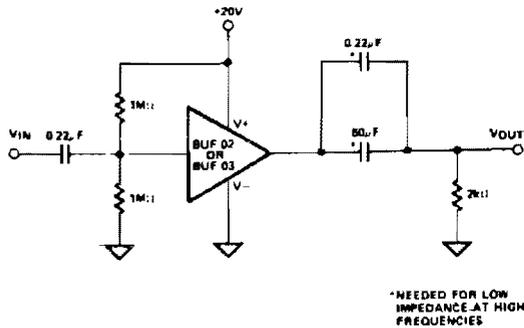


Circuit Notes

The input is dc biased to mid-operating point and is ac coupled. Its input impedance is approximately 500K at low frequencies. For dc loads referenced to ground, the quiescent current is increased by the load current set at the input dc bias voltage.

Fig. 13-2

SINGLE SUPPLY AC BUFFER (HIGH SPEED)



f_{LOW} AT $V_{IN} = 1.48\text{Hz}$ } -3dB
 f_{LOW} AT $V_{OUT} = 1.89\text{Hz}$
 ASSUME $V_{IN} = 10\text{V P-P}$ SINE WAVE (5V-PEAK)
 THEN FULL POWER BANDWIDTH IS
 796kHz FOR BUF 02, AND
 895kHz FOR BUF 03

*NEEDED FOR LOW IMPEDANCE AT HIGH FREQUENCIES

Fig. 13-3

HIGH IMPEDANCE LOW CAPACITANCE WIDEBAND BUFFER

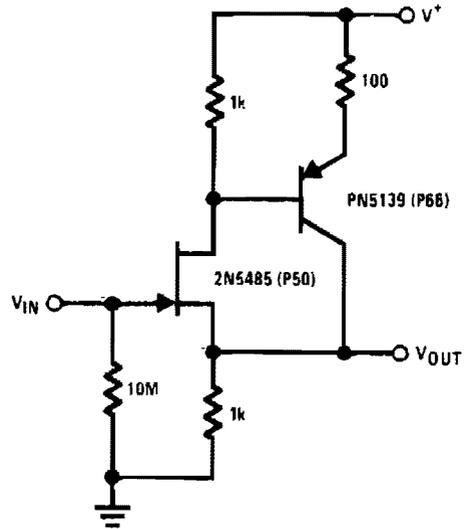


Fig. 13-5

Circuit Notes

The 2N5485 has low input capacitance which makes this compound series-feedback buffer a wide-band unity gain amplifier.

HIGH SPEED 6-BIT A/D BUFFER

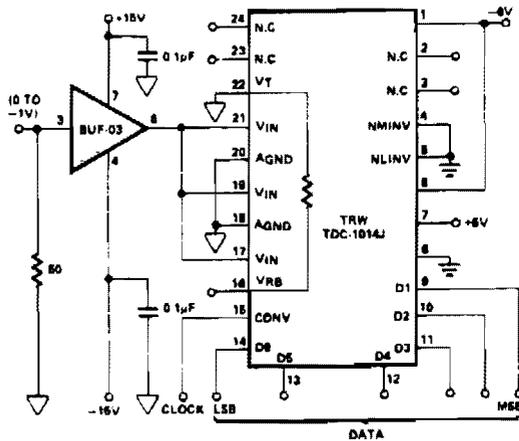
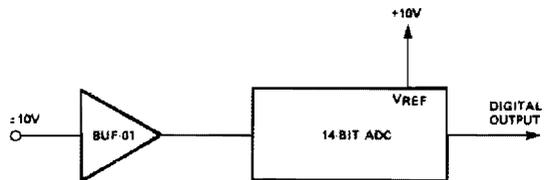


Fig. 13-4

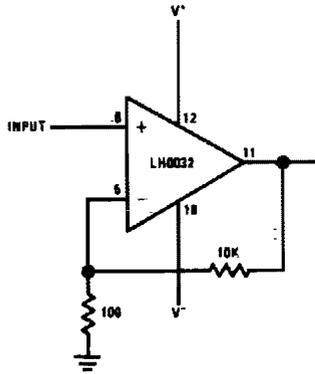
HIGH RESOLUTION ADC INPUT BUFFER



- MAXIMUM ERROR FROM BUF-01 IS 300µV
- RESOLUTION OF 10V, 14-BIT ADC IS 810µV
- BUF-01 RESOLVES 1/2 LSB OF 14-BIT SYSTEM.

Fig. 13-6

100 × BUFFER AMPLIFIER



TYP. $BW_{3dB} = 5 \text{ MHz}$

Fig. 13-7

STABLE, HIGH IMPEDANCE BUFFER

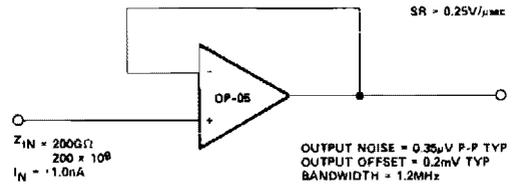
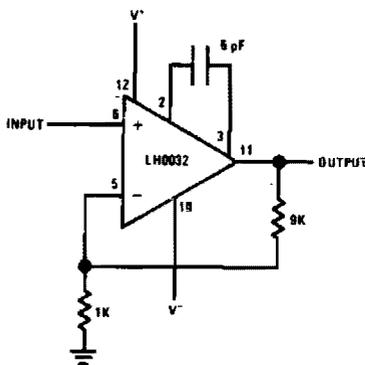


Fig. 13-9

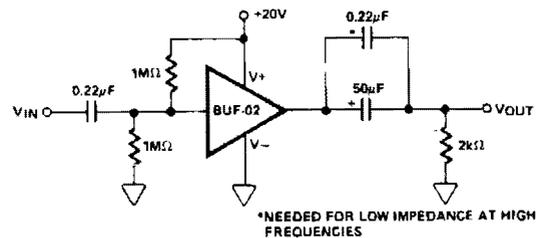
10 × BUFFER AMPLIFIER



TYP. $BW_{3dB} = 10 \text{ MHz}$

Fig. 13-8

HIGH-SPEED SINGLE-SUPPLY AC BUFFER



*NEEDED FOR LOW IMPEDANCE AT HIGH FREQUENCIES

I_{LOW} AT $V_{IN} = 1.45 \text{ Hz}$
 I_{LOW} AT $V_{OUT} = 1.60 \text{ Hz}$ -3dB
 ASSUME $V_{IN} = 10 \text{ V P-P SINE WAVE (5V PEAK)}$
 THEN FULL POWER BANDWIDTH IS
 APPROXIMATELY 800kHz

Fig. 13-10

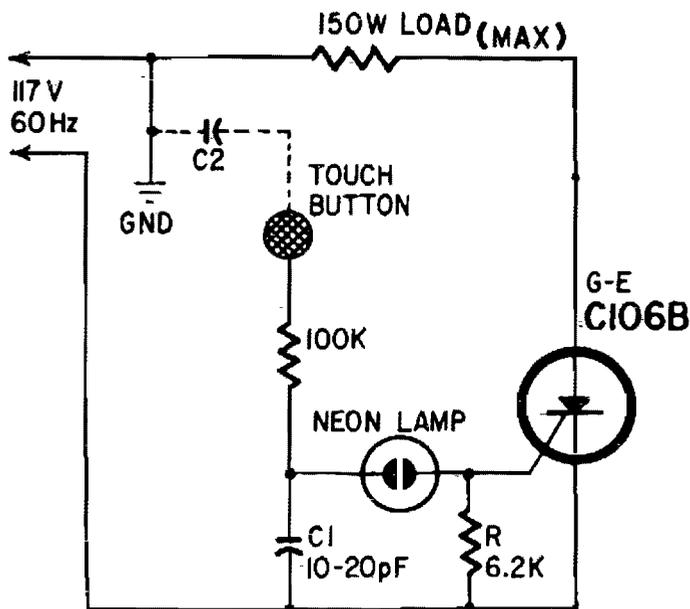
14

Capacitance (Touch) Operated Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Capacitance Relay	Self-Biased Proximity Sensor Works on De-
Capacitance Operated, Battery Powered Light	tected Changing Fields
Touch Sensitive Switch	Touch Switch or Proximity Detector
Low Current Touch Switch	Finger Touch Touch or Control Switch
Capacitance Switched Light	Proximity Detector
Momentary Operation Touch Switch	Touch Circuit
Touch Triggered Bistable	CMOS Touch Switch
Capacitance Operated Alarm to Foil Purse	Latching Double-Button Touch
Snatchers	Switch

CAPACITANCE RELAY



NOTE: ALL RESISTORS 1/2 WATT

Fig. 14-1

Circuit Notes

Capacitor C1 and body capacitance (C2) of the operator form the voltage divider from the hot side of the ac line to ground. The voltage across C1 is determined by the ratio of C1 to C2. The higher voltage is developed across the smaller capacitor. When no one is close to the touch button, C2 is smaller than C1. When a hand is brought close to the button, C2 is many times larger than C1 and the major portion of

the line voltage appears across C1. This voltage fires the neon lamp, C1 and C2 discharge through the SCR gate, causing it to trigger and pass current through the load. The sensitivity of the circuit depends on the area of the touch plate. When the area is large enough, the circuit responds to the proximity of an object rather than to touch. C1 may be made variable so sensitivity can be adjusted.

CAPACITANCE OPERATED, BATTERY POWERED LIGHT

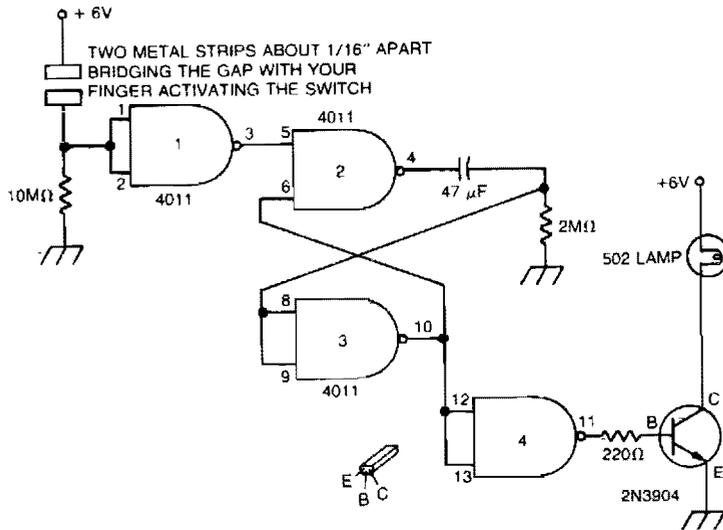


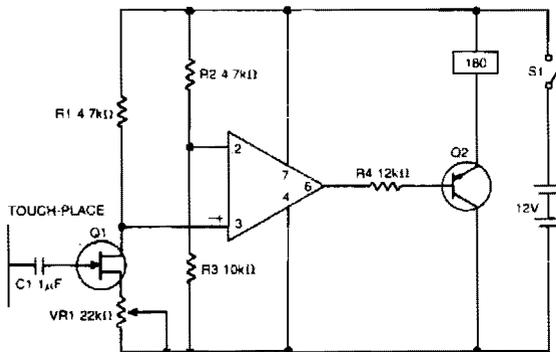
Fig. 14-2

Circuit Notes

Touch the plate and the light will go on and remain on for a time determined by the time

constant of the 47 μ F capacitor and the 2M resistor.

TOUCH-SENSITIVE SWITCH



Circuit Notes

A high impedance input is provided by Q1, a general purpose field effect transistor. 741 op amp is used as a sensitive voltage level switch which in turn operates the current Q2, a medium current PNP bipolar transistor, thereby energizing the relay which can be used to control equipment, alarms, etc.

Fig. 14-3

LOW CURRENT TOUCH SWITCH

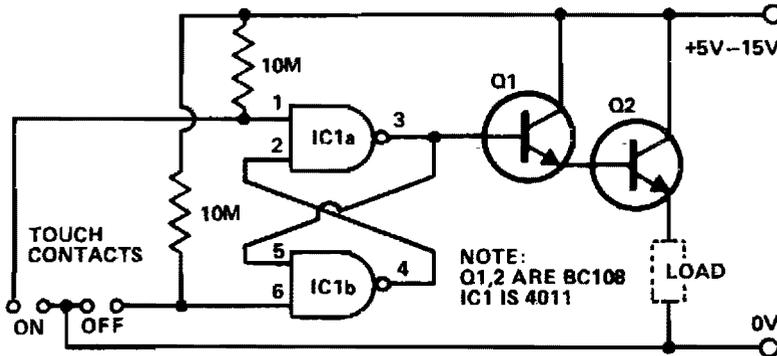


Fig. 14-4

Circuit Notes

Touching the on contacts with a finger brings pin 3 high, turning on the Darlington pair and supplying power to the load (transistor radio etc). Q1 must be a high gain transistor, and Q2 is chosen for the current required by the load circuit.

CAPACITANCE SWITCHED LIGHT

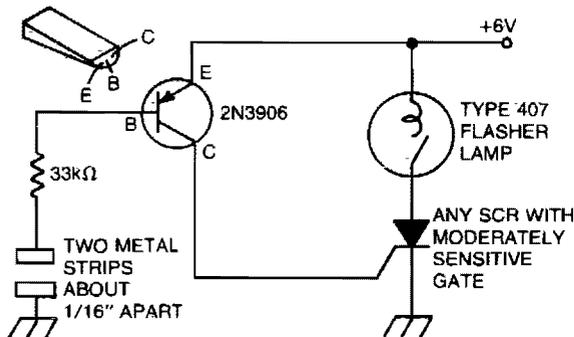


Fig. 14-5

Circuit Notes

The battery powered light turns on easily, stays on for just a few seconds, and then turns off again. The circuit is triggered when you place a finger across the gap between two strips of metal, about 1/16th inch apart. Enough current will flow through your finger to trigger the SCR after being amplified by the 2N3906. Once the SCR is fired, current will flow through the bulb until its internal bimetal switch turns it off. Once that happens, the SCR will return to its nonconducting state.

MOMENTARY OPERATION TOUCH SWITCH

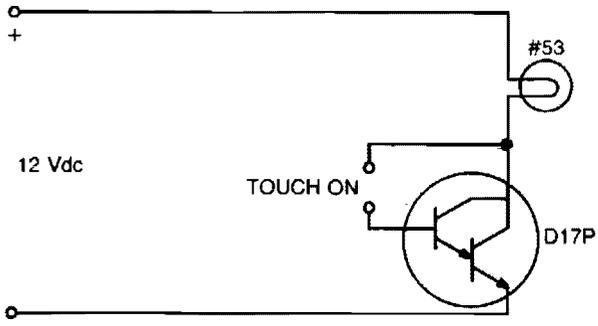


Fig. 14-6

TOUCH TRIGGERED BISTABLE

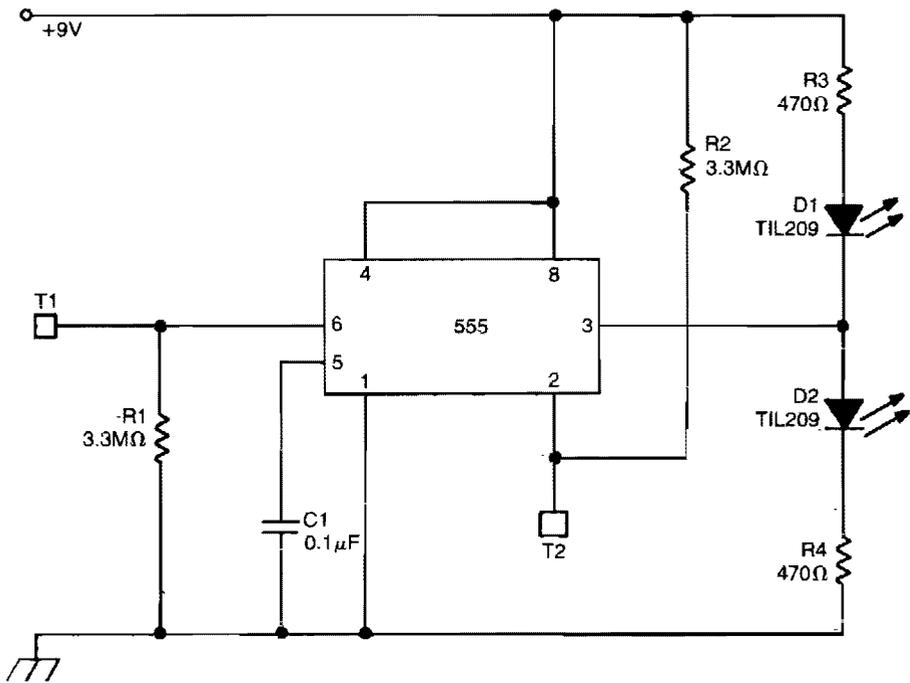


Fig. 14-7

Circuit Notes

This circuit uses a 555 timer in the bistable mode. Touching T2 causes the output to go high; D2 conducts and D1 extinguishes. Touching T1 causes the output to go low; D1 conducts and D2 is cut off. The output from pin 3 can also be used to operate other circuits

(e.g., a triac controlled lamp). In this case, the LEDs are useful for finding the touch terminals in the dark. C1 is not absolutely necessary but helps to prevent triggering from spurious pulses.

CAPACITANCE OPERATED ALARM TO FOIL PURSE SNATCHERS

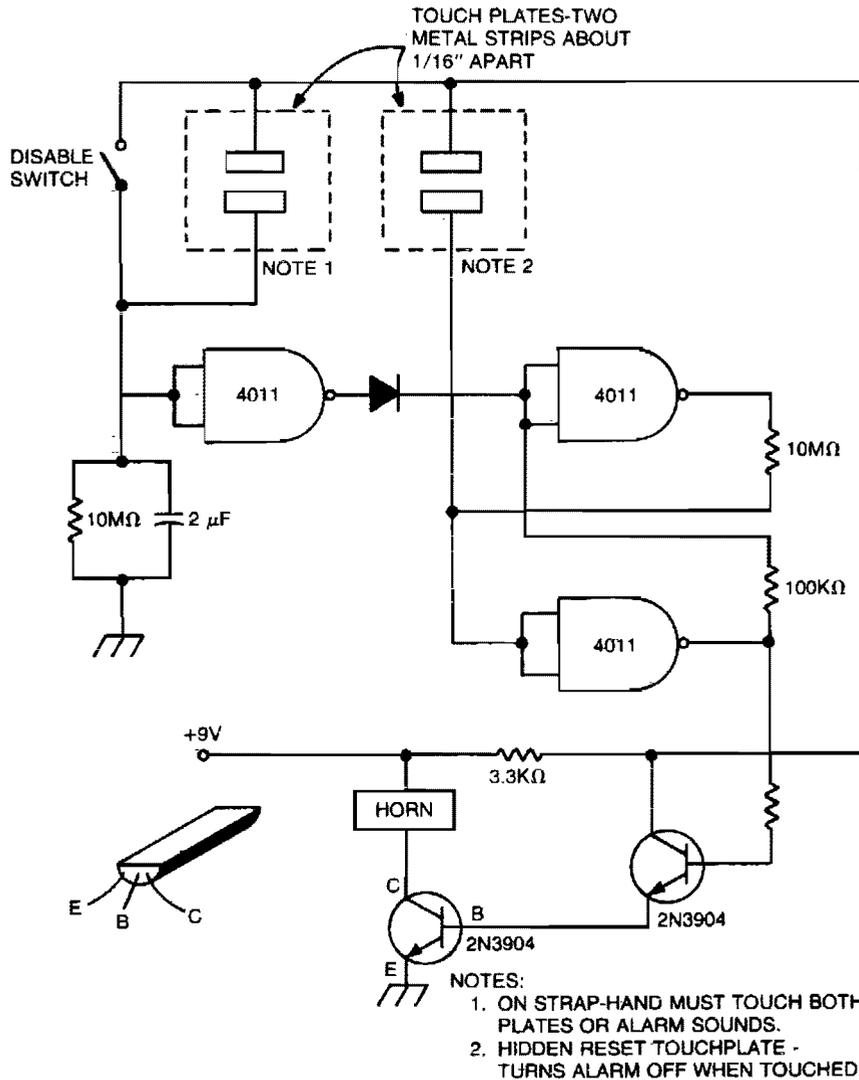
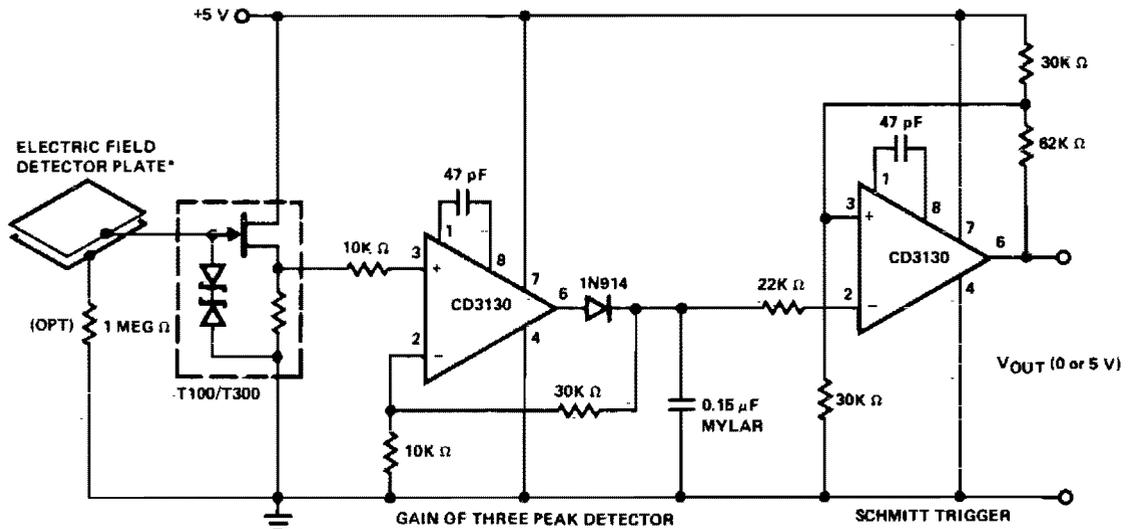


Fig. 14-8

Circuit Notes

As long as touch plates (1) are touched together, the alarm is off. If not held for about 30 seconds, the alarm goes off. The circuit can be disabled with switch or by touching the plates (2). The alarm is battery operated by a bicycle horn.

SELF-BIASED PROXIMITY SENSOR WORKS ON DETECTED CHANGING FIELD



*DETECTOR PLATE MAY BE DOUBLE-SIDED PC BOARD OR ANY INSULATED METAL SHEET

Fig. 14-9

TOUCH SWITCH OR PROXIMITY DETECTOR

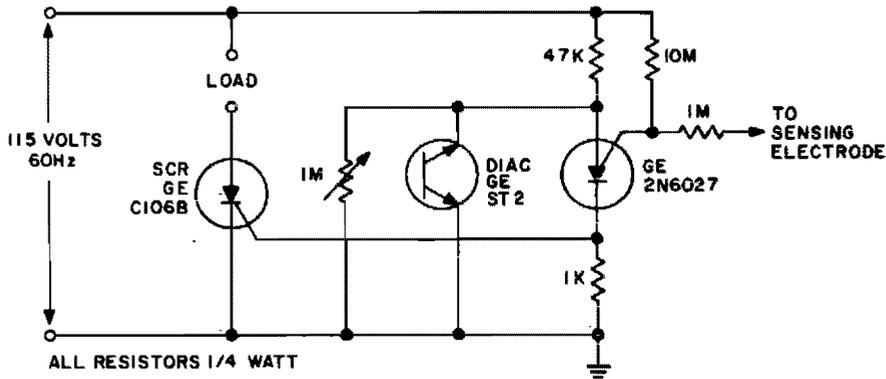


Fig. 14-10

Circuit Notes

This circuit is actuated by an increase in capacitance between a sensing electrode and the ground side of the line. The sensitivity can be adjusted to switch when a human body is within inches of the insulated plate used as the

sensing electrode. Thus, sensitivity is adjusted with the 1 megohm potentiometer which determines the anode voltage level prior to clamping. This sensitivity will be proportional to the area of the surface opposing each other.

FINGER TOUCH OR CONTACT SWITCH

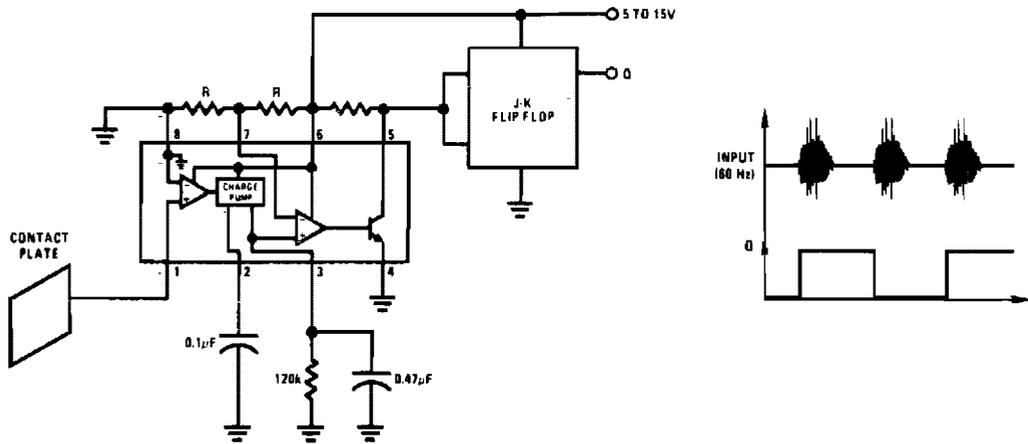


Fig. 14-11

PROXIMITY DETECTOR

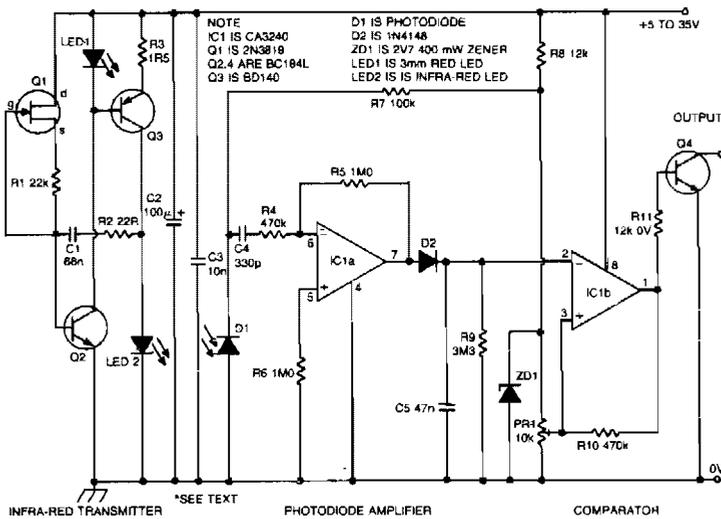


Fig. 14-12

Circuit Notes

The proximity sensor works on the principle of transmitting a beam of modulated infra-red light from the emitter diode LED2, and receiving reflections from objects passing in front of the beam with a photodiode detector

D1. The circuit can be split into three distinct stages; the infra-red transmitter, the photodiode amplifier, and a variable threshold comparator.

TOUCH CIRCUIT

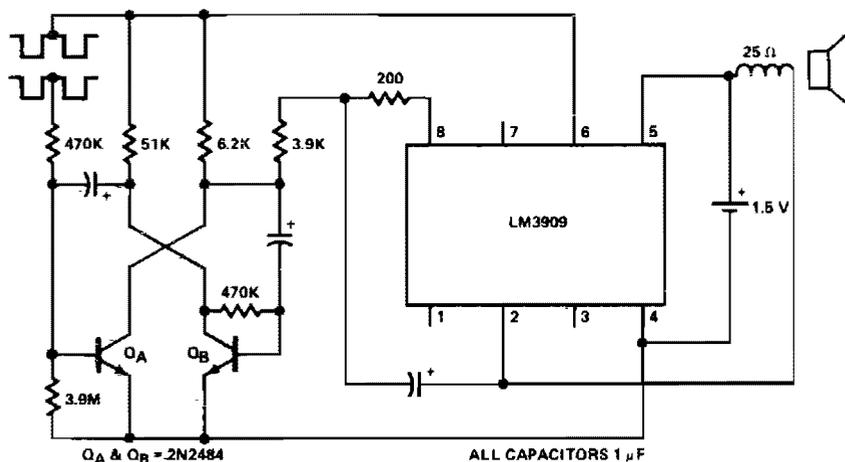


Fig. 14-13

CMOS TOUCH SWITCH

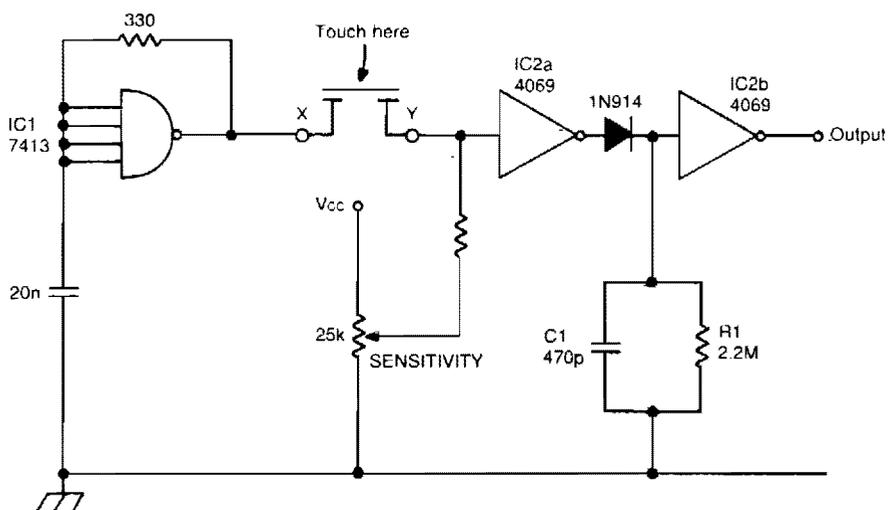


Fig. 14-14

Circuit Notes

This touch switch does not rely on mains hum for switching. It can be used with battery powered circuits. Schmitt trigger IC1 forms a 100 kHz oscillator and IC2a which is biased into the linear region, amplifies the output and

charges C1 via the diode. IC2b acts as a level detector. When the sensor is touched, the oscillator signal is severely attenuated which causes C1 to discharge and IC2b to change state.

LATCHING, DOUBLE BUTTON TOUCH SWITCH

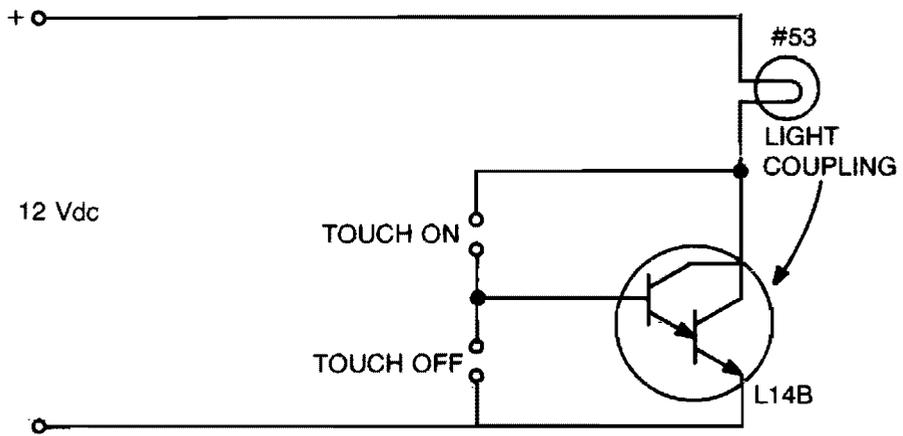


Fig. 14-15

15

Carrier Current Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

FM Carrier Current Remote Speaker
System

200 kHz Line Carrier Transmitter with
On/Off Carrier Modulation

Carrier Current Receiver

Carrier Current Transmitter

Carrier Current Transmitter

Integrated Circuit Current Transmitter

Single Transistor Carrier Current Receiver

IC Carrier-Current Receiver

Carrier-Current Remote Control or
Intercom

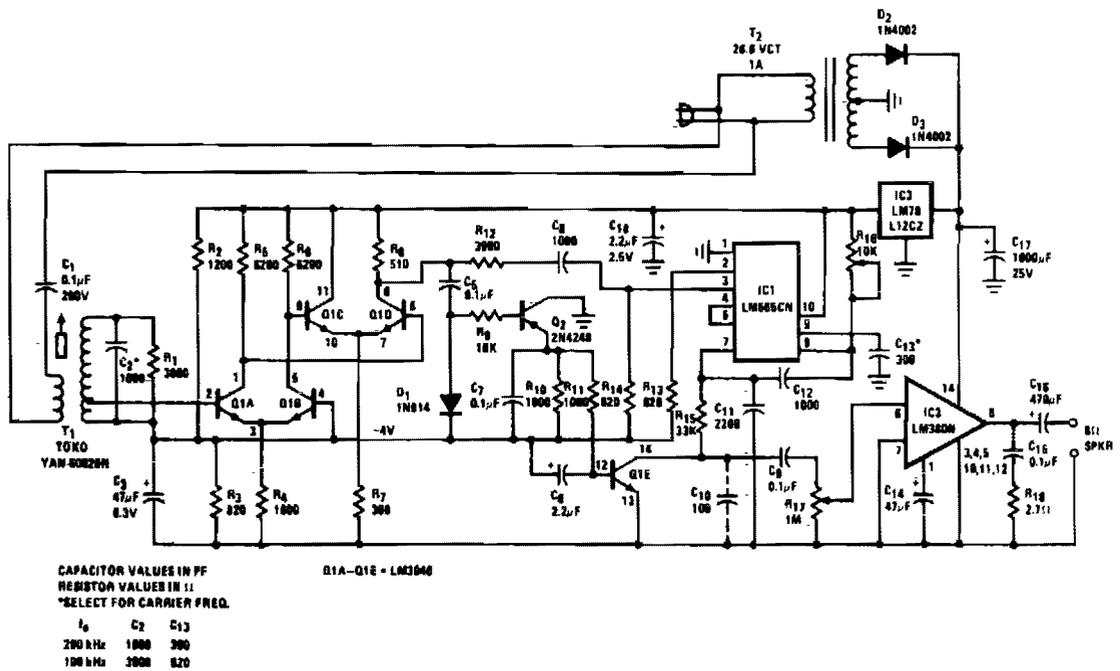
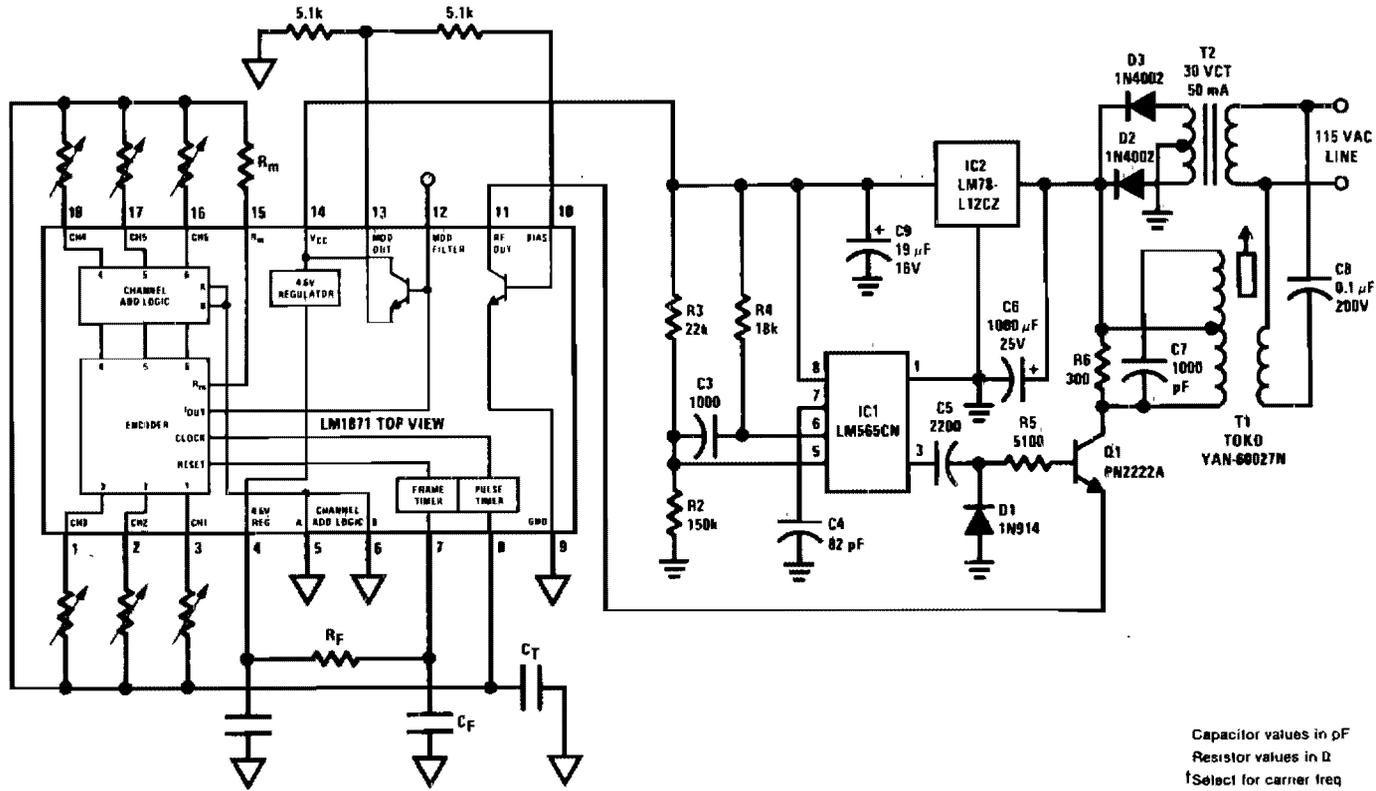


Fig. 15-1

The receiver amplifies, limits, and demodulates the received FM signal. It provides

audio mute in the absence of carrier and 2.5 W output to a speaker.

200 kHz LINE CARRIER TRANSMITTER WITH ON/OFF CARRIER MODULATOR



Capacitor values in pF
Resistor values in Ω
f Select for carrier freq

f _c	C4	C7
200 kHz	82	1000
100 kHz	160	3000

Fig. 15-2

CARRIER CURRENT RECEIVER

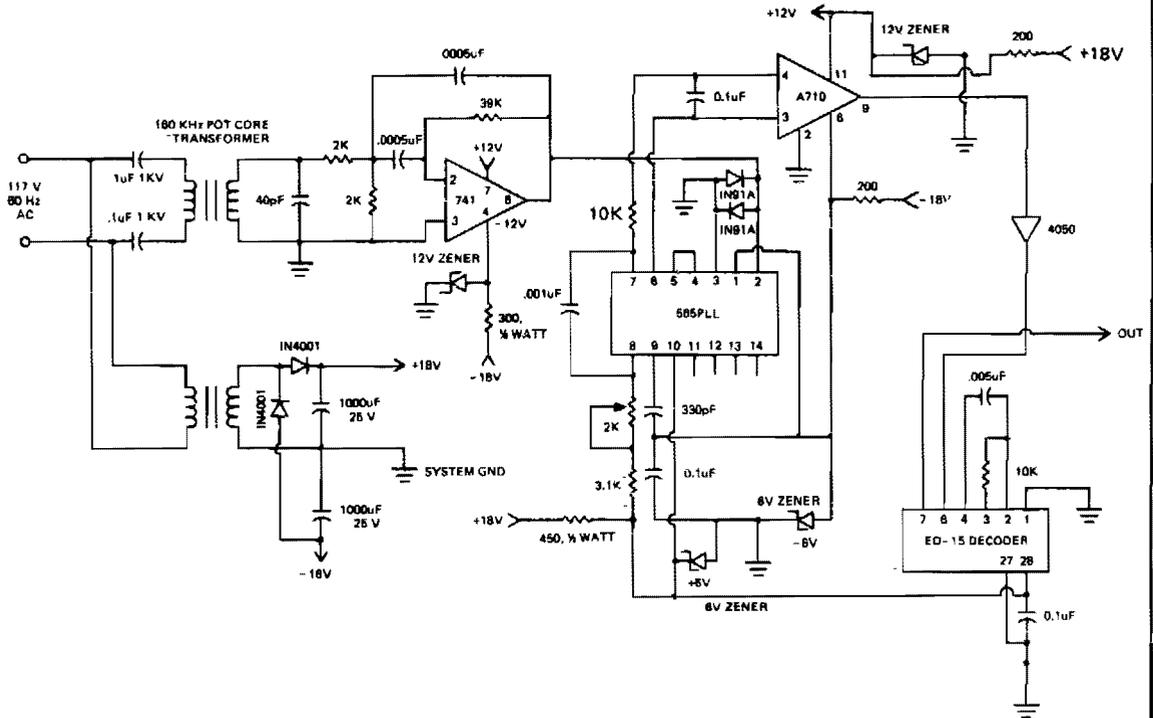


Fig. 15-3

Circuit Notes

160 kHz transformer consists of a 18×11 mm ungapped pot core (Siemens, Ferrcube, etc.), utilizing magnetics incorporated type "F" material wound with $80\frac{1}{2}$ turns of No.

35 wire for the secondary and $5\frac{1}{2}$ turns for the primary. This gives a turns ratio of approximately 15 to 1.

IC CARRIER CURRENT TRANSMITTER

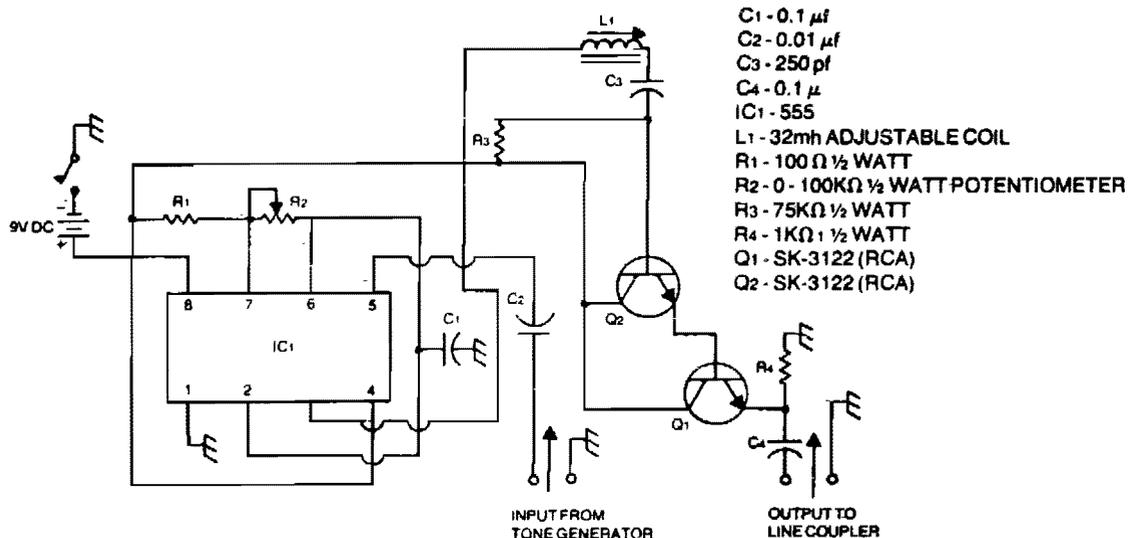


Fig. 15-6

SINGLE TRANSISTOR CARRIER CURRENT RECEIVER

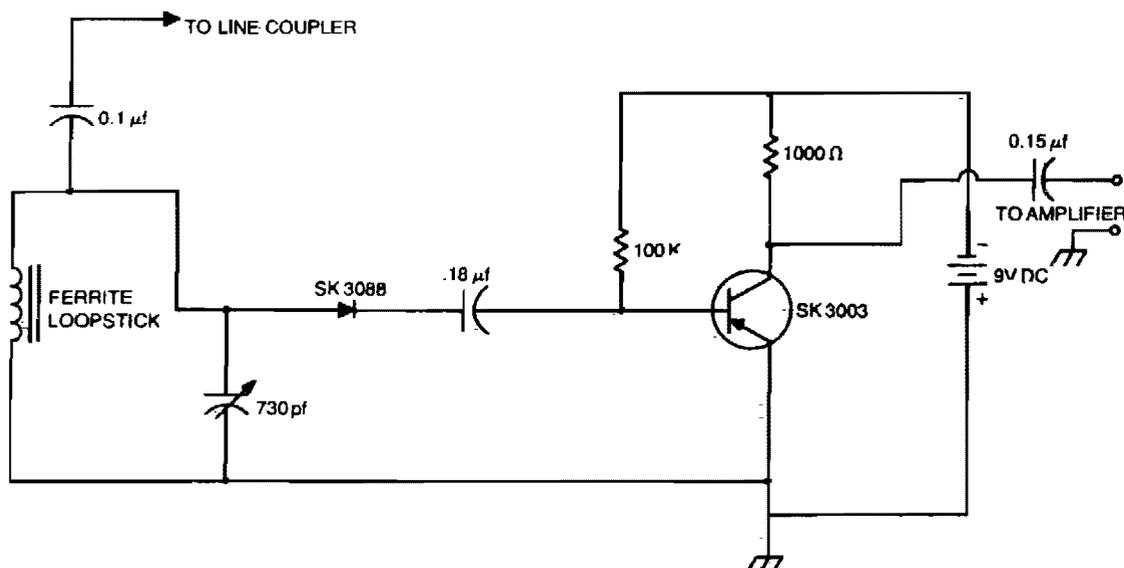


Fig. 15-7

IC CARRIER-CURRENT RECEIVER

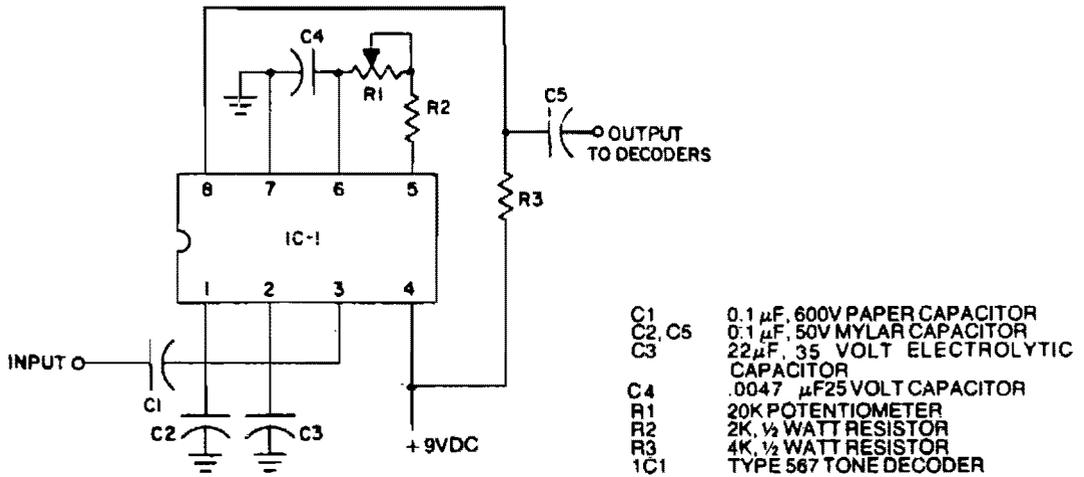


Fig. 15-8

CARRIER-CURRENT REMOTE CONTROL OR INTERCOM

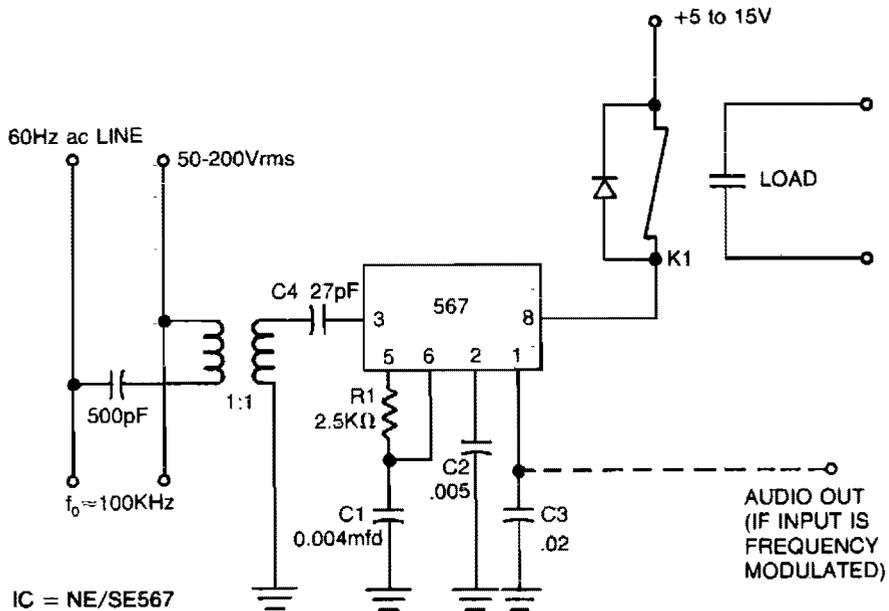


Fig. 15-9

16

Comparators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Null Detector	Window Comparator
Comparator with Variable Hysteresis	Micropower Double-Ended Limit Detector
Diode Feedback Comparator	Opposite Polarity Input Voltage Comparator
Undervoltage/Overvoltage Indicator	Limit Comparator
Dual Limit Comparator	Comparator Clock Circuit
High/Low Limit Alarm	Double-Ended Limit Comparator
Window Comparator	Limit Comparator
Window Comparator Driving High/Low Lamps	Precision, Dual Limit Go/No Go Tester
Comparator with Time Out	Comparator with Hysteresis
Noninverting Comparator with Hysteresis	High Impedance Comparator
Inverting Comparator with Hysteresis	Comparator

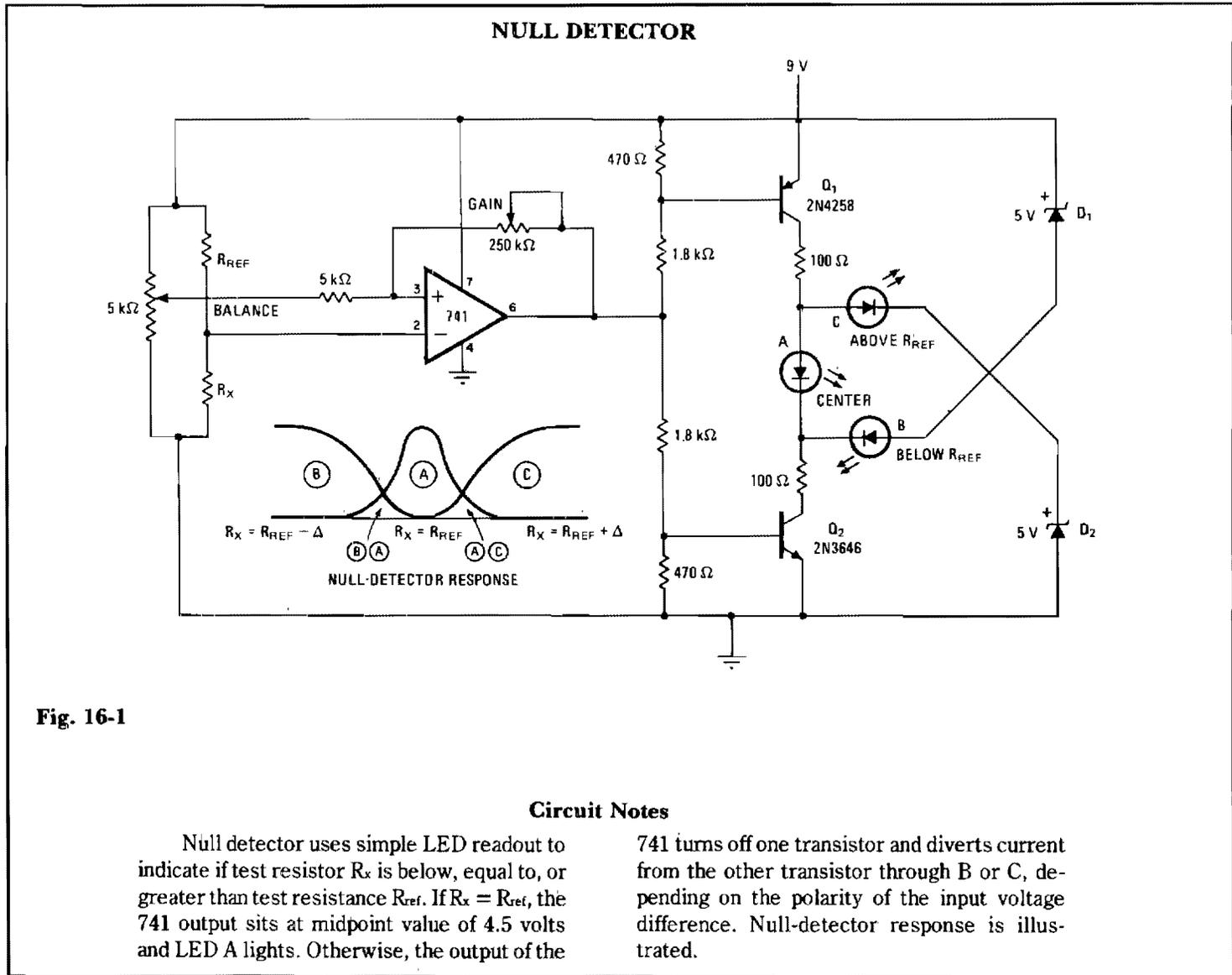


Fig. 16-1

Circuit Notes

Null detector uses simple LED readout to indicate if test resistor R_x is below, equal to, or greater than test resistance R_{ref} . If $R_x = R_{ref}$, the 741 output sits at midpoint value of 4.5 volts and LED A lights. Otherwise, the output of the

741 turns off one transistor and diverts current from the other transistor through B or C, depending on the polarity of the input voltage difference. Null-detector response is illustrated.

**COMPARATOR WITH VARIABLE
HYSTERESIS (WITHOUT SHIFTING INITIAL TRIP POINT)**

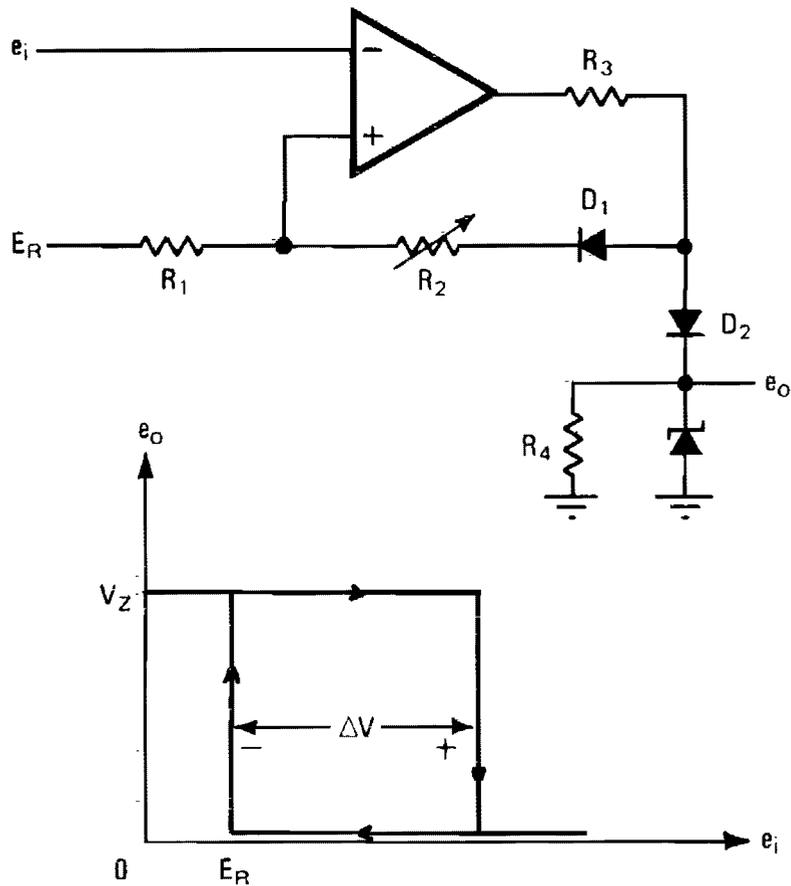


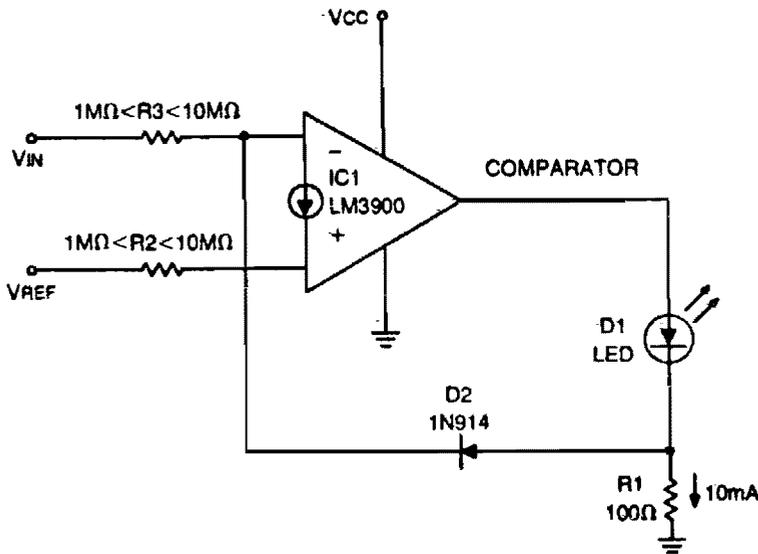
Fig. 16-2

Circuit Notes

An operational amplifier can be used as a convenient device for analog comparator applications that require two different trip points. The addition of a positive-feedback network introduces a precise variable hysteresis into the usual comparator switching action. Such feedback develops two comparator trip points

centered about the initial trip point or reference point. The voltage difference, ΔV , between the trip points can be adjusted by varying resistor R_2 . When the output voltage is taken from the zener diode, as shown, it switches between zero and V_Z , the zener voltage.

DIODE FEEDBACK COMPARATOR



- Parts list**
 IC1—LM3900
 D1—LED Lafayette 32P06331V
 D2—1N914
 All resistors 1/4W
 R1—100Ω
 R2—(See circuit) 1MΩ to 10MΩ
 R3—(See circuit) 1MΩ to 10MΩ

Fig. 16-3

Circuit Notes

This circuit can drive an LED display with constant current independently of wide power supply voltage changes. It can operate with a power supply range of at least 4V to 30V. With 10M resistances for R2 and R3 and the invert-

ing input of the comparator grounded, the circuit becomes an LED driver with very high input impedance. The circuit can also be used in many other applications where a controllable constant current source is needed.

UNDervOLTAGE/OVERVOLTAGE INDICATOR

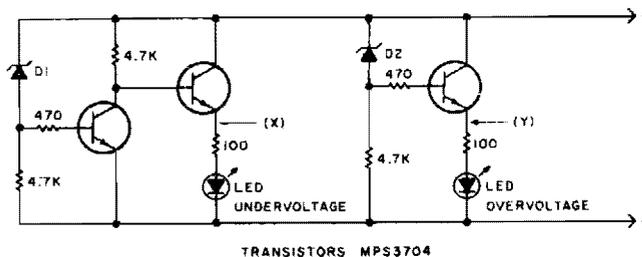


Fig. 16-4

Circuit Notes

This circuit will make the appropriate LED glow if the monitored voltage goes below

or above the value determined by zener diodes D1 and D2.

DUAL LIMIT COMPARATOR

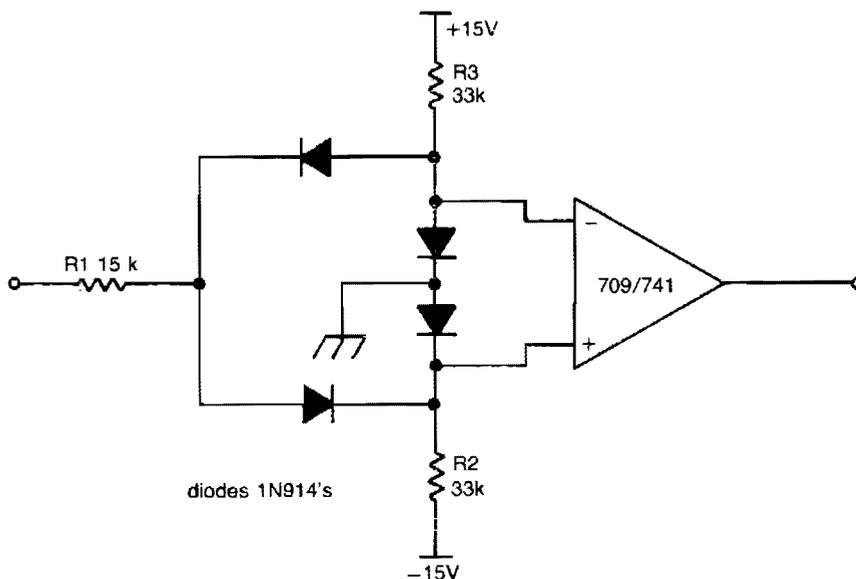


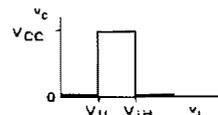
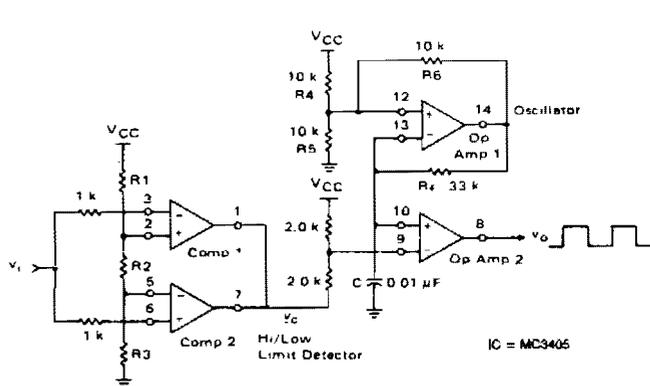
Fig. 16-5

Circuit Notes

This circuit gives a positive output when the input voltage exceeds 8.5 volts. Between these limits the output is negative. The positive limit point is determined by the ratio of R1, R2, and the negative point by R1, R3. The

forward voltage drop across the diodes must be allowed for. The output may be inverted by reversing the inputs to the op amp. The 709 is used without frequency compensation.

HIGH/LOW LIMIT ALARM



$$V_{IL} = V_{CC} \frac{R_3}{R_1 + R_2 + R_3}$$

$$V_{IH} = V_{CC} \frac{R_2 + R_3}{R_1 + R_2 + R_3}$$

Oscillator

$$f = 0.72 / R_1 C$$

As Shown, $f = 2.2 \text{ kHz}$

v_o Will Oscillate If $V_{IH} < v_i$, or $V_{IL} > v_i$

v_o Will Be Low If $V_{IL} < v_i < V_{IH}$

Fig. 16-6

WINDOW COMPARATOR

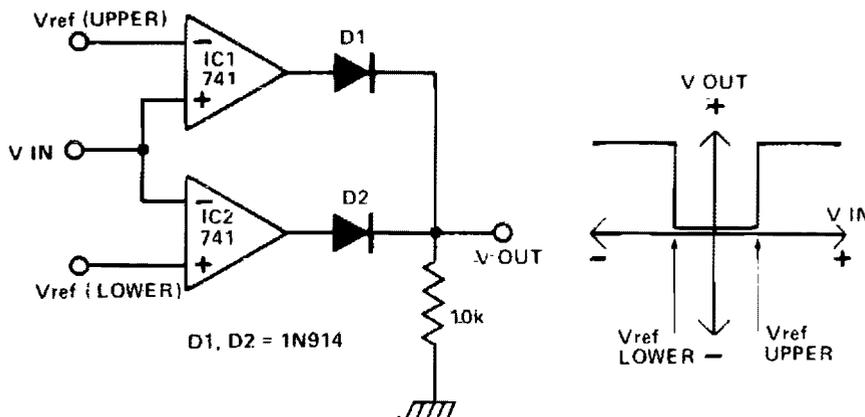


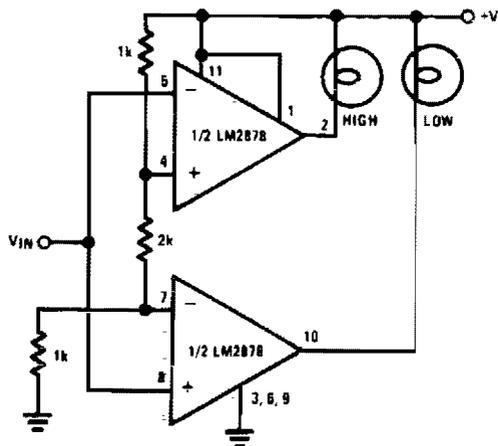
Fig. 16-7

Circuit Notes

This circuit gives an output (which in this case is 0V) when an input voltage lies in between two specified voltages. When it is outside this window, the output is positive. The two op amps are used as voltage comparators. When V_{IN} is more positive than V_{ref} (upper) the output of IC1 is positive and D1 is forward

biased. Otherwise the output is negative, D1 reverse biased and hence V_{out} is 0V. Similarly, when V_{in} is more negative than V_{ref} (lower), the output of IC2 is positive; D2 is forward biased and this V_{out} is positive. Otherwise V_{out} is 0V. When V_{in} lies within the window set by the reference voltages, V_{out} is 0V.

WINDOW COMPARATOR DRIVING HIGH/LOW LAMPS



TRUTH TABLE

V_{IN}	High	Low
$< 1/4 V^+$	Off	On
$1/4 V^+ \text{ to } 3/4 V^+$	Off	Off
$> 3/4 V^+$	On	Off

Fig. 16-8

COMPARATOR WITH TIME OUT

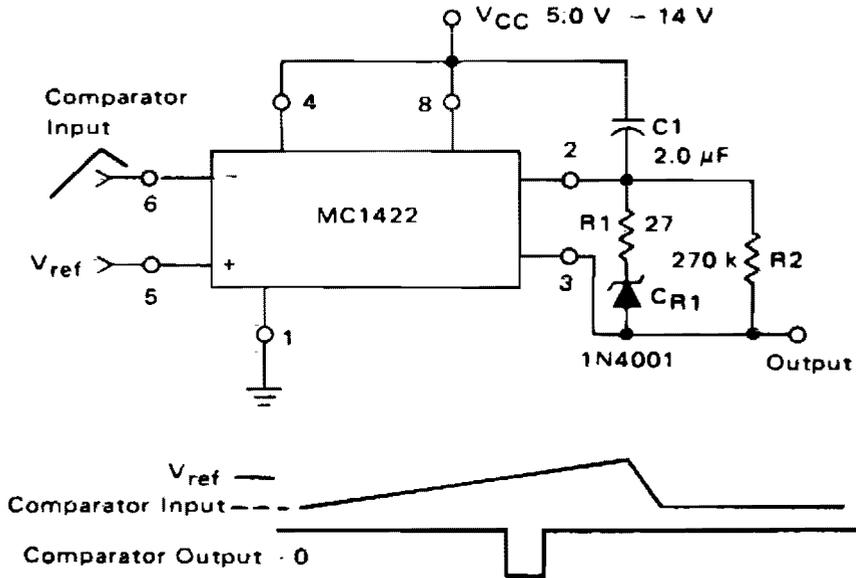


Fig. 16-9

Circuit Notes

The MC1422 is used as a comparator with the capability of a timing output pulse when the inverting input (Pin 6) is \geq the noninverting

input (Pin 5). The frequency of the pulses for the values of R2 and C1 as shown is approximately 2.0 Hz, and the pulse width 0.3 ms.

NONINVERTING COMPARATOR WITH HYSTERESIS

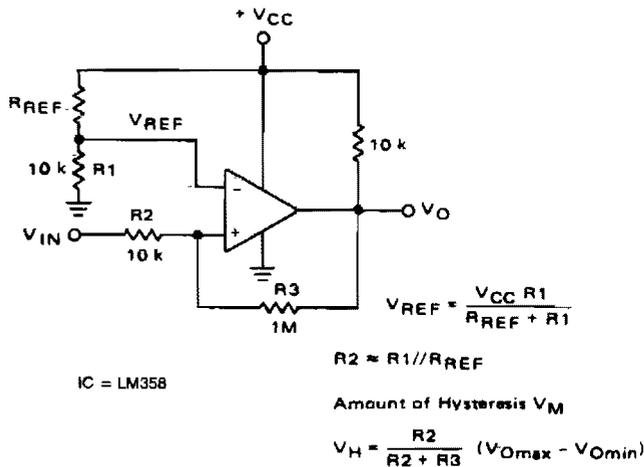
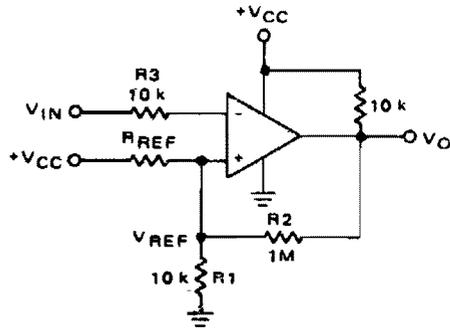


Fig. 16-10

INVERTING COMPARATOR WITH HYSTERESIS



$$V_{REF} \approx \frac{V_{CC} R_1}{R_{REF} + R_1}$$

$$R_3 > R_1 // R_{REF} // R_1$$

$$V_H = \frac{R_1 // R_{REF}}{R_1 // R_{REF} + R_2} (V_{Omax} - V_{Omin})$$

Fig. 16-11

WINDOW COMPARATOR

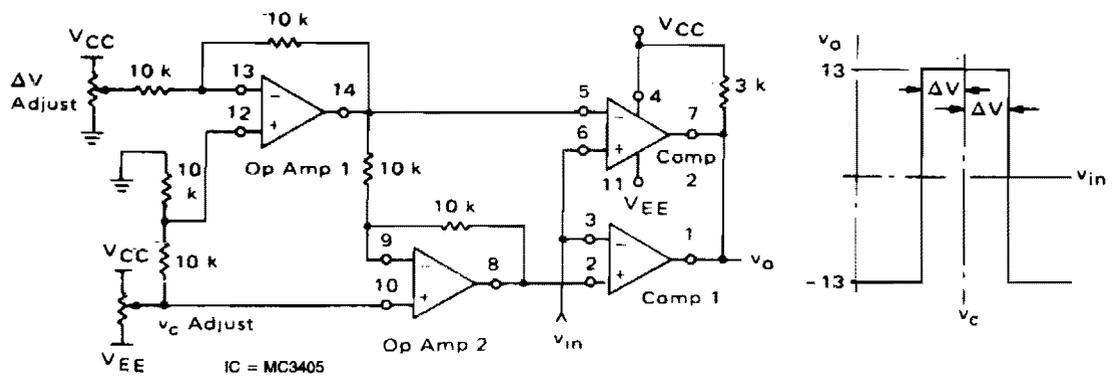


Fig. 16-12

MICROPOWER DOUBLE-ENDED LIMIT DETECTOR

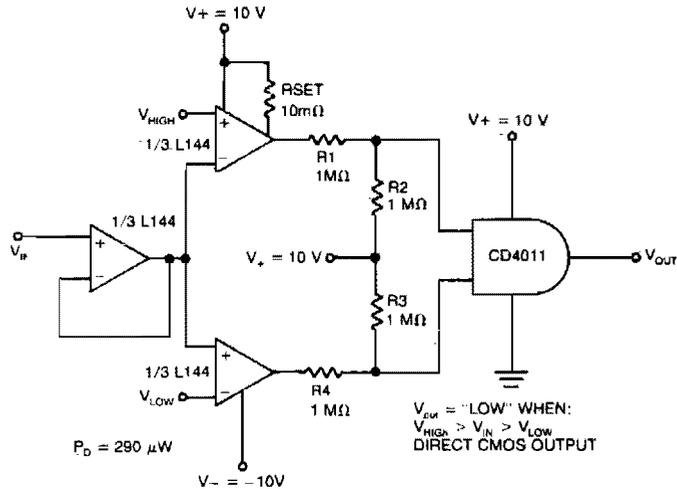


Fig. 16-13

Circuit Notes

The detector uses three sections of an L144 and a DC4011 type CMOS NAND gate to make a very low power voltage monitor. If the input voltage, V_{IN} , is above V_{HIGH} or below V_{LOW} , the output will be a logical high. If (and only if) the input is between the limits will the output be low. The 1 megohm resistors R_1 , R_2 , R_3 , and R_4 translate the bipolar $\pm 10V$ swing of the op amps to a 0 to 10V swing acceptable to the ground-referenced CMOS logic.

OPPOSITE POLARITY INPUT VOLTAGE COMPARATOR

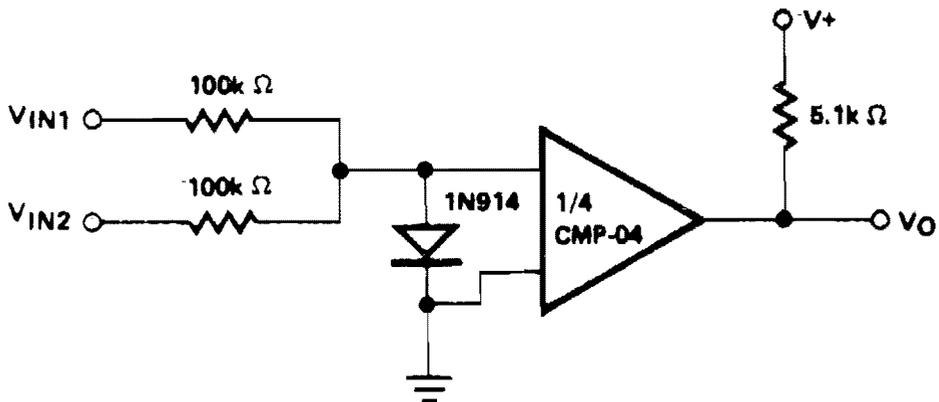


Fig. 16-14

LIMIT COMPARATOR

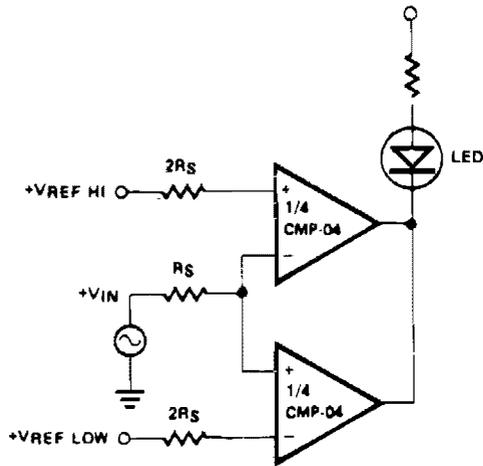


Fig. 16-15

DOUBLE-ENDED LIMIT COMPARATOR

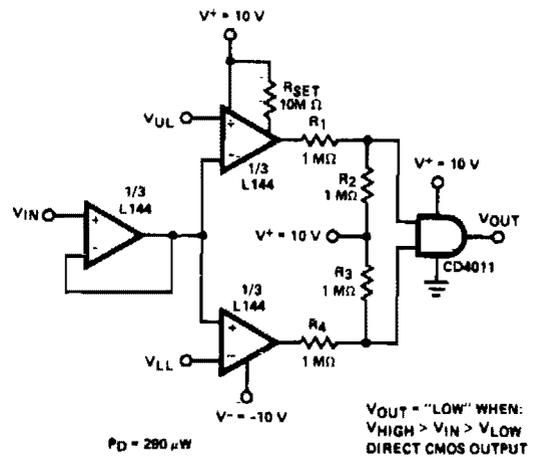


Fig. 16-17

COMPARATOR CLOCK CIRCUIT

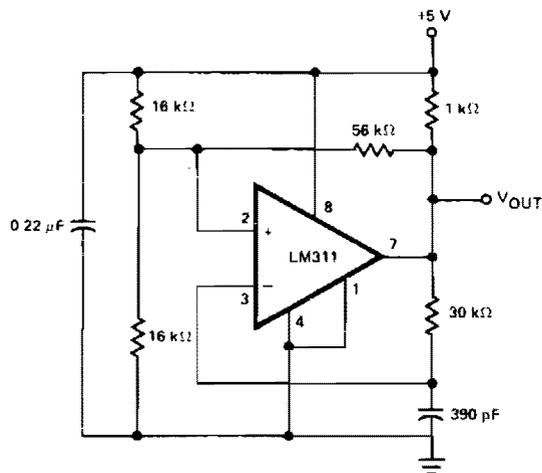


Fig. 16-16

LIMIT COMPARATOR

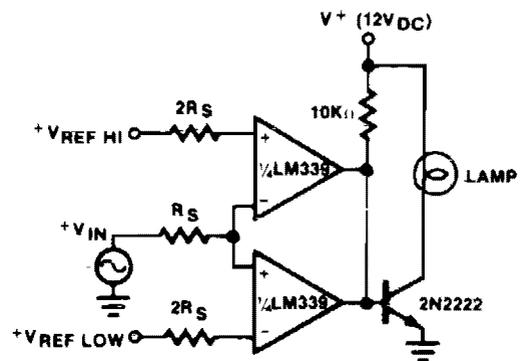


Fig. 16-18

PRECISION, DUAL LIMIT, GO/NO GO TESTER

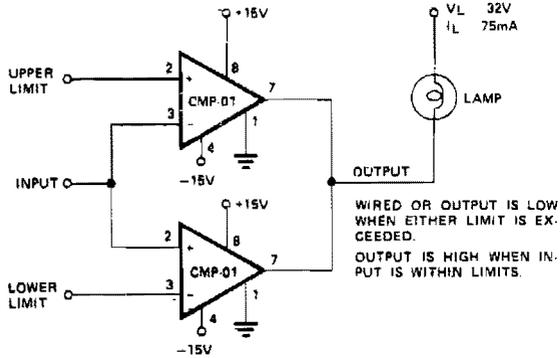


Fig. 16-19

HIGH IMPEDANCE COMPARATOR

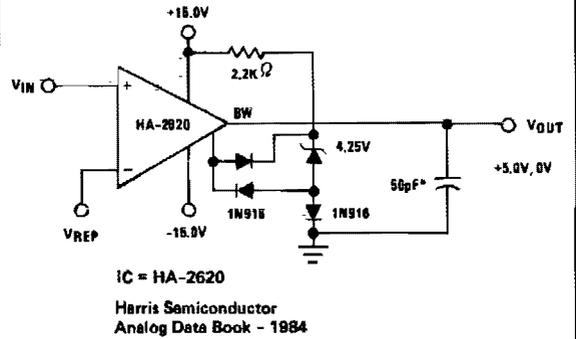


Fig. 16-21

COMPARATOR WITH HYSTERESIS

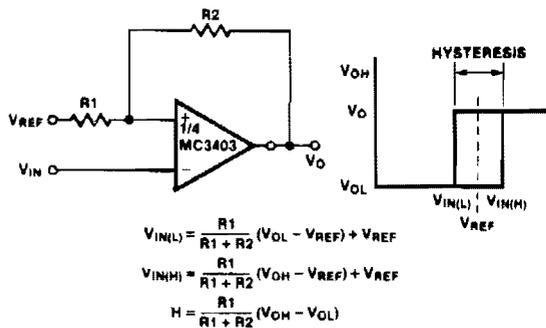


Fig. 16-20

COMPARATOR

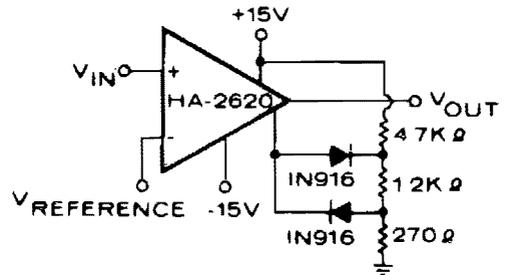


Fig. 16-22

Circuit Notes

An operational amplifier is used as a comparator which is capable of driving approximately 10 logic gates.

17

Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Picoampere-to-Frequency Converter
- BCD-to-Analog Converter
- Resistance-to-Voltage Converter
- Low Cost, μ P Interfaced, Temperature-to-Digital Converter
- Hi-Lo Resistance-to-Voltage Converter
- Current-to-Voltage Converter
- Calculator-to-Stopwatch Converter
- Power Voltage-to-Current Converter
- High Impedance Precision Rectifier for Ac/Dc Converter
- Wide Range Current-to-Frequency Converter
- Ac-to-Dc Converter
- Current-to-Voltage Converter with 1% Accuracy
- Polarity Converter
- Voltage-to-Current Converter
- Wideband, High-Crest Factor, RMS-to-Dc Converter
- Light Intensity-to-Frequency Converter
- Ohms-to-Volts Converter
- Temperature-to-Frequency Converter
- Multiplexed BCD-to-Parallel BCD Converter
- Fast Logarithmic Converter
- Sine Wave-to-Square Wave Converter
- Self Oscillating Flyback Converter
- TTL-to-MOS Logic Converter
- Picoampere-to-Voltage Converter with Gain

BCD-TO-ANALOG CONVERTER

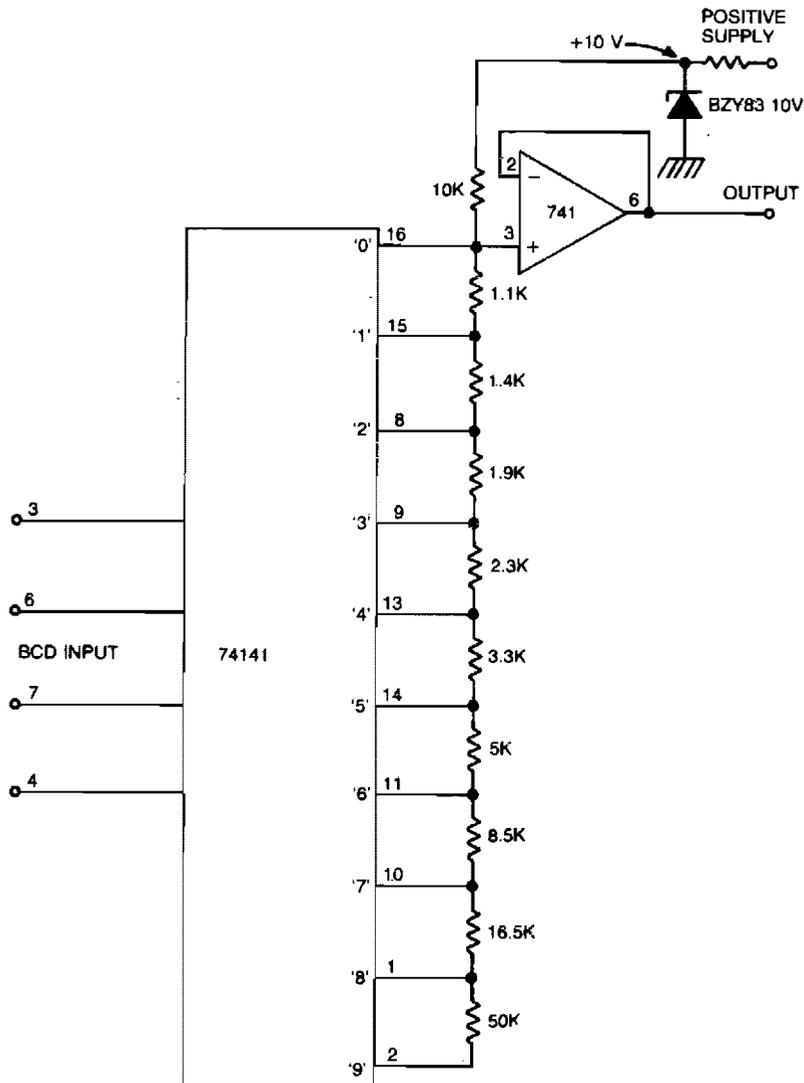


Fig. 17-2

Circuit Notes

This circuit will convert four-bit BCD into a variable voltage from 0-9 V in 1 V steps. The SN74141 is a Nixie driver, and has ten open-collector outputs. These are used to ground a selected point in the divider chain determined by the BCD code at the input, and so produce a

corresponding voltage at the output. Accuracy of the circuit depends on the tolerance of the resistors and the accuracy of the reference voltage. However, presets can be used in the divider chain, with correct calibration. The 741 is used as a buffer.

RESISTANCE-TO-VOLTAGE CONVERTER

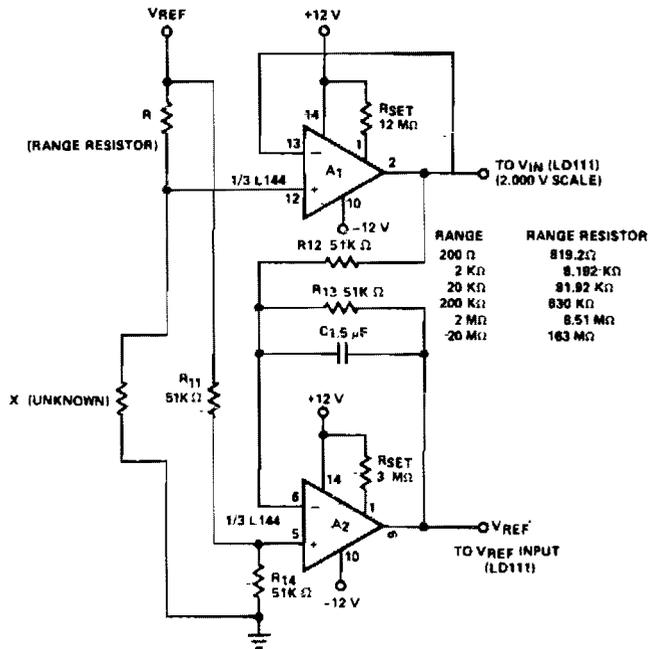


Fig. 17-3

Circuit Notes

Circuit will measure accurately to 20 M when associated with a buffer amplifier (A1) having a low input bias current (I_{IN}) < 30 nA). The circuit uses two of the three amplifiers contained in the Siliconix L144 micropower triple op amp.

LOW-COST, μ P INTERFACED, TEMPERATURE-TO-DIGITAL CONVERTER

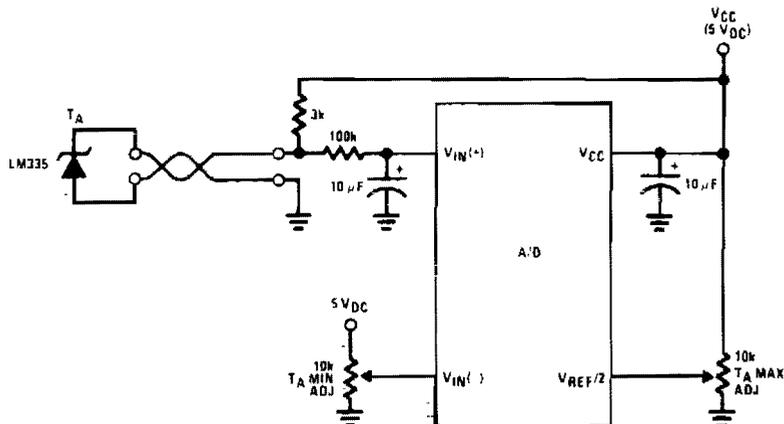


Fig. 17-4

HI-LO RESISTANCE-TO-VOLTAGE CONVERTER

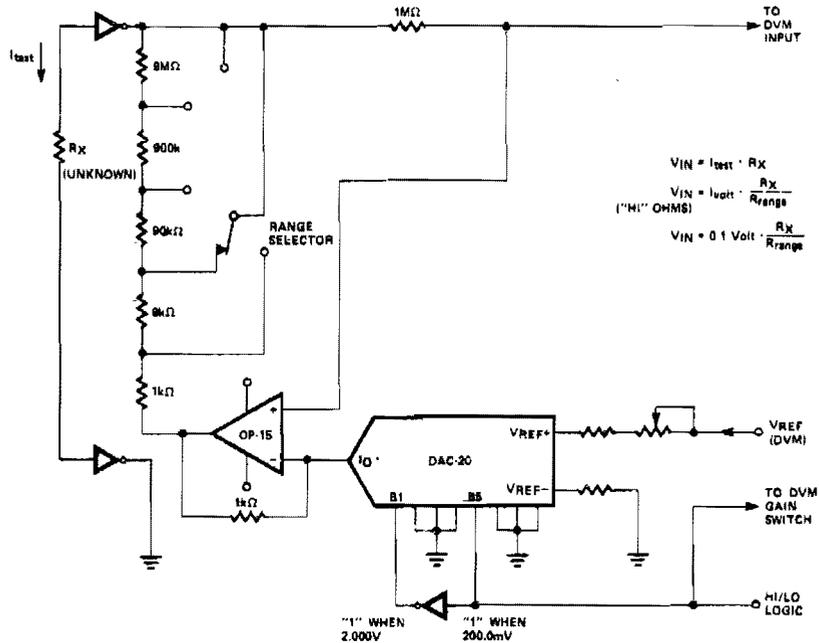
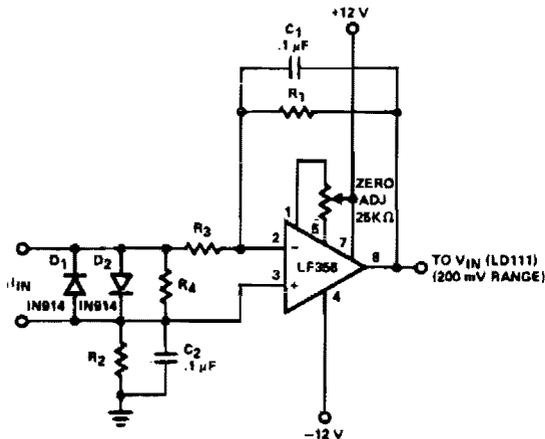


Fig. 17-5

CURRENT-TO-VOLTAGE CONVERTER



Circuit Notes

Converter features eight decades of current range. The circuit is intended to be used with the 200.0 mV range of a DVM.

CURRENT RANGE	R ₁	R ₂	R ₃	R ₄
200 nA	500 KΩ	500 KΩ	0	∞
2 μA	50 KΩ	50 KΩ	0	∞
20 μA	5 KΩ	5 KΩ	0	∞
200 μA	1 KΩ	0	0	∞
2 mA	50 KΩ	0	5.0 K	10.0 Ω
20 mA	50 KΩ	0	5.0 K	1.0 Ω
200 mA	50 KΩ	0	5.0 K	.1 Ω
2 A	50 KΩ	0	5.0 K	.01 Ω

Fig. 17-6

CALCULATOR-TO-STOPWATCH CONVERTER

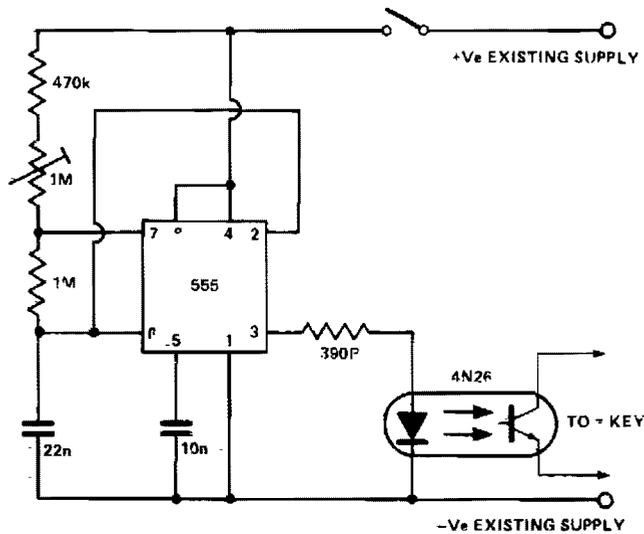


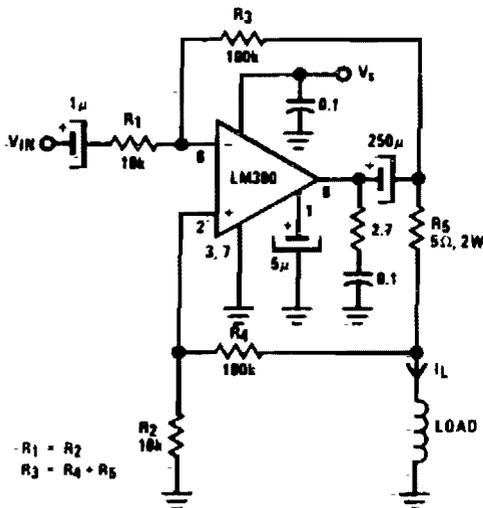
Fig. 17-7

Circuit Notes

This circuit can be fitted to any calculator with an automatic constant to enable it to be used as a stop-watch. The 555 timer is set to run at a suitable frequency and connected to the

existing calculator battery via the push-on push-off switch and the existing calculator on-off switch.

POWER VOLTAGE-TO-CURRENT CONVERTER



Circuit Notes

Low cost converter is capable of supplying constant ac currents up to 1 A over variable loads.

Fig. 17-8

HIGH IMPEDANCE PRECISION RECTIFIER FOR AC/DC CONVERTER

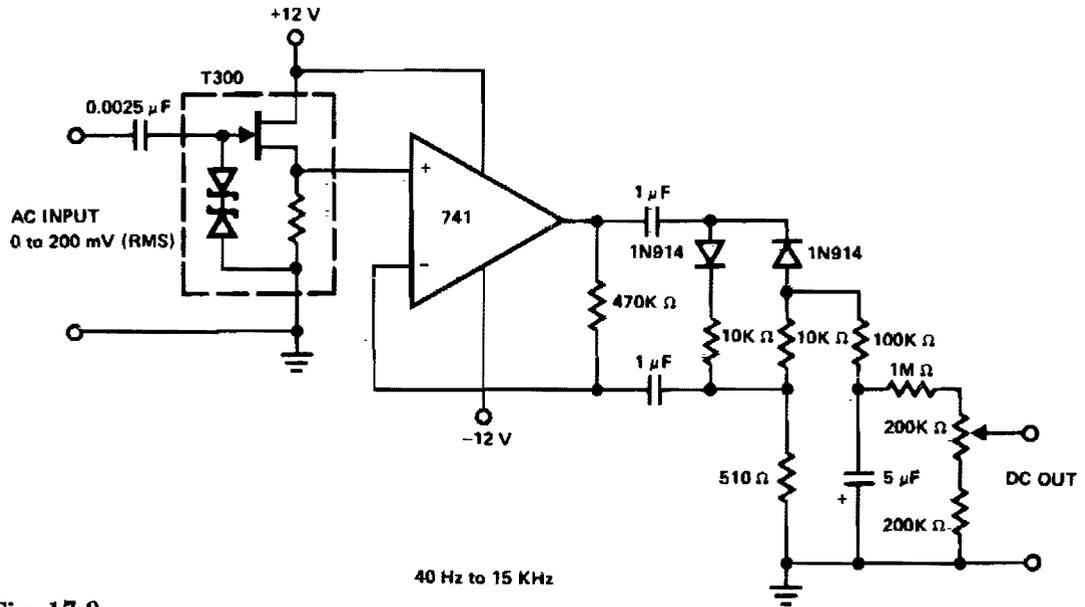
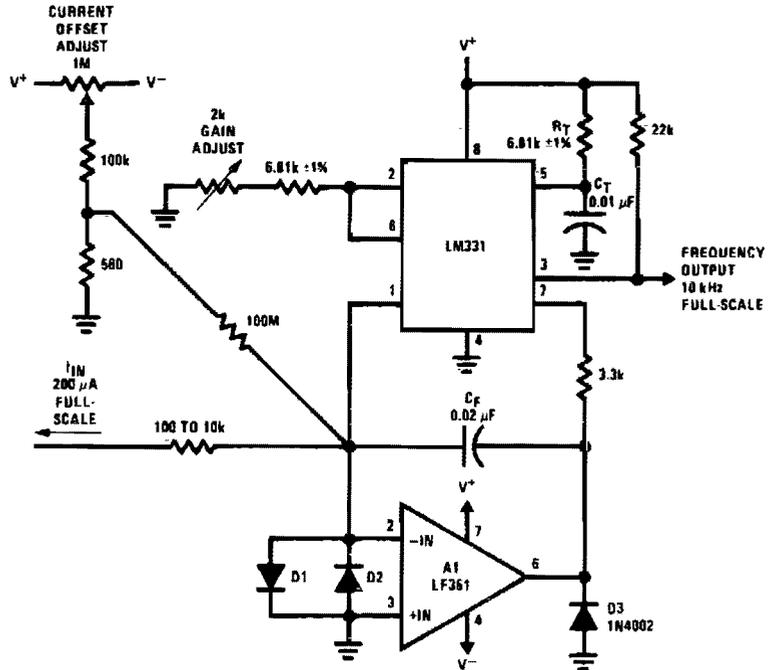


Fig. 17-9

WIDE-RANGE CURRENT-TO-FREQUENCY CONVERTER



D1, D2 = 1N457, 1N484, or similar low-leakage planar diode

Fig. 17-10

AC-TO-DC CONVERTER

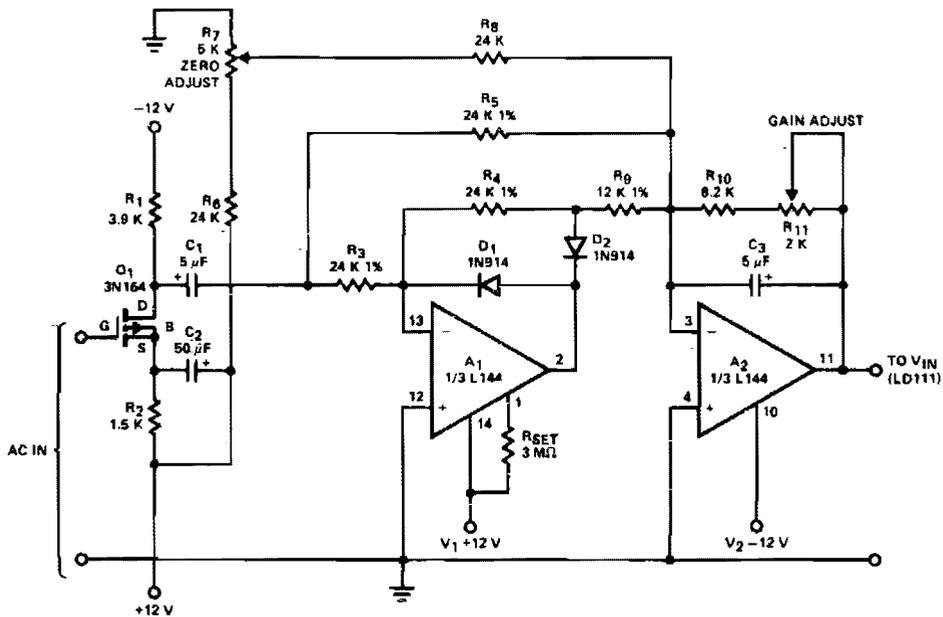


Fig. 17-11

Circuit Notes

This circuit includes a PMOS enhancement-mode FET input buffer amplifier, coupled to a classical absolute value circuit which essentially eliminates the effect of the forward voltage drop across diodes D1 and D2.

CURRENT-TO-VOLTAGE CONVERTER WITH 1% Accuracy

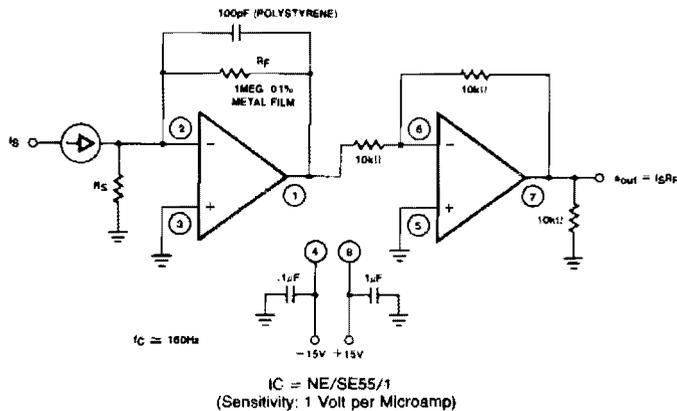


Fig. 17-12

Circuit Notes

A filter removes the dc component of the rectified ac, which is then scaled to RMS. The output is linear from 40 Hz to 10 kHz or higher.

POLARITY CONVERTER

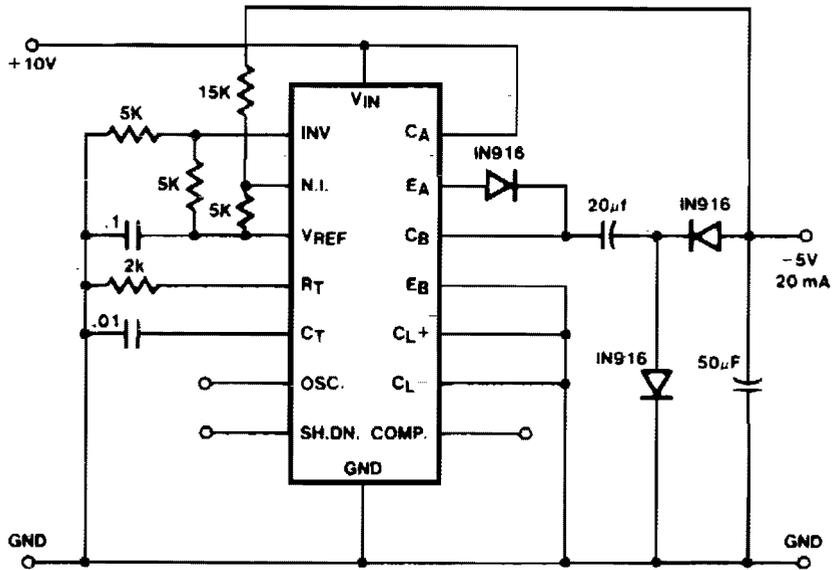


Fig. 17-13

Circuit Notes

The capacitor-diode output circuit is used here as a polarity converter to generate a -5 volt supply from +15 volts. This circuit is useful for an output current of up to 20 mA with no additional boost transistors required. Since the

output transistors are current limited, no additional protection is necessary. Also, the lack of an inductor allows the circuit to be stabilized with only the output capacitor.

VOLTAGE-TO-CURRENT CONVERTER

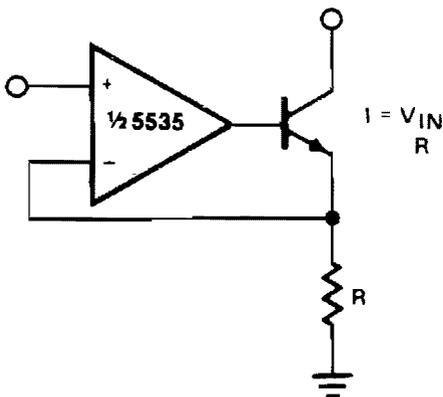


Fig. 17-14

Circuit Notes

The current out is $I_{OUT} \cong V_{IN}/R$. For negative currents, a PNP can be used and, for better accuracy, a Darlington pair can be substituted for the transistor. With careful design, this circuit can be used to control currents of many amps. Unity gain compensation is necessary.

OHMS-TO-VOLTS CONVERTER

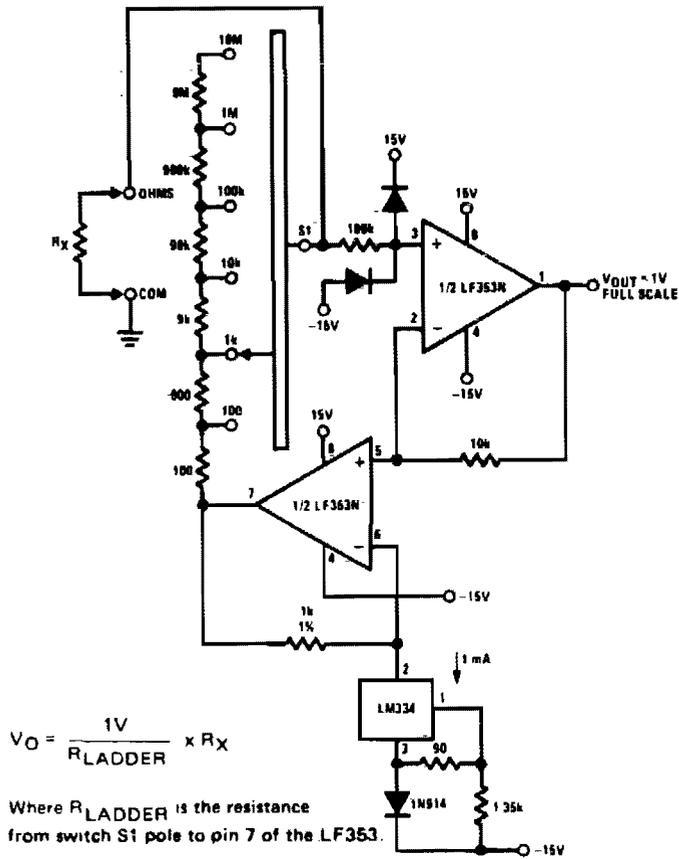


Fig. 17-17

TEMPERATURE-TO-FREQUENCY CONVERTER

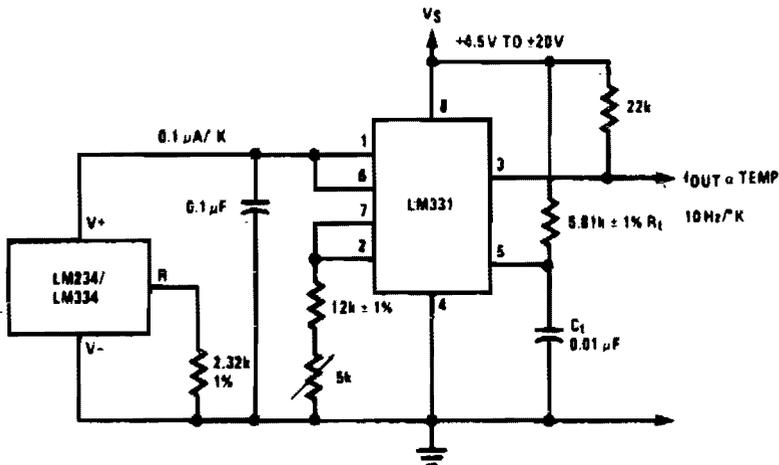
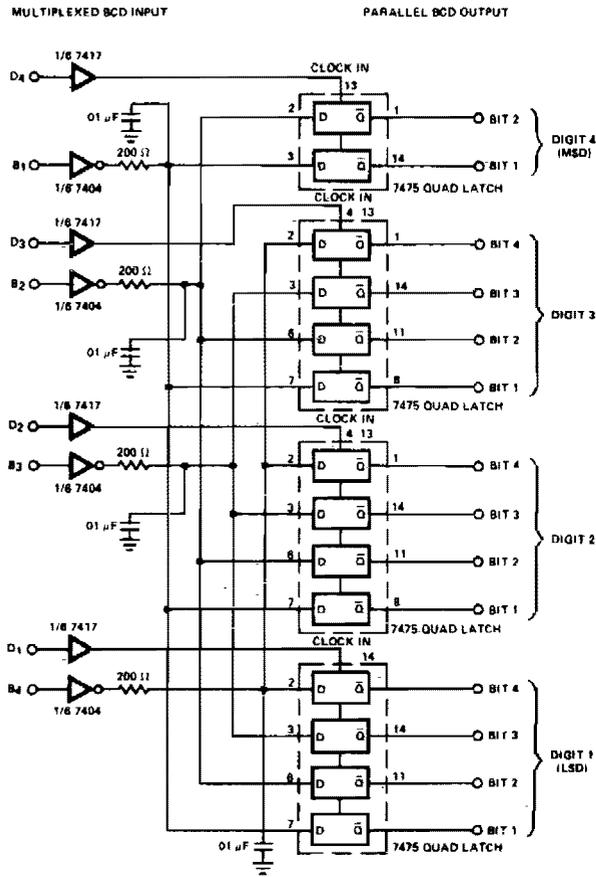


Fig. 17-18

MULTIPLEXED BCD-TO-PARALLEL BCD CONVERTER

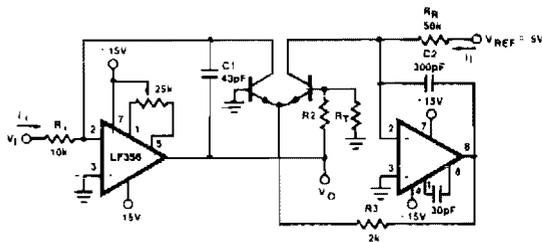


Circuit Notes

Converter consists of four quad bistable latches activated in the proper sequence by the digit strobe output of the LD110. The complemented outputs (Q) of the quad latch set reflects the state of the bit outputs when the digit strobe goes high. It will maintain this state when the digit strobe goes low.

Fig. 17-19

FAST LOGARITHMIC CONVERTER



$$V_{out} = \left[1 + \frac{R_2}{R_1} \right] \frac{kT}{q} \ln V_1 \left[\frac{R_4}{V_{REF} R_1} \right] - \log V_1 \frac{1}{R_1 I_{10}}$$

* $R_2 = 15.71$ * $R_1 = 1k$ * $0.3\%/^{\circ}C$ (for temperature compensation)

- Dynamic range: $100\mu A \leq I_1 \leq 1mA$ (5 decades, $I_{V0} = 1V/\text{decades}$)
- Transient response: $3\mu s$ for $\Delta = 10$ decades
- C1, C2, R2, R3 added dynamic compensation
- V_{OS} adjust the LFP356 to minimize quiescent error
- R_1 : Tel Labs type Q81 + $0.3\%/^{\circ}C$

Fig. 17-20

SINE WAVE-TO-SQUARE WAVE CONVERTER

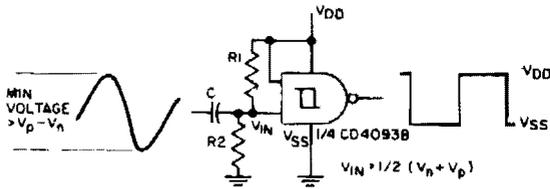


Fig. 17-21

Circuit Notes

The sine input is ac coupled by capacitor C; R1 and R2 bias the input midway between V_n and V_p , the input threshold voltages, to provide a square wave at the output.

TTL-TO-MOS LOGIC CONVERTER

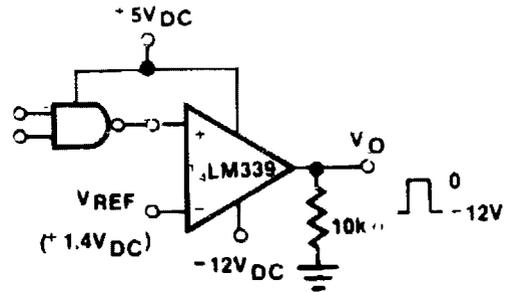


Fig. 17-23

SELF OSCILLATING FLYBACK CONVERTER

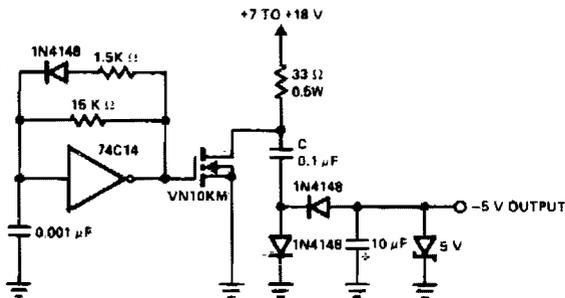


Fig. 17-22

Circuit Notes

A low-power converter suitable for deriving a higher voltage from a main system rail in an on-board application. With the transformer shown, the operating frequency is 250 kHz. Z1 serves as a dissipative voltage regulator for the output and also clips the drain voltage to a level below the rated VMOS breakdown voltage.

PICOAMPERE-TO-VOLTAGE CONVERTER WITH GAIN

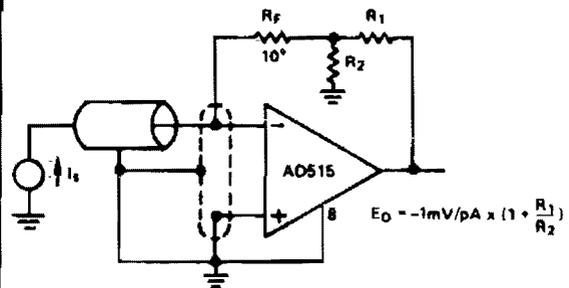


Fig. 17-24

18

Crossover Networks

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Active Crossover Network

Asymmetrical Third Order Butterworth
Active Crossover Network

Third Order Butterworth Crossover
Network

ACTIVE CROSSOVER NETWORK

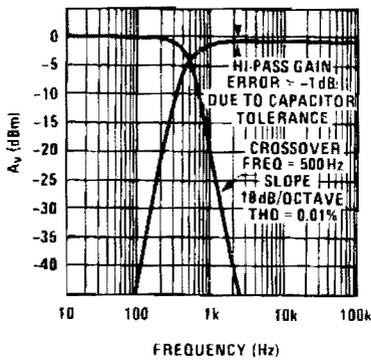
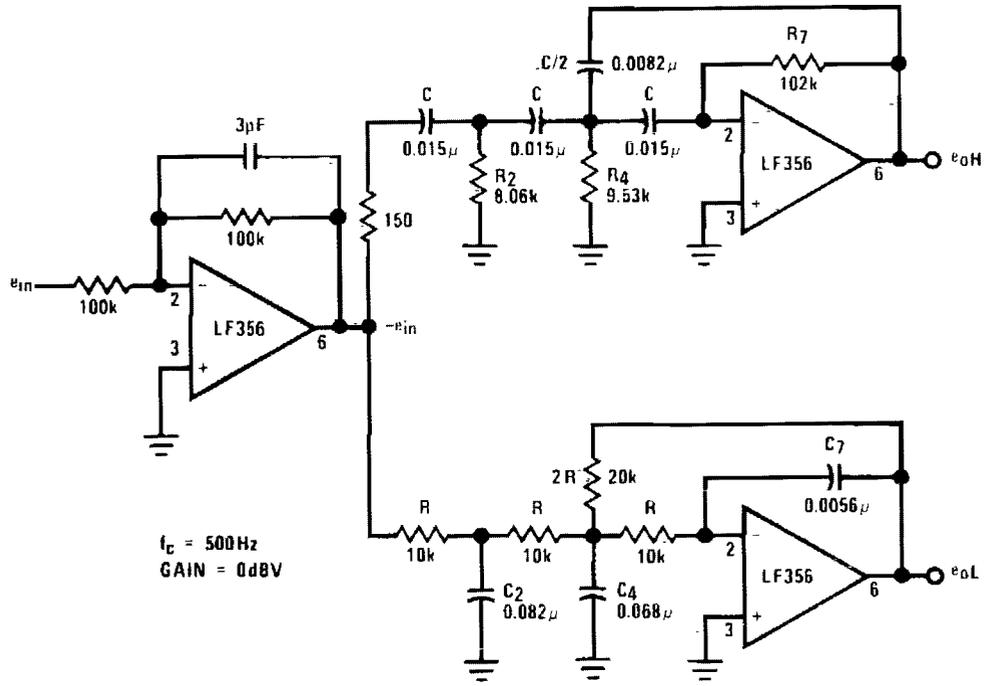


Fig. 18-1

ASYMMETRICAL THIRD ORDER BUTTERWORTH ACTIVE CROSSOVER NETWORK

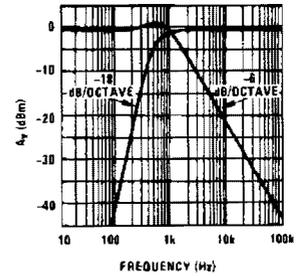
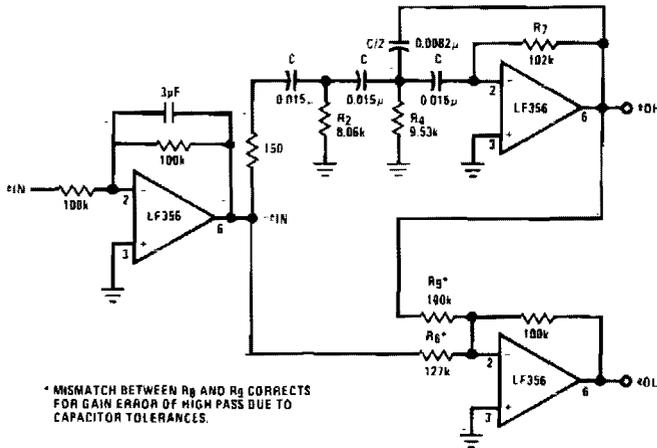


Fig. 18-2

THIRD ORDER BUTTERWORTH CROSSOVER NETWORK

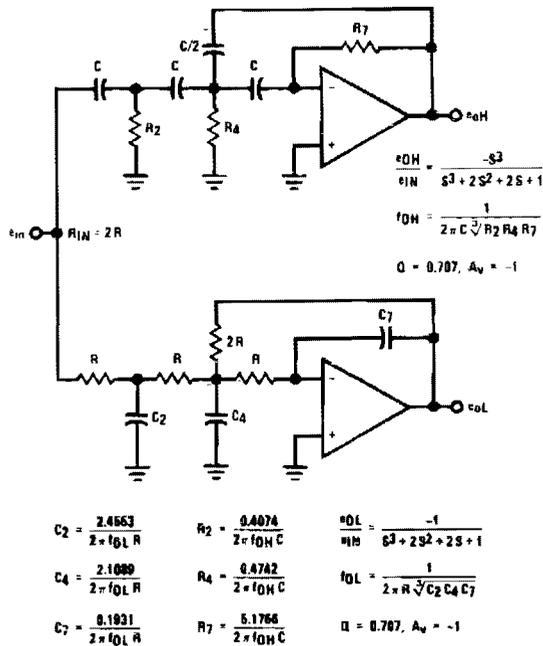


Fig. 18-3

19

Crystal Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

High Frequency Crystal Oscillator	Pierce Harmonic Oscillator
Overtone Crystal Oscillator	Colpitts Harmonic Oscillator
Overtone Crystal Oscillator	International Crystal OF-1 LO Oscillator
TTL Oscillator for 1 MHz-10 MHz	Butler Emitter Follower Oscillator
Crystal Checker	Colpitts Harmonic Oscillator
96 MHz Crystal Oscillator	Butler Emitter Follower Oscillator
Simple TTL Crystal Oscillator	Butler Common Base Oscillator
Crystal Oscillator	Pierce Harmonic Oscillator
Overtone Crystal Oscillator	Tube Type Crystal Oscillator
Schmitt Trigger Crystal Oscillator	Precision Clock Generator
50 MHz-150 MHz Overtone Oscillator	Miller Oscillator
Fifth Overtone Oscillator	Butler Emitter Follower Oscillator
Crystal Controlled Butler Oscillator	Colpitts Oscillator
Overtone Oscillator with Crystal Switching	Crystal-Controlled Oscillator
Crystal Oscillator	Pierce Oscillator
Crystal Oscillator/Doubler	Butler Aperiodic Oscillator
Low Frequency Crystal Oscillator	Parallel-mode Aperiodic Crystal Oscillator
Crystal Oscillator	International Crystal OF-1 HI Oscillator
100 kHz Crystal Calibrator	Standard Crystal Oscillator for 1 MHz
Third Overtone Crystal Oscillator	TTL-Compatible Crystal Oscillator
Crystal Checker	Crystal Controlled Sine Wave Oscillator
CMOS Crystal Oscillator	Crystal Oscillator
Temperature-Compensated Crystal Oscillator	Stable Low Frequency Crystal Oscillator
Crystal Controlled Transistor Oscillator	JFET Pierce Crystal Oscillator
	CMOS Oscillator
	Pierce Harmonic Oscillator

OVERTONE CRYSTAL OSCILLATOR

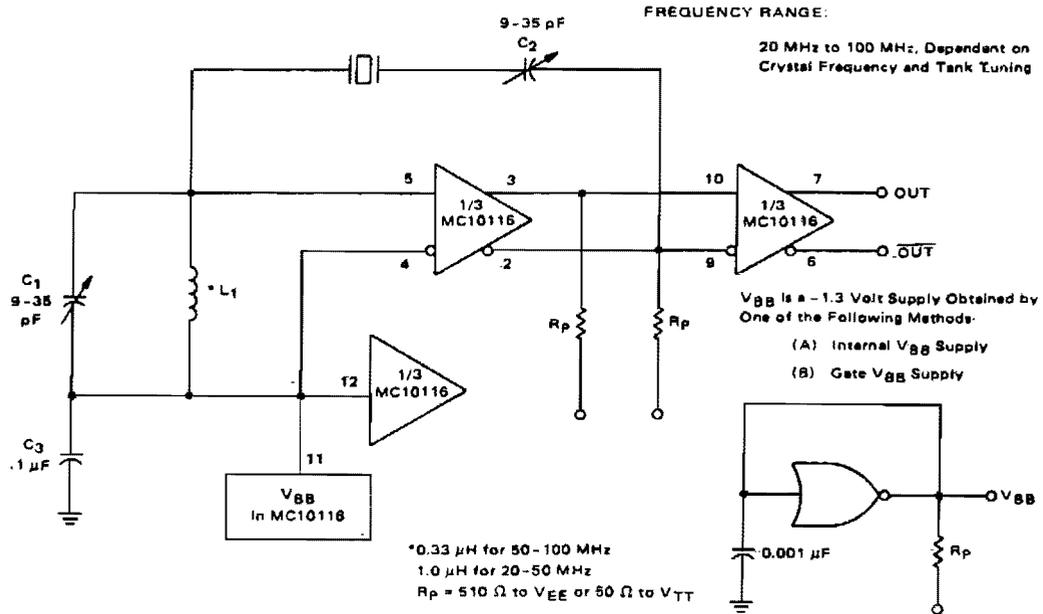


Fig. 19-2

Circuit Notes

This circuit employs an adjustable resonant tank circuit which insures operation at the desired crystal overtone. C_1 and L_1 form the resonant tank circuit, which with the values specified as a resonant frequency adjustable from approximately 50 MHz to 100 MHz. Overtone operation is accomplished by adjusting the

tank circuit frequency at or near the desired frequency. The tank circuit exhibits a low impedance shunt to off-frequency oscillations and a high impedance to the desired frequency, allowing feedback from the output. Operation in this manner guarantees that the oscillator will always start at the correct overtone.

OVERTONE CRYSTAL OSCILLATOR

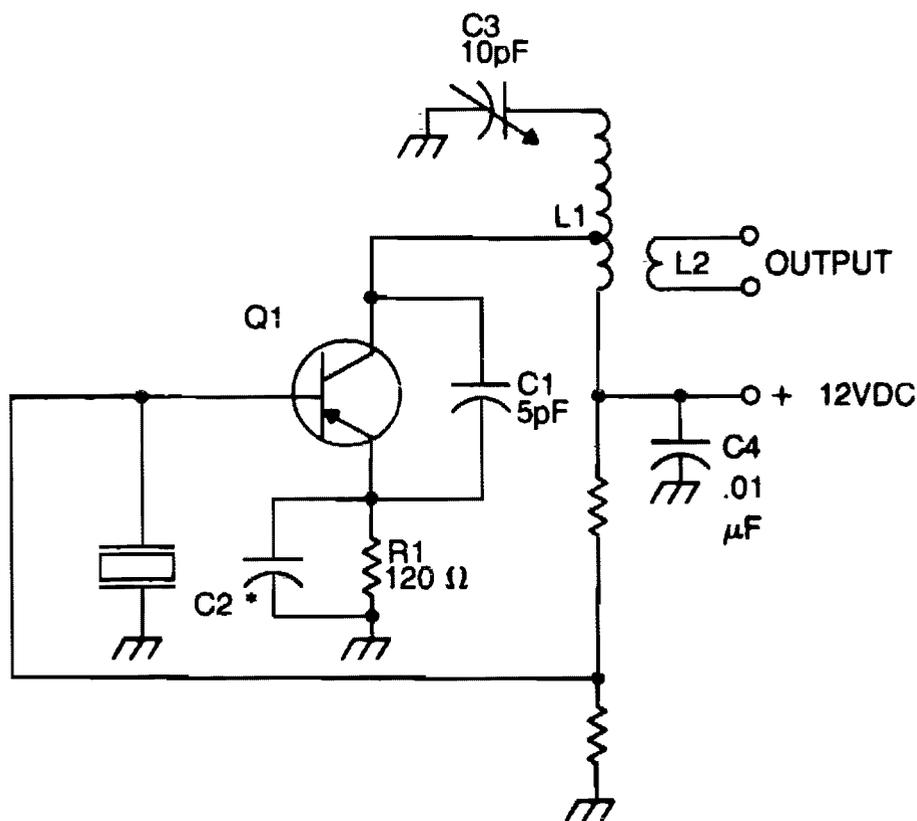


Fig. 19-3

Circuit Notes

The crystal element in this circuit is connected directly between the base and ground. Capacitor C1 is used to improve the feedback due to the internal capacitances of the transistor. This capacitor should be mounted as close as possible to the case of the transistor. The LC tank circuit in the collector of the transistor is tuned to the overtone frequency of the crystal. The emitter resistor capacitor must have a capacitive reactance of approximately 90 ohms

at the frequency of operation. The tap on inductor L1 is used to match the impedance of the collector of the transistor. In most cases, the optimum placement of this tap is approximately one-third from the cold end of the coil. The placement of this tap is a trade-off between stability and maximum power output. The output signal is taken from a link coupling coil, L2, and operates by transformer action.

CRYSTAL CHECKER

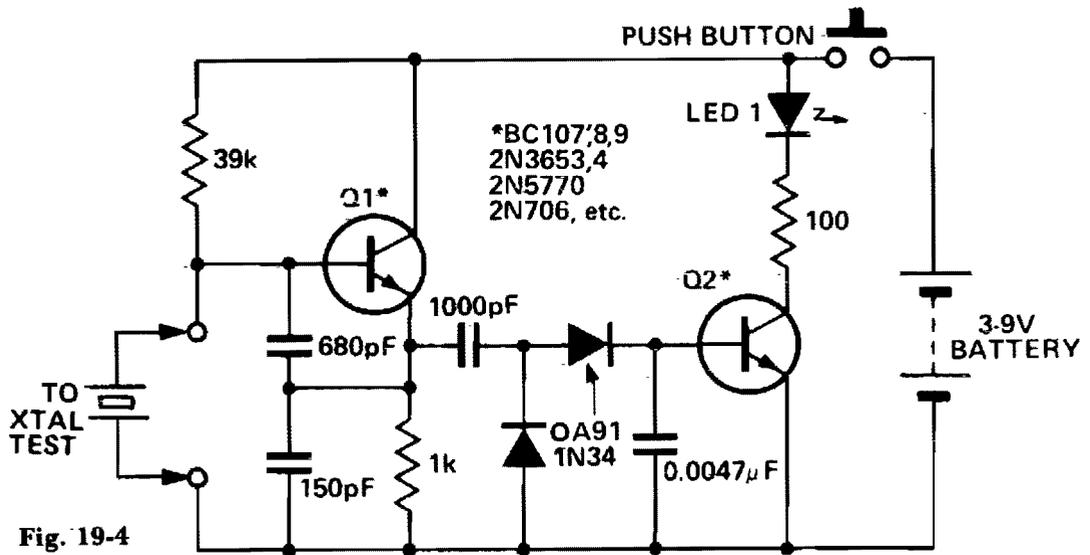


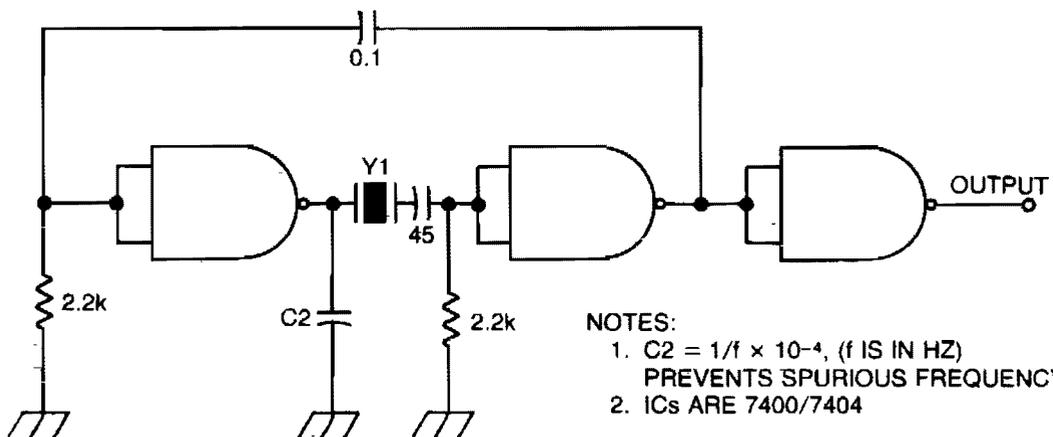
Fig. 19-4

Circuit Notes

Use this circuit for checking fundamental HF crystals on a 'Go-No-Go' basis. An untuned Colpitts oscillator drives a voltage multiplier rectifier and a current amplifier. If the crystal

oscillates, Q2 conducts and the LED lights. A3 or 6V, 40mA bulb could be substituted for the LED.

TTL OSCILLATOR FOR 1 MHz-10 MHz

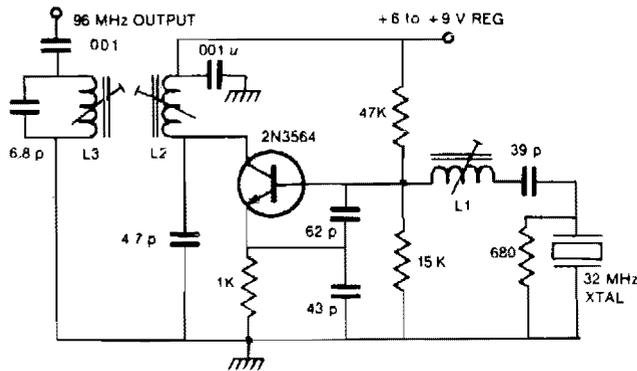


NOTES:

1. $C2 = 1/f \times 10^{-4}$, (f IS IN HZ)
PREVENTS SPURIOUS FREQUENCY
2. ICs ARE 7400/7404

Fig. 19-5

96 MHz CRYSTAL OSCILLATOR



L1, 4 mm former, F29 slug (Neosid AZ assembly)
 30 turns 4 mm enamel wire
 L2, L3 7300 CAN TWO 722:1 FORMERS F29 SLUGS
 (Neosid double assembly) 12 turns 63 mm enamel
 wire

Fig. 19-6

Circuit Notes

By using a crystal between 27.5 and 33 MHz, the 3rd harmonic will deliver between 82.5 and 99 MHz.

SIMPLE TTL CRYSTAL OSCILLATOR

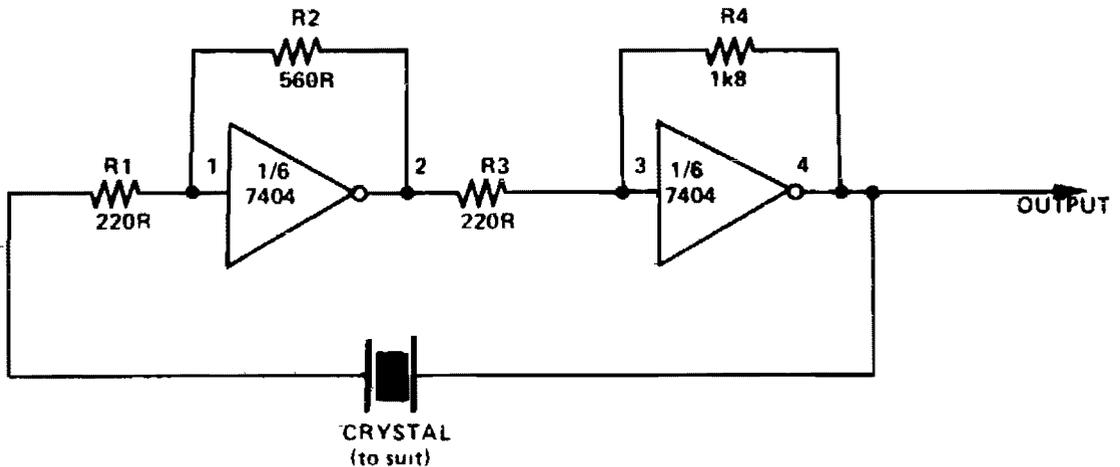


Fig. 19-7

Circuit Notes

This simple and cheap crystal oscillator comprises one third of a 7404, four resistors and a crystal. The inverters are biased into

their linear regions by R1 to R4, and the crystal provides the feedback. Oscillation can only occur at the crystal's fundamental frequency.

CRYSTAL OSCILLATOR

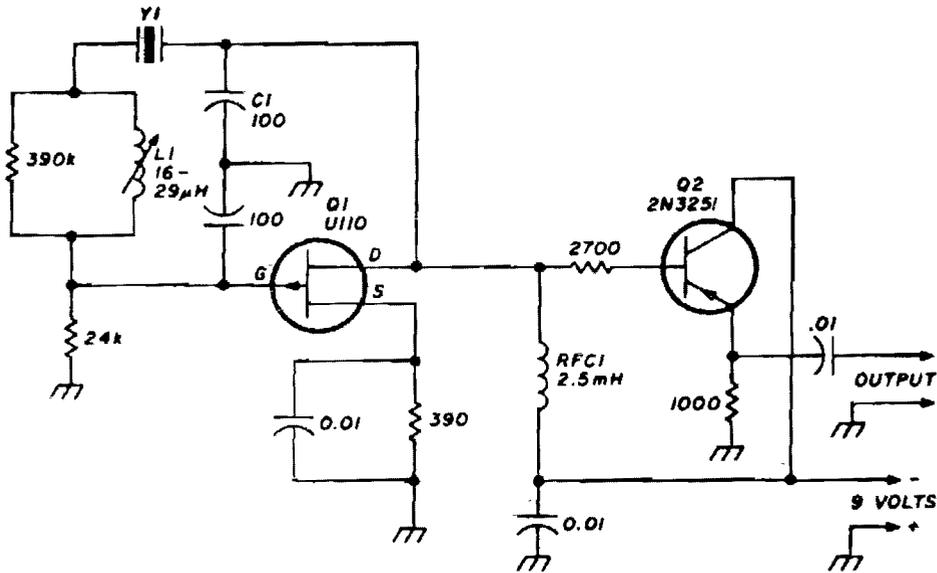


Fig. 19-8

Circuit Notes

Stable VXO using 6- or 8-MHz crystals uses a capacitor and an inductor to achieve frequency pulling on either side of series resonance.

OVERTONE CRYSTAL OSCILLATOR

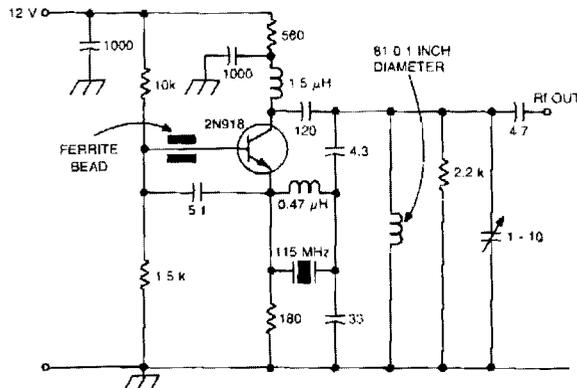


Fig. 19-9

Circuit Notes

This design is for high reliability over a wide temperature range using fifth and seventh overtone crystals. The inductor in parallel with the crystal causes antiresonance of crystal C_0 to minimize loading. This technique is commonly used with overtone crystals.

SCHMITT TRIGGER CRYSTAL OSCILLATOR

SCHMITT TRIGGER OSCILLATOR UP TO 10 MHz

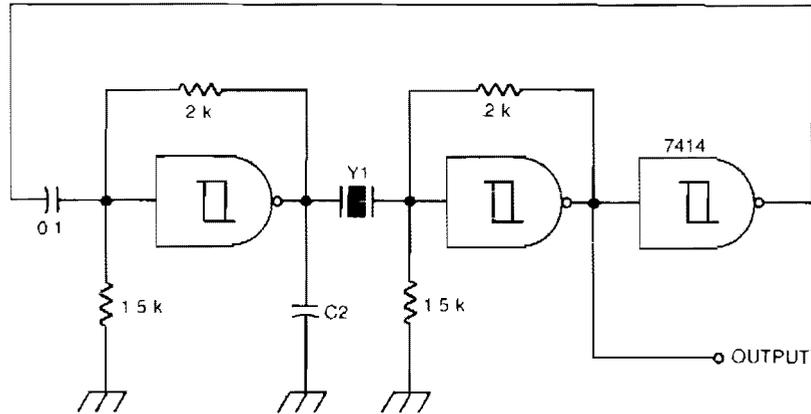


Fig. 19-10

Circuit Notes

A Schmitt trigger provides good squaring of the output, sometimes eliminating the need for an extra output stage.

50 MHz-150 MHz OVERTONE OSCILLATOR

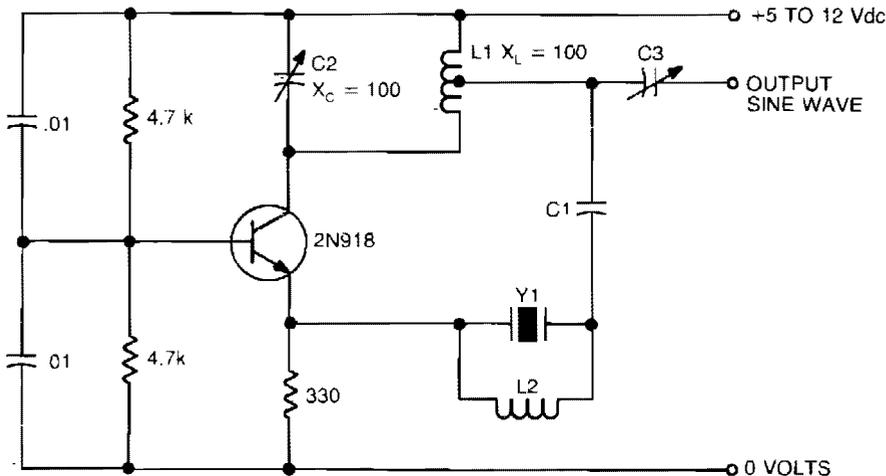


Fig. 19-11

NOTES:

1. Y1 IS AT CUT OVERTONE CRYSTAL.
2. TUNE L1 AND C2 TO OPERATING FREQUENCY
3. L2 AND SHUNT CAPACITANCE, CO. OF CRYSTAL (APPROXIMATELY 6pF) SHOULD RESONATE TO OSCILLATOR OUTPUT FREQUENCY (L2 = .5 μ H AT 90 MHz). THIS IS NECESSARY TO TUNE OUT EFFECT OF CO.
4. C3 IS VARIED TO MATCH OUTPUT.

FIFTH-OVERTONE OSCILLATOR

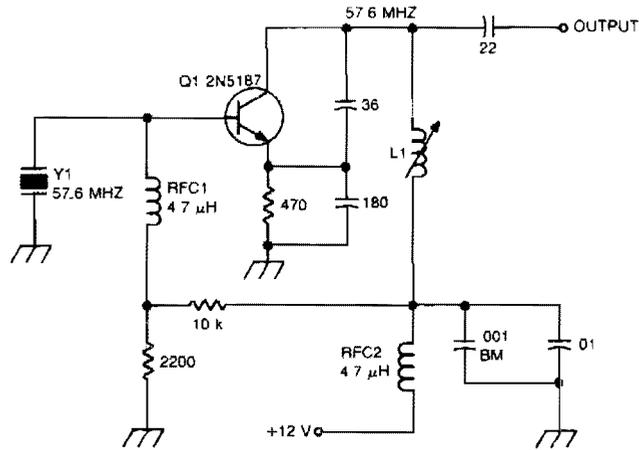


Fig. 19-12

Circuit Notes

This circuit isolates the crystal from the dc base supply with an rf choke for better starting characteristics.

CRYSTAL CONTROLLED BUTLER OSCILLATOR

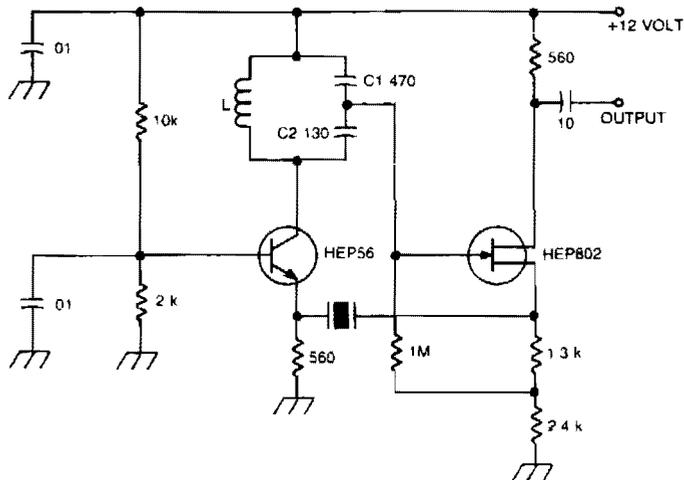
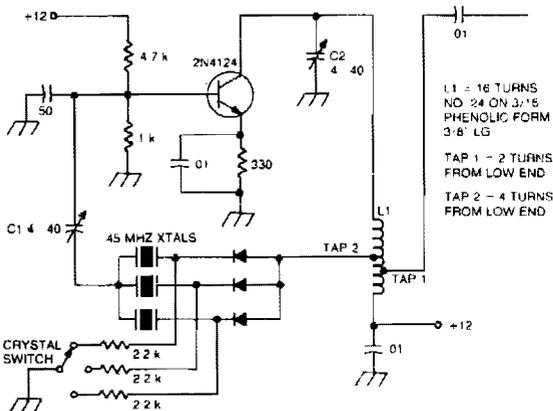


Fig. 19-13

Circuit Notes

A typical Butler oscillator (20-100 MHz) uses an FET in the second stage; the circuit is not reliable with two bipolars. Sometimes two FETs are used. Frequency is determined by LC values.

OVERTONE OSCILLATOR WITH CRYSTAL SWITCHING

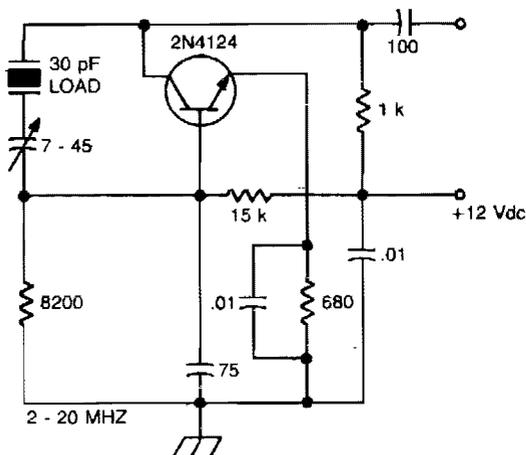


Circuit Notes

The large inductive phase shift of L1 is compensated for by C1. Overtone crystals have very narrow bandwidth; therefore, the trimmer has a smaller effect than for fundamental-mode operation.

Fig. 19-14

CRYSTAL OSCILLATOR



Circuit Notes

The crystal is in a feedback circuit from collector to base. A trimmer capacitor in series shifts the point on the reactance curve where the crystal operates, thus providing a frequency trim. The capacitor has a negative reactance so the crystal is shifted to operate in the positive reactance region.

Fig. 19-15

CRYSTAL OSCILLATOR

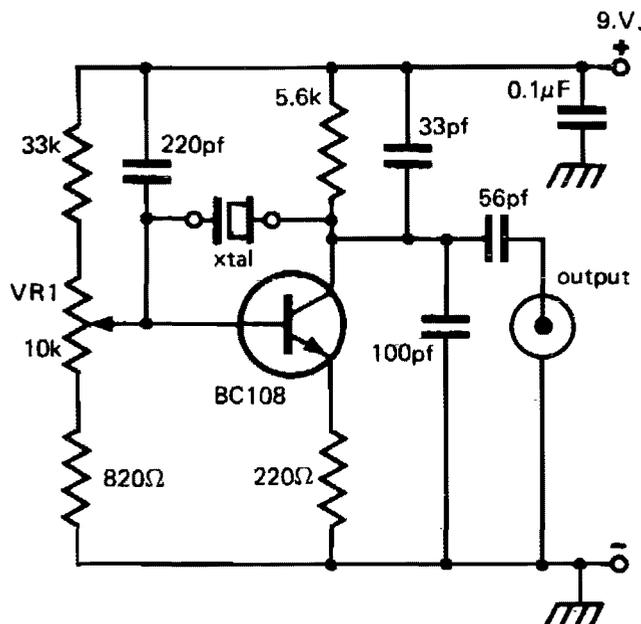
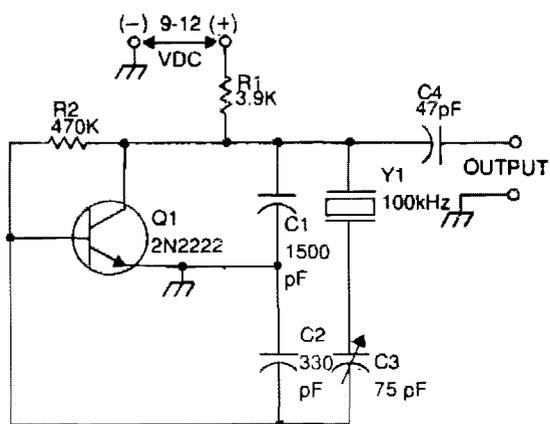


Fig. 19-18

Circuit Notes

This circuit provides reliable oscillation and an output close to one volt peak-to-peak. Power consumption is around 1 mA from a nine volt supply.

100 kHz CRYSTAL CALIBRATOR



Circuit Notes

This circuit is often used by amateur radio operators, shortwave listeners, and other operators of shortwave receivers to calibrate the dial pointer. The oscillator operates at a fundamental frequency of 100 kHz, and the harmonics are used to locate points on the shortwave dial, provided that the output of the calibrator is coupled to the antenna circuit of the receiver. The crystal shunts the feedback voltage divider, and is in series with a variable capacitor (C3) that is used to set the actual operating frequency of the calibrator.

Fig. 19-19

CMOS CRYSTAL OSCILLATOR

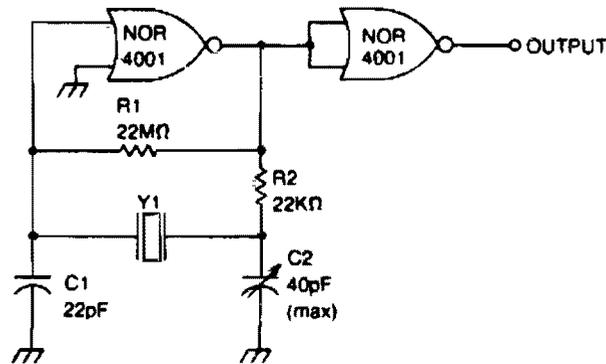


Fig. 19-22

Circuit Notes

This circuit has a frequency range of 0.5 MHz to 2.0 MHz. Frequency can be adjusted to a precise value with trimmer capacitor C2. The second NOR gate serves as an output buffer.

TEMPERATURE-COMPENSATED CRYSTAL OSCILLATOR

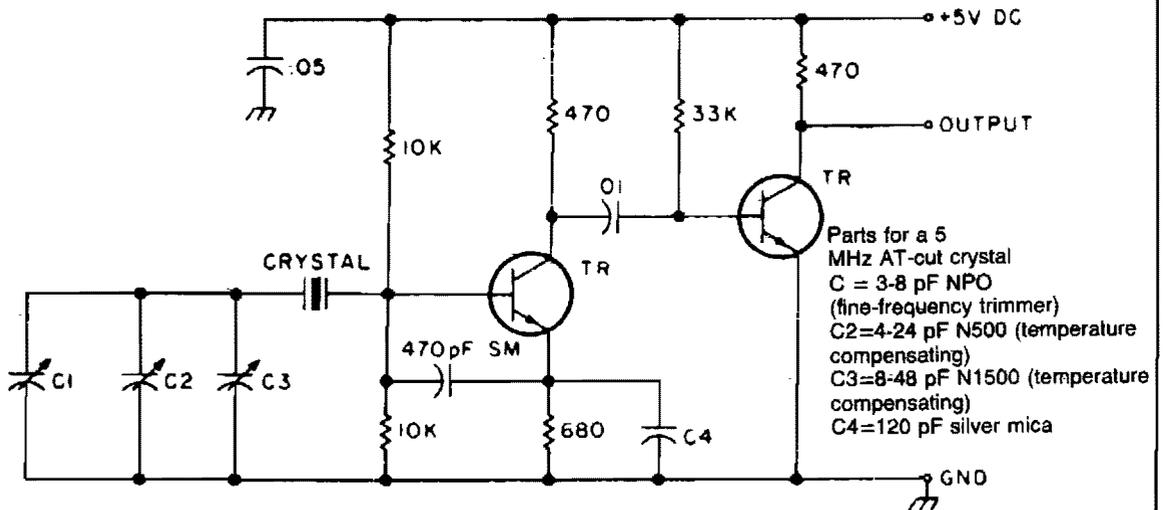


Fig. 19-23

Circuit Notes

Two different negative-coefficient capacitors are blended to produce the desired change in capacitance to counteract or compensate for the decrease in frequency of the "normal" AT-cut characteristics.

CRYSTAL-CONTROLLED, TRANSISTOR OSCILLATOR

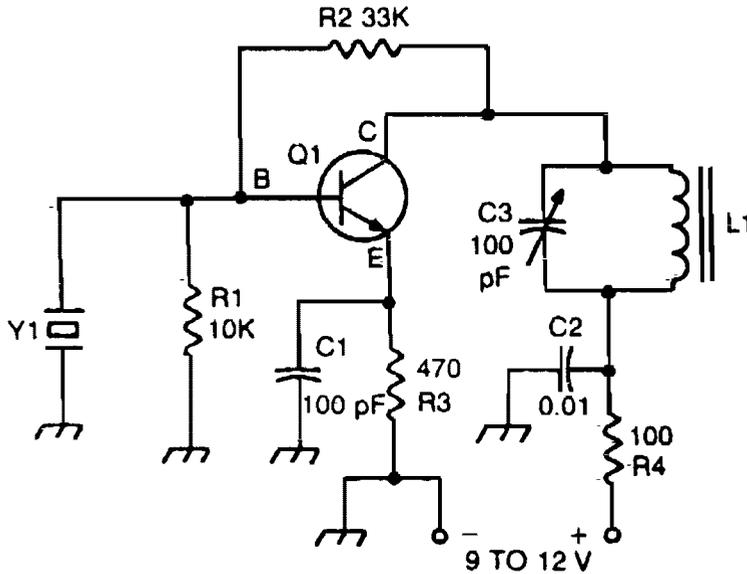


Fig. 19-24

PIERCE HARMONIC OSCILLATOR (20 MHz)

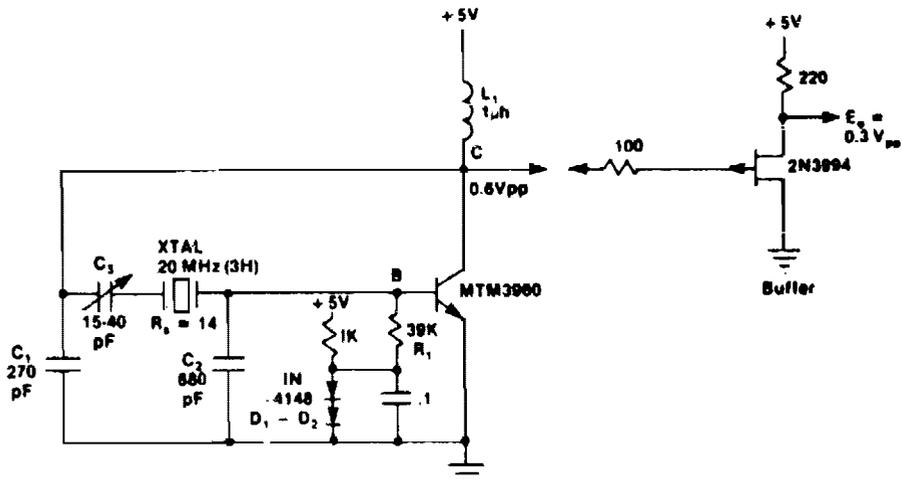


Fig. 19-25

Circuit Notes

This circuit has excellent short term frequency stability because the external load tied across the crystal is mostly capacitive rather than resistive, giving the crystal a high in-circuit Q.

COLPITTS HARMONIC OSCILLATOR (100 MHz)

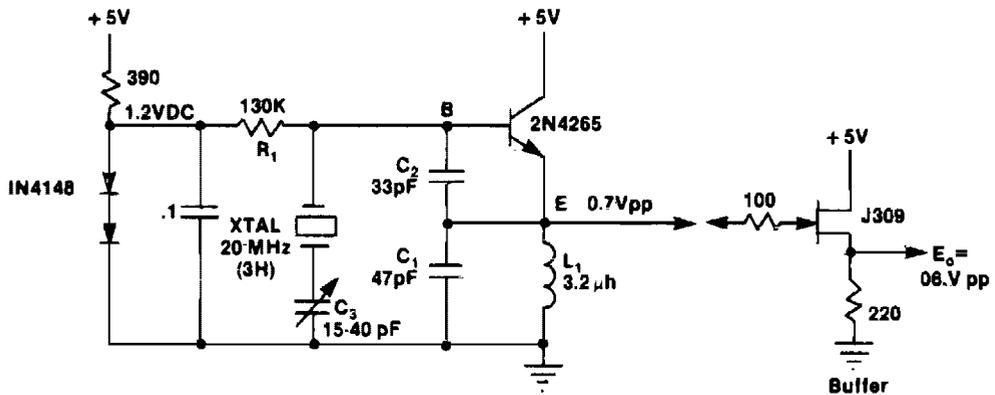


Fig. 19-26

Circuit Notes

L1C1 are selected to be resonant at a frequency below the desired crystal harmonic but above the crystal's next lower odd harmonic. C2 should have a value of 30-70 pF, independent of the oscillation frequency. There is no requirement for any specific ratio

of C1/C2, but practical harmonic circuits seem to work best when C1 is approximately 1-3 times the value of C2. Diodes D1-D3 provide a simple regulated bias supply. The resistance of R1 should be as high as possible, as it affects the crystal's in-circuit Q.

INTERNATIONAL CRYSTAL OF-1 LO OSCILLATOR

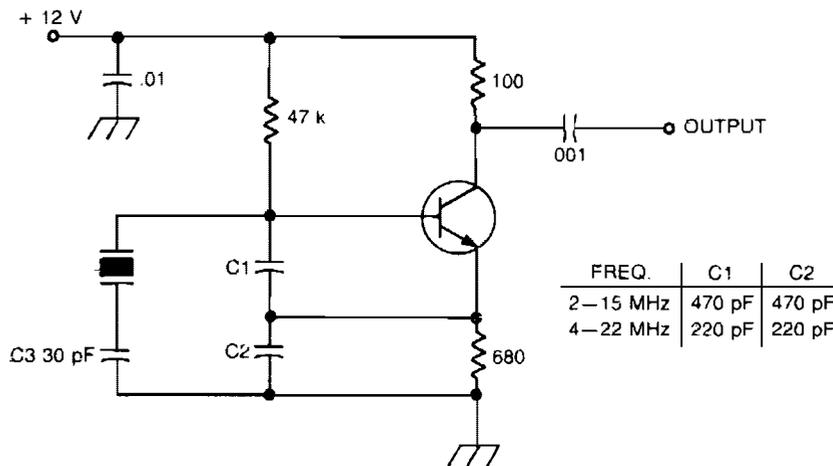
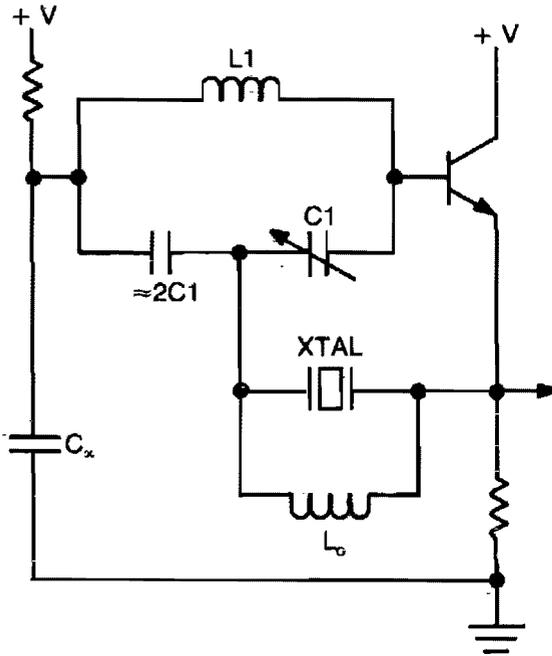


Fig. 19-27

Circuit Notes

International Crystal OF-1 LO oscillator circuit for fundamental-mode crystals.

BUTLER Emitter Follower Oscillator (Basic Circuit)

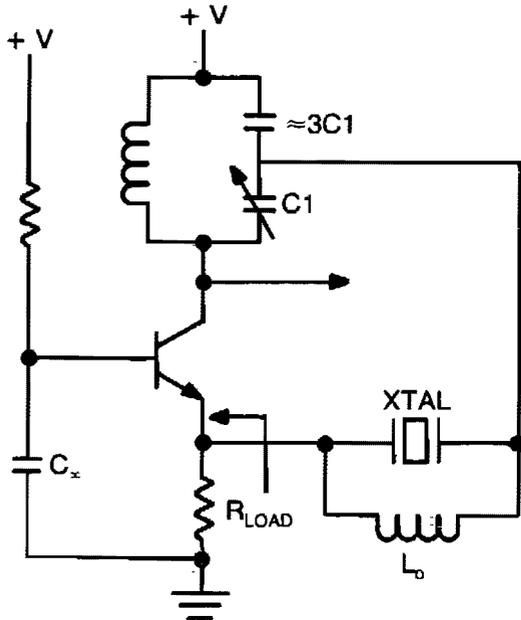


Circuit Notes

This circuit operates at or near series resonance. It is a good circuit design with no parasitics. It is easy to tune with good frequency stability.

Fig. 19-30

BUTLER Common Base Oscillator (Basic Circuit)

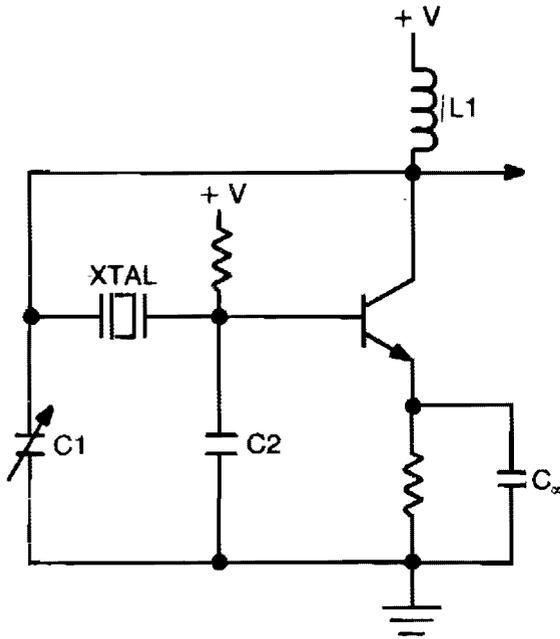


Circuit Notes

This circuit operates at or near series resonance. It has fair to poor circuit design with parasitics, touch to tune, and fair frequency stability.

Fig. 19-31

PIERCE HARMONIC OSCILLATOR (BASIC CIRCUIT)

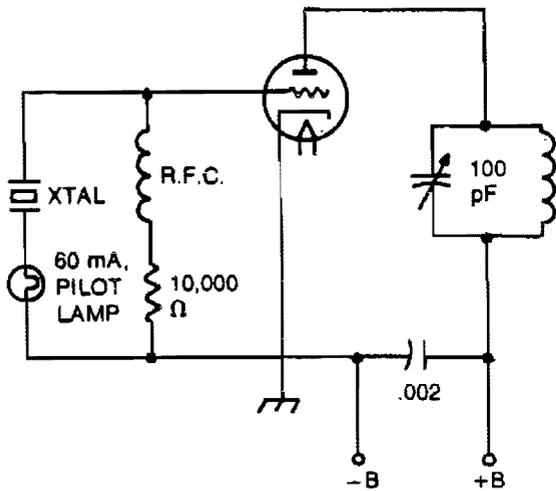


Circuit Notes

This circuit operates 10-40 ppm above series resonance. It is a good circuit design with good to very good frequency stability.

Fig. 19-32

TUBE-TYPE CRYSTAL OSCILLATOR



Circuit Notes

The pilot lamp limits current to prevent damage to the crystal.

Fig. 19-33

PRECISION CLOCK GENERATOR

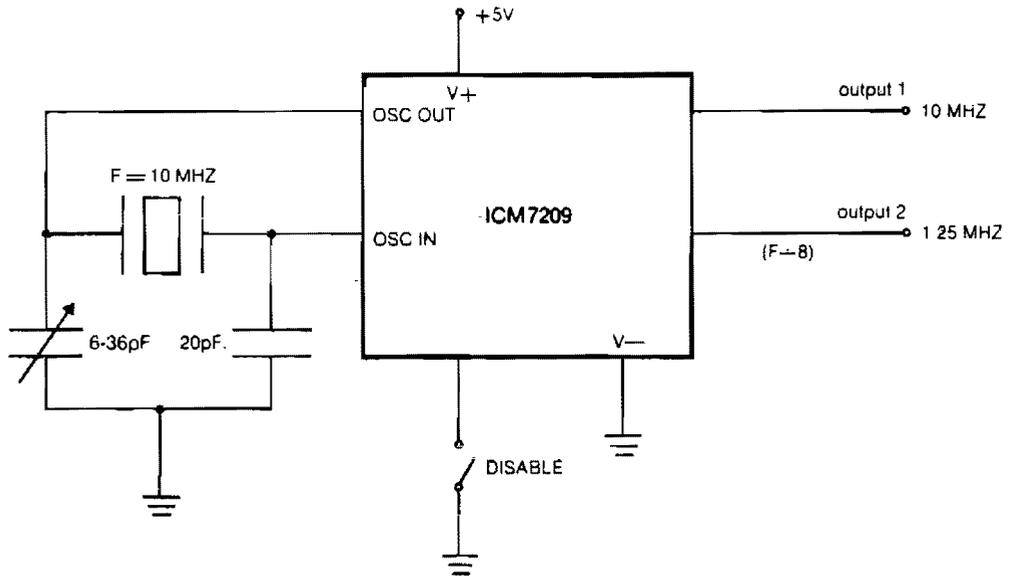
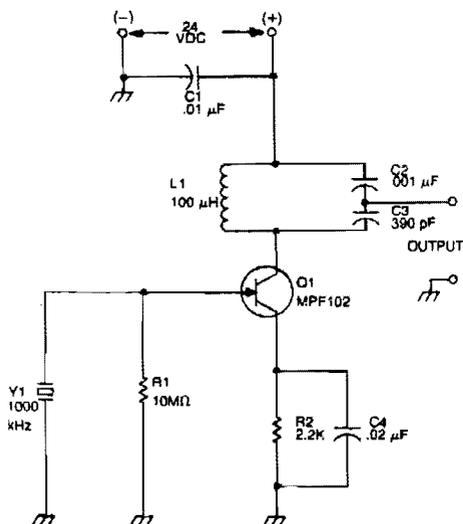


Fig. 19-34

Circuit Notes

The CMOS IC directly drives 5 TTL loads from either of 2 buffered outputs. The device operates to 10 MHz and is bipolar, MOS, and CMOS compatible.

MILLER OSCILLATOR (CRYSTAL CONTROLLED)



Circuit Notes

The drain of the JFET Miller oscillator is tuned to the resonant frequency of the crystal by an LC tank circuit.

Fig. 19-35

BUTLER Emitter Follower Oscillator (20 MHz)

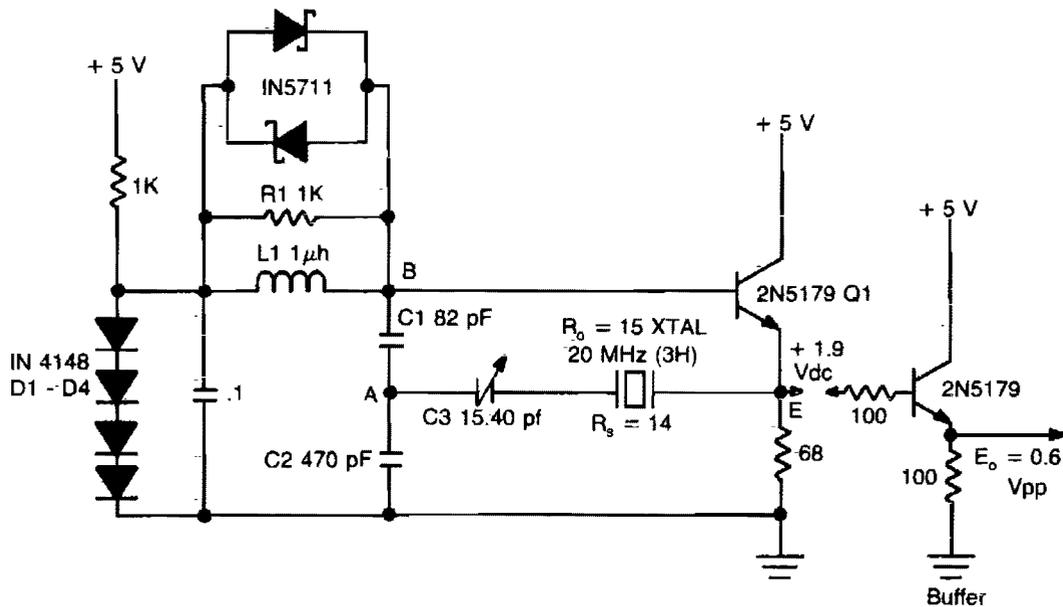
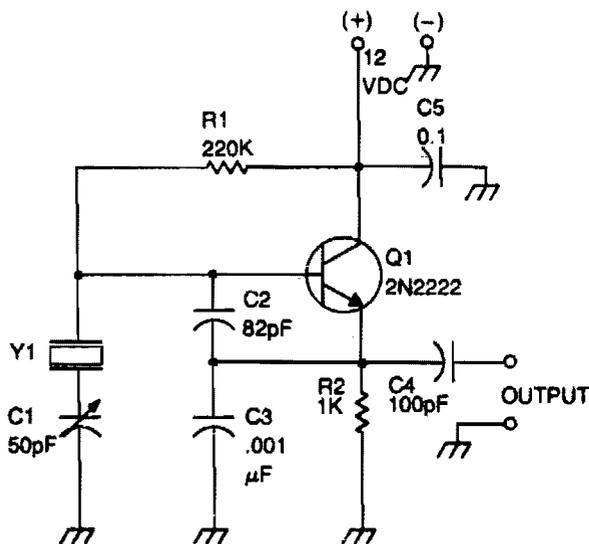


Fig. 19-36

COLPITTS OSCILLATOR



Circuit Notes

This circuit will operate with fundamental-mode crystals in the range of 1 MHz to 20 MHz. Feedback is controlled by capacitor voltage divider C2/C3. The rf voltage across the emitter resistor provides the basic feedback signal.

Fig. 19-37

CRYSTAL-CONTROLLED OSCILLATOR

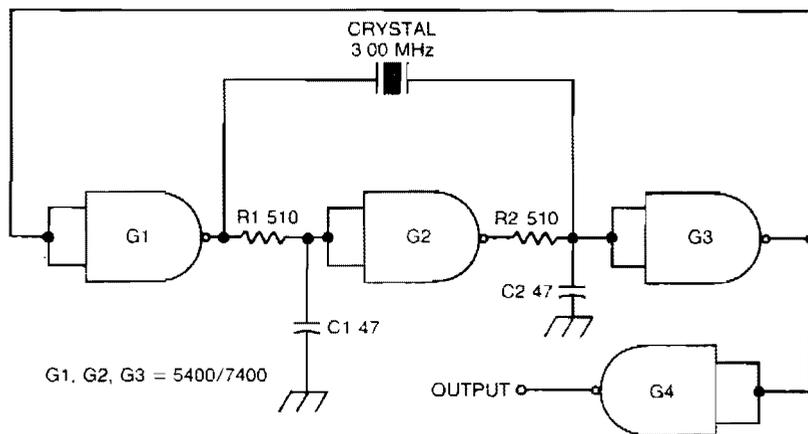


Fig. 19-38

Circuit Notes

This circuit oscillates without the crystal. With the crystal in the circuit, the frequency will be that of the crystal. The circuit has good starting characteristics even with the poorest crystals.

PIERCE OSCILLATOR

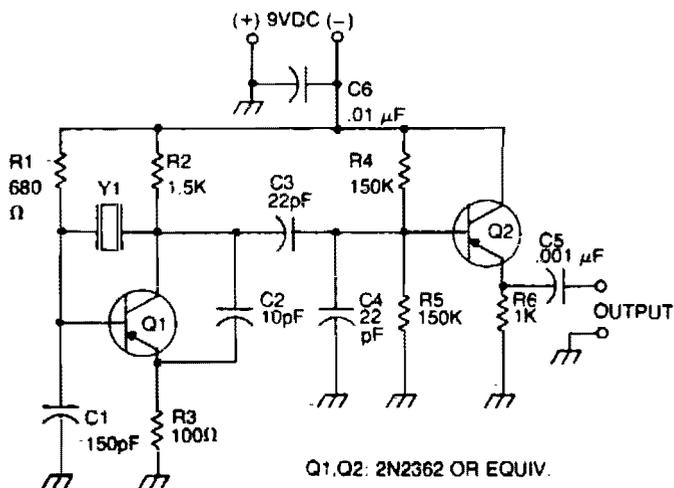


Fig. 19-39

Circuit Notes

The oscillator transistor is Q1, and the crystal is placed between the collector and base. Feedback is improved by the use of the collector-emitter capacitor C2. Transistor Q2 is used as an output buffer.

BUTLER APERIODIC OSCILLATOR

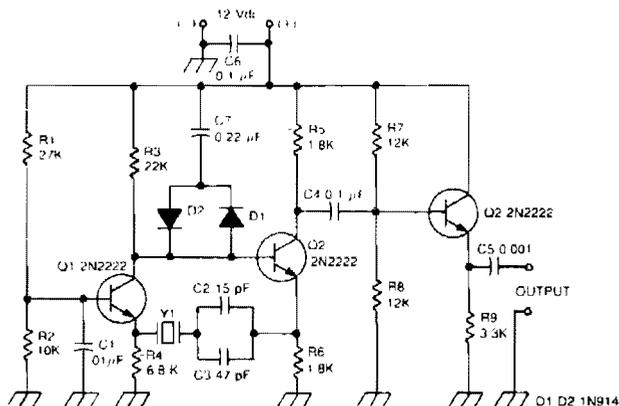


Fig. 19-40

Circuit Notes

This circuit works well in the range of 50 kHz to 500 kHz. Slight component modifications are needed for higher frequency operation. For operation over 3000 kHz, select a

transistor that provides moderate gain (in the 60 to 150 range) at the frequency of operation and a gain-bandwidth product of at least 100 MHz.

PARALLEL-MODE APERIODIC CRYSTAL OSCILLATOR

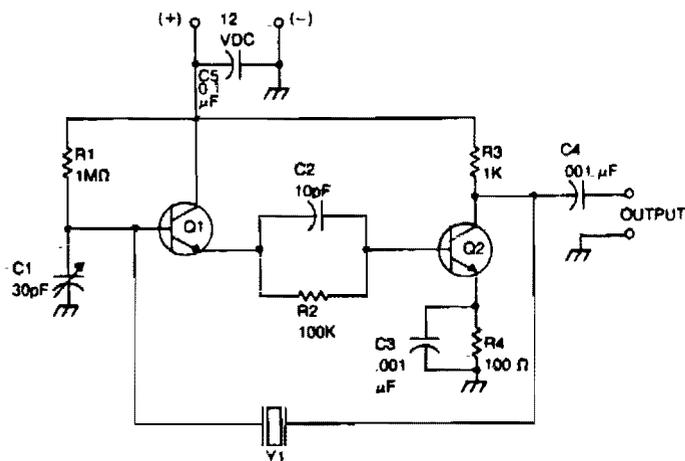


Fig. 19-41

Circuit Notes

The crystal is placed between the collector of the output stage and the base of the input stage. The frequency of oscillation can be set to a precise value with trimmer capacitor C1. The

range of operation for this circuit is 500 kHz to 10 MHz. Extend the range downward (100 kHz) by increasing the value of C1 to 75 pF and increasing the value of C2 to 22pF.

INTERNATIONAL CRYSTAL OF-1 HI OSCILLATOR

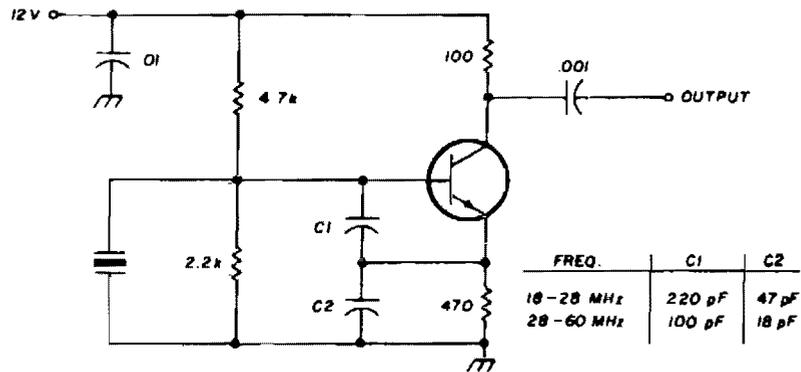


Fig. 19-42

Circuit Notes

International Crystal OF-1 HI oscillator circuit for third-overtone crystals. The circuit does not require inductors.

STANDARD CRYSTAL OSCILLATOR FOR 1 MHz

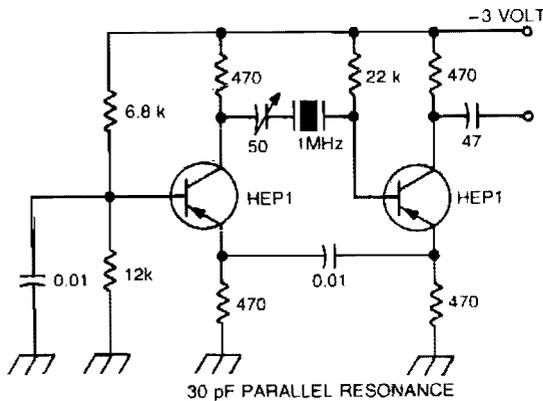


Fig. 19-43

TTL-COMPATIBLE CRYSTAL OSCILLATOR

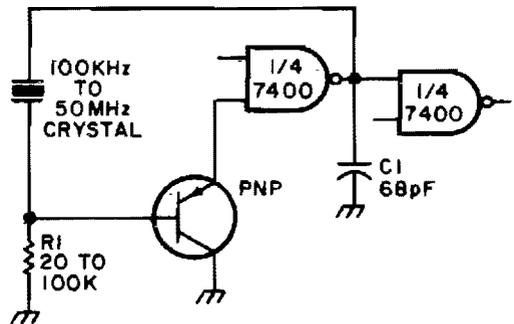


Fig. 19-44

Circuit Notes

Adjust R1 for about 2 volts at the output of the first gate. Adjust C1 for best output.

CRYSTAL CONTROLLED SINE WAVE OSCILLATOR

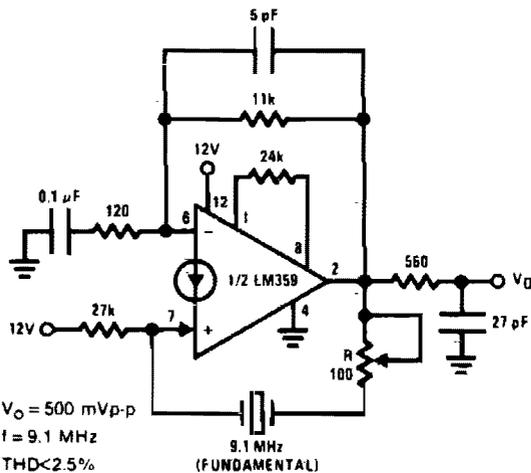


Fig. 19-45

STABLE LOW FREQUENCY CRYSTAL OSCILLATOR

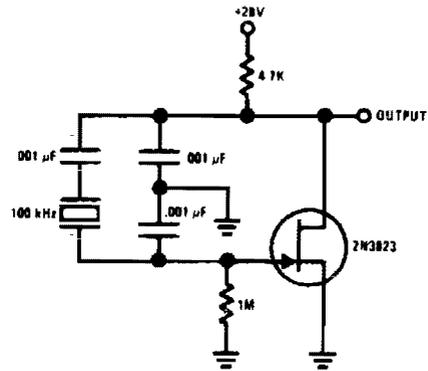


Fig. 19-47

Circuit Notes

This Colpitts-crystal oscillator is ideal for low frequency crystal oscillator circuits. Excellent stability is assured because the 2N3823 JFET circuit loading does not vary with temperature.

CRYSTAL OSCILLATOR

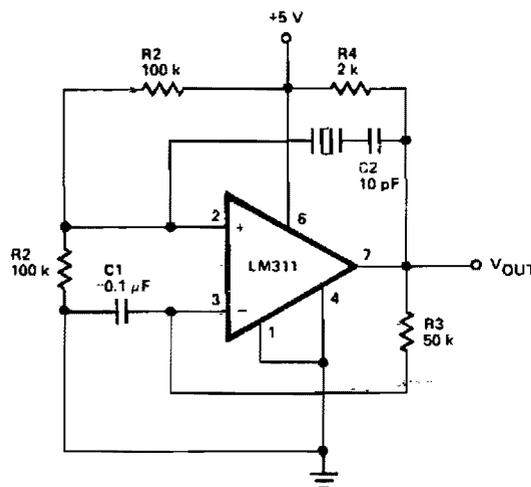


Fig. 19-46

JFET PIERCE CRYSTAL OSCILLATOR

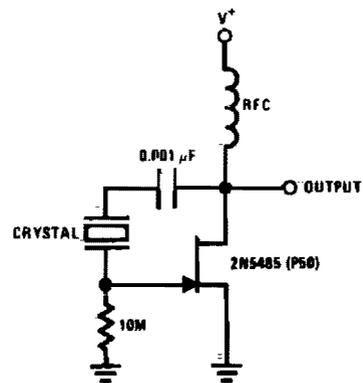
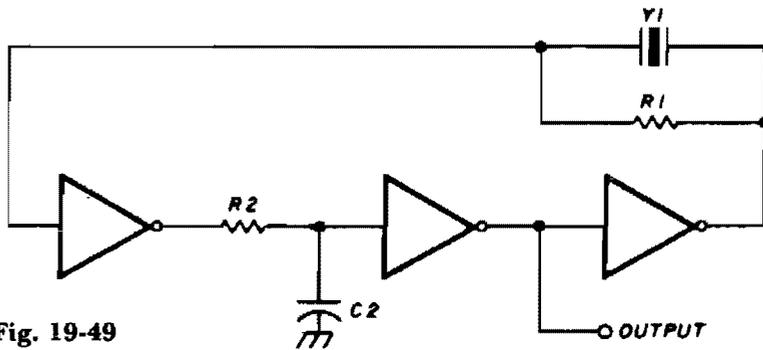


Fig. 19-48

Circuit Notes

The JFET Pierce crystal oscillator allows a wide frequency range of crystals to be used without circuit modification. Since the JFET gate does not load the crystal, good Q is maintained, thus insuring good frequency stability.

CMOS OSCILLATOR-1 MHz-4 MHz



- NOTES:
1. $1M < R1 < 5M$
 2. SELECT $R2$ AND $C2$ TO PREVENT SPURIOUS FREQUENCIES
 3. ICs ARE 74C04 OR EQUIVALENT

Fig. 19-49

PIERCE HARMONIC OSCILLATOR (100 MHz)

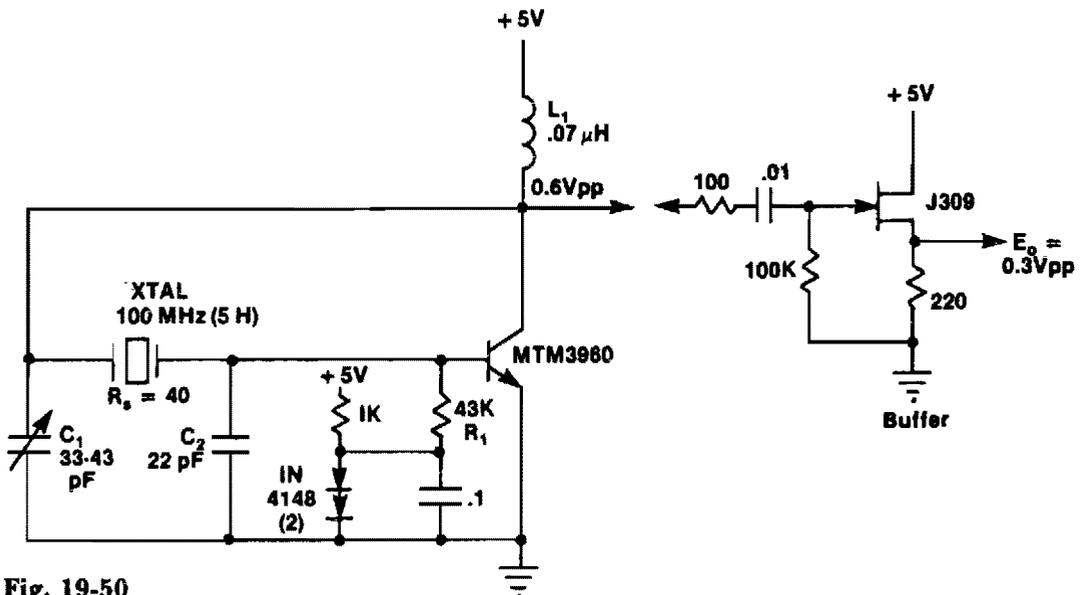


Fig. 19-50

Circuit Notes

The output resistance of the transistor's collector, together with the effective value of $C1$, provides an RC phase lag of 30-50°. The crystal normally oscillates slightly above series resonance, where it is both resistive and inductive. Above series resonance, the crystal's internal impedance (resistive and inductive) together with $C2$ provides an RLC phase

lag of 130-150°. The transistor inverts the signal, providing a total of 360° of phase shift around the loop. Inductor $L1$ is selected to resonate with $C1$ at a frequency between the crystal's desired harmonic and its next lower odd harmonic. Inductor $L1$ offsets part of the negative reactance of $C1$ at the oscillation frequency.

20

Current Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ammeter

Pico Ammeter

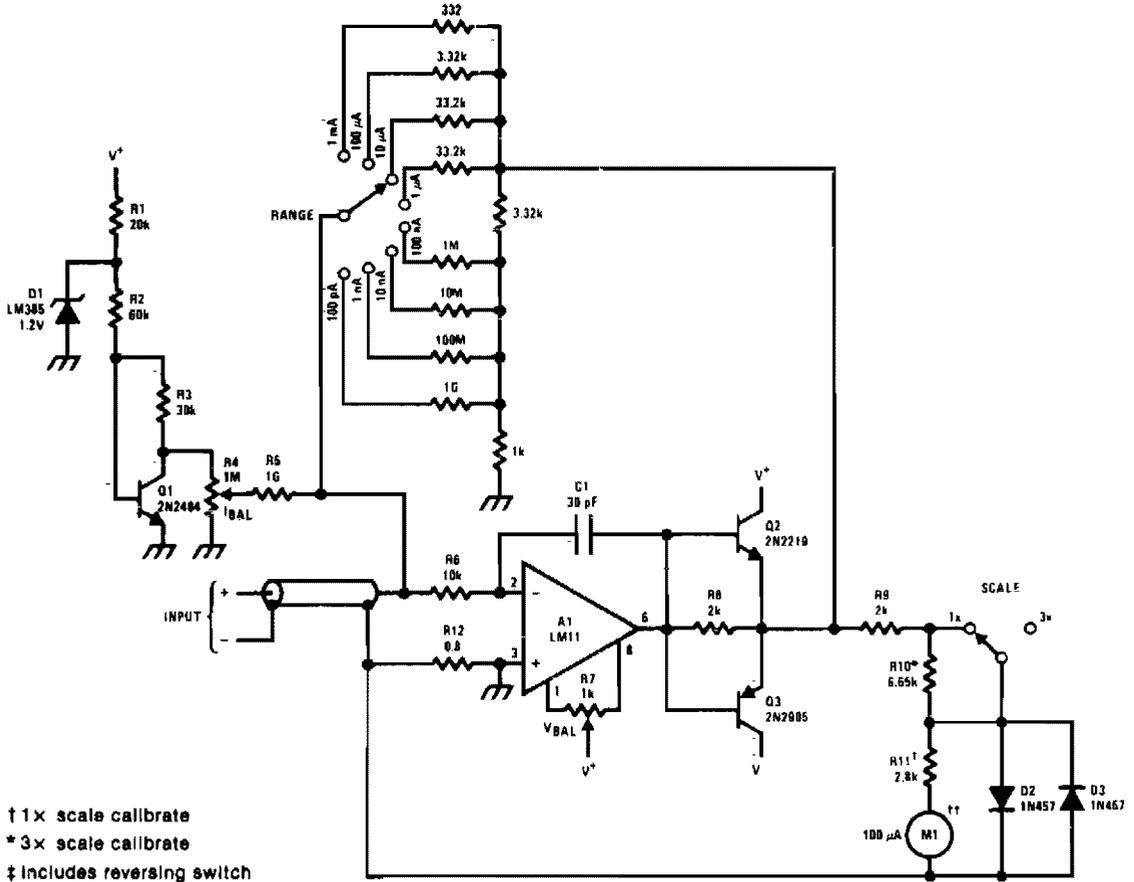
Nano Ammeter

Nanoampere Sensing Circuit with 100

Megohm Input Impedance

Current Monitor

AMMETER



- † 1x scale calibrate
- * 3x scale calibrate
- ‡ Includes reversing switch

Fig. 20-1

Circuit Notes

Current meter ranges from 100 pA to 3 mA full scale. Voltage across input is 100 μ V at lower ranges rising to 3 mV at 3 mA. The buffers on the op amp are to remove ambiguity with high-current overload. The output can also drive a DVM or a DPM.

PICO AMMETER

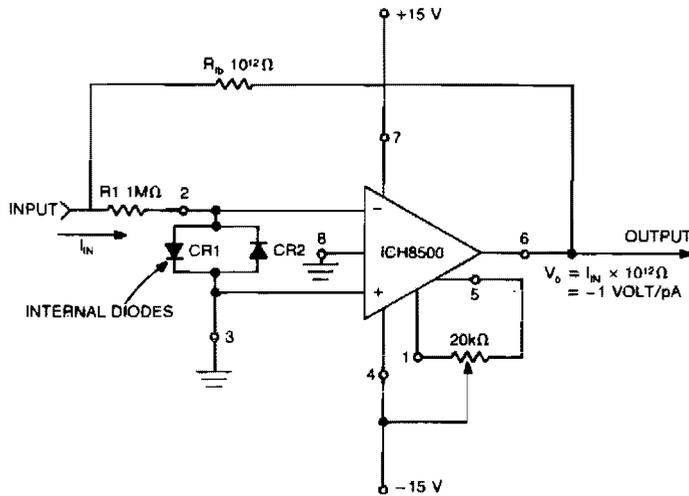


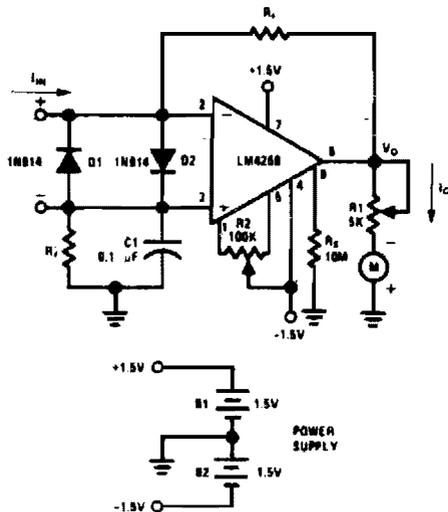
Fig. 20-2

Circuit Notes

A very sensitive pico ammeter (-1 V/pA) employs the amplifier in the inverting or current summing mode. Care must be taken to eliminate stray currents from flowing into the current summing mode. It takes approximately 5 for the circuit to stabilize to within 1% of its

final output voltage after a step function of input current has been applied. The internal diodes CR1 and CR2 together with external resistor R1 to protect the input stage of the amplifier from voltage transients.

NANO AMMETER



Resistance Values for
DC Nano and Micro Ammeter

I FULL SCALE	$R_f [\Omega]$	$R_f^* [\Omega]$
100 nA	1.5M	1.5M
500 nA	300k	300k
1 μA	300k	0
5 μA	60k	0
10 μA	30k	0
50 μA	6k	0
100 μA	3k	0

The complete meter amplifier is a differential current-to-voltage converter with input protection, zeroing and full scale adjust provisions, and input resistor balancing for minimum offset voltage.

Fig. 20-3

NANOAMPERE SENSING CIRCUIT WITH 100 MEGOHM INPUT IMPEDANCE

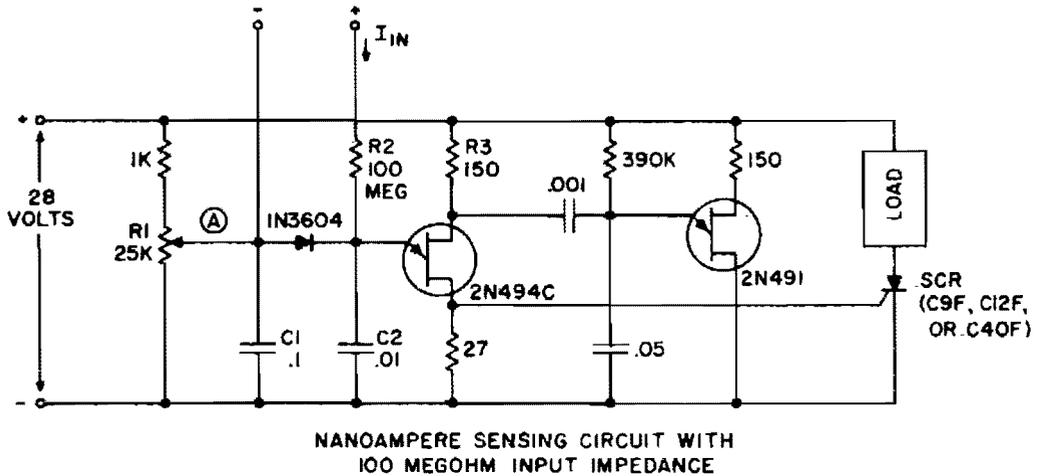


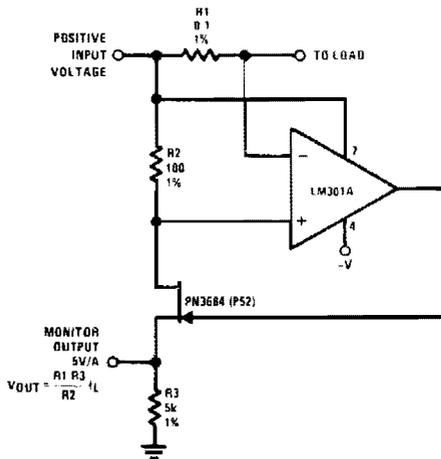
Fig. 20-4

Circuit Notes

The circuit may be used as a sensitive current detector or as a voltage detector having high input impedance. R1 is set so that the voltage at point (A) is $\frac{1}{2}$ to $\frac{3}{4}$ volts below the level that fires the 2N494C. A small input current (I_{in}) of only 40 nanoamperes will charge C2 and raise the voltage at the emitter to the

firing level. When the 2N494C fires, both capacitors, C1 and C2, are discharged through the 27 ohm resistor, which generates a positive pulse with sufficient amplitude to trigger a controlled rectifier (SCR), or other pulse sensitive circuitry.

CURRENT MONITOR



Circuit Notes

R1 senses current flow of a power supply. The JFET is used as a buffer because $I_b = I_s$; therefore the output monitor voltage accurately reflects the power supply current flow.

Fig. 20-5

21

Current Sources and Sinks

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Current source
Precision Current Source

Precision 1 μA to 1 mA Current Sources
Precision Current Sink

CURRENT SOURCE

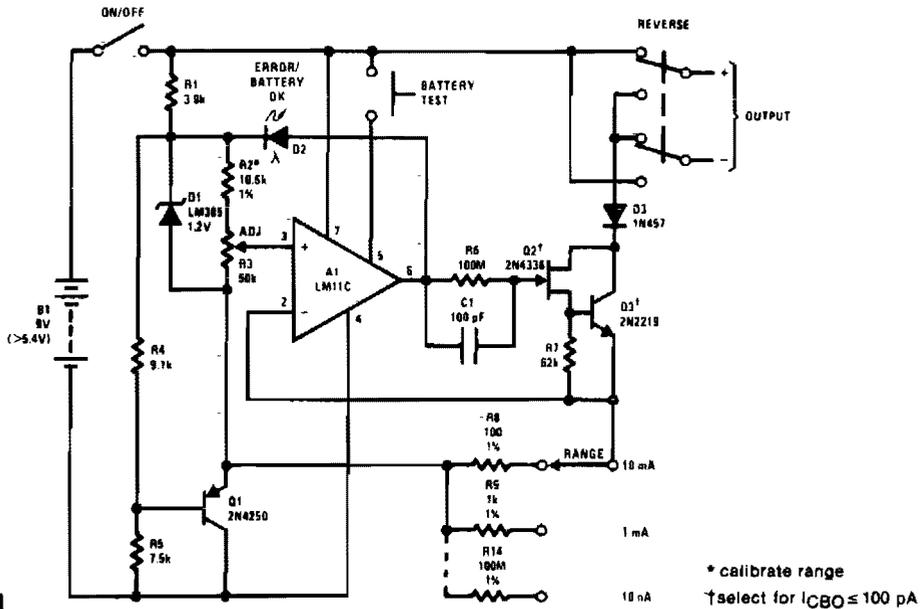
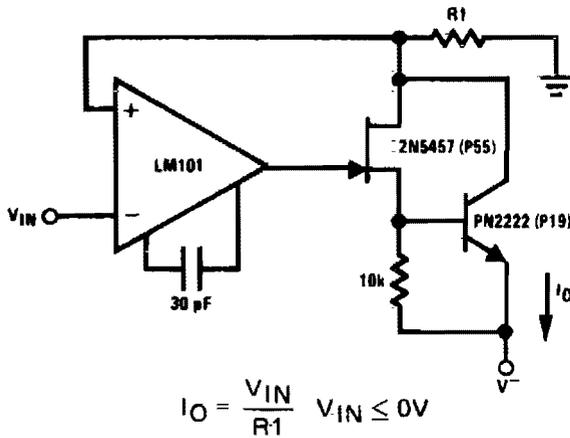


Fig. 21-1

Circuit Notes

This precision current source has 10 μA to 10 mA ranges with output compliance of 30V to -5V . Output current is fully adjustable on each range with a calibrated, ten-turn potentiometer. Error light indicates saturation.

PRECISION CURRENT SOURCE



Circuit Notes

The 2N5457 and PN2222 bipolar serve as voltage isolation devices between the output and the current sensing resistor, R1. The LM101 provides a large amount of loop gain to assure that the circuit acts as a current source. For small values of current ($<1 \text{ mA}$), the PN2222 and 10K resistor may be eliminated with the output appearing at the source of the 2N5457.

Fig. 21-2

PRECISION 1 μA to 1 mA CURRENT SOURCES

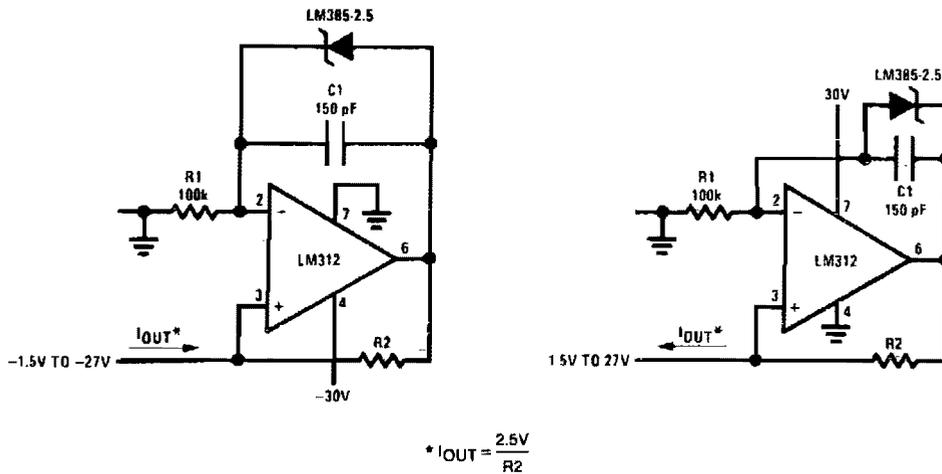


Fig. 21-3

PRECISION CURRENT SINK

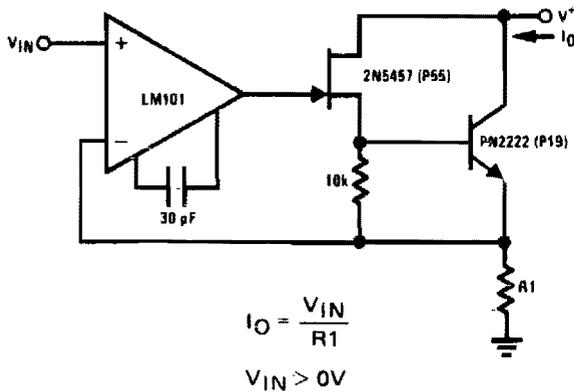


Fig. 21-4

Circuit Notes

The 2N5457 JFET and PN2222 bipolar have inherently high output impedance. Using R1 as a current sensing resistor to provide feedback to the LM101 op amp provides a large amount of loop gain for negative feedback to enhance the true current sink nature of this circuit. For small current values, the 10 K resistor and PN2222 may be eliminated if the source of the JFET is connected to R1.

22

Dc/Dc and Dc/Ac Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dc-to-Dc/Ac Inverter

Dc-to-Dc SMPS Using NE5561 Variable 18
V to 30 V Out at 0.2 A

Mini Power Inverter as High Voltage, Low

Current Source

Regulated Dc-to-Dc Converter

400 V, 60 W Push-Pull Dc/Dc Converter

Dc/Dc Regulating Converter

Flyback Converter

DC-TO-DC/AC INVERTER

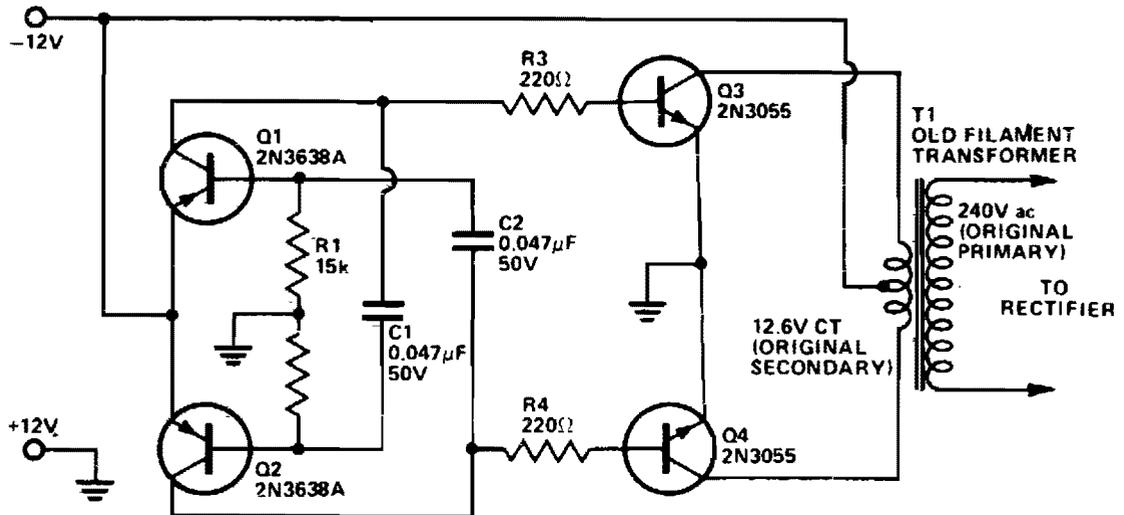


Fig. 22-1

Circuit Notes

This inverter uses no special components such as the toroidal transformer used in many inverters. Cost is kept low with the use of cheap, readily available components. Essentially, it is a power amplifier driven by an astable multivibrator. The frequency is around 1200 Hz which most 50/60 Hz power transformers handle well without too much loss. Increasing the value of capacitors C1 and C2 will

lower the frequency if any trouble is experienced. However, rectifier filtering capacitors required are considerably smaller at the higher operating frequency. The two 2N3055 transistor should be mounted on an adequately sized heatsink. The transformer should be rated according to the amount of output power required allowing for conversion efficiency of approximately 60%.

DC-TO-DC SMPS USING NE5561 VARIABLE 18 V to 30 V OUT AT 0.2 A

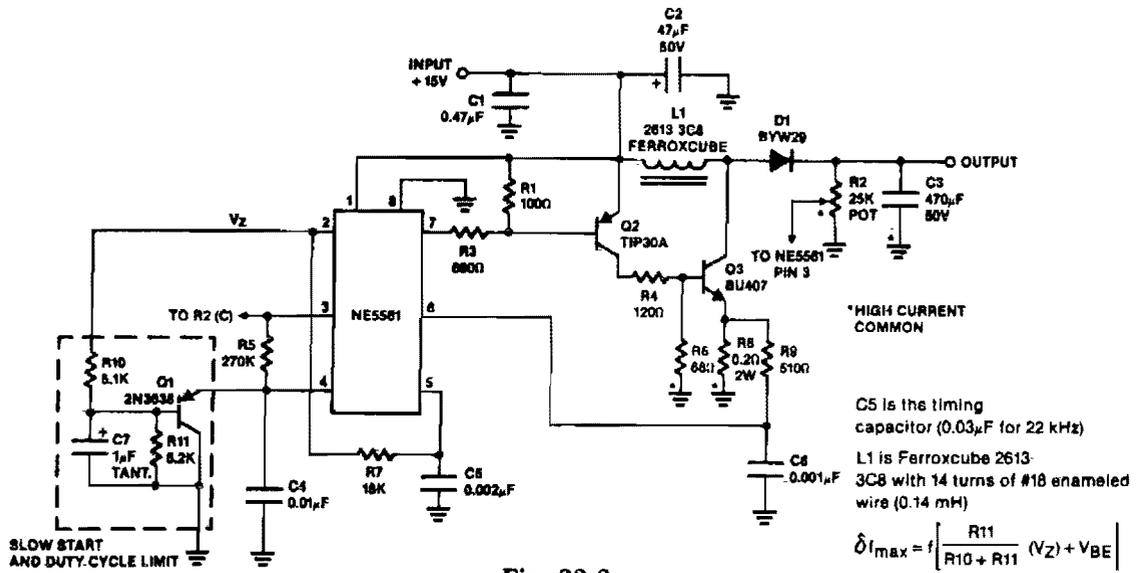


Fig. 22-2

MINI POWER INVERTER AS HIGH VOLTAGE, LOW CURRENT SOURCE

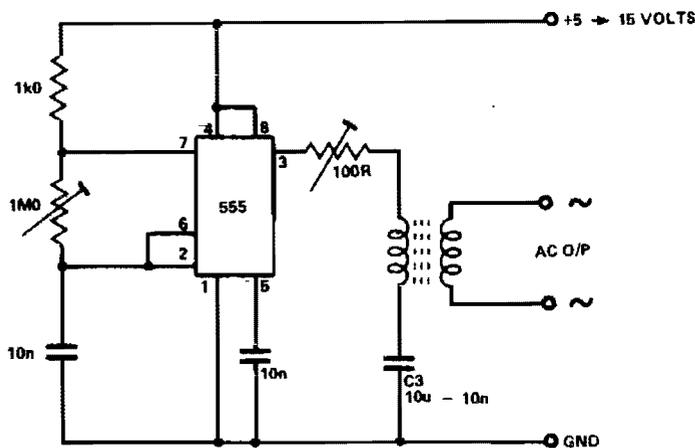


Fig. 22-3

Circuit Notes

The circuit is capable of providing power for portable Geiger counters, dosimeter chargers, high resistance meters, etc. The 555 timer IC is used in its multivibrator mode, the frequency adjusted to optimize the transformer characteristics. When the output of the IC is

high, current flows through the limiting resistor, the primary coil to charge C3. When the output is low, the current is reversed. With a suitable choice of frequency and C3, a good symmetric output is sustained.

REGULATED DC-TO-DC CONVERTER

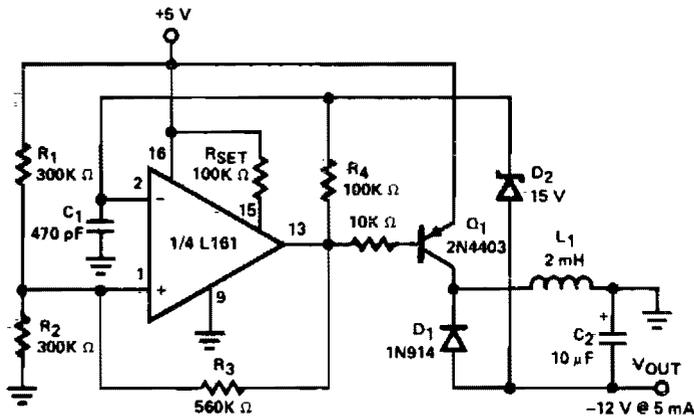


Fig. 22-4

Circuit Notes

Low power dc to dc converter obtained by adding a flyback circuit to a square wave oscillator. Operating frequency is 20 kHz to minimize the size of L1 and C2. Regulation is

achieved by zener diode D2. Maximum current available before the converter drops out of regulation is 5.5 mA.

400 V, 60 W PUSH-PULL DC/DC CONVERTER

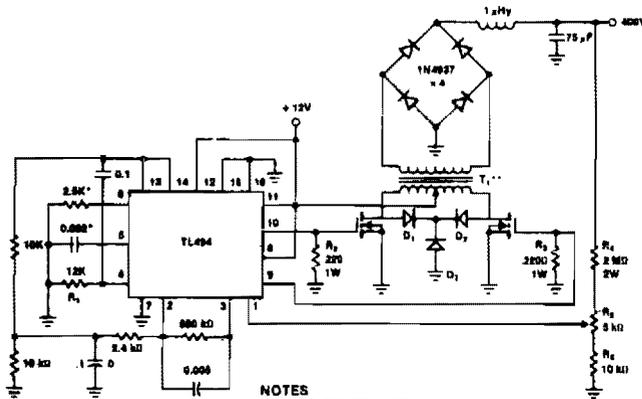


Fig. 22-5

NOTES
UNLESS OTHERWISE NOTED,
ALL RESISTORS 5% 1/4W
ALL CAPACITOR VALUES IN MICROFARADS, 25V
Q1 & Q2: VN64GA ON HEAT SINK
D1 & D2: 1N4834
D3: 23V, 2W ZENER
T1: PRI: 12T, CT, NO 18 AWG
SEC: 273T, NO 24 AWG
CORE: INO GEN 8201-1

Circuit Notes

The TL494 switching regulator governs the operating frequency and regulates output voltage. Switching frequency approximately 100 kHz for the values shown. Output regulation is typically 1.25% from no-load to full 60 W.

DC/DC REGULATING CONVERTER

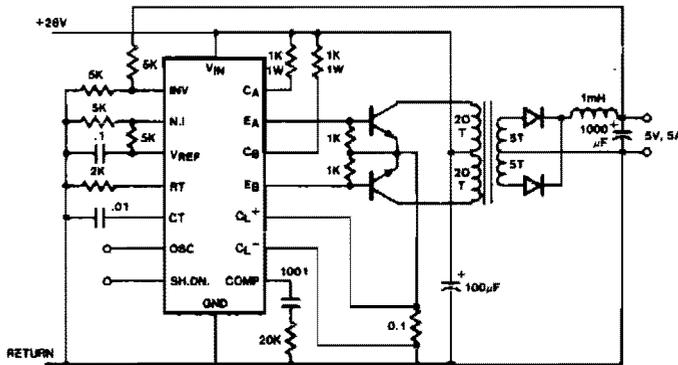


Fig. 22-6

Circuit Notes

Push-pull outputs are used in this transformer-coupled dc-dc regulating converter. Note that the oscillator must be set at twice the desired output frequency as the SG1524's internal flip-flop divides the fre-

quency by 2 as it switches the PWM signal from one output to the other. Current limiting is done here in the primary so that the pulse width will be reduced should transformer saturation occur.

FLYBACK CONVERTER

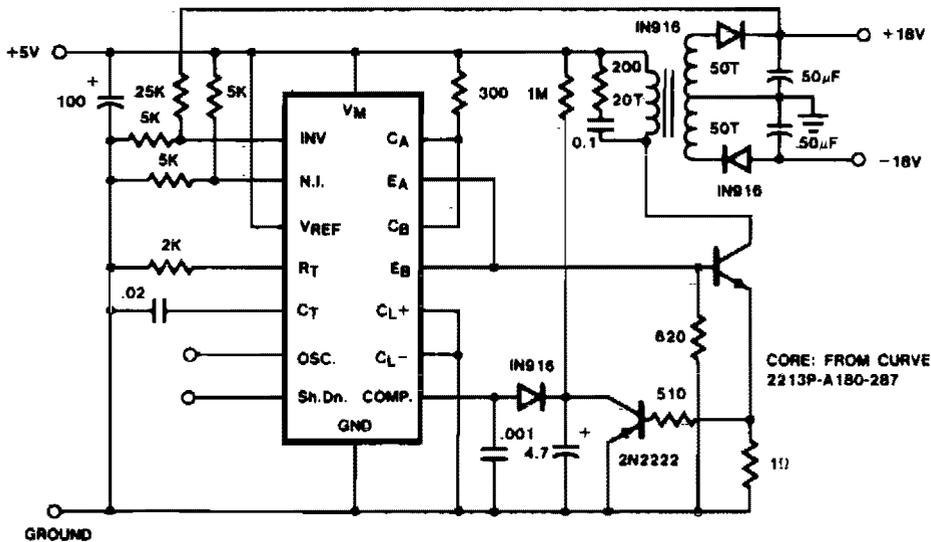


Fig. 22-7

Circuit Notes

A low-current flyback converter is used here to generate ± 15 volts at 20 mA from a +5 volt regulated line. The reference generator in the SG1524 is unused with the input voltage

providing the reference. Current limiting in a flyback converter is difficult and is accomplished here by sensing current in the primary line and resetting a soft-start circuit.

23

Decoders

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Tone Alert Decoder

Tone Decoder with Relay Output

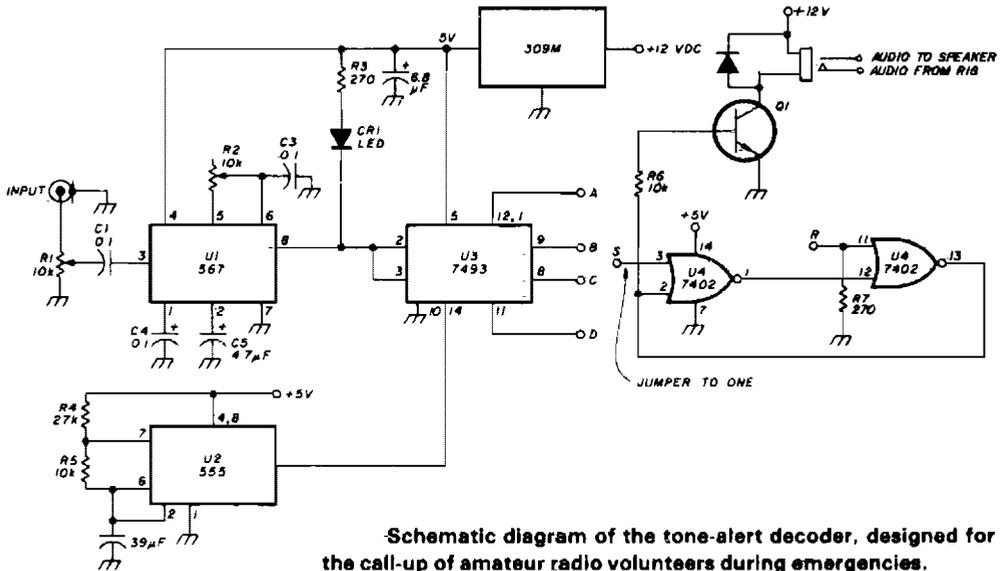
SCA Decoder

10.8 MHz FSK Decoder

24% Bandwidth Tone Decoder

Dual-Tone Decoder

TONE-ALERT DECODER



Schematic diagram of the tone-alert decoder, designed for the call-up of amateur radio volunteers during emergencies.

Fig. 23-1

Circuit Notes

PLL (U1) is set with R2 to desired tone frequency. LED lights to indicate lock-up of PLL. Reduce signal level (R1) and readjust R2 to assure lock-up. Delay is selected from counter U3 output. Circuits latches (turns on

Q1 to allow audio to speaker) when proper frequency/duration signal is received. To reset latch, a positive voltage must be applied briefly to the R input of U4.

TONE DECODER WITH RELAY OUTPUT

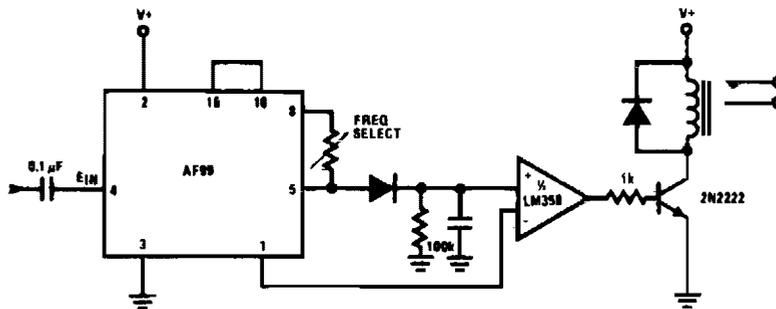


Fig. 23-2

24% BANDWIDTH TONE DECODER

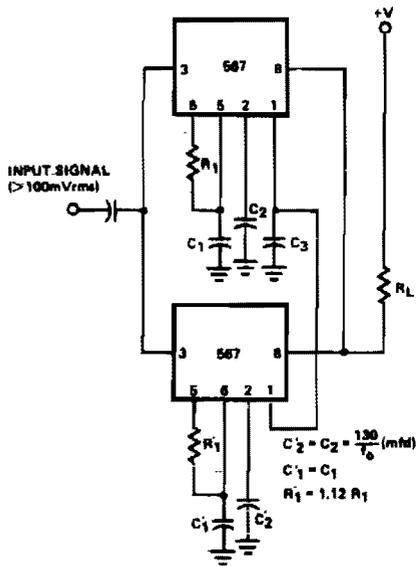


Fig. 23-5

DUAL-TONE DECODER

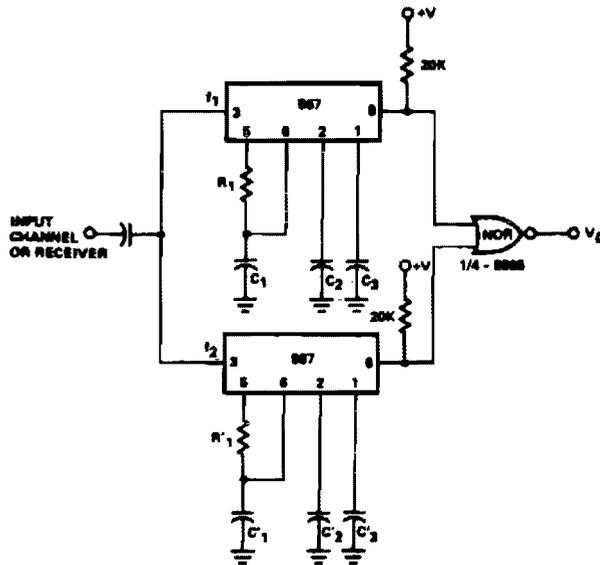


Fig. 23-6

1. Resistor and capacitor values chosen for desired frequencies and bandwidth.
2. If C_3 is made large so as to delay turn-on of the top 567, decoding of sequential ($f_1 f_2$) tones is possible.

24

Delays

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Long Time Delay
Time Delay Generator
Door Chimes Delay
Time Delay Generator

Long Delay Timer Using PUT
Ultra-Precise Long Time Delay Relay
Long Duration Time Delay
Simple Time Delay Using Two SCRs

LONG TIME DELAY

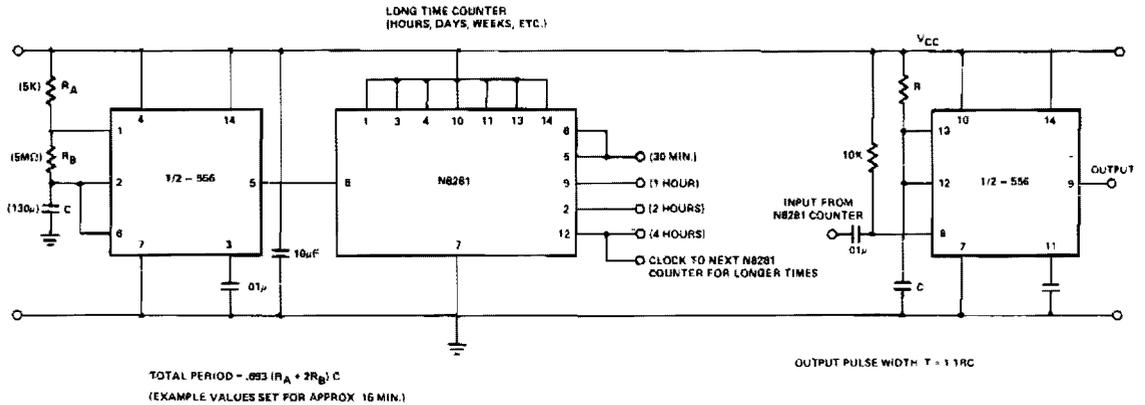


Fig. 24-1

Circuit Notes

In the 556 timer, the timing is a function of the charging rate of the external capacitor. For long time delays, expensive capacitors with extremely low leakage are required. The practicality of the components involved limits the time between pulses to something in the neighborhood of 10 minutes. To achieve longer time periods, both halves of a dual timer may be

connected in tandem with a "Divide-by" network in between the first timer section operates in an oscillatory mode with a period of $1/f_0$. This signal is then applied to a "Divide-by-N" network to give an output with the period of N/f_0 . This can then be used to trigger the second half of the 556. The total time delay is now a function of N and f_0 .

TIME DELAY GENERATOR

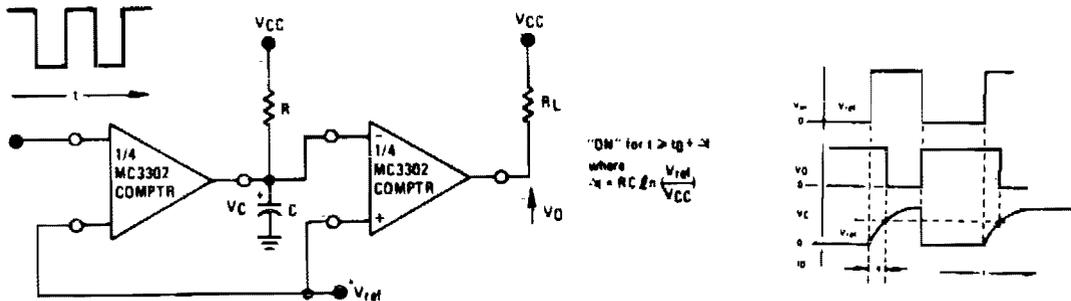


Fig. 24-2

DOOR CHIMES DELAY

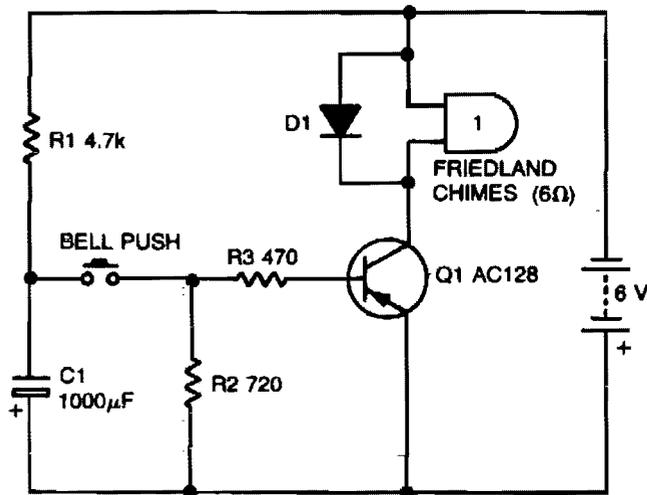


Fig. 24-3

Circuit Notes

With values shown, this simple circuit will permit one operation every 10 seconds or so. Capacitor C1 charges through R1 when the

button is released. Making R1 larger will increase the delay.

TIME DELAY GENERATOR

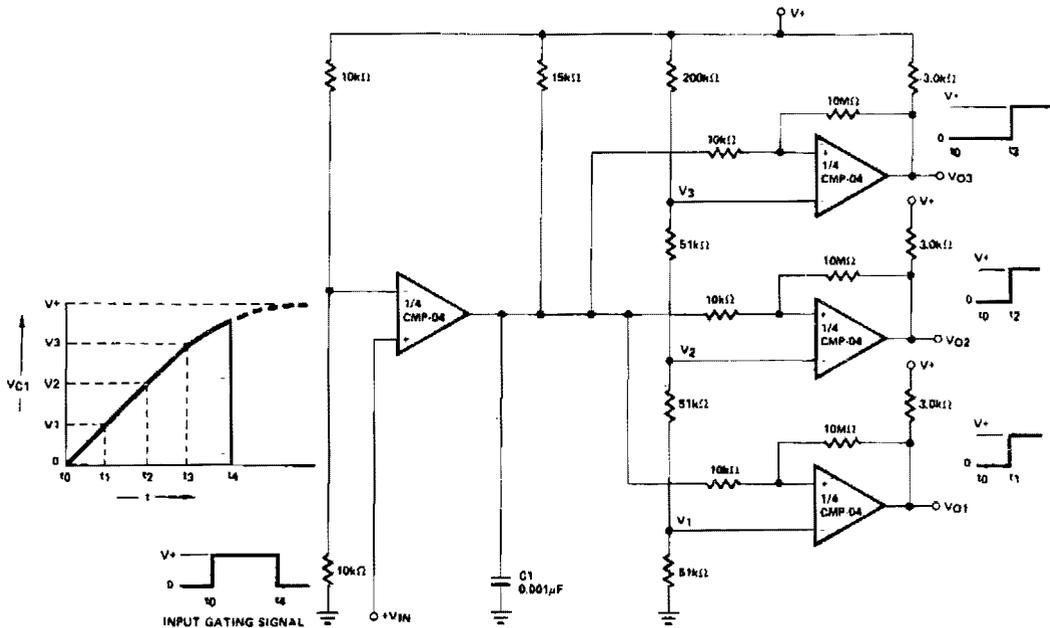


Fig. 24-4

LONG DELAY TIMER USING PUT

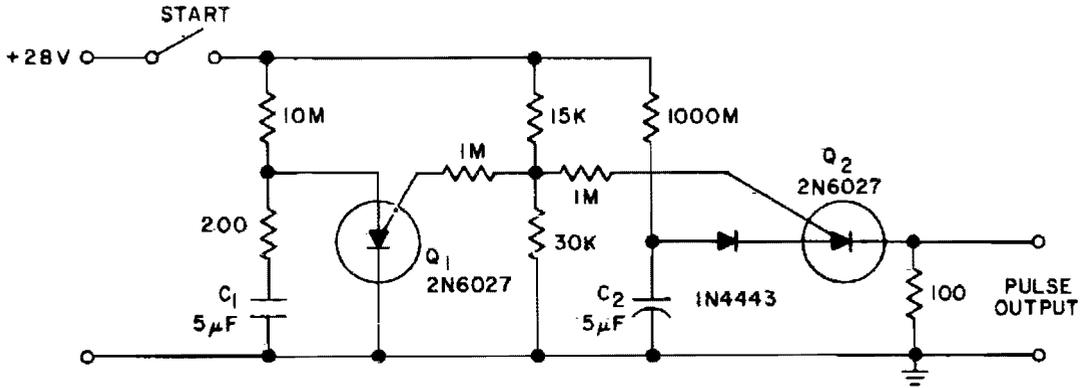


Fig. 24-5

Circuit Notes

The PUT is used as both a timing element and sampling oscillator. A low leakage film capacitor is required for C2 due to the low current supplied to it.

ULTRA-PRECISE LONG TIME DELAY RELAY

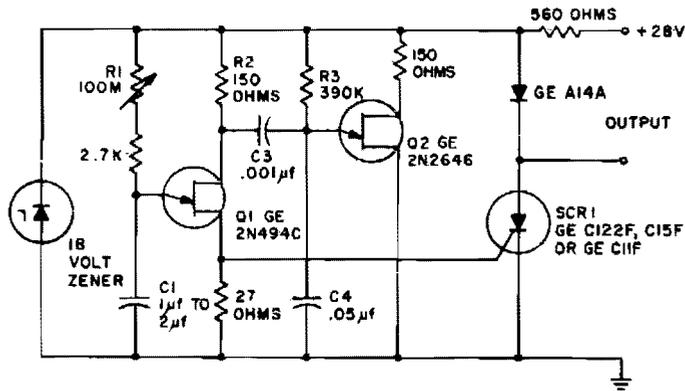


Fig. 24-6

Circuit Notes

Predictable time delays from as low as 0.3 milliseconds to over 3 minutes are obtainable without resorting to a large value electrolytic-type timing capacitor. Instead, a stable low

leakage paper or mylar capacitor is used and the peak point current of the timing UJT (Q1) is effectively reduced, so that a large value emitter resistor (R1) may be substituted.

LONG DURATION TIME DELAY

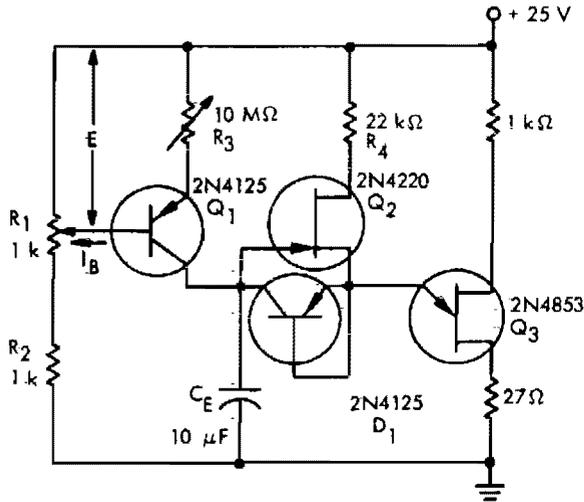


Fig. 24-7

SIMPLE TIME DELAY

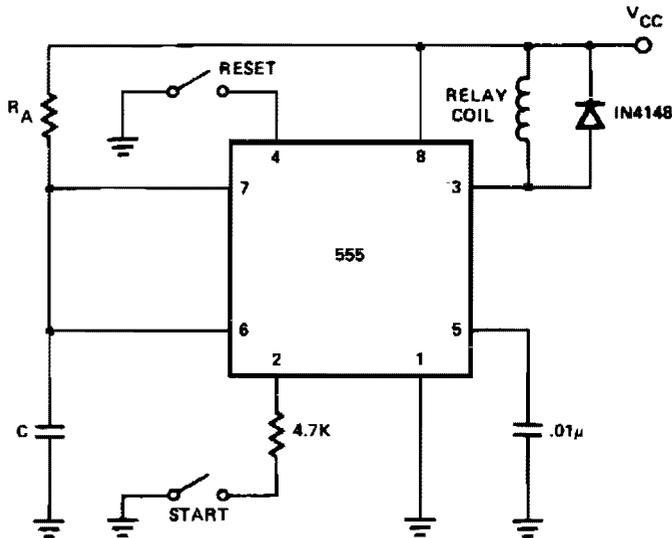


Fig. 24-8

25

Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Air-Motion Detector	Half-Wave Rectifier
Product Detector	Tone Detector
Low Voltage Detector	FM Tuner with a Single-Tuned Detector Coil
Positive Peak Detector	Missing Pulse Detector
Negative Peak Detector	High Speed Peak Detector
Precision Peak Voltage Detector With Along Memory Time	Detector for Magnetic Transducer
Edge Detector	Double-Ended Limit Detector
Ultra-Low Drift Peak Detector	FM Demodulator at 5 V
Pulse Width Discriminator	FM Demodulator at 12 V
True RMS Detector	Precision Full-Wave Rectifier
Fast Half Wave Rectifier	Negative Peak Detector
Telemetry Demodulator	Level Detector with Hysteresis
Full-Wave Rectifier and Averaging Filter	Window Detector
Double-Ended Limit Detector	Air Flow Detector
Positive Peak Detector	

AIR-MOTION DETECTOR

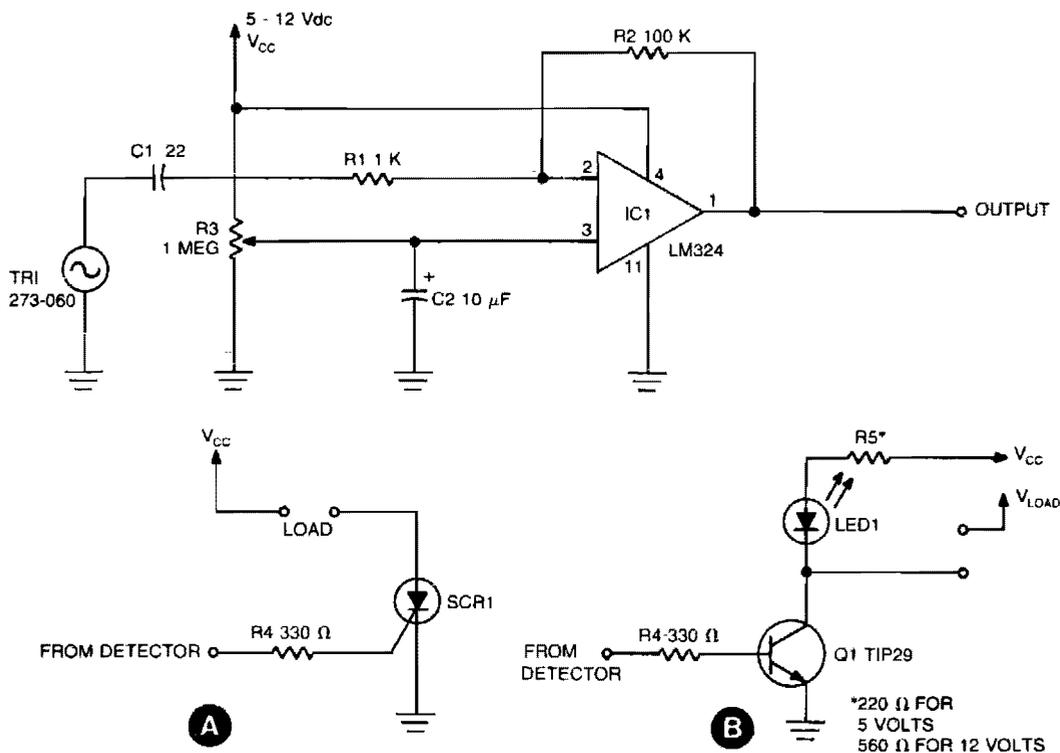


Fig. 25-1

Circuit Notes

Sensing circuit detects either steady or fluctuating air flows. The heart of the circuit is a Radio Shack piezo buzzer (P/N 273-060) and an LM324 quad op amp. (Red wire from the piezo element connects to capacitor C1, and the black wire to ground.) When a current of air hits the piezo element, a small signal is generated and is fed through C1 and R1 to the inverting input (pin 2) of one section of the LM324. That causes the output (pin 1) to go high. Resistor R3 adjusts sensitivity. The cir-

cuit can be made sensitive enough to detect the wave of a hand or the sensitivity can be set so low that blowing on the element hard will produce no output. Resistor R2 is used to adjust the level of the output voltage at pin 1. The detector circuit can be used in various control applications. For example, an SCR can be used to control 117-volt AC loads as shown in A. Also, an NPN transistor, such as a TIP29, can be used to control loads as shown in B.

LOW VOLTAGE DETECTOR

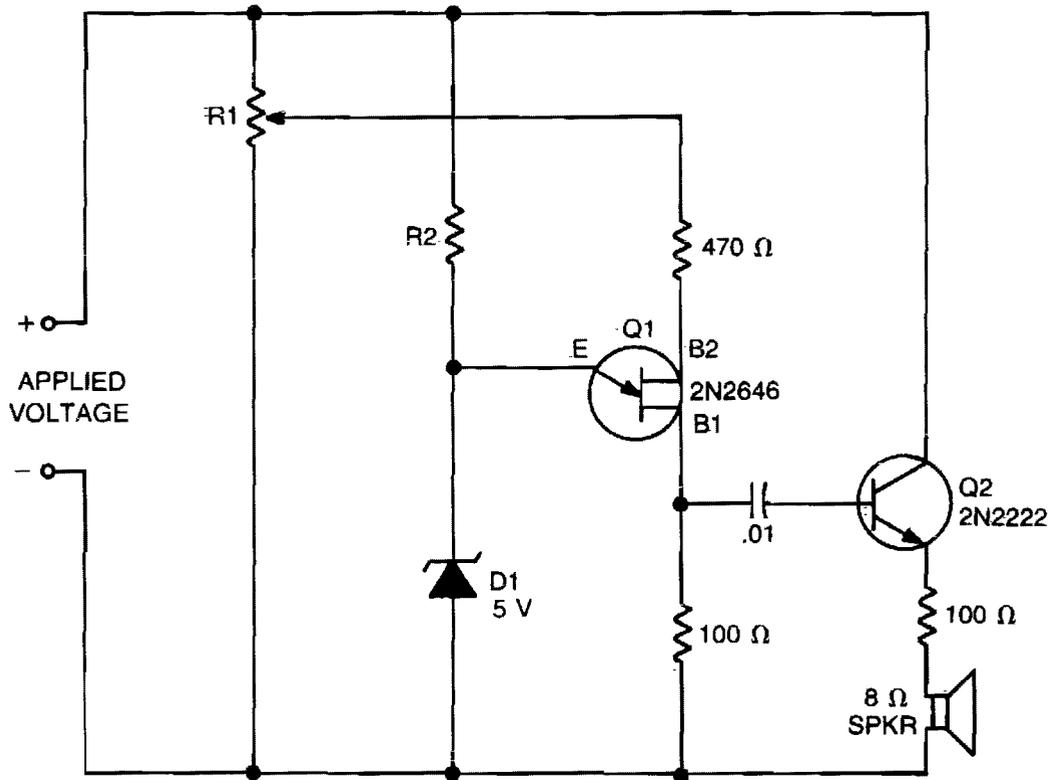


Fig. 25-3

Circuit Notes

The values of R1, R2, and D1 are selected for the voltage applied. Using a 12-volt battery, R1 = 10 K, R2 = 5.6 K and D1 is a 5-volt zener diode, or a string of forward-biased silicon rectifiers equaling about 5 volts. Transistor Q1 is a general-purpose UJT (Unijunction Transistor), and Q2 is any small-signal or switching NPN transistor. When detector is connected across the battery terminals, it draws little current and does not interfere with other de-

vices powered by the battery. If voltage drops below the trip voltage selected with the R1 setting, the speaker beeps a warning. The frequency of the beeps is determined by the amount of undervoltage. If other voltages are being monitored, select R1 so that it draws only 1 mA or 2 mA. Zener diode D1 is about one-half of the desired trip voltage, and R2 is selected to bias it about 1 mA.

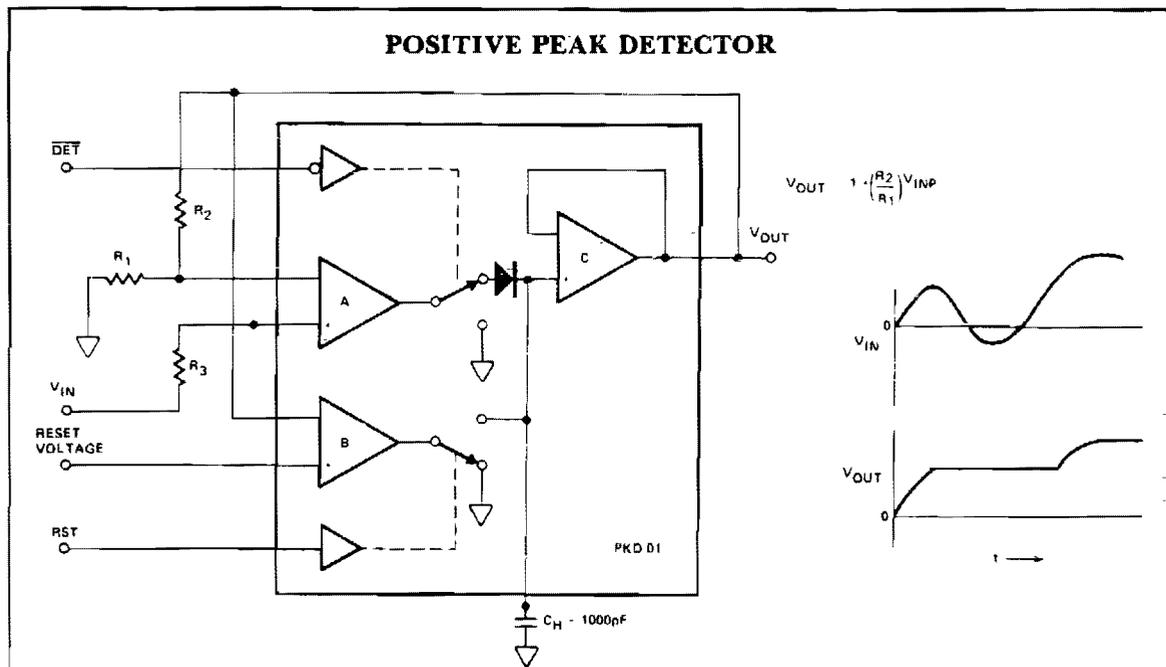


Fig. 25-4

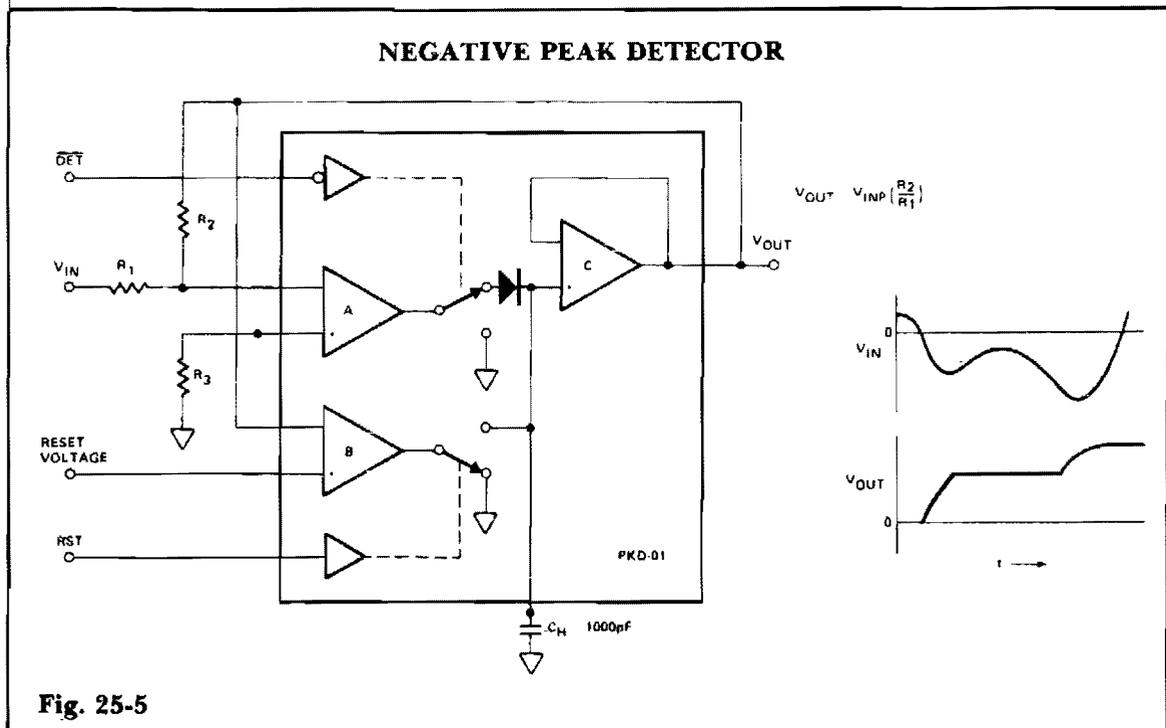


Fig. 25-5

PRECISION PEAK VOLTAGE DETECTOR WITH A LONG MEMORY TIME

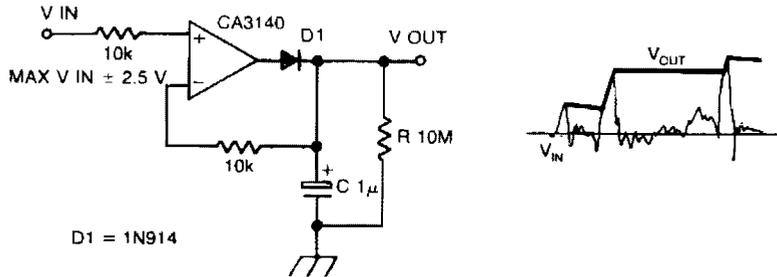


Fig. 25-6

Circuit Notes

The circuit has negative feedback only for positive signals. The inverting input can only get some feedback when diode D1 is forward biased and only occurs when the input is positive. With a positive input signal, the output of the op amp rises until the inverting input signal reaches the same potential. In so doing, the capacitor C is also charged to this potential. When the input goes negative, the diode D1

becomes reverse biased, the voltage on the capacitor remains, being slowly discharged by the op amp input bias current of 10 pico amps. Thus the discharge of the capacitor is dominantly controlled by the resistor R, giving a time constant of 10 seconds. Thus, the circuit detects the most positive peak voltage and remembers it.

EDGE DETECTOR

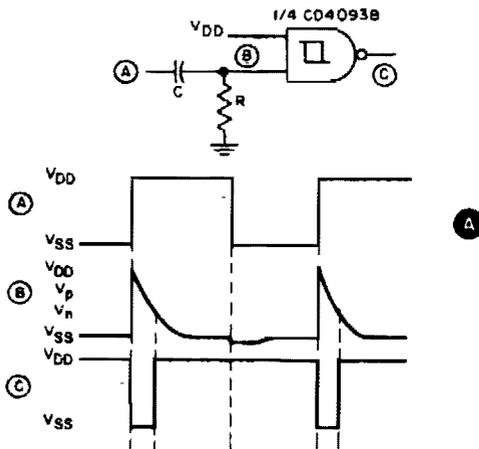
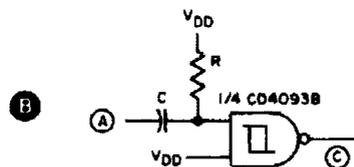


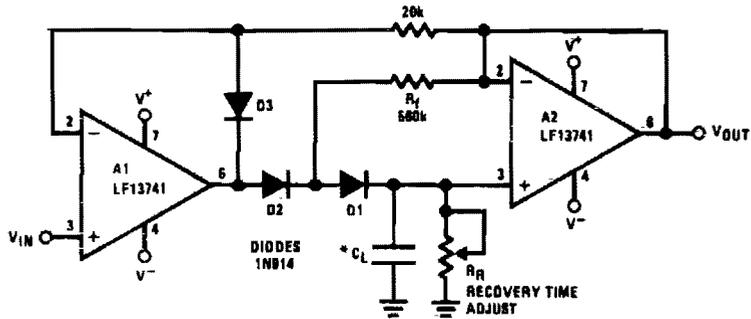
Fig. 25-7

Circuit Notes

This circuit provides a short negative-going output pulse for every positive-going edge at the input. The input waveform is coupled to the input by capacitor C; the pulse length depends, as before, on R and C. If a negative going edge detector is required, the circuit in B should be used.



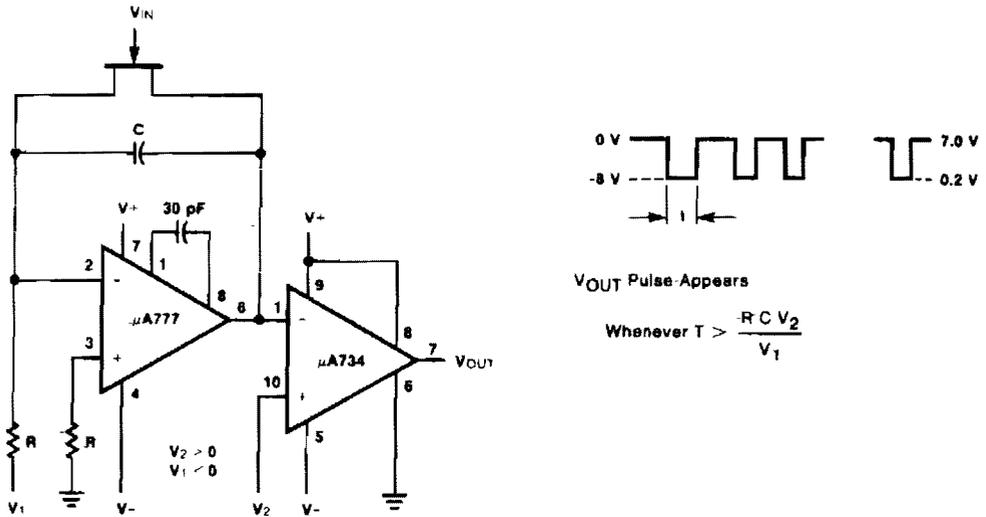
ULTRA-LOW DRIFT PEAK DETECTOR



- By adding D1 and R_f , $V_{D1} = 0$ during hold mode. Leakage of D2 provided by feedback path through R_f .
 - Leakage of circuit is I_B plus leakage of C_H .
 - D3 clamps V_{OUT} A1 to $V_{IN} - V_{D3}$ to improve speed and to limit the reverse bias of D2.
 - Maximum input frequency should be $\ll 1/2\pi R_f C_{D2}$, where C_{D2} is the shunt capacitance of D2.
- *Low leakage capacitor

Fig. 25-8

PULSE WIDTH DISCRIMINATOR

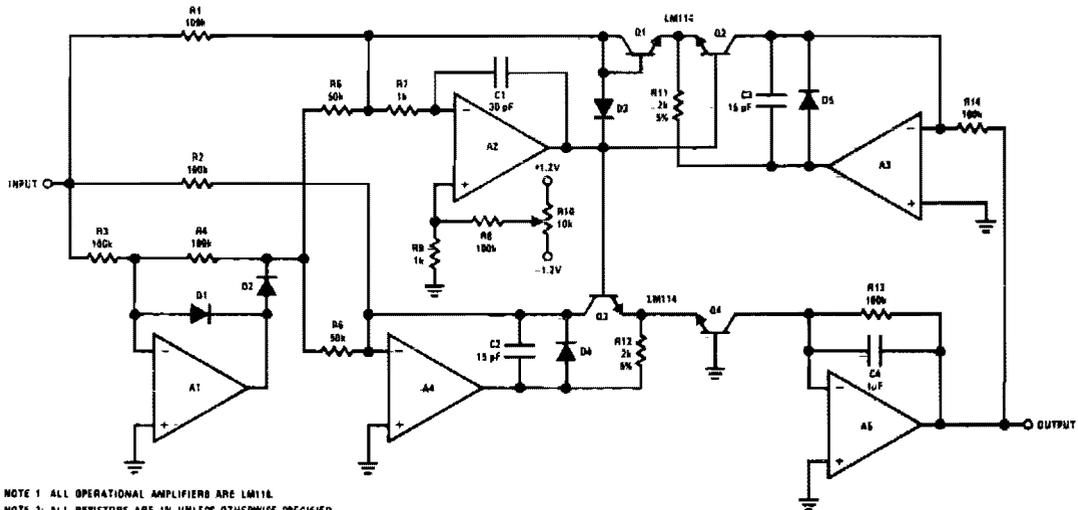


V_{OUT} Pulse Appears

$$\text{Whenever } T > \frac{RC V_2}{V_1}$$

Fig. 25-9

TRUE RMS DETECTOR



NOTE 1 ALL OPERATIONAL AMPLIFIERS ARE LM114.
 NOTE 2 ALL RESISTORS ARE 1% UNLESS OTHERWISE SPECIFIED
 NOTE 3 ALL DIODES ARE 1N914.
 NOTE 4 SUPPLY VOLTAGE -15V.

Fig. 25-10

Circuit Notes

The circuit will provide a dc output equal to the rms value of the input. Accuracy is typically 2% for a 20 V_{PP} input signal from 50-Hz to 100 kHz, although it's usable to about 500 kHz.

The lower frequency is limited by the size of the filter capacitor. Since the input is dc coupled, it can provide the true rms equivalent of a dc and ac signal.

FAST HALF-WAVE RECTIFIER

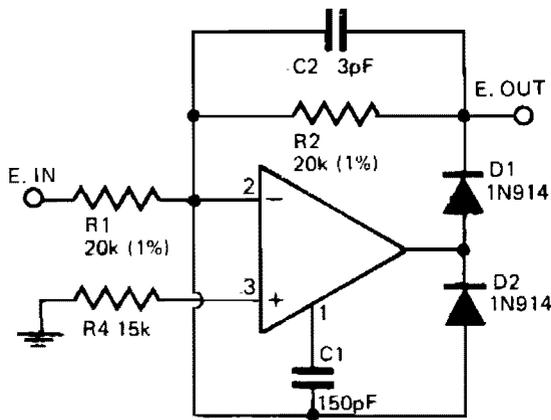


Fig. 25-11

Circuit Notes

Precision half wave rectifier using an operational amplifier will have a rectification accuracy of 1% from dc to 100 kHz.

TELEMETRY DEMODULATOR

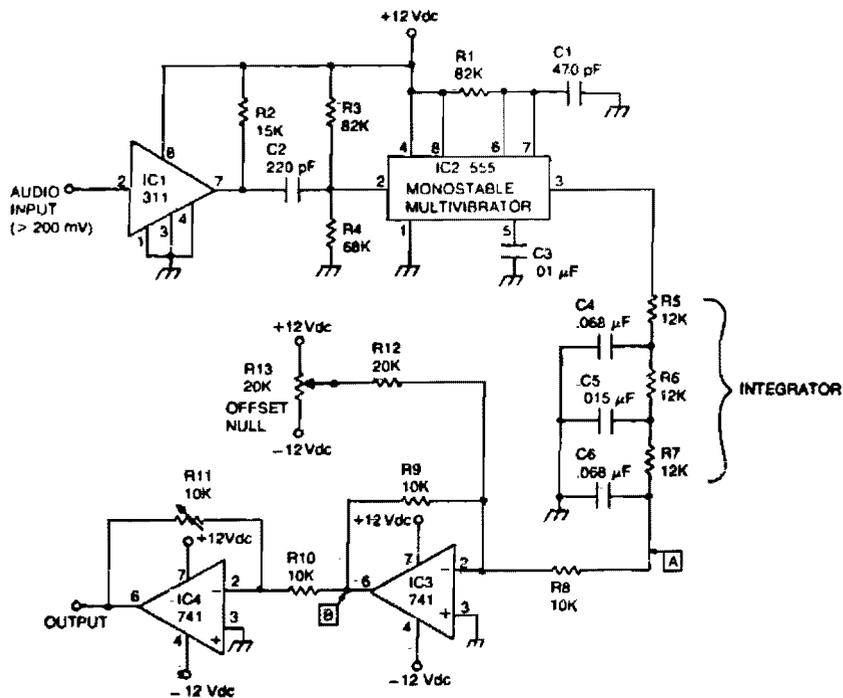


Fig. 25-12

Circuit Notes

The circuit recovers an FM audio signal that varies from less than 1 kHz to about 10 kHz.

FULL-WAVE RECTIFIER AND AVERAGING FILTER

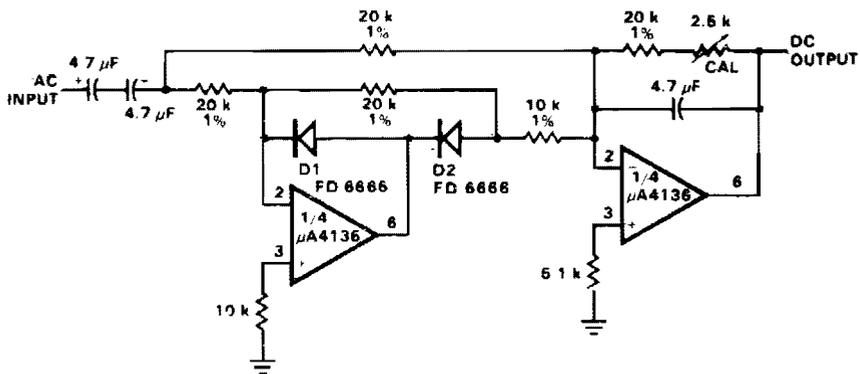
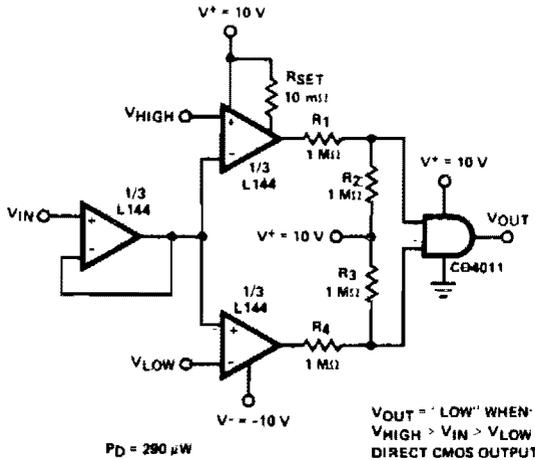


Fig. 25-13

DOUBLE-ENDED LIMIT DETECTOR

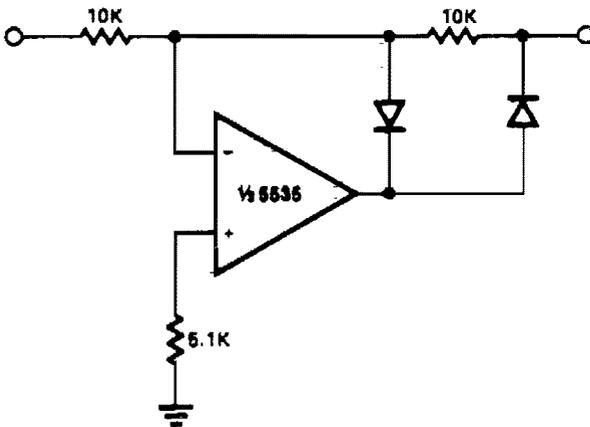


Circuit Notes

Detector uses three sections of an L144 and a CMOS NAND gate to make a very low power voltage monitor. The $1\text{ M}\Omega$ resistors R_1 , R_2 , R_3 , and R_4 translate the bipolar $\pm 10\text{ V}$ swing of the op amps to a 0 to 10 V swing acceptable to the ground-referenced CMOS logic. The total power dissipation is $290\ \mu\text{W}$ while in limit and $330\ \mu\text{W}$ while out of limit.

Fig. 25-14

HALF-WAVE RECTIFIER



All resistor values are in ohms.

Fig. 25-15

Circuit Notes

This circuit provides for accurate half wave rectification of the incoming signal. For positive signals, the gain is 0 ; for negative signals, the gain is -1 . By reversing both diodes, the polarity can be inverted. This circuit provides an accurate output, but the output

impedance differs for the two input polarities and buffering may be needed. The output must slew through two diode drops when the input polarity reverses. The NE5535 device will work up to 10 kHz with less than 5% distortion.

MISSING PULSE DETECTOR

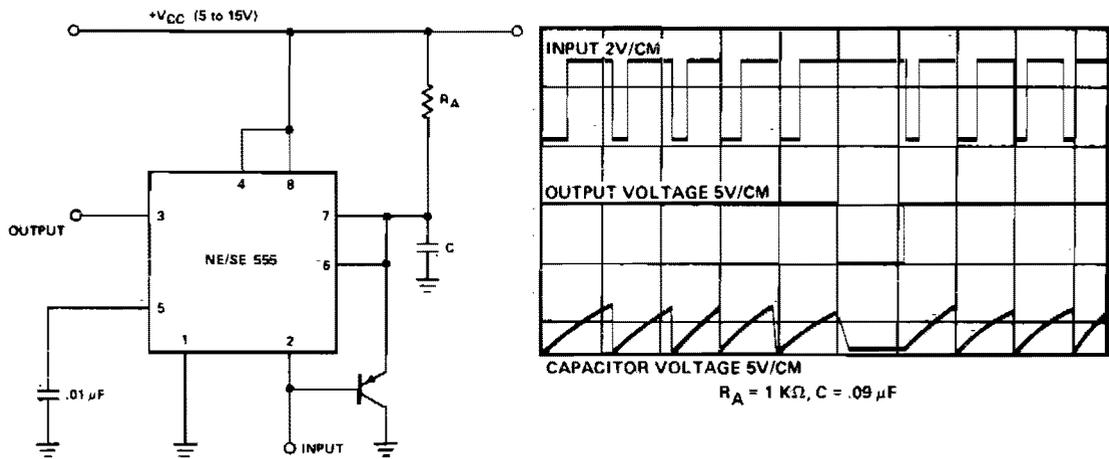


Fig. 25-18

Circuit Notes

The timing cycle is continuously reset by the input pulse train. A change in frequency, or a missing pulse, allows completion of the timing cycle which causes a change in the output level. For this application, the time delay

should be set to be slightly longer than the normal time between pulses. The graph shows the actual waveforms seen in this mode of operation.

HIGH SPEED PEAK DETECTOR

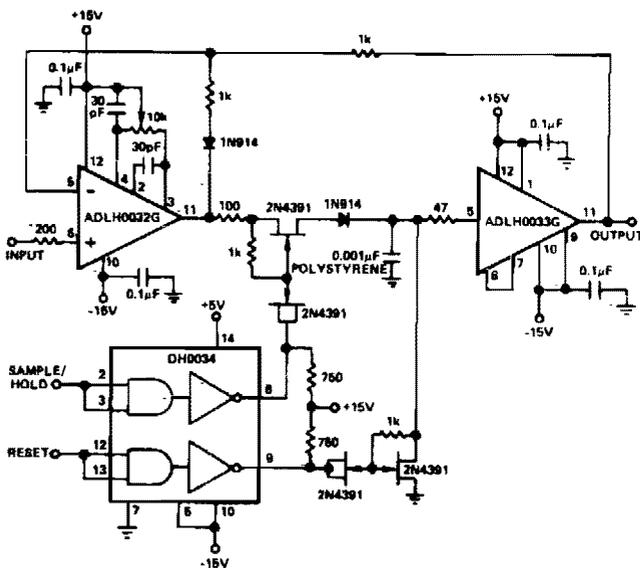


Fig. 25-19

DETECTOR FOR MAGNETIC TRANSDUCER

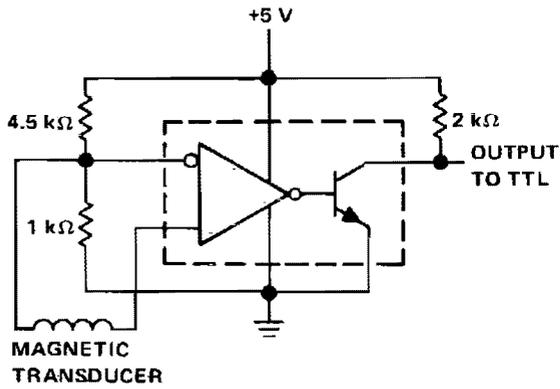


Fig. 25-20

FM DEMODULATOR AT 5 V

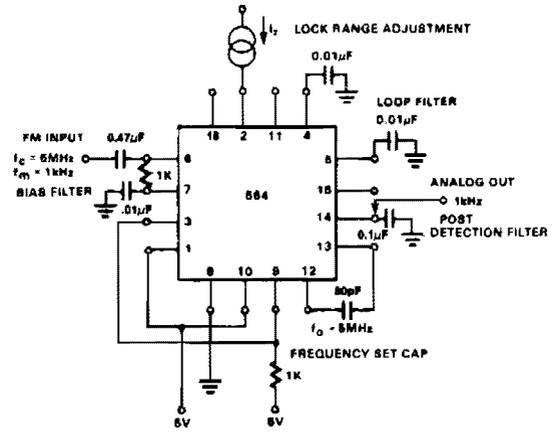


Fig. 25-22

DOUBLE-ENDED LIMIT DETECTOR

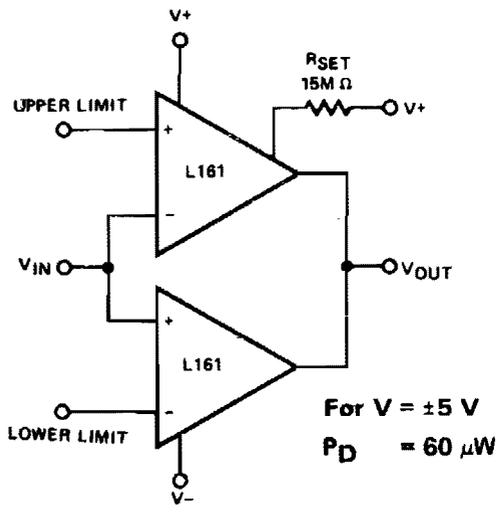


Fig. 25-21

FM DEMODULATOR AT 12 V

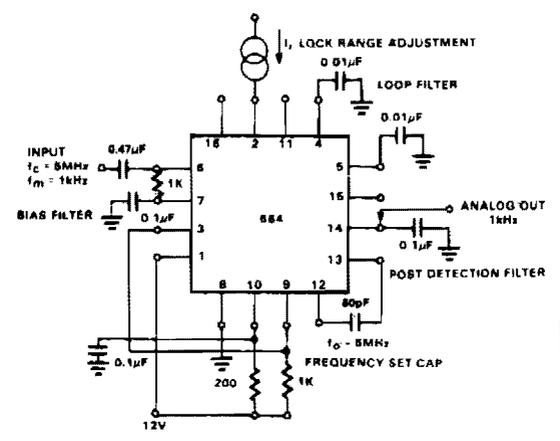


Fig. 25-23

PRECISION FULL WAVE RECTIFIER

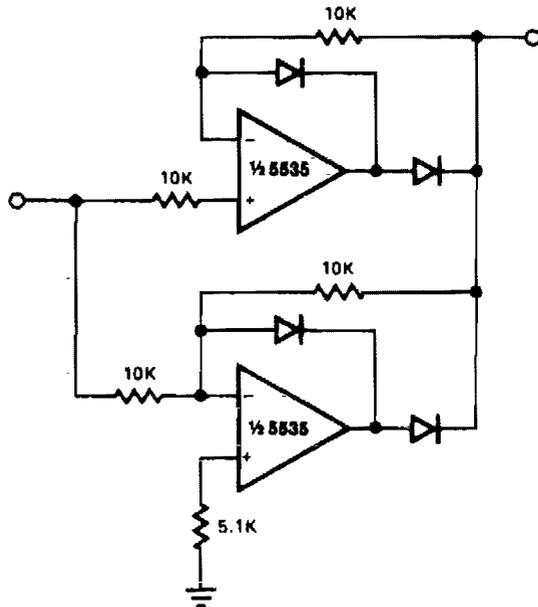


Fig. 25-24

Circuit Notes

The circuit provides accurate full wave rectification. The output impedance is low for both input polarities, and the errors are small at all signal levels. Note that the output will not sink heavy current, except a small amount through the 10 K resistors. Therefore, the load applied should be referenced to ground or a

negative voltage. Reversal of all diode polarities will reverse the polarity of the output. Since the outputs of the amplifiers must slew through two diode drops when the input polarity changes, 741 type devices give 5% distortion at about 300 Hz.

NEGATIVE PEAK DETECTOR

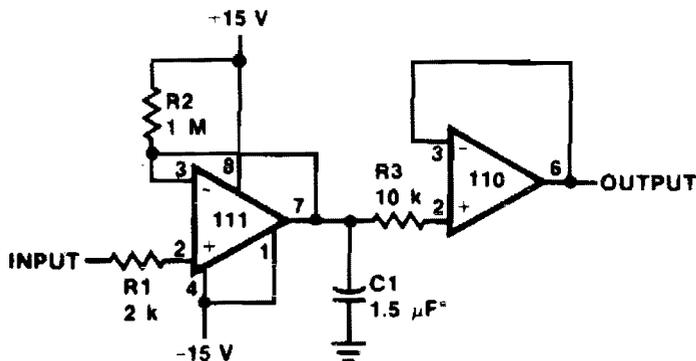


Fig. 25-25

*Solid tantalum

LEVEL DETECTOR WITH HYSTERESIS (POSITIVE FEEDBACK)

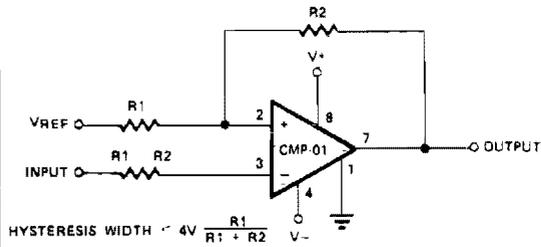
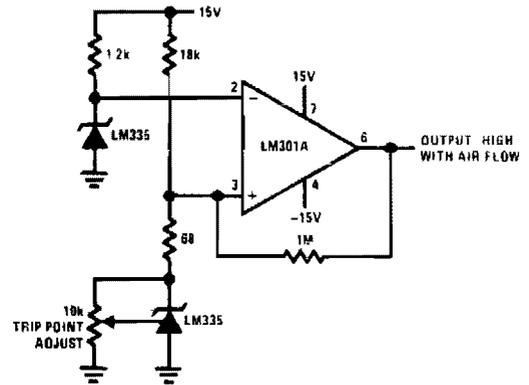


Fig. 25-26

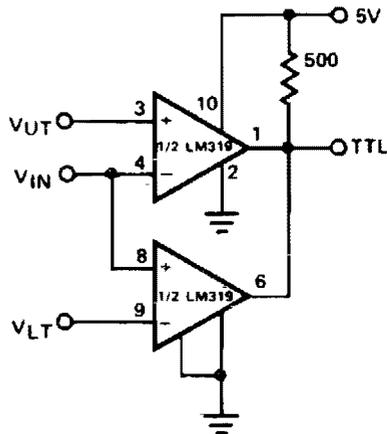
AIR FLOW DETECTOR



*Self heating is used to detect air flow

Fig. 25-28

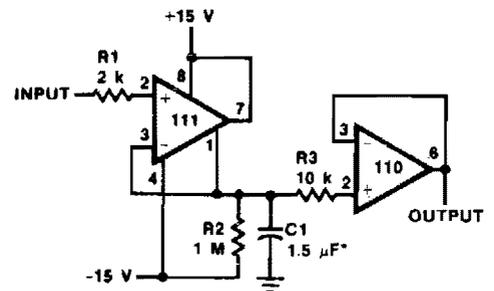
WINDOW DETECTOR



$V_{OUT} = 5V$ for $V_{LT} < V_{IN} < V_{UT}$
 $V_{OUT} = 0$ for $V_{IN} < V_{LT}$ or $V_{IN} > V_{UT}$

Fig. 25-27

POSITIVE PEAK DETECTOR



*Solid tantalum

Fig. 25-29

26

Digital-to-Analog Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

14-Bit Binary D/A Converter (Unipolar)

10-Bit D/A Converter

Fast Voltage Output D/A Converter

Resistor Terminated DAC (0 to -5 V Output)

Three-Digit BCD D/A Converter

8-Bit D/A Converter

High-Speed 8-Bit D/A Converter

10-Bit, 4 Quadrant Multiplexing D/A

Converter (Offset Binary Coding)

8-Bit D/A Converter

± 10 V Full-Scale Bipolar DAC

Precision 12-Bit D/A Converter

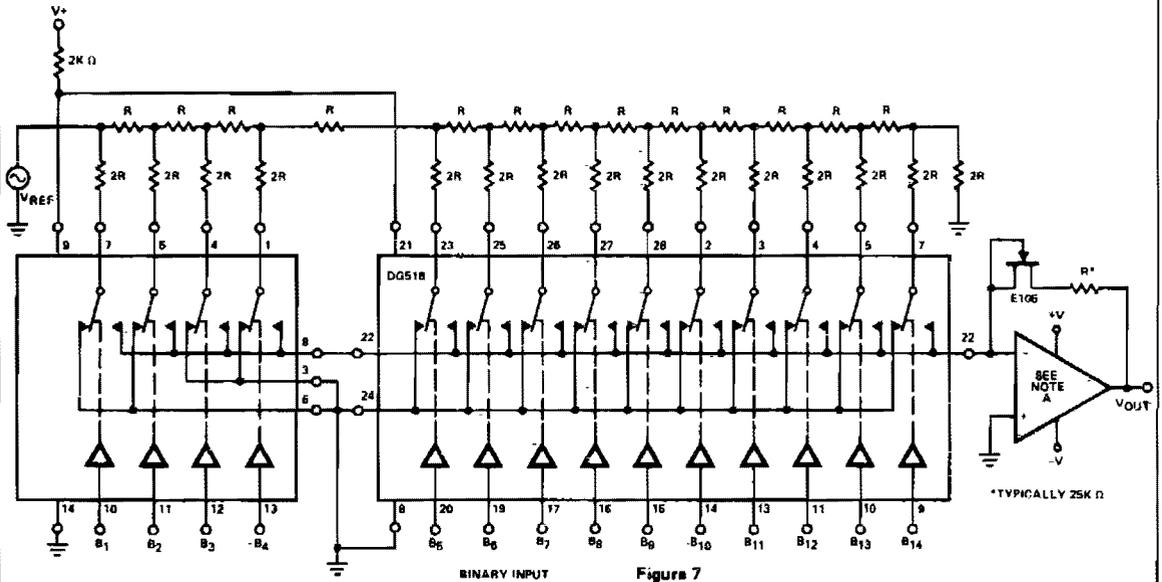
8-Bit D/A with Output Current-to-Voltage
Conversion

16-Bit Binary DAC

± 10 V Full-Scale Unipolar DAC

High-Speed Voltage Output DAC

14-BIT BINARY D/A CONVERTER (UNIPOLAR)



NOTE:

A. Op-Amp characteristics effect D/A accuracy and settling time. The following Op-Amps, listed in order of increasing speed, are suggested:

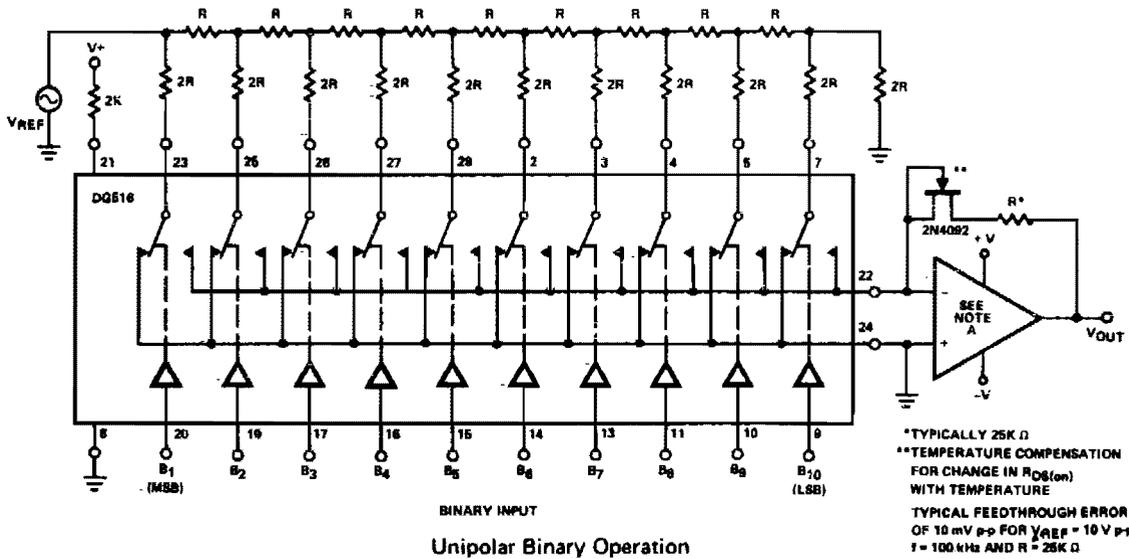
1. LM101A
2. LF156A
3. LM118

Unipolar Binary Operation

DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1 - 2^{-14})$
1 0 0 0 0 0 0 0 0 0 0 0 0 1	$-V_{REF} (1/2 + 2^{-14})$
1 0 0 0 0 0 0 0 0 0 0 0 0 0	$-V_{REF}/2$
0 1 1 1 1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1/2 - 2^{-14})$
0 0 0 0 0 0 0 0 0 0 0 0 0 1	$-V_{REF} (2^{-14})$
0 0 0 0 0 0 0 0 0 0 0 0 0 0	0

Fig. 26-1

10 BIT D/A CONVERTER



DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1 - 2^{-10})$
1 0 0 0 0 0 0 0 0 1	$-V_{REF} (1/2 + 2^{-10})$
1 0 0 0 0 0 0 0 0 0	$-V_{REF}/2$
0 1 1 1 1 1 1 1 1 1	$-V_{REF} (1/2 - 2^{-10})$
0 0 0 0 0 0 0 0 0 1	$-V_{REF} (2^{-10})$
0 0 0 0 0 0 0 0 0 0	0

NOTE:

Op-Amp characteristics affect D/A accuracy and settling time. The following Op-Amps, listed in order of increasing speed, are suggested:

1. LM101A
2. LF156A
3. LM118

Fig. 26-2

FAST VOLTAGE OUTPUT D/A CONVERTER

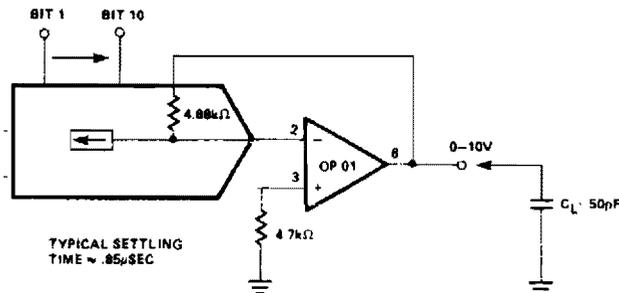
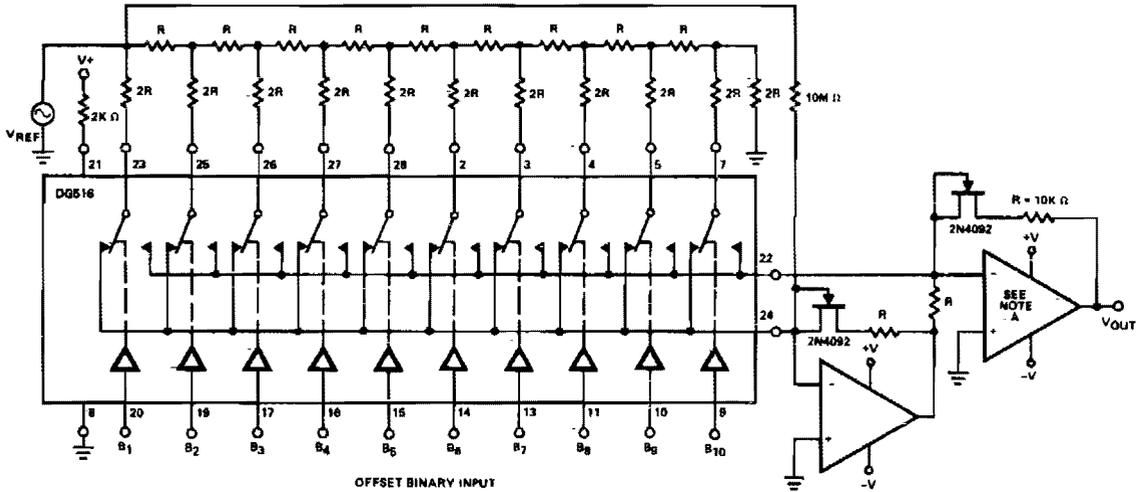


Fig. 26-3

10-BIT, 4 QUADRANT MULTIPLEXING D/A CONVERTER (OFFSET BINARY CODING)



Bipolar (Offset Binary)* Operation

DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1 - 2^{-9})$
1 0 0 0 0 0 0 0 0 1	$-V_{REF} (2^{-9})$
1 0 0 0 0 0 0 0 0 0	0
0 1 1 1 1 1 1 1 1 1	$V_{REF} (2^{-9})$
0 0 0 0 0 0 0 0 0 1	$V_{REF} (1 - 2^{-9})$
0 0 0 0 0 0 0 0 0 0	V_{REF}

NOTE: 1 LSB = $2^{-9} V_{REF}$
*Complementing B_1 (MSB) will give 2's complement coding.

Fig. 26-8

8-BIT D/A CONVERTER

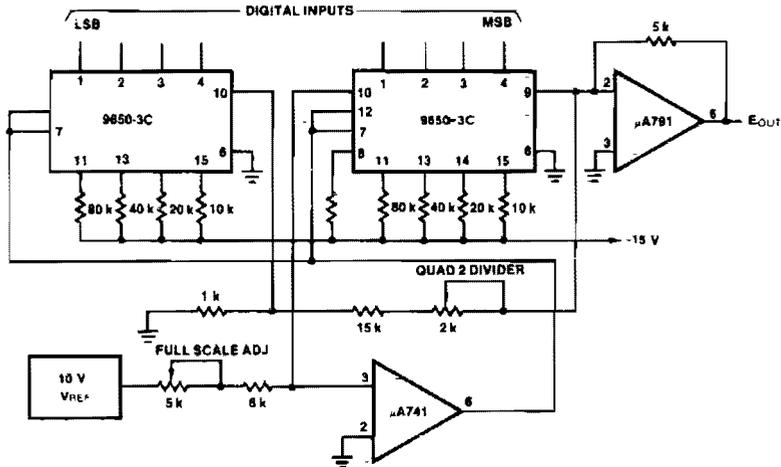
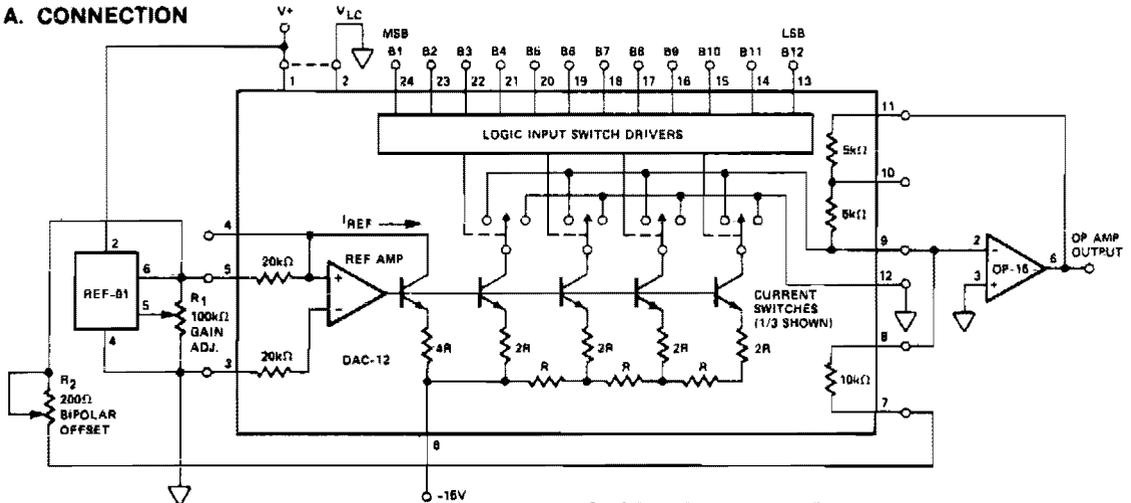


Fig. 26-9

±10 V FULL-SCALE BIPOLAR DAC

A. CONNECTION



B. ADJUSTMENT PROCEDURE

1. SET ALL BITS TO "0" STATE
2. ADJUST R_2 UNTIL OUTPUT IS $-10V$
3. BIT 1 TO "1" STATE
4. ADJUST R_1 UNTIL OUTPUT = $0.00V$

C. TRANSFER CURVE

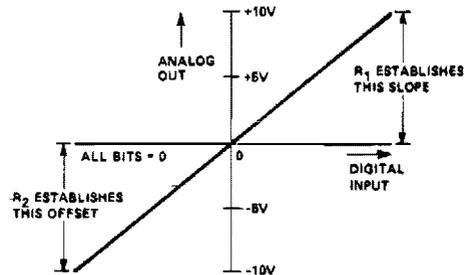


Fig. 26-10

PRECISION 12-BIT D/A CONVERTER

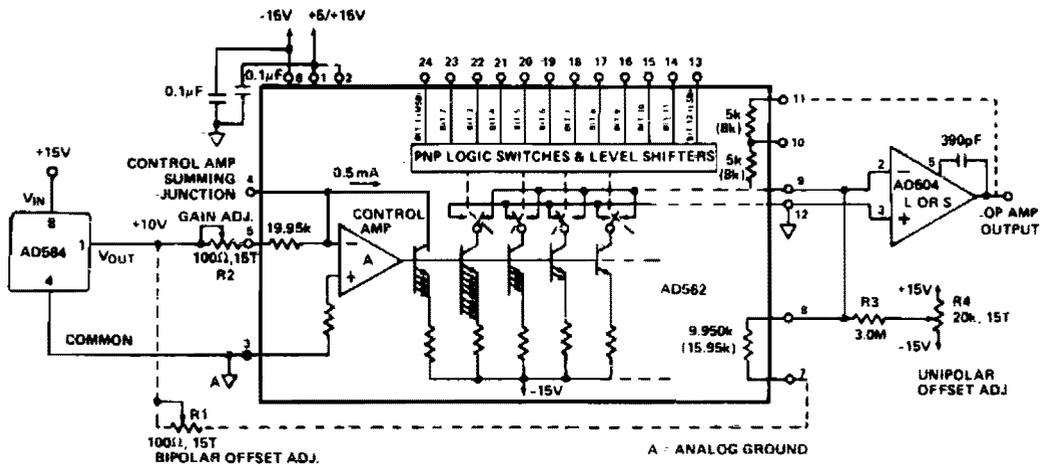


Fig. 26-11

8-BIT D/A WITH OUTPUT CURRENT-TO-VOLTAGE CONVERSION

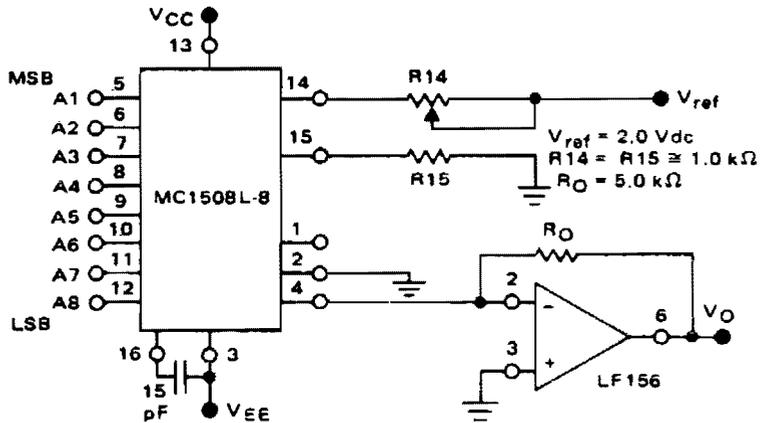


Fig. 26-12

Theoretical V_O

$$V_O = \frac{V_{ref}}{R_{14}} (R_O) \left[\frac{A_1}{2} + \frac{A_2}{4} + \frac{A_3}{8} + \frac{A_4}{16} + \frac{A_5}{32} + \frac{A_6}{64} + \frac{A_7}{128} + \frac{A_8}{256} \right]$$

Adjust V_{ref} , R_{14} or R_O so that V_O with all digital inputs at high level is equal to 9.961 volts.

$$V_O = \frac{2V}{1k} (5k) \left[\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \frac{1}{128} + \frac{1}{256} \right]$$

$$= 10V \left[\frac{255}{256} \right] = 9.961V$$

16-BIT BINARY DAC

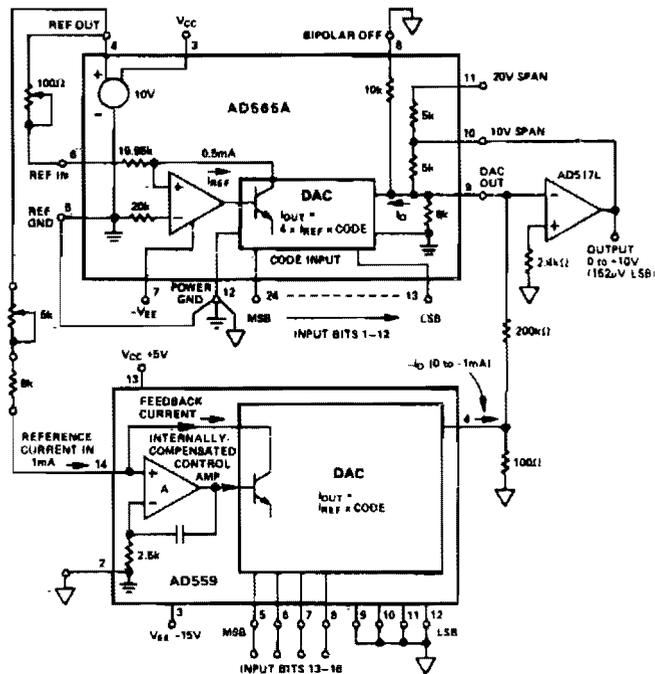
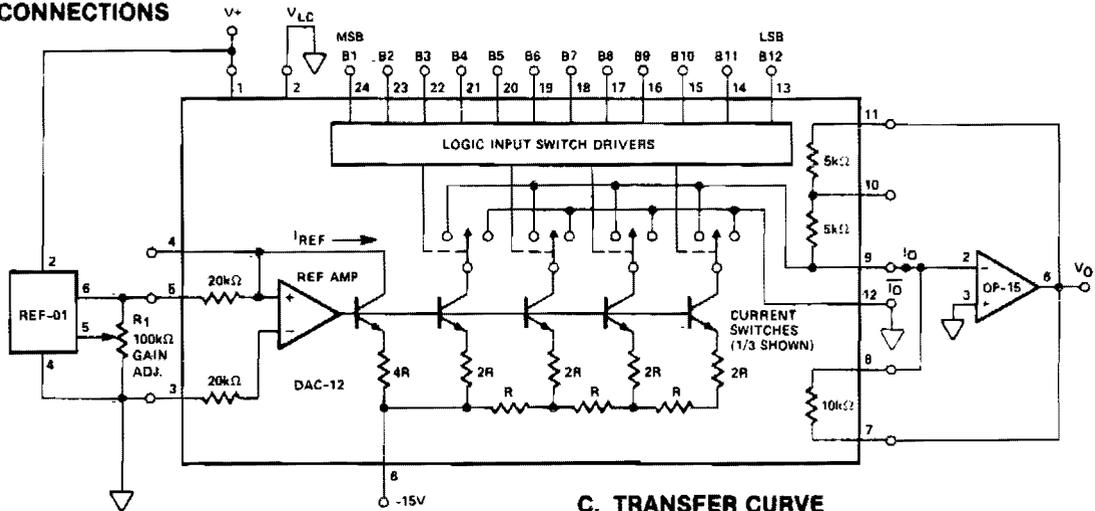


Fig. 26-13

±10 V FULL-SCALE UNIPOLAR DAC

A. CONNECTIONS



B. ADJUSTMENT PROCEDURE

1. ALL BITS TO "1" STATE ("0" STATE IF PINS 9 AND 12 INTERCHANGED)
2. ADJUST R_1 UNTIL OUTPUT IS +9.9975

$$\frac{4095}{4096} \times 10V$$

C. TRANSFER CURVE

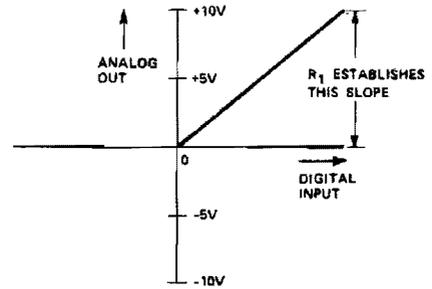


Fig. 26-14

HIGH-SPEED VOLTAGE OUTPUT DAC

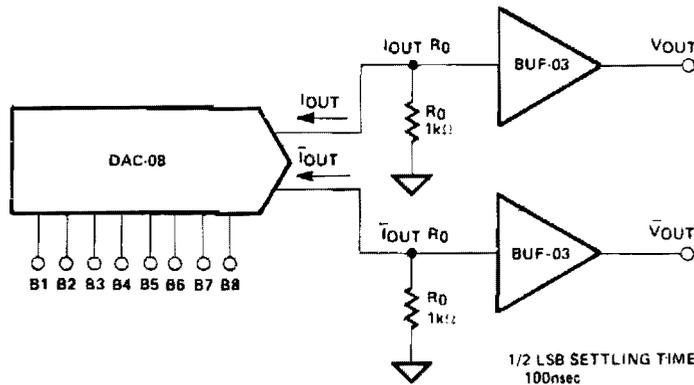


Fig. 26-15

SYSTEM WILL DRIVE CABLES OR TWISTED PAIRS.

27

Dip Meters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dip Meter Using Dual-Gate IGFET (MOSFET)

Varicap-Tuned FET DIP Meter with 1 kHz
Modulator

Dip Meter Using N-Channel IGFET (MOS-
FET) and Separate Diode Detector

Basic Grid-Dip Meter

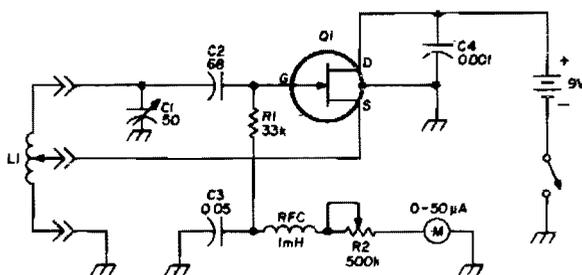
Dip Meter Using Germanium PNP

Bipolar Transistor with Separate Diode De-
tector

Gate-Dip Meter Covers 1.8 - 150 MHz

Dip Meter Using Silicon Junction FET

GATE-DIP METER COVERS 1.8 - 150 MHz



Coil data.

frequency range (MHz)	no. turns	wire size AWG	wire size (mm)	winding length inches	winding length (mm)	tap*	coil diameter inches	coil diameter (mm)
1.8 - 3.8	82	26 enamel	(0.4)	1 9/16	(40.0)	12	1 1/4	(32)
3.6 - 7.3	29	26 enamel	(0.4)	9/16	(14.5)	5	1 1/4	(32)
7.3 - 14.4	18	22 enamel	(0.6)	3/4	(19.0)	3	1	(25)
14.4 - 32	7	22 enamel	(0.6)	1/2	(12.5)	2	1	(25)
29 - 64	3 1/2	18 tinned	(1.0)	3/4	(19.0)	3/4	1	(25)

61 - 150 Hairpin of 16 no. AWG (1.3mm) wire, 5/8 inch (16mm) spacing, 2 3/8 inches (60mm) long including coil-form pins. Tapped at 2 inches (51mm) from ground end.

*Turns from ground-end. 1 inch (25mm) forms are Milten 45004 available from Burstein-Applebee

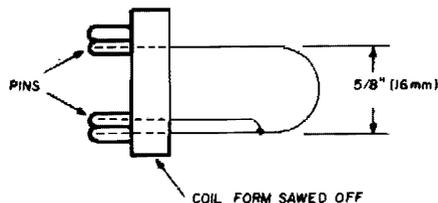


Fig. 27-6

DIP METER USING SILICON JUNCTION FET

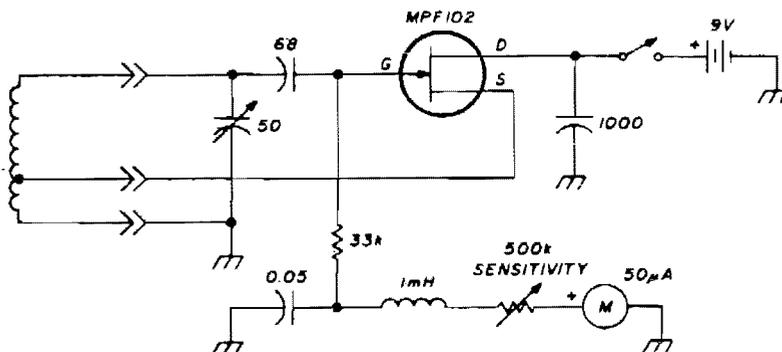


Fig. 27-7

Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. $k = 1,000$ $M = 1,000,000$

28

Displays

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

LED Brightness Control

LED Bar/Dot Level Meter

60 dB Dot Mode Display

Bar Display with Alarm Flasher

12-Hour Clock with Gas Discharge Displays

Precision Frequency Counter (~ 1 MHz
Maximum)

Exclamation Point Display

LED Bar Peak Program Meter Display
for Audio

10 MHz Universal Counter

LED BRIGHTNESS CONTROL

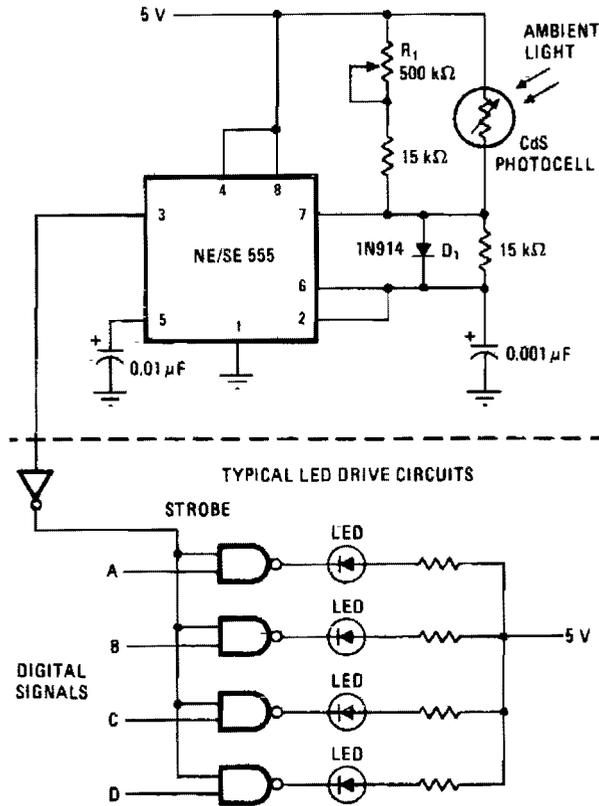


Fig. 28-1

Circuit Notes

The brightness of LED display is varied by using a photocell in place of one timing resistor in a 555 timer, and bypassing the other

timing resistor to boost the timer's maximum duty cycle. The result is a brighter display in sunlight and a fainter one in the dark.

LED BAR/DOT LEVEL METER

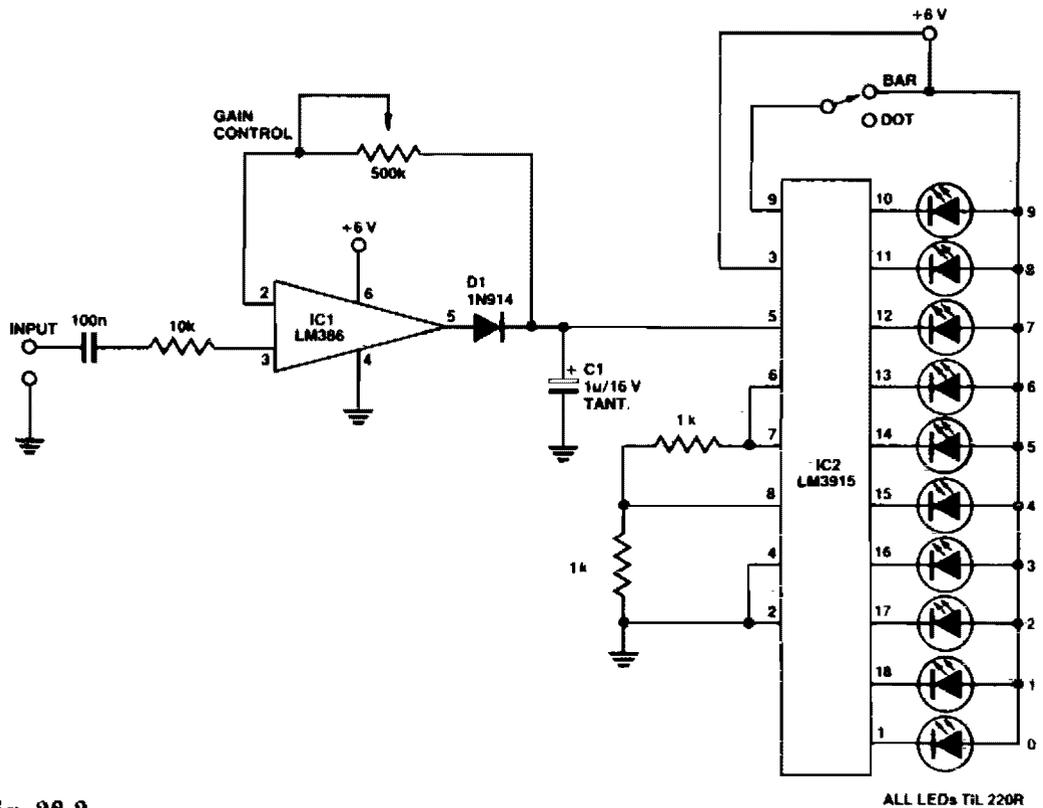


Fig. 28-2

Circuit Notes

A simple level of power meter can be arranged to give a bar or dot display for a hi-fi system. Use green LEDs for 0 to 7; yellow for 8 and red for 9 to indicate peak power. The gain control is provided to enable calibration on the

equipment with which the unit is used. Because the unit draws some 200 mA, a power supply is advisable instead of running the unit from batteries.

12-HOUR CLOCK WITH GAS DISCHARGE DISPLAYS

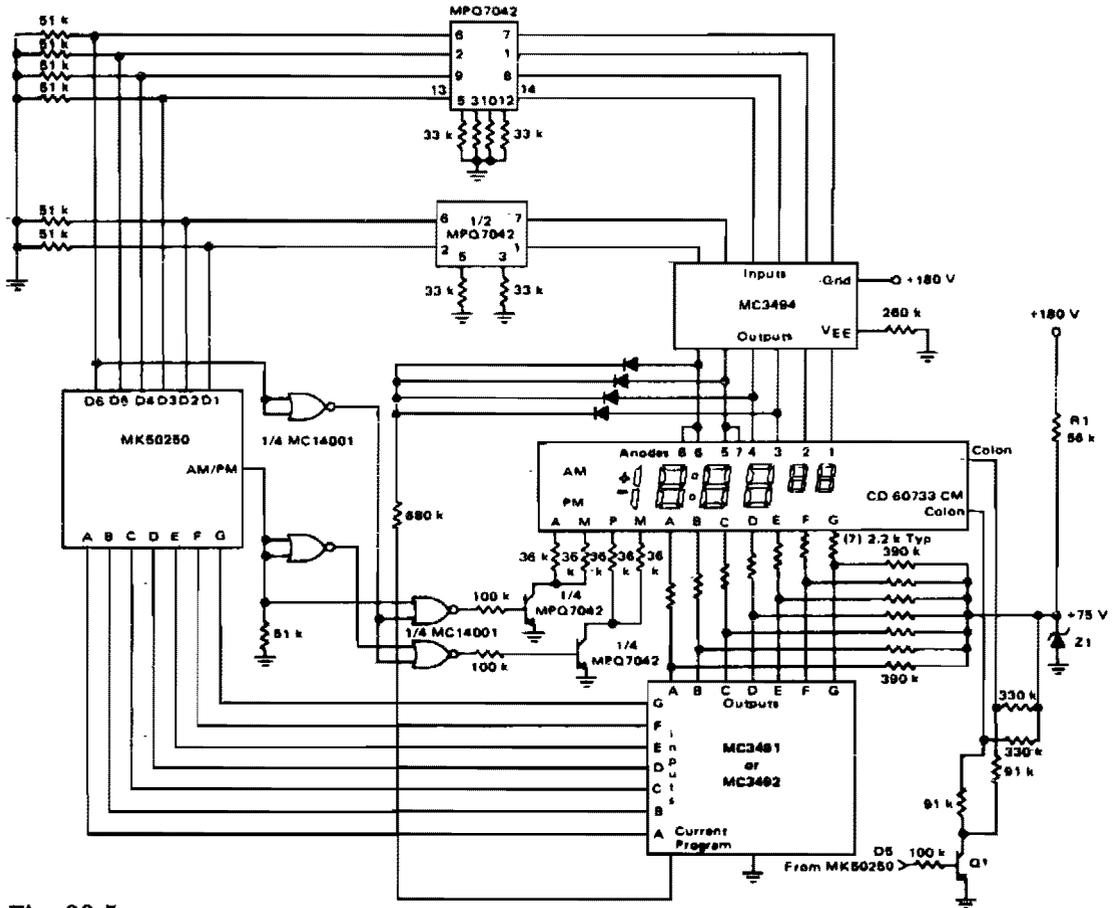


Fig. 28-5

PRECISION FREQUENCY COUNTER (~1 MHz MAXIMUM)

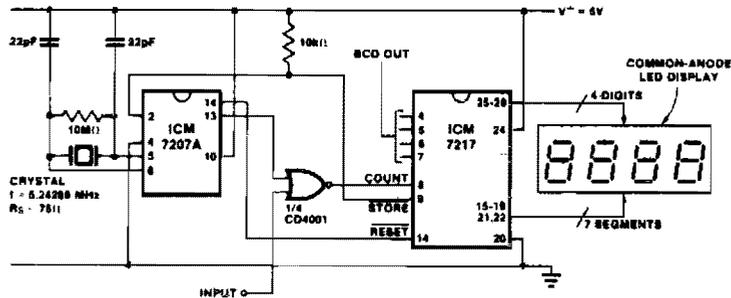


Fig. 28-6

EXCLAMATION POINT DISPLAY

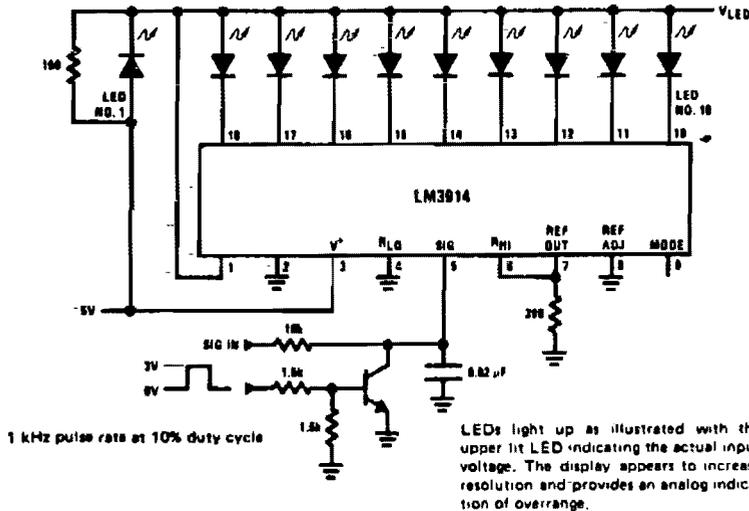
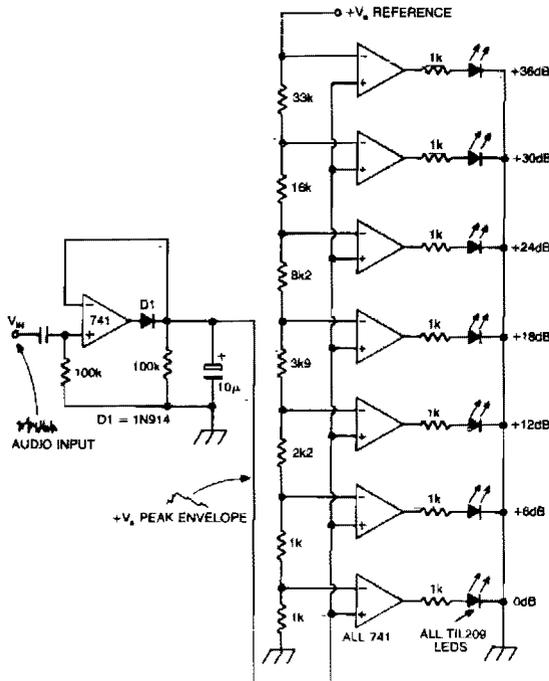


Fig. 28-7

LED BAR PEAK PROGRAM METER DISPLAY FOR AUDIO



Circuit Notes

A bar column of LEDs is arranged so that as the audio signal level increases, more LEDs in the column light up. The LEDs are arranged vertically in 6 dB steps. A fast response time and a one second decay time give an accurate response to transients and a low "flicker" decay characteristic. On each of the op amps inverting inputs is a dc reference voltage, which increases in 6 dB steps. All noninverting inputs are tied together and connected to the positive peak envelope of the audio signal. Thus, as this envelope exceeds a particular voltage reference, the op amp output goes high and the LED lights up. Also, all the LEDs below this are illuminated.

Fig. 28-8

29

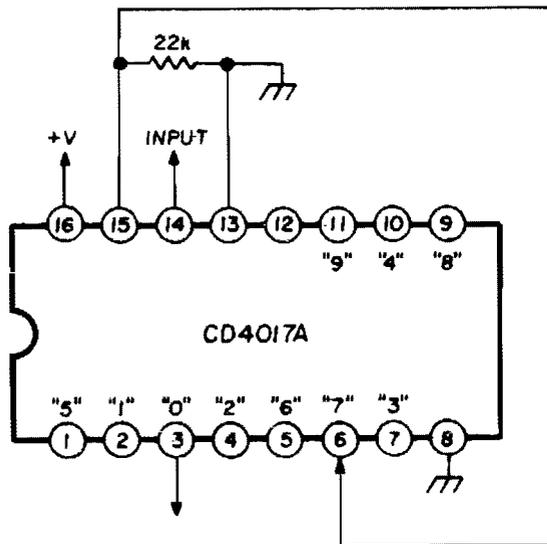
Dividers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

CMOS Programmable Divide-by-N Counter
Frequency Divider Chain
Frequency Divider with Transient

Free Output
Binary Divider Chain
Decade Frequency Divider

CMOS PROGRAMMABLE DIVIDE-BY-N COUNTER



Circuit Notes

A single connection change permits division by any integer between 2 and 10. The RCA CD4017A Johnson decade counter is shown connected as a divide by 7 counter. The resistor is used to hold the reset line low. When the appropriate number is reached, that output and the reset line are driven high, resetting the counter. To divide by other integers, pin 15 should be connected to the desired output. For example, pin 1 for a divide by 5, or pin 7 for a divide by 3. The output of the divider appears on the 0 line.

Fig. 29-1

FREQUENCY DIVIDER CHAIN

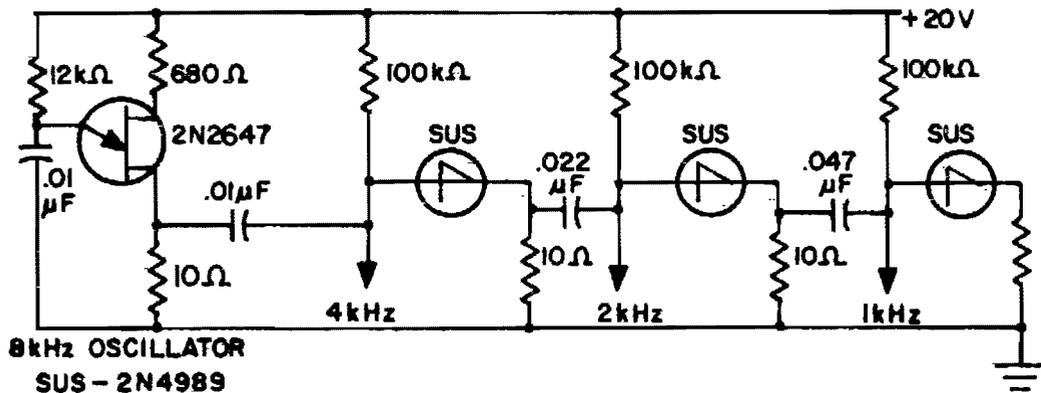


Fig. 29-2

Circuit Notes

Sawtooth output from each stage is one half frequency of preceding stage.

FREQUENCY DIVIDER WITH TRANSIENT FREE OUTPUT

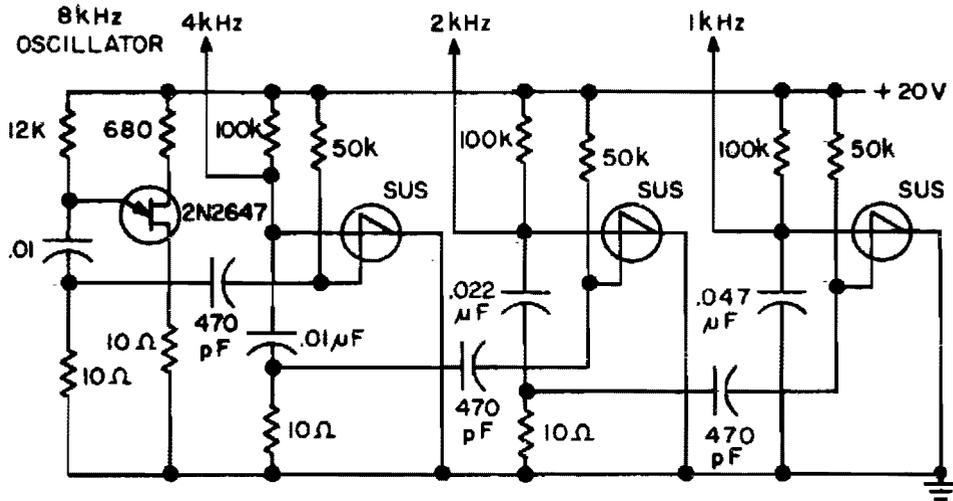


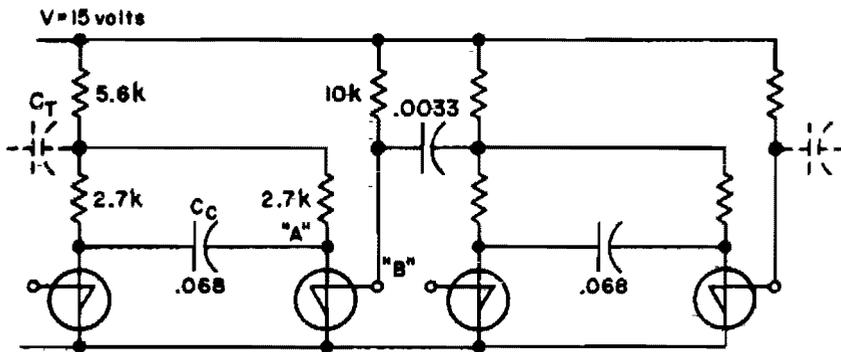
Fig. 29-3

SUS - 2N4989

Circuit Notes

Spikes in the center of a sawtooth wave are eliminated in this circuit by triggering at gate.

BINARY DIVIDER CHAIN



SUS'S - 2N4987

Fig. 29-4

Circuit Notes

This circuit uses fewer components than transistor flip flops. Output at "B" gives a transient-free waveform.

DECADE FREQUENCY DIVIDER

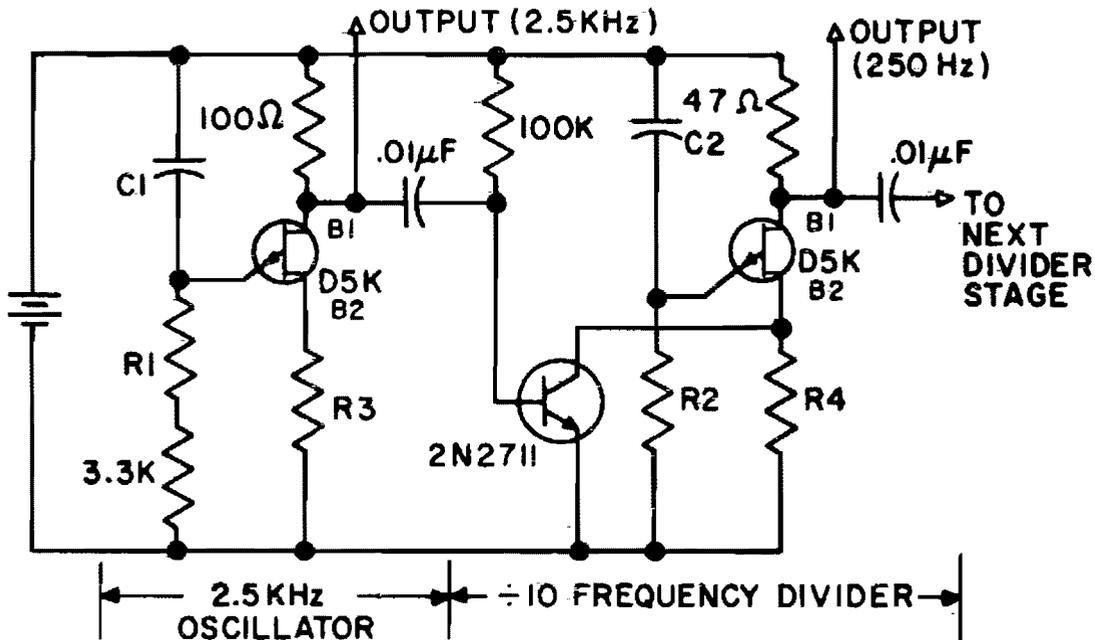


Fig. 29-5

Circuit Notes

In the next stage, the product of R2 and C2 should be $10 \times$ that of the preceding stage ($\pm 2\%$). R2 should be between 27K and 10 M.

C1 & C2— $.0047 \mu\text{F}$ ($\pm 1\%$)

R1—100K ($\pm 1\%$)

R2—1M ($\pm 1\%$)

R3—R4—1K (may need to be adjusted for variation of R_{BB} of UJT)

30

Drivers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Driver Circuits	High Speed Line Driver for Multiplexers
50 Ohm Driver	High Impedance Meter Driver
Line Driver	CRT Deflection Yoke
High Speed Laser Diode Driver	CRT Yoke Driver
Capacitive Load Driver	Solenoid Driver
Relay Driver	Coaxial Cable Driver
Relay Driver	High Speed Shield/Line Driver
BIFET Cable Driver	Relay Driver with Strobe

Direct Dc Drive Interface of a Triac

DRIVER CIRCUITS

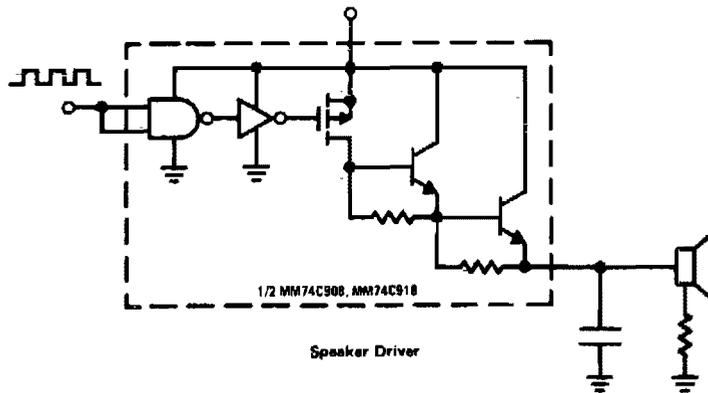
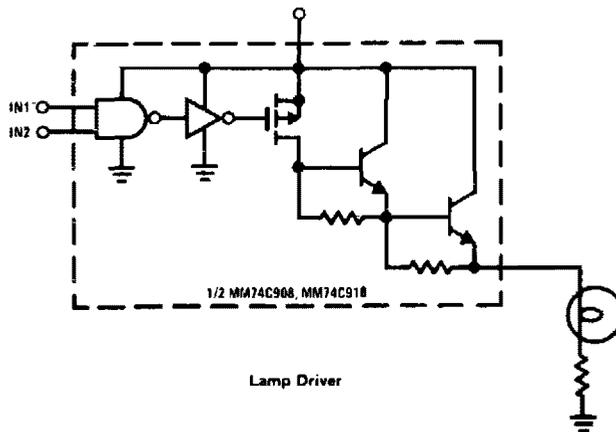
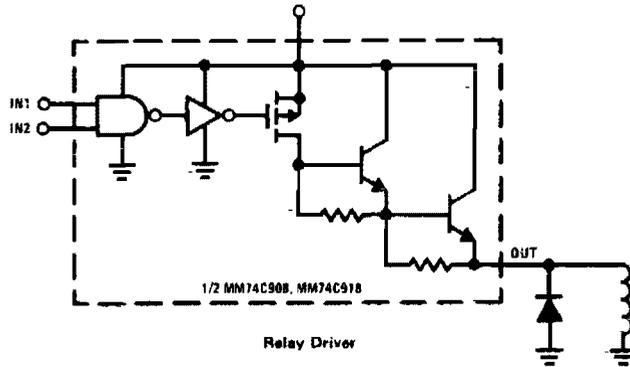
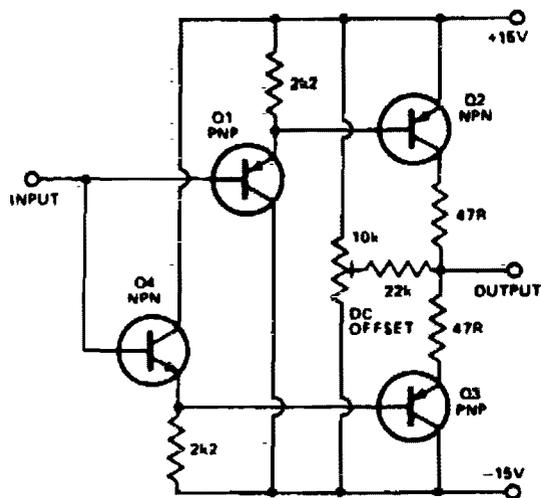


Fig. 30-1

Circuit Notes

CMOS drivers for relays, lamps, speakers, etc., offers extremely low standby power. At $V_{CC} = 15\text{ V}$, power dissipation per package is typically 750 nW when the outputs are not drawing current. Thus, the drivers can be sitting out on line (a telephone line, for example) drawing essentially zero current until activated.

50 OHM DRIVER



Circuit Notes

To buffer a test generator to the outside world requires an amplifier with sufficient bandwidth and power handling capability. The circuit is a very simple unity gain buffer. It has a fairly high input impedance, a 50 ohm output impedance, a wide bandwidth, and high slew rate. The circuit is simply two pairs of emitter followers. The base emitter voltages of Q1 and Q2 cancel out, and so do those of Q3 and Q4. The preset is used to zero out any small dc offsets due to mismatching in the transistors.

Fig. 30-2

LINE DRIVER

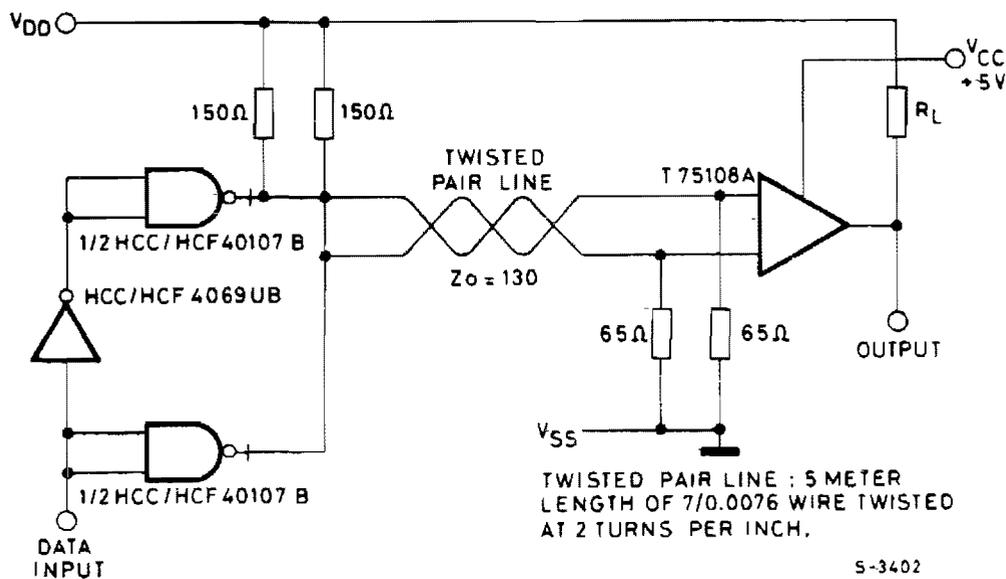


Fig. 30-3

HIGH-SPEED LASER DIODE DRIVER

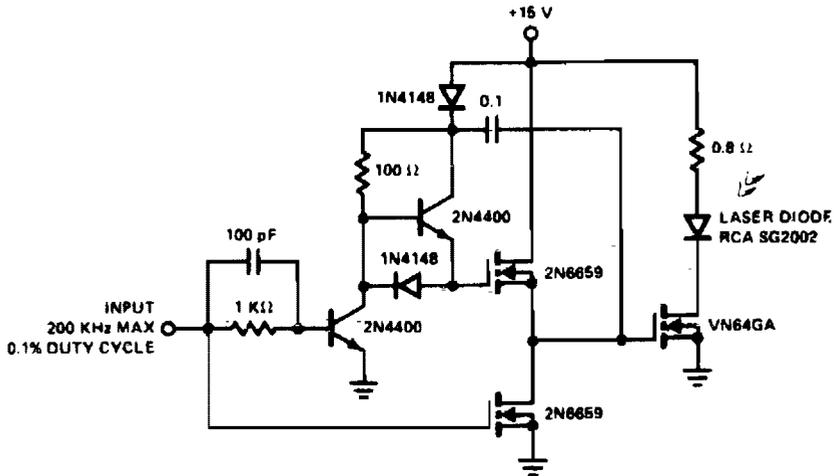


Fig. 30-4

Circuit Notes

A faster driver can supply higher peak gate current to switch the VN64GA very quickly. The circuit uses a VMOS totempole stage to drive the high power switch.

CAPACITIVE LOAD DRIVER

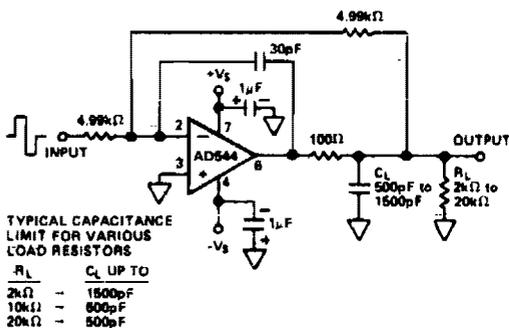


Fig. 30-5

Circuit Notes

The circuit employs a 100 ohm isolation resistor which enables the amplifier to drive capacitive loads exceeding 500 pF; the resistor effectively isolates the high frequency feedback from the load and stabilizes the circuit. Low frequency feedback is returned to the amplifier summing junction via the low pass filter formed by the 100 ohm series resistor and the load capacitance, C_L .

RELAY DRIVER

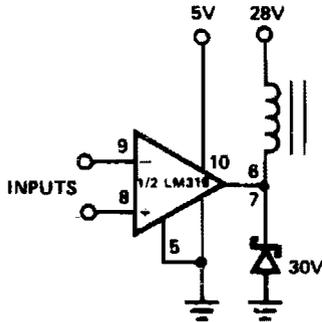
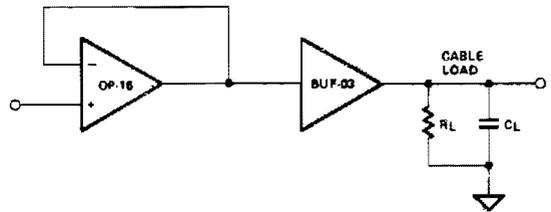


Fig. 30-6

BIFET CABLE DRIVER



CAPACITIVE LOAD STABILITY OF BUF-03 MAKES IT AN IDEAL INTERFACE BETWEEN BIFET OP AMPS AND SHIELDED CABLES*

NOTE: TO MAINTAIN ACCURACY IN THE BUFFER $R_L > 1k\Omega$ IS RECOMMENDED.

Fig. 30-8

RELAY DRIVER

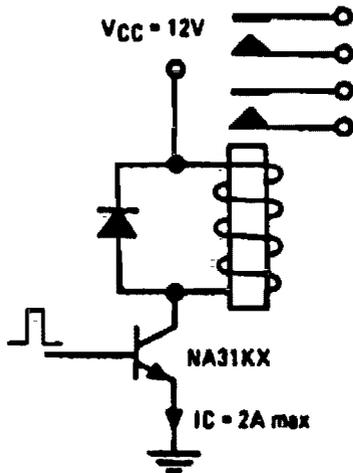
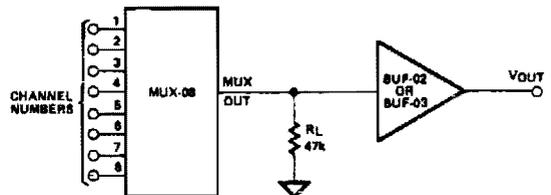


Fig. 30-7

HIGH SPEED LINE DRIVER FOR MULTIPLEXERS



NOTE 1: STRAY CAPACITANCE AT MULTIPLEXER OUTPUT NODE SHOULD BE MINIMIZED TO REDUCE CHANNEL-TO-CHANNEL CROSSTALK.

NOTE 2: A BUFFER WHOSE SLEW RATE IS TOO SMALL WILL INCREASE CHANNEL-TO-CHANNEL CROSSTALK.

Fig. 30-9

HIGH IMPEDANCE METER DRIVER

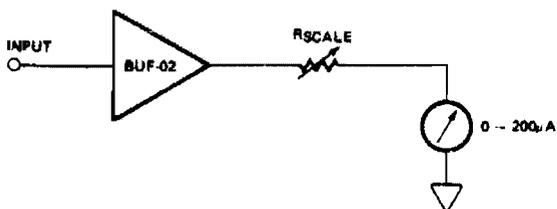


Fig. 30-10

CRT YOKE DRIVER

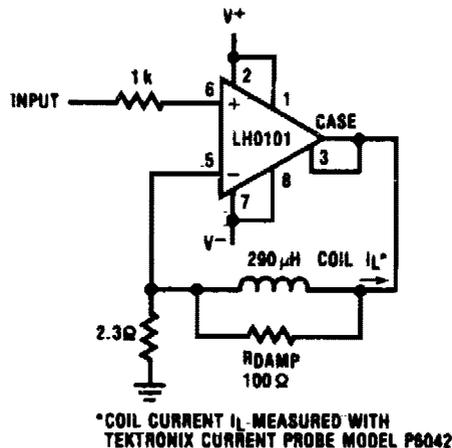


Fig. 30-12

Circuit Notes

A 500 mV peak-to-peak triangular waveform about ground is input to the amplifier, giving rise to a 100 mA peak current to the inductor.

CRT DEFLECTION YOKE DRIVER

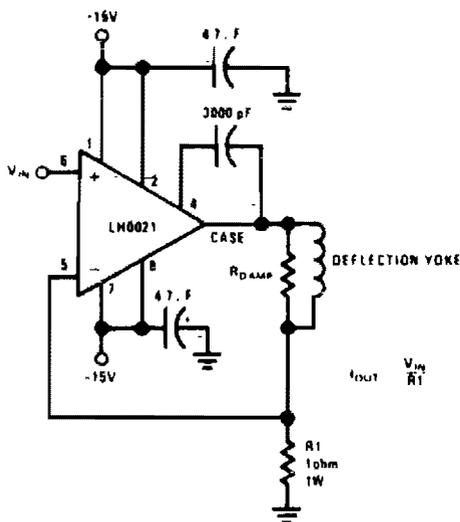


Fig. 30-11

SOLENOID DRIVER

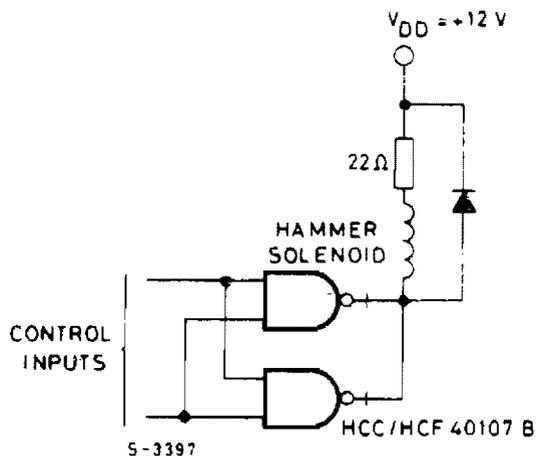


Fig. 30-13

COAXIAL CABLE DRIVER

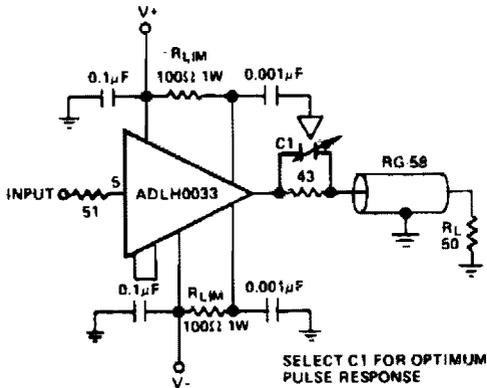
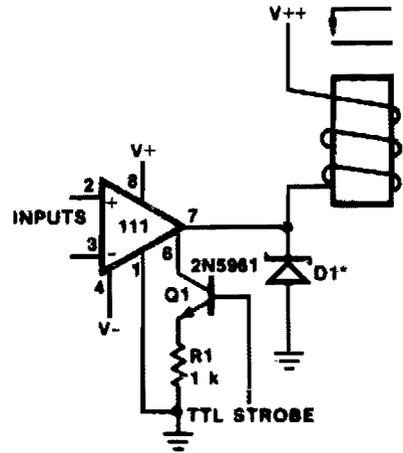


Fig. 30-14

RELAY DRIVER WITH STROBE



* Absorbs inductive kickback of relay and protects IC from severe voltage transients on V++ line.

Fig. 30-16

HIGH SPEED SHIELD/LINE DRIVER

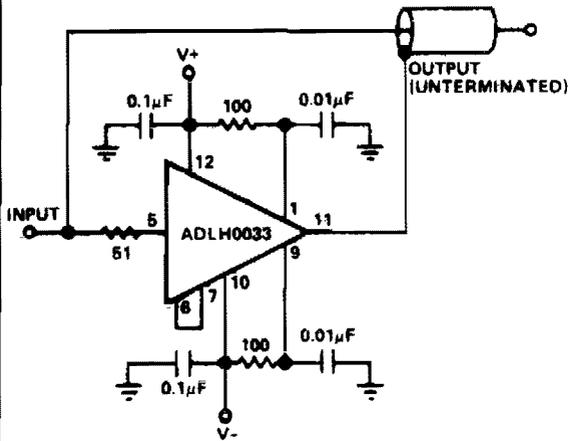


Fig. 30-15

DIRECT DC DRIVE INTERFACE OF A TRIAC

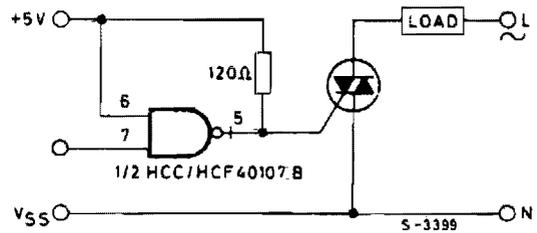


Fig. 30-17

31

Fiber Optic Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Fiber-Optics Half Duplex Information Link
Fiber-Optic Receiver, Very High Sensitivity, Low Speed, 3 nW
Fiber-Optic Link

Fiber-Optic Link Repeater
Fiber-Optic Receiver, High Sensitivity, 30 nW
Fiber-Optic Receiver, Low Sensitivity, 300 nW

FIBER-OPTICS HALF DUPLEX INFORMATION LINK

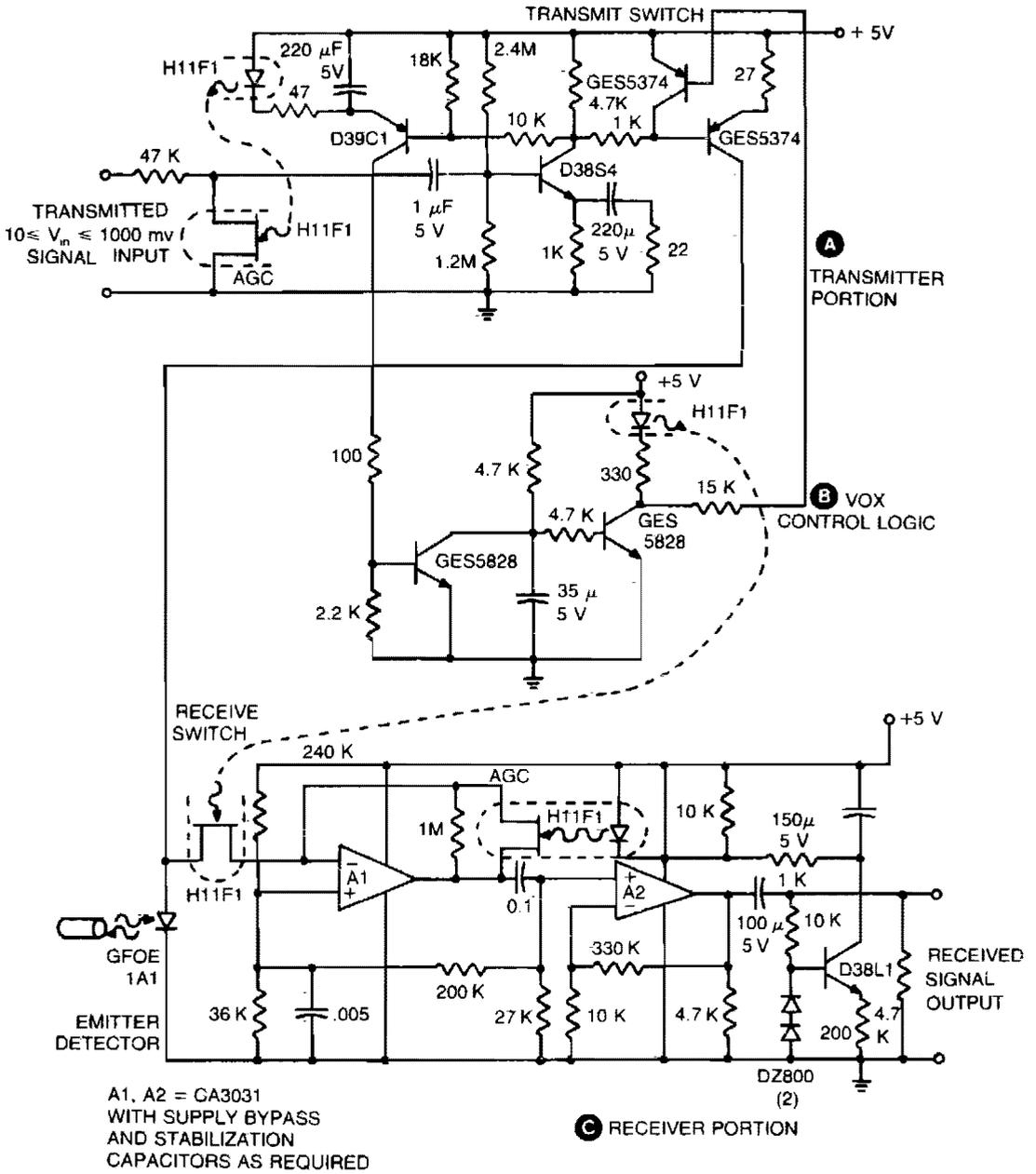


Fig. 31-1

FIBER-OPTIC RECEIVER, VERY HIGH SENSITIVITY, LOW SPEED, 3nW

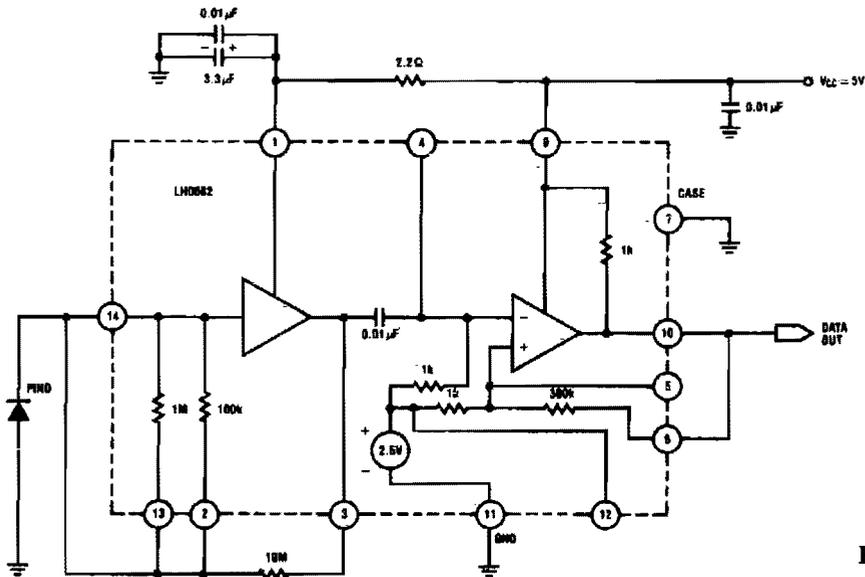


Fig. 31-2

FIBER-OPTIC LINK

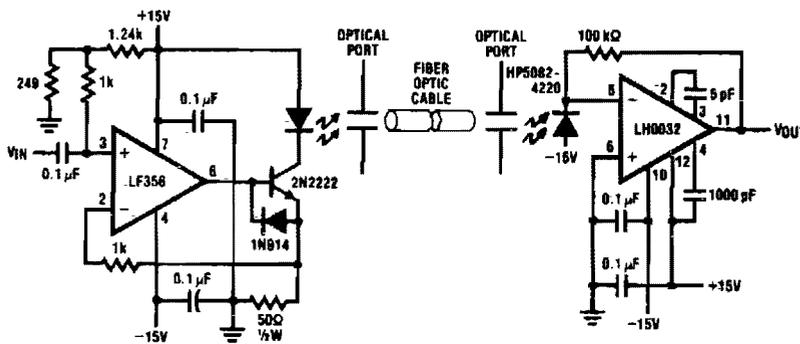


Fig. 31-3

Circuit Notes

Fiber Optic applications require analog drivers and receivers operating in the megahertz region. This complete analog transmission system is suitable for optical communication applications up to 3.5 MHz. The transmitter LED is normally biased at 50 mA operating current. The input is capacitively

coupled and ranges from 0 to 5 V, modulating the LED current from 0 to 100 mA. The receiver circuit is configured as a transimpedance amplifier. The photodiode with 0.5 amp per watt responsivity generates a 50 mV signal at the receiver output for 1 μ W of light input.

FIBER-OPTIC LINK REPEATER

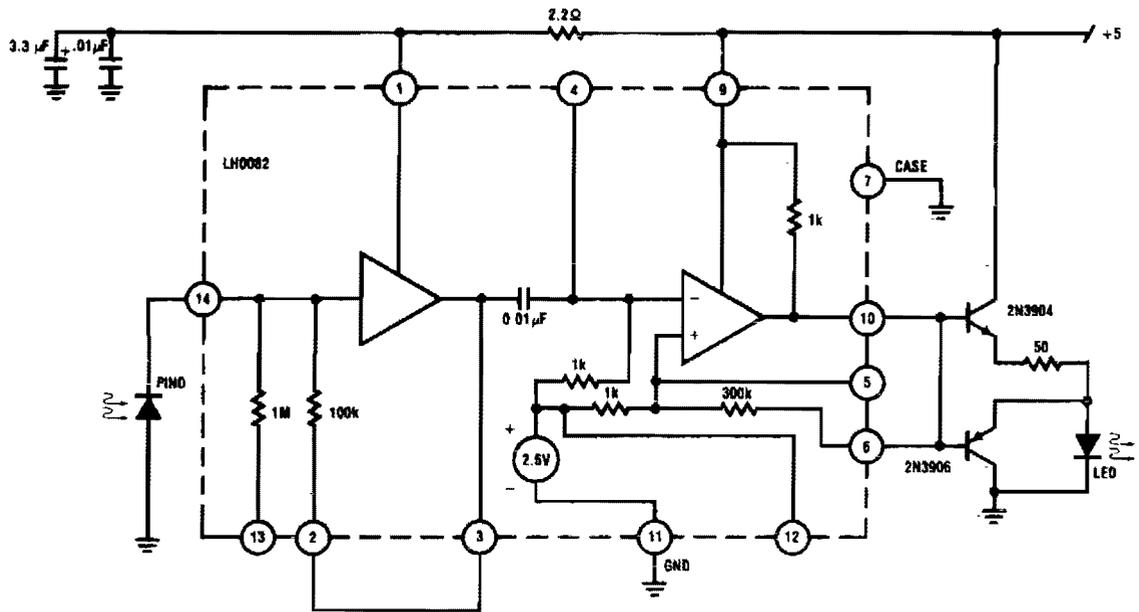


Fig. 31-4

FIBER-OPTIC RECEIVER, HIGH SENSITIVITY, 30nW

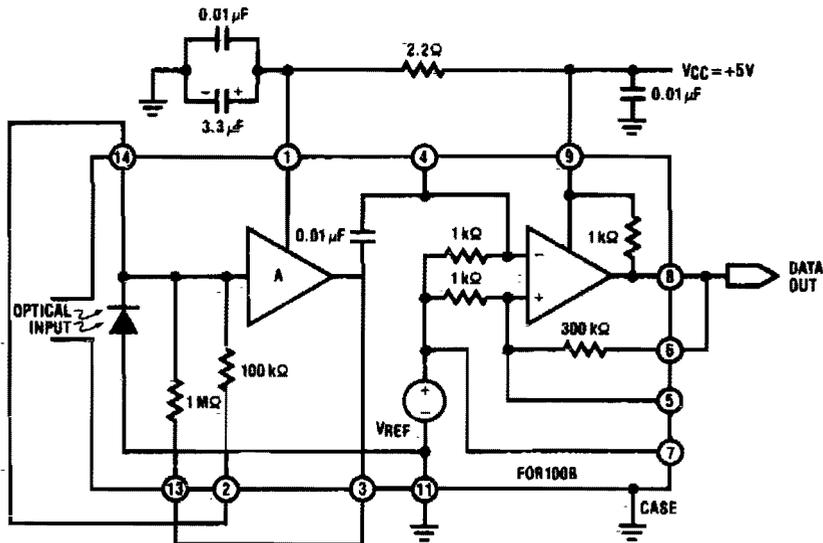


Fig. 31-5

FIBER-OPTIC RECEIVER, LOW SENSITIVITY, 2 μW

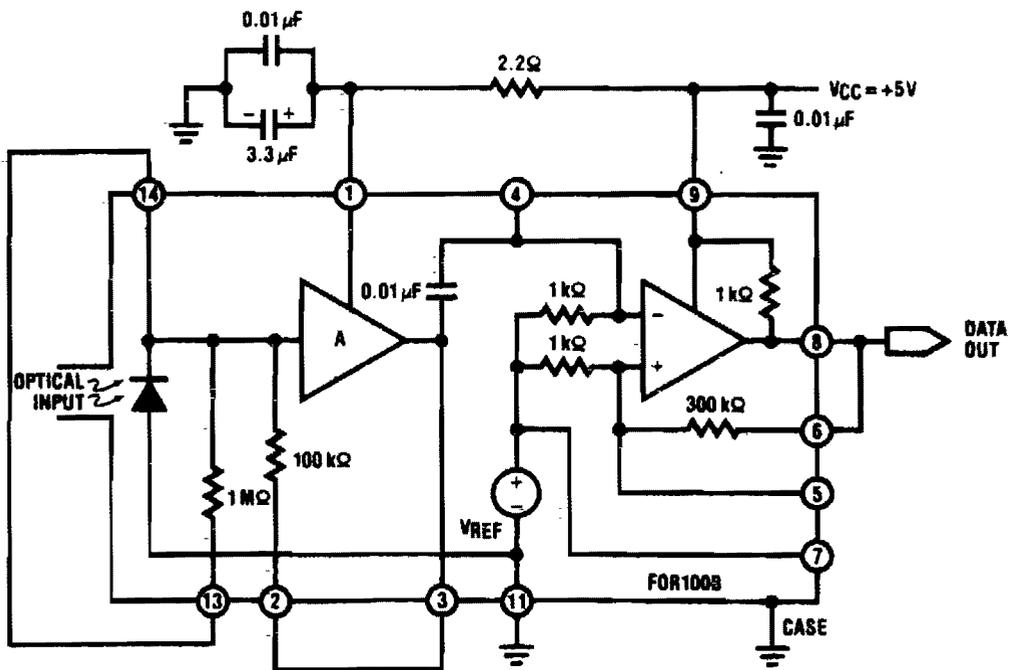


Fig. 31-6

32

Field Strength Meters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Cost Microwave Field Strength Meter
Sensitive Field-Strength Meter
Adjustable Sensitivity Field-Strength
Indicator

Field Strength Meter – 1.5 to 150 MHz
Simple Field Strength Meter
Untuned Field Strength Meter
Tuned Field Strength Meter

VOM Field Strength Meter

LOW COST MICROWAVE FIELD STRENGTH METER

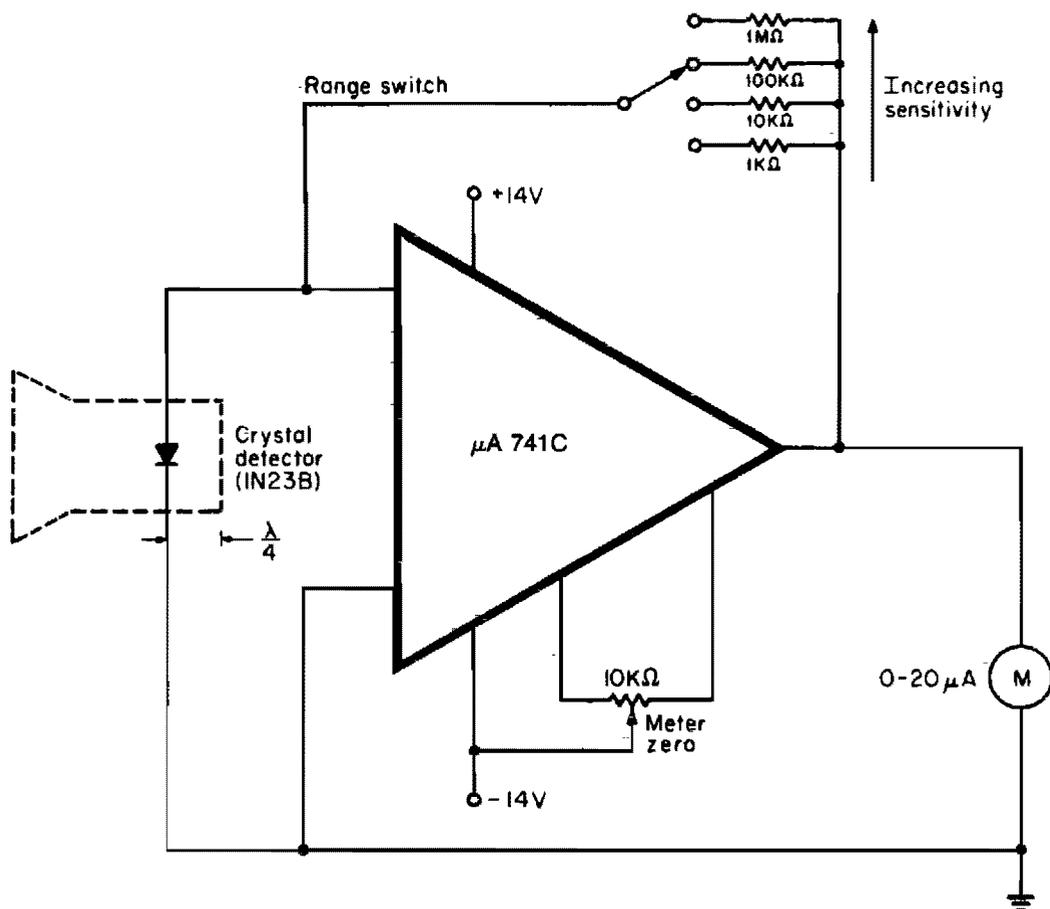


Fig. 32-1

Circuit Notes

When operating, a waveguide directs energy onto a crystal detector. The diode shown is for X-band operation. The waveguide is a 1½ inch piece of plastic tubing with the ends flared. The plastic is coated with an electroless copper solution to provide a conducting surface. The dimensions are not critical. For

calibrated readings, the meter is placed in a known field or else compared to a calibrated meter. To operate the meter, point it away from the signal. Switch the meter to the desired range, and adjust the zero control for a 0 reading. Then point the waveguide at the signal, and read field strength directly.

SENSITIVE FIELD-STRENGTH METER

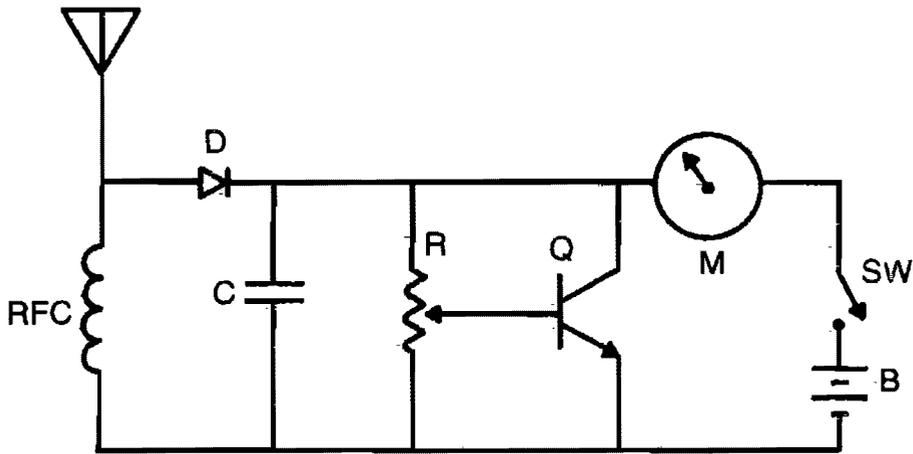


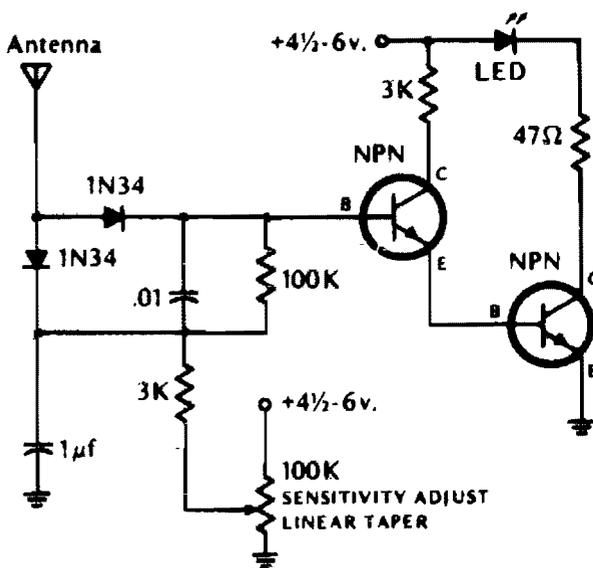
Fig. 32-2

Circuit Notes

Increased sensitivity gives field strength reading from low power transmitters. Operating range 3-30 MHz. To operate, adjust R for $\frac{1}{2}$ to $\frac{1}{2}$ scale reading. RFC = 2.5 mH choke, C =

1,000 pF, R = 50 K pot, M = 0 - 1 mA, D = 1N34 or 1N60 (Germanium), Q = NPN (RCASK3020, 2N3904 or equivalent).

ADJUSTABLE-SENSITIVITY FIELD-STRENGTH INDICATOR



Circuit Notes

The LED lights if the rf field is higher than the pre-set field strength level. Diodes should be germanium. Transistors (NPN) = 2N2222, 2N3393, 2N3904 or equivalent.

Fig. 32-3

FIELD STRENGTH METER - 1.5 to 150 MHz

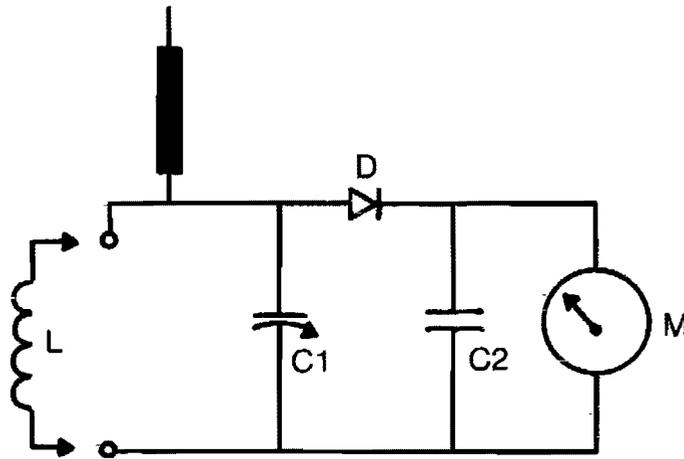


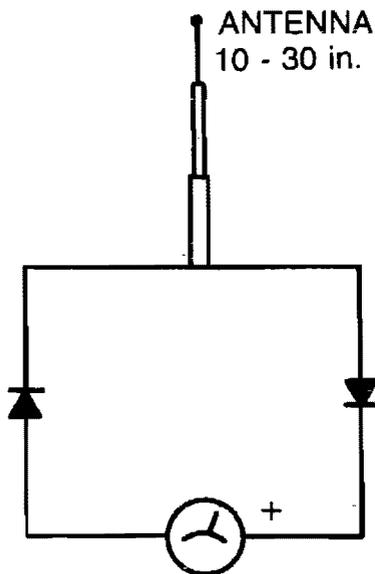
Fig. 32-4

Circuit Notes

The tuning range is determined by coil (L) dimensions and setting of C1. Coils can be plugged in for multirange use or soldered in place if only limited frequency range is of inter-

est. C1 = 36 pF variable, C2 = .0047 disc, D = 1N60 (germanium) and M = 0-1 mA meter. For increased sensitivity, use 50 μ A meter.

SIMPLE FIELD STRENGTH METER

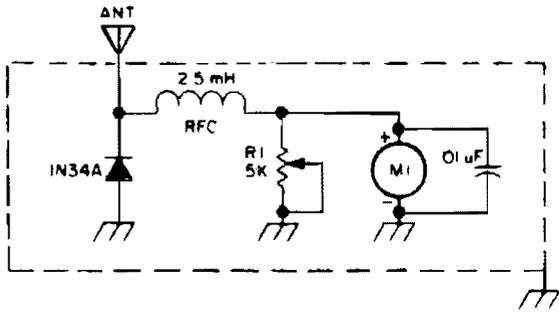


Circuit Notes

The circuit is frequency selective. It has been used from 2 meters through 160 meters. The telescoping antenna may be adjusted to its shortest length when working at 2 meters to keep the needle on the scale. Meter should be a 100 microamp to a 500 microamp movement. The diodes are germanium type, such as 1N34, etc. Silicon diodes will also work, but they are a bit less sensitive.

Fig. 32-5

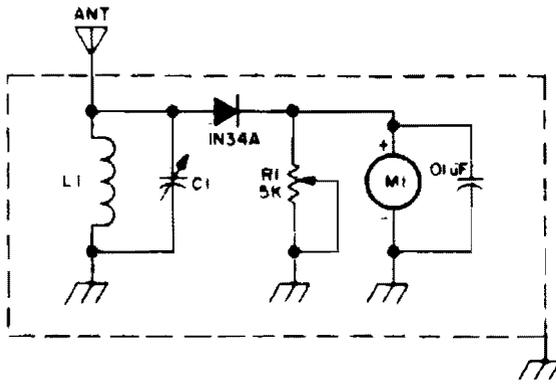
UNTUNED FIELD STRENGTH METER



Circuit Notes
Sensitivity is controlled by R1 and sensitivity of Meter M1.

Fig. 32-6

TUNED-FIELD STRENGTH METER



Circuit Notes
Resonant combination of L1 and C1 are selected to cover frequencies desired.

Fig. 32-7

VOM FIELD STRENGTH METER

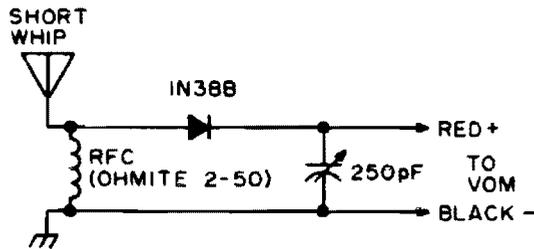


Fig. 32-8

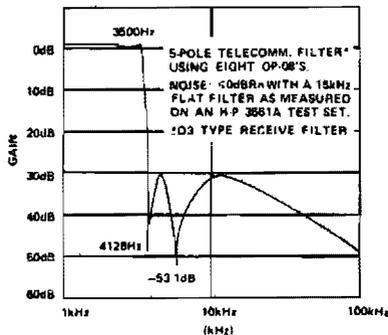
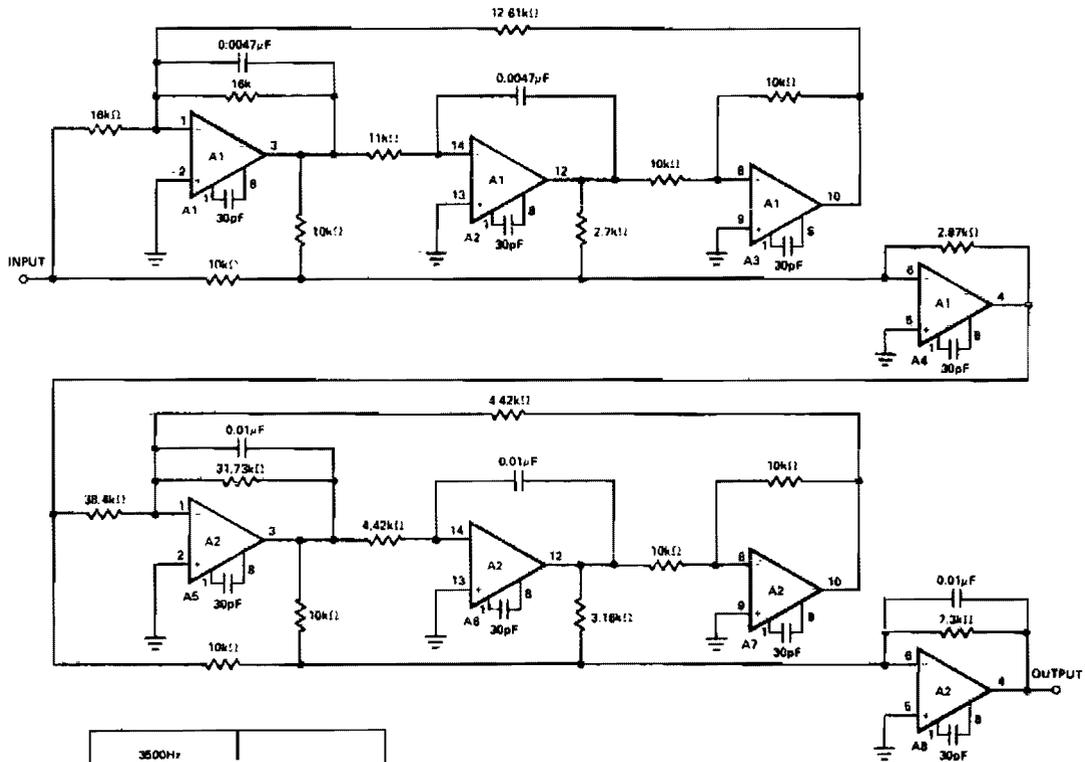
33

Filters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Five-Pole Active Filter
Digitally Tuned Low Power Active Filter
10 kHz Sallen-Key Low-Pass Filter
Fourth Order High-Pass Butterworth Filter
Tunable Notch Filter to Suppress Hum
Three Amplifier Notch Filter (or Elliptical Filter Building Block)
Selectable Bandwidth Notch Filter
4.5 MHz Notch Filter
High Q Notch Filter
Rejection Filter
Notch Filter Using the $\mu\text{A} 4136$ as a Gyrator
1 kHz Bandpass Active Filter
Bandpass Active Filter with 60 dB Gain
Multiple Feedback Bandpass Filter
Biquad RC Active Bandpass Filter
400 Hz Low-Pass Butterworth Active Filter
Variable Bandwidth Bandpass Active Filter
Low-Pass Filter
High Q Bandpass Filter
MFB Bandpass Filter for Multichannel Tone Decoder
Sallen-Key Second Order Low-Pass Filter
Three Amplifier Active Filter
Bandpass State Variable Filter
Universal State Variable Filter
500 Hz Sallen-Key Bandpass Filter
Filter Networks
Equal Component Sallen-Key Low-Pass Filter
Biquad Filter
Second Order State Variable Filter (1 kHz, $Q = 10$)
Biquad Filter
Tunable Active Filter
Active RC Filter for Frequencies up to 150 kHz
Pole Active Low-Pass Filter (Butterworth Maximally Flat Response)
Speech Filter (300 Hz .3 kHz Bandpass)
0.1 Hz to 10 Hz Bandpass Filter
High-Pass Active Filter
Second Order High-Pass Active Filter
High Pass Filter (High Frequency)
160 Hz Bandpass Filter
Multiple Feedback Bandpass Filter (1.0 kHz)
20 kHz Bandpass Active Filter
Rumble Filter Using LM387
Scratch Filter Using LM287

FIVE-POLE ACTIVE FILTER



The above realization of a type D3 receive filter is accomplished using eight OP-08's. As can be seen from the response curve, the $>30\text{dB}$ attenuation in the stop band requirement has been met. In addition, the noise performance of $<0\text{dB RN}$ has been measured. One of the unique features of the OP-08 is its low supply current of $800\mu\text{A}$ maximum. Thus the total supply drain for all eight op amps is only 4.8mA .

Fig. 33-1

DIGITALLY TUNED LOW POWER ACTIVE FILTER

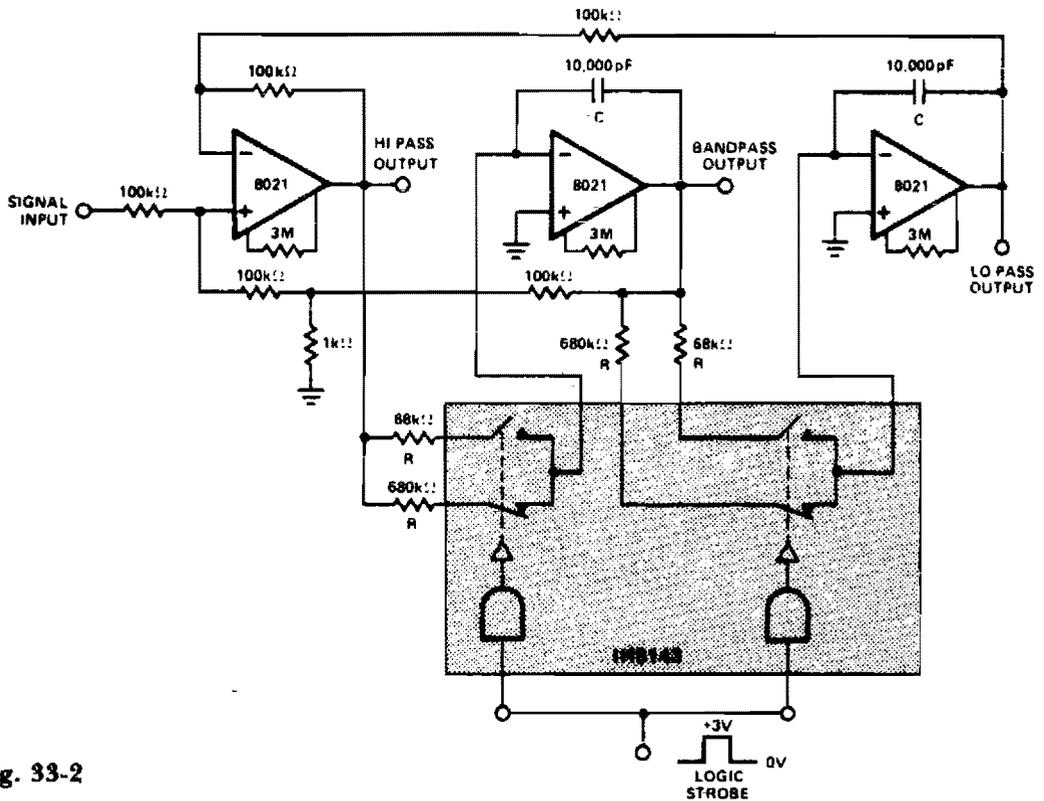


Fig. 33-2

Circuit Notes

Constant gain, constant Q, variable frequency filter which provides simultaneous low-pass, bandpass, and high-pass outputs. With the component values shown, center fre-

quency will be 235 Hz and 23.5 Hz for high and low logic inputs respectively, $Q = 100$, and gain = 100.

$$f_n = \text{center frequency} = \frac{1}{2\pi RC}$$

10 kHz SALLEN-KEY LOW-PASS FILTER

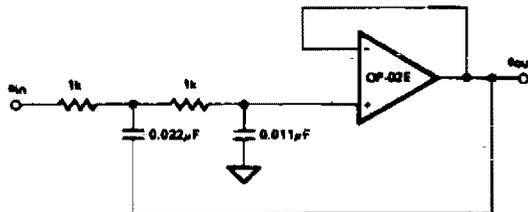
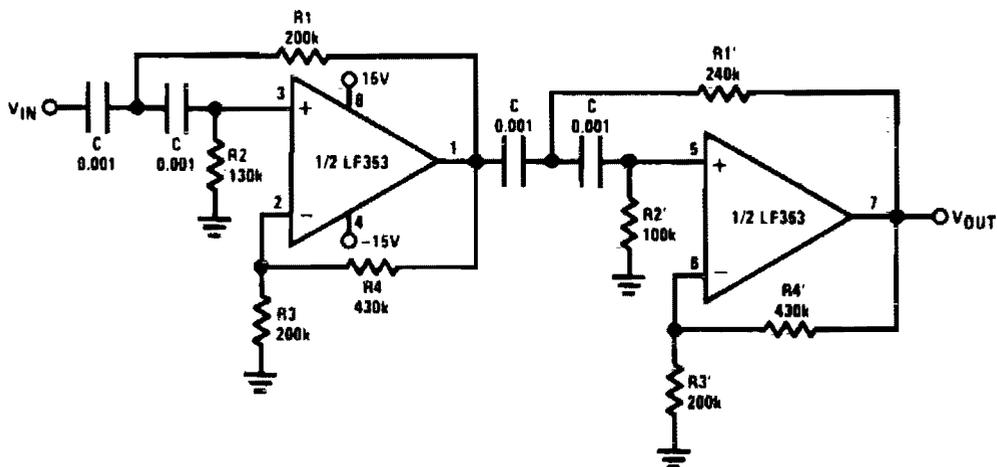


Fig. 33-3

FOURTH ORDER HIGH-PASS BUTTERWORTH FILTER



- Corner frequency (f_c) = $\sqrt{\frac{1}{R_1 R_2 C^2}} \cdot \frac{1}{2\pi} = \sqrt{\frac{1}{R_1' R_2' C^2}} \cdot \frac{1}{2\pi}$
- Passband gain (H_0) = $(1 + R_4/R_3)(1 + R_4'/R_3')$
- First stage $Q = 1.31$
- Second stage $Q = 0.541$
- Circuit shown uses closest 5% tolerance resistor values for a filter with a corner frequency of 1 kHz and a passband gain of 10

Fig. 33-4

TUNABLE NOTCH FILTER TO SUPPRESS HUM

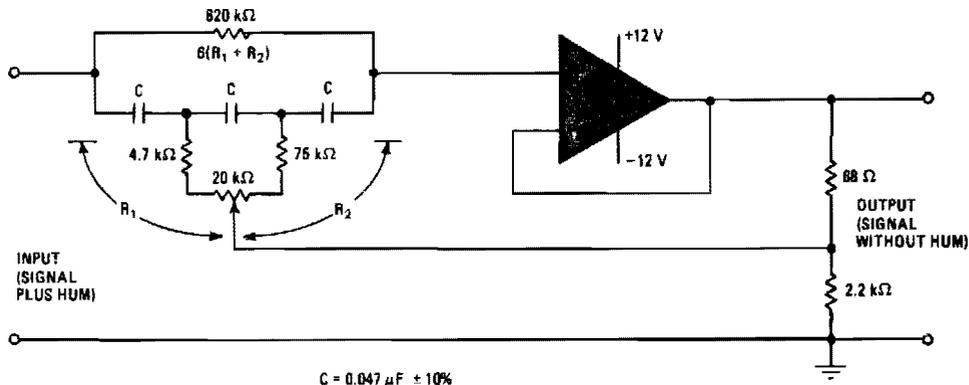


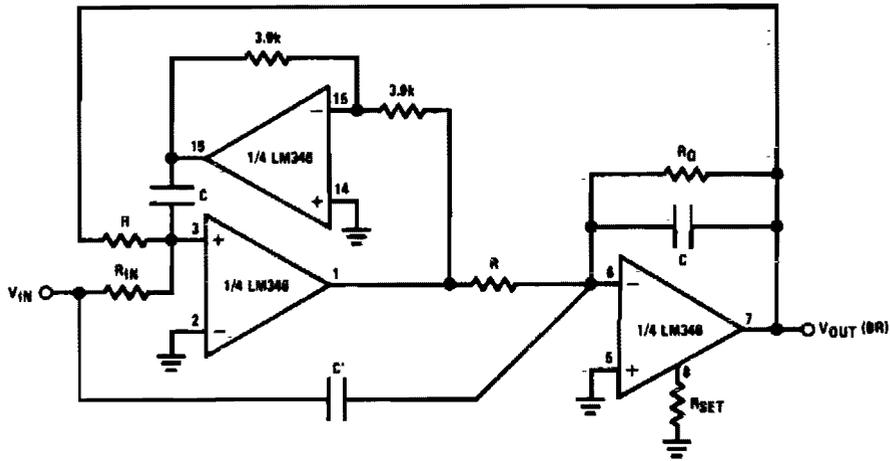
Fig. 33-5

Circuit Notes

This narrow-stop-band filter can be tuned by the pot to place the notch at any frequency from 45 to 90 Hz. It attenuates power-line hum

or other unwanted signals by at least 30 dB. Because the circuit uses wide-tolerance parts, it is inexpensive to build.

THREE-AMPLIFIER NOTCH FILTER (OR ELLIPTIC FILTER BUILDING BLOCK)



Circuit Synthesis Equations

$$R \times C = \frac{0.159}{f_0} ; R_Q = Q_0 \times R ; R_{IN} = \frac{0.159 \times f_0}{C' \times f_{notch}^2}$$

• For nothing but a notch output: $R_{IN} = R, C' = C$.

$$H_o(BR) \Big|_{f \ll f_{notch}} = \frac{R}{R_{IN}} H_o(BR) \Big|_{f \gg f_{notch}} = \frac{C'}{C}$$

Fig. 33-6

SELECTABLE BANDWIDTH NOTCH FILTER

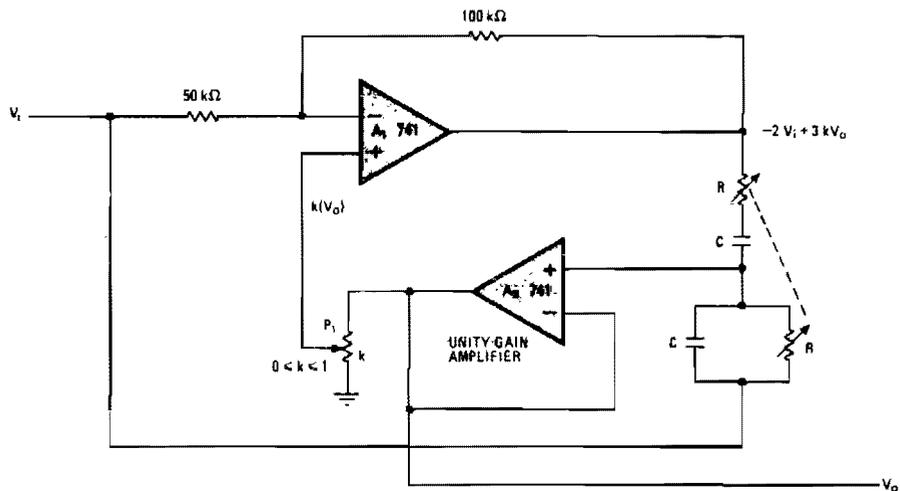


Fig. 33-7

Circuit Notes

This notch filter, which operates at up to 200 kHz, uses a modified Wien bridge to select bandwidth over which frequencies are re-

jected. RC components determine filter's center frequency, P1 selects notch bandwidth. Notch depth is fixed at about 60 dB.

4.5 MHz NOTCH FILTER

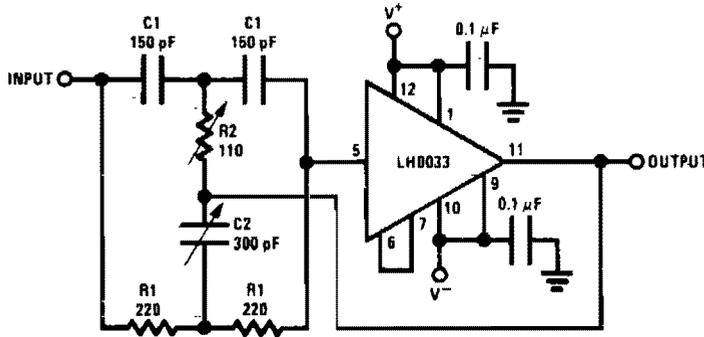


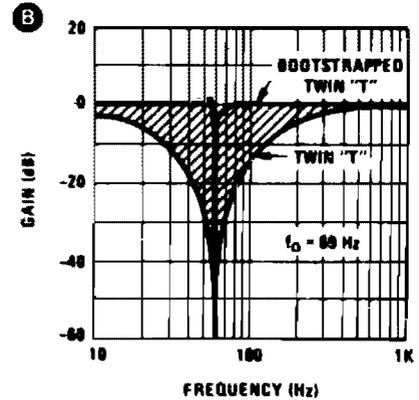
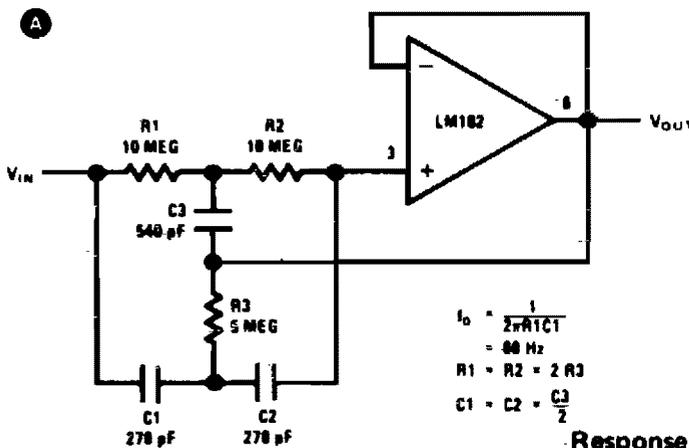
Fig. 33-8

Circuit Notes

Component value sensitivity is extremely critical, as are temperature coefficients and matching of the components. Best performance is attained when perfectly matched components are used and when the gain of the

amplifier is unity. To illustrate, the quality factor Q is very high as amplifier gain approaches 1 with all components matched (in fact, theoretically it approaches ∞) but decreases to about 12.5 with the amplifier gain at 0.98.

HIGH Q NOTCH FILTER



Response of High and Low Q Notch Filter

Fig. 33-9

Circuit Notes

A shows a twin-T network connected to an LM102 to form a high Q, 60 Hz notch filter. The junction of R3 and C3, which is normally connected to ground, is bootstrapped to the output of the follower. Because the output of the follower is a very low impedance, neither the

depth nor the frequency of the notch change; however, the Q is raised in proportion to the amount of signal fed back to R3 and C3. B shows the response of a normal twin-T and the response with the follower added.

REJECTION FILTER

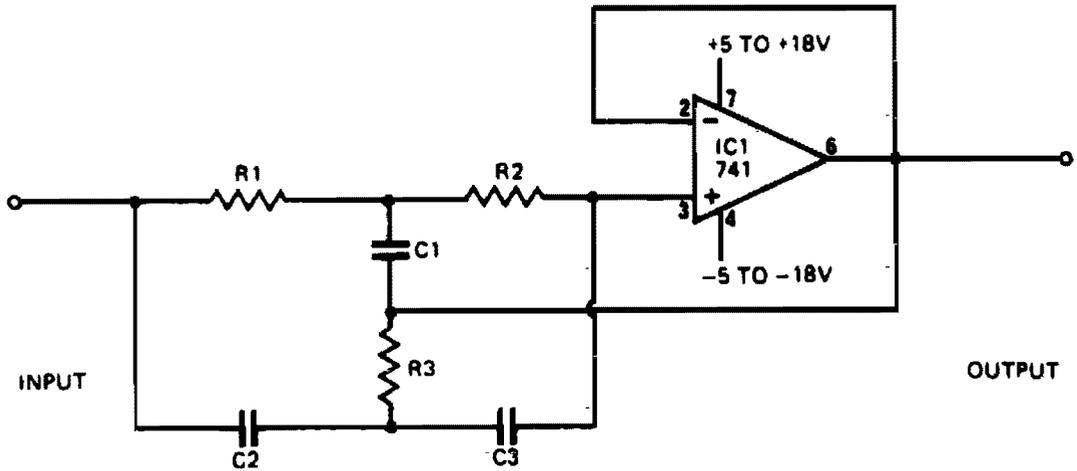


Fig. 33-10

Circuit Notes

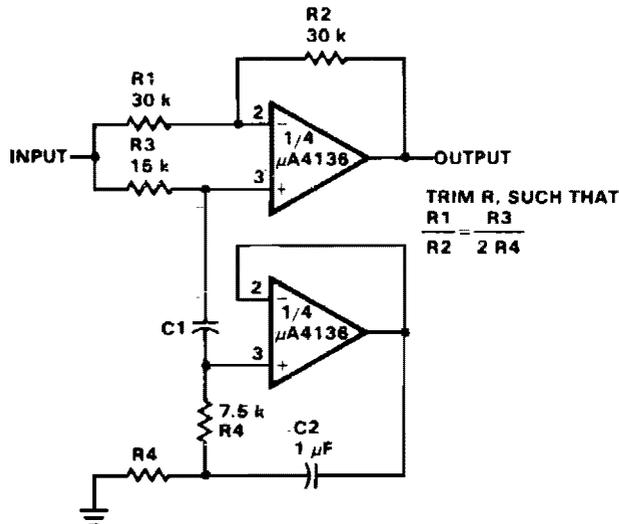
This narrowband filter using the 741 operational amplifier can provide up to 60 dB of rejection. With resistors equal to 100 K and capacitors equal to 320 pF, the circuit will reject 50 Hz. Frequencies within the range 1 Hz to 10 kHz may be rejected by selecting compo-

nents in accordance with the formula:

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

To obtain rejections better than 40 dB, resistors should be matched to 0.1% and capacitors to 1%.

NOTCH FILTER USING THE μ A4136 AS A GYRATOR



Notch Frequency as a Function of C1

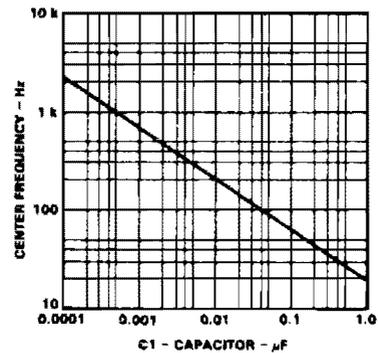


Fig. 33-11

1 kHz BANDPASS ACTIVE FILTER

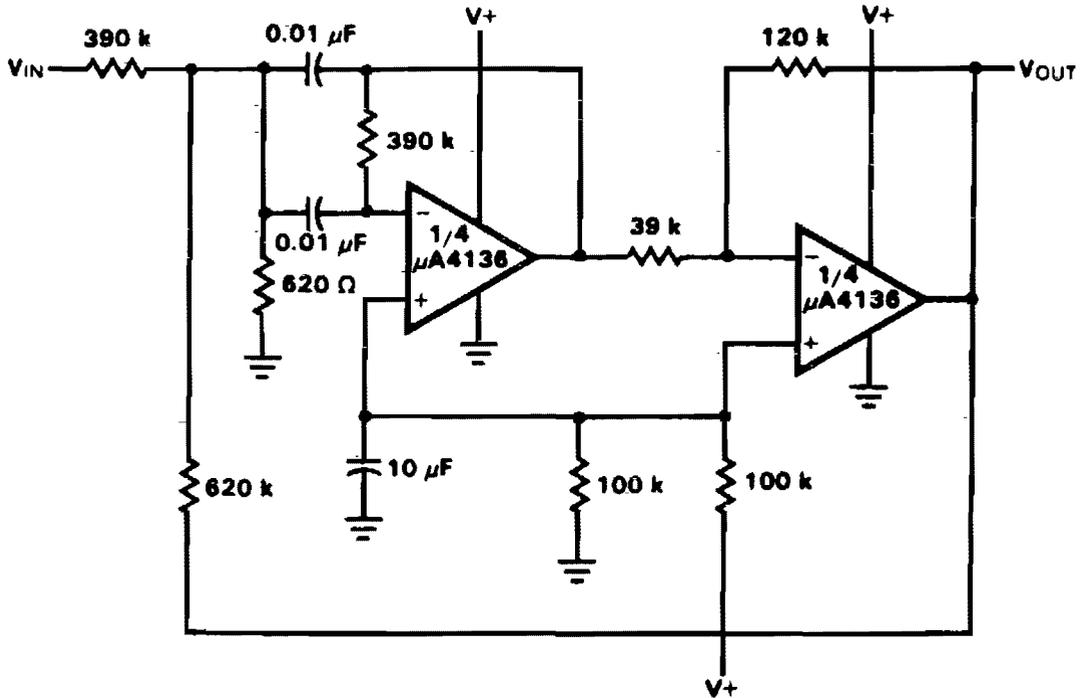
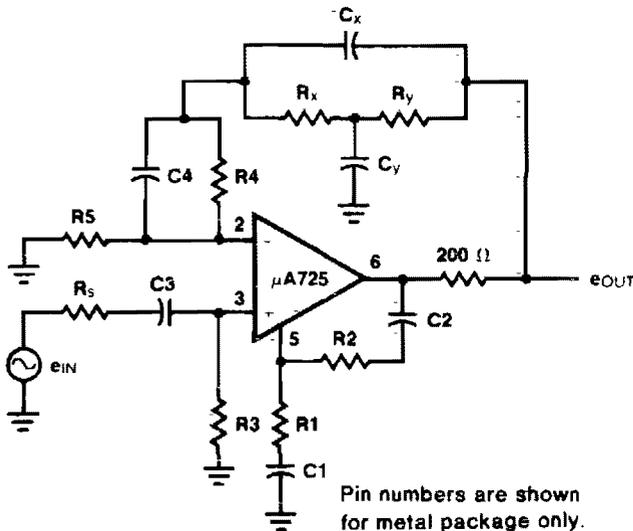


Fig. 33-12

BANDPASS ACTIVE FILTER WITH 60 dB GAIN



Pin numbers are shown for metal package only.

Active Filter Frequency Response

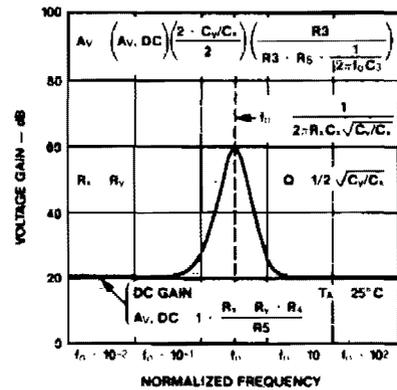
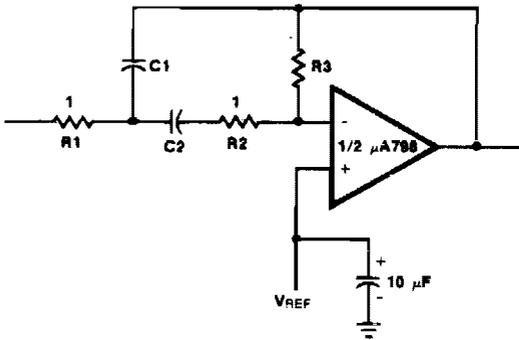


Fig. 33-13

MULTIPLE FEEDBACK BANDPASS FILTER



$f_0 = \Delta$
 f_0 = center frequency

$BW = \Delta$
 BW = Bandwidth

R in k Ω

C in μ F

$$Q = \frac{f_0}{BW} < 10$$

$$C1 = C2 = \frac{Q}{3}$$

$$\left. \begin{array}{l} R1 = R2 = 1 \\ R3 = 9Q^2 - 1 \end{array} \right\} \text{Use scaling factors in these expressions}$$

If source impedance is high or varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Design example:

given: $Q = 5$, $f_0 = 1$ kHz

Let $R1 = R2 = 10$ k Ω

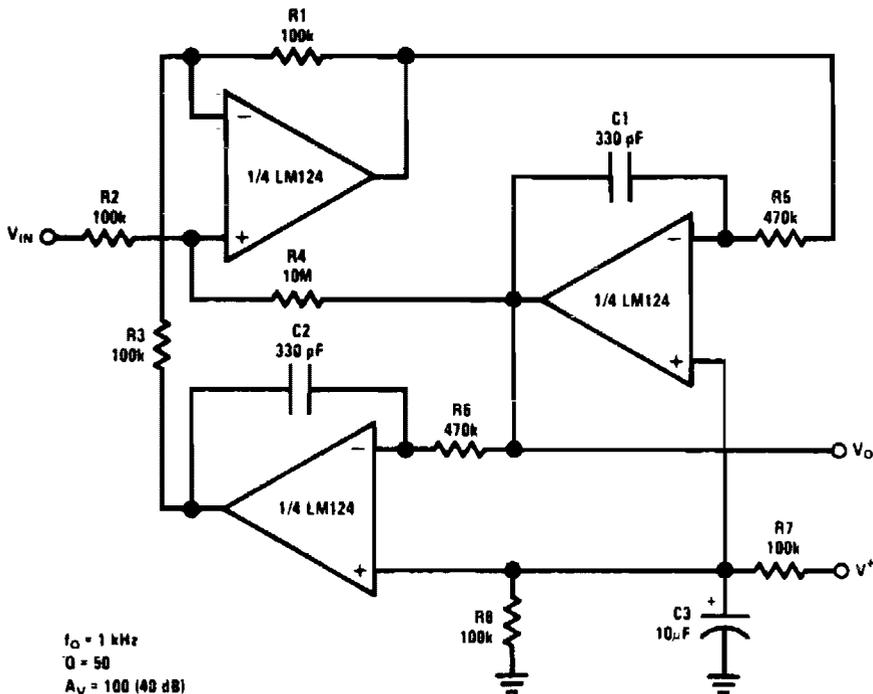
then $R3 = 9(5)^2 - 10$

$R3 = 215$ k Ω

$C = \frac{5}{3} = 1.6$ nF

Fig. 33-14

BIQUAD RC ACTIVE BANDPASS FILTER



$f_0 = 1$ kHz
 $Q = 50$
 $A_v = 100$ (40 dB)

Fig. 33-15

400 Hz LOW-PASS BUTTERWORTH ACTIVE FILTER

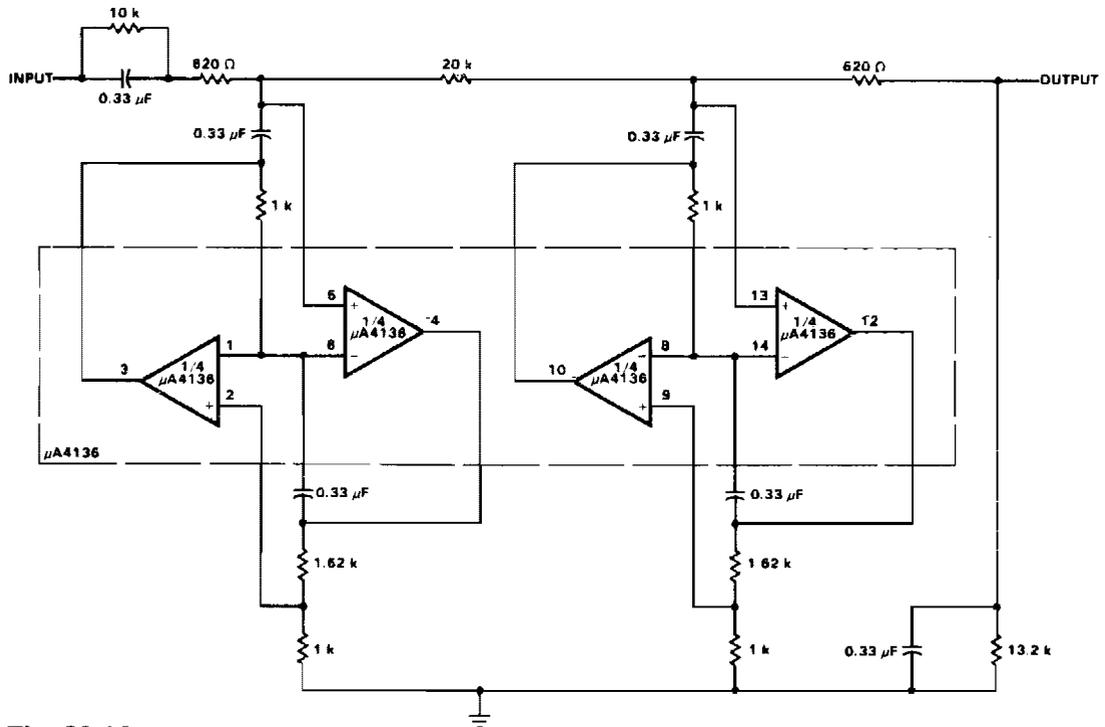


Fig. 33-16

VARIABLE BANDWIDTH BANDPASS ACTIVE FILTER

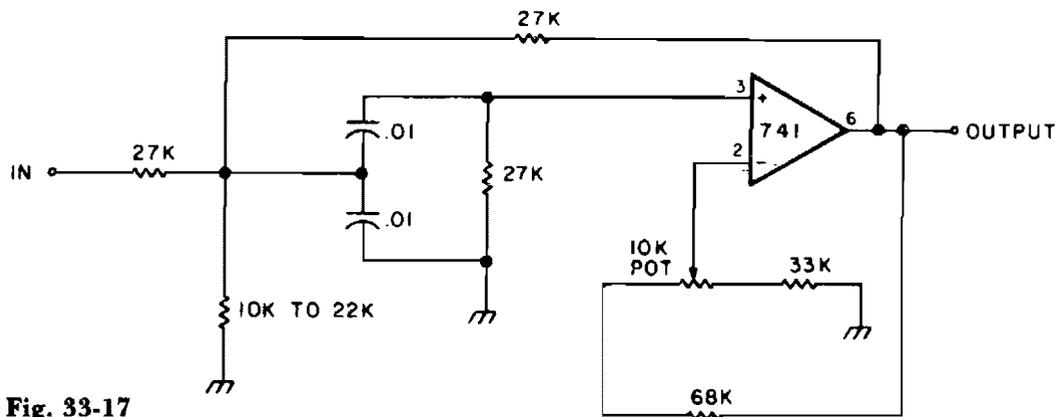


Fig. 33-17

Circuit Notes

This circuit has adjustable bandwidth with values for a center frequency of about 800 Hz. The 10.K pot adjusts bandwidth from approximately ± 350 Hz to ± 140 Hz at 3 dB down points.

LOW-PASS FILTER

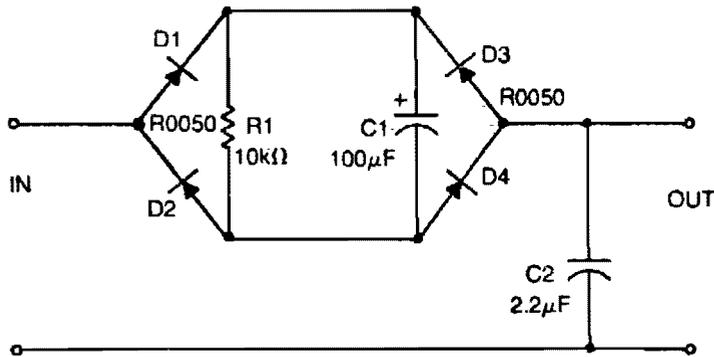


Fig. 33-18

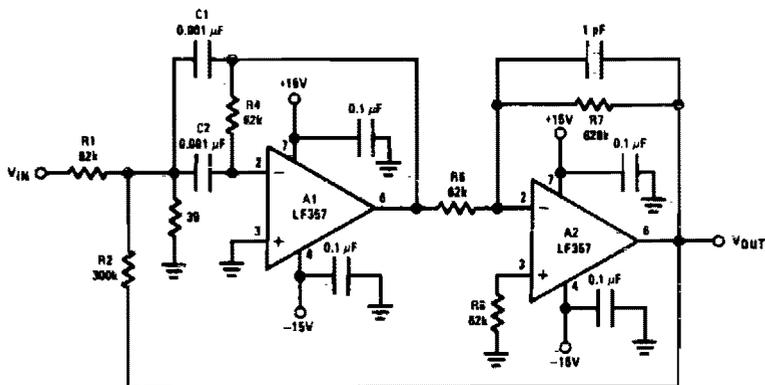
D1, D2, D3, D4—HEP R0050 C2—2.2μF
 C1—100μF, 50V electrolytic R1—10kΩ, 1/2W

Circuit Notes

This nonlinear, passive filter circuit rejects ripple (or unwanted but fairly steady voltage) without appreciably affecting the rise time of a signal. The circuit works best when the signal level is considerably lower than the

unwanted ripple, provided the ripple level is fairly constant. The circuit has characteristics similar to two peak-detecting sample-and-hold circuits in tandem with a voltage averager.

HIGH Q BANDPASS FILTER



- By adding positive feedback (R2) Q increases to 40
- $f_{BP} = 100 \text{ kHz}$

$$\frac{V_{OUT}}{V_{IN}} = 10\sqrt{Q}$$

- Clean layout recommended
- Response to a 1 Vp-p tone burst: 300 μs

Fig. 33-19

MFB BANDPASS FILTER FOR MULTICHANNEL TONE DECODER

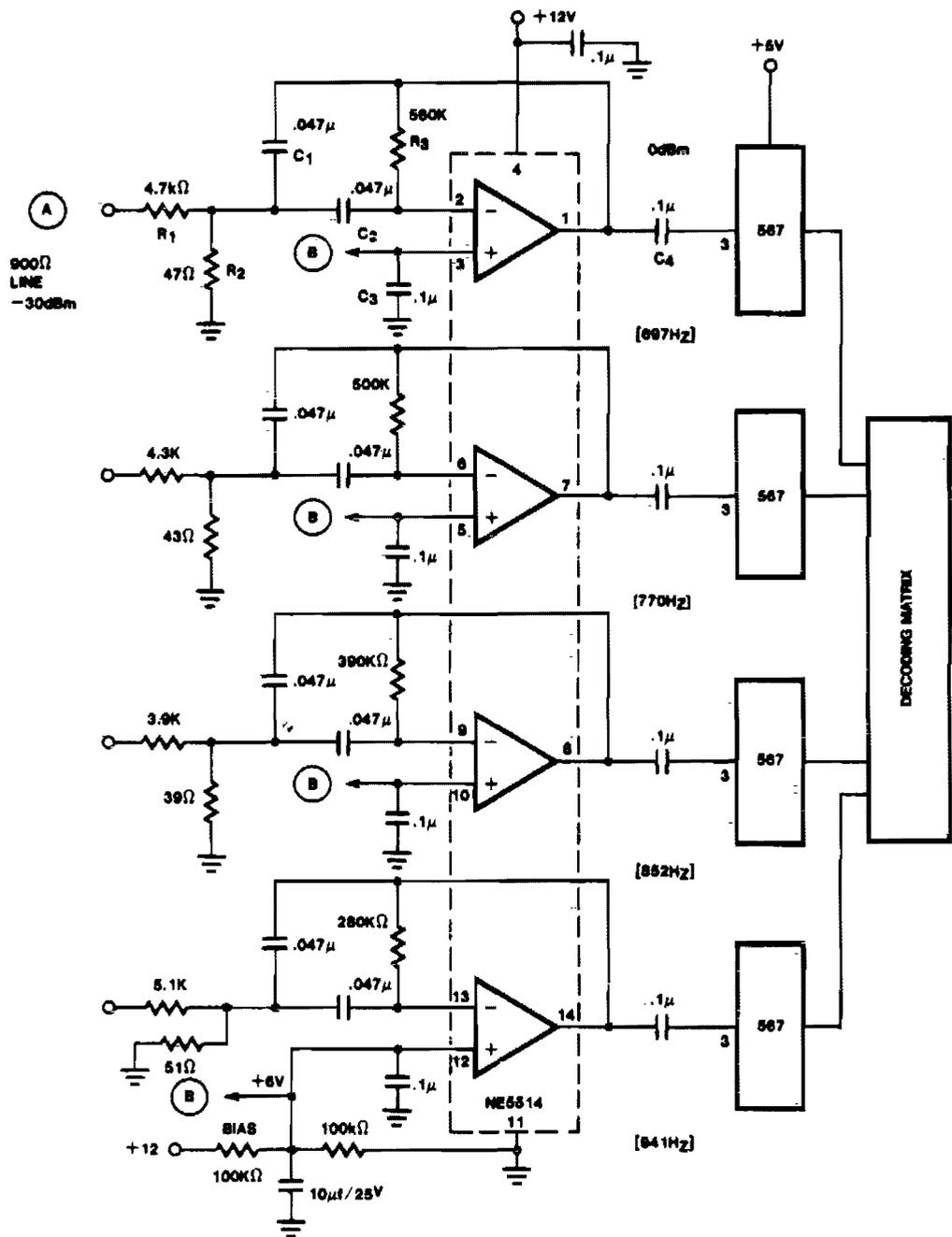
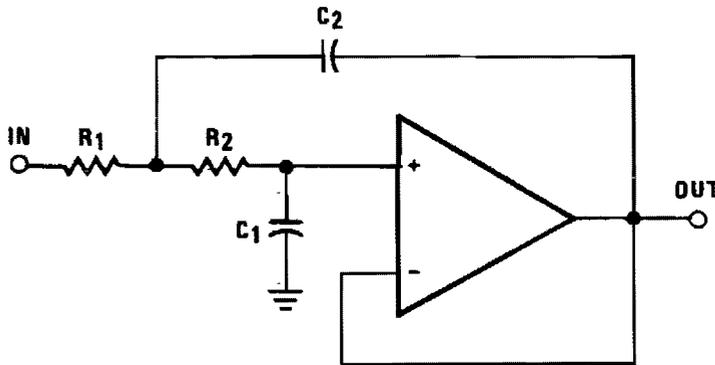


Fig. 33-20

SALLEN-KEY SECOND ORDER LOW-PASS FILTER

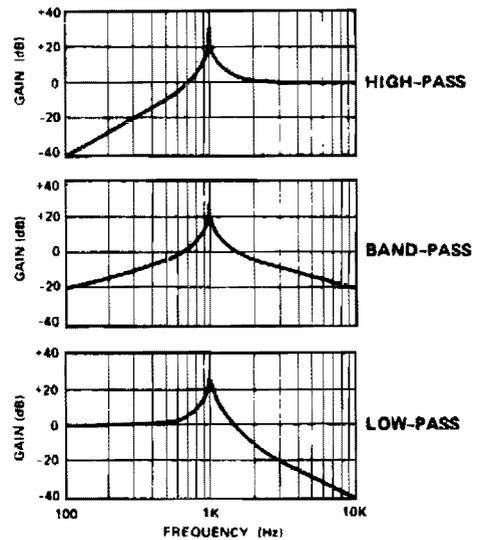
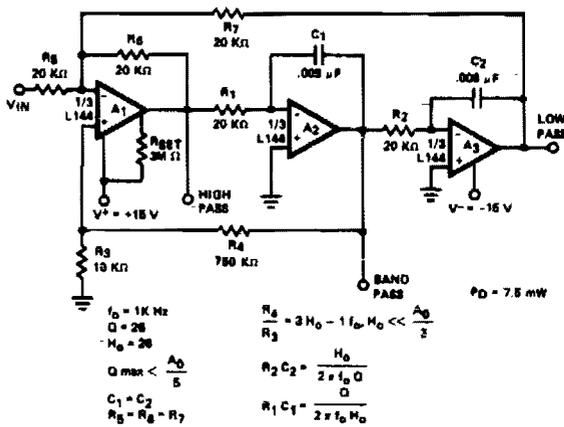


NOTES:

1. Make $R_1 = R_2$
2. $f_c = \frac{1}{2 R_1 \sqrt{C_1 C_2}}$
3. $Q = \frac{1}{2} \sqrt{\frac{C_2}{C_1}}$

Fig. 33-21

THREE AMPLIFIER ACTIVE FILTER



Bode plots of Active Filter Output

Fig. 33-22

Circuit Notes

The active filter is a state variable filter with bandpass, high-pass and low-pass outputs. It is a classical analog computer method of implementing a filter using three amplifiers and only two capacitors.

BANDPASS STATE VARIABLE FILTER

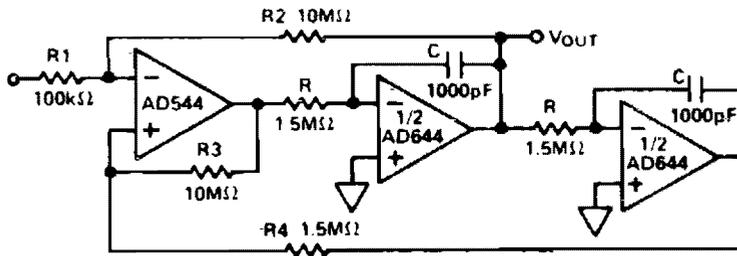
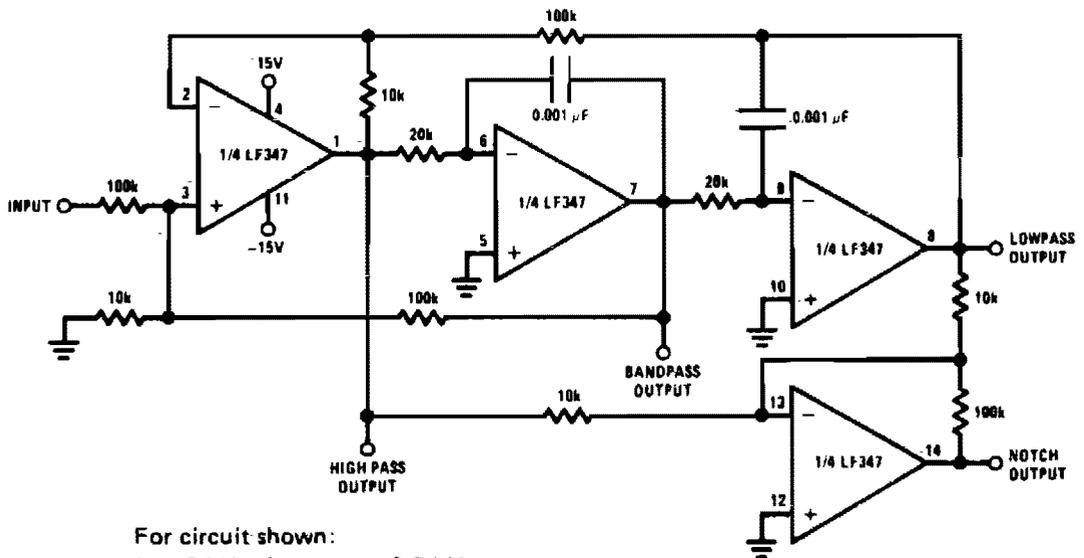


Fig. 33-23

$f_o = \text{CENTER FREQUENCY} = 1/2 \pi R_C$ Q_o IS ADJUSTABLE BY VARYING R_2
 $Q_o = \text{QUALITY FACTOR} = \frac{R_1 + R_2}{2R_1}$ f_o IS ADJUSTABLE BY VARYING R OR C
 $H_o = \text{GAIN AT RESONANCE} = R_2/R_1$
 $R_3 = R_4 = 10^8/f_o$

UNIVERSAL STATE VARIABLE FILTER



For circuit shown:
 $f_o = 3 \text{ kHz}$, $f_{\text{NOTCH}} = 9.5 \text{ kHz}$
 $Q = 3.4$
 Passband gain:
 Highpass - 0.1
 Bandpass - 1
 Lowpass - 1
 Notch - 10

- $f_o \times Q \leq 200 \text{ kHz}$
- 10V peak sinusoidal output swing without slew limiting to 200 kHz
- See LM348 data sheet for design equations

Fig. 33-24

500 Hz SALLEN-KEY BANDPASS FILTER

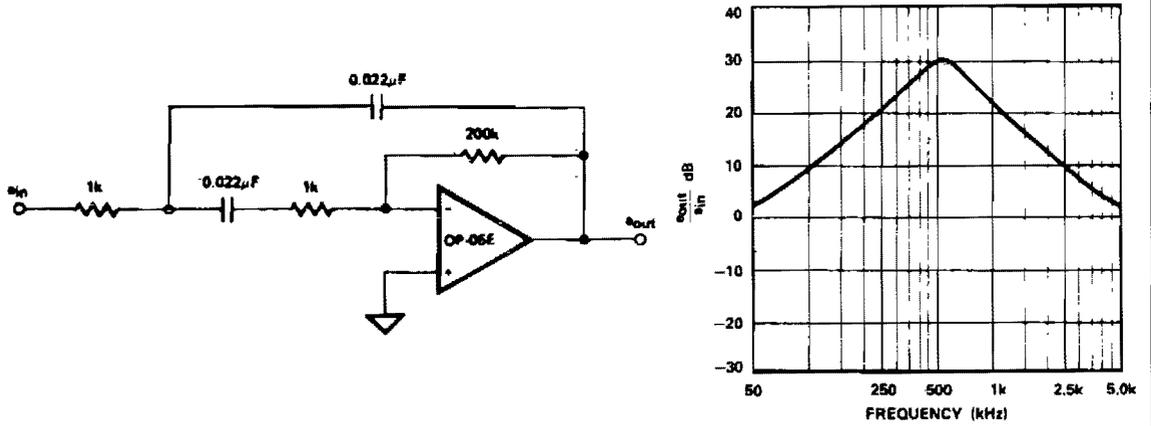
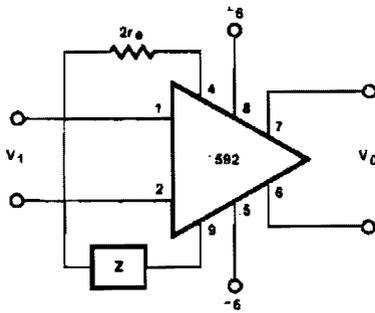


Fig. 33-25

FILTER NETWORKS



$$\frac{V_0(s)}{V_1(s)} \approx \frac{1.4 \times 10^4}{Z(s) + 2r_e}$$

$$\approx \frac{1.4 \times 10^4}{Z(s) + 32}$$

BASIC CONFIGURATION

Z NETWORK	FILTER TYPE	$V_0(s)$ TRANSFER $V_1(s)$ FUNCTION
	LOW PASS	$\frac{1.4 \times 10^4}{L} \left[\frac{1}{s + R/L} \right]$
	HIGH PASS	$\frac{1.4 \times 10^4}{R} \left[\frac{s}{s + 1/RC} \right]$
	BAND PASS	$\frac{1.4 \times 10^4}{L} \left[\frac{s}{s^2 + R/L s + 1/LC} \right]$
	BAND REJECT	$\frac{1.4 \times 10^4}{R} \left[\frac{s^2 + 1/LC}{s^2 + 1/LC + s/RC} \right]$

NOTE

In the networks above, the R value used is assumed to include $2r_e$, or approximately 32Ω .

Fig. 33-26

EQUAL COMPONENT SALLEN-KEY LOW-PASS FILTER

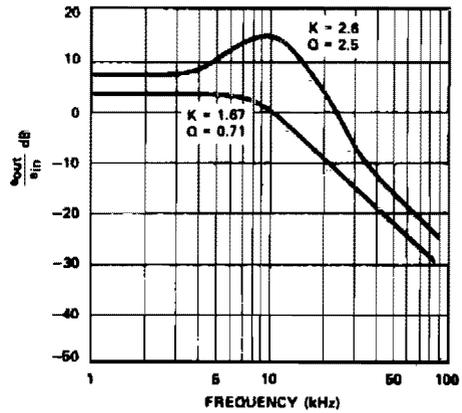
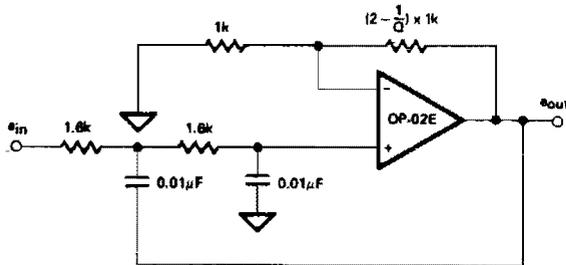


Fig. 33-27

Equal R, Equal C Sallen-Key Response

BIQUAD FILTER

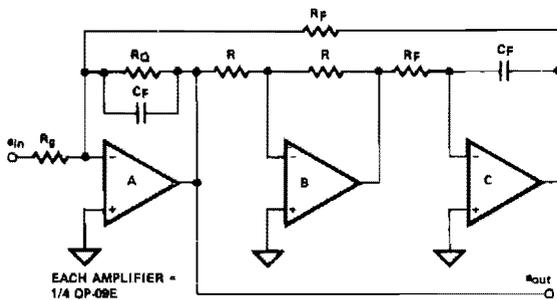


Fig. 33-28

Circuit Notes

The biquad filter, while appearing very similar to the state-variable filter, has a bandwidth that is fixed regardless of center frequency. This type of filter is useful in applications such as spectrum analyzers, which require a filter with a fixed bandwidth.

SECOND ORDER STATE VARIABLE FILTER (1 kHz, Q = 10)

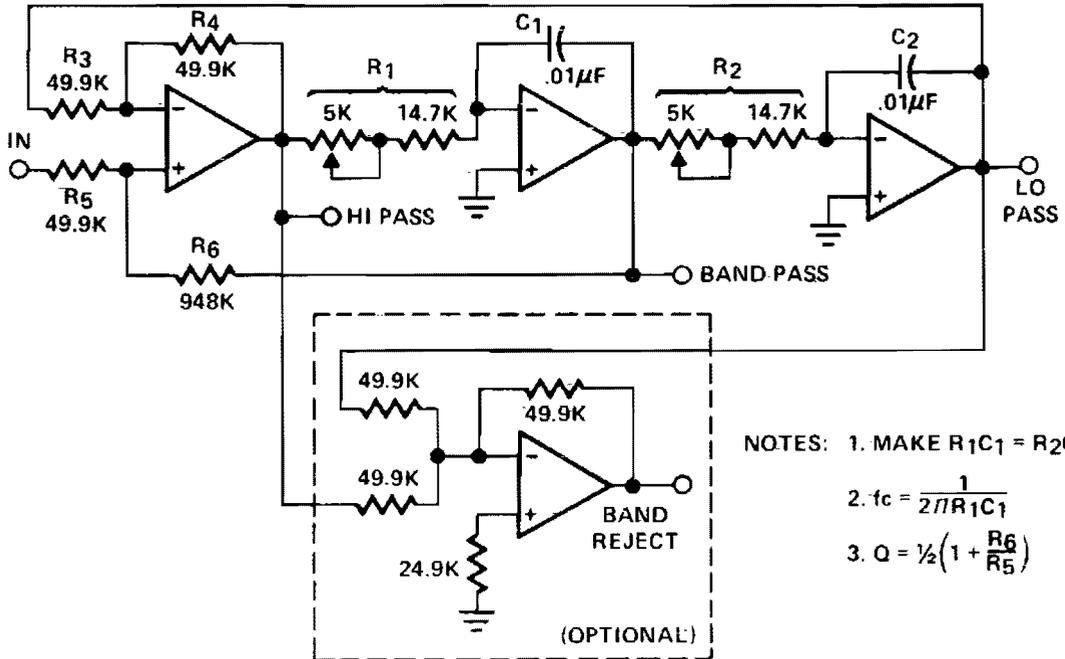


Fig. 33-29

BIQUAD FILTER

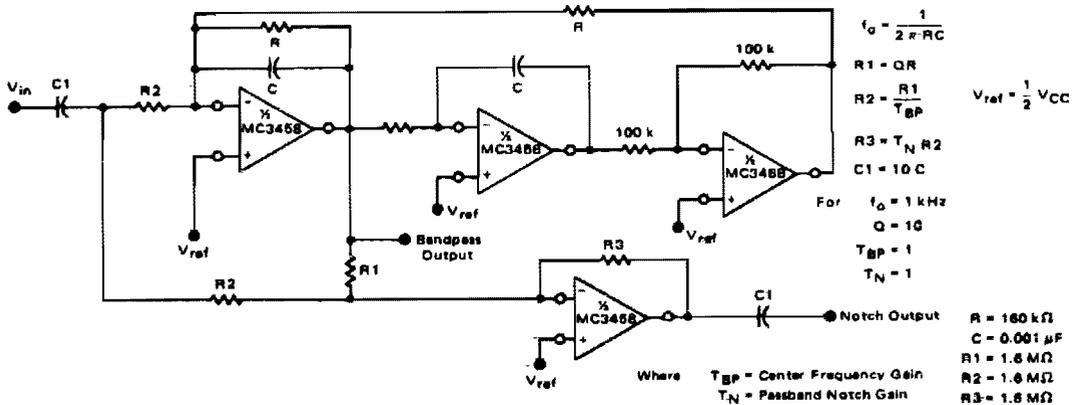


Fig. 33-30

TUNABLE ACTIVE FILTER

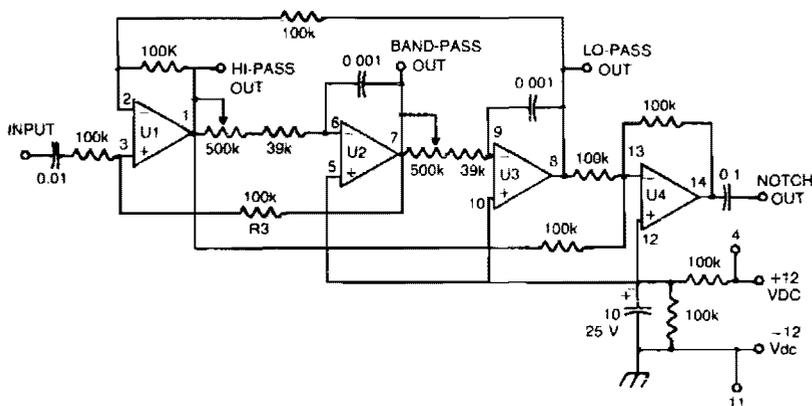


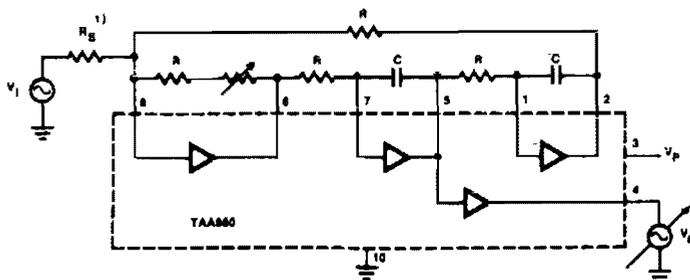
Fig. 33-31

Circuit Notes

The high-pass and low-pass outputs covering the range of 300 Hz to 3000 Hz have been summed in the fourth op amp to provide a notch

output. The potentiometers must have a reversing the range of 300 Hz to 3000 Hz have been summed in the fourth op amp to provide a notch center frequency is 1 kHz, with a Q of 50.

ACTIVE RC FILTER FOR FREQUENCIES UP TO 150 kHz



R = 10kΩ

This frequency range can be extended to 200kHz if a feed forward capacitor is connected between pin 5 and 8

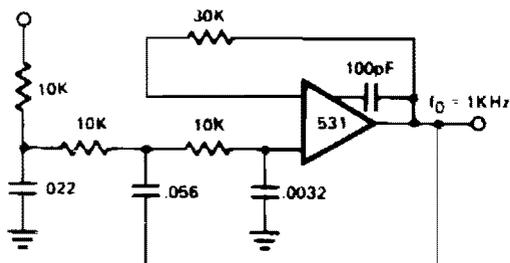
Fig. 33-32

f	Frequency	$\frac{1}{2\pi RC}$	
Vp	Supply voltage	6	V
Q	Filter performance at TA = 25°C	40 to 55	
Q	at TA = -30 to +65°C	35 to 55	
V1	Input voltage	400	mV
V0	Output voltage	400	mV
dist	Distortion at V0 = 350mV	2	%
S/N	S/N ratio at V0 = 400mV	50	dB
Rs	Input resistor*	470	kΩ

*NOTE

Value of input resistor to be determined for $\frac{V_0}{V_1} = 0.90$ to 1.1.

POLE ACTIVE LOW-PASS FILTER (BUTTERWORTH MAXIMALLY FLAT RESPONSE)



*Reference—EDN Dec. 15, 1970
Simplify 3-Pole Active Filter Design
A. Paul Brokow

RESPONSE OF 3-POLE ACTIVE BUTTERWORTH MAXIMALLY FLAT FILTER

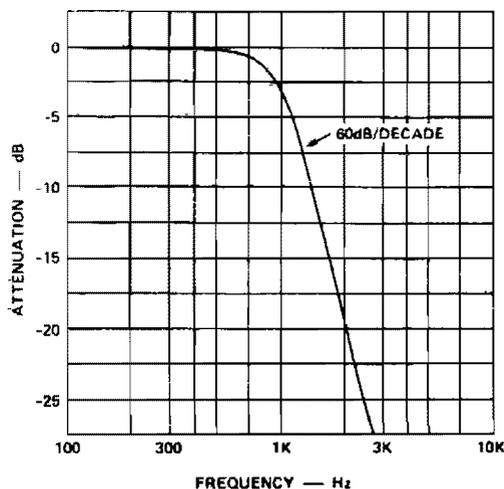
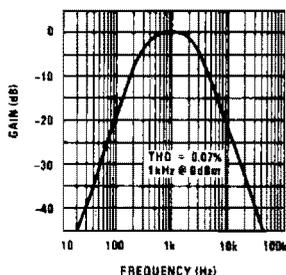
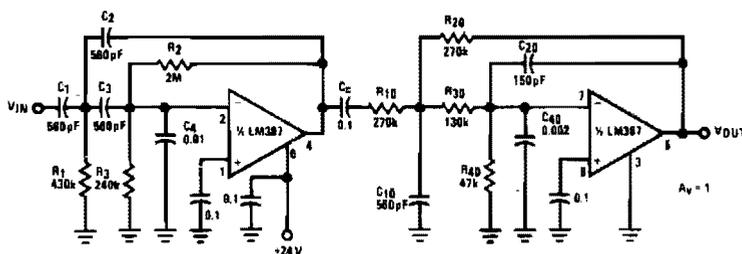


Fig. 33-33

SPEECH FILTER (300 Hz .3 kHz BANDPASS)



Speech Filter Frequency Response

Fig. 33-34

0.1 Hz TO 10 Hz BANDPASS FILTER

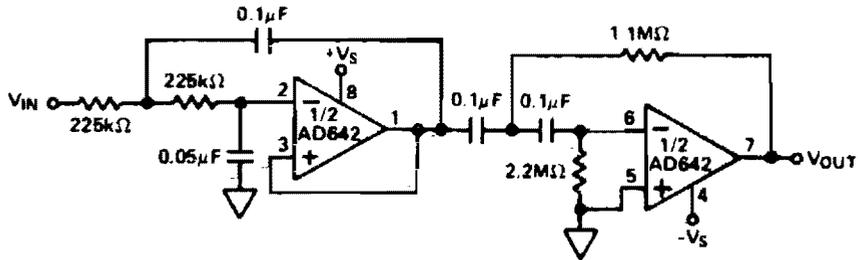


Fig. 33-35

HIGH-PASS ACTIVE FILTER

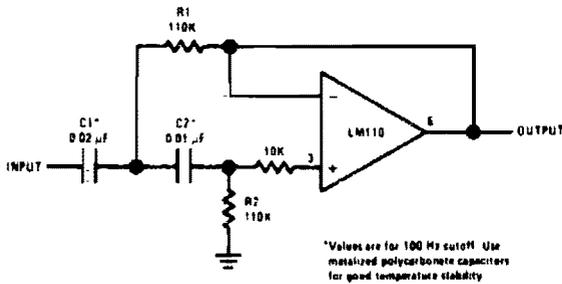
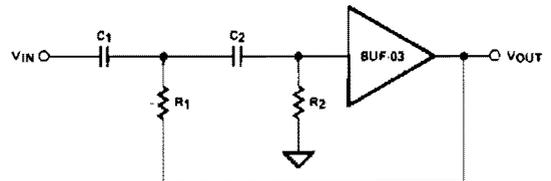


Fig. 33-36

HIGH-PASS FILTER (HIGH FREQUENCY)



$$\omega_c = \left(\frac{1}{R_1 R_2 C_1 C_2} \right)^{1/2}$$

IF $C_1 = C_2 = C$, THEN

$$Q = \frac{(R_1 R_2)^{1/2}}{2}$$

f_c Hz	C pF	R1 Ω	R2 Ω	Q
100K	220	2.06K	1.02K	0.71

Fig. 33-38

SECOND ORDER HIGH-PASS ACTIVE FILTER

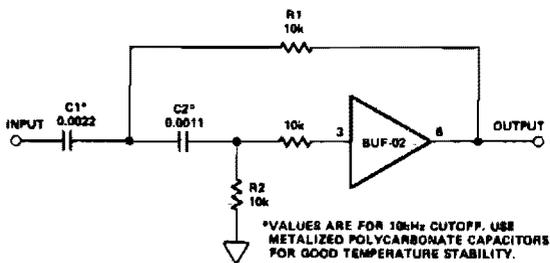


Fig. 33-37

160 Hz BANDPASS FILTER

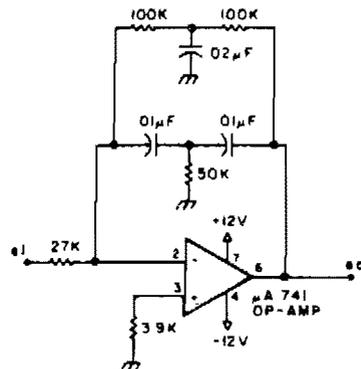


Fig. 33-39

MULTIPLE FEEDBACK BANDPASS FILTER (1.0 kHz)

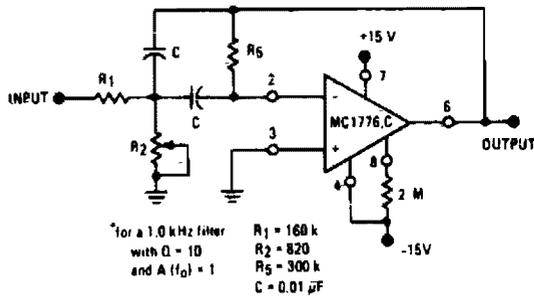


Fig. 33-40

RUMBLE FILTER USING LM387

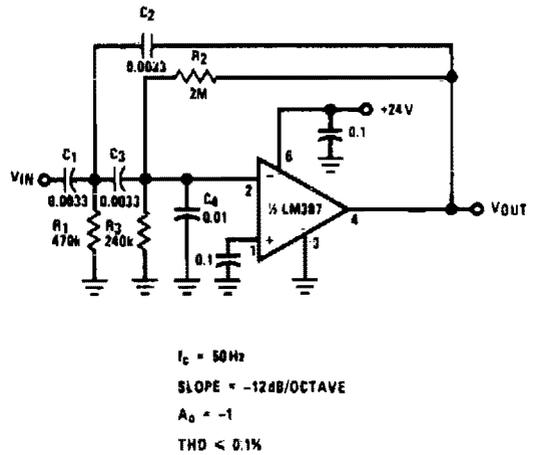


Fig. 33-42

20 kHz BANDPASS ACTIVE FILTER

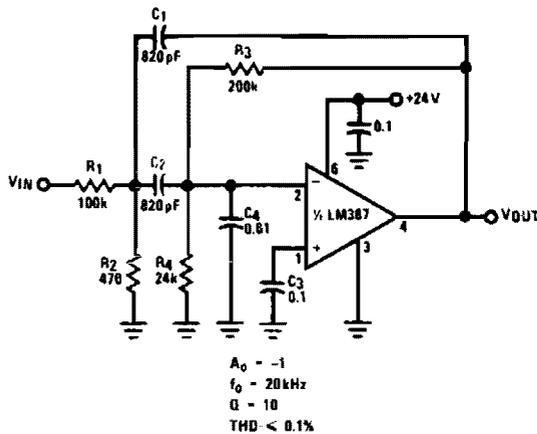


Fig. 33-41

SCRATCH FILTER USING LM387

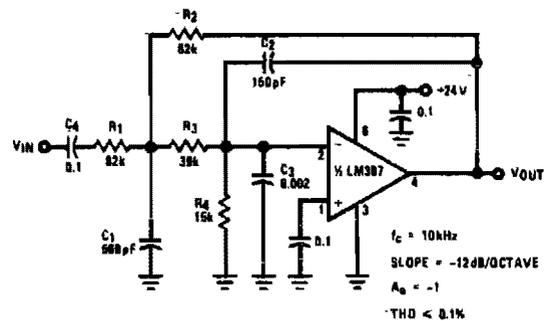


Fig. 33-43

34

Flashers and Blinkers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Auto, Boat, or Barricade Flasher	Low Voltage Flasher
Flip-Flop Flasher	1 A Lamp Flasher
Flashlight Finder	Fast Blinker
Low Frequency Lamp Flasher/Relay Driver	3 V Flasher
Low Cost Ring Counter	Incandescent Bulb Flasher
Ring Counter for Incandescent Lamps	Flasher for 4 Parallel LEDs
Dual LED CMOS Flasher	LED Booster
Automatic Safety Flasher	Safe, High Voltage Flasher
Neon Blinker	Alternating Flasher
Transistorized Flasher	Variable Flasher
Flasher/Light Control	Emergency Lantern/Flasher
Neon Tube Flasher	High Efficiency Parallel Circuit Flasher
Dc Flasher with Adjustable On and Off Time	Minimum Power Flasher

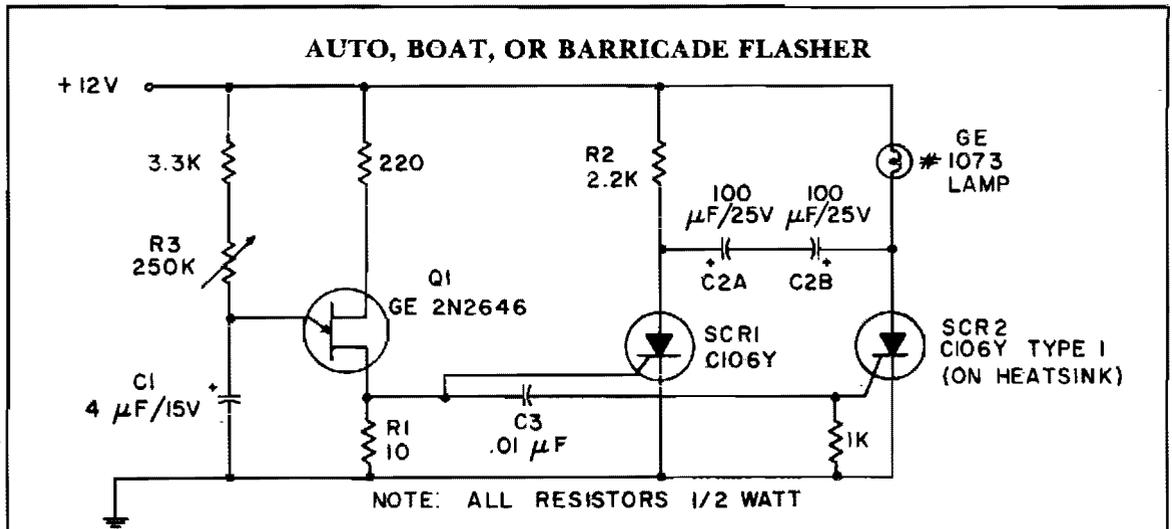


Fig. 34-1

Circuit Notes

Because of its ability to withstand the heavy inrush currents, this incandescent lamp flasher uses the C106 SCR. With the components shown, the flash-rate is adjustable by potentiometer R3 within the range of 36 flashes per minute to 160 flashes per minute.

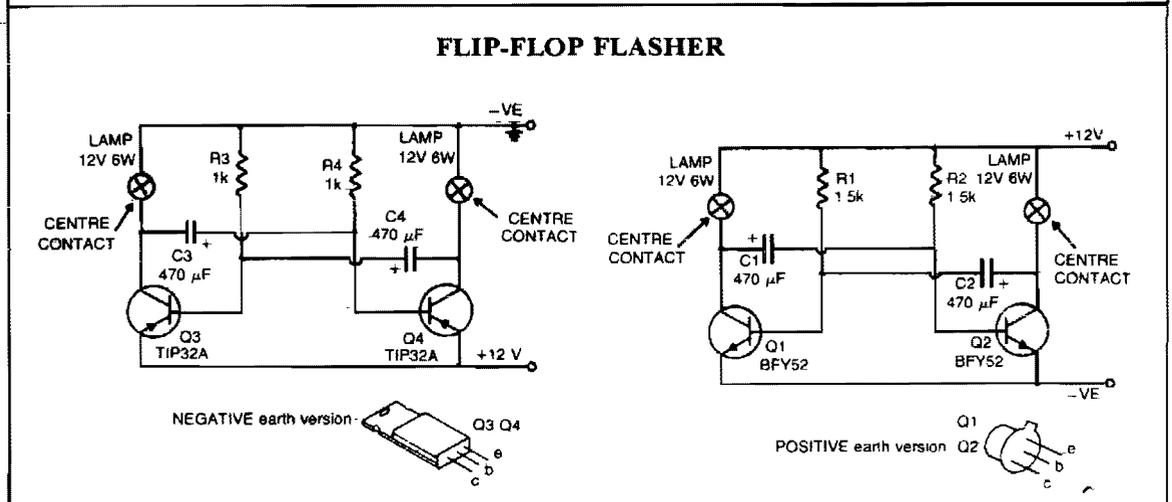
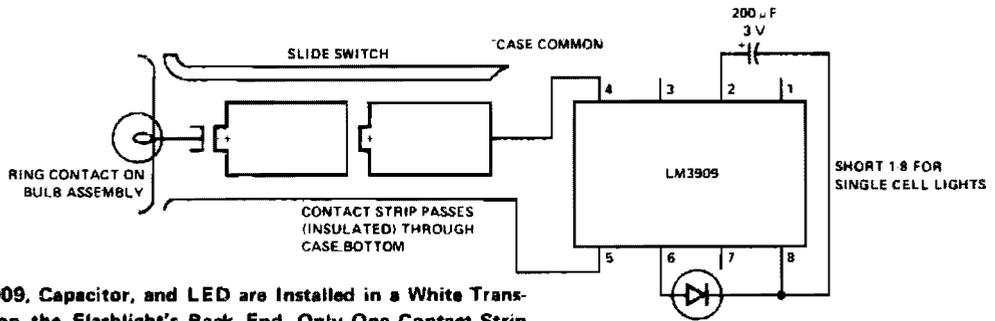


Fig. 34-2

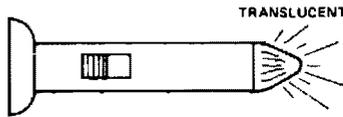
Circuit Notes

The flashing action is provided by a simple astable multivibrator timed to give a flashing rate of about 60 flashes for each lamp per minute. Circuit for positive earth systems uses NPN transistors. The other uses PNP transistors.

FLASHLIGHT FINDER



Note: LM3909, Capacitor, and LED are Installed in a White Translucent Cap on the Flashlight's Back End. Only One Contact Strip (in Addition to the Case Connection) is Needed for Flasher Power. Drawing Current Through the Bulb Simplifies Wiring and Causes Negligible Loss Since Bulb Resistance Cold is Typically Less than 2Ω .



Note: Winking LED Inside, Locates Light in Total Darkness

Fig. 34-3

LOW FREQUENCY LAMP FLASHER/RELAY DRIVER

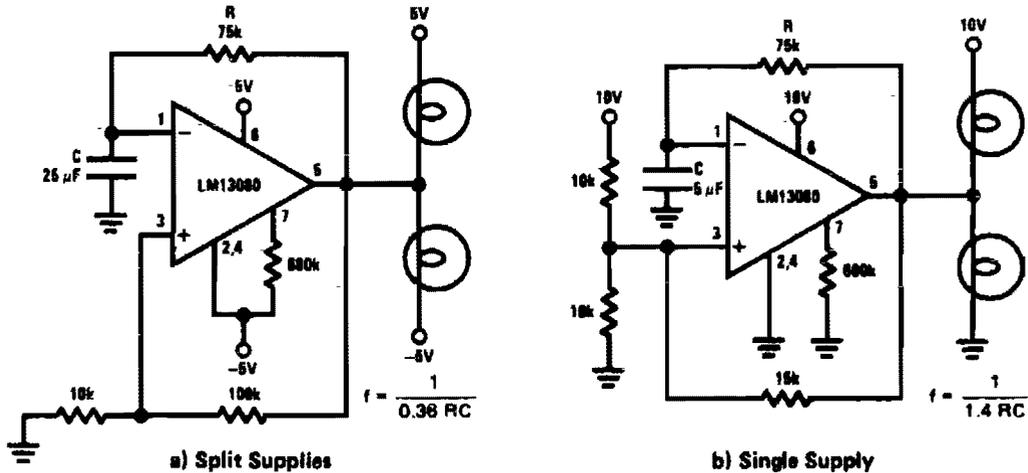


Fig. 34-4

Circuit Notes

This circuit is a low frequency warning device. The output of the oscillator is a square wave that is used to drive lamps or small relays. The circuit alternately flashes two incandescent lamps.

DUAL LED CMOS FLASHER

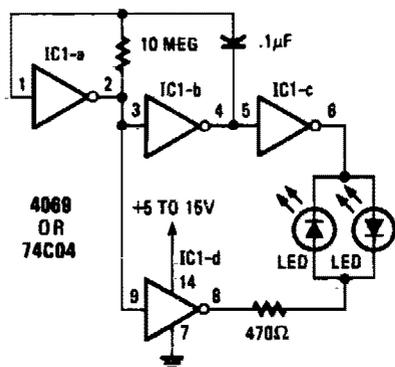


Fig. 34-7

Circuit Notes

Inverters IC1-a and IC1-b form a multivibrator and IC1-c is a buffer. Inverter IC1-d is connected so that its output is opposite that of IC1-c; when pin 6 is high, then pin 8 is low and vice versa. Because pins 6 and 8 are constantly changing state, first one LED and then the other is on since they are connected in reverse. The light seems to jump back and forth between the LED's. The 470-ohm resistor limits LED current. Depending upon the supply voltage used, the value of the resistor may have to be changed to obtain maximum light output. To change the switching rate, change the value of the capacitor.

AUTOMATIC SAFETY FLASHER

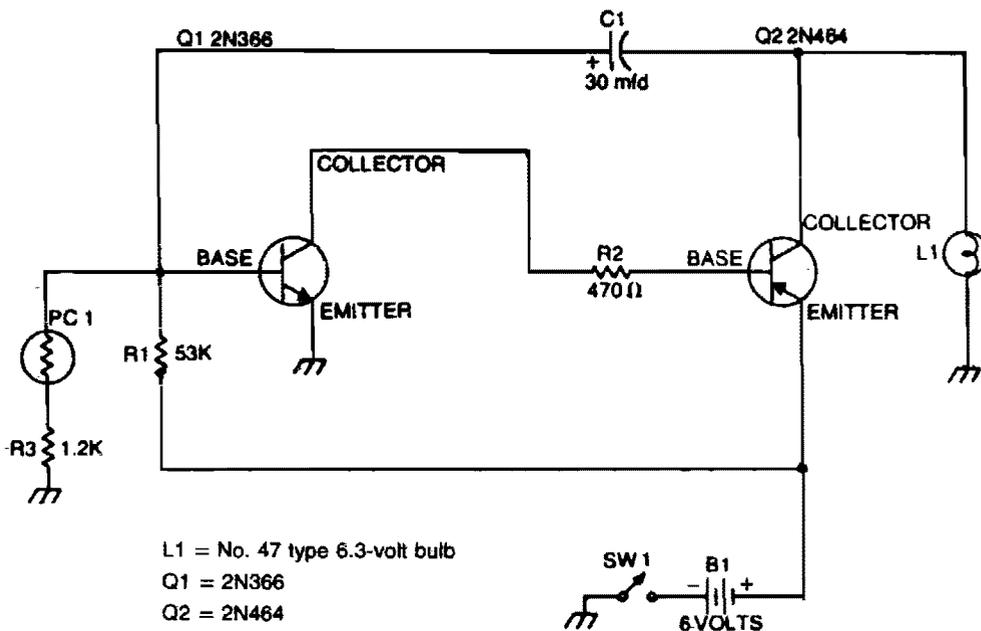


Fig. 34-8

Circuit Notes

This flasher only comes on at night. It furnishes a bright nighttime illumination, and shuts itself off automatically as soon as the sun

comes up. The photocell must be mounted on top of the unit in such a way as to detect the greatest amount of available light.

NEON BLINKER

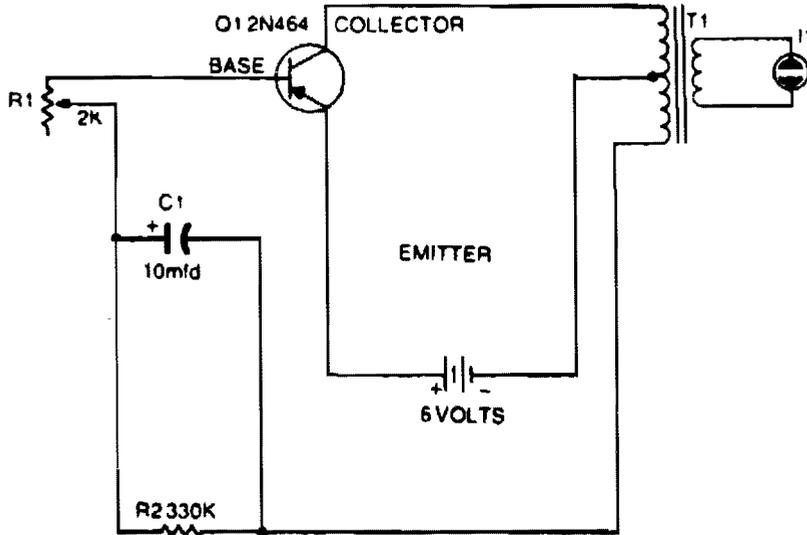
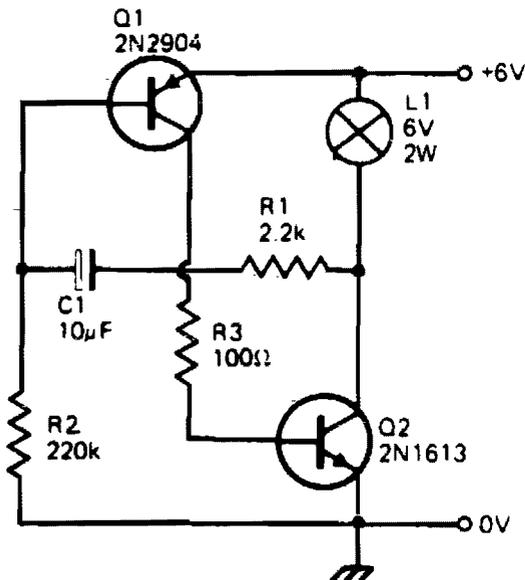


Fig. 34-9

Circuit Notes

The universal output transformer and the transistor form a low-frequency oscillator. The rate of flashing of the neon bulb is determined by potentiometer R1.

TRANSISTORIZED FLASHER

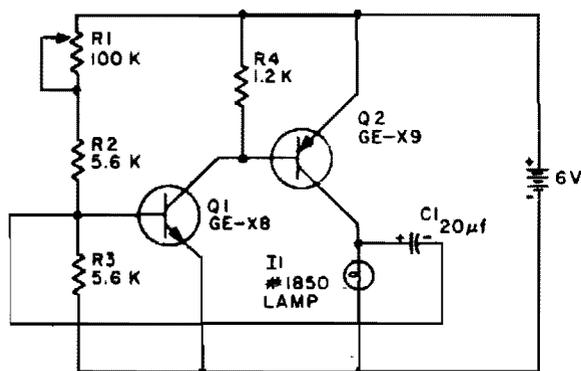


Circuit Notes

This simple circuit will flash a 6 volt lamp at a rate determined by the size of capacitor C1. It is most economical on power as it only draws current when the lamp is on. When the lamp is off, both transistors are biased off.

Fig. 34-10

FLASHER/LIGHT CONTROL



Parts List

- C1* — 20-mfd, 6-volt electrolytic capacitor
- I1* — 6-volt, GE No. 1850 lamp and socket
- Q1* — GE-X8 transistor
- Q2* — GE-X9 transistor
- R1* — 100K-ohm, 2-watt potentiometer
- R2, R3* — 5.6K-ohm, 1/2-watt resistor
- R4* — 1.2K-ohm, 1/2-watt resistor
- Battery* — 6-volt dry pack

Fig. 34-11

Circuit Notes

The circuit is a two-stage, direct-coupled transistor amplifier connected as a free-running multivibrator. Both the flash duration and flash interval can be changed by turning the potentiometer, R1.

NEON TUBE FLASHER

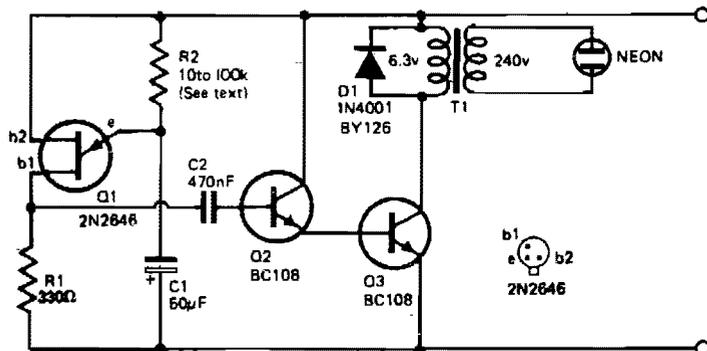


Fig. 34-12

Circuit Notes

The voltage required to ignite the neon tube is obtained by using an ordinary filament transformer (240-6.3 V) in reverse. Battery drain is quite low, around 1 to 2 milliamperes for a nine volt battery. The pulses from Q1, unijunction transistor, operated as a relaxation oscillator and are applied to Q2 which in turn

drives Q3 into saturation. The sharp rise in current through the 6.3 V winding of the transformer as Q3 goes into saturation induces a high voltage in the secondary winding causing the neon to flash. The diode D1 protects the transistor from high voltage spikes generated when switching currents in the transformer.

DC FLASHER WITH ADJUSTABLE ON AND OFF TIME

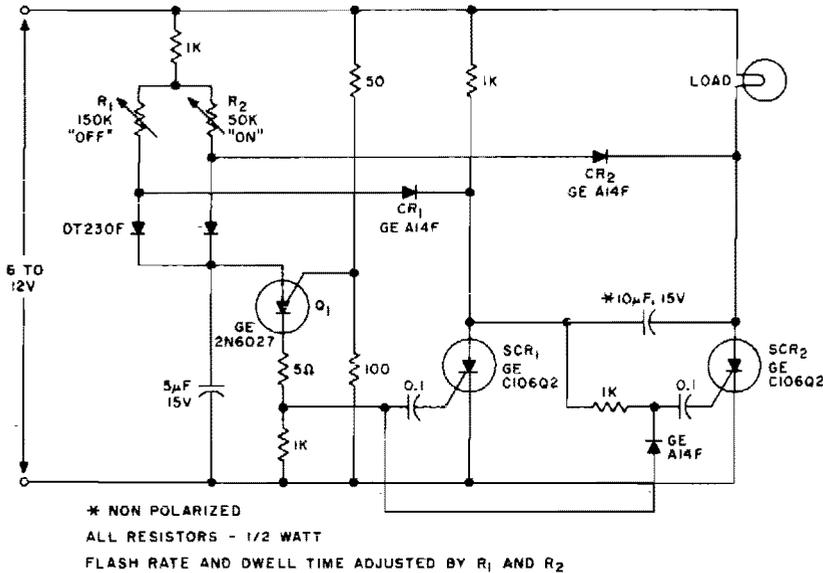


Fig. 34-13

Circuit Notes

This circuit utilizes a power flip-flop and programmable unijunction (PUT) to obtain adjustable on and off times.

LOW VOLTAGE FLASHER

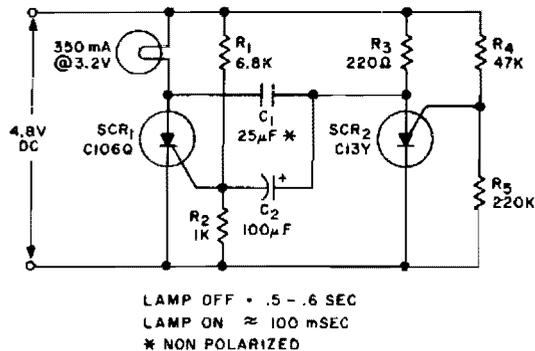


Fig. 34-14

Circuit Notes

Applying voltage to the circuit triggers SCR1. With SCR1 on, the voltage on the anode of SCR2 rises until SCR2 triggers to commutate SCR1. The voltage on the gate of SCR1 will swing negative at this time, and only after a

positive potential of ≈ 0.5 volt is once again attained, will SCR1 retrigger. The circuit could be used for higher voltage levels, but the peak negative voltage on the gate of SCR1 must be limited to less than 6 volts.

1 A LAMP FLASHER

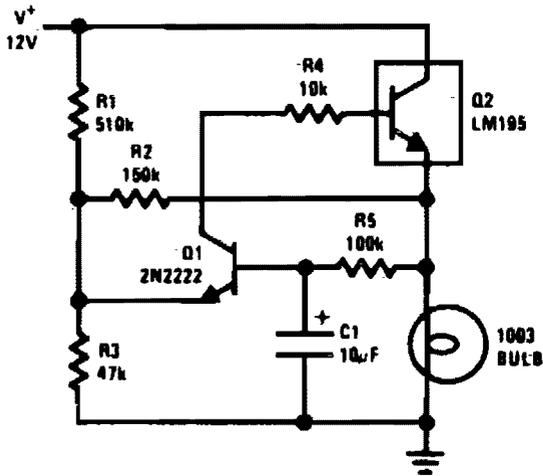
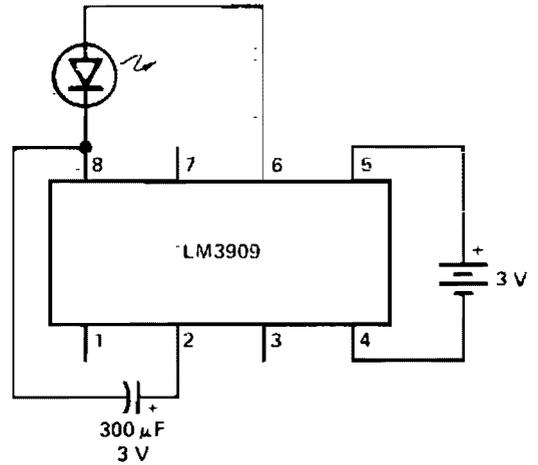


Fig. 34-15

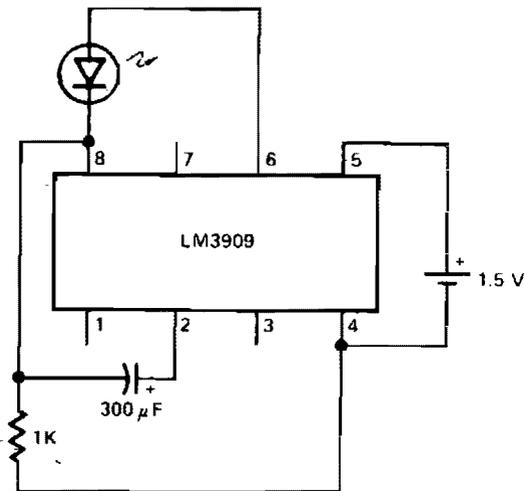
3 V FLASHER



Note: Nominal Flash Rate:
1 Hz. Average $I_{DRAIN} = 0.77 \text{ mA}$

Fig. 34-17

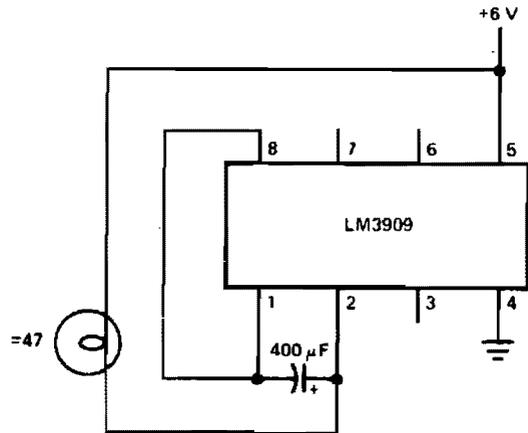
FAST BLINKER



Note: Nominal Flash Rate:
2.6 Hz. Average $I_{DRAIN} = 1.2$

Fig. 34-16

INCANDESCENT BULB FLASHER



Note: Flash Rate: 1.5 Hz

Fig. 34-18

FLASHER FOR 4 PARALLEL LEDs

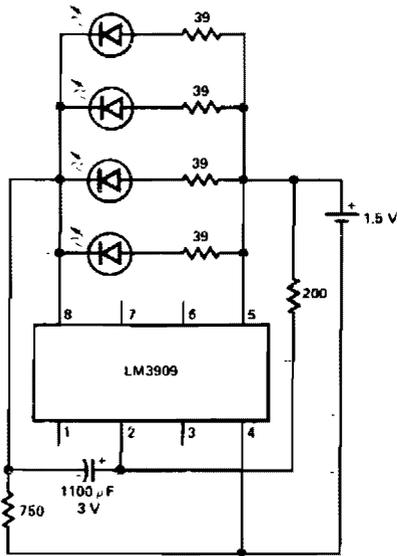


Fig. 34-19

Note: Nominal Flash Rate:
1.3 Hz. Average $I_{DRAIN} = 2 \text{ mA}$

SAFE, HIGH VOLTAGE FLASHER

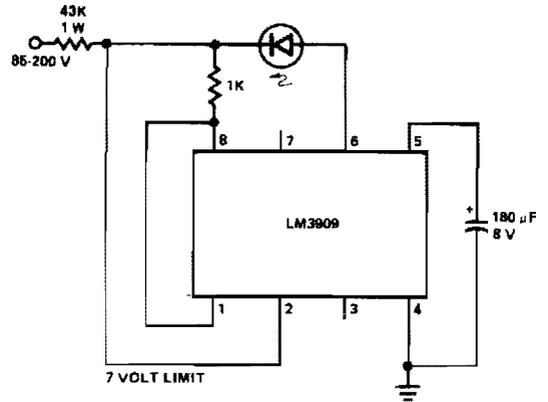
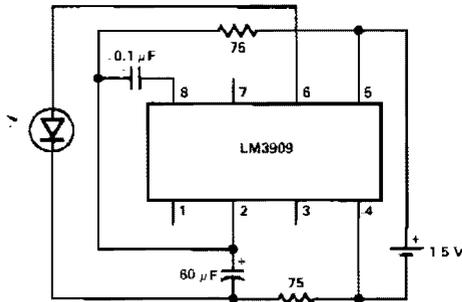


Fig. 34-21

LED BOOSTER



Note: High efficiency, 4 mA drain

Note: Continuous Appearing Light Obtained By Supplying Short, High Current, Pulses (2 kHz) to LEDs With Higher Than Battery Voltage Available.

Fig. 34-20

ALTERNATING FLASHER

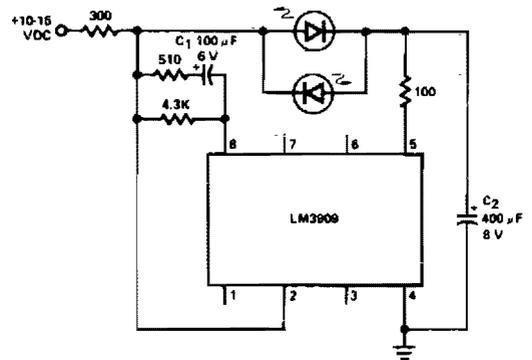
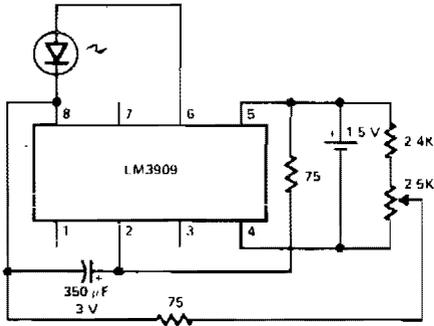


Fig. 34-22

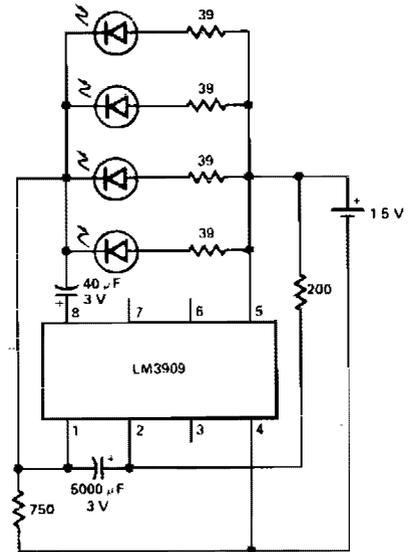
VARIABLE FLASHER



Note: Flash Rate: 0-20 Hz

Fig. 34-23

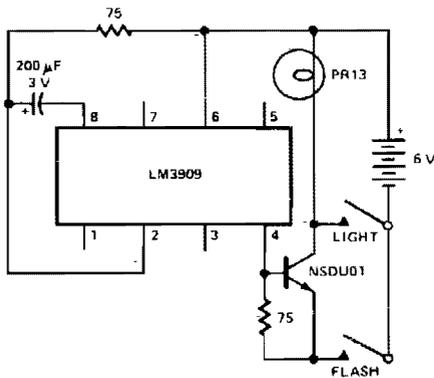
HIGH EFFICIENCY PARALLEL CIRCUIT FLASHER



Note: Nominal Flash Rate:
1.5 Hz. Average $I_{DRAIN} = 1.5 \text{ mA}$

Fig. 34-25

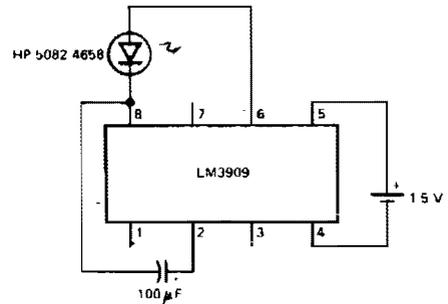
EMERGENCY LANTERN/FLASHER



Note: Nominal Flash Rate: 1.5 Hz

Fig. 34-24

MINIMUM POWER FLASHER (1.5 V)



Note: Nominal Flash Rate: 1.1 Hz. Average $I_{DRAIN} = 0.32 \text{ mA}$

Fig. 34-26

35

Frequency Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Inexpensive Frequency Counter/
Tachometer

Linear Frequency Meter
Power-Line Frequency Meter

Audio Frequency Meter

POWER-LINE FREQUENCY METER

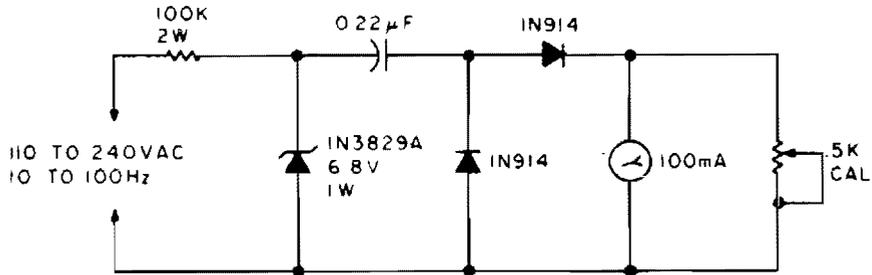


Fig. 35-3

Circuit Notes

The meter will indicate the frequency from a power generator. Incoming sine waves are converted to square waves by the 100 K resistor and the 6.8 V zener. The square wave is differentiated by the capacitor and the cur-

rent is averaged by the diodes. The average current is almost exactly proportional to the frequency and can be read directly on a 100 mA meter. To calibrate, hook the circuit up to a 60 Hz powerline and adjust the 5 K pot to read 60 mA.

AUDIO FREQUENCY METER

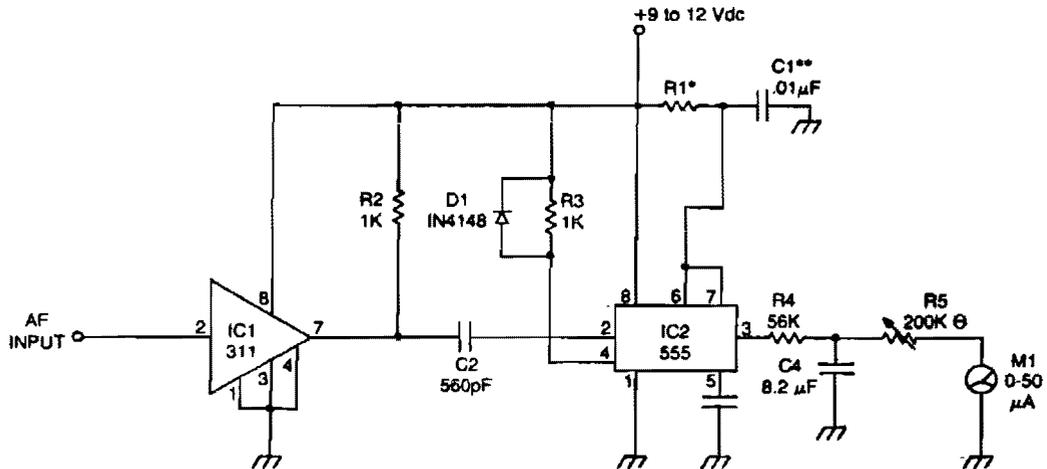


Fig. 35-4

*R1: 1 meg 100K 10K
RANGE: 50 500 5000
(Hz)

**C1: POLYSTYRENE OR SILVER-MICA

Circuit Notes

The meter uses time averaging to produce a direct current that is proportional to the frequency of the input signal.

36

Frequency Multipliers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Broadband Frequency Doubler
Frequency Doubler
150 to 300 MHz Doubler

Low-Frequency Doubler
Oscillator with Double Frequency
Output

BROADBAND FREQUENCY DOUBLER

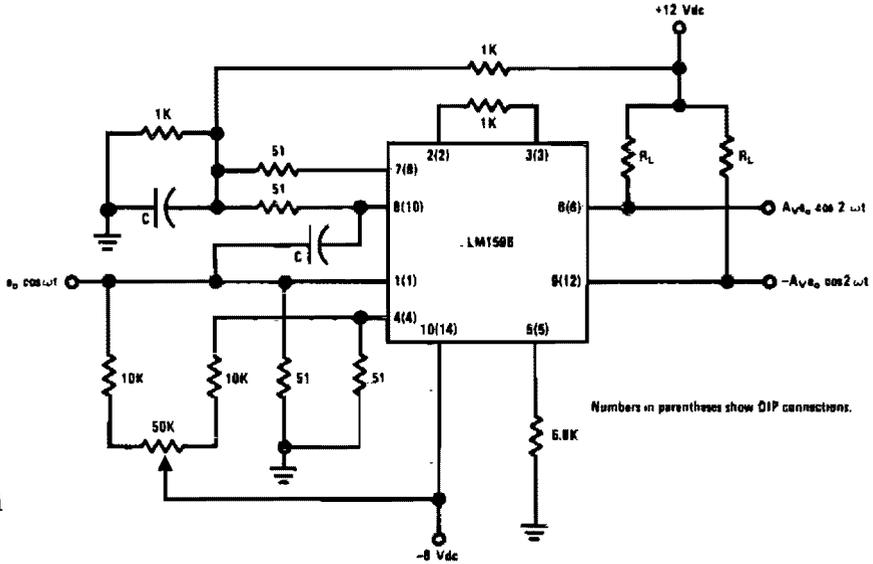


Fig. 36-1

Circuit Notes

This circuit will double low-level signals with low distortion. The value of C should be chosen for low reactance at the operating frequency. Signal level at the carrier input must be less than 25 mV peak to maintain operation in the linear region of the switching differential

amplifier. Levels to 50 mV peak may be used with some distortion of the output waveform. If a larger input signal is available, a resistive divider may be used at the carrier input with full signal applied to the signal input.

FREQUENCY DOUBLER

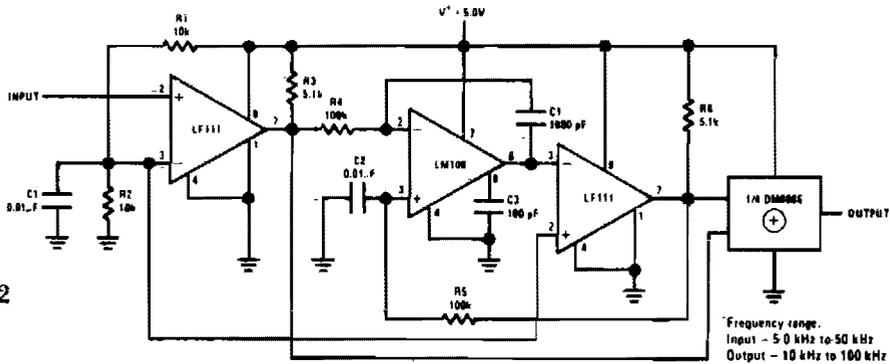


Fig. 36-2

37

Frequency-to-Voltage Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

DC-10 kHz Frequency/Voltage Converter
Frequency-to-Voltage Converter
Zener Regulated Frequency-to-Voltage
Converter
Simple Frequency-to-Voltage Converter

F/V Conversion, TTL Input
Frequency-to-Voltage Converter with 2-
Pole Butterworth Filter to Reduce Rip-
ple
Precision Frequency-to-Voltage Converter

DC-10 kHz FREQUENCY/VOLTAGE CONVERTER

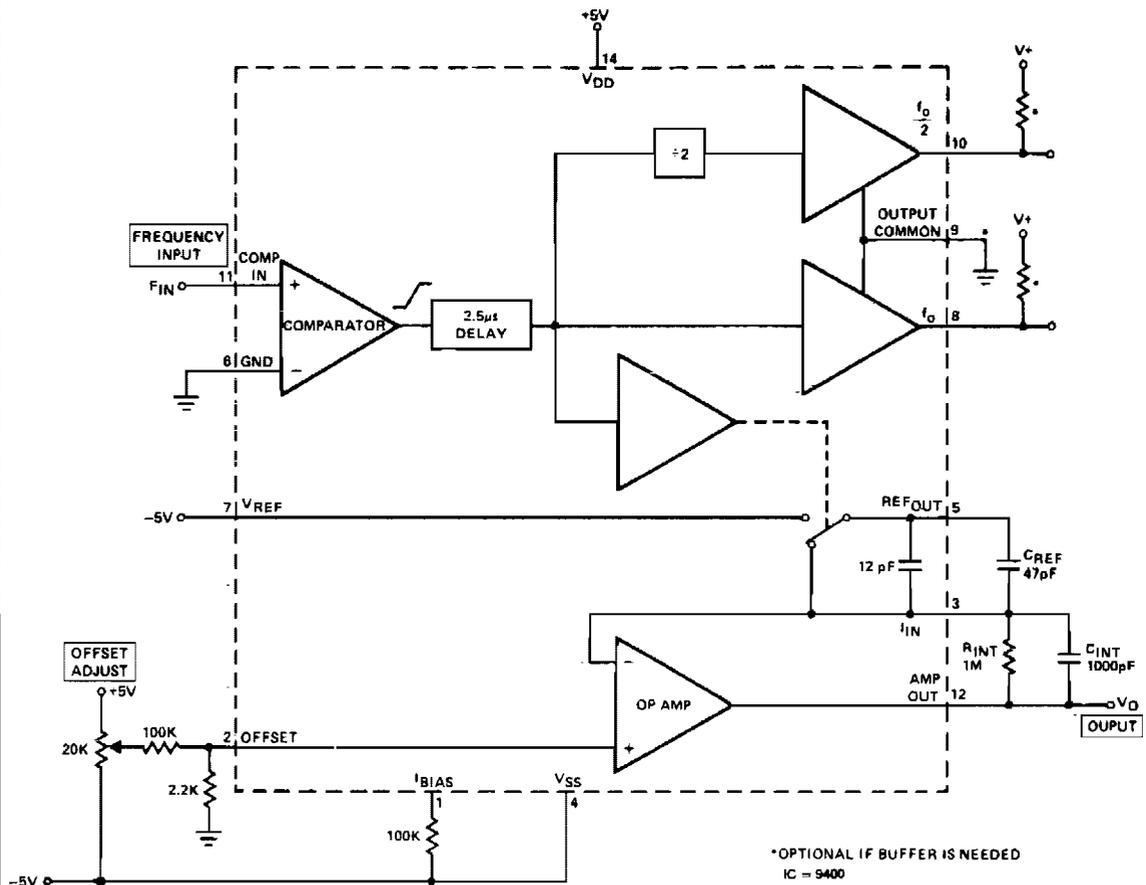


Fig. 37-1

Circuit Notes

The converter generates an output voltage which is linearly proportional to the input frequency waveform. Each zero crossing at the comparator's input causes a precise amount of change to be dispensed into the op amp's summing junction. This charge in turn flows

through the feedback resistor generating voltage pulses at the output of the op amp. Capacitor (C_{INT}) across R_{INT} averages these pulses into a dc voltage which is linearly proportional to the input frequency.

FREQUENCY-TO-VOLTAGE CONVERTER (DIGITAL FREQUENCY METER)

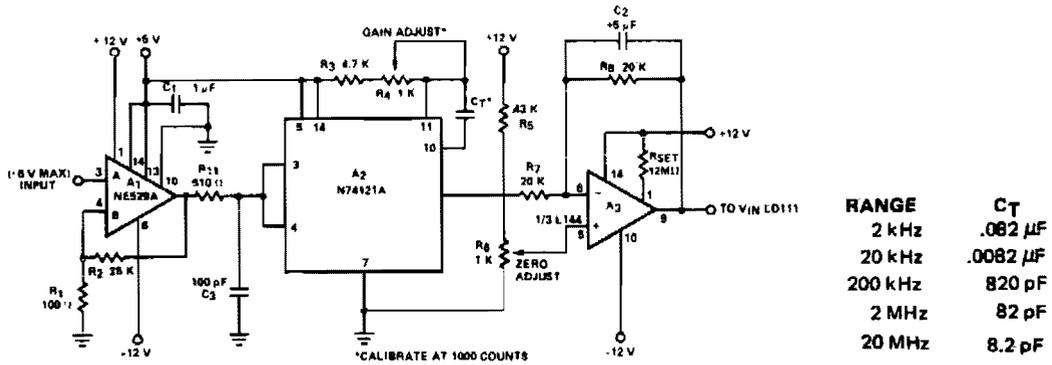


Fig. 37-2

Circuit Notes

This circuit converts frequency to voltage by taking the average dc value of the pulses from the 74121 monostable multivibrator. The one shot is triggered by the positive-going ac signal at the input of the 529 comparator. The amplifier acts as a dc filter, and also provides

zeroing. The accuracy is 2% over a 5 decade range. The input signal to the comparator should be greater than 0.1 volt peak-to-peak, and less than 12 volts peak-to-peak for proper operation.

ZENER REGULATED FREQUENCY-TO-VOLTAGE CONVERTER

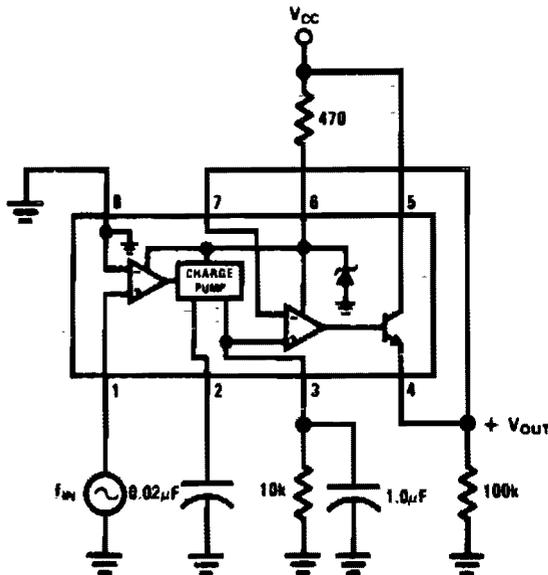
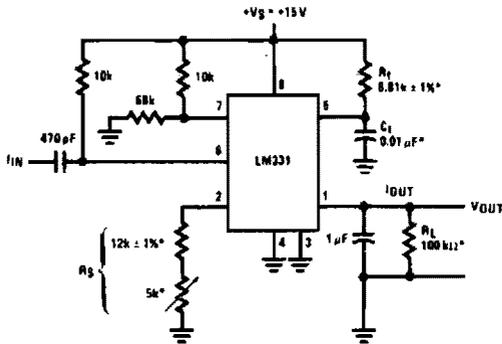


Fig. 37-3

SIMPLE FREQUENCY-TO-VOLTAGE CONVERTER (10 kHz FULL-SCALE, ±0.006% NON-LINEARITY)

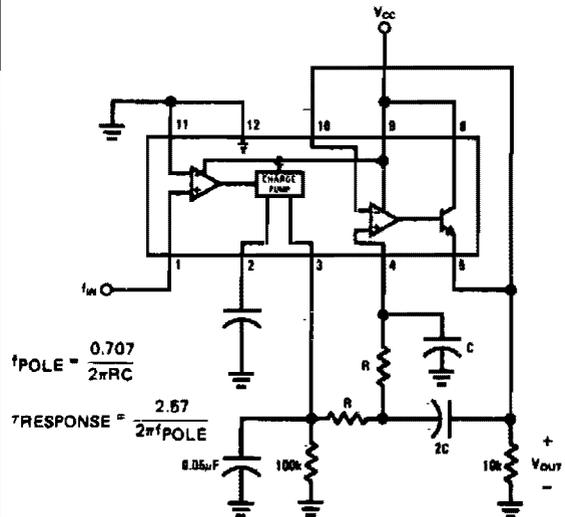


$$V_{OUT} = f_{IN} = 2.00V \times \frac{R_L}{R_3} \times (R_1 C_1)$$

*Use stable components with low temperature coefficients.

Fig. 37-4

FREQUENCY-TO-VOLTAGE CONVERTER WITH 2-POLE BUTTERWORTH FILTER TO REDUCE RIPPLE



$$f_{POLE} = \frac{0.707}{2\pi RC}$$

$$f_{RESPONSE} = \frac{2.67}{2\pi f_{POLE}}$$

Fig. 37-6

F/V CONVERSION, TTL INPUT

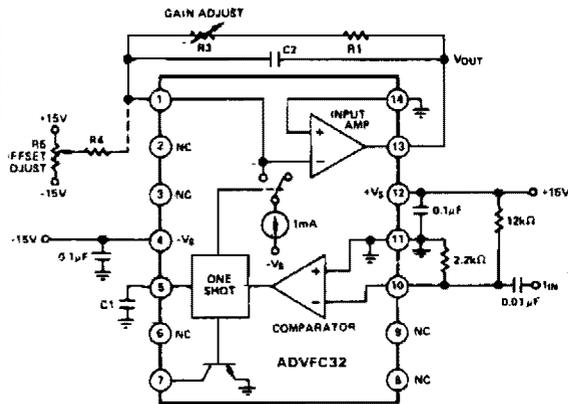
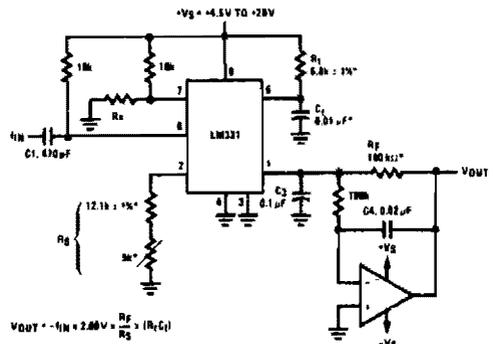


Fig. 37-5

PRECISION FREQUENCY-TO-VOLTAGE CONVERTER (10 kHz FULL-SCALE WITH 2-POLE FILTER, ±0.01% NON-LINEARITY MAXIMUM)



$$V_{OUT} = f_{IN} = 2.00V \times \frac{R_L}{R_3} \times (R_1 C_1)$$

$$\text{SELECT } R_4 = \frac{(V_S - 2V)}{0.2 \text{ mA}}$$

*Use stable components with low temperature coefficients.

Fig. 37-7

38

Fuzz Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Fuzz Box 1
Fuzz Box 2
Fuzz Box 3

Fuzz Box 4
Fuzz Box 5
Guitar Fuzz

FUZZ BOX 1

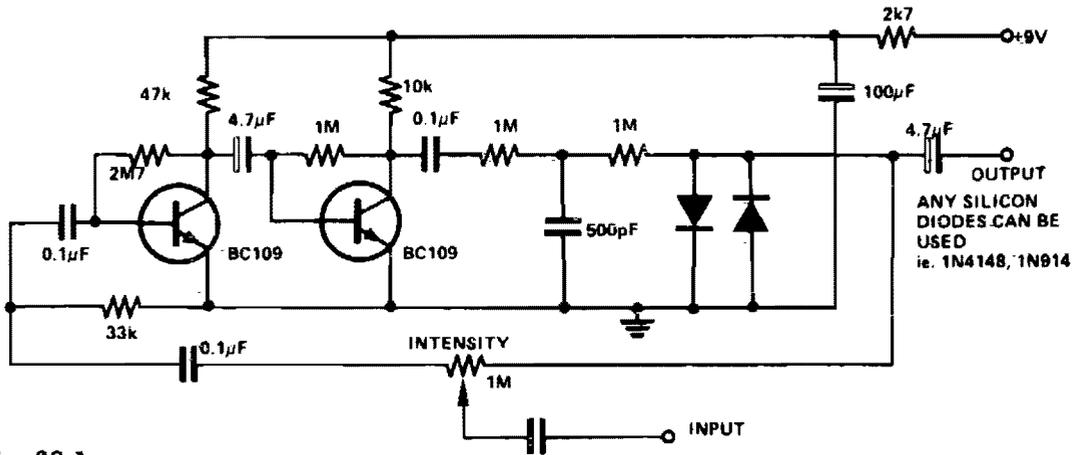


Fig. 38-1

Circuit Notes

The input signal is amplified by the transistors. The distorted output is then clipped by the two diodes and the high frequency noise is filtered from the circuit via the 500 pF

capacitor. The 1 M pot adjusts the intensity of the fuzz from maximum to no fuzz (normal playing).

FUZZ BOX 2

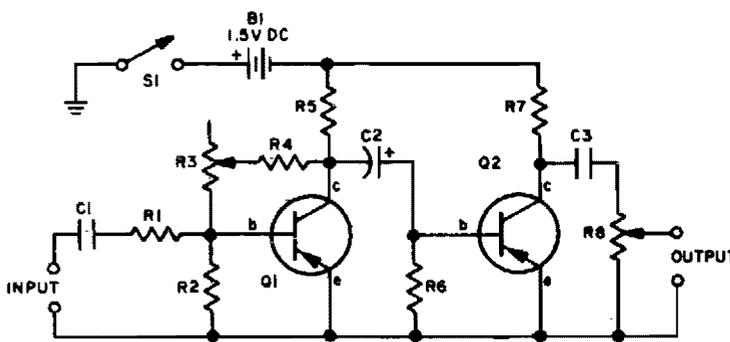


Fig. 38-2

Circuit Notes

Potentiometer R3 sets the degree of fuzz, and R8 sets the output level. Since the fuzz effect cannot be completely eliminated by R3, fuzz-free sound requires a bypass switch from the input to output terminals.

- B1—1.5-V AA battery
- C1, C3—0.1-μF, 50-VDC capacitor
- C2—4.7-μF, 10-VDC electrolytic capacitor
- Q1, Q2—pnp transistor—HEP-632
- R1, R6—22,000-ohm, ½-watt resistor
- R2—18,000-ohm, ½-watt resistor
- R3—1-megohm pot
- R4—100,000-ohm, ½-watt resistor
- R5, R7—10,000-ohm, ½-watt resistor
- R8—50,000-ohm pot
- S1—Spst switch

FUZZ BOX 3

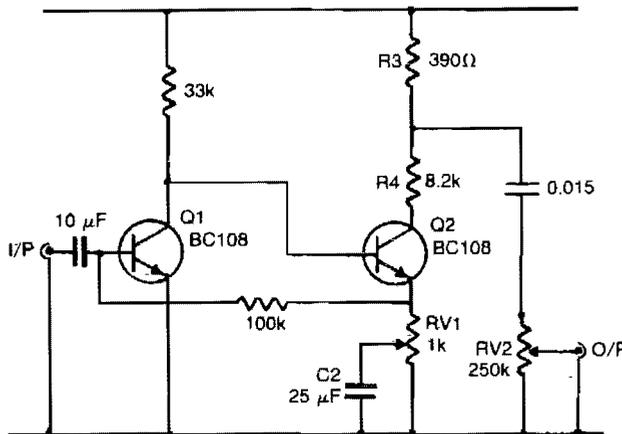


Fig. 38-3

Circuit Notes

Q1 and Q2 form a voltage amplifier which has sufficient gain to be overdriven by a relatively low input, such as an electric guitar. The result is that the output from Q2 is a Squared-Off version of the input, giving the required fuzz sound. RV1 adjusts the amount of negative

feedback inserted into the circuit by C2, and thus the amount of squaring of the signal. The purpose of R3 and R4 is to lower the output voltage to a suitable level, which is then adjusted as required with the volume control VR2.

FUZZ BOX 4

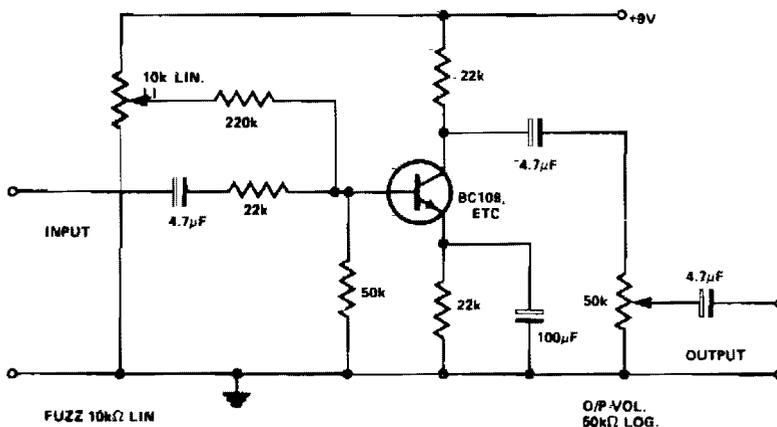


Fig. 38-4

Circuit Notes

None of the components are particularly critical in value or quality, as distortion is the sole object! The transistor could be BC107-8-9, 2N2926, etc.

FUZZ BOX 5

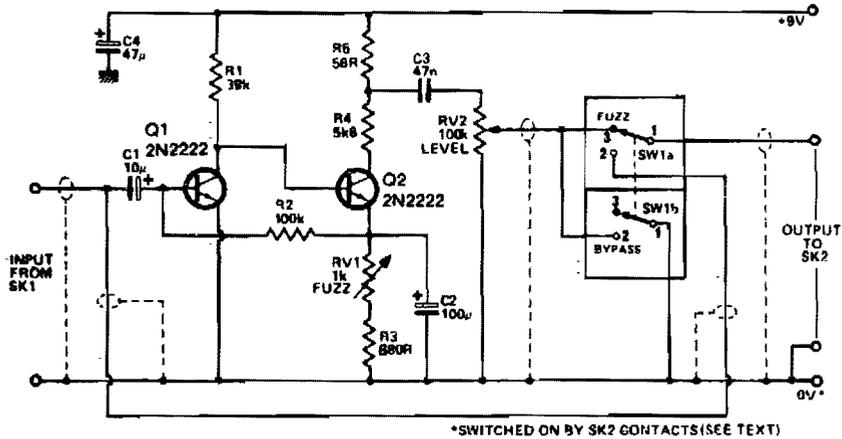


Fig. 38-5

Circuit Diagram

Circuit Notes

Transistors Q1 and Q2 amplify the incoming signal, and the gain is such that the input will overload when used with an electric guitar. RV1 adjusts the amount of feedback

present, and hence voltage gain. The output is, therefore, a squared version of the input signal. The amount of squaring is varied by RV1.

GUITAR FUZZ

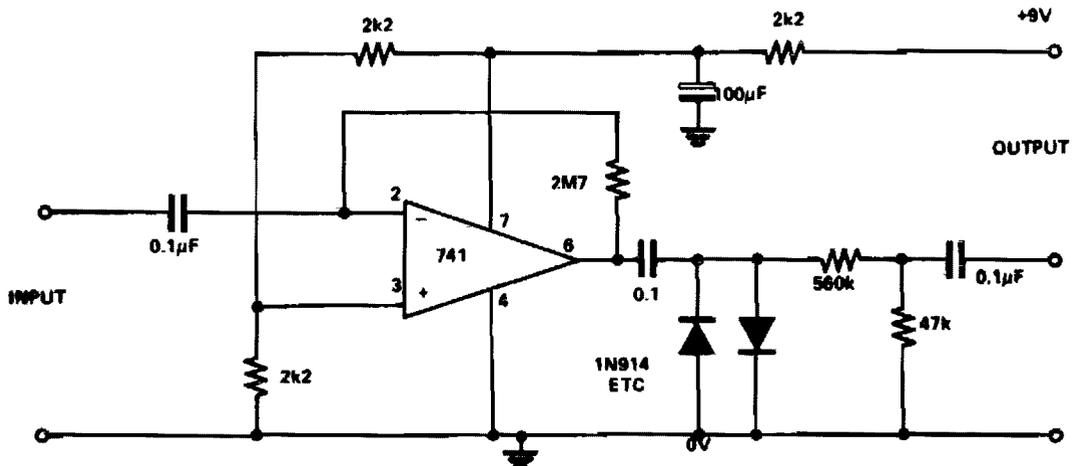


Fig. 38-6

Circuit Notes

The 741 has a maximum gain of 20,000, but the circuit is so designed that the IC's gain is 2,700,000 which then distorts the output. This distortion gives the fuzz effect. The two

diodes clip the output to drop the level, also lowered by the potential divider. This circuit also sustains the notes, due to clipping, giving a totally new sound.

39

Games

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ready, Set, Go!

Electronic Dice

Game Roller or Chase Circuit

Toss-A-Coin Binary Box

Electronic Coin Toss

Heads or Tails

Pot Shot

Low Cost Heads or Tails

Who Is First

Windicator

READY, SET, GO!

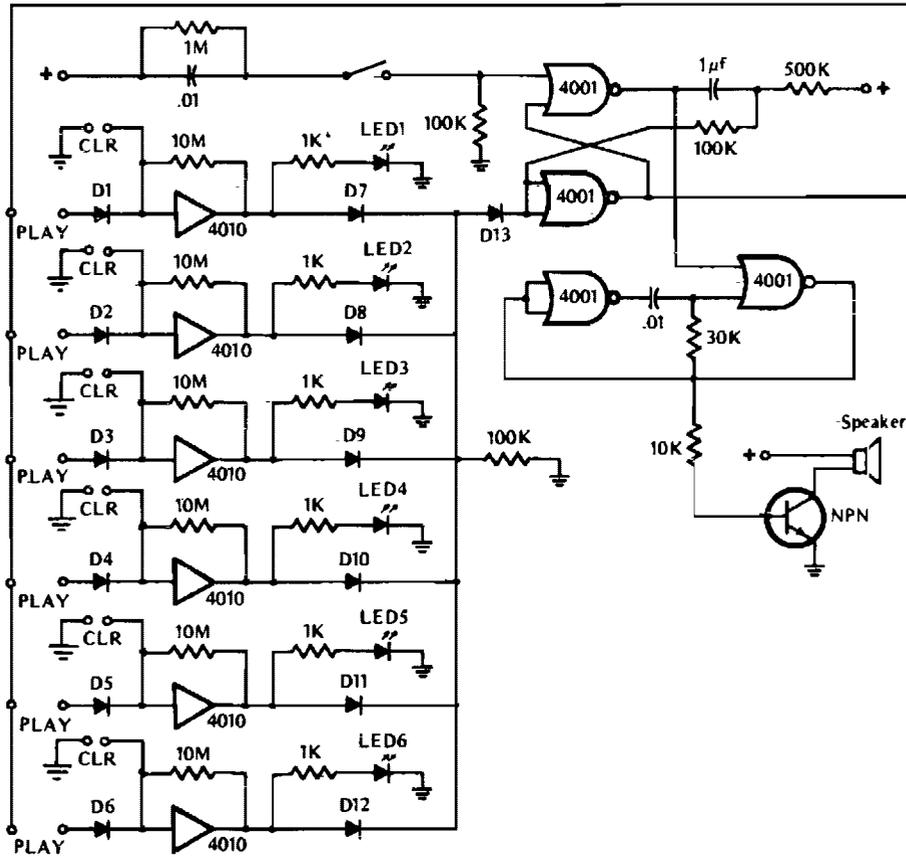


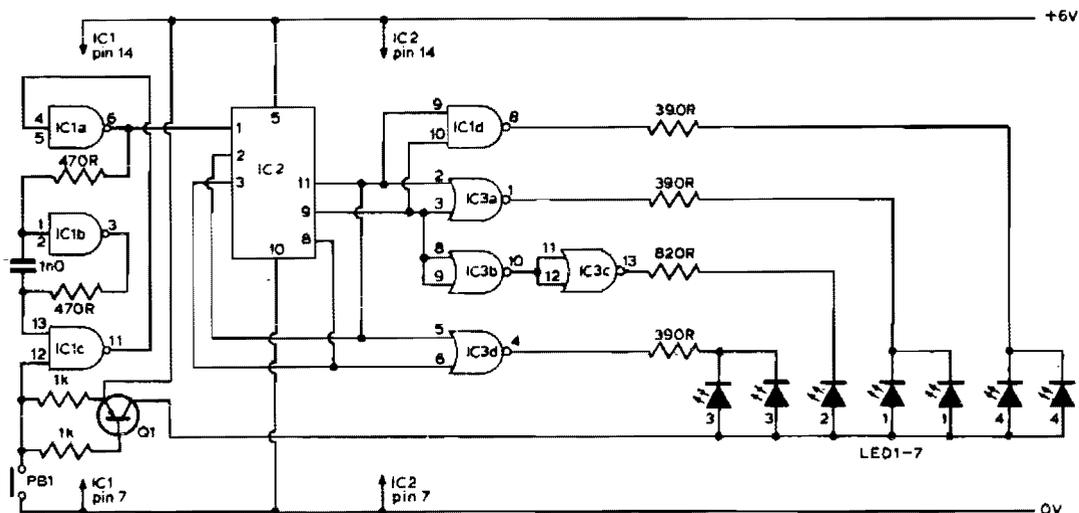
Fig. 39-1

Circuit Notes

This game tests a player's reaction time. It is activated by closing switch S1, which starts the tone generator and arms the circuit. The touchplate, labeled PLAY in the diagram, consists of two metal strips about 1/16th-inch apart. The first player to bridge the gap with his

or her finger turns off the tone and lights the associated LED indicator. A second touchplate, labeled CLR in the diagram, clears the circuit, extinguishing the LED, when its gap is bridged by a fingertip.

ELECTRONIC DICE



NOTE
 LED1-7 are TIL209 or equivalent
 IC1 is 7400
 IC2 is 7493
 IC3 is 7402
 Q1 gen purp. PNP $I_{cmax} > 50\text{mA}$
 PB1 is normally closed

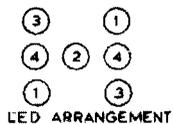


Fig. 39-2

Circuit Notes

Six LEDs are arranged to produce a display the same as the dots on a dice. When PB1 is depressed, the display is blanked and the oscillator (IC1 a, b, c) clocks IC2 at about 1MHz.

IC2 counts from zero and resets on seven. When PB1 is released, the display is enabled and a decoding system (IC3) produces the correct output on the LEDs.

GAME ROLLER OR CHASE CIRCUIT

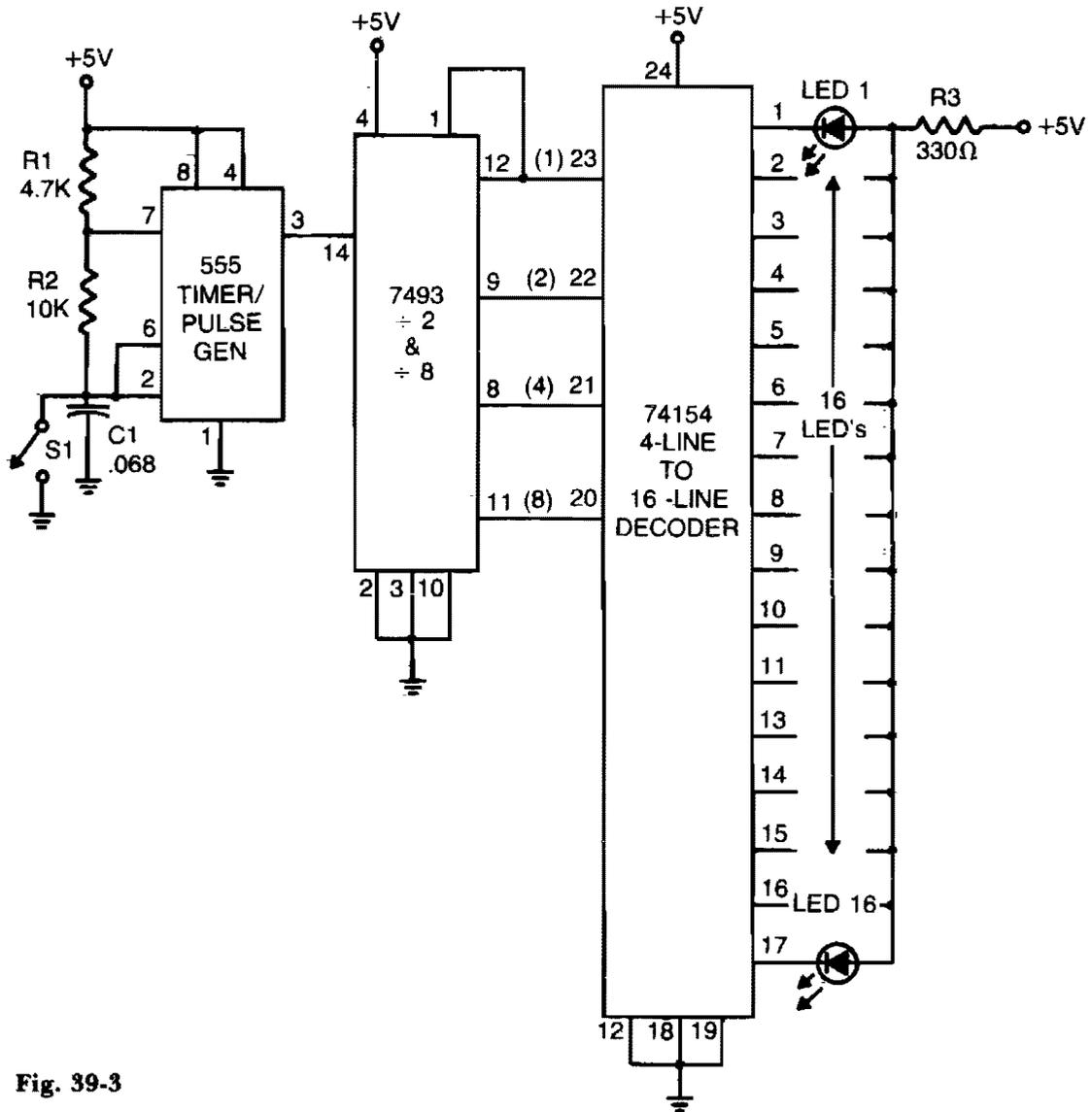


Fig. 39-3

Circuit Notes

The 555 timer produces a rapid series of pulses whenever switch S1 is open. These pulses are counted in groups of 16 and converted into binary form by the 7493 and applied to the 74154 (a 1-of-16 decoder/demultiplexer) wired so that each of its 16 output lines goes

low sequentially and in step with the binary count delivered by the 7493. When the switch is closed, only one LED remains on. Only one current limiting resistor (R3) is used for all the LED's since only one is on at any one time.

TOSS-A-COIN BINARY BOX

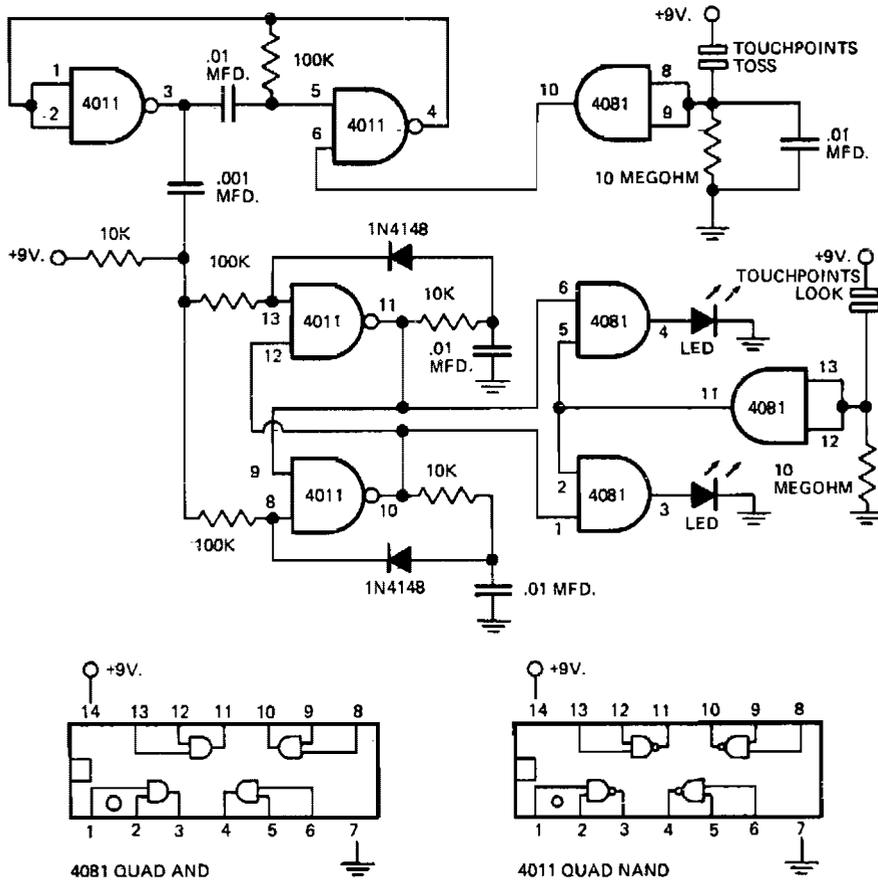


Fig. 39-4

Circuit Notes

Circuit uses an astable multivibrator to vary the heads-or-tails condition, and a flip-flop to store the condition given by the multivibrator. Consequently, the circuit is wired so

that the flip-flop's state is changed once for each full cycle the multivibrator goes through to assure an absolutely even 50-50 chance of a heads or tails loss.

ELECTRONIC COIN TOSSER

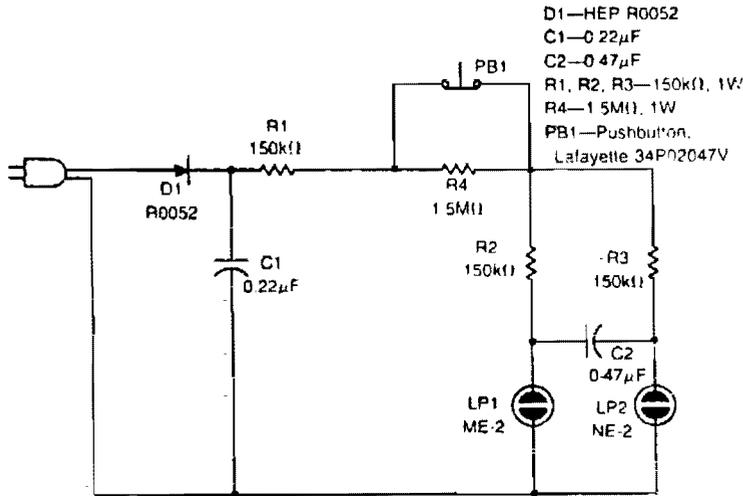


Fig. 39-5

Circuit Notes

The circuit shown simulates the flipping of a coin by merely pushing switch PB1.

HEADS OR TAILS

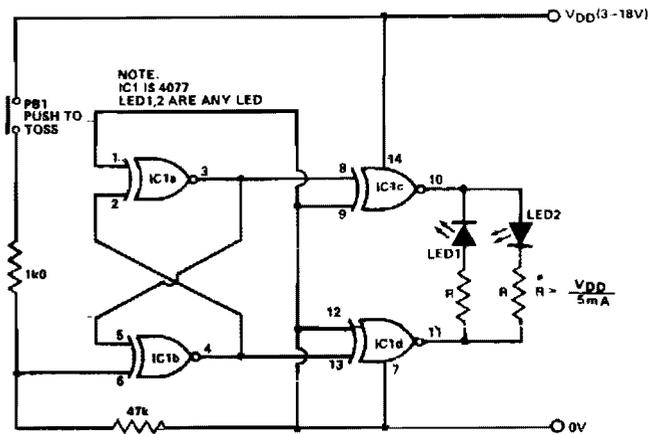


Fig. 39-6

Circuit Notes

This ultra-simple heads or tails indicator uses a single 4077 and no capacitor.

The circuit is normally in a latched bistable mode; when the switch is closed the circuit

will oscillate, i.e. toss the coin. The astable frequency is approximately 5-10 MHz. PB1 is a normally closed switch.

POT SHOT

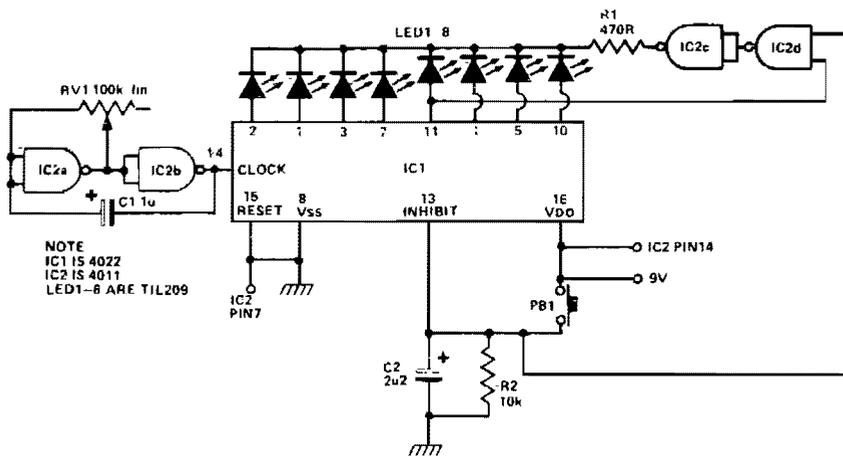


Fig. 39-7

Circuit Notes

This is a circuit for a game of the shooting gallery variety. IC2a and b form an astable multivibrator clocking IC1 which causes LEDs 1-8 to flash in turn LED 5 is the target LED and the object of the game is to depress PBI just as LED 5 comes on. If this is done, the whole

display is blanked for a few seconds signifying a hit. Otherwise, the LED which was lit remains lit. When the push button is released, C2 discharges through R2 taking 8 pin 13 low again and the LEDs will start to flash again.

LOW COST "HEADS OR TAILS"

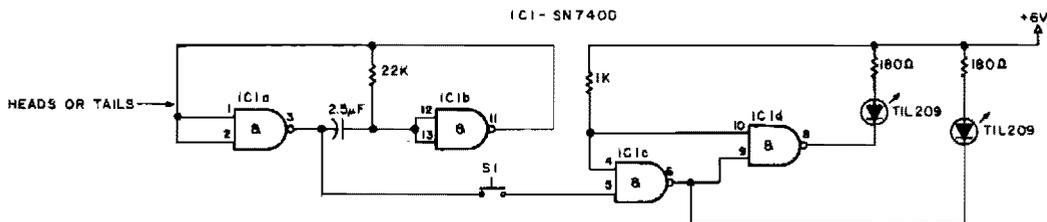


Fig. 39-8

Circuit Notes

S1 must be a push-to-make, release-to-break, switch.

WHO IS FIRST

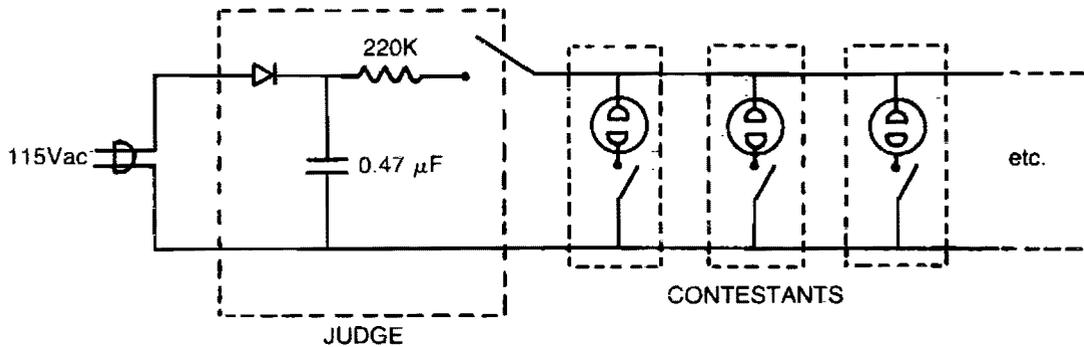


Fig. 39-9

Circuit Notes

Here is a circuit for any question-and-answer party game. The first button pushed ionizes the neon bulb dropping the dc voltage

on the parallel neons (the other contestants) below the ionization level; determining unequivocally the first person to press the button.

WINDICATOR

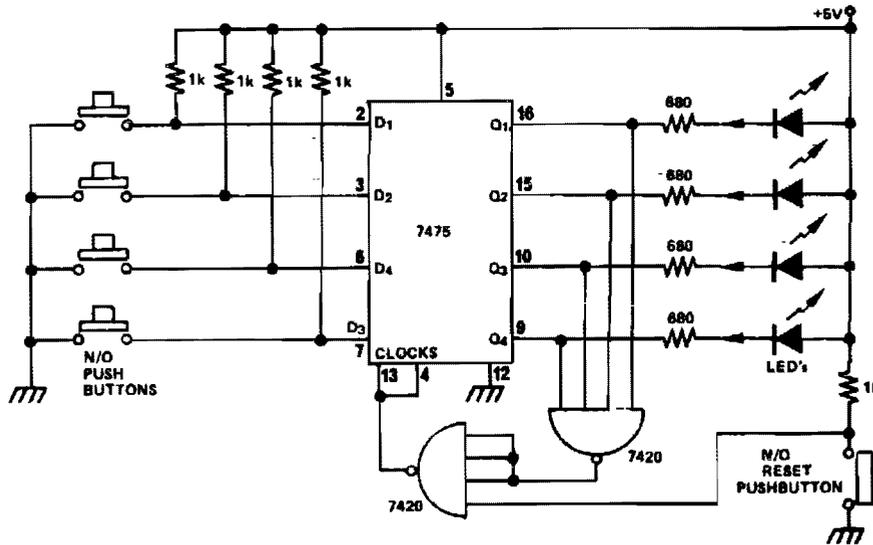


Fig. 39-10

Circuit Notes

Two TTL ICs and a handful of other components are all that is needed for a circuit that will indicate which of four buttons was pressed first, as well as lock out all other entries. A

logic 0 at one of the Q outputs, lights the appropriate LED and locks out other entries by taking the clock input low.

40

Gas/Vapor Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source-entry in the Sources section.

Gas and Smoke Detector

Ionization Chamber Smoke Detector

Ionization Chamber Smoke Detector

GAS AND SMOKE DETECTOR

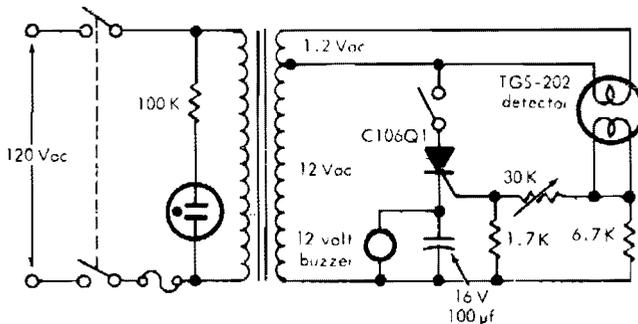


Fig. 40-1

Circuit Notes

This circuit can detect smoke and a number of gases (CO, CO₂, methane, coal gas and others) with a 10 ppm sensitivity. It uses a heated surface semiconductor sensor. Detec-

tion occurs when the gas concentration increase causes a decrease of the sensor element internal resistance. The switch in series with the SCR is used for resetting the alarm.

IONIZATION CHAMBER SMOKE DETECTOR

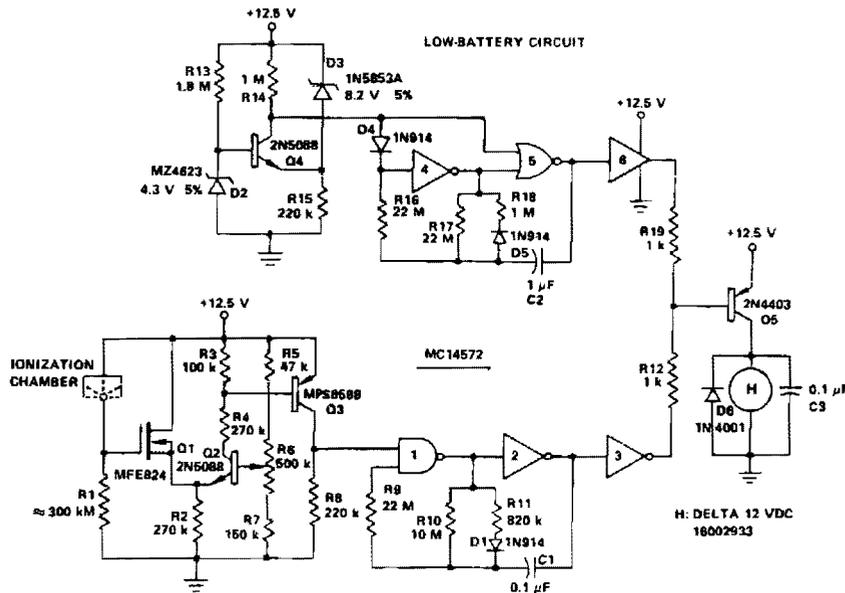


Fig. 40-2

Circuit Notes

Battery-operated, ionization chamber smoke detector includes a circuit to generate a unique alarm when the battery reaches the end of its useful life. The circuit uses the MCMOS

MC14572 for two alarm oscillators (smoke and low battery). This circuit additionally uses five discrete transistors as buffers and comparators.

IONIZATION CHAMBER SMOKE DETECTOR

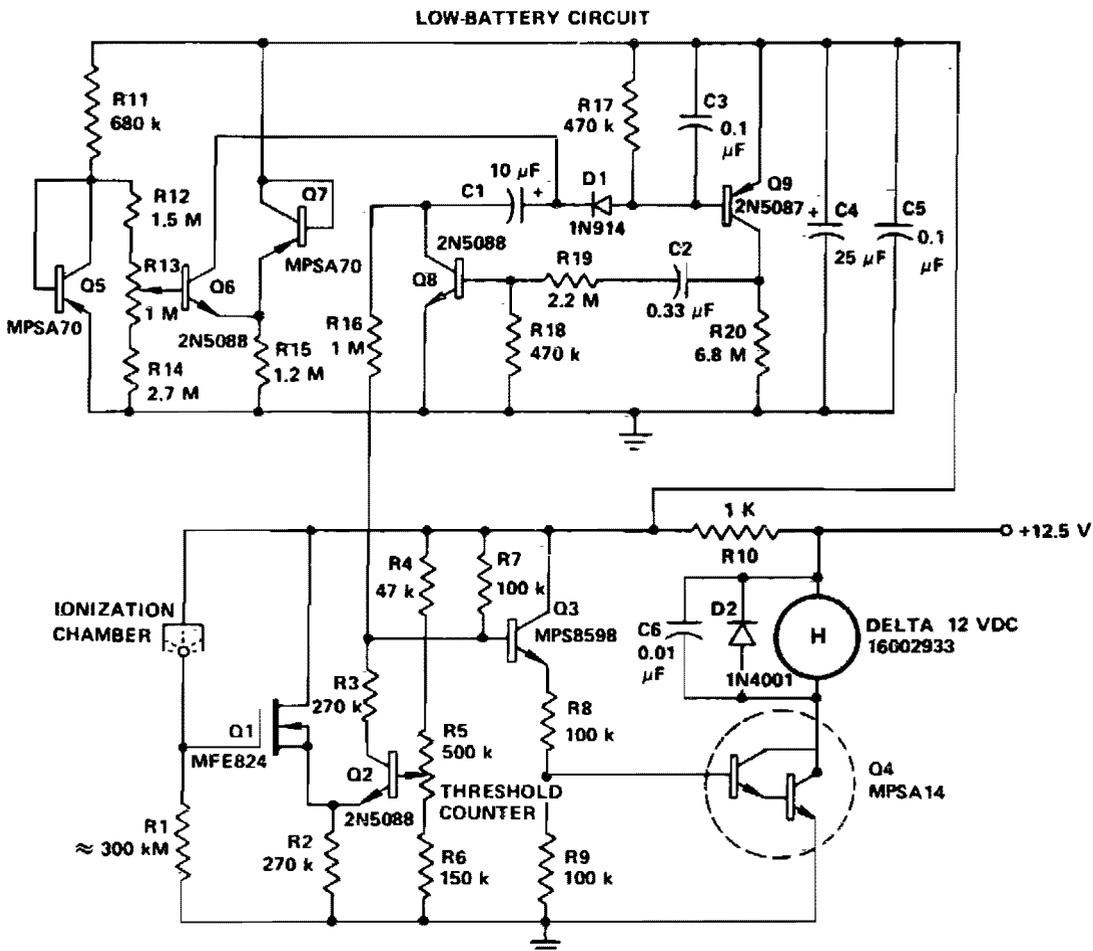


Fig. 40-3

Circuit Notes

If the smoke alarm signal must be a continuous one rather than pulsating, then the slightly less expensive, all discrete transistor version of the MC14572 may be used.

41

Indicators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ten-Step Voltage-Level Indicator
Beat Frequency Indicator
Three-Step Level Indicator
Indicator and Alarm

Five-Step Voltage-Level Indicator
Visible Voltage Indicator
Voltage Level Detector
Zero Center Indicator for FM Receivers

Visual Zero-Beat Indicator

TEN-STEP VOLTAGE-LEVEL INDICATOR

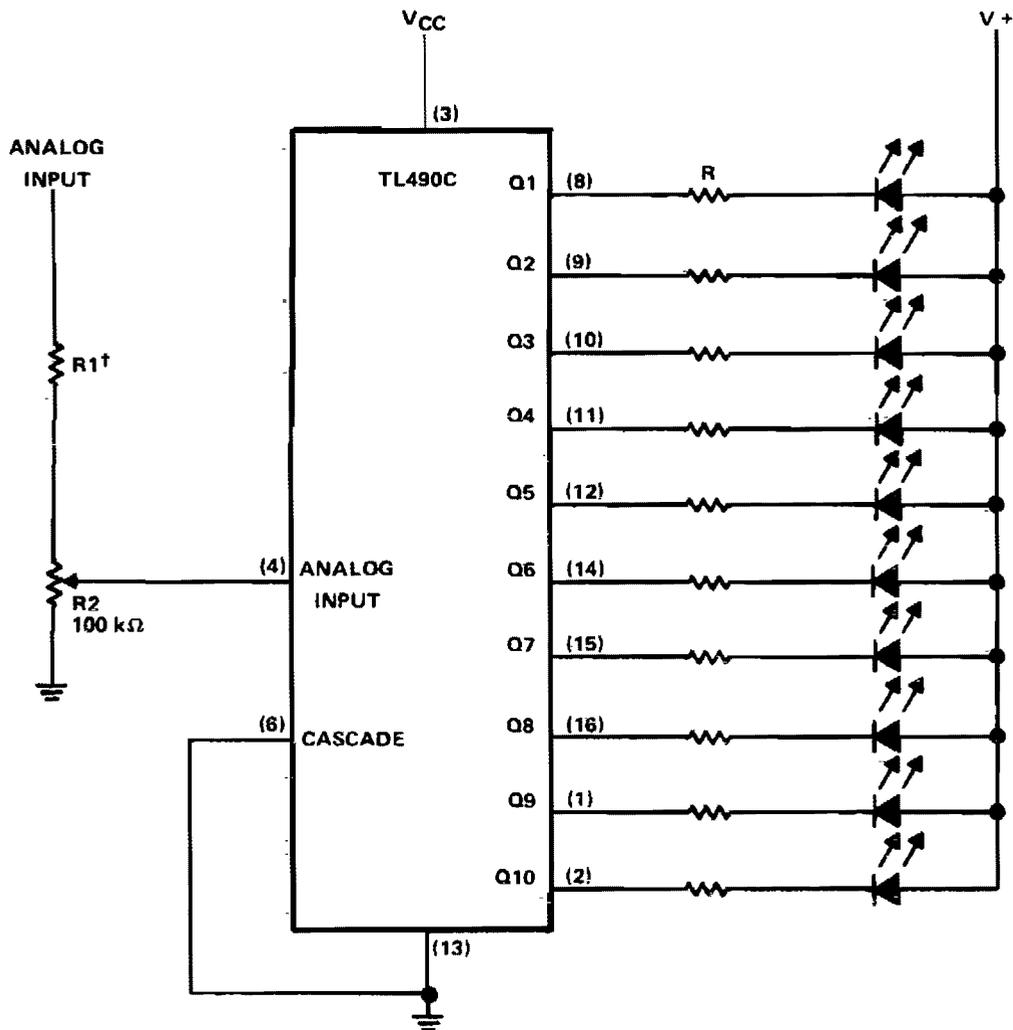


Fig. 41-1

Circuit Notes

This ten-step adjustable analog level detector is capable of sinking up to 40 milliamperes at each output. The voltage range at the input pin should range from 0 to 2 volts. Circuits of this type are useful as liquid-level indi-

cators, pressure indicators, and temperature indicators. They may also be used with a set of active filters to provide a visual indication of harmonic content of audio signals.

BEAT FREQUENCY INDICATOR

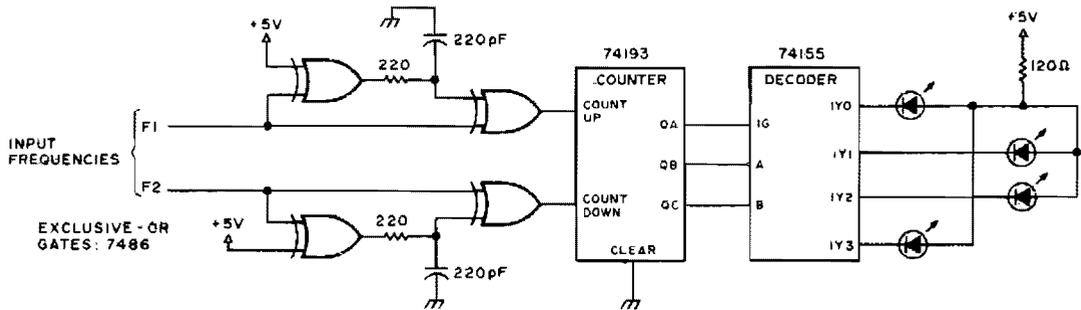


Fig. 41-2

Circuit Notes

This circuit uses LEDs to display the beat frequency of two-tone oscillators. Only one LED is on at a time, and the apparent rotation of the dot is an exact indication of the best fre-

quency. When f_1 is greater than f_2 , a dot of light rotates clockwise; when f_1 is less than f_2 , the dot rotates counterclockwise; and when f_1 equals f_2 , there is no rotation.

THREE-STEP LEVEL INDICATOR

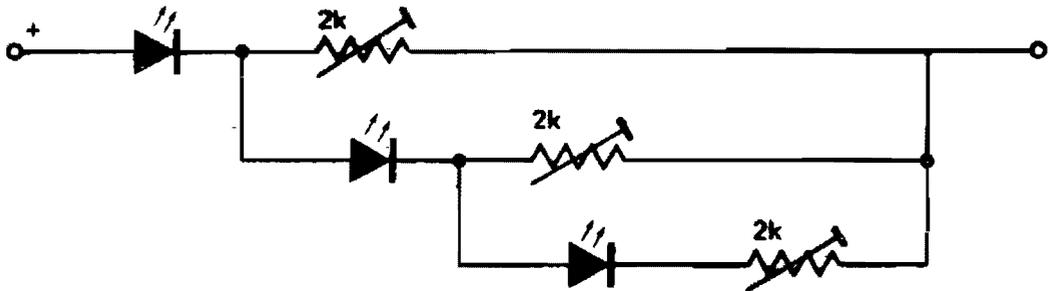


Fig. 41-3

Circuit Notes

This circuit makes a very compact level indicator where a meter would be impractical or not justified due to cost. Resistor values will depend on type of LED used. For MV50 LEDs the resistors are 2 K for steps of approx 2 V and

current drain with all three LEDs on of 5 mA. The chain can be extended but current drain increases rapidly and the first LED carries all the current drawn from the supply.

INDICATOR AND ALARM

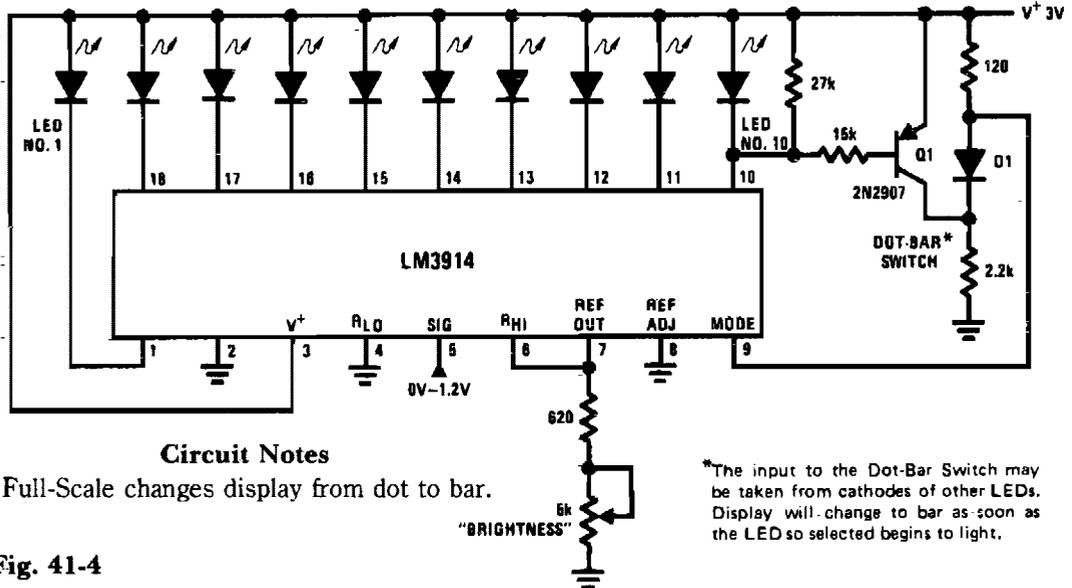


Fig. 41-4

FIVE-STEP VOLTAGE-LEVEL INDICATOR

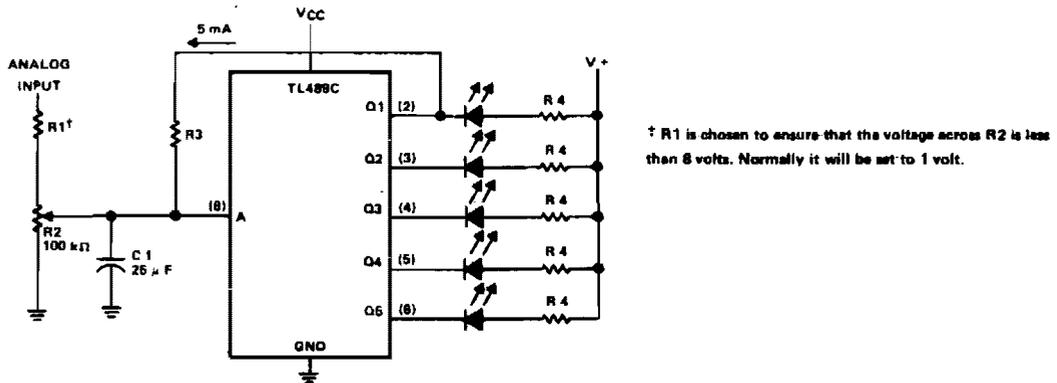


Fig. 41-5

Circuit Notes

This circuit provides a visual indication of the input analog voltage level. It has a high input impedance at pin 8 and open-collector outputs capable of sinking up to 40 milliamperes. It is suitable for driving a linear array of

5 LEDs to indicate the level is 5 steps. The voltage at the analog input should be in the range of zero to approximately one volt and should never exceed eight volts.

VISIBLE VOLTAGE INDICATOR

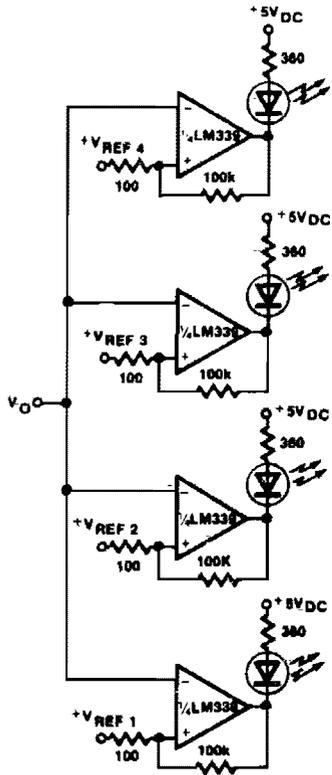


Fig. 41-6

VOLTAGE LEVEL DETECTOR

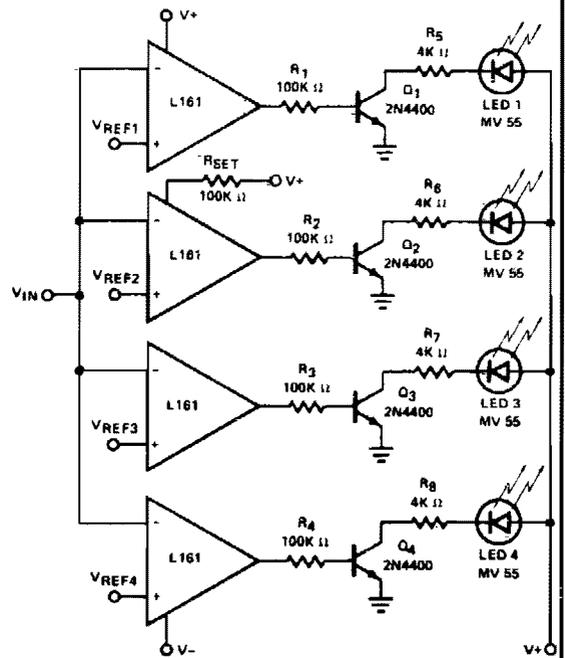


Fig. 41-8

ZERO CENTER INDICATOR FOR FM RECEIVERS

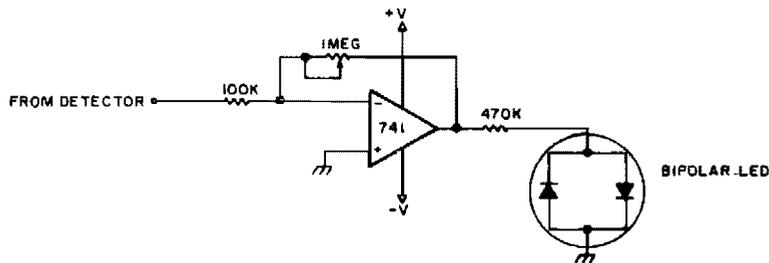
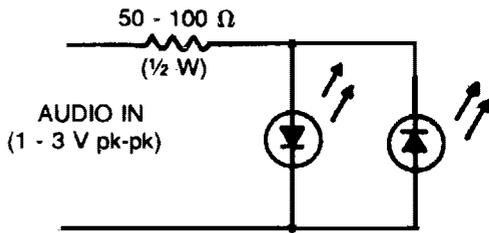


Fig. 41-7

Circuit Notes

To adjust, tune in a station and adjust the $1M$ pot for a null. Then ask the station to modulate and fine adjust so modulation peaks don't light the LEDs. Stations are properly tuned when neither LED is lit.

VISUAL ZERO-BEAT INDICATOR



LEDs: FAIRCHILD FLV-100 RED,
OR MONSANTO MV-5094 RED/RED,
OR MONSANTO MV-5491 RED/GREEN

Fig. 41-9

Circuit Notes

Light-emitting diodes connected with reverse polarity provide a visual indication of zero-beat frequency. Each LED is on for only half a cycle of the input. When the input frequency is more than 1 kilohertz away from the zero-beat frequency, both LEDs appear to be on all the time. As the input frequency comes within about 20 hertz of zero beat, the LEDs will flicker until zero beat is reached. Both LEDs glow or flicker until zero beat is reached, when they go out.

42

Infrared Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

IR Type Data Link

IR Remote Control Transmitter/Receiver

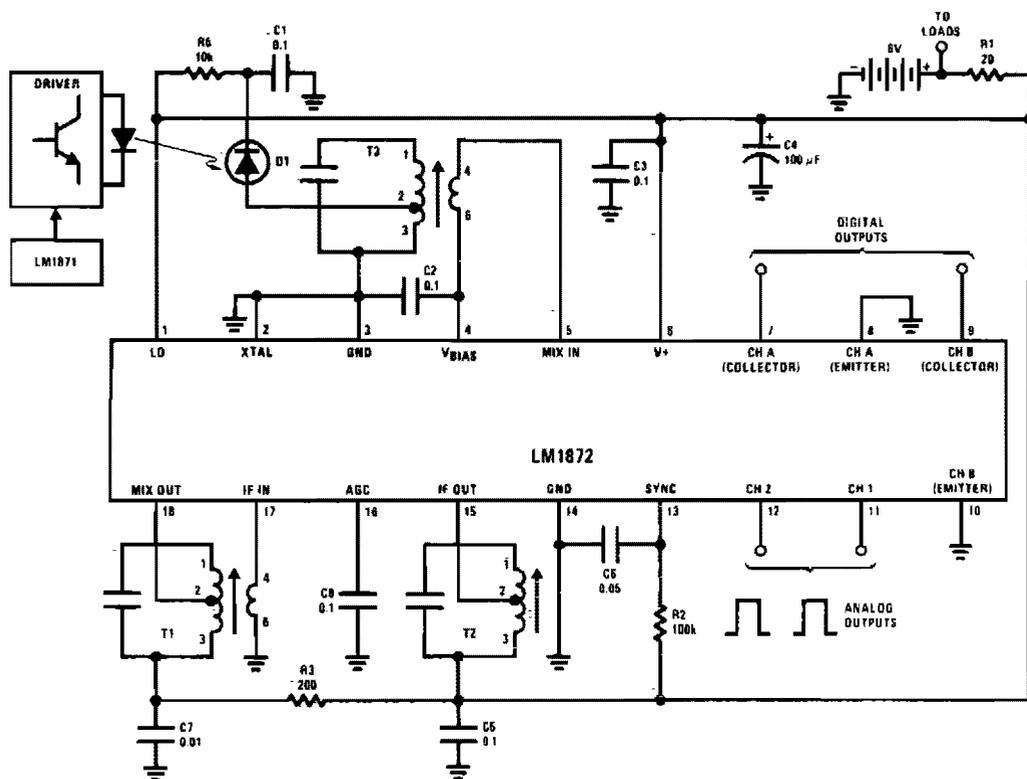
Compact IR Receiver

IR Transmitter

Remote Loudspeaker Via IR Link

Proximity Detector

IR TYPE DATA LINK

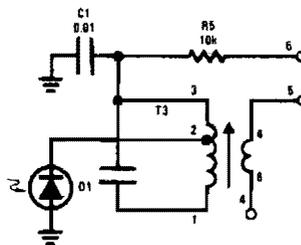


- R1 - Load decoupling
- R2 - Sync timer; $R2 = \frac{t}{0.7 C6}$, $R2 \leq 470k$
- R3 - Preamp decoupling
- R5 - Photodiode decoupling
- C1 - Photodiode decoupling
- C2 - V_{BIAS} bypass
- C3 - V^+ bypass
- C4 - Load decoupling
- C5 - IF bypass; optional
- C6 - Sync timer; $C6 = \frac{t_{SYNC}}{0.7 R2}$, $C6 \leq 0.5 \mu F$
- C7 - Preamp decoupling
- C8 - AGC
- T1 - 455 kHz preamp transformer
Toko* 10 EZC type (RMC-502182), $Q_u = 110$
Pin 1-2, 82T; pin 2-3, 82T
Pin 1-3, 164T; pin 4-6, 30T
- T2 - 455 kHz IF transformer
Toko* 10 EZC type (RMC-402503), $Q_u = 110$
Pin 1-2, 98T; pin 2-3, 66T
Pin 1-3, 164T; pin 4-6, 8T
- T3 - 455 kHz input transformer
Toko* 10 EZC type (RMC-202313), $Q_u = 110$
Pin 1-2, 131T; pin 2-3, 33T
Pin 1-3, 164T; pin 4-6, 5T
- D1 - PN or PIN Silicon Photodiode

BOTTOM VIEW

Photodiode, D1		Active Area (cm ²)
Vactec	VTS 5088	0.18
Vactec	VTS 6089	0.52
UDT	PIN 6D or 6 DP	0.20
UDT	PIN 220 DP	2.0
Siemens	BPY 12	0.20

* Toko America, Inc.
5520 West Touhy Ave.
Skokie, Ill. 60077
(312)677-3640 Tlx 72-4372



Input Stage Where the Case of D1 is Connected to the Anode

Fig. 42-1

IR REMOTE CONTROL TRANSMITTER/RECEIVER

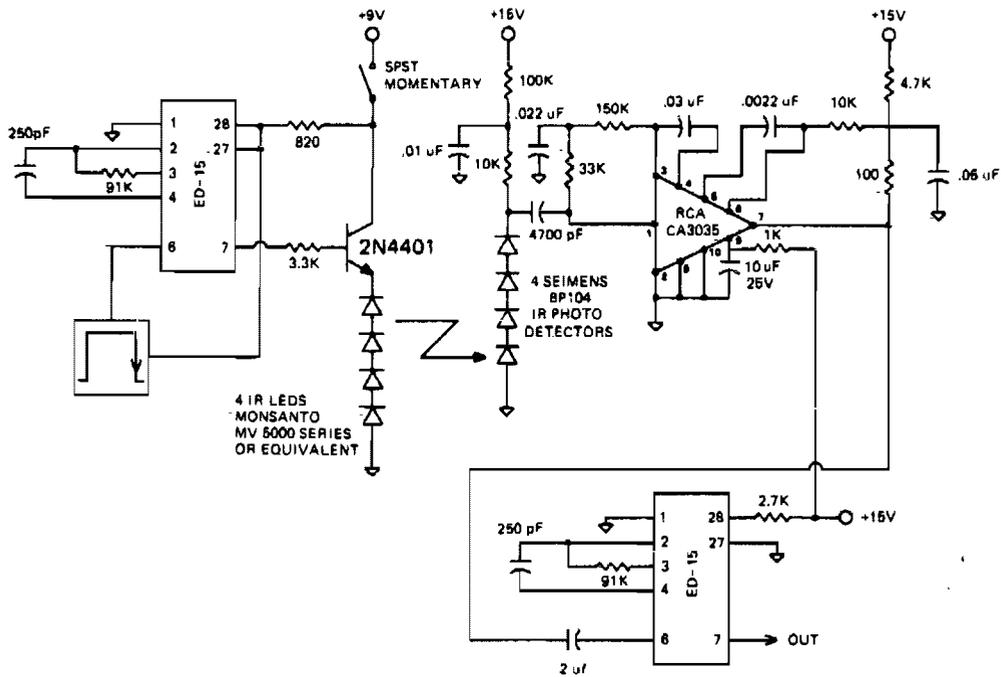


Fig. 42-2

Circuit Notes

The circuit is designed to operate at 25 kHz. The data stream turns the 2N4401 hard on or off depending upon the coded state. This in turn switches the series infrared LEDs on and

off. The receiver circuit consists of a three stage amplifier with photo diodes arrayed for maximum coverage of the reception area. The range of this set-up should be about 10 meters.

COMPACT IR RECEIVER

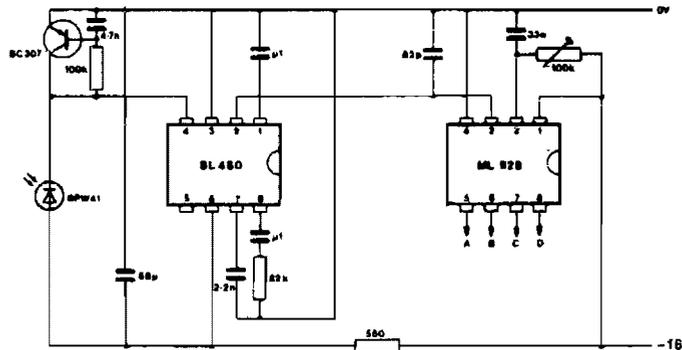


Fig. 42-3

PROXIMITY DETECTOR

NOTE
 IC1 IS CA3240
 Q1 IS 2N3819
 Q2,4 ARE BC184L
 Q3 IS BD140

D1 IS PHOTODIODE
 D2 IS 1N4148
 ZD1 IS 2V7 400mW ZENER
 LED1 IS 3mm RED LED
 LED2 IS IS INFRA RED LED

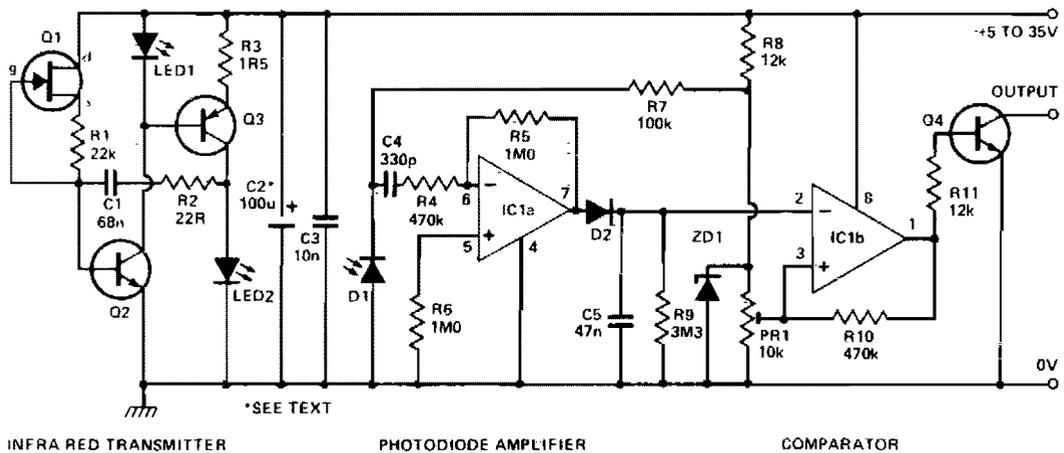


Fig. 42-6

Circuit Notes

This circuit provides a means of detecting the presence of anything by the reflection of infra-red light and provides a direct digital output of object detection. By the use of modulation and high power bursts of infra-red at a very low duty cycle, a detection range of over a foot is achieved. Works on the principle of transmit-

ting a beam of modulated infra-red light from the emitter diode LED2, and receiving reflections from objects passing in front of the beam with a photodiode detector D1. The circuit consists of an infra-red transmitter, photodiode amplifier, and a variable threshold comparator.

Instrumentation Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Instrumentation Amplifier
- Triple Op-Amp Instrumentation Amplifier
- Differential Input Instrumentation Amplifier with High CMRR
- Instrumentation Amplifier with High CMRR
- Level-Shifting Isolation Amplifier
- Variable Gain, Differential-Input Instrumentation Amplifier
- Instrumentation Amplifier
- Low Signal Level, High Impedance Instrumentation Amplifier
- Chopper Channel Amplifier
- Battery Powered Buffer Amplifier for Standard Cell
- Bridge Transducer Amplifier
- Instrumentation Amplifier
- Isolation Amplifier for Medical Telemetry
- High Gain Differential Instrumentation Amplifier
- High Impedance Bridge Amplifier
- Instrumentation Amplifier (Two Op Amp Design)
- Instrumentation Amplifier
- Differential Input Instrumentation Amplifier
- High Impedance Differential Amplifier
- High Speed Instrumentation Amplifier
- Very High Impedance Instrumentation Amplifier
- Precision FET Input Instrumentation Amplifier
- High Stability Thermocouple Amplifier
- High Stability Thermocouple Amplifier
- High Impedance, Low Drift Instrumentation Amplifier

INSTRUMENTATION AMPLIFIER

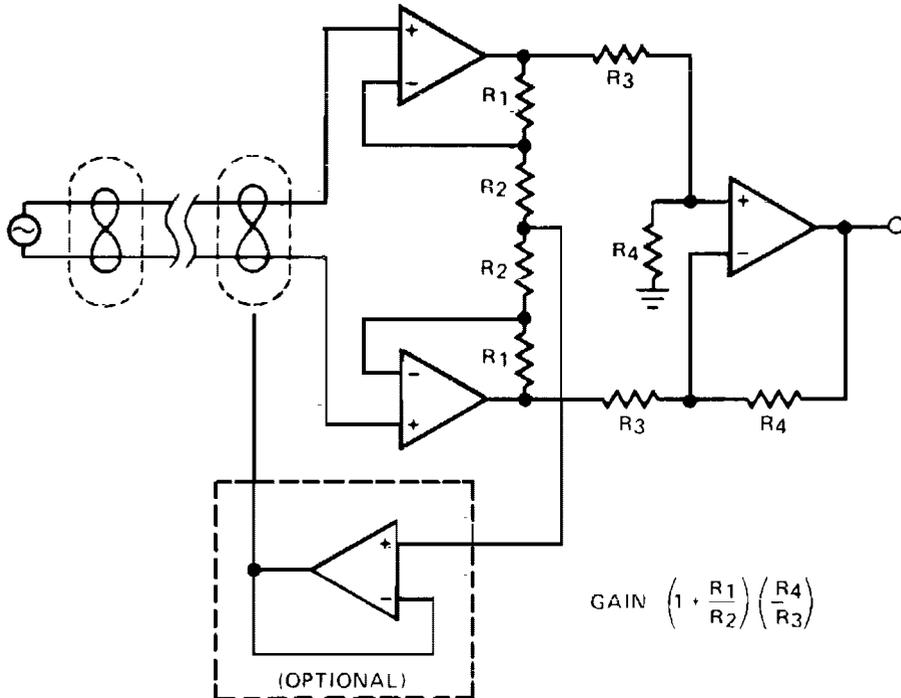


Fig. 43-1

Circuit Notes

Instrumentation amplifiers (differential amplifiers) are specifically designed to extract and amplify small differential signals from much larger common mode voltages. To serve as building blocks in instrumentation amplifiers, op amps must have very low offset voltage drift, high gain and wide bandwidth.

The HA-4620/5604 is suited for this application. The optional circuitry makes use of the fourth amplifier section as a shield driver which enhances the ac common mode rejection by nullifying the effects of capacitance-to-ground mismatch between input conductors.

TRIPLE OP-AMP INSTRUMENTATION AMPLIFIER

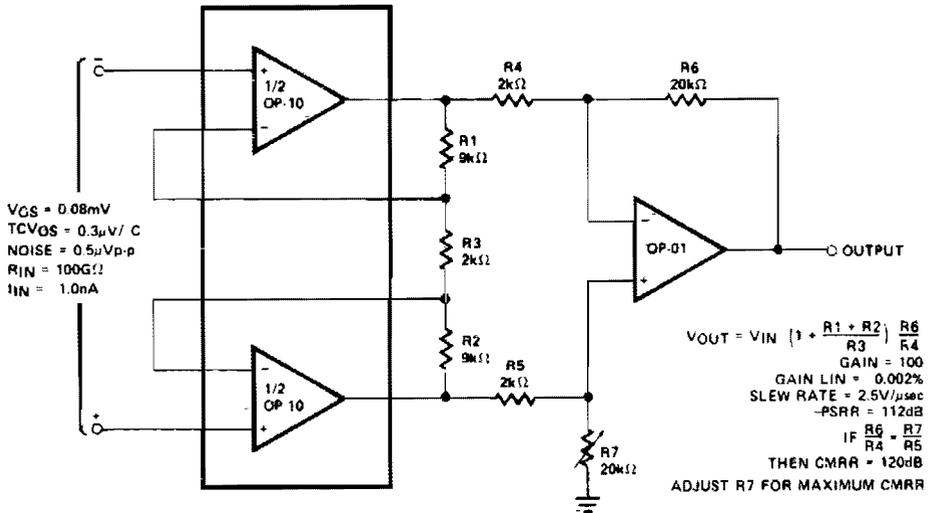


Fig. 43-2

DIFFERENTIAL INPUT INSTRUMENTATION AMPLIFIER WITH HIGH COMMON MODE REJECTION

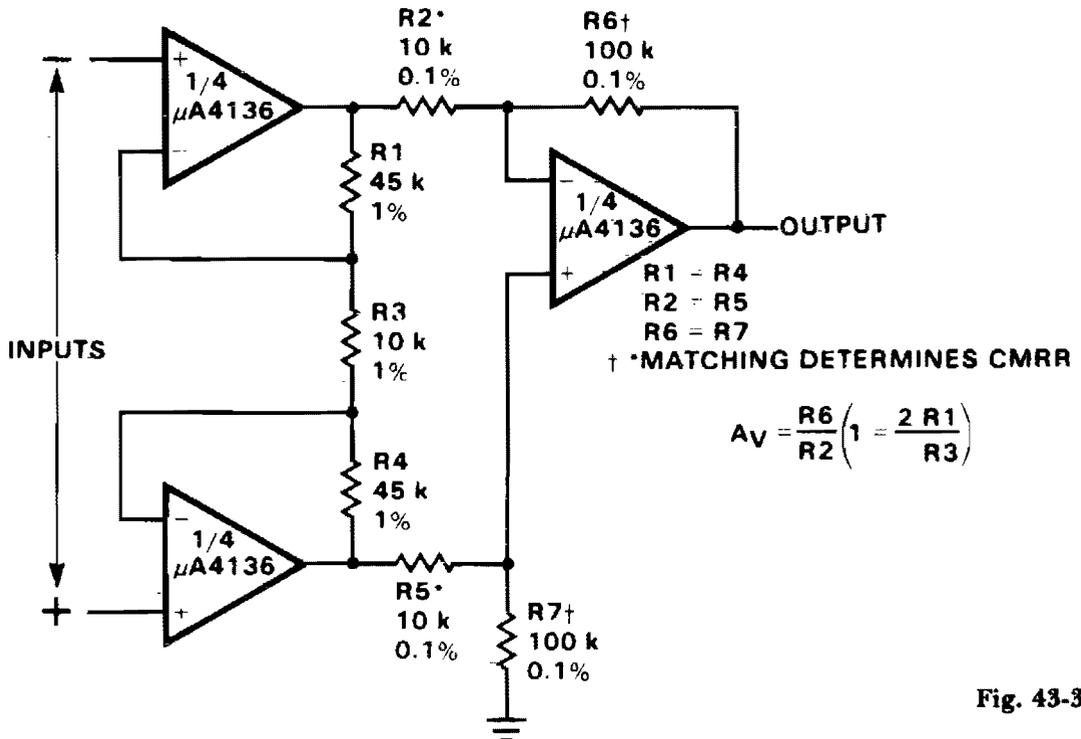


Fig. 43-3

INSTRUMENTATION AMPLIFIER WITH HIGH COMMON MODE REJECTION

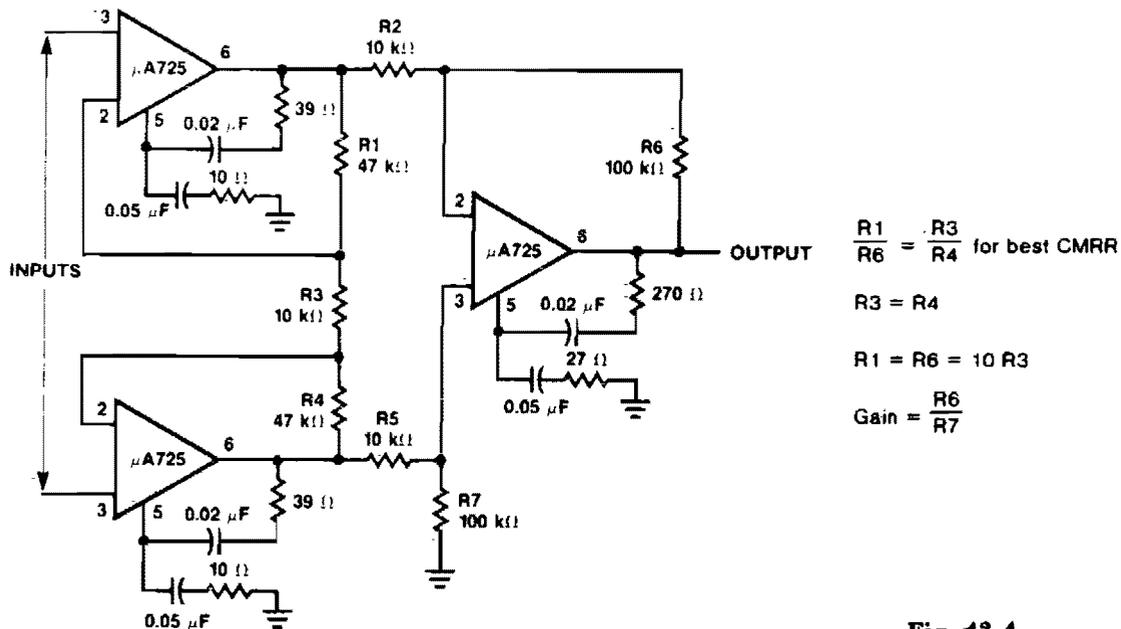


Fig. 43-4

LEVEL-SHIFTING ISOLATION AMPLIFIER

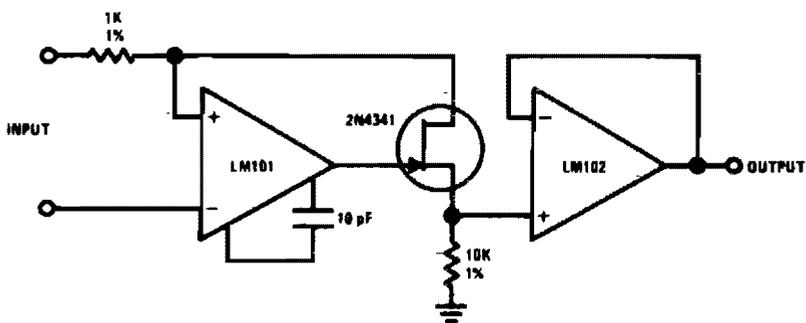


Fig. 43-5

Circuit Notes

The 2N4341 JFET is used as a level shifter between two op amps operated at different power supply voltages. The JFET is ideally

suited for this type of application because $I_D = I_S$.

VARIABLE GAIN, DIFFERENTIAL-INPUT INSTRUMENTATION AMPLIFIER

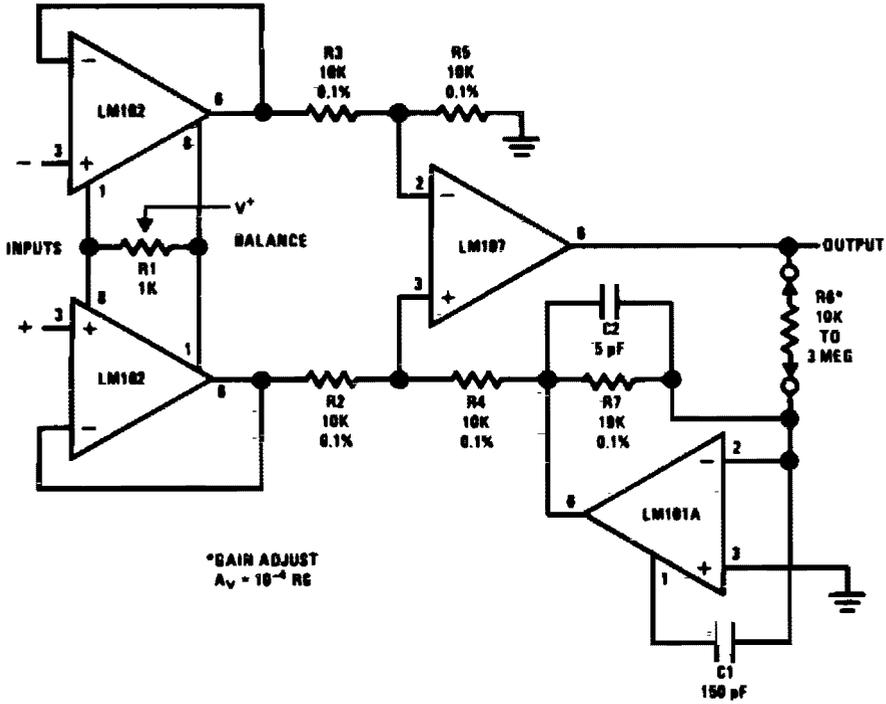


Fig. 43-6

INSTRUMENTATION AMPLIFIER

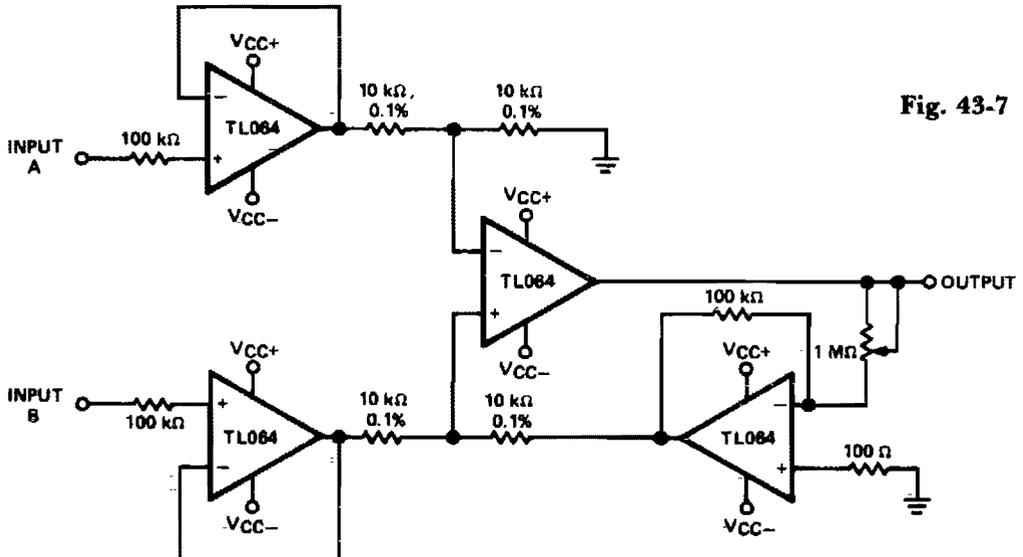


Fig. 43-7

LOW SIGNAL LEVEL, HIGH IMPEDANCE INSTRUMENTATION AMPLIFIER

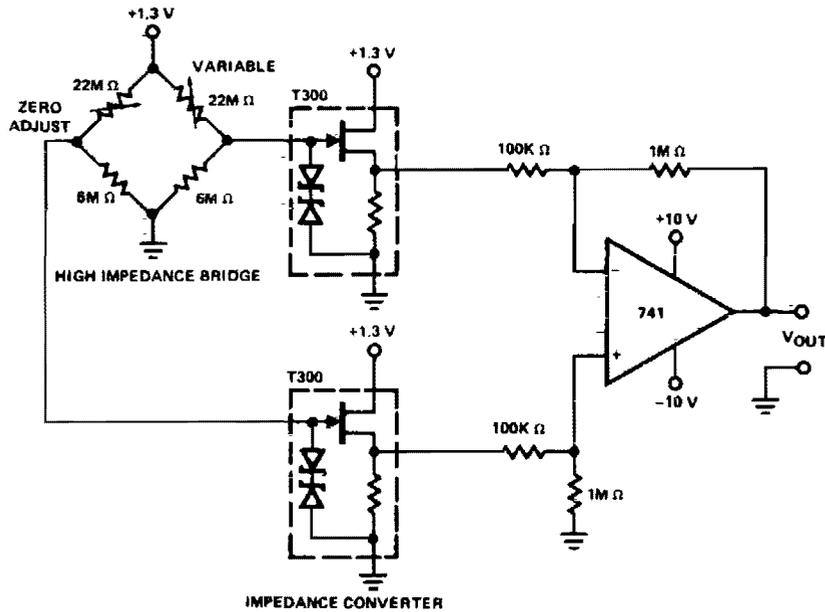


Fig. 43-8

CHOPPER CHANNEL AMPLIFIER

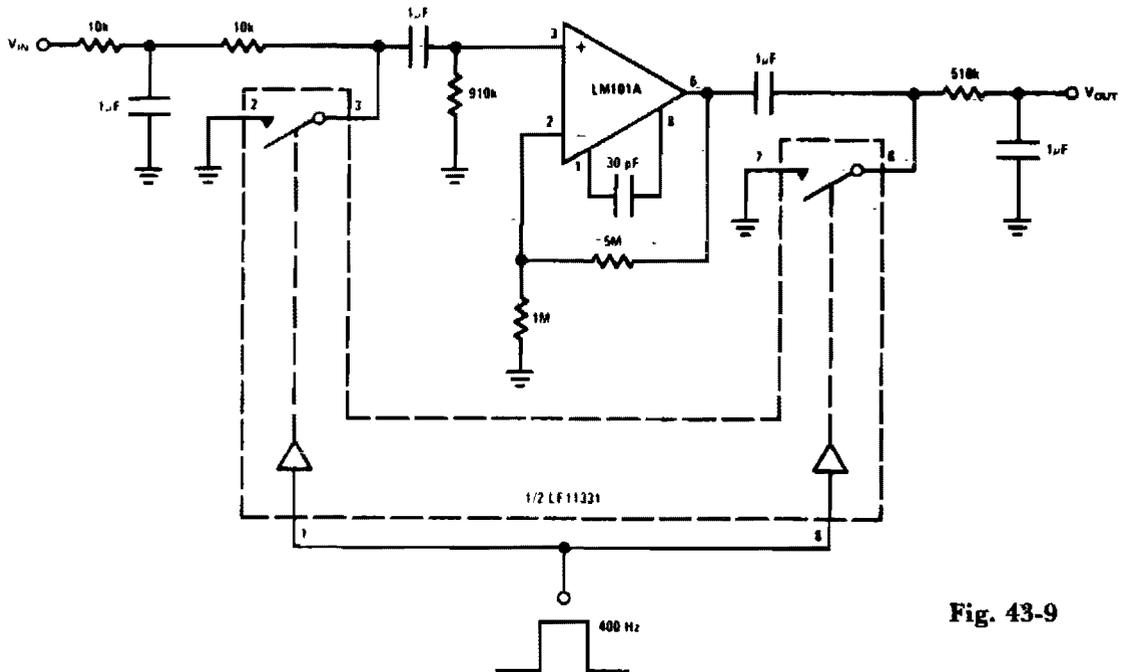
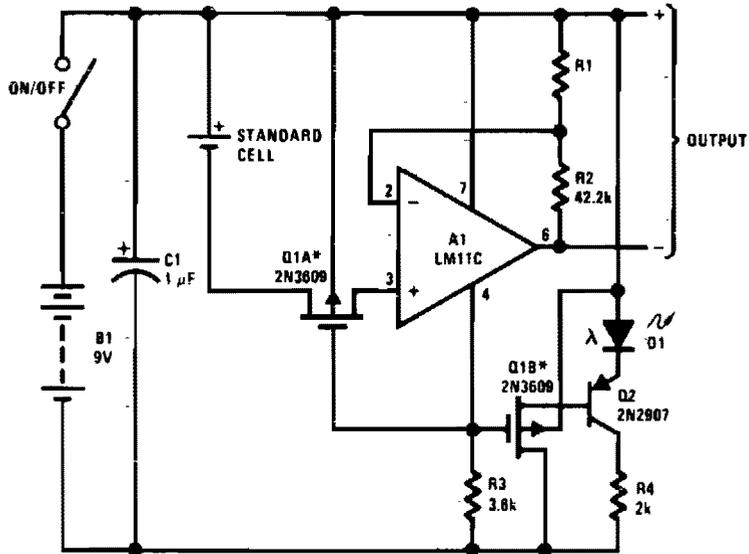


Fig. 43-9

BATTERY POWERED BUFFER AMPLIFIER FOR STANDARD CELL



* cannot have gate protection diode; $V_{TH} > V_{OUT}$

Fig. 43-10

Circuit Notes

This circuit has negligible loading and disconnects the cell for low supply voltage or overload on output. The indicator diode extinguishes as disconnect circuitry is activated.

BRIDGE TRANSDUCER AMPLIFIER

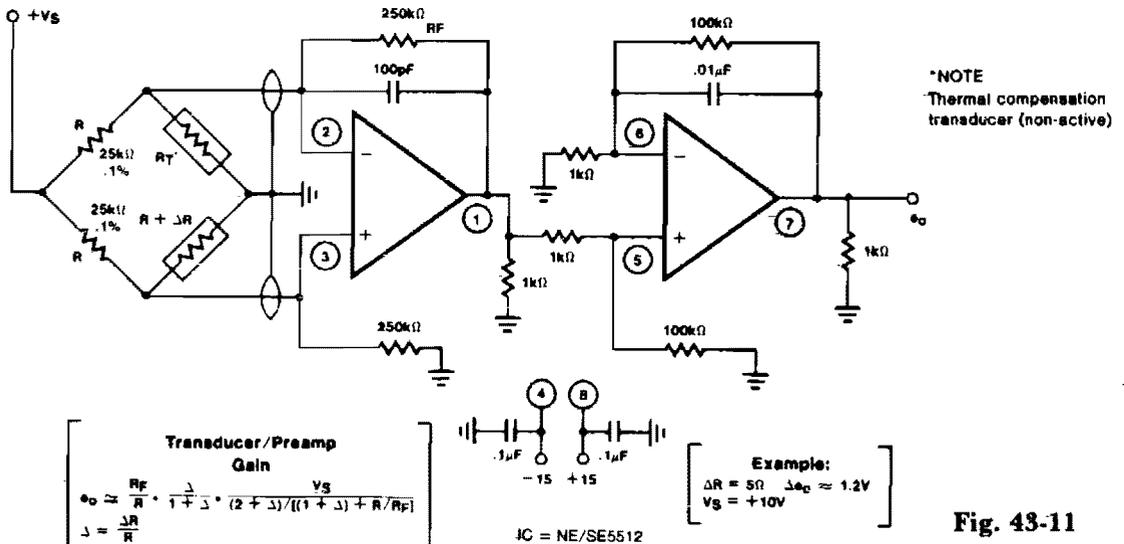


Fig. 43-11

INSTRUMENTATION AMPLIFIER

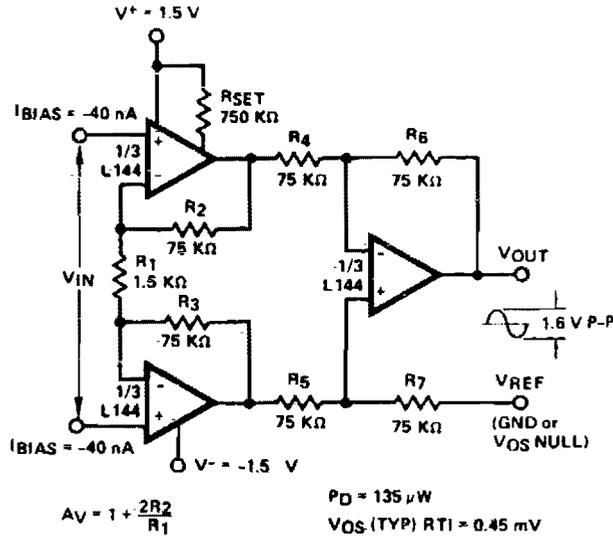


Fig. 43-12

Circuit Notes

Three-amplifier circuit consumes only $135 \mu W$ of power from a $\pm 1.5 V$ power supply. With a gain of 101, the instrumentation amplifier is ideal in sensor interface and biomedical preamplifier applications. The first

stage provides all of the gain while the second stage is used to provide common mode rejection and double-ended to single-ended conversion.

ISOLATION AMPLIFIER FOR MEDICAL TELEMETRY

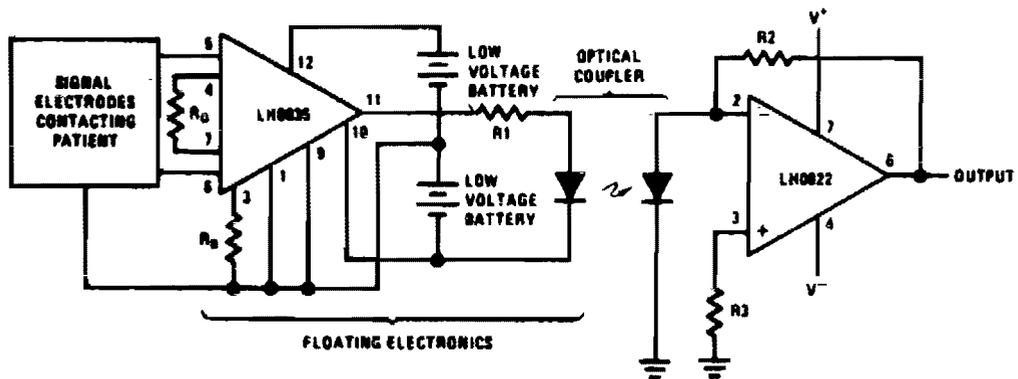


Fig. 43-13

HIGH GAIN DIFFERENTIAL INSTRUMENTATION AMPLIFIER

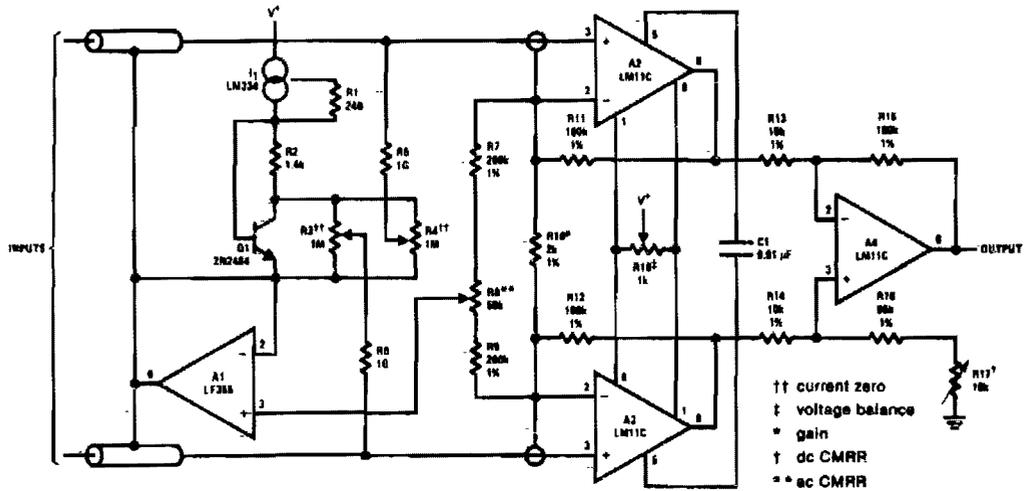


Fig. 43-14

Circuit Notes

This circuit includes input guarding, cable bootstrapping, and bias current compensation. Differential bandwidth is reduced by C1 which also makes common-mode rejection less dependent on matching of input amplifiers.

HIGH IMPEDANCE BRIDGE AMPLIFIER

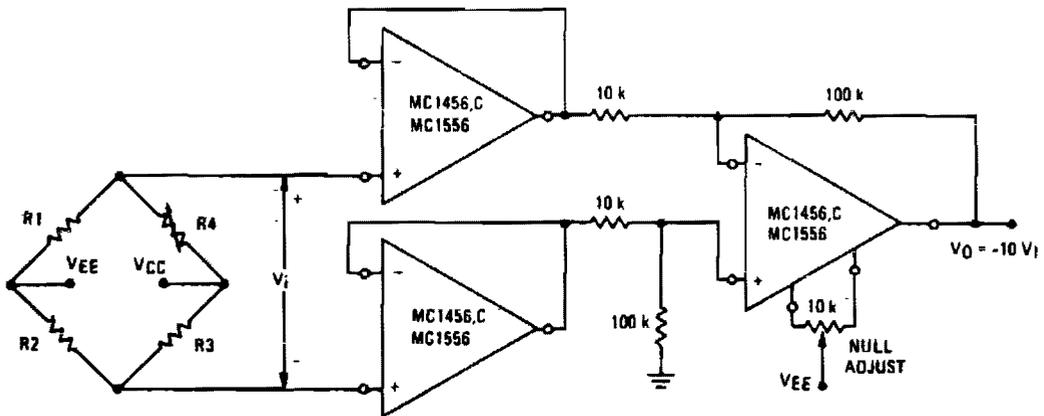


Fig. 43-15

INSTRUMENTATION AMPLIFIER (TWO OP AMP DESIGN)

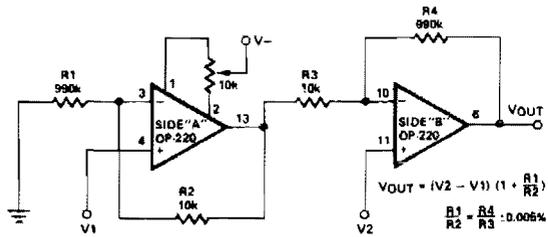


Fig. 43-16

HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER

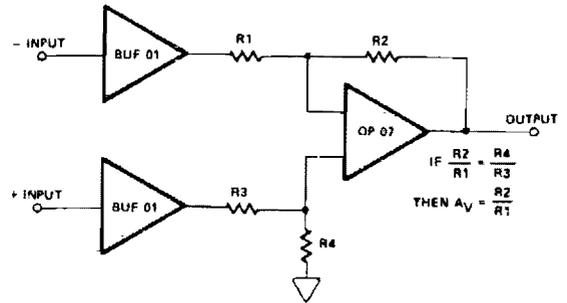


Fig. 43-19

INSTRUMENTATION AMPLIFIER

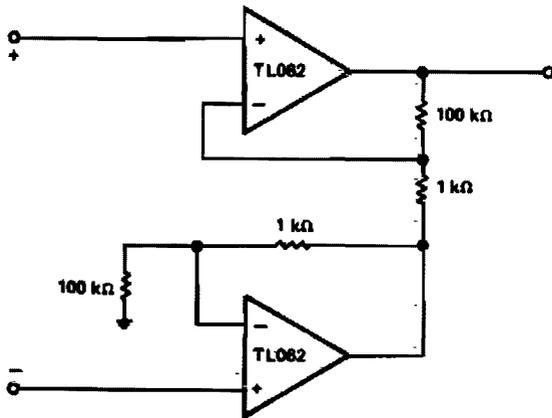


Fig. 43-17

HIGH SPEED INSTRUMENTATION AMPLIFIER

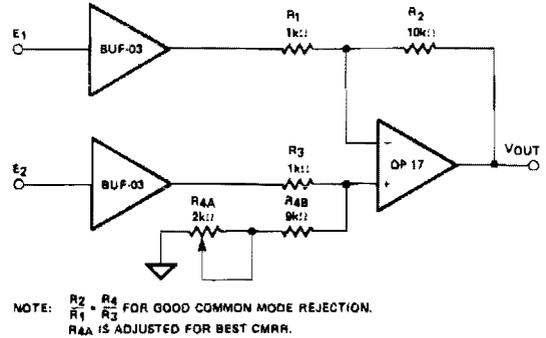


Fig. 43-20

DIFFERENTIAL INPUT INSTRUMENTATION AMPLIFIER

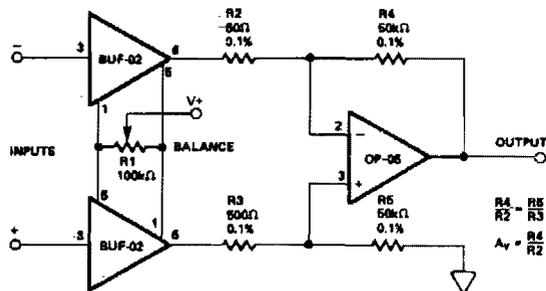


Fig. 43-18

VERY HIGH IMPEDANCE INSTRUMENTATION AMPLIFIER

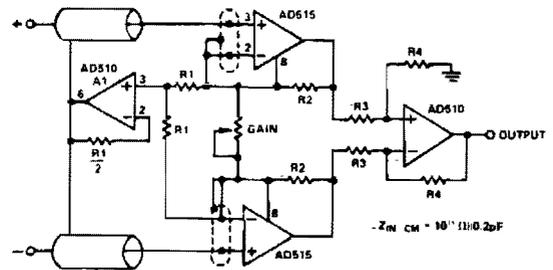
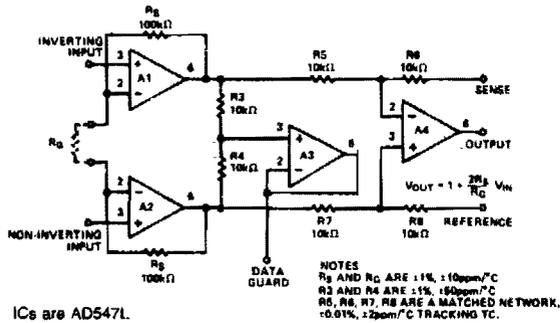


Fig. 43-21

(ALL-RESISTORS OF SAME NUMBER SHOULD BE MATCHED ±0.1%)
(BUFFER A1 BOOSTS COMMON MODE Z_{IN} BY DRIVING CABLE SHIELDS AT COMMON MODE VOLTAGE AND NEUTRALIZING CM CAPACITANCE)

PRECISION FET INPUT INSTRUMENTATION AMPLIFIER



ICs are AD547L.

Fig. 43-22

HIGH STABILITY THERMOCOUPLE AMPLIFIER

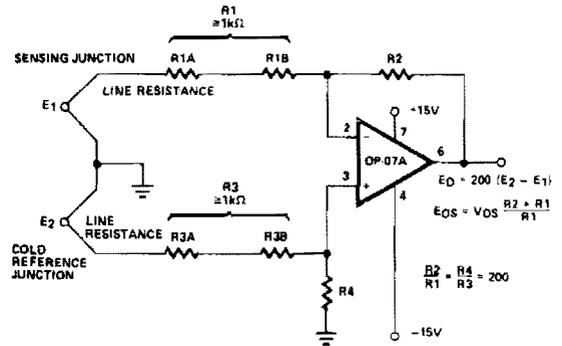


Fig. 43-24

HIGH STABILITY THERMOCOUPLE AMPLIFIER

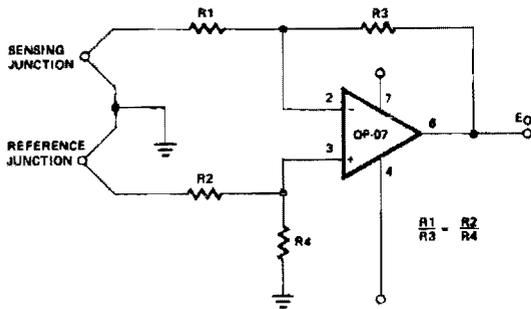
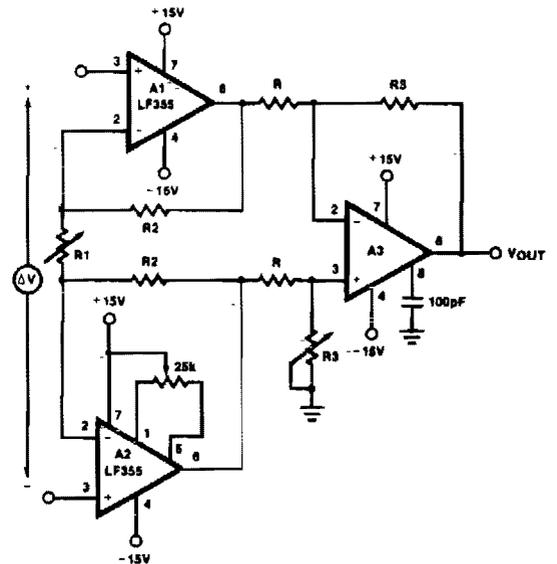


Fig. 43-23

HIGH IMPEDANCE LOW DRIFT INSTRUMENTATION AMPLIFIER



$$V_{OUT} = \frac{R_3}{R} \left[\frac{2R_2}{R_1} + 1 \right] \Delta V, V^- + 2V \leq V_{IN \text{ Common-Mode}} \leq V^+$$

- System V_{OS} adjusted via A2 V_{OS} adjust
- Trim R3 to boost up CMRR to 120dB.

Fig. 43-25

44

Light Activated Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Pulse Generation by Interrupting a Light Beam

Optical Communication System

Four Quadrant Photo-Conductive Detector Amplifier

Precision Photodiode Comparator

Automatic Night Light

Receiver for 50 kHz FM Optional Transmitter

Photodiode Amplifier

Optical Schmitt Trigger

Adjustable Light Detection Switch

Photocell Memory Switch for AC Power Control

Optical Transmitter

Light Interruption Detector

Optical Receiver

Light Isolated Power Relay Circuit

Precision Photodiode Level Detector

Light Beam Operated On-Off Relay

Logarithmic Light Sensor

FM (PRM) Optical Transmitter

Light Level Sensor

PULSE GENERATION BY INTERRUPTING A LIGHT BEAM

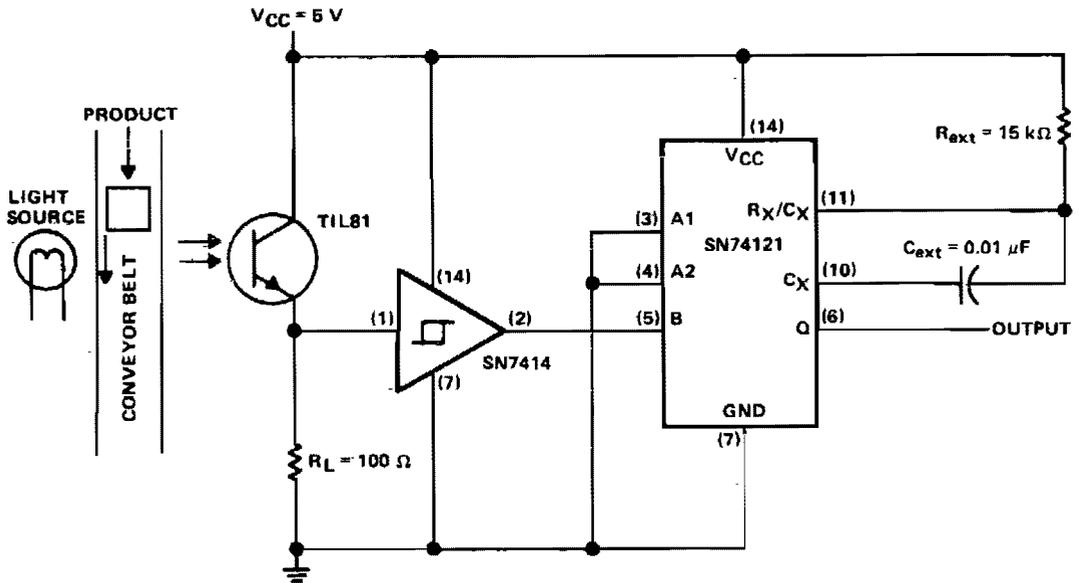


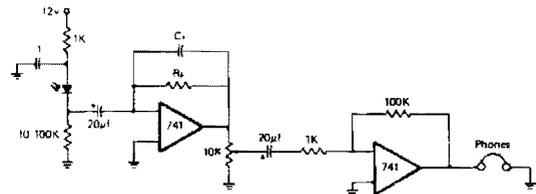
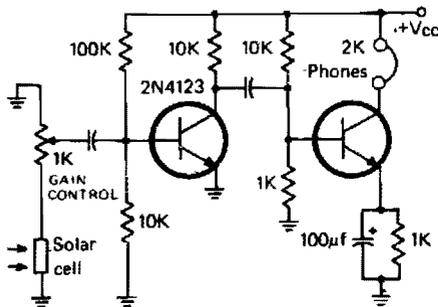
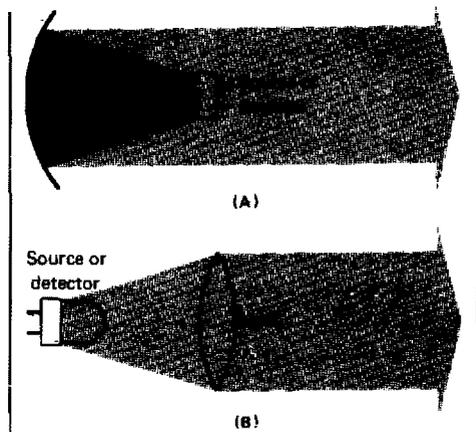
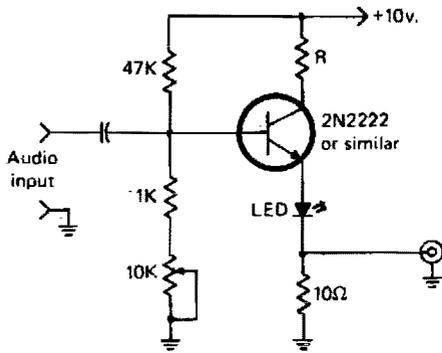
Fig. 44-1

Circuit Notes

This circuit puts out a pulse when an object on the conveyor belt blocks the light source. The light source keeps the phototransistor turned on. This produces a high-logic-level voltage at the Schmitt-trigger inverter

and a TTL-compatible low logic level at pin 5 of the monostable. When an object blocks the light, TIL81 turns off the Schmitt-trigger inverter to trigger the one shot.

OPTICAL COMMUNICATION SYSTEM



Circuit Notes

The simple modulator stage will accommodate most common LEDs. By adjusting the potentiometer, the bias of the transistor is varied until the LED is at its half output point. Then, audio will cause it to vary above and

below this point. The purpose of R1 is to limit the current through the LED to a safe level and the purpose of the 10 ohm resistor is to allow a portion of the modulating signal to be observed on a scope.

Fig. 44-2

FOUR QUADRANT PHOTO-CONDUCTIVE DETECTOR AMPLIFIER

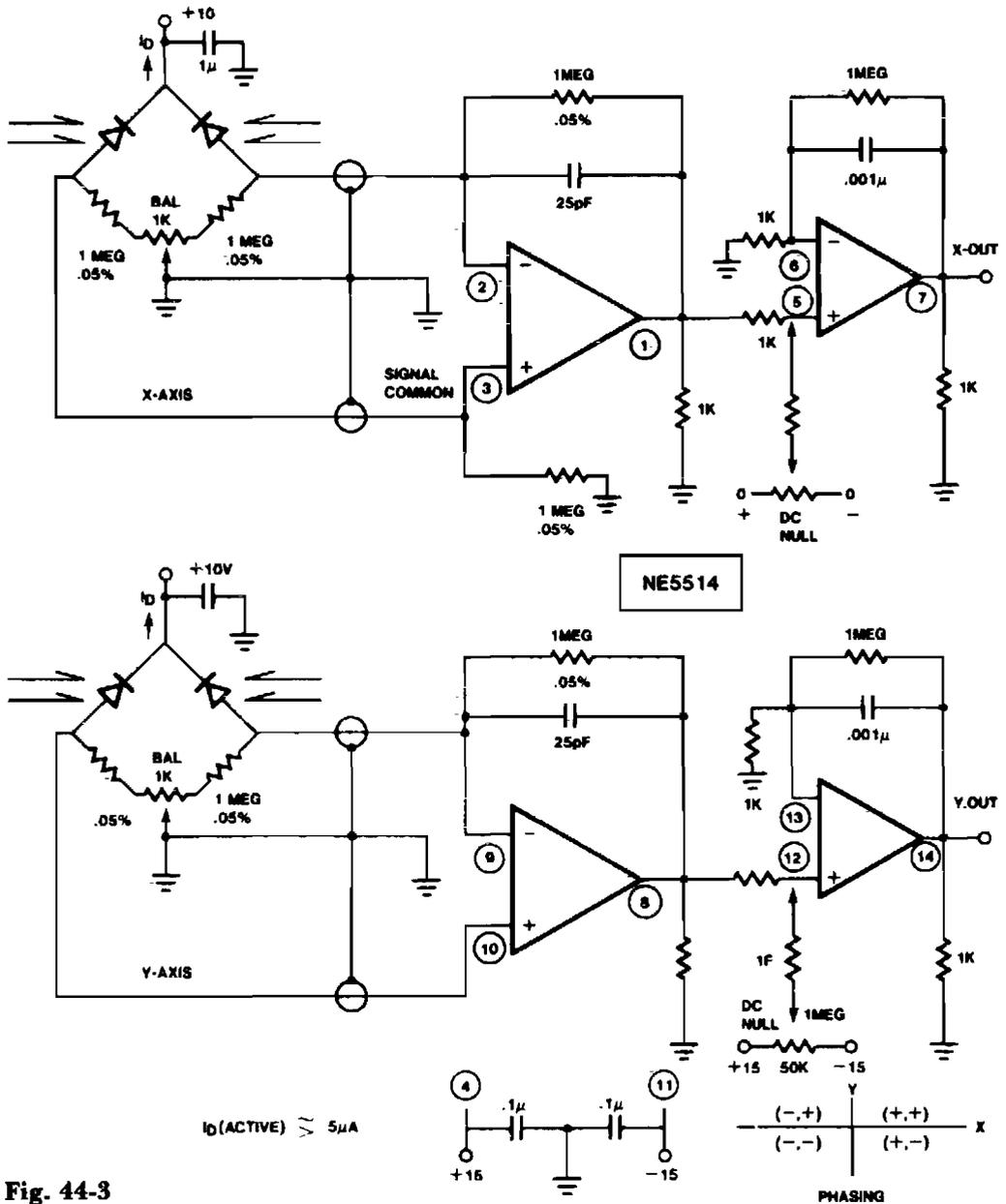


Fig. 44-3

Circuit Notes

Use this circuit to sense four quadrant motion of a light source. By proper summing of the signals from the X and Y axes, four quadrant output may be fed to an X-Y plotter, oscilloscope, or computer for simulation. IC = NE/SE5514

PRECISION PHOTODIODE COMPARATOR

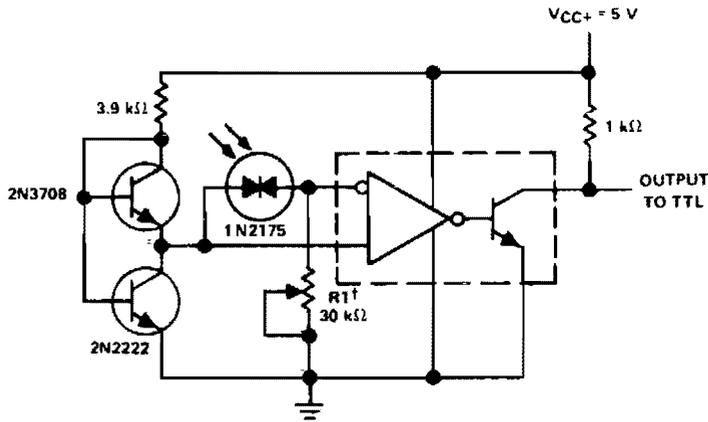


Fig. 44-4

Circuit Notes

R1 sets the comparison level. At comparison, the photodiode has less than 5 mV across it, decreasing dark current by an order of magnitude. IC = LM 111/211/311.

AUTOMATIC NIGHT LIGHT

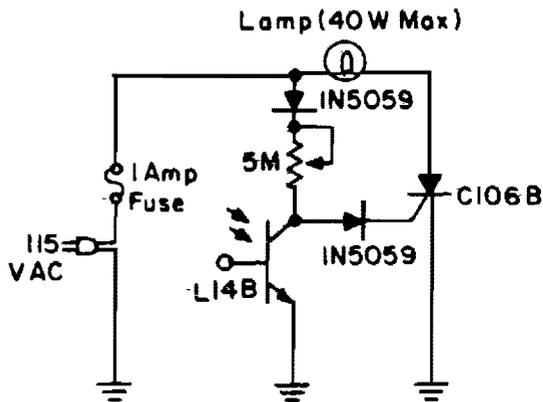


Fig. 44-5

Circuit Notes

During daylight hours, the L14B photo-Darlington (JEDEC registered as 2N5777 through 2N5780) shunts all gate current to ground. At night, the L14B effectively provides a high resistance, diverting the current into the gate of the C106B and turning on the lamp.

RECEIVER FOR 50 kHz FM OPTICAL TRANSMITTER

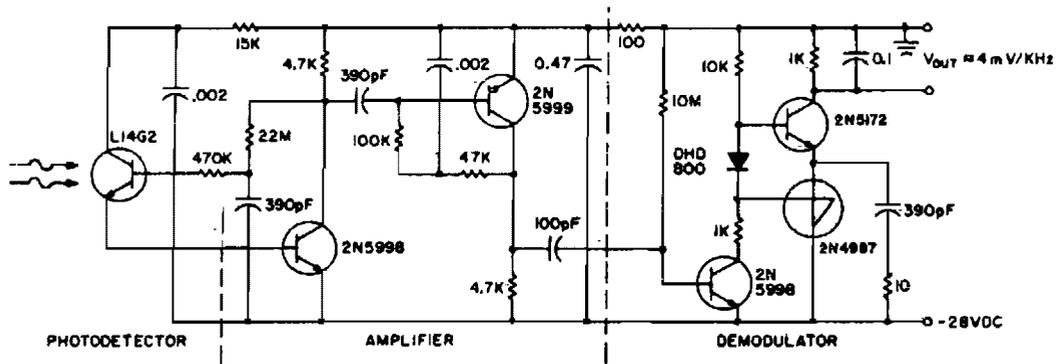


Fig. 44-6

Circuit Notes

This circuit consists of a L14G2 detector, two stages of gain, and a FM demodulator. Better sensitivity can be obtained using more stages of stabilized gain with AGC.

PHOTODIODE AMPLIFIER

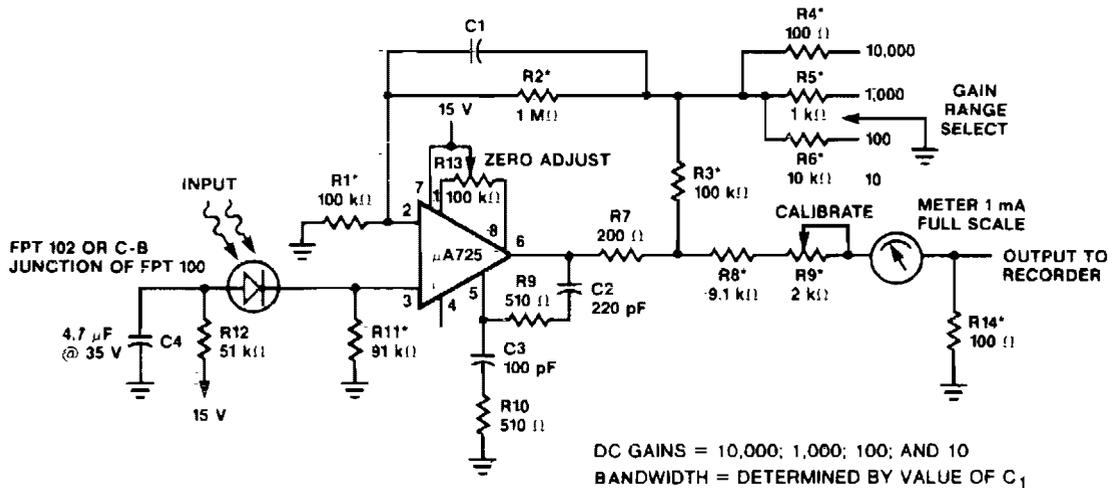


Fig. 44-7

OPTICAL SCHMITT TRIGGER

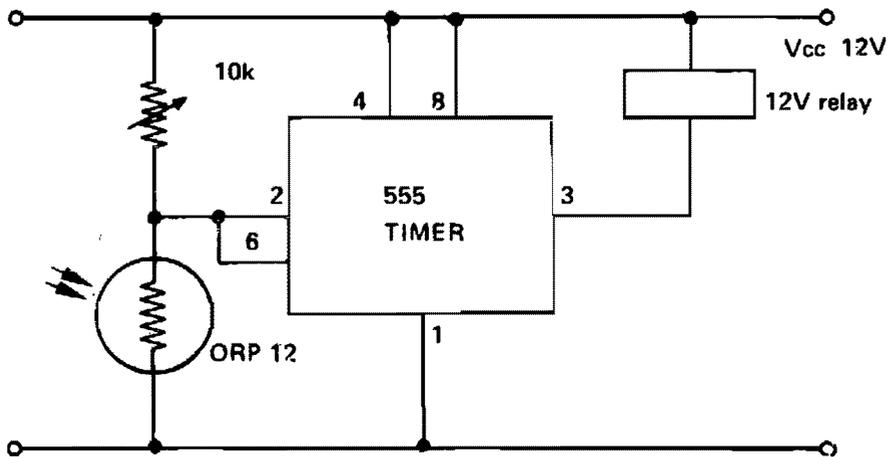


Fig. 44-8

Circuit Notes

This circuit shows a 555 with its trigger and threshold inputs connected together used to energize a relay when the light level on a photoconductive cell falls below a preset value.

Circuit can be used in other applications where a high input impedance and low output impedance are required with the minimum component count.

ADJUSTABLE LIGHT DETECTION SWITCH

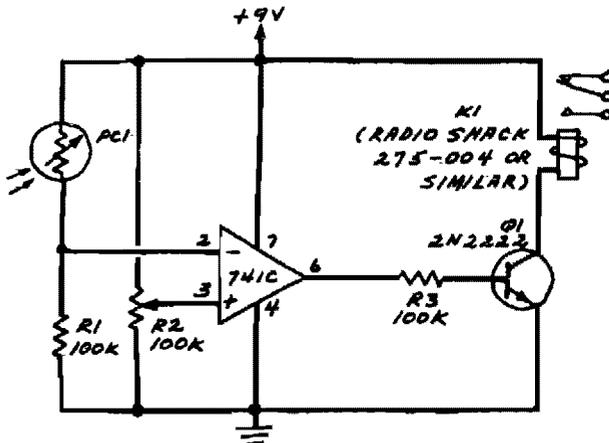


Fig. 44-9

Circuit Notes

R2 sets the circuit's threshold. When the light intensity at PCI's surface is decreased, the resistance of PCI a cadmium-sulfide photoresistor is increased. This decreases the voltage at the inverting input of the 741. When the

reference voltage at the 741's noninverting input is properly adjusted via R2, the comparator will switch from low to high when PCI is darkened. This turns on Q1 which, in turn, pulls in relay K1.

PHOTOCELL MEMORY SWITCH FOR AC POWER CONTROL

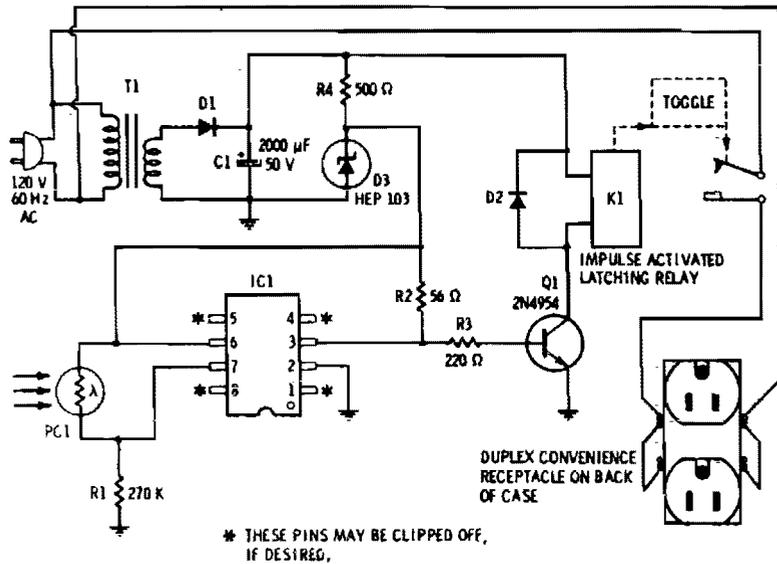


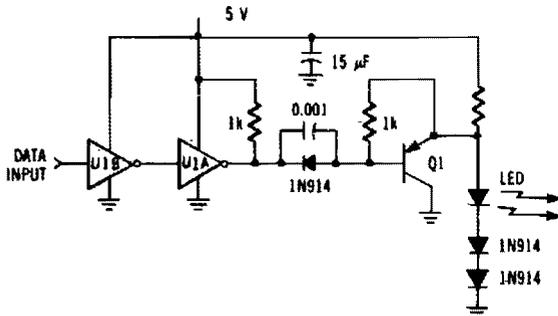
Fig. 44-10

Circuit Notes

Provides remote control for ac-powered devices by using the beam of a flashlight as a magic wand. The important aspect of this gadget is that it remembers. Activate it once to apply power to a device and it stays on. Acti-

vate it a second time and power goes off and stays off. It consists of a combination of a high-sensitivity photocell, a high-gain IC Schmitt trigger, and an impulse-actuated latching relay.

OPTICAL TRANSMITTER



Circuit Notes

Driver circuit uses an MC74LS04 and one discrete transistor. The circuit can drive the LED (MFOE1200) at up to 1 Mbps data rate.

Fig. 44-11

LIGHT INTERRUPTION DETECTOR

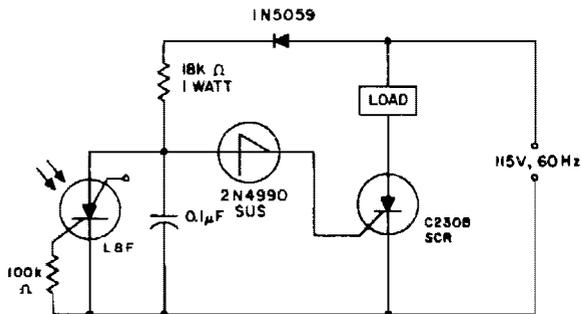
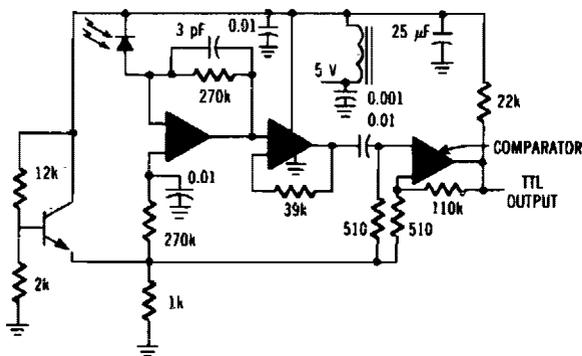


Fig. 44-12

Circuit Notes

When the light incident on the LASCR is interrupted, the voltage at the anode to the 2N4990 unilaterial switch goes positive on the next positive cycle of the power which in turn triggers the switch and the C230 SCR when the switching voltage of the unilaterial switch is reached. This will cause the load to be energized for as long as light is not incident on the LASCR.

OPTICAL RECEIVER



Circuit Notes

The MFOD1100 PIN diode requires shielding from emi.

Fig. 44-13

LIGHT ISOLATED SOLID STATE POWER RELAY CIRCUITS

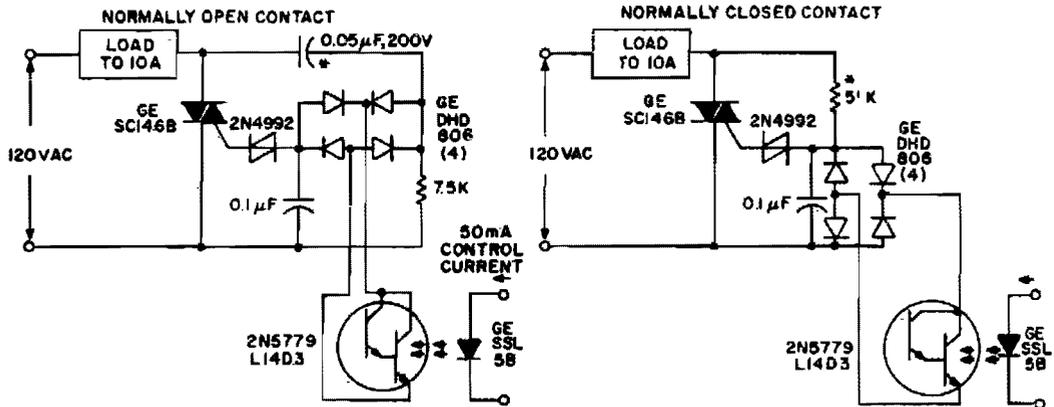


Fig. 44-14

Circuit Notes

Both circuits use the G.E. SC146B, 200 V, 10 A Triac as load current contacts. These triacs are triggered by normal SBS (2N4992) trigger circuits, which are controlled by the photo-Darlington, acting through the DA806 bridge as an ac photo switch. To operate the

relays at other line voltages the asterisked (*) components are scaled to supply identical current. Ratings must be changed as required. Incandescent lamps may be used in place of the light emitting diodes, if desired.

PRECISION PHOTODIODE LEVEL DETECTOR

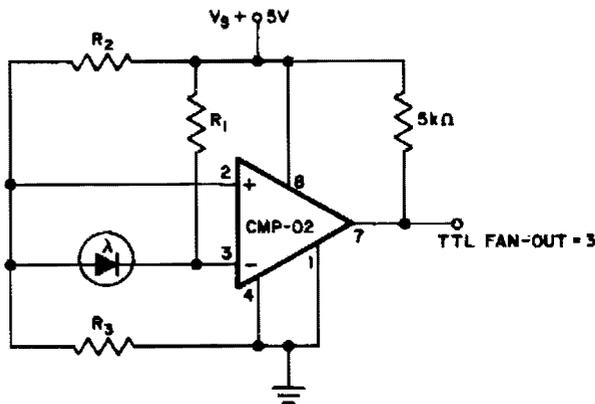


Fig. 44-15

Circuit Notes

For $R_1 = 2.5 \text{ M}$, $R_2 = R_3 = 5 \text{ M}$. The output state changes at a photo diode current of $0.5 \mu\text{A}$.

LIGHT BEAM OPERATED ON-OFF RELAY

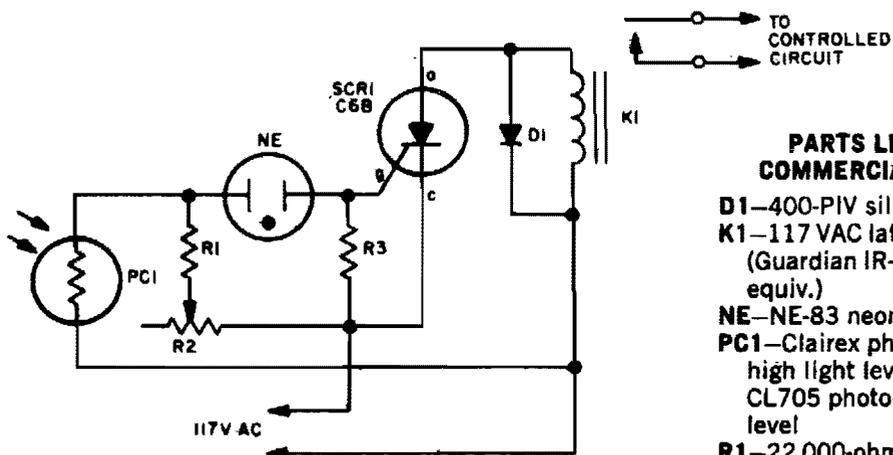


Fig. 44-16

PARTS LIST FOR COMMERCIAL KILLER

- D1—400-PIV silicon rectifier
- K1—117 VAC latching relay
(Guardian IR-610L-A115 or
equiv.)
- NE—NE-83 neon lamp
- PC1—Clairex photo cell CL505 for
high light level; CL704 or
CL705 photocell for low light
level
- R1—22,000-ohm, ½-watt resistor
- R2—1-megohm potentiometer
- R3—100-ohm, ½-watt resistor
- SCR1—HEP R1218, 200V, 4A,
silicon-controlled rectifier

Circuit Notes

When a beam of light strikes the photocell, the voltage across neon lamp NE-1 rises sharply. NE-1 turns on and fires the SCR. K1 is an impulse relay whose contacts stay in posi-

tion even after coil current is removed. The first impulse opens K1's contacts, the second impulse closes them, etc.

LOGARITHMIC LIGHT SENSOR

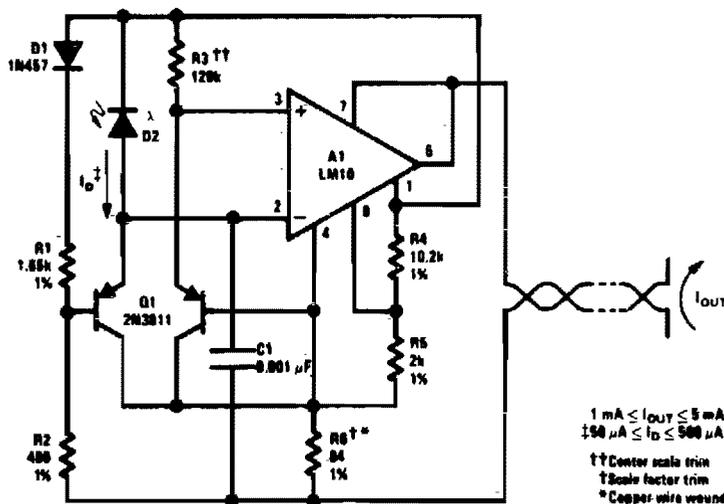


Fig. 44-17

- 1 mA ≤ I_{OUT} ≤ 5 mA
- 150 μA ≤ I_D ≤ 500 μA
- †† Center scale trim
- ‡ Scale factor trim
- * Copper wire wound

FM (PRM) OPTICAL TRANSMITTER

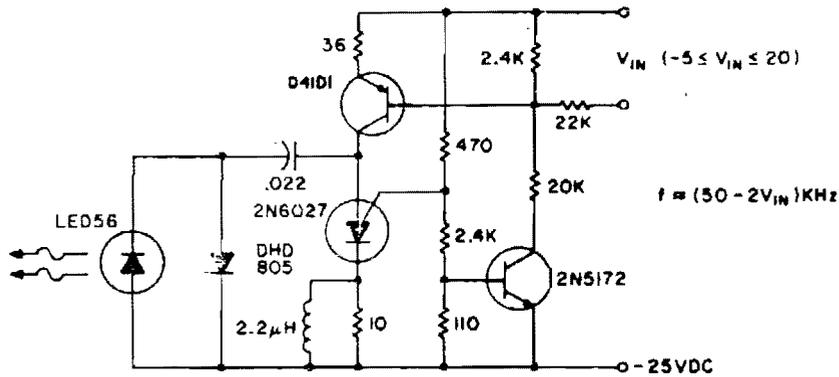


Fig. 44-18

Circuit Notes

The basic circuit can be operated at 80 kHz and is limited by the PUT capacitor combination. 60 kHz is the maximum modulation frequency. The pulse repetition rate is a linear function of V_{IN} , the modulating voltage. Lenses or reflectors minimizes stray light noise ef-

fects. Greater output can be obtained by using a larger capacitor, which also gives a lower operating frequency, or using a higher power output IRED such as the F5D1. Average power consumption of the transmitter circuit is less than 3 watts.

LIGHT LEVEL SENSOR

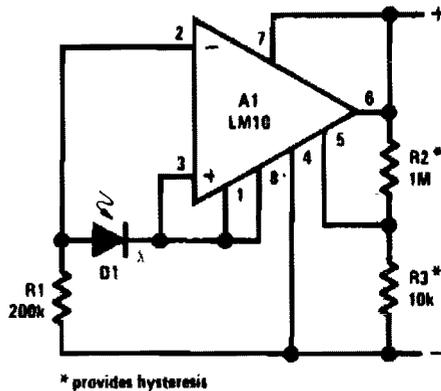


Fig. 44-19

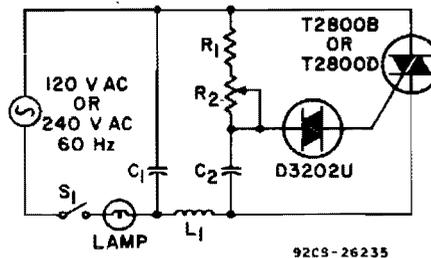
45

Light Controls

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Light Dimmers	800 W Soft-Start Light Dimmer
Remote Control for Lamp or Appliance	Low Loss Brightness Control
High Power Control for Sensitive Contacts	Half-Wave Ac Phase-Controlled Circuit
Complementary Lighting Control	Emergency Light
Floodlamp Power Control	Neon Lamp Driver
Hysteresis-Free Phase Control Circuit	Complementary Ac Power Switching
Low Cost Lamp Dimmer	Battery Lantern Circuit
Zero Point Switch	Shift Register
800 W Triac Light Dimmer	Light Level Controller
Full-Wave SCR Control	2.2 W Incandescent Lamp Driver
860 W Limited Range Low Cost Precision Light Control	

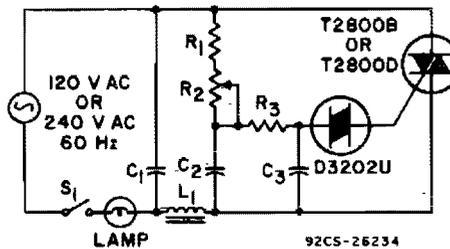
LIGHT DIMMERS



(a) Single-time-constant light-dimmer circuit.

Parts List

120-Volt, 60-Hz Operation	tiometer, 0.25 megohm, 0.5 watt	$C_2 = 0.05 \mu\text{F}$, 400 V
$C_1, C_2 = 0.1 \mu\text{F}$, 200 V		$L_1 = 200 \mu\text{H}$
$L_1 = 100 \mu\text{H}$	240-Volt, 50/60 Hz Operation	$R_1 = 4700$ ohms, 0.5 watt
$R_1 = 3300$ ohms, 0.5 watt		$R_2 =$ light control, poten- tiometer, 0.25 megohm, 1 watt
$R_2 =$ light control, poten- tiometer, 0.25 megohm, 1 watt	$C_1 = 0.1 \mu\text{F}$, 400 V	



(b) Double-time-constant light-dimmer circuit.

Parts List

120-Volt, 60-Hz Operation	tiometer, 0.1 megohm, 0.5 watt	$C_1 = 0.1 \mu\text{F}$, 100 V
$C_1, C_2 = 0.1 \mu\text{F}$, 200 V		$L_1 = 100 \mu\text{H}$
$C_3 = 0.1 \mu\text{F}$, 100 V		$R_1 = 7500$ ohms, 2 watts
$L_1 = 100 \mu\text{H}$	240-Volt, 60-Hz Operation	$R_2 =$ light control, poten- tiometer, 0.2 megohm, 1 watt
$R_1 = 1000$ ohms, 0.5 watt		$R_3 = 7500$ ohms, 2 watts
$R_2 =$ light control, poten- tiometer, 0.2 megohm, 1 watt	$C_1 = 0.1 \mu\text{F}$, 400 V	
	$C_2 = 0.05 \mu\text{F}$, 400 V	

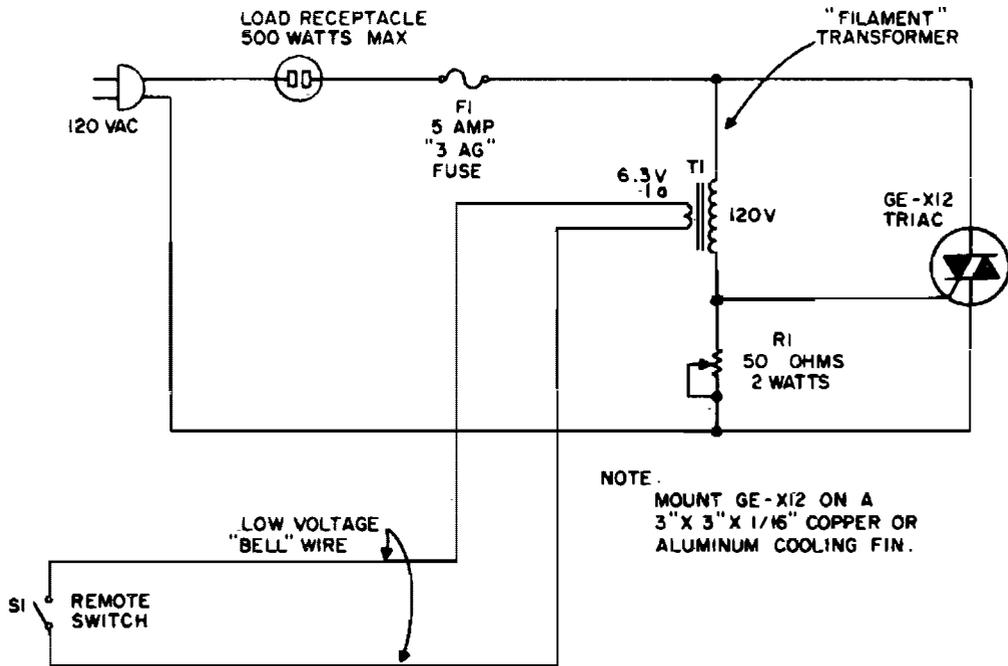
Fig. 45-1

Circuit Notes

The two lamp-dimmer circuits differ in that (a) employs a single-time-constant trigger network and (b) uses a double-time-constant trigger circuit that reduces hysteresis effects and thereby extends the effective range of the light-control potentiometer. (Hysteresis refers to a difference in the control potentiometer setting at which the lamp turns on and the setting at which the light is extin-

guished.) The additional capacitor C_2 in (b) reduces hysteresis by charging to a higher voltage than capacitor C_3 . During gate triggering, C_3 discharges to form the gate current pulse. Capacitor C_2 , however, has a longer discharge time constant and this capacitor restores some of the charge removed from C_3 by the gate current pulse.

REMOTE CONTROL FOR LAMP OR APPLIANCE



NOTE.
MOUNT GE-X12 ON A
3" X 3" X 1/16" COPPER OR
ALUMINUM COOLING FIN.

Fig. 45-2

Circuit Notes

The circuit uses the primary current of a small 6.3 volt filament transformer to actuate a triac and energize the load. When switch S1, in the six-volt secondary, of the transformer is open, a small "magnetizing" current flows through the primary winding. This magnetizing current may be large enough to trigger the triac. Therefore, a shunting resistor, R1, is required to prevent such triggering. R1, is ad-

justed for the highest resistance that will not cause the triac to trigger with S1 open. When single-pole remote switch, S1, closes, the secondary of the transformer is shorted and a high current flows through the 120-volt primary. This triggers the triac and energizes the load. When the triac conducts, current through the primary stops and thus prevents burning out the transformer.

HIGH POWER CONTROL FOR SENSITIVE CONTACTS

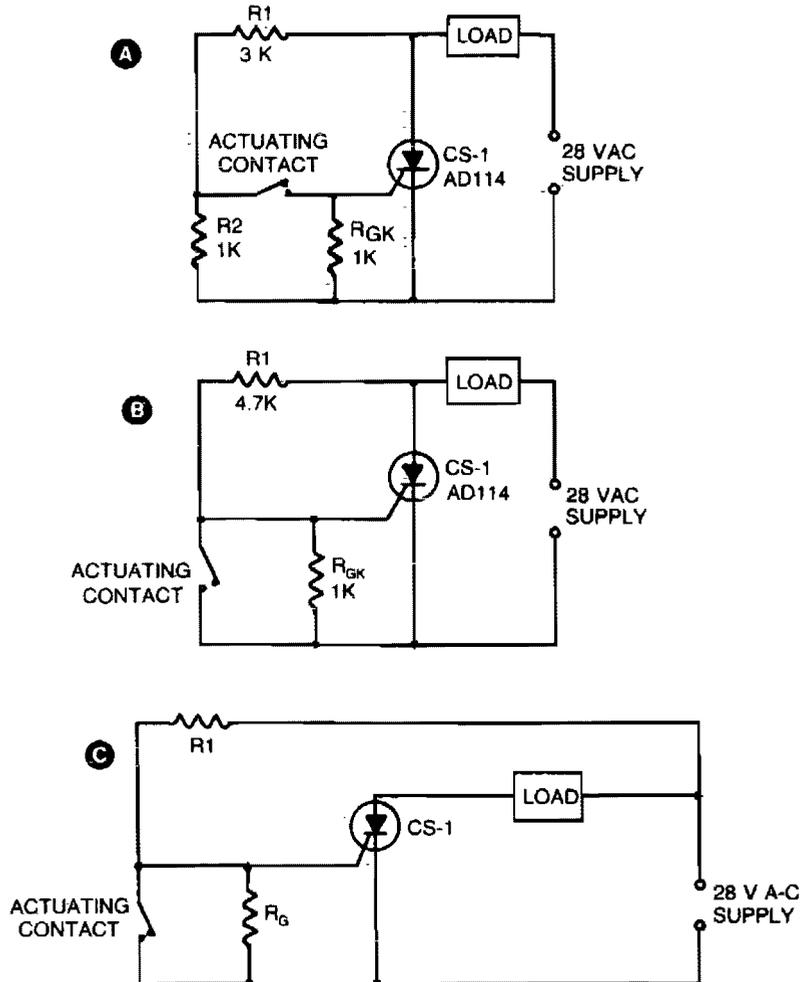


Fig. 45-3

Circuit Notes

Two simple arrangements for resistive loads are shown in A & B. The circuit in A will provide load power when the actuating contact is closed, and no power when the contact is open. B provides the reverse of this action—power being supplied to the load when the contact is open with no load power when the contact is closed. If desired, both circuits can

be made to latch by operating with dc instead of the indicated ac supply. In both of these circuits, voltage across the sensitive contacts is under 5 volts, and contact current is below 5 mA. For inductive loads, R1 would normally be returned to the opposite side of the load as shown in C.

COMPLEMENTARY LIGHTING CONTROL

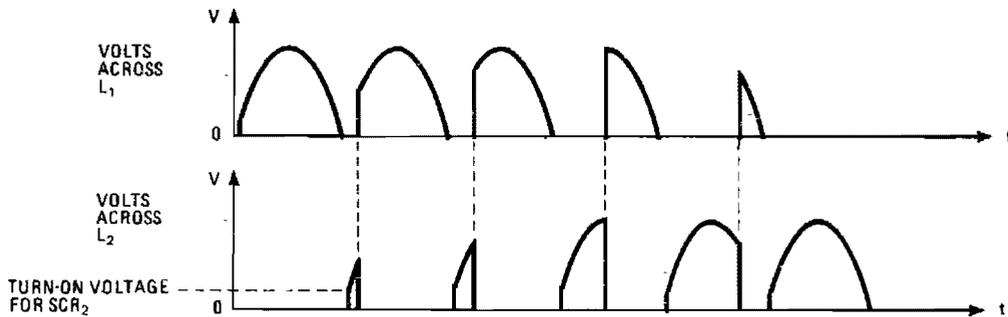
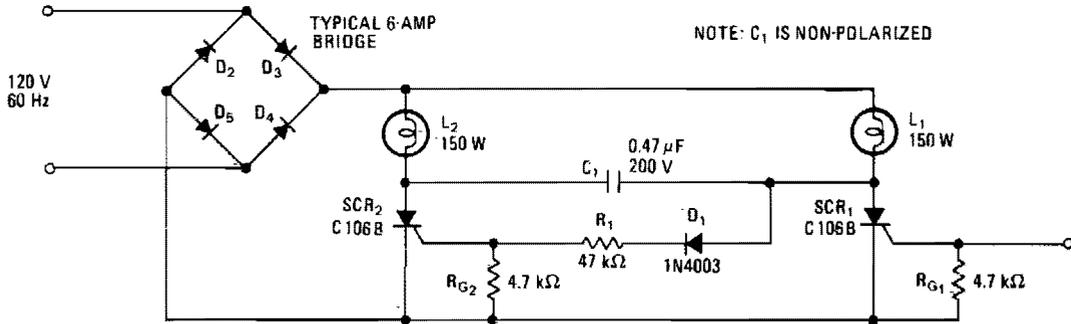


Fig. 45-4

Circuit Notes

This lighting-control unit will fade out one lamp while simultaneously increasing the light output of another. The two loads track each other accurately without adjustments. The gate of SCR1, a silicon-controlled rectifier, is driven from a standard phase-control circuit, based, for example, on a unijunction transistor or a

diac. It controls the brightness of lamp L1 directly. Whenever SCR1 is not on, a small current flows through L1, D1, and R1, permitting SCR2 to fire. When SCR1 turns on, current flow ceases through D1 and R1; the energy stored in C1 produces a negative spike that turns SCR2 off.

FLOODLAMP POWER CONTROL

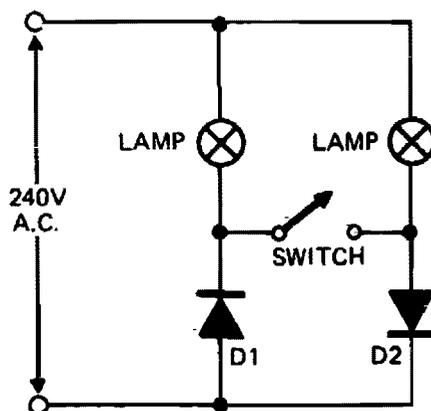


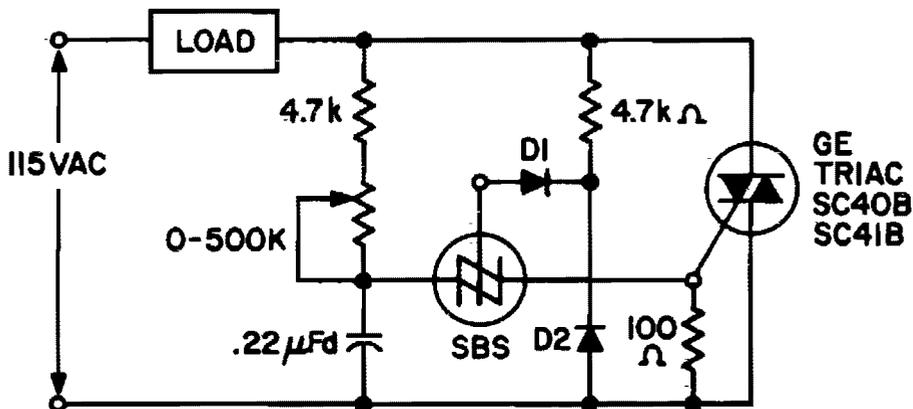
Fig. 45-5

Circuit Notes

When setting up photographic floodlamps, it is sometimes desirable to operate the lamps at lower power levels until actually ready to take the photograph. The circuit allows the

lamps to operate on half cycle power when the switch is open, and full power, when the switch is closed. The diodes D1 and D2 should have a 400 volt PIV rating at 5 amps.

HYSTERESIS-FREE PHASE CONTROL CIRCUIT



SBS 2N4992
D1, D2 - GE 6RS5GC1LAJ1
- COMMON CATHODE

Fig. 45-6

Circuit Notes

This circuit is intended for lamp dimming and similar applications. It requires only one RC phase lag network. To avoid the hysteresis

(or "snap-on") effect, the capacitor is reset to approximately 0 volts at the end of every positive half cycle using the gate lead.

LOW COST LAMP DIMMER

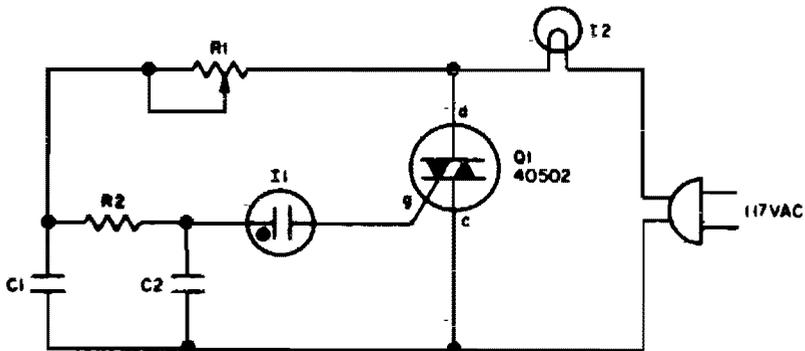


Fig. 45-7

PARTS LIST FOR LO-COST LAMP DIMMER

- | | |
|--|--|
| C1, C2 —0.068- μ F, 200-VDC capacitor | 400 watts |
| I1 —NE-2 neon lamp | Q1 —RCA 40502 Triac |
| I2 —External lamp not to exceed | R1 —50,000-ohm, pot. |
| | R2 —15,000-ohm, ½-watt resistor |

Circuit Notes

Without a heatsink, Triac Q1 handles up to a 400-watt lamp. The neon lamp does not trip the gate until it conducts so the lamp turns on a medium brilliance. The lamp can then be backed off to a soft-glow.

ZERO-POINT SWITCH

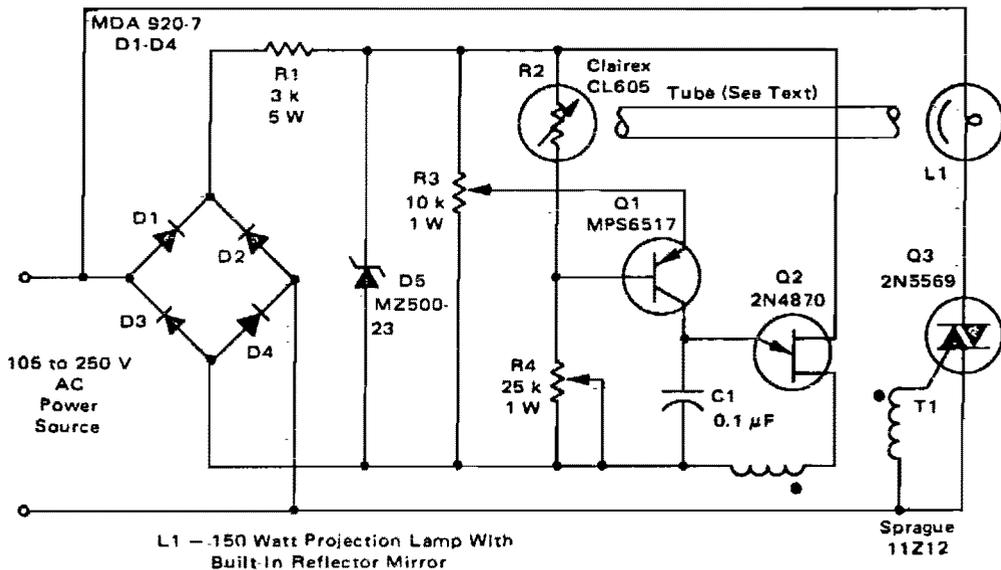


Fig. 45-8

800 W TRIAC LIGHT DIMMER

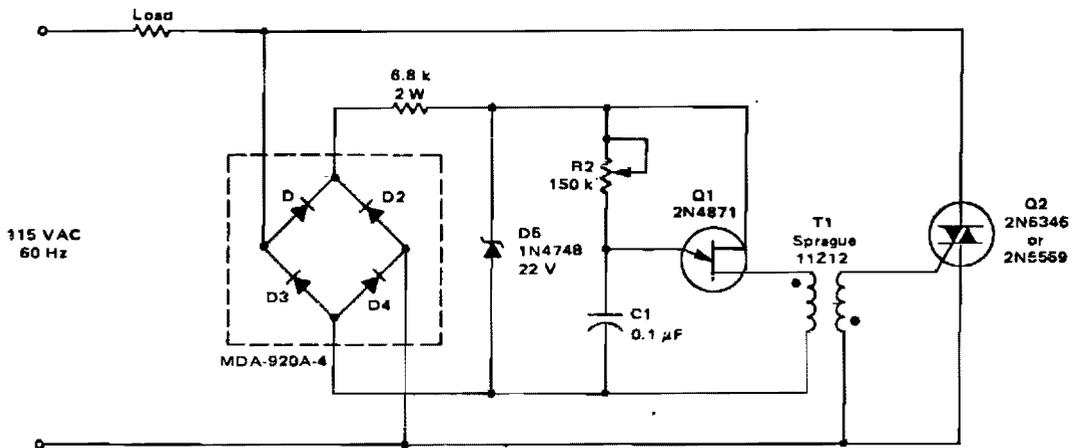


Fig. 45-9

FULL-WAVE SCR CONTROL

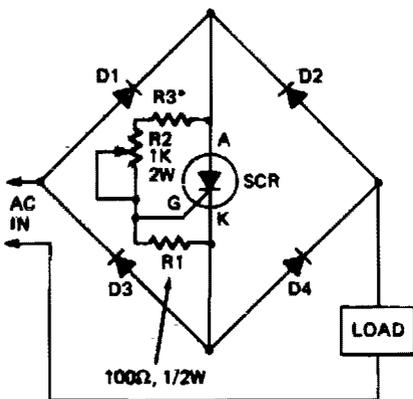
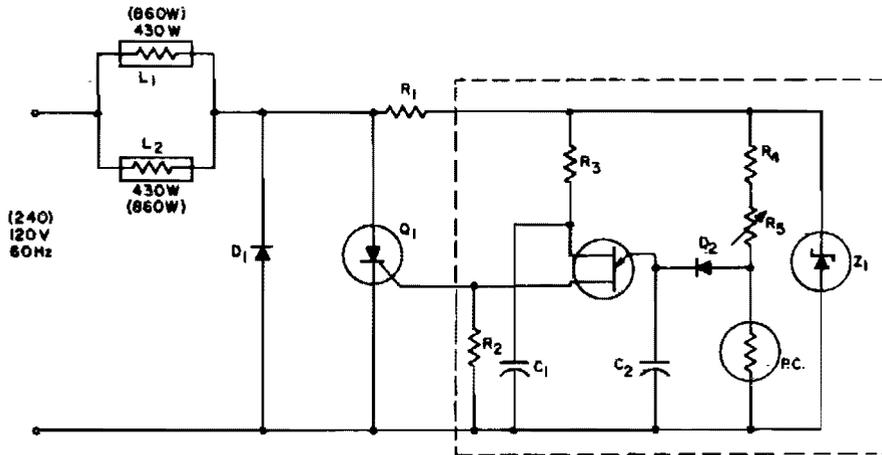


Fig. 45-10

Circuit Notes

This circuit enables a single SCR to provide fullwave control of resistive loads. Resistor R3 should be chosen so that when potentiometer R2 is at its minimum setting, the current in the load is at the required minimum level. Diodes should have same current and voltage rating as the SCR.

860 WATT LIMITED-RANGE LOW COST PRECISION LIGHT CONTROL



R_1 - 6.8K Ω , 2W (15K, 5W)
 R_2 - 47 Ω
 R_3 - 1K Ω
 R_4 - 680 Ω
 R_5 - 9K Ω , 1/2W POT
 P.C. - GE A35

Q_1 - GE C122B (C122D)
 Q_2 - GE 2N2646
 D_1 - GE A48B (A41D)
 D_2 - GE A14F
 Z_1 - 16 V ZENER
 L_1, L_2 - 430W INCANDESCENT LAMP

C_1 - 0.03 μ Fd, 25V
 C_2 - 0.1 μ Fd, 25V
 NOTE: ALL RESISTANCES
 1/2W, 10% UNLESS
 OTHERWISE NOTED.
 VALUES IN PARANTHESES
 FOR 240V

Fig. 45-11

Circuit Notes

The system is designed to regulate an 860 watt lamp load from half to full power. This is achieved by the controlled-half-plus-fixed-half-wave phase control method. Half power

applied to an incandescent lamp results in 30% of the full light output. Consequently the circuit is designed to control the light output of the lamp from 30% to 100% of maximum.

800 W SOFT-START LIGHT DIMMER

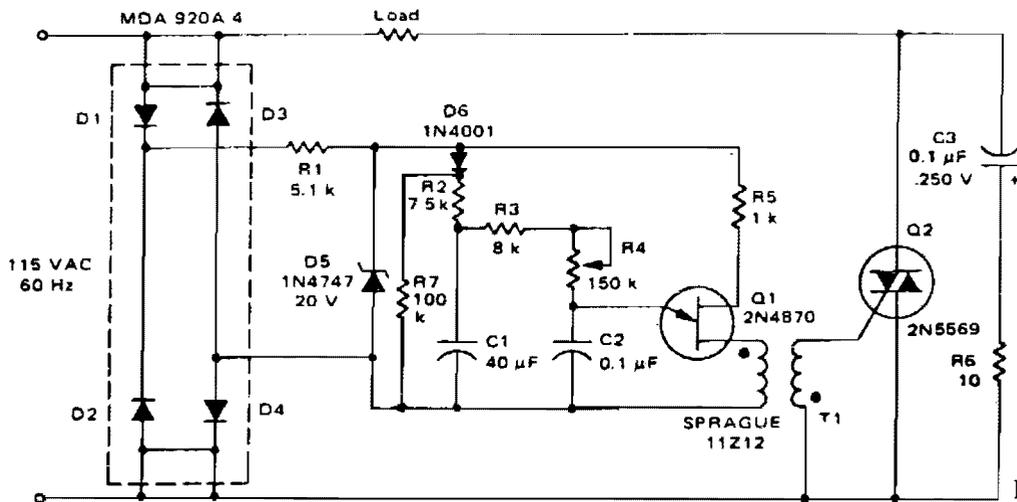


Fig. 45-12

LOW LOSS BRIGHTNESS CONTROL

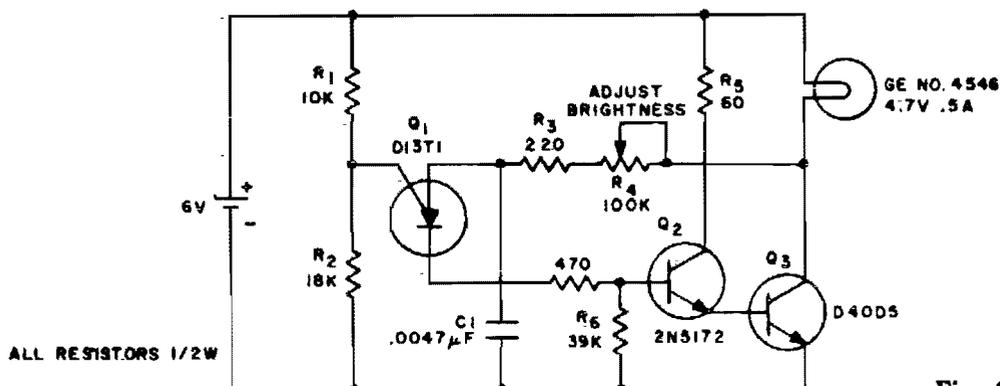


Fig. 45-13

Circuit Notes

This circuit changes the average value of the dc supply voltage because of the high switching frequency. The tungsten lamp will have an almost continuous adjustable light output between 0 and 100%. If a light emitting

diode is used as the emitting device, the irradiance will be in phase with the applied current pulses and will decrease to zero when the supply current is zero.

HALF WAVE AC PHASE-CONTROLLED CIRCUIT

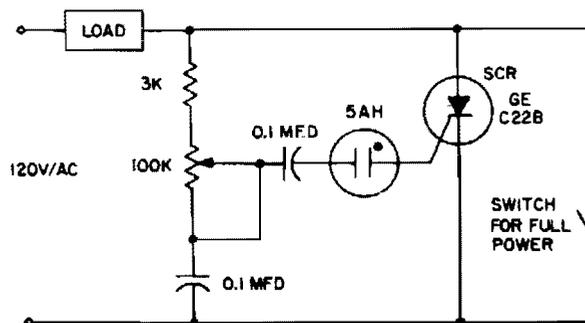


Fig. 45-14

Circuit Notes

The 5AH will trigger when the voltage across the two 0.1 μ F capacitors reaches the breakdown voltage of the lamp. Control can be obtained full off to 95% of the half wave RMS output voltage. Full power can be obtained with the addition of the switch across the SCR.

EMERGENCY LIGHT

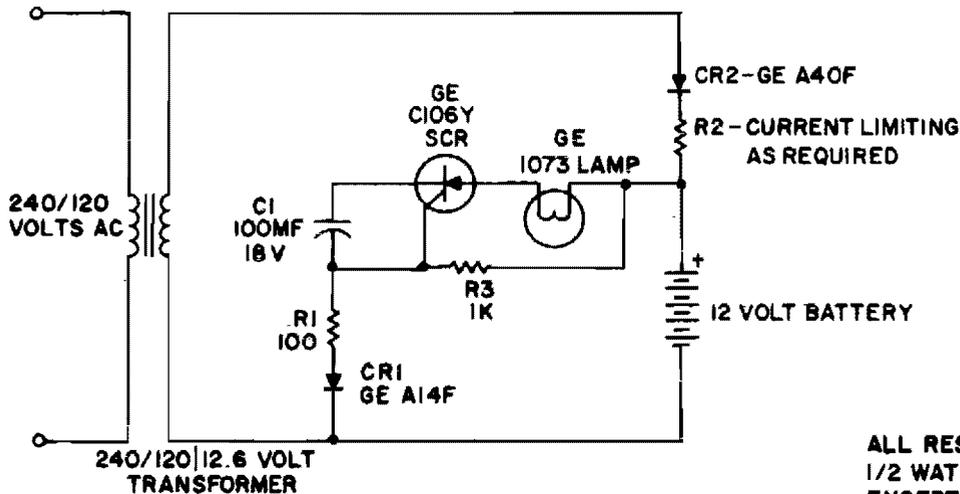


Fig. 45-15

ALL RESISTORS
1/2 WATT
EXCEPT AS
NOTED

Circuit Notes

This simple circuit provides battery operated emergency lighting instantaneously upon failure of the regular ac service. When line power is restored, the emergency light turns off and the battery recharges automatically. The circuit is ideal for use in elevator cars, corridors and similar places where loss of light due to power failure would be undesirable. Completely static in operation, the circuit requires no maintenance. With ac power on, capacitor C1 charges through rectifier CR1 and resistor R1 to develop a negative voltage at the

gate of the C106Y SCR. By this means, the SCR is prevented from being triggered, and the emergency light stays off. At the same time, the battery is kept fully charged by rectifier CR2 and resistor R2. Should the ac power fail, C1 discharges and the SCR is triggered on by battery power through resistor R3. The SCR then energizes the emergency light. Reset is automatic when ac is restored, because the peak ac line voltage biases the SCR and turns it off.

NEON LAMP DRIVER

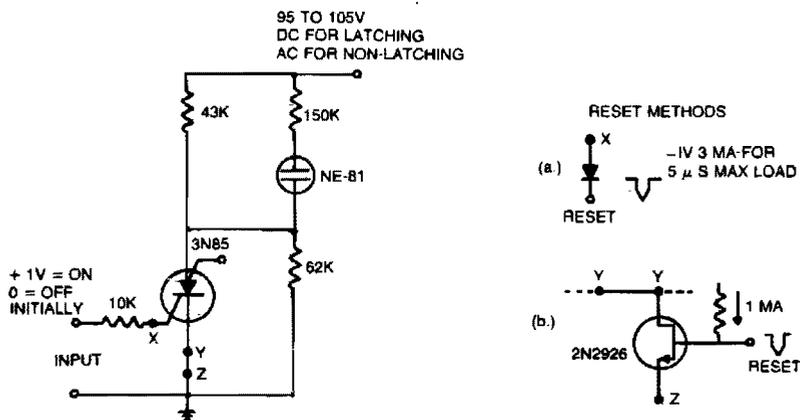


Fig. 45-16

COMPLEMENTARY AC POWER SWITCHING

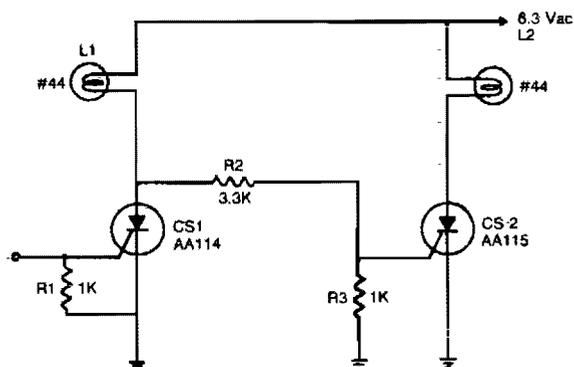


Fig. 45-17

Circuit Notes

An input signal of less than 1 mA and 1 V is required to switch on CS1. As long as this input signal is maintained, CS1 will conduct during each positive half cycle of anode voltage, thereby energizing load L1 with half-wave rectified dc. L2 remains de-energized, since the anode of CS1 will not go more positive than 1.5 volts, and voltage divider R2 - R3 cannot provide enough voltage to trigger CS2. Upon removal of the input signal, CS1 will drop out. L1 will be de-energized, except for a small amount of ac current through R2 and R3. CS2

will be triggered on at the beginning of each positive half-cycle, when CS1 anode voltage reaches 2 to 3 volts. CS2 will conduct for nearly the entire positive half-cycle energizing L2. It should be noted that the 6.3 volt lamps used will operate at $\frac{1}{3}$ the rated brilliance because of the controlled switch half-wave rectifying action and will extend the operating lamp life by several orders of magnitude. Should full brilliance be desired, the anode supply voltage level should be raised to 9 volts ac.

BATTERY LANTERN CIRCUIT

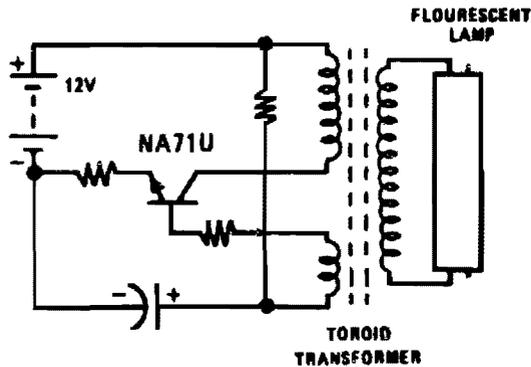


Fig. 45-18

LIGHT-LEVEL CONTROLLER

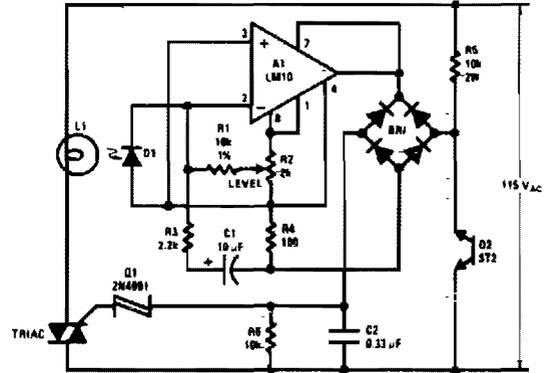


Fig. 45-20

SHIFT REGISTER

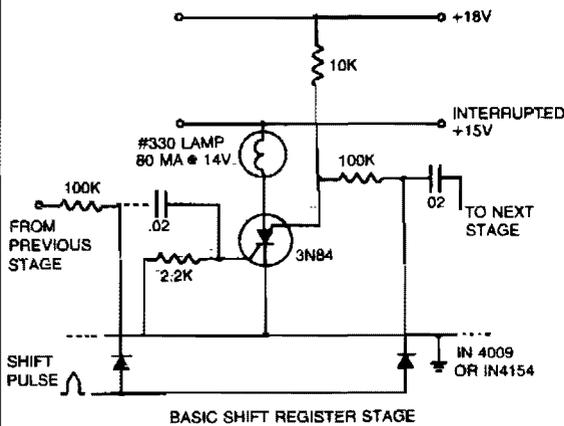


Fig. 45-19

Circuit Notes

The shift pulse amplitude is less than 15 volts. If a stage is off, the shift pulse will not be coupled to the next stage. If it is on, the diode will conduct and trigger the next stage. Just prior to the shift pulse the anode supply is interrupted to turn off all stages. The stored capacitor charge determines which stages will be triggered.

2.2 WATT INCANDESCENT LAMP DRIVER

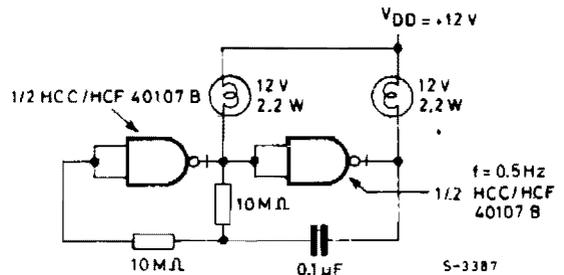


Fig. 45-21

46

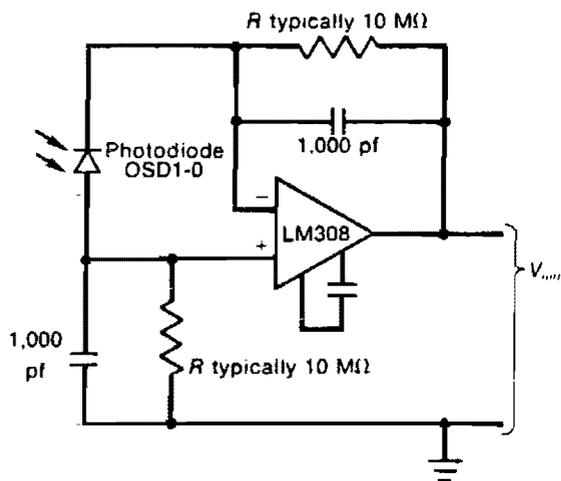
Light Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Linear Light Meter Circuit
Logarithmic Light-Meter Circuit
Light Meter

Light Meter
Light Meter
Precision Photodiode Comparator

LINEAR LIGHT-METER CIRCUIT



Circuit Notes

This circuit uses a low-input-bias op amp to give a steady dc indication of light level. To reduce circuit sensitivity to light, R1 can be reduced, but should not be less than 100 K. The capacitor values in the circuit are chosen to provide a time constant sufficient to filter high-frequency light variations that might arise, for example, from fluorescent lights.

Fig. 46-1

LOGARITHMIC LIGHT-METER CIRCUIT

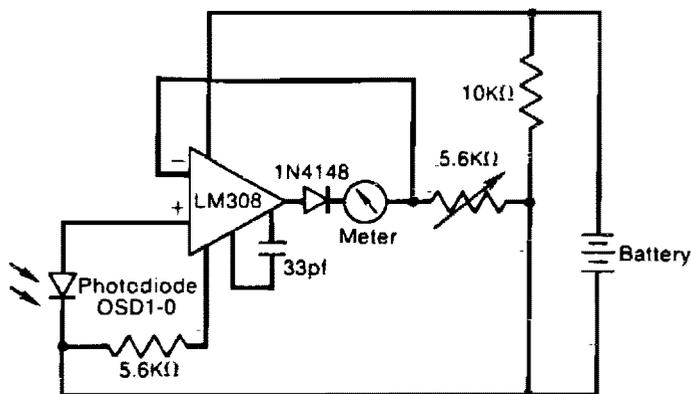


Fig. 46-2

Circuit Notes

The meter reading is directly proportional to the logarithm of the input light power. The logarithmic circuit behavior arises from the nonlinear diode pn junction current/voltage relationship. The diode in the amplifier output

prevents output voltage from becoming negative (thereby pegging the meter), which may happen at low light levels due to amplifier bias currents. R1 adjusts the meter full-scale deflection, enabling the meter to be calibrated.

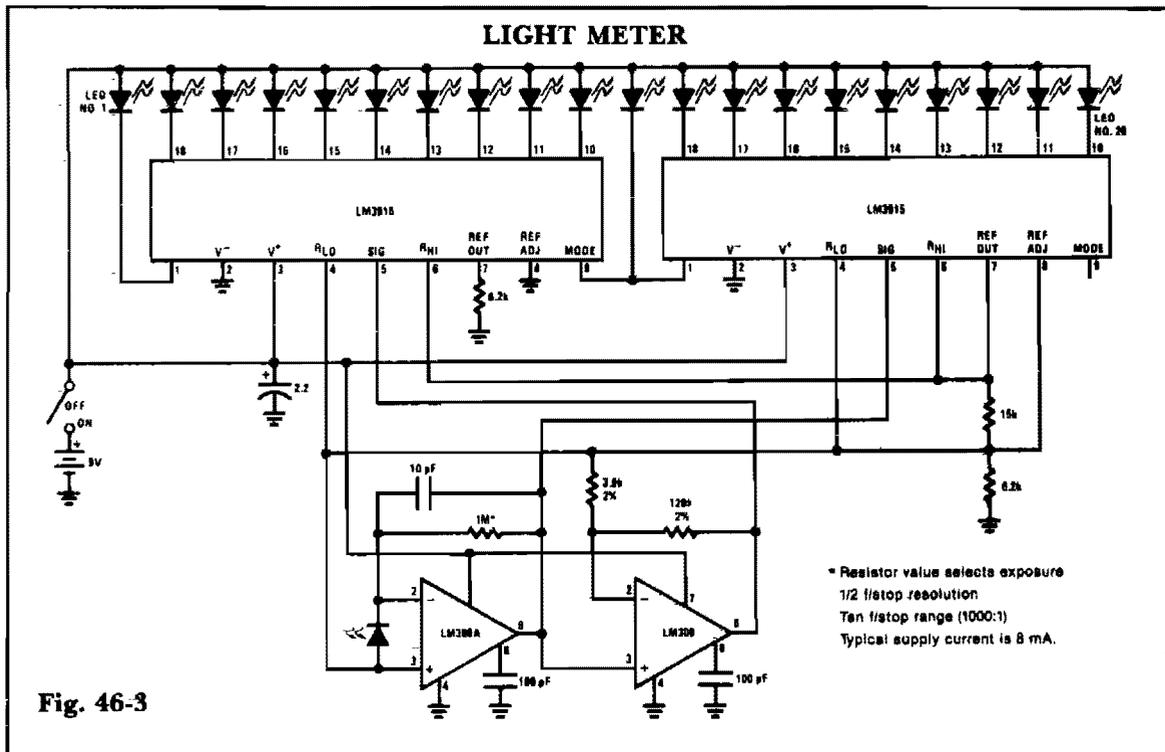


Fig. 46-3

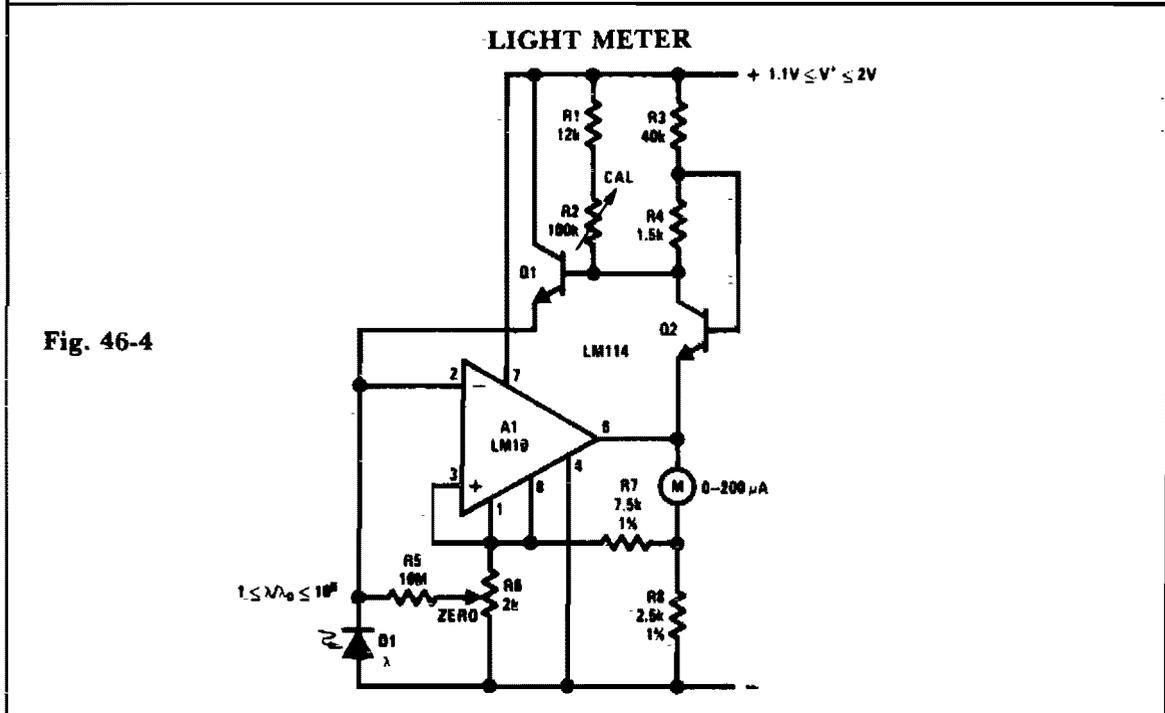
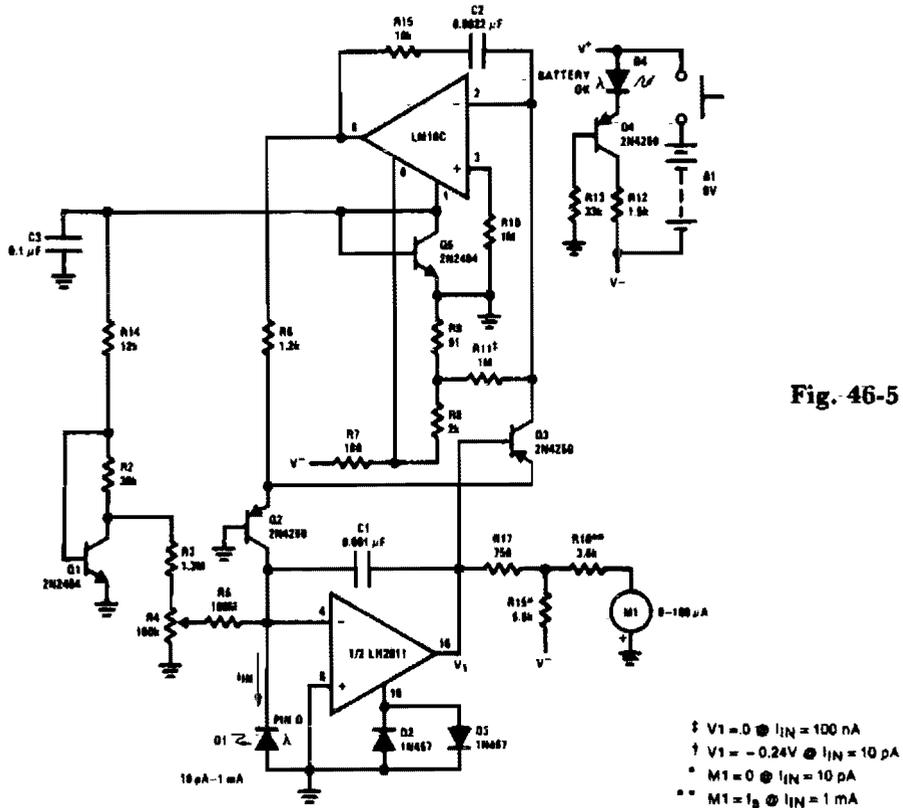


Fig. 46-4

LIGHT METER

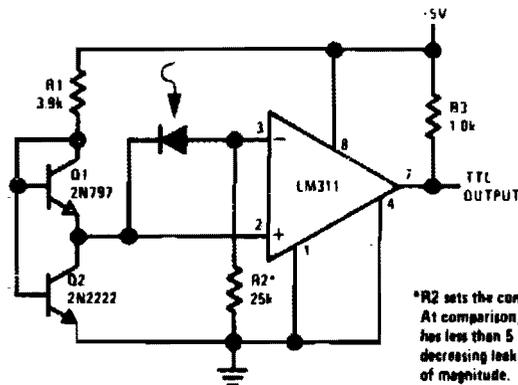


Circuit Notes

This light meter has an eight-decade range. Bias current compensation can give input current resolution of better than ± 2 pA over 15 °C to 55 °C.

- ‡ V1 = 0 @ $I_{IN} = 100$ nA
- † V1 = -0.24V @ $I_{IN} = 10$ pA
- M1 = 0 @ $I_{IN} = 10$ pA
- ** M1 = I_B @ $I_{IN} = 1$ mA

PRECISION PHOTODIODE COMPARATOR



*R2 sets the comparison level. At comparison, the photodiode has less than 5 mV across it, decreasing leakage by an order of magnitude.

47

Liquid Level Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Level Sensor for Cryogenic Fluids
Fluid Level Controller
High Level Warning Device
Liquid Level Control
Liquid Level Detector Latching

Water Level Alarm
Water-Level Sensing Control Circuit
Flood Alarm
Liquid Level Detector
Low-Level Warning with Audio Output

LEVEL SENSOR FOR CRYOGENIC FLUIDS

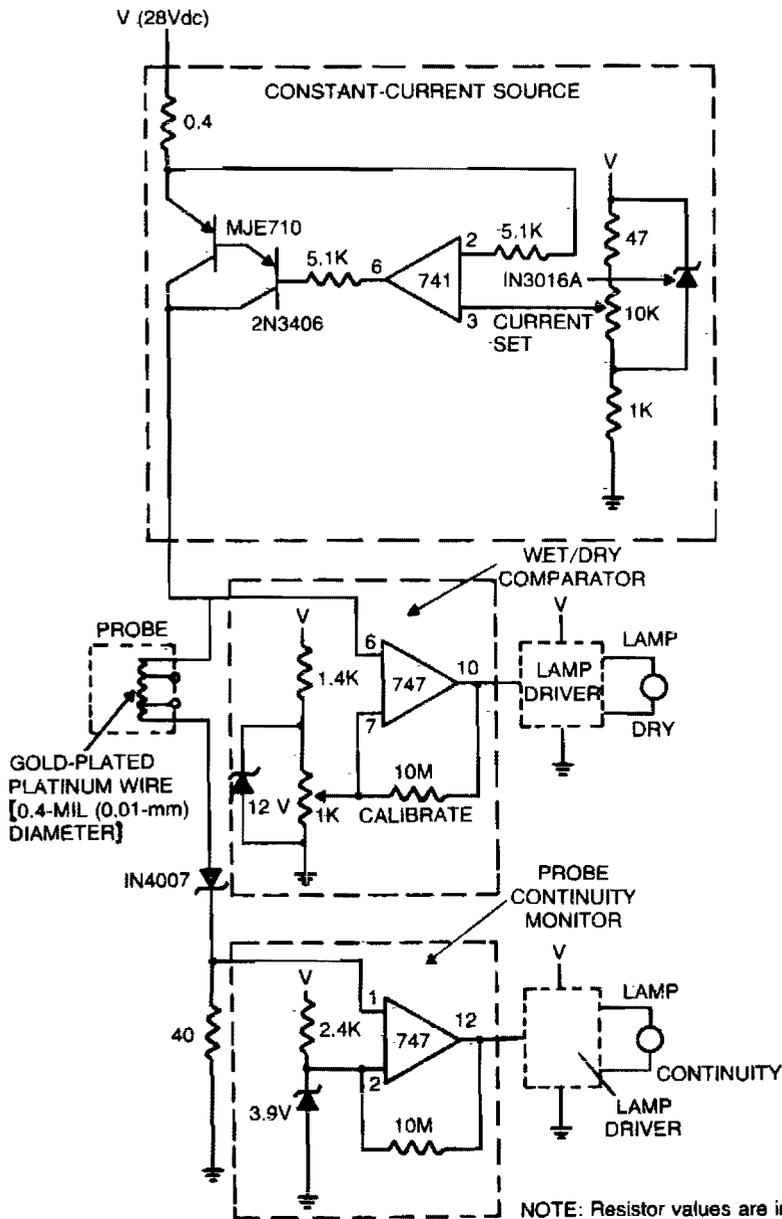


Fig. 47-1

Circuit Notes

The sensor circuit is adaptable to different liquids and sensors. The constant-current source drives current through the sensing probe and a fixed resistor. The voltage-comparator circuits interpret the voltage drops to tell whether the probe is immersed in liquid and whether there is current in the probe.

FLUID LEVEL CONTROLLER

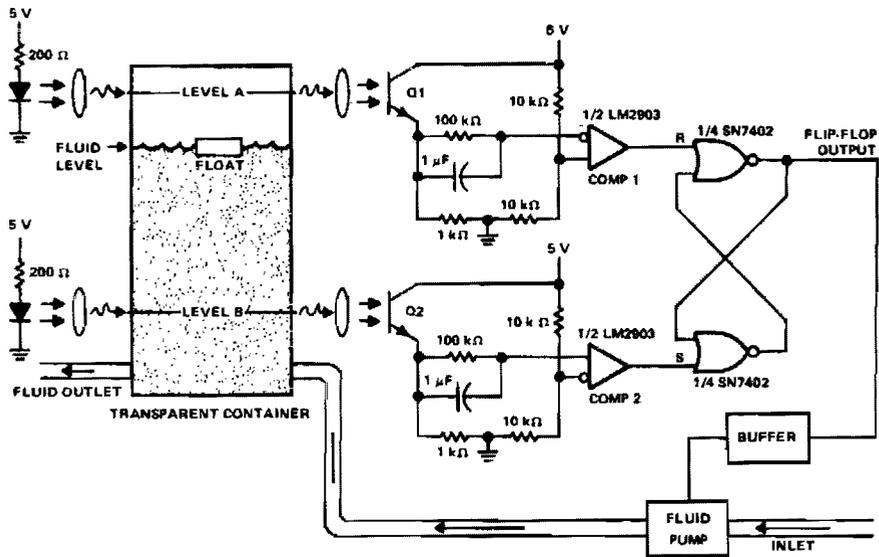


Fig. 47-2

Circuit Notes

This circuit can be used to maintain fluid between two levels. Variations on this control circuit can be made to keep something that moves within certain boundary conditions.

HIGH LEVEL WARNING DEVICE

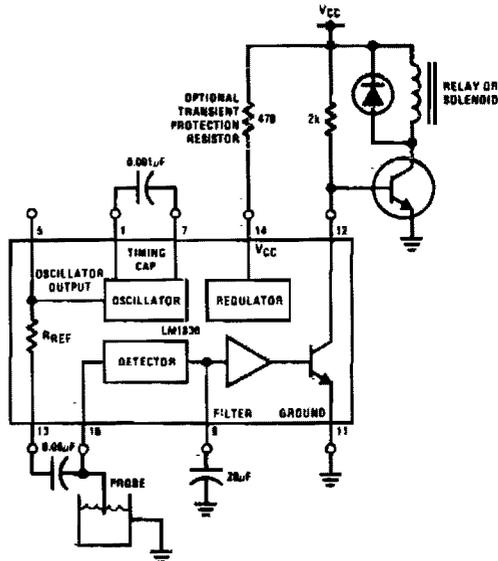


Fig. 47-3

The output is suitable for driving a sump pump or opening a drain valve, etc.

LIQUID LEVEL CONTROL

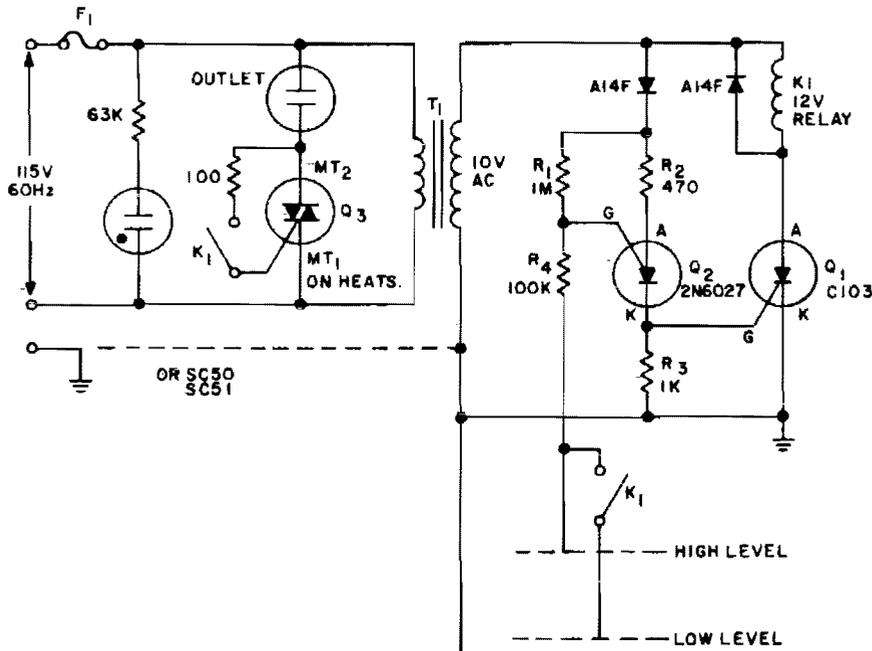


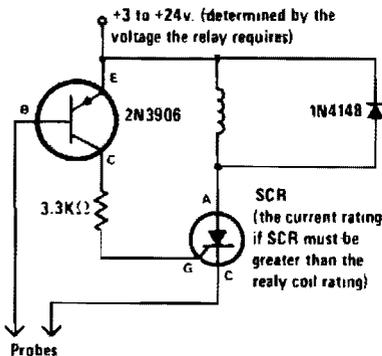
Fig. 47-4

Circuit Notes

Use this circuit to keep the fluid level of a liquid between two fixed points. Two modes, for filling or emptying are possible by simple reversing the contact connections of K1. The loads can be either electric motors or solenoid operated valves, operating from ac power. Liquid level detection is accomplished by two

metal probes, one measuring the high level and the other the low level. An inversion of the logic (keeping the container filled) can be accomplished by replacing the normally open contact on the gate of Q3 with a normally closed contact.

LIQUID LEVEL DETECTOR (LATCHING)



Circuit Notes

Alarm is actuated when liquid level is above the probes and remains activated even if the level drops below the probes. This latching action lets you know that the pre-set level has been reached or exceeded sometime in the past.

Fig. 47-5

WATER LEVEL ALARM

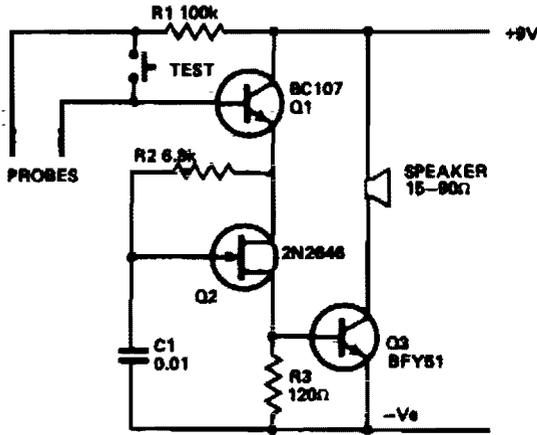


Fig. 47-6

Circuit Notes

The circuit draws so little current that the shelf-life of the battery is the limiting factor. The only current drawn is the leakage of the transistor. The circuit is shown in the form of a water level alarm but by using different forms of probe can act as a rain alarm or shorting alarm; anything from zero to about 1 M between the probes will trigger it. Q1 acts as a

switch which applies current to the unijunction relaxation oscillator Q2. Alarm signal frequency is controlled by values and ratios of C1/R2. Pulses switch Q3 on and off, applying a signal to the speaker. Almost any NPN silicon transistor can be used for Q1 and Q3 and almost any unijunction for Q2.

WATER-LEVEL SENSING CONTROL CIRCUIT

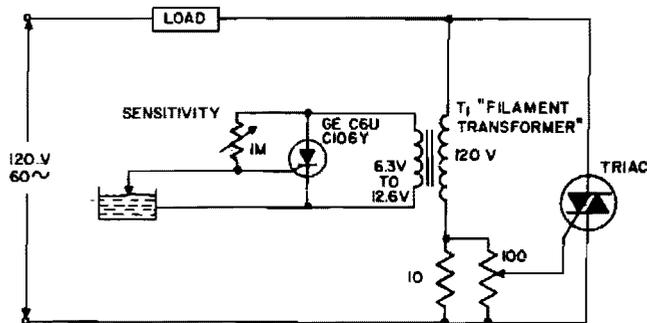
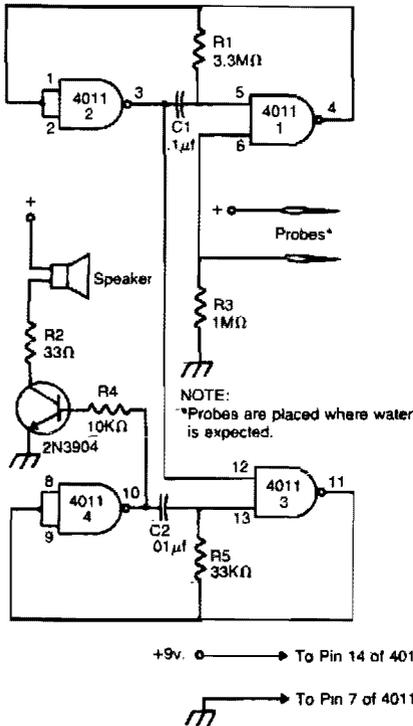


Fig. 47-7

Circuit Notes

The circuit applies power to the load until the water conducts through the probe, and bypasses gate current from the low current SCR. This gives an isolated low voltage probe to satisfy safety requirements.

FLOOD ALARM

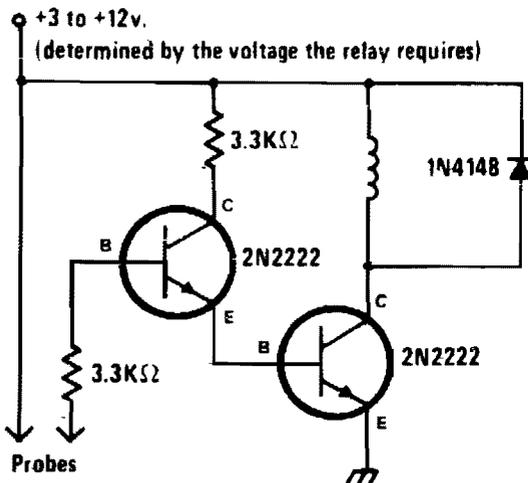


Circuit Notes

The alarm is built around two audio oscillators, each using two NAND gates. The detection oscillator is gated on by a pair of remote probes. One of the probes is connected to the battery supply, the other to the input of one of the gates. When water flows between the probes, the detection oscillator is gated on. The alarm oscillator is gated on by the output of the detection oscillator. The values given produce an audio tone of about 3000 Hz. The detection oscillator gates this audio tone at a rate of about 3 Hz. The result is a unique pulsating note. Use any 8 ohm speaker to sound the alarm. The 2N3904 can be replaced by any similar NPN transistor. The circuit will work from any six to 12-volt supply.

Fig. 47-8

LIQUID LEVEL DETECTOR



Circuit Notes

When liquid level reaches both probes, alarm is turned on. When water level recedes it goes off.

Fig. 47-9

LOW-LEVEL WARNING WITH AUDIO OUTPUT

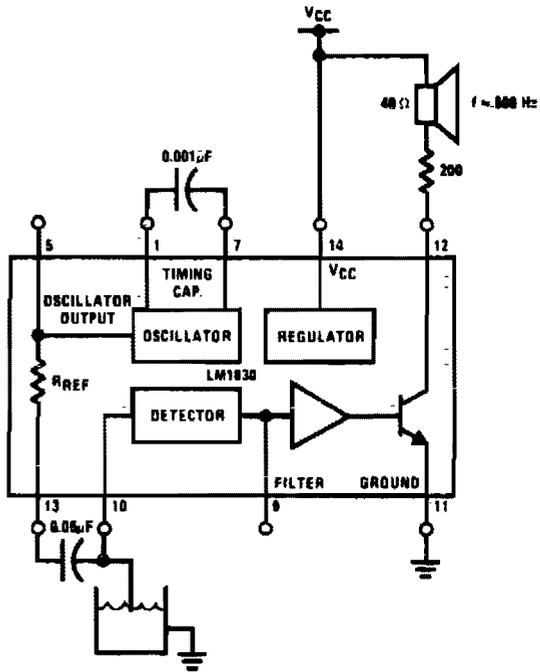


Fig. 47-10

48

Logic Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Light Activated Logic Circuits

Programmable Gate

Negative to Positive Supply Logic Level

Shifter

OR Gate

OR Gate

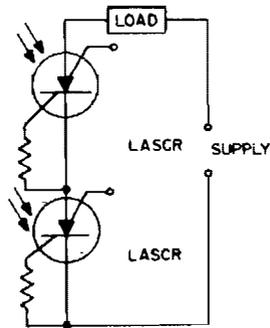
Large Fan-In AND Gate

AND Gate

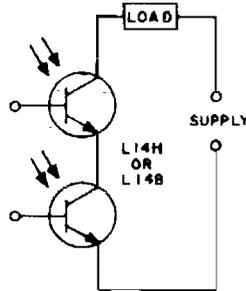
R-S Flip-Flop

AND Gate

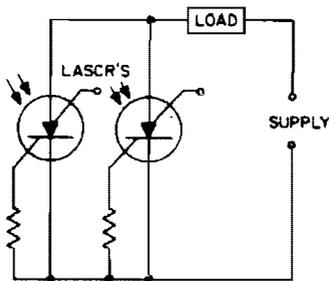
LIGHT ACTIVATED LOGIC CIRCUITS



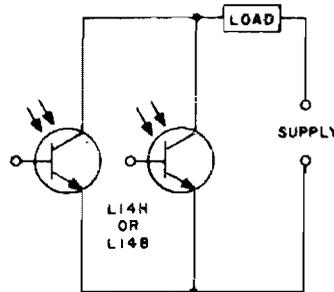
(a) AND Circuit



(b) AND Circuit

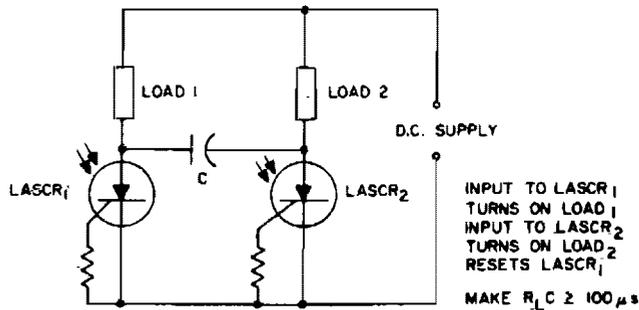


(c) OR Circuit



(d) OR Circuit

Fig. 48-1



(e) Flip-Flop

Circuit Notes

These circuits illustrate some of the common logic functions that can be implemented.

PROGRAMMABLE GATE

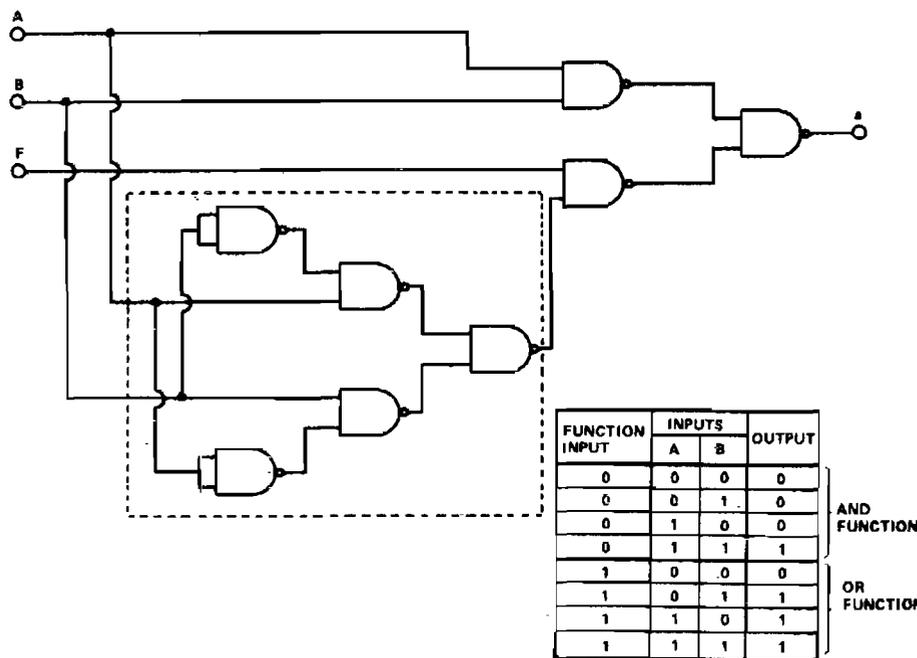
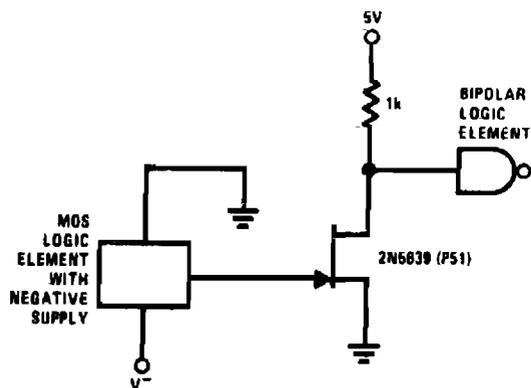


Fig. 48-2

Circuit Notes

This gate converts an AND gate or an OR gate by applying a logic '1' on the function input. The logic design uses 8 two-input NAND gates. The number of gates may be reduced by replacing the 5 NAND gates enclosed by the dotted line with a two-input exclusive-OR, such as the TTL 7486.

NEGATIVE TO POSITIVE SUPPLY LOGIC LEVEL SHIFTER



Circuit Notes

This simple circuit provides for level shifting from any logic function (such as MOS) operating from minus to ground supply to any logic level (such as TTL) operating from a plus to ground supply. The 2N5639 provides a low I_{dc} (ON) and fast switching times.

Fig. 48-3

OR GATE

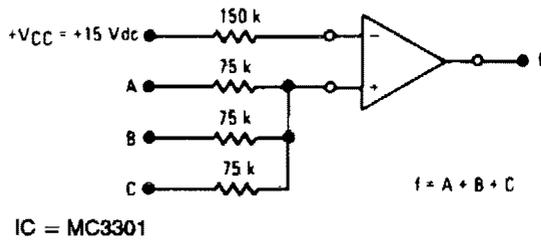


Fig. 48-4

AND GATE

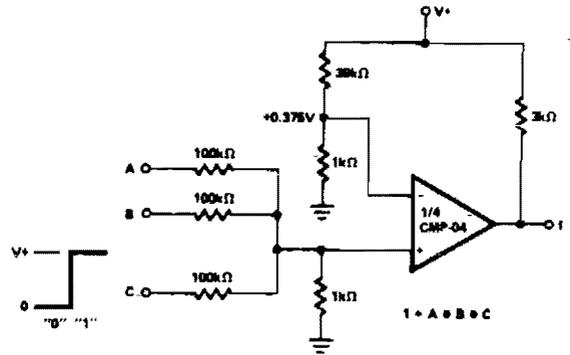


Fig. 48-7

OR GATE

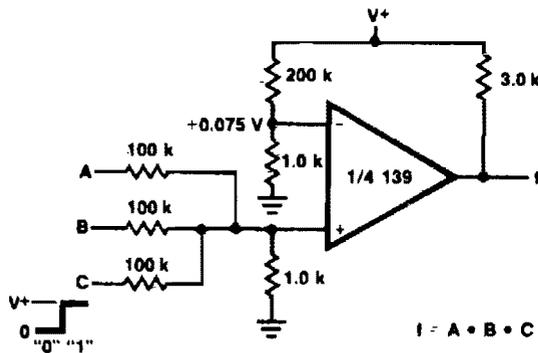


Fig. 48-5

R-S FLIP-FLOP

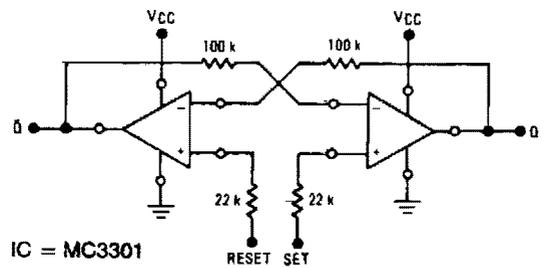


Fig. 48-8

LARGE FAN-IN AND GATE

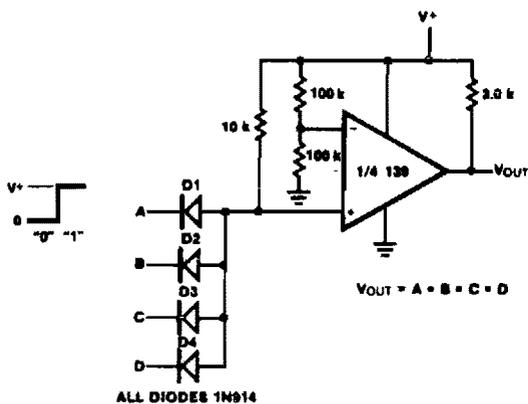


Fig. 48-6

AND GATE

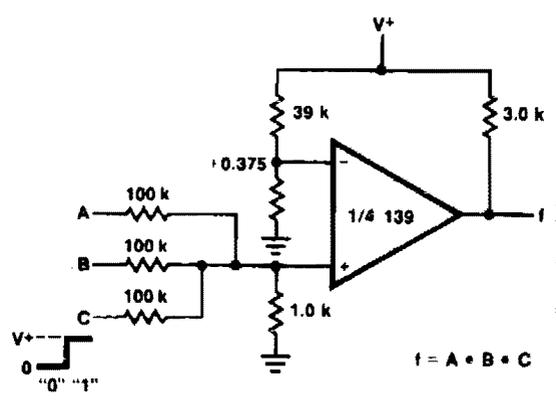


Fig. 48-9

49

Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

FET Curve Tracer	Sound Level Monitor
Digital Weight Scale	Linear Variable Differential Transformer
Low Cost pH Meter	(LVDT) Driver Demodulator
pH Probe Amplifier/Temperature	Linear Variable Differential Transformer
Compensator	(LVDT) Measuring Gauge
Capacitance Meter	Vibration Meter
Zener Tester	Sensitive RF Voltmeter
Transistor Sorter/Tester	Minimum Component Tachometer
Go/No-Go Diode Tester	Phase Meter
Diode Tester	Precision Calibration Standard
Peak Level Indicator	Zener Diode Checker

FET CURVE TRACER

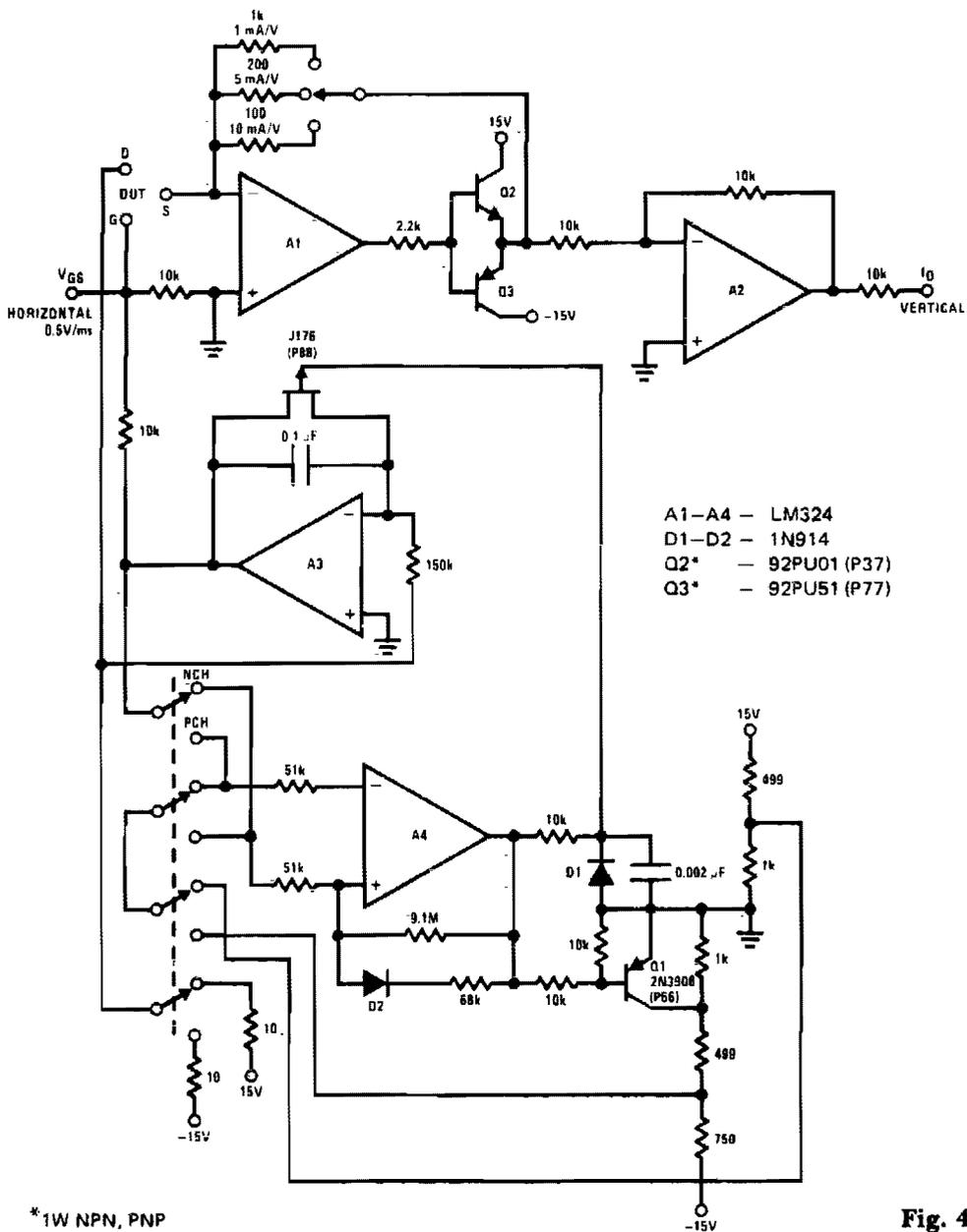
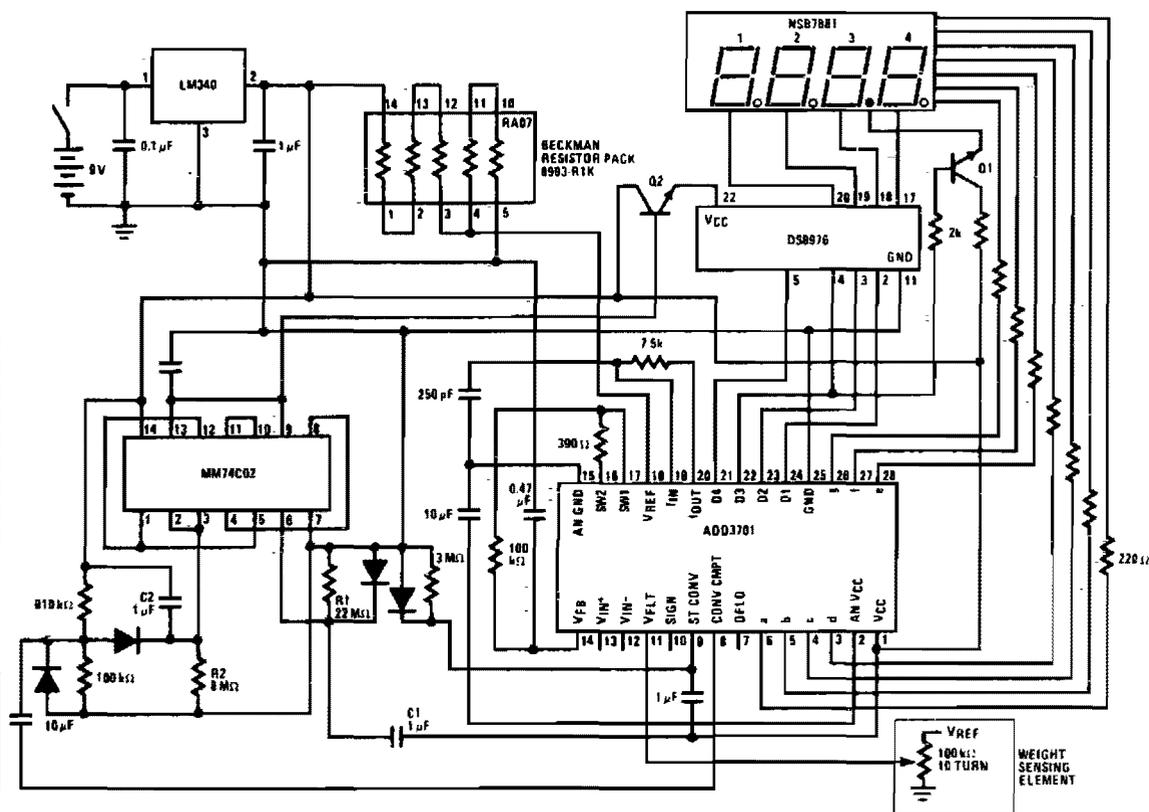


Fig. 49-1

Circuit Notes

The circuit displays drain current versus gate voltage for both P and N-channel JFETs at a constant drain voltage.

DIGITAL WEIGHT SCALE



Notes:

1. R1, C1 defines POWER ON display blanking interval. R2, C2 defines display ON time.
2. All V_{CC} connections should use a single V_{CC} point and all ground/analog ground connections should use a single ground/analog ground-point.
3. Display sequence for Rev 'A' kkt implementation:

t = 0 sec	• power ON
t = 0 → 5 sec	• display blanked
	• system converging
t = 5 → 10 sec	• conversion complete
	• display ENABLE
t ≥ 10 sec	• display blanked
	• wait for new POWER UP cycle

Fig. 49-2

Circuit Notes

This circuit employs a potentiometer as the weight sensing element. An object placed upon the scale displaces the potentiometer wiper, an amount proportional to its weight. Conversion of the wiper voltage to digital information is performed, decoded, and interfaced to the numeric display.

LOW COST pH METER

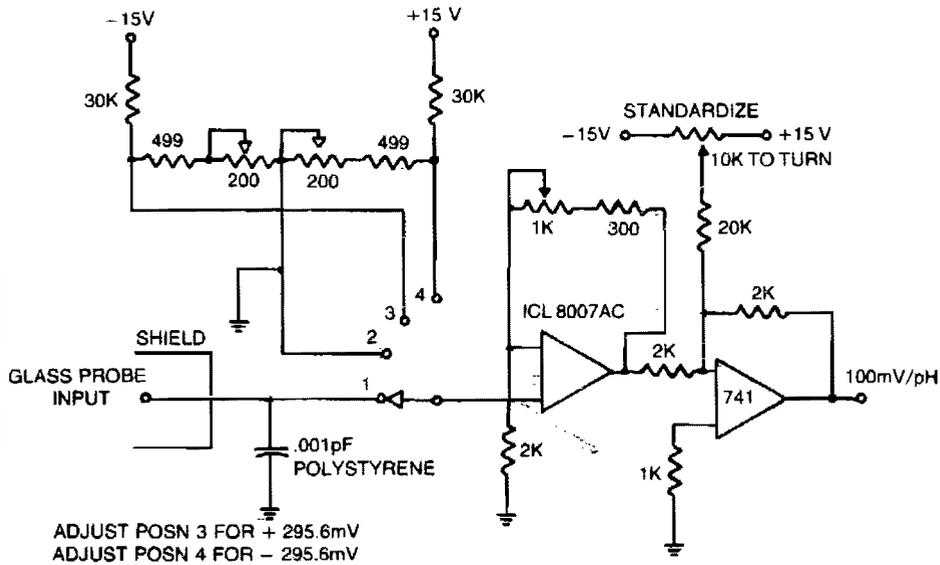
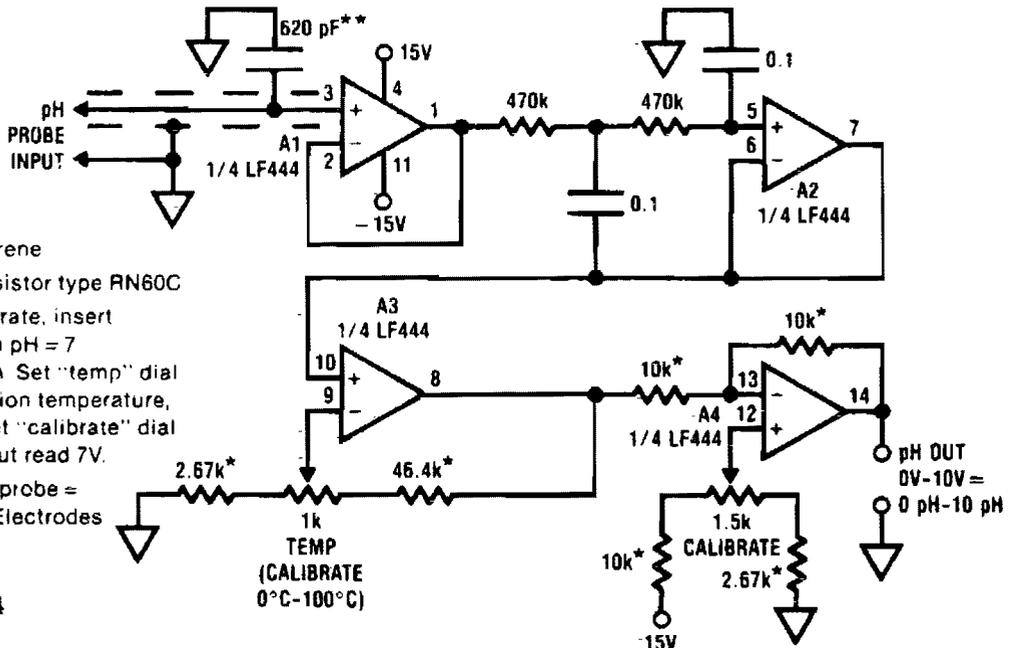


Fig. 49-3

Circuit Notes

With guaranteed 1 pA input bias, the ICL 8007A is ideal as a pH meter or long term sample and hold.

pH PROBE AMPLIFIER/TEMPERATURE COMPENSATOR



** Polystyrene

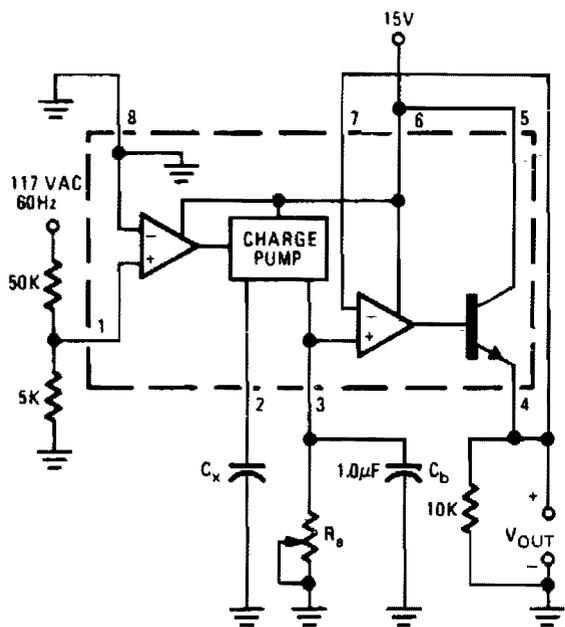
* Film resistor type RN60C

To calibrate, insert probe in pH = 7 solution. Set "temp" dial to solution temperature, then, set "calibrate" dial so output read 7V.

Typical probe = Ingold Electrodes #465-35

Fig. 49-4

CAPACITANCE METER



Circuit Notes

Output voltage is proportional to the capacitance connected to pin 2 of the charge pump. The meter works over a range of 0.01 to 0.1 μF with R_b set at 111 K. Over this range of capacitance, the output voltage varies from 1 to 10 volts with a 15 volt power supply. A constant frequency reference is taken from the 60-Hz line.

Fig. 49-5

ZENER TESTER

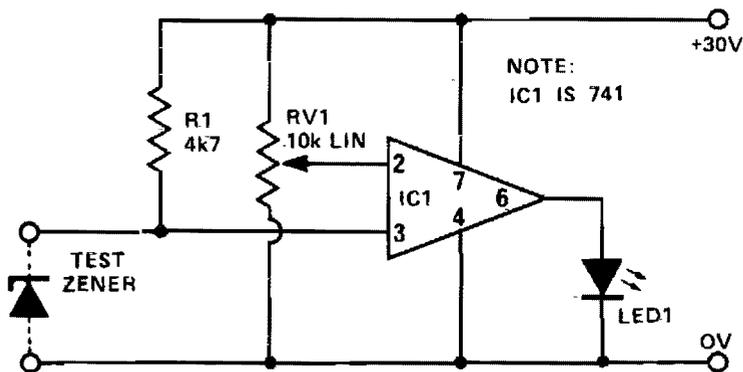


Fig. 49-6

Circuit Notes

This circuit provides a low cost and reliable method of testing zener diodes. RV1 can be calibrated in volts, so that when LED 1 just lights, the voltage on pins 2 and 3 are nearly equal. Hence, the zener voltage can be read

directly from the setting of RV1. The supply need only be as high a value as the zener itself. For a more accurate measurement, a precision pot could be added and calibrated.

TRANSISTOR SORTER/TESTER

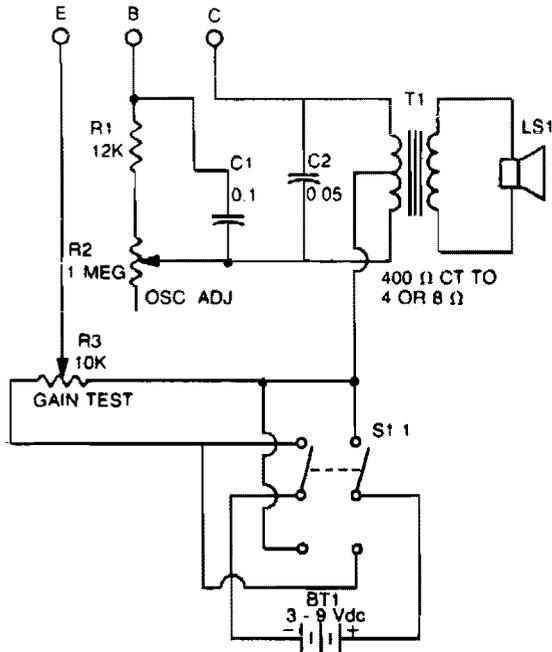


Fig. 49-7

Circuit Notes

This tester checks transistor for polarity (PNP or NPN). An audible signal will give an indication of gain. Tester can also be used as a GO/NO GO tester to match unmarked devices.

GO/NO-GO DIODE TESTER

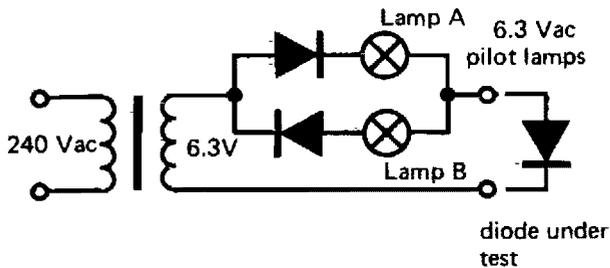


Fig. 49-8

Circuit Notes

If lamp A or B is illuminated, the diode is serviceable. If both light, the diode is short circuited. If neither light, diode is an open circuit.

DIODE TESTER

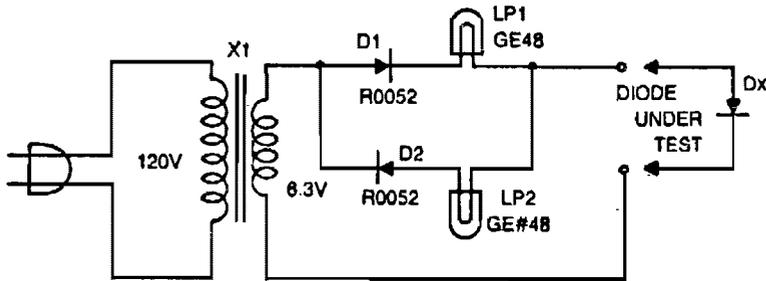


Fig. 49-9

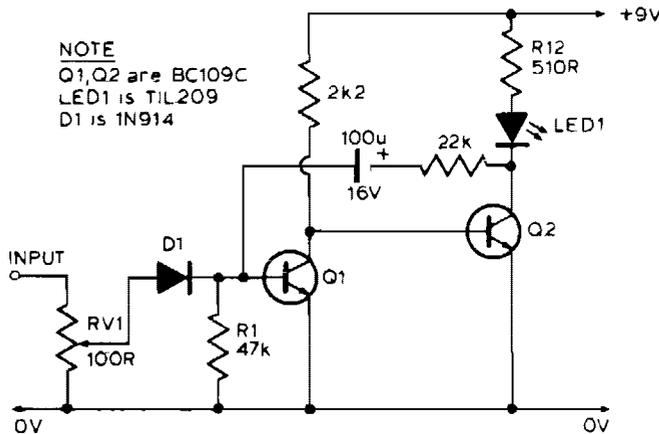
Parts list

- D1, D2—HEP R0052
- LP1, LP2—GE 48 lamp
- X1—120V to 6.3V, transformer, Lafayette 33P80508

Circuit Notes

The circuit tests whether or not a diode is open, shorted, or functioning correctly. If lamp A lights, the diode under test is functional. When lamp B is lit, the diode is good but connected backwards. When both lamps are lit, the diode is shorted, and it is open if neither lamp is lit.

PEAK LEVEL INDICATOR



NOTE
 Q1, Q2 are BC109C
 LED1 is TIL209
 D1 is 1N914

Fig. 49-10

Circuit Notes

The LED is normally lit, but it will be briefly extinguished if the input exceeds a preset (by RV1) level. A possible application is to monitor the output voltage across a loudspeaker; the LED will flicker with large signals.

SOUND LEVEL MONITOR

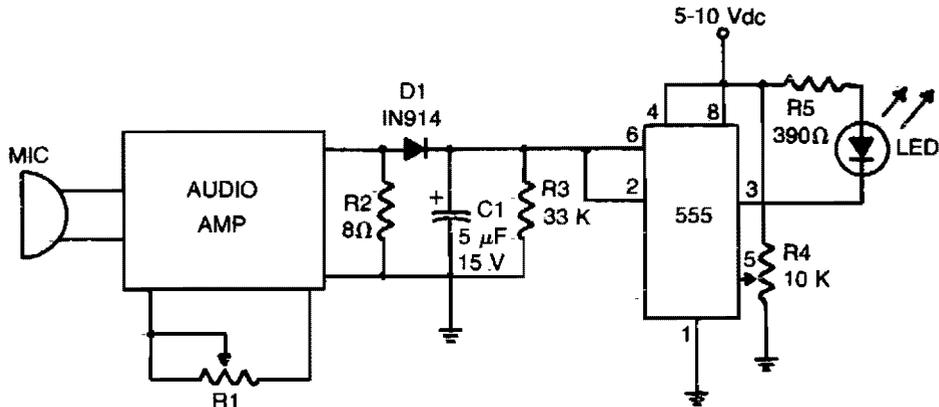


Fig. 49-11

Circuit Notes

Loudness detector consists of a 555 IC wired as a Schmitt trigger. The output changes state—from high to low—whenever the input crosses a certain voltage. That threshold voltage is established by the setting of R4.

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT) DRIVER DEMODULATOR

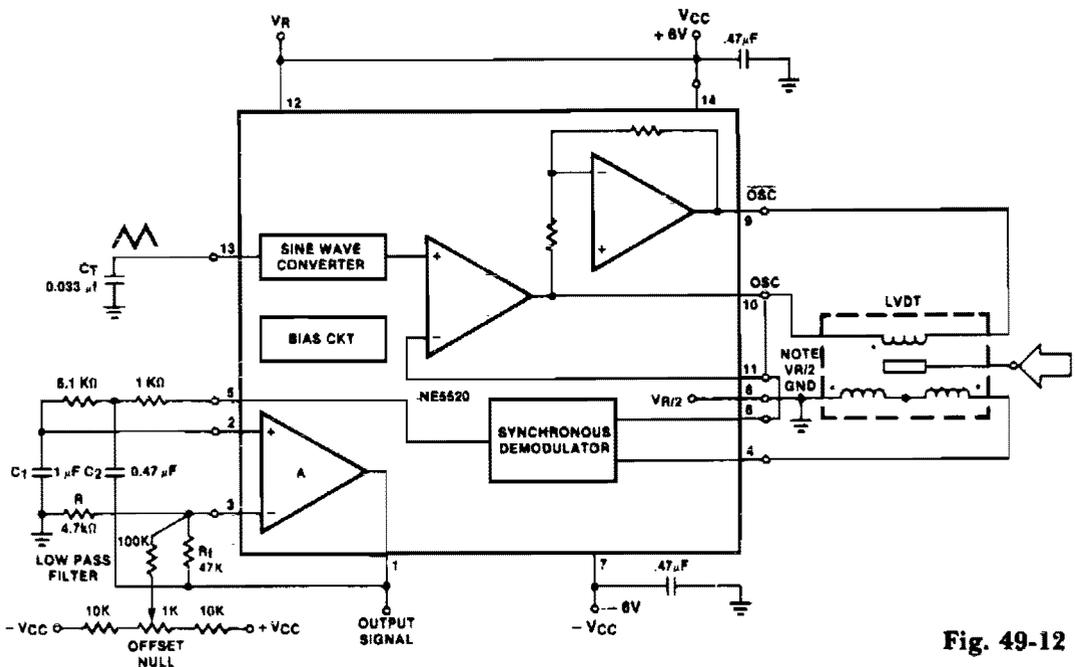


Fig. 49-12

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT) MEASURING GAUGE

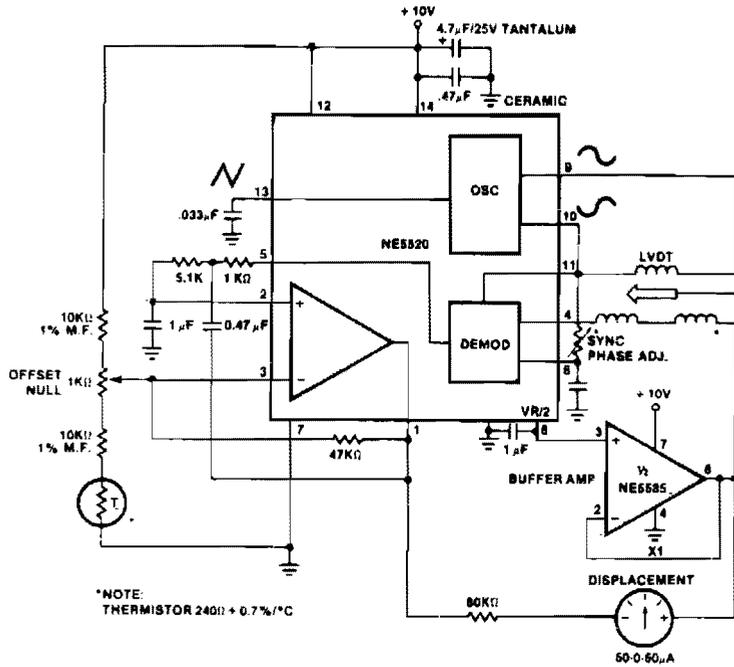


Fig. 49-13

VIBRATION METER

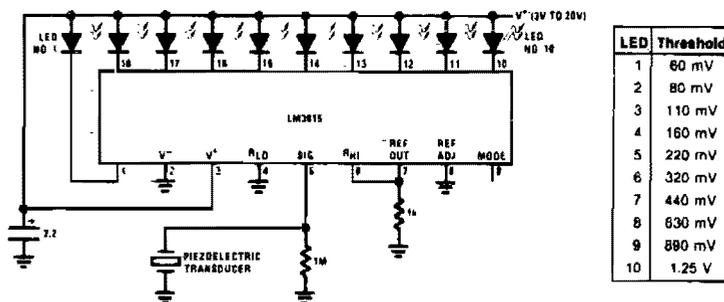


Fig. 49-14

SENSITIVE RF VOLTMEETER

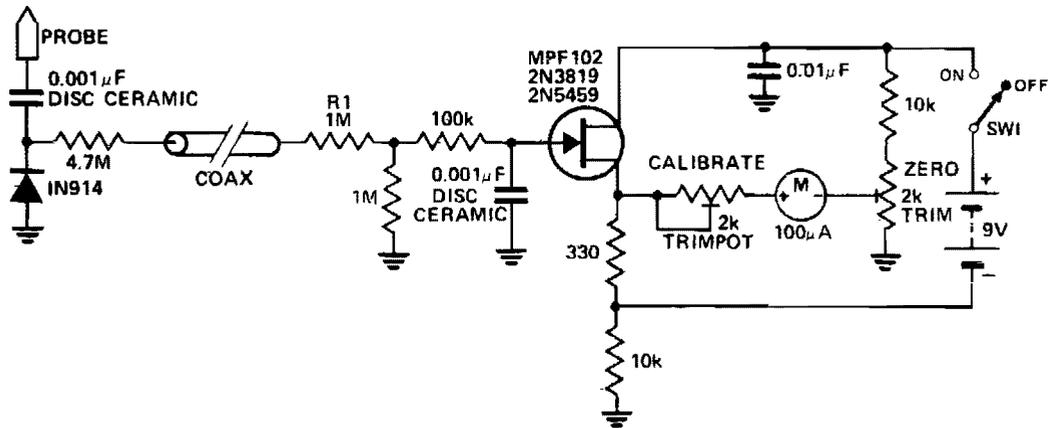


Fig. 49-15

Circuit Notes

This circuit measures RF voltages beyond 200 MHz and up to about 5 V. The diode should be mounted in a remote probe, close to the probe tip. Sensitivity is excellent and voltages less than 1 V peak can be easily measured. The

unit can be calibrated by connecting the input to a known level of RF voltage, such as a calibrated signal generator, and setting the calibrate control.

MINIMUM COMPONENT TACHOMETER

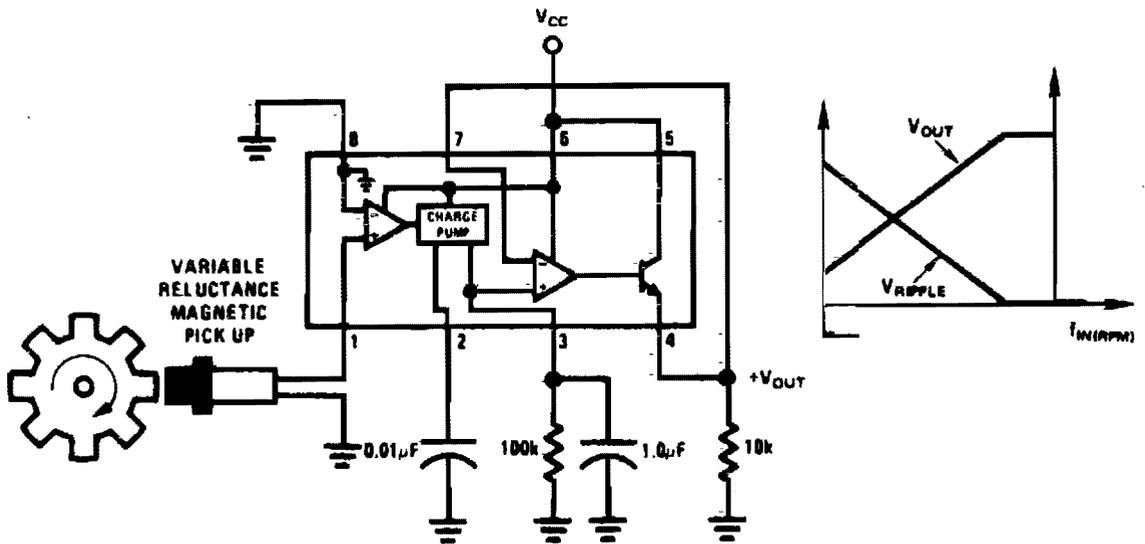


Fig. 49-16

PHASE METER

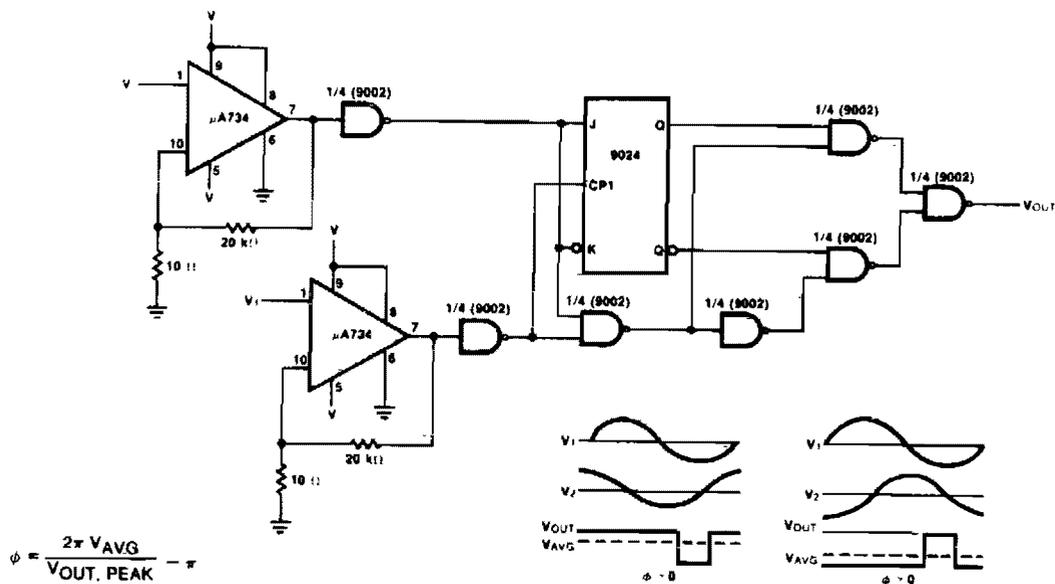


Fig. 49-17

PRECISION CALIBRATION STANDARD

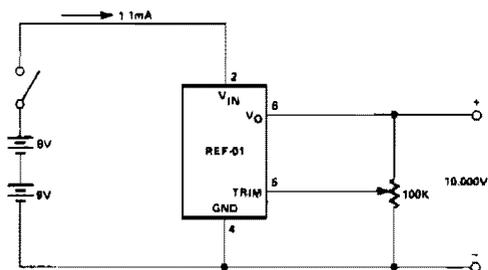


Fig. 49-18

Circuit Notes

An external power supply that gives a voltage higher than the highest expected rating of the zener diodes to be tested is required. Potentiometer RV1 is adjusted until the meter reading stabilizes. This reading is the zener diode's breakdown voltage.

ZENER DIODE CHECKER

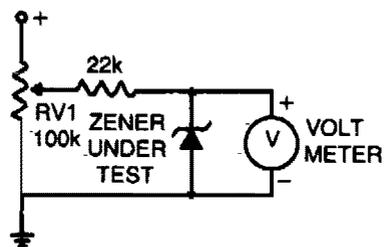


Fig. 49-19

50

Metal Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Micropower Metal Detector

Lo-Parts Treasure Locator

MICROPOWER METAL DETECTOR

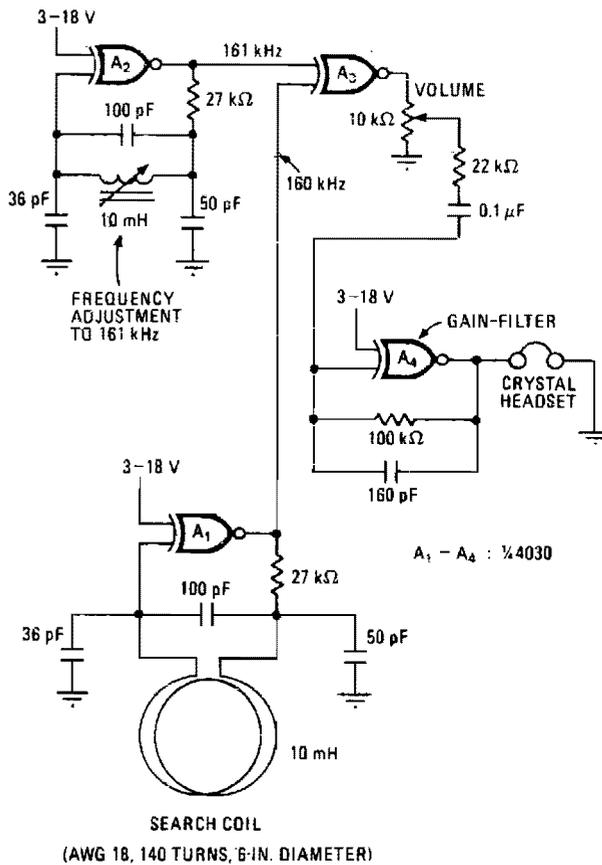


Fig. 50-1

Circuit Notes

This battery-powered metal detector uses four exclusive-OR gates contained in the 4030 CMOS integrated circuit. The gates are wired as a twin-oscillators and a search coil serves as the inductance element in one of the oscillators. When the coil is brought near metal, the resultant change in its effective inductance changes the oscillator's frequency. Gates A1 and A2 form the two oscillators which are tuned to 160 and 161 kilohertz respectively. The pulses produced by each oscillator are mixed in A3, its output contains sum and difference frequencies at 1 and 321 kHz. The 321 kHz signal is filtered out by the 10 kHz low-pass filter at A4, leaving the 1 kHz signal to be amplified for the crystal headset connected at the output. The device's sensitivity is sufficient to detect coin-sized objects a foot away.

LO-PARTS TREASURE LOCATOR

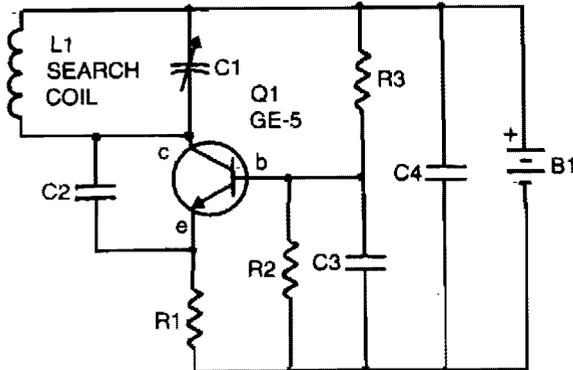


Fig. 50-2

PARTS LIST FOR

LO-PARTS TREASURE LOCATOR

- B1—9-Vdc transistor battery
- C1—365-pF trimmer or variable capacitor
- C2—100-pF, 100-V silver mica capacitor
- C3—0.05- μ F, disc capacitor
- C4—4.7- or 5- μ F, 12-V electrolytic capacitor
- L1—Search coil consisting of 18 turns of #22 enamel wire scramble wound on 4-in. diameter form
- Q1—RCA SK3011 npn transistor or equiv.
- R1—680-ohm, $\frac{1}{2}$ -watt resistor
- R2—10,000-ohm, $\frac{1}{2}$ -watt resistor
- R3—47,000-ohm, $\frac{1}{2}$ -watt resistor

Circuit Notes

Locator uses a transistor radio as the detector. With the radio tuned to a weak station, adjust C1 so the locator oscillator beats against the received signal. When the search head passes over metal, the inductance of L1 changes thereby changing the locator oscillator's frequency and changing the beat tone in the radio.

The search coil consists of 18 turns of #22 enameled wire scramble wound on a 4-in. diameter form. After the coil is wound and checked for proper operation, saturate the coil with RTV adhesive for stable operation of the locator.

51

Metronomes

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Accentuated Beat Metronome

Sight N' Sound Metronome

Micrometronome

ACCENTUATED BEAT METRONOME

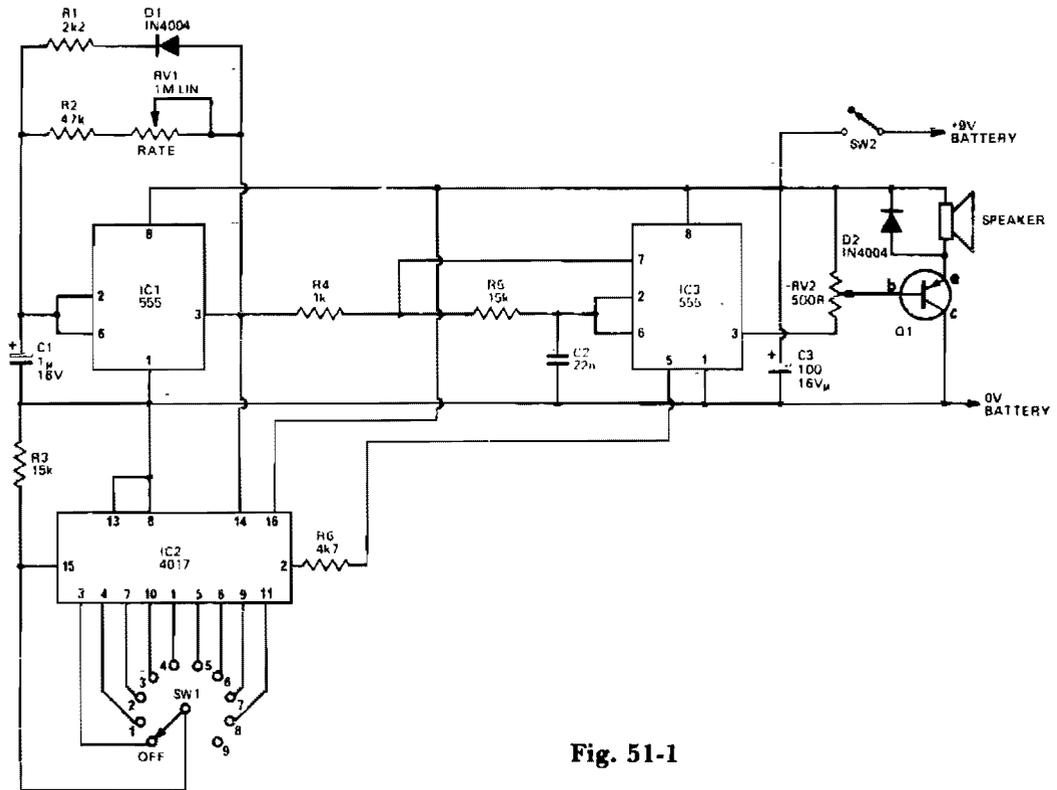


Fig. 51-1

Circuit Notes

IC3 acts as an oscillator which operates if the output of IC1 is high. With the values used the two frequencies produced are about 800 Hz and 2500 Hz. The output is buffered by Q1 which drives the speaker. The first IC is used to generate the tone duration and the time interval between beats. The interval is adjustable by RV1 while the tone duration is set by R1. The output of IC1 also clocks IC2, a decade counter with 10 decoded outputs. Each of these outputs go high in sequence on each clock. The

second output of IC2 is connected to the control input of IC3 and is used to change the frequency. Therefore the first tone will be high frequency, the second low and the third to tenth will be high again. This gives the 9-1 beat. If for example the 5th output is connected to the reset, the first tone will be high, the second low, and the third and fourth high, then when the 5th output goes to a high it resets it back to the first which is a high tone. We then have 3 high and one low tones or a 3-1.

SIGHT N' SOUND METRONOME

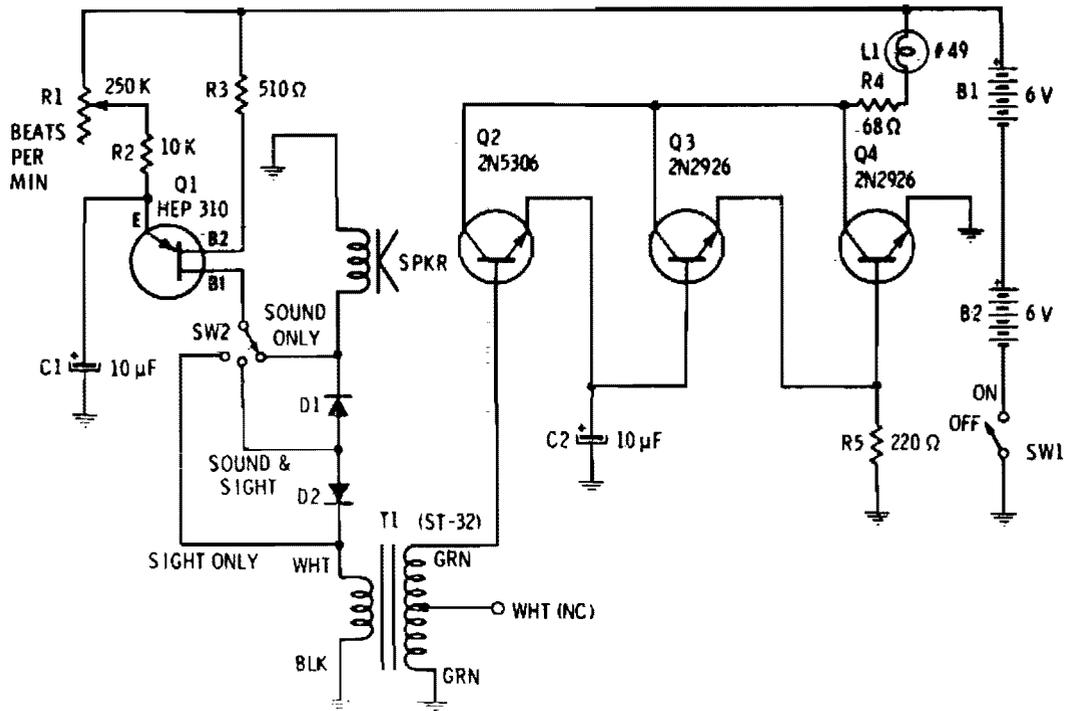


Fig. 51-2

Circuit Notes

Precise, adjustable control of beats per minute from a largo of 18 to a frenzied, high presto of 500. These beats are produced acoustically through a speaker. A light flashes at the same rate. When SW1 is closed, C1 begins to charge through R1 and R2. C1 will eventually reach a voltage at which the emitter of unijunction transistor is switched on, "dumping" the

energy stored in C1 into an 8 ohm speaker. To produce a distinct "plop", brief pulses across T2 secondary drive Q2 into conduction. The extra gain of Q3 and Q4 are sufficient to briefly switch L1 on, then off, as the pulse wave passes. Capacitor C2 "stretches" the pulse slightly to overcome the thermal inertia of the lamp, so that a bright flash occurs.

MICROMETRONOME

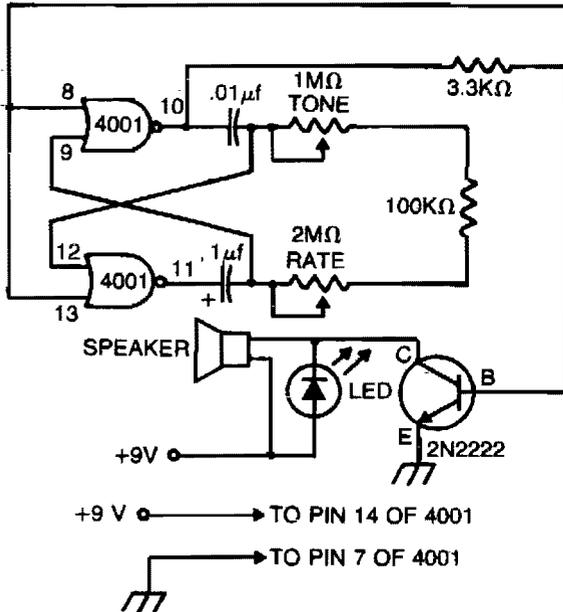
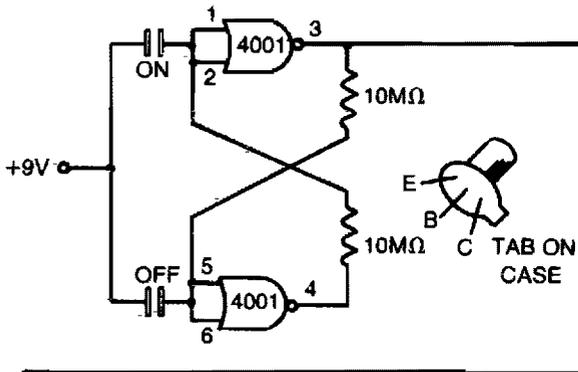


Fig. 51-3

Circuit Notes

This compact metronome will run for years on a single nine-volt transistor battery. Has both tone and pulse rate controls, and uses touch plates to start and stop, can be built in a case no larger than a pack of cigarettes. The

touch plates consist of two strips of metal about 1/16-inch apart mounted on, but insulated from, the case. Bridging the gap closes the switch.

52

Miscellaneous Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Intercom	Positive-Edge Differentiator
Musical Organ	Four Channel Data Acquisition System
Laser Diode Pulser	Triac Trigger
Capacitance Multiplier	Precision Rectifiers
Simulated Inductor	Voltage Control Resistor
Active Inductor	Fast Inverter Circuit
Positive Input/Negative Output Charge Pump	Inverse Scaler
Shift Register Driver	5.0 V Square Wave Calibrator
Tape Recorder	Low Drift Integrator and Low-Leakage Guarded Reset
Negative-Edge Differentiator	Differentiator with High Common Mode Noise Rejection
Stylus Organ	

Digital Transmission Isolator

LASER DIODE PULSER

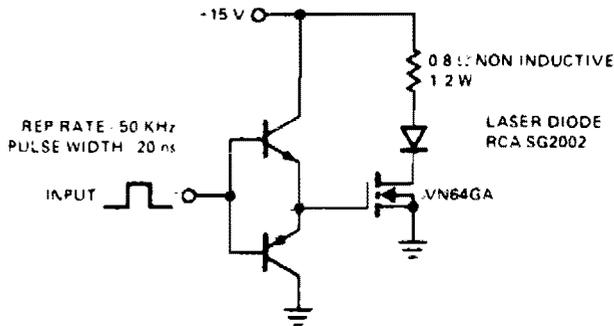


Fig. 52-3

Circuit Notes

This drive is capable of driving the laser diode with 10 ampere, 20 ns pulses. For a 0.1% duty cycle, the repetition rate will be 50 kHz. A complementary emitter-follower is used as a driver. Switching speed is determined by the f_T of the bipolar transistors used and the impedance of the drive source.

CAPACITANCE MULTIPLIER

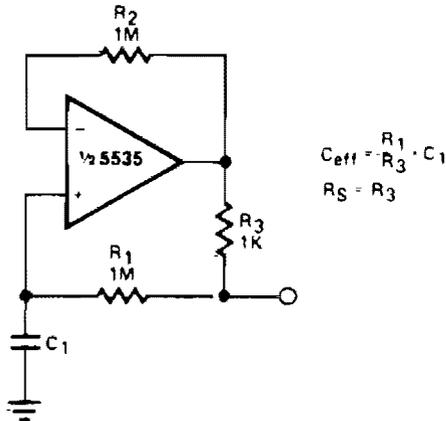


Fig. 52-4

All resistor values are in ohms

Circuit Notes

This circuit can be used to simulate large capacitances using small value components. With the values shown and $C = 10 \mu F$, an effective capacitance of $10,000 \mu F$ was obtained. The Q available is limited by the effective series resistance. So R_1 should be as large as practical.

SIMULATED INDUCTOR

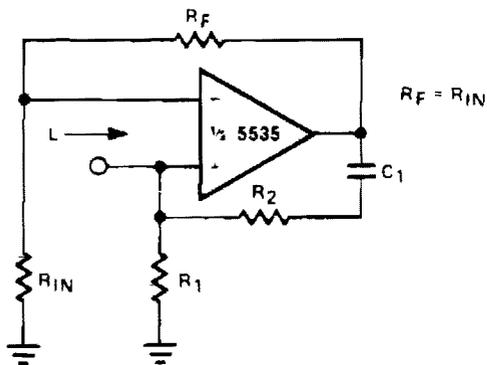


Fig. 52-5

Circuit Notes

With a constant current excitation, the voltage dropped across an inductance increases with frequency. Thus, an active device whose output increases with frequency can be characterized as an inductance. The circuit yields such a response with the effective inductance being equal to: $L = R_1R_2C$. The Q of this inductance depends upon R_1 being equal to R_2 . At the same time, however, the positive and negative feedback paths of the amplifier are equal leading to the distinct possibility of instability at high frequencies. R_1 should, therefore, always be slightly smaller than R_2 to assure stable operation.

ACTIVE INDUCTOR

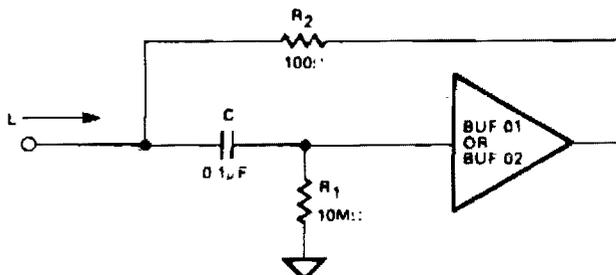


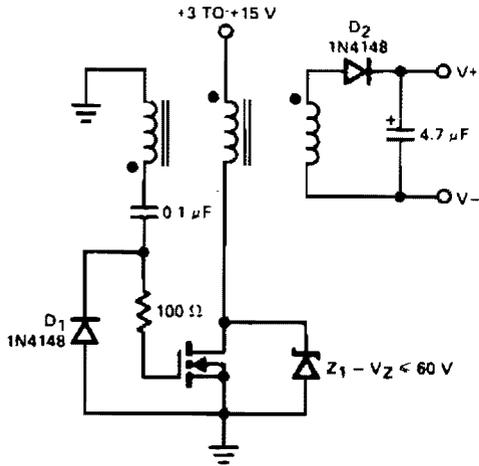
Fig. 52-6

$L = R_1R_2C = 100 \text{ HENRIES}$
 $R_2 = R_1 = 100\Omega$
 $R_1 = R_1 = 10 \text{ MEG}\Omega$
 ASSUMING C_{STRAY} (ACROSS R_1) OF $5 \mu\text{F}$ THE UPPER
 FREQUENCY LIMIT IS APPROXIMATELY 7kHz
 $X_L = 100\Omega$ AT $f = 0.159\text{Hz}$

Circuit Notes

An active inductor is realized with an eight-lead IC, two carbon resistors, and a small capacitor. A commercial inductor of 50 henries may occupy up to five cubic inches.

POSITIVE INPUT/NEGATIVE OUTPUT CHARGE PUMP



TRANSFORMER:
INDIANA GENERAL CORE F626-12-O₂
26 TURNS NO. 28 WIRE TRIFILAR WOUND

Circuit Notes

A simple means of generating a low-power voltage supply of opposite polarity from the main supply. Self oscillating driver produces pulses at a repetition frequency of 100 kHz. When the VMOS device is off, capacitor C is charged to the positive supply. When the VMOS transistor switches on, C delivers a negative voltage through the series diode to the output. The zener serves as a dissipative regulator.

Fig. 52-7

SHIFT REGISTER DRIVER

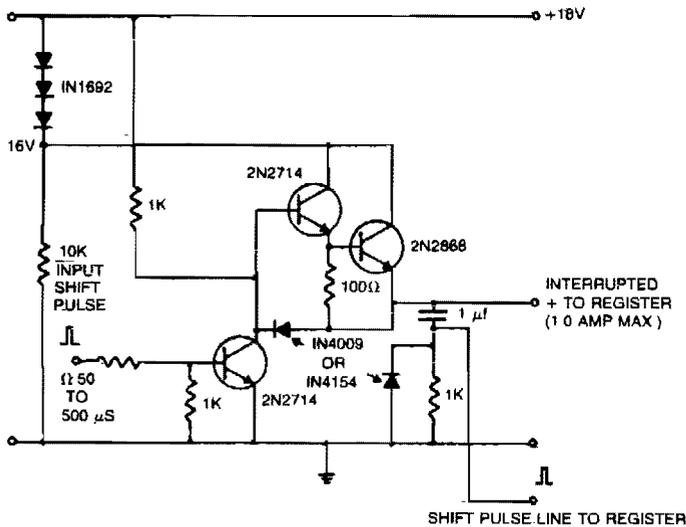


Fig. 52-8

Circuit Notes

A 16 V power supply can be synthesized as shown using IN1692 rectifiers. A shift pulse input saturates the 2N2714 depriving the Darlington combination (2N2714 and 2N2868) of

base drive. The negative pulse so generated on the 15 V line is differentiated to produce a positive trigger pulse at its trailing edge.

TAPE RECORDER

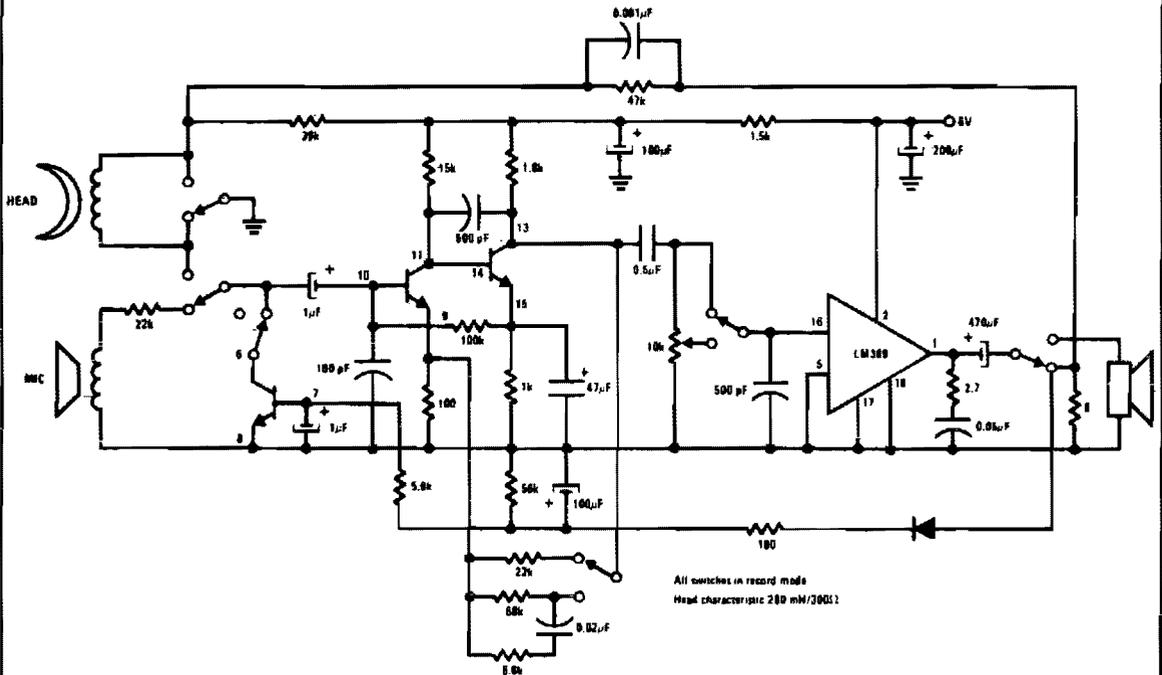


Fig. 52-9

Circuit Notes

Complete record/playback cassette tape machine amplifier. Two of the transistors act as signal amplifiers, with the third used for automatic level control during the record mode.

NEGATIVE-EDGE DIFFERENTIATOR

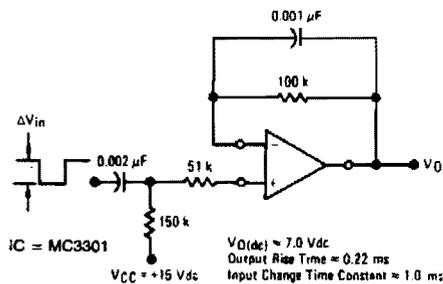


Fig. 52-10

STYLUS ORGAN

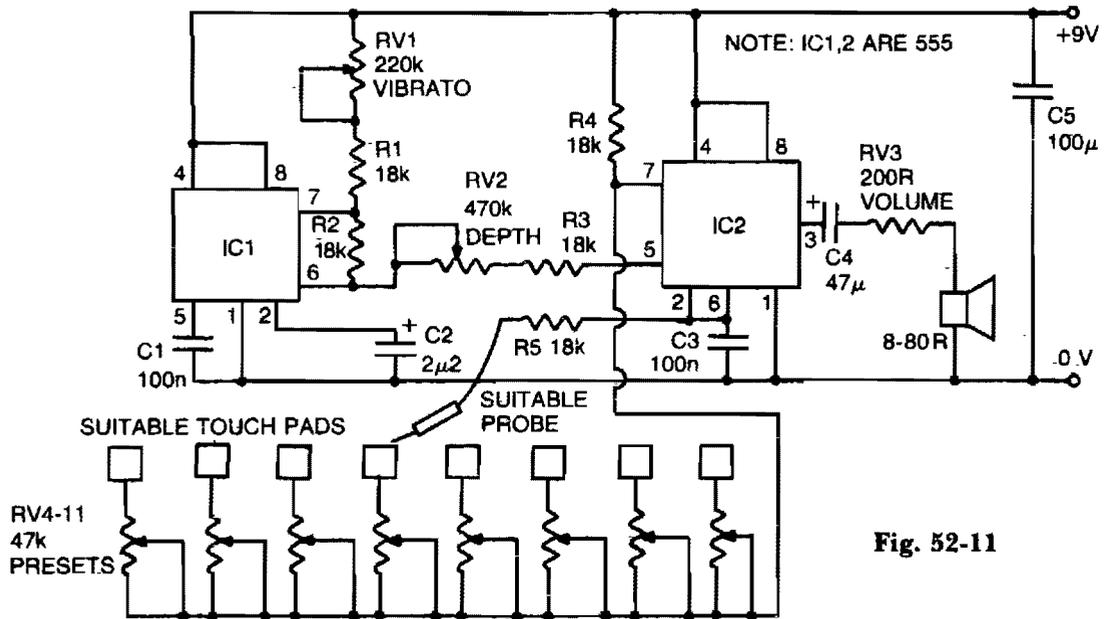


Fig. 52-11

Circuit Notes

IC2 is an audio frequency oscillator. Its frequency is primarily controlled by the resistance between pins 2 and 7. RV4-11 control the oscillator frequency and by touching a stylus (connected via limiting resistor R5 to pin 2) to each preset, different notes can be played. IC1 is a low frequency oscillator (approximately

3-10Hz), the frequency of which is variable by RV1. The output of this oscillator is connected through depth control RV2 and limiting resistor R3 to the voltage control input of the audio frequency oscillator. Thus a vibrato effect occurs.

POSITIVE-EDGE DIFFERENTIATOR

Output Rise Time ≈ 0.22 ms
 Input Change Time Constant ≈ 1.0 ms

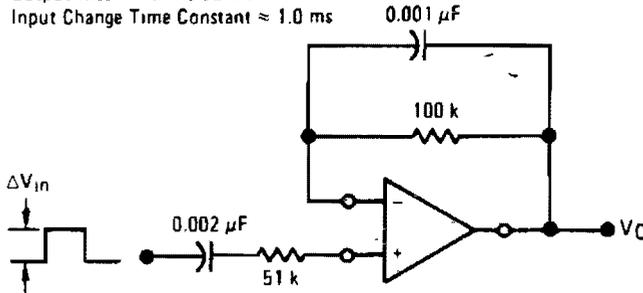


Fig. 52-12

FOUR CHANNEL DATA ACQUISITION SYSTEM

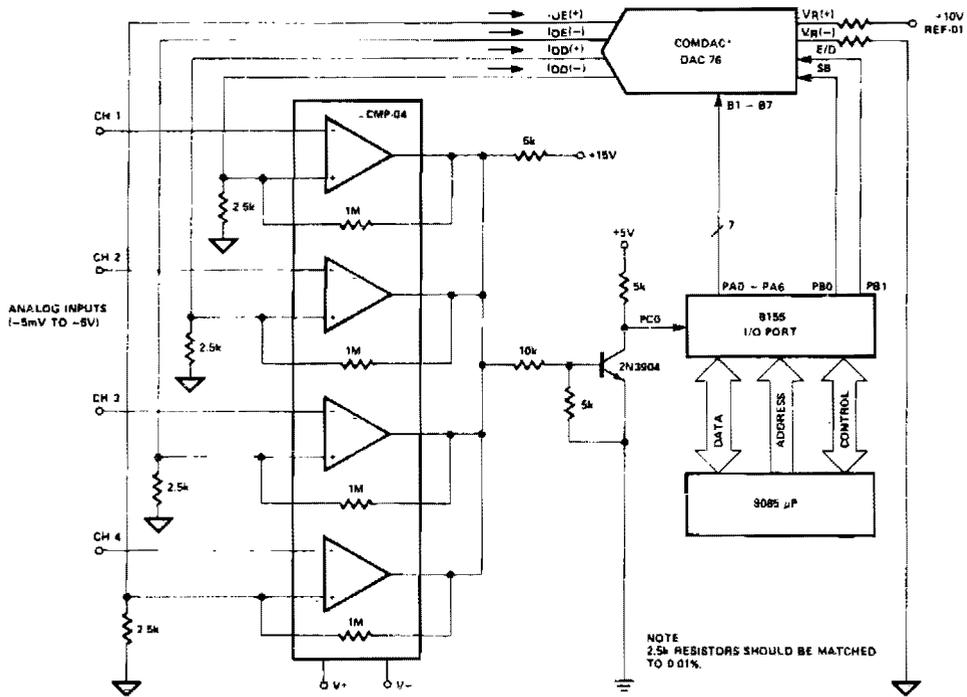


Fig. 52-13

TRIAC TRIGGER

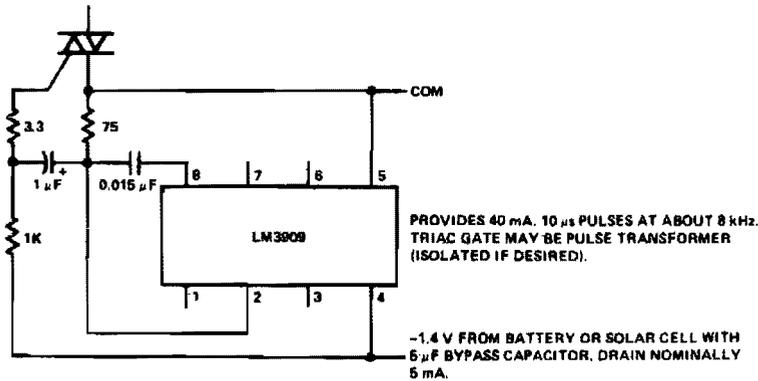
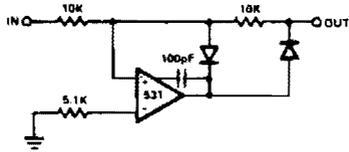


Fig. 52-14

PRECISION RECTIFIERS

(a) HALF WAVE



(b) FULL WAVE

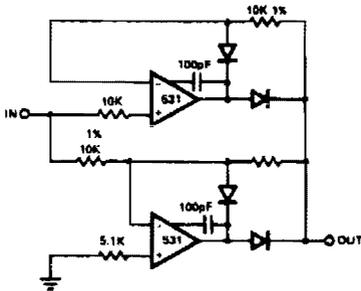


Fig. 52-15

FAST INVERTER CIRCUIT

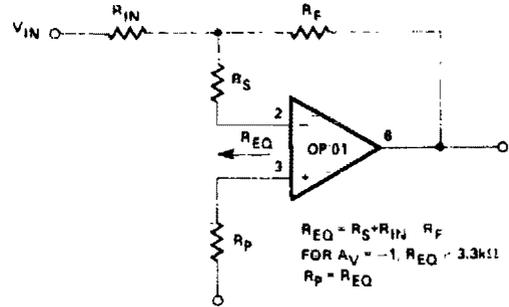


Fig. 52-17

VOLTAGE CONTROL RESISTOR

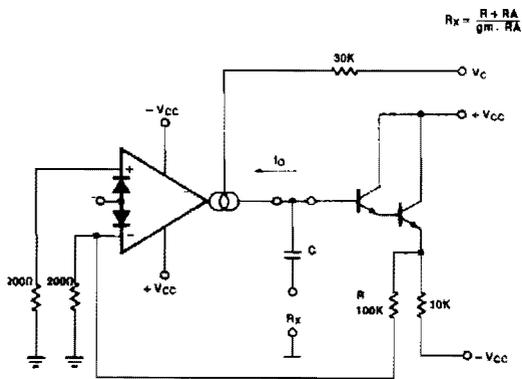


Fig. 52-16

INVERSE SCALER

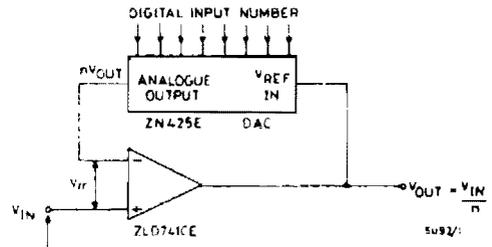


Fig. 52-18

Circuit Notes

If a DAC is operated in the feedback loop of an operational amplifier, then the amplifier gain is inversely proportional to the input digital number or code to the DAC. The version giving scaling inversely proportional to positive voltage is shown.

5.0 V SQUARE WAVE CALIBRATOR

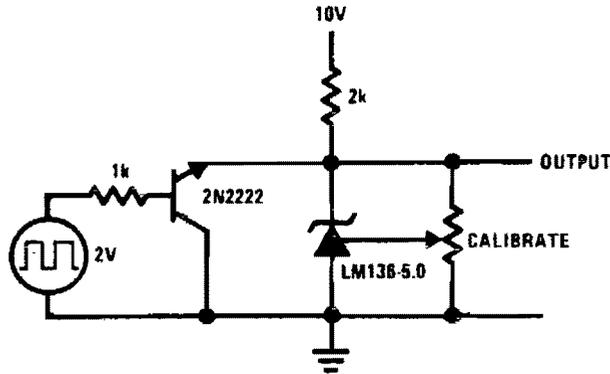


Fig. 52-19

LOW DRIFT INTEGRATOR AND LOW-LEAKAGE GUARDED RESET

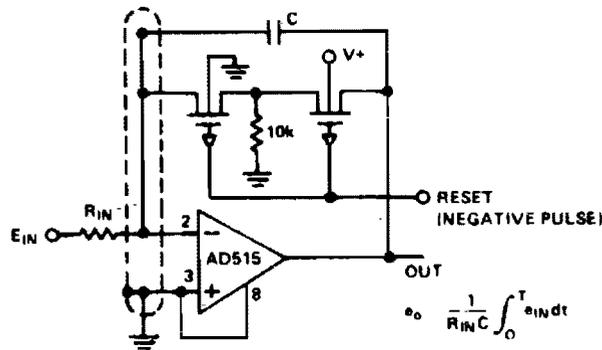
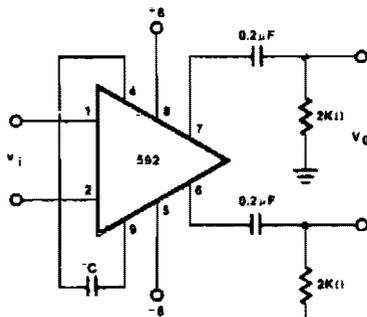


Fig. 52-20

DIFFERENTIATOR WITH HIGH COMMON MODE NOISE REJECTION



FOR FREQUENCY $F_1 \ll 1/2 \pi (32) C$
 $V_O \approx 1.4 \times 10^4 C \frac{dV_i}{dT}$

Fig. 52-21

DIGITAL TRANSMISSION ISOLATOR

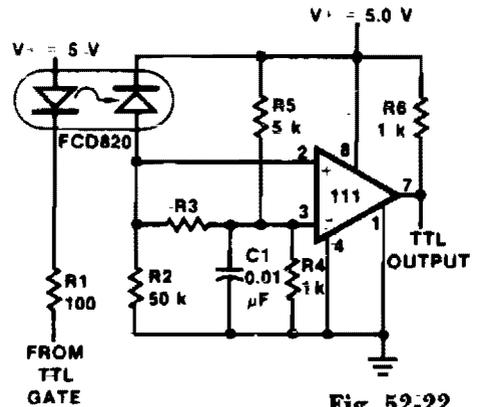


Fig. 52-22

53

Mixers and Multiplexers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Differential Mux/Demux System
Eight Channel Mux/Demux System
Doubly Balanced Mixer

Common-Source Mixer
100 MHz Mixer
Multiplexer/Mixer

Wide Band Differential Multiplexer

EIGHT CHANNEL MUX/DEMUX SYSTEM

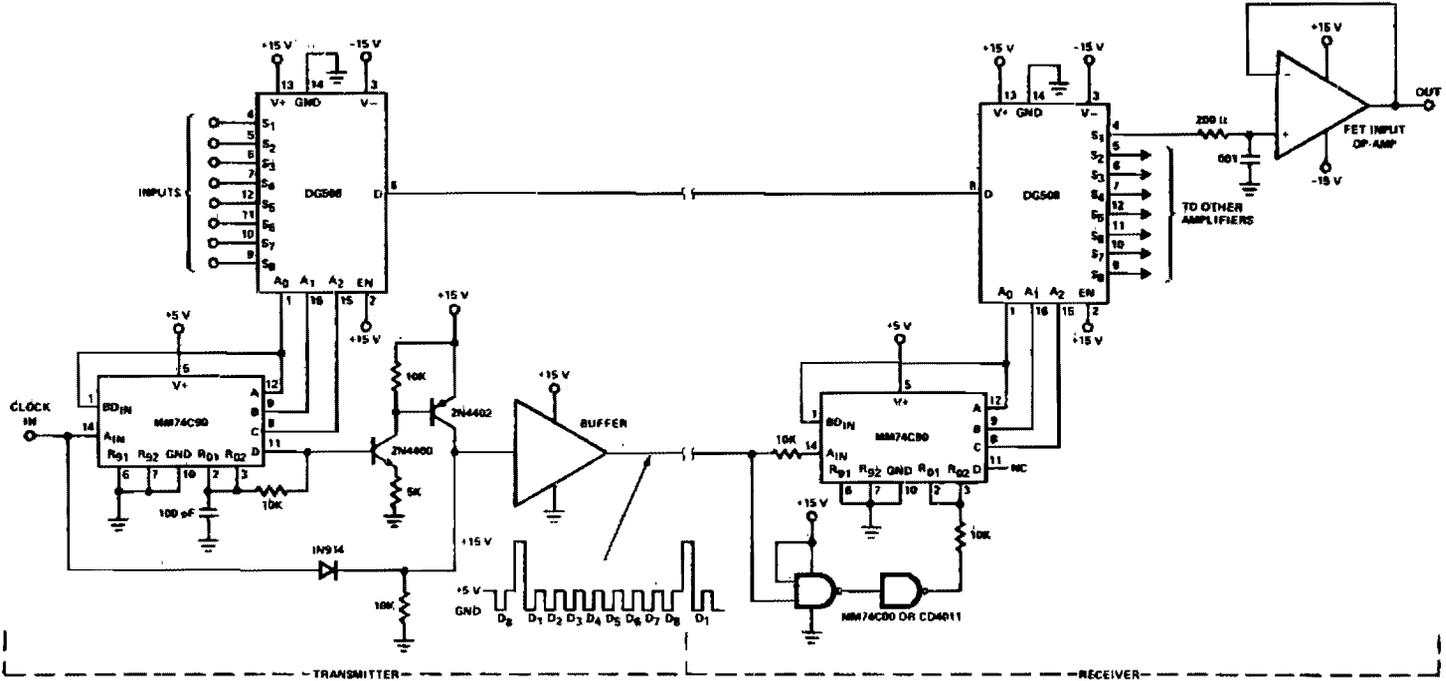


Fig. 53-2

WIDE BAND DIFFERENTIAL MULTIPLEXER

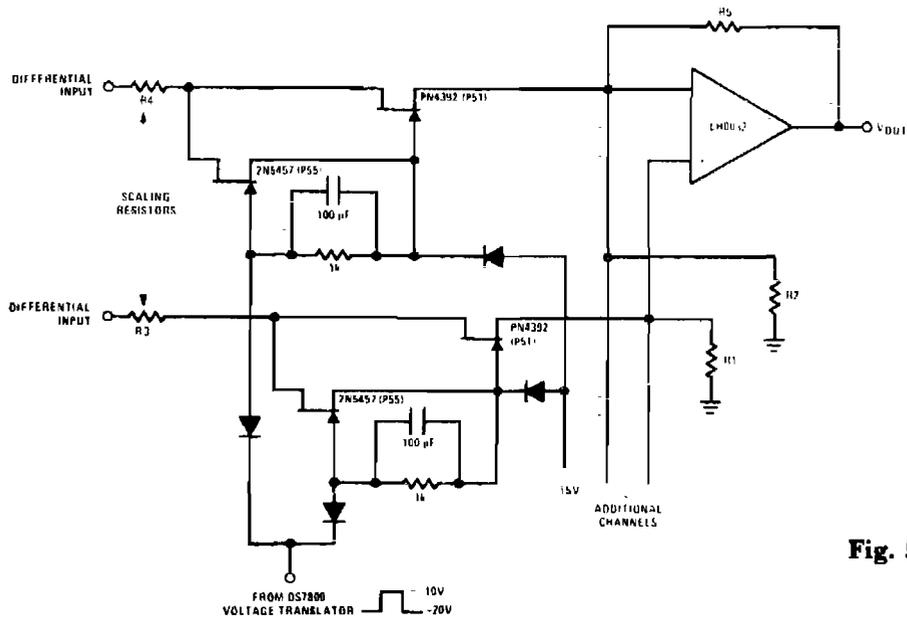


Fig. 53-7

Circuit Notes

This design allows high frequency signal handling and high toggle rates simultaneously. Toggle rates up to 1 MHz and MHz signals are possible with this circuit.

54

Modulation Monitors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Modulation Monitor

Visual Modulation Indicator

CB Modulation Monitor

MODULATION MONITOR

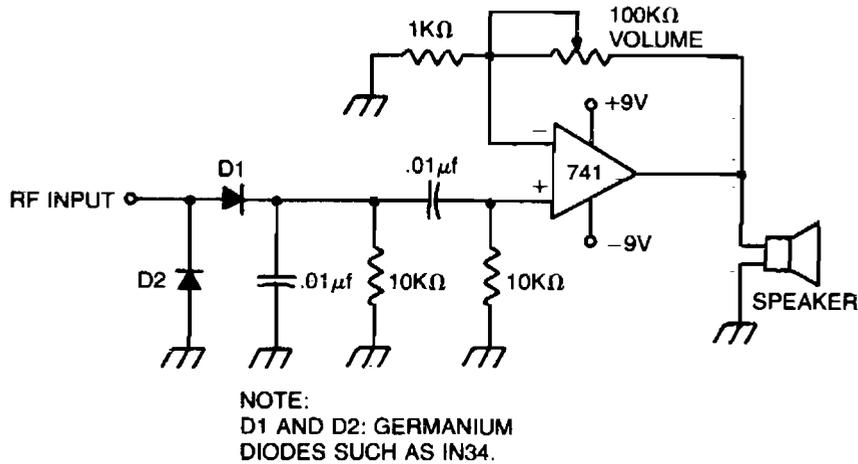


Fig. 54-1

Circuit Notes

Broad-tuned receiver demodulates the RF signal picked up by a loosely coupled wire placed near the transmitting antenna.

VISUAL MODULATION INDICATOR

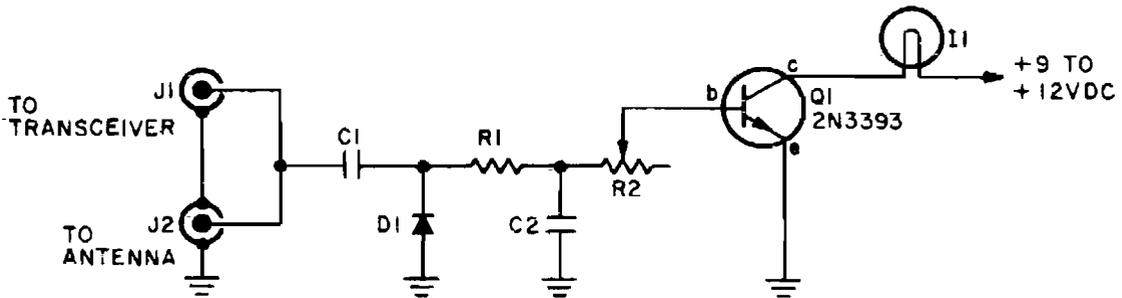


Fig. 54-2

Circuit Notes

Indicator lamp brightness varies in step with modulated RF signal. Adjust R2 with transmitter on (modulated) until the lamp flashes in step with modulation. C1 = 5 pf, C2 = 100 pF, D1 = 1N60 or 1N34 (Germanium),

R3 = 10 K pot, I1 = 6-8 V, 30-60 mA incandescent bulb, Q1 = 2N3393 (for increased sensitivity use 2N3392 or other high-gain transistor).

CB MODULATION MONITOR

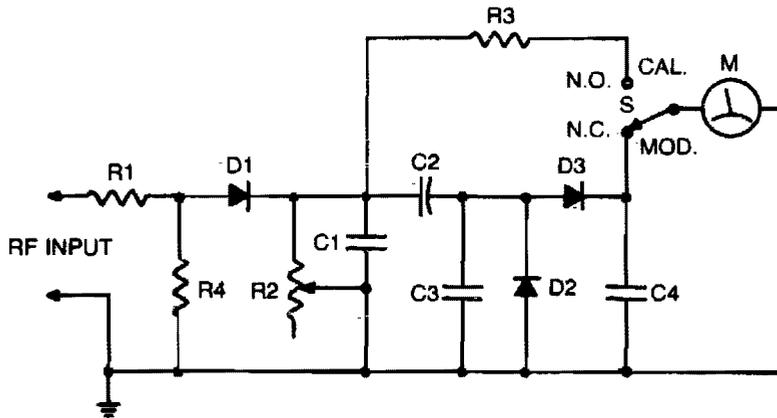


Fig. 54-3

PARTS LIST

- C1—500-pF, 100-Vdc capacitor
- C2—10- μ F, 10-Vdc electrolytic capacitor
- C3—200-pF, 100-Vdc capacitor
- C4—300-pF, 100-Vdc capacitor
- D1, D2, D3—1N60
- M1—0-1 mA DC high-speed meter
- R1, R4—1000-ohm, 1/2-watt resistor
- R2—1000-ohm pot
- R3—910-ohm, 1/2-watt resistor, 5%
- S1—Spdt spring-return switch

Circuit Notes

Connect this circuit to a transceiver with a coaxial T connector in the transmission line. Key the transmitter (unmodulated), set S1 to CAL, and adjust R2 for a full scale reading. Return S1 to MOD position. The meter will read % modulation with 10% accuracy.

55

Modulators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

TV Modulator

TV Modulator

Pulse-Position Modulator

Pulse-Width Modulator

Pulse-Width Modulator

RF Modulator

Linear Pulse-Width Modulator

Balanced Modulator

Video Modulator

Modulator

Pulse-Width Modulator

AM Modulator

TV Modulator Using a Motorola MC1374

Pulse-Width Modulator

Pulse-Width Modulator

VHF Modulator

TV MODULATOR

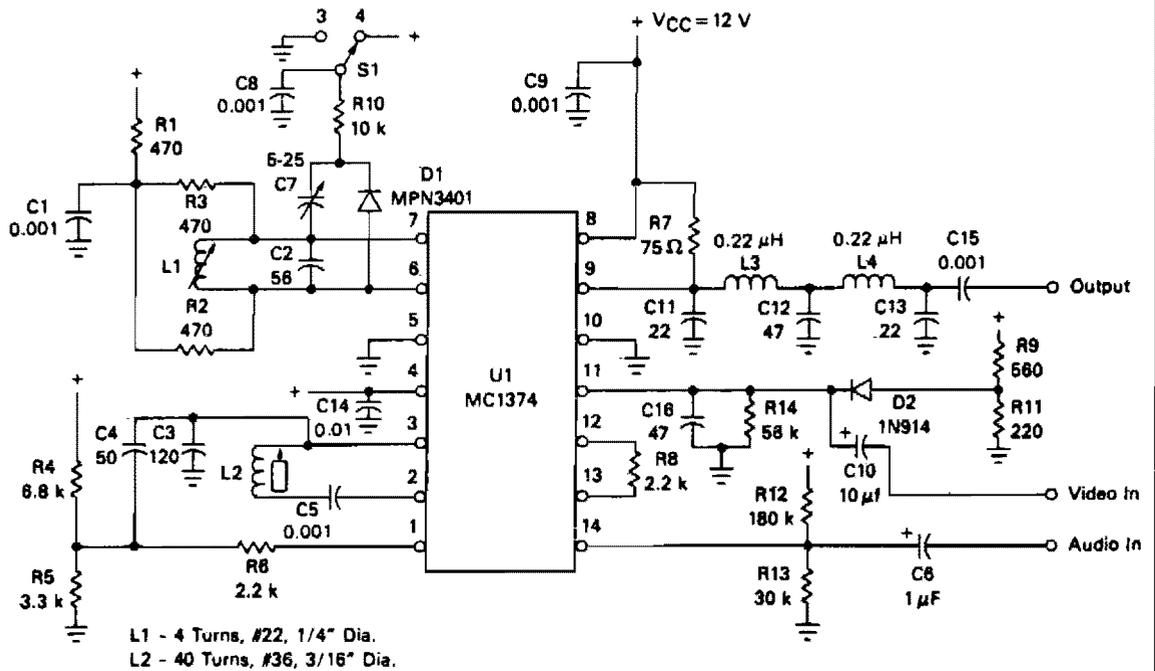


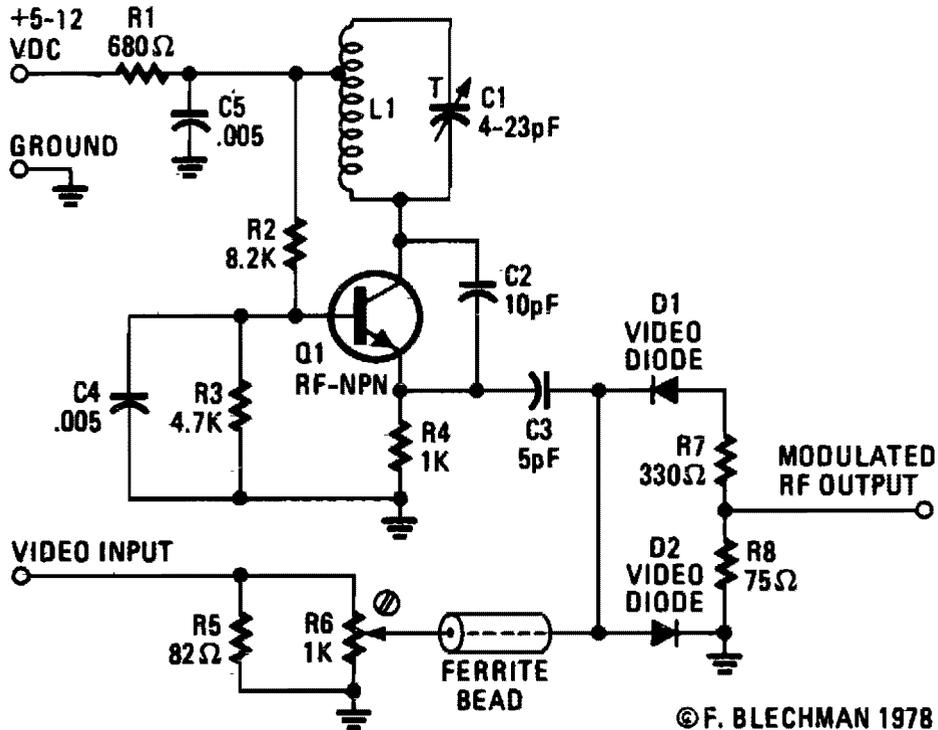
Fig. 55-1

Circuit Notes

The FM oscillator/modulator is a voltage-controlled oscillator, which exhibits a nearly linear output frequency versus input voltage characteristic for a wide deviation. It provides a good FM source with a few inexpen-

sive external parts. It has a frequency range of 1.4 to 14 MHz and can typically produce a ± 25 kHz modulated 4.5 MHz signal with about 0.6% total harmonic distortion.

TV MODULATOR



© F. BLECHMAN 1978

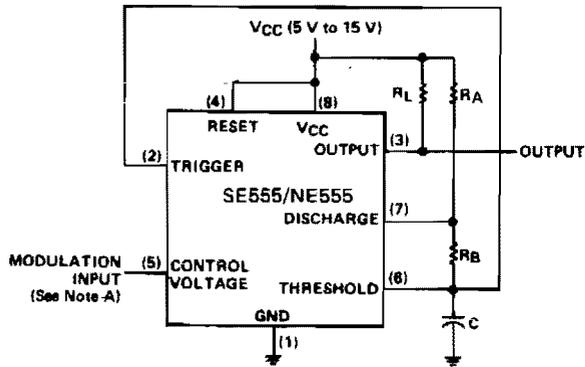
Fig. 55-2

Circuit Notes

The VHF frequency is generated by a tuned Hartley oscillator circuit. Resistors R2, R3, and R4 bias the transistor, with tapped inductor L1 and trimmer capacitor C1 forming the tank circuit. Adjusting C1 determines the frequency. Capacitor C2 provides positive feedback from the tank circuit to the emitter at Q1. Capacitor C4 provides an RF ground for the base of Q1. Bypass capacitor C5 and resistor

R1 filter out the radio frequencies generated in the tank circuit to prevent radiation from the power-supply lines. The video signal enters the parallel combination of resistors R5 and R6; this combination closely matches the 75 ohm impedance of most video cables. Resistor R6 is a small screwdriver-adjusted potentiometer that is used to control the video input level to mixer diodes D1 and D2.

PULSE-POSITION MODULATOR



NOTE A: The modulating signal may be direct or capacitively coupled to the control voltage terminal. For direct coupling, the effects of modulation source voltage and impedance on the bias of the SE555/NE555 should be considered.

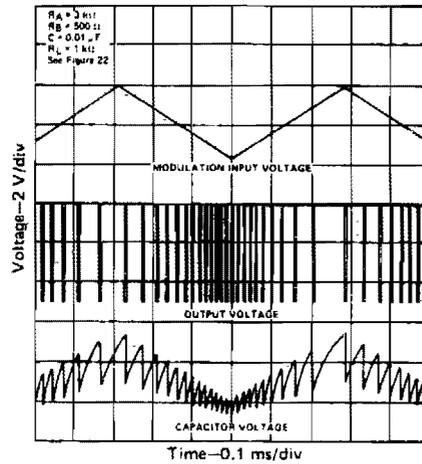


Fig. 55-3

Circuit Notes

The threshold voltage, and thereby the time delay, of a free-running oscillator is shown modulated with a triangular-wave modulation signal; however, any modulating wave-shape could be used.

PULSE-WIDTH MODULATOR

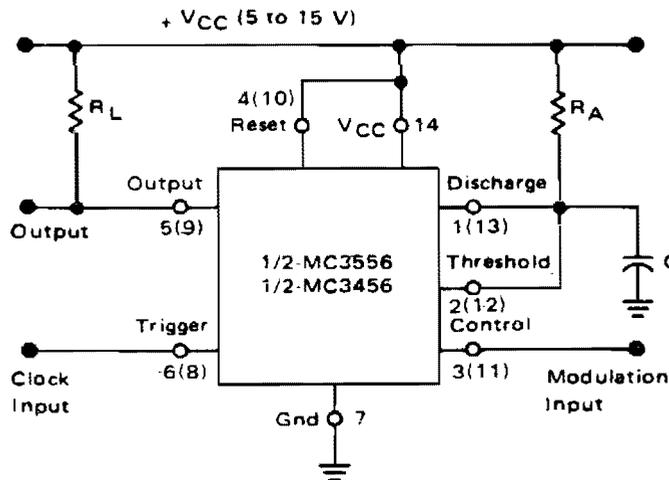


Fig. 55-4

Circuit Notes

If the timer is triggered with a continuous pulse train in the monostable mode of operation, the charge time of the capacitor can be varied by changing the control voltage at pin 3.

In this manner, the output pulse width can be modulated by applying a modulating signal that controls the threshold voltage.

PULSE-WIDTH MODULATOR

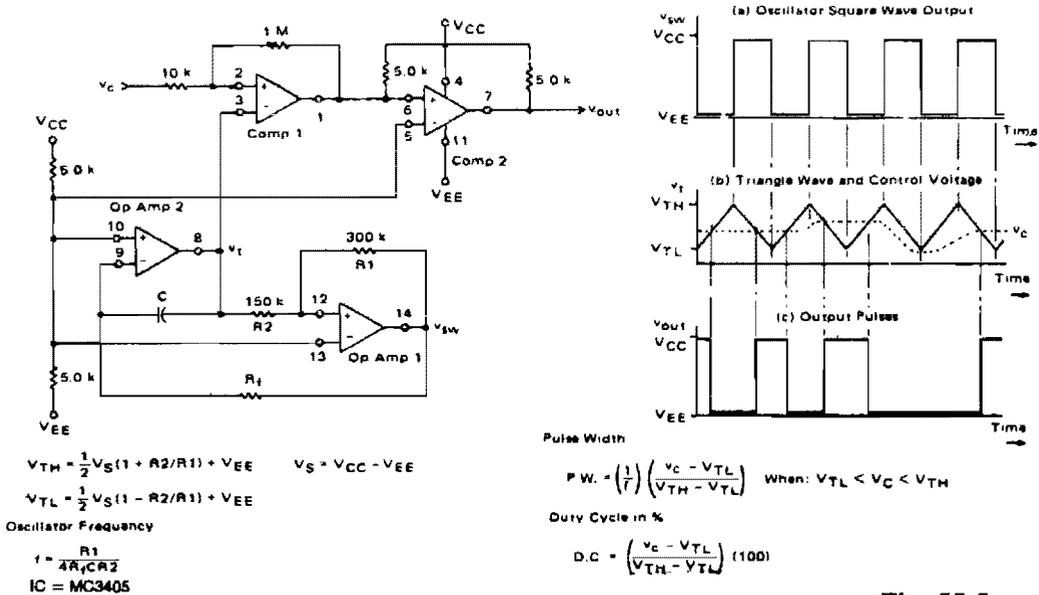


Fig. 55-5

RF MODULATOR

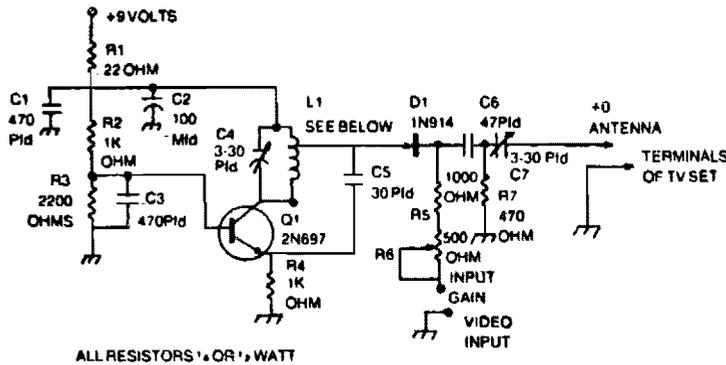


Fig. 55-6

Circuit Notes

Capacitors C1, C3, C5, and C6 should be dipped mica. C4 and C7 are compression or piston trimmer types. R6 is PC-board mount trimpot. L1 is 6 turns of No. 14 enameled wire, 3/8 inch I.D. by 3/4 inch long, tapped at 1 turn from top.

LINEAR PULSE-WIDTH-MODULATOR

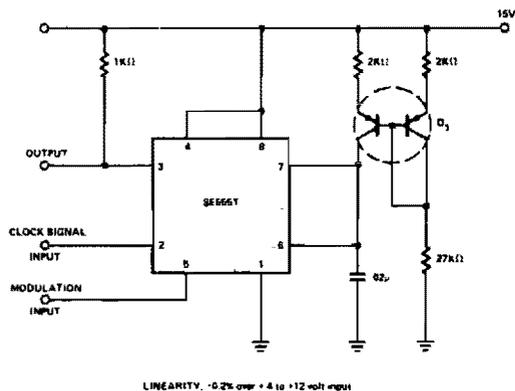


Fig. 55-7

VIDEO MODULATOR

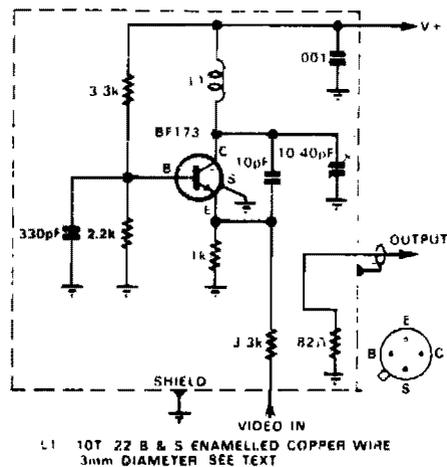


Fig. 55-9

BALANCED MODULATOR (+12 Vdc SINGLE SUPPLY)

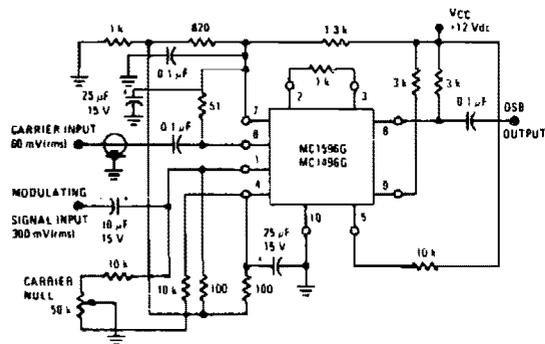


Fig. 55-8

MODULATOR

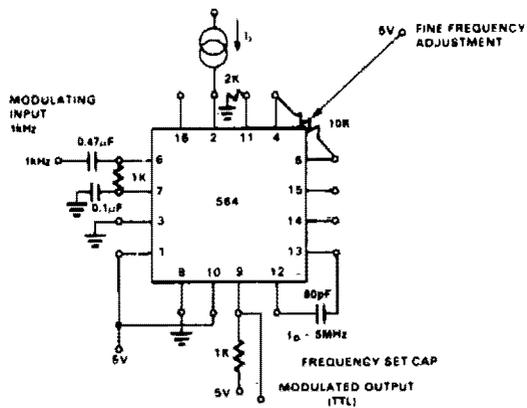
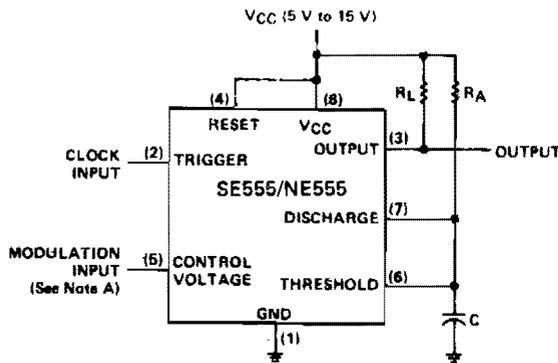


Fig. 55-10

PULSE-WIDTH MODULATOR



NOTE A: The modulating signal may be direct or capacitively coupled to the control voltage terminal. For direct coupling, the effects of modulation source voltage and impedance on the bias of the SE555/NE555 should be considered.

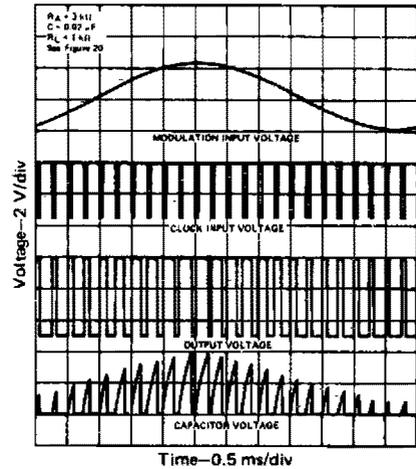


Fig. 55-11

Circuit Notes

The monostable circuit is triggered by a continuous input pulse train and the threshold voltage is modulated by a control signal. The resultant effect is a modulation of the output pulse width, as shown. A sine-wave modulation signal is illustrated, but any wave-shape could be used.

AM MODULATOR

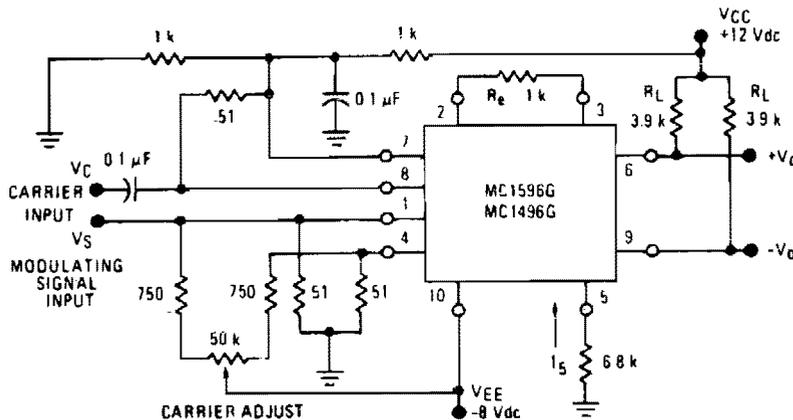


Fig. 55-12

TV MODULATOR USING A MOTOROLA MC1374

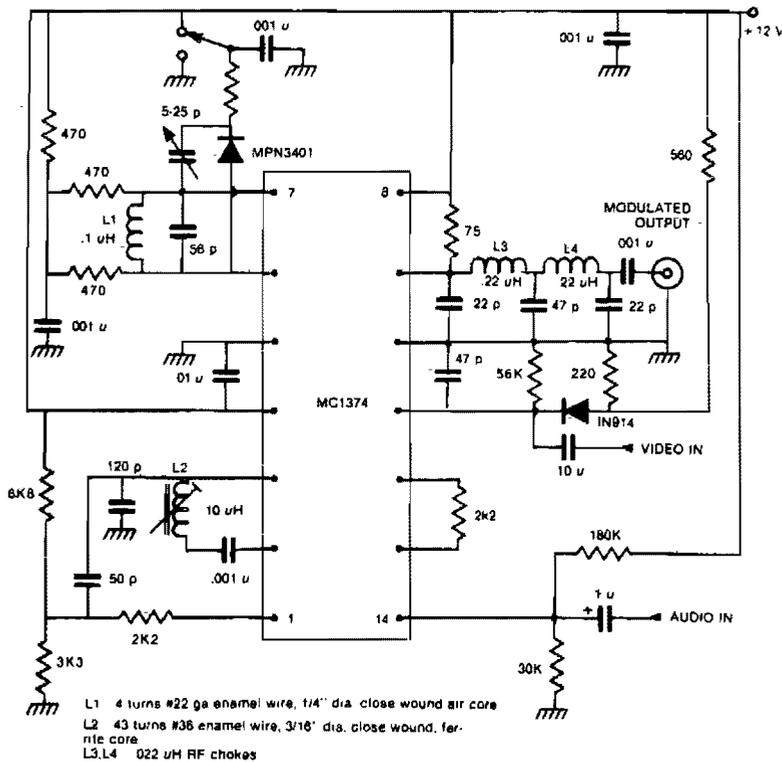
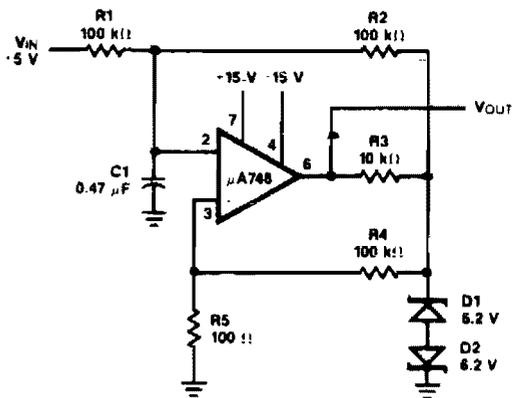


Fig. 55-13

Circuit Notes

This one-chip modulator requires some outboard circuitry and a shielded box.

PULSE-WIDTH MODULATOR



$$f_c = \frac{1}{2\pi R_2 C_1}$$

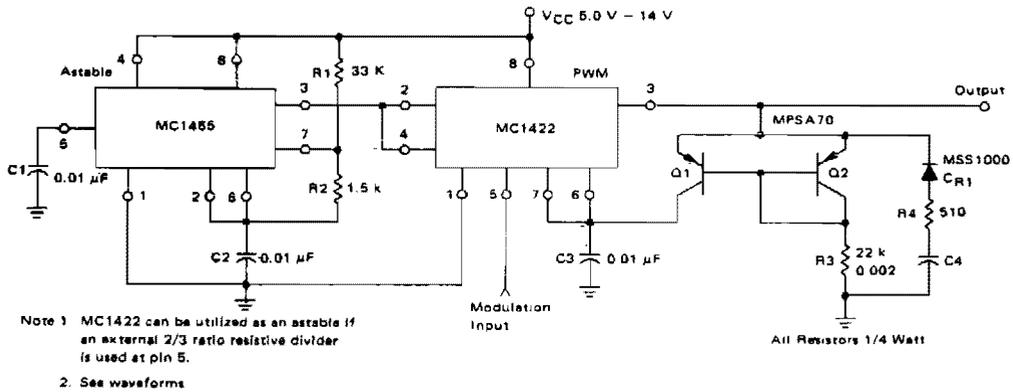
$$f_n = \frac{1}{2\pi R_1 C_1}$$

$$= \frac{1}{2\pi R_2 C_2}$$

$$f_c < f_n < f_{\text{unity gain}}$$

Fig. 55-14

PULSE-WIDTH MODULATOR



- PULSE WIDTH MODULATOR WAVEFORMS

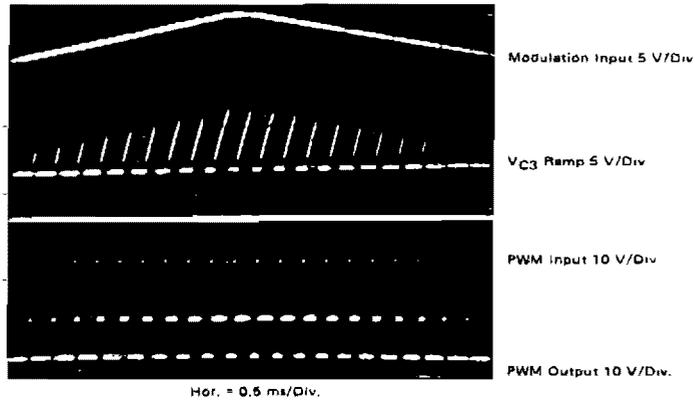


Fig. 55-15

VHF MODULATOR

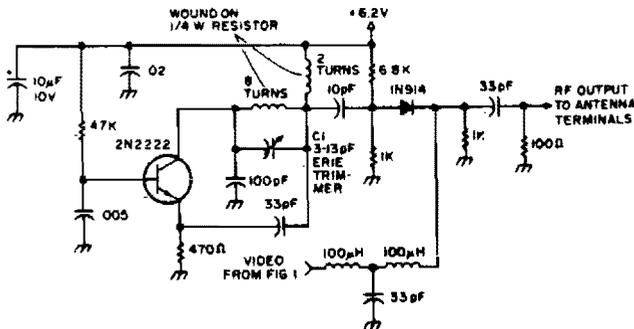


Fig. 55-16

56

Moisture and Rain Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Rain Alarm
Moisture Detector

Automatic Plant Waterer
Rain Alarm/Door Bell

RAIN ALARM

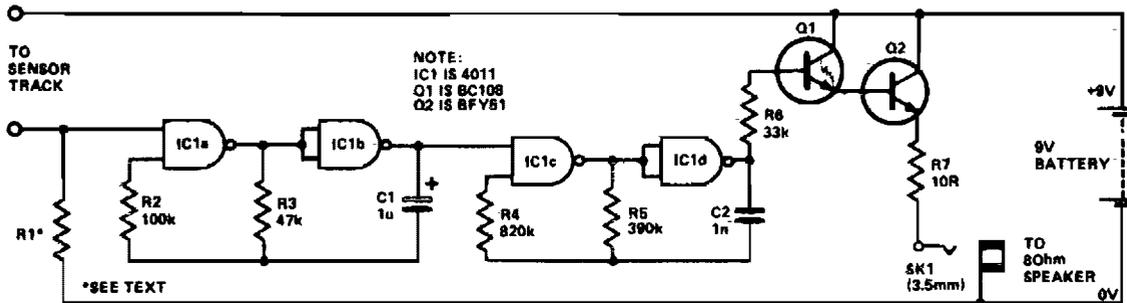


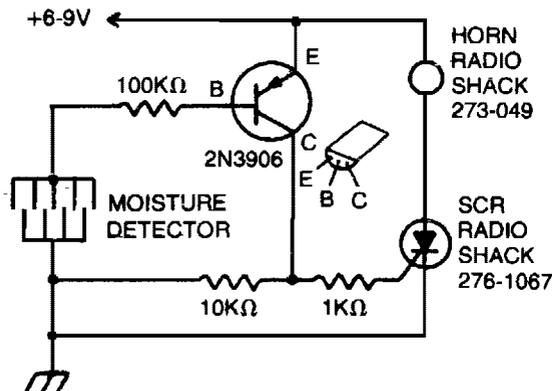
Fig. 56-1

Circuit Notes

The circuit uses four NAND gates of a 4011 package. In each oscillator, while one gate is configured as a straightforward inverter, the other has one input that can act as a control input. Oscillator action is inhibited if this input is held low. The first oscillator (IC1a and IC1b) has this input tied low via a high value resistor (R1) that acts as a sensitivity control. Thus this

oscillator will be disabled until the control input is taken high. Any moisture bridging the sensor track will so enable the output which is a square wave at about 10 Hz. This in turn will gate on and off the 500 Hz oscillator formed by IC1c and IC1d. This latter oscillator drives the loudspeaker via R6, the Darlington pair formed by Q1 and Q2, and resistor R7.

MOISTURE DETECTOR



Circuit Notes

The detector is made of fine wires spaced about one or two inches apart. When the area between a pair of wires becomes moistened, the horn will sound. To turn it off, dc power must be disconnected.

Fig. 56-2

AUTOMATIC PLANT WATERER

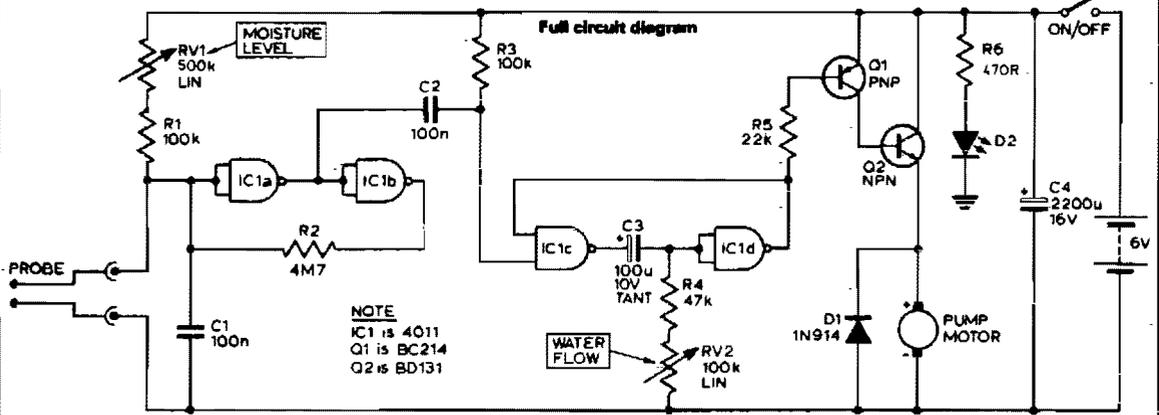


Fig. 56-3

Circuit Notes

The unit consists of a sensor, timer, and electric water pump. The sensor is embedded in the soil, and when dry, the electronics operate the water pump for a preset time. The circuit is composed of a level sensitive Schmitt trigger, variable time monostable, and output

driver. When the resistance across the probe increases beyond a set value (i.e., the soil dries), the Schmitt is triggered. C2 feeds a negative going pulse to the monostable when the Schmitt triggers and R2 acts as feedback, to ensure a fast-switching action.

RAIN ALARM/DOOR BELL

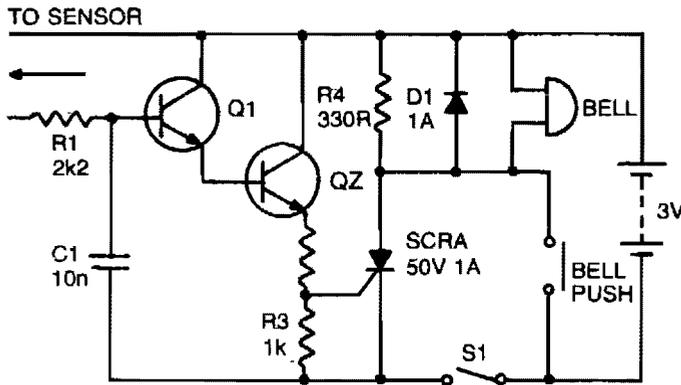


Fig. 56-4

NOTE
Q1, Q2 are 2N3706
D1 is 1N4001

Circuit Notes

With S1 open the circuit functions as a doorbell. With S1 closed, rain falling on the sensor will turn on Q1, triggering Q2 and the thyristor and activating the bell, R4 provides the holding for the thyristor while D1 prevents

any damage to the thyristor from back EMF in the bell coil. The sensor can be made from 3 square inches of copper clad board with a razor cut down the center. C1 prevents any mains pickup in the sensor leads.

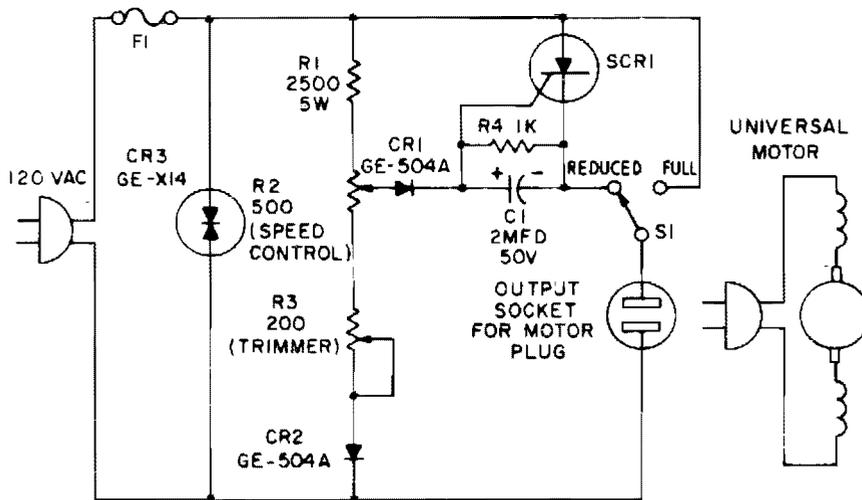
57

Motor Controls

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- | | |
|--|--|
| Motor Speed Control | Motor Speed Control |
| Plug-In Speed Control for Tools or Appliances | Model Train Speed Control |
| Motor Speed Control with Feedback | Induction Motor Control |
| Direction and Speed Control for Series-Wound Motors | DC Motor Speed Control |
| High-Torque Motor Speed Control | Universal Motor Control with Built-In Self Timer |
| Motor Speed Control | Speed Control for Model Trains or Cars |
| Constant Current Motor Drive Circuit | Direction and Speed Control for Shunt-Wound Motors |
| Ac Motor Power Brake | Two-Phase Motor Drive |
| Universal-Motor Speed Control with Load-Dependent Feedback | Dc Servo Amplifier |
| Dc Motor Speed/Direction Control Circuit | Universal Motor Speed Control |
| Servo Motor Amplifier | Power Tool Torque Control |
| | Ac Servo Amplifier—Bridge Type |

PLUG-IN SPEED CONTROL FOR TOOLS OR APPLIANCES



COMPONENT	MOTOR NAMEPLATE RATING	
	LIGHT DUTY 3 AMP MAX	HEAVIER DUTY 5 AMP MAX
SCR1	GE-X1	GE-C30B
FI	3 AMP	5 AMP

Fig. 57-2

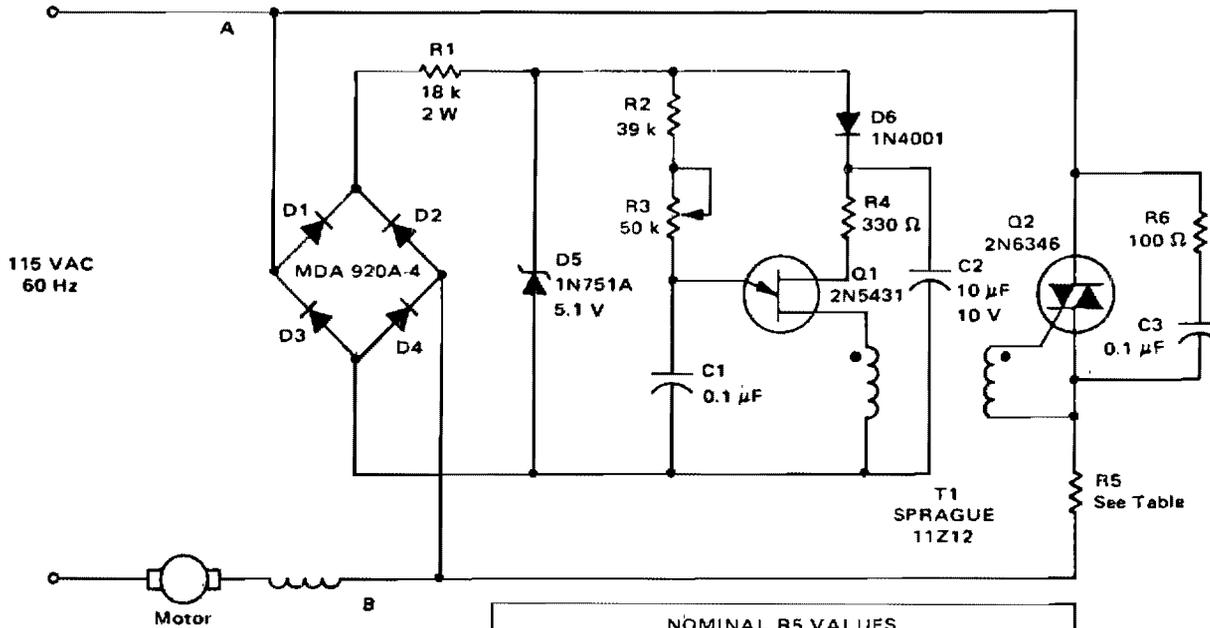
Circuit Notes

Most standard household appliances and portable hand tools can be adapted to variable-speed operation by use of this simple half-wave SCR phase control. It can be used as the speed control unit for the following typical loads provided they use series universal (brush type) motors.

Drills	Fans
Sewing Machines	Lathes
Saber saws	Vibrators
Portable band saws	Movie projectors
Food mixers	Sanders
Food blenders	

During the positive half cycle of the supply voltage, the arm on potentiometer R2 taps off a fraction of the sine wave supply voltage and compares it with the counter emf of the motor through the gate of the SCR. When the pot voltage rises above the armature voltage, current flows through CR1 into the gate of the SCR, triggering it, and thus applying the remainder of that half cycle supply voltage to the motor. The speed at which the motor operates can be selected by R2. Stable operation is possible over approximately a 3-to-1 speed range.

MOTOR SPEED CONTROL WITH FEEDBACK



NOMINAL R5 VALUES			
Motor Rating (Amperes)	R5		$R5 = \frac{2}{I_M}$ I _M = Max. Rated Motor Current (RMS)
	OHMS	Watts	
2	1	5	
3	0.67	10	
6.5	0.32	15	

Fig. 57-3

DIRECTION AND SPEED CONTROL FOR SERIES-WOUND MOTORS

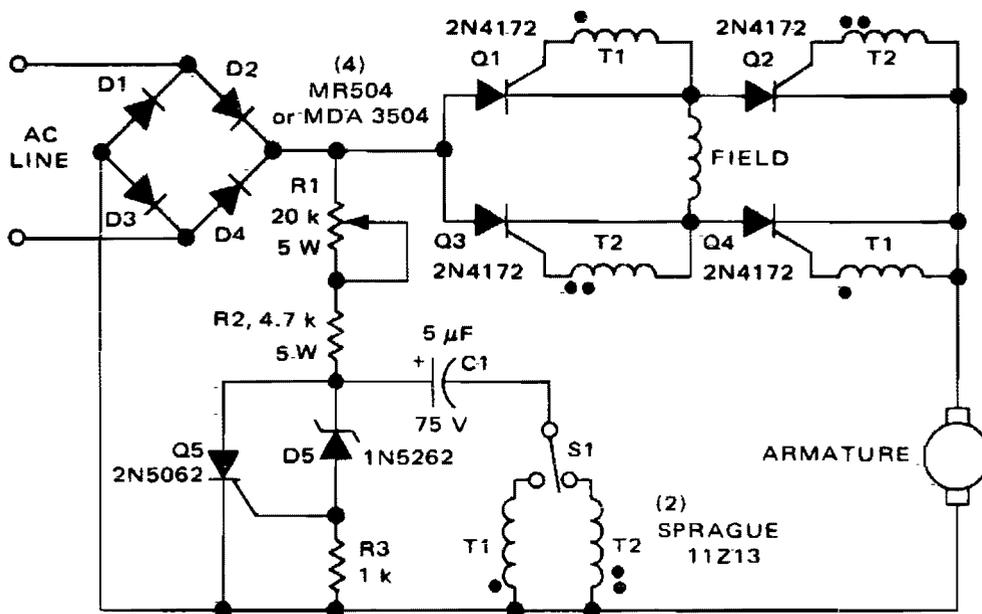


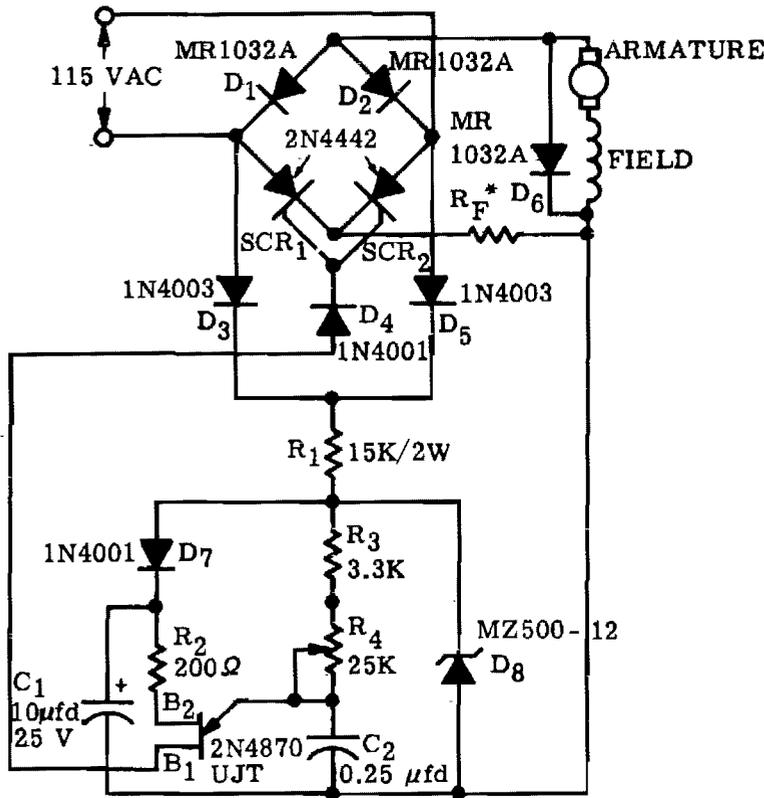
Fig. 57-4

Circuit Notes

The circuit shown here can be used to control the speed and direction of rotation of a series-wound dc motor. Silicon controlled rectifiers Q1-Q4, which are connected in a bridge arrangement, are triggered in diagonal pairs. Which pair is turned on is controlled by switch S1 since it connects either coupling transformer T1 or coupling transformer T2 to a pulsing circuit. The current in the field can be reversed by selecting either SCRs Q2 and Q3

for conduction, or SCRs Q1 and Q4 for conduction. Since the armature current is always in the same direction, the field current reverses in relation to the armature current, thus reversing the direction of rotation of the motor. A pulse circuit is used to drive the SCRs through either transformer T1 or T2. The pulse required to fire the SCR is obtained from the energy stored in capacitor C1.

HIGH-TORQUE MOTOR SPEED CONTROL



R_F^* = FEEDBACK RESISTOR
(SEE TEXT)

Fig. 57-5

Circuit Notes

A bridge circuit consisting of two SCRs and two silicon rectifiers furnishes full-wave power to the motor. Diodes, D3 and D5, supply dc to the trigger circuit through dropping resistors, R1. Phase delay of SCR firing is obtained by charging C2 through resistors R3 and R4 from the voltage level established by the zener diode, D8. When C2 charges to the firing voltage of the unijunction transistor, the UJT fires,

triggering the SCR that has a positive voltage on its anode. When C2 discharges sufficiently, the unijunction transistor drops out of conduction. The value of R_F is dependent upon the size of the motor and on the amount of feedback desired. A typical value for R_F can be calculated from: $R_F = \frac{2}{I_M}$ where S_M is the max rated load current (rms).

MOTOR SPEED CONTROL

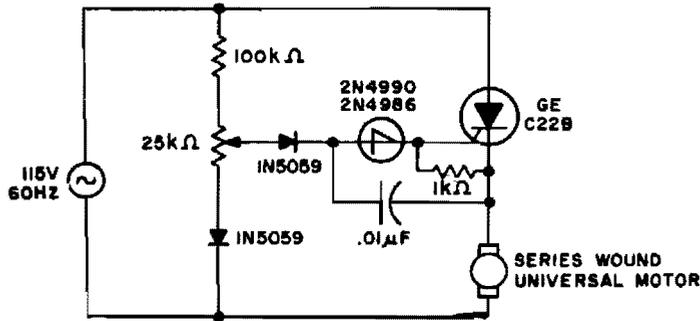
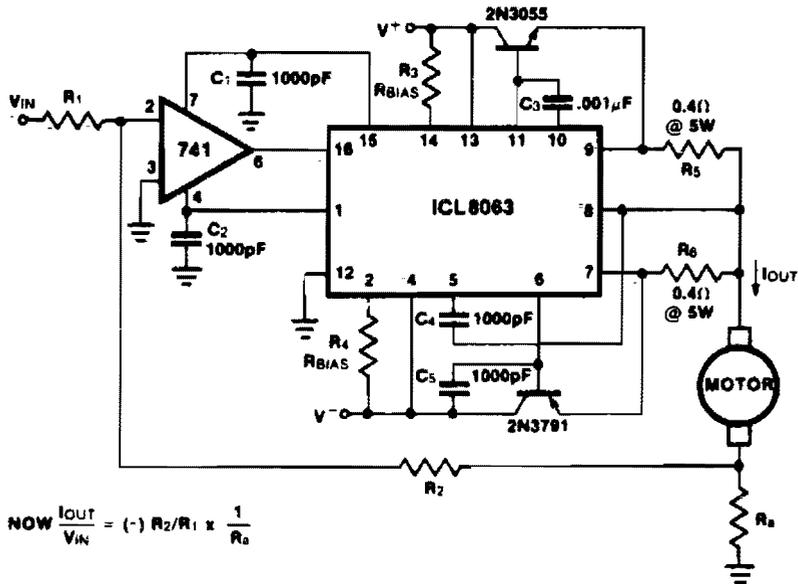


Fig. 57-6

Circuit Notes

Switching action of the 2N4990 allows smaller capacitors to be used while achieving reliable thyristor triggering.

CONSTANT CURRENT MOTOR DRIVE CIRCUIT



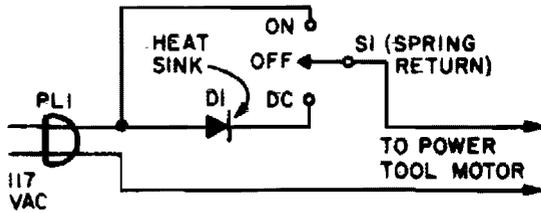
$$\text{NOW } \frac{I_{OUT}}{V_{IN}} = (-) \frac{R_2}{R_1} \times \frac{1}{R_A}$$

Fig. 57-7

Circuit Notes

This minimum device circuit can be used to drive dc motors where there is some likelihood of stalling or lock up; if the motor locks, the current drive remains constant and the system does not destroy itself.

AC MOTOR BRAKE



PARTS LIST FOR AC MOTOR POWER BRAKE

- PL1**—AC plug
D1—Silicon rectifier, 200 PIV, 20 A.
S1—Spdt switch. Center off, one side spring return
Misc.—Metal cabinet

Circuit Notes

A shot of direct current will instantly stop any ac power tool motor. Switch S1 is a center-off, one side spring return. With S1 on, ac will be fed to the motor and the motor will run. To brake the motor, simply press S1 down and a quick shot of dc will instantly stop it. The switch returns to the center off position when released. This Power Brake can only be used with ac motors; it will not brake universal (ac-dc) motors. A heat sink must be provided for the diode.

Fig. 57-8

UNIVERSAL-MOTOR SPEED CONTROL WITH LOAD-DEPENDENT FEEDBACK (FOR MIXER, SEWING MACHINE, ETC.)

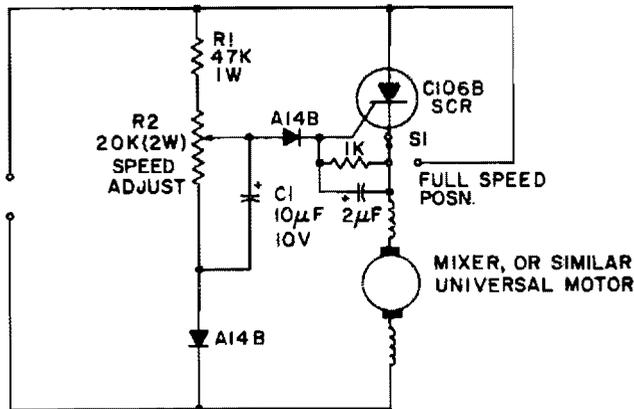


Fig. 57-9

NOTE: RESISTORS 1/2 WATT EXCEPT AS NOTED

Circuit Notes

Simple half-wave motor speed control is effective for use with small universal (ac/dc) motors. Maximum current capability 2.0 amps RMS. Because speed-dependent feedback is provided, the control gives excellent torque

characteristics to the motor, even at low rotational speeds. Normal operation at maximum speed can be achieved by closing switch S1, thus bypassing the SCR.

DC MOTOR SPEED/DIRECTION CONTROL CIRCUIT

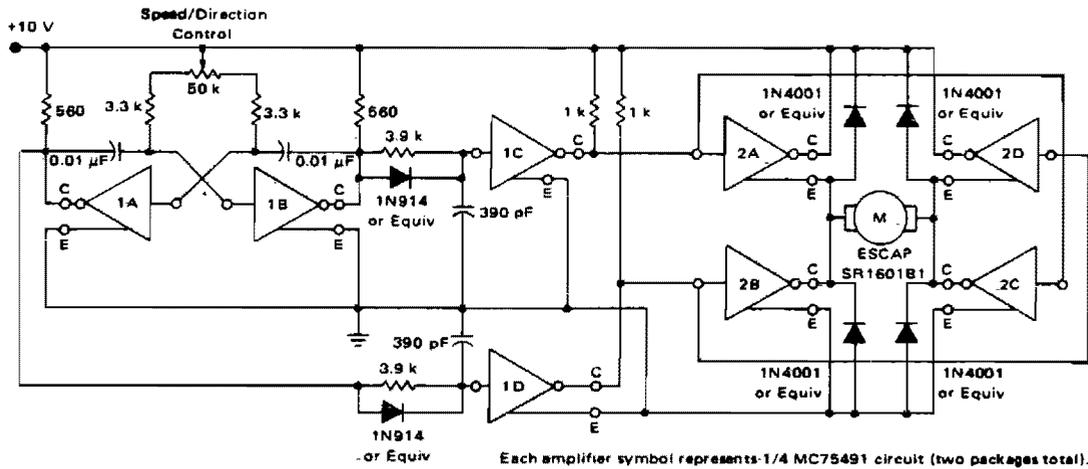


Fig. 57-10

SERVO MOTOR AMPLIFIER

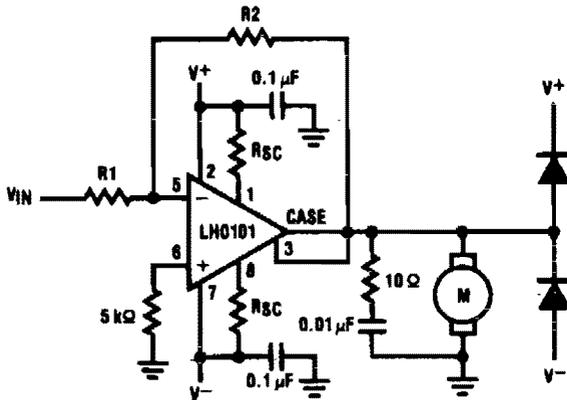
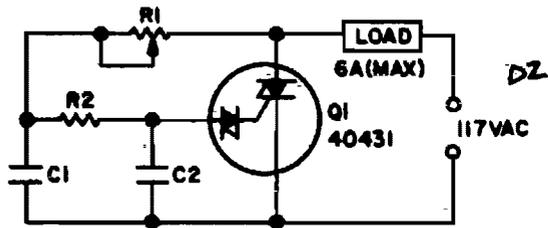


Fig. 57-11

Circuit Notes

Motor driver amplifier will deliver the rated current into the motor. Care should be taken to keep power dissipation within the permitted level. This precision speed regulation circuit employs rate feedback for constant motor current at a given input voltage.

MOTOR SPEED CONTROL



C1, C2—0.1- μ F, 200-VDC capacitor
Q1—RCA 40431 Triac-Diac
R1—100,000-ohm linear taper potentiometer
R2—10,000-ohm, 1-watt resistor

Fig. 57-12

Circuit Notes

Universal motors and shaded-pole induction motors can be easily controlled with a full-wave Triac speed controller. Q1 combines both the triac and diac trigger diodes in the same case. The motor used for the load must be

limited to 6 amperes maximum. Triac Q1 must be provided with a heat sink. With the component values shown, the Triac controls motor speed from full off to full on.

MODEL TRAIN SPEED CONTROL

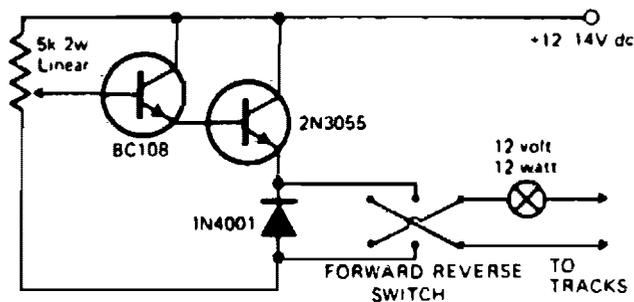


Fig. 57-13

Circuit Notes

Virtually any NPN small signal transistor may be used in place of the BC 108 shown. Likewise any suitable NPN power transistor can be used in place of the 2N3055. The output transistor must be mounted on a suitable heat-sink. Short circuit protection may be provided

by wiring a 12 volt 12 watt bulb in series with the output. This will glow in event of a short circuit and thus effectively current-limit the output, it also acts as a visual short-circuit alarm.

INDUCTION-MOTOR CONTROL

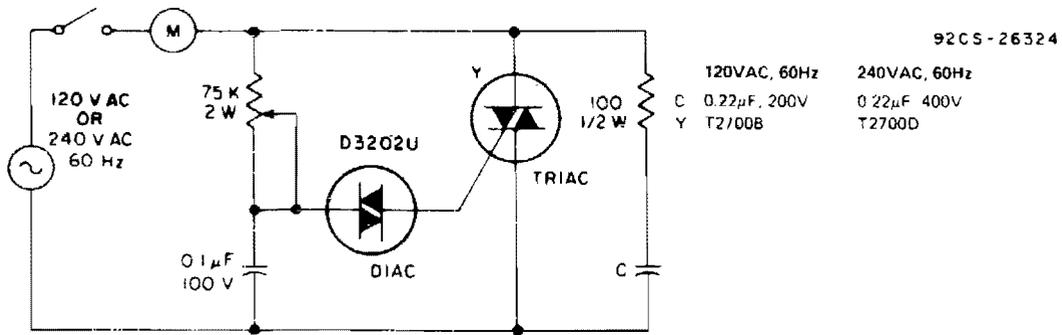


Fig. 57-14

Circuit Notes

This single time-constant circuit can be used as proportional speed control for induction motors such as shaded pole or permanent split-capacitor motors when the load is fixed.

The circuit is best suited to applications which require speed control in the medium to full-power range.

DC MOTOR SPEED CONTROL

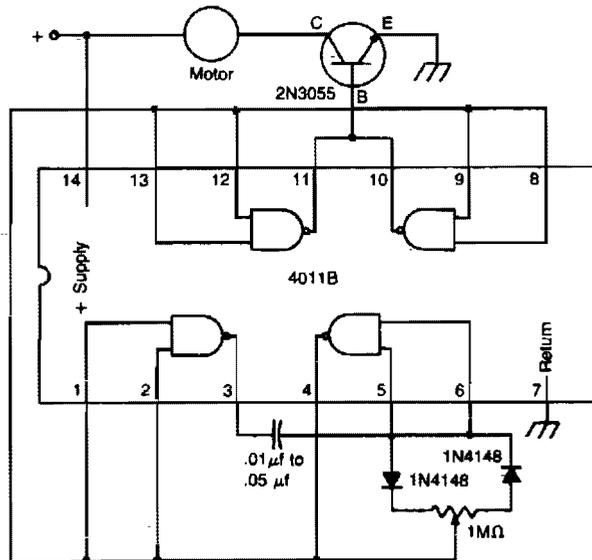


Fig. 57-15

Circuit Notes

The circuit uses a 4011 CMOS NAND gate, a pair of diodes and an NPN power transistor to provide a variable duty-cycle dc source. Adjusting the speed control varies the average voltage applied to the motor. The peak

voltage, however, is not changed. This pulse power is effective at very low speeds, constantly kicking the motor along. At higher speeds, the motor behaves in a nearly normal manner.

UNIVERSAL MOTOR CONTROL WITH BUILT-IN SELF TIMER

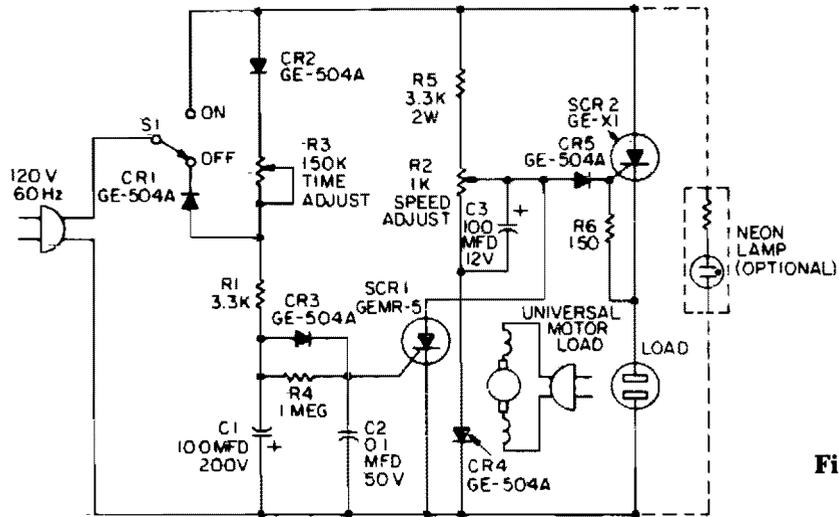


Fig. 57-16

Circuit Notes

When the time delay expires, SCR1 conducts and removes the gate signal from SCR2, which stops the motor. Both the time delay and motor speed are adjustable by potentiometers R2 and R3. If heavier motor loads are anti-

ci-
pated, use the larger C30B SCR in place of the GE-X1 for SCR2. Also, the capacitance of C1 can be increased to lengthen the time delay, if desired.

SPEED CONTROL FOR MODEL TRAINS OR CARS

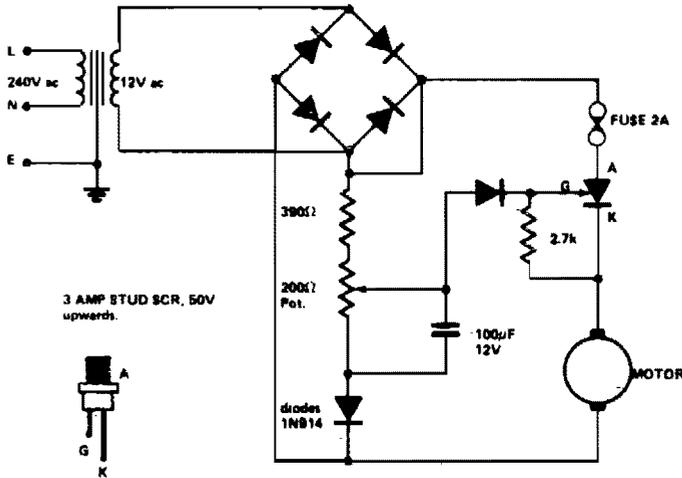


Fig. 57-17

Circuit Notes

Low voltage speed control gives very good starting torque and excellent speed regulation. A reversing switch may be incorporated in the leads to the motor.

DIRECTION AND SPEED CONTROL FOR SHUNT-WOUND MOTORS

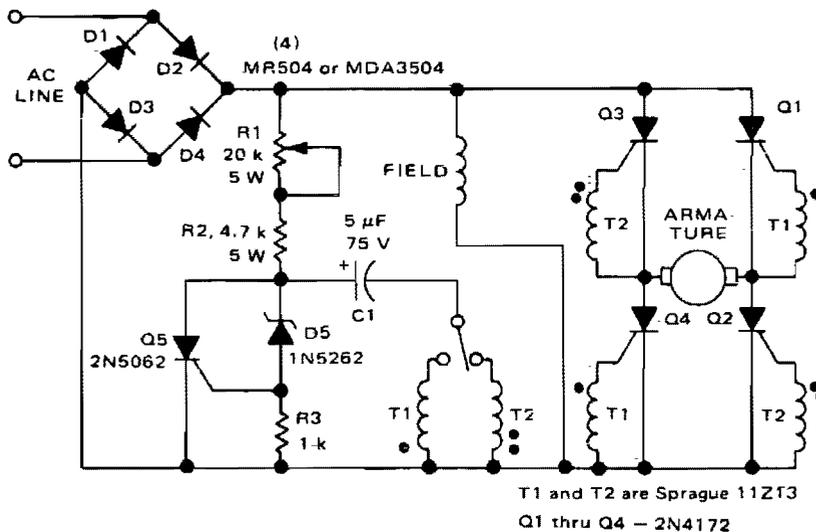


Fig. 57-18

Circuit Notes

This circuit operates like the one shown in Fig. 57-4. The only differences are that the field is placed across the rectified supply and the armature is placed in the SCR bridge. Thus

the field current is unidirectional but armature current is reversible; consequently the motor's direction of rotation is reversible. Potentiometer R1 controls the speed.

TWO-PHASE MOTOR DRIVE

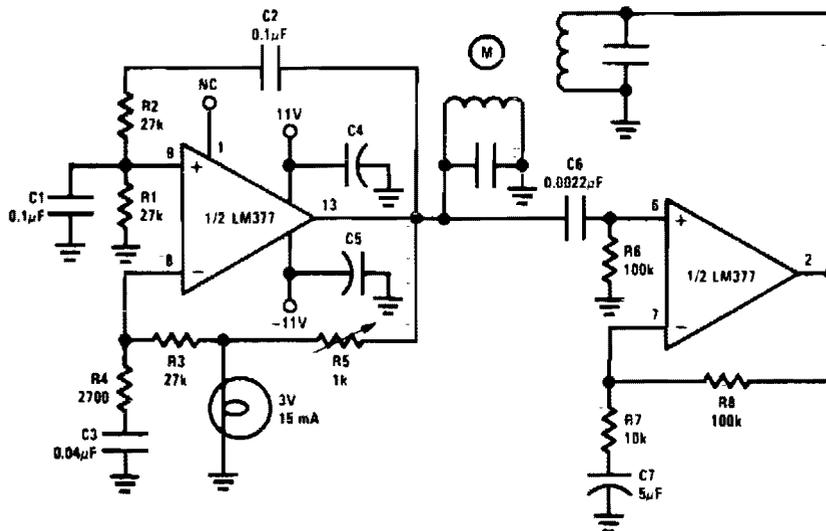


Fig. 57-19

DC SERVO AMPLIFIER

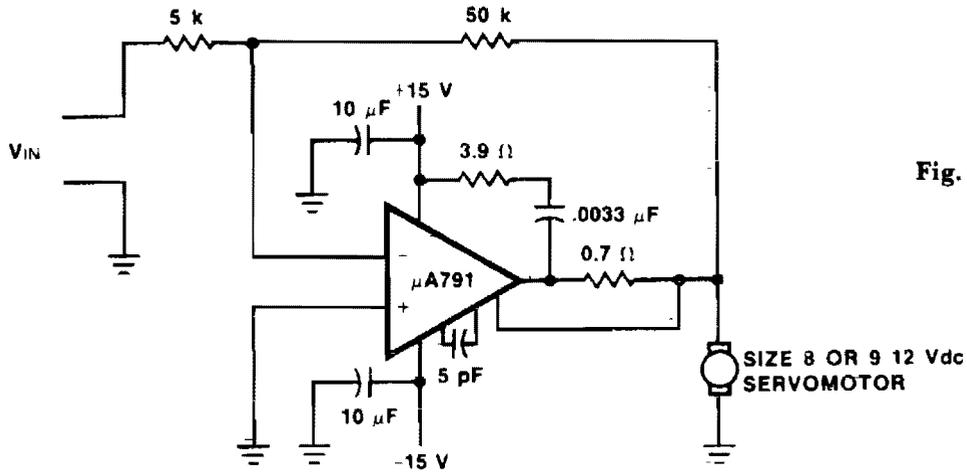
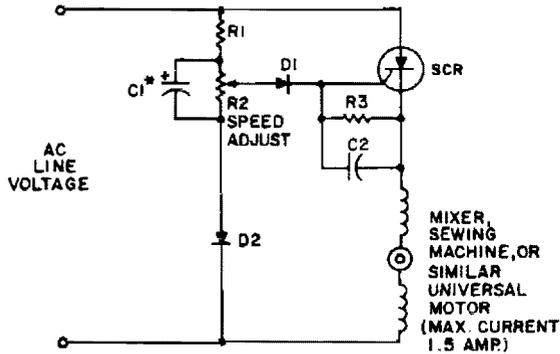


Fig. 57-20

UNIVERSAL MOTOR SPEED CONTROL



Line Voltage	120V	240V
R1	47K	100K
R2	10K	20K
R3	1K	1K
C1	1μF, 50V	1μF, 100V
C2	0.1μF, 50V	0.1μF, 50V
D1	1N5059	1N5060
D2	1N5059	1N5060
SCR	C106B1	C106D1

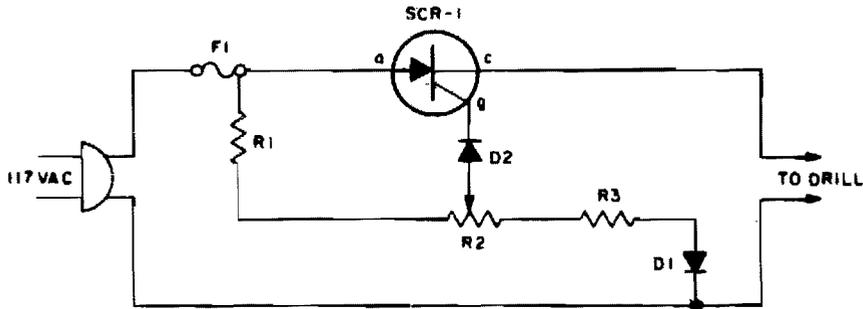
Fig. 57-21

Circuit Notes

The resistor capacitor network R1-R2-C1 provides a ramp-type reference voltage superimposed on top of a dc voltage adjustable with the speed-setting potentiometer R2. This reference voltage appearing at the wiper of R2 is balanced against the residual counter emf of the motor through the SCR gate. As the motor slows down due to heavy loading, its counter emf falls, and the reference ramp triggers the

SCR earlier in the ac cycle. More voltage is thereby applied to the motor causing it to pick up speed again. Performance with the C106 SCR is particularly good because the low trigger current requirements of this device allow use of a flat top reference voltage, which provides good feedback gain and close speed regulation.

POWER TOOL TORQUE CONTROL



PARTS LIST FOR POWER TOOL TORQUE CONTROL

D1, D2—1A, 400 PIV silicon
rectifier (Calectro K4-557 or
equiv.)
F1—3-A "Slo-blo" fuse
R1—2500-ohm, 5-watt resistor

R2—250-ohm, 4-watt potentiometer
R3—33-ohm, ½-watt resistor
SCR1—8-A, 400-PIV silicon
controlled rectifier (HEP R1222)

Fig. 57-22

Circuit Notes

As the speed of an electric drill is decreased by loading, its torque also drops. A compensating speed control like this one puts the oomph back into the motor. When the drill slows down, a back voltage developed across the motor—in series with the SCR cathode and gate—decreases. The SCR gate voltage therefore increases relatively as the back voltage is

reduced. The extra gate voltage causes the SCR to conduct over a larger angle and more current is driven into the drill, even as speed falls under load. The SCR should be mounted in ¼-in. thick block of aluminum or copper at least 1-in. square. If the circuit is used for extended periods use a 2 inch square piece.

AC SERVO AMPLIFIER—BRIDGE TYPE

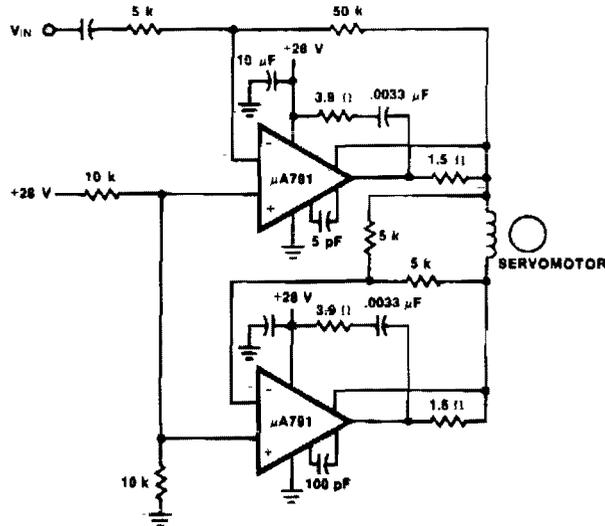


Fig. 57-23

58

Multivibrators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Monostable Circuit
Astable Multivibrator
Astable Oscillator
Digitally Controlled Astable Multivibrator
Dual Astable Multivibrator
UJT Monostable
Monostable Multivibrator with Input
Lock-Out

TTL Monostable
Monostable Circuit
One-Shot Multivibrator
Monostable Multivibrator
Bistable Multivibrator
100 kHz Free-Running Multivibrator

MONOSTABLE CIRCUIT

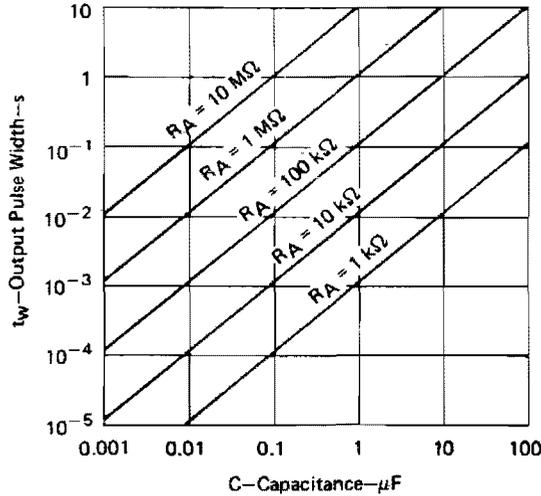
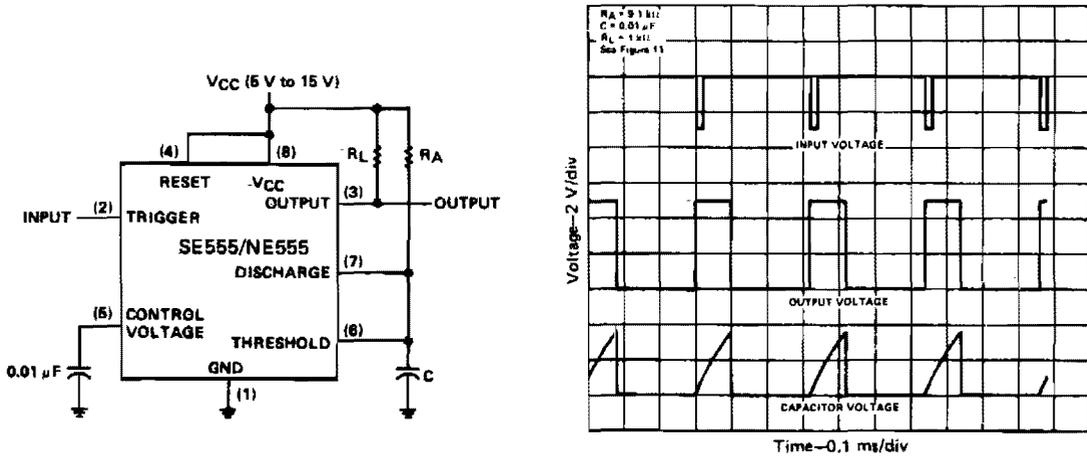


Fig. 58-1

Circuit Notes

If the output is low, application of a negative-going pulse to the trigger input sets the flip-flop (Q goes low), drives the output high, and turns off 1. Capacitor C is then charged through R_A until the voltage across the capacitor reaches the threshold voltage of the threshold input. If the trigger input has returned to a high level, the output of the

threshold comparator will reset the flip-flop (Q goes high), drive the output low, and discharge C through $Q1$. Monostable operations is initiated when the trigger input voltage falls below the trigger threshold. Once initiated, the sequence will complete only if the trigger input is high at the end of the timing interval.

ASTABLE MULTIVIBRATOR

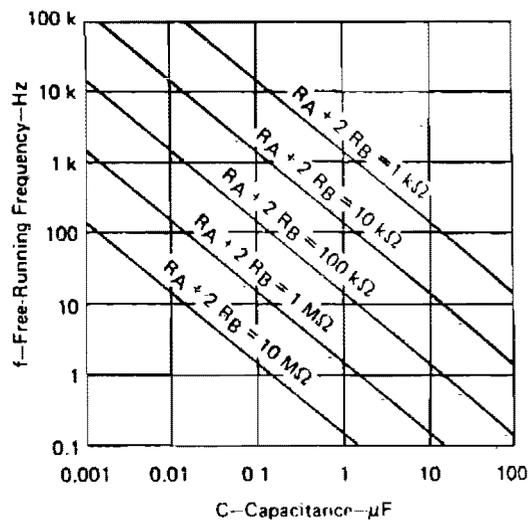
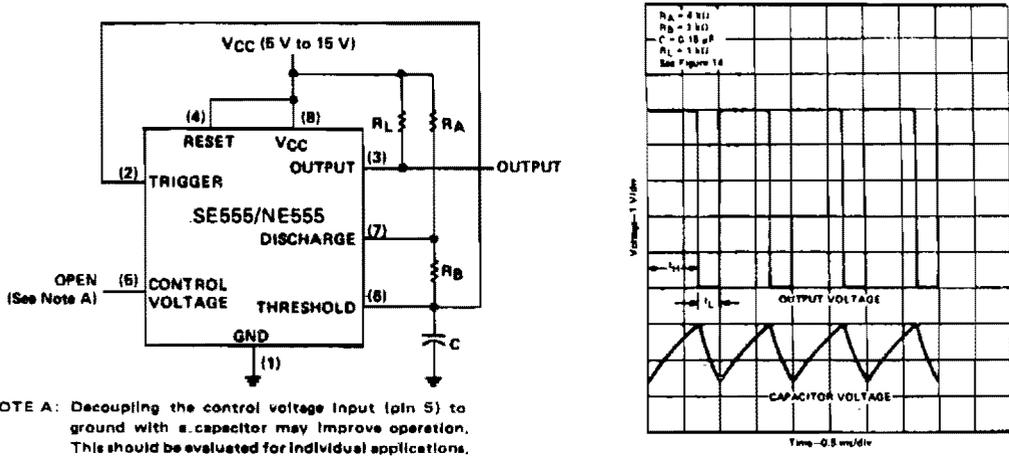
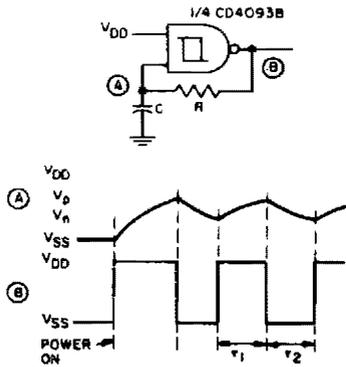


Fig. 58-2

Circuit Notes

The capacitor C will charge through R_A and R_B , and then discharge through R_B only. The duty cycle may be controlled by the values of R_A and R_B .

ASTABLE OSCILLATOR

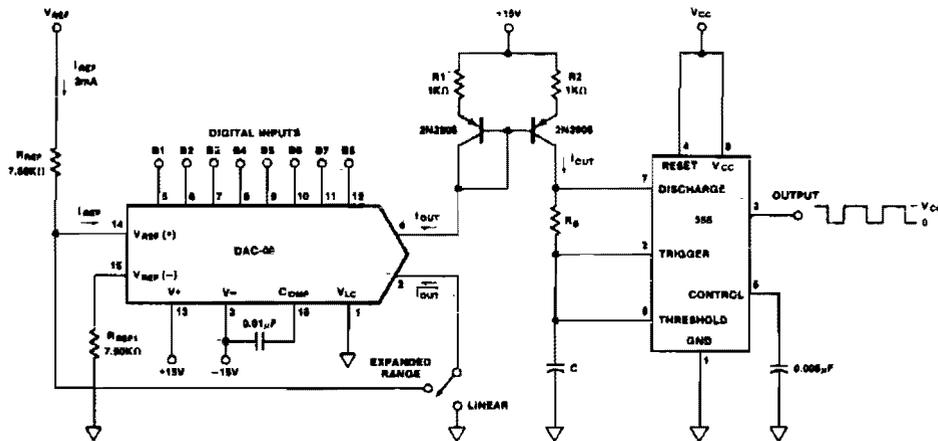


Circuit Notes

Before power is applied, the input and output are at ground potential and capacitor C is discharged. On power-on, the output goes high (V_{DD}) and C charges through R until V is reached; the output then goes low (V_{SS}). C is now discharged through R until V_n is reached. The output then goes high and charges C towards V_p through R. Thus input A alternately swings between V_p and V_n as the output goes high and low. This circuit is self-starting at power-on.

Fig. 58-3

DIGITALLY CONTROLLED ASTABLE MULTIVIBRATOR

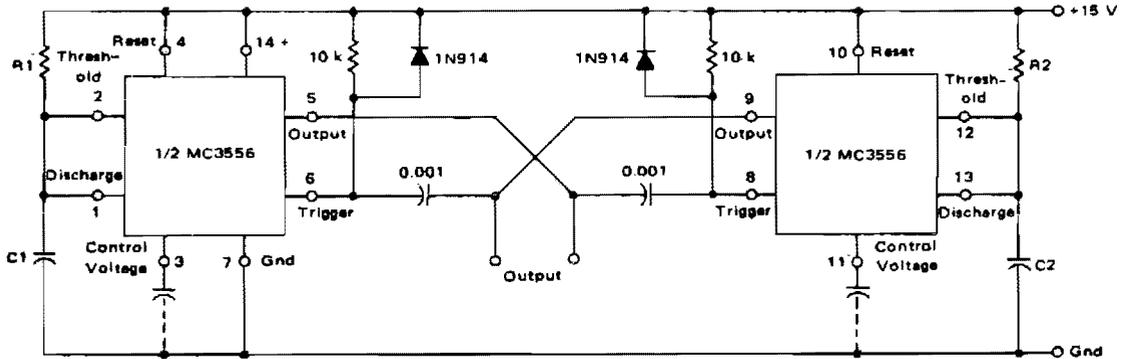


$$\text{FREQUENCY, } f = \frac{1}{\frac{1}{3} \frac{R_{REF} C}{(D)} \frac{V_{CC}}{V_{REF}} + 0.695 R_B C} \quad \text{FOR LINEAR MODE}$$

$$\text{FREQUENCY, } f = \frac{1}{\frac{1}{3} R_{REF} C \frac{V_{CC}}{V_{REF}} \left[\frac{2 - (D)}{(D)} \right] + 0.695 R_B C} \quad \text{FOR EXPANDED MODE}$$

Fig. 58-4

DUAL ASTABLE MULTIVIBRATOR



$$f = \frac{0.91}{(R1+R2)C}$$
 for C1 - C2

$$\text{Duty Cycle} = \frac{R2}{R1+R2}$$

Fig. 58-5

Circuit Notes

This dual astable multivibrator provides versatility not available with single timer circuits. The duty cycle can be adjusted from 5% to 95%. The two outputs provide two phase

clock signals often required in digital systems. It can also be inhibited by use of either reset terminal.

UJT MONOSTABLE

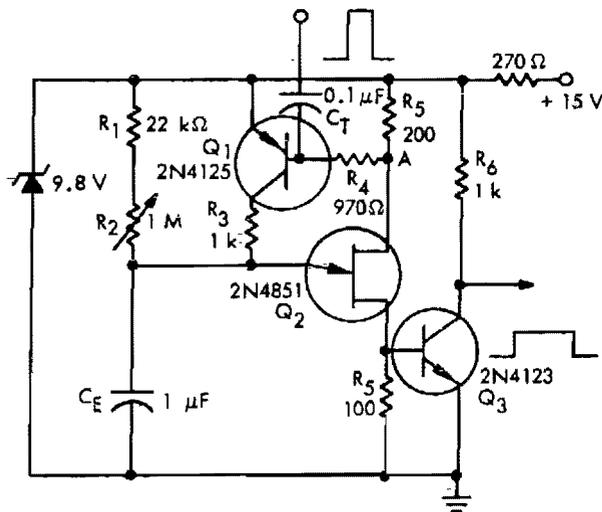


Fig. 58-6

MONOSTABLE MULTIVIBRATOR WITH INPUT LOCK-OUT

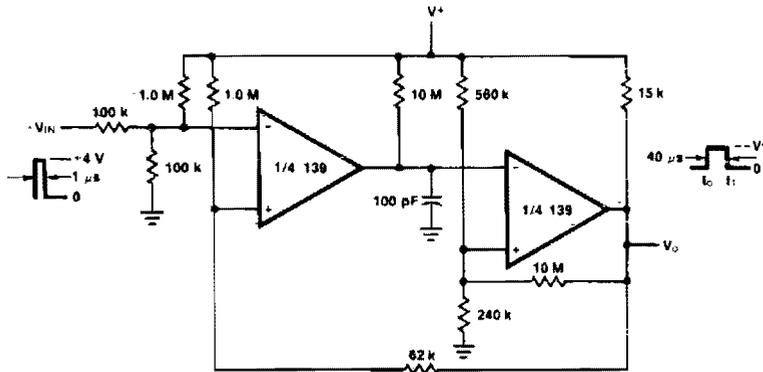


Fig. 58-7

TTL MONOSTABLE

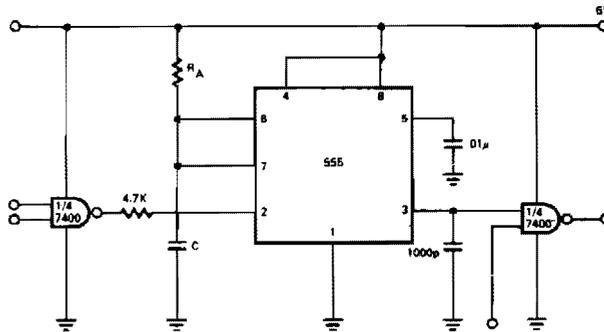


Fig. 58-8

MONOSTABLE CIRCUIT

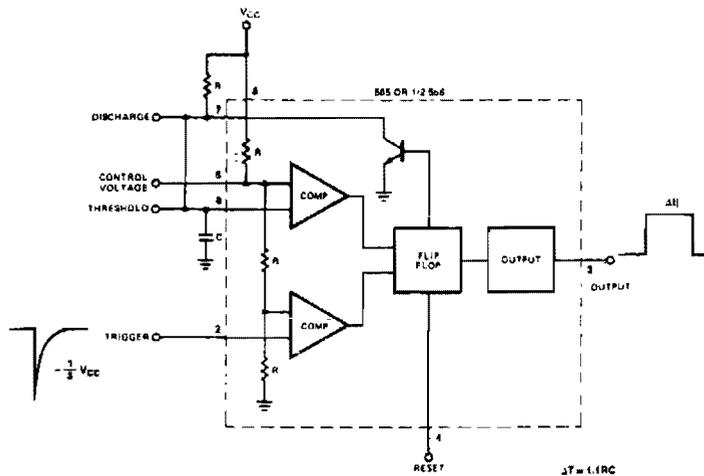


Fig. 58-9

ONE-SHOT MULTIVIBRATOR

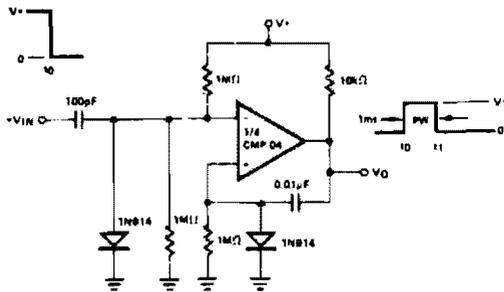


Fig. 58-10

BISTABLE MULTIVIBRATOR

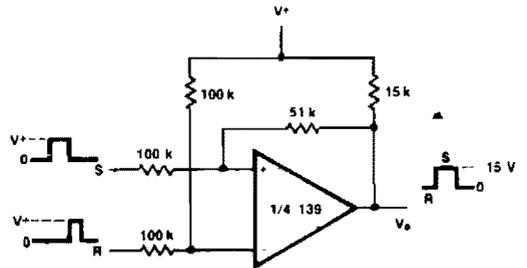


Fig. 58-12

MONOSTABLE MULTIVIBRATOR

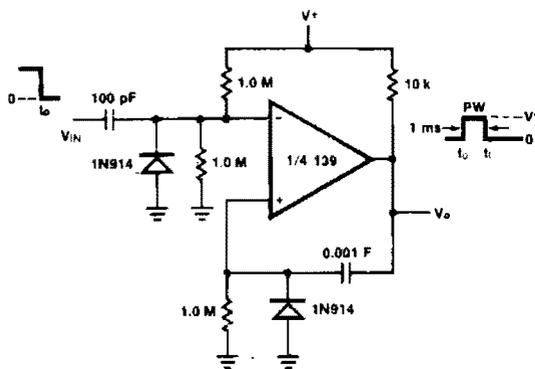


Fig. 58-11

100 kHz FREE-RUNNING MULTIVIBRATOR

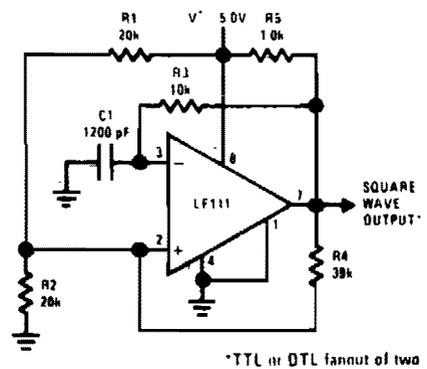


Fig. 58-13

59

Noise Generators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Audio Noise Generator
Pink Noise Generator

Noise Generator
Wideband Noise Generator

Noise Generator Circuit

AUDIO NOISE GENERATOR

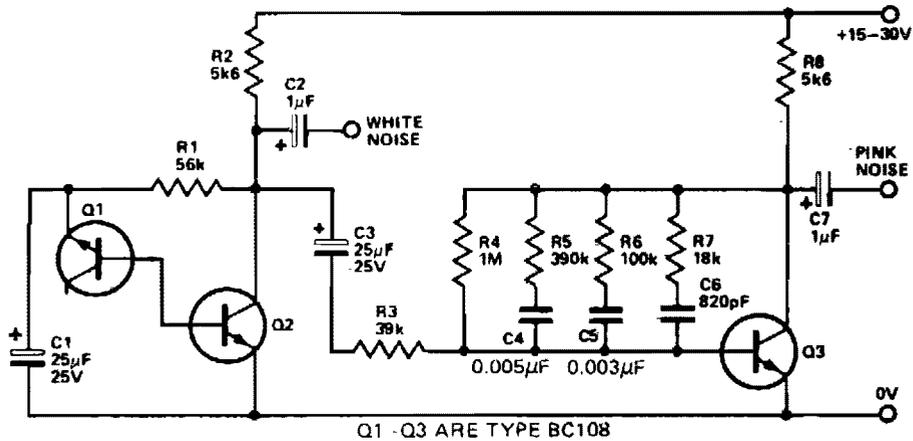


Fig. 59-1

Circuit Notes

This simple circuit generates both white and pin noise. Transistor Q1 is used as a zener diode. The normal base-emitter junction is reverse-biased and goes into zener breakdown at about 7 to 8 volts. The zener noise current from Q1 flows into the base of Q2 such that an output of about 150 millivolts of white noise is available. To convert the white noise to pink, a filter is required which provides a 3 dB cut per octave as the frequency increases.

Since such a filter attenuates the noise considerably an amplifier is used to restore the output level. Transistor Q3 is this amplifier and the pink noise filter is connected as a feedback network, between collector and base in order to obtain the required characteristic by controlling the gain-versus-frequency of the transistor. The output of transistor Q3 is thus the pink noise required and is fed to the relevant output socket.

PINK NOISE GENERATOR

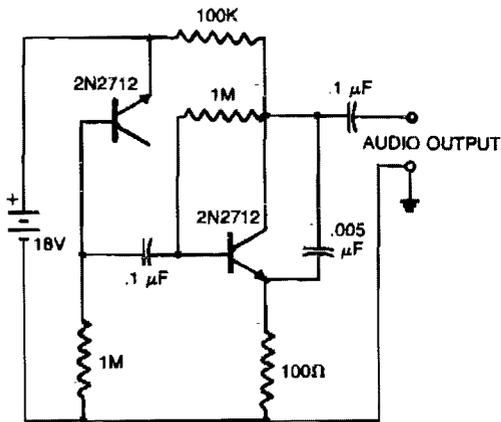


Fig. 59-2

Circuit Notes

A reverse-biased pn junction of a 2N2712 transistor is used as a noise generator. The second 2N2712 is an audio amplifier. The 0.005 μF capacitor across the amplifier output removes some high-frequency components to

simulate pink noise more closely. The audio output may be connected to high-impedance earphones or to a driver amplifier for speaker listening.

NOISE GENERATOR

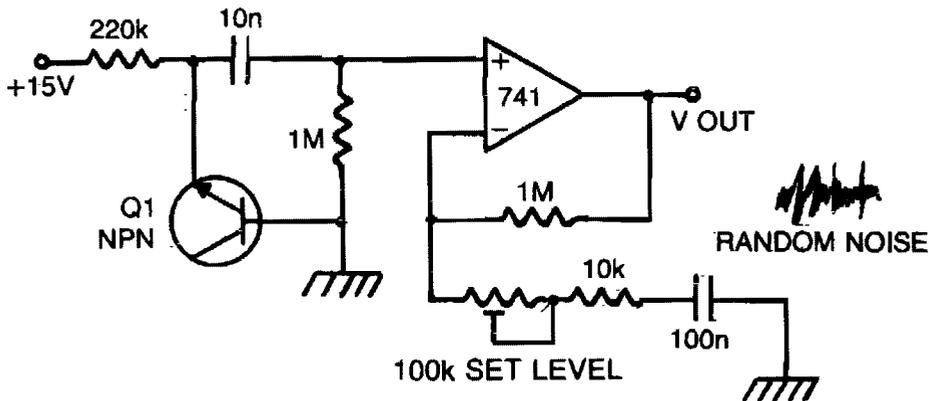


Fig. 59-3

Circuit Notes

The zener breakdown of a transistor junction is used as a noise generator. The breakdown mechanism is random and this voltage has a high source impedance. By using the op amp as a high input impedance, high ac gain

amplifier, a low impedance, large signal noise source is obtained. The 100K potentiometer is used to set the noise level by varying the gain from 40 to 20 dB.

WIDEBAND NOISE GENERATOR

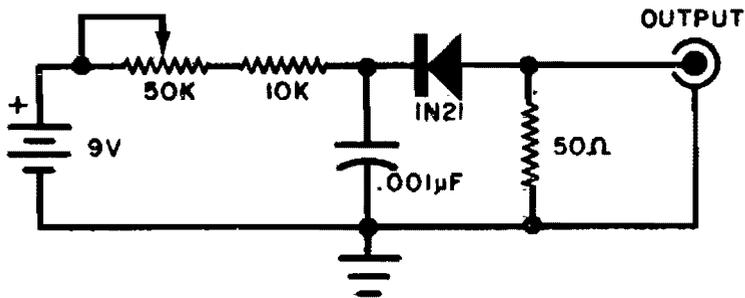


Fig. 59-4

Circuit Notes

This circuit will produce wideband rf noise. It uses a reverse-biased diode and has a low-impedance output. Can be used to align receivers for optimum performance.

NOISE GENERATOR CIRCUIT

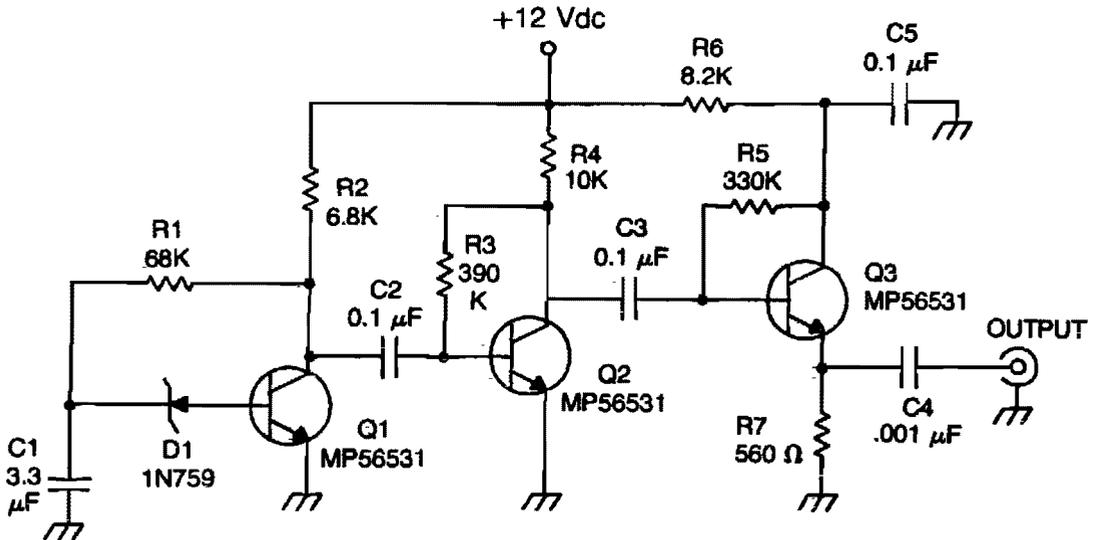


Fig. 59-5

Circuit Notes

The zener diode is an avalanche rectifier in the reverse bias mode connected to the input circuit of a wideband rf amplifier. The noise is amplified and applied to the cascade wideband amplifier, transistors Q2 and Q3.

60

Oscilloscope Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Oscilloscope Converter Provides Four-
Channel Displays
Add-On Triggered Sweep
10.7 MHz Sweep Generator

Drawing Circles on a Scope
Transmitter-Oscilloscope Coupler for CB
Signals
Oscilloscope Monitor

Beam Splitter for Oscilloscope

OSCILLOSCOPE CONVERTER PROVIDES FOUR-CHANNEL DISPLAYS

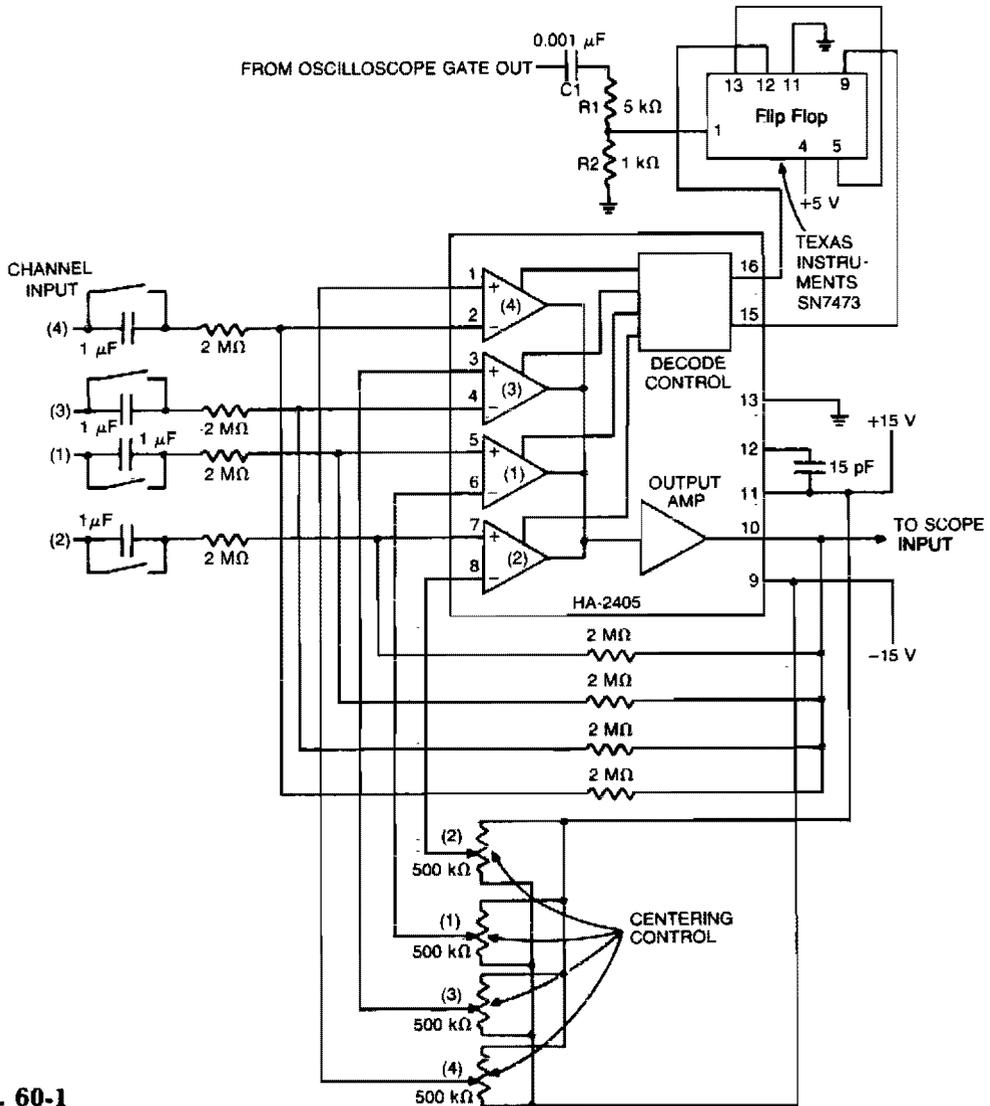


Fig. 60-1

Circuit Notes

The monolithic quad operational amplifier provides an inexpensive way to increase display capability of a standard oscilloscope. Binary inputs drive the IC op amp; a dual flip-flop divides the scope's gate output to obtain chan-

nel selection signals. All channels have centering controls for nulling offset voltage. A negative-going scope gate signal selects the next channel after each trace. The circuit operates out to 5 MHz.

DRAWING CIRCLES ON A SCOPE

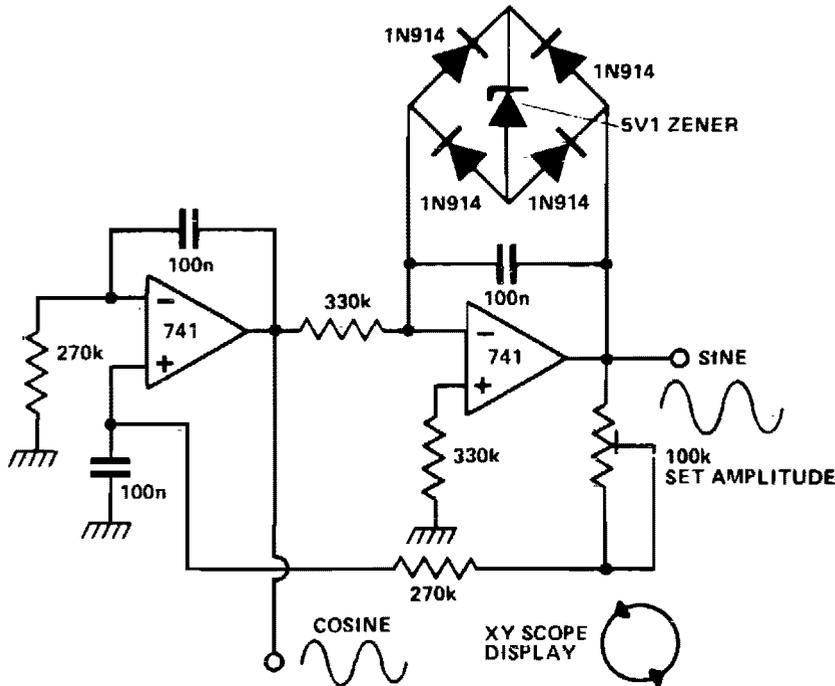


Fig. 60-4

Circuit Notes

The circuit is that of a quadrature sine and cosine oscillator. To generate circular displays, connect the two outputs to the X and Y inputs.

TRANSMITTER-OSCILLOSCOPE COUPLER FOR CB SIGNALS

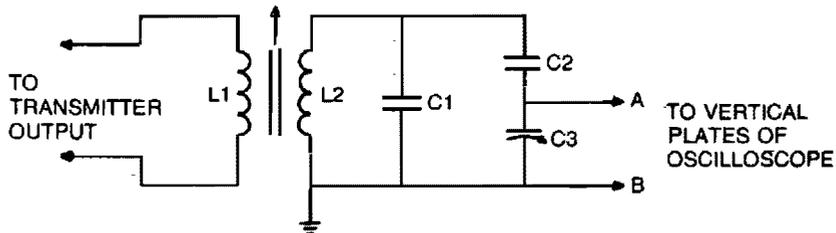


Fig. 60-5

Circuit Notes

To display an rf signal, connect L1 to the transmitter and points A and B to the vertical plates of the oscilloscope. Adjust L1 for minimum SWR and C3 for the desired trace

height on the CRT. L2 = 4 turns #18 on $\frac{3}{4}$ " slug tuned rf coil form, L1 = 3 turns #22 adjacent to grounded end of L2, C1, and C2 = 5 pF, C3 = 75 pF trimmer.

OSCILLOSCOPE MONITOR

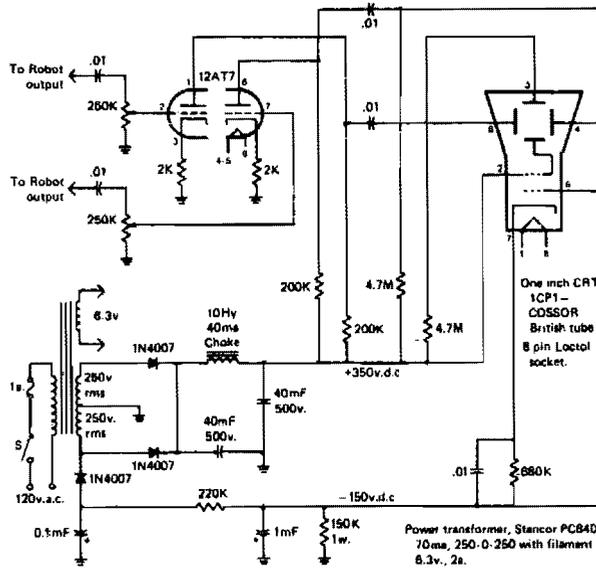


Fig. 60-6

BEAM SPLITTER FOR OSCILLOSCOPE

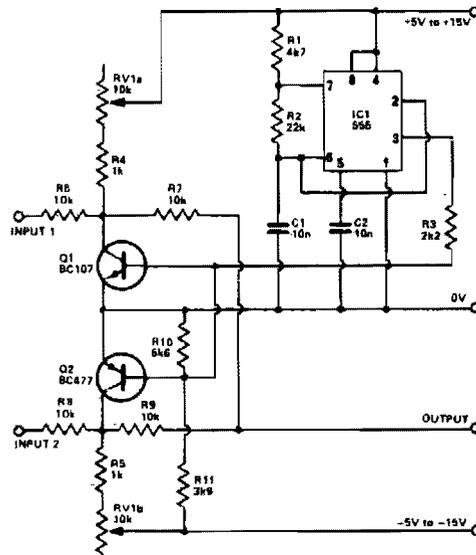


Fig. 60-7

Circuit Notes

The basis of the beam-splitter is a 555 timer connected as an astable multivibrator. Signals at the two inputs are alternately displayed on the oscilloscope with a clear separation between them. The output is controlled by the tandem potentiometer RV1a/b which also varies the amplitude of the traces.

61

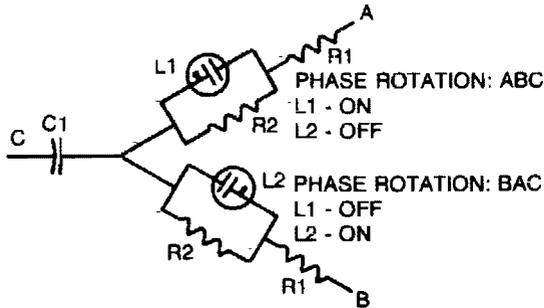
Phase Sequence and Phase Shift Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Phase Sequence Indicator
Single Transistor Phase Shifter
0° to 180° Phase Shifter

Phase Shift Circuits
Precision Phase Splitter
0 to 360° Phase Shifter

PHASE SEQUENCE INDICATOR



Circuit Notes

Simple, portable phase-sequence indicator determines the proper phase rotation in polyphase circuits. Major components are two neon lamps, two resistors, and a capacitor. In operation, the leg voltages are unbalanced, so that the lamp with the maximum voltage—or proper phase sequence—lights. Table shows typical component values for various circuit frequencies.

Fig. 61-1

SINGLE TRANSISTOR PHASE SHIFTER

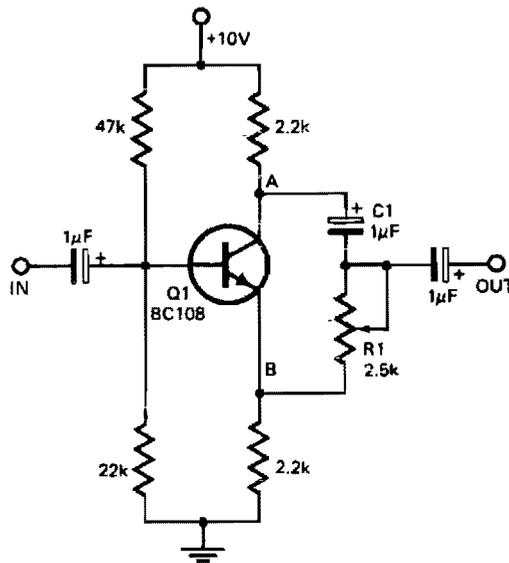


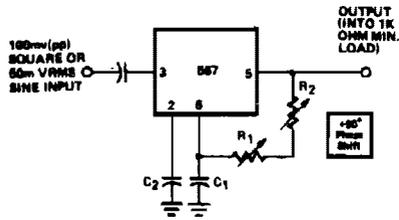
Fig. 61-2

Circuit Notes

This circuit provides a simple means of obtaining phase shifts between zero and 170° . The transistor operates as a phase splitter, the output at point A being 180° out of phase with the input. Point B is in phase with the input

phase. Adjusting R1 provides the sum of various proportions of these and hence a continuously variable phase shift is provided. The circuit operates well in the 600 Hz to 4 kHz range.

0° TO 180° PHASE SHIFTER



$$R_2 = R_1/5$$

Adjust R_1 so that $\phi = 90^\circ$ with control midway

Fig. 61-3

PRECISION PHASE SPLITTER

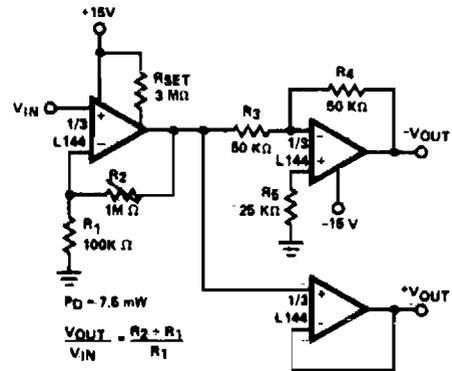
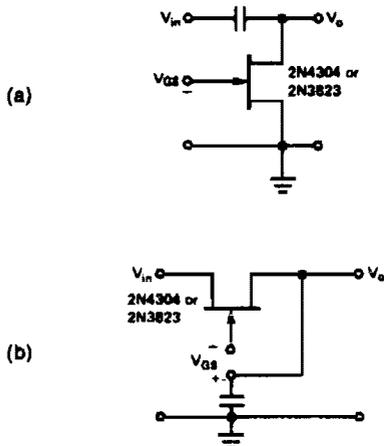


Fig. 61-5

PHASE SHIFT CIRCUITS



(a) Phase advance circuit.

(b) Phase retard circuit.

Fig. 61-4

0° TO 360° PHASE SHIFTER

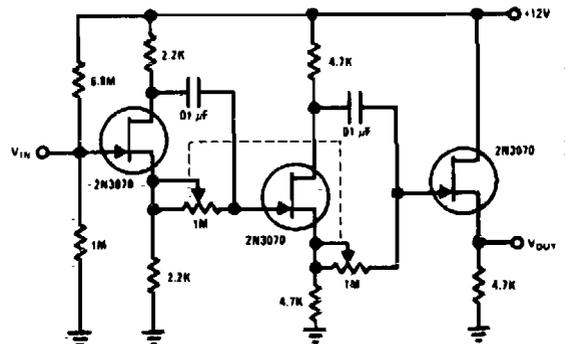


Fig. 61-6

Circuit Notes

Each stage provides 0° to 180° phase shift. By ganging the two stages, 0° to 360° phase shift is achieved. The 2N3070 JFETs do not load the phase shift networks.

62

Photography Related Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Automatic Contrast Meter
Darkroom Timer
Photo Stop Action
Sound Light-Flash Trigger
Sound Activated Strobe Trip

Flash Slave Driver
Remote Flash Trigger
Flash Exposure Meter
Shutter Tester
Photographic Timer

AUTOMATIC CONTRAST METER

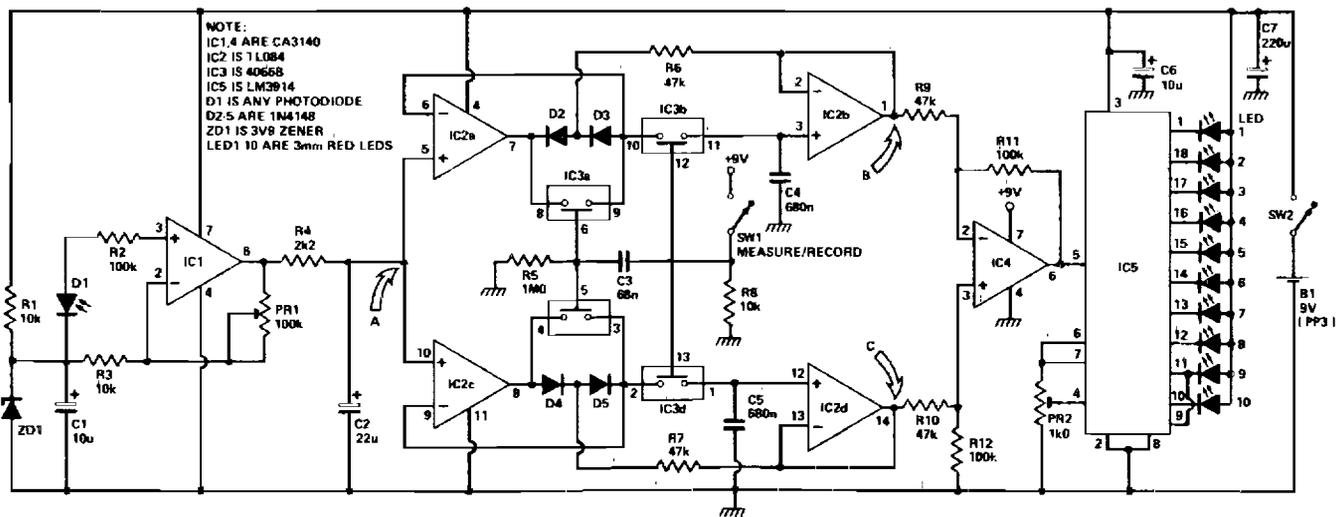


Fig. 62-1

Circuit Notes

The circuit arrangement consists of a photo-amplifier which feeds a voltage derived from varying light levels in an enlarger to a pair of peak detectors. One follows the peak positive voltage and the other the peak negative voltage. The capacitors used for storing the

voltage peaks in the followers also form part of sample and hold circuits which are then switched to hold after the measurement. Their outputs represent the maximum and minimum values of light intensity. A differential amplifier then computes the ratio of these values, and the result is displayed on an LED bargraph meter.

DARKROOM TIMER

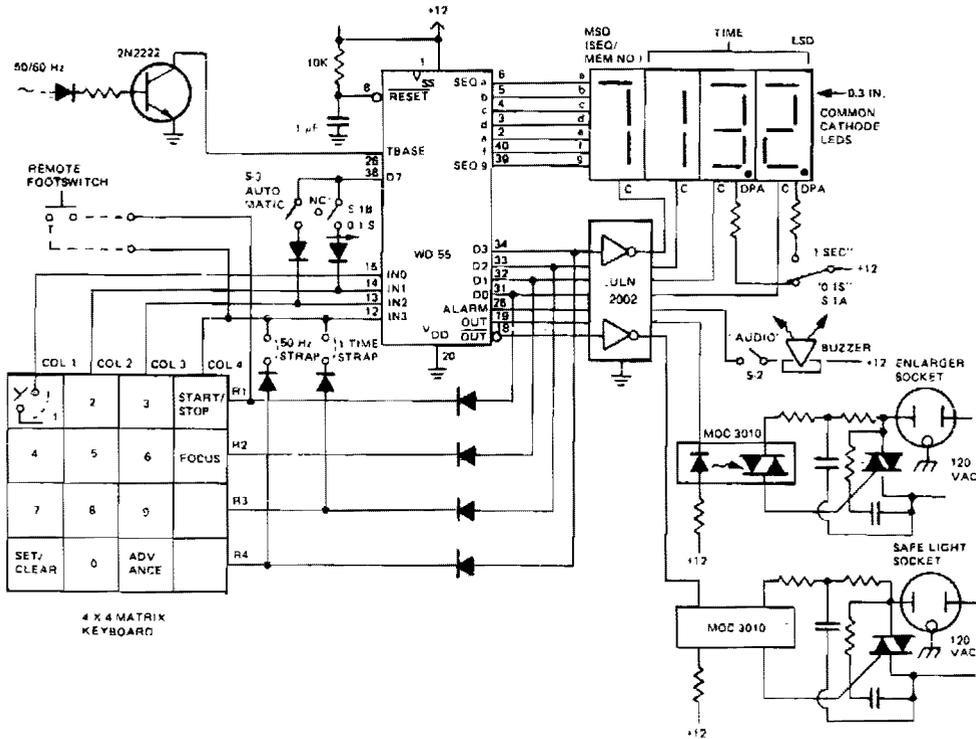


Fig. 62-2

Circuit Notes

The darkroom timer/controller uses few external components: a display, a digit driver, keyboard, and output switching devices. A 4-digit common-cathode LED display is desirable for dark room environments. The time base is provided by shaping up the 50/60 Hz ac line. A DPDT switch (S1) is used to select a resolution of .1 or 1 seconds and to simultane-

ously move the decimal point. Timer/controller has two switched ac outlets, one for the enlarger and one for the safe light. They are the complements of each other in that the safe light is on when the enlarger is not active and is off when the enlarger is printing. The buzzer is of the self-contained oscillator variety and operates with dc drive.

SOUND LIGHT-FLASH TRIGGER

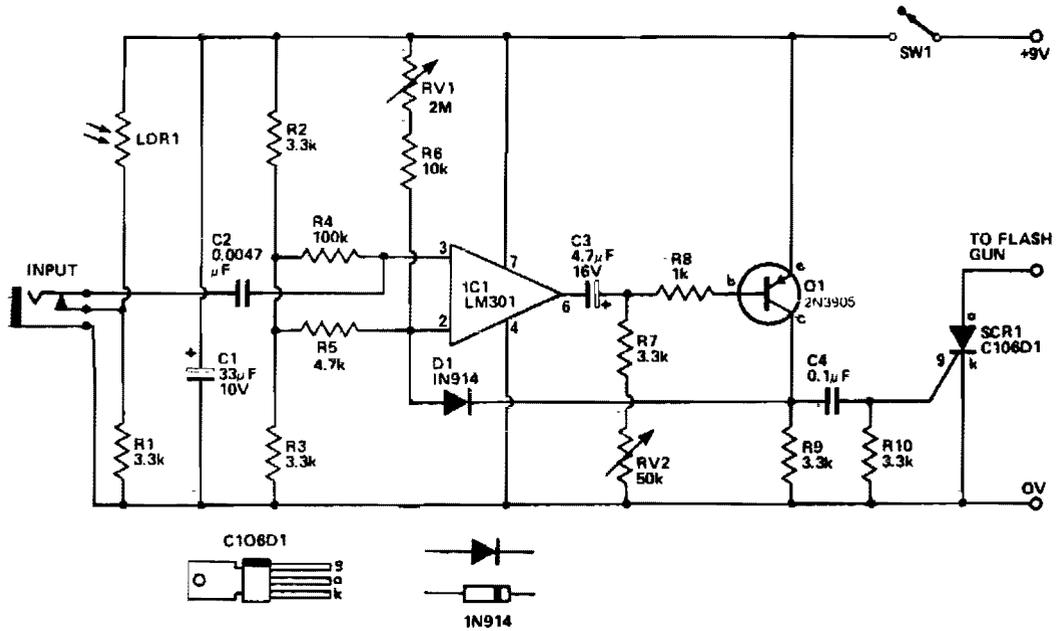


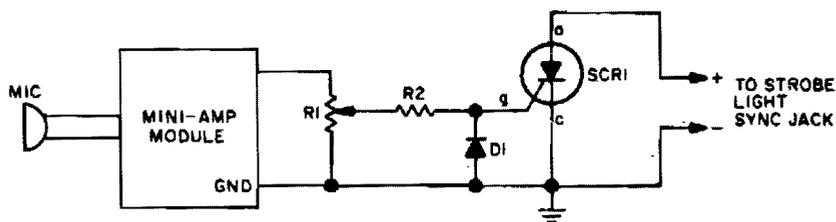
Fig. 62-4

Circuit Notes

Sound input to the microphone triggers the IC monostable circuit which subsequently triggers an SCR, and hence the flash, after a

time delay. This delay is adjustable—by varying the monostable on-time—from 5 milliseconds to 200 milliseconds.

SOUND ACTIVATED STROBE TRIP



D1—HEP-154 silicon rectifier
R1—5000-ohm potentiometer
R2—2700-ohm, ½-watt resistor
SCR1— silicon-controlled rectifier
MIC—Ceramic microphone

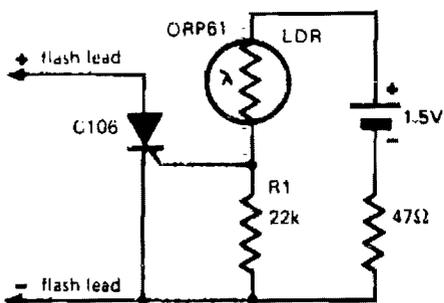
Fig. 62-5

Circuit Notes

Take strobe-flash pictures the instant a pin pricks a balloon, a hammer breaks a lamp bulb or a bullet leaves a gun. Use a transistor amplifier of 1-watt rating or less. (It must have an output transformer.) The amplifier is terminated with a resistor on its highest output im-

pedance, preferably 16 ohms. To test, darken room lights, open camera shutter, and break a lamp bulb with a hammer. The sound of the hammer striking the lamp will trigger the flash, and the picture will have been taken at that instant.

FLASH SLAVE DRIVER



Circuit Notes

In photography, a separate flash, triggered by the light of a master flash light, is often required to provide more light, fill-in shadows etc. The sensitivity of this circuit depends on the proximity of the master flash and the value of R1. Increasing R1 gives increased sensitivity.

Fig. 62-6

REMOTE FLASH TRIGGER

Q1—300-V light-activated silicon-controlled rectifier (LASCR)
R1—47,000-ohm, ½-watt resistor

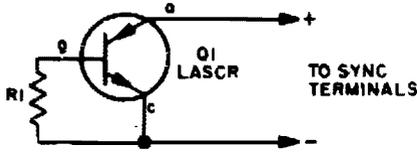


Fig. 62-7

Circuit Notes

Transistor **Q1** is a light-activated silicon-controlled rectifier (LASCR). The gate is tripped by light entering a small lens built into the top cap. To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that matches the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the positive sync terminal. When using the device, bend the connecting wires so the LASCR lens faces the main flash. This will fire the remote unit.

FLASH EXPOSURE METER

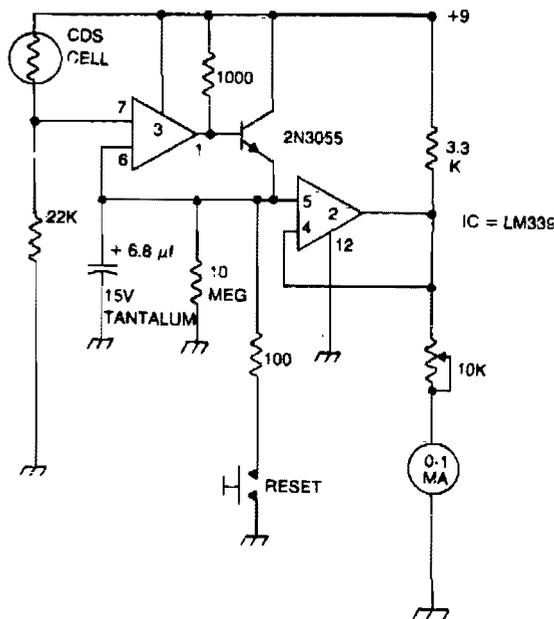


Fig. 62-8

Circuit Notes

Strobe light meter catches the peak of flash intensity and holds it long enough to give a reading. The reset button must be pressed before each measurement.

63

Power Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Extended Range VU Meter (Dot Mode)
Audio Power Meter

Audio Power Meter
Power Meter (1 kW Full Scale)

60 MHz Power Gain Test Circuit

AUDIO POWER METER

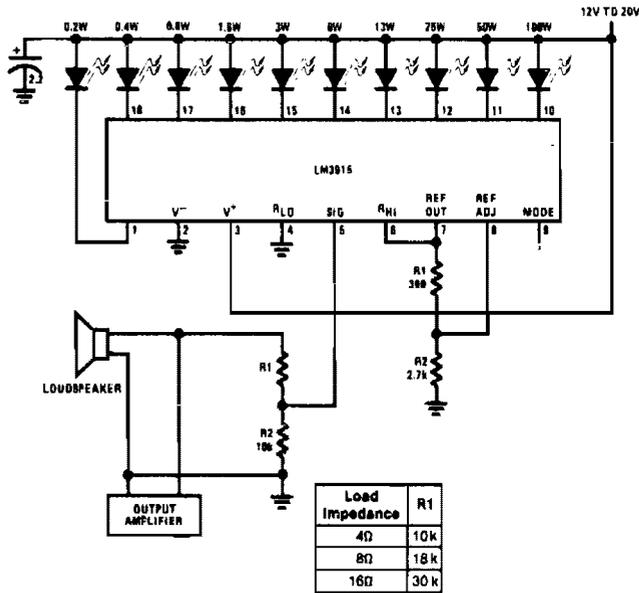


Fig. 63-2

See Application Mints for optional Peak or Average Detector

AUDIO POWER METER

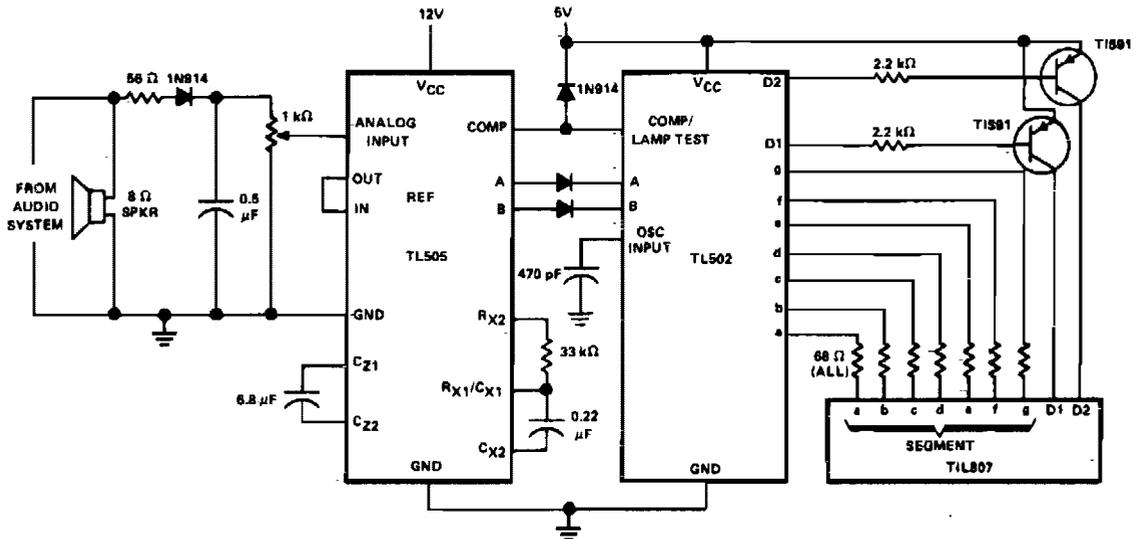


Fig. 63-3

POWER METER (1 kW FULL SCALE)

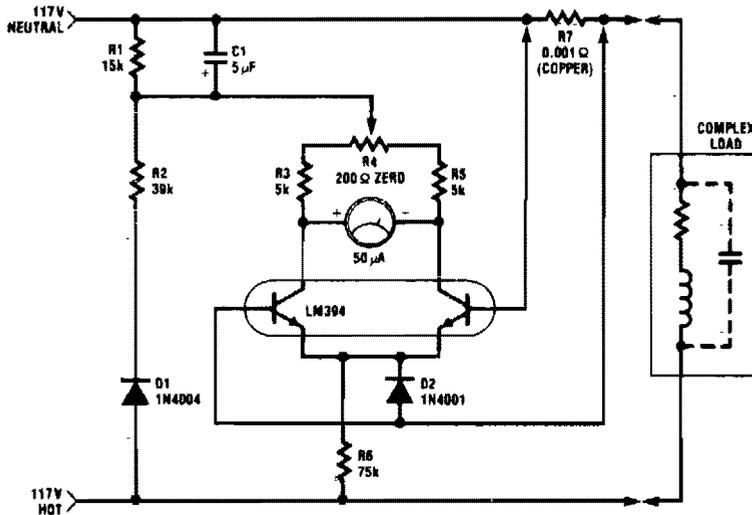


Fig. 63-4

Circuit Notes

The circuit is intended for 117 Vac \pm 50 Vac operation, but can be easily modified for higher or lower voltages. It measures true (nonreactive) power being delivered to the load and requires no external power supply. Idling power drain is only 0.5 W. Load current

sensing voltage is only 10 mV, keeping load voltage loss to 0.01%. Rejection of reactive load currents is better than 100:1 for linear loads. Nonlinearity is about 1% full scale when using a 50 μ A meter movement.

60 MHz POWER GAIN TEST CIRCUIT

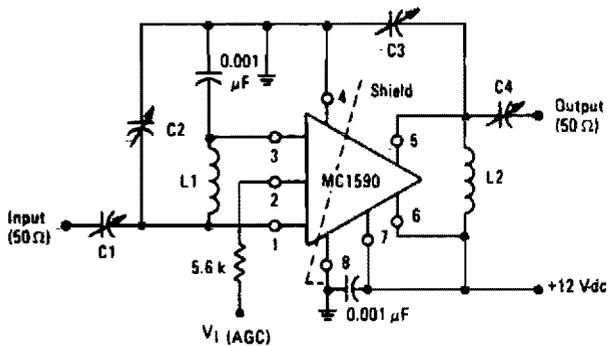


Fig. 63-5

- L1 = 7 Turns, #20 AWG Wire, 5/16" Dia., 5/8" Long
 L2 = 6 Turns, #14 AWG Wire, 9/16" Dia., 3/4" Long
 C1, C2, C3 = (1-30) pF
 C4 = (1-10) pF

64

Power Supplies (Fixed)

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Switching Regulator Operating at 200 kHz
5 V, 0.5 A Power Supply

3 W Switching Regulator Application Circuit
Regulated Split Supplies from a Single
Supply

Switching Step-Down Regulator
Single-Ended Regulator

± 50 V Push-Pull Switched Mode Converter
5 V/0.5 A Buck Converter

± 50 V Feed Forward Switch Mode
Converter

Traveller's Shaver Adapter

100 Vrms Voltage Regulator

Transistor Increases Zener Rating

Dual Polarity Power Supply

5.0 V/6.0 A, 25 kHz Switching Regulator
with Separate Ultra-Stable Reference

Mobile Voltage Regulator

Negative Switching Regulator

Positive Switching Regulator

Positive Floating Regulator

Negative Floating Regulator

Negative Voltage Regulator

-15 V Negative Regulator

Slow Turn-On 15 V Regulator

High Stability 10 V Regulator

5 V/1 A Switching Regulator

15 V/1 A Regulator with Remote Sense

Low Ripple Power Supply

5.0 V/10 A Regulator

5.0 V/3.0 A Regulator

100 V/10.25 A Switch Mode Converter

Voltage Regulator

Low Voltage Regulators with Short Circuit
Protection

High Stability 1 A Regulator

100 V/0.25 A Switch Mode Converter

SWITCHING REGULATOR OPERATING AT 200 kHz

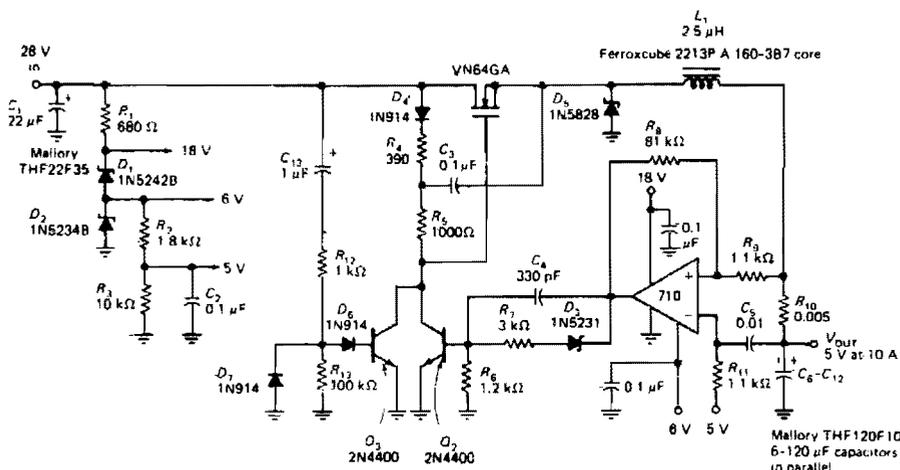


Fig. 64-1

Circuit Notes

This circuit provides a regulated dc with less than 100 mV of ripple for microprocessor applications. Necessary operating voltages are taken from the bleeder resistor network connected across the unregulated 28 V supply. The output of the LM710 comparator (actually an

oscillator running at 200 kHz) is fed through a level-shifting circuit to the base of bipolar transistor Q2. This transistor is part of a bootstrap circuit necessary to turn the power MOSFET full on in totem-pole MOSFET arrays.

5 V, 0.5 A POWER SUPPLY

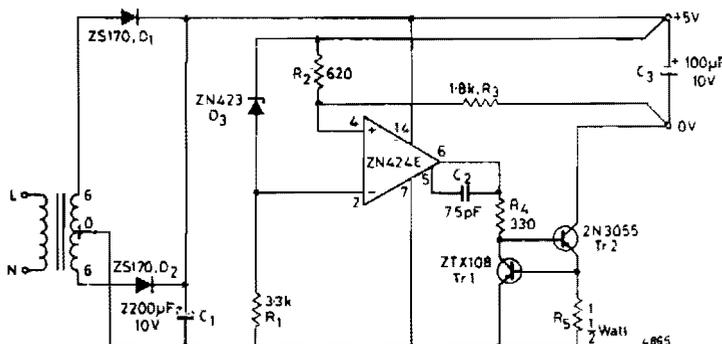


Fig. 64-2

Circuit Notes

The circuit is essentially a constant source modified by the feedback components R2 and R3 to give a constant voltage output. The output of the ZN424E need only be 2 volts above the negative rail, by placing the load in the collector of the output transistor Tr2. The

current limit is achieved by Tr1 and R5. This simple circuit has the following performance characteristics: Output noise and ripple (full load) = 1 mV rms. Load regulation (0 to 0.5 A) = 0.1%. Temperature coefficient = ± 100 ppm/ $^{\circ}$ C. Current limit = 0.65 A.

3 W SWITCHING REGULATOR APPLICATION CIRCUIT

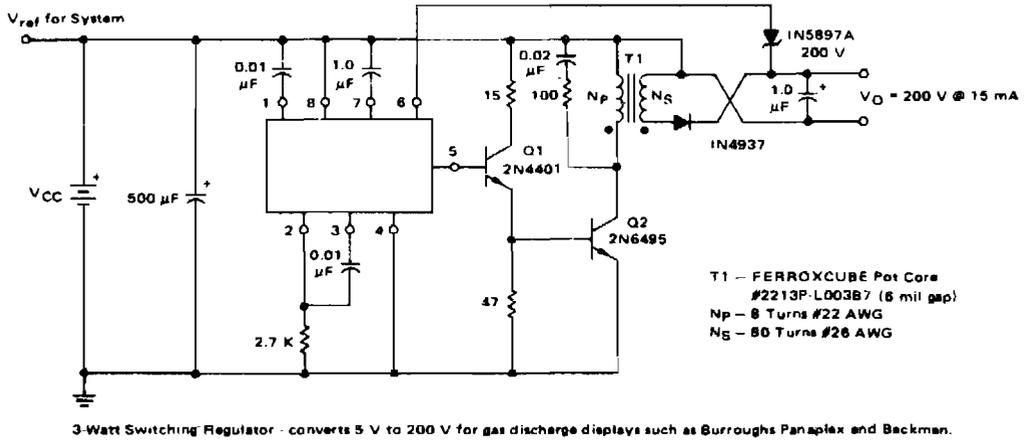


Fig. 64-3

REGULATED SPLIT POWER SUPPLIES FROM A SINGLE SUPPLY

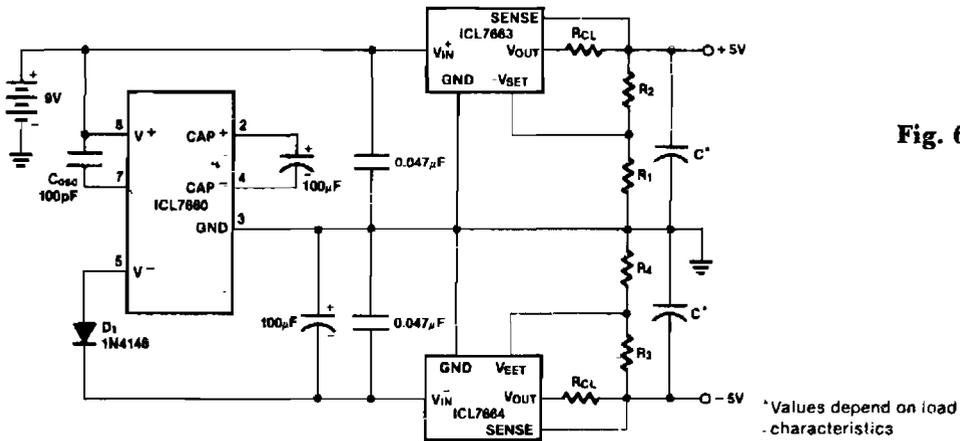


Fig. 64-4

Circuit Notes

The oscillation frequency of the ICL7660 is reduced by the external oscillator capacitor, so that it inverts the battery voltage more efficiently.

±50 V PUSH-PULL SWITCHED-MODE CONVERTER

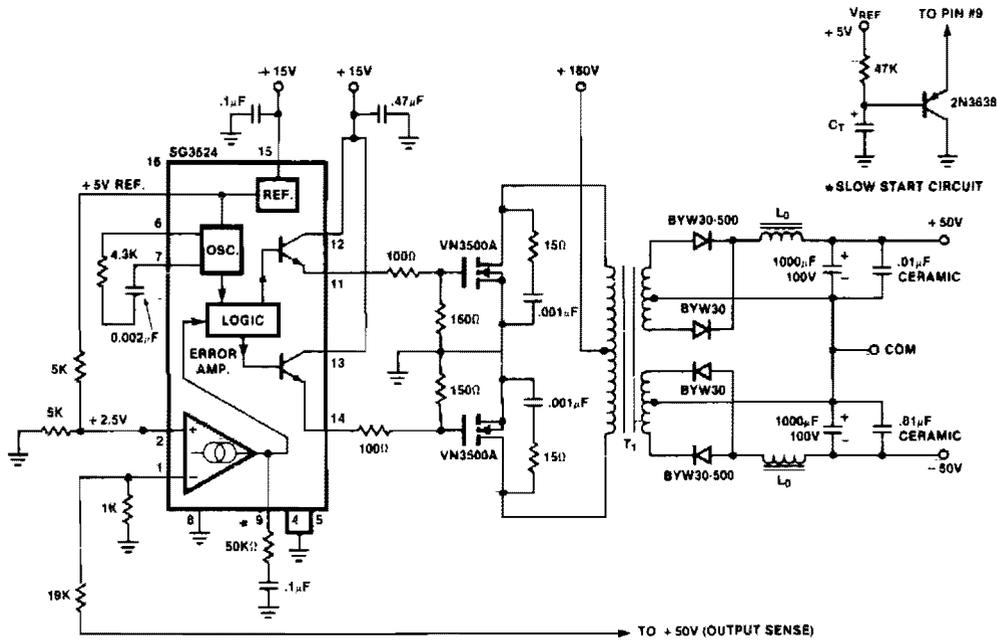


Fig. 64-7

5 V/0.5 A BUCK CONVERTER

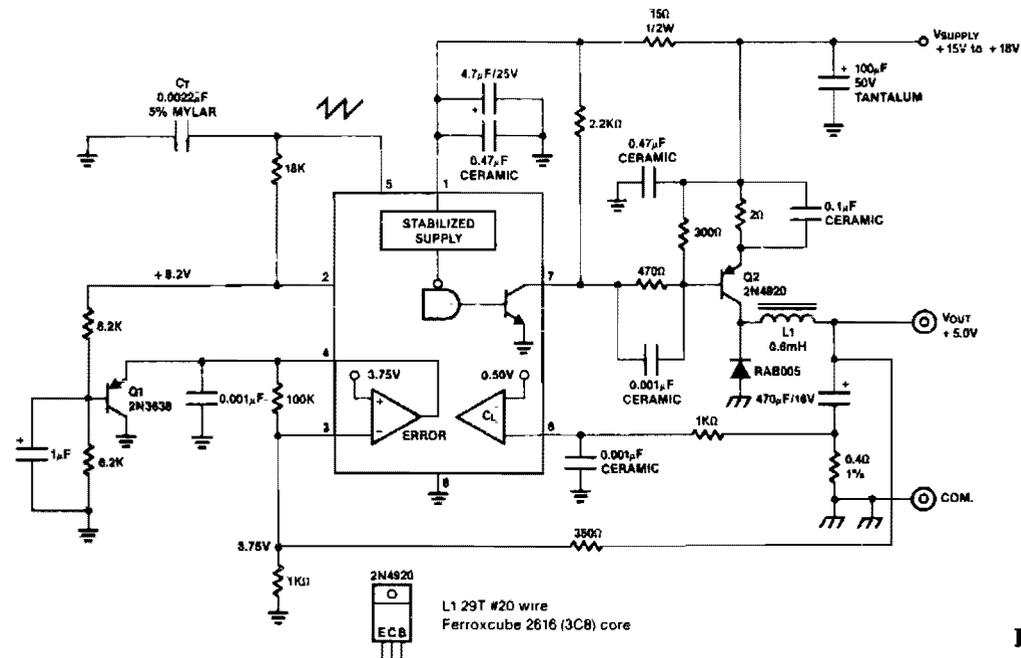


Fig. 64-8

±50 V FEED FORWARD SWITCH MODE CONVERTER

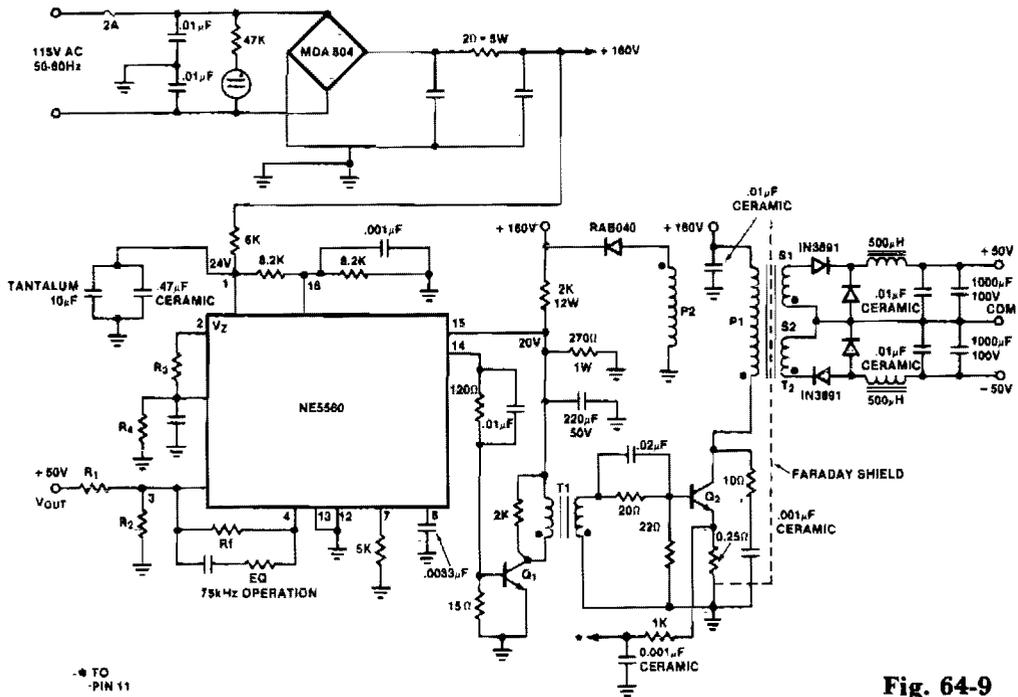


Fig. 64-9

TRAVELLER'S SHAVER ADAPTER

Circuit Notes

Many countries have 115 volts mains supplies. This can be a problem if your electric shaver is designed for 220/240 volts only. This simple rectifier voltage doubler enables motor driven 240 volt shavers to be operated at full speed from a 115 volt supply. As the output voltage is dc, the circuit can only be used to drive small ac/dc motors. It cannot be used, for example, to operate vibrator-type shavers, or radios unless the latter are ac/dc operated.

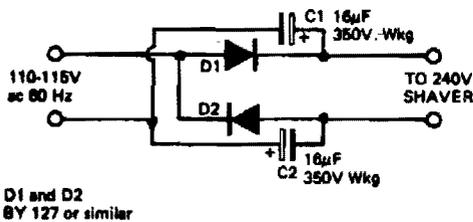


Fig. 64-10

DUAL POLARITY POWER SUPPLY

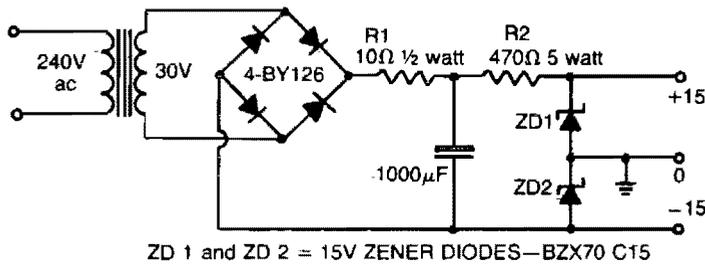


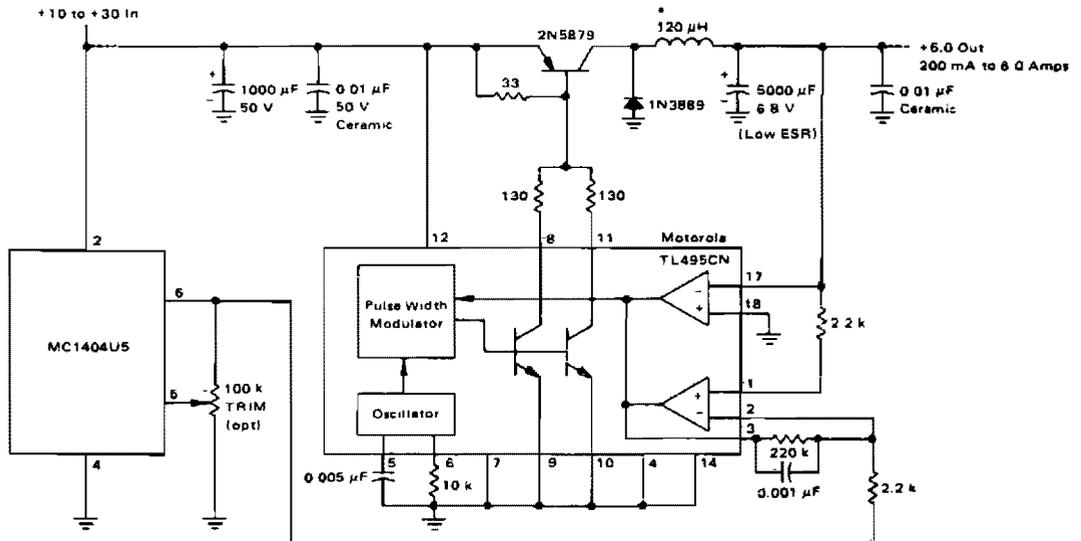
Fig. 64-13

Circuit Notes

This simple circuit gives a positive and negative supply from a single transformer winding and one full-wave bridge. Two zener

diodes in series provide the voltage division and their centerpoint is grounded. (The filter capacitor must not be grounded via its case).

5.0 V/6.0 A 25 kHz SWITCHING REGULATOR WITH SEPARATE ULTRA-STABLE REFERENCE



* 40 Turns #16 Wire, Arnold A 894075-2 Ferrite Core

Fig. 64-14

MOBILE VOLTAGE REGULATOR

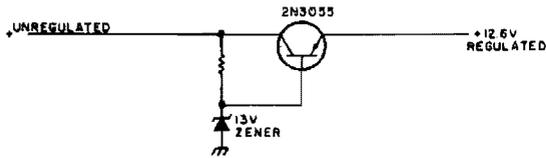


Fig. 64-15

Circuit Notes

This simple mobile voltage regulator circuit may save your two meter or CB transceiver if the voltage regulator fails. The 2N3055 should be heat sunk if current drawn by the rig is in excess of 2 A on transmit. This circuit will do little under normal operating conditions, but could save expensive equipment if the vehicle's electrical system loses regulation.

NEGATIVE SWITCHING REGULATOR

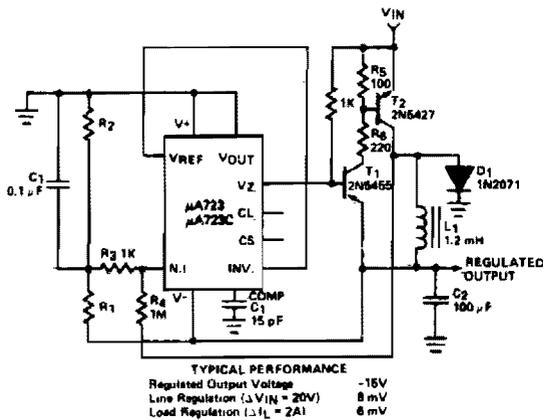


Fig. 64-16

POSITIVE FLOATING REGULATOR

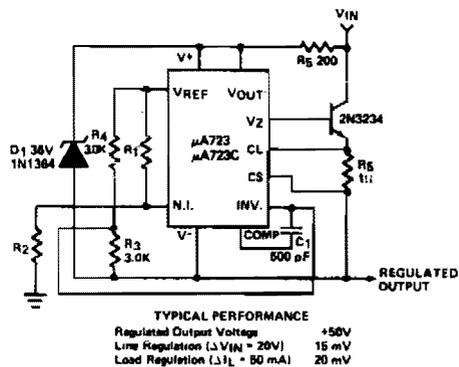


Fig. 64-18

POSITIVE SWITCHING REGULATOR

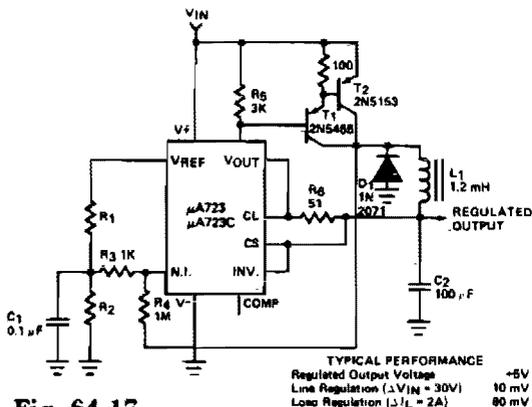


Fig. 64-17

NEGATIVE FLOATING REGULATOR

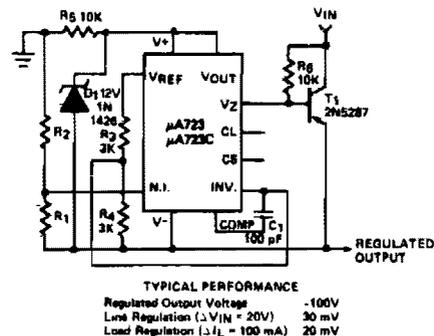
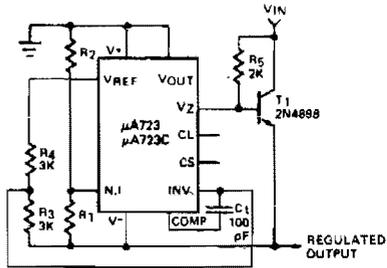


Fig. 64-19

NEGATIVE VOLTAGE REGULATOR



TYPICAL PERFORMANCE
 Regulated Output Voltage -15V
 Line Regulation ($\Delta V_{IN} = 3V$) 1 mV
 Load Regulation ($\Delta I_L = 100 \text{ mA}$) 2 mV

Fig. 64-20

HIGH STABILITY 10 V REGULATOR

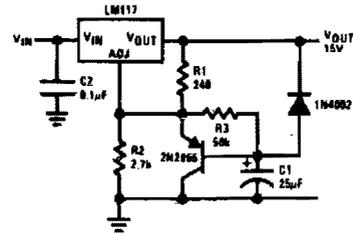


Fig. 64-23

-15 V NEGATIVE REGULATOR

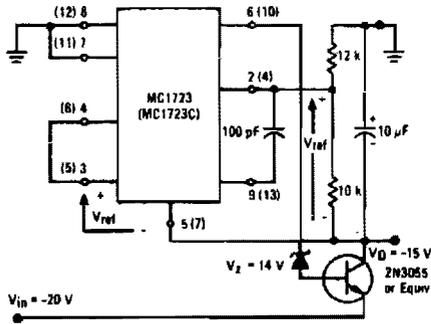


Fig. 64-21

5 V/1 A SWITCHING REGULATOR

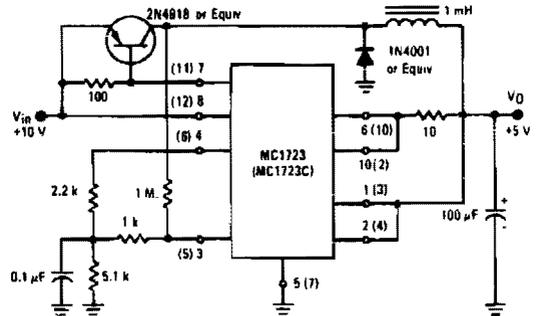


Fig. 64-24

SLOW TURN-ON 15 V REGULATOR

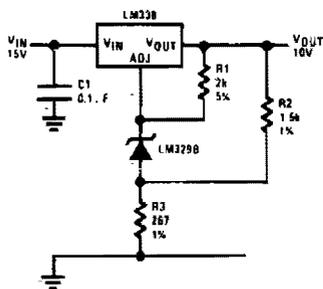


Fig. 64-22

15 V/1 A REGULATOR WITH REMOTE SENSE

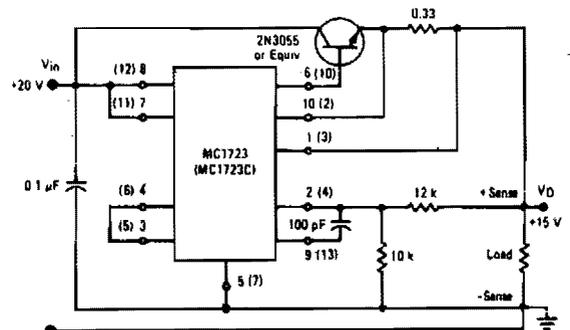


Fig. 64-25

LOW RIPPLE POWER SUPPLY

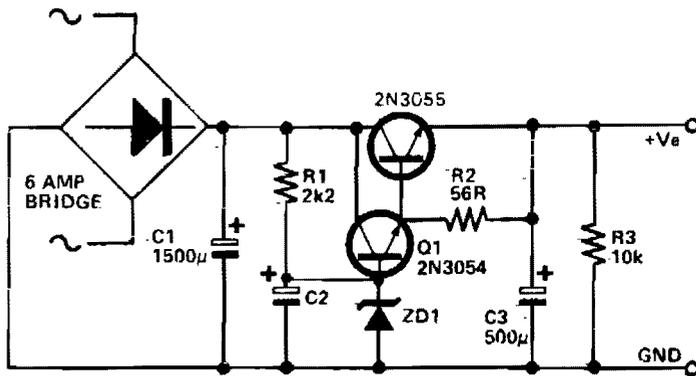


Fig. 64-26

Circuit Notes

This circuit may be used where a high current is required with a low ripple voltage (such as in a high powered class AB amplifier when high quality reproduction is necessary). Q1, Q2, and R2 may be regarded as a power darlington transistor. ZD1 and R1 provide a reference voltage at the base of Q1. ZD1 should

be chosen thus: $ZD1 = V_{out} - 1.2$. C2 can be chosen for the degree of smoothness as its value is effectively multiplied by the combined gains of Q1/Q2, if $100 \mu F$ is chosen for C2, assuming minimum hfe for Q1 and Q2, $C = 100 \times 15(Q1) \times 25(Q2) = 37,000 \mu F$.

5.0 V/10 A REGULATOR

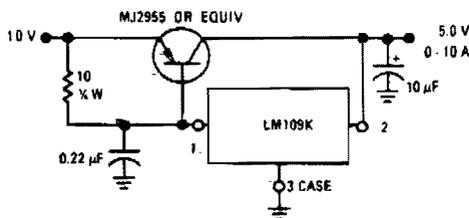


Fig. 64-27

5.0 V/3.0 A REGULATOR

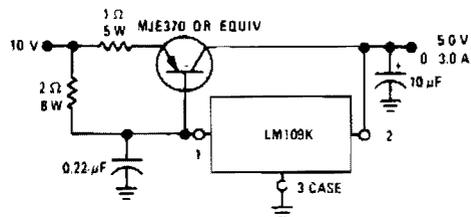
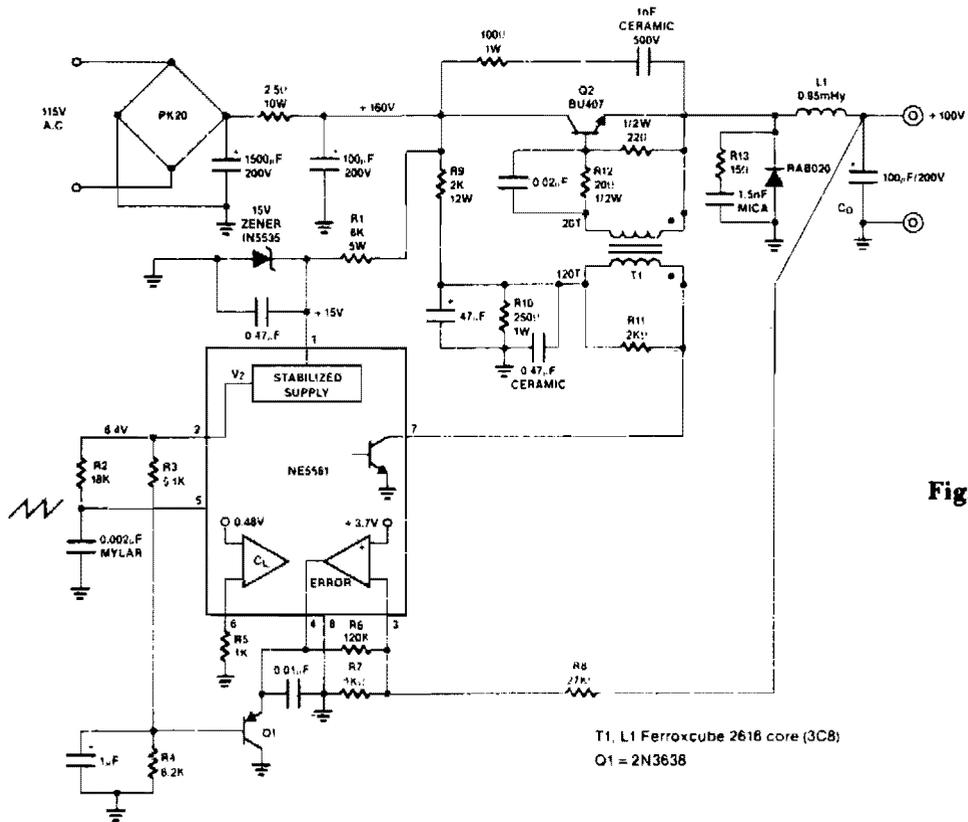
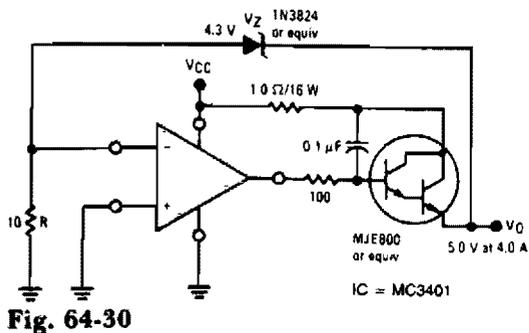


Fig. 64-28

100 V/0.25 A SWITCH MODE CONVERTER



VOLTAGE REGULATOR

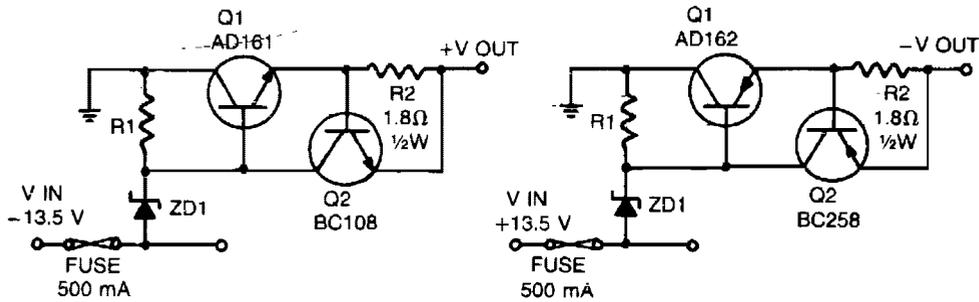


$$V_O = V_Z + 0.6 \text{ Vdc}$$

NOTE 1 R is used to bias the zener

NOTE 2 If the Zener TC is positive, and equal in magnitude to the negative TC of the input to the operational amplifier ($\approx 2.0 \text{ mV}/^\circ\text{C}$), the output is zero TC. A 7.0 Volt Zener will give approximately zero TC

LOW VOLTAGE REGULATORS WITH SHORT CIRCUIT PROTECTION



VOLTAGE	ZD1 400mW	R1
6V	6V2	680Ω
7.5V	7V5	390Ω
9V	9V1	220Ω

Fig. 64-31

Circuit Notes

These short-circuit protected regulators give 6, 7.5, and 9 V from an automobile battery supply of 13.5 V nominal; however, they will function just as well if connected to a smoothed dc output from a transformer/rectifier circuit. Two types are shown for both positive and negative ground systems. The power transistors can be mounted on the heatsink without a mica insulating spacer thus allowing for greater cooling efficiency. Both circuits are protected

against overload or short-circuits. The current cannot exceed 330 mA. Under normal operating conditions the voltage across R2 does not rise above the 500 mV necessary to turn Q2 on and the circuit behaves as if there was only Q1 present. If excessive current is drawn, Q2 turns on and cuts off Q1, protecting the regulating transistor. The table gives the values of R1 for different zener voltages.

HIGH STABILITY 1 A REGULATOR

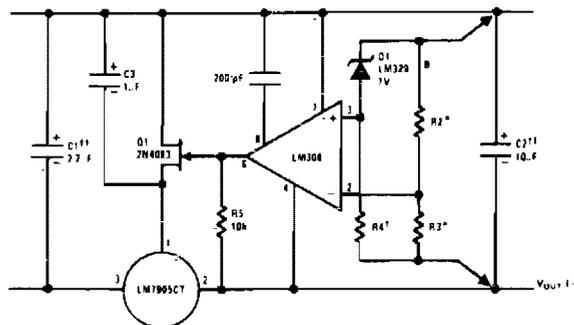


Fig. 64-32

Load and line regulation $\leq 0.01\%$ temperature stability $\leq 0.2\%$

† Determines Zener current

†† Solid tantalum

* Select resistors to set output voltage 2 ppm/°C tracking suggested

65

Power Supplies (Variable)

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dual Output Bench Power Supply
Power Supply with Adjustable Current
Limit and Output Voltage
Adjustable Output Regulator
10 mA Negative-Voltage from a Positive
Source
Regulated Voltage Divider
Variable Zener Diode
12 V To 9, 7.5 or 6 V Converter
5 A Constant Voltage/Constant Current
Regulator
Power Pack for Battery-Powered Cal-
culators, Radios, or Cassette Players

Precision High Voltage Regulator
Remote Shutdown Regulator with Current
Limiting
0 to 22 V Regulator
0 to 30 V Regulator
10 A Regulator
Adjustable Regulator 0-10 V at 3 A
High Voltage Regulator
Low Voltage Regulator
Simple Split Power Supply
Adjustable Output Regulator
Multiple Output Switching Regulator for
-Use with MPUs

6.0 A Variable Output Switching Regulator

DUAL OUTPUT BENCH POWER SUPPLY

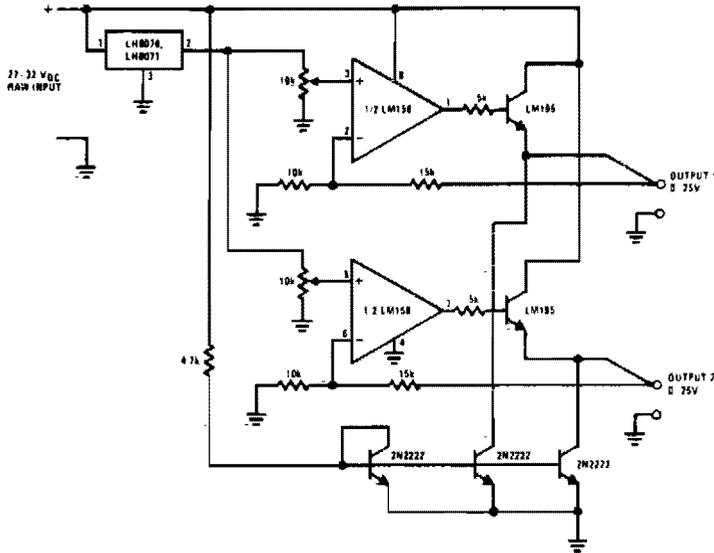


Fig. 65-1

POWER SUPPLY WITH ADJUSTABLE CURRENT LIMIT AND OUTPUT VOLTAGE

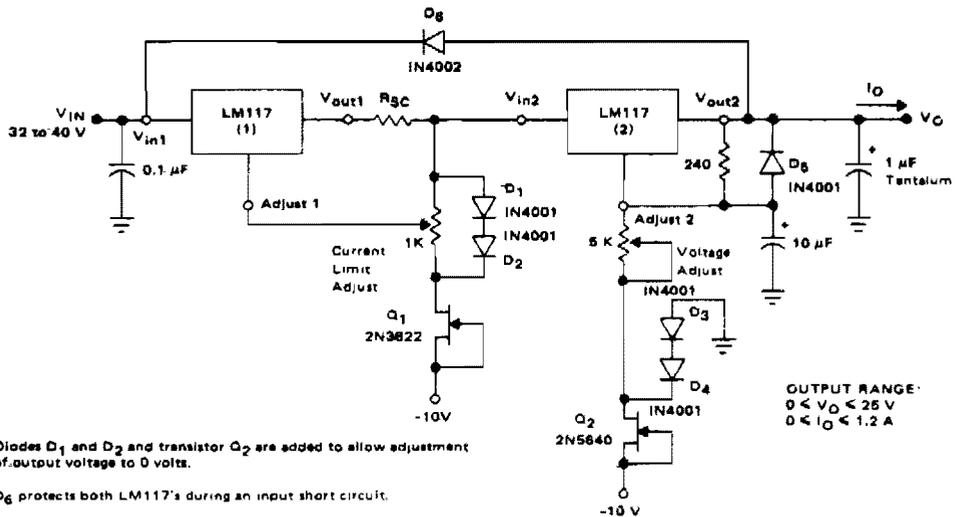
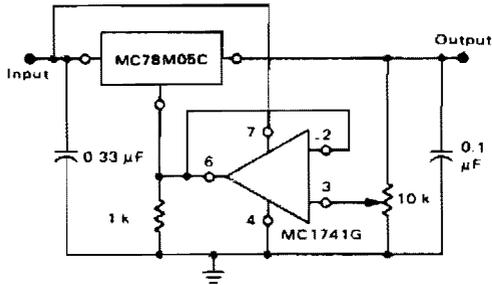


Fig. 65-2

Diodes D_1 and D_2 and transistor Q_2 are added to allow adjustment of output voltage to 0 volts.

D_6 protects both LM117's during an input short circuit.

ADJUSTABLE OUTPUT REGULATOR



$$V_O: 7.0 \text{ V to } 20 \text{ V}$$

$$V_{IN}: V_O \geq 2.0 \text{ V}$$

Fig. 65-3

Circuit Notes

The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with this arrangement is 2.0 volts greater than the regulator voltage.

RF PROBE FOR VTVM

Circuit Notes

This circuit combines a 555 timer with a 2N2222 transistor and an external potentiometer. The pot adjusts the output voltage to the desired value. To regulate the output voltage, the 2N2222 varies the control voltage of the 555 IC, increasing or decreasing the pulse repetition rate. A 1.2 K resistor is used as a collector load. The transistor base is driven from the external pot. If the output voltage becomes less negative, the control voltage moves closer to ground, causing the repetition rate of the 555 to increase, which, in turn, causes the 3 µF capacitor to charge more frequently. Output voltage for the circuit is 0 to 10 V, adjusted by the external pot. Output regulation is less than five percent for 0 to 10 mA and less than .05 percent for 0 to 0.2 mA.

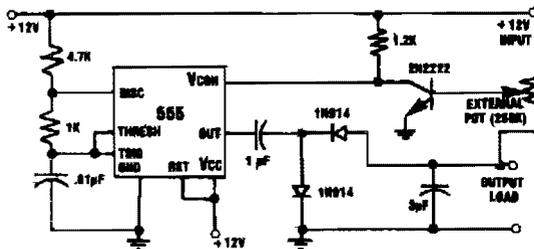


Fig. 65-4

REGULATED VOLTAGE DIVIDER

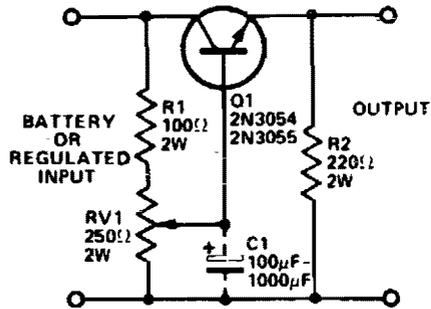


Fig. 65-5

Circuit Notes

ICs requiring 3.6 or 6 volts can be run from a battery or fixed regulated supply of a higher voltage by using the circuit shown. The transistor should be mounted on a heatsink as considerable power will be dissipated by its collector. Additional filtering can be obtained by fitting a capacitor (C1) as shown. The capacitance is effectively multiplied by the gain of the transistor. A ripple of 200 mV (peak to peak) at the input can be reduced to 2 mV in this fashion. Maximum output current depends on the supply rating and transistor type (with heatsink) used.

VARIABLE ZENER DIODE

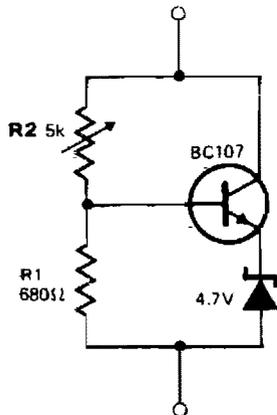
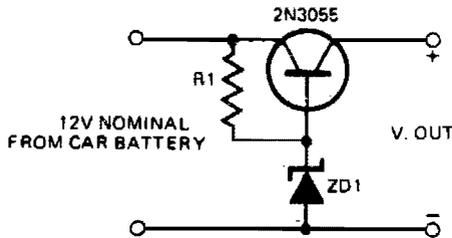


Fig. 65-6

Circuit Notes

The circuit behaves like a zener diode over a large range of voltages. The current passing through the voltage divider R1-R2 is substantially larger than the transistor base current and is in the region of 8 mA. The stabilizing voltage is adjustable over the range 5-45 V by changing the value of R2. The total current drawn by the circuit is variable over the range 15 mA to 50 mA. This value is determined by the maximum dissipation of the zener diode. In the case of a 250 mW device, this is of the order of 50 mA.

12 V TO 9, 7.5 or 6 V CONVERTER



OUTPUT VOLTAGE	9	7.5	6
R1 (1/2 WATT)	180Ω	270Ω	330Ω
ZENER DIODE (250 mW)	10V	8V1	6V6

Circuit Notes

This circuit enables transistorized items such as radio, cassettes, and other electrical devices to be operated from a car's electrical supply. The table gives values for resistors and specified diode types for different voltage. Should more than one voltage be required a switching arrangement could be incorporated. For high currents, the transistor should be mounted on a heatsink.

Fig. 65-7

5 A CONSTANT VOLTAGE/CONSTANT CURRENT REGULATOR

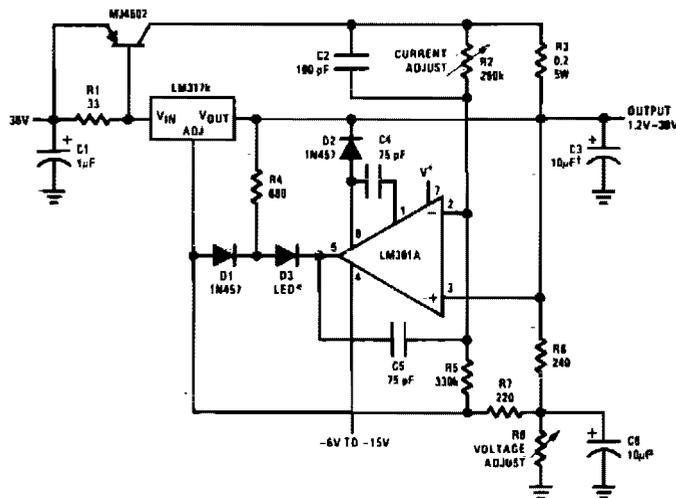


Fig. 65-8

† Solid tantalum

* Lights in constant current mode

POWER PACK FOR BATTERY-POWERED CALCULATORS, RADIOS, OR CASSETTE PLAYERS

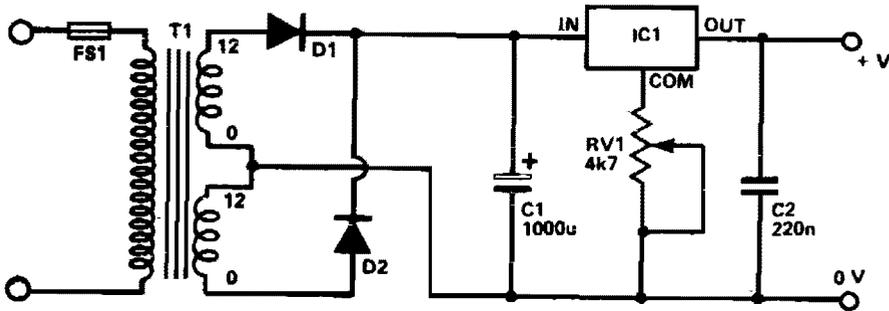


Fig. 65-9

NOTES:
IC1 IS 7805
D1,2 ARE 1N4001

Circuit Notes

This circuit gives a regulated output of between 5 V and 15 Vdc, adjusted and set by a preset resistor. Current output up to about 350 mA. An integrated circuit regulates the output

voltage and although this IC (the 7805) is normally used in a fixed-voltage (5 Vdc) supply it is for a variable output voltage.

PRECISION HIGH VOLTAGE REGULATOR

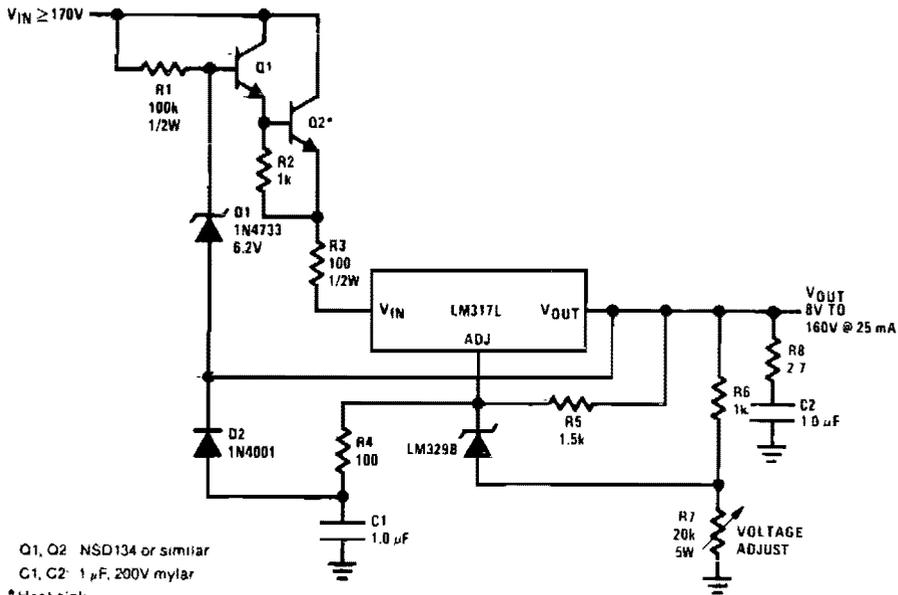


Fig. 65-10

Q1, Q2 NSD134 or similar
C1, C2: 1 µF, 200V mylar
*Heat sink

REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING
 ($V_{out} = 2 \text{ TO } 7 \text{ V}$)

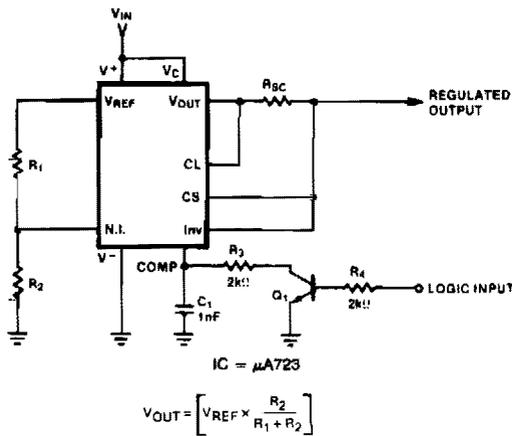


Fig. 65-11

0 TO 30 V REGULATOR

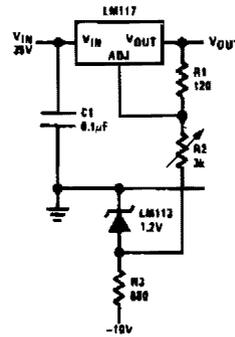


Fig. 65-13

0 TO 22 V REGULATOR

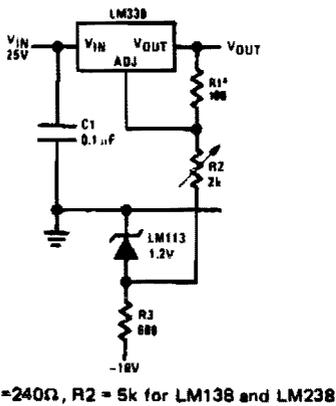


Fig. 65-12

10 A REGULATOR

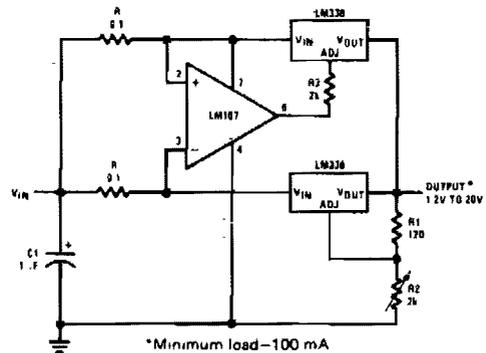


Fig. 65-14

ADJUSTABLE REGULATOR 0-10 V AT 3 A

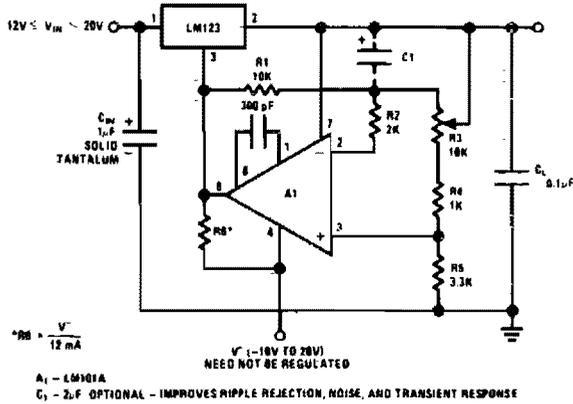
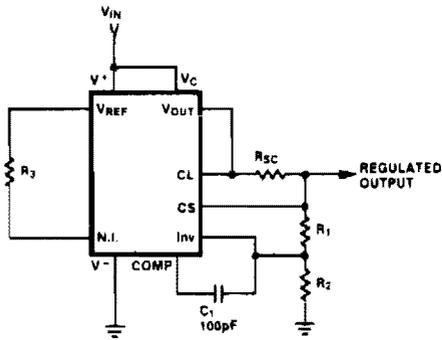


Fig. 65-15

HIGH VOLTAGE REGULATOR ($V_{out} = +7V$ TO $37V$)



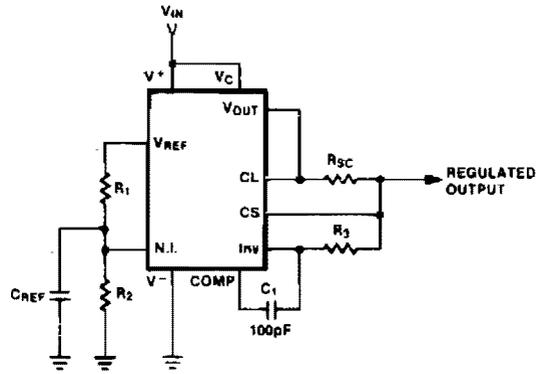
$$V_{OUT} = \left[V_{REF} \times \frac{R_1 + R_2}{R_2} \right]$$

$$R_3 = \frac{R_1 R_2}{R_1 + R_2} \text{ for minimum temperature drift}$$

R_3 may be eliminated for minimum component count

Fig. 65-16

LOW VOLTAGE REGULATOR ($V_{out} = 2$ TO $7V$)



$$V_{OUT} = \left[V_{REF} \times \frac{R_2}{R_1 + R_2} \right]$$

$$R_3 = \frac{R_1 R_2}{R_1 + R_2} \text{ for minimum temperature drift}$$

Fig. 65-17

SIMPLE SPLIT POWER SUPPLY

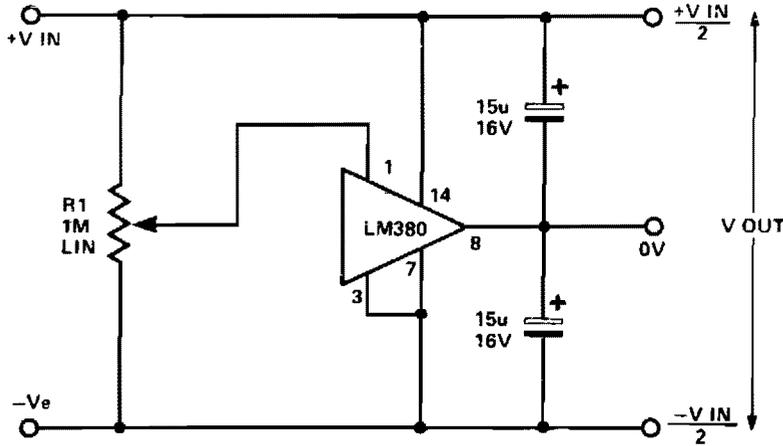


Fig. 65-18

Circuit Notes

This circuit utilizes the quasi-complementary output stage of the popular LM380 audio power IC. The device is internally biased so that with no input the output is held midway between the supply rails. R1, which should be initially set to mid-travel, is used to nullify any imbalance in the output. Regulation of V_{out} depends upon the circuit feeding the LM380, but positive and negative

outputs will track accurately irrespective of input regulation and unbalanced loads. The free-air dissipation is a little over 1 watt, and so extra cooling may be required. The device is fully protected and will go into thermal shut-down if its rated dissipation is exceeded. Current limiting occurs if the output current exceeds 1.3 A. The input voltage should not exceed 20 V.

ADJUSTABLE OUTPUT REGULATOR

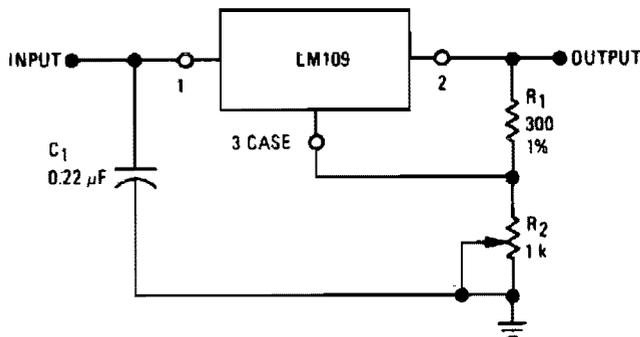


Fig. 65-19

66

Power Supply Protection Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Electronic Crowbar for Ac or Dc Lines
Power Protection Circuit
Simple Crowbar
Overvoltage Protection with Automatic
Reset

Overvoltage Protection for Logic
Fast Acting Power Supply Protection
5 V Crowbar

ELECTRONIC CROWBAR FOR AC OR DC LINES

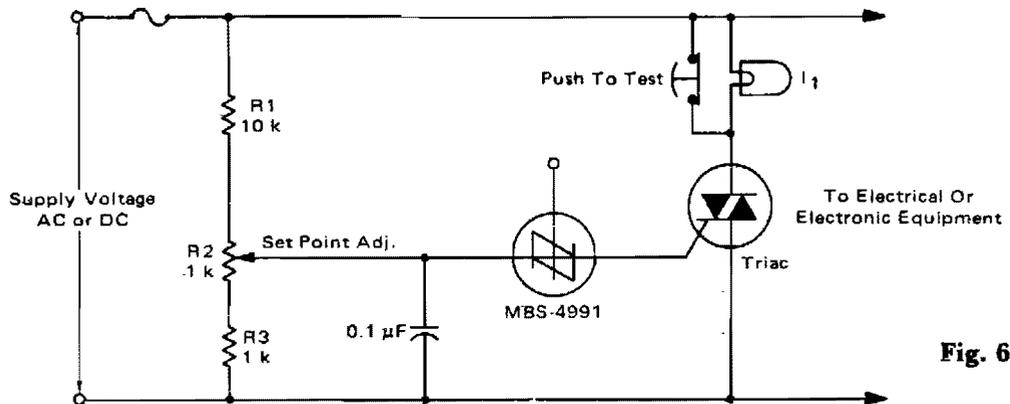


Fig. 66-1

Circuit Notes

For positive protection of electrical or electronic equipment, use this against excessive supply voltage. Due to improper switching, wiring, short circuits, or failure of regulators, an electronic crowbar circuit can quickly place a short circuit across the power lines, thereby dropping the voltage across the protected device to near zero and blowing a fuse. The triac and SBS are both bilateral devices, the circuit is equally useful on ac or dc supply lines. With the values shown for R1, R2, and R3, the crowbar operating point can be adjusted over the range of 60 to 120 volts dc or 42 to 84 volts ac. The resistor values can be

changed to cover a different range of supply voltages. The voltage rating of the triac must be greater than the highest operating point as set by R2. I1 is a low power incandescent lamp with a voltage rating equal to the supply voltage. It may be used to check the set point and operation of the unit by opening the test switch and adjusting the input or set point to fire the SBS. An alarm unit such as the Mallory Sonalert may be connected across the fuse to provide an audible indication of crowbar action. (This circuit may not act on short, infrequent power line transients).

POWER PROTECTION CIRCUIT

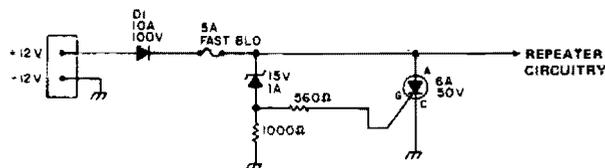


Fig. 66-2

Circuit Notes

To safeguard portable, emergency power repeaters from reverse or excessive voltage, D1 prevents incorrect polarity damage, and zener voltage determines the maximum vol-

tage that will reach the rest of the circuitry. Use fast blowing fuse rated greater than the SCR current rating.

SIMPLE CROWBAR

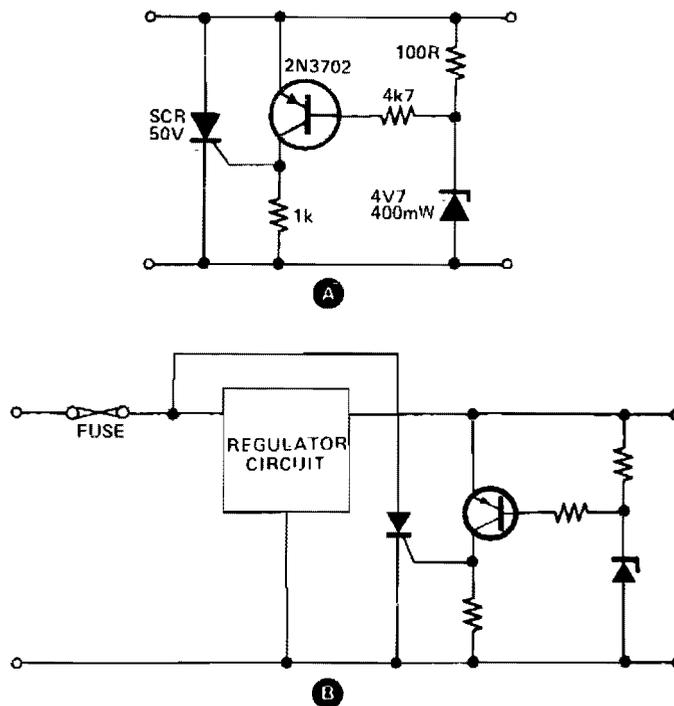


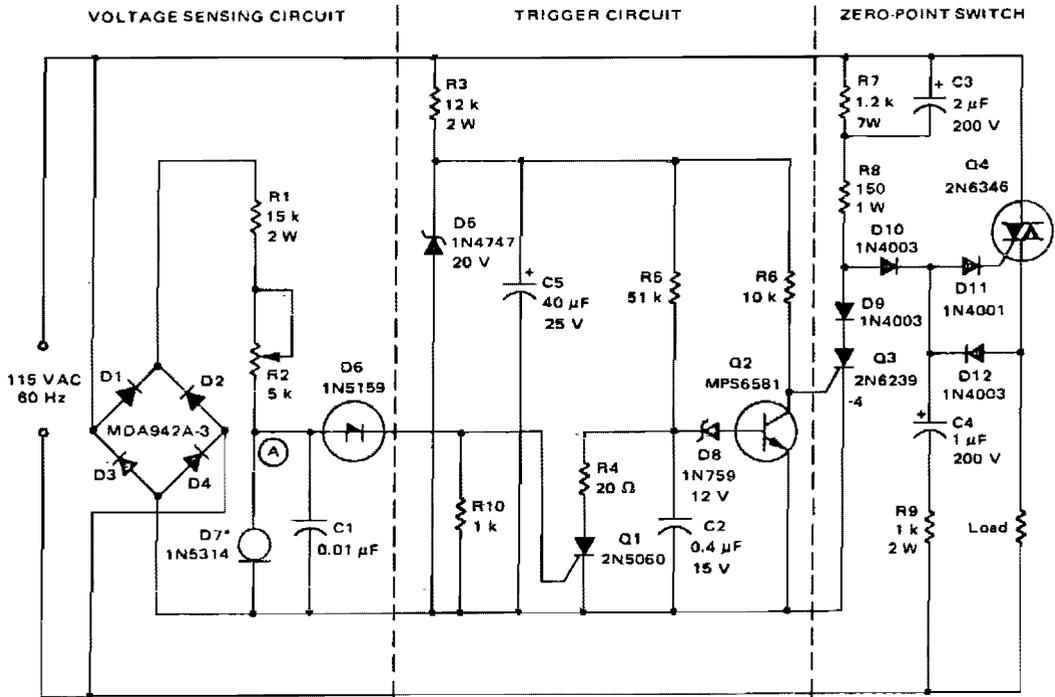
Fig. 66-3

Circuit Notes

These circuits provide overvoltage protection in case of voltage regulator failure or application of an external voltage. Intended to be used with a supply offering some form of short circuit protection, either foldback, current limiting, or a simple fuse. The most likely application is a 5 V logic supply, since TTL is easily damaged by excess voltage. The values chosen in A are for a 5 V supply, although any supply up to about 25 V can be protected by simply choosing the appropriate zener. When the supply voltage exceeds the zener

voltage +0.7 V, the transistor turns on and fires the thyristor. This shorts out the supply, and prevents the voltage rising any further. In the case of a supply with only fuse protection, it is better to connect the thyristor the regulator circuit when the crowbar operates. The thyristor should have a current rating about twice the expected short circuit current and a maximum voltage greater than the supply voltage. The circuit can be reset by either switching off the supply, or by breaking the thyristor circuit with a switch.

OVERVOLTAGE PROTECTION WITH AUTOMATIC RESET



*Two Diodes In Parallel

Fig. 66-4

OVERVOLTAGE PROTECTION FOR LOGIC

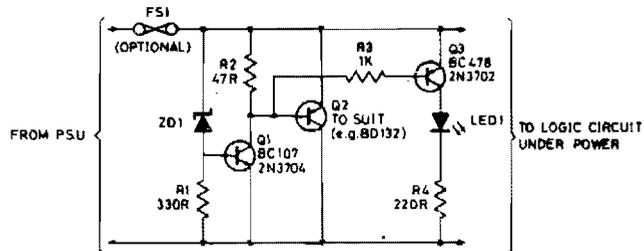


Fig. 66-5

Circuit Notes

Zener diode ZD1 senses the supply, and should the supply rise above 6 V, Q1 will turn on. In turn, Q2 conducts clamping the rail. Subsequent events depend on the source supply. It will either shut down, go into current limit or blow its supply fuse. None of these will damage

the TTL chips. The rating of Q2 depends on the source supply, and whether it will be required to operate continuously in the event of failure. Its current rating has to be in excess of the source supply.

FAST ACTING POWER SUPPLY PROTECTION

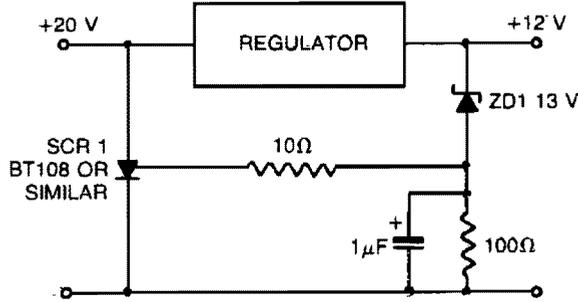


Fig. 66-6

Circuit Notes

When using a regulated power supply to reduce a supply voltage, there is always the danger that component failure in the power supply might lead to a severe overvoltage condition across the load. To cope with overvoltage situations, the circuit is designed to protect the load under overvoltage conditions. Component values given are for a 20 V supply

with regulated output at 12 V. The zener diode can be changed according to whatever voltage is to be the maximum. If the voltage at the regulator output rises to 13 V or above, the zener diode breaks down and triggers the thyristor which shorts out the supply line and blows the main fuse.

5 V CROWBAR

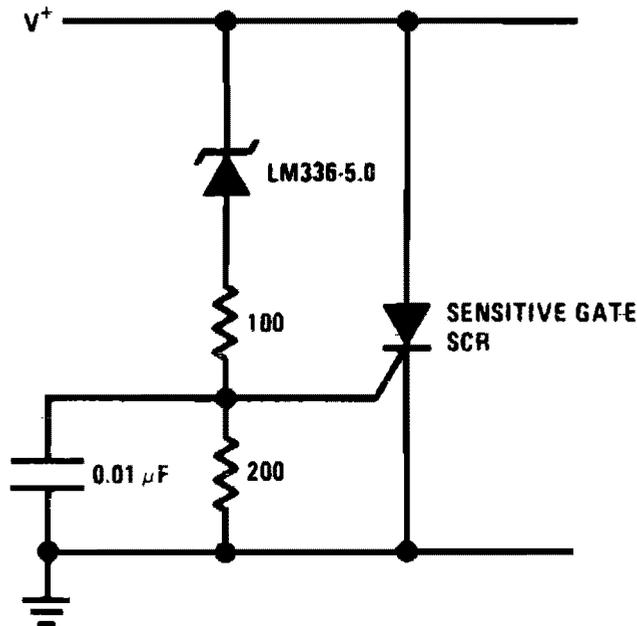


Fig. 66-7

67

Probes

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Logic Probe Yields Three Discrete States
Signal Injector/Tracer
Injector/Tracer
CMOS Logic Probe
RF Probe for VOM
100 K Megohm DC Probe

Audible TTL Probe
Logic Probe
Logic Test Probe with Memory
Logic Probe
Simple Logic Probe
Audio-RF Signal Tracer Probe

TTL Logic Tester

LOGIC PROBE YIELDS THREE DISCRETE STATES

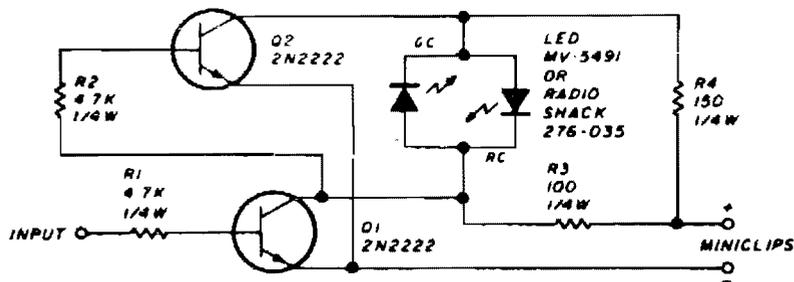


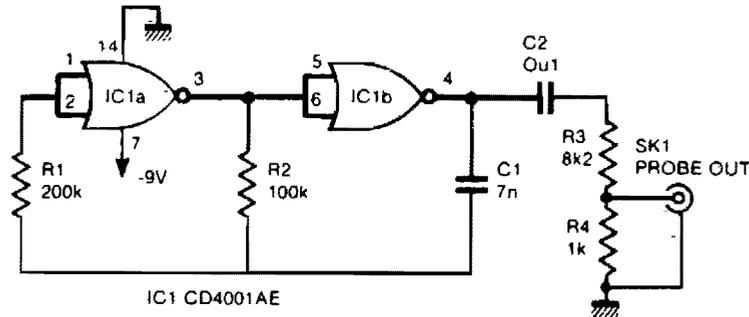
Fig. 67-1

Circuit Notes

The circuit uses a dual LED. When power is applied to the probe through the power leads, and the input is touched to a low level or ground, Q1 is cut off. This will cause Q2 to conduct since the base is positive with respect to the emitter. With Q1 cut off and Q2 conducting, the green diode of the dual LED will be forward biased, yielding a green output. Touching the probe tip to a high level will cause

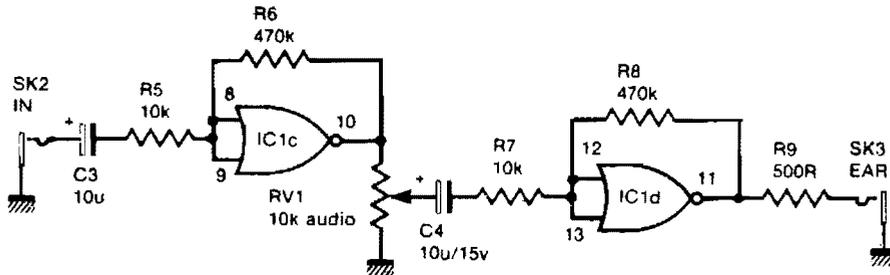
Q1 and Q2 to complement, and the red diode will be forward biased, yielding a red output from the LED. An alternating signal will cause alternating conduction of the red and green diodes and will yield an indication approximately amber. In this manner, both static and dynamic signals can be traced with the logic probe.

SIGNAL INJECTOR/TRACER



Injector circuit diagram.

Fig. 67-2



Tracer circuit diagram.

Circuit Notes

The injector is a CMOS oscillator with period approximately equal to $1.4 \times C1 \times R2$ seconds. The values are given for 1 kHz operation. Resistors R3 and R4 divide the output to 1 V. Whereas the oscillator employs the gates in their digital mode, the tracer used them in a linear fashion by applying negative feedback from output to input. They are used in much the same way as op amps. The circuit uses positive

ground. It offers an advantage at the earphone output because one side of the earphone must be connected to ground via the case. Use of a positive ground allows the phone to be driven by the two N-channel transistors inside the CD4001 which are arranged in parallel and are thus able to handle more current for better volume.

INJECTOR/TRACER

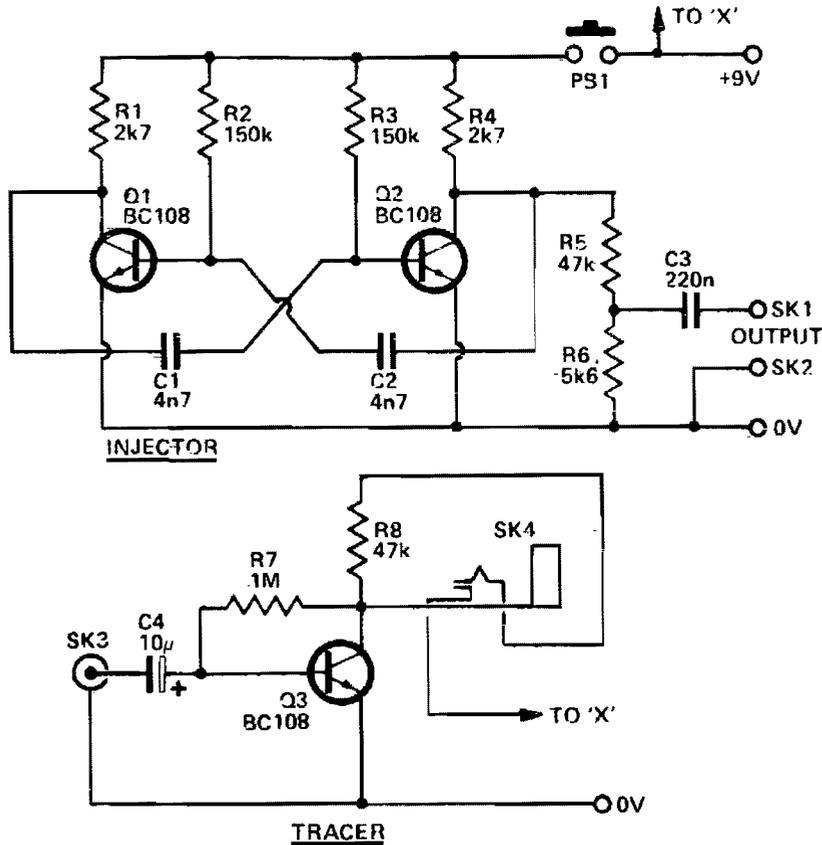


Fig. 67-3

The circuit diagrams for both parts of the injector/tracer. Note that SK4 is used to apply power to the amplifier section.

Circuit Notes

The unit has a separate amplifier and oscillator section allowing them to be used separately if need be. The injector is a multivibrator running at 1 kHz, with R5 and R6 dividing down

the output to a suitable level (≈ 1 V). The tracer is a single-stage amplifier that drives the high impedance earpiece. C4 decouples the input.

CMOS LOGIC PROBE

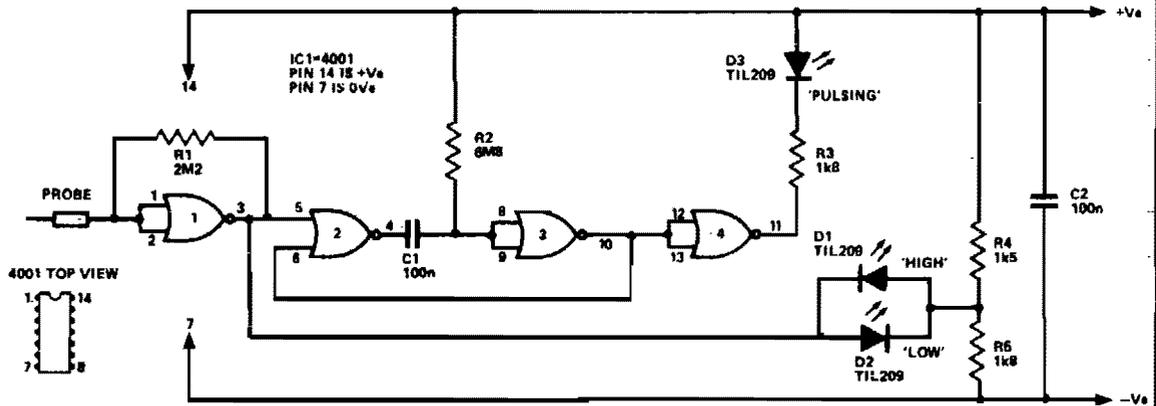


Fig. 67-4

Circuit Notes

The logic probe can indicate four input states, as follows: floating input—all LEDs off; logic 0 input—D2 switched on (D3 will briefly flash on); logic 1 input—D1 switched on; puls-

ing input—D3 switched on, or pulsing in the case of a low frequency input signal (one or both of the other indicators will switch on, showing if one input state predominates).

RF PROBE FOR VOM

PARTS LIST FOR RF PROBE FOR VOM

- C1—500-pF, 400-VDC capacitor
- C2—0.001- μ F, disc capacitor
- D1—1N4149 diode
- R1—15,000-ohm, 1/2-watt resistor

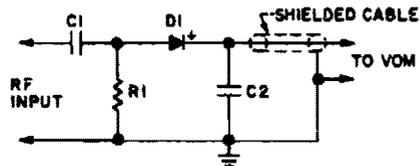


Fig. 67-5

Circuit Notes

This probe makes possible relative measurements of rf voltages to 200 MHz on a 20,000 ohms-per-volt multimeter. Rf voltage must not exceed the breakdown rating of the 1N4149—approximately 100 V.

100 K MEGOHM DC PROBE

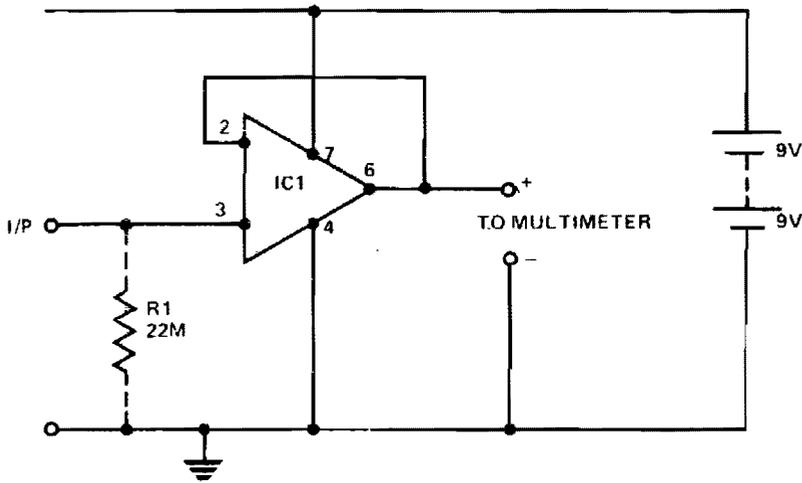


Fig. 67-6

Circuit Notes

A 741 op amp is used with 100% ac and dc feedback to provide a typical input impedance of 10^{11} ohm and unity gain. To avoid hum and rf pickup the input leads should be kept as short as possible and the circuit should be mounted in a small grounded case. Output leads may be

long since the output impedance of the circuit is a fraction of an ohm. With no input the output level is indeterminate. Including R1 in the circuit through lowers the input impedance to 22 M.

AUDIBLE TTL PROBE

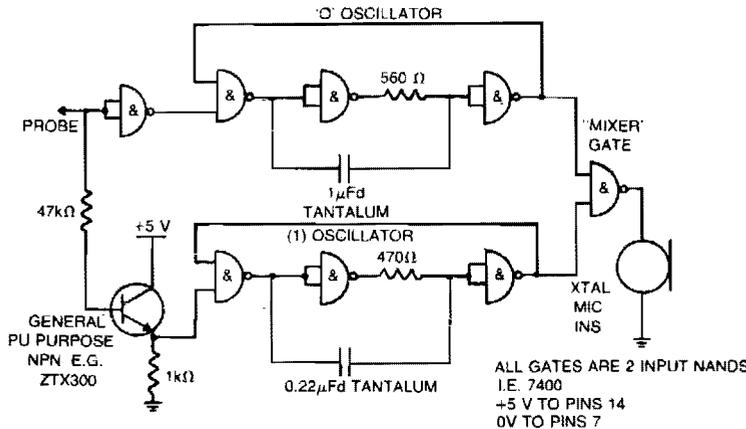


Fig. 67-7

Circuit Notes

When the probe is in contact with a TTL low (0) the probe emits a low note. With a TTL high (1), a high note is emitted. Power is supplied by the circuit under test.

LOGIC PROBE

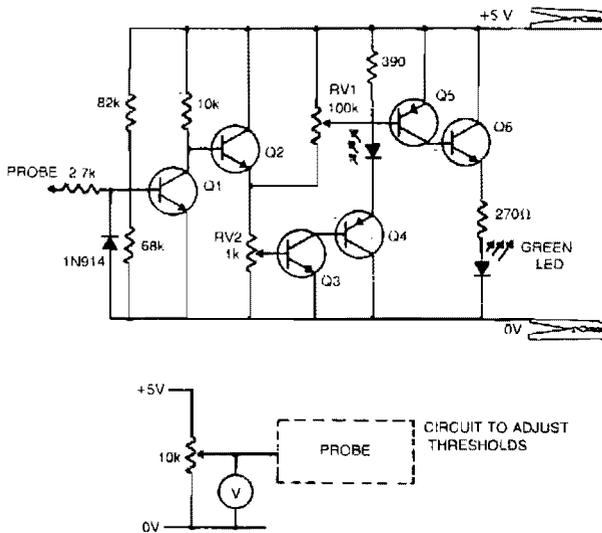


Fig. 67-8

Circuit Notes

Transistors Q1 and Q2 form a buffer, providing the probe with a reasonable input impedance. Q3 and Q4 form a level detecting circuit. As the voltage across the base-emitter junction of the Q3 rises above 0.6 V the transistor turns on thus turning on Q4 and lighting the red (high) LED. Q5 and Q6 perform the same func-

tion but for the green (low) LED. Q1, Q4, Q5 are all PNP general purpose silicon transistors (BC178 etc). Q2, Q3, Q6 are all PNP general purpose silicon transistors (BC 108 etc.) The threshold low is ≤ 0.8 V, and the threshold high is ≥ 2.4 V.

LOGIC TEST PROBE WITH MEMORY

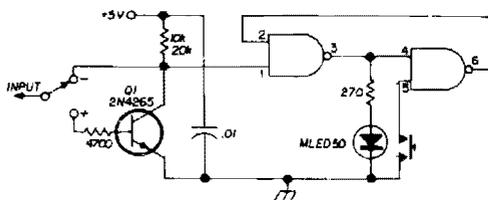


Fig. 67-9

Circuit Notes

There are two switches: a memory disable switch and a pulse polarity switch. Memory disable is a push-button that resets the memory to the low state when depressed. Pulse polarity is a toggle switch that selects whether the probe responds to a high-level or pulse (+5 V) or a low-level or pulse (ground). (Use IC logic of the same type as is being tested).

LOGIC PROBE

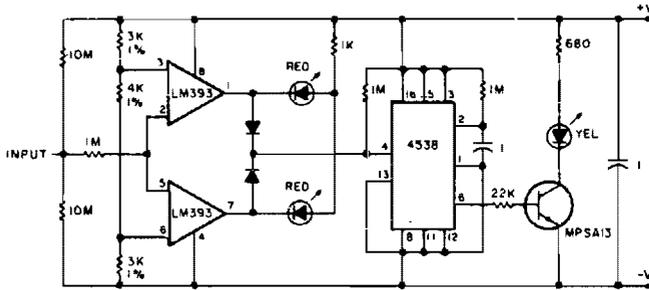


Fig. 67-10

Circuit Notes

The probe indicates a high or low at 70% and 30% of $V+$ (5 to 12 V). One section of the voltage comparator (LM393) senses V in over 70% of supply and the second section senses V in under 30%. These two sections direct-drive the appropriate LEDs. The pulse detector is a

CMOS oneshot (MC14538) triggered on the rising edge of the LM393 outputs through 1N4148 diodes. With the RC values shown, it triggered reliably at greater than 30 kHz on both sine and square waves.

SIMPLE LOGIC PROBE

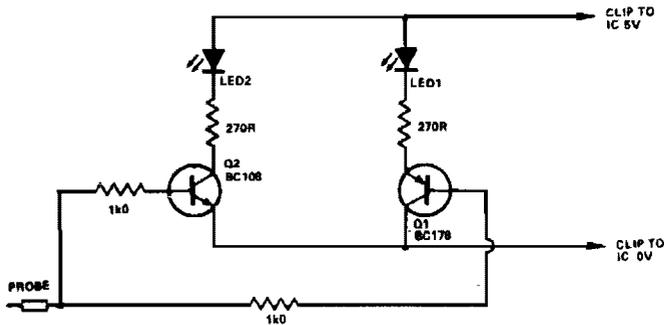
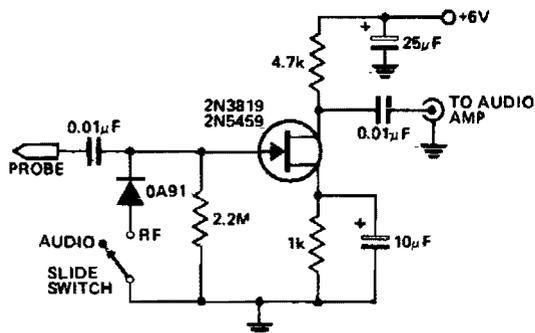


Fig. 67-11

Circuit Notes

If the probe is connected to logic 0, Q1 will be turned on lighting D1. At logic 1, Q2 will be turned on lighting D2. For Q1 and Q2 any NPN or PNP transistors will do. Similarly, D1 and D2 can be any LEDs.

AUDIO-RF SIGNAL TRACER PROBE



Circuit Notes

This economical signal tracer is useful for servicing and alignment work in receivers and low power transmitters. When switched to RF, the modulation on any signal is detected by the diode and amplified by the FET. A twin-core shielded lead can be used to connect the probe to an amplifier and to feed 6 volts to it.

Fig. 67-12

TTL LOGIC TESTER

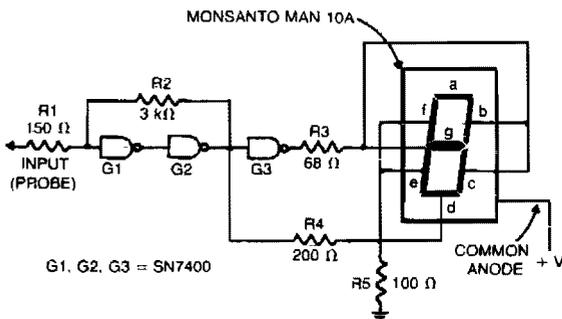


Fig. 67-13

Circuit Notes

Gates G1 and G2 together with resistors R1 and R2 form a simple voltage monitor that has a trip point of 1.4 volts. Gate G3 is simply an inverter. The display section of the tester consists of a common anode alphanumeric LED

and current-limiting resistors. It indicates whether the input voltage is above or below 1.4 V, and displays a H or a L (for high or low logic-level) respectively.

68

Pulse Generators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Pulse Generator
Single Op Amp Oscillator
Programmable Pulse Generator
Unijunction Transistor Pulse Generators
Pulse Generator

Pulse Generator
Free-Running Oscillator
Pulse Generator with 25% Duty Cycle
Pulse Generator
555 Timer Oscillator

Versatile Two-Phase Pulse Generator

PULSE GENERATOR

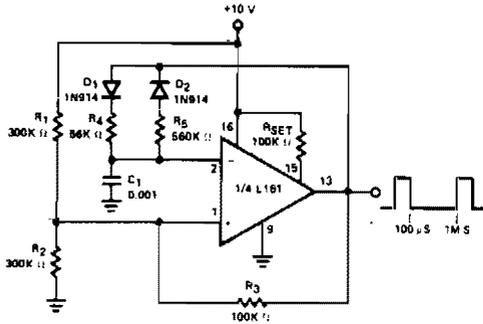


Fig. 68-1

Circuit Notes

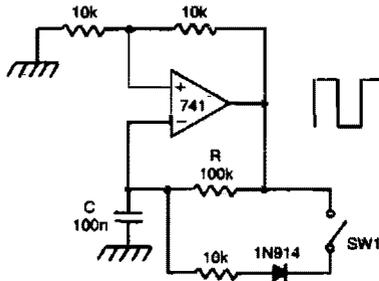
The duty cycle of the output pulse is equal to $R4/(R4 + R5) \times 100\%$. For duty cycles of less than 50%, D1 can be eliminated and R2 raised according to the following formula:

$$R4(\text{actual}) = \frac{R5 \times R4(\text{eff})}{R5 - R4(\text{eff})}$$

R4(eff) is the effective value of R4 in the circuit and R4(actual) is the actual value used; R4(actual) will always be larger than R4(eff).

SINGLE OP AMP OSCILLATOR

Circuit Notes

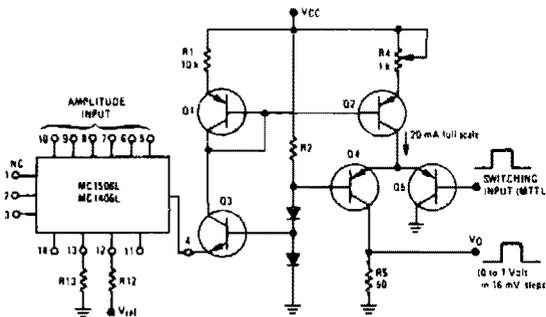


This circuit has a Schmitt trigger and integrator built around one op amp. Timing is controlled by the RC network. Voltage at the inverting input follows the RC charging exponential within the upper and lower hysteresis levels. By closing the switch SW1, the discharge time of the capacitor becomes ten times as fast as the rise time. Thus a square wave with an 10:1 mark space ratio is generated.

Fig. 68-2

PROGRAMMABLE PULSE GENERATOR

Circuit Notes



Fast rise and fall times require the use of high speed switching transistors for the differential pair, Q4 and Q5. Linear ramps and sine waves may be generated by the appropriate reference input.

Fig. 68-3

UNIJUNCTION TRANSISTOR PULSE GENERATORS

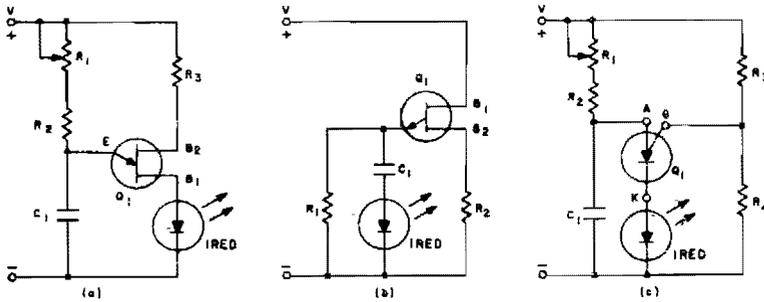


Fig. 68-4

(a) Pulsar With Unijunction Transistor

(b) Pulsar With Complementary Unijunction Transistor

(c) Pulsar With Programmable Unijunction Transistor

PULSE GENERATOR

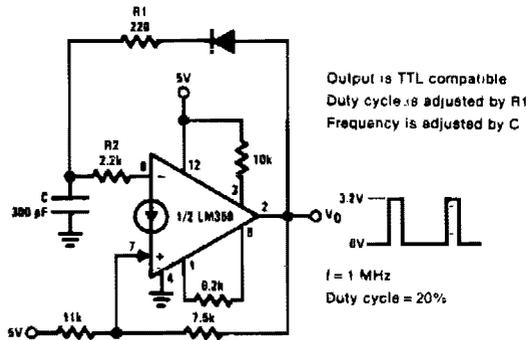


Fig. 68-5

PULSE GENERATOR

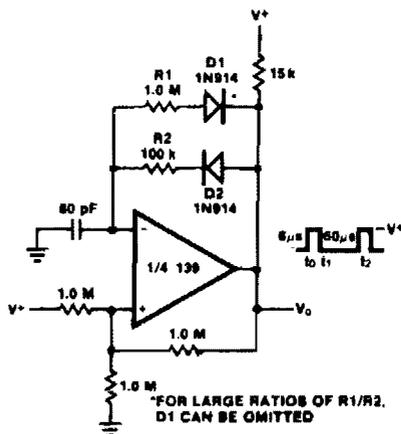


Fig. 68-6

FREE-RUNNING OSCILLATOR

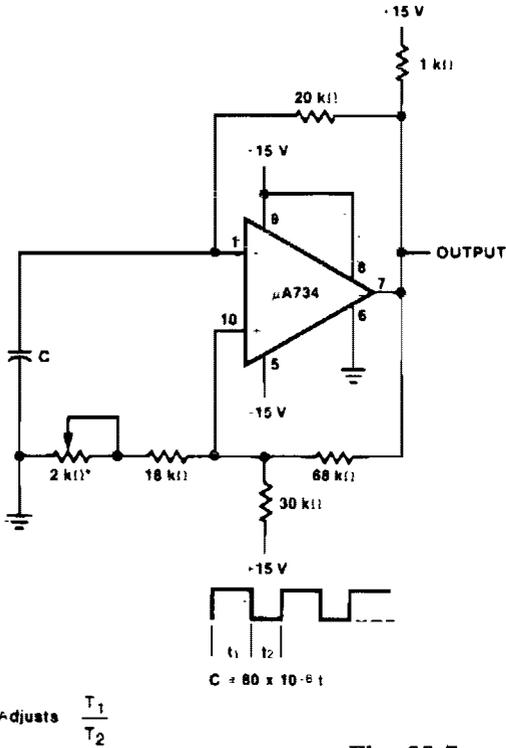


Fig. 68-7

PULSE GENERATOR

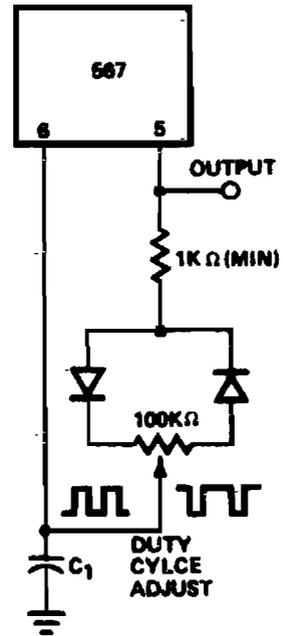


Fig. 68-9

PULSE GENERATOR WITH 25% DUTY CYCLE

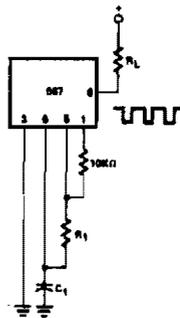
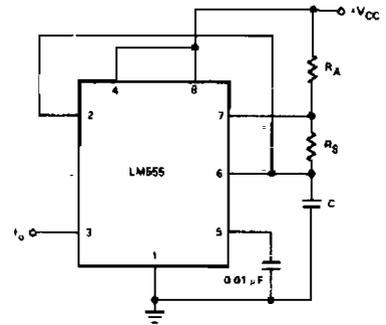


Fig. 68-8

555 TIMER OSCILLATOR



$$f = \frac{1.44}{(R_A + 2 R_B) C} \quad \text{duty cycle} = \frac{R_B}{R_A + 2 R_B}$$

a. $f = 120 \text{ kHz}$, $C = 1200 \text{ pF}$, $R_A = R_B = 10 \text{ k} \Omega$

Fig. 68-10

VERSATILE TWO-PHASE PULSE GENERATOR

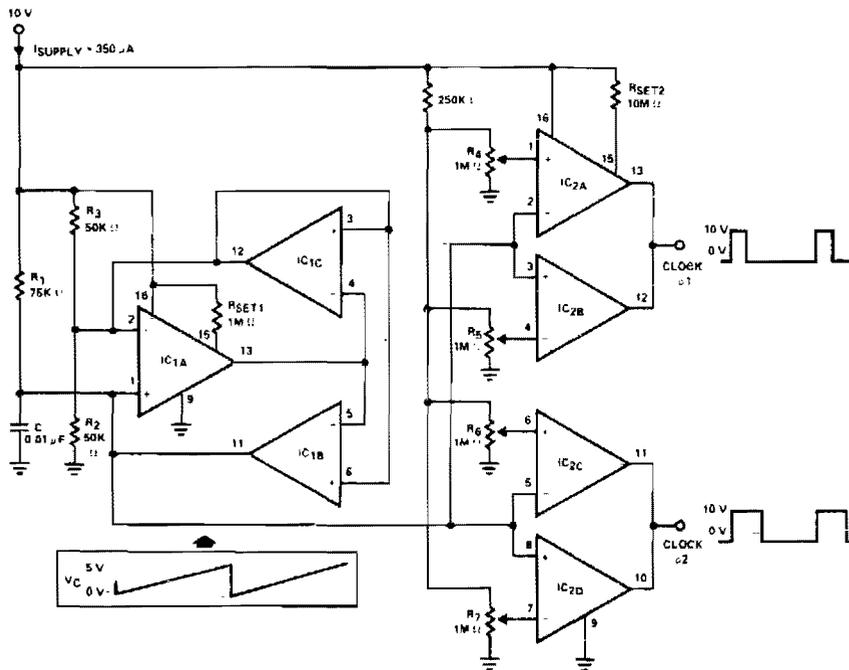
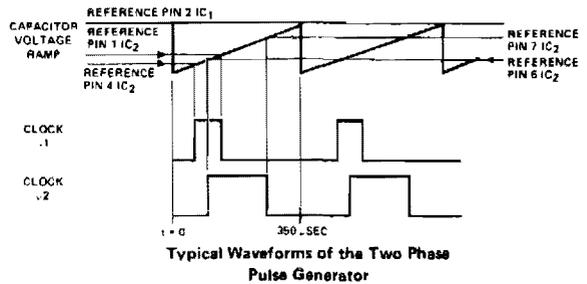


Fig. 68-11

Circuit Notes

Two-phase clock generator uses two L161s to generate pulses of adjustable widths and phase relationships. Ramp generator feeds two variable window comparators formed by IC_{2A}-IC_{2B} and IC_{2C}-IC_{2D} respectively.

69

Radiation Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dosage-Rate Meter
Wideband Radiation Monitor
Gamma Ray Pulse Integrator

Sensitive Geiger Counter
Geiger Counter
Nuclear Particle Detector

DOSAGE-RATE METER

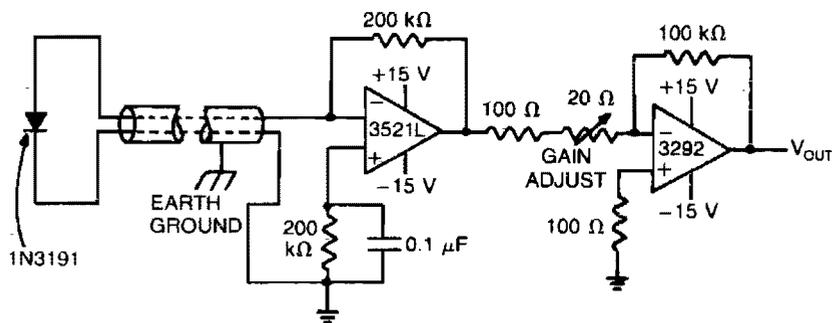
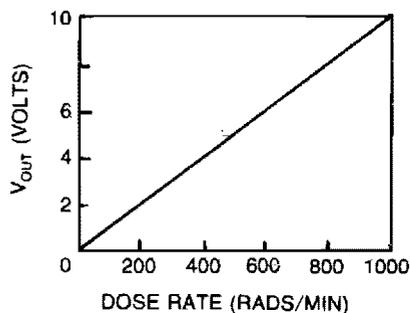


Fig. 69-1



Circuit Notes

A commercial diode is the detector in this highly accurate radiation monitor. The lowdrift FET-input op amp amplifies detector current to a usable level, and the chopper-stabilized amplifier then provides additional gain while minimizing any error caused by ambient-temperature fluctuations. Gain is adjusted so

that the output voltage is 1% of incident radiation intensity in rads per minute; therefore voltage can be displayed on 3½ digit DVM for direct reading of dosage rate. Output voltage from the monitor is linearly proportional to radiation intensity at the diode.

WIDEBAND RADIATION MONITOR

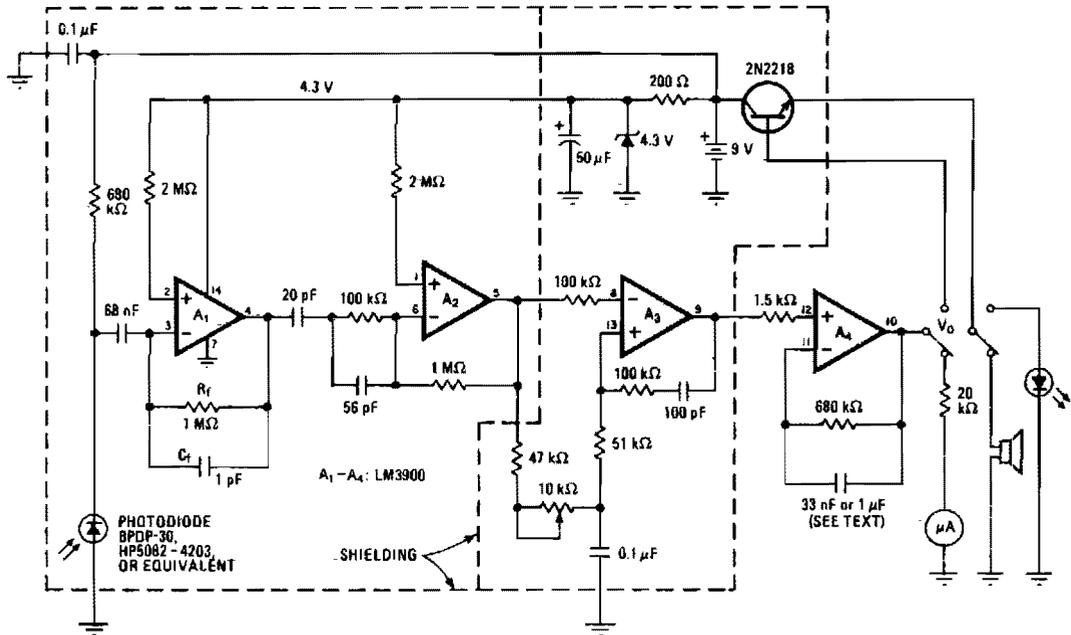


Fig. 69-2

Circuit Notes

A sensitive radiation monitor may be simply constructed with a large-area photodiode and a quad operational amplifier. Replacing the glass window of the diode with Mylar foil will shield it from light and infrared energy, enabling it to respond to such nuclear radiation as alpha and beta particles and gamma rays. A4

integrates the output of A3 in order to drive a microammeter. A 1 microfarad capacitor is used in the integrating network. A lower value, say, 33 nanofarads, will make it possible to drive a small loudspeaker (50-hertz output signal) or light-emitting diode.

GAMMA RAY PULSE INTEGRATOR

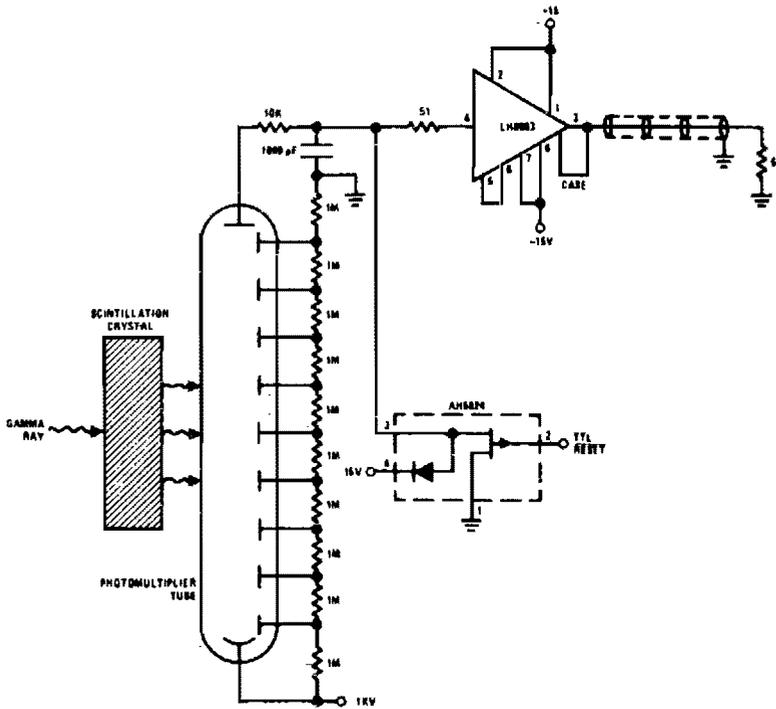


Fig. 69-3

SENSITIVE GEIGER COUNTER

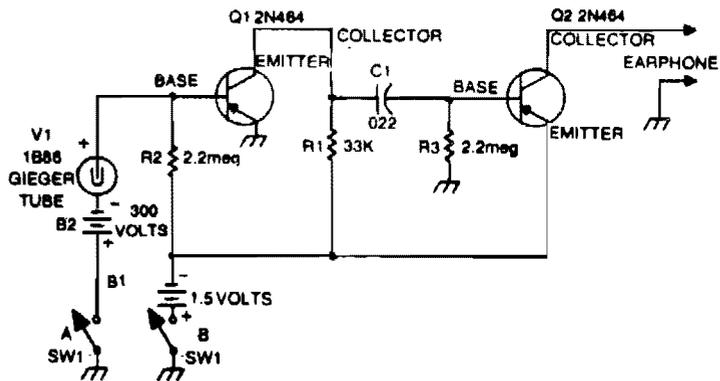


Fig. 69-4

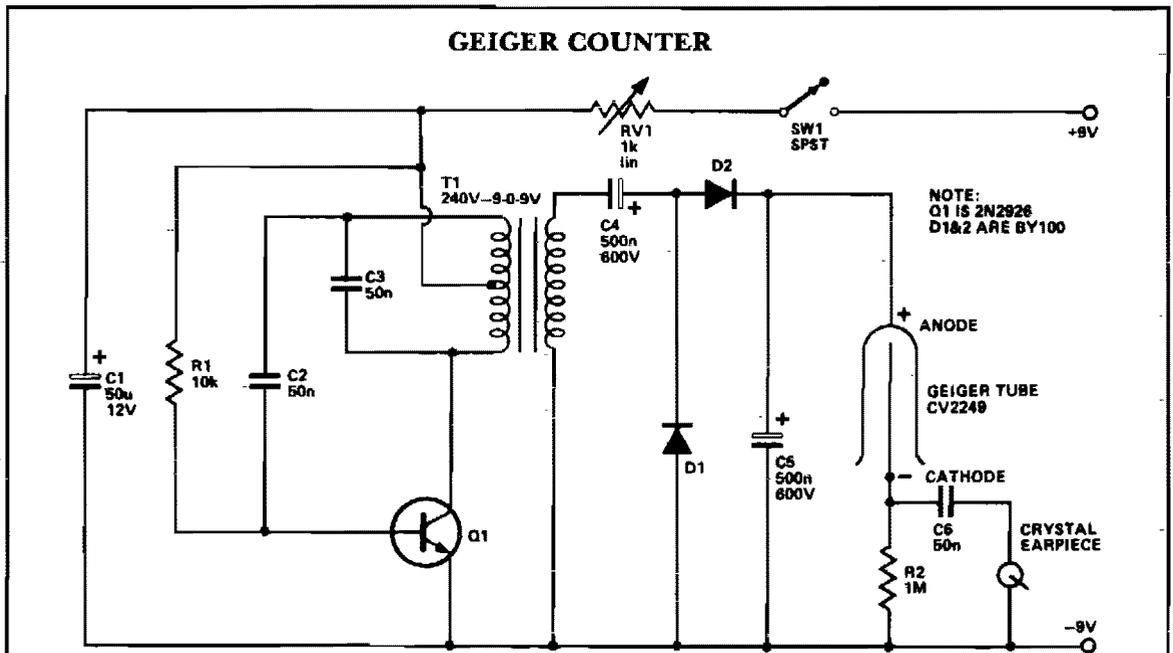


Fig. 69-5

Circuit Notes

The Geiger tube needs a high voltage supply which consists of Q1 and its associated components. The transformer is connected in reverse; the secondary is connected as a Hartley oscillator, and R1 provides base bias.

D1, D2, C4, and C5 comprise a voltage doubler. RV1 should be set so that each click heard is nice and clean because over a certain voltage range all that will be heard is a continuous buzz.

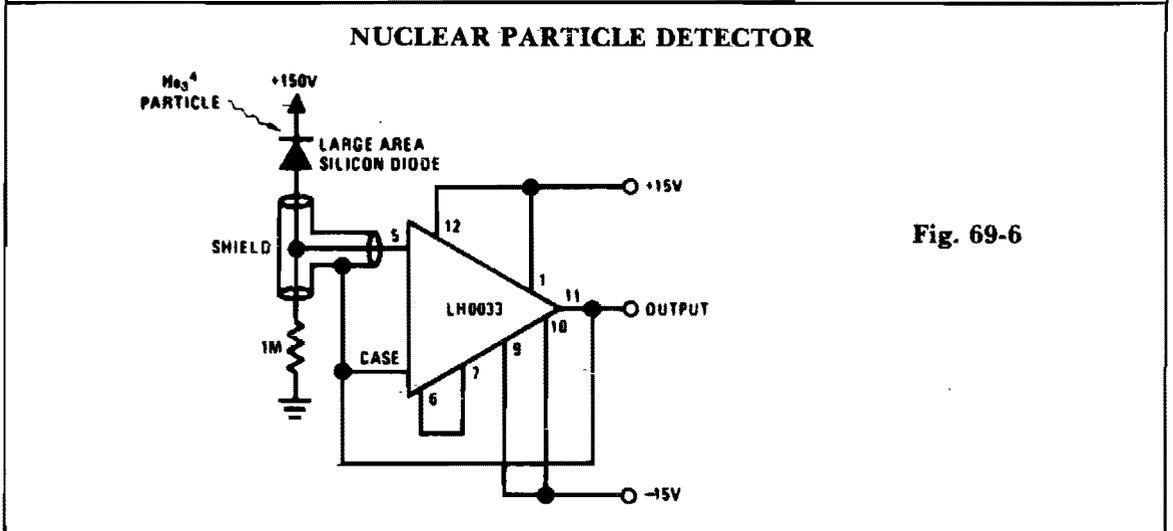


Fig. 69-6

70

Ramp Generators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Staircase Generator

Linear Voltage Ramp Generator

Precision Ramp Generator

Ramp Generator with Variable Reset Level

STAIRCASE GENERATOR

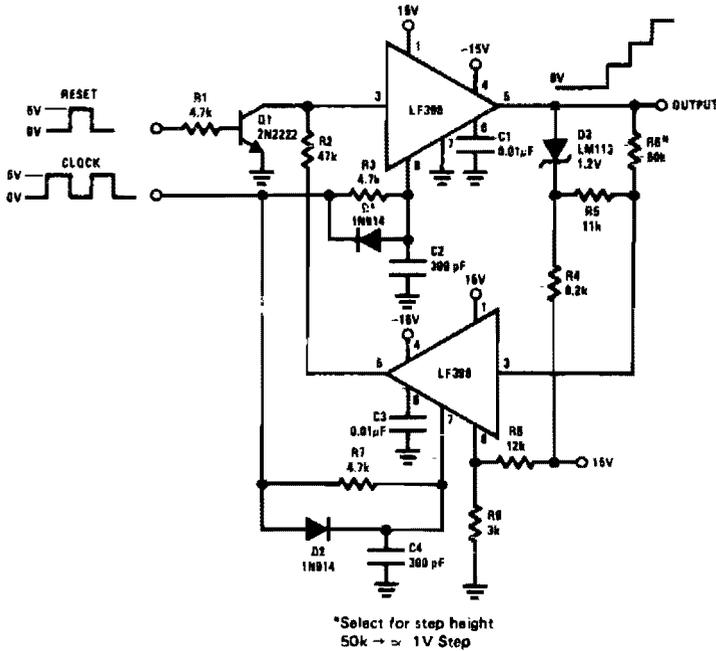


Fig. 70-1

LINEAR VOLTAGE RAMP GENERATOR

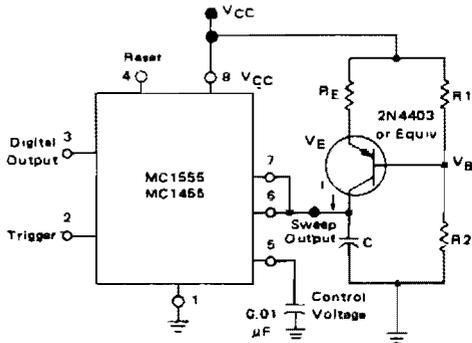


Fig. 70-2

Circuit Notes

In the monostable mode, the resistor can be replaced by a constant current source to provide a linear ramp voltage. The capacitor still charges from 0 to $2/3 V_{CC}$. The linear ramp time is given by the following equation:

$$I = \frac{V_{CC} - V_B - V_{BE}}{R_E} \quad t = \frac{2}{3} \frac{V_{CC}}{I}$$

If V_B is much larger than V_{BE} , then t can be made independent of V_{CC} .

PRECISION RAMP GENERATOR

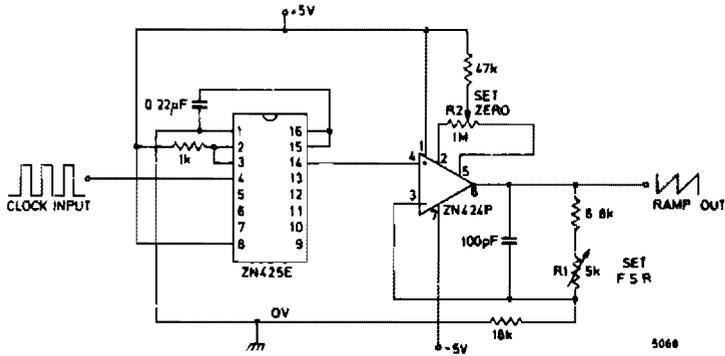


Fig. 70-3

RAMP GENERATOR WITH VARIABLE RESET LEVEL

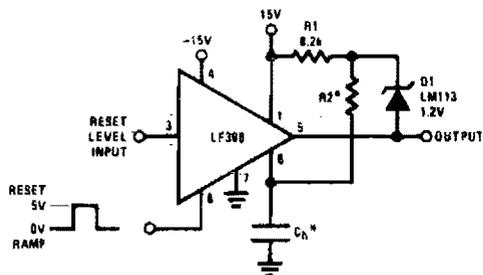


Fig. 70-4

*Select for ramp rate
 $R \geq 10k$

$$\frac{\Delta V}{\Delta T} = \frac{1.2V}{(R2)(C_n)}$$

71

Receivers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Clock Radio
AM/FM Clock Radio
AM Radio
FM Stereo Demodulation System
Analog Receiver

FM Radio
Simple LF Converter
CMOS Line Receiver
Squelch Circuit for AM or FM
VLF Converter

CLOCK RADIO

ICM7223 VF
TYPICAL AUTO CLOCK/RADIO
APPLICATION

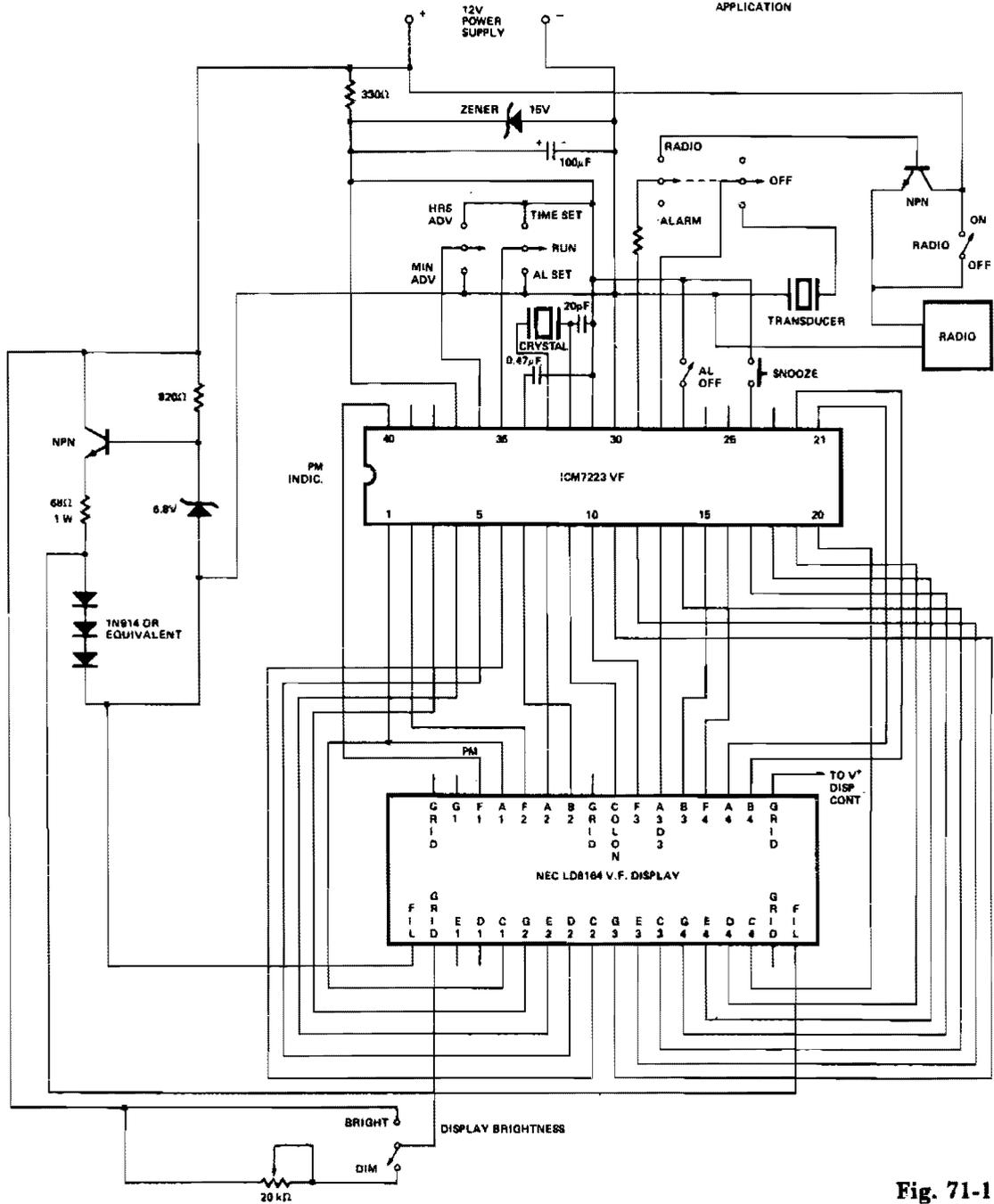
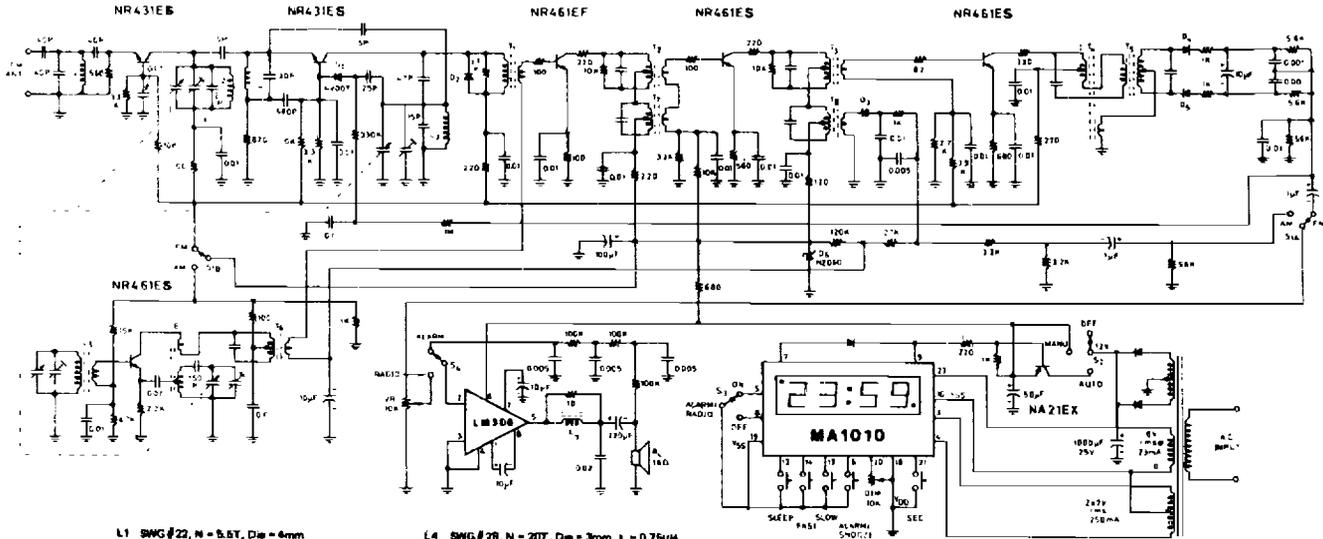


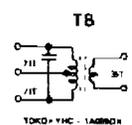
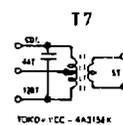
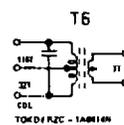
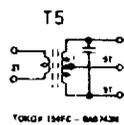
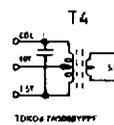
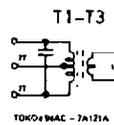
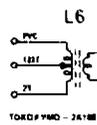
Fig. 71-1

AM/FM CLOCK RADIO



- L1 SWG #22, N = 5.5T, D_o = 4mm
- L2 SWG #22, N = 4T, D_o = 4mm
- L3 SWG #22, N = 4T, D_o = 3mm

- L4 SWG #28, N = 20T, D_o = 3mm L = 0.75μH
- L5 95T, 8T, L = 600μH, C_u = 300
- L7 N = 1.5T, PHILIPS #6312-020-34401



FM performance (88-108 MHz)

- 30dB quieting sensitivity: 5μV
- limiting sensitivity: 20μV
- AM rejection: 40dB
- AFC holding range: 800KHz
- Bandwidth: 180KHz

AM performance (525-1650 KHz)

- maximum sensitivity: 100μV/M
- 20dB quieting sensitivity: 280μV/M
- selectivity ± 10KHz: -28dB
- AGC figure of merit: 40dB
- overload distortion: 6%

AUDIO performance

- gain at 1 KHz: 200
- 10% THD output power: 900mW
- frequency response: 70Hz - 12KHz
- typical system dist: 0.8%
- alarm tone frequency: 600Hz

Fig. 71-2

SIMPLE LF CONVERTER

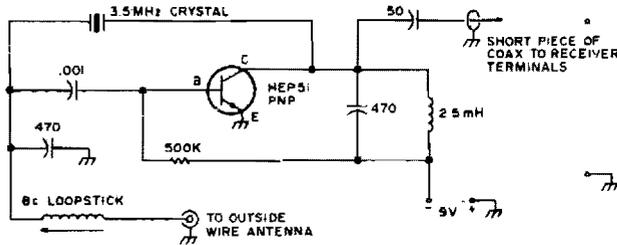


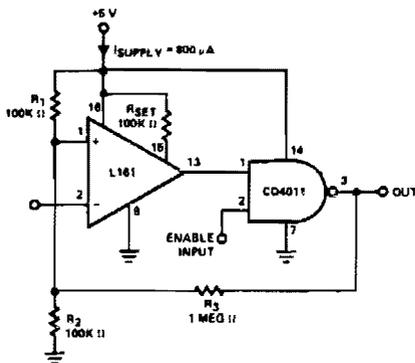
Fig. 71-7

Circuit Notes

This converter allows coverage from 25 kHz up to 500 kHz. Use short coax from the converter to receiver antenna input. Tune the receiver to 3.5 MHz, peak for loudest crystal

calibrator and tune your receiver higher in frequency to 3.6 MHz and you're tuning the 100 kHz range. 3.7 MHz puts you at 200 kHz, 3.8 MHz equals 300 kHz, 3.9 MHz yields 500 kHz, and 4.0 MHz gives you 500 kHz.

CMOS LINE RECEIVER



Circuit Notes

The trip point is set half way between the supplies by R1 and R2; R3 provides over 200 mV of hysteresis to increase noise immunity. Maximum frequency of operation is about 300 kHz. If response to TTL levels is desired, change R2 to 39 K. The trip point is now centered at 1.4 V.

Fig. 71-8

SQUELCH CIRCUIT FOR AM OR FM

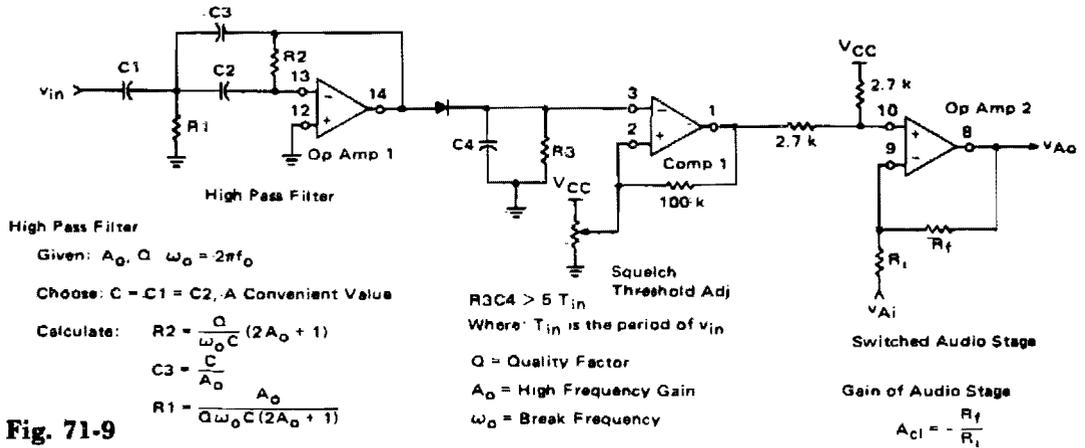


Fig. 71-9

VLF CONVERTER

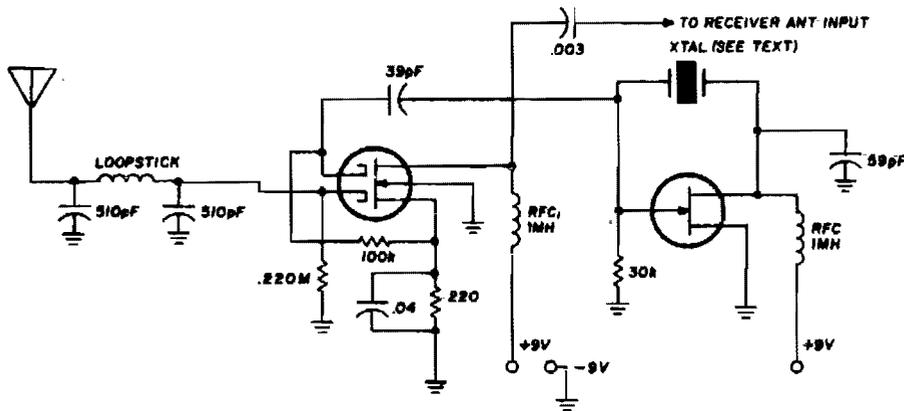


Fig. 71-10

Circuit Notes

This converter uses a low-pass filter instead of the usual tuned circuit so the only tuning required is with the receiver. The dual-gate MOSFET and FET used in the mixer and oscillator aren't critical. Any crystal having a frequency compatible with the receiver tuning range may be used. For example, with a 3500

kHz crystal, 3500 kHz on the receiver dial corresponds to zero kHz; 3600 to 100 kHz; 3700 to 200 kHz, etc. (At 3500 kHz on the receiver all one can hear is the converter oscillator, and VLF signals start to come in about 20 kHz higher.)

72

Resistance and Continuity Measuring Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Linear Scale Ohmmeter
Ohmmeter

Low Parts Count Ratiometric Resistance
Measurement

Audio Continuity Tester

Low Resistance Continuity Tester

“Buzz Box” Continuity and Coil Checker

Linear Scale Ohmmeter

Bridge Circuit

LOW PARTS COUNT RATIOMETRIC RESISTANCE MEASUREMENT

Circuit Notes

The unknown resistance is put in series with a known standard and a current passed through the pair. The voltage developed across the unknown is applied to the input and the voltage across the known resistor applied to the reference input. If the unknown equals the standard, the display will read 1000. The displayed reading can be determined from the following expression:

$$\text{Displayed Reading} = \frac{R_{\text{unknown}}}{R_{\text{standard}}} \times 1000$$

The display will overrange for $R_{\text{unknown}} \geq 2 \times R_{\text{standard}}$.

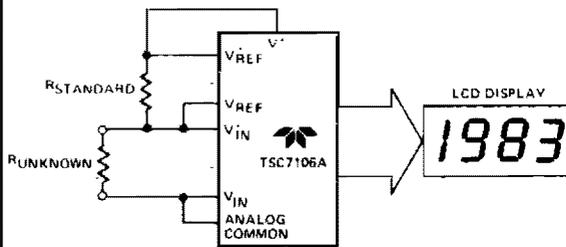


Fig. 72-3

AUDIO CONTINUITY TESTER

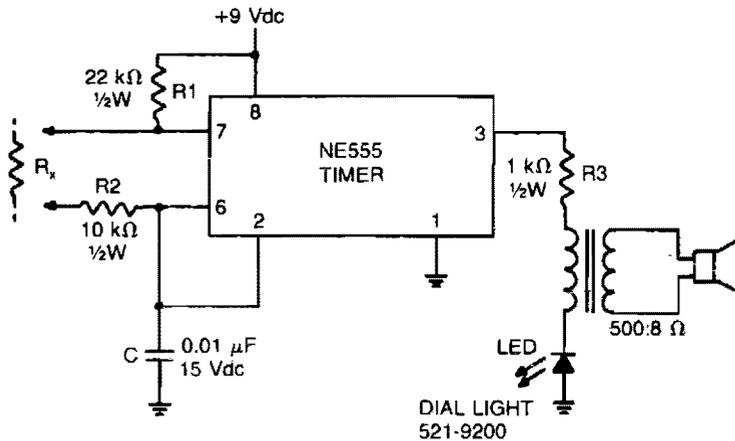


Fig. 72-4

Circuit Notes

This low-current audio continuity tester indicates the unknown resistance value by the frequency of audio tone. A high tone indicates a low resistance, and a tone of a few pulses per second indicates a resistance as high as 30 megohms.

LOW RESISTANCE CONTINUITY TESTER

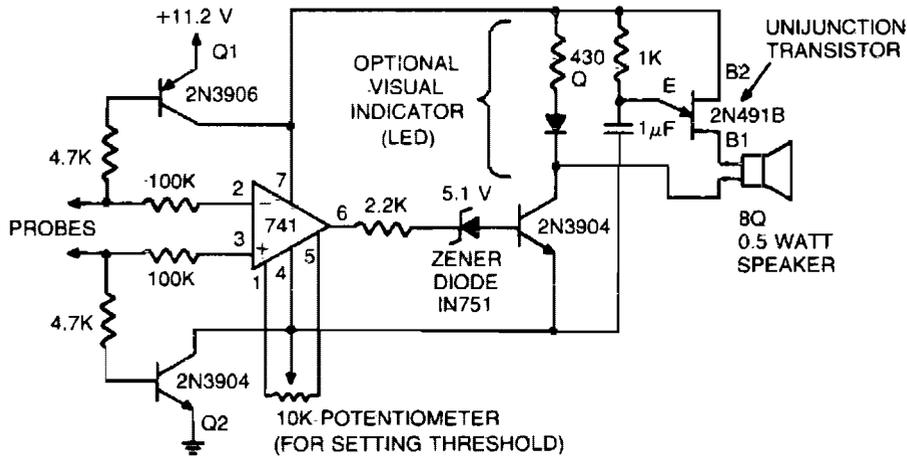


Fig. 72-5

NOTE: ALL RESISTANCES ARE IN OHMS UNLESS OTHERWISE INDICATED.

Circuit Notes

This tester can be used to check IC printed circuit boards. Two 4.7 K resistors and the transistors connected to them prevent current flow through the operational amplifier until the probe circuit is completed. The zener

diode in series with the operational amplifier output prevents audio oscillator operation until the positive output of the operational amplifier has sufficient amplitude.

"BUZZ BOX" CONTINUITY AND COIL CHECKER

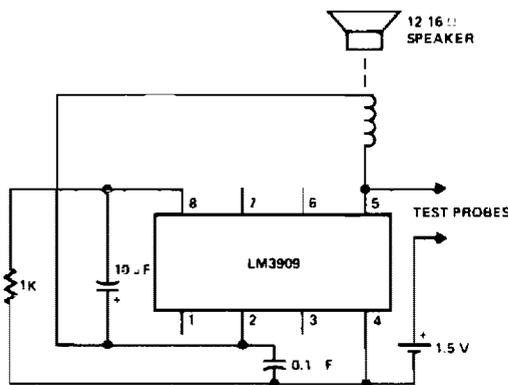


Fig. 72-6

Circuit Notes

Differences between shorts, coils, and a few ohms of resistance can be heard.

LINEAR SCALE OHMMETER

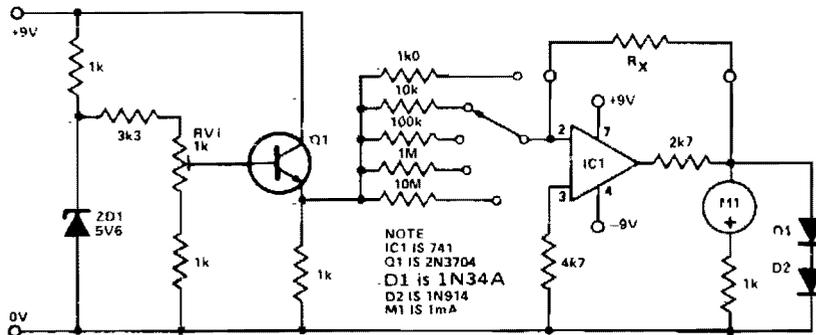


Fig. 72-7

Circuit Notes

One preset resistor is used for all the ranges, simplifying the setting up. Diode clamping is included to prevent damage to the meter if the unknown resistor is higher than the range selected. When the meter has been as-

sembled, a 10 K precision resistor is placed in the test position, R_x ; the meter is set to the 10 K range and RV1 is adjusted for full scale deflection.

BRIDGE CIRCUIT

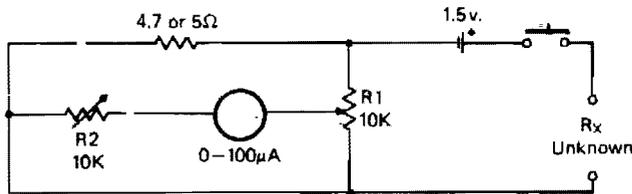


Fig. 72-8

Circuit Notes

For measurement of resistances from about 5 ohms down to about 1/10 ohm.

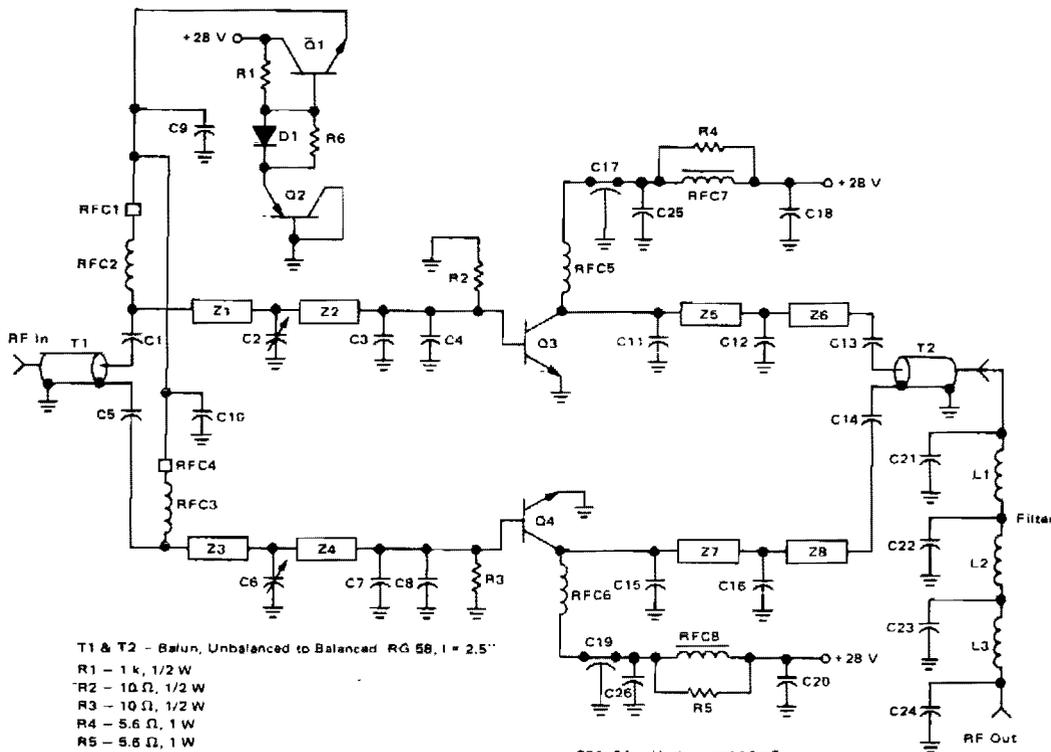
RF Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

100 W PEP 420-450 MHz Push-Pull Linear Amplifier
 140 W (PEP) Amateur Radio Linear Amplifier (230 MHz)
 160 W (PEP) Broadband Linear Amplifier
 80 W (PEP) Broadband/Linear Amplifier Single-Device, 80 W, 50 Ohm VHF Amplifier
 600 W RF Power Amplifier
 Wideband UHF Amplifier with High-Performance FETs
 10 MHz Coaxial Line Driver
 VHF Preamplifier
 Shortwave FET Booster
 Low-Noise 30 MHz Preamplifier
 Low-Noise Broadband Amplifier
 Two-Meter 10 Watt Power Amplifier
 Two-Stage 60 MHz IF Amplifier

28 V Wideband Amplifier
 200 MHz Cascode Amplifier
 135-175 MHz Amplifier
 200 MHz Cascode Amplifier
 100 MHz and 400 MHz Neutralized Common Source Amplifier
 Ultra High Frequency Amplifier
 UHF Amplifier Inverting Gain of 2 with Lag-Lead Compensation
 Transistorized Q-Multiplier for Use with IFs in the 1400 kHz Range
 60 MHz Amplifier
 30 MHz Amplifier
 Two Meter Amplifier, 5 W Output
 80 MHz Cascode Amplifier
 200 MHz Neutralized Common Source Amplifier
 450 MHz Common-Source Amplifier

100 W PEP 420-450 MHz PUSH-PULL LINEAR AMPLIFIER



T1 & T2 - Balun, Unbalanced to Balanced RG 58, 1 = 2.5"

R1 - 1 k, 1/2 W

R2 - 10 Ω, 1/2 W

R3 - 10 Ω, 1/2 W

R4 - 5.6 Ω, 1 W

R5 - 5.6 Ω, 1 W

R6 - 2.7 Ω, 1/4 W

Z1 & Z3 - Microstrip - W = 200 mils, l = 1.8"

Z2 & Z4 - Microstrip - W = 200 mils, l = 300 mils

Z5 & Z6 - Microstrip - W = 150 mils, l = 300 mils

Z6 & Z8 - Microstrip - W = 150 mils, l = 1.4"

RFC1, 4 - Ferroxcube Bead 56 590-65-38

RFC2, 3 - 0.15 μH Cambion Mailed Coil

RFC5, 6 - 1 Turn #20 Enameled Wire Wound on 5/16" Bolt

RFC7, 8 - VK20D 20/4B

C1, 3, 4, 5, 7, 8, 11, 15 - Underwood 40 pF

C12, 16 - Underwood 25 pF

C13, 14, 22, 23 - Underwood 16 pF

C9, 10, 18, 20 - 1 μF Tantalum

C21, 24 - Underwood 10 pF

C2, 6 - Arcb 403

C17, 19 - Underwood J102, 1000 pF Feed Thru

C25, 26 - 0.1 μF, Erie Red Cap

L1 - 24 nH, #14 Wire, l = 1.2"

L2 - 12 nH, #14 Wire, l = 0.6"

L3 - 24 nH, #14 Wire, l = 1.2"

Board - G10, cR ≈ 5, t = 0.062", l = 8.0", W = 4.0"

Q1 - 2N5192

Q2 - 2N5194

Q3 - MRF309

Q4 - MRF309

D1 - 1N4001

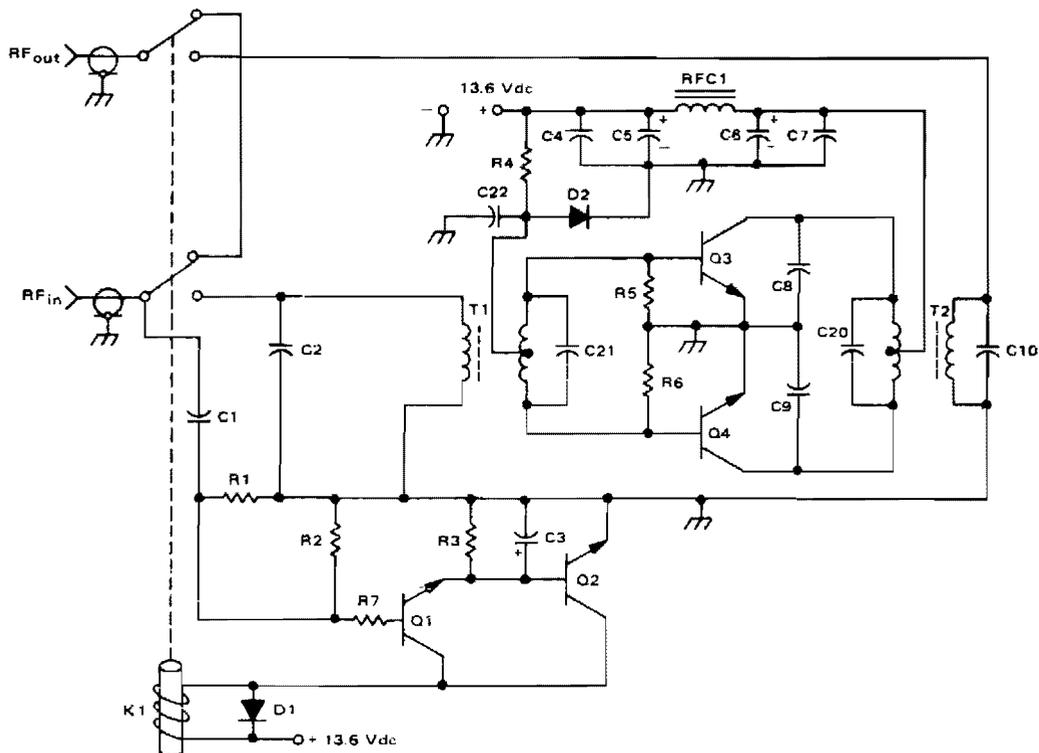
Fig. 73-1

Circuit Notes

This 100 watt linear amplifier may be constructed using two MRF309 transistors in push-pull, requiring only 16 watts drive from 420 to 450 MHz. Operating from a 28 volt supply, eight dB of power gain is achieved along with excellent practical performance

featuring: maximum input SWR of 2:1, harmonic suppression more than -63 dB below 100 watts output, efficiency greater than 40%, circuit stability with a 3:1 collector mismatch at all phase angles.

140 W (PEP) AMATEUR RADIO LINEAR AMPLIFIER (2-30 MHz)



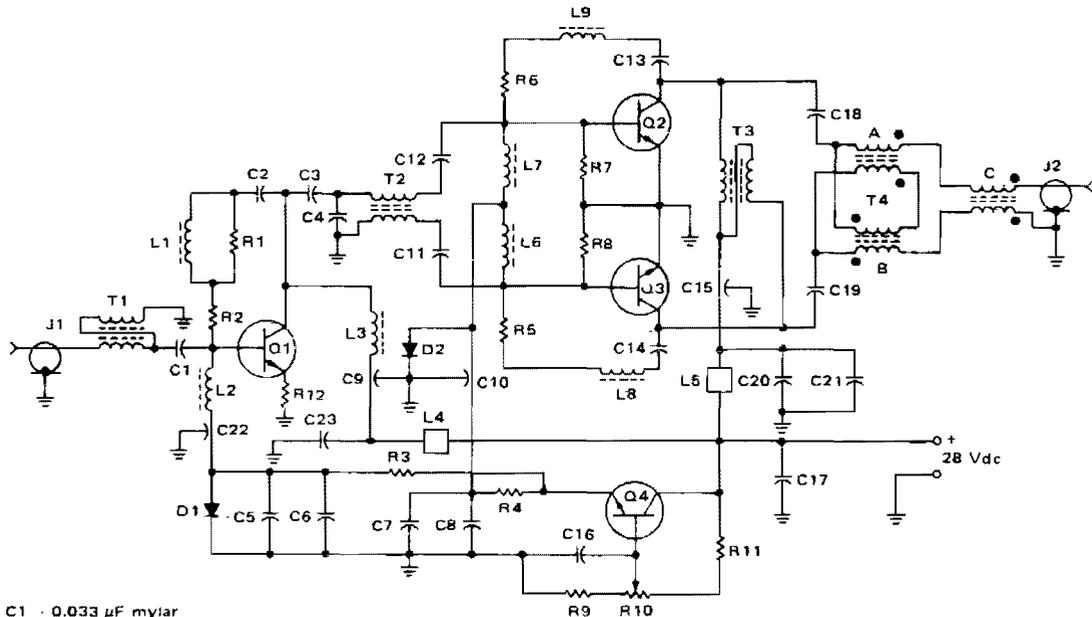
- | | | | |
|-------|--|--------|--|
| C1 | = 33 pF Dipped Mica | R7 | = 100 Ω 1/4 W Resistor |
| C2 | = 18 pF Dipped Mica | RFC1 | = 9 Ferroxcube Beads on #18 AWG Wire |
| C3 | = 10 μ F 35 Vdc for AM operation,
100 μ F 35 Vdc for SSB operation. | D1 | = 1N4001 |
| C4 | = .1 μ F Erie | D2 | = 1N4997 |
| C5 | = 10 μ F 35 Vdc Electrolytic | Q1, Q2 | = 2N4401 |
| C6 | = 1 μ F Tantalum | Q3, 4 | = MRF454 |
| C7 | = .001 μ F Erie Disc | T1, T2 | = 16:1 Transformers |
| C8, 9 | = 330 pF Dipped Mica | C20 | = 910 pF Dipped Mica |
| R1 | = 100 k Ω 1/4 W Resistor | C21 | = 1100 pF Dipped Mica |
| R2, 3 | = 10 k Ω 1/4 W Resistor | C10 | = 24 pF Dipped Mica |
| R4 | = 33 Ω 5 W Wire Wound Resistor | C22 | = 500 μ F 3 Vdc Electrolytic |
| R5, 6 | = 10 Ω 1/2 W Resistor | K1 | = Potter & Brumfield
KT11A 12 Vdc Relay or Equivalent |

Fig. 73-2

Circuit Notes

This inexpensive, easy to construct amplifier uses two MRF454 devices. Specified at 80 W power output with 5 W of input drive, 30 MHz, and 12.5 Vdc.

160 W (PEP) BROADBAND LINEAR AMPLIFIER



C1 - 0.033 μ F mylar

C2, C3 - 0.01 μ F mylar

C4 - 620 pF dipped mica

C5, C7, C16 - 0.1 μ F ceramic

C6 - 100 μ F/15 V electrolytic

C8 - 500 μ F/6 V electrolytic

C9, C10, C15, C22 - 1000 pF feed through

C11, C12 - 0.01 μ F

C13, C14 - 0.015 μ F mylar

C17 - 10 μ F/35 V electrolytic

C18, C19, C21 - Two 0.068 μ F mylars in parallel

C20 - 0.1 μ F disc ceramic

C23 - 0.1 μ F disc ceramic

R1 - 220 Ω , 1/4 W carbon

R2 - 47 Ω , 1/2 W carbon

R3 - 820 Ω , 1 W wire W

R4 - 35 Ω , 5 W wire W

R5, R6 - Two 150 Ω , 1/2 W carbon in parallel

R7, R8 - 10 Ω , 1/2 W carbon

R9, R11 - 1 k, 1/2 W carbon

R10 - 1 k, 1/2 W potentiometer

R12 - 0.85 Ω (6.5 Ω or 43.3 Ω 1/4 W resistors in parallel, divided equally between both emitter leads)

T1 - 4:1 Transformer, 6 turns, 2 twisted pairs of #26 AWG enameled wire (8 twists per inch)

T2 - 1:1 Balun, 6 turns, 2 twisted pairs of #24 AWG enameled wire (6 twists per inch)

T3 - Collector choke, 4 turns, 2 twisted pairs of #22 AWG enameled wire (6 twists per inch)

T4 - 1:4 Transformer Balun, A&B - 5 turns, 2 twisted pairs of #24, C - 8 turns, 1 twisted pair of #24 AWG enameled wire (All windings 6 twists per inch). (T4 - Indiana General F624-19Q1, - All others are Indiana General F627-8Q1 ferrite toroids or equivalent.)

PARTS LIST

L1 - .33 μ H, molded choke

L2, L6, L7 - 10 μ H, molded choke

L3 - 1.8 μ H (Onmite 2144)

L4, L5 - 3 ferrite beads each

L8, L9 - 22 μ H, molded choke

Q1 - 2N6370

Q2, Q3 - 2N5942

Q4 - 2N5190

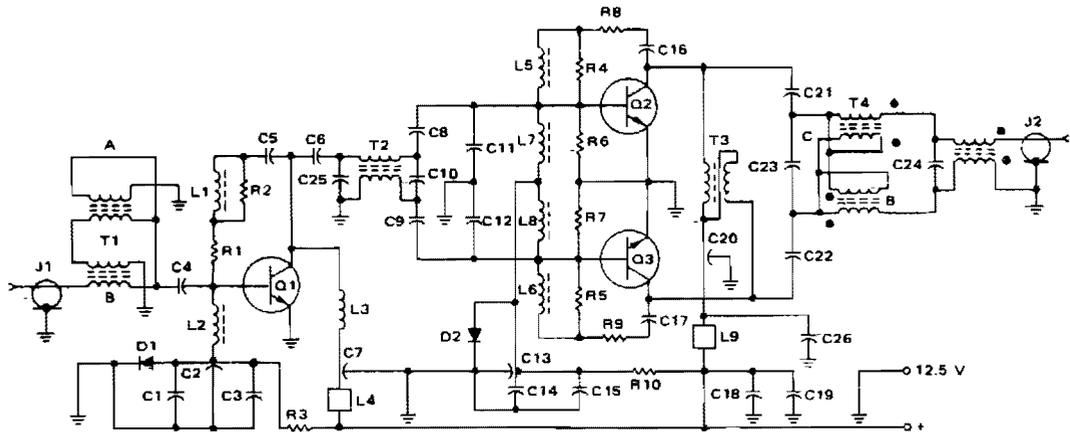
D1 - 1N4001

D2 - 1N4997

J1, J2 - BNC connectors

Fig. 73-3

80 W (PEP) BROADBAND/LINEAR AMPLIFIER



C1, C14, C18 — 0.1 μ F ceramic.
 C2, C7, C13, C20 — 0.001 μ F feed through.
 C3 — 100 μ F/3V.
 C4, C6 — 0.033 μ F mylar
 C5 — 0.0047 μ F mylar.
 C8, C9 — 0.015 and 0.033 μ F mylars in parallel.
 C10 — 470 pF mica.
 C11, C12 — 560 pF mica.
 C15 — 1000 μ F/3 V
 C16, C17 — 0.015 μ F mylar
 C19 — 10 pF 15 V
 C21, C22 — two 0.068 μ F mylars in parallel.
 C23 — 330 pF mica
 C24 — 39 pF mica
 C25 — 680 pF mica
 C26 — .01 μ F ceramic

R1, R6, R7 — 10 Ω , 1/2 W carbon.
 R2 — 51 Ω , 1/2 W carbon
 R3 — 240 Ω , 1 wire W
 R4, R5 — 18 Ω , 1 W carbon
 R8, R9 — 27 Ω , 2 W carbon
 R10 — 33 Ω , 6 W wire W

L1 — 0.22 μ h molded choke
 L2, L7, L8 — 10 μ h molded choke
 L5, L6 — 0.15 μ h
 L3 — 25 t, #26 wire, wound on a 100 Ω , 2 W resistor. (1.0 μ h)
 L4, L9 — 3 ferrite beads each.

T1 — 2 twisted pairs of #26 wire, 8 twists per inch. A = 4 turns, B = 8 turns. Core — Stackpole 57-9322-11, Indiana General F627-8Q1 or equivalent

T2 — 2 twisted pairs of #24 wire, 8 twists per inch, 6 turns. (Core as above.)

T3 — 2 twisted pairs of #20 wire, 6 twists per inch, 4 turns. (Core as above.)

T4 — A and B = 2 twisted pairs of #24 wire, 8 twists per inch. 5 turns each. C = 1 twisted pair of #24 wire, 8 turns. Core — Stackpole 57-9074-11, Indiana General F624-19Q1 or equivalent.

Q1 — 2N6367

Q2, Q3 — 2N6388

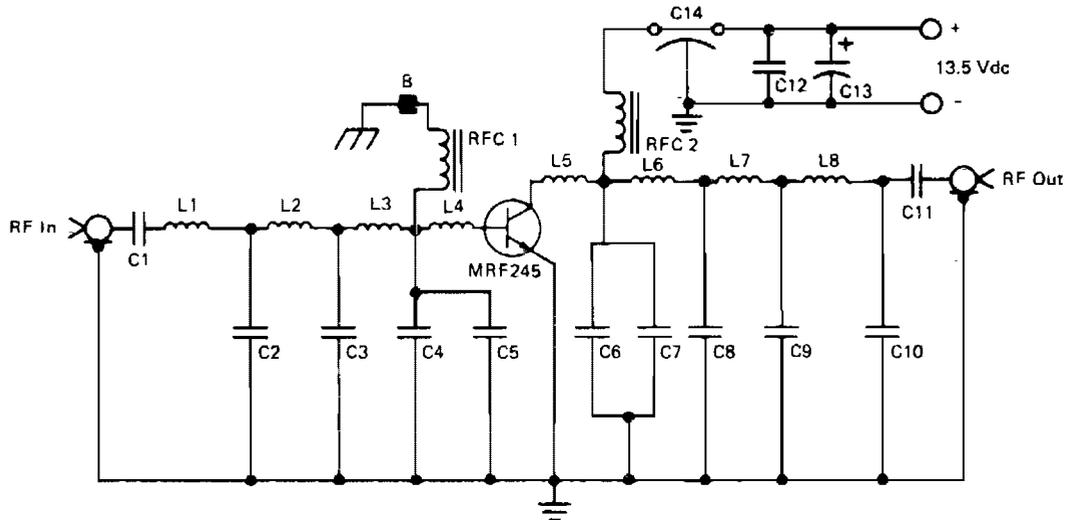
D1 — 1N4001

D2 — 1N4997

J1, J2 — BNC connectors

Fig. 73-4

SINGLE-DEVICE, 80 W, 50 Ohm VHF AMPLIFIER



C1, 11 – 500 pF Dipped mica
 C2, 9 – 10 pF UNELCO
 C3 – 60 pF UNELCO
 C4, 5 – 250 pF UNELCO
 C6, 7 – 250 pF UNELCO
 C8 – 80 pF UNELCO
 C10 – 40 pF UNELCO
 C12 – 0.1 μ F Erie Redcap
 C13 – 1 μ F Tantalum
 C14 – 680 pF Allen Bradley Feed-Thru

L1 – 1.2 X 0.3 cm Airline Inductor
 L2 – 3.5 X 0.3 cm Airline Inductor
 L3 – 4.0 X 0.3 cm Airline Inductor
 L4, L5 – 0.3 X 0.3 cm Airline Inductor
 L6 – 2.7 X 0.3 cm Airline Inductor
 L7 – 0.8 X 0.3 cm Airline Inductor
 L8 – 3.0 X 0.3 cm Airline Inductor

Board: G10, $\epsilon_r \approx 5$, $t = 0.16$ cm, 57 gm, Copper-Clad
 connectors = BNC

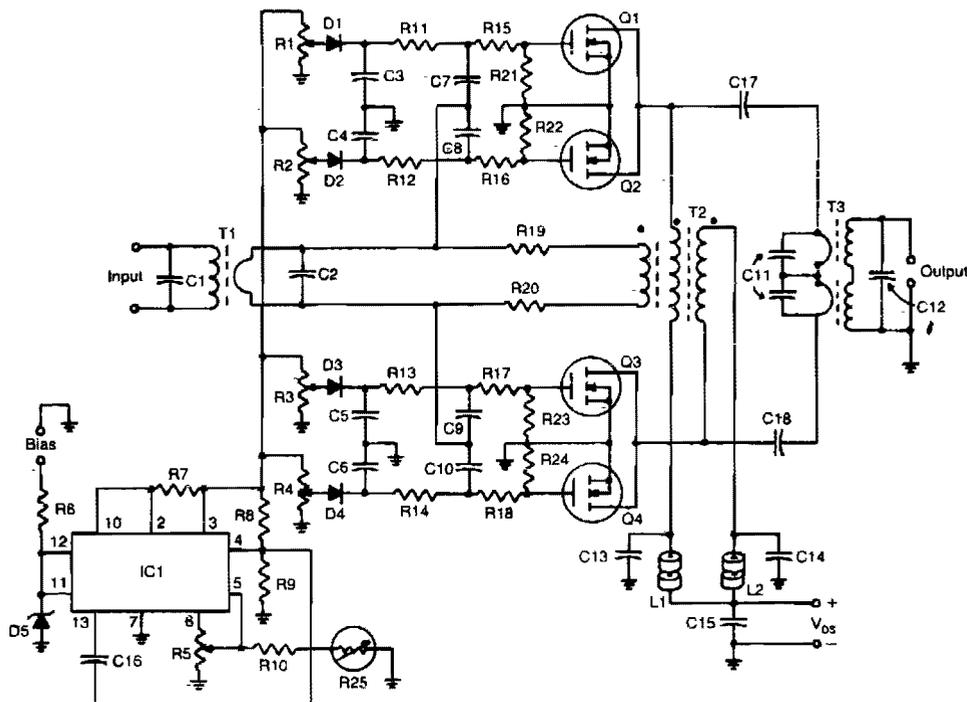
RFC 1 – 0.15 μ H Molded choke
 RFC 2 – 10 T NO. 18 AWG Enameled Wire, 1/4" I.D.
 B – Ferroxcube Bead 56-590-65, 3 Beads

Fig. 73-5

Circuit Notes

The amplifier uses a single MRF245 and provides 80 W with 9.4 dB gain across the 143 to 156 MHz band.

600 W RF POWER AMPLIFIER



R1-R5—10 k Ω trimpot
 R6—1.0 k Ω /1.0W
 R7—10 Ω
 R8—2.0 k Ω
 R9, R21-R24—10 k Ω
 R10—8.2 k Ω
 R11-R14—100 Ω
 R15-R18—1.0 Ω
 R19-R20—10 Ω /2.0 W Carbon
 R25—thermistor, 10 k Ω (25 $^{\circ}$ C), 2.5 k Ω (75 $^{\circ}$ C)
 C1—not used
 C2—820 pF ceramic chip
 C3-C6, C13, C14—0.1 μ F ceramic
 C7-C10—0.1 μ F ceramic chip
 C11—1200 pF each, 680 pF mica in parallel with an Arco 469 variable or three or more smaller value mica capacitors in parallel

C12—not used
 C15—10 μ F, 100 V electrolytic
 C16—1000 pF ceramic
 C17, C18—two 0.1 μ F, 100 V ceramic each, (ATC 200/823 or equivalent)
 D1-D4—1N4148
 D5—28 V zener, 1N5362 or equivalent
 L1, L2—Two Fair-Rite 2673021801 ferrite beads each or equivalent 40 μ H
 T1-T3—see text
 Q1-Q4—MRF150
 IC1—MC1723CP
 All resistors are 0.5W carbon or metal film unless otherwise designated.

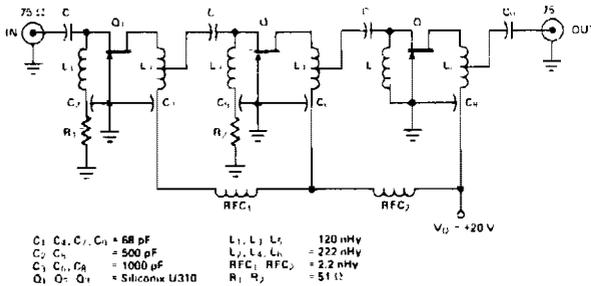
Fig. 73-6

Circuit Notes

A unique push-pull parallel circuit. It uses four MRF150 RF power FETs paralleled at relatively high power levels. Supply voltages of 40 to 50 Vdc can be used, depending on

linearity requirements. The bias for each device is independently adjustable; therefore, no matching is required for the gate threshold voltages.

WIDEBAND UHF AMPLIFIER WITH HIGH-PERFORMANCE FETs

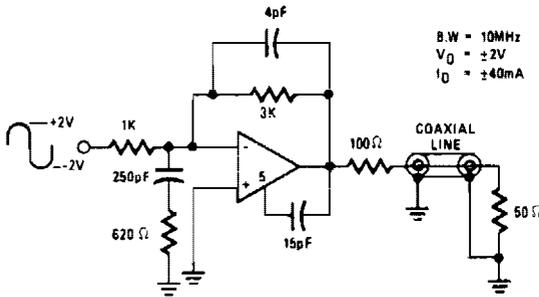


Circuit Notes

The amplifier circuit is designed for 225 MHz center frequency, 1 dB bandwidth of 50 MHz, low input VSWR in a 75-ohm system, and 24 dB gain. Three stages of U310 FETs are used in a straight forward design.

Fig. 73-7

10 MHz COAXIAL LINE DRIVER

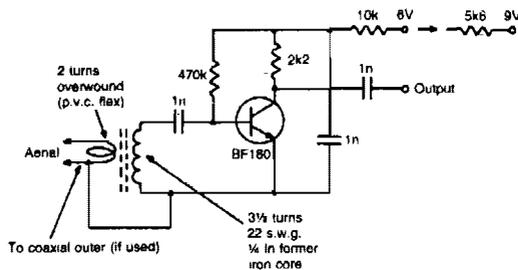


Circuit Notes

The circuit will find excellent usage in high frequency line driving systems that require wide-power bandwidths at high output current levels. (IC=HA2530) The bandwidth of the circuit is limited only by the single pole response of the feedback components, namely $f(-3 \text{ dB}) = \frac{1}{2} \pi R_f C_f$. As such, the response is flat with no peaking and yields minimum distortion.

Fig. 73-8

VHF PREAMPLIFIER

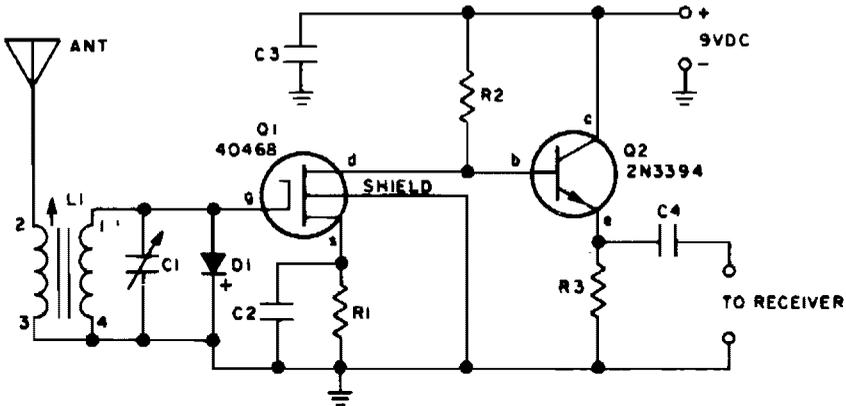


Circuit Notes

This simple circuit gives 15 dB gain and can be mounted on 1 in² PCB. Coil data is given for 85 to 95 MHz. For other frequencies modify coil as required.

Fig. 73-9

SHORTWAVE FET BOOSTER



PARTS LIST FOR SWL'S FET BOOSTER

- C1**—365-pF tuning capacitor
- C2, C3**—0.05- μ F, 25-VDC capacitor
- C4**—470-pF, 25-VDC capacitor
- D1**—1N914 diode
- L1**—Antenna coil: 1.7-5.5 KHz use Miller B-5495A, 5.5-15 MHz use

- Miller C-5495A, 12-36 MHz use Miller D-5495-A
- Q1**—RCA 40468 FET transistor (Do not substitute)
- Q2**—2N3394 npn transistor
- R1**—470-ohm, $\frac{1}{2}$ -watt resistor
- R2**—2400-ohm, $\frac{1}{2}$ -watt resistor
- R3**—4700-ohm, $\frac{1}{2}$ -watt resistor

Fig. 73-10

Circuit Notes

This two transistor preselector provides up to 40 dB gain from 3.5 to 30 MHz. Q1 (MOSFET) is sensitive to static charges and must be handled with care.

LOW-NOISE 30 MHz PREAMPLIFIER

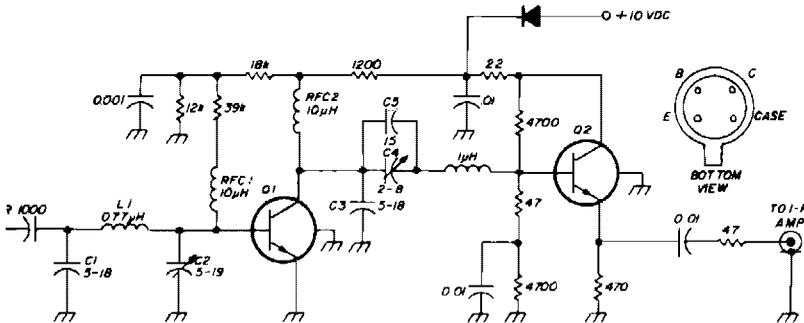


Fig. 73-11

Circuit Notes

Low-noise preamplifier has a noise figure of 1.1 dB at 30 MHz and 3 dB bandwidth of 10 MHz. Gain is 19 dB. Total current drain with a +10 volt supply is 13 mA. All resistors are $\frac{1}{4}$ watt carbon; bypass capacitors are 50-volt ceramics.

LOW-NOISE BROADBAND AMPLIFIER

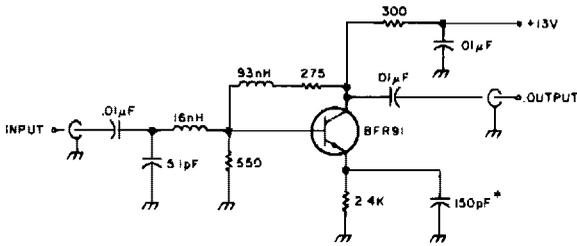


Fig. 73-12

Circuit Notes

The amplifier provides 10 dB of gain from 10-600 MHz and has a 1.5-to-1 match at 50 ohms. The BFR91 has a 1.5 dB noise figures at 500 MHz. The circuit requires 13.5 Vdc at about 13 mA. Keep the leads on the 150 pF emitter bypass capacitor as short as possible. The 16 nH coil is 2.5 turns of #26 enamel wire on the shank of a #40 drill. The 93 nH inductor is 10 turns of the same material.

TWO-METER 10 WATT POWER AMPLIFIER

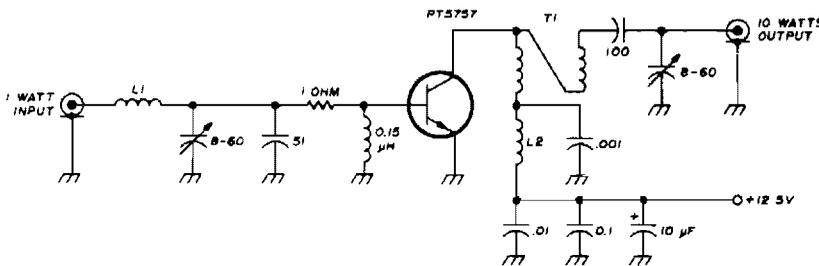


Fig. 73-13

Circuit Notes

This 10-watt, 144-MHz power amplifier uses a TRW PT5757 transistor. L1 is 4 turns of no. 20 enameled, 3/32" ID; L2 is 10 turns of no. 20 enameled, 3/32" ID. Transformer T1 is

a 4:1 transmission-line transformer made from a 3" length of twisted pair of no. 20 enameled wire.

TWO-STAGE 60 MHz IF AMPLIFIER (POWER GAIN ≈ 80 dB, BW ≈ 1.5 MHz)

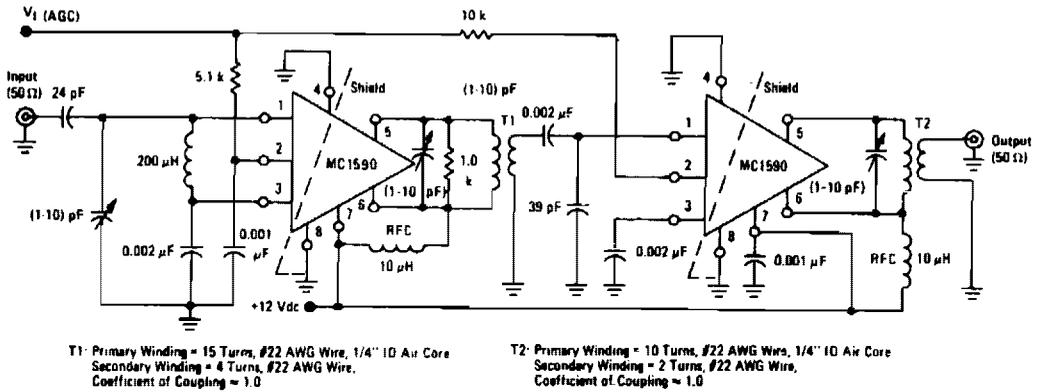


Fig. 73-14

28 V WIDEBAND AMPLIFIER (3 to 100 MHz)

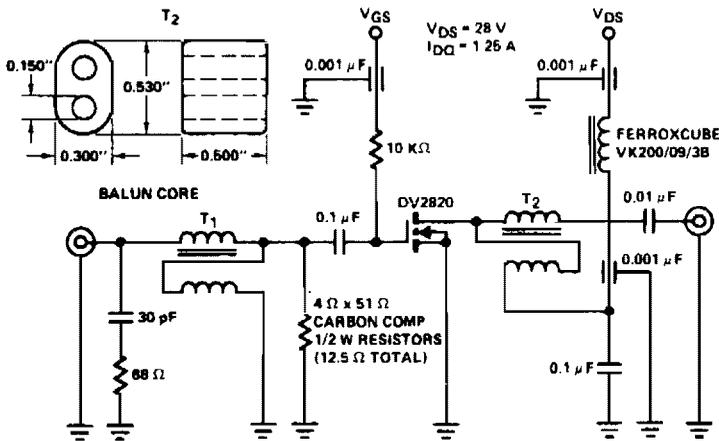
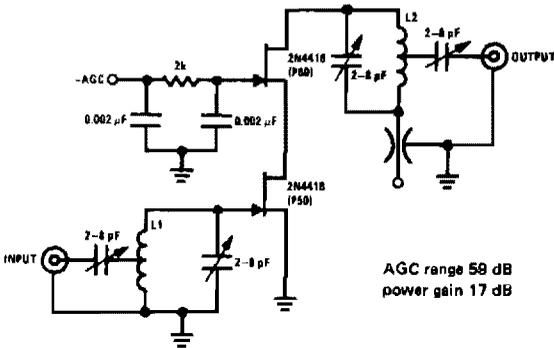


Fig. 73-15

200 MHz CASCODE AMPLIFIER



AGC range 59 dB
power gain 17 dB

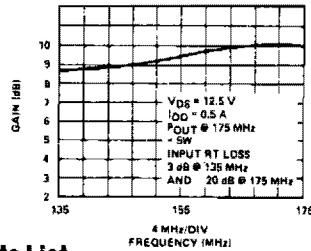
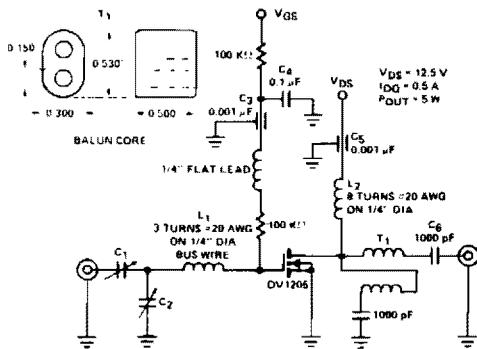
L1 = 0.07 μ Hy center tap
L2 = 0.07 μ Hy tap 1/4 up from ground

Circuit Notes

This 200 MHz JFET cascode circuit features low cross-modulation, large signal handling ability, no neutralization, and AGC controlled by biasing the upper cascode JFET. The only special requirement of this circuit is that I_{DSS} of the upper unit must be greater than that of the lower unit.

Fig. 73-16

135-175 MHz AMPLIFIER

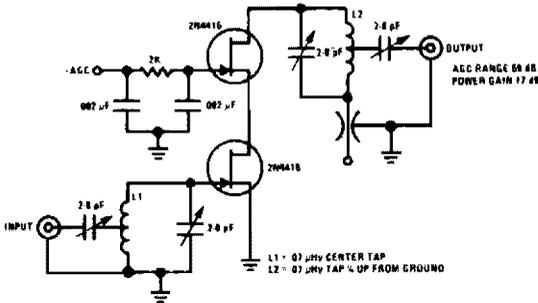


Parts List

C1, C2 ARCO #462, 2 to 80 pF, trimmer capacitors
L1, 3 turns byss wire #20 AWG on 1/4" diameter
L2, 8 turns #20 AWG on 1/4" diameter
T1, 1 turn of 25 Ω coax on 2 balun cores.
Stackpole #57-0973 μ O = 35.

Fig. 73-17

200 MHz CASCODE AMPLIFIER

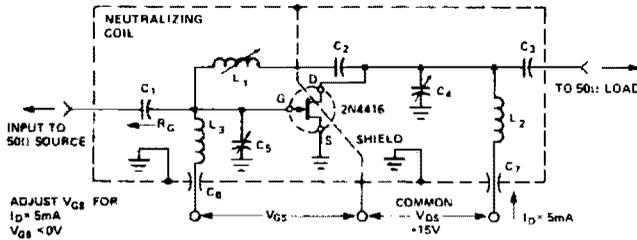


Circuit Notes

This 200 MHz JFET cascode circuit features low cross-modulation, large signal handling ability, no neutralization, and AGC controlled by biasing the upper cascode JFET. The only special requirement of this circuit is that I_{DSS} of the upper unit must be greater than that of the lower unit.

Fig. 73-18

100 MHz AND 400 MHz NEUTRALIZED COMMON SOURCE AMPLIFIER



REFERENCE DESIGNATION	VALUE	
	100MHz	400MHz
C ₁	70pF	1.8pF
C ₂	1000pF	27pF
C ₃	3.0pF	1.0pF
C ₄	1.0-12pF	0.8-8pF
C ₅	1.0-12pF	0.8-8pF
C ₆	0.0015μF	0.001μF
C ₇	0.0015μF	0.001μF
L ₁	3.0μH	0.2μH
L ₂	0.25μH	0.022μH
L ₃	0.14μH	0.022μH
T _{yp} NF	1.2dB	2.4dB
T _{yp} G _{ps}	21dB	12dB

Fig. 73-19

ULTRA HIGH FREQUENCY AMPLIFIER

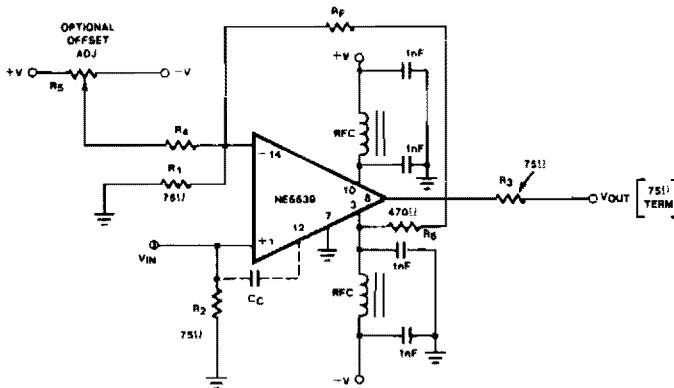
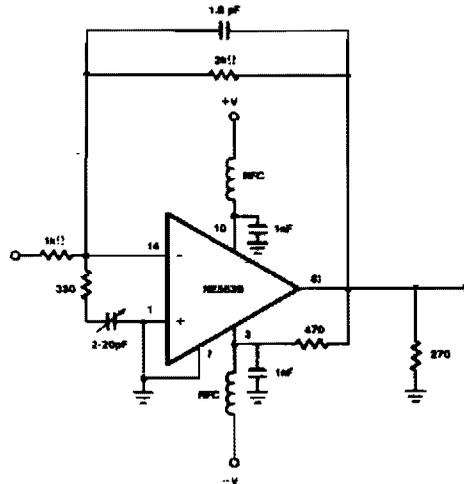


Fig. 73-20

- R₁ = 75Ω 5% CARBON
- R₂ = 75Ω 5% CARBON
- R₃ = 75Ω 5% CARBON
- R₄ = 18K 5% CARBON
- R₅ = 20K TRIMPOT (CERMET)
- R₆ = 1.5K (25dB GAIN)
- R₇ = 470Ω 5% CARBON
- RFC 3T # 20 BUBBWRFE ON FERROXIDE W/ 200 09 28 CORE
- BYPASS CAPACITORS 1nF CERAMIC (MEPCO OR EQUIV.)

UHF AMPLIFIER WITH INVERTING GAIN OF 2 AND LAG-LEAD COMPENSATION (GAIN BANDWIDTH PRODUCT 350 MHz)



NOTE
Resistors — 1/4 watt carbon.
RFC-3T #28 bus wire on Ferroxcube VK200-09/3B
wideband threaded core

Fig. 73-21

**TRANSISTORIZED Q-MULTIPLIER
FOR USE WITH IFS IN THE 1400 kHz RANGE**

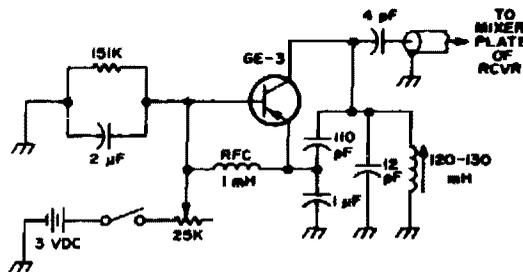
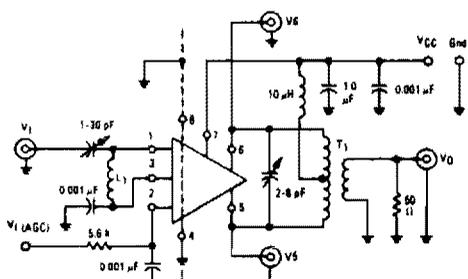


Fig. 73-22

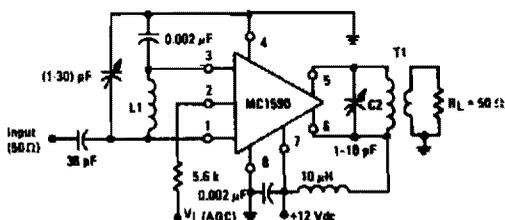
60 MHz AMPLIFIER



- L1 7 Turns, #22 AWG Wire on 3/16" Dia Form, 5/8" Long
 T1 Close Wound Over 1/4" Form
 Primary Winding = 18 Turns = 28 AWG, Center Tapped
 Secondary Winding = 2 Turns = 28 AWG

Fig. 73-23

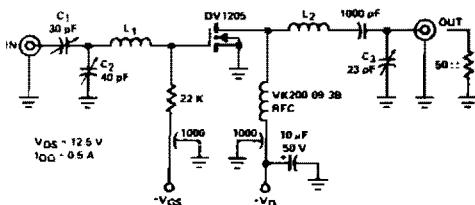
30 MHz AMPLIFIER (POWER GAIN = 50 dB, BW ≈ 1.0 MHz)



- L1 = 12 Turns #22 AWG Wire on a Toroid Core, (T37-5 Micro Metal or Equiv)
 T1: Primary = 17 Turns #20 AWG Wire on a Toroid Core, (T44-5 Micro Metal or Equiv)
 Secondary = 2 Turns #20 AWG Wire

Fig. 73-24

TWO METER AMPLIFIER, 5 W OUTPUT



Parts List

- L1, 60 nHy 4T #22 AWG close wound 0.125" I.D.
 L2, 54 nHy 3 1/2T #22 AWG close wound 0.125" I.D.
 C1, C2, C3, ARCO #462 5-80 pF

Fig. 73-25

80 MHz CASCODE AMPLIFIER

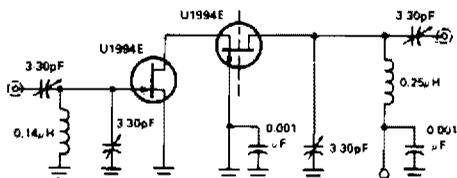


Fig. 73-26

74

RF Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

500 MHz Oscillator
Low Distortion Oscillator
400 MHz Oscillator
2 MHz Oscillator

1.0 MHz Oscillator
Hartley Oscillator
Colpitts Oscillator
RF Oscillator

500 MHz OSCILLATOR

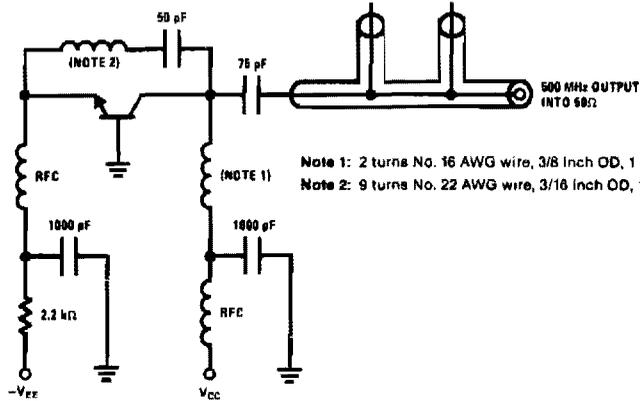
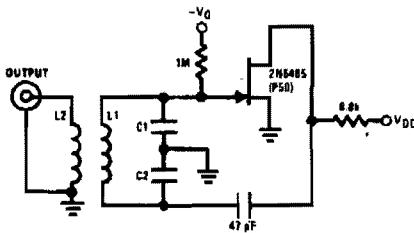


Fig. 74-1

LOW DISTORTION OSCILLATOR



20 MHz oscillator values

C1 = 700 pF L1 = 1.3 μH
 C2 = 75 pF L2 = 10T 3/8" dia 3/4" long
 VDD = 16V ID = 1 mA

20 MHz oscillator performance

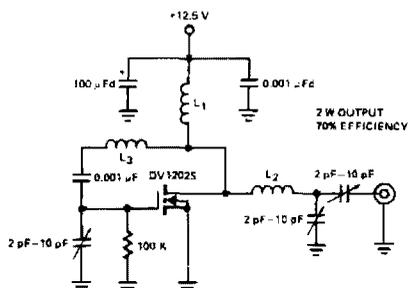
Low distortion 20 MHz osc
 2nd harmonic - 60 dB
 3rd harmonic > -70 dB

Fig. 74-2

Circuit Notes

The 2N5485 JFET is capable of oscillating in a circuit where harmonic distortion is very low. The JFET local oscillator is excellent when a low harmonic content is required for a good mixer circuit.

400 MHz OSCILLATOR



Parts List

- L₁—8 turns #22 closewound on 1/4" diameter
- L₂—1/2 inch #16 wire
- L₃—1 inch #16 wire

Fig. 74-3

1.0 MHz OSCILLATOR

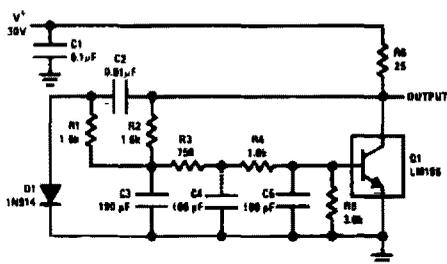


Fig. 74-5

2 MHz OSCILLATOR

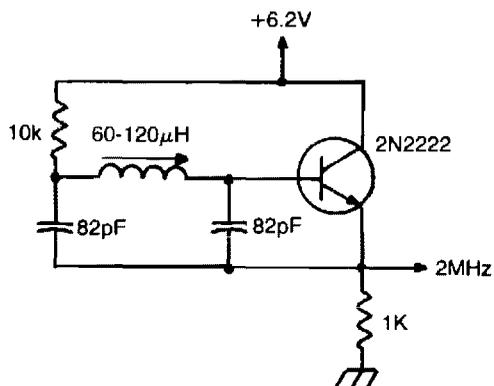


Fig. 74-4

Circuit Notes

Miller 9055 miniature slotted coil; all resistors 1/4W 5%; all caps min. 25 V ceramic.

HARTLEY OSCILLATOR

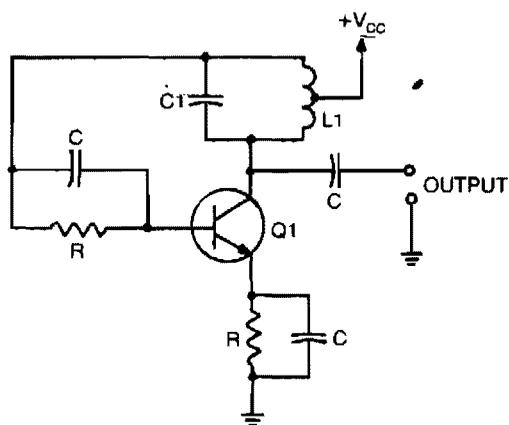
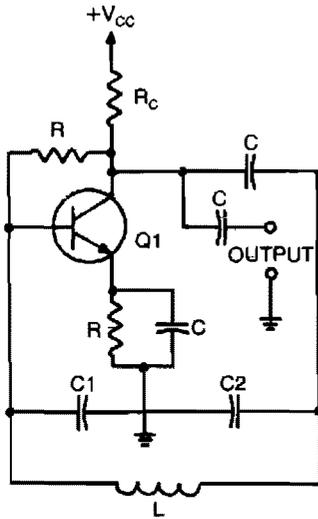


Fig. 74-6

Circuit Notes

Resonant frequency is $\frac{1}{2} \pi \sqrt{L1C1}$.

COLPITTS OSCILLATOR

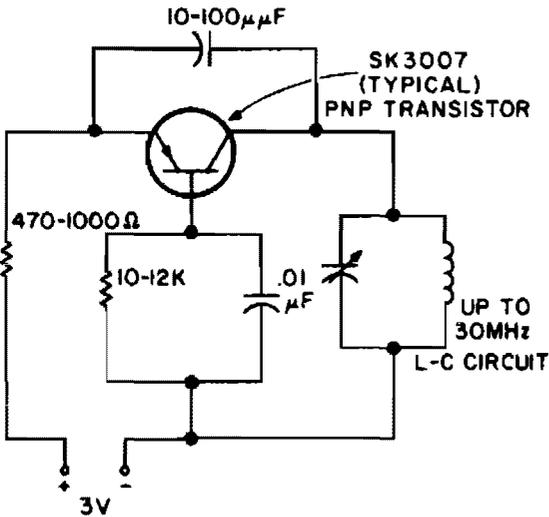


Circuit Notes

When calculating its resonant frequency, use $C1C2/C1+C2$ for the total capacitance of the L-C circuit.

Fig. 74-7

RF OSCILLATOR



Circuit Notes

This rf oscillator is useful up to 30 MHz. An SK 3007 PNP transistor is recommended.

Fig. 74-8

75

Remote Control Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Radio Control Receiver/Decoder
Carrier Operated Relay
Remote Control Servo System

Tone-Actuated Relay
Radio Control Motor Speed Controller
Remote On-Off Switch

Automatic Turn Off for TV Set

CARRIER OPERATED RELAY

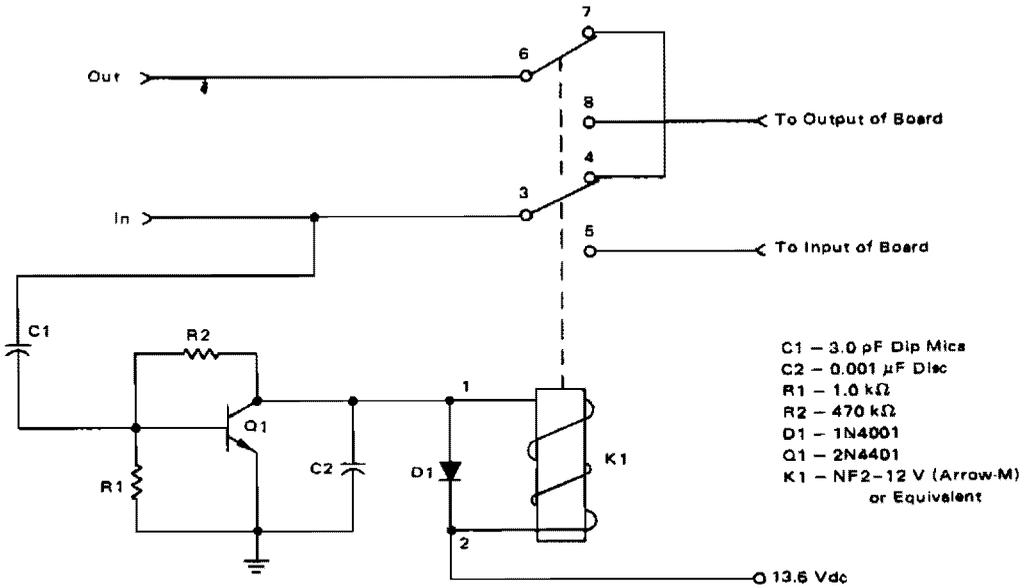


Fig. 75-2

REMOTE CONTROL SERVO SYSTEM

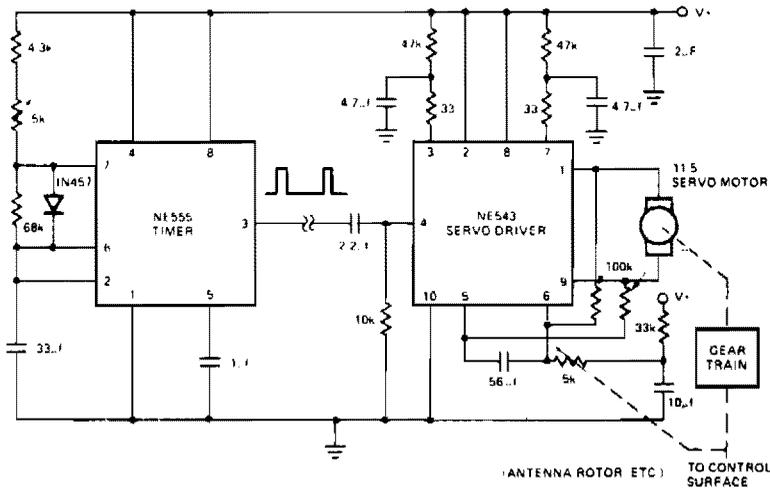
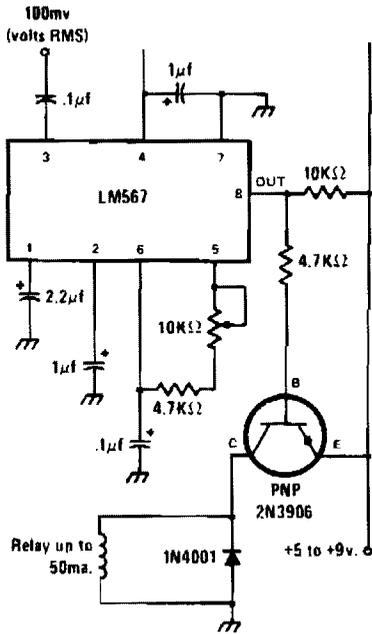


Fig. 75-3

TONE-ACTUATED RELAY



Circuit Notes

The circuit is built around the LM567 tone decoder IC that requires about 100 millivolts at its operating frequency. The frequency is set by a 10 K variable resistor and can be between 700 and 1500 Hz. When a tone at the set frequency is present, the 567's output goes low to energize a relay through a 2N3906 PNP transistor.

Fig. 75-4

RADIO CONTROL MOTOR SPEED CONTROLLER

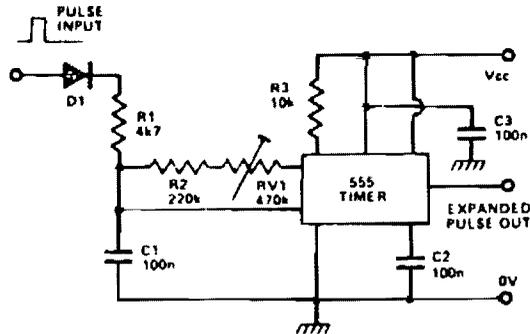


Fig. 75-5

REMOTE ON-OFF SWITCH

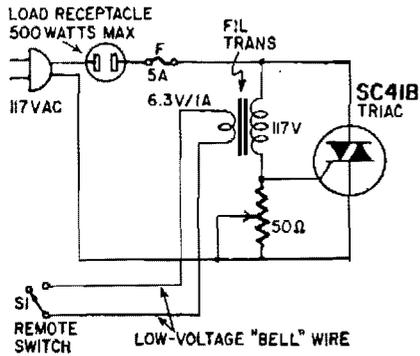


Fig. 75-6

Circuit Notes

This circuit provides power control without running line-voltage switch leads. The primary of a 6-volt filament transformer is connected between the gate and one of the main terminals of a triac. The secondary is connected to the remote switch through ordinary low-voltage line. With switch open, transformer blocks gate current, prevents the triac from firing and applying power to the equipment. Closing the switch short-circuits the secondary, causing the transformer to saturate and trigger the triac.

AUTOMATIC TURN OFF FOR TV SET

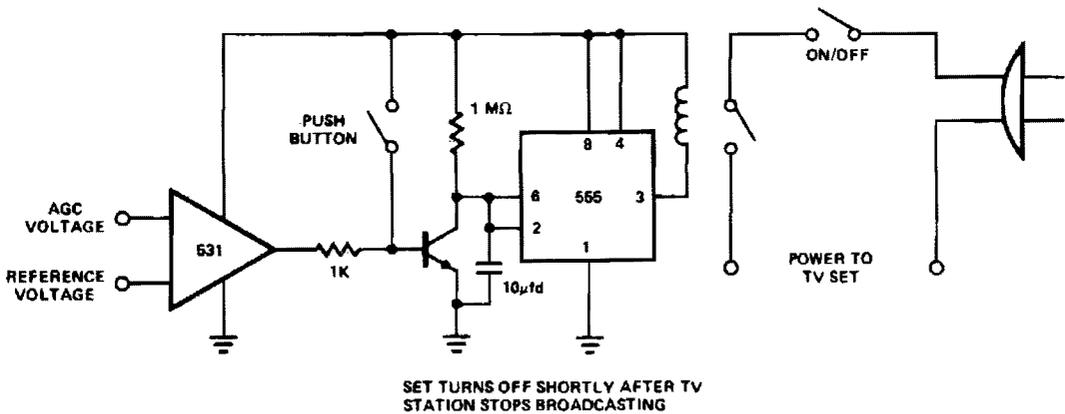


Fig. 75-7

76

Safety and Security Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Tarry Light	Power Failure Alarm
Ground Tester	Ac Hot Wire Probe
Ground-Fault Interrupter	Power Failure Detector
Single Source Emergency Lighting System	Power-Failure Alarm

Electronic Combination Lock

TARRY LIGHT

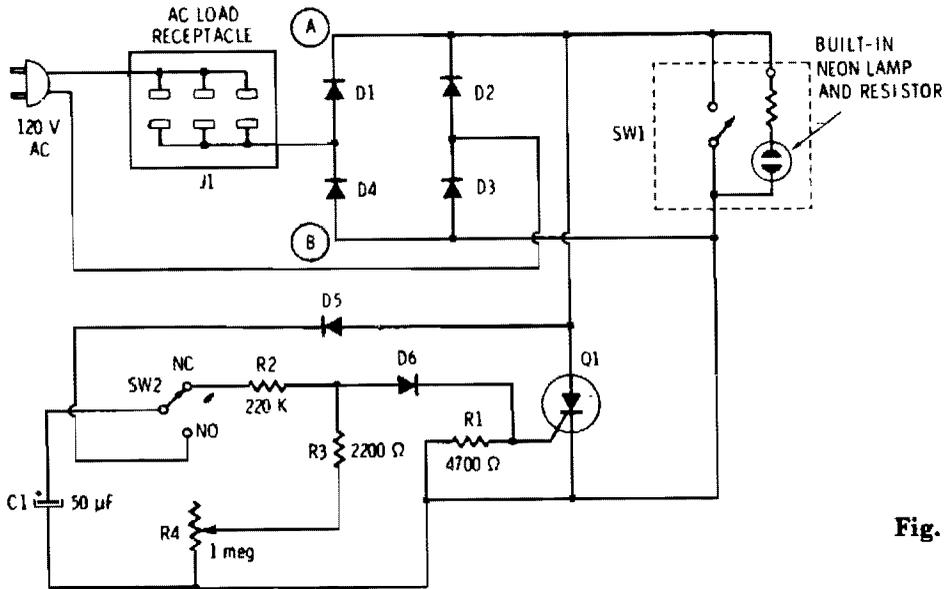


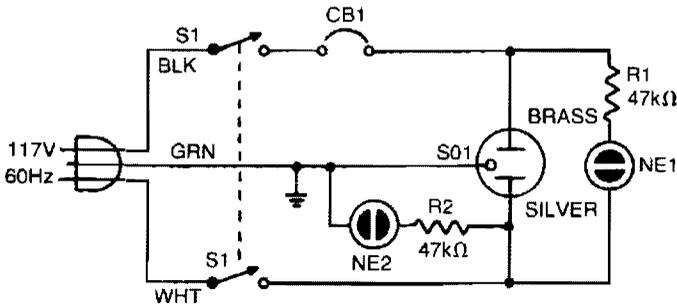
Fig. 76-1

Circuit Notes

The push button and potentiometer initiate a time delay that turns a light on then automatically turns it off again after a predetermined time. The potentiometer can be set for a delay of a few seconds to just under three minutes. When the push-button switch SW2 is pressed, capacitor C1 gets charged through D5 to the full dc voltage developed by the diode bridge. When the button is released, the charged capacitor is connected across the series combination of R2, R3, and potentiometer R4 whose setting determines the total resistance and thereby sets the time it takes for

the capacitor to discharge. A steering diode, D6, connected to the junction of R2 and R3, and potentiometer R4 whose setting determines The total resistance and thereby sets the time it takes for the capacitor to discharge. Diode, D6 picks off a portion of this decaying dc voltage and applies it to the gates terminal of Q1, the SCR, triggering it into a conductive state. This SCR will remain on as long as there is sufficient voltage on its gate. As soon as this voltage decays below the minimum holding voltage of the SCR, it will turn off on the next line alternation.

GROUND TESTER



Parts list
 S2—DPDT Switch
 CB1—10A fuse or circuit breaker
 S01—Radio Shack 61-2760, 3 terminal socket
 R1, R2, R3—47kΩ, ½W
 NE1, NE2, NE3—GE NE-2
 S1—SPDT, Lafayette 34P0238V

Fig. 76-2

Circuit Notes

This circuit checks the reliability of appliances so that the equipment may be used safely. The test circuit must be plugged into a properly wired three terminal wall outlet. When a two-lead or three-lead appliance is

plugged into circuit outlet S01, neon lamps NE1 and NE2 will light if the appliance is safe. If neon NE2 is lit the appliance is dangerous, because the neutral lead is 110 Vac above ground.

GROUND-FAULT INTERRUPTER (120 Hz NEUTRAL TRANSFORMER APPROACH)

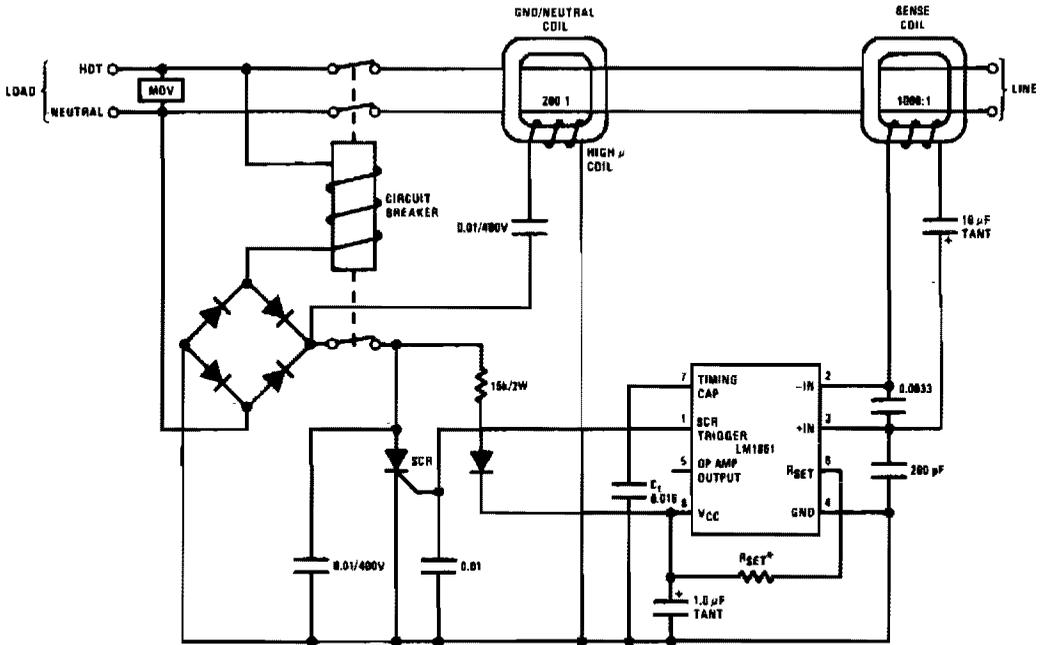


Fig. 76-3

SINGLE SOURCE EMERGENCY LIGHTING SYSTEM

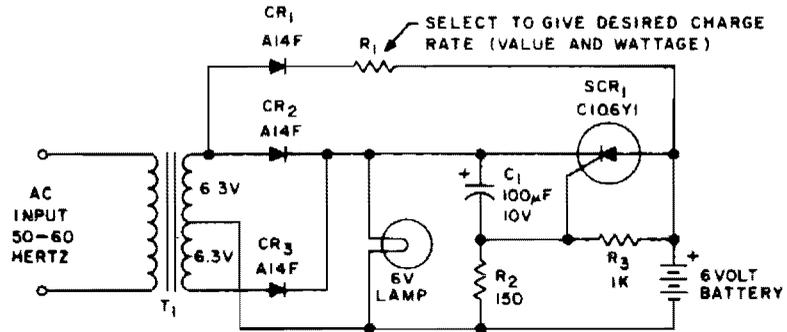


Fig. 76-4

Circuit Notes

This emergency lighting system maintains a 6 volt battery at full charge and switches automatically from the ac supply to the battery.

POWER FAILURE ALARM

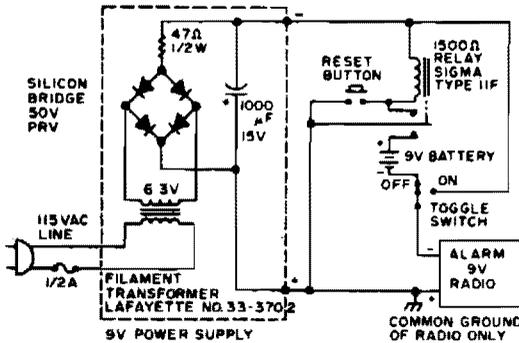


Fig. 76-5

Circuit Notes

If the power fails, the radio alarm goes on. No loud siren, bell, or whistle. Even if the power is restored, the alarm stays on until RESET button is pushed.

AC HOT WIRE PROBE

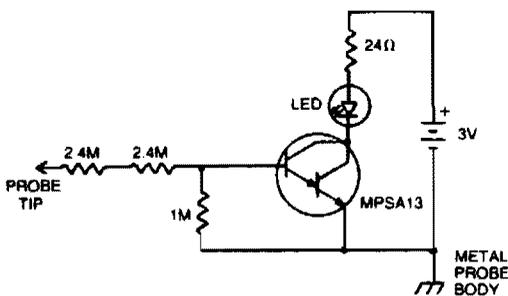


Fig. 76-6

Circuit Notes

Insert the probe tip into either terminal of an ac outlet and hold the probe body against anything that the circuit ground is connected to. The LED will glow when the hot terminal is touched. Two 2.4 M resistors are used in the probe tip for safety (redundancy) reasons.

POWER FAILURE DETECTOR

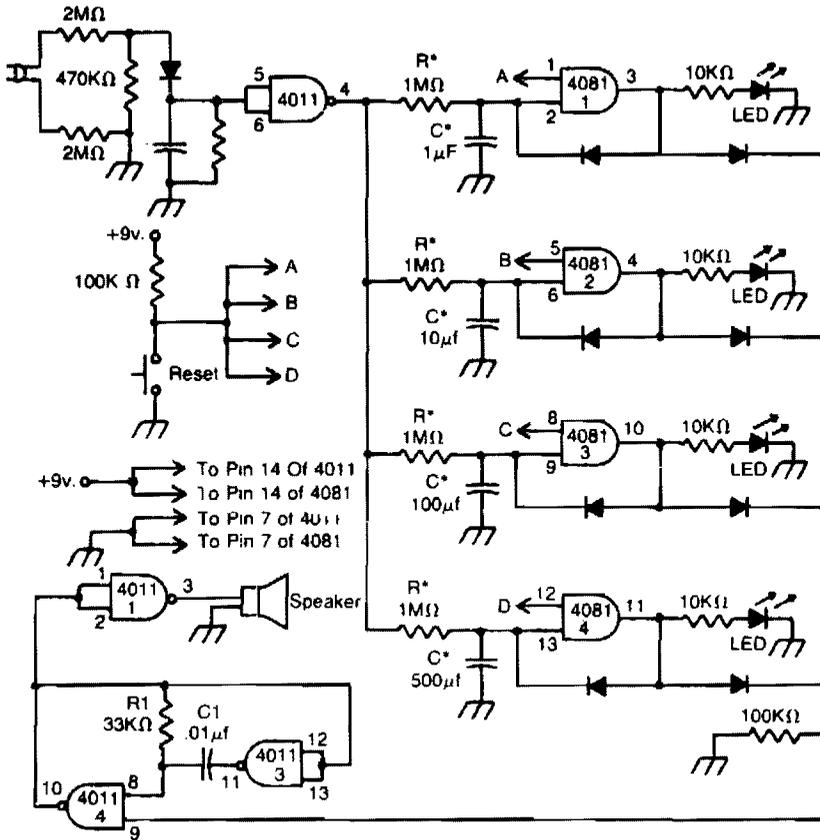


Fig. 76-7

Circuit Notes

This circuit indicates that a power outage occurred for 1, 10, 100, and 500 seconds with the values given for R^* and C^* . After a power failure, the circuit can be reset by pushing the Reset button.

POWER FAILURE ALARM

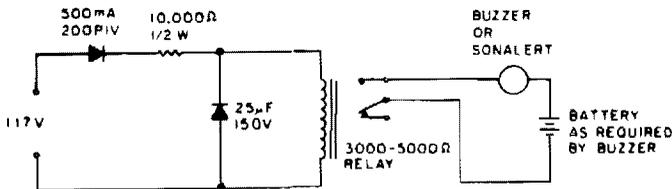


Fig. 76-8

Circuit Notes

While the power is on, the relay is held open, but when the power fails the buzzer-circuit contacts close.

ELECTRONIC COMBINATION LOCK

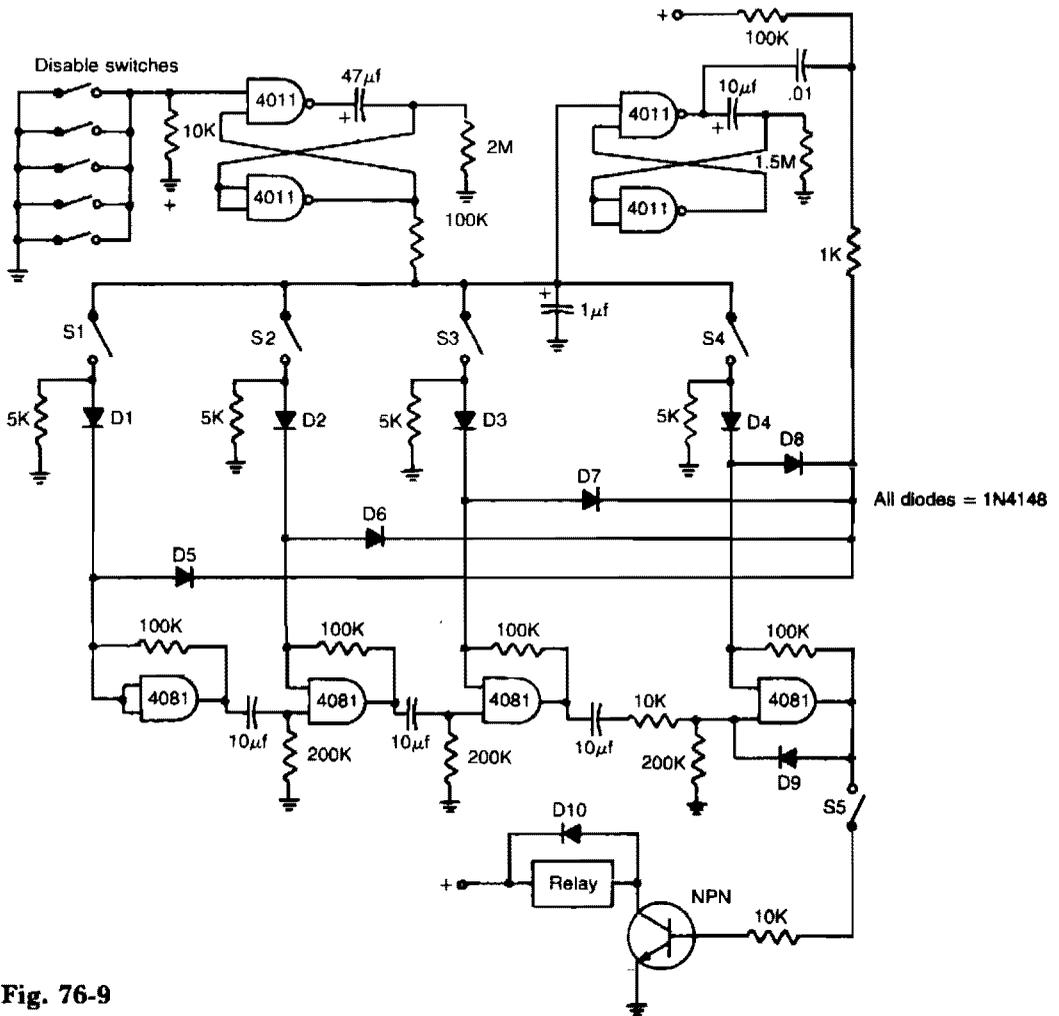


Fig. 76-9

Circuit Notes

Switches S1 through S5 must be operated in rapid sequence to operate the lock. They can be any numbers on a 10-button switch pad. If an incorrect button is pushed, alarm sounds and the circuit is disabled for two minutes.

Sample and Hold Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Peak Detect and Hold
Low Drift Sample and Hold
JFET Sample and Hold
High Speed Sample and Hold Amplifier
High Speed Sample and Hold
High Speed Sample and Hold

Sample and Hold with Offset Adjustment
Differential Hold
× 1000 Sample and Hold
Sample and Hold
High Accuracy Sample and Hold
High Speed Sample and Hold

PEAK DETECT AND HOLD

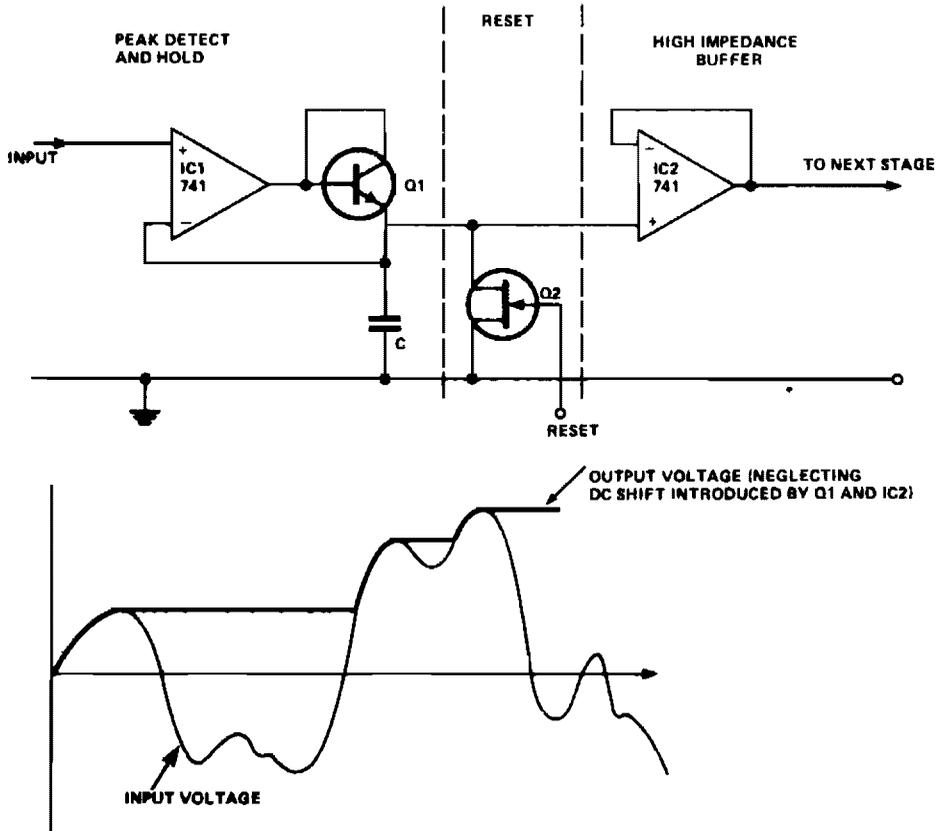


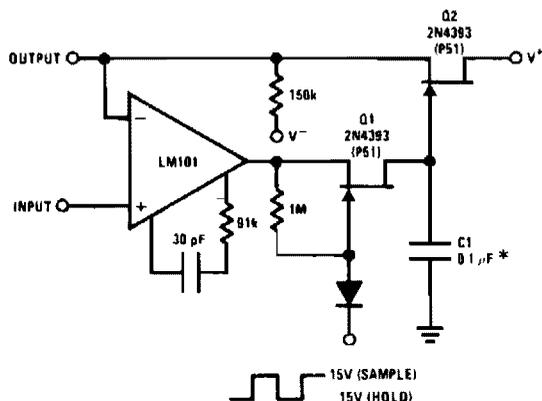
Fig. 77-1

Circuit Notes

If the voltage at the input exceeds the voltage on the capacitor, then the output of the 741 goes positive, the diode conducts, and the capacitor is charged up to the input voltage-forward voltage drop of diode. When the voltage at the input is less than that on the capacitor, the output of the 741 goes negative,

and the diode cuts off. To prevent the capacitor from discharging through the input resistance of the next stage, a high input impedance buffer stage (IC2) is used. The circuit can be reset by means of a FET or similar high impedance device connected across the capacitor.

LOW DRIFT SAMPLE AND HOLD



*Polycarbonate dielectric capacitor

Circuit Notes

The JFETs, Q1 and Q2, provide complete buffering to C1, the sample and hold capacitor. During sample, Q1 is turned on and provides a path, $I_{ds(on)}$, for charging C1. During hold, Q1 is turned off, thus leaving Q1 $I_{D(off)}$ (< 100 pA) and Q2 I_{GSS} (< 100 pA) as the only discharge paths. Q2 serves a buffering function so feedback to the LM101 and output current are supplied from its source.

Fig. 77-2

JFET SAMPLE AND HOLD

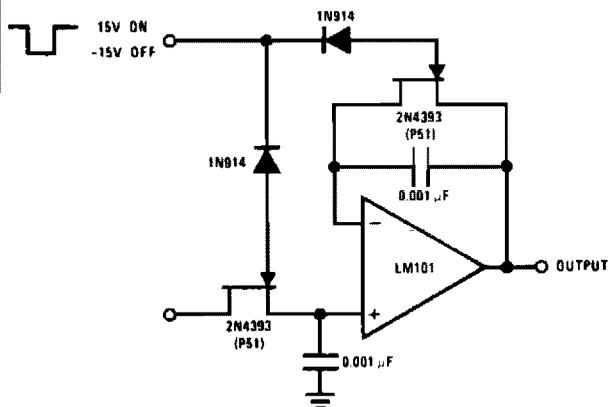


Fig. 77-3

Circuit Notes

The logic voltage is applied simultaneously to the sample and hold JFETs. By matching input impedance and feedback resistance and capacitance, errors due to $I_{ds(on)}$ of the JFETs are minimized.

HIGH SPEED SAMPLE AND HOLD AMPLIFIER

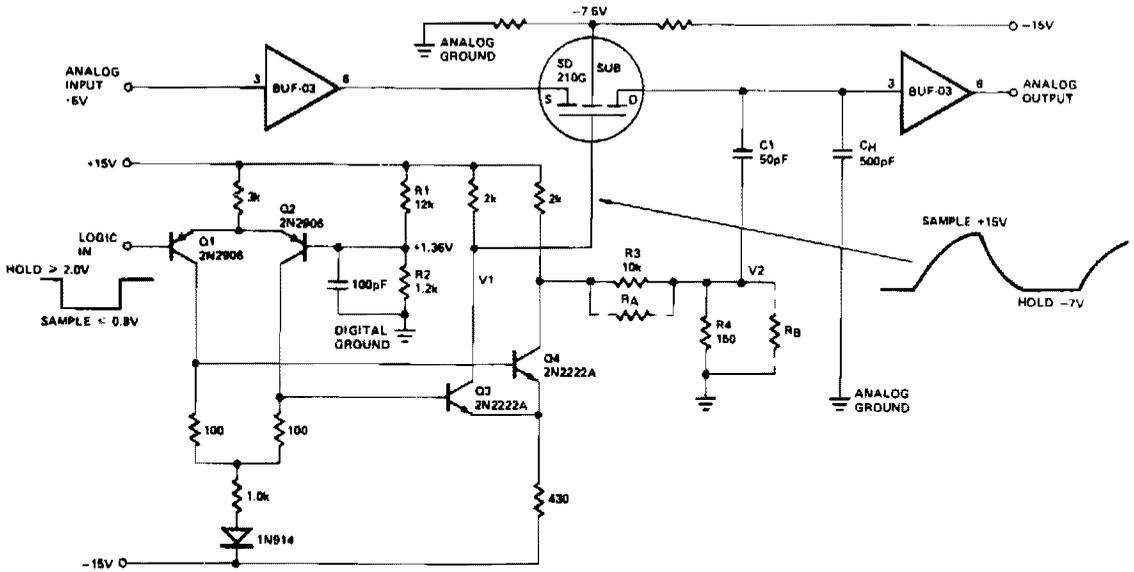
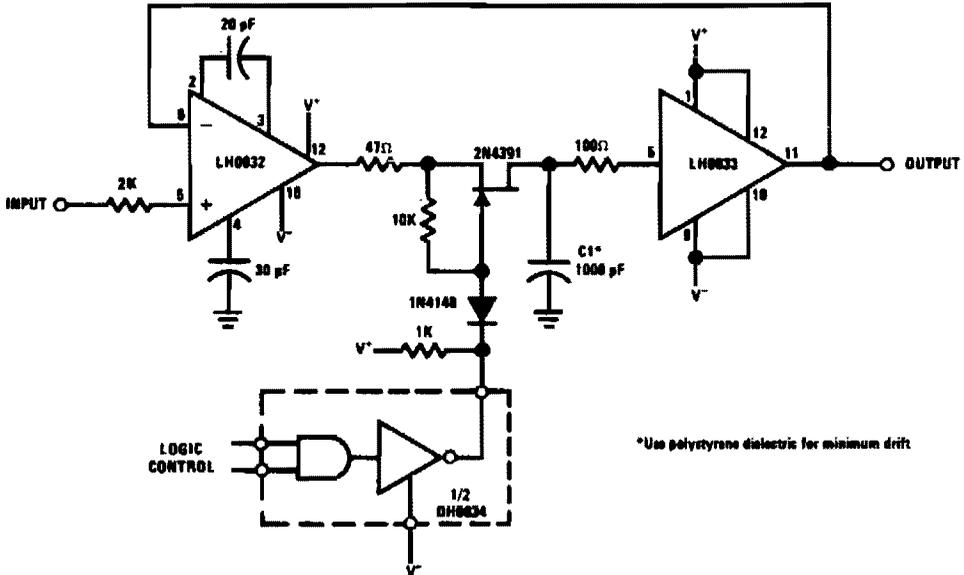


Fig. 77-4

HIGH SPEED SAMPLE AND HOLD



*Use polystyrene dielectric for minimum drift

Fig. 77-5

HIGH SPEED SAMPLE AND HOLD

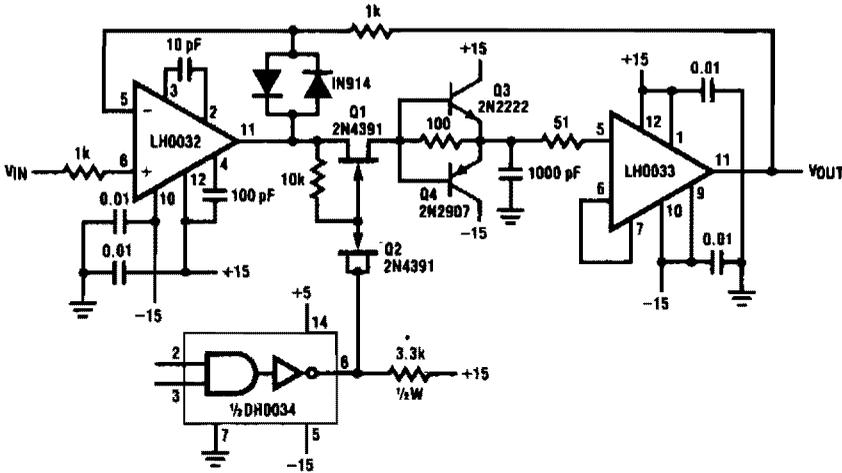


Fig. 77-6

Circuit Notes

This circuit exhibits a 10 V acquisition time of 900 ns to 0.1% accuracy and a droop rate of only $100 \mu\text{V}/\text{ms}$ at 25°C ambient condition. An even faster acquisition time can be obtained using a smaller value hold-capacitor.

By decreasing the value from 1000 pF to 220 pF, the acquisition time improves to 500 ns for a 10 V step. However, the droop rate increases to $500 \mu\text{V}/\text{ms}$.

SAMPLE AND HOLD WITH OFFSET ADJUSTMENT

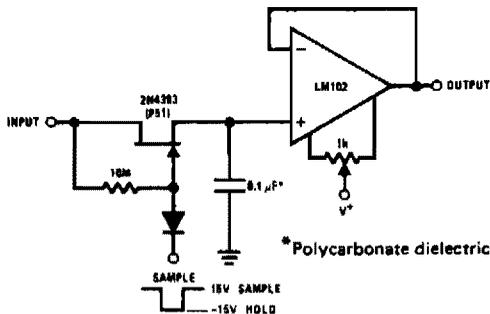


Fig. 77-7

Circuit Notes

The 2N4393 JFET was selected because of its low I_{GSS} ($< 100 \text{ pA}$), very low $I_{\text{D(off)}}$ ($< 100 \text{ pA}$) and low pinchoff voltage. Leakages of this level put the burden of circuit performance on clean, solder-resin free, low leakage circuit layout.

DIFFERENTIAL HOLD

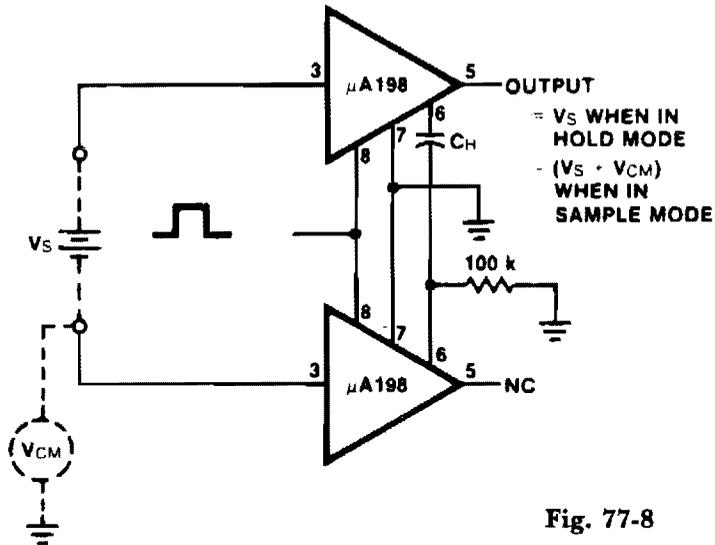
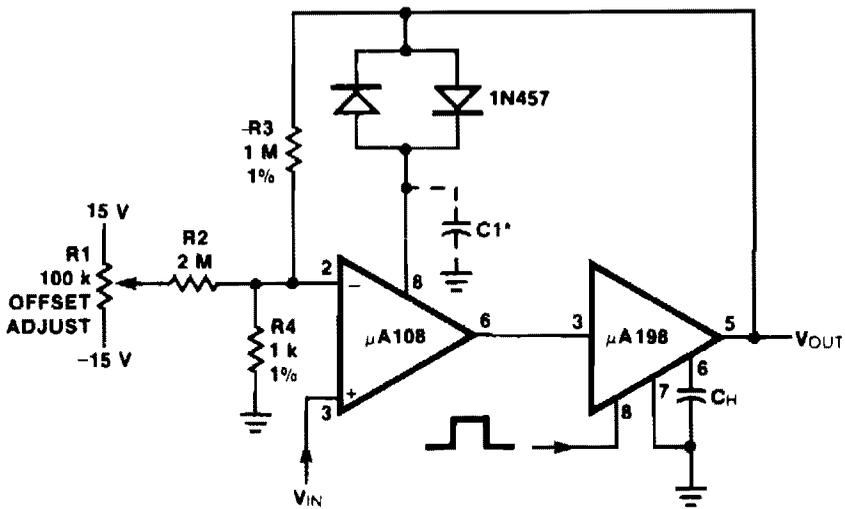


Fig. 77-8

× 1000 SAMPLE AND HOLD



Notes

For lower gains, the $\mu A108$ must be frequency compensated

Use $\approx \frac{100}{A_V}$ pF from comp 2 to ground

Fig. 77-9

78

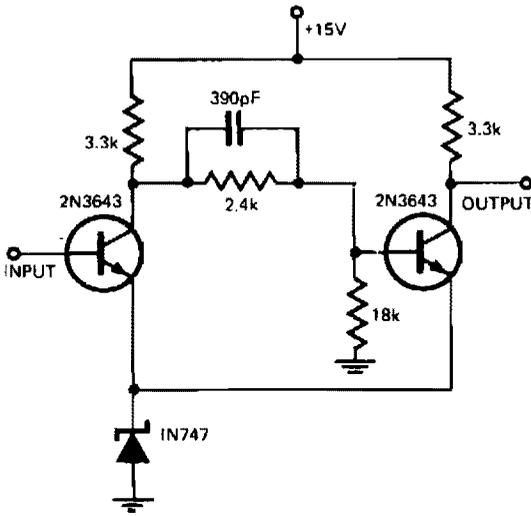
Schmitt Triggers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Schmitt Trigger Without Hysteresis
Schmitt Trigger with Programmable
Hysteresis

Schmitt Trigger (Zero Crossing Detector with
Hysteresis)
Schmitt Trigger

SCHMITT TRIGGER WITHOUT HYSTERESIS



Circuit Notes

By replacing the common-emitter resistor in a conventional Schmitt by a zener diode, the hysteresis normally associated with these circuits is eliminated.

Fig. 78-1

SCHMITT TRIGGER WITH PROGRAMMABLE HYSTERESIS

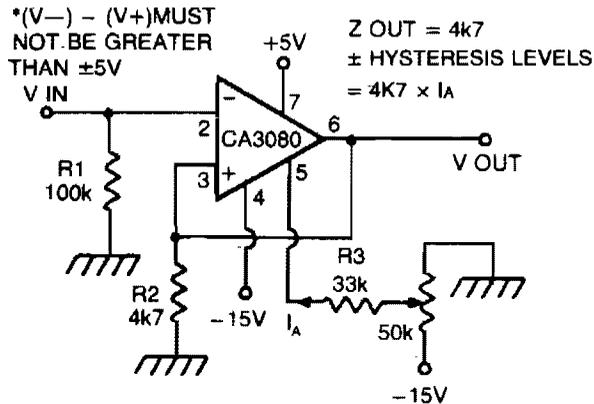


Fig. 78-2

Circuit Notes

CA 3088 is used as a versatile Schmitt trigger. The size of the hysteresis levels is determined by I_A that flows out of the amplifier's output and through R2. Increasing I_A increases hysteresis and vice versa. The positive and negative hysteresis levels are symmetrical about 0 V.

SCHMITT TRIGGER (ZERO CROSSING DETECTOR WITH HYSTERESIS)

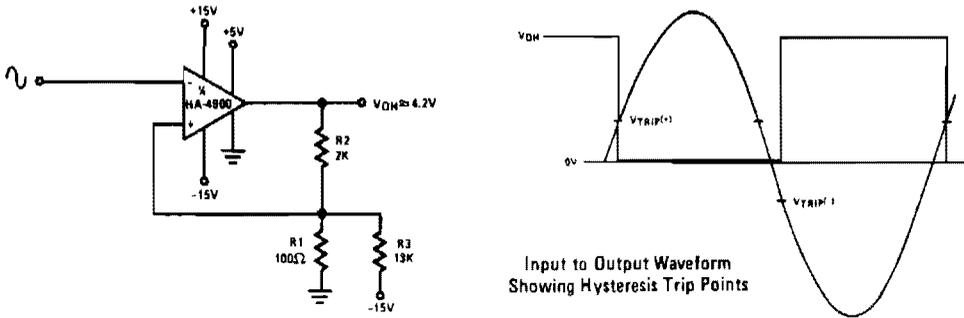


Fig. 78-3

Circuit Notes

This circuit has a 100 mV hysteresis which can be used in applications where very fast transition times are required at the output even though the signal is very slow. The hys-

teresis loop also reduces false triggering due to noise on the input. The waveforms show the trip points developed by the hysteresis loop.

SCHMITT TRIGGER

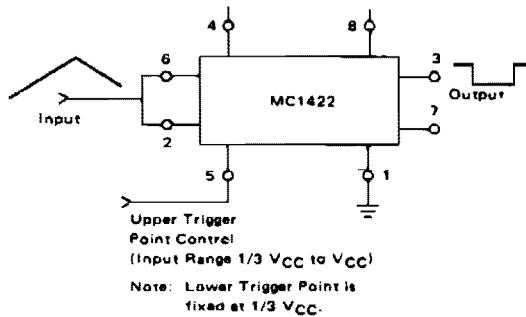


Fig. 78-4

Circuit Notes

The lower trigger point is fixed at $\frac{1}{3} V_{CC}$, but the upper trigger point is adjustable by means of Pin 5 from $\frac{1}{3} V_{CC}$ to slightly less than V_{CC} . The Schmitt trigger will operate with input frequencies up to 50 kHz.

79

Smoke and Flame Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Photoelectric Smoke Detector (Non-Latching)
1.9 V Battery Operated Ionization Type
Smoke Detector

Line-Operated Photo-Electric Smoke
Alarm Using Light Sensitive Resistor
(Includes Detection of Open-Circuited
LED)

PHOTOELECTRIC SMOKE DETECTOR (NON-LATCHING)

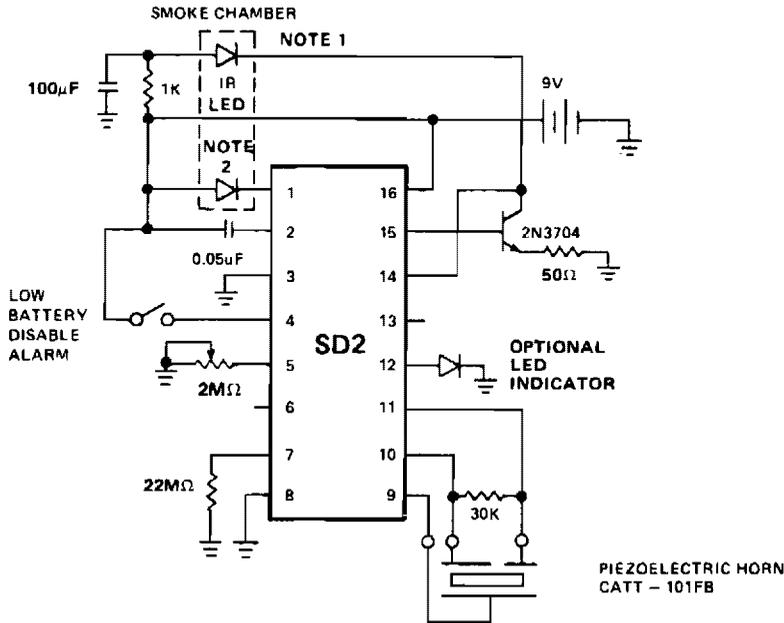


Fig. 79-1

- Notes: 1. IR Diode RCA Type SG 1010A or Spectronics Type SE 5455-4
 Clairex Type CLED-1
 2. IR Photo detectors Vactec VTS4085

Circuit Notes

The LED predriver output pulses an external transistor which in turn, switches on the infrared light emitting diode at a very low duty cycle. The desired IR LED pulse period is determined by the value of the external timing resistor. The Smoke Sensitivity is adjustable through a trimmer resistor which varies the IR

LED pulse width. The light sensing element is a silicon photovoltaic cell which is held at near zero bias to minimize leakage currents. The circuit can detect signals as low as 1 mV and generate an alarm. The IR LED pulse repetition rate increases when smoke is detected.

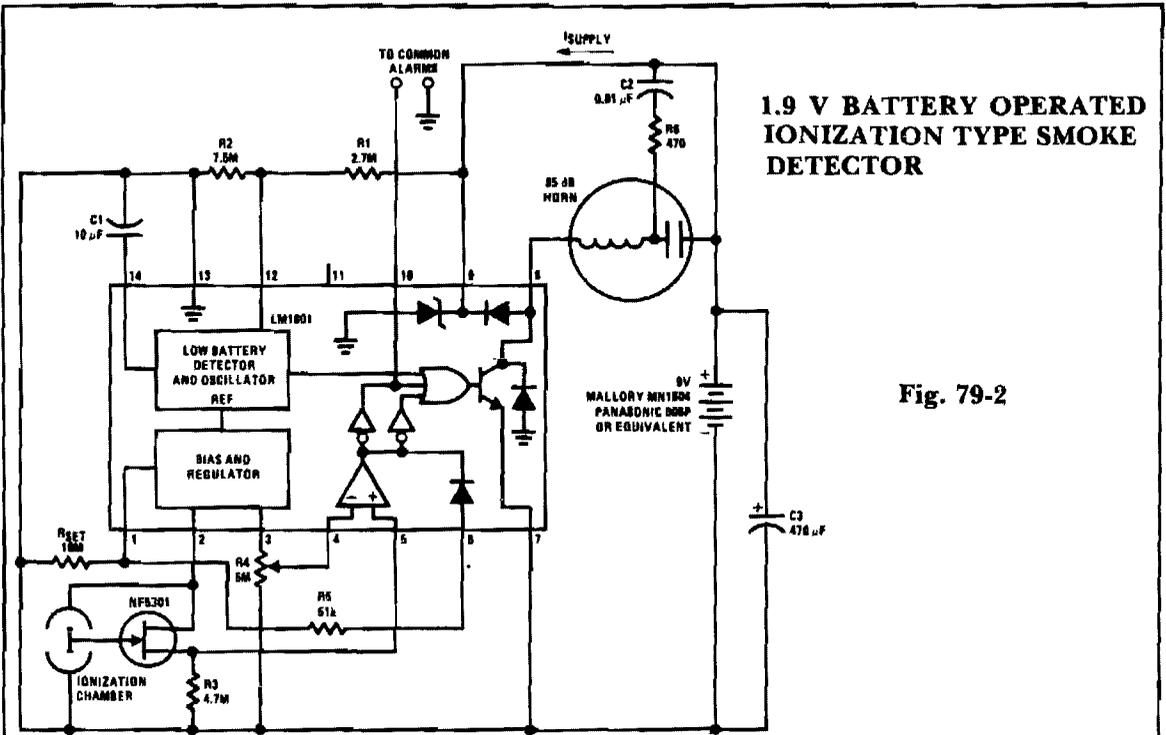


Fig. 79-2

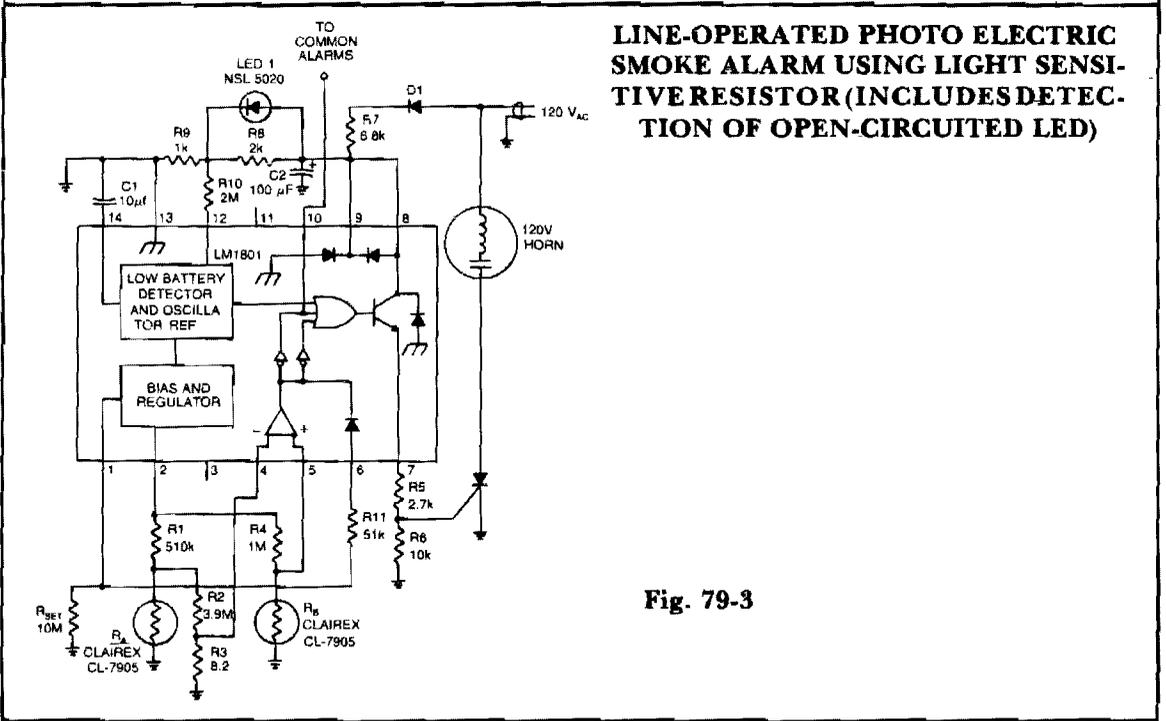


Fig. 79-3

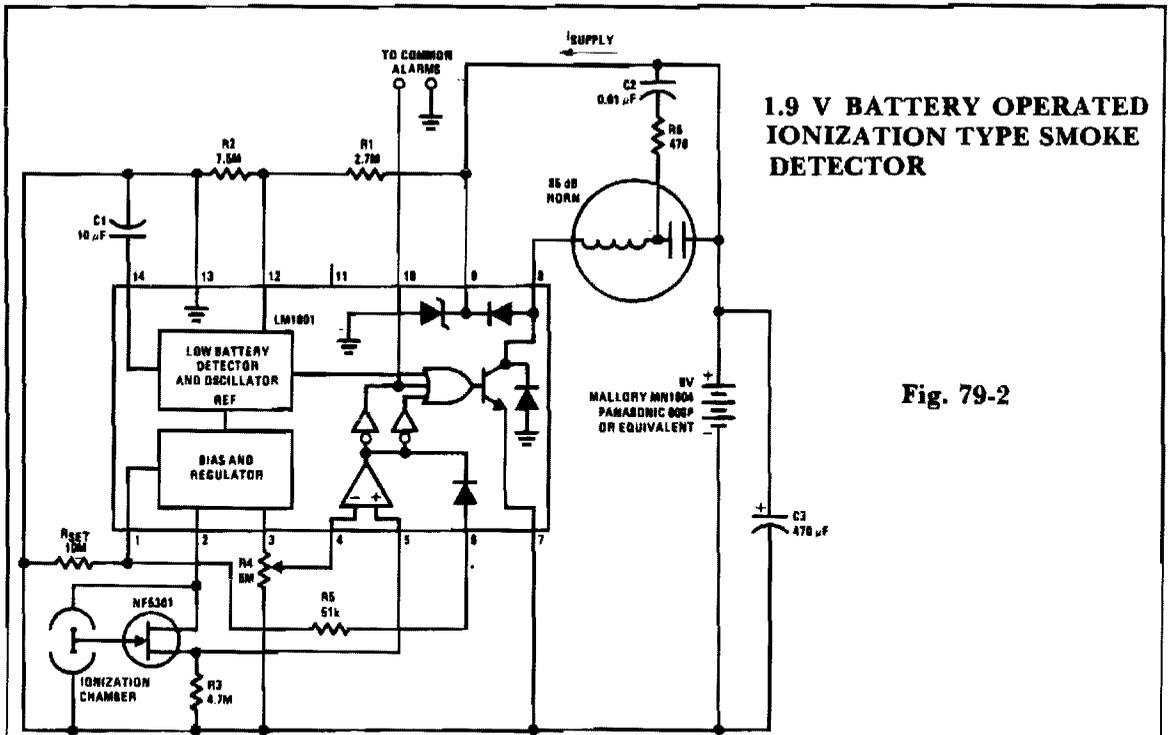


Fig. 79-2

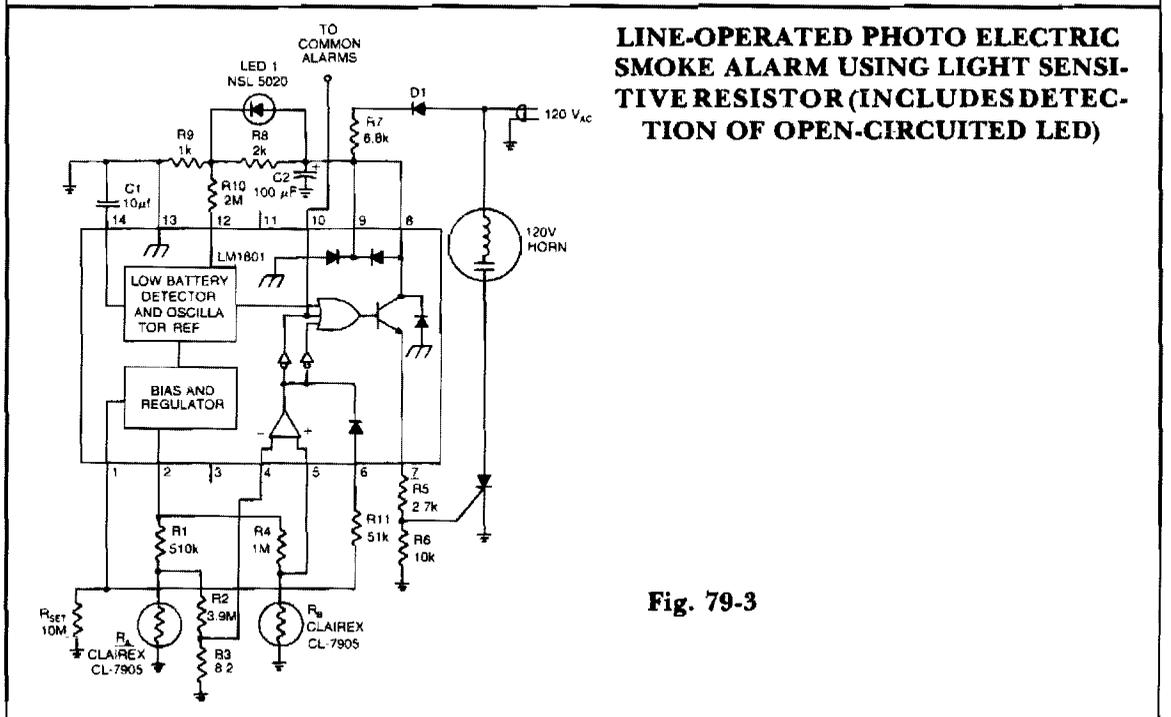


Fig. 79-3

80

Sound Effect Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Voltage-Controlled Amplifier or Tremolo Circuit	Tone Burst Generator
Music Synthesizer	Musical Chime Generator
Preprogrammed Single-Chip Microcontroller for Musical Organ	Sound Effect Generator
Musical Envelope Generator and Modulator	Programmable Bird Sounds
Stereo Reverb System	Stereo Reverb Enhancement System
	Siren/Space War/Phasor Gun
	Four Channel Synthesizer

VOLTAGE-CONTROLLED AMPLIFIER OR TREMOLO CIRCUIT

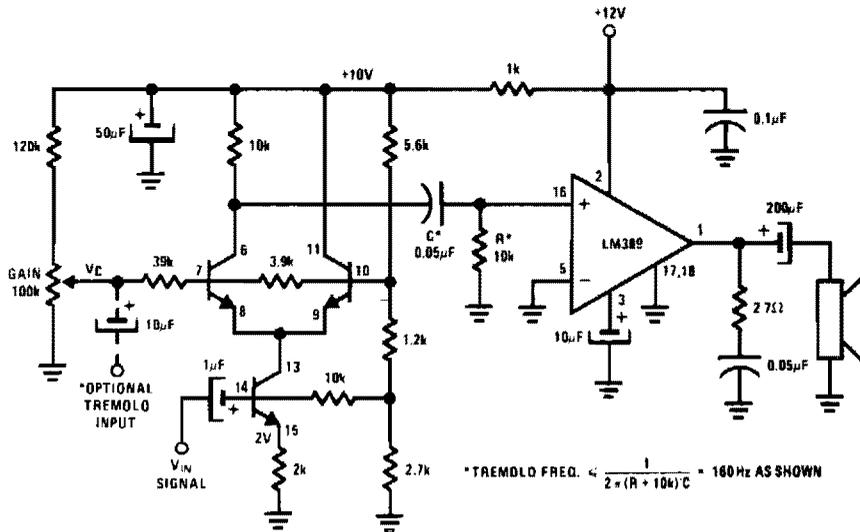


Fig. 80-1

Circuit Notes

The transistors form a differential pair with an active current-source tail. This configuration, known technically as a variable-transconductance multiplier, has an output proportional to the product of the two input signals. Multiplication occurs due to the dependence of the transistor transconductance on

the emitter current bias. Tremolo (amplitude modulation of an audio frequency by a sub-audio oscillator—normally 5-15 Hz) applications require feeding the low frequency oscillator signal into the optional input shown. The gain control pot maybe set for optimum depth.

MUSIC SYNTHESIZER

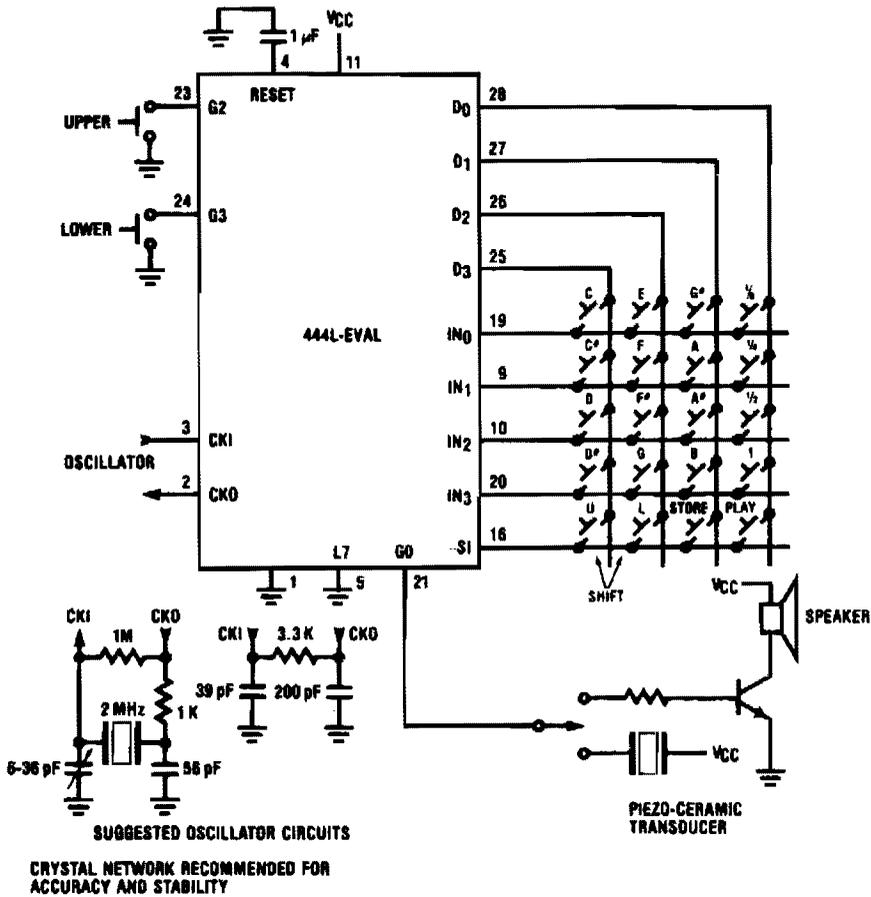


Fig. 80-2

Circuit Notes

Three modes of operation are available in the music synthesizer mode: play a note, play one of four stored tunes, or record a tune for subsequent replay.

PREPROGRAMMED SINGLE-CHIP MICROCONTROLLER FOR MUSICAL ORGAN

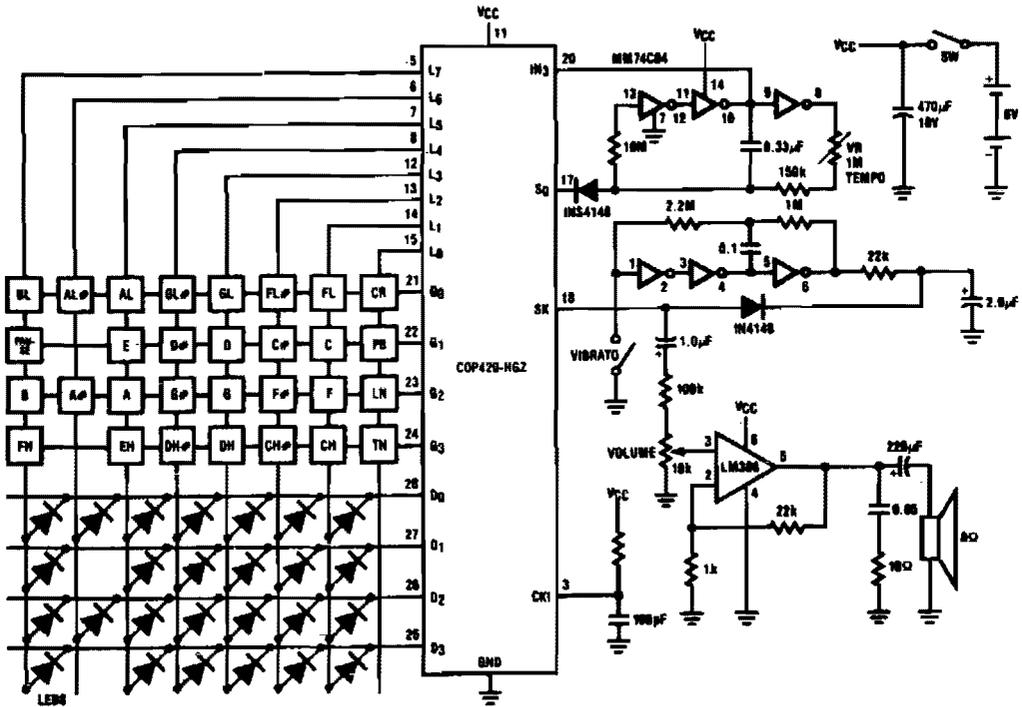


Fig. 80-3

Circuit Notes

Twenty-five musical keys and 25 LEDs are provided to denote F to F'' with half notes in between. Memory can store a played tune. There are ten preprogrammed tunes (each has an average of 55 notes) masked in the chip. Any

tune can be recalled by depressing the Tune Button followed by the corresponding Sharp Key. In learn mode, the player can learn the ten preprogrammed tunes.

MUSICAL ENVELOPE GENERATOR AND MODULATOR

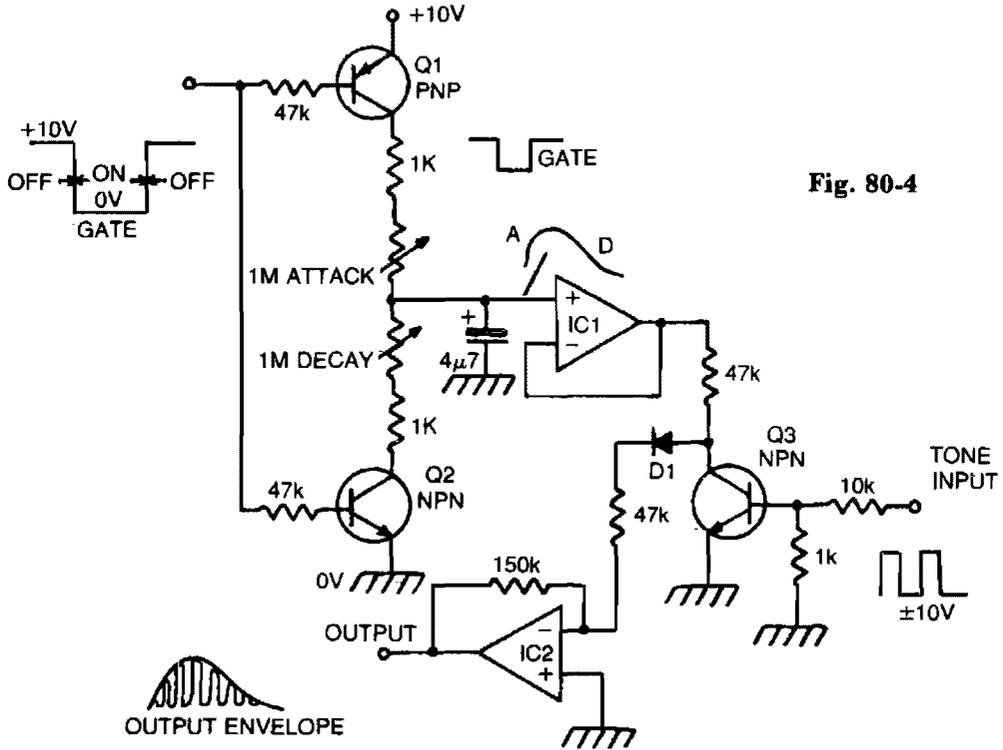


Fig. 80-4

Circuit Notes

When a gate voltage is applied, Q1 is turned on and capacitor C is charged via the attack pot in series with the 1 K resistor varying this pot, attack time constant. A fast attack gives a percussive sound, a slow attack the affect of "backward" sounds. When the gate voltage returns to its off state, Q2 is turned on and capacitor is discharged via decay pot to ground. The envelope is buffered by IC1 and applied to Q3, which is used as a transistor

chopper. A musical tone in the form of a squarewave is connected to the base of Q3. This turns the transistor on or off and thus the envelope is chopped up at regular intervals, the intervals being determined by the pitch of the squarewave. The resultant waveform has the amplitude of the envelope and the harmonic structure of the squarewave. IC2 buffers the signal and D1 ensures that the envelope dies away at the end of a note.

STEREO REVERB SYSTEM

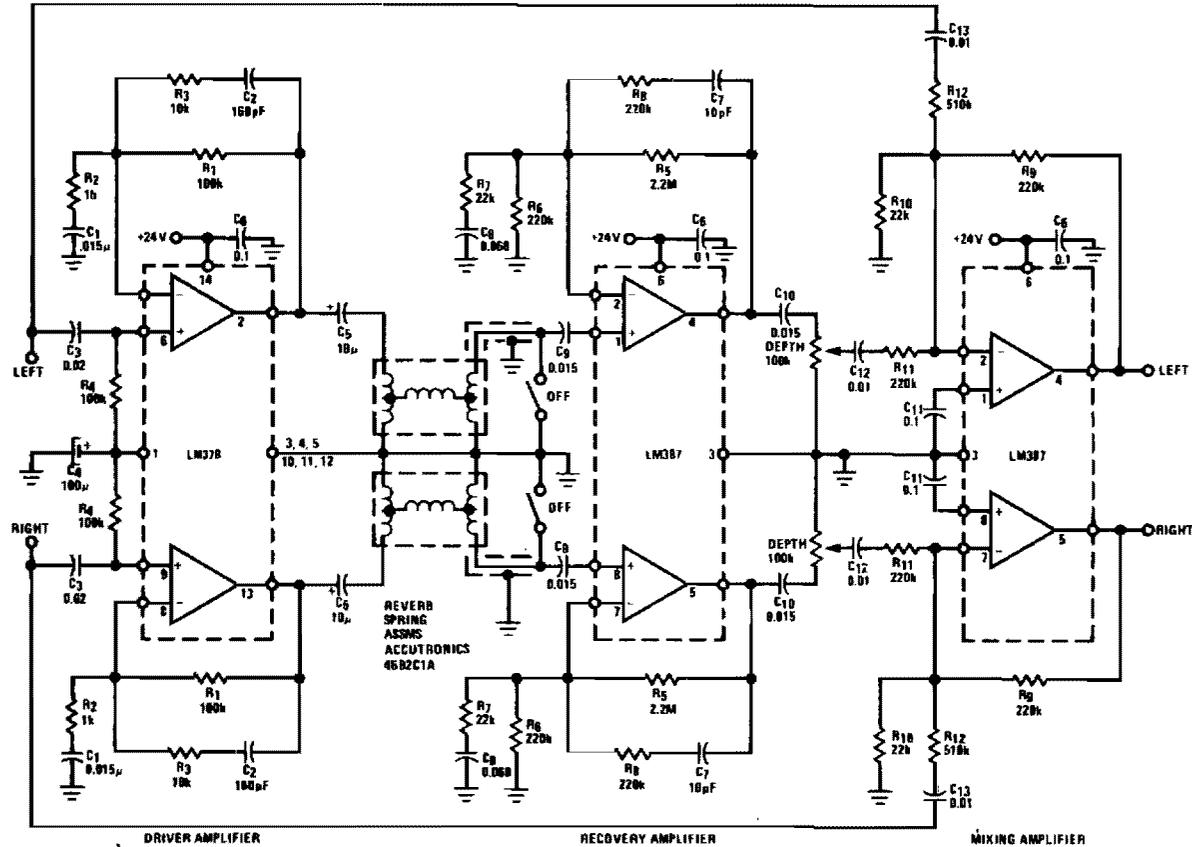


Fig. 80-5

Circuit Notes

The LM378 dual power amplifier is used as the spring driver. The recovery amplifier is a low noise dual preamplifier. Mixing of the delayed signal with the original is done with another LM387 used in an inverting summing configuration.

TONE BURST GENERATOR

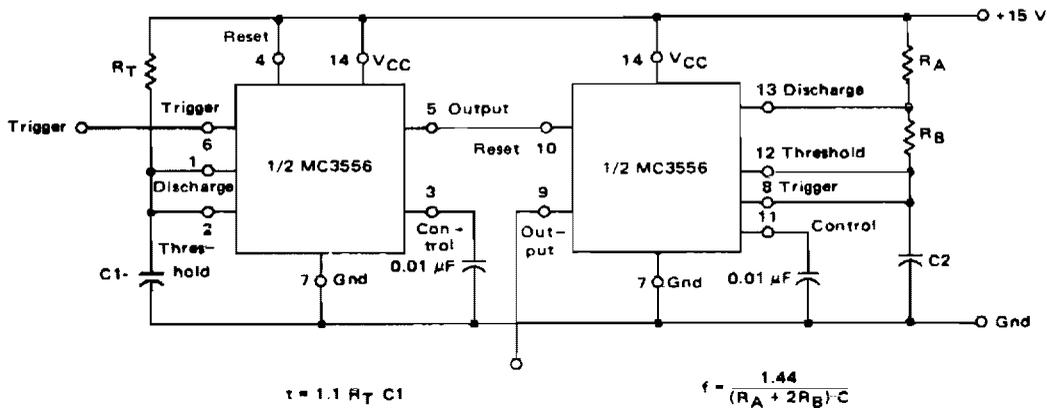


Fig. 80-7

Circuit Notes

The first timer is used as a monostable and determines the tone duration when triggered by a positive pulse at pin 6. The second timer is

enabled by the high output of the monostable. It is connected as an astable and determines the frequency of the tone.

MUSICAL CHIME GENERATOR

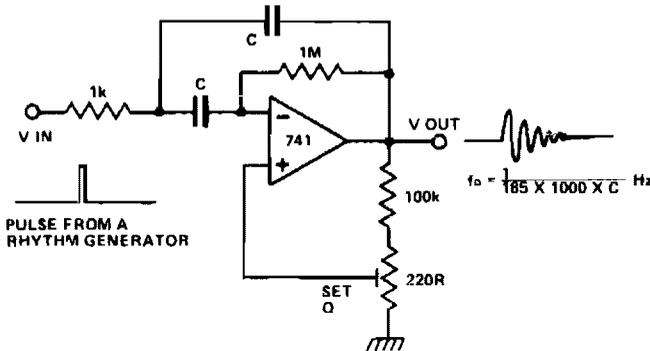


Fig. 80-8

Circuit Notes

The circuit is that of a multiple feedback bandpass filter. A short click (pulse), makes it ring with a frequency which is its natural resonance frequency. Oscillations die away exponentially and closely resemble many naturally occurring percussive or plucked sounds. The higher the Q the longer the decay time con-

stant. High frequency resonances resemble chimes, lower frequencies sound like claves or bongos. Several circuits, all with different tuning, driven by pulses from a rhythm generator can produce an interesting pattern of sounds.

SOUND EFFECT GENERATOR

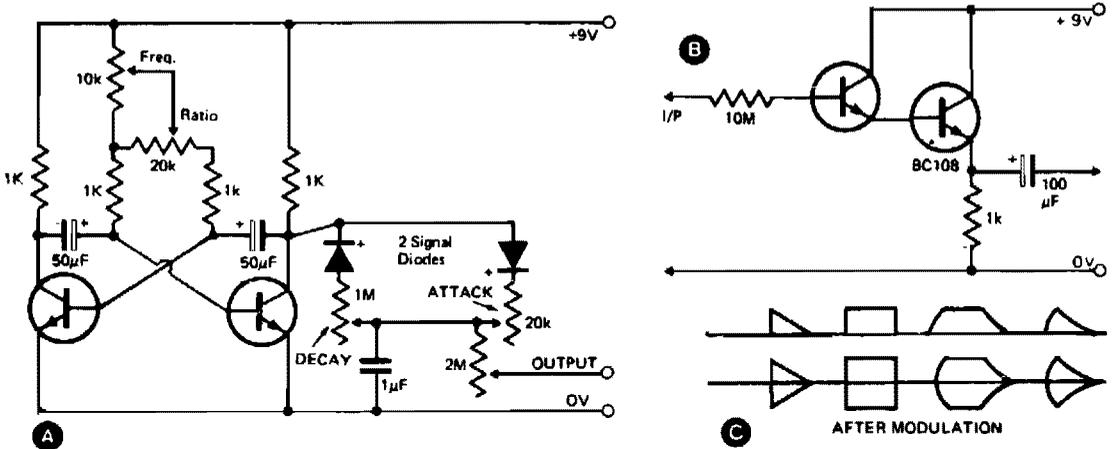


Fig. 80-9

Circuit Notes

This waveshape generator is basically a slow running oscillator with variable attack and decay. A variable amplitude (high impedance) output is available via the 2 M potentiometer. B

shows an add-on circuit which should be used if a low impedance output is required. Some of the output waveforms that can be produced are shown in C.

PROGRAMMABLE BIRD SOUNDS

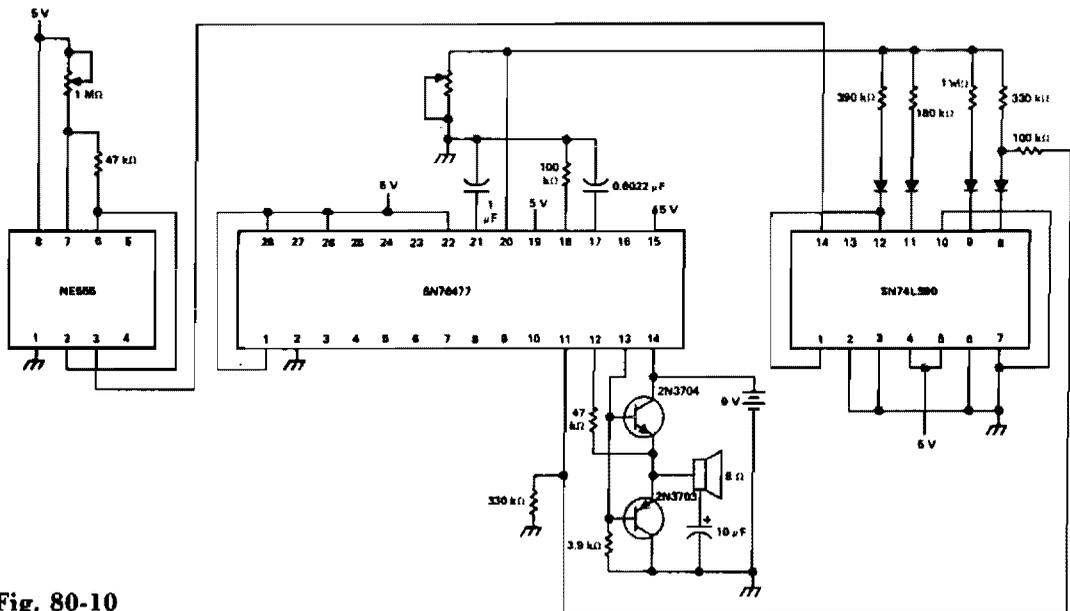


Fig. 80-10

STEREO REVERB ENHANCEMENT SYSTEM

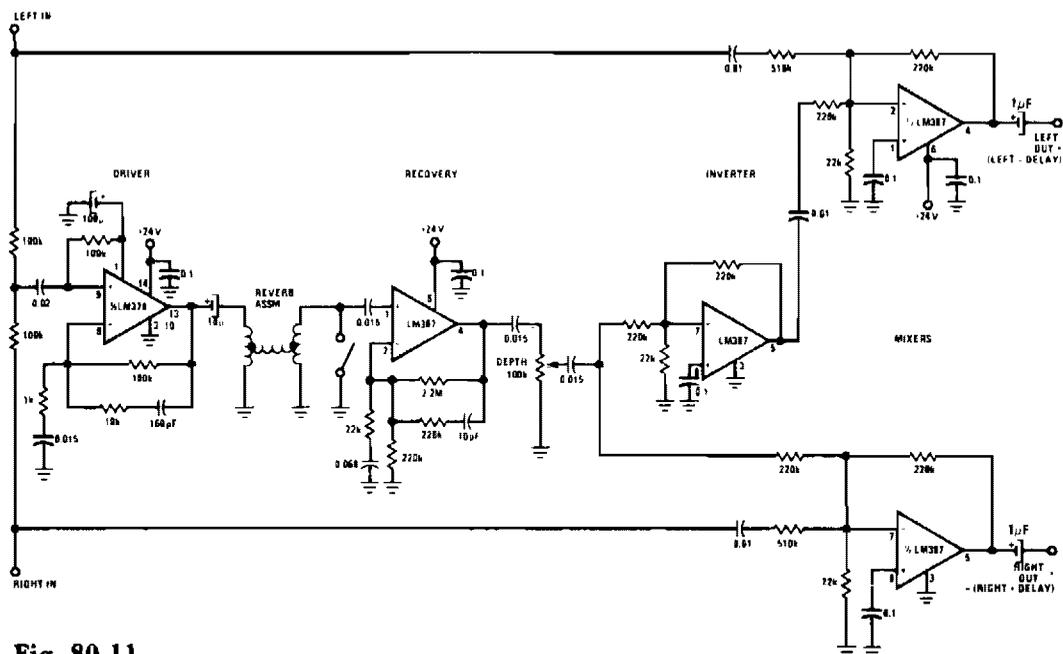


Fig. 80-11

Circuit Notes

The system can be used to synthesize a stereo effect from a monaural source such as AM radio or FM-mono broadcast, or it can be added to an existing stereo (or quad) system where it produces an exciting "opening up" special effect that is truly impressive.

SIREN/SPACE WAR/PHASOR GUN

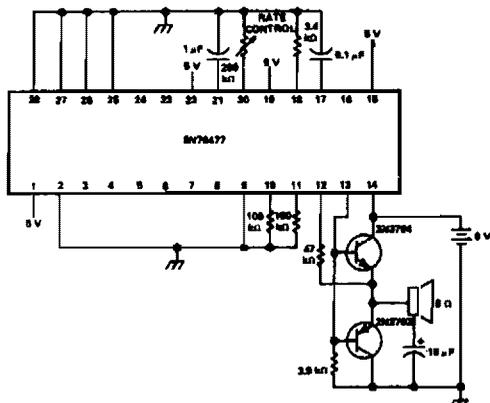


Fig. 80-12

Circuit Notes

The one shot and decay functions could be added to make an ideal phasor gun sound.

81

Sound (Audio) Operated Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Voice Activated Switch and Amplifier
Audio Operated Relay
Sound-Modulated Light Source

Audio-Controlled Lamp
Sound Activated Relay
Sound Operated Two-Way Switch

VOICE ACTIVATED SWITCH AND AMPLIFIER

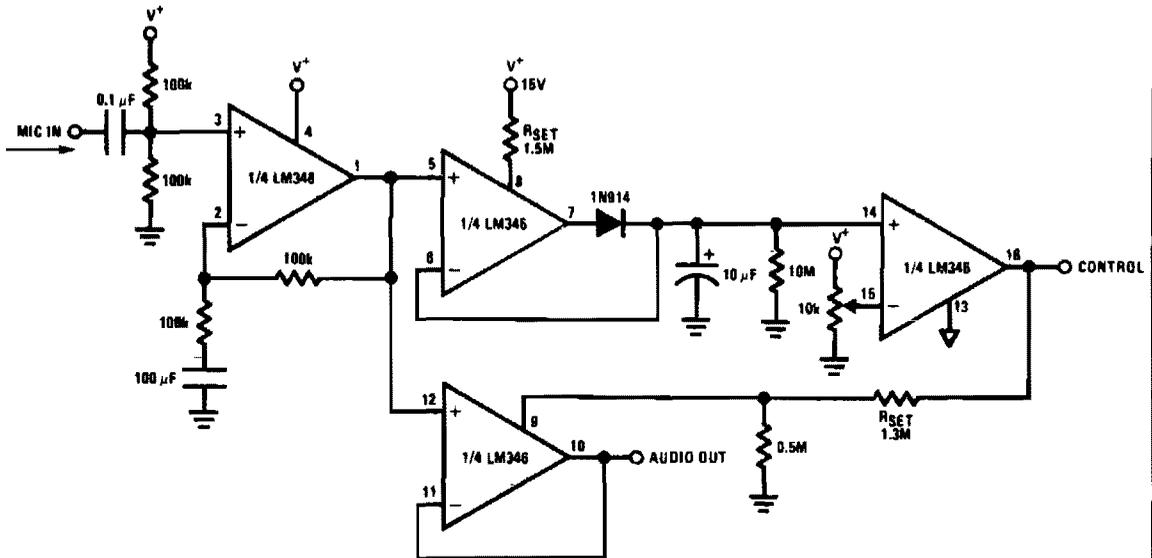


Fig. 81-1

AUDIO OPERATED RELAY

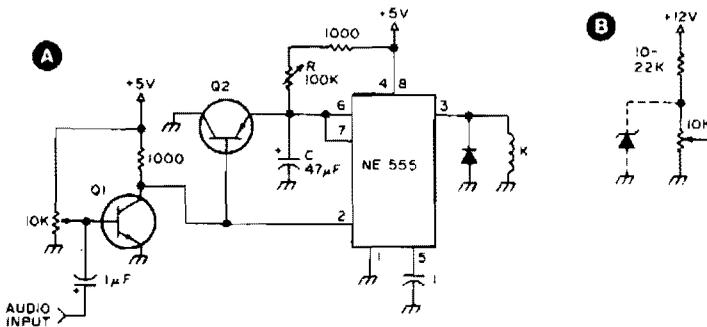


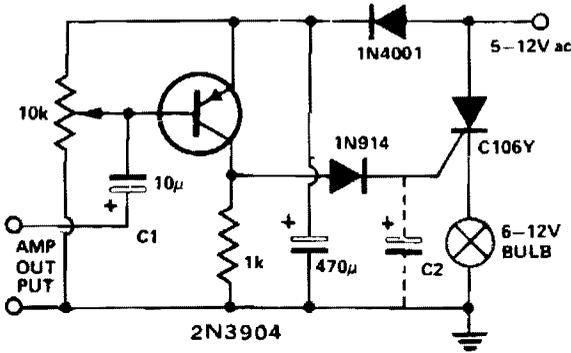
Fig. 81-2

Circuit Notes

Q1 and Q2 are general purpose transistors. The 10 K input pot is adjusted to a point just short of where Q1 turns on as indicated by K pulling in. K is any 5 V reed relay. With the values shown for R (100 K) and C (47 μF),

timing values from .05 to slightly over 5 seconds can be achieved. B shows the addition of a 22 K series resistor to the 10 K input pot if a 12 V supply is used. A suitable 12 V reed relay must be used at K.

SOUND-MODULATED LIGHT SOURCE



Circuit Notes

This circuit modulates a light beam with voice or music from the output of an amplifier. If the 10 K pot is adjusted to slightly less than the V_{be} of the transistor, the circuit forms a peak detector. This drives the gate of the SCR, lighting the bulb whose brightness will vary as the sound level varies. C2 may be removed for a faster response.

Fig. 81-3

AUDIO-CONTROLLED LAMP

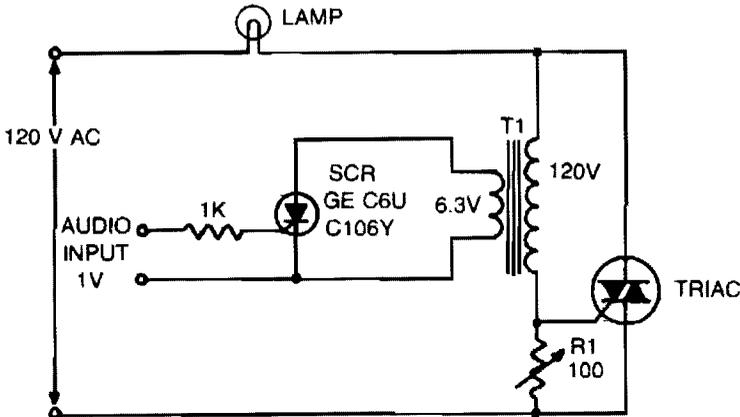


Fig. 81-4

NOTE: T1 IS A 6.3V, 1A. "FILAMENT" TRANSFORMER. ADJUST R1 FOR MAXIMUM RESISTANCE THAT WILL NOT TURN ON LAMP WITH ZERO INPUT.

Circuit Notes

This is an on-off control with isolated, low voltage input. Since the switching action is very rapid, compared with the response time of the lamp and the response of the eye, the effect

produced with audio input is similar to a proportional control circuit. If the input signal to the SCR consists of phase-controlled pulses, full wave control of the lamp load is obtained.

SOUND ACTIVATED RELAY

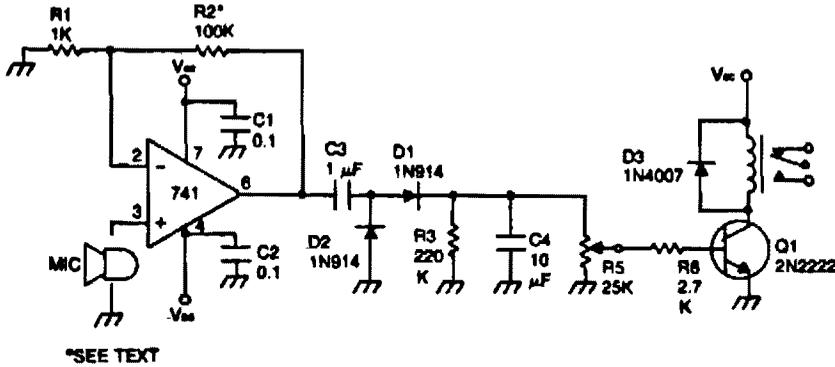


Fig. 81-5

Circuit Notes

The device remains format (in an off condition) until some sound causes it to turn on. The input stage is a 741 operational amplifier connected as a noninverting follower audio amplifier. Gain is approximately 100. To in-

crease gain raise the value of R2. The amplified signal is rectified and filtered to a dc level by R4. Then R5 is set to the audio level desired to activate the relay.

SOUND OPERATED TWO-WAY SWITCH

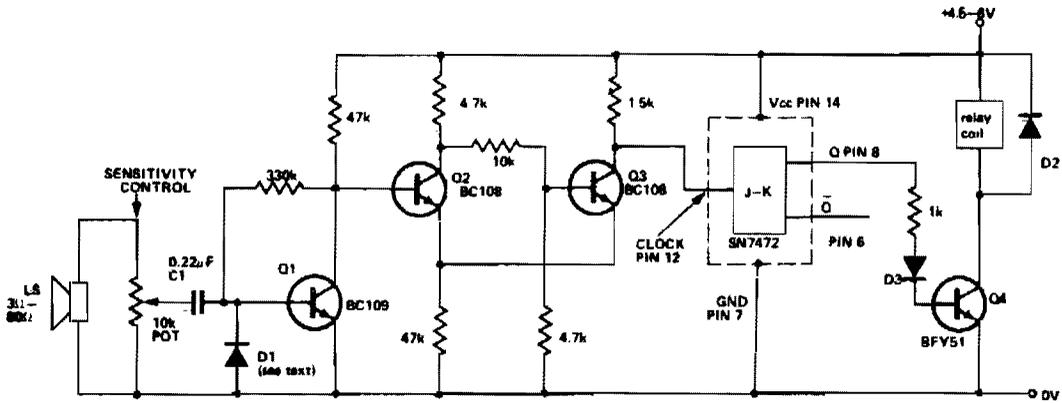


Fig. 81-6

Circuit Notes

This circuit operates a relay each time a sound of sufficient intensity is made, thus one clap of the hands will switch it one way, a second clap will revert the circuit to the original condition. Q2 and Q3 form a Schmitt trig-

ger. The JK flip-flop is used as a bistable whose output changes state every time a pulse is applied to the clock input (pin 12). Q4 allows the output to drive a relay.

82

Square Wave Oscillators

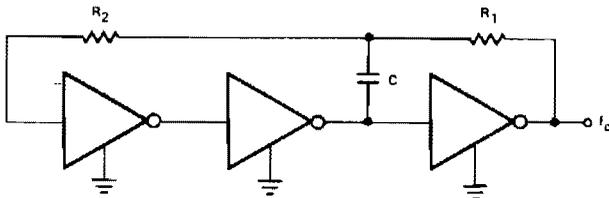
The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

R/C Oscillator
1 kHz Square Wave Oscillator
TTL Oscillator
Square Wave Oscillator
Adjustable TTL Clock
Square Wave Oscillator
Oscillator/Clock Generator

CMOS Oscillator
Free-Running Square-Wave Oscillator
Precision Squares
Square Wave Oscillator
0.5 Hz Square-Wave Oscillator
Simple Triangle/Square Wave Oscillator
Squarewave Oscillator

R/C OSCILLATOR

$$f_o = \frac{1}{2 C [0.41 R_P + 0.70 R_1]}, \quad R_P = \frac{R_1 R_2}{R_1 + R_2}$$



Gates are 74C04

a. If $R_1 = R_2 = R_1$, $f \cong 0.55/RC$

b. If $R_2 \gg R_1$, $f \cong 0.45/R_1 C$

c. If $R_2 \ll R_1$, $f \cong 0.72/R_1 C$

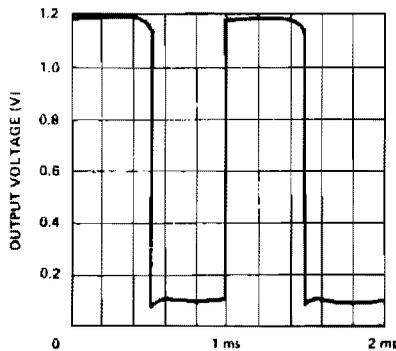
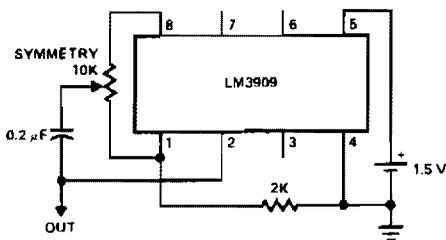
a. $f = 120 \text{ kHz}$, $C = 420 \text{ pF}$
 $R_1 = R_2 \approx 10.9 \text{ k}\Omega$

b. $f = 120 \text{ kHz}$, $C = 420 \text{ pF}$, $R_2 = 50 \text{ k}\Omega$
 $R_1 = 8.93 \text{ k}\Omega$

c. $f = 120 \text{ kHz}$, $C = 220 \text{ pF}$, $R_2 = 5 \text{ k}\Omega$
 $R_1 = 27.3 \text{ k}\Omega$

Fig. 82-1

1 kHz SQUARE WAVE OSCILLATOR



Note: Output Voltage Through a 10K Load to Ground

Fig. 82-2

TTL OSCILLATOR

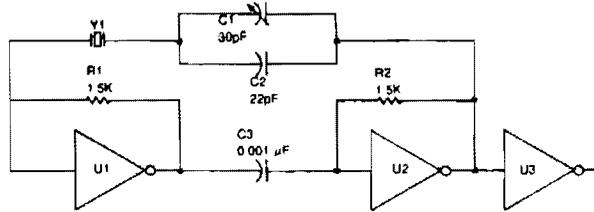


Fig. 82-3

Circuit Notes

TTL inverter stages, U1 and U2, are cross-connected with a crystal Y1. A resistor in each stage biases the normally digital gates into a region where they operate as amplifiers. Inverter stage U3 is used as a buffer.

SQUARE WAVE OSCILLATOR

Oscillator Frequency for Various Capacitor Values

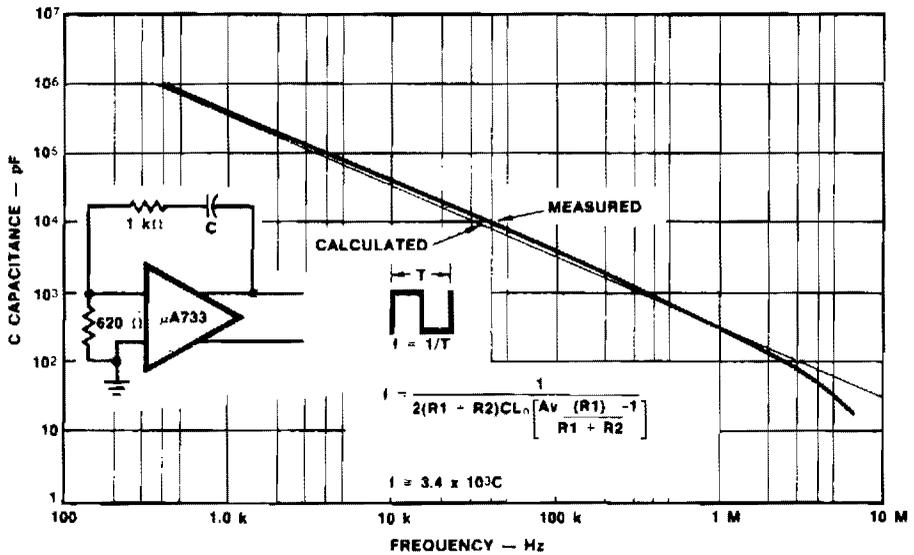


Fig. 82-4

ADJUSTABLE TTL CLOCK (MAINTAINS 50% DUTY CYCLE)

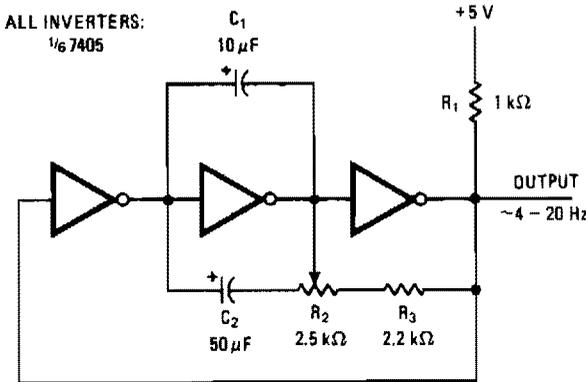


Fig. 82-5

Circuit Notes

Symmetry of the square-wave output is maintained by connecting the right side of R2 through resistor R3 to the output of the third amplifier stage. This changes the charging current to the capacitors in proportion to the setting of frequency-adjusting potentiometer R2. Thus, a duty cycle of 50% is constant over the entire range of oscillation. The lower fre-

quency limit is set by capacitor C2. With the components shown, the frequency of oscillation can be varied by R2 from about 4 to 20 hertz. Other frequency ranges can be obtained by changing the values of C1 and R3, which control the upper limit of oscillation, or C2, which limits the low-frequency end.

SQUARE WAVE OSCILLATOR

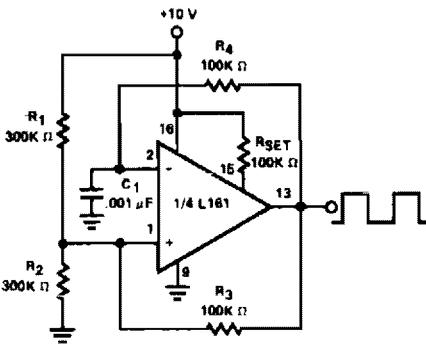
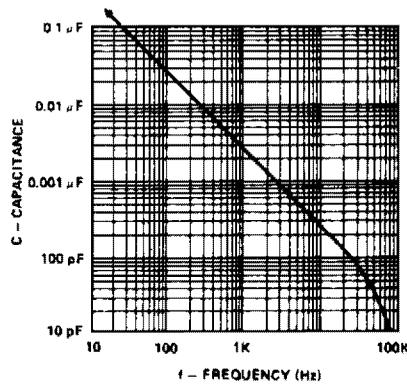


Fig. 82-6



Frequency vs the Value of C₁ for the Squarewave Oscillator

Circuit Notes

This generator is operable to over 100 kHz. The low frequency limit is determined by C1. Frequency is constant for supply voltages down to +5 V.

OSCILLATOR/CLOCK GENERATOR

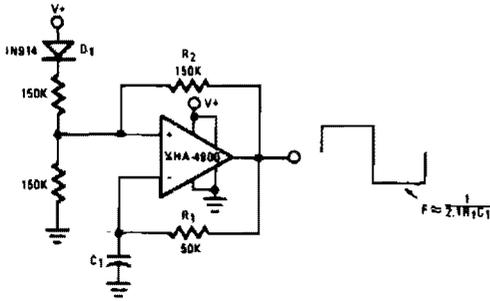


Fig. 82-7

Circuit Notes

This self-starting fixed frequency oscillator circuit gives excellent frequency stability. R1 and C1 comprise the frequency determining network while R2 provides the regenerative feedback. Diode D1 enhances the stability by compensating for the difference between V_{OH} and V_{Supply} . In applications where a precision clock generator up to 100 kHz is required, such as in automatic test equipment, C1 may be replaced by a crystal.

CMOS OSCILLATOR

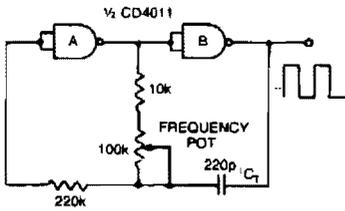


Fig. 82-8

Circuit Notes

Varying the 100 K pot changes the discharge rate of C_1 and hence the frequency. A square wave output is generated. The maximum frequency-using CMOS is limited to 2 MHz.

FREE-RUNNING SQUARE-WAVE OSCILLATOR

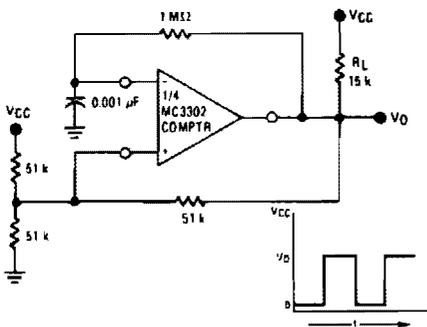
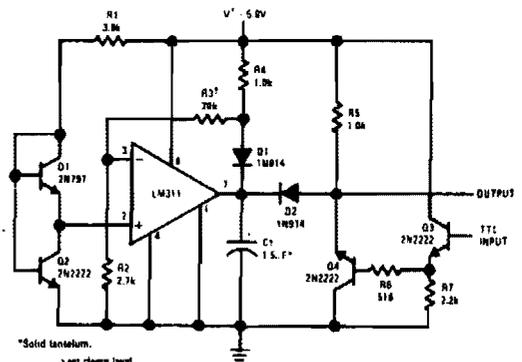


Fig. 82-9

PRECISION SQUARER



*Solid tantalum.
† set clamp level

Fig. 82-10

SQUARE WAVE OSCILLATOR

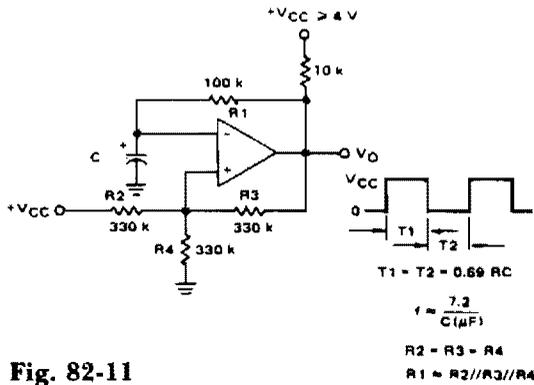


Fig. 82-11

0.5 Hz SQUARE-WAVE OSCILLATOR

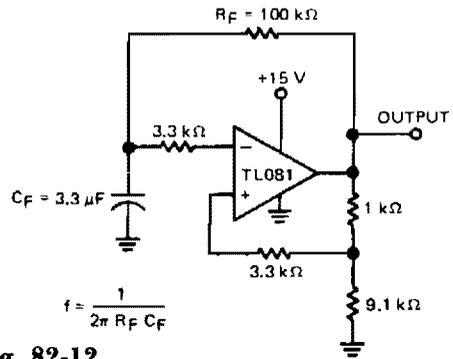


Fig. 82-12

SIMPLE TRIANGLE/SQUARE WAVE OSCILLATOR

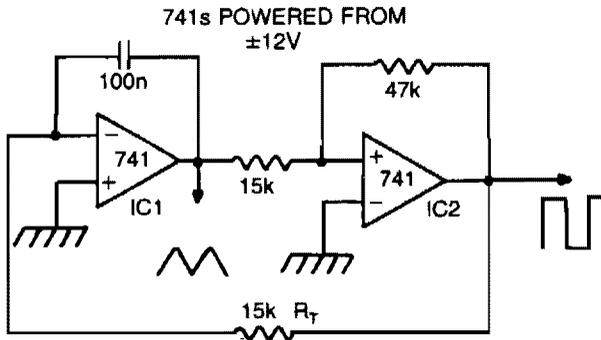


Fig. 82-13

Circuit Notes

By making R_T variable it is possible to alter the operating frequency over a 100 to 1 range. Versatile triangle/square wave oscillator has a possible frequency range of 0.1 Hz to 100 kHz.

SQUAREWAVE OSCILLATOR

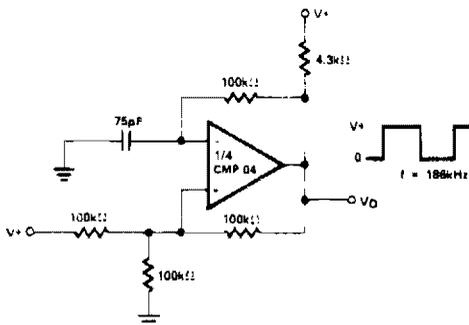


Fig. 82-14

83

Stereo Balance Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Stereo Balance Meter

Stereo Balancer

Stereo Balance Meter

STEREO BALANCE METER

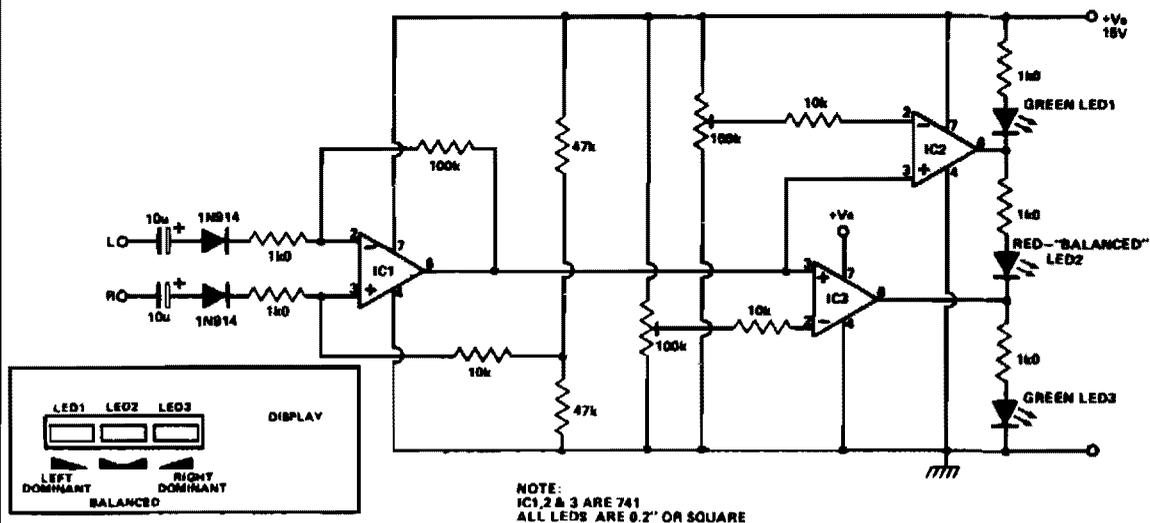


Fig. 83-1

Circuit Notes

Outputs from each channel are fed to the two inputs of IC1 connected as a differential amplifier. IC2 and 3 are driven by the output of IC1. Output of IC1 is connected to the noninverting inputs of IC2 and 3. If the output of IC1 approaches the supply rail, the outputs of ICs 2 and 3 will also go high, illuminating LED3. This

would happen if the right channel were dominating. If the left channel was dominant, the outputs of ICs 2 and 3 would be low, illuminating LED1. If the two channels are equal in amplitude, the outputs of ICs 2 and 3 would be high and low respectively, lighting up LED2.

STEREO BALANCER

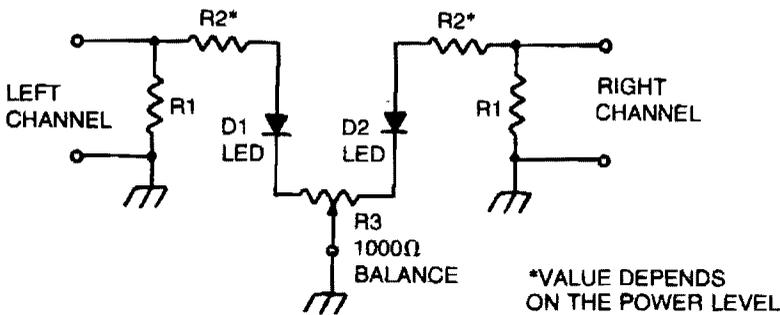


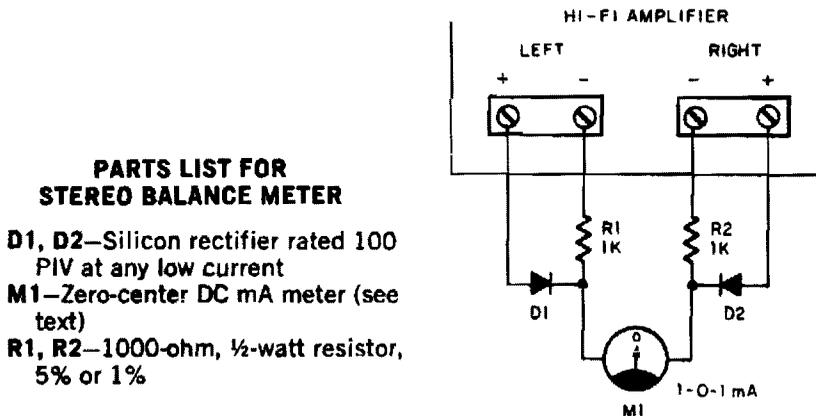
Fig. 83-2

Circuit Notes

This circuit will allow you to set the gain of two stereo channels to the same level. The signal across the two channel-load resistors is sampled by resistors R2. (Values of these resistors will depend upon the power level.) For most 20 milliamper LED, use approximately 2.5 K per watt. (For a 10-watt system use a 25,000 ohm resistor.) To set up, short the two inputs and connect them to one channel of a power amplifier. Apply a signal and adjust R3

until both LEDs glow at the same brightness level. The balancer is ready for use. Connect the inputs of the stereo balancer across the output of the power amplifier, and then turn up either the independent volume controls, or the balance control until both LEDs glow at the same level. To use this circuit in-line with loudspeakers, disconnect both R1s, and use the speakers as the load.

STEREO BALANCE METER



PARTS LIST FOR STEREO BALANCE METER

- D1, D2**—Silicon rectifier rated 100 PIV at any low current
- M1**—Zero-center DC mA meter (see text)
- R1, R2**—1000-ohm, ½-watt resistor, 5% or 1%

Fig. 83-3

Circuit Notes

Play any stereo disc or tape and then set the amplifier to mono. Adjust left and right channel balance until meter M1 indicates zero; then the left and right output level are identical.

84

Switches

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

DTL-TTL Controlled Buffered Analog
Switch

High Toggle Rate High Frequency Analog
Switch

Differential Analog Switch

High Frequency Switch

Two-Channel Switch

10 A, 25 VDC Solid State Relays

DTL-TTL CONTROLLED BUFFERED ANALOG SWITCH

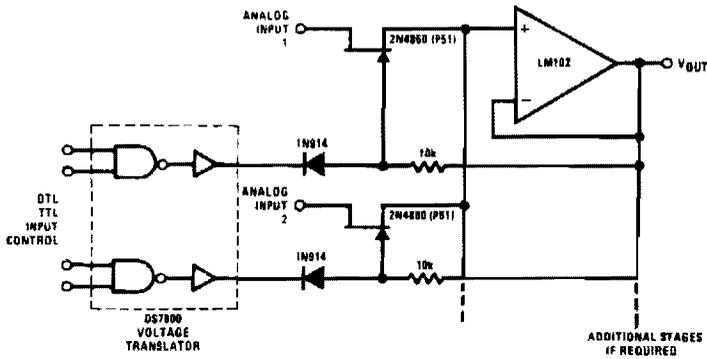


Fig. 84-1

Circuit Notes

This analog switch uses the 2N4860 JFET for its 25 ohm r_{on} and low leakage. The LM102 serves as a voltage buffer. This circuit can be adapted to a dual trace oscilloscope chopper.

The DS7800 monolithic IC provides adequate switch drive controlled by DTL/TTL logic levels.

HIGH TOGGLE RATE HIGH FREQUENCY ANALOG SWITCH

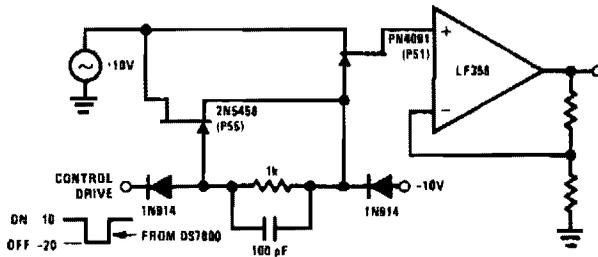


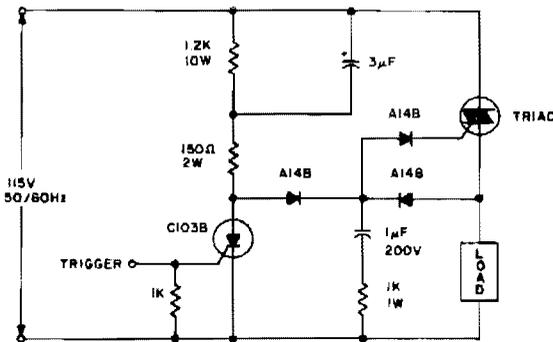
Fig. 84-2

Circuit Notes

Commutator circuit provides low impedance gate drive to the PN4091 analog switch for both on and off drive conditions. This circuit also approaches the ideal gate drive conditions

for high frequency signal handling by providing a low ac impedance for off drive and high ac impedance for on drive to the PN4091

TRIAC ZERO VOLTAGE SWITCHING

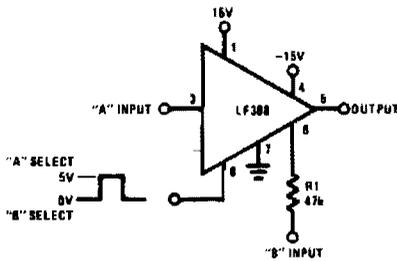


Circuit Notes

The triac will be gated on at the start of the positive half cycle by current flow through the $3\ \mu\text{F}$ capacitor as long as the C103 SCR is off. The load voltage then charges up the $1\ \mu\text{F}$ capacitor so that the triac will again be energized during the subsequent negative half cycle of line voltage. A selected gate triac is required because of the III+ triggering mode.

Fig. 84-5

TWO-CHANNEL SWITCH



	A	B
Gain	$1 \pm 0.02\%$	$1 \pm 0.2\%$
Z_{iN}	$10^{10}\ \Omega$	$47\ \text{k}\Omega$
BW	$\approx 1\ \text{MHz}$	$\approx 400\ \text{kHz}$
Crosstalk @ 1 kHz	$-90\ \text{dB}$	$-90\ \text{dB}$
Offset	$\leq 6\ \text{mV}$	$\leq 75\ \text{mV}$

Fig. 84-6

10 A, 25 Vdc SOLID STATE RELAYS

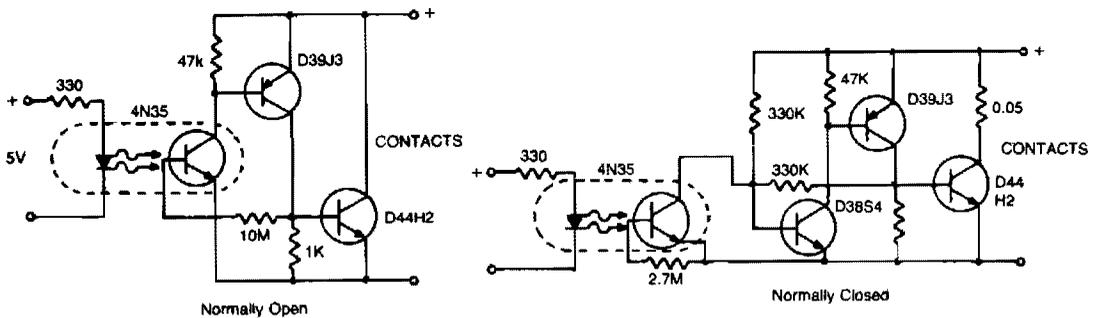


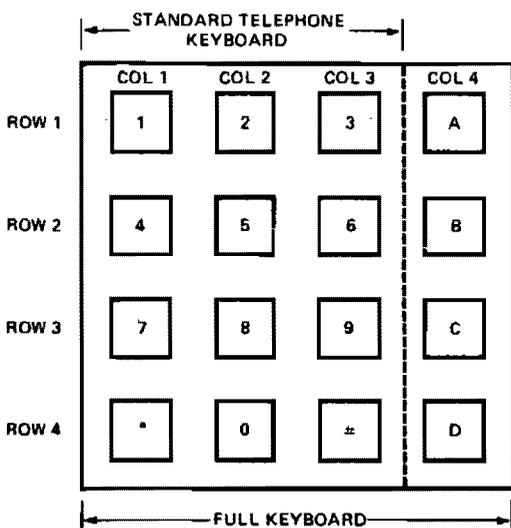
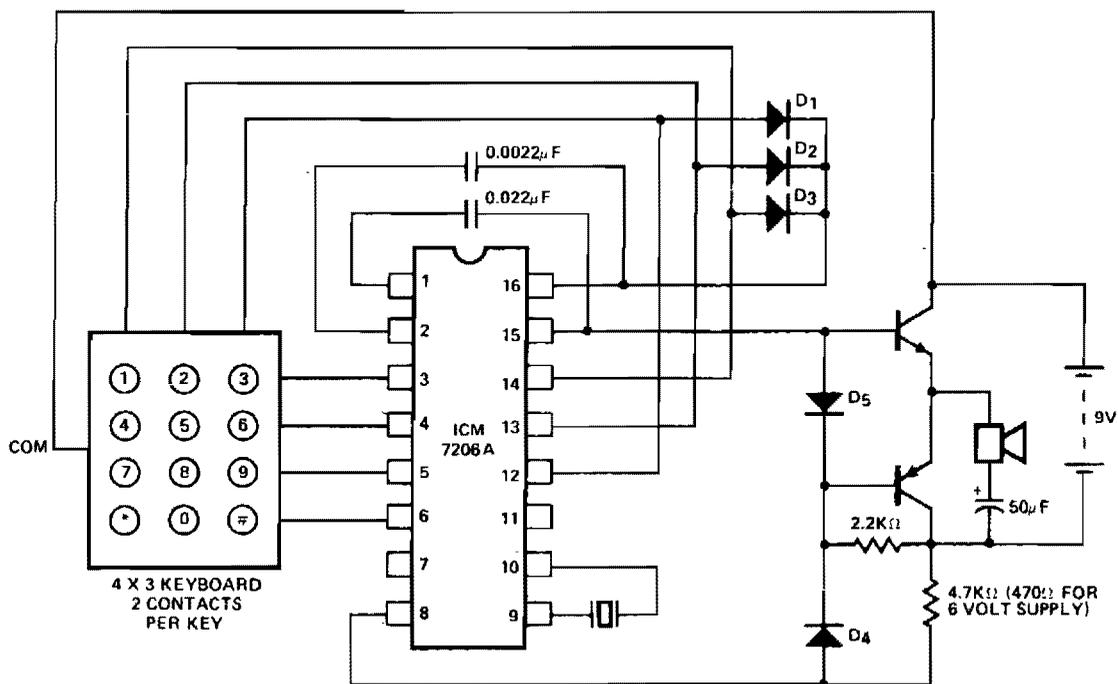
Fig. 84-7

Telephone Related Circuits

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Portable Tone Generator	Tone Dial Decoder
Telephone Status Monitor Using an Op- toisolator	Telephone Relay
Telephone Tone Ringer	Telephone-Controlled Tape Starter (TCTS)
F.C.C. Approved Telephone Tone Ringer	Telephone Line Powered Repertory Dialer
Telephone or Extension Tone Ringer	Telephone Off-Hook Indicator
Telephone Line Monitor	Telephone Handset Tone Dial Encoder
Tone Dial Generator	Low Line Loading Ring Detector
Tone Dial Encoder	Phone Auto Answer and Ring Indicator
Tone Dial Sequence Decoder	Autopatch Telephone Phone Line Interface
Remote Ring Extender Switch	Telephone Ringer Uses Piezoelectric De- vice
	Electronic Phone Bell

PORTABLE TONE GENERATOR



KEY	LOW BAND FREQ. Hz	HI BAND FREQ. Hz
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
*	941	1209
0	941	1336
#	941	1477
A	697	1633
B	770	1633
C	852	1633
D	941	1633

Fig. 85-1

TELEPHONE STATUS MONITOR USING AN OPTOISOLATOR

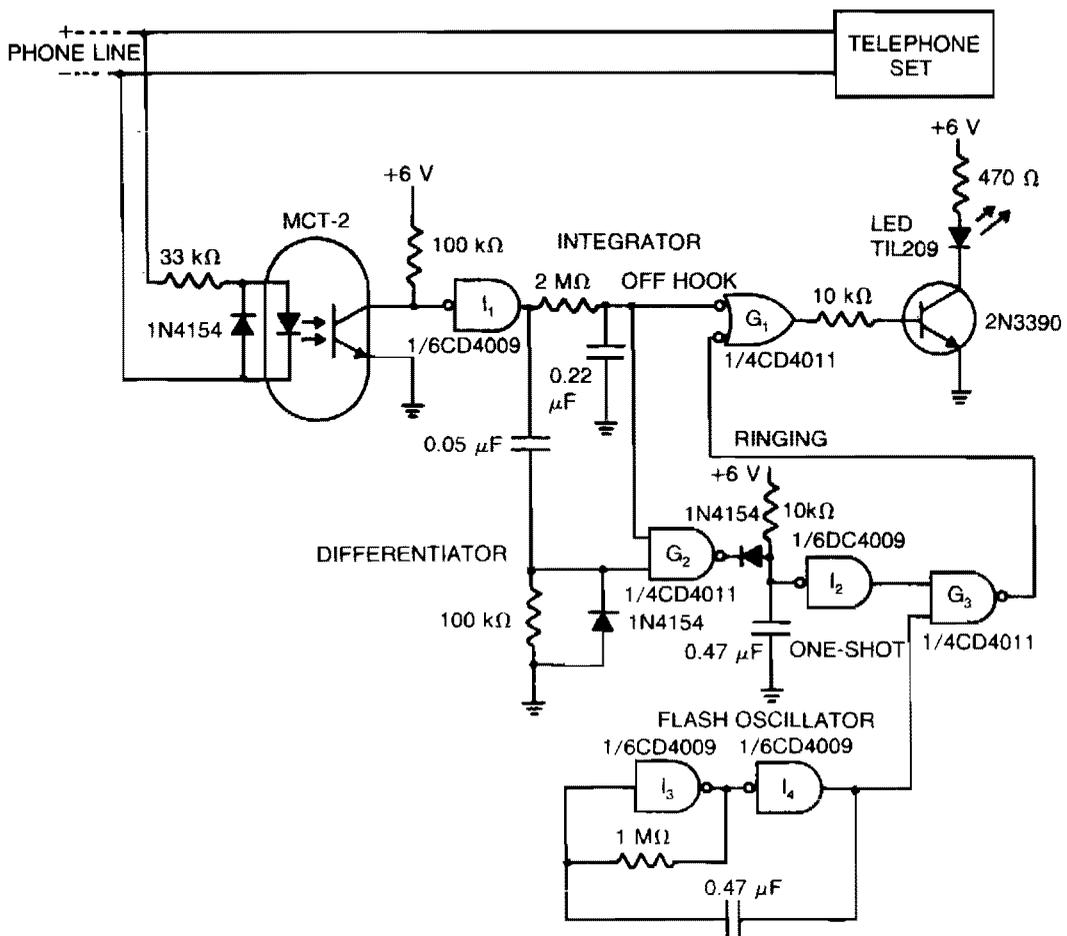


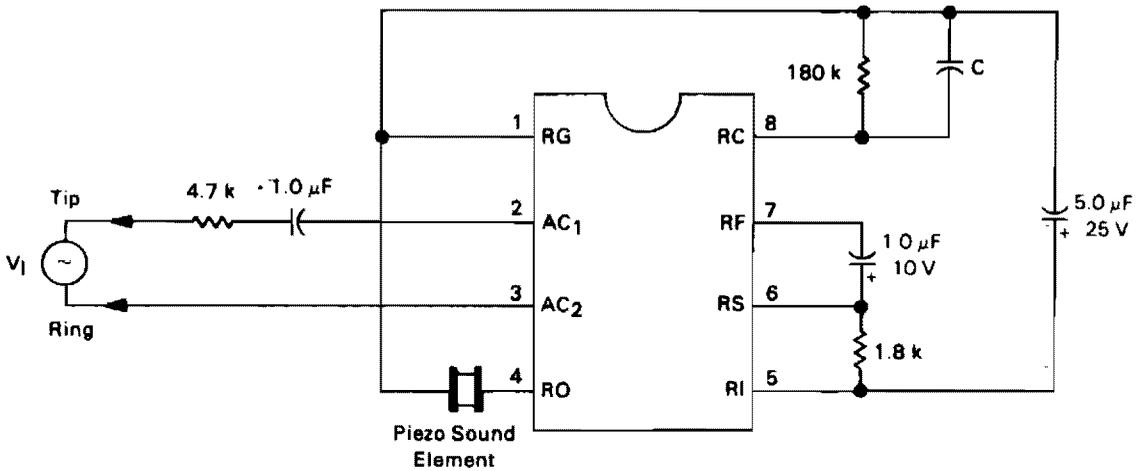
Fig. 85-2

Circuit Notes

The LED indicates the status of a remote telephone. The light is off if the phone is hung up. It shines steadily if the phone is off hook, and it flashes on and off while phone rings and for 5 seconds after ringing stops. The flashing

oscillator operates continuously but can drive the LED only when a ringing signal discharges the one shot capacitor to enable NAND gate G₃. Thus, one oscillator handles several phone lines.

TELEPHONE TONE RINGER



- MC34012-1: C = 1000 pF
- MC34012-2: C = 500 pF
- MC34012-3: C = 2000 pF

Fig. 85-3

Circuit Notes

This is a complete telephone bell replacement circuit with minimum external components with on-chip diode bridge and transient protection and direct drive for piezoelectric transducers.

F.C.C. APPROVED TELEPHONE TONE RINGER

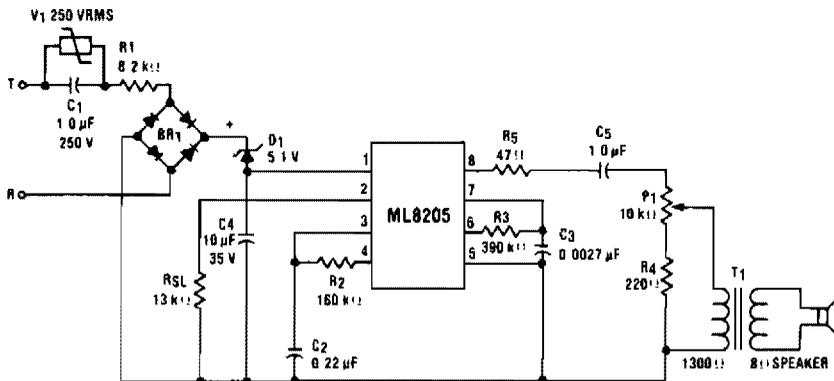


Fig. 85-4

TELEPHONE OR EXTENSION TONE RINGER

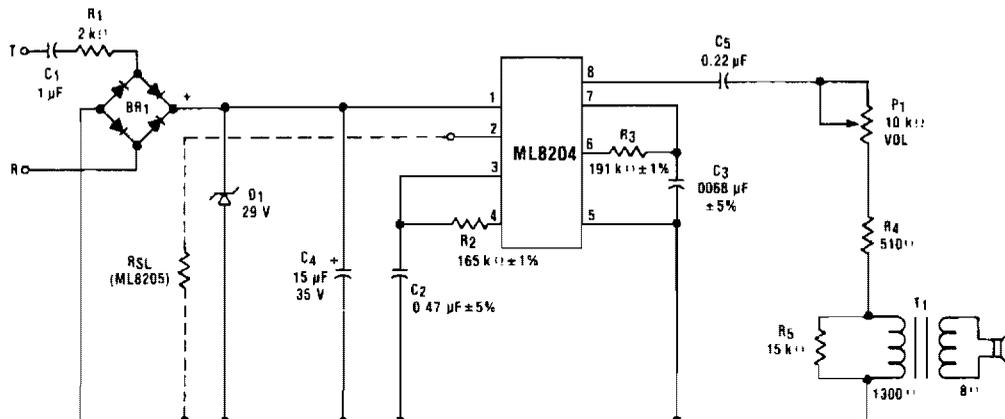


Fig. 85-5

Circuit Notes

This circuit uses ML8204/ML8205 devices. With the components shown, the output frequency chops between 512 Hz (f_{n1}) and 640 Hz (f_{n2}) at a 10 Hz (f_n) rate.

TELEPHONE LINE MONITOR

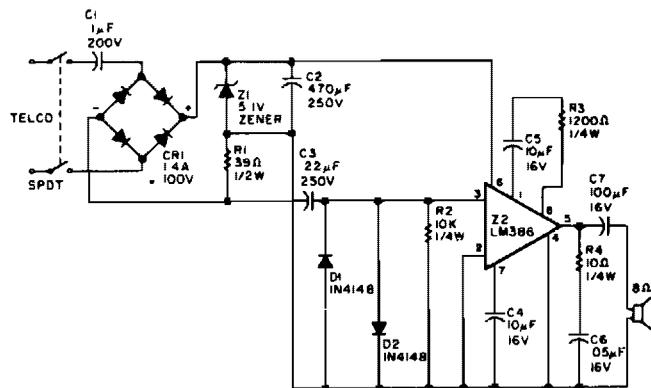


Fig. 85-6

Circuit Notes

Using rectified audio as a power supply, this monitor will send the telephone line audio into an 8 ohm speaker.

TONE DIAL GENERATOR

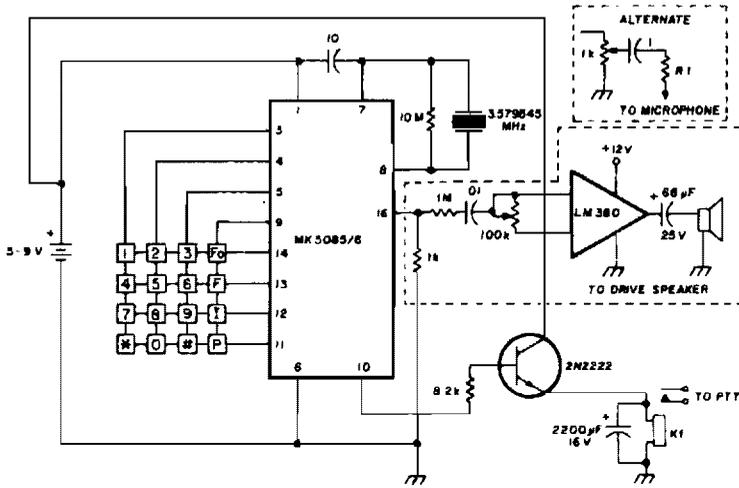


Fig. 85-7

Circuit Notes

The circuit requires a minimum of parts and uses a low cost standard 3.579645-MHz television color-burst crystal. The speaker can be eliminated and the output fed directly into the microphone input of a transmitter.

TONE DIAL ENCODER

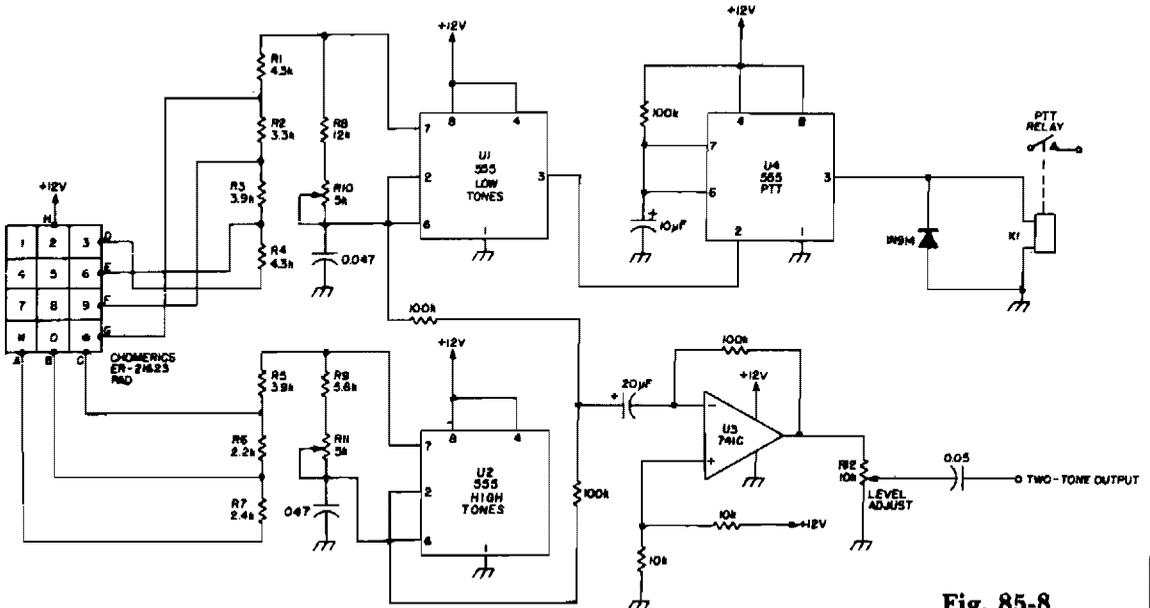


Fig. 85-8

Circuit Notes

Tone dial encoder with automatic PTT control uses the 555 timers.

TONE DIAL SEQUENCE DECODER

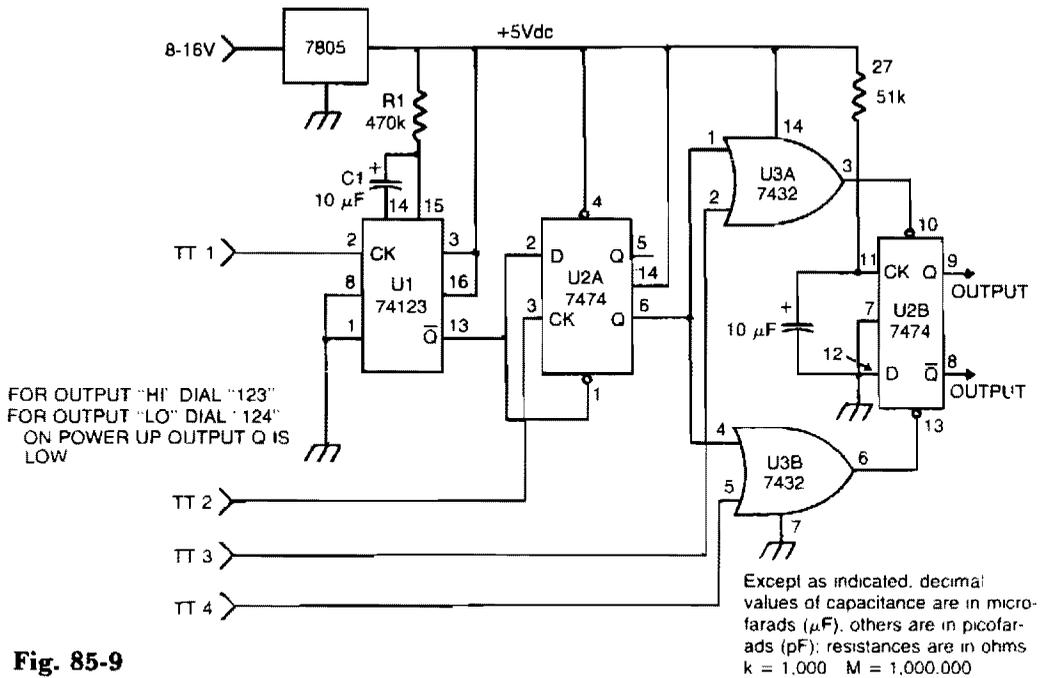
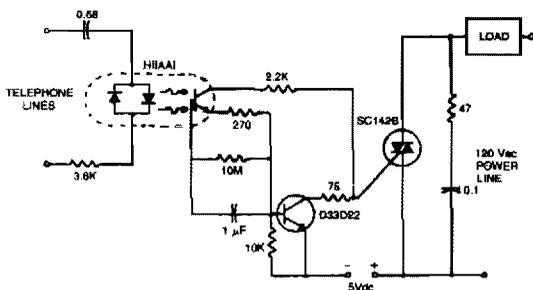


Fig. 85-9

Circuit Notes

The circuit takes active low inputs from a Touch Tone decoder and reacts to a proper sequence of digits. The proper sequence is determined by which Touch Tone digits the user connects to the sequence decoder inputs TT1, TT2, TT3, and TT4.

REMOTE RING EXTENDER SWITCH



Circuit Notes

The circuit can operate lamps and buzzers from the 120 V, 60 Hz power line while maintaining positive isolation between the telephone line and the power line. Use of the isolated tab triac simplifies heat sinking by removing the constraint of isolating the triac heat sink from the chassis.

Fig. 85-10

TONE DIAL DECODER

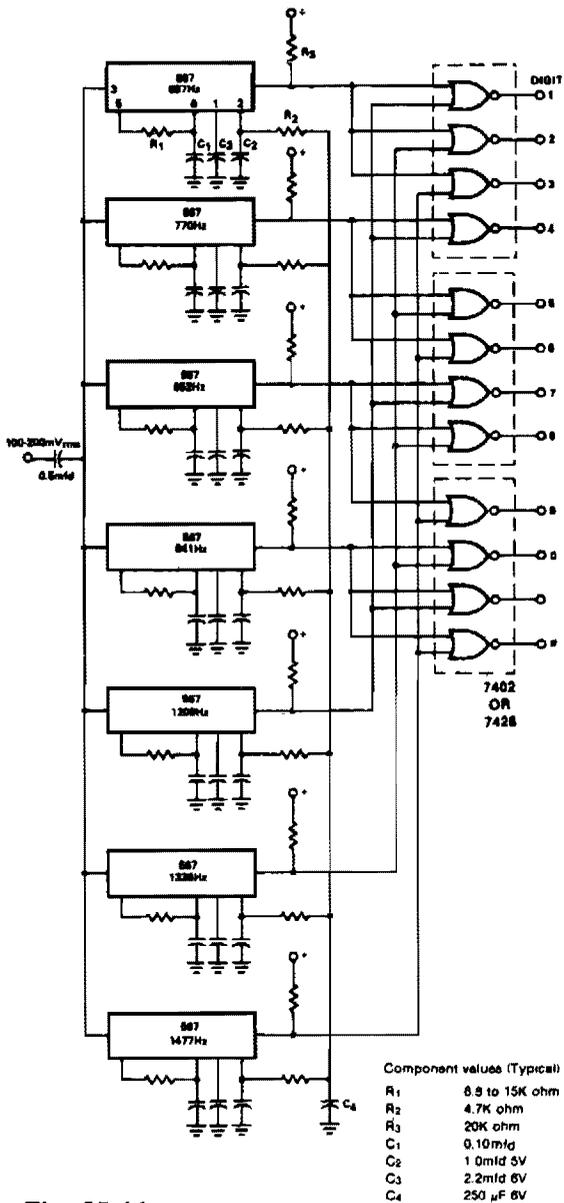
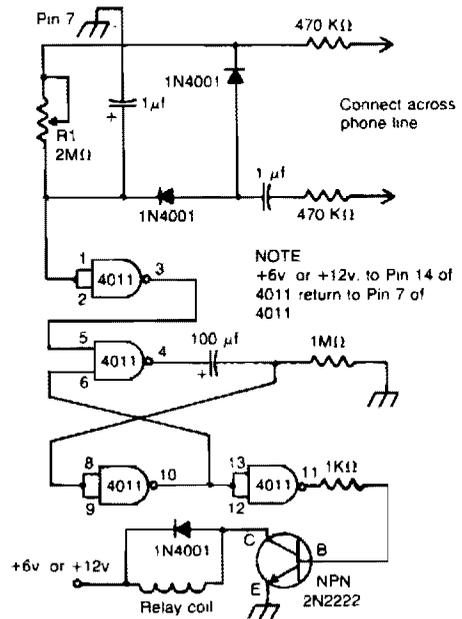


Fig. 85-11

TELEPHONE RELAY



Circuit Notes

Connected across the bell circuit of phone, this circuit closes a relay when the phone is ringing. Use the delay contacts to actuate any bell, siren, buzzer or lamp.

Fig. 85-12

TELEPHONE-CONTROLLED TAPE STARTER (TCTS)

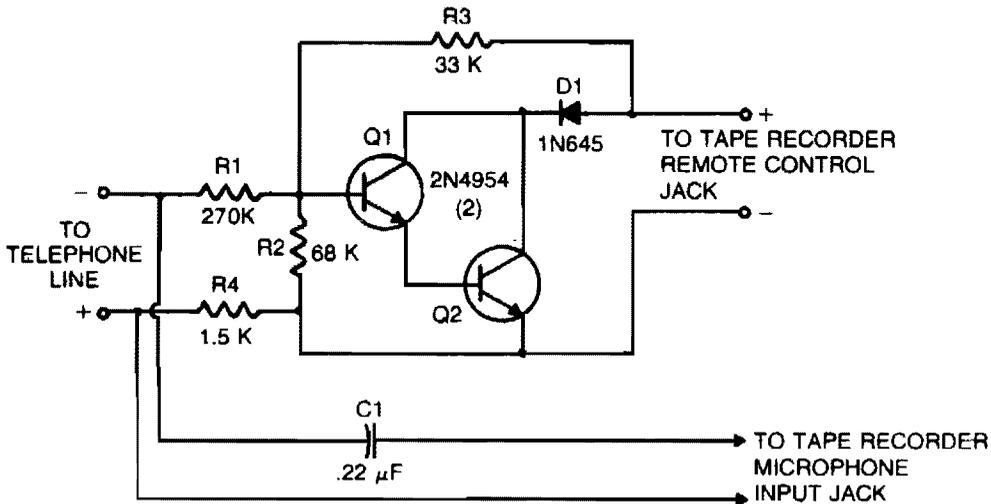


Fig. 85-13

Circuit Notes

This circuit converts a tape recorder into a completely automatic telephone conversation recording instrument that needs no external power source. Voltage at the switch terminals of tape recorder applied to a pair of Darlington-connected transistors, Q1 and Q2, will turn on and start the tape recorder. To turn the transistors off, and thereby stop the machine, apply a negative voltage to the base of Q1 from the phone line. When the telephone

receiver is on the hook, there is typically about 50 volts dc across the phone divided across R1, R2, and R4 in such a way that the base of Q1 is sufficiently negative to keep the tape recorder off. When the phone's receiver is picked up, the voltage on the telephone line drops to about 5 volts, which leaves insufficient negative voltage on the base of Q1 to keep it cut off, so the tape recorder starts and begins to record.

TELEPHONE-LINE POWERED REPERTORY DIALER

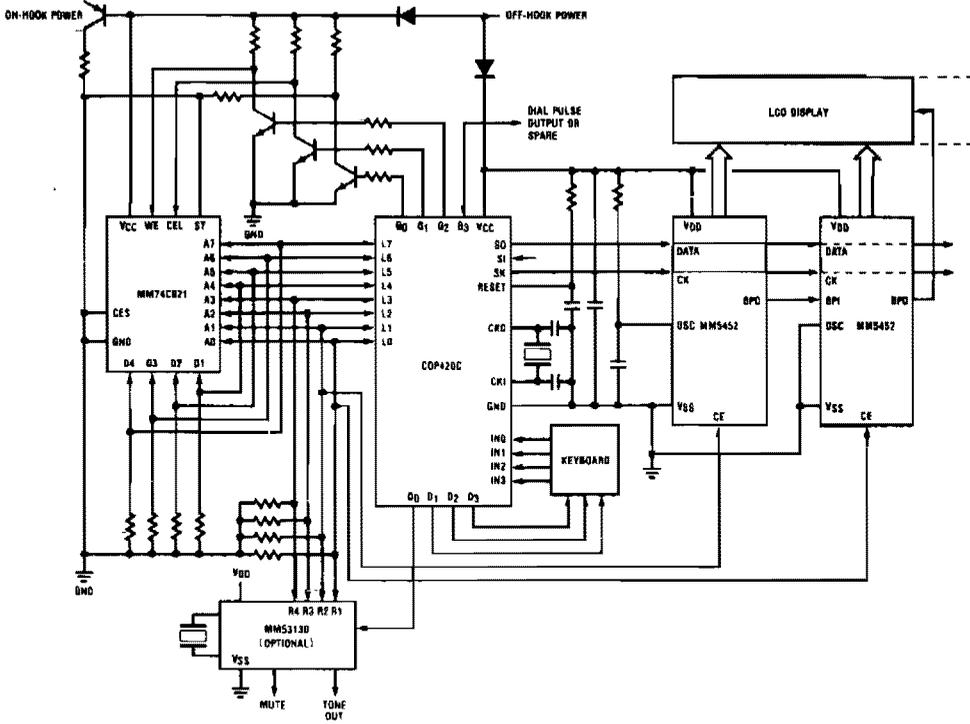


Fig. 85-14

Circuit Notes

Repertory dialer phone has a library of fifteen frequently used numbers, (plus the last number dialed) stored in a standard CMOS RAM. A pushbutton keyboard enables tele-

phone numbers to be keyed in and dialed out directly or a telephone number to be stored in the RAM and dialed automatically.

TELEPHONE OFF-HOOK INDICATOR

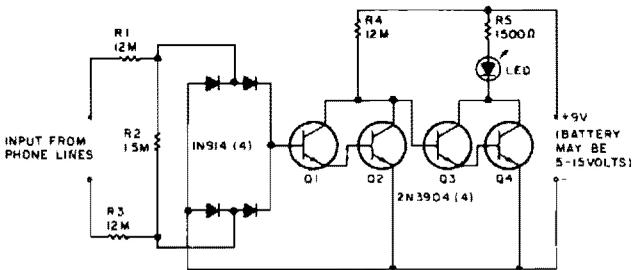


Fig. 85-15

Circuit Notes

The LED flickers when the phone is ringing or being dialed. It glows steadily when the phone is off the hook.

TELEPHONE HANDSET TONE DIAL ENCODER

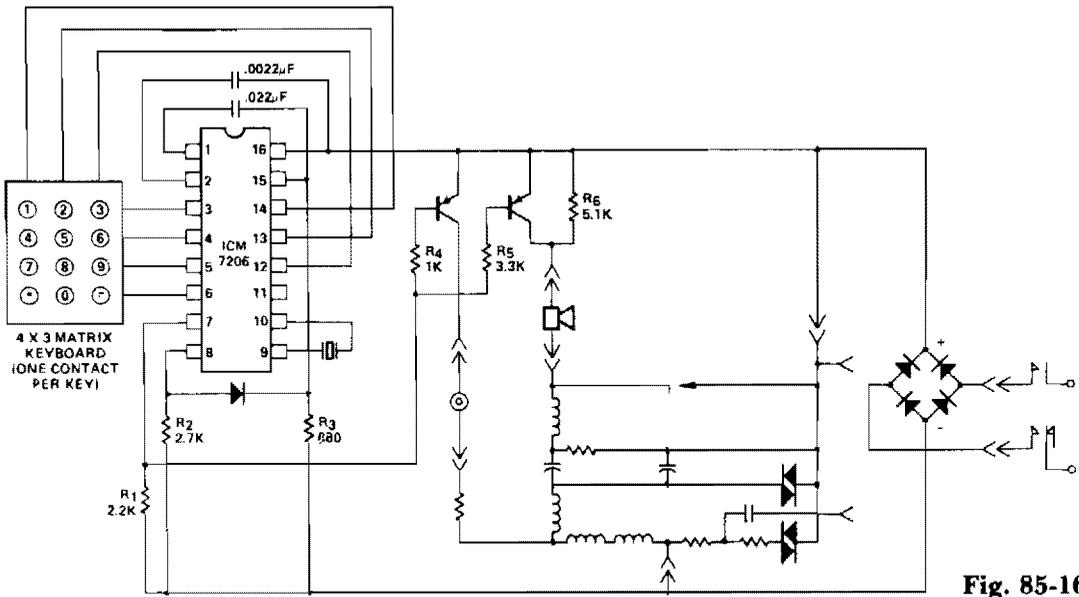


Fig. 85-16

Circuit Notes

This encoder uses a single contact per key keyboard and provides all other switching function electronically. The diode between terminals 8 and 15 prevents the output going more

than 1 volt negative with respect to the negative supply V^- . The circuit operates over the supply voltage range from 3.5 volts to 15 volts.

LOW LINE LOADING RING DETECTOR

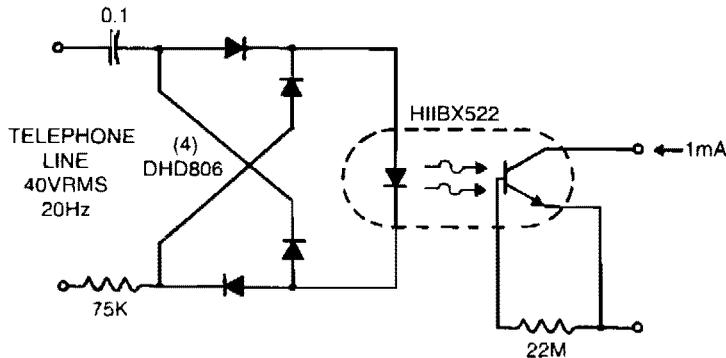
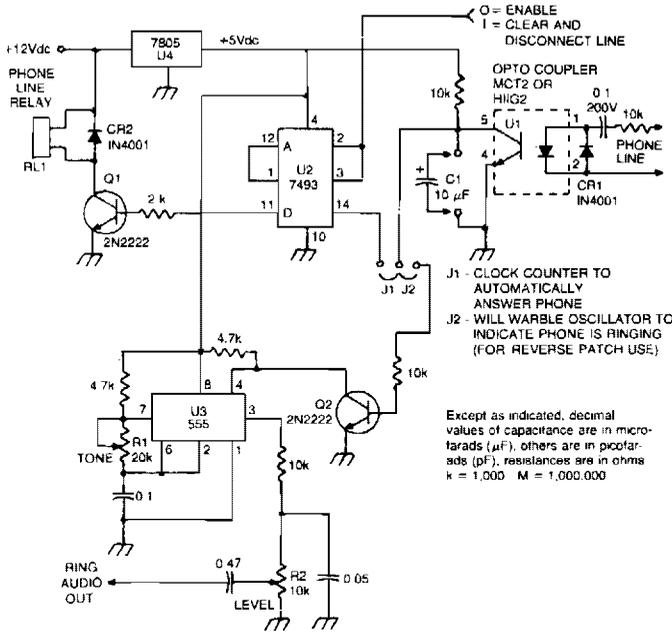


Fig. 85-17

Circuit Notes

Low line current loading is provided by the H11BX52 photodarlington optocoupler, which provides a 1 mA output from a 0.5 mA input.

PHONE AUTO ANSWER AND RING INDICATOR

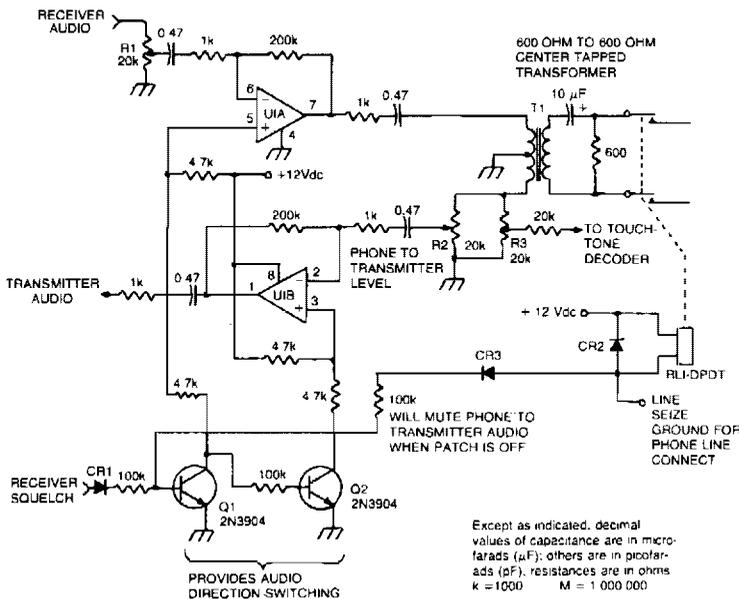


Circuit Notes

Ring detect circuit for automatic phone answering or tone generation for reverse autopatch use.

Fig. 85-18

AUTOPATCH TELEPHONE LINE INTERFACE



Circuit Notes

This circuit provides for the receiver-to-phone line and phone line-to-transmitter link, with both using an op amp for gain.

Fig. 85-19

TELEPHONE RINGER USES PIEZOELECTRIC DEVICE

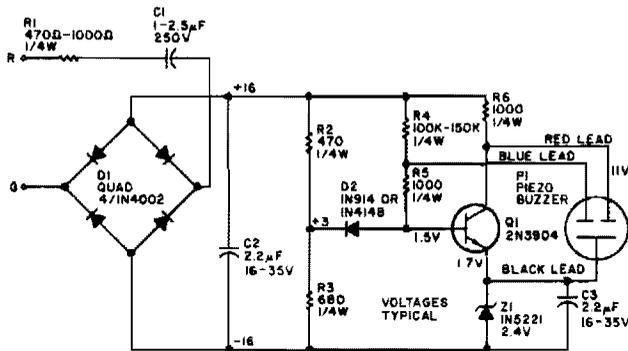


Fig. 85-20

Circuit Notes

The electronic bell needs no power supply. Most of the resistors are not critical, although C2, R2, and R3 work best at the values given. Leaving out R1 will make the unit ring louder. The piezo buzzer may vary from store

to store. If it has two leads, connect the red lead to the collector and the black lead to the emitter of Q1. If a third (blue) lead is present, connect it to the base of Q1.

ELECTRONIC PHONE BELL

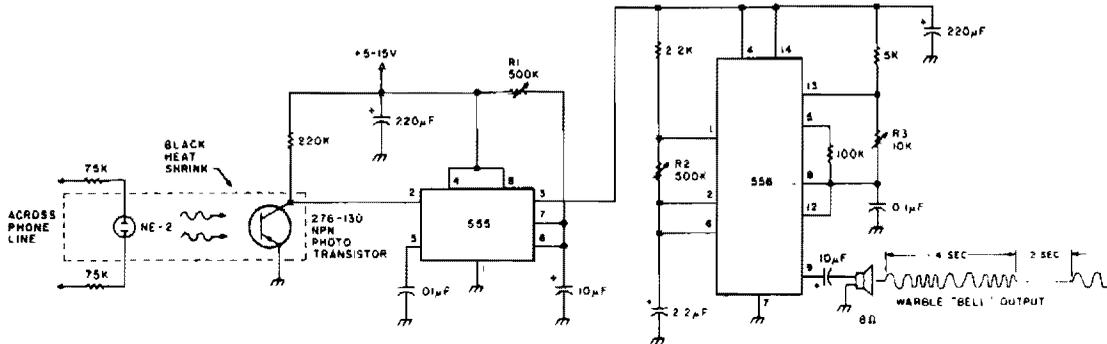


Fig. 85-21

Circuit Notes

The speaker emits a distinctive warble tone when ring pulses are applied to the phone line. Use this circuit as a remote bell or disconnect the phone's ringer for direct use. R1 adjusts the duration of the output; R2 and R3

control the tone's duty cycle and frequency. The transistor is a general-purpose NPN photodevice. The neon bulb and transistor are coupled with the heat-shrink tubing to form an optoisolator.

86

Temperature Controls

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Boiler Control	Temperature Controller
Heater Control	Single-Setpoint Temperature Controller
Two-Wire Remote AC Electronic Thermostat	Temperature Controller
Three-Wire Electronic Thermostat	Temperature Control
Temperature-Sensitive Heater Control	Temperature Controller
	Temperature Controller
Portable Calibrator	

BOILER CONTROL

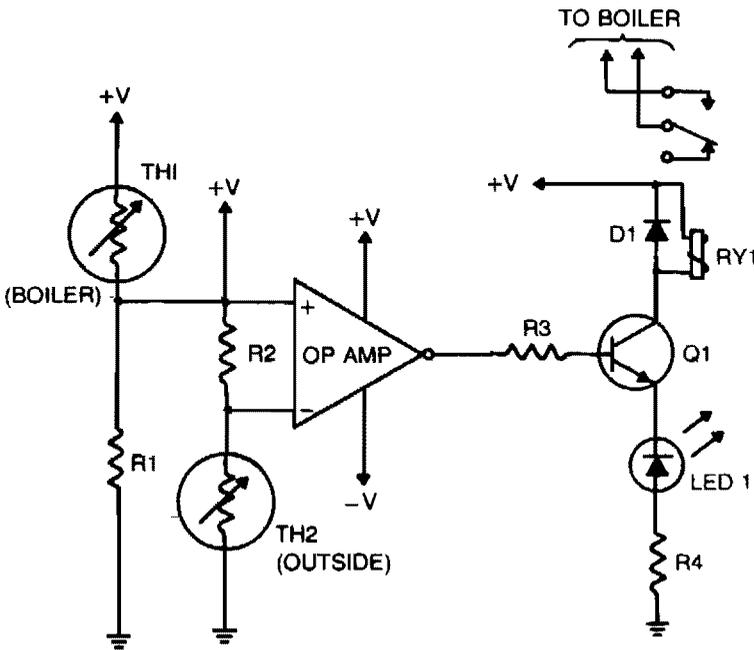


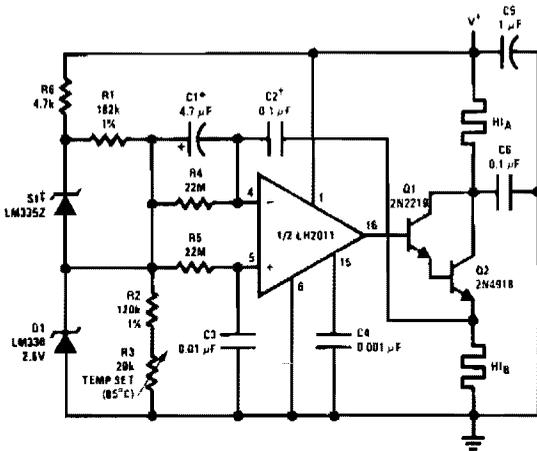
Fig. 86-1

Circuit Notes

The purpose of this circuit is to control the water temperature in a hot-water heating system. What it does is to lower the boiler temperature as the outside air temperature increases. The op amp is used as a comparator. Thermistor TH2 and R2 form a voltage divider that supplies a reference voltage to the op-amp's inverting input. Thermistor TH2 is placed outdoors, and the values of TH2 and R2 should be chosen so that when the outside temperature is 25 °F, the resistance of the thermistor and resistor are equal. Resistor R1

and thermistor TH1 make up a voltage divider that supplies a voltage to the op amp's noninverting input. Thermistor TH1 is placed inside the boiler and the values of TH1 and R1 should be chosen so that when the boiler's temperature is 160 °F, their resistances are equal. The output of the op amp controls Q1, which is configured as a transistor switch. When the logic output of the op amp is high, Q1 is turned on, energizing relay RY1. The relay's contacts should be wired so that the boiler's heat supply is turned off (relay energized).

HEATER CONTROL



Circuit Notes

This proportional control crystal oven heater uses lead/lag compensation for fast setting. The time constant is changed with R4 and compensating resistor R5. If Q2 is inside the oven, a regulated supply is recommended for 0.1 °C. control.

- * solid tantalum
- † mylar
- ‡ close thermal coupling between sensor and oven shell is recommended

Fig. 86-2

TWO-WIRE REMOTE AC ELECTRONIC THERMOSTAT (GAS OR OIL FURNACE CONTROL)

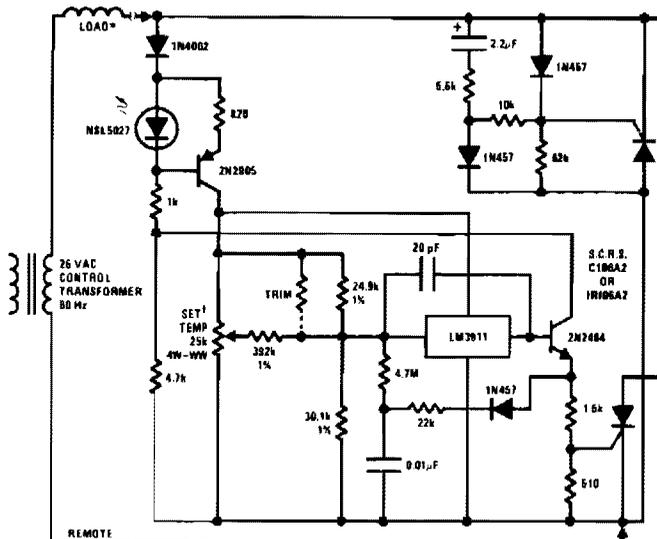


Fig. 86-3

- * Silencor or 6-15W heater
- † Pot will provide about a 50 F to 90 F setting range. The trim resistor (100k) is selected to bring 70°F near the middle of the pot rotation.
- ‡ SCR heating, by proper positioning, can preheat the sensor giving control compensation as is presently used in many home thermostats.

THREE-WIRE ELECTRONIC THERMOSTAT

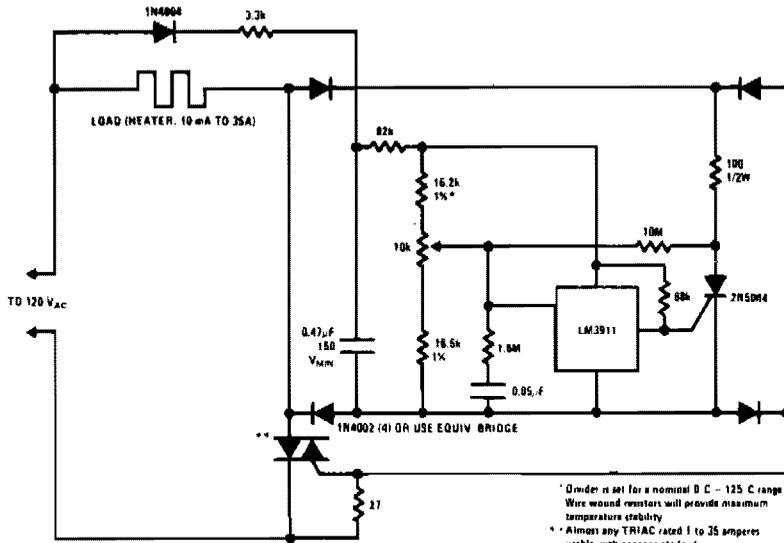


Fig. 86-4

TEMPERATURE-SENSITIVE HEATER CONTROL

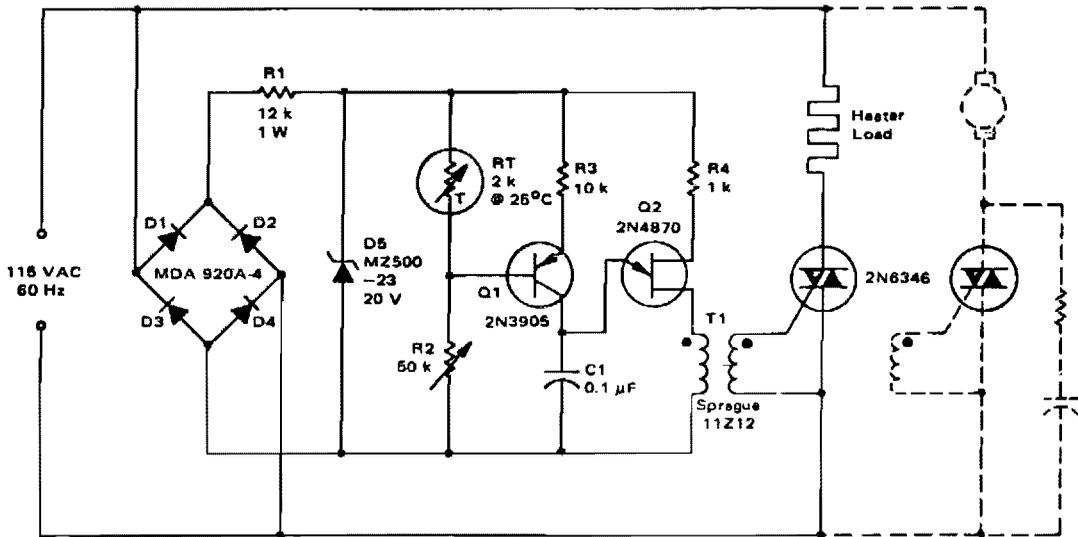


Fig. 86-5

TEMPERATURE CONTROLLER

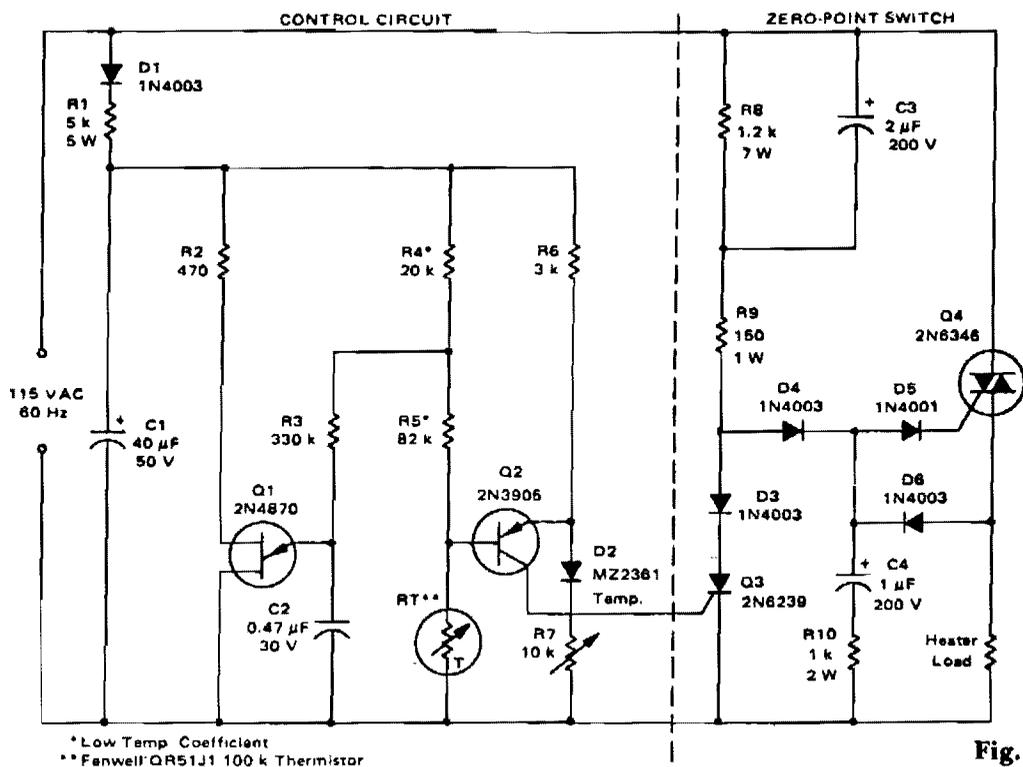


Fig. 86-6

SINGLE-SETPOINT TEMPERATURE CONTROLLER

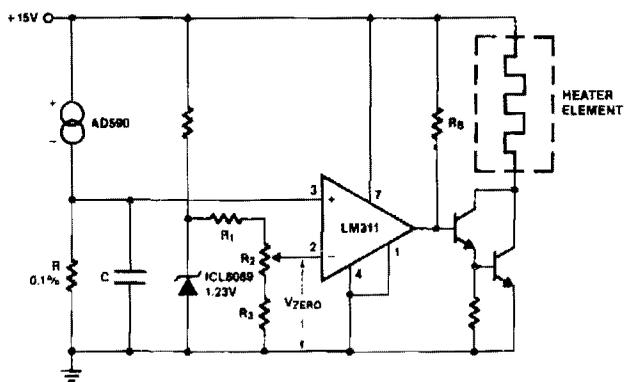


Fig. 86-7

Circuit Notes

The AD590 produces a temperature-dependent voltage across R (C is for filtering noise). Setting R2 produces a scale-zero voltage. For the Celsius scale, make R = 1 K and $V_{zero} = 0.273$ volts. For Fahrenheit, R = 1.8 K and $V_{zero} = 0.460$ volts.

TEMPERATURE CONTROLLER

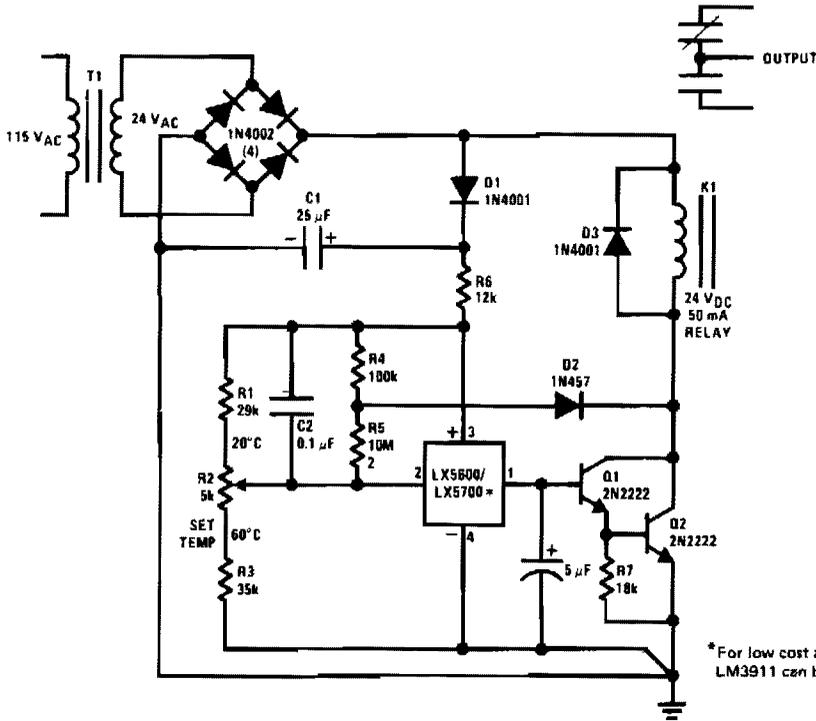


Fig. 86-8

Circuit Notes

The sensor is a standard TO-5 or TO-46 package. For surface or air temperature sensing. Small clip-on heat sinks can be used. A simple probe can be made using heat-shrink tubing and RTV silicon rubber. Three-leads-plus-shield cable is a good choice for wire with

the shield connected to pin 4. The controller can be used for baths, ovens, oven-temperature protection, or even home thermostats. Long-term stability and repeatability is better than 0.5 °C.

TEMPERATURE CONTROL

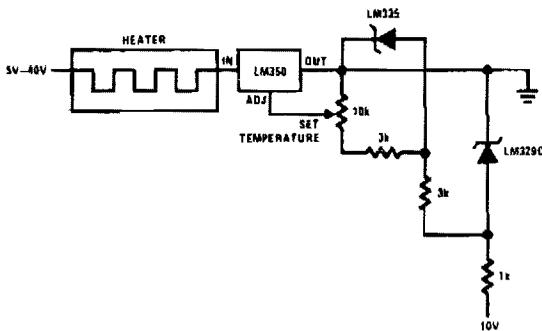


Fig. 86-9

PORTABLE CALIBRATOR

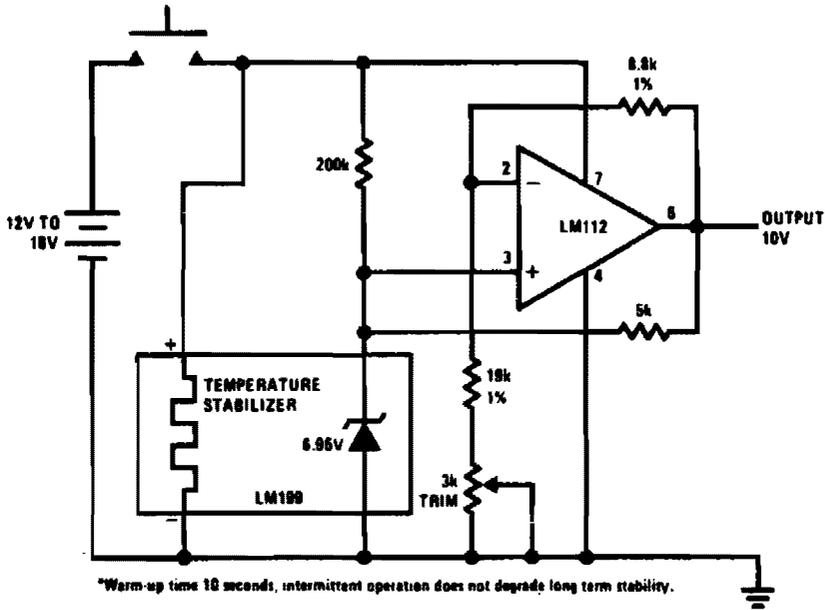


Fig. 86-12

Temperature Sensors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Linear Temperature-to-Frequency Transducer	Optical Pyrometer
Temperature Meter	Remote Temperature Sensing
Four-Channel Temperature Sensor	Simple Differential Temperature Sensor
Temperature Sensor	Differential Temperature Sensor
Integrated Circuit Temperature Sensor	Centigrade Thermometer
Precision Temperature Transducer with Remote Sensor	Meter Thermometer with Trimmed Output
Centigrade Calibrated Thermocouple Thermometer	Kelvin Thermometer with Ground Referred Output
μ P Controlled Digital Thermometer	Lower Power Thermometer
Isolated Temperature Sensor	0 °F-50 °F Thermometer
Digital Thermometer	Temperature-to-Frequency Converter
Variable Offset Thermometer	0 °C-100 °C Thermometer
Differential Thermometer	Ground Referred Fahrenheit Thermometer
Basic Digital Thermometer, Kelvin Scale	Ground Referred Centigrade Thermometer
Basic Digital Thermometer, Kelvin Scale with Zero Adjust	Ground Referred Centigrade Thermometer Temperature Sensor
Thermocouple Amplifier	Positive Temperature Coefficient Resistor Temperature Sensor
	Basic Digital Thermometer
	Fahrenheit Thermometer

LINEAR TEMPERATURE-TO-FREQUENCY TRANSDUCER

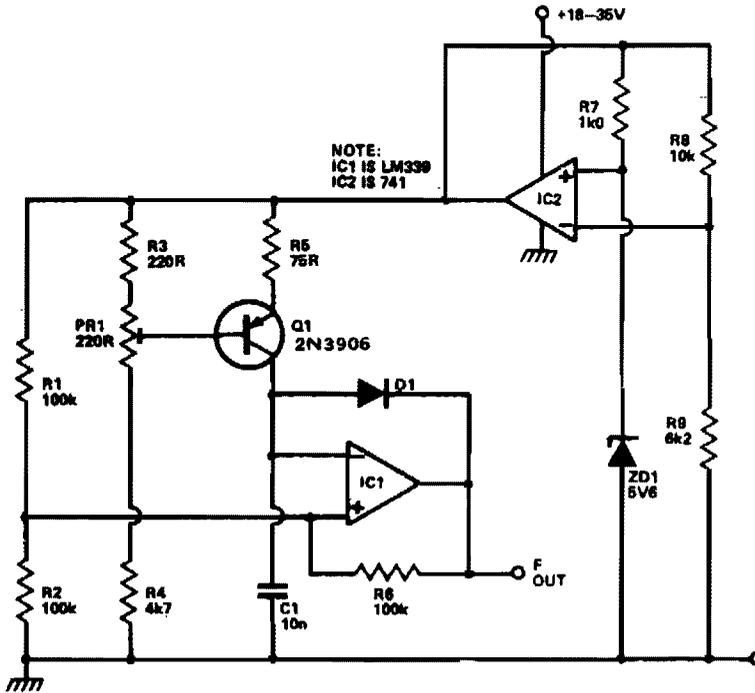


Fig. 87-1

Circuit Notes

This circuit provides a linear increase of frequency of 10 Hz/°C over 0-100 °C and can thus be used with logic systems, including microprocessors. Temperature probes Q1 V_{be} changes 2.2 mV/°C. This transistor is incorporated in a constant current source circuit. Thus, a current proportional to temperature will be available to charge C1. The circuit is powered

via the temperature stable reference voltage supplied by the 741. Comparator IC1 is used as a Schmitt trigger whose output is used to discharge C1 via D1. To calibrate the circuit Q1 is immersed in boiling distilled water and PR1 adjusted to give 1 kHz output. The prototype was found to be accurate to within 0.2 °C.

TEMPERATURE METER

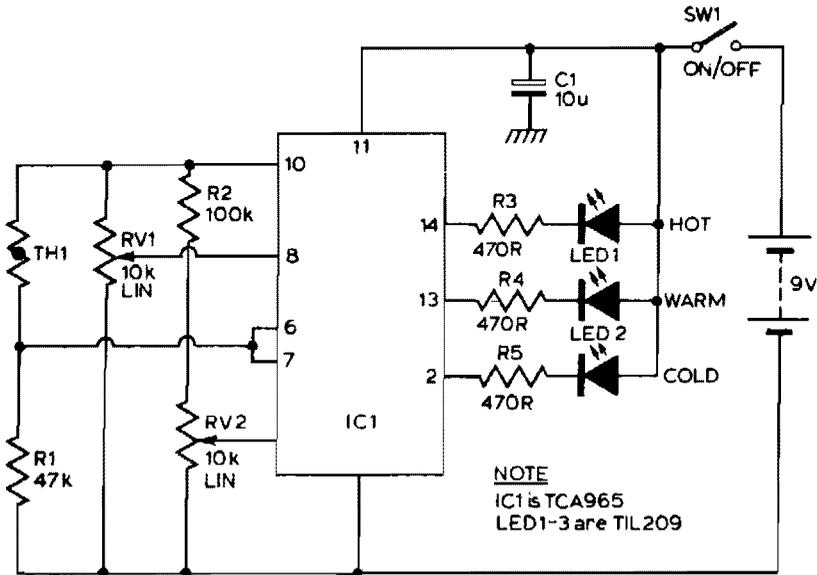


Fig. 87-2

Circuit Notes

TCA965 window discriminator IC allows the potentiometers RV1 and RV2 to set up a window height and window width respectively. R1 and thermistor TH1 for a potential divider connected across the supply lines. R1 is chosen such that at ambient temperature the voltage at the junction of these two components will be approximately half supply. As the temperature of the sensor changes, the voltage will change.

RV1 will set the point which corresponds to the center voltage of a window the width of which is set by RV2. The switching points of the IC feature a Schmitt characteristic with low hysteresis. The outputs of IC1 indicate whether the input voltage is within the window or outside by virtue of being either too high or too low. The outputs of IC1 drive the LEDs via a current limiting resistor.

FOUR-CHANNEL TEMPERATURE SENSOR (0-50 °C)

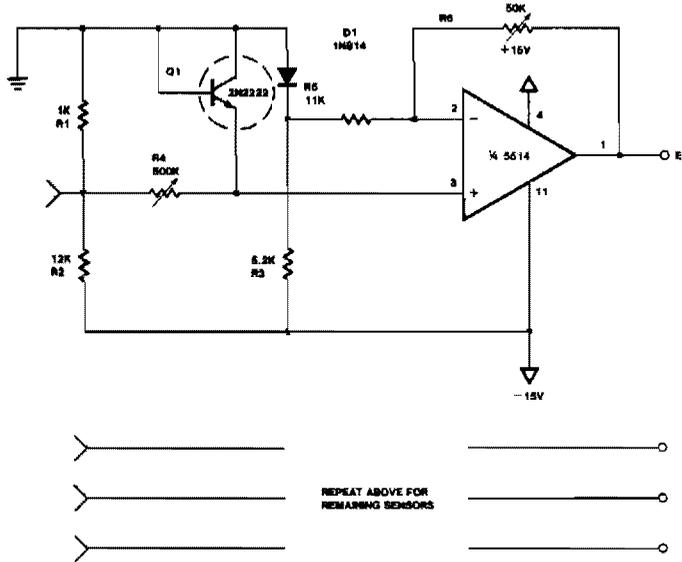


Fig. 87-3

TEMPERATURE SENSOR

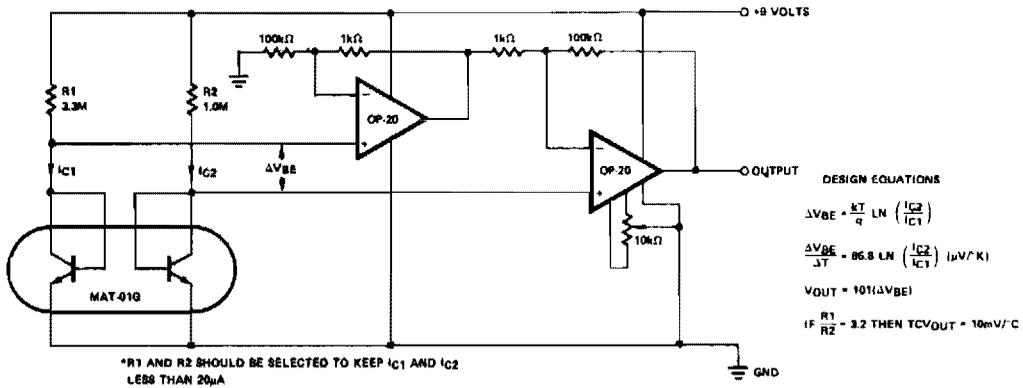


Fig. 87-4

INTEGRATED CIRCUIT TEMPERATURE SENSOR

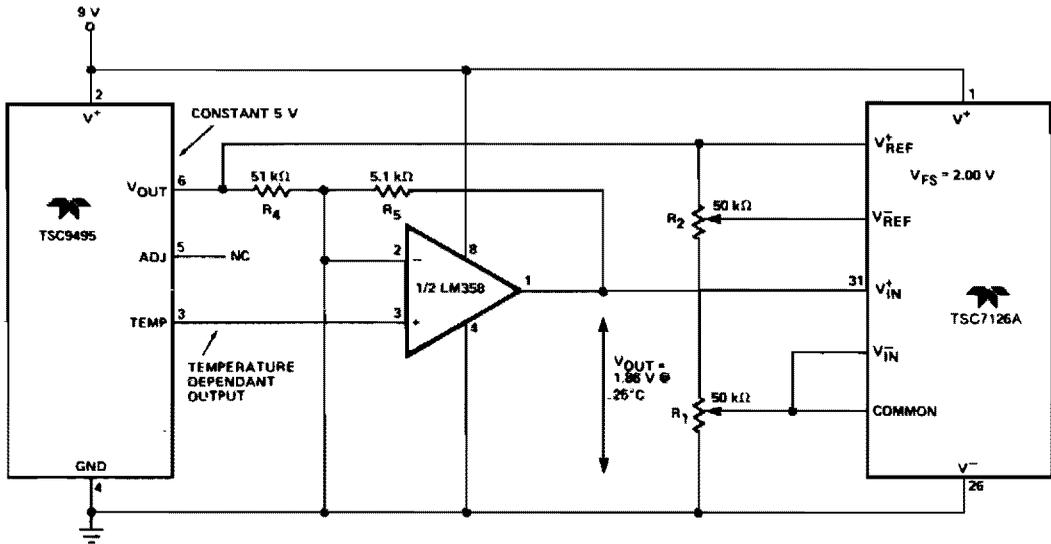
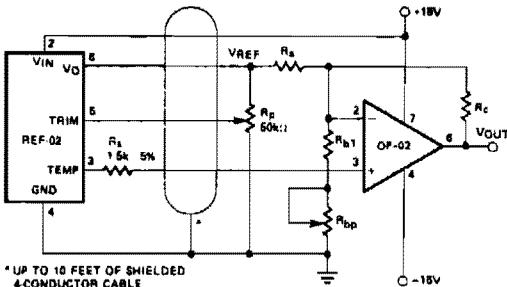


Fig. 87-5

PRECISION TEMPERATURE TRANSDUCER WITH REMOTE SENSOR



* UP TO 10 FEET OF SHIELDED 4-CONDUCTOR CABLE

FOR THEORY OF OPERATION AND CALIBRATION PROCEDURE CONSULT APPLICATION NOTE 18, "THERMOMETER APPLICATIONS OF THE REF-02".

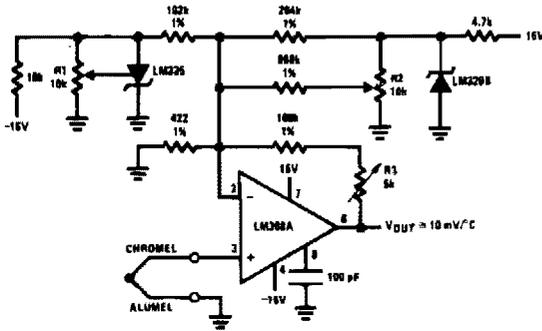
RESISTOR VALUES

	10mV/°C	100mV/°C	10mV/°F
TCV _{OUT} SLOPE (S)	10mV/°C	100mV/°C	10mV/°F
TEMPERATURE RANGE	-55°C to +125°C	-55°C to +125°C	-67°F to +257°C
OUTPUT VOLTAGE RANGE	-0.55V to +1.25V	-5.5V to +12.5V	-0.67V to +2.57V
ZERO SCALE	0V @ 0°C	0V @ 0°C	0V @ 0°F
R _A (± 1% resistor)	9.09kΩ	15kΩ	7.5kΩ
R _{B1} (± 1% resistor)	1.5kΩ	1.82kΩ	1.21kΩ
R _{BP} (Potentiometer)	200Ω	500Ω	200Ω
R _C (± 1% resistor)	5.11kΩ	84.5kΩ	8.25kΩ

* For 125°C operation, the op amp output must be able to swing to +12.5V, increase V_{IN} to +18V from +15V if this is a problem.

Fig. 87-6

CENTIGRADE CALIBRATED THERMOCOUPLE THERMOMETER



Terminate thermocouple reference junction in close proximity to LM335.

Adjustments:

1. Apply signal in place of thermocouple and adjust R3 for a gain of 245.7.
2. Short non-inverting input of LM308A and output of LM3298 to ground.
3. Adjust R1 so that $V_{OUT} = 2.982V @ 25^{\circ}C$.
4. Remove short across LM3298 and adjust R2 so that $V_{OUT} = 246 mV @ 25^{\circ}C$.
5. Remove short across thermocouple.

Fig. 87-7

μP CONTROLLED DIGITAL THERMOMETER

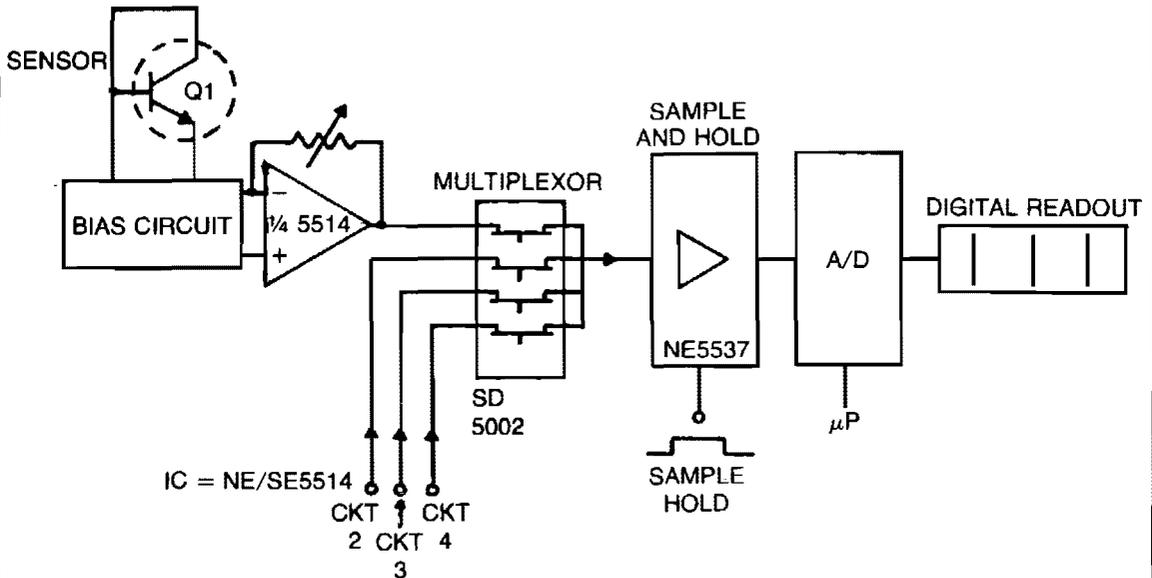


Fig. 87-8

ISOLATED TEMPERATURE SENSOR

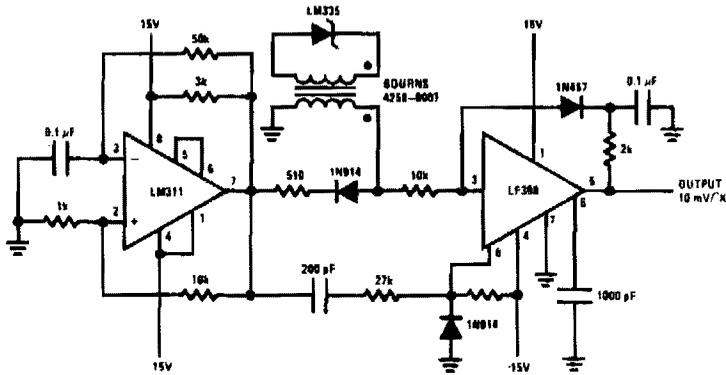


Fig. 87-9

DIGITAL THERMOMETER

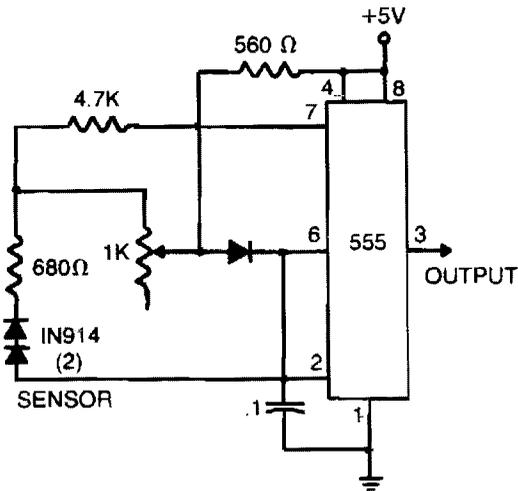


Fig. 87-10

Circuit Notes

The sensor consists of two series-connected 1N914s, part of the circuit of a 555 multivibrator. Wired as shown, the output pulse rate is proportional to the temperature of the diodes. This output is fed to a simple frequency-counting circuit.

VARIABLE OFFSET THERMOMETER

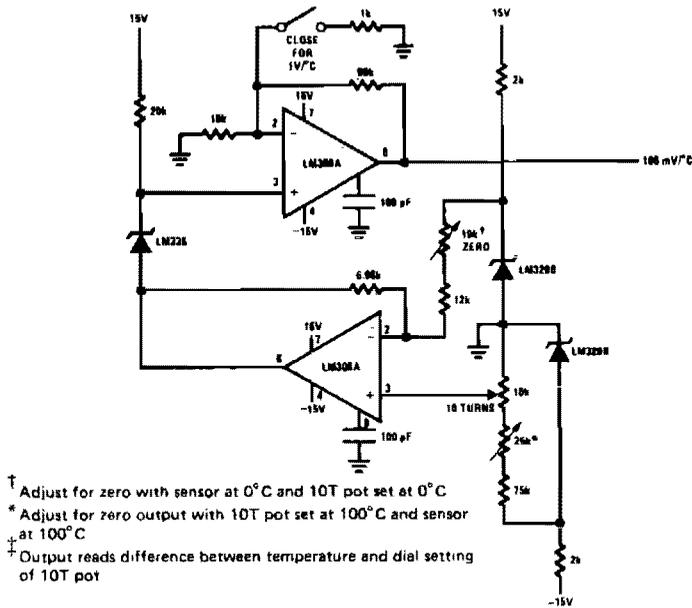


Fig. 87-11

DIFFERENTIAL THERMOMETER

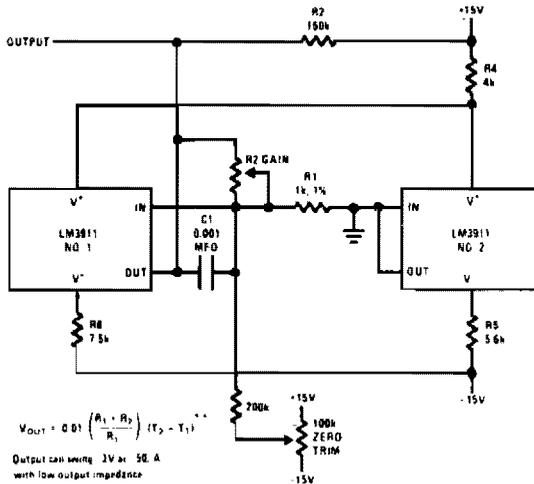
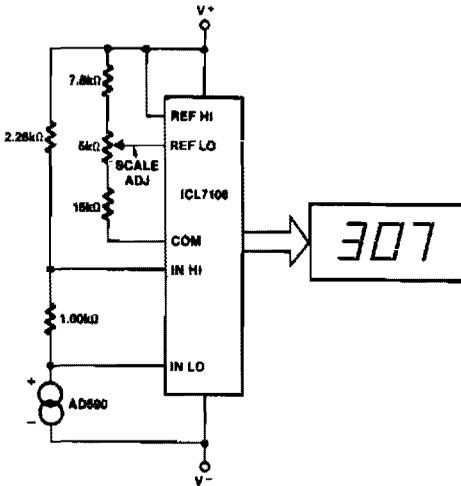


Fig. 87-12

BASIC DIGITAL THERMOMETER, KELVIN SCALE



Circuit Notes

The Kelvin scale version reads from 0 to 1999 °K theoretically, and from 223 °K to 473 °K actually. The 2.26 K resistor brings the input within the ICL7106 V_{CM} range: two general-purpose silicon diodes or an LED may be substituted.

Fig. 87-13

BASIC DIGITAL THERMOMETER, KELVIN SCALE WITH ZERO ADJUST

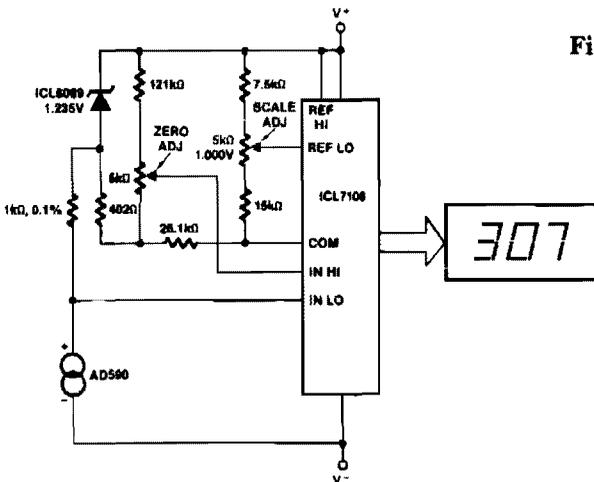
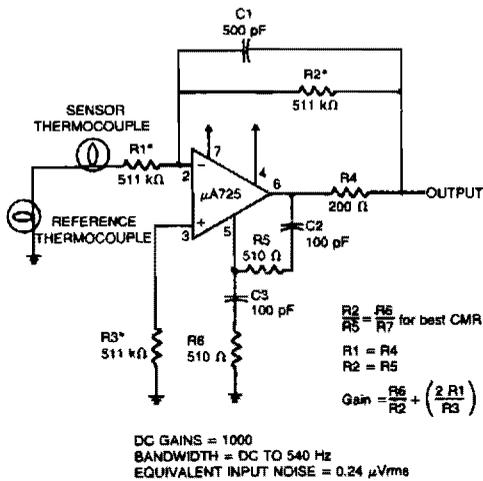


Fig. 87-14

Circuit Notes

This circuit allows zero adjustment as well as slope adjustment. The ICL8069 brings the input within the common-mode range, while the 5 K pots trim any offset at 218 °K (−55 °C), and set scale factor.

THERMOCOUPLE AMPLIFIER



Notes
 *Indicates $\pm 1\%$ metal film resistors recommended for temperature stability.
 Pin numbers are shown for metal package only

Fig. 87-15

REMOTE TEMPERATURE SENSING

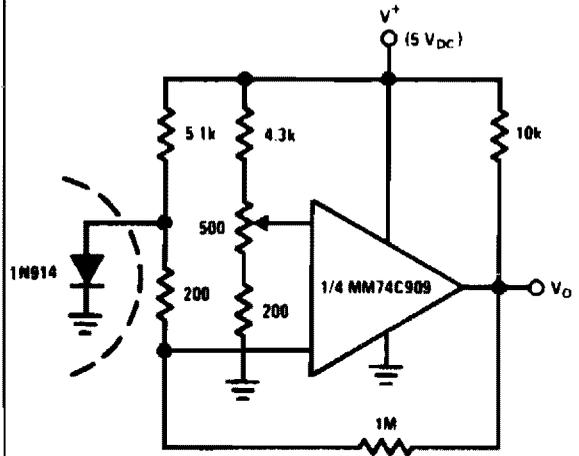


Fig. 87-17

OPTICAL PYROMETER

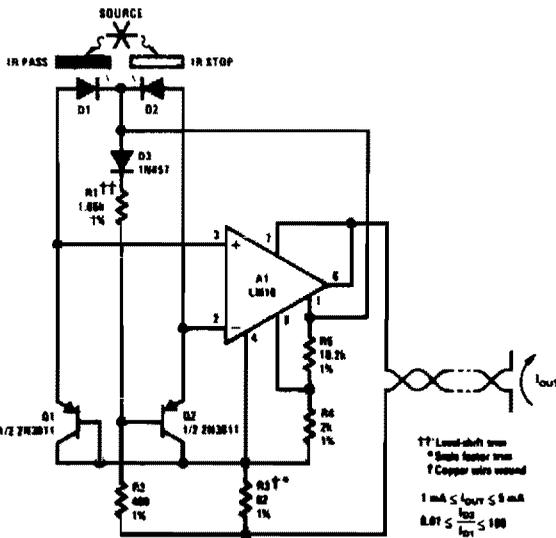


Fig. 87-16

SIMPLE DIFFERENTIAL TEMPERATURE SENSOR

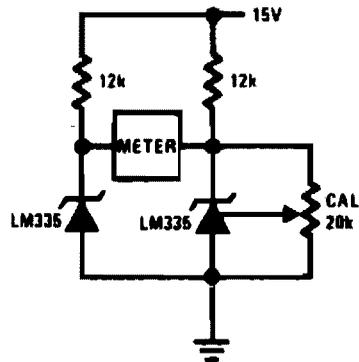
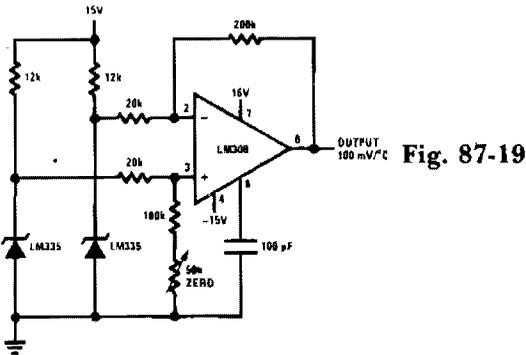
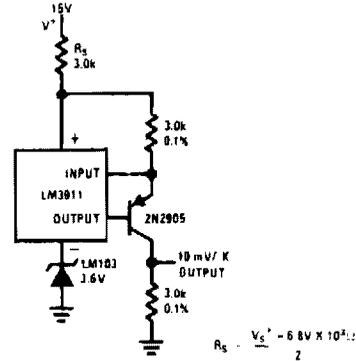


Fig. 87-18

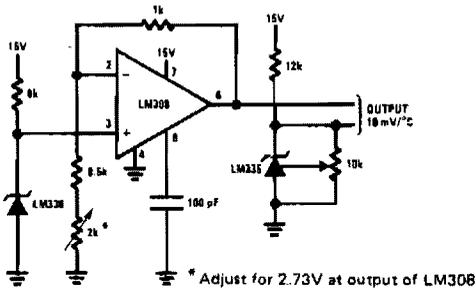
DIFFERENTIAL TEMPERATURE SENSOR



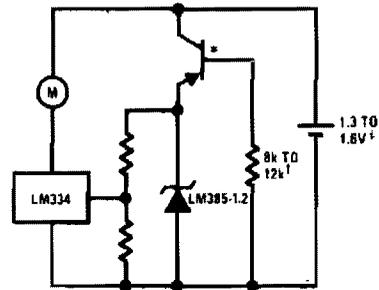
KELVIN THERMOMETER WITH GROUND REFERRED OUTPUT



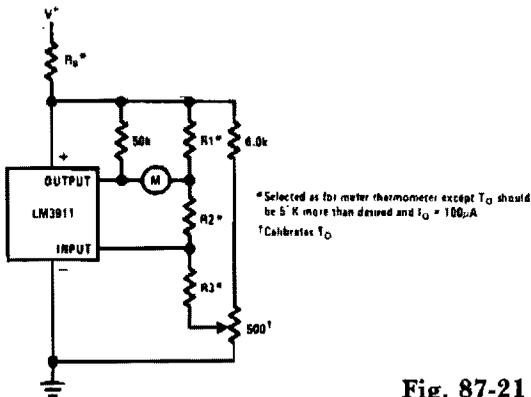
CENTIGRADE THERMOMETER



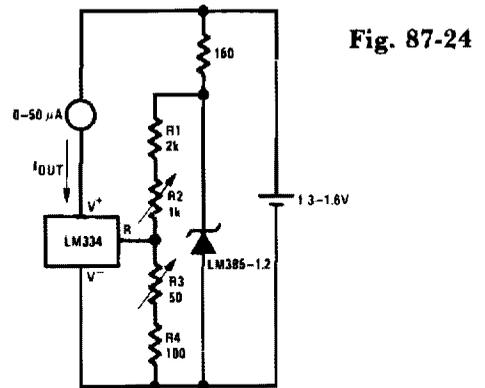
LOWER POWER THERMOMETER



METER THERMOMETER WITH TRIMMED OUTPUT



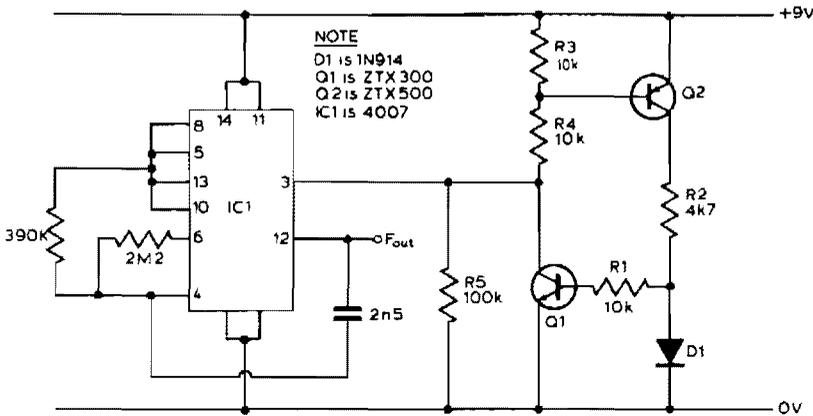
0 °F-50 °F THERMOMETER



Calibration

1. Short LM385-1.2, adjust R3 for $I_{OUT} = I_{temp}$ at $1.8\mu A/^\circ K$
2. Remove short, adjust R2 for correct reading in $^\circ F$

TEMPERATURE-TO-FREQUENCY CONVERTER



NOTE
 D1 is 1N914
 Q1 is ZTX300
 Q2 is ZTX500
 IC1 is 4007

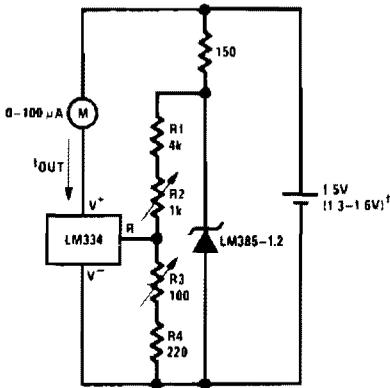
Fig. 87-25

Circuit Notes

The circuit exploits the fact that when fed from a constant current source, the forward voltage of a silicon diode varies with temperature in a reasonably linear way. Diode D1 and resistor R2 form a potential divider fed from the constant current source. As the temperature rises, the forward voltage of D1 falls

tending to turn Q1 off. The output voltage from Q1 will thus rise, and this is used as the control voltage for the CMOS VCO. With the values shown, the device gave an increase of just under 3 Hz/°C (between 0 °C and 60 °C) giving a frequency of 470 Hz at 0 °C.

0 °C-100 °C THERMOMETER

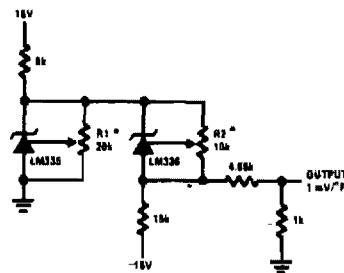


Calibration

- 1 Short LM385-1.2 adjust R3 for $I_{OUT} = \text{temp at } 1 \mu\text{A}/^\circ\text{K}$
 - 2 Remove short adjust R2 for correct reading in centigrade
- I_Q at 1.3V \approx 500 μA
 I_Q at 1.6V \approx 2.4 mA

Fig. 87-26

GROUND REFERRED FAHRENHEIT THERMOMETER



* Adjust R2 for 2.554V across LM336.
 Adjust R1 for correct output.

Fig. 87-27

**GROUND REFERRED
CENTIGRADE THERMOMETER**

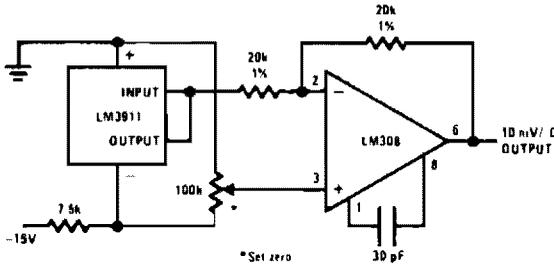


Fig. 87-28

TEMPERATURE SENSOR

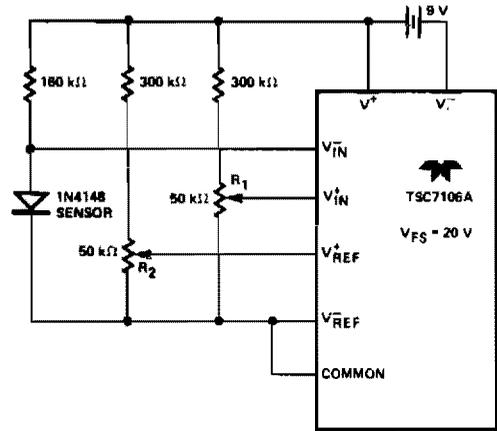


Fig. 87-30

**GROUND REFERRED
CENTIGRADE THERMOMETER**

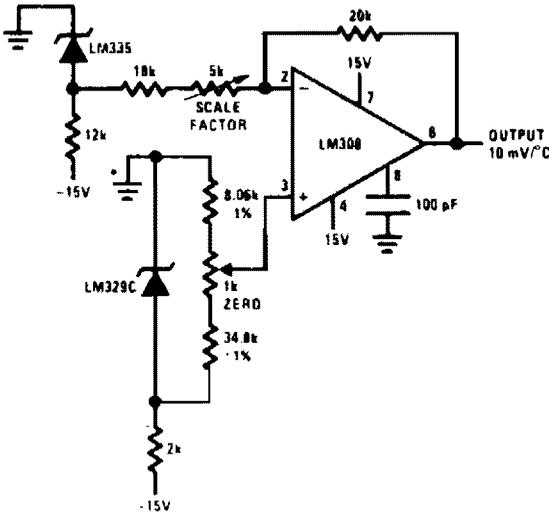


Fig. 87-29

**POSITIVE TEMPERATURE
SENSOR COEFFICIENT
RESISTOR**

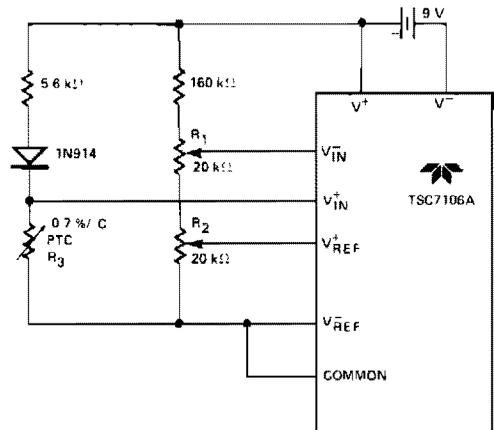
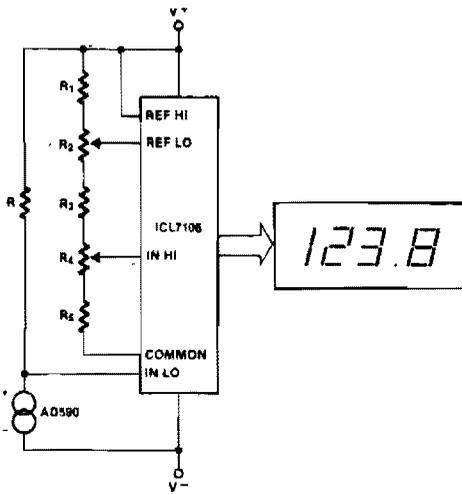


Fig. 87-31

BASIC DIGITAL THERMOMETER (CELSIUS AND FAHRENHEIT SCALES)



	R	R ₁	R ₂	R ₃	R ₄	R ₅
°F	9.00	4.02	2.0	12.4	10.0	0
°C	5.00	4.02	2.0	5.11	5.0	11.8

Fig. 87-32

Circuit Notes

Maximum reading on the Celsius range is 199.9 °C, limited by the (short-term) maximum allowable sensor temperature. Maximum reading on the Fahrenheit range is 199.9 °F (93.3 °C), limited by the number of display digits. V_{REF} for both scales is 500 mV.

FAHRENHEIT THERMOMETER

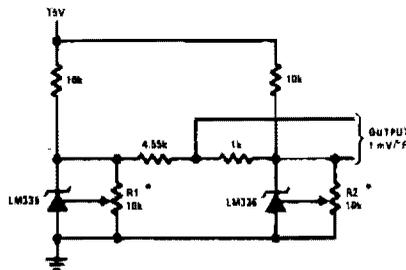


Fig. 87-33

* To calibrate adjust R2 for 2.554V across LM336.
Adjust R1 for correct output

Timers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Thumbwheel Programmable Interval Timer	Precision Solid State Time Delay Circuit
Sequential Timer	Electronic Egg Timer
Sequential Timer	On/Off Controller
Sequential UJT Timer Circuit	Timing Circuit
Time-Delayed Relay	Simple Timer
0.1 to 90 Second Timer	Long Interval RC Timer
Sequential Timing	Timer
Solid-State Timer for Industrial Applications	741 Timer
	Washer Timer
	Simple Time Delay

THUMBWHEEL PROGRAMMABLE INTERVAL TIMER

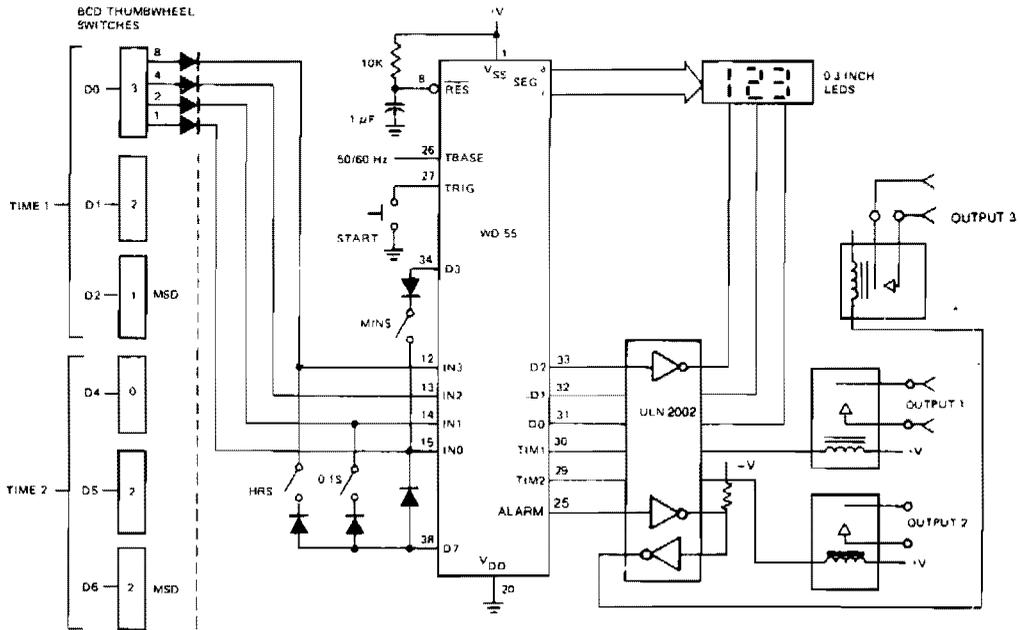


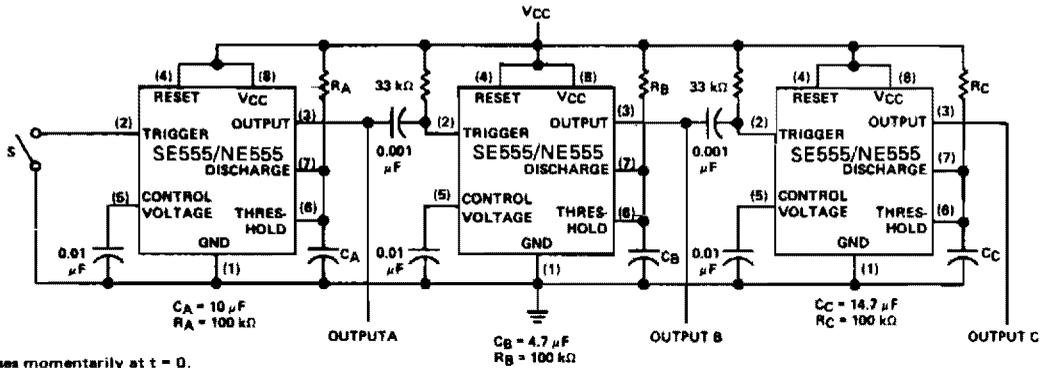
Fig. 88-1

Circuit Notes

Switch programmable on/off or interval timer, has three relay-switched outputs. Output one is active for the duration of time 1, output two is active for the duration of time 2, and output three is active for the duration of both one and two. Timing data is input through 6 BCD-encoded thumbwheel switches. Three SPST switches inform the WD-55 to interpret

this data as NNN seconds. NNN seconds, NNN minutes, or NNN hours. The LED display will show the time remaining and the countdown when operating. Since the data is input through switches, the display may be deleted. Also, since the timing information is read from switches, the data is nonvolatile and no battery backup is required.

SEQUENTIAL TIMER



S closes momentarily at $t = 0$.

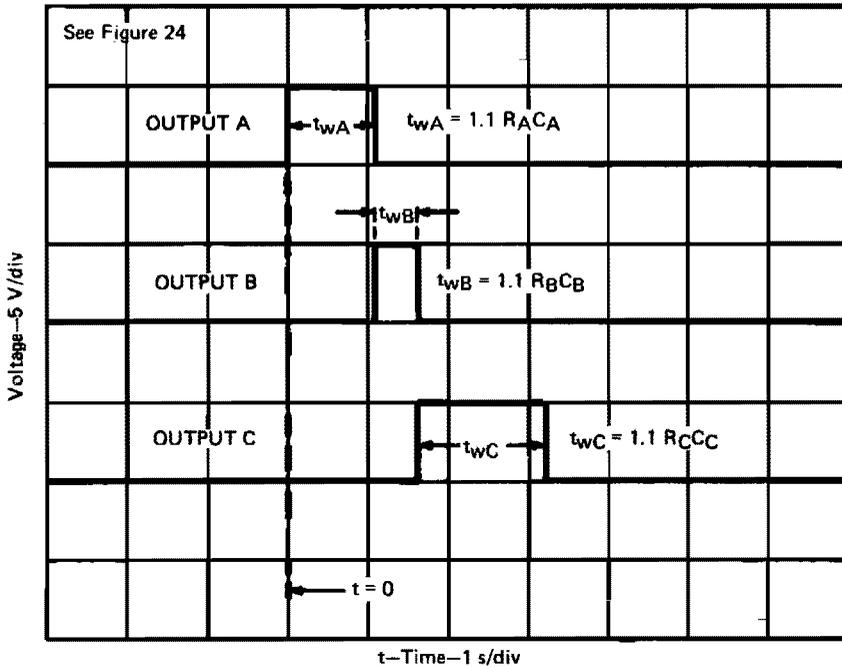


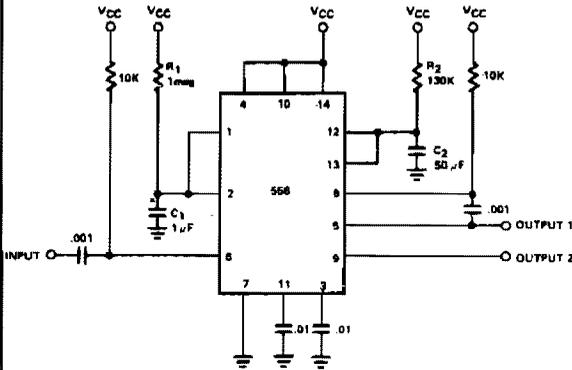
Fig. 88-2

Circuit Notes

Many applications, such as computers, require signals for initializing conditions during start-up. Other applications such as test equipment require activation of test signals in sequence. SE555/NE555 circuits may be con-

nected to provide such sequential control. The timers may be used in various combinations of astable or monostable circuit connections, with or without modulation, for extremely flexible waveform control.

SEQUENTIAL TIMER



ALL RESISTOR VALUES ARE IN OHMS

Circuit Notes

By utilizing both halves of a dual timer it is possible to obtain sequential timing. By connecting the output of the first half to the input of the second half via a .001 μF coupling capacitor sequential timing may be obtained. Delay t_1 is determined by the first half and t_2 by the second half delay. The first half of the timer is started by momentarily connecting pin 6 to ground. When it is turned out (determined by $1.1R_1C_1$), the second half begins. Its duration is determined by $1.1R_2C_2$.

Fig. 88-3

SEQUENTIAL UJT TIMER

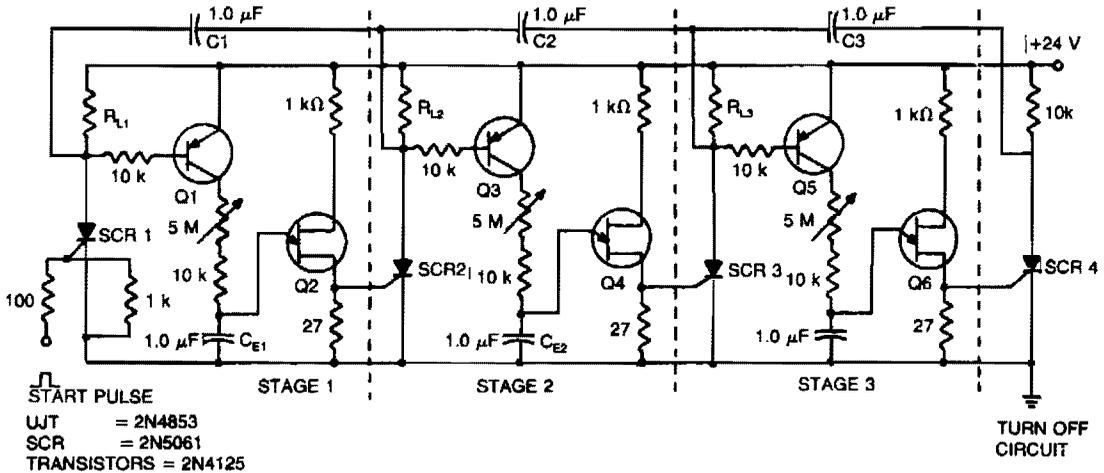


Fig. 88-4

TIME-DELAYED RELAY (FOR PATIO-LIGHT, GARAGE LIGHT, ENLARGER PHOTOTIMER, ETC.)

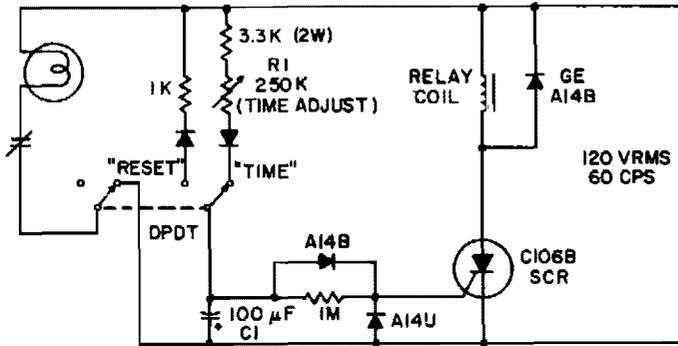


Fig. 88-5

NOTE: ALL RESISTORS 1/2 WATT

Circuit Notes

This simple timing circuit can delay an output switching function from .01 seconds to about 1 minute. The SCR is triggered by only a few microamps from the timing network R1-C1 to energize the output relay.

0.1 TO 90 SECOND TIMER

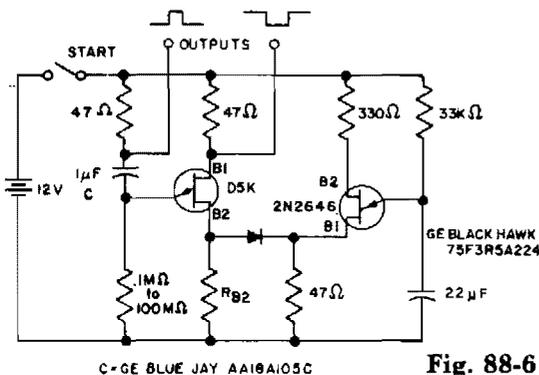


Fig. 88-6

Circuit Notes

The timer interval starts when power is applied to circuit and terminates when voltage is applied to load. 2N2646 is used in oscillator which pulses base 2 of D5K. This reduces the effective I of D5K and allows a much larger timing resistor and smaller timing capacitor to be used than would otherwise be possible.

SEQUENTIAL TIMING

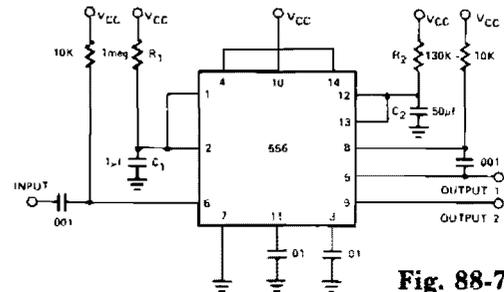


Fig. 88-7

Circuit Notes

By utilizing both halves of the dual timer it is possible to obtain sequential timing. By connecting the output of the first half to the input of the second half via a .001 μ F coupling capacitor, sequential timing may be obtained. Delay t_1 is determined by the first half and t_2 by the second half delay. The first half of the timer is started by momentarily connecting pin 6 to ground. When it is timed out (determined by $1.1R_1C_1$) the second half begins. Its time duration is determined by $1.1R_2C_2$.

SOLID-STATE TIMER FOR INDUSTRIAL APPLICATIONS

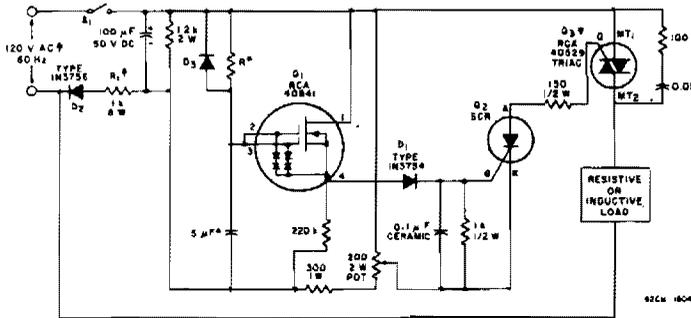


Fig. 88-8

1. Cornell-Dubilier Electronics—Type MMW or equivalent
R controls duration of time delay. At R = 60 MΩ up to 5-minute delay. (RC resistor, Type CGH or equivalent)
2. This circuit can also be used as supply voltages of 240 V AC and 24V AC (60 Hz) by changing the values of R1 and Q2.

TIMING CIRCUIT CHARACTERISTICS
 $T_A = -26^{\circ}\text{C}$ to $+80^{\circ}\text{C}$
 Accuracy: $\pm 10\%$ (over temperature)
 Repeatability: $\pm 3\%$ (at 25°C)
 Rise Time: Less than 150 ms

Q2: $V_{ORM} = 60\text{V}$
 $I_{GT} = 200\mu\text{A}$
 $I_T = 0.8\text{A}$
 D3: $I_R = 1\text{mA}$
 $V_R = 60\text{V}$

PRECISION SOLID STATE TIME DELAY CIRCUIT

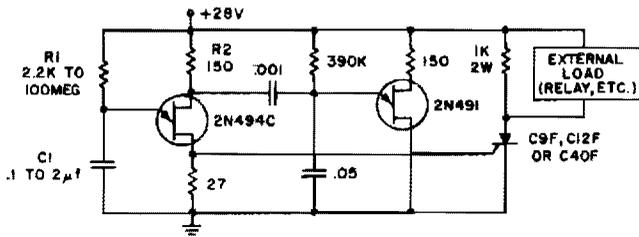


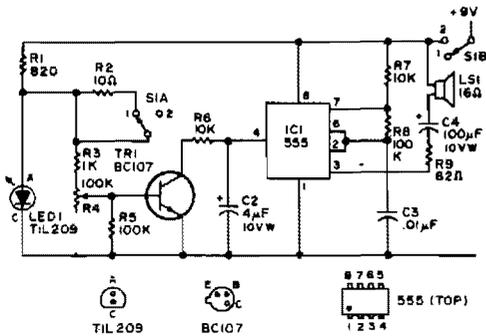
Fig. 88-9

Circuit Notes

Time delays from 0.3 milliseconds to over three minutes are possible with this circuit without using a tantalum or electrolytic capacitor. The timing interval is initiated by applying power to the circuit. At the end of the timing interval, which is determined by the value of R_1C_1 , the 2N494C fires the controlled rectifier. This places the supply voltage minus

about one volt across the load. Load currents are limited only by the rating of the controlled rectifier which is from 1 ampere up to 25 amperes for the types specified in the circuit. A calibrated potentiometer could be used in place of R_1 to permit setting a predetermined time delay after one initial calibration.

ELECTRONIC EGG TIMER



Circuit Notes

The IC functions as an astable multivibrator which is controlled by the external transistor. S1A/B is the on-off toggle switch.

Fig. 88-10

ON/OFF CONTROLLER

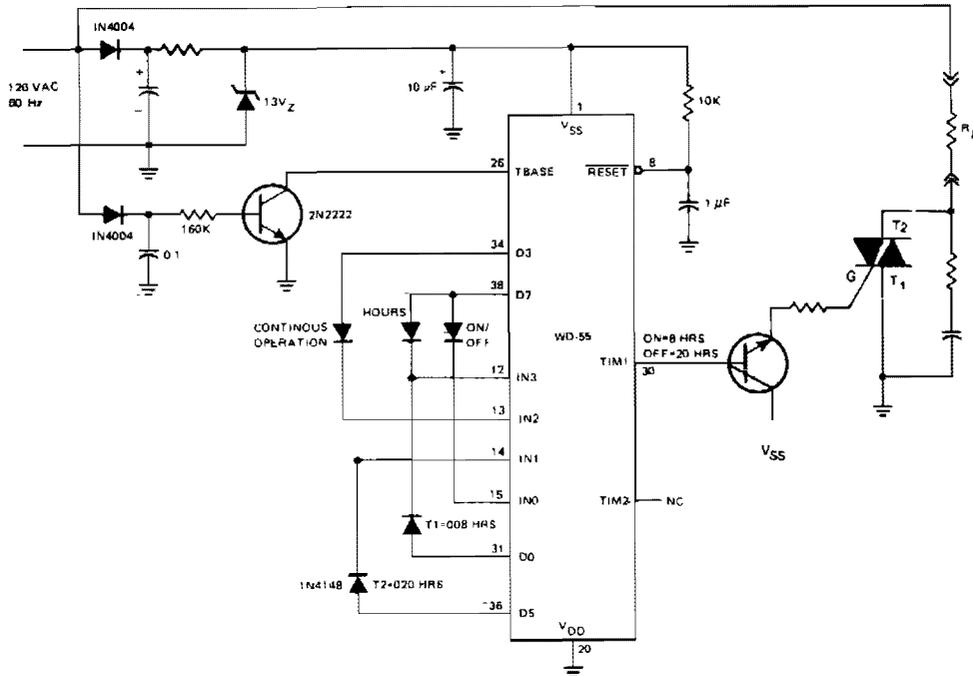


Fig. 88-11

Circuit Notes

The ac line-operated on/off controller is a simple, reliable solid-state alternative to a motive driven cam switch. Time 1 and time 2 are programmed by diodes to be 8 hours and 20 hours respectively. The TIM1 output is buf-

fered by a transistor to supply gate current to a triac which switches the output load. When power is applied to the circuit, the output load is switched on for 8 hours then off for 20 hours repeatedly.

LONG INTERVAL RC TIMER

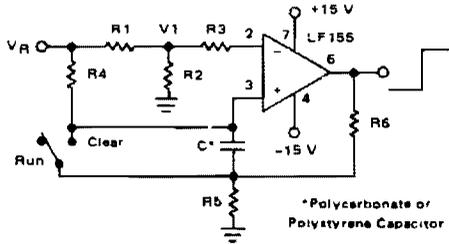


Fig. 88-14

$$\text{Time (t)} = R_4 C \ln(V_R / V_R - V_1)$$

If $R_1 = R_2$: $t = 0.693 R_4 C$

Design Example: 100 Second Timer

$$V_R = 10 \text{ V} \quad C = 1 \mu\text{F} \quad R_3 = R_4 = 144 \text{ M}$$

$$R_6 = 20 \text{ k} \quad R_5 = 2 \text{ k} \quad R_1 = R_2 = 1 \text{ k}$$

741 TIMER

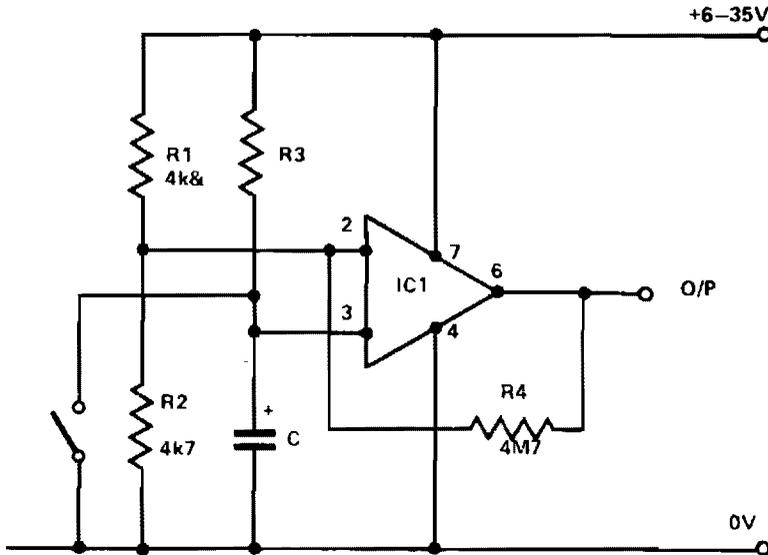


Fig. 88-15

Circuit Notes

R1 and R2 hold the inverting input at half supply voltage. R4 applies feedback to increase the input impedance at pin 3. Pin 3, the noninverting input, is connected to the junction of R3 and C. After the switch is opened, C charges via R3. When the capacitor has charged sufficiently for the potential at pin 3 to exceed that at pin 2 the output abruptly changes from 0 V to posi-

tive line potential. If reverse polarity operation is required, simply transpose R3 and C. R3 and C can be any values. Time delays from a fraction of a second to several hours can be obtained by judicious selection. The time delay—independent of supply voltage—is $0.7CR$ seconds where C is in farads.

TIMER

Circuit Notes

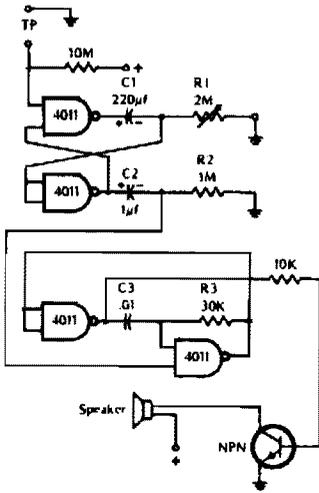


Fig. 88-16

The timer can be used wherever time periods of up to seven minutes duration are needed. To turn on just touch the turn-on plate, and after the selected time has elapsed, an alarm will sound for a short period, then automatically turn off. The turn-on touch plate, labeled TP in the diagram, is made up of two metal strips about 1/16-inch apart. Bridging the gap with your finger activates the timer. For more time range, increase R1 and/or C1. R2 and C2 determine the period of time that the alarm will sound. Increasing either will extend the time. The tone of the alarm is determined by R3 and C3. Increasing either lowers the tone, decreasing them raises the tone.

WASHER TIMER

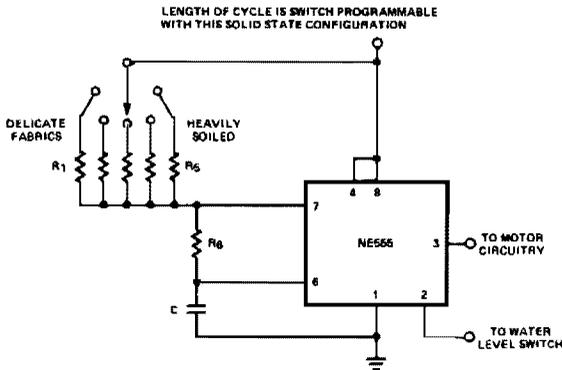


Fig. 88-17

SIMPLE TIME DELAY

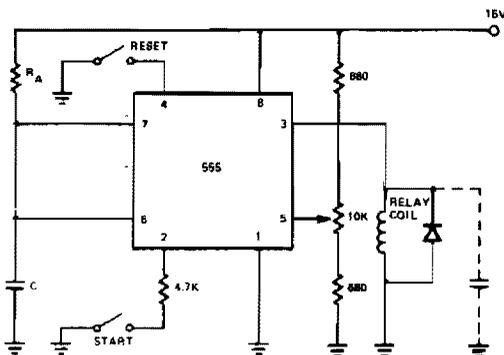


Fig. 88-18

Tone Controls

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Stereo Phonograph Amplifier with Bass
Tone Control
Equalizer
Three-Channel Tone Control
IC Preamplifier with Tone Control
Amplifier with Bass Boost
Active Bass and Treble Tone Control with
Buffer

Passive Bass and Treble Tone Control
Baxendall Tone-Control Circuit
High Quality Tone Control
Microphone Preamplifier with Tone
Control
Hi-Fi Tone Control Circuit
Three-Band Active Tone Control
Tone Control Circuit

STEREO PHONOGRAPH AMPLIFIER WITH BASS TONE CONTROL

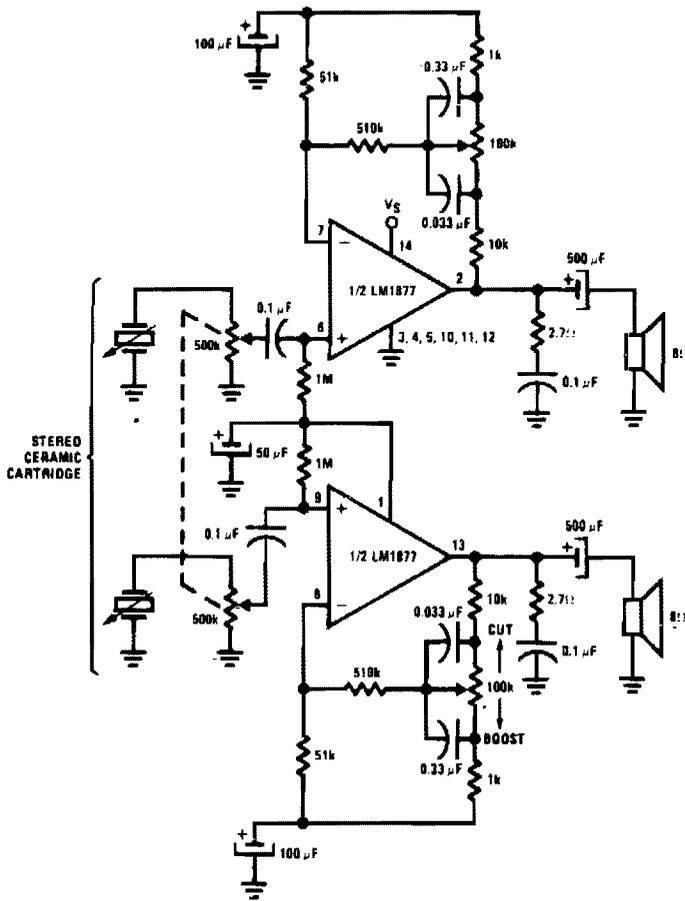
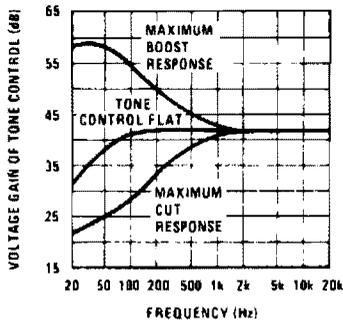
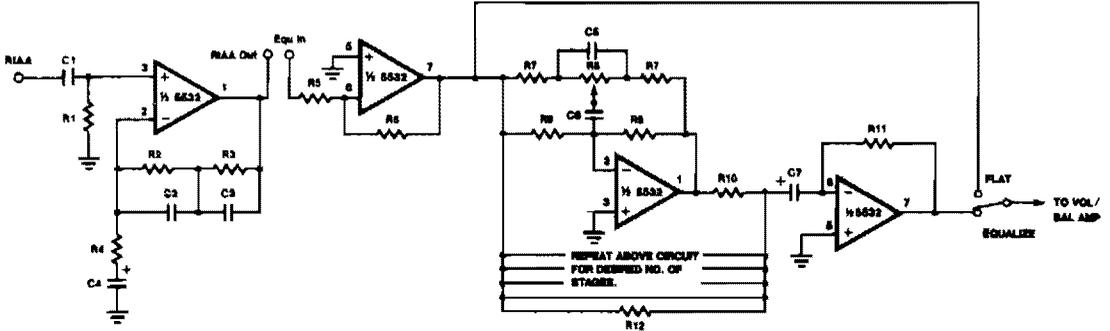


Fig. 89-1



EQUALIZER



COMPONENT VALUE TABLES

R8 = 25k R7 = 2.4k R9 = 240k			R8 = 50k R7 = 5.1k R9 = 510k			R8 = 100k R7 = 10k R9 = 1meg		
fo	C5	C6	fo	C5	C6	fo	C5	C6
23 Hz	1μF	.1μF	25 Hz	.47μF	.047μF	12 Hz	.47μF	.047μF
50 Hz	.47μF	.047μF	38 Hz	.33μF	.033μF	18 Hz	.33μF	.033μF
72 Hz	.33μF	.033μF	54 Hz	.22μF	.022μF	27 Hz	.22μF	.022μF
108 Hz	.22μF	.022μF	79 Hz	.15μF	.015μF	39 Hz	.15μF	.015μF
158 Hz	.15μF	.015μF	119 Hz	.1μF	.01μF	59 Hz	.1μF	.01μF
238 Hz	.1μF	.01μF	145 Hz	.082μF	.0082μF	72 Hz	.082μF	.0082μF
290 Hz	.082μF	.0082μF	175 Hz	.068μF	.0068μF	87 Hz	.068μF	.0068μF
350 Hz	.068μF	.0068μF	212 Hz	.056μF	.0056μF	106 Hz	.056μF	.0056μF
425 Hz	.056μF	.0056μF	253 Hz	.047μF	.0047μF	128 Hz	.047μF	.0047μF
506 Hz	.047μF	.0047μF	380 Hz	.033μF	.0033μF	180 Hz	.033μF	.0033μF
721 Hz	.033μF	.0033μF	541 Hz	.022μF	.0022μF	270 Hz	.022μF	.0022μF
1082 Hz	.022μF	.0022μF	794 Hz	.015μF	.0015μF	397 Hz	.015μF	.0015μF
1588 Hz	.015μF	.0015μF	1181 Hz	.01μF	.001μF	585 Hz	.01μF	.001μF
2382 Hz	.01μF	.001μF	1452 Hz	.0082μF	820pF	726 Hz	.0082μF	820pF
2904 Hz	.0082μF	820pF	1751 Hz	.0068μF	680pF	875 Hz	.0068μF	680pF
3502 Hz	.0068μF	680pF	2126 Hz	.0056μF	560pF	1063 Hz	.0056μF	560pF
4253 Hz	.0056μF	560pF	2534 Hz	.0047μF	470pF	1287 Hz	.0047μF	470pF
5068 Hz	.0047μF	470pF	3809 Hz	.0033μF	330pF	1804 Hz	.0033μF	330pF
7218 Hz	.0033μF	330pF	5413 Hz	.0022μF	220pF	2706 Hz	.0022μF	220pF
10827 Hz	.0022μF	220pF	7940 Hz	.0015μF	150pF	3970 Hz	.0015μF	150pF
15880 Hz	.0015μF	150pF	11910 Hz	.001μF	100pF	5955 Hz	.001μF	100pF
23820 Hz	.001μF	100pF	14524 Hz	820pF	82pF	7262 Hz	820pF	82pF
			17514 Hz	680pF	68pF	8757 Hz	680pF	68pF
			21267 Hz	560pF	56pF	10633 Hz	560pF	56pF
						12870 Hz	470pF	47pF
						18045 Hz	330pF	33pF

COMPONENT VALUES

R1	1meg	C1	22μF
R2	100k	C2	780pF
R3	100k	C3	.0033μF
R4	1meg	C4	36μF
R5	100k	C5	SEE TABLE
R6	100k	C6	SEE TABLE
R7	SEE TABLE	C7	1.2μF
R8	(see) SEE TABLE		
R9	SEE TABLE		
R10	100k		
R11	100k		
R12	20k (5 STAGES)		

Fig. 89-2

THREE-CHANNEL TONE CONTROL

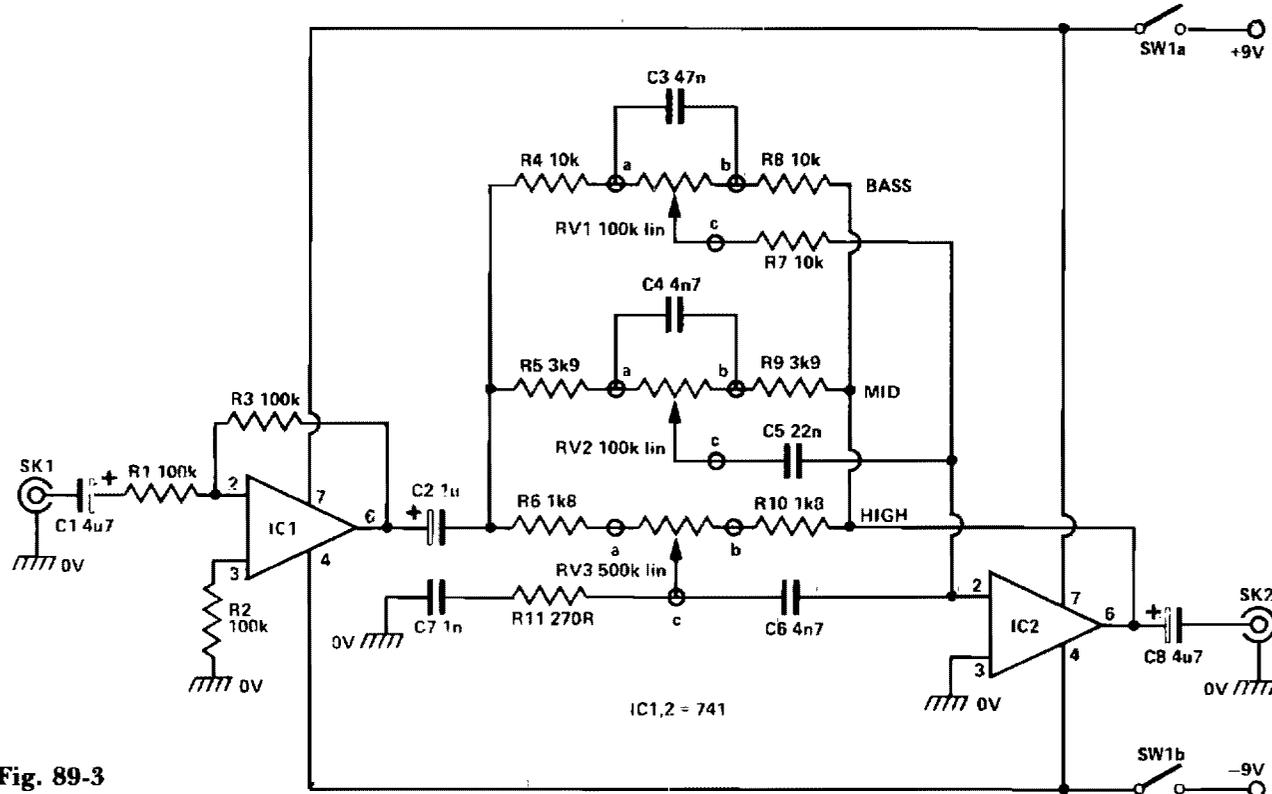


Fig. 89-3

Circuit Notes

The input signal is fed via SK1 to the first active stage built around IC1. Configured as a noninverting amplifier whose gain is set by the ratio of R3 and R1. In this case, the gain is set at unity. This initial stage is required to isolate the following stage from any loading effects. The output from IC1 is fed via three frequency

shaping networks to IC2. The three networks built around RV1, RV2, and RV3 are also included in the feedback path of IC2, another inverting op amp stage. The components associated with the three variable resistors are chosen to give the required frequency control.

IC PREAMPLIFIER WITH TONE CONTROL

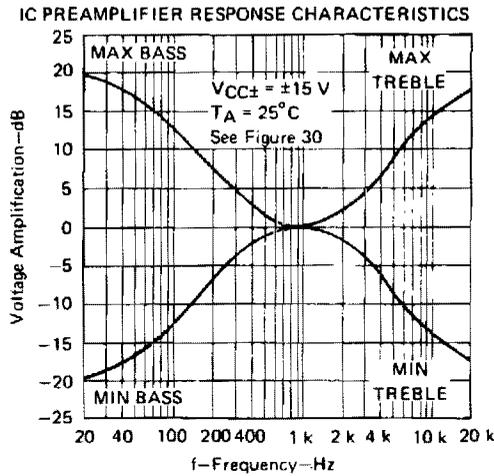
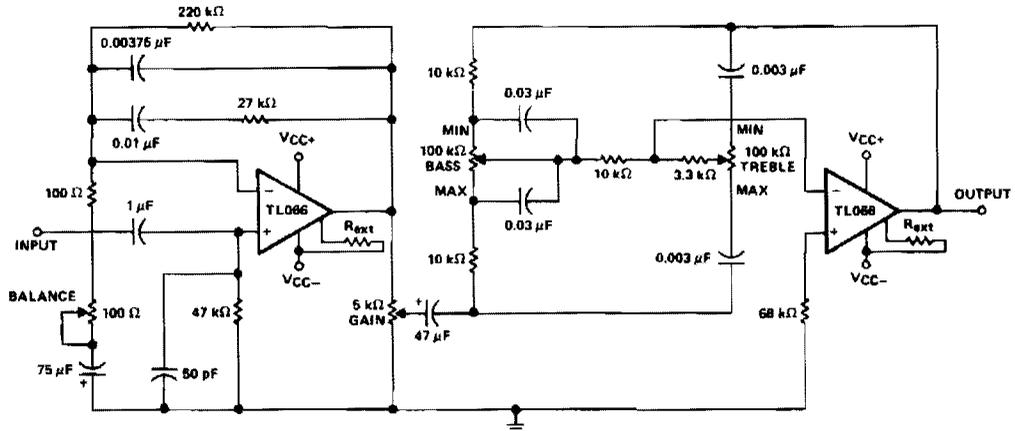


Fig. 89-4



AMPLIFIER WITH BASS BOOST

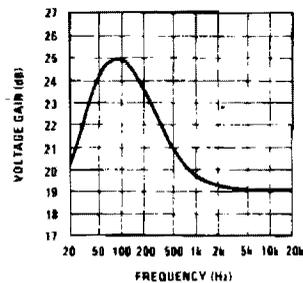
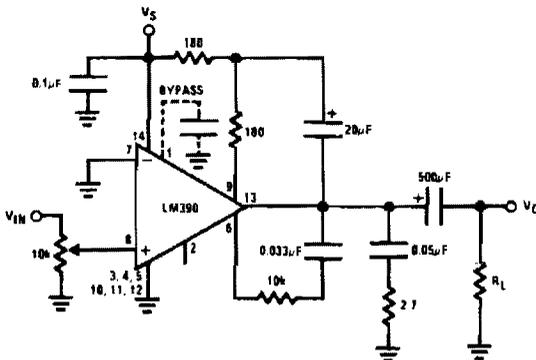


Fig. 89-5

Frequency Response with Bass Boost

ACTIVE BASS & TREBLE TONE CONTROL WITH BUFFER

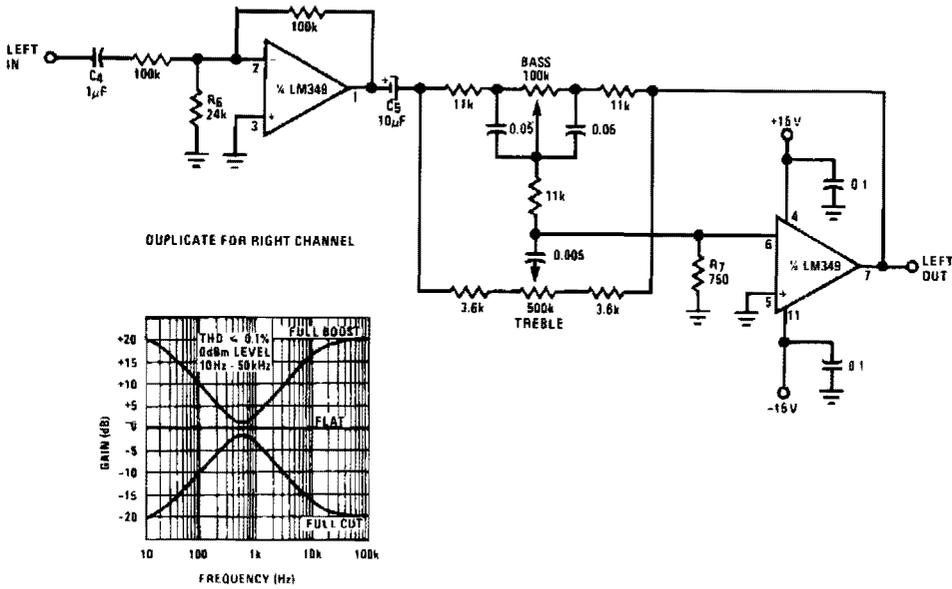


Fig. 89-6

PASSIVE BASS & TREBLE TONE CONTROL

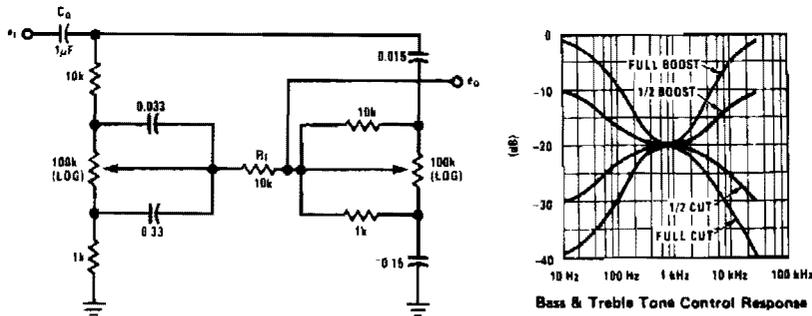


Fig. 89-7

BAXENDALL TONE-CONTROL CIRCUIT

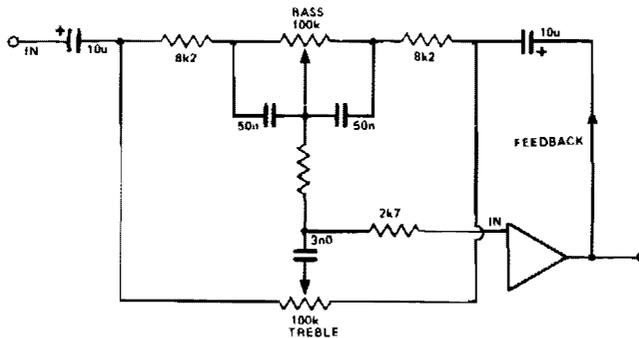


Fig. 89-8

HI-FI TONE CONTROL CIRCUIT (HIGH Z INPUT)

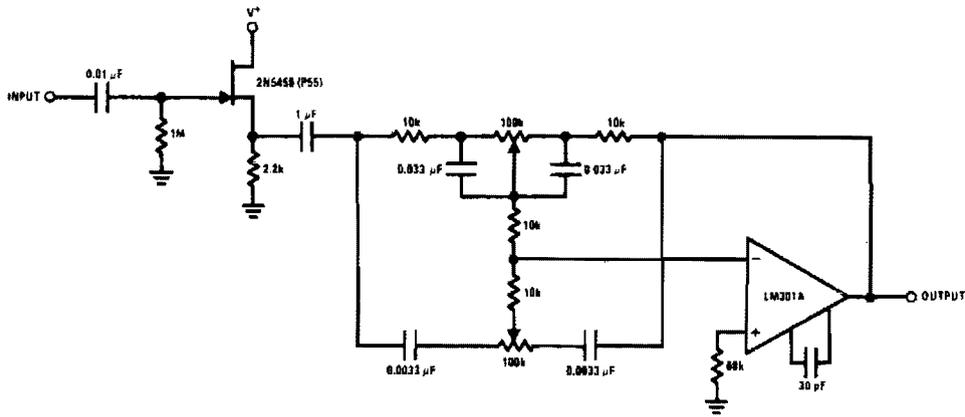


Fig. 89-11

Circuit Notes

The 2N5458 JFET provides the function of a high input impedance and low noise characteristics to buffer an op amp feedback tone control circuit.

THREE-BAND ACTIVE TONE CONTROL

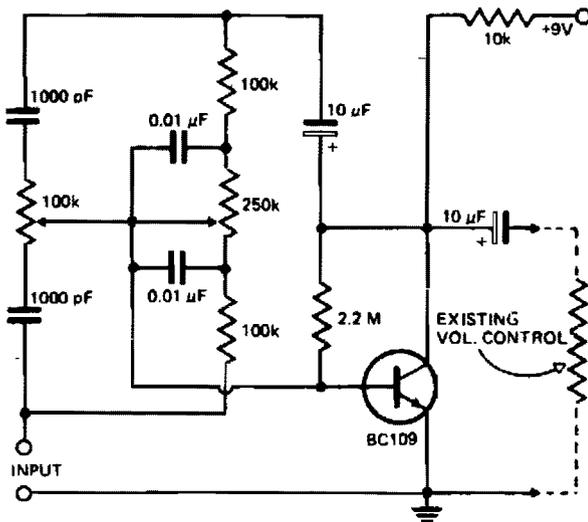
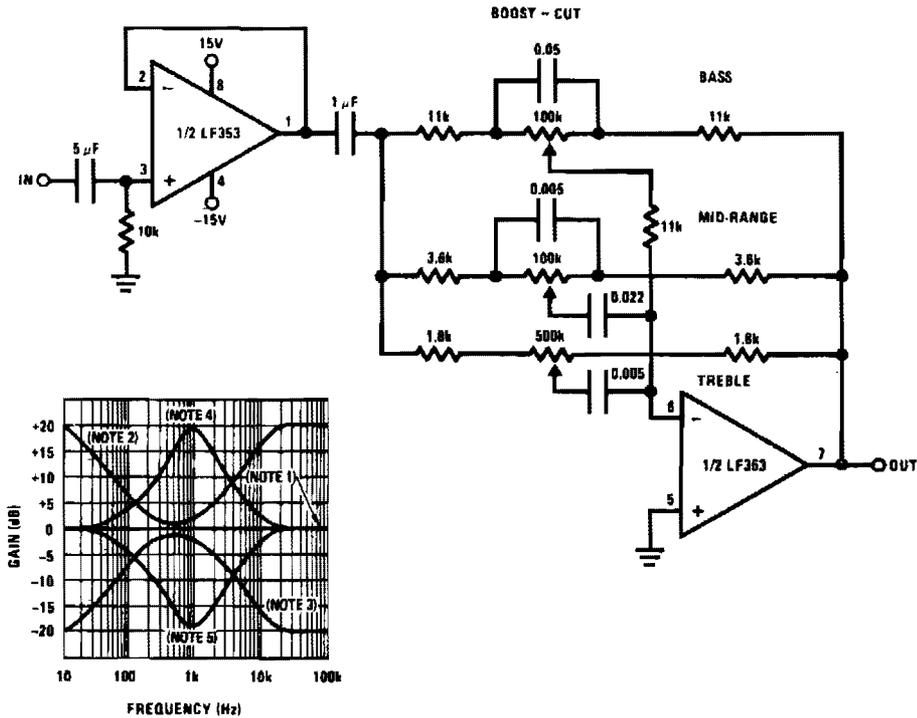


Fig. 89-12

TONE CONTROL CIRCUIT



- Note 1: All controls flat.
- Note 2: Bass and treble boost, mid flat.
- Note 3: Bass and treble cut, mid flat.
- Note 4: Mid boost, bass and treble flat.
- Note 5: Mid cut, bass and treble flat.

- All potentiometers are linear taper
- Use the LF347 Quad for stereo applications

Fig. 89-13

Circuit Notes

A simple single-transistor circuit will give approximately 15 dB boost or cut at 100 Hz and 15 kHz respectively. A low noise audio type transistor is used, and the output can be fed

directly into any existing amplifier volume control to which the tone control is to be fitted. The gain of the circuit is near unity when controls are set in the flat position.

90

Transmitters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Wireless AM Microphone
27 MHz and 49 MHz RF Oscillator/
Transmitter

1-2 MHz Broadcaster Transmitter
One Tube, 10 Watt C.W. Transmitter
Simple FM Transmitter

ONE TUBE, 10 WATT C.W. TRANSMITTER

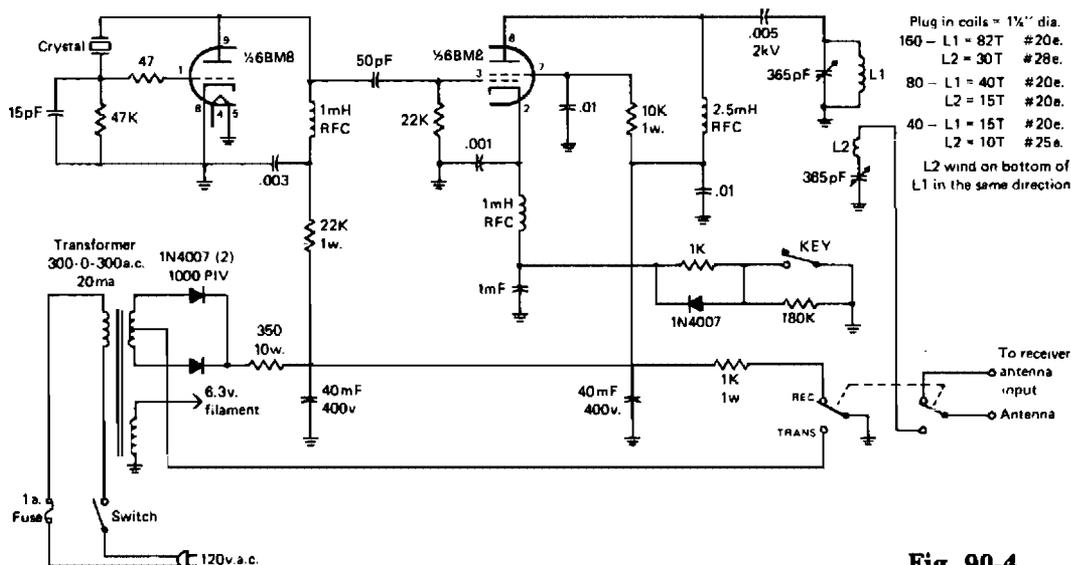


Fig. 90-4

SIMPLE FM TRANSMITTER

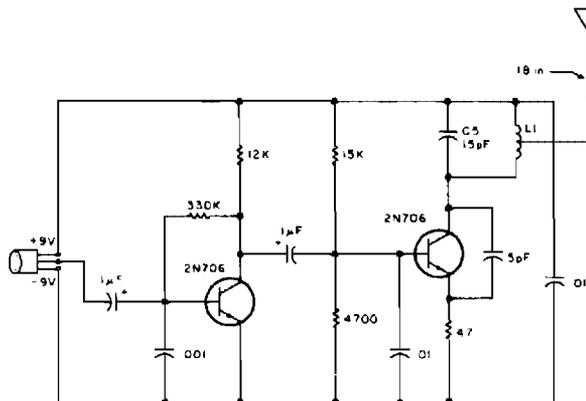


Fig. 90-5

Circuit Notes

This transmitter can be tuned to the FM broadcast band, 2 meters, or other VHF bands by changing C5 and L1. The values given for C5 and L1 will place the frequency somewhere in the FM broadcast band. L1 is 4 turns of #20 enameled wire airwound, 1/4 inch in diameter, 5mm long and center-tapped. The microphone is an electret type and the antenna is 18 inches of any type of wire. Keep all leads as short as possible to minimize stray capacitance. The range of the transmitter is several hundred yards.

91

Ultrasonics

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ultrasonic Switch

Ultrasonic Bug-Chaser

Ultrasonic Pest Repeller

Mosquito-Repelling Circuit

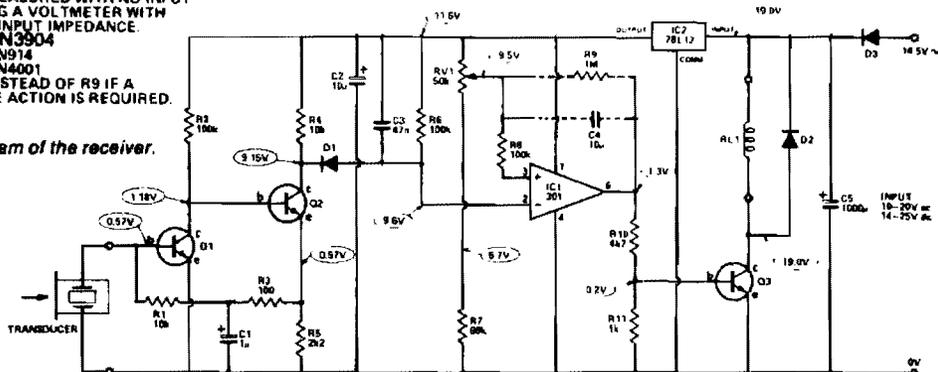
40 kHz Ultrasonic Transmitter

ULTRASONIC SWITCH

NOTES:

VOLTAGES MEASURED WITH NO INPUT SIGNAL USING A VOLTMETER WITH 10 MEG OHM INPUT IMPEDANCE.
 Q1-Q3 ARE 2N3904
 D1 IS 1N914
 D2, D3 ARE 1N4001
 C4 IS USED INSTEAD OF R9 IF A MONOSTABLE ACTION IS REQUIRED.

Circuit diagram of the receiver.

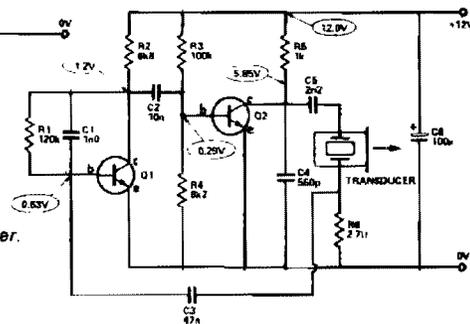


NOTE:

VOLTAGES MEASURED USING A VOLTMETER WITH 10 MEG OHM INPUT IMPEDANCE.

Q1-2 ARE 2N3904

Circuit diagram of the transmitter.



Circuit Notes

Receiver. Output from the transducer is amplified by Q1 and Q2, and rectified by D1. Voltage on pin 2 of IC1 will go more negative as the input signal increases. IC1 is used as a comparator and checks the voltage on pin 2 (i.e., the sound level), to that on pin 3 which is the reference level. If pin 2 is at a lower voltage than pin 3 (i.e., a signal is present), the output of IC1 will be high (about 10.5 volts) and this will turn on Q3 which will close the relay. The

converse occurs if pin 2 is at a higher voltage than pin 3.

Transmitter. The oscillator frequency is determined by the transducer characteristics [(minimum (series resonance) at 39.8 kHz followed by a maximum (parallel resonance) at 41.5 kHz.)] Two transistors from a noninverting amplifier and positive feedback is supplied via the transducer, R6 and C3. At the series resonant frequency, this feedback is strong enough to cause oscillation.

ULTRASONIC BUG-CHASER

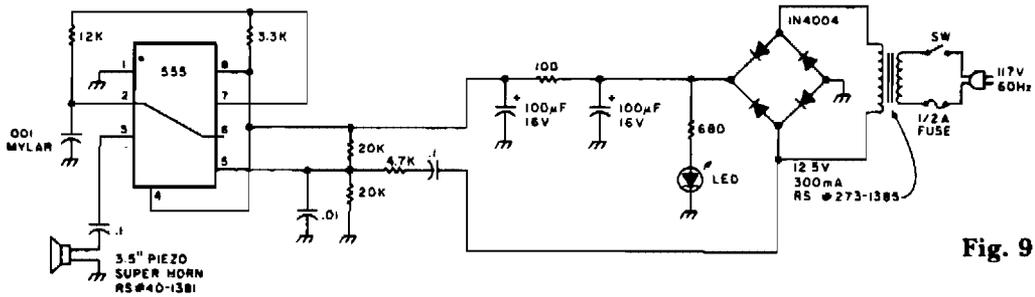


Fig. 91-2

Circuit Notes

Low-intensity ultrasonic sound waves in the 30-45 kHz frequency band repel insects and small rodents. The unit is designed to generate a swept square wave from 30 to 45 kHz. The LM555 IC is wired as an ultrasonic oscillator

driving a piezoelectric speaker of the hi-fi super-tweeter type. The output of the oscillator is swept by a 60-Hz signal from the ac input of the bridge rectifier. The LED acts as a pilot.

MOSQUITO-REPELLING CIRCUIT

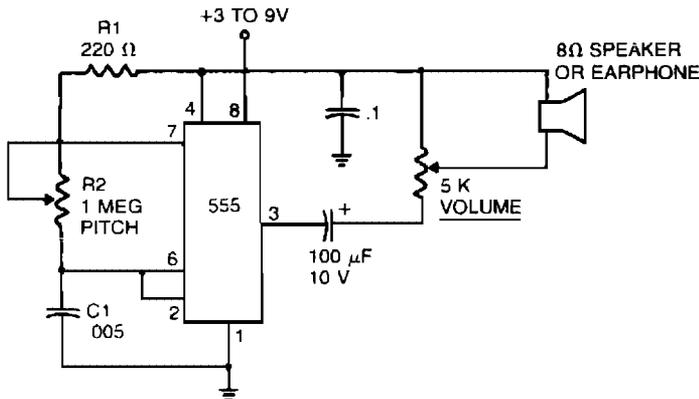


Fig. 91-3

Circuit Notes

In the 555 oscillator circuit, adjusting R2 will provide output frequencies from below 200 Hz to above 62 kHz. Use a good quality mini-

ature speaker so that it will produce frequencies on the order of 20 kHz.

ULTRASONIC PEST REPELLER

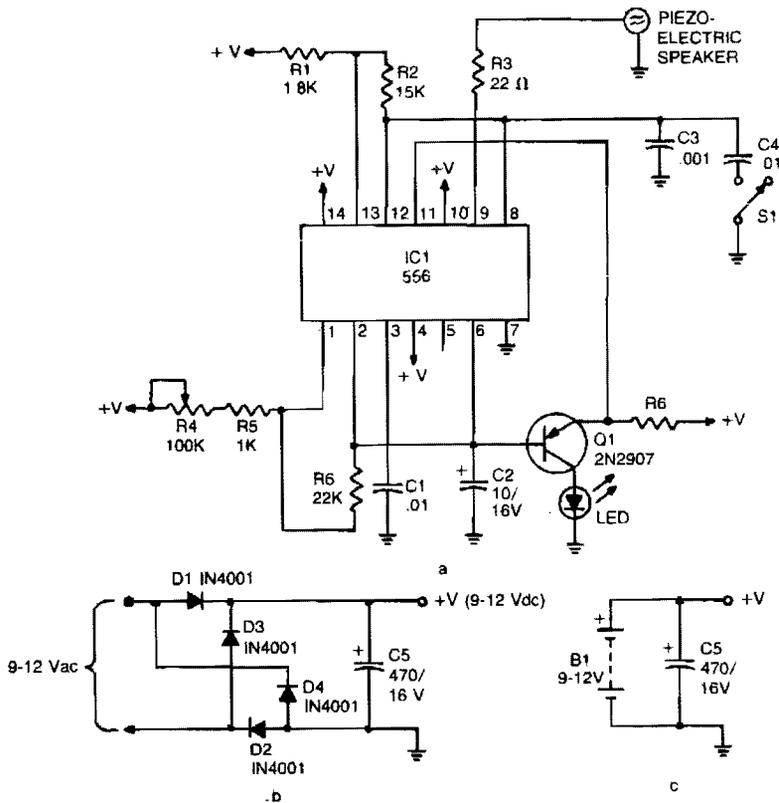


Fig. 91-4

Circuit Notes

The device emits ultrasonic sound waves that sweep between 65,000 and 25,000 hertz. Designed around a 556 dual timer, one half operated as an astable multivibrator with an adjustable frequency of 1 to 3 Hz. The second half is also operated as an astable multivibrator but with a fixed free running frequency around

45,000 Hz. The 25-65 kHz sweep is accomplished by coupling the voltage across C2 (the timing capacitor for the first half of the 556) via Q1 to the control voltage terminal (pin 11) of the second half of the 556. The device that radiates the ultrasonic sound is a piezo tweeter.

40 kHz ULTRASONIC TRANSMITTER

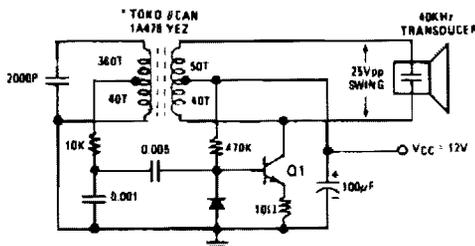


Fig. 91-5

Video Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Video IF Amplifier and Low-Level Video
Detector Circuit

Television IF Amplifier and Detector Using
an MC1330 and an MC1352

Two-Stage Wideband Amplifier

Video IF Amplifier and Low-Level Video
Detector Circuit

TV Sound IF or FM IF Amplifier with Quad-
rature Detector

IF Amplifier

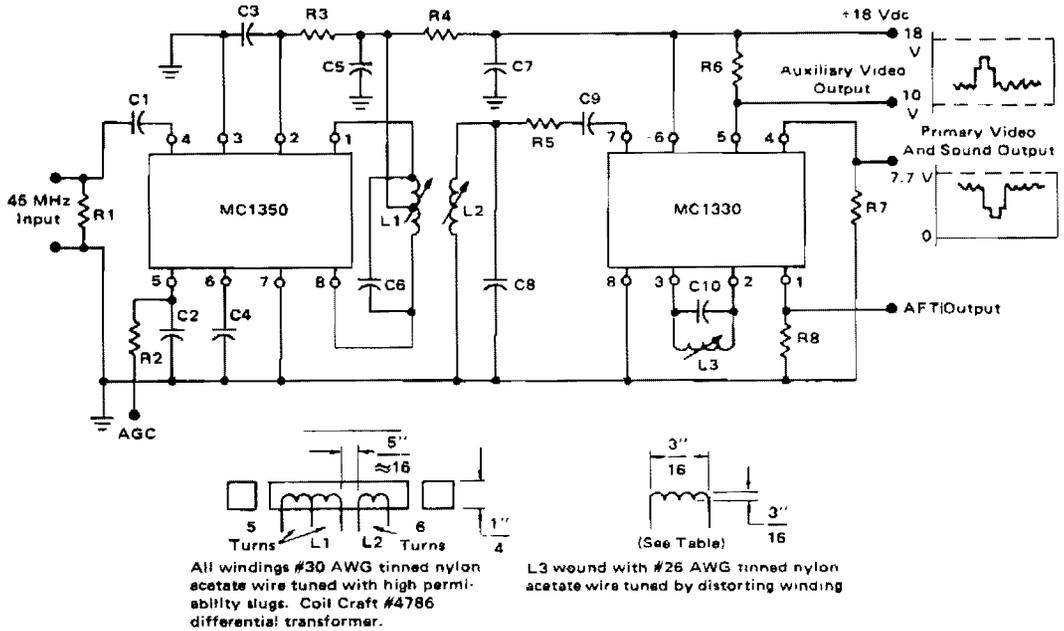
FET Cascode Video Amplifier

High Impedance Low Capacitance Amplifier

JFET Bipolar Cascode Video Amplifier
Video Amplifier

Video Amplifier

VIDEO IF AMPLIFIER AND LOW-LEVEL VIDEO DETECTOR CIRCUIT



All windings #30 AWG tinned nylon acetate wire tuned with high permeability slugs. Coil Craft #4786 differential transformer.

L3 wound with #26 AWG tinned nylon acetate wire tuned by distorting winding

C1 = 0.001 μ F	C6 = See Table	R1 = 50 Ω	R6 = 3.3 k Ω
C2 = 0.002 μ F	C7 = 0.1 μ F	R2 = 5 k	R7 = 3.9 k Ω
C3 = 0.002 μ F	C8 = See Table	R3 = 470 Ω	R8 = 3.9 k Ω
C4 = 0.002 μ F	C9 = 68 pF	R4 = 220 Ω	All Resistors
C5 = 0.002 μ F	C10 = See Table	R5 = 22 Ω	1/4-W \pm 10%

All Caps Marked μ F Ceramic HiK
All Caps Marked pF Silver Mica 5%

Table of Component Values

Component	36 MHz	45 MHz	58 MHz
C6	24 pF	15 pF	10 pF
C8	18 pF	12 pF	10 pF
C10	33 pF	33 pF	18 pF
L3	12 Turns	10 Turns	10 Turns

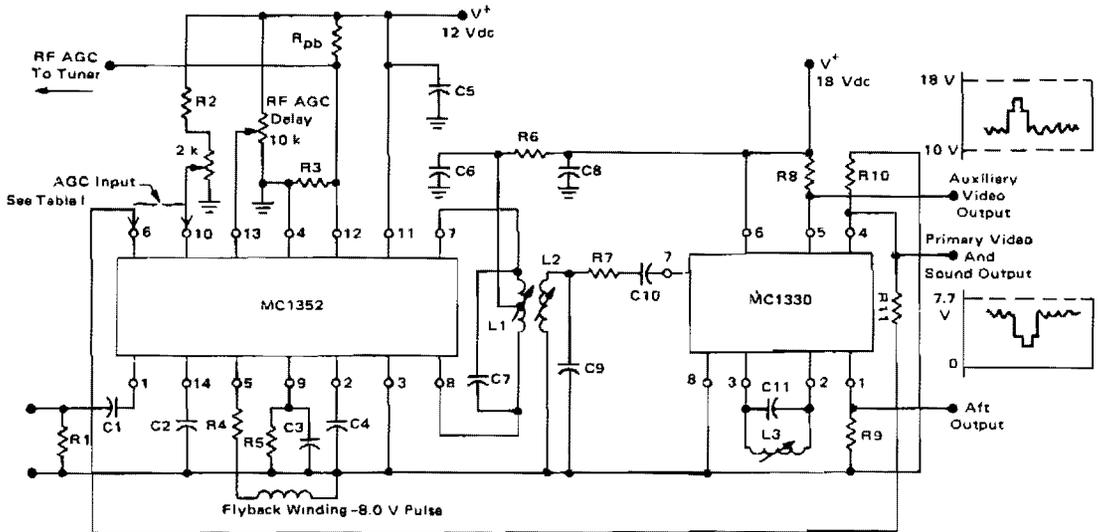
Fig. 92-1

Circuit Notes

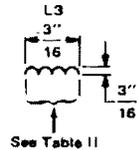
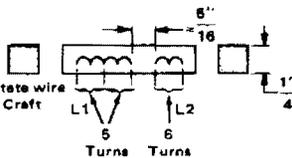
The circuit has a typical voltage gain of 84 dB and a typical AGC range of 80 dB. It gives very small changes in bandpass shape, usually less than 1 dB tilt for 60 dB compression. There are no shielded sections. The detector

uses a single tuned circuit (L3 and C10). Coupling between the two integrated circuits is achieved by a double tuned transformer (L1 and L2).

TELEVISION IF AMPLIFIER AND DETECTOR USING AN MC1330 AND AN MC1352



All windings #30 AWG tinned nylon acetate wire tuned with high permeability slugs. Coil Craft #4786 differential transformer.



C10 = 62 pF
C11 = (See Table II)
All Resistors 1/4-Watt ±5%

Wound with #26 AWG tinned nylon acetate wire tuned by distorting winding.

TABLE I

Video Polarity	Pin 6 Voltage	Pin 10 Voltage	R4
Negative-Going Sync	5.5 2.0 0	Adj. 1.0-4.0 Vdc Nom 2.0 V	0
Positive-Going Sync	Adj. 1.0-8.0 Vdc Nom 4.5 V	4.5 0	3.9 k

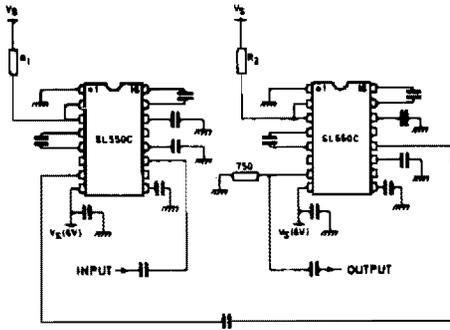
TABLE II

Component	36 MHz	45 MHz	58 MHz
C7	24 pF	16 pF	10 pF
C9	18 pF	12 pF	10 pF
C11	33 pF	33 pF	18 pF
L3	12 Turns	10 Turns	10 Turns

R_{pb} (See Text) R10 = 3.9 kΩ
R1 = 50 Ω R11 = 4.7 kΩ
R2 = 3.9 kΩ C1 = 0.001 μF
R3 = (See Text) C2 = 0.1 μF
R4 = (See Table I) C3 = 0.25 μF
R5 = 220 kΩ C5 = 0.1 μF
R6 = 220 Ω C6 = 0.1 μF
R7 = 22 Ω C7 = (See Table II)
R8 = 3.3 kΩ C8 = 0.1 μF
R9 = 3.9 kΩ C9 = (See Table II)

Fig. 92-2

TWO-STAGE WIDEBAND AMPLIFIER



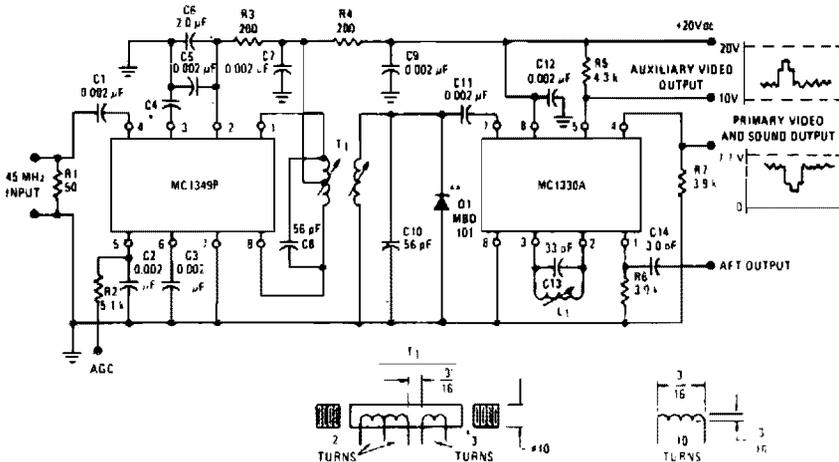
ALL CAPACITORS 1000 pF

Fig 92-3

Circuit Notes

A wideband high gain configuration using two SL550s connected in series. The first stage is connected in common emitter configuration, the second stage is a common base circuit. Stable gains of up to 65 dB can be achieved by the proper choice of R1 and R2. The bandwidth is 5 to 130 MHz, with a noise figure only marginally greater than the 2.0 dB specified for a single stage circuit.

VIDEO IF AMPLIFIER AND LOW-LEVEL VIDEO DETECTOR CIRCUIT



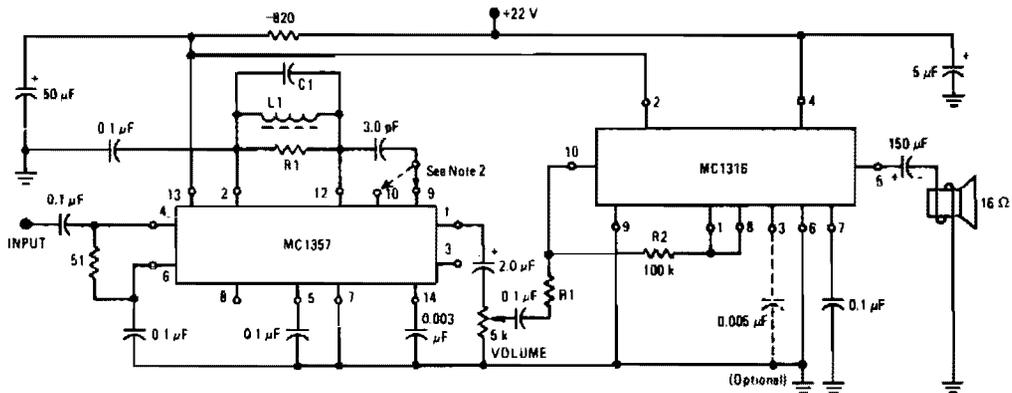
All windings 22 AWG tinned nylon acetate wire tuned with Copicrafts #61 slugs, size 10-32, or equivalent

L₁ wound with 26 AWG tinned nylon acetate wire tuned by disturbing winding

Fig. 92-4

*See Note 1 (page 3), and C4, Parts List (page 4) for this specification on the MC1349P Data Sheet
 **See Input Overload Section of the Design Characteristics Page 3, and General Information, Page 5, Note 6

TV SOUND IF OR FM IF AMPLIFIER WITH QUADRATURE DETECTOR



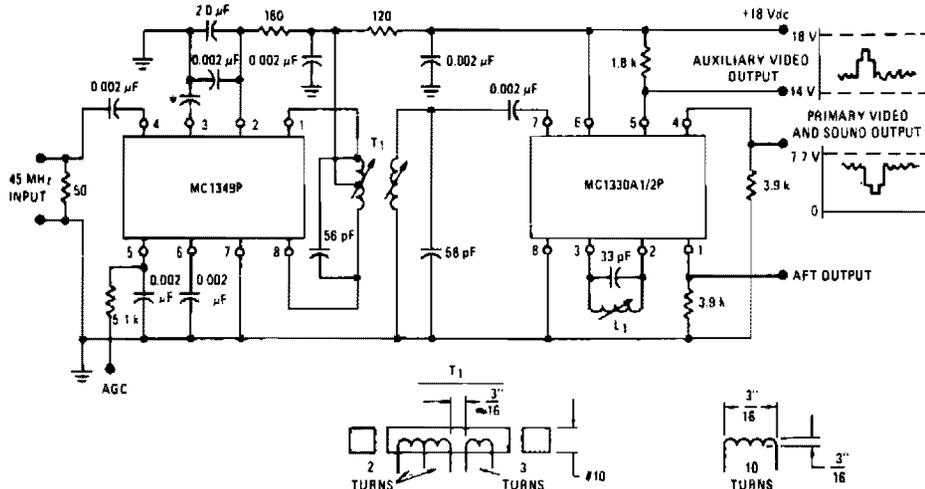
Typical Performance:
 2 Watts Output
 2% Distortion
 250 μ V Sensitivity (3 dB Lim.)

C1 = 120 pF
 L1 = 14 μ H
 R1 = 20 k Ω
 Q = 30

Fig. 92-5

IF AMPLIFIER

— TYPICAL APPLICATION OF MC1349P VIDEO IF AMPLIFIER
 and MC1330A1/2P LOW-LEVEL VIDEO DETECTOR CIRCUIT



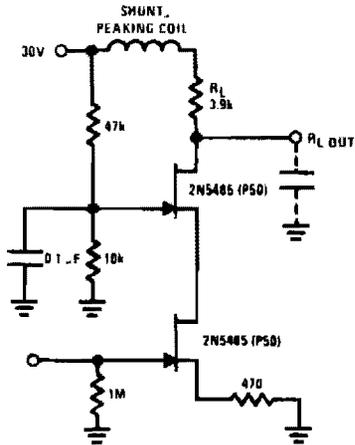
All windings #22 AWG binned nylon acetate wire tuned with Colcraft #61 Sugs. size 18-32, or equivalent

*See Note 1 (page 3), and C4, Parts List (page 4) of this specification

L1 wound with #26 AWG binned nylon acetate wire tuned by distorting winding

Fig. 92-6

FET CASCODE VIDEO AMPLIFIER



Circuit Notes

The FET cascode video amplifier features very low input loading and reduction of feedback to almost zero. The 2N5485 is used because of its low capacitance and high Y_{fs} . Bandwidth of this amplifier is limited by R_L and load capacitance.

Fig. 92-7

HIGH IMPEDANCE LOW CAPACITANCE AMPLIFIER

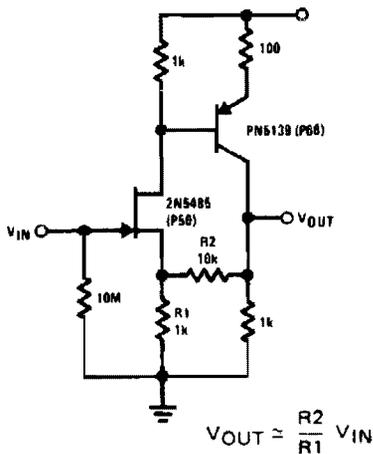
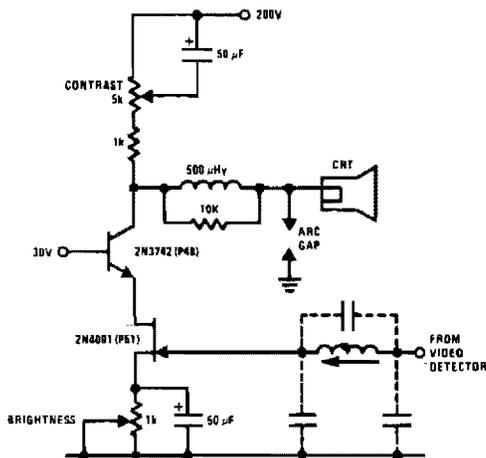


Fig. 92-8

Circuit Notes

This compound series-feedback circuit provides high input impedance and stable, wide-band gain for general purpose video amplifier applications.

JFET BIPOLAR CASCODE VIDEO AMPLIFIER



Circuit Notes

The JFET-bipolar cascode circuit will provide full video output for the CRT cathode drive. Gain is about 90. The cascode configuration eliminates Miller capacitance problems with the 2N4001 JFET, thus allowing direct drive from the video detector. An m-derived filter using stray capacitance and a variable inductor prevents 4.5 MHz sound frequency from being amplified by the video amplifier.

Fig. 92-9

VIDEO AMPLIFIER

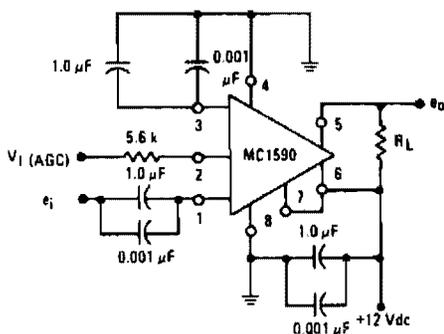


Fig. 92-10

VIDEO AMPLIFIER

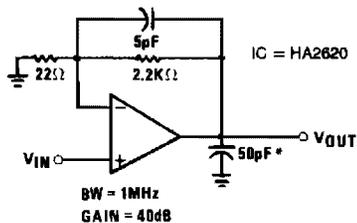


Fig. 92-11

*A small load capacitance of at least 30pF (including stray capacitance) is recommended to prevent possible high frequency oscillations.

Voltage and Current Sources and References

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- | | |
|---|--|
| Bilateral Current Source | Inverting Bipolar Current Source |
| 0 V to 20 V Power Reference | Precision Reference Micropower 10 V Reference |
| Programmable Voltage Source | Precision Reference Low Noise Buffered Reference |
| Bilateral Current Source | Constant Current Source |
| Noninverting Bipolar Current Source | Precision Dual Tracking Voltage References |
| Voltage Reference | Precision Reference Bipolar Output Reference |
| Low Voltage Adjustable Reference Supply | Precision Reference 0 V to 20 V Power Reference |
| Voltage Reference | Precision Reference Standard Cell Replacement |
| Low Power Regulator Reference | |
| High Stability Voltage Reference | |
| ± 3 V Reference | |
| ± 5 V Reference | |
| Zenerless Precision Millivolt Source | |
| ± 10 V Reference | |
| Precision Reference Square Wave Voltage Reference | |

BILATERAL CURRENT SOURCE

Circuit Notes

The circuit will produce the current relationship to within 2% using 1% values for R1 through R5. This includes variations in R_L from 100 ohm to 2000 ohm. The use of large resistors for R1 through R4 minimizes the error due to R_L variations. The large resistors are possible because of the excellent input bias current performance of the OP-08.

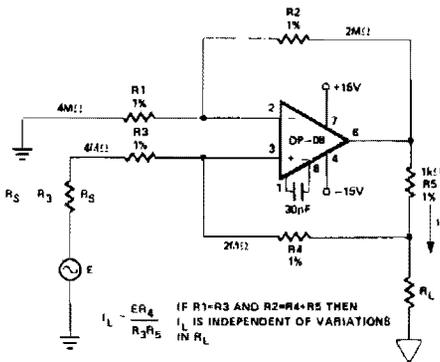


Fig. 93-1

0 V TO 20 V POWER REFERENCE

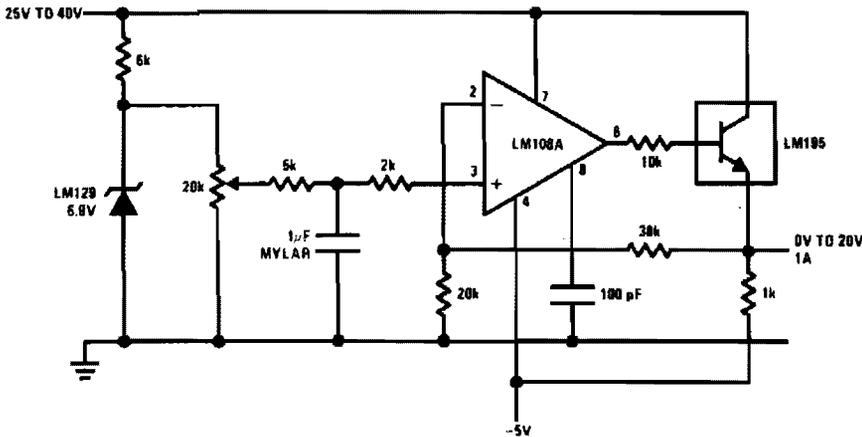


Fig. 93-2

PROGRAMMABLE VOLTAGE SOURCE

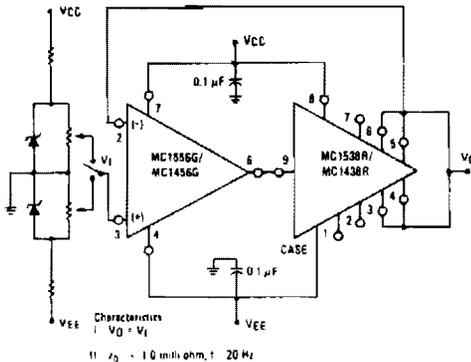


Fig. 93-3

BILATERAL CURRENT SOURCE

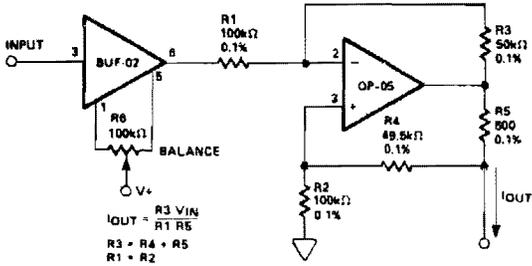


Fig. 93-4

LOW VOLTAGE ADJUSTABLE REFERENCE SUPPLY

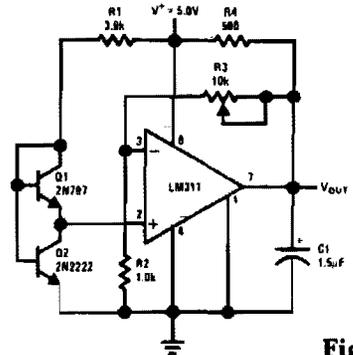


Fig. 93-7

NONINVERTING BIPOLAR CURRENT SOURCE

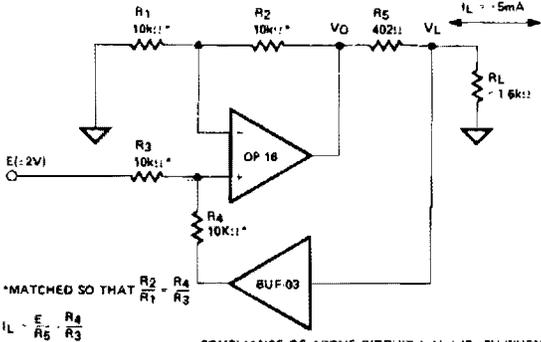


Fig. 93-5

COMPLIANCE OF ABOVE CIRCUIT (ΔV_L) IS .8V WHEN $E = -2V$ AND $R_L < 1.6k\Omega$. NOTE THAT V_O IS .10V UNDER THESE CONDITIONS.

VOLTAGE REFERENCE

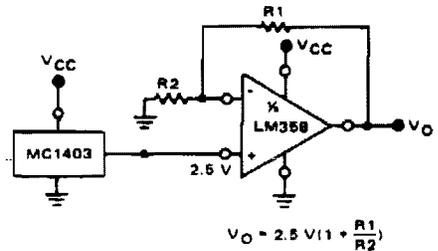


Fig. 93-8

VOLTAGE REFERENCE

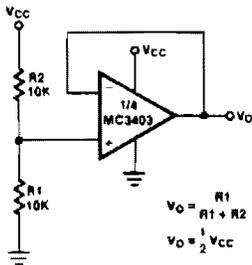


Fig. 93-6

LOW POWER REGULATOR REFERENCE

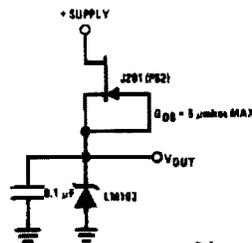


Fig. 93-9

Circuit Notes

This simple reference circuit provides a stable voltage reference almost totally free of supply voltage hash. Typical power supply rejection exceeds 100 dB.

HIGH STABILITY VOLTAGE REFERENCE

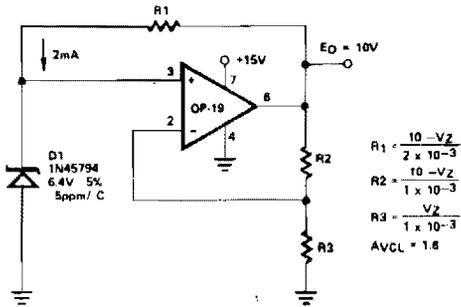


Fig. 93-10

ZENERLESS PRECISION MILLIVOLT SOURCE

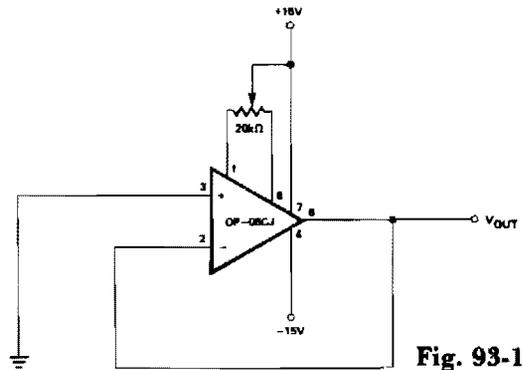


Fig. 93-13

± 3 V REFERENCE

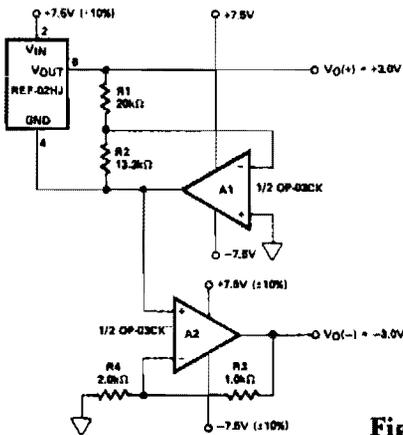


Fig. 93-11

± 10 V REFERENCE

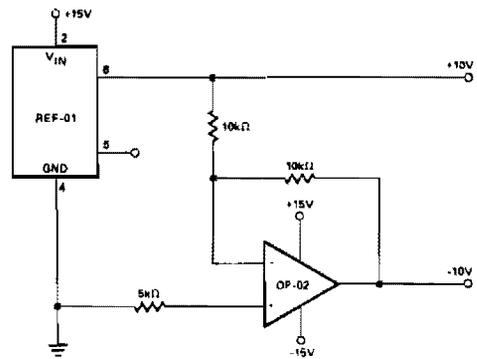


Fig. 93-14

± 5 V REFERENCE

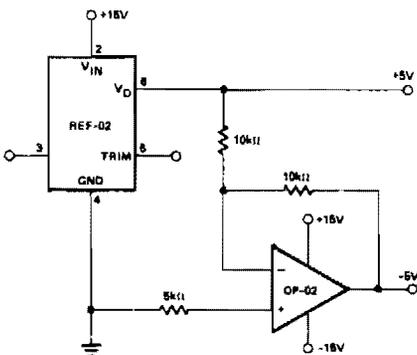


Fig. 93-12

PRECISION REFERENCE SQUARE WAVE VOLTAGE REFERENCE

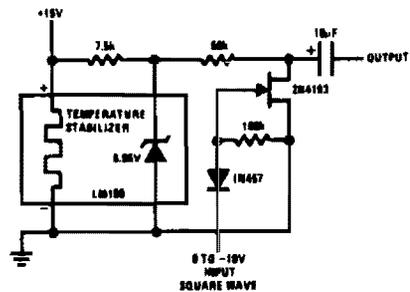
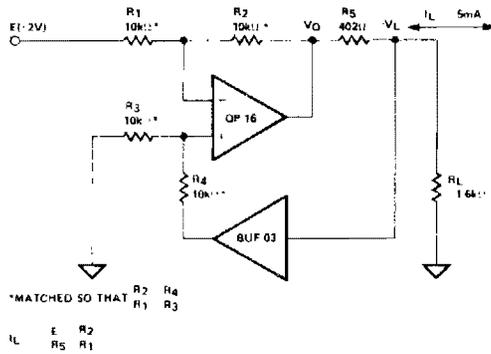


Fig. 93-15

INVERTING BIPOLAR CURRENT SOURCE (HIGH SPEED)



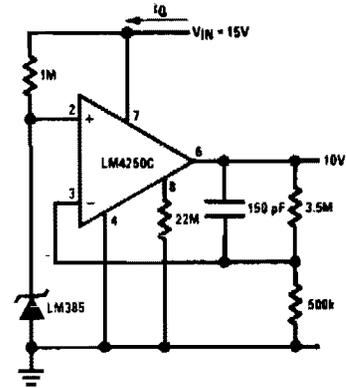
*MATCHED SO THAT $\frac{R_2}{R_1} = \frac{R_4}{R_3}$

$I_L = \frac{E}{R_5} \frac{R_2}{R_1}$

COMPLIANCE OF ABOVE CIRCUIT IS V_{L1} IS 8V WHEN $E = 2V$ AND $R_L = 16k$. NOTE THAT V_{Q1} IS 10V UNDER THESE CONDITIONS

Fig. 93-16

PRECISION REFERENCE MICROPOWER 10 V REFERENCE



* $I_Q \approx 20 \mu A$ standby current

Fig. 93-17

PRECISION REFERENCE LOW NOISE BUFFERED REFERENCE

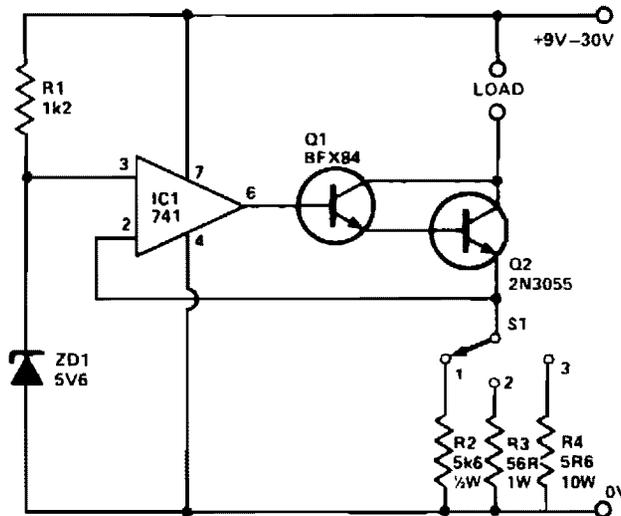


Fig. 93-18

Circuit Notes

The circuit will provide 3 preset currents which will remain constant despite variations of ambient temperature or line voltage. ZD1 produces a temperature stable reference voltage which is applied to the noninverting input of IC1. 100% feedback is applied from the output to the inverting input holding the voltage at

Q2s emitter at the same potential as the noninverting input. The current flowing into the load therefore is defined solely by the resistor selected by S1. With the values employed here, a preset current of 10 mA, 100mA or 1 A can be selected. Q2 should be mounted on a suitable heatsink.

CONSTANT CURRENT SOURCE

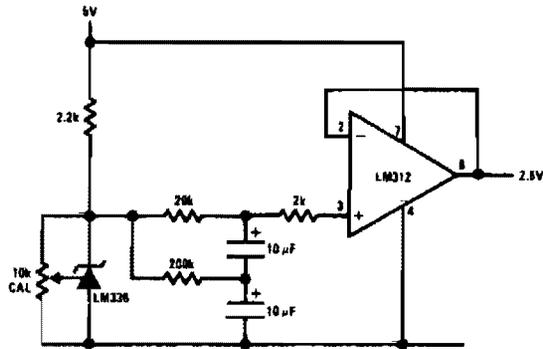


Fig. 93-19

PRECISION DUAL TRACKING VOLTAGE REFERENCES

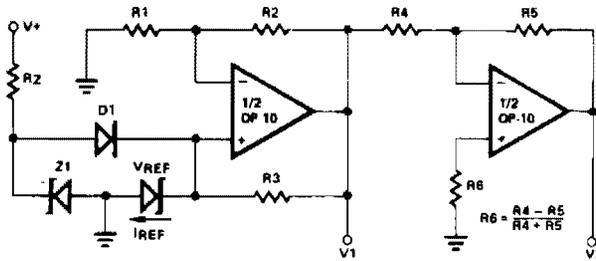


Fig. 93-20

PRECISION REFERENCE BIPOLAR OUTPUT REFERENCE

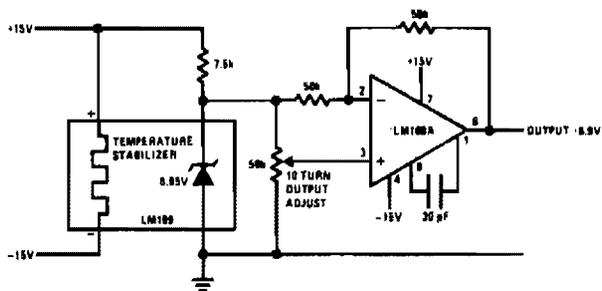


Fig. 93-21

PRECISION REFERENCE 0 V TO 20 V POWER REFERENCE

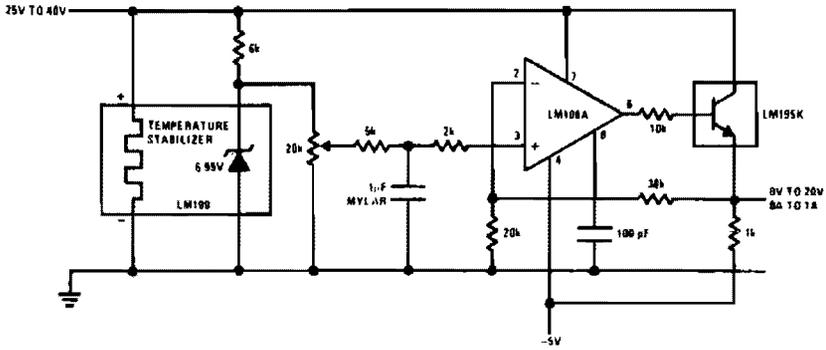


Fig. 93-22

PRECISION REFERENCE STANDARD CELL REPLACEMENT

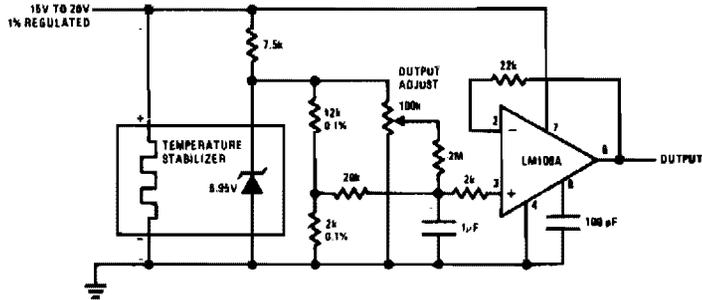


Fig. 93-23

94

Voltage- Controlled Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Linear Voltage Controlled Oscillator
10 Hz to 10 kHz Voltage Controlled Oscillator
Precision Voltage Controlled Oscillator
Voltage Controlled Oscillator

Simple Voltage Controlled Oscillator
Three Decades VCO
Two-Decade High-Frequency VCO
Voltage Controlled Oscillator
Voltage Controlled Oscillator

LINEAR VOLTAGE CONTROLLED OSCILLATOR

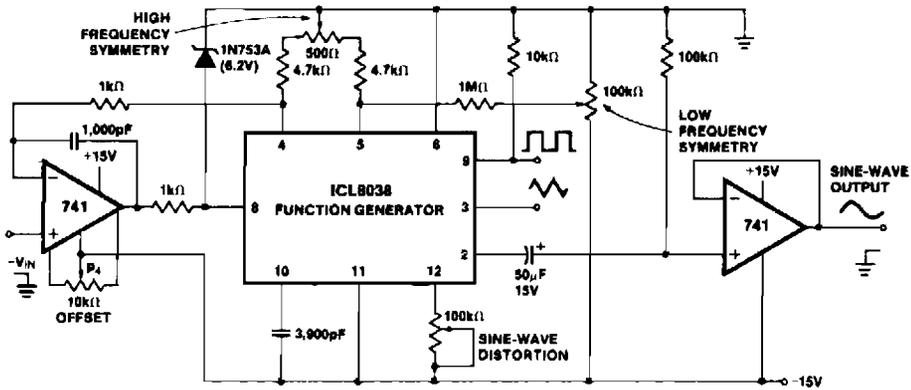


Fig. 94-1

Circuit Notes

The linearity of input sweep voltage versus output frequency is significantly improved by using an op amp.

10 Hz TO 10 kHz VOLTAGE CONTROLLED OSCILLATOR

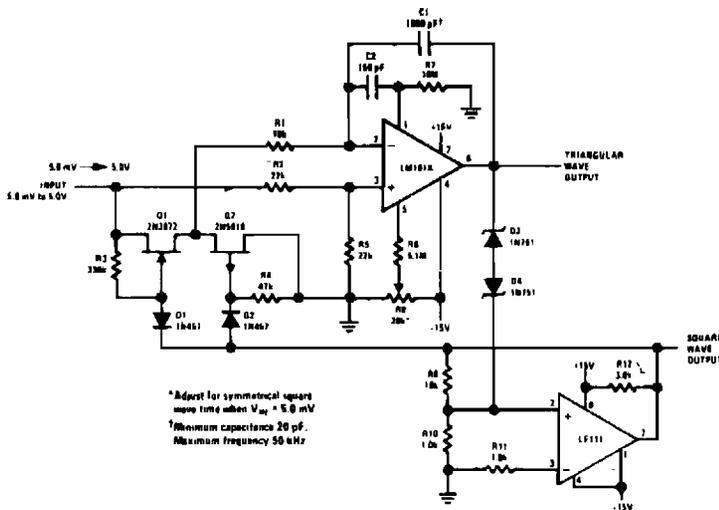


Fig. 94-2

PRECISION VOLTAGE CONTROLLED OSCILLATOR

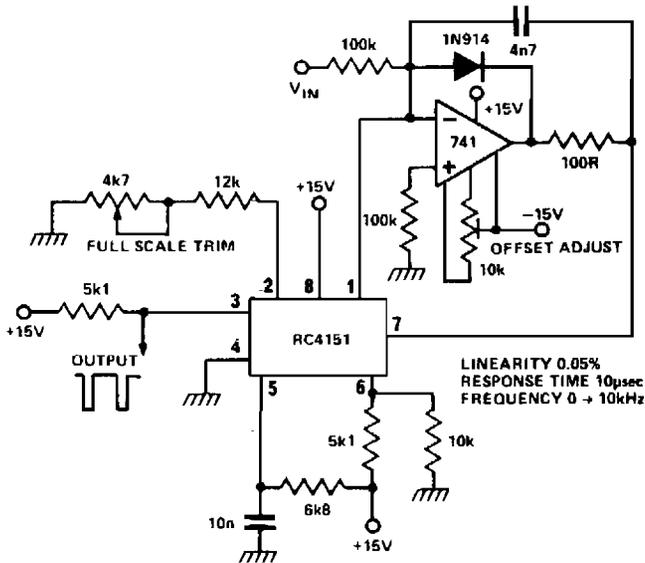
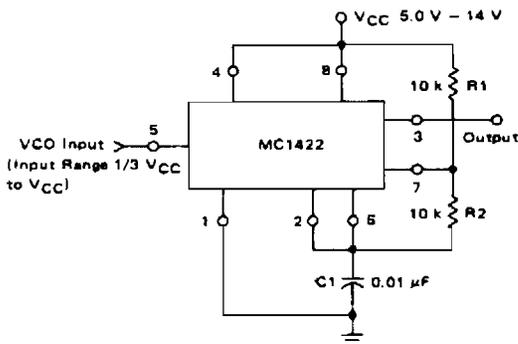


Fig. 94-3

Circuit Notes

RC 4151 precision voltage-to-frequency converter generates a pulse train output linearly proportional to the input voltage.

VOLTAGE CONTROLLED OSCILLATOR



Circuit Notes

The VCO circuit, which has a nonlinear transfer characteristic, will operate satisfactorily up to 200 kHz. The VCO input range is effective from $\frac{1}{3} V_{CC}$ to $V_{CC} - 2$ V, with the highest control voltage producing the lowest output frequency.

Fig. 94-4

SIMPLE VOLTAGE CONTROLLED OSCILLATOR

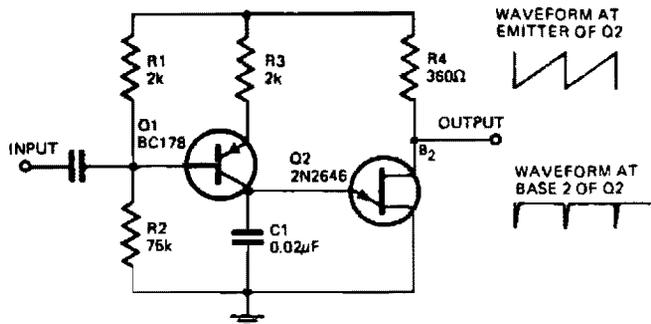


Fig. 94-5

Circuit Notes

With the component values shown, the oscillator has a frequency of 8 kHz. When an input signal is applied to the base of Q1 the current flowing through Q1 is varied, thus varying the time required to charge C1. Due to the phase inversion in Q1 the direction of output frequency change is 180 degrees out of phase with the input signal. The output may be used to trigger a bistable flip-flop.

THREE DECADES VCO

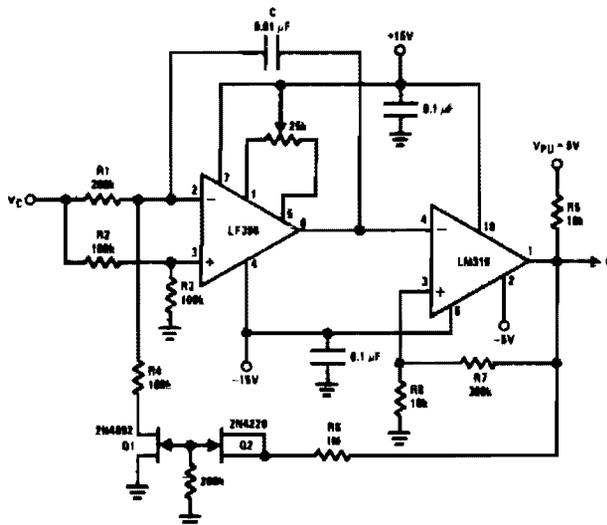


Fig. 94-6

$$f = \frac{V_C (R_B + R_7)}{[8 V_{PU} R_B R_1] C} \quad , 0 \leq V_C \leq 30V, 10 \text{ Hz} \leq f \leq 10 \text{ kHz}$$

R1, R4 matched. Linearity 0.1% over 2 decades.

TWO-DECADE HIGH-FREQUENCY VCO

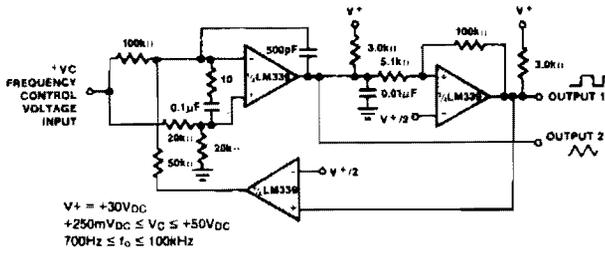


Fig. 94-7

VOLTAGE CONTROLLED OSCILLATOR

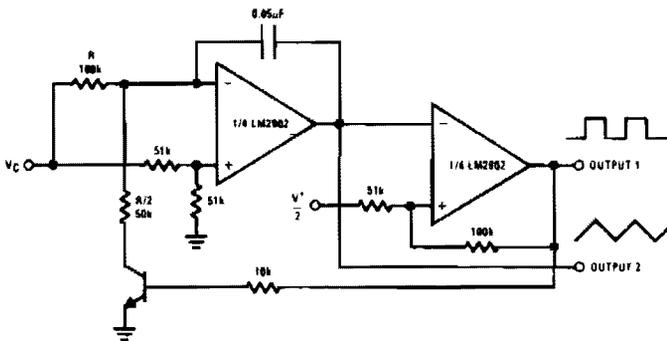
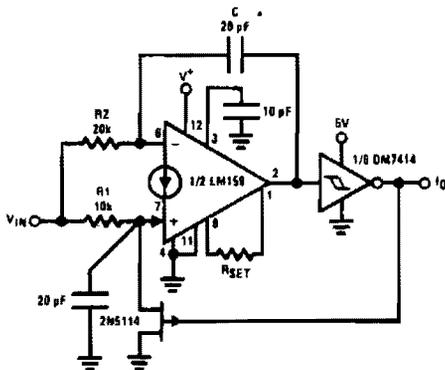


Fig. 94-8

VOLTAGE CONTROLLED OSCILLATOR



$$f_o = \frac{V_{IN} - \dagger}{4C\Delta V R_1}$$

where: $R_2 = 2R_1$

$\dagger =$ amplifier input voltage = 0.6V

$\Delta V =$ DM7414 hysteresis, typ 1V

- 5 MHz operation
- T^2L output

Fig. 94-9

95

Voltage-to-Frequency Converters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

10 Hz to 10 kHz Voltage/Frequency Converter

Voltage-to-Frequency Converter

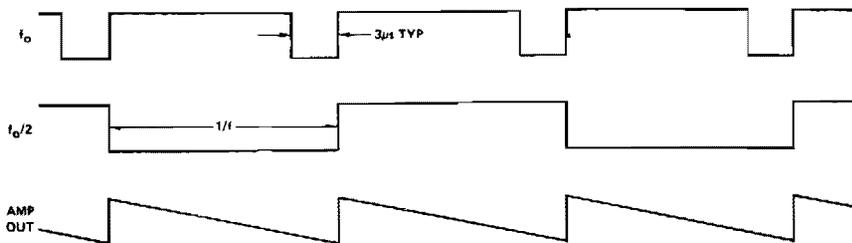
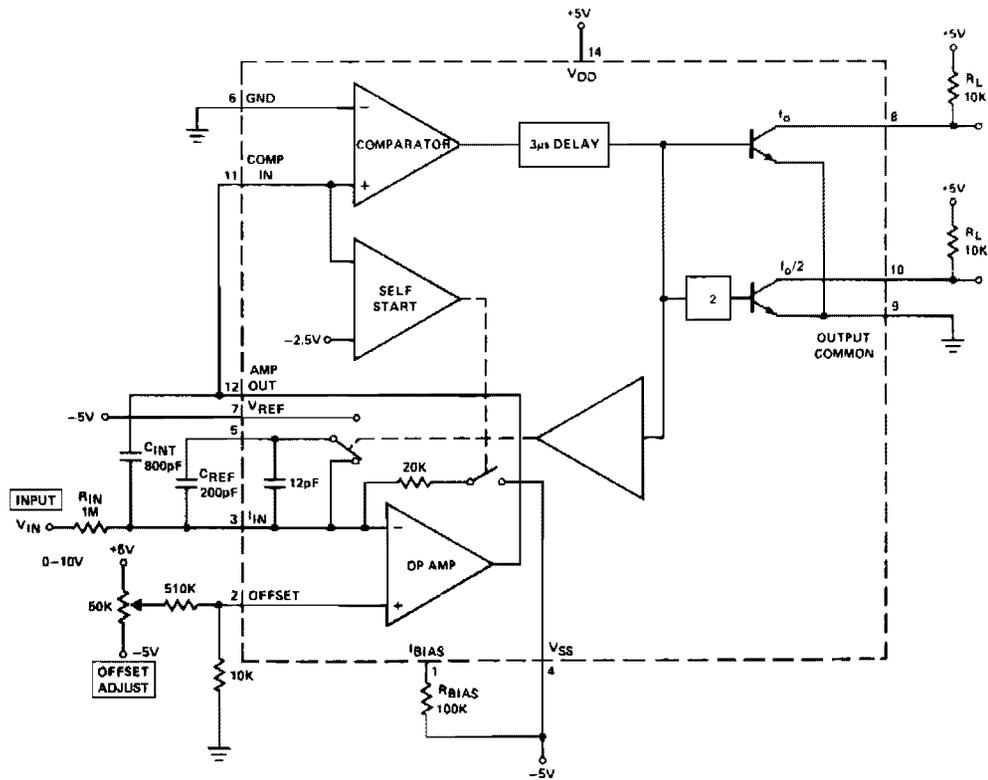
Voltage-to-Frequency Converter

V/F Conversion, Positive Input Voltage

Ultraprecision V/F Converter

V/F Conversion, Negative Input Voltage

10 Hz TO 10 kHz VOLTAGE/FREQUENCY CONVERTER



1. To adjust f_{min} , set $V_{IN} = 10mV$ and adjust the 50K offset for 10Hz out.
2. To adjust f_{max} , set $V_{IN} 10V$ and adjust R_{IN} or V_{REF} for 10KHz out.
3. To increase f_{OUTMAX} to 100KHz change C_{REF} to 15pF and C_{INT} to 75pF
4. For high performance applications use high stability components for R_{IN} , C_{REF} , V_{REF} (metal film resistors and glass film capacitors). Also separate the output ground (Pin 9) from the input ground (Pin 6).

Output Waveforms

Fig. 95-1

ULTRAPRECISION V/F CONVERTER

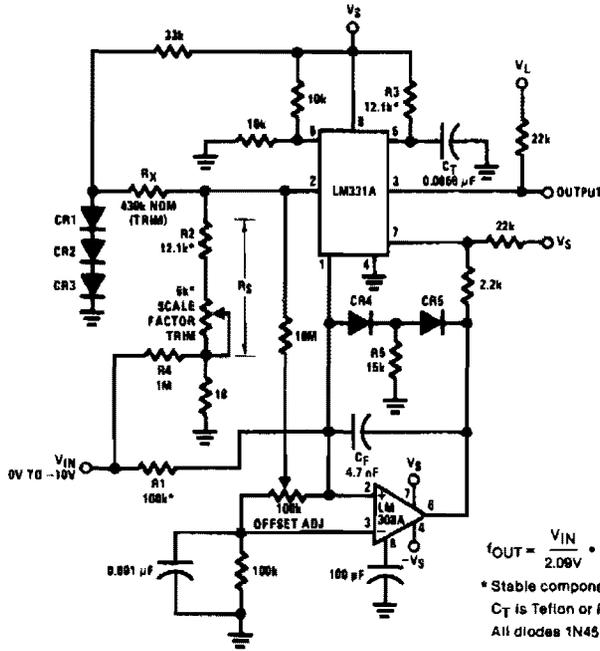


Fig. 95-5

Circuit Notes

The circuit is capable of better than 0.02% error and 0.003% nonlinearity for a $\pm 20^\circ\text{C}$ range about room temperature.

V/F CONVERSION, NEGATIVE INPUT VOLTAGE

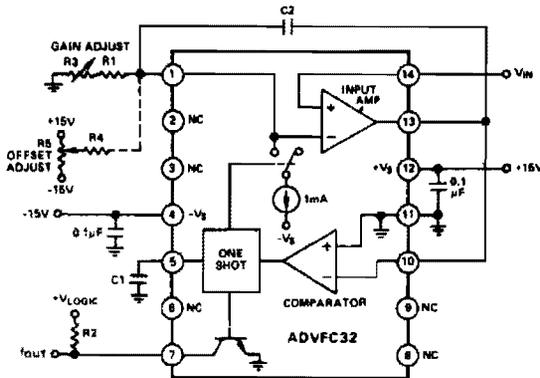


Fig. 95-6

96

Voltmeters

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

3-¾ Digit DVM, Four Decade, ± 0.4 V, ± 4
V, ± 40 V, and ± 400 V Full Scale

Automatic Nulling DVM

3-½ Digit True RMS AC Voltmeter

3-½ Digit DVM Common Anode Display

DVM Auto-Calibrate Circuit

FET Voltmeter

Extended Range VU Meter (Bar Mode)

High Input Impedance Millivoltmeter

Wide Band AC Voltmeter

Suppressed Zero Meter

Ac Millivoltmeter

4½ Digit LCD-DVM

Sensitive Low Cost VTVM

3- $\frac{3}{4}$ DIGIT DVM, FOUR DECADE,
 ± 0.4 V, ± 4 V, ± 40 V, AND ± 400 V FULL SCALE

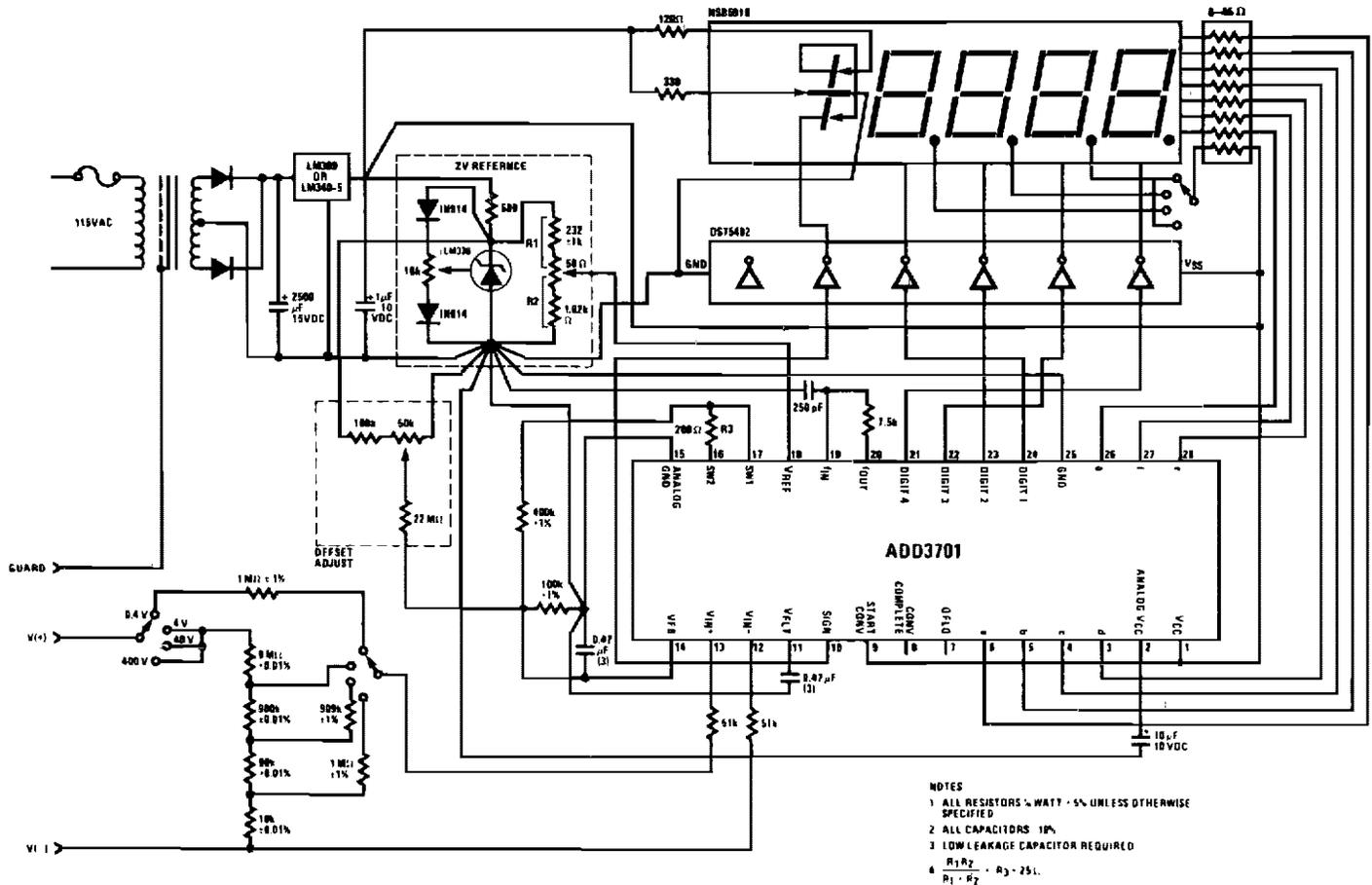
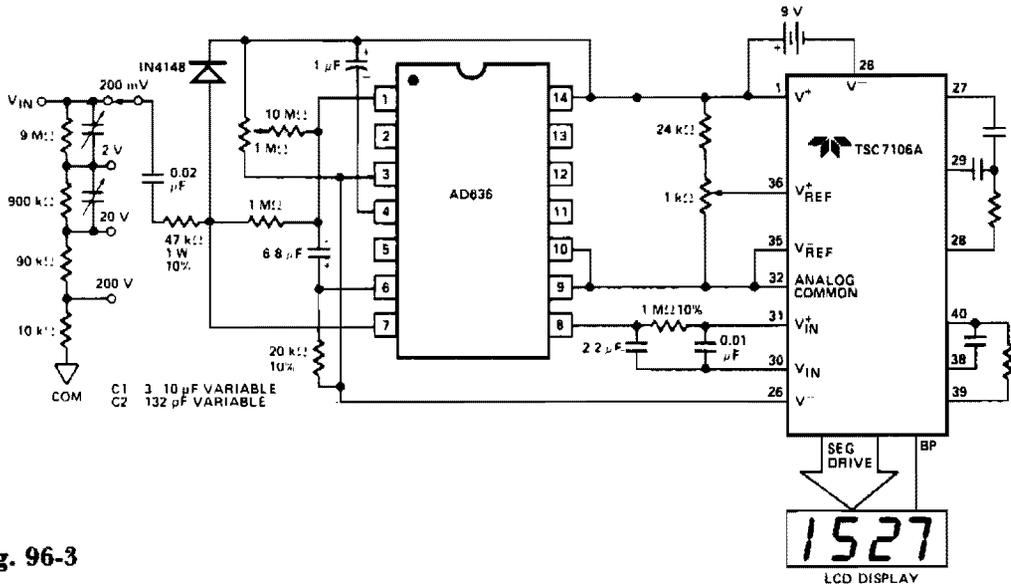
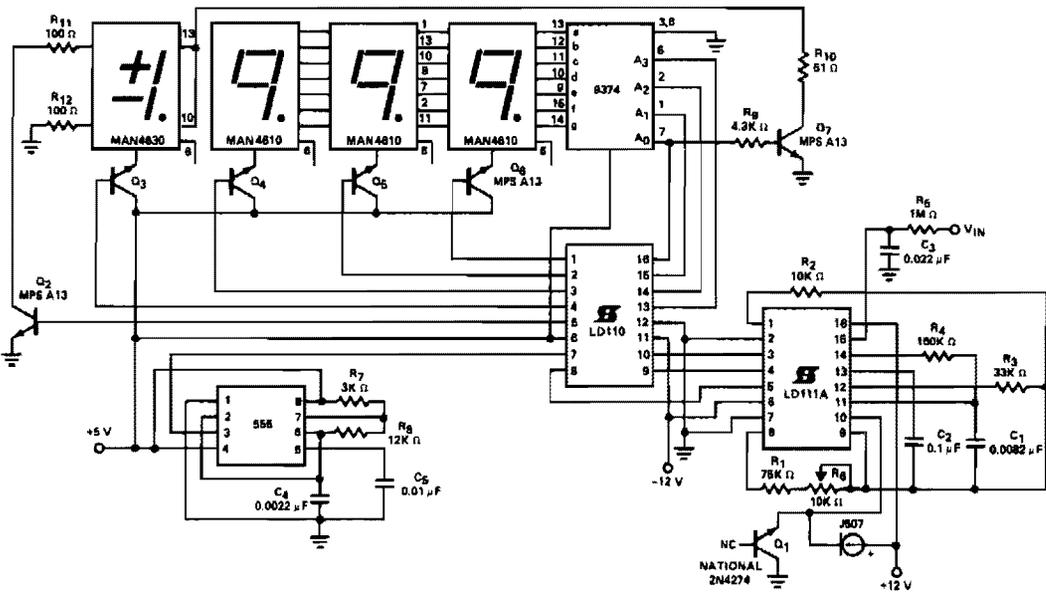


Fig. 96-1

3-1/2 DIGIT TRUE RMS AC VOLTMETER



3-1/2 DIGIT DVM (± 200.0 mV) COMMON ANODE DISPLAY



EXTENDED RANGE VU METER (BAR MODE)

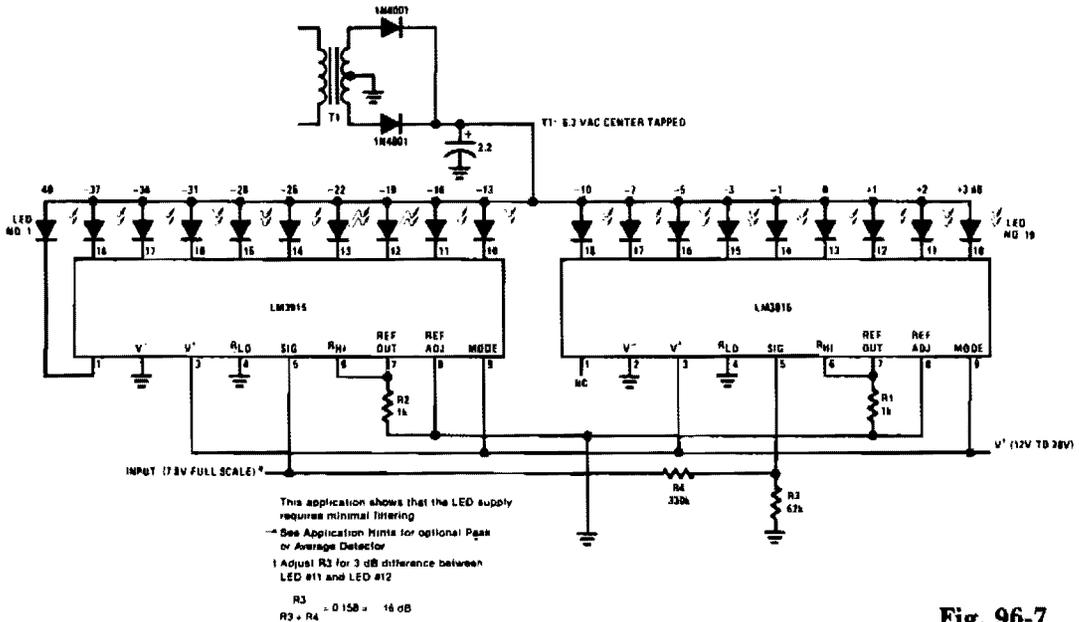


Fig. 96-7

HIGH INPUT IMPEDANCE MILLIVOLTMETER

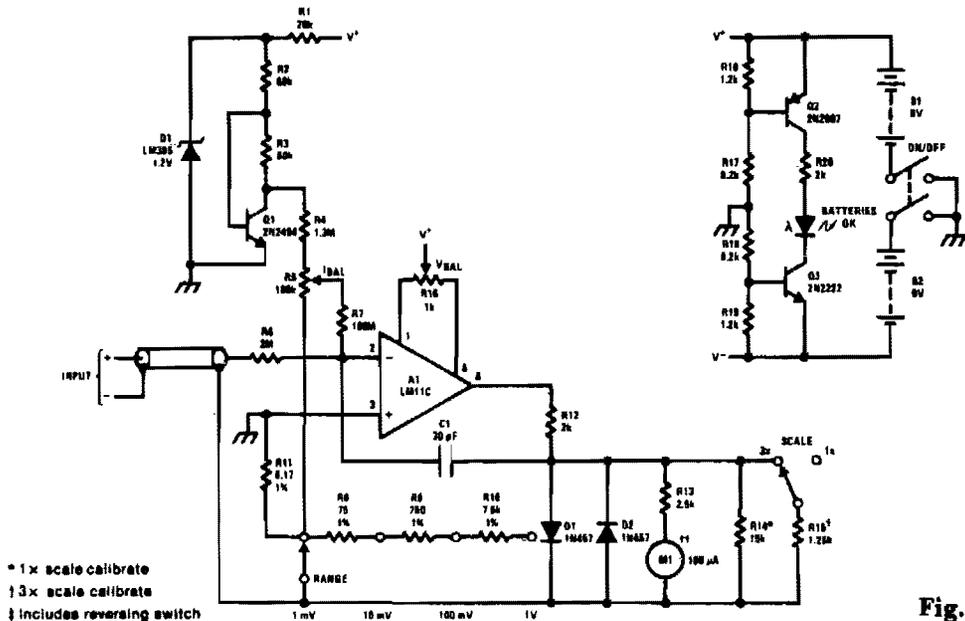
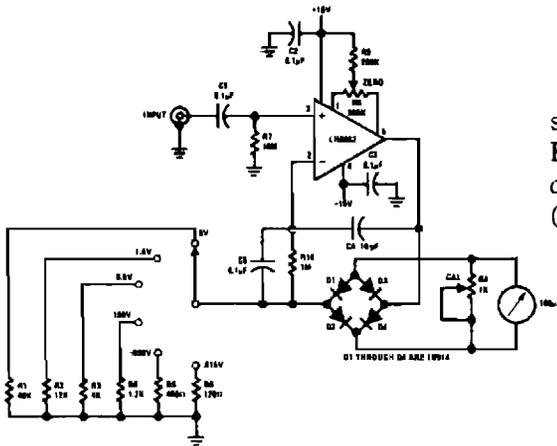


Fig. 96-8

WIDE BAND AC VOLTMETER



Circuit Notes

This voltmeter is capable of measuring ac signals as low as 15 mV at frequencies from 100 Hz to 500 kHz. Full scale sensitivity may be changed by altering the values R1 through R6 ($R = V_{IN}/100 \mu A$).

Fig. 96-9

SUPPRESSED ZERO METER

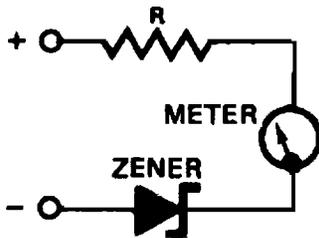


Fig. 96-10

Circuit Notes

A zener diode placed in series with a voltmeter will prevent the meter from reading until the applied voltage exceeds the zener voltage. Thus, a 10 volt zener in series with a 5-volt meter will allow the condition of a 12 V car battery to be monitored with much greater sensitivity than would be possible with a meter reading 0-15 volts.

AC MILLIVOLTMETER

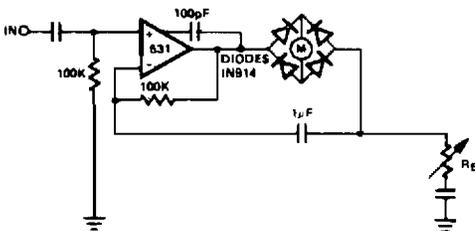


Fig. 96-11

97

Waveform and Function Generators

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Cost Adjustable Function Generator
DAC Controlled Function Generator
Programmed Function Generator
100-kHz Quadrature Oscillator
Strobe-Tone Burst Generator
Low Cost High Frequency Generator
Tone-Burst Oscillator and Decoder
Triangle and Square Waveform Generator
10 kHz Oscillator
50 kHz Oscillator
Variable Audio Oscillator, 20 Hz to 20 kHz

Gated Oscillator
Exponential Digitally-Controlled Oscillator
Function Generator
Clock Source
Precision Oscillator with 20 ns Switching
Oscillator with Quadrature Output
Wide Range Variable Oscillator
Frequency Divider and Staircase Generator
Precision Oscillator to Switch 100 mA
Loads

LOW COST ADJUSTABLE FUNCTION GENERATOR

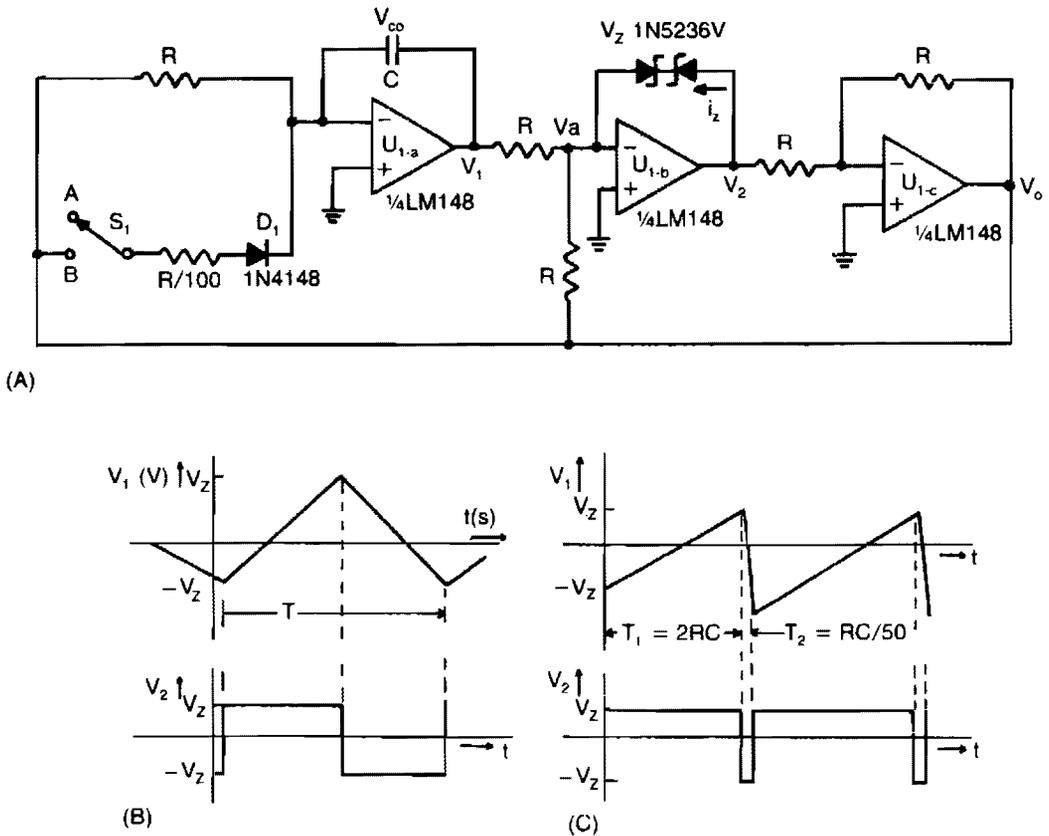


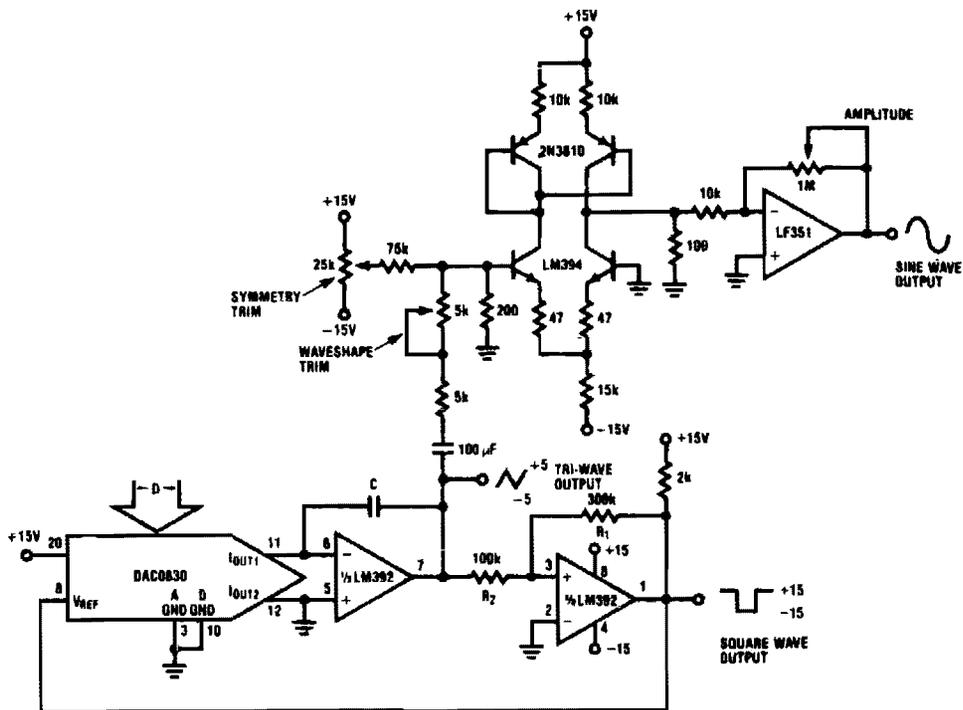
Fig. 97-1

Circuit Notes

This low-cost operational-amplifier circuit (A) generates four different functions with adjustable periods. For the components shown here, the period of the output waveforms is given by $T = 4RC$ and $T = 2RC$. With switch S_1

in position A, V_1 is a triangular waveform, while V_2 is a square wave (B). With the switch in position B, a sawtooth waveform is generated at V_1 and a pulse at V_2 (C).

DAC CONTROLLED FUNCTION GENERATOR



- DAC controls the frequency of sine, square, and triangle outputs.
- $f = \frac{D}{256(20k)C}$ for $V_{OMAX} = V_{OMIN}$ of square wave output and $R_1 = 3R_2$
- 255 to 1 linear frequency range; oscillator stops with $D = 0$
- Trim symmetry and wave-shape for minimum sine wave distortion.

Fig. 97-2

PROGRAMMED FUNCTION GENERATOR

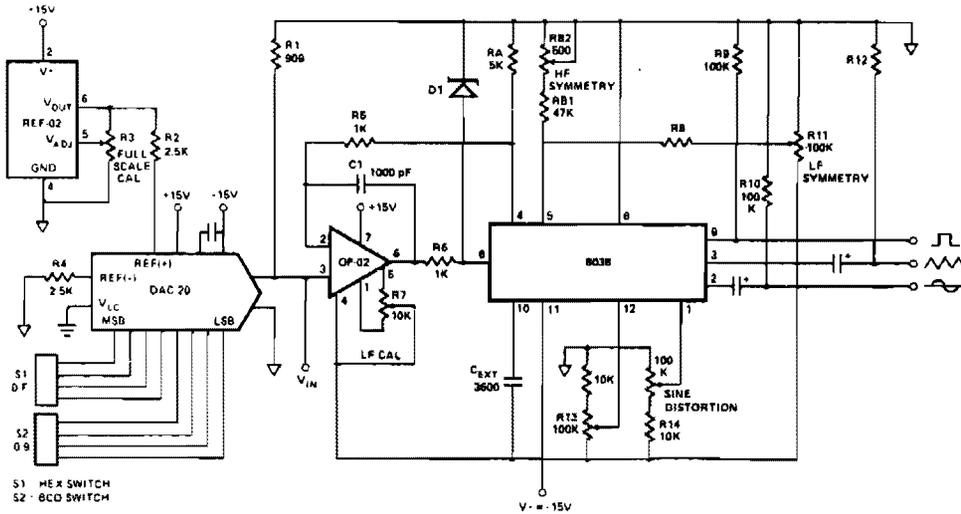


Fig. 97-3

100-kHz QUADRATURE OSCILLATOR

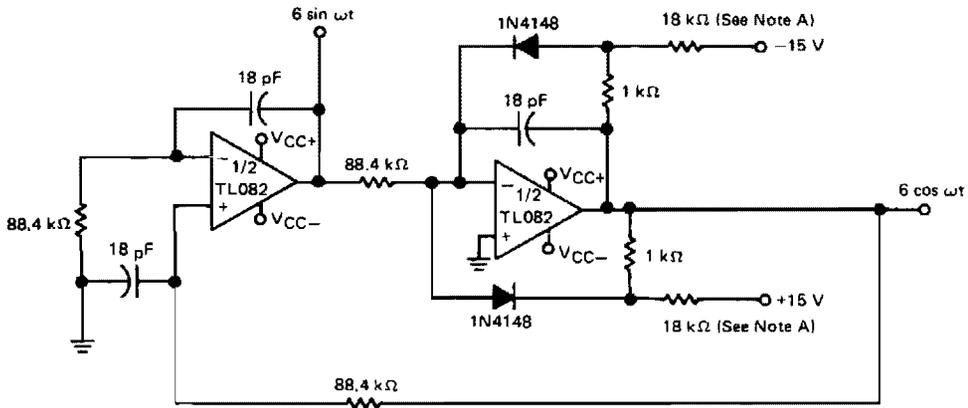
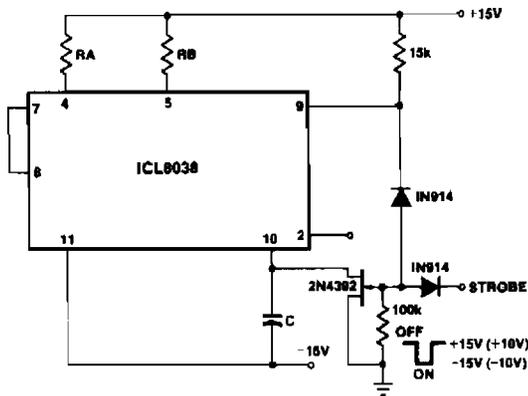


Fig. 97-4

STROBE-TONE BURST GENERATOR



Circuit Notes

With a dual supply voltage, the external capacitor on pin 10 can be shorted to ground to halt the 8038 oscillation. The circuit uses a FET switch and diode ANDed with an input strobe signal to allow the output to always start on the same slope.

Fig. 97-5

LOW COST HIGH FREQUENCY GENERATOR

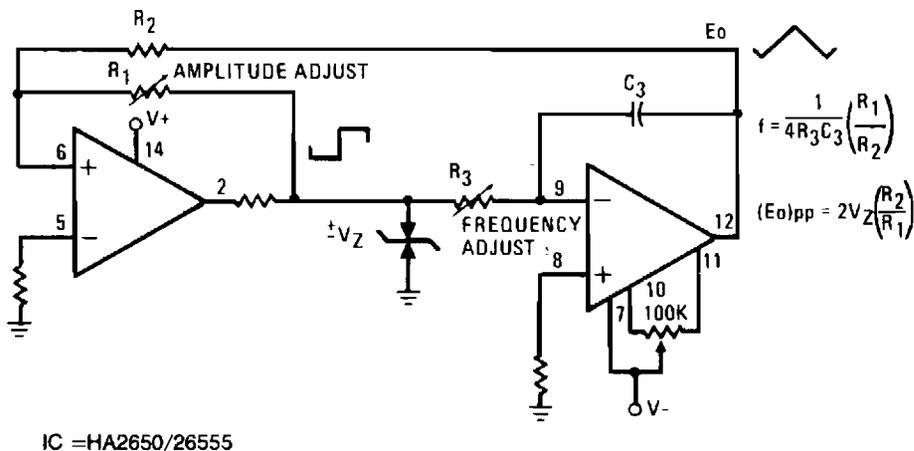


Fig. 97-6

TONE-BURST OSCILLATOR AND DECODER

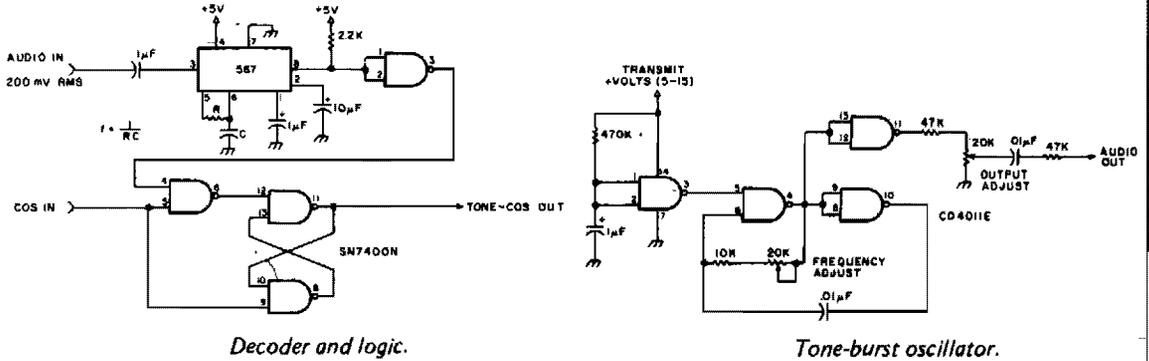


Fig. 97-7

Circuit Notes

A tone burst sent at the beginning of each transmission is decoded (at receiver) by a PLL causing output from pin 3 of logic gate to turn on carrier-operated switch (COS).

TRIANGLE AND SQUARE WAVEFORM GENERATOR

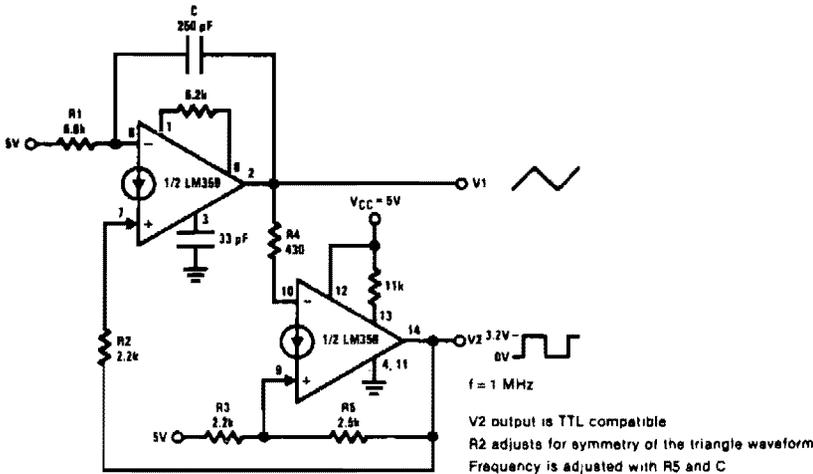
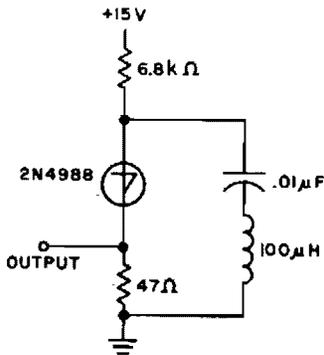


Fig. 97-8

10 kHz OSCILLATOR



Circuit Notes

The capacitor charges until switching voltage is reached. When SUS switches on, the inductor causes current to ring. When the current thru SUS drops below the holding current, the device turns off and the cycle repeats.

Fig. 97-9

50 kHz OSCILLATOR

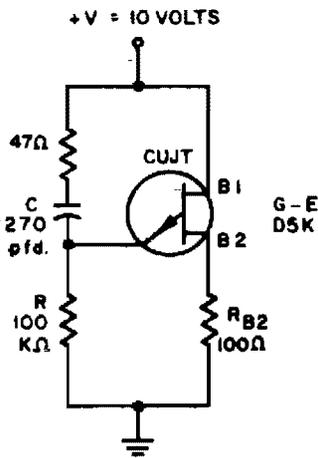


Fig. 97-10

Circuit Notes

A 50 kHz circuit is possible because of the more nearly ideal characteristics of the D5K.

VARIABLE AUDIO OSCILLATOR, 20 Hz TO 20 kHz

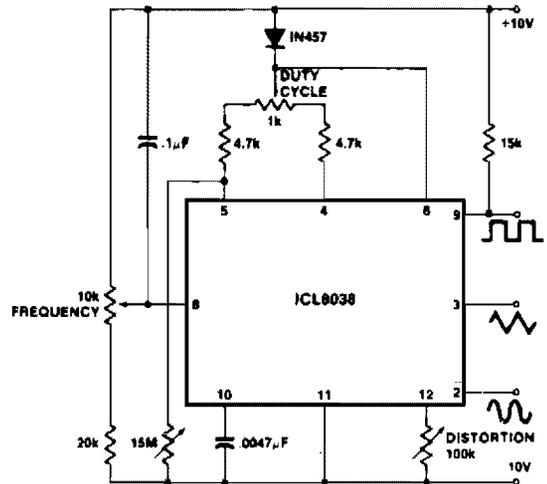


Fig. 97-11

Circuit Notes

To obtain a 1000:1 Sweep Range, the voltage across external resistors R_A and R_B must decrease to nearly zero. This requires that the highest voltage on control pin 8 exceed the voltage at the top of R_A and R_B by a few hundred millivolts. The circuit achieves this by using a diode to lower the effective supply voltage on the 8038. The large resistor on pin 5 helps reduce duty cycle variations with sweep.

GATED OSCILLATOR

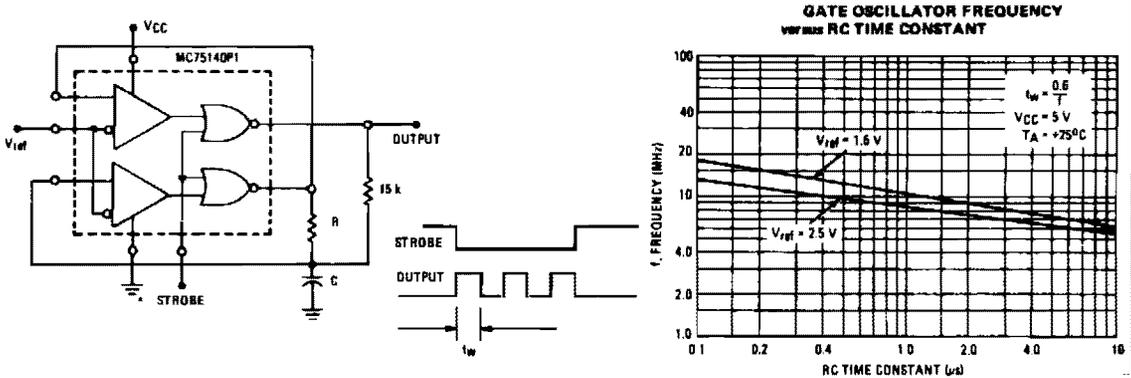


Fig. 97-12

EXPONENTIAL DIGITALLY-CONTROLLED OSCILLATOR

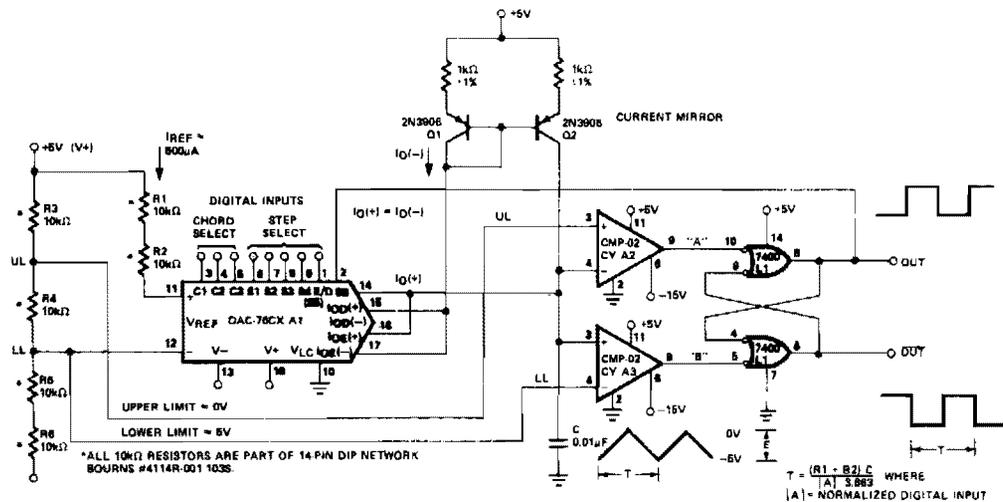


Fig. 97-13

Circuit Notes

The microprocessor-controlled oscillator has a 8159 to 1 frequency range covering 2.5 Hz to 20 kHz. An exponential, current output IC DAC functioning as a programmable current source alternately charges and discharges a

capacitor between precisely-controlled upper and lower limits. The circuit features instantaneous frequency change, operates with $\pm 5 \pm 1\text{ V}$ and $-15\text{ V} \pm 3\text{ V}$ supplies, and has the dynamic range of a 13-bit DAC.

FUNCTION GENERATOR

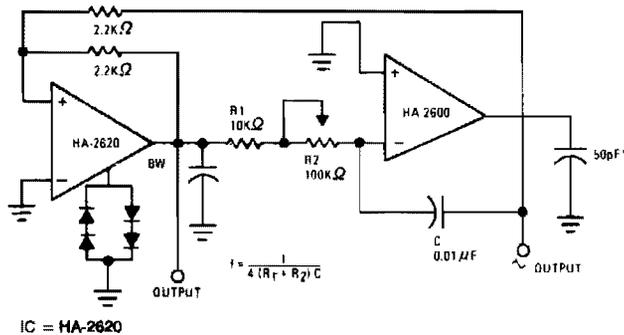
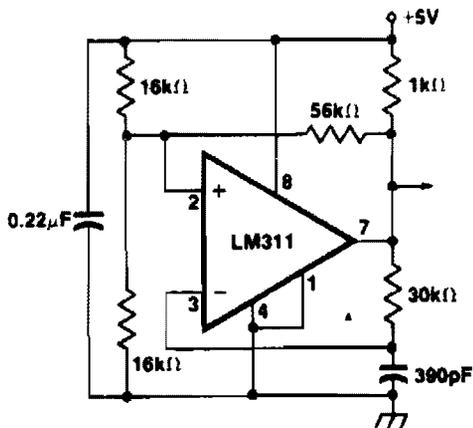


Fig. 97-14

CLOCK SOURCE



Circuit Notes

A clock source using LM311 voltage comparator in positive feedback mode to minimize clock frequency shift problem.

Fig. 97-15

PRECISION OSCILLATOR WITH 20 NS SWITCHING

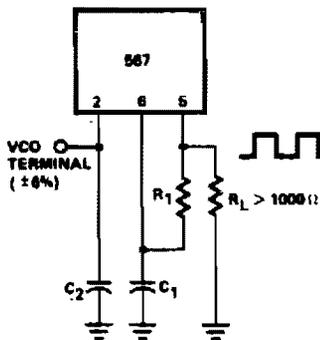


Fig. 97-16

OSCILLATOR WITH QUADRATURE OUTPUT

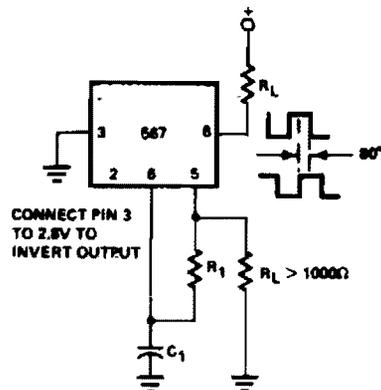


Fig. 97-17

WIDE RANGE VARIABLE OSCILLATOR

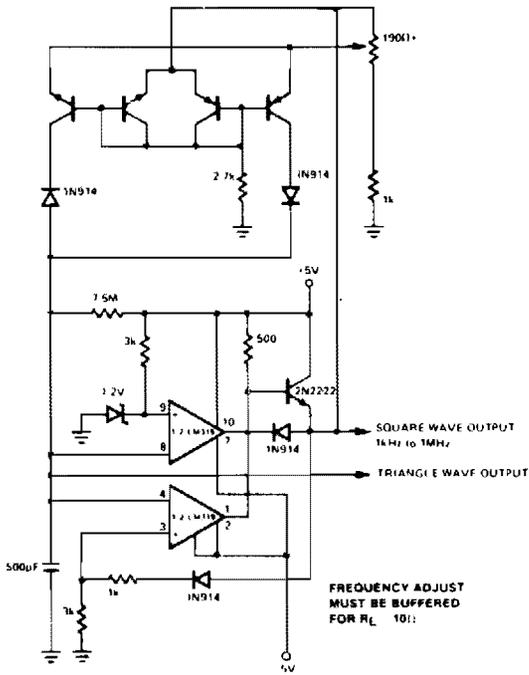
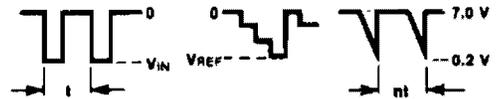
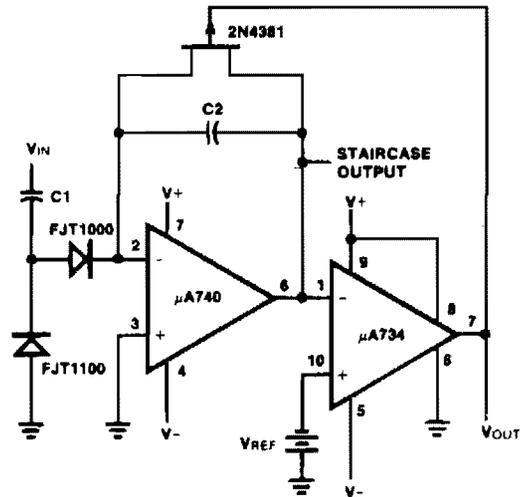


Fig. 97-18

FREQUENCY DIVIDER AND STAIRCASE GENERATOR



$$|V_{REF}| = 2V_D + N \left[3.5T + 2V_D - \frac{C_1 V_{IN}}{C_2} \right]$$

T in Seconds

V_D for FJT 1000 \approx 0.31 V

Fig. 97-19

PRECISION OSCILLATOR TO SWITCH 100 mA LOADS

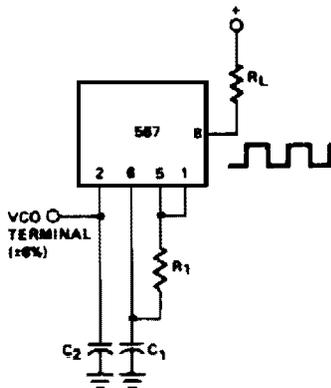


Fig. 97-20

98

Zero Crossing Detectors

The sources of the following circuits are contained in the Sources section beginning on page 730. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Zero Crossing Switch

Zero Crossing Detector with Temperature
Sensor

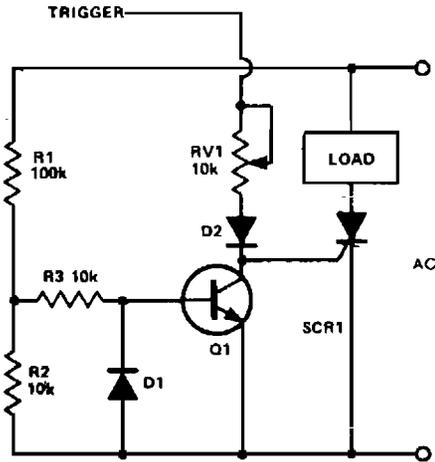
Zero Crossing Detector

Zero Crossing Detector

Zero Crossing Detector

Zero Crossing Detector

ZERO CROSSING SWITCH



Q1=GENERAL PURPOSE GERMANIUM
D1,2=GENERAL PURPOSE SILICON
SCR1=TO SUIT APPLICATION

Fig. 98-1

Circuit Notes

When switching loads with the aid of a thyristor, a large amount of RFI can be generated unless some form of zero crossing switch is used. The circuit shows a simple single transistor zero crossing switch. R1 and R2 act as a potential divider. The potential at their junction is about 10% of the ac voltage. This voltage level is fed, via R3, to the transistor's base. If the voltage at this point is above 0.2, the transistor will conduct, shunting any thyristor gate current to ground. When the line potential is less than about 2 V, it is possible to trigger the thyristor. The diode D1 is to remove any negative potential that might cause reverse breakdown.

ZERO CROSSING DETECTOR

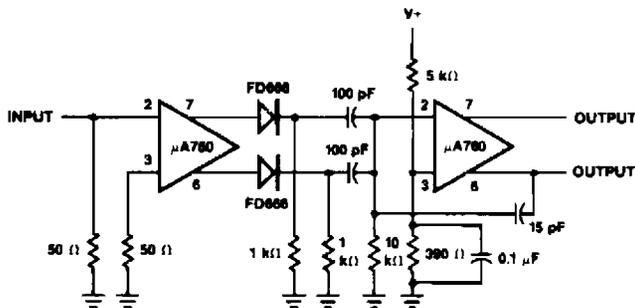


Fig. 98-2

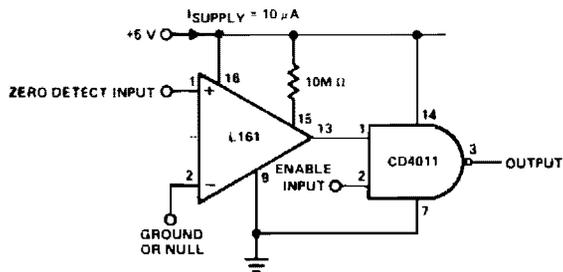
Total Delay = 30 ns

Input frequency = 300 Hz to 3 MHz

Minimum input voltage = 20 mVpk-pk

ZERO CROSSING DETECTOR

Circuit Notes



This detector is useful in sine wave squaring circuits and A/D converters. The positive input may either be grounded or connected to a nulling voltage which cancels input offsets and enables accuracy to within microvolts of ground. The CMOS output will switch to within a few millivolts of either rail for an input voltage change of less than $200 \mu V$.

Fig. 98-3

ZERO CROSSING DETECTOR WITH TEMPERATURE SENSOR

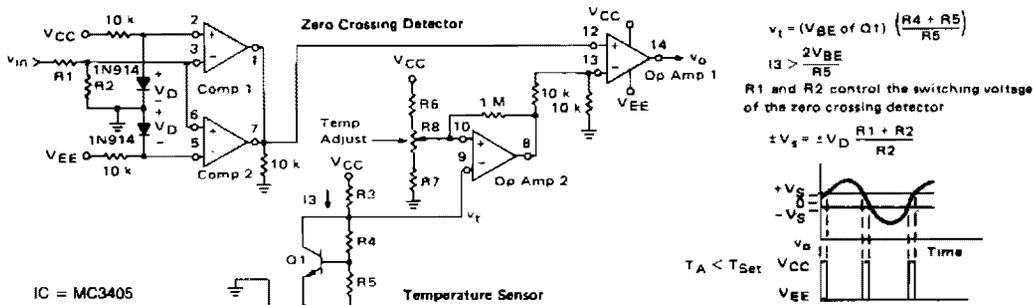
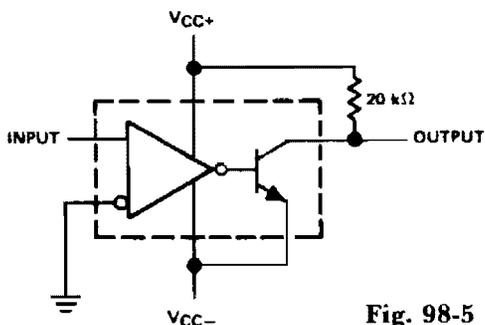
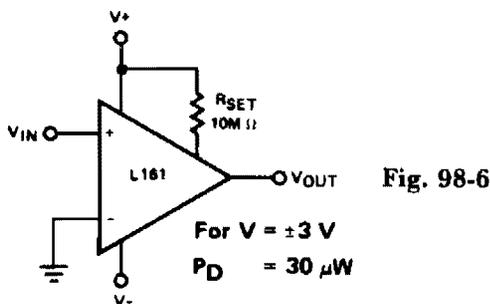


Fig. 98-4

ZERO-CROSSING DETECTOR



ZERO CROSSING DETECTOR



Sources

Chapter 1

- Fig. 1-1: *The Build-It Book Of Electronics Projects*, TAB Book No. 1498, p. 73.
- Fig. 1-2: *QST*, 7/81, p. 28.
- Fig. 1-3: *Radio Electronics*, 10/78, p. 41.
- Fig. 1-4: *'73 Magazine*, 10/77, p. 122.
- Fig. 1-5: *Modern Electronics*, 2/78, p. 50.
- Fig. 1-6: *Electronics Today International*, 3/82, p. 69.
- Fig. 1-7: *Modern Electronics*, 7/78, p. 51.
- Fig. 1-8: *Electronics Today International*, 4/83, p. 72.
- Fig. 1-9: *101 Electronic Projects*, 1977, #64.
- Fig. 1-10: *Electronics Today International*, 10/78, p. 94.
- Fig. 1-11: *Modern Electronics*, 2/78, p. 55.
- Fig. 1-12: *Modern Electronics*, 2/78, p. 48.
- Fig. 1-13: *Signetics 555 Timers*, 1973, p. 26.
- Fig. 1-14: *Electronics Today International*, 3/83, p. 23.
- Fig. 1-15: *Electronics Today International*, 3/83, p. 23.
- Fig. 1-16: *National Semiconductor, Linear Databook*, 1982, p. 3-288.
- Fig. 1-17: *Electronics Today International*, 3/83, p. 23.
- Fig. 1-18: *Signetics 555 Timers*, 1973, p. 22.
- Fig. 1-19: *101 Electronic Projects*, 1977, #65.
- Fig. 1-20: *Modern Electronics*, 6/78, p. 58.
- Fig. 1-21: *Modern Electronics*, 6/78, p. 55.

Chapter 2

- Fig. 2-1: *Modern Electronics*, 3/78, p. 69.

- Fig. 2-2: *Electronics Today International*, 10/78, p., 30.
- Fig. 2-3: *CQ*, 5/77, p. 50.
- Fig. 2-4: *Ham Radio*, 10/78, p. 34.
- Fig. 2-5: *Ham Radio*, 10/78, p. 89.
- Fig. 2-6: *73 Magazine*, 7/78, p. 62.
- Fig. 2-7: *101 Electronic Projects*, 1975, p. 22.
- Fig. 2-8: *73 Magazine*, 7/82, p. 46.
- Fig. 2-9: *73 Magazine*, 7/83, p. 103.
- Fig. 2-10: *101 Electronic Projects*, 1975, p. 13.
- Fig. 2-11: *Ham Radio*, 5/78, p. 87.
- Fig. 2-12: *73 Magazine*, p. 164.
- Fig. 2-13: *Modern Electronics*, 2/78, p. 16.
- Fig. 2-14: *73 Magazine*, 10/77, p. 52.
- Fig. 2-15: *73 Magazine*, 7/77, p. 34.
- Fig. 2-16: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 120.
- Fig. 2-17: *Ham Radio*, 10/70, p. 76.
- Fig. 2-18: *Electronics Today International*, 7/77, p. 72.

Chapter 3

- Fig. 3-1: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 4-119.
- Fig. 3-2: *Signetics Analog Data Manual*, 1982, p. 3-83.
- Fig. 3-3: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 11-207.
- Fig. 3-4: *Signetics Analog Data Manual*, 1983, p. 10-99.
- Fig. 3-5: *Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 3-107.
- Fig. 3-6: *Reprinted with the permission of National Semiconductor Corp. Transistor Databook*, 1982, p. 11-29.
- Fig. 3-7: *Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook*, 1980, p. 2-67.
- Fig. 3-8: *Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 7-7.
- Fig. 3-9: *Electronics Today International*, 2/82, p. 58.
- Fig. 3-10: *Signetics Analog Data Manual*, 1983, p. 10-100.
- Fig. 3-11: *Precision Monolithics Incorporated 1981 Full Line Catalog*, p. 12-50.
- Fig. 3-12: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 9-17.
- Fig. 3-13: *Signetics Analog Data Manual*, 1977, p. 35.
- Fig. 3-14: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 5-39.
- Fig. 3-15: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 6-10.
- Fig. 3-16: *Courtesy of Motorola Inc. Motorola Semiconductor Library, Volume 6, Series B*, p. 8-21.
- Fig. 3-17: *Signetics Analog Data Manual*, 1983, p. 17-17.
- Fig. 3-18: *Intersil Data Book*, 5/83, p. 5-36.
- Fig. 3-19: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 3-17.
- Fig. 3-20: *Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 1-83.
- Fig. 3-21: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 16-160.
- Fig. 3-22: *Signetics Analog Data Manual*, 1982, p. 3-103.
- Fig. 3-23: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 6-127.
- Fig. 3-24: *Courtesy of Motorola Inc., Linear Integrated Circuits*, 1979, p. 3-83.
- Fig. 3-25: *Courtesy of Motorola Inc.*

Linear Integrated Circuits, 1979, p. 3-131.

Fig. 3-26: *Harris Semiconductor, Analog Data Book* 1984.

Fig. 3-27: *Intersil Data Book*, 5/83, p. 5-36.

Fig. 3-28: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 16-37.

Fig. 3-29: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 3-31.

Fig. 3-30: *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-21.

Fig. 3-31: *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-15.

Fig. 3-32: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 16-37.

Fig. 3-33: *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 7-56.

Fig. 3-34: *Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook*, 1982, p. 4-119.

Fig. 3-35: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 4-42.

Fig. 3-36: *Courtesy of Motorola Inc., Linear Integrated Circuits*, p. 3-17.

Fig. 3-37: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 6-23.

Fig. 3-38: *Courtesy of Texas Instruments Incorporated. Linear Control Circuits Data Book, Second Edition*, p. 145.

Fig. 3-39: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 3-83.

Fig. 3-40: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 4-41.

Fig. 3-41: *Canadian Projects Number 1, Spring/78*, p. 29.

Fig. 3-42: *Reprinted with the permission of National Semiconductor Corp. Application Note AN125*, p. 2.

Fig. 3-43: *Harris Semiconductor, Linear & Data Acquisition Products*, p. 2-58.

Fig. 3-44: *Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook* 1982, p. 4-98.

Fig. 3-45: *Reprinted with the permission of National Semiconductor Corp. Application Note AN125*, p. 3.

Chapter 4

Fig. 4-1: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 7-8.

Fig. 4-2: *Intersil Data Book*, 5/83, p. 4-83.

Fig. 4-3: *Ferranti, Technical Handbook Vol. 10, Data Converters*, 1983, p. 7-10.

Fig. 4-4: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 16-12.

Fig. 4-5: *Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook*, 1982, p. 10-241.

Fig. 4-6: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 8-13.

Fig. 4-7: *Reprinted with the permission of National Semiconductor Corp. National Semiconductor CMOS Databook*, 1981, p. 3-63.

Fig. 4-8: *Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook*, 1982, p. 10-240.

Fig. 4-9: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 7-39.

Fig. 4-10: *Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook*, 1982, p. 10-50.

Fig. 4-11: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 5-32.

Fig. 4-12: *Precision Monolithics Incorporated 1981 Full Line Catalog*, p. 8-13.

Chapter 5

Fig. 5-1: *Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 3-22.

Fig. 5-2: *Reprinted with the permission of National Semiconductor Corp. Transistor Databook*, 1982, p. 11-29.

Fig. 5-3: *Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 8-64.

Fig. 5-4: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 12-39.

Chapter 6

Fig. 6-1: *Electronics Today International*, 3/82, p. 66.

Fig. 6-2: *101 Electronic Projects*, 1977, IC 23.

Fig. 6-3: *Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook*, 1980, p. 2-66.

Fig. 6-4: *Electronics Today International*, 10/79, p. 93.

Fig. 6-5: *No reference.*

Fig. 6-6: *No reference.*

Fig. 6-7: *Electronics Today International*, 3/75, p. 66.

Fig. 6-8: *Electronics Today International*, 3/78, p. 52.

Fig. 6-9: *Electronics Today International*, 5/78, p. 85.

Fig. 6-10: *Modern Electronics*, 7/78, p. 58.

Chapter 7

Fig. 7-1: *Courtesy of Fairchild Camera & Instrument Corporation. Fairchild Semiconductor Application Note* 300.

Fig. 7-2: *Ham Radio*, 1/78, p. 78.

Fig. 7-3: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 6-23.

Fig. 7-4: *73 Magazine*, 12/76, p. 97.

Fig. 7-5: *73 Magazine*, 7/77, p. 34.

Fig. 7-6: *Reprinted with the permission of National Semiconductor Corp. Linear Applications Handbook*, 1982, p. AN29-9.

Fig. 7-7: *Reprinted with the permission of National Semiconductor Corp. Linear Applications Handbook*, 1982, P. LB16-1.

Fig. 7-8: *Reprinted with the permission of National Semiconductor Corp. Transistor Databook*, 1982, p. 11-31.

Fig. 7-9: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 10-25.

Fig. 7-10: *How to Design/Build Remote Control Devices TAB Book No. 1277*, p. 230.

Fig. 7-11: *Radio Electronics*, 7/83, p. 7.

Fig. 7-12: *Electronics Today International, Summer* 1982, p. 45.

Fig. 7-13: *73 Magazine*, p. 31.

Fig. 7-14: *Reprinted from Electronics*, 11/83. Copyright 1983, McGraw Hill Inc. All rights reserved.

Fig. 7-15: *Electronics Today International*, 7/72, p. 84.

Fig. 7-16: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 3-42.

Fig. 7-17: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 3-171.

Chapter 8

Fig. 8-1: *Courtesy of Fairchild Camera & Instrument Corporation, Fairchild Progress*, 11-12/76, p. 26.

Fig. 8-2: *Courtesy of Fairchild Camera & Instrument Corporation. Fairchild Progress*, 5-6/77, p. 22.

Fig. 8-3: *Reprinted with the permission*

of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-44.
Fig. 8-4: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-14.
Fig. 8-5: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-14.
Fig. 8-6: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 7-23.
Fig. 8-7: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-51.
Application Note AN125, p. 7.
Fig. 8-8: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-51.
Application Note AN125, p. 6.
Fig. 8-9: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-171.
Fig. 8-10: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-63.
Fig. 8-11: No reference.
Fig. 8-12: *Electronics Today International*, 3/78, p. 81.
Fig. 8-13: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Volume 6, Series B*, p. 8-21.
Fig. 8-14: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Volume 6, Series B*, p. 8-21.
Fig. 8-15: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Volume 6, Series B*, p. 8-21.
Fig. 8-16: Reprinted with the permission of National Semiconductor Corp. *National Semiconductor Application Note AN125*, p. 7.
Fig. 8-17: Reprinted with the permission of National Semiconductor Corp. *Application Note AN69*, p. 4.
Fig. 8-18: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-25.
Fig. 8-19: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 5-17.
Fig. 8-20: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-170.
Fig. 8-21: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-170.
Fig. 8-22: Reprinted with permission of National Semiconductor, Corp. *Application Note AN69*, p. 4.
Fig. 8-23: Courtesy of Fairchild Cam-

era & Instrument Corporation. *Linear Databook*, 1982, p. 4-89.

Fig. 8-24: Reprinted with permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-203.

Chapter 9

Fig. 9-1: *Canadian Projects Number 1, Spring/78*, p. 27.

Fig. 9-2: No reference.

Fig. 9-3: *Electronics Today International*, 4/79, p. 18.

Fig. 9-4: Reprinted with permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-389.

Fig. 9-5: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-29.

Fig. 9-6: Reprinted with permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-91.

Fig. 9-7: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-45.

Fig. 9-8: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-43.

Fig. 9-9: Reprinted with permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-28.

Fig. 9-10: *Signetics Analog Data Manual*, 1982, p. 4-8.

Fig. 9-11: *Signetics Analog Data Manual*, 1982, p. 15-6.

Fig. 9-12: *Signetics Analog Data Manual*, 1977, p. 466.

Fig. 9-13: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-27.

Fig. 9-14: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-32.

Fig. 9-15: *Signetics Analog Data Manual*, 1982, p. 15-6.

Fig. 9-16: *Signetics Analog Data Manual*, 1977, p. 466.

Fig. 9-17: Reprinted with permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-88.

Fig. 9-18: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-20.

Fig. 9-19: Reprinted with permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-21.

Fig. 9-20: *Signetics Analog Data Manual*, 1977, p. 466.

Fig. 9-21: *Signetics Analog Data Manual*, 1983, p. 10-92.

Fig. 9-22: *Signetics Analog Data Manual*, 1982, p. 15-6.

Chapter 10

Fig. 10-1: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. AN162-10.

Fig. 10-2: *Electronics Today International*, 6/79, p. 75.

Fig. 10-3: *Signetics 555 Timers*, 1973, p. 24.

Fig. 10-4: *Electronics Today International*, 12/75, p. 72.

Fig. 10-5: *Electronics Today International*, 2/75, p. 51.

Fig. 10-6: *Electronics Today International*, 7/81, p. 22.

Fig. 10-7: *Electronics Today International*, 7/77, p. 32.

Fig. 10-8: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. LB33-1.

Fig. 10-9: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-141.

Fig. 10-10: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 3-138.

Fig. 10-11: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 7-31.

Fig. 10-12: *73 Magazine*, 7/77, p. 34.

Fig. 10-13: *Modern Electronics*, 2/78, p. 56.

Fig. 10-14: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-140.

Fig. 10-15: *The Build-It Book of Electronic Projects*, TAB Book No. 1498, p. 80.

Fig. 10-16: *73 Magazine*, 1/82, p. 41.

Fig. 10-17: *Electronics Today International*, 10/77, p. 47.

Fig. 10-18: *Modern Electronics*, 9/78, p. 37.

Fig. 10-19: *Electronics Today International*, 10/77, p. 38.

Fig. 10-20: *The Build-It Book of Electronic Projects*, TAB Book No. 1498, p. 111.

Fig. 10-21: *Modern Electronics*, 5/78, p. 7.

Fig. 10-22: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-143.

Fig. 10-23: Reprinted with the permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 207.

Fig. 10-24: No reference.

Chapter 11

Fig. 11-1: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 7-32.

Fig. 11-2: 101 *Electronics Projects*, 1977, p. 97.

Fig. 11-3: Courtesy of Motorola Inc. *Application Note AN-294*, p. 6.

Fig. 11-4: 73 *Magazine*, 2/79, p. 156.

Fig. 11-5: 73 *Magazine*, 7/77.

Fig. 11-6: *Ham Radio*, 12/79, p. 67.

Fig. 11-7: 73 *Magazine*, 2/83, p. 99.

Fig. 11-8: 44 *Electronics Projects For SWLS, CBers & Radio Experimenters*, TAB Book No. 1258, p. 153.

Fig. 11-9: Yuasa Battery (America) Inc. *Application Manual for NP type battery*.

Fig. 11-10: *Electronics Today International*, 11/80.

Fig. 11-11: 73 *Magazine*, 7/77.

Fig. 11-12: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 203.

Fig. 11-14: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-31.

Fig. 11-15: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-141.

Chapter 12

Fig. 12-1: NASA Tech Brief, B73-10249.

Fig. 12-2: *Electronics Today International*, 1/75, p. 66.

Fig. 12-3: *Electronics Australia*, 2/76, p. 91.

Fig. 12-4: 73 *Magazine*, 2/79, p. 78.

Fig. 12-5: *Electronics Today International*, 6/79, p. 103.

Fig. 12-6: *Ham Radio*, 9/82, p. 78.

Fig. 12-7: Courtesy of Texas Instruments Incorporated. *Optoelectronics Databook*, 1983-84, p. 15-5.

Fig. 12-8: 73 *Magazine*, 2/79, p. 78.

Fig. 12-9: © Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-19.

Fig. 12-10: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-109.

Fig. 12-11: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-109.

Chapter 13

Fig. 13-1: *Intersil Data Book*, 5/83, p. 5-238.

Fig. 13-2: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-131.

Fig. 13-3: Precision Monolithics Incorporated, 1981 *Full Line Catalog*, p. 16-160.

Fig. 13-4: Precision Monolithics Incorporated, 1981 *Full Line Catalog*, p. 7-17.

Fig. 13-5: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-31.

Fig. 13-6: Precision Monolithics Incorporated, 1981 *Full Line Catalog*, p. 16-159.

Fig. 13-7: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-324.

Fig. 13-8: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-324.

Fig. 13-9: Precision Monolithics Incorporated, 1981 *Full Line Catalog*, p. 6-35.

Fig. 13-10: Precision Monolithics Incorporated, 1981 *Full Line Catalog*, p. 7-11.

Chapter 14

Fig. 14-1: *Radio - Electronics*, 1/67.

Fig. 14-2: *Modern Electronics*, 2/78, p. 17.

Fig. 14-3: *Electronics Today International*, 5/75, p. 68.

Fig. 14-4: *Electronics Today International*, 4/78, p. 81.

Fig. 14-5: *Modern Electronics*, 6/78, p. 14.

Fig. 14-6: Reprinted with permission from General Electric Semiconductor Department. *General Electric*, 2/68.

Fig. 14-7: *Electronics Today International*, 6/74, p. 67.

Fig. 14-8: *Modern Electronics*, 2/78, p. 16.

Fig. 14-9: © Siliconix incorporated. *T100/T300 Applications*.

Fig. 14-10: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 224.

Fig. 14-11: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-143.

Fig. 14-12: *Electronics Today International*, 6/82, p. 69.

Fig. 14-13: © Siliconix incorporated. *Siliconix Application Note AN154*.

Fig. 14-14: *Wireless World*, 5/78, p. 69.

Fig. 14-15: Reprinted with permission from General Electric Semiconductor Department. *General Electric*, 2/68.

Chapter 15

Fig. 15-1: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. AN146-1.

Fig. 15-2: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-112.

Fig. 15-3: *Supertex Data Book*, 1983, p. 5-23.

Fig. 15-4: *Supertex Data Book*, 1983, p. 5-22.

Fig. 15-5: *How To Design/Build Remote Control Devices*, TAB Book No. 1277, p. 287.

Fig. 15-6: *How To Design/Build Remote Control Devices*, TAB Book No. 1277, p. 289.

Fig. 15-7: *How To Design/Build Remote Control Devices*, TAB Book No. 1277, p. 290.

Fig. 15-8: *How To Design/Build Remote Control Devices*, TAB Book No. 1277, p. 291.

Fig. 15-9: *Signetics Analog Data Manual*, 1982, p. 16-28.

Chapter 16

Fig. 16-1: Reprinted from *Electronics*, 6/78, p. 150. Copyright 1978, McGraw Hill Inc. All rights reserved.

Fig. 16-2: Reprinted from *Electronics*, 5/73, p. 96. Copyright 1973, McGraw Hill Inc. All rights reserved.

Fig. 16-3: 303 *Dynamic Electronic Circuits*, TAB Book No. 1060, p. 290.

Fig. 16-4: 73 *Magazine*, 2/79, p. 79.

Fig. 16-5: *Wireless World*, 12/74, p. 504.

Fig. 16-6: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-123.

Fig. 16-7: *Electronics Today International*, 3/78, p. 51.

Fig. 16-8: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 10-215.

Fig. 16-9: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-17.

Fig. 16-10: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, 1979, p. 7-8.

Fig. 16-11: Courtesy of Motorola Inc. *Linear Interface Circuits*, 1979, p. 7-8.

Fig. 16-12: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-123.

Fig. 16-13: Siliconix Application Note AN73-6, p. 5.

Fig. 16-14: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 8-31.

Fig. 16-15: Precision Monolithics Incorporated 1981 Fall Line Catalog, p. 8-31.

Fig. 16-16: Teledyne Semiconductor, Databook, p. 9.

Fig. 16-17: ©Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 6-4.

Fig. 16-18: Signetics Analog Data Manual, 1982, p. 8-14.

Fig. 16-19: Precision Monolithics Incorporated 1981 Full Line Catalog, p. 8-12.

Fig. 16-20: Signetics Analog Data Manual, 1982, p. 3-38.

Fig. 16-21: Harris Semiconductor, Linear & Data Acquisition Products, p. 2-46.

Fig. 16-22: Harris Semiconductor Application Note 509.

Chapter 17

Fig. 17-1: Reprinted with the permission of National Semiconductor Corp. Linear Applications Handbook, 1982, p. AN240-5.

Fig. 17-2: Electronics Today International, 10/77, p. 45.

Fig. 17-3: ©Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 7-29.

Fig. 17-4: Reprinted with the permission of National Semiconductor Corp. National Semiconductor CMOS Databook, 1981, p. 3-61.

Fig. 17-5: Precision Monolithics Incorporated 1981 Full Line Catalog, p. 16-142.

Fig. 17-6: ™Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 7-29.

Fig. 17-7: Electronics Today International, 10/77, p. 39

Fig. 17-8: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 4-28.

Fig. 17-9: ©Siliconix Incorporated. T100/T300 Applications.

Fig. 17-10: Reprinted with the permission of National Semiconductor Corp. Linear Applications Handbook, 1982, p. AN240-2.

Fig. 17-11: ©Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 7-30.

Fig. 17-12: Signetics Analog Data Manual, 1982, p. 3-71.

Fig. 17-13: Signetics Analog Data Manual, 1982, p. 6-20.

Fig. 17-14: Signetics Analog Data Manual, 1983, p. 10-99.

Fig. 17-15: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 6-27.

Fig. 17-16: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 8-258.

Fig. 17-17: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 3-50.

Fig. 17-18: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 8-258.

Fig. 17-19: ©Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 7-31.

Fig. 17-20: Signetics Analog Data Manual, 1982, p. 3-15.

Fig. 17-21: RCA Corporation, Solid State Division, Digital Integrated Circuits Application Note ICAN-6346, p. 4.

Fig. 17-22: ©Siliconix incorporated. MOSPOWER Design Catalog, 1/83, p. 6-42.

Fig. 17-23: Signetics Analog Data Manual, 1982, p. 8-14.

Fig. 17-24: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 4-56.

Chapter 18

Fig. 18-1: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 5-4.

Fig. 18-2: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 5-5.

Fig. 18-3: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 5-4.

Chapter 19

Fig. 19-1: Courtesy of Motorola Inc. Application Note AN-417B, p. 5.

Fig. 19-2: Courtesy of Motorola Inc. Application Note AN417B, p. 3.

Fig. 19-3: The Complete Handbook of Amplifiers, Oscillators & Multivibrators, TAB Book No. 1230, p. 326.

Fig. 19-4: Electronics Today International, 1/76, p. 46.

Fig. 19-5: Ham Radio, 2/79, p. 40.

Fig. 19-6: Electronics Today International, 8/83, p. 57.

Fig. 19-7: Electronics Today International, 11/76, p. 44.

Fig. 19-8: Ham Radio, 2/79, p. 40.

Fig. 19-9: Ham Radio, 2/79, p. 42.

Fig. 19-10: Ham Radio, 2/79, p. 41.

Fig. 19-11: Ham Radio, 2/79, p. 43.

Fig. 19-12: Ham Radio, 2/79, p. 43.

Fig. 19-13: Ham Radio, 2/79, p. 43.

Fig. 19-14: Ham Radio, 2/79, p. 43.

Fig. 19-15: Ham Radio, 2/79, p. 38.

Fig. 19-16: Ham Radio, 2/79, p. 39.

Fig. 19-17: Ham Radio, 3/82, p. 66.

Fig. 19-18: Electronics Today International, 8/73, p. 82.

Fig. 19-19: The Complete Handbook of Amplifiers, Oscillators & Multivibrators, TAB Book No. 1230, p. 322.

Fig. 19-20: Ham Radio, 4/78, p. 51.

Fig. 19-21: Modern Electronics, 6/78, p. 57.

Fig. 19-22: The Complete Handbook of Amplifiers, Oscillators & Multivibrators, TAB Book No. 1230, p. 336.

Fig. 19-23: 73 Magazine, 8/78, p. 80.

Fig. 19-24: Third Book Of Electronic Projects, TAB Book No. 1446, p. 22.

Fig. 19-25: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 69.

Fig. 19-26: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 64.

Fig. 19-27: Ham Radio, 4/78, p. 50.

Fig. 19-28: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 64.

Fig. 19-29: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-30: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-31: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-32: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-33: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-34: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-35: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-36: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-37: CRYSTAL OSCILLATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

LATOR CIRCUITS, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-33: *Third Book Of Electronic Projects*, TAB Book No. 1446, p. 21.

Fig. 19-34: *Intersil*.

Fig. 19-35: *The Complete Handbook Of Amplifiers, Oscillators & Multivibrators*, Tab Book No. 1230, p. 324.

Fig. 19-36: *CRYSTAL OSCILLATOR CIRCUITS*, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 64.

Fig. 19-37: *The Complete Handbook Of Amplifiers, Oscillators & Multivibrators*, TAB Book No. 1230, p. 325.

Fig. 19-38: *Ham Radio*, 2/79, p. 41.

Fig. 19-40: *The Complete Handbook Of Amplifiers, Oscillators & Multivibrators*, TAB Book No. 1230, p. 330.

Fig. 19-41: *The Complete Handbook Of Amplifiers, Oscillators & Multivibrators*, TAB Book No. 1230, p. 331.

Fig. 19-42: *Ham Radio*, 4/78, p. 50.

Fig. 19-43: *Ham Radio*, 2/79, p. 40.

Fig. 19-44: *73 Magazine*.

Fig. 19-45: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-241.

Fig. 19-46: *Teledyne Semiconductor Databook*, p. 9.

Fig. 19-47: Reprinted with the permission of National Semiconductor Corp. *Application Note 32*, p. 8.

Fig. 19-48: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 7-26.

Fig. 19-49: *Ham Radio*, 2/79, p. 40.

Fig. 19-50: *CRYSTAL OSCILLATOR CIRCUITS*, Robert J. Mathys, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 66.

Chapter 20

Fig. 20-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-123.

Fig. 20-2: *Intersil Data Book*, 5/83, p. 5-289.

Fig. 20-3: Reprinted with the permission of National Semiconductor Corp. *Application Note AN-71*, p. 5.

Fig. 20-4: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook*, Third Edition, p. 305.

Fig. 20-5: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-35.

Chapter 21

Fig. 21-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-123.

Fig. 21-2: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-30.

Fig. 21-3: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-112.

Fig. 21-4: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-30.

Chapter 22

Fig. 22-1: *Electronics Today International*, 9/75, p. 65.

Fig. 22-2: *Signetics Analog Data Manual*, 1982, p. 6-13.

Fig. 22-3: *Electronic Today International*, 8/79, p. 99.

Fig. 22-4: © Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-15.

Fig. 22-5: © Siliconix incorporated. *MOSPOWER Design Catalog*, 1/83, p. 6-41.

Fig. 22-6: *Signetics Analog Data Manual*, 1982, p. 6-21.

Fig. 22-7: *Signetics Analog Data Manual*, 1982, p. 6-21.

Chapter 23

Fig. 23-1: *Ham Radio* 11/78, p. 64.

Fig. 23-2: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 2-5.

Fig. 23-3: *Signetics Analog Data Manual*, 1983, p. 11-15.

Fig. 23-4: *Signetics Analog Data Manual*, 1983, p. 11-10.

Fig. 23-5: *Signetics Analog Data Manual*, 1982, p. 16-28.

Fig. 23-6: *Signetics Analog Manual*, 1982, p. 16-28.

Chapter 24

Fig. 24-1: *Signetics 555 Timers*, 1973, p. 19.

Fig. 24-2: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, 1979, p. 7-30.

Fig. 24-3: *Electronics Today International*, 1/76, p. 45.

Fig. 24-4: *Precision Monolithics Incorporated 1981 Full Line Catalog*, p. 8-33.

Fig. 24-5: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual*, Sixth Edition, 1979, p. 219.

Fig. 24-6: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual*, Sixth Edition, 1979, p. 218.

Fig. 24-7: Courtesy of Motorola Inc. *Application Note AN294*.

Fig. 24-8: *Signetics 555 Timers*, 1973, p. 20.

Chapter 25

Fig. 25-1: *Radio-Electronics*, 2/83, p. 76.

Fig. 25-2: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-98.

Fig. 25-3: *Radio-Electronics*, 12/78, p. 77.

Fig. 25-4: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 14-17.

Fig. 25-5: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 14-17.

Fig. 25-6: *Electronics Today International*, 3/78, p. 50.

Fig. 25-7: RCA Corp., Solid State Division, *Digital Integrated Circuits Application Note ICAN-6346*, p. 5.

Fig. 25-8: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-97.

Fig. 25-9: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 5-25.

Fig. 25-10: Reprinted with the permission of National Semiconductor Corp. *National Semiconductor, Application Note LB-25*.

Fig. 25-11: *Electronics Today International*, 9/72, p. 86.

Fig. 25-12: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 56.

Fig. 25-13: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-180.

Fig. 25-14: © Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-9.

Fig. 25-15: *Signetics Analog Data Manual*, 1983, p. 10-100.

Fig. 25-16: © Siliconix incorporated. *Siliconix Application Note AN73-6*, p. 4.

Fig. 25-17: Signetics Analog Data Manual, 1983, p. 13-6.

Fig. 25-18: Signetics 555 Timers, 1973, p. 17.

Fig. 25-19: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 4-123.

Fig. 25-20: Courtesy of Texas Instruments Incorporated. Linear Control Circuits Data Book, Second Edition, p. 205.

Fig. 25-21: Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 6-14.

Fig. 25-22: Signetics Analog Data Manual, 1983, p. 11-9.

Fig. 25-23: Signetics Analog Data Manual, 1983, p. 11-9.

Fig. 25-24: Signetics Analog Data Manual, 1983, p. 10-100.

Fig. 25-25: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-38.

Fig. 25-26: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 8-12.

Fig. 25-27: Signetics Analog Data Manual, 1977, p. 264.

Fig. 25-28: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-31.

Fig. 25-29: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-38.

Chapter 26

Fig. 26-1: © Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 8-5.

Fig. 26-2: © Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 8-4.

Fig. 26-3: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-10.

Fig. 26-4: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 11-55.

Fig. 26-5: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-10.

Fig. 26-6: Ferranti, Technical Handbook Vol. 10, Data Converters, 1983, p. 1-25.

Fig. 26-7: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 4-50.

Fig. 26-8: © Siliconix incorporated. Siliconix Analog Switch & IC Product Data Book, 1/82, p. 8-5.

Fig. 26-9: Courtesy of Fairchild Camera & Instrument Corporation. Linear

Databook, 1982, p. 7-7.

Fig. 26-10: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 11-55.

Fig. 26-11: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 8-20.

Fig. 26-12: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-17.

Fig. 26-13: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 10-50.

Fig. 26-14: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 11-54.

Fig. 26-15: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-159.

Chapter 27

Fig. 27-1: Ham Radio, 8/81, p. 27.

Fig. 27-2: Ham Radio, 8/81, p. 28.

Fig. 27-3: Ham Radio, 8/81, p. 27.

Fig. 27-4: Ham Radio, 8/81, p. 26.

Fig. 27-5: Ham Radio, 8/81, p. 26.

Fig. 27-6: Ham Radio, 6/77, p. 42.

Fig. 27-7: Ham Radio, 8/81, p. 27.

Chapter 28

Fig. 28-1: Reprinted from Electronics, 12/74, p. 105. Copyright 1974, McGraw Hill Inc. All rights reserved.

Fig. 28-2: Electronics Today International, 10/82, p. 80.

Fig. 28-3: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-188.

Fig. 28-4: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-172.

Fig. 28-5: Courtesy of Motorola Inc. Linear Interface Integrated Circuits, 1979, p. 5-102.

Fig. 28-6: Intersil Data Book, 5/83, p. 6-52.

Fig. 28-7: Reprinted with the permission of National Semiconductor Corp., Linear Databook, 1982, p. 9-171.

Fig. 28-8: Electronics Today International, 3/78, p. 50.

Fig. 28-9: Intersil Data Book, 5/83, p. 6-34.

Chapter 29

Fig. 29-1: Ham Radio, 1/78, p. 94

Fig. 29-2: Reprinted with permission from General Electric Semiconductor Department GE Semiconductor Data Handbook, Third Edition, p. 577.

Fig. 29-3: Reprinted with permission from General Electric Semiconductor

Department GE Semiconductor Data Handbook, Third Edition, p. 577.

Fig. 29-4: Reprinted with permission from General Electric Semiconductor Department GE Semiconductor Data Handbook, Third Edition, p. 573.

Fig. 29-5: Reprinted with permission from General Electric Semiconductor Department GE Semiconductor Data Handbook, Third Edition, p. 183.

Chapter 30

Fig. 30-1: Reprinted with the permission of National Semiconductor Corp. National Semiconductor CMOS Databook, 1981, p. 8-44.

Fig. 30-2: Electronics Today International, 4/79, p. 22.

Fig. 30-3: SGS-ATES Databook COS/MOS B-Series, 2/82, p. 548.

Fig. 30-4: © Siliconix incorporated. MOSPOWER Design Catalog, 1/83, p. 6-60.

Fig. 30-5: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 4-81.

Fig. 30-6: Signetics Analog Data Manual, 1982, p. 8-10.

Fig. 30-7: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 7-19.

Fig. 30-8: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-159.

Fig. 30-9: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-159.

Fig. 30-10: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 7-11.

Fig. 30-11: Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook, 1982, p. 1-21.

Fig. 30-12: Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook, 1982, p. 17-167.

Fig. 30-13: SGS-ATES Databook COS/MOS B-Series, 2/82, p. 548.

Fig. 30-14: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 4-123.

Fig. 30-15: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 4-123.

Fig. 30-16: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-39.

Fig. 30-17: SGS-ATES Databook COS/MOS B-Series, 2/82, p. 548.

Chapter 31

Fig. 31-1: Reprinted with permission from General Electric Semiconductor Department. *Optoelectronics, Second Edition*, p. 113.

Fig. 31-2: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 13-11.

Fig. 31-3: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-153.

Fig. 31-4: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 13-14.

Fig. 31-5: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 13-20.

Fig. 31-6: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 13-20.

Chapter 32

Fig. 32-1: No reference.

Fig. 32-2: No reference.

Fig. 32-3: *Modern Electronics*, 2/78, p. 47.

Fig. 32-4: No reference.

Fig. 32-5: *The Giant Book Of Electronics Projects*, TAB Book No. 1367, p. 480.

Fig. 32-6: *The Giant Book Of Electronics Projects*, TAB Book No. 1367, p. 114.

Fig. 32-7: *The Giant Book Of Electronics Projects*, TAB Book No. 1367, p. 114

Fig. 32-8: 73 Magazine.

Chapter 33

Fig. 33-1: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-58.

Fig. 33-2: *Intersil Data Book*, 5/83, p. 3-135.

Fig. 33-3: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-114.

Fig. 33-4: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-50.

Fig. 33-5: *Electronics*, 9/76, p. 100.

Fig. 33-6: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-117.

Fig. 33-7: Reprinted from *Electronics*, 12/78, p. 124. Copyright 1978, Mc-

Graw Hill Inc. All rights reserved.

Fig. 33-8: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, 17-132.

Fig. 33-9: Reprinted with the permission of National Semiconductor Corp. *Application Note LB-5*, p. 1.

Fig. 33-10: *Electronics Today International*, 11/74, p. 67.

Fig. 33-11: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-180.

Fig. 33-12: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-179.

Fig. 33-13: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-41.

Fig. 33-14: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-119.

Fig. 33-15: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-177.

Fig. 33-16: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-178.

Fig. 33-17: 73 Magazine, 4/79, p. 42.

Fig. 33-18: 303 Dynamic Electronic Circuits, TAB Book No. 1060, p. 289.

Fig. 33-19: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-15.

Fig. 33-20: *Signetics Analog Data Manual*, 1982, p. 3-77.

Fig. 33-21: Harris Semiconductor. *Linear & Data Acquisition Products*, p. 2-85.

Fig. 33-22: © Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 6-9.

Fig. 33-23: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 4-104.

Fig. 33-24: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-23.

Fig. 33-25: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-116.

Fig. 33-26: *Signetics Analog Data Manual*, 1982, p. 4-8.

Fig. 33-27: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-115.

Fig. 33-28: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-116.

Fig. 33-29: Harris Semiconductor, *Linear & Data Acquisition Products*, p. 2-84.

Fig. 33-30: Courtesy of Motorola Inc. *Motorola Semiconductor Library Vol. 6, Series B*, p. 3-126.

Fig. 33-31: *Ham Radio*, 2/78, p. 72.

Fig. 33-32: *Signetics Analog Data Manual*, p. 401.

Fig. 33-33: *Signetics Analog Data Manual*, p. 75.

Fig. 33-34: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-58.

Fig. 33-35: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 4-97.

Fig. 33-36: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-157.

Fig. 33-37: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 7-11.

Fig. 33-38: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-158.

Fig. 33-39: 73 Magazine, 1/79, p. 127.

Fig. 33-40: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 3-131.

Fig. 33-41: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-59.

Fig. 33-42: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-56.

Fig. 33-43: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 2-58.

Chapter 34

Fig. 34-1: Reprinted with permission from General Electric Semiconductor Department. *GE Application Note* 201.10.

Fig. 34-2: *Electronics Today International*, 4/75, p. 42.

Fig. 34-3: © Siliconix incorporated, *Application Note AN154*.

Fig. 34-4: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-289.

Fig. 34-5: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Second Edition*, p. 905.

Fig. 34-6: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Third Edition*, p. 573.

Fig. 34-7: *Radio-Electronics*, 5/79, p. 84.

Fig. 34-8: 49 Easy To Build Electronic Projects, TAB Book No. 1337, p. 22.
Fig. 34-9: 49 Easy To Build Electronic Projects, TAB Book No. 1337, p. 98.
Fig. 34-10: Electronics Today International, 12/74, p. 66.

Fig. 34-11: No reference.

Fig. 34-12: Electronics Today International, 5-75, p. 67.

Fig. 34-13: Reprinted with permission from General Electric Semiconductor Department. General Electric SCR Manual, Sixth Edition, 1979, p. 205.

Fig. 34-14: Reprinted with permission from General Electric Semiconductor Department. General Electric SCR Manual, Sixth Edition, 1979, p. 207.

Fig. 34-15: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 12-14.

Fig. 34-16: © Siliconix incorporated, Application Note AN154.

Fig. 34-17: © Siliconix incorporated, Application Note AN154.

Fig. 34-18: © Siliconix incorporated, Application Note AN154.

Fig. 34-19: © Siliconix incorporated, Application Note AN154.

Fig. 34-20: © Siliconix incorporated, Application Note AN154.

Fig. 34-21: © Siliconix incorporated, Application Note AN154.

Fig. 34-22: © Siliconix incorporated, Application Note AN154.

Fig. 34-23: © Siliconix incorporated, Application Note AN154.

Fig. 34-24: © Siliconix incorporated, Application Note AN154.

Fig. 34-25: © Siliconix incorporated, Application Note AN154.

Fig. 34-26: © Siliconix incorporated, Application Note AN154.

Chapter 35

Fig. 35-1: Intersil Data Book, 5/83, p. 6-49.

Fig. 35-2: The Giant Book Of Electronic Projects, TAB Book No. 1367, p. 109.

Fig. 35-3: 73 Magazine, 6/83, p. 106.

Fig. 35-4: 104 Weekend Electronic Projects, TAB Book No. 1436, p. 166.

Chapter 36

Fig. 36-1: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 10-110.

Fig. 36-2: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 5-9.

Fig. 36-3: Courtesy of Motorola Inc.

Linear Integrated Circuits, 1979, p. 6-99.

Fig. 36-4: Courtesy of Motorola Inc. Linear Integrated Circuits, p. 6-99.

Fig. 36-5: Signetics Analog Data Manual, 1982, p. 16-29.

Chapter 37

Fig. 37-1: Teledyne Semiconductor Publication DG-114-87, p. 7.

Fig. 37-2: © Siliconix incorporated, Analog Switch & IC Product Data Book, 1/82, p. 7-30.

Fig. 37-3: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-140.

Fig. 37-4: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 8-257.

Fig. 37-5: Reprinted with permission of Analog Devices, Inc. Data Acquisition Databook, 1982, p. 12-20.

Fig. 37-6: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-143.

Fig. 37-7: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 8-257.

Chapter 38

Fig. 38-1: Electronics Today International, 1/77, p. 83.

Fig. 38-2: 101 Electronic Projects, 1975, #32.

Fig. 38-3: Electronics Today International, 10/76, p. 66.

Fig. 38-4: Electronics Today International, 4/75, p. 67.

Fig. 38-5: Canadian Project Number 1, Spring 78, p. 55.

Fig. 38-6: Electronics Today International, 11/76, p. 44.

Chapter 39

Fig. 39-1: Modern Electronics, 2/78, p. 49.

Fig. 39-2: Electronics Today International, 10/78, p. 103.

Fig. 39-3: Radio-Electronics, 3/78, p. 76.

Fig. 39-4: Popular Mechanics, 5/78, p. 45.

Fig. 39-5: 303 Dynamic Electronic Circuits, TAB Book No. 1060, p. 36.

Fig. 39-6: Electronics Today International, 9/82, p. 70.

Fig. 39-7: Electronics Today International, 4/78, p. 77.

Fig. 39-8: 73 Magazine.

Fig. 39-9: No reference

Fig. 39-10: Electronics Today International, 2/77, p. 73.

Chapter 40

Fig. 40-1: Reprinted with permission of Control Engineering, 1301 S. Grove Ave. Barrington, Illinois 12/73, p. 43.

Fig. 40-2: Courtesy of Motorola Inc. Communications Engineering Bulletin EB-33.

Fig. 40-3: Courtesy of Motorola Inc. Communications Engineering Bulletin EB-33.

Chapter 41

Fig. 41-1: Courtesy of Texas Instruments Incorporated. Optoelectronics Databook, 1983-84, p. 15-12.

Fig. 41-2: 73 Magazine, 7/77, p. 35.

Fig. 41-3: Electronics Today International, 6/76, p. 40.

Fig. 41-4: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-172.

Fig. 41-5: Courtesy of Texas Instruments Incorporated. Optoelectronics Databook, 1983-84, p. 15-11.

Fig. 41-6: Signetics Analog Data Manual, 1982, p. 8-14.

Fig. 41-7: © Siliconix incorporated, Analog Switch & IC Product Data Book, 1/82, p. 6-14.

Fig. 41-8: 73 Magazine.

Fig. 41-9: Reprinted from Electronics, 3/73, p. 119. Copyright 1973, McGraw Hill Inc. All rights reserved.

Chapter 42

Fig. 42-1: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-127.

Fig. 42-2: Supertex Data Book, 1983, p. 5-20.

Fig. 42-3: Plessey Semiconductors, Linear IC Handbook, 5/82, p. 86.

Fig. 42-4: Plessey Semiconductors, Linear IC Handbook, 5/82, p. 91.

Fig. 42-5: Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook, 1982, p. 1-74.

Fig. 42-6: Electronics Today International, 6/82, p. 70.

Chapter 43

Fig. 43-1: Harris Semiconductor, Linear & Data Acquisition Products, 1977, p. 2-85.

Fig. 43-2: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-77.

Fig. 43-3: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 4-178.

Fig. 43-4: Courtesy of Fairchild Cam-

era & Instrument Corporation. *Linear Databook*, 1982, p. 4-43.

Fig. 43-5: Reprinted with the permission of National Semiconductor Corp. *Application Note 32*, p. 5.

Fig. 43-6: Reprinted with the permission of National Semiconductor Corp. *Application Note LB1*, p. 2.

Fig. 43-7: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 120.

Fig. 43-8: ©Siliconix incorporated. *T100/T300 Applications*.

Fig. 43-9: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 4-27.

Fig. 43-10: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. AN242-15.

Fig. 43-11: Signetics Analog Data Manual, 1982, p. 3-71.

Fig. 43-12: ©Siliconix incorporated. *Application Note, AN73-6*, p. 3.

Fig. 43-13: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 3-7.

Fig. 43-14: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-102.

Fig. 43-15: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 3-82.

Fig. 43-16: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-171.

Fig. 43-17: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 122.

Fig. 43-18: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 7-11.

Fig. 43-19: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 7-6.

Fig. 43-20: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-159.

Fig. 43-21: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 4-56.

Fig. 43-22: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 4-92.

Fig. 43-23: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-50.

Fig. 43-24: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-37.

Fig. 43-25: Signetics Analog Data Manual, 1982, p. 3-15.

Chapter 44

Fig. 44-1: Courtesy of Texas Instruments Incorporated. *Optoelectronics Databook*, 1983, p. 15-13.

Fig. 44-2: CQ, 3/78, p. 72.

Fig. 44-3: Signetics Analog Data Manual, 1982, p. 3-76.

Fig. 44-4: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 207.

Fig. 44-5: Reprinted with permission from General Electric Semiconductor Department. *General Electric Newsletter*, Vol. 11, No. 1, p. 5.

Fig. 44-6: Reprinted with permission from General Electric Semiconductor Department. *Optoelectronics, Second Edition*, p. 112.

Fig. 44-7: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-42.

Fig. 44-8: *Electronics Today International*, 5/77, p. 77.

Fig. 44-9: Reprinted from *Computers & Electronics. Copyright Ziff-Davis Publishing Company*, 4/83, p. 109.

Fig. 44-10: *The Build-It Book Of Electronic Projects*, TAB Book No. 1498, p. 42.

Fig. 44-11: Copyright by Computer Design. All rights reserved. Reprinted by permission, 1/83, p. 77.

Fig. 44-12: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 440.

Fig. 44-13: Copyright by Computer Design. All rights reserved. Reprinted by permission, 1/83, p. 77.

Fig. 44-14: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Third Edition*, p. 1371-4.

Fig. 44-15: Precision Monolithics Incorporated, *Linear & Conversion IC Products*, 7/78, p. 7-12.

Fig. 44-16: *Electronic Projects*, 1977, p. 82.

Fig. 44-17: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-109.

Fig. 44-18: Reprinted with permission from General Electric Semiconductor Department. *Optoelectronics, Second Edition*, p. 111

Fig. 44-19: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-88.

Chapter 45

Fig. 45-1: RCA Corporation, *RCA Solid-State Devices Manual*, 1975, p. 734.

Fig. 45-2: Reprinted with permission from General Electric Semiconductor Department. *GE Project H5*, p. 157.

Fig. 45-3: *Solid State Products, New Design Idea*, No. 5.

Fig. 45-4: Reprinted from *Electronics*, 12/74, p. 111. Copyright 1974, McGraw Hill Inc. All rights reserved.

Fig. 45-5: *Electronics Today International*, 12/72, p. 86.

Fig. 45-6: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Second Edition*, p. 585.

Fig. 45-7: *101 Electronic Projects*, 1975.

Fig. 45-8: Courtesy of Motorola Inc. *Motorola Semiconductor Products. Circuit Applications for the Triac (AN-466)*, p. 12.

Fig. 45-9: Courtesy of Motorola Inc. *Motorola Semiconductor Products Circuit Applications for the Triac (AN-466)*, p. 5.

Fig. 45-10: *Electronics Today International*, 7/75, p. 41.

Fig. 45-11: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual Sixth Edition*, 1979, p. 264.

Fig. 45-12: Courtesy of Motorola Inc. *Motorola Semiconductor Products Circuit Applications for the Triac (AN-466)*, p. 6.

Fig. 45-13: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 443.

Fig. 45-14: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual Sixth Edition*, 1979, p. 114.

Fig. 45-15: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Third Edition*, p. 64.

Fig. 45-16: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Second Edition*, p. 727.

Fig. 45-17: *Solid State Products, New Design Idea*, No. 9.

Fig. 45-18: Reprinted with the permis-

sion of National Semiconductor Corp. Transistor Databook, 1982, p. 7-35.
Fig. 45-19: Reprinted with permission from General Electric Semiconductor Department. GE Semiconductor Data Handbook, Second Edition, p. 727.
Fig. 45-20: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 3-111.
Fig. 45-21: SGS-ATES Databook COS/MOS B-Series, 2/82, p. 548.

Chapter 46

Fig. 46-1: Machine Design, 9/80, p. 126.
Fig. 46-2: Machine Design, 9/80, p. 127.
Fig. 46-3: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-191.
Fig. 46-4: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 3-91.
Fig. 46-5: Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook, 1982, p. 1-89.
Fig. 46-6: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 13-50.

Chapter 47

Fig. 47-1: NASA Tech Briefs, Spring 1983, p. 249.
Fig. 47-2: Courtesy of Texas Instruments Incorporated. Optoelectronics Databook, 1983-84, p. 15-9.
Fig. 47-3: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-93.
Fig. 47-4: Reprinted with permission from General Electric Semiconductor Department. General Electric SCR Manual, Sixth Edition, 1979, p. 226.
Fig. 47-5: Modern Electronics, 7/78, p. 55.
Fig. 47-6: Electronics Today International, 8/74, p. 66.
Fig. 47-7: Reprinted with permission from General Electric Semiconductor Department. GE Semiconductor Application Note, 200.35, p. 14.
Fig. 47-8: Modern Electronics, 3/78, p. 68.
Fig. 47-9: Modern Electronics, 7/78, p. 55.
Fig. 47-10: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-93.

Chapter 48

Fig. 48-1: Reprinted with permission from General Electric Semiconductor Department. General Electric SCR Manual, Sixth Edition, 1979, p. 438.
Fig. 48-2: Electronics Today International, 1/78, p. 83.
Fig. 48-3: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-29.
Fig. 48-4: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-138.
Fig. 48-5: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-46.
Fig. 48-6: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-48.
Fig. 48-7: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 8-32.
Fig. 48-8: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-139.
Fig. 48-9: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-46.

Chapter 49

Fig. 49-1: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-49.
Fig. 49-2: Reprinted with the permission of National Semiconductor Corp. National Semiconductor CMOS Databook, 1981, p. 8-124.
Fig. 49-3: Intersil Data Book, 1978.
Fig. 49-4: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 3-86.
Fig. 49-5: Radio-Electronics, 10/77, p. 72.
Fig. 49-6: Electronics Today International, 8/78, p. 91.
Fig. 49-7: Third Book Of Electronic Projects, TAB Book No. 1446, p. 40.
Fig. 49-8: Electronics Today International, 8/73, p. 82.
Fig. 49-9: 303 Dynamic Electronic Circuits, TAB Book No. 1060, p. 153.
Fig. 49-10: Electronics Today International, 10/78, p. 97.
Fig. 49-11: Radio-Electronics, 1/80, p. 68.
Fig. 49-12: Signetics Analog Data Manual, 1983, p. 9-40.
Fig. 49-13: Signetics Analog Data Manual, 1983, p. 9-38.
Fig. 49-14: Reprinted with the permission of National Semiconductor Corp.

Linear Databook, 1982, p. 9-187.
Fig. 49-15: Electronics Today International, 1/76, p. 47.
Fig. 49-16: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-140.
Fig. 49-17: Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook, 1982, p. 5-25.
Fig. 49-18: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-8.
Fig. 49-19: Electronics Today International, 7/75, p. 40.

Chapter 50

Fig. 50-1: Reprinted from Electronics, 12/77, p. 78. Copyright 1978, McGraw Hill Inc. All rights reserved.
Fig. 50-2: 101 Electronic Projects, 1977, p. 48.

Chapter 51

Fig. 51-1: ETI Canada, 7/78, p. 46.
Fig. 51-2: The Build-It Book Of Electronic Projects, TAB Book No. 1498, p. 131.
Fig. 51-3: Modern Electronics, 3/78, p. 7.

Chapter 52

Fig. 52-1: Reprinted with the permission of National Semiconductor Corp. Application Note AN69, p. 6.
Fig. 52-2: Courtesy of Texas Instruments Incorporated. Complex Sound Generator, Bulletin No. DL-S 12612, p. 13.
Fig. 52-3: ©Siliconix incorporated. MOSPOWER Design Catalog, 1/83, p. 6-60.
Fig. 52-4: Signetics Analog Data Manual, 1983, p. 10-99.
Fig. 52-5: Signetics Analog Data Manual, 1983, p. 10-99.
Fig. 52-6: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-157.
Fig. 52-7: ©Siliconix incorporated. MOSPOWER Design Catalog, 1/83, p. 6-42.
Fig. 52-8: Reprinted with permission from General Electric Semiconductor Department. GE Semiconductor Data Handbook. Second Edition, p. 727.
Fig. 52-9: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 4-37.
Fig. 52-10: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-139.
Fig. 52-11: Electronics Today International, 6/82, p. 64.

Fig. 52-12: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 3-139.

Fig. 52-13: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-163.

Fig. 52-14: ©Siliconix incorporated. *Application Note AN154*.

Fig. 52-15: Signetics Analog Data Manual, 1982, p. 3-50.

Fig. 52-16: Signetics Analog Data Manual, 1983, p. 10-20.

Fig. 52-17: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-10.

Fig. 52-18: FERRANTI, *Technical Handbook*, Vol. 10, *Data Converters*, 1983, p. 7-26.

Fig. 52-19: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-60.

Fig. 52-20: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 4-56.

Fig. 52-21: Signetics Analog Data Manual, 1982, p. 4-8.

Fig. 52-22: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 5-38.

Chapter 53

Fig. 53-1: ©Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 4-24.

Fig. 53-2: ©Siliconix incorporated. *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 4-23.

Fig. 53-3: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-99.

Fig. 53-4: Teledyne Semiconductor, *Data & Design Manual*, 1981, p. 11-178.

Fig. 53-5: Courtesy of Motorola Inc. *Motorola Semiconductor Library*, Vol. 6, Series B, p. 8-58.

Fig. 53-6: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 4-26.

Fig. 53-7: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-34.

Chapter 54

Fig. 54-1: *Modern Electronics*, 3/78, p. 6.

Fig. 54-2: 101 Electronic Projects, 1977, p. 25.

Fig. 54-3: 101 Electronic Projects, 1975, p. 53.

Chapter 55

Fig. 55-1: Courtesy of Motorola Inc. *Application Note AN-829*.

Fig. 55-2: *Radio-Electronics*, 8/78, p. 41.

Fig. 55-3: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 288.

Fig. 55-4: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-137.

Fig. 55-5: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-122.

Fig. 55-6: 44 *Electronics Projects for Hams, SWLs, CBers, & Radio Experimenters*, TAB Book No. 1258, p. 133.

Fig. 55-7: Signetics 555 Timers, 1973, p. 23.

Fig. 55-8: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 3-17.

Fig. 55-9: *Electronics Australia*, 4/78, p. 51.

Fig. 55-10: Signetics Analog Data Manual, 1983, p. 11-9.

Fig. 55-11: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 288.

Fig. 55-12: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-98.

Fig. 55-13: *Electronics Today International*, 8/83, p. 57.

Fig. 55-14: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-81.

Fig. 55-15: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-16.

Fig. 55-16: *The Giant Book Of Electronics Projects*, TAB Book No. 1367.

Chapter 56

Fig. 56-1: *Electronics Today International*, 4/78, p. 63.

Fig. 56-2: *Modern Electronics*, 5/78, p. 6.

Fig. 56-3: *Electronics Today International*, 8/78, p. 61.

Fig. 56-4: *Electronics Today International*, 12/78, p. 93.

Chapter 57

Fig. 57-1: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-201.

Fig. 57-2: Reprinted with permission from General Electric Semiconductor Department. *Project H13*, p. 191.

Fig. 57-3: Courtesy of Motorola Inc. *Circuit Applications for the Triac*, AN-466, p. 7.

Fig. 57-4: Courtesy of Motorola Inc. AN-443.

Fig. 57-5: Courtesy of Motorola Inc. AN-198.

Fig. 57-6: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Third Edition*, p. 573.

Fig. 57-7: *Intersil Data Book*, 5/83, p. 5-261.

Fig. 57-8: 101 *Electronic Projects*, 1977, p. 98.

Fig. 57-9: Reprinted with permission from General Electric Semiconductor Department. *GE Application Note* 201.7.

Fig. 57-10: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, p. 5-145.

Fig. 57-11: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-167.

Fig. 57-12: 101 *Electronic Projects*, 1975, p. 55.

Fig. 57-13: *Electronics Today International*, 6/75.

Fig. 57-14: *RCA Solid State Devices Manual*, 1975, p. 501.

Fig. 57-15: *Modern Electronics*, 6/78, p. 56.

Fig. 57-16: Reprinted with permission from General Electric Semiconductor Department. *GE Project H16*, p. 203.

Fig. 57-17: *Electronics Today International*, 4/75, p. 65.

Fig. 57-18: Courtesy of Motorola Inc. AN-443.

Fig. 57-19: Reprinted with the permission of National Semiconductor Corp. *Application Note AN125*, p. 9.

Fig. 57-20: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-114.

Fig. 57-21: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook, Third Edition*, p. 964.

Fig. 57-22: 101 *Electronic Projects*, 1977, p. 93.

Fig. 57-23: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 4-114.

Chapter 58

Fig. 58-1: Courtesy of Texas Instru-

ments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 285.

Fig. 58-2: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 286.

Fig. 58-3: RCA Corporation, Solid State Division, *Digital Integrated Circuits Application Note, ICAN-6346*, p. 5.

Fig. 58-4: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-154.

Fig. 58-5: Courtesy of Motorola Inc. *Linear Integrated Circuits*, p. 6-136.

Fig. 58-6: Courtesy of Motorola Inc. *Application Note, AN294*.

Fig. 58-7: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook, 1982*, p. 5-47.

Fig. 58-8: Signetics 555 Timers, 1973, p. 22.

Fig. 58-9: Signetics Analog Data Manual, 1983, p. 15-6.

Fig. 58-10: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 8-32.

Fig. 58-11: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook, 1982*, p. 5-46.

Fig. 58-12: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook, 1982*, p. 5-46.

Fig. 58-13: Reprinted with the permission of National Semiconductor Corp. *Linear Databook, 1982*, p. 5-7.

Chapter 59

Fig. 59-1: *Electronics Today International, 4/76*, p. 23.

Fig. 59-2: *Popular Electronics, 4/75*, p. 87.

Fig. 59-3: *Electronics Today International, 4/78*, p. 30.

Fig. 59-4: *Popular Electronics, 12/76*, p. 28.

Fig. 59-5: *The Radio Hobbyist's Handbook, TAB Book No. 1346*, p. 256.

Chapter 60

Fig. 60-1: Reprinted from *Electronics, 7/72*, p. 77. Copyright 1972, McGraw Hill Inc. All rights reserved.

Fig. 60-2: Reprinted from *Electronics, 10/73*, p. 125. Copyright 1973, McGraw Hill Inc. All rights reserved.

Fig. 60-3: *73 Magazine, 12/76*, p. 170.

Fig. 60-4: *Electronics Today International, 1978*.

Fig. 60-6: *CQ, 11/83*, p. 72.

Fig. 60-7: *Electronics Today International, 7/77*, p. 77.

Chapter 61

Fig. 61-1: *Machine Design, 7/75*, p. 39.

Fig. 61-2: *Electronics Today International, 4/73*, p. 89.

Fig. 61-3: *Signetics Analog Data Manual, 1982*, p. 16-28.

Fig. 61-4: *Teledyne Semiconductor Data & Design Manual, 1981*, p. 11-207.

Fig. 61-5: ©Siliconix Incorporated, *Analog Switch & IC Product Data Book, 1/82*, p. 6-4.

Fig. 61-6: Reprinted with the permission of National Semiconductor Corp. *Application Note 32*, p. 8.

Chapter 62

Fig. 62-1: *Electronics Today International, 4/82*, p. 39.

Fig. 62-2: *Western Digital, Components Handbook, 1983*, p. 577.

Fig. 62-3: *Modern Electronics, 2/78*, p. 72.

Fig. 62-4: *Canadian Projects Number 1, Spring 1978*, p. 78.

Fig. 62-5: *101 Electronic Projects, 1977*, p. 49.

Fig. 62-6: *Electronics Today International, 10/74*, p. 67.

Fig. 62-8: *44 Electronics Projects For The Darkroom, TAB Book No. 1248*, p. 282.

Fig. 62-9: *44 Electronics Projects For The Darkroom, TAB Book No. 1248*, p. 284.

Fig. 62-10: *Signetics 555 Timers, 1973*, p. 23.

Chapter 63

Fig. 63-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook, 1982*, p. 9-205.

Fig. 63-2: Reprinted with the permission of National Semiconductor Corp. *Linear Databook, 1982*, p. 9-191.

Fig. 63-3: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 374.

Fig. 63-4: Reprinted with the permission of National Semiconductor Corp. *Application Note 222*.

Fig. 63-5: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Vol. 6, Series B*, p. 8-58.

Chapter 64

Fig. 64-1: ©Siliconix Incorporated, *MOSPOWER Design Catalog, 1/83*, p. 6-71.

Fig. 64-2: Ferranti Semiconductors,

Technical Handbook, Volume 10, Data Converters, 1983, p. 3-12.

Fig. 64-3: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 5-144.

Fig. 64-4: *Intersil Data Book, 5/83*, p. 5-201.

Fig. 64-5: *Signetics 555 Timers, 1973*, p. 27.

Fig. 64-6: *Signetics Analog Data Manual, 1982*, p. 6-21.

Fig. 64-7: *Signetics Analog Data Manual, 1983*, p. 12-36.

Fig. 64-8: *Signetics Analog Data Manual, 1983*, p. 12-26.

Fig. 64-9: *Signetics Analog Data Manual, 1983*, p. 12-22.

Fig. 64-10: *Electronics Today International, 7/75*, p. 39.

Fig. 64-11: Courtesy of Motorola Inc. *Circuit Applications for the Triac, AN-466*, p. 12.

Fig. 64-13: *Electronics Today International, 3/75*, p. 67.

Fig. 64-14: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-50.

Fig. 64-15: *73 Magazine, 3/77*, p. 152.

Fig. 64-16: *Intersil Data Book, 5/83*, p. 5-77.

Fig. 64-17: *Intersil Data Book, 5/83*, p. 5-77.

Fig. 64-18: *Intersil Data Book, 5/83*, p. 5-77.

Fig. 64-19: *Intersil Data Book, 5/83*, p. 5-77.

Fig. 64-20: *Intersil Data Book, 5/83*, p. 5-76.

Fig. 64-21: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-105.

Fig. 64-22: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-15.

Fig. 64-23: Reprinted with the permission of National Semiconductor Corp. *Voltage Regulator Handbook*, p. 10-77.

Fig. 64-24: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-105.

Fig. 64-25: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-105.

Fig. 64-26: *Electronics Today International, 6/77*, p. 77.

Fig. 64-27: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-15.

Fig. 64-28: Courtesy of Motorola Inc. *Linear Integrated Circuits, 1979*, p. 4-15.

Fig. 64-29: *Signetics Analog Data Manual*, 1982, p. 6-14.

Fig. 64-30: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 3-147.

Fig. 64-31: *Electronics Today International*, 3/75, p. 67.

Fig. 64-32: *Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-179.

Fig. 64-33: *Signetics Analog Data Manual*, 1983, p. 12-28.

Chapter 65

Fig. 65-1: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 2-8.

Fig. 65-2: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 4-23.

Fig. 65-3: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 4-152.

Fig. 65-4: *101 Electronic Projects*, 1975, p. 49.

Fig. 65-5: *Electronics Today International*, 9/75, p. 64.

Fig. 65-6: *Electronics Today International*, 3/75, p. 68.

Fig. 65-7: *Electronics Today International*, 1/75, p. 67.

Fig. 65-8: *Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-15.

Fig. 65-9: *Electronics Today International*, 4/82, p. 29.

Fig. 65-10: *Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-142.

Fig. 65-11: *Signetics Analog Data Manual*, 1982, p. 6-25.

Fig. 65-12: *Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-77.

Fig. 65-13: *Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-15.

Fig. 65-14: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 1-68.

Fig. 65-15: *Reprinted with the permission of National Semiconductor Corp.*

Fig. 65-16: *Signetics Analog Data Manual*, 1982, p. 6-25.

Fig. 65-17: *Signetics Analog Data Manual*, 1982, p. 6-25.

Fig. 65-18: *Electronics Today International*, 8/78, p. 91.

Fig. 65-19: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 4-15.

Fig. 65-20: *Courtesy of Motorola Inc. Linear Integrated Circuits*, 1979, p. 5-147.

Fig. 65-21: *Reprinted with the permission of National Semiconductor Corp. CMOS Databook*, 1981, p. 6-38.

Chapter 66

Fig. 66-1: *No reference.*

Fig. 66-2: *73 Magazine.*

Fig. 66-3: *Electronics Today International*, 3/77, p. 71.

Fig. 66-4: *Courtesy of Motorola Inc. Circuit Applications for the Triac*, AN-466, p. 14.

Fig. 66-5: *Electronics Today International*, 1/79, p. 95.

Fig. 66-6: *Electronics Today International*, 8/76, p. 66.

Fig. 66-7: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 2-39.

Chapter 67

Fig. 67-1: *Ham Radio*, 8/80, p. 18.

Fig. 67-2: *Canadian Projects Number 1*, p. 86.

Fig. 67-3: *Electronics Today International*, 5/77, p. 37.

Fig. 67-4: *Electronics Today International*, 3/81, p. 19.

Fig. 67-5: *101 Electronic Projects*, 1975, p. 47.

Fig. 67-6: *Electronics Today International*, 1/76, p. 52.

Fig. 67-7: *Electronics Today International*, 1/76, p. 51.

Fig. 67-8: *Electronics Today International*, 11/75, p. 74.

Fig. 67-9: *Ham Radio*, 2/73, p. 56.

Fig. 67-10: *73 Magazine*, 10/83, p. 66.

Fig. 67-11: *Electronics Today International*, 6/79, p. 103.

Fig. 67-12: *Electronics Today International*, 1/76, p. 44.

Fig. 67-13: *Reprinted from Electronics*, 7/76, p. 121. Copyright 1976, McGraw Hill Inc. All rights reserved.

Chapter 68

Fig. 68-1: ©Siliconix incorporated, *Analog Switch & IC Product Data Book*, 1/82, p. 6-20.

Fig. 68-2: *Electronics Today International*, 6/79, p. 17.

Fig. 68-3: *Courtesy of Motorola Inc. Motorola Semiconductor Library, Volume 6, Series B*, p. 5-52.

Fig. 68-4: *Reprinted with permission from General Electric Semiconductor*

Department. General Electric SCR Manual, Sixth Edition, 1979, p. 445.

Fig. 68-5: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 3-241.

Fig. 68-6: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 5-48.

Fig. 68-7: *Courtesy of Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 5-24.

Fig. 68-8: *Signetics Analog Data Manual*, 1982, p. 16-29.

Fig. 68-9: *Signetics Analog Data Manual*, 1982, p. 16-29.

Fig. 68-10: *Teledyne Semiconductor, Databook*, p. 8.

Fig. 68-11: ©Siliconix incorporated, *Analog Switch & IC Product Data Book*, 1/82, p. 6-20.

Chapter 69

Fig. 69-1: *Reprinted from Electronics*, 3/75, p. 117. Copyright 1975, McGraw Hill Inc. All rights reserved.

Fig. 69-2: *Reprinted from Electronics*, 8/78, p. 106. Copyright 1978, McGraw Hill Inc. All rights reserved.

Fig. 69-3: *Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 2-15.

Fig. 69-4: *49 Easy To Build Projects*, TAB Book No. 1337, p. 77.

Fig. 69-5: *Electronics Today International*, 1/79, p. 97.

Fig. 69-6: *Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 2-16.

Chapter 70

Fig. 70-1: *Reprinted with the permission of National Semiconductor Corp. Linear Databook*, 1982, p. 7-12.

Fig. 70-2: *Courtesy of Motorola Inc. Linear Integrated Circuits*, p. 6-49.

Fig. 70-3: *Ferranti. Technical Handbook Vol. 10, Data Converters*, 1983, p. 7-13.

Fig. 70-4: *Reprinted with the permission of National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 4-23.

Chapter 71

Fig. 71-1: *Intersil Data Book*, 5/83, p. 7-83.

Fig. 71-2: *Reprinted with the permission of National Semiconductor Corp. Transistor Databook*, 1982, p. 7-67.

Fig. 71-3: *Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook*, 1980, p. 4-37.

- Fig. 71-4: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 3-16.
- Fig. 71-5: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 13-17.
- Fig. 71-6: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 5-77.
- Fig. 71-7: *73 Magazine*.
- Fig. 71-8: ©Siliconix incorporated, *Analog Switch & IC Product Data Book*, 1/82, p. 6-18.
- Fig. 71-9: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-123.
- Fig. 71-10: *Ham Radio*, 7/76, p. 69.

Chapter 72

- Fig. 72-1: *73 Magazine*.
- Fig. 72-2: *CQ*, 6/78, p. 32.
- Fig. 72-3: *Teledyne Semiconductor Databook*, p. 11.
- Fig. 72-4: Reprinted from *Electronics* 4/76, p. 104. Copyright , McGraw Hill Inc. All rights reserved.
- Fig. 72-5: Reprinted by permission from the Aug. 1981 issue of *Insulation/Circuits* magazine. Copyright 1981, Lake Publishing Corporation, Libertyville, Illinois, 60048-9989, USA.
- Fig. 72-6: ©Siliconix incorporated, *Application Note AN154*.
- Fig. 72-7: *Electronics Today International*, 11/78, p. 68.
- Fig. 72-8: *CQ*, 6/78, p.33.

Chapter 73

- Fig. 73-1: Courtesy of Motorola Inc. *Communications Engineering Bulletin EB-67*.
- Fig. 73-2: Courtesy of Motorola Inc. *Communications Engineering Bulletin EB-63*.
- Fig. 73-3: Courtesy of Motorola Inc. *Application Note AN593*, p. 3.
- Fig. 73-4: Courtesy of Motorola Inc. *Application Note AN-593*, p. 6.
- Fig. 73-5: Courtesy of Motorola Inc. *Communications Engineering Bulletin EB-46*.
- Fig. 73-6: *Microwaves & RF*, 1/83, p. 89.
- Fig. 73-7: ©Siliconix incorporated, *Small Signal FET Design Catalog*, 7/83, p. 5-52.
- Fig. 73-8: *Harris Semiconductor, Linear & Data Acquisition Products*, 1977, p. 7-54.
- Fig. 73-9: *Wireless World*, 11/79, p. 76.

- Fig. 73-10: *101 Electronic Projects*, 1975, p. 3.
- Fig. 73-11: *Ham Radio*, 10/78, p. 38.
- Fig. 73-12: *73 Magazine*, 4/83, p. 106.
- Fig. 73-13: *Ham Radio*, 1/74, p. 67.
- Fig. 73-14: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Vol. 6, Series B*, p. 8-59.
- Fig. 73-15: ©Siliconix incorporated. *MOSPOWER Design Catalog*, 1/83, p. 5-36.
- Fig. 73-16: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-33.
- Fig. 73-17: ©Siliconix incorporated. *MOSPOWER Design Catalog*, 1/83, p. 5-10.
- Fig. 73-18: Reprinted with the permission of National Semiconductor Corp. *Application Note 32*, p. 9.
- Fig. 73-19: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 11-178.
- Fig. 73-20: *Signetics Analog Data Manual*, 1983, p. 17-13.
- Fig. 73-21: *Signetics Analog Data Manual*, 1983, p. 17-15.
- Fig. 73-22: *73 Magazine*.
- Fig. 73-23: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Vol. 6, Series B*, p. 8-58.
- Fig. 73-24: Courtesy of Motorola Inc. *Motorola Semiconductor Library, Vol. 6, Series B*, p. 8-58.
- Fig. 73-25: ©Siliconix incorporated. *MOSPOWER Design Catalog*, 1/83, p. 5-10.
- Fig. 73-26: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 11-178.
- Fig. 73-27: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 11-178.
- Fig. 73-28: *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 11-178.

Chapter 74

- Fig. 74-1: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 8-63.
- Fig. 74-2: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-32.
- Fig. 74-3: ©Siliconix incorporated. *MOSPOWER Design Catalog*, 1/83, p. 5-6.
- Fig. 74-4: *The Giant Book Of Electronics Projects*, TAB Book No. 1367.
- Fig. 74-5: Reprinted with the permission of National Semiconductor Corp.

- Linear Databook*, 1982, p. 12-14.
- Fig. 74-6: *Radio-Electronics*, 7/83, p. 7.
- Fig. 74-7: *Radio-Electronics*, 7/83, p. 7.
- Fig. 74-8: *73 Magazine*, 7/77, p. 35.

Chapter 75

- Fig. 75-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-126.
- Fig. 75-2: Courtesy of Motorola Inc. *Communications Engineering Bulletin, EB-46*.
- Fig. 75-3: *Signetics Analog Data Manual*, p. 556.
- Fig. 75-4: *Modern Electronics*, 7/78, p. 55.
- Fig. 75-5: *Electronics Today International*, 6/79, p. 43.
- Fig. 75-6: *Radio-Electronics*, 8/69, p. 74.
- Fig. 75-7: *Signetics 555 Timers*, 1973, p. 25.

Chapter 76

- Fig. 76-1: *The Build-It Book Of Electronic Projects*, TAB Book No. 1498, p. 20.
- Fig. 76-2: *303 Dynamic Electronic Circuits*, TAB Book No. 1060, p. 153.
- Fig. 76-3: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-100.
- Fig. 76-4: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual*, Sixth Edition, 1979, p. 225.
- Fig. 76-5: *73 Magazine*, 9/75, p. 105.
- Fig. 76-6: *Howard S. Leopold*.
- Fig. 76-7: *Modern Electronics*, 3/78, p. 50.
- Fig. 76-8: *73 Magazine*, 6/83, p. 106.
- Fig. 76-9: *Modern Electronics*, 2/78, p. 50.

Chapter 77

- Fig. 77-1: *Electronics Today International*.
- Fig. 77-2: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-30.
- Fig. 77-3: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-31.
- Fig. 77-4: *Precision Monolithics Incorporated*, 1981 *Full Line Catalog*, p. 7-18.
- Fig. 77-5: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-325.
- Fig. 77-6: Reprinted with the permis-

sion of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-152.

Fig. 77-7: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-25.

Fig. 77-8: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 7-25.

Fig. 77-9: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 7-25.

Fig. 77-10: Signetics Analog Data Manual, 1982, p. 3-50.

Fig. 77-11: Signetics Analog Data Manual, 1982, p. 3-15.

Fig. 77-12: Precision Monolithics Incorporated. 1981 Full Line Catalog, p. 16-159.

Chapter 78

Fig. 78-1: *Electronics Today International*, 9/72, p. 86.

Fig. 78-2: *Electronics Today International*, 1978.

Fig. 78-3: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-76.

Fig. 78-3: Harris Semiconductor, *Linear & Data Acquisition Products*, 1977, p. 2-96.

Fig. 78-4: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-17.

Chapter 79

Fig. 79-1: *Supertex Data Book*, 1983, p. 5-26.

Fig. 79-2: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-75.

Fig. 79-3: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-76.

Chapter 80

Fig. 80-1: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-40.

Fig. 80-2: Reprinted with the permission of National Semiconductor Corp. *COPS Microcontrollers Databook*, 1982, p. 9-123.

Fig. 80-3: Reprinted with the permission of National Semiconductor Corp. *COPS Microcontrollers Databook*, 1982, p. 10-3.

Fig. 80-4: *Electronics Today International*, 4/78, p. 31.

Fig. 80-5: Reprinted with the permis-

sion of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 5-8.

Fig. 80-6: *Electronics Today International*, 1/79, p. 68.

Fig. 80-7: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-136.

Fig. 80-8: *Electronics Today International*, 4/78, p. 29.

Fig. 80-9: *Electronics Today International*, 1/76, p. 49.

Fig. 80-10: Courtesy of Texas Instruments Incorporated. *Bulletin No. DL-S 12612*, p. 14.

Fig. 80-11: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 5-9.

Fig. 80-12: Courtesy of Texas Instruments Incorporated. *Bulletin No. DL-S 12612*, p. 12.

Chapter 81

Fig. 81-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-204.

Fig. 81-2: *73 Magazine*, 10/77, p. 115.

Fig. 81-3: *Electronics Today International*, 7/81, p. 75.

Fig. 81-4: Reprinted with permission from General Electric Semiconductor Department. *GE Application Note 200.35, 3/66*, p. 14.

Fig. 81-5: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 64.

Fig. 81-6: *Electronics Today International*, 1975, p. 72.

Chapter 82

Fig. 82-1: *Teledyne Semiconductor, Databook*, p. 8.

Fig. 82-2: ©Siliconix incorporated. *Application Note AN154*.

Fig. 82-3: *The Complete Handbook of Amplifiers, Oscillators & Multivibrators*, TAB Book No. 1230, p. 335.

Fig. 82-4: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 9-28.

Fig. 82-5: Reprinted from *Electronics*, 2/77, p. 107. Copyright 1977, McGraw Hill Inc. All rights reserved.

Fig. 82-6: ©Siliconix incorporated. *Analog Switch & IC Product Data Book*, 1/82, p. 6-19.

Fig. 82-7: Harris Semiconductor, *Linear & Data Acquisition Products*, 1977, p. 2-96.

Fig. 82-8: *Electronics Today International*, 7/78, p. 16.

Fig. 82-9: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, p. 7-30.

Fig. 82-10: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 13-50.

Fig. 82-11: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, 1979, p. 7-9.

Fig. 82-12: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book, Second Edition*, p. 145.

Fig. 82-13: *Electronics Today International*, 7/78, p. 16.

Fig. 82-14: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 8-31.

Chapter 83

Fig. 83-1: *Electronics Today International*, 7/81, p. 72.

Fig. 83-2: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 233.

Fig. 83-3: *101 Electronic Projects*, 1977, p. 40.

Chapter 84

Fig. 84-1: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-32.

Fig. 84-2: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-33.

Fig. 84-3: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-28.

Fig. 84-4: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-29.

Fig. 84-5: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual, Sixth Edition*, 1979, p. 313.

Fig. 84-6: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 11-10.

Fig. 84-7: Reprinted with permission from General Electric Semiconductor Department. *Optoelectronics, Second Edition*, p. 141.

Chapter 85

Fig. 85-1: *Intersil Data Book*, 5/83, p. 7-48.

Fig. 85-2: Reprinted from *Electronics*, 11/75, p. 120. Copyright 1975, McGraw Hill Inc. All rights reserved.

Fig. 85-3: Courtesy of Motorola Inc. *Mitel Databook*, p. 2-17.

Fig. 85-4: *Mitel Databook*, p. 2-13.

Fig. 85-5: *73 Magazine*, 12/83, p. 115.

Fig. 85-6: *Ham Radio*, 2/77, p. 70.

Fig. 85-7: *Ham Radio*, 8/77, p. 41.

sion of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-152.

Fig. 77-7: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-25.

Fig. 77-8: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 7-25.

Fig. 77-9: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 7-25.

Fig. 77-10: Signetics Analog Data Manual, 1982, p. 3-50.

Fig. 77-11: Signetics Analog Data Manual, 1982, p. 3-15.

Fig. 77-12: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-159.

Chapter 78

Fig. 78-1: *Electronics Today International*, 9/72, p. 86.

Fig. 78-2: *Electronics Today International*, 1978.

Fig. 78-3: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-76.

Fig. 78-3: Harris Semiconductor, *Linear & Data Acquisition Products*, 1977, p. 2-96.

Fig. 78-4: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-17.

Chapter 79

Fig. 79-1: *Supertex Data Book*, 1983, p. 5-26.

Fig. 79-2: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-75.

Fig. 79-3: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. 9-76.

Chapter 80

Fig. 80-1: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 4-40.

Fig. 80-2: Reprinted with the permission of National Semiconductor Corp. *COPS Microcontrollers Databook*, 1982, p. 9-123.

Fig. 80-3: Reprinted with the permission of National Semiconductor Corp. *COPS Microcontrollers Databook*, 1982, p. 10-3.

Fig. 80-4: *Electronics Today International*, 4/78, p. 31.

Fig. 80-5: Reprinted with the permis-

sion of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 5-8.

Fig. 80-6: *Electronics Today International*, 1/79, p. 68.

Fig. 80-7: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-136.

Fig. 80-8: *Electronics Today International*, 4/78, p. 29.

Fig. 80-9: *Electronics Today International*, 1/76, p. 49.

Fig. 80-10: Courtesy of Texas Instruments Incorporated. *Bulletin No. DL-S 12612*, p. 14.

Fig. 80-11: Reprinted with the permission of National Semiconductor Corp. *Audio/Radio Handbook*, 1980, p. 5-9.

Fig. 80-12: Courtesy of Texas Instruments Incorporated. *Bulletin No. DL-S 12612*, p. 12.

Chapter 81

Fig. 81-1: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-204.

Fig. 81-2: *73 Magazine*, 10/77, p. 115.

Fig. 81-3: *Electronics Today International*, 7/81, p. 75.

Fig. 81-4: Reprinted with permission from General Electric Semiconductor Department. *GE Application Note 200.35, 3/66*, p. 14.

Fig. 81-5: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 64.

Fig. 81-6: *Electronics Today International*, 1975, p. 72.

Chapter 82

Fig. 82-1: *Teledyne Semiconductor Databook*, p. 8.

Fig. 82-2: ©Siliconix Incorporated. *Application Note AN154*.

Fig. 82-3: *The Complete Handbook of Amplifiers, Oscillators & Multivibrators*, TAB Book No. 1230, p. 335.

Fig. 82-4: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 9-28.

Fig. 82-5: Reprinted from *Electronics*, 2/77, p. 107. Copyright 1977, McGraw Hill Inc. All rights reserved.

Fig. 82-6: © Siliconix Incorporated. *Analog Switch & IC Product Data Book*, 1/82, p. 6-19.

Fig. 82-7: Harris Semiconductor, *Linear & Data Acquisition Products*, 1977, p. 2-96.

Fig. 82-8: *Electronics Today International*, 7/78, p. 16.

Fig. 82-9: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, p. 7-30.

Fig. 82-10: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 13-50.

Fig. 82-11: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, 1979, p. 7-9.

Fig. 82-12: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book*, Second Edition, p. 145.

Fig. 82-13: *Electronics Today International*, 7/78, p. 16.

Fig. 82-14: *Precision Monolithics Incorporated*, 1981 Full Line Catalog, p. 8-31.

Chapter 83

Fig. 83-1: *Electronics Today International*, 7/81, p. 72.

Fig. 83-2: *104 Weekend Electronics Projects*, TAB Book No. 1436, p. 233.

Fig. 83-3: *101 Electronic Projects*, 1977, p. 40.

Chapter 84

Fig. 84-1: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-32.

Fig. 84-2: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-33.

Fig. 84-3: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-28.

Fig. 84-4: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-29.

Fig. 84-5: Reprinted with permission from General Electric Semiconductor Department. *General Electric SCR Manual*, Sixth Edition, 1979, p. 313.

Fig. 84-6: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 11-10.

Fig. 84-7: Reprinted with permission from General Electric Semiconductor Department. *Optoelectronics*, Second Edition, p. 141.

Chapter 85

Fig. 85-1: *Intersil Data Book*, 5/83, p. 7-48.

Fig. 85-2: Reprinted from *Electronics*, 11/75, p. 120. Copyright 1975, McGraw Hill Inc. All rights reserved.

Fig. 85-3: Courtesy of Motorola Inc. *Mitel Databook*, p. 2-17.

Fig. 85-5: *Mitel Databook*, p. 2-13.

Fig. 85-6: *73 Magazine*, 12/83, p. 115.

Fig. 85-7: *Ham Radio*, 2/77, p. 70.

Fig. 85-8: *Ham Radio*, 8/77, p. 41.

- Fig. 85-9: *Ham Radio*, 1/84, p. 94.
 Fig. 85-10: Reprinted with permission from *General Electric Semiconductor Department. Optoelectronics, Second Edition*, p. 119.
 Fig. 85-11: *Signetics Analog Data Manual*, 1982, p. 16-27.
 Fig. 85-12: *Modern Electronics*, 7/78, p. 56.
 Fig. 85-13: *The Build-It Book Of Electronic Projects*, TAB Book No. 1498, p. 3.
 Fig. 85-14: Reprinted with the permission of *National Semiconductor Corp. COPS Microcontrollers Databook*, 1982, p. 9-118.
 Fig. 85-15: *73 Magazine*, 1/84, p. 115.
 Fig. 85-16: *Intersil Data Book*, 5/83, p. 7-47.
 Fig. 85-17: Reprinted with permission from *General Electric Semiconductor Department Optoelectronics, Second Edition*, p. 119.
 Fig. 85-18: *Ham Radio*, 1/84, p. 93.
 Fig. 85-19: *Ham Radio*, 1/84, p. 91.
 Fig. 85-20: *73 Magazine*, 4/83.
 Fig. 85-21: *73 Magazine*, 9/82, p. 92.

Chapter 86

- Fig. 86-1: *Radio-Electronics*, 7/81, p. 73.
 Fig. 86-2: Reprinted with the permission of *National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 1-87.
 Fig. 86-3: Reprinted with the permission of *National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 12-17.
 Fig. 86-4: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-162.
 Fig. 86-5: Courtesy of *Motorola Inc. Circuit Applications for the Triac (AN-466)*, p. 9.
 Fig. 86-6: Courtesy of *Motorola Inc. Circuit Applications for the Triac, AN-466*, p. 13.
 Fig. 86-7: *Intersil Data Book*, 5/83, p. 5-68.
 Fig. 86-8: Reprinted with the permission of *National Semiconductor Corp. Linear Applications Handbook*, 1982, p. LB36-2.
 Fig. 86-9: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-29.
 Fig. 86-10: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 16-6.
 Fig. 86-11: Reprinted with the permission of *National Semiconductor Corp.*

Linear Databook, 1982, p. 9-29.

Fig. 86-12: Reprinted with the permission of *National Semiconductor Corp. Hybrid Products Databook*, 1982, p. 7-33.

Chapter 87

- Fig. 87-1: *Electronics Today International*, 4/81, p. 86.
 Fig. 87-2: *Electronics Today International*, 12/78, p. 32.
 Fig. 87-3: *Signetics Analog Data Manual*, 1983, p. 10-65.
 Fig. 87-4: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 6-147.
 Fig. 87-5: *Teledyne Semiconductor, Databook*, p. 12.
 Fig. 87-6: *Precision Monolithics Incorporated, 1981 Full Line Catalog*, p. 10-16.
 Fig. 87-7: Reprinted with the permission of *National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 12-9.
 Fig. 87-8: *Signetics Analog Data Manual*, 1982, p. 3-78.
 Fig. 87-9: Reprinted with the permission of *National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 12-7.
 Fig. 87-10: *Radio-Electronics*, 3/80, p. 60.
 Fig. 87-11: Reprinted with the permission of *National Semiconductor Corp. Data Conversion/Acquisition Databook*, 1980, p. 12-10.
 Fig. 87-12: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-162.
 Fig. 87-13: *Intersil Data Book*, 5/83, p. 5-71.
 Fig. 87-14: *Intersil Data Book*, 5/83, p. 5-71.
 Fig. 87-15: Courtesy of *Fairchild Camera & Instrument Corporation. Linear Databook*, 1982, p. 4-42.
 Fig. 87-16: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 3-108.
 Fig. 87-17: Reprinted with the permission of *National Semiconductor Corp. CMOS Databook*, 1981, p. 6-7.
 Fig. 87-18: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-31.
 Fig. 87-19: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-31.
 Fig. 87-20: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-29.

Fig. 87-21: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-160.

Fig. 87-22: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-162.

Fig. 87-23: Reprinted with the permission of *National Semiconductor Corp. Voltage Regulator Handbook*, p. 10-107.

Fig. 87-24: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 2-46.

Fig. 87-25: *Electronics Today International*, 10/78, p. 101.

Fig. 87-26: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 2-46.

Fig. 87-27: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-29.

Fig. 87-28: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-160.

Fig. 87-29: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-31.

Fig. 87-30: *Teledyne Semiconductor, Databook*, p. 11.

Fig. 87-31: *Teledyne Semiconductor, Databook*, p. 11.

Fig. 87-32: *Intersil Data Book*, 5/83, p. 5-70.

Fig. 87-33: Reprinted with the permission of *National Semiconductor Corp. Linear Databook*, 1982, p. 9-29.

Chapter 88

- Fig. 88-1: *Western Digital, Components Handbook*, 1983, p. 579.
 Fig. 88-2: Courtesy of *Texas Instruments Incorporated. Linear Control Circuits Data Book, Second Edition*, p. 289.
 Fig. 88-3: *Signetics Analog Data Manual*, 1983, p. 15-11.
 Fig. 88-4: Courtesy of *Motorola Inc. Application Note AN-294*, p. 6.
 Fig. 88-5: Reprinted with permission from *General Electric Semiconductor Department. Application Note 201.11*.
 Fig. 88-6: Reprinted with permission from *General Electric Semiconductor Department. GE Semiconductor Data Handbook, Third Edition*, p. 1183.
 Fig. 88-7: *Signetics 555 Timers*, 1973, p. 19.
 Fig. 88-8: *RCA Corporation, Linear Integrated Circuits And MOS/FETS*, p. 437.
 Fig. 88-9: Reprinted with permission from *General Electric Semiconductor*

Department. GE Semiconductor Data Handbook, Second Edition, p. 412.

Fig. 88-10: 73 Magazine, 8/75, p. 140.

Fig. 88-11: Western Digital, Components Handbook, 1983, p. 581.

Fig. 88-12: Reprinted with permission from General Electric Semiconductor Department. GE Semiconductor Data Handbook, Second Edition, p. 727.

Fig. 88-13: Electronics Today International, 3/82, p. 67.

Fig. 88-14: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-17.

Fig. 88-15: Electronics Today International, 1/76, p. 52.

Fig. 88-16: Modern Electronics, 2/78, p. 49.

Fig. 88-17: Signetics 555 Timers, 1973, p. 26.

Fig. 88-18: Signetics 555 Timers, 1973, p. 20.

Chapter 89

Fig. 89-1: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 10-170.

Fig. 89-2: Signetics Analog Data Manual, 1982, p. 3-89.

Fig. 89-3: Electronics Today International, 10/77, p. 34.

Fig. 89-4: Courtesy of Texas Instruments Incorporated. Linear Control Circuits Data Book, Second Edition, p. 130.

Fig. 89-5: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 10-63.

Fig. 89-6: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 2-53.

Fig. 89-7: Reprinted with the permission of National Semiconductor Corp. Audio/Radio Handbook, 1980, p. 2-49.

Fig. 89-8: Electronics Today International, 6/79, p. 105.

Fig. 89-9: Electronics Today International, 6/82, p. 66.

Fig. 89-10: Courtesy of Texas Instruments Incorporated. Linear Control Circuits Data Book, Second Edition, p. 130.

Fig. 89-11: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 7-27.

Fig. 89-12: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 3-48.

Fig. 89-13: Electronics Today International.

Chapter 90

Fig. 90-1: Radio-Electronics, 12/81, p.

52.

Fig. 90-2: Reprinted with the permission of National Semiconductor Corp. Linear Databook, 1982, p. 9-108.

Fig. 90-3: 73 Magazine, 6/77, p. 49.

Fig. 90-4: CQ, 6/83, p. 46.

Fig. 90-5: 73 Magazine, 8/83, p. 100.

Chapter 91

Fig. 91-1: Electronics Today International, 6/78, p. 29.

Fig. 91-2: 73 Magazine, 2/83, p. 90.

Fig. 91-3: Radio-Electronics, 3/80, p. 60.

Fig. 91-4: Radio-Electronics, 8/83, p. 96.

Fig. 91-5: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 7-11.

Chapter 92

Fig. 92-1: Courtesy of Motorola Inc. Application Note AN-545A, p. 7.

Fig. 92-2: Courtesy of Motorola Inc. Application Note AN-545A, p. 12.

Fig. 92-3: Plessey Semiconductors, Linear IC Handbook, 5/82, p. 129.

Fig. 92-4: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 5-50.

Fig. 92-5: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 5-73.

Fig. 92-6: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 5-51.

Fig. 92-7: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 7-26.

Fig. 92-8: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-31.

Fig. 92-9: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-30.

Fig. 92-10: Courtesy of Motorola Inc. Motorola Semiconductor Library, Volume 6, Series B.

Fig. 92-11: Harris Semiconductor, Linear & Data Acquisition Products, 1977, p. 2-46.

Chapter 93

Fig. 93-1: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-59.

Fig. 93-2: Reprinted with the permission of National Semiconductor Corp. Voltage Regulator Handbook, p. 10-47.

Fig. 93-3: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 6-23.

Fig. 93-4: Precision Monolithics Incorporated,

1981 Full Line Catalog, p. 7-11.

Fig. 93-5: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-158.

Fig. 93-6: Signetics Analog Data Manual, 1982, p. 3-38.

Fig. 93-7: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 13-50.

Fig. 93-8: Courtesy of Motorola Inc. Linear Integrated Circuits, 1979, p. 3-42.

Fig. 93-9: Reprinted with the permission of National Semiconductor Corp. Transistor Databook, 1982, p. 11-25.

Fig. 93-10: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-142.

Fig. 93-11: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-18.

Fig. 93-12: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-15.

Fig. 93-13: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-16.

Fig. 93-14: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-8.

Fig. 93-15: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 14-52.

Fig. 93-16: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 16-158.

Fig. 93-17: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 14-44.

Fig. 93-18: Electronics Today International, 8/78, p. 91.

Fig. 93-19: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 14-41.

Fig. 93-20: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 6-78.

Fig. 93-21: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 14-53.

Fig. 93-22: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Databook, 1980, p. 14-53.

Fig. 93-23: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Data-

Chapter 94

- Fig. 94-1: *Intersil Data Book*, 5/83, p. 5-238.
- Fig. 94-2: Reprinted with the permission of National Semiconductor Corp. *Data Databook*, 1982, p. 5-9.
- Fig. 94-3: *Electronics Today International*, 12/78, p. 20.
- Fig. 94-4: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-17.
- Fig. 94-5: *Electronics Today International*, 7/72, p. 84.
- Fig. 94-6: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-13.
- Fig. 94-7: *Signetics Analog Data Manual*, 1982, p. 8-14.
- Fig. 94-8: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-179.
- Fig. 94-9: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-238.

Chapter 95

- Fig. 95-1: *Teledyne Semiconductor*, Publication DG-114-87, p. 3.
- Fig. 95-2: ©Siliconix incorporated. *Analog Switch & IC Product Data Book*, 1/82, p. 1-25.
- Fig. 95-3: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 7-7.
- Fig. 95-4: Reprinted with the permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 12-19.
- Fig. 95-5: Reprinted with the permission of National Semiconductor Corp. *Linear Applications Handbook*, 1982, p. D-7.
- Fig. 95-6: Reprinted with permission of Analog Devices, Inc. *Data Acquisition Databook*, 1982, p. 12-20.

Chapter 96

- Fig. 96-1: Reprinted with the permission of National Semiconductor Corp. *National Semiconductor CMOS Databook*, 1981, p. 3-50.
- Fig. 96-2: *Precision Monolithics Incorporated*, 1981, *Full Line Catalog*, p. 16-138.

Fig. 96-3: *Teledyne Semiconductor*, *Databook*, p. 11.

Fig. 96-4: ©Siliconix incorporated, *Analog Switch & IC Product Data Book*, 1/82, p. 7-21.

Fig. 96-5: *Precision Monolithics Incorporated*, 1981 *Full Line Catalog*, p. 16-141.

Fig. 96-6: Reprinted with the permission of National Semiconductor Corp. *Application Note 32*, p. 2.

Fig. 96-7: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 9-204.

Fig. 96-8: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 3-103.

Fig. 96-9: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 17-54.

Fig. 96-10: *Electronics Today International*, 7/72, p. 83.

Fig. 96-11: *Signetics Analog Data Manual*, 1982, p. 3-50.

Fig. 96-12: *Siliconix Analog Switch & IC Product Data Book*, 1/82, p. 1-7.

Fig. 96-13: Reprinted with the permission of National Semiconductor Corp. *Hybrid Products Databook*, 1982, p. 1-27.

Chapter 97

Fig. 97-1: Reprinted from *Electronics*, 7/83, p. 135. Copyright 1983, McGraw Hill Inc. All rights reserved.

Fig. 97-2: Reprinted with the permission of National Semiconductor Corp. *Data Conversion/Acquisition Databook*, 1980, p. 8-33.

Fig. 97-3: *Precision Monolithics Incorporated*, 1981 *Full Line Catalog*, p. 16-173.

Fig. 97-4: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book*, Second Edition, p. 145.

Fig. 97-5: *Intersil Data Book*, 5/83, p. 5-238.

Fig. 97-6: *Harris Semiconductor*, *Linear & Data Acquisition Products*, p. 2-58.

Fig. 97-7: *73 Magazine*, 8/78, p. 132.

Fig. 97-8: Reprinted with the permission of National Semiconductor Corp. *Linear Databook*, 1982, p. 3-241.

Fig. 97-9: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook*, Third Edition, p. 577.

Fig. 97-10: Reprinted with permission from General Electric Semiconductor Department. *GE Semiconductor Data Handbook*, Third Edition, p. 1183.

Fig. 97-11: *Intersil Data Book*, 5/83, p. 5-238.

Fig. 97-12: Courtesy of Motorola Inc. *Linear Interface Integrated Circuits*, 1979, p. 5-119.

Fig. 97-13: *Precision Monolithics Incorporated*, 1981 *Full Line Catalog*, p. 16-81.

Fig. 97-14: *Harris Semiconductor Linear - Data Acquisition Products*, p. 2-46.

Fig. 97-15: *Intersil Data Book* 5/83, p. 4-93.

Fig. 97-16: *Signetics Analog Data Manual*, 1982, p. 16-29.

Fig. 97-17: *Signetics Analog Data Manual*, 1982, p. 16-29.

Fig. 97-18: *Signetics Analog Data Manual*, 1977, p. 264.

Fig. 97-19: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 5-25.

Fig. 97-20: *Signetics Analog Data Manual*, 1982, p. 16-29.

Chapter 98

Fig. 98-1: *Electronics Today International*, 8/78, p. 69.

Fig. 98-2: Courtesy of Fairchild Camera & Instrument Corporation. *Linear Databook*, 1982, p. 5-32.

Fig. 98-3: ©Siliconix incorporated. *Analog Switch & IC Product Data Book*, 1/82, p. 6-18.

Fig. 98-4: Courtesy of Motorola Inc. *Linear Integrated Circuits*, 1979, p. 6-123.

Fig. 98-5: Courtesy of Texas Instruments Incorporated. *Linear Control Circuits Data Book*, Second Edition, p. 205.

Fig. 98-6: ©Siliconix incorporated. *Analog Switch & IC Product Data Book*, 1/82, p. 6-14.

Index

Numbers preceded by an "I-," "II-," and "III" are from *Encyclopedia of Electronic Circuits Vol. I., Vol. II, and Vol. III* respectively.

- 0/01 percent analog multiplier, II-392
- 1 MHz FET crystal oscillator, II-144
- 1 kHz oscillator, II-427
- 1 watt/2.3 GHz amplifier, II-540
- 10 amp regulator, current and thermal protection with, II-474
- 10 MHz crystal oscillator, II-141
- 10 MHz fiber optic receiver, II-205
- 10 watt/225-400 MHz rf amplifier, II-548
- 100 MHz converter, II-130
- 12 to 14 V regulated 3 amp power supply, II-480
- 12-bit D/A, variable step size in, II-181
- 12ns circuit breaker, II-97
- 125 Watt 150 MHz amplifier, II-544
- 14-volt, 4-amp battery charger/power supply, II-73
- 1800 Hz notch filter, II-398
- 2 MHz square wave generator TTL gates in, II-598
- 2 to 6 Watt audio amplifier with preamp, II-451
- 20 kHz ring counter, II-135
- 25 watt amplifier, II-452
- 400 Hz servo amplifier, II-386
- 400V/60W push-pull power supply, II-473
- 5 MHz phase-encoded data read circuitry, II-365
- 5 MHz VFO, II-551
- 5 v powered linearized platinum RTD signal conditioner, II-650
- 5 watt rf power amplifier, II-542
- 50-ohm transmission line driver, II-192
- 500 kHz switching inverter for 12V systems, II-474
- 550 Hx notch filter, II-399
- 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
- 565 SCA demodulator, III-150
- 6-meter kilowatt rf amplifier, II-545
- 6-meter preamp with 20 dB gain and low NF, II-543
- 60 Hz clock pulse generator, II-102
- 600-ohm balanced driver for line signals, II-192
- 600-ohm high output line driver, II-193
- 650 MHz amplifying prescaler probe, II-502
- 650 × microprocessors, interface to, III-98
- 680 × microprocessors, interface to, III-98
- 7400 siren, II-575
- 8-amp regulated power supply, mobile equipment, II-461
- 800 W light dimmer, II-309
- 8048/IM80C48 microprocessor 8-char/16-seg ASCII triplex LCD, II-116
- 90-watt power amplifier with safe area protection, II-459

A

- absolute value amplifier, I-31
- absolute value circuit, precision, I-37
- 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 for, II-383
 - two-phase driver for, II-382
- ac sequential flasher, II-238
- ac switcher, high-voltage optically coupled, III-408
- ac-coupled amplifiers, dynamic, III-17
- ac-line operated unijunction metronome, II-355

- accurate null/variable gain circuit, III-69
acid rain monitor, II-245, III-361
active antennas, III-1-2
active clamp-limiting amplifiers, III-15
active crossover networks, I-172-173
active filter
 band reject, II-401
 bandpass, III-190, II-221, II-223
 digitally tuned low power, II-218
 low pass, digitally selected break frequency, II-216
 low-power, digitally selectable center frequency, III-186
 programmable, III-185
 state-variable, III-189
ten-band graphic equalizer using, II-684
 universal, II-214
active integrator, inverting buffer, II-299
adapter
 dc transceiver and, hand-held, III-461
 program, second-audio, III-142
 traveller's shaver, I-495
adder, III-327
adjustable ac timer, .2 to 10 seconds, II-681
adjustable audible continuity tester, II-536
adjustable delay circuit, III-148
adjustable oscillator, over 10:1 range, II-423
adjustable Q notch filter, II-398
adjustable sine wave audio oscillator, II-568
adjustable threshold temperature alarm, II-644
AGC amplifiers
 rf, wideband adjustable, III-545
 squelch control, III-33
 wide-band, III-15
air conditioner, auto, smart clutch for, III-46
air flow detector, I-235, II-242
air flow meter (*see* anemometer)
air-motion detector, III-364
airplane propeller sound effect, II-592
alarms (*see also* detectors; indicators; sensors), III-3-9
 auto burglar, II-2, I-3, III-4, I-7, I-10
 auto, single-IC, III-7
 blown fuse, I-10
 boat, I-9
 burglar, III-8, III-9
 burglar, one-chip, III-5
 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, Hall-effect circuit, III-256
 doorbell, rain, I-443
 door open, II-284
 fail-safe, semiconductor, III-6
 field disturbance, II-507
 flood, III-206, I-390
 freezer meltdown, I-13
 headlights-on, III-52
 high/low limit, I-151
 ice formation, II-58
 latching burglar, I-8, I-12
 line-operated photoelectric smoke, I-596
 low-battery disconnect and, III-65
 low-battery warning, III-59
 low volts, II-493
 motion-actuated car, I-9
 motion-actuated motorcycle, I-9
 multiple circuit for, II-2
 photoelectric, II-319
 photoelectric system for, II-4
 piezoelectric, I-12
 power failure, III-511, I-581, I-582
 proximity, II-506, III-517
 pulsed-tone, I-11
 purse-snatcher, capacitance operated, I-134
 rain, I-442, I-443
 road ice, II-57
 security, I-4
 self-arming, I-2
 shutoff, automatic, I-4
 signal-reception, receivers, III-270
 smoke, SCR, III-251
 solar powered, I-13
 speed, I-95
 Star Trek red alert, II-577
 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
 water level, I-389
alarm flasher, bar display with, I-252
alarm shutoff, automatic, I-4
allophone generator, III-733
alternating flasher, II-227
alternators
 battery-alternator monitor, automotive, III-63
ambience amplifier, rear speaker, II-458
ambient light effects, cancellization circuit for, II-328
AM demodulator, II-160
AM integrated receiver, III-535
AM microphone, wireless, I-679
AM radio, I-544
 power amplifier for, I-77
 receivers, III-529
 receivers, carrier-current, III-81
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 for, III-534
 transmitter, 80-M, III-675
ambient light ignoring optical sensor, III-413
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
amplifier, II-5-22, III-10-21
 1 watt/2.3 GHz, II-540
 2-30 MHz, 140W amateur radio linear, I-555
 2 to 6 W, with preamp, II-451
 4W bridge, I-79
 5W output, two-meter, I-567
 6W 8-ohm output-transformerless, I-75
 10 dB-gain, III-543
 10W power, I-76
 10 x buffer, I-128
 12 W low-distortion power, I-76
 16 W bridge, I-82
 25-watt, II-452
 30 MHz, I-567
 60 MHz, I-567
 80 MHz cascade, I-567
 80W PEP broadband/linear, I-557
 100 MHz/400MHz neutralized common source, I-565
 100W PEP 420-450 MHz push-pull, I-554
 100 x buffer, I-128
 135-175 MHz, I-564
 160W PEP broadband, I-556
 200 MHz neutralized common source, I-568
 450 MHz common-source, I-568
 600 W rf power, I-559
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
AM radio power, I-77
attenuator and, digitally controlled, I-53

audio, III-32-39
 audio, booster, 20 dB, III-35
 audio, circuit bridge load drive, III-35
 audio, distribution, I-39, II-39
 audio, low power, II-454
 audio, Q-multiplier, II-20
 audio, signal, II-41-47
 audio, tone control, II-686
 auto fade circuit for, II-42
 automatic level control for, II-20
 Av/200, stereo, I-77
 balance, II-46
 balance, loudness control, II-47, II-395
 balancing circuit, inverting, I-33
 basic transistor, I-85
 bass tone control, stereo phonograph, I-670
 bridge, I-74
 bridge, ac servo, I-458
 bridge, audio power, I-81
 bridge transducer, III-71, II-84, I-351
 capacitive load, isolation, I-34
 cascaded, III-13
 chopper, +/- 15V, III-12
 chopper channel, I-350
 chopper stabilized, II-7
 clamp-limiting, active, III-15
 color video, I-34, III-724
 common source low power, II-84
 complementary-symmetry audio, I-78
 composite, II-8, III-13
 constant-bandwidth, III-21
 current-shunt, III-21
 current collector head, II-11, II-295
 dc servo, I-457
 dc to video log, I-38
 detector and, MC1330/MC1352 used in, television IF, I-688
 differential, III-14, I-38
 differential, input instrumentation, I-347
 differential, two op amp bridge type, II-83
 dynamic, ac-coupled, III-17
 electrometer, overload protected, II-155
 electronic balanced input microphone, I-86
 fast, dc-stabilized, III-18
 fast, summing, I-36
 FET cascade video, I-691
 FET input, II-7
 flat response, I-92, III-673
 forward-current booster, III-17
 four quadrant photo-conductive detector, I-359
 gain-controlled, III-34
 gate, I-36
 hi-fi compander as, II-12
 hi-fi expander, II-13
 high-frequency, III-259-265
 high gain differential instrumentation, I-353
 high gain inverting ac, I-92
 high impedance bridge, I-353
 high impedance differential, I-27, I-354
 high impedance/high gain/high frequency, I-41
 high impedance/low capacitance, I-691
 high impedance/low drift, instrumentation, I-355
 high-input-high impedance 20 dB micropower, II-44
 high-input-impedance differential, II-19
 high-performance FET, wideband UHF, I-560
 high speed current to voltage, I-35
 high speed instrumentation, I-354
 high speed sample and hold, I-587
 high stability thermocouple, I-355
 IF, I-690
 infinite sample and hold, II-558
 input/output buffer for analog multiplexers, III-11
 instrumentation, III-278-284, I-346, I-348, I-349, I-352, I-354
 inverting, III-14, II-41, I-42
 inverting gain of 2, lag-lead compensation, UHF, I-566
 inverting power, I-79
 inverting unity gain, I-80
 isolation rf, II-547
 JFET bipolar cascade video, I-692
 level-shifting isolation, I-348
 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-distortion audio limiter, II-15
 low-level video detector circuit and, I-687
 low-noise broadband, I-562
 low-power common source, II-84
 low-signal level/high impedance instrumentation, I-350
 magnetic pickup hone, I-89
 medical telemetry, isolation, I-352
 meter-driver, rf, 1-MHz, III-545
 micro-sized, III-36
 microphone, III-34, I-87
 monostable using, II-268
 noninverting, III-14, I-32, I-33, I-41
 noninverting ac power, I-79
 Norton, absolute value, III-11
 op amp clamping for, II-22
 op amp, intrinsically safe protected, III-12
 oscilloscope sensitivity, III-436
 output, four-channel D/A, III-165
 phone, I-81
 phono, I-80
 photodiode, II-324, I-361, 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, 90-W, safe area protection, II-459
 power GaAsFET with single supply, II-10
 pre-amp, NAB tape playback, professional, III-38
 pre-amp, phono, magnetic, III-37
 pre-amp, read-head, automotive circuits, III-44
 pre-amp, RIAA, III-38
 precision, I-40
 precision FET input instrumentation, I-355
 precision summing, I-36
 precision weighted resistor programmable gain, II-9
 programmable, II-334, III-504-508
 pulse-width proportional controller circuit for, II-21
 PWM servo, III-379
 reference voltage, I-36
 remote, I-91
 rf (*see* rf amplifier), II-537
 selectable input, programmable gain, I-32
 servo, 400 Hz, II-386
 servo motor, I-452
 servo motor drive, II-384
 signal distribution, I-39
 sinewave output buffer, I-126
 single-device, 80W/50-ohm, VHF, I-558
 single supply, ac buffer, I-126
 single supply, noninverting, I-75
 sound mixer and, II-37
 speaker, hand-held transceivers, III-39
 speaker, overload protector for, II-16
 speech compressor, II-15
 split supply, noninverting, I-75
 stable unity gain buffer, II-6
 standard cell, battery powered buffer, I-351
 standard cell, saturated, II-296
 stereo, gain control, II-9
 summing, III-16, I-37
 switching power, I-33

- amplifier (*con't.*)
 - tape playback, I-92
 - tape recording, I-90
 - telephone, III-621
 - thermocouple, III-14, I-654
 - thermocouple, cold junction compensation in, II-649
 - transducer, I-86, III-669-673
 - transistor headphone, II-43
 - tremolo circuit or, voltage-controlled, I-598
 - triple op amp instrumentation, I-347
 - TV audio, III-39
 - two-meter 10W power, I-562
 - two-stage 60MHz IF, I-563
 - two-stage wideband, I-689
 - two-wire to four-wire audio converter, II-14
 - ultra high frequency, I-565
 - ultra high gain audio, I-87
 - ultra high Z ac unity gain, II-7
 - ultra low leakage preamp, II-7
 - unity gain, I-27
 - variable gain, differential input instrumentation, I-349
 - very high impedance instrumentation, I-354
 - video, I-692, III-708-712
 - voice activated switch, I-608
 - voltage, differential-to-single-ended, III-670
 - voltage-follower, signal-supply operation III-20
 - voltage controlled, I-31, I-598
 - voltage controlled, attenuator for, II-18
 - voltage controlled, variable gain, I-28-29
 - volume, II-46
 - walkman, II-456
 - wideband unity gain inverting, I-35
 - wide bandwidth, low noise/low drift, I-38
 - wide frequency range, III-262
 - write, III-18
 - ×10 operational, I-37
 - ×100 operational, I-37
- amplitude modulator, low distortion low level, II-370
- analog counter circuit, II-137
- analog multiplexer,
 - 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 converter, II-23-31, III-22-26
 - 8-bit, I-44, I-46
 - 8-bit successive approximation, I-47
 - 10-bit, II-28
 - 10-bit serial output, II-27
 - 16-bit, II-26
 - capacitance meter, 3 1/2 digit, III-76
 - cyclic, II-30
 - differential input system for, II-31
 - fast precision, I-49
 - four-digit (10,000 count), II-25
 - half-flash, III-26
 - high speed 3-bit, I-50
 - high speed 12-bit, II-29
 - IC, low cost, I-50
 - LCD display, 3 1/2 digit, I-49
 - successive approximation, II-24, II-30, I-45
 - switched-capacitor, III-23
 - three-decade logarithmic, I-48
 - tracking, III-24
- analyzer, gas, II-281
- AND gate, I-395
 - large fan-in, I-395
- anemometer
 - hot-wire, III-342
 - thermally based, II-241
- angle of rotation detector, II-283
- announcer, ac line-voltage, III-730
- annunciators, III-27-28, II-32-34
 - electronic bell, II-33
 - large fan-in, I-395
 - low-cost chime circuit, II-33
 - sliding tone doorbell, II-34
- antennas, active, III-1-2
- 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 multivibrator, III-196, III-233, III-238, II-269, II-510
 - op amp, III-224
 - programmable-frequency, III-237
 - square wave generation with, II-597
- attendance counter, II-138
- attenuator, III-29-31
 - analog signals, microprocessor-controlled, III-101
 - digitally programmable, III-30
 - digitally selectable precision, I-52
 - programmable, III-30
 - programmable (1 to 0.00001), I-53
 - variable, I-52
 - voltage-controlled, II-18, III-31
- audible slow logic pulses, II-345
- audio amplifier, III-32-39
 - AGC, squelch control, III-33
 - audio booster, 20 dB, III-35
 - audio circuit bridge load drive, III-35
 - complementary-symmetry, I-78
 - 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
 - speaker, hand-held transceivers, III-39
 - television type, III-39
 - tone control, II-686
 - ultra-high gain, I-87
- audio automatic gain control, II-17
- audio booster, III-35, II-455
- audio circuits
 - biquad filter, III-185
 - bridge load drive, III-35
 - carrier-current transmitter, III-79
- audio clipper, precise, II-394
- audio compressor, II-44
- audio continuity tester, I-550
- audio converter, two-wire to four-wire, II-14
- audio distribution amplifier, II-39, I-39
- audio frequency meter, I-311
- audio generator, III-559
 - one-IC, II-569
 - two-tone, II-570
- audio LED bar peak program meter display, I-254
- audio limiter, low distortion, II-15
- audio millivoltmeter, III-767, III-769
- audio mixer, I-23, II-35
- audio mixer, one transistor, I-59
- audio notch filter, II-400
- audio operated circuits (*see* sound operated circuits)
- audio operated relay, I-608
- audio oscillator, II-24, I-64, III-427
 - 20Hz to 20kHz, variable, I-727
 - light-sensitive, III-315
 - sine wave, II-562
- audio-controlled lamp, I-609
- audio power amplifier, II-451, III-454
 - 20-W, III-456
 - 50-W, III-451
 - 6-W, with preamp, III-454
 - bridge, I-81
- audio power meter, I-488
- audio-powered noise clipper, II-396

- audio Q multiplier, II-20
 - audio-rf signal tracer probe, I-527
 - audio signal amplifiers, II-41-47
 - audio compressor, II-44
 - auto fade, II-42
 - balance, II-46
 - balance and loudness amplifier, II-47
 - loudness, II-46
 - microphone preamp, II-45
 - micropower high-input-impedance 20-dB amplifier, II-44
 - power, II-46
 - stereo preamplifier, II-43, II-45
 - transistor headphone amplifier, II-43
 - volume, II-46
 - audio sine-wave generator, II-564
 - audio squelch, II-394
 - audio switching/mixing, silent, I-59
 - audio waveform generators, precision, III-230
 - auto-advance projector, II-444
 - auto battery charger, Ni-Cad, I-115
 - auto battery current analyzer, I-104
 - auto burglar alarm, II-2, I-3, III-4, III-7, I-7, I-10
 - autodrum sound effect, II-591
 - auto fade circuit, II-42
 - auto flasher, I-299
 - auto high speed warning device, I-101
 - auto lights-on reminder, I-109
 - auto-zeroing scale bridge circuits, III-69
 - automatic gain control, audio, II-17
 - automatic headlight dimmer, II-63
 - automatic keyer, II-15
 - automatic level control, II-20
 - automatic mooring light, II-323
 - automatic power down protection circuit, II-98
 - automatic shutoff battery charger, II-113
 - automatic tape recording, II-21
 - automatic telephone recording device, II-622
 - automatic TTL morse code keyer, II-25
 - automatic turn off for TV, II-577
 - automobile locator, III-43
 - automotive circuits, III-40-52, II-48-63
 - air conditioner smart clutch, III-46
 - automatic headlight dimmer, II-63
 - automobile locator, III-43
 - automotive exhaust emissions analyzer, II-51
 - back-up beeper, III-49
 - bar-graph voltmeter, II-54
 - battery-alternator monitor, III-63
 - brake light, delayed extra, III-44
 - brake lights, flashing third, III-51
 - car horn, electronic, III-50
 - car wiper control, II-62
 - 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
 - garage stop light, II-53
 - glow plug driver, II-52
 - headlight alarm, III-52
 - headlight delay circuit, III-49, II-59
 - headlight dimmer, II-57
 - ice formation alarm, II-58
 - ignition substitute, III-41
 - ignition timing light, II-60
 - immobilizer, II-50
 - intermittent windshield wiper with dynamic braking, II-49
 - lights-on warning, III-42, II-55
 - PTC thermistor automotive temperature indicator, II-56
 - read-head pre-amplifier, III-44
 - road ice alarm, II-57
 - slow-sweep wiper control, II-55
 - tachometer, set point, III-47
 - tachometer/dwell meter, III-45
 - voltage regulator, III-48
 - automotive exhaust emissions analyzer, II-51
 - auto turn signals, sequential flasher for, II-109, III-1
- ## B
- back-biased GaAs LED light sensor, II-321
 - back EMF PM motor speed control, II-379
 - balanced input microphone amplifier, electronic, I-86
 - balanced microphone preamp, low noise transformerless, I-88
 - balanced modulator, III-376
 - balancer, stereo, I-619
 - bar-graph car voltmeter, I-99
 - barricade flasher, I-299
 - battery charge/discharge indicator, I-122
 - balance amplifier, III-46
 - loudness control in, II-395
 - balance and loudness amplifier, II-47
 - balance indicator, bridge circuit, II-82
 - band reject filter, active, II-401
 - bandpass filter, II-222
 - active, III-190, II-221, II-223
 - Chebyshev fourth-order, III-191
 - multiple feedback, II-224
 - notch and, II-223
 - second-order biquad, III-188
 - bar-code scanner, III-363
 - bar expanded scale meter, II-186
 - bar graph
 - ac signal indicator, II-187
 - voltmeter, II-54
 - basic single-supply voltage regulator, II-471
 - bass tuner, 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
 - battery charger, III-53-59, II-64, II-69, I-113
 - constant voltage, current limited, I-115
 - control for 12V, I-112
 - current limited 6V, I-118
 - 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
 - Ni-Cad, I-118
 - ni-cad zapper, II-66
 - portable, ni-cad, III-57
 - power supply and, 14V, III-4A, II-73
 - PUT, III-54
 - regulator for, 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 for, II-76
 - wind powered, II-70
 - battery condition checker, I-108
 - battery condition indicator, I-121
 - battery indicator, low, I-124
 - battery instruments, bipolar power supply for, II-475
 - battery lantern circuit, I-380
 - battery level indicator, II-124
 - battery monitor, III-60-67, II-74-79, I-106
 - analyzer, ni-cad batteries, III-64
 - automatic shutoff, battery-powered projects, III-61
 - battery saver, electric vehicles, III-67
 - battery status indicator, II-77
 - battery-life extender, 9 V, III-62
 - capacity tester, III-66
 - dynamic, constant current load fuel cell/battery tester, II-75
 - lithium battery, state of charge indicator, II-78

- battery monitor (*con't.*)
 - low-battery detector, III-63
 - low-battery indicator, II-77
 - 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
 - step-up switching regulator for 6V, II-78
 - voltage, II-79
 - voltage detector relay in, II-76
- battery-life extender, 9 V, III-62
- battery-operated equipment, automatic shutoff, III-61
 - undervoltage indicator for, I-123
- battery-operated flasher, high powered, II-229
- battery-powered buffer amplifier for standard cell, I-351
- battery-powered calculators/radios/cassette players, power pack, I-509
- battery-powered fence charger, II-202
- battery-powered light, capacitance operated, I-131
- battery-powered warning light, II-320
- battery status indicator, II-77
- battery threshold indicator, I-124
- battery voltage indicator, solid state, I-120
- battery voltage monitor, II-79
 - HTS, precision, I-122
- battery zapper, simple Ni-Cad, I-116
- beacon transmitter, III-683
- beep transformer, III-555, III-566
- beeper
 - back-up, automotive circuits, III-49
 - repeater, I-19
- bell, electronic, II-33
- bell, electronic phone, I-636
- bench top power supply, II-472
- bidirectional intercom system, III-290
- bidirectional proportional motor control, II-374
- 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, III-185
 - second-order bandpass, III-188
- bird chirp sound effect, III-577, II-588
- blinker (*see also* flashers), III-193, II-225
 - fast, I-306
 - neon, I-303
 - telephone, II-629
- blinking phone light monitor, II-624
- blown-fuse alarm, I-10
- boiler control, I-638
- bongos, electronic, II-587
- booster
 - audio, III-35, II-455
 - forward-current, III-17
 - LED, I-307
 - shortwave FET, I-561
 - 12ns, II-97
 - high speed electronic, II-96
- bootstrapping, cable, I-34
- brake light,
 - extra, delayed, III-44
 - flashing, extra, III-51
- brake, PWM speed control/energy recovering, III-380
- breaker
 - 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 circuit, III-68-71, II-80-85, I-552
 - ac, II-81
 - ac servo amplifier with, III-387
 - accurate null/variable gain circuit, III-69
 - auto-zeroing scale, III-69
 - balance indicator, II-82
 - bridge transducer amplifier, III-71
 - low power common source amplifier, II-84
 - QRP SWR, III-336
 - remote sensor loop transmitter, III-70
 - strain gauge signal conditioner, III-71, II-85
 - transducer, amplifier for, II-84
 - two op amp differential amplifier using, II-83
 - 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
 - bridge load driver, audio circuit, III-35
 - brightness control, III-308
 - LED, I-250
 - low loss, I-377
 - broadcast band rf amplifier, III-264, II-546
 - buck converter, 5V/0.5A, I-494
 - buck/boost converter, III-113
 - buckling regulator, high-voltages, III-481
 - buffer
 - capacitance, low-input, III-498
 - capacitance, stabilized low-input, III-502
 - high impedance low capacitance wide-band, I-127
 - high resolution ADC input, I-127
 - high speed 6-bit A/D, I-127
 - high speed single supply ac, I-127, I-128
 - input/output, for analog multiplexers, III-11
 - stable, high impedance, I-128
 - unity gain, stable, good speed and high input impedance, II-6
 - video, low-distortion, III-712
 - buffer amplifier
 - 100 \times , I-128
 - 10 \times , I-128
 - sinewave output, I-126
 - single supply ac, I-126
 - standard cell battery powered, II-351
 - buffered breakout box, II-120
 - bug detector, III-365
 - bug tracer, III-358
 - bulb horn, II-453
 - burglar alarm
 - auto, II-2
 - one-chip, III-5
 - burst generator, III-72-74, II-86-90
 - multi-, square waveform, II-88
 - rf, portable, III-73
 - single timer IC square wave, II-89
 - single tone, II-87
 - strobe tone, II-90
 - tone, II-90
 - tone burst, European repeaters, III-74
 - burst power control, III-362
 - bus interface, eight bit uP, II-114
 - buzzer
 - 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
 - calibrator
 - 100kHz crystal, I-185
 - 5.0V square wave, I-423
 - oscilloscope, II-433, III-436
 - portable, I-644
 - camera alarm trigger, III-444
 - camera link, video, wireless, III-718
 - canceller, central image, III-358
 - capacitance buffer
 - low-input, III-498

- stabilized low-input, III-502
- capacitance meter, III-75-77, II-91-94, I-400
 - A/D, three-and-a-half digit, III-76
 - capacitance to voltage, II-92
 - digital, II-94
- capacitance multiplier, II-200, I-416
- capacitance operated battery powered light, I-131
- 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 alarm, motion actuated, I-9
- car battery condition checker, I-108
- car battery monitor, I-106
- car horn, III-50
- car port, automatic light controller for, II-308
- car radio, receiver for, II-525
- car voltmeter, bargraph, I-99
- car wiper control, II-62
- carrier-current, III-78-82
 - AM receiver, III-81
 - audio transmitter, III-79
 - 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, I-575
- 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
- centigrade thermometer, II-648, I-655, II-662
- central image canceller, III-358
- charge compensated sample and hold, II-559
- charge pool power supply, III-469
- charge pump, positive input/negative output, III-360, I-418
- chargers (*see* battery charger)
- chase circuit, III-197, I-326
- Chebyshev filter
 - 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, II-7, III-12, I-350
- checker
 - 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 breaker
 - 12ns, II-97
 - ac, III-512
 - high speed electronic, II-96
- circuit protection circuit, II-95-99
 - 12ns circuit breaker, II-97
 - automatic power down, II-98
 - electronic crowbar, II-99
 - high speed electronic circuit breaker, II-96
 - line dropout detector, II-98
 - low voltage power disconnecter, II-97
 - overvoltage, II-96
- clamp-on-current probe compensator, II-501
- clamp-limiting amplifiers, active, III-15
- clamping circuit
 - video signal, III-726
 - video summing amplifier and, III-710
- class-D power amplifier, III-453
- clipper, II-394
 - audio-powered noise, II-396
- clock circuits, III-83-85, II-100-102
 - 60Hz clock pulse generator, II-102
 - adjustable TTL, I-614
 - comparator, I-156
 - digital, with alarm, III-84
 - gas discharge displays, III-12-hour, I-253
 - oscillator/clock generator, III-85
 - phase lock, 20-Mhz to Nubus, III-105
 - single op amp, III-85
 - three phase from reference, II-101
 - TTL, wide-frequency, III-85
 - Z80 computer, II-121
- clock generator
 - oscillator, I-615
 - precision, I-193
- clock pulse generator, 60 Hz, II-102
- clock radio, I-542
 - AM/FM, I-543
- clock source, I-729
- closed loop tachometer feedback control, II-390
- closed-loop tracer, III-356
- 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
 - programmable precision timer, III-652
 - short-pulse generator, III-523
 - touch switch, I-137
 - universal logic probe, III-499
- coaxial cable, five transistor pulse booster for, II-191
- code-practice oscillator, I-15, I-20, I-22, II-428 431
- coil drivers, current-limiting, III-173
- coin flipper circuit, III-244
- cold junction compensation, thermocouple amplifier with, II-649
- color amplifier, video, III-724
- color organ, II-583, II-584
- color video amplifier, I-34
- Colpitts crystal oscillator, II-147
- common-gate amplifiers, rf, 450-MHz, III-544
- communication system, optical, I-358, II-416
- combination lock
 - electronic, II-196
 - electronic, three-dial, II-195
- commutator, four-channel, II-364
- compander, hi- β , II-12
- clock circuit, I-156
- comparator, III-86-90, II-103-112, I-157
 - demonstration circuit, II-109
 - diode feedback, I-150
 - display and, II-105
 - double-ended limit, II-105, I-156
 - 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 10 μ V hysteresis, II-104
 - microvolt, dual limit, III-89

comparator (*con't.*)

microvolt, with hysteresis, III-88
monostable using, II-268
opposite polarity input voltage, I-155
oscillator, tunable signal, I-69
power supply overvoltage, glitches
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
variable hysteresis, I-149
voltage monitor and, II-104
window, III-87, III-90, II-106, I-152, I-
154, III-776-781
with hysteresis, I-157
with hysteresis, inverting, I-154
with hysteresis, noninverting, I-153
compass, 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
audio, II-44
hi-fi, de-emphasis, III-95
hi-fi, pre-emphasis, III-93
low-voltage, III-92
speech, II-2
variable slope, III-94
computalarm, I-2
computer circuit, III-96-108, II-113-122
8-bit uP bus interface, II-114
8048/IM80C48 8-char/16-seg ASCII
triplex LCD, II-116
buffered breakout box, II-120
clock phase lock, 20-MHz-to-Nubus, III-
105
CMOS data acquisition system, II-117
data separator for floppy disks, II-122
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
logic line monitor, III-108
long delay line, logic signals, III-107
microprocessor selected pulse width
control, II-116
multiple inputs detector, III-102
one-of-eight channel transmission

system, III-100
RGB blue box, III-99
RS-232 dataselector, automatic, III-97
RS-232-to-CMOS line receiver, III-102
RS-232C LED circuit, III-103
signal attenuator, analog,
microprocessor-controlled, III-101
socket debugger, coprocessor, III-104
speech synthesizer for, III-732
Vpp generator for EPROMs, II-114
XOR gate up/down counter, III-105
Z80 clock, II-121
computers
memory saving power supply for, II-486
power supply watchdog for, II-494
uninterruptible power supply for, II-462
constant-bandwidth amplifiers, III-21
constant-current charging time delay, II-
668
constant-current stimulator, III-352
constant-voltage, current limited charger,
I-115
contact switch, I-136
continuity tester, III-345, II-533, II-535,
III-538-540
adjustable audible, II-536
cable tester, III-539
PCB, II-342, II-535
continuous-tone 2kHz buzzer, I-11
contrast meter, II-447
automatic, I-472
control circuit
dc motor speed/direction, I-452
high Z input, hi-fi tone, I-676
hysteresis-free phase, I-373
tone, I-677
water-level sensing, I-389
controller, III-378-390
860 W limited range low cost precision
light, I-376
ac servo amplifier, bridge-type, III-387
boiler, I-638
built-in self timer, universal motor, I-451
dc motor speed, I-454
direction, series-wound motors, I-448
direction, shunt-wound motors, I-456
driver, motor, constant-speed, III-386
driver, motor, dc, speed-controlled
reversible, III-388
driver, motor, dc, with fixed speed
control, III-387
fan speed, III-382
feedback speed, I-447
floodlamp power, I-373
fluid level, I-387
full-wave SCR, I-375
heater, I-639
high power, sensitive contacts for, I-371

high quality tone, I-675
high torque motor speed, I-449
IC preamplifier with tone, I-673
induction motor, I-454
LED brightness, I-250
light-level, I-380
liquid level, I-388
load-dependent, universal motor, I-451
low loss brightness, I-377
model train or car, I-455
model train speed, I-453
motor speed, II-455, I-450, I-453
motor-speed, closed-loop, III-385
motor-speed, high-efficiency, III-390
motor-speed, switched-mode, III-384
motor-speed, tachless, III-386
on/off, I-665
power tool torque, I-458
PWM motor controller, III-389
PWM servo amplifier, III-379
PWM speed control/energy-recovering
brake, III-380
radio control motor speed, I-576
sensitive contact, high power, I-371
servo system, III-384
single-setpoint temperature, I-641
speed, shunt-wound motors, I-456
speed, feedback, I-447
speed, model train or car, I-455
speed, series-wound motors, I-448
speed, tools or appliances, I-446
start-and-run motor circuit, III-382
stepping motor drive, III-390
switching, III-383
temperature, I-641-643
temperature-sensitive heater, I-640
three-band active tone, I-676
three-channel tone, I-672
three-phase power-factor, II-388
universal motor speed, I-457
voltage-, pulse generator and, III-524
windshield wiper hesitation, I-105
windshield wiper, I-105
with buffer, active bass/treble tone, I-
674
conversion
negative input voltage, V/F, I-708
positive input voltage, V/F, I-707
converter, III-109-122, II-123-132, I-503
3-5 V regulated output, III-739
4-18 MHz, III-114
5V-to-isolated 5V at 20MA, III-474
5V/0.5A buck, I-494
8-bit A/D, III-44, I-46
8-bit D/A, I-240-241
8-bit successive approximation A/D, I-
47
8-bit tracking A/D, I-46

10 bit D/A, I-238
 10 Hz to 10kHz voltage/frequency, I-706
 12 V to 9, 7.5, or 6 V, I-508
 12-to-16 V, III-747
 14-bit binary D/A, I-237
 +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
 400 V, 60 W push pull dc/dc, I-210
 ac-to-dc, I-165
 analog-to-digital, III-22-26, III-22
 BCD to analog, I-160
 bipolar dc to dc, no inductor, II-132
 buck/boost, III-113
 calculator to stopwatch, I-153
 capacitance to pulse width, II-126
 current to voltage, I-162, I-165
 current to voltage, grounded bias and sensor, II-126
 D/A, II-179-181
 dc 10kHz frequency/voltage, I-316
 dc-dc, isolated +15V., III-115
 dc-dc regulating, III-121, I-211
 dc-dc, step up-step down, III-118
 dc-to-dc, 3-25 V, III-744
 digital frequency meter, frequency-to-voltage, I-317
 fast logarithmic, I-169
 fast precision A/D, I-49
 fast voltage output D/A, I-238
 fixed power supply, III-470
 flyback, I-211
 flyback, voltage, high-efficiency, III-744
 frequency, I-159
 frequency-to-voltage, I-318, III-219-220
 high impedance precision rectifier for ac/dc, I-164
 high speed 3-bit A/D, I-50
 high speed 8-bit D/A, I-240
 high-to-low impedance, I-41
 LCD display, 3 1/2 digit A/D, I-49
 light intensity to frequency, I-167
 low/frequency, III-111
 multiplexed BCD to parallel, I-169
 offset binary coding, 10-bit 4 quadrant multiplying D/A, I-241
 ohms to volts, I-168
 oscilloscope, I-471
 photodiode current to voltage, II-128
 pico ampere 70 voltage with gain, I-170
 PIN photodiode-to-frequency, III-120
 polarity, I-166
 positive-to-negative, III-112, III-113
 power voltage to current, I-163
 precision 12-bit D/D, I-242
 precision peak to peak ac-dc, II-127
 precision voltage to frequency, II-131
 pulse height-to-width, III-119
 pulse train-to-sinusoid, III-122
 pulse width-to-voltage, III-117
 regulated 15-Vout 6-V driven, III-745
 regulated dc to dc, II-125, I-210
 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
 self oscillating flyback, II-128, I-170
 shortwave, III-114
 simple frequency to voltage, I-318
 simple LF, I-546
 sine wave to square wave, I-170
 square-to-sine wave, III-118
 temperature-to-frequency, I-168
 temperature-to-time, III-632-633, III-632
 three-decade log A/D, I-48
 three-IC low cost A/D, I-50
 triangle to sine, II-127
 TTL square wave to triangle wave, II-125
 TTL-to-MOS logic, II-125, I-170
 two-wire to four-wire audio, II-14
 ultraprecision V/F, I-708
 unipolar-to-dual voltage supply, III-743
 VLF, I-547
 voltage ratio-to-frequency, III-116
 voltage, III-742-748, III-742
 voltage, offline, 1.5-W, III-746
 voltage-to-current, II-124, I-166
 voltage-to-current, zero IB error, III-120
 voltage-to-frequency, I-707, III-749-757
 voltage-to-frequency, 10 Hz-to-10KHz, III-110
 voltage-to-pulse duration, II-124
 wide range current to frequency, I-164
 zener regulated frequency to voltage, I-317
 coprocessor socket debugger, III-104
 countdown timer, II-680
 counter, III-123-130, II-133-139
 8-digit up/down, II-134
 10 MHz universal, II-139, I-255
 20 kHz ring, II-135
 100 MHz frequency, period, II-136
 analog circuit, II-137
 attendance, II-138
 binary, II-135
 CMOS programmable divide by N, I-257
 frequency, III-340, III-768
 frequency, 1.2 GHz, III-129
 frequency, 10-MHz, III-126
 frequency, low-cost, III-124
 frequency, preamp, III-128
 frequency, tachometer and, I-310
 geiger, I-536-537
 odd-number divider and, III-217
 preamplifier, oscilloscope/, III-438
 precision frequency, I-253
 programmable, low-power wide-range, III-126
 ring, incandescent lamp, I-301
 ring, low cost, I-301
 ring, SCR, III-195
 ring, variable timing, II-134
 universal, 40-MHz, III-127
 up/down, extreme count freezer, III-125
 up/down, XOR gate, III-105
 coupler
 CMOS, optical, III-414
 linear, ac analog, II-412
 linear analog, II-413
 linear, dc, II-411
 photon, II-412
 transmitter oscilloscope for CB signals, I-473
 TTL, optical, III-416
 courtesy light delay switch, automotive circuits, III-42
 courtesy light extender, III-50, I-98
 CRO doubler, III-439
 cross fader, II-312
 cross-hatch generator, color TV, III-724
 crossover network, 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
 crowbar
 electric, III-510
 electronic, II-99
 SCR, II-496
 simple, I-516
 crystal calibrator, 100 kHz, I-185
 crystal checker, I-178, I-186
 crystal controlled Butler oscillator, I-182
 crystal controlled sine wave oscillator, I-198
 crystal OF-1 HI oscillator, international, I-197
 crystal OF-1 LO oscillator, international, I-189
 crystal oscillator, III-131-140, II-140-151, I-180, I-183, I-185, I-198
 1 MHz FET, II-144
 10 MHz, II-141
 CMOS, III-134, I-187
 Colpitts, II-147
 crystal-controlled oscillator as, II-147

- crystal oscillator (*con't.*)
 - crystal-stabilized IC timer for subharmonic frequencies, II-151
 - crystal tester, II-151
 - doubler and, I-184
 - easy start-up, III-132
 - fundamental-frequency, III-132
 - high frequency, II-148, I-175
 - high frequency signal generator as, II-150
 - IC-compatible, II-145
 - JFET Pierce, I-198
 - LO for SSB transmitter controlled by, II-142
 - low-frequency-10 kHz to 150 kHz, II-146
 - low-frequency, I-184
 - low-noise, II-145
 - low-power 5V driven temperature compensated, II-142
 - marker generator, III-138
 - mercury cell crystal-controlled oscillator as, II-149
 - overtone, III-146, I-176, I-177, I-180
 - parallel-mode aperiodic, I-196
 - Pierce, II-144
 - Pierce, 1-MHz, III-134
 - 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
 - simple TTL, I-179
 - stable low frequency, I-198
 - standard, 1 MHz, I-197
 - temperature-compensated, III-137, I-187
 - third-overtone, I-186
 - TTL-compatible, I-197
 - tube-type, I-192
 - varactor tuned 10 MHz ceramic oscillator, II-141
 - VHF, 100-MHz, III-139
 - VHF, 20-MHz, III-138
 - VHF, 50-MHz, III-140
 - voltage-controlled, III-135
 - crystal-controlled oscillator, I-195
 - transistorized, I-188
 - crystal-controlled reflection oscillator, III-136
 - crystal switching, overtone oscillator with, I-183
 - crystal-stabilized IC timer for subharmonic frequencies, II-151
 - crystal tester, II-151
 - current analyzer, auto battery, I-104
 - current booster, I-30, I-35
 - current collector head amplifier, II-11, II-295
 - current limited charger, constant voltage, I-115
 - current meter, II-152-157
 - current sensing in supply rails, II-153
 - electrometer amplifier with overload protection, II-155
 - guarded input pico ammeter circuit, II-156
 - pico ammeter, II-154, II-157
 - six decade range ammeter, II-153, II-156
 - current monitor, I-203
 - Hall-effect circuit, III-255
 - current monitor/alarm, III-338
 - current readout, rf, I-22
 - current sensing, supply rails, II-153
 - current sink, precision, I-206
 - current source, I-205
 - bilateral, III-469, I-694-695
 - constant, safe, III-472
 - current, I-697
 - inverting bipolar, I-697
 - noninverting bipolar, I-695
 - precision, I-205
 - precision, 1mA to 1mA, I-206
 - regulator and, variable power supply, III-490
 - voltage-controlled, grounded source/load, III-468
 - current-limiting coil drivers, III-173
 - current-shunt amplifiers, III-21
 - current-to-frequency converter, 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, FET, I-397
 - CW radio
 - filter, razor sharp, II-219
 - transmitter, 1-W, III-678
 - transmitter, 40-M, III-684
 - transmitter, 902-MHz, III-686
 - transmitter, QRP, III-690
 - cyclic A/D converter, II-30
- ## D
- darkroom timer, I-480
 - darkroom enlarger timer, III-445
 - data acquisition
 - CMOS system for, II-117
 - four channel, I-421
 - high speed system for, II-118
 - data link, IR type, I-341
 - data read circuit, 5MHz phase-encoded, II-365
 - data selector, RS-232, III-97
 - data separator floppy disk, II-122
 - dc adapter/transceiver, hand-held, III-461
 - dc generators, high-voltage, III-481
 - dc lamp dimmer, II-307
 - dc linear coupler, II-411
 - dc motor speed control, II-380
 - dc restorer, video, III-723
 - dc servo drive, bipolar control input, II-385
 - dc-stabilized fast amplifiers, III-18
 - dc static switch, II-367
 - dc-to-dc converter
 - 3-25V, III-744
 - bipolar, no inductor, II-132
 - dual output +/- 12-15V, III-746
 - isolated +15V, III-115
 - regulated, III-121, II-125
 - step up/step down, III-118
 - dc to dc SMPS variable 18 to 30 V out at 0.2A power supply, II-480
 - debouncer, switch, III-592
 - debugger, coprocessor sockets, III-104
 - decibel level detector, audio, with meter driver, III-154
 - decoder, III-141-145, II-162
 - 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, III-166, III-170, I-214
 - 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, III-143, I-231
 - tone, dual time constant, II-166
 - tone, relay output, I-213
 - delay circuit, III-146-148
 - adjustable, III-148
 - headlights, II-59
 - leading-edge, III-147
 - precision solid state, I-664
 - pulse, dual-edge trigger, III-147
 - delayed-action windshield wiper control, II-55
 - delayed pulse generator, II-509

delay relay, ultra-precise long time, II-211
 delay unit
 door chimes, I-218
 headlight, I-107
 long duration time, I-220
 long time, I-217
 simple time, II-220, I-668
 universal wiper, I-97
 demodulator, III-149-150, II-158-160
 5V FM, I-233
 12V FM, I-233
 565 SCA, III-150
 AM, II-160
 chroma, with RGB matrix, III-716
 FM, II-161
 linear variable differential transformer driver, I-403
 LVDT circuit, III-323-324, III-323
 LVDT driver and, II-337
 narrow band FM, carrier detect in, II-159
 stereo, II-159
 telemetry, I-229
 demonstration comparator circuit, II-109
 demultiplexer, III-394
 descrambler, II-162
 gated pulse, II-165
 outband, II-164
 sine wave, II-163
 detect and hold, peak, I-585
 detection switch, adjustable light, I-362
 detector (*see also* alarms; sensors), III-151-162, II-171-178
 air flow, I-235, II-240-242
 air motion, I-222, III-364
 amplifier, four quadrant photoconductive, I-359
 angle of rotation, II-283
 bug, III-365
 circuit for, video IF amplifier/low level video, I-687-689
 decibel level, audio, with meter driver, III-154
 double ended limit, I-230, I-233
 edge, III-157, I-226
 electrostatic, III-337
 envelope, precision, III-155
 flame, III-313
 flow, III-202-203, III-202
 flow, low-rate thermal, III-203
 fluid and moisture, III-204-210, II-243-248
 frequency limit, II-177
 frequency window, III-777
 frequency, digital, III-158
 frequency-boundary, III-156
 gas, III-246-253, II-278
 gas and smoke, I-332
 gas and vapor, II-279
 high frequency peak, II-175
 high speed peak, I-232
 infrared, III-276, II-289
 IR, long-range objects, III-273
 level, II-174
 level, with hysteresis, I-235
 light interruption, I-364
 light level, III-316
 line-current, optically coupled, III-414
 liquid level, I-388, I-390
 low-light level drop, III-313
 low line loading ring, I-634
 low voltage, I-224
 magnetic transducer, I-233
 MC1330/MC1352 television IF amplifier in, I-688
 metal, II-350-352
 missing pulse, III-159, I-232
 moisture, I-442
 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
 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, positive, III-169
 peak, wide-bandwidth, III-162
 peak, wide-range, III-152
 pH level, probe and, III-501
 phase, III-440-442
 phase, 10-bit accuracy, II-176^o
 positive peak, I-225, I-235
 power loss, II-175
 precision peak voltage, I-226
 precision photodiode level, I-365
 product, I-223, I-861
 proximity, II-135, II-136, I-344
 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
 Schmitt trigger, III-153
 smoke, III-246-253, II-278
 smoke, ionization chamber, I-332-333
 smoke, operated ionization type, I-596
 smoke, photoelectric, I-595
 speech activity on phone lines, III-615, II-617
 telephone ring, III-619
 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
 ultra-low drift peak, I-227
 voltage level, I-8, II-172
 window, I-235, III-776-781
 zero crossing, II-173, I-732, I-733
 zero crossing, with temperature sensor, I-733
 dial pulse indicator, telephone, III-613
 dialer
 pulse-dialing telephone, III-610
 pulse/tone, single-chip, III-603
 telephone-line powered repertory, I-633
 tone-dialing telephone, III-607
 dice, electronic, III-245, I-325
 differential amplifier, I-38
 high impedance, I-27, I-354
 high input high impedance, II-19
 instrumentation, 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, II-365, I-589
 differential-input A/D system, II-31
 differential-input instrumentation amplifier, I-347, I-354
 high gain, I-353
 variable gain, I-349
 differential-input voltage-to-frequency converter, III-750
 differential-to-single-ended voltage amplifier, III-670
 differential multiplexer
 demultiplexer/, I-425
 wide band, I-428
 differential thermometer, III-638, II-661
 differential voltage or current alarm, II-3
 differentiator, 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 oscillator, resistance controlled, II-426
 digital tachometer, II-61
 digital temperature measuring circuit, II-653

digital theremin, II-656
 digital thermocouple thermometer, II-658
 digital thermometer, Kelvin, zero adjust, II-661
 digital transmission isolator, II-414* digital voltmeter
 3.5-digit, full-scale, four-decade, III-761
 4.5-digit, III-760
 digital-to-analog converter, III-163-169, II-179-181, I-241
 0 to -5V output, resistor terminated, I-239
 8-bit, I-240
 8-bit, output current to voltage, I-243
 10-bit, I-238
 +10V full scale bipolar, I-242
 +10V full scale unipolar, I-244
 12-bit, variable step size, II-181
 14-bit binary, I-237
 16-bit binary, I-243
 binary twos complement, 12-bit, III-166
 CMOS, 9-bit, III-167
 fast voltage output, I-238
 high speed 8-bit, I-240
 high speed voltage output, I-244
 multiplying, III-168
 offset binary coding, 10-bit 4 quadrant multiplying, I-241
 output amplifier, four-channel, III-165
 precision 12-bit, I-242
 three-digit BCD, I-239
 two 8-bit to 12-bit, II-180
 digitally controlled amplifier/attenuator, I-53
 digitally programmable attenuators, III-30
 digitally selectable precision attenuator, I-52
 digitally tuned low power active filter, II-218
 digitizer, tilt meter, III-644-646, III-644
 dimmer, II-309
 800 W soft start light, I-376
 800 W triac light, I-375
 800 W, II-309
 dc lamp, II-307
 halogen lamps, III-300
 headlight, II-57
 headlight, automatic, II-63
 light, I-369
 low cost, I-373
 soft-start, 800-W, III-304
 tandem, II-312
 triac, III-303, II-310
 diode checker, zener, I-406
 diode emitter driver, pulsed infrared, II-292
 diode tester, II-343, III-402
 go/no-go, I-401
 diodeless rectifier, precision, III-537
 dip meter, II-182-183, I-247
 basic grid, I-247
 dual gate IGFET, I-246
 little dipper, II-183
 varicap tuned FET, I-246
 direction detector decoder, III-144
 direction-of-rotation circuit, III-335
 directional signals monitor, auto, III-48
 discharge current stabilizer, laser, II-316
 disco strobe light, II-610
 discrete current booster, II-30
 discrete sequence oscillator, III-421
 discriminator
 multiple-aperture, window, III-781
 pulse amplitude, III-356
 pulse width, II-227
 window, III-776-781, III-776
 display circuit, III-170-171, II-184-188
 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
 exclamation point, II-254
 expanded scale meter, dot or bar, II-186
 LED bar graph driver, II-188
 LED matrix, two-variable, III-171
 display fluorescent, II-185
 brightness control, III-316
 comparator and, II-105
 oscilloscope, eight-channel voltage, III-435
 dissolver, lamp, solid-state, III-304
 distribution circuits, II-35
 distribution amplifier
 audio, II-39, I-39
 signal, I-39
 divider
 binary chain, I-258
 decade frequency, I-259
 frequency, III-213-218, II-254, I-258
 frequency, divide-by-1 1/2, III-216
 low frequency, II-253
 mathematical, one trim, III-326
 odd-number counter and, III-217
 pulse, non-interger programmable, III-226, II-511
 Dolby B noise reduction circuit
 decode mode, III-401
 encode mode, III-400
 Dolby B/C noise reduction circuit, III-399
 door bell, I-443
 rain alarm, I-443
 sliding tone, II-34
 door chimes delay, I-218
 door open alarm, III-46, II-284
 Hall-effect circuit, III-256
 door opener, III-366
 dot expanded scale meter, II-186
 double ended limit comparator, II-105
 double frequency output, oscillator, I-314
 double-sideband suppressed-carrier modulator, III-377
 double-sideband, suppressed-carrier rf, II-366
 doubler
 150 to 300 MHz, I-314
 broadband frequency, I-313
 CRO, oscilloscope, III-439
 crystal oscillator, I-184
 frequency, III-215, I-313
 frequency, digital, III-216
 frequency, single-chip, III-218
 low-frequency, I-314
 to 1 MHz, II-252
 voltage, III-459
 voltage, triac-controlled, III-468
 downbeat-emphasized metronome, III-353-354
 drive circuits, III-172-175
 coil, current-limiting, III-173
 line-synchronized, III-174
 RS-232C, low-power, III-175
 totem-pole, with bootstrapping, III-175
 two-phase motor, I-456
 drive interface of triac, direct dc, I-266
 driver, II-189-193, I-260
 10 MHz coaxial line, I-560
 50 ohm, I-262
 BIFET cable, I-264
 bridge loads, audio circuits, III-35
 capacitive load, I-263
 coaxial cable, I-266
 CRT deflection yoke, I-265
 fiber optic, 50-Mb/s, III-178
 five-transistor pulse booster for coax, II-191
 flash slave, I-483
 glow plug, II-52
 high impedance meter, I-265
 high speed laser diode, I-263
 instrumentation meter, II-296
 indicator lamp, optically coupled, III-413
 lamp, I-380
 lamp, short-circuit proof, II-310
 LED bar graph, II-188
 line signals, 600-ohm balanced, II-192
 line, 50-ohm transmission, II-192
 line, I-262
 line, full rail excursions in, II-190
 load, timing threshold and, III-648
 low frequency lamp flasher/relay, I-300
 LVDT demodulator and, III-323-324, II-337
 meter-driver rf amplifier, 1-MHz, III-545

microprocessor triac array, II-410
motor, constant-speed, III-386
motor, dc, speed-controlled reversible, III-388
motor, dc, with fixed speed control, III-387
motor, stepping, III-390
multiplexer, high speed line, I-264
neon lamp, I-379
optoisolated, high-voltage, III-482
pulsed infrared diode emitter, II-292
relay, I-264
relay, delay and controls closure time, II-530
relay, with strobe, I-266
shift register, I-418
solenoid, I-265, III-571-573
SSB, low distortion 1.6 to 30MH, II-538
stepping motor, II-376
driver demodulator, linear variable differential transformer, I-403
drum sound effect, II-591
dual-edge trigger pulse delay, III-147
dual-limit microvolt comparator, III-89
dual-output over/under temperature monitor, II-646
dual-time constant tone decoder, II-166
dual-tone decoding, II-620
dual-tracking regulator, III-462
duplex line amplifier, III-616
duty cycle monitor, III-329
duty-cycle multivibrator, 50-percent, III-584
duty-cycle oscillator
50-percent, III-426
variable, fixed-frequency, III-422
DVM
3 3/4 digit, I-711
auto-calibrate circuit, I-714
automatic nulling, I-712
common anode display, 3 1/2 digit, I-713
four 1/2 digit LCD, I-717
interface and temperature sensor, II-647
dwell meter
breaker point, I-102
digital, III-45
dynamic ac-coupled amplifiers, III-17

E

easy start-up crystal oscillator, III-132
eavesdropper, telephone, wireless, III-620
edge detector, III-157, I-226
EEPROM pulse generator, 5V-powered, III-99
eight channel mux/demux system, III-115

eight-bit uP bus interface, II-114
eight-digit up/down counter, II-134
EKG simulator, three-chip, III-350
elapsed time timer, II-680
electric fence charger, II-202
electric vehicle battery saver, III-67
electrometer amplifier, overload protected, II-155
electronic bell, II-33
electronic-circuit breaker, high speed, II-96
electronic combination lock, II-196
electronic crossover circuit, II-36
electronic crowbar, II-99, I-515
electronic dice, III-245
electronic flash trigger, II-448
electronic light flasher, II-228
electronic lock, II-194-197
combination, II-196
three-dial combination, II-195
electronic music, III-360
electronic roulette, II-276
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
emissions analyzer, automotive exhaust, II-51
emitter-coupled big loop oscillator, II-422
emitter-coupled RC oscillator, II-266
emulator, II-198-200
capacitance multiplier, II-200
JFET ac coupled integrator, II-200
resistor multiplier, II-199
simulated inductor, II-199
encoder,
decoder and, III-14
telephone handset tone dial, III-613, I-634
tone dial, I-629
tone, I-67
tone, two-wire, II-364
engine tachometer, I-94
enlarger timer, III-445, II-446
envelope detectors, precision, III-155
EPROM, V_{pp} generator for, II-114
equalizer, I-671
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 meter
analog, III-774
dot or bar, II-186

expander circuits, III-91-95
hi-6, II-13
extended-play circuit, tape-recorders, III-600
extractor, square-wave pulse, III-584
extreme count freezing up/down counter, III-125

F

fail-safe semiconductor alarm, III-6
fans, speed controller, automatic, III-382
Fahrenheit thermometer, I-658
fast and precise sample and hold circuit, II-556
fast dc-stabilized amplifiers, III-18
fault monitor, single-supply, III-495
feedback oscillator, I-67
fence charger, II-201-203
battery-powered, II-202
electric, II-202
solid-state, II-203
FET dual-trace scope switch, II-432
FET input amplifier, II-7
FET probe, III-501
FET voltmeter, III-765, III-770
fiber optics, III-176-181, II-204-207
dc variable speed motor control via, II-206
half duplex information link, I-268
high sensitivity, 30nW, I-270
interface for, II-207
LED driver, 50-Mb/s, III-178
link, III-179, I-269
low sensitivity, 300nW, I-271
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
transmitter, III-177
very high sensitivity, low speed, 3nW, I-269
field disturbance sensor/alarm, II-507
field strength meter, III-182-183, II-208-212
1.5- 150 MHz, I-275
adjustable sensitivity indicator, I-274
high sensitivity, II-211
LF or HF, II-212
low cost microwave, I-273
rf sniffer, II-210
sensitive, III-183, I-274

- field strength meter (*con't.*)
 - transmission indicator, II-211
 - tuned, I-276
 - version II, II-209
 - VOM, I-276
- fifth order Chebyshev multiple feedback
 - low pass filter, II-219
- five-overtone oscillator, I-182
- filter circuits, III-184-192, II-213-224
 - 0.1 to 10 Hz bandpass, I-296
 - 1.0 kHz, multiple feedback bandpass, I-297
 - 1kHz bandpass active, I-284
 - 1kHz, Q/10, second order state variable, I-293
 - 4.5 MHz notch, I-282
 - 10kHz Sallen-Key low pass, I-279
 - 20 kHz bandpass active, I-297
 - 160 Hz bandpass, I-296
 - 300 Hz 3kHz bandpass, speech, I-295
 - 500 Hz Sallen-Key bandpass, I-291
 - active, band reject, II-401
 - active, bandpass, III-190, II-221, II-223
 - active, digitally tuned low power, II-218
 - active, low pass, digitally selected break frequency, II-216
 - active, low-power, digitally selectable center frequency, III-186
 - active, programmable, III-185
 - active, RC, up to 150 kHz, I-294
 - active, state-variable, III-189
 - audio, biquad, III-185
 - bandpass, II-222
 - bandpass, active, with 60dB gain, I-284
 - bandpass, and notch, II-223
 - bandpass, Chebyshev, fourth-order, III-191
 - bandpass, multiple feedback, II-224
 - bandpass, second-order biquad, III-188
 - bandpass, state variable, I-290
 - biquad RC active bandpass, I-285
 - biquad, I-292-293
 - CW, razor-sharp, II-219
 - digitally tuned low power active, I-279
 - equal component Sallen-Key low pass, I-292
 - fifth order Chebyshev multiple feedback low pass, II-219
 - five pole active, I-279
 - fourth order high pass Butterworth, I-280
 - full wave rectifier and averaging, I-229
 - high pass, I-296
 - high pass, active, I-296
 - high-pass, Chebyshev, fourth-order, III-191
 - high-pass, sixth-order elliptical, III-191
 - high pass, wideband two-pole, II-215
 - high Q bandpass, I-287
 - high Q notch, I-282
 - low pass, I-287
 - low pass, precision, fast settling, II-220
 - MFB bandpass, multichannel tone decoder, I-288
 - multiple feedback bandpass, I-285
 - networks of, I-291
 - noise, dynamic, III-190
 - noisy signals, III-188
 - notch and bandpass, II-223
 - notch, I-283, II-397, III-402-404
 - notch, high-Q, III-404
 - notch, twin-T, III-403
 - pole active low pass, I-295
 - programmable, twin-T bridge, II-221
 - rejection, I-283
 - rumble, III-192
 - rumble, LM387 in, I-297
 - rumble/scratch, III-660
 - Sallen-Key second order LO pass, I-289
 - scratch, III-189
 - scratch, LM287 in, I-297
 - second order high pass active, I-297
 - selectable bandwidth notch, I-281
 - state variable, II-215
 - state-variable, multiple outputs, III-190
 - three amplifier active, I-289
 - three amplifier notch, I-281
 - tunable active, I-294
 - tunable notch, hum suppressing, I-280
 - turbo, glitch free, III-186
 - universal active, II-214
 - universal state variable, I-290
 - Wien-bridge, III-659
 - variable bandwidth bandpass active, I-286
 - voltage-controlled, III-187
 - filtered sample-and-hold circuits, III-550
 - five-transistor pulse booster for coaxial cable, II-191
 - fixed pnp regulator, zener diode to increase voltage output of, II-484
 - fixed power supplies, III-457-477
 - 12-VDC battery-operated 120-VAC, III-464
 - bilateral current source, III-469
 - charge pool, III-469
 - constant-current source, safe, III-472
 - converter, III-470
 - converter, 5V-to-isolated 5V at 20MA, III-474
 - dc adapter/transceiver, hand-held, III-461
 - dual-tracking regulator, III-462
 - general-purpose, III-465
 - isolated feedback, III-460
 - linear regulator, low cost, low dropout, III-459
 - low-power inverter, III-466
 - programmable, III-467
 - rectifier, low forward-drop, III-471
 - 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
 - switching power supply, III-458
 - switching, 50-W off-line, III-473
 - 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 active, I-289
 - fixed-frequency variable duty-cycle oscillator, III-422
 - flame ignitor, III-362
 - flame monitor, III-313
 - flash exposure meter, I-484
 - flash meter, III-446
 - flash slave driver, I-483
 - flash trigger
 - electronic, II-448
 - remote, I-484
 - sound, II-449
 - xenon flash, slave, III-447
 - flashers and blinkers, III-193-210, II-225
 - 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, II-227, I-307
 - 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

- emergency lantern, I-308
- flash light, 60-W, III-200
- 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
- lamp, III-201
- lamp, low current consumption, II-231
- lamp, low voltage, II-226
- lamp, series SCR, wide load range, II-230
- LED, alternating, III-198, III-200
- LED, PUT used in, II-239
- LED, ring-around, III-194
- LED, three-year, III-194
- LED, UJT used in, II-231
- light control and, I-304
- light, electronic, II-228
- light, miniature transistorized, II-227
- low voltage, I-305
- minimum component, III-201
- 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
- relay driver, low frequency lamp, I-300
- SCR, III-197
- SCR chaser, III-197
- SCR relaxation, II-230
- SCR ring counter, III-195
- sequential ac, II-238
- sequential, II-233
- single-lamp, III-196
- transistorized, III-200, I-303
- transistorized, table of, II-236
- variable, I-308
- flashlight finder, I-300
- flip-flop
 - astable, with starter, II-239
 - flasher circuit, 1 kW, use of, II-234
 - inverter, III-103
 - SCR, II-367
- flood alarm, III-206, I-390
- flow detector, III-202-203, II-240-242
 - air, II-242
 - low-rate thermal, III-203
 - thermally based anemometer, II-241
- flowmeter, liquid, II-248
- fluid and moisture detector, III-204-210, II-243-248
 - acid rain monitor, II-245
 - flood alarm, III-206
 - fluid-level control, III-205
 - liquid flow meter, II-248
 - liquid-level checker, III-209
 - liquid-level monitor, III-210
 - liquid-level, dual, III-207
 - plant water, II-245
 - plant water gauge, II-248
 - rain warning bleeper, II-244
 - single chip pump controller, II-247
 - soil moisture, III-208
 - temperature monitor, III-206
 - water-level, III-206
 - water-level indicator, II-244
 - water-level sensing and control, II-246
- fluid-level controller, III-205, I-387
- fluid level sensor for cryogenics, I-386
- fluid watcher, windshield washer, I-107
- fluorescent display, vacuum, II-185
- fluorescent lamp inverter, 8-W, III-306
- flyback converter, I-211
 - self oscillating, II-128, I-170, III-748
 - voltage, high-efficiency, III-744
- flyback regulator, off-line, II-481
- FM (PRM) optical transmitter, I-367
- FM carrier current remote speaker system, I-140
- FM demodulator, II-161
 - 12 V, I-233
 - 5 V, I-233
- FM IF amplifier with quadrature detector, TV sound IF, I-690
- FM generators, low-frequency, III-228
- FM MPX/SCA receiver, III-530
- FM narrow-band receiver, III-532
- FM optical transmitter/receiver, 50 kHz, I-361
- FM radio, I-545
- FM receivers
 - carrier-current circuit, III-80
 - zero center indicator, I-338
- FM snooper, III-680
- FM squelch circuit for AM, I-547
- FM stereo demodulation system, I-544
- FM transmitter
 - multiplex, III-688
 - one-transistor, III-687
 - optical, 50 kHz center frequency, II-417
 - simple, I-681
- FM tuner, I-231, III-529
- FM voice transmitter, III-678
- FM wireless microphone, III-682, III-685, III-691
- FM/AM clock radio, I-543
- foldback current, HV regulator limiting, II-478
- followers, III-211-212
 - inverting, high-frequency, III-212
 - noninverting, high-frequency, III-212
 - simple, III-212
 - source, photodiode, III-419
 - unity gain, I-27
- voltage, III-212
- forward-current booster, III-17
- four-channel commutator, II-364
- four-channel comparator, III-90
- four-channel mixer, I-60, III-369
 - four track, II-40
 - high level, I-56
- four-channel multiplexer, III-394
- four-decade variable oscillator, single control for, II-424
- four-digit (10,000 count) A/D converter, II-25
- four-input stereo mixer, I-55
- four-track four-channel mixer, II-40
 - free running multivibrator, 100 kHz, I-465
- free-running multivibrators, programmable-frequency, III-235
- freezer, voltage, III-763
- freezer meltdown alarm, I-13
- frequency comparator, II-109
 - LED, II-110
- frequency control, telephone, II-623
- frequency converter, I-159
- frequency counter
- frequency counter, III-340, III-768
 - 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 detector, digital, III-158
- frequency divider, II-251, II-254, I-258
 - decade, I-259
 - low, II-253
- frequency division multiplex stereo decoder, II-169
- frequency doubler, I-313
 - broadband, I-313
- frequency generators, fixed-frequency, III-231
- frequency indicator, beat, I-336
- frequency inverters, variable frequency, complementary output, III-297
- frequency limit detector, II-177
- frequency meter, II-249-250
 - audio, I-311
 - linear, I-310
 - low cost, II-250
 - power, II-250
 - power-line, I-311
- frequency multipliers/dividers, III-213-218, II-251
 - counter, odd-number, III-217

divide-by-1 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 synthesizer, programmable
voltage controlled, II-265
frequency-to-voltage converter, III-219-
220, II-255-257, I-318
dc-10kHz, I-316
simple, I-318
zener regulated, I-317
FSK data, receiver, III-533
FSK decoder, 10.8MHz, I-214
FSK generators, low-cost, III-227
full-wave rectifier
absolute value, II-528
precision, I-234, III-537
function generator, III-221-242, III-258-
274, II-271, I-729
555 astable, low duty cycle, II-267
astable multivibrator, III-233, III-238,
II-269
astable multivibration, op amp, III-224
astable multivibrators, programmable-
frequency, III-237
basic, III-240
complementary signals, XOR gate, III-
226
emitter-coupled RC oscillator, II-266
fixed-frequency, III-231
FM, low-frequency, III-228
free-running multivibrator,
programmable-frequency, III-235
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 ampli-
fier and comparator, II-268
multiplying pulse width circuit, II-264
multivibrator, low-frequency, III-237
multivibrator, single-supply, III-232
one-shot, precision, III-222
one-shot, retriggerable, III-238

oscillator/amplifier, wide frequency
range, II-262
precise wave, II-274
pulse divider, noninteger, programma-
ble, III-226
pulse, 2-ohm, III-231
quad op amp, four simultaneous syn-
chronized 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
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
fundamental-frequency crystal oscillator,
III-132
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, III-243-245, II-275-277
coin flipper, III-244
electronic dice, III-245
electronic roulette, II-276
lie detector, II-277
who's first, III-244

garage stop light, II-53
gas analyzer, II-281
gas detector, II-278-279
analyzer and, II-281
toxic, II-280
gas/smoke detectors, III-246-253, III-246
furnace exhaust, temp monitor/low-
supply detection, III-248
methane concentration, linearized
output, III-250
SCR, III-251
smoke/gas/vapor detector, III-250
gated oscillator, last-cycle completing, III-
427
gated pulse descrambler, II-165
Geiger counter, I-536-537
high voltage supply for, II-489
pocket-sized, II-514
gel cell charger, II-66
generator
10.7 MHz sweep, I-472
audio sine wave, II-564
audio, sine-wave oscillator, III-559
audio, one-IC, II-569
battery-powered, high-voltage, III-482
burst (*see* burst generator)
cross-hatch, color TV, III-724
DAC controlled function, I-722
dc, high-voltage, III-481
function (*see* function generator)
harmonic, I-24
high-voltage, capacitor-discharge, III-
485
linear voltage ramp, I-539
low cost adjustable function, I-721
musical chime, I-640
musical envelope, modulator and,
I-601
noise, I-468
oscillator/clock, I-615
portable tone, I-625
precision clock, I-193
precision ramp, I-540
programmable pulse, I-529
programmed function, I-724
pulse (*see* pulse generator)
pulse, single, II-175
ramp (*see* ramp generator)
ramp, variable reset level, I-540
signal, high frequency, III-150
sound effect, III-575, II-586, I-605
sound: sirens, warblers, wailers, III-
560-568, III-560
square wave (*see* square wave genera-
tor)
staircase (*see* staircase generator)
staircase, I-539
strobe-tone burst, I-721

time delay, I-217-218
tone burst, I-604
tone dial, I-629
tone, warbling, II-573
Touchtone, telephone, III-609
triangle and square waveform, I-726
two-tone, II-570
ultra high voltage, II-488
unijunction transistor pulse, I-530
versatile two-phase pulse, I-532
very low frequency, I-64
generator circuit, noise, I-469
generator test circuit, frequency shift
keyer tone, I-723
glitches, comparator to detect, II-107
glow plug driver, II-52
graphic equalizer, ten-band, active filter
in, II-684
ground tester, II-345
ground-noise probe, battery-powered, III-
500
guarded input pico ammeter circuit, II-156
guitar, treble boost for, II-683
guitar 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 rectifier, I-230, III-528
fast, I-228
Hall-effect circuits, III-254-258, II-282-
284
-angle of rotation detector, II-283
compass, III-258
current monitor, III-255
door open alarm, II-284
security door-ajar alarm, III-256
switches using, III-257
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 generator, I-24, III-228
HC-based oscillators, III-423
HCU/HTC-based oscillator, III-426
headlight alarm, III-52
headlight delay unit, III-49, I-107
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 control, I-639
temperature sensitive, I-640
heater element temperature control, II-
642
heater protector, servo-sensed, III-624
hee-haw siren, III-565, II-578
HF or LF field strength meter, II-212
hi-fi compander, II-12
hi-fi compressor, pre-emphasis and, III-93
hi-fi expander, II-13
de-emphasis, III-95
hi-fi tone control circuit, high Z input, I-
676
high drive oscillator/flasher, II-235
high-frequency amplifiers, III-259-265
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 crystal oscillator, II-148
high-frequency oscillator, III-426
high-frequency peak detector, II-175
high-frequency signal generator, II-150
high-input-high impedance 20 dB amplifier
micropower, II-44
high-input impedance differential amplifier,
II-19
high-isolation telephone ringer, II-625
high-level preamp and tone control, II-688
high-output 600-ohm line driver, II-193
high-pass filter
Chebyshev fourth-order, III-191
sixth-order elliptical, III-191
wideband two-pole, II-215
high-performance sample and hold, II-557
high-performance video switch, III-728
high-power battery operated flasher, II-
229
high-power siren, II-578
high-Q notch filter, III-404
high-sensitivity field strength meter, II-
211
high-speed 12-bit A/D converter, II-29
high-speed data acquisition system, II-118
high-speed electronic circuit breaker, II-96
high-speed paper tape reader, II-414
high-speed sample-and-hold circuits, III-
550

high-voltage power supply, III-478-486, II-
490
arc-jet power supply, starting circuit,
III-479
battery-powered generator, III-482
bucking regulator, III-481
dc generator, III-481
generator, capacitor-discharge, III-485
inverter, III-484
optoisolated driver, III-482
preregulated, III-480
regulator, III-485
simple design, III-483
solid-state, remote adjustable, III-486
high/low level comparator, one op amp, II-
108
high/low temperature sensor, II-650
hold button, telephone, 612m II-628
home security 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, III-266-267, II-285-287
HV regulator, foldback current limiting, II-
478
hybrid power amplifier, III-455

I

IC timer, crystal-stabilized, subharmonic
frequencies for, II-151
IC-compatible crystal oscillator, II-145
ice alarm, automotive, II-57
ice formation alarm, II-58
ice warning and lights reminder, I-106
ICOM IC-2A battery charger, II-65
ignition substitute automotive circuits, 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), III-268-270
adjustable sensitivity field strength, I-
274
alarm and, I-337
battery charge/discharge, I-122
battery condition, I-121
battery level, I-124
battery threshold, I-124
beat frequency, I-336

- indicators (*cont.*)
 - dial pulse, III-613
 - five step voltage level, I-337
 - lamp driver, optically coupled, III-413
 - low battery, I-124
 - low-voltage, III-769
 - 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-actuated relay, III-270
 - simulated, I-417
 - solid state battery voltage, I-120
 - stereo reception, III-269
 - SWR warning, I-22
 - telephone off-hook, I-633
 - ten-step voltage level, I-335
 - three step level, I-336
 - undervoltage, battery operated equipment, I-123
 - visible voltage, I-338
 - visual modulation, I-430
 - visual level, III-269
 - voltage, III-758-772, III-758
 - voltage, visible, III-772
 - voltage-level, I-718, III-759
 - zero center, FM receivers, I-338
- in-use indicator, telephone, II-629
- induction heater, ultrasonic, 120-KHz 500-W, III-704
- inductor
 - active, I-417
 - simulated, II-199
- infinite sample and hold, amplifier for, II-558
- infrared circuit, III-271-277, II-288-292
 - detector of IR, III-276
 - diode emitter drive, pulsed, II-292
 - laser rifle, invisible pulsed, II-291
 - long-range object detector, III-273
 - low noise detector for, II-289
 - receiver, III-274, II-292
 - transmitter, III-274, III-276, III-277, II-289, II-290
 - transmitter, digital, III-275
 - wireless speaker system, III-272
- infrared detector, low noise, II-289
- infrared receiver, II-292
- infrared transmitter, II-289, II-290
- injector-tracer, I-522
 - single, II-500
 - signal, I-521
- input selector
 - audio, low distortion, II-38
- input-buffered mixer, III-369
- input/output buffer, analog multiplexers, III-11
- instrumentation amplifier, III-278-284, II-293-295, I-346, I-348, I-349, I-352
 - +/-100 volt common mode range, III-294
 - current collector head amplifier, II-295
 - differential, III-283
 - differential, biomedical, III-282
 - differential, input, I-354
 - high gain differential, I-353
 - high impedance low drift, I-355
 - high speed, I-354
 - low signal level/high impedance, I-350
 - low-power, III-284
 - meter driver, II-296
 - pre-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
- integrated solid state relay, II-408
- integrator, III-285-286, II-297-300
 - 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 and, initial condition reset, III-527
 - resettable, III-286
- intercom, III-287-292, II-301-303, I-415
 - bidirectional, III-290
 - carrier current, I-146
 - hands-off, III-291
 - party-line, II-303
 - pocket pager, III-288
 - two-way, III-292
- interface
 - 680x, 650x, 8080 families, III-98
 - cassette-to-telephone, III-618
 - DVM, temperature sensor and, II-647
 - fiber optic, II-207
 - optical sensor-to-TTL, III-314
 - precision process control, I-30
 - tape recorder, II-614
- interrupter, ground fault, I-580
- interval timer, low power microprocessor
 - programmable, II-678
- inverter, III-293-298
 - dc to dc/ac, I-208
 - fast, I-422
 - flip-flop, III-103
 - fluorescent lamp, 8-W, III-306
 - high-voltage, III-484
 - 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
 - ultrasonic, arc welding, 20 KHz, III-700
 - variable frequency, complementary output, III-297
 - voltage, precision, III-298
- inverting amplifier, III-14, I-41-42
 - balancing circuit in, I-33
 - low power, digitally selectable gain, II-333
 - programmable-gain, III-505
 - wideband unity gain, I-35
- inverting buffer, active integrator using, II-299
- inverting comparator, hysteresis in, I-154
- inverting followers, high-frequency, III-212
- inverting power amplifier, I-79
- inverting sample-and-hold, III-552
- inverting unity gain amplifier, I-80
- IR link, remote loudspeaker via, I-343
- IR receiver, compact, I-342
- IR remote control transmitter/receiver, I-342
- IR transmitter, I-343
- IR type data link, I-341
- isolated feedback power supply, III-460
- isolation amplifier
 - capacitive load, I-34
 - level shifter, I-348
 - medical telemetry, I-352
 - rf, II-547
- isolation and zero voltage switching logic, II-415
- isolator
 - digital transmission, II-414
 - stimulus, III-351

J

JFET ac coupled integrator, III-200

K

Kelvin thermometer, I-655
zero adjust, III-661

- keyer
 - automatic TTL morse code, I-25
 - electronic, I-20
- L**
- lamp-control circuits, II-304-312
 - 800 W dimmer, II-309
 - audio-controlled, I-609
 - automatic light controller for carport, II-308
 - cross fader, II-312
 - dimmer, II-309
 - dimmer, dc, II-307
 - dimmer, soft-start, 800-W, III-304
 - dimmer, triac, III-303, II-310
 - dissolver, solid-state, III-304
 - indicator lamp driver, optically coupled, III-413
 - inverter, fluorescent, 8-W, III-306
 - lamp life extender, III-302
 - light modulator, III-302
 - light-controlled switch, III-314
 - machine vision illumination stabilizer, II-306
 - night light, automatic, line-voltage operated, III-306
 - phase control, II-303, II-305
 - remote-controller, I-370
 - sequencer, pseudorandom, III-301
 - short-circuit proof lamp driver, II-310
 - strobe, variable, III-589-590
 - tandem dimmer, II-312
 - triac light dimmer, II-310
 - triac zero point switch, II-311
 - voltage regulator for projection lamp, II-305
- lamp driver, I-380
 - neon, I-379
 - short-circuit proof, II-310
- lamp flasher
 - low current consumption, II-231
 - low voltage, II-226
 - series SCR, wide load range, II-230
- laser circuits, III-309-311, II-313-317
 - discharge current stabilizer, II-316
 - gun, visible red, III-310
 - light detector, II-314
 - pulsers, laser diode, III-311, I-416
 - rifle, invisible IR pulsed, II-291
- latches
 - 12-V, solenoid driver, III-572
 - comparator and, III-88
- latching burglar alarm, I-8, I-12
- latching relays, dc, optically coupled, III-417
- latching switch,
 - double touchbutton, I-138
 - SCR-replacing, III-593
- lead-acid batteries
 - battery chargers, III-55
 - low-battery detector, III-56
- leading-edge delay circuit, III-147
- LED circuits
 - alternating flasher, III-198, III-200
 - bar graph driver, II-188
 - flasher, PUT, II-239
 - flasher, UJT, II-231
 - frequency comparator, II-110
 - matrix display, two-variable, III-171
 - 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
- level, ultra simple, II-666
- level controller
 - audio, automatic, II-20
 - cryogenic fluid, I-386
 - fluid, I-387
 - liquid, I-388
 - water, I-389
- level indicators/monitors, II-174
 - alarm, water, I-389
 - hysteresis in, I-235
 - liquid, I-388, 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
- level shifter, negative to positive supply, I-394
- LF or HF field strength meter, II-212
- lie detector, II-277
- lights
 - automatic night, I-360
 - capacitance operated, battery powered, I-131
 - capacitance switch, I-132
 - carport, automatic controller for, II-308
 - detection switch, adjustable, I-362
 - emergency, I-378
 - interruption detector, I-364
 - level controller, I-380
 - level detector, III-316, I-367
 - meter for, I-383
 - meter for, linear, I-382
 - modulator, III-302
 - on/off reminder, auto, I-109
 - reminder and ice warning, I-106
 - sensor, back-biased GaAs LED, II-321
 - sensor, logarithmic, I-366
 - sound-modulated source, I-609
 - system, single source emergency, I-581
 - tarry, I-579
 - telephone, II-625
- light-activated circuits
 - logic circuit, I-393
 - on/off relay, I-366
 - optical sensor, ambient light ignoring, III-413
 - power outage light, line-operated, III-415
 - pulse generation by interrupting, I-357
 - switch, II-320
- light-controlled circuits, II-318-331, III-312-319
 - 860W limited range precision, I-376
 - ambient light effects cancellization, II-328
 - audio oscillator, light-sensitive, III-315
 - automatic mooring light, II-323
 - back-biased GaAs LED light sensor, II-321
 - brightness control, lighted displays, III-316
 - complementary, I-372
 - electronic wake-up call, II-324
 - flame monitor, III-313
 - lamp switch, III-314
 - light level detector, III-316
 - light-operated switch, II-320
 - light-seeking robot, II-325
 - low-light level drop detector, III-313
 - marker light, III-317
 - monostable photocell, self-adjust trigger, II-329
 - one-shot timer, III-317
 - optical sensor-to-TTL interface, III-314
 - photo alarm, II-319
 - photocurrent integrator, II-326
 - photoelectric sensor amplifier, II-324
 - photoelectric switch, III-319, II-321
 - robot eyes, II-327
 - sun tracker, III-318
 - switch, solar triggered, III-318
 - synchronous photoelectric switch, II-326
 - thermally stabilized PIN photodiode signal conditioner, II-330
 - twilight-triggered circuit, II-322
 - warning light, III-317
 - warning light, battery powered, II-320
- light-isolated solid state power relay circuit, I-365
- light-seeking robot, II-325
- lights-on warning, automotive, III-42, II-55

- limit alarm, high/low, I-151
- limit comparator, III-104, I-156
 - double ended, II-105, I-156
- limit detector
 - double ended, I-230, I-233
 - micropower double ended, I-155
- limiters, III-320-322
 - audio, low distortion, II-15
 - dynamic noise reduction circuit, III-321
 - hold-current, solenoid driver, III-573
 - noise, III-321, II-395
 - output, III-322
 - power-consumption, III-572
- line amplifier, duplex, telephone, III-616
- line driver
 - 50-ohm transmission, II-192
 - 600-ohm balanced, II-192
 - full rail excursions with, 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 receiver
 - digital data, III-534
 - low-cost, III-532
- line sync, noise immune 60 Hz, II-367
- line-activated solid-state switch, telephone, III-617
- line-current detector, optically coupled, III-414
- line-current monitor, III-341
- line-hum touch switch, III-664
- line-operated audio amplifiers, III-37
- line-synchronized driver circuit, III-174
- line-voltage announcer, ac, III-730
- line-voltage monitor, III-511
- linear amplifier
 - 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
- linear coupler
 - 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 regulator
 - fixed power supply, low dropout low cost, III-459
 - radiation-hardened 125A, II-468
- linear triangle/square wave VCO, II-263
- link, fiber optic, III-179
- liquid flowmeter, II-248
- liquid-level detectors, I-388, I-390
 - checker, III-209
 - control, I-388
 - dual, III-207
 - monitoring, III-210
 - temperature control and, II-643
- lithium battery
 - charger for, II-67
 - state of charge indicator for, II-78
- little dipper dip meter, II-183
- locator, lo parts treasure, I-409
- lock, electronic combination, II-194, I-583
- locomotive whistle, II-589
- log-ratio amplifier, I-42
- logarithmic A/D converter, three-decade, I-48
- logarithmic amplifier, II-8, I-29, I-35
 - dc to video, I-38
- 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
 - light-activated, I-393
 - line monitor, III-108
 - isolation and zero voltage switching, II-415
 - overvoltage protection, I-517
 - pulser, III-520
 - signals, long delay line for, III-107
 - tester, audible, III-343
 - tester, TTL, I-527
- logic amplifier, 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 probe, I-520, I-525, I-526
 - CMOS, III-499, I-523
 - digital, III-497
 - memory installed, I-525
 - simple, I-526
- 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 transmitter, remote sensors, III-70
- loudness amplifier, II-46
- loudness control, balance amplifier with, II-395
- loudspeaker coupling circuit, I-78
- low-battery detector, III-56, III-63
- low-battery indicator, II-77
- low-battery protector, III-65
- low-battery warning alarm, III-59
- low-battery warning/disconnect, III-65
- low-cost chime circuit, II-33
- low-cost frequency indicator, II-250
- low-current consumption lamp flasher, II-231
- 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 crystal oscillator, II-146
- low-frequency divider, II-253
- low-frequency oscillator, III-428
- low-frequency oscillator/flasher, II-234
- low-frequency Pierce oscillator, III-133
- low-frequency TTL oscillator, II-595
- low-noise crystal oscillator, II-145
- low-noise infrared detector, II-289
- low-noise photodiode amplifiers, III-19
- low-pass filter
 - active, digitally selected break frequency, II-216
 - fifth order Chebyshev multiple feedback, II-219
 - precision fast settling, II-220
- low-power 5V driven temperature compensated crystal oscillator, II-142
- low-power audio amplifier, II-454
- low-power binary to 10n gain low frequency amplifier, II-333
- low-power common source amplifier, II-84
- low-power comparator, less than 10uV hysteresis in, II-104
- low-power inverting amplifier, digitally selectable gain, II-333
- low-power microprocessor programmable interval timer, II-678
- low-power noninverting amplifier, digitally selectable input and gain, II-334
- low-power zero voltage switch temperature controller, II-640
- low-voltage alarm, II-493
- low-voltage lamp flasher, II-226
- low-voltage power disconnect, II-97
- low-voltage indicator, III-769
- LVDT circuits, III-323-324, II-336-339
 - 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 bone preamplifier, I-89
- magnetometer, II-341
- marker generator, III-138
- marker light, III-317
- mathematical circuits, III-325-327
 - adder, III-327
 - divide/multiply, one trim, III-326
 - subtractor, III-327
- measurement/test circuits, III-328-348, II-340
 - 3-in-1 test set, III-330
 - anemometer/, hot-wire, III-342
 - audible logic tester, III-343
 - breath alert alcohol tester, III-359
 - cable tester, III-539
 - continuity tester, III-345, III-540
 - current monitor/alarm, III-338
 - digital frequency meter, III-344
 - direction-of-rotation circuit, III-335
 - duty cycle monitor, III-329
 - electrostatic detector, III-337
 - frequency counter, III-340
 - LC checker, III-334
 - LED panel meter, III-347
 - line-current monitor, III-341
 - low-current measurement, III-345
 - magnetic current sensor, low-power, III-341
 - magnetometer, II-341
 - motor hour, III-340
 - ohmmeter, linear, III-540
 - 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
 - picoammeter, III-338
 - pulse-width, very short, III-336
 - QRP SWR bridge, III-336
 - resistance ratio detector, II-342
 - resistance/continuity meters, III-538-540, III-538
 - rf power, wide-range, III-332
 - SCR tester, III-344
 - signal strength (S), III-342
 - sound-level meter, III-346
 - stereo power meter, III-331
 - stud finder, III-339
 - tachometer, III-335, III-340
 - tachometer, optical pick-up, III-347
 - test probe, 4-220 V, III-499
 - thermometers, III-637-643, III-637
 - measuring gauge, linear variable differential transformer, I-404
 - 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
 - memories, EEPROM pulse generator, 5V-powered, III-99
 - memory saving power supply, II-486
 - metal detectors, II-350-352
 - micropower, I-408
 - meters (*see also* measurement/test circuits)
 - ac voltmeters, III-765
 - 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
 - digital frequency, III-344
 - dip, I-247
 - DIP, dual-gate IGFET in, I-246
 - dosage rate, I-534
 - field strength, III-182-183, III-182
 - field strength 1.5 to 150 MHz, I-275
 - flash exposure, III-446, I-484
 - 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
 - meter-driver rf amplifier, 1-MHz, III-545
 - microwave field strength, I-273
 - motor hour, III-340
 - ohmmeter, linear, III-540
 - 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, III-538
 - rf power, I-16
 - rf power, wide-range, III-332
 - rf voltmeter, III-766
 - sensitive field strength, I-274
 - simple field strength, I-275
 - signal strength (S), III-342
 - soil moisture, III-208
 - sound level, telephone, III-614
 - sound level, III-346
 - stereo balance, I-618-619
 - stereo power, III-331
 - suppressed zero, I-716
 - SWR power, I-16
 - tachometer, III-335, III-340, III-347
 - temperature, I-647
 - thermometers, III-637-643, III-637
 - tilt meter, III-644-646, III-644
 - tuned field strength, I-276
 - untuned field strength, I-276
 - varicap tuned FET DIP, I-246
 - vibration, I-404
 - voltage, III-758-772, III-758
 - voltmeter, 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
 - methane concentration detector, linearized output, III-250
 - metronome, II-353-355, III-353-354, I-413
 - ac-line operated unijunction, II-355
 - accentuated beat, I-411
 - downbeat-emphasized, III-353-354
 - sight and sound, I-412
 - simple, II-354
 - version II, II-355
 - microcontroller, musical organ, preprogrammed single-chip, I-600
 - micro-sized amplifiers, III-36
 - microphone
 - amplifiers for, III-34, I-87
 - amplifiers for, electronic balanced input, I-86
 - FM wireless, III-682, III-685, III-691
 - mixer, II-37
 - preamp for, II-45
 - preamp for, low noise transformerless balanced, I-88

- microphone (*con't.*)
 - preamp for, tone control in, I-675, II-687
 - wireless AM, I-679
- micropower bandgap reference power supply, II-470
- micropower high-input-high-impedance 20 dB amplifier, II-44
- micropower radioactive radiation detector, II-513
- microprocessor display, eight-digit, III-106
- microprocessor power supply watchdog, II-494
- microprocessor programmable interval timer, II-678
- microprocessor triac array driver, II-410
- microprocessor-controlled analog signal attenuator, III-101
- microprocessor-selected pulse width control, II-116
- millivolt comparator
 - dual limit, III-89
 - hysteresis-including, III-88
- millivolt probe, II-499
- Miller oscillator, I-193
- millivoltmeter
 - ac, I-716
 - audio, III-767, III-769
 - high input impedance, I-715
- mini-stereo audio amplifiers, III-38
- miniature transistorized light flasher, II-227
- miniature wideband amplifiers, III-265
- mixer, III-367-370
 - 1-MHz, I-427
 - audio, I-23
 - CMOS, I-57
 - common-source, I-427
 - doubly balanced, I-427
 - four-channel, I-60, III-369
 - four-channel, four-track, II-40
 - four-input stereo, I-55
 - high level four channel, I-56
 - hybrid, I-60
 - input-buffered, III-369
 - microphone, II-37
 - multiplexer, I-427
 - one transistor audio, 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
 - universal stage, III-370
- mobile equipment, III-8-amp regulated power supply, II-461
- model rocket launcher, II-358
- modems, power-line, carrier-current circuit, III-82
- modified UJT relaxation oscillator, II-566
- modulated light beam circuit, ambient light effect cancellization with, II-328
- modulated readback systems, disc/tape phase, I-89
- modulation indicator, visual, I-430
- modulation monitor, I-430
 - CB, I-431
- modulator, II-368-372, III-371-377, I-437
 - +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, III-375, I-435
 - pulse-width, III-376, I-435, I-436, I-438-440
 - rf, III-372, III-374, I-436
 - rf, double sideband, suppressed carrier, II-369
 - saw oscillator, III-373
 - TTL oscillator for television display, II-372
 - TV, II-433, II-434, I-439
 - VHF, I-440, III-684
 - video, II-371, II-372, I-437
- moisture detector (*see also* fluid detectors), I-442
- momentary backup for power supply, II-464
- monitor (*see also* controller), III-378-390
 - acid rain, III-361
 - battery, III-60-67, III-60
 - 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 supply balance, III-494
 - power supply, III-493-495, III-493
 - power supply, single-supply fault, III-495
- 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
- undervoltage, III-762
- voltage, III-767
 - voltage, III-758-772, III-758
- monostable circuit, II-460, I-464
- monostable multivibrator, III-230, III-235, I-465
 - 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 inverter, III-295
- mosquito repelling circuit, I-684
- motion-actuated car alarm, I-9
- motion-actuated motorcycle alarm, I-9
- motion sensor
 - UHF, III-516
 - unidirectional, II-346
- motor amplifier, servo, I-452
- motor control, II-373-390
 - 400 Hz servo amplifier, II-386
 - ac, II-375
 - back EMF PM speed control, II-379
 - bi-directional proportional, II-374
 - dc servo drive, bipolar control input, II-385
 - dc variable, fiber optic, II-206
 - dc, low cost speed regulator, II-377
 - dc, motor speed control, II-380
 - direction and speed, series wound, II-456
 - direction and speed, shunt wound, II-456
 - driver, constant-speed, III-386
 - driver, dc, speed-controlled reversible, III-388
 - driver, dc, with fixed speed control, III-387
 - driver, stepping motor, II-376
 - driver, two-phase, II-456
 - hours-in-use meter, III-340
 - induction, I-454
 - motor/tachometer speed control, II-389
 - N-phase motor drive, II-382
 - power brake, ac, II-451
 - PWM, controller, III-389
 - PWM, motor speed, II-376
 - reversing motor drive, dc control signal, II-381

- servo motor drive amplifier, II-384
- speed control, II-378, II-379, I-445, I-450, I-453
- speed control, back EMF PM, II-379
- speed control, closed-loop, III-385
- speed control, dc, III-377, III-380, I-454
- speed control, dc, direction and, II-452
- speed control, feedback, II-447
- speed control, fixed, driver and, III-387
- speed control, high-efficiency, III-390
- speed control, high-torque, II-449
- speed control, PWM, II-376
- speed control, PWM, energy-recovering brake and, III-380
- speed control, radio control, II-576
- speed control, switched-mode, III-384
- speed control, tachless, III-386
- speed control, tachometer and, II-389
- speed control, tachometer feedback for, II-378
- speed control, universal, II-457
- speed control, universal, load-dependent, II-451
- start-and-run circuit, III-382
- stepping, driver for, III-390
- tachometer feedback control, closed loop, II-390
- tachometer feedback for speed control, II-378
- three-phase ac motor driver, II-383
- three-phase power-factor controller, II-388
- two-phase ac motor driver, II-382
- universal, built-in self timer, I-455
- motorcycle alarm, motion acutated, II-9
- multiburst generator, square waveform, II-88
- multifunction siren system, II-574
- multiple alarm circuit, II-2
- multiple-aperture window discriminator, III-781
- multiple-feedback bandpass filter, II-224
- multiple-input detector, III-102
- multiplexed common-cathode LED-display ADC, III-764
- multiplexer, III-391-397
 - 1-of-8 channel transmission system, III-395
 - analog, buffered input and output, III-396
 - analog, input/output buffer for, III-11
 - analog, single- to four-trace converter, II-431
 - de-, III-394
 - four-channel, low-cost, III-394
 - oscilloscopes, add-on, III-437
 - three-channel, sample and hold, III-396
- two-level, III-392
- video, III-1-of-15 cascaded, III-393
- wideband differential, II-428
- multipliers, II-391-392
 - 0/01 percent analog, II-392
 - analog, II-392
 - capacitance, II-200, II-416
 - frequency, III-213-218
 - mathematical, one trim, III-326
 - pulse-width, III-214
 - resistor, II-199
- multiplying D/A converter, III-168
- multiplying pulse width circuit, II-264
- multivibrator
 - 100 kHz free running, II-485
 - astable, III-196, III-224, III-233, III-238, II-269, I-461, II-510
 - astable, digital-control, II-462
 - astable, dual, II-463
 - astable, programmable-frequency, III-237
 - bistable, II-465
 - car battery, II-106
 - CB modulation, II-431
 - current, II-203
 - duty-cycle, III-50-percent, III-584
 - free-running, programmable-frequency, III-235
 - low-frequency, III-237
 - low-voltage, II-123
 - modulation, II-430
 - monostable, III-229, III-230, III-235, III-237, II-465
 - monostable, input lock-out, II-464
 - one-shot, II-465
 - oscilloscope, II-474
 - single-supply, III-232
 - sound level, II-403
 - telephone line, II-628
 - wideband radiation, II-535
- music circuits
 - bagpipes, electronic, III-561
 - chime generator, II-604
 - electronic, III-360
 - envelope generator/modulator, II-601
 - hold for telephone, II-623
 - synthesizer, II-599
 - telephone ringer, II-619
- mux/demux system
 - differential, I-425
 - eight channel, II-115, I-426
- NAB tape playback pre-amp, III-38
- nano ammeter, I-202
- narrow band FM demodulator, carrier detect in, II-159
- neon flasher
 - five-lamp, III-198
 - two-state oscillator, III-200
- network
 - filter, I-291
 - speech, telephone, II-633
- ni-cad battery
 - 12V, 200mA-hour charger for, I-114
 - analyzer for, III-64
 - battery chargers, III-57
 - charger for, I-116
 - current and voltage limiting charger for, I-114
 - fast charger for, I-118
 - packs, automotive charger for, I-115
 - protection circuit, III-62
 - simple charger for, I-112
 - thermally controlled charger for, II-68
 - zapper for, I-6
 - zapper II, II-68
- night light
 - automatic, line-voltage operated, III-306
 - telephone-controlled, III-604
- noise clipper, audio-powered, III-396
- noise filters, III-188
 - dynamic, III-190
- noise generator, I-468
 - circuit for, I-469
 - pink, I-468
 - wide band, I-469
- noise immune 60Hz line sync, II-367
- noise limiter, III-321, II-395
- noise reduction circuits, II-393-396, III-398-401
 - audio squelch, II-394
 - audio-powered noise clipper, II-396
 - balance amplifier with loudness control, II-395
 - Dolby B, decode mode, III-401
 - Dolby B, encode mode, III-400
 - Dolby B/C, III-399
 - dynamic, III-321
 - noise limiter, II-395
 - precise audio clipper, II-394
- noise, audio, I-467
- non-integer programmable pulse divider, II-511
- noninverting amplifier, III-14, I-41
 - 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

- noninverting amplifier (*con't.*)
 - power, I-79
 - programmable-gain, III-505
 - single supply, I-74
 - split supply, I-75
 - noninverting integrator, improved design, II-298
 - noninverting voltage follower, I-33
 - high-frequency, III-212
 - nonselective frequency tripler, transistor saturation, II-252
 - Norton amplifier, absolute value, III-11
 - notch filter, II-397-403, III-402-404
 - 1800 Hz, II-398
 - 550 Hz, II-399
 - active band reject, II-401
 - adjustable Q, II-398
 - audio, II-400
 - bandpass and, II-223
 - high-Q, III-404
 - passive bridged, differentiator tunable, II-403
 - tunable audio, II-399
 - tunable audio filter, II-402
 - tunable, op amp, II-400
 - twin-T, III-403
 - Wien bridge, II-402
 - null circuit, variable gain and accurate, III-69
 - null detector, I-148, III-162
- O**
- off-line flyback regulator, II-481
 - ohmmeter, I-549
 - linear, III-540
 - linear scale, I-549
 - ohms-to-volts converter, I-168
 - on/off inverter, III-594
 - on/off switches
 - touch switch, II-691
 - touch, digital, III-663
 - touch, electronic, III-663
 - one-chip burglar alarm, III-5
 - one-chip radar detection circuit, II-519
 - one-IC audio generator, II-569
 - one-of-eight channel transmission system, III-100
 - one-second-1kHz oscillator, II-423
 - one-shot function generator, I-465
 - digitally controlled, I-720
 - precision, III-222
 - retriggerable, III-238
 - one-shot timer, III-654
 - light-controlled, III-317
 - voltage-controlled high speed, II-266
 - op amp, II-404-406, III-405-406
 - astable multivibrator, III-224
 - clamping for, II-22
 - clock circuit using, III-85
 - intrinsically safe protected, III-12
 - quad, simultaneous waveform generator using, II-259
 - single potentiometer to adjust gain over bipolar range, II-406
 - tunable notch filter with, II-400
 - variable gain and sign, II-405
 - $\times 10$, I-37
 - $\times 100$, I-37
 - 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 transmitter, I-363
 - FM (PRM), I-367
 - optically-coupled circuits, II-407-419, III-407-419
 - 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-413
 - indicator lamp driver, III-413
 - integrated solid state relay, II-408
 - isolation and zero voltage switching logic, II-415
 - 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
 - paper tape reader, II-414
 - power outage light, line-operated, III-415
 - receiver for 50 kHz FM optical transmitter, II-418
 - relays, dc solid-state, open/closed, III-412
 - source follower, photodiode, III-419
 - stable optocoupler, II-409
 - telephone ring detector, III-611
 - 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
 - optocoupler
 - linear, instrumentation, II-417
 - stable, II-409
 - optoisolator
 - 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
 - oscillator, II-420-429, III-420-432
 - 0.5 Hz square wave, I-616
 - 1 kHz, II-427
 - 1 MHz FET crystal, II-144
 - 1 MHz to 4MHz CMOS, I-199
 - 1.0 MHz, I-571
 - 1kHz square wave, I-612
 - 2MHz, II-571
 - 5-V, III-432
 - 10 Hz to 10kHz voltage-controlled, II-701
 - 20Hz to 20kHz variable audio, II-727
 - 50 kHz, I-727
 - 50 MHz to 100 MHz overtone, I-181
 - 96 MHz crystal, I-179
 - 400 MHz, I-571
 - 500 MHz, I-570
 - 500 timer, I-531
 - 800 Hz, I-68
 - adjustable over 10:1 range, II-423
 - astable, I-462
 - audio, I-245, III-427
 - audio, light-sensitive, III-315
 - Butler aperiodic, I-196
 - Butler common base, I-191
 - Butler emitter follower, II-190-191, II-194
 - cassette bias, II-426
 - clock generator and, III-85, I-615
 - CMOS crystal, I-187
 - CMOS, I-615
 - code practice, I-15, I-20, I-22, II-428, III-431
 - Colpitts harmonic, I-189-190
 - Colpitts, II-147, I-194, I-572
 - crystal-controlled, III-131-140, II-147, I-180, I-184, I-185, I-195, I-198
 - crystal-controlled, doubler and, I-184

crystal-controlled, mercury cell in, II-149
crystal-controlled, sine wave, I-198
crystal-controlled, transistorized, I-188
crystal overtone, I-177
double frequency output, I-314
discrete sequence, III-421
duty-cycle, III-50-percent, III-426
emitter-coupled big loop, II-422
emitter-coupled RC, II-266
exponential digitally controlled, I-728
feedback, I-67
fifth overtone, I-182
flasher and, high drive, II-235
flasher and, low frequency, II-234
free running square wave, I-615
free running, I-531
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, II-148, I-175
IC-compatible crystal, II-145
international crystal OF-1 LO, I-189
international crystal OF-1 HI, I-197
JFET Pierce crystal, I-198
linear voltage-controlled, I-701
low-distortion, I-570
low-frequency, III-428
low-frequency crystal, II-146, I-184
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 crystal, II-146, I-176, I-180
overtone, crystal switching, I-183
parallel mode aperiodic crystal, I-196
phase shift, II-66, I-68
Pierce crystal, II-144
Pierce harmonic, II-192, I-199
Pierce, I-195
precision voltage-controlled, I-702
precision, 20 ns switching, I-729
precision, 100 mA load switching, I-730
quadrature, III-428
quadrature output, I-729
quadrature-output, square-wave generator, III-585
R/C, I-612
reflection, crystal-controlled, III-136

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
simple triangle/square wave, II-422, I-616
simple TTL crystal, I-179
simple voltage-controlled, I-703
sine-wave (*see also* sine wave oscillator), I-65, III-560
sine-wave, III-556-559
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,
stable low frequency crystal, I-198
standard crystal, 1MHz, I-197
temperature compensated, low power 5v-driven, II-142
temperature stable, II-427
temperature-compensated crystal, I-187
third overtone crystal, I-186
tone-burst, decoder and, I-726
transmitter and, 27 MHz and 49 MHz rf, I-680
TTL, 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, four-decade, single control for, II-424
variable, wide range, II-429
variable-duty cycle, fixed-frequency, III-422
voltage-controlled (*see also* voltage-controlled oscillators), III-735
voltage-controlled, II-702, I-704
voltage-controlled, precision, III-431
wide-frequency range, II-262
wide-range, I-69, III-425
wide-range, variable, I-730
Wien-bridge, I-62-63, I-70, III-429
Wien-bridge, low-voltage, III-432
Wien-bridge, sinewave, I-66, I-70
Wien-bridge, variable, III-424
XOR-gate, III-429
yelp, II-577

oscilloscope, II-430-433, III-433-439
analog multiplexer, single-trace to four-trace scope converter, II-431
beam splitter, I-474
calibrator for, 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
monitor, I-474
multiplexer, add-on, III-437
preamplifier, III-437
preamplifier, counter/, III-438
sensitivity amplifier, III-436
triggered sweep, III-438
outband descrambler, II-164
out-of-bounds pulse-width detector, III-158
output amplifiers, four-channel D/A, III-165
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 oscillator, II-146
overvoltage
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
passive tone control circuit, II-689
PCB continuity tester, II-342
peak decibel meter, III-348
peak detector, II-174, II-175, II-434-436
analog, with digital hold, III-153
digital, III-160
high-bandwidth, III-161
high-frequency, II-175

- peak detector (*con't.*)
 - high-speed, I-232
 - low-drift, III-156
 - negative, I-225, I-234
 - positive, III-169, I-225, I-235, II-435
 - 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
- period counter, 100 MHz, frequency and, II-136
- pest-repeller, ultrasonic, III-699, III-706, III-707
- pH meter, I-399
- pH probe, I-399, III-501
- phase detector, 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
- phase selector, phase detector/sync rectifier/balanced modulator, III-441
- phase sequence circuits, II-437-442
 - detector, II-439, III-441, II-442
 - detector, version II, II-441
 - indicator, II-439, I-476
 - rc circuit, phase sequence reversal detection by, II-438
 - reversal, rc circuit to detect, II-438
 - three phase tester, II-440
- phase splitter, precision, III-582
- phase tracking three-phase square wave generator, II-598
- phasor gun, I-606
- phono amplifier, I-80-81
 - magnetic pickup, I-89
 - stereo, bass tone control, I-670
- phono preamp, I-91
 - equalized, III-671
 - LM382, I-90
 - magnetic, III-37, I-91
- photo conductive detector amplifier, four quadrant, I-359
- photo memory switch for ac power control, I-363
- photo stop action, I-481
- 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
 - 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 ac power switch, III-319
- photoelectric alarm system, II-4
- photoelectric controlled flasher, II-232
- photoelectric smoke alarm, line operated, I-596
- photoelectric smoke detector, I-595
- photoelectric switch, II-321
 - synchronous, II-326
- photoflash, electronic, III-449
- photographic circuits, II-443-449, III-443-449
 - auto-advance projector, II-444
 - camera alarm trigger, III-444
 - contrast meter, II-447
 - darkroom enlarger timer, III-445
 - electronic flash trigger, II-448
 - enlarger timer, II-446
 - flash meter, III-446
 - photoflash, electronic, III-449
 - shutter speed tester, II-445
 - slide timer, III-448
 - slide-show timer, III-444
 - sound trigger for flash unit, II-449
 - timer, I-485
 - xenon flash trigger, slave, III-447
- photomultiplier output-gating circuit, II-516
- picoammeter, II-154, I-202, III-338
 - circuit for, II-157
 - guarded input circuit, II-156
- pico ampere 70 voltage converter with gain, I-170
- picture fixer/inverter, III-722
- Pierce crystal oscillator, II-144
 - 1-MHz, III-134
 - 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
- plug-in remote telephone ringer, II-627
- pocket pager, III-288
- polarity converter, I-166
- polarity-reversing amplifiers, low-power, III-16
- portable battery chargers, ni-cad, III-57
- portable power amplifier, III-452
- 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
 - 10W, I-76
 - 12 W low distortion, I-76
 - 25-watt, II-452
 - 90W, safe area protection, II-459
 - am radio, I-77
 - audio, II-451, III-454
 - 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-power audio, II-454
 - noninverting ac, I-79
 - noninverting, I-79
 - output-stage booster, III-452
 - portable, III-452
 - rear speaker ambience amplifier, II-458
 - rf, 1296-MHz solid state, III-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 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 meter, 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 supply, II-460-486, III-464
 5V including momentary backup, II-464
 5V, 0.5A, I-491
 8-amp regulated, mobile equipment operation, II-461
 10A regulator, current and thermal protection, II-474
 12-14V regulated 3A, II-480
 90V rms voltage regulator with PUT, II-479
 500 kHz switching inverter for 12V, II-474
 adjustable current limit and output voltage, I-505
 arc lamp, 25W, II-476
 arc-jet, starting circuit, III-479
 balance indicator, III-494
 battery charger and, 14V, 4A, II-73
 bench top, II-472
 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 output bench, I-505
 dual polarity, I-497
 fault monitor, single-supply, III-495
 fixed, III-457-477
 fixed pup regulator, zener diode to increase voltage output, II-484
 general-purpose, III-465
 glitches in, comparator to detect, II-107
 high voltage, III-478-486, II-487-490
 high voltage, Geiger counter supply, II-489
 high voltage, simple design for, II-489
 high voltage, ultra high voltage generator, II-488
 HV regulator with foldback current limiting, II-478
 increasing zener diode power rating, II-485
 isolated feedback, III-460
 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 for, II-491-497, III-493-495
 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 for, 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
 switch mode, II-470
 switching, 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, III-487-492, III-487
 variable current source, 100mA to 2A, II-471
 voltage regulator, II-484
 power switching, complementary ac, I-379
 power-consumption limiters, III-572
 power-down
 memory save power supply for, II-486
 protection circuit, II-98
 power-failure alarm, III-511
 power-line connections monitor, ac, III-510
 power-line modem, III-82
 power-on reset, II-366
 power-switching circuit, II-466
 power/frequency meter, II-250
 preamp, I-41
 2 to 6 watt audio amplifier with, II-451
 6-meter, 20 dB gain and low NF, II-543
 audio power amplifier, 6-W and, III-454
 equalized, for magnetic phono cartridges, III-671
 frequency counter, III-128
 general purpose, I-84
 high level, tone control and, II-688
 IC, tone control and, III-657
 LM382 phono, I-91
 low noise 30MHz, I-561
 low noise transformerless balanced microphone, I-88
 magnetic phono, I-91, III-673
 medical instrument, II-349
 microphone, II-45
 microphone, tone control for, II-687
 NAB tape playback, professional, III-38
 NAB, record, III-673
 NAB, two-pole, III-673
 oscilloscope, III-437
 oscilloscope/counter, III-438
 phono, I-91
 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, IC, I-673
 tone control, mixer, I-58
 transformerless microphone, unbalanced inputs in, I-88
 two meter, handtalkies, I-19
 UHF-TV, III-546
 ultra low leakage, II-7, I-38
 VHF, I-560
- precise audio clipper, II-394
 precise wave generator, II-274
 precision A/D converter, I-49
 precision absolute value circuit, I-37
 precision amplifier, I-40
 digitally programmable input and gain, II-335
 precision attenuator, digitally selectable, I-52
 precision linearized platinum RTD signal conditioner, II-639
 precision peak to peak ac/dc converter, II-127
 precision power booster, I-33
 precision process control interface, I-30
 precision summing amplifier, I-36
 precision voltage to frequency converter, II-131
 precision weighted resistor programmable gain amplifier, II-9
 preregulated high-voltage power supply, III-480
 preregulator, tracking, III-492
 prescaler probe, amplifying, 650 MHz, II-502
 preserved input voltage-to-frequency converter, III-753
 probe, III-496-503, II-498-504
 100 K megaohm dc, I-524
 ac hot wire, I-581

- probe (*con't.*)
- audible TTL, I-524
 - audio-rf signal tracer, I-527
 - capacitance buffer, low-input, III-498
 - capacitance buffer, stabilized low-input, III-502
 - 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, I-526
 - logic, CMOS universal, III-499
 - logic, digital, III-497
 - logic, memory-tester, I-525
 - microvolt, II-499
 - pH, I-399, III-501
 - prescaler, 650 MHz amplifying, II-502
 - rf, III-498, III-502, I-523
 - single injector-tracer, II-500
 - test, 4-220V, III-499
 - tone, digital IC testing, II-504
- process control interface, I-30
- processor, CW signal, I-18
- product detector, I-223
- programmable amplifier, 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
 - variable-gain, wide-range digital control, III-506
- programmable attenuator, III-30, I-53
- programmable counters, low-power wide-range, III-126
- programmable-frequency sine-wave oscillators, III-424
- programmable-gain amplifier with selectable input, I-32
- programmable gate, I-394
- programmable multi-tone ringer, II-634
- programmable twin-T bridge filter, II-221
- programmable voltage-controlled frequency synthesizer, II-265
- programmable voltage-controlled timer, II-676
- projector
- auto-advance for, II-444
 - voltage regulator for lamp in, II-305
- proportional temperature controller, III-626
- protection circuit, III-509-513
- circuit breaker, ac, III-512
 - crowbars, electric, III-510
 - heater protector, servo-sensed, III-624
 - line-voltage monitor, III-511
 - logic, overvoltage, I-517
 - overvoltage, fast, III-513
 - power-failure alarm, III-511
 - power-line connections monitor, ac, III-510
 - power supply, II-497, I-518
 - proximity sensor, I-135-136, I-344, II-505-507, III-514-518
 - alarm for, II-506
 - capacitive, III-515
 - field disturbance sensor/alarm, II-507
 - SCR alarm, III-517
 - self-biased, changing field, I-135
 - switch, III-517
 - UHF movement detector, III-516
- pseudorandom sequencer, III-301
- PTC thermistor automotive temperature indicator, II-56
- pulse amplitude discriminator, III-356
- pulse coincidence detector, II-178
- pulse delay, dual-edge trigger, III-147
- pulse detector, missing-pulse, III-159
- pulse divider, non-integer programmable, III-226, II-511
- pulse extractor, square-wave, III-584
- pulse generator, 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
 - logic, III-520
 - sawtooth-wave generator and, III-241
 - single, II-175
 - very low duty-cycle, III-521
 - voltage-controller and, III-524
 - wide-ranging, III-522
- pulse height-to-width converters, III-119
- pulse sequence detector, II-172
- pulse tone alarm, I-11
- pulse train-to-sinusoid converters, III-122
- pulse-dialing telephone, III-610
- pulse-position modulator, III-375
- pulse-width-to-voltage converters, III-117
- pulse-width modulators (PWM)
- brightness controller, III-307
 - control, microprocessor selected, II-116
 - modulator, III-376
 - motor speed control, II-376, III-389
 - multiplier circuit for, III-214, II-264
 - 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
- pulsed infrared diode emitter drive, II-292
- pulsers, laser diode, III-311
- pump, positive input/negative output charge, I-418
- pump controller, single chip, II-247
- push on/off electronic switch, II-359
- push-pull power supply, 400V/60W, II-473
- PUT battery chargers, III-54
- PUT long duration timer, II-675
- pyrometer, optical, I-654

Q

- Q-multiplier
- 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 oscillator, 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 detector, II-518-520
- 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/FM clock, I-543
 - automotive, receiver for, II-525
 - clock, I-542
 - FM, I-542
 - radio control motor speed controller, I-576
 - radio control receiver/decoder, I-574
 - radio controller, single SCR, II-361
 - radioactive radiation, micropower detector for, II-513
 - rain warning bleeper, II-244
- RAM, non-volatile CMOS, stand-by power supply, II-477

ramp generator, II-521-523, III-525-527
 accurate, III-526
 integrator and, initial condition reset, III-527
 linear, II-270
 variable reset level, II-267
 voltage-controlled, II-523
 ranging system, ultrasonic, III-697
 RC audio oscillator, III-555 timer used as, II-567
 RC circuit, phase sequence reversal by, II-438
 RC oscillator, emitter-coupled, II-266
 read-head pre-amplifier, automotive circuits, III-44
 readback system, disc/tape phase modulated, I-89
 readout, rf current, I-22
 rear speaker ambience amplifier, II-458
 receiver, II-524-526, III-528-535
 50kHz FM optical transmitter, I-361
 AM radio, III-529
 AM, carrier-current circuit, III-81
 AM, integrated, III-535
 analog, I-545
 car radio, capacitive diode tuning/
 electronic MW/LW switching, II-525
 carrier current, I-143
 carrier system, I-141
 CMOS line, I-546
 compact IR, I-342
 fiber optic, 10 MHz, II-205
 fiber optic, 50-Mb/s, III-181
 fiber optic, digital, III-178
 fiber optic, low-cost, 100-M baud rate, III-180
 FM MPX/SCA, III-530
 FM narrow-band, III-532
 FM tuner, III-529
 FM, carrier-current circuit, III-80
 FSK data, III-533
 ham-band, III-534
 high sensitivity, 30nW fiber optic, I-270
 IC carrier-current, I-146
 infrared, III-274, II-292
 line-type, digital data, III-534
 line-type, low-cost, III-532
 low sensitivity, 300nW fiber optic, I-271
 monitor for, II-526
 optical, I-364, II-418
 PLL/BC, II-526
 radio control, decoder and, I-574
 RS-232 to CMOS, III-102
 single transistor carrier current, I-145
 signal-reception alarm, III-270
 tracer, III-357
 ultrasonic, III-698, III-705
 very high sensitivity, low speed 3nW
 fiber optic, I-269
 zero center indicator for FM, I-338
 receiver monitor, II-526
 recorder, tape, I-419
 recorder, telephone, III-616
 recording amplifier, I-90
 recording
 automatic tape, I-21
 telephone, automatic, II-622
 rectifier, II-527-528, III-536-537
 absolute value, ideal full wave, II-528
 averaging filter and, I-229
 diodeless, precision, III-537
 fast half wave, I-228
 full-wave, precision, III-537
 half-wave, I-230, II-528
 high impedance precision, for ac/dc converter, I-164
 low forward-drop, III-471
 precision full wave, I-234
 precision, I-422
 synchronous, phase detector-selector/
 balanced modulator, III-441
 redial, electronic telephone set with, III-606
 reference
 +/- 10V, I-696
 +/- 3V, I-696
 +/- 5V, I-696
 0 to 20 volt power, I-694
 high stability voltage, I-696
 low power regulator, I-695
 precision bipolar output, I-698
 precision dual tracking voltage, I-698
 precision low noise buffered, I-698
 precision micropower 10 V, I-697
 precision reference 0 to 20 volt power, I-699
 precision square wave voltage, I-696
 precision standard cell replacement, I-699
 voltage, I-695, III-773-775
 reference clock, three phase clock from, II-101
 reference supply, low voltage adjustable, I-695
 reference voltage amplifier, I-36
 reflection oscillator, crystal-controlled, III-136
 reflectometer, I-16
 register, shift, II-366
 register driver, shift, I-418
 register, shift, I-380
 regulated dc to dc converter, II-125
 regulated power supply
 8-amp, II-461
 12 to 14V at 3 A, II-480
 + 15V 1-A, III-462
 - 15V 1-A, III-463
 regulated split power supplies, I-492
 regulator, I-511
 0 to 22 V, I-510
 0 to 30 V, I-510
 0-10V at 3A adjustable, I-511
 3W switching application circuit for, I-492
 5.0 V/1.0A, I-500
 6.0A variable output switching, I-513
 10-A, I-510
 10-A, adjustable, III-492
 15V/1A, with remote sense, I-499
 15V slow turn-on, III-477
 45 V/1A switching, I-499
 100 Vrms voltage, I-496
 - 15 V negative, I-499
 adjustable output, I-506, I-512
 battery charging, I-117
 bucking, high-voltage, III-481
 constant voltage/constant current, I-508
 current and thermal protection, III-10
 amp, II-474
 dual-tracking, III-462
 fixed pnp, zener diode to increase
 voltage output of, II-484
 flyback, off-line, II-481
 high stability 1A, I-502
 high stability, I-499
 HV, foldback current limiting, II-478
 low voltage, I-511
 linear, low cost, low dropout, III-459
 mobile voltage, I-498
 multiple output switching, for use with
 MPU, I-513
 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
 precision high voltage, I-509
 radiation-hardened 125A linear, II-468
 remote shutdown, I-510
 short circuit protection, low voltage, I-502
 single ended, I-493
 slow turn on 15 V, I-499
 switching, 3-A, III-472
 switching, 5.0/6.0A 25kHz, with separate ultrastable reference, I-497
 switching, 200kHz, I-491
 switching, step down, I-493
 switching, high-current inductorless, III-476

- regulator, (*con't.*)
switching, low-power, III-490
voltage, II-484, I-501
variable power supply, current source and, III-490
voltage, 10V high stability, III-468
voltage, 5-V low-dropout, III-461
voltage, ac, III-477
voltage, high-voltage, III-485
voltage, negative, III-474
voltage, PUT, 90V rms voltage, II-479
voltage, single supply, II-471
voltage, variable, III-491
- rejection filter, I-283
- relaxation oscillator, SCR, III-430
- relay, II-529-532
10 A 25Vdc solid state, I-623
ac, optically coupled, III-418
ac, photon coupler in, II-412
audio operated, I-608
capacitance, I-130
carrier operated, I-575
dc latching, optically coupled, III-417
dc solid-state, normally open/closed, III-412
driver for, delay and controls closure time with, II-530
integrated solid state, II-408
light beam operated on/off, I-366
light isolated solid state power, I-365
rf-actuated, III-270
ringer, telephone, III-606
solid-state ZVS, antiparallel SCR output, III-416
solid-state, III-569-570, III-569
solid-state, ac, III-570
sound actuated, I-610
telephone, I-631
time delayed, I-663
tone actuated, I-576
TR circuit, II-532
triac, contact protection, II-531
ultra precise long time delay, I-219
- remote ac electronic thermostat, two-wire, I-639
- remote amplifier, I-99
- remote control
carrier, current, I-146
lamp or appliance, I-370
servo system, I-575
transmitter/receiver, IR, I-342
- remote loudspeaker via IR link, I-343
- remote on/off switch, I-577
- remote ringer, telephone, III-614
- remote sensor, precision temperature transducer, I-649
- remote telephone monitor, II-626
- remote temperature sensing, II-654
- remote thermometer, II-659
- repeater
European-type, tone burst generator for, III-74
fiber optic link, I-270
telephone, III-607
- repeater beeper, I-19
- reset, power-on, II-366
- resistance/continuity meters, III-538-540
cable tester, III-539
continuity tester, III-540
ohmmeter, linear, III-540
- resistance controlled digital oscillator, II-426
- resistance measurement, low parts count ratiometric, I-550
- resistance meter, II-533
single chip checker in, II-534
- resistance ratio detector, II-342
- 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 enhancement system, stereo, I-606
- reverb system, stereo, I-602
- reversing motor drive, dc control signal, II-381
- rf amplifier, II-537-549, III-542-547
1 watt/2.3 GHz, II-540
10 watt/225-400 MHz, II-548
10 dB-gain, III-543
2-30 MHz, III-544
5-W 150-MHz, III-546
5W 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 Watt/150 MHz, II-544
AGC, wideband adjustable, III-545
broadcast-band, III-264, II-546
common-gate, 450-MHz, III-544
isolation amplifier, II-547
low distortion 1.6 to 30MHz SSB driver, II-538
meter-driver, 1-MHz, III-545
power amp, 1296-MHz solid-state, III-542
UHF-TV preamp, III-546
- rf burst generators, portable, III-73
- rf current readout, I-22
- rf detector, II-500
- rf genie, II-421
- rf modulator, III-372, III-374, I-436
double sideband suppressed carrier, II-369
- rf oscillator, I-550-551, I-572
- 5 MHz VFO, II-551
- transmitter and, 27MHz and 49MHz, I-680
- rf power
meter, I-16
sidetone oscillator, I-24
switch, III-592
wide-range meter, III-332
- rf probe, III-498, III-502, I-523
- rf signal tracer probe, audio, I-527
- rf sniffer, II-210
- rf switch, low-cost, III-361
- rf voltmeter, I-405, III-766
- rf-actuated relays, III-270
- RGB video amplifier, III-709
- RGB-composite video signal converter, III-714
- RIAA pre amp, III-38
- ring counter
20 kHz, II-135
incandescent lamps, I-301
low cost, I-301
SCR, III-195
variable timing, II-134
- ring detector
low line loading, I-634
telephone, III-619, II-623
telephone, optically interfaced, III-611
- ring extender switch, remote, I-630
- ring indicator, telephone auto answer, I-635
- ring-around flasher, LED, III-194
- ringer
high isolation, II-625
programmable multi-tone, II-634
remote, plug-in, II-627
telephone or extension phone, I-628
telephone tone, I-627
telephone, piezoelectric device, I-636
telephone, relay, III-619
tone, II-630, II-631
- RLC oscillator, III-423
- rms-to-dc converter, II-129, I-167
thermal, 50-MHz, III-117
- road ice alarm, II-57
- robot
eyes for, II-327
light-seeking, II-325
robot eyes, II-327
rocket launcher, II-358
rotation detector, II-283
roulette, electronic, II-276
- RS-232
CMOS-to, line receiver, III-102
datasector, automatic, III-97
drive circuit, low-power, III-175
LED circuit, III-103
RS flip flop, I-395

RTD signal conditioner
5V powered linearized platinum, II-650
precision, linearized platinum, II-639
rumble filter, III-192, I-297, III-660

S

S meter, III-342
safe area protection, power amplifier with, III-459
safety flare, II-608
sample and hold, III-548-553, II-552-559, I-590
charge compensated, II-559
fast and precise, II-556
filtered, III-550
high accuracy, I-590
high performance, II-557
high speed amplifier, I-587
high speed, III-550, I-587-588, I-590
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
version II, II-553
×1000, I-589
sampling circuit, hour time delay, II-668
saturated standard cell amplifier, II-296
sawtooth waves
oscillator modulator, III-373
pulse generator and, III-241
SCA decoder, II-166, II-170, I-214
SCA demodulator, III-565, III-150
scale, digital weight, I-398
scaler, inverse, I-422
scanner, bar codes, III-363
Schmitt trigger, III-153, I-593
crystal oscillator, I-181
programmable hysteresis, I-592
TTL-compatible, II-111
without hysteresis, I-592
scratch filter using LM287, I-297
SCR circuits
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
scrambler, telephone, II-618
scratch filter, III-189, III-660
second-audio program adapter, III-142
security alarm, I-4
security circuits, III-3-9, III-3
security monitor, home system, I-6
security system, vehicular, I-5
self-oscillating flyback converter, II-128, III-748
semiconductor fail-safe alarm, III-6
sense of slope tilt meter, II-664
sensing circuit, nanoampere, 100 megohm input impedance, I-203
sensing control circuit, water level, I-389
sensor (*see also* alarms; detectors)
0-50C, four channel temperature, I-648
ambient light ignoring optical, III-413
capacitive, alarm for, III-515
cryogenic fluid level, I-386
differential temperature, I-655
humidity, III-266-267, II-285-287
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, unidirectional, II-346
photodiode amplifier for, II-324
precision temperature transducer with remote, I-649
proximity, II-505, III-514-518
remote, loop transmitter for, III-70
remote temperature, I-654
self-biased proximity, detected changing field, I-135
simple differential temperature, I-654
temperature (*see also* temperature sensor), II-645, I-648, I-657
temperature, III-629-631, III-629
voltage-level, III-770
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 amplifier
400 Hz, II-386
bridge type ac, I-458
dc, I-457
servo motor drive amplifier, II-384
servo system
controller, III-384
remote control, I-575
shaper, sine wave, II-561
shift register, II-366, I-380
driver for, I-418
shifter
0-180 degree phase, I-477
0-360 degree phase, I-477
single transistor phase, I-476
ship siren, electronic, II-576
short-circuit proof lamp driver, II-310
shortwave converters, III-114
shortwave FET booster, I-561
shutoff, automatic, battery-powered projects, III-61
shutter speed tester, II-445
sidetone oscillator, rf-powered, I-24
signal attenuator, analog, microprocessor-controlled, III-101
signal combiner, III-368
signal conditioner
5V powered linearized platinum RTD, II-650
bridge circuit, strain gauge, II-85
LVDT, II-338
precision, linearized platinum RTD, II-639
thermally stabilized PIN photodiode, II-330
-signal distribution amplifier, I-39
signal generator
high frequency, II-150
square-wave, III-583-585, III-583
staircase, III-586-588, III-586
two-function, III-234
signal injectors, III-554-555
signal source, crystal-controlled, II-143
signal-supply, voltage-follower amplifiers, III-20
simple field strength meter, II-275
simple metronome, II-354
simulated inductor, II-199
simulators, EKG, three-chip, III-350
sine-wave descrambler, II-163
sine-wave generators, square-wave and, tunable oscillator, III-232
sine-wave oscillator, III-556-559, II-560-570
555 used as RC audio oscillator, II-567
adjustable, II-568
audio, II-562
audio, generator, III-559
audio, simple generator for, II-564
low distortion, II-561
one-IC audio generator, II-569
programmable-frequency, III-424

- sine-wave oscillator (*con't.*)
 - relaxation, modified UJT for clean audio sinusoids, II-566
 - sine wave shaper, II-561
 - two-tone generator, II-570
 - variable, super low-distortion, III-558
 - Wien bridge, I-66, I-70, II-566
 - Wien bridge, CMOS chip in, II-568
 - Wien-bridge, low-distortion, thermal stable, III-557
 - Wien-bridge, single-supply, III-558
- 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 oscillator, I-65
- single-IC auto alarm, III-7
- single-lamp flasher, III-196
- single-pulse generator, II-175
- single-supply function generator, II-273
- single-supply voltage regulator, II-471
- single-timer IC square wave tone burst, II-89
- single-tone burst generator, II-87
- sirens, III-560-568, II-571, I-606
 - adjustable-rate programmable-frequency, III-563
 - electronic, III-566
 - 7400, II-575
 - hee-haw, III-565, II-578
 - high power, II-578
 - linear IC, III-564
 - multifunction system for, II-574
 - ship, electronic, II-576
 - Star Trek red alert, II-577
 - 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
 - yelp oscillator, III-562, II-577
- six decade range ammeter, II-153, II-156
- sixteen-bit A/D converter, II-26
- slide timer, III-448
- slide-show timer, III-444
- sliding tone doorbell, II-34
- slow-sweep windshield wiper control, II-559
- smart clutch, auto air conditioner, III-46
- smoke alarm, line operated photoelectric, I-596
- smoke detector, III-246-253, II-278
 - gas, I-332
 - ionization chamber, I-332-333
 - operated ionization type, I-596
 - photoelectric, I-595
- snooper, FM, III-680
- socket debugger, coprocessor, III-104
- 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 electric fence charger, II-203
- solid-state high-voltage supply, remote adjustable, III-486
- solid-state relays, III-569-570, III-569 ac, III-570
- solid-state stepping switch, II-612
- solid-state switch, line-activated, telephone, III-617
- sound-activated circuits
 - decoder, III-145
 - relay, I-610
 - switch, III-580, II-581, III-600, III-601
 - switch, ac, II-581
- sound generators, III-559-568, II-585-593
 - allophone, III-733
 - autodrum, II-591
 - bagpipes, electronic, III-561
 - bird chirp, III-577, II-588, I-605
 - bongos, II-587
 - chug-chug, III-576
 - funk box, II-593
 - fuzz box, III-575
 - race-car motor/crash, III-578
 - sound effects, III-574-578
 - steam locomotive whistle, III-568, II-589
 - steam train/prop plane, II-592
 - super, III-564
 - train chuffer, II-588
 - tremolo circuits, III-692-695, III-692
 - twang-twang, II-592
 - unusual fuzz, II-590
 - voice circuits, III-729-734, III-729
 - waa-waa circuit, II-590
- sound-level
 - meter, III-346
 - meter/monitor, telephone, III-614
- sound light flash trigger, I-481
- sound modulated light source, I-609
- sound-operated circuits, III-579-580, II-580-584
 - color organ, II-583
 - color organ, basic, II-584
 - switch, III-580, II-581, III-600, III-601
 - speech activity detector, telephone, III-615
 - two way switch, I-610
 - voice-operated switch, III-580
 - vox box, II-582
- sound trigger for flash unit, II-449
- sources
 - bilateral current, I-694-695
 - constant current, I-697
 - inverting bipolar current, I-697
 - noninverting bipolar current, I-695
 - programmable voltage, I-694
 - zenerless precision millivolt, I-696
- source follower, photodiode, III-419
- SPDT switch, ac-static, II-612
- space war, I-606
- speaker system
 - FM carrier current remote, I-140
 - hand-held transceivers, amplifiers for, III-39
 - overload protector for, II-16
 - wireless, IR, III-272
- speakerphone, III-608, II-611
- speech activity detector, III-615, II-617
- speech compressor, II-15
- speech filter, 300 Hz-3kHz bandpass, I-295
- speech network, II-633
- speed alarm, I-95
- speed controller
 - closed-loop, III-385
 - fans, automatic, III-382
 - dc motor, I-454
 - dc motor, direction control and, I-452
 - dc variable, fiber optic, II-206
 - feedback, I-447
 - fixed speed, driver and, III-387
 - high torque motor, I-449
 - load-dependent, I-451
 - model trains and cars, I-455
 - motor, I-450, I-453
 - motor, dc, reversible, driver and, III-388
 - motor, high-efficiency, III-390
 - PWM, energy-recovering brake and, III-380
 - radio control, I-576
 - series wound motors, I-448
 - shunt-wound motors, I-456
 - switched-mode, III-384
 - tachless, III-386
 - tools and appliances, I-446
 - universal motor, load dependent, I-451
- speed warning device, I-96, I-101
- splitter, 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 generator, III-583-585, II-594-600

2MHz using two TTL gates, II-598
 555 timer in, II-595
 astable multivibrator as, II-597
 CMOS 555 astable, true rail-to-rail, II-596
 duty-cycle multivibrator, III-50-percent, III-584
 high-current oscillator, III-585
 line frequency, II-599
 low frequency TTL oscillator, II-595
 oscillator, II-597
 oscillator, with frequency doubled output, II-596
 phase tracking three-phase, II-598
 pulse extractor, III-584
 quadrature-outputs oscillator, III-585
 sine-wave and, tunable oscillator, III-232
 three-phase, II-600
 triangle-wave and, III-239
 triangle-wave and, precision, III-242
 triangle-wave and, programmable, III-225
 triangle-wave and, wide-range, III-242
 square-wave tone burst generator
 single timer IC in, II-89
 square-to-sine wave converters, III-118
 square waveform multiburst generator, III-88
 squelch, II-394
 AM/FM, I-547
 squib firing circuits, II-357
 SSB driver
 low distortion 1.6 to 30MHz, II-538
 SSB transmitter
 crystal-controlled LO for, II-142
 stable optocoupler, II-409
 stable unity gain buffer
 good speed and high input impedance, II-6
 staircase generator, III-586-588, II-601-602
 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)
 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 filter, III-189, II-215
 steam locomotive sound effect, II-592
 steam locomotive whistle, III-568, II-589
 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 amplifier, Av/200, I-77
 stereo balance circuit, II-603-605
 stereo balance meter, II-605, I-618-619
 stereo balance tester, II-604
 stereo decoder
 frequency division multiplex, II-169
 time division multiplex, II-18
 stereo demodulator, II-159
 FM, I-544
 stereo mixer, four input, I-55
 stereo phonograph amplifier with bass tone control, I-670
 stereo power meter, III-331
 stereo preamplifier, II-43, II-45
 stereo reception indicator, III-269
 stereo reverb systems, I-602, I-606
 gain control in, II-9
 stereo TV decoder, II-167
 stimulator, constant-current, III-352
 stimulus isolator, III-351
 stop light, garage, II-53
 strain gauge
 bridge excitation, III-71
 bridge signal conditioner, II-85
 instrumentation amplifier, III-280
 strobe circuits, II-606-610
 disco-, II-610
 safety flare, II-608
 simple, II-607
 tone burst generator, II-90
 trip switch, sound activated, I-483
 variable strobe, III-589-590, III-589
 stud finder, III-339
 subharmonic frequencies, crystal-stabilized IC timer for, II-151
 subtractor, III-327
 successive approximation A/D converter, II-24, II-30
 summing amplifier, III-16
 video, clamping circuit and, III-710
 sun tracker, III-318
 supply rails, current sensing in, II-153
 suppressed-carrier, double-sideband, modulator, III-377
 sweep generator, 10.7 MHz, I-472
 sweep
 add-on triggered, I-472
 oscilloscope-triggered, III-438
 switched-capacitor analog-to-digital converters, III-23
 switch, II-611-612
 ac, sound activated, II-581
 ac power, photoelectric, III-319
 ac switcher, high-voltage, optically coupled, III-408
 ac-static SPDT, II-612
 adjustable light detection, I-362
 analog, one MOSpower FET, III-593
 CMOS touch, I-137
 contact, I-136
 dc static, II-367
 debouncer, III-592
 delay, auto courtesy light, III-42
 differential analog, I-622
 DTL-TTL controlled buffered analog, I-621
 FET dual-trace (oscilloscope), II-432
 Hall-effect, III-257
 high frequency, I-622
 high toggle rate, high frequency analog, I-621
 latching, double button touch, I-138
 light operated, III-314, II-320
 low current touch, I-132
 on/off inverter, III-594
 on/off touch, II-691
 photoelectric memory, ac power control, I-363
 photoelectric, II-321
 photoelectric, synchronous, II-326
 proximity, III-517
 push on/off, II-359
 remote on/off, I-577
 remote ring extender, I-630
 rf, low-cost, III-361
 solar-triggered, III-318
 solid state stepping, II-612
 sonar transducer/, III-703
 sound activated, III-580, II-581, III-600, III-601
 sound operated two way, I-610
 speed, I-104
 switching controller, III-383
 temperature control, low power zero voltage, II-640
 touch, I-131, I-135-136, III-661-665, II-692
 touchomatic, II-693
 triac zero point, II-311
 triac zero voltage, I-623
 two channel, I-623
 ultrasonic, I-683
 video, automatic, III-727
 video, general purpose, III-725
 video, high-performance, III-728
 video/, very high off isolation, III-719
 voice-operated, III-580
 zero crossing, I-732
 zero point, I-373
 zero-voltage switching, closed contact half-wave, III-412
 zero-voltage switching, solid-state, optically coupled, III-410

- switch and amplifier, voice activated, I-608
 - switch mode power supply, II-470
 - switched light, capacitance, I-132
 - switched mode converter, +50V push pull, I-494
 - switching circuits, III-591-594
 - analog switch, one-MOSpower FET, III-593
 - debouncer, III-592
 - latching, SCR-replacing, III-593
 - on/off inverters, III-594
 - rf power switch, III-592
 - switching inverter, 500 kHz, 12 V systems, II-474
 - switching power amplifier, I-33
 - switching power supply, III-458
 - 100-KHZ, multiple-output, III-488
 - 50-W off-line, III-473
 - switching regulator
 - 3-A, III-472
 - 200kHz, I-491
 - 5V/6A 25uHz, separate ultrastable reference, I-497
 - 6.0A variable output, I-513
 - application circuit, 3W, I-492
 - 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
 - synchronous photoelectric switch, II-326
 - sync separator, single-supply wide-range, III-715
 - synthesizer
 - four channel, I-603
 - frequency, programmable voltage-controlled, II-265
 - music, I-599
- T**
- tachometer, I-100, I-102, II-175, III-335, 340, III-595-598
 - calibrated, III-598
 - closed loop, feedback control of, II-390
 - digital, III-45, II-61
 - frequency counter, I-310
 - gasoline engine, I-94
 - low-frequency, III-596
 - minimum component, I-405
 - motor speed control and, II-389
 - motor speed control using feedback from, II-378
 - optical pick-up, III-347
 - set point, III-47
 - tamper proof burglar alarm, I-8
 - tandem dimmer, II-312
 - tap, telephone, III-622
 - tape playback amplifier, I-92
 - tape preamplifier, I-90
 - tape-recorder circuits, I-419, III-599-601
 - extended-play circuit, III-600
 - flat-response amplifier, III-673
 - interface for, II-614
 - playback amplifier, III-672
 - position indicator/controller, II-615
 - sound-activated switch, III-600, III-601
 - telephone-to-cassette interface, III-618
 - tape recording
 - amplifier for, I-90
 - automatic, I-21
 - tape starter, telephone controlled, I-632
 - telemetry demodulator, I-229
 - telephone-related circuits, III-602-622, II-616-635
 - amplifier for, III-621
 - auto answer and ring indicator for, I-635
 - automatic recording device, II-622
 - blinker, II-629
 - blinking phone light monitor, II-624
 - cassette interface, III-618
 - dial pulse indicator, III-613
 - dialed phone number vocalizer, III-731
 - dialer, pulse/tone, single-chip, III-603
 - dual tone decoding, II-620
 - duplex line amplifier, III-616
 - eavesdropper, wireless, III-620
 - frequency and volume controller, II-623
 - hands-free telephone, III-605
 - handset encoder, III-613
 - handset tone dial encoder, I-634
 - hold button, III-612, II-628
 - in use indicator, II-629
 - light for, II-625
 - line interface, autopatch, I-635
 - line monitor, I-628
 - musical hold, II-623
 - musical ringer for, 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
 - plug-in remote ringer for, II-627
 - programmable multi-tone ringer, II-634
 - pulse-dialing, III-610
 - recorder, III-616
 - redial, III-606
 - relay, I-631
 - remote monitor for, II-626
 - remote ringer, III-614
 - repeater, III-607
 - repertory dialer, line powered, I-633
 - ring detector, III-619, II-623
 - ring detector, optically interfaced, III-611
 - ringer, high isolation, II-625
 - ringer relay, III-606
 - scrambler, II-618
 - series connection, III-609
 - sound level meter monitor, III-614
 - speakerphone, III-608, II-632
 - speech activity detector, III-615, II-617
 - speech network, II-633
 - status monitor using optoisolator, I-626
 - switch, solid-state, line-activated, III-617
 - tap, III-622
 - tape starter controlled by, I-632
 - tone-dialing, III-607
 - tone ringer for, I-628
 - tone ringer II, II-631
 - tone ringer, I-627
 - tone ringer, II-630
 - Touchtone generator, III-609
 - television-related circuits
 - audio amplifiers for, III-39
 - automatic turn off for, I-577
 - cross-hatch generator, III-724
 - IF amplifier and detector using MC130/MC1352, I-688
 - modulator for, II-433-434, I-439
 - sound IF or FM IF amplifier with quadrature detector, I-690
 - stereo, decoder for, II-167
 - transmitter, III-676
 - TTL oscillator interfaces data for, II-372
 - UHF preamplifier, III-546
 - temperature alarm, II-4, II-643
 - adjustable threshold, II-644
 - temperature compensated crystal oscillator, I-187
 - temperature control, III-623-628, II-636-644, I-641-643
 - adjustable threshold alarm for, II-644
 - alarm for, II-643
 - circuit for, II-637
 - dual-timer chip, liquid level monitor and, II-643
 - heater element, II-642
 - heater protector, servo-sensed, III-624
 - heat sniffer, electronic, III-627
 - low cost circuit for, II-638
 - low power zero voltage switch, II-640
 - piezoelectric fan-based, III-627
 - precision, linearized platinum RTD signal conditioner, II-639
 - proportional, III-626
 - single setpoint, I-641
 - zero-point switching, III-624
 - temperature indicator
 - PTC thermistor for automotive, II-56

temperature measuring circuit, digital, II-653
 temperature meter, I-647
 temperature monitor, III-206
 temperature sensitive heater control, I-640
 temperature sensor, III-629-631, II-645-650, I-648, I-657
 0-50-degree C four channel, I-648
 0-63 degrees C, III-631
 5V powered linearized platinum RTD signal conditioner, II-650
 Centigrade thermometer, II-648
 coefficient resistor, positive, I-657
 differential, I-655
 dual output over/under, II-646
 DVM interface, II-647
 hi/lo, II-650
 integrated circuit, I-649
 isolated, III-631, I-651
 remote, I-654
 simple differential, I-654
 thermocouple amplifier with cold junction compensation, II-649
 thermocouple multiplex system, III-630
 zero crossing detector, I-733
 temperature stable oscillator, II-427
 temperature to frequency converter, I-168, II-651-653, I-656
 digital measuring circuit for, II-653
 temperature to frequency transducer, linear, I-646
 temperature transducer with remote sensor, I-649
 temperature-compensated crystal oscillator, III-137
 temperature-to-time converters, III-632-633, III-632
 ten-band graphic equalizer, active filter in, II-684
 ten-bit A/D converter, II-28
 ten-bit serial output A/D converter, II-27
 Tesla coils, III-634-636
 test circuit, III-328-348, II-340
 60MHz power gain, I-489
 audible slow logic pulses, II-345
 continuity for PCB, II-342
 diode, II-343
 frequency shift keyer tone generator, I-723
 ground, II-345
 unidirectional motion sensor, II-346
 wire tracer, II-343
 test probe
 4-220V, III-499
 logic, with memory, I-525
 tester
 audio continuity, I-550
 crystal, II-151
 diode, I-402
 go/no-go diode, I-401
 ground, I-580
 low resistance continuity, I-551
 precision, dual limit, go/no-go, I-157
 shutter, I-485
 transistor, I-401
 TTL logic, I-527
 zener, I-400
 text adder, composite-video signal, III-716
 theremins, II-654-656
 digital, II-656
 electronic, II-655
 thermal flowmeter, low-rate flow, III-203
 thermally controlled ni-cad battery charger, II-68
 thermally stabilized PIN photodiode signal conditioner, II-330
 thermocouple circuits
 digital thermometer using, II-658
 multiplex, temperature sensor system, III-630
 pre-amp using, III-283
 thermometer, centigrade calibrated, I-650
 thermocouple amplifier, II-14, I-654
 cold junction compensation in, II-649
 high stability, I-355
 thermometer, III-637-643, II-657-662
 0-50 degree F, I-656
 0-100 degree C, I-656
 adapter for, III-642
 add-on for DMM digital voltmeter, III-640
 basic digital, I-658
 Centigrade, II-648, II-662
 centigrade, I-655
 centigrade, calibrated, I-650
 differential, III-638, I-652, II-661
 digital, I-651
 digital, temperature-reporting, III-638
 digital, thermocouple, II-658
 electronic, III-639, II-660
 Fahrenheit, I-658
 ground referred Centigrade, I-657
 ground referred Fahrenheit, I-656
 implantable/ingestible, III-641
 Kelvin scale with zero adjust, I-653
 Kelvin with zero adjust, II-661
 Kelvin, ground referred output, I-655
 linear, III-642
 low power, I-655
 meter, trimmed output, I-655
 remote, II-659
 uP controlled digital, I-650
 variable offset, I-652
 thermostat
 three wire electronic, I-640
 two wire remote ac electronic, I-639
 third overtone crystal oscillator, I-186
 three-channel multiplexer, sample and hold, III-396
 three-decade logarithmic A/D converter, I-48
 three-dial combination electronic lock, II-195
 three-in-one test set, III-330
 three-minute timer, III-654
 three-phase clock, reference clock to, II-101
 three-phase ac motor driver, II-383
 three-phase power factor controller, II-388
 three-phase square wave output generator, II-600
 three-phase tester, II-440
 three-rail power supply, III-466
 threshold detectors, precision, III-157
 tilt meter, III-644-646, II-663-666
 differential capacitance measurement circuit, II-665
 sense of slope, II-664
 ultra-simple level, II-666
 time delay, III-647-649, II-667-670
 circuit, precision solid state, I-664
 constant current charging, II-668
 electronic, III-648
 generator, I-218
 hour sampling circuit, II-668
 long duration, I-220
 low cost integrator to multiply 555, II-669
 relay, I-663
 relay, ultra precise long, I-219
 simple, II-220, I-668
 timing threshold and load driver, III-648
 two SCR, II-670
 time division multiplex stereo decoder, II-168
 timebase, crystal oscillator, III-133
 timer, III-650-655, I-668, II-671-681
 0.1 to 90 second, I-663
 741, I-667
 adjustable ac .2 to 10 seconds, II-681
 alarm with, II-674
 CMOS, programmable precision, III-652
 circuit for, II-675
 darkroom, I-480
 electronic egg, I-665
 IC, crystal-stabilized, II-151
 long delay, PUT, I-219
 long interval RC, I-667
 long term electronic, II-672
 long-time, III-653
 low power microprocessor programmable interval, II-678

- timer (*con't.*)
- one-shot, III-654
 - photographic, I-485
 - photographic darkroom enlarger, III-445
 - precision elapsed time/countdown, II-680
 - programmable voltage-controlled, II-676
 - PUT long duration, II-675
 - sequential, III-651, I-661-662
 - sequential UJT, I-662
 - simple, I-666
 - slide-show, III-444
 - slides, photographic, III-448
 - solid-state, industrial applications, I-664
 - three-minute, III-654
 - thumbwheel programmable interval, I-660
 - triangle-wave generator, linear, III-222
 - variable duty cycle output, III-240
 - washer, I-668
- timing, sequential, I-663
- timing circuit, I-666
- timing light, ignition, II-60
- timing threshold and load driver, III-648
- TMOS voltage-controlled oscillator, balanced, III-736
- tone alert decoder, I-213
- tone annunciator, transformerless, III-27-28, III-27
- tone burst generator, II-90, I-604
- European repeaters, III-74
- tone control, III-656-660, I-677, II-682-689
- active bass and treble, with buffer, I-674
 - audio amplifier, II-686
 - equalizer, ten-band octave, III-658
 - guitar treble booster, II-683
 - high level preamp and, II-688
 - high quality, I-675
 - high z input, hi fi, I-676
 - IC preamplifier, III-657, I-673
 - microphone preamp with, II-687
 - microphone preamp, I-675
 - mixer preamp, I-58
 - passive circuit, II-689
 - rumble/scratch filter, III-660
 - ten band graphic equalizer, active filter, II-684
 - three-band active, III-658, I-676
 - three channel, I-672
 - Wien-bridge filter, III-659
- tone decoder, III-143, I-231
- dual time constant, II-166
 - 24 percent bandwidth, I-215
 - relay output, I-213
- tone detectors, 500-Hz, III-154
- tone dial decoder, I-631
- tone dial encoder, I-629
- tone dial generator, I-629
- tone dial sequence decoder, I-630
- tone-dialing telephone, III-607
- tone encoder, I-67
- subaudible, I-23
 - two-wire, II-364
- tone generator
- FSK test circuit, I-723
 - portable, I-625
 - warbling, II-573
- 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 switch, I-135-136, III-661-665, II-690-693
- CMOS, I-137
 - digital on/off, III-663
 - electronic on/off, III-663
 - latching, double button, I-138
 - low current, I-132
 - momentary operation, I-133
 - line-hum, III-664
 - negative-triggered, III-662
 - on/off, II-691
 - positive-triggered, III-662
 - touchomatic, II-693
 - two-terminal, III-663
- touchomatic switch, II-693
- Touchtone generator, telephone, III-609
- touch triggered bistable, I-133
- toxic gas detector, II-280
- toy siren, II-575
- TR circuit, II-532
- tracer
- bug, III-358
 - closed-loop, III-356
 - receiver, III-357
- tracer probe, audio ref signal, I-527
- track-and-hold circuit, III-667
- sample-and-hold circuit, III-549, III-552
 - signal, III-668
- tracking A/D converter, 8-bit, III-24, I-46
- 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
- transceiver
- dc adapter and, hand-held, III-461
 - hand-held, speaker amplifiers, III-39
 - 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, equalized, for magnetic phono cartridges, III-671
- preamp, magnetic phono, III-673
- tape playback, III-672
- voltage, differential-to-single-ended, III-670
- transducer, I-86
- bridge type, amplifier for, III-71, II-84
 - detector for magnetic, I-233
 - sonar, switch and, III-703
 - temperature, precision, remote sensor, I-649
- transformerless tone annunciator, III-27-28
- transistor flasher, III-200
- transistor headphone amplifier, II-43
- transistor saturated nonselective frequency tripler, II-252
- transistor sorter, I-401
- transistor tester, I-401
- transistorized flashers, table of, II-236
- transmission indicator, II-211
- transmitter, III-674-691
- 1-of-8 channel multiplexed transmission system, III-395
 - 1-2 MHz broadcast, I-680
 - 40 kHz ultrasonic, I-685
 - 200 kHz line carrier with on/off, I-142
 - amateur radio, 80-M, III-675
 - audio, carrier-current circuit, III-79
 - beacon, III-683
 - carrier current, I-144
 - CW, 1-W, III-678
 - CW, 40-M, III-684
 - CW, 902-MHz, III-686
 - CW, QRP, III-690
 - fiber optic, III-177
 - 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
 - infrared, III-277, II-289, II-290
 - infrared, digital, III-275
 - integrated circuit carrier current, I-145
 - IR, I-343
 - low-frequency, III-682
 - one tube, 10 W CW, I-681
 - one-of-eight channel, computer circuit, III-100
 - optical, I-363
 - optical, FM, 50 kHz center frequency, II-417

optical, receiver for, II-418
oscillator and, 27 and 49 MHz, I-680
receiver and, IR remote control, I-342
remote sensors, loop-type, III-70
simple FM, I-681
television, III-676
VHF modulator, III-684
VHF tone, III-681
treasure locator, lo-parts, I-409
treble booster, guitar, II-683
tremolo circuit, I-59, III-692-695
voltage-controlled amplifier, I-598
triac circuits
lamp dimmer, III-303, II-310
relay-contact protection with, II-531
zero point switch, II-311
triac-controlled voltage doubler, III-468
triangle to sine converter, II-127
triangle/square wave oscillator, II-422
triangle-wave generators, III-234
square-wave and, III-225, III-239
square-wave and, precision, III-242
square-wave and, wide-range, III-242
timer, linear, III-222
trickle charger, 12 V battery, I-117
trigger
50-MHz, III-364
camera alarm, III-444
flash, photograph, 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
tunable audio filter, II-402
tunable audio notch filter circuit, II-399
tunable frequency oscillator, II-425
tunable notch filter, op amp, II-400
tuner
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 8-bit to 12 D/A converter, II-180
two-channel panning circuit, I-57
two-gate quartz oscillator, III-136
two-level multiplexer, III-392
two-meter preamp for handtalkies, I-19
two-op amp bridge type differential
amplifier, II-83
two-phase ac motor driver, II-382
two-state siren, III-567
two-tone generator, II-570
two-tone siren, III-562
two-way intercom, III-292
two-wire to four wire audio converter, II-14
two-wire tone encoder, II-364
two's complement, D/A conversion
system, binary, 12-bit, III-166

U

UA2240 staircase generator, III-587
UHF, wideband amplifier, high perfor-
mance FETs, III-264
UHF-TV preamplifier, III-546
UJT circuits
battery chargers, III-56
metronome, II-355
monostable circuit, bias voltage change
insensitive, II-268
ultra high gain audio amplifier, I-87
ultra high voltage generator, II-488
ultra high Z ac unity gain amplifier, II-7
ultra low leakage preamp, II-7, I-38
ultrasonics, III-696-707
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
ranging system, III-697
receiver, III-698, III-705
sonar transducer/switch, III-703
switch, I-683
transceiver, III-702, III-704
transmitter, I-685
undervoltage, monitor for, III-762
unidirectional motion sensor, II-346
uninterruptible power supply, II-462
+5V, III-477
unity gain amplifier
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
unipolar-to-dual supply voltage converter,
III-743

universal active filter, II-214
universal battery chargers, III-56, III-58
universal counter
10 MHz, II-139
40-MHz, III-127
universal mixer stage, III-370
universal power supply, 3-30V, III-489
universal wiper delay, I-97
untuned field strength meter, I-276
unusual fuzz sound effect, II-590
up/down counter, extreme count freezer,
III-125

V

vacuum fluorescent display circuit, II-185
vapor detector, II-279
varactor tuned 10 MHz ceramic resonator
oscillator, II-141
variable attenuator, I-52
variable-capacitance diode-sparked VCO,
III-737
variable current source, 100 mA to 2A, II-
471
variable duty-cycle oscillator, fixed-
frequency, III-422
variable-frequency inverter, complemen-
tary 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 oscillator, II-421
four-decade, single control for, II-424
wide range, II-429
variable power supplies 487-492
adjustable 10-A regulator, III-492
regulator/current source, III-490
switching regulator, low-power, III-490
switching, 100-KHz multiple-output, III-
488
tracking preregulator, III-492
universal 3-30V, III-489
variable voltage regulator, III-491
variable sine-wave oscillator, super low-
distortion, III-558
variable slope compressor/expander, III-
94
variable timed ring counter, II-134
varying frequency warning alarm, II-579
vehicle security system, I-5
versatile battery charger, II-72
very low frequency generator, II-64,
VFO, 5 MHz, II-551
VHF crystal oscillator
20-MHz, III-138
50-MHz, III-140
100-MHz, III-139

- VHF modulator, I-440, III-684
VHF tone transmitter, III-681
video amplifier, 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 and, II-687, I-689
JFET bipolar cascade, I-692
line driving, III-710
RGB, III-709
summing, clamping circuit and, III-710
video circuits (*see also* television-related), III-713-728
chroma demodulator with RGB matrix, III-716
color amplifier, III-724
composite-video signal text adder, III-716
cross-hatch generator, color TV, III-724
dc restorer, III-723
high-performance video switch, III-728
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
switch/, very high off isolation, III-719
sync separator, single-supply wide-range, III-715
video switch, automatic, III-727
video switch, general purpose, III-725
wireless camera link, III-71
video log amplifier, dc to, I-38
video modulator, II-371, II-372, I-437
video monitors, RGB, blue box, III-99
video multiplexer, 1-of-15 cascaded, III-393
visible voltage indicator, III-772
voice activated switch and amplifier, I-608
voice circuits, III-729-734
ac line-voltage announcer, III-730
allophone generator, III-733
computer speech synthesizer, III-732
dialed phone number vocalizer, III-731
voice substitute, electronic, III-734
voice substitute, electronic, III-734
voice-operated switch, III-580
voltage amplifier
differential-to-single-ended, III-670
reference, I-36
voltage control resistor, I-422
voltage-controlled amplifier, I-31, I-598
voltage-controlled attenuator, II-18, III-31
voltage-controlled crystal oscillator, III-135
voltage-controlled filter, III-187
voltage-controlled high speed one shot, II-266
voltage-controlled ramp generator, II-523
voltage-controlled timer, programmable, II-676
voltage-controlled amplifier, tremolo circuit or, I-598
voltage-controlled oscillator, I-702-704
3-5 V regulated output converter, III-739
10Hz to 10kHz, I-701, III-735-741
linear, I-701
linear triangle/square wave, II-263
logarithmic sweep, III-738
precision, III-431, I-702
simple, I-703
supply voltage splitter, III-738
three decade, I-703
TMOS, balanced, III-736
two decade high frequency, I-704
variable-capacitance diode-sparked, III-737
waveform generator and, III-737
voltage-controlled variable gain amplifier, I-28-29
voltage-controller, pulse generator and, 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 +/- 12-15 V, III-746
flyback, high-efficiency, III-744
flyback-switching, self-oscillating, III-748
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 doubler, III-459
triac-controlled, III-468
voltage follower, I-40, III-212
fast, I-34
noninverting, I-33
signal-supply operation, amplifiers for, III-20
voltage indicator
solid-state battery, I-120
visible, I-338
voltage inverters, precision, III-298
voltage level detector, II-172, I-338
voltage level indicator, III-759, III-770
five step, I-337
ten step, I-335
voltage meters/monitors/indicators, III-758-772
ac voltmeter, III-765
ac voltmeter, wide-range, III-772
audio millivoltmeter, III-767, III-769
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
frequency counter, III-768
high-input resistance voltmeter, III-768
HTS, precision, I-122
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
visible voltage indicator, III-772
voltage freezer, III-763
voltage monitor, III-767
voltage-level, III-759
voltage-level sensor, III-770
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
voltage regulator, II-484
5-V low-dropout, III-461
10V high stability, III-468
ac, III-477
automotive circuits, III-48
high-voltage, III-485
negative, III-474
projection lamp, II-305
PUT, 90V rms voltage, II-479
single supply, II-471
variable, III-491
voltage source, programmable, I-694
voltage splitter, III-738
voltage-to-current converter, III-110, II-124, I-166
voltage-to-frequency converters, I-707, III-749-757
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
accurate, III-756

differential-input, III-750
low-cost, III-751
precision, II-131
preserved input, III-753
wide-range, III-751, III-752
voltage-to-pulse duration converter, II-124
voltmeter
3 1/2 digit, I-712
3 1/2 digital true rms ac, I-712
5-digit, III-760
ac, III-765
ac, wide-range, III-772
add-on thermometer for, III-640
bar-graph, II-54
bargraph car, I-99
dc, III-763
dc, high-input resistance, III-762
digital, III-4
digital, 3.5-digit, full-scale, four-decade, III-761
FET, I-713, III-765, III-770
high-input resistance, III-768
rf, III-766
sensitive rf, I-405
wide band ac, I-715
volume amplifier, II-46
volume control, telephone, II-623
vox box, II-582
Vpp generator, EPROM, II-114
VU meter, extended range, II-487, I-714

W

waa-waa circuit, II-590
wailers, III-560-568, II-571
alarm using, II-572
wailing siren, III-563
wake-up call, electronic, II-324
walkman amplifier, II-456
warblers, III-560-568, II-571
alarm using, II-573
generator for, II-572
tone generator, II-573
warning, auto lights-on, II-55
warning alarm, varying frequency, II-579
warning device
high level, I-387

high speed, I-101
low level, audio output, I-391
speed, I-96
warning light, III-317
battery powered, II-320
water-level sensors
detector and control, III-206
indicator, II-244
sensing and control, II-246
wattmeter, I-17
waveform generator, II-269, II-272
audio, precision, III-230
four-output, III-223
precise, II-274
VCO and, III-737
weight scale, digital, II-398
whistle, steam locomotive, III-568, II-589
who's first game circuit, III-244
wide-band AGC amplifiers, III-15
wide-frequency range oscillator/amplifier, II-262
wide-frequency TTL clock, III-85
wide-range oscillator, III-425
wide-range peak detectors, III-152
wide-range variable oscillator, II-429
wideband amplifiers
hybrid, 500 kHz-1 GHz, III-265
instrumentation, III-281
miniature, III-265
UHF amplifiers, high-performance FETs, III-264
wideband signal splitter, III-582
wideband two-pole high pass filter, II-215
Wien-bridge filter, III-659
Wien-bridge notch filter, II-402
Wien-bridge oscillator
CMOS chip in, II-568
low-distortion, thermally stable, III-557
low-voltage, III-432
sine wave, II-566
single-supply, III-558
variable, III-424
wind powered battery charger, II-70
windicator, I-330
window comparator, 87, III-90, II-106
high-input-impedance, II-108
window detectors/comparators/
discriminators, III-776-781

digital frequency window, III-777
multiple-aperture discriminator, III-781
windshield wiper circuits
control circuit for, II-62, I-103, I-105
delayed-action control for, II-55
hesitation control unit for, I-105
intermittent, dynamic braking in, II-49
slow-sweep control for, II-55
windshield washer fluid watcher, I-107
wire tracer, II-343
wireless speaker system, IR, III-272
write amplifiers, III-18

X

xenon flash trigger, slave, III-447
XOR gates
complementary signals generator, III-226
oscillator, III-429
up/down counter, III-105

Y

yelp oscillator, II-577
yelping siren, III-562

Z

Z80 clock, II-121
zapper, II-64
ni-cad battery, II-66
ni-cad battery, version II, II-68
zener diode
increasing power rating of, II-485
variable, I-507
zener rating, transistor increases, I-496
zener tester, I-400
zero crossing detector, II-173
zero meter, suppressed, I-715
zero point switch
temperature control, III-624
triac, II-311
zero-voltage switching
closed contact half-wave, III-412
solid-state relay, antiparallel SCR output, III-416
solid-state, optically coupled, III-410

Other Bestsellers of Related Interest

HOW TO USE SPECIAL-PURPOSE ICs

—Delton T. Horn

A truly excellent overview of the newest and most useful special purpose ICs available today, this source-book covers practical uses for circuits ranging from voltage regulators to CPUs . . . from telephone ICs to multiplexers and demultiplexers . . . from video ICs to stereo synthesizers . . . and more! Easy-to-follow explanations are supported by drawings, diagrams, and schematics. 400 pages, 392 illustrations. Book No. 2625, \$16.95 paperback only

THE LINEAR IC HANDBOOK—Michael S. Morley

Far more than a replacement for manufacturers' data books, *The Linear IC Handbook* covers linear IC offerings from all major manufacturers—complete with specifications, data sheet parameters, and price information—along with technological background on linear ICs. It gives you instant access to data on how linear ICs are fabricated, how they work, what types are available, and techniques for designing them. 624 pages, 366 illustrations. Book No. 2672, \$49.50 hardcover only

ALARMS: 55 Electronic Projects and Circuits—Charles D. Rakes

Make your home or business a safer place to live and work—for a price you can afford. Almost anything can be monitored by an electronic alarm circuit—from detecting overheating equipment to low fluid levels, from smoke in a room to an intruder at the window. This book shows you the variety of alarms that are available. There are step-by-step instructions, work-in-progress diagrams, troubleshooting tips, and advice for building each project. 178 pages, 150 illustrations. Book No. 2996, \$13.95 paperback only

50 CMOS IC PROJECTS—Delton T. Horn

Delton T. Horn presents a general introduction to CMOS ICs and technology . . . provides full schematics including working diagrams and parts lists . . . offers construction hints as well as suggestions for project variations and combinations. This book discusses: the basics of digital electronics, safe handling of CMOS devices, breadboarding, tips on experimenting with circuits, and more. You'll find signal generator and music-making projects, time-keeping circuits, game circuits, and a host of other miscellaneous circuits. 224 pages, 226 illustrations. Book 2995, \$16.95 paperback, \$25.95 hardcover

MASTER HANDBOOK OF 1001 PRACTICAL ELECTRONIC CIRCUITS—Solid-State Edition

—Edited by Kendall Webster Sessions

Tested and proven circuits that you can put to immediate use in a full range of practical applications! You'll find circuits ranging from battery chargers to burglar alarms, from test equipment to voltage multipliers, from power supplies to audio amplifiers, from repeater circuits to transceivers, transmitters, and logic circuits. Whatever your interest or electronics speciality, the circuits you need are here, ready to be put to immediate use. 420 pages, 632 illustrations. Book No. 2980, \$19.95 paperback only

HOW TO DESIGN SOLID-STATE CIRCUITS

—2nd Edition—Mannie Horowitz and Delton T. Horn

Design and build useful electronic circuits from scratch! The authors provide the exact data you need on every aspect of semiconductor design, performance characteristics, applications potential, operating reliability, and more! Four major categories of semiconductors are examined: diodes, transistors, integrated circuits, and thyristors. It's filled with procedures, advice, techniques, and background information—all the hands-on direction you need to understand and use semiconductors in all kinds of electronic devices. 380 pages, 297 illustrations. Book No. 2975, \$16.95 paperback, \$24.95 hardcover

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, \$34.95 hardcover

500 ELECTRONIC IC CIRCUITS WITH PRACTICAL APPLICATIONS—James A. Whitson

More than just an electronics book that provides circuit schematics or step-by-step projects, this complete sourcebook provides both practical electronics circuits AND the additional information you need about specific components. You will be able to use this guide to improve your IC circuit-building skills as well as become more familiar with some of the popular ICs. 336 pages, 600 illustrations. Book No. 2920, \$24.95 paperback, \$29.95 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

THE BENCHTOP ELECTRONICS REFERENCE MANUAL—2nd Edition—Victor F.C. Veley

Praise for the first edition:

"... a one-stop source of valuable information on a wide variety of topics... deserves a prominent place on your bookshelf."

—*Modern Electronics*

Veley has completely updated this edition and added new sections on mathematics and digital electronics. All of the most common electronics topics are covered—ac, dc, circuits, communications, microwave, and more—this is the most complete reference available on the subject. 784 pages, 389 illustrations. Book No. 3414, \$29.95 paperback, \$39.95 hardcover

ELECTRONICS EQUATIONS HANDBOOK

—Stephen J. Erst

Here is immediate access to equations for nearly every imaginable application! In this book, Stephen Erst provides an extensive compilation of formulas from his 40 years' experience in electronics. He covers 21 major categories and more than 600 subtopics in offering the over 800 equations. This broadbased volume includes equations in everything from basic voltage to microwave system designs. 280 pages, 219 illustrations. Book No. 3241, \$16.95 paperback only

BASIC ELECTRONICS THEORY—3rd Edition

—Delton T. Horn

"All the information needed for a basic understanding of almost any electronic device or circuit..." was how *Radio-Electronics* magazine described the previous edition of this now-classic sourcebook. This completely updated and expanded edition provides a resource tool that belongs in a prominent place on every electronics bookshelf. Packed with illustrations, schematics, projects, and experiments, it's a book you won't want to miss! 544 pages, 650 illustrations. Book No. 3195, \$21.95 paperback only

INTERNATIONAL ENCYCLOPEDIA OF INTEGRATED CIRCUITS—Stan Gibilisco

How would you like to have the answers to just about any IC or IC application question in one easy-to-use "master" source? Now you can, with the new, all-inclusive sourcebook. This convenient, quick-reference source provides pin-out diagrams, internal block diagrams and schematics, characteristic curves, descriptions and applications—for foreign and domestic ICs! 1,000 pages, 4,500 illustrations. Book No. 3100 \$75.00 hardcover only

TROUBLESHOOTING AND REPAIRING ELECTRONIC CIRCUITS—2nd Edition

—Robert L. Goodman

Here are easy-to-follow, step-by-step instructions for troubleshooting and repairing all major brands of the latest electronic equipment, with hundreds of block diagrams, specs, and schematics to help you do the job right the first time. You will find expert advice and techniques for working with both old and new circuitry, including tube-type transistor, IC microprocessor, and analog and digital logic circuits. 320 pages, 236 illustrations. Book No. 3258, \$18.95 paperback, \$27.95 hardcover

COMPUTER TECHNICIAN'S HANDBOOK

—3rd Edition—Art Margolis

"This is a clear book, with concise and sensible language and lots of large diagrams... use [it] to cure or prevent problems in [your] own system... the [section on troubleshooting and repair] is worth the price of the book."

—*Science Software Quarterly*

More than just a how-to manual of do-it-yourself fix-it techniques, this book offers complete instructions on interfacing and modification that will help you get the most out of your PC. 579 pages, 97 illustrations. Book No. 3279, \$24.95 paperback, \$36.95 hardcover

ELECTRONIC CONVERSION: 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 conversion, symbols, formulas, and tables. 280 pages, 94 illustrations. Book No. 2865, \$14.95 paperback, \$21.95 hardcover

TROUBLESHOOTING AND REPAIRING THE NEW PERSONAL COMPUTERS—Art Margolis

This is a treasury of time- and money-saving tips and techniques that shows personal computer owners and service technicians how to troubleshoot and repair today's new 8- and 16-bit computers (including IBM® PC/XT/AT and compatibles, the Macintosh®, the Amiga, the Commodores, and other popular brands). Margolis examines the symptoms, describes the problem, and indicates which chips or circuits are most likely to be the source of the trouble. 416 pages, 351 illustrations. Book No. 2809, \$19.95 paperback only

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

Charge my VISA MasterCard American Express

Acct. No. _____ Exp. _____

Signature: _____

Name: _____

Address: _____

City: _____

State: _____ Zip: _____

Subtotal \$ _____

Postage and Handling (\$3.00 in U.S., \$5.00 outside U.S.) \$ _____

Add applicable state and local sales tax \$ _____

TOTAL \$ _____

TAB Books catalog free with purchase; otherwise send \$1.00 in check or money order and receive \$1.00 credit on your next purchase.

Orders outside U.S. must pay with international money order in U.S. dollars.

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.