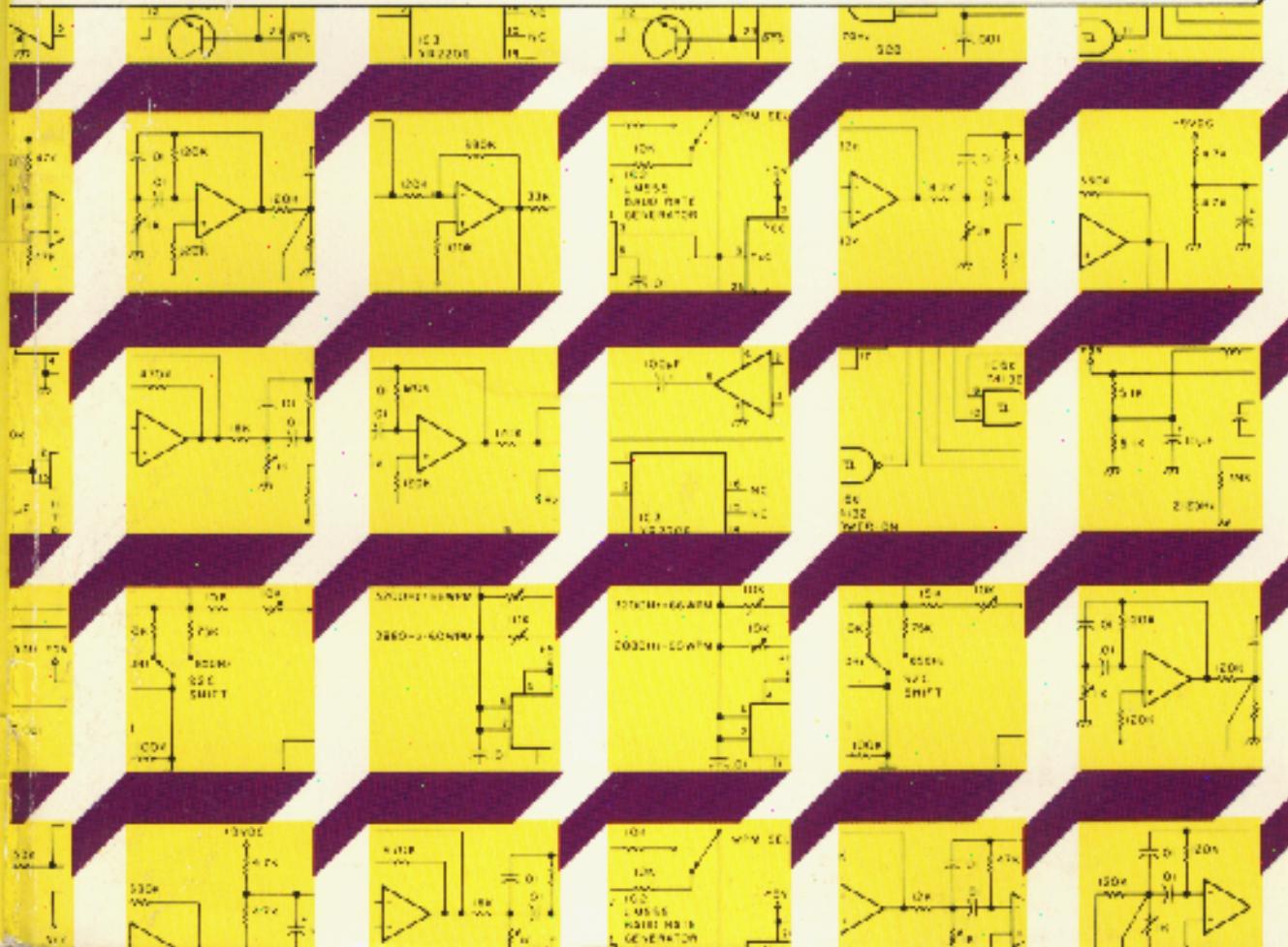


1938

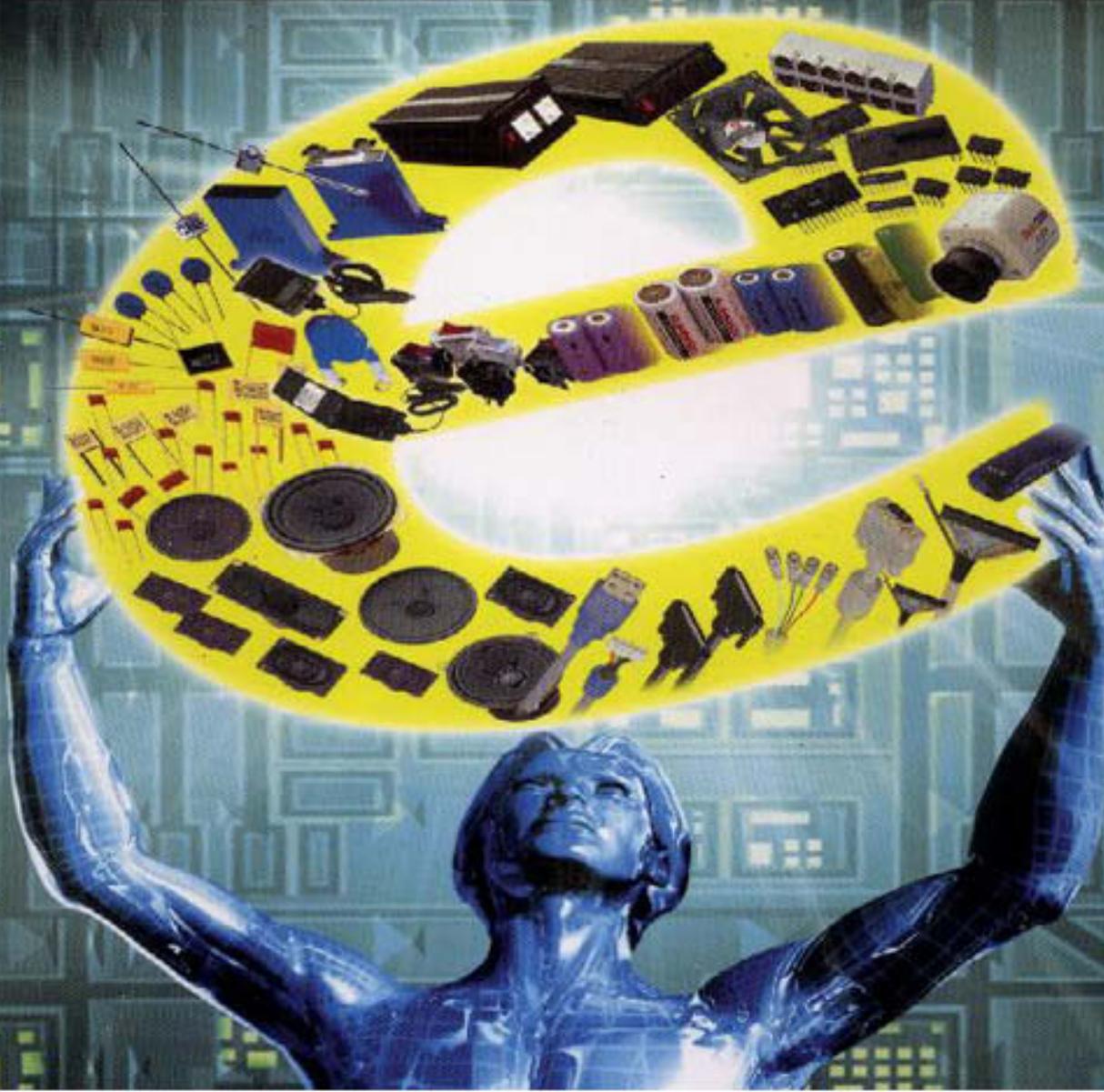
1938

ENCYCLOPEDIA OF ELECTRONIC CIRCUITS

VOLUME 1
RUDOLF F. GRAF



ELECTRONICS



مركز الموسعة الإلكترونية - المهندس محمد نذير المتن

استيراد وتوزيع كافة أنواع القطع و التجهيزات الإلكترونية - نشر وتوزيع كتب الكترونية

نحن نستورد مباشرة أجود الأنواع من أفضل الشركات العالمية

دمشق - حلبوي - شارع مسلم البارودي - هاتف 2221161-2451161 فاكس 2239468

E.mail:nazir@matni.com www.matni.com



NAZIR MATNI ELECTRONICS

HALBOUNI, MOSALAM BAROUDI STR., DIAB BLDG. FL/1,P.O.BOX:12071
DAMASCUS - SYRIA

TEL:+963-11-2221161

FAX:+963-11-2239468

E-Mail: nazir@matni.com

www.matni.com

Importers / Exporters / Distributors / Retailers / Mail orders :
All kinds Electronic Components , Parts , Devices ,

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.

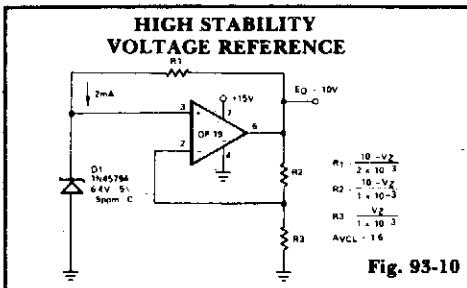


Fig. 93-10

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.

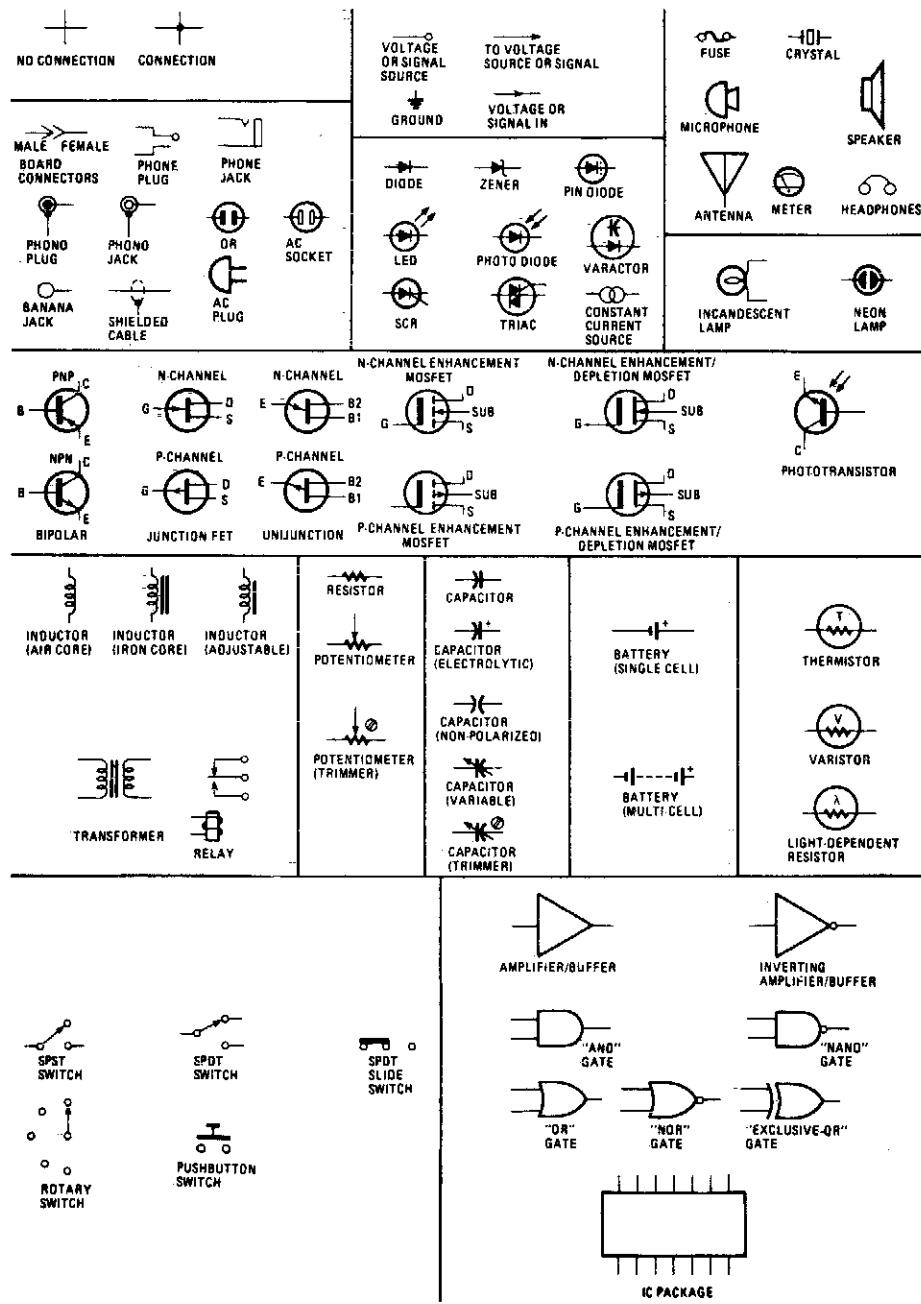
Fig. 93-11: Precision Monolithics Incorporated, 1981 Full Line Catalog, p. 10-18.

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

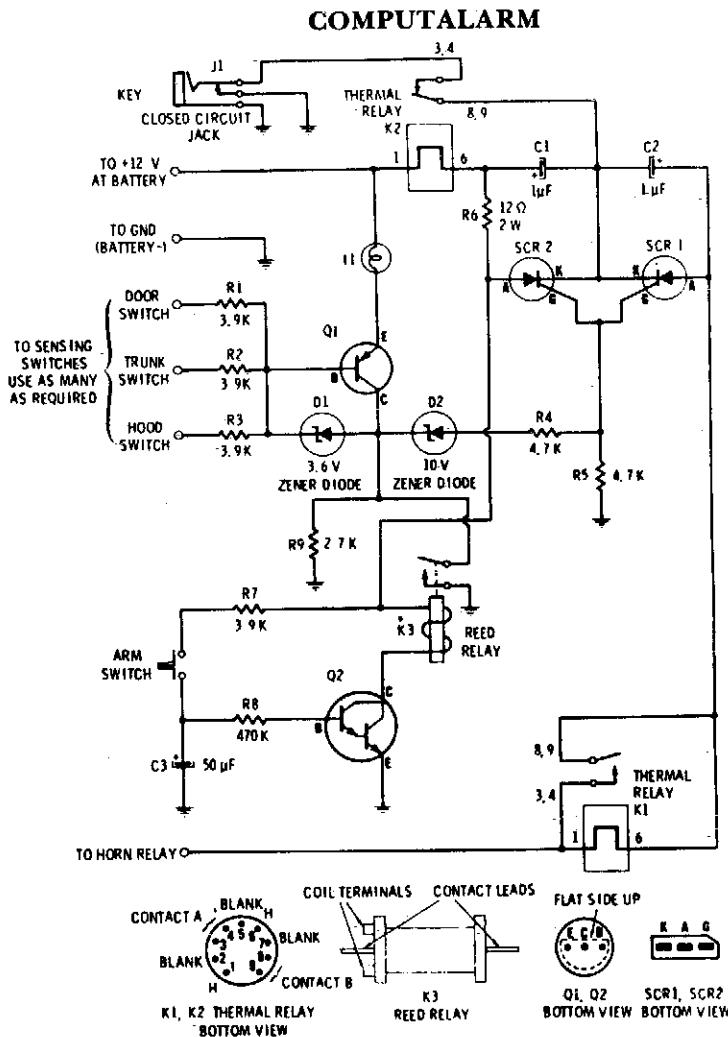


Fig. 1-1

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 (approximate

mately 1 to 2 seconds apart) for a period of one minute. Then the Computalarm automatically shuts itself off (to save your battery) and rearms. 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.

AUTOMOTIVE BURGLAR ALARM

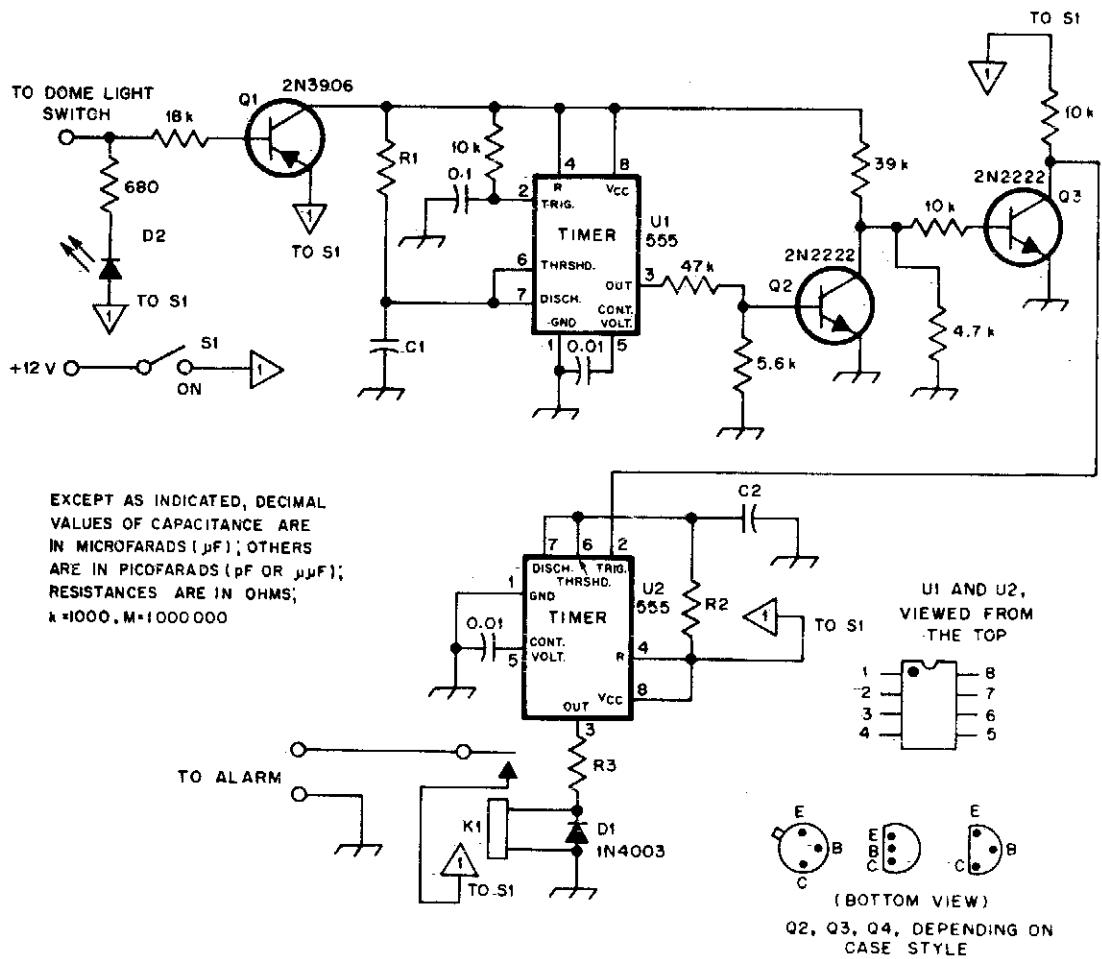


Fig. 1-2

Circuit Notes

Alarm triggers on after a 13 second delay and stays on for 1-1½ minutes. Then it resets automatically. It can also be turned off and reset by opening and reclosing S1.

SECURITY ALARM

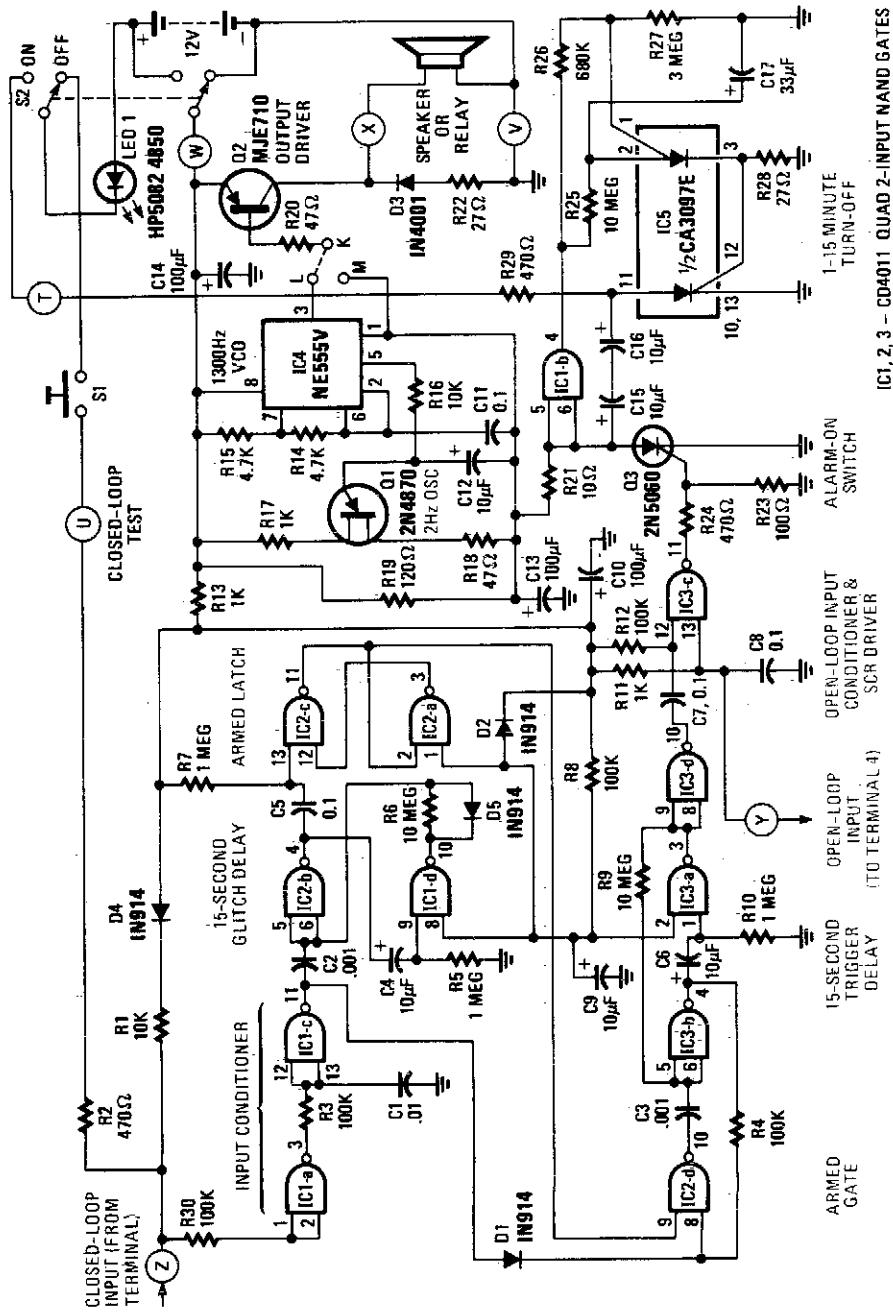


Fig. 1-3

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.

Circuit Notes

VEHICLE SECURITY SYSTEM

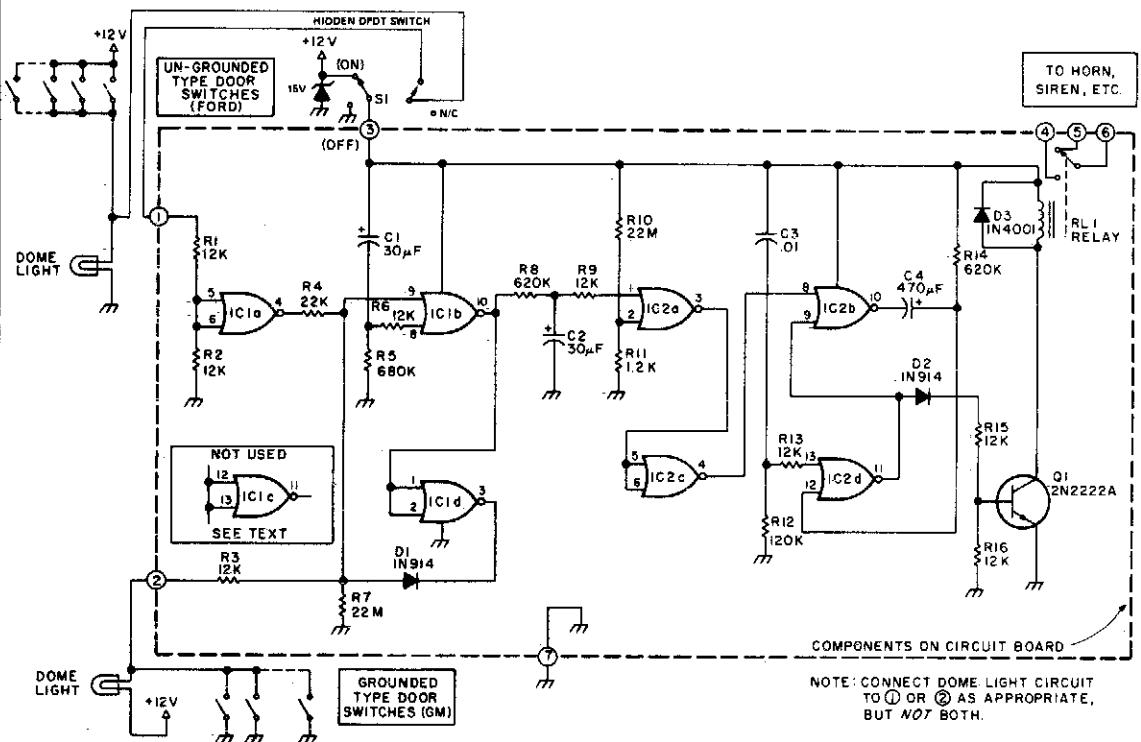


Fig. 1-4

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.

HOME SECURITY MONITOR SYSTEM

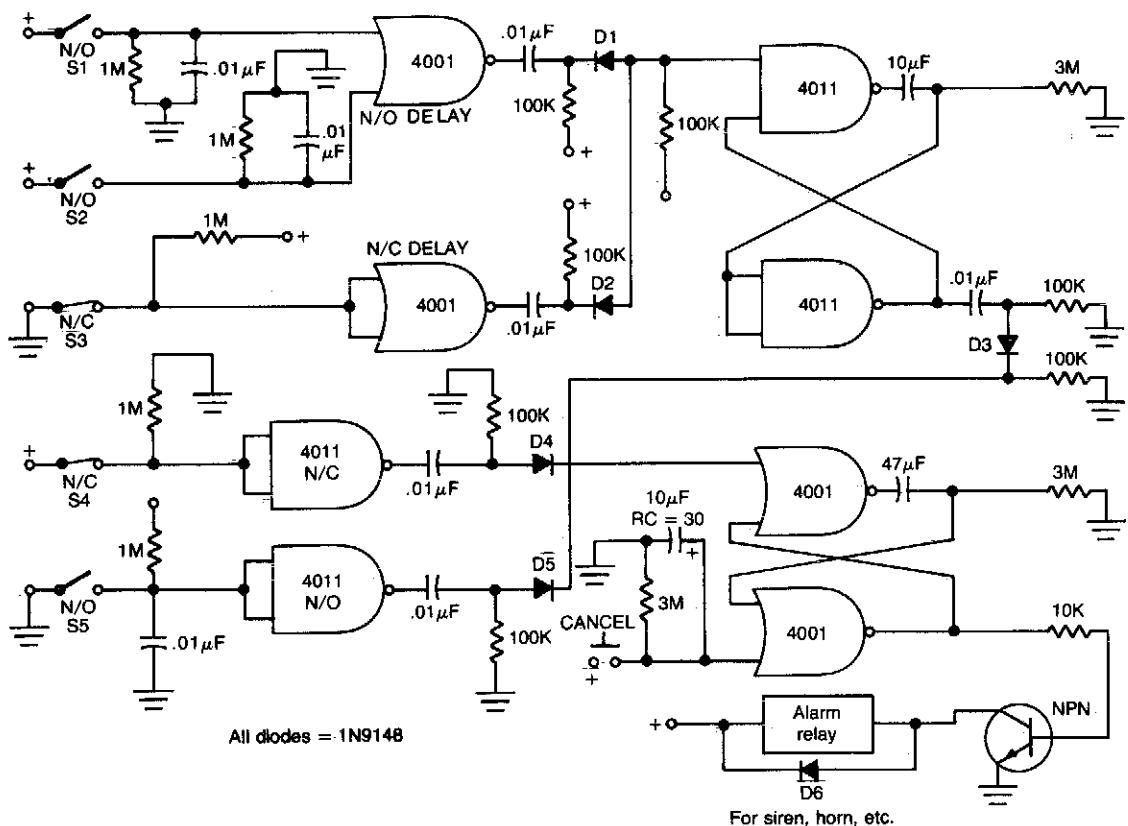


Fig. 1-5

Circuit Notes

This circuit provides normally open (NO) and normally closed (NC) contacts S1, S2, and S3 to turn on the alarm after a 30 second delay. S4 and S5 operate instantly. The CANCEL switch resets the alarm.

ANTITHEFT DEVICE

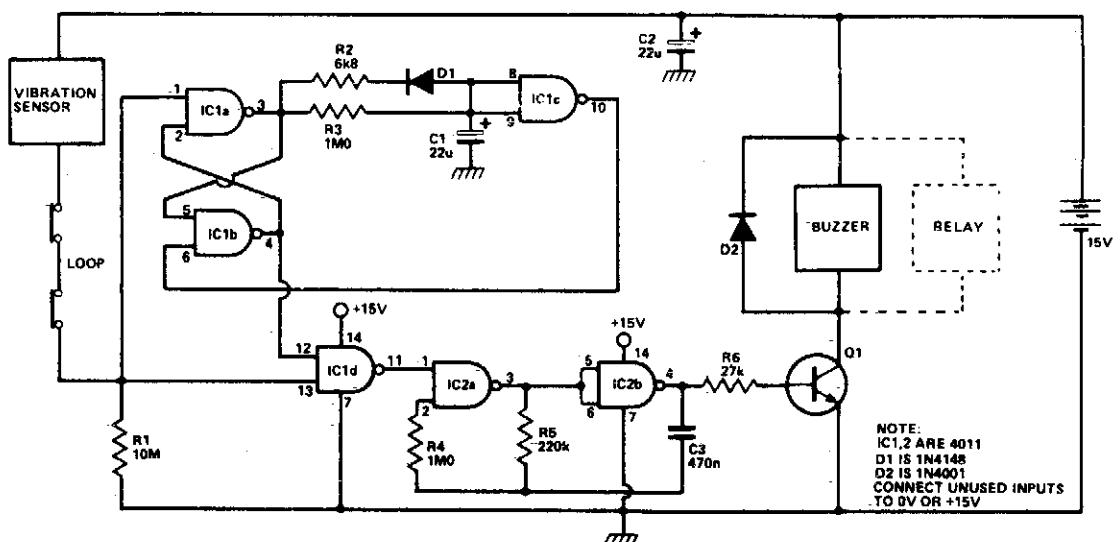


Fig. 1-6

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.

AUTO BURGLAR ALARM

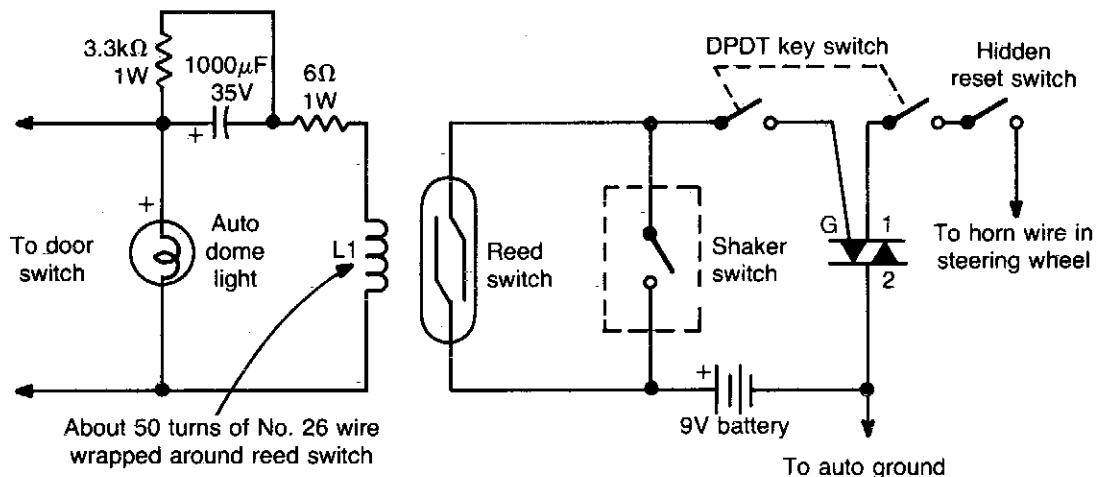
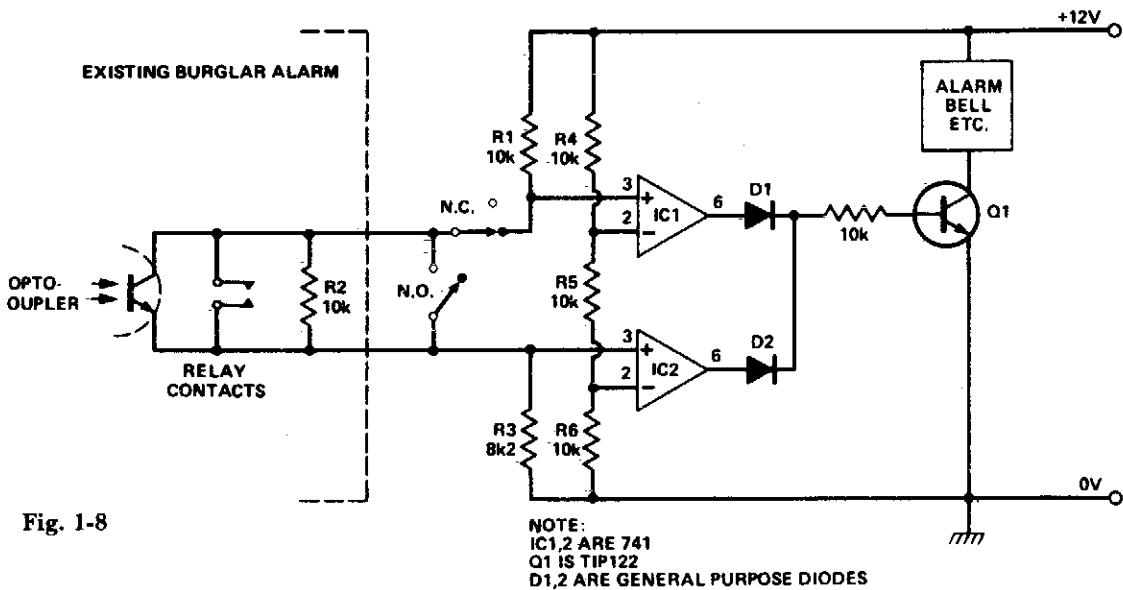


Fig. 1-7

Circuit Notes

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

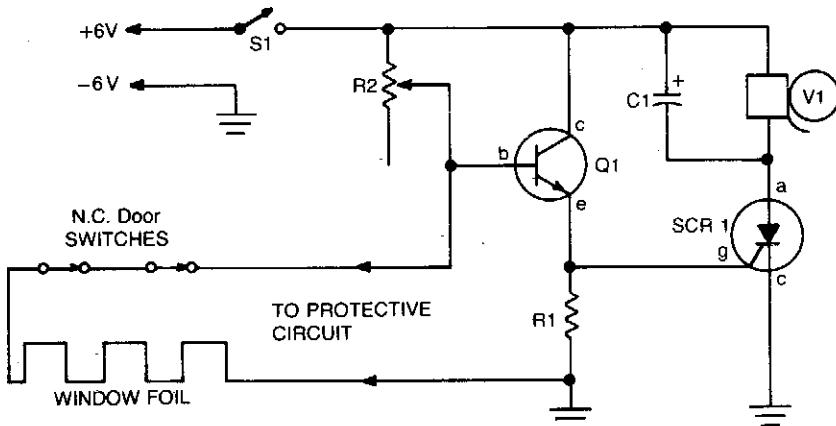
TAMPER-PROOF BURGLAR ALARM



Circuit Notes

If R2 is opened or shorted, the alarm sounds.

LATCHING BURGLAR ALARM



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

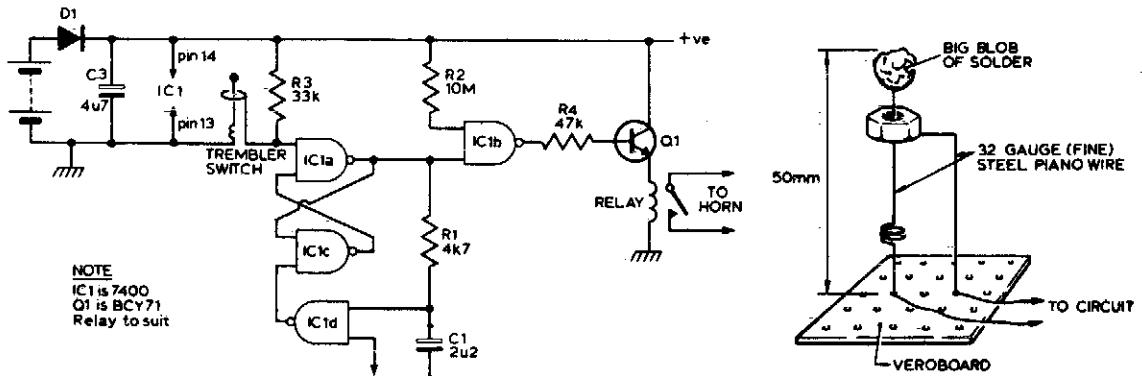


Fig. 1-10

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

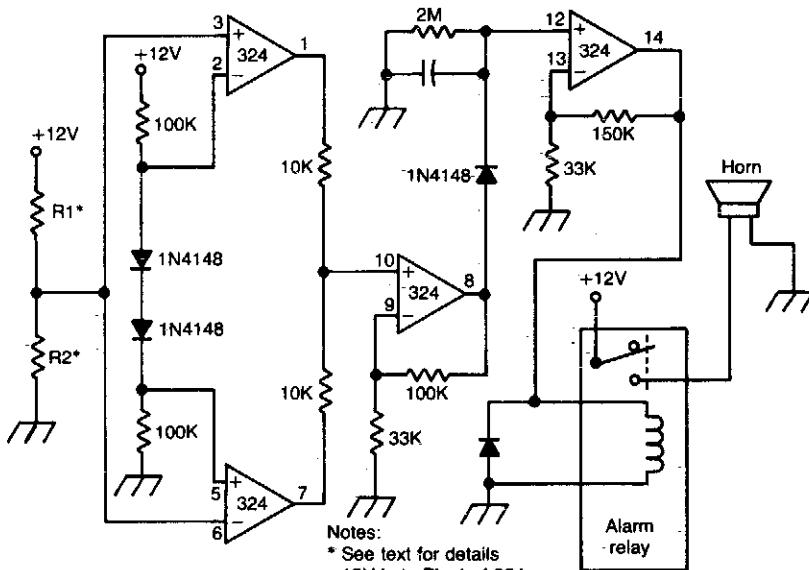


Fig. 1-11

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

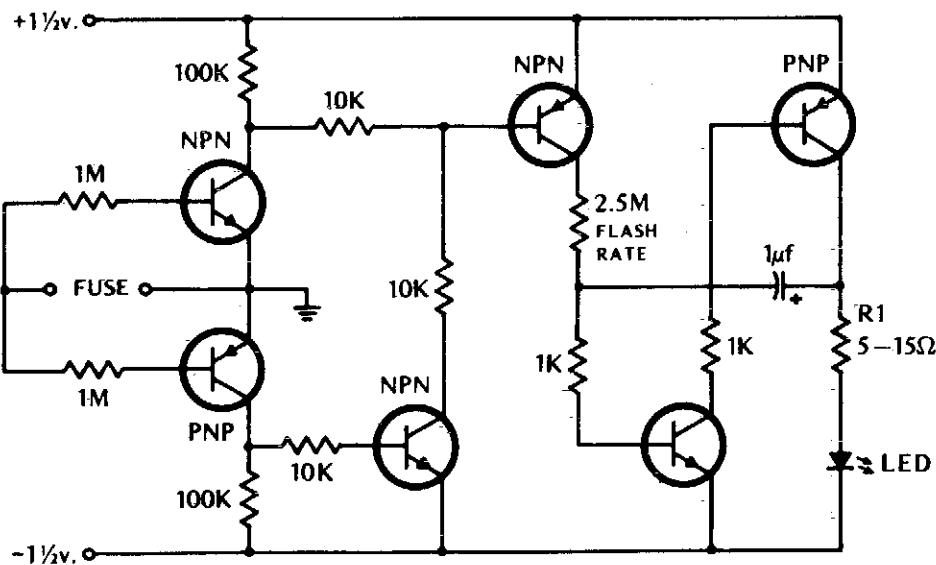


Fig. 1-12

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

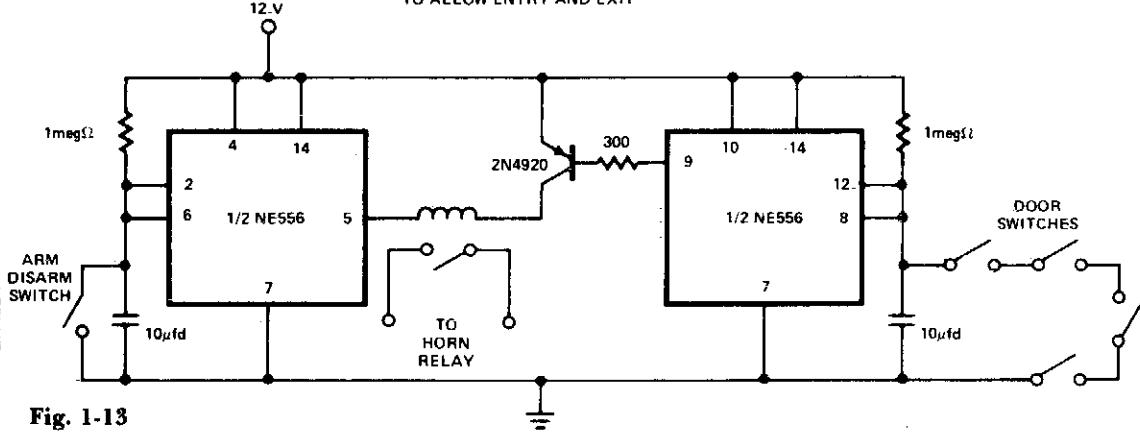


Fig. 1-13

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

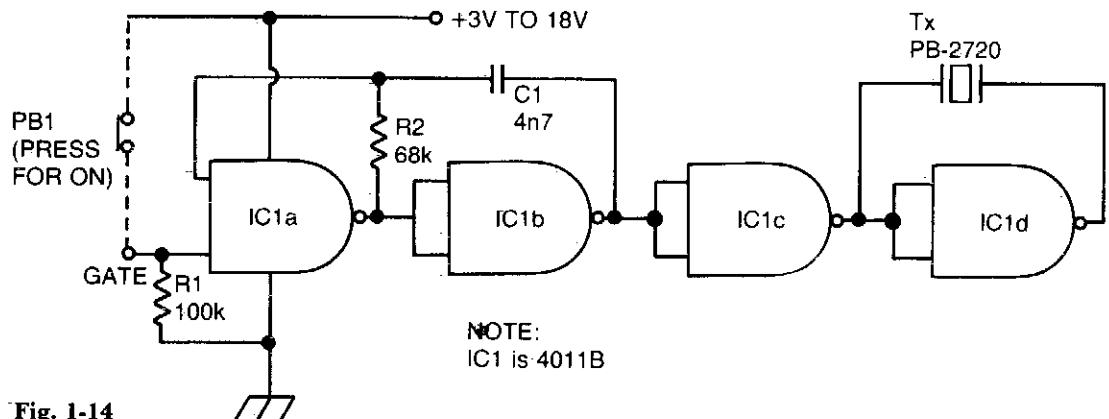


Fig. 1-14

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

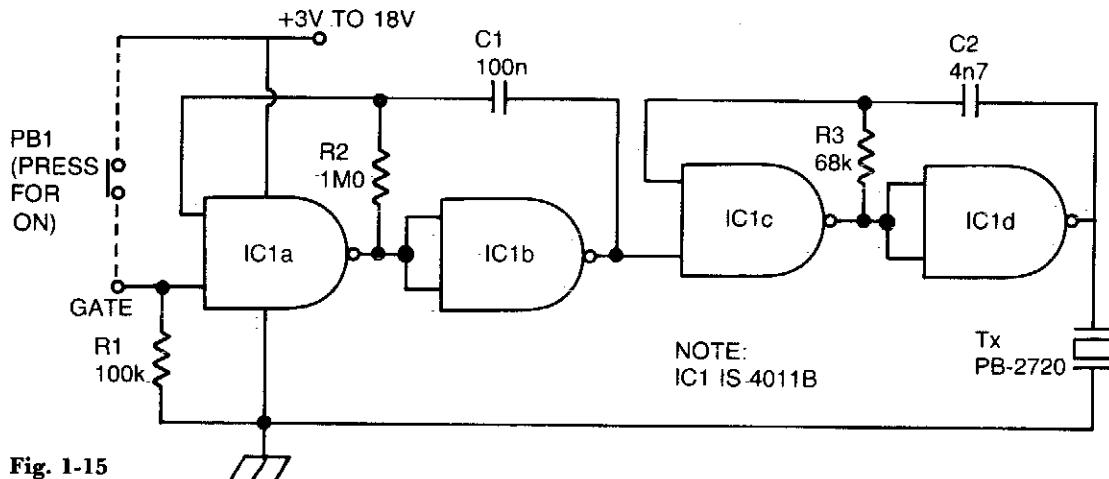


Fig. 1-15

PIEZOELECTRIC ALARM

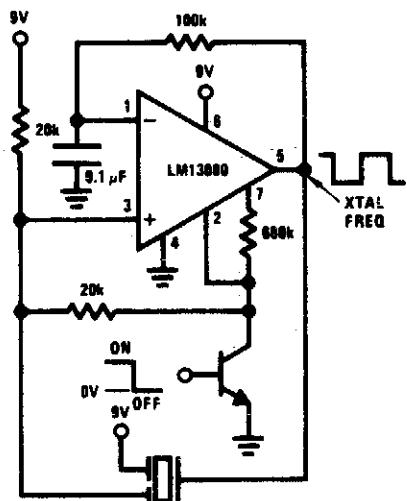


Fig. 1-16

BURGLAR ALARM

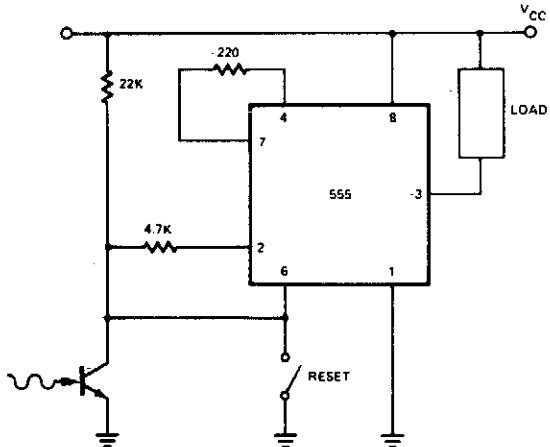


Fig. 1-18

GATED 2 kHz BUZZER

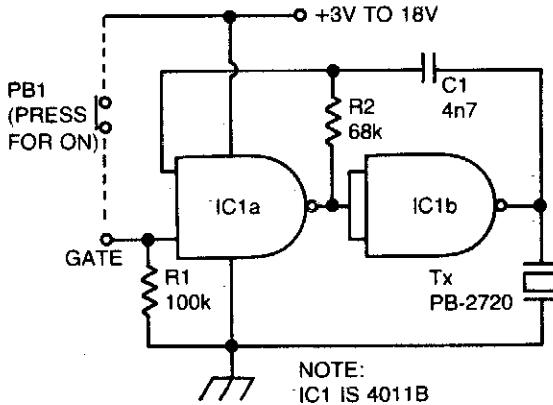


Fig. 1-17

LATCHING BURGLAR ALARM

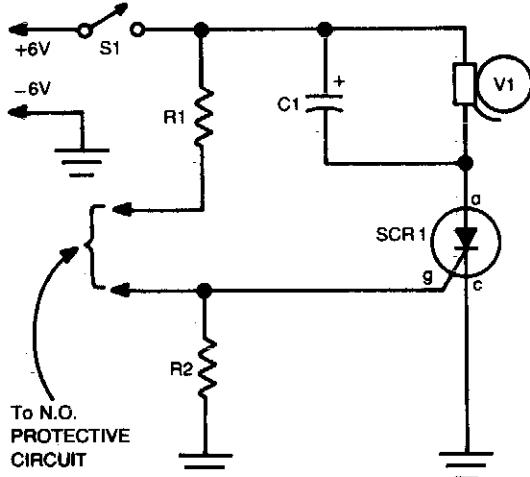


Fig. 1-19

Circuit Notes

Closing the protective circuit (i.e., R1 to R2) applies positive voltage to the gate of SCR1 and sounds the alarm. It can only be turned off with S1.

SUN-POWERED ALARM

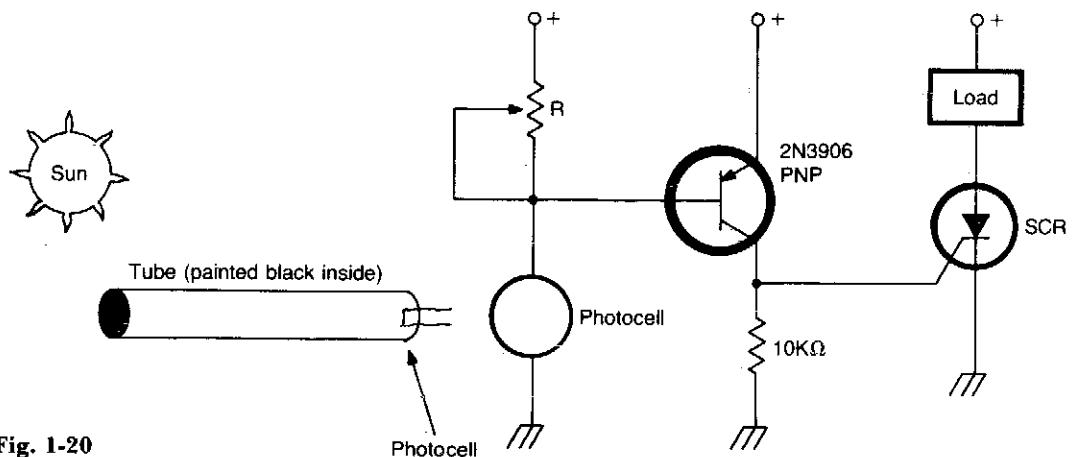


Fig. 1-20

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

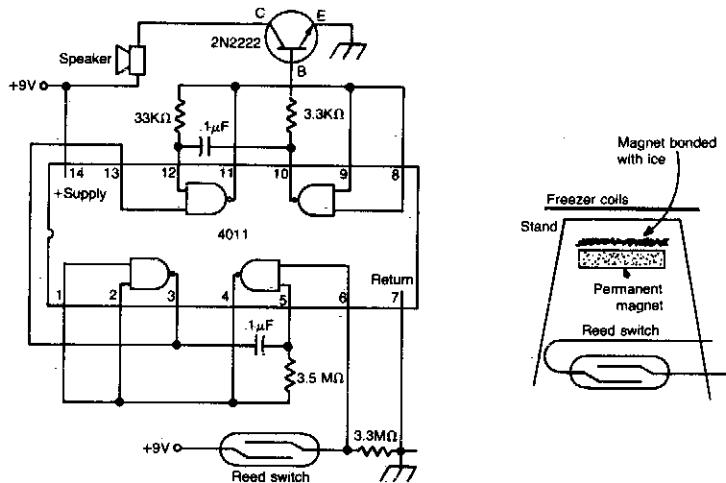


Fig. 1-21

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

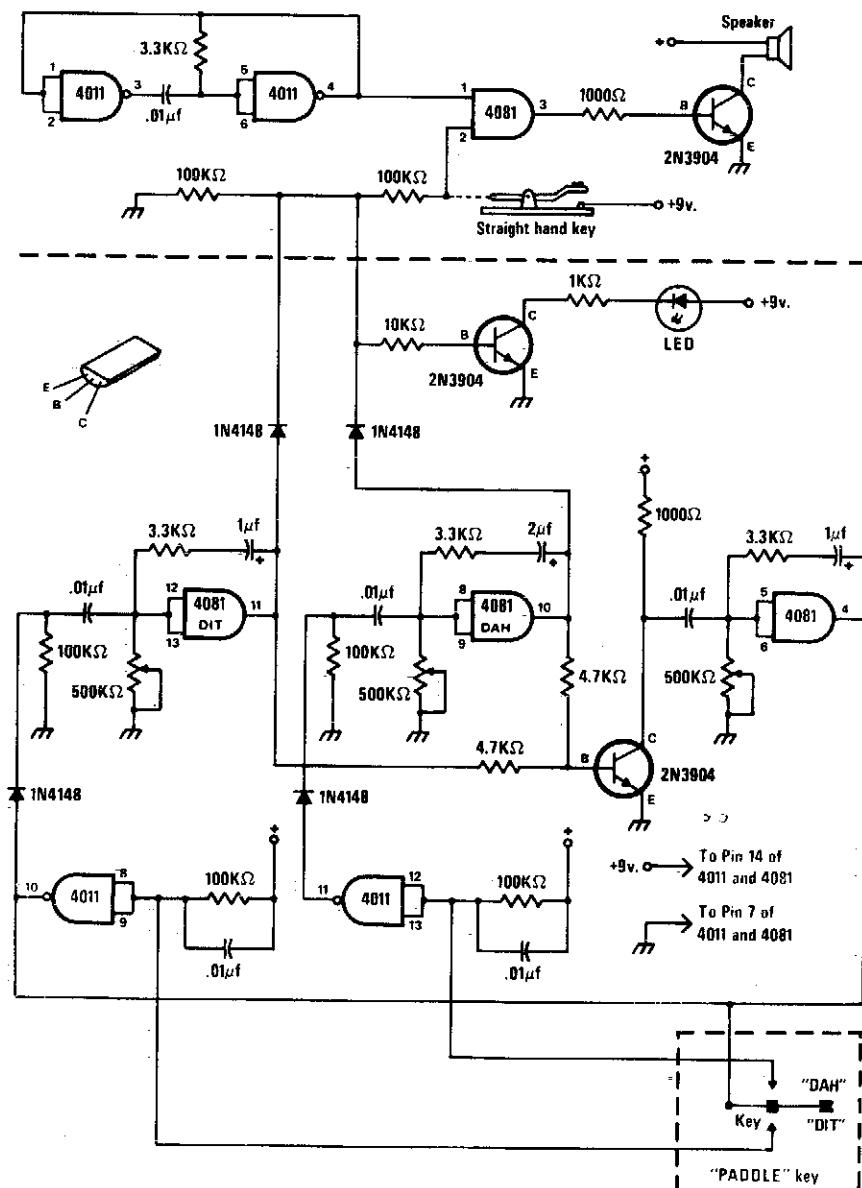


Fig. 2-1

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

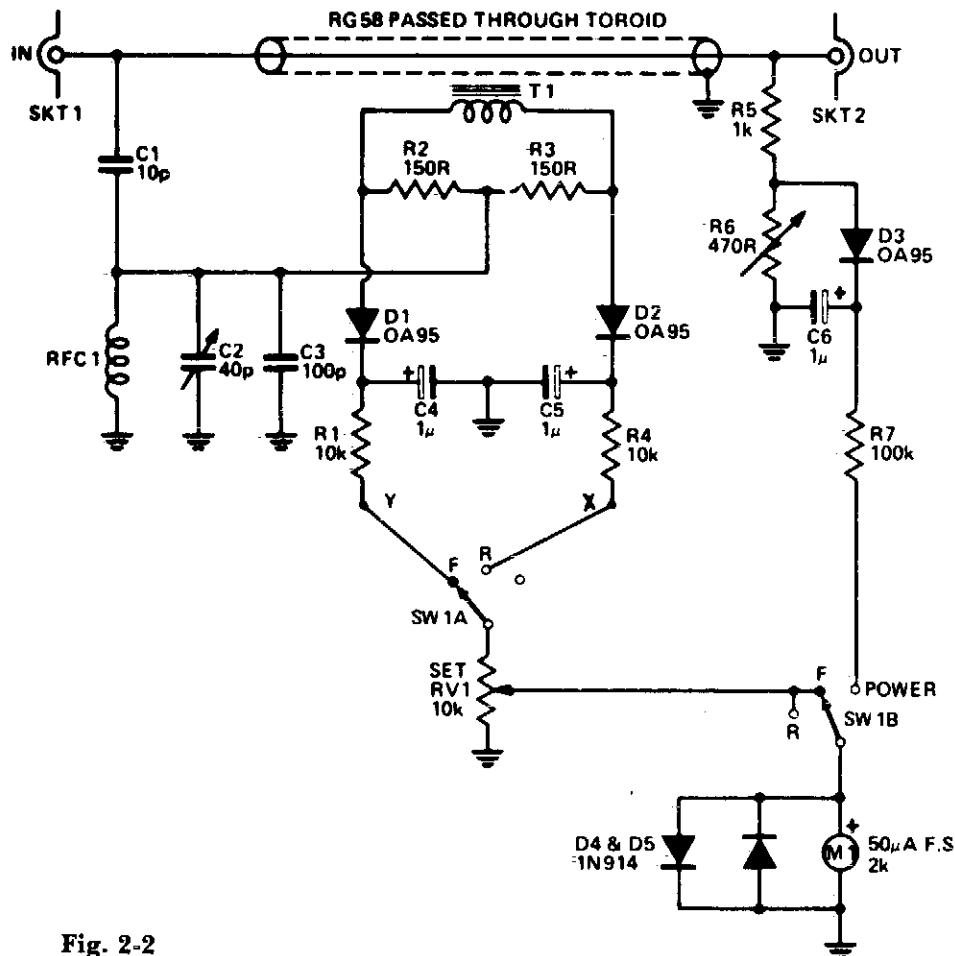


Fig. 2-2

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

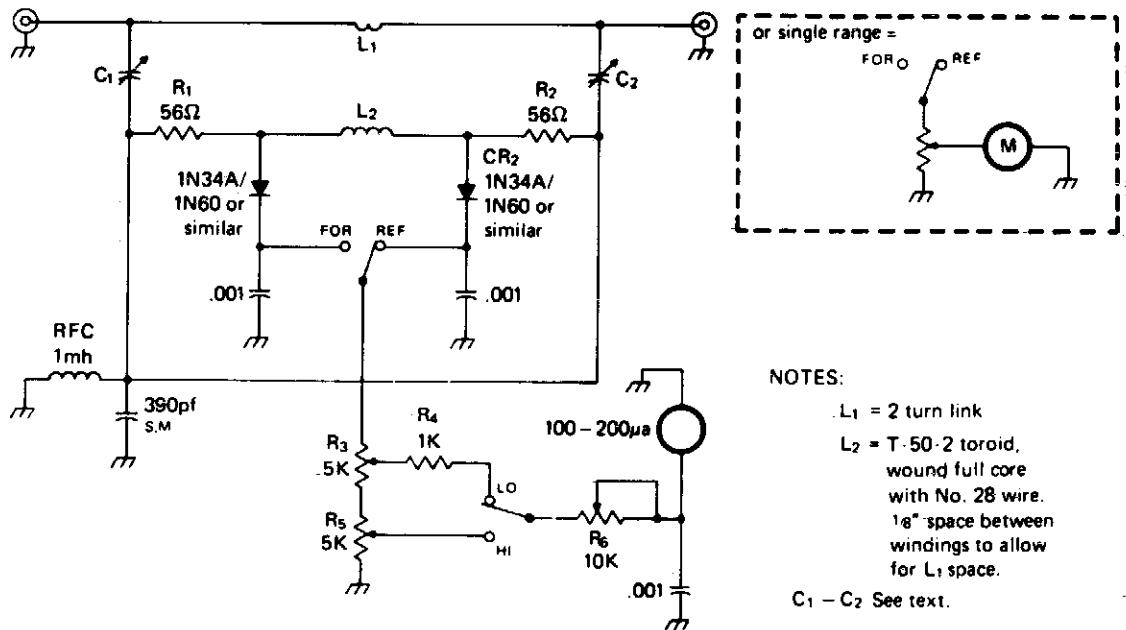


Fig. 2-3

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 L_2 , the voltage divider capacitors C_1-2 and C_3 , and the resistances of R_1-2 are chosen properly. R_1-2 and CR_1-2 should be matched for best results. Generally, R_1-2 must be small compared to the

reactance of L_2 so as to avoid any significant effect on the L_2 current which is induced by the transmission line current flowing through L_1 . The lower frequency limit of the bridge is set by the R_1-R_2/L_s ratio, and the cutoff is at the point where the value of R_1-R_2 becomes significant with reference to the reactance of L_2 at that frequency point.

CW SIGNAL PROCESSOR

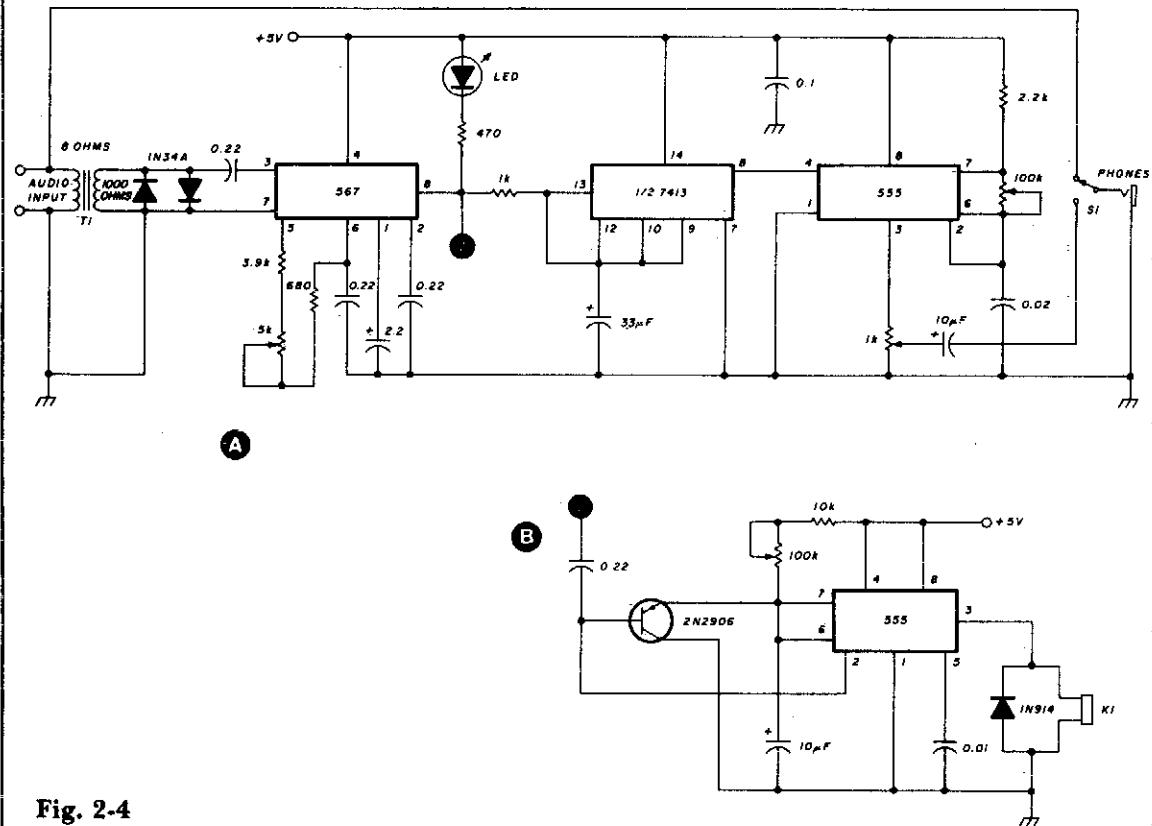


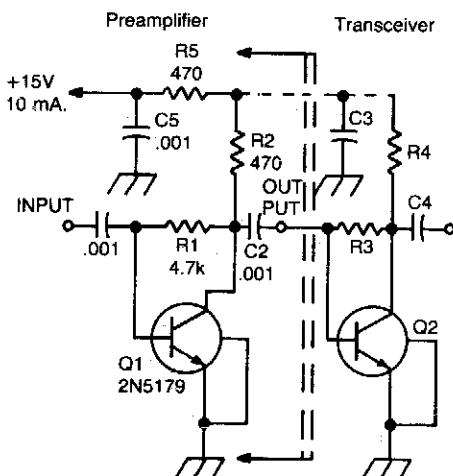
Fig. 2-4

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

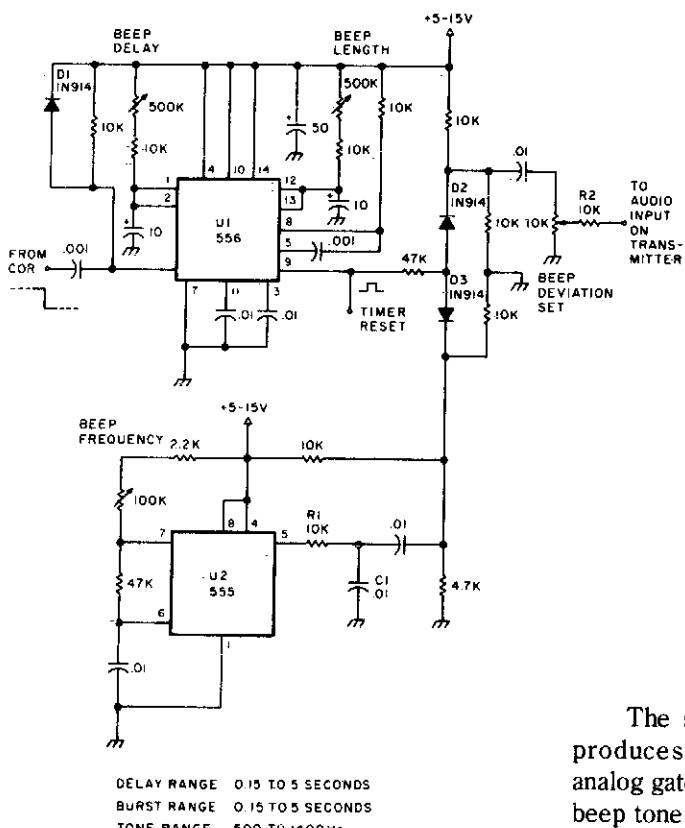


Fig. 2-6

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.

ELECTRONIC KEYER

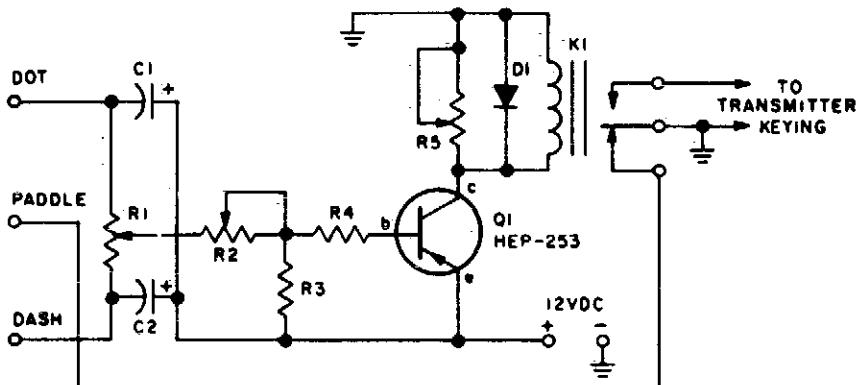


Fig. 2-7

PARTS LIST FOR HAM'S KEYER

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—1200-ohm, $\frac{1}{2}$ -watt resistor
 R4—560-ohm, $\frac{1}{2}$ -watt resistor
 R5—5000-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

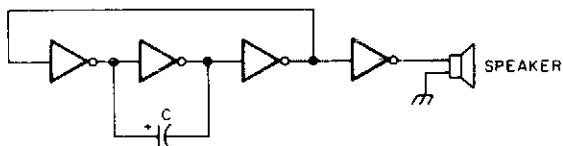
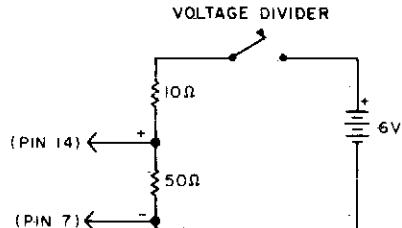
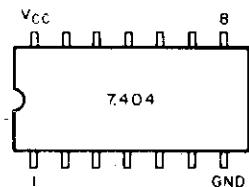


Fig. 2-8



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

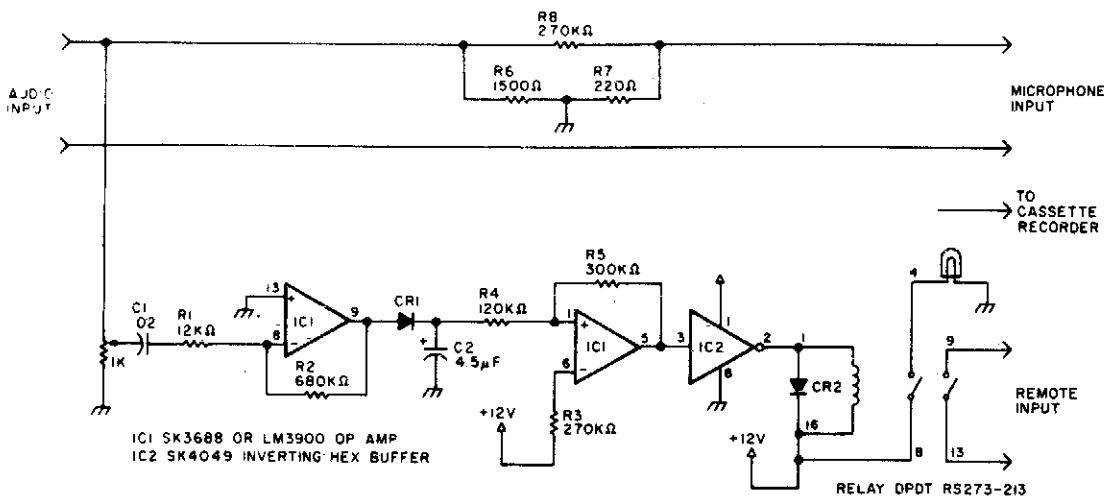


Fig. 2-9

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

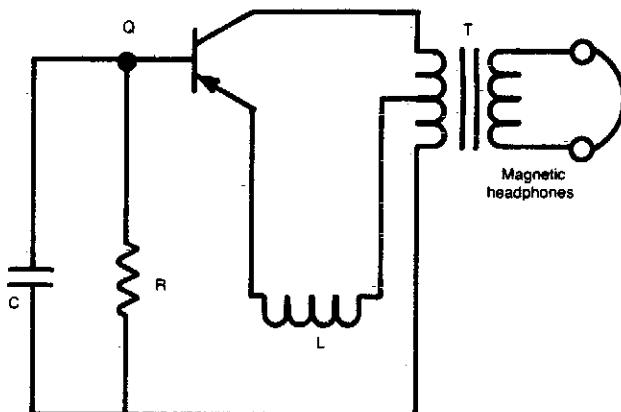
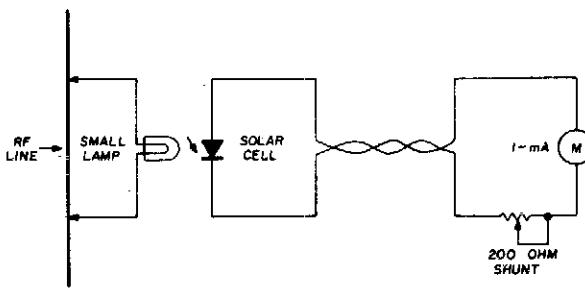


Fig. 2-10

Circuit Notes

Position L near the transmitter output tank to hear the key-down tone. Then tape the coil in place. $C = .047 \mu F$, $R = 8.2 K$, $Q = HEP 253$ (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

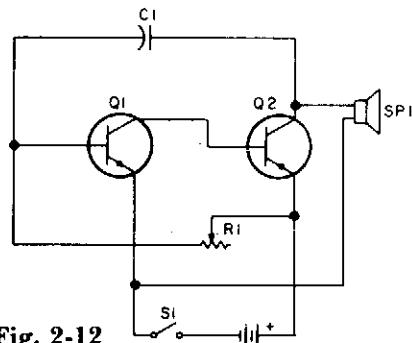


Fig. 2-12

Circuit Notes

Oscillator, works with 2 to 12 Vdc (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.

SWR WARNING INDICATOR

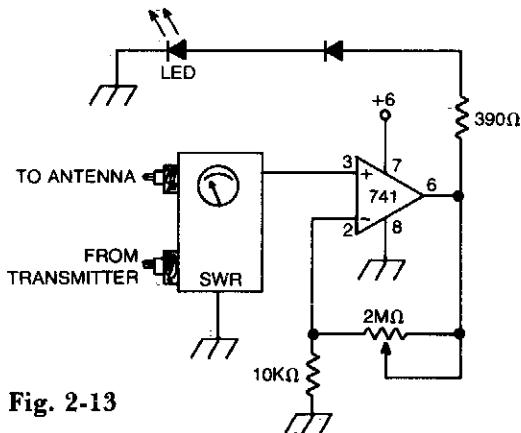


Fig. 2-13

Circuit Notes

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

SUBAUDIBLE TONE ENCODER

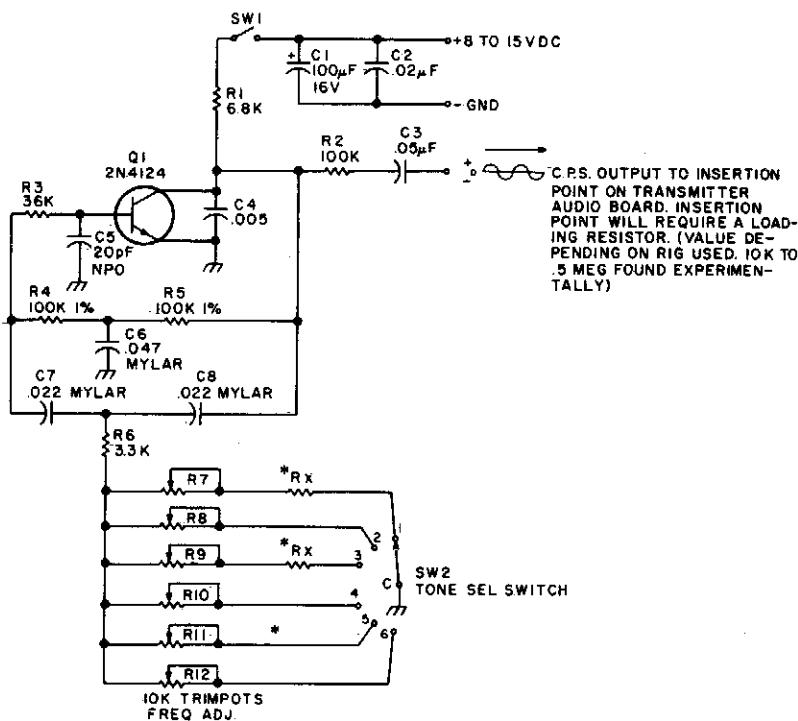


Fig. 2-14

Circuit Notes

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

AUDIO MIXER

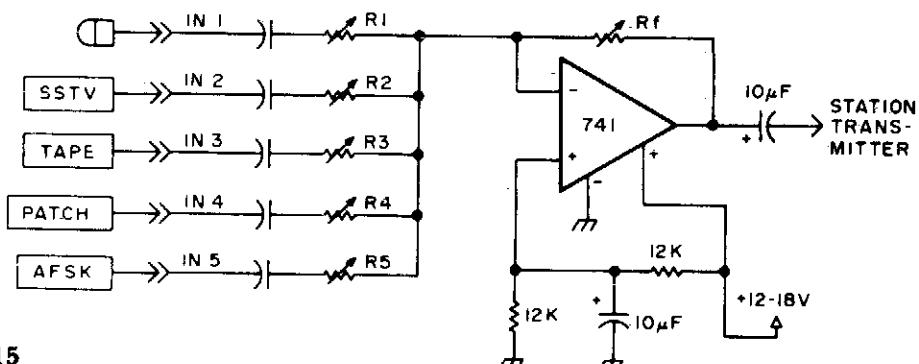


Fig. 2-15

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

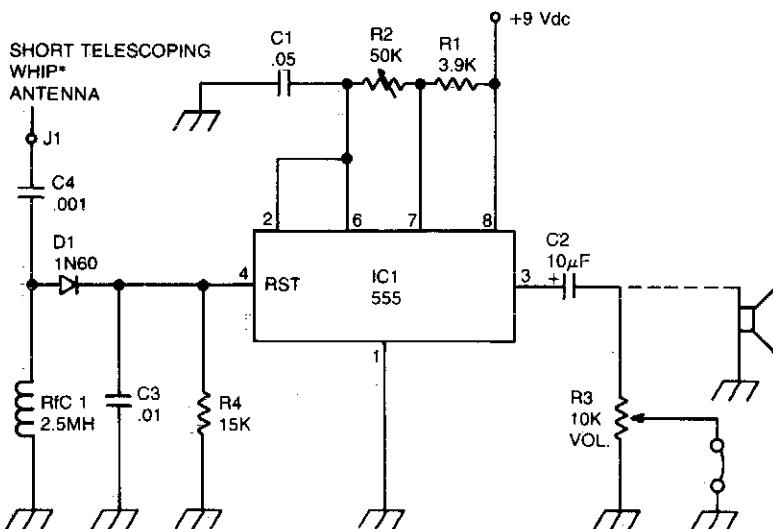


Fig. 2-16

*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

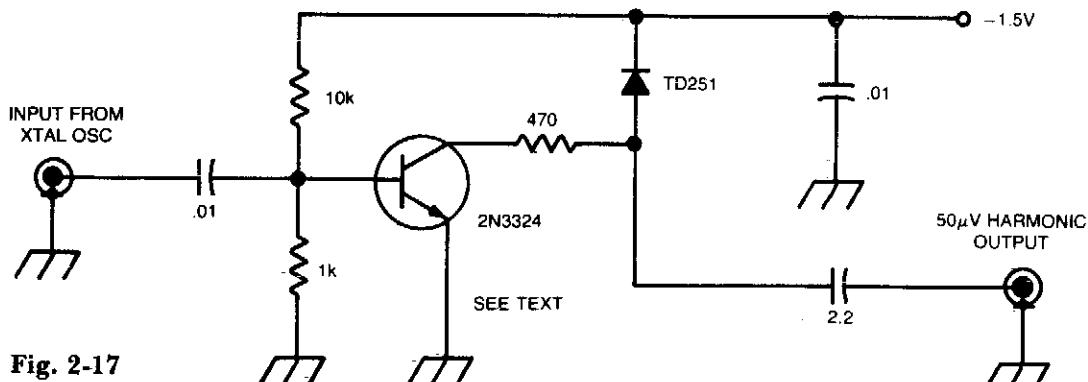


Fig. 2-17

Circuit Notes

This circuit will produce 50 μV 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 KEYER

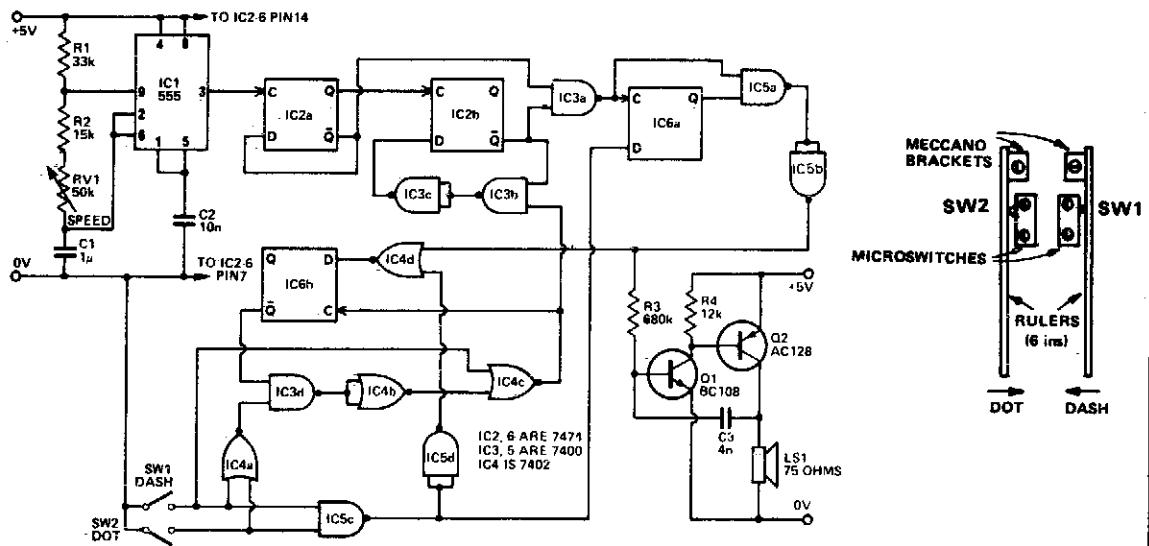


Fig. 2-18

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
x 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
x 10 Operational Amplifier Using L161
x 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 Frequency
Inverting Amp
Log-Ratio Amplifier
Inverting Amplifier
Logarithmic Amplifier

HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER

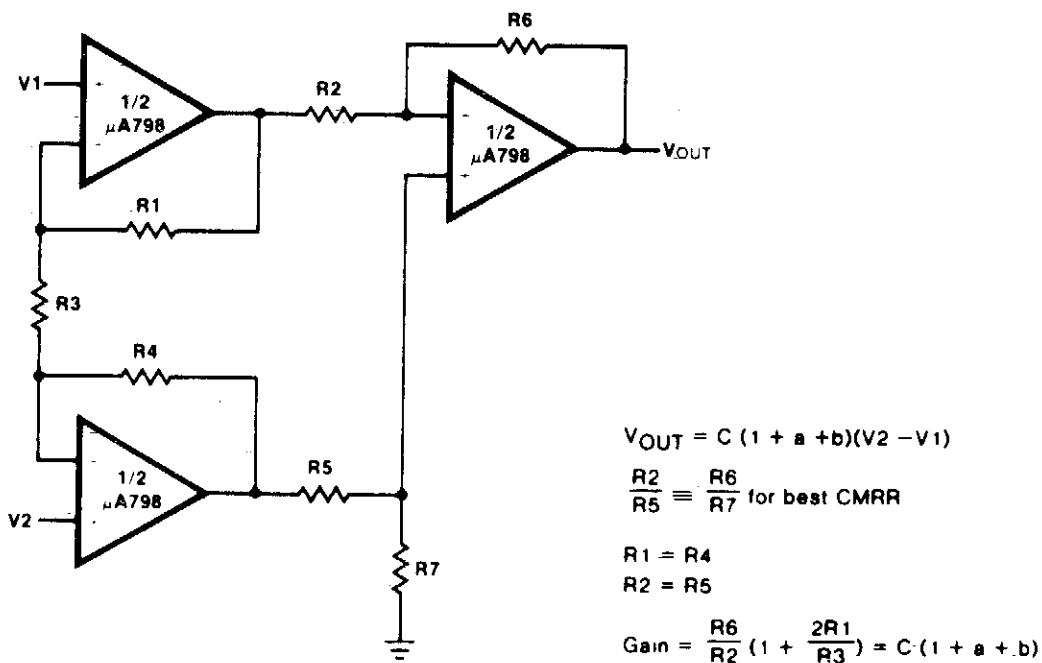


Fig. 3-1

UNITY GAIN FOLLOWER

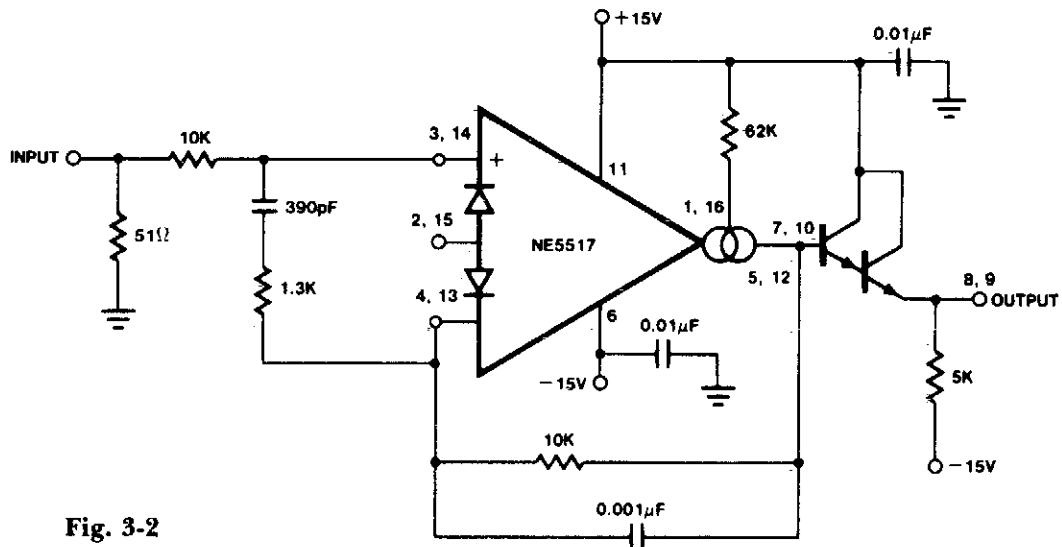
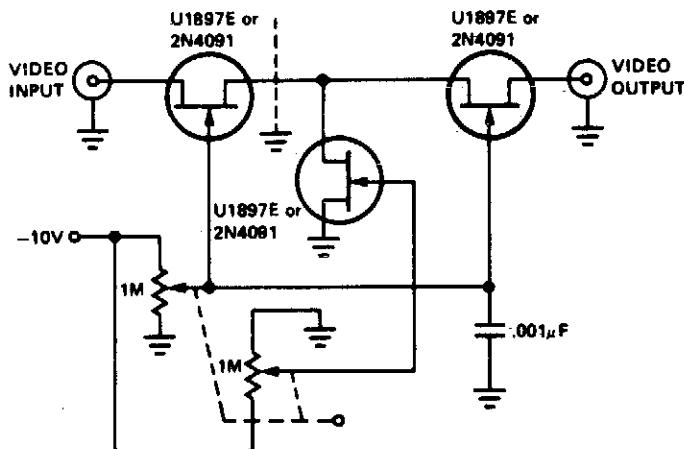


Fig. 3-2

VOLTAGE CONTROLLED VARIABLE GAIN AMPLIFIER

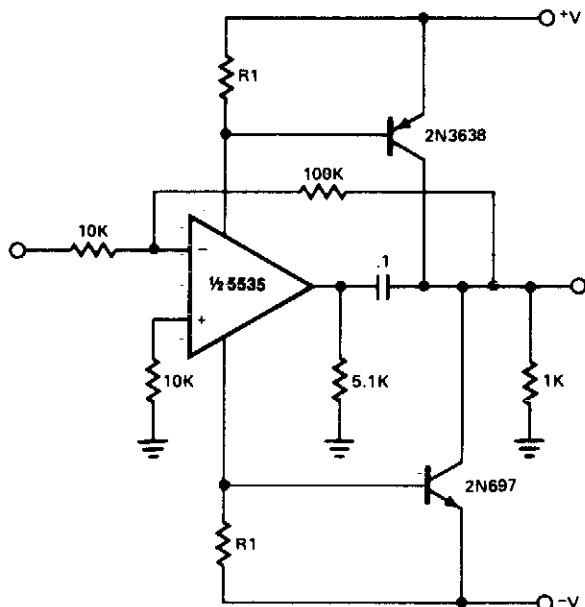
Fig. 3-3



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 R_1 values are changed because of the I_{cc} current required by the amplifier. R_1 should be calculated from the following expression:

$$R_1 = \frac{600 \text{ mW}}{I_{cc}}$$

All resistor values are in ohms.

Fig. 3-4

LOGARITHMIC AMPLIFIER

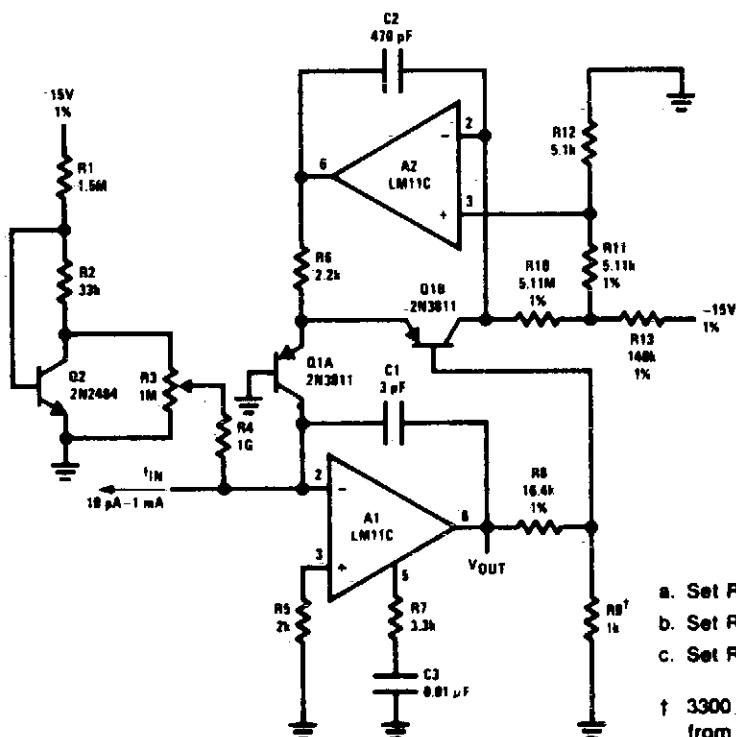


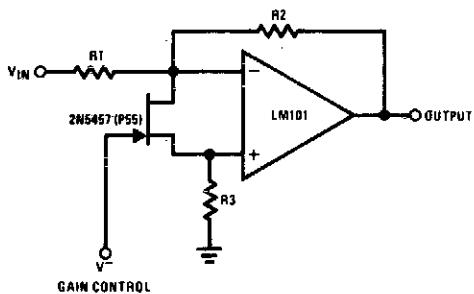
Fig. 3-5

- 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 $i_{IN} = 10 \mu A$
- † 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 $-55^{\circ}C$ to $100^{\circ}C$. 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

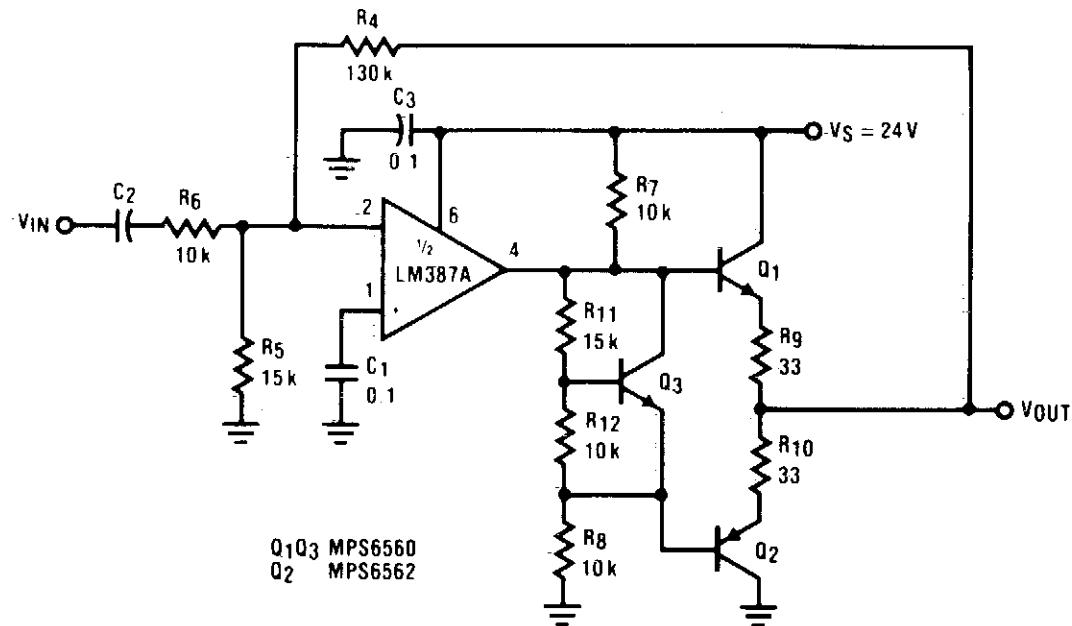


Fig. 3-7

PRECISION PROCESS CONTROL INTERFACE

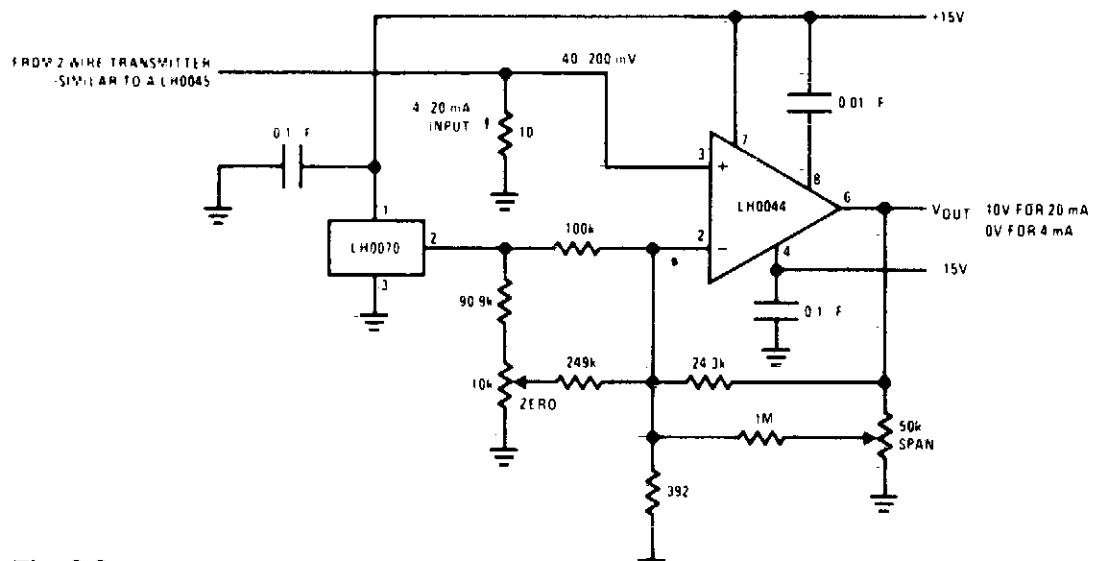


Fig. 3-8

VOLTAGE CONTROLLED AMPLIFIER

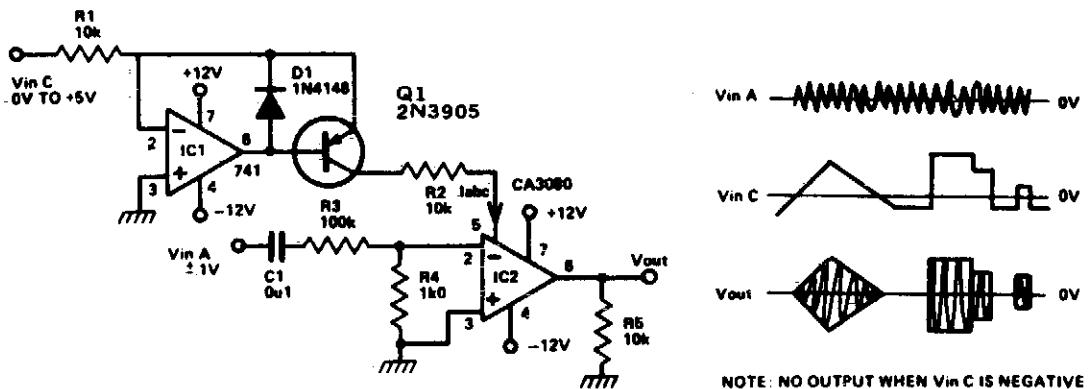


Fig. 3-9

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

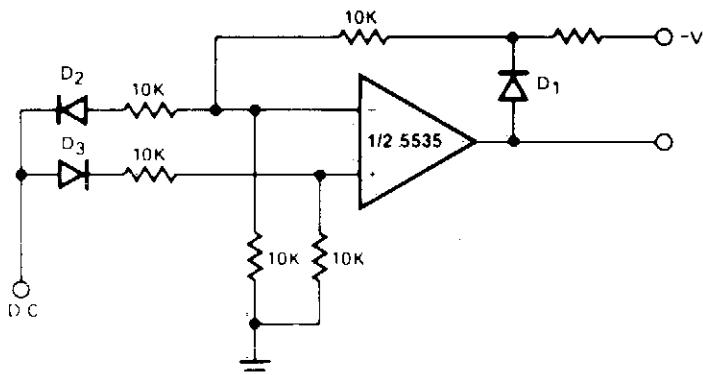


Fig. 3-10

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

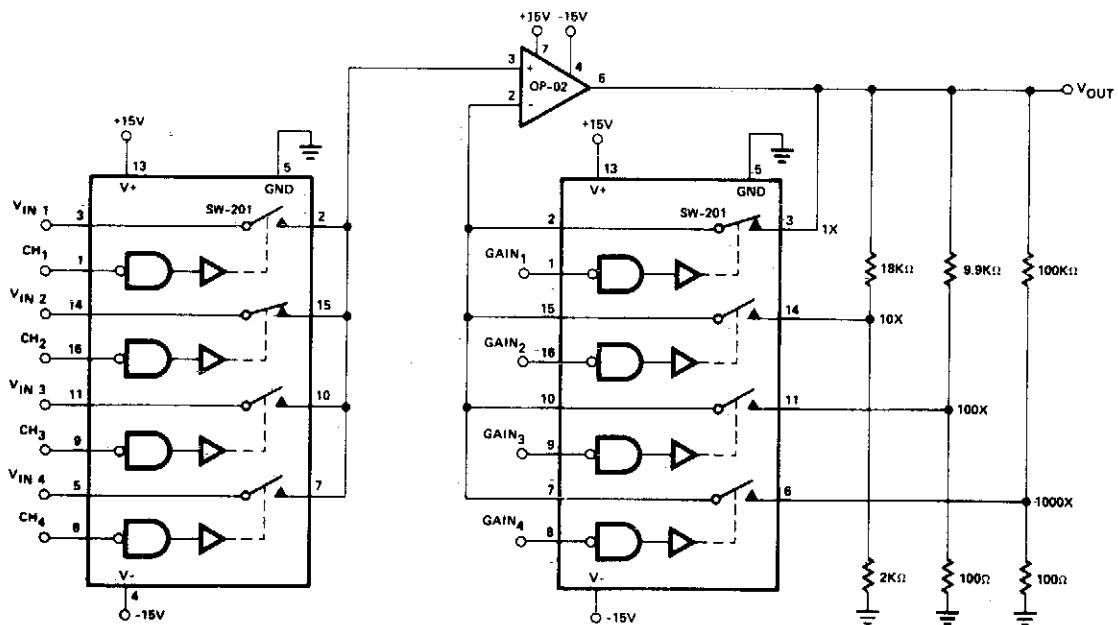


Fig. 3-11

× 1000 AMPLIFIER CIRCUIT

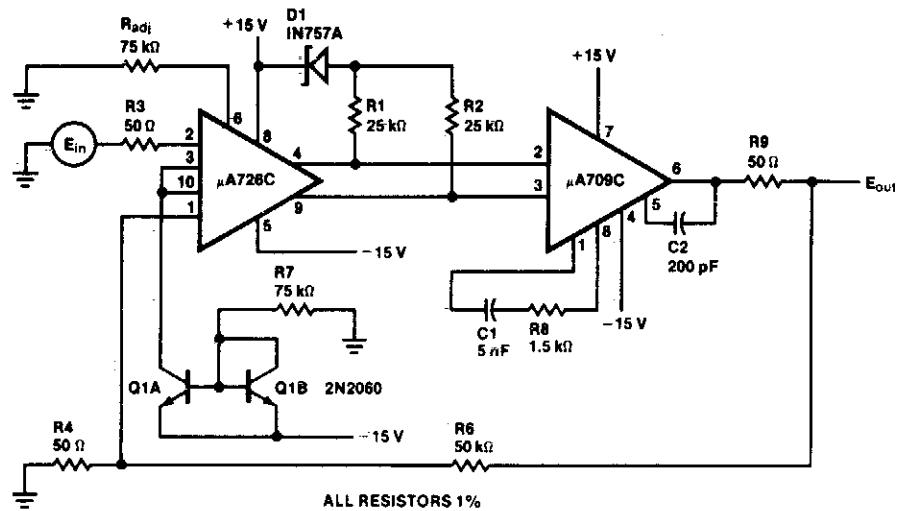


Fig. 3-12

INVERTING AMPLIFIER WITH BALANCING CIRCUIT

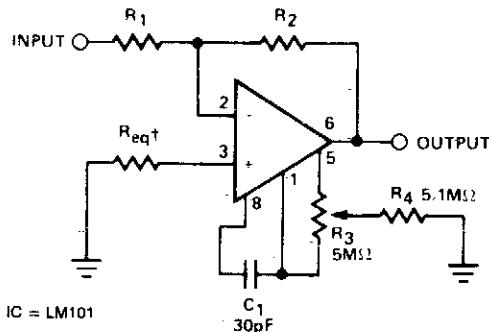


Fig. 3-13

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

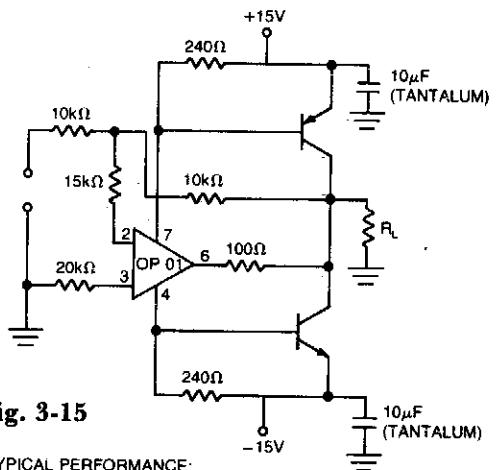


Fig. 3-15

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

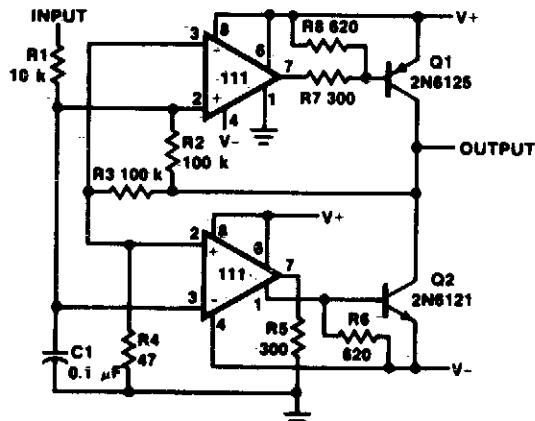


Fig. 3-14

NONINVERTING VOLTAGE FOLLOWER

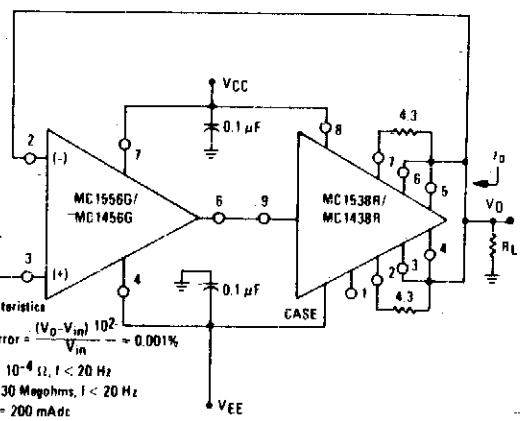


Fig. 3-16

COLOR VIDEO AMPLIFIER

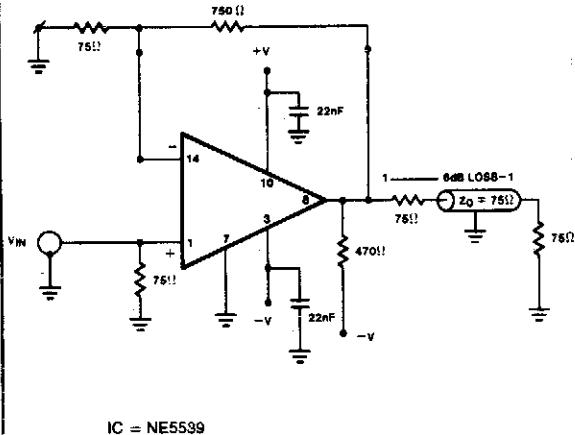
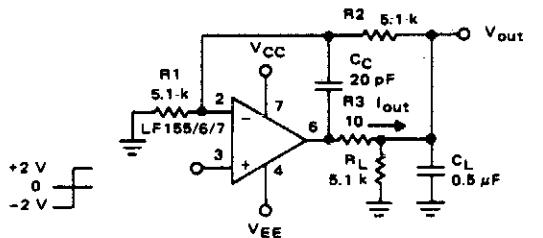


Fig. 3-17

ISOLATION AMPLIFIER FOR CAPACITIVE LOADS



- Overshoot 6%
- $t_s = 10 \mu s$
- When driving large C_L , the V_{out} slew rate is determined by C_L and $I_{out(max)}$:

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

Fig. 3-19

FAST VOLTAGE FOLLOWER

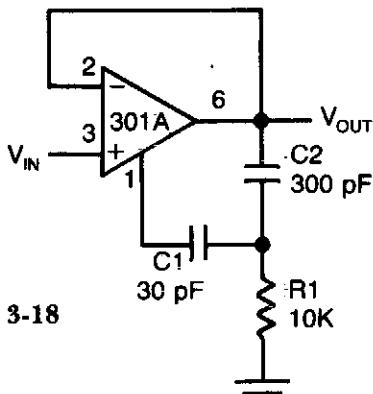


Fig. 3-18

Power Bandwidth: 15 kHz
Slew Rate: $1V/\mu s$

CABLE BOOTSTRAPPING

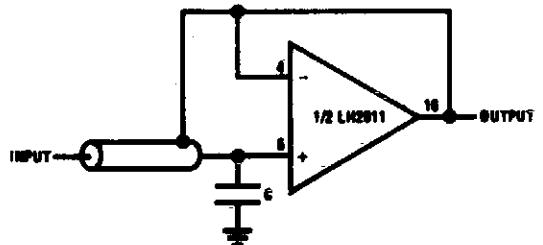
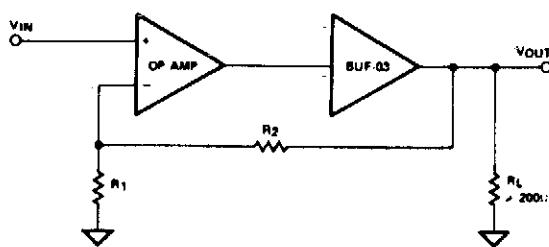


Fig. 3-20

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



$$\text{GAIN} = \frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_2}{R_1}$$

MAXIMUM LOAD CURRENT = $\pm 80\text{mA}$ ($10\text{V} \div 200\Omega$)

Fig. 3-21

HIGH-SPEED CURRENT TO VOLTAGE OUTPUT AMPLIFIER

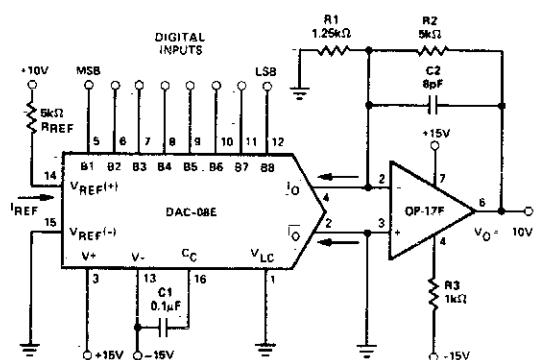


Fig. 3-23

WIDEBAND UNITY GAIN INVERTING AMPLIFIER IN A 75 OHM SYSTEM

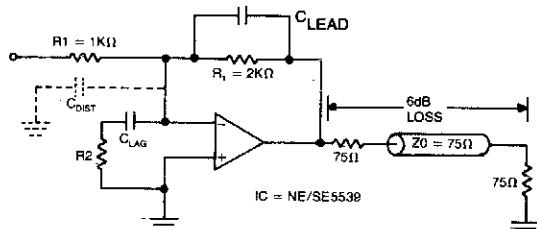


Fig. 3-22

LOGARITHMIC AMPLIFIER

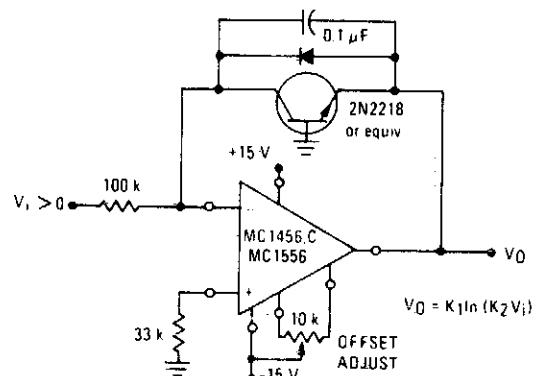


Fig. 3-24

GATED AMPLIFIER

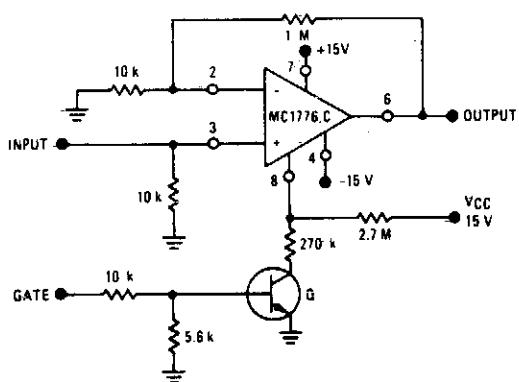
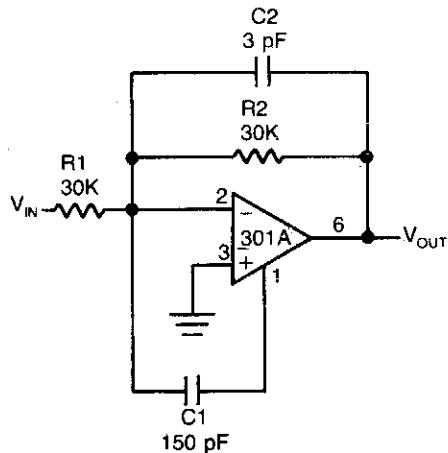


Fig. 3-25

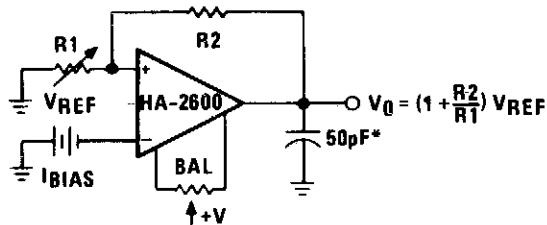
FAST SUMMING AMPLIFIER



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

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

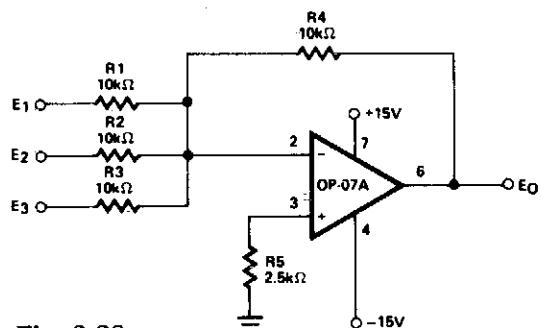
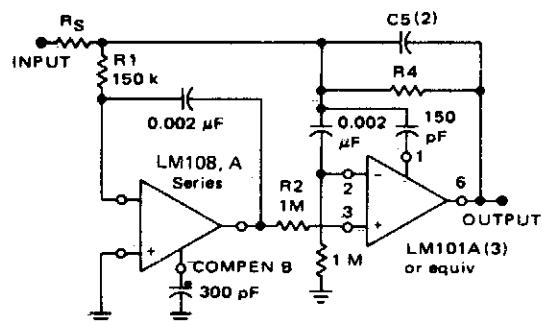


Fig. 3-28

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) $C_5 = \frac{6 \times 10^{-8}}{R_1}$
- (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

$\times 100$ OPERATIONAL AMPLIFIER USING L161

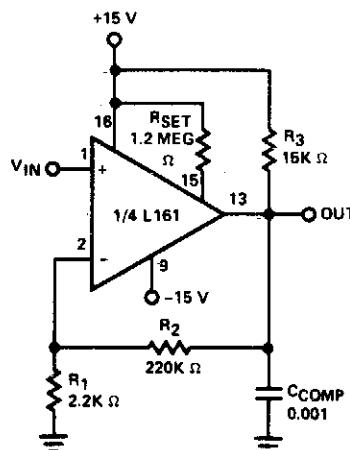


Fig. 3-31

Circuit Notes

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

$\times 10$ OPERATIONAL AMPLIFIER USING L161

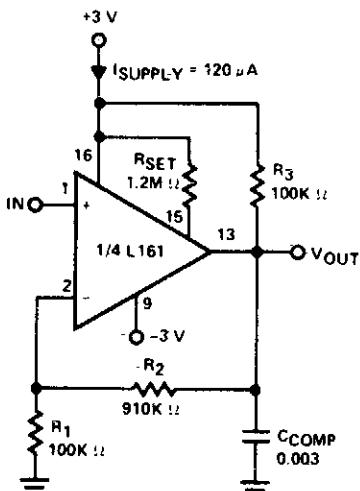
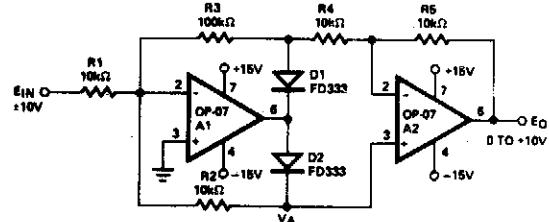


Fig. 3-30

Circuit Notes

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

PRECISION ABSOLUTE VALUE CIRCUIT



POSITIVE INPUT

1. $V_A = 0, D2 \text{ OFF}, D1 \text{ ON}$
2. $E_O = \left(\frac{-EIN}{R1}\right) \cdot \left(\frac{-R5}{R4}\right) = EIN \frac{R2 \cdot R5}{R1 \cdot R4}$
3. WITH $R1 = R2 = R4 = R6$: $E_O = EIN$
4. $V_{OVS} \text{ ERROR INCLUDED}$:
 $E_O = EIN + ZV_{OVS2}$
3. $E_O = V_A \left(1 + \frac{R6}{R3 + R4}\right)$
4. WITH $R3 = R4 = R6$: $E_O = 1.5V_A$
6. $E_O = \frac{(R2) (R3 + R4) (1.5) EIN}{R1 (R2 + R3 + R4)}$
6. WITH $R1 = R2 = R3 = R4$: $E_O = -EIN$
7. $V_{OVS} \text{ ERROR INCLUDED}$:
 $E_O = -EIN + 1.5V_{OVS2} - 0.5V_{OVS1}$
8. FOR BOTH INPUTS: $E_O = + EIN$

Fig. 3-32

ULTRA-LOW-LEAKAGE PREAMP

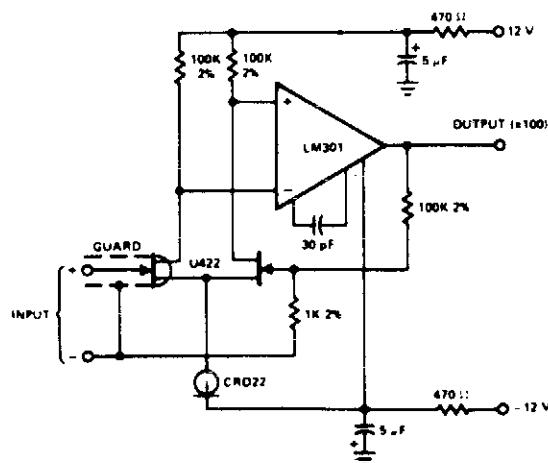
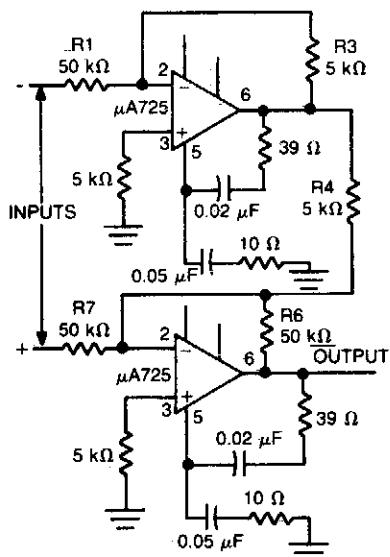


Fig. 3-33

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

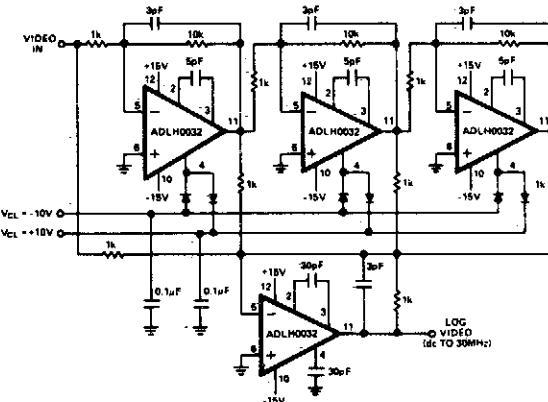
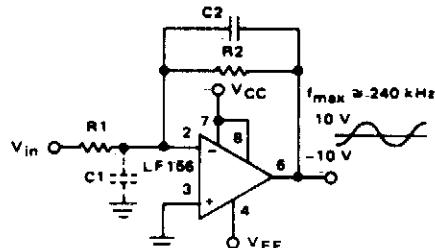


Fig. 3-34

WIDE BANDWIDTH, LOW NOISE, LOW DRIFT AMPLIFIER



- Power BW: $f_{max} = \frac{S_r}{2\pi V_p} \approx 240$ kHz
- Parasitic input capacitance ($C_1 \approx 3$ pF for LF155, LF156, and LF157 plus any additional layout capacitance) interacts with feedback elements and creates undesirable high frequency pole. To compensate add C_2 such that: $R_2 C_2 \approx R_1 C_1$.

Fig. 3-36

SIGNAL DISTRIBUTION AMPLIFIER

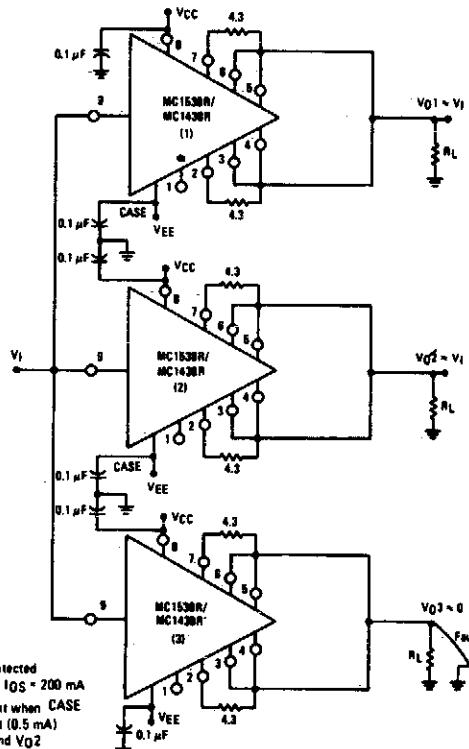


Fig. 3-37

AUDIO DISTRIBUTION AMPLIFIER

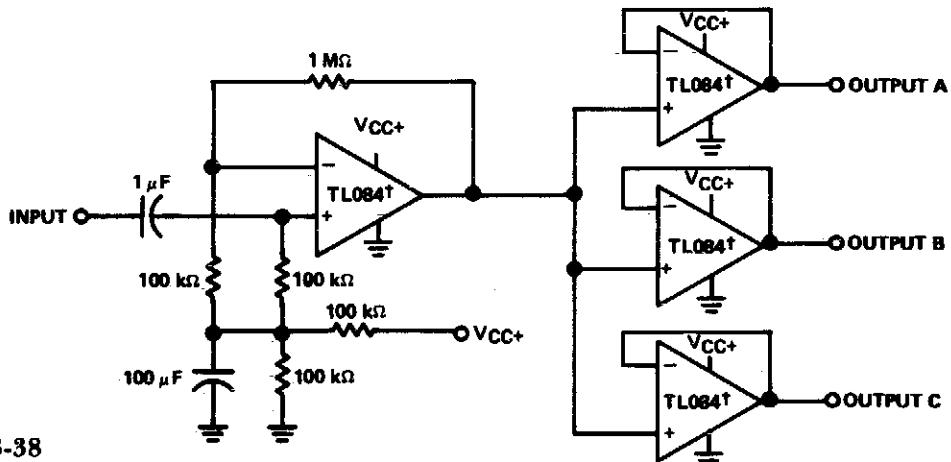


Fig. 3-38

HIGH INPUT IMPEDANCE, HIGH OUTPUT CURRENT VOLTAGE FOLLOWER

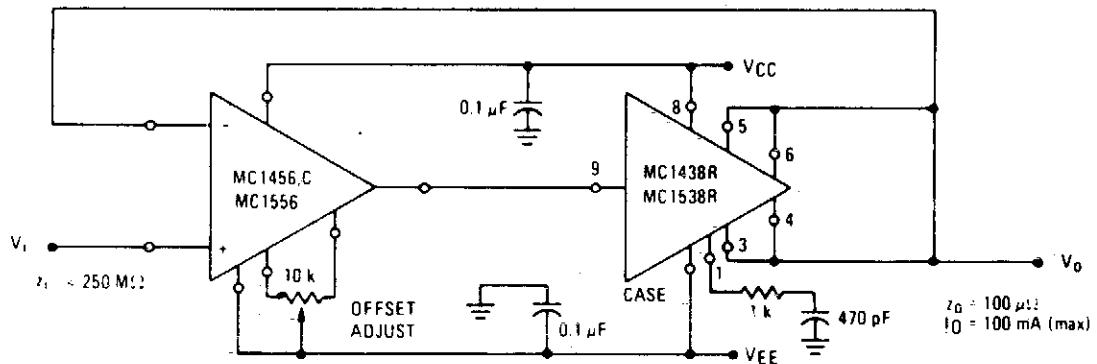
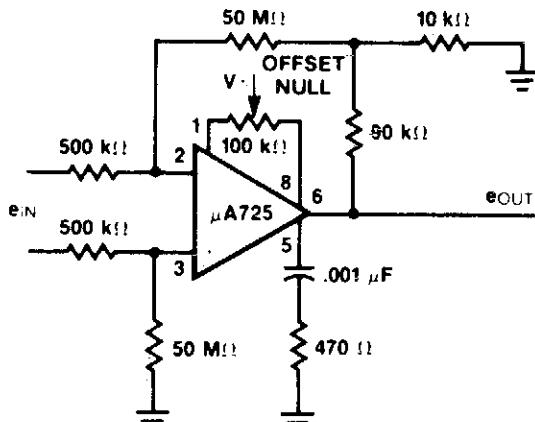


Fig. 3-39

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 MΩ

Typical amplifying capability

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

Caution: Minimize Stray Capacitance

$A_{vCL} = 1000$

Fig. 3-40

PREAMPLIFIER AND HIGH-TO-LOW IMPEDANCE CONVERTER

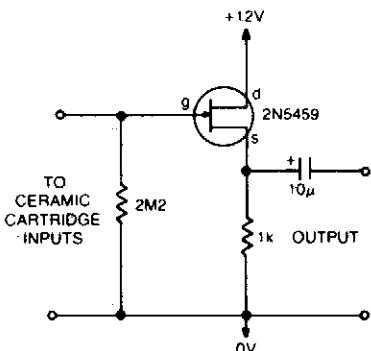


Fig. 3-41

Circuit Notes

This circuit matches the very high impedance of ceramic cartridges, unity gain, and low impedance output. By "loading" the cartridge with a 2M2 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

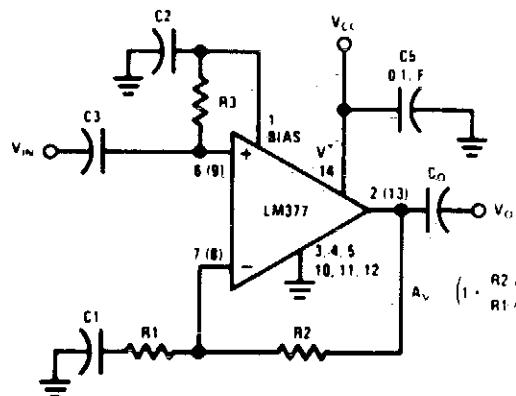


Fig. 3-42

HIGH IMPEDANCE, HIGH GAIN, HIGH FREQUENCY INVERTING AMP

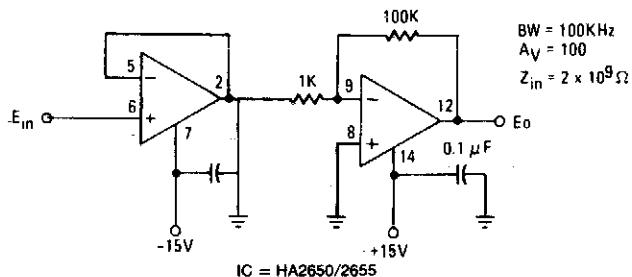
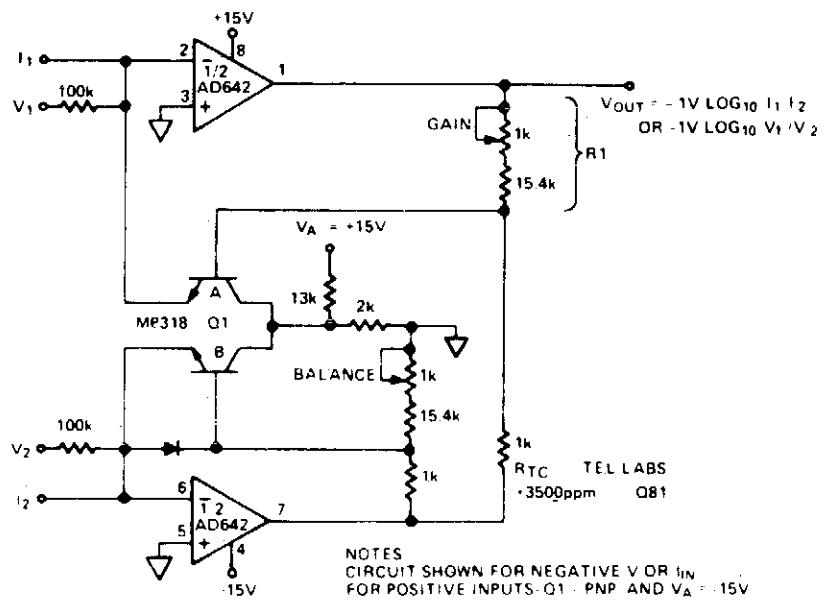


Fig. 3-43

LOG-RATIO AMPLIFIER



INVERTING AMPLIFIER

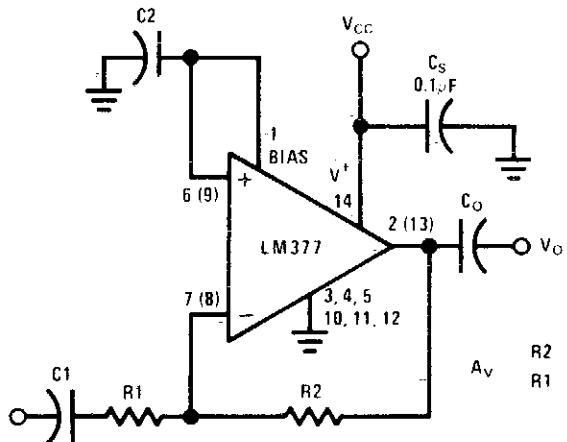


Fig. 3-45

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

8-BIT A/D CONVERTER

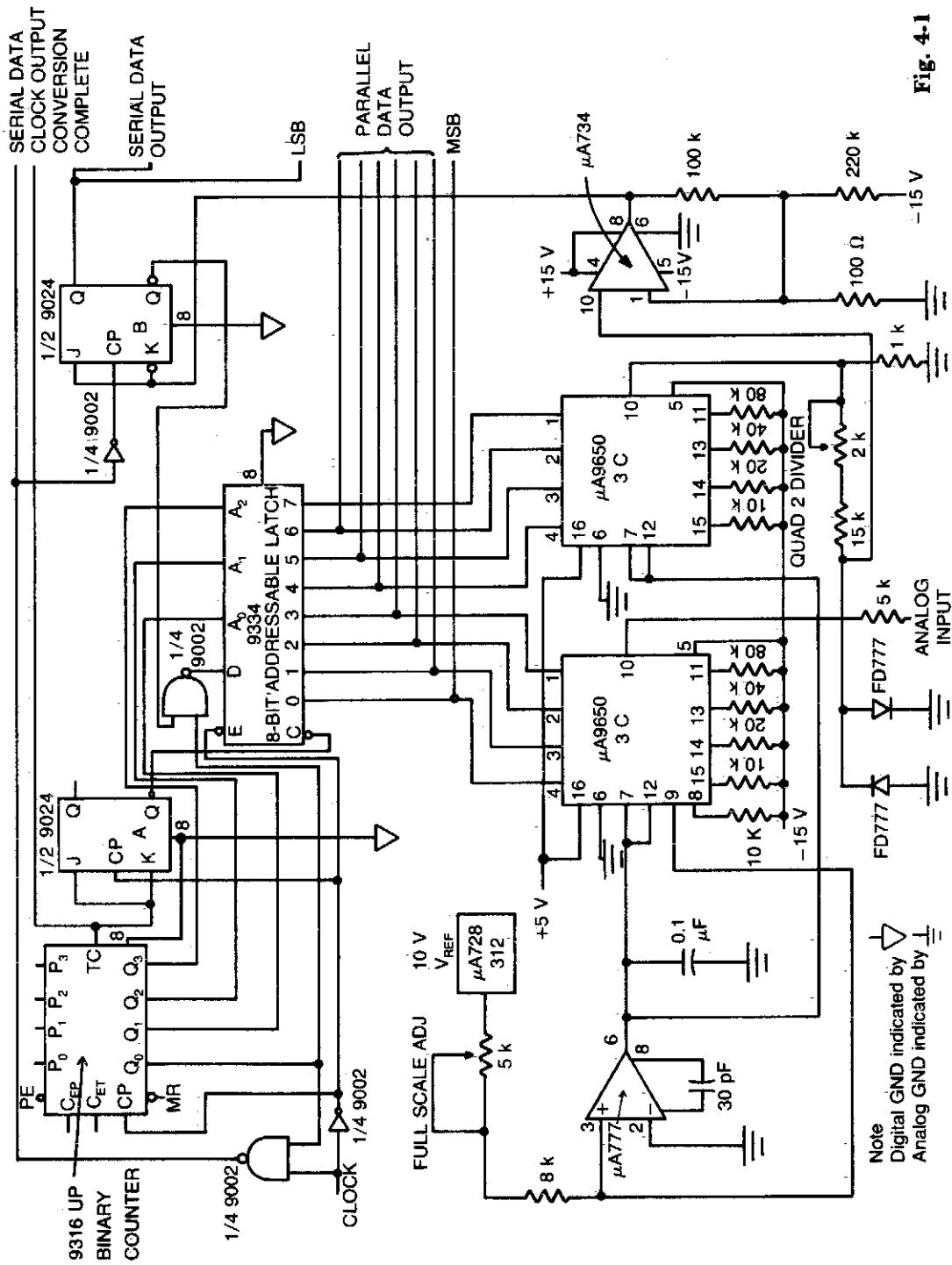


Fig. 4-1

SUCCESSIVE APPROXIMATION A/D CONVERTER

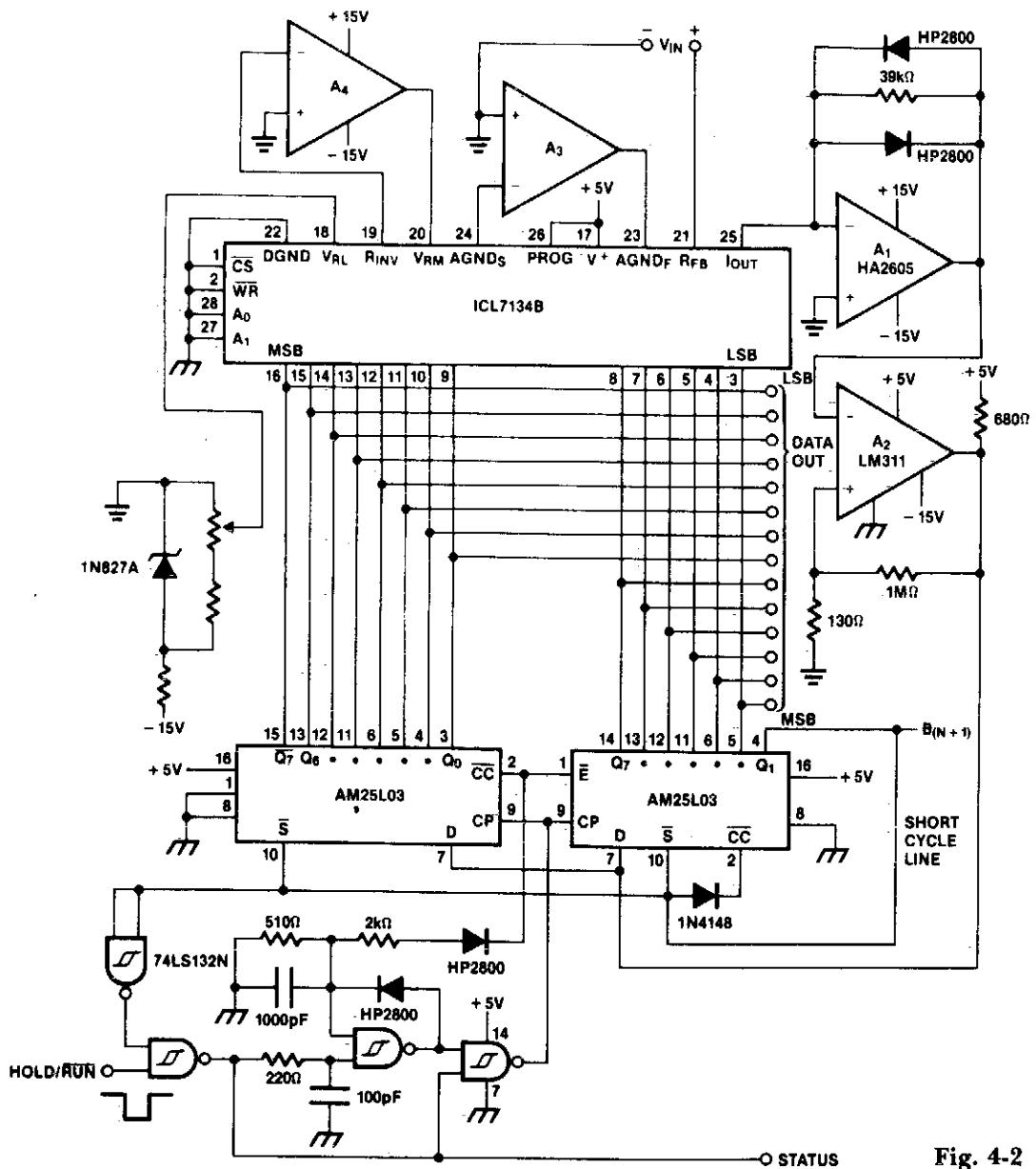


Fig. 4-2

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 A/D CONVERTER

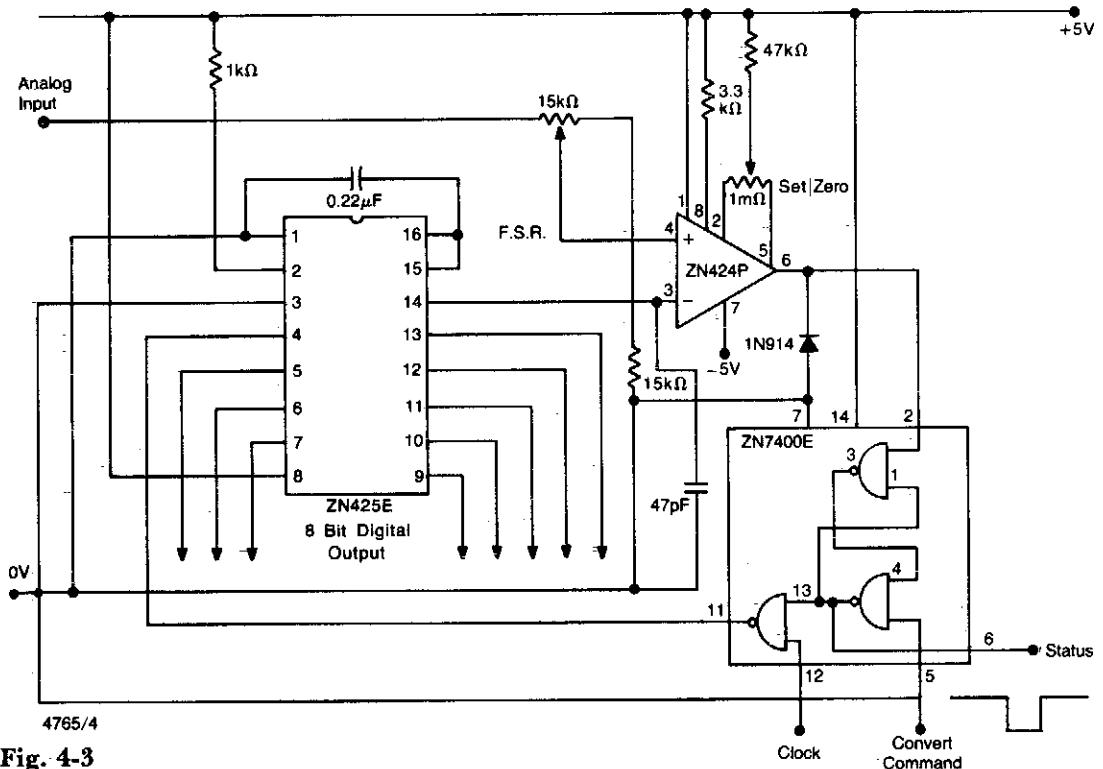


Fig. 4-3

8-BIT TRACKING A/D CONVERTER

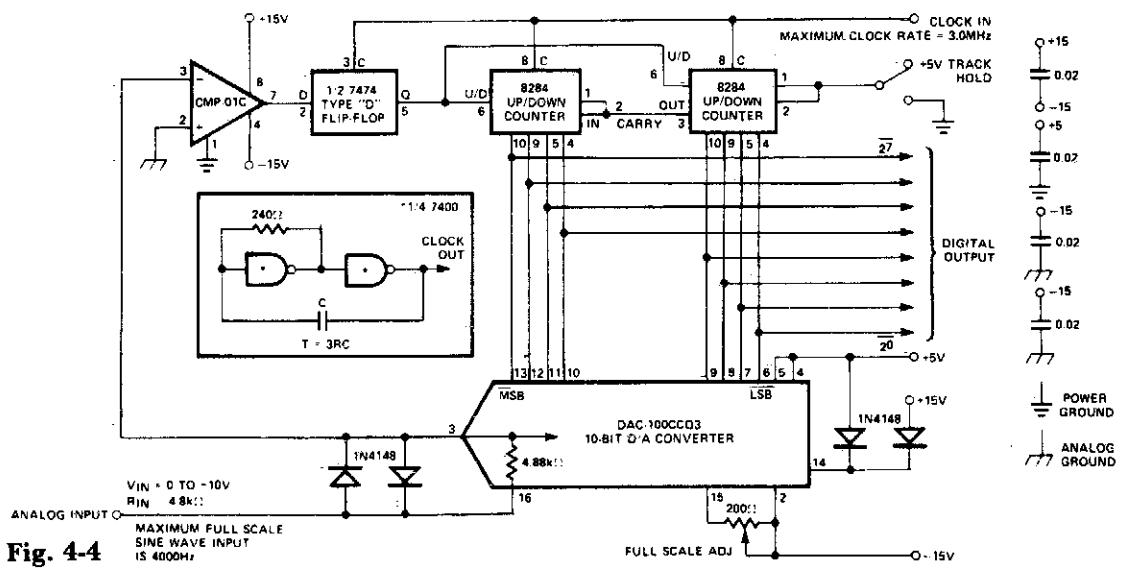


Fig. 4-4

8-BIT SUCCESSIVE APPROXIMATION A/D CONVERTER

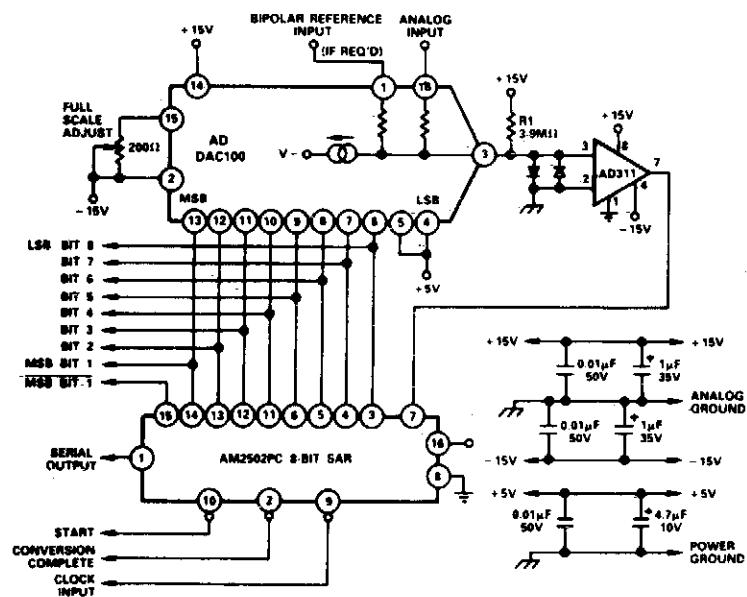


Fig. 4-5

FOUR CHANNEL DIGITALLY MULTIPLEXED RAMP A/D CONVERTER

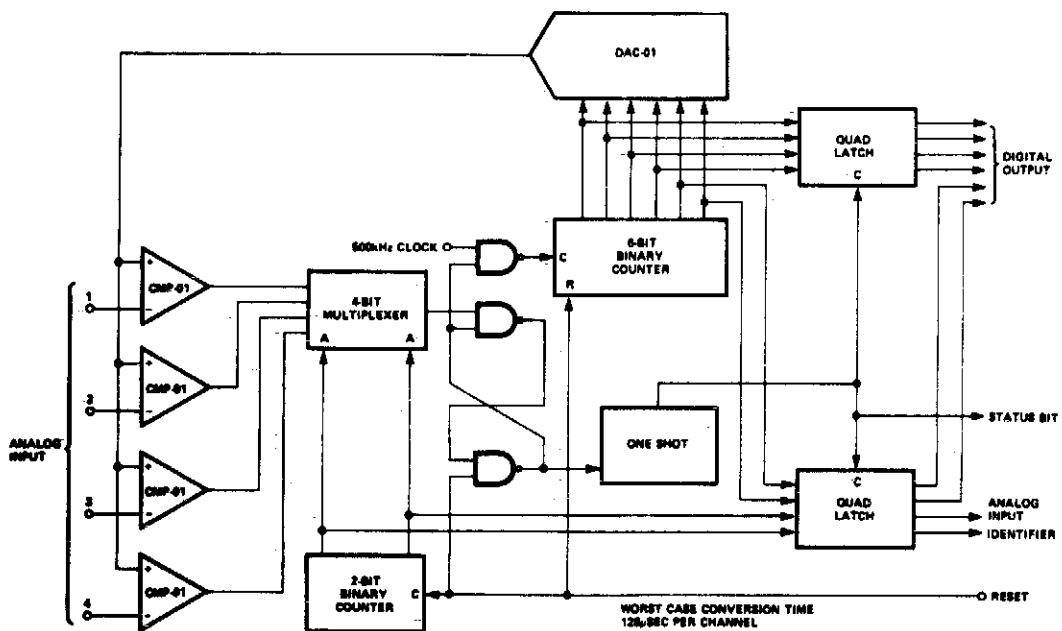


Fig. 4-6

THREE-DECADE LOGARITHMIC A/D CONVERTER

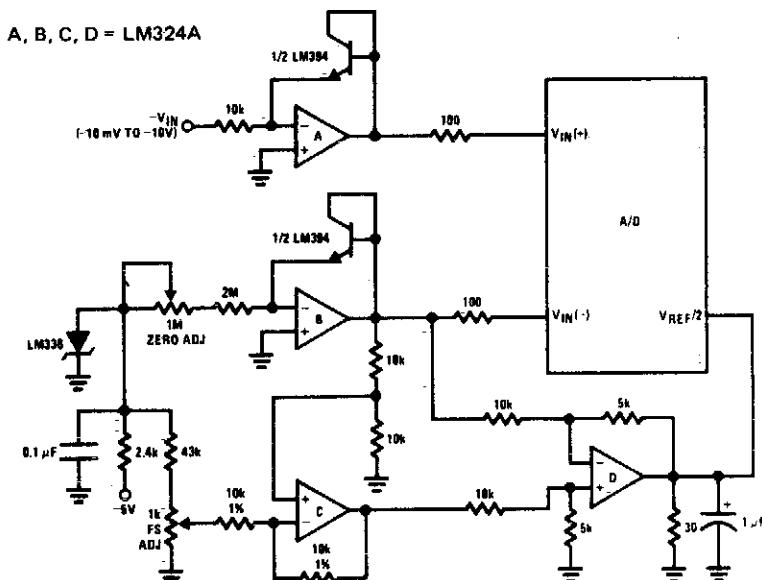


Fig. 4-7

TRACKING (SERVO TYPE) A/D CONVERTER

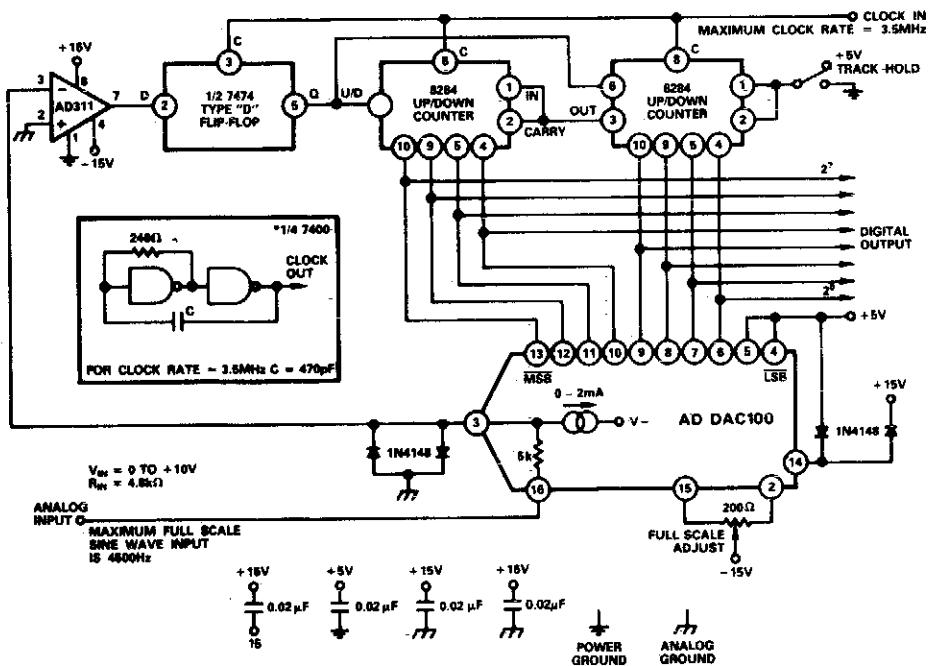


Fig. 4-8

3½ DIGIT A/D CONVERTER WITH LCD DISPLAY

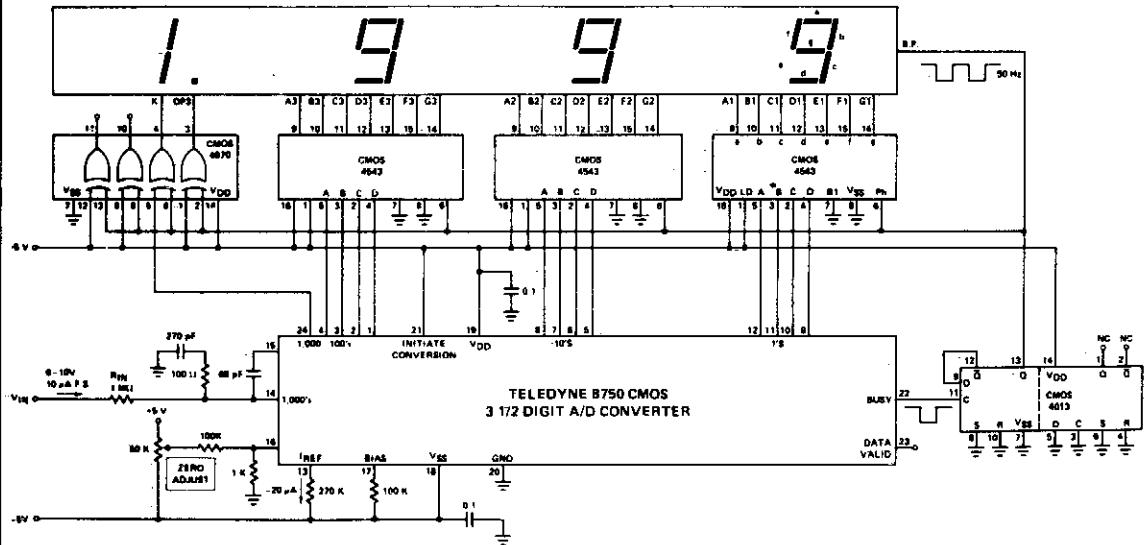


Fig. 4-9

FAST PRECISION A/D CONVERTER

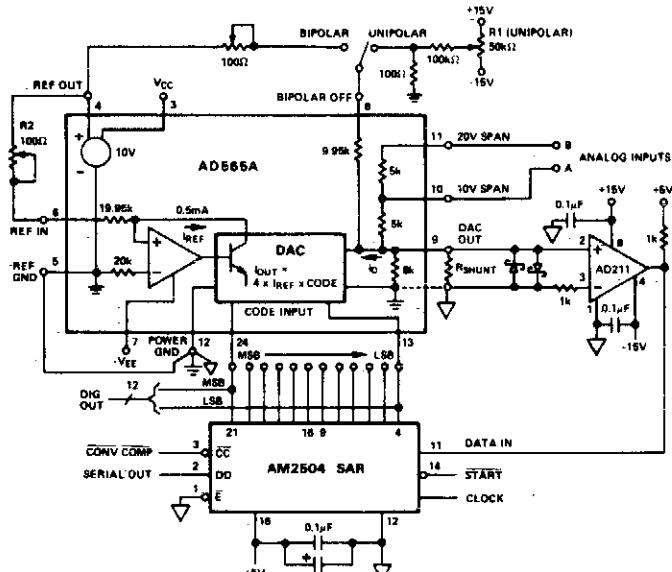


Fig. 4-10

INPUT RANGES	Unipolar	Bipolar	Connect	Equip. DAC Z _{OUT}
D TO +10	±5		INPUT TO A	2.35kΩ
D TO +6	±2.5		INPUT TO A	1.90kΩ
D TO +20	±10		INPUT TO B	3.09kΩ
			B TO DAC OUT	

HIGH SPEED 3-BIT A/D CONVERTER

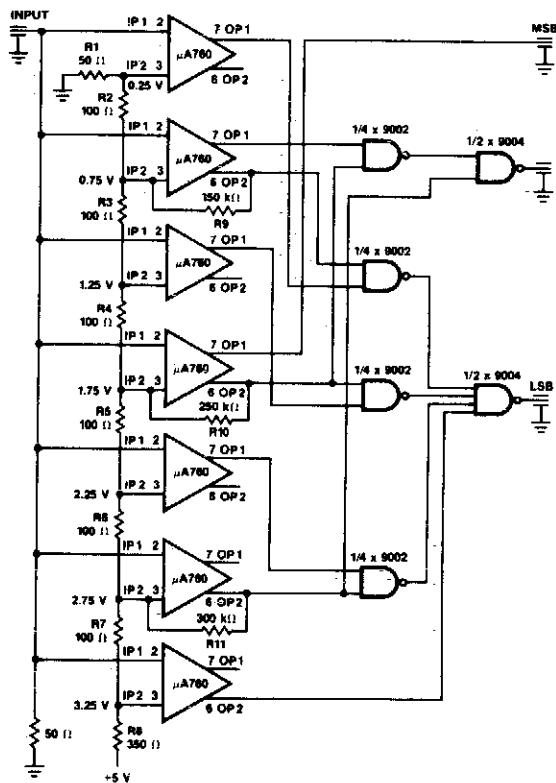


Fig. 4-11

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

THREE IC LOW COST A/D CONVERTER

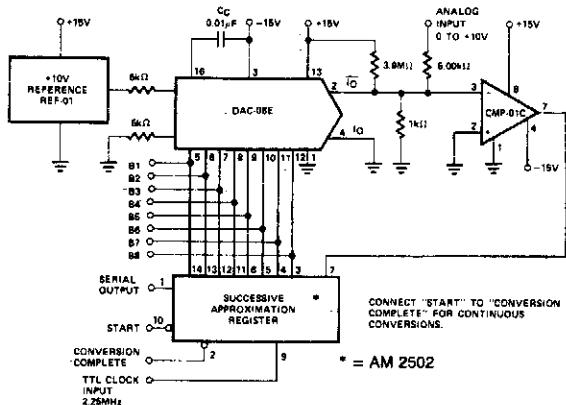


Fig. 4-12

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

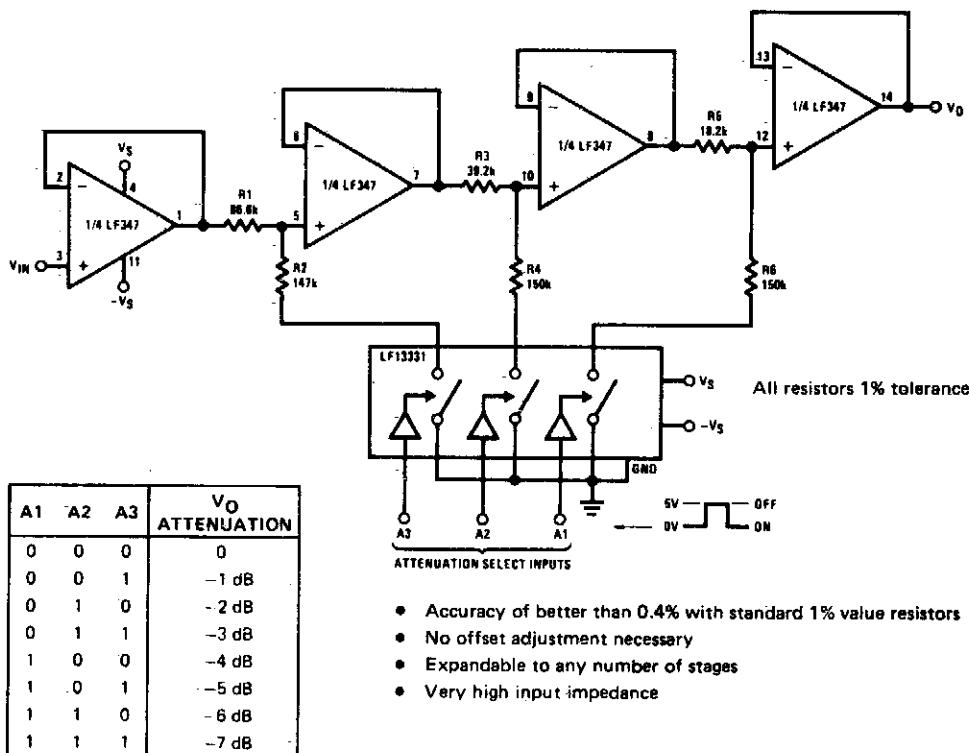
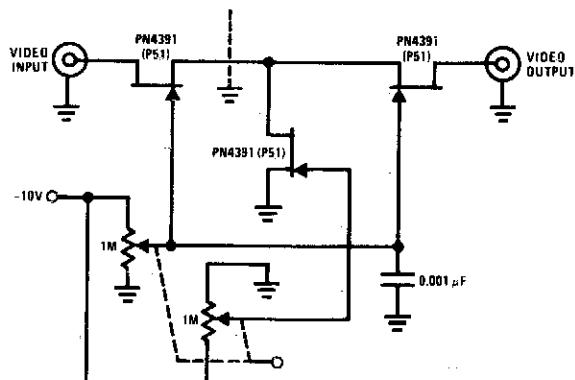


Fig. 5-1

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

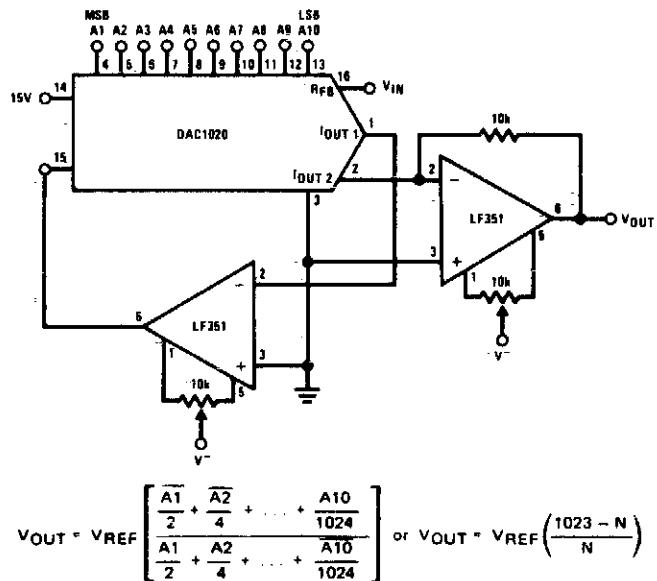


Fig. 5-3

PROGRAMMABLE ATTENUATOR (1 TO 0.0001)

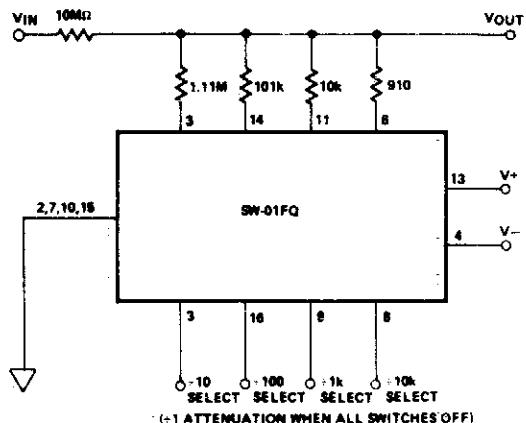


Fig. 5-4

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

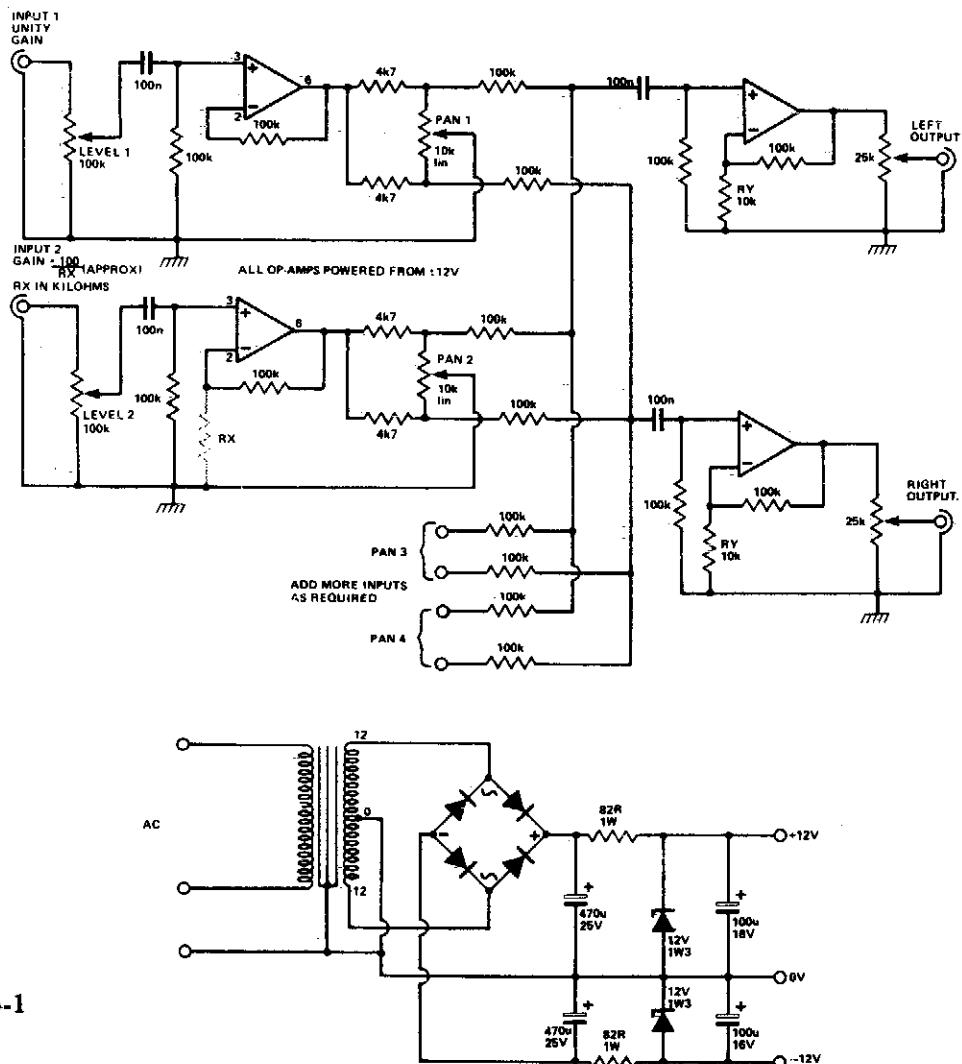


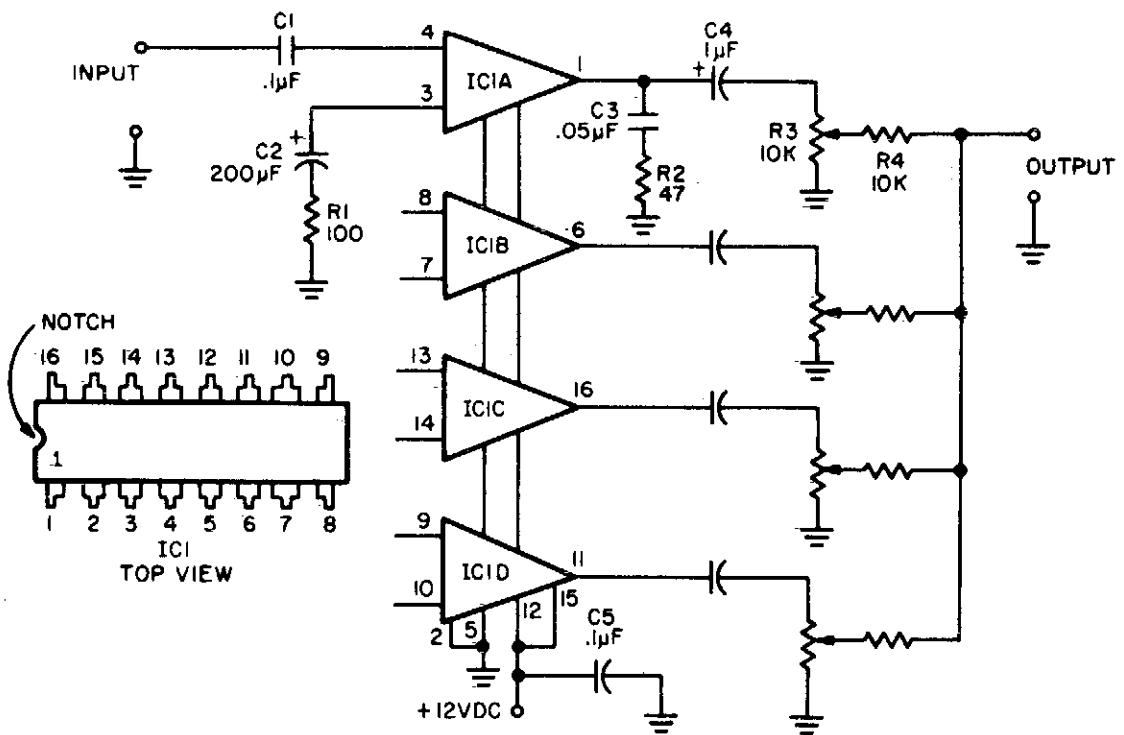
Fig. 6-1

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- μ F, 3 VDC capacitor
- C2—200- μ F, 3 VDC capacitor
- C3—0.05- μ F, 75 VDC disc capacitor
- C4—1- μ F, 15 VDC capacitor
- C5—0.1- μ F, 15 VDC capacitor
- IC1—RCA CA 3052
- R1—100-ohms, $\frac{1}{2}$ -watt resistor
- R2—47-ohms, $\frac{1}{2}$ -watt resistor
- R3—Potentiometer, 10,000-ohms audio taper
- R4—10,000-ohms, $\frac{1}{2}$ -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-

cophone 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

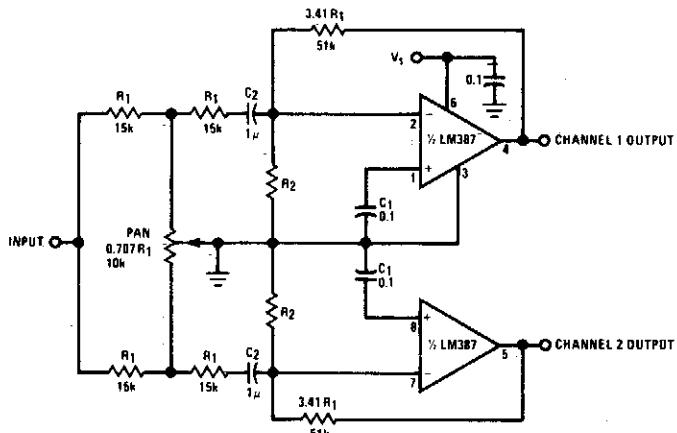


Fig. 6-3

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

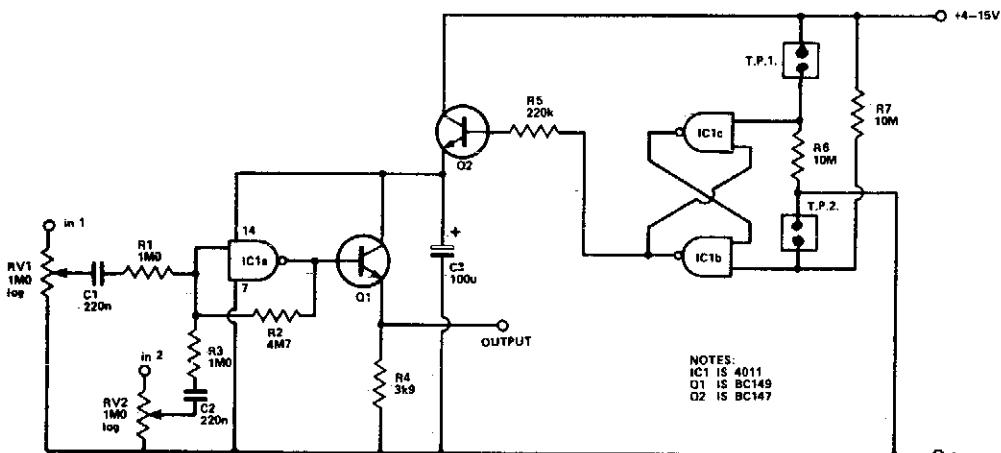


Fig. 6-4

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.

MIXER PREAMPLIFIER WITH TONE CONTROL

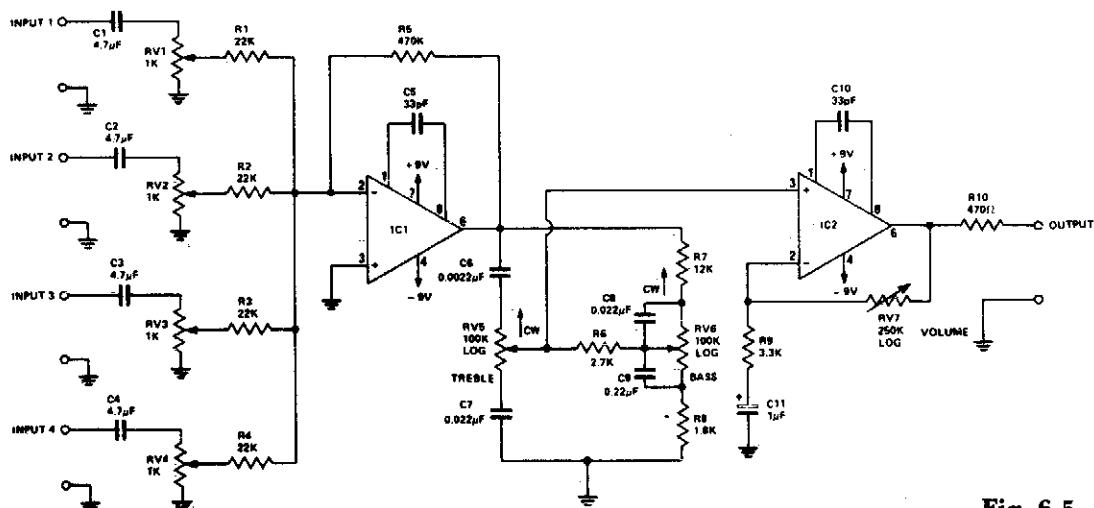


Fig. 6-5

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

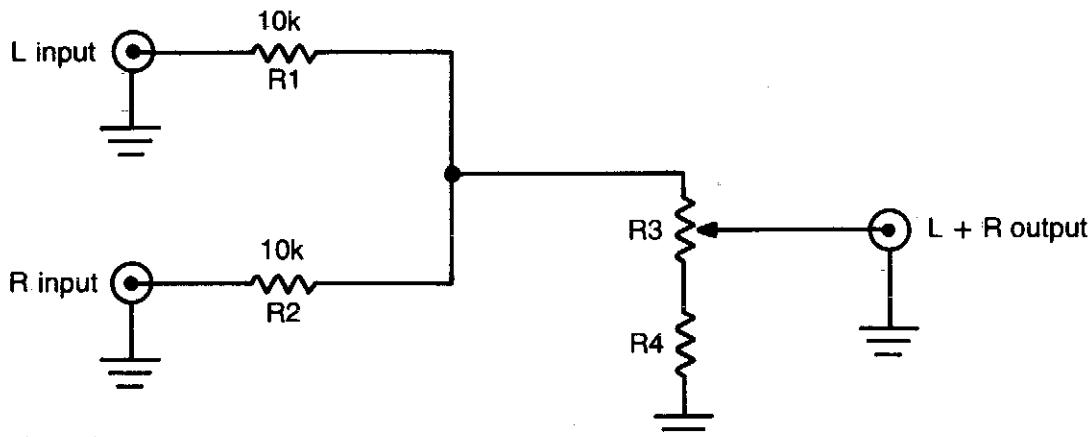


Fig. 6-6

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

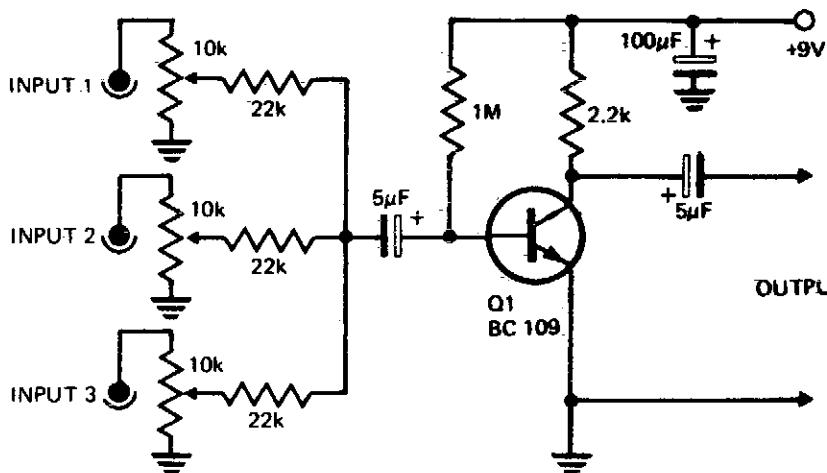


Fig. 6-7

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

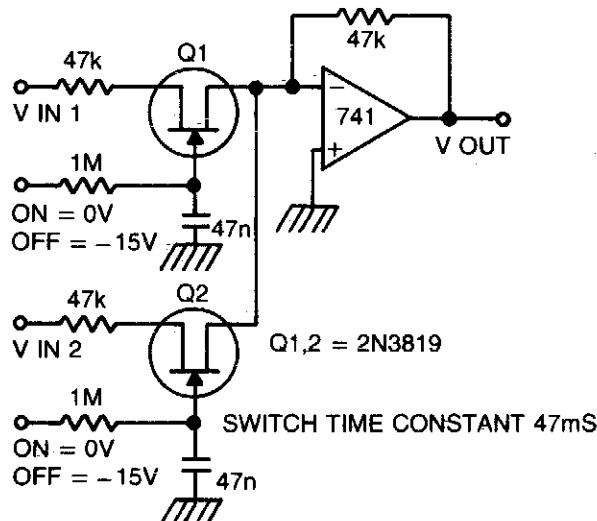


Fig. 6-8

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

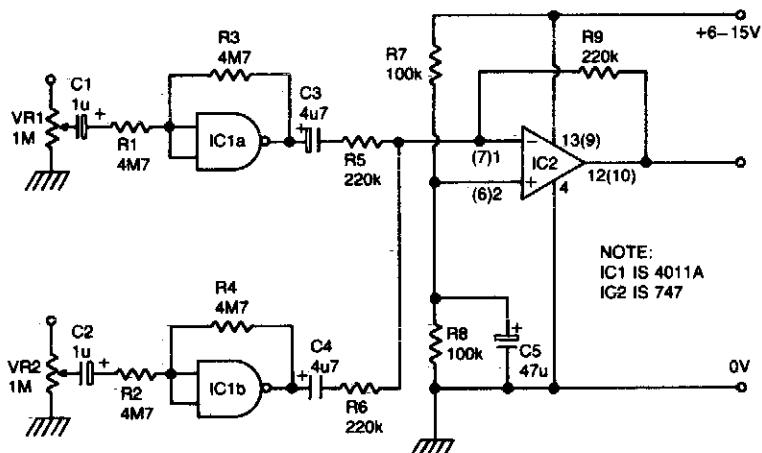


Fig. 6-9

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

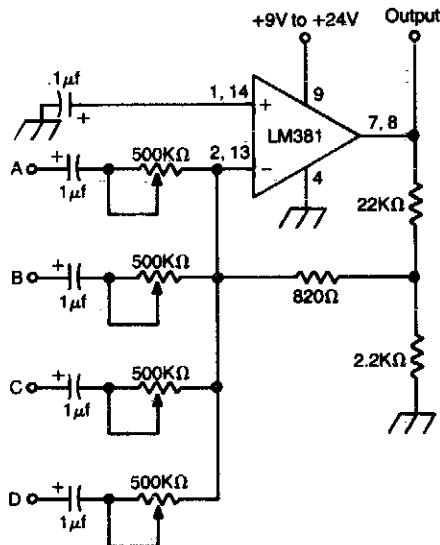


Fig. 6-10

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

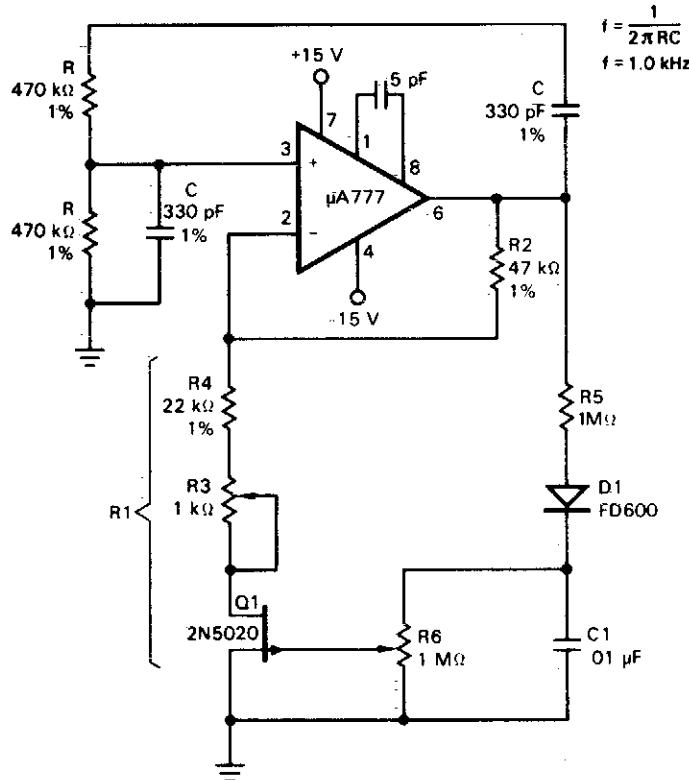


Fig. 7-1

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.

WIEN BRIDGE OSCILLATOR

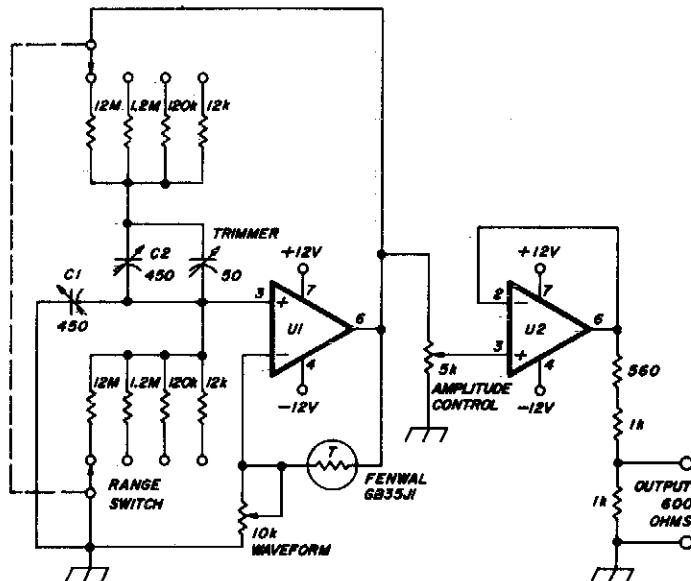


Fig. 7-2

Circuit Notes

Wien bridge sine-wave oscillator using two RCA CA3140 op amps covers 30 Hz to 100 kHz with less than 0.5 percent total harmonic distortion. The 10k pot is adjusted for the best waveform. Capacitor C1 and C2 are a two-gang, 450-pF variable with its frame isolated from ground. Maximum output into a 600-ohm load is about 1 volt rms.

WIEN BRIDGE OSCILLATOR

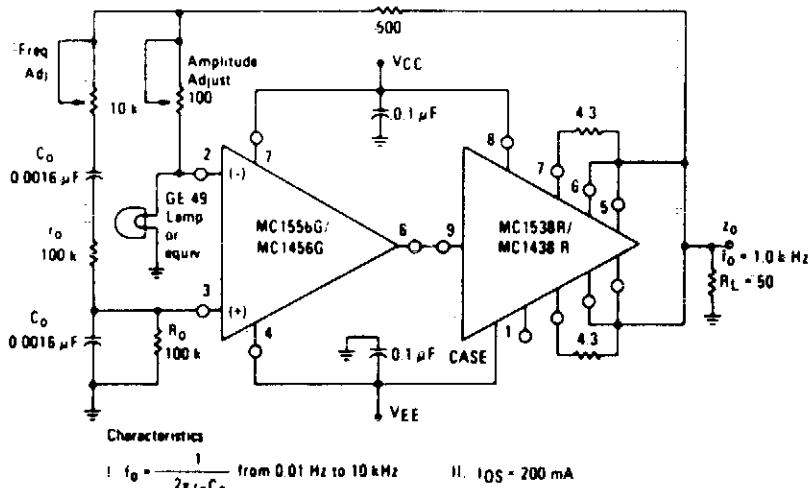


Fig. 7-3

VERY LOW FREQUENCY GENERATOR

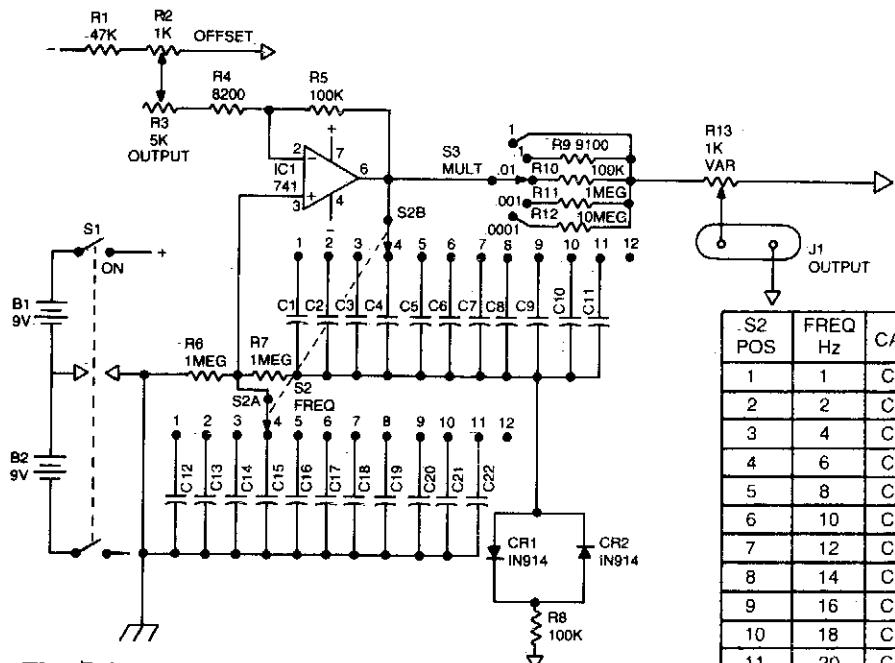


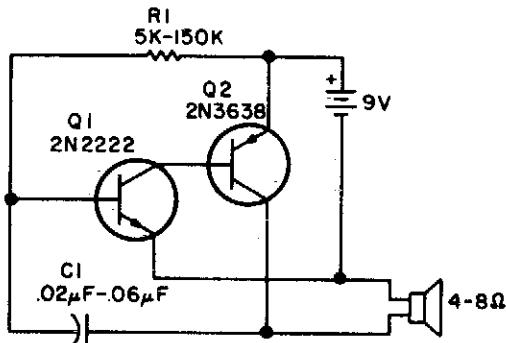
Fig. 7-4

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



Circuit Notes

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

Fig. 7-5

SINE WAVE OSCILLATOR

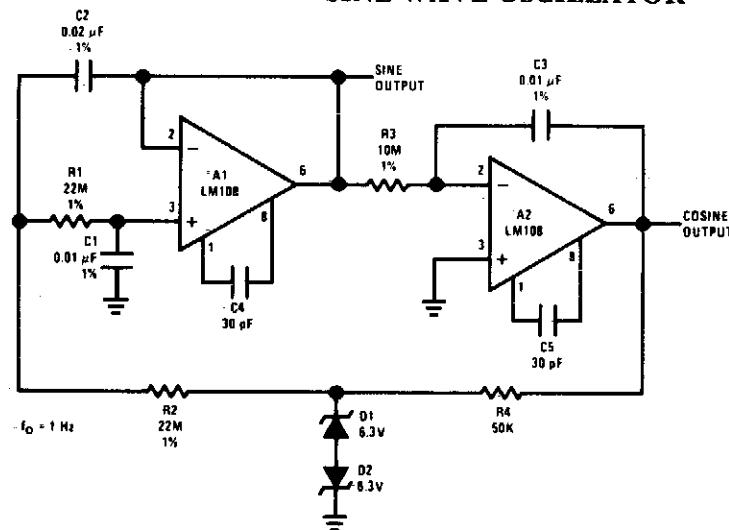


Fig. 7-6

Circuit Notes

The oscillator delivers a high-purity sinusoid with a stable frequency and amplitude.

EASILY TUNED SINE/SQUARE WAVE OSCILLATORS

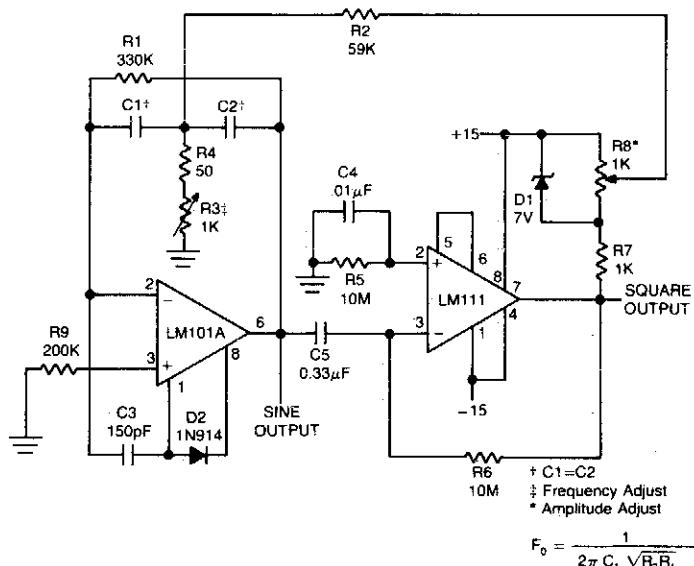


Fig. 7-7

Circuit Notes

This circuit will provide both a sine and square wave output for frequencies from below 20 Hz to above 20 kHz. The frequency of oscillation is easily tuned by varying a single resistor.

WIEN BRIDGE SINE WAVE OSCILLATOR

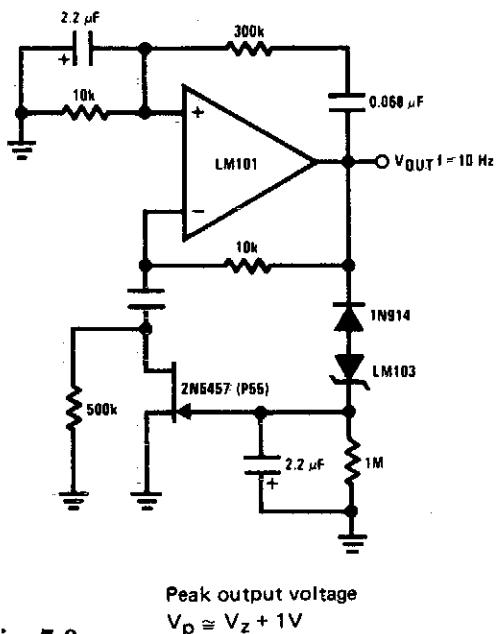


Fig. 7-8

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.

PHASE-SHIFT OSCILLATOR

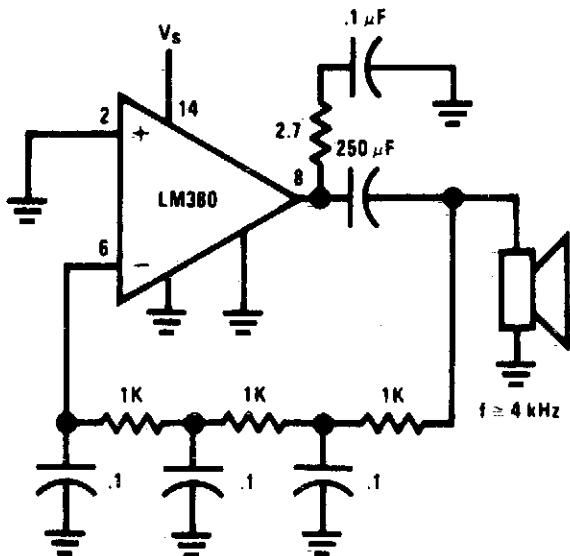


Fig. 7-9

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.

TONE ENCODER

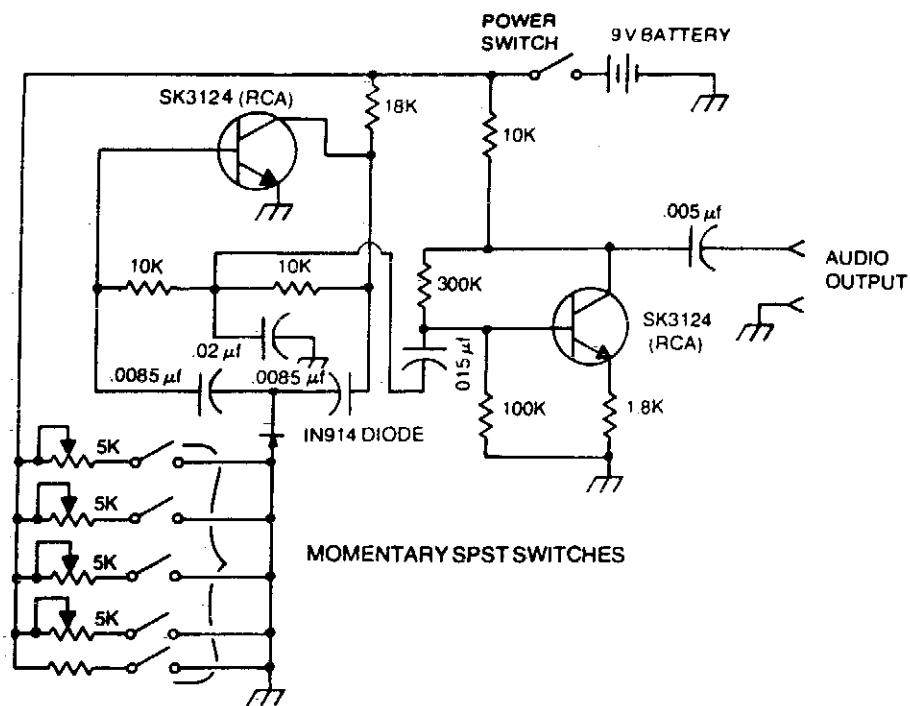
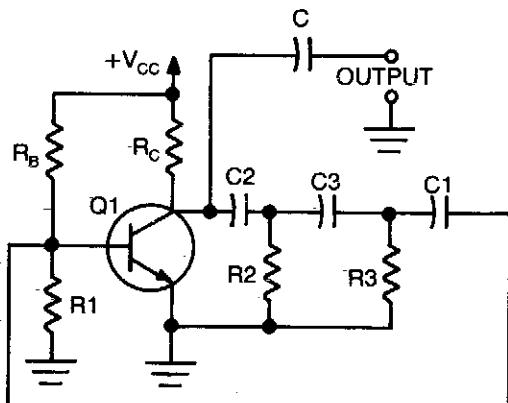


Fig. 7-10

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

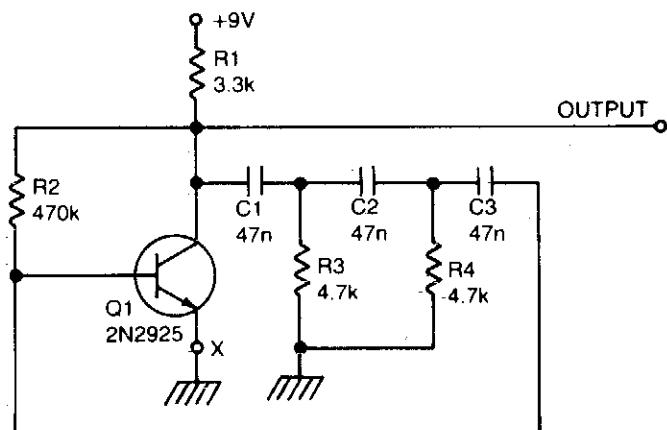
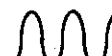


Fig. 7-12



250 Hz

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

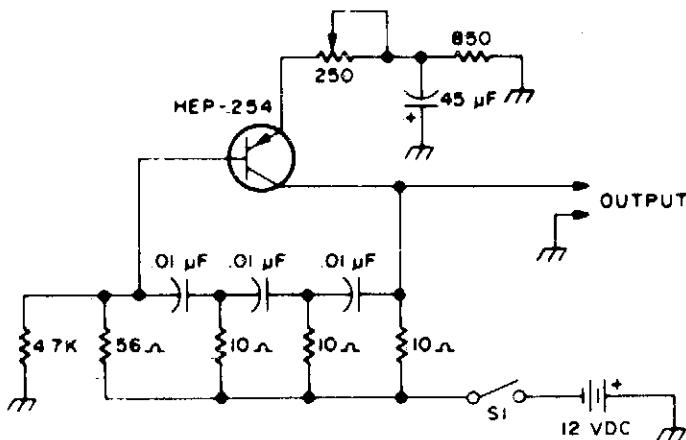


Fig. 7-13

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

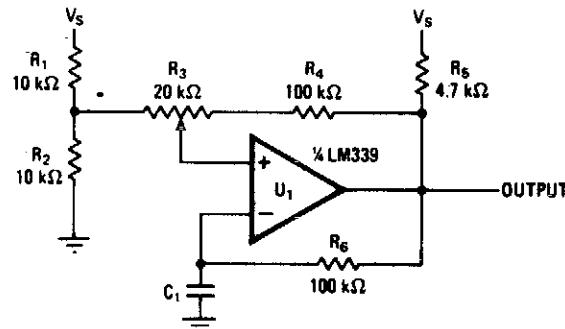
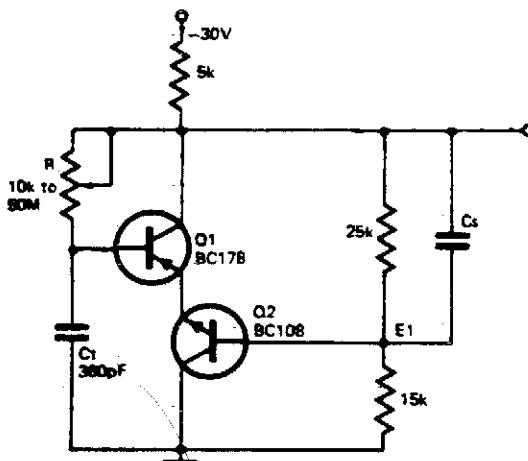


Fig. 7-14

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 R6C1 determines how much time it takes for C1 to charge or discharge to the new threshold after the output voltage switches.

WIDE RANGE OSCILLATOR (FREQUENCY RANGE OF 5000 TO 1)



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 Q1 ensures that Q1 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 Q2 plus the base emitter drops of Q1 and Q2. 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.

Fig. 7-15

WIEN BRIDGE OSCILLATOR

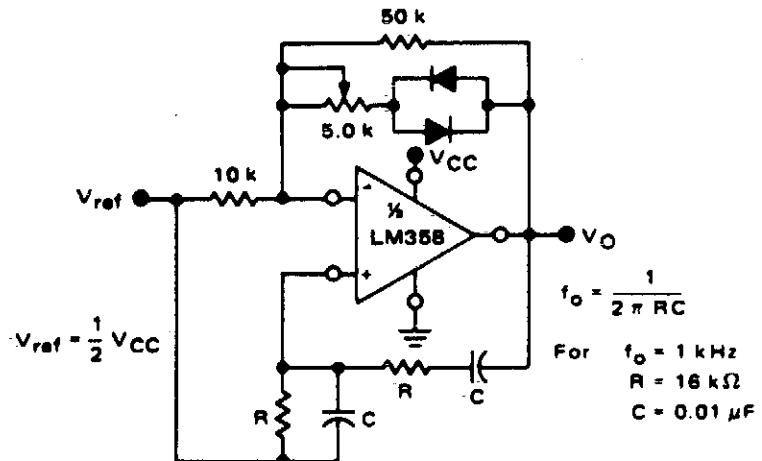


Fig. 7-16

WIEN BRIDGE SINE WAVE OSCILLATOR

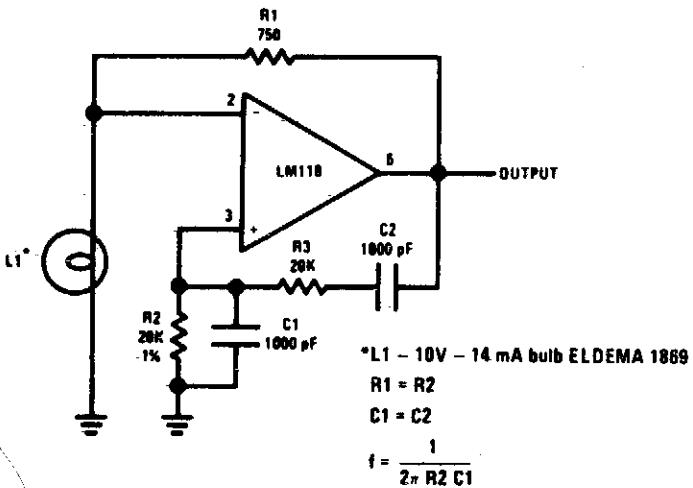


Fig. 7-17

8

Audio Power 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.

- | | |
|---------------------------------------------------|-------------------------------------------------------------------|
| Low Cost 20 W Audio Amplifier | Novel Loudspeaker Coupling Circuit |
| 75 Watt Audio Amplifier with Load Line Protection | Noninverting Ac Power Amplifier |
| Bridge Amplifier | Inverting Power Amplifier |
| Noninverting Amplifier Using Single Supply | Noninverting Power Amplifier |
| Noninverting Amplifier Using Split Supply | 4 W Bridge Amplifier |
| 6 W, 8 Ohm Output Transformerless Amplifier | Phono Amplifier with a "Common Mode" Volume and Tone with Control |
| 12 W Low-Distortion Power Amplifier | Phono Amplifier |
| 10 W Power Amplifier | Phonograph Amplifier (Ceramic Cartridge) |
| Stereo Amplifier with $A_v = 200$ | Inverting Unity Gain Amplifier |
| AM Radio Power Amplifier | Bridge Audio Power Amplifier |
| 470 mW Complementary-Symmetry Audio Amplifier | Phono Amplifier |
| | High Slew Rate Power Op Amp/Audio Amp |
| | 16 W Bridge Amplifier |

LOW COST 20 W AUDIO AMPLIFIER

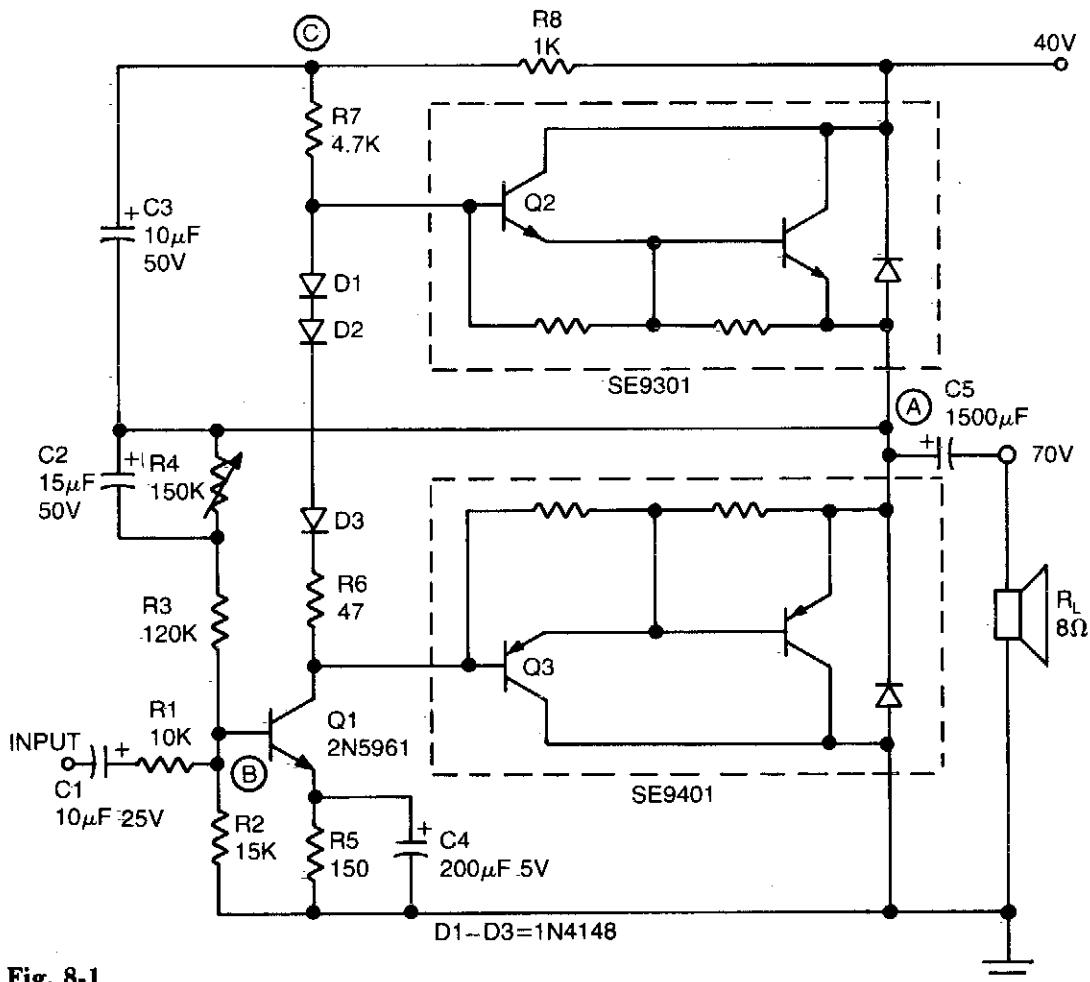


Fig. 8-1

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 Darlingtons. 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

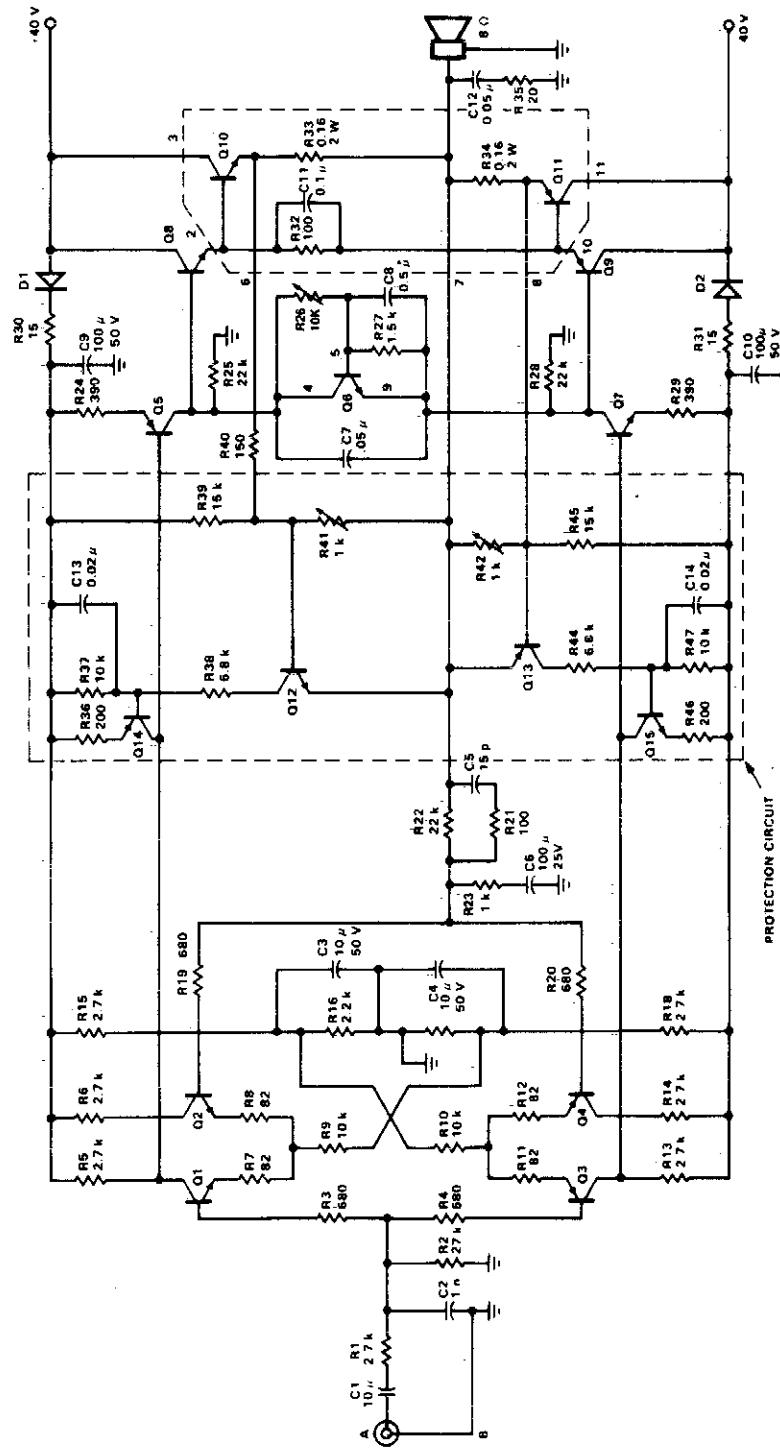


Fig. 8-2

BRIDGE AMPLIFIER

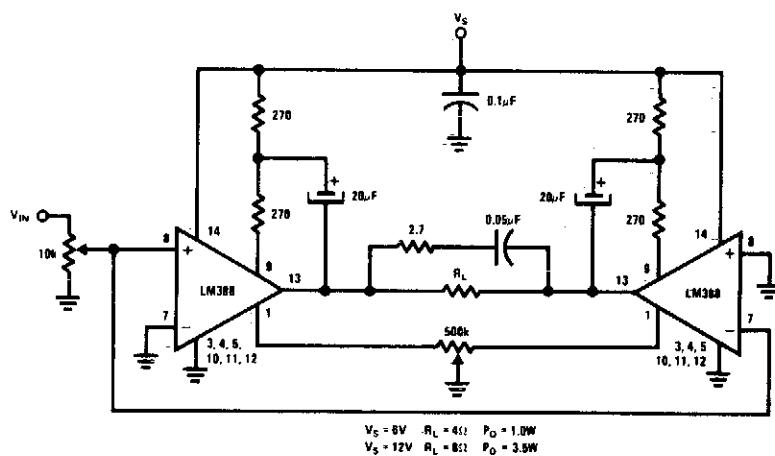


Fig. 8-3

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 V 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

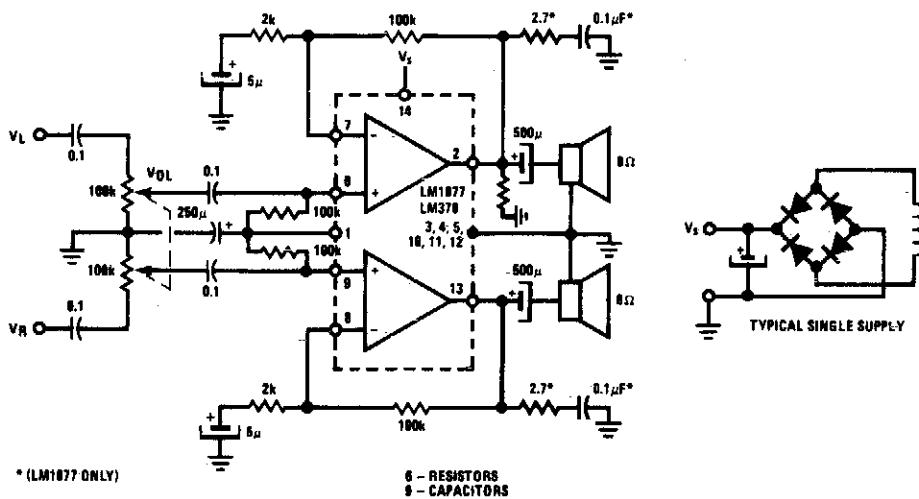


Fig. 8-4

NONINVERTING AMPLIFIER USING SPLIT SUPPLY

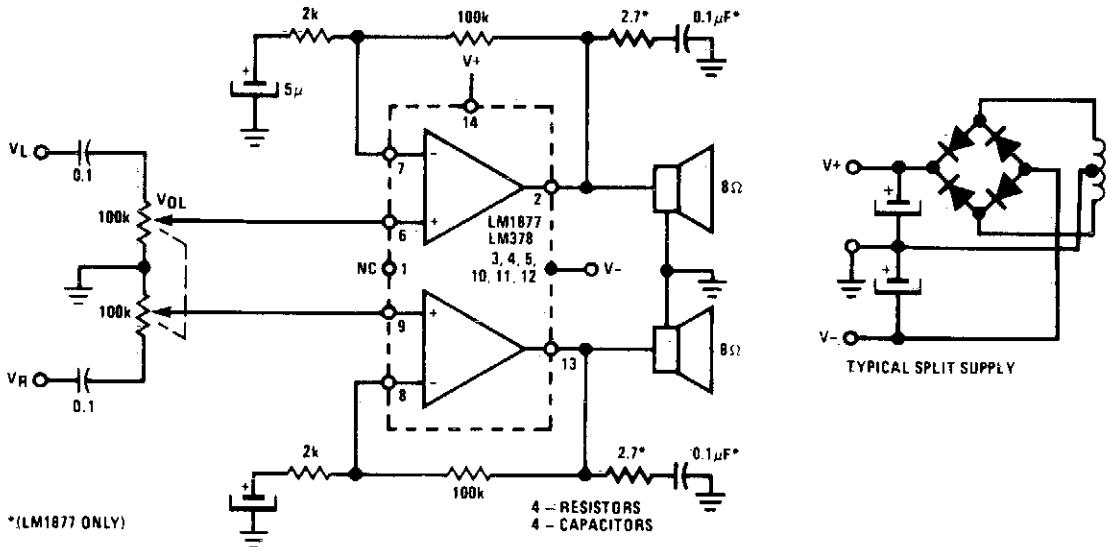


Fig. 8-5

6 W, 8 Ω OHM OUTPUT TRANSFORMERLESS AMPLIFIER

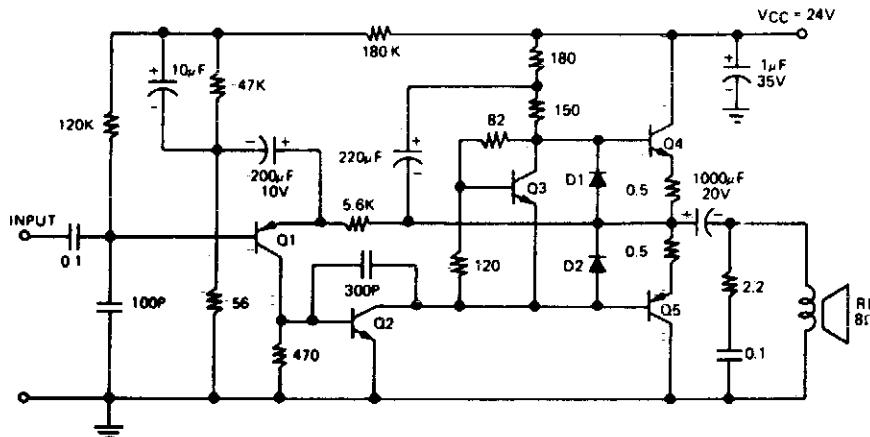


Fig. 8-6

12 W LOW-DISTORTION POWER AMPLIFIER

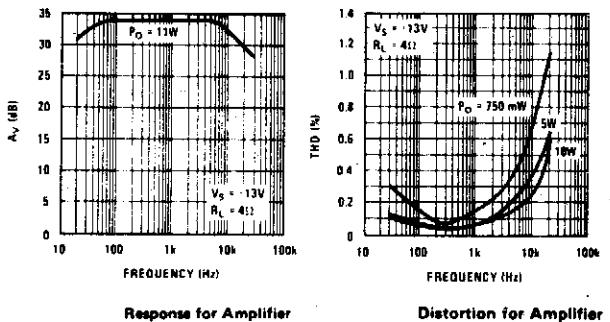
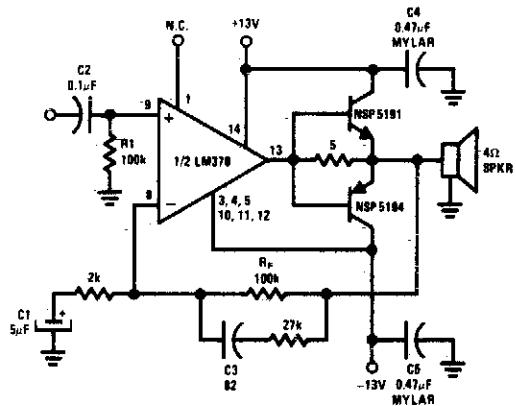
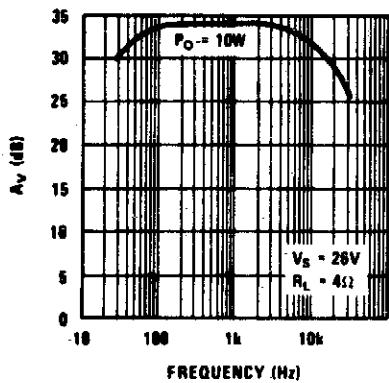
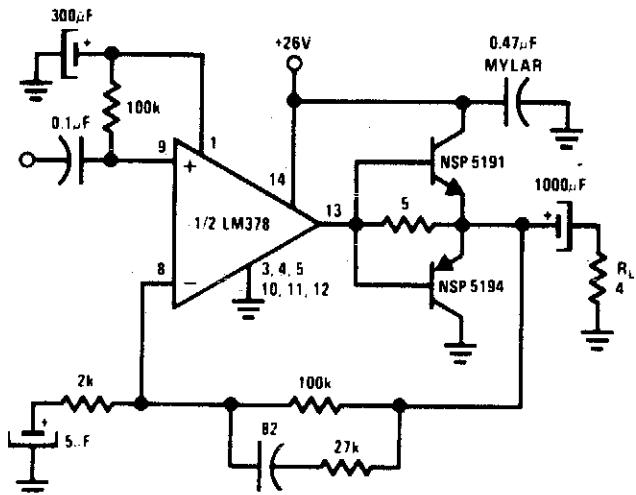


Fig. 8-7

10 W POWER AMPLIFIER



Frequency Response

Fig. 8-8

STEREO AMPLIFIER WITH $A_v = 200$

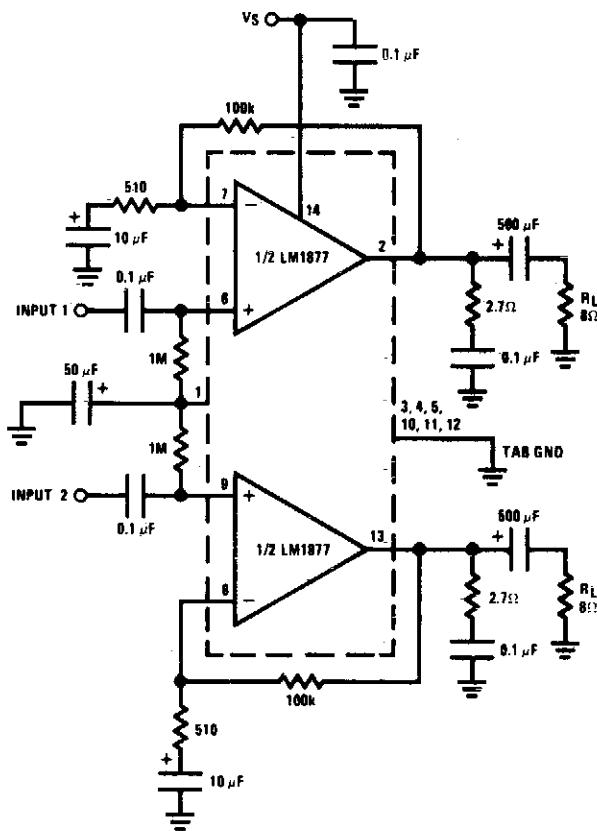
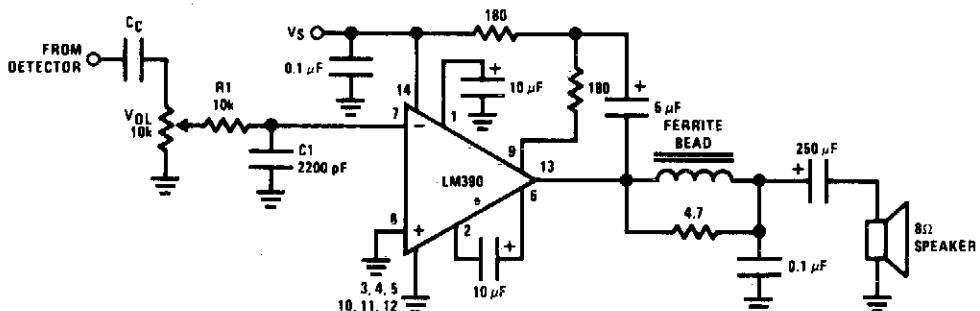


Fig. 8-9

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

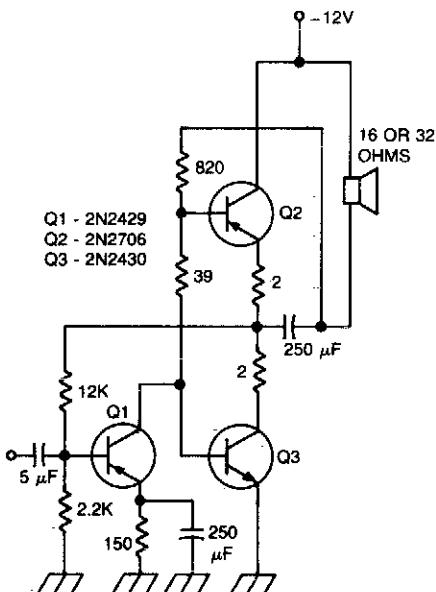


Fig. 8-11

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

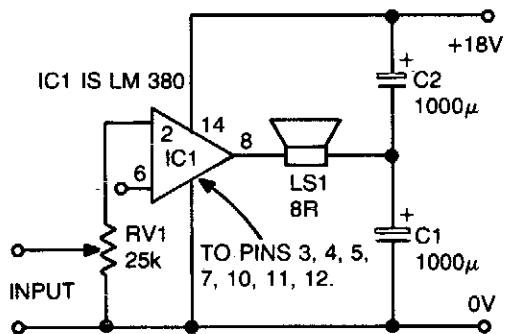


Fig. 8-12

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 C_1 (if C_1 and C_2 are equal); so as the supply voltage builds up, the dc voltage across the speaker will remain zero, eliminating the switch-on surge. C_1 and C_2 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

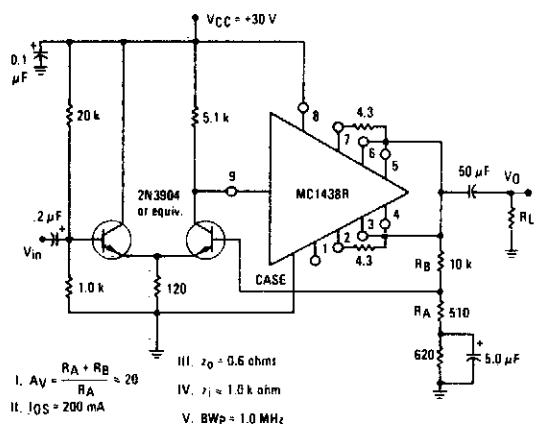


Fig. 8-13

NONINVERTING POWER AMPLIFIER

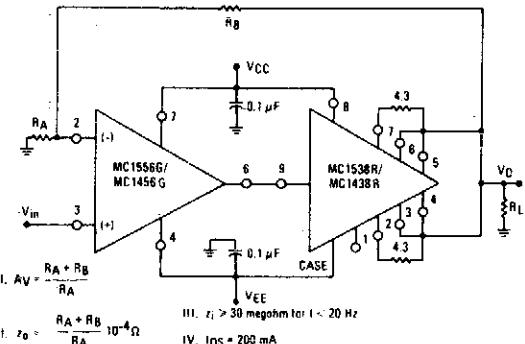


Fig. 8-15

INVERTING POWER AMPLIFIER

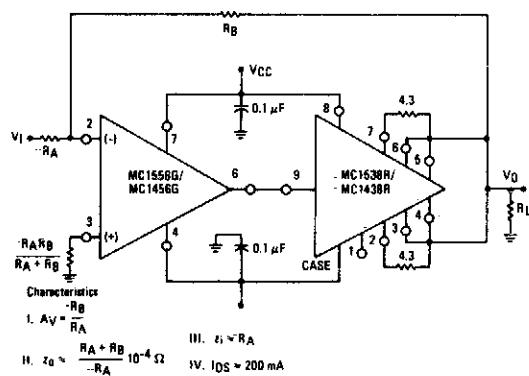


Fig. 8-14

4 W BRIDGE AMPLIFIER

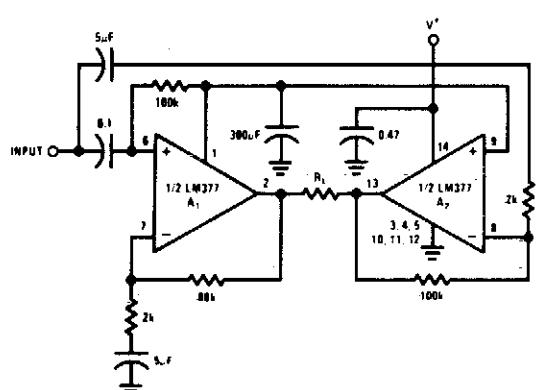
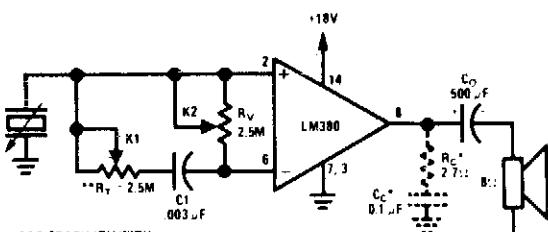


Fig. 8-16

PHONO AMPLIFIER WITH "COMMON MODE" VOLUME AND TONE CONTROL



*FOR STABILITY WITH
HIGH CURRENT LOADS
**AUDIO TAPE POTENTIOMETER
(10% OF R_V AT 50% ROTATION)

Fig. 8-17

PHONOGRAPH AMPLIFIER (CERAMIC CARTRIDGE)

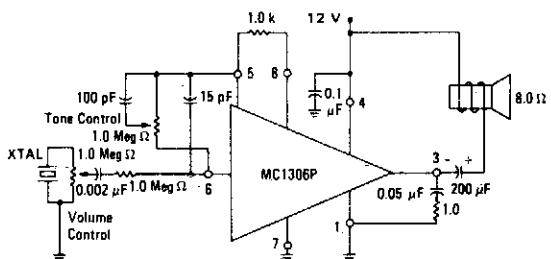


Fig. 8-19

PHONO AMPLIFIER

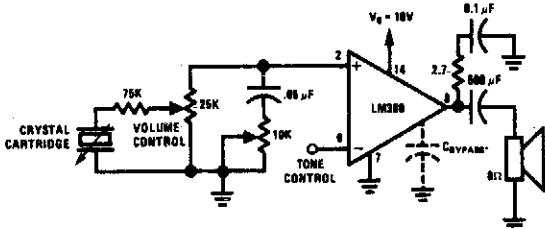


Fig. 8-18

INVERTING UNITY GAIN AMPLIFIER

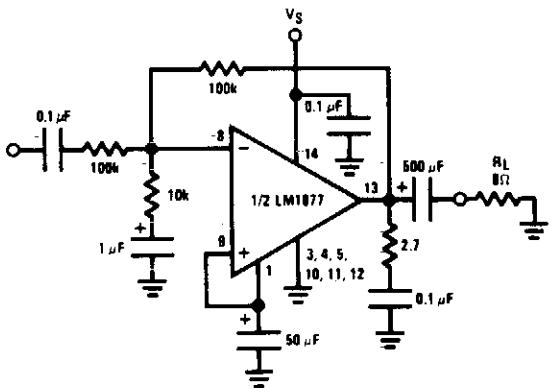
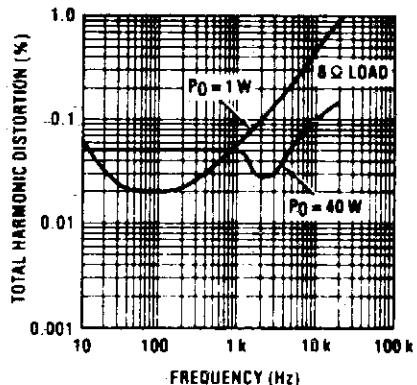
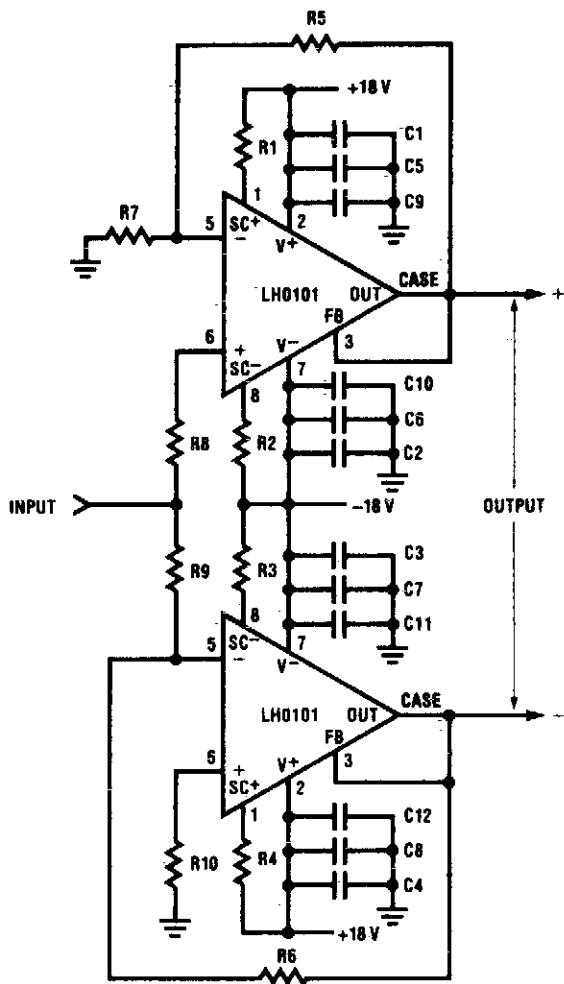


Fig. 8-20

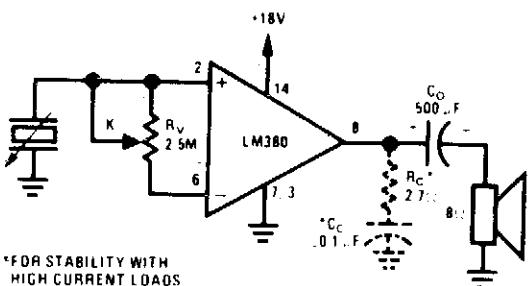
BRIDGE AUDIO POWER AMPLIFIER



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

Fig. 8-21

PHONO AMPLIFIER



Circuit Notes

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

*FOR STABILITY WITH HIGH CURRENT LOADS

Fig. 8-22

HIGH SLEW RATE POWER OP AMP/AUDIO AMP

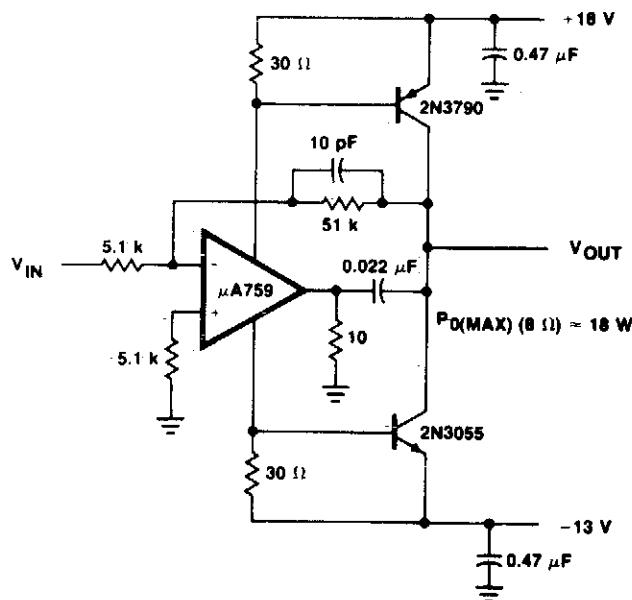


Fig. 8-23

Features

- High Slew Rate 9 V/μs
- High 3 dB Power Bandwidth 85 kHz
- 18 Watts Output Power Into an 8 Ω Load.
- Low Distortion — .2%, 10 VRMS, 1 kHz Into 8 Ω

16 W BRIDGE AMPLIFIER

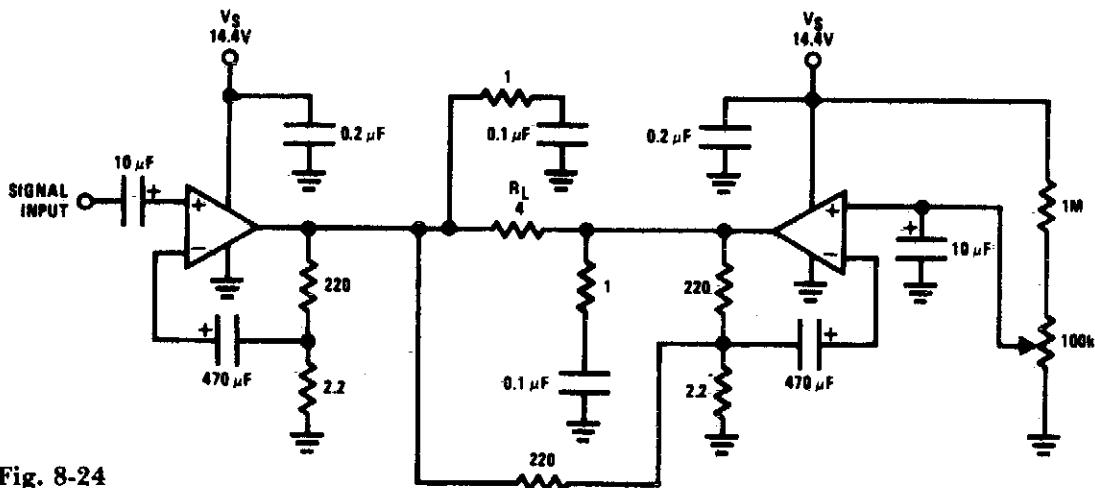


Fig. 8-24

9

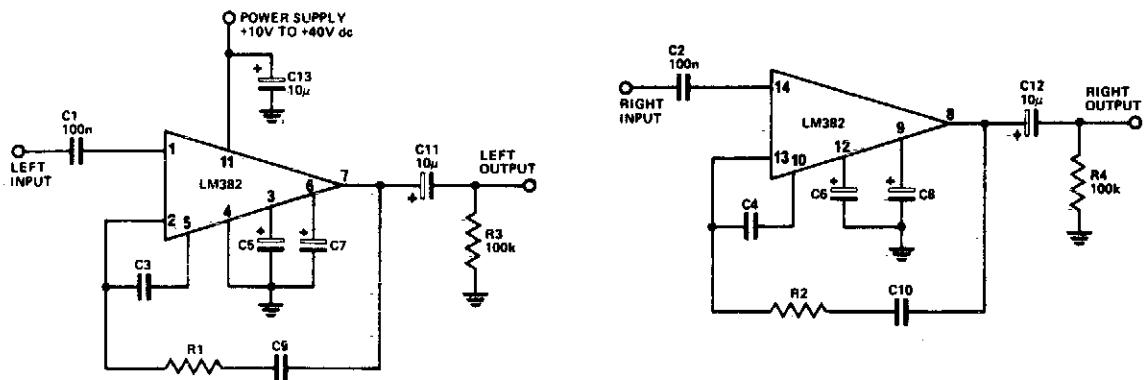
Audio Signal Amplifiers

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



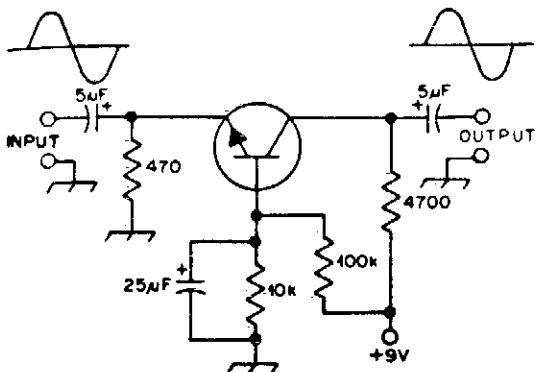
FUNCTION	C3, 4	C5, 6	C7, 8	C9, 10	R1, 2
Phono preamp (RIAA)	330n	10 μ F	10 μ F	1n5	1k
Tape preamp (NAB)	68n	10 μ F	10 μ F	—	—
Flat 40dB gain	—	—	10 μ F	—	—
Flat 55dB gain	—	10 μ F	—	—	—
Flat 80dB gain	—	10 μ F	10 μ F	—	—

Fig. 9-1

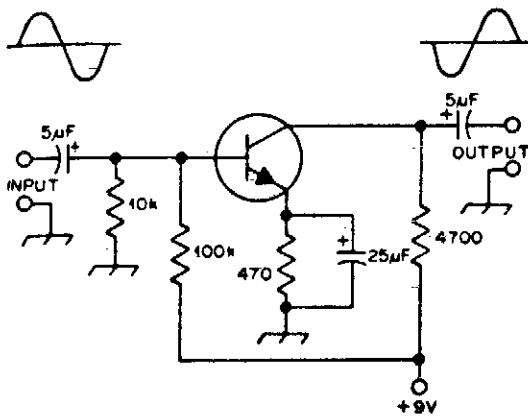
Circuit Notes

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

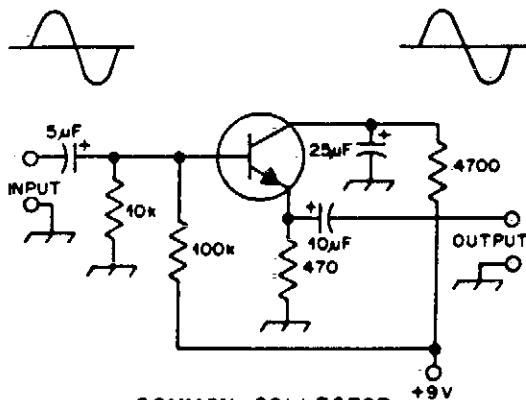


Fig. 9-2

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.

ELECTRONIC BALANCED INPUT MICROPHONE AMPLIFIER

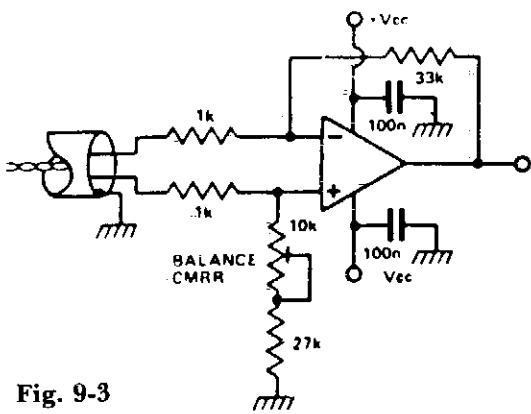


Fig. 9-3

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

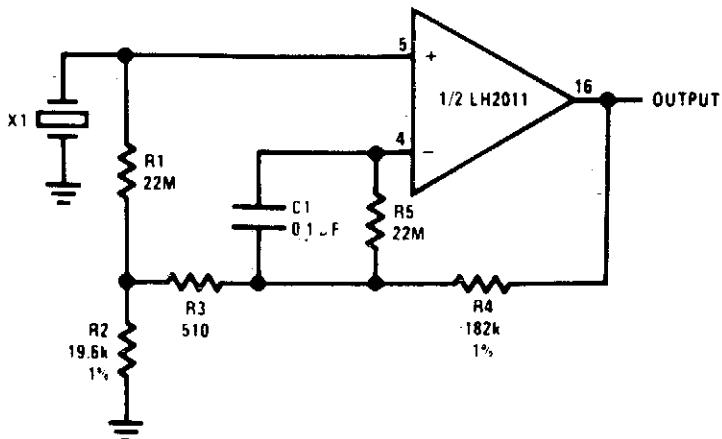


Fig. 9-4

$$R_{IN} = R_1 \left(1 + \frac{R_2}{R_3} \right) A_v = \frac{R_2 + R_3 + R_4}{R_2 + R_3}$$

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

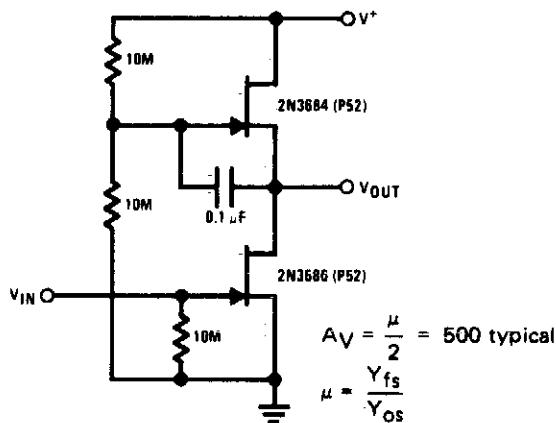


Fig. 9-5

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.

MICROPHONE AMPLIFIER

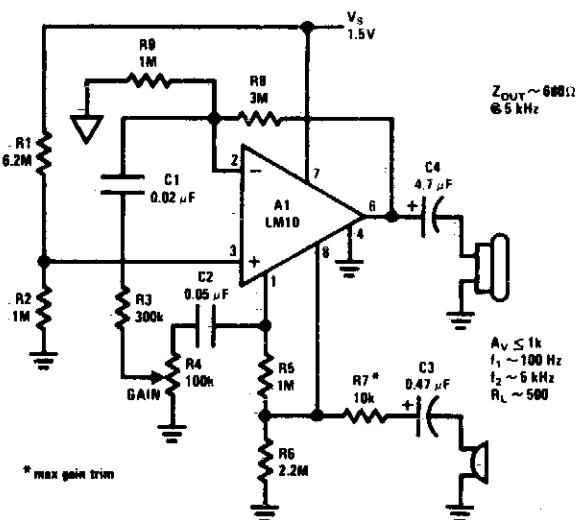


Fig. 9-6

Circuit Notes

This circuit operates from a 1.5 Vdc source.

TRANSFORMERLESS (BALANCE INPUTS) MICROPHONE PREAMP

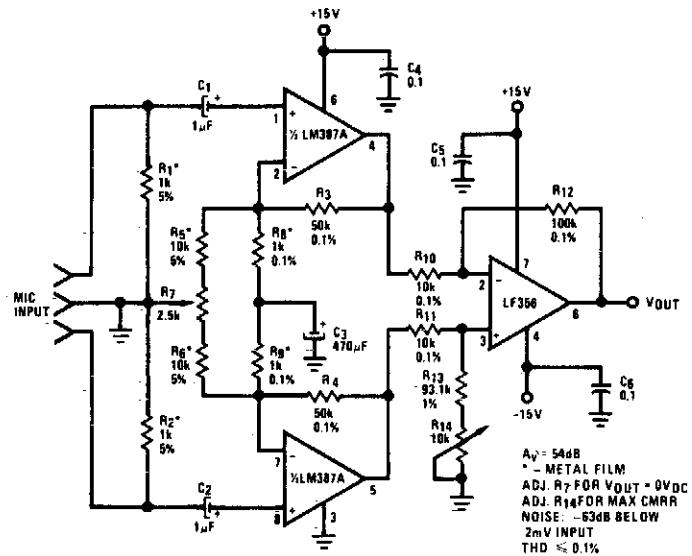


Fig. 9-7

TRANSFORMERLESS MICROPHONE PREAMPS (UNBALANCED INPUTS)

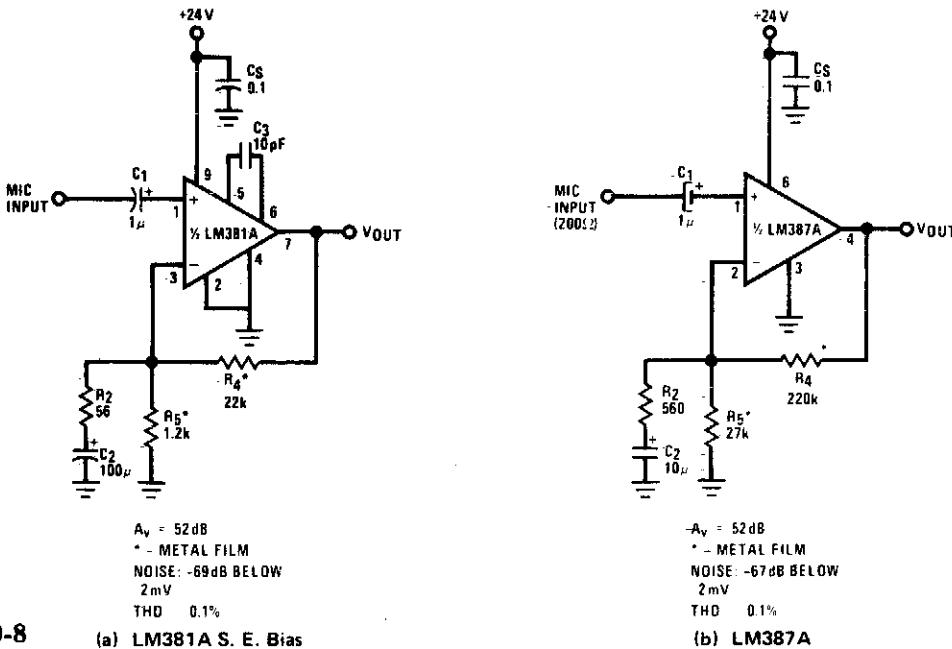


Fig. 9-8

(a) LM381A S. E. Bias

(b) LM387A

MAGNETIC PICKUP PHONO PREAMPLIFIER

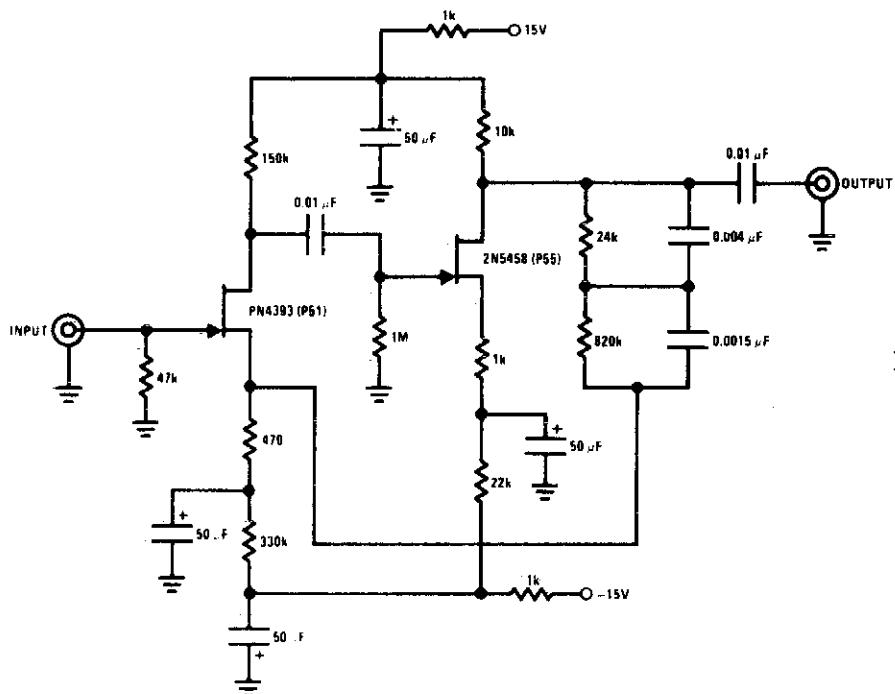


Fig. 9-9

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

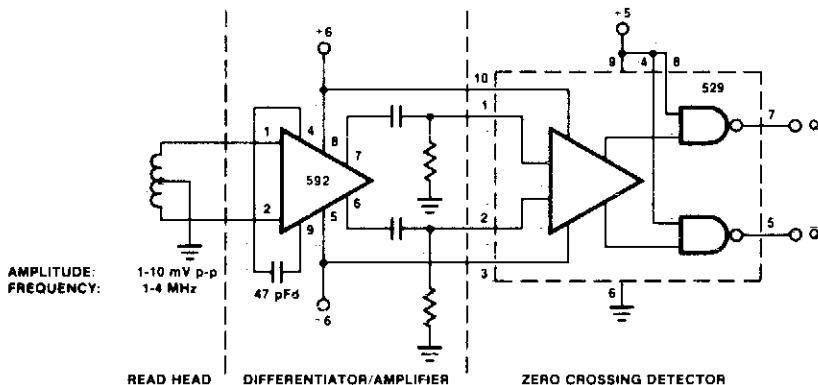


Fig. 9-10

TWO-POLE FAST TURN-ON NAB TAPE PREAMPLIFIER

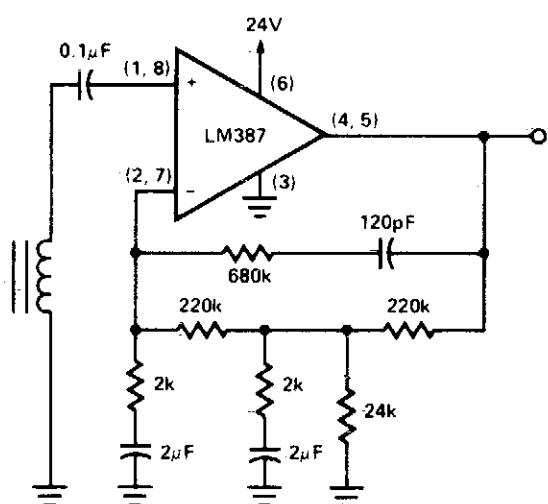


Fig. 9-11

LM382 PHONO PREAMPLIFIER (RIAA)

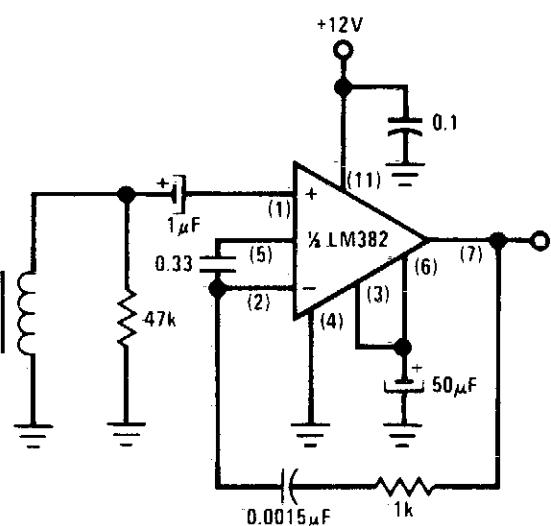


Fig. 9-13

TAPE PREAMPLIFIER (NAB EQUALIZATION)

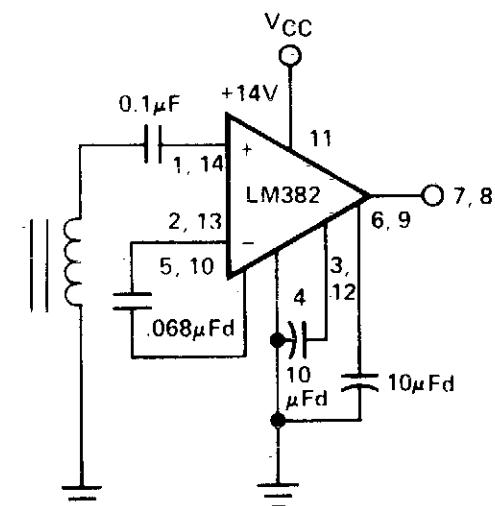


Fig. 9-12

TAPE RECORDING AMPLIFIER

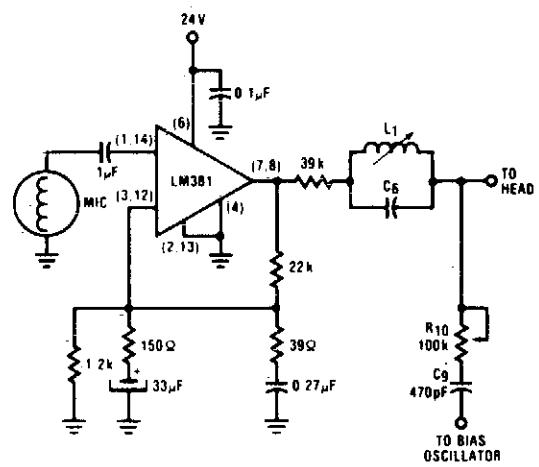


Fig. 9-14

MAGNETIC PHONO PREAMPLIFIER

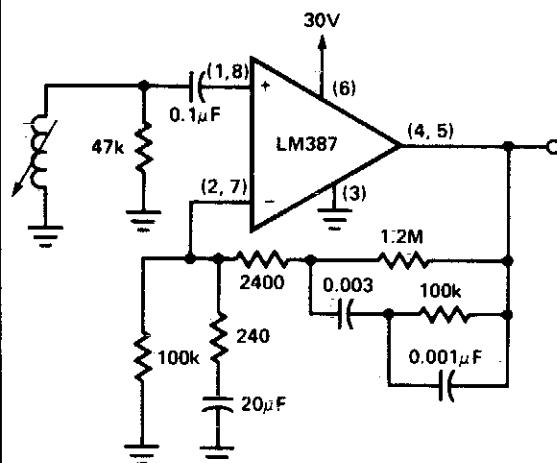


Fig. 9-15

REMOTE AMPLIFIER

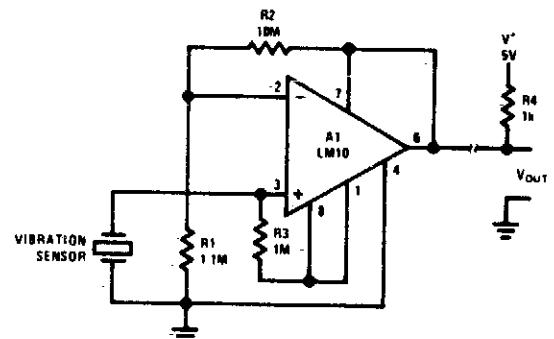
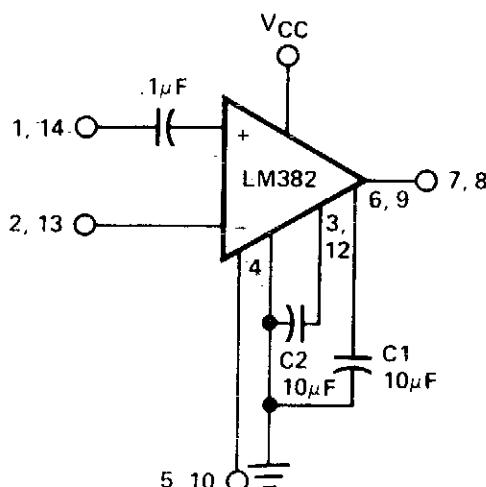


Fig. 9-17

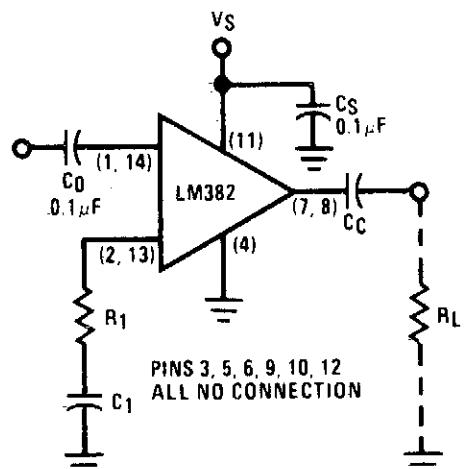
PHONO PREAMP (RIAA EQUALIZATION)



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

Fig. 9-16

ADJUSTABLE GAIN NONINVERTING AMPLIFIER



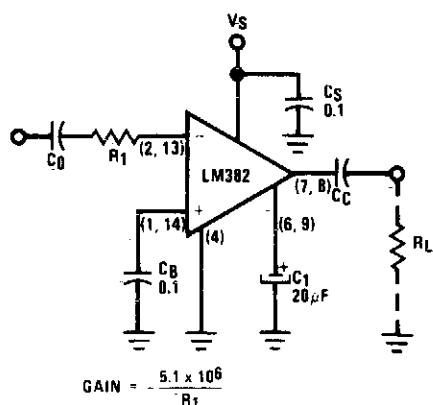
$$\text{GAIN} = 1 + \frac{267k}{R_1}$$

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

f₀ = LOW FREQUENCY -3dB CORNER

Fig. 9-18

HIGH GAIN INVERTING AC AMPLIFIER



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

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

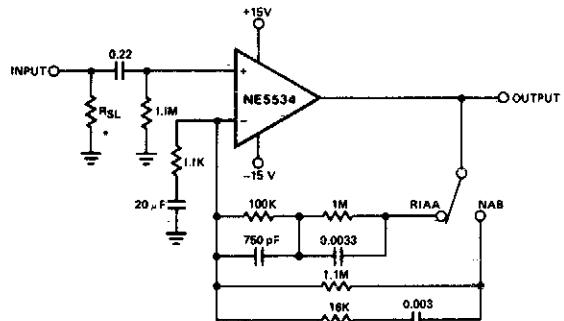
f_0 = LOW FREQUENCY -3dB CORNER ($C_C R_L \gg C_0 R_1$)

INPUT IMPEDANCE = R_1

PINS 3, 5, 10, 12 NOT USED

Fig. 9-19

PREAMPLIFIER WITH RIAA/NAB COMPENSATION



*Select to provide specified transducer loading.
Output Noise $\geq 0.8\text{mV rms}$ (with input shorted)

All resistor values are in ohms.

Fig. 9-21

FLAT RESPONSE AMPLIFIER (FIXED GAIN CONFIGURATION)

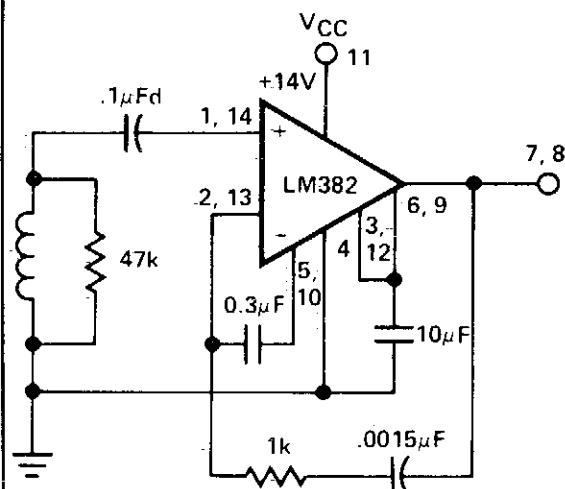


Fig. 9-20

TAPE PLAYBACK AMPLIFIER

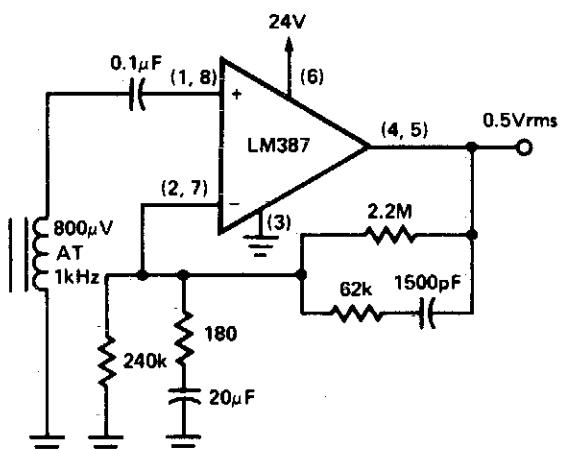


Fig. 9-22

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	Auto Battery Current Analyzer
Speed Alarm	Speed Switch
Speed Warning Device	Windshield Wiper Controller
Universal Wiper Delay	Windshield Wiper Hesitation Control Unit
Courtesy Light Extender	Ice Warning and Lights Reminder
Bargraph Car Voltmeter	Car Battery Monitor
Tachometer	Headlight Delay Unit
High Speed Warning Device	Windshield Washer Fluid Watcher
Breaker Point Dwell Meter	Car Battery Condition Checker
Tachometer	Overspeed Indicator
Capacitor Discharge Ignition System	Sequential Flasher for Auto Turn Signals
Windshield Wiper Control	Auto Lights-On Reminder

GASOLINE ENGINE TACHOMETER

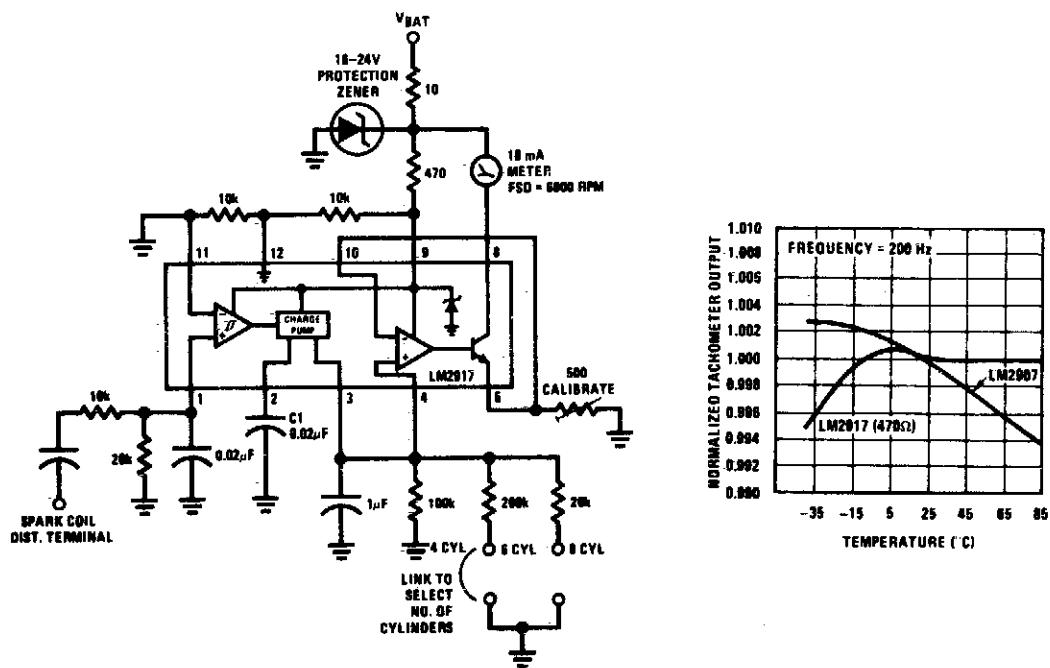


Fig. 10-1

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

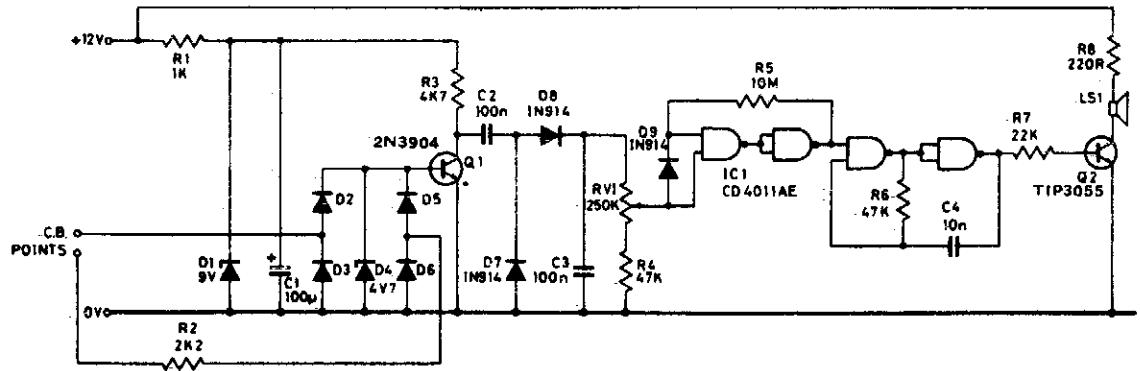


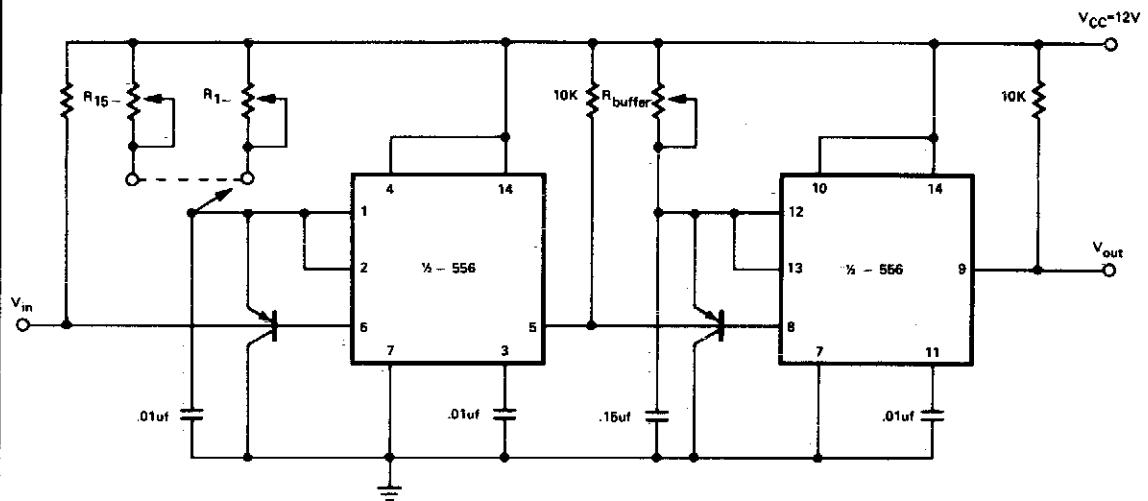
Fig. 10-2

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

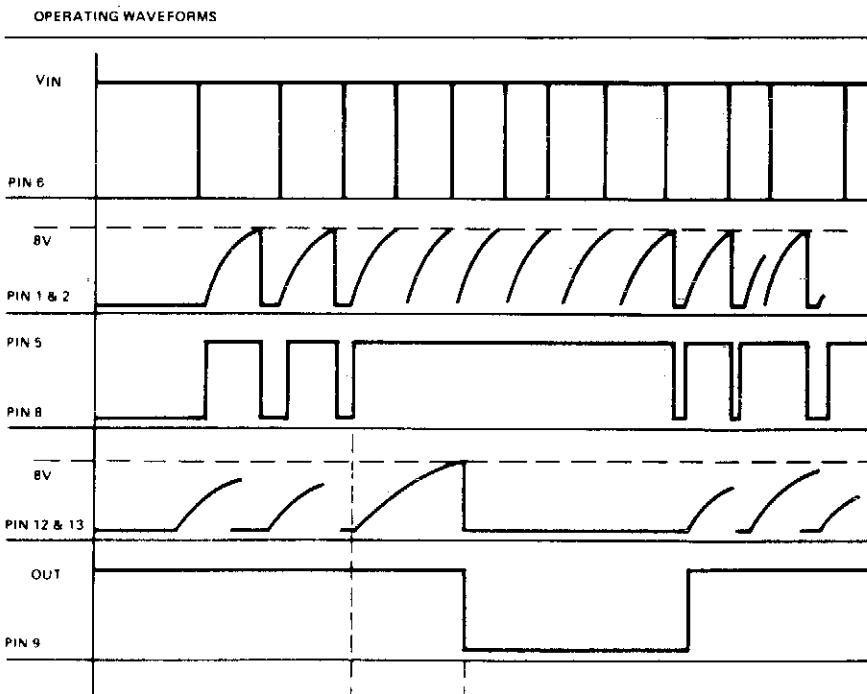


Fig. 10-3

UNIVERSAL WIPER DELAY

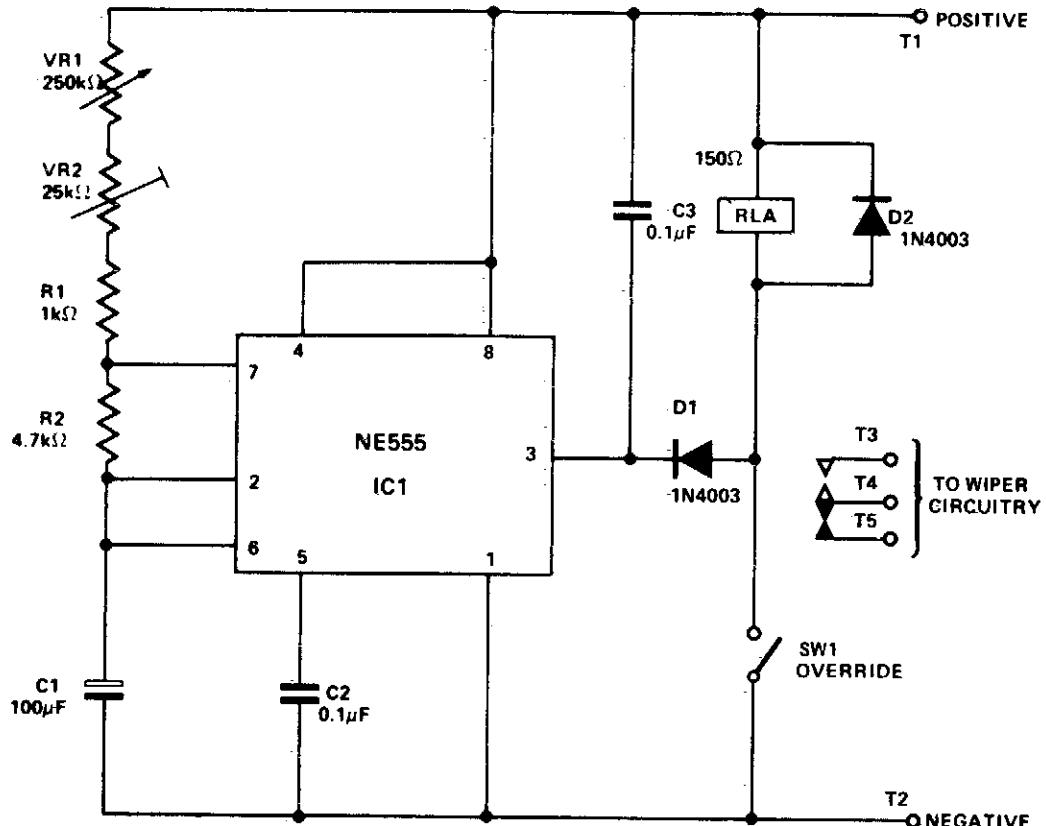


Fig. 10-4

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

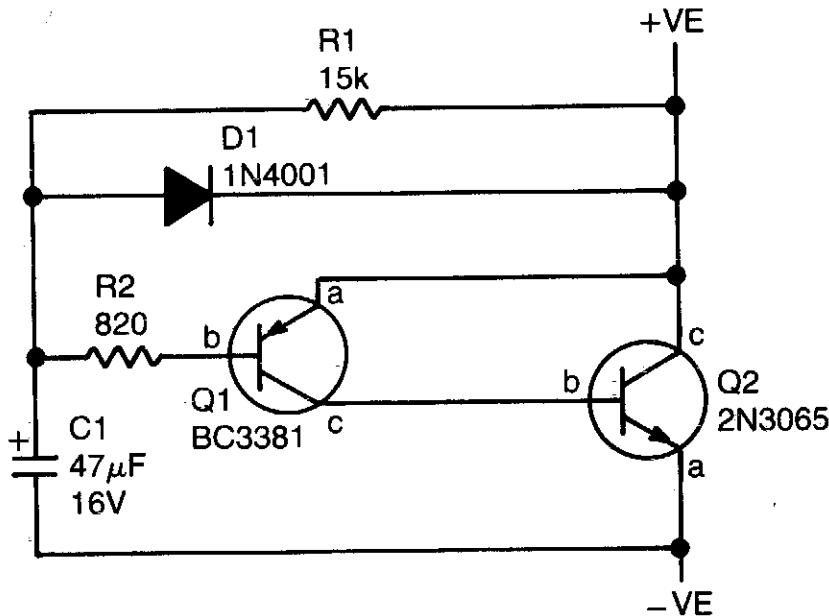


Fig. 10-5

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.

BARGRAPH CAR VOLTMETER

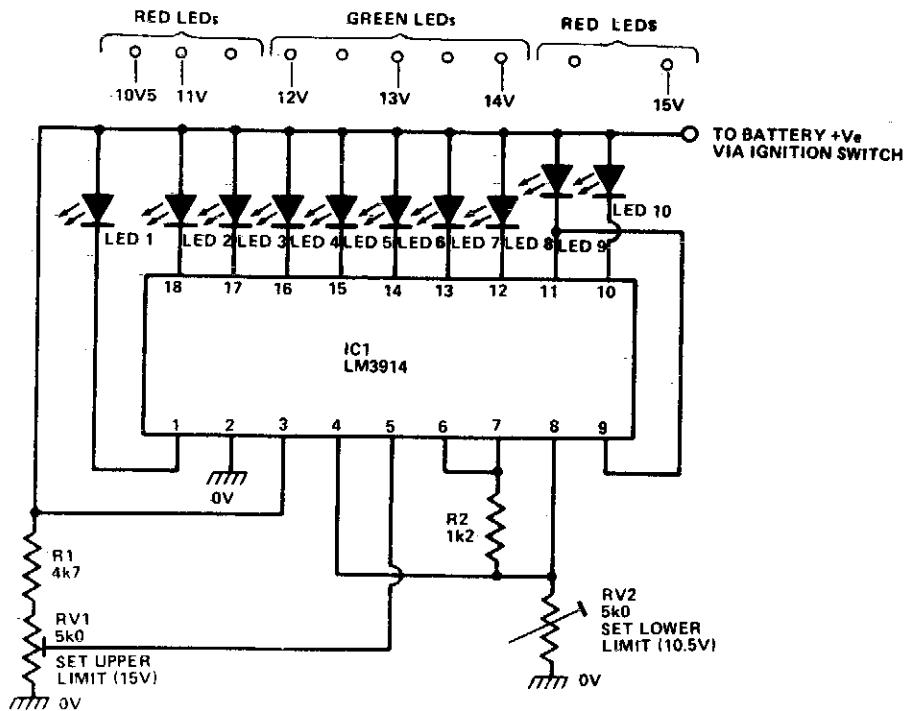


Fig. 10-6

Circuit Notes

The LM3914 acts as a LED-driving voltmeter that has its basic maximum and minimum readings determined by the values of R2 and RV2. When correctly adjusted, the unit actually covers the 2.5 volt to 3.6 volt range, but it is made to read a supply voltage span of 10-10.5 volts to 15 volts by interposing potential divider R1-RV1 between the supply line

and the pin-5 input terminal of the IC. The IC is configured to give a 'dot' display, in which only one of the ten LEDs is illuminated at any given time. If the supply voltage is below 10.5 volts none of the LEDs illuminate. If the supply equals or exceeds 15 volts, LED 10 illuminates.

TACHOMETER

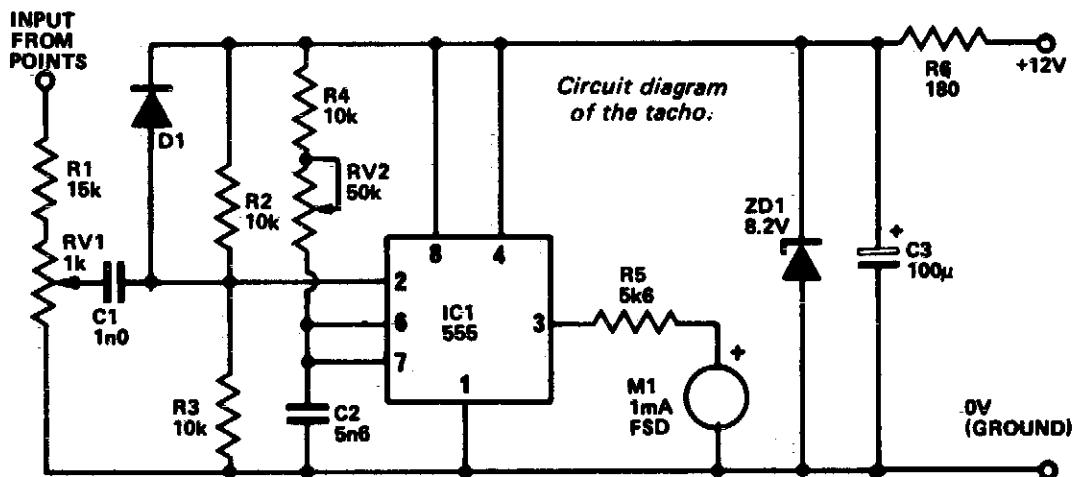


Fig. 10-7

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 $R_4 + R_{V2}$ and C_2 . Resistors R_2

and R_3 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 ($\frac{1}{3}$ of supply voltage), and this occurs due to the voltage swing when the breaker points open. An adjustment potentiometer RV_1 enables the input level to be set to avoid false triggering. Zener diode ZD_1 and the 180 ohm resistor stabilize the unit against voltage variations.

HIGH SPEED WARNING DEVICE

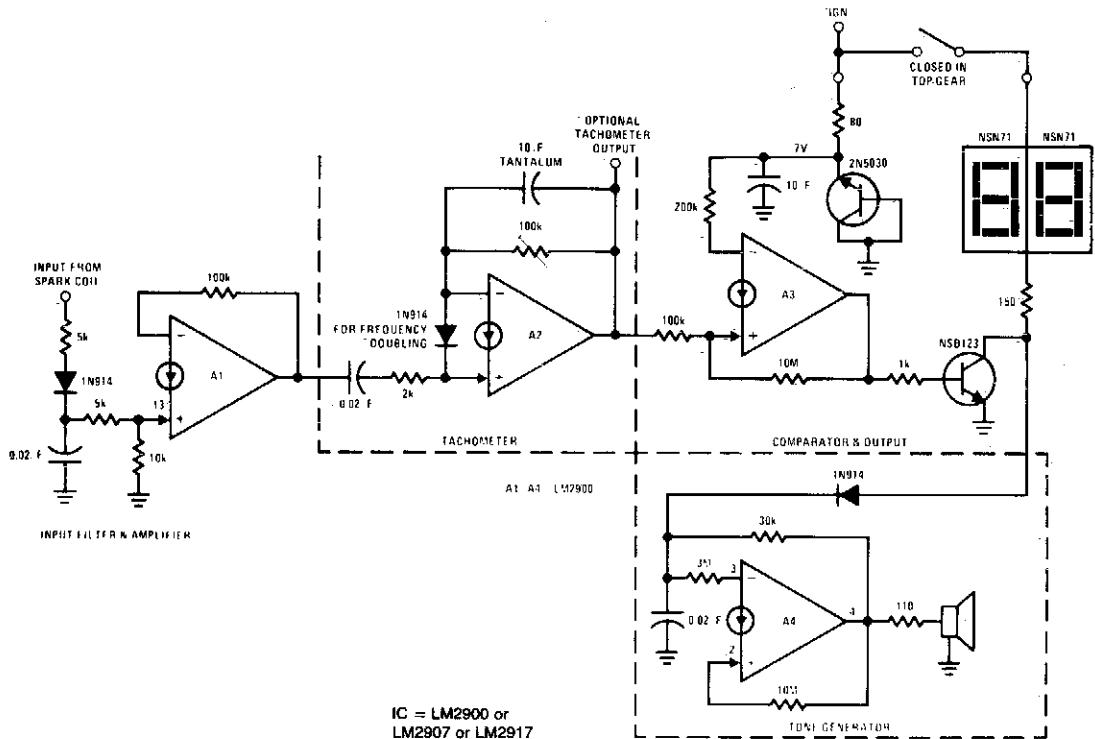


Fig. 10.8

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

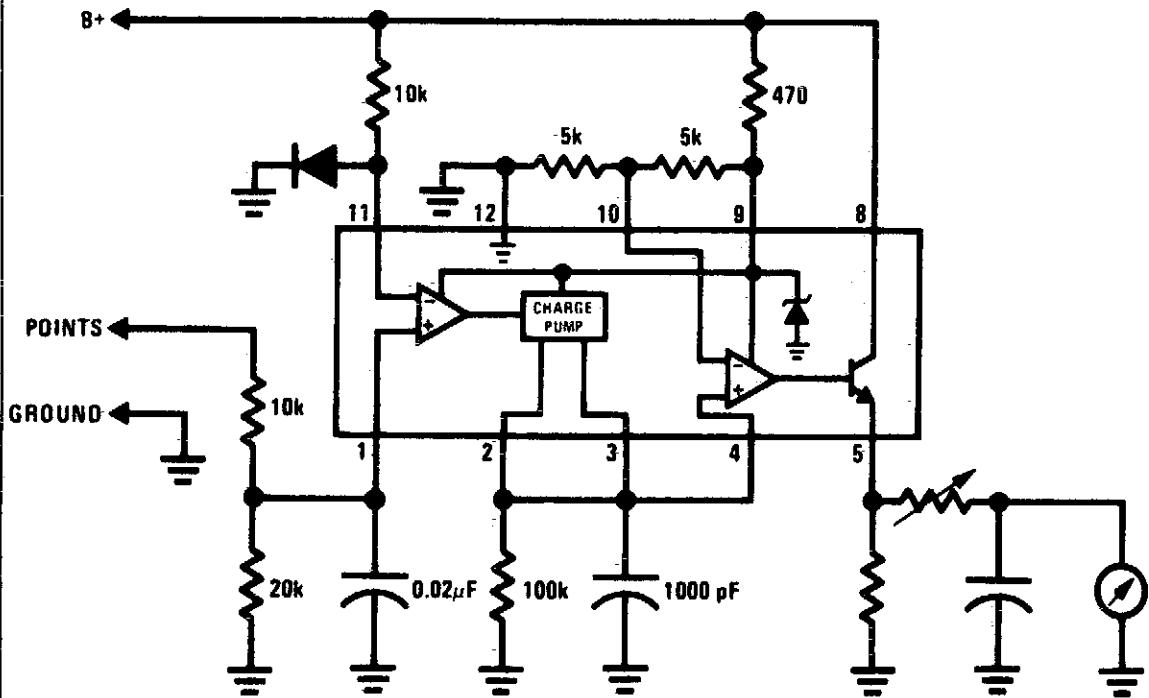


Fig. 10-9

TACHOMETER

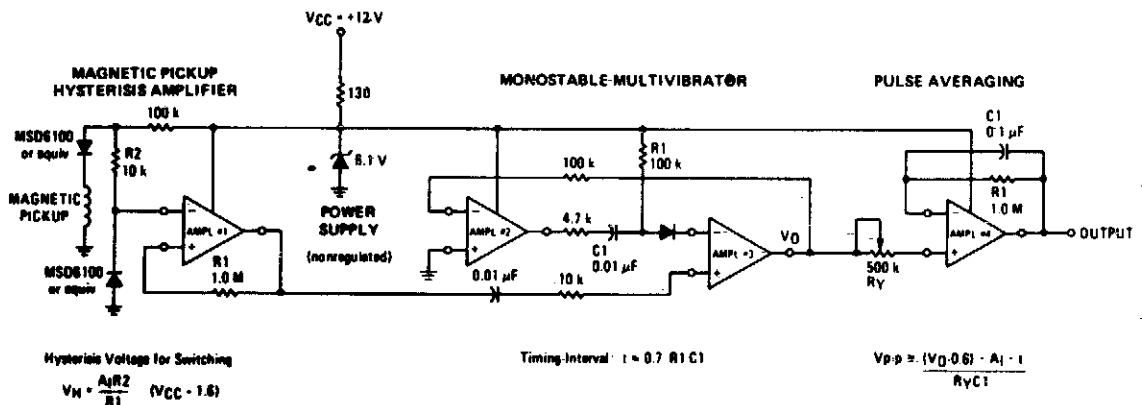


Fig. 10-10

CAPACITOR DISCHARGE IGNITION SYSTEM

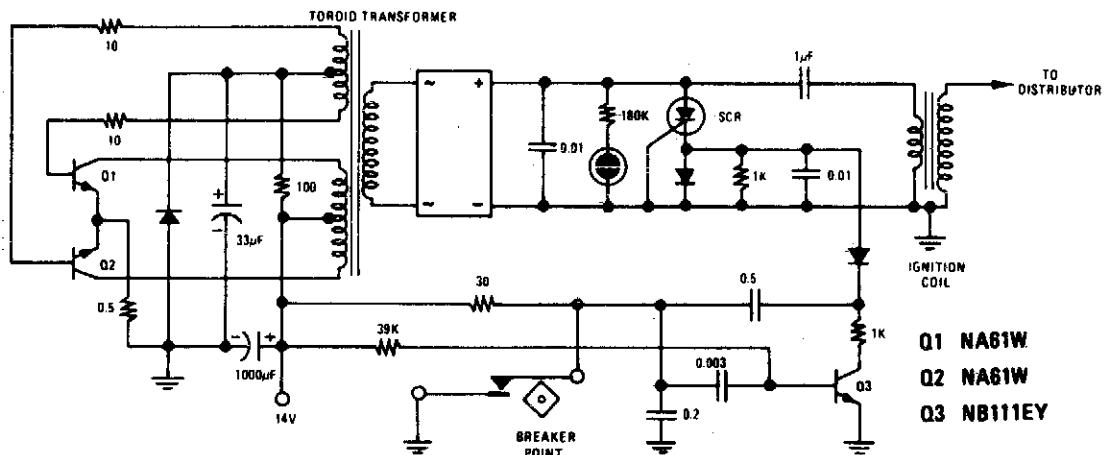


Fig. 10-11

WINDSHIELD WIPER CONTROL

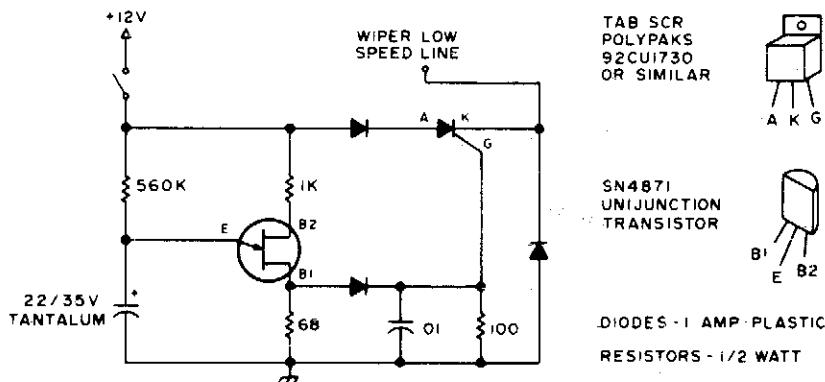


Fig. 10-12

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

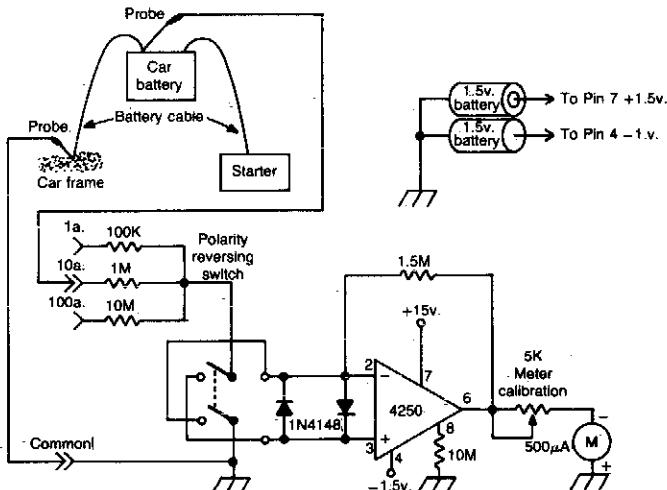


Fig. 10-13

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

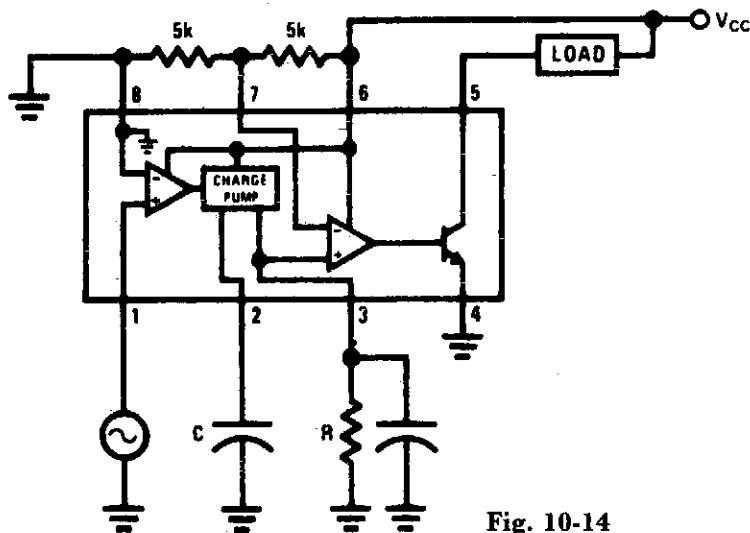


Fig. 10-14

Circuit Notes

Load is energized when

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

WINDSHIELD WIPER CONTROLLER

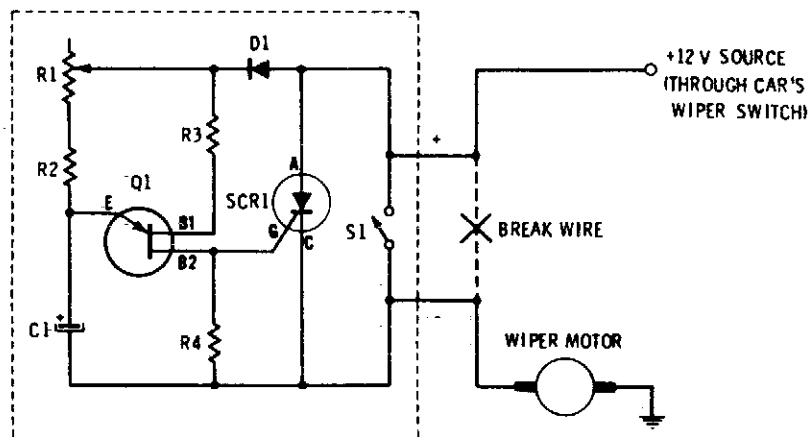


Fig. 10-15

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

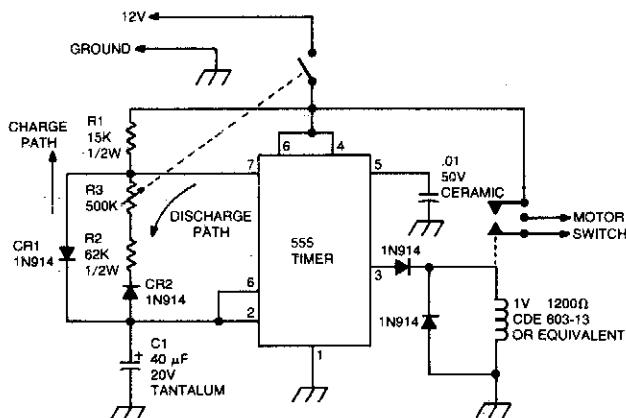


Fig. 10-16

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

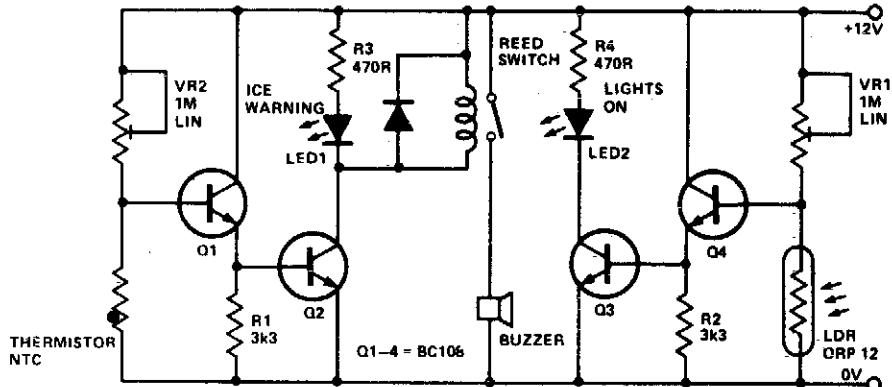


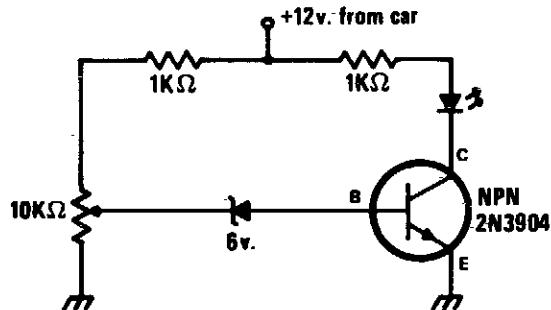
Fig. 10-17

Circuit Notes

This device will tell a driver if his lights should be on and will warn him if the outside temperature is nearing zero by lighting a LED and sounding a buzzer. VR1 adjusts sensitivity

for temperature, VR2 for light. Both thermistor and LDR should be well protected. Most high gain NPN transistors will work.

CAR BATTERY MONITOR



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.

Fig. 10-18

HEADLIGHT DELAY UNIT

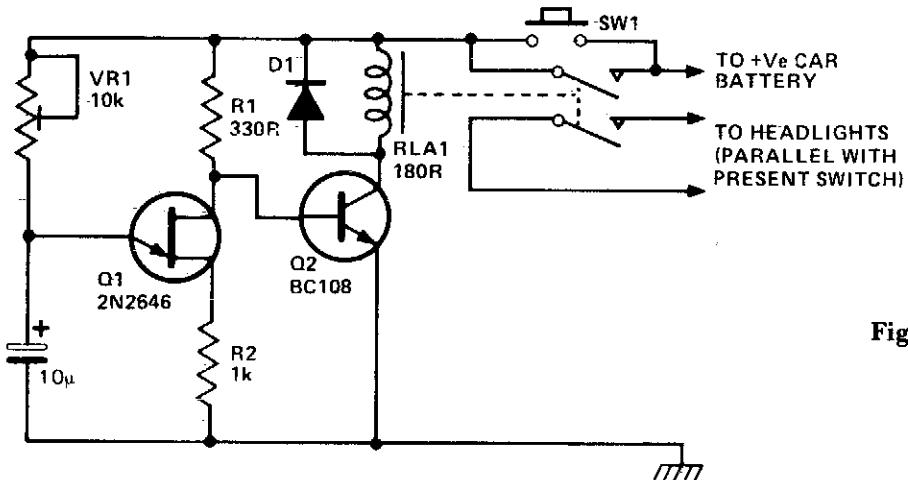


Fig. 10-19

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

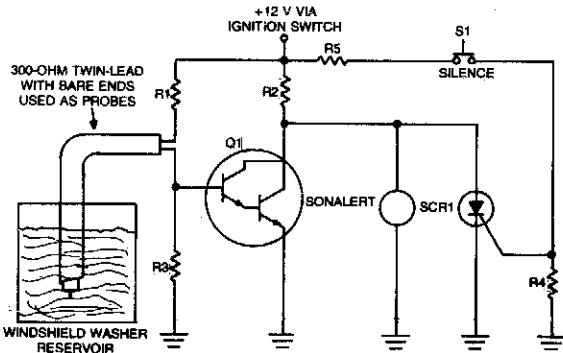
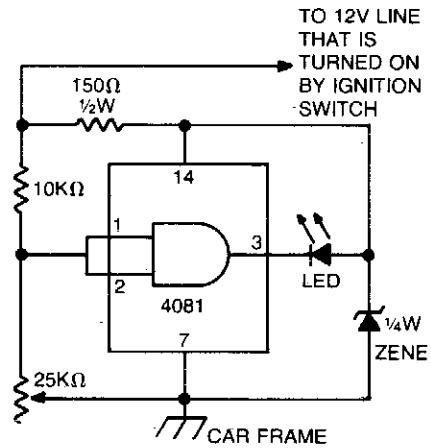


Fig. 10-20

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 Sonolert sounds.

CAR BATTERY CONDITION CHECKER

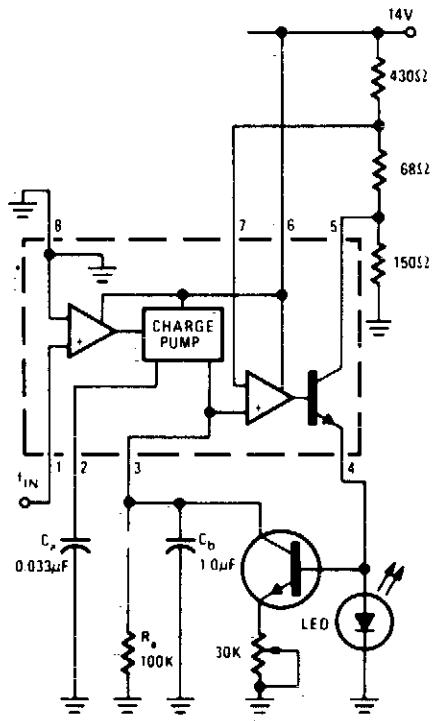


Circuit Notes

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



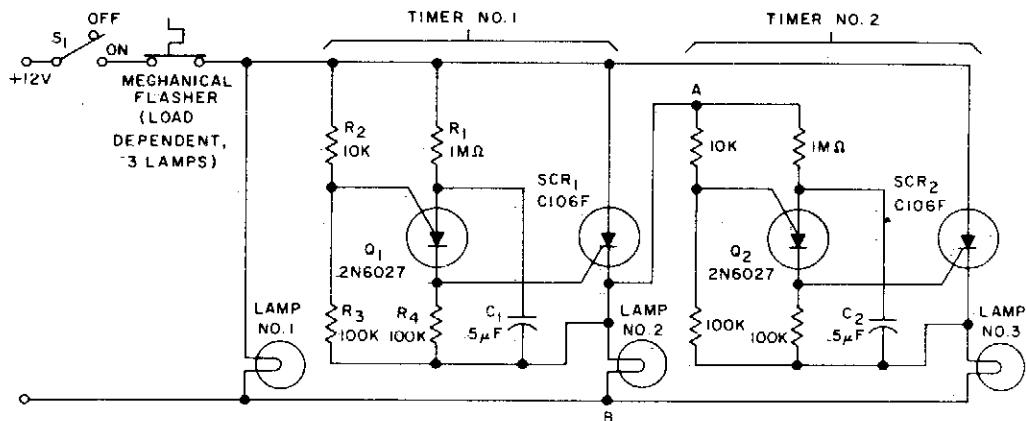
FLASHING BEGINS WHEN $i_{IN} > 100$ Hz
FLASH RATE INCREASES WITH INPUT FREQUENCY
INCREASE BEYOND TRIP POINT

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 S1 is closed, lamp #1 will be activated and capacitor C1 will charge to the triggered voltage of Q1. As soon as the anode voltage on Q1 exceeds its gate voltage by 0.5 V, Q1 will switch into the low resistance mode, thereby triggering SCR1 to activate lamp #2 and the second timing circuit.

After Q2 switches into the low resistance state, SCR2 will be triggered to activate lamp #3. When the thermal flasher interrupts the current to all three lamps, SCR1 and SCR2 are commutated and the circuit is ready for another cycle.

Fig. 10-23

AUTO LIGHTS-ON REMINDER

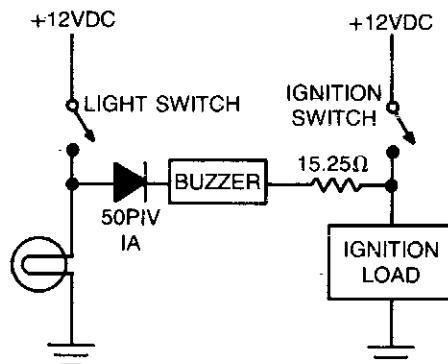


Fig. 10-24

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

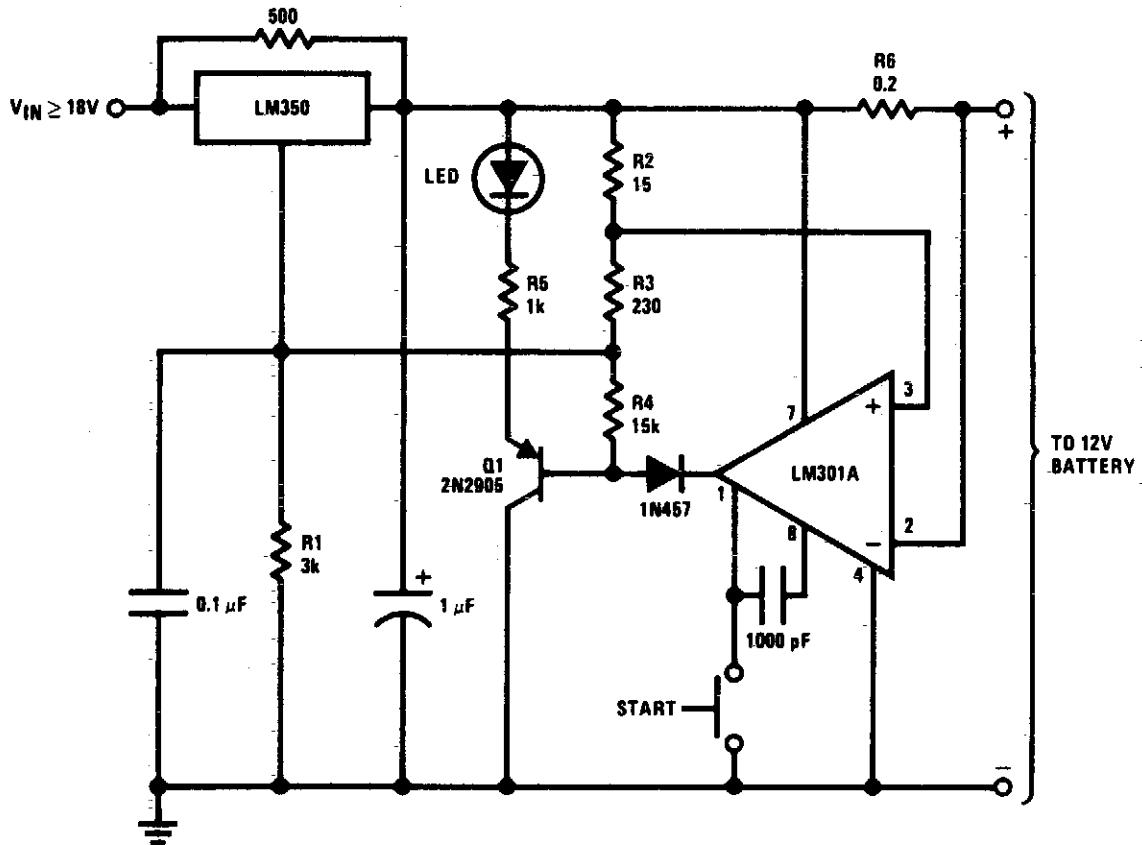


Fig. 11-1

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

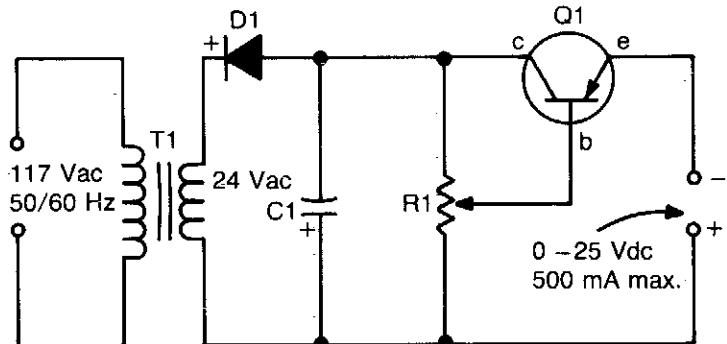
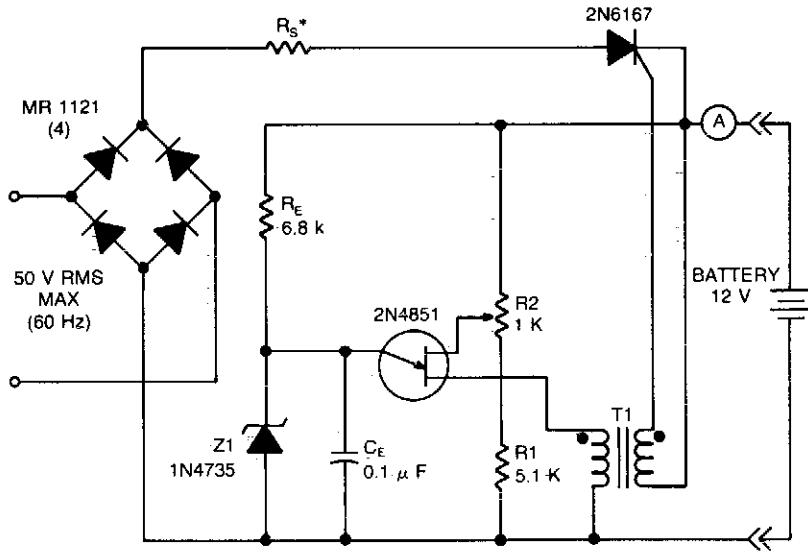


Fig. 11-2

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
 RS - SERIES RESISTANCE TO LIMIT CURRENT THROUGH SCR.
 2N6167 IS RATED AT 20 AMPS RMS.

Fig. 11-3

BATTERY CHARGER

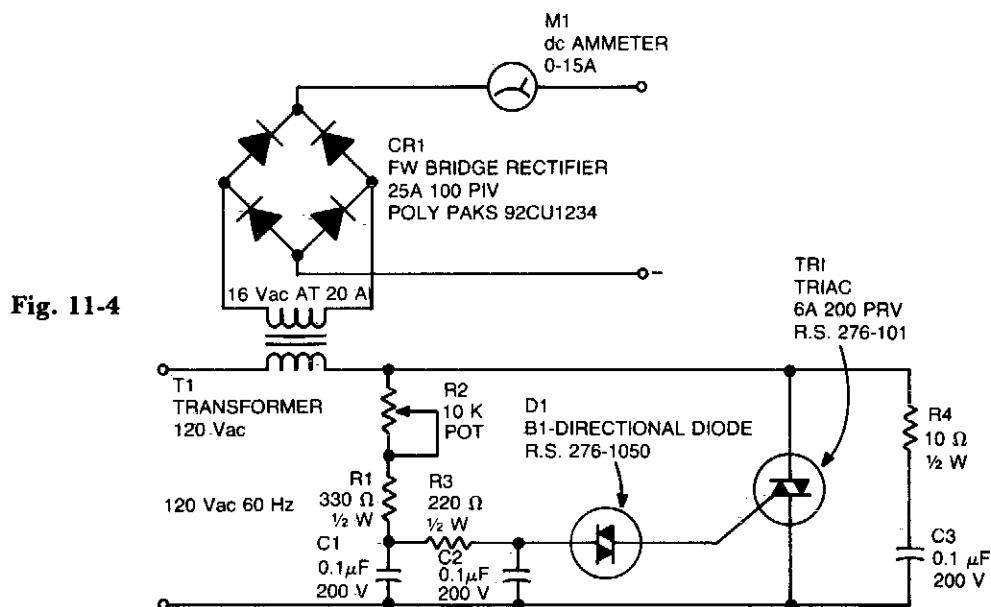


Fig. 11-4

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

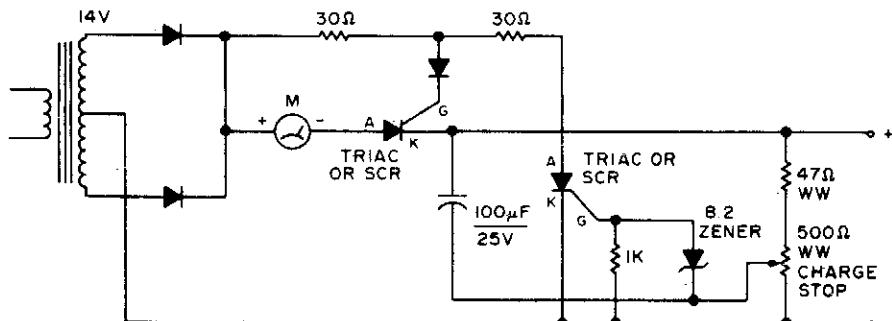


Fig. 11-5

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

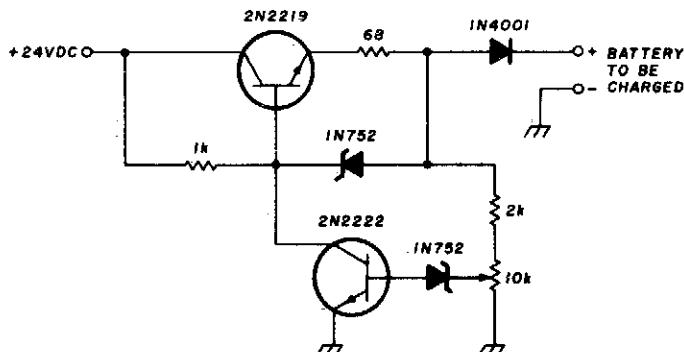


Fig. 11-6

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

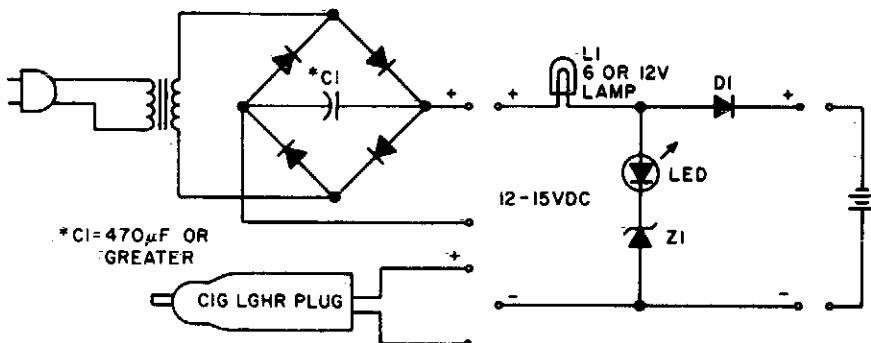


Fig. 11-7

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

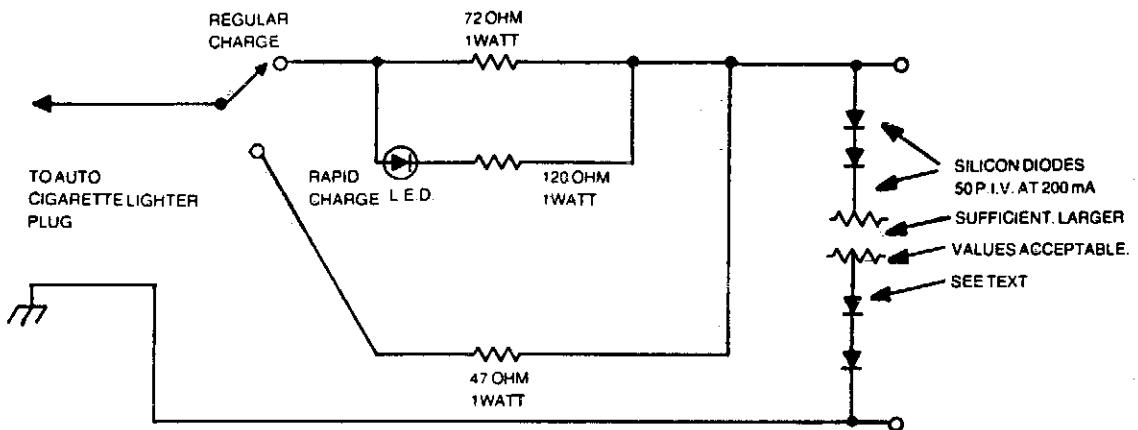


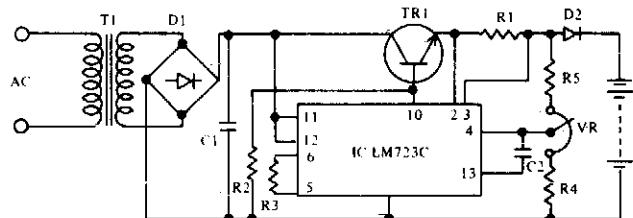
Fig. 11-8

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.)



Circuit Notes

For 12 V sealed lead-acid batteries.

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 3%
R2 5.1K OHM 1/4W
R3 3.9K OHM 1/4W
R4 7.5K OHM 1/4W
R5 8.3K OHM 1/4W
VR 2K OHM
C2 50V 1000PF

Fig. 11-9

NI-CAD CHARGER

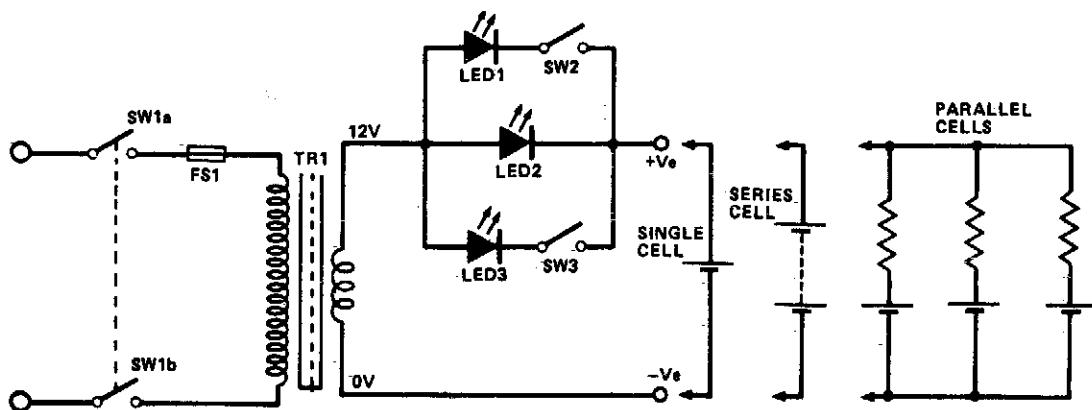


Fig. 11-10

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

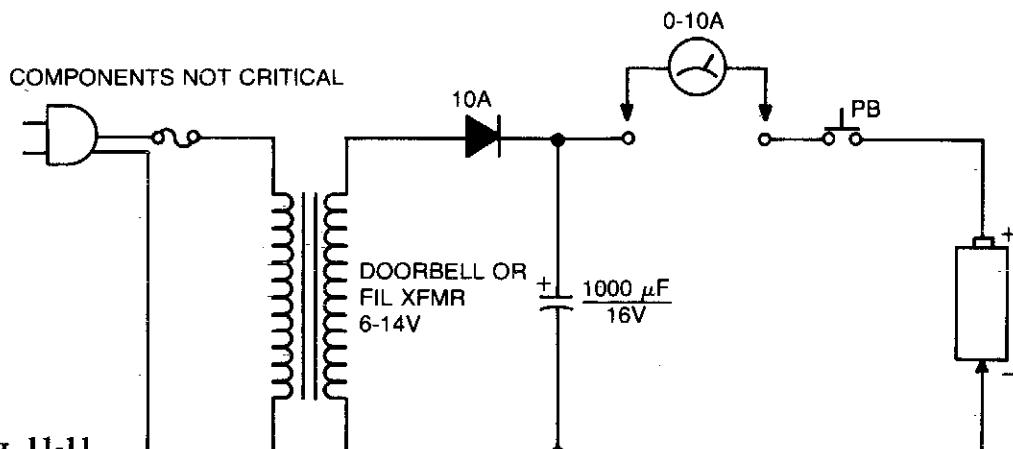


Fig. 11-11

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

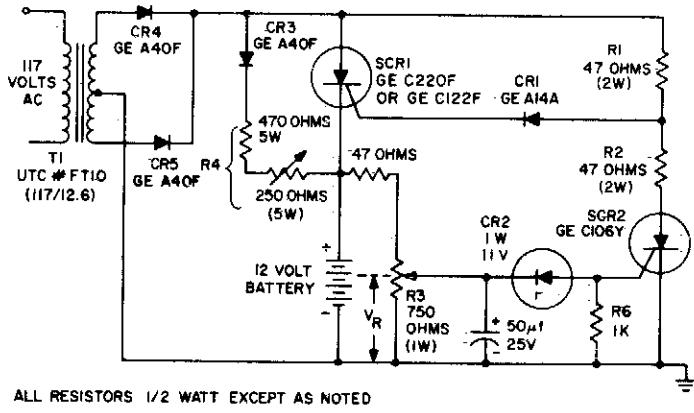


Fig. 11-12

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

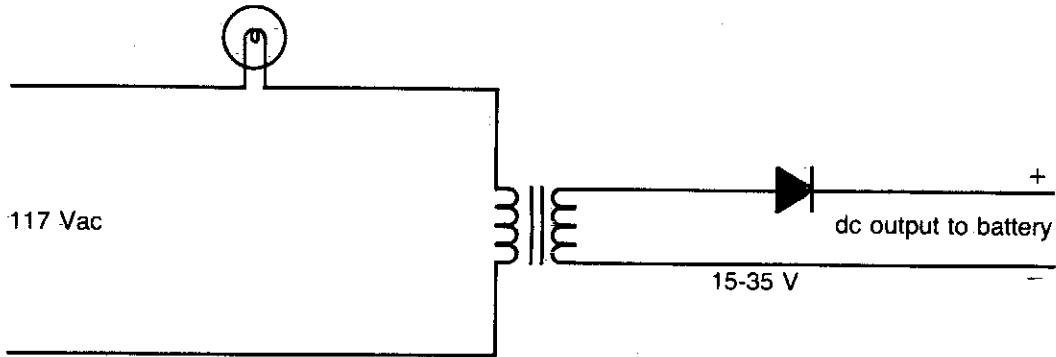


Fig. 11-13

Circuit Notes

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

FAST CHARGER FOR NI-CAD BATTERIES

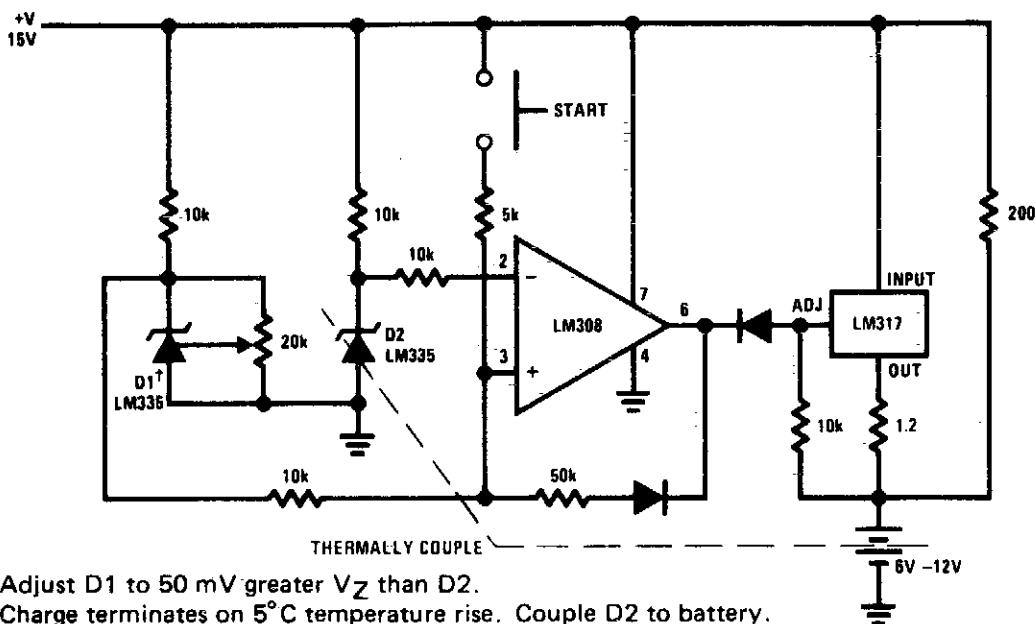


Fig. 11-14

CURRENT LIMITED 6 V CHARGER

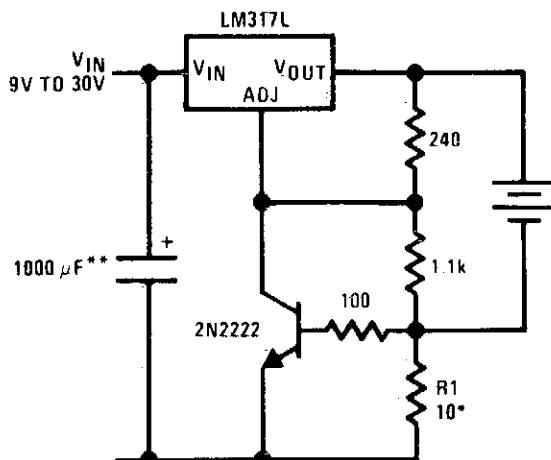


Fig. 11-15

* Sets peak current, $I_{PEAK} = 0.6V/R_1$

** 1000 μ F is recommended to filter out any input transients.

12

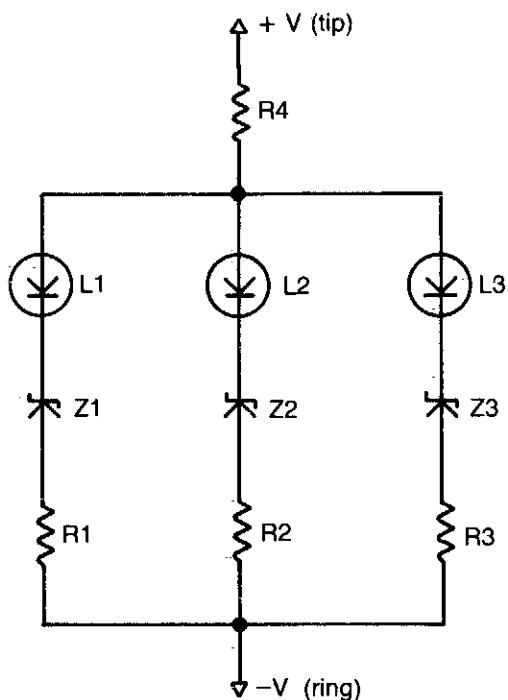
Battery Monitors

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 HTs

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

SOLID-STATE BATTERY VOLTAGE INDICATOR

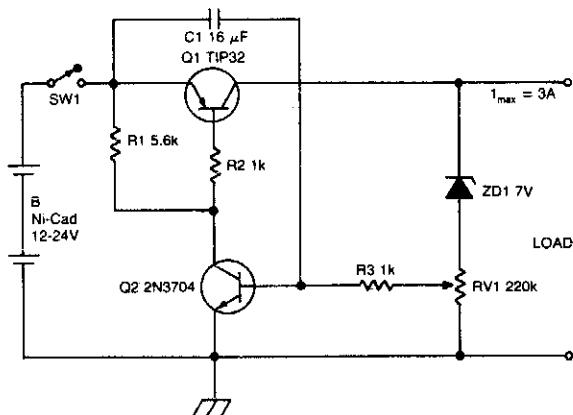


$R_1, R_2, R_3 = 47 \Omega$
 $R_4 = 39 \Omega$
 $Z_1 = 9.8 \text{ volt zener diode}$
 $Z_2 = 11.1 \text{ volt zener diode}$
 $Z_3 = 11.5 \text{ volt zener diode}$
 $L_1 - L_3 = \text{light emitting diodes}$

Two lights on - OK ($L_1 + L_2$)
 One light on - low voltage (L_1 only)
 Three lights on - overvoltage ($L_1 + L_2 + L_3$)

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

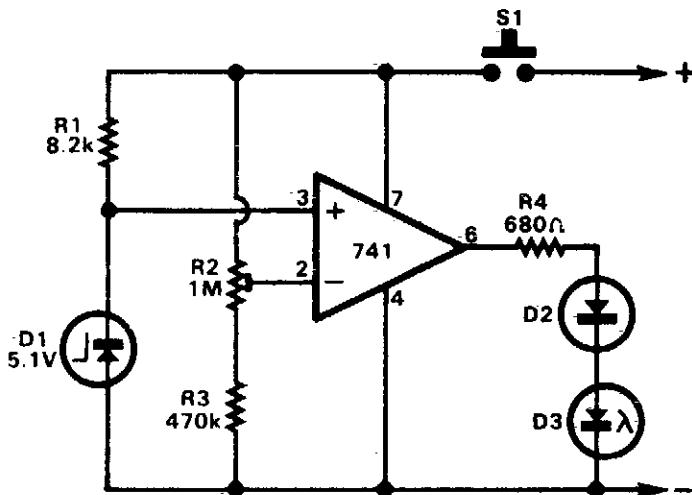


Fig. 12-3

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

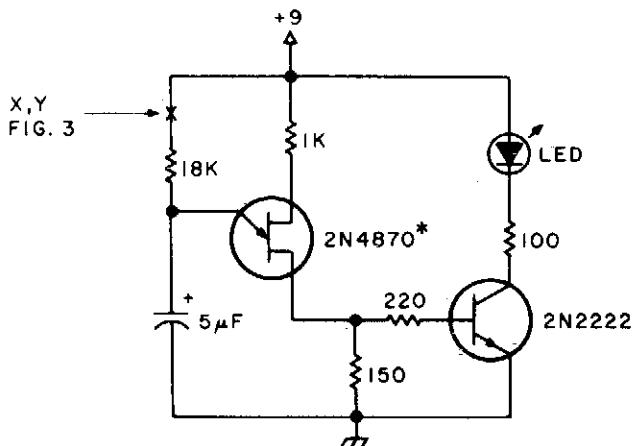


Fig. 12-4

*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

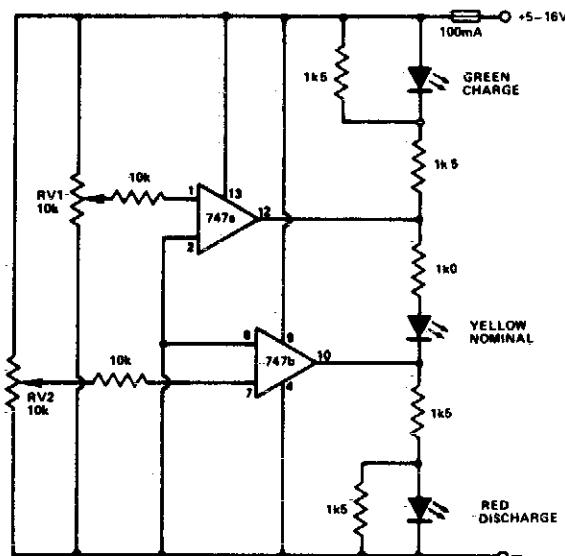


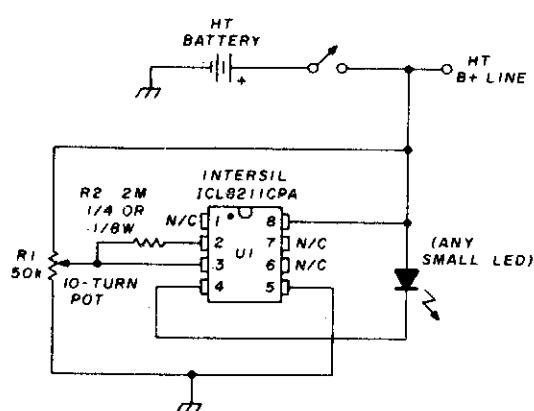
Fig. 12-5

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

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.

Fig. 12-6

LOW-VOLTAGE MONITOR

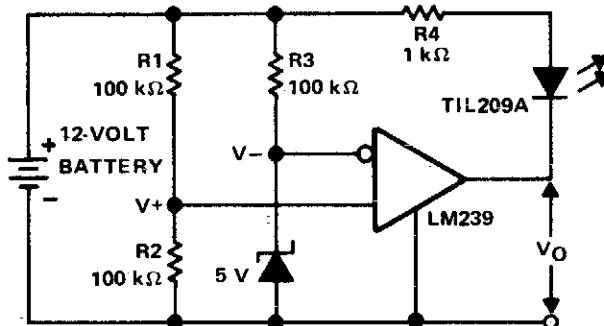


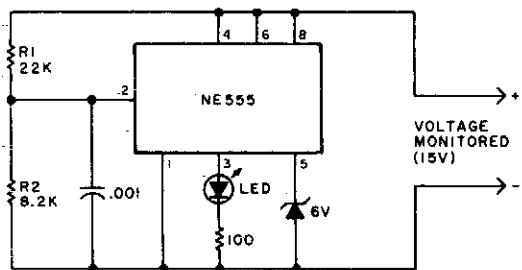
Fig. 12-7

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

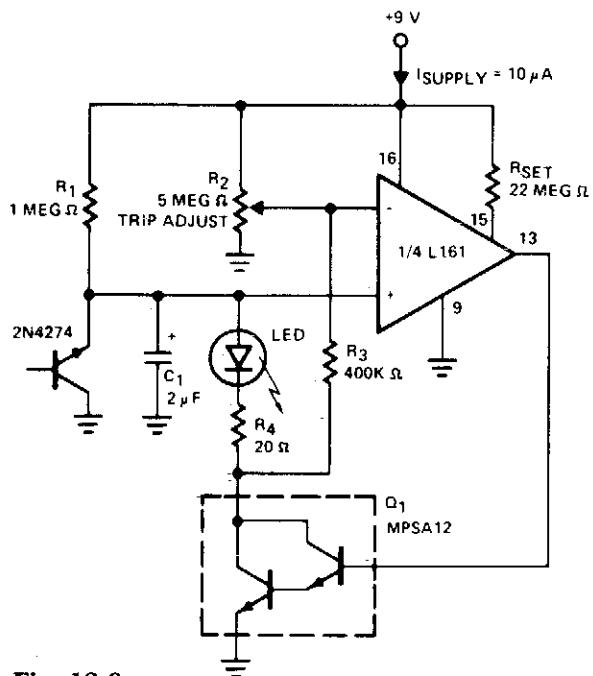


Fig. 12-9

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 $10 \mu\text{A}$ average power drain.

BATTERY-LEVEL INDICATOR

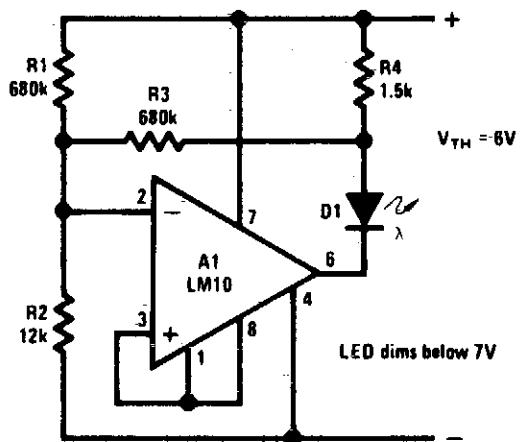


Fig. 12-10

BATTERY-THRESHOLD INDICATOR

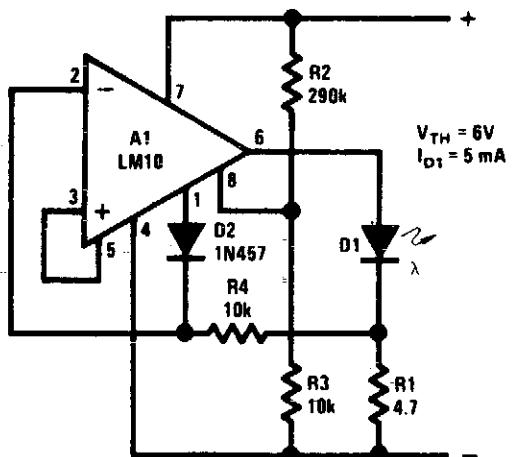


Fig. 12-11

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

Wideband Buffer

Single-Supply AC Buffer Amplifier

High Resolution ADC Input Buffer

Single-Supply AC Buffer

100 × Buffer Amplifier

High-Speed 6-Bit A/D Buffer

10 × Buffer Amplifier

High Impedance, Low Capacitance

Stable High Impedance Buffer

High-Speed Single Supply AC Buffer

SINE WAVE OUTPUT BUFFER AMPLIFIER

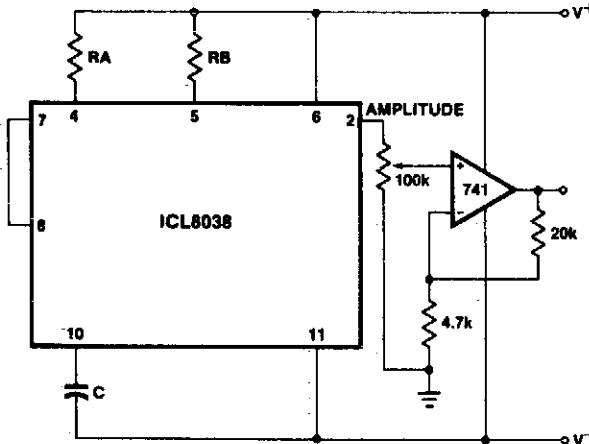
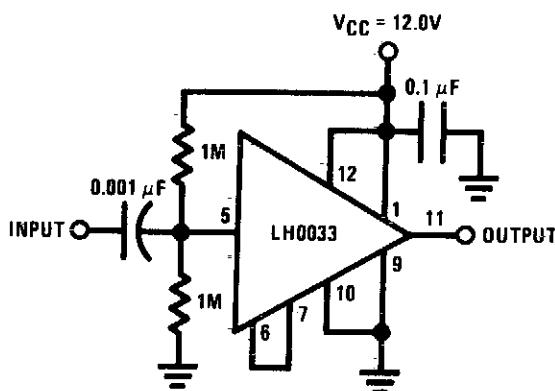


Fig. 13-1

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.

SINGLE SUPPLY AC BUFFER AMPLIFIER

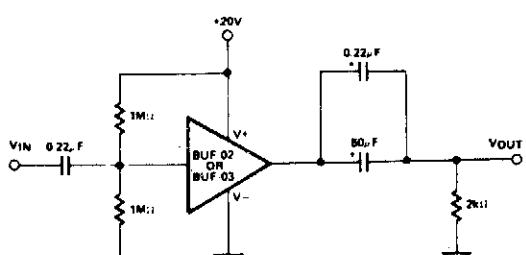


Circuit Notes

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)



(LOW AT $V_{IN} = 1.45\text{Hz}$) -3dB
 (LOW AT $V_{OUT} = 1.59\text{Hz}$)
 ASSUME $V_{IN} = 10\text{V}$ P-P SINE WAVE (5V-Peak)
 THEN FULL POWER BANDWIDTH IS
 786Hz FOR BUF-02, AND
 955MHz FOR BUF-03

Fig. 13-3

HIGH IMPEDANCE LOW CAPACITANCE WIDEBAND BUFFER

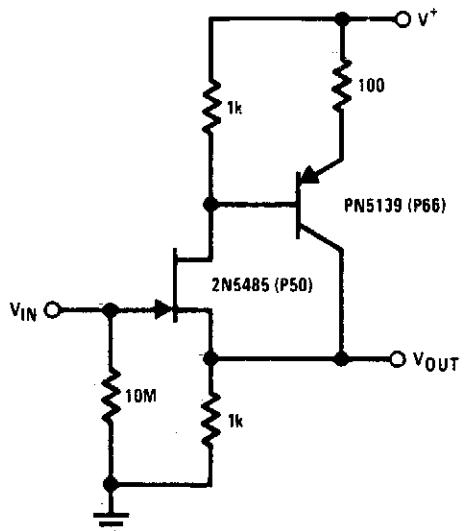


Fig. 13-5

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

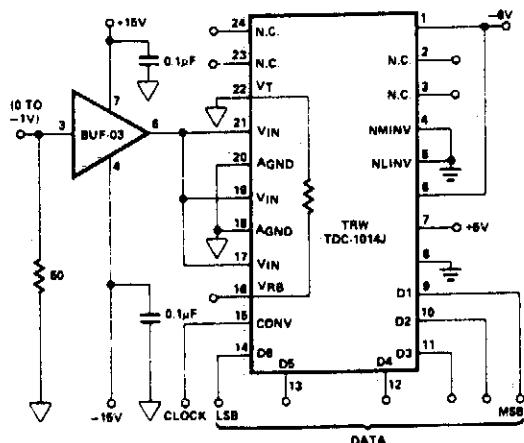
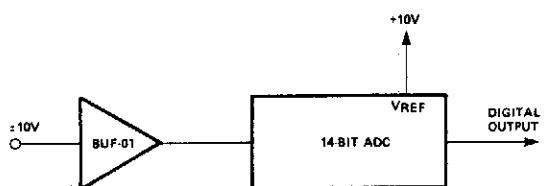


Fig. 13-4

HIGH RESOLUTION ADC INPUT BUFFER



- MAXIMUM ERROR FROM BUF-01 IS 300 μV .
- RESOLUTION OF 10V, 14-BIT ADC IS 610 μV .
- BUF-01 RESOLVES 1/2 LSB OF 14-BIT SYSTEM.

Fig. 13-6

100 × BUFFER AMPLIFIER

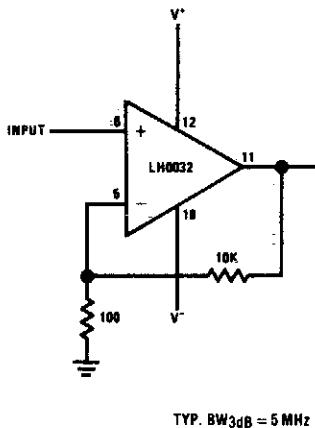


Fig. 13-7

STABLE, HIGH IMPEDANCE BUFFER

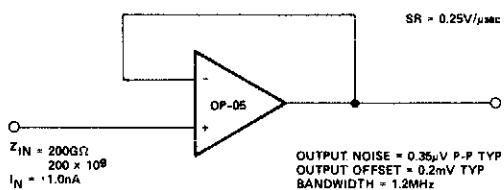


Fig. 13-9

10 × BUFFER AMPLIFIER

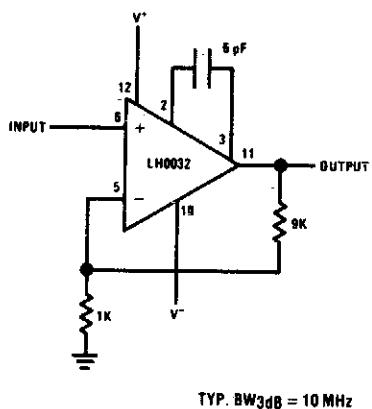
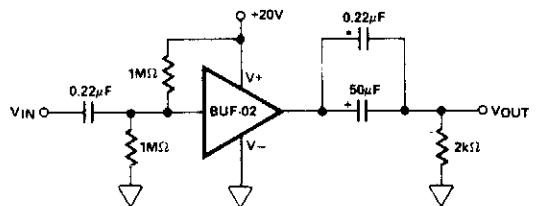


Fig. 13-8

HIGH-SPEED SINGLE-SUPPLY AC BUFFER



I_{LOW} AT V_{IN} = 1.45Hz -3dB
 I_{LOW} AT V_{OUT} = 1.59Hz -3dB
 ASSUME V_{IN} = 10V P-P SINE WAVE (5V PEAK)
 THEN FULL POWER BANDWIDTH IS
 APPROXIMATELY 800kHz.

Fig. 13-10

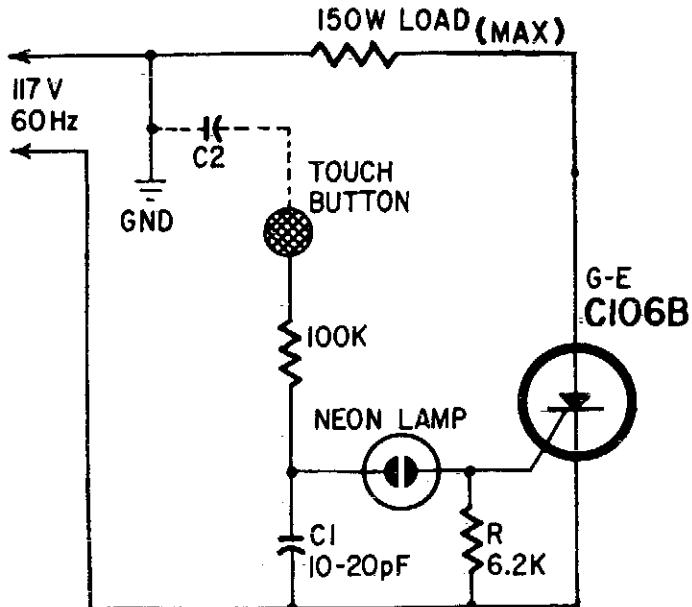
14

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 Detected Changing Fields |
| Capacitance Operated, Battery Powered Light | Touch Switch or Proximity Detector |
| Touch Sensitive Switch | Finger Touch Touch or Control Switch |
| Low Current Touch Switch | Proximity Detector |
| Capacitance Switched Light | Touch Circuit |
| Momentary Operation Touch Switch | CMOS Touch Switch |
| Touch Triggered Bistable | Latching Double-Button Touch Switch |
| Capacitance Operated Alarm to Foil Purse Snatchers | |

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

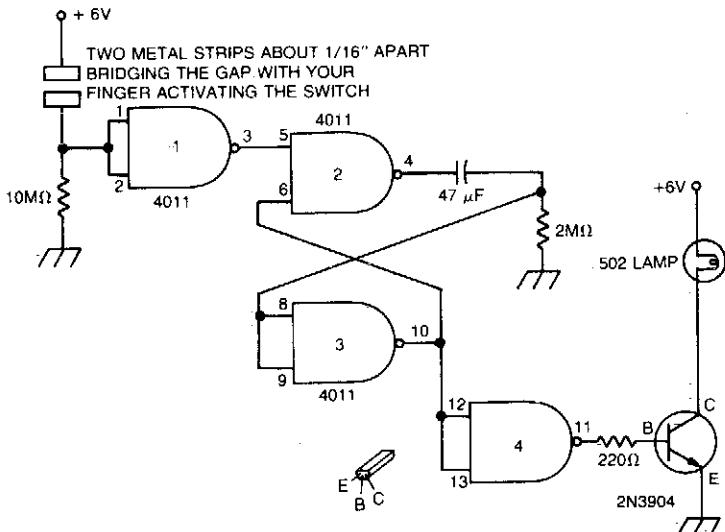


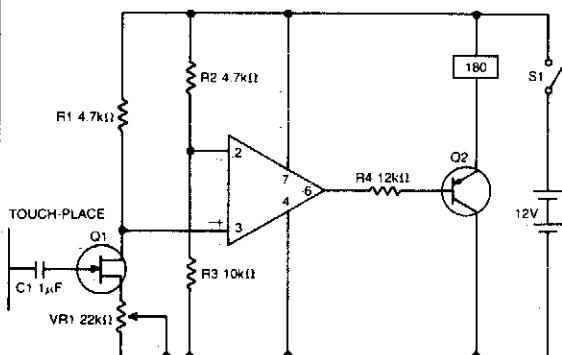
Fig. 14-2

Circuit Notes

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

constant of the $47 \mu\text{F}$ capacitor and the $2\text{M}\Omega$ 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

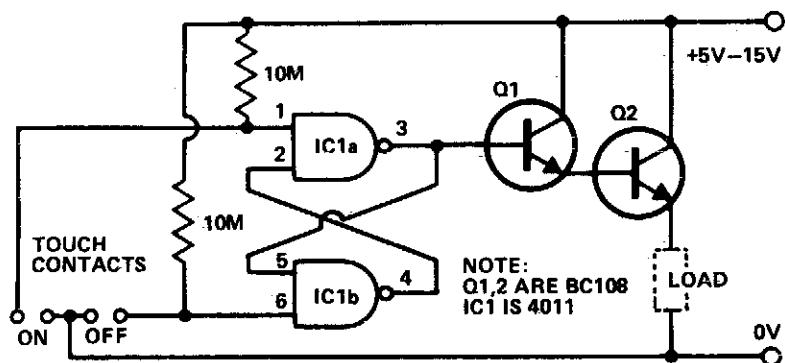


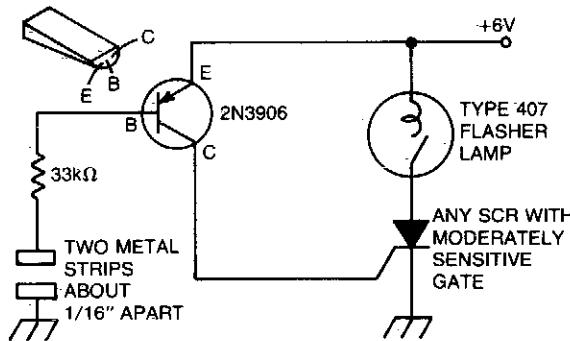
Fig. 14-4

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

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.

Fig. 14-5

MOMENTARY OPERATION TOUCH SWITCH

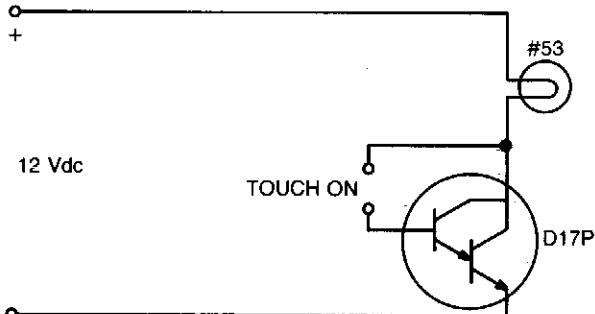


Fig. 14-6

TOUCH TRIGGERED BISTABLE

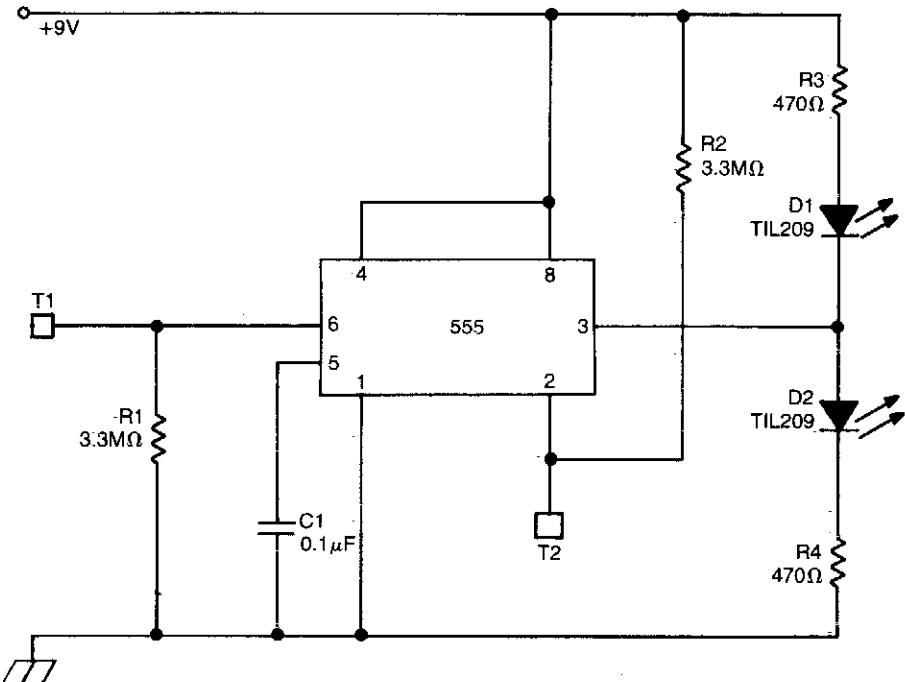


Fig. 14-7

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

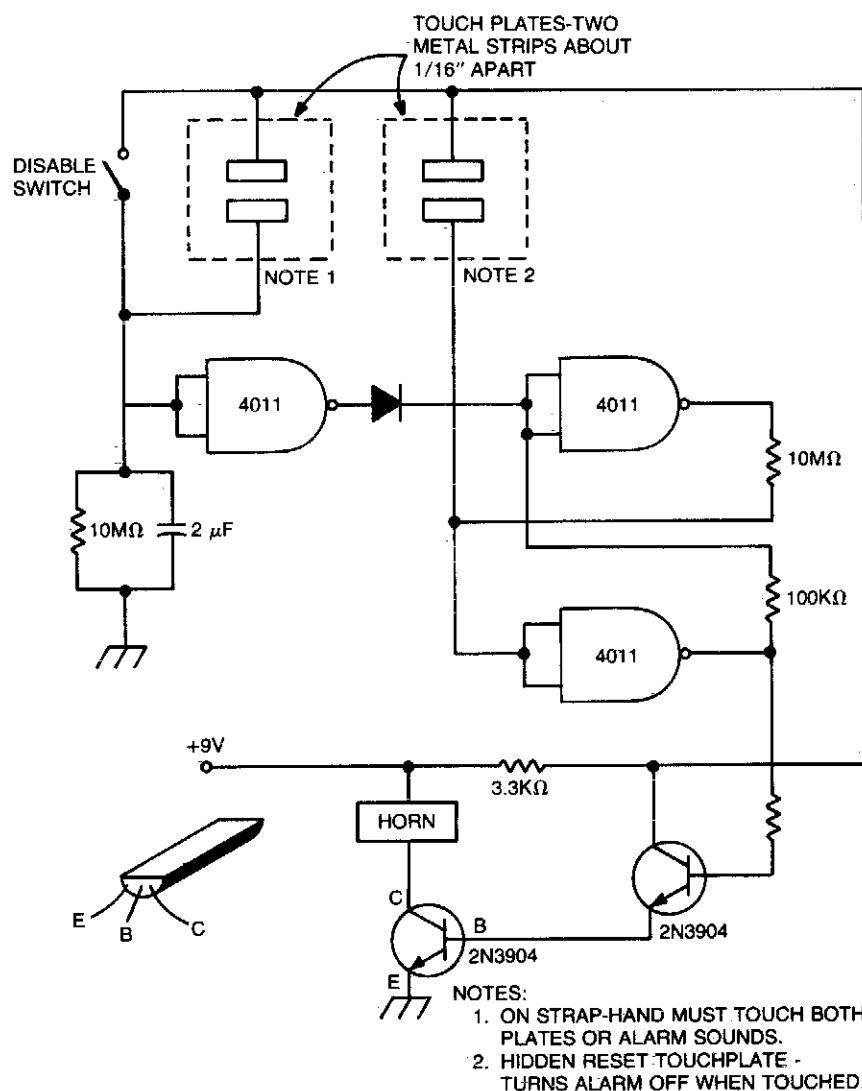
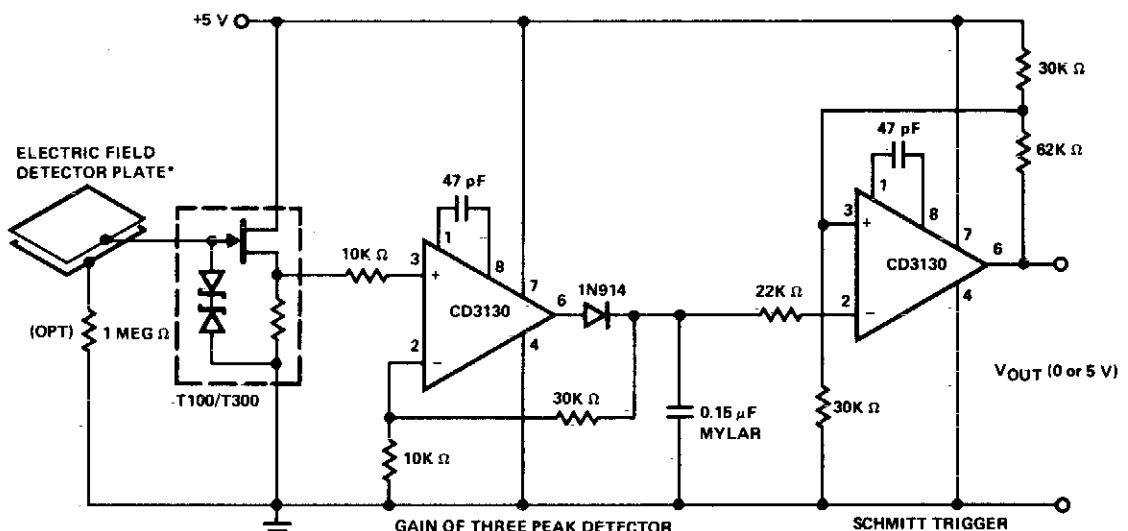


Fig. 14-8

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

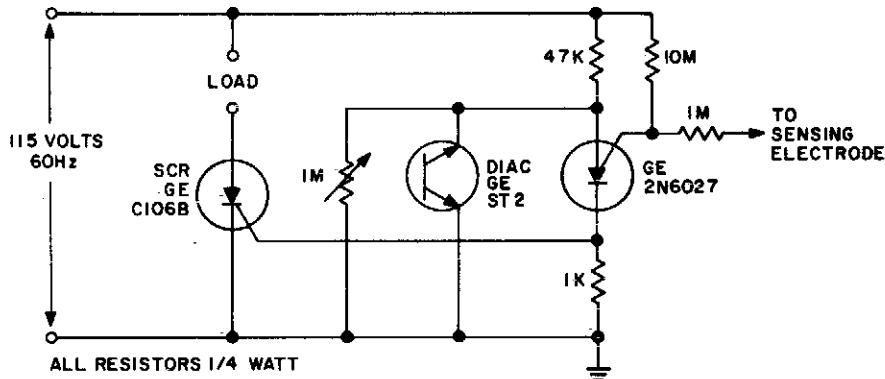


Fig. 14-10

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

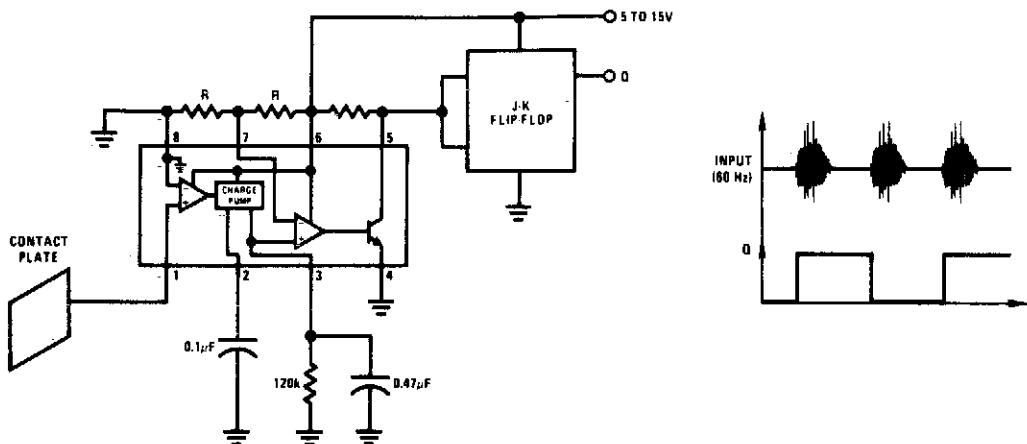


Fig. 14-11

PROXIMITY DETECTOR

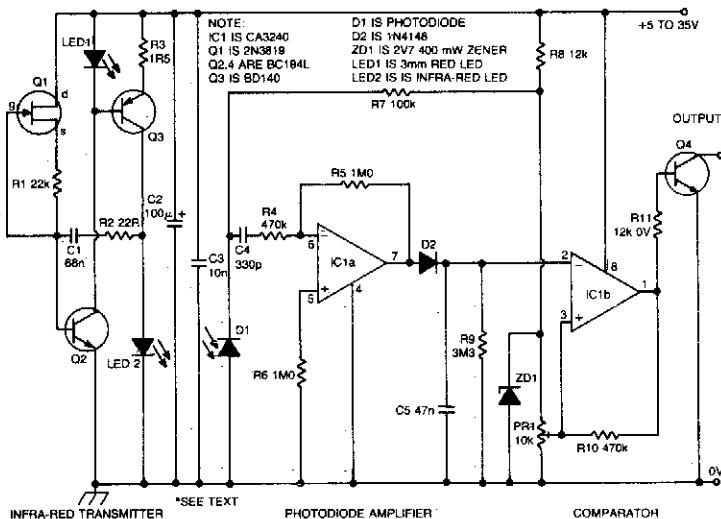


Fig. 14-12

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

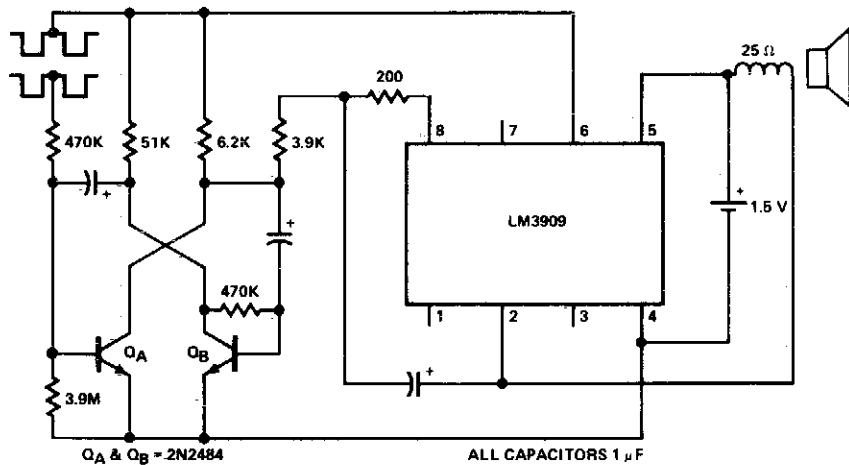


Fig. 14-13

CMOS TOUCH SWITCH

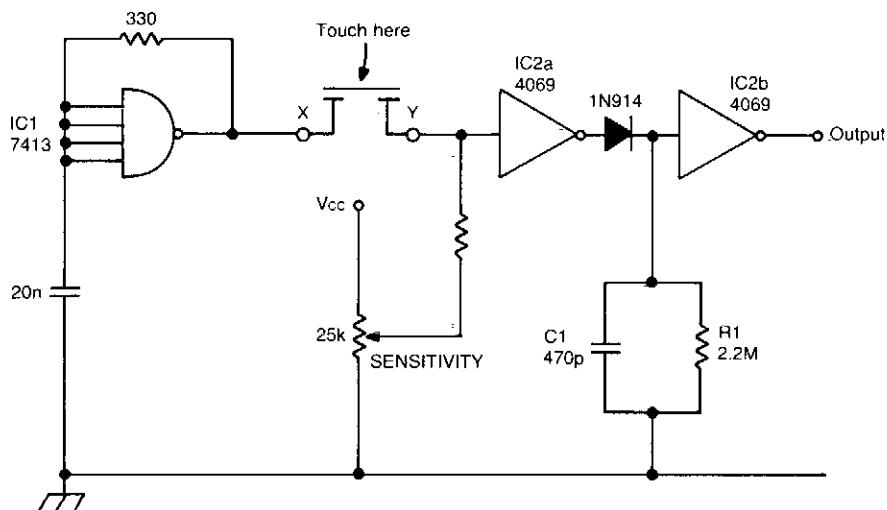


Fig. 14-14

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

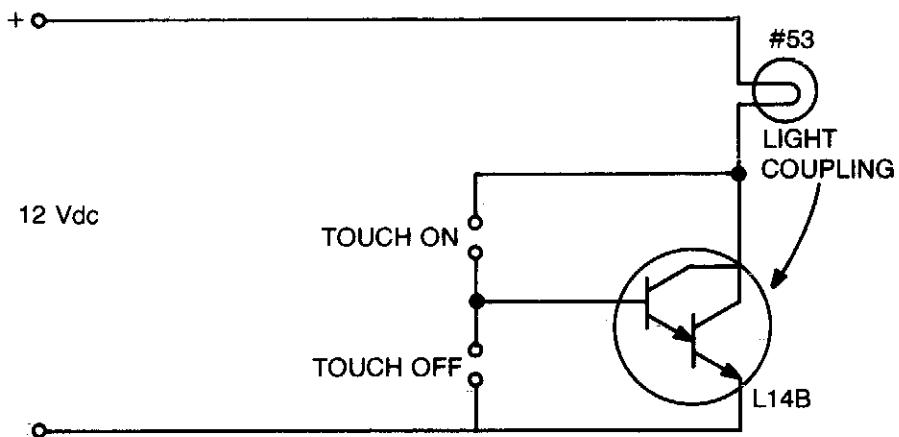


Fig. 14-15

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

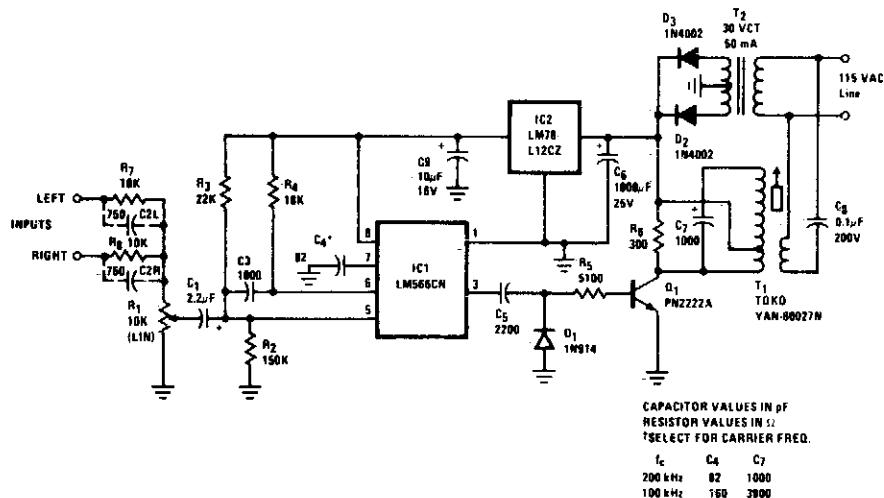
Integrated Circuit Current Transmitter

Single Transistor Carrier Current Receiver

IC Carrier-Current Receiver

Carrier-Current Remote Control or
Intercom

Carrier System Transmitter



Carrier System Receiver

FM CARRIER CURRENT REMOTE SPEAKER SYSTEM

Circuit Notes

High quality, noise free, wireless FM transmitter/receiver operates over standard power lines. Complete system is suitable for high-quality transmission of speech or music, and will operate from any ac outlet anywhere on a one-acre homesite. Frequency response is 20-20, 000 Hz and THD is under ½%. Trans-

mission distance along a power line is at least adequate to include all outlets in and around a suburban home and yard.

Two input terminals are provided so that both left and right signals of a stereo set may be combined for mono transmission to a single remote speaker if desired.

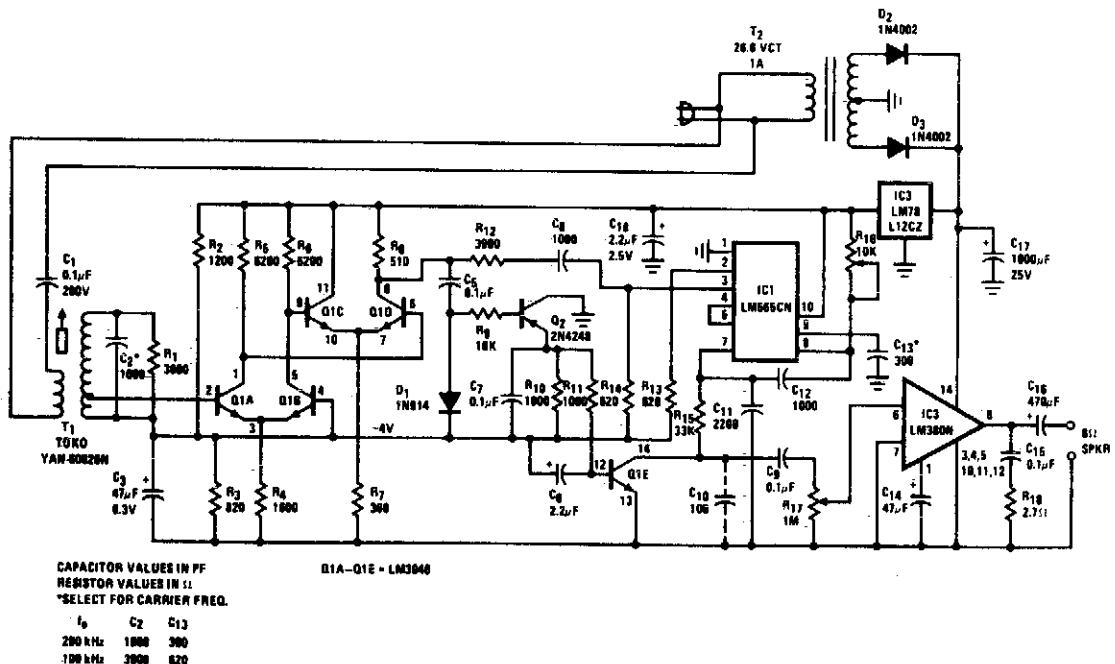
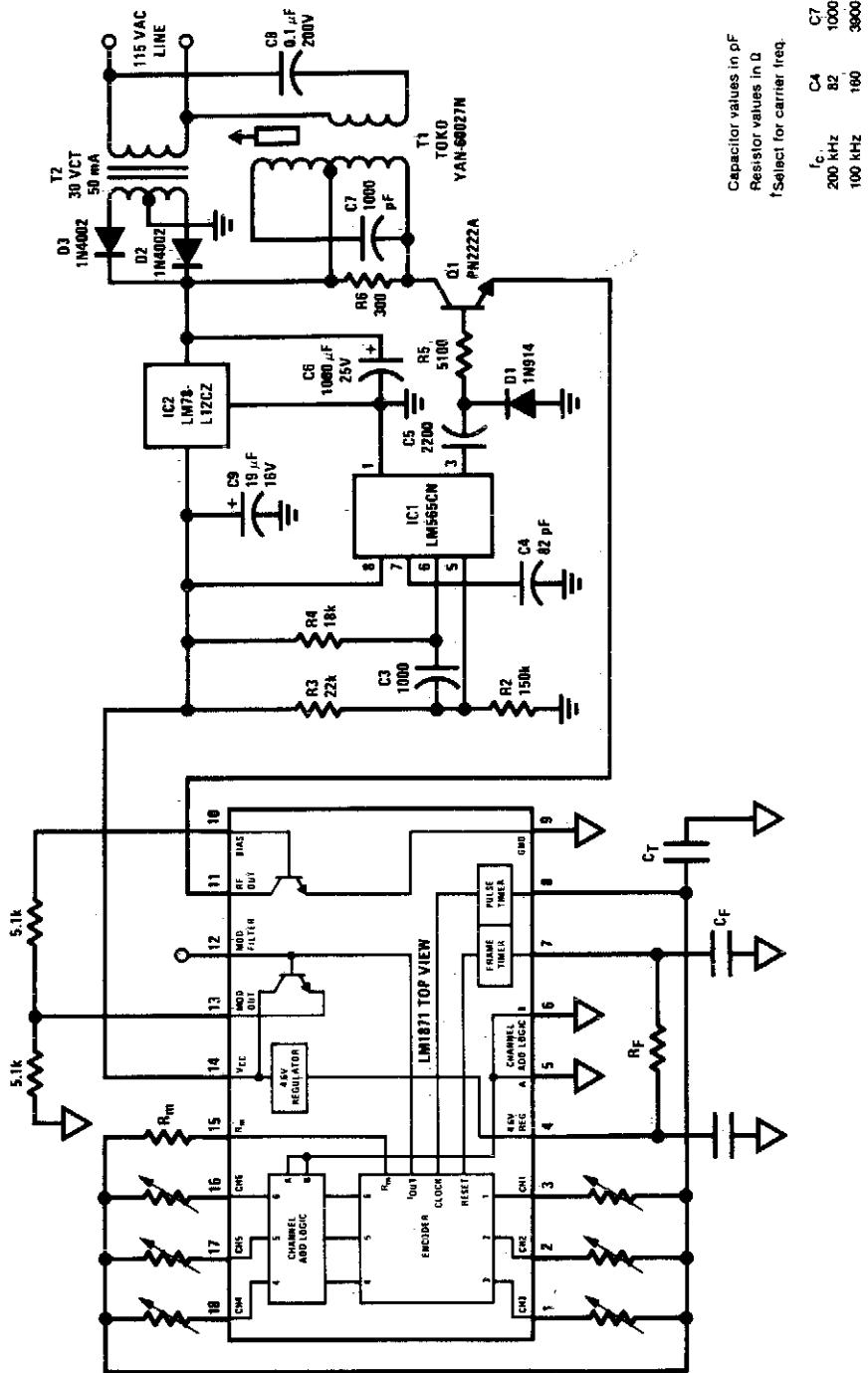


Fig. 15-1

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**



CARRIER CURRENT RECEIVER

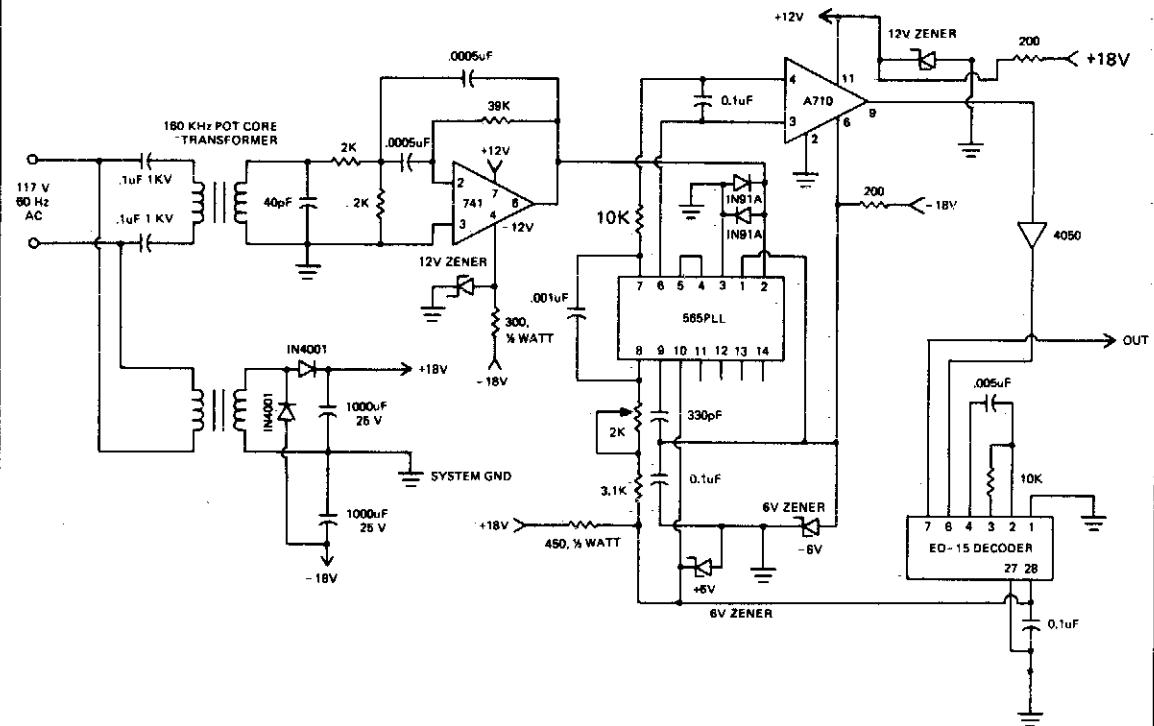


Fig. 15-3

Circuit Notes

160 kHz transformer consists of a 18 x 11mm ungapped pot core (Siemens, Ferrocube, etc.), utilizing magnetics incorporated type "F" material wound with 80½ turns of No.

35 wire for the secondary and 5½ turns for the primary. This gives a turns ratio of approximately 15 to 1.

CARRIER CURRENT TRANSMITTER

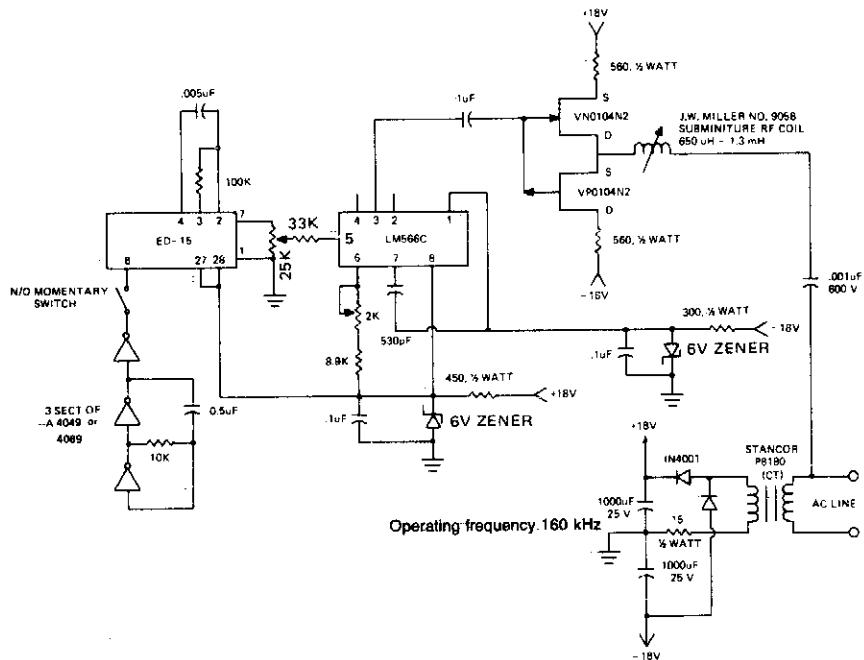


Fig. 15-4

CARRIER CURRENT TRANSMITTER

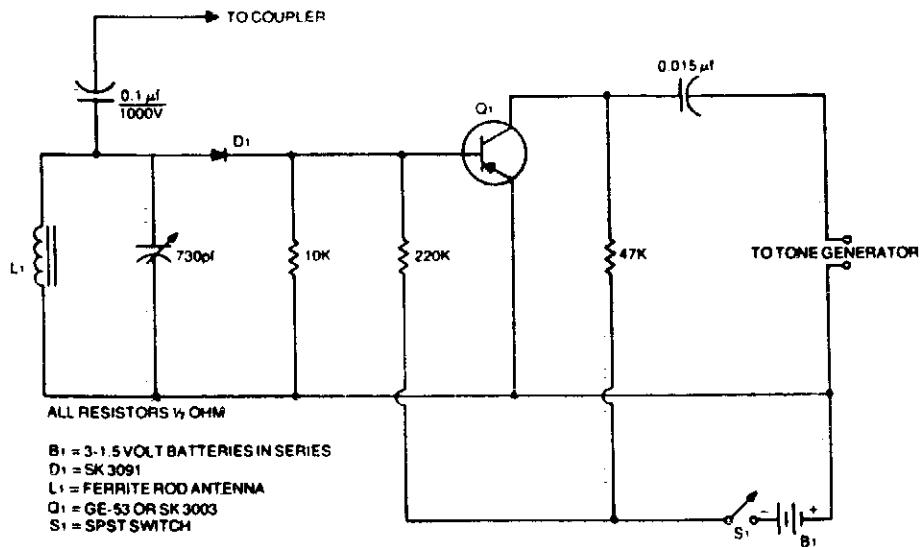


Fig. 15-5

IC CARRIER CURRENT TRANSMITTER

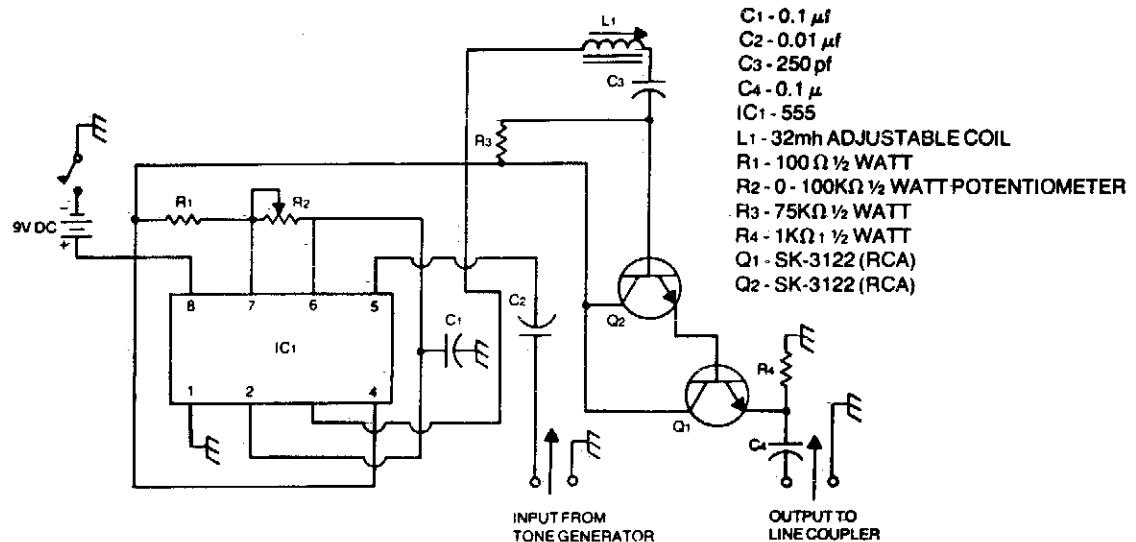


Fig. 15-6

SINGLE TRANSISTOR CARRIER CURRENT RECEIVER

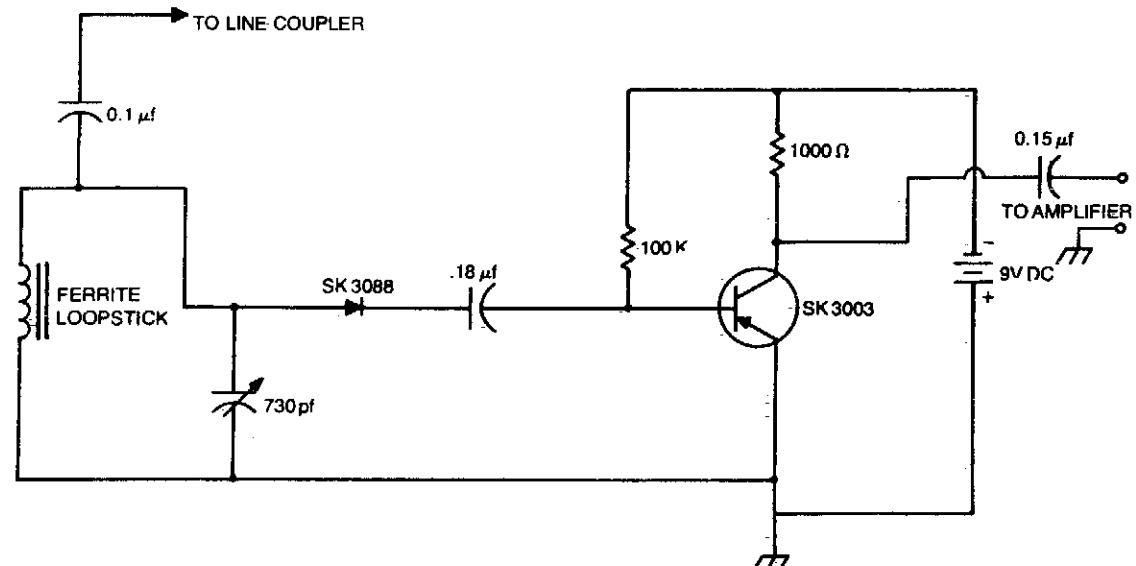


Fig. 15-7

IC CARRIER-CURRENT RECEIVER

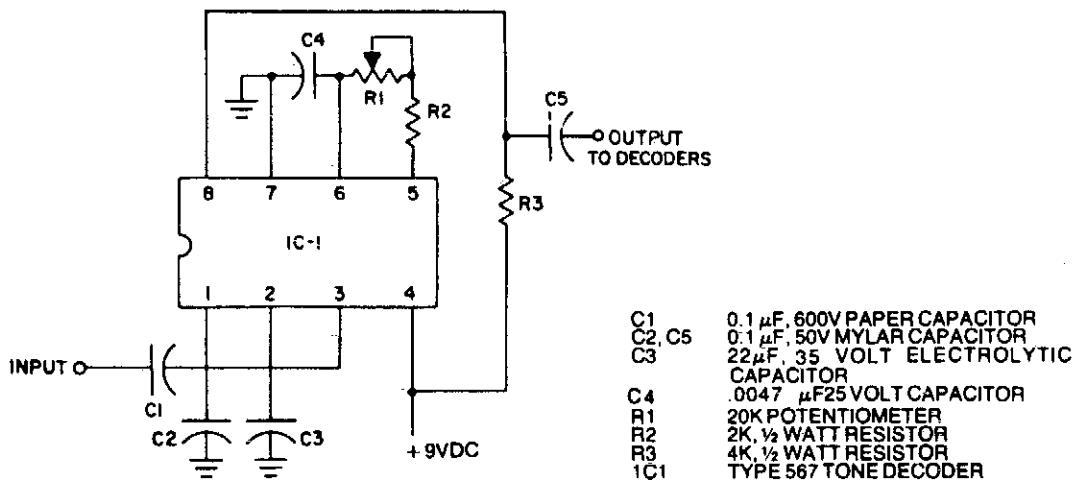


Fig. 15-8

CARRIER-CURRENT REMOTE CONTROL OR INTERCOM

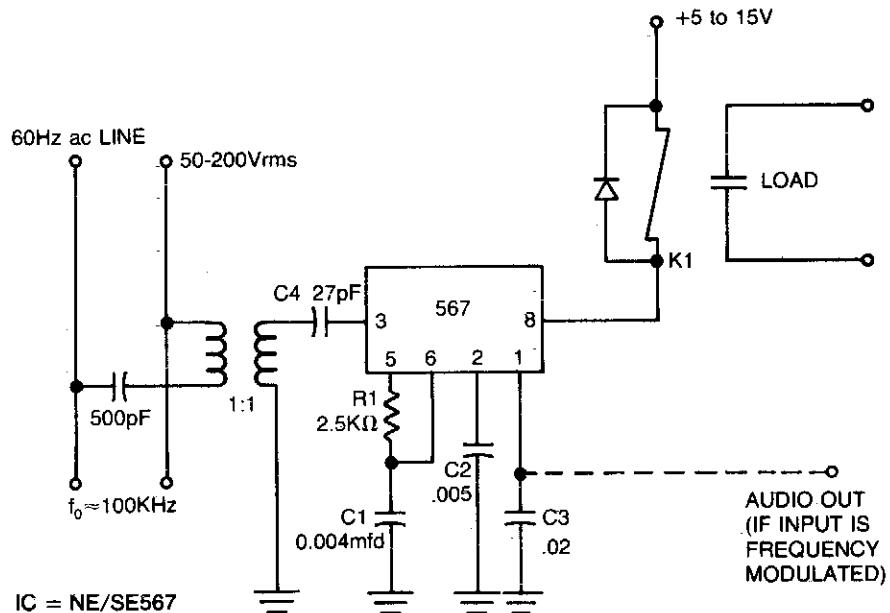


Fig. 15-9

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/O vervoltage 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

NULL DETECTOR

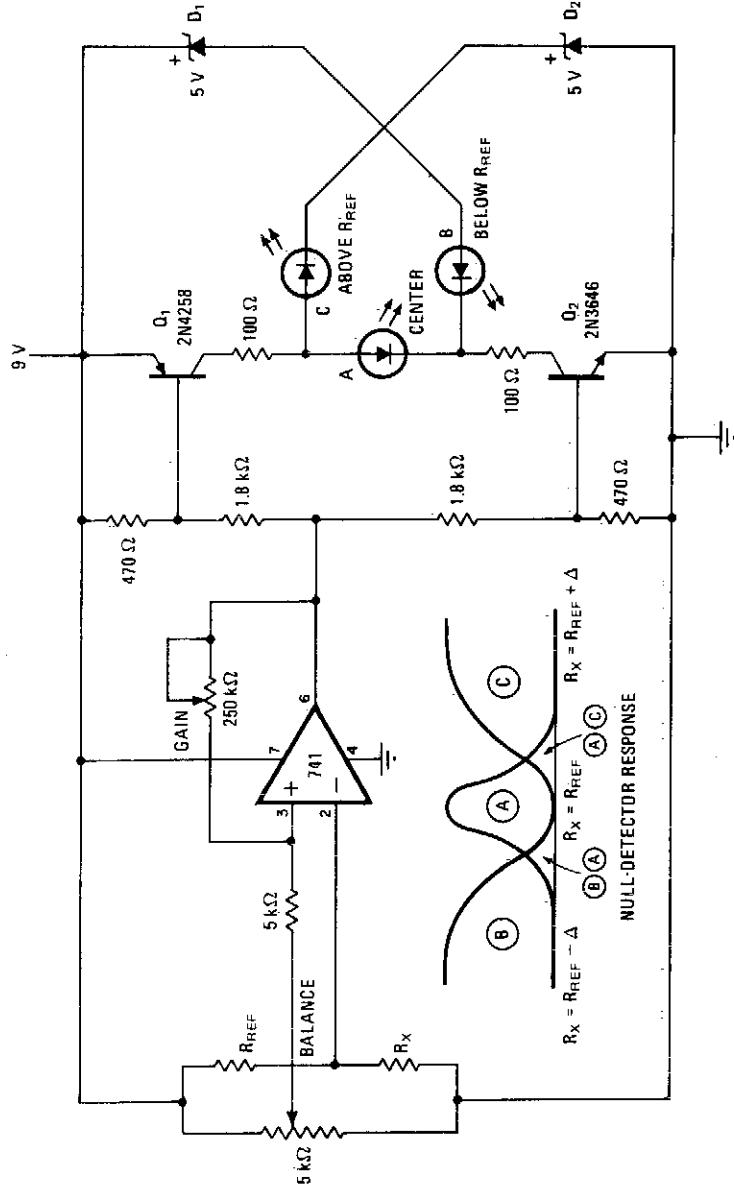


Fig. 16-1

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 $R_x = R_{\text{ref}}$, 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)**

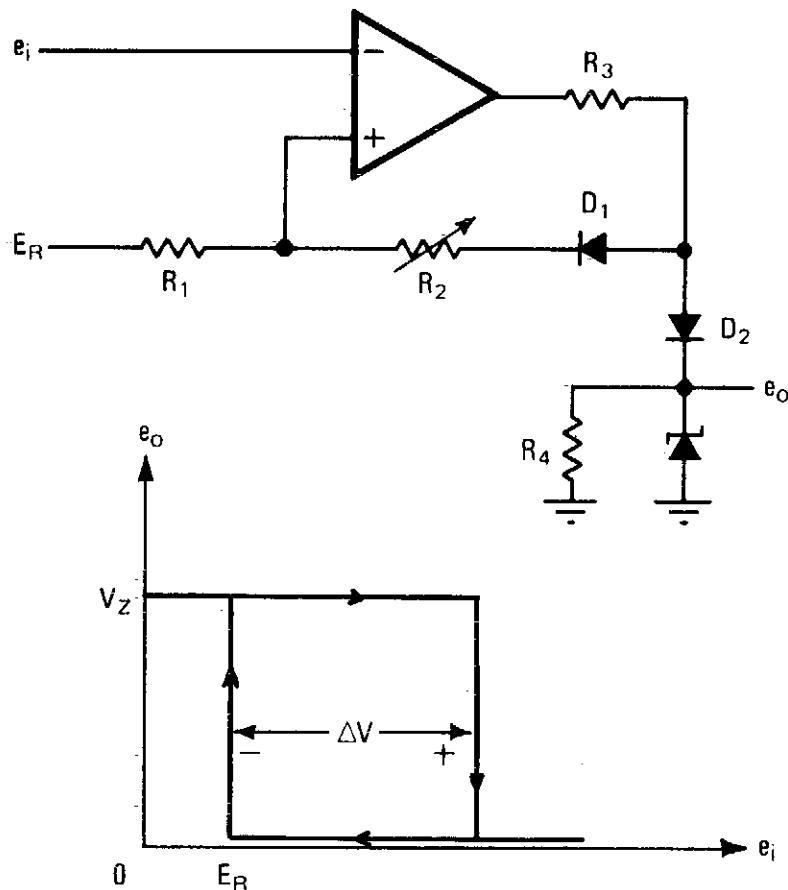


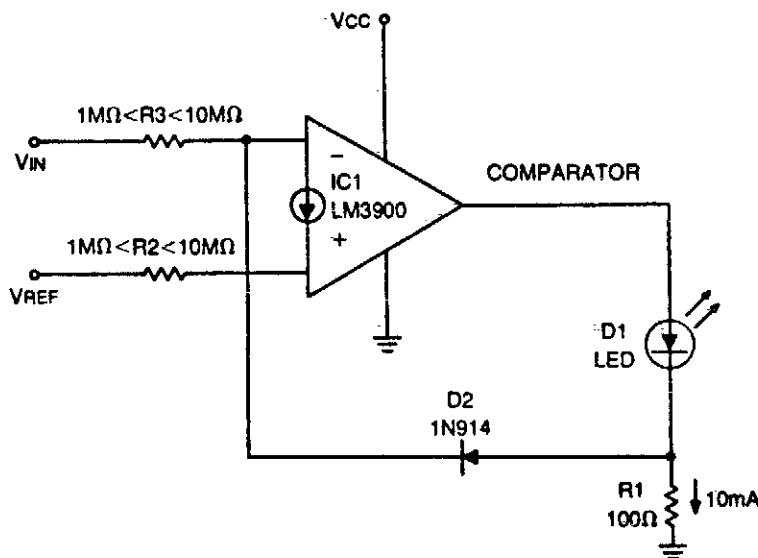
Fig. 16-2

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

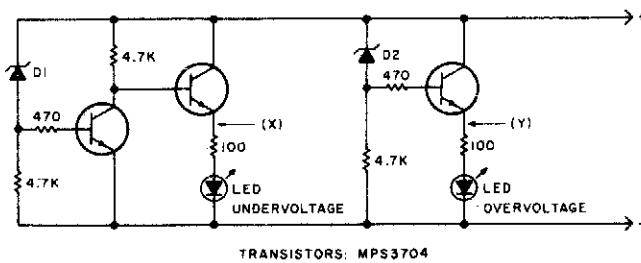


Fig. 16-4

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

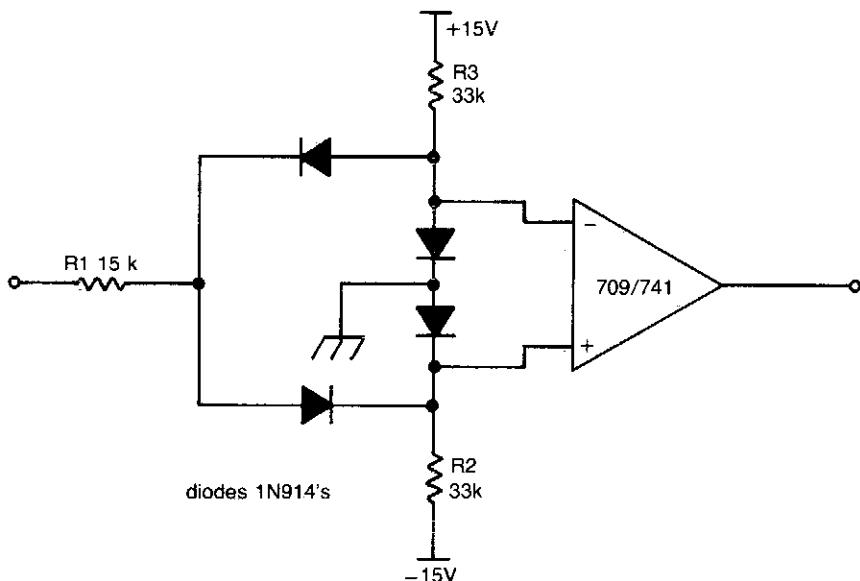


Fig. 16-5

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

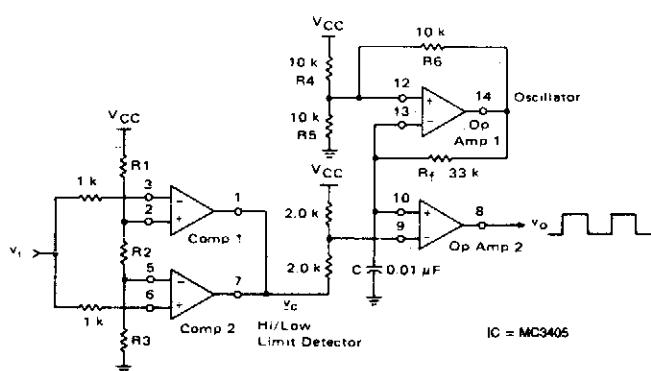


Fig. 16-6



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

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

Oscillator

$$\text{If } R_4 = R_5 \approx R_6 \dots$$

$$f = 0.72/R_f C$$

As Shown, f = 2.2 kHz

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

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

WINDOW COMPARATOR

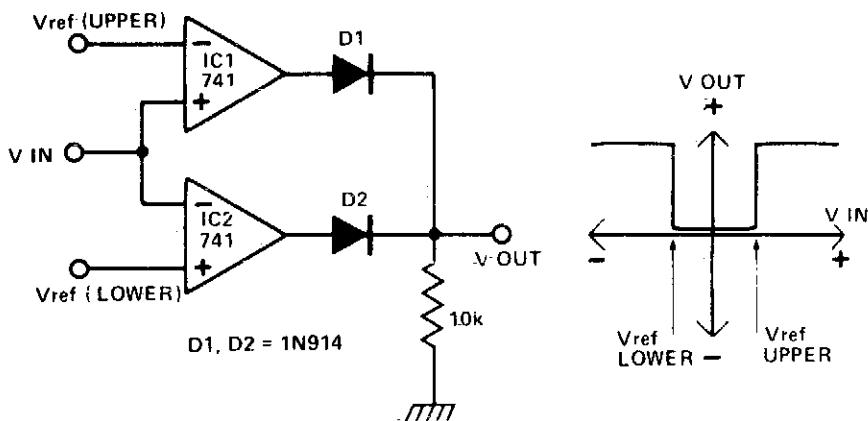


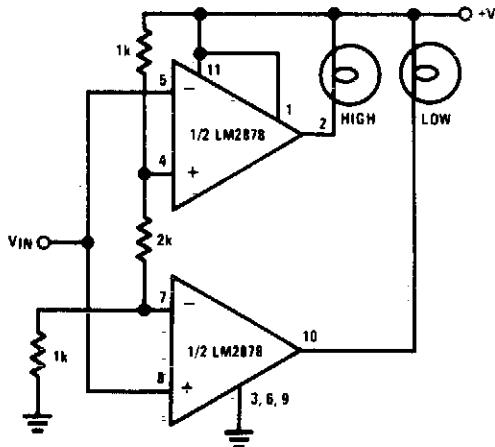
Fig. 16-7

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

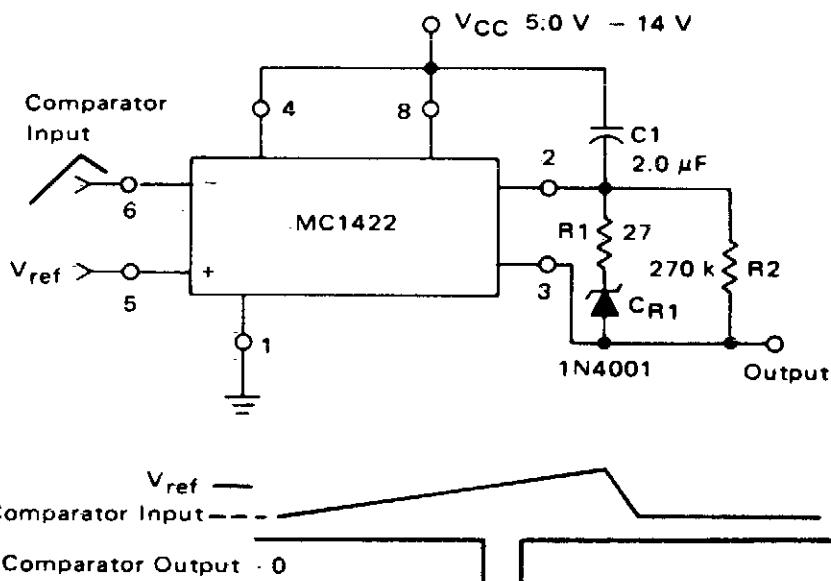


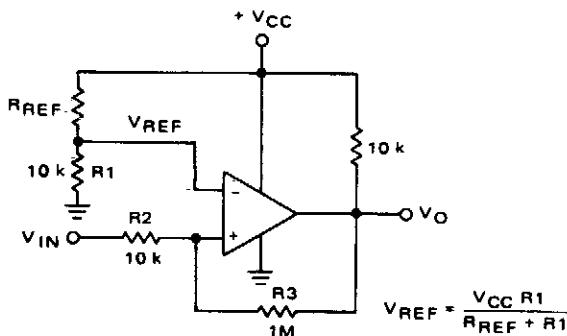
Fig. 16-9

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



IC = LM358

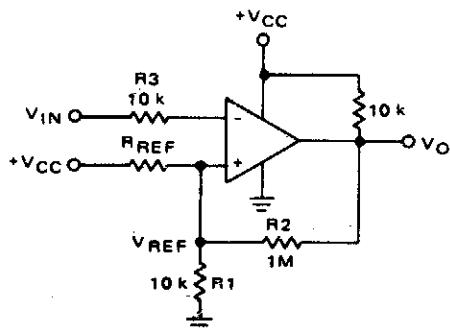
$$R_2 = R_1 // R_{REF}$$

Amount of Hysteresis V_H

$$V_H = \frac{R_2}{R_2 + R_3} (V_{Omax} - V_{Omin})$$

Fig. 16-10

INVERTING COMPARATOR WITH HYSTERESIS



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

$$R_3 \geq R_1 // R_{REF} // R_1$$

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

Fig. 16-11

WINDOW COMPARATOR

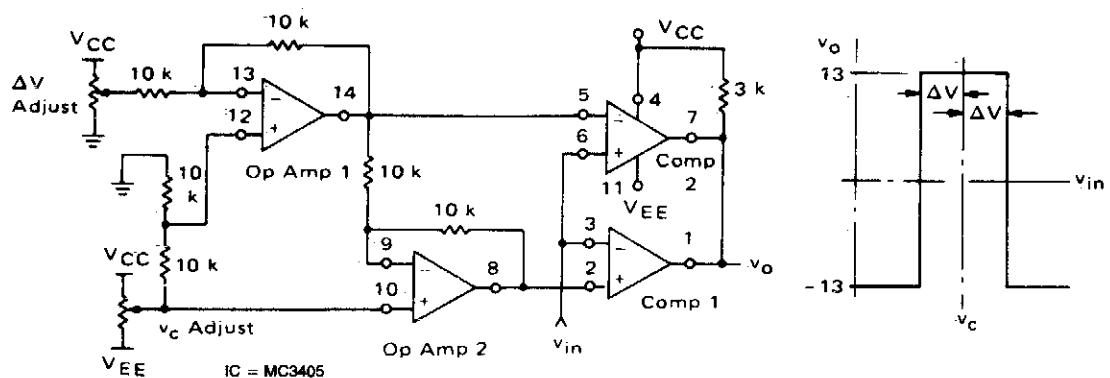


Fig. 16-12

MICROPOWER DOUBLE-ENDED LIMIT DETECTOR

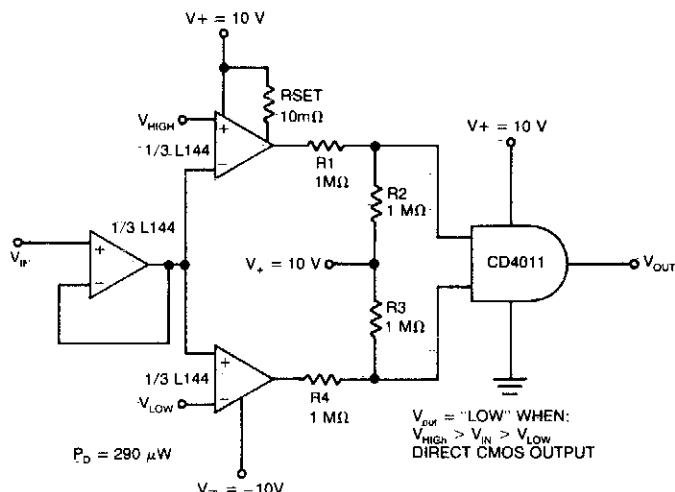


Fig. 16-13

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 R1, R2, R3, and R4 translate the bipolar $\pm 10\text{V}$ swing of the op amps to a 0 to 10V swing acceptable to the ground-referenced CMOS logic.

OPPOSITE POLARITY INPUT VOLTAGE COMPARATOR

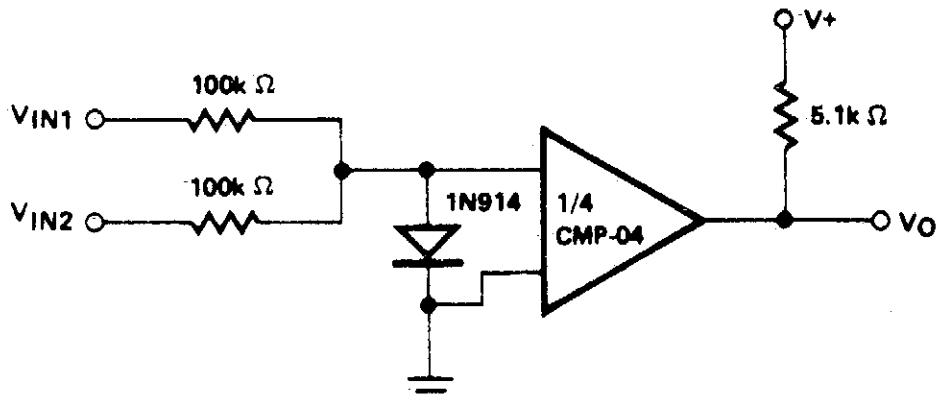


Fig. 16-14

LIMIT COMPARATOR

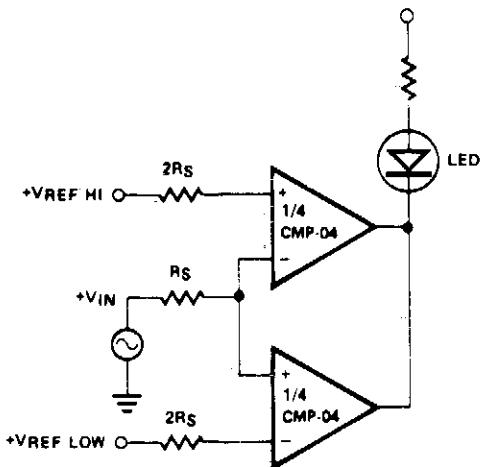


Fig. 16-15

DOUBLE-ENDED LIMIT COMPARATOR

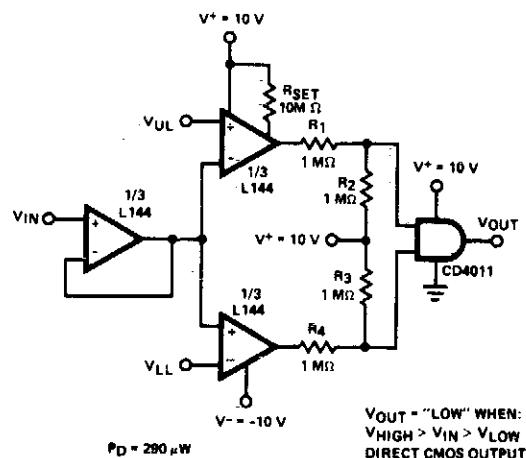


Fig. 16-17

COMPARATOR CLOCK CIRCUIT

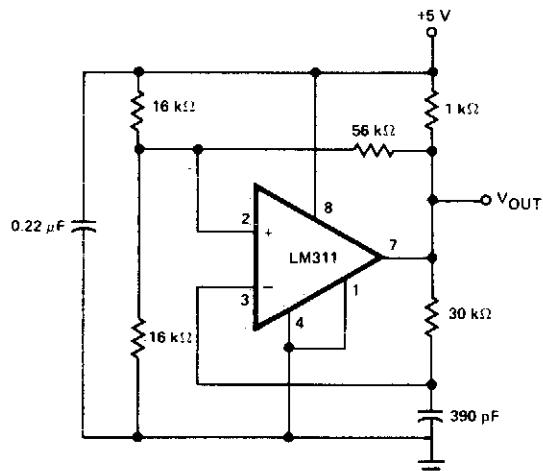


Fig. 16-16

LIMIT COMPARATOR

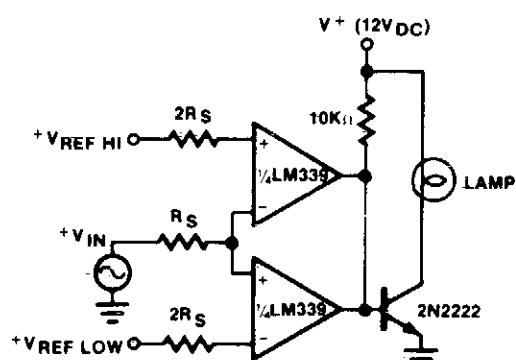


Fig. 16-18

PRECISION, DUAL LIMIT, GO/NO GO TESTER

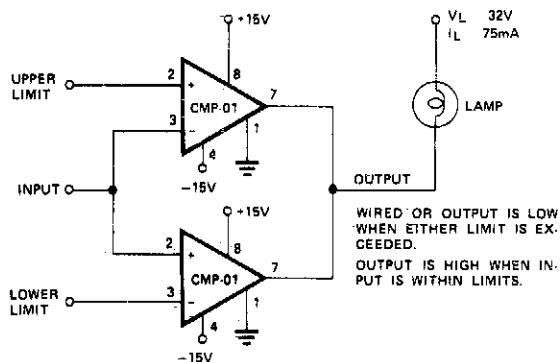


Fig. 16-19

HIGH IMPEDANCE COMPARATOR

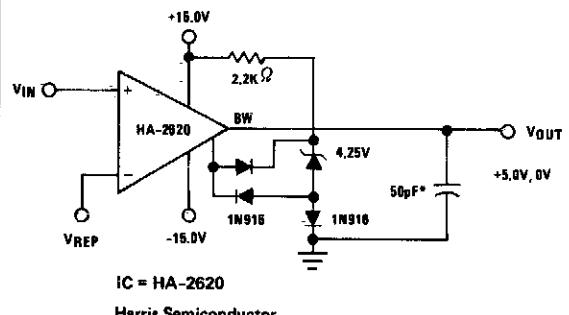


Fig. 16-21

COMPARATOR WITH HYSTERESIS

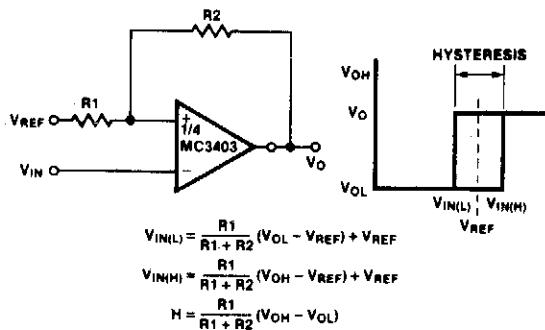


Fig. 16-20

COMPARATOR

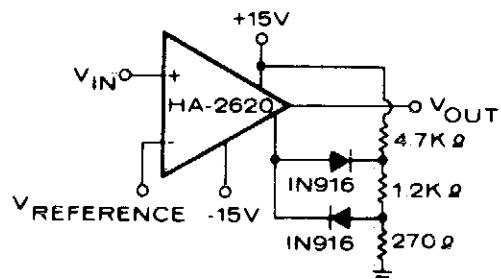


Fig. 16-22

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

PICOAMPERE-TO-FREQUENCY CONVERTERS

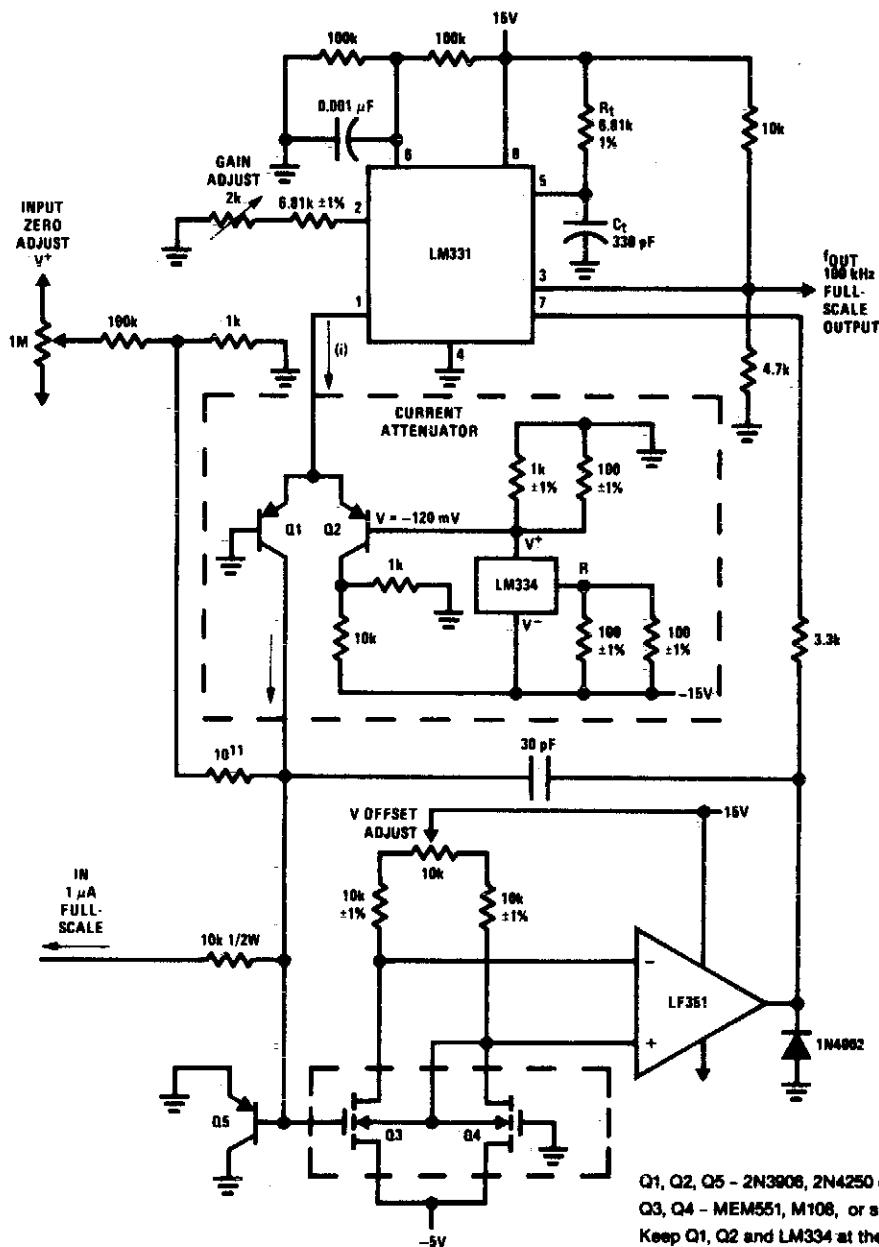


Fig. 17-1

BCD-TO-ANALOG CONVERTER

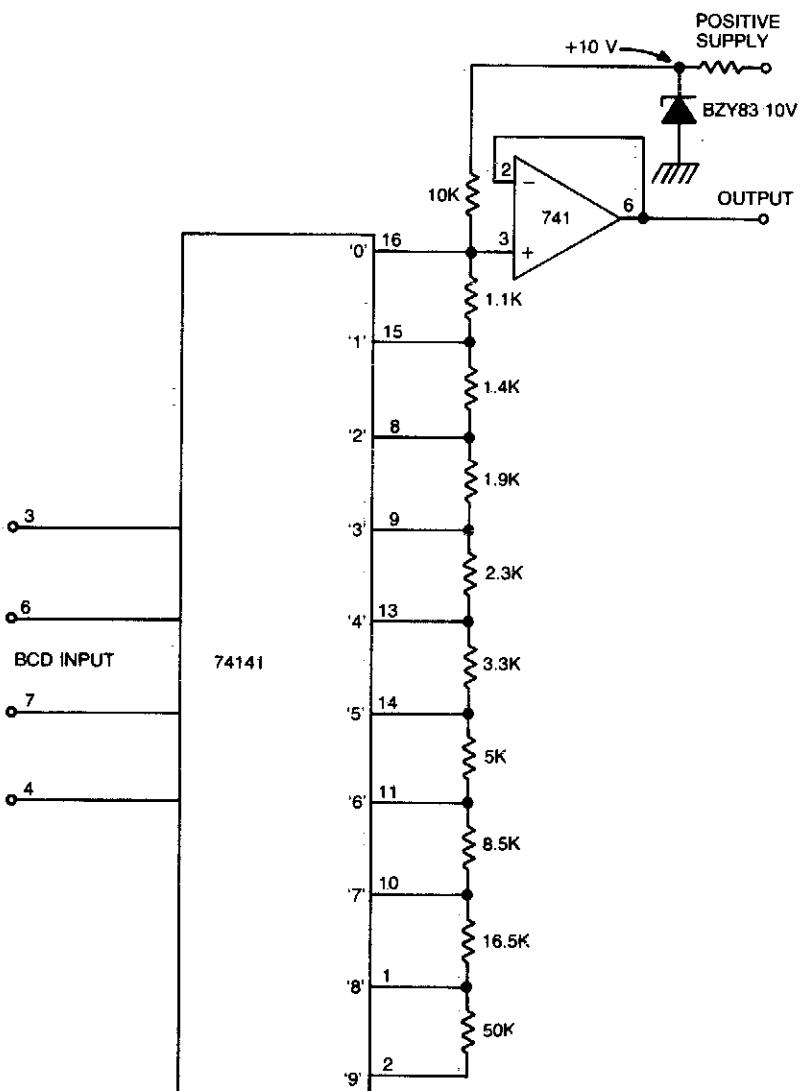


Fig. 17-2

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

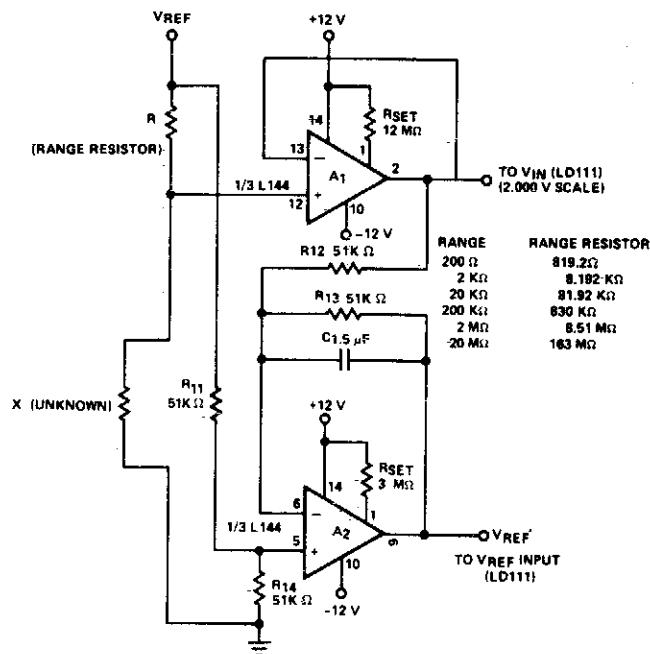


Fig. 17-3

Circuit Notes

Circuit will measure accurately to 20 M when associated with a buffer amplifier (A1) having a low input bias current ($I_{IN} < 30 \text{ nA}$). 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

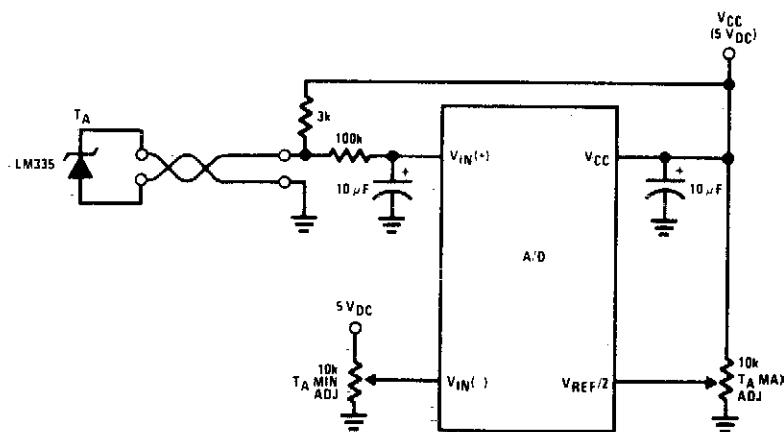


Fig. 17-4

HI-LO RESISTANCE-TO-VOLTAGE CONVERTER

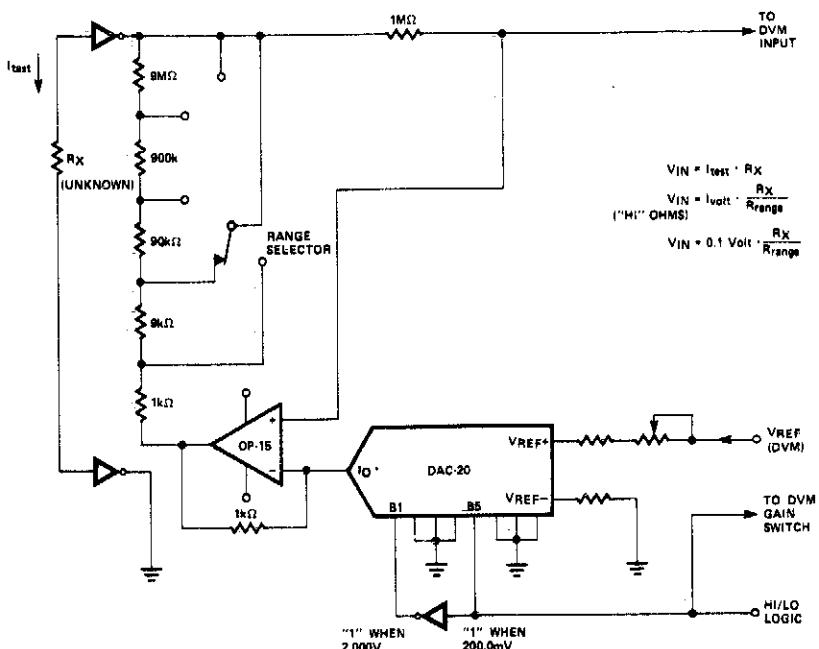
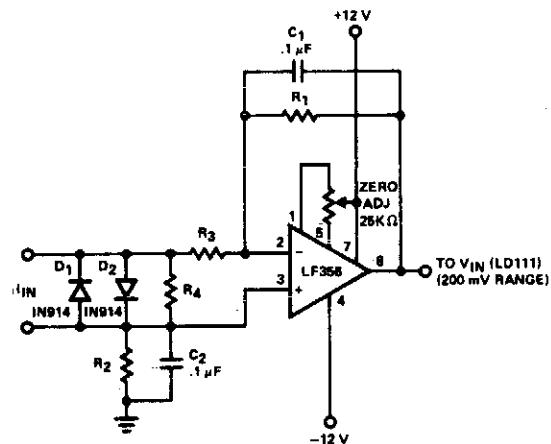


Fig. 17-5

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

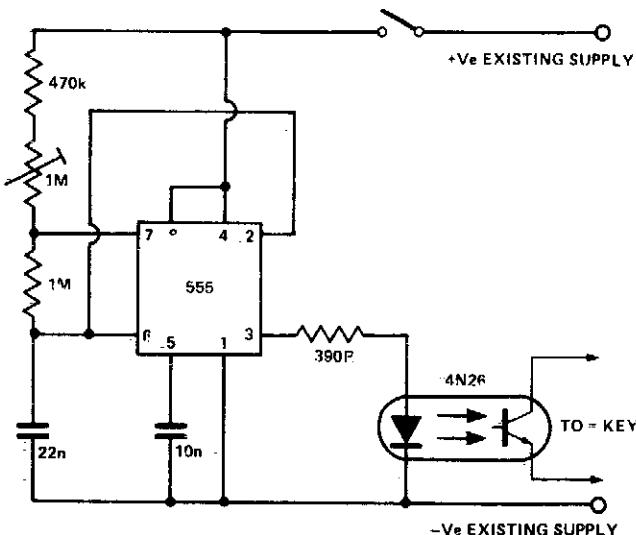


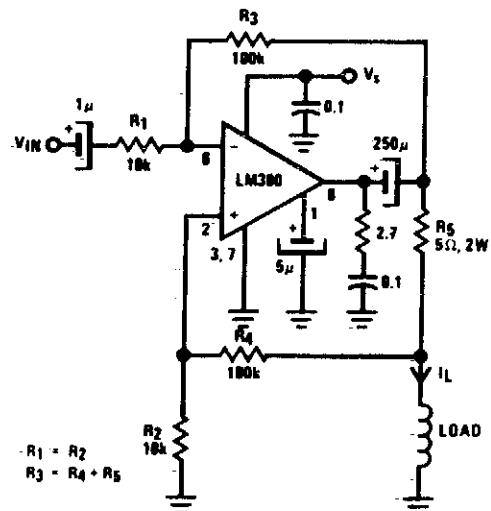
Fig. 17-7

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

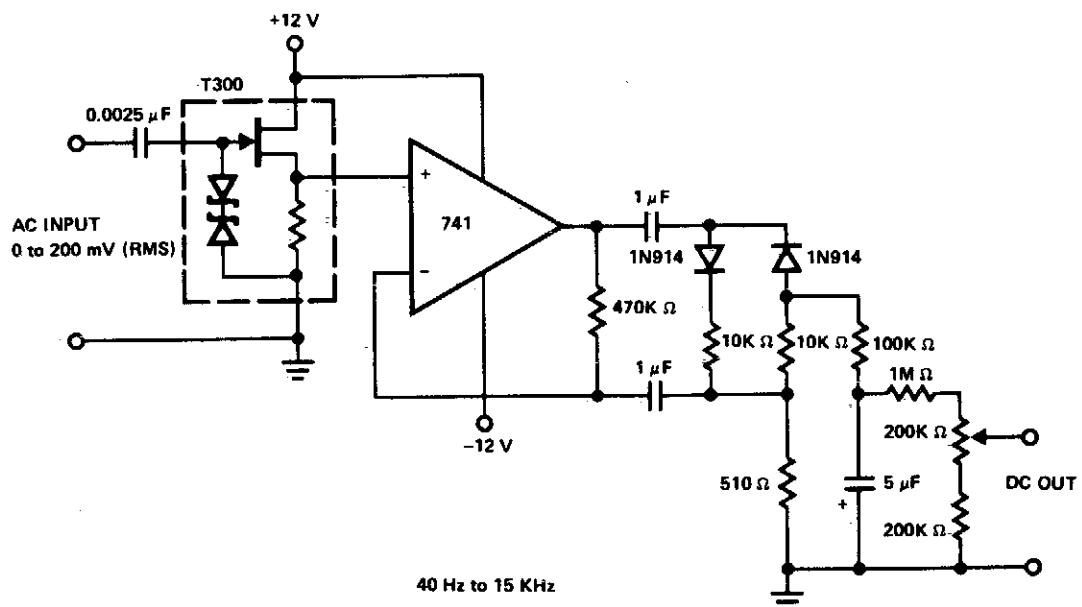
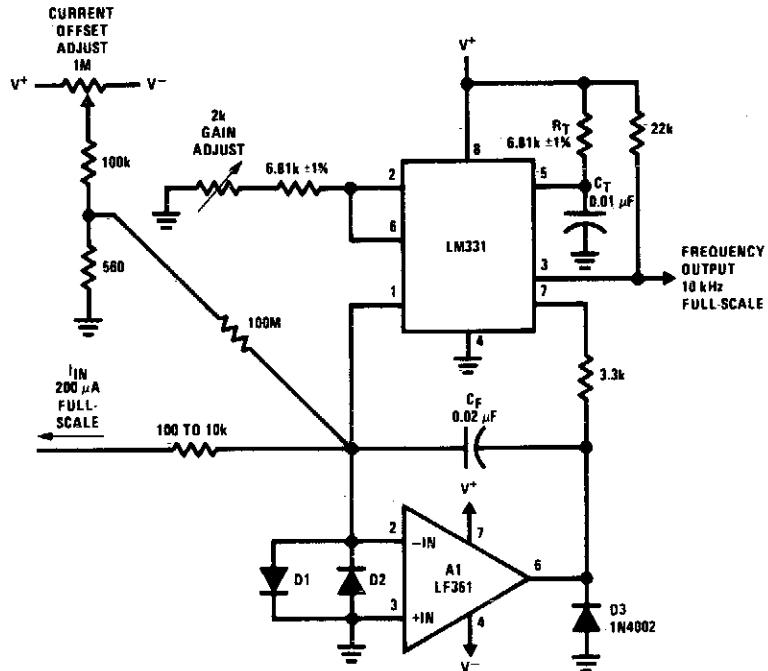


Fig. 17-9

WIDE-RANGE CURRENT-TO-FREQUENCY CONVERTER



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

Fig. 17-10

AC-TO-DC CONVERTER

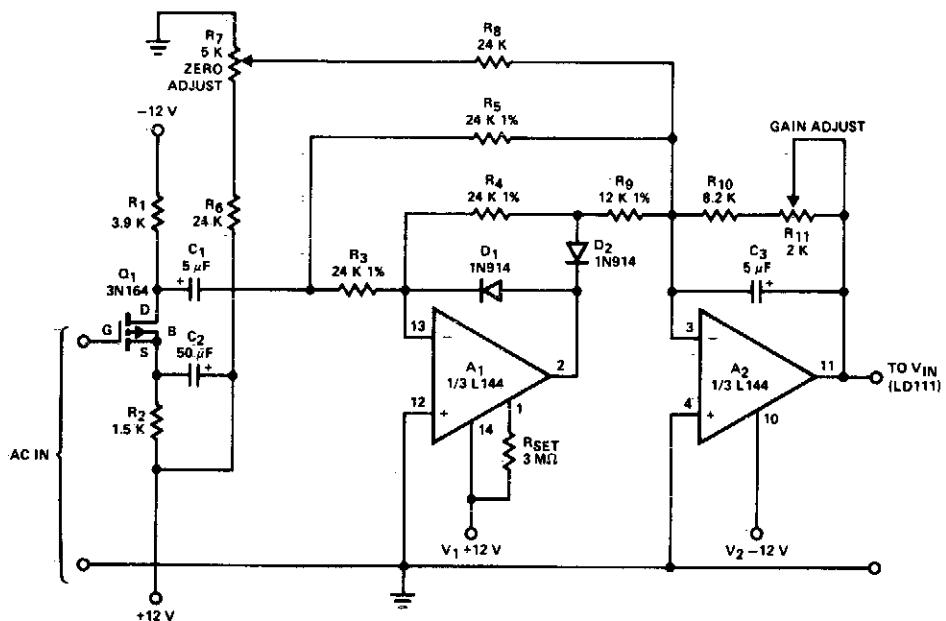


Fig. 17-11

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

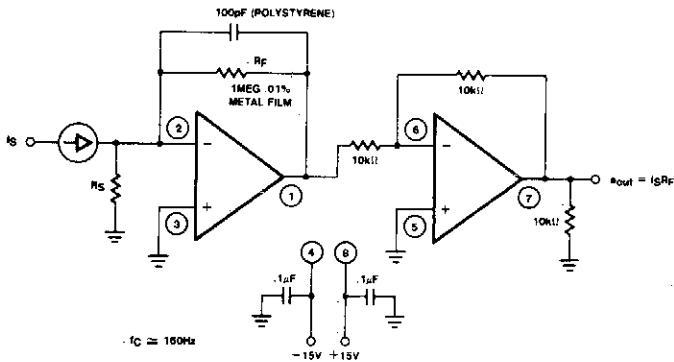


Fig. 17-12

$$IC = NE/SE55/1$$

(Sensitivity: 1 Volt per Microamp)

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

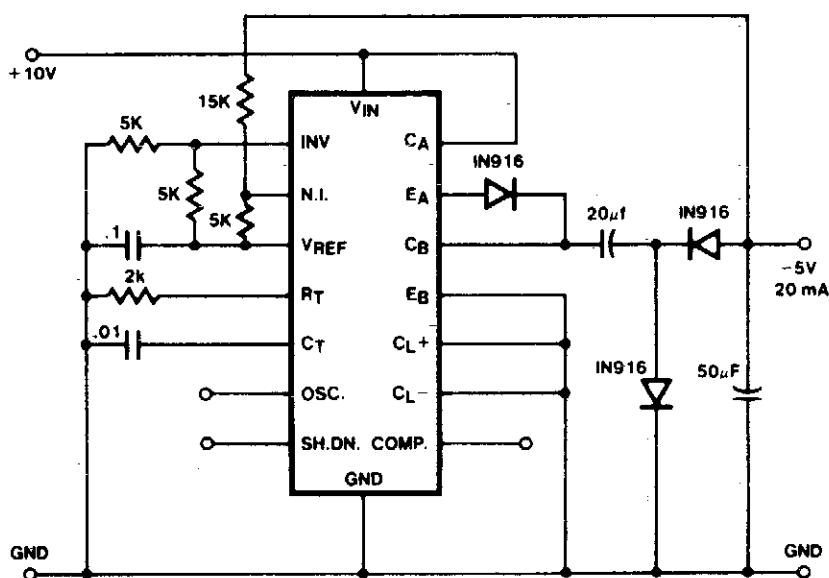


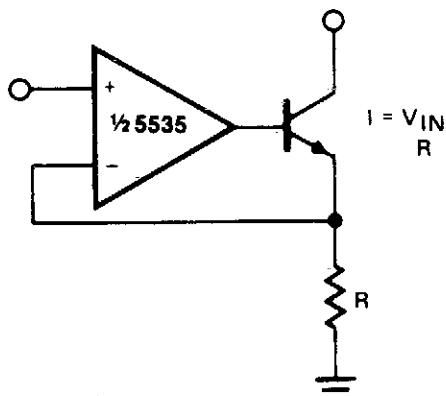
Fig. 17-13

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

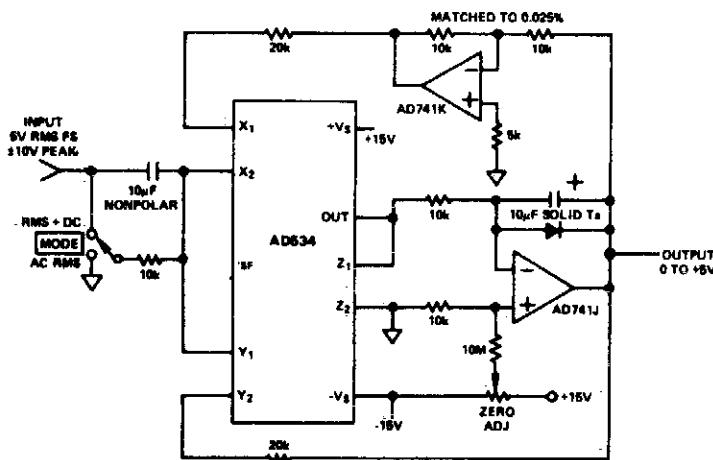


Circuit Notes

The current out is $I_{OUT} \approx V_{IN}/R$. 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.

Fig. 17-14

WIDEBAND, HIGH-CREST FACTOR, RMS-TO-DC CONVERTER



CALIBRATION PROCEDURE:

WITH 'MODE' SWITCH IN 'RMS + DC' POSITION, APPLY AN INPUT OF +1.00VDC. ADJUST ZERO UNTIL OUTPUT READS SAME AS INPUT. CHECK FOR INPUTS OF ±10V; OUTPUT SHOULD BE WITHIN 30.00% (6mV).

ACCURACY IS MAINTAINED FROM 50Hz TO 100kHz, AND IS TYPICALLY HIGH BY 0.6% AT 1MHz FOR $V_{IN} = 4V$ RMS (SINE, SQUARE OR TRIANGULAR WAVE).

PROVIDED THAT THE PEAK INPUT IS NOT EXCEEDED, CREST-FACTORS UP TO AT LEAST TEN HAVE NO APPRECIABLE EFFECT ON ACCURACY.

INPUT IMPEDANCE IS ABOUT 10kΩ; FOR HIGH (10MΩ) IMPEDANCE, REMOVE MODE SWITCH AND INPUT COUPLING COMPONENTS.

FOR GUARANTEED SPECIFICATIONS THE AD638A AND AD638 IS OFFERED AS A SINGLE PACKAGE RMS-TO-DC CONVERTER.

Fig. 17-15

LIGHT INTENSITY-TO-FREQUENCY CONVERTER

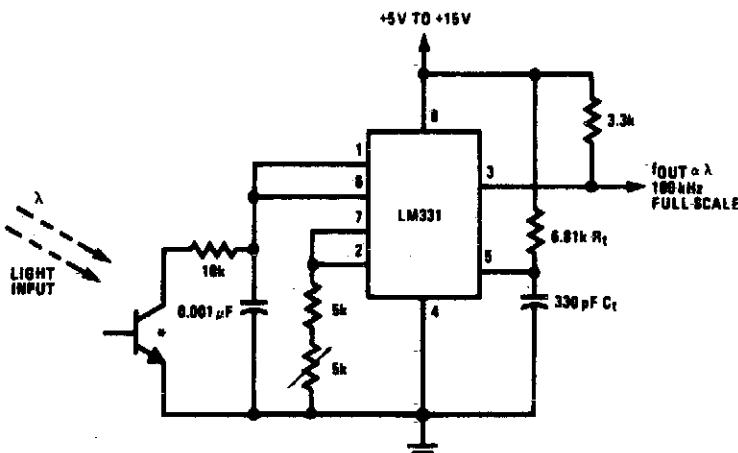


Fig. 17-16

*L14F-1, L14G-1 or L14H-1, photo transistor (General Electric Co.) or similar

OHMS-TO-VOLTS CONVERTER

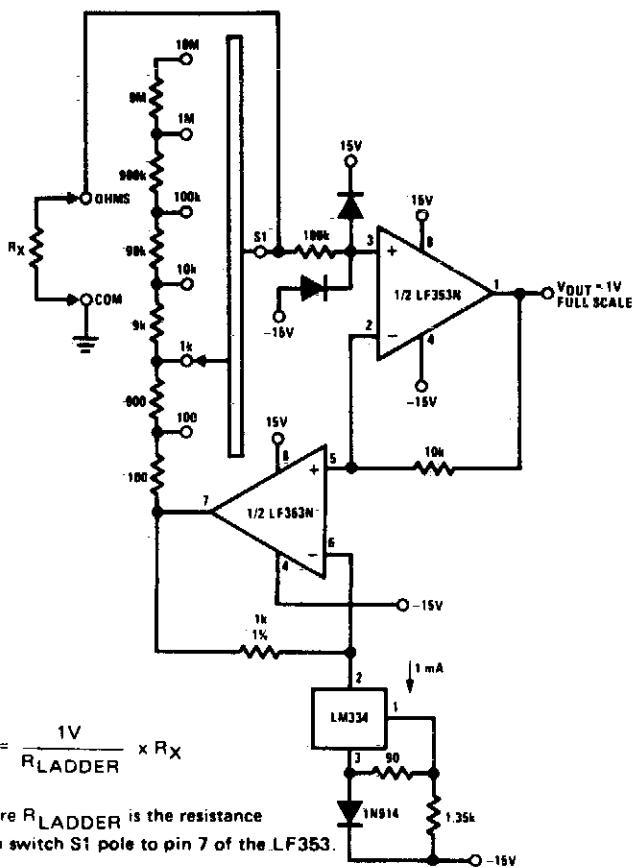


Fig. 17-17

TEMPERATURE-TO-FREQUENCY CONVERTER

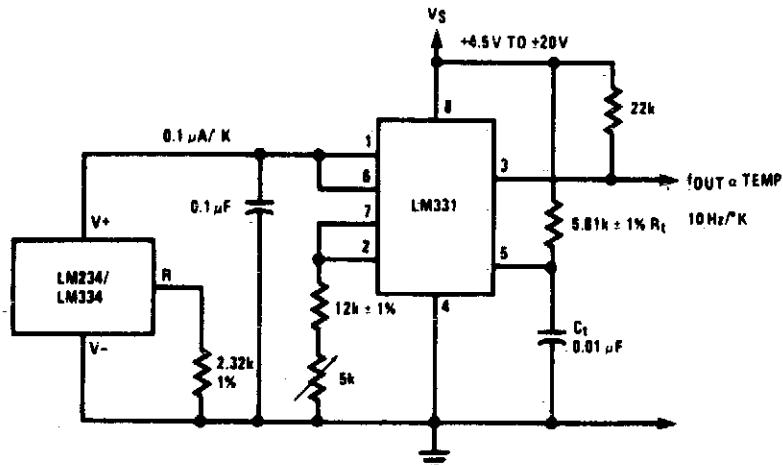
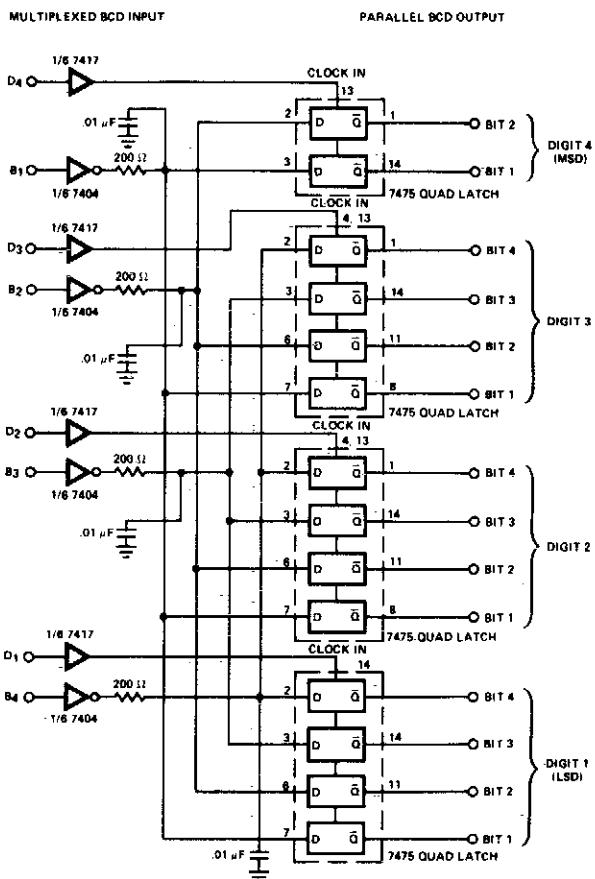


Fig. 17-18

MULTIPLEXED BCD-TO-PARALLEL BCD CONVERTER

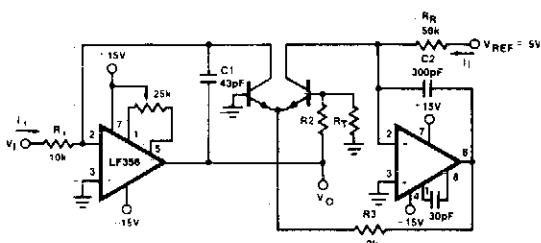


Circuit Notes

Converter consists of four quad bistable latches activated in the proper sequence by the digit strobe output of the LD110. The complemented outputs (\bar{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



$$V_{OUT} = \left[1 + \frac{R_2}{R} \right] \frac{kT}{q} \ln \frac{V_1}{V_{REF} R_1} = \log \frac{V_1}{R_1 I_H}$$

$R_2 = 15.71$, $R_1 = 1k$, $0.3\%/\text{C}$ (for temperature compensation)

- Dynamic range: $100\mu\text{A} \leq I \leq 1\text{mA}$ (5 decades), $|V_O| = 1\text{V}/(\text{decades})$
- Transient response: $3\mu\text{s}$ for $\Delta = \text{decades}$
- C_1, C_2, R_2, R_3 : added dynamic compensation
- V_{os} adjust the LF356 to minimize quiescent error
- R_T : Tel Labs type Q81 + $0.3\%/\text{C}$.

Fig. 17-20

SINE WAVE-TO-SQUARE WAVE CONVERTER

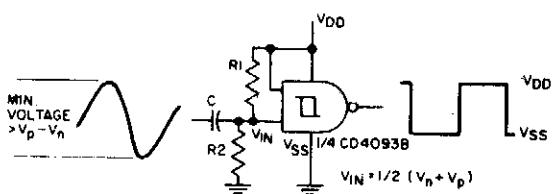


Fig. 17-21

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

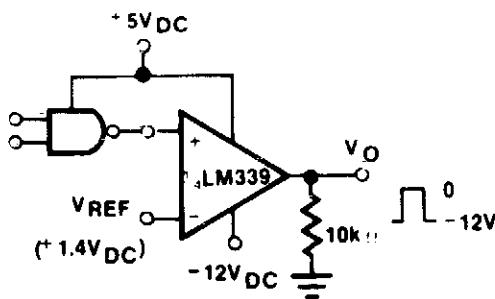


Fig. 17-23

SELF OSCILLATING FLYBACK CONVERTER

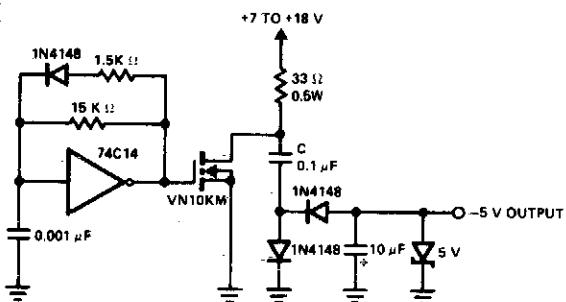


Fig. 17-22

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

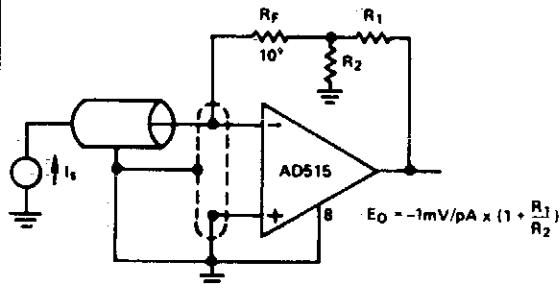


Fig. 17-24

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

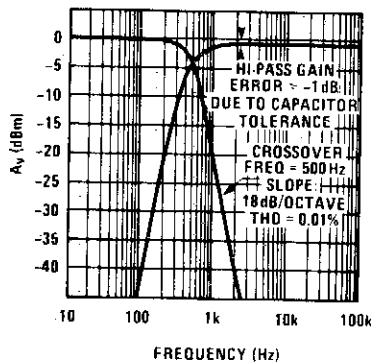
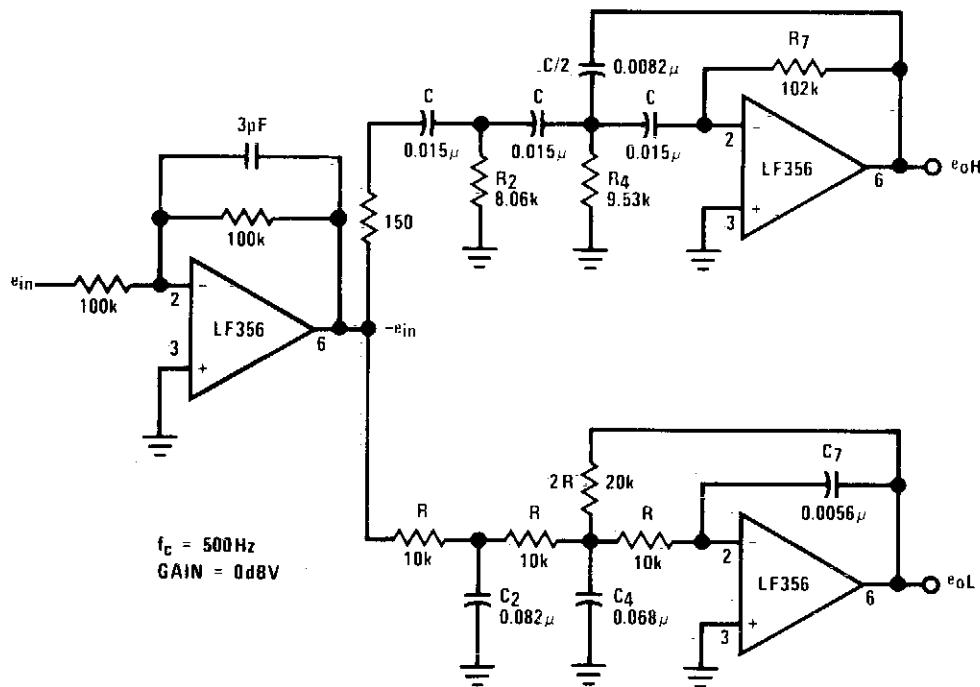


Fig. 18-1

ASYMMETRICAL THIRD ORDER BUTTERWORTH ACTIVE CROSSOVER NETWORK

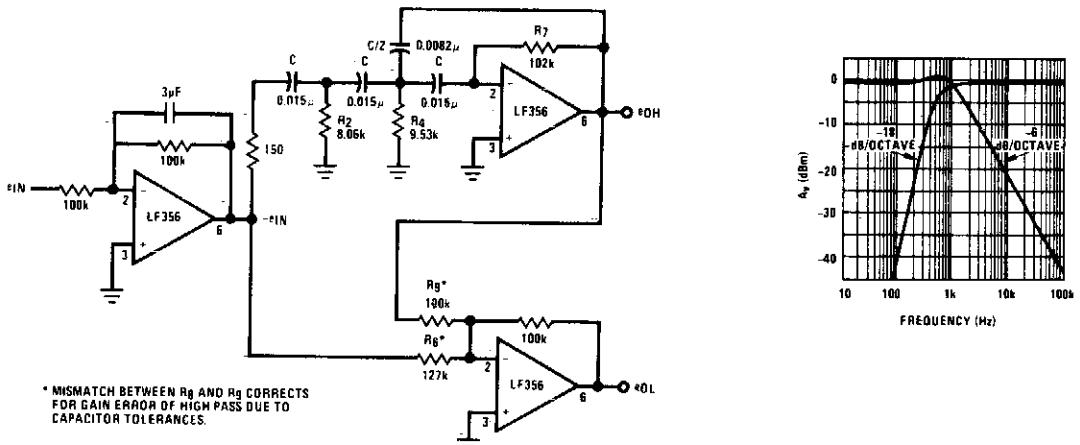
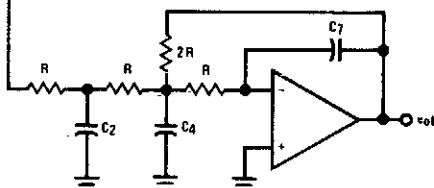
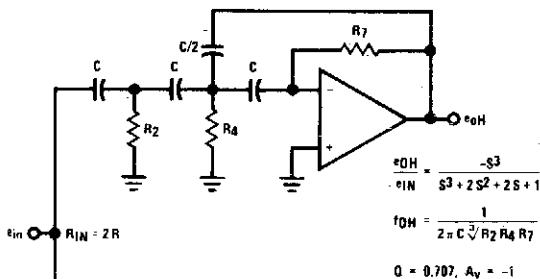


Fig. 18-2

THIRD ORDER BUTTERWORTH CROSSOVER NETWORK



$$C_2 = \frac{2.4563}{2\pi f_{OL} R}$$

$$R_2 = \frac{0.4074}{2\pi f_{OH} C}$$

$$f_{OH} = \frac{-1}{s^3 + 2s^2 + 2s + 1}$$

$$C_4 = \frac{2.1089}{2\pi f_{OL} R}$$

$$R_4 = \frac{0.4742}{2\pi f_{OH} C}$$

$$f_{OL} = \frac{1}{2\pi R \sqrt[3]{C_2 C_4 C_7}}$$

$$C_7 = \frac{0.1931}{2\pi f_{OL} R}$$

$$R_7 = \frac{5.1766}{2\pi f_{OH} C}$$

$$\Omega = 0.707, A_v = -1$$

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 |

HIGH FREQUENCY CRYSTAL OSCILLATOR

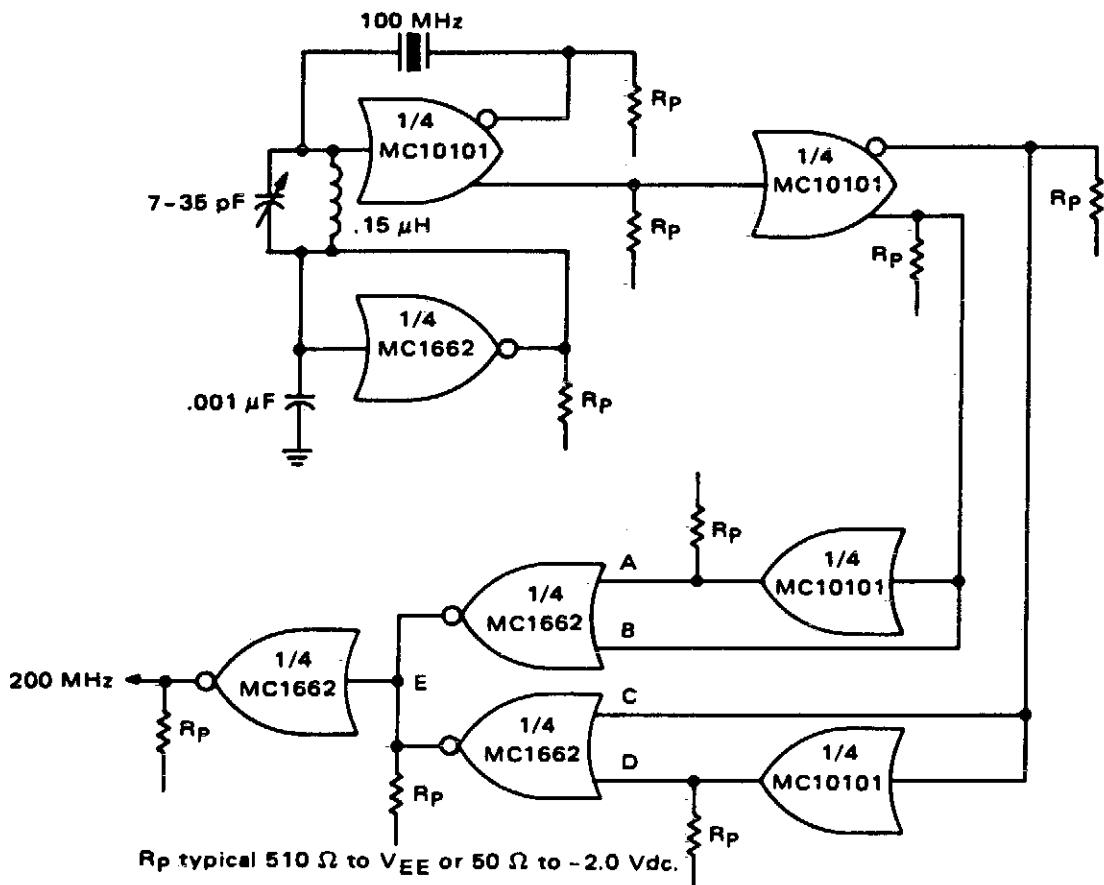


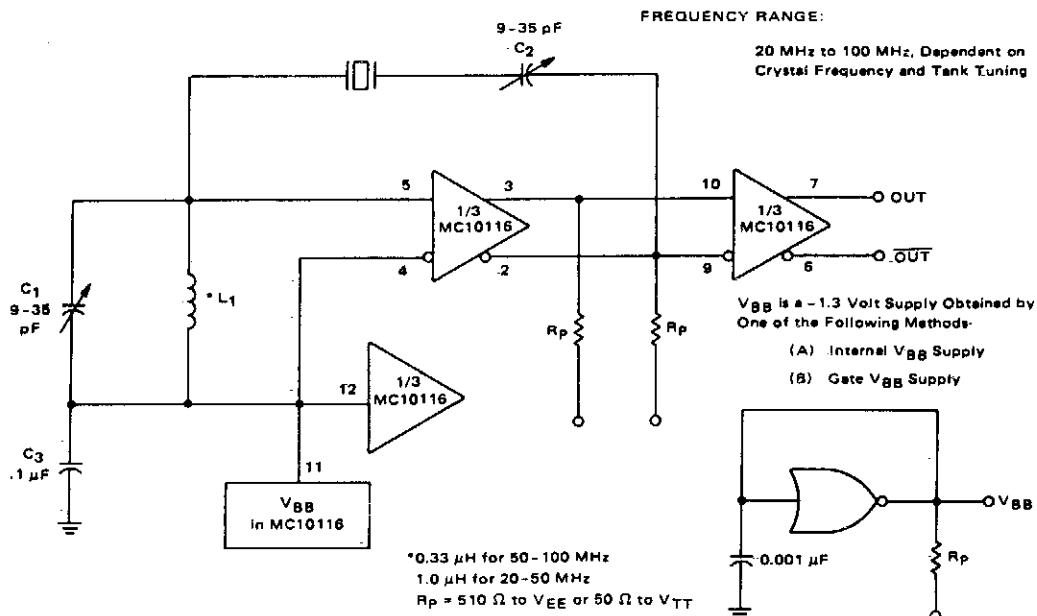
Fig. 19-1

Circuit Notes

One section of the MC10101 is connected as a 100 MHz crystal oscillator with the crystal in series with the feedback loop. The LC tank circuit tunes the 100 MHz harmonic of the crystal and may be used to calibrate the circuit to the exact frequency. A second section of the MC10101 buffers the crystal oscillator and gives complementary 100 MHz signals. The

frequency doubler consists of two MC10101 gates as phase shifters and two MC1662 NOR gates. For a 50% duty cycle at the output, the delay to the true and complement 100 MHz signals should be 90° . This may be built precisely with 2.5 ns delay lines for the 200 MHz output or approximated by the two MC10101 gates as shown.

OVERTONE CRYSTAL OSCILLATOR



OVERTONE CRYSTAL OSCILLATOR

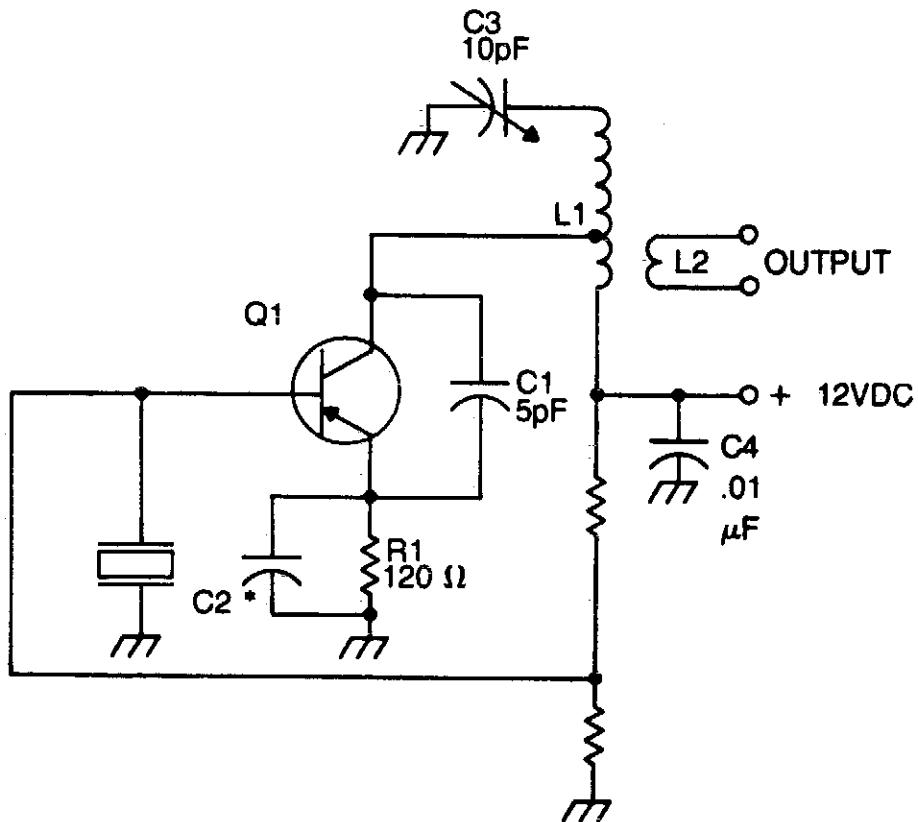


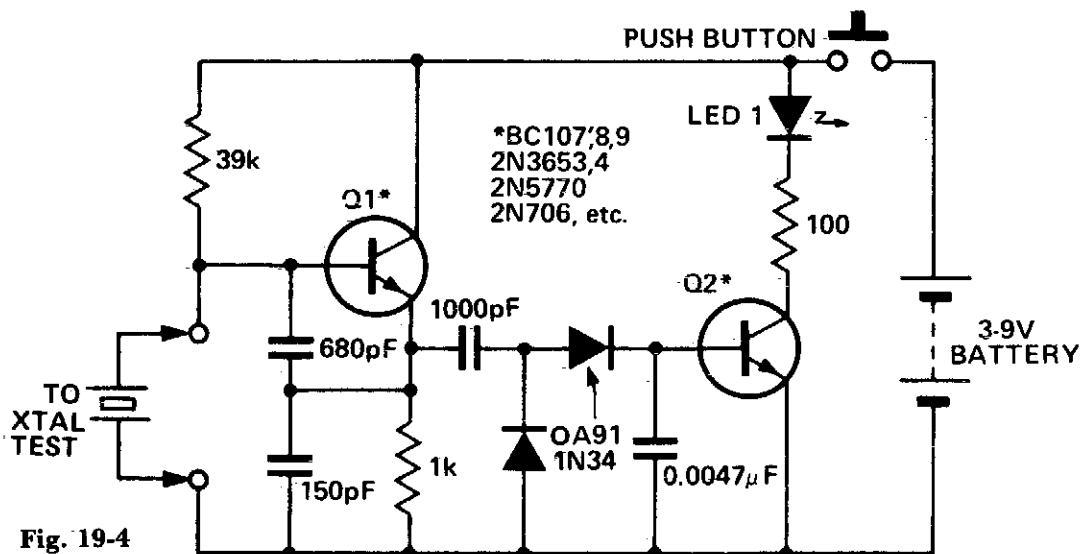
Fig. 19-3

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



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. A 3 or 6V, 40mA bulb could be substituted for the LED.

TTL OSCILLATOR FOR 1 MHz-10 MHz

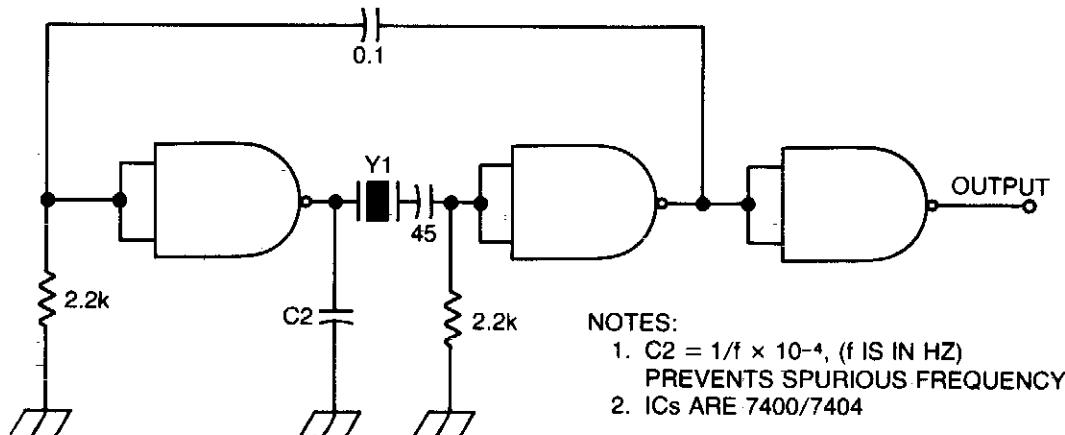


Fig. 19-5

96 MHz CRYSTAL OSCILLATOR

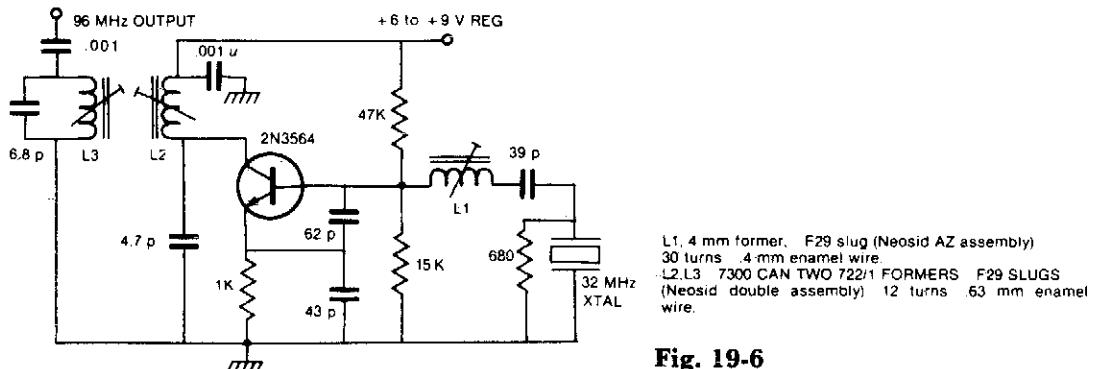


Fig. 19-6

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

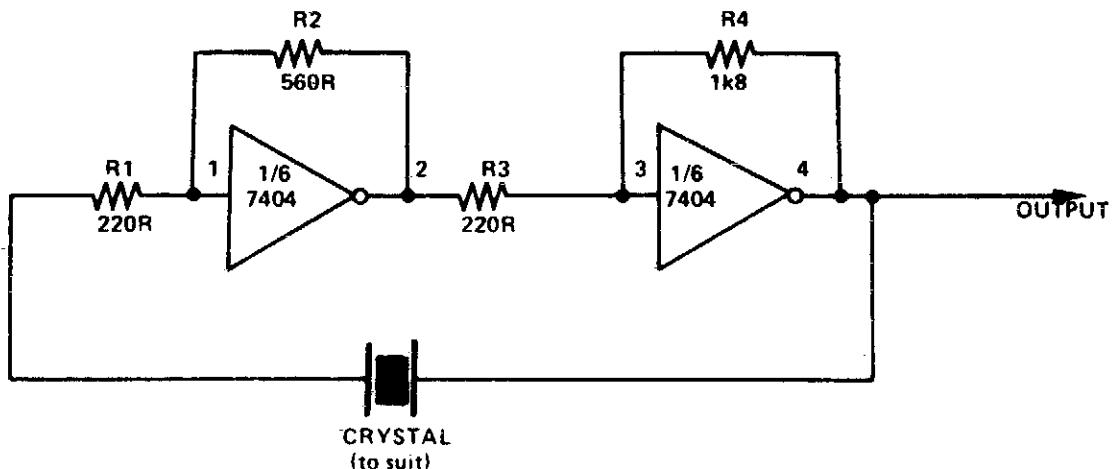


Fig. 19-7

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 crystals fundamental frequency.

CRYSTAL OSCILLATOR

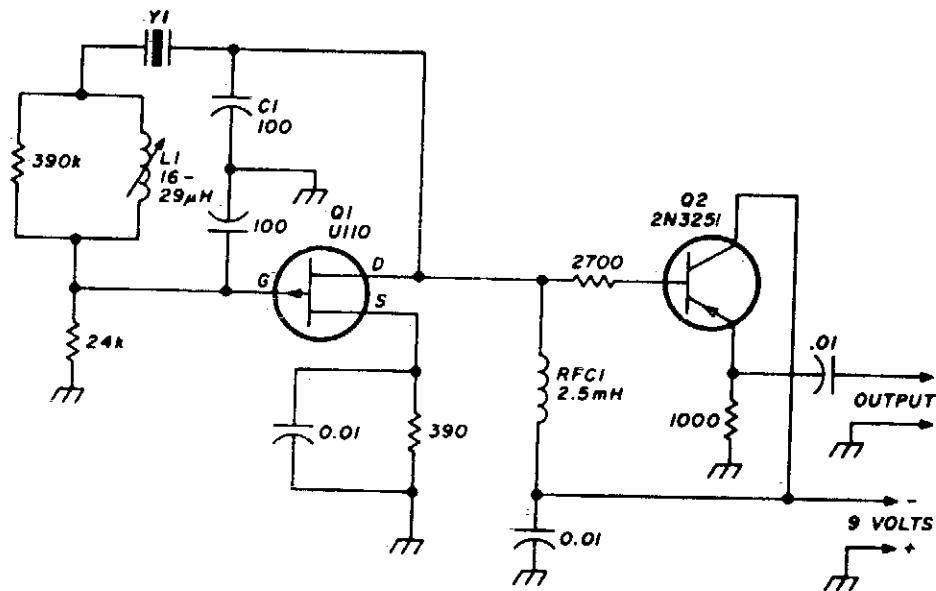


Fig. 19-8

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

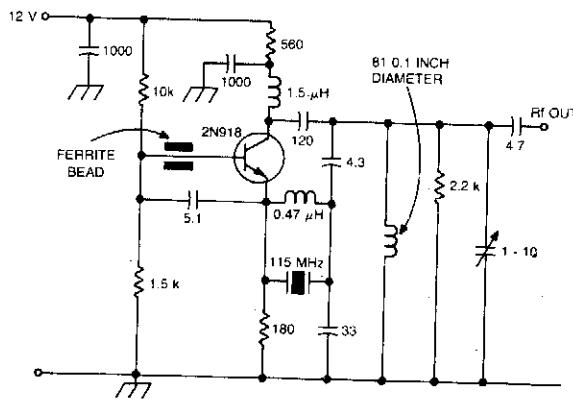


Fig. 19-9

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

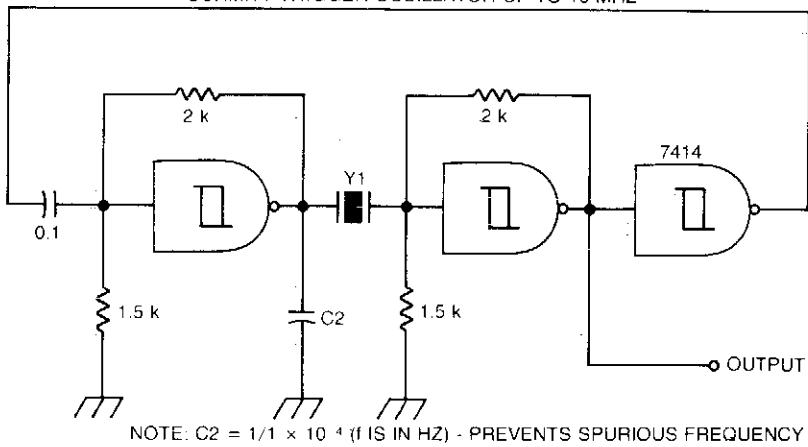


Fig. 19-10

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

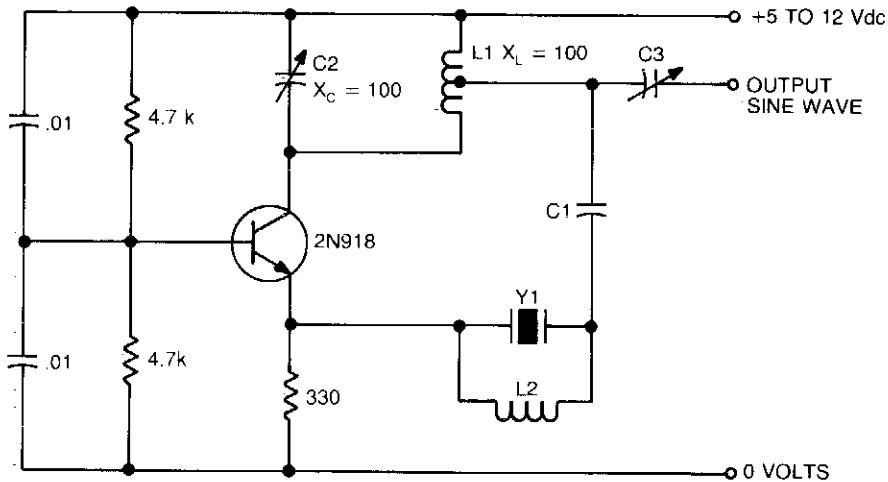


Fig. 19-11

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 ($L_2 = .5 \mu\text{H}$ AT 90 MHZ). THIS IS NECESSARY TO TUNE OUT EFFECT OF CO.
4. C3 IS VARIED TO MATCH OUTPUT.

FIFTH-OVERTONE OSCILLATOR

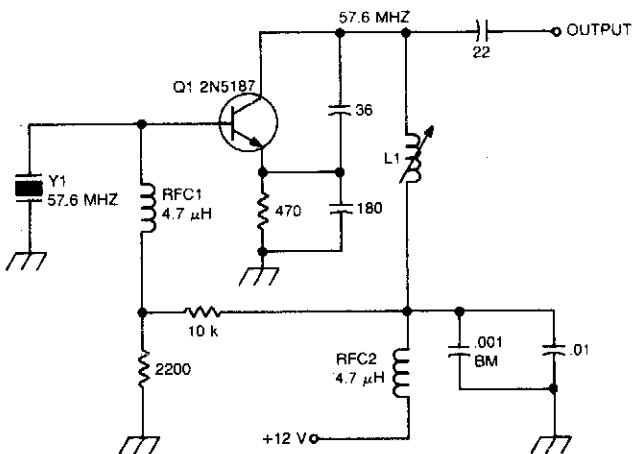


Fig. 19-12

Circuit Notes

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

CRYSTAL CONTROLLED BUTLER OSCILLATOR

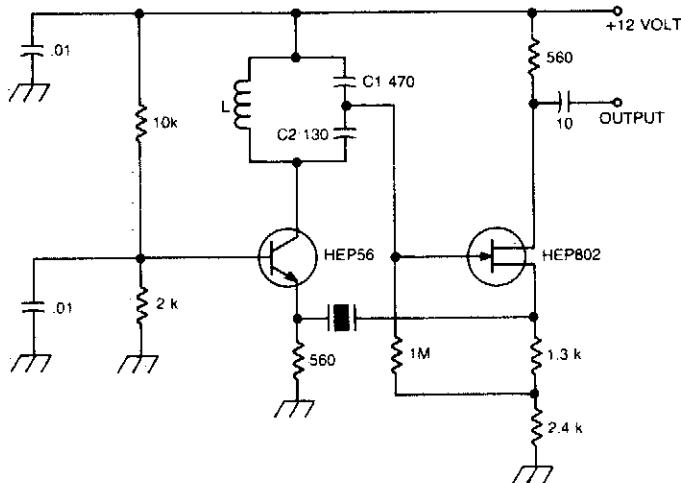
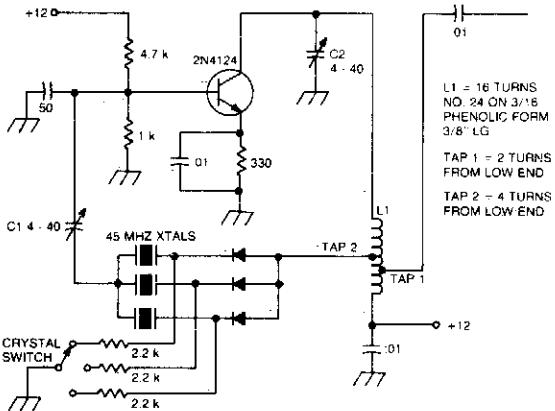


Fig. 19-13

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

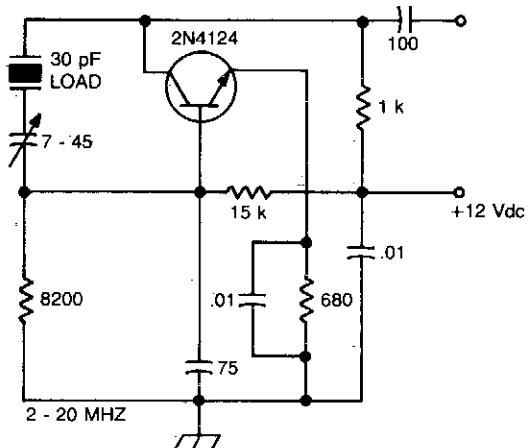


Circuit Notes

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/DOUBLER

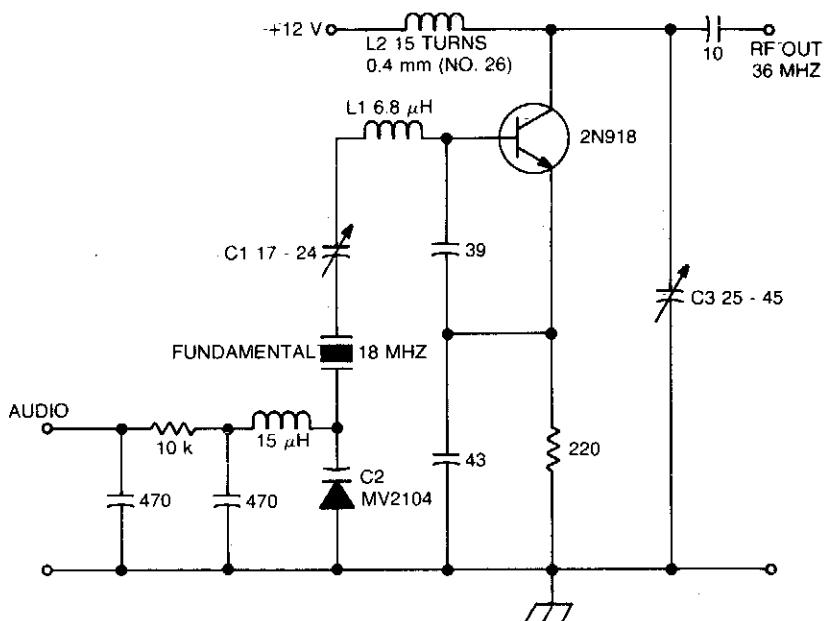


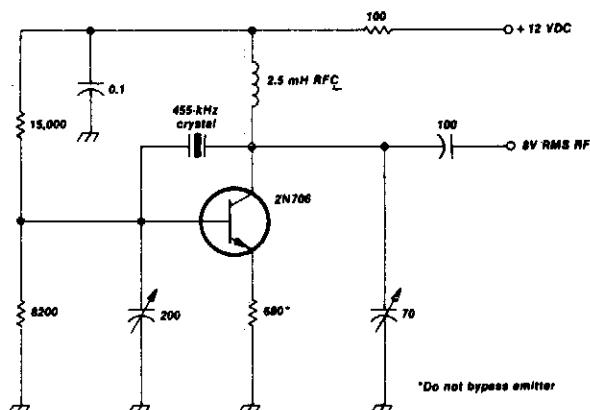
Fig. 19-16

Circuit Notes

The crystal operates into a complex load at series resonance. L1, C1, and C2 balance the crystal at zero reactance. Capacitor C1 fine-tunes the center frequency. Tank circuit L2, C3 doubles the output frequency the circuit operates as an FM oscillator-doubler.

LOW-FREQUENCY CRYSTAL OSCILLATOR

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



Circuit Notes

This crystal-oscillator circuit uses a 455-kHz crystal.

Fig. 19-17

CRYSTAL OSCILLATOR

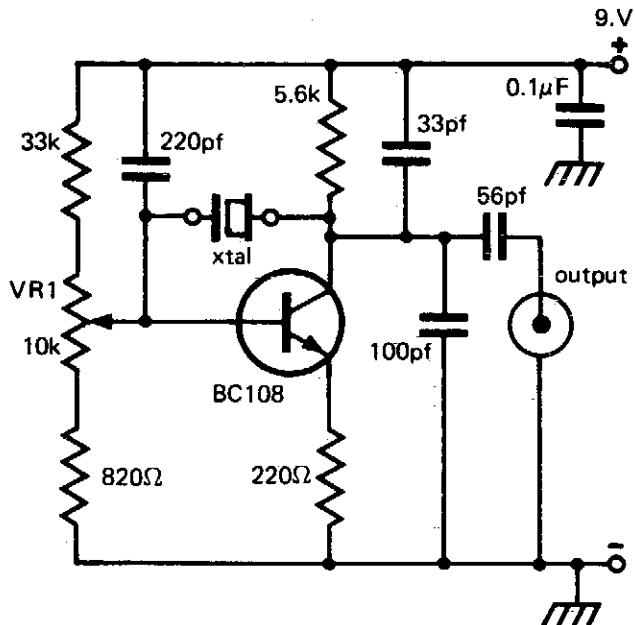
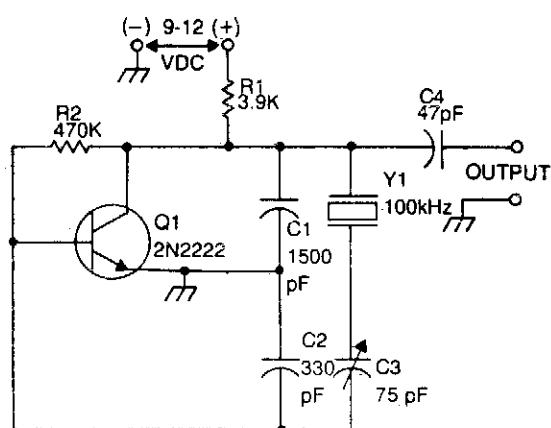


Fig. 19-18

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

THIRD-OVERTONE CRYSTAL OSCILLATOR

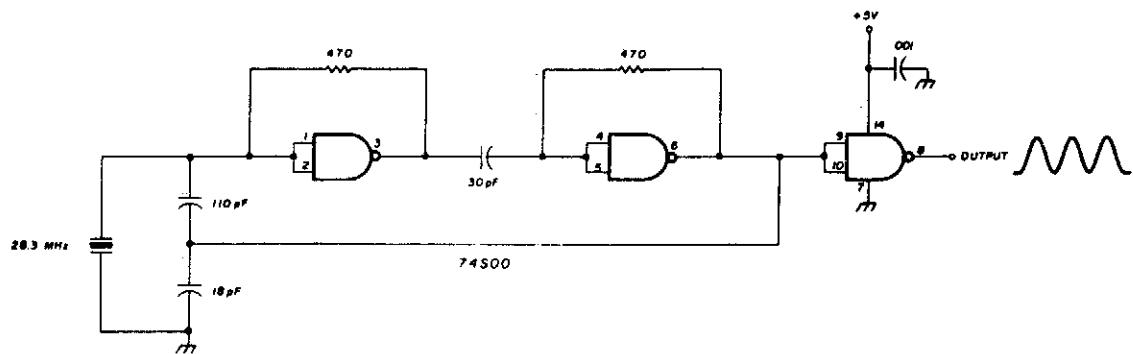
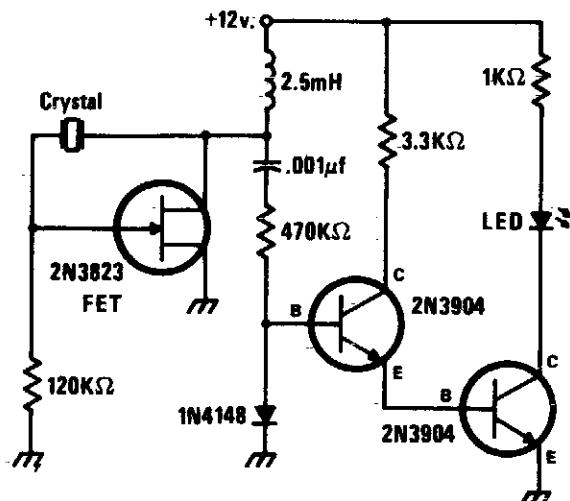


Fig. 19-20

Circuit Notes

This circuit uses a 74S00 Schottky TTL gate; no inductors are required.

CRYSTAL CHECKER



Circuit Notes

This circuit is a simple Pierce oscillator with an LED go/no go display. Checker works best with crystals having fundamental frequencies in the seven to eight megahertz range.

Fig. 19-21

CMOS CRYSTAL OSCILLATOR

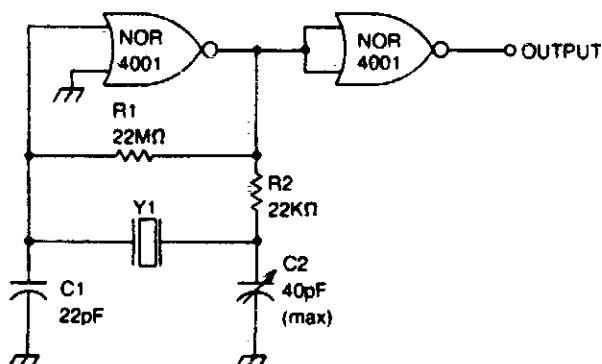


Fig. 19-22

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

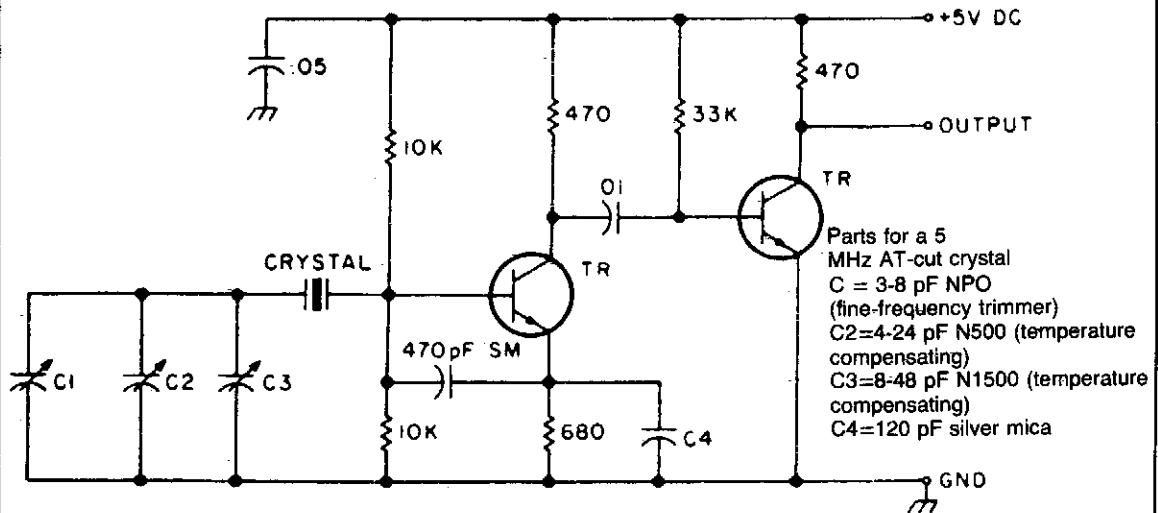


Fig. 19-23

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

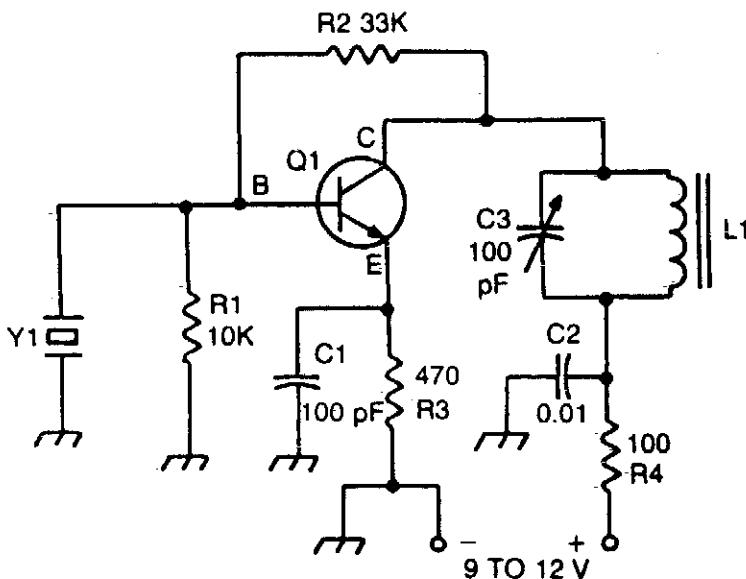


Fig. 19-24

PIERCE HARMONIC OSCILLATOR (20 MHz)

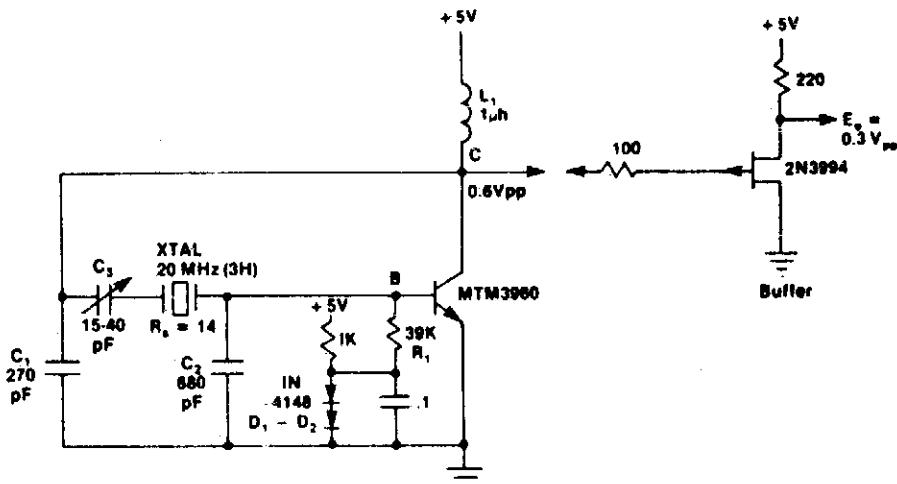


Fig. 19-25

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)

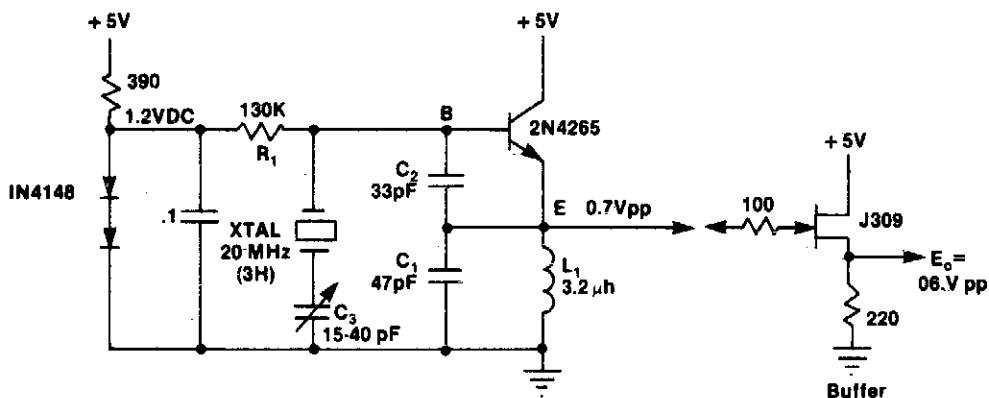


Fig. 19-26

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

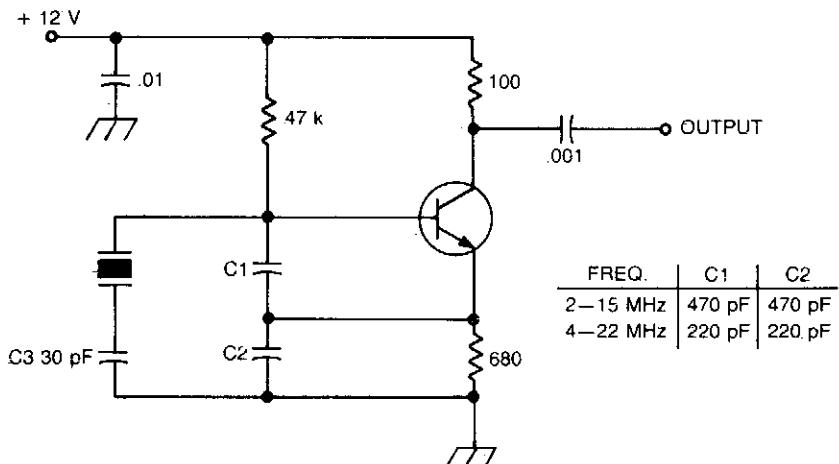


Fig. 19-27

Circuit Notes

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

BUTLER Emitter Follower Oscillator (100 MHz)

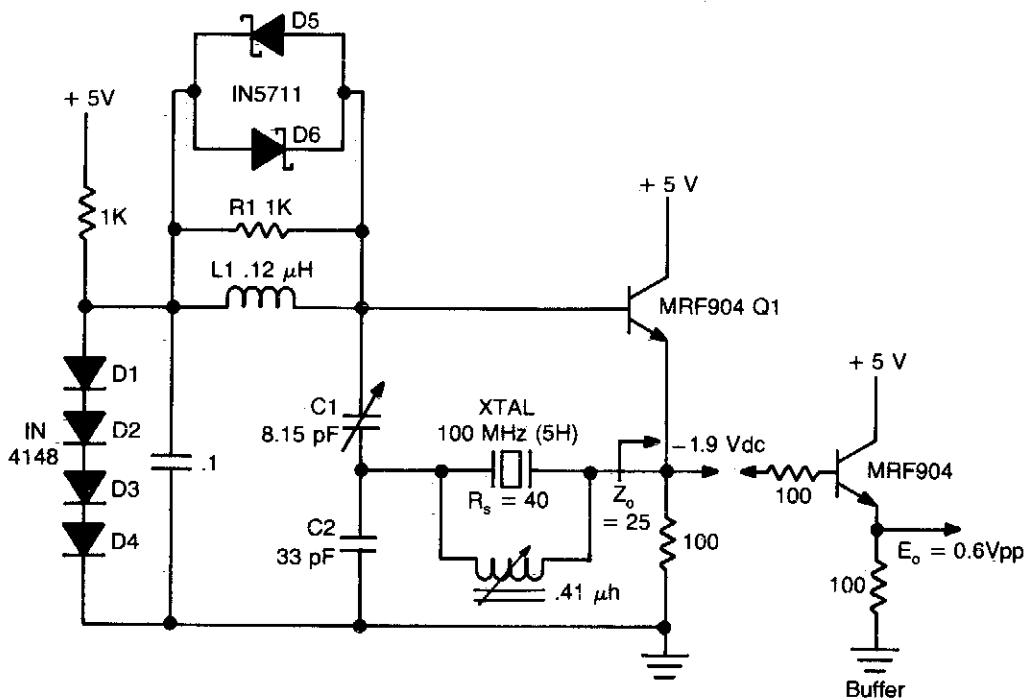
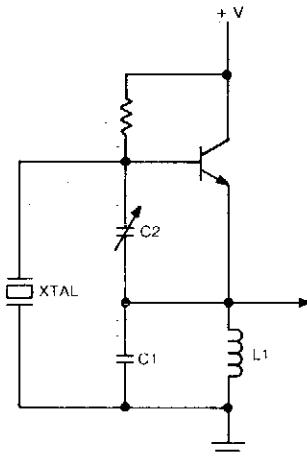


Fig. 19-28

Circuit Notes

This circuit has good performance without any parasitics because emitter follower amplifier has a gain of only one with built-in negative feedback to stabilize its gain.

COLPITTS HARMONIC OSCILLATOR (BASIC CIRCUIT)

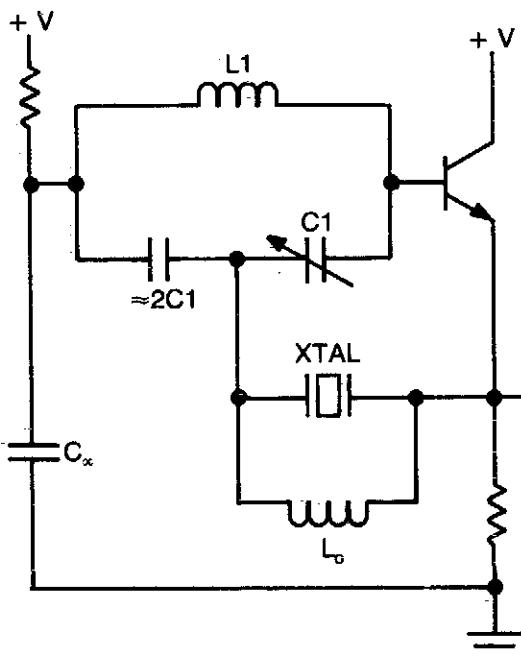


Circuit Notes

This circuit operates 30-200 ppm above series resonance. Physically simple, but analytically complex. It is inexpensive with fair frequency stability.

Fig. 19-29

BUTLER Emitter Follower Oscillator (BASIC CIRCUIT)

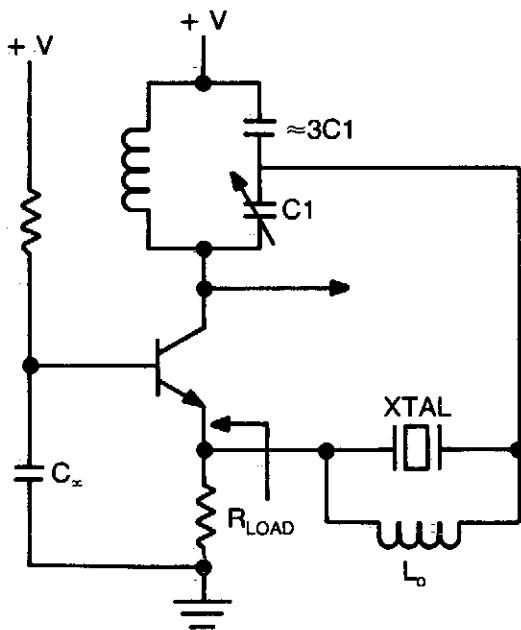


Circuit Notes

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)

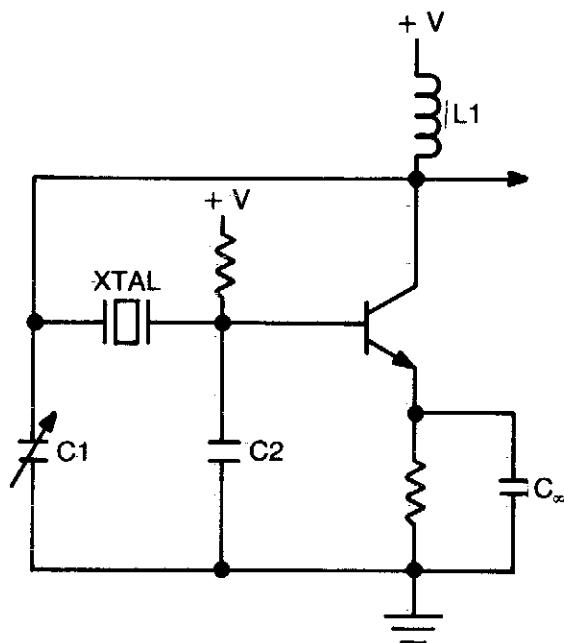


Circuit Notes

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)

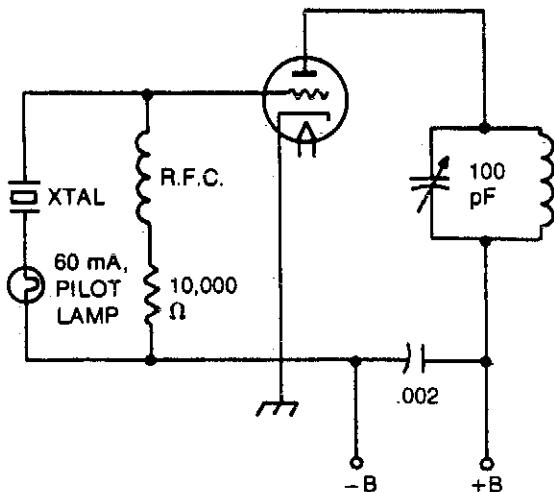


Circuit Notes

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

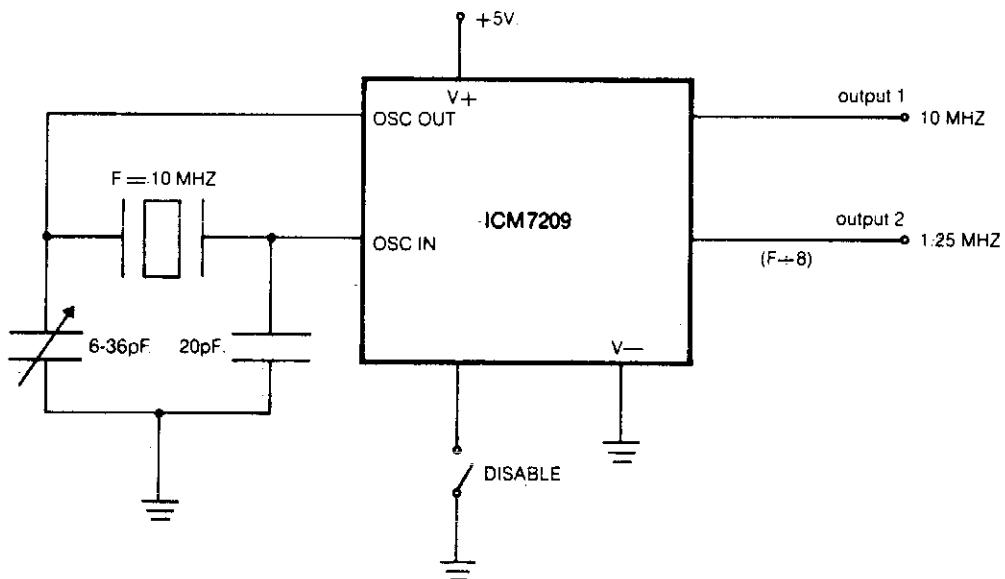
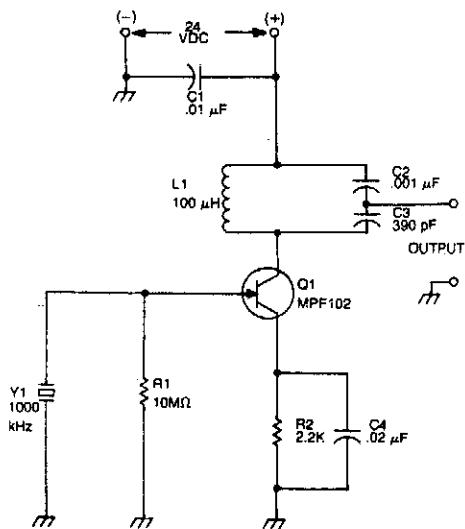


Fig. 19-34

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)

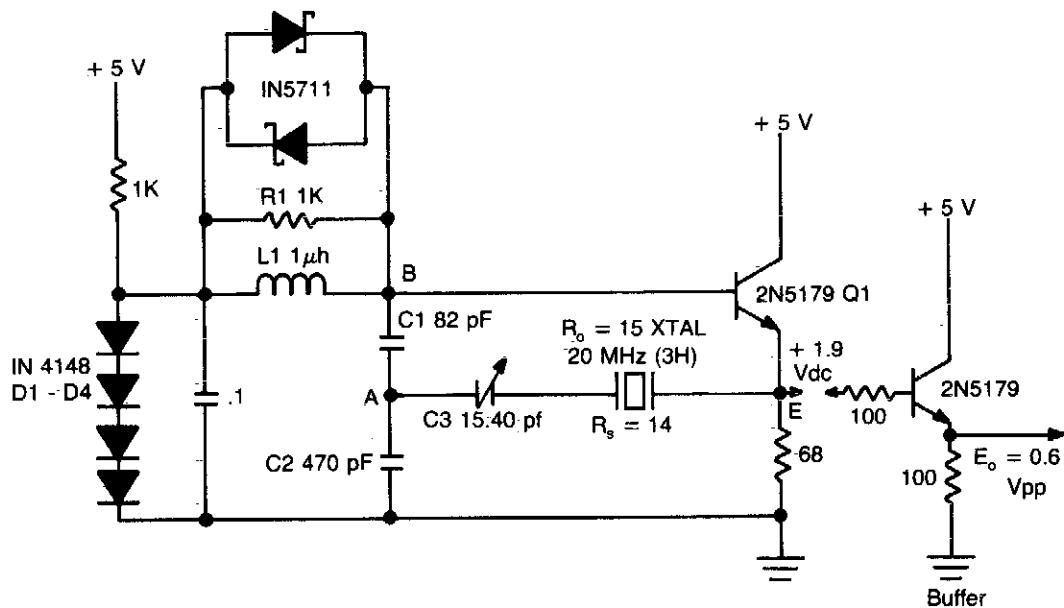
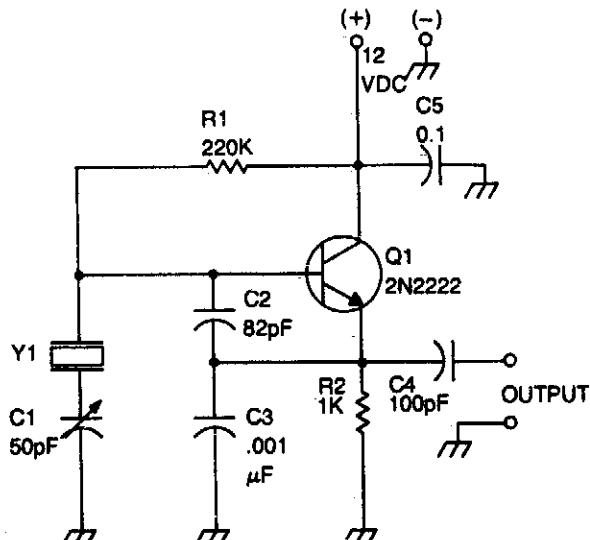


Fig. 19-36

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

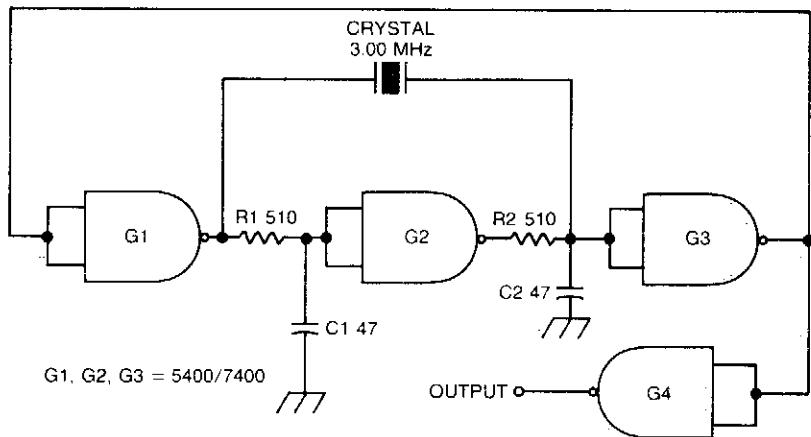


Fig. 19-38

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

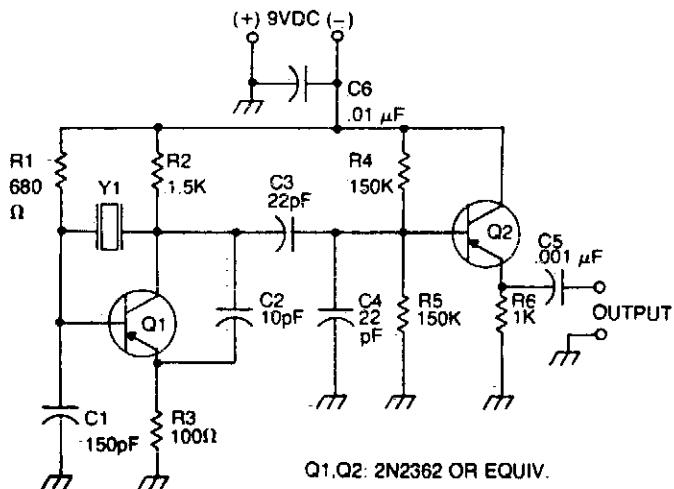


Fig. 19-39

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

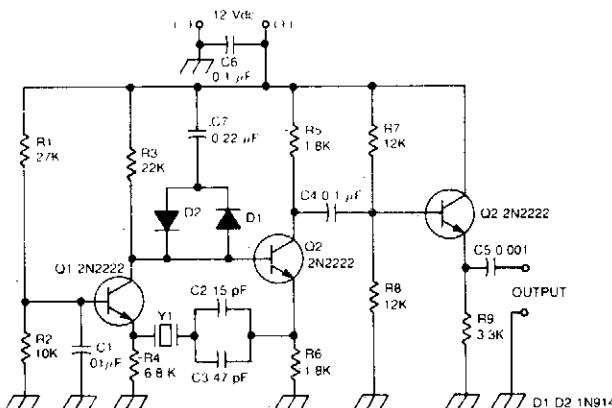


Fig. 19-40

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

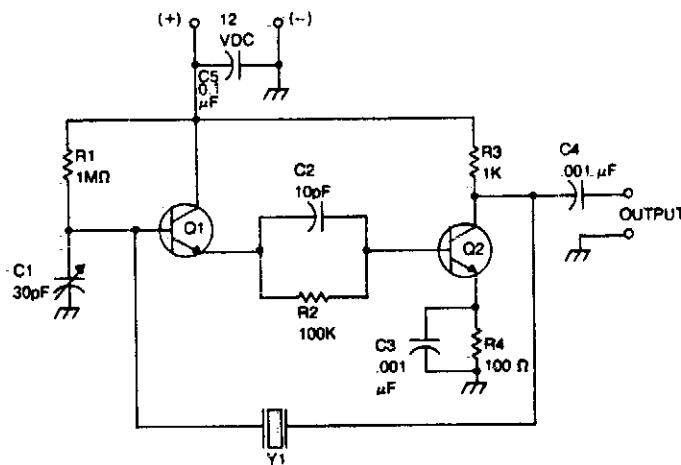


Fig. 19-41

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 22 pF.

INTERNATIONAL CRYSTAL OF-1 HI OSCILLATOR

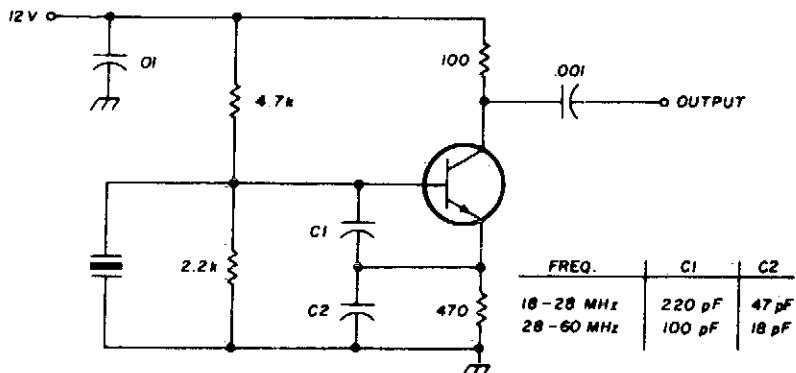


Fig. 19-42

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

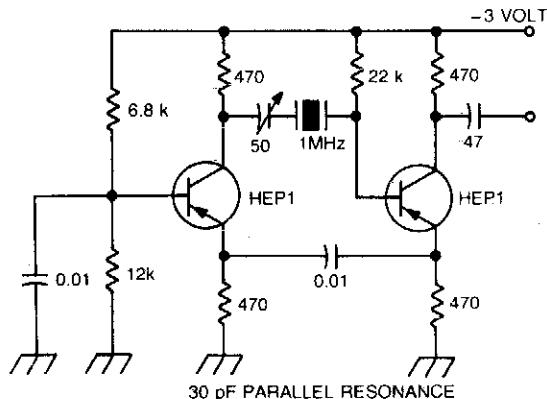


Fig. 19-43

TTL-COMPATIBLE CRYSTAL OSCILLATOR

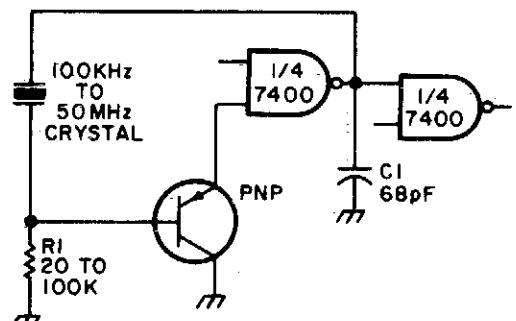


Fig. 19-44

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

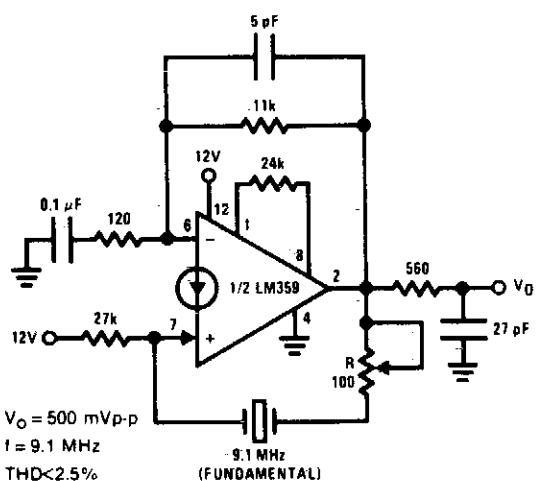


Fig. 19-45

STABLE LOW FREQUENCY CRYSTAL OSCILLATOR

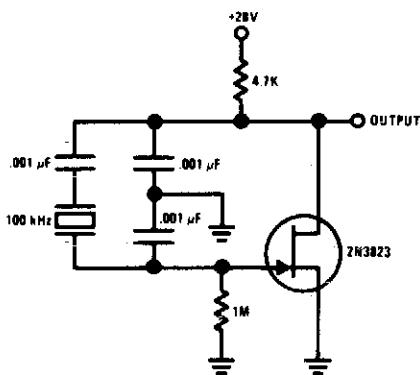


Fig. 19-47

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

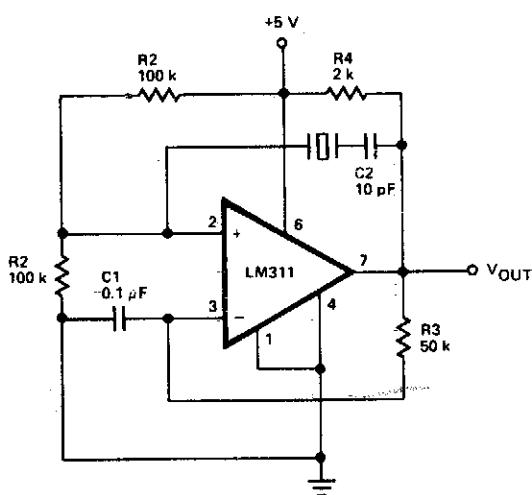


Fig. 19-46

JFET PIERCE CRYSTAL OSCILLATOR

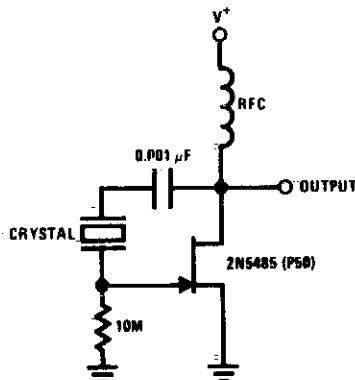


Fig. 19-48

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

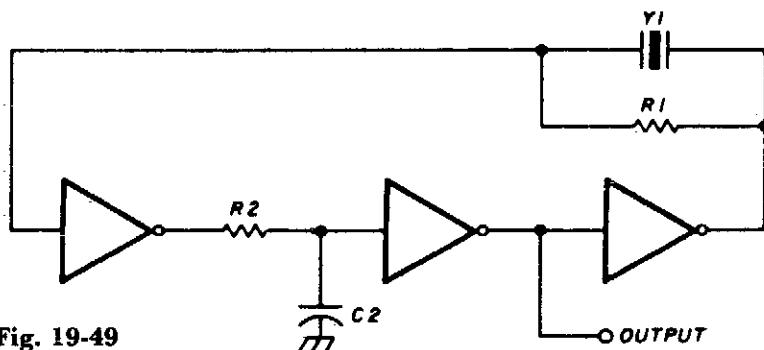


Fig. 19-49

NOTES:

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

PIERCE HARMONIC OSCILLATOR (100 MHz)

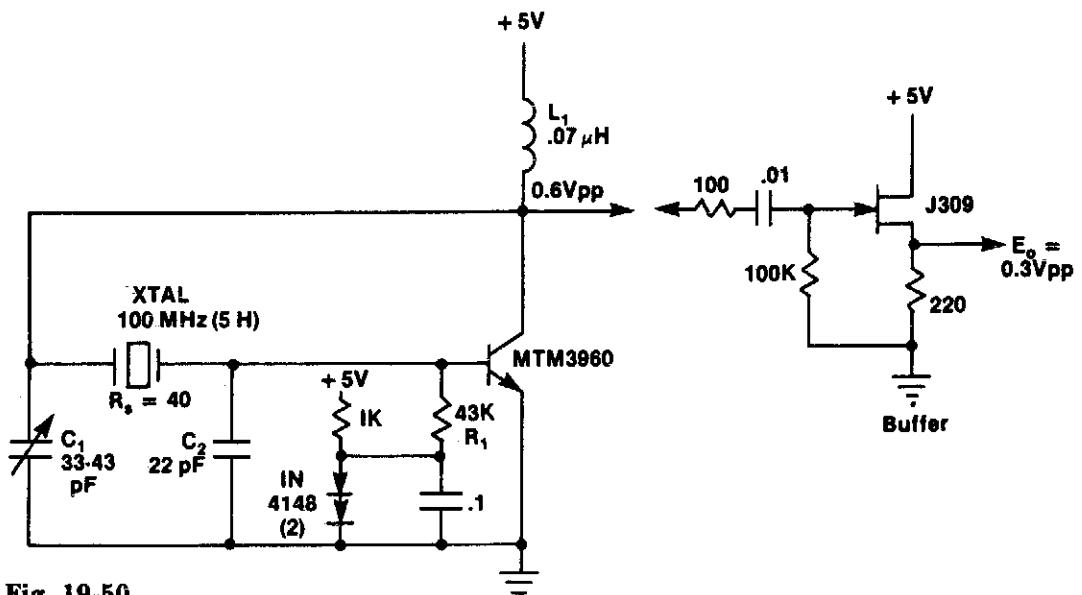


Fig. 19-50

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

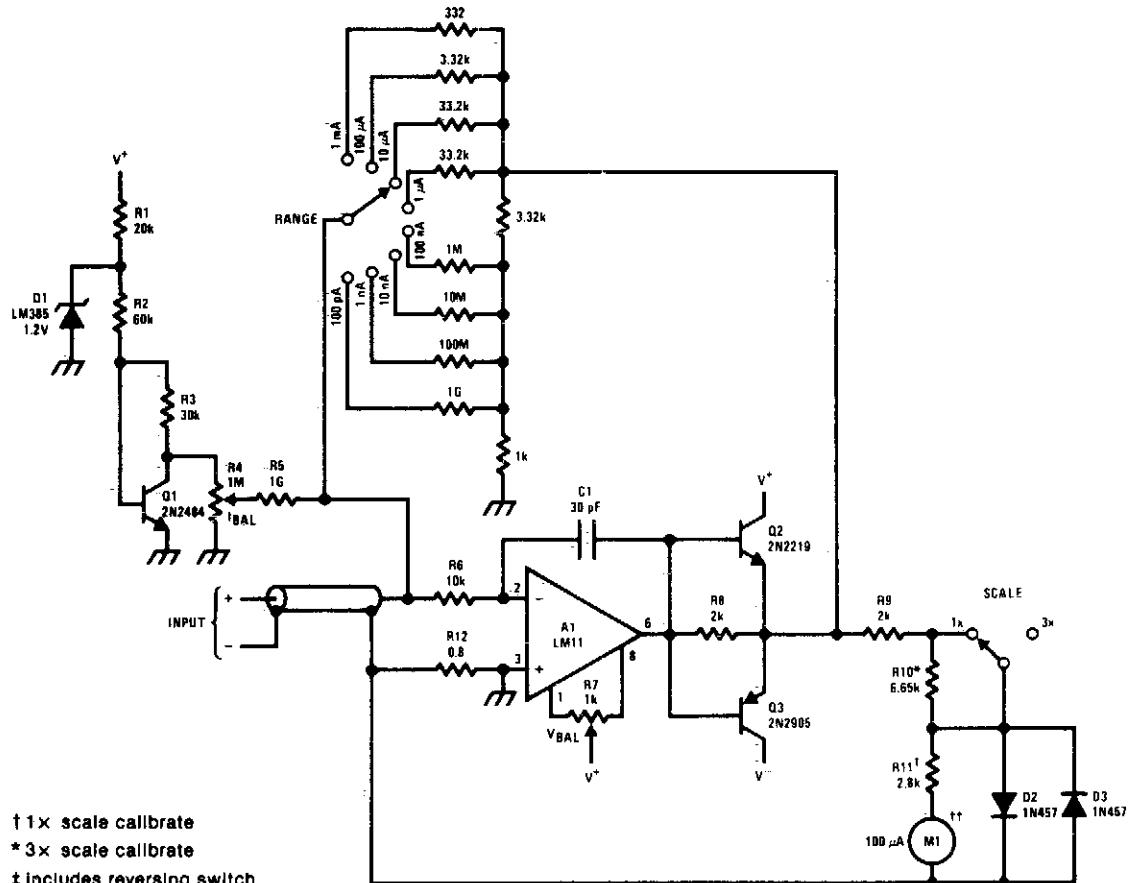
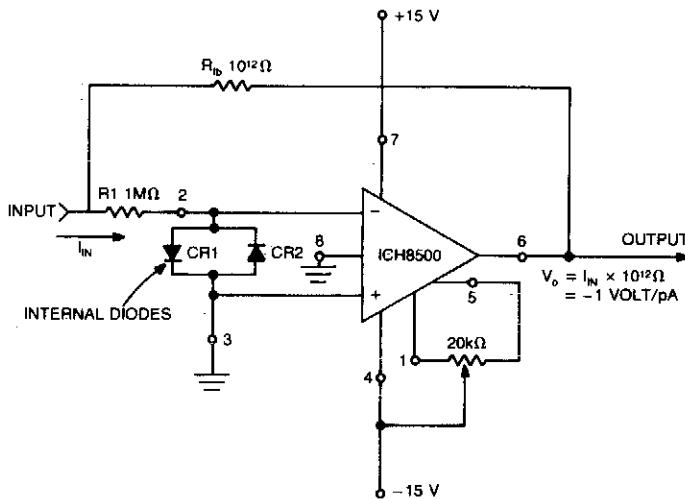


Fig. 20-1

Circuit Notes

Current meter ranges from 100 pA to 3 mA full scale. Voltage across input is $100 \mu\text{V}$ 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

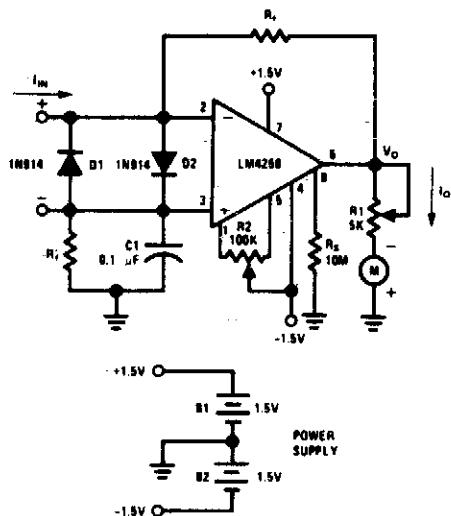


Circuit Notes

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



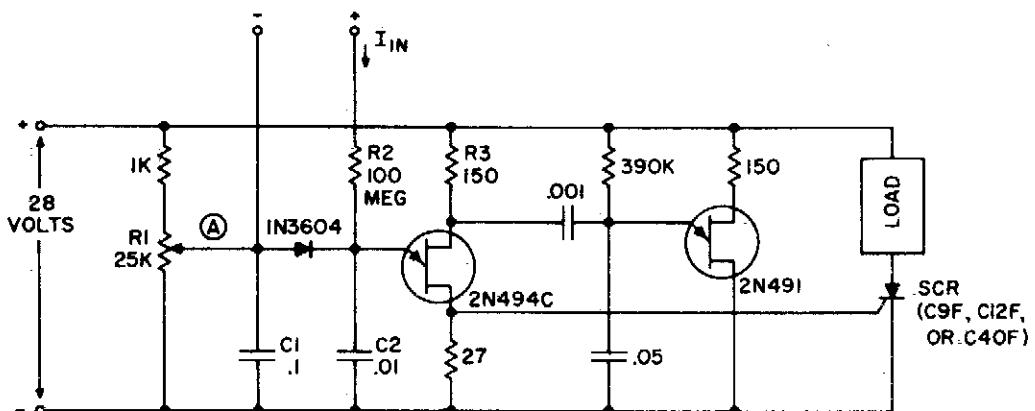
Resistance Values for
DC Nano-and Micro Ammeter

I FULL SCALE	R _f [Ω]	R _i [Ω]
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



NANOAMPERE SENSING CIRCUIT WITH
100 MEGOHM INPUT IMPEDANCE

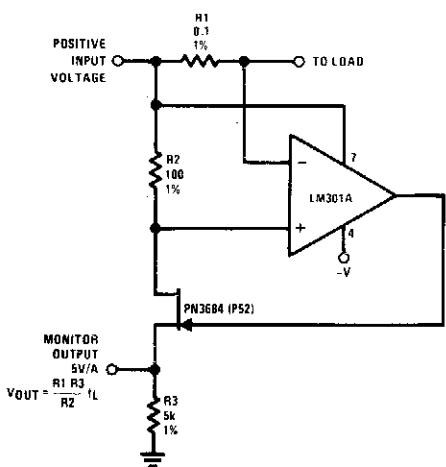
Fig. 20-4

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 μ A to 1 mA Current Sources

Precision Current Sink

CURRENT SOURCE

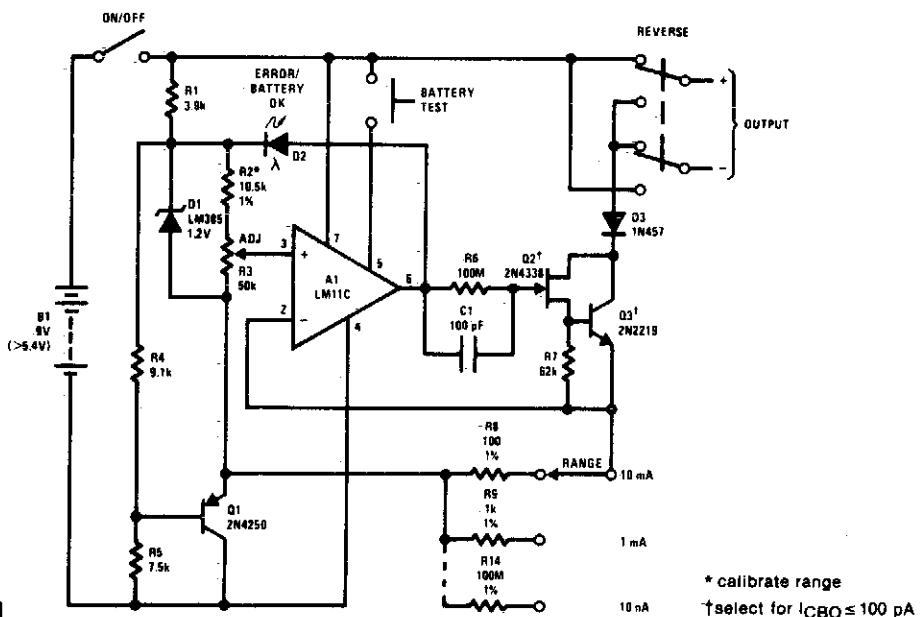


Fig. 21-1

Circuit Notes

This precision current source has $10 \mu\text{A}$ 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

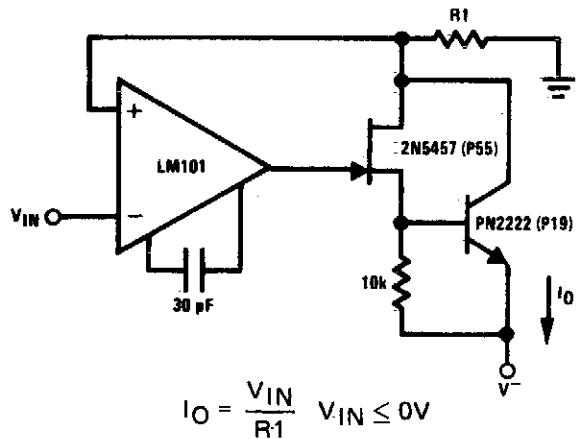


Fig. 21-2

Circuit Notes

The 2N5457 and PN2222 bipolar serve as voltage isolation devices between the output and the current sensing resistor, R_1 . 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 mA), the PN2222 and 10K resistor may be eliminated with the output appearing at the source of the 2N5457.

PRECISION 1 μ A to 1 mA CURRENT SOURCES

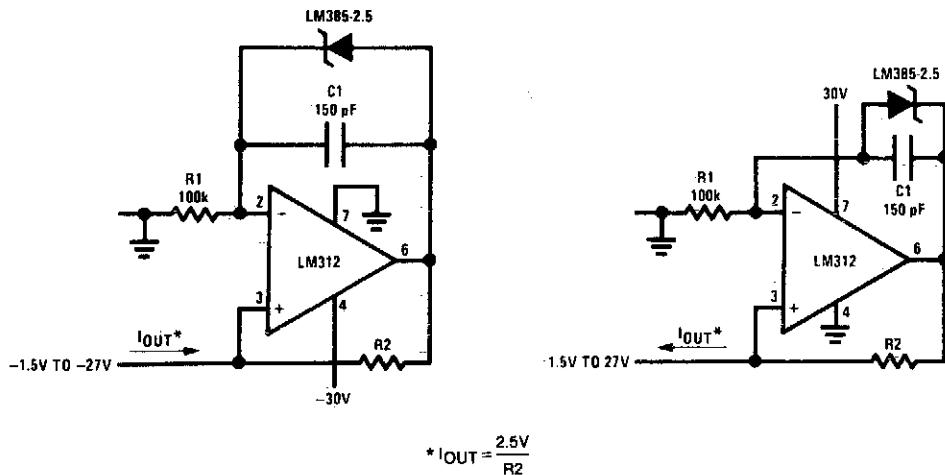
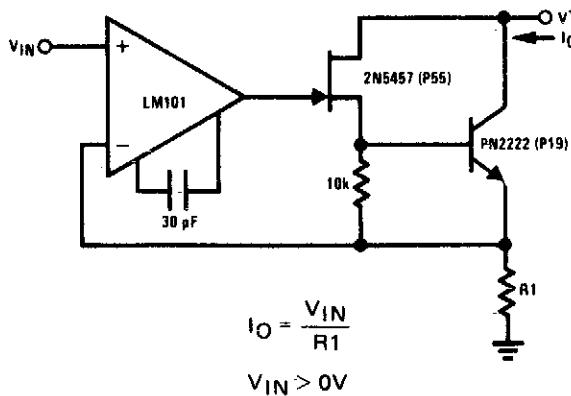


Fig. 21-3

PRECISION CURRENT SINK



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.

Fig. 21-4

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

Current Source

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

Regulated Dc-to-Dc Converter

Mini Power Inverter as High Voltage, Low

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

Dc/Dc Regulating Converter

Flyback Converter

DC-TO-DC/AC INVERTER

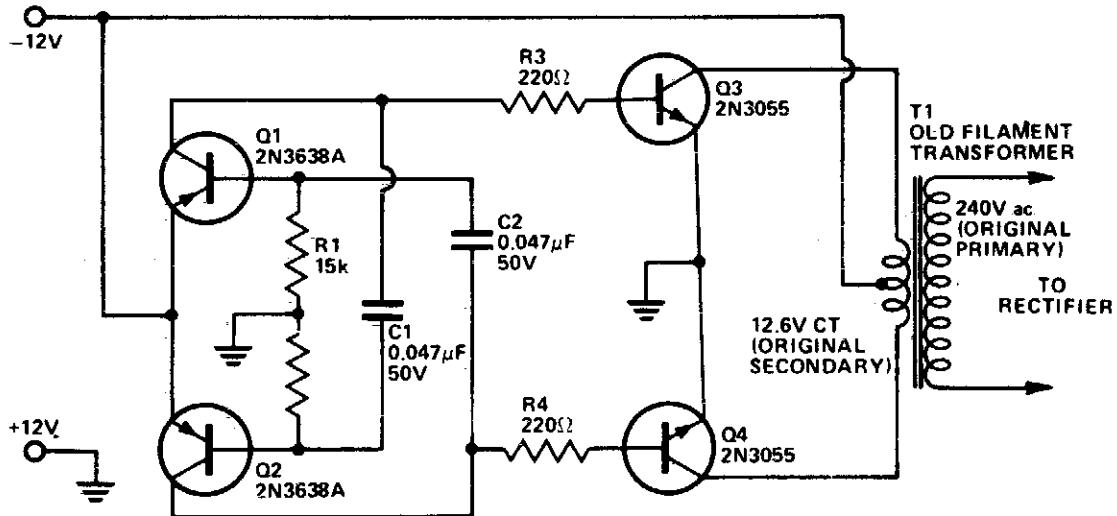


Fig. 22-1

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

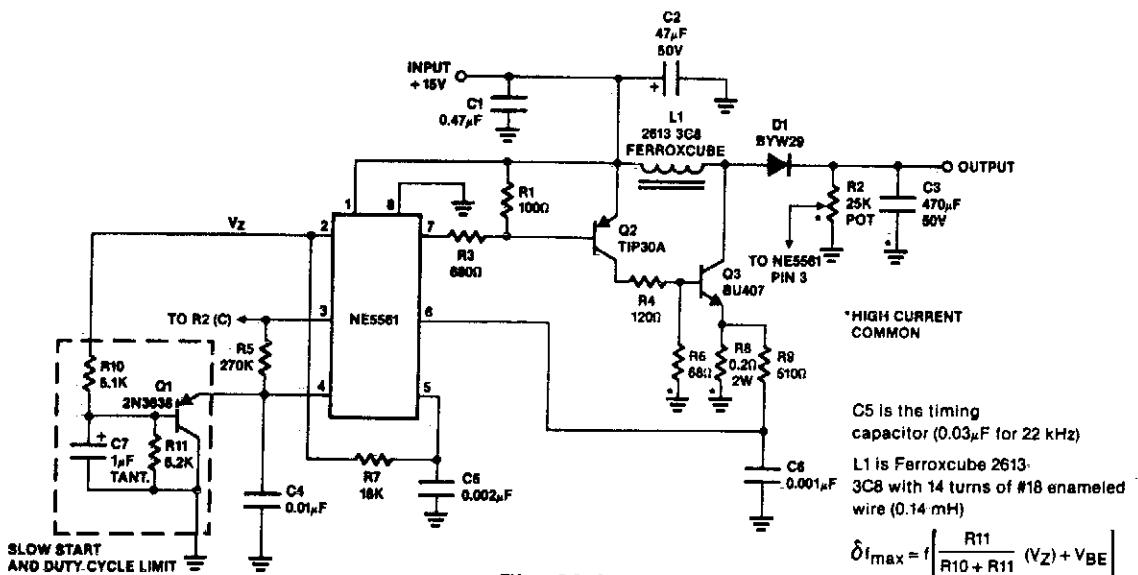


Fig. 22-2

MINI POWER INVERTER AS HIGH VOLTAGE, LOW CURRENT SOURCE

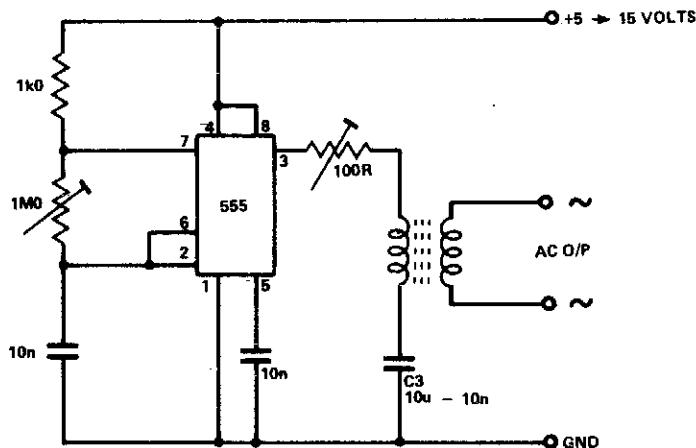


Fig. 22-3

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

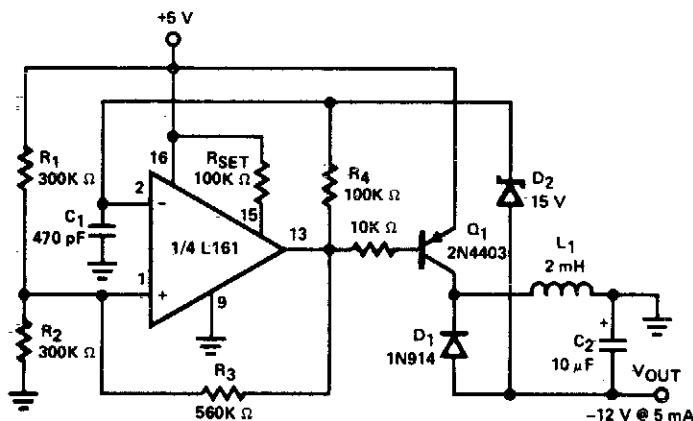


Fig. 22-4

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

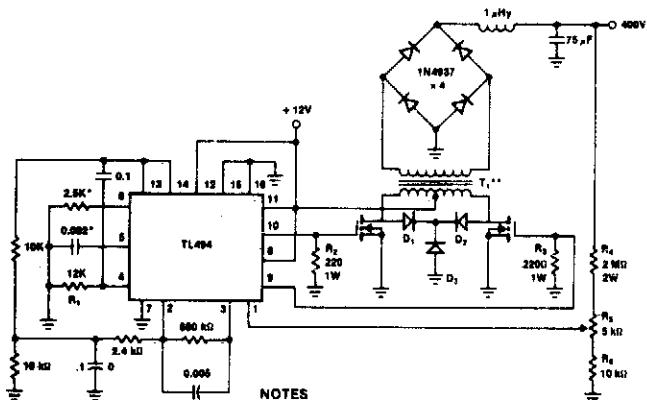


Fig. 22-5

NOTES
UNLESS OTHERWISE NOTED,
ALL RESISTORS 5%, 1/4W
ALL CAPACITOR VALUES IN MICROFARADS, 25V
Q₁ & Q₂: VN64GA ON HEAT SINK
D₁ & D₂: 1N4934
D₃: 33V, 3W ZENER
T₁: PRI: 12T, CT, NO 18 AWG
SEC: 27T, NO 24 AWG
CORE: IND GEN 8231-1

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

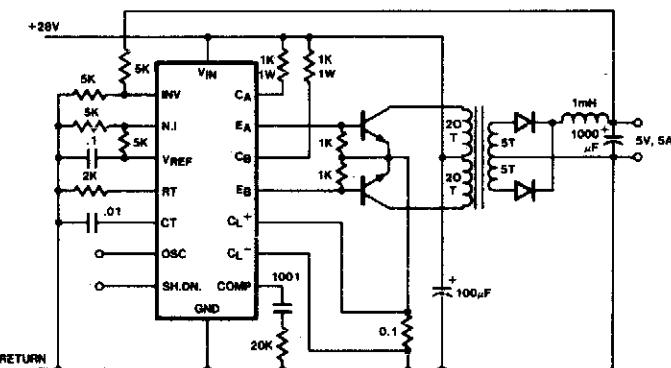


Fig. 22-6

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 frequency 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

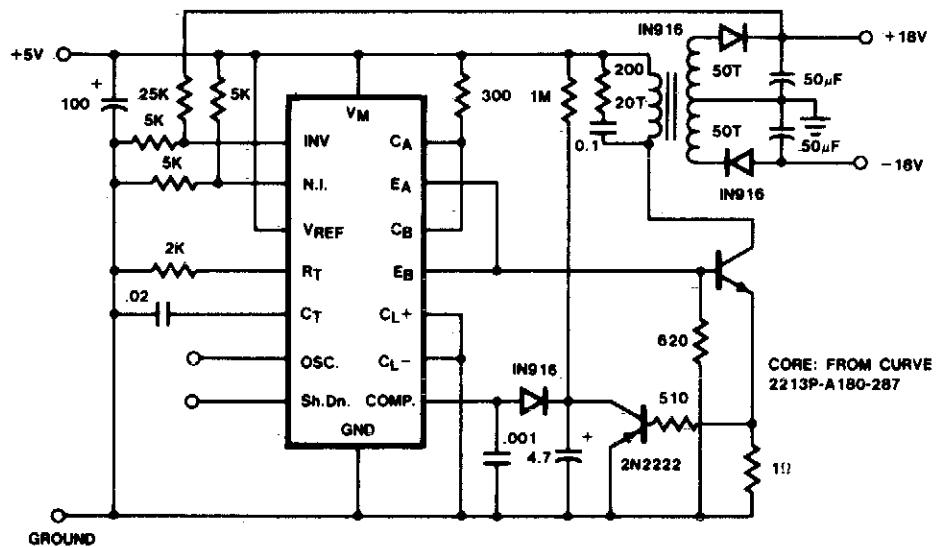


Fig. 22-7

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

10.8 MHz FSK Decoder

Tone Decoder with Relay Output

24% Bandwidth Tone Decoder

SCA Decoder

Dual-Tone Decoder

TONE-ALERT DECODER

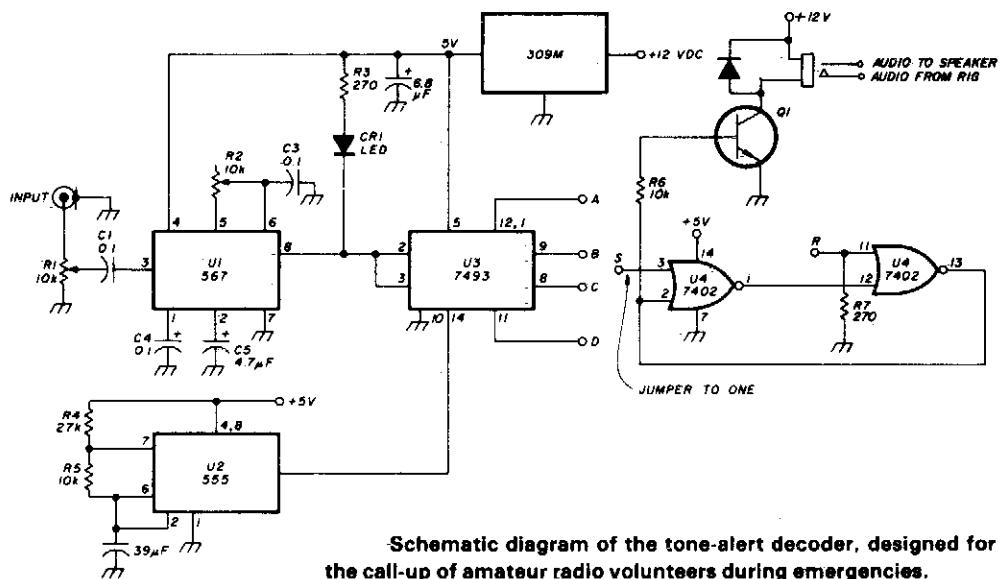


Fig. 23-1

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

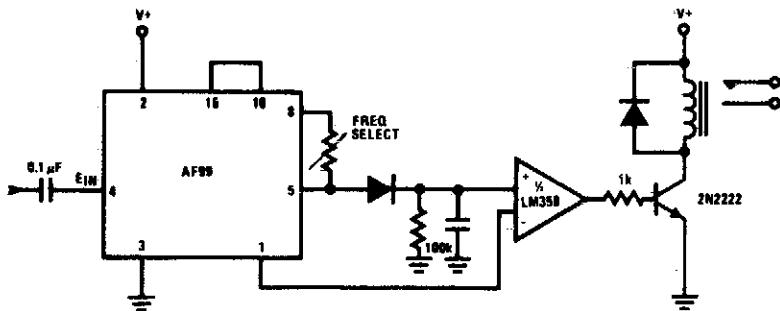


Fig. 23-2

SCA (BACKGROUND MUSIC) DECODER

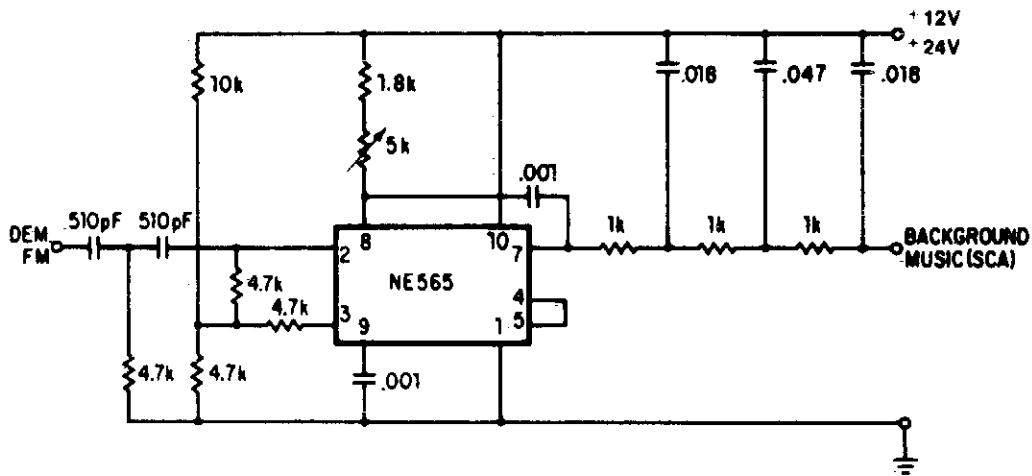


Fig. 23-3
Circuit Notes

A resistive voltage divider is used to establish a bias voltage for the input (pins 2 and 3). The demodulated (multiplex) FM signal is fed to the input through a two-stage high-pass filter, both to effect capacitive coupling and to attenuate the strong signal of the regular channel. A total signal amplitude, between 80 mV and 300 mV, is required at the input. Its source should have an impedance of less than 10,000 ohms. The Phase Locked Loop is tuned to 67

kHz with a 5000 ohm potentiometer; only approximate tuning is required, since the loop will seek the signal. The demodulated output (pin 7) passes through a three-stage low-pass filter to provide de-emphasis and attenuate the high-frequency noise which often accompanies SCA transmission. The demodulated output signal is in the order of 50m V and the frequency response extends to 7 kHz.

10.8 MHz FSK DECODER

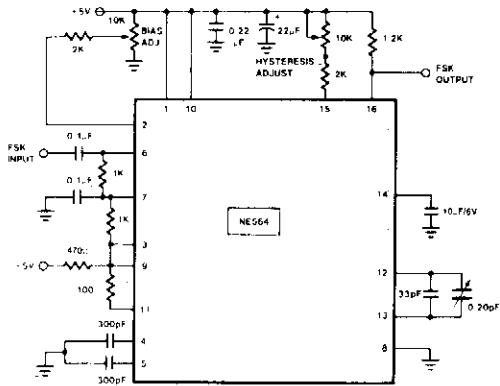


Fig. 23-4

24% BANDWIDTH TONE DECODER

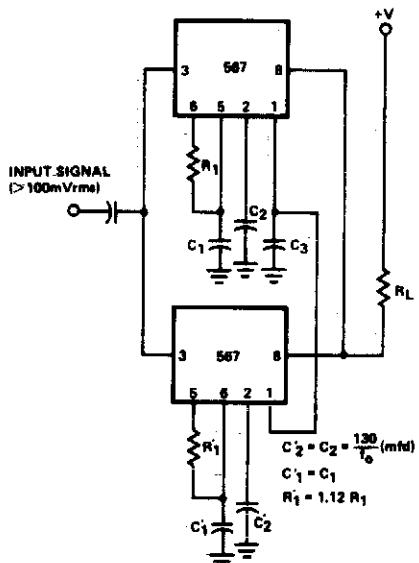


Fig. 23-5

DUAL-TONE DECODER

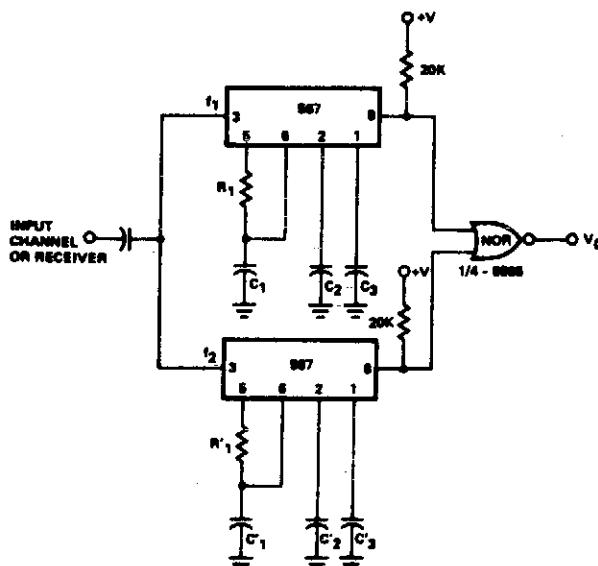


Fig. 23-6

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

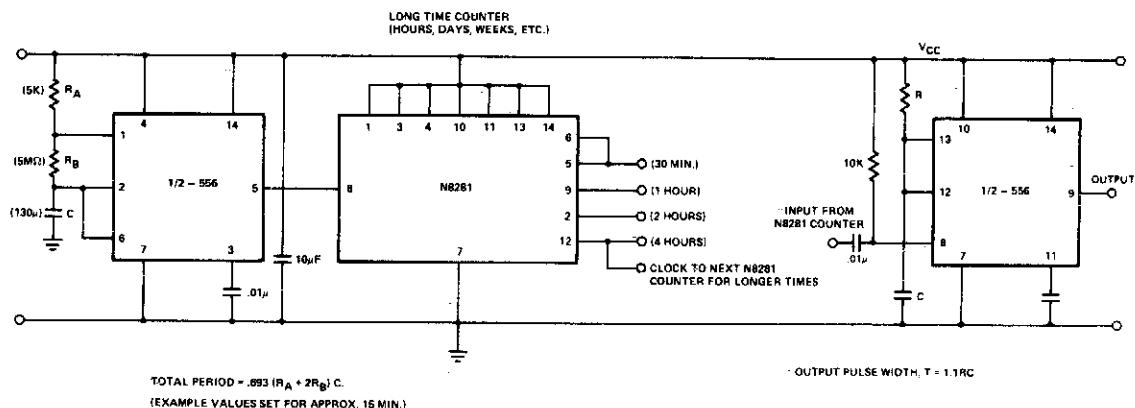


Fig. 24-1

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

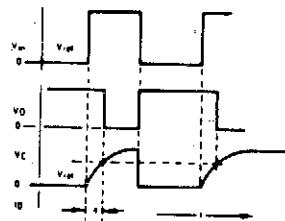
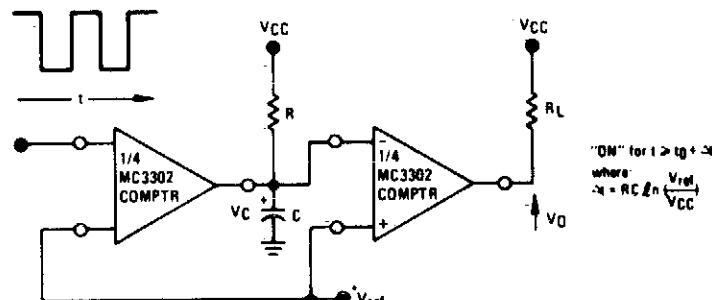


Fig. 24-2

DOOR CHIMES DELAY

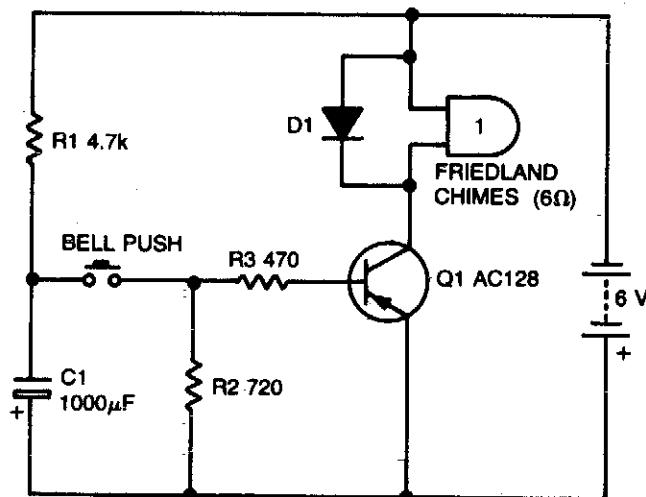


Fig. 24-3

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

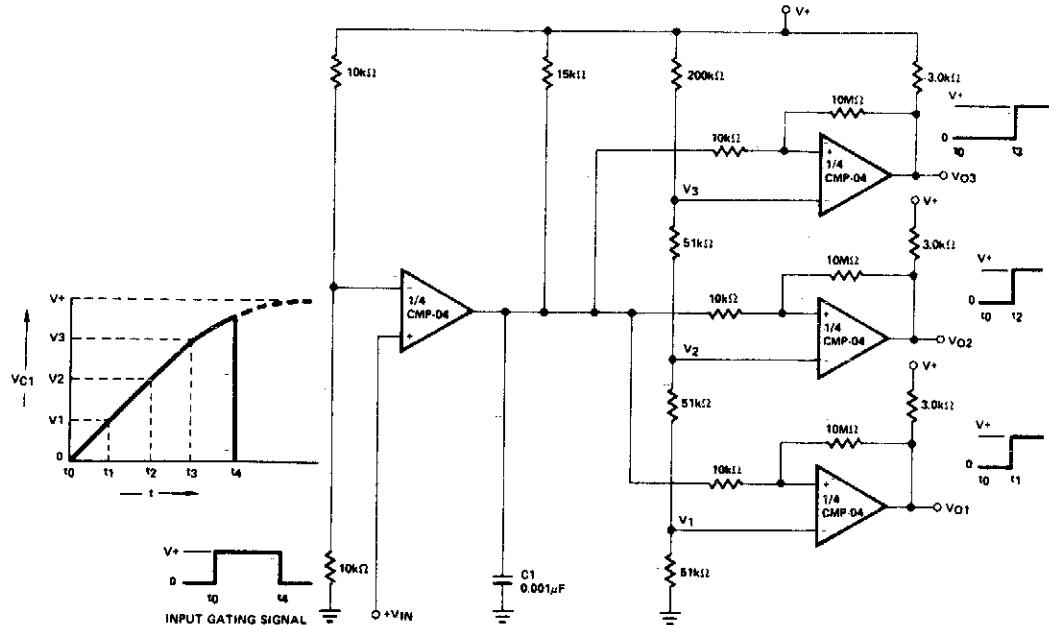


Fig. 24-4

LONG DELAY TIMER USING PUT

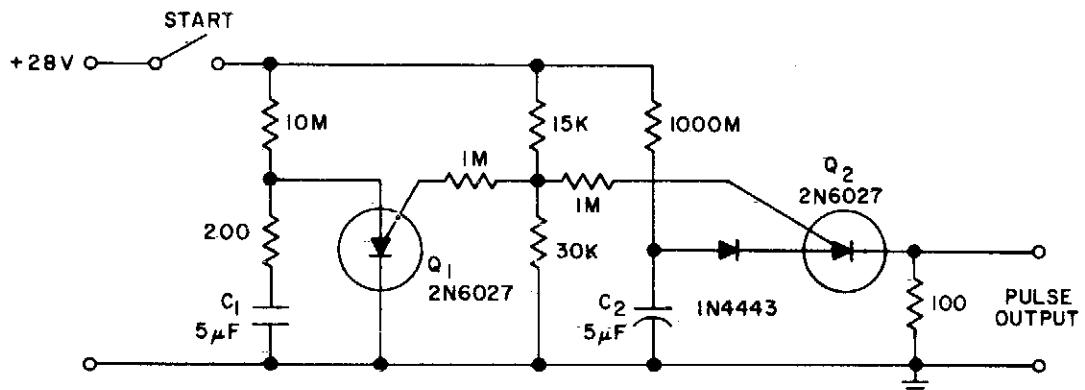


Fig. 24-5

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

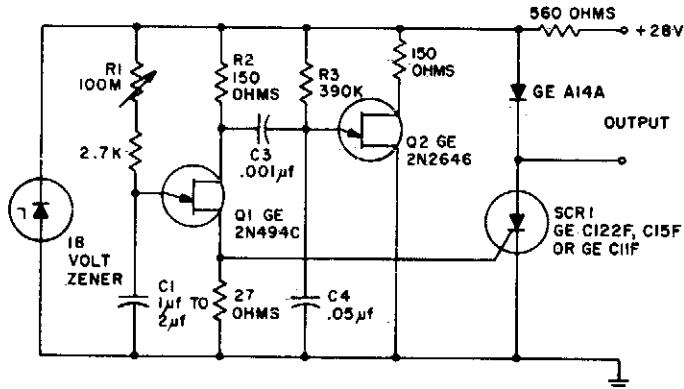


Fig. 24-6

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

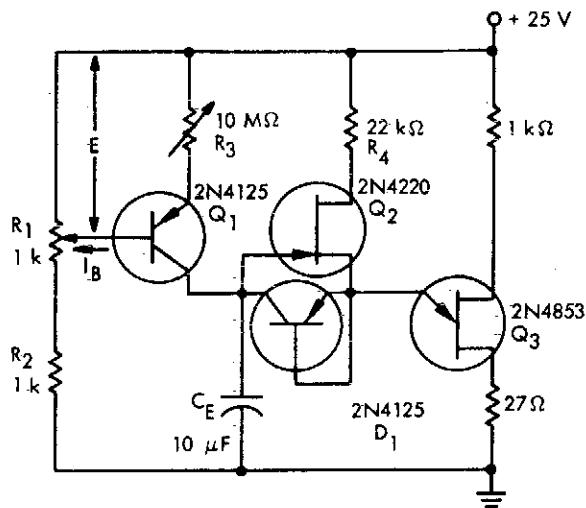


Fig. 24-7

SIMPLE TIME DELAY

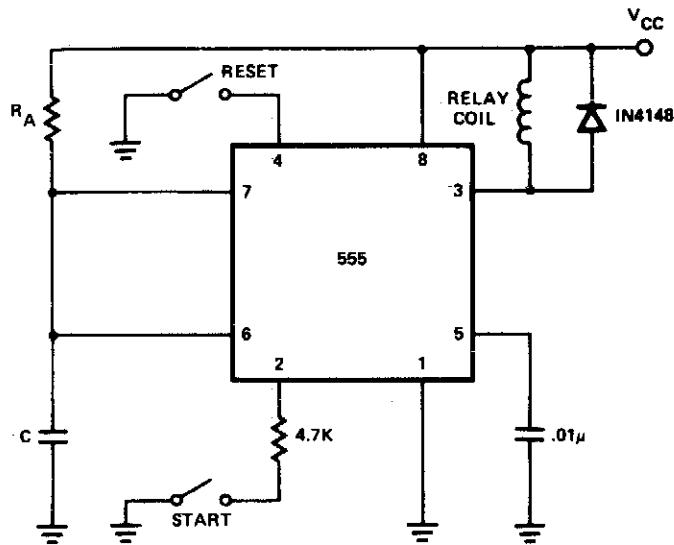


Fig. 24-8

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

AIR-MOTION DETECTOR

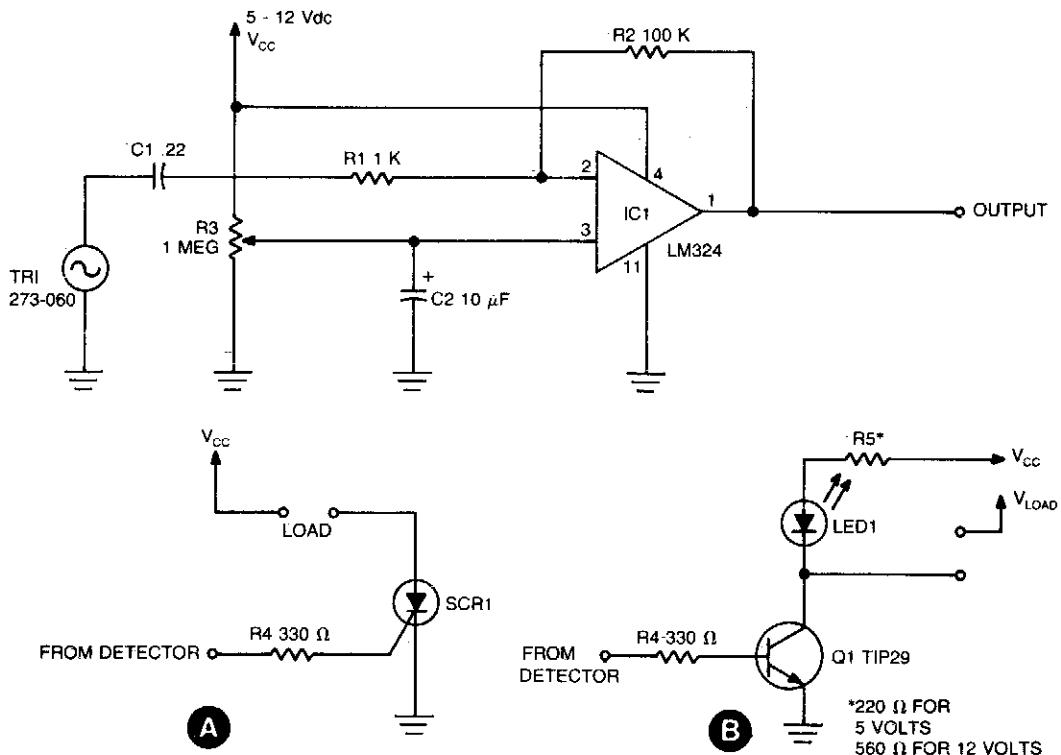


Fig. 25-1

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.

PRODUCT DETECTOR

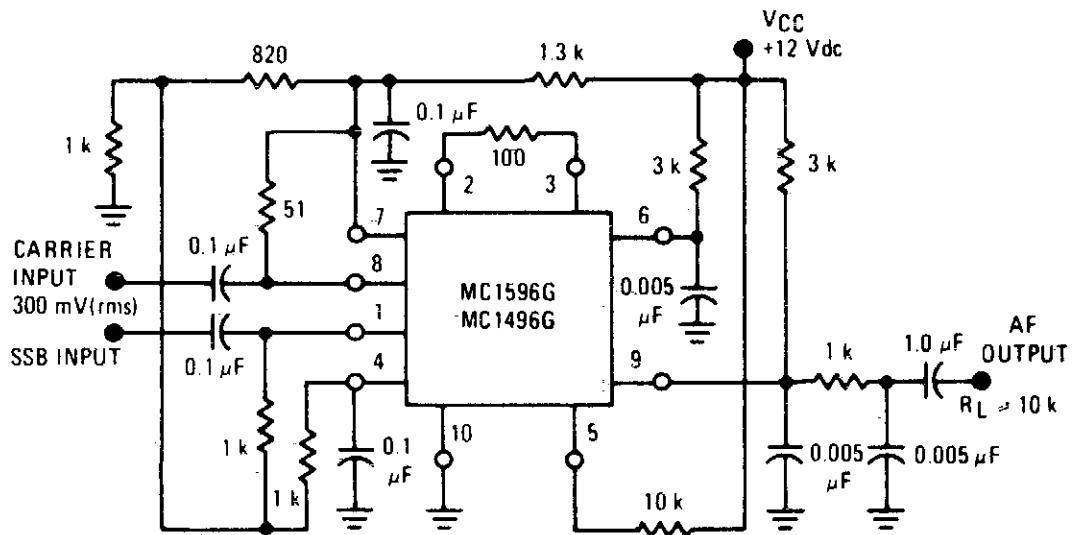


Fig. 25-2

Circuit Notes

The MC1596/MC1496 makes an excellent SSB product detector. This product detector has a sensitivity of 3.0 microvolts and a dynamic range of 90 dB when operating at an intermediate frequency of 9 MHz. The detector is broadband for the entire high frequency range. For operation at very low intermediate frequencies down to 50 kHz the 0.1 μ F capacitors on pins 7 and 8 should be increased to 1.0 μ F. Also, the output filter at pin 9 can be tailored to a specific intermediate frequency and audio amplifier input impedance. The emitter resistance between pins 2 and 3 may be

increased or decreased to adjust circuit gain, sensitivity, and dynamic range. This circuit may also be used as an AM detector by introducing carrier signal at the carrier input and an AM signal at the SSB input. The carrier signal may be derived from the intermediate frequency signal or generated locally. The carrier signal may be introduced with or without modulation, provided its level is sufficiently high to saturate the upper quad differential amplifier. If the carrier signal is modulated, a 300 mV (rms) input level is recommended.

LOW VOLTAGE DETECTOR

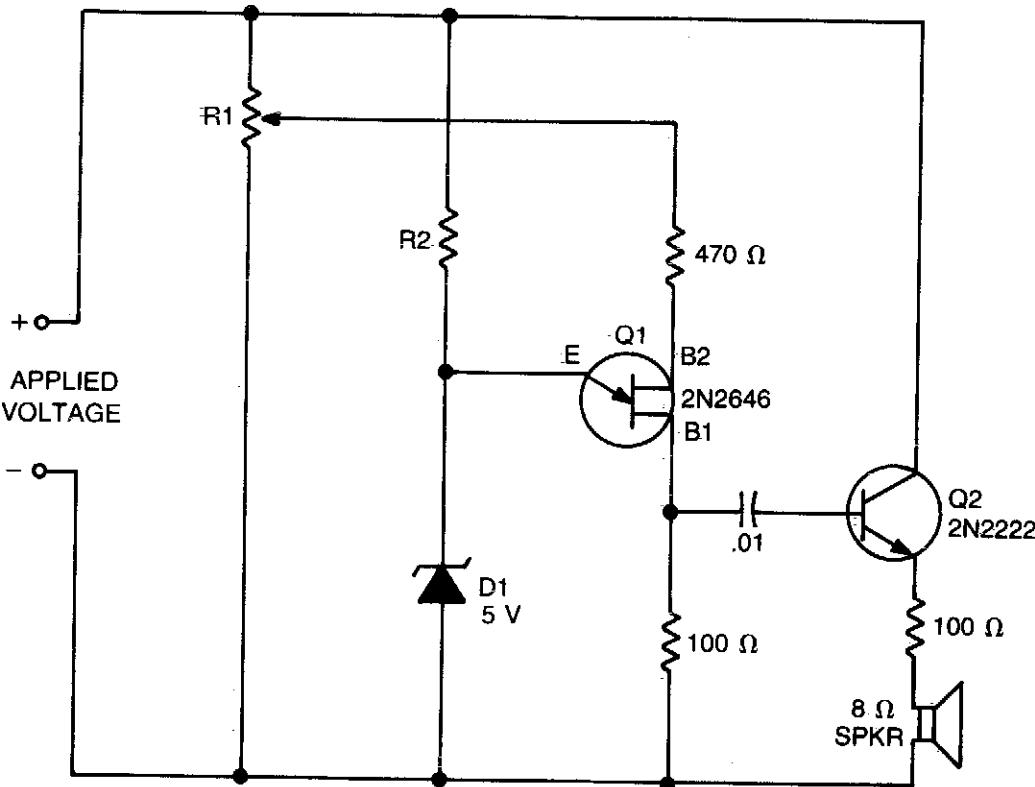


Fig. 25-3

Circuit Notes

The values of R_1 , R_2 , and D_1 are selected for the voltage applied. Using a 12-volt battery, $R_1 = 10\text{ K}$, $R_2 = 5.6\text{ K}$ and D_1 is a 5-volt zener diode, or a string of forward-biased silicon rectifiers equaling about 5 volts. Transistor Q_1 is a general-purpose UJT (Unijunction Transistor), and Q_2 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 R_1 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 R_1 so that it draws only 1 mA or 2 mA. Zener diode D_1 is about one-half of the desired trip voltage, and R_2 is selected to bias it about 1 mA.

POSITIVE PEAK DETECTOR

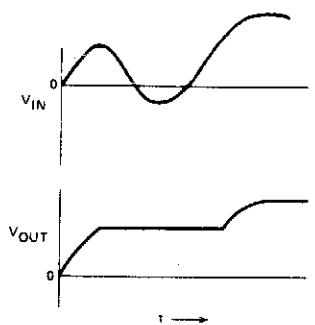
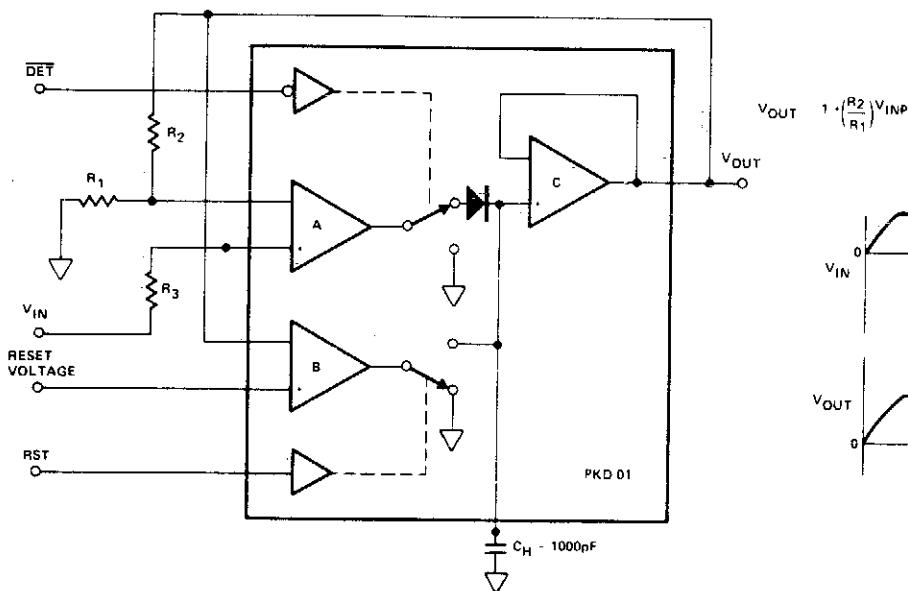


Fig. 25-4

NEGATIVE PEAK DETECTOR

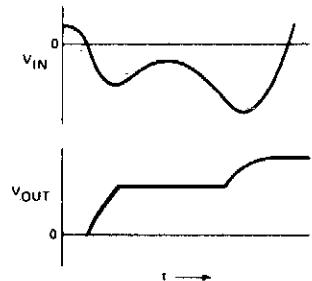
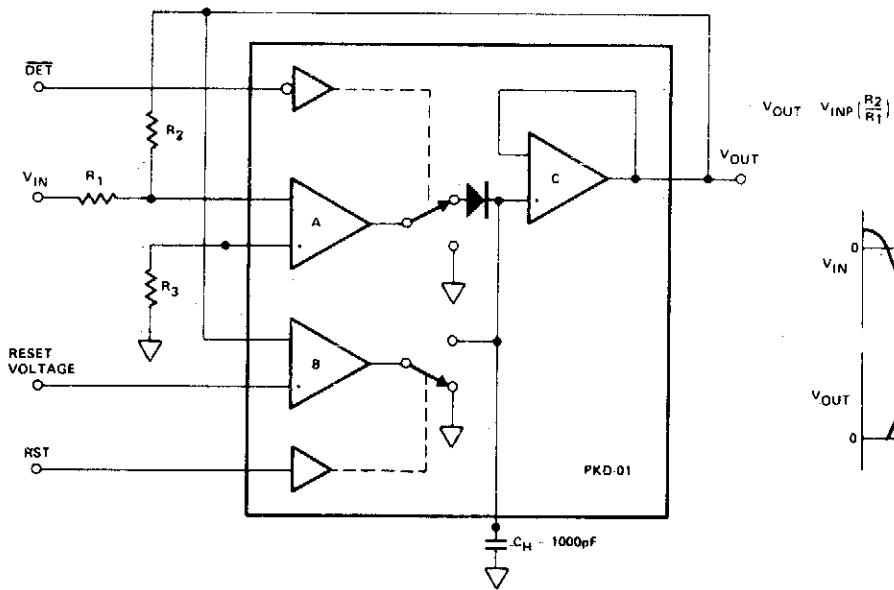


Fig. 25-5

PRECISION PEAK VOLTAGE DETECTOR WITH A LONG MEMORY TIME

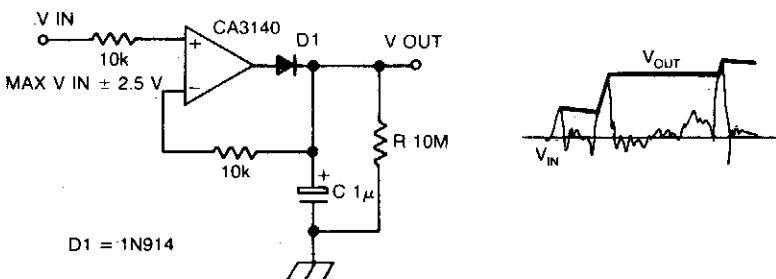


Fig. 25-6

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

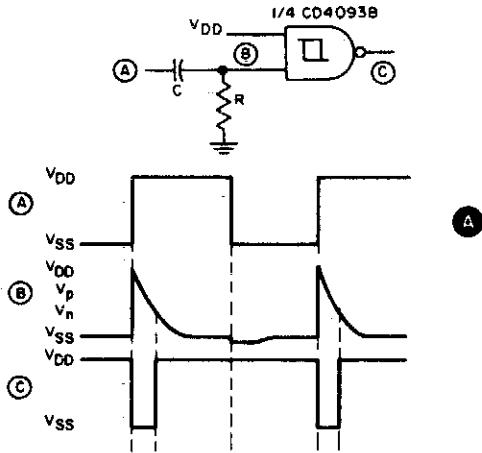
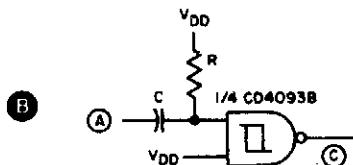


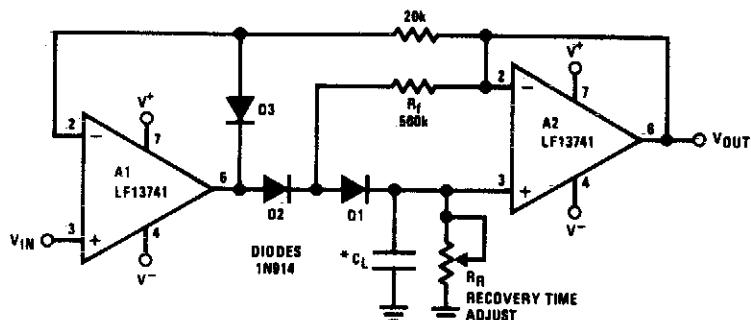
Fig. 25-7

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_g 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

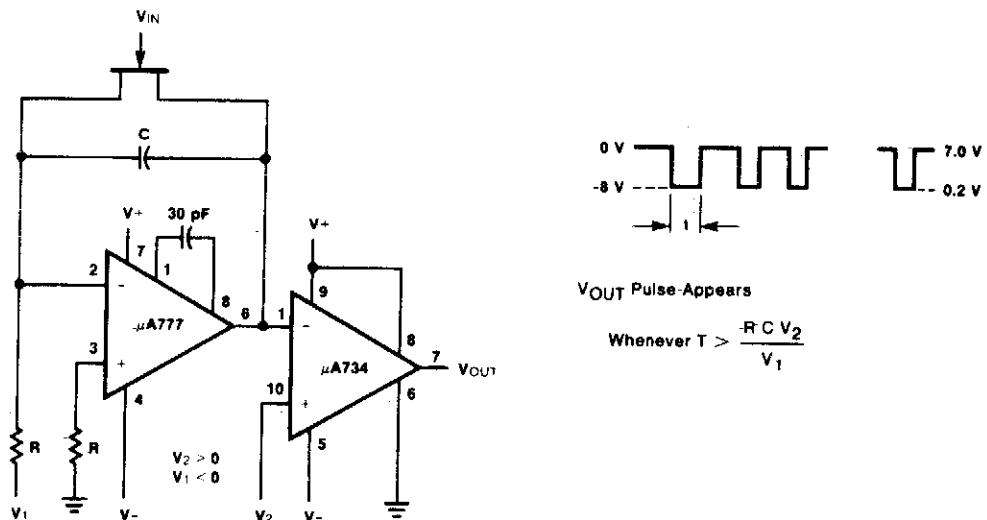
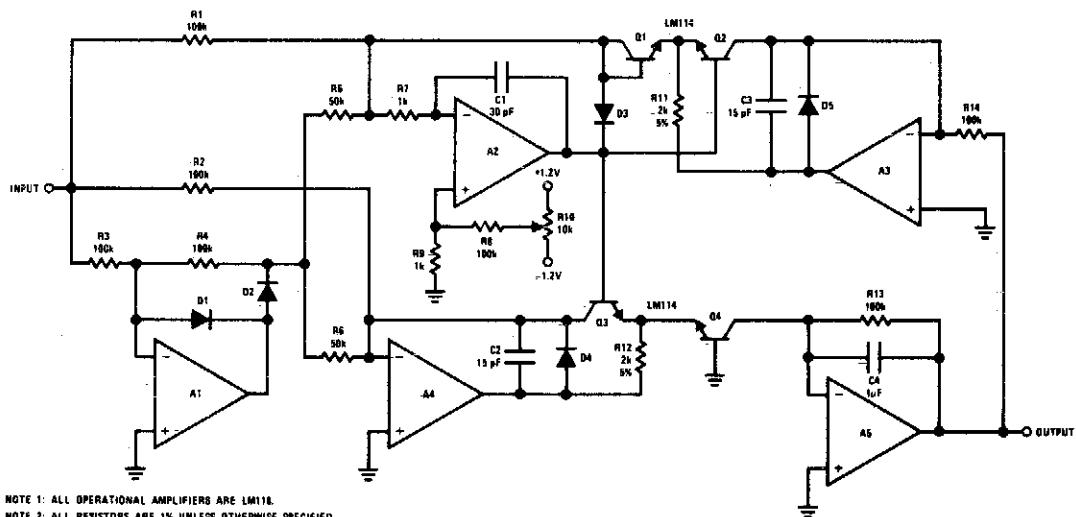


Fig. 25-9

TRUE RMS DETECTOR



NOTE 1: ALL OPERATIONAL AMPLIFIERS ARE LM111.
 NOTE 2: ALL RESISTORS ARE 1% UNLESS OTHERWISE SPECIFIED.
 NOTE 3: ALL DIODES ARE 1N914.
 NOTE 4: SUPPLY VOLTAGE >15V.

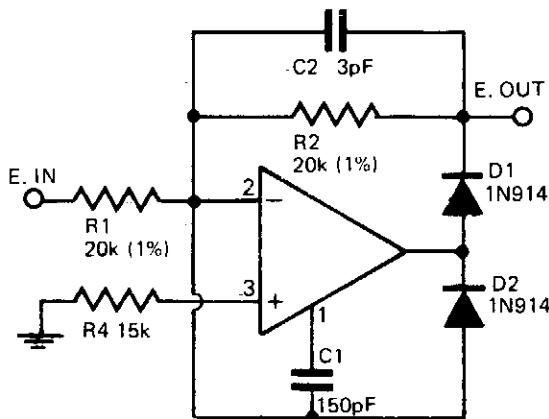
Fig. 25-10

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



Circuit Notes

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

Fig. 25-11

TELEMETRY DEMODULATOR

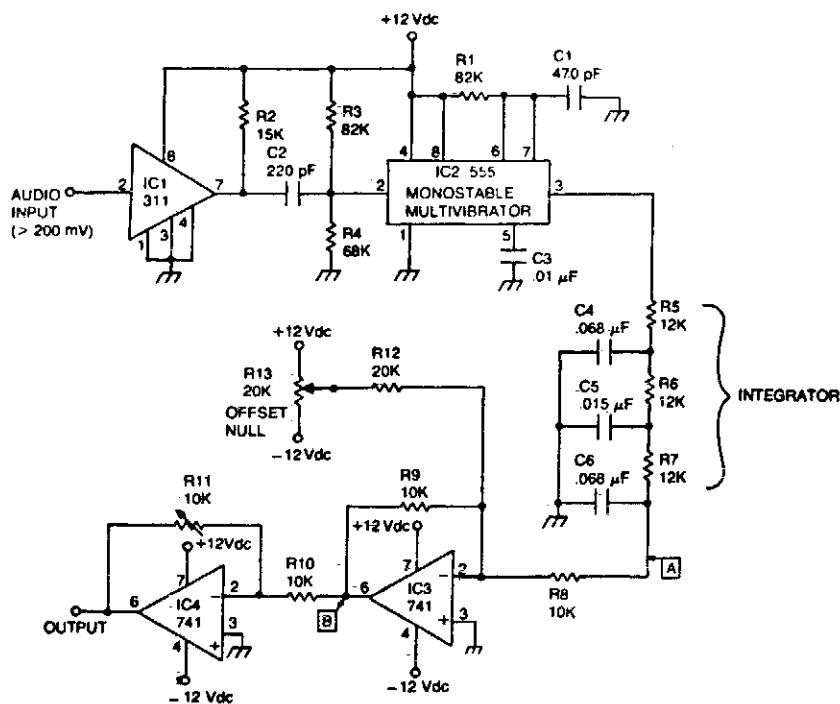


Fig. 25-12

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

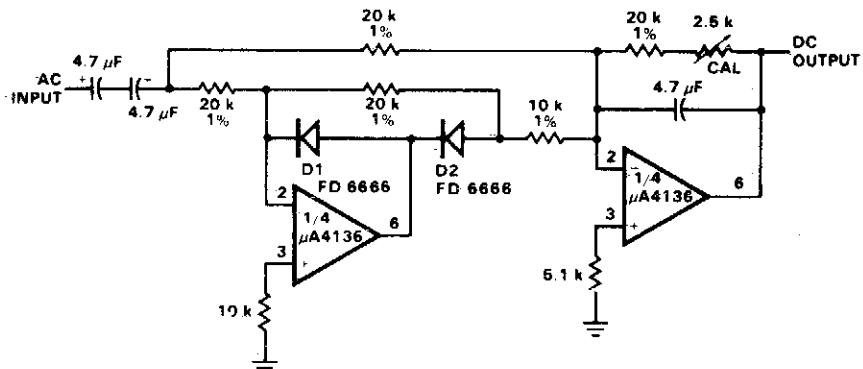
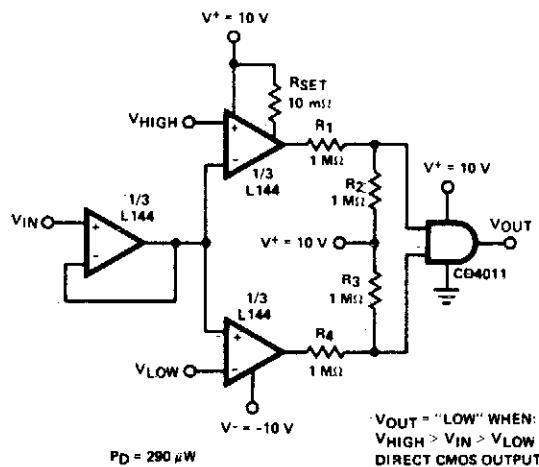


Fig. 25-13

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 R₁, R₂, R₃, and R₄ 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 $290\text{ }\mu\text{W}$ while in limit and $330\text{ }\mu\text{W}$ while out of limit.

Fig. 25-14

HALF-WAVE RECTIFIER

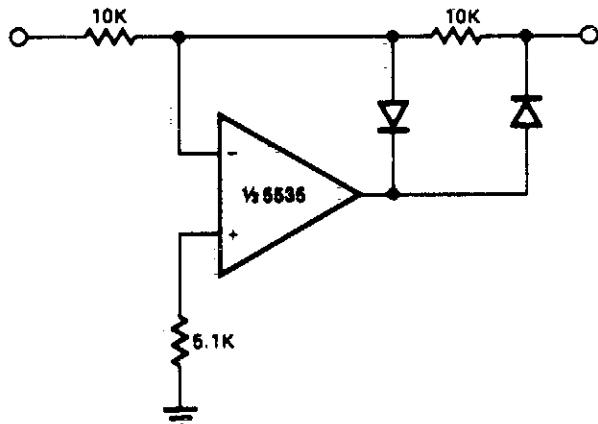


Fig. 25-15

All resistor values are in ohms.

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.

TONE DETECTOR

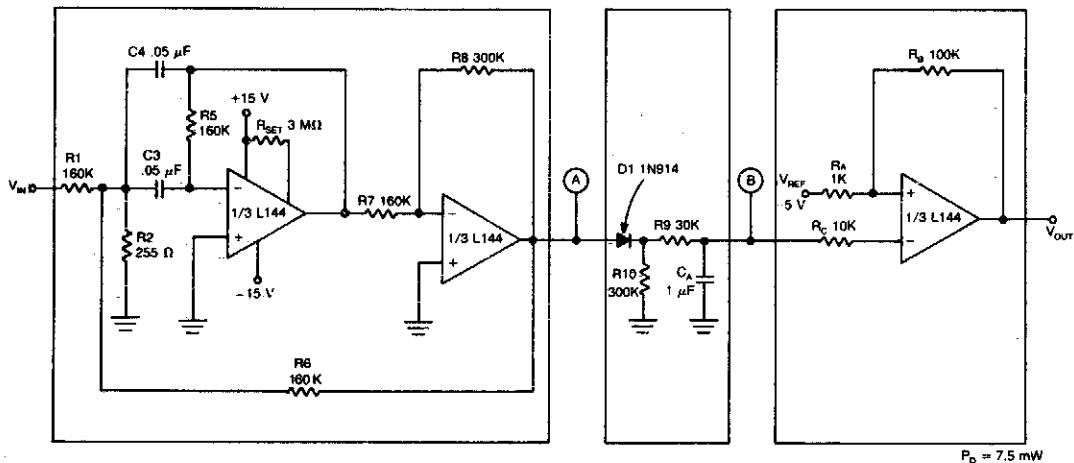


Fig. 25-16

Circuit Notes

The detector circuit is made up a two-amplifier multiple feedback bandpass filter followed by an ac-to-dc detector section and a Schmitt Trigger. The bandpass filter (with a Q of greater than 100) passes only 500 Hz inputs which are in turn rectified by D1 and filtered by

R9 and CA. This filtering action in combination with the trigger level of 5 V for the Schmitt device insures that at least 55 cycles of 500 Hz input must be present before the output will react to a tone input.

FM TUNER WITH A SINGLE-TUNED DETECTOR COIL

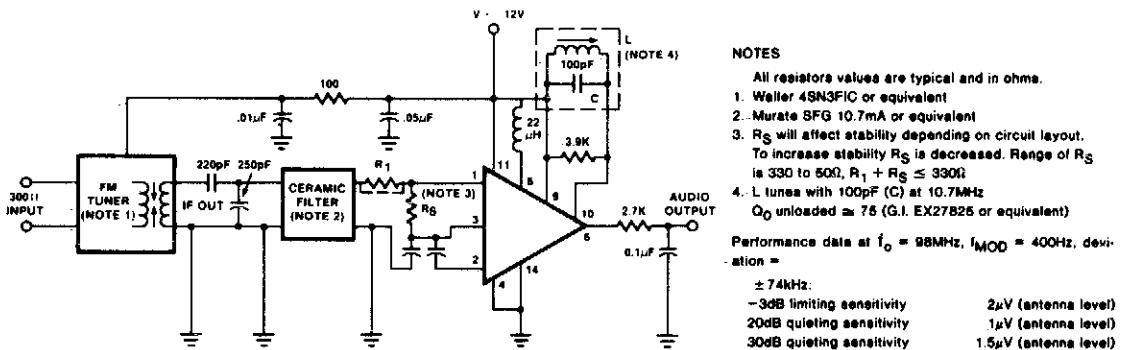


Fig. 25-17

MISSING PULSE DETECTOR

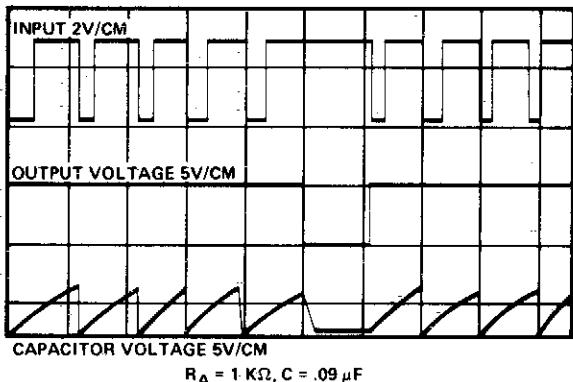
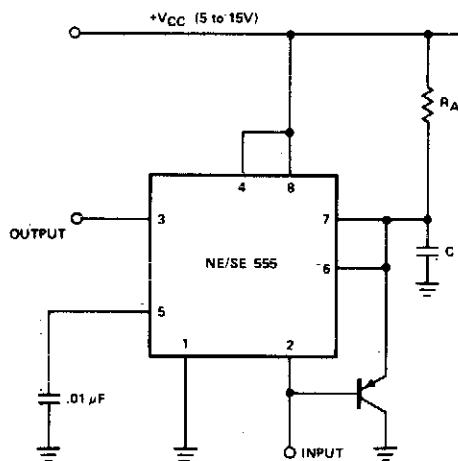


Fig. 25-18

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

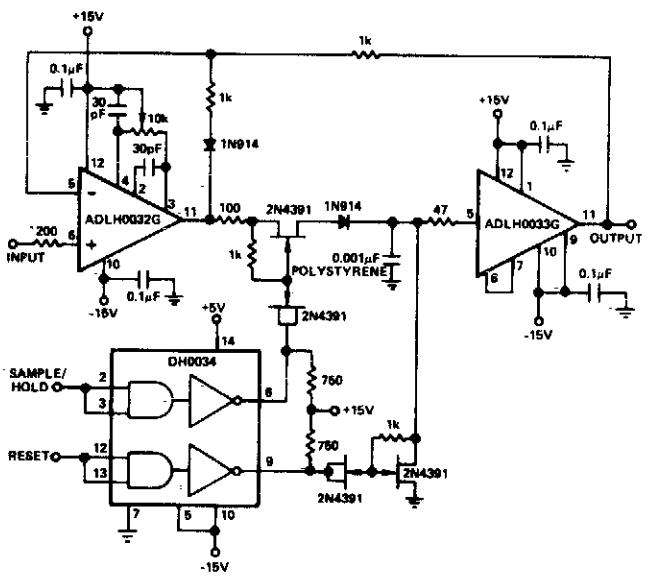


Fig. 25-19

DETECTOR FOR MAGNETIC TRANSDUCER

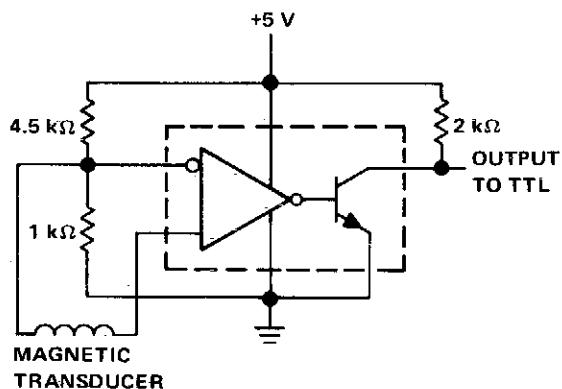


Fig. 25-20

FM DEMODULATOR AT 5 V

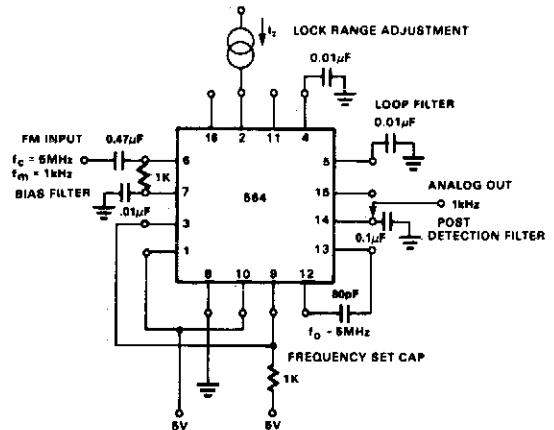


Fig. 25-22

DOUBLE-ENDED LIMIT DETECTOR

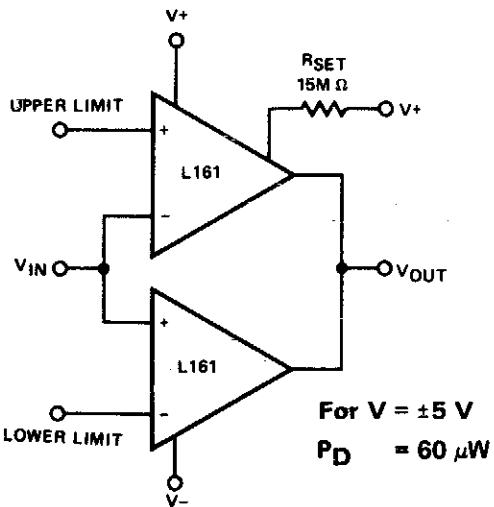


Fig. 25-21

FM DEMODULATOR AT 12 V

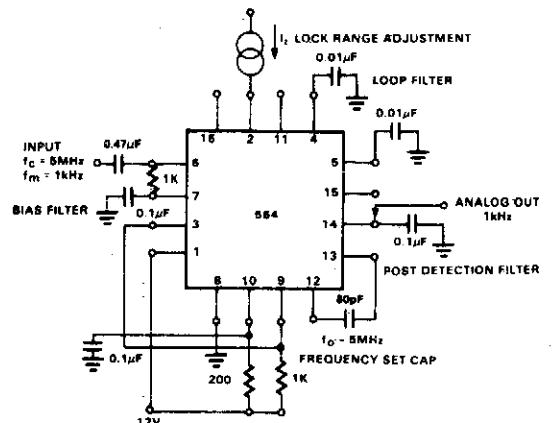


Fig. 25-23

PRECISION FULL WAVE RECTIFIER

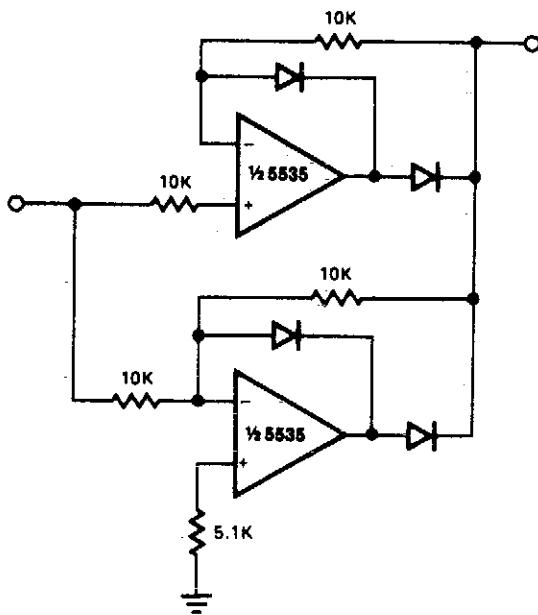


Fig. 25-24

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

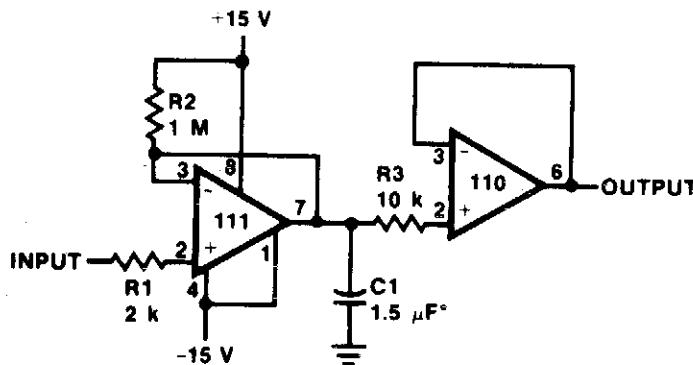


Fig. 25-25

*Solid tantalum

LEVEL DETECTOR WITH HYSTERESIS (POSITIVE FEEDBACK)

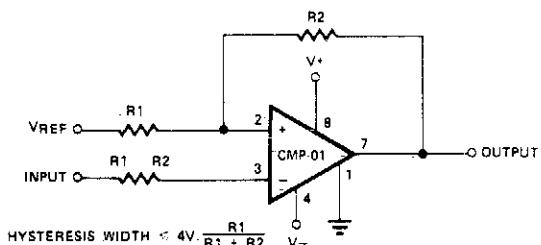
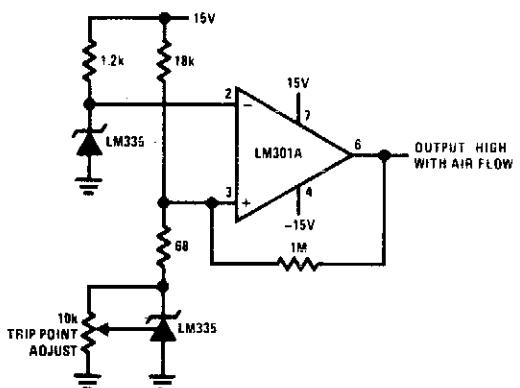


Fig. 25-26

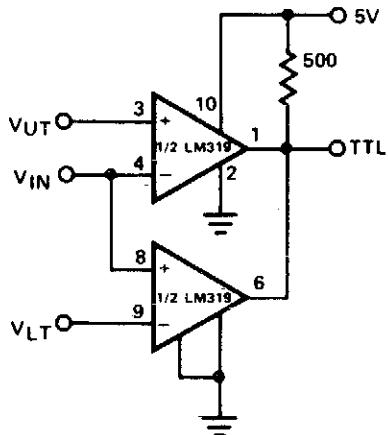
AIR FLOW DETECTOR



* Self heating is used to detect air flow

Fig. 25-28

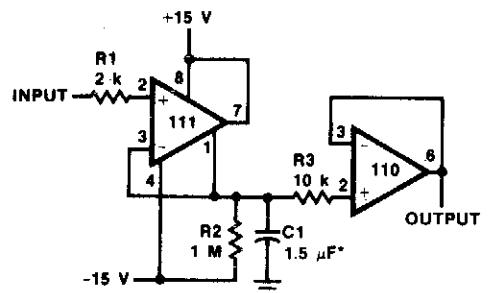
WINDOW DETECTOR



$V_{OUT} = 5V$ 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)

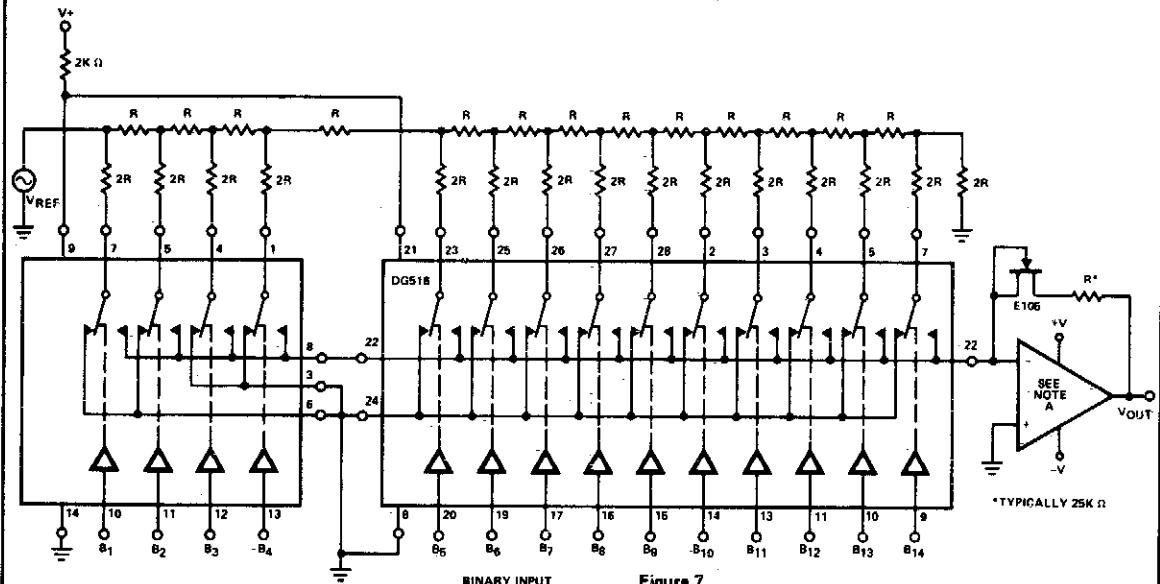


Figure 7

NOTE:

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

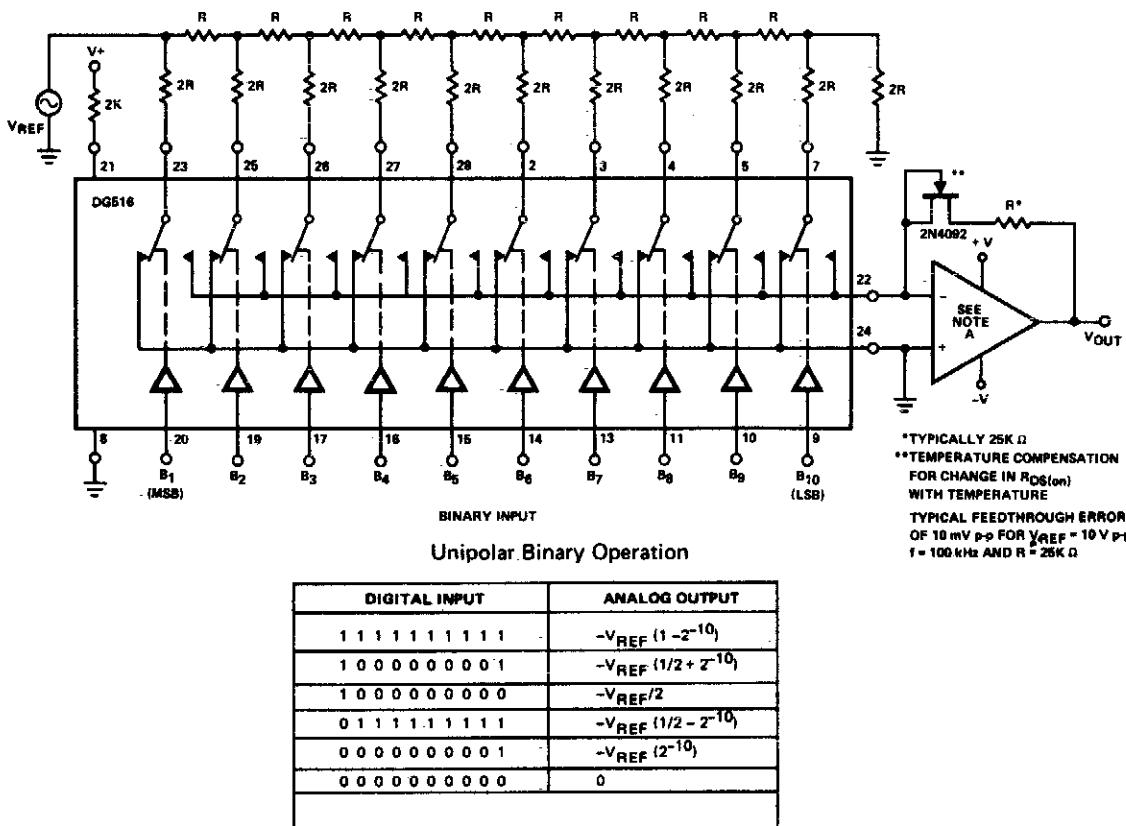
1. LM101A
2. LF156A
3. LM118

Unipolar Binary Operation

DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1 1 1 1 1 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



NOTE:

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

Fig. 26-2

FAST VOLTAGE OUTPUT D/A CONVERTER

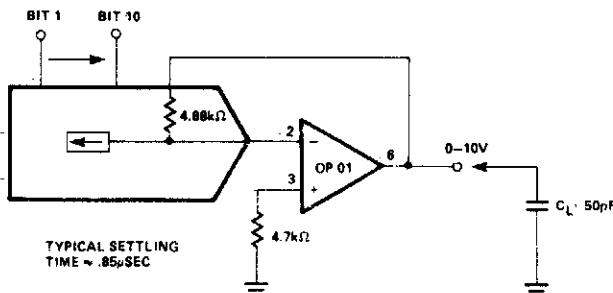


Fig. 26-3

RESISTOR TERMINATED DAC (0 TO -5 V OUTPUT)

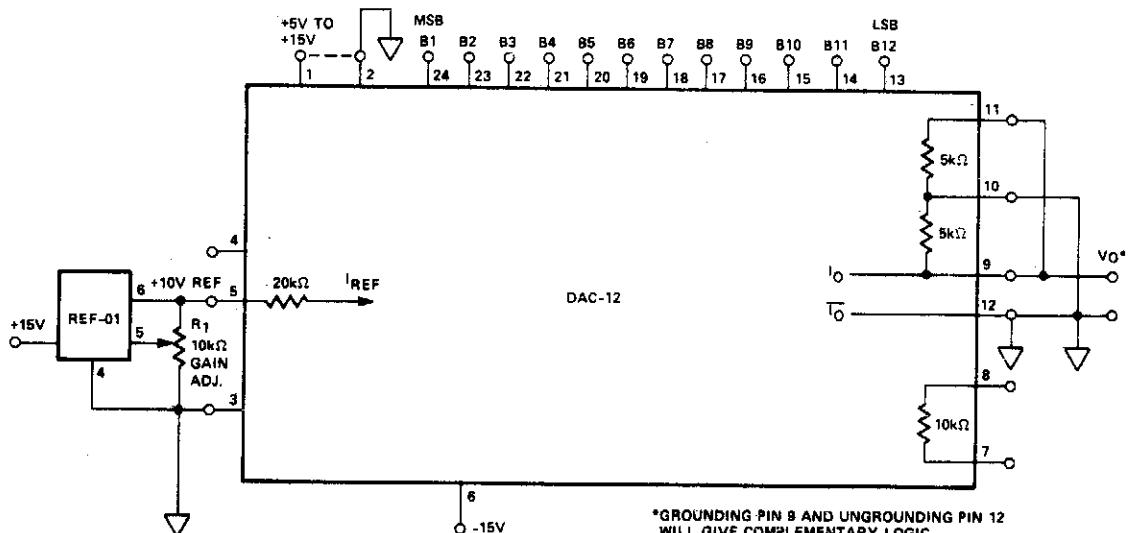


Fig. 26-4

THREE-DIGIT BCD D/A CONVERTER

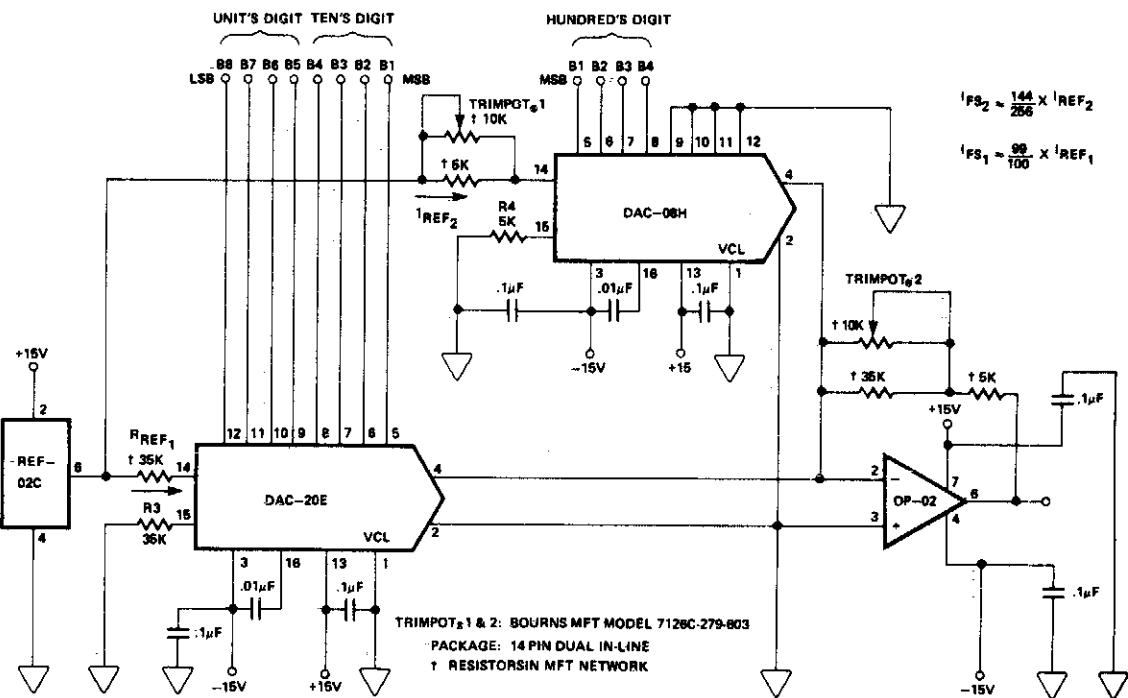


Fig. 26-5

8-BIT D/A CONVERTER

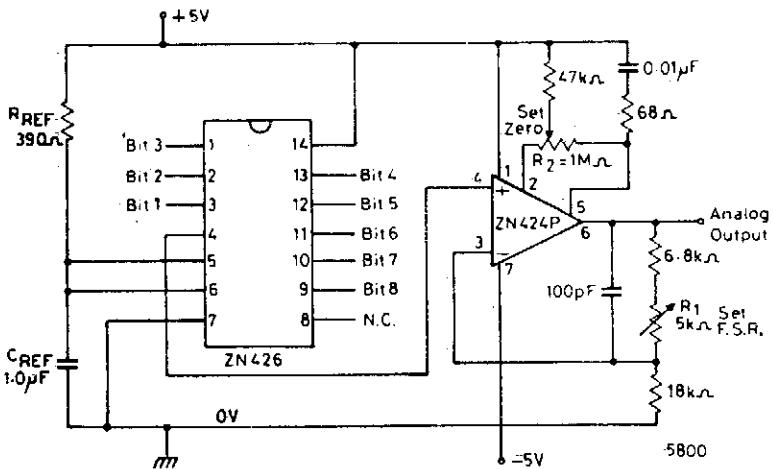


Fig. 26-6

HIGH-SPEED 8-BIT D/A CONVERTER

I_{FS} is set to 51.000 mA with R1

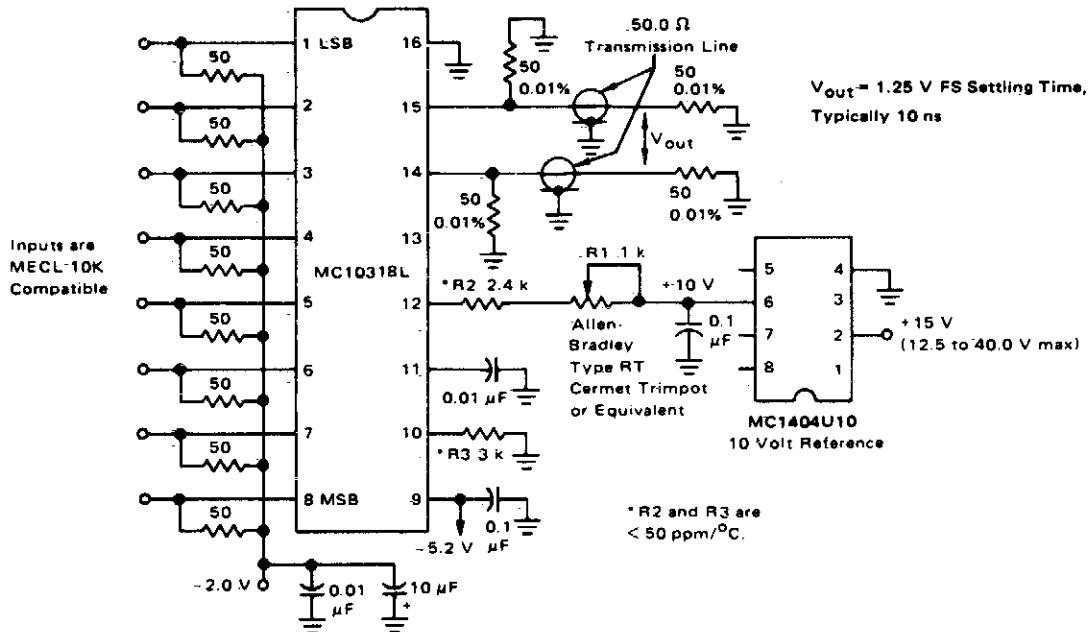
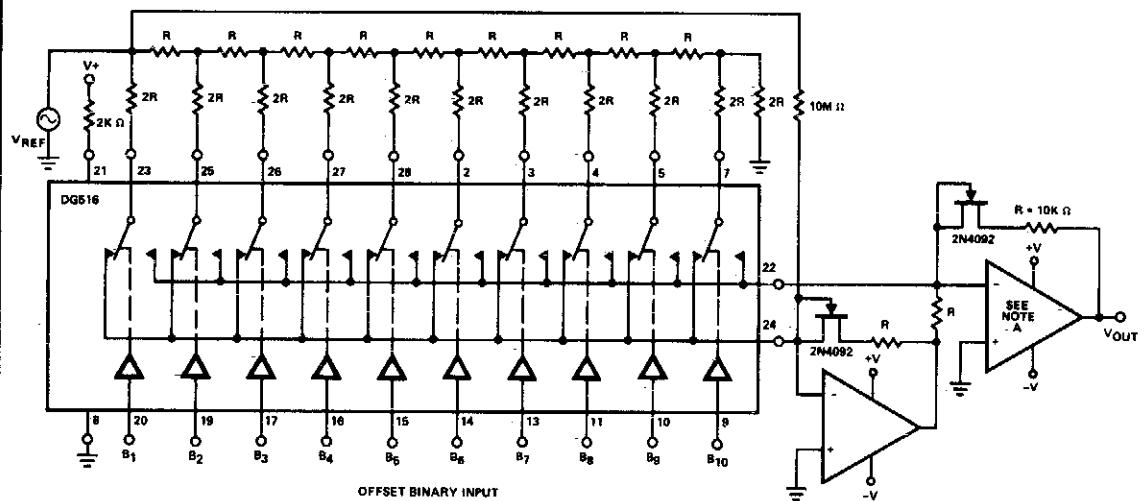


Fig. 26-7

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

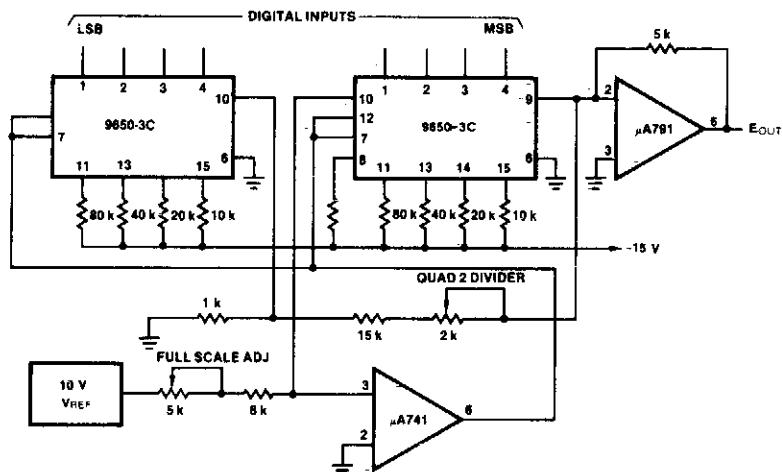
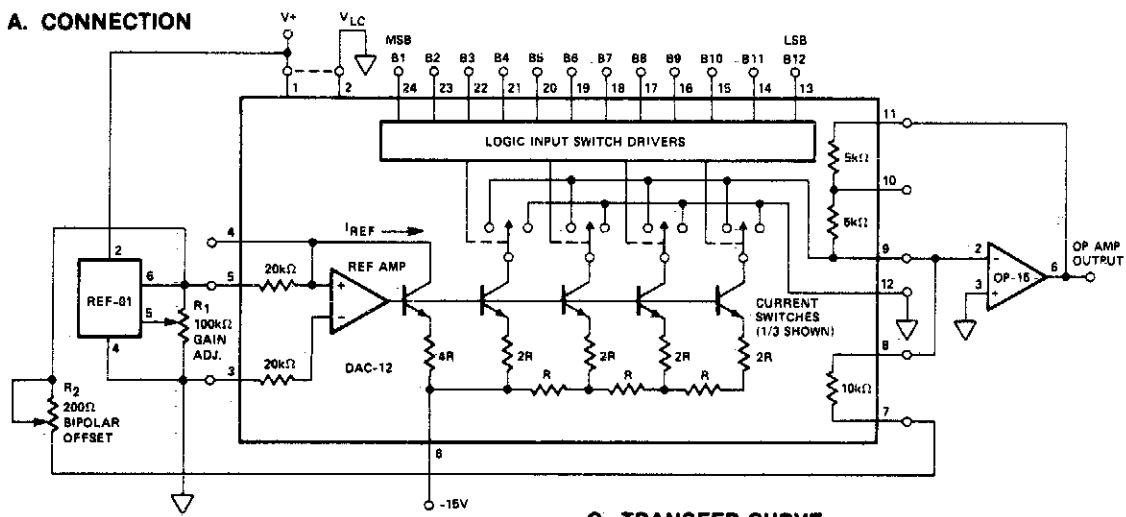


Fig. 26-9

± 10 V FULL-SCALE BIPOLAR DAC

A. CONNECTION



C. TRANSFER CURVE

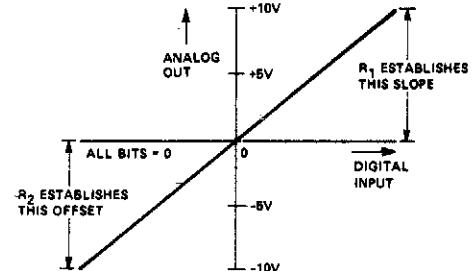


Fig. 26-10

PRECISION 12-BIT D/A CONVERTER

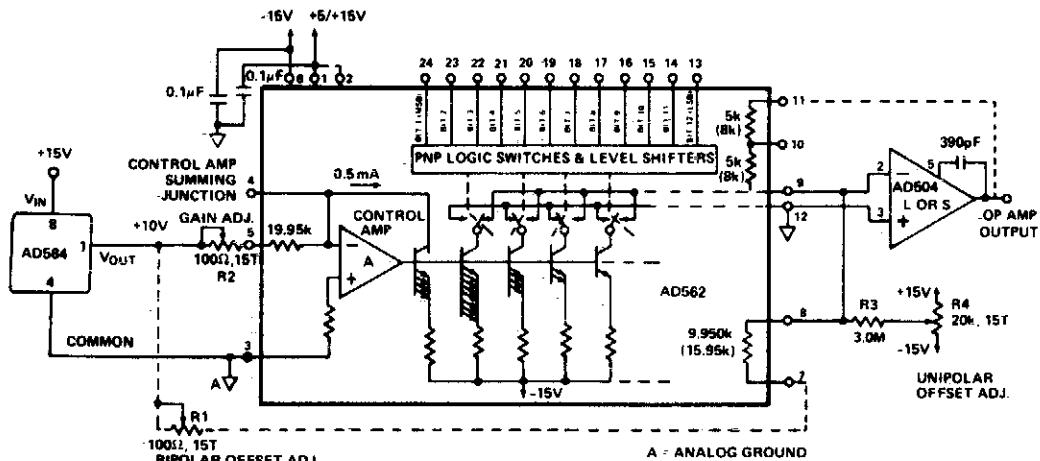


Fig. 26-11

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

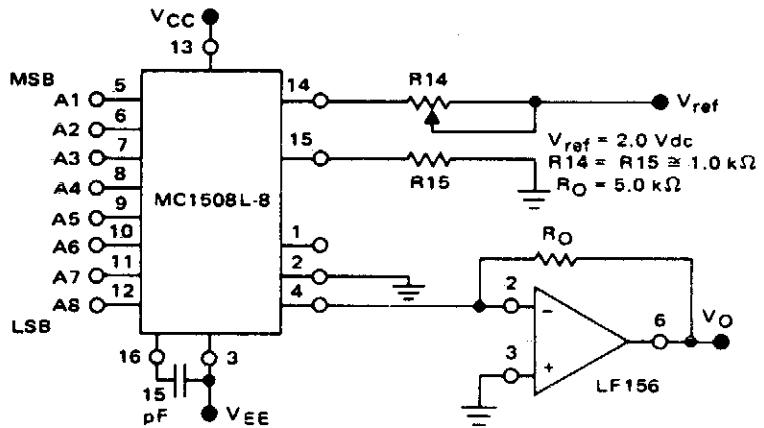


Fig. 26-12

Theoretical V_O

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

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.

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

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

16-BIT BINARY DAC

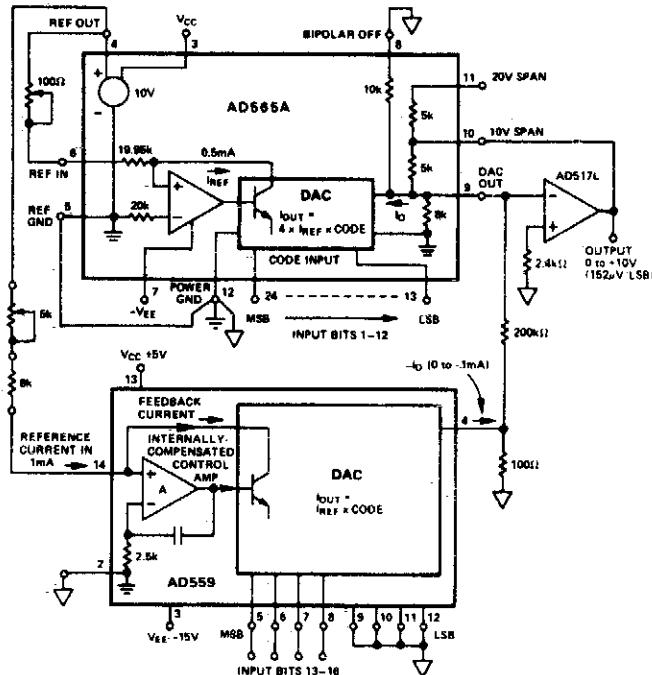
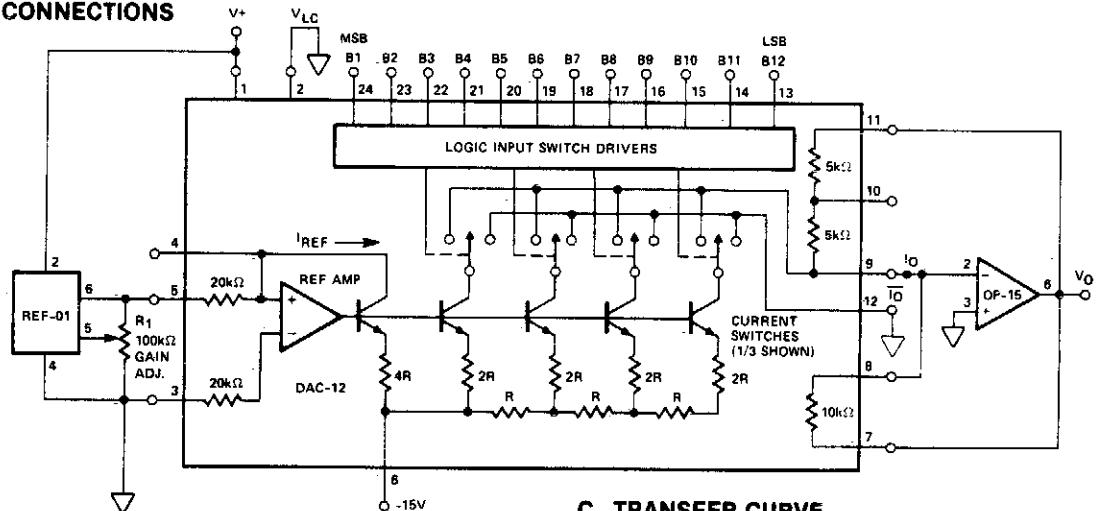


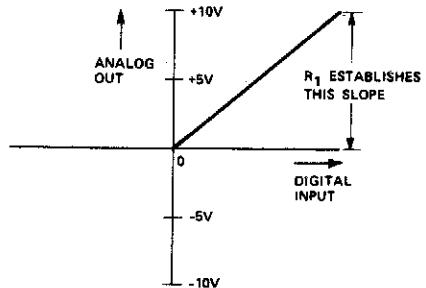
Fig. 26-13

±10 V FULL-SCALE UNIPOLAR DAC

A. CONNECTIONS



C. TRANSFER CURVE

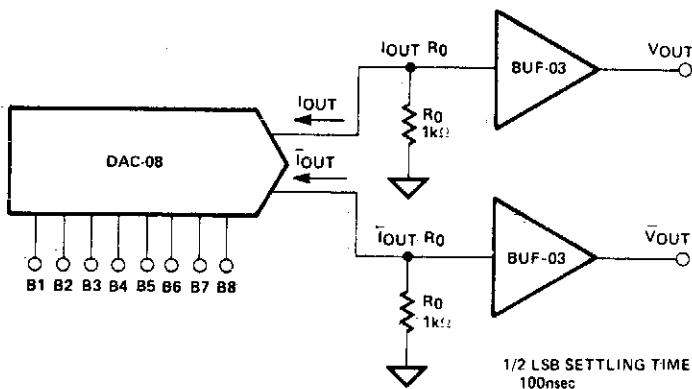


B. ADJUSTMENT PROCEDURE

1. ALL BITS TO "1" STATE ("0" STATE IF PINS 9 AND 12 INTERCHANGED)
2. ADJUST R1 UNTIL OUTPUT IS +9.9975
 $\frac{4095}{4096} \times 10V$

Fig. 26-14

HIGH-SPEED VOLTAGE OUTPUT DAC



SYSTEM WILL DRIVE CABLES OR TWISTED PAIRS.

Fig. 26-15

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)

Basic Grid-Dip Meter

Varicap-Tuned FET DIP Meter with 1 kHz
Modulator

Dip Meter Using Germanium PNP

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

Bipolar Transistor with Separate Diode De-
tector

Gate-Dip Meter Covers 1.8 - 150 MHz

Dip Meter Using Silicon Junction FET

DIP METER USING DUAL-GATE IGFET (MOSFET)

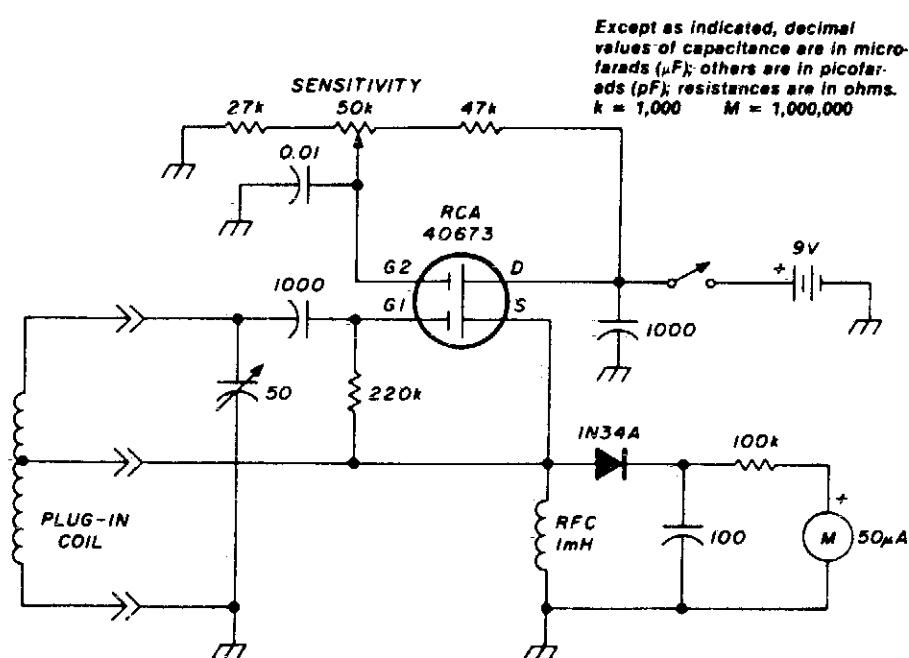
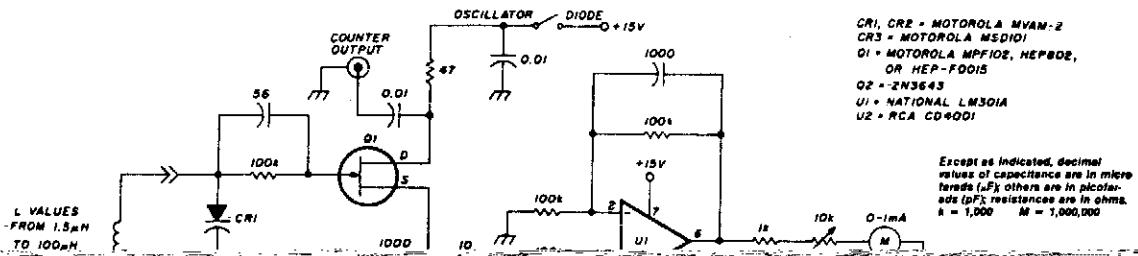


Fig. 27-1

Circuit Notes

Gate 2 is used to adjust the oscillation level.

VARICAP-TUNED FET DIP METER WITH 1-kHz MODULATION



DIP METER USING N-CHANNEL IGFET (MOSFET) AND SEPARATE DIODE DETECTOR

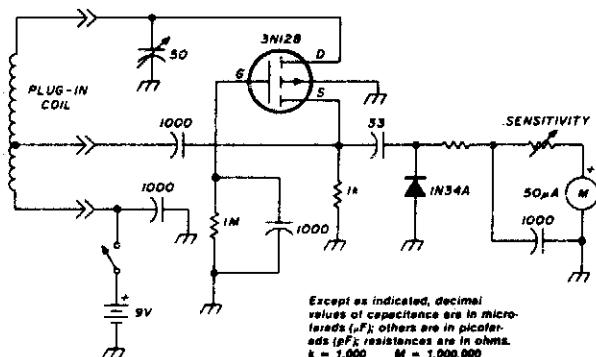
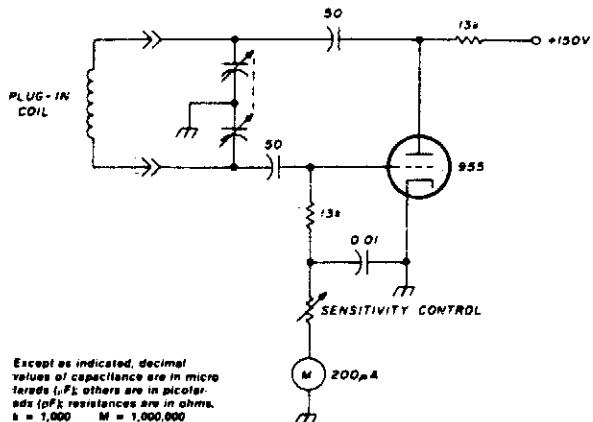


Fig. 27-3

BASIC GRID-DIP METER



Circuit Notes

This circuit uses a triode vacuum-tube (9002 and 6C4 also commonly used).

Fig. 27-4

DIP METER USING GERMANIUM PNP BIPOLAR TRANSISTOR WITH SEPARATE DIODE DETECTOR

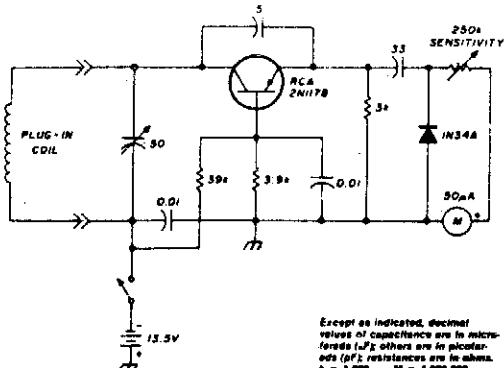
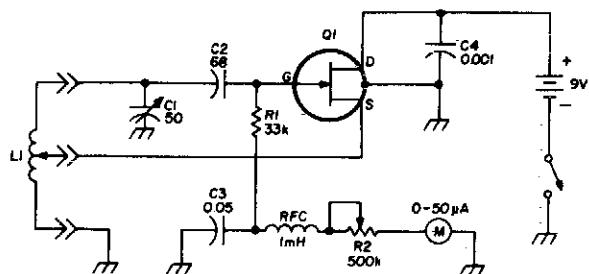


Fig. 27-5

GATE-DIP METER COVERS 1.8 - 150 MHz

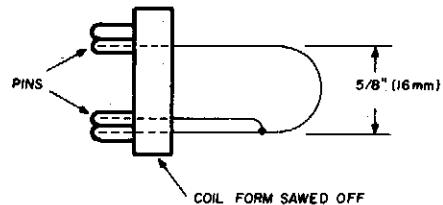


Coil data.

frequency

range (MHz)	no. turns	wire size AWG (mm)	winding length inches (mm)	tap*	coil diameter inches (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 Millen 45004 available from Burstein-Applebee

Fig. 27-6

DIP METER USING SILICON JUNCTION FET

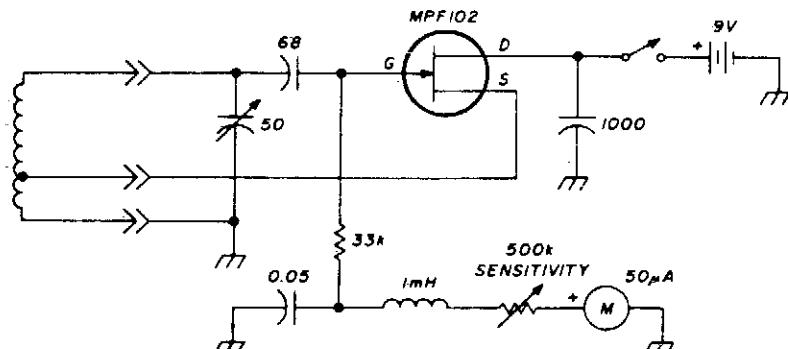


Fig. 27-7

Except as indicated, decimal values of capacitance are in microfarads (μ F); 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

Precision Frequency Counter (~ 1 MHz

LED Bar/Dot Level Meter

Maximum)

60 dB Dot Mode Display

Exclamation Point Display

Bar Display with Alarm Flasher

LED Bar Peak Program Meter Display

12-Hour Clock with Gas Discharge Displays

for Audio

10 MHz Universal Counter

LED BRIGHTNESS CONTROL

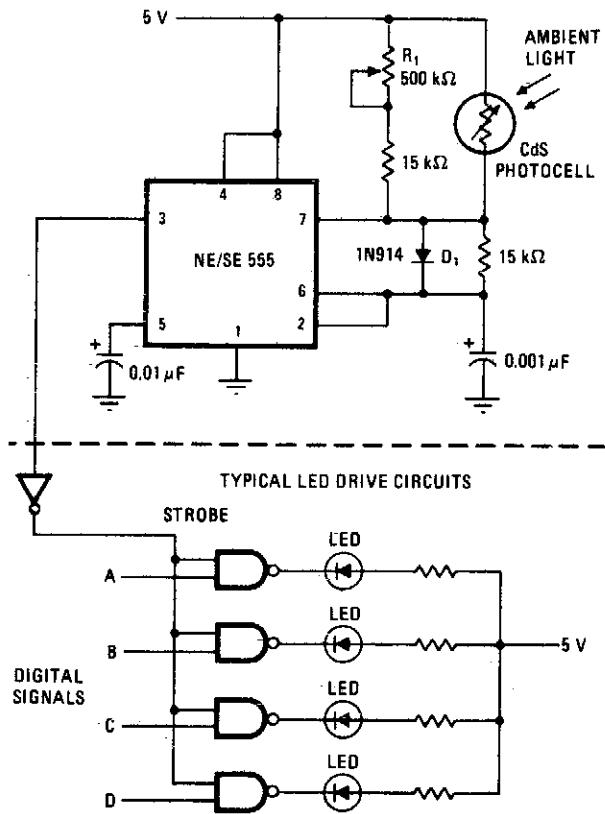


Fig. 28-1

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

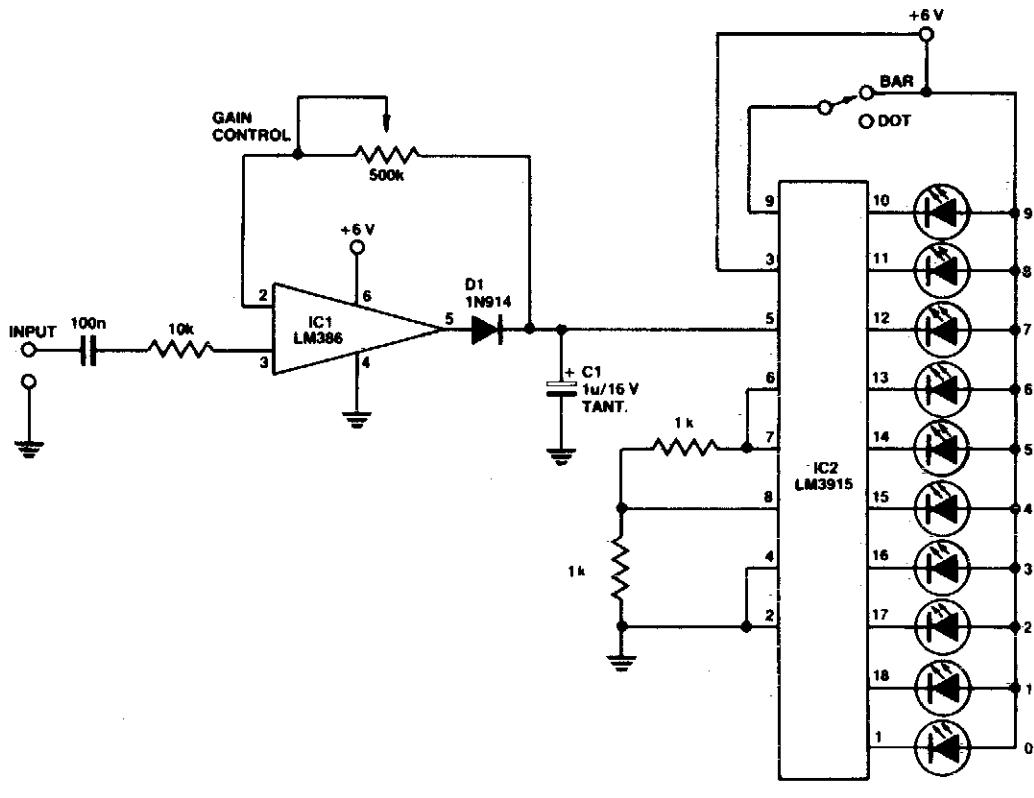


Fig. 28-2

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.

60 dB DOT MODE DISPLAY

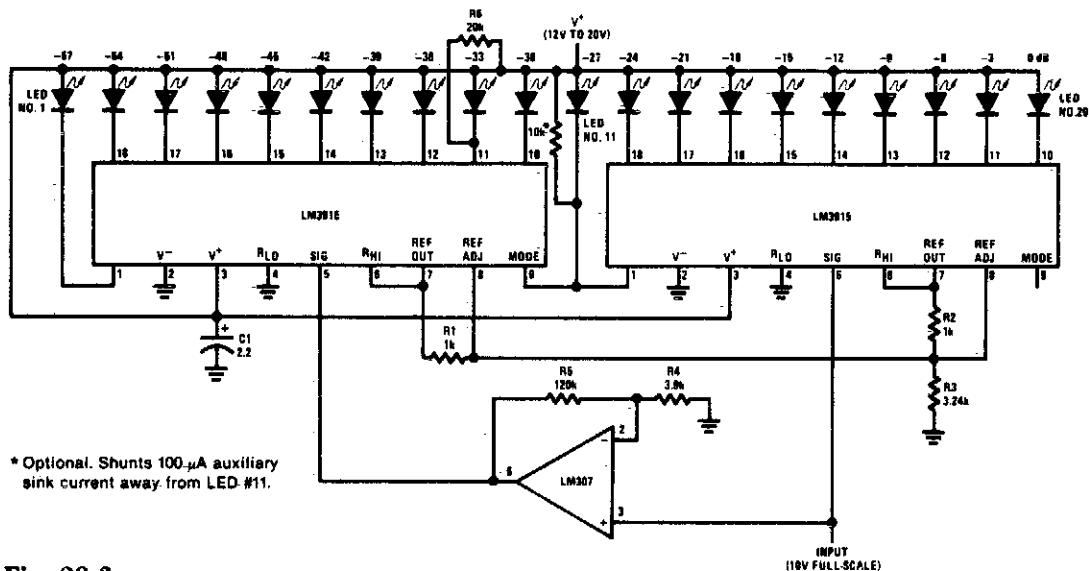
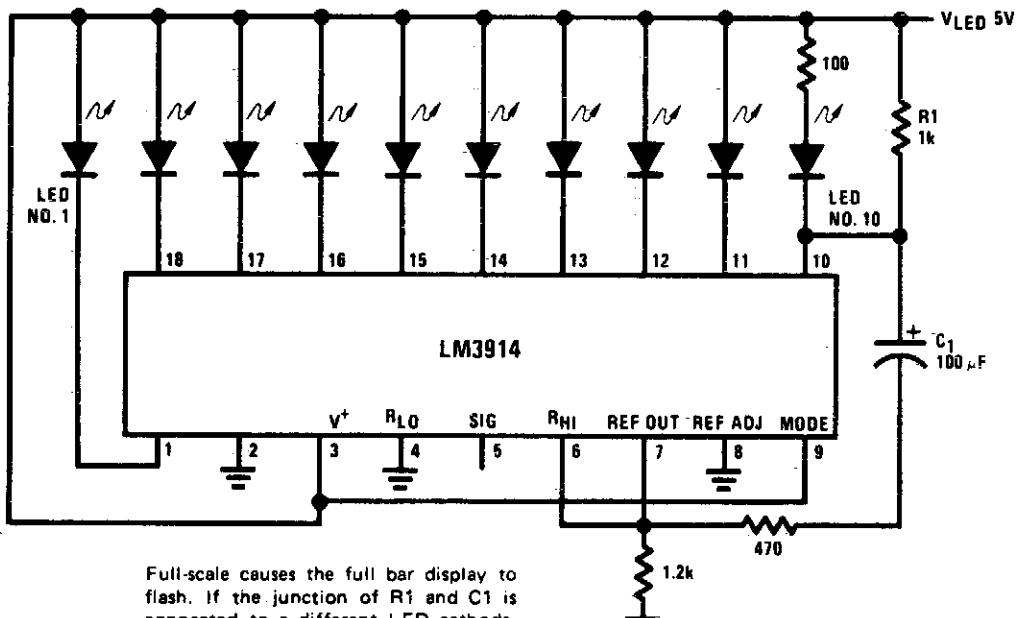


Fig. 28-3

BAR DISPLAY WITH ALARM FLASHER



Full-scale causes the full bar display to flash. If the junction of R1 and C1 is connected to a different LED cathode, the display will flash when that LED lights, and at any higher input signal.

Fig. 28-4

12-HOUR CLOCK WITH GAS DISCHARGE DISPLAYS

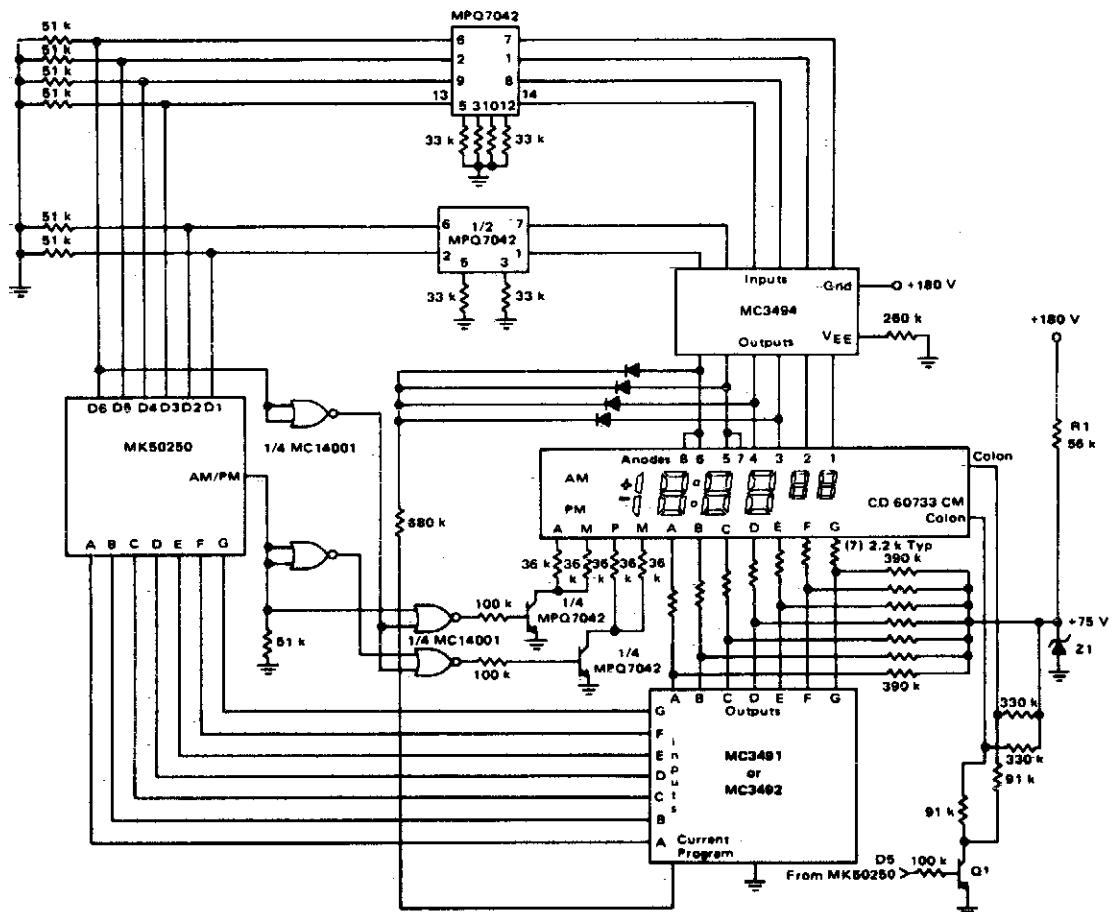


Fig. 28-5

PRECISION FREQUENCY COUNTER (~1 MHz MAXIMUM)

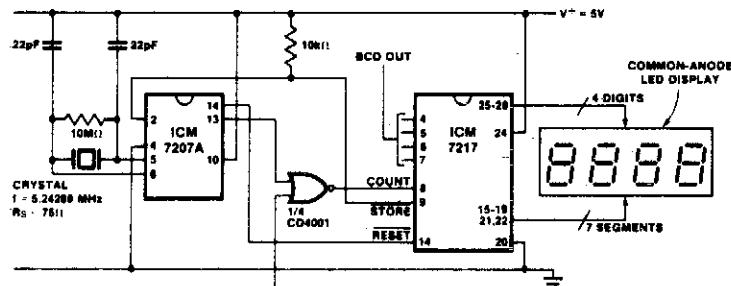


Fig. 28-6

EXCLAMATION POINT DISPLAY

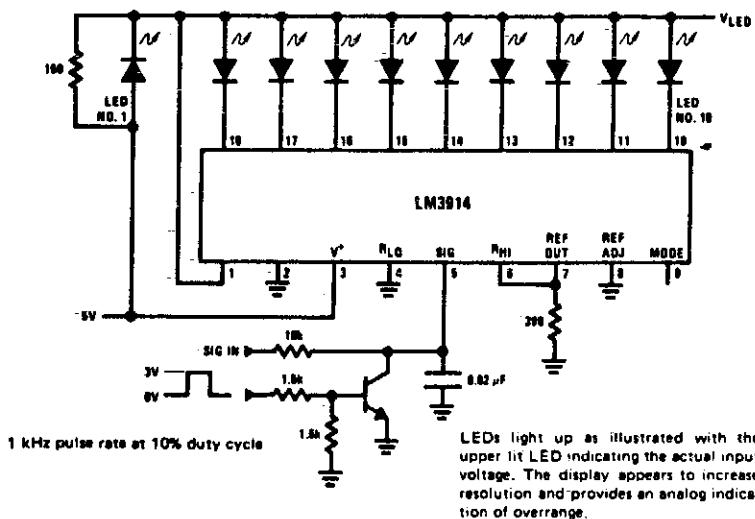
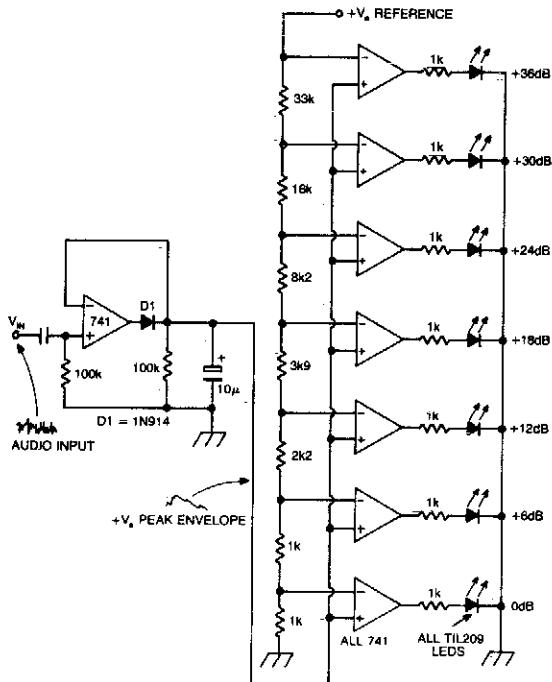


Fig. 28-7

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

10 MHz UNIVERSAL COUNTER

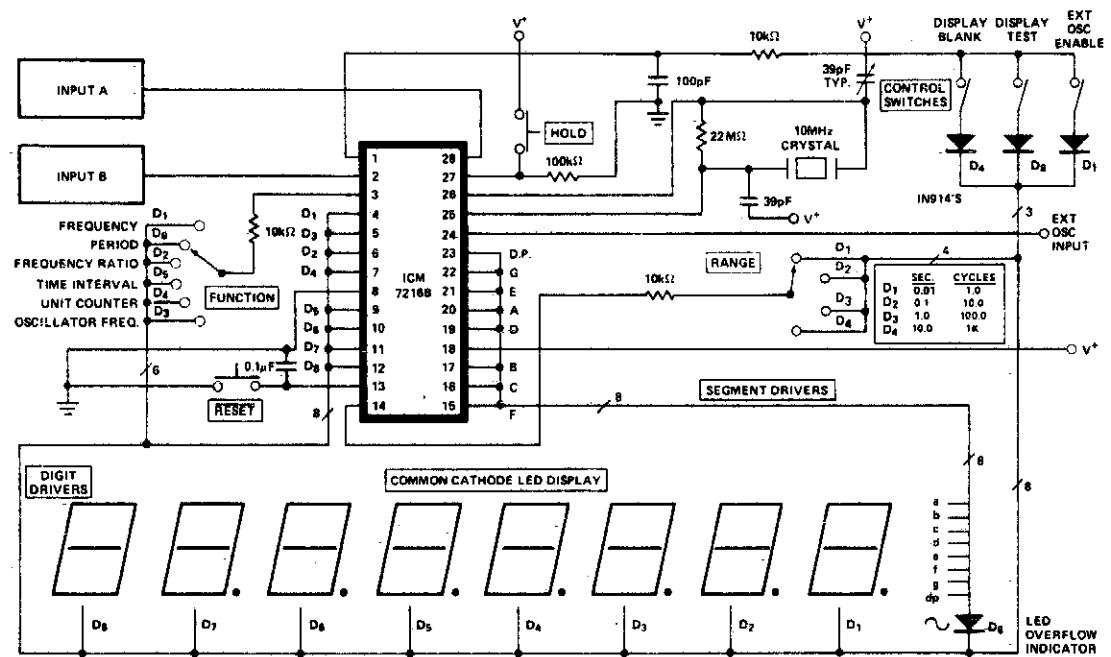


Fig. 28-9

Circuit Notes

This is a minimum component complete Universal Counter. It can use input frequencies up to 10 MHz at INPUT A and 2 MHz at INPUT B. If the signal at INPUT A has a very low duty

cycle, it may be necessary to use a 74121 monostable multivibrator or similar circuit to stretch the input pulse width to be able to guarantee that it is at least 50 ns in duration.

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

Free Output

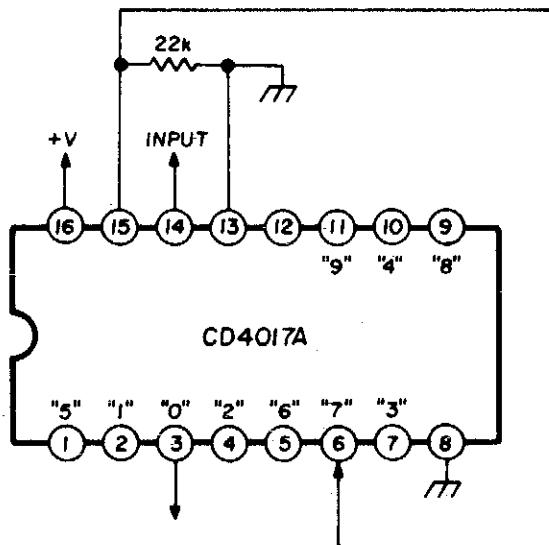
Frequency Divider Chain

Binary Divider Chain

Frequency Divider with Transient

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

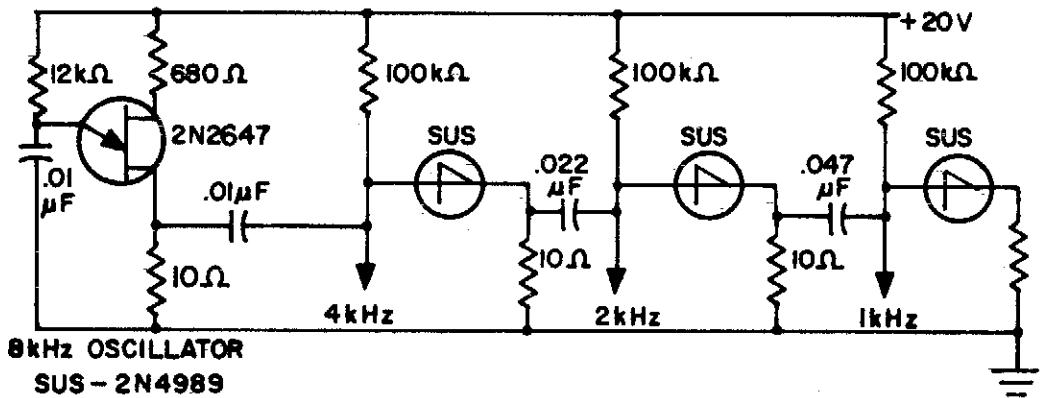


Fig. 29-2

Circuit Notes

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

FREQUENCY DIVIDER WITH TRANSIENT FREE OUTPUT

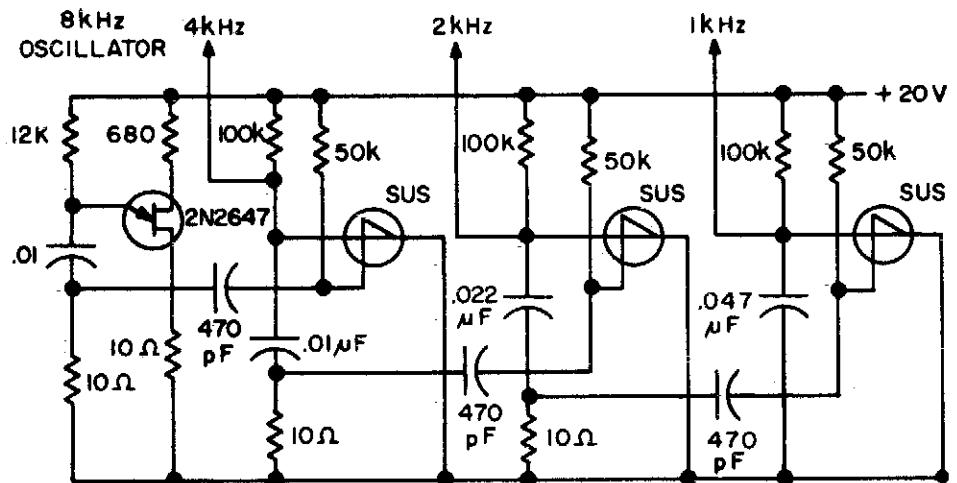


Fig. 29-3

SUS - 2N4989

Circuit Notes

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

BINARY DIVIDER CHAIN

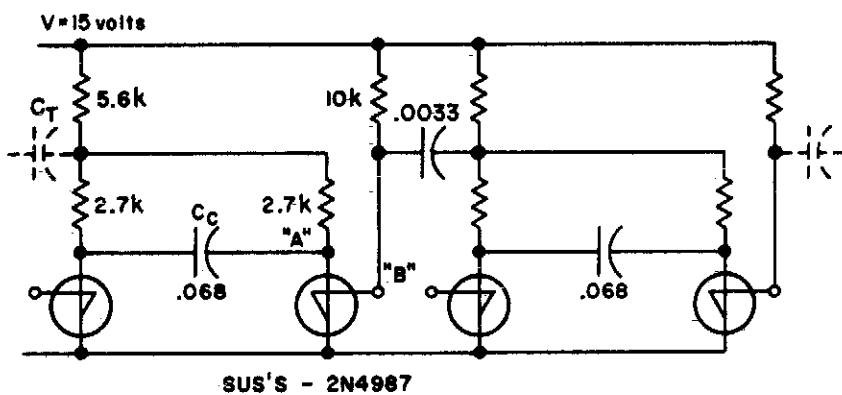


Fig. 29-4

Circuit Notes

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

DECADE FREQUENCY DIVIDER

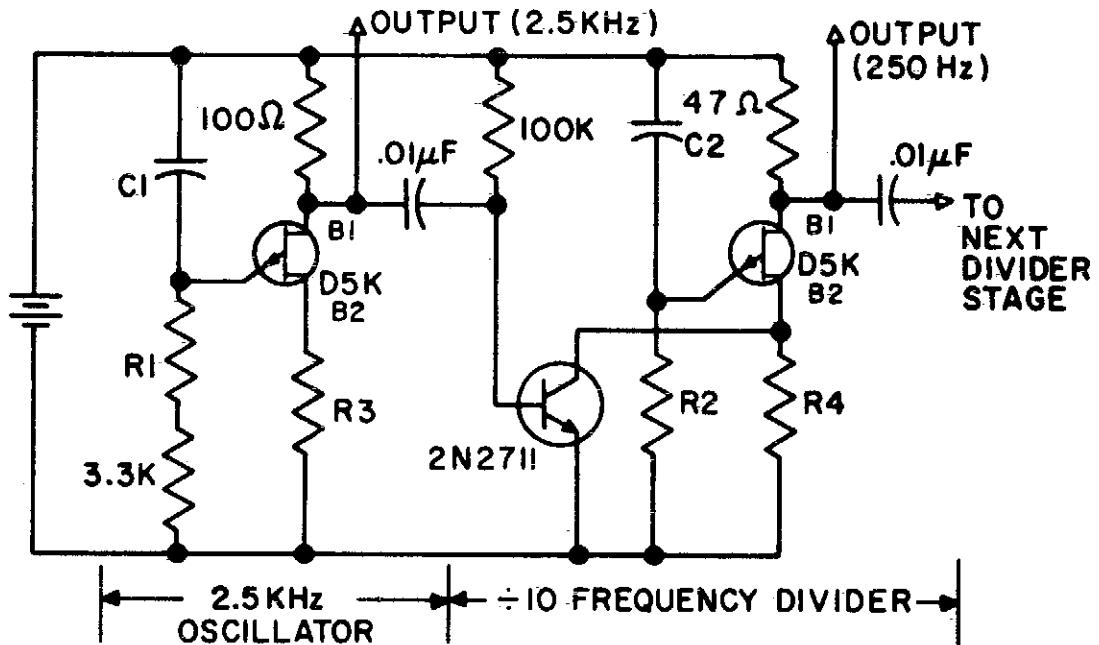


Fig. 29-5

Circuit Notes

In the next stage, the product of R_2 and C_2 should be $10 \times$ that of the preceding stage ($\pm 2\%$). R_2 should be between 27K and 10 M.

C_1 & C_2 — $.0047 \mu F$ ($\pm 1\%$)

R_1 — $100K$ ($\pm 1\%$)

R_2 — $1M$ ($\pm 1\%$)

R_3 — R_4 — $1K$ (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

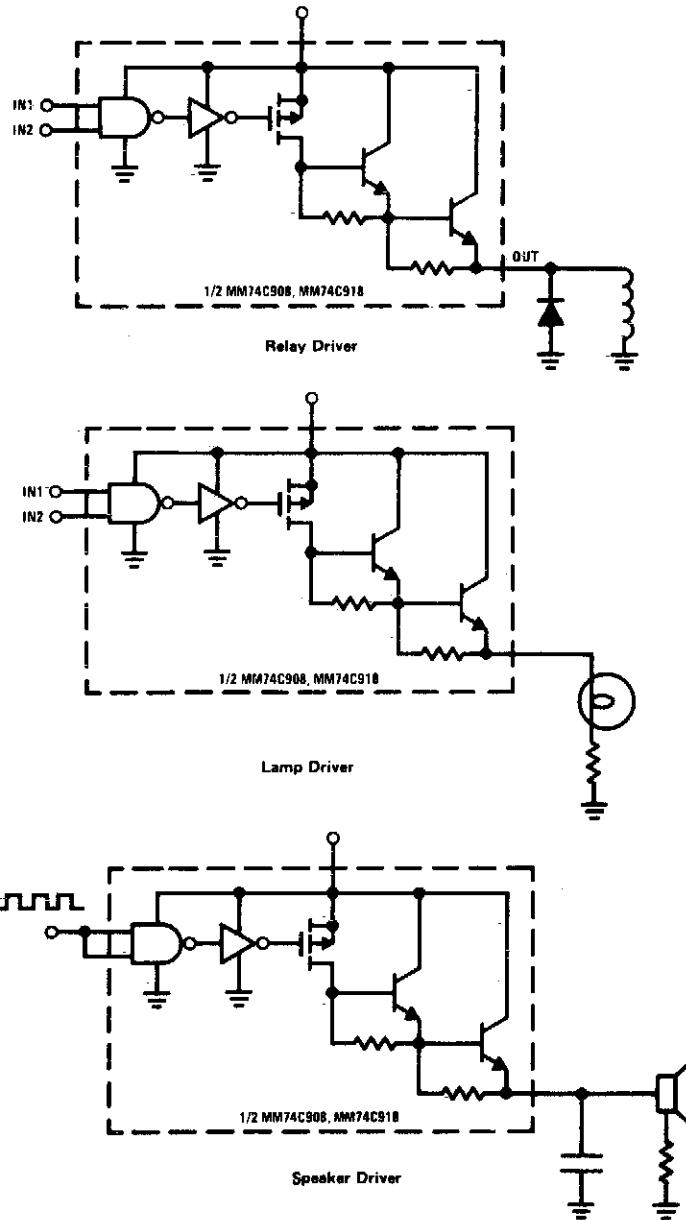


Fig. 30-1

Circuit Notes

CMOS drivers for relays, lamps, speakers, etc., offers extremely low standby power. At $V_{cc} = 15$ 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

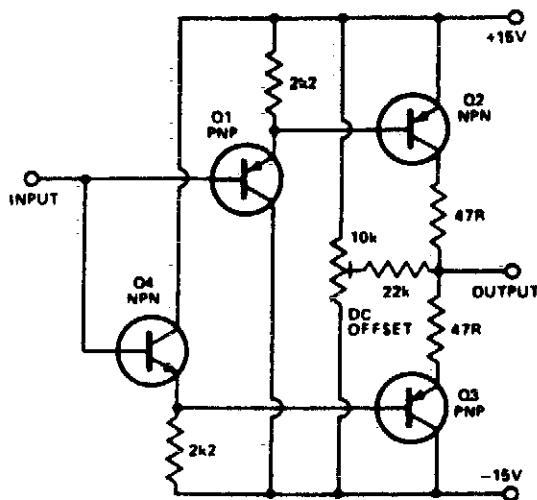
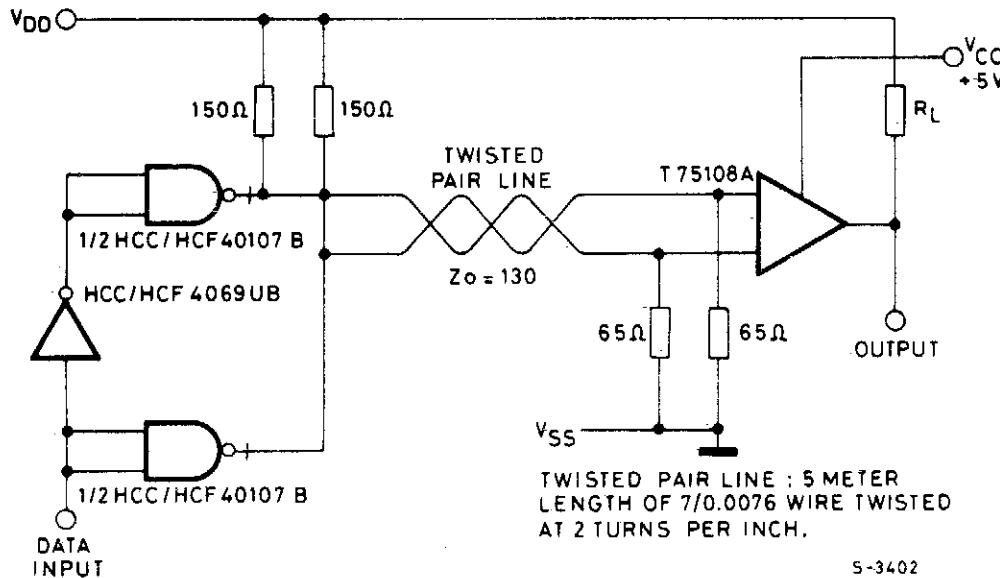


Fig. 30-2

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.

LINE DRIVER



S-3402

Fig. 30-3

HIGH-SPEED LASER DIODE DRIVER

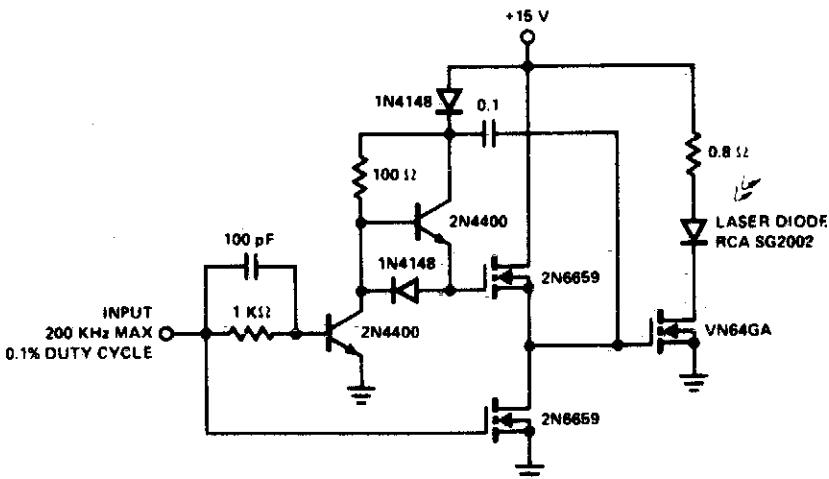


Fig. 30-4

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

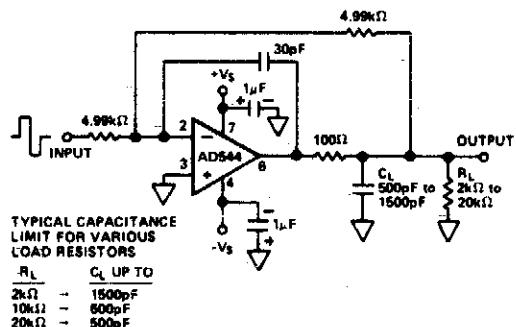


Fig. 30-5

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

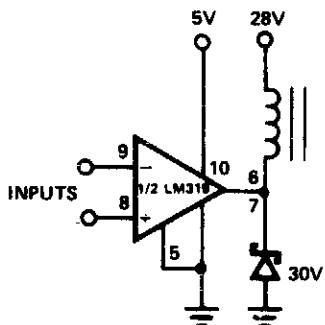


Fig. 30-6

BIFET CABLE DRIVER

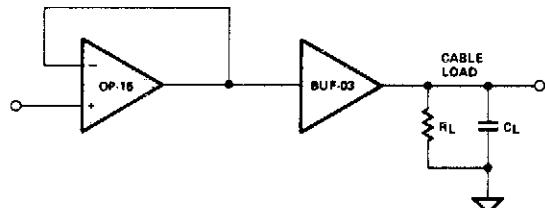


Fig. 30-8

RELAY DRIVER

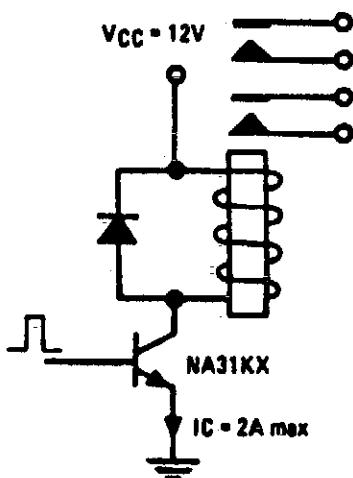


Fig. 30-7

HIGH SPEED LINE DRIVER FOR MULTIPLEXERS

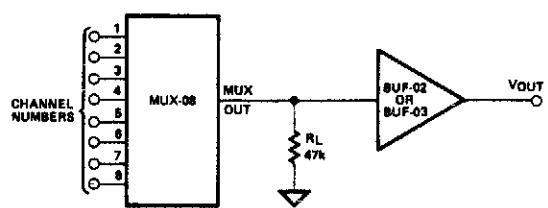


Fig. 30-9

HIGH IMPEDANCE METER DRIVER

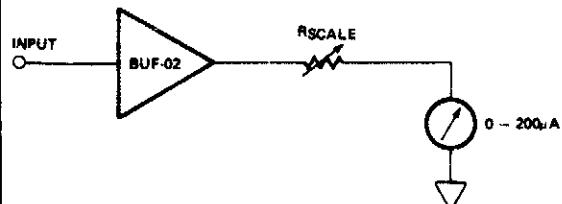
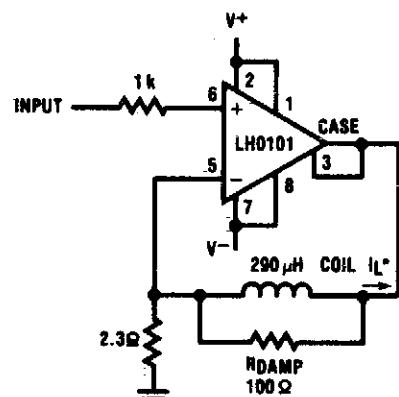


Fig. 30-10

CRT YOKE DRIVER



*COIL CURRENT I_L MEASURED WITH TEKTRONIX CURRENT PROBE MODEL P6042

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

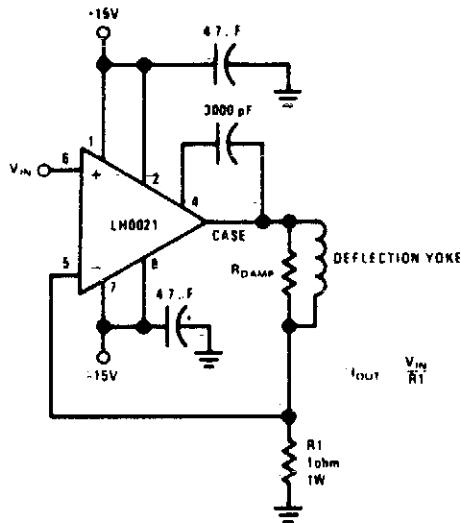


Fig. 30-11

SOLENOID DRIVER

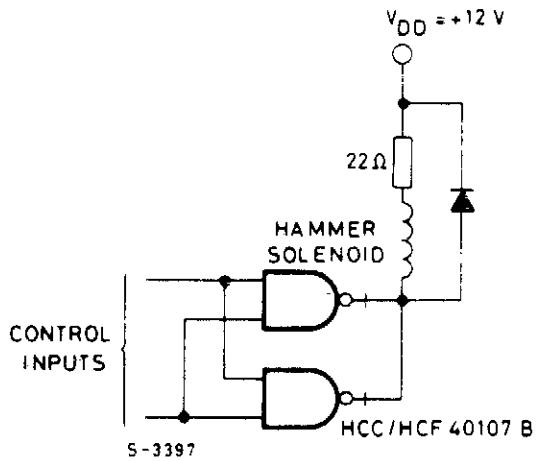


Fig. 30-13

COAXIAL CABLE DRIVER

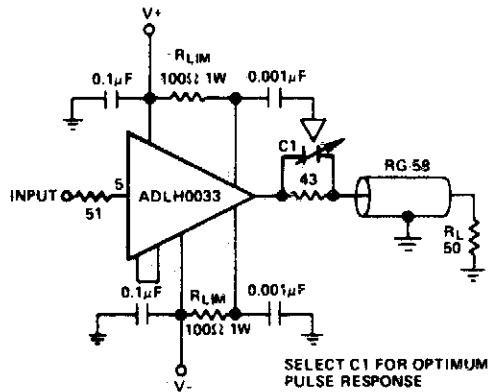
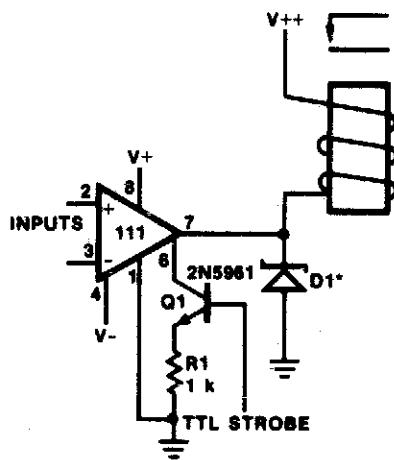


Fig. 30-14

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

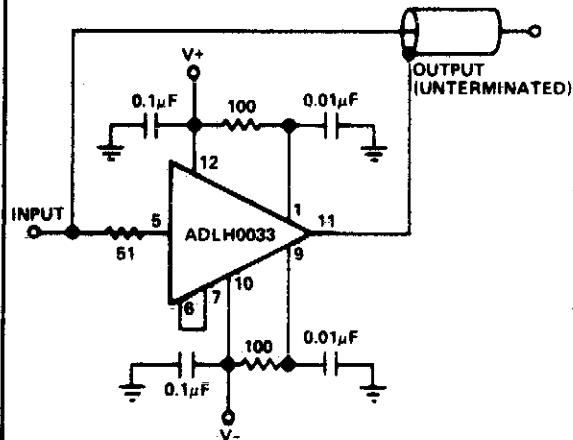


Fig. 30-15

DIRECT DC DRIVE INTERFACE OF A TRIAC

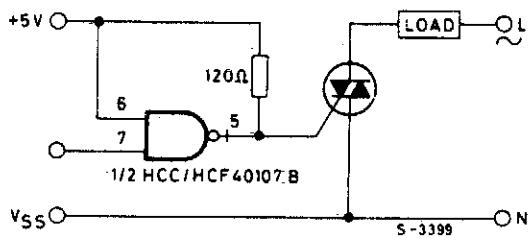


Fig. 30-17

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

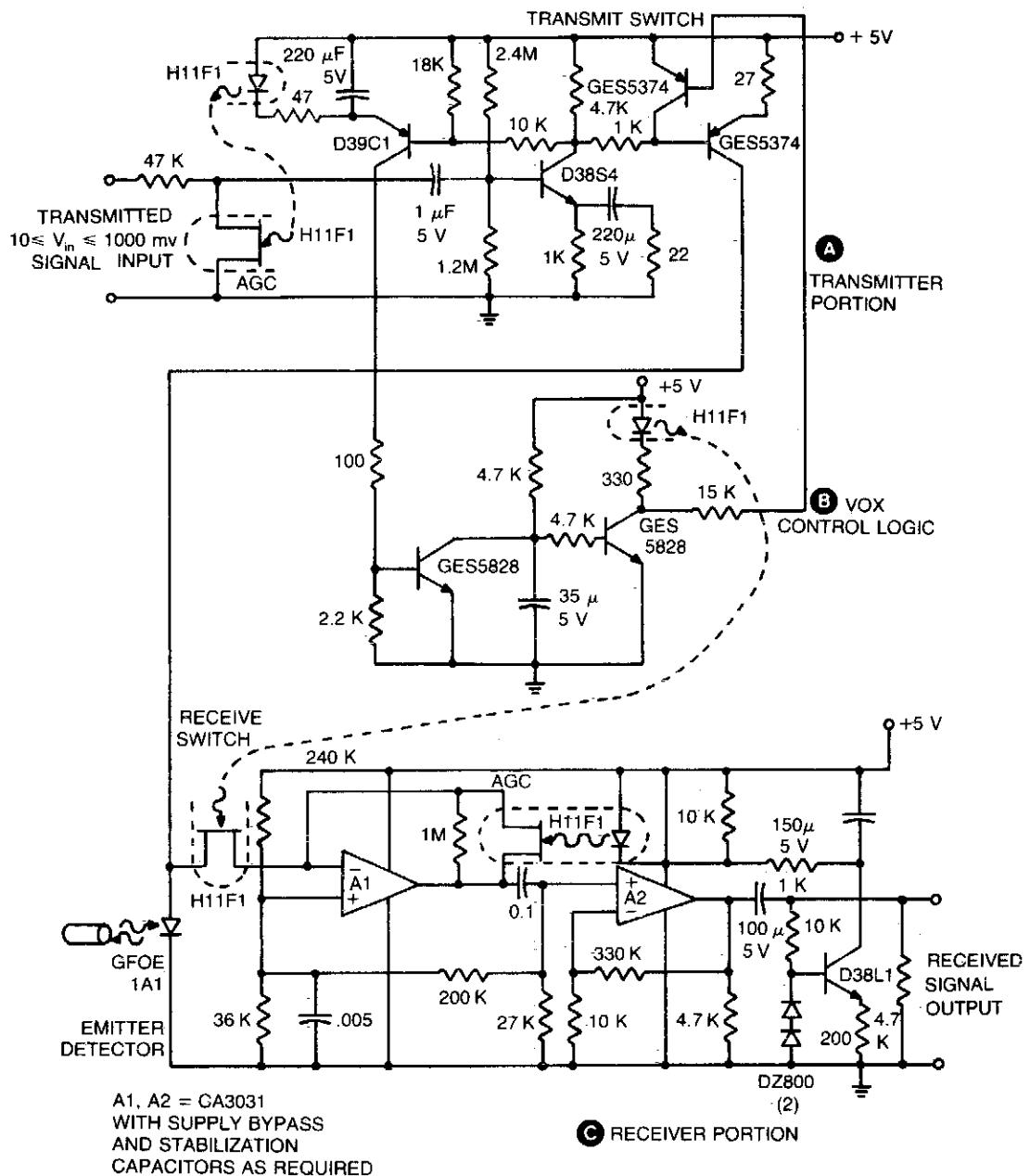


Fig. 31-1

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

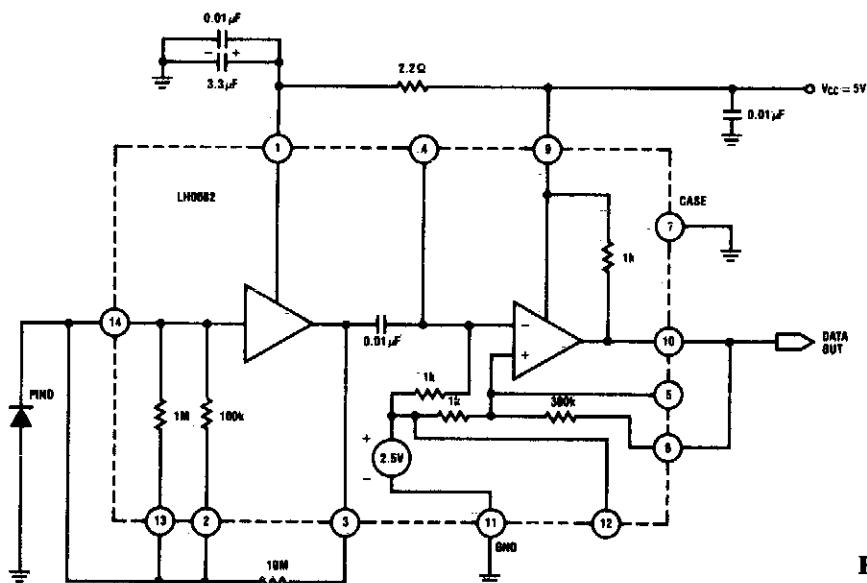


Fig. 31-2

FIBER-OPTIC LINK

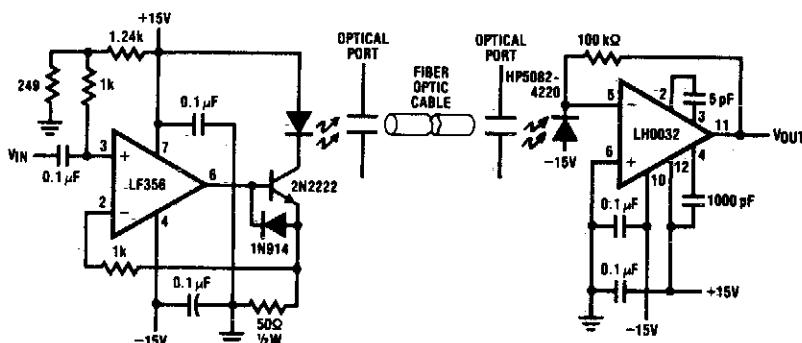


Fig. 31-3

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 μW of light input.

FIBER-OPTIC LINK REPEATER

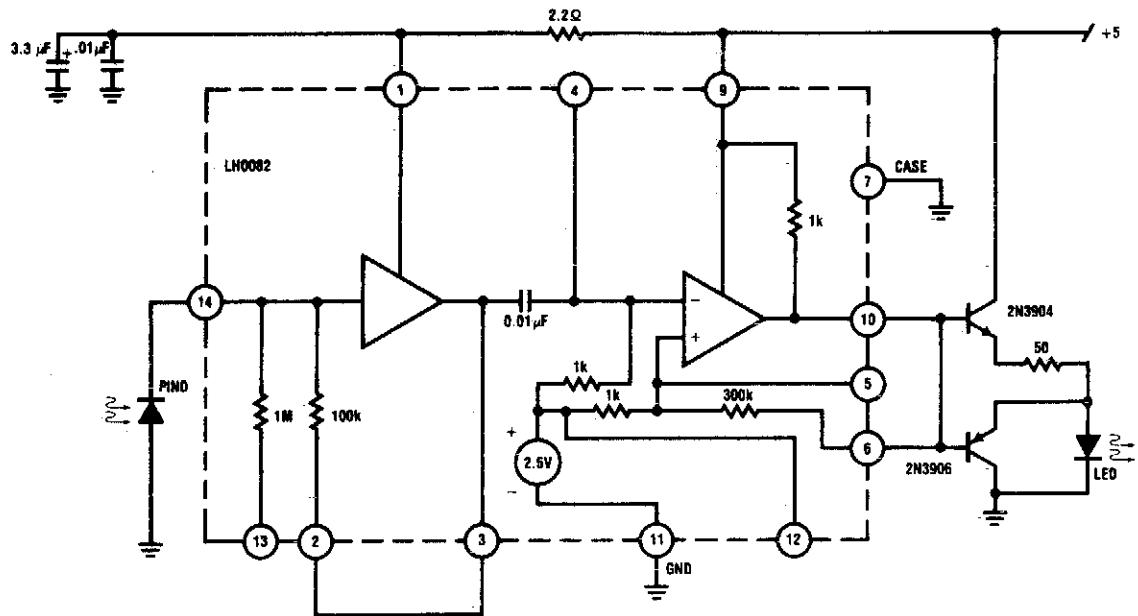


Fig. 31-4

FIBER-OPTIC RECEIVER, HIGH SENSITIVITY, 30nW

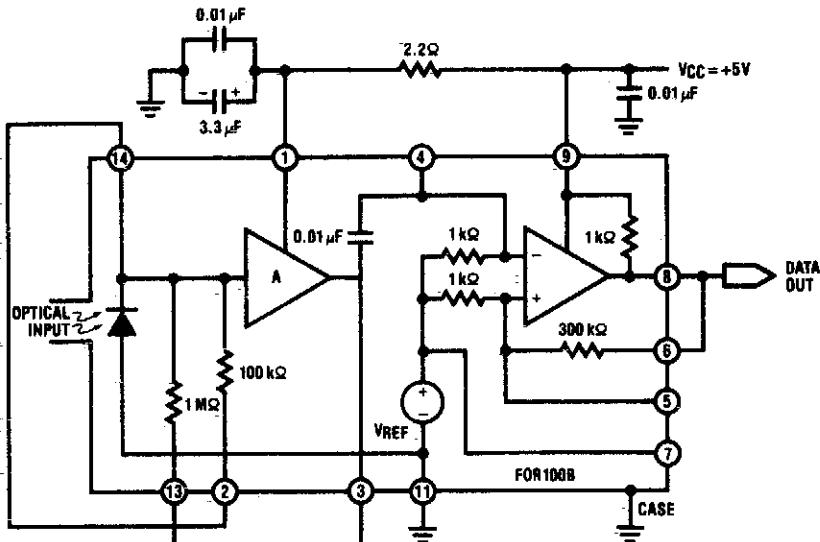


Fig. 31-5

FIBER-OPTIC RECEIVER, LOW SENSITIVITY, 2 μ W

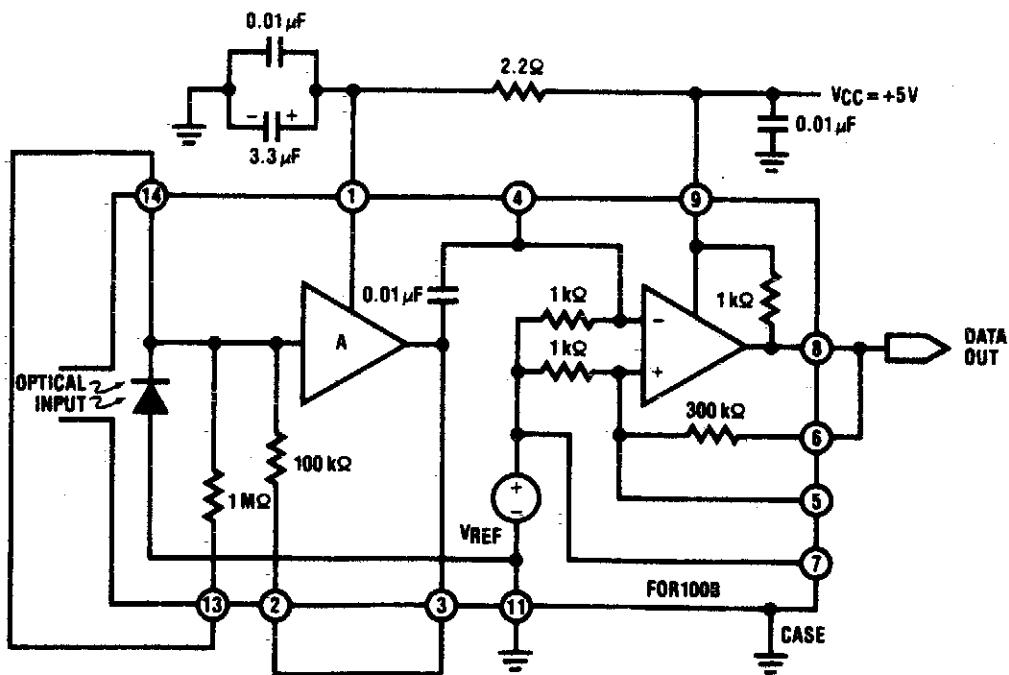


Fig. 31-6

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

Field Strength Meter - 1.5 to 150 MHz

Sensitive Field-Strength Meter

Simple Field Strength Meter

Adjustable Sensitivity Field-Strength

Untuned Field Strength Meter

Indicator

Tuned Field Strength Meter

VOM Field Strength Meter

LOW COST MICROWAVE FIELD STRENGTH METER

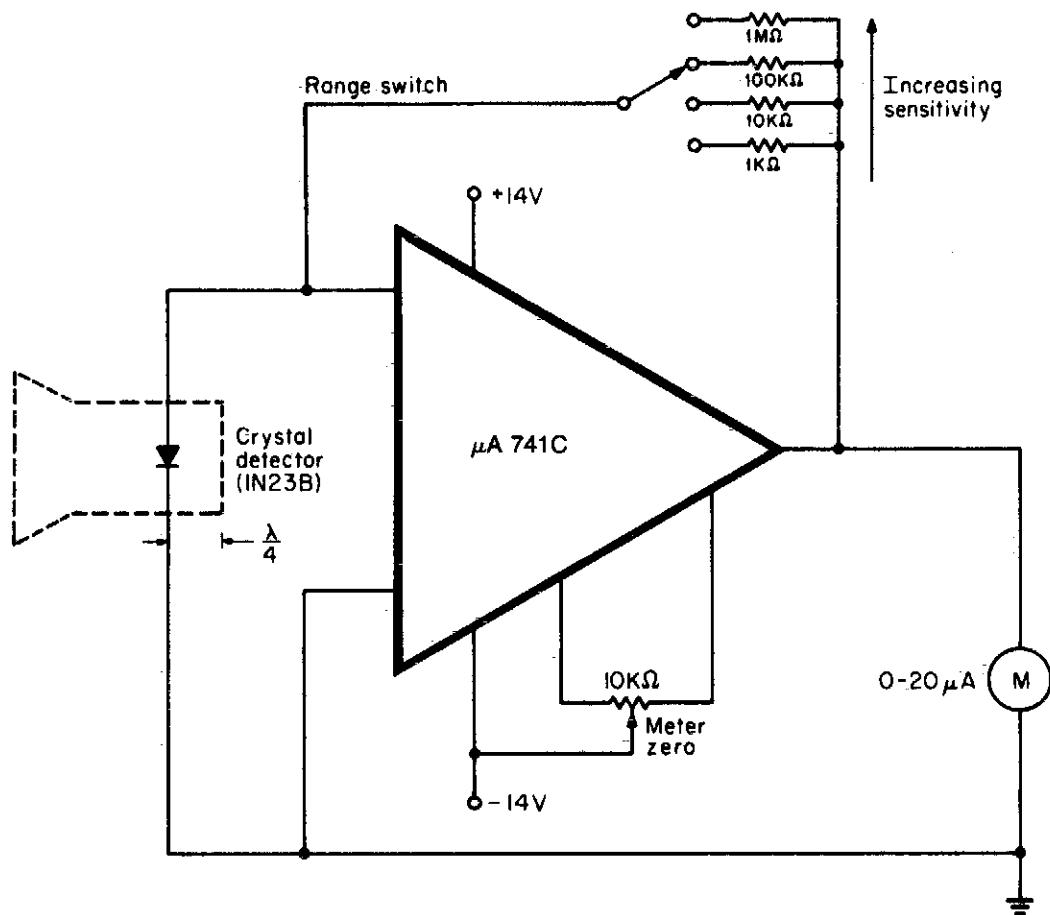


Fig. 32-1

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

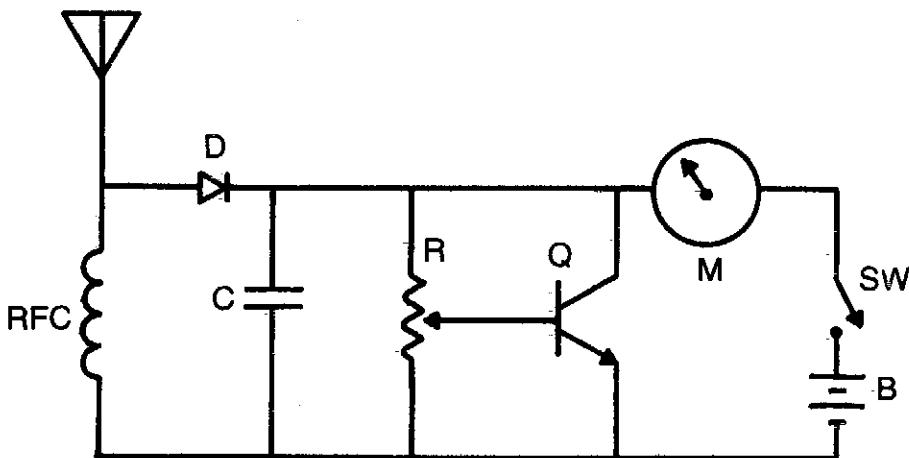


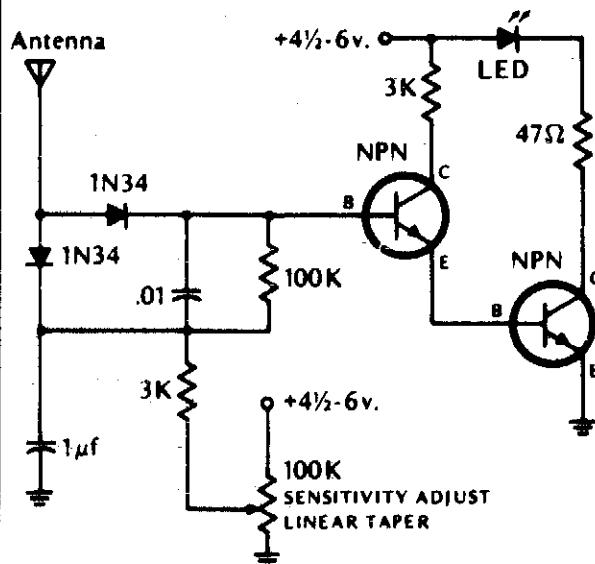
Fig. 32-2

Circuit Notes

Increased sensitivity gives field strength reading from low power transmitters. Operating range 3-30 MHz. To operate, adjust R for $\frac{1}{3}$ 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 (RCAS3020, 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

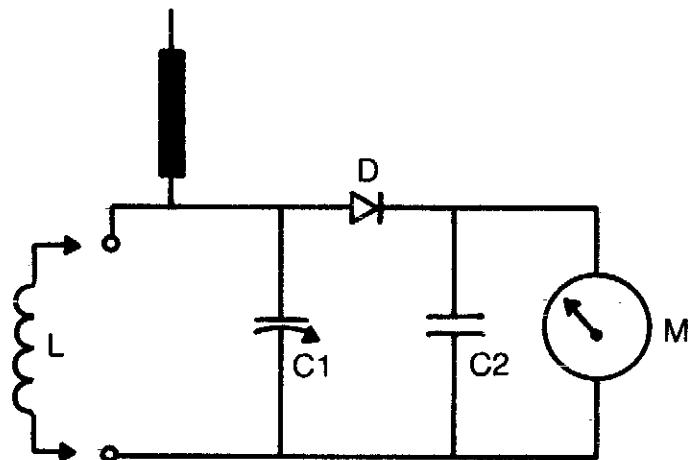


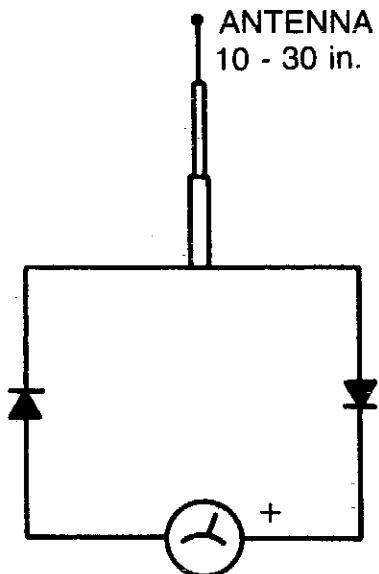
Fig. 32-4

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

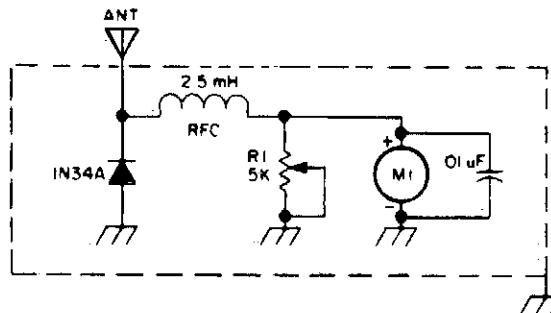


Circuit Notes

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

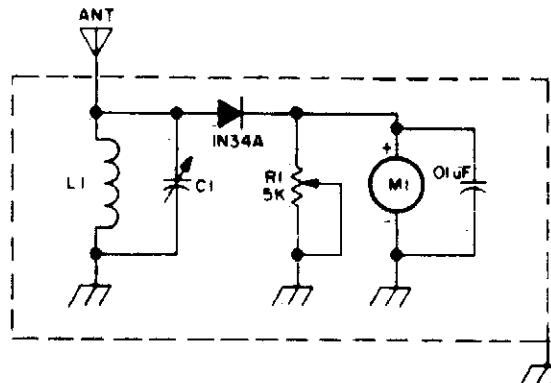


Circuit Notes

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

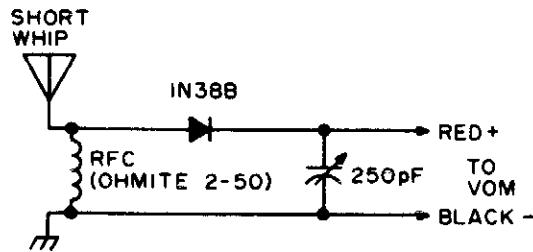


Fig. 32-8

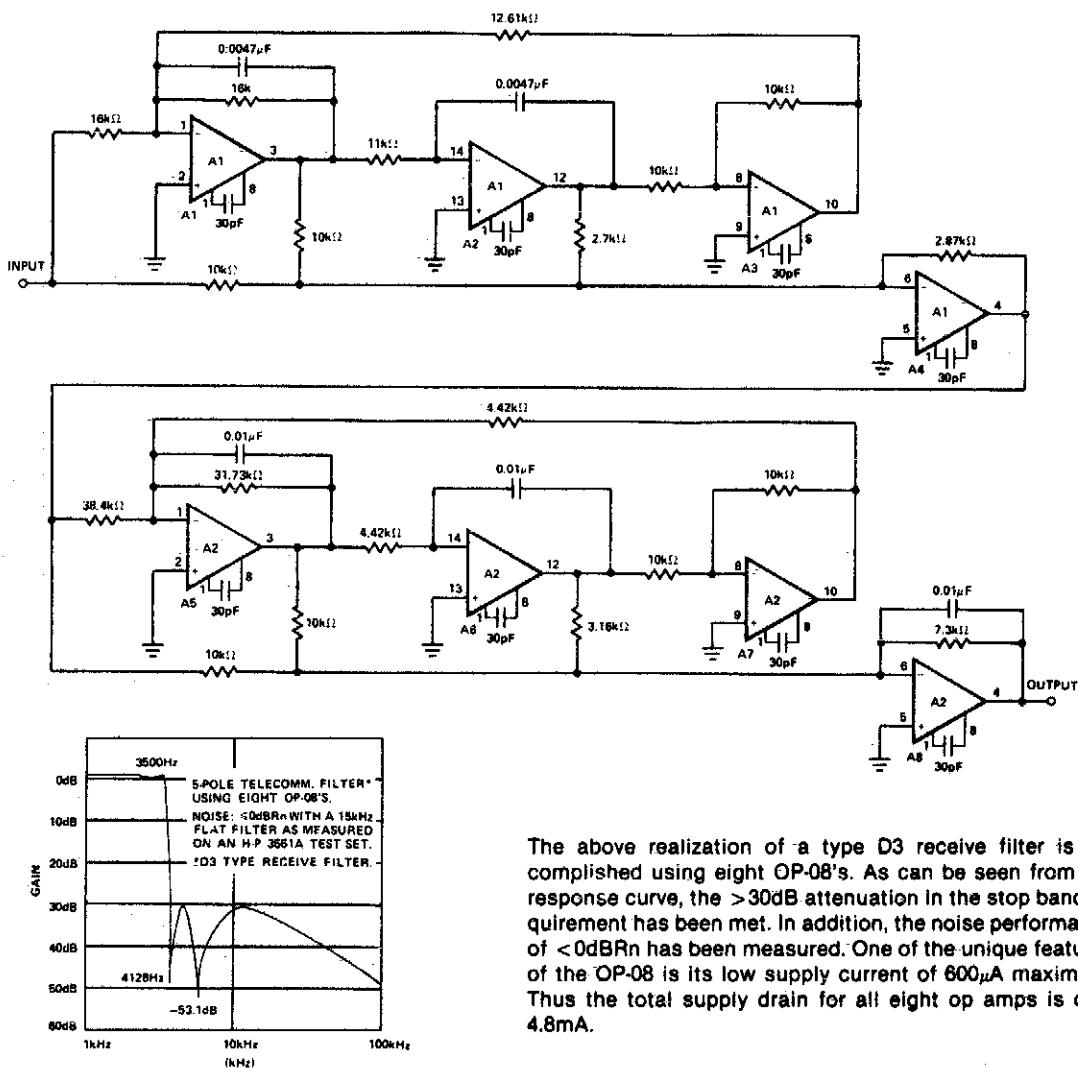
33

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 μ 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 >30dB attenuation in the stop band requirement has been met. In addition, the noise performance of <0dBRn has been measured. One of the unique features of the OP-08 is its low supply current of $600\mu A$ maximum. Thus the total supply drain for all eight op amps is only 4.8mA.

Fig. 33-1

DIGITALLY TUNED LOW POWER ACTIVE FILTER

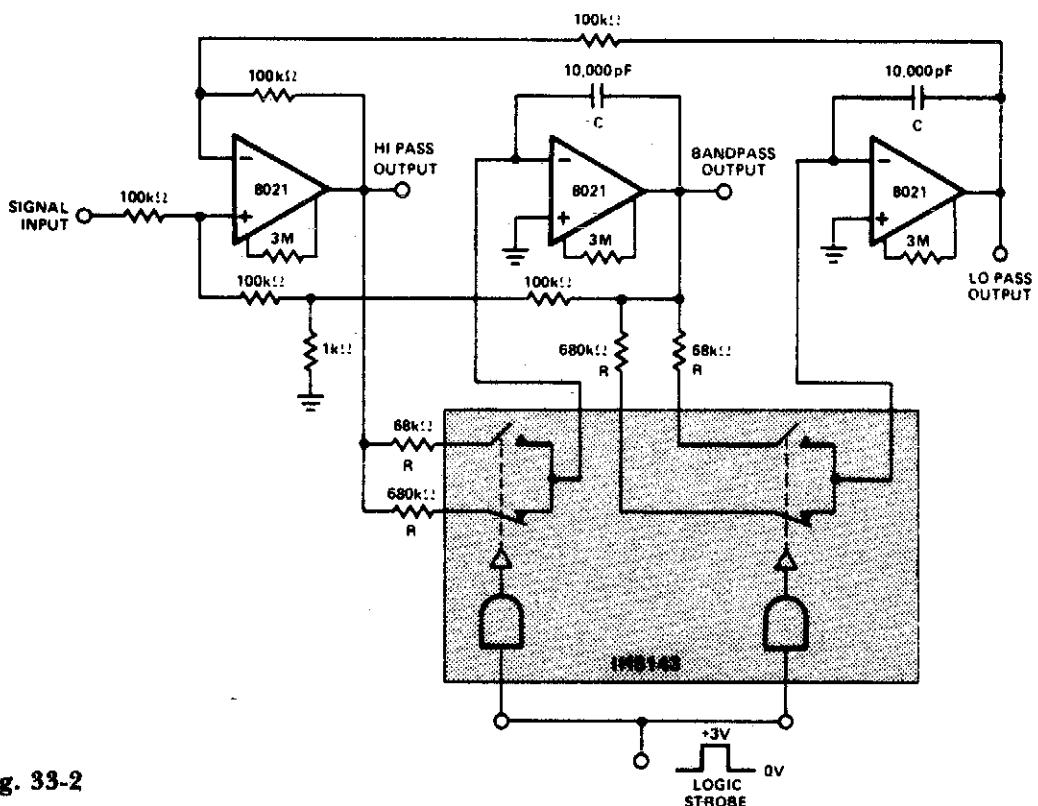


Fig. 33-2

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.

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

10 kHz SALLEN-KEY LOW-PASS FILTER

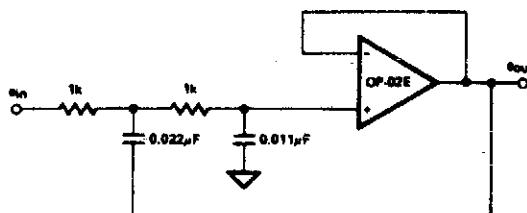
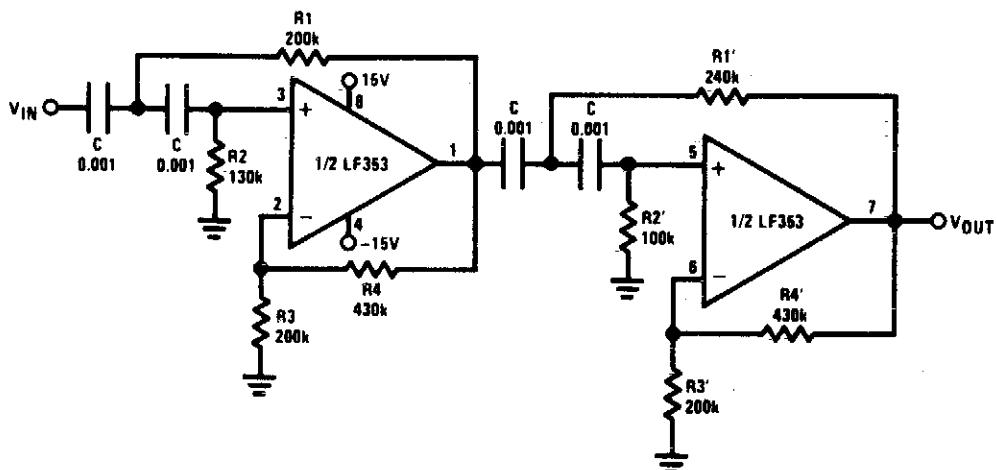


Fig. 33-3

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_O) = $(1 + R_4/R_3)(1 + R'_4/R'_3)$
- 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

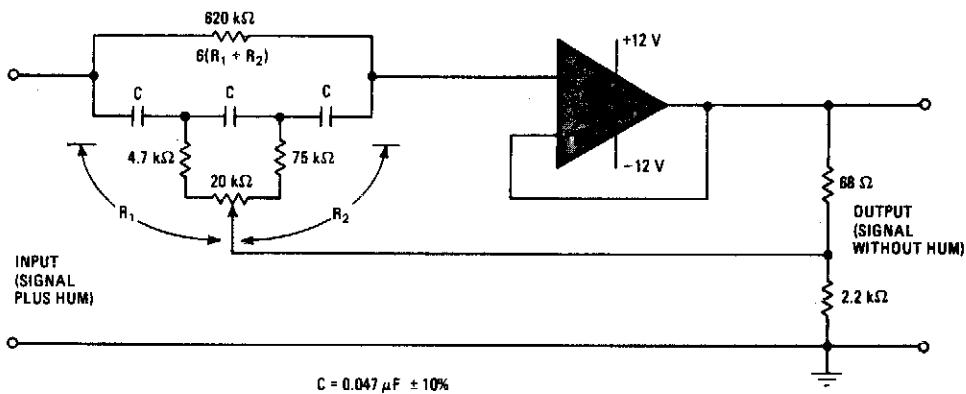


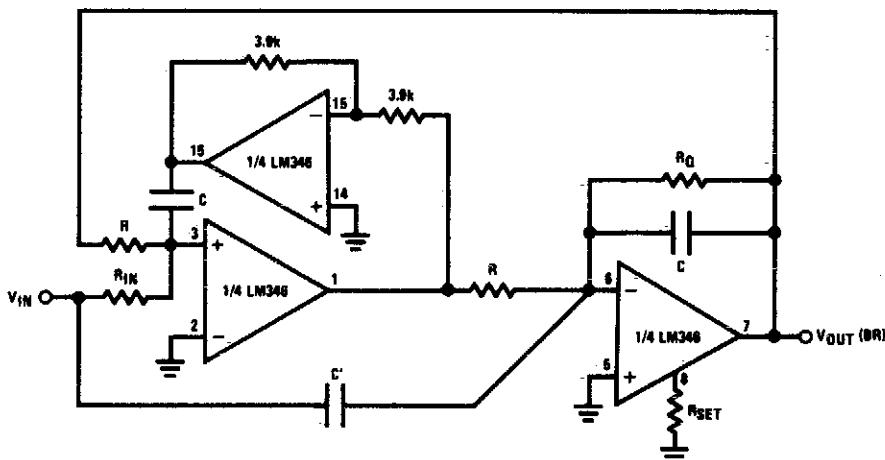
Fig. 33-5

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: $R_{IN} = R$, $C' = C$.

$$H_0(BR) \Big|_{f \ll f_{notch}} = \frac{R}{R_{IN}} H_0(BR) \Big|_{f \gg f_{notch}} = \frac{C'}{C}$$

Fig. 33-6

SELECTABLE BANDWIDTH NOTCH FILTER

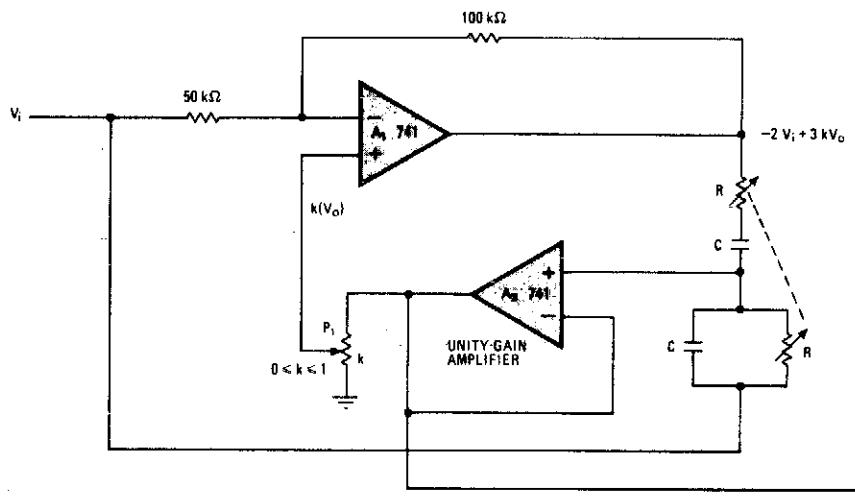


Fig. 33-7

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

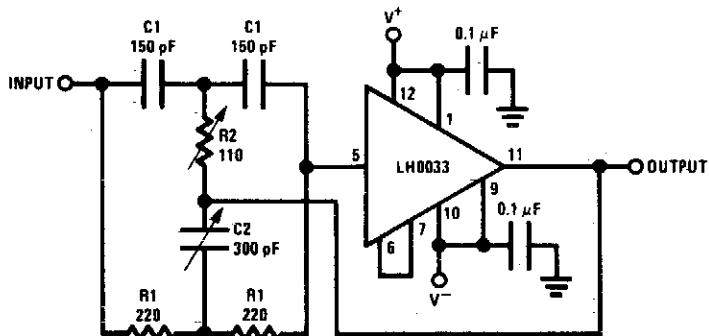


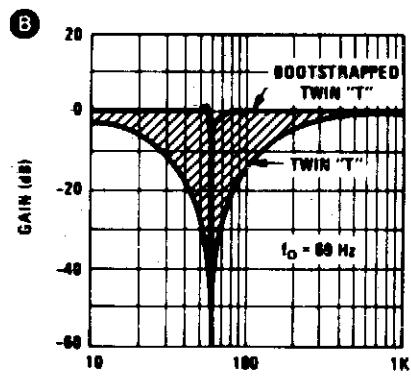
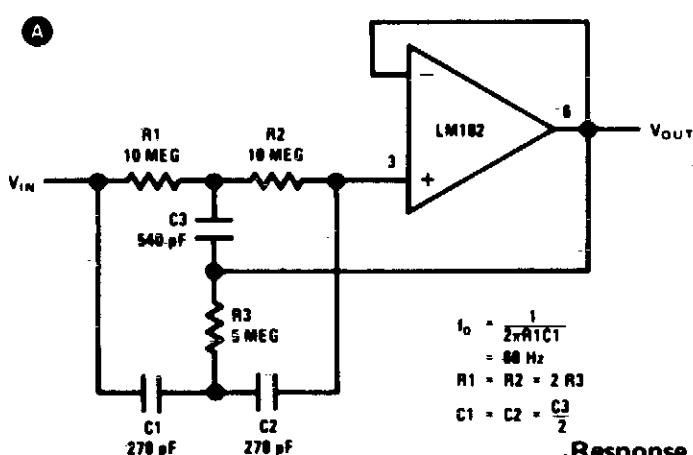
Fig. 33-8

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 R_3 and C_3 , 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 R_3 and C_3 . B shows the response of a normal twin-T and the response with the follower added.

REJECTION FILTER

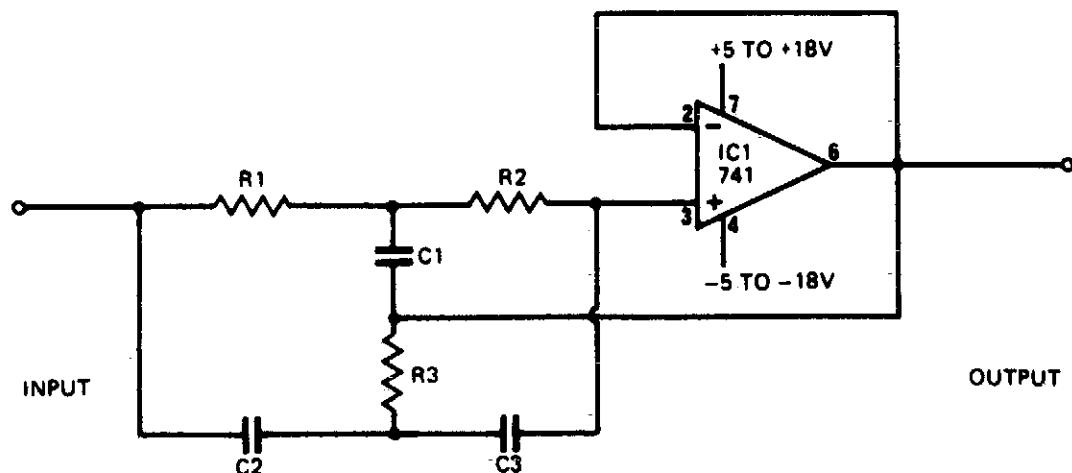


Fig. 33-10

Circuit Notes

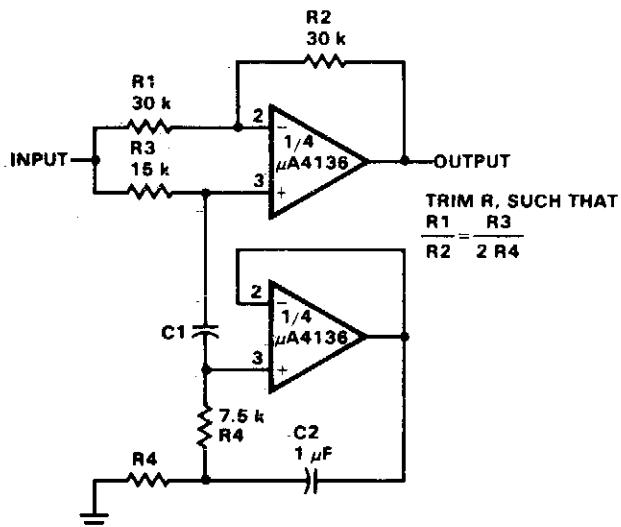
This narrowband filter using the 741 operational amplifier can provide up to 60 dB of rejection. With resistors equal to 100 K and capacitors equal to 320 pF, the circuit will reject 50 Hz. Frequencies within the range 1 Hz to 10 kHz may be rejected by selecting compo-

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

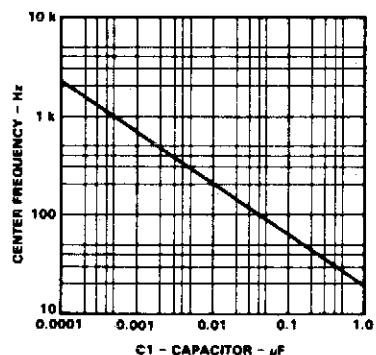


Fig. 33-11

1 kHz BANDPASS ACTIVE FILTER

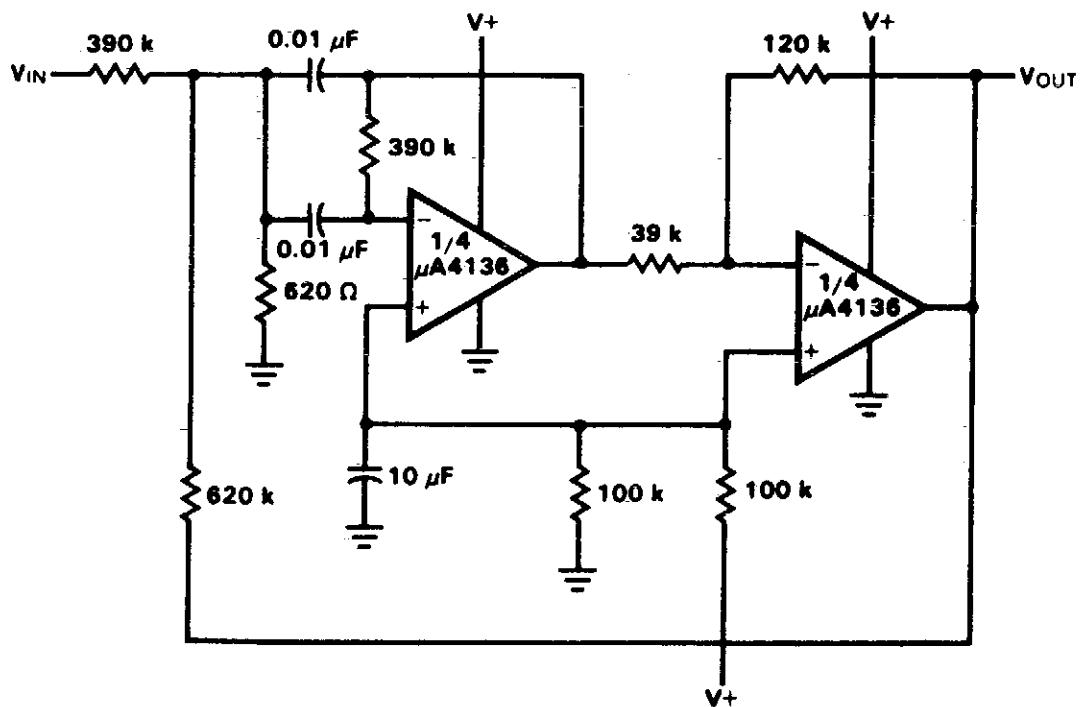
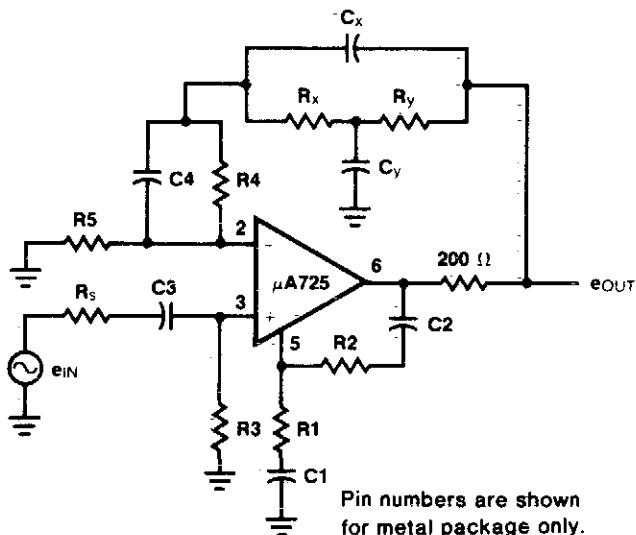


Fig. 33-12

BANDPASS ACTIVE FILTER WITH 60 dB GAIN



Pin numbers are shown
for metal package only.

Active Filter Frequency Response

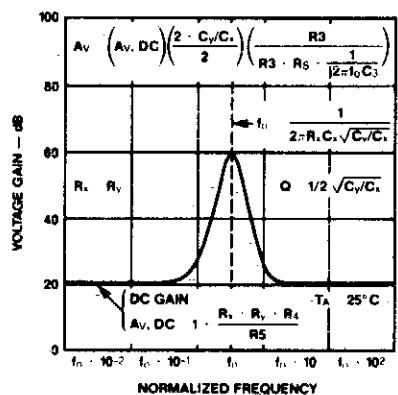
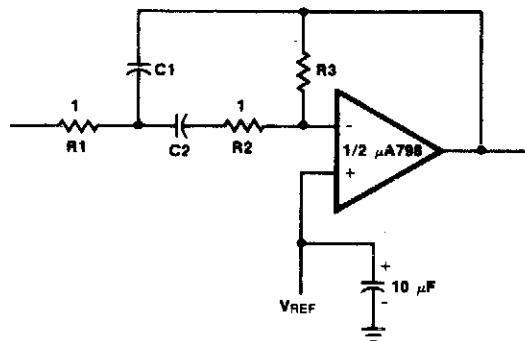


Fig. 33-13

MULTIPLE FEEDBACK BANDPASS FILTER



$f_0 = \frac{\Delta}{BW}$ center frequency

Δ BW = Bandwidth

R in kΩ

C in μF

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

$$C_1 = C_2 = \frac{Q}{3}$$

$R_1 = R_2 = 1$
 $R_3 = 9Q^2 - 1$ } 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: $Q = 5$, $f_0 = 1 \text{ kHz}$

Let $R_1 = R_2 = 10 \text{ k}\Omega$

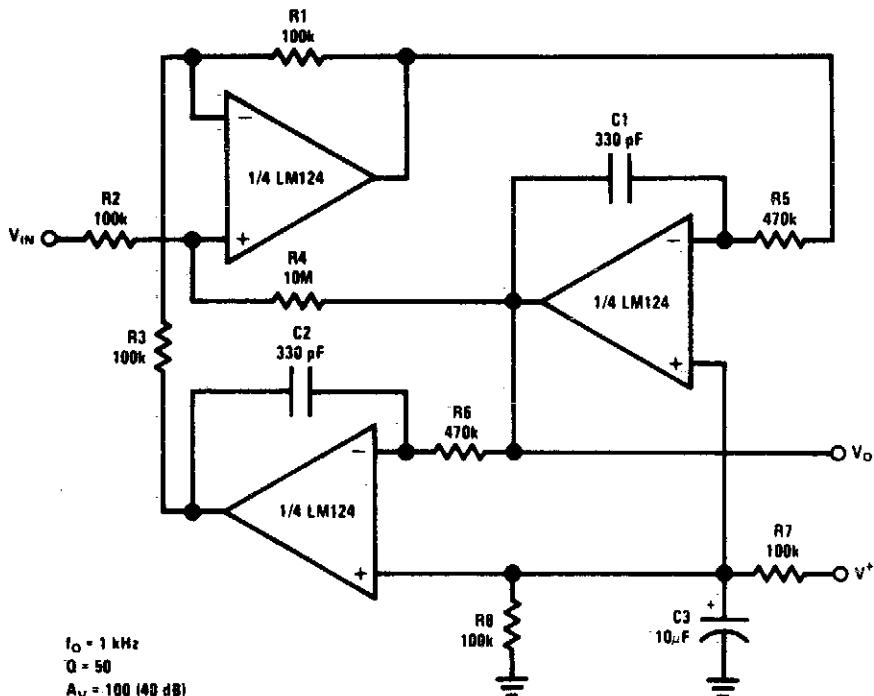
then $R_3 = 9(5)^2 - 10$

$R_3 = 215 \text{ k}\Omega$

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

Fig. 33-14

BIQUAD RC ACTIVE BANDPASS FILTER



$f_0 = 1 \text{ kHz}$
 $Q = 50$
 $A_v = 100$ (40 dB)

Fig. 33-15

400 Hz LOW-PASS BUTTERWORTH ACTIVE FILTER

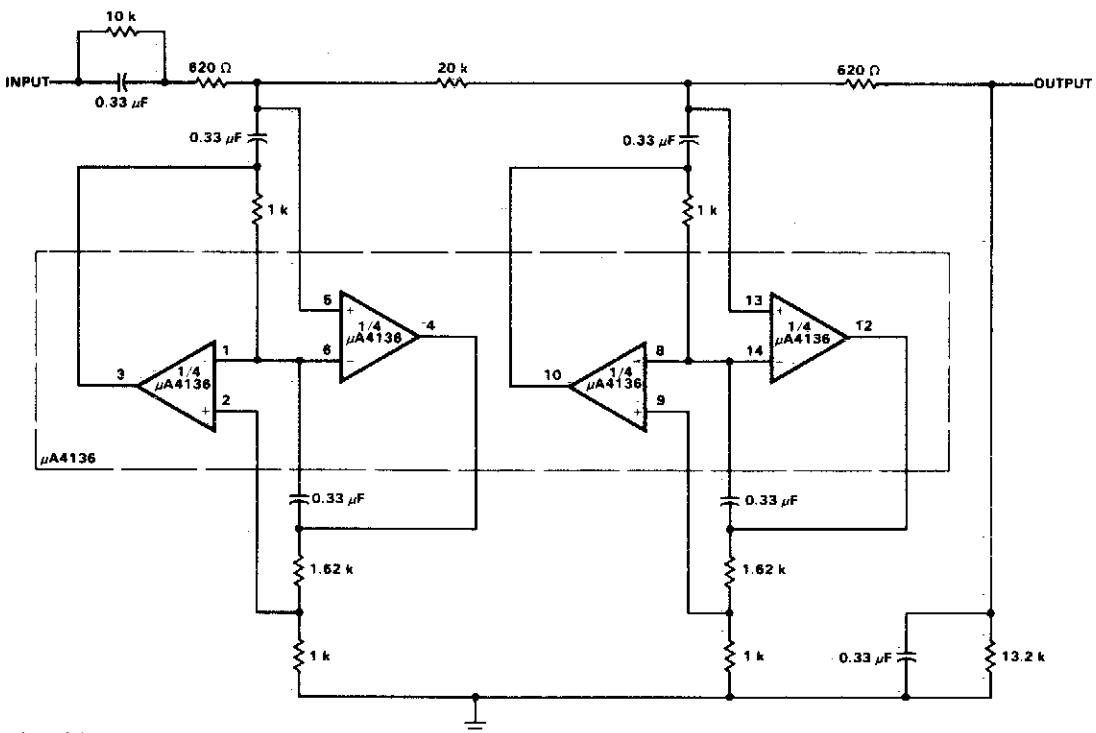


Fig. 33-16

VARIABLE BANDWIDTH BANDPASS ACTIVE FILTER

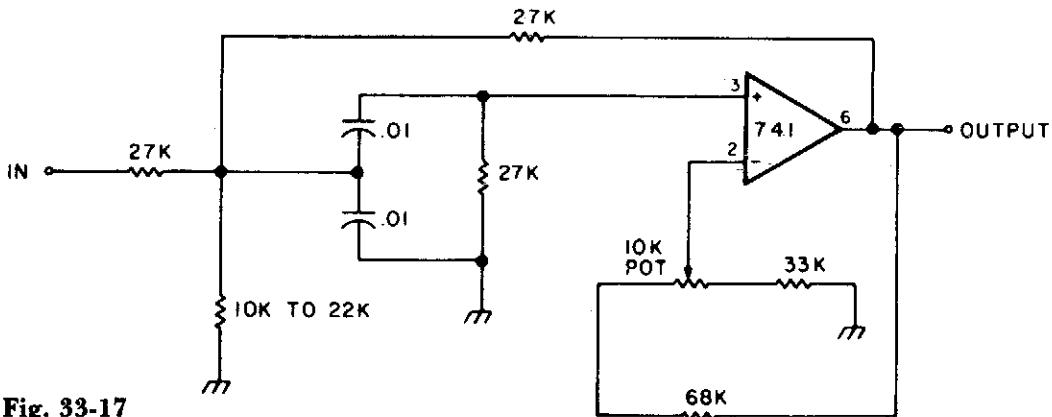
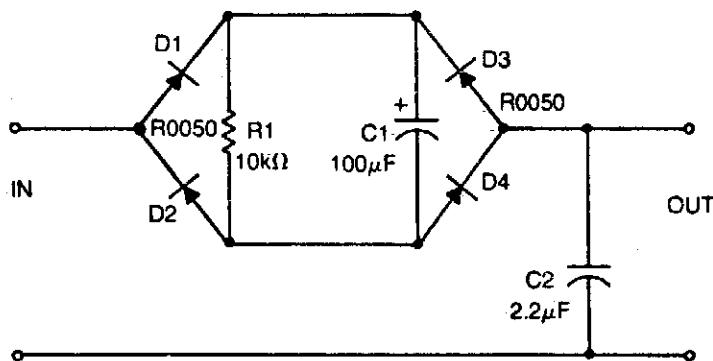


Fig. 33-17

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



D1, D2, D3, D4—HEP R0050 C2— $2.2\mu F$
 C1— $100\mu F$, 50V electrolytic R1— $10k\Omega$, 1/2W

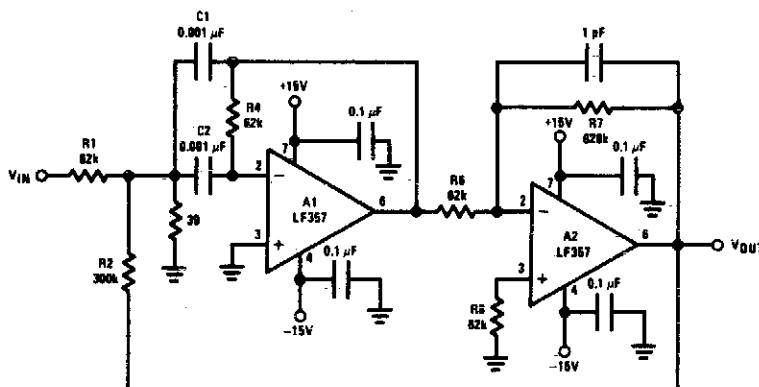
Fig. 33-18

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

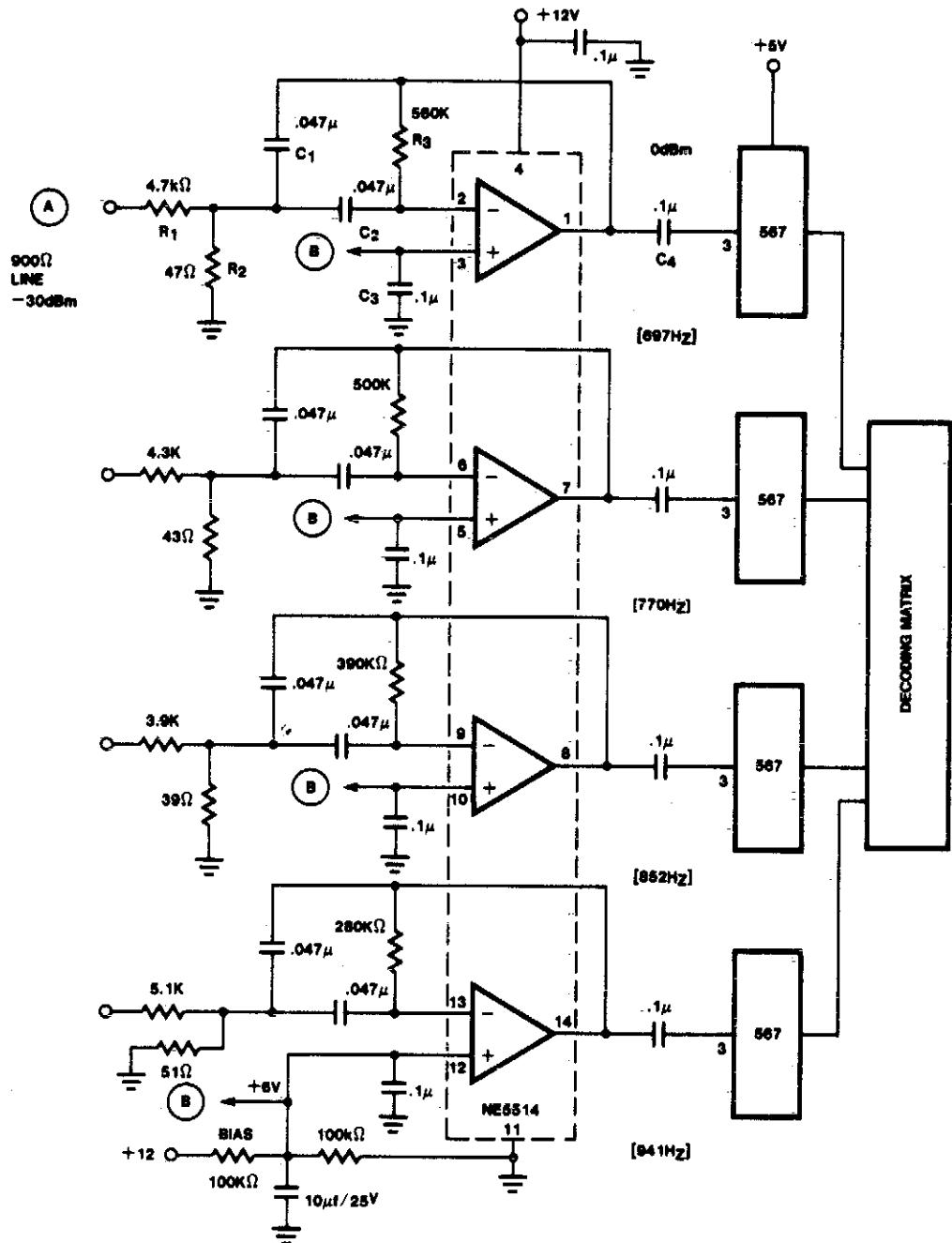
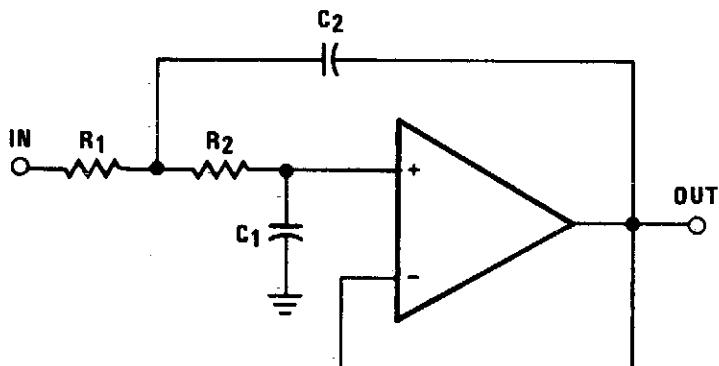


Fig. 33-20

SALLEN-KEY SECOND ORDER LOW-PASS FILTER



NOTES:

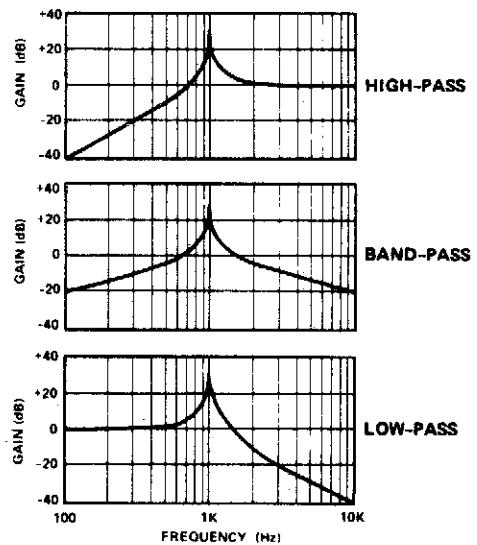
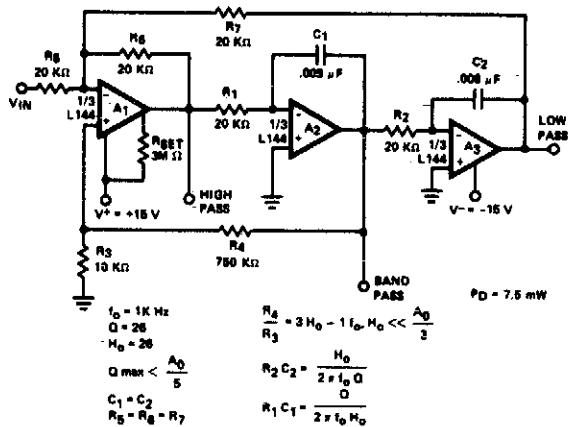
1. Make $R_1 = R_2$

$$2. f_c = \frac{1}{2 \pi R_1 \sqrt{C_1 C_2}}$$

$$3. Q = \frac{1}{2} \sqrt{\frac{C_2}{C_1}}$$

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

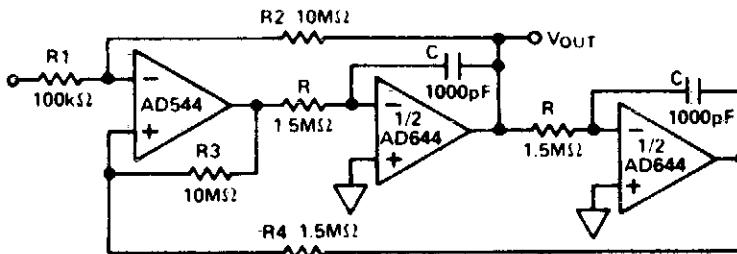


Fig. 33-23

$$f_0 = \text{CENTER FREQUENCY} = 1/2 \pi R_C$$

$$Q_0 = \text{QUALITY FACTOR} = \frac{R_1 + R_2}{2R_1}$$

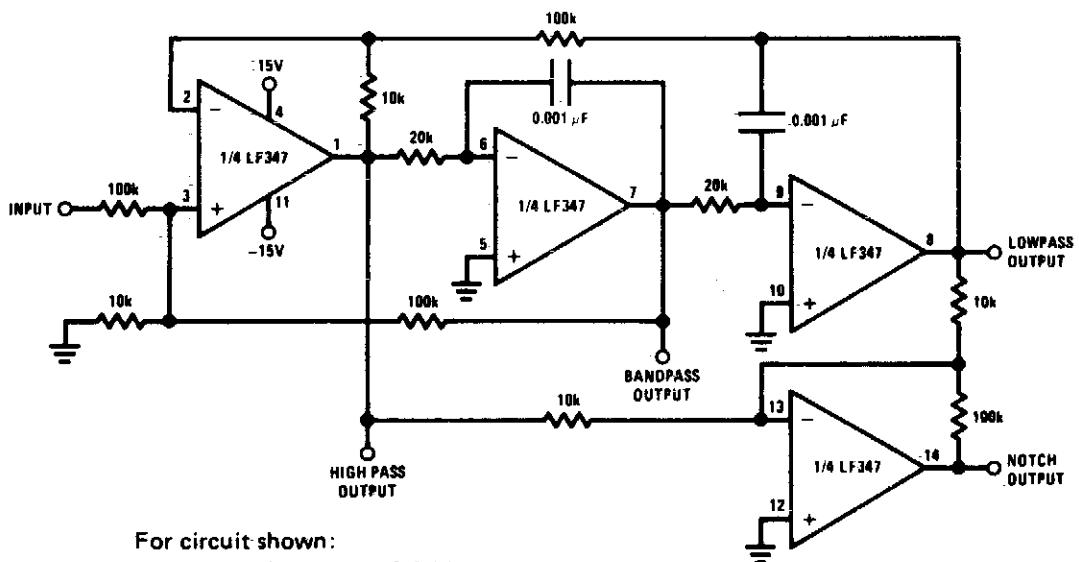
$$H_0 = \text{GAIN AT RESONANCE} = R_2/R_1$$

$$R_3 = R_4 \approx 10^8/f_0$$

Q_0 IS ADJUSTABLE BY VARYING R_2

f_0 IS ADJUSTABLE BY VARYING R OR C

UNIVERSAL STATE VARIABLE FILTER



For circuit shown:

$$f_0 = 3 \text{ kHz}, f_{\text{NOTCH}} = 9.5 \text{ kHz}$$

$$Q = 3.4$$

Passband gain:

Highpass — 0.1

Bandpass — 1

Lowpass — 1

Notch — 10

- $f_0 \times Q \leq 200 \text{ kHz}$

- 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

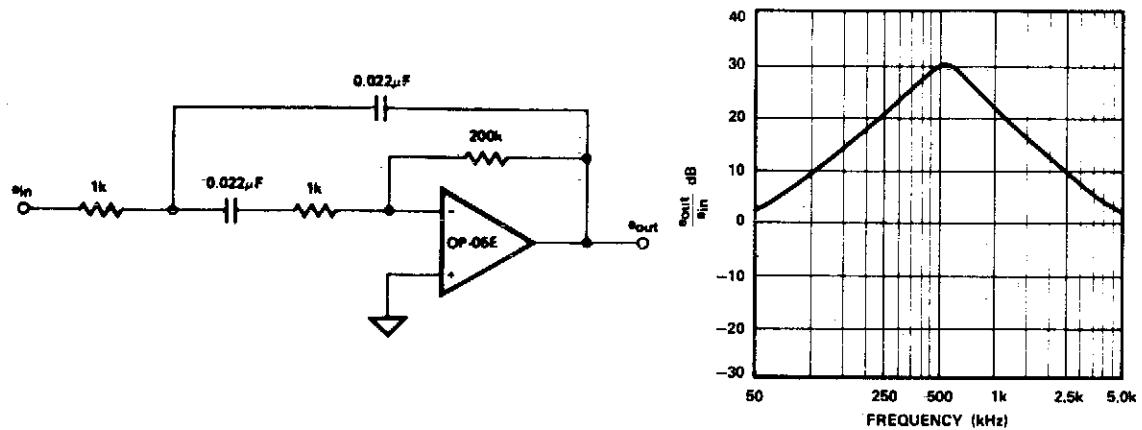
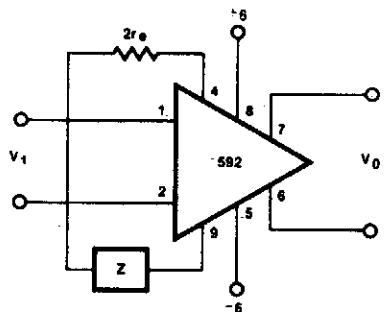


Fig. 33-25

FILTER NETWORKS



$$\begin{aligned} \frac{V_0(s)}{V_1(s)} &\approx \frac{1.4 \times 10^4}{Z(s) + 2r_e} \\ &\approx \frac{1.4 \times 10^4}{Z(s) + 32} \end{aligned}$$

BASIC CONFIGURATION

Z NETWORK	FILTER TYPE	$\frac{V_0(s)}{V_1(s)}$ 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

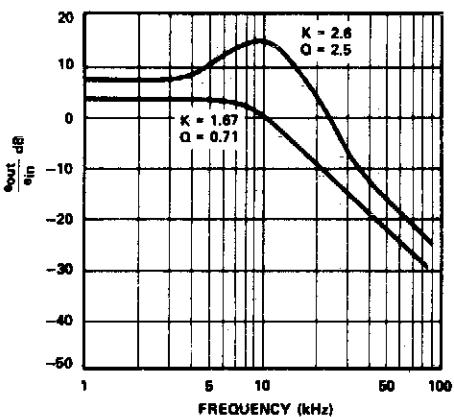
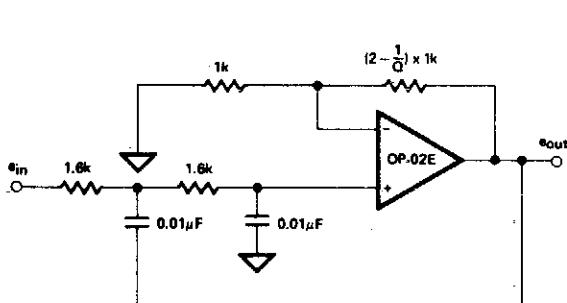
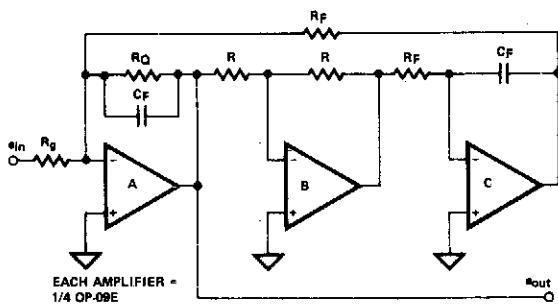


Fig. 33-27

Equal R, Equal C Sallen-Key Response

BIQUAD FILTER



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.

Fig. 33-28

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

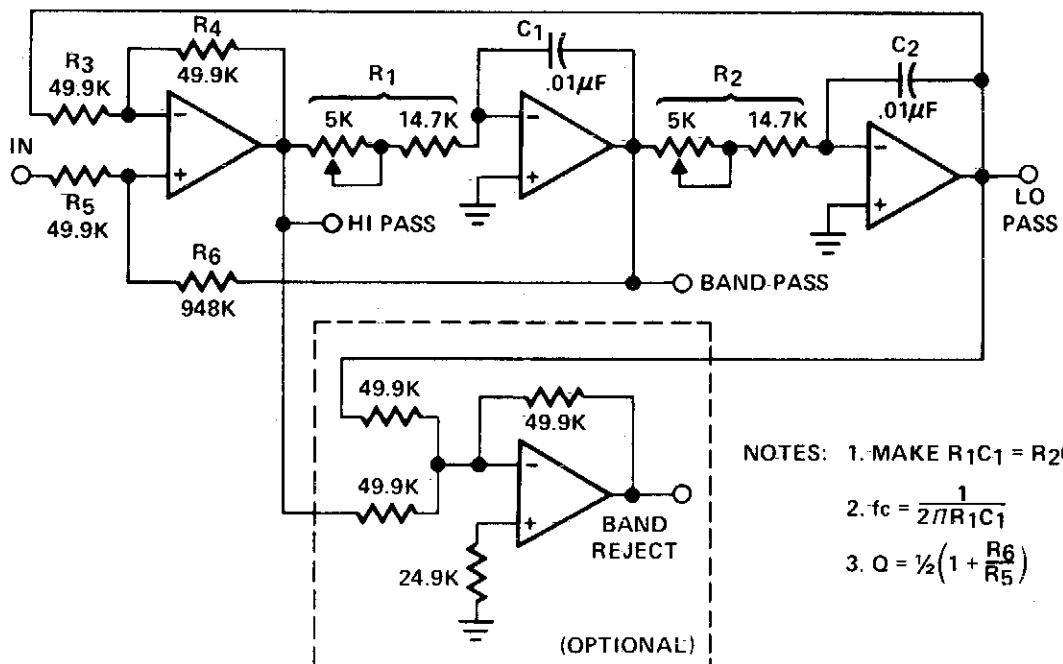


Fig. 33-29

BIQUAD FILTER

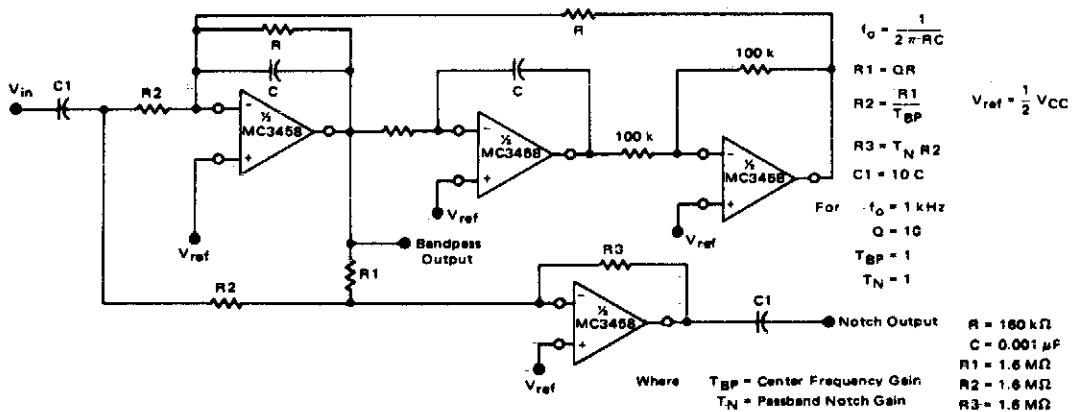


Fig. 33-30

TUNABLE ACTIVE FILTER

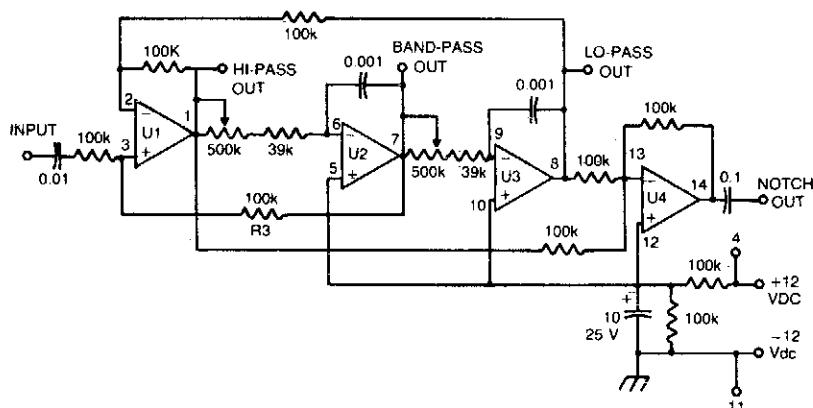
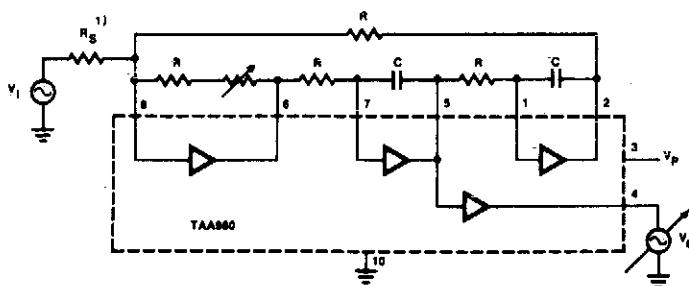


Fig. 33-31

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 reverse log taper. Fixed-frequency active filter center frequency is 1 kHz, with a Q of 50.

ACTIVE RC FILTER FOR FREQUENCIES UP TO 150 kHz



$R = 10\text{k}\Omega$

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

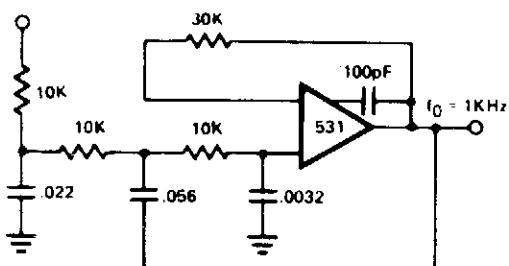
Fig. 33-32

f	Frequency	$\frac{1}{2\pi RC}$	V
V_p	Supply voltage	6	
	Filter performance		
Q	at $T_A = 25^\circ\text{C}$	40 to 55	
Q	at $T_A = -30$ to $+65^\circ\text{C}$	35 to 55	
V_i	Input voltage	400	mV
V_o	Output voltage	400	mV
d_{tot}	Distortion at $V_o = 350\text{mV}$	2	%
S/N	S/N ratio at $V_o = 400\text{mV}$	50	dB
R_s	Input resistor*	470	k Ω

*NOTE

Value of input resistor to be determined for $\frac{V_o}{V_i} = 0.90$ 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**

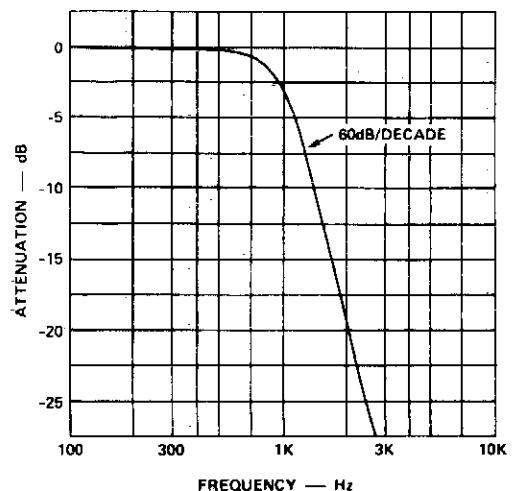
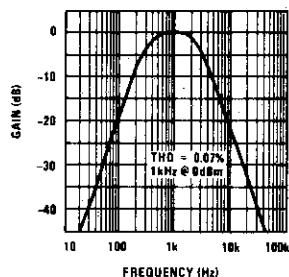
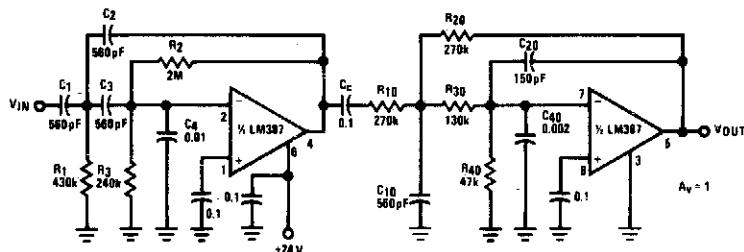


Fig. 33-33

SPEECH FILTER (300 Hz .3 kHz BANDPASS)



Speech Filter Frequency Response

Fig. 33-34

0.1 Hz TO 10 Hz BANDPASS FILTER

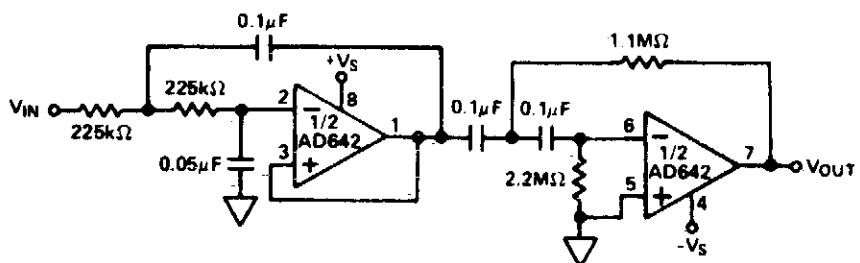


Fig. 33-35

HIGH-PASS ACTIVE FILTER

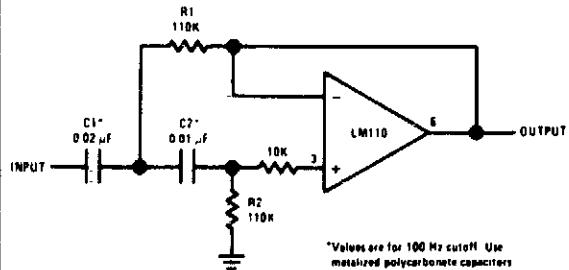


Fig. 33-36

HIGH-PASS FILTER (HIGH FREQUENCY)

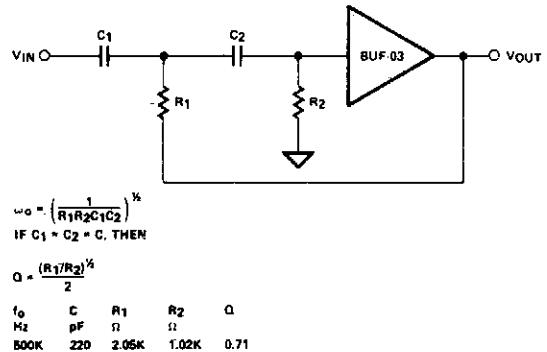


Fig. 33-38

SECOND ORDER HIGH-PASS ACTIVE FILTER

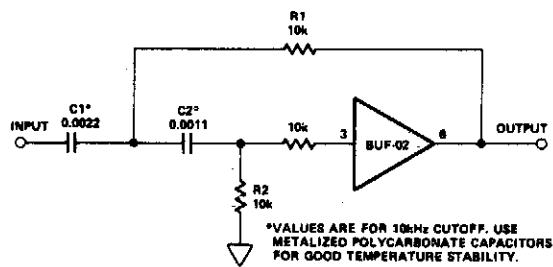


Fig. 33-37

160 Hz BANDPASS FILTER

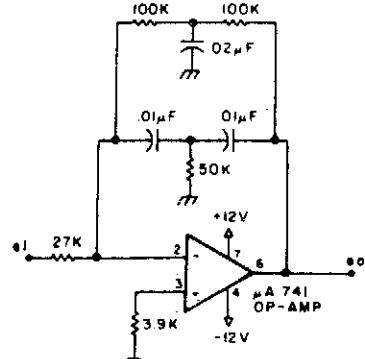


Fig. 33-39

MULTIPLE FEEDBACK BANDPASS FILTER (1.0 kHz)

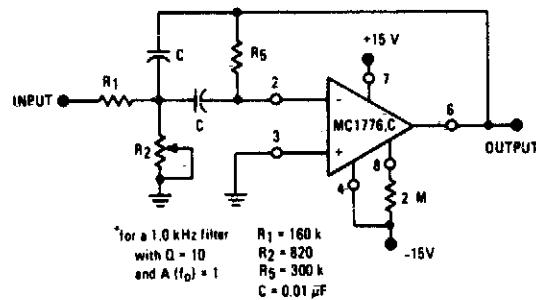


Fig. 33-40

RUMBLE FILTER USING LM387

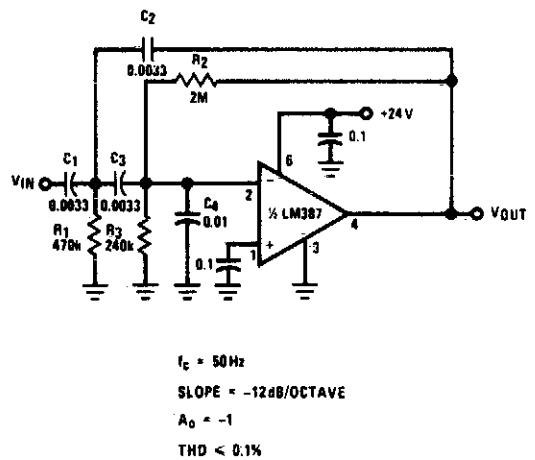


Fig. 33-42

20 kHz BANDPASS ACTIVE FILTER

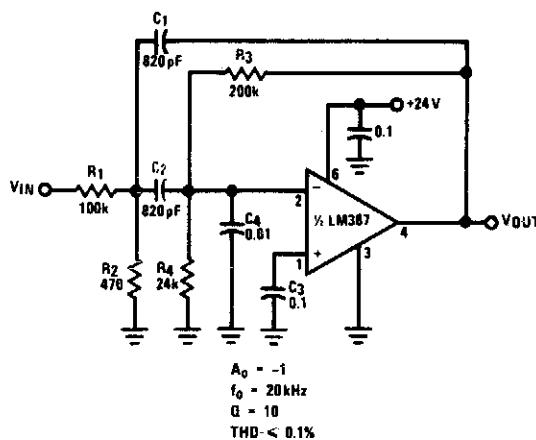


Fig. 33-41

SCRATCH FILTER USING LM387

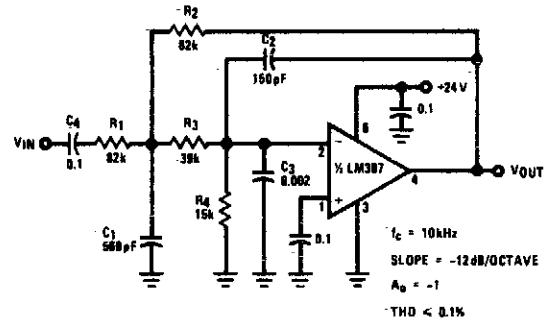


Fig. 33-43

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

AUTO, BOAT, OR BARRICADE FLASHER

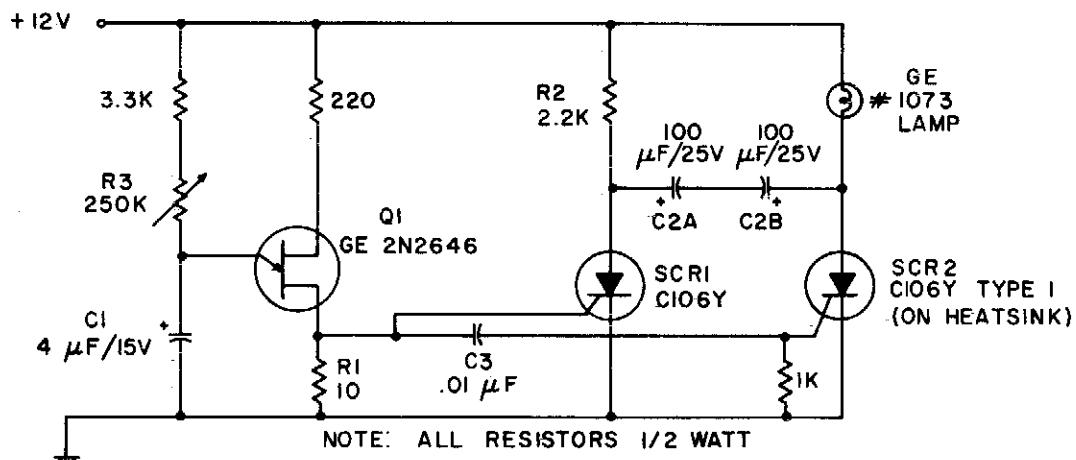


Fig. 34-1

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.

FLIP-FLOP FLASHER

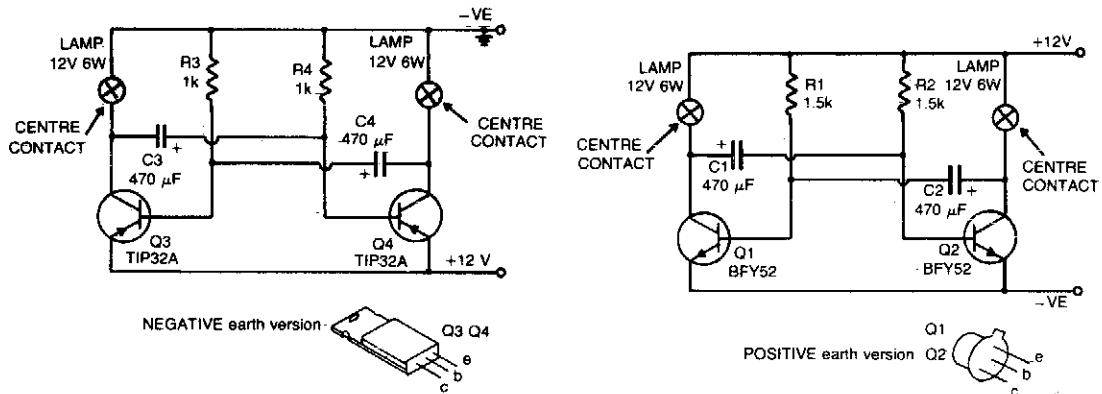
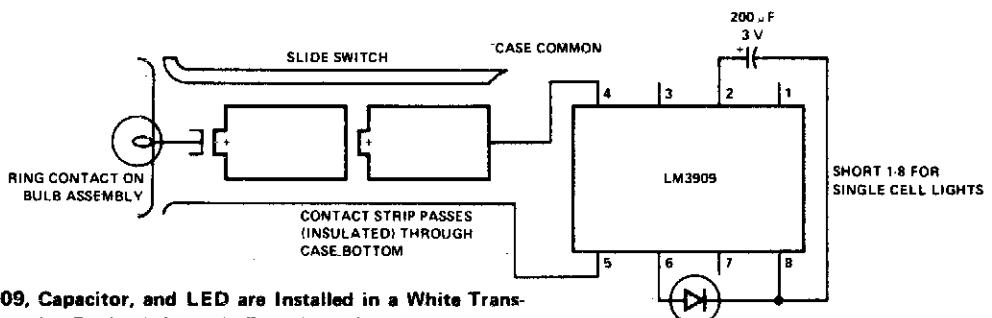


Fig. 34-2

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

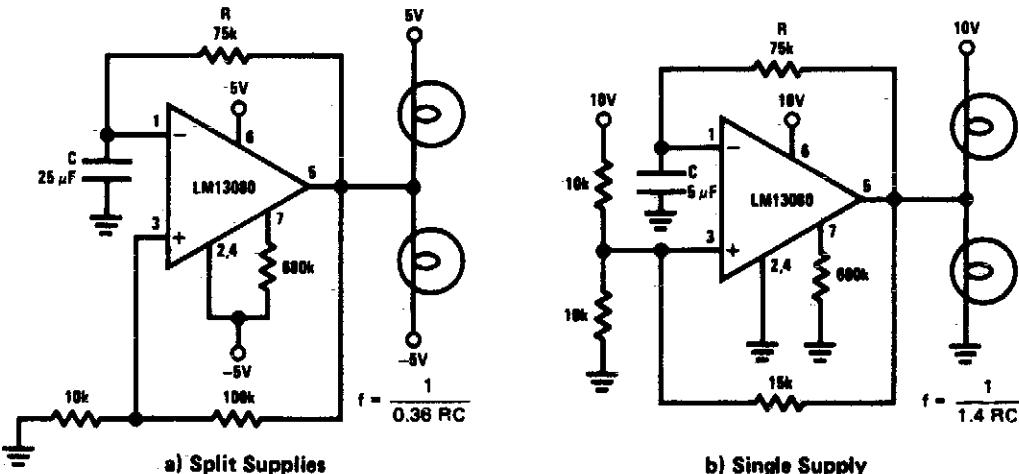


Fig. 34-4

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.

LOW COST RING COUNTER

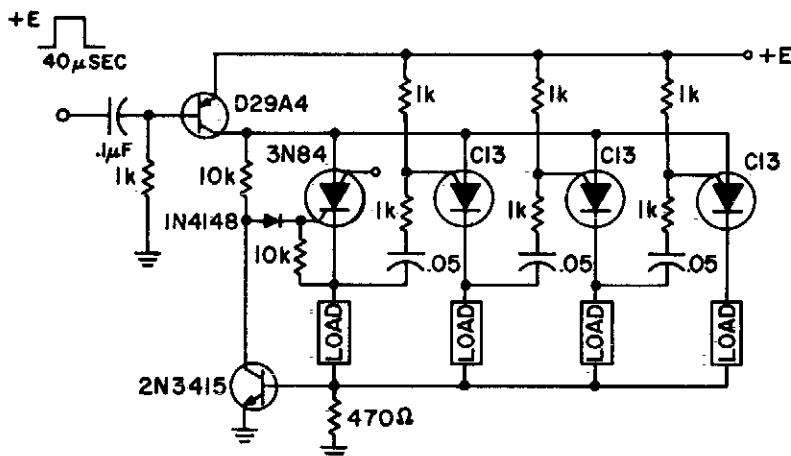


Fig. 34-5

Circuit Notes

This ring counter makes an efficient, low cost circuit featuring automatic resetting via the first stage 3N84. As many stages as desired may be cascaded.

RING COUNTER FOR INCANDESCENT LAMPS

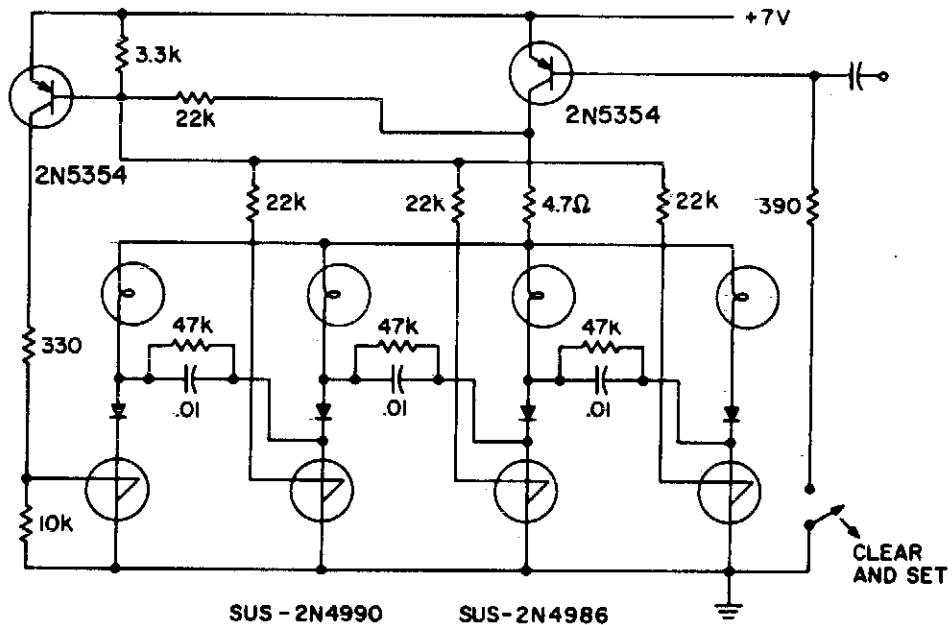


Fig. 34-6

DUAL LED CMOS FLASHER

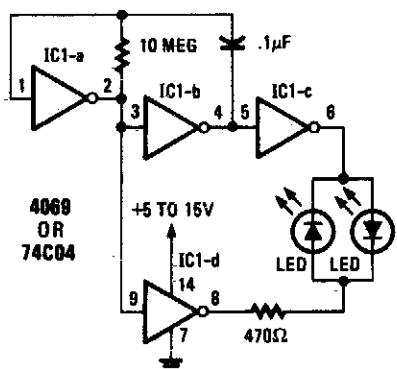


Fig. 34-7

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

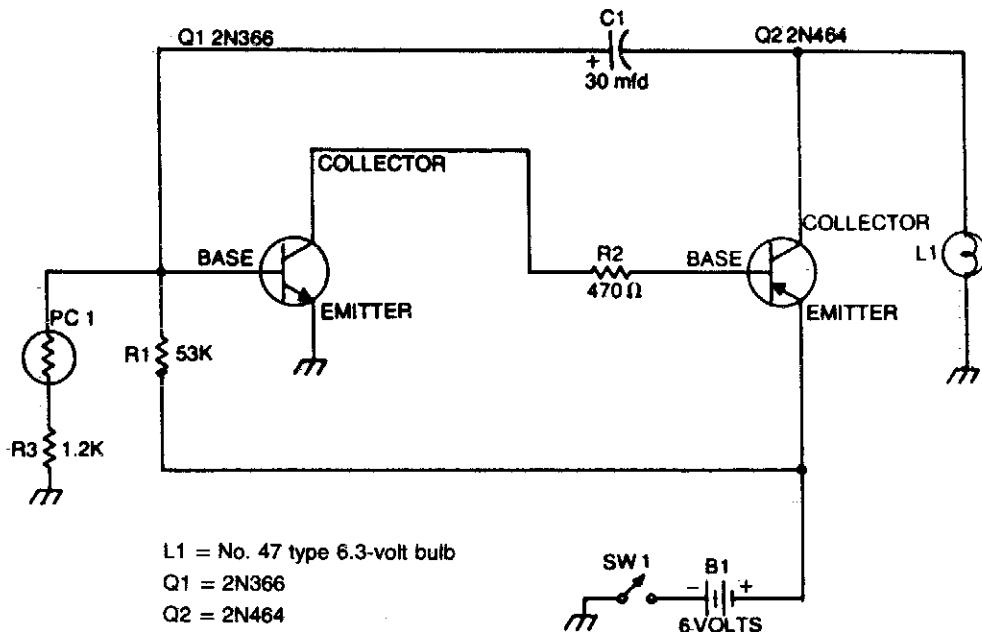


Fig. 34-8

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

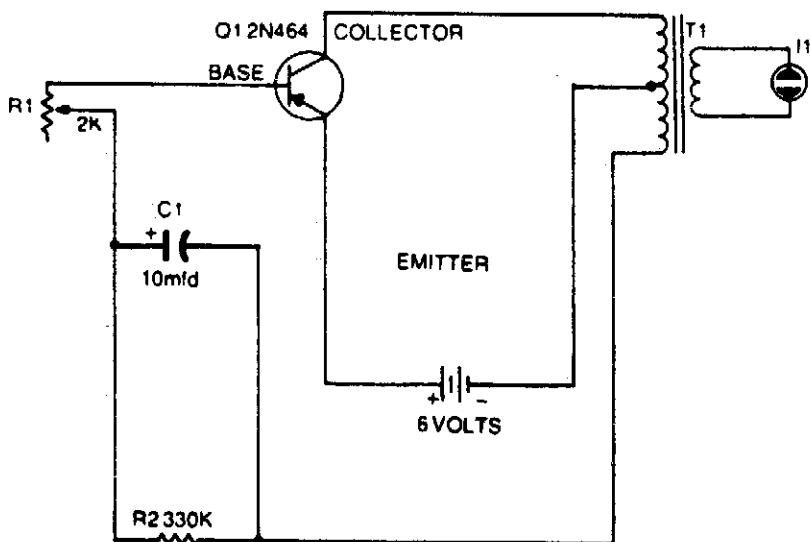
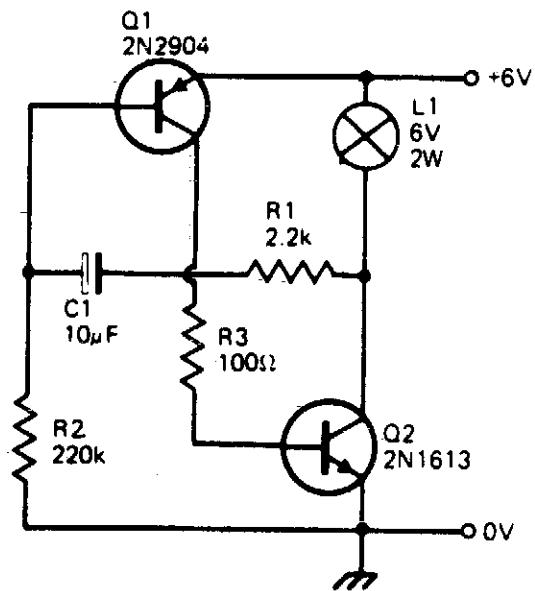


Fig. 34-9

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

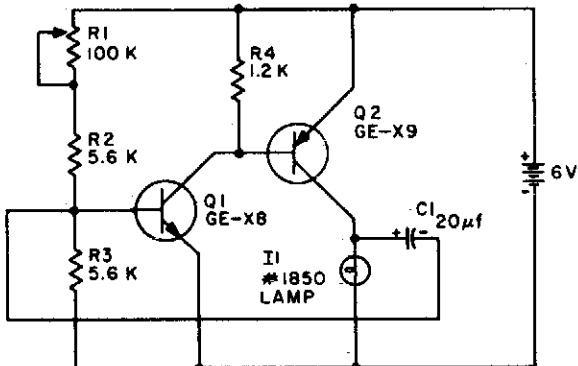


Fig. 34-11

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

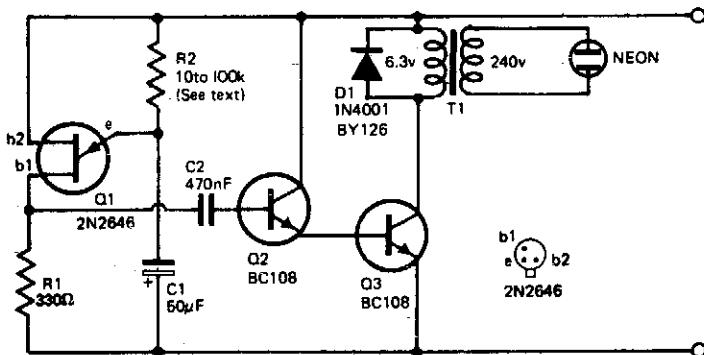


Fig. 34-12

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 milliamps 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

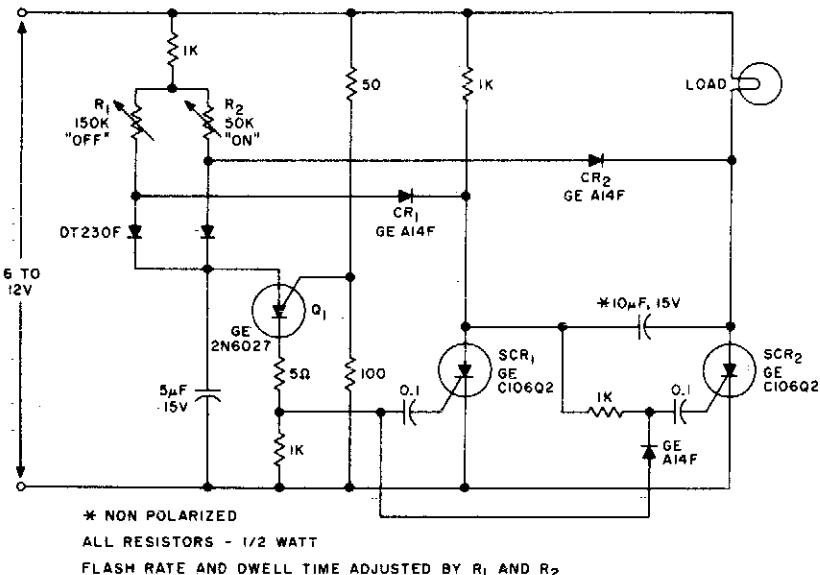


Fig. 34-13

Circuit Notes

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

LOW VOLTAGE FLASHER

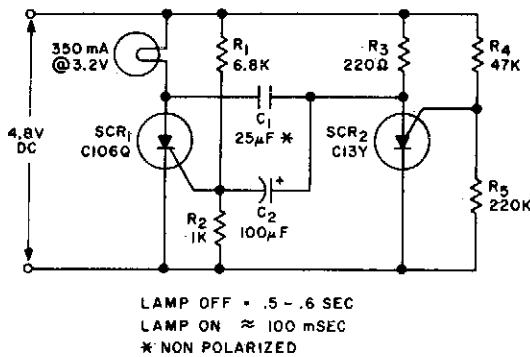


Fig. 34-14

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

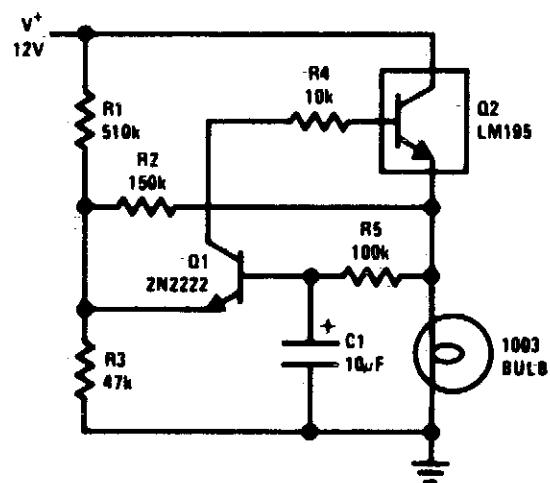
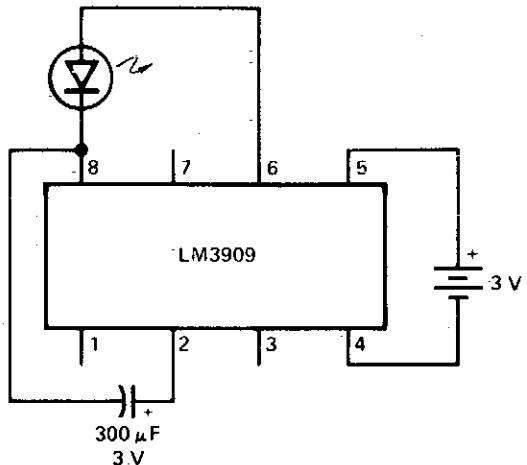


Fig. 34-15

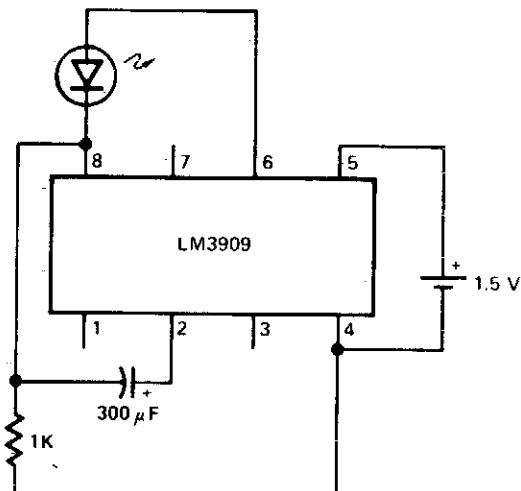
3 V FLASHER



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

Fig. 34-17

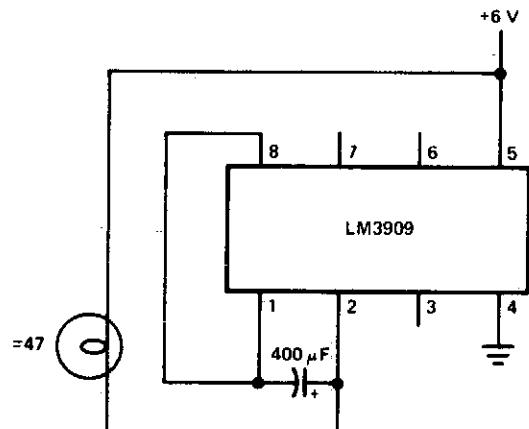
FAST BLINKER



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

Fig. 34-16

INCANDESCENT BULB FLASHER



Note: Flash Rate: 1.5 Hz

Fig. 34-18

FLASHER FOR 4 PARALLEL LEDs

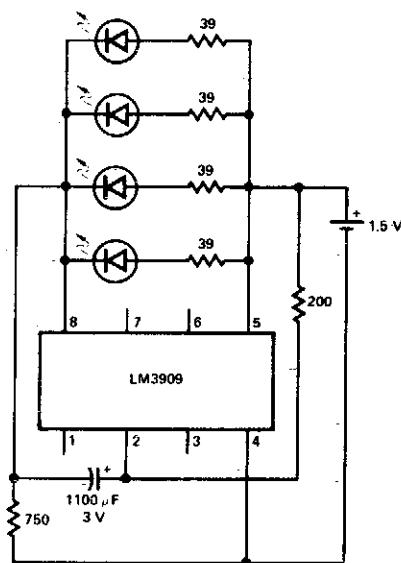


Fig. 34-19

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

SAFE, HIGH VOLTAGE FLASHER

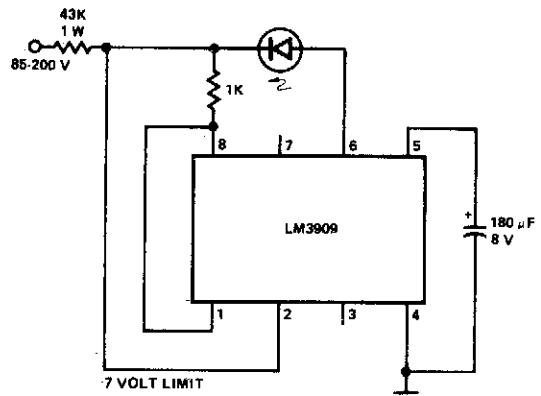
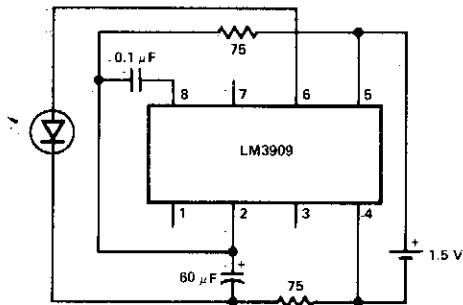


Fig. 34-21

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

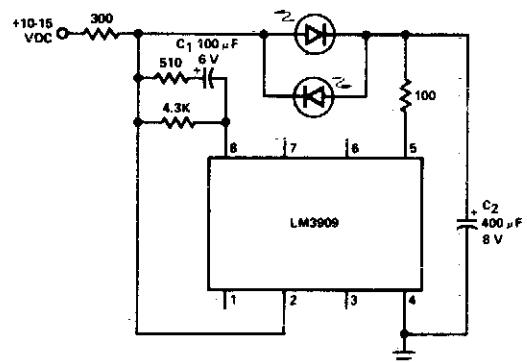
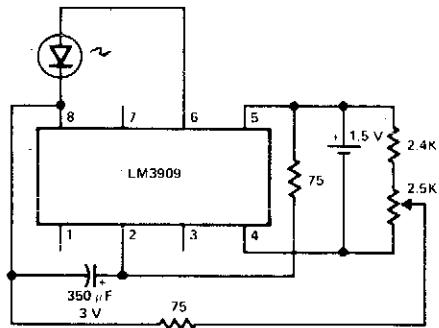


Fig. 34-22

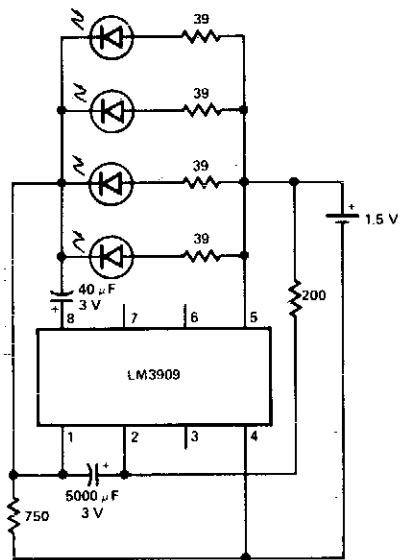
VARIABLE FLASHER



Note: Flash Rate: 0-20 Hz

Fig. 34-23

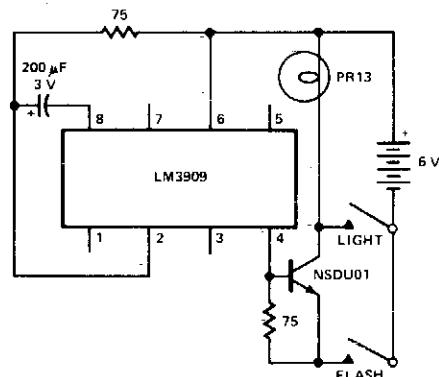
HIGH EFFICIENCY PARALLEL CIRCUIT FLASHER



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

Fig. 34-25

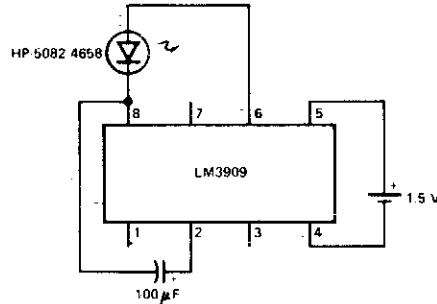
EMERGENCY LANTERN/FLASHER



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

Audio Frequency Meter

Linear Frequency Meter
Power-Line Frequency Meter

INEXPENSIVE FREQUENCY COUNTER/TACHOMETER

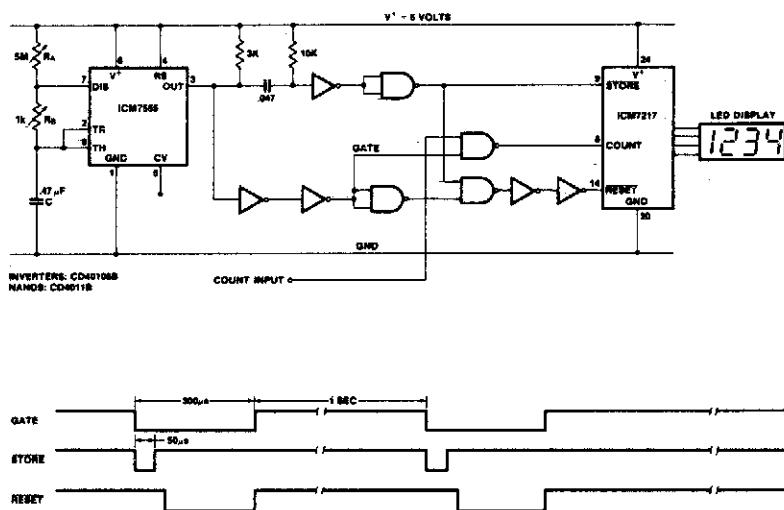


Fig. 35-1

Circuit Notes

This circuit uses the low power ICM7555 (CMOS 555) to generate the gating, STORE and RESET signals. To provide the gating signal, the timer is configured as an astable multivibrator. The system is calibrated by using a 5 M potentiometer for R_A as a coarse control and a 1 k potentiometer for R_B as a fine control. CD40106B's are used as a monostable multivibrator and reset time delay.

This circuit uses the low power ICM7555 (CMOS 555) to generate the gating, STORE and RESET signals. To provide the gating signal, the timer is configured as an astable multivibrator. The system is calibrated by using a 5 M potentiometer for R_A as a coarse control and a 1 k potentiometer for R_B as a fine control. CD40106B's are used as a monostable multivibrator and reset time delay.

LINEAR FREQUENCY METER (AUDIO SPECTRUM)

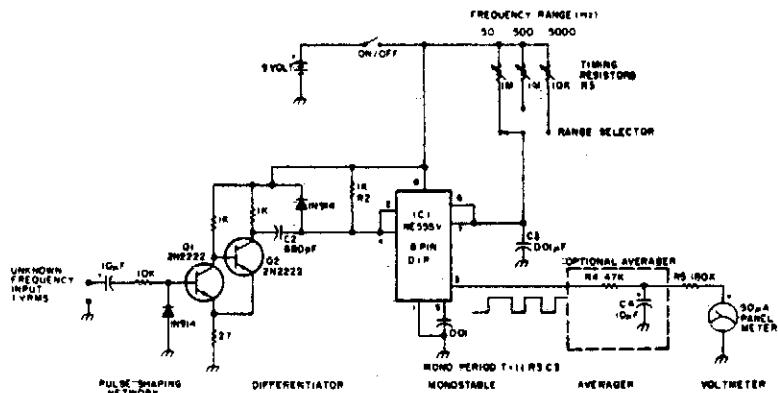


Fig. 35-2

Circuit Notes

The 555 is used in a monostable multivibrator circuit that puts out a fixed timewidth pulse, which is triggered by the unknown input frequency.

POWER-LINE FREQUENCY METER

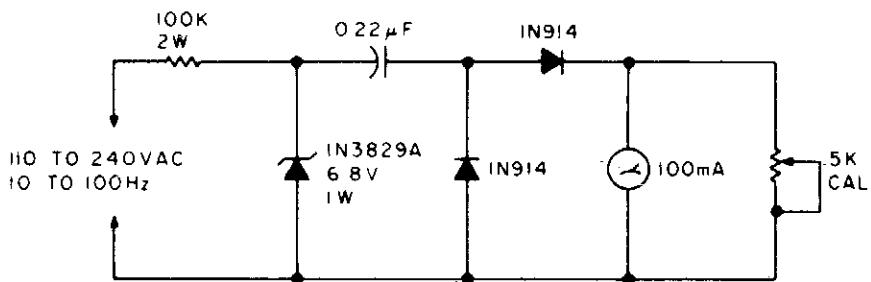


Fig. 35-3

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

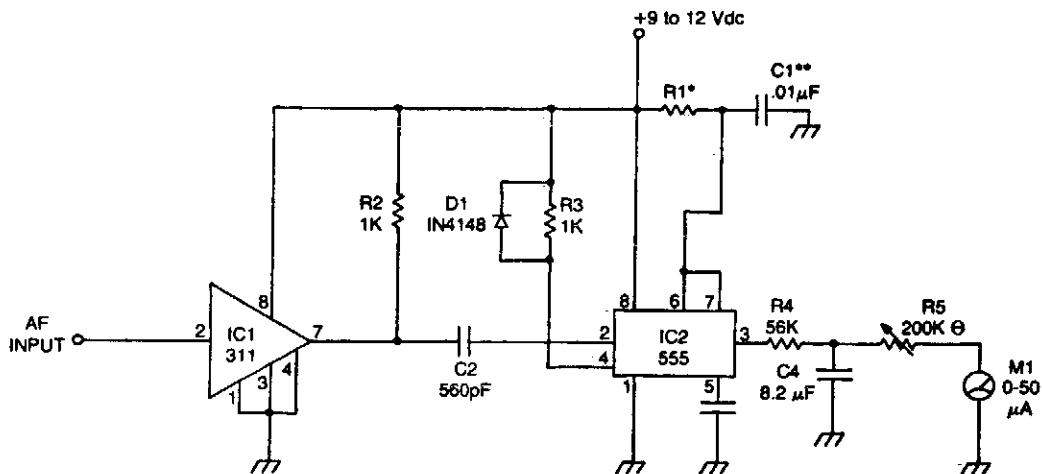


Fig. 35-4

*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

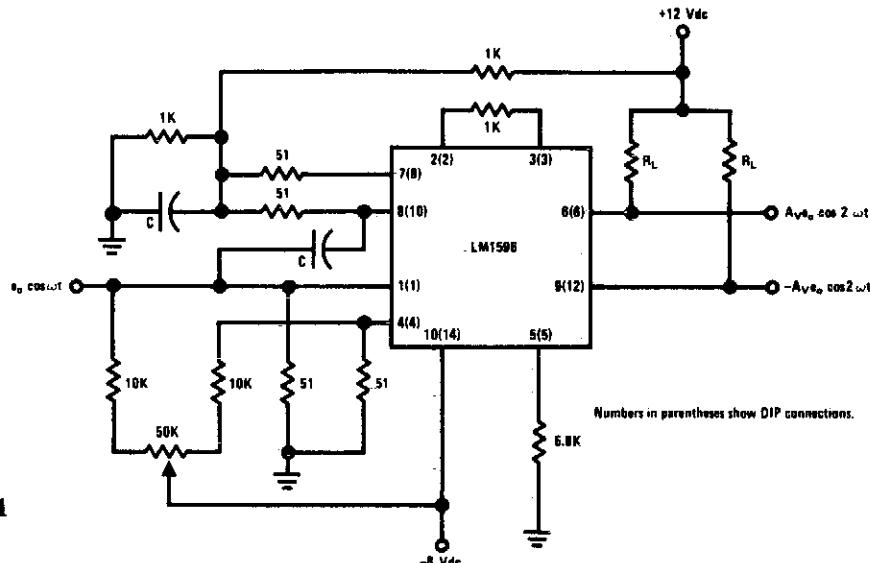


Fig. 36-1

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

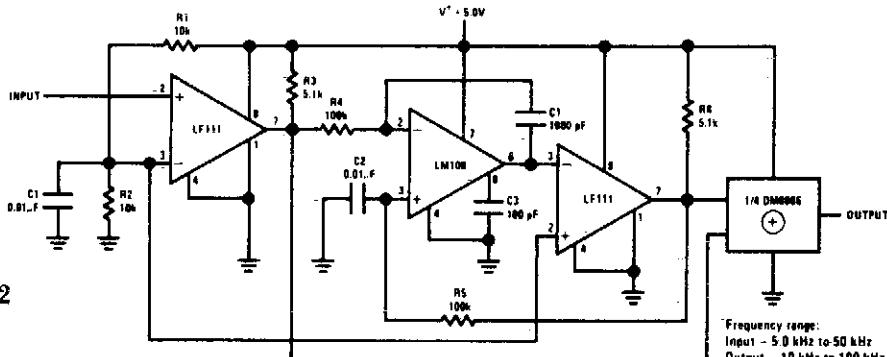


Fig. 36-2

150 TO 300 MHz DOUBLER

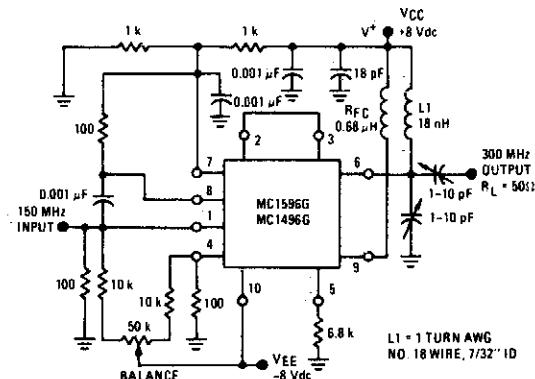


Fig. 36-3

LOW-FREQUENCY DOUBLER

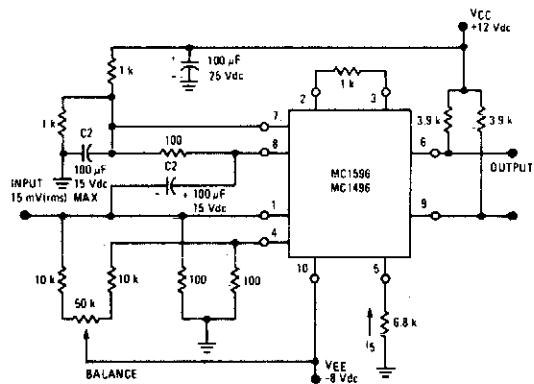


Fig. 36-4

OSCILLATOR WITH DOUBLE FREQUENCY OUTPUT

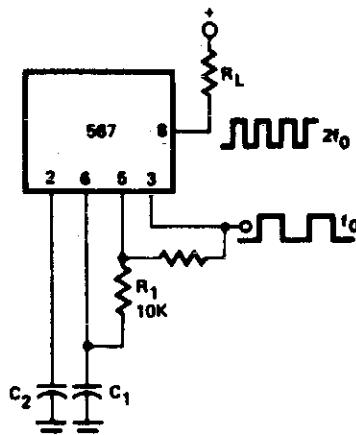


Fig. 36-5

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 Ripple
Precision Frequency-to-Voltage Converter

DC-10 kHz FREQUENCY/VOLTAGE CONVERTER

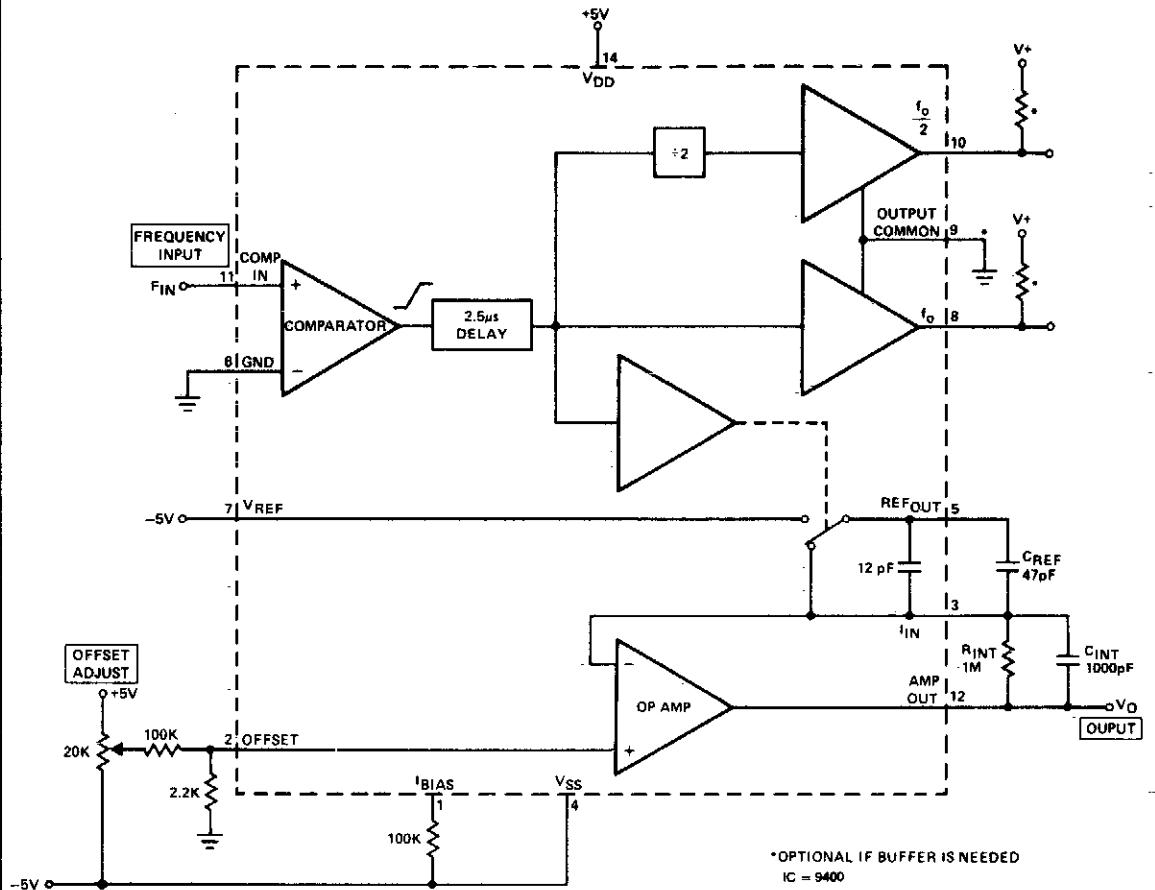


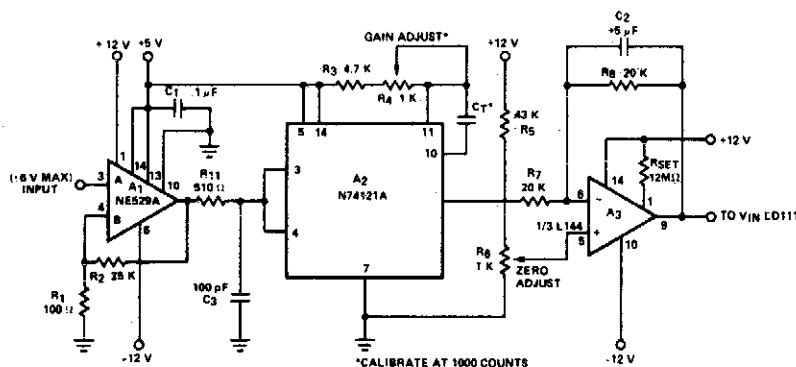
Fig. 37-1

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)



RANGE	C _T
2 kHz	.082 μF
20 kHz	.0082 μF
200 kHz	820 pF
2 MHz	82 pF
20 MHz	8.2 pF

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

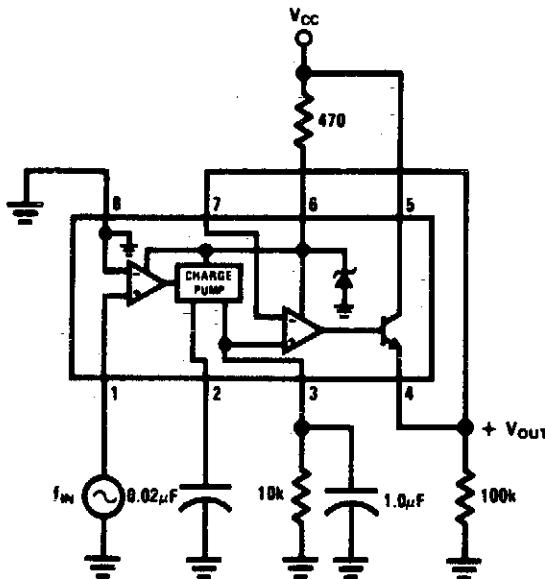
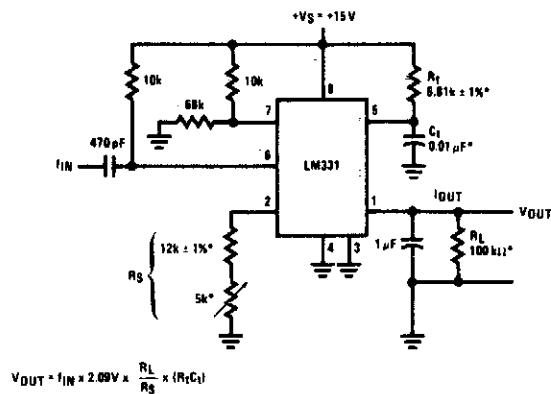


Fig. 37-3

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



*Use stable components with low temperature coefficients.

Fig. 37-4

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

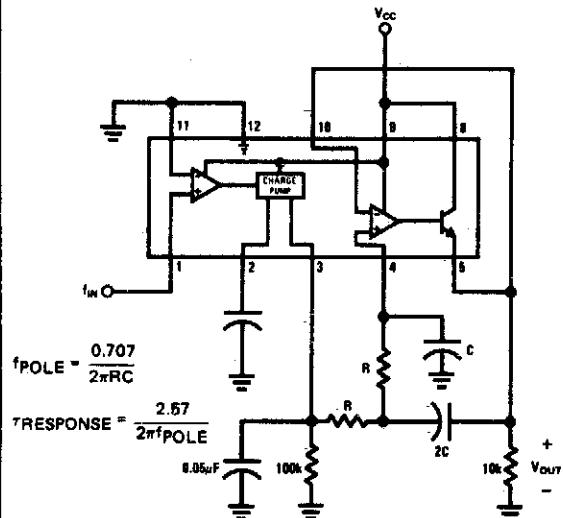


Fig. 37-6

F/V CONVERSION, TTL INPUT

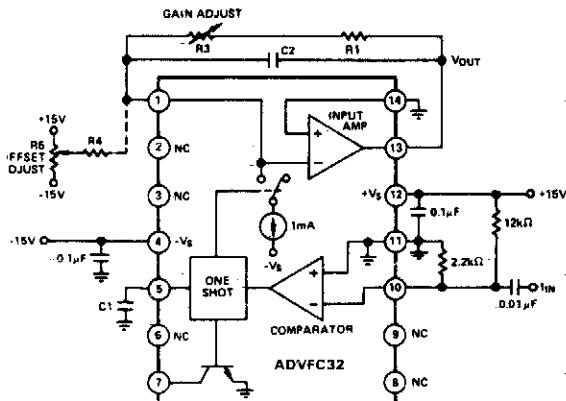
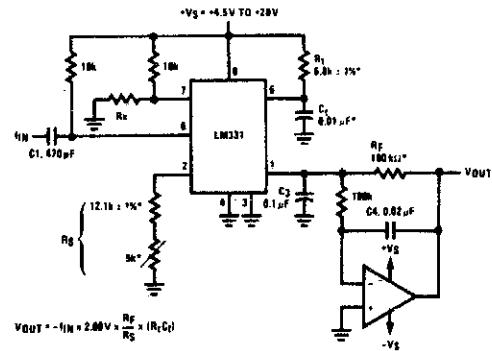


Fig. 37-5

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



*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

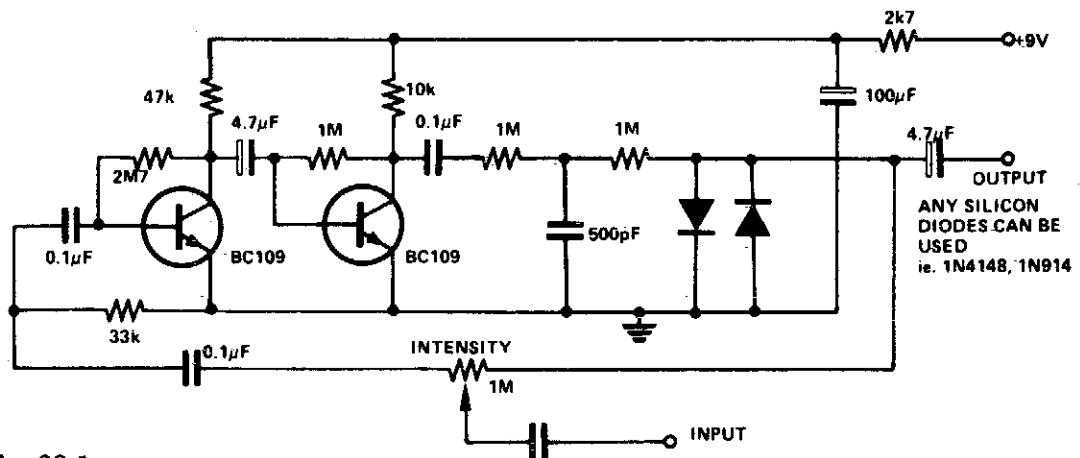


Fig. 38-1

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

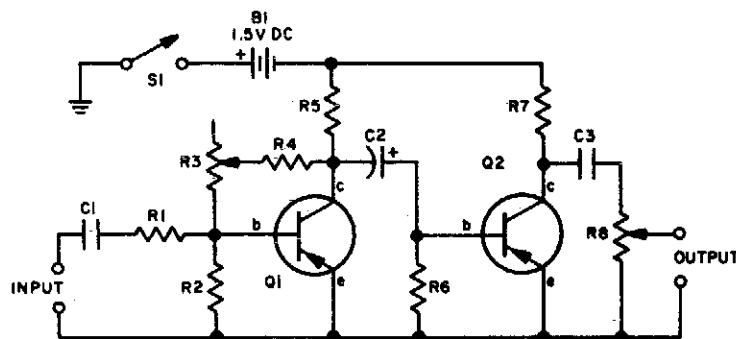


Fig. 38-2

B1—1.5-V AA battery
C1, C3—0.1- μ F, 50-VDC capacitor
C2—4.7- μ F, 10-VDC electrolytic capacitor
Q1, Q2—pnp transistor—HEP-632
R1, R6—22,000-ohm, 1/2-watt resistor
R2—18,000-ohm, 1/2-watt resistor
R3—1-megohm pot
R4—100,000-ohm, 1/2-watt resistor
R5, R7—10,000-ohm, 1/2-watt resistor
R8—50,000-ohm pot
S1—Spst switch

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.

FUZZ BOX 3

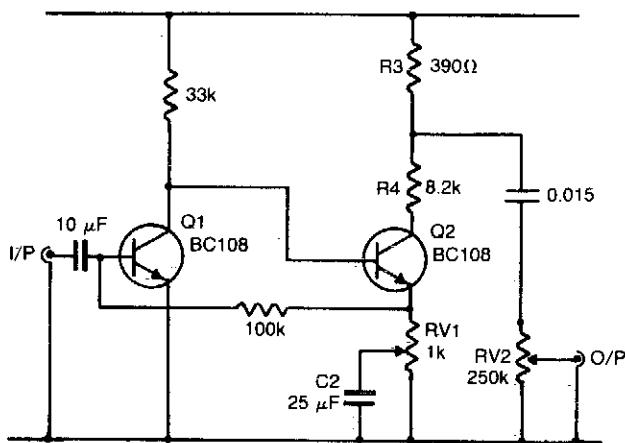


Fig. 38-3

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

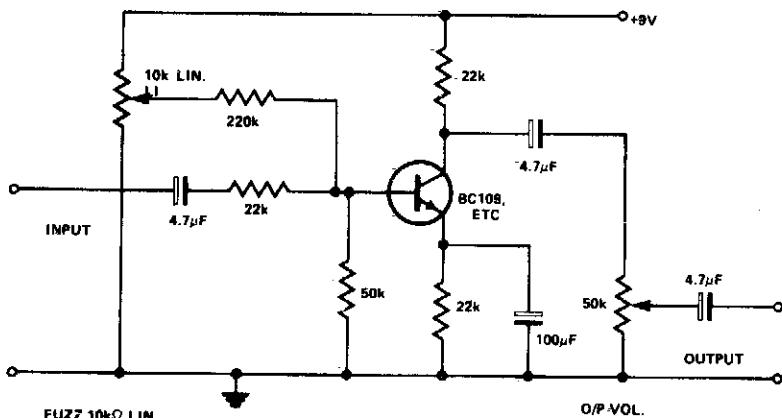


Fig. 38-4

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

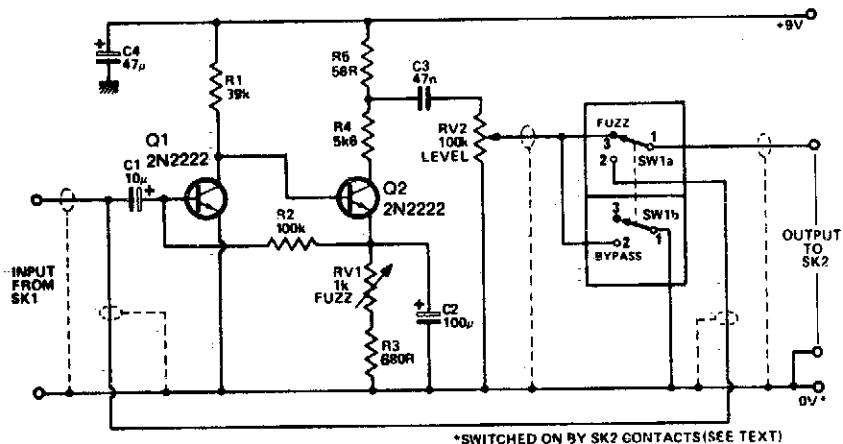


Fig. 38-5

Circuit 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

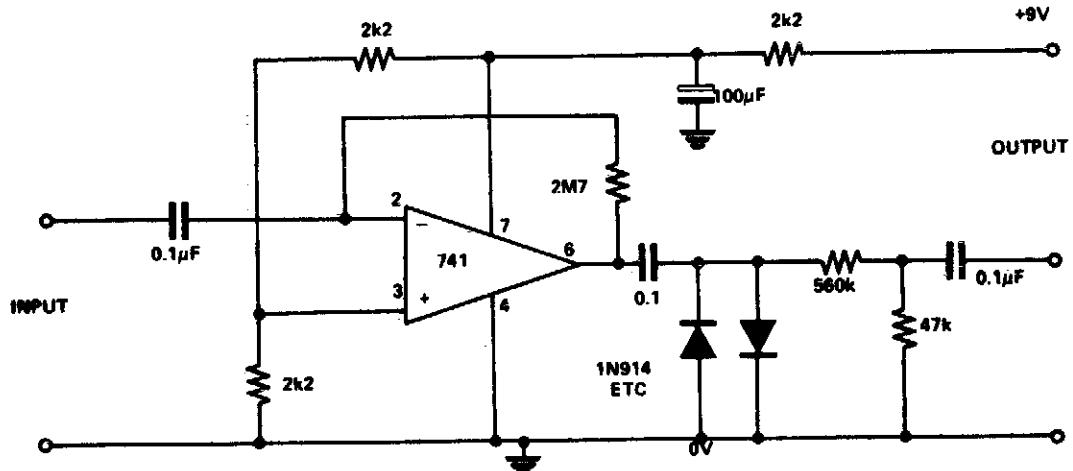


Fig. 38-6

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 Tosser

Heads or Tails
Pot Shot
Low Cost Heads or Tails
Who Is First
Windicator

READY, SET, GO!

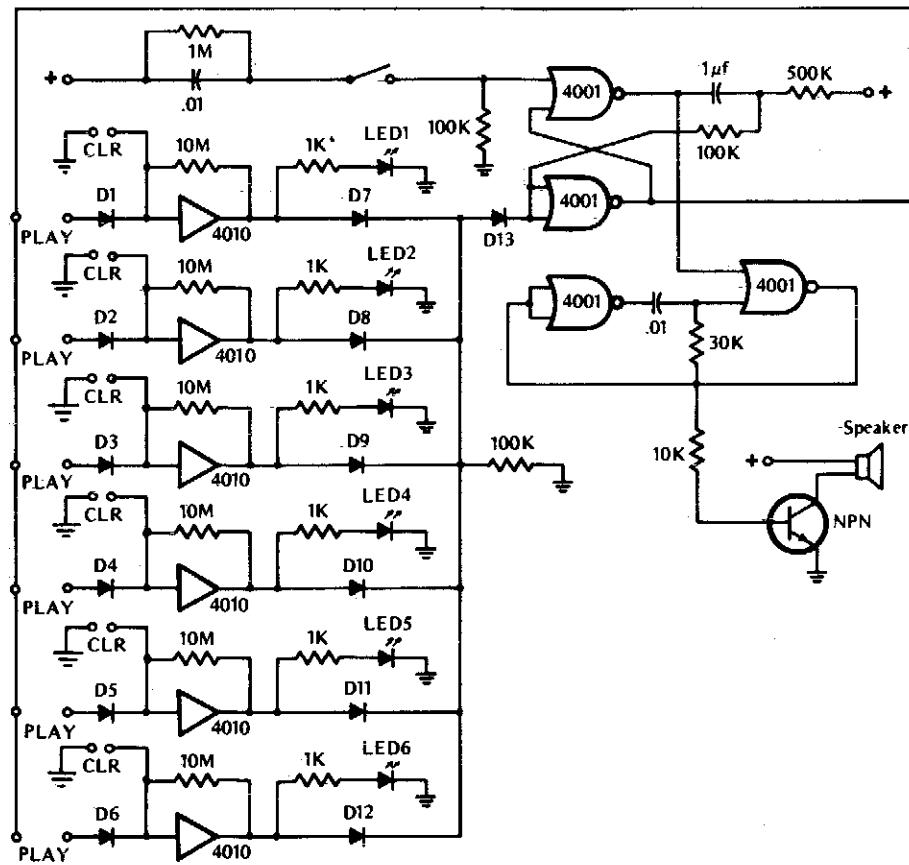


Fig. 39-1

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

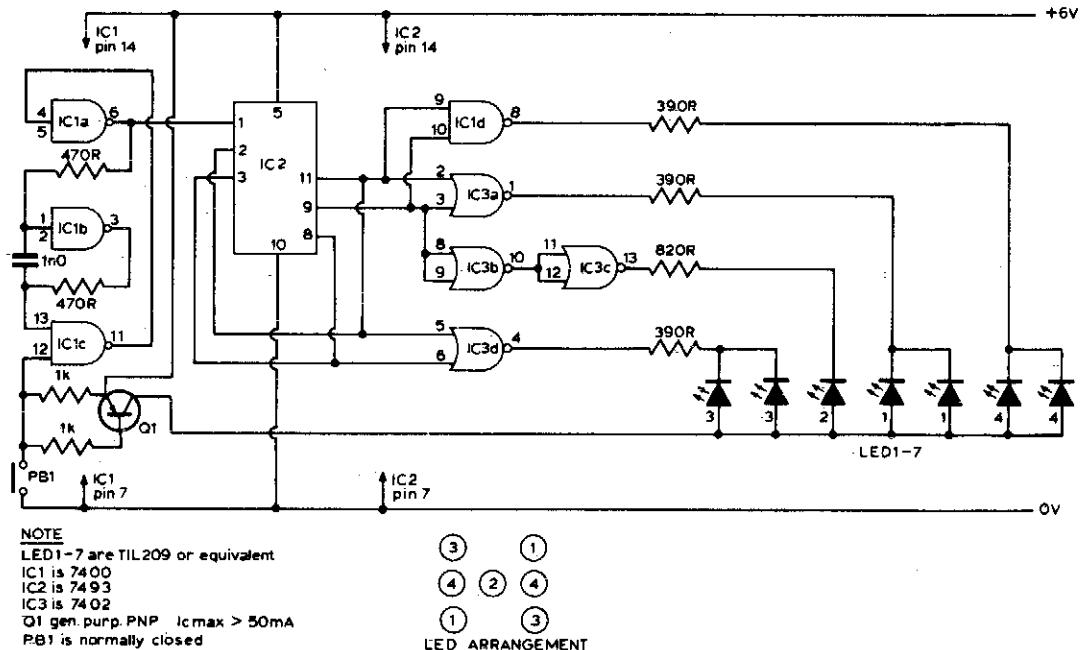


Fig. 39-2

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

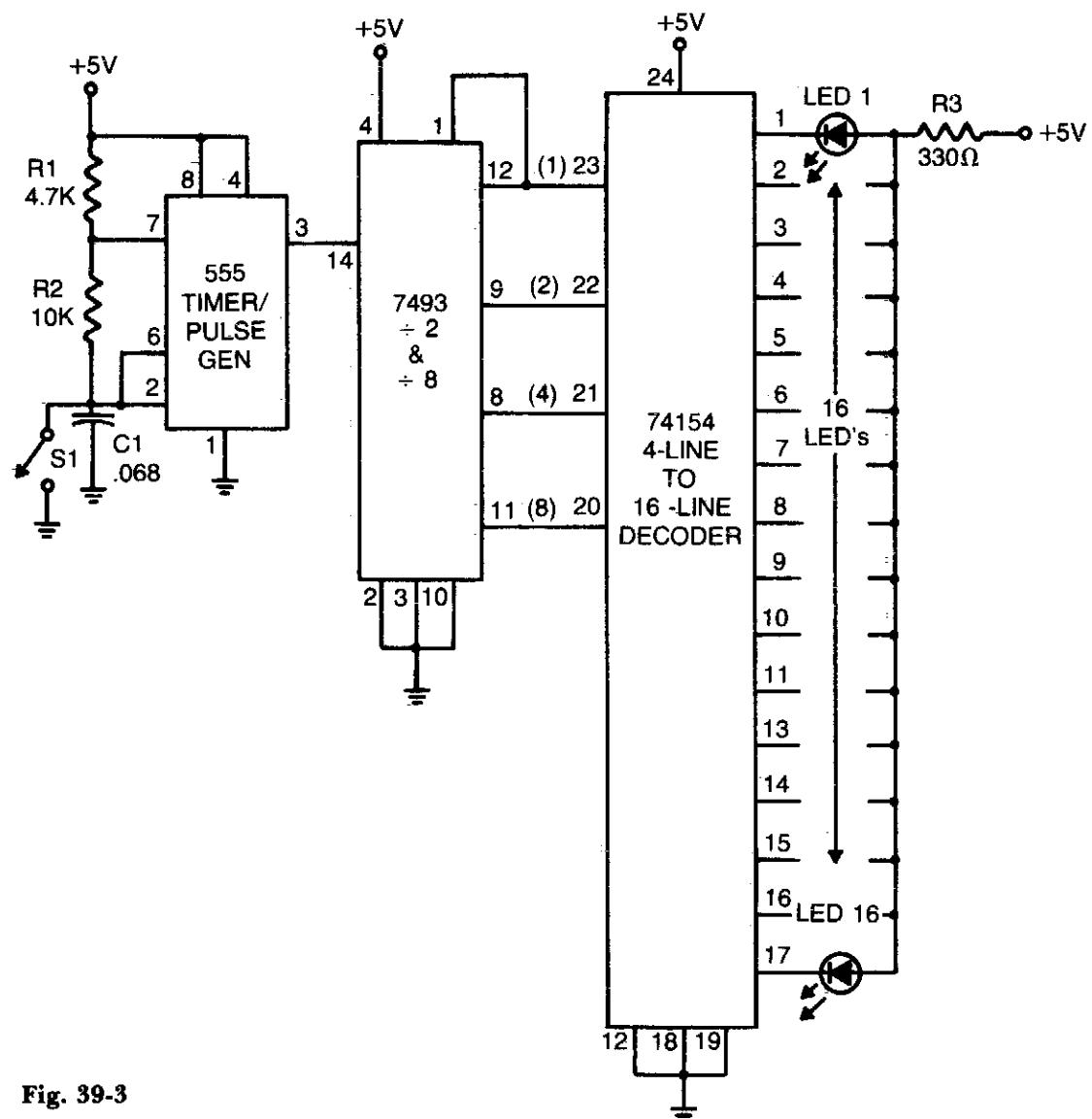


Fig. 39-3

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

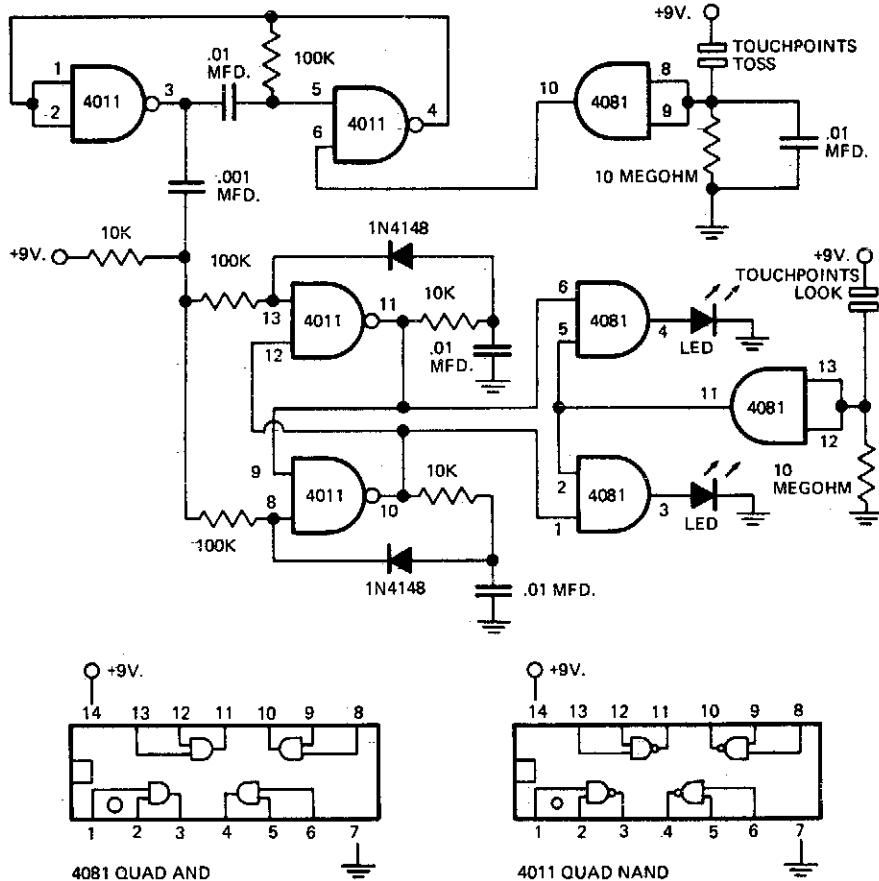


Fig. 39-4

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 TOSSE

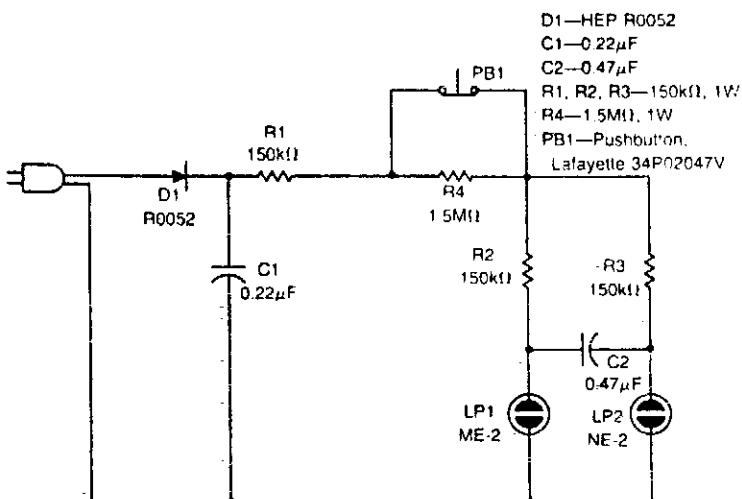


Fig. 39-5

Circuit Notes

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

HEADS OR TAILS

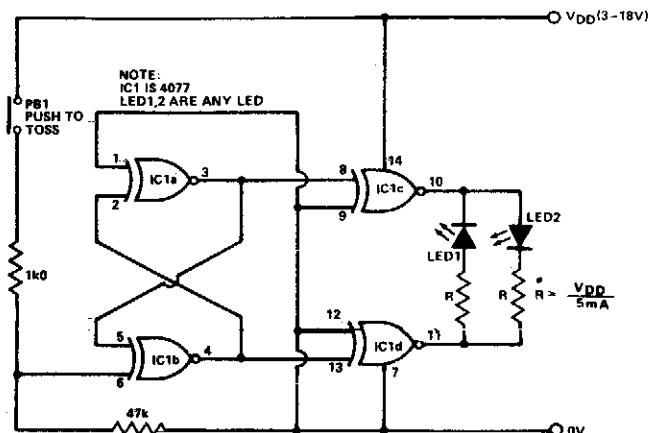


Fig. 39-6

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

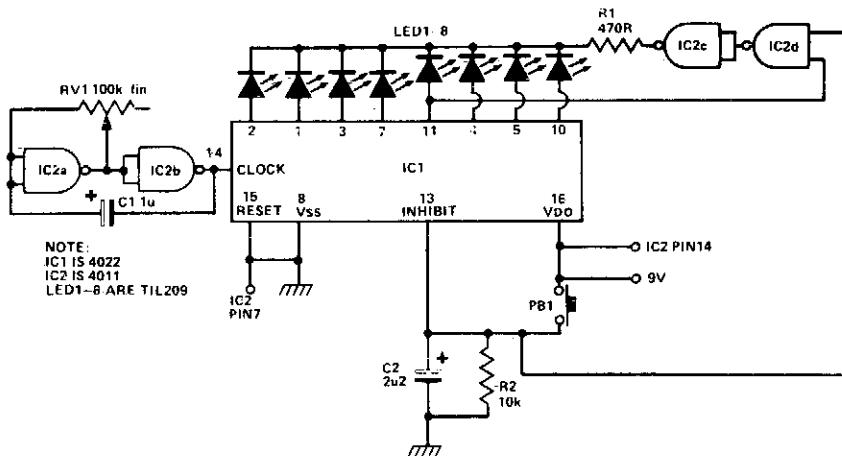


Fig. 39-7

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 PB1 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"

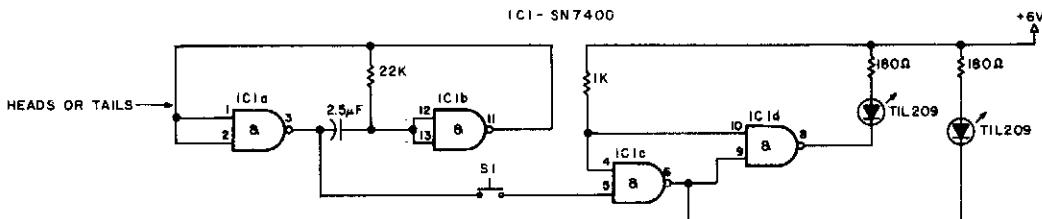


Fig. 39-8

Circuit Notes

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

WHO IS FIRST

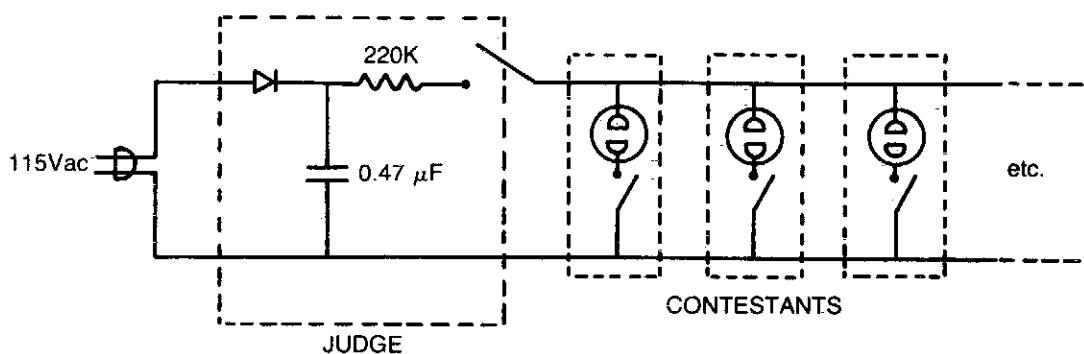


Fig. 39-9

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

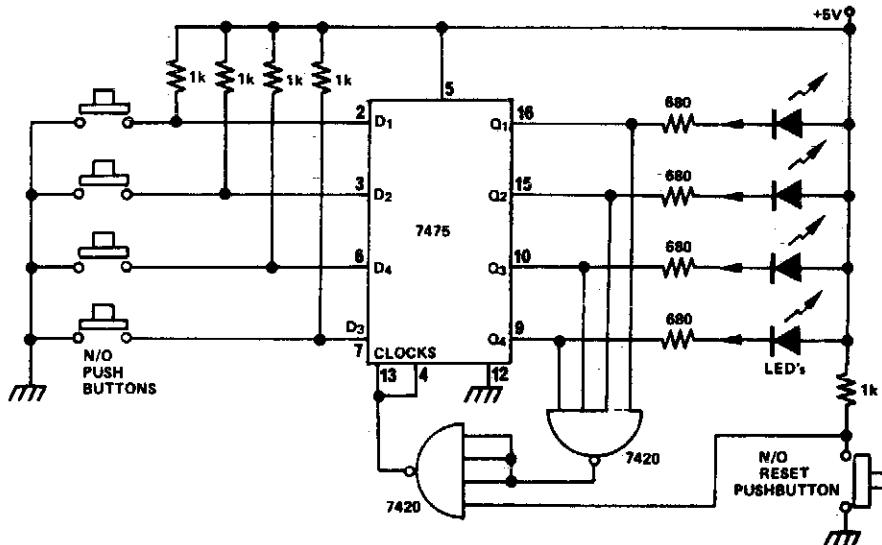


Fig. 39-10

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

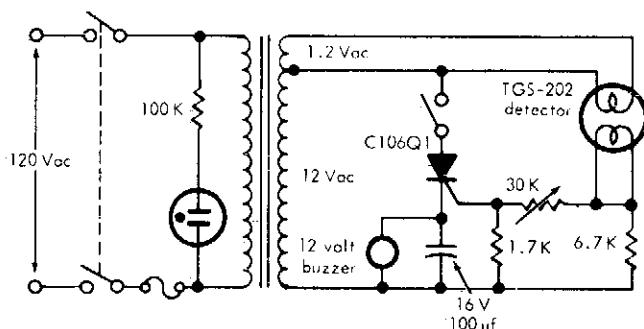


Fig. 40-1

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

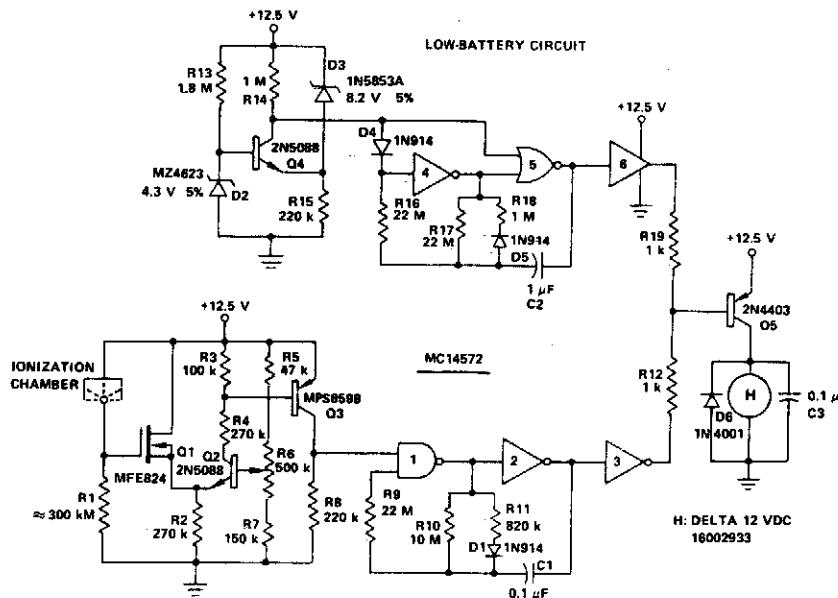


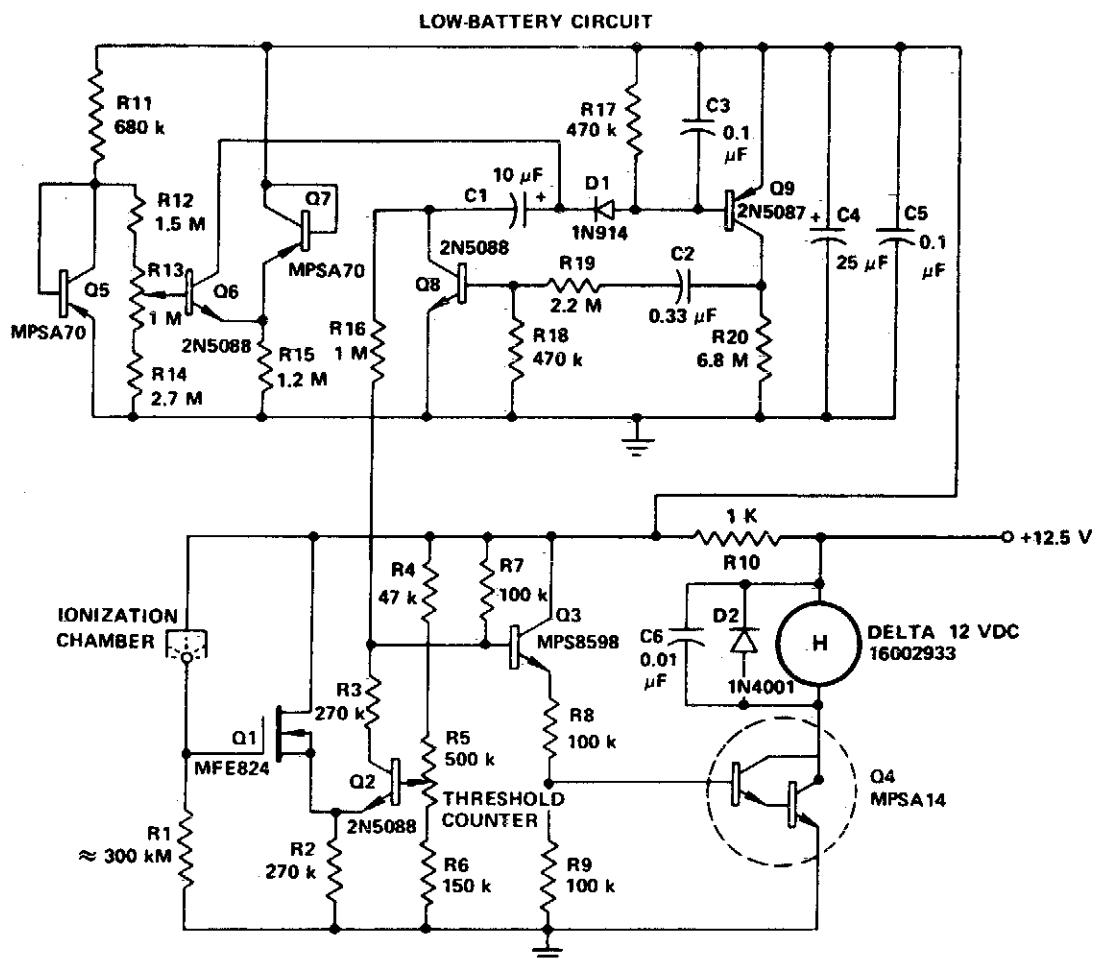
Fig. 40-2

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



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

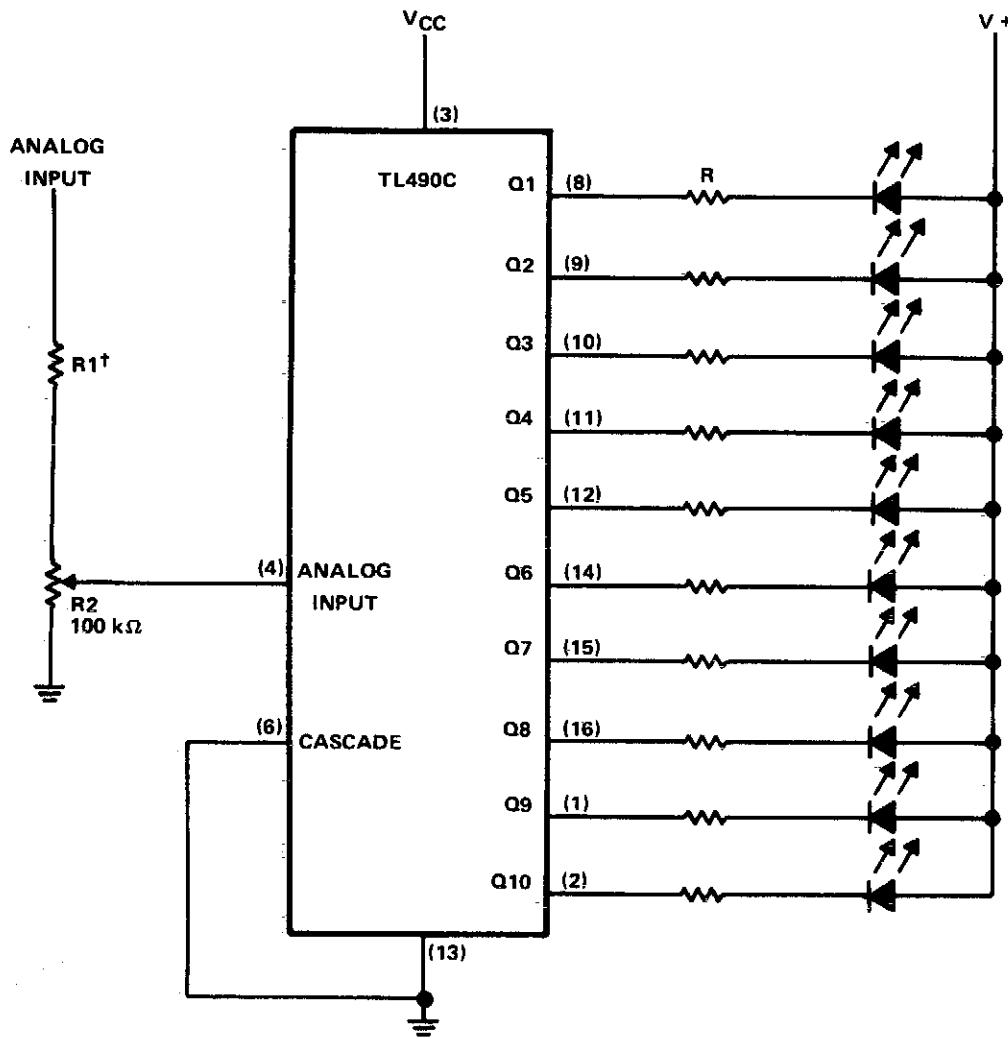


Fig. 41-1

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

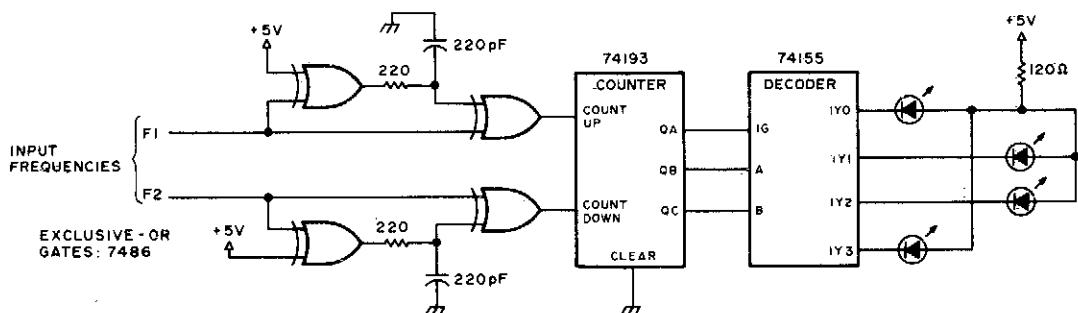


Fig. 41-2

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

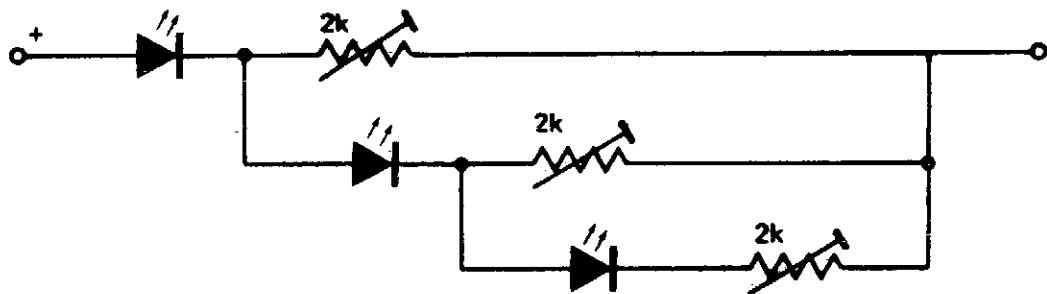


Fig. 41-3

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

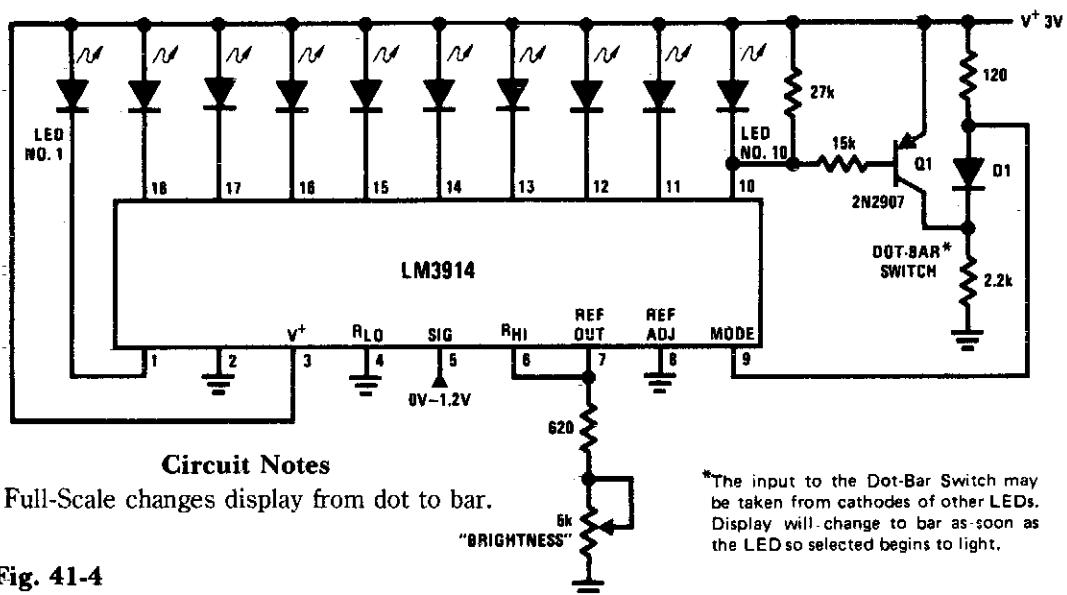


Fig. 41-4

FIVE-STEP VOLTAGE-LEVEL INDICATOR

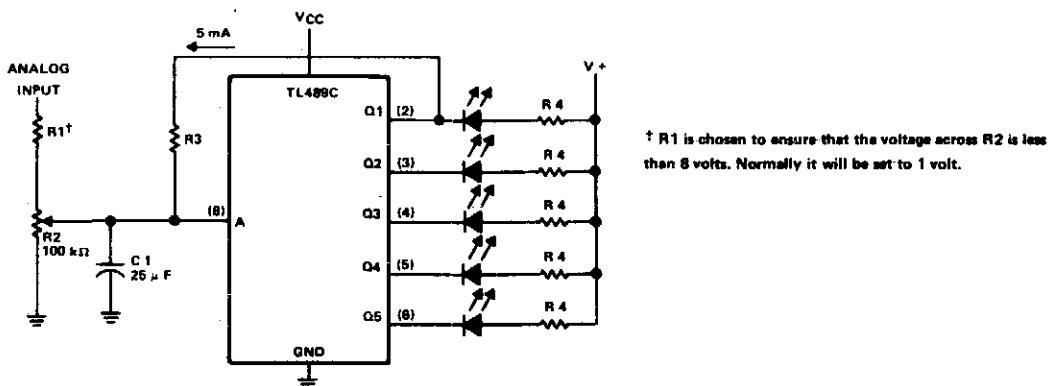


Fig. 41-5

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

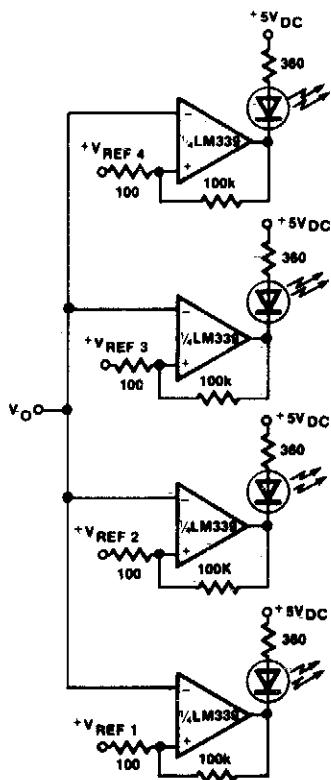


Fig. 41-6

VOLTAGE LEVEL DETECTOR

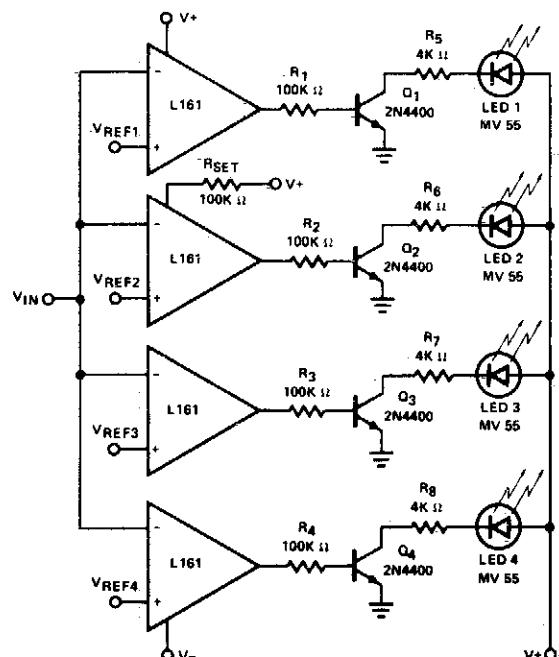


Fig. 41-8

ZERO CENTER INDICATOR FOR FM RECEIVERS

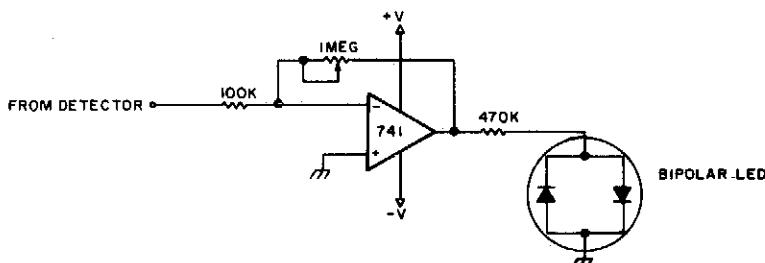
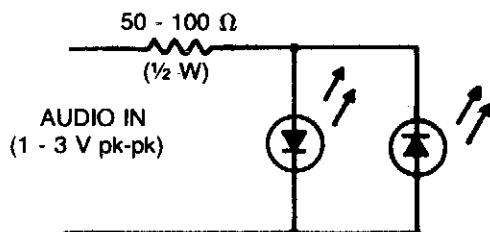


Fig. 41-7

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

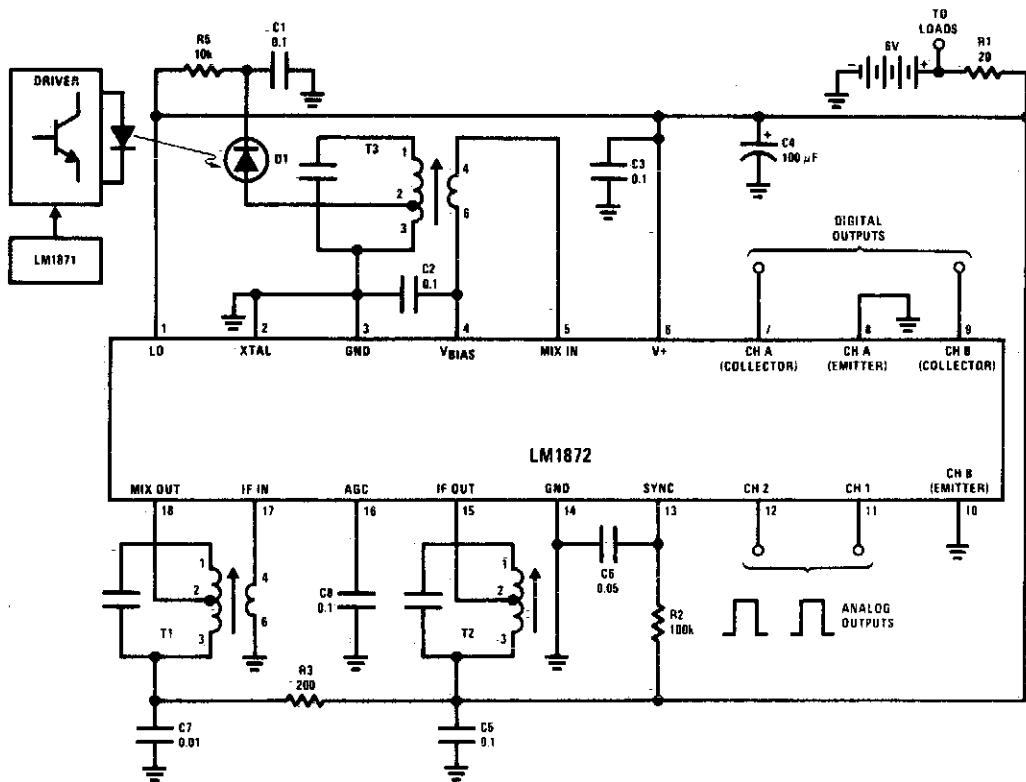
Compact IR Receiver

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; $C6 = \frac{t}{0.7 R2}$, $C6 \leq 0.5 \mu F$

C7 - Preamp decoupling

C8 - AGC

T1 - 455 kHz IF preamp transformer

Toko* 10 EZC type (RMC-502182), Qu = 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), Qu = 110
Pin 1-2, 98T; pin 2-3, 88T
Pin 1-3, 164T; pin 4-6, 8T

T3 - 455 kHz input transformer

Toko* 10 EZC type (RMC-202313), Qu = 110
Pin 1-2, 131T; pin 2-3, 33T
Pin 1-3, 164T; pin 4-6, 5T

D1 - PN or PIN Silicon Photodiode

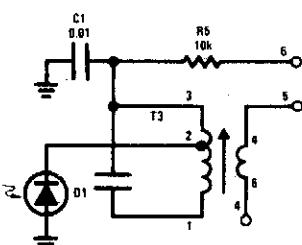
BOTTOM VIEW

Photodiode, D1

Active Area (cm²)

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 Telex: 72-4372



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

Fig. 42-1

IR REMOTE CONTROL TRANSMITTER/RECEIVER

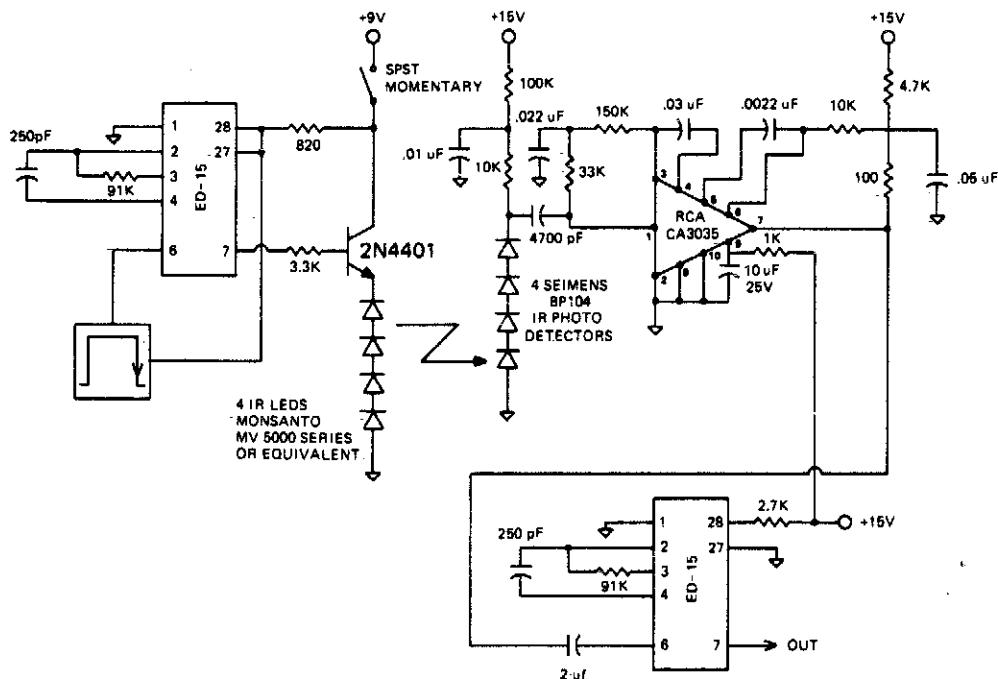


Fig. 42-2

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

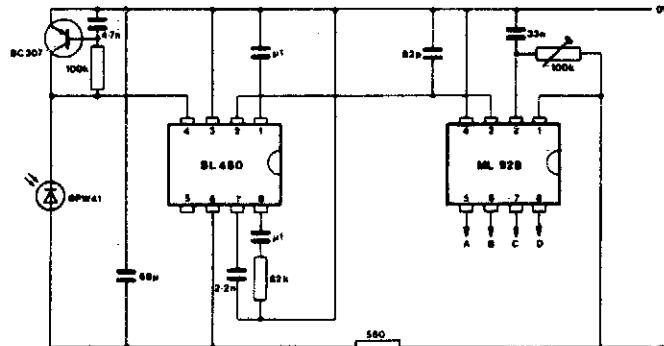


Fig. 42-3

IR TRANSMITTER

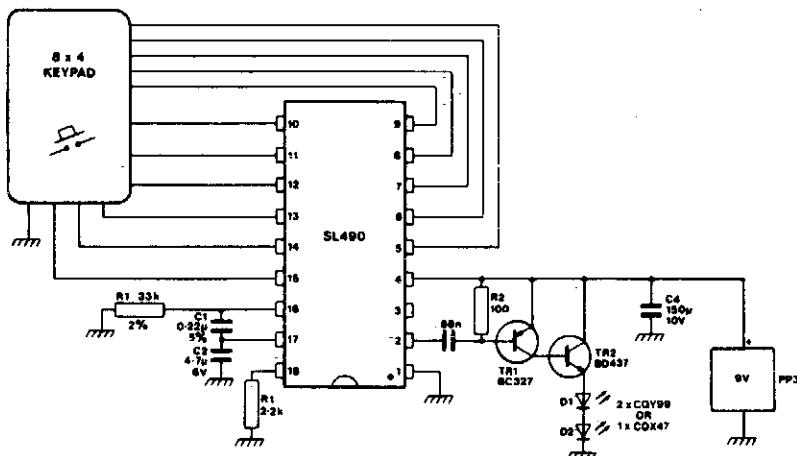


Fig. 42-4

Circuit Notes

This simple infra-red transmitter, where the PPM output from pin 2 of the SL490 is fed to the base of the PNP transmitter TR1, pro-

duces an amplified current pulse about $15 \mu\text{sec}$ wide. This pulse is further amplified by TR2 and applied to the infra-red diodes D1 and D2.

REMOTE LOUDSPEAKER VIA IR LINK

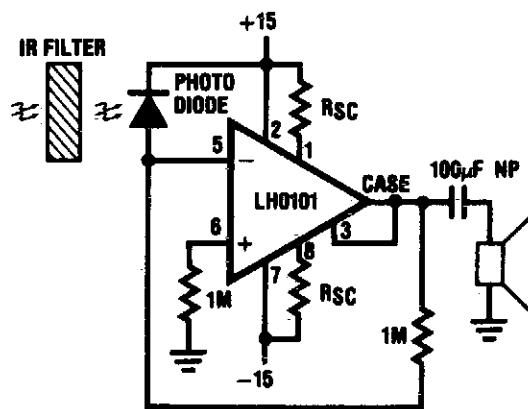


Fig. 42-5

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 INFRA-RED LED

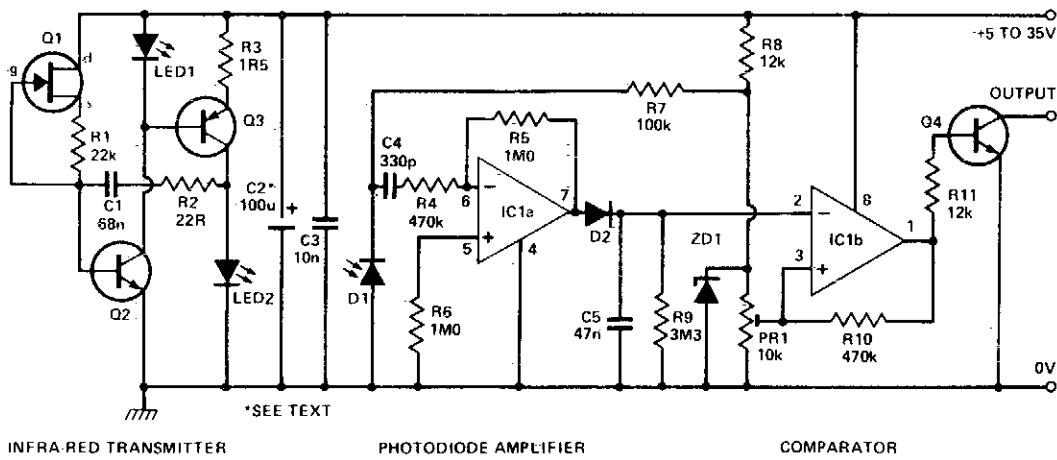


Fig. 42-6

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.

43

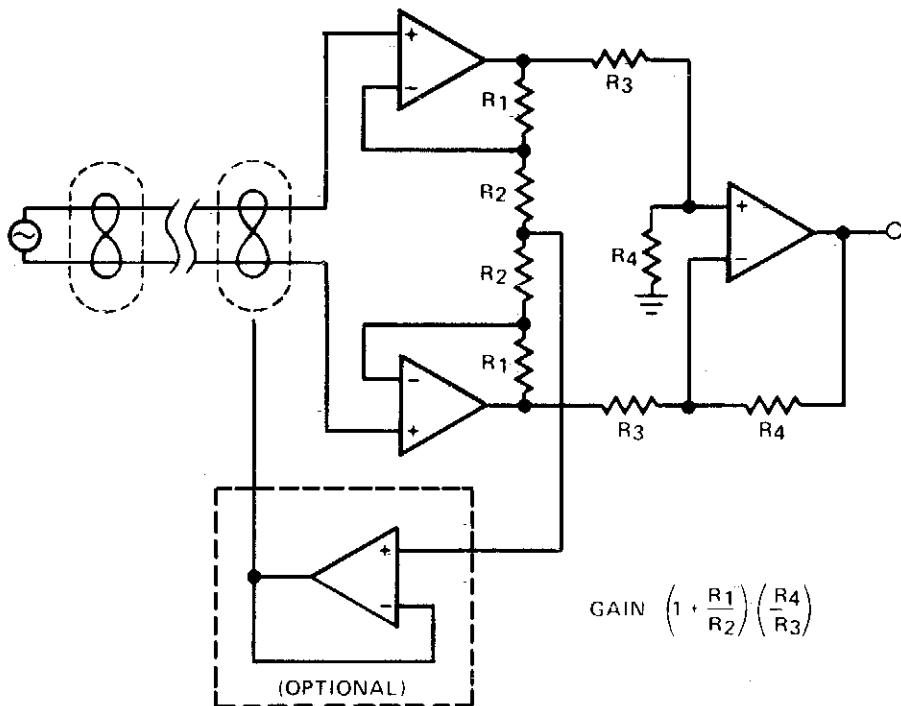
Instrumentation Amplifiers

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

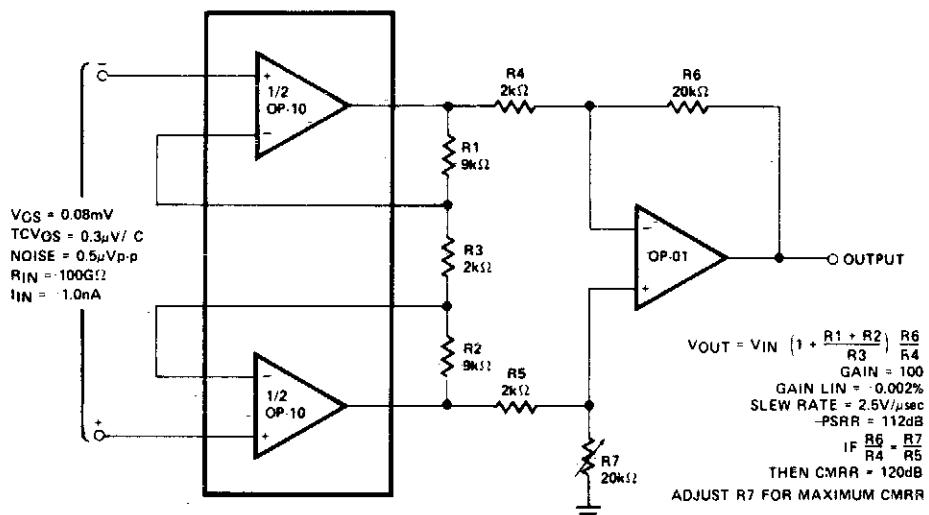


Circuit Notes

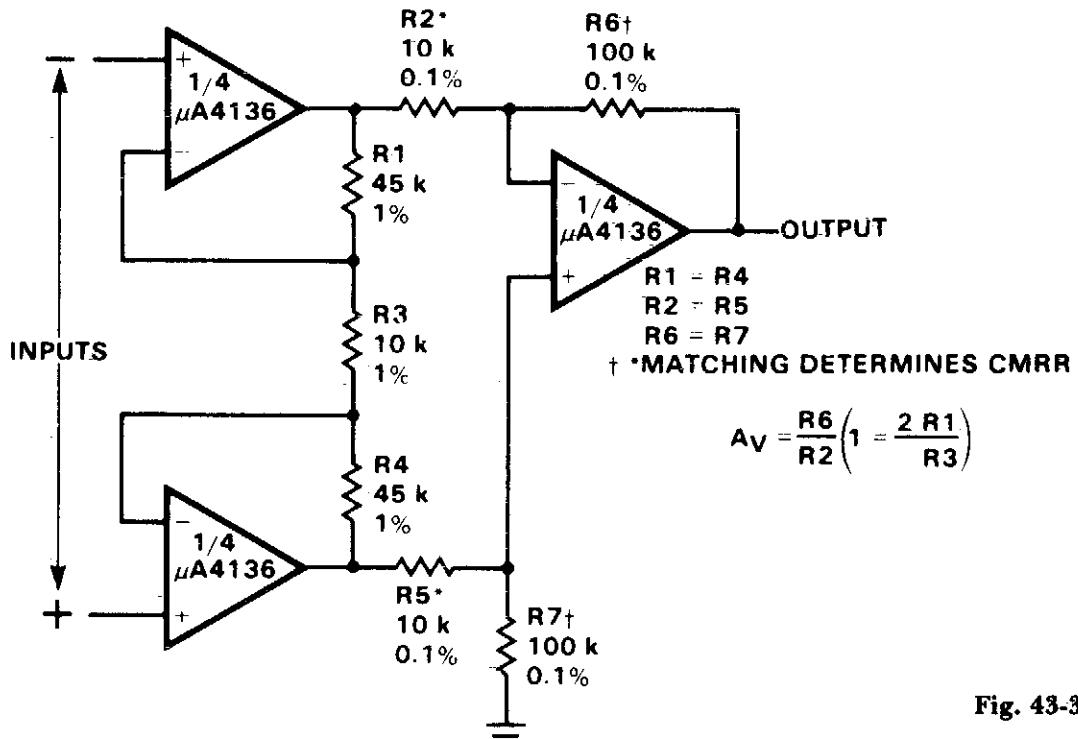
Instrumentation amplifiers (differential amplifiers) are specifically designed to extract and amplify small differential signals from much larger common mode voltages. To serve as building blocks in instrumentation amplifiers, op amps must have very low offset voltage drift, high gain and wide bandwidth.

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



DIFFERENTIAL INPUT INSTRUMENTATION AMPLIFIER WITH HIGH COMMON MODE REJECTION



INSTRUMENTATION AMPLIFIER WITH HIGH COMMON MODE REJECTION

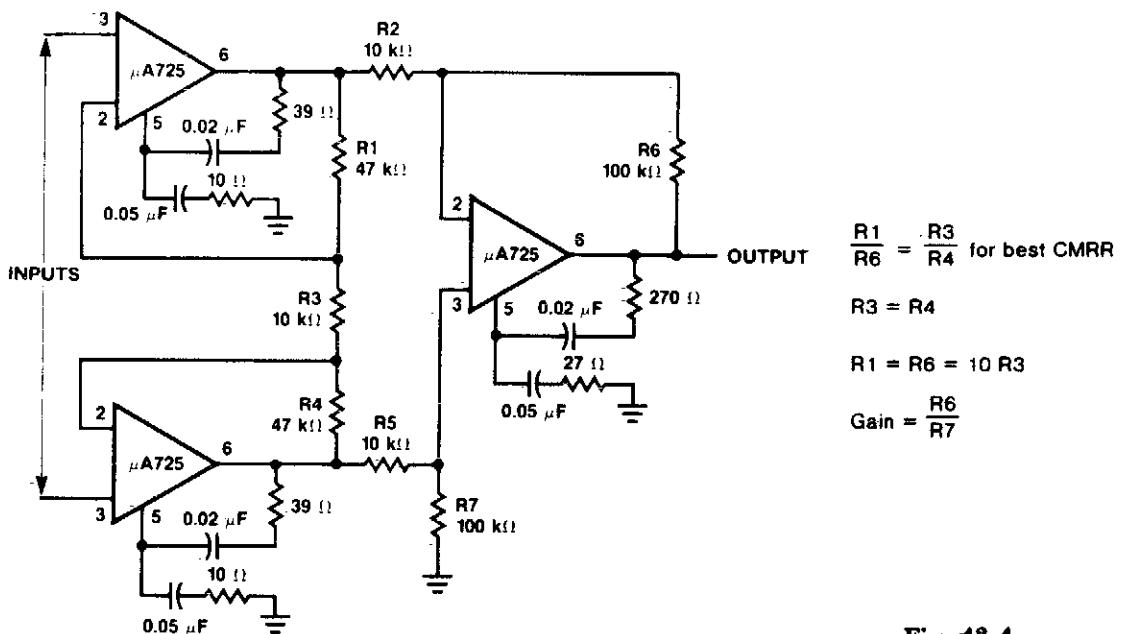


Fig. 43-4

LEVEL-SHIFTING ISOLATION AMPLIFIER

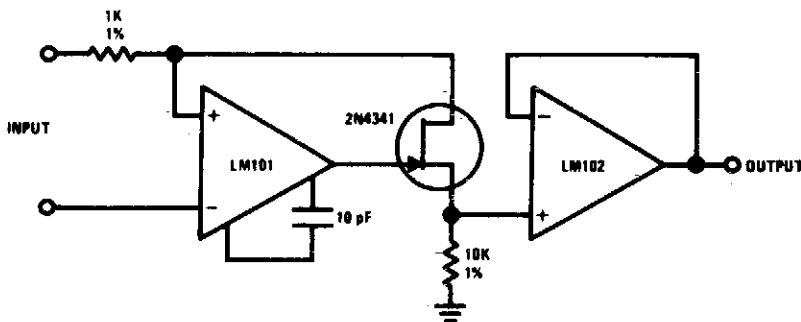


Fig. 43-5

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**

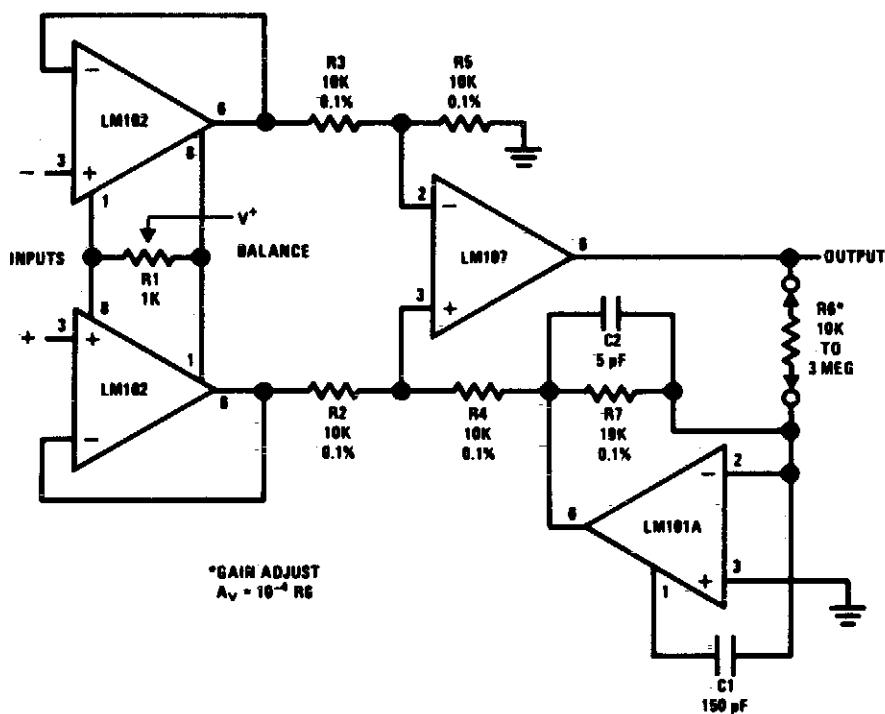


Fig. 43-6

INSTRUMENTATION AMPLIFIER

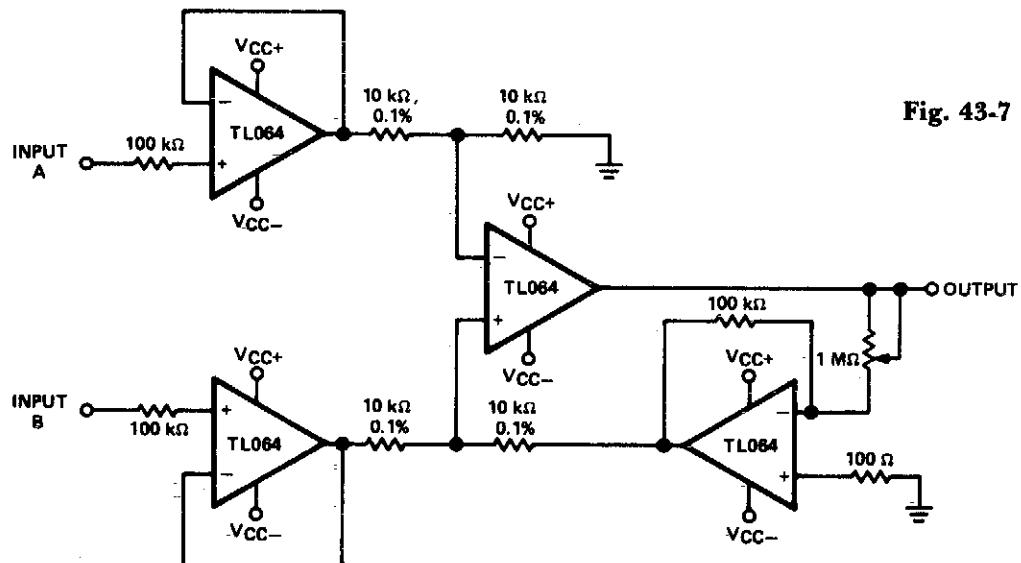


Fig. 43-7

**LOW SIGNAL LEVEL, HIGH
IMPEDANCE INSTRUMENTATION AMPLIFIER**

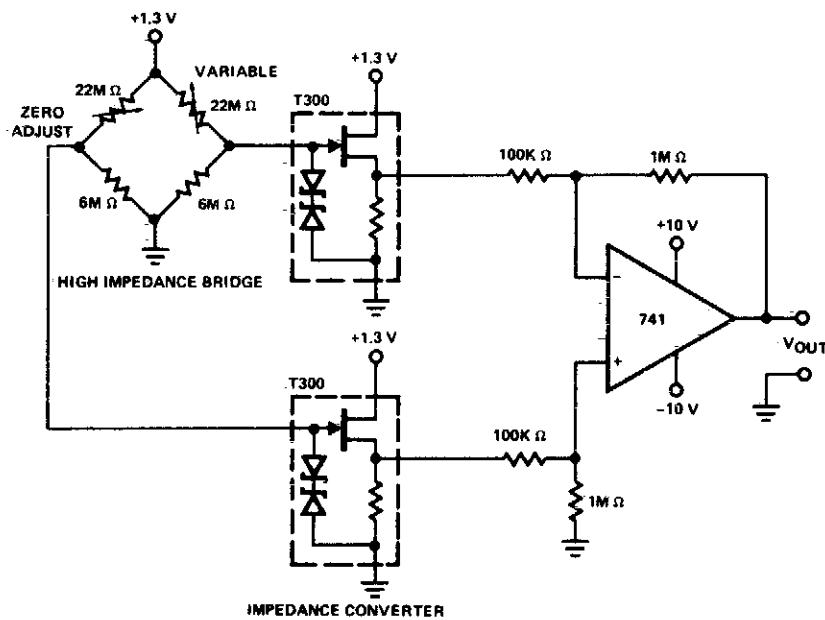


Fig. 43-8

CHOPPER CHANNEL AMPLIFIER

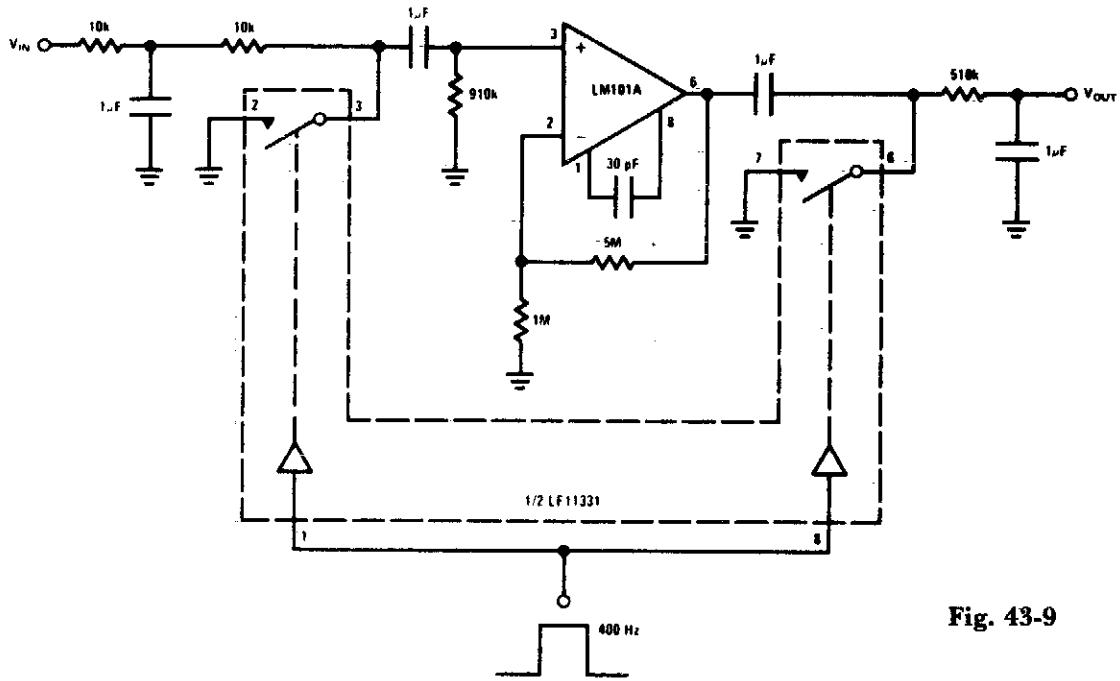
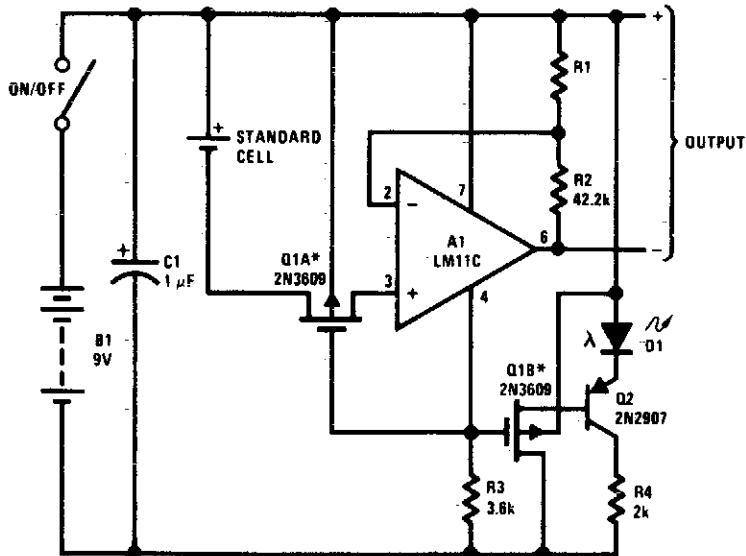


Fig. 43-9

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

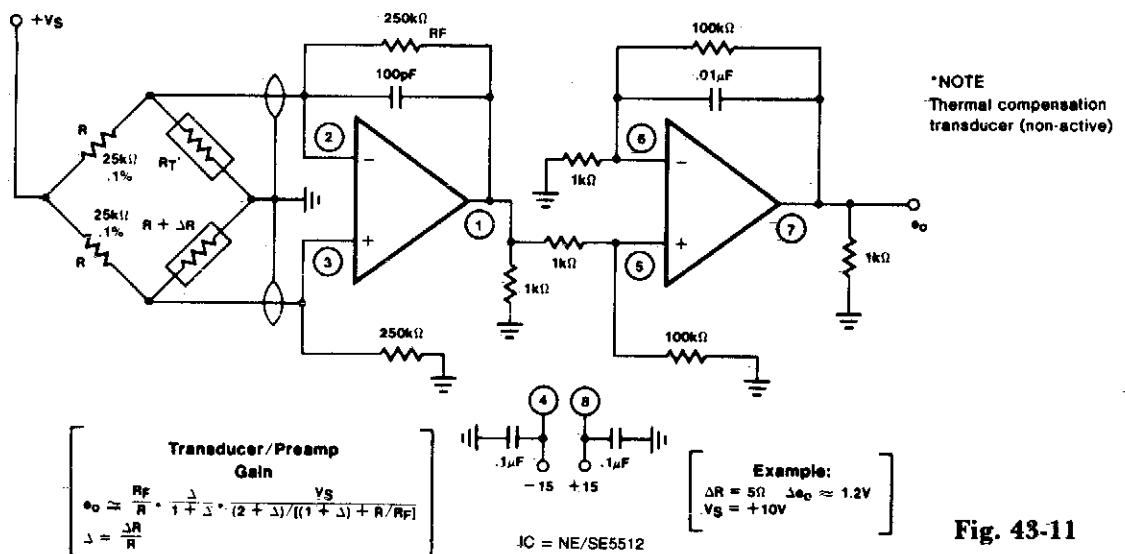


Fig. 43-11

INSTRUMENTATION AMPLIFIER

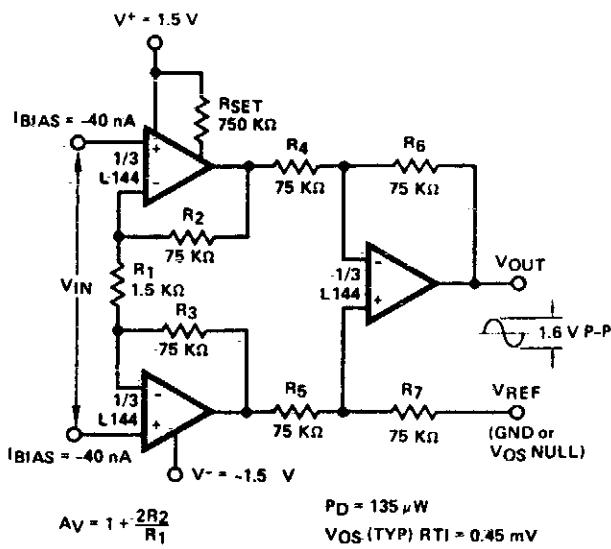


Fig. 43-12

Circuit Notes

Three-amplifier circuit consumes only $135 \mu\text{W}$ of power from a $\pm 1.5 \text{ V}$ 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

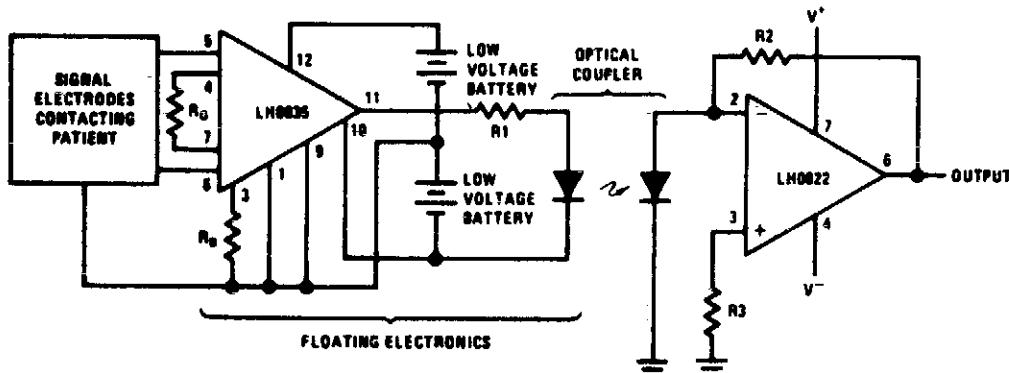


Fig. 43-13

HIGH GAIN DIFFERENTIAL INSTRUMENTATION AMPLIFIER

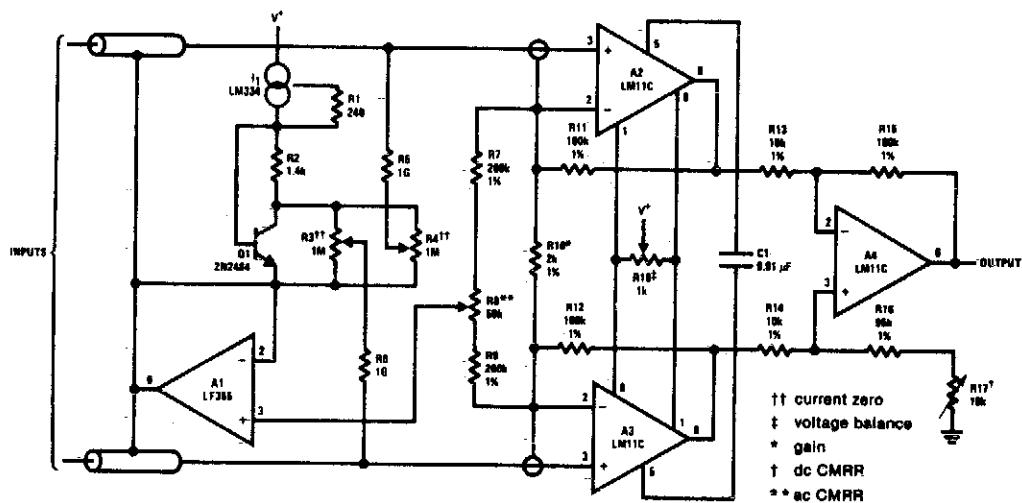


Fig. 43-14

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

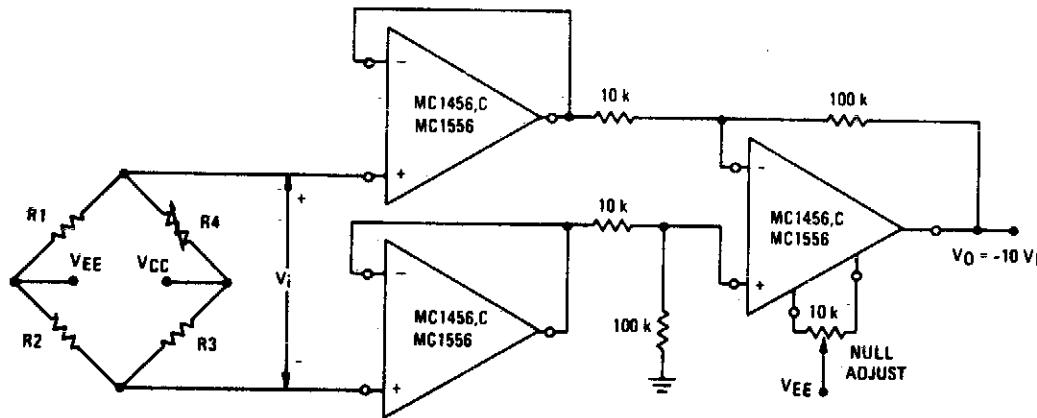


Fig. 43-15

INSTRUMENTATION AMPLIFIER (TWO OP AMP DESIGN)

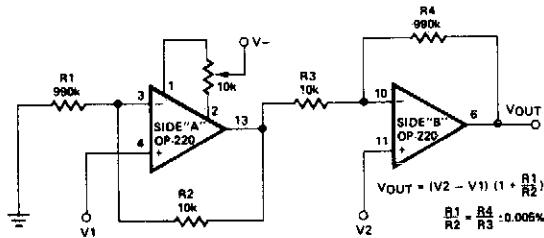


Fig. 43-16

HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER

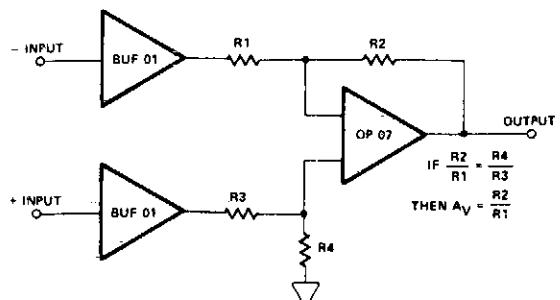


Fig. 43-19

INSTRUMENTATION AMPLIFIER

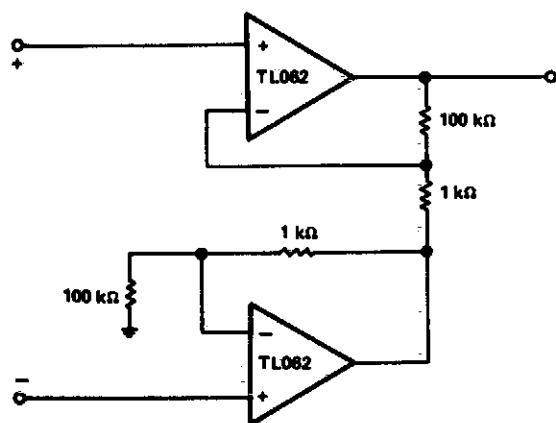


Fig. 43-17

HIGH SPEED INSTRUMENTATION AMPLIFIER

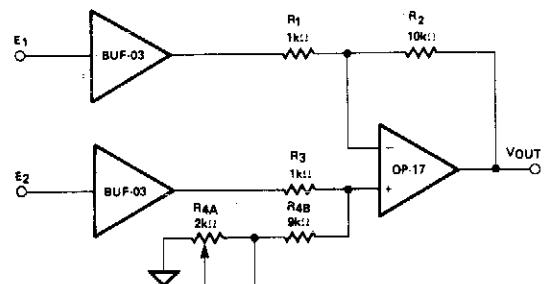


Fig. 43-20

DIFFERENTIAL INPUT INSTRUMENTATION AMPLIFIER

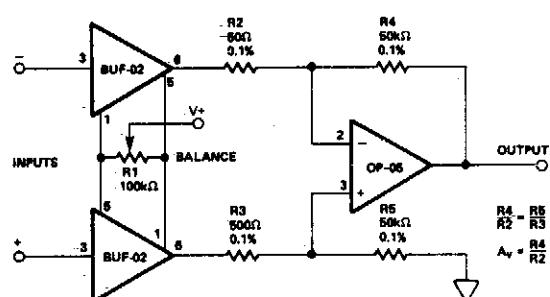


Fig. 43-18

VERY HIGH IMPEDANCE INSTRUMENTATION AMPLIFIER

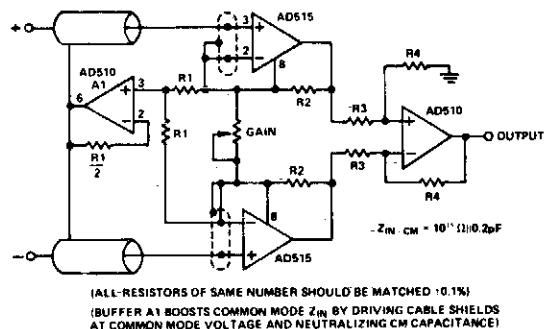


Fig. 43-21

PRECISION FET INPUT INSTRUMENTATION AMPLIFIER

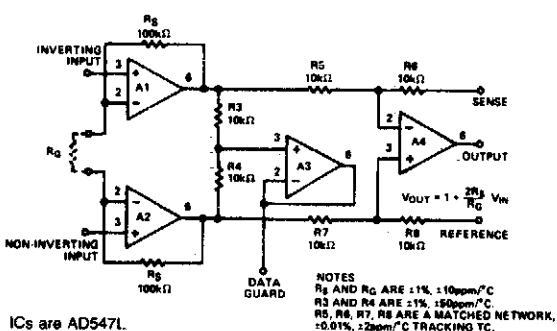


Fig. 43-22

HIGH STABILITY THERMOCOUPLE AMPLIFIER

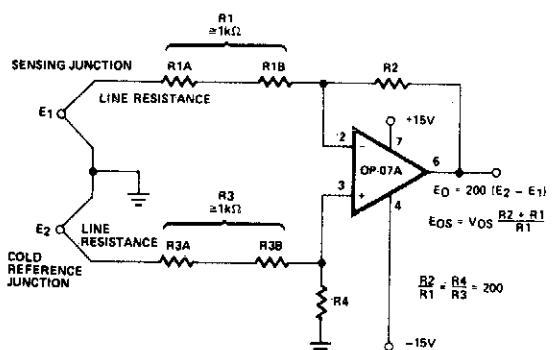


Fig. 43-24

HIGH IMPEDANCE LOW DRIFT INSTRUMENTATION AMPLIFIER

HIGH STABILITY THERMOCOUPLE AMPLIFIER

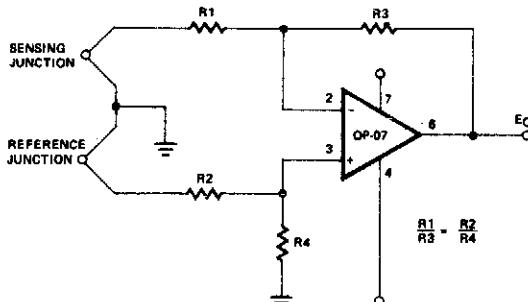
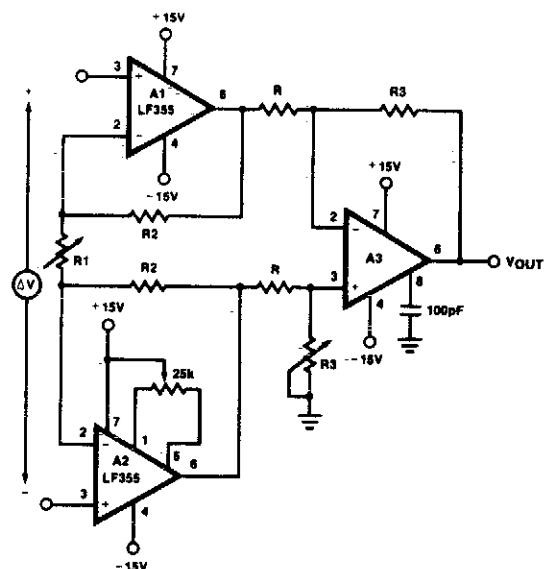


Fig. 43-23



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

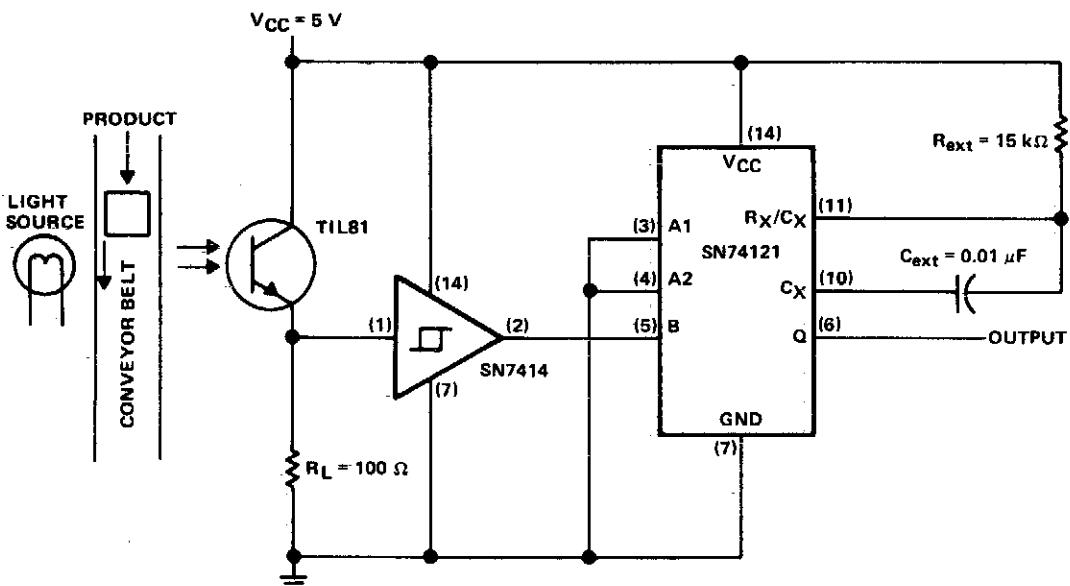


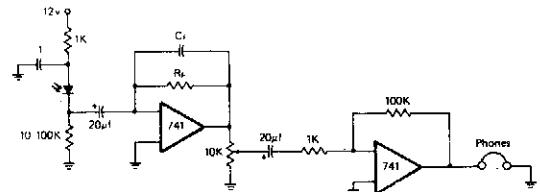
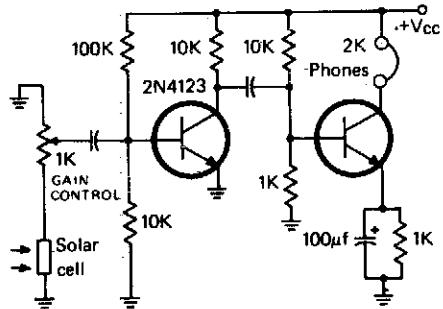
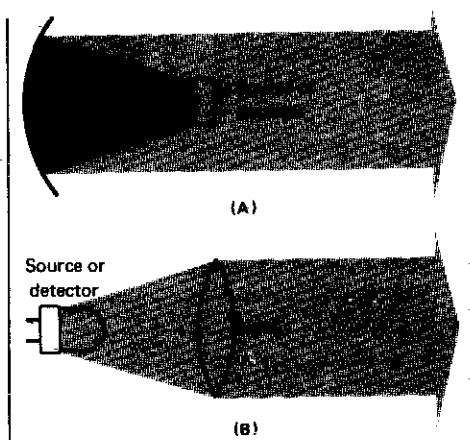
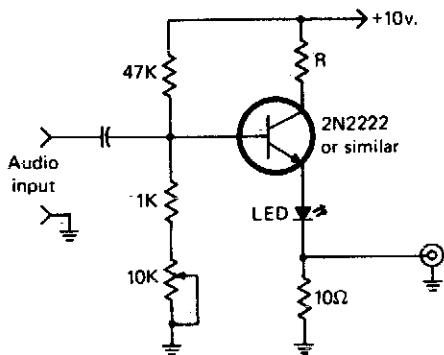
Fig. 44-1

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 triggers the one shot.

OPTICAL COMMUNICATION SYSTEM



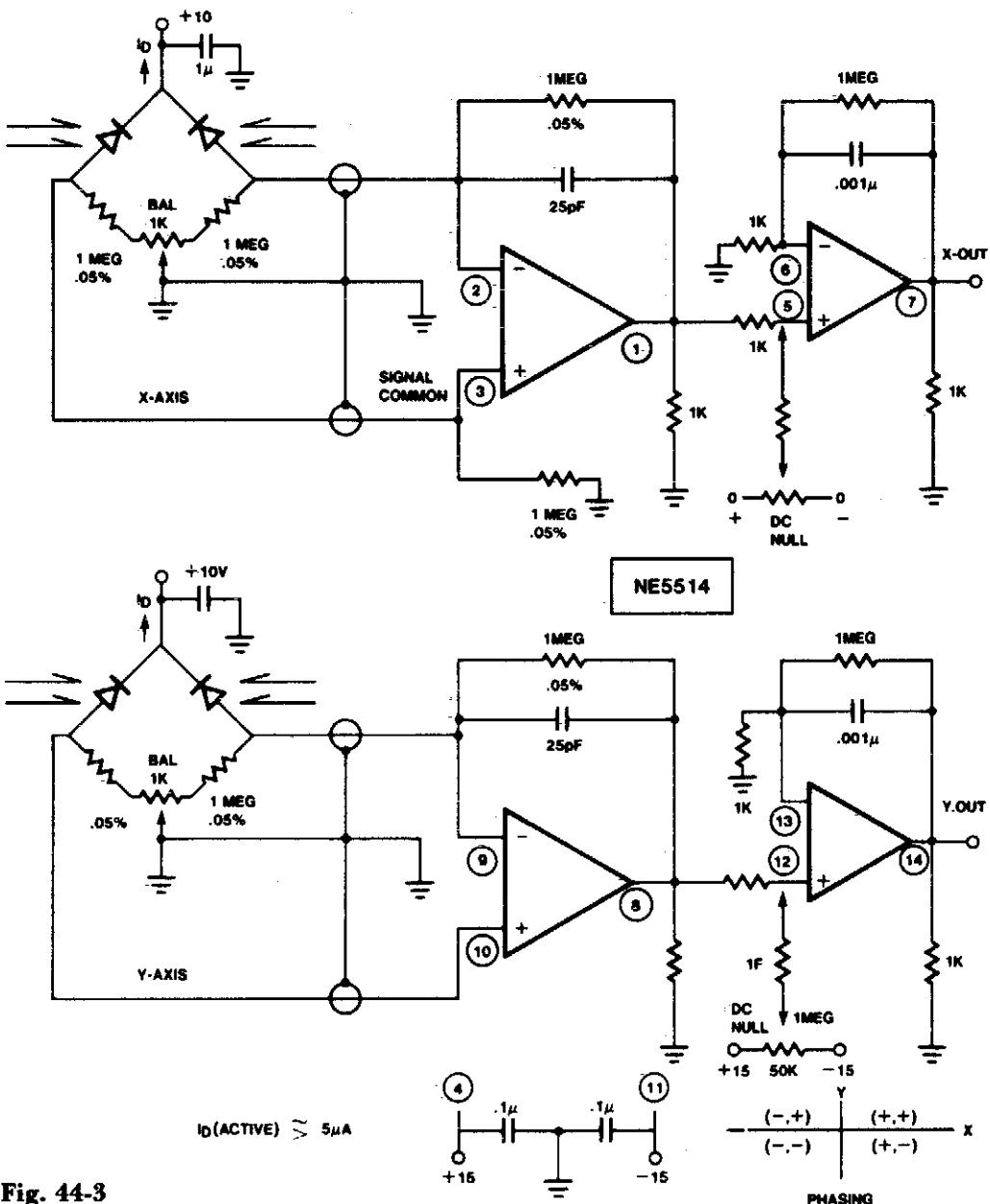
Circuit Notes

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



PRECISION PHOTODIODE COMPARATOR

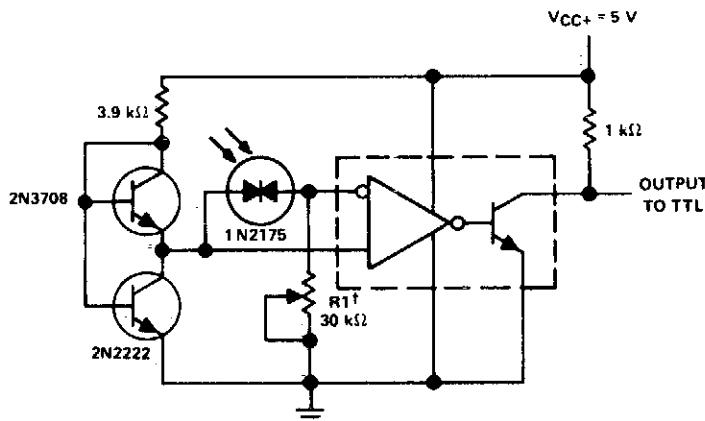


Fig. 44-4

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

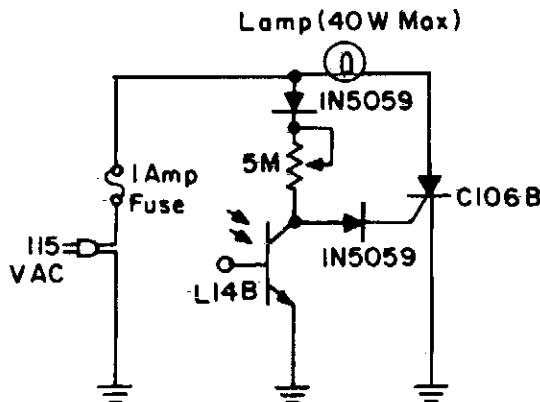


Fig. 44-5

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

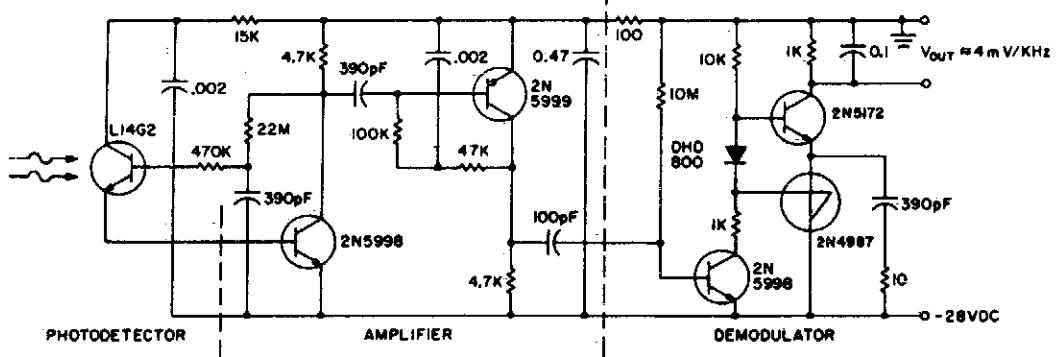


Fig. 44-6

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

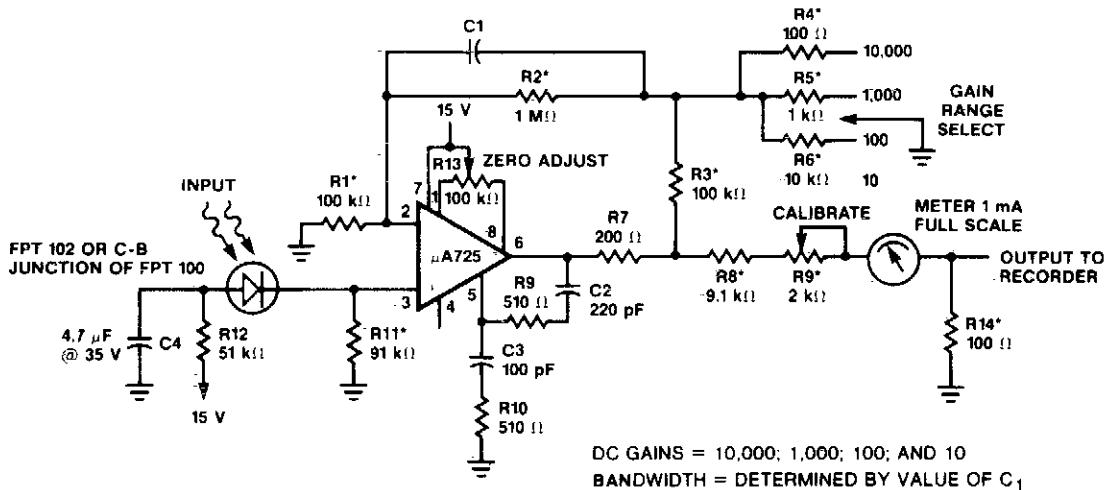


Fig. 44-7

OPTICAL SCHMITT TRIGGER

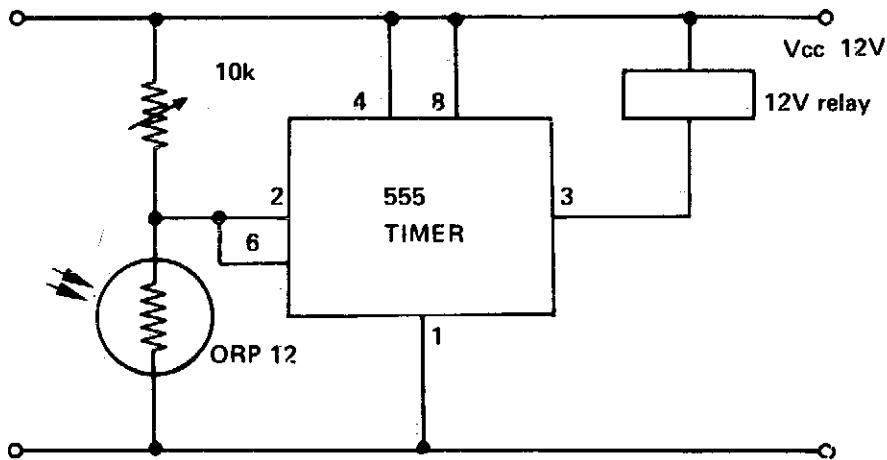


Fig. 44-8

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

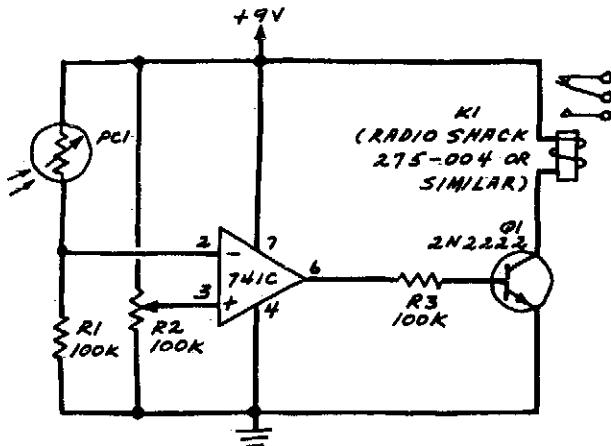


Fig. 44-9

Circuit Notes

R2 sets the circuit's threshold. When the light intensity at PC1's surface is decreased, the resistance of PC1 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 R1, the comparator will switch from low to high when PC1 is darkened. This turns on Q1 which, in turn, pulls in relay K1.

PHOTOCELL MEMORY SWITCH FOR AC POWER CONTROL

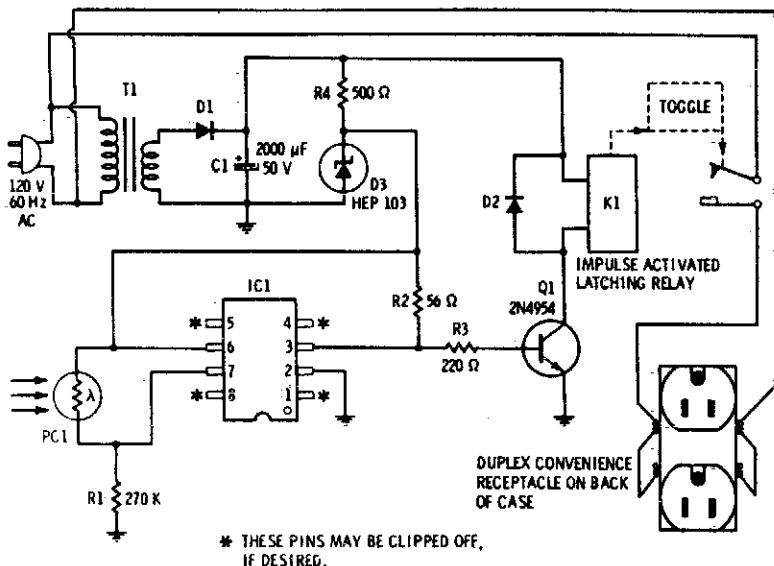


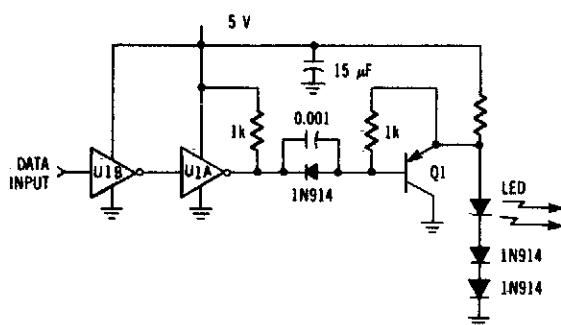
Fig. 44-10

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

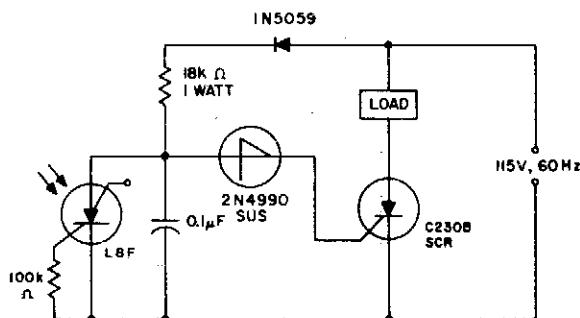
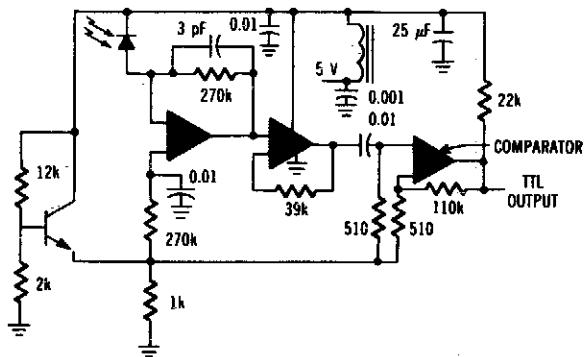


Fig. 44-12

Circuit Notes

When the light incident on the LASCR is interrupted, the voltage at the anode to the 2N4990 unilateral 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 unilateral 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

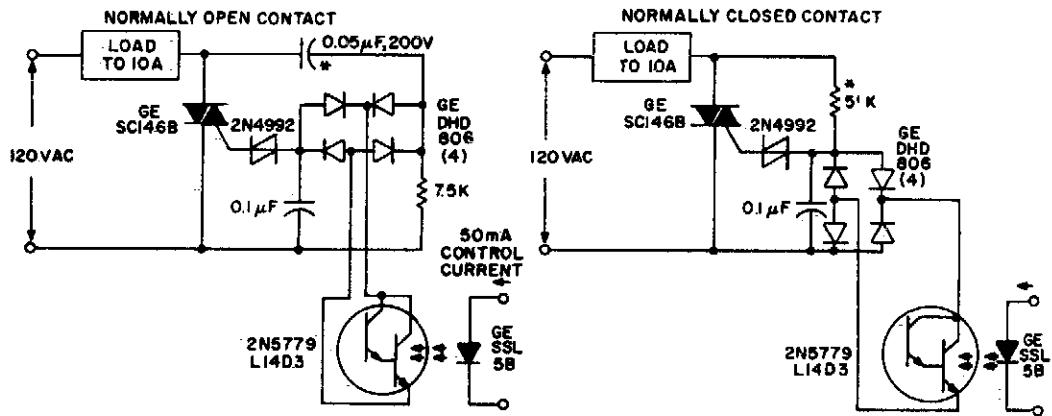


Fig. 44-14

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

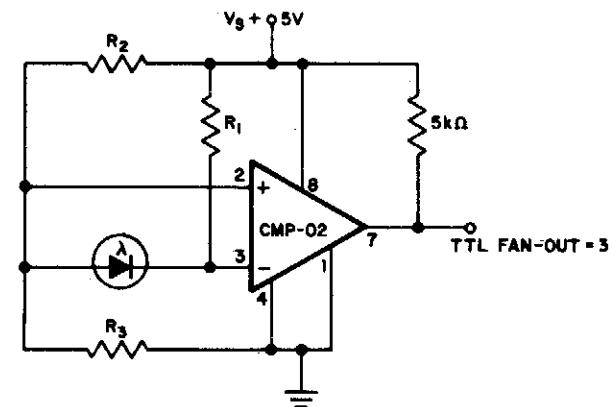


Fig. 44-15

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

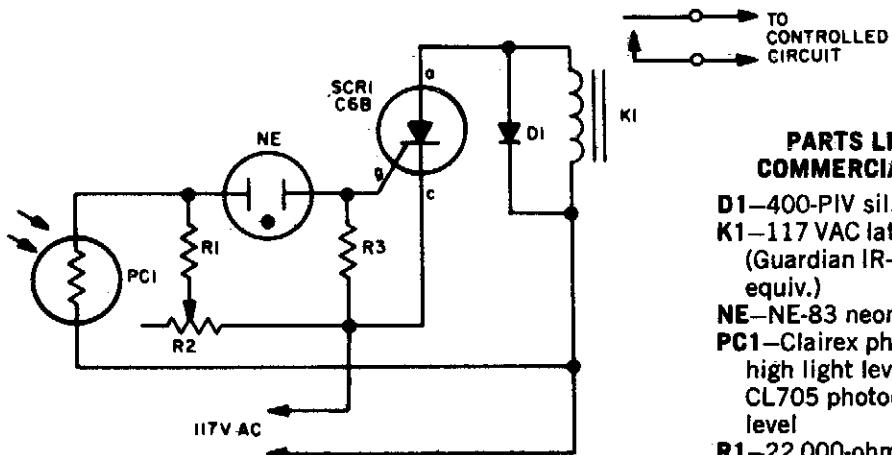


Fig. 44-16

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.

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, $\frac{1}{2}$ -watt resistor
- R2—1-megohm potentiometer
- R3—100-ohm, $\frac{1}{2}$ -watt resistor
- SCR1—HEP R1218, 200V, 4A, silicon-controlled rectifier

LOGARITHMIC LIGHT SENSOR

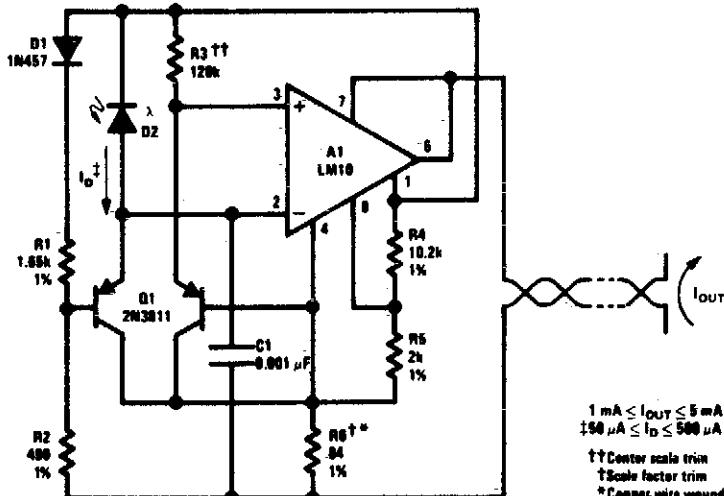


Fig. 44-17

FM (PRM) OPTICAL TRANSMITTER

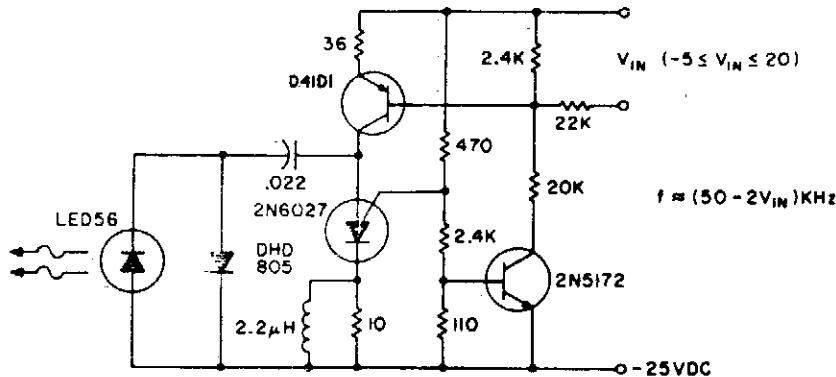


Fig. 44-18

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

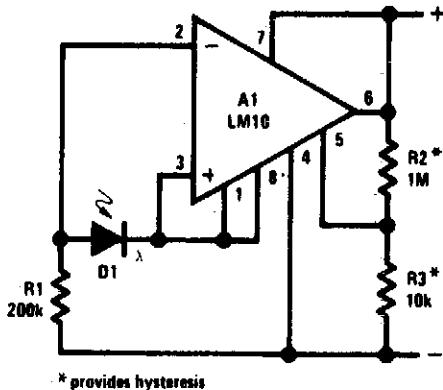


Fig. 44-19

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

Remote Control for Lamp or Appliance

High Power Control for Sensitive Contacts

Complementary Lighting Control

Floodlamp Power Control

Hysteresis-Free Phase Control Circuit

Low Cost Lamp Dimmer

Zero Point Switch

800 W Triac Light Dimmer

Full-Wave SCR Control

860 W Limited Range Low Cost Precision

Light Control

800 W Soft-Start Light Dimmer

Low Loss Brightness Control

Half-Wave Ac Phase-Controlled Circuit

Emergency Light

Neon Lamp Driver

Complementary Ac Power Switching

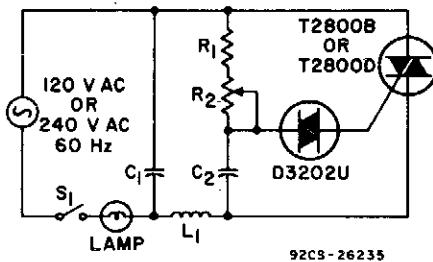
Battery Lantern Circuit

Shift Register

Light Level Controller

2.2 W Incandescent Lamp Driver

LIGHT DIMMERS



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

Parts List

120-Volt, 60-Hz Operation

$C_1, C_2 = 0.1 \mu\text{F}, 200 \text{ V}$

$L_1 = 100 \mu\text{H}$

$R_1 = 3300 \text{ ohms}, 0.5 \text{ watt}$

$R_2 = \text{light control, poten-$

tiometer, 0.25 megohm,
0.5 watt

240-Volt, 50/60 Hz Operation

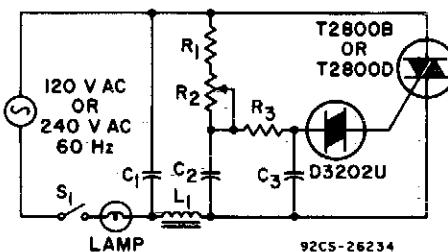
$C_1 = 0.1 \mu\text{F}, 400 \text{ V}$

$C_2 = 0.05 \mu\text{F}, 400 \text{ V}$

$L_1 = 200 \mu\text{H}$

$R_1 = 4700 \text{ ohms}, 0.5 \text{ watt}$

$R_2 = \text{light control, poten-$
tiometer, 0.25 megohm,
1 watt



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

Parts List

120-Volt, 60-Hz Operation

$C_1, C_2 = 0.1 \mu\text{F}, 200 \text{ V}$

$C_3 = 0.1 \mu\text{F}, 100 \text{ V}$

$L_1 = 100 \mu\text{H}$

$R_1 = 1000 \text{ ohms}, 0.5 \text{ watt}$

$R_2 = \text{light control, poten-$

tiometer, 0.1 megohm,
0.5 watt

$C_3 = 0.1 \mu\text{F}, 100 \text{ V}$

$L_1 = 100 \mu\text{H}$

$R_1 = 7500 \text{ ohms}, 2 \text{ watts}$

$R_2 = \text{light control, poten-$
tiometer, 0.2 megohm,
1 watt

$R_3 = 7500 \text{ ohms}, 2 \text{ watts}$

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

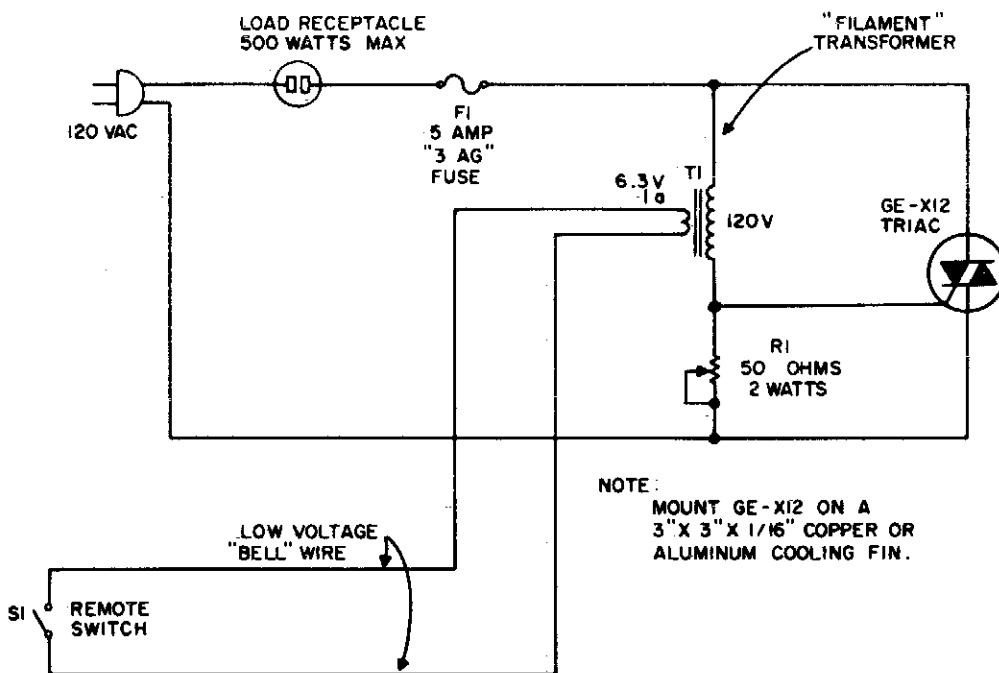


Fig. 45-2

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 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

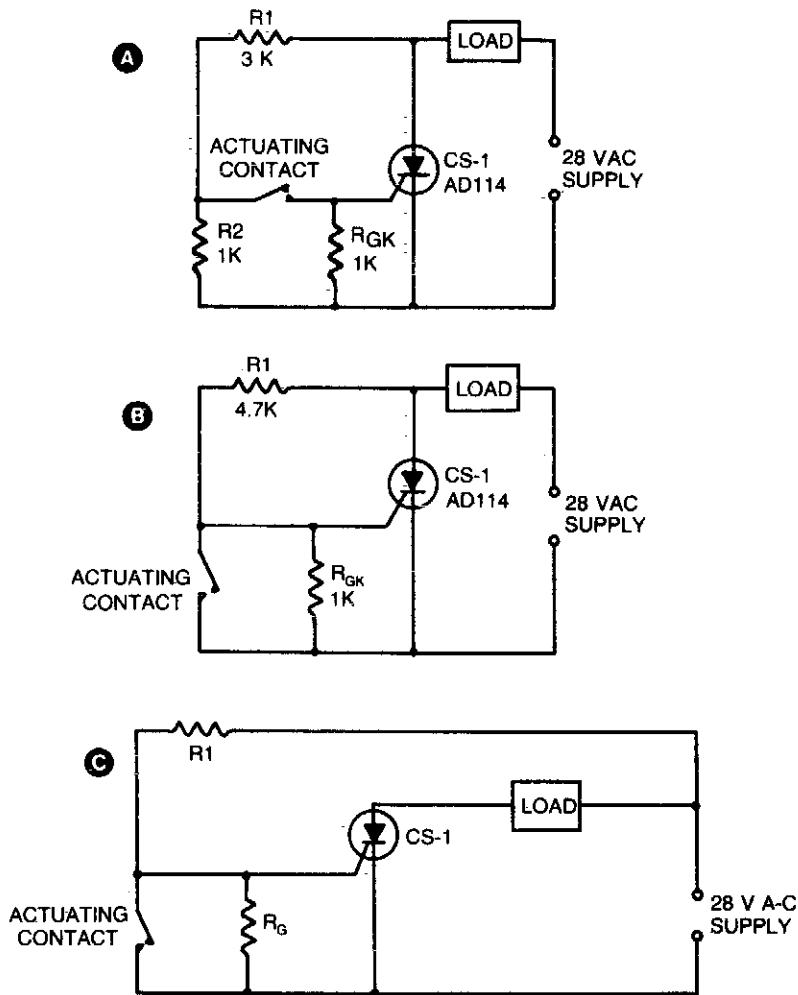


Fig. 45-3

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

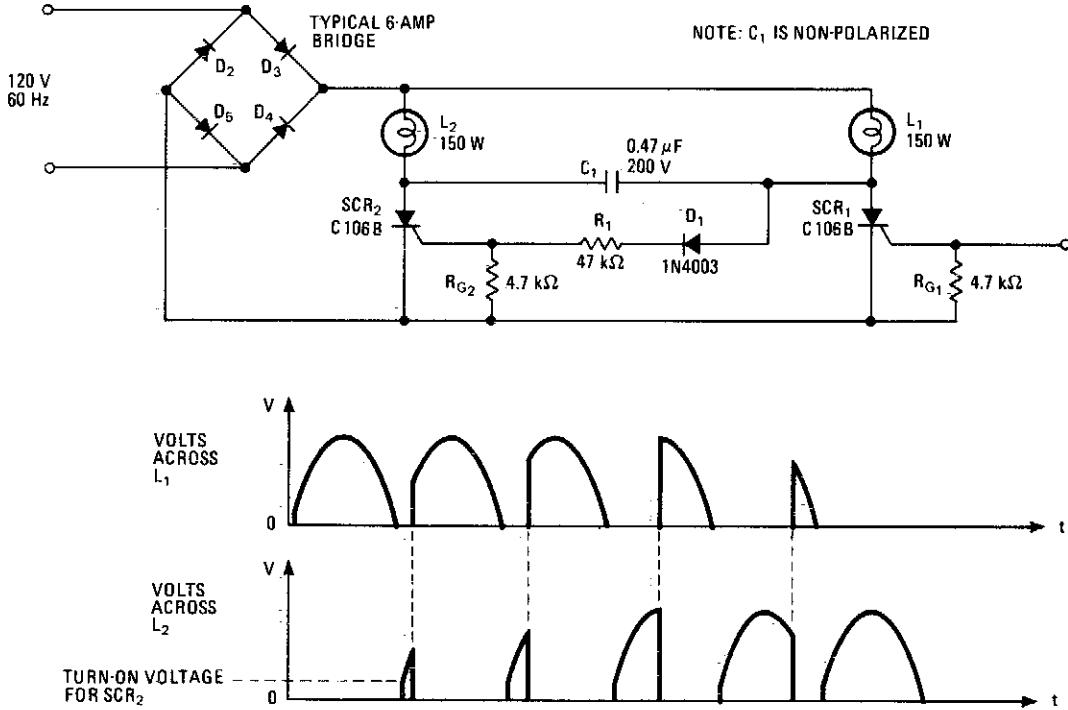


Fig. 45-4

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

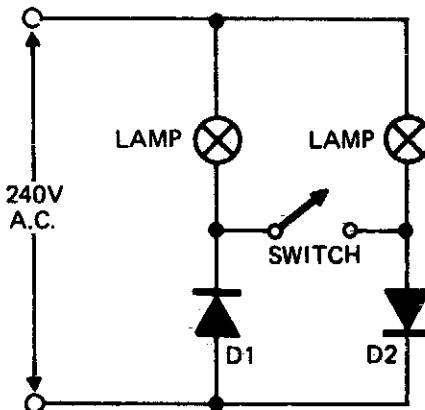


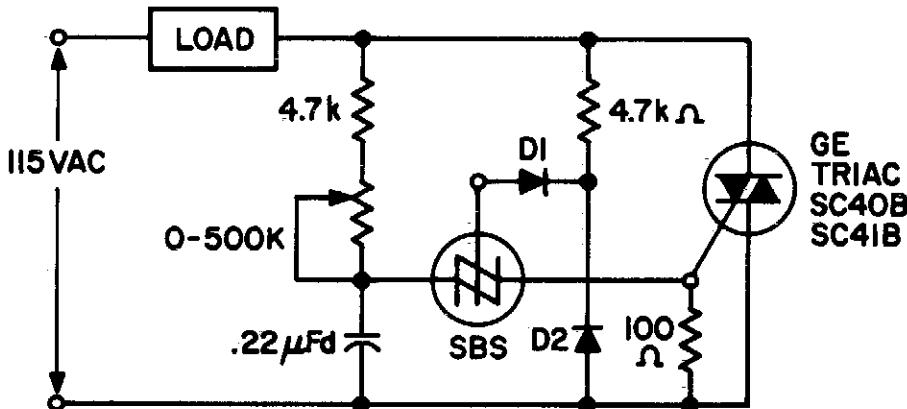
Fig. 45-5

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
DI, D2 - GE 6RS5GC1AJ1
- 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

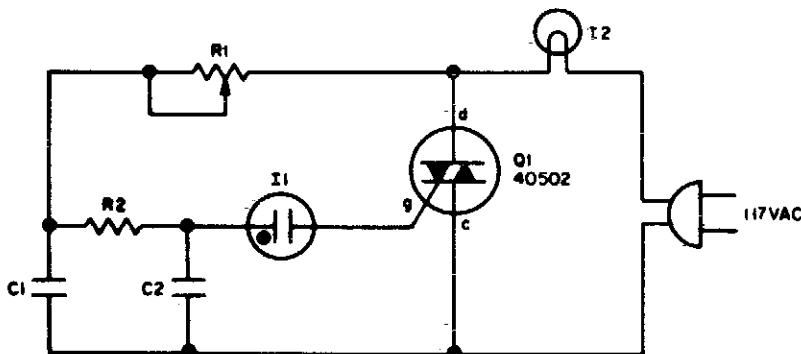


Fig. 45-7

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, $\frac{1}{2}$ -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

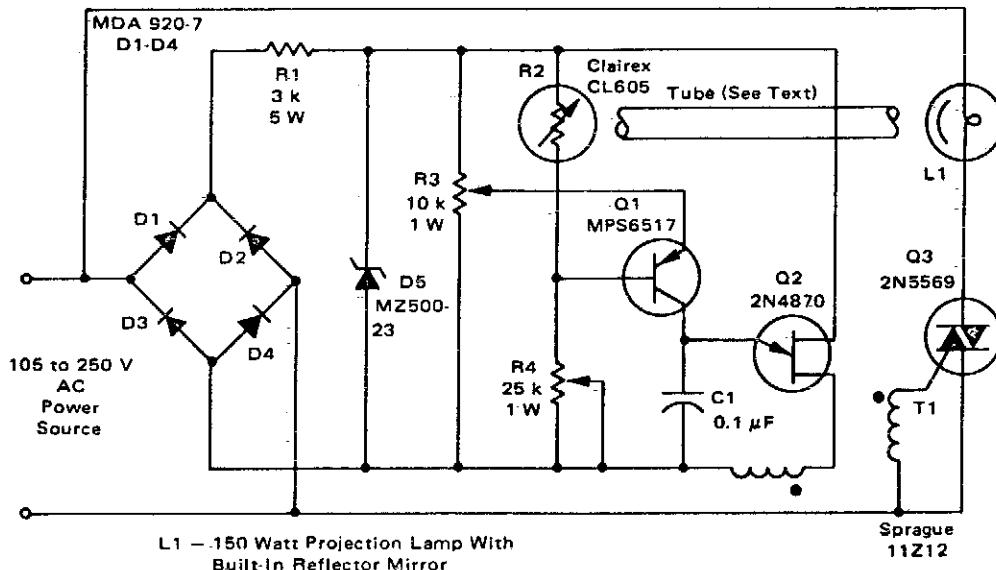


Fig. 45-8

800 W TRIAC LIGHT DIMMER

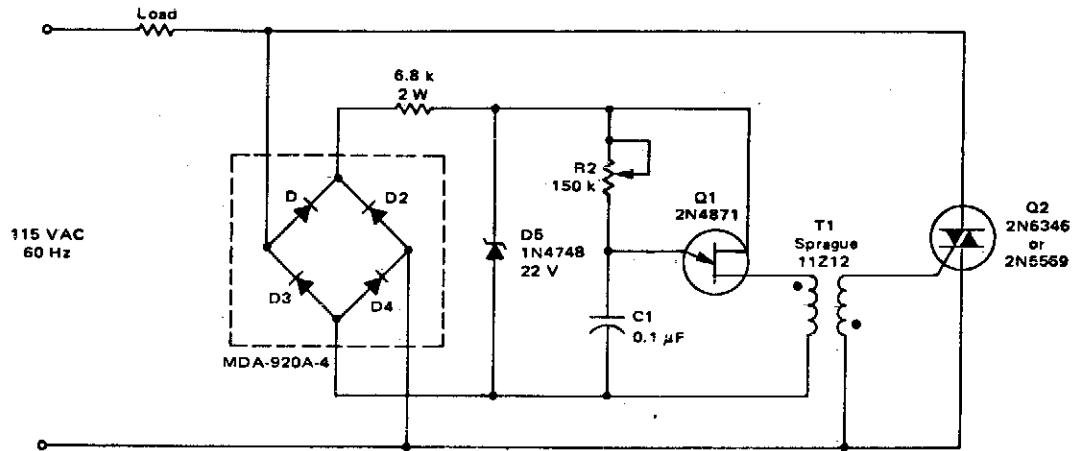
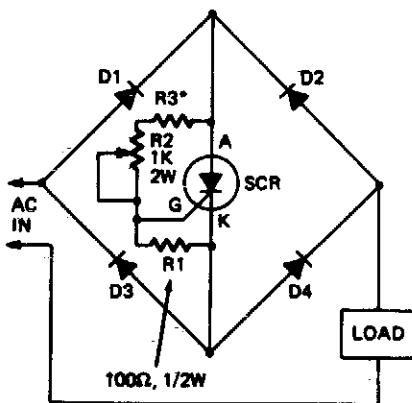


Fig. 45-9

FULL-WAVE SCR CONTROL



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.

Fig. 45-10

860 WATT LIMITED-RANGE LOW COST PRECISION LIGHT CONTROL

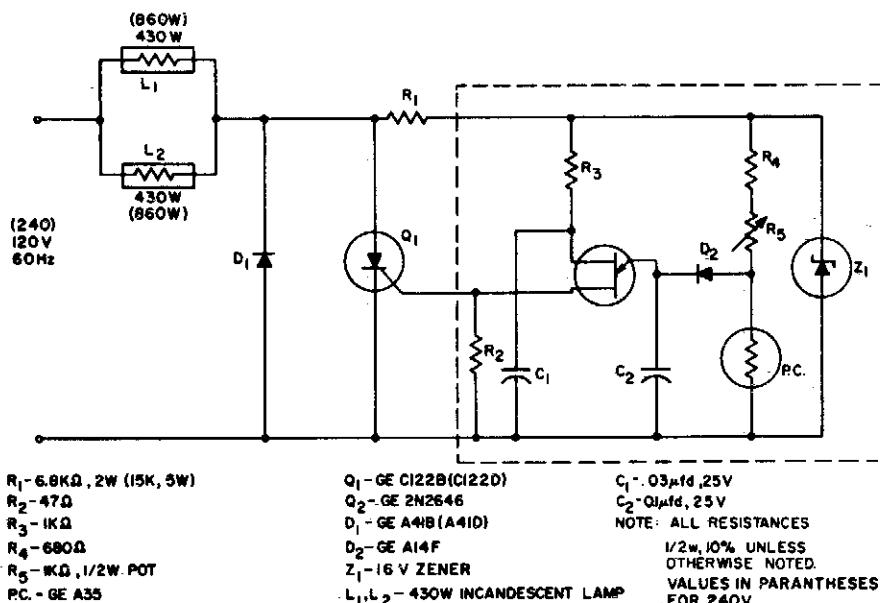


Fig. 45-11

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

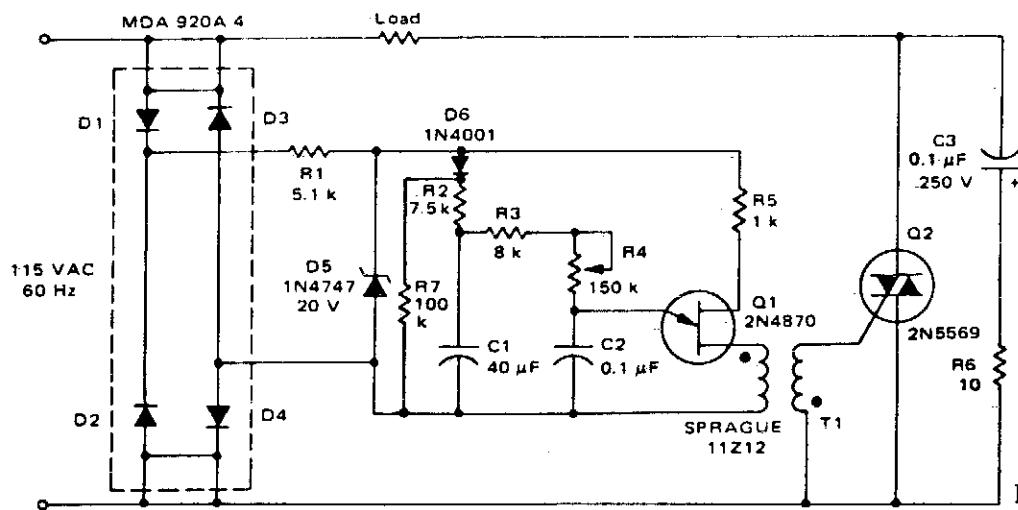


Fig. 45-12

LOW LOSS BRIGHTNESS CONTROL

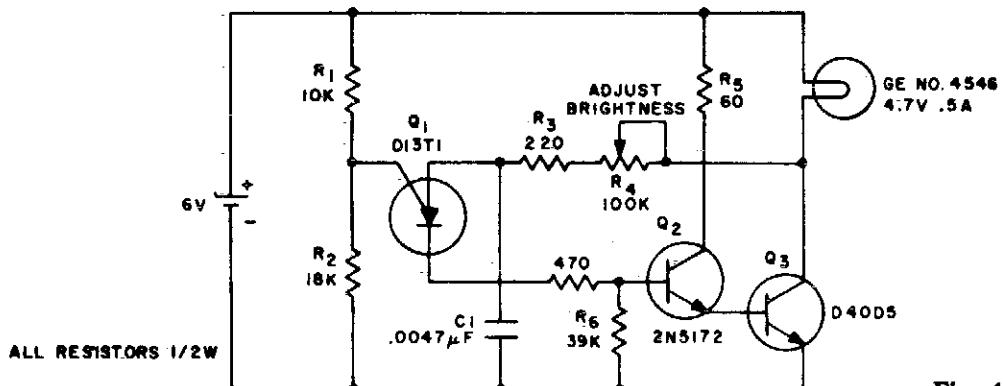


Fig. 45-13

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

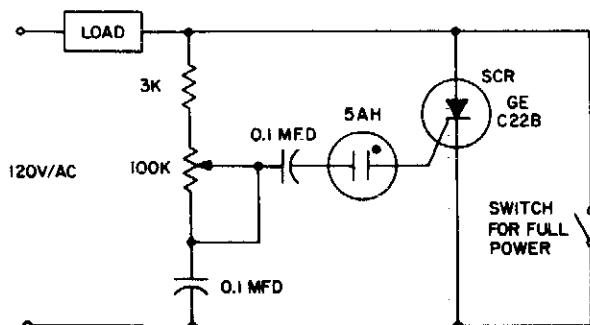


Fig. 45-14

Circuit Notes

The 5AH will trigger when the voltage across the two $0.1 \mu\text{F}$ 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

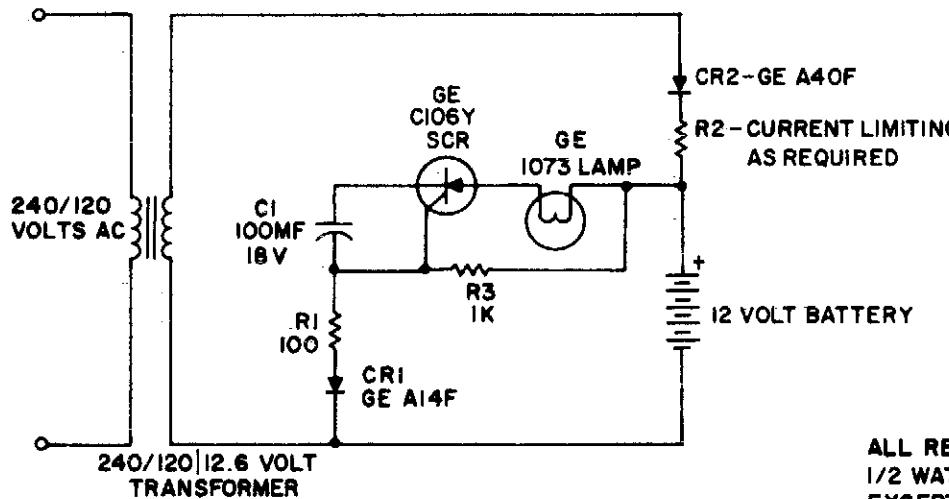


Fig. 45-15

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

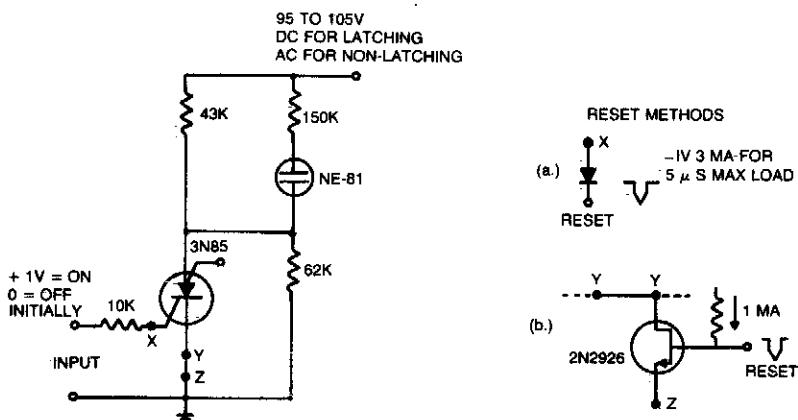


Fig. 45-16

COMPLEMENTARY AC POWER SWITCHING

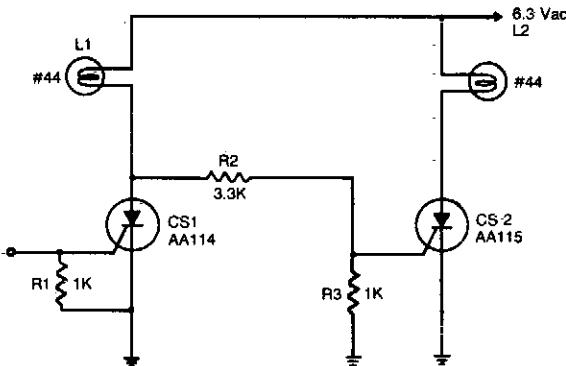


Fig. 45-17

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

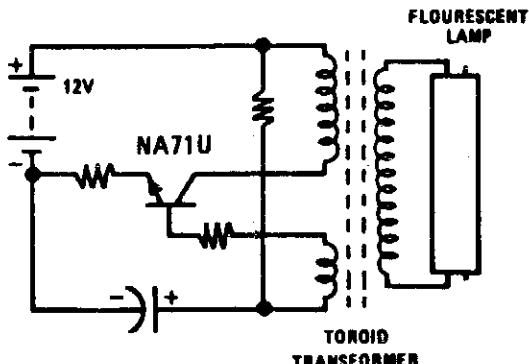


Fig. 45-18

SHIFT REGISTER

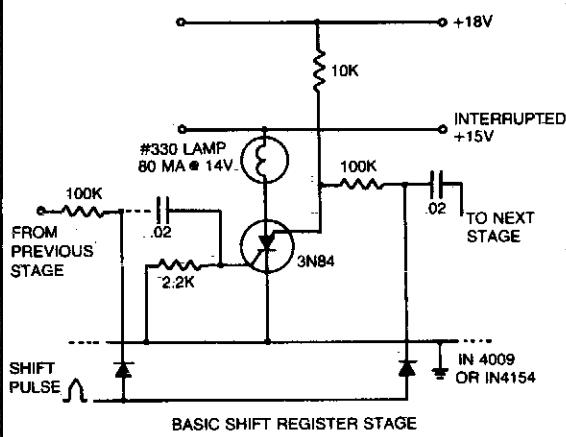


Fig. 45-19

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.

LIGHT-LEVEL CONTROLLER

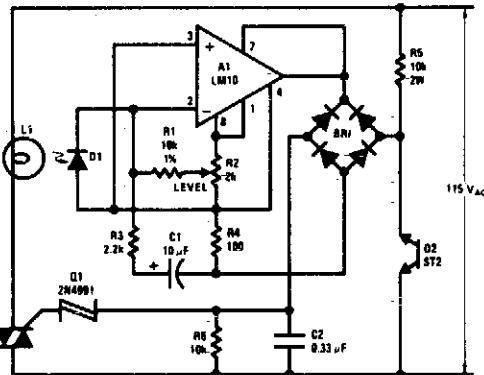


Fig. 45-20

2.2 WATT INCANDESCENT LAMP DRIVER

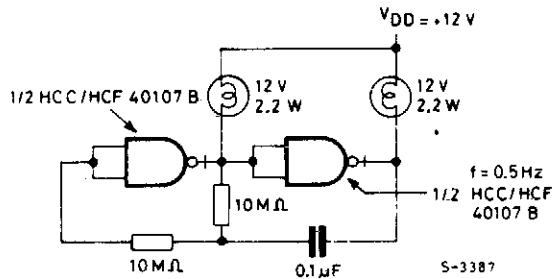


Fig. 45-21

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

Light Meter

Logarithmic Light-Meter Circuit

Light Meter

Light Meter

Precision Photodiode Comparator

LINEAR LIGHT-METER CIRCUIT

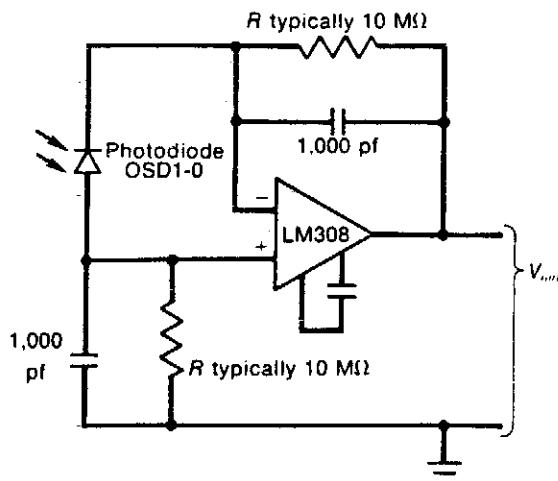


Fig. 46-1

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.

LOGARITHMIC LIGHT-METER CIRCUIT

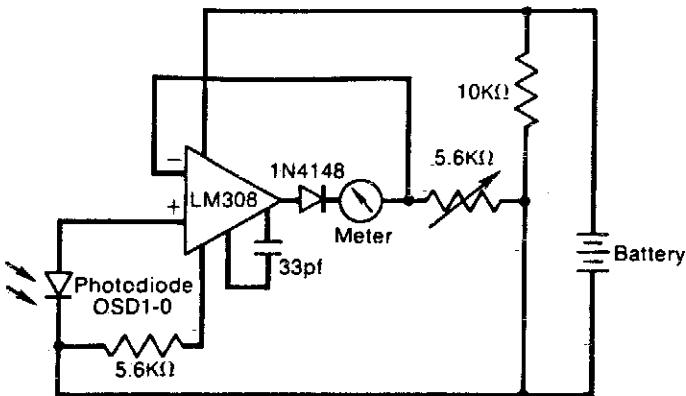


Fig. 46-2

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 pnjunction 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.

LIGHT METER

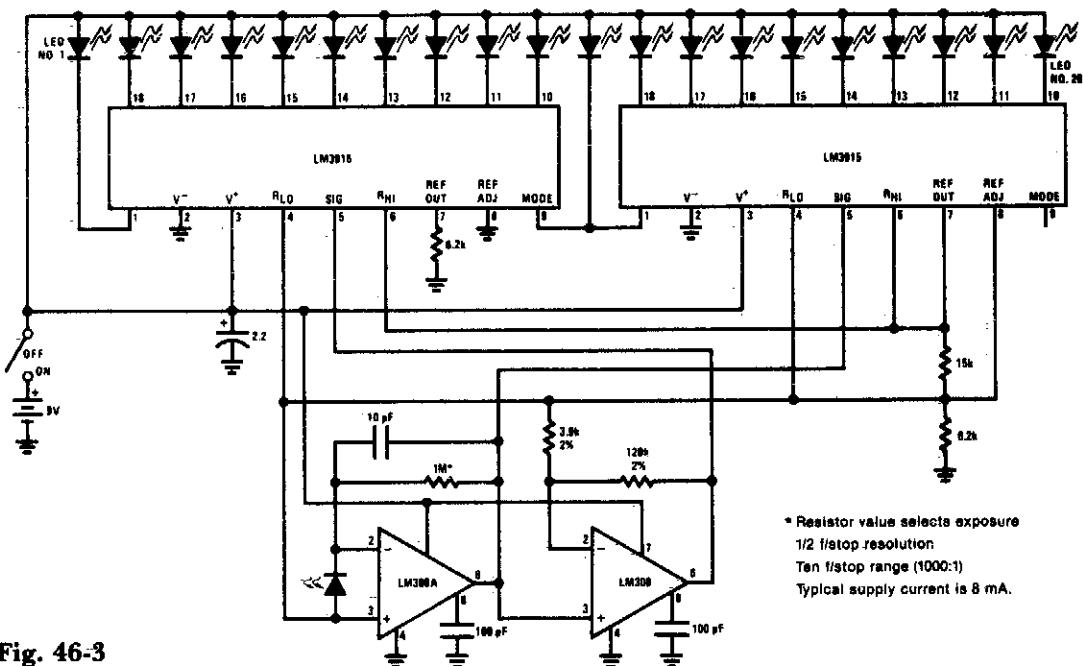


Fig. 46-3

LIGHT METER

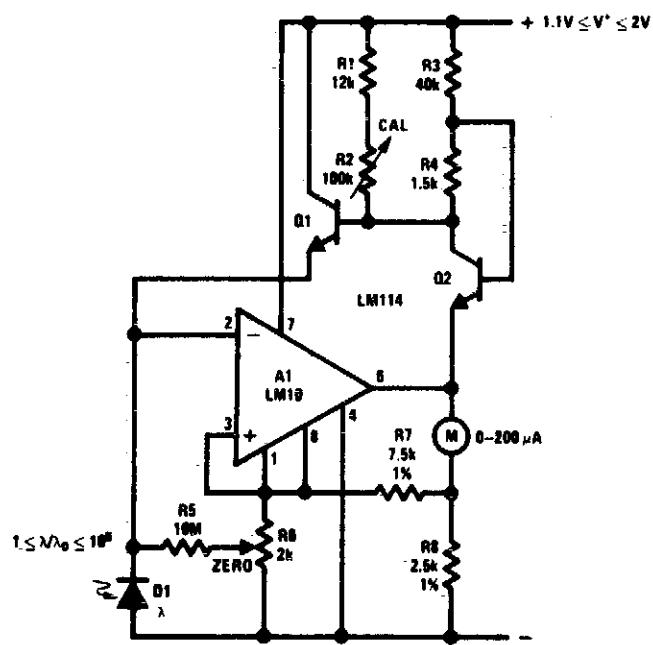


Fig. 46-4

LIGHT METER

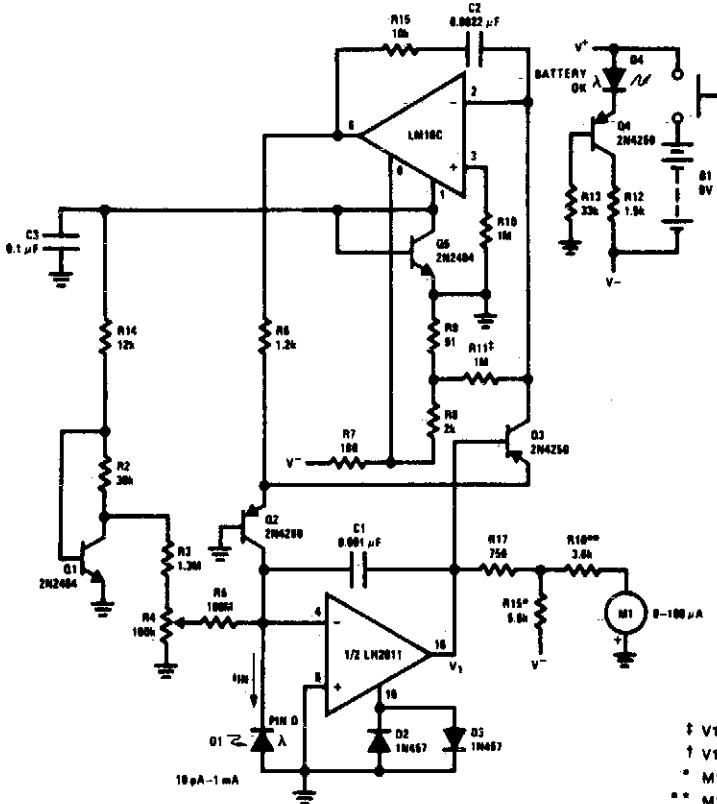


Fig. - 46-5

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.

PRECISION PHOTODIODE COMPARATOR

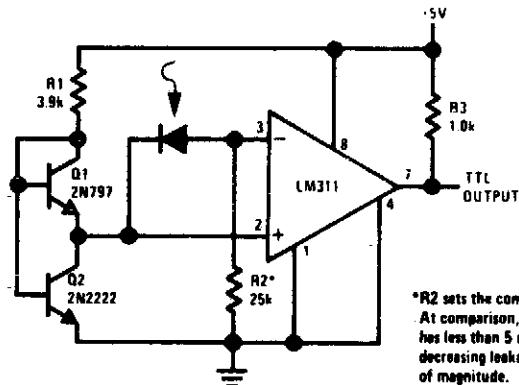


Fig. 46-6

- * R2 sets the comparison level.
- . At comparison, the photodiode has less than 5 mV across it, decreasing leakages 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

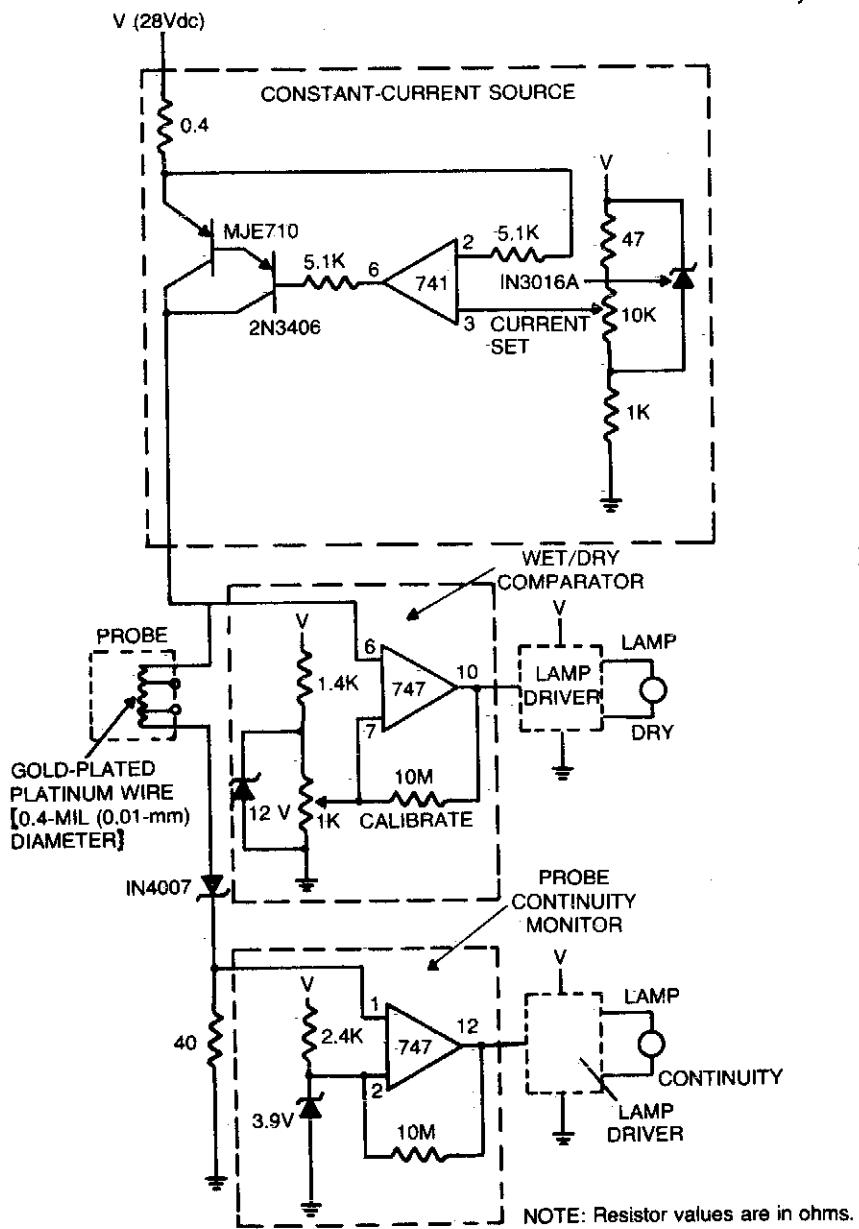


Fig. 47-1

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

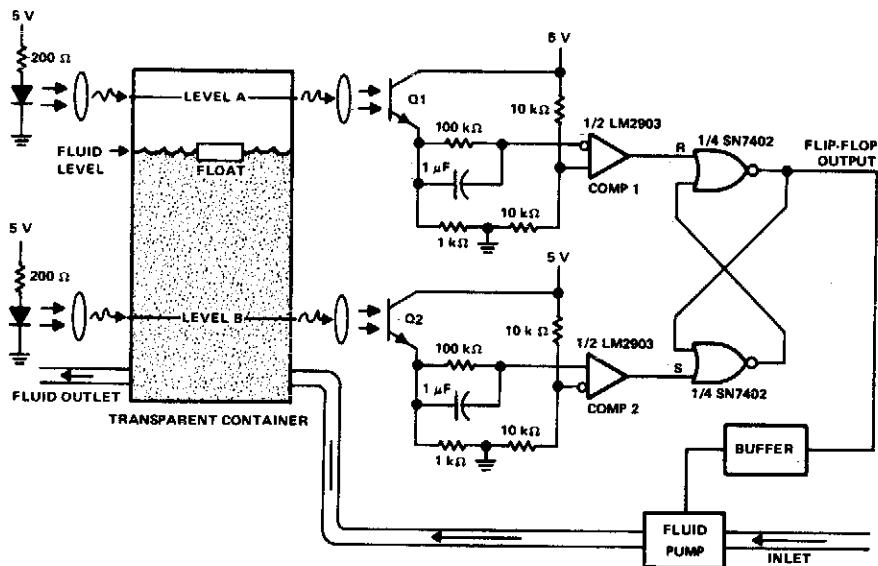


Fig. 47-2

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

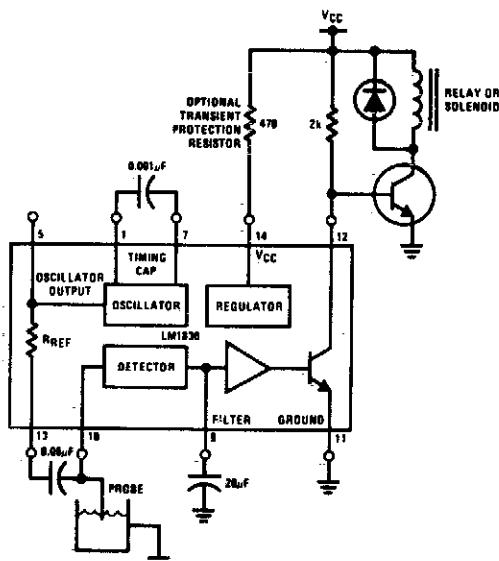


Fig. 47-3

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

LIQUID LEVEL CONTROL

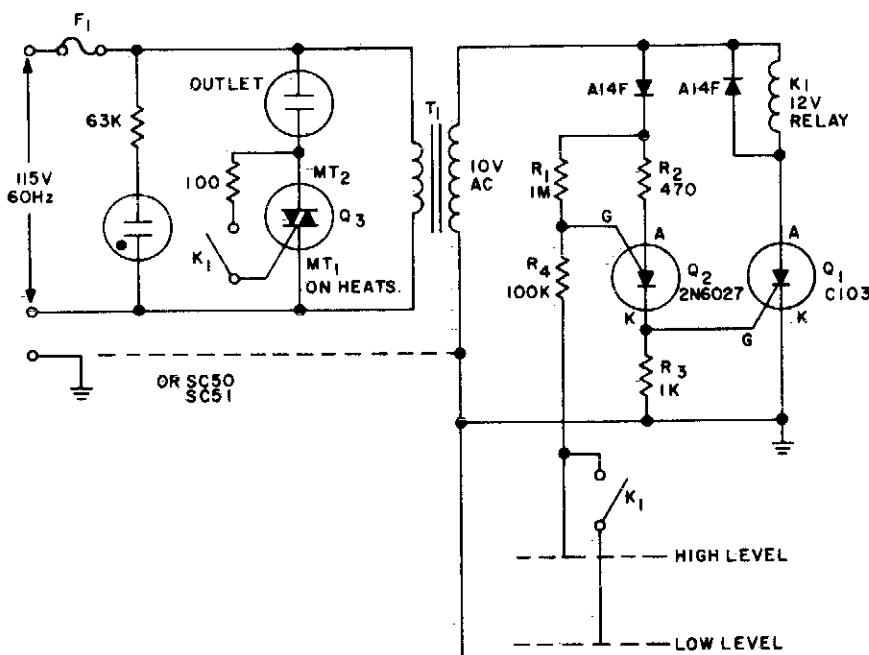


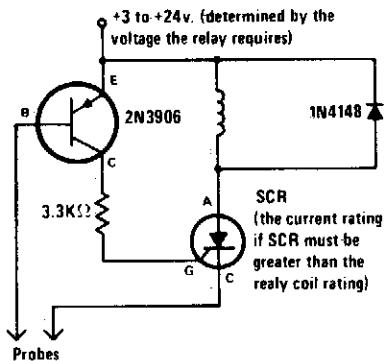
Fig. 47-4

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

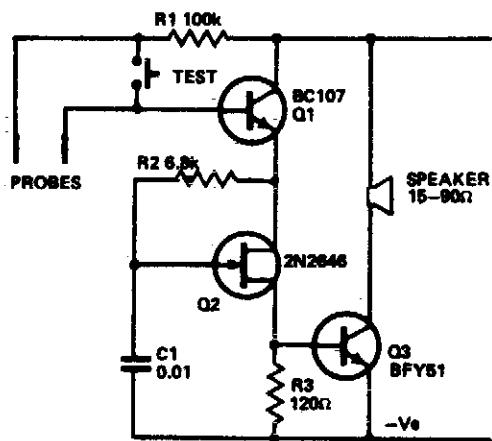


Fig. 47-6

Circuit Notes

The circuit draws so little current that the shelf-line 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

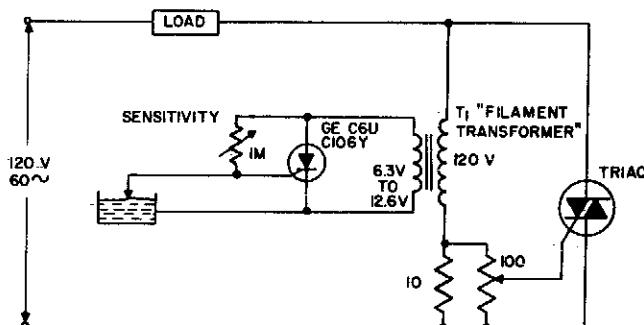
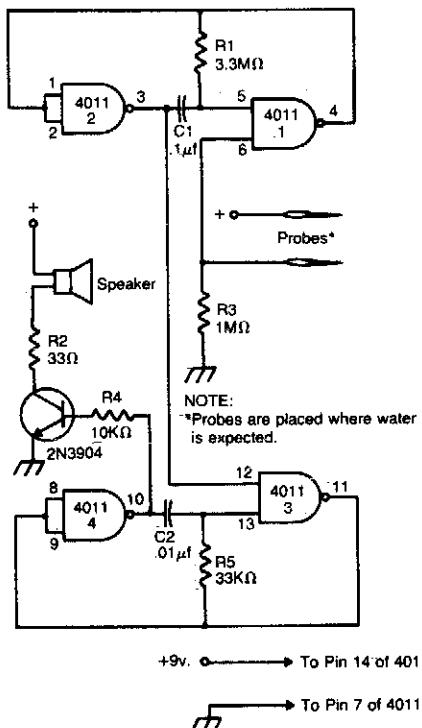


Fig. 47-7

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

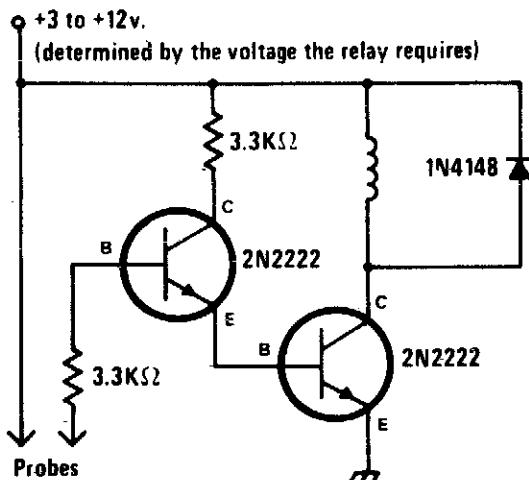


Circuit Notes

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

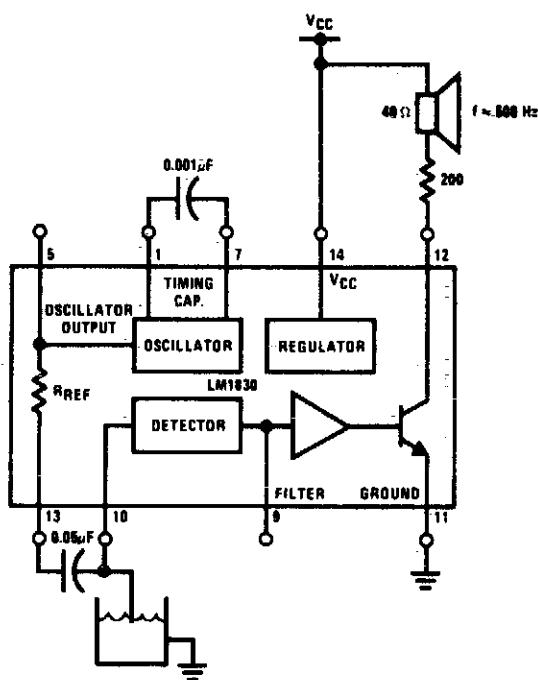


Fig. 47-10

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

OR Gate

Programmable Gate

Large Fan-In AND Gate

Negative to Positive Supply Logic Level

AND Gate

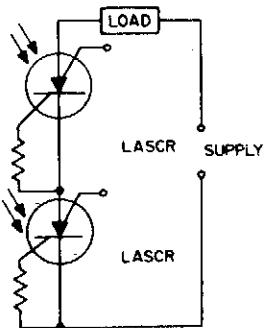
Shifter

R-S Flip-Flop

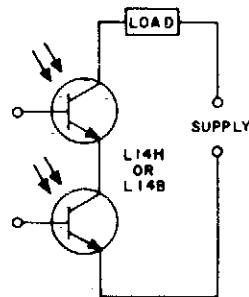
OR Gate

AND Gate

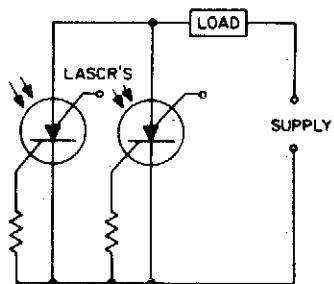
LIGHT ACTIVATED LOGIC CIRCUITS



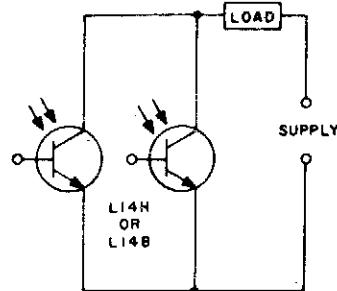
(a) AND Circuit



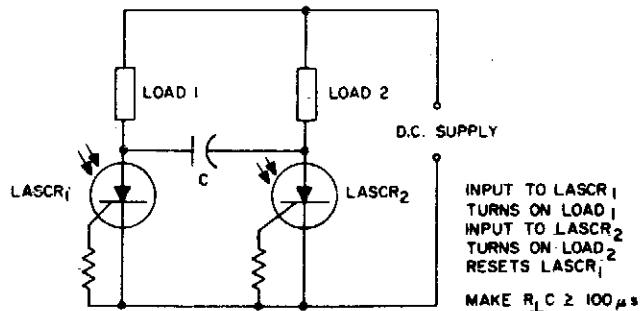
(b) AND Circuit



(c) OR Circuit



(d) OR Circuit



(e) Flip-Flop

Circuit Notes

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

PROGRAMMABLE GATE

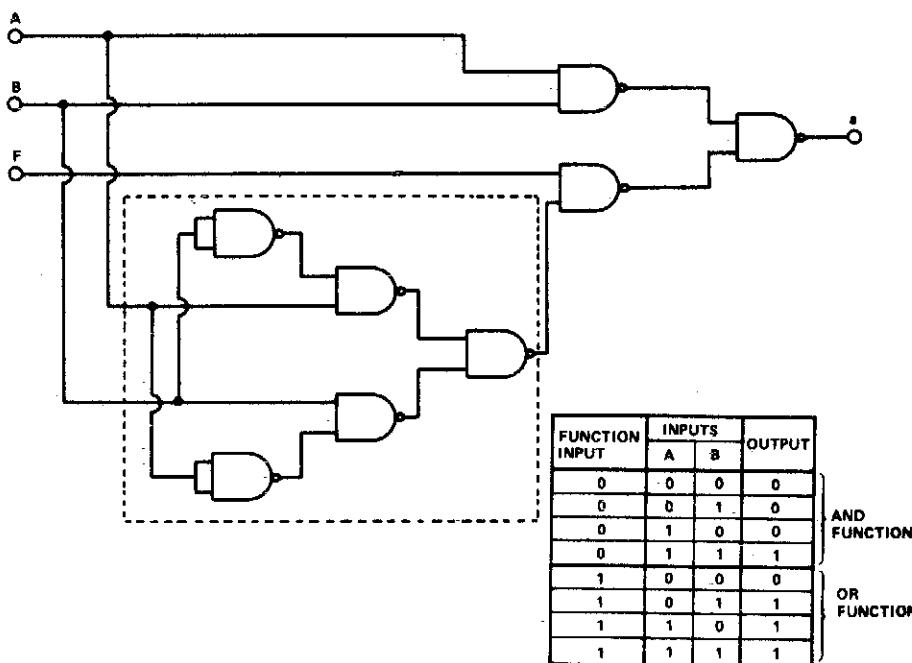
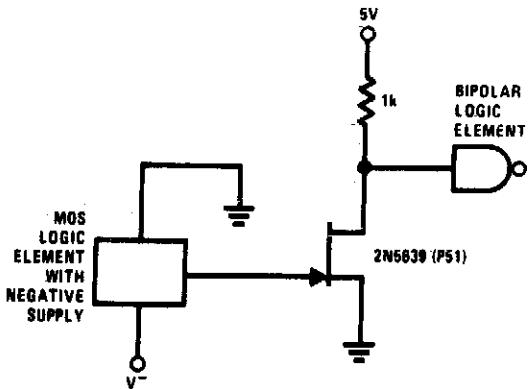


Fig. 48-2

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

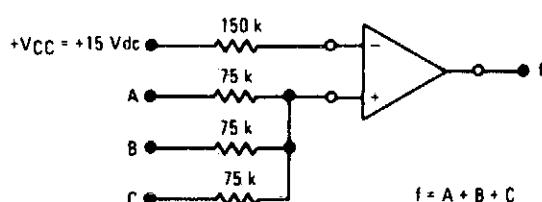


Circuit Notes

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



IC = MC3301

Fig. 48-4

AND GATE

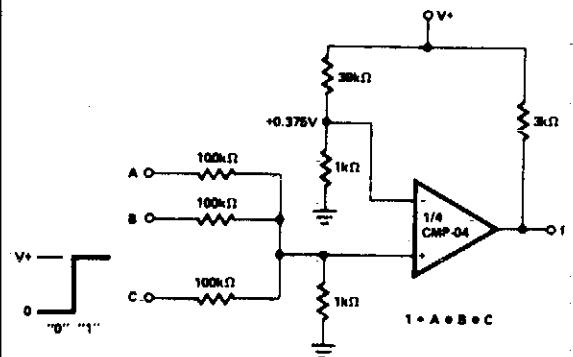


Fig. 48-7

OR GATE

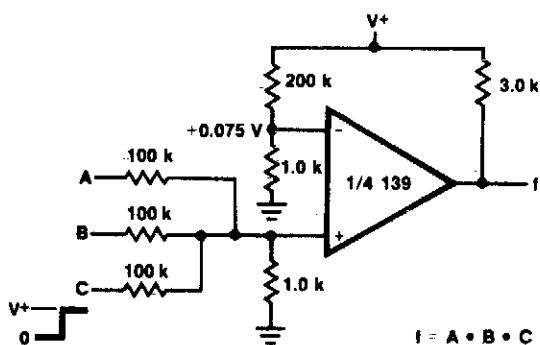


Fig. 48-5

R-S FLIP-FLOP

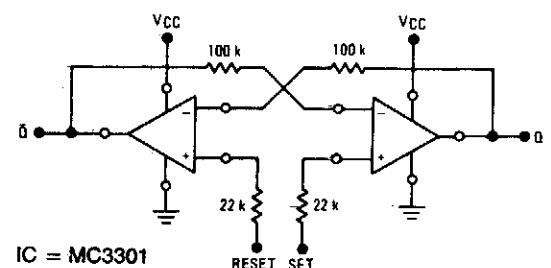


Fig. 48-8

LARGE FAN-IN AND GATE

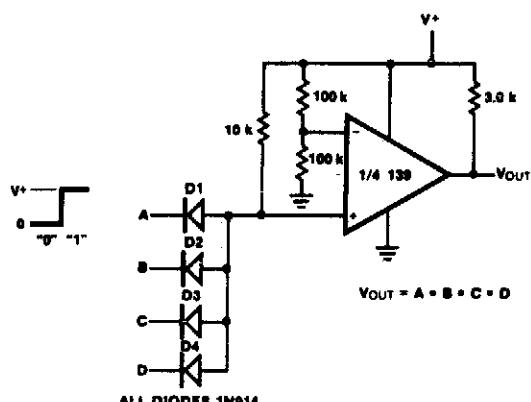


Fig. 48-6

AND GATE

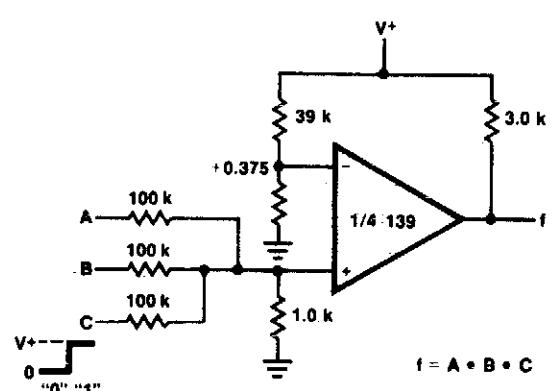


Fig. 48-9

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 Compensator	Linear Variable Differential Transformer (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

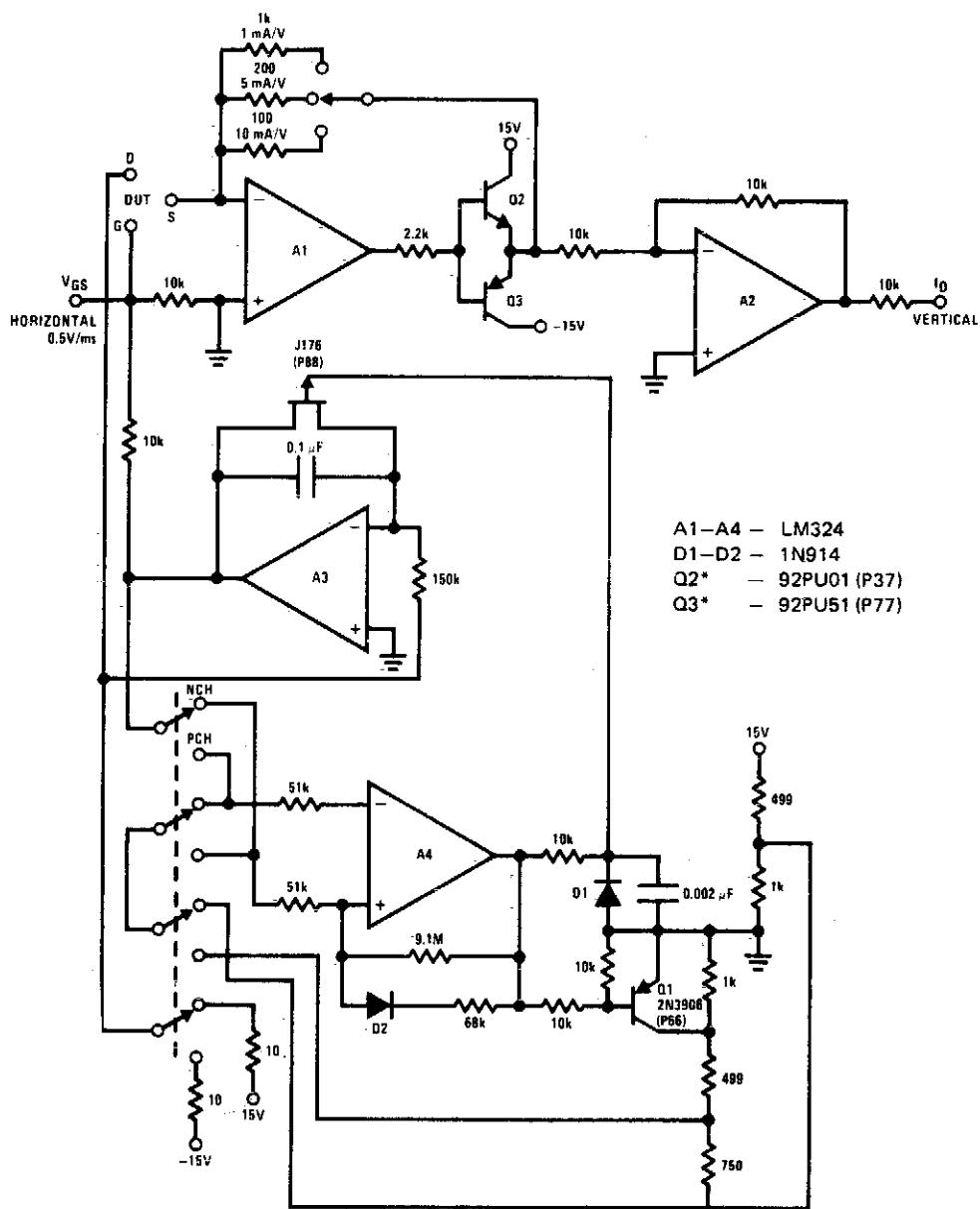
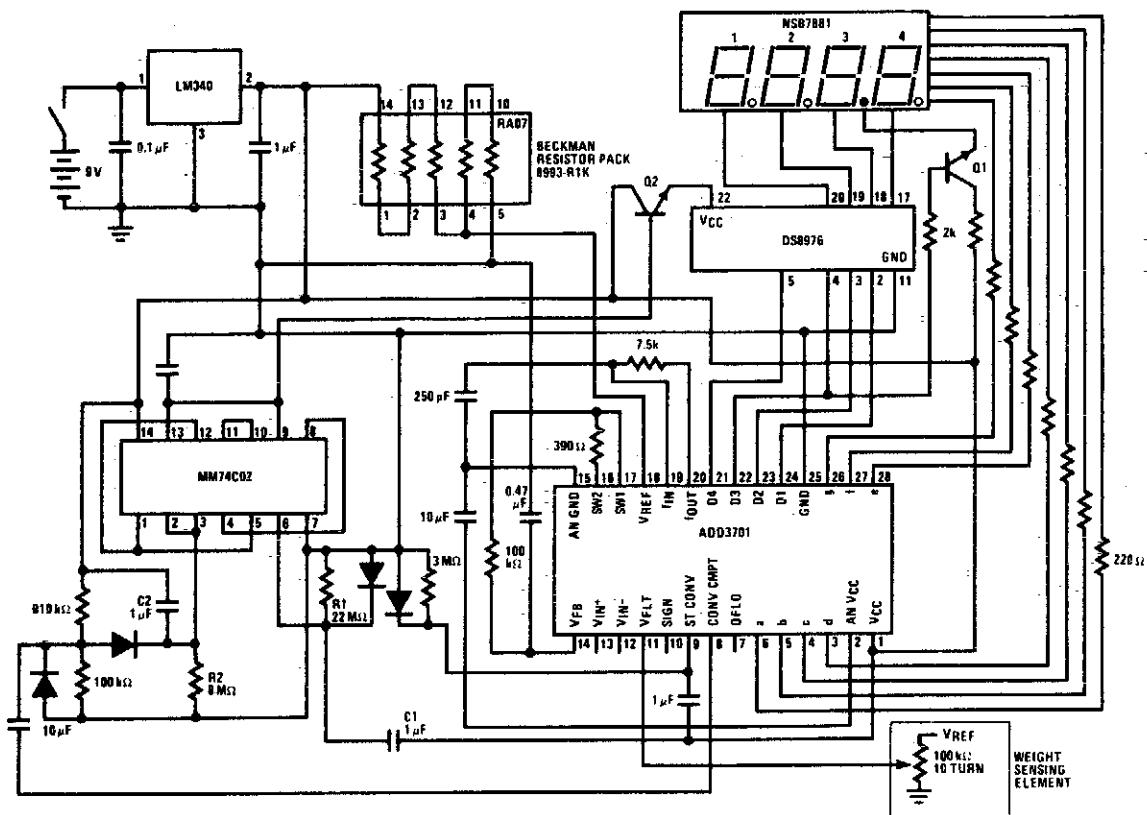


Fig. 49-1

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 ckt implementation:

$t = 0 \text{ sec}$	• power ON
$t = 0 \rightarrow 5 \text{ sec}$	• display blanked
	• system converging
$t = 5 \rightarrow 10 \text{ sec}$	• conversion complete
	• display ENABLE
$t \geq 10 \text{ sec}$	• 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

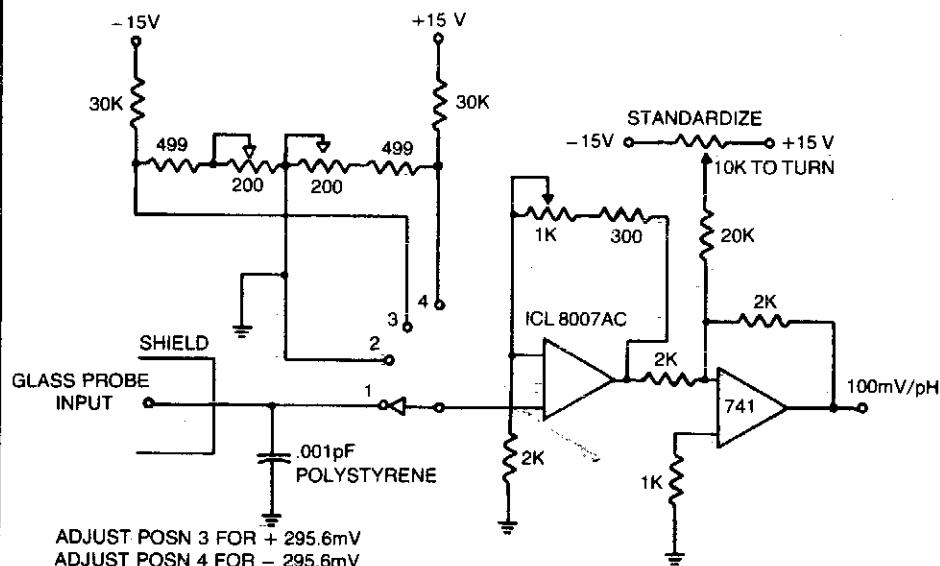


Fig. 49-3

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

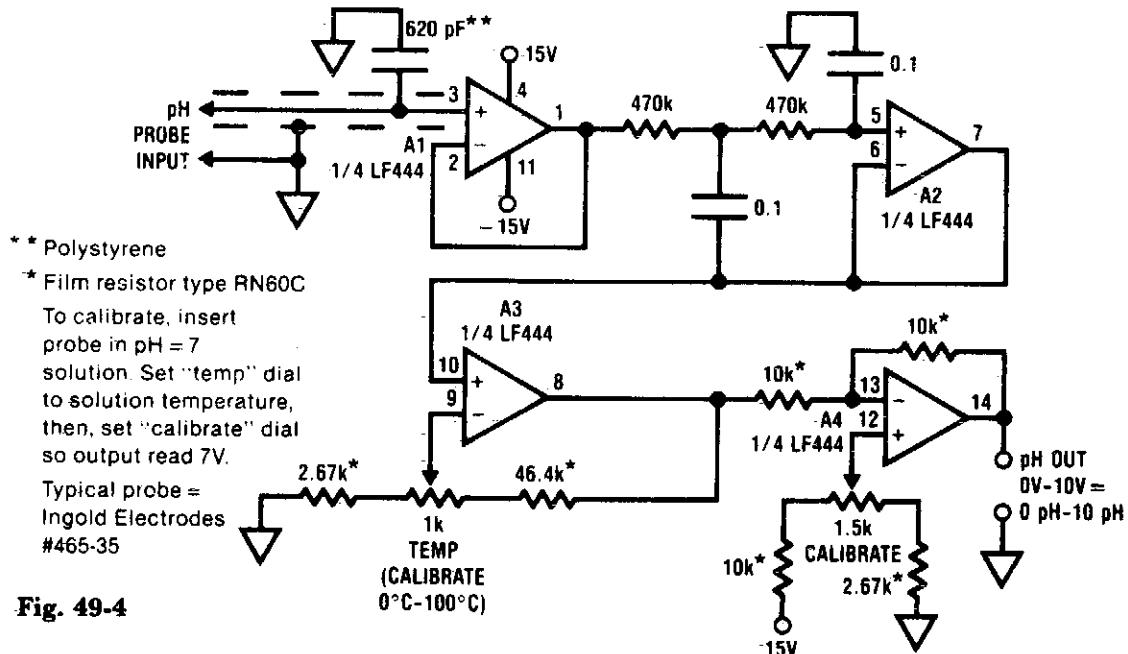
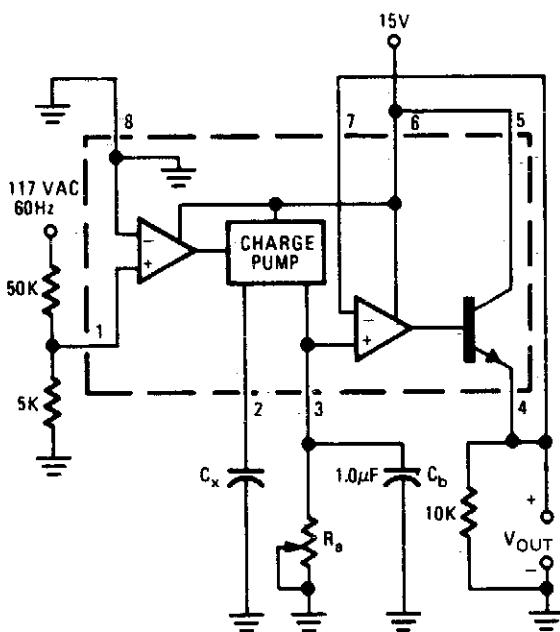


Fig. 49-4

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_a 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

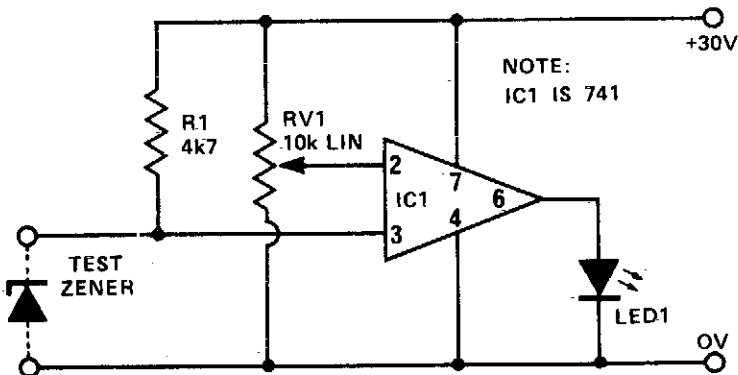


Fig. 49-6

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

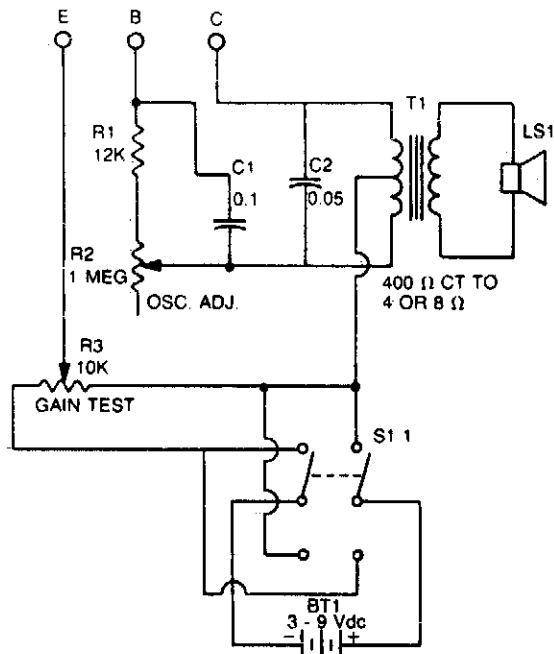


Fig. 49-7

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

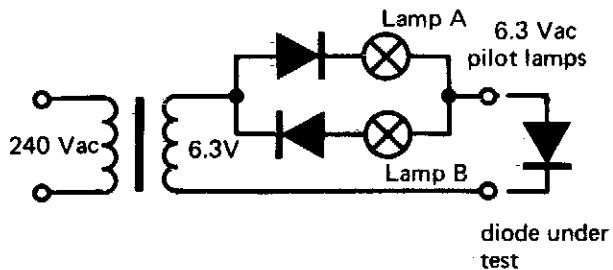


Fig. 49-8

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

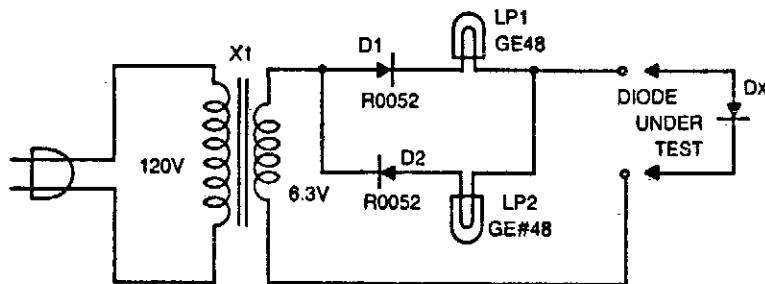


Fig. 49-9

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

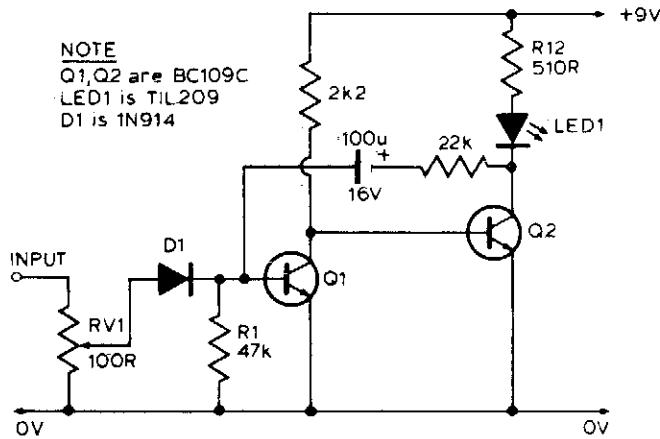


Fig. 49-10

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

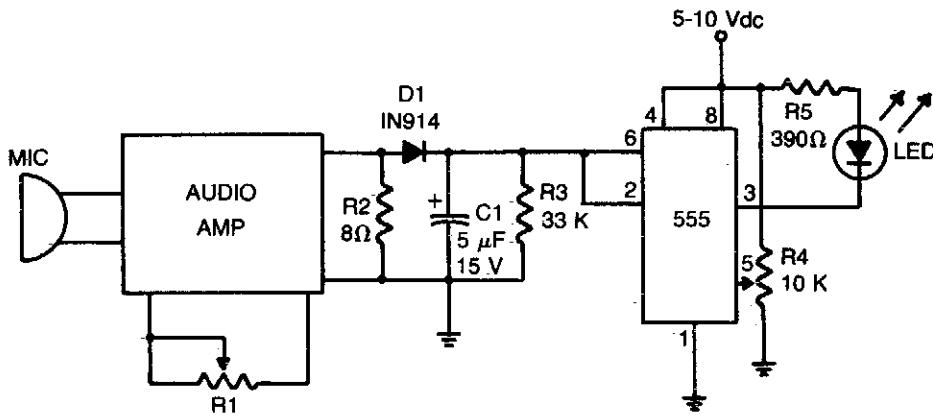


Fig. 49-11

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

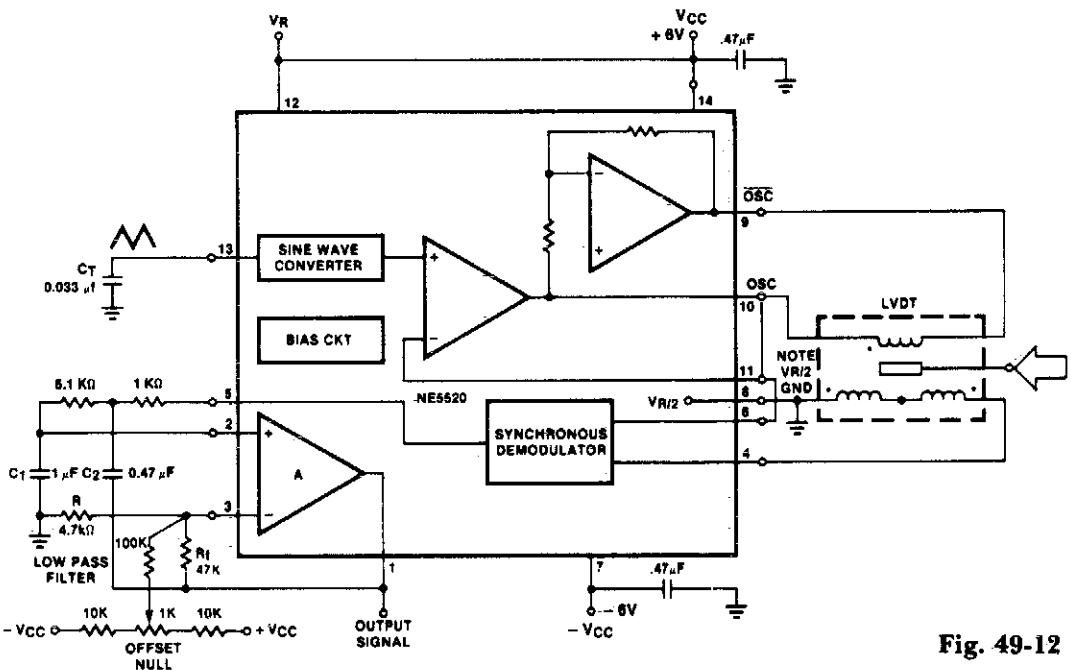


Fig. 49-12

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT) MEASURING GAUGE

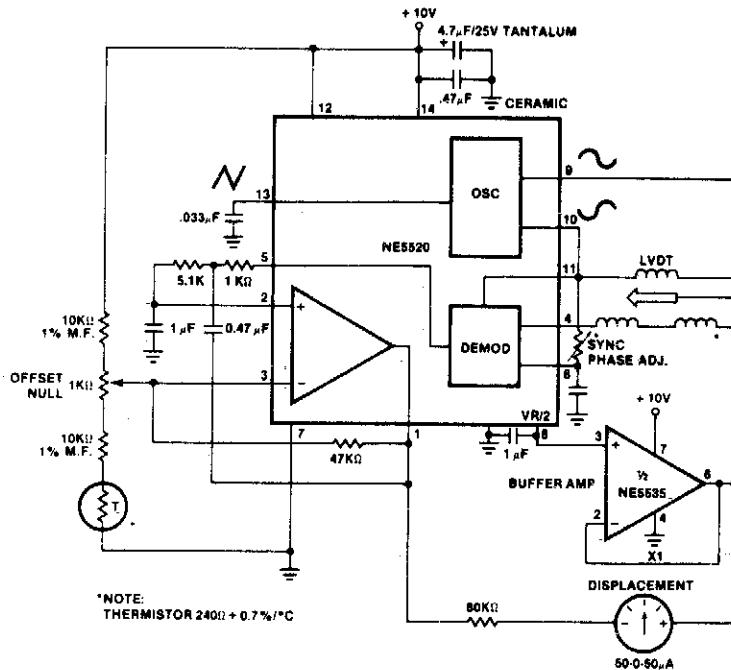


Fig. 49-13

VIBRATION METER

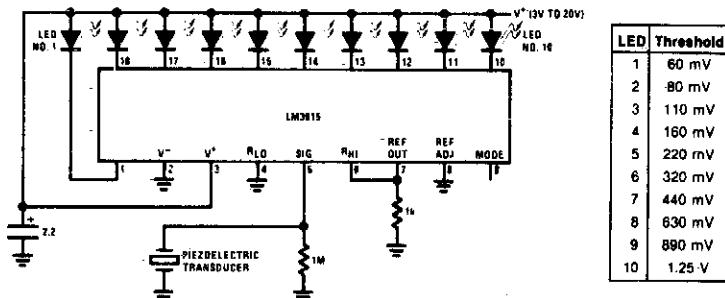


Fig. 49-14

SENSITIVE RF VOLTMETER

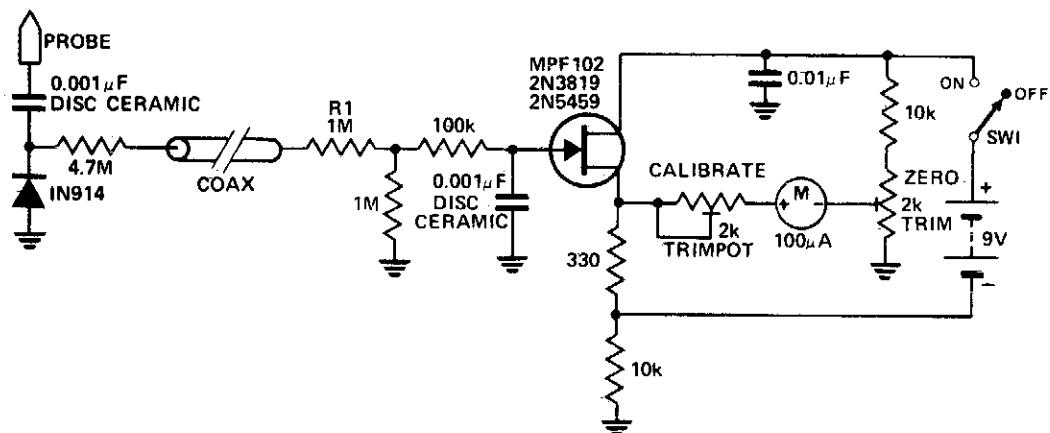


Fig. 49-15

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

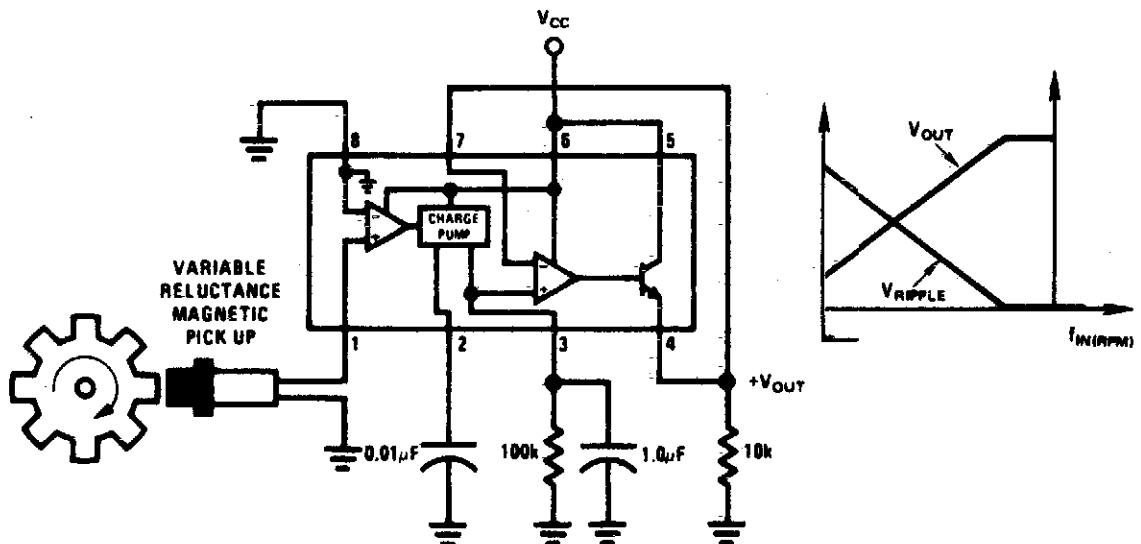


Fig. 49-16

PHASE METER

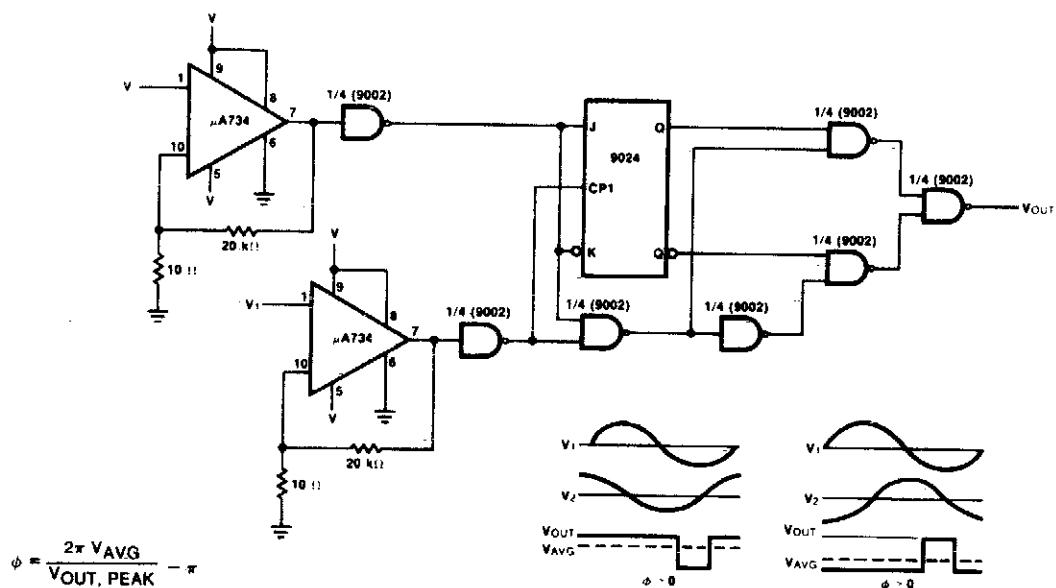


Fig. 49-17

PRECISION CALIBRATION STANDARD

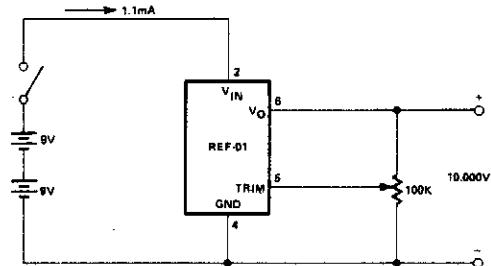


Fig. 49-18

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

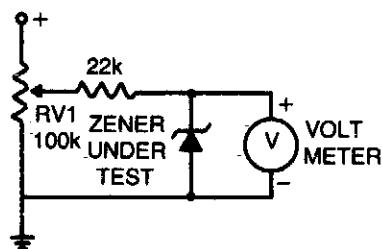


Fig. 49-19

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

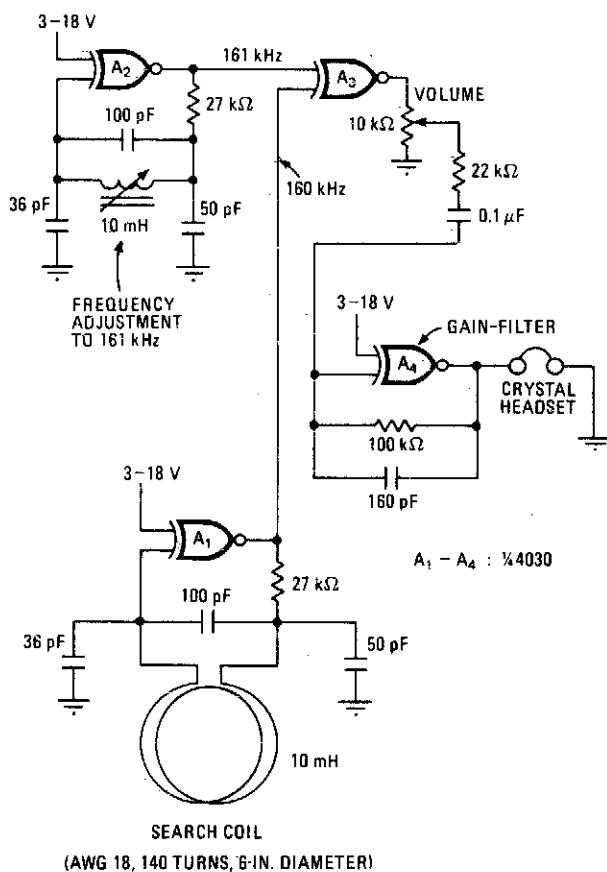


Fig. 50-1

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

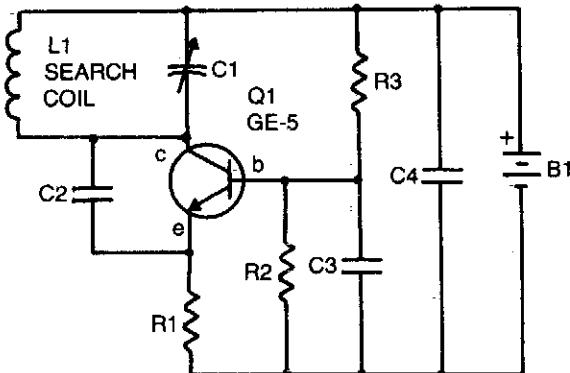


Fig. 50-2

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, 1/2-watt resistor
R2—10,000-ohm, 1/2-watt resistor
R3—47,000-ohm, 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

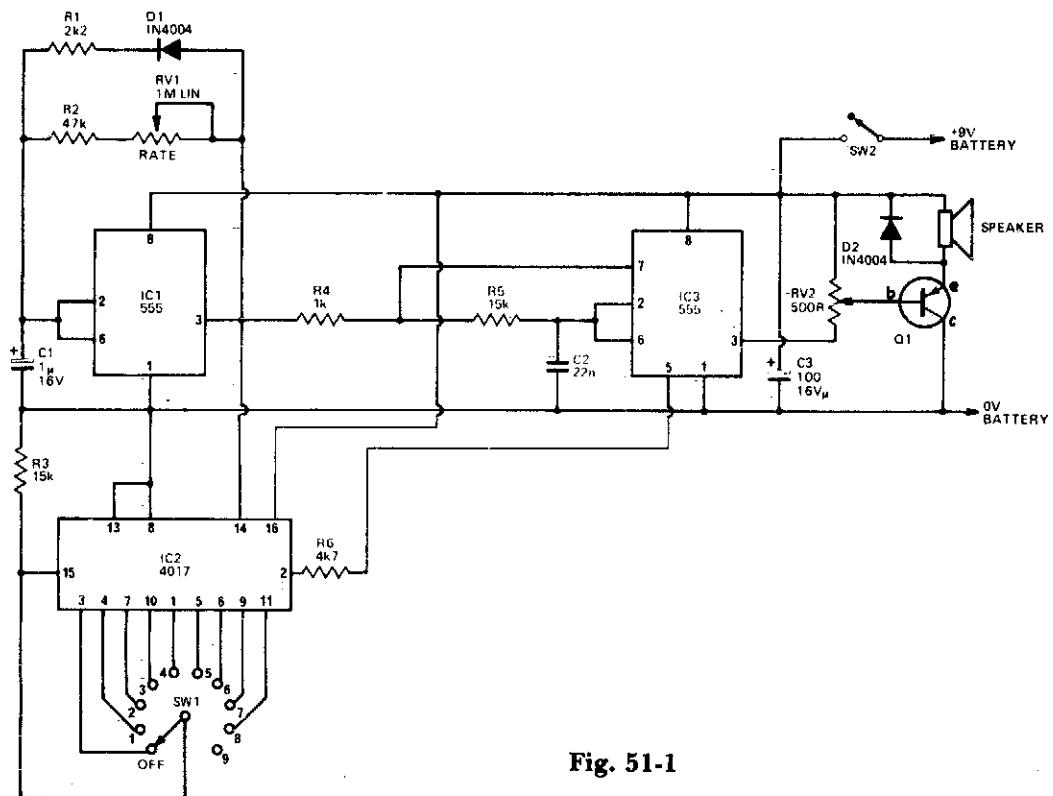


Fig. 51-1

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

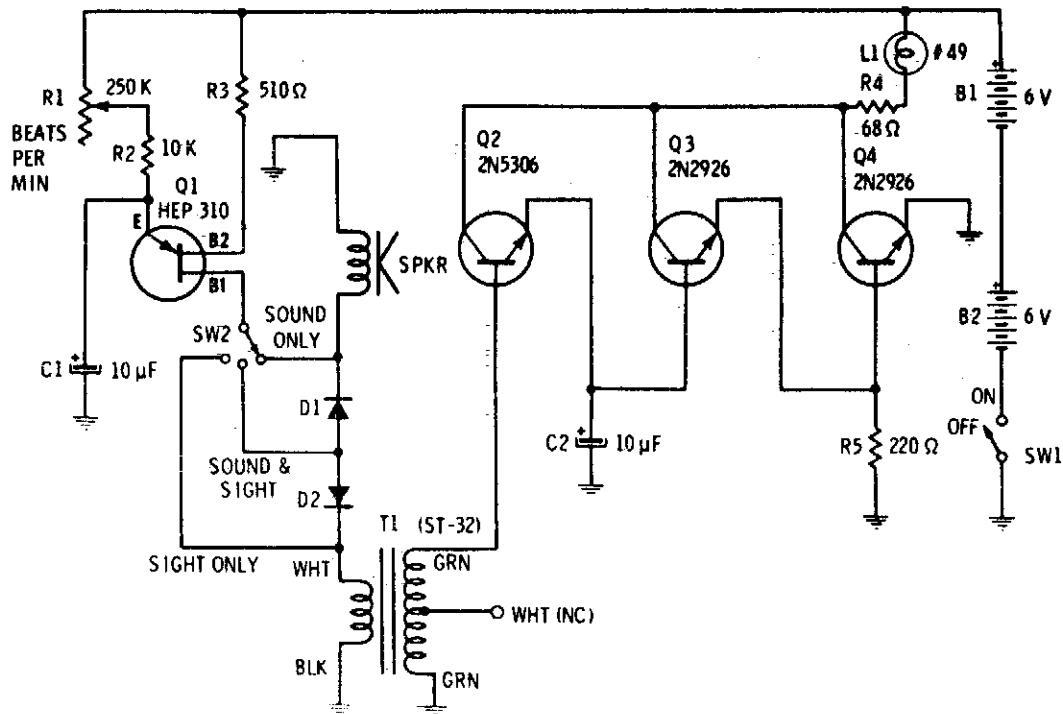


Fig. 51-2

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

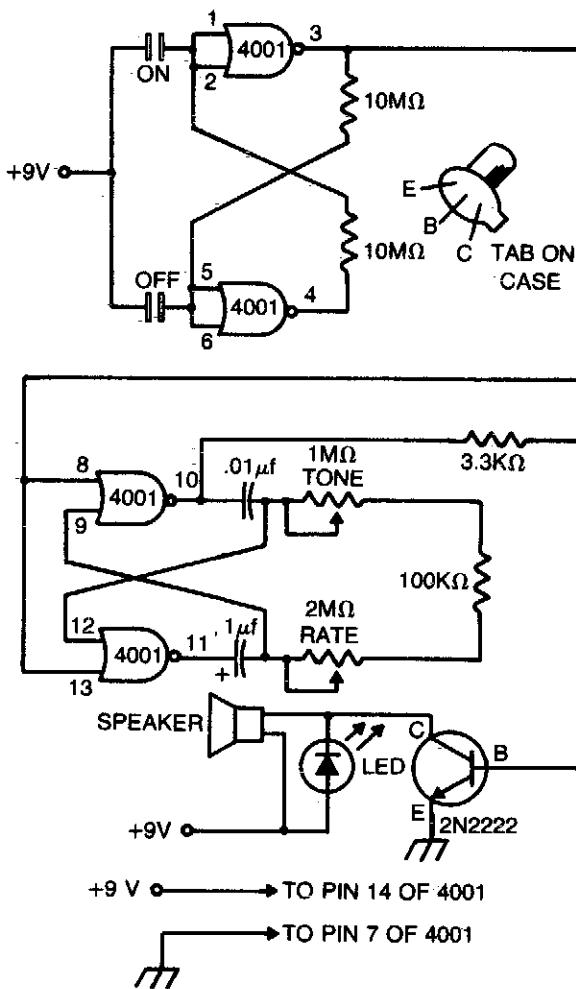


Fig. 51-3

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

INTERCOM

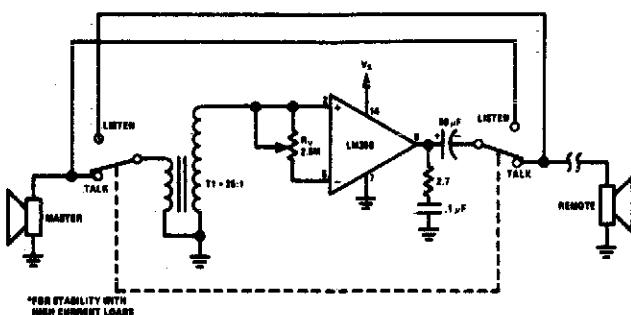


Fig. 52-1

Circuit Notes

The circuit provides a minimum component intercom. With switch S1 in the talk position, the speaker of the master station acts as the microphone with the aid of step-up transformer T1. A turns ratio of 25 and a device gain

of 50 allows a maximum loop gain of 1250. R_v provides a common mode volume control. Switching S1 to the listen position reverses the role of the master and remote speakers.

MUSICAL ORGAN

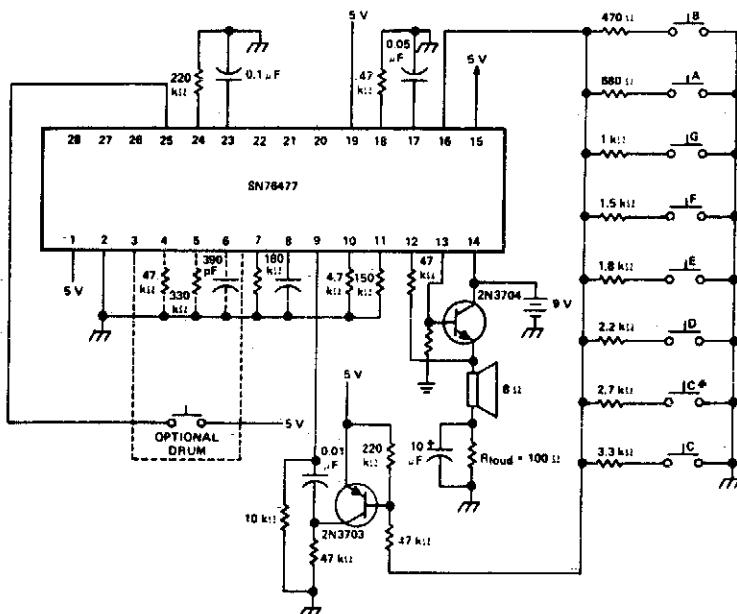


Fig. 52-2

LASER DIODE PULSER

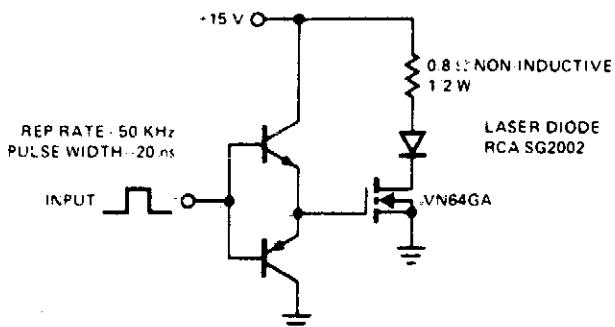


Fig. 52-3

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

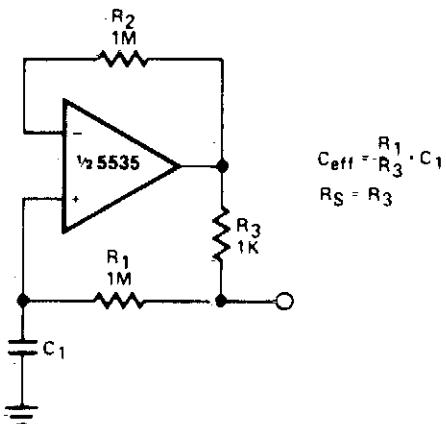


Fig. 52-4

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 μF was obtained. The Q available is limited by the effective series resistance. So R_1 should be as large as practical.

SIMULATED INDUCTOR

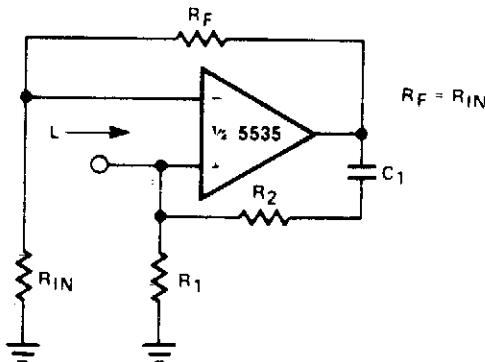


Fig. 52-5

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: $L = R_1 R_2 C$. 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

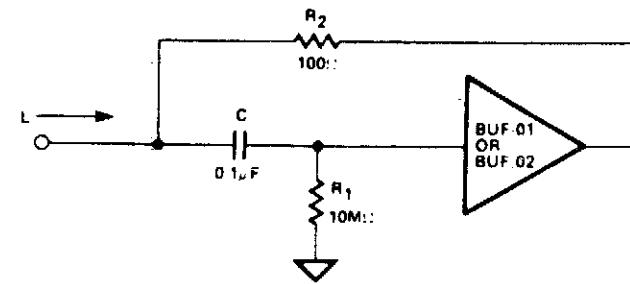


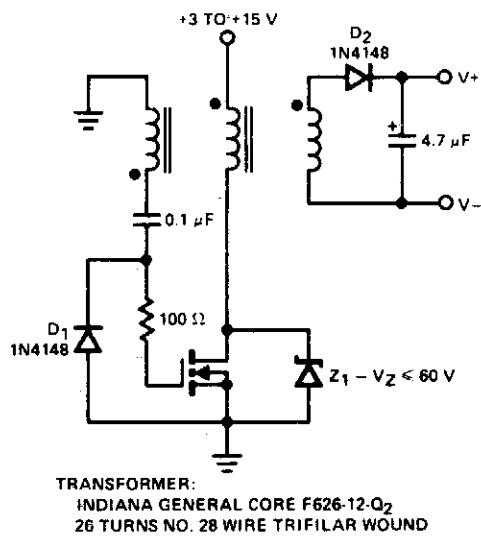
Fig. 52-6

$L = R_1 R_2 C = 100$ HENRIES
 $R_S = R_2 = 100\Omega$
 $R_P = R_1 = 10$ MEGΩ
 ASSUMING CSTRAY (ACROSS R_1) OF 5 pF THE UPPER
 FREQUENCY LIMIT IS APPROXIMATELY 7kHz.
 $X_L = 100\Omega$ AT $f = 0.159$ 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



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

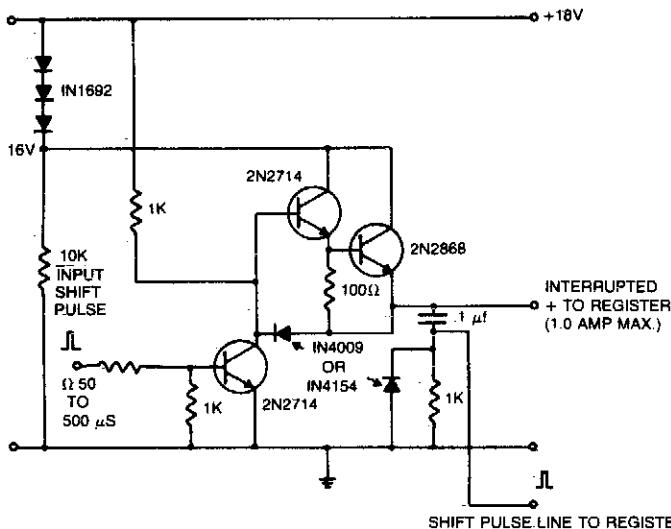


Fig. 52-8

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

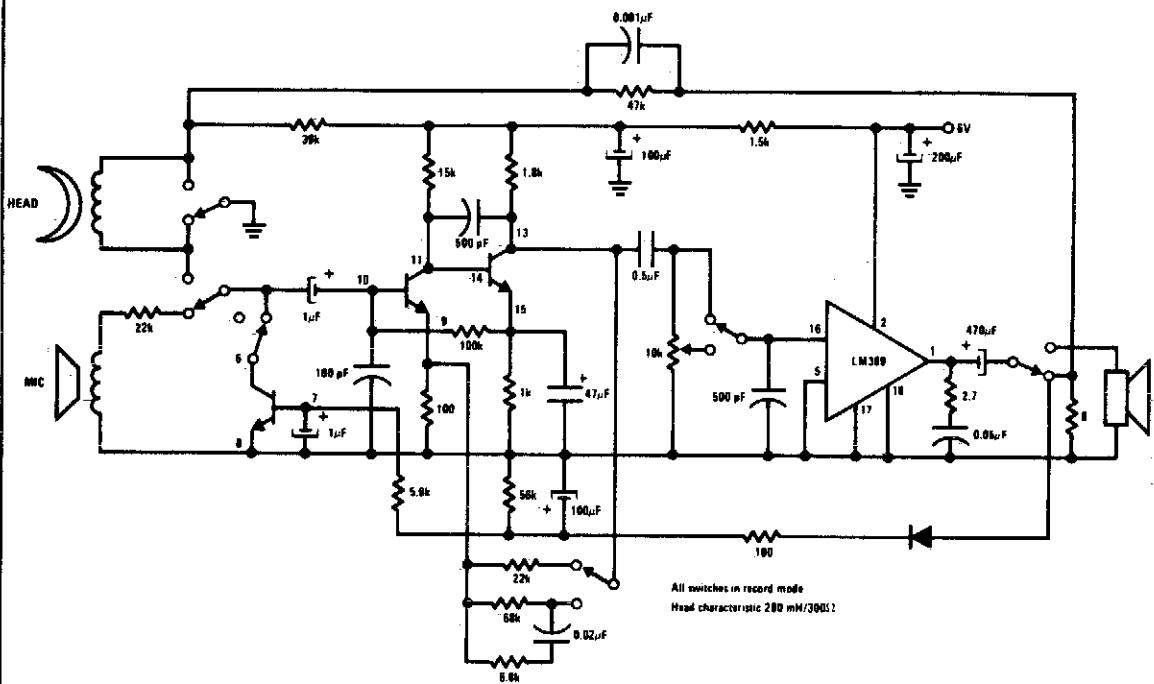


Fig. 52-9

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

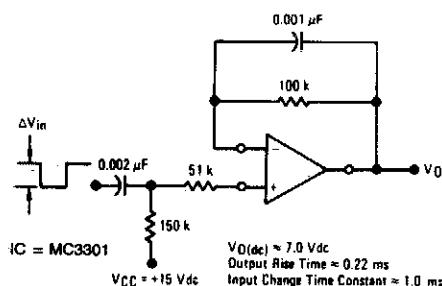
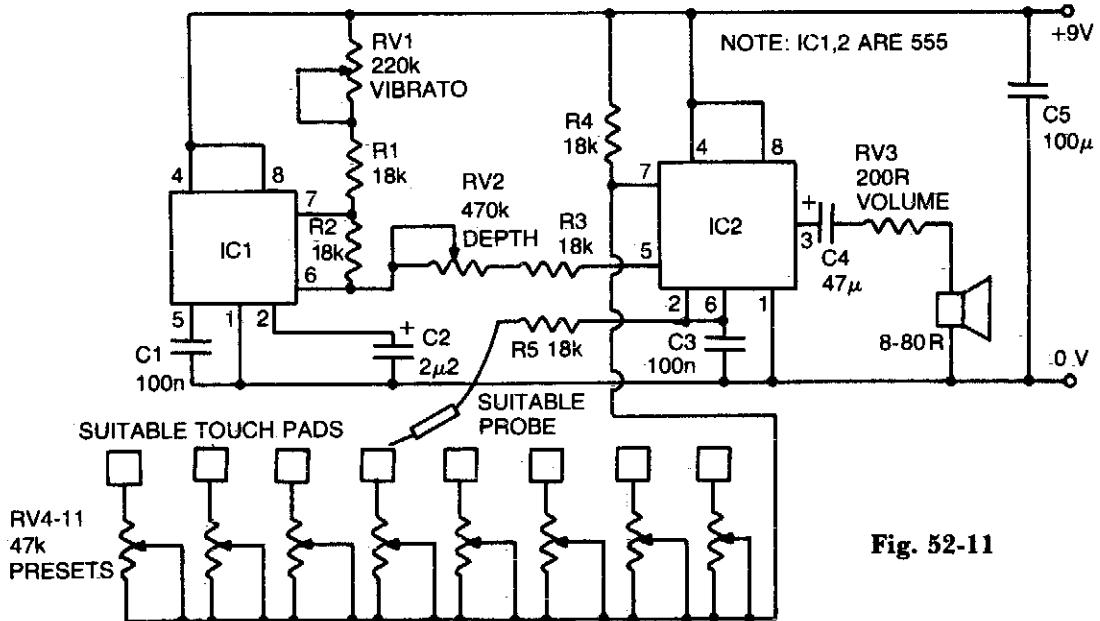


Fig. 52-10

STYLUS ORGAN



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 $0.001 \mu\text{F}$

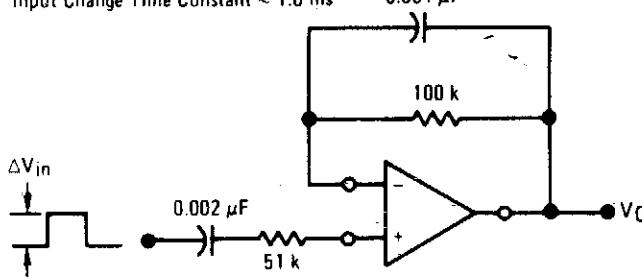


Fig. 52-12

FOUR CHANNEL DATA ACQUISITION SYSTEM

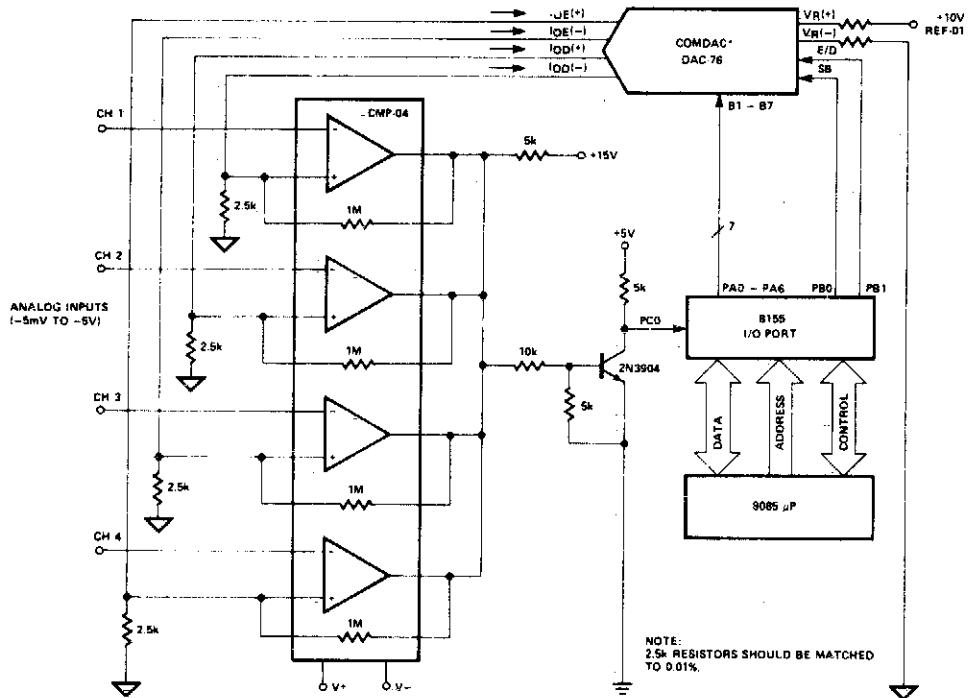


Fig. 52-13

TRIAC TRIGGER

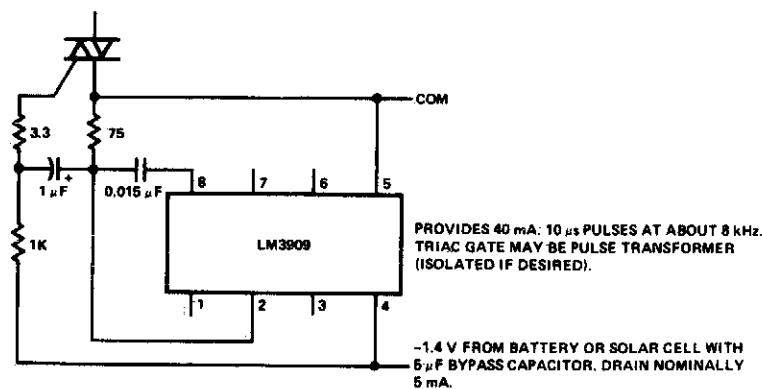
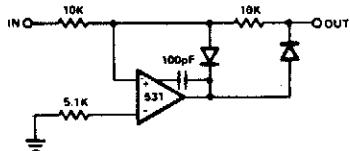


Fig. 52-14

PRECISION RECTIFIERS

(a) HALF WAVE



(b) FULL WAVE

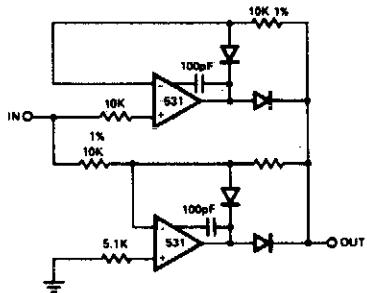


Fig. 52-15

FAST INVERTER CIRCUIT

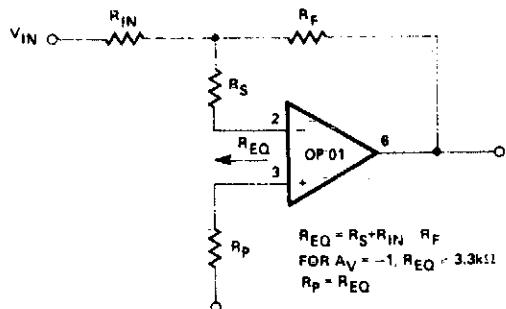


Fig. 52-17

VOLTAGE CONTROL RESISTOR

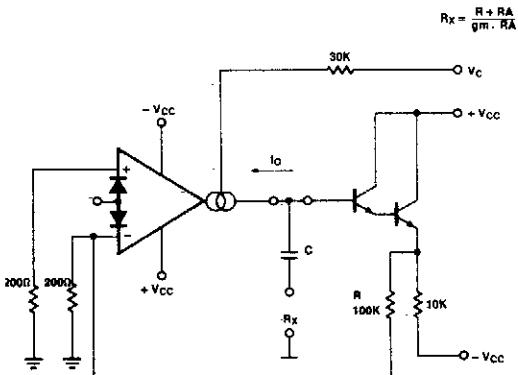


Fig. 52-16

INVERSE SCALER

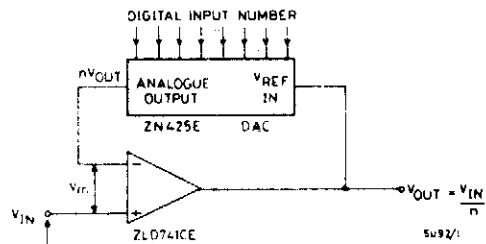


Fig. 52-18

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

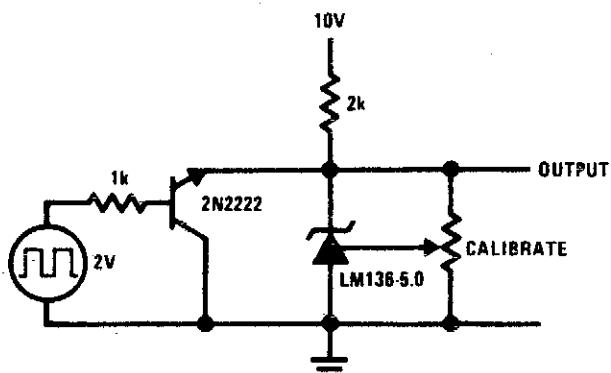


Fig. 52-19

LOW DRIFT INTEGRATOR AND LOW-LEAKAGE GUARDED RESET

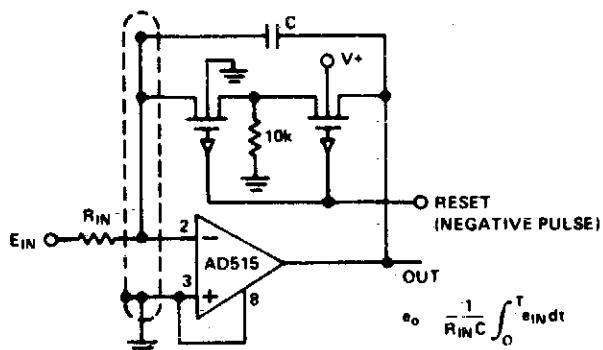
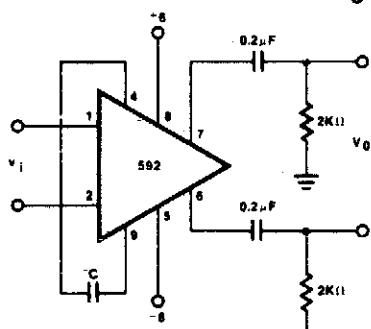


Fig. 52-20

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

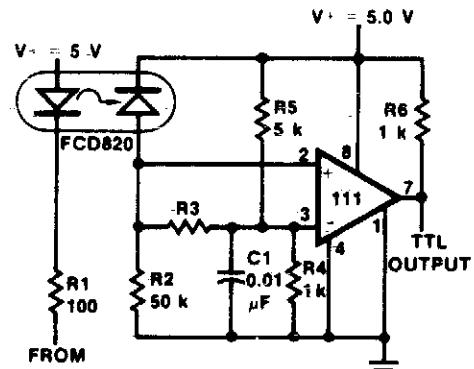


Fig. 52-22

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

DIFFERENTIAL MUX/DEMUX SYSTEM

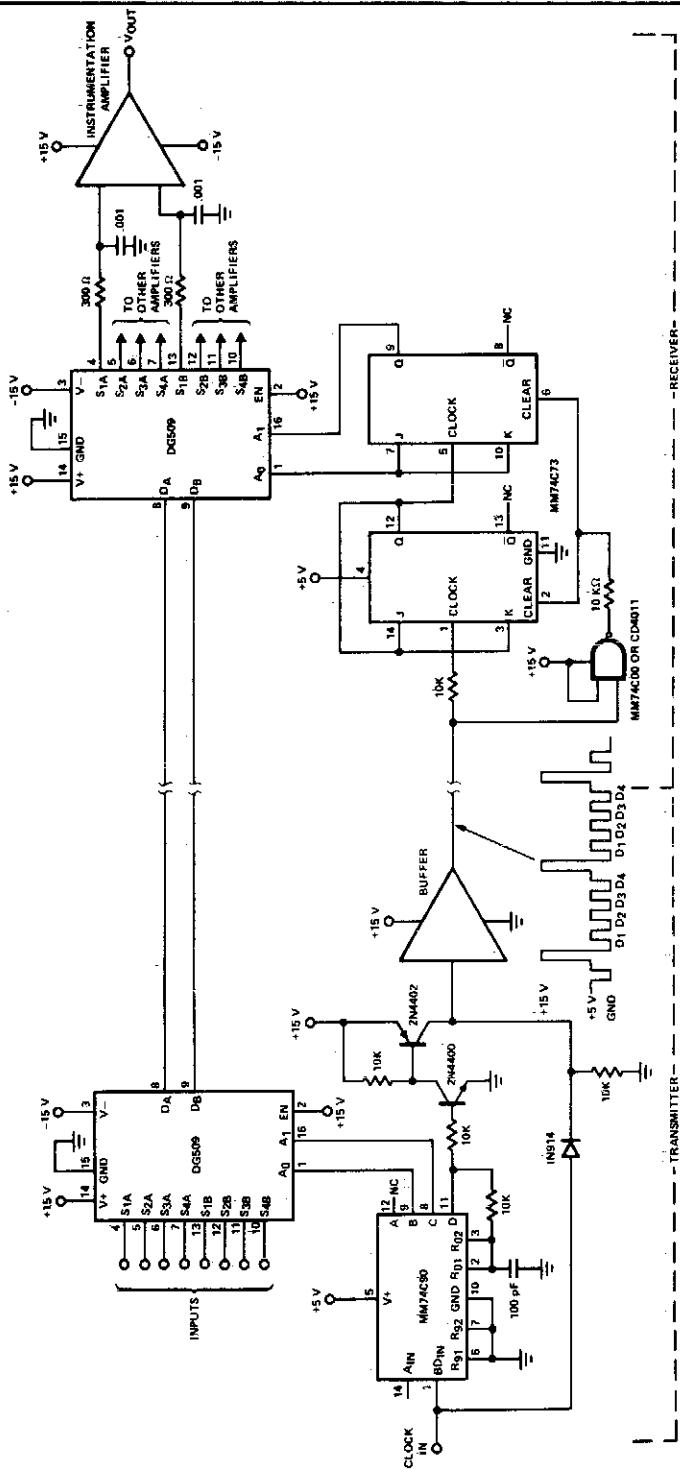


Fig. 53-1

EIGHT CHANNEL MUX/DEMUX SYSTEM

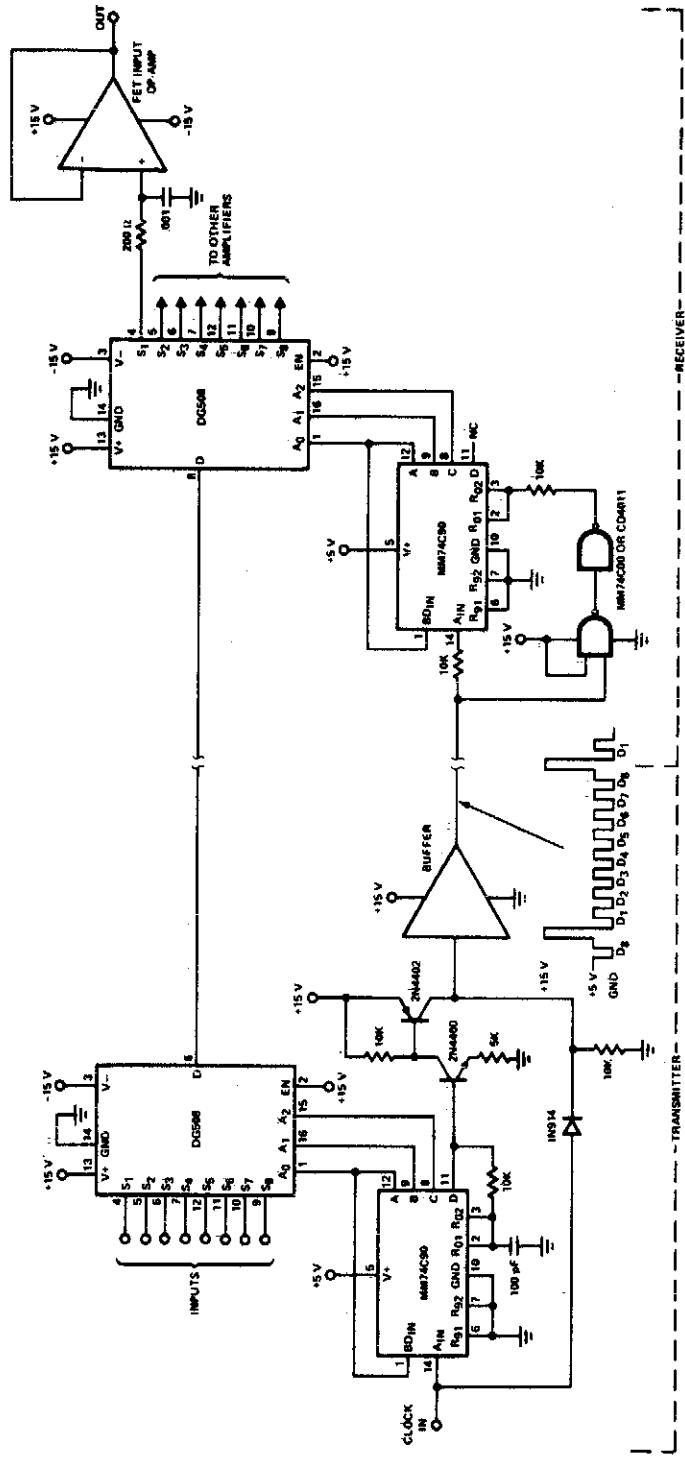


Fig. 53-2

**DOUBLY BALANCED
MIXER (BROADBAND INPUTS,
9.0 MHz TUNED OUTPUT)**

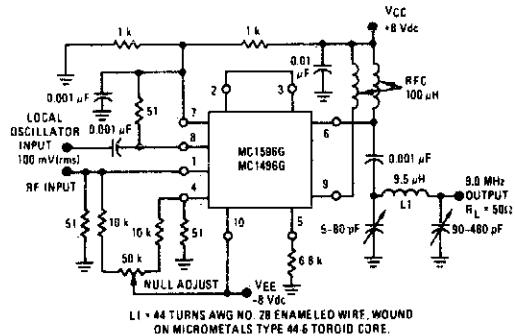
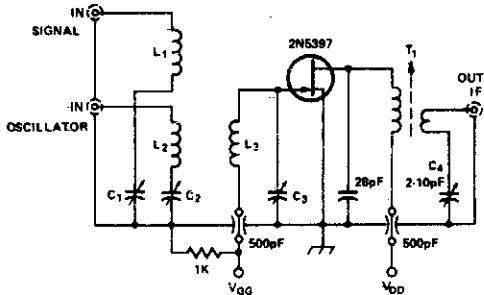


Fig. 53-3

COMMON-SOURCE MIXER



L_1 - 1.4" long; #22 enamel, close coupled to L_3
 L_2 - 1.6" long; #22 enamel, close coupled to L_3
 L_3 - 1.75" long; #18 copper
 T_1 - Primary, 13T; #22 enamel, close wound on 1/4"
 form = β_{1D}
 Secondary, 3T; #22 enamel, close wound over primary
 C_1, C_2, C_3, C_4 - 0.8 to 12pF; Johansson type 2950

Fig. 53-4

100 MHz MIXER

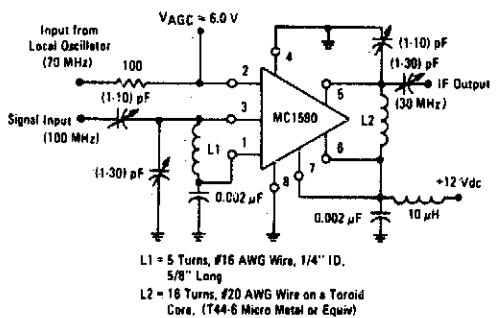


Fig. 53-5

MULTIPLEXER/MIXER

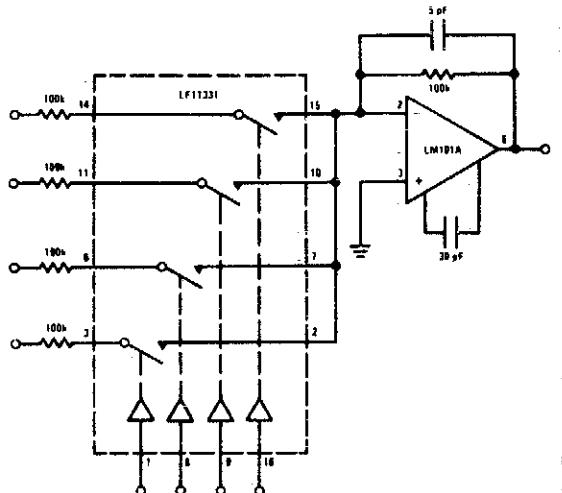


Fig. 53-6

WIDE BAND DIFFERENTIAL MULTIPLEXER

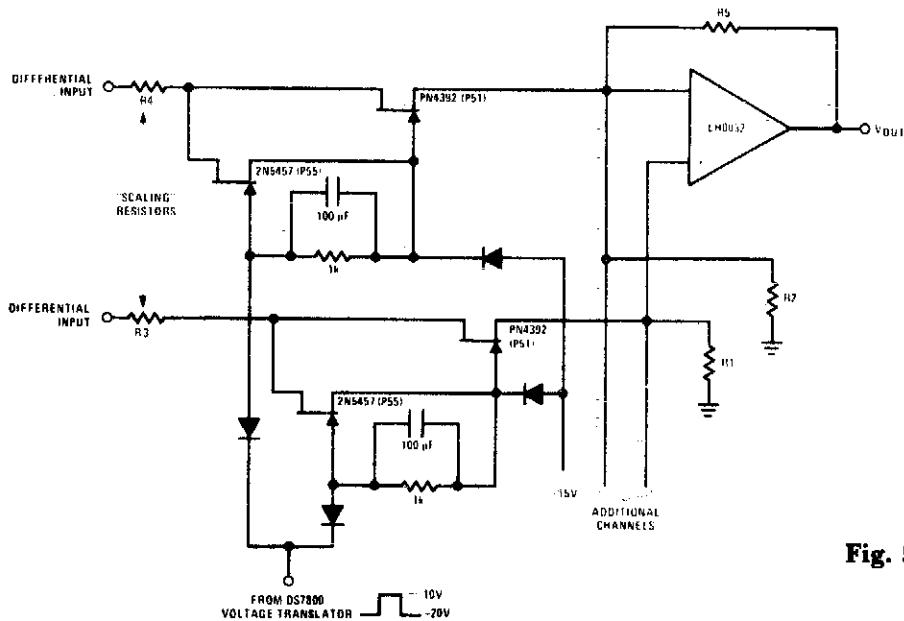


Fig. 53-7

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

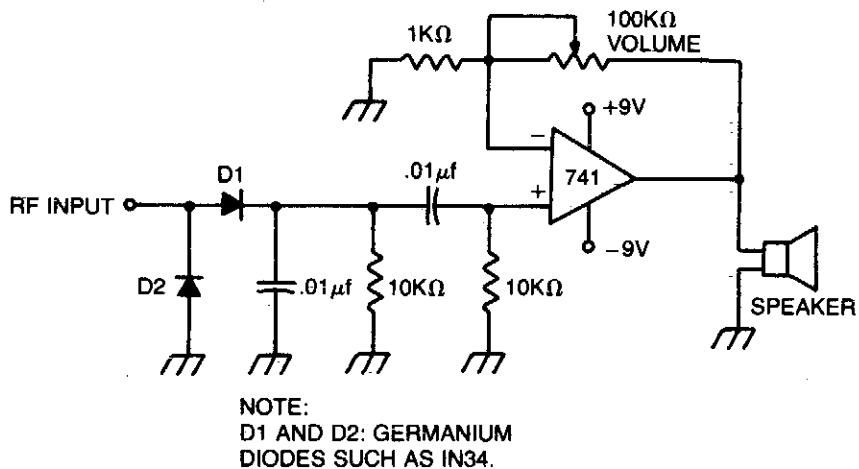


Fig. 54-1

Circuit Notes

Broad-tuned receiver demodulates the RF signal picked up by a loosely coupled wire placed near the transmitting antenna.

VISUAL MODULATION INDICATOR

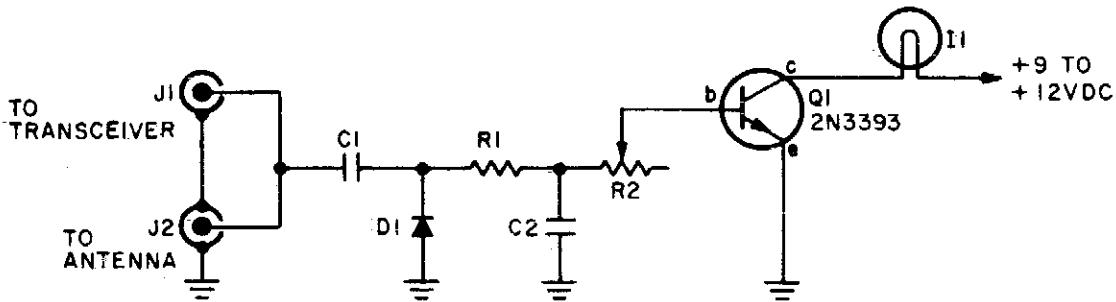


Fig. 54-2

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

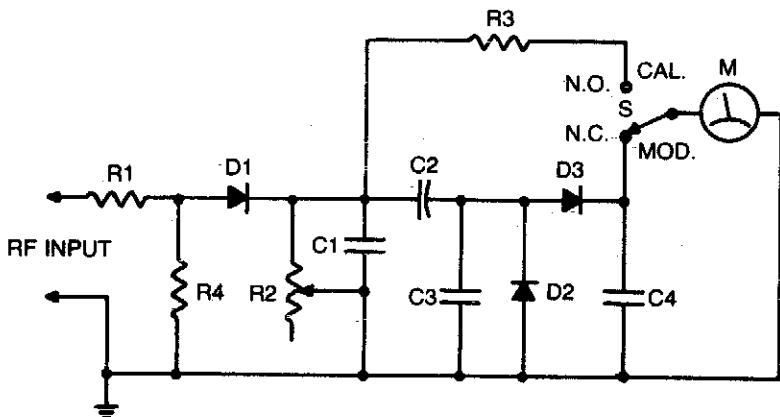


Fig. 54-3

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, ½-watt resistor
- R2—1000-ohm pot
- R3—910-ohm, ½-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	Video Modulator
TV Modulator	Modulator
Pulse-Position Modulator	Pulse-Width Modulator
Pulse-Width Modulator	AM Modulator
Pulse-Width Modulator	TV Modulator Using a Motorola MC1374
RF Modulator	Pulse-Width Modulator
Linear Pulse-Width Modulator	Pulse-Width Modulator
Balanced Modulator	VHF Modulator

TV MODULATOR

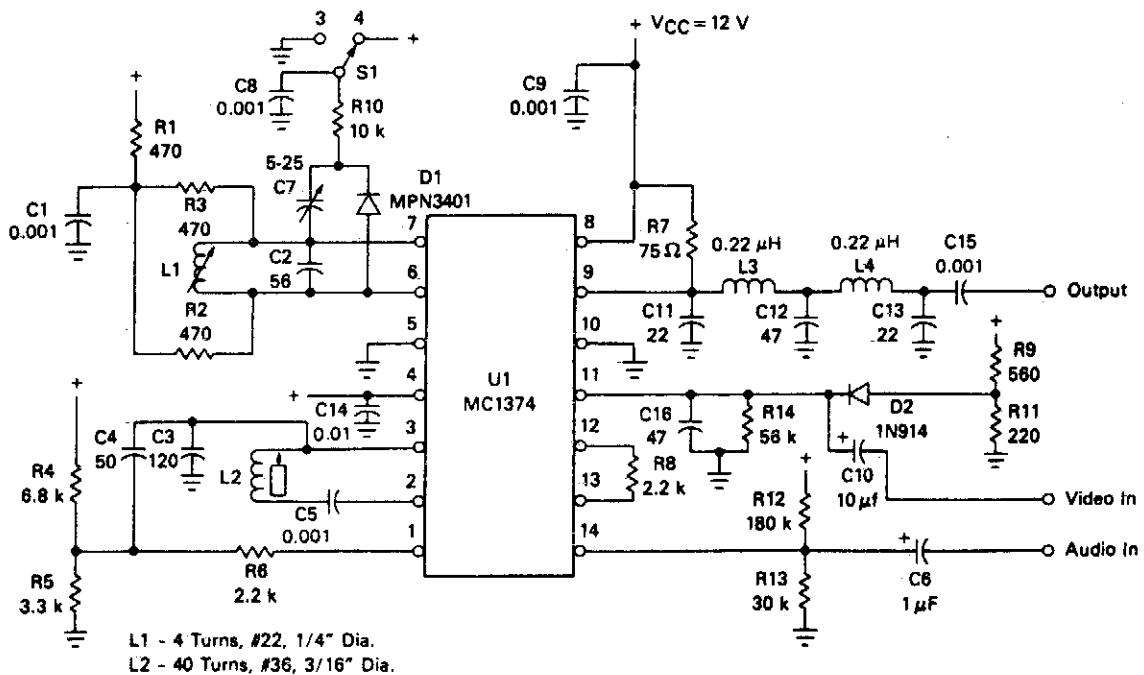


Fig. 55-1

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.

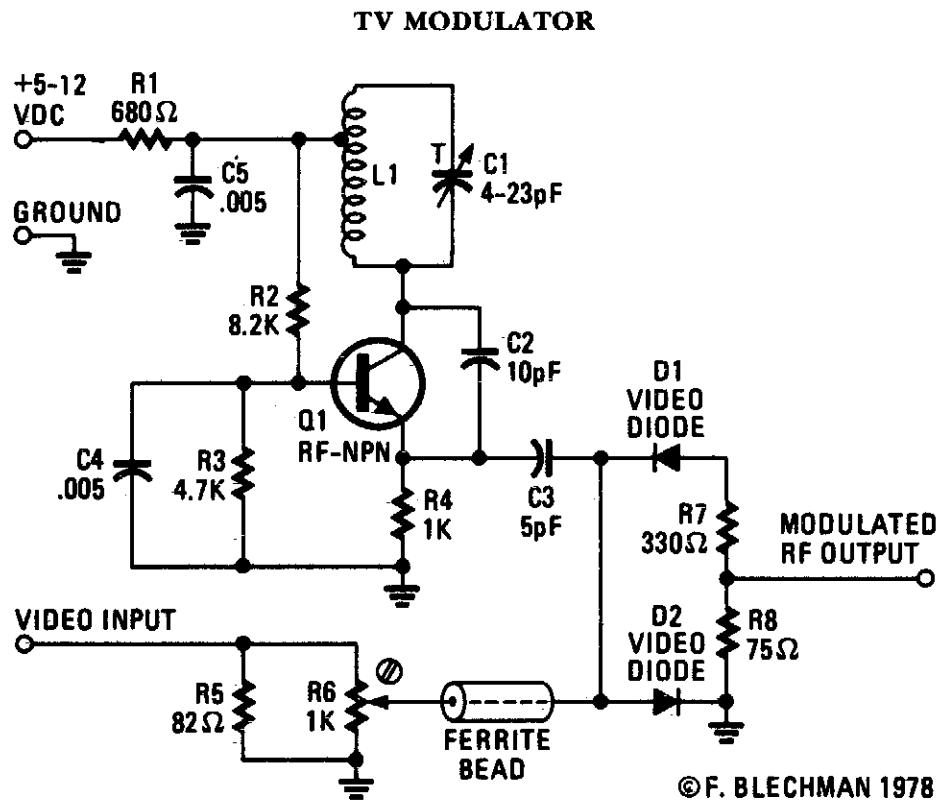


Fig. 55-2

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

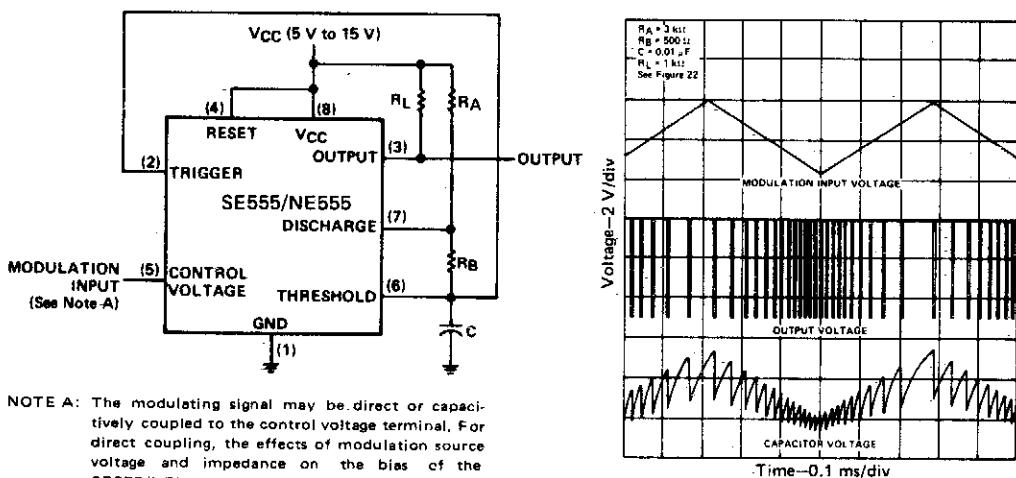


Fig. 55-3

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

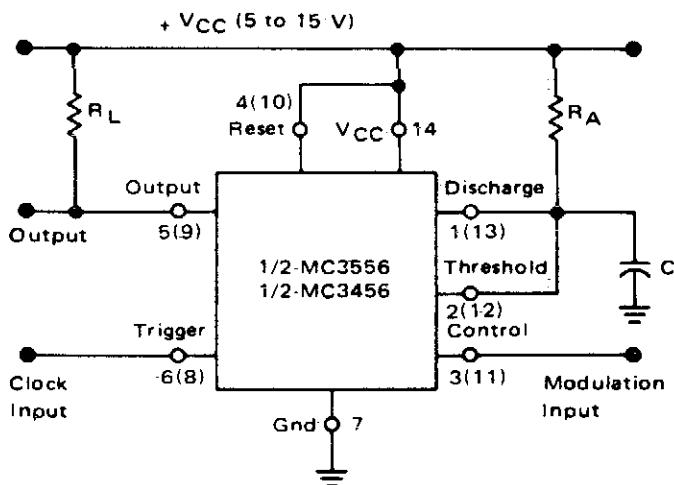


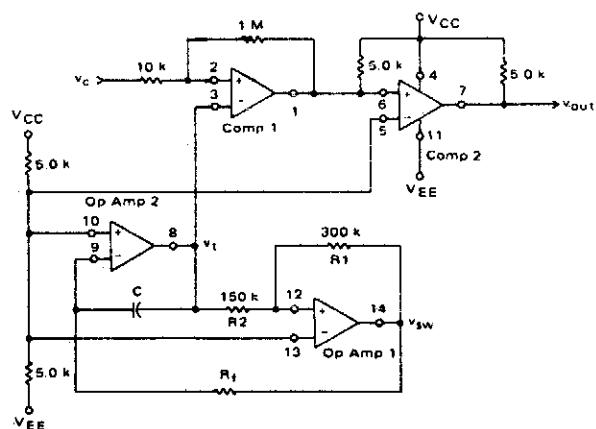
Fig. 55-4

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



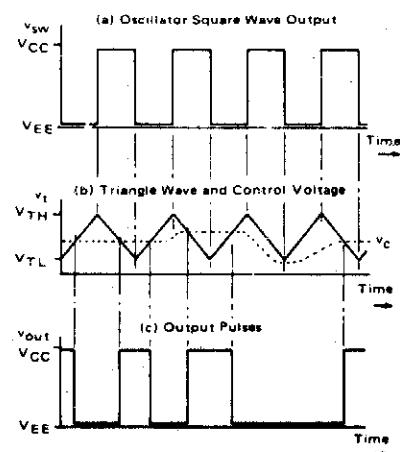
$$V_{TH} = \frac{1}{2} V_S (1 + R_2/R_1) + V_{EE} \quad V_S = V_{CC} - V_{EE}$$

$$V_{TL} = \frac{1}{2} V_S (1 - R_2/R_1) + V_{EE}$$

Oscillator Frequency

$$f = \frac{R_1}{4R_2 C R_2}$$

IC = MC3405



Pulse Width

$$P.W. = \left(\frac{1}{f} \right) \left(\frac{V_c - V_{TC}}{\sqrt{V_{TH} - V_{TL}}} \right) \quad \text{When: } V_{TL} < V_c < V_{TH}$$

Duty Cycle in %

$$D.C. = \left(\frac{V_c - V_{TL}}{\sqrt{V_{TH} - V_{TL}}} \right) (100)$$

Fig. 55-5

RF MODULATOR

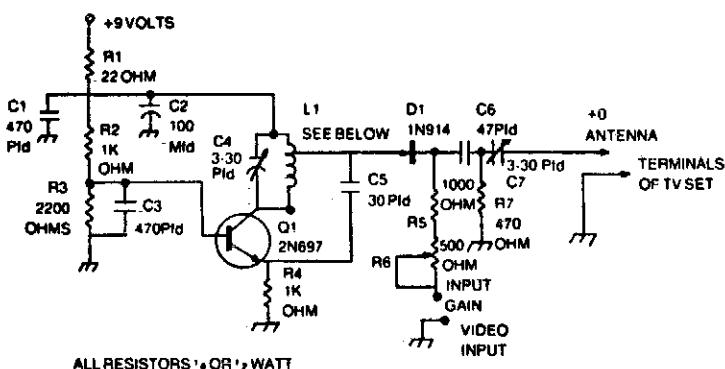


Fig. 55-6

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, $\frac{3}{8}$ inch I.D. by $\frac{3}{4}$ inch long, tapped at 1 turn from top.

LINEAR PULSE-WIDTH MODULATOR

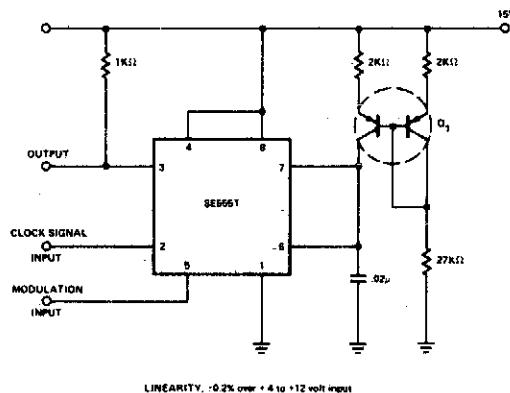


Fig. 55-7

VIDEO MODULATOR

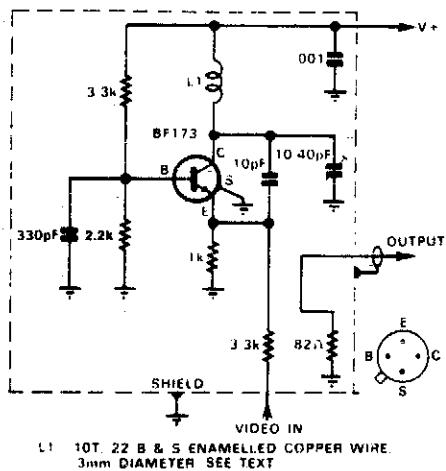


Fig. 55-9

BALANCED MODULATOR (+12 Vdc SINGLE SUPPLY)

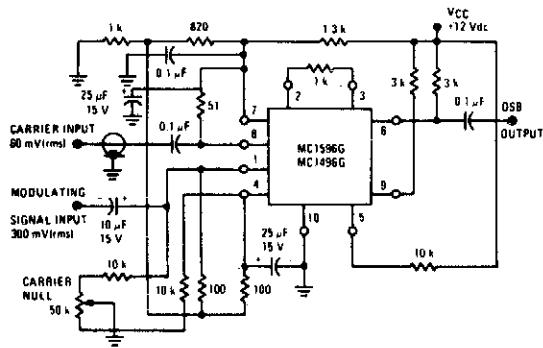


Fig. 55-8

MODULATOR

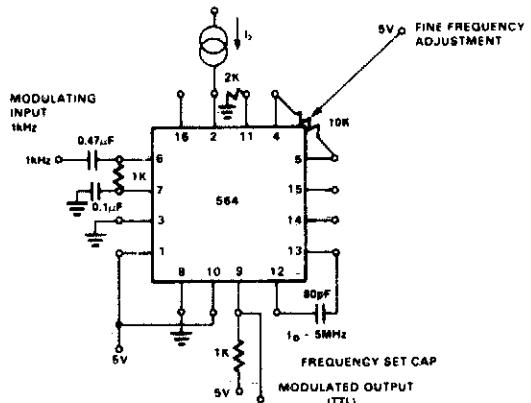
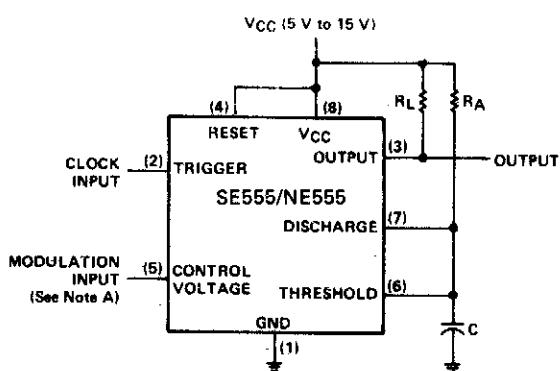


Fig. 55-10

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.

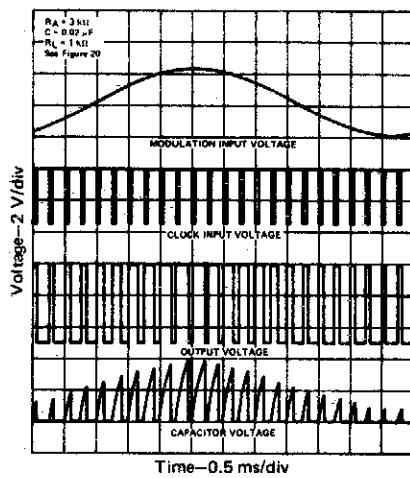


Fig. 55-11

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

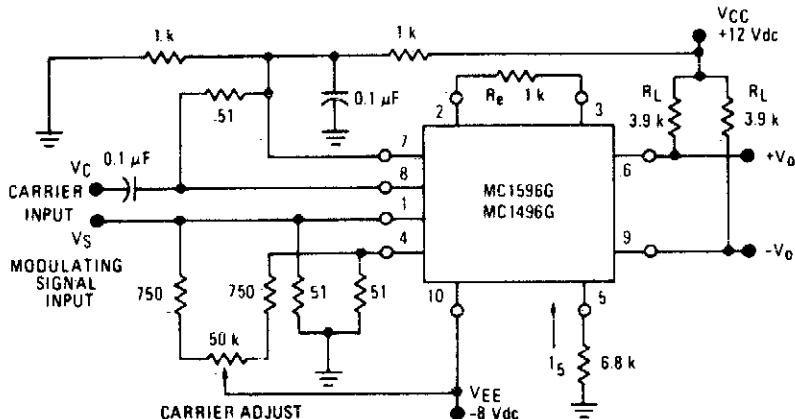


Fig. 55-12

TV MODULATOR USING A MOTOROLA MC1374

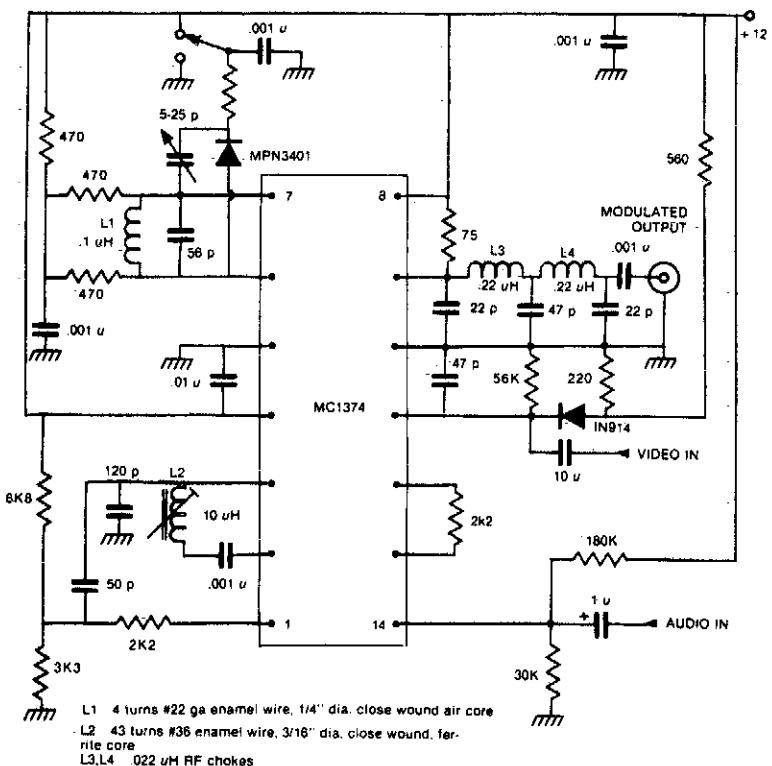


Fig. 55-13

Circuit Notes

This one-chip modulator requires some outboard circuitry and a shielded box.

PULSE-WIDTH MODULATOR

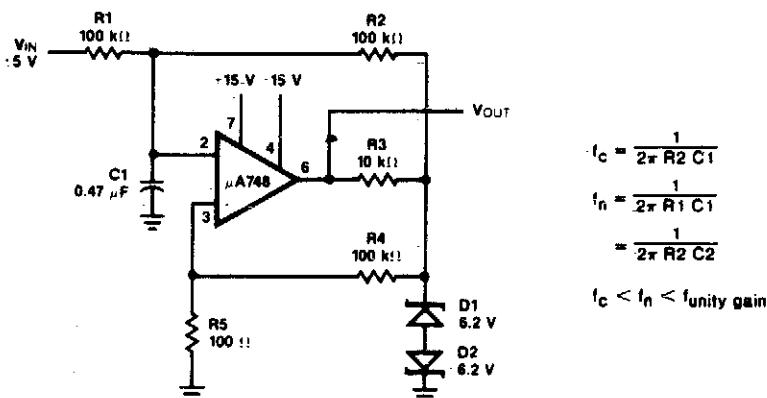
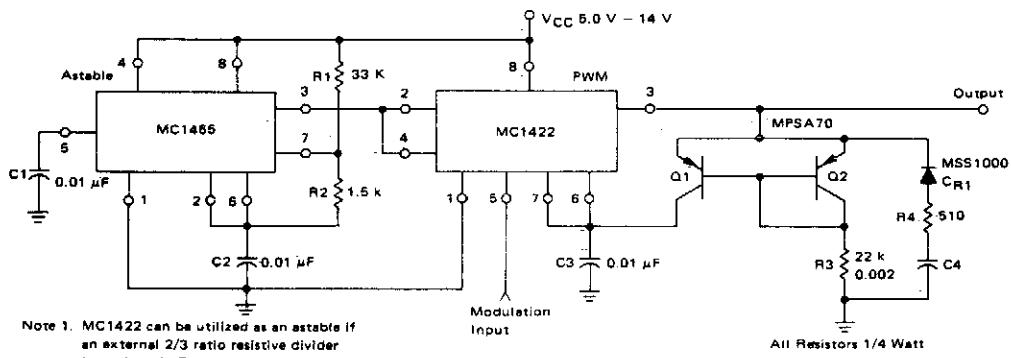


Fig. 55-14

PULSE-WIDTH MODULATOR



Note 1. MC1422 can be utilized as an astable if an external 2/3 ratio resistive divider is used at pin 5.

2. Sea waveforms

- PULSE WIDTH MODULATOR WAVEFORMS

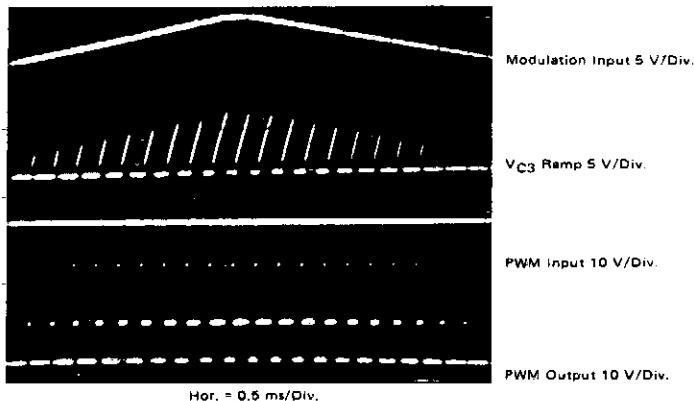


Fig. 55-15

VHF MODULATOR

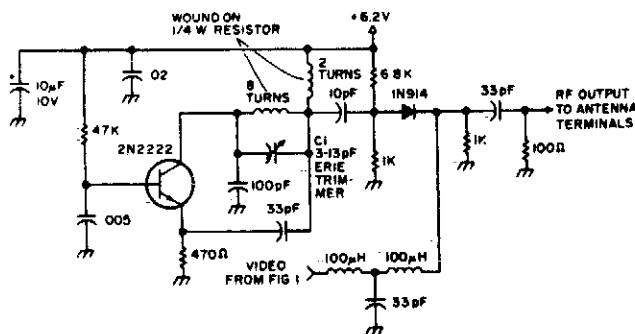


Fig. 55-16

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

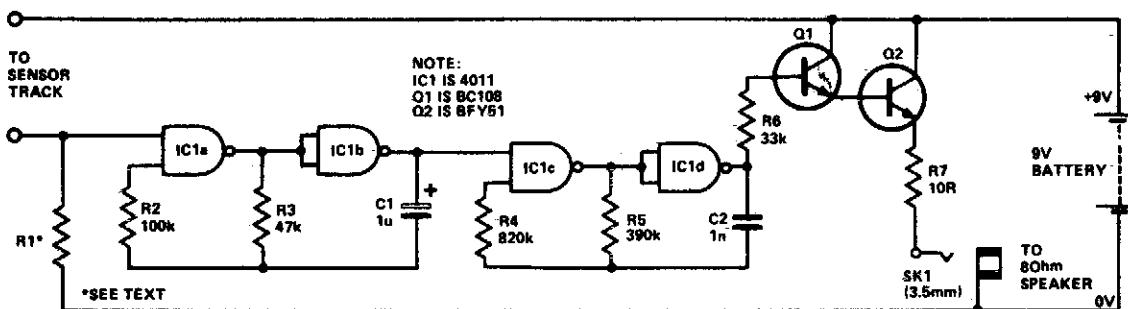


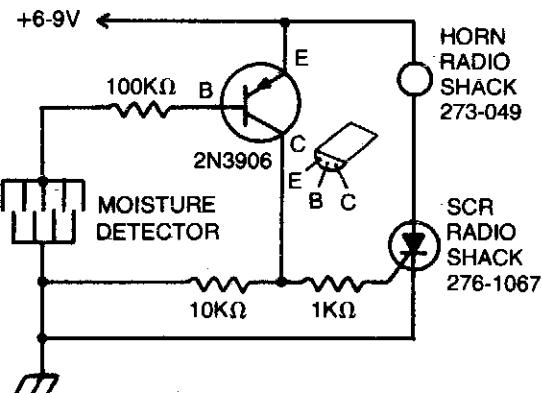
Fig. 56-1

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

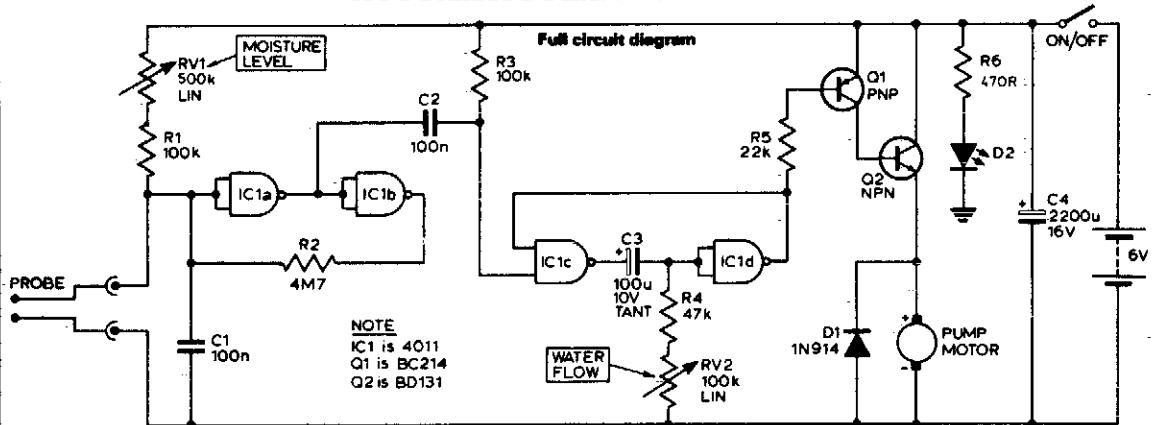


Fig. 56-3

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

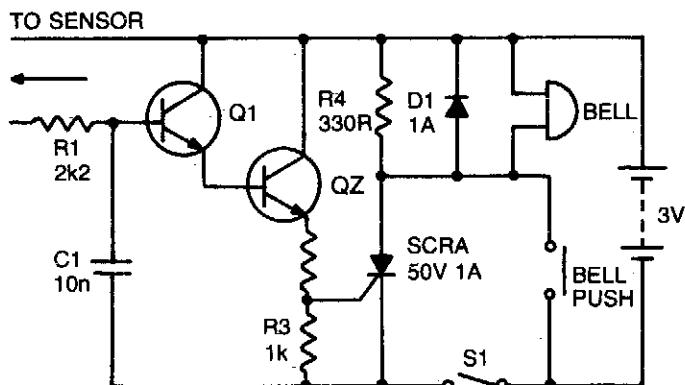


Fig. 56-4

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
Plug-In Speed Control for Tools or Appliances
Motor Speed Control with Feedback
Direction and Speed Control for Series-Wound Motors
High-Torque Motor Speed Control
Motor Speed Control
Constant Current Motor Drive Circuit
Ac Motor Power Brake
Universal-Motor Speed Control with Load-Dependent Feedback
Dc Motor Speed/Direction Control Circuit
Servo Motor Amplifier

Motor Speed Control
Model Train Speed Control
Induction Motor Control
DC Motor Speed Control
Universal Motor Control with Built-In Self Timer
Speed Control for Model Trains or Cars
Direction and Speed Control for Shunt-Wound Motors
Two-Phase Motor Drive
Dc Servo Amplifier
Universal Motor Speed Control
Power Tool Torque Control
Ac Servo Amplifier—Bridge Type

MOTOR SPEED CONTROL

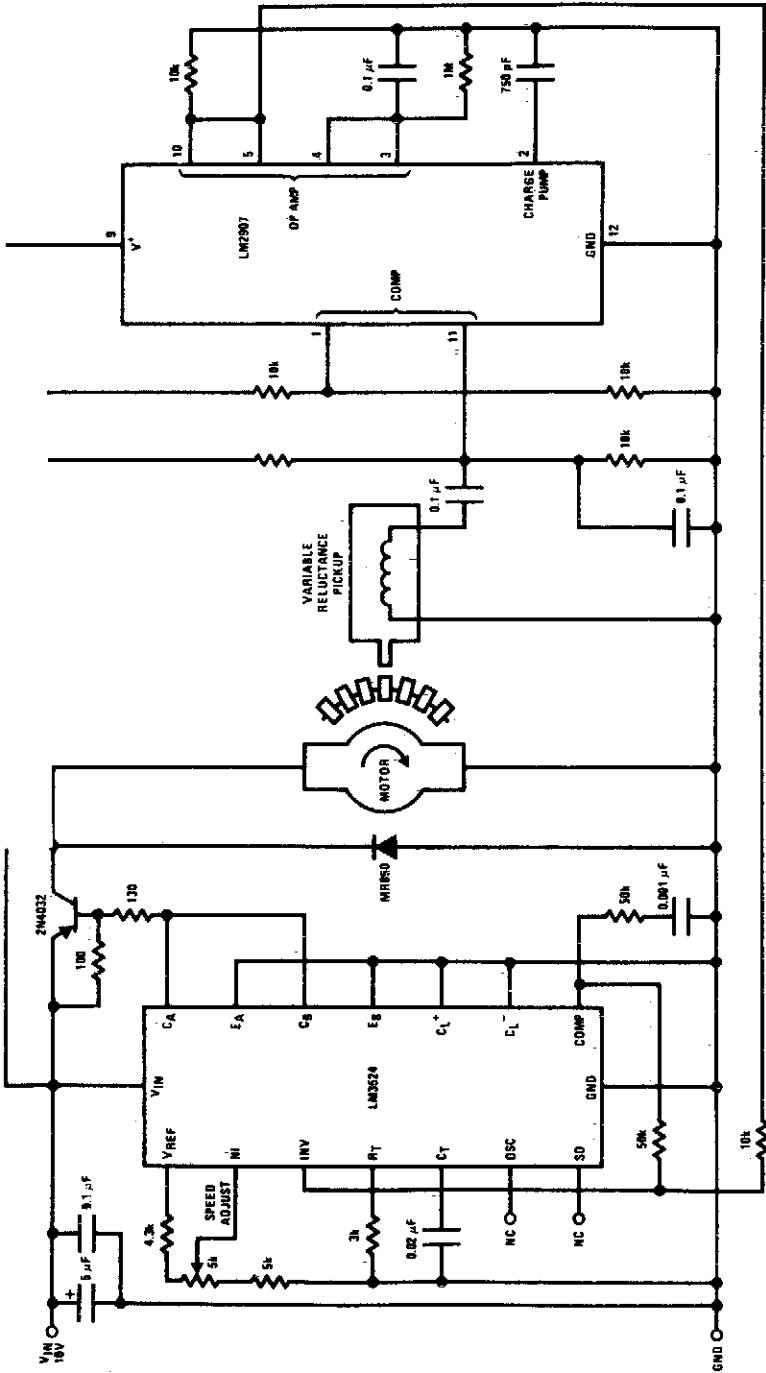


Fig. 57.1

Circuit Notes

This circuit is a regulating series dc motor speed control using the LM3524 for the control and drive for the motor and the LM2907 as a speed sensor for the feedback network.

PLUG-IN SPEED CONTROL FOR TOOLS OR APPLIANCES

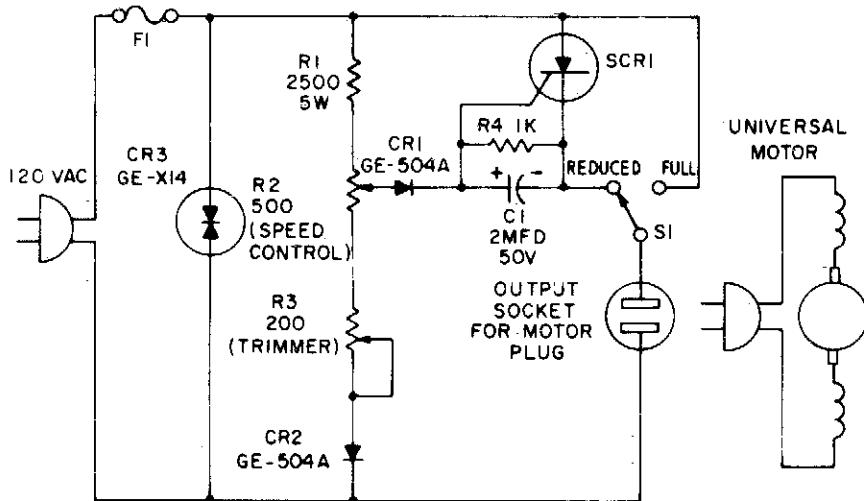


Fig. 57-2

COMPONENT	MOTOR NAMEPLATE RATING	
	LIGHT DUTY 3 AMP MAX	HEAVIER DUTY 5 AMP MAX
SCR1	GE - XI	GE - C30B
FI	3 AMP	5 AMP

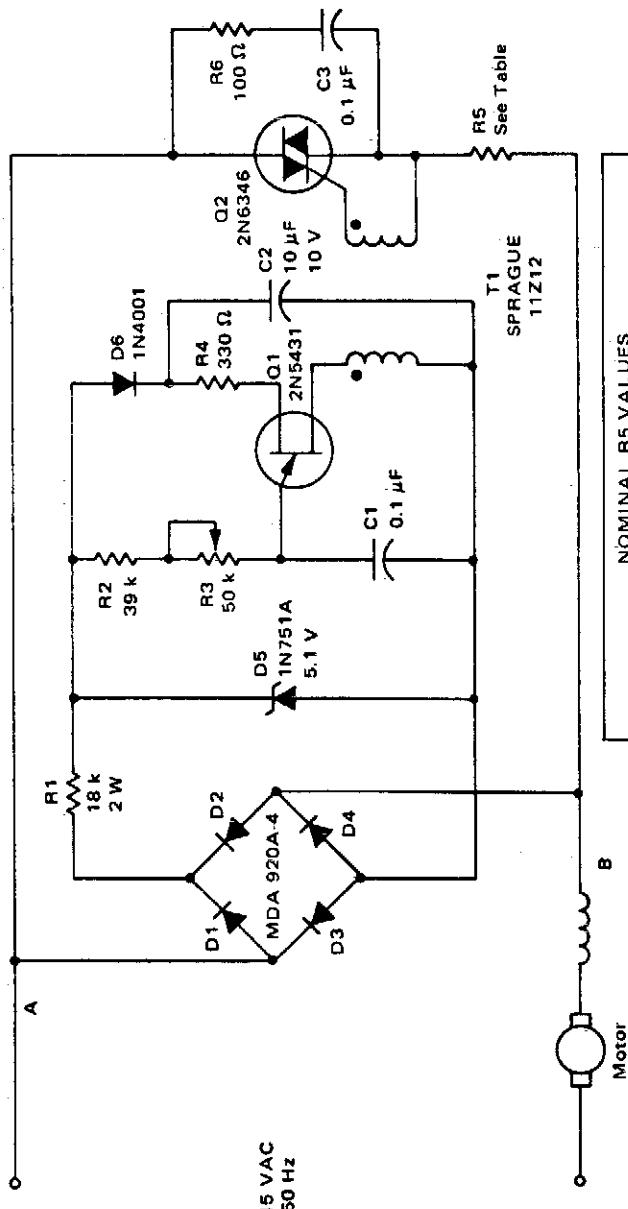
Circuit Notes

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



R₅
See Table

T₁
SPRAGUE
11Z12

NOMINAL R ₅ VALUES			
Motor Rating (Amperes)	R ₅ OHMS	Watts	
2	1	5	$R_5 = \frac{2}{I_M}$
3	0.67	10	I _M = Max. Rated Motor Current (RMS)
6.5	0.32	15	

Fig. 57-3

DIRECTION AND SPEED CONTROL FOR SERIES-WOUND MOTORS

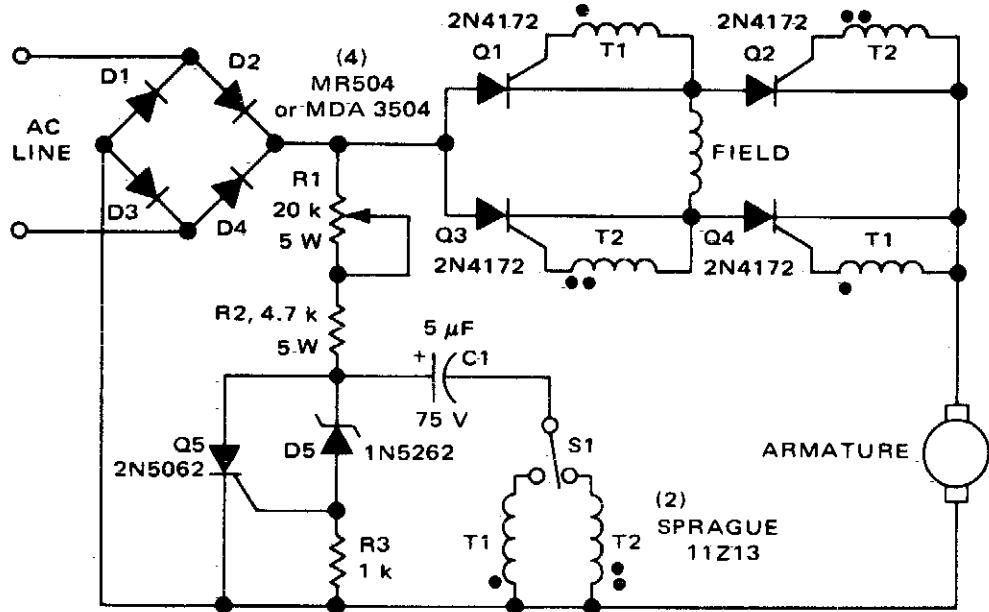


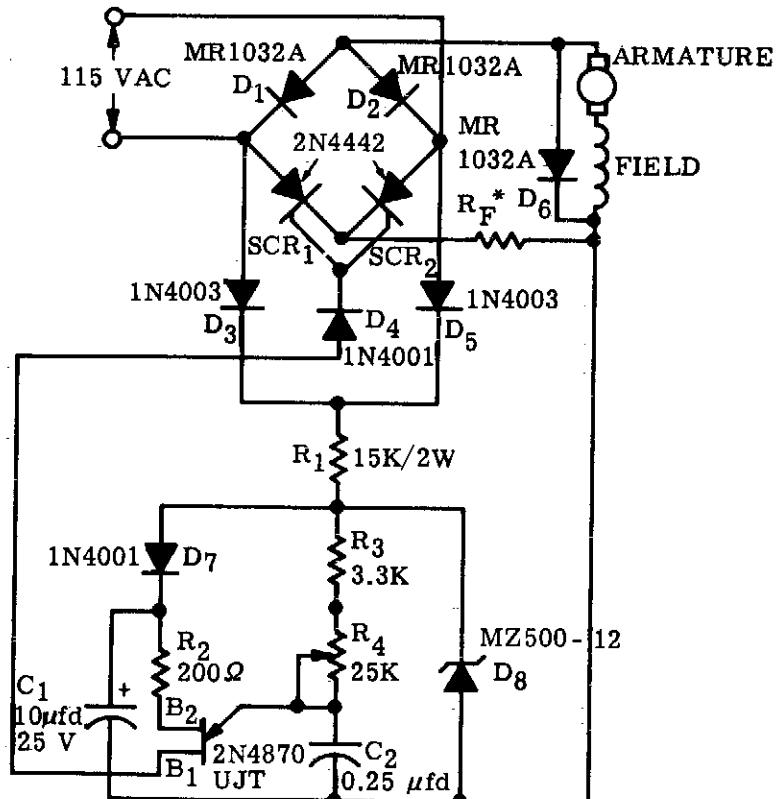
Fig. 57-4

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 I_M is the max rated load current (rms).

MOTOR SPEED CONTROL

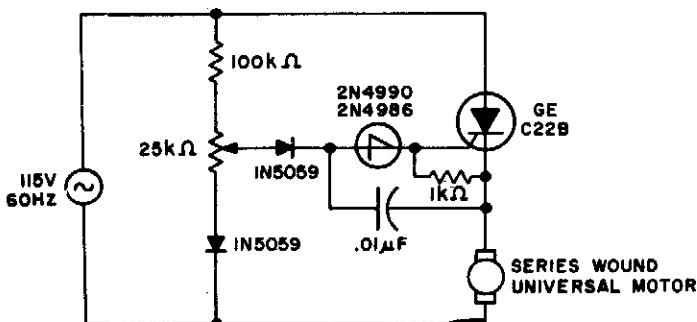
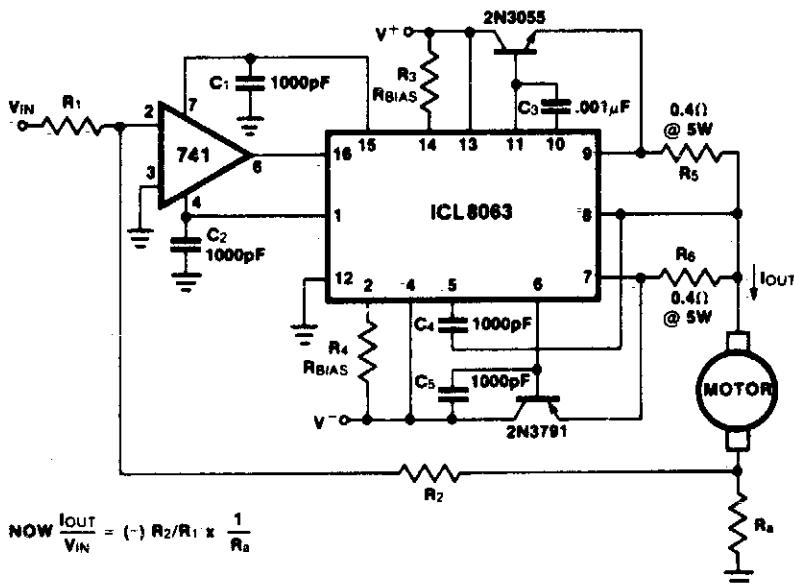


Fig. 57-6

Circuit Notes

Switching action of the 2N4990 allows smaller capacitors to be used while achieving reliable thyristor triggering.

CONSTANT CURRENT MOTOR DRIVE CIRCUIT



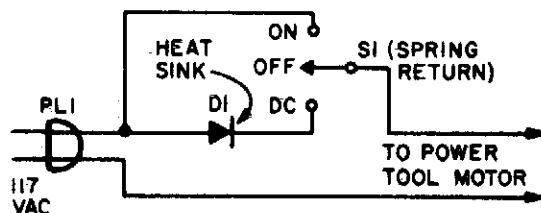
$$\text{NOW } \frac{I_{\text{OUT}}}{V_{\text{IN}}} = (-) \frac{R_2}{R_1} \times \frac{1}{R_a}$$

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.)

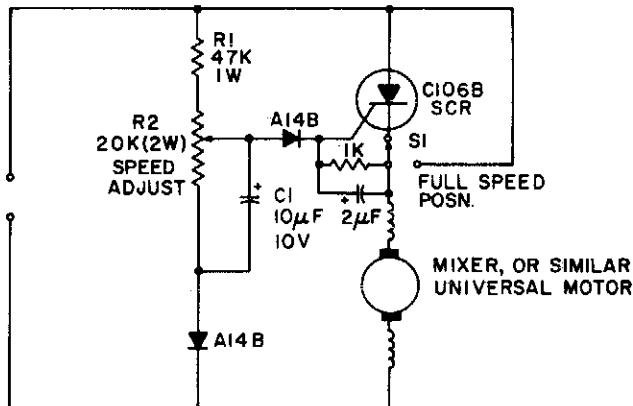


Fig. 57-9

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

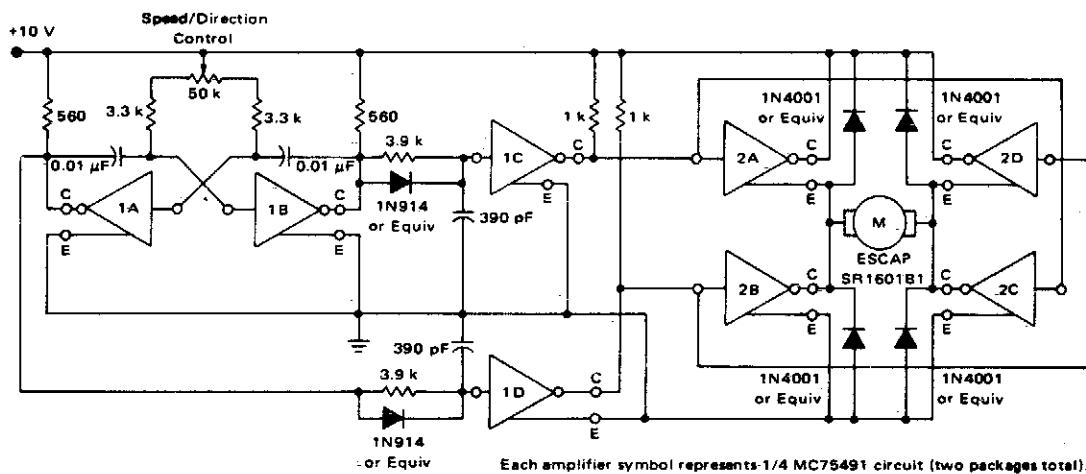
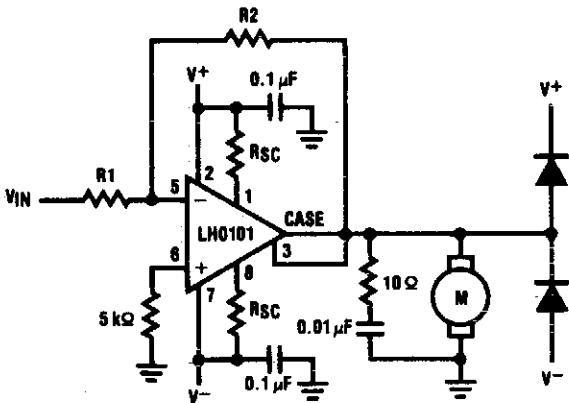


Fig. 57-10

SERVO MOTOR AMPLIFIER

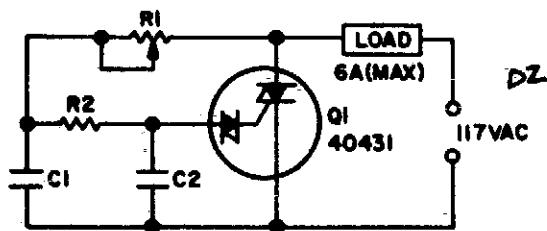


Circuit Notes

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.

Fig. 57-11

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

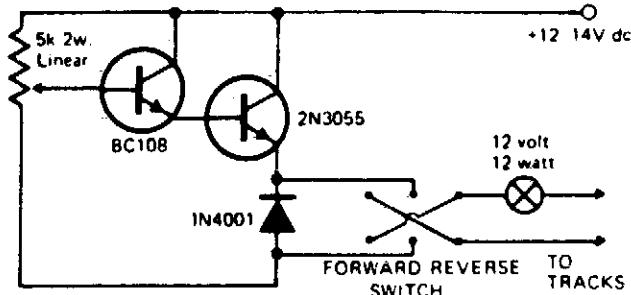


Fig. 57-13

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

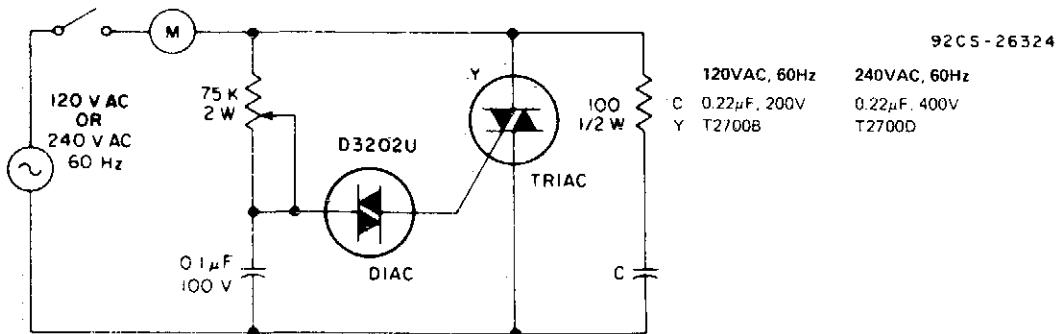


Fig. 57-14

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

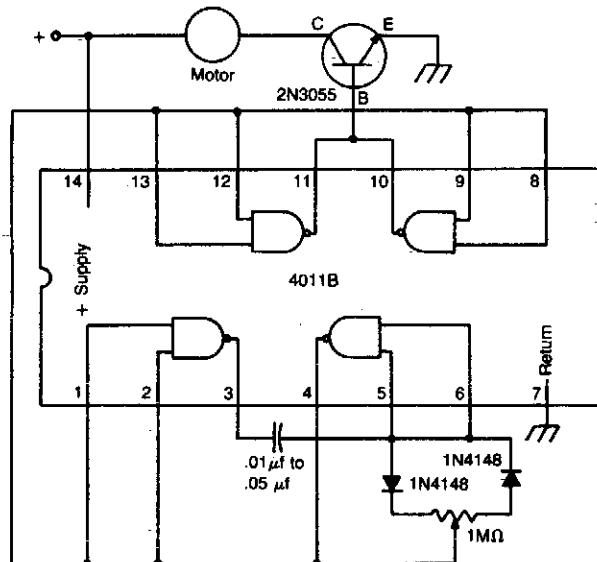


Fig. 57-15

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

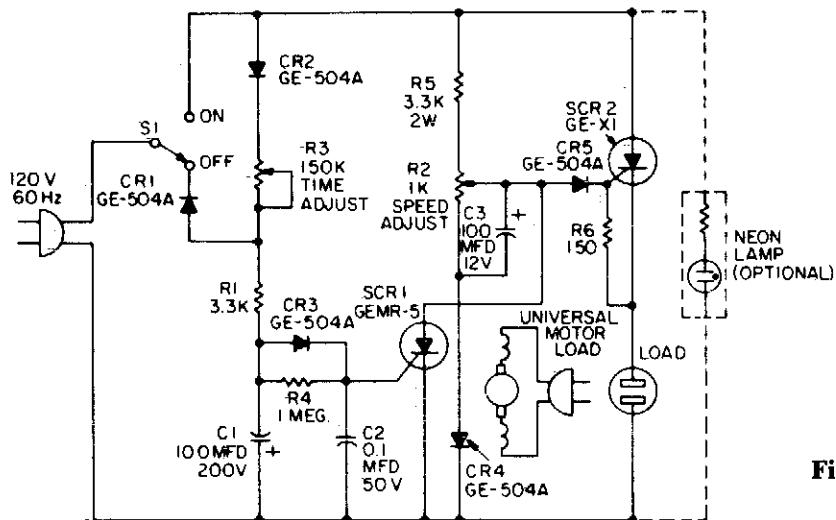


Fig. 57-16

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 anticipated,

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

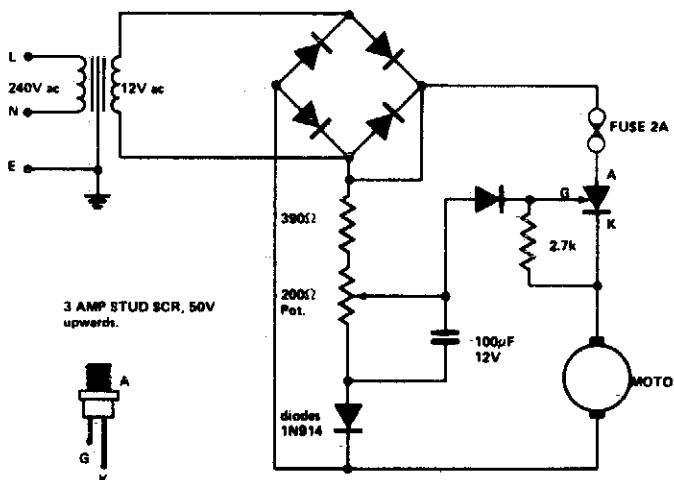


Fig. 57-17

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

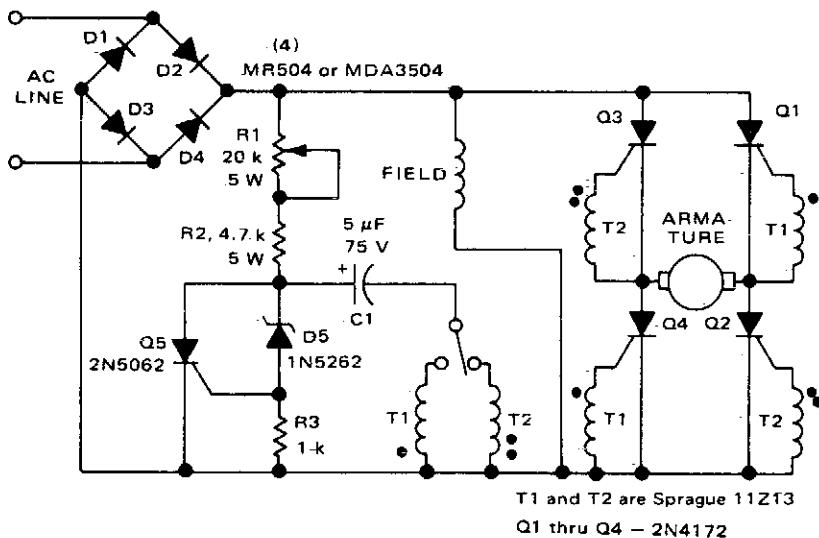


Fig. 57-18

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

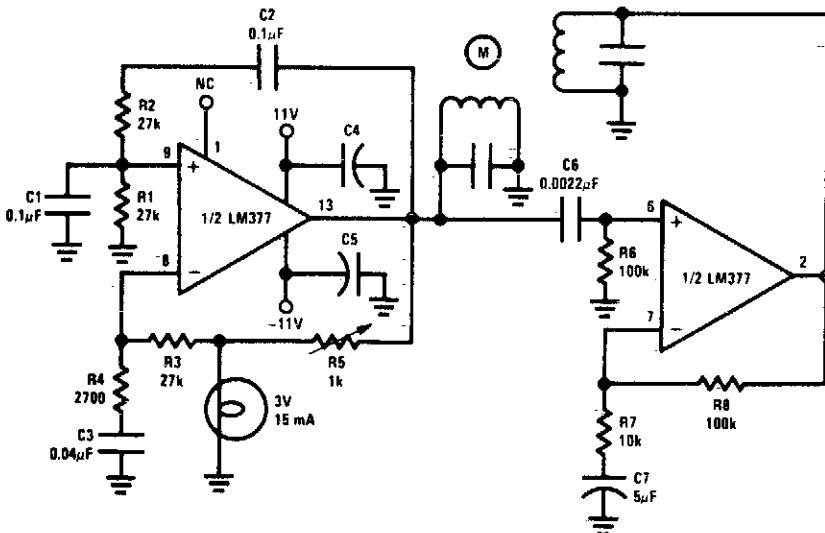


Fig. 57-19

DC SERVO AMPLIFIER

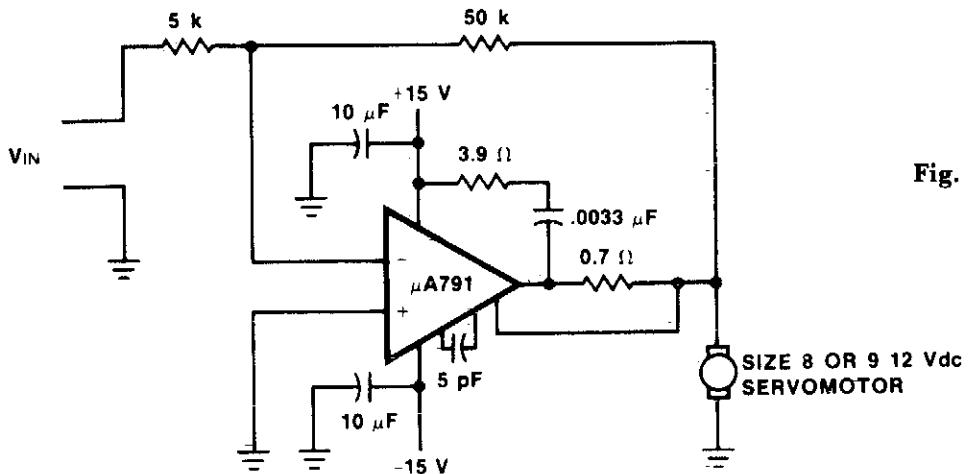
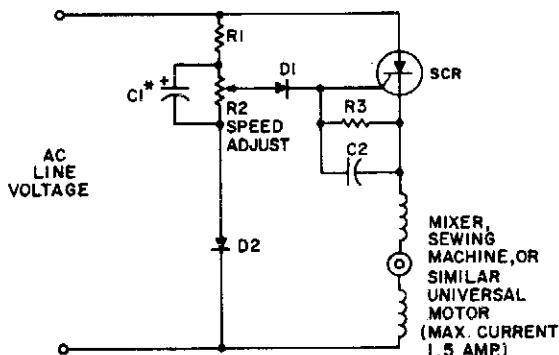


Fig. 57-20

UNIVERSAL MOTOR SPEED CONTROL



Line Voltage	120V	240V
R ₁	47K	100K
R ₂	10K	20K
R ₃	1K	1K
C ₁	1μF, 50V	1μF, 100V
C ₂	0.1μF, 50V	0.1μF, 50V
D ₁	1N5059	1N5060
D ₂	1N5059	1N5060
SCR	C106B1	C106D1

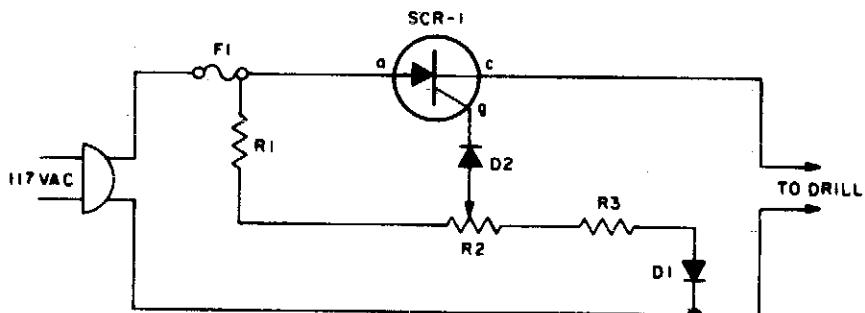
Fig. 57-21

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 $\frac{1}{4}$ -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

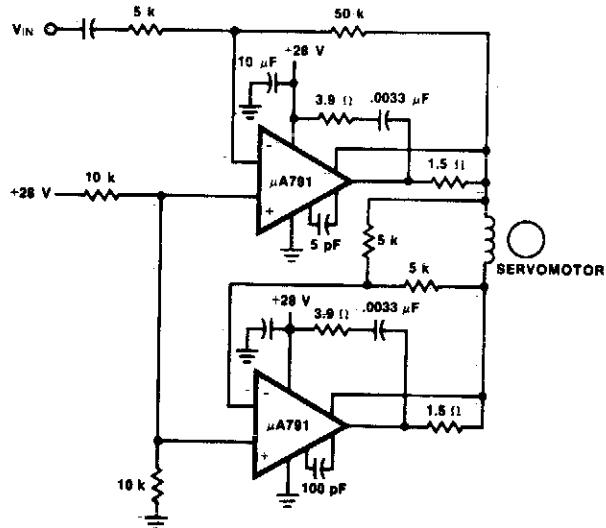


Fig. 57-23

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 | TTL Monostable |
| Astable Multivibrator | Monostable Circuit |
| Astable Oscillator | One-Shot Multivibrator |
| Digitally Controlled Astable Multivibrator | Monostable Multivibrator |
| Dual Astable Multivibrator | Bistable Multivibrator |
| UJT Monostable | 100 kHz Free-Running Multivibrator |
| Monostable Multivibrator with Input Lock-Out | |

MONOSTABLE CIRCUIT

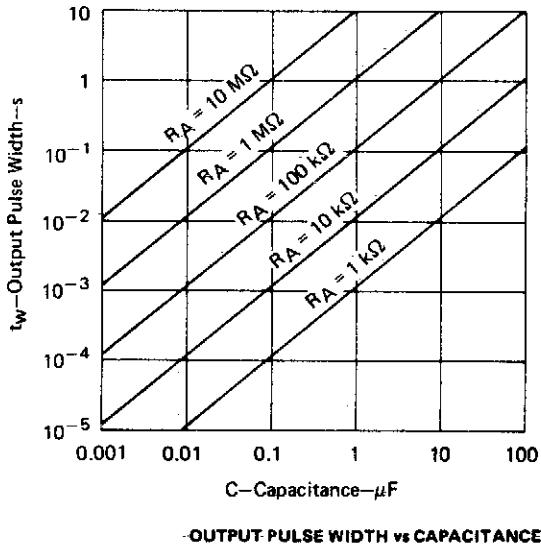
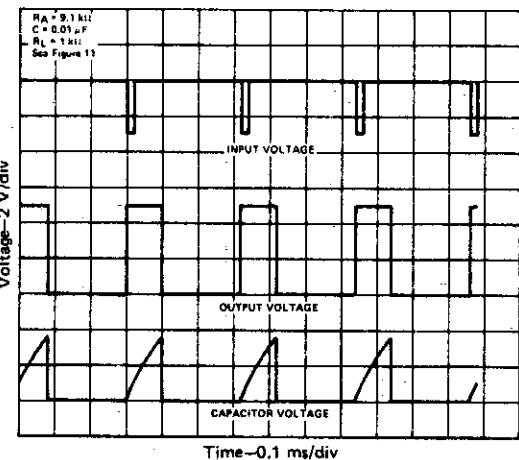
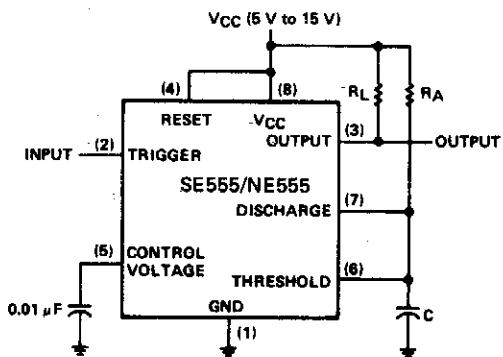


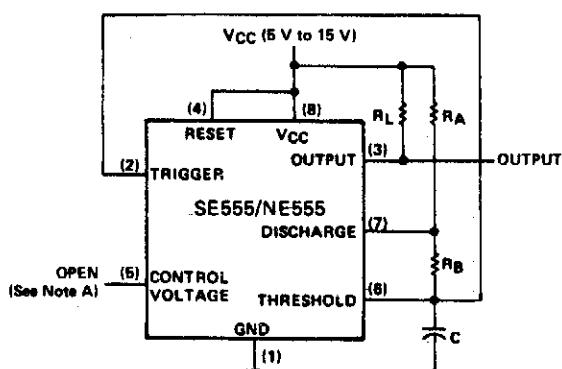
Fig. 58-1

Circuit Notes

If the output is low, application of a negative-going pulse to the trigger input sets the flip-flop (Q goes high), drives the output high, and turns off T_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 Q_1 . 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



NOTE A: Decoupling the control voltage input (pin 5) to ground with a capacitor may improve operation. This should be evaluated for individual applications.

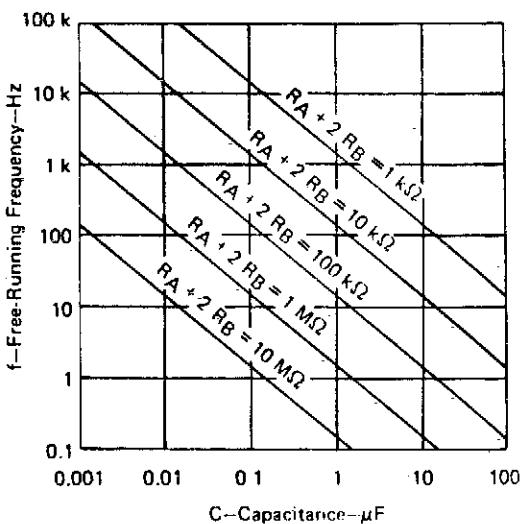
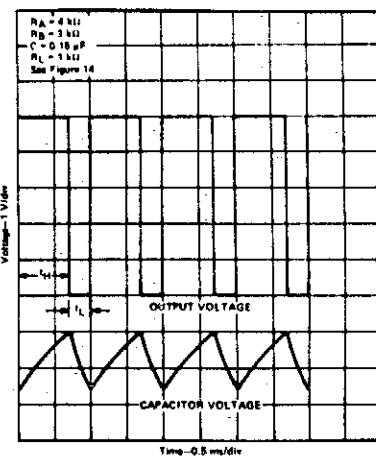
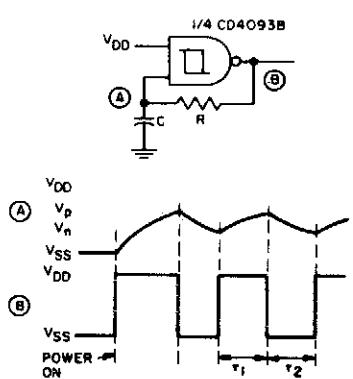


Fig. 58-2

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

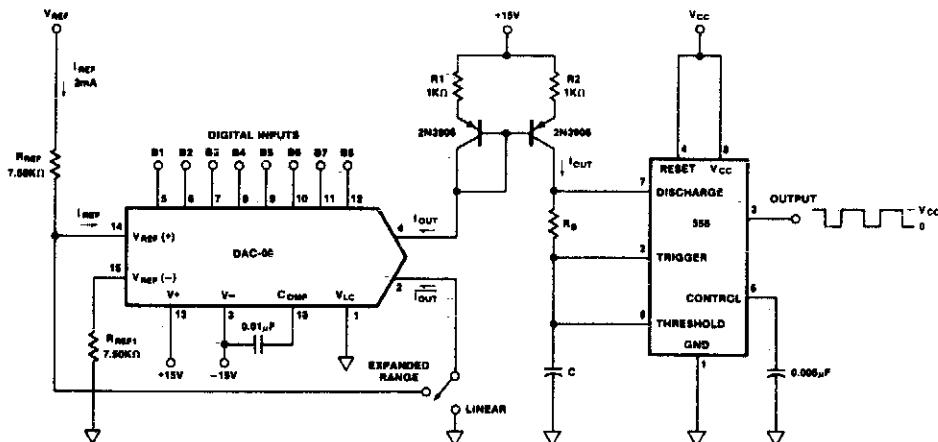


Circuit Notes

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

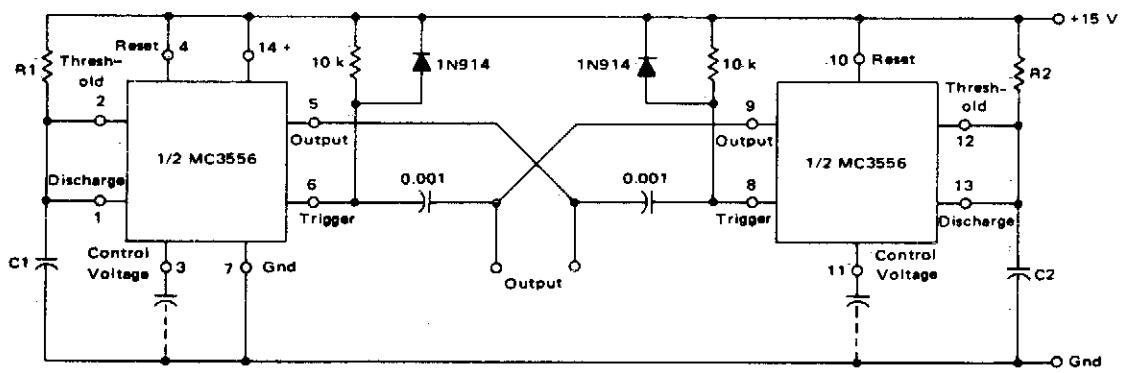


$$\text{FREQUENCY, } f = \frac{1}{3 \frac{R_{REFC}}{\{D\}} \frac{V_{CC}}{V_{REF}} + 0.695 R_B C} \quad \text{FOR LINEAR MODE}$$

$$\text{FREQUENCY, } f = \frac{1}{3 \frac{R_{REFC}}{\{D\}} \frac{V_{CC}}{V_{REF}} \left[2 - \frac{1}{\{D\}} \right] + 0.695 R_B C} \quad \text{FOR EXPANDED MODE}$$

Fig. 58-4

DUAL ASTABLE MULTIVIBRATOR



$$f = \frac{0.91}{(R_1+R_2)C} \text{ for } C_1 = C_2$$

$$\text{Duty Cycle } \frac{R_2}{R_1+R_2}$$

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

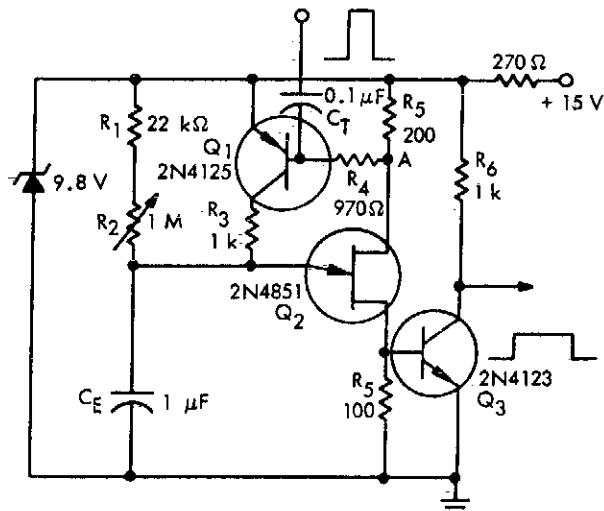


Fig. 58-6

MONOSTABLE MULTIVIBRATOR WITH INPUT LOCK-OUT

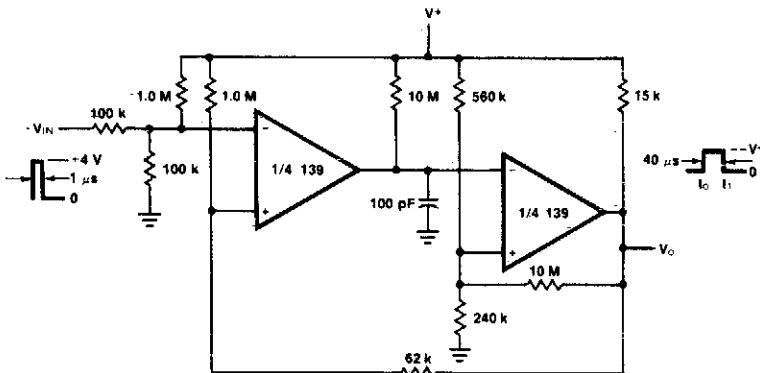


Fig. 58-7

TTL MONOSTABLE

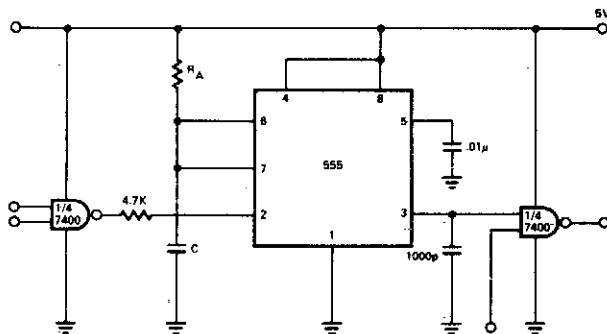


Fig. 58-8

MONOSTABLE CIRCUIT

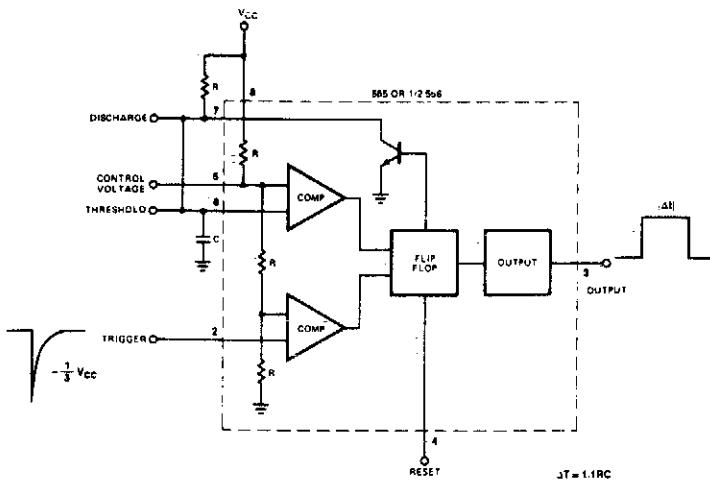


Fig. 58-9

ONE-SHOT MULTIVIBRATOR

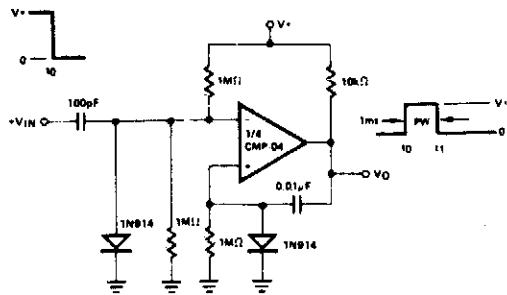


Fig. 58-10

BISTABLE MULTIVIBRATOR

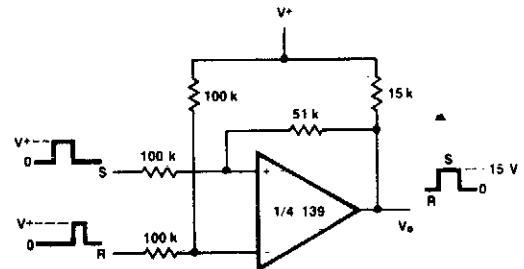


Fig. 58-12

MONOSTABLE MULTIVIBRATOR

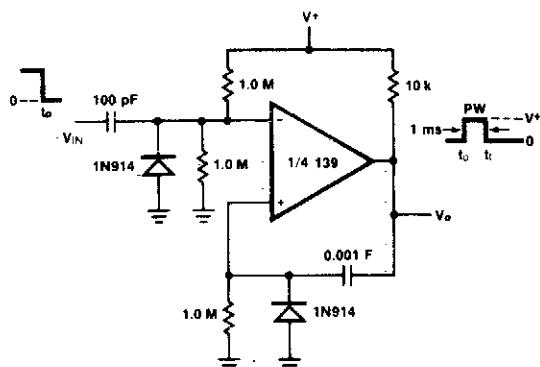


Fig. 58-11

100 kHz FREE-RUNNING MULTIVIBRATOR

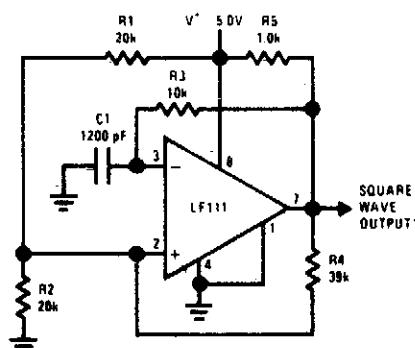


Fig. 58-13

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

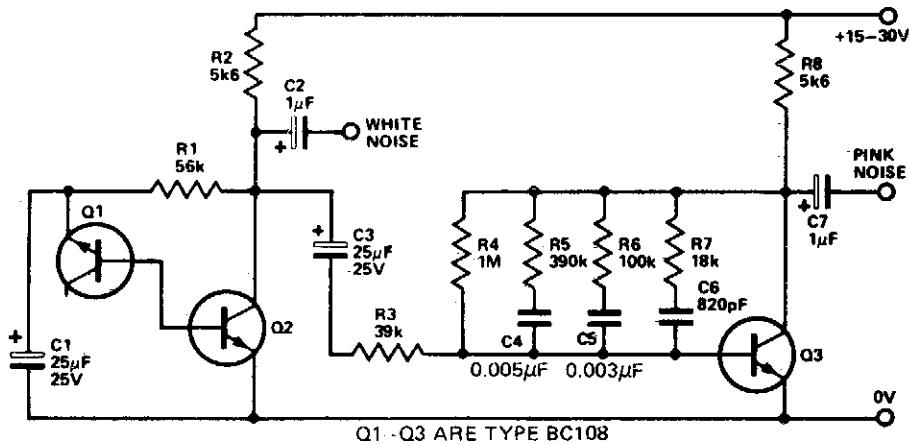


Fig. 59-1

Circuit Notes

This simple circuit generates both white and pink 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

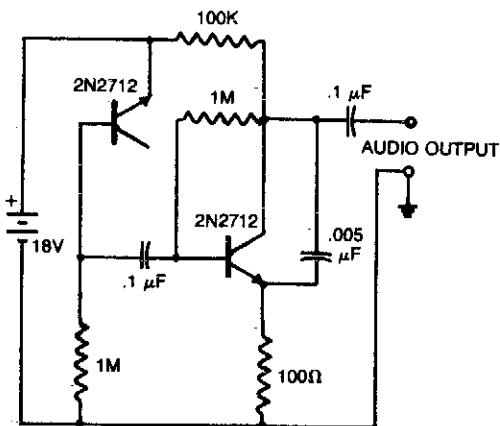


Fig. 59-2

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

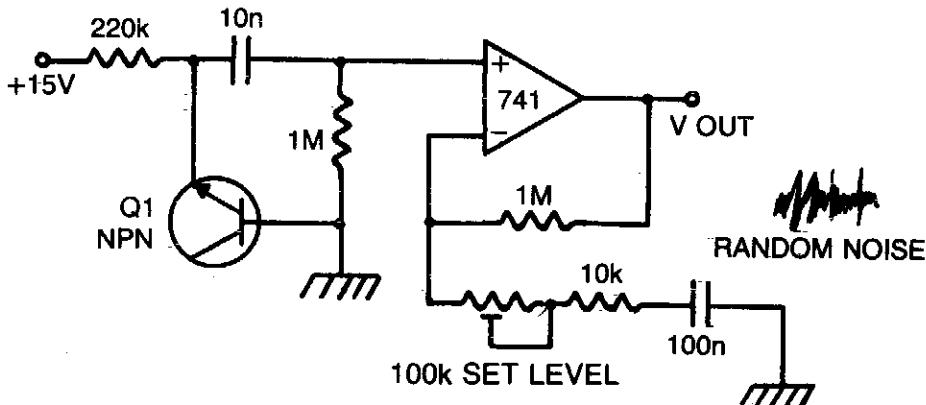


Fig. 59-3

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

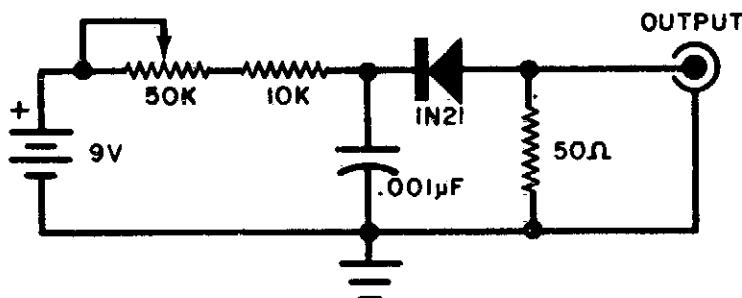


Fig. 59-4

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

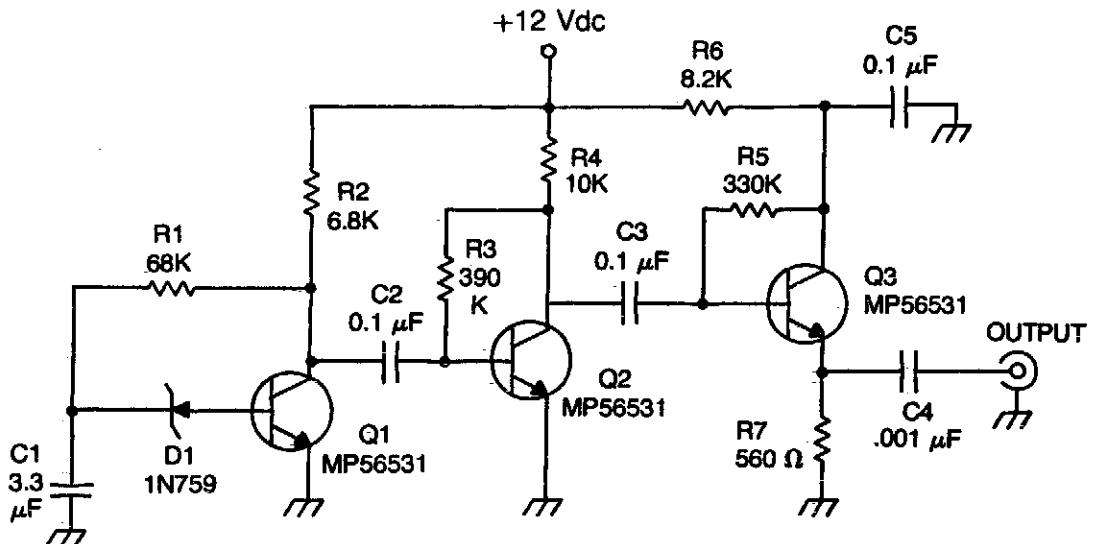


Fig. 59-5

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

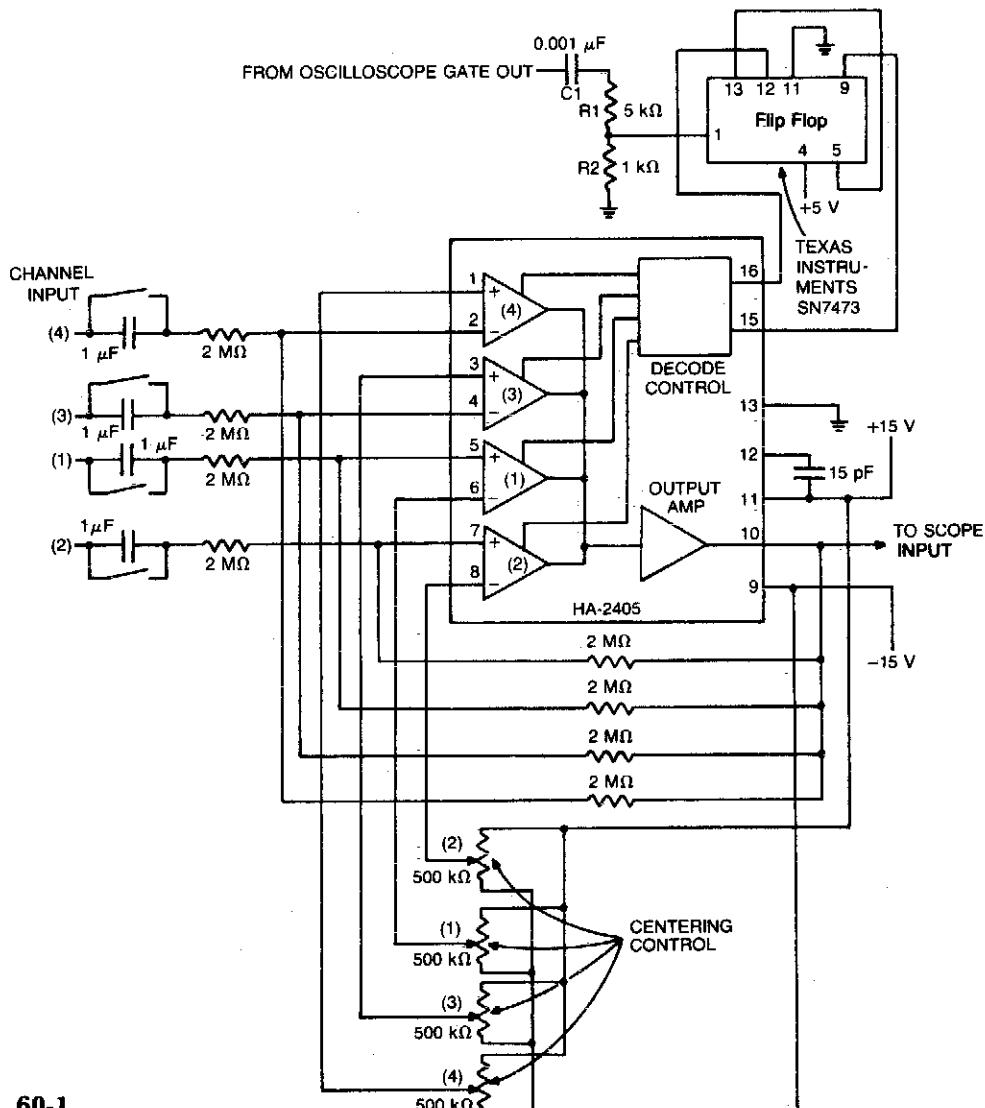


Fig. 60-1

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.

ADD-ON TRIGGERED SWEEP

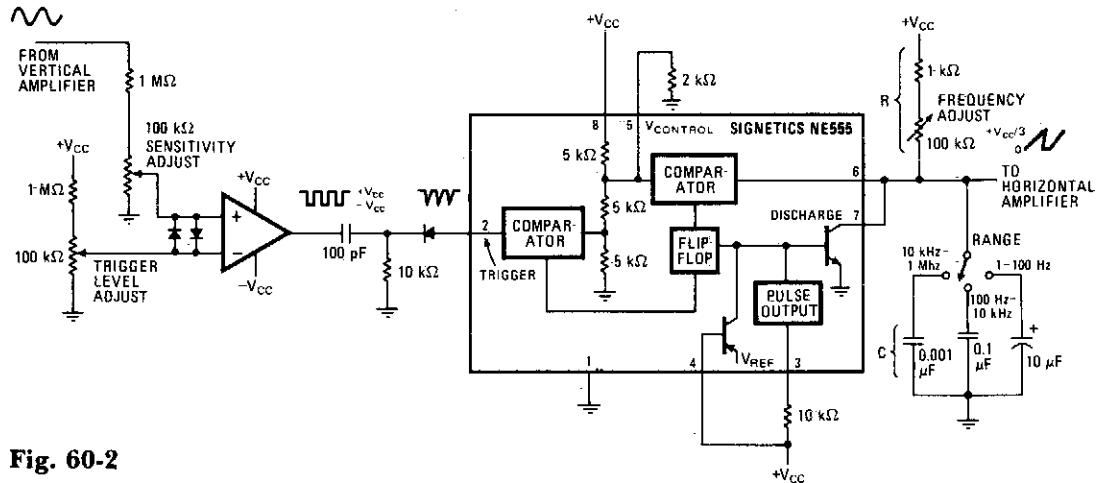


Fig. 60-2

Circuit Notes

The circuit's input op amp triggers the timer, setting its flip-flop and cutting off its discharge transistor so that capacitor C can charge. When the capacitor voltage reaches the timer's control voltage (0.33V_{cc}), the flip-flop resets and the transistor conducts, discharging the capacitor.

10.7 MHz SWEEP GENERATOR

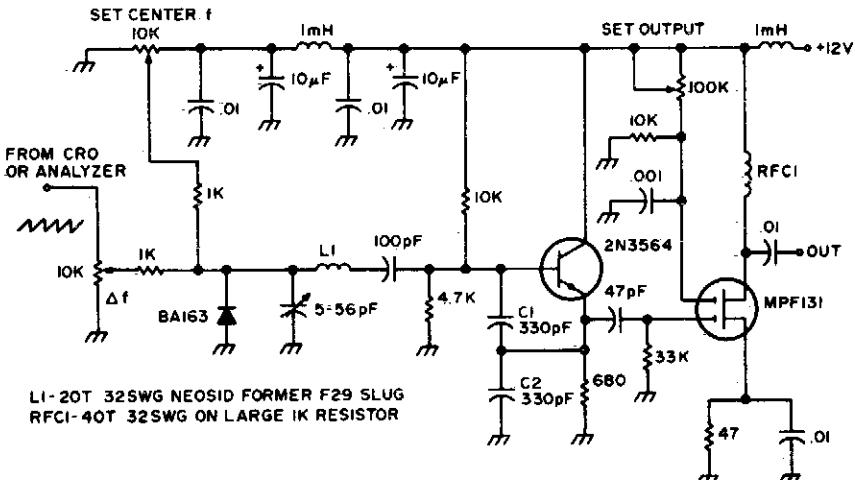


Fig. 60-3

Circuit Notes

This circuit is used to observe the response of an if amp or a filter. It can be used with an oscilloscope or, for more dynamic range, with a spectrum analyzer.

DRAWING CIRCLES ON A SCOPE

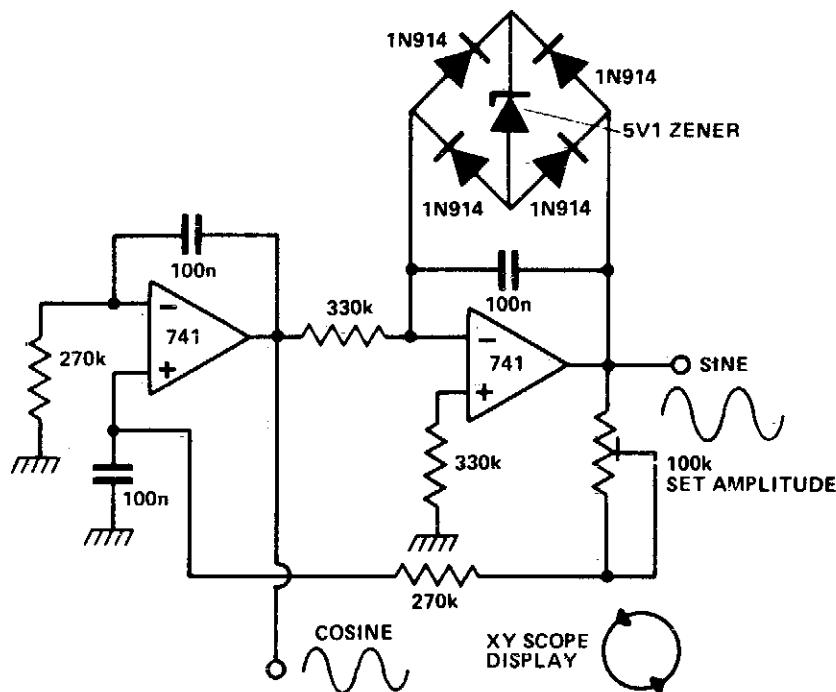


Fig. 60-4

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

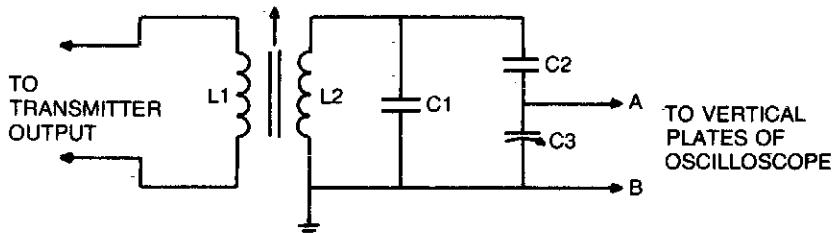


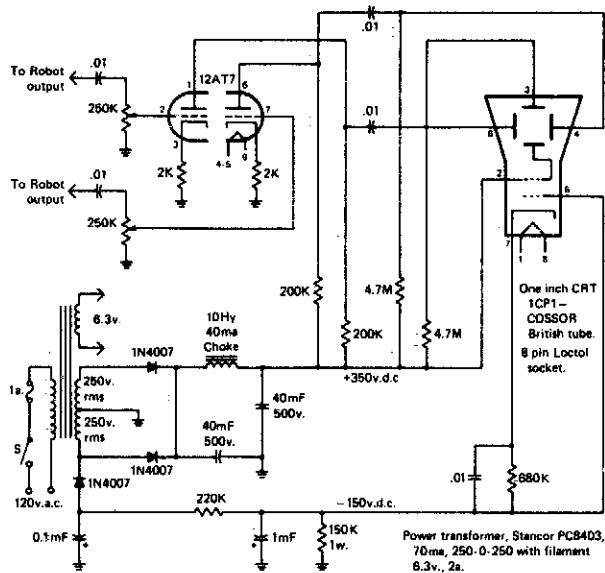
Fig. 60-5

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 L1, C1, and C2 = 5 pF, C3 = 75 pF trimmer.

OSCILLOSCOPE MONITOR



BEAM SPLITTER FOR OSCILLOSCOPE

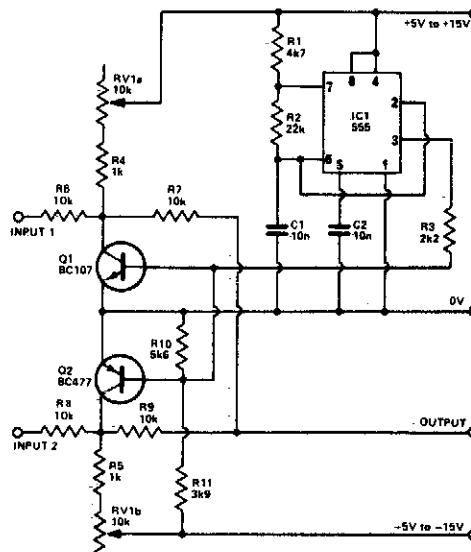


Fig. 60-7

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

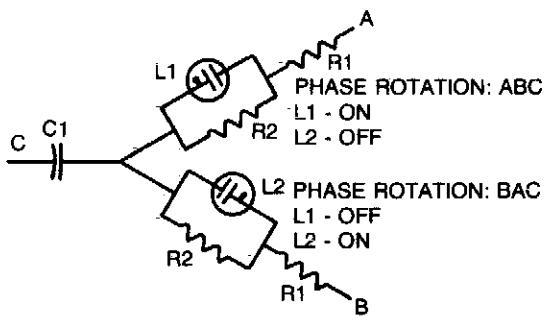
0° to 180° Phase Shifter

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

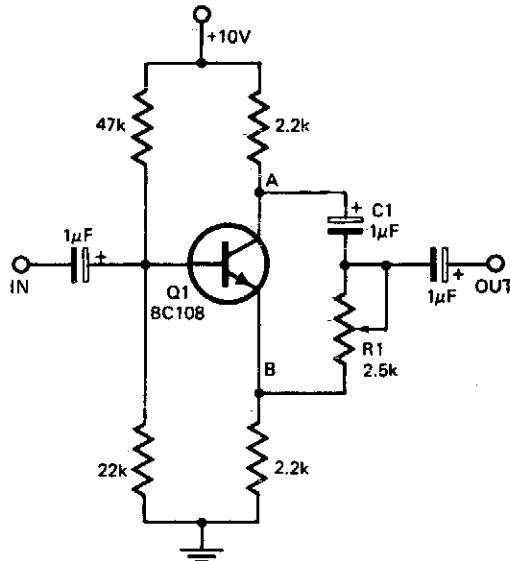


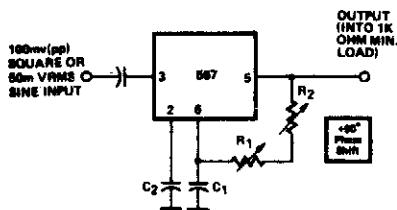
Fig. 61-2

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

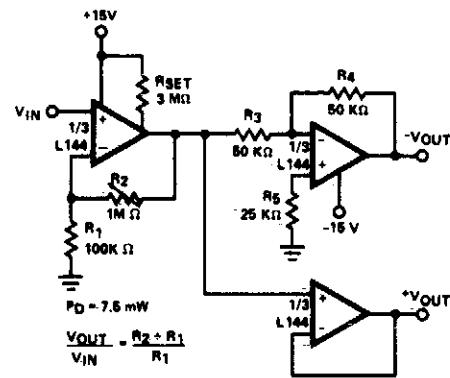
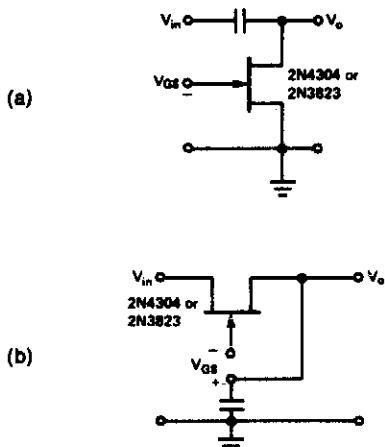


Fig. 61-5

PHASE SHIFT CIRCUITS



- (a) Phase advance circuit.
- (b) Phase retard circuit.

Fig. 61-4

0° TO 360° PHASE SHIFTER

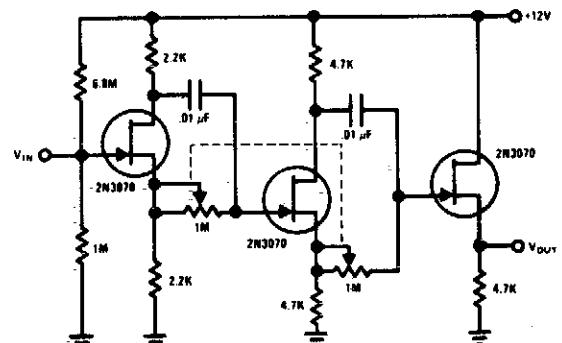


Fig. 61-6

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

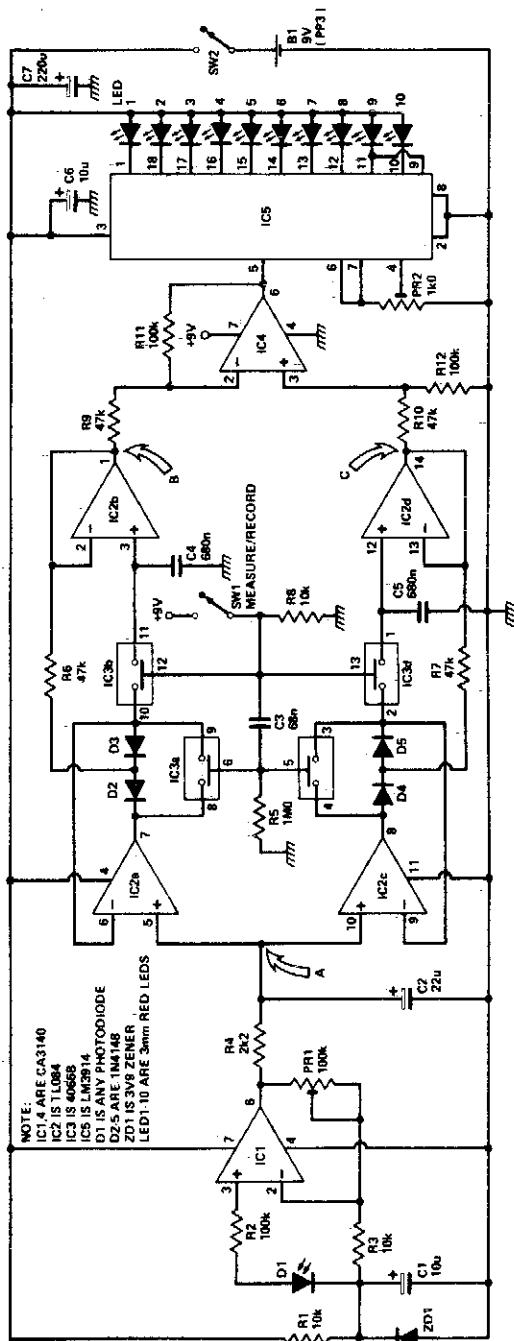


Fig. 62-1

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

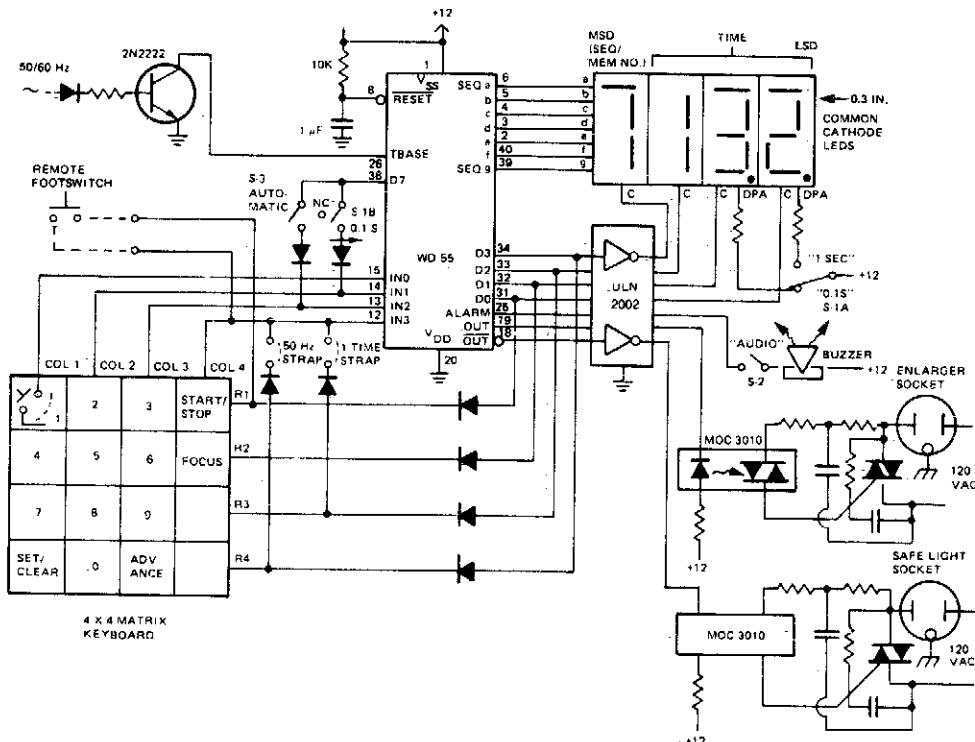


Fig. 62-2

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.

PHOTO STOP ACTION

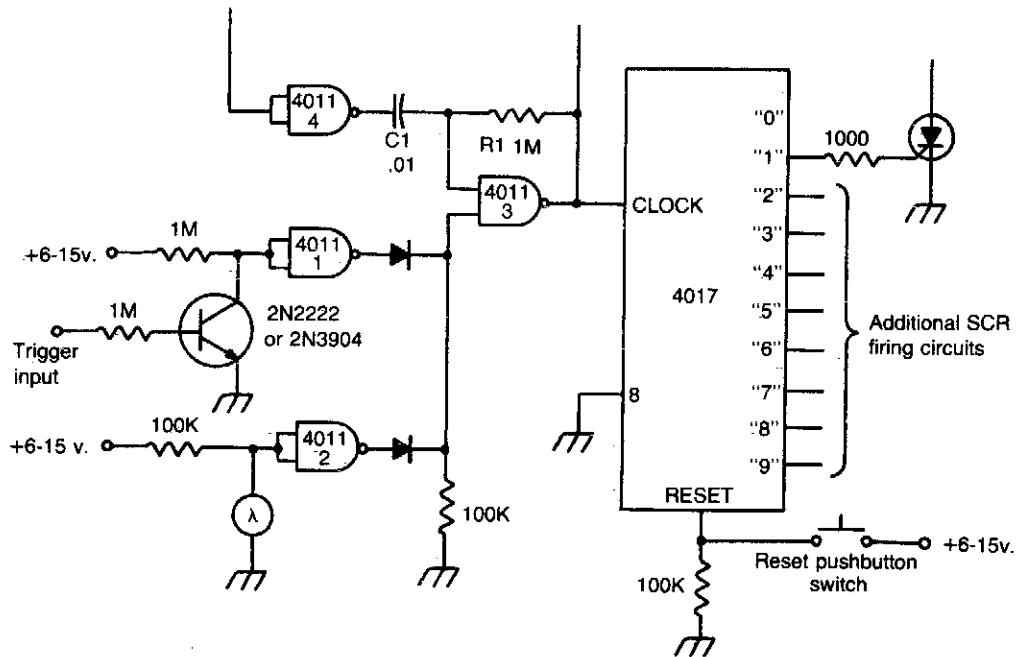


Fig. 62-3

Circuit Notes

This circuit gives multiple "stop-action" photographic effects like showing a bouncing ball in up to nine locations in a single photograph. The circuit will automatically fire the bulbs sequentially with the time between each firing variable. The circuit is functionally complete except for the actual firing system. In many cases, a simple SCR will work, as shown. The firing can be initiated in one of two ways. A

trigger pulse can be applied to the trigger input terminal through a capacitor, or can operate the unit as a slave. Light from a camera-mounted flash will activate the circuit through its built-in photocell pickup. The time period between each successive flash is determined by C1 and R1, which is variable. After firing the circuit, it must be reset by momentarily depressing the reset button.

SOUND LIGHT-FLASH TRIGGER

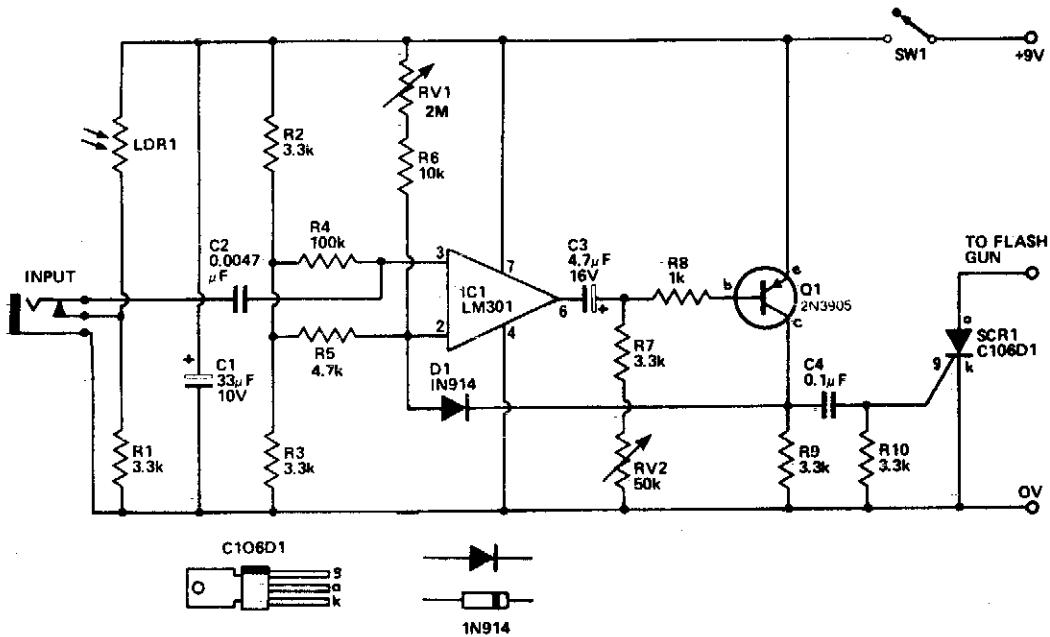


Fig. 62-4

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

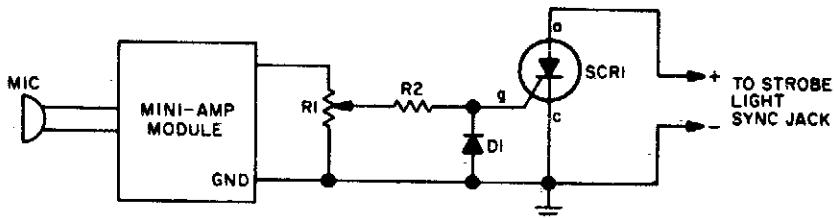


Fig. 62-5

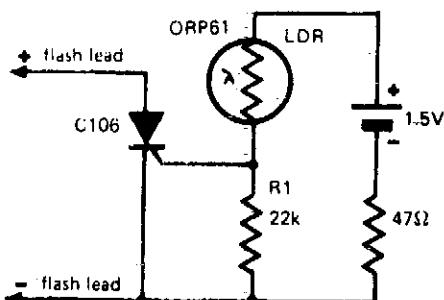
D1—HEP-154 silicon rectifier
R1—5000-ohm potentiometer
R2—2700-ohm, $\frac{1}{2}$ -watt resistor
SCR1—silicon-controlled rectifier
MIC.—Ceramic microphone

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

Circuit Notes

Q1—300-V light-activated silicon-controlled rectifier (LASCR)
R1—47,000-ohm, $\frac{1}{2}$ -watt resistor

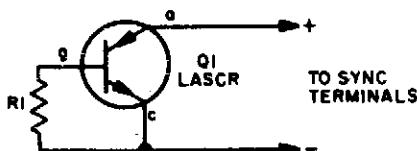


Fig. 62-7

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

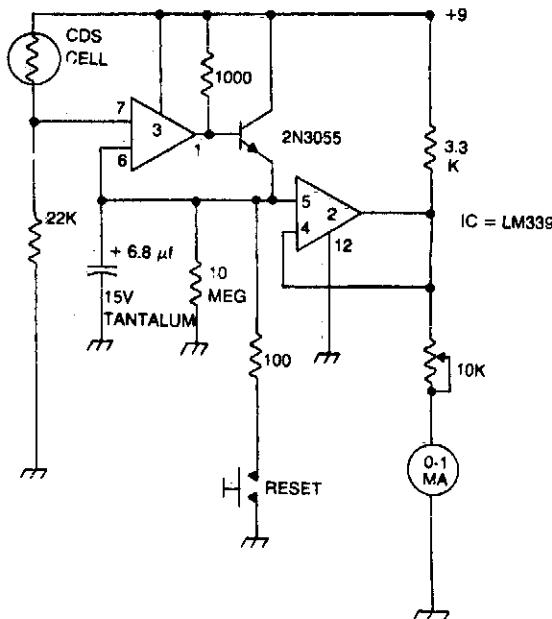


Fig. 62-8

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.

SHUTTER TESTER

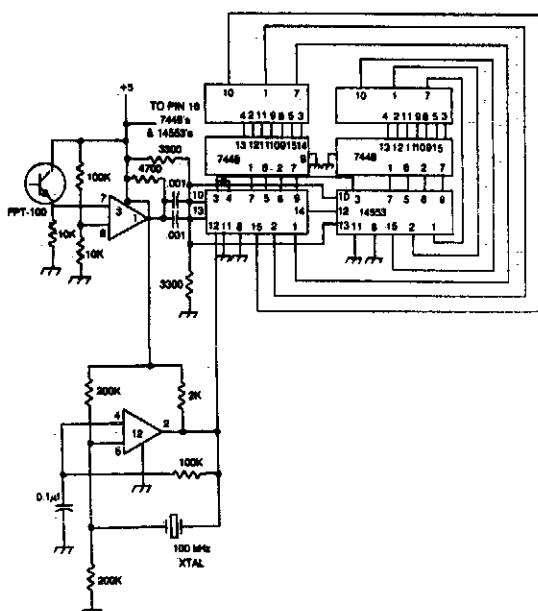


Fig. 62-9

Circuit Notes

Shutter speed tester combines frequency counter, crystal oscillator, and phototransistor-operated gate generator. Oscillator pulses are counted as long as the shutter is open. Reset is automatic at the instant the shutter opens.

PHOTOGRAPHIC TIMER

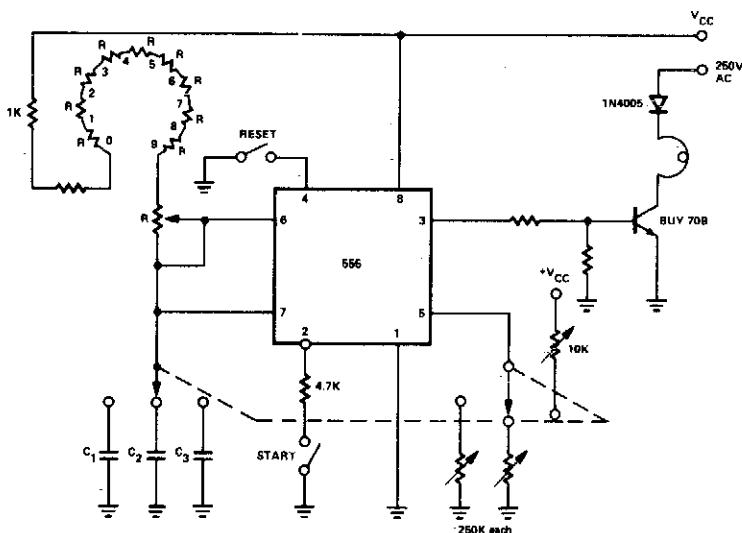


Fig. 62-10

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

EXTENDED RANGE VU METER (DOT MODE)

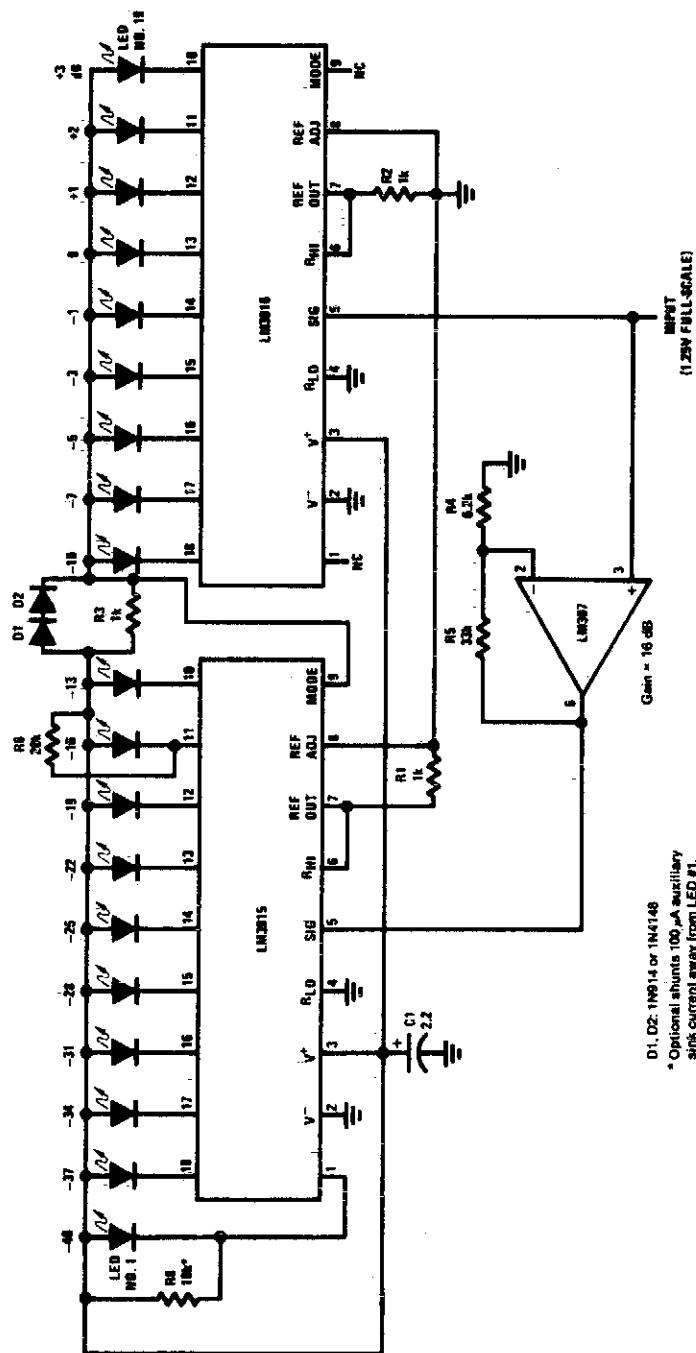


Fig. 63-1

01-02-110914 or 110914

- * Optional shunts 100 μ A auxiliary sink current away from LED #1.

[†]See Application Hints for optional peak or average detector.

AUDIO POWER METER

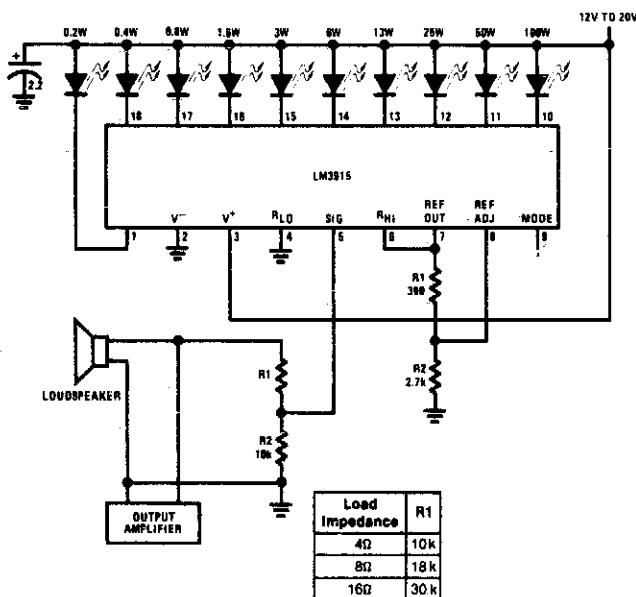


Fig. 63-2

AUDIO POWER METER

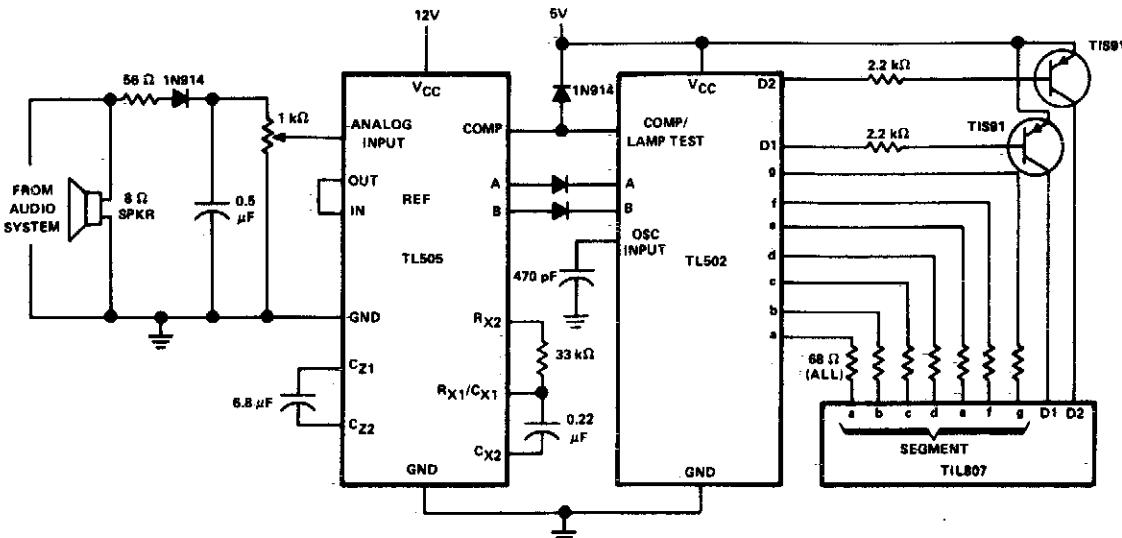


Fig. 63-3

POWER METER (1 kW FULL SCALE)

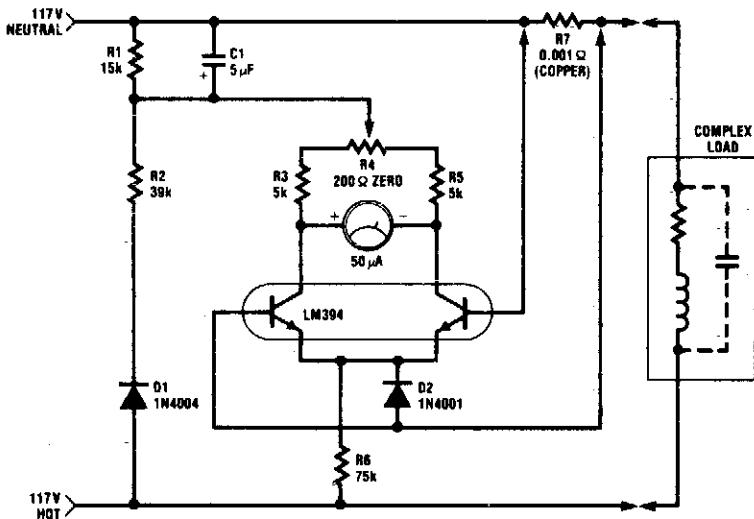


Fig. 63-4

Circuit Notes

The circuit is intended for 117 Vac \pm 5% 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

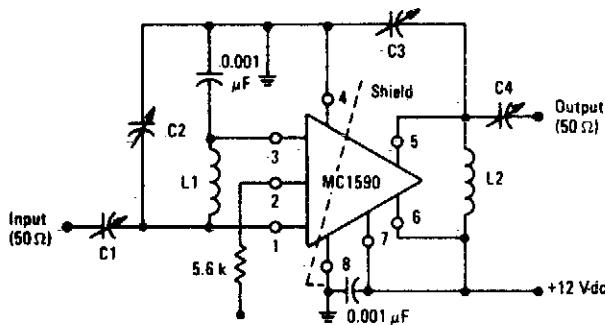


Fig. 63-5

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 | Negative Switching Regulator |
| 3 W Switching Regulator Application Circuit | Positive Switching Regulator |
| Regulated Split Supplies from a Single
Supply | Positive Floating Regulator |
| Switching Step-Down Regulator | Negative Floating Regulator |
| Single-Ended Regulator | Negative Voltage Regulator |
| ± 50 V Push-Pull Switched Mode Converter | -15 V Negative Regulator |
| 5 V/0.5 A Buck Converter | Slow Turn-On 15 V Regulator |
| ± 50 V Feed Forward Switch Mode
Converter | High Stability 10 V Regulator |
| Traveller's Shaver Adapter | 5 V/1 A Switching Regulator |
| 100 Vrms Voltage Regulator | 15 V/1 A Regulator with Remote Sense |
| Transistor Increases Zener Rating | Low Ripple Power Supply |
| Dual Polarity Power Supply | 5.0 V/10 A Regulator |
| 5.0 V/6.0 A, 25 kHz Switching Regulator
with Separate Ultra-Stable Reference | 5.0 V/3.0 A Regulator |
| Mobile Voltage 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

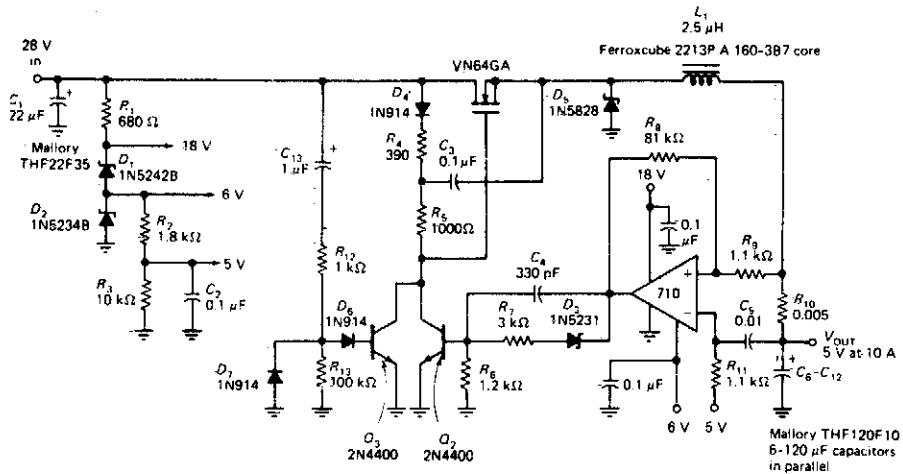


Fig. 64-1

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

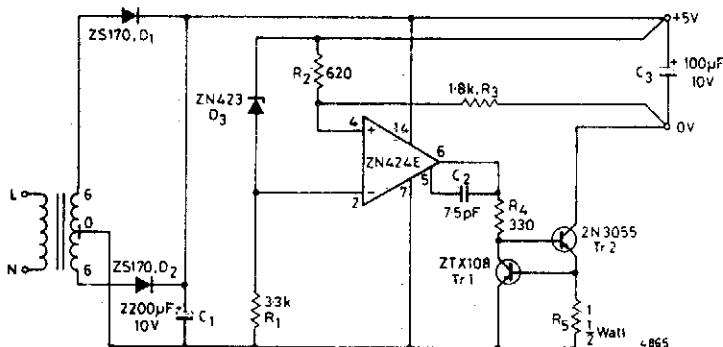


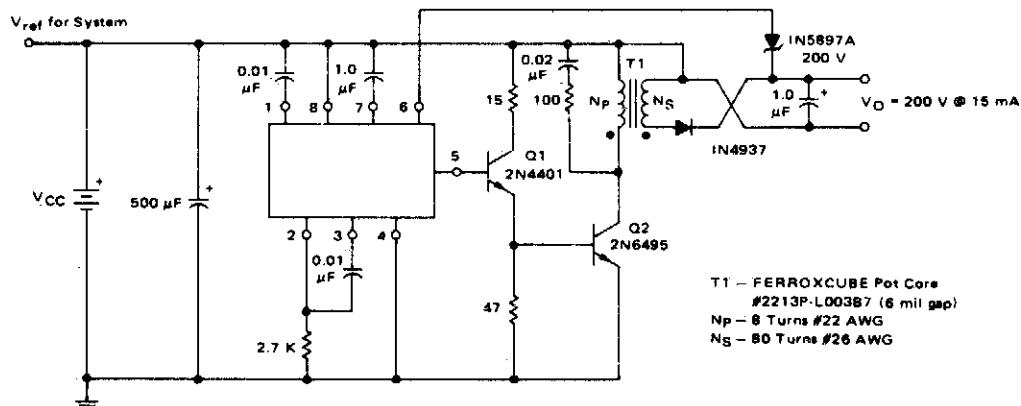
Fig. 64-2

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 circuit 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 = \pm 100 ppm/ $^{\circ}$ C. Current limit = 0.65 A.

3 W SWITCHING REGULATOR APPLICATION CIRCUIT



3-Watt Switching Regulator - converts 5 V to 200 V for gas discharge displays such as Burroughs Panaplex and Beckman.

Fig. 64-3

REGULATED SPLIT POWER SUPPLIES FROM A SINGLE SUPPLY

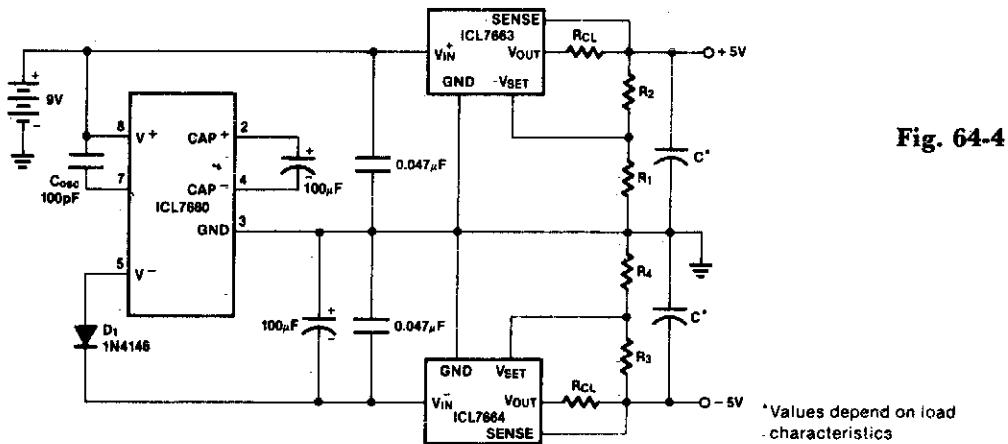


Fig. 64-4

Circuit Notes

The oscillation frequency of the ICL7660 is reduced by the external oscillator capacitor, so that it inverts the battery voltage more efficiently.

SWITCHING STEP-DOWN REGULATOR

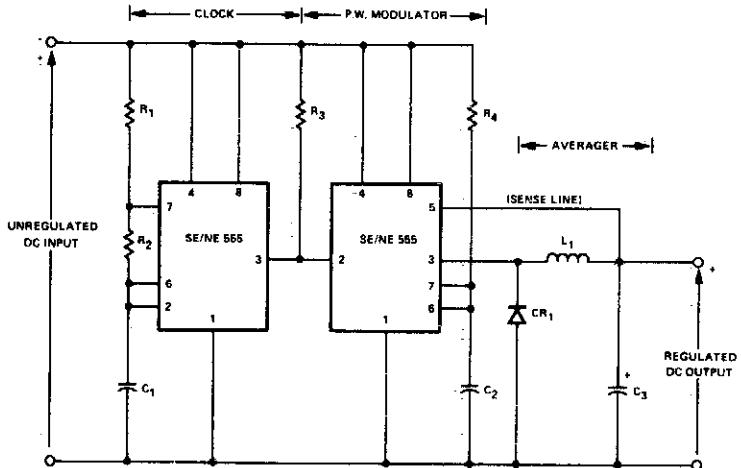


Fig. 64-5

SINGLE-ENDED REGULATOR

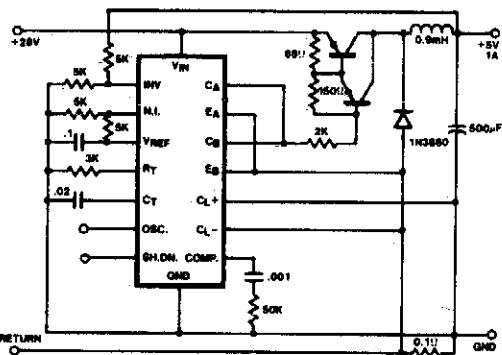


Fig. 64-6

Circuit Notes

In this conventional single-ended regulator circuit, the two outputs of the SG1524 are connected in parallel for effective 0-90% duty-cycle modulation. The use of an output inductor requires an RC phase compensation network for loop stability.

±50 V PUSH-PULL SWITCHED MODE CONVERTER

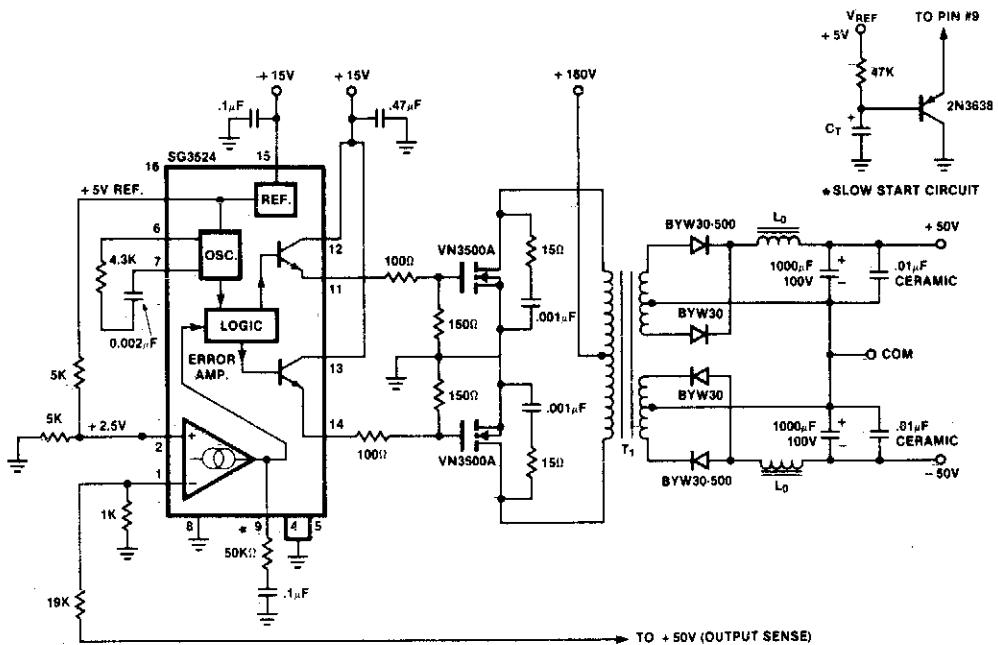


Fig. 64-7

5 V/0.5 A BUCK CONVERTER

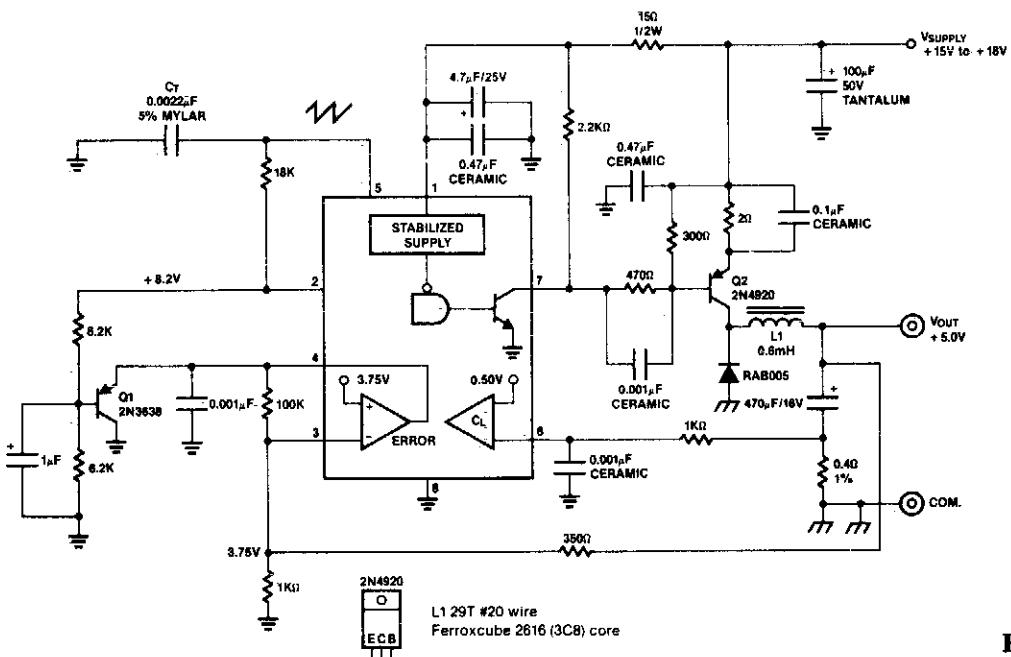


Fig. 64-8

± 50 V FEED FORWARD SWITCH MODE CONVERTER

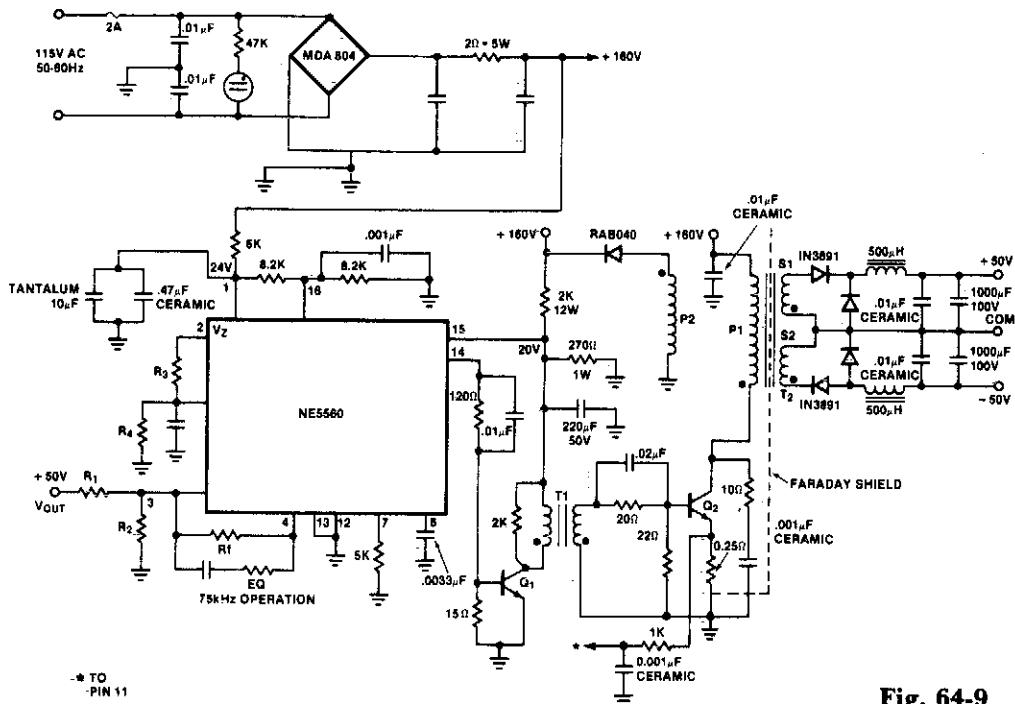


Fig. 64-9

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.

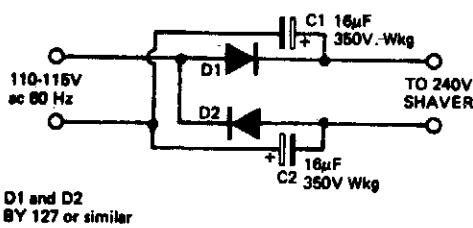


Fig. 64-10

100 Vrms VOLTAGE REGULATOR

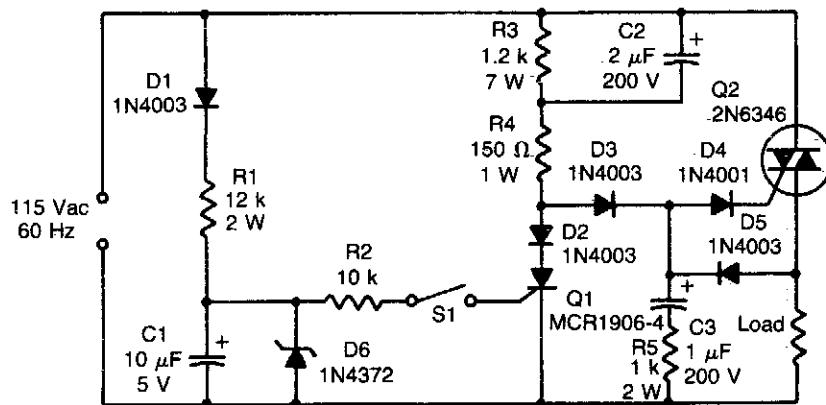


Fig. 64-11

TRANSISTOR INCREASES ZENER RATING

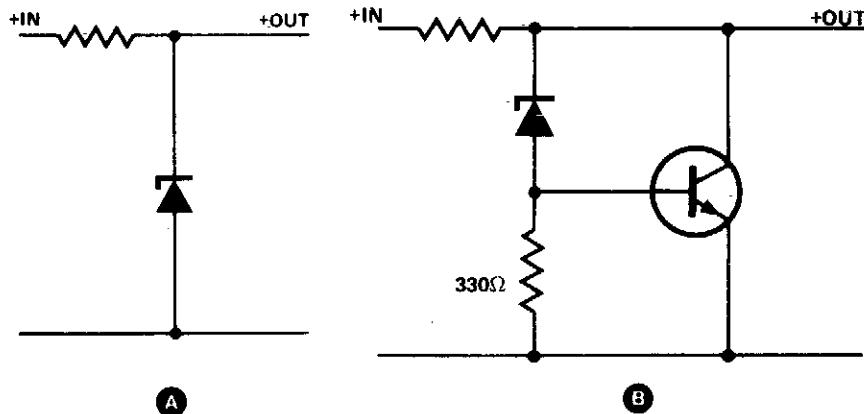


Fig. 64-12

Circuit Notes

The simple zener shunt in A may not handle sufficient current if the zener available is of low wattage. A power transistor will do most of the work for the zener as shown in B.

Once the zener starts conducting, a bias voltage develops across the resistor (330Ω to 1 K), turning on the transistor. The output voltage is 0.7 V greater than the zener voltage.

DUAL POLARITY POWER SUPPLY

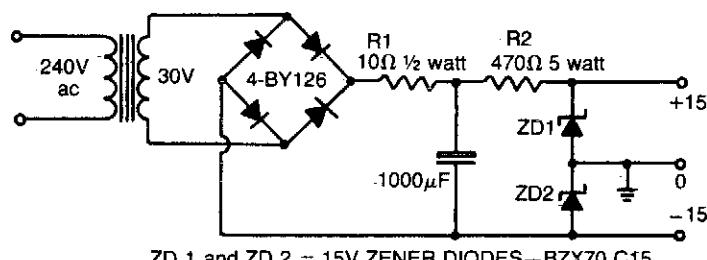


Fig. 64-13

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

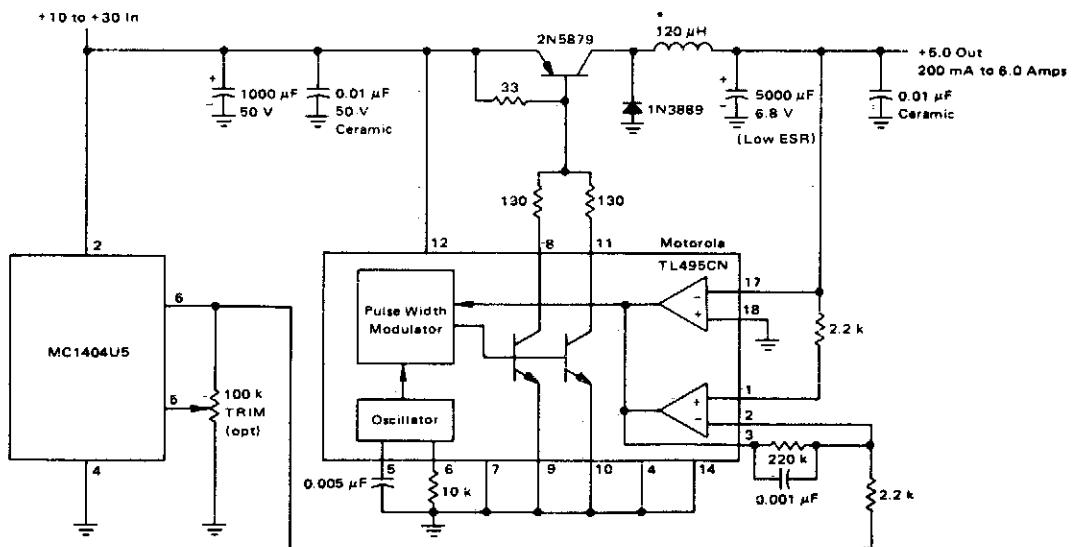


Fig. 64-14

MOBILE VOLTAGE REGULATOR

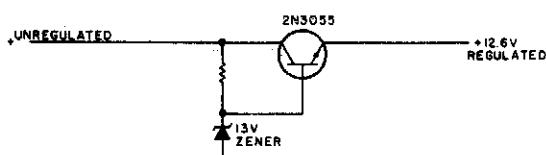


Fig. 64-15

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

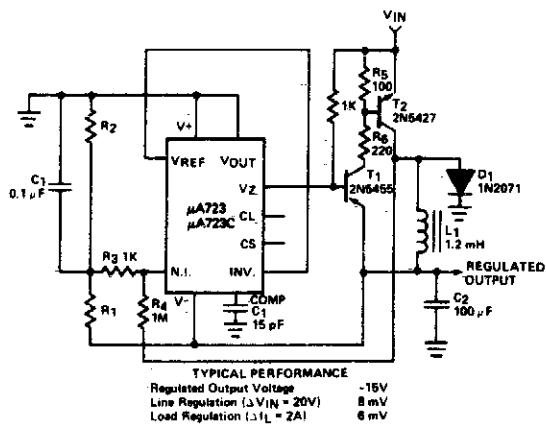


Fig. 64-16

POSITIVE FLOATING REGULATOR

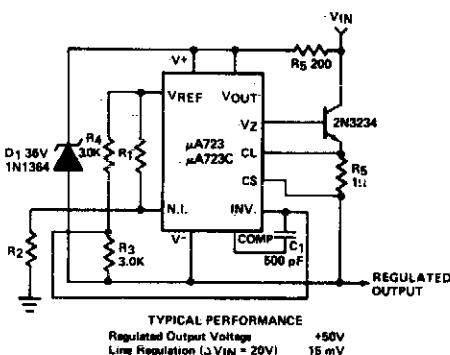


Fig. 64-18

POSITIVE SWITCHING REGULATOR

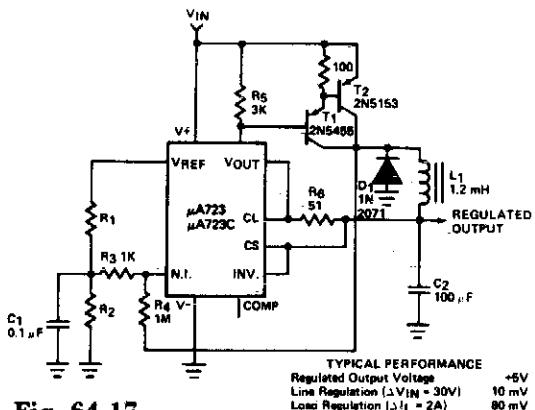


Fig. 64-17

NEGATIVE FLOATING REGULATOR

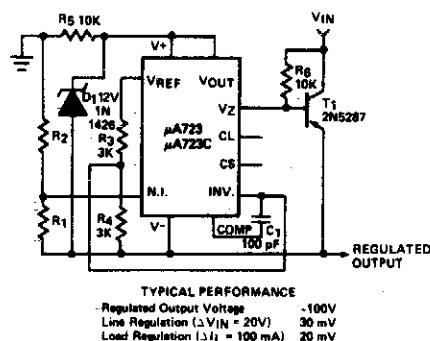


Fig. 64-19

NEGATIVE VOLTAGE REGULATOR

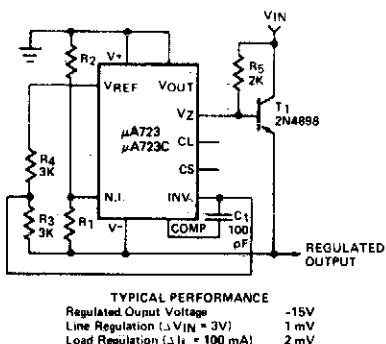


Fig. 64-20

-15 V NEGATIVE REGULATOR

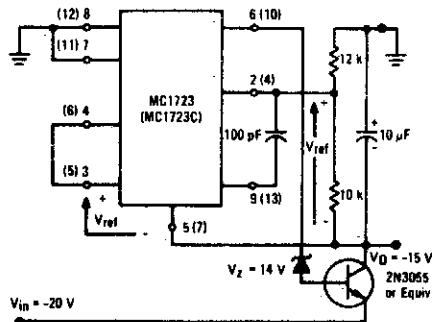


Fig. 64-21

SLOW TURN-ON 15 V REGULATOR

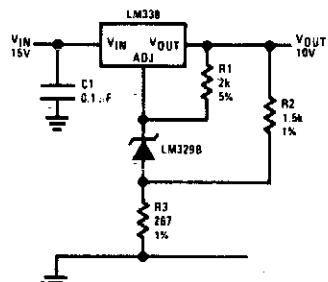


Fig. 64-22

HIGH STABILITY 10 V REGULATOR

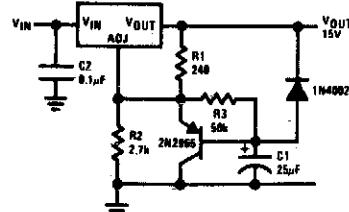


Fig. 64-23

5 V/I A SWITCHING REGULATOR

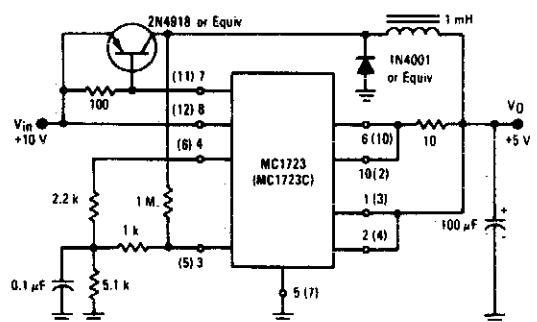


Fig. 64-24

15 V/1 A REGULATOR WITH REMOTE SENSE

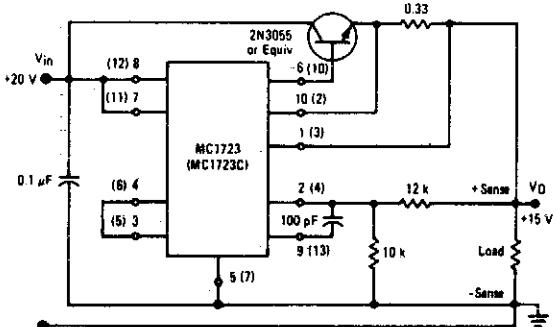


Fig. 64-25

LOW RIPPLE POWER SUPPLY

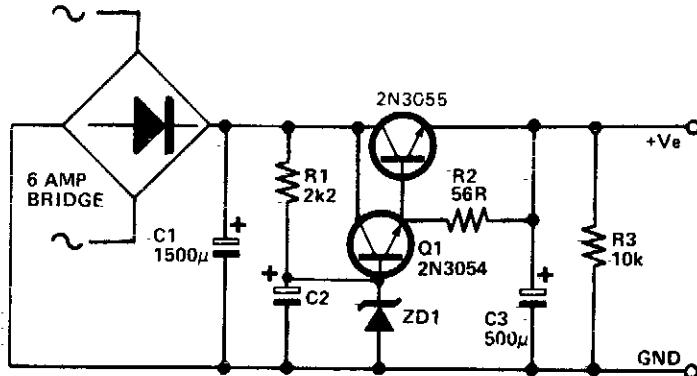


Fig. 64-26

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 μF is chosen for C2, assuming minimum hfe for Q1 and Q2, $C = 100 \times 15(\text{Q1}) \times 25(\text{Q2}) = 37,000 \mu\text{F}$.

5.0 V/10 A REGULATOR

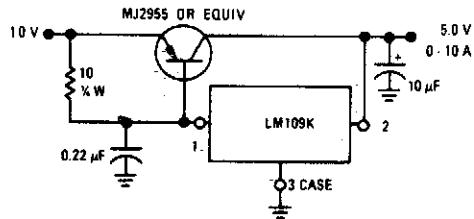


Fig. 64-27

5.0 V/3.0 A REGULATOR

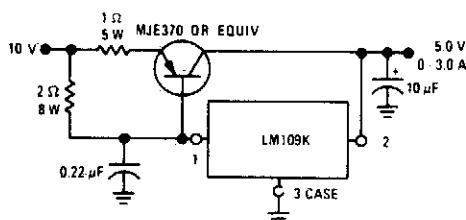


Fig. 64-28

100 V/0.25 A SWITCH MODE CONVERTER

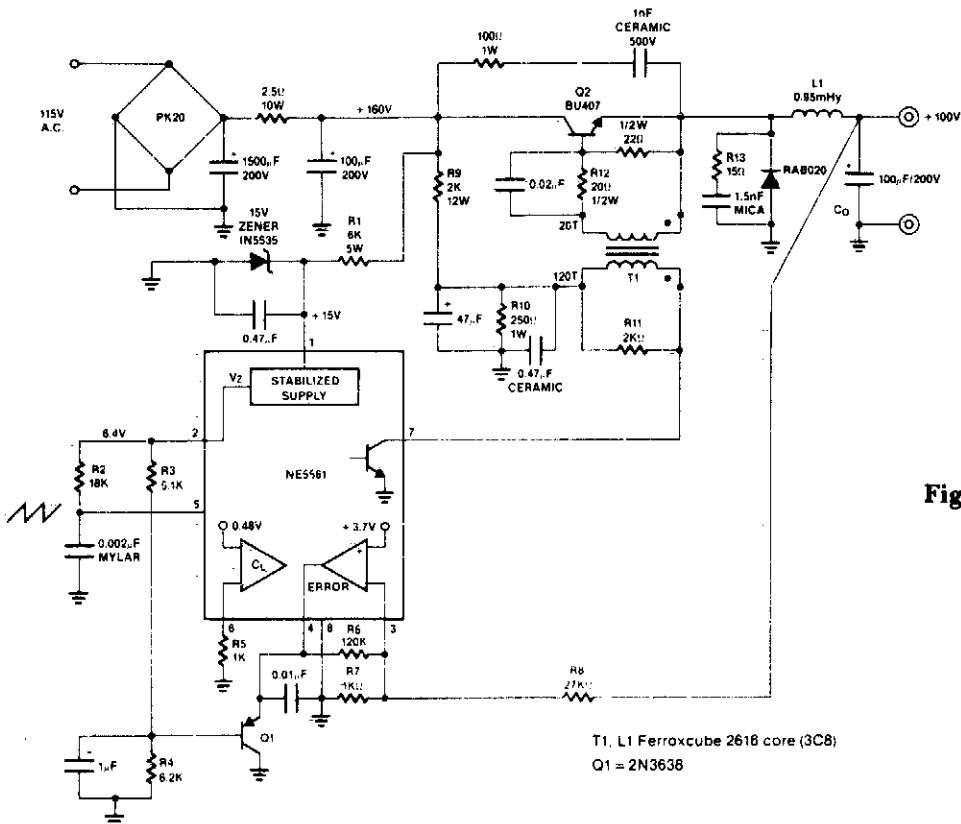
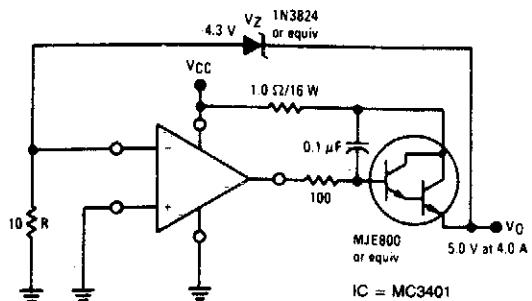


Fig. 64-29

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.

Fig. 64-30

LOW VOLTAGE REGULATORS WITH SHORT CIRCUIT PROTECTION

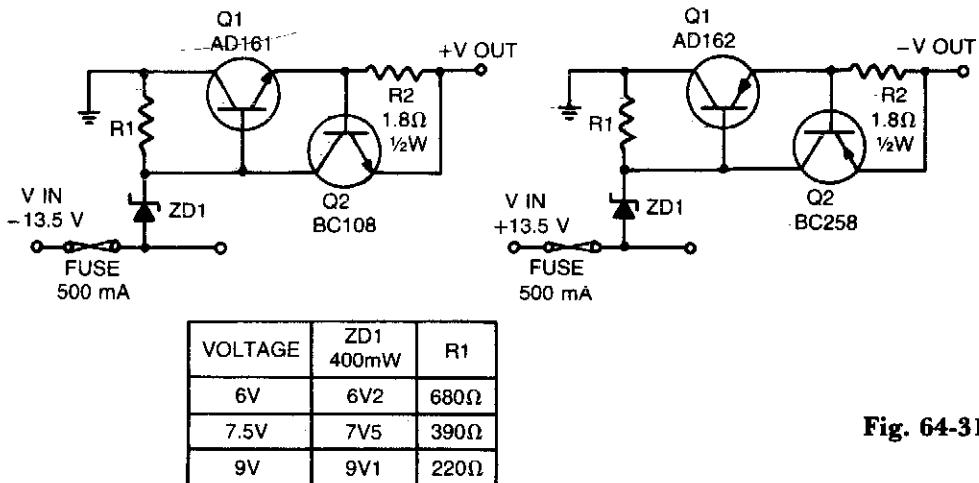


Fig. 64-31

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

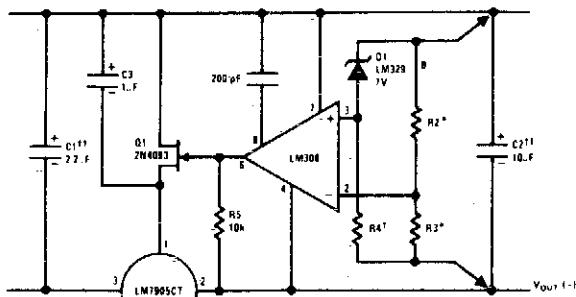


Fig. 64-32

Load and line regulation < 0.01% temperature stability $\leq 0.2\%$

†Determines Zener current

††Solid tantalum

*Select resistors to set output voltage. 2 ppm/ $^{\circ}\text{C}$ tracking suggested

100 V/0.25 A SWITCH MODE CONVERTER

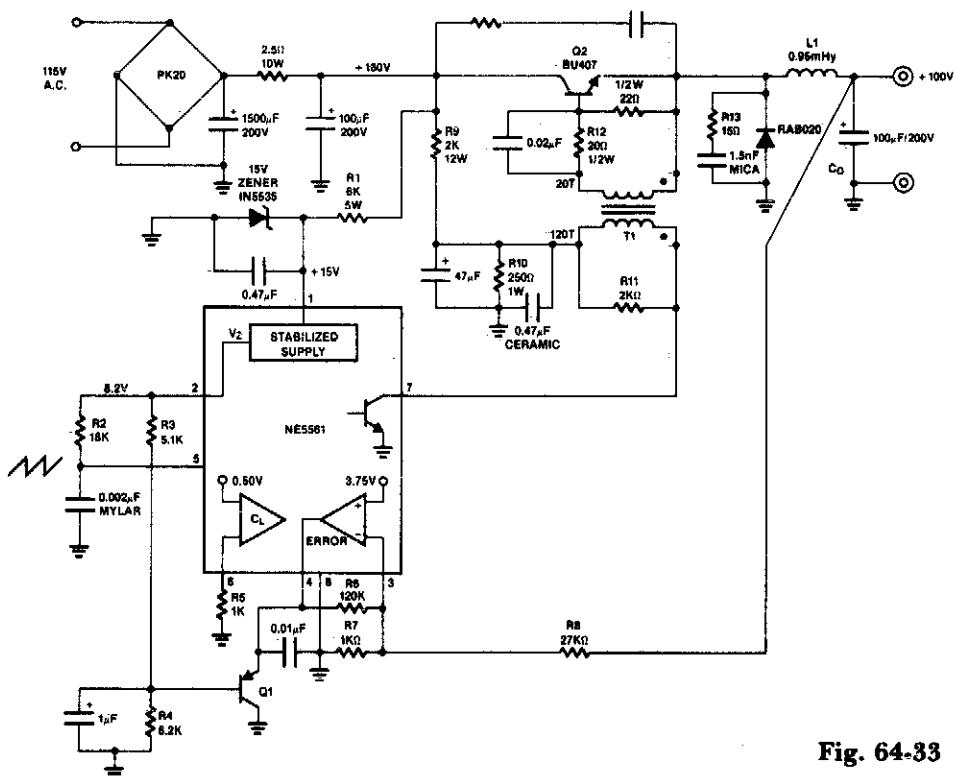


Fig. 64-33

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 Calculators, 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

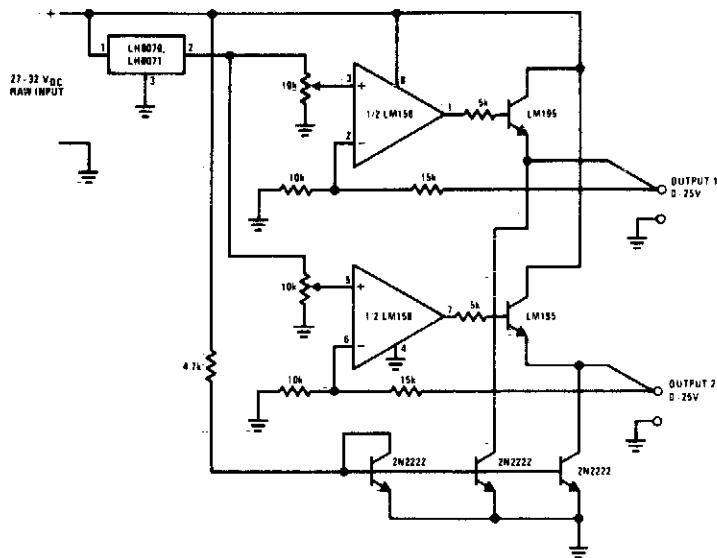


Fig. 65-1

POWER SUPPLY WITH ADJUSTABLE CURRENT LIMIT AND OUTPUT VOLTAGE

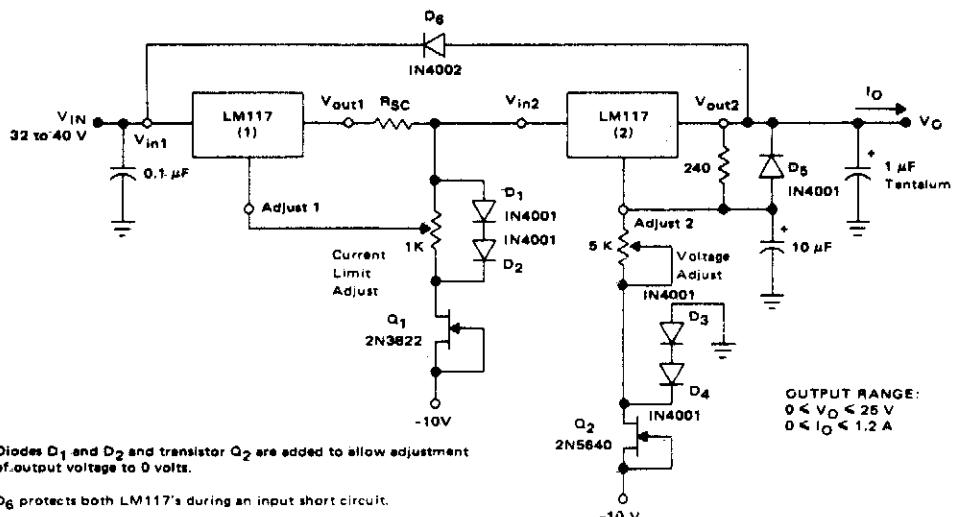


Fig. 65-2

ADJUSTABLE OUTPUT REGULATOR

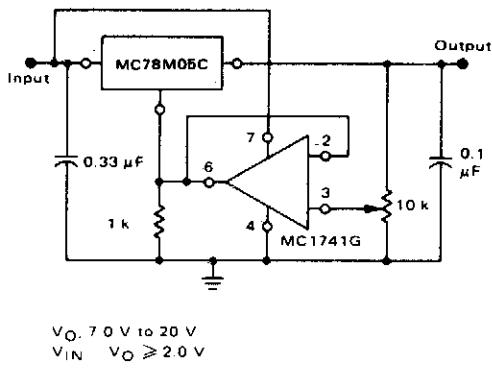


Fig. 65-3

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.

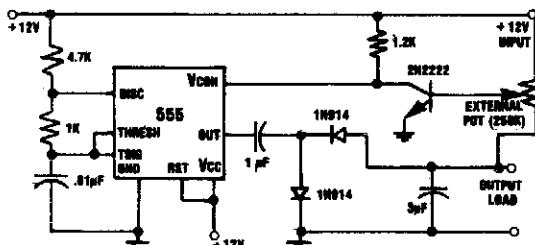


Fig. 65-4

REGULATED VOLTAGE DIVIDER

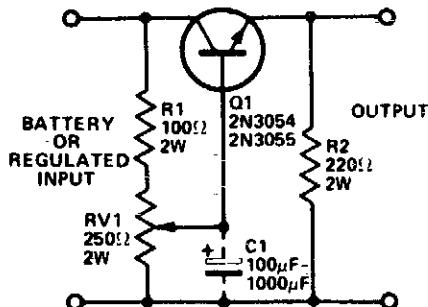


Fig. 65-5

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

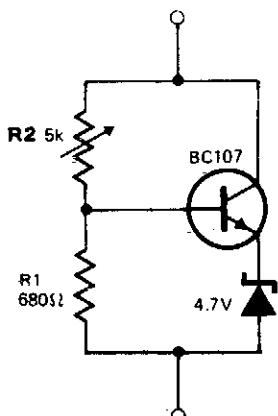
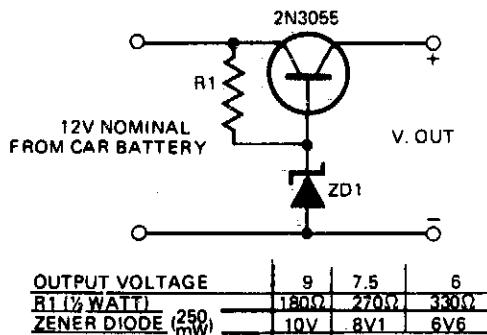


Fig. 65-6

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



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

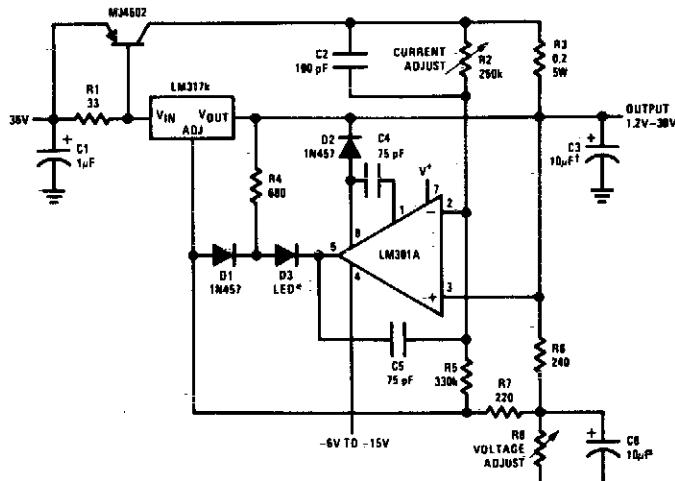
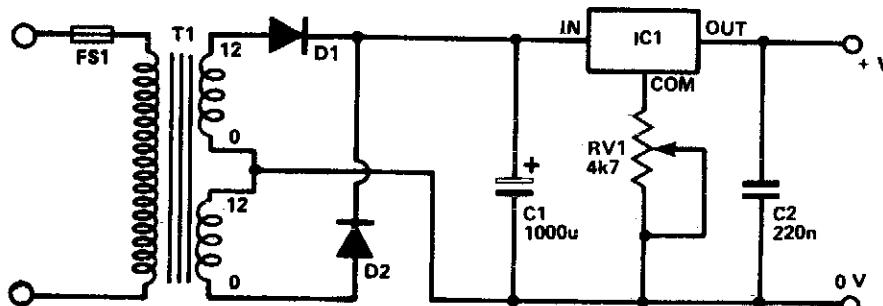


Fig. 65-8

^tSolid tantalum

*Lights in constant current mode

**POWER PACK FOR BATTERY-POWERED
CALCULATORS, RADIOS, OR CASSETTE PLAYERS**



NOTES:
IC1 IS 7805
D1,2 ARE 1N4001

Fig. 65-9

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

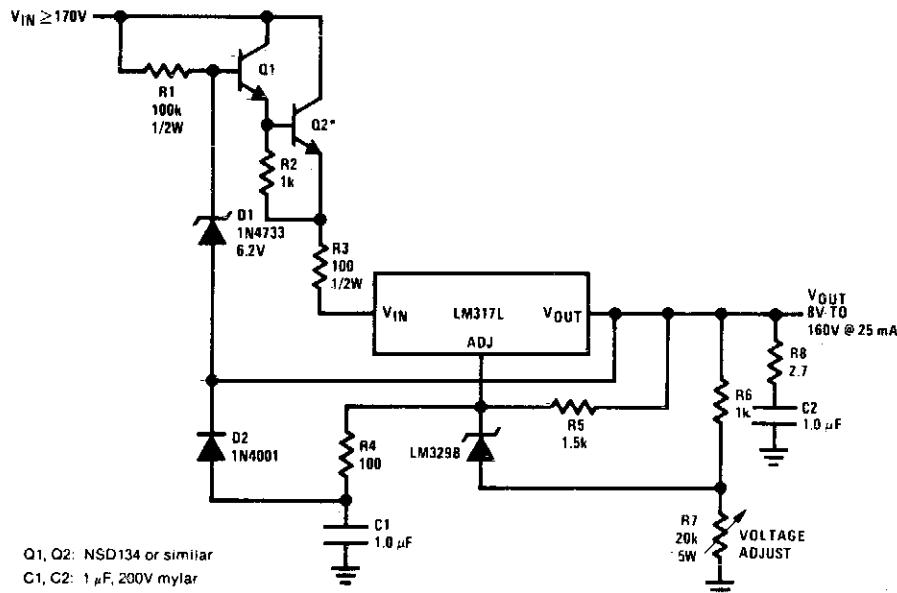


Fig. 65-10

Q1, Q2: NSD134 or similar
C1, C2: 1 μ F, 200V mylar
*Heat sink

**REMOTE SHUTDOWN REGULATOR
WITH CURRENT LIMITING
($V_{out} = 2$ TO 7 V)**

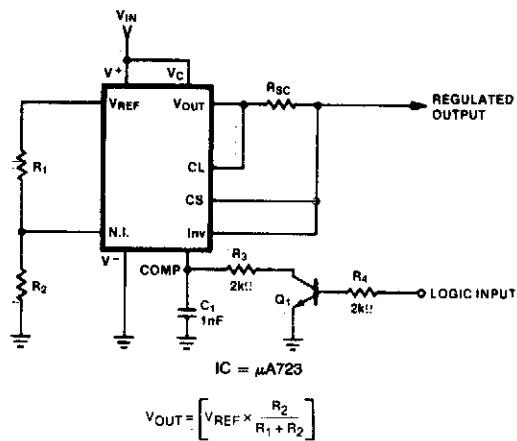


Fig. 65-11

0 TO 30 V REGULATOR

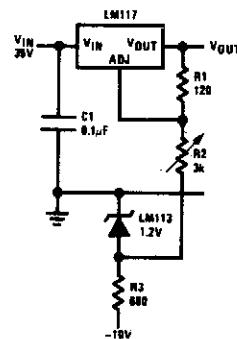
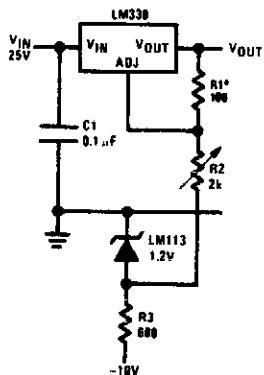


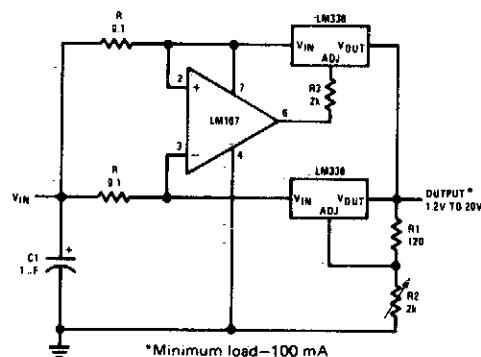
Fig. 65-13

0 TO 22 V REGULATOR



*R1=240Ω, R2 = 5k for LM138 and LM238

10 A REGULATOR



*Minimum load—100 mA

Fig. 65-12

Fig. 65-14

ADJUSTABLE REGULATOR 0-10 V AT 3 A

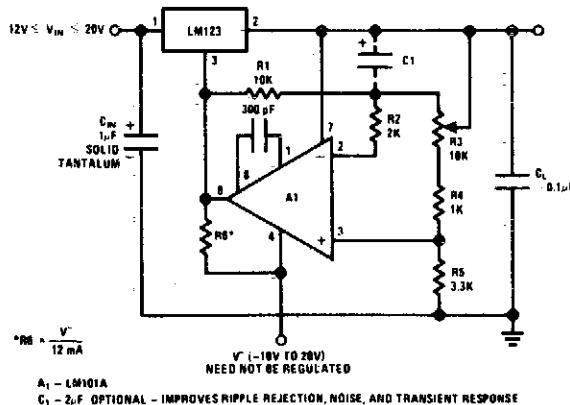
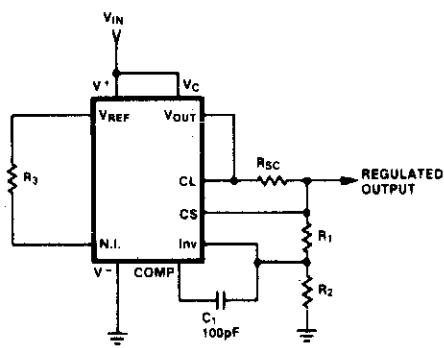


Fig. 65-15

HIGH VOLTAGE REGULATOR ($V_{out} = +7 \text{ V TO } 37 \text{ V}$)

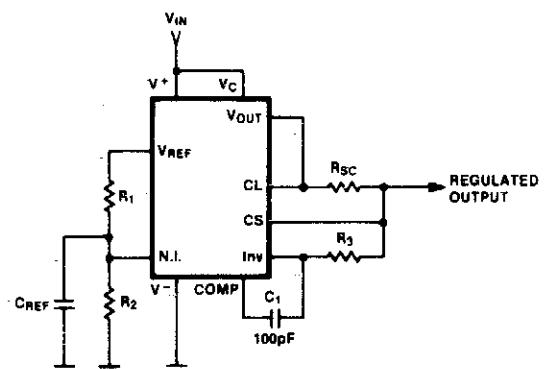


$$V_{OUT} = \left[V_{REF} \times \frac{R_1 + R_2}{R_2} \right]$$

$$R_3 = \frac{R_1 R_2}{R_1 + R_2} \text{ for minimum temperature drift}$$

R_3 may be eliminated for minimum component count

LOW VOLTAGE REGULATOR ($V_{out} = 2 \text{ TO } 7 \text{ V}$)



$$V_{OUT} = \left[V_{REF} \times \frac{R_2}{R_1 + R_2} \right]$$

$$R_3 = \frac{R_1 R_2}{R_1 + R_2} \text{ for minimum temperature drift}$$

Fig. 65-16

Fig. 65-17

SIMPLE SPLIT POWER SUPPLY

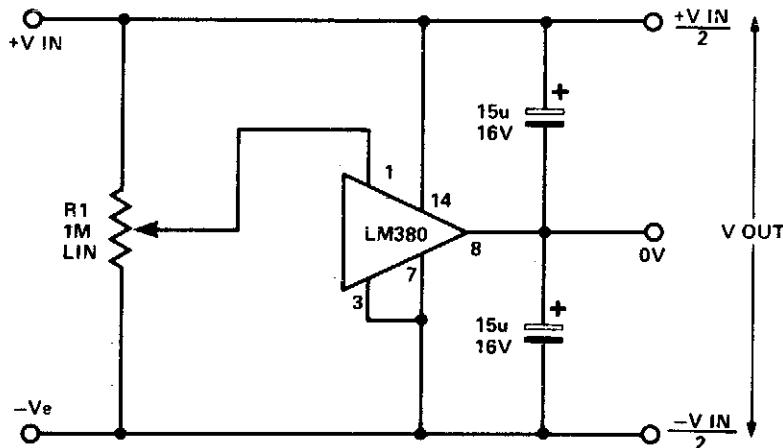


Fig. 65-18

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 shutdown 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

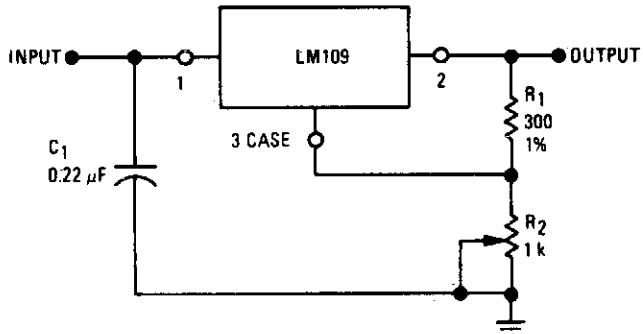
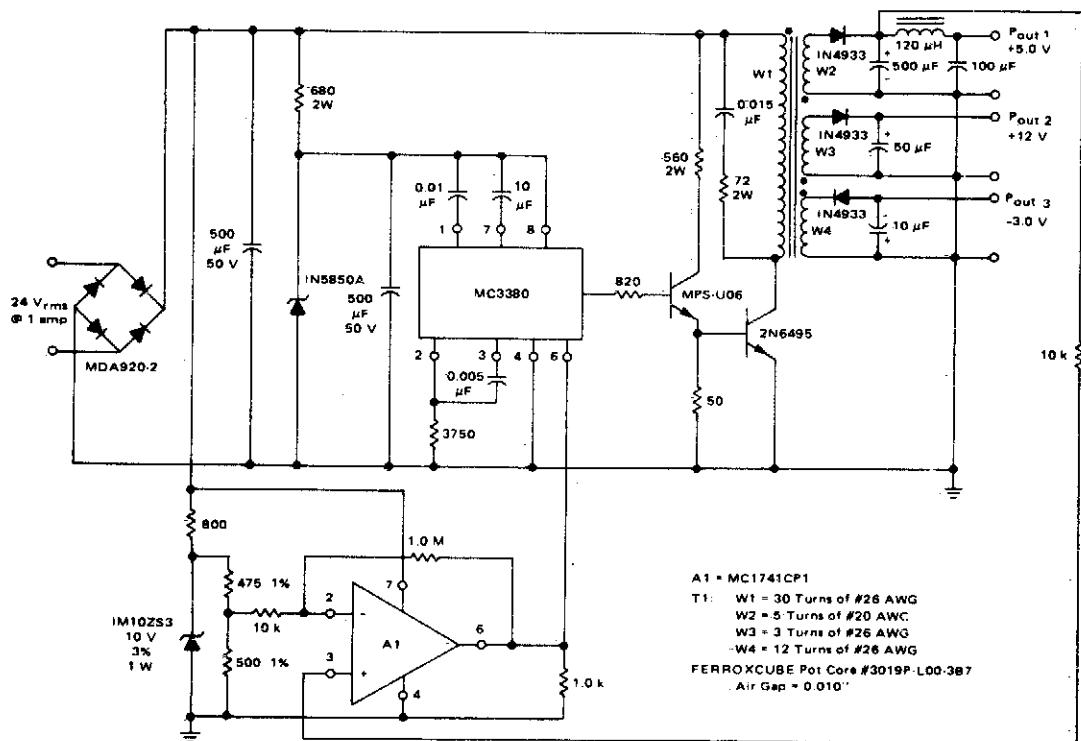


Fig. 65-19

MULTIPLE OUTPUT SWITCHING REGULATOR FOR USE WITH MPUs



TYPICAL PERFORMANCE

$P_{out1} = 4$ Watts
 $(V_O = 5 V \pm 5\%)$
 $5 V$ Ripple Component = 50 mV
 $(120 Hz \pm 20 \text{ kHz})$

$P_{out2} = 600$ mW
 $(V_O = 12 V \pm 10\%)$

$P_{out3} = 3$ mW
 $(V_O = -3 V \pm 10\%)$

A1 = MC3380P

Fig. 65-20

6.0 A VARIABLE OUTPUT SWITCHING REGULATOR

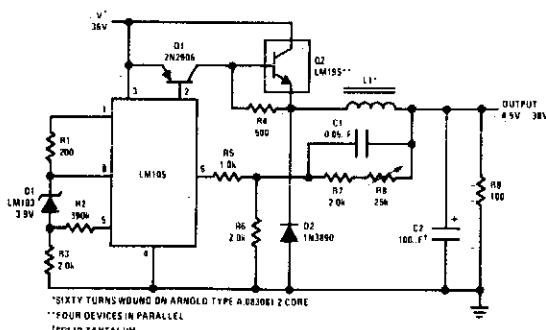


Fig. 65-21

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

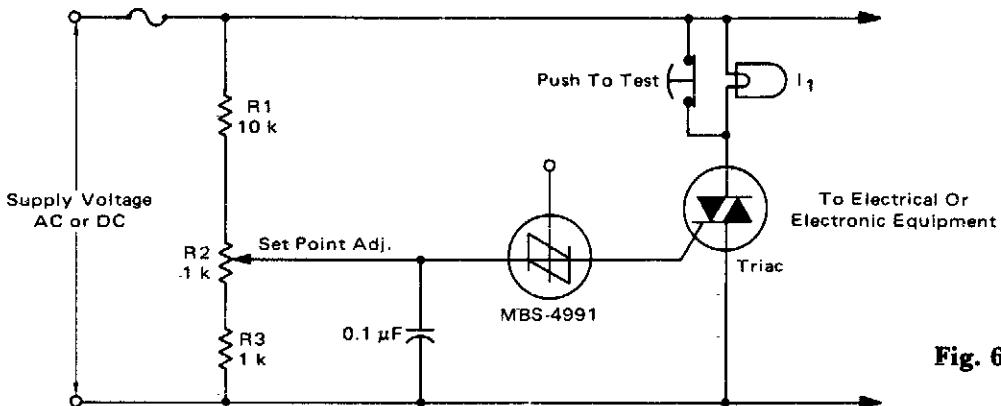


Fig. 66-1

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. If it 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

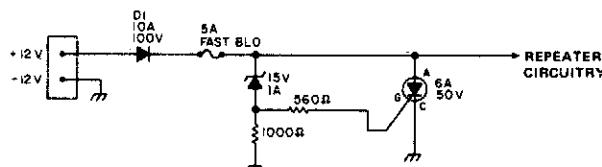


Fig. 66-2

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

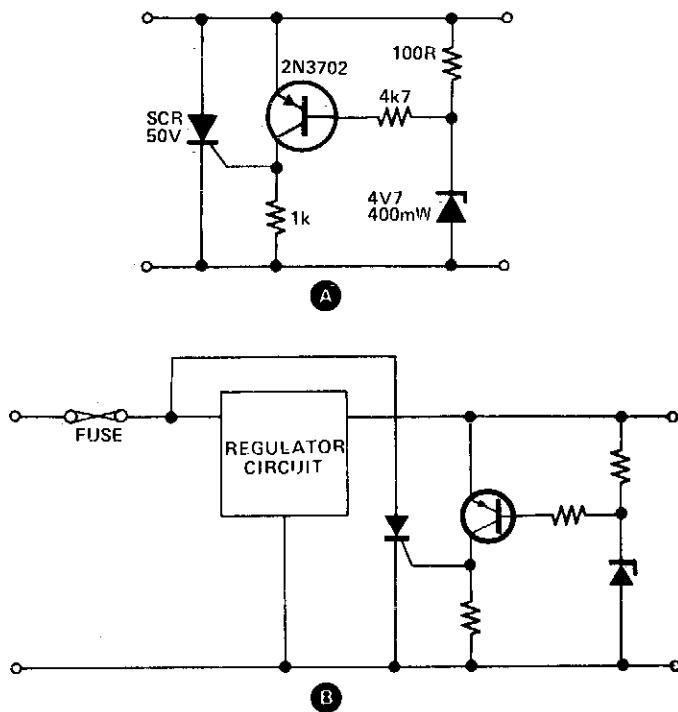


Fig. 66-3

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 diode. 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

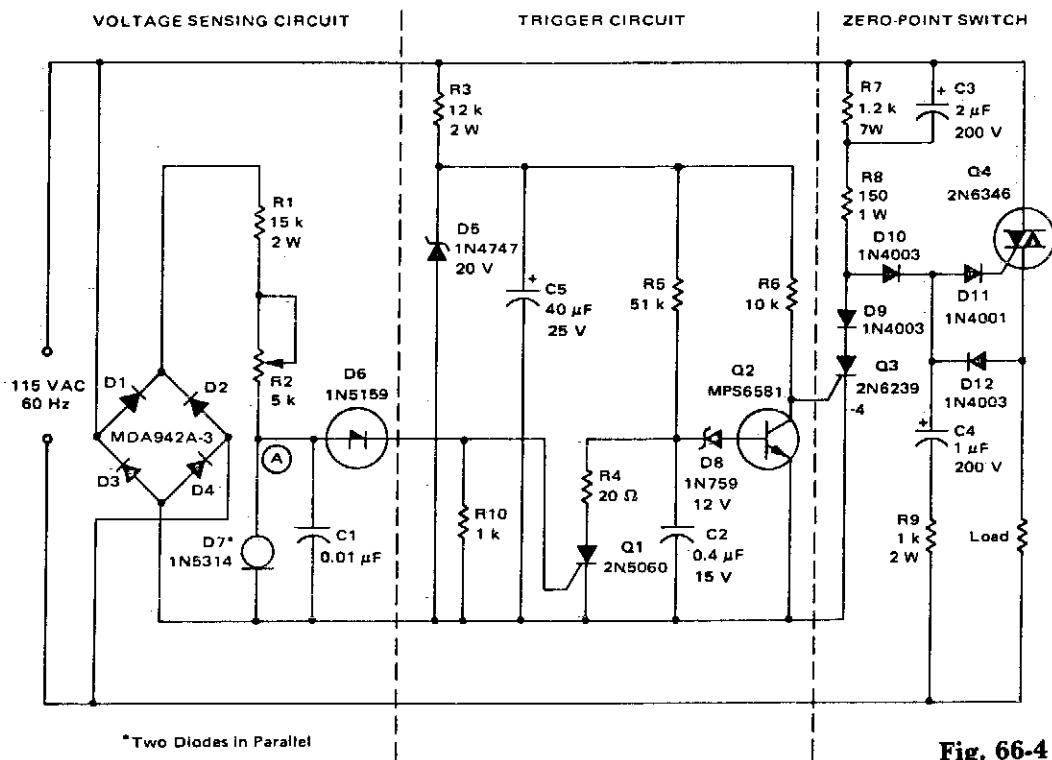


Fig. 66-4

OVERVOLTAGE PROTECTION FOR LOGIC

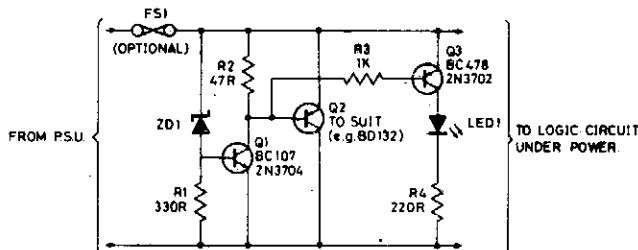


Fig. 66-5

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

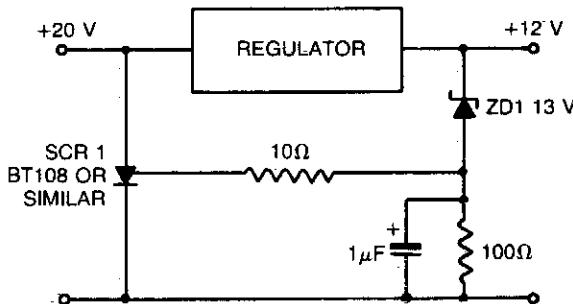


Fig. 66-6

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

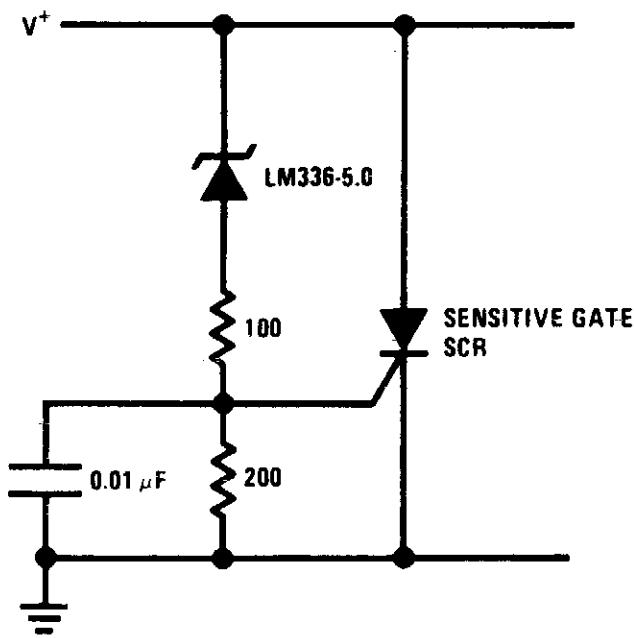


Fig. 66-7

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

Audible TTL Probe

Signal Injector/Tracer

Logic Probe

Injector/Tracer

Logic Test Probe with Memory

CMOS Logic Probe

Logic Probe

RF Probe for VOM

Simple Logic Probe

100 K Megohm DC Probe

Audio-RF Signal Tracer Probe

TTL Logic Tester

LOGIC PROBE YIELDS THREE DISCRETE STATES

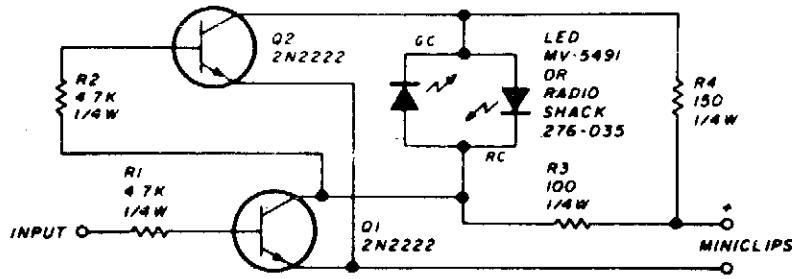


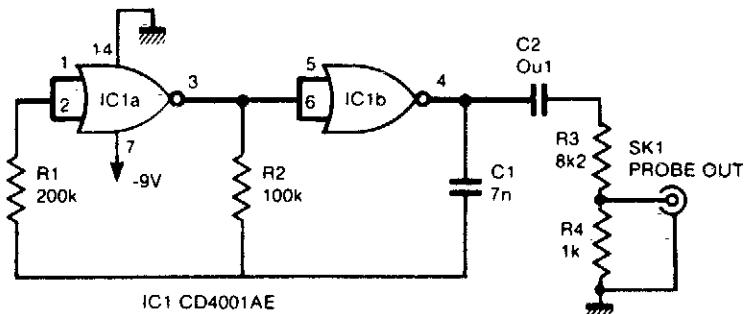
Fig. 67-1

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

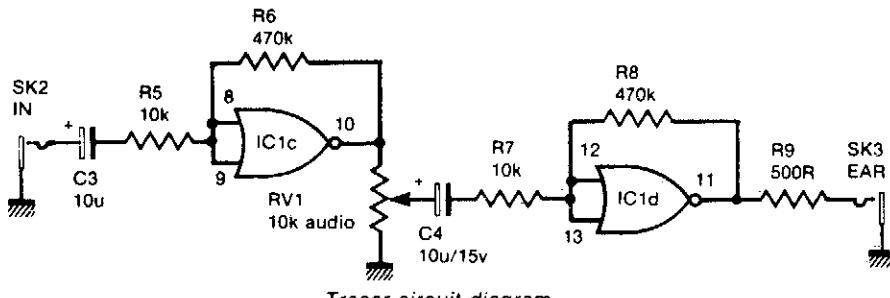
Q1 and Q2 to complement, and the red diode will be forward biased, yielding a red output from the LED. An alternating signal will cause alternating conduction of the red and green diodes and will yield an indication approximately amber. In this manner, both static and dynamic signals can be traced with 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 $1.4 \times C_1 \times R_2$ 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

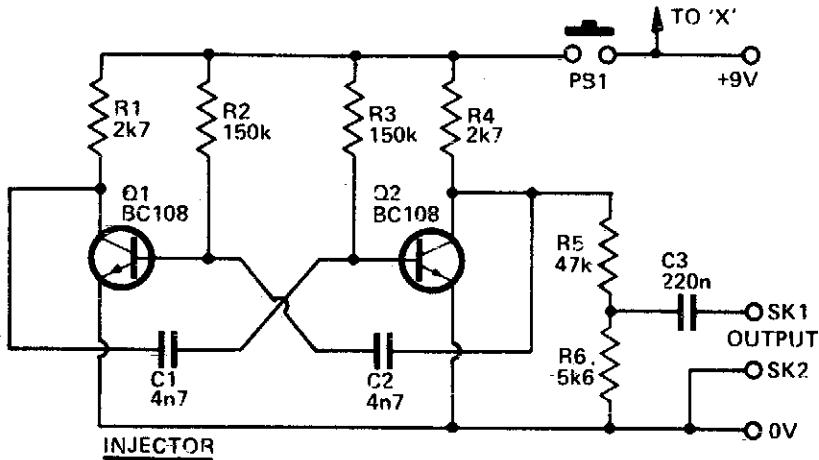
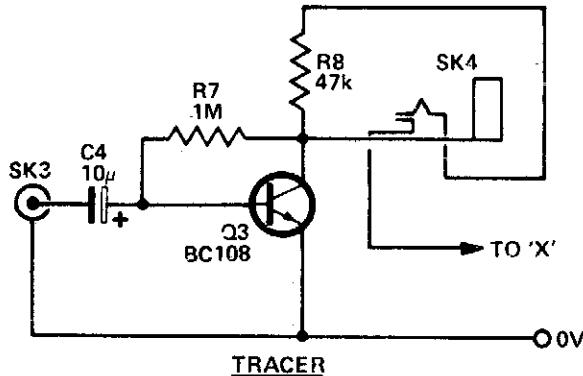


Fig. 67-3



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

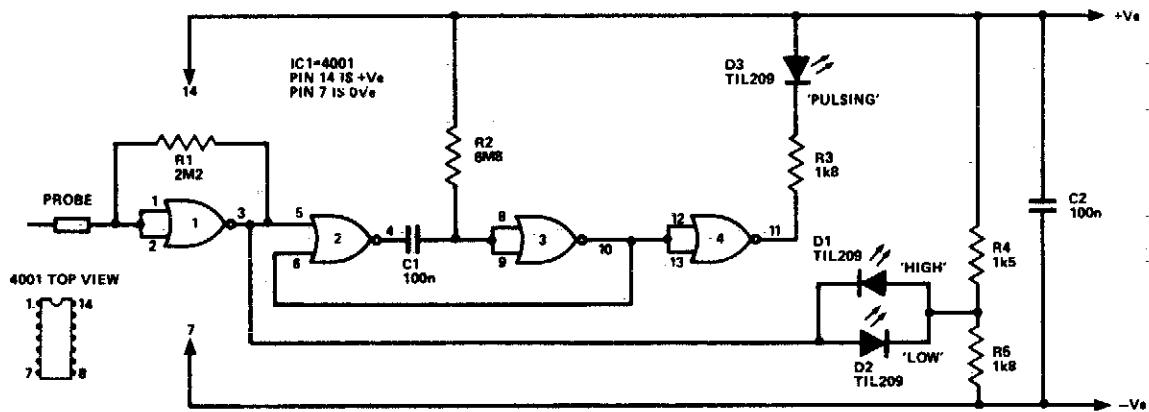


Fig. 67-4

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-uF, disc capacitor
D1—1N4149 diode
R1—15,000-ohm, $\frac{1}{2}$ -watt resistor

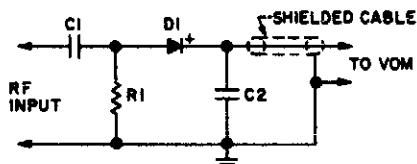


Fig. 67-5

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

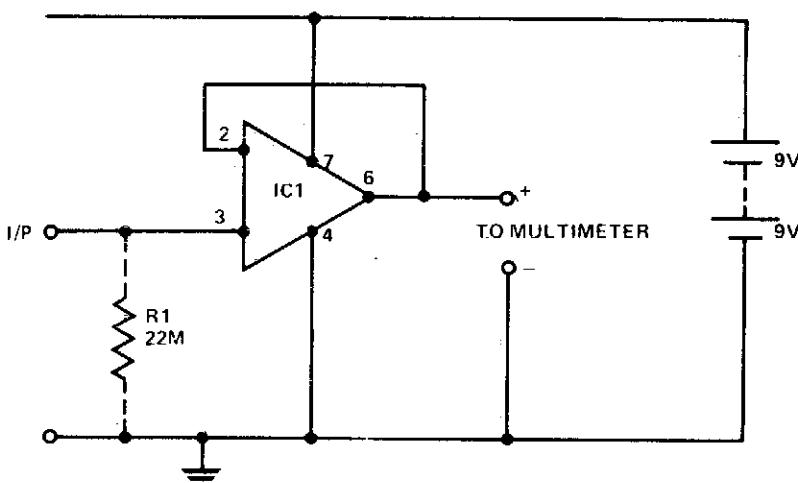


Fig. 67-6

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

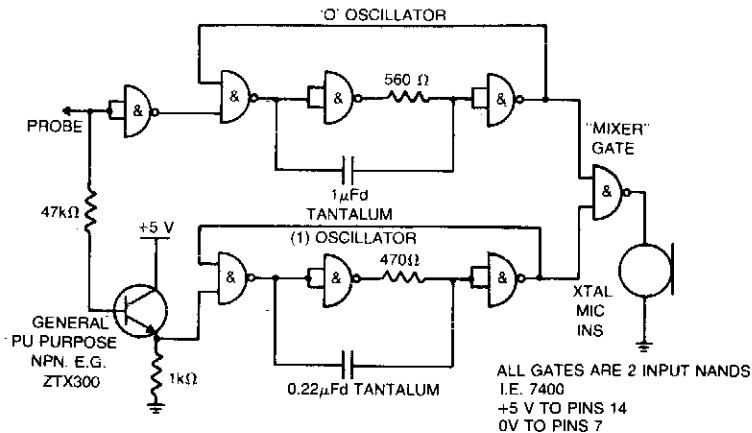


Fig. 67-7

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

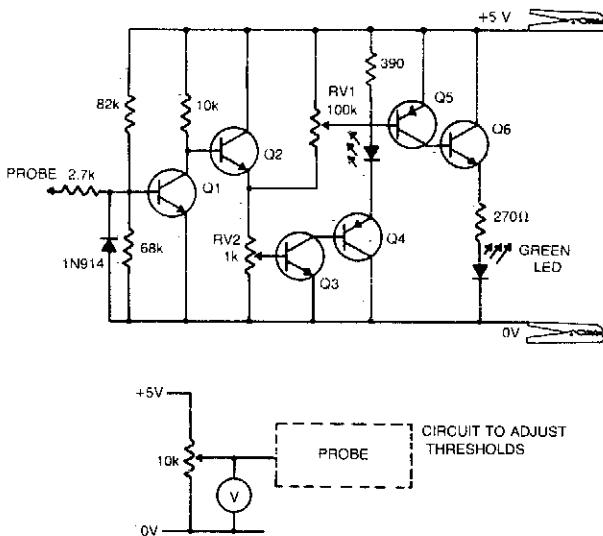


Fig. 67-8

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

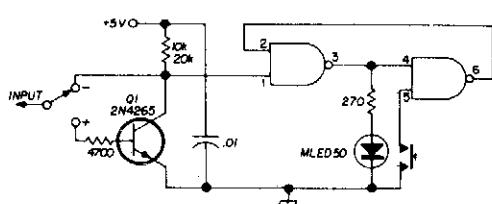


Fig. 67-9

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

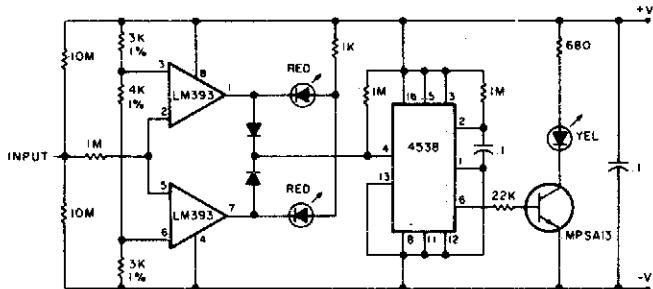


Fig. 67-10

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

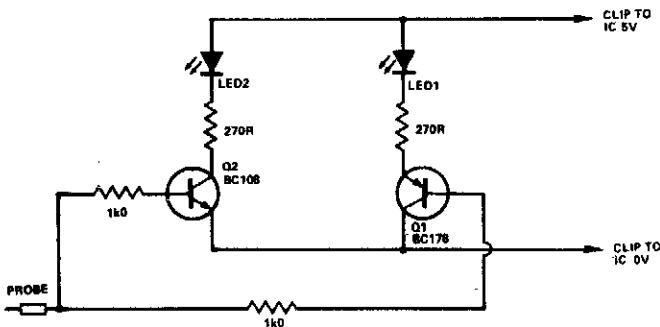
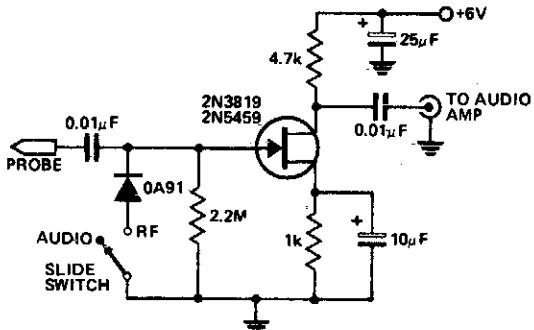


Fig. 67-11

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

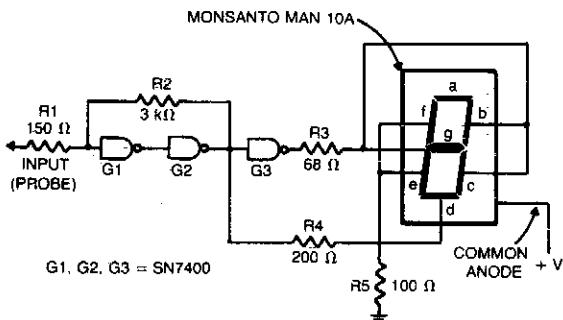


Fig. 67-13

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

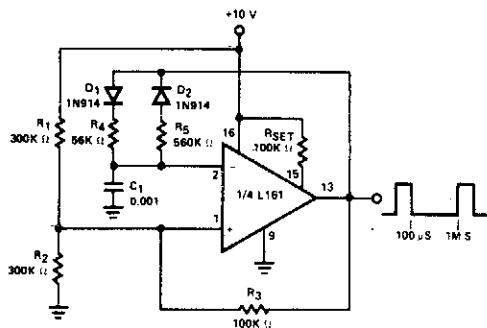


Fig. 68-1

Circuit Notes

The duty cycle of the output pulse is equal to $R_4/(R_4 + R_5) \times 100\%$. For duty cycles of less than 50%, D1 can be eliminated and R2 raised according to the following formula:

$$R_4(\text{actual}) = \frac{R_5 \times R_4(\text{eff})}{R_5 - R_4(\text{eff})}$$

$R_4(\text{eff})$ is the effective value of R_4 in the circuit and $R_4(\text{actual})$ is the actual value used; $R_4(\text{actual})$ will always be larger than $R_4(\text{eff})$.

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.

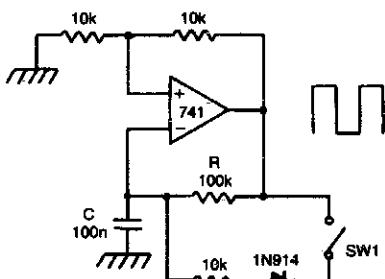


Fig. 68-2

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.

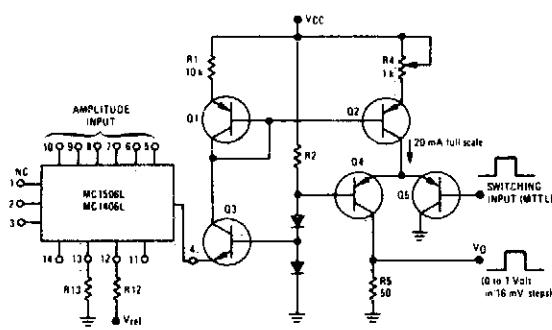


Fig. 68-3

UNIJUNCTION TRANSISTOR PULSE GENERATORS

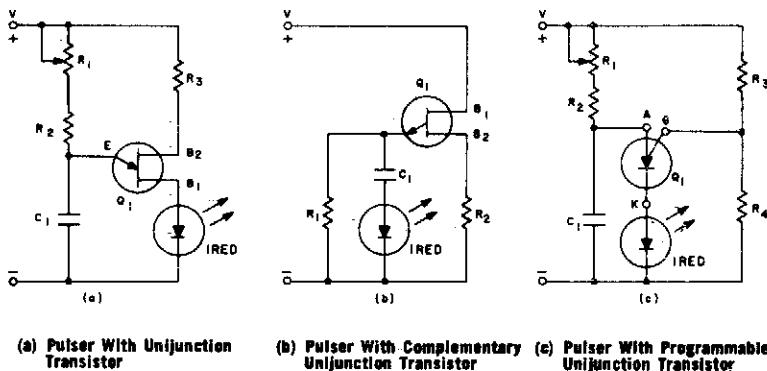


Fig. 68-4

PULSE GENERATOR

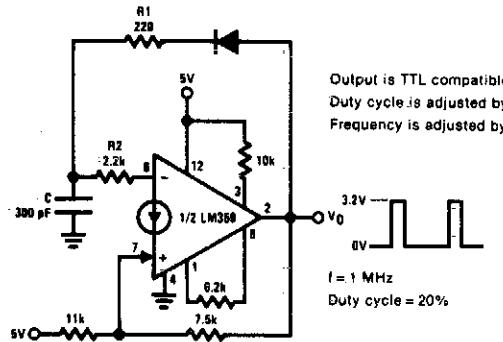


Fig. 68-5

PULSE GENERATOR

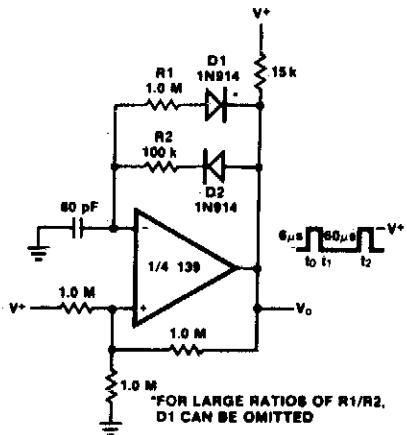


Fig. 68-6

FREE-RUNNING OSCILLATOR

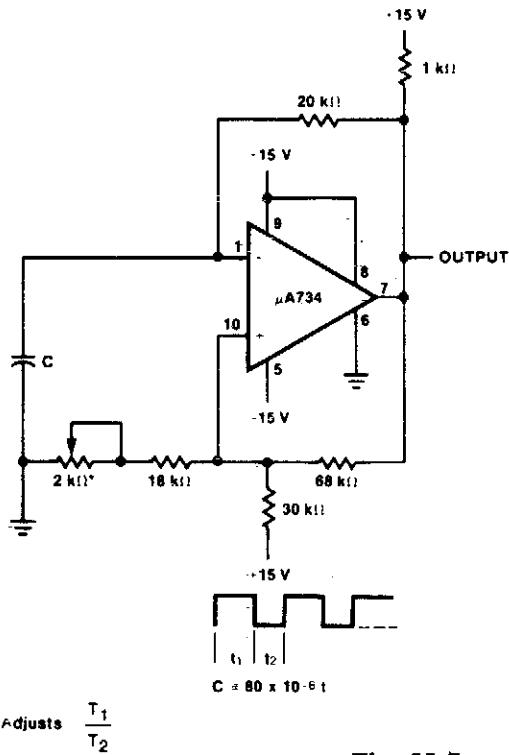


Fig. 68-7

PULSE GENERATOR

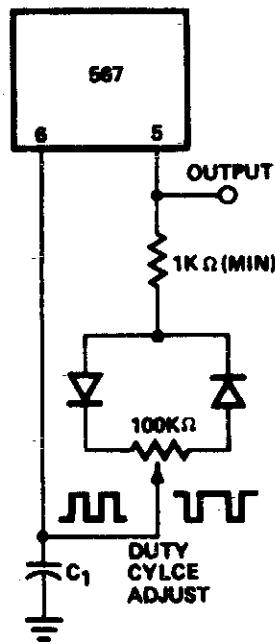


Fig. 68-9

PULSE GENERATOR WITH 25% DUTY CYCLE

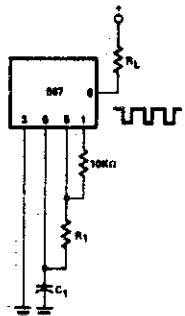
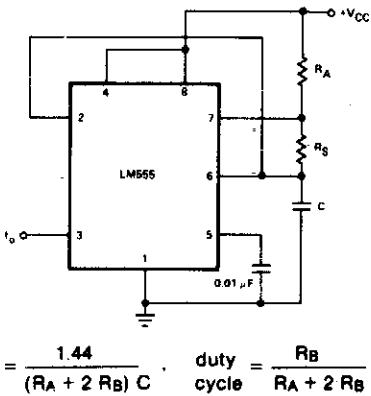


Fig. 68-8

555 TIMER OSCILLATOR



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

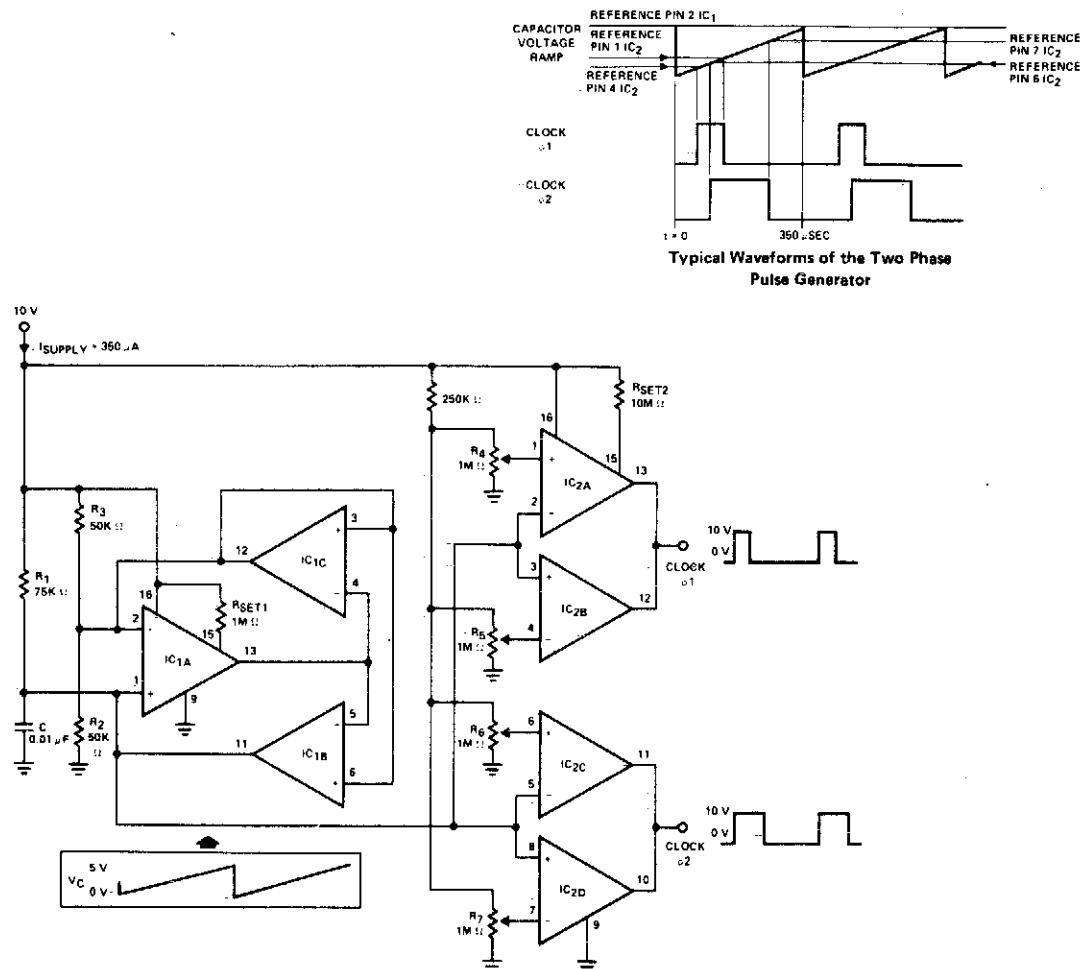


Fig. 68-11

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

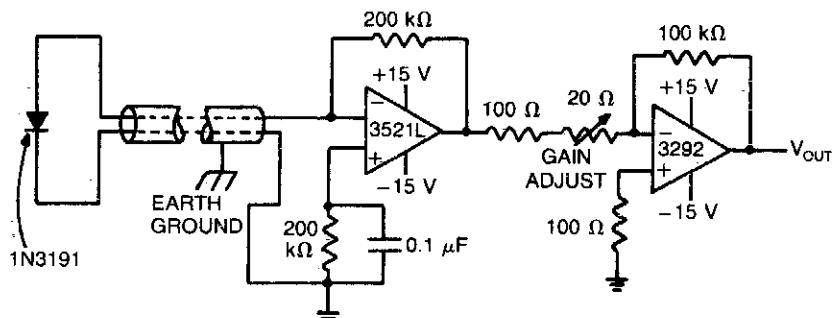
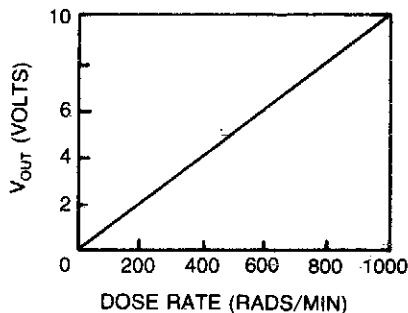


Fig. 69-1



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

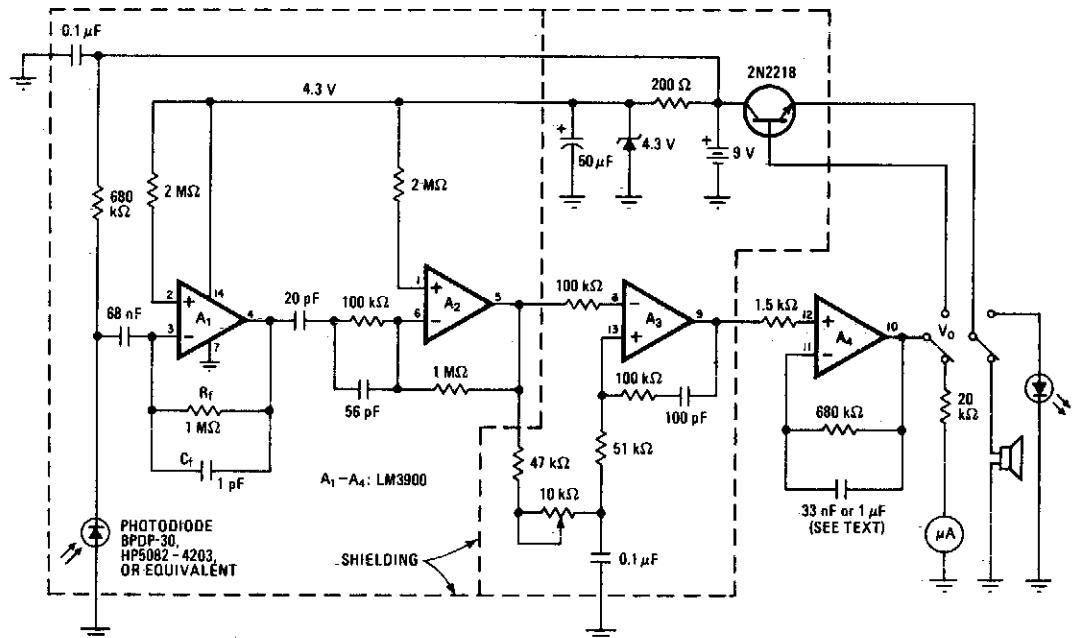


Fig. 69-2

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

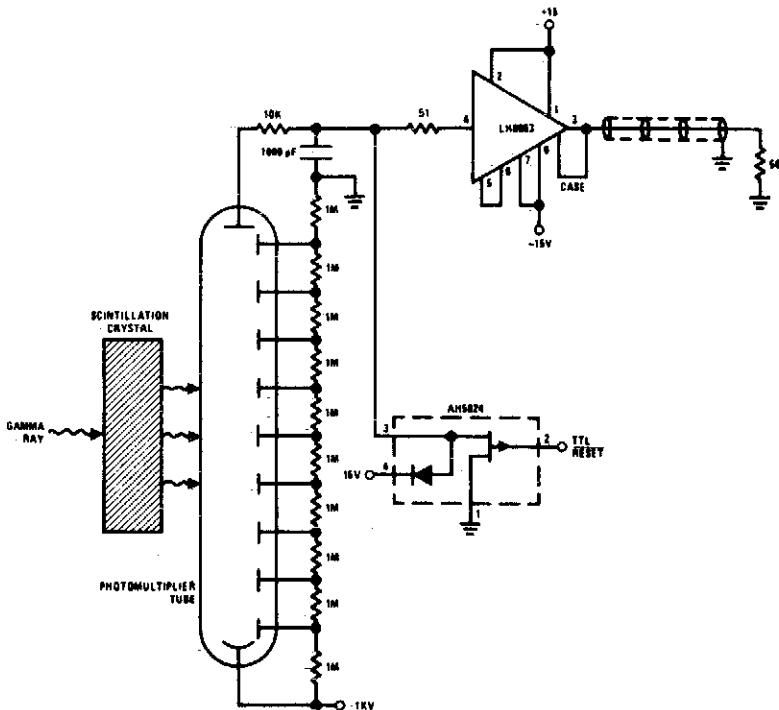


Fig. 69-3

SENSITIVE GEIGER COUNTER

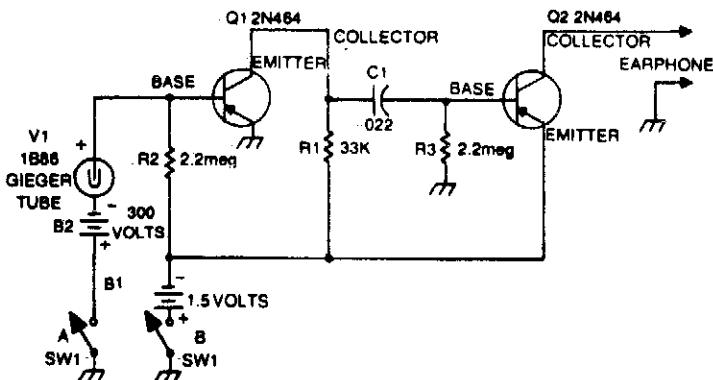


Fig. 69-4

GEIGER COUNTER

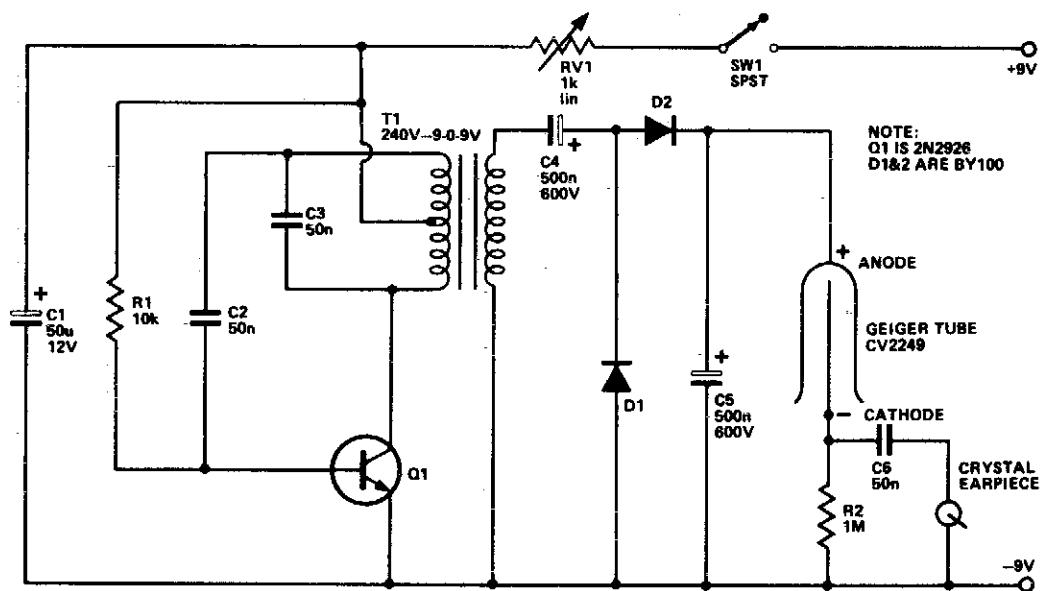


Fig. 69-5

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.

NUCLEAR PARTICLE DETECTOR

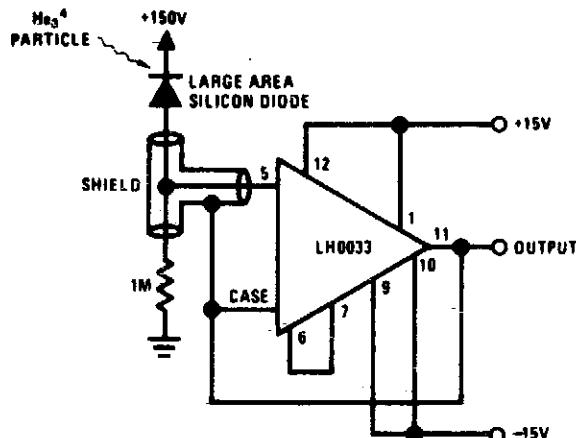


Fig. 69-6

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

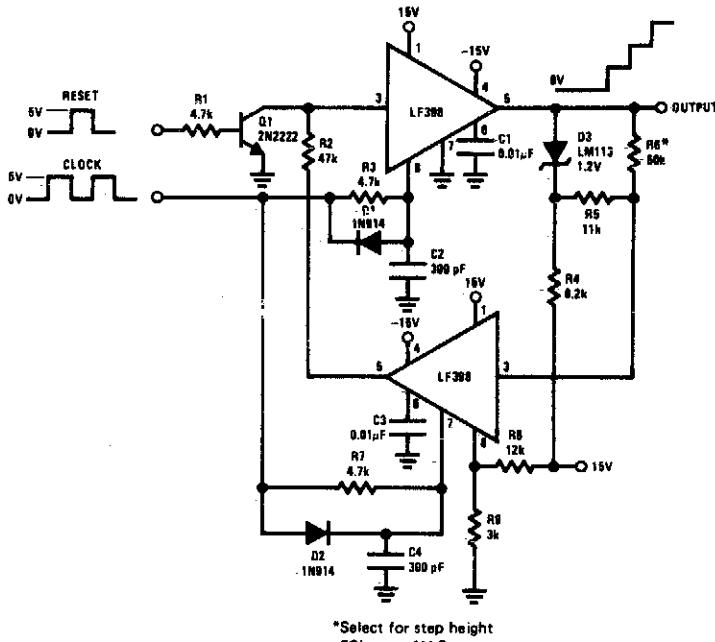


Fig. 70-1

LINEAR VOLTAGE RAMP GENERATOR

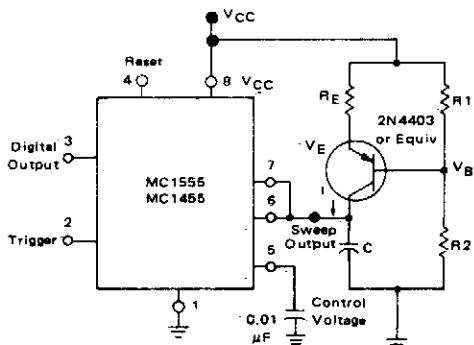


Fig. 70-2

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

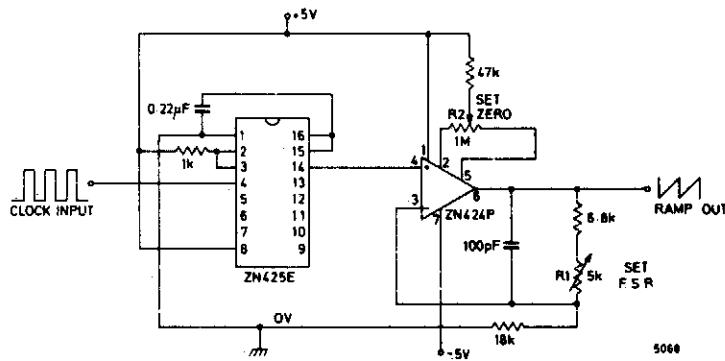


Fig. 70-3

RAMP GENERATOR WITH VARIABLE RESET LEVEL

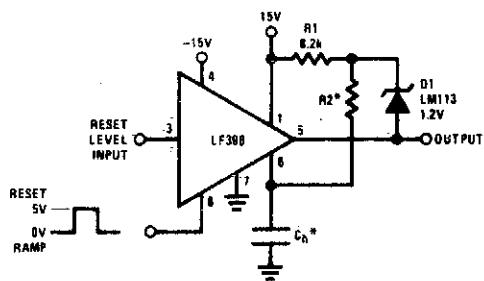


Fig. 70-4

$$\text{Select for ramp rate } R \geq 10k \quad \frac{\Delta V}{\Delta T} = \frac{1.2V}{(R2)(C_h)}$$

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

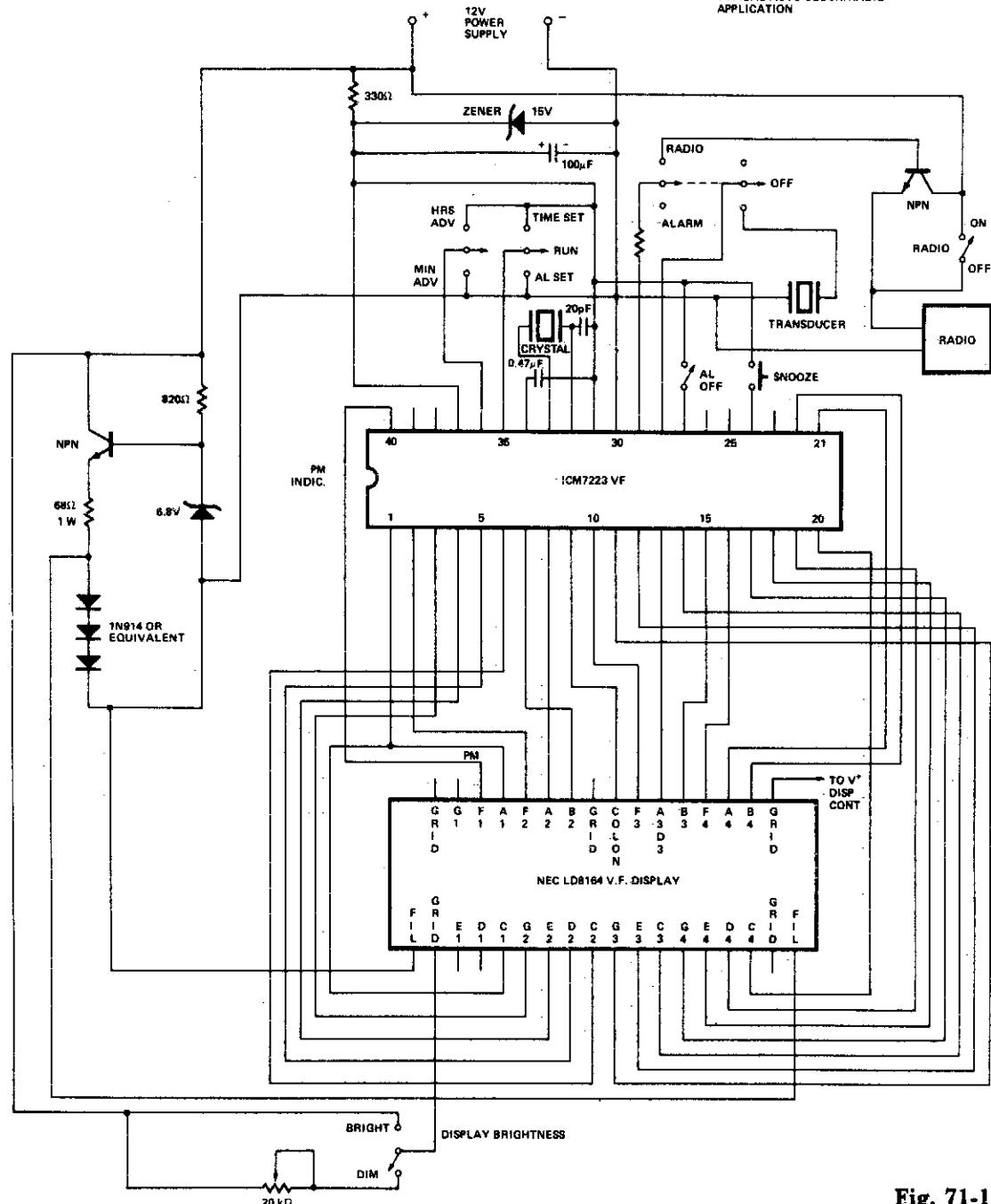


Fig. 71-1

AM/FM CLOCK RADIO

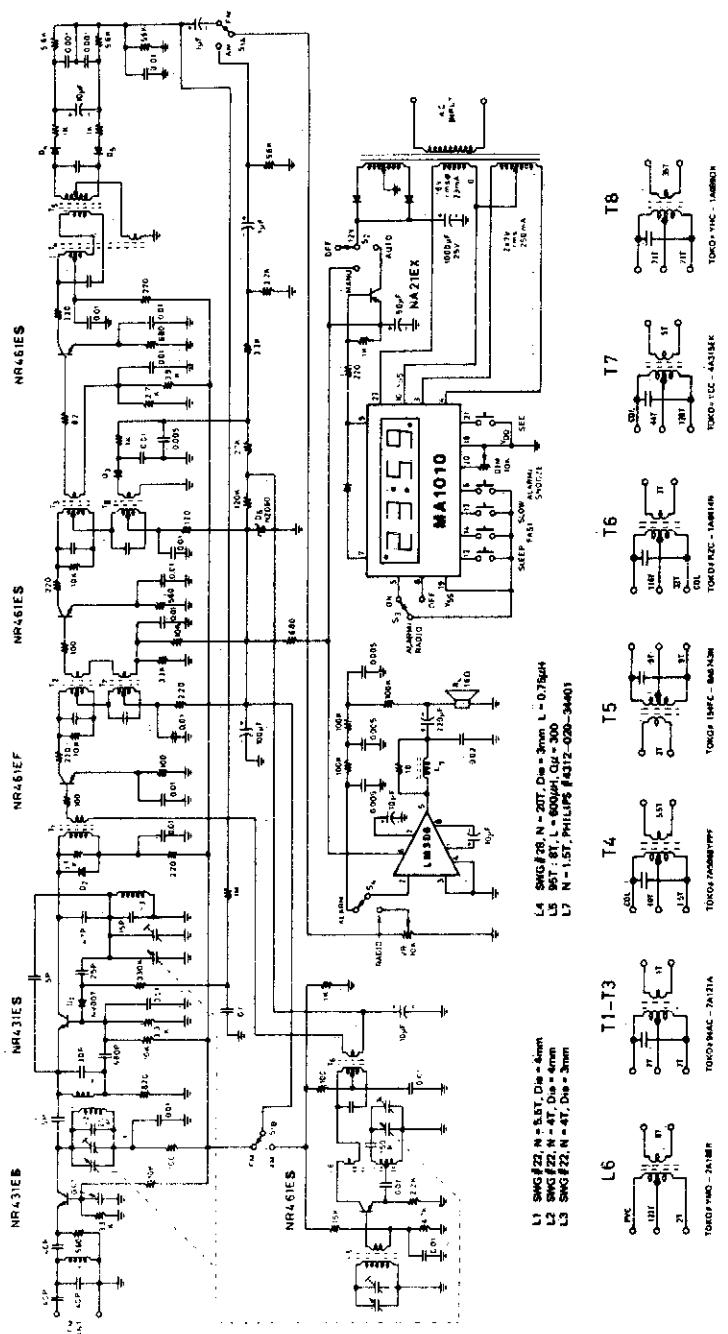


Fig. 71-2

AM RADIO

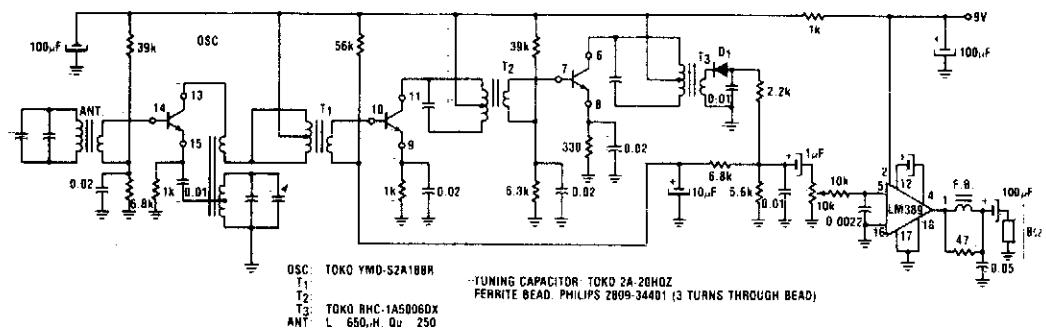


Fig. 71-3

FM STEREO DEMODULATION SYSTEM

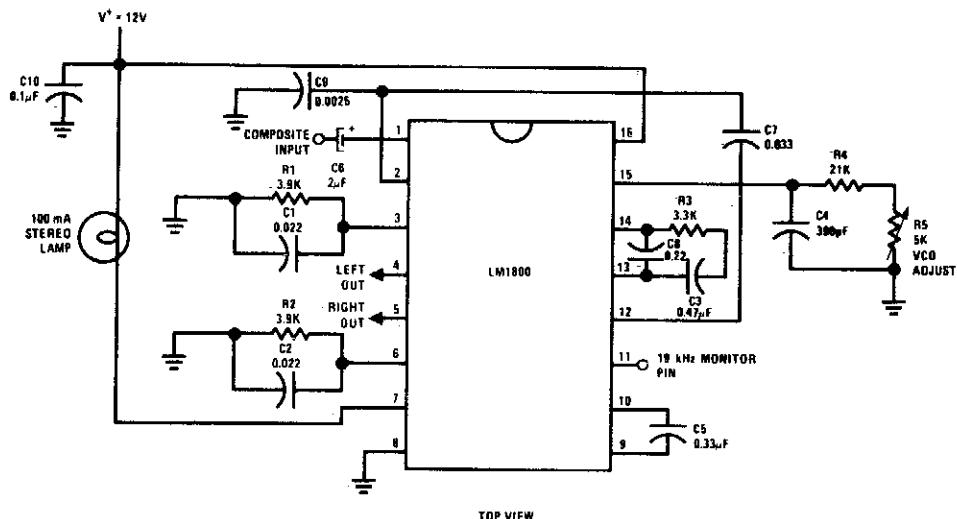


Fig. 71-4

ANALOG RECEIVER (LOW TEMPERATURE DRIFT)

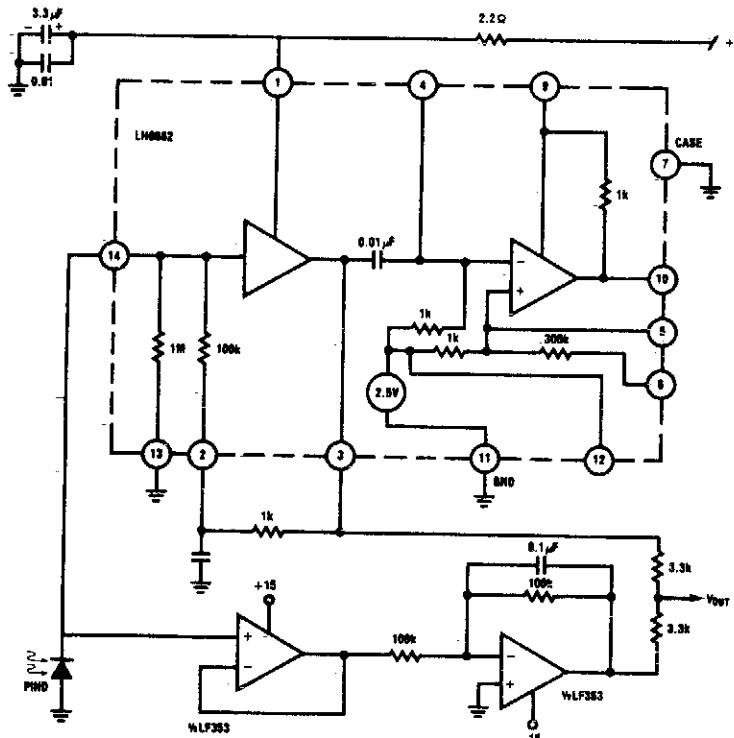


Fig. 71-5

FM RADIO

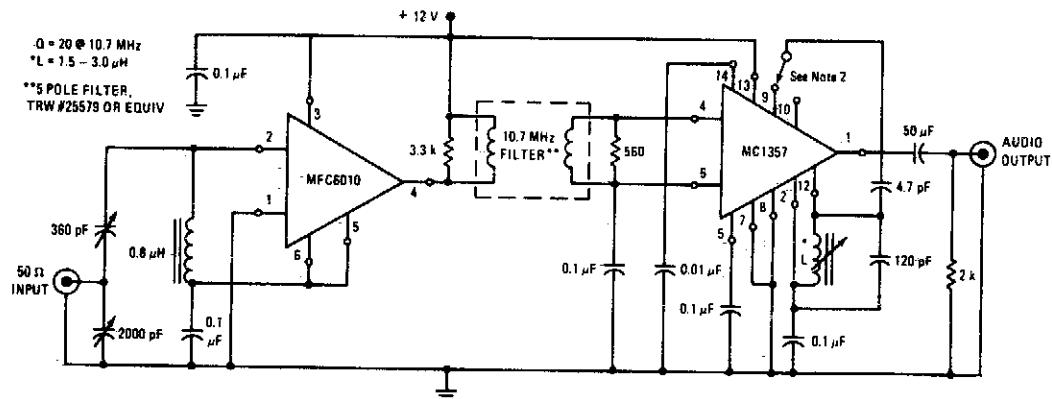


Fig. 71-6

SIMPLE LF CONVERTER

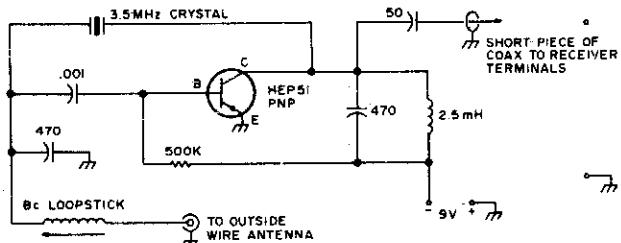


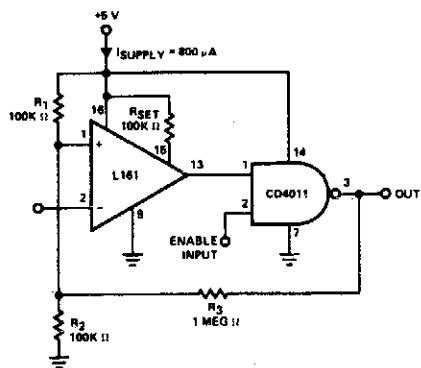
Fig. 71-7

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 fre-

quency 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

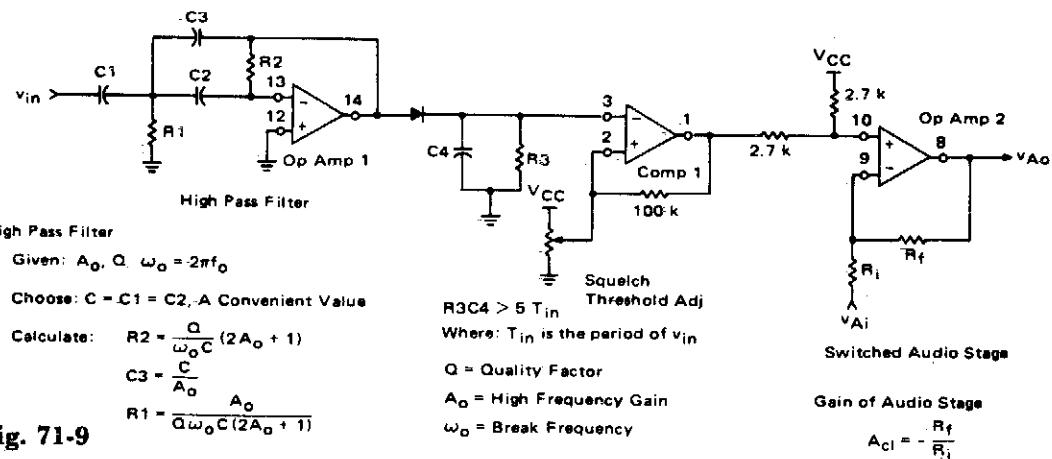


Fig. 71-9

VLF CONVERTER

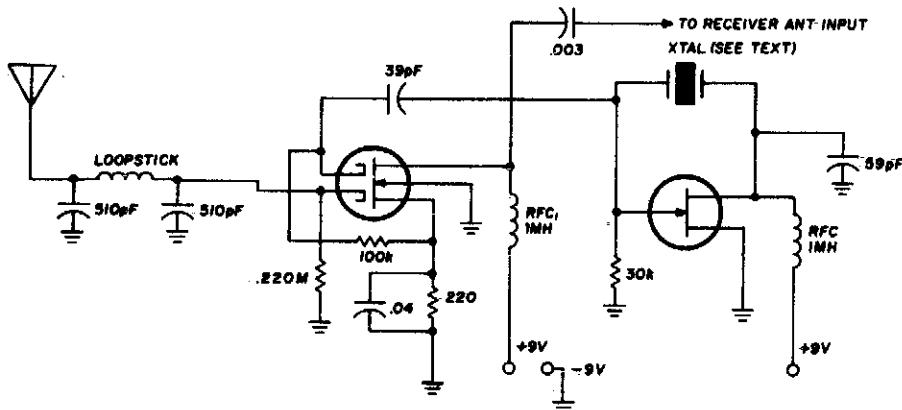


Fig. 71-10

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.)

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

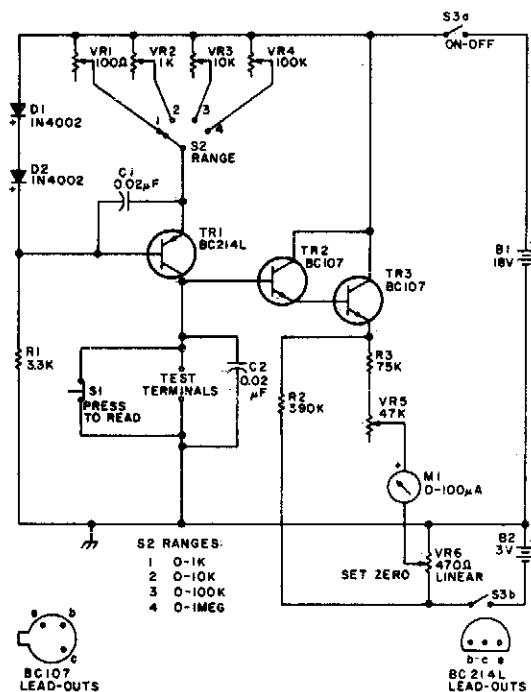
Low Resistance Continuity Tester

"Buzz Box" Continuity and Coil Checker

Linear Scale Ohmmeter

Bridge Circuit

LINEAR SCALE OHMMETER



Circuit Notes

This circuit is designed to provide accurate measurement and a linear resistance scale at the high end. The circuit has four ranges. Another meter with a current range of $10 \mu\text{A}$ to 10 mA and sensitivity of 10,000 ohms per volt is needed for setting up.

Fig. 72-1

OHMMETER

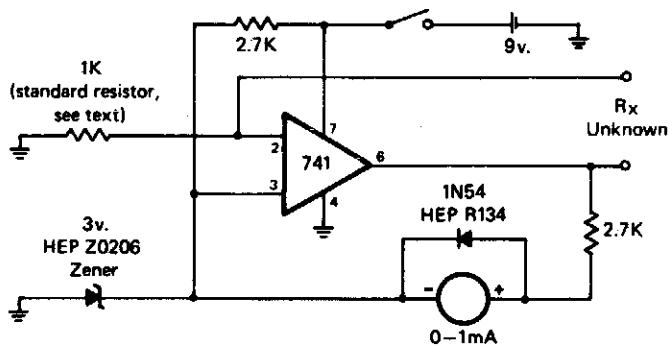


Fig. 72-2

Circuit Notes

This circuit has a linear reading scale, requires no calibration, and requires no zero adjustment. It may be made multirange by switching in different standard resistors.

LOW PARTS COUNT RATIO METRIC RESISTANCE MEASUREMENT

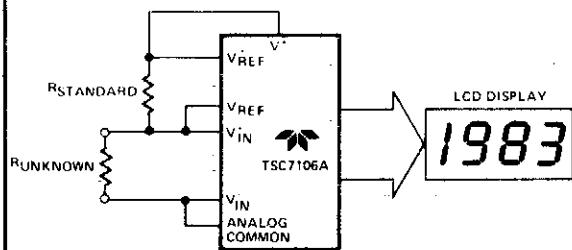
Circuit Notes

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

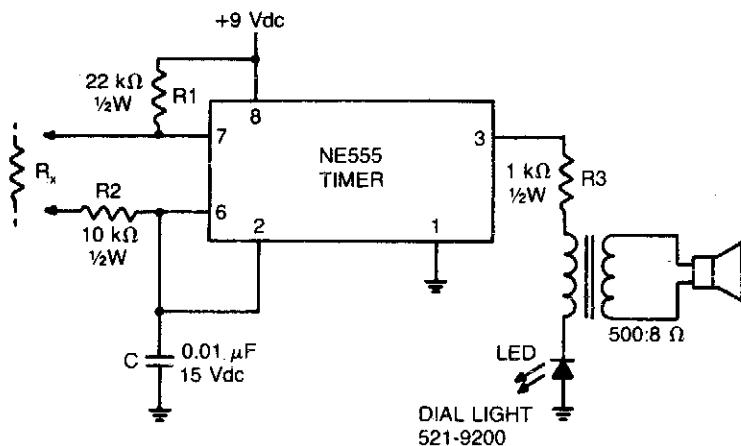


Fig. 72-4

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

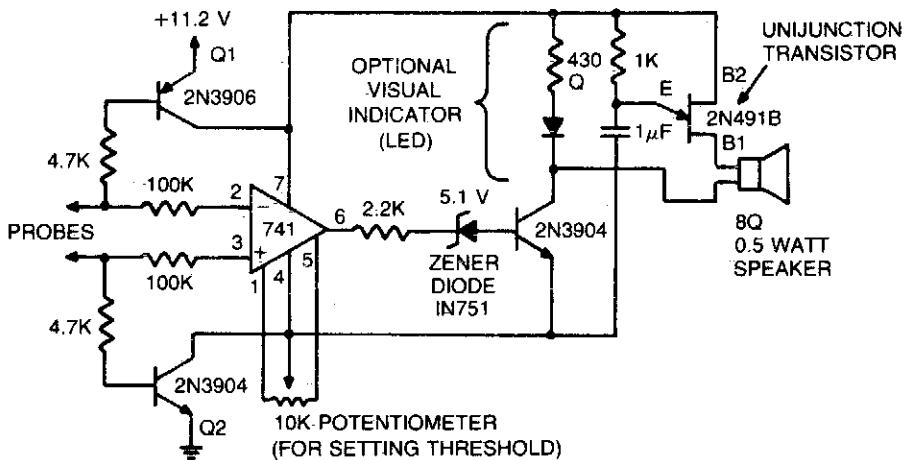


Fig. 72-5

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

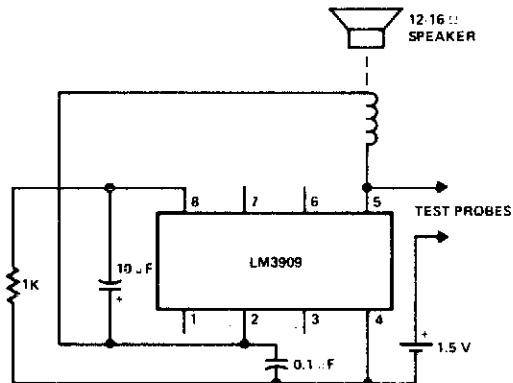


Fig. 72-6

Circuit Notes

Differences between shorts, coils, and a few ohms of resistance can be heard.

LINEAR SCALE OHMMETER

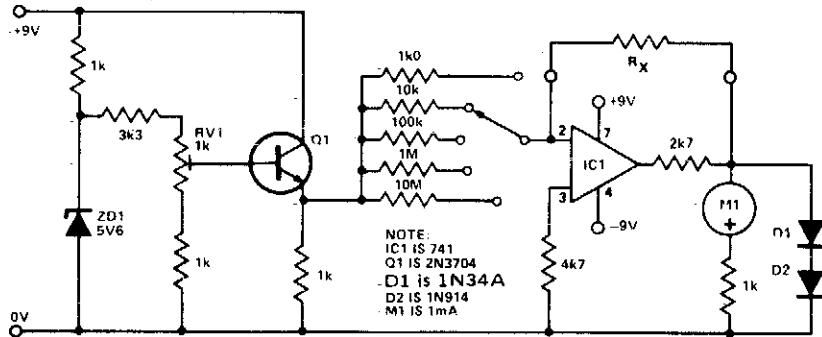


Fig. 72-7

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 RV_1 is adjusted for full scale deflection.

BRIDGE CIRCUIT

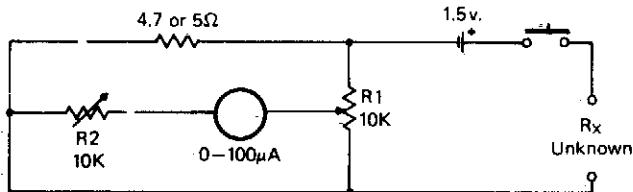


Fig. 72-8

Circuit Notes

For measurement of resistances from about 5 ohms down to about 1/10 ohm.

73

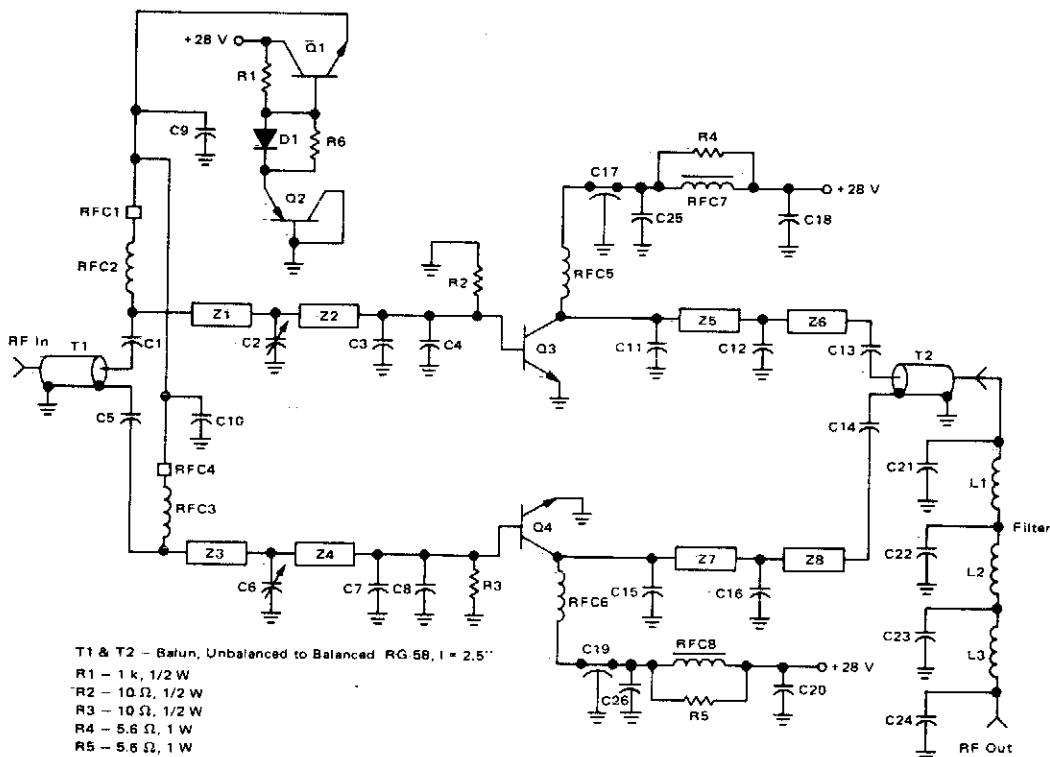
RF Amplifiers

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, $l = 2.5''$
 R1 - 1 k, 1/2 W
 R2 - 10 Ω , 1/2 W
 R3 - 10 Ω , 1/2 W
 R4 - 5.6 Ω , 1 W
 R5 - 5.6 Ω , 1 W
 R6 - 2.7 Ω , 1/4 W

Z1 & Z3 - Microstrip - $W = 200$ mils, $l = 1.8''$
 Z2 & Z4 - Microstrip - $W = 200$ mils, $l = 300$ mils
 Z5 & Z6 - Microstrip - $W = 150$ mils, $l = 300$ mils
 Z7 & Z8 - Microstrip - $W = 150$ mils, $l = 1.4''$
 RFC1, 4 - Ferroxolute Bead 56-590-65-38
 RFC2, 3 - 0.15 μ H Cambion Molded Coil
 RFC5, 6 - 1 Turn #20 Enamelled Wire Wound on 5/16" Bolt
 RFC7, 8 - VK200 20/48
 C1, 3, 4, 5, 7, 8, 11, 15 - Underwood 40 pF
 C12, 16 - Underwood 25 pF
 C13, 14, 22, 23 - Underwood 15 pF
 C9, 10, 18, 20 - 1 μ F Tantalum

C21, 24 - Underwood 10 pF
 C2, 6 - Arco 403
 C17, 19 - Underwood J102, 1000 pF Feed Thru
 C25, 26 - 0.1 μ F, 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, $cR \approx 5$, $t = 0.062''$, $l = 8.0''$, $W = 4.0''$
 Q1 - 2N5192
 Q2 - 2N5194
 Q3 - MRF309
 Q4 - MRF309
 D1 - 1N4001

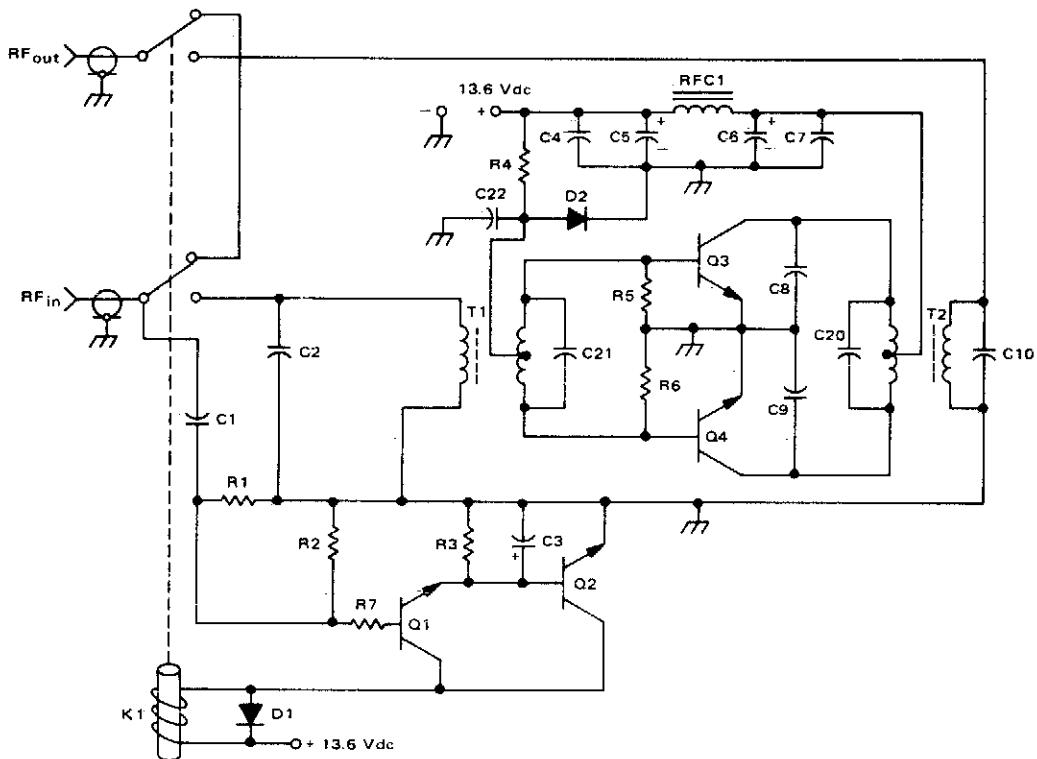
Fig. 73-1

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
C2 = .18 pF Dipped Mica
C3 = 10 μ F 35 Vdc for AM operation,
100 μ F 35 Vdc for SSB operation.
C4 = .1 μ F Erie
C5 = 10 μ F 35 Vdc Electrolytic
C6 = 1 μ F Tantalum
C7 = .001 μ F Erie Disc
C8, 9 = 330 pF Dipped Mica
R1 = 100 k Ω 1/4 W Resistor
R2, 3 = 10 k Ω 1/4 W Resistor
R4 = 33 Ω 5 W Wire Wound Resistor
R5, 6 = 10 Ω 1/2 W Resistor

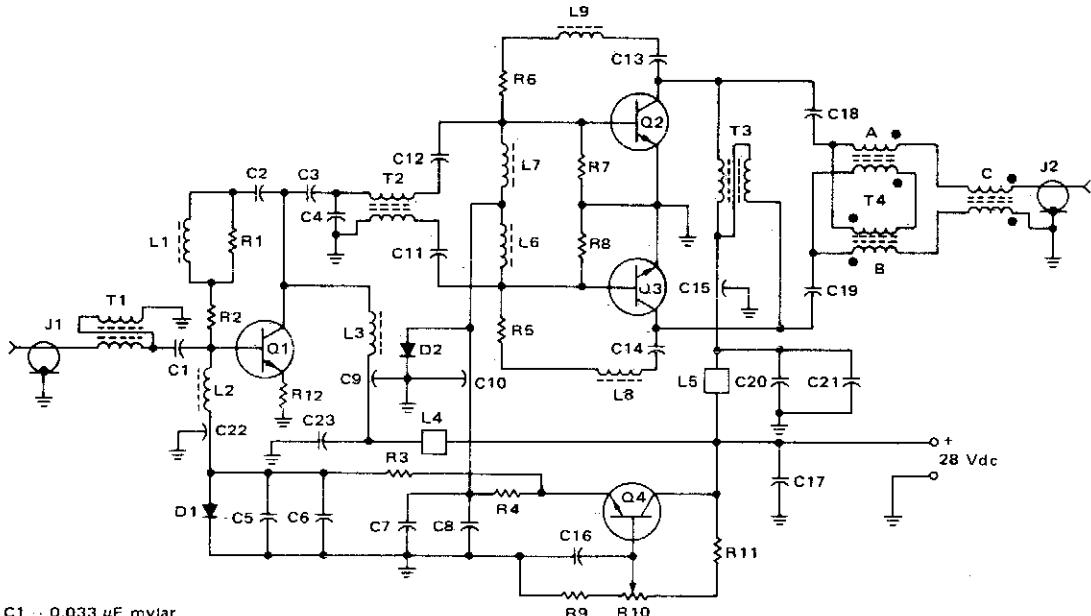
R7 = 100 Ω 1/4 W Resistor
RFC1 = 9 Ferroxcube Beads on #18 AWG Wire
D1 = 1N4001
D2 = 1N4997
Q1, Q2 = 2N4401
Q3, 4 = MRF454
T1, T2 = 16:1 Transformers
C20 = 910 pF Dipped Mica
C21 = 1100 pF Dipped Mica
C10 = 24 pF-Dipped Mica
C22 = 500 μ F 3 Vdc Electrolytic
K1 = Potter & Brumfield
 KT11A 12 Vdc Relay 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 (6.5.1 Ω or 4.3.3 Ω 1/4 W resistors in parallel, divided equally between both emitter leads)

T1 - 4:1 Transformer, 6 turns, 2 twisted pairs of #26 AWG enameled wire (8 twists per inch)

T2 - 1:1 Balun, 6 turns, 2 twisted pairs of #24 AWG 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

Q1 - 2N6370

L2, L6, L7 - 10 μ H, molded choke

Q2, Q3 - 2N5942

L3 - 1.8 μ H (Ohmite 2-144)

Q4 - 2N5190

L4, L5 - 3 ferrite beads each

D1 - 1N4001

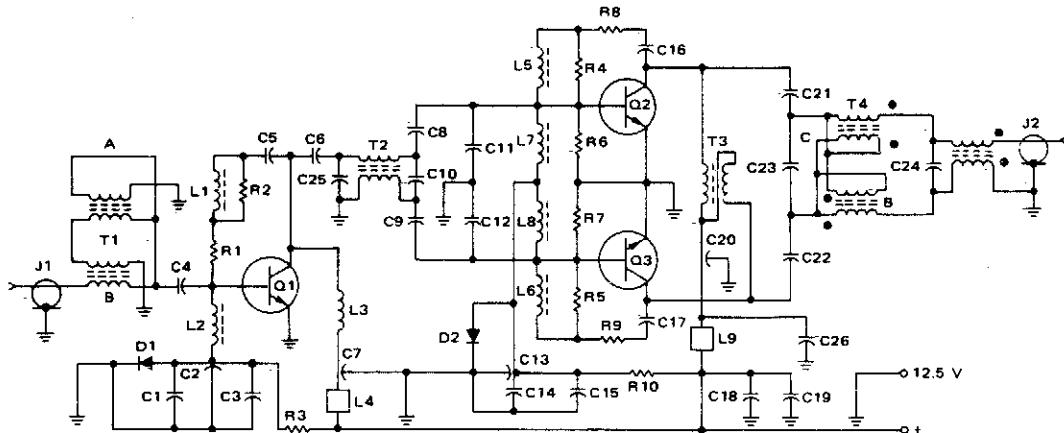
L8, L9 - .22 μ H, molded choke

D2 - 1N4997

J1, J2 - BNC connectors

Fig. 73-3

80 W (PEP) BROADBAND/LINEAR AMPLIFIER



C1, C14, C18 – 0.1 μF ceramic.
C2, C7, C13, C20 – 0.001 μF feed through.
C3 – 100 μF /3V.
C4, C6 – 0.033 μF mylar.
C5 – 0.0047 μF mylar.
C8, C9 – 0.015 and 0.033 μF mylars in parallel.
C10 – 470 pF mica.
C11, C12 – 560 pF mica.
C15 – 1000 μF /3 V
C16, C17 – 0.015 μF mylar.
C19 – 10 pF 15 V
C21, C22 – two 0.068 μF mylars in parallel.
C23 – 330 pF mica
C24 – 39 pF mica
C25 – 680 pF mica
C26 – .01 μF ceramic

R1, R6, R7 – 10 Ω , 1/2 W carbon.
R2 – 51 Ω , 1/2 W carbon
R3 – 240 Ω , 1 wire W
R4, R5 – 18 Ω , 1 W carbon
R8, R9 – 27 Ω , 2 W carbon
R10 – 33 Ω , 6 W wire W

L1 – 0.22 μh molded choke
L2, L7, L8 – 10 μh molded choke
L5, L6 – 0.15 μh
L3 – 25 t, #26 wire, wound on a 100 Ω , 2 W resistor. (1.0 μh)
L4, L9 – 3 ferrite beads each.

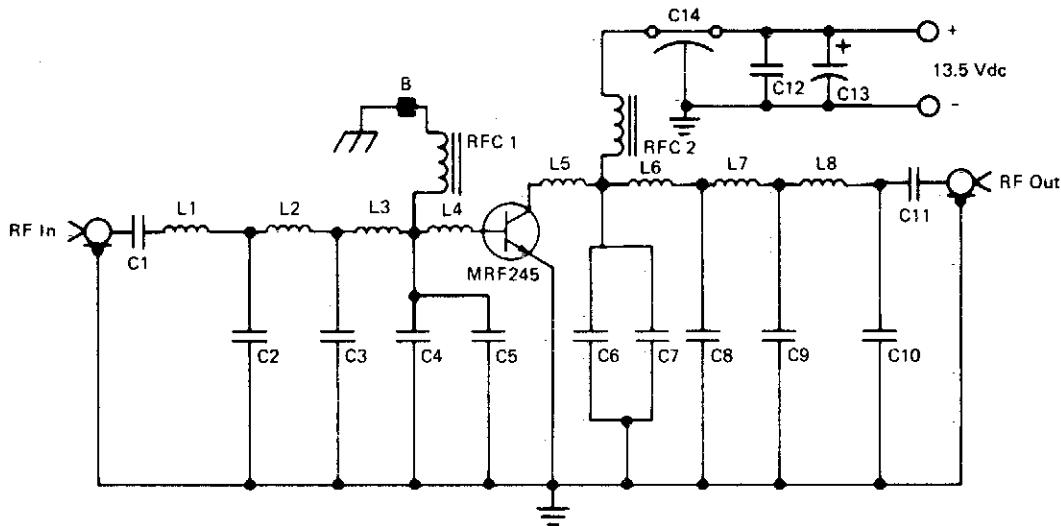
T1 – 2 twisted pairs of #26 wire, 8 twists per inch. A = 4 turns,
 B = 8 turns. Core - Stack pole 57-9322-11, Indiana General
 F627-8Q1 or equivalent
T2 – 2 twisted pairs of #24 wire, 8 twists per inch, 6 turns.
 (Core as above.)
T3 – 2 twisted pairs of #20 wire, 6 twists per inch, 4 turns.
 (Core as 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 - Stack pole 57-9074-11, Indiana General F624-19Q1
 or equivalent.

Q1 – 2N6367
Q2, Q3 – 2N6368
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 Enamelled Wire, 1/4" I.D.

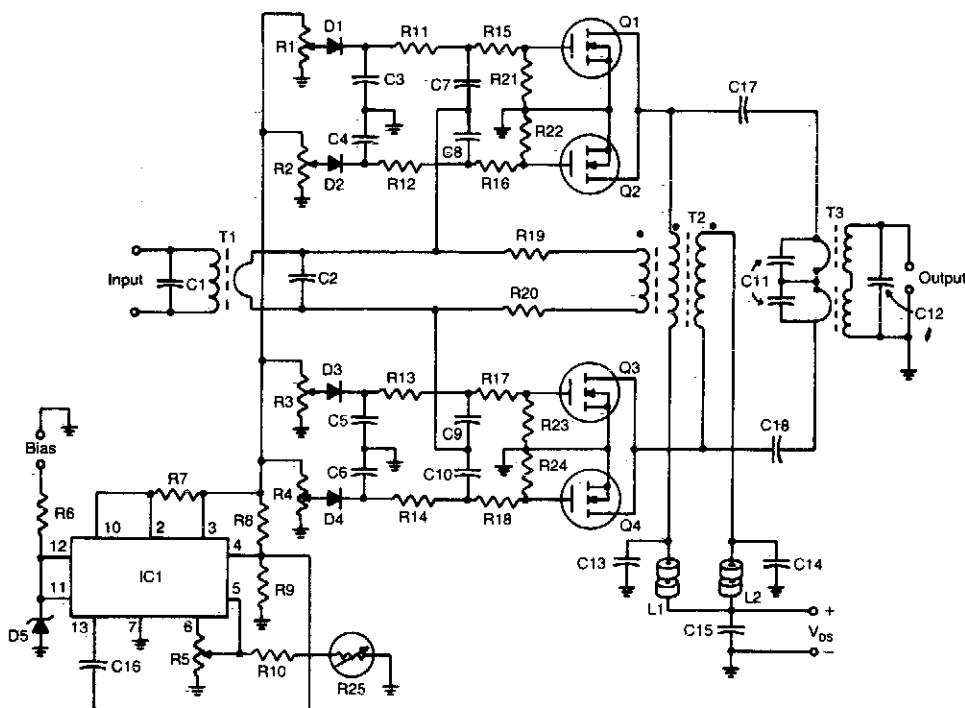
B – Ferroxcube Bead 56-590-65, 3-Beads

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— $10\text{ k}\Omega$ trimpot
 R6— $1.0\text{ k}\Omega/1.0\text{W}$
 R7— $10\ \Omega$
 R8— $2.0\text{ k}\Omega$
 R9,R21-R24— $10\text{ k}\Omega$
 R10— $8.2\text{ k}\Omega$
 R11-R14— $100\ \Omega$
 R15-R18— $1.0\ \Omega$
 R19-R20— $10\ \Omega/2.0\text{ W}$ Carbon
 R25—theristor, $10\text{ k}\Omega$ (25°C), $2.5\text{ k}\Omega$ (75°C)
 C1—not used
 C2— 820 pF ceramic chip
 C3-C6,C13,C14— $0.1\text{ }\mu\text{F}$ ceramic
 C7-C10— $0.1\text{ }\mu\text{F}$ 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— $10\text{ }\mu\text{F}$, 100 V electrolytic
 C16— 1000 pF ceramic
 C17,C18—two $0.1\text{ }\mu\text{F}$, 100 V ceramic each,
 (ATC 200/823 or equivalent)
 D1-D4—IN4148
 D5— 28 V zener, IN5362 or equivalent
 L1,L2—Two Fair-Rite 2673021801 ferrite beads
 each or equivalent $4.0\ \mu\text{H}$
 T1-T3—see text
 Q1-Q4—MRF150
 IC1—MC1723CP
 All resistors are 0.5 W 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

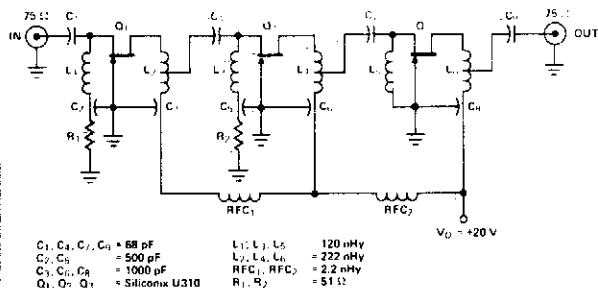


Fig. 73-7

10 MHz COAXIAL LINE DRIVER

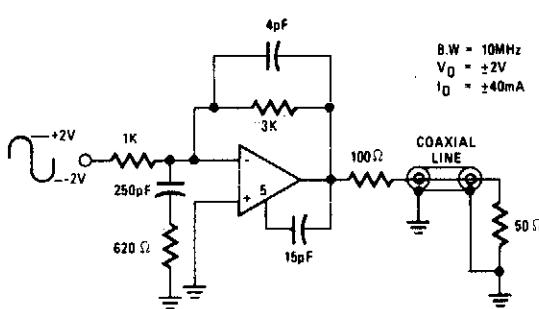


Fig. 73-8

VHF PREAMPLIFIER

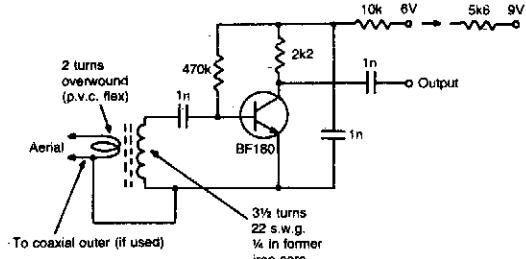
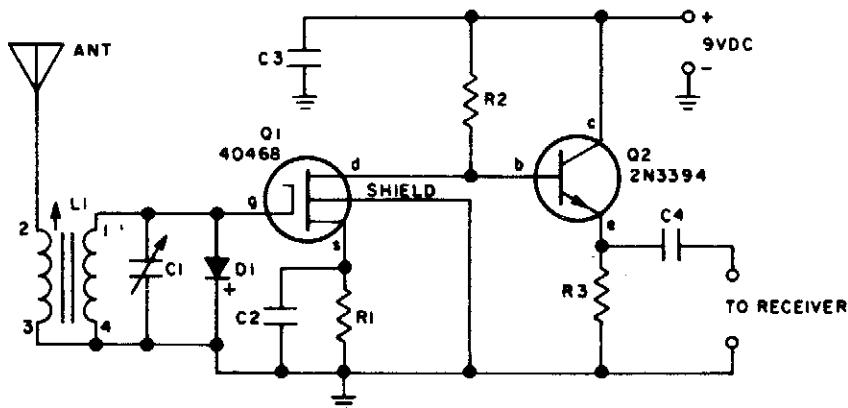


Fig. 73-9

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 C-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

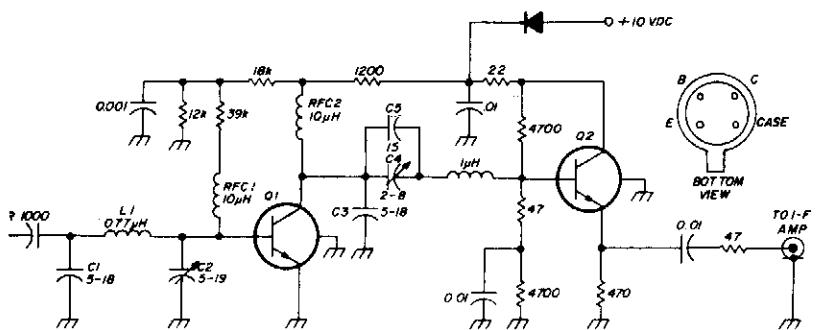


Fig. 73-11

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

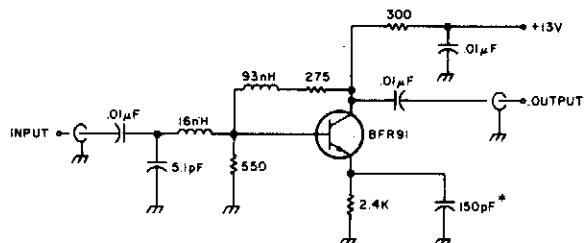


Fig. 73-12

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

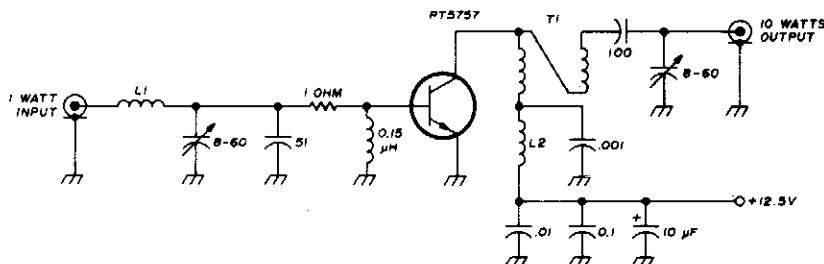
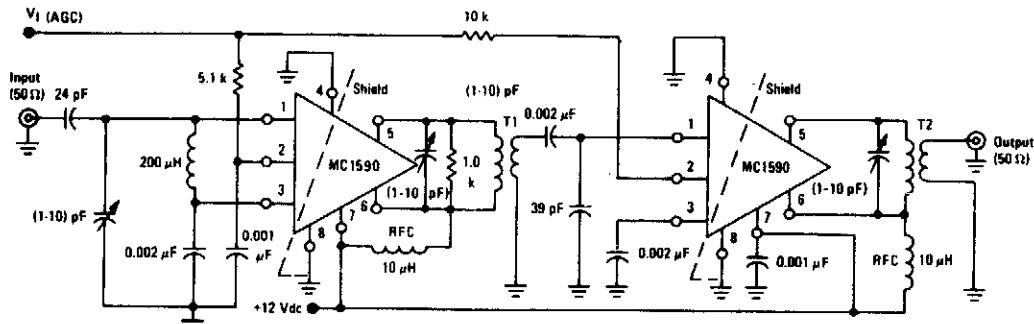


Fig. 73-13

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 \approx 80 dB, BW \approx 1.5 MHz)**



T1: Primary Winding = 15 Turns, #22 AWG Wire, 1/4" ID Air Core
Secondary Winding = 4 Turns, #22 AWG Wire,
Coefficient of Coupling \approx 1.0

T2: Primary Winding = 10 Turns, #22 AWG Wire, 1/4" ID Air Core
Secondary Winding = 2 Turns, #22 AWG Wire,
Coefficient of Coupling \approx 1.0

Fig. 73-14

28 V WIDEBAND AMPLIFIER (3 to 100 MHz)

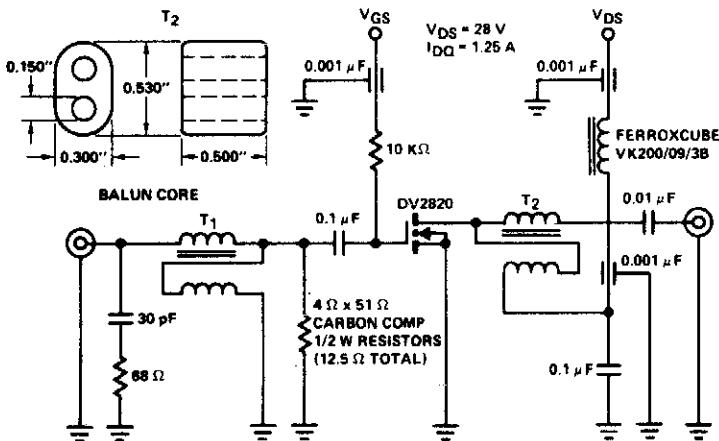
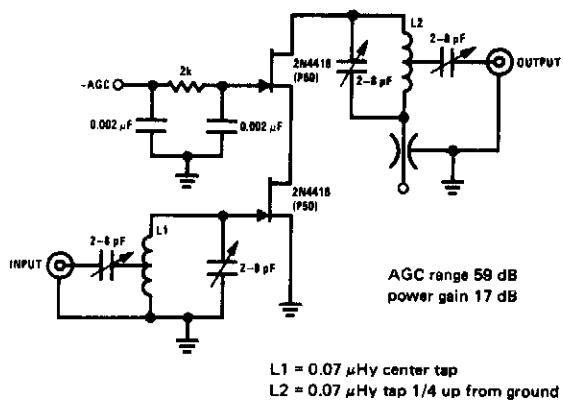


Fig. 73-15

Parts List

- T₁, 20 turns 30 Ω, #30 bifilar on micrometals T-50-6 Toroid
- T₂, 1 turn of 2-50 Ω coax cables in parallel through 2 balun cores stackpole #57-9130 μ = 125

200 MHz CASCODE AMPLIFIER

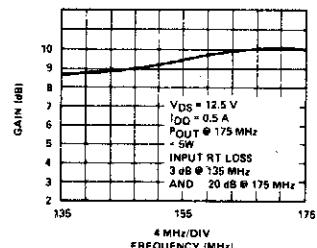
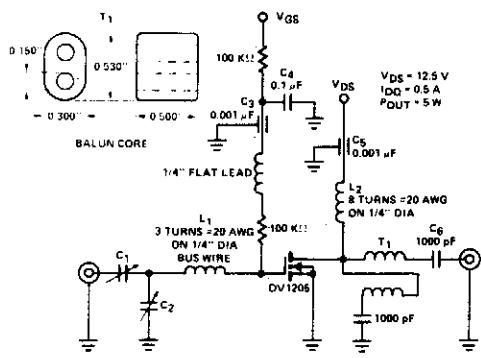


Circuit Notes

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_{DS} of the upper unit must be greater than that of the lower unit.

Fig. 73-16

135-175 MHz AMPLIFIER

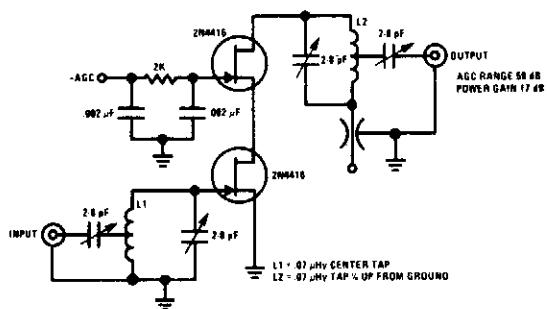


Parts List

- C1, C2 ARCO #462, 2 to 80 pF, trimmer capacitors
- L1, 3 turns buss 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 Ω = 35.

Fig. 73-17

200 MHz CASCODE AMPLIFIER

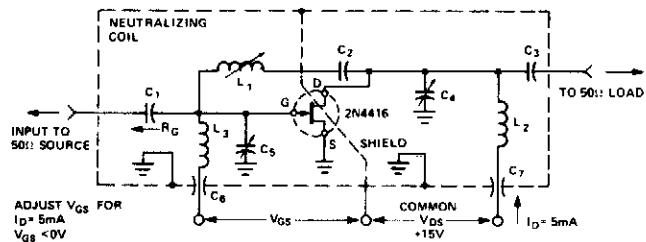


Circuit Notes

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 loss 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	100MHz	400MHz
C_1	7.0pF	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	0.0015pF	0.001pF
C_7	0.0015pF	0.001pF
L_1	3.0μH	0.2μH
L_2	0.26μH	0.03μH
L_3	0.14μH	0.022μH
Typ NF	1.2dB	2.4dB
Typ G_m	+21dB	12dB

Fig. 73-19

ULTRA HIGH FREQUENCY AMPLIFIER

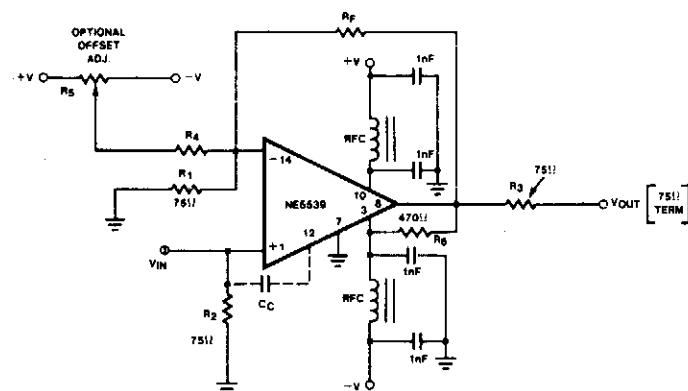


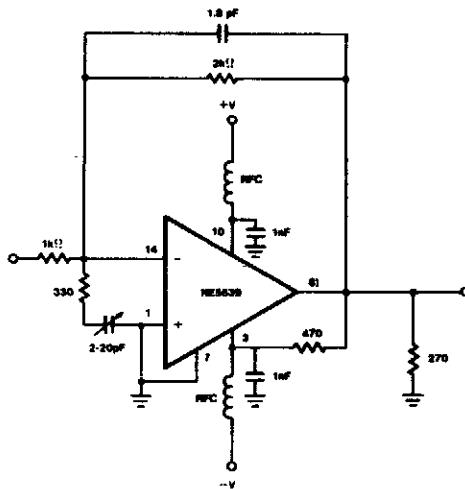
Fig. 73-20

R1 = 75Ω 5% CARBON
R2 = 75Ω 5% CARBON
R3 = 75Ω 5% CARBON
R4 = 38K 5% CARBON

R5 = 20K TRIM POT (CERMET)
Rf = 1.5K (2dB GAIN)
R6 = 470Ω 5% CARBON

RFC 3T # 28 BUSSWIRE ON
FERMOLITE VK 200 09/38 CORE
BYPASS CAPACITORS
1μF 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 #26 bus wire on Ferroxcube VK200 093B
wideband threaded core.

Fig. 73-21

**TRANSISTORIZED Q-MULTIPLIER
FOR USE WITH IFS IN THE 1400 kHz RANGE**

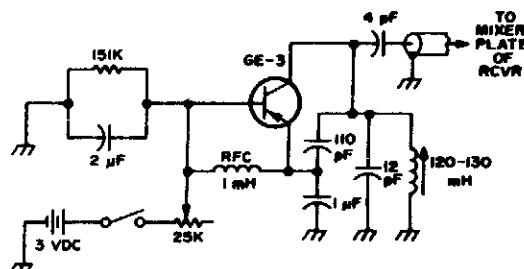


Fig. 73-22

60 MHz AMPLIFIER

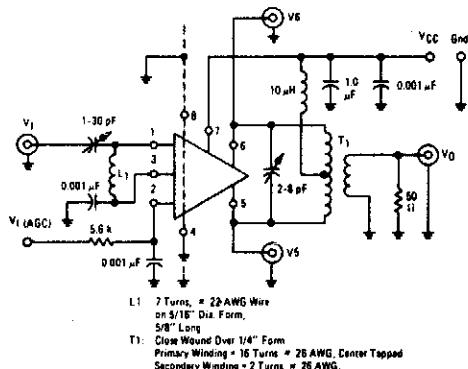


Fig. 73-23

30 MHz AMPLIFIER (POWER GAIN = 50 dB, BW ≈ 1.0 MHz)

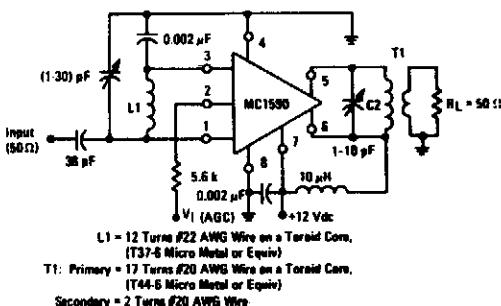
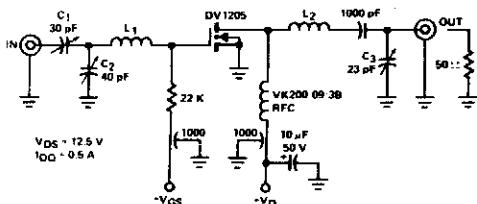


Fig. 73-24

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

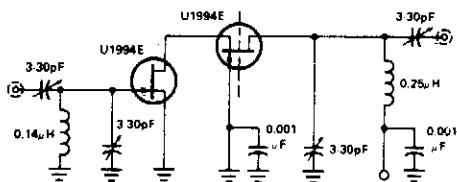


Fig. 73-26

200 MHz NEUTRALIZED COMMON SOURCE AMPLIFIER

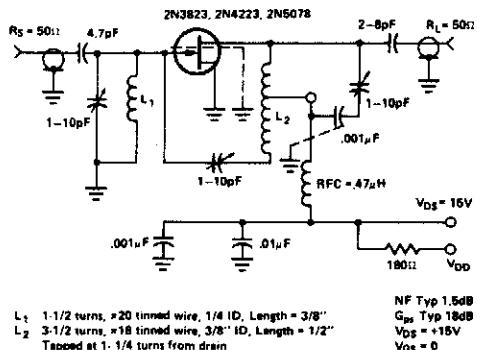


Fig. 73-27

450 MHz COMMON-SOURCE AMPLIFIER

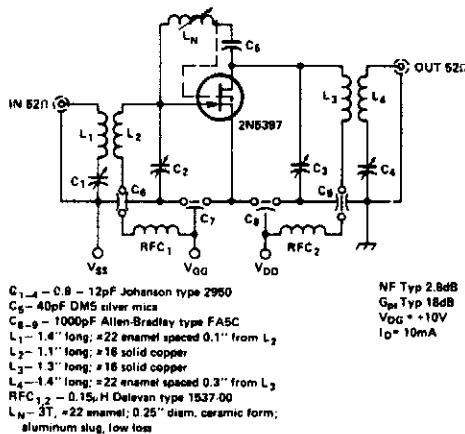


Fig. 73-28

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

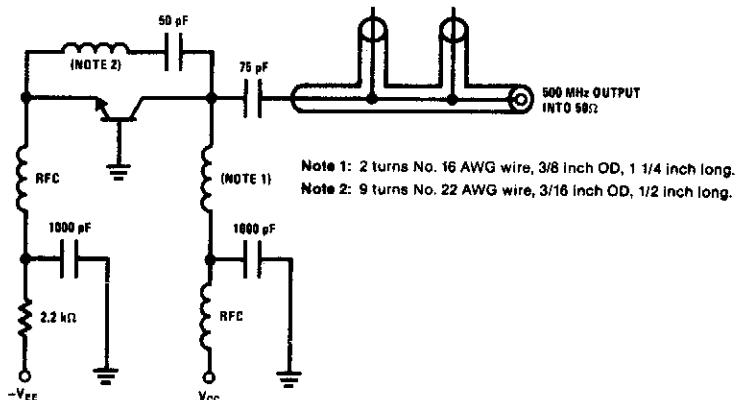


Fig. 74-1

LOW DISTORTION OSCILLATOR

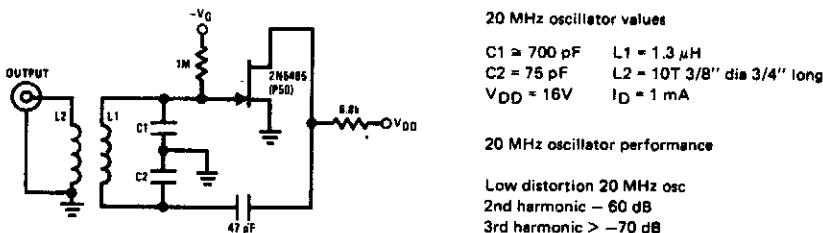
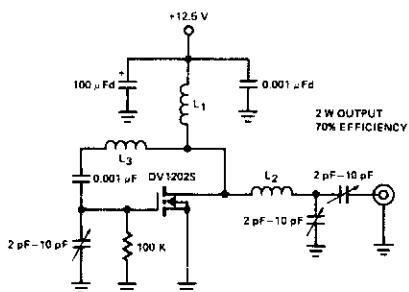


Fig. 74-2

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

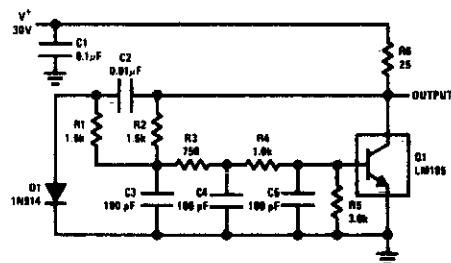


Fig. 74-5

2 MHz OSCILLATOR

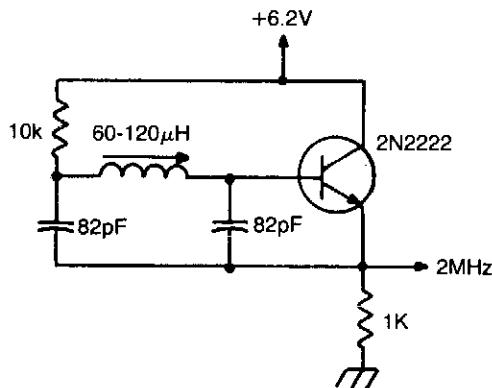


Fig. 74-4

Circuit Notes

Miller 9055 miniature slugtuned coil; all resistors 1/4W 5%; all caps min. 25 V ceramic.

HARTLEY OSCILLATOR

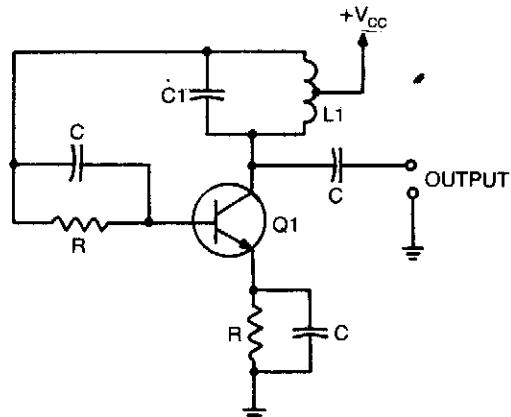
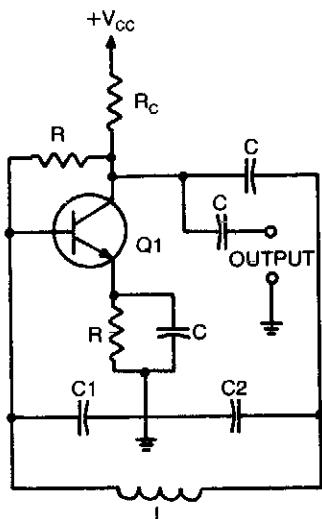


Fig. 74-6

Circuit Notes

Resonant frequency is $\frac{1}{2} \pi \sqrt{L1C1}$.

COLPITTS OSCILLATOR

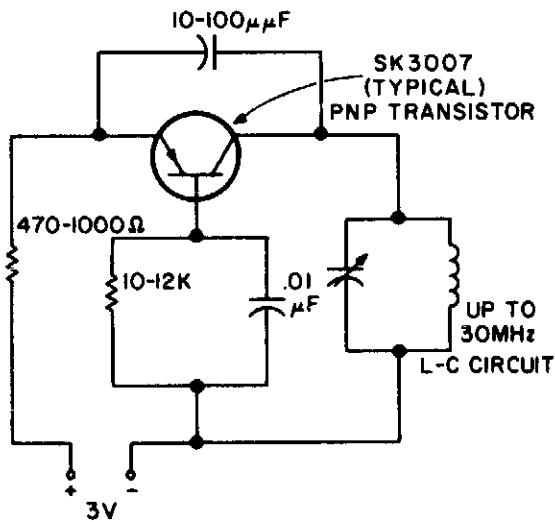


Circuit Notes

When calculating its resonant frequency, use $C_1 C_2 / (C_1 + C_2)$ 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

RADIO CONTROL RECEIVER/DECODER

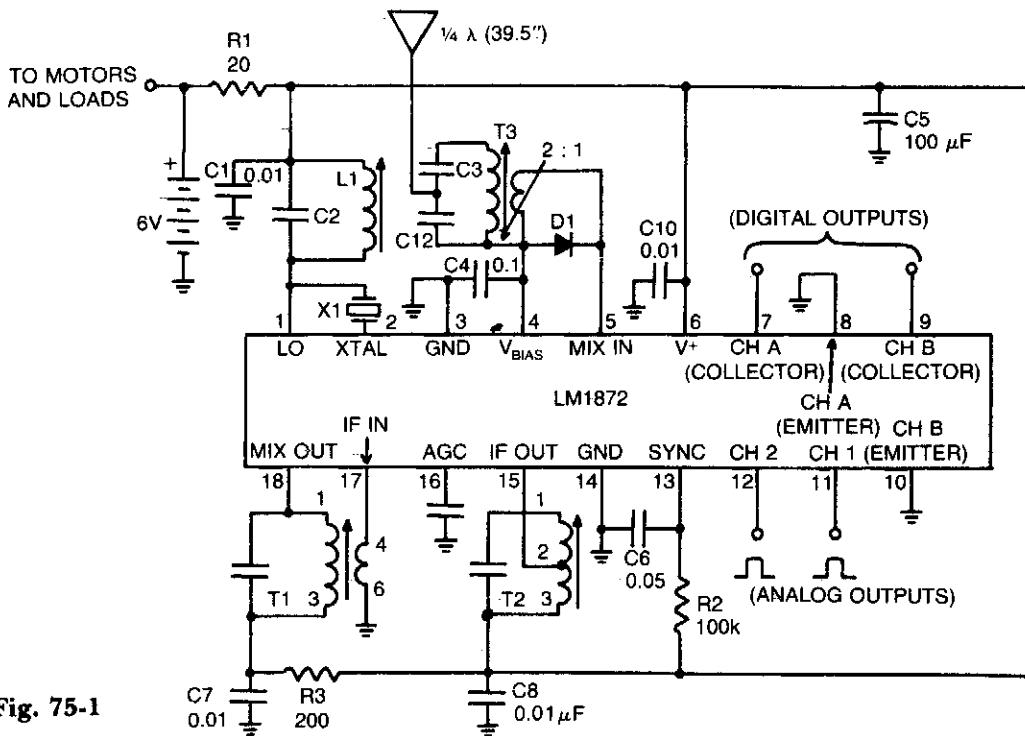


Fig. 75-1

R1 - Motor decoupling

R2 - Sync timer; $R2 = \frac{1}{0.7} \text{ SYNC}$, $R2 \leq 470\text{k}$

R3 - Mixer decoupling

C1 - LO bypass; optional

C2 - LO tank; $C2 = 22 \mu\text{F}$ @ 72 MHz

C3 - Ant. input tank; $C3 = 24 \mu\text{F}$ @ 72 MHz

C4 - V_{BIAS} bypass

C5 - Motor decoupling

C6 - Sync timer; $C6 = \frac{1}{0.7} \text{ R2}$, $C6 + 0.5 \mu\text{F}$

C7 - Mixer decouple; $0.01 \mu\text{F} \leq C7 \leq 1 \mu\text{F}$

C8 - AGC

C9 - IF bypass; optional

C10 - V^+ bypass; $0.01 \mu\text{F} \leq C10 \leq 0.1 \mu\text{F}$

C12 - Ant. input tank; $C12 = 160 \mu\text{F}$ @ 72 MHz

L1 - LO coil

Toko* 10k type (KENC) 4T; $0.2 \mu\text{H}$ @ 72 MHz

L1 could be made a fixed coil, if desired.

T1 - 455 kHz mixer transformer

Toko* 10 EZC type (RMC-502182), Qu = 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-502503), Qu = 110
Pin 1-2, 82T; pin 2-3, 8T

T3 - Ant. input transformer

Toko 10k type (KENC), 4T sec. & 2T pri. of $0.2 \mu\text{H}$ @ 72 MHz

X1 - 5th overtone crystal, parallel-mode, 72 MHz

D1 - Electrostatic discharge (ESD) protection

* Toko America, Inc.

5520 West Touhy Ave.

Skokie, Ill. 60077

(312)677-3640 Tlx: 72-4372

CARRIER OPERATED RELAY

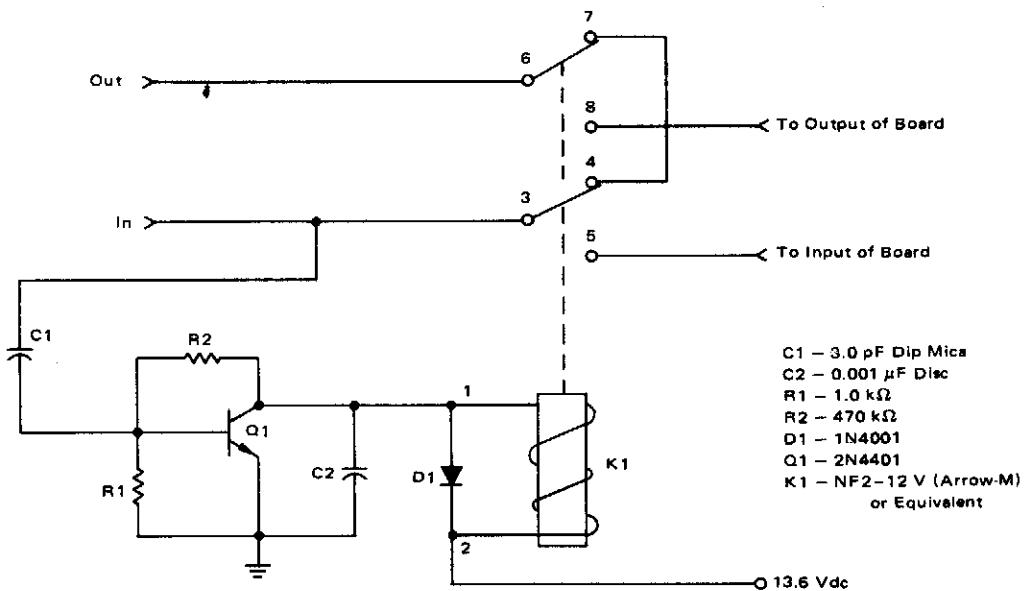


Fig. 75-2

REMOTE CONTROL SERVO SYSTEM

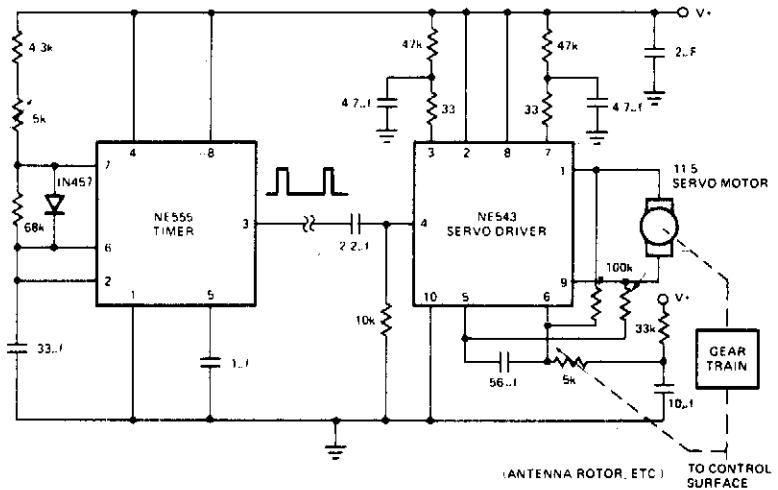
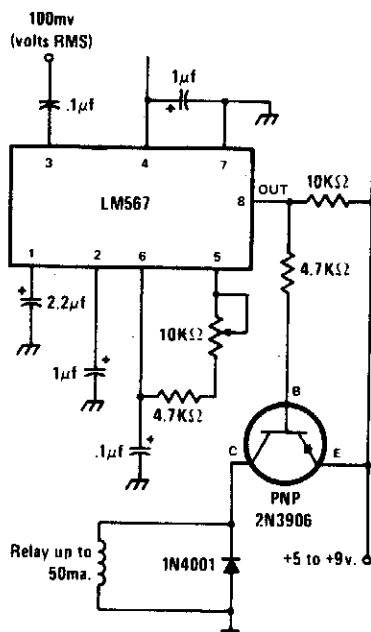


Fig. 75-3

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

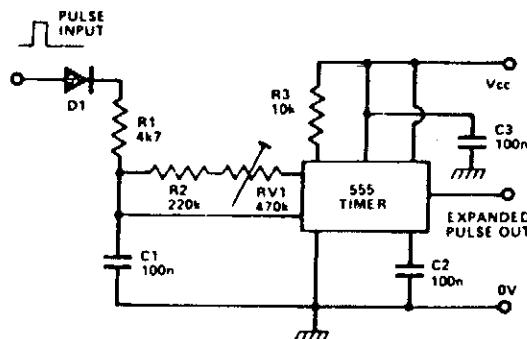


Fig. 75-5

REMOTE ON-OFF SWITCH

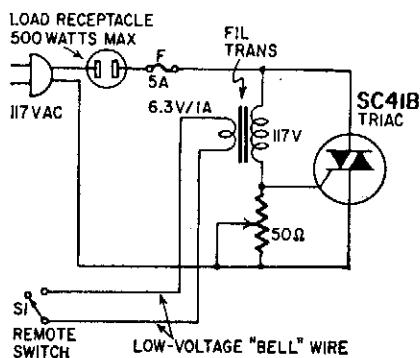


Fig. 75-6

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

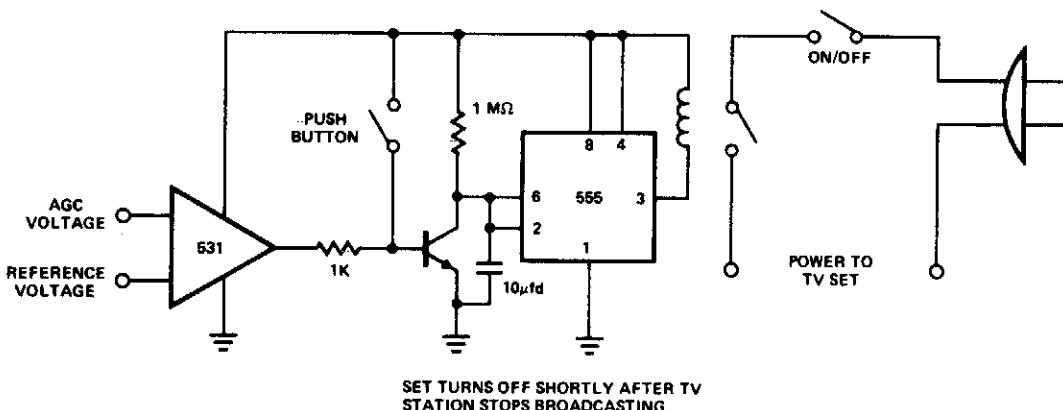


Fig. 75-7

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

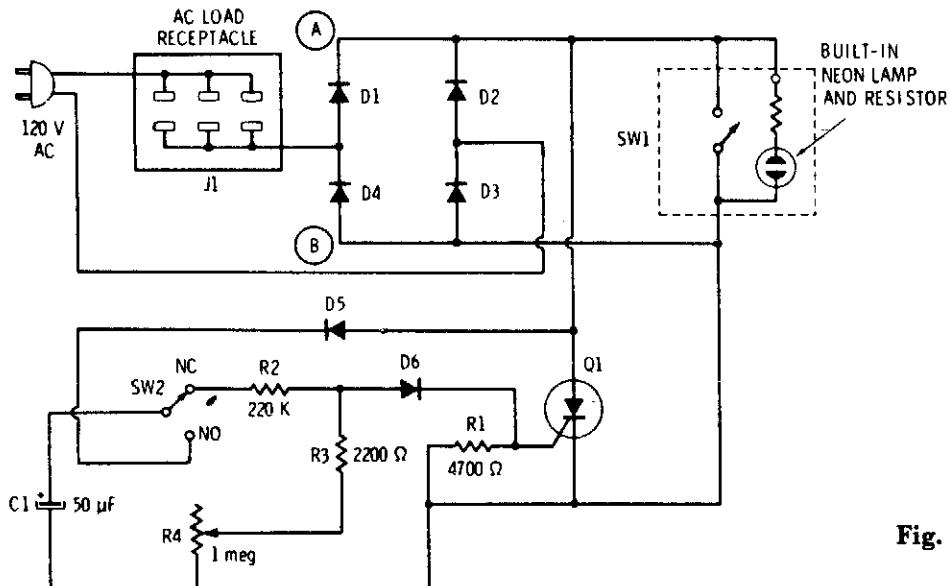


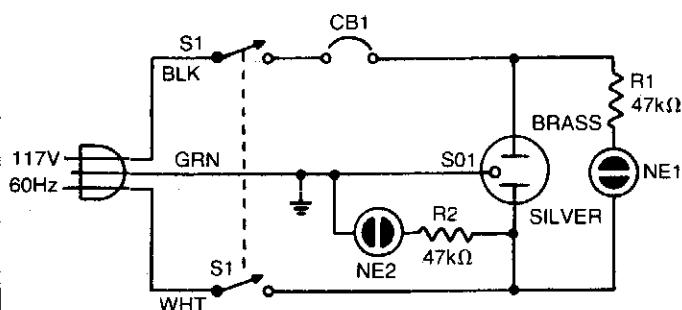
Fig. 76-1

Circuit Notes

The push button and potentiometer initiate a time delay that turns a light on then automatically turns it off again after a pre-determined 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—47k Ω , 1/2W
 NE1, NE2, NE3—GE NE-2
 S1—SPDT, Lafayette 34P0238V

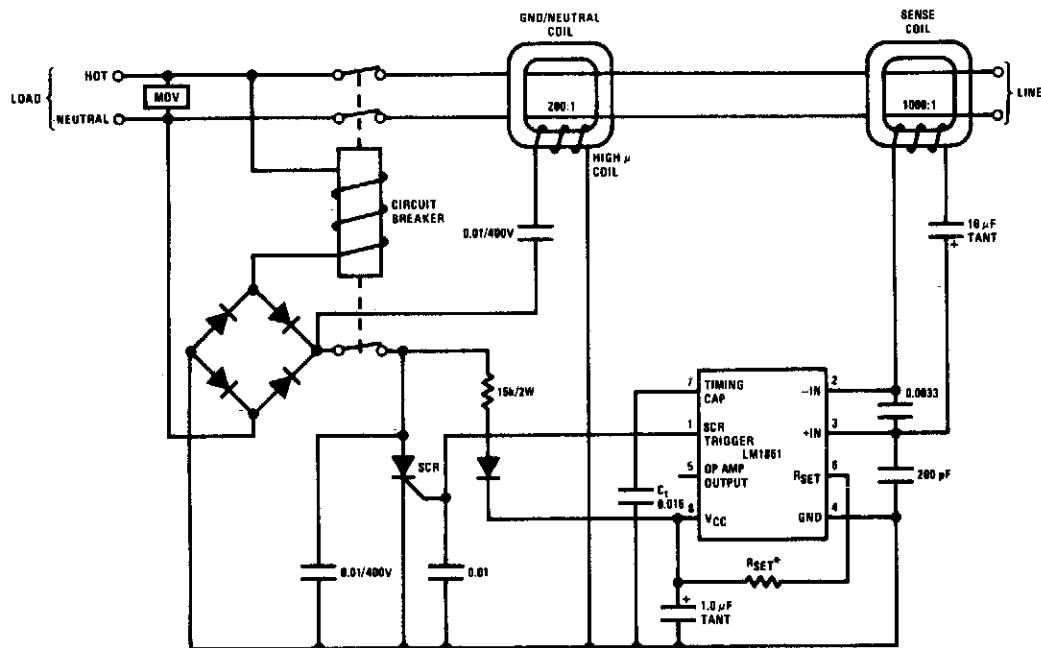
Fig. 76-2

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)



* Adjust R_{SET} for desired sensitivity

Fig. 76-3

SINGLE SOURCE EMERGENCY LIGHTING SYSTEM

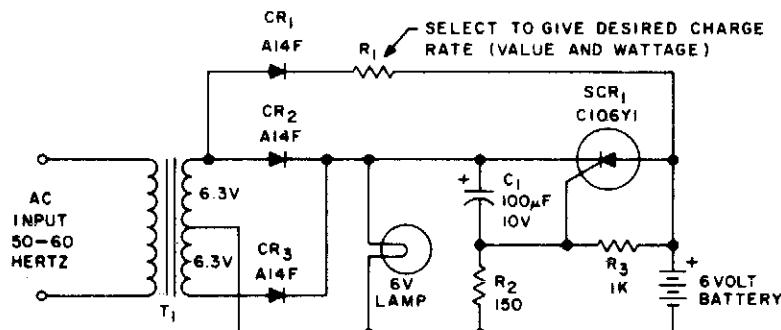
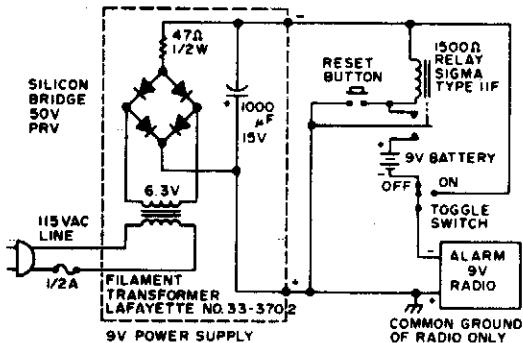


Fig. 76-4

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

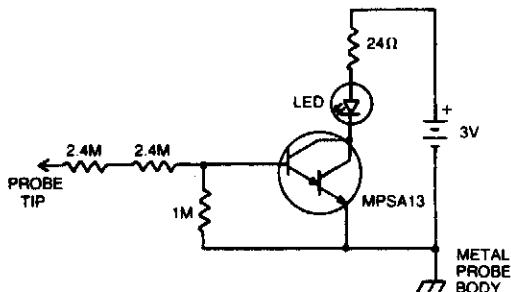


Circuit Notes

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.

Fig. 76-5

AC HOT WIRE PROBE



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.

Fig. 76-6

POWER FAILURE DETECTOR

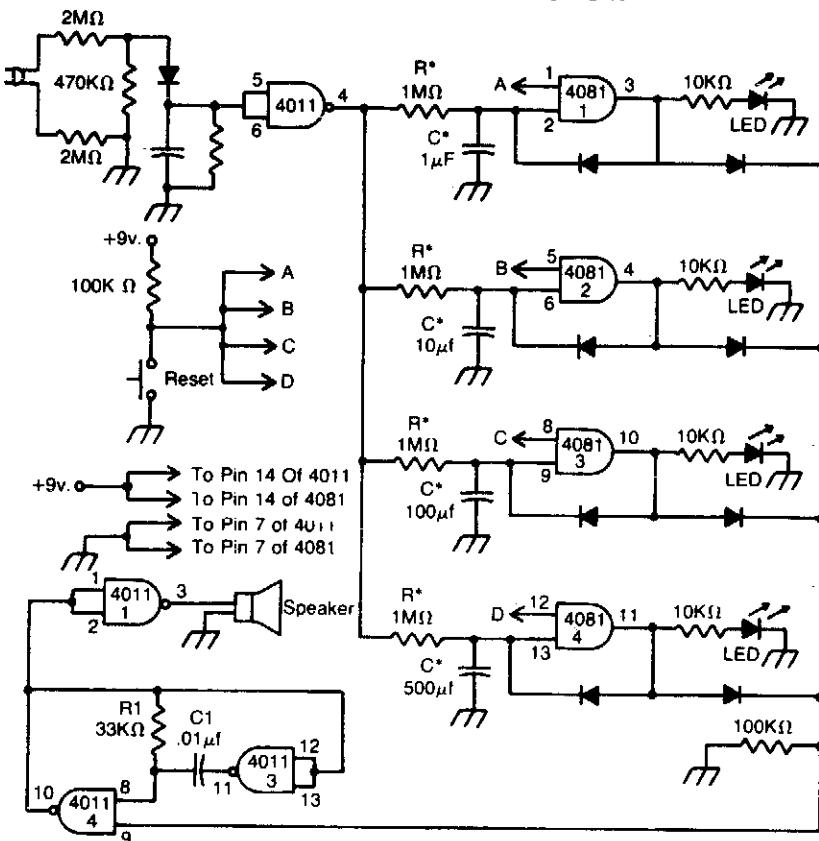


Fig. 76-7

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

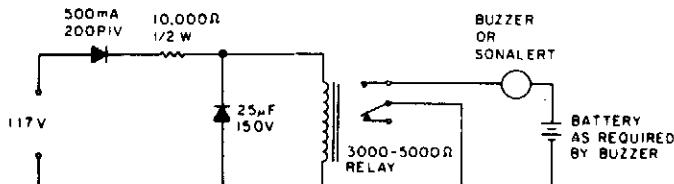


Fig. 76-8

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

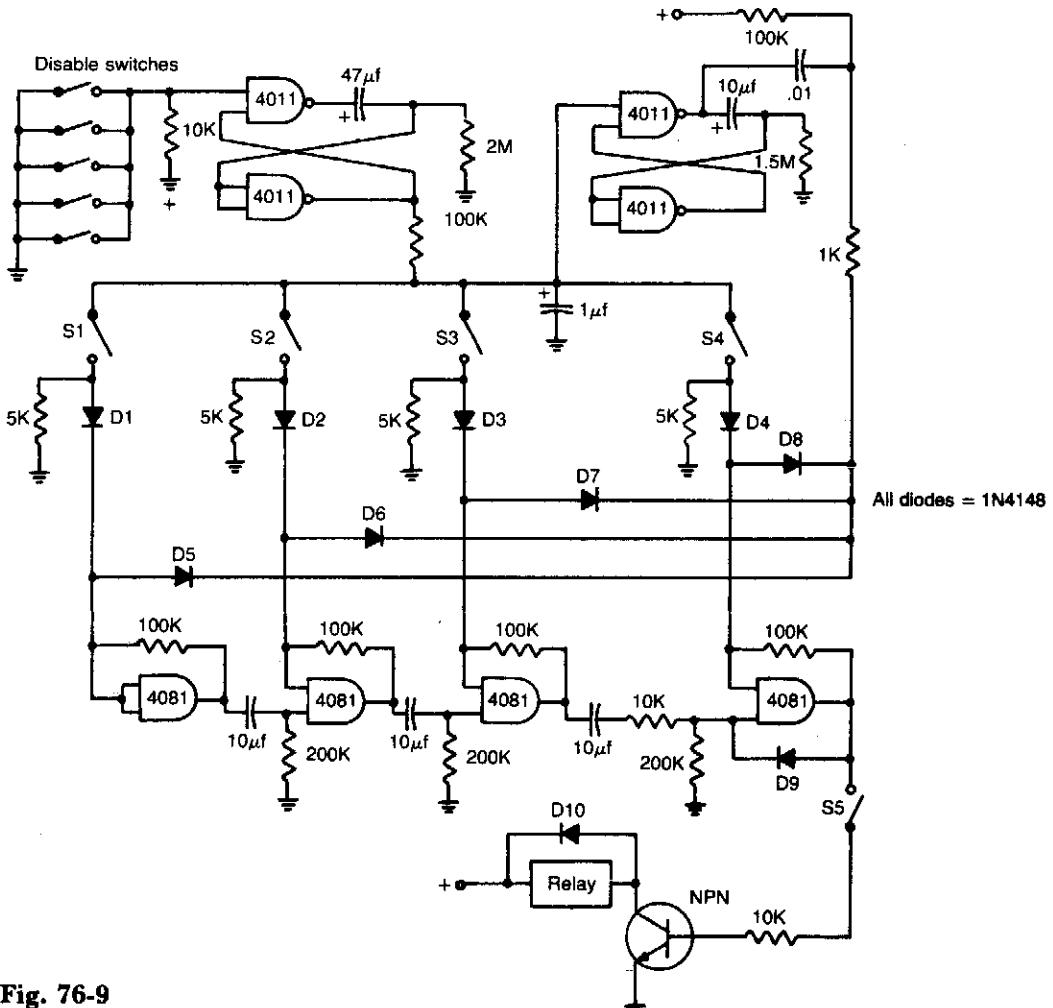


Fig. 76-9

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.

77

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

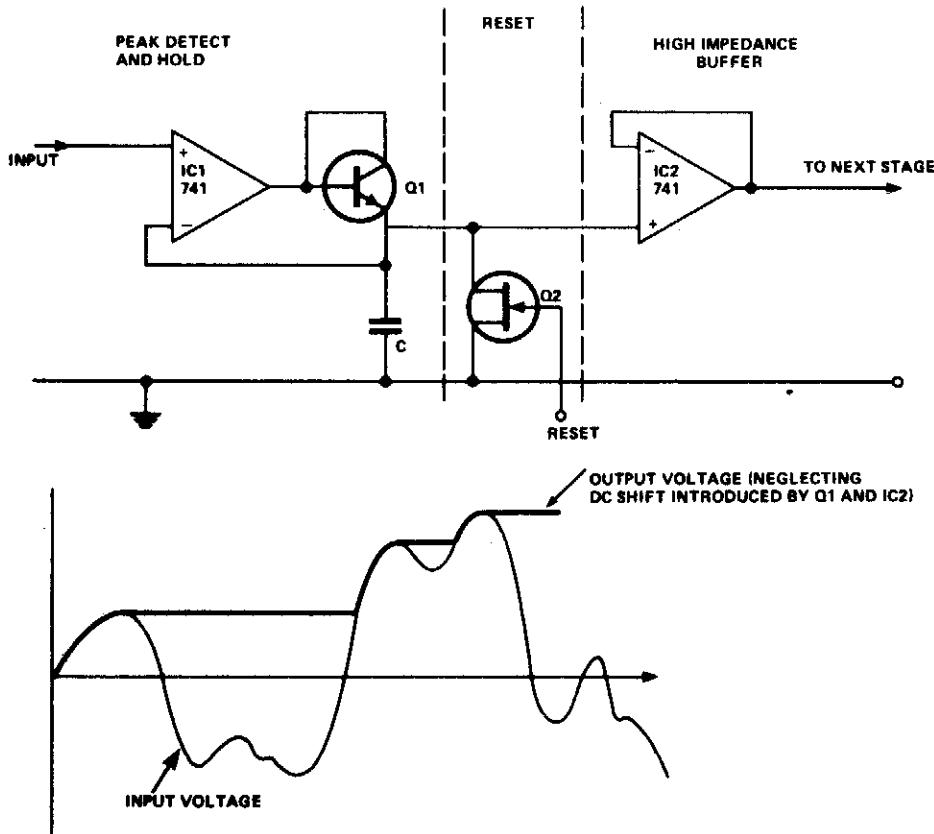


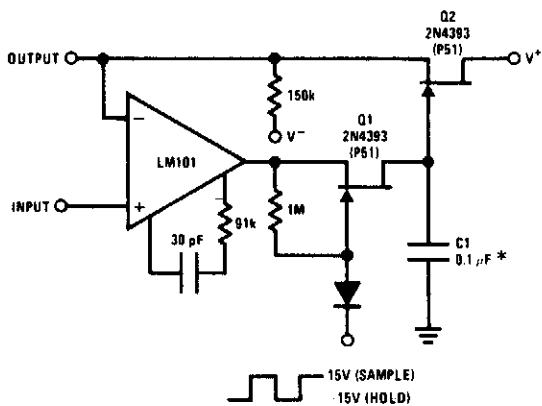
Fig. 77-1

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



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, $r_{ds(on)}$, for charging C1. During hold, Q1 is turned off, thus leaving Q1 $I_{d(on)}$ (< 100 pA) and Q2 $I_{d(off)}$ (< 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.

*Polycarbonate dielectric capacitor

Fig. 77-2

JFET SAMPLE AND HOLD

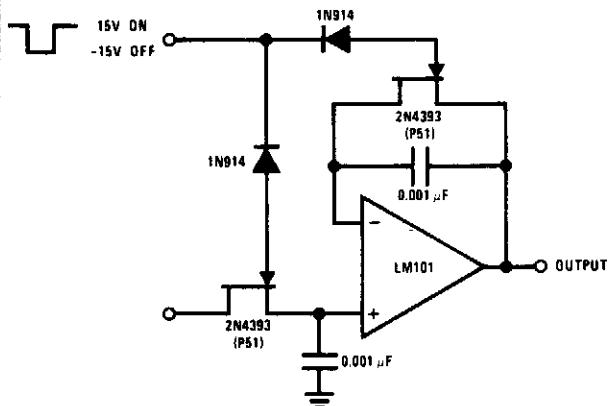


Fig. 77-3

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 $r_{ds(on)}$ of the JFETs are minimized.

HIGH SPEED SAMPLE AND HOLD AMPLIFIER

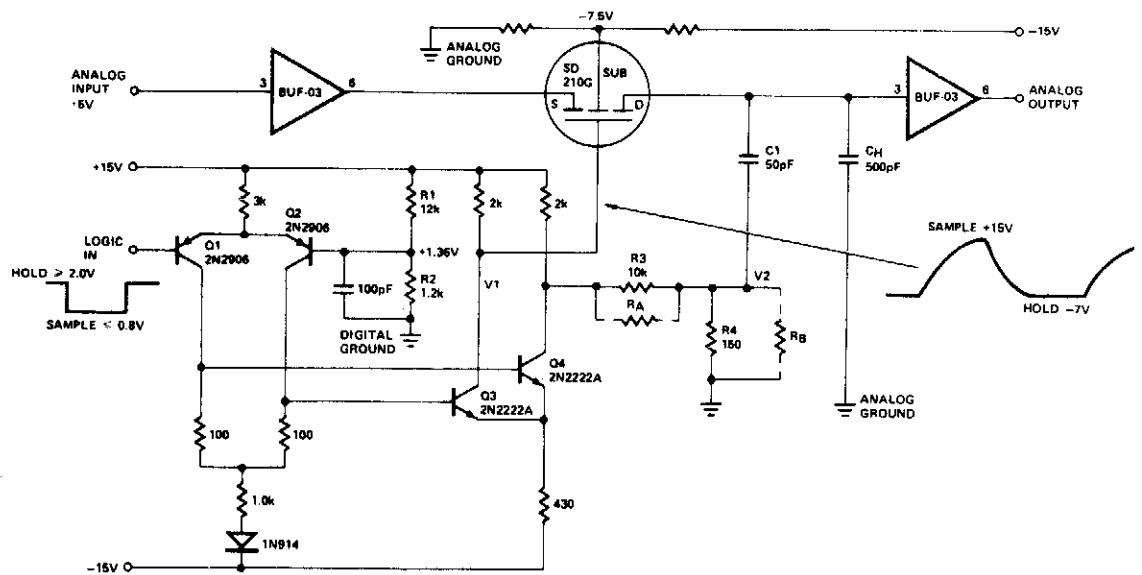


Fig. 77-4

HIGH SPEED SAMPLE AND HOLD

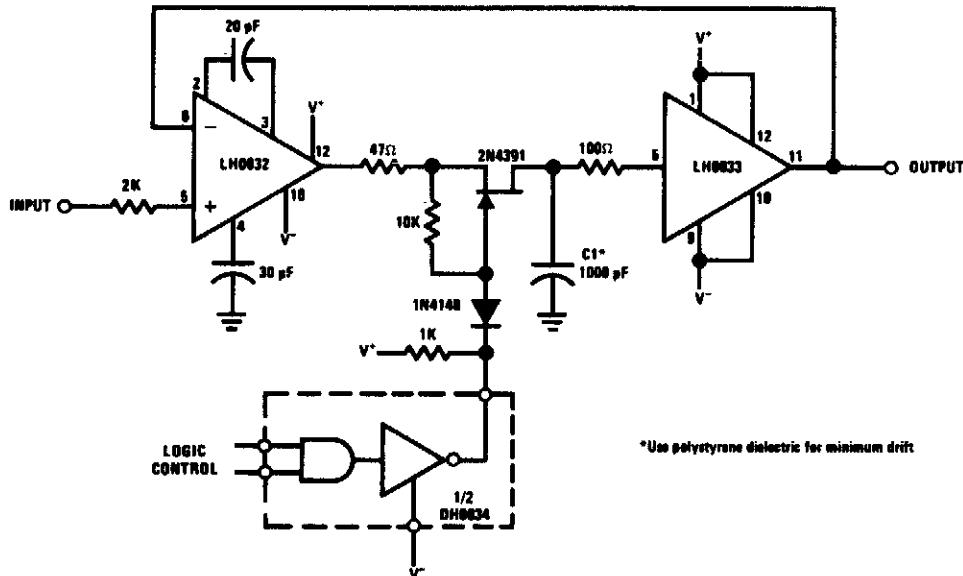


Fig. 77-5

HIGH SPEED SAMPLE AND HOLD

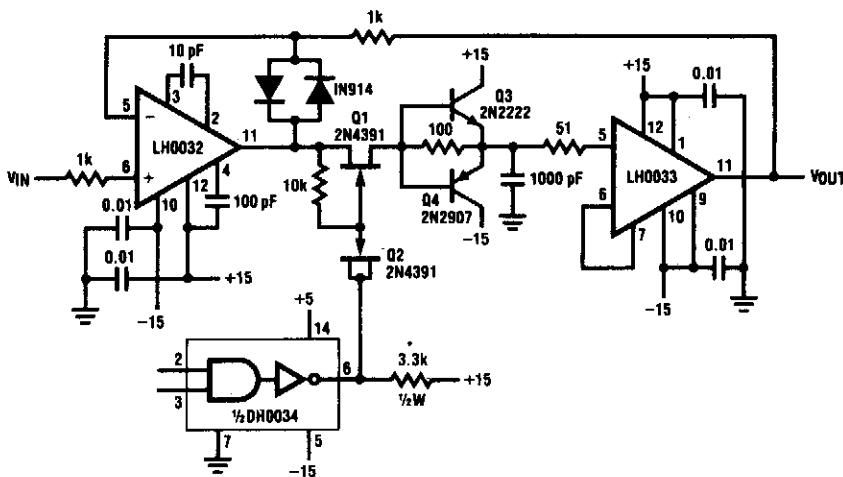


Fig. 77-6

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

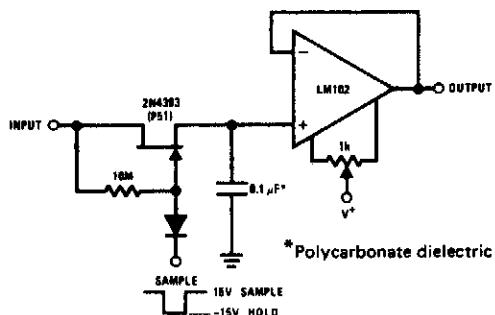


Fig. 77-7

Circuit Notes

The 2N4393 JFET was selected because of its low I_{CSS} ($< 100 \text{ pA}$), very low $I_{\text{D(OFF)}}$ ($< 100 \text{ pA}$) and low pinchoff voltage. Leaks of this level put the burden of circuit performance on clean, solder-resin free, low leakage circuit layout.

DIFFERENTIAL HOLD

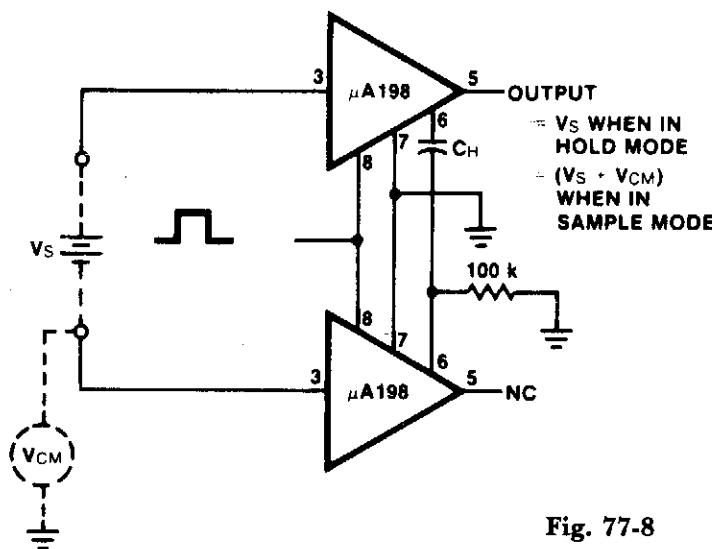
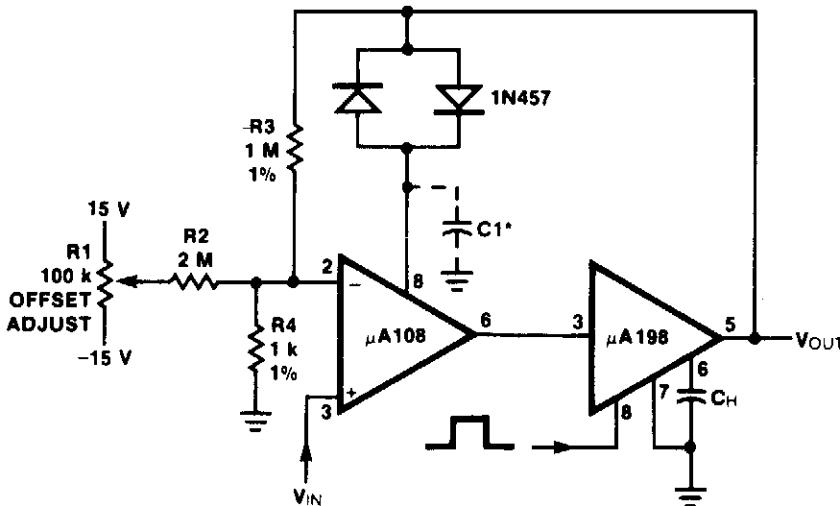


Fig. 77-8

× 1000 SAMPLE AND HOLD



Notes

For lower gains, the μ A108 must be frequency compensated.

Use $\approx \frac{100}{A_v}$ pF from comp 2 to ground

Fig. 77-9

SAMPLE AND HOLD

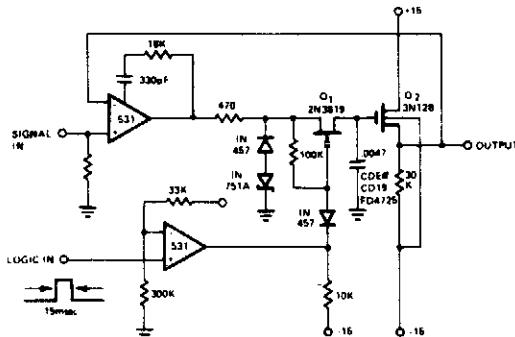
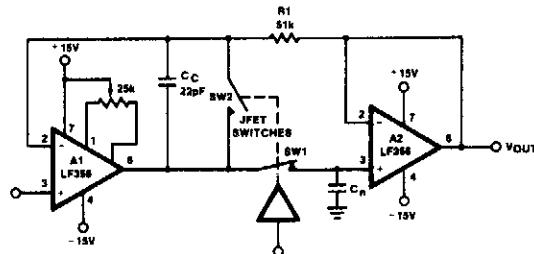


Fig. 77-10

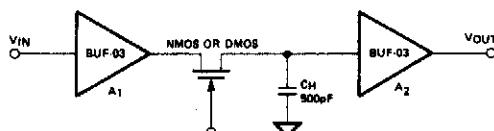
HIGH ACCURACY SAMPLE AND HOLD



- By closing the loop through A2 the V_{OUT} accuracy will be determined uniquely by A1. No V_{OS} adjust required for A2.
- T_A can be estimated by same considerations as previously but, because of the added on propagation delay in the feedback loop (A2) the overshoot is not negligible.
- Overall system slower than fast sample and hold.
- R1, C_C: additional compensation
- Use LF356 for
 - Fast settling time
 - Low V_{OS}

Fig. 77-11

HIGH SPEED SAMPLE AND HOLD



I_{CHARGE} OF BUF-03 IS ±80mA. THEREFORE THE SLEW RATE INTO A 500pF HOLD CAPACITOR WILL BE 120V/SEC. THUS THE SLEW RATE OF THE SAMPLE AND HOLD CIRCUIT IS LIMITED BY THE CAPACITOR CHARGING TIME.

Fig. 77-12

78

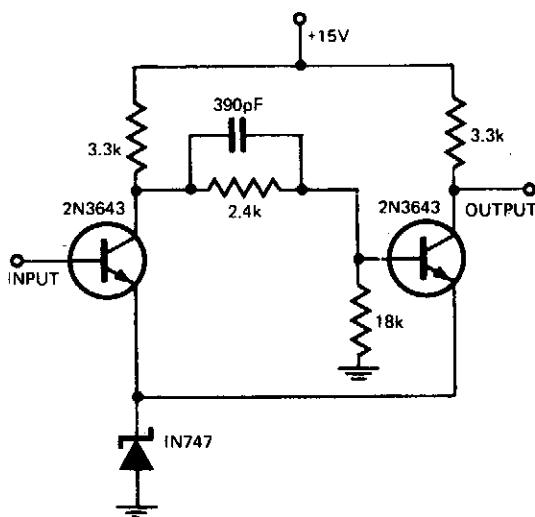
Schmitt Triggers

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

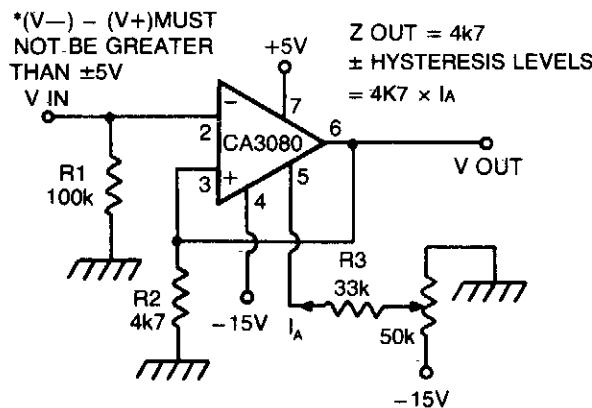


Fig. 78-2

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)

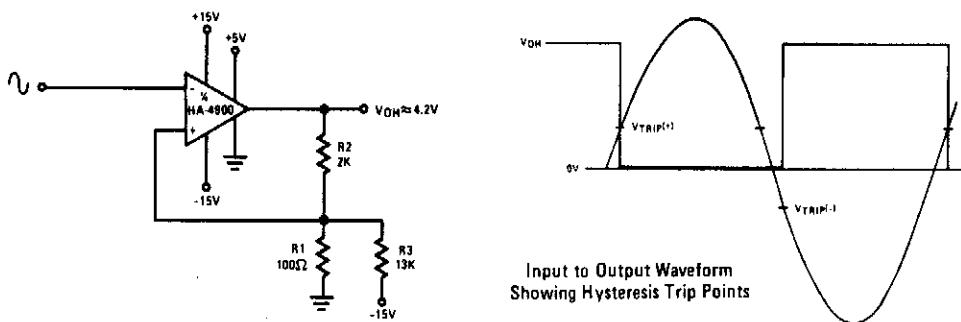


Fig. 78-3

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

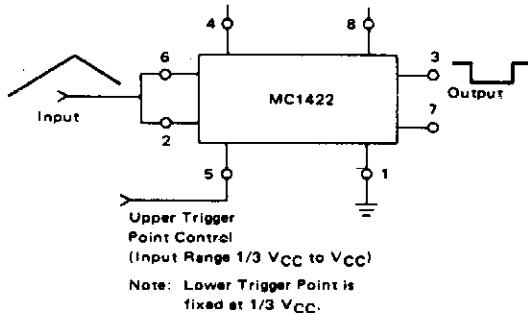


Fig. 78-4

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)

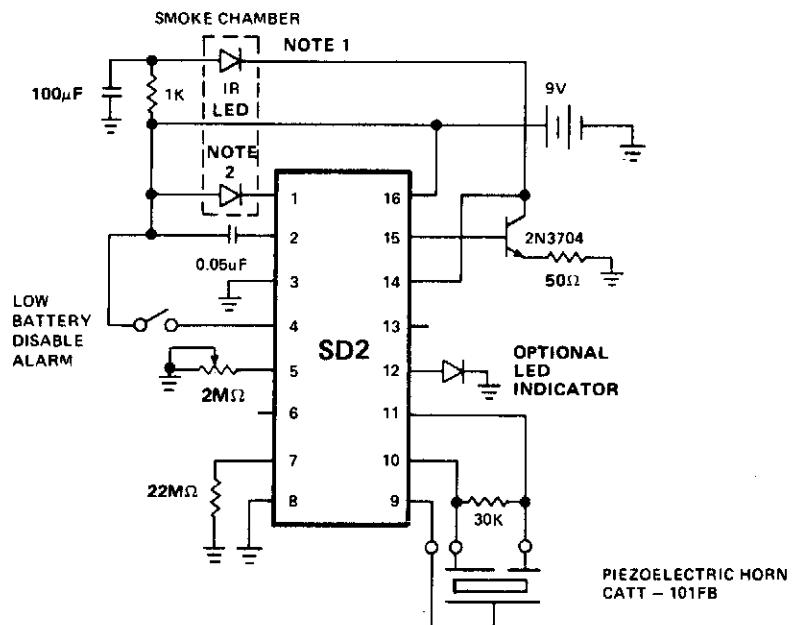


Fig. 79-1

- 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.

**1.9 V BATTERY OPERATED
IONIZATION TYPE SMOKE
DETECTOR**

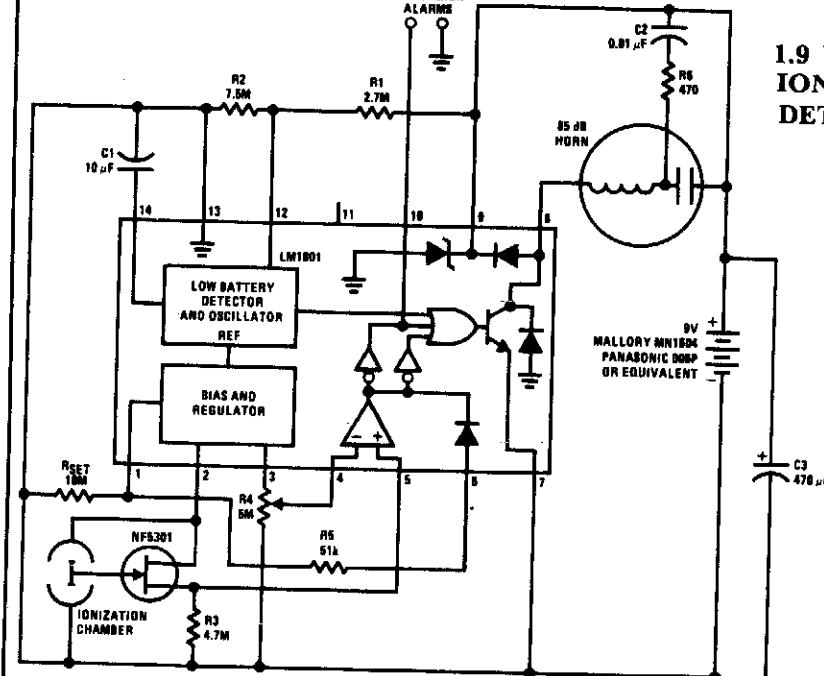


Fig. 79-2

**LINE-OPERATED PHOTO ELECTRIC
SMOKE ALARM USING LIGHT SENSI-
TIVE RESISTOR (INCLUDES DETEC-
TION OF OPEN-CIRCUITED LED)**

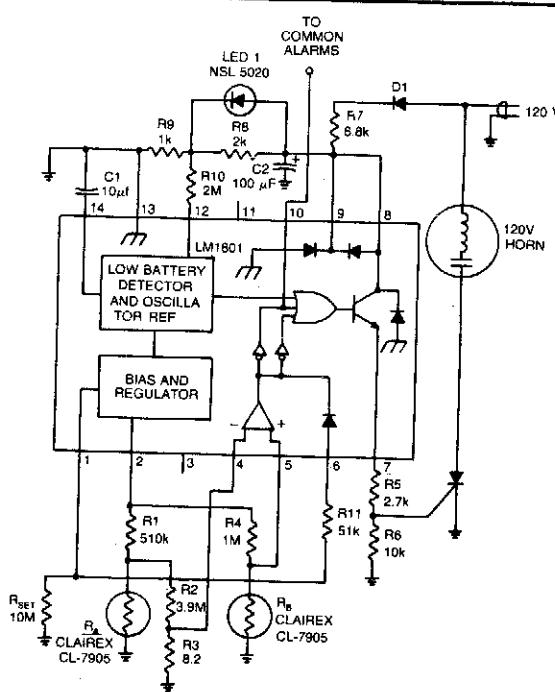


Fig. 79-3

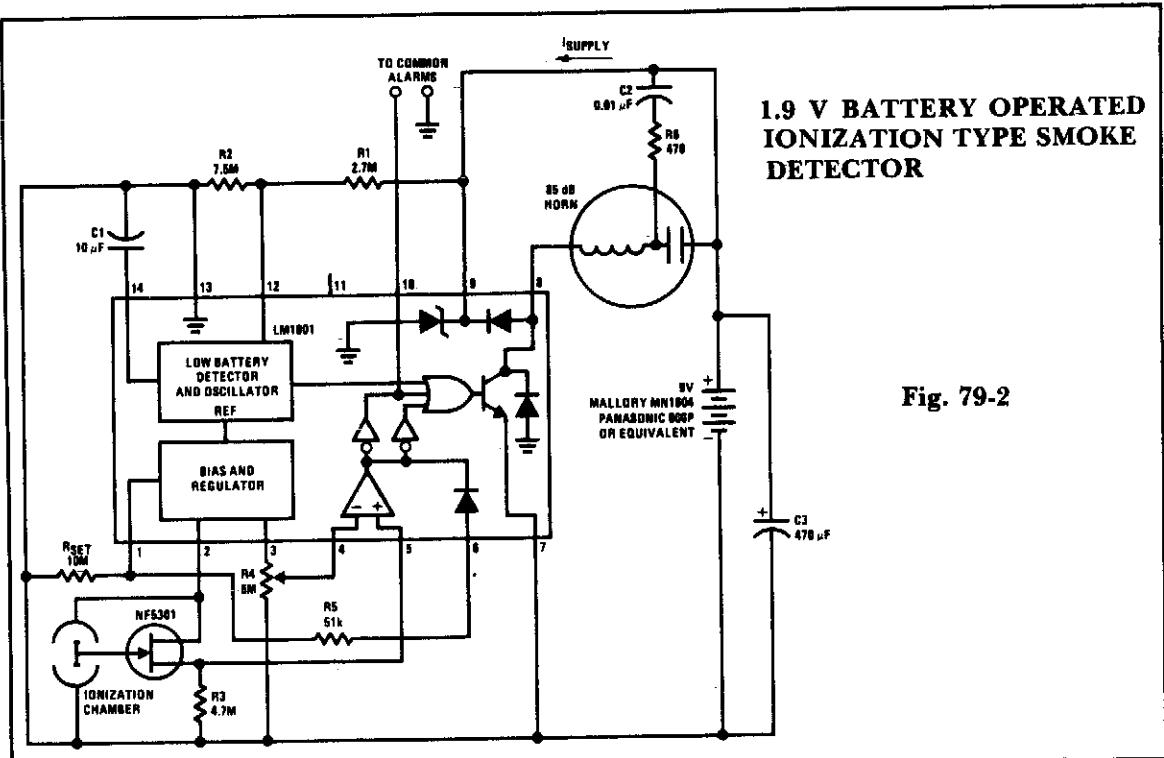


Fig. 79-2

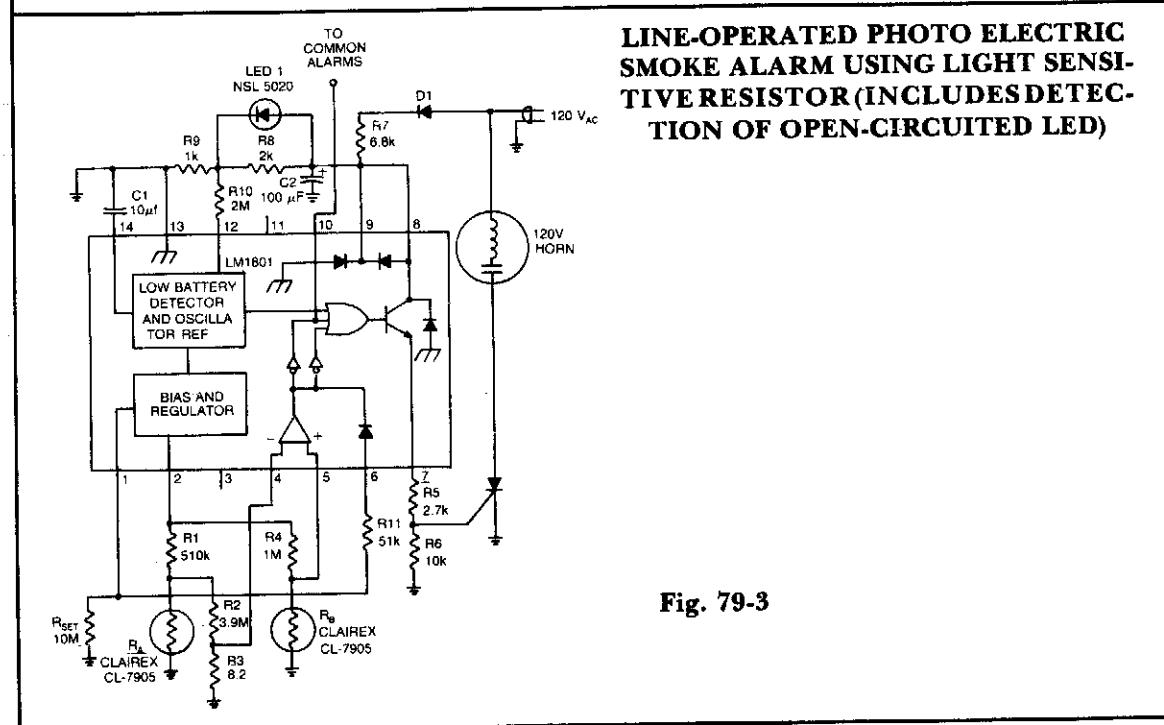


Fig. 79-3

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

Music Synthesizer

Preprogrammed Single-Chip Microcontroller for
Musical Organ

Musical Envelope Generator and Modulator

Stereo Reverb System

Tone Burst Generator

Musical Chime Generator

Sound Effect Generator

Programmable Bird Sounds

Stereo Reverb Enhancement System

Siren/Space War/Phasor Gun

Four Channel Synthesizer

VOLTAGE-CONTROLLED AMPLIFIER OR TREMOLO CIRCUIT

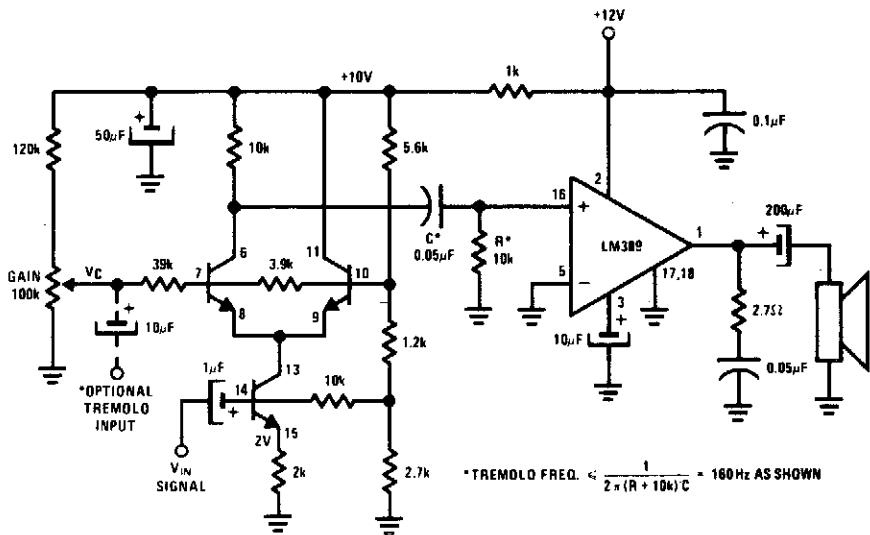


Fig. 80-1

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 may be set for optimum depth.

MUSIC SYNTHESIZER

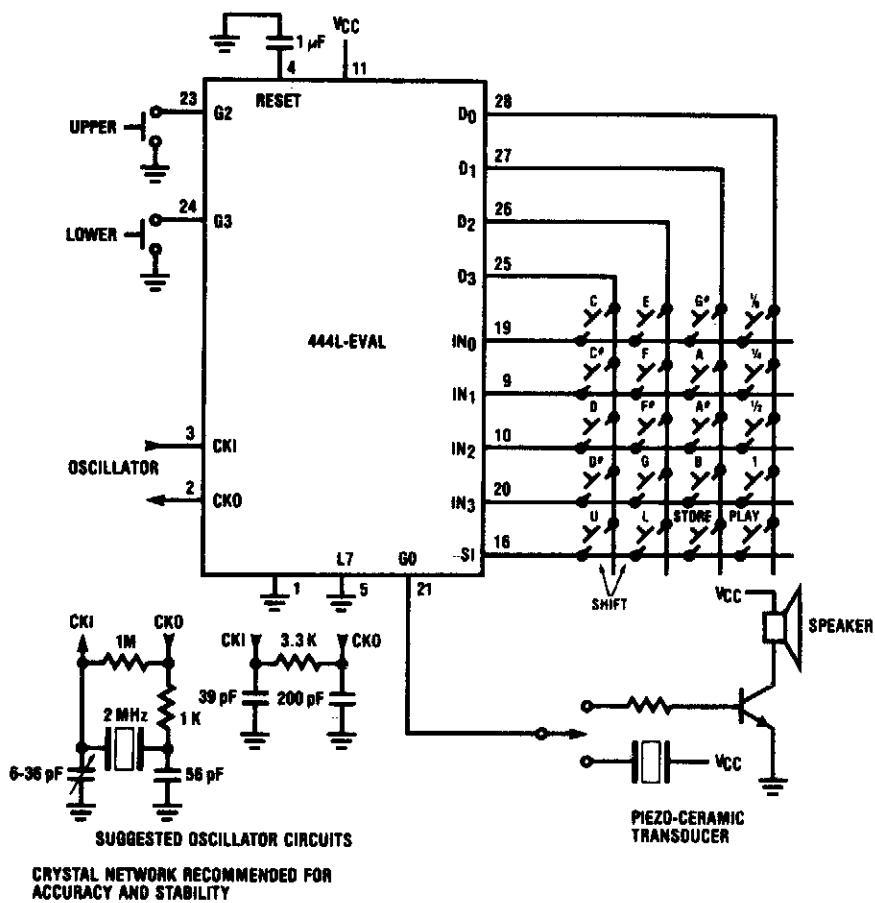


Fig. 80-2

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

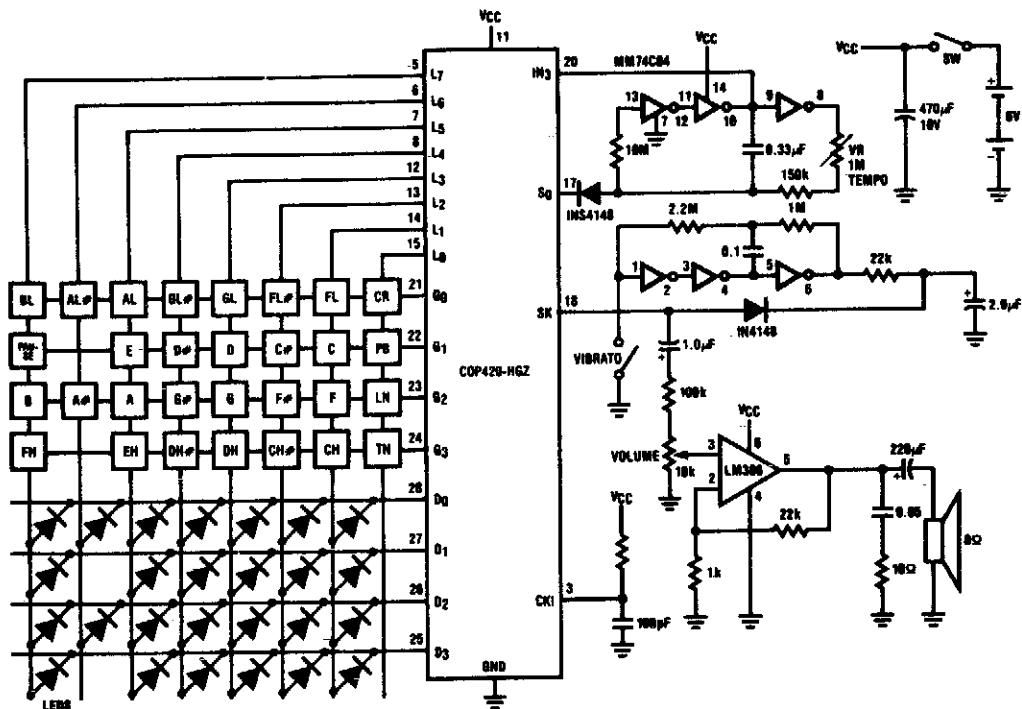


Fig. 80-3

Circuit Notes

Twenty-five musical keys and 25 LEDs are provided to denote F to F'' with halfnotes 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

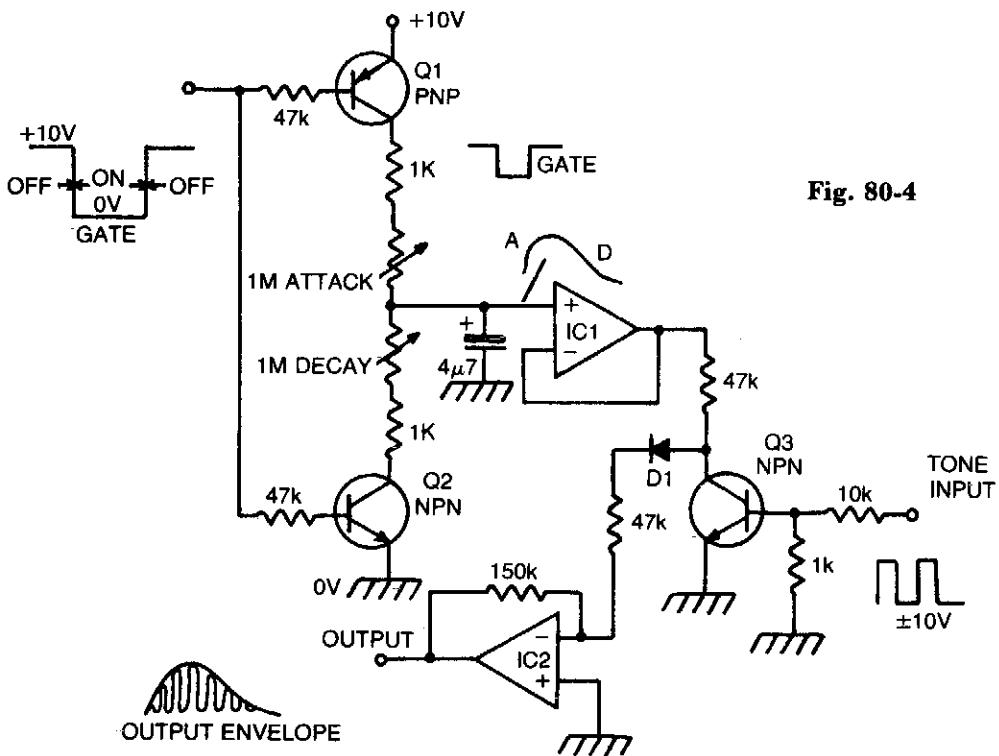


Fig. 80-4

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 effect 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

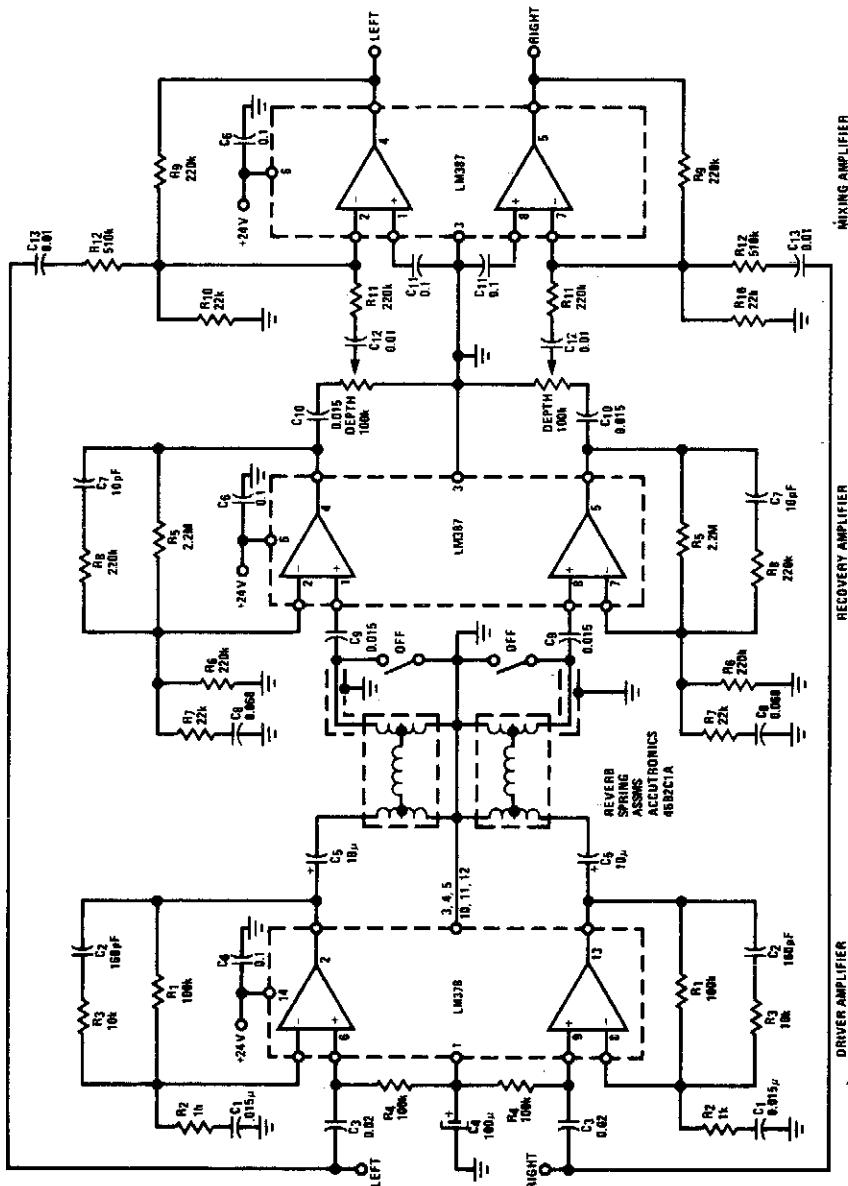


Fig. 80-5

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.

FOUR CHANNEL SYNTHESIZER

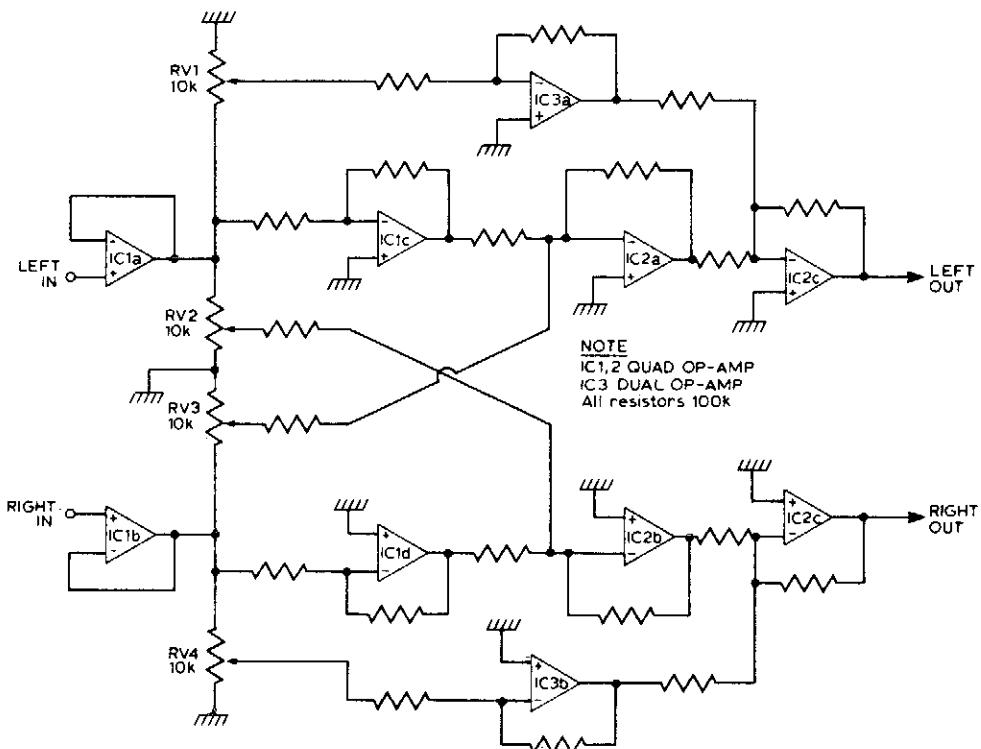


Fig. 80-6

Circuit Notes

This circuit will synthesize two rear channels for quadraphonic sound when fed with a stereo signal. The rear output for the left channel, is a combination of the left channel input

180 out of phase, added to a proportion of the right hand channel (also out of phase). The right hand rear output is obtained in a similar way.

TONE BURST GENERATOR

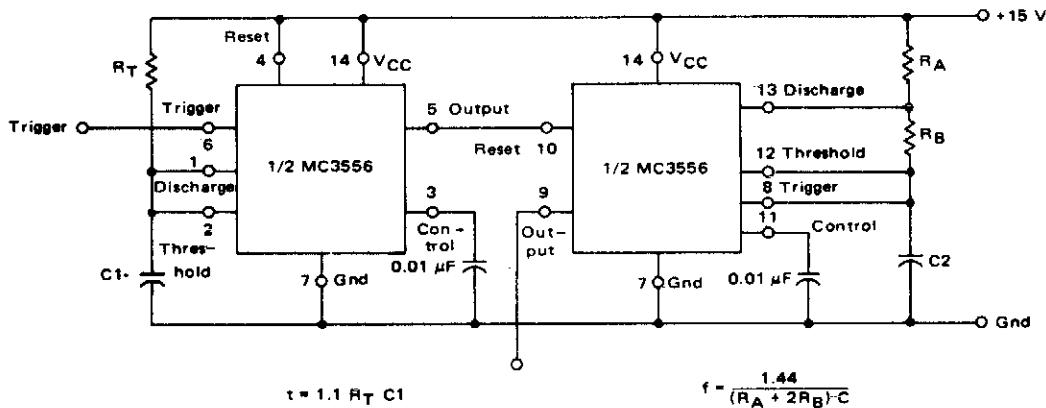


Fig. 80-7

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

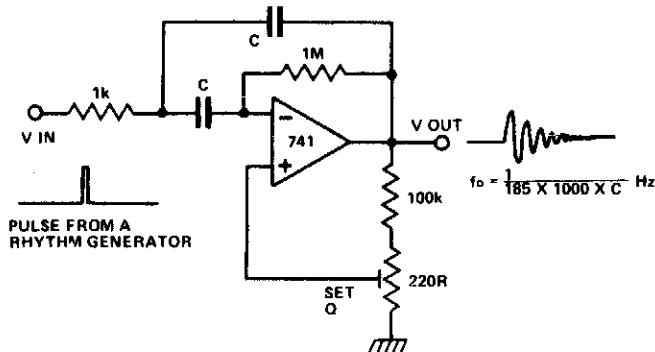


Fig. 80-8

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

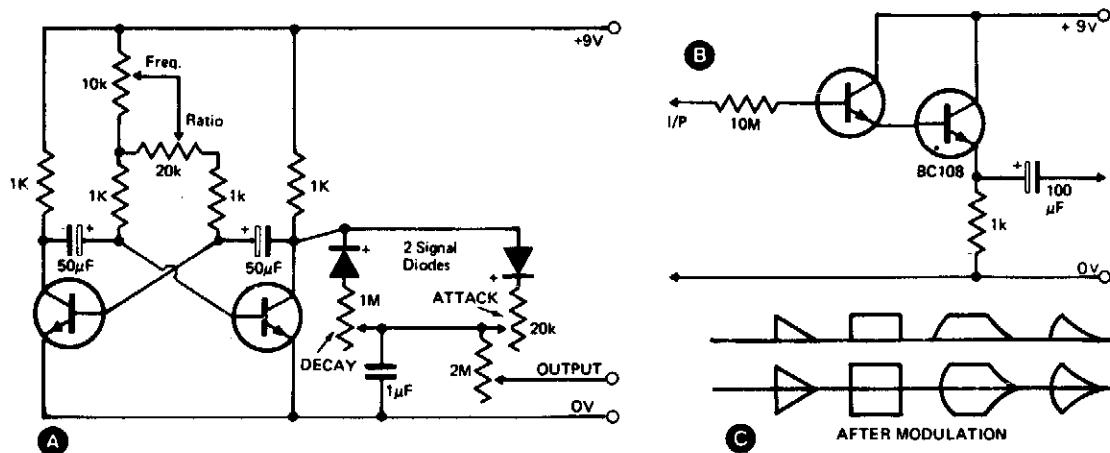


Fig. 80-9

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

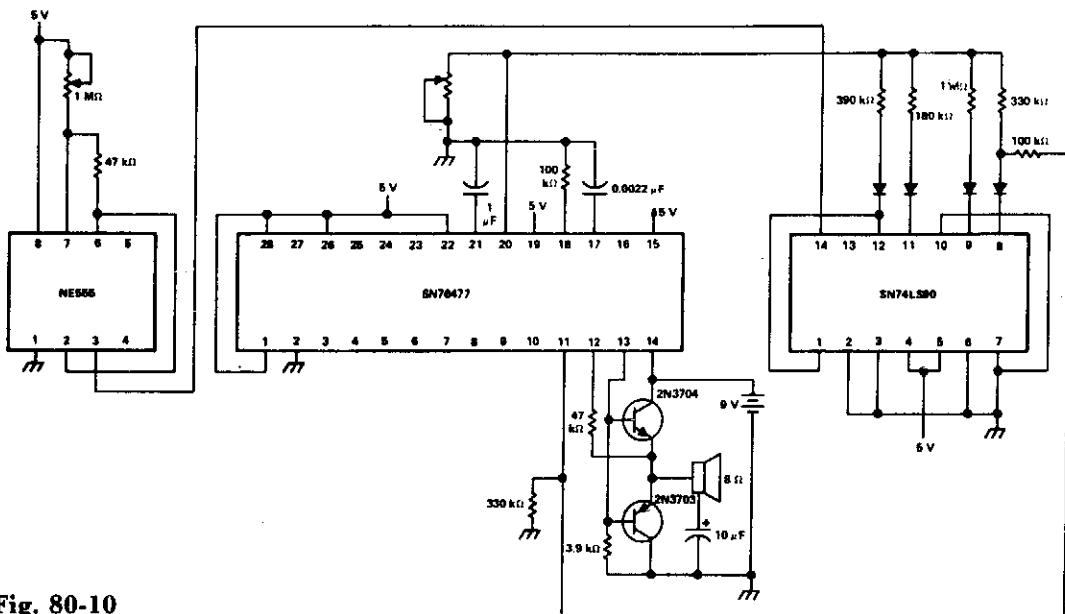


Fig. 80-10

STEREO REVERB ENHANCEMENT SYSTEM

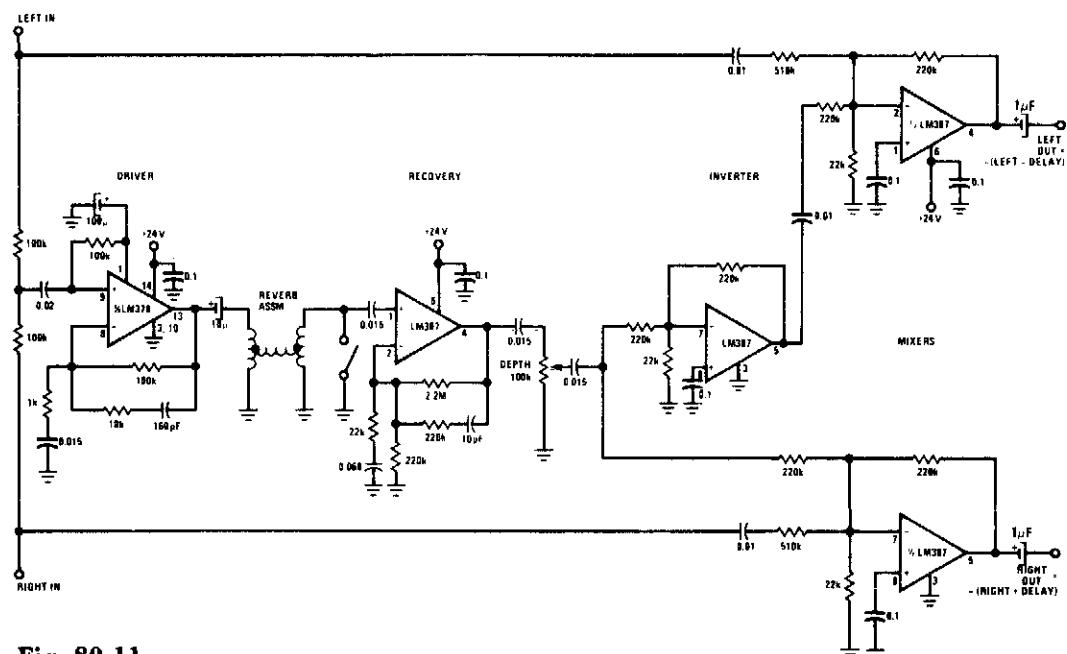


Fig. 80-11

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

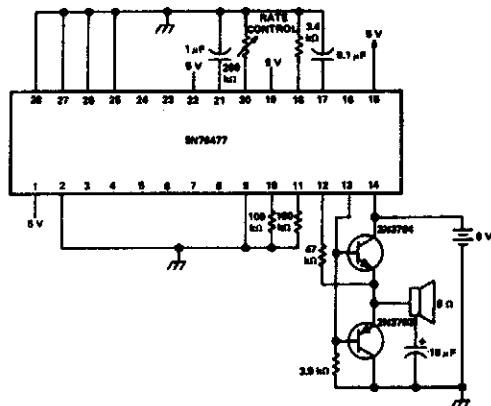


Fig. 80-12

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

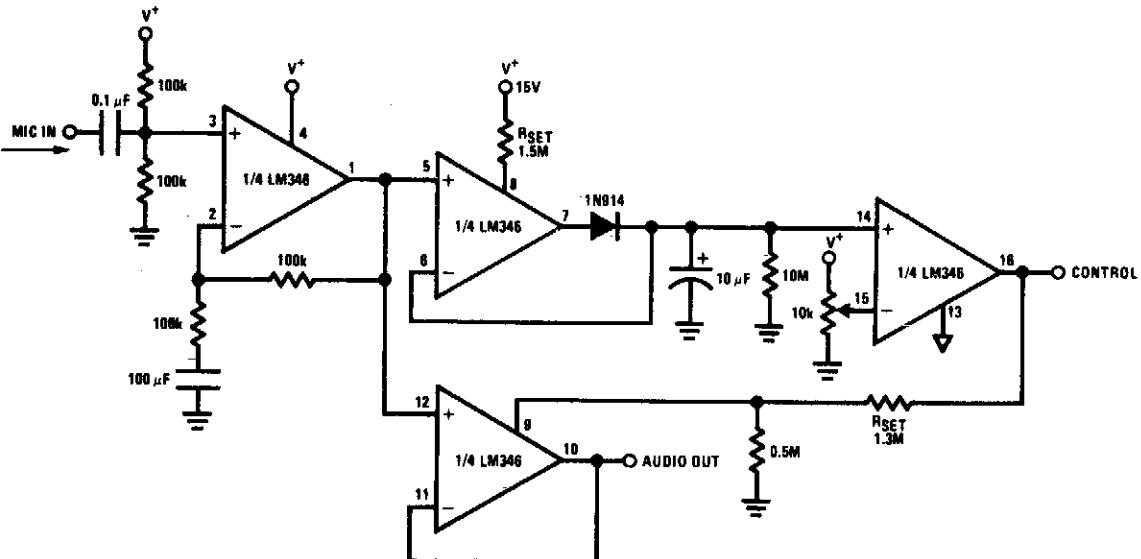


Fig. 81-1

AUDIO OPERATED RELAY

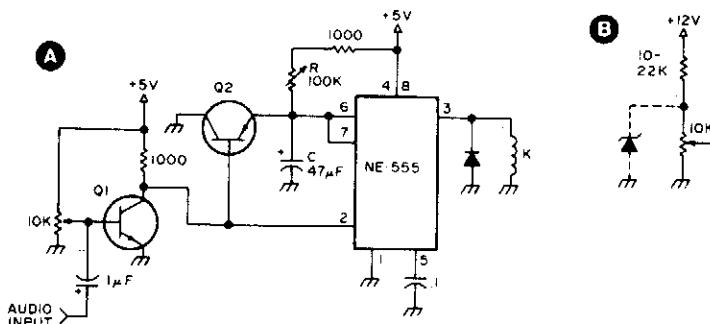


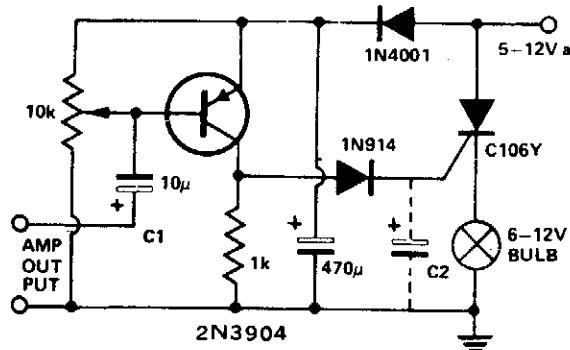
Fig. 81-2

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 μ F),

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 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

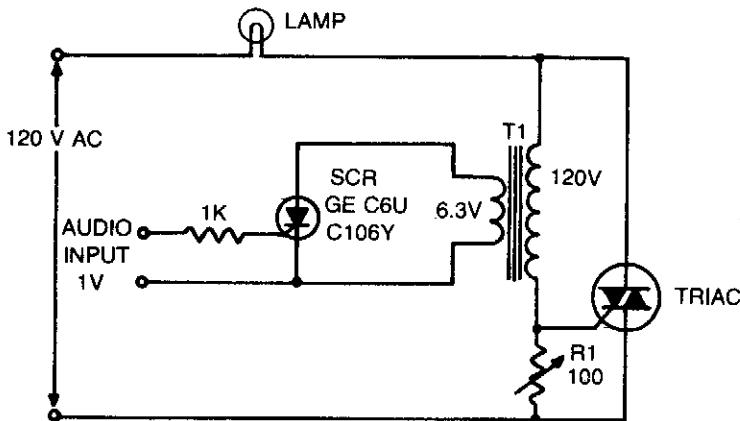


Fig. 81-4

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

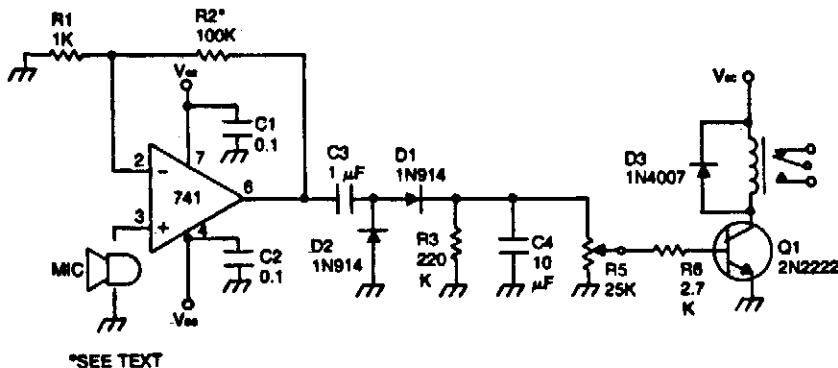


Fig. 81-5

*SEE TEXT

Circuit Notes

The device remains dormant (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

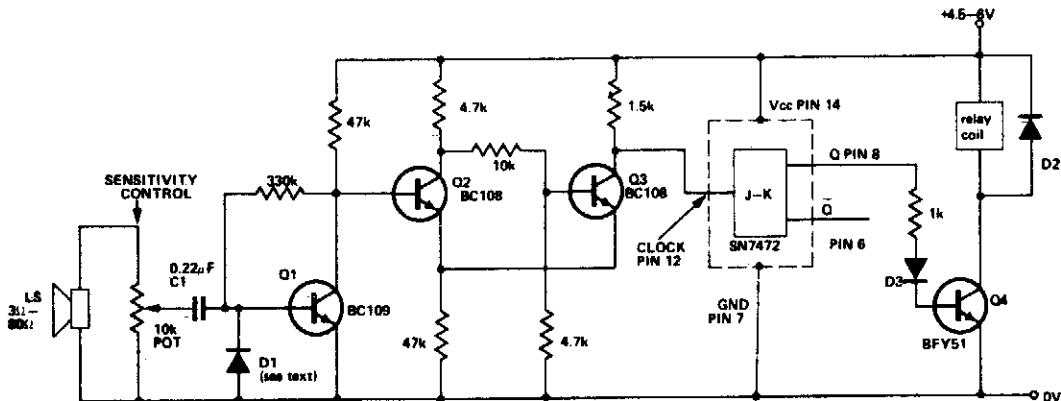


Fig. 81-6

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

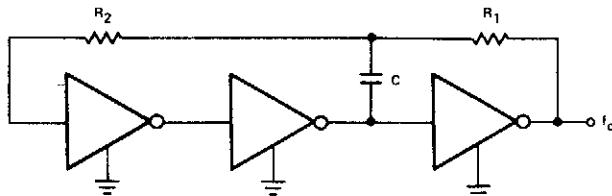
0.5 Hz Square-Wave Oscillator

Simple Triangle/Square Wave Oscillator

Squarewave Oscillator

R/C OSCILLATOR

$$f_0 = \frac{1}{2 C [0.41 R_P + 0.70 R_1]}, \quad R_P = \frac{R_1 R_2}{R_1 + R_2}$$

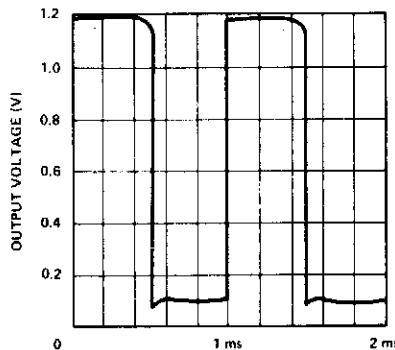
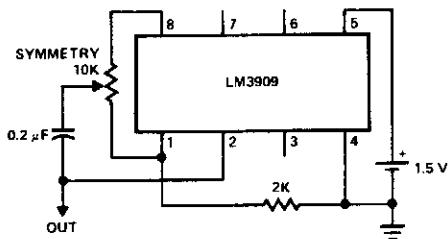


Gates are 74C04

- a. If $R_1 = R_2 = R_1$, $f \approx 0.55/RC$
- b. If $R_2 \gg R_1$, $f \approx 0.45/R_1C$
- c. If $R_2 \ll R_1$, $f \approx 0.72/R_1C$
- 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

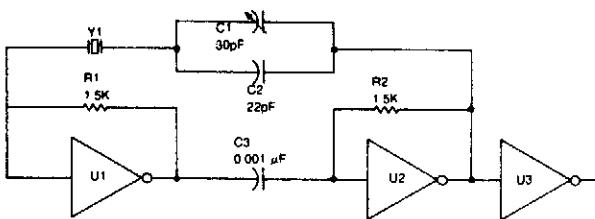


Fig. 82-3

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

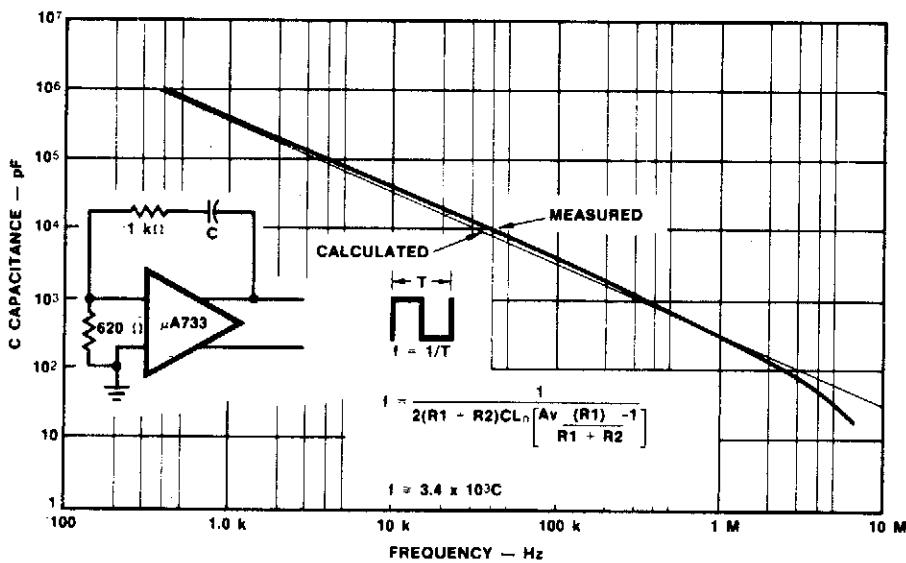


Fig. 82-4

ADJUSTABLE TTL CLOCK (MAINTAINS 50% DUTY CYCLE)

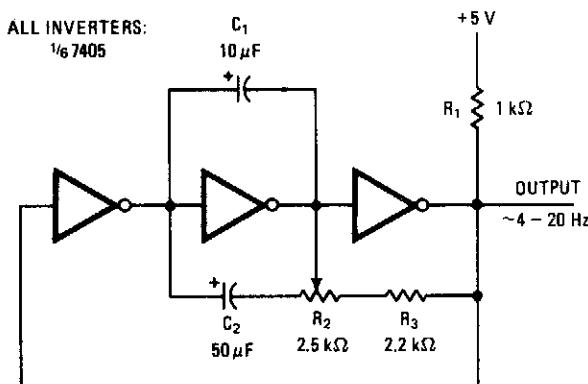


Fig. 82-5

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

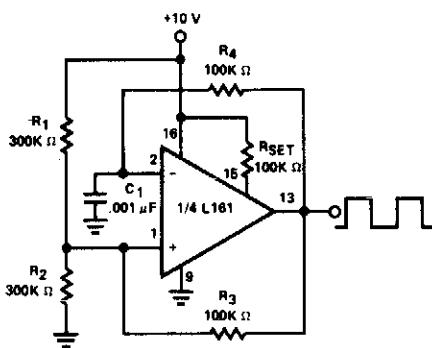
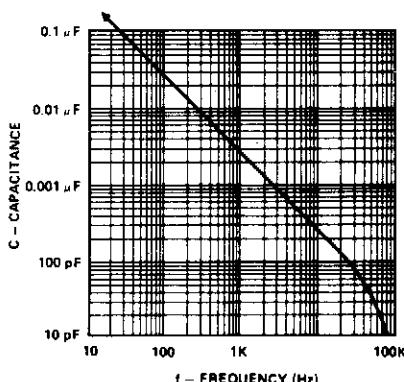


Fig. 82-6



Frequency vs the Value of C_1
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

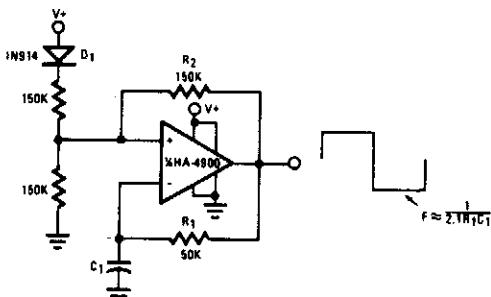
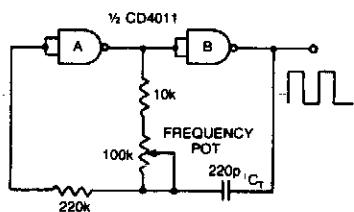


Fig. 82-7

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



Varying the 100 K pot changes the discharge rate of C_T and hence the frequency. A square wave output is generated. The maximum frequency using CMOS is limited to 2 MHz.

Fig. 82-8

FREE-RUNNING SQUARE-WAVE OSCILLATOR

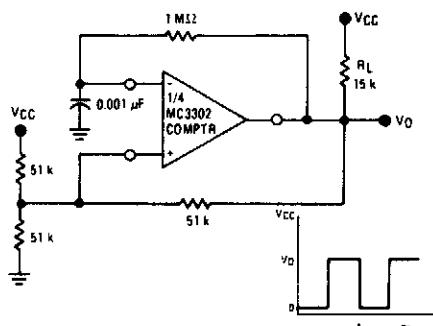


Fig. 82-9

PRECISION SQUARER

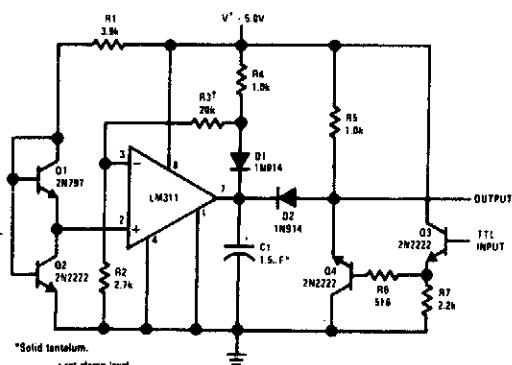


Fig. 82-10

SQUARE WAVE OSCILLATOR

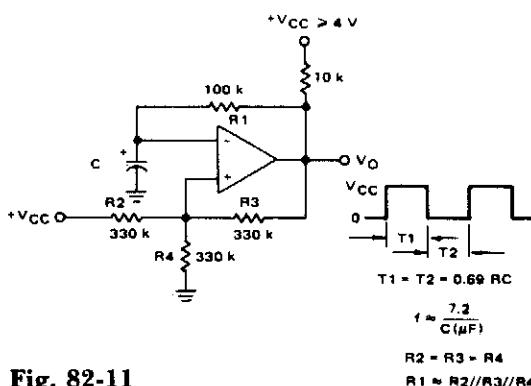


Fig. 82-11

0.5 Hz SQUARE-WAVE OSCILLATOR

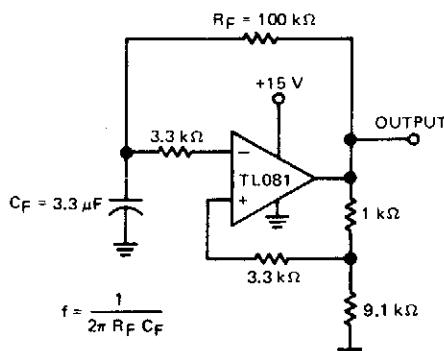


Fig. 82-12

SIMPLE TRIANGLE/SQUARE WAVE OSCILLATOR

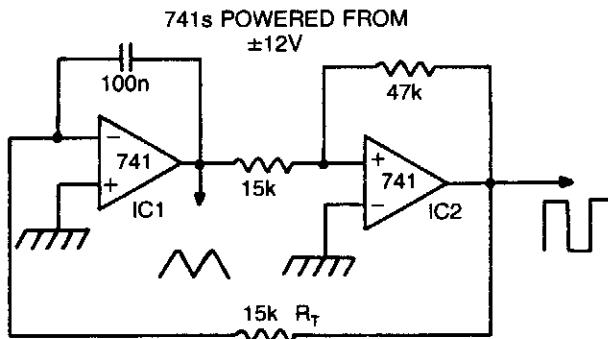


Fig. 82-13

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

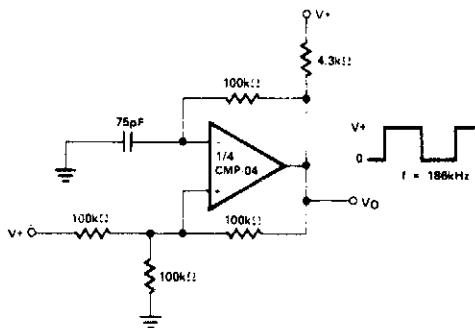


Fig. 82-14

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

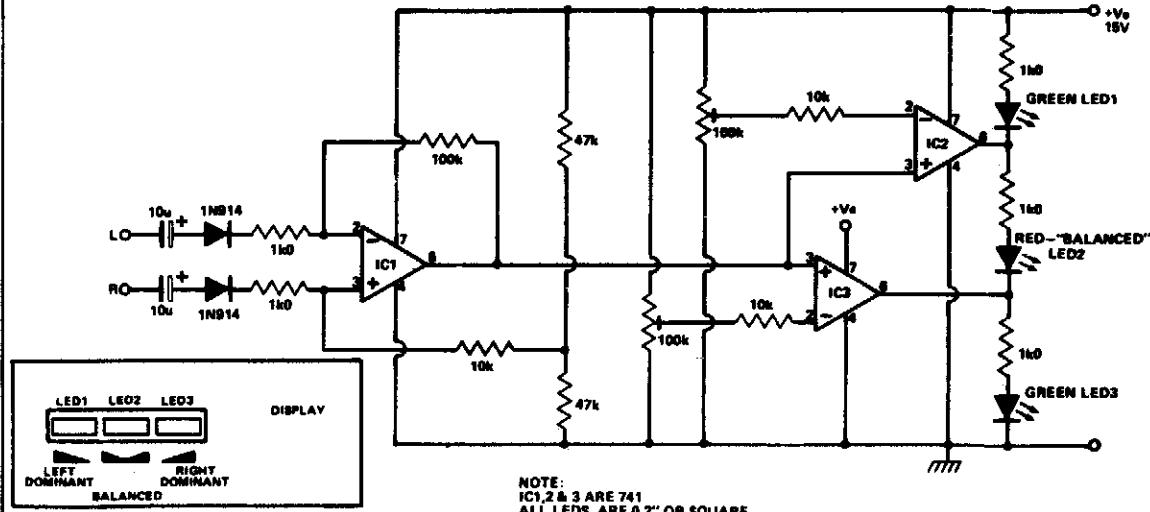


Fig. 83-1

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

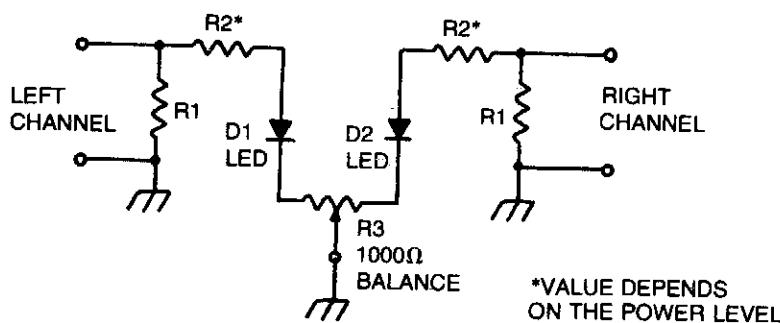


Fig. 83-2

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 milliampere 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, $\frac{1}{2}$ -watt resistor, 5% or 1%

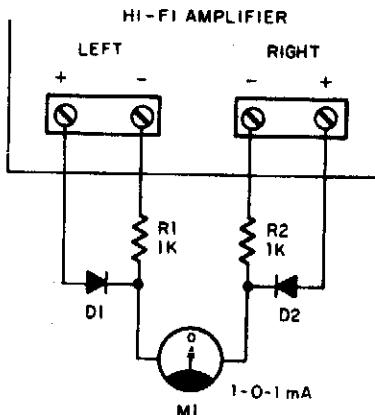


Fig. 83-3

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

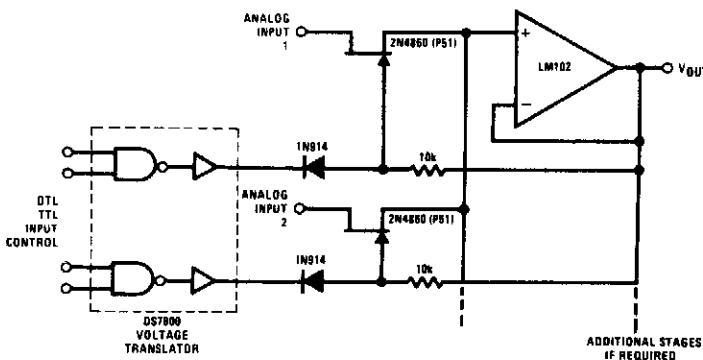


Fig. 84-1

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

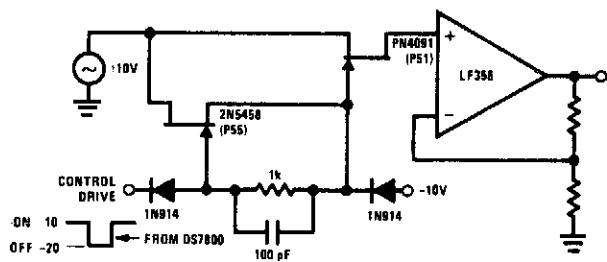


Fig. 84-2

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

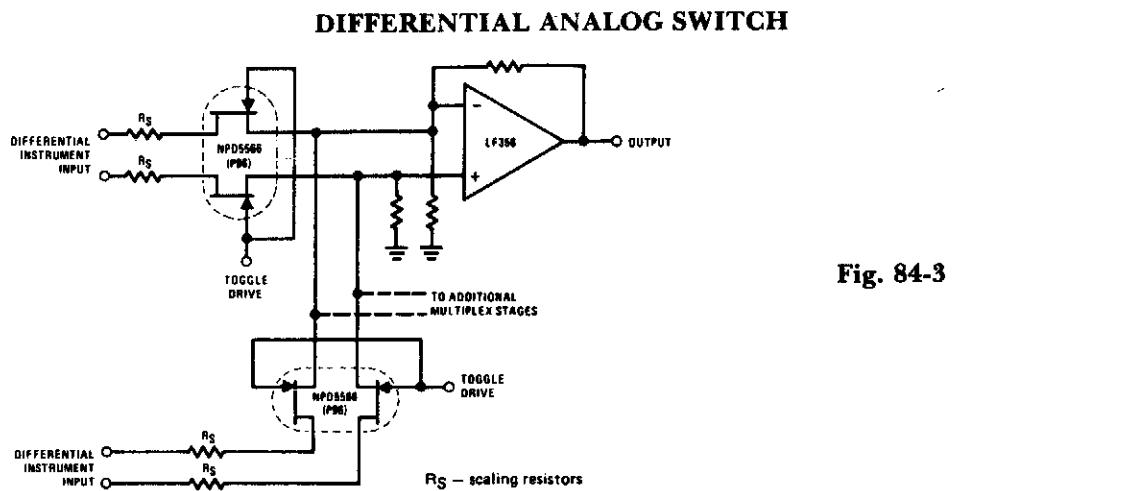


Fig. 84-3

Circuit Notes

The NPD5566 monolithic dual is used in a differential multiplex application where $R_{ds(ON)}$ should be closely matched. Since $R_{ds(ON)}$ for the monolithic dual tracks at better than $\pm 1\%$ over wide temperature ranges ($-25^\circ C$ to $+125^\circ C$),

this makes it an unusual but ideal choice for an accurate multiplexer. This close tracking greatly reduces errors due to common-mode signals.

HIGH FREQUENCY SWITCH

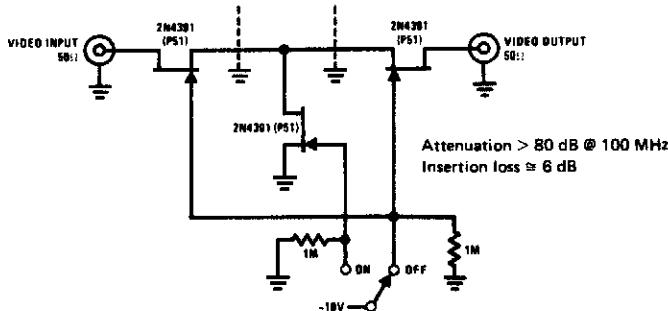
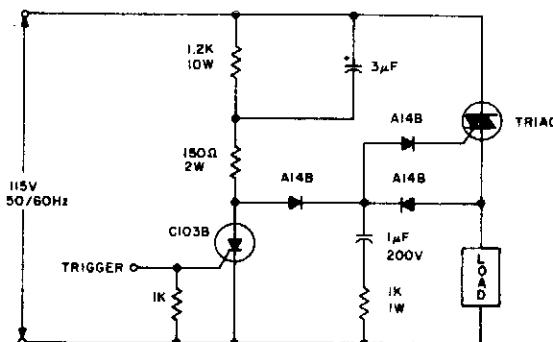


Fig. 84-4

Circuit Notes

The 2N4391 provides a low ON resistance of 30 ohm and a high OFF impedance (< 0.2 pF) when off. With proper layout and an ideal switch, the performance stated above can be readily achieved.

TRIAC ZERO VOLTAGE SWITCHING

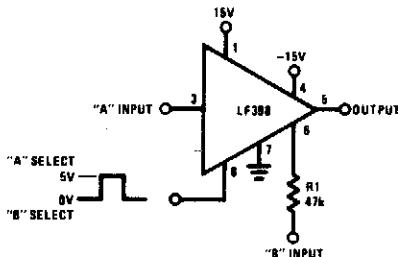


Circuit Notes

The triac will be gated on at the start of the positive half cycle by current flow through the $3\ \mu F$ capacitor as long as the C103 SCR is off. The load voltage then charges up the $1\ \mu F$ 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}	$10^{10}\ \Omega$	$47\ k\Omega$
BW	$\approx 1\ MHz$	$\approx 400\ kHz$
Crosstalk @ 1 kHz	-90 dB	-90 dB
Offset	$\leq 6\ mV$	$\leq 75\ mV$

Fig. 84-6

10 A, 25 Vdc SOLID STATE RELAYS

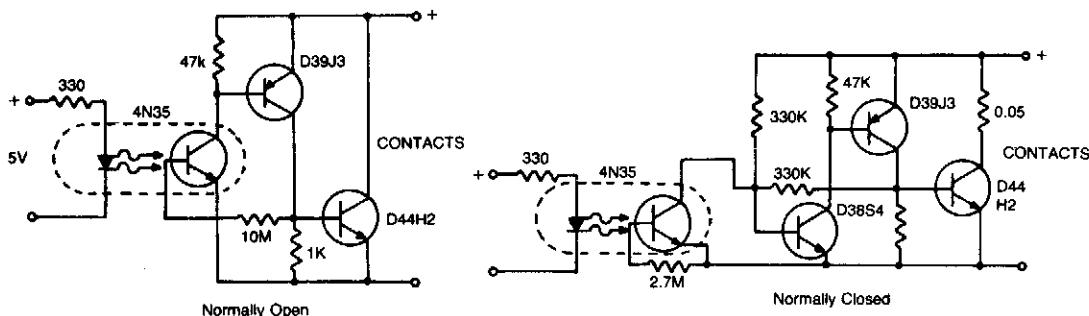


Fig. 84-7

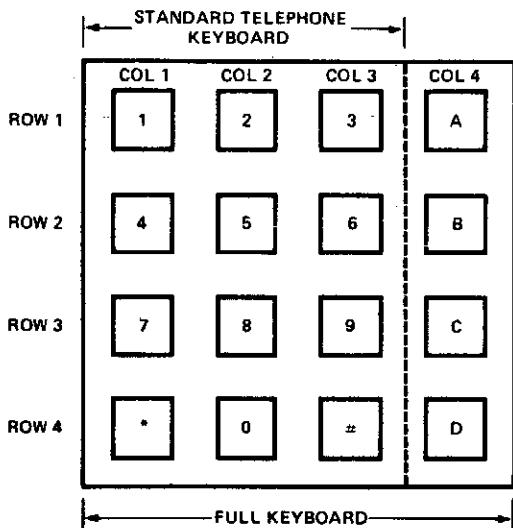
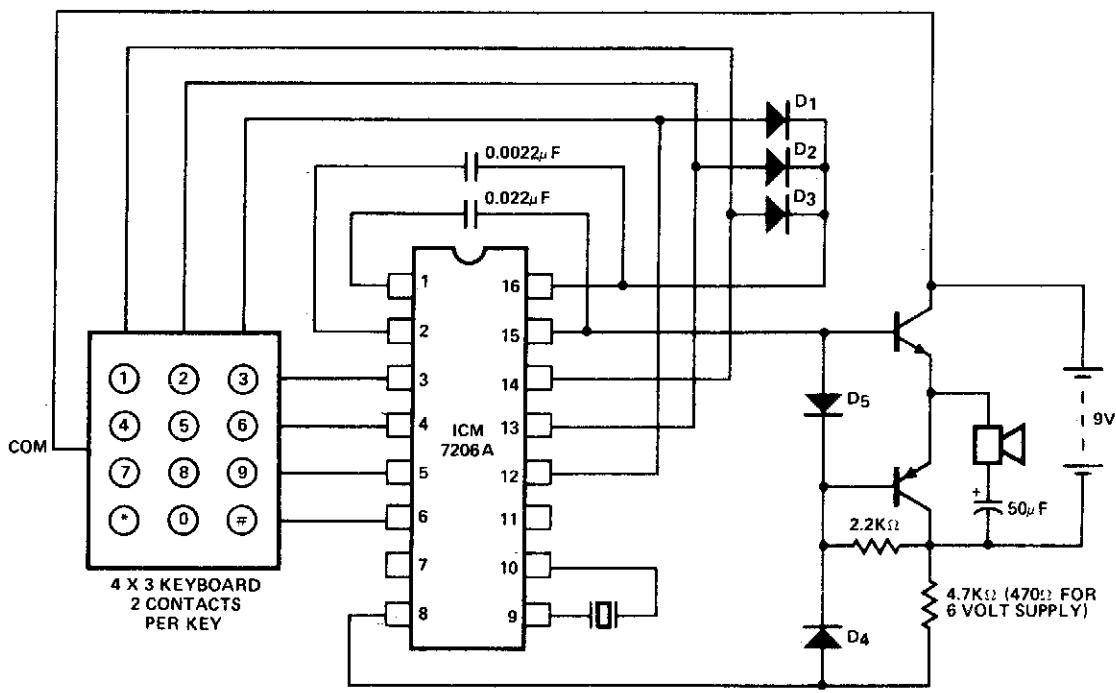
85

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 Optoisolator | 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 Device |
| | 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

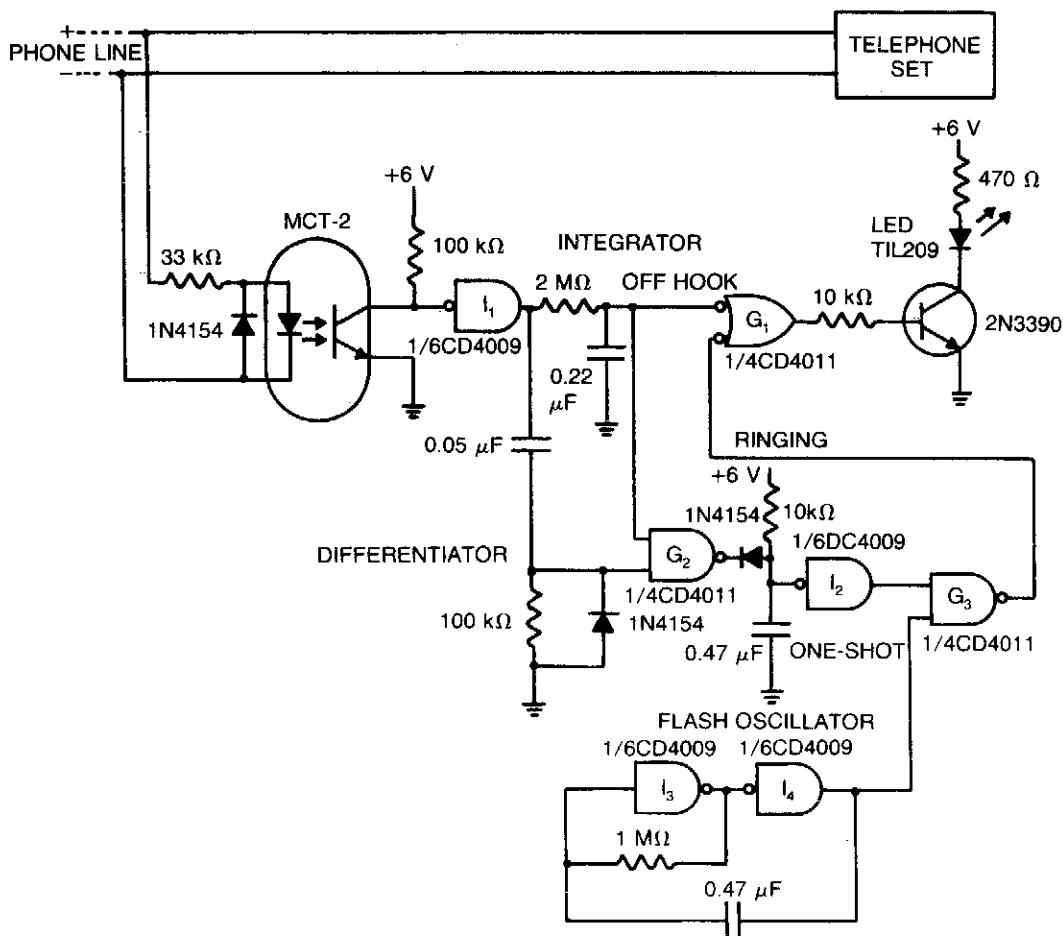


Fig. 85-2

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

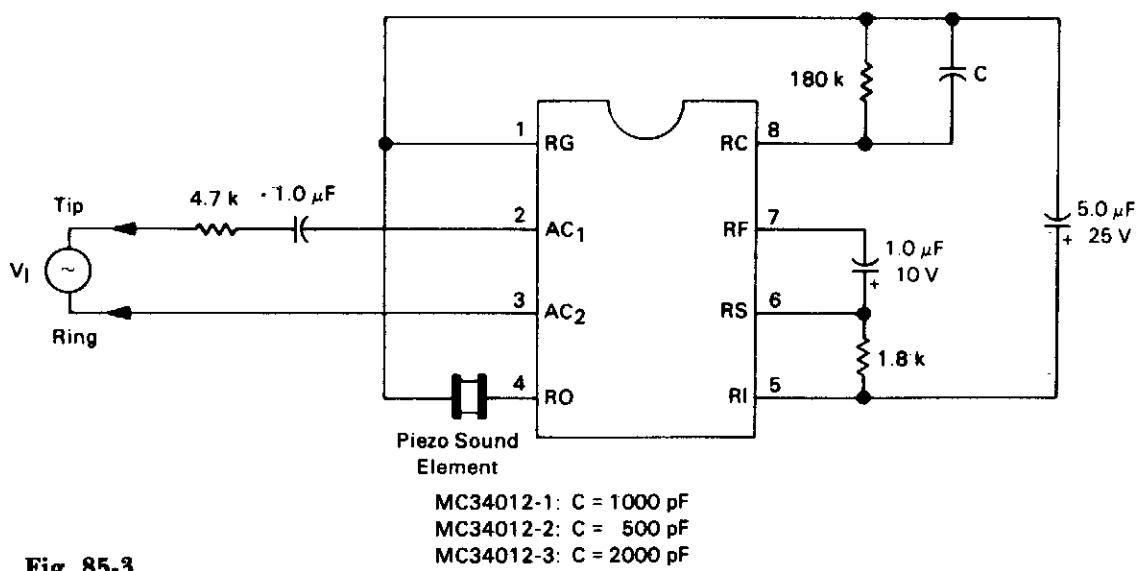


Fig. 85-3

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

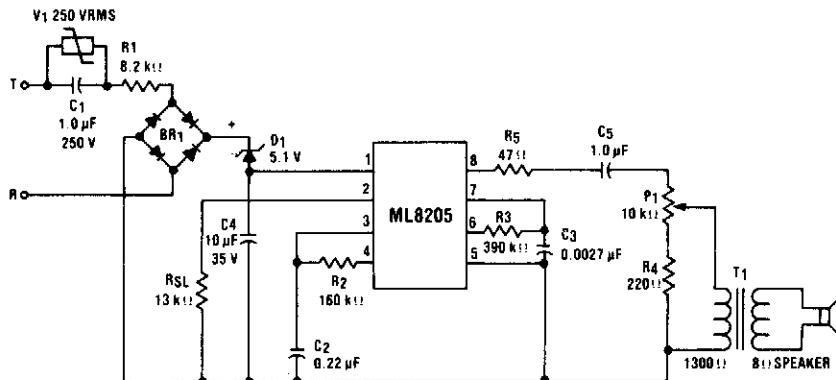


Fig. 85-4

TELEPHONE OR EXTENSION TONE RINGER

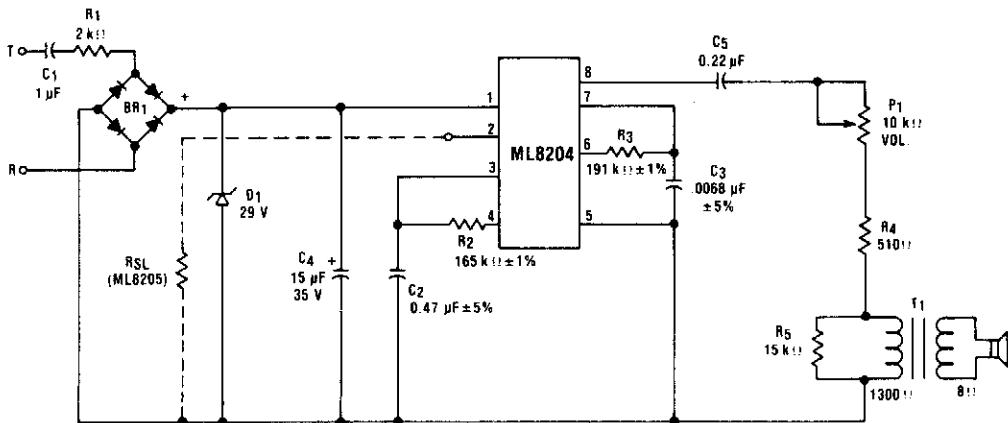


Fig. 85-5

Circuit Notes

This circuit uses ML8204/ML8205 devices. With the components shown, the output frequency chops between 512 Hz (f_{H1}) and 640 Hz (f_{H2}) at a 10 Hz (f_L) rate.

TELEPHONE LINE MONITOR

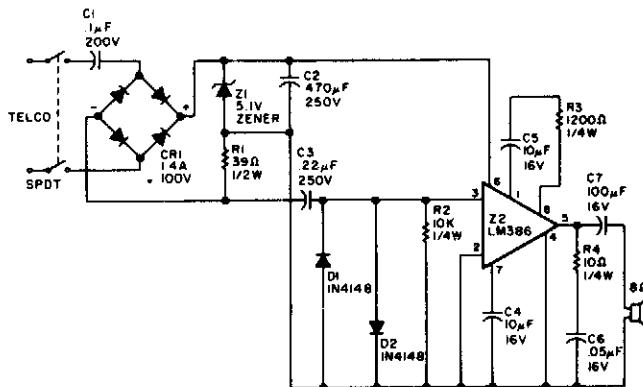


Fig. 85-6

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

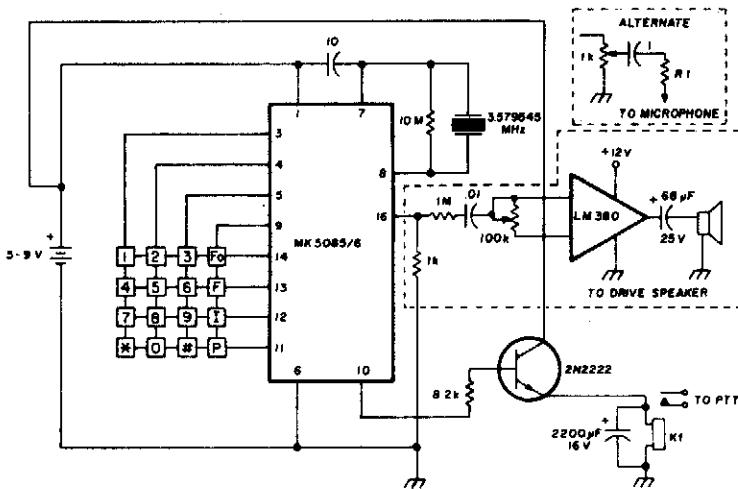


Fig. 85-7

Circuit Notes

The circuit requires a minimum of parts and uses a low cost standard 3.579545-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

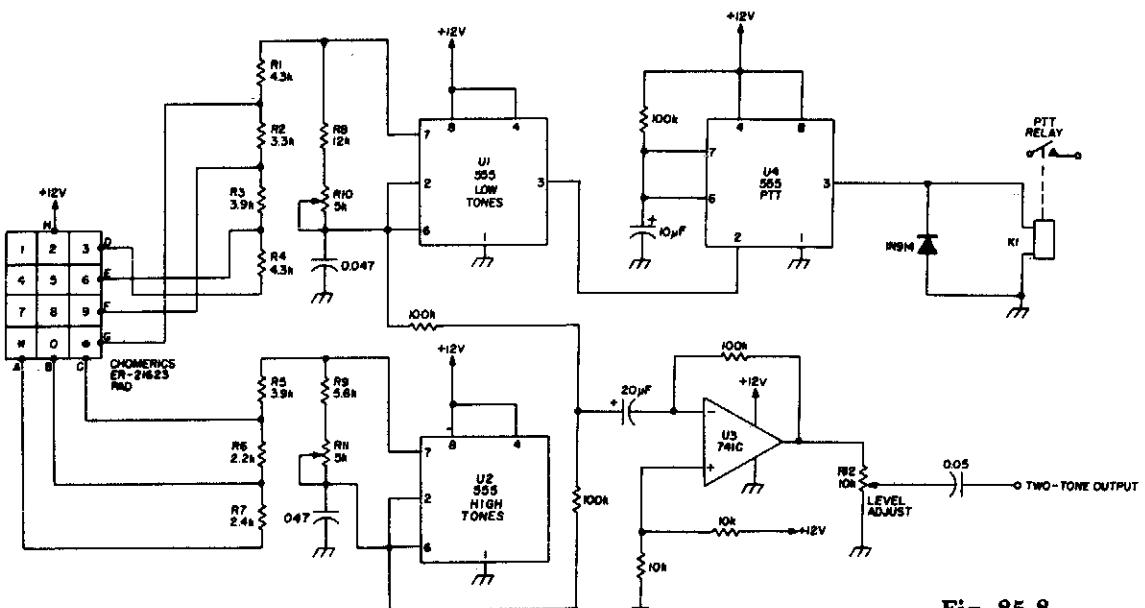


Fig. 85-8

Circuit Notes

Tone dial encoder with automatic PTT control uses the 555 timers.

TONE DIAL SEQUENCE DECODER

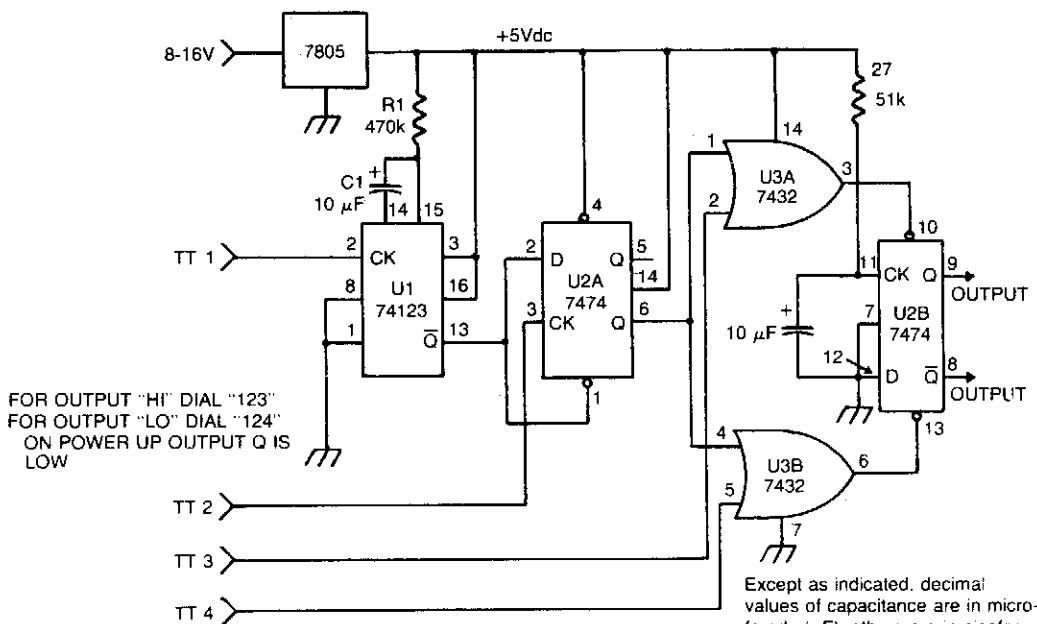
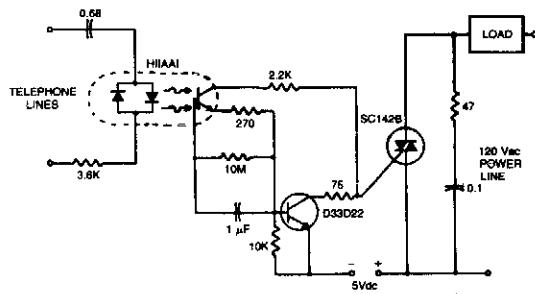


Fig. 85-9

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

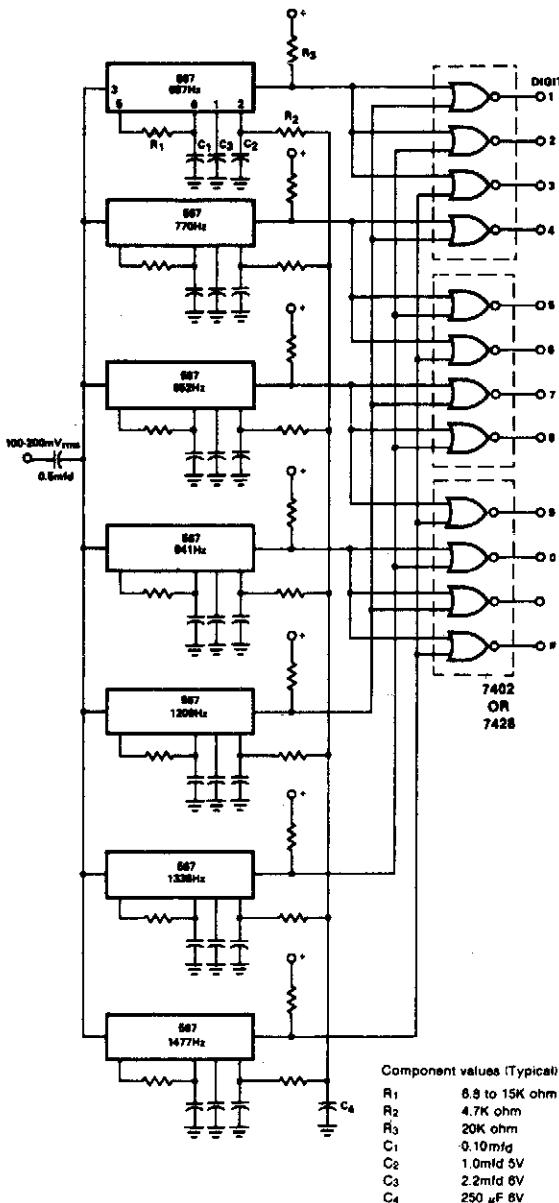
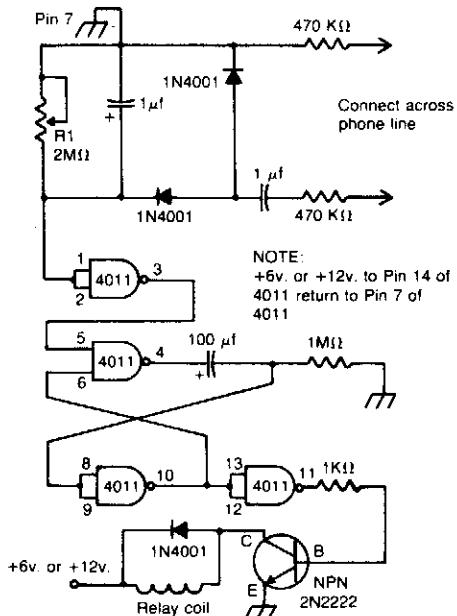


Fig. 85-11

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)

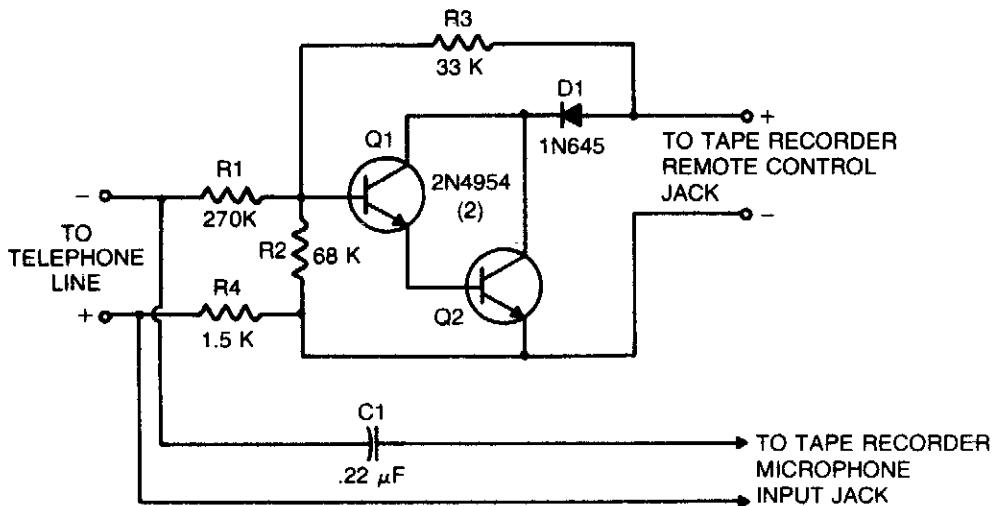


Fig. 85-13

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

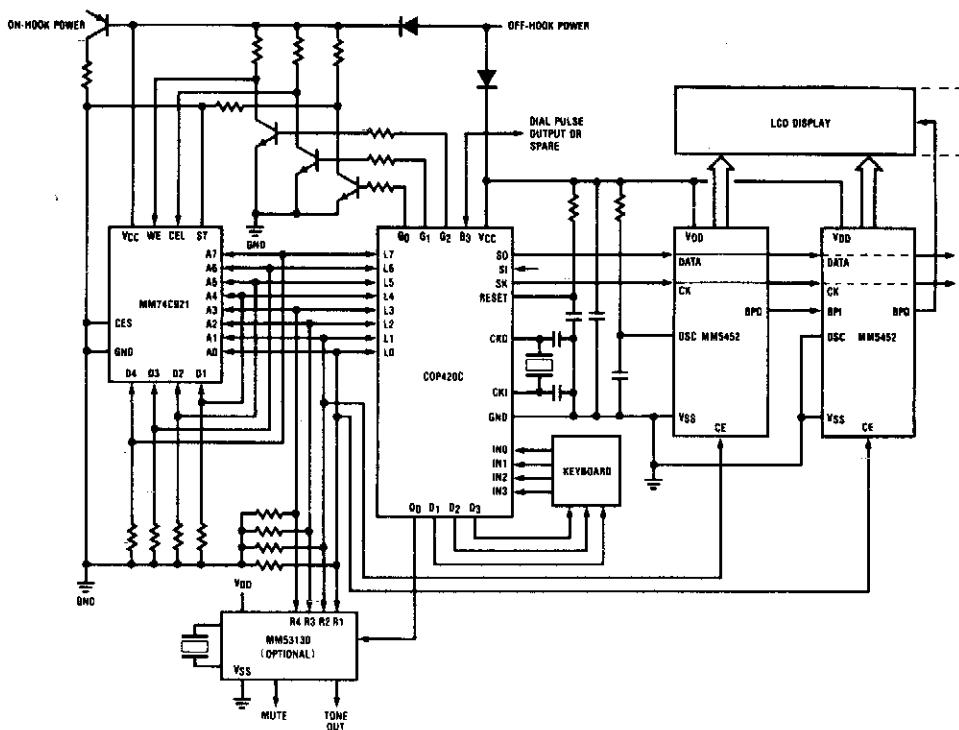


Fig. 85-14

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

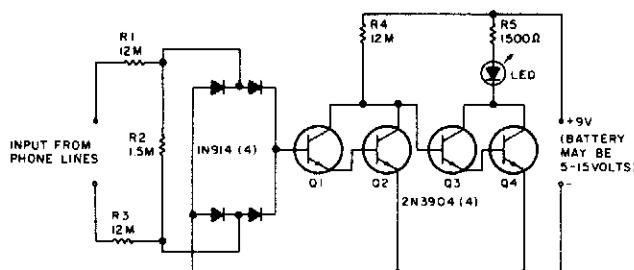


Fig. 85-15

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

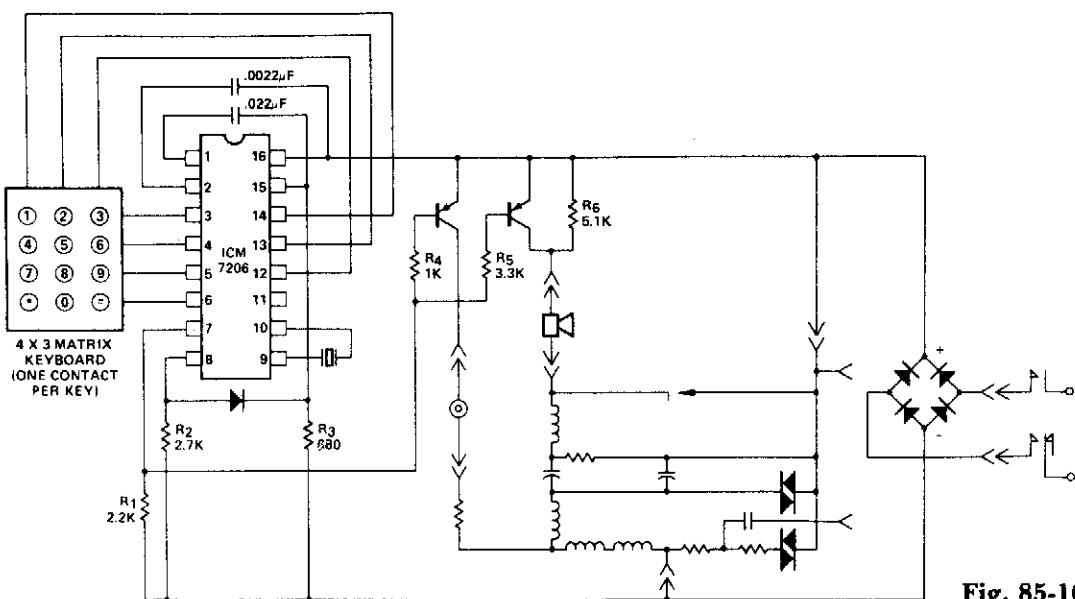


Fig. 85-16

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

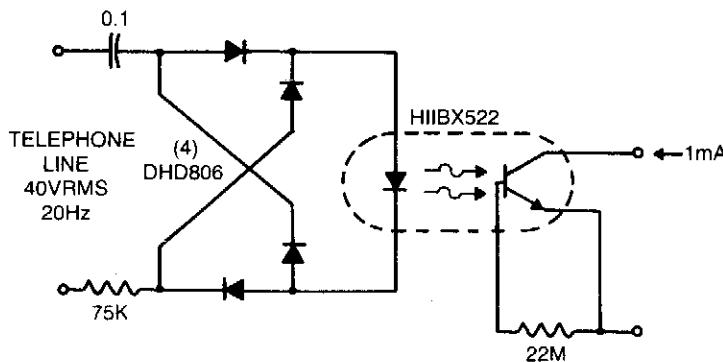


Fig. 85-17

Circuit Notes

Low line current loading is provided by the H11BX522 photodarlington op-photocoupler, which provides a 1 mA output from a 0.5 mA input.

PHONE AUTO ANSWER AND RING INDICATOR

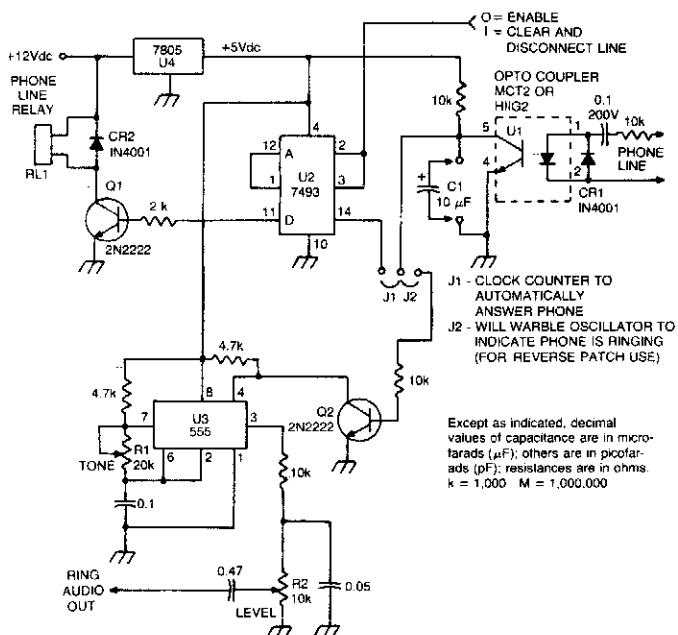


Fig. 85-18

AUTOPATCH TELEPHONE LINE INTERFACE

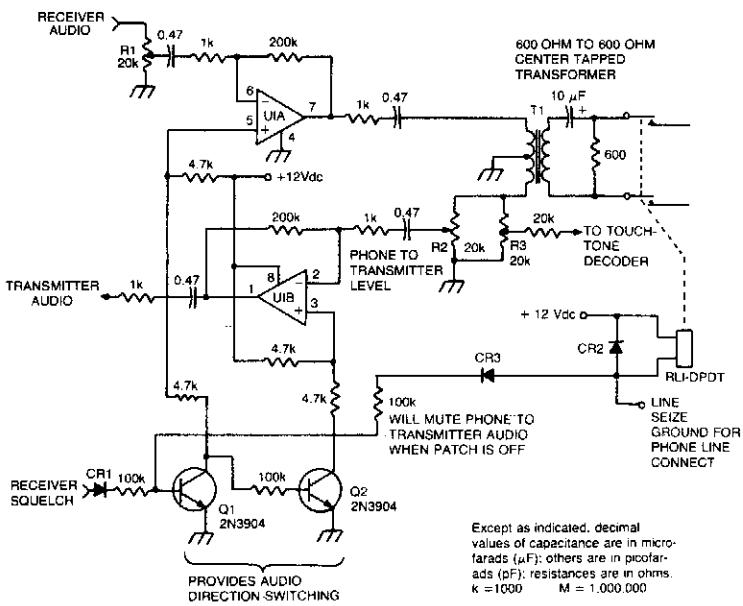


Fig. 85-19

TELEPHONE RINGER USES PIEZOELECTRIC DEVICE

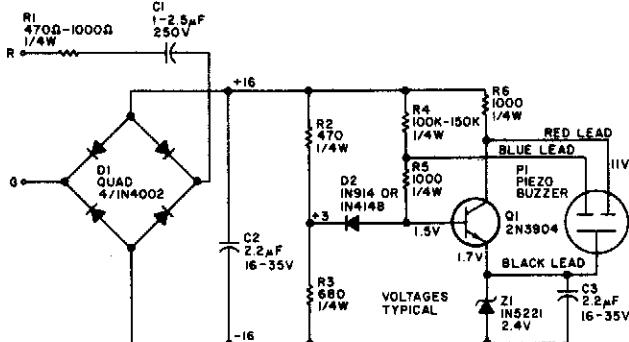


Fig. 85-20

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

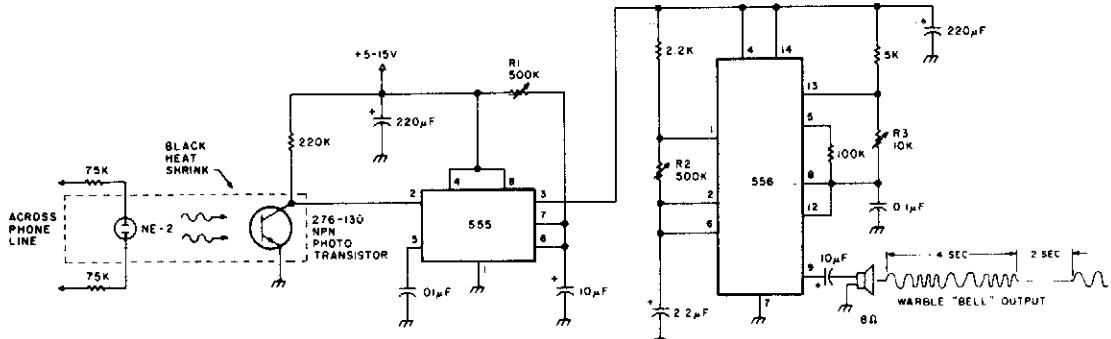


Fig. 85-21

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

Portable Calibrator

BOILER CONTROL

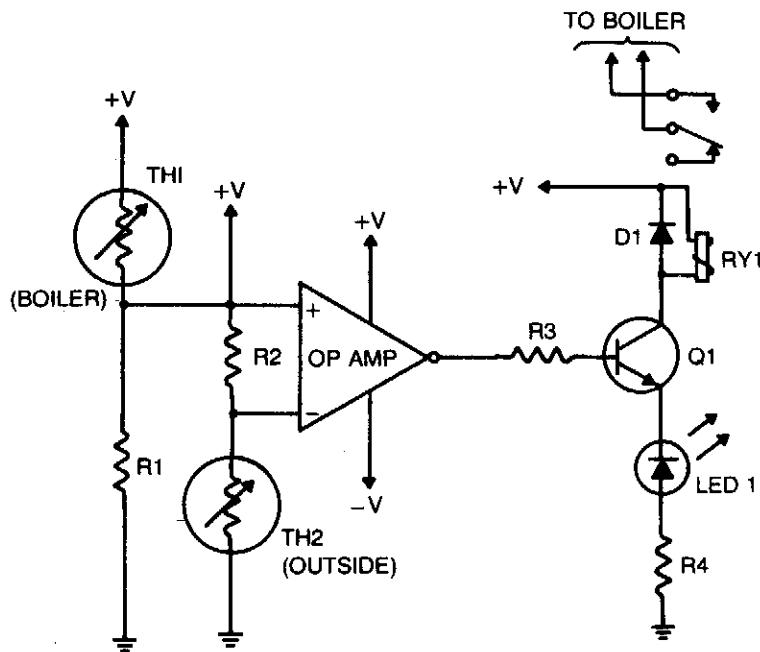


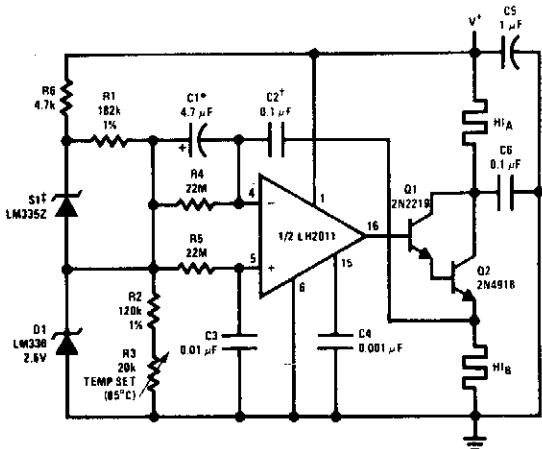
Fig. 86-1

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



* solid tantalum

† mylar

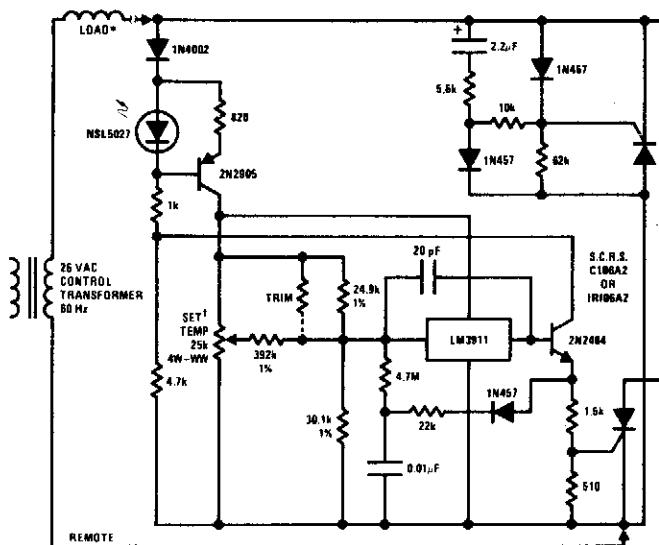
‡ close thermal coupling between sensor and oven shell is recommended.

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.

Fig. 86-2

TWO-WIRE REMOTE AC ELECTRONIC THERMOSTAT (GAS OR OIL FURNACE CONTROL)



* Solenoid 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 anticipation as is presently used in many home thermostats.

Fig. 86-3

THREE-WIRE ELECTRONIC THERMOSTAT

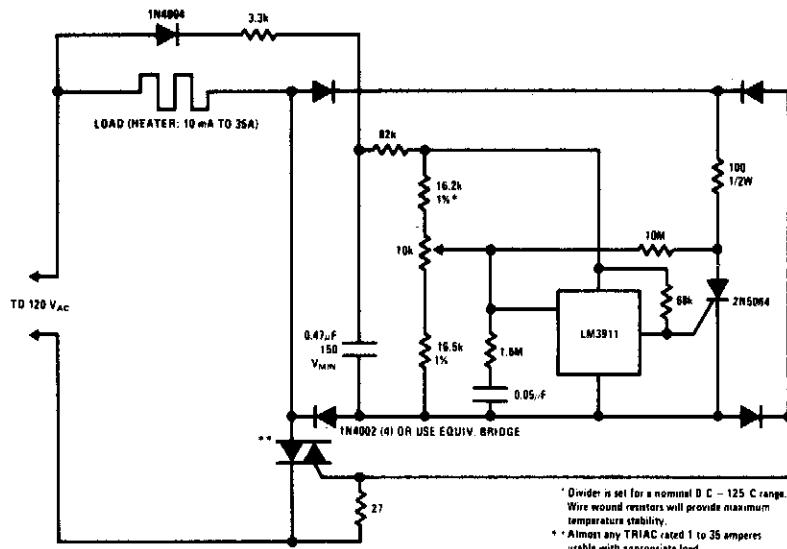


Fig. 86-4

TEMPERATURE-SENSITIVE HEATER CONTROL

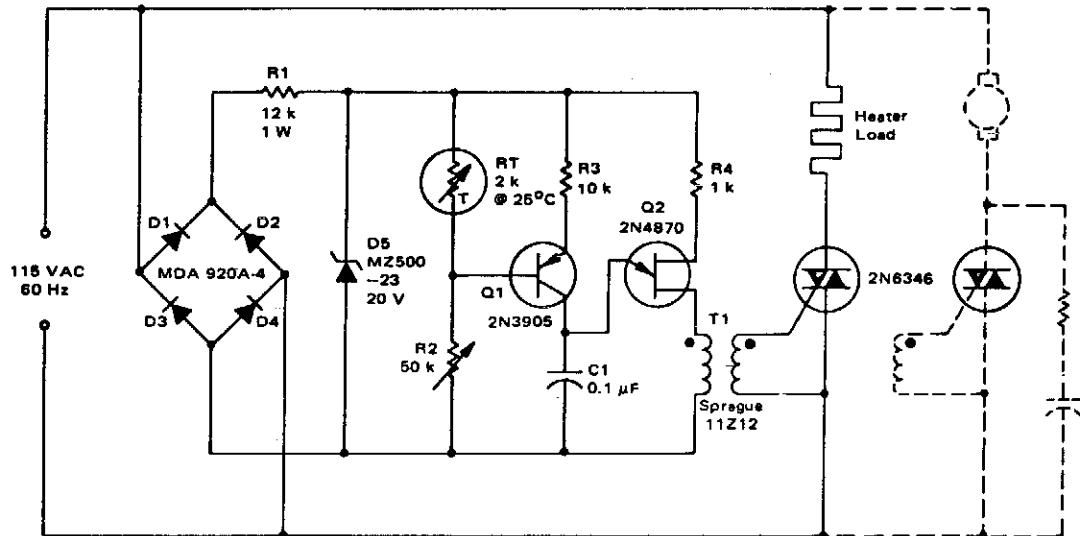


Fig. 86-5

TEMPERATURE CONTROLLER

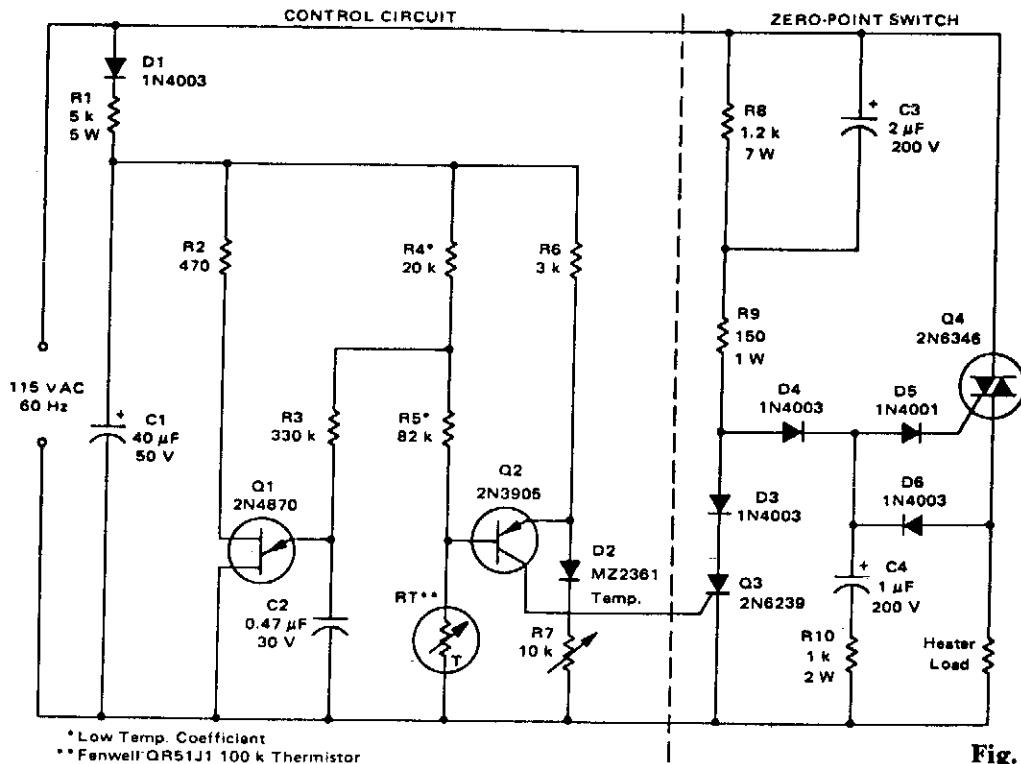


Fig. 86-6

SINGLE-SETPONT TEMPERATRE CONTROLLER

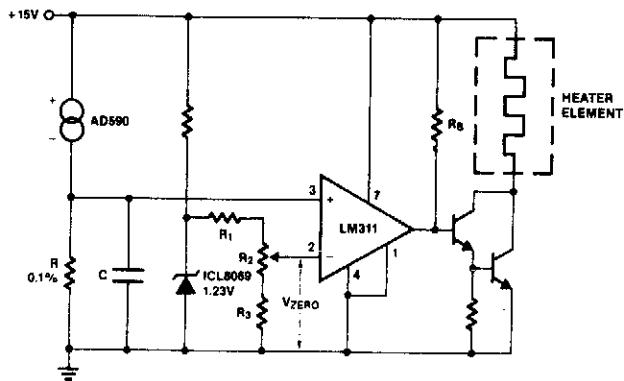


Fig. 86-7

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

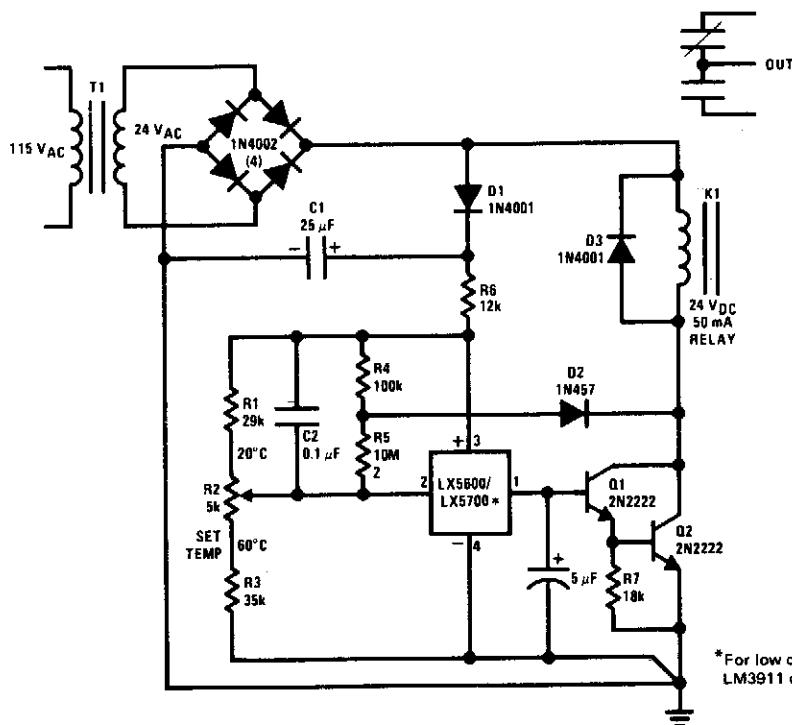


Fig. 86-8

*For low cost applications, an LM3911 can be used

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

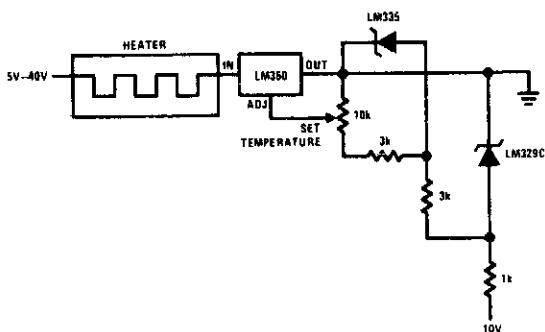


Fig. 86-9

TEMPEATURE CONTROLLER

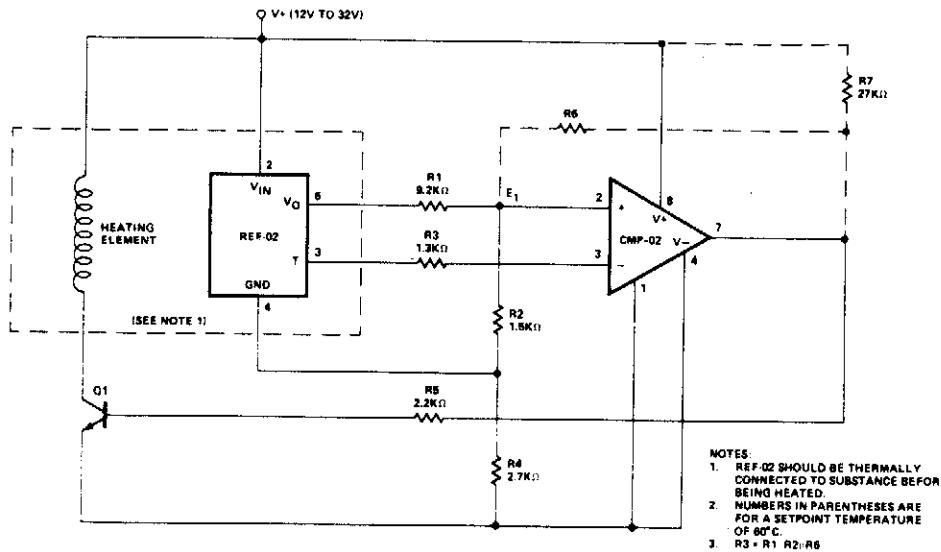


Fig. 86-10

Circuit Notes

Temperature control is achieved using the REF-02 +5 V Reference/Termometer and a CMP-02 Precision Low Input Current Comparator. The CMP-02 turns on a heating element driver (Q1) whenever the present tem-

perature drops below a setpoint temperature determined by the ratio of R1 to R2. The circuit also provides adjustable hysteresis and single supply operation.

TEMPERATURE CONTROLLER

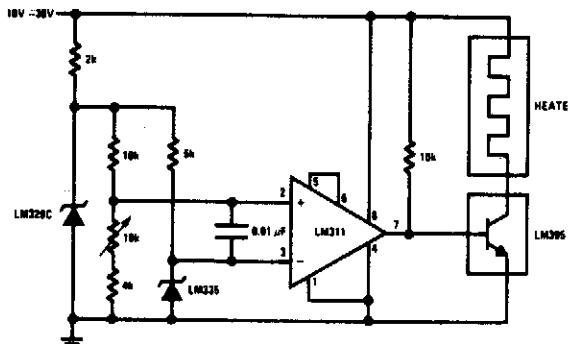


Fig. 86-11

PORTRABLE CALIBRATOR

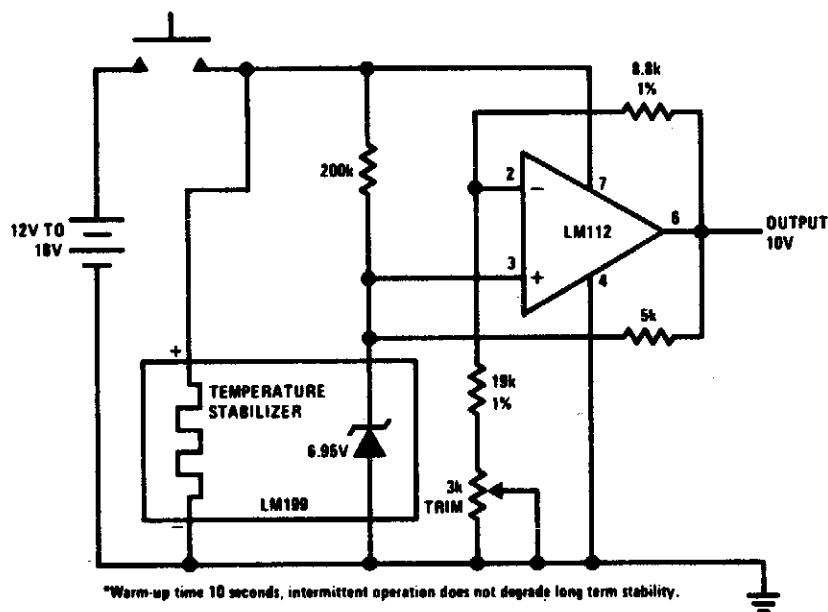


Fig. 86-12

*Warm-up time 10 seconds; intermittent operation does not degrade long term stability.

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 Transconductor | 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 |
| Thermocouple Amplifier | Temperature Sensor |
| | Positive Temperature Coefficient Resistor |
| | Temperature Sensor |
| | Basic Digital Thermometer |
| | Fahrenheit Thermometer |

LINEAR TEMPERATURE-TO-FREQUENCY TRANSCONDUCTER

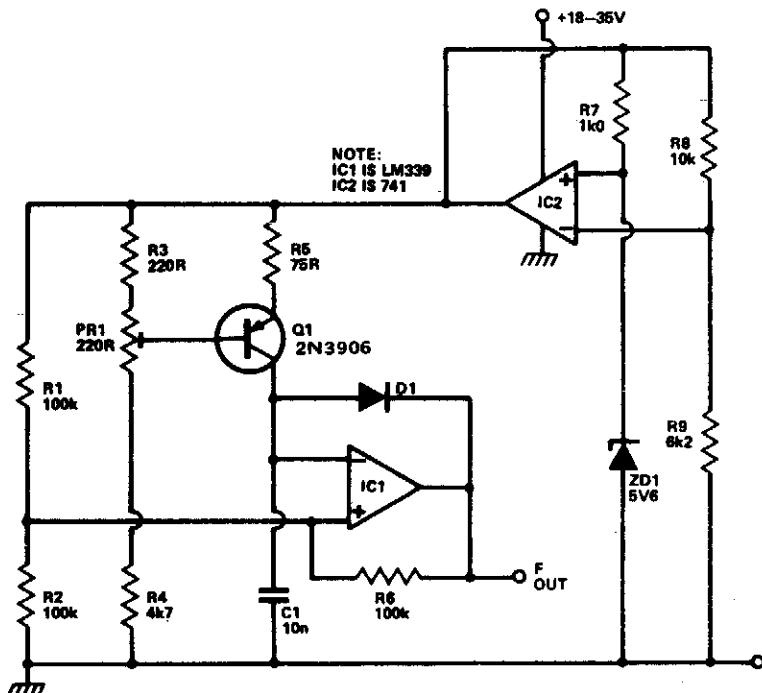


Fig. 87-1

Circuit Notes

This circuit provides a linear increase of frequency of $10 \text{ Hz}/^{\circ}\text{C}$ over $0\text{--}100^{\circ}\text{C}$ and can thus be used with logic systems, including microprocessors. Temperature probe Q1 V_{be} changes $2.2 \text{ mV}/^{\circ}\text{C}$. 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

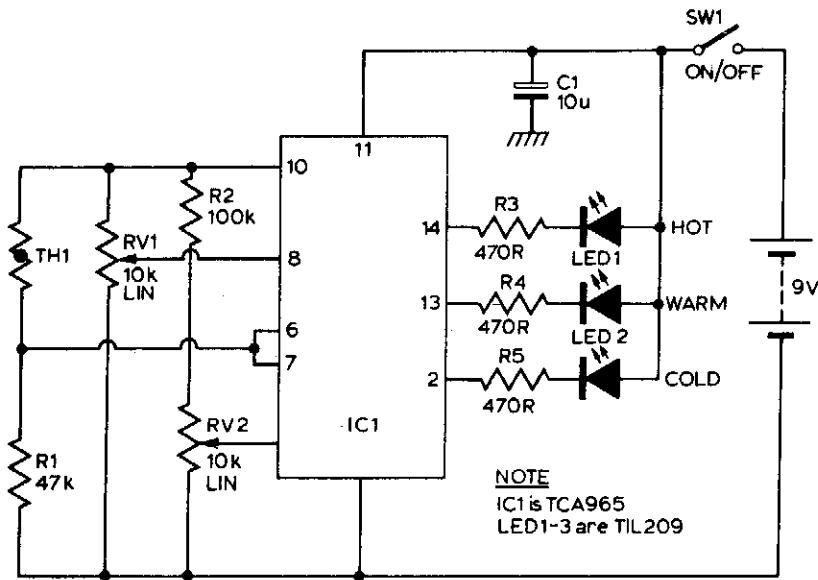


Fig. 87-2

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)

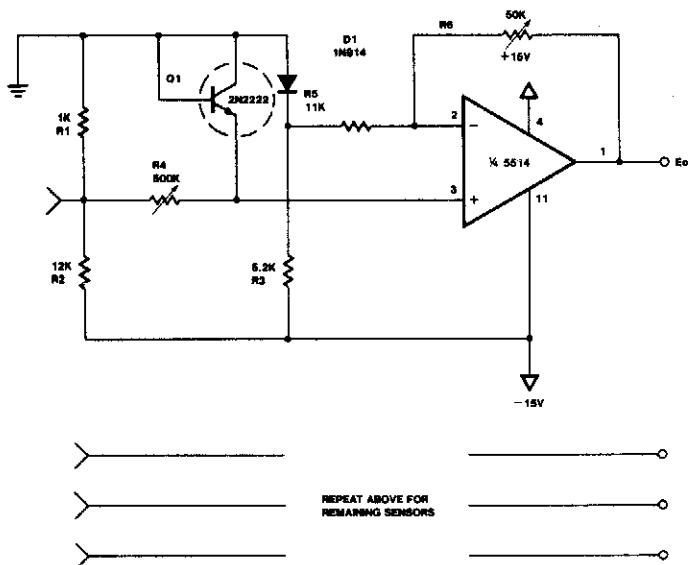


Fig. 87-3

TEMPERATURE SENSOR

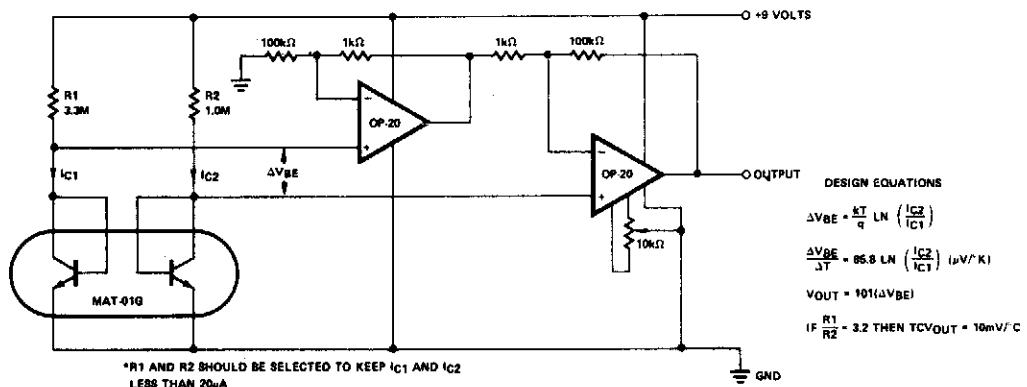


Fig. 87-4

INTEGRATED CIRCUIT TEMPERATURE SENSOR

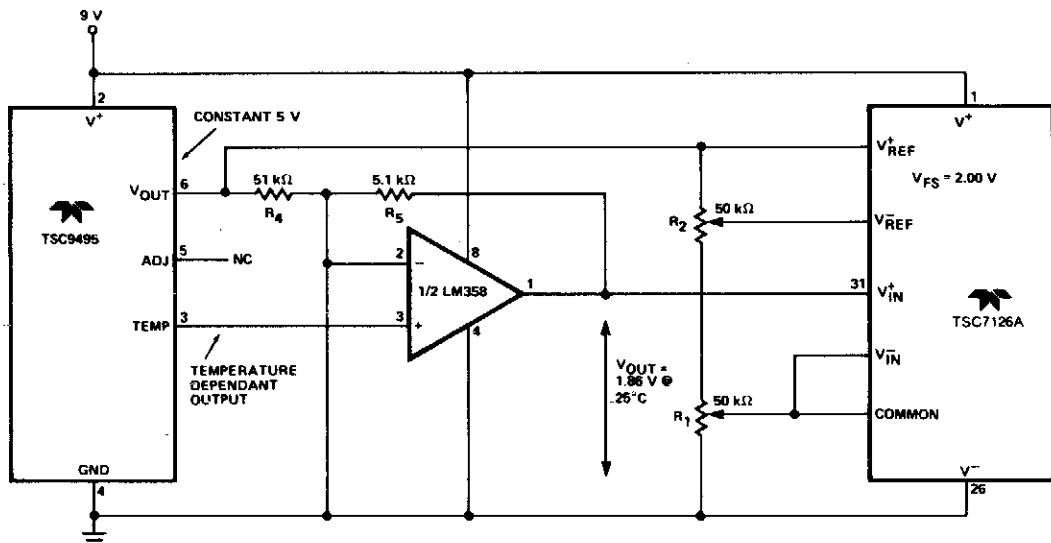
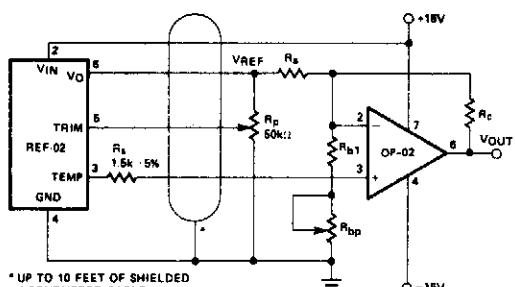


Fig. 87-5

PRECISION TEMPERATURE TRANSDUCER WITH REMOTE SENSOR



FOR THEORY OF OPERATION AND CALIBRATION PROCEDURE CONSULT APPLICATION NOTE 18, "THERMOMETER APPLICATIONS OF THE REF-02".

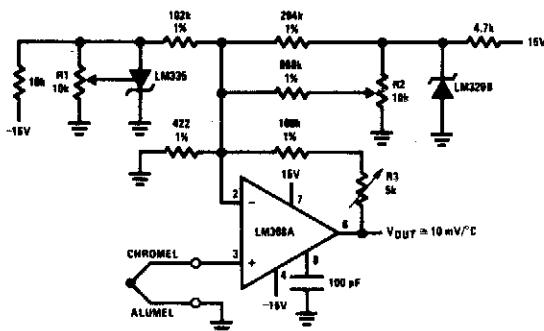
RESISTOR VALUES

TCV _{OUT} SLOPE (\$)	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	-0.87V to +2.57V
ZERO SCALE	0V@0°C	0V@0°C	0V@0°F
R _a ($\pm 1\%$ resistor)	9.09kΩ	15kΩ	7.5kΩ
R _{b1} ($\pm 1\%$ resistor)	1.5kΩ	1.82kΩ	1.21kΩ
R _{bp} (Potentiometer)	200Ω	500Ω	200Ω
R _c ($\pm 1\%$ 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 LM329B to ground.
3. Adjust R1 so that $V_{OUT} = 2.982V @ 25^{\circ}\text{C}$.
4. Remove short across LM329B and adjust R2 so that $V_{OUT} = 246 \text{ mV} @ 25^{\circ}\text{C}$.
5. Remove short across thermocouple.

Fig. 87-7

μP CONTROLLED DIGITAL THERMOMETER

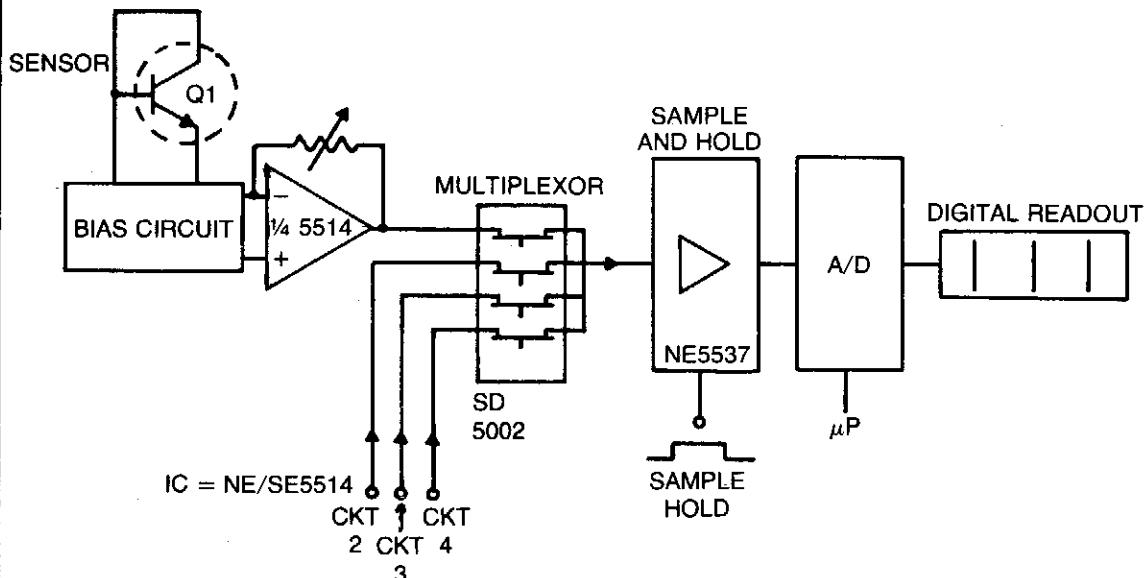


Fig. 87-8

ISOLATED TEMPERATURE SENSOR

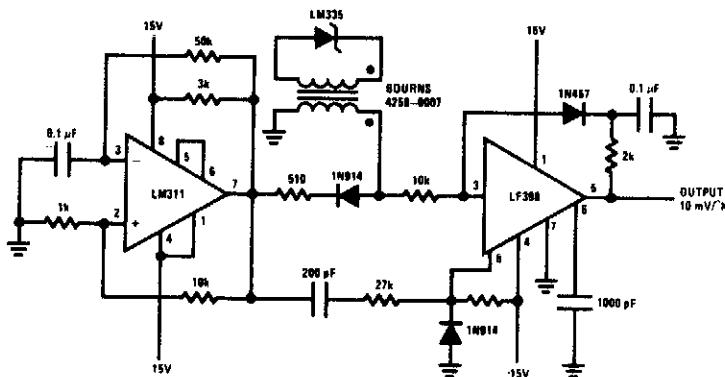


Fig. 87-9

DIGITAL THERMOMETER

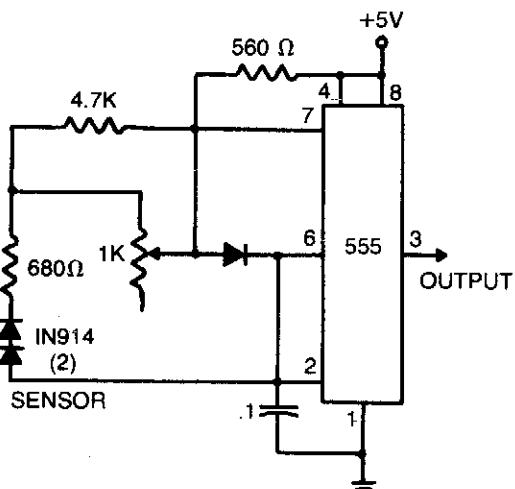


Fig. 87-10

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

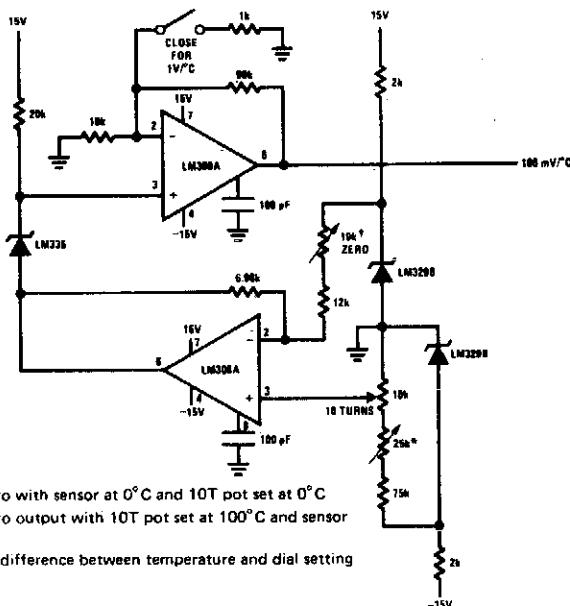


Fig. 87-11

DIFFERENTIAL THERMOMETER

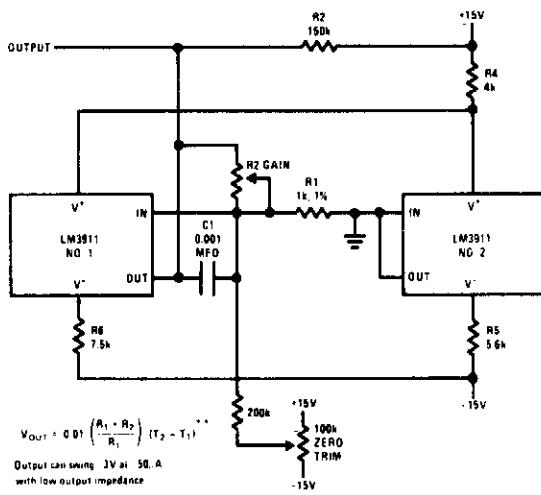
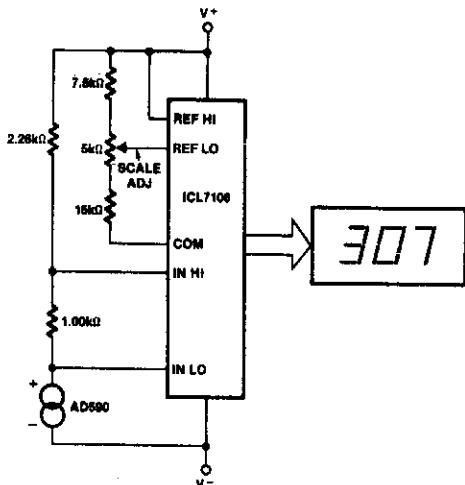


Fig. 87-12

* The D.D.T. of the above equation is in units of V/K or V/°C, and is a result of the basic 0.01 V/K sensitivity of the transducer.

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

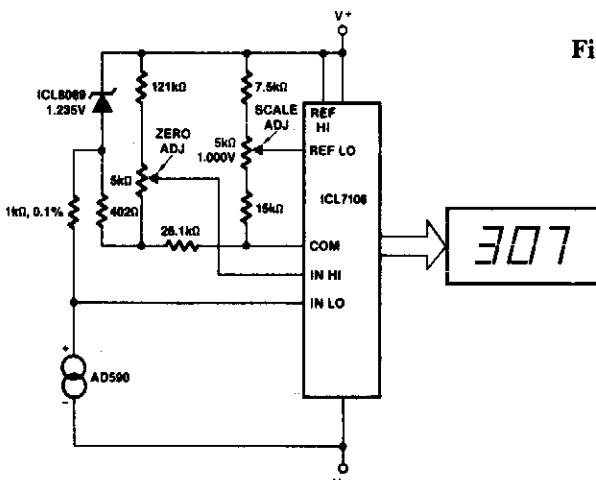
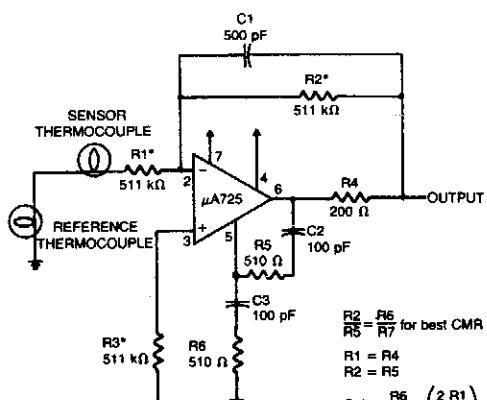


Fig. 87-14

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



DC GAINS = 1000
BANDWIDTH = DC TO 540 Hz
EQUIVALENT INPUT NOISE = 0.24 μ Vrms

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

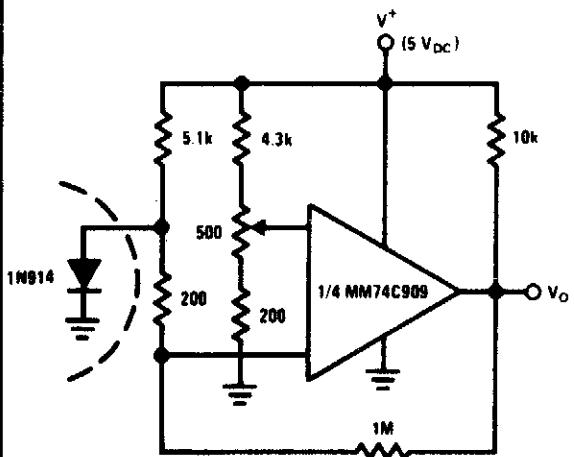


Fig. 87-17

OPTICAL PYROMETER

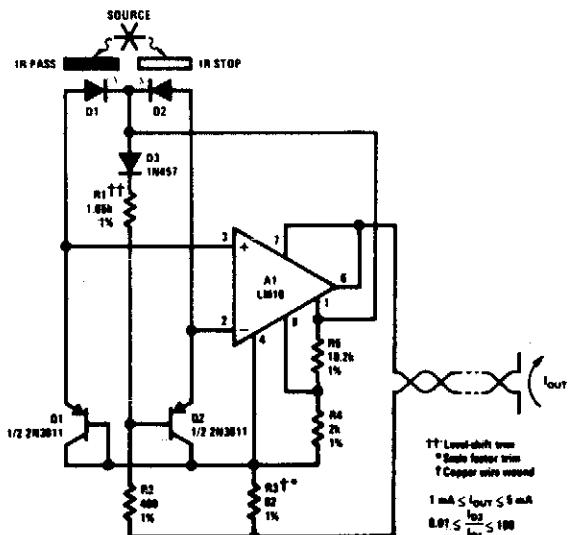


Fig. 87-16

SIMPLE DIFFERENTIAL TEMPERATURE SENSOR

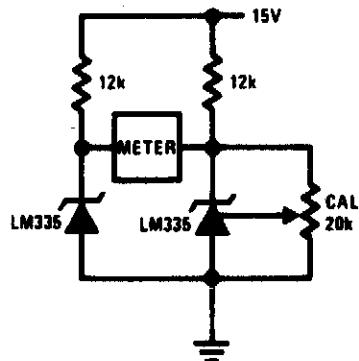


Fig. 87-18

DIFFERENTIAL TEMPERATURE SENSOR

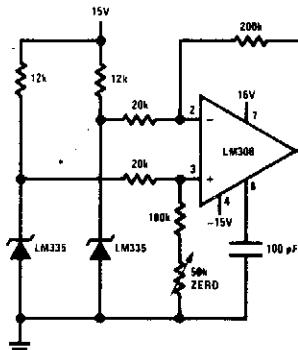


Fig. 87-19

KELVIN THERMOMETER WITH GROUND REFERRED OUTPUT

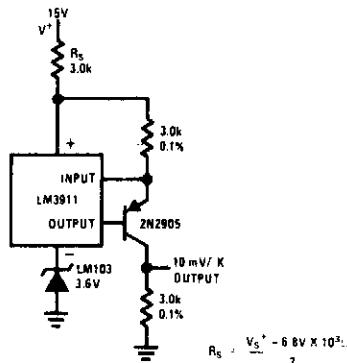


Fig. 87-22

CENTIGRADE THERMOMETER

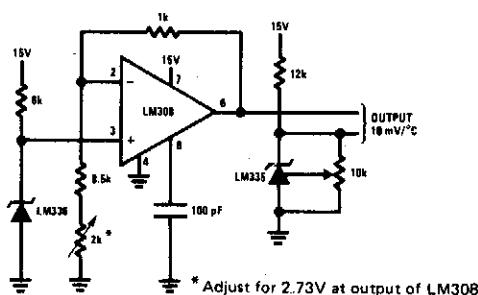


Fig. 87-20

LOWER POWER THERMOMETER

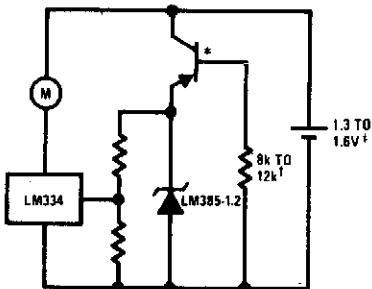


Fig. 87-23

METER THERMOMETER WITH TRIMMED OUTPUT

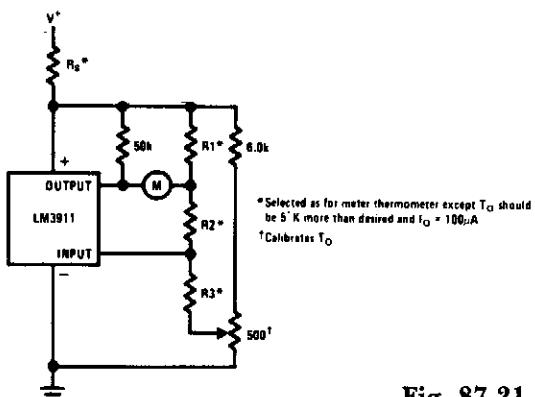


Fig. 87-21

0 °F-50 °F THERMOMETER

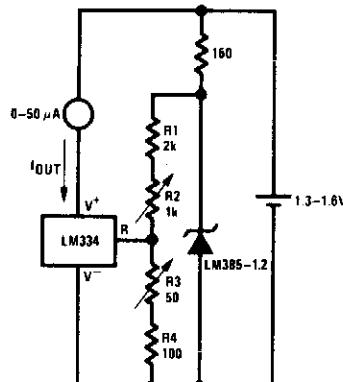


Fig. 87-24

Calibration

1. Short LM385-1.2, adjust R3 for $I_{OUT} = \text{temp}$ at $1.8 \mu A/\text{°K}$
2. Remove short, adjust R2 for correct reading in °F

TEMPERATURE-TO-FREQUENCY CONVERTER

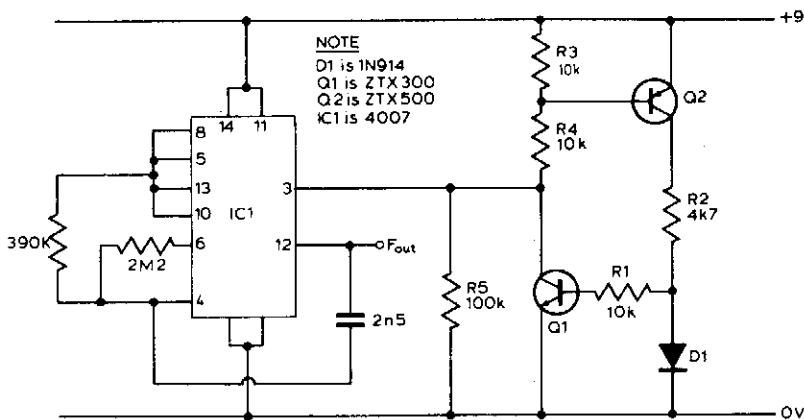


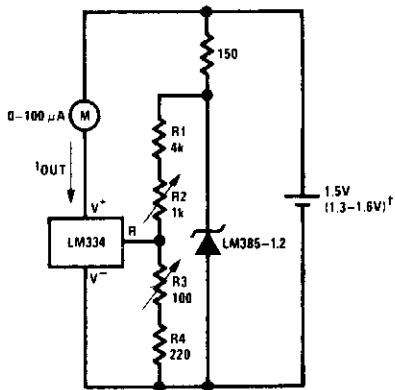
Fig. 87-25

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

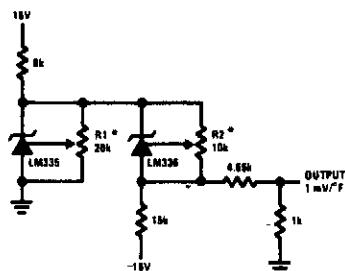


Calibration

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 μ A
 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

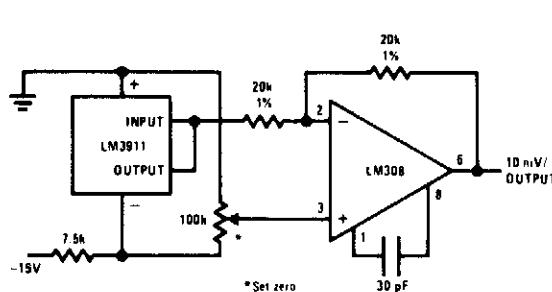


Fig. 87-28

TEMPERATURE SENSOR

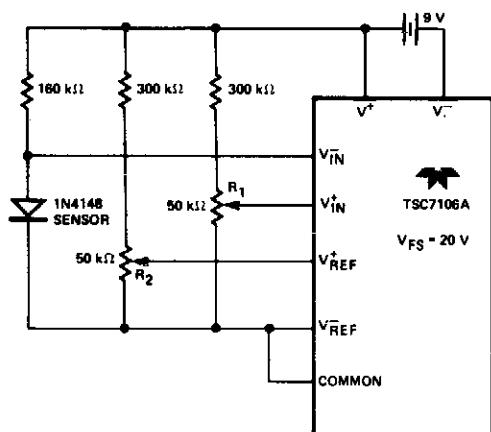


Fig. 87-30

GROUND REFERRED CENTIGRADE THERMOMETER

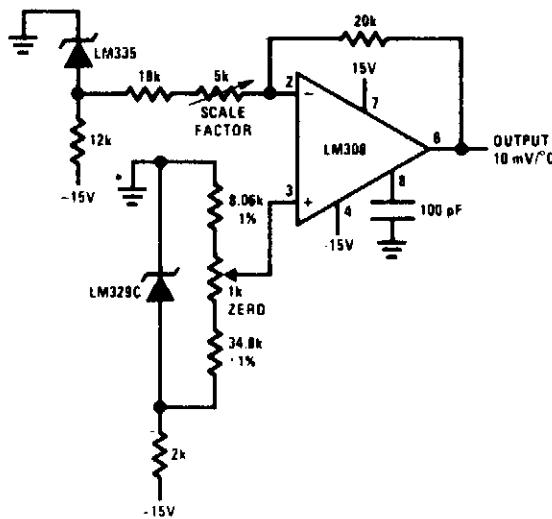


Fig. 87-29

POSITIVE TEMPERATURE SENSOR COEFFICIENT RESISTOR

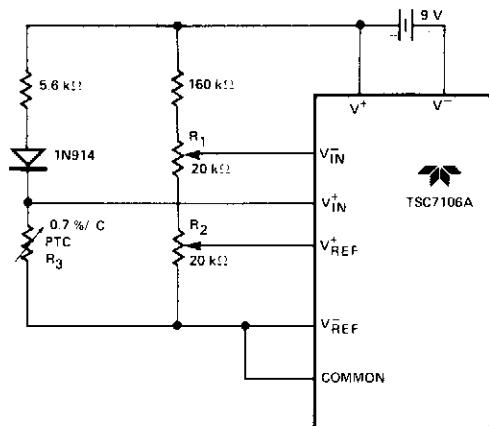


Fig. 87-31

BASIC DIGITAL THERMOMETER (CELSIUS AND FAHRENHEIT SCALES)

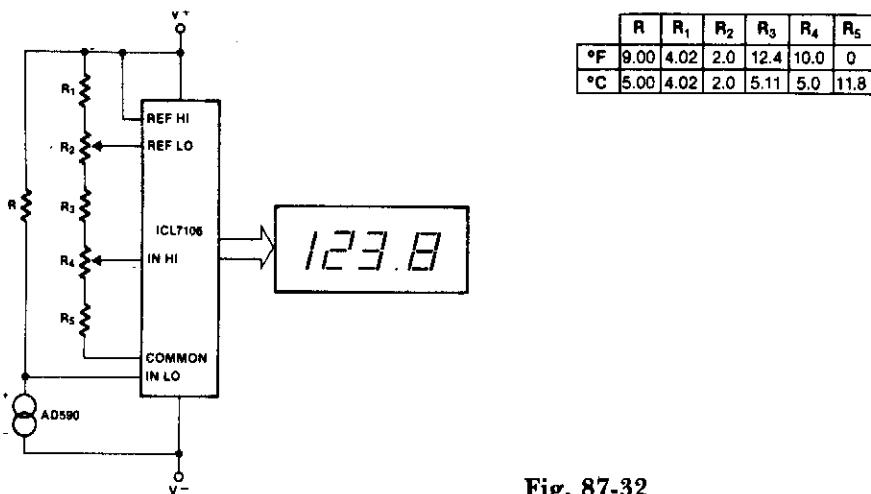


Fig. 87-32

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

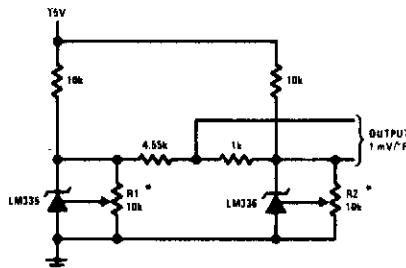


Fig. 87-33

* To calibrate adjust R2 for 2.554V across LM336.
Adjust R1 for correct output.

88

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

Sequential Timer

Sequential Timer

Sequential UJT Timer Circuit

Time-Delayed Relay

0.1 to 90 Second Timer

Sequential Timing

Solid-State Timer for Industrial Applications

Precision Solid State Time Delay Circuit

Electronic Egg Timer

On/Off Controller

Timing Circuit

Simple Timer

Long Interval RC Timer

Timer

741 Timer

Washer Timer

Simple Time Delay

THUMBWHEEL PROGRAMMABLE INTERVAL TIMER

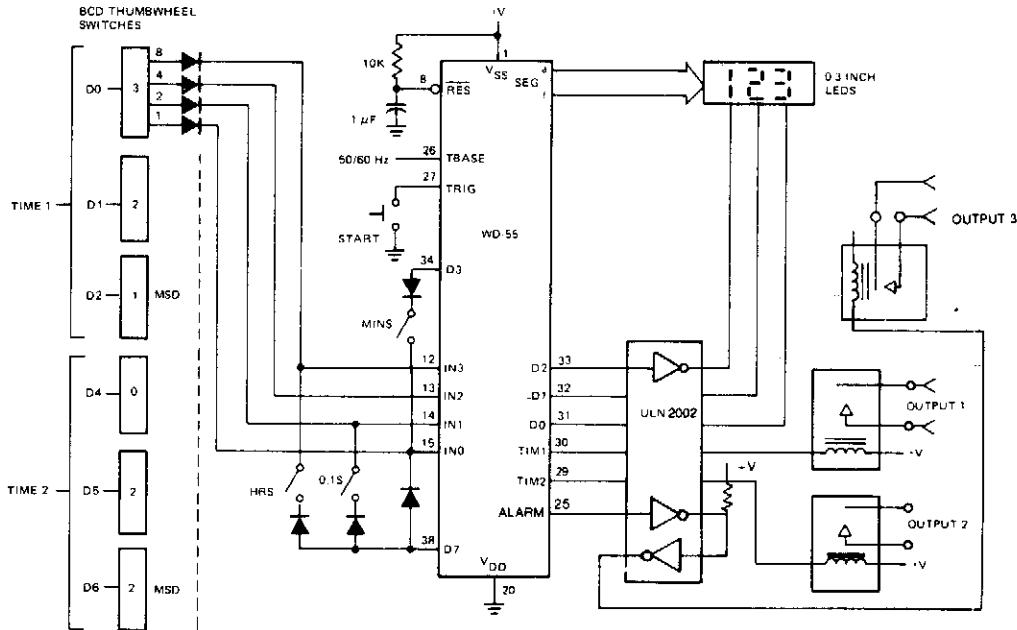


Fig. 88-1

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 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

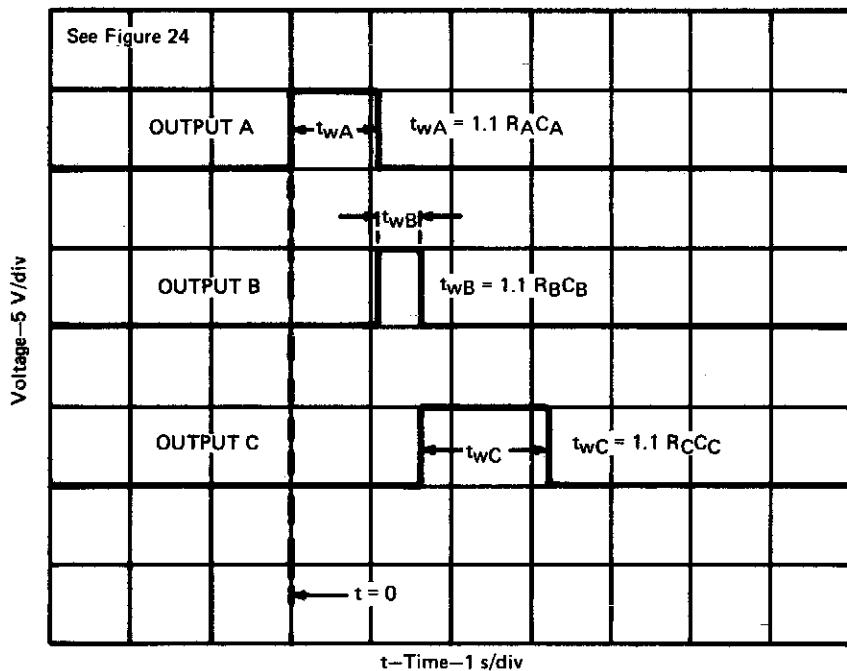
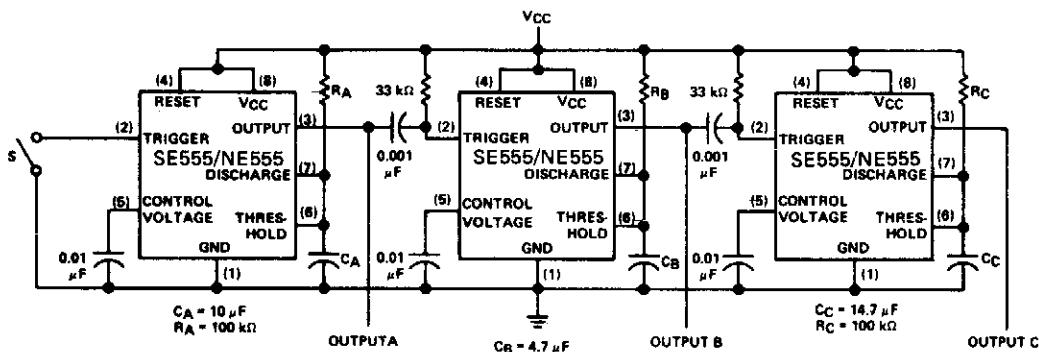


Fig. 88-2

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

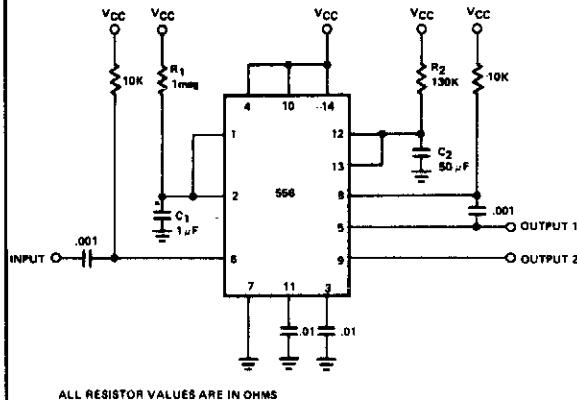


Fig. 88-3

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 $0.001 \mu\text{F}$ 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 turned out (determined by $1.1R_1C_1$), the second half begins. Its duration is determined by $1.1R_2C_2$.

SEQUENTIAL UJT TIMER

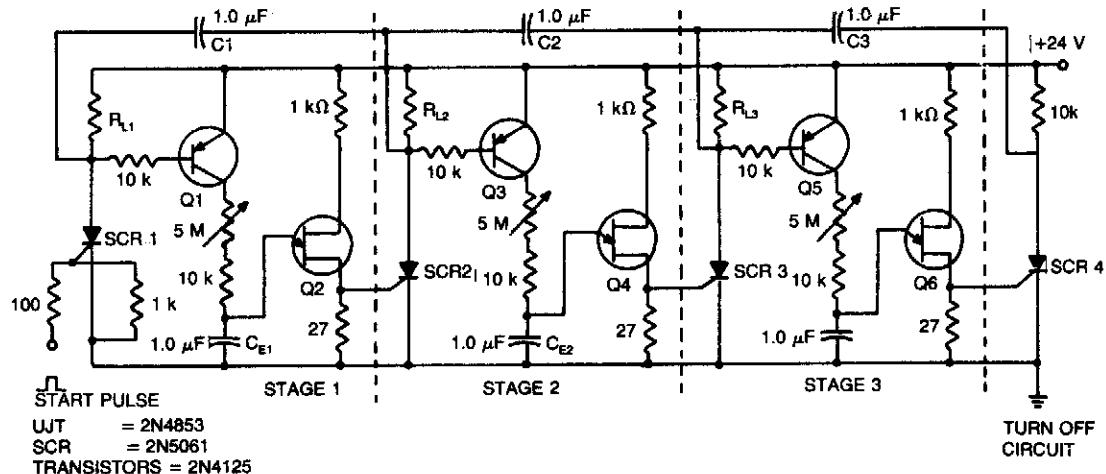


Fig. 88-4

TIME-DELAYED RELAY (FOR PATIO-LIGHT, GARAGE LIGHT, EN-LARGER PHOTOTIMER, ETC.)

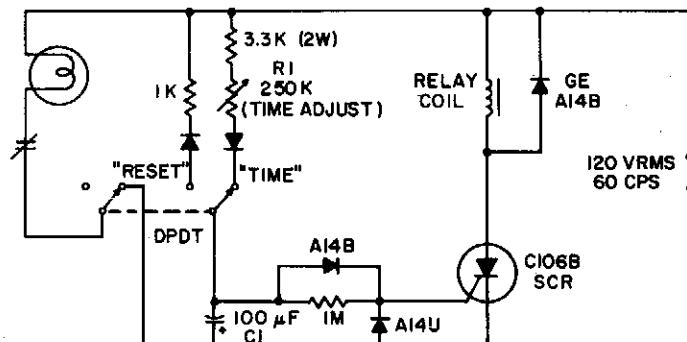


Fig. 88-5

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

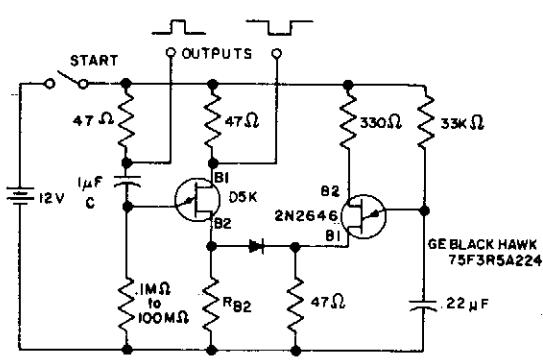


Fig. 88-6

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_L of D5K and allows a much larger timing resistor and smaller timing capacitor to be used than would otherwise be possible.

SEQUENTIAL TIMING

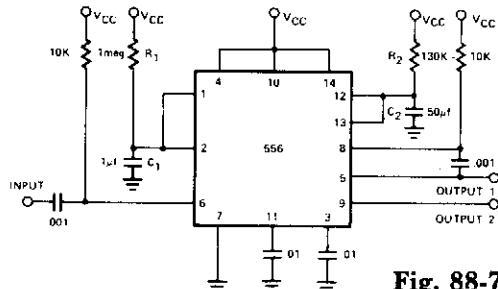


Fig. 88-7

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 1.1R1C1) the second half begins. Its time duration is determined by 1.1R2C2.

SOLID-STATE TIMER FOR INDUSTRIAL APPLICATIONS

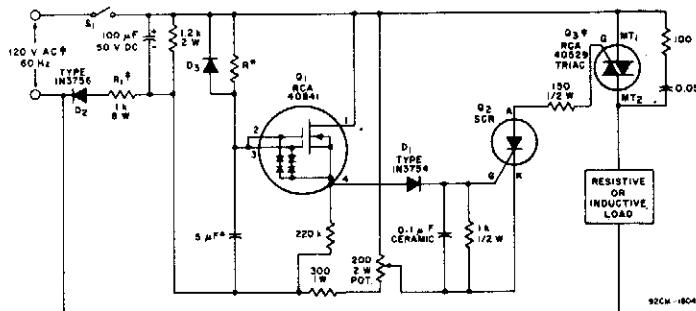


Fig. 88-8

- * Cornell-Dubilier Electronics—Type MMW or equivalent.
- R controls duration of time delay. At $R = 60 \text{ M}\Omega$ up to 5-minute delay (IRC resistor, Type CGH or equivalent).
- This circuit can also be used at supply voltages of 240 V AC and 24 V AC (60 Hz) by changing the values of R1 and Q3.

TIMING CIRCUIT CHARACTERISTICS
 $T_A = -25^\circ\text{C}$ to $+60^\circ\text{C}$
 Accuracy: $\pm 10\%$ (over temperature)
 Repeatability: $\pm 3\%$ (at 25°C)
 Reset Time: Less than 150 ms

Q2: $V_{DRM} = 60\text{V}$
 $I_{GT} = 200\mu\text{A}$
 $I_T = 0.8\text{A}$

D3: $I_R = 1\text{nA}$
 $V_R = 60\text{V}$

PRECISION SOLID STATE TIME DELAY CIRCUIT

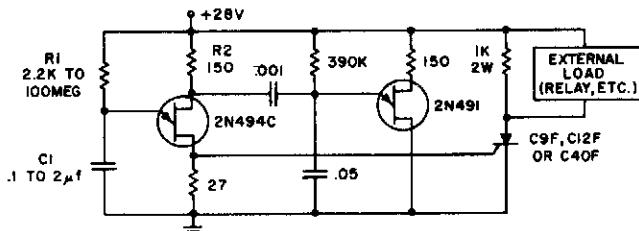


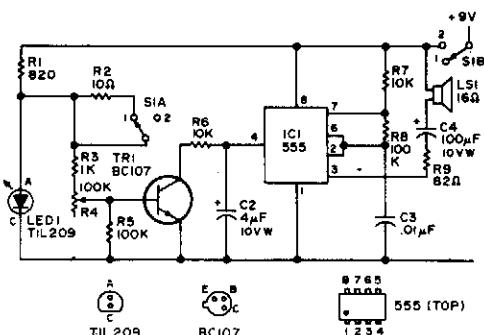
Fig. 88-9

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

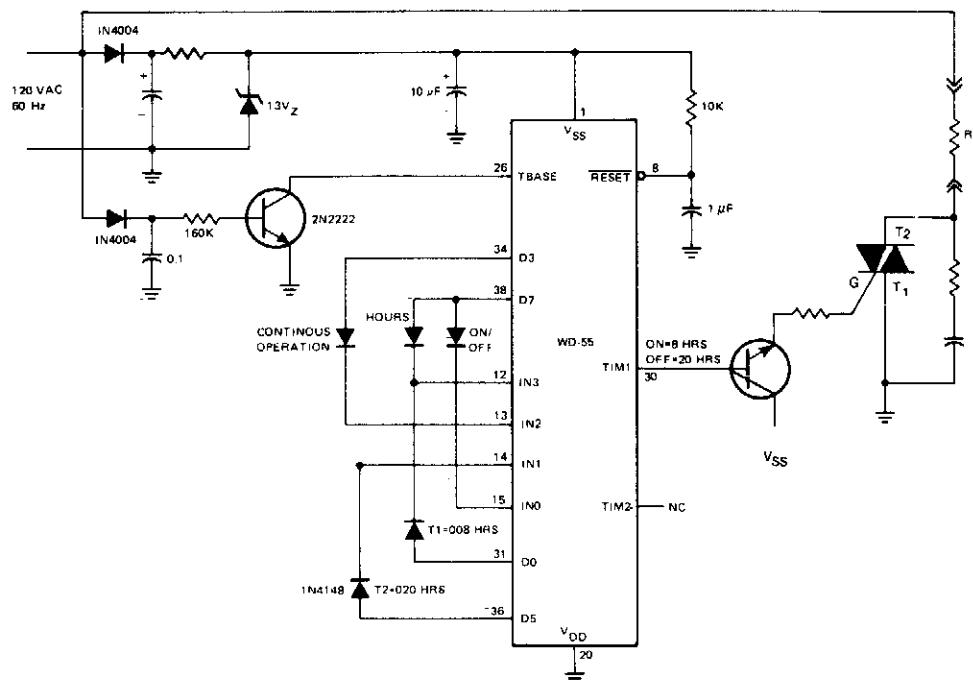


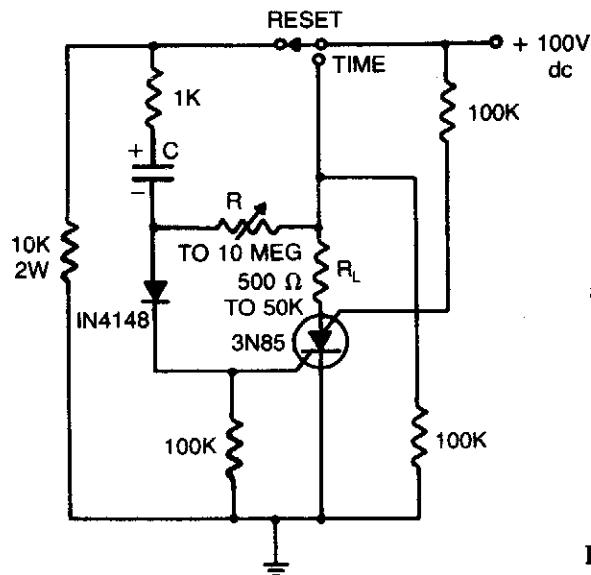
Fig. 88-11

Circuit Notes

The ac line-operated on/off controller is a simple, reliable solid-state alternative to a motor-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.

TIMING CIRCUIT



Circuit Notes

Load current starts approximately 0.5 RC after the switch is thrown.

Fig. 88-12

SIMPLE TIMER

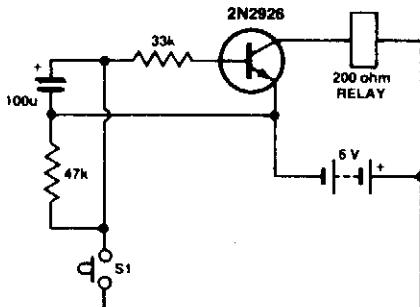


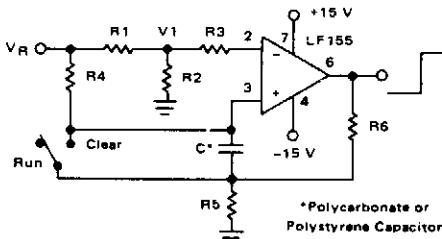
Fig. 88-13

Circuit Notes

Press S1. The $100 \mu\text{F}$ electrolytic capacitor rapidly charges up at about 0.7 V . The transistor will be forward biased, and collector current will flow operating the relay. Release S1. The capacitor will begin to discharge via the 33 K resistor at the base of the transistor. When the voltage across the capacitor gets down to half a volt or so, the transistor base will no longer be forward biased, collector current

will cease, and the relay will drop out. The capacitor will continue to discharge via the 47 K resistor. With the values shown, the relay will remain operated for about eight seconds. Long times are possible with lower values of capacitance by substituting a Darlington pair for the 2N2926. In this case, increase the two resistor values into the megohm range.

LONG INTERVAL RC TIMER



Time (t) = $R4CRn(V_R/V_R - V_1)$, $R_3 = R_4$, $R_5 = 0.1 R_6$
If $R_1 = R_2$: $t = 0.693 R_4 C$

Design Example: 100 Second Timer

$V_R = 10\text{ V}$ $C = 1\ \mu\text{F}$ $R_3 = R_4 = 144\text{ M}$
 $R_6 = 20\text{ k}$ $R_5 = 2\text{ k}$ $R_1 = R_2 = 1\text{ k}$

Fig. 88-14

741 TIMER

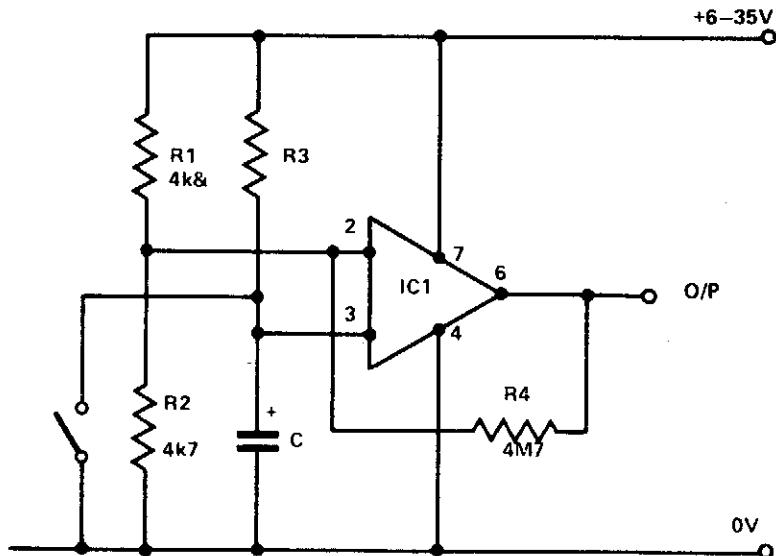


Fig. 88-15

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

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.

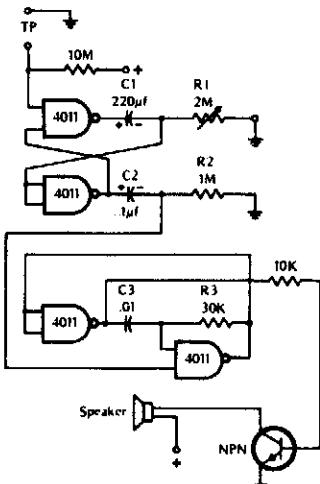


Fig. 88-16

WASHER TIMER

LENGTH OF CYCLE IS SWITCH PROGRAMMABLE
WITH THIS SOLID STATE CONFIGURATION

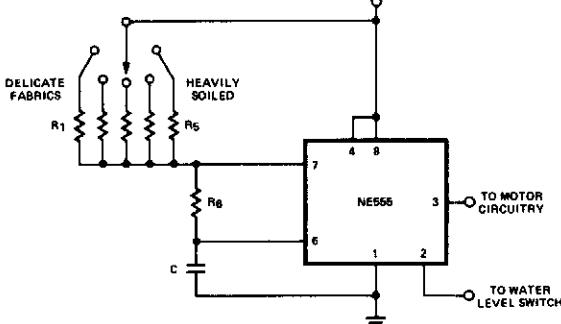


Fig. 88-17

SIMPLE TIME DELAY

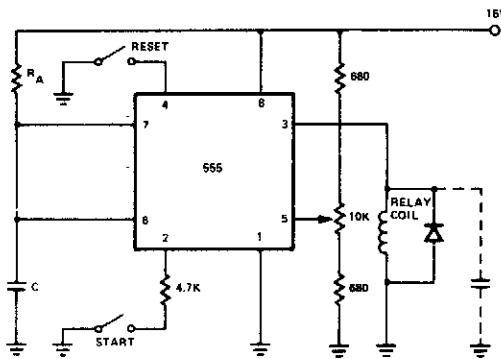


Fig. 88-18

89

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

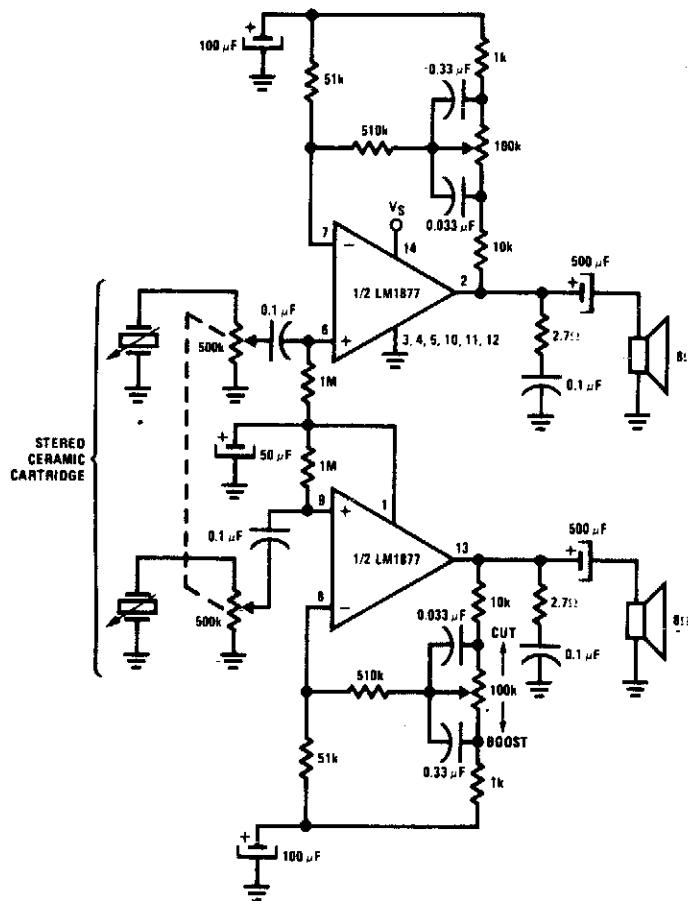
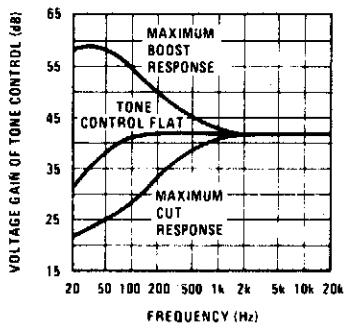
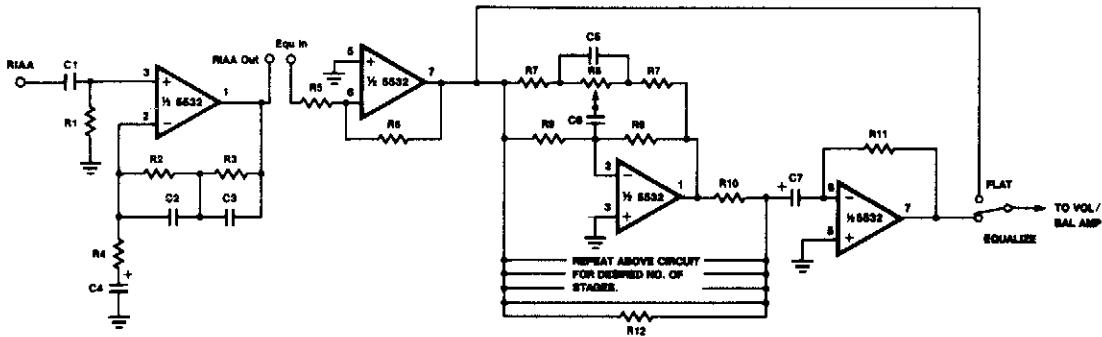


Fig. 89-1



EQUALIZER



COMPONENT VALUE TABLES

R8 = 25k			R8 = 50k			R8 = 100k		
R7 = 2.4k	R8 = 240k		R7 = 5.1k	R8 = 510k		R7 = 10k	R8 = 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	36 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	1191 Hz	.01μF	.001μF	585 Hz	.01μF	.001μF
2382 Hz	.01μF	.001μF	1452 Hz	.0082μF	.820pF	728 Hz	.0082μF	.820pF
2904 Hz	.0082μF	.820pF	1751 Hz	.0068μF	.680pF	875 Hz	.0068μF	.680pF
3502 Hz	.0068μF	.680pF	2126 Hz	.0056μF	.560pF	1083 Hz	.0056μF	.560pF
4253 Hz	.0056μF	.560pF	2534 Hz	.0047μF	.470pF	1287 Hz	.0047μF	.470pF
5068 Hz	.0047μF	.470pF	3609 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	5965 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	10833 Hz	.560pF	.56pF
						12670 Hz	.470pF	.47pF
						18045 Hz	.330pF	.33pF

COMPONENT VALUES		
R1	1meg	C1 .22μF
R2	100k	C2 .750μF
R3	1meg	C3 .0034μF
R4	1.1k	C4 .33μF
R5	100k	C5 SEE TABLE
R6	100k	C6 SEE TABLE
R7	SEE TABLE	C7 .22μF
R8	SEE TABLE	
R9	SEE TABLE	
R10	100k	
R11	100k	
R12	20k (5 STAGES)	

Fig. 89-2

THREE-CHANNEL TONE CONTROL

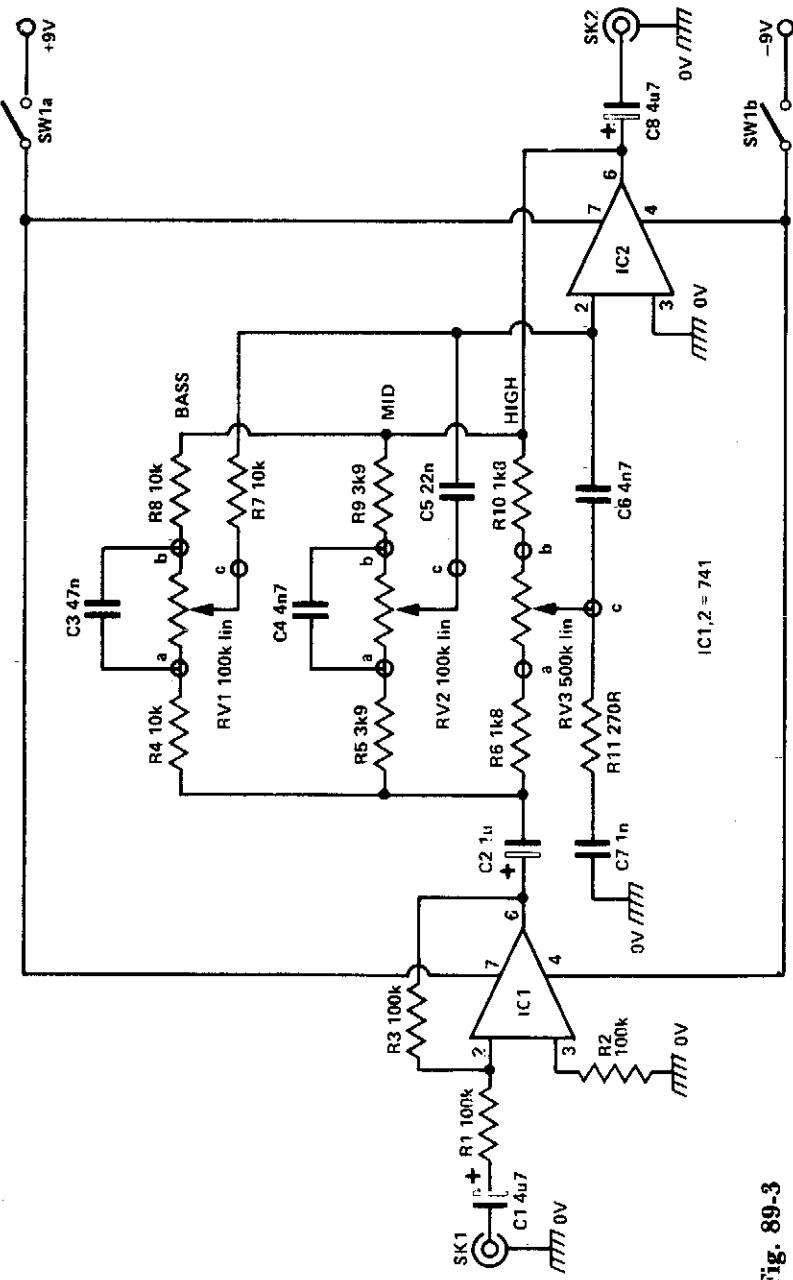


Fig. 89-3

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

Circuit Notes

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

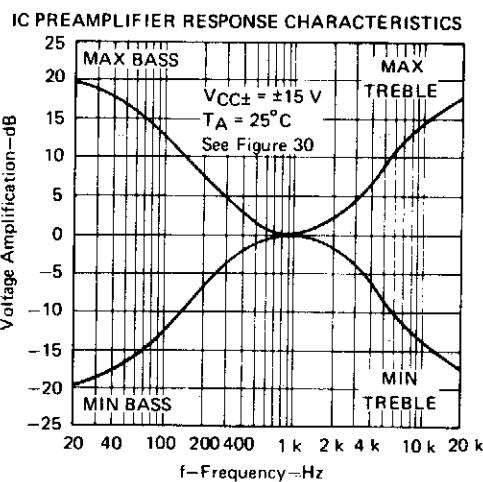
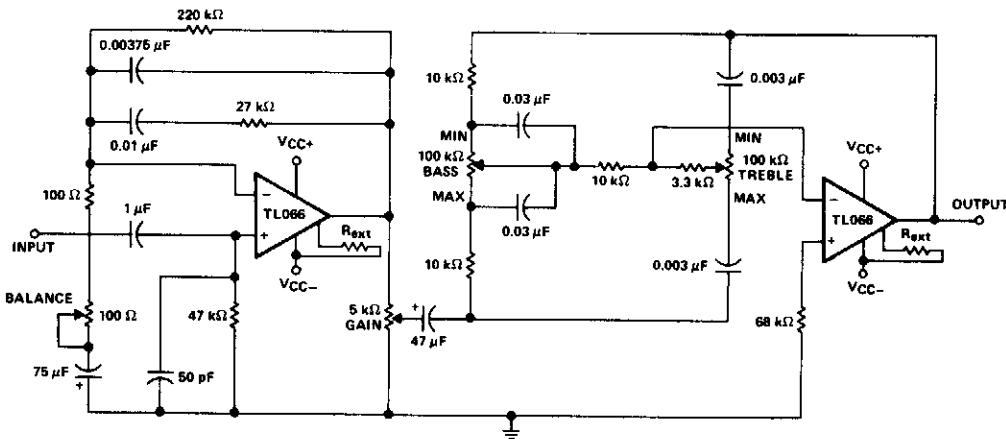


Fig. 89-4



AMPLIFIER WITH BASS BOOST

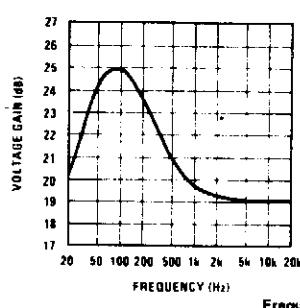
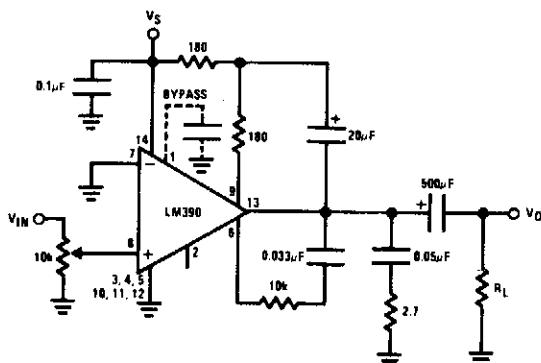


Fig. 89-5

ACTIVE BASS & TREBLE TONE CONTROL WITH BUFFER

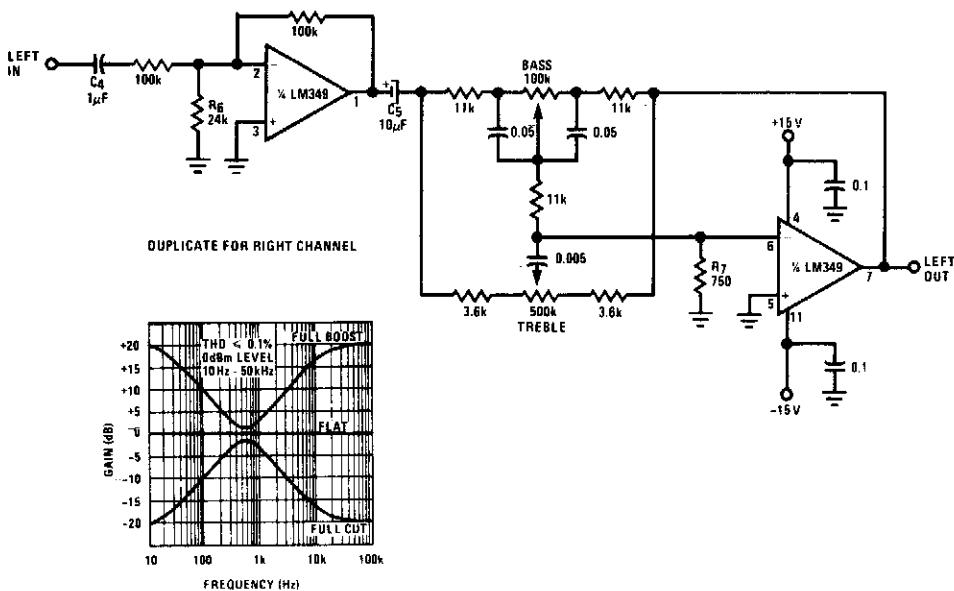


Fig. 89-6

PASSIVE BASS & TREBLE TONE CONTROL

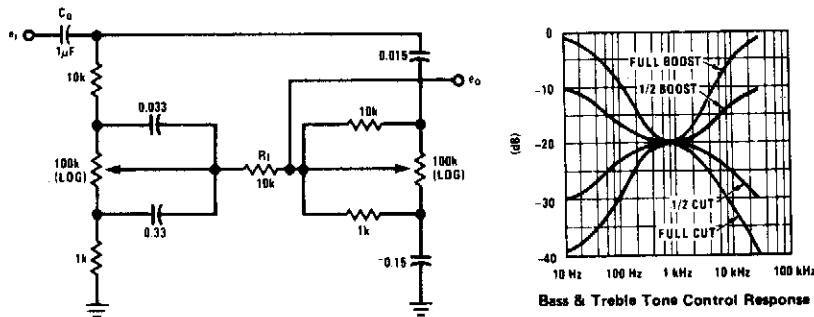


Fig. 89-7

BAXENDALL TONE-CONTROL CIRCUIT

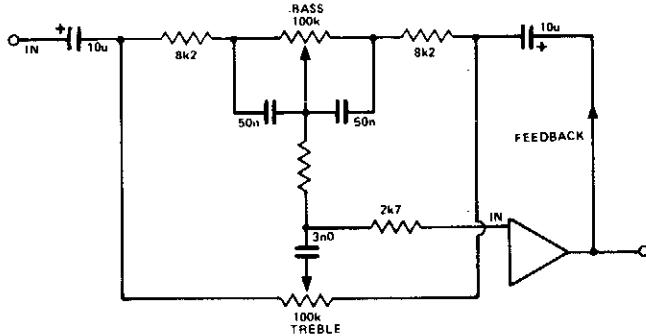


Fig. 89-8

HIGH QUALITY TONE CONTROL

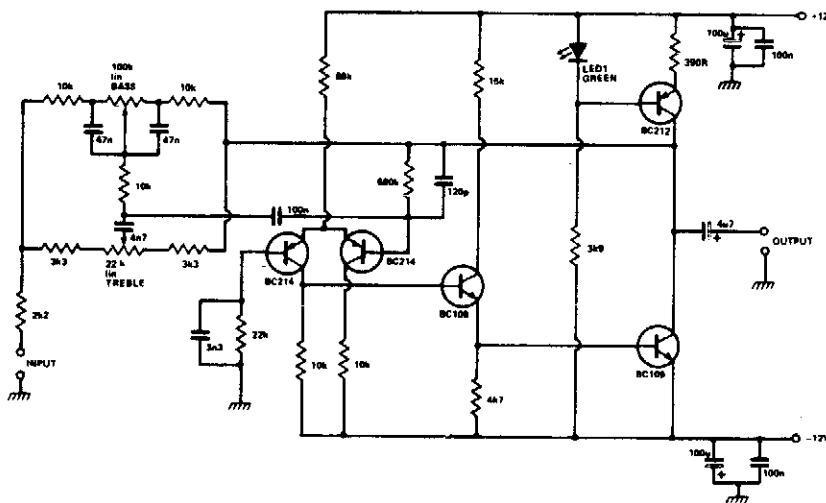


Fig. 89-9

Circuit Notes

The circuit is based on an inverting op amp using discrete transistors to overcome poor slew rate, fairly high distortion, and high noise problems. The output stage is driven by a constant current source, biased by a green LED to provide temperature compensation. With the controls flat, the unit provides unity gain so the

stage can be switched in or out. The design is suitable for inputs between 100 mV and 1 V and provides a good overload margin at low distortion for the accurate reproduction of transients. The usual screening precautions against hum should be carried out.

MICROPHONE PREAMPLIFIER WITH TONE CONTROL

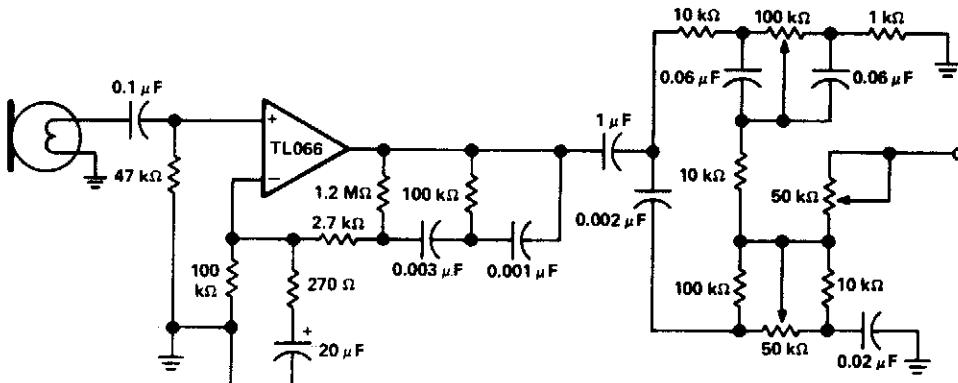


Fig. 89-10

HI-FI TONE CONTROL CIRCUIT (HIGH Z INPUT)

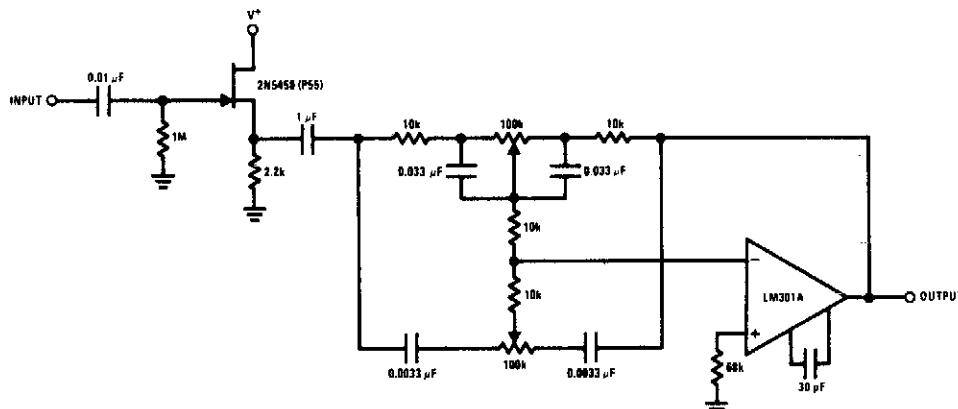


Fig. 89-11

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

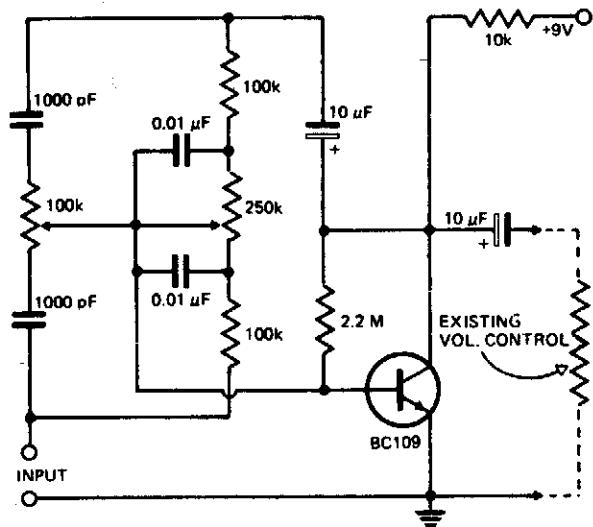
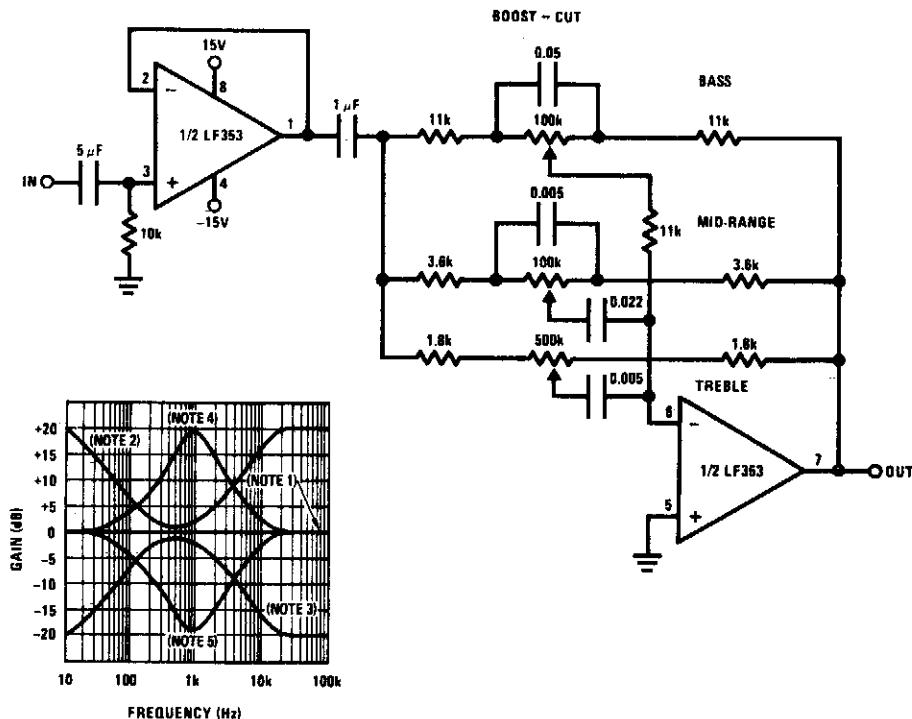


Fig. 89-12

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

WIRELESS AM MICROPHONE

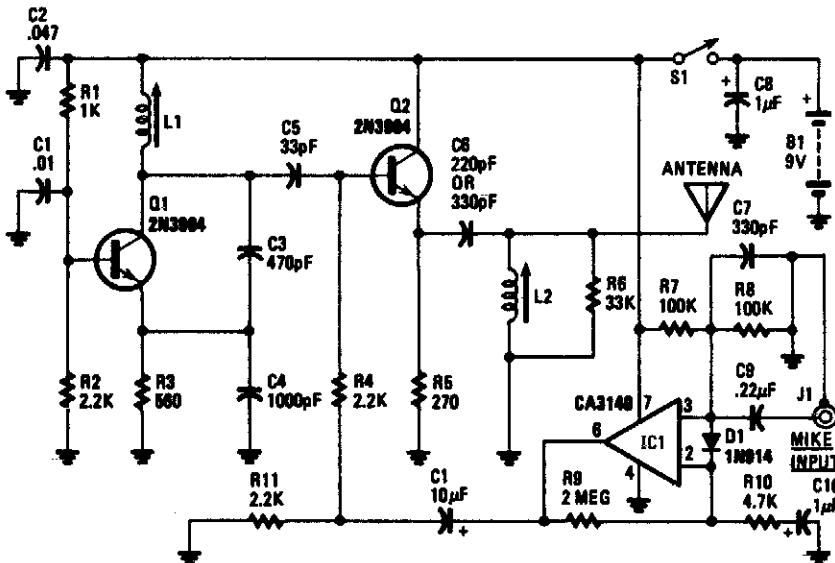
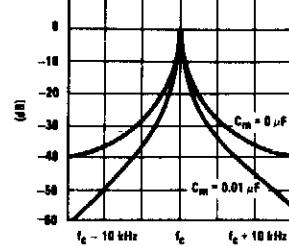
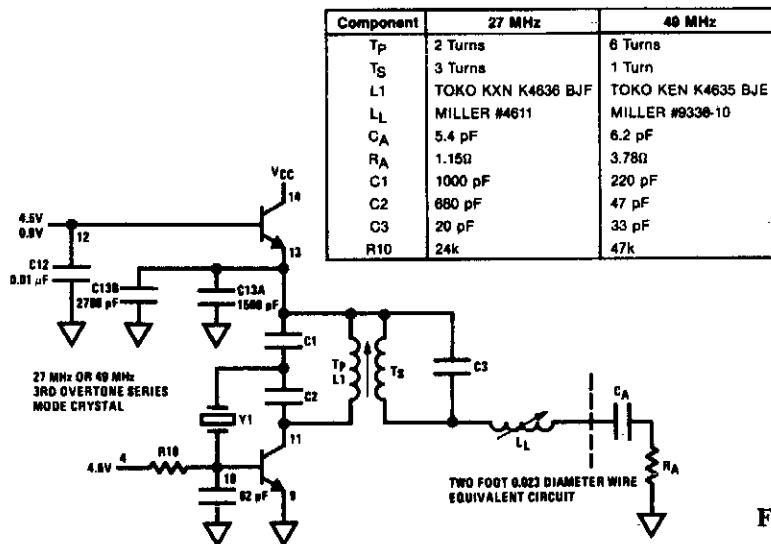


Fig. 90-1

Circuit Notes

Transistor Q1 and its associated components comprise a tuneable rf oscillator. The rf signal is fed to transistor Q2, the modulator. Operational amplifier IC1 increases the audio signal and applies it through resistor R4 to the base of Q2. Tune an AM radio to an unused frequency between 800 to 1600 kHz. Tune L1 for a change in the audio level coming from the radio. Peak the output by adjusting L2. If L1 is disturbed, it may be necessary to readjust L2 for peak performance. Depending on the impedance of the microphone audio sensitivity can be increased by decreasing the value of R10 and vice versa.

27 MHz AND 49 MHz RF OSCILLATOR/TRANSMITTER



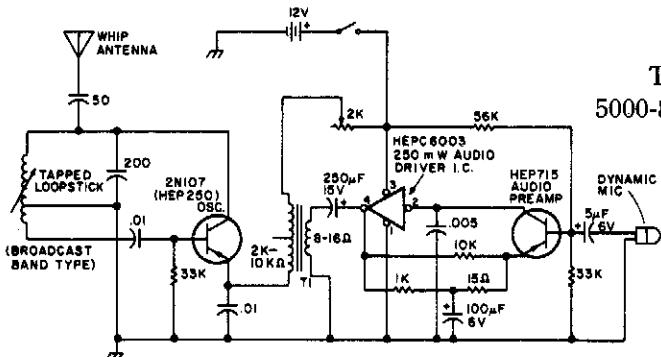
Envelope of Transmitted Spectrum for Circuit

Fig. 90-2

Circuit Notes

The modulator and oscillator consist of two NPN transistors. The base of the modulator transistor is driven by a bidirectional current source with the voltage range for the high condition limited by a saturating PNP collector to the pin 4 V_{REG} voltage and low condition limited by a saturating NPN collector in series with a diode to ground. The crystal oscillator/transmitter transistor is configured to oscillate in a class C mode. Because third overtone crystals are used for 27 MHz or 49 MHz applications a tuned collector load must be used to guarantee operation at the correct frequency.

1-2 MHz BROADCAST TRANSMITTER



Circuit Notes

T1 is a low impedance output transformer
5000-8 ohms.

Fig. 90-3

ONE TUBE, 10 WATT C.W. TRANSMITTER

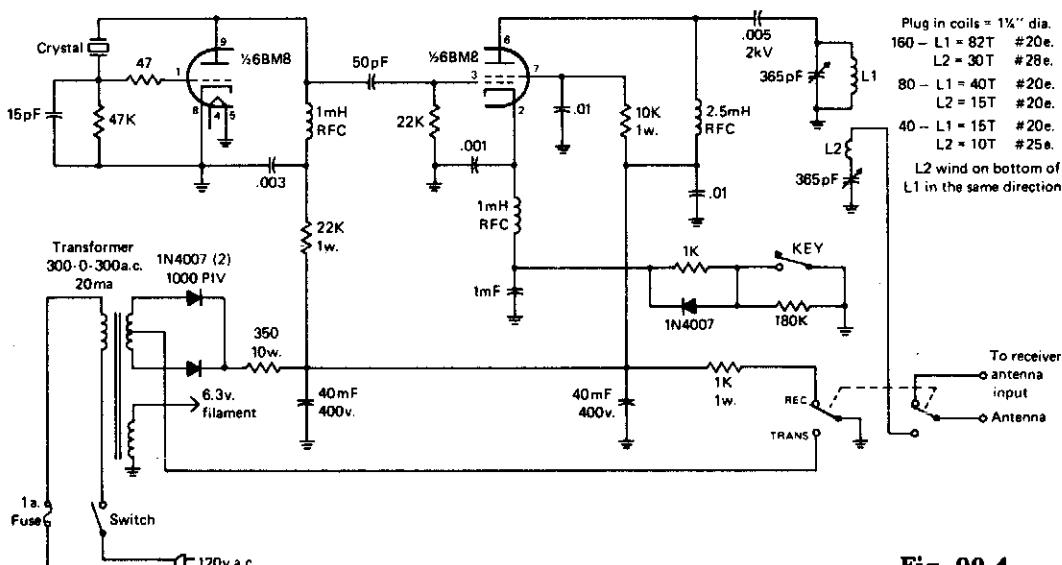


Fig. 90-4

SIMPLE FM TRANSMITTER

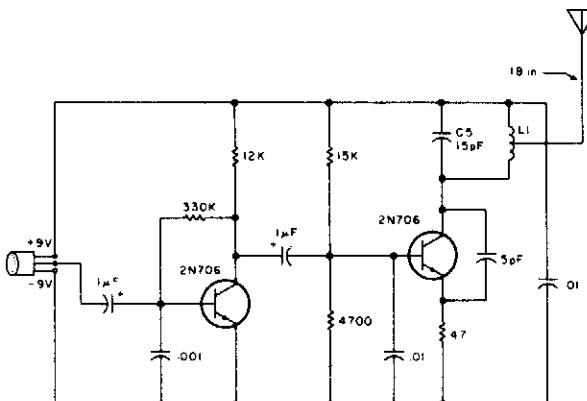


Fig. 90-5

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 IN N3004
D1 - IS - 1N34A
D2 D3 ARE IN N4040.
P1 IS USED INSTEAD OF R9 IF A CALIBRATION UNIT IS NOT AVAILABLE.

Circuit diagram of the receiver.

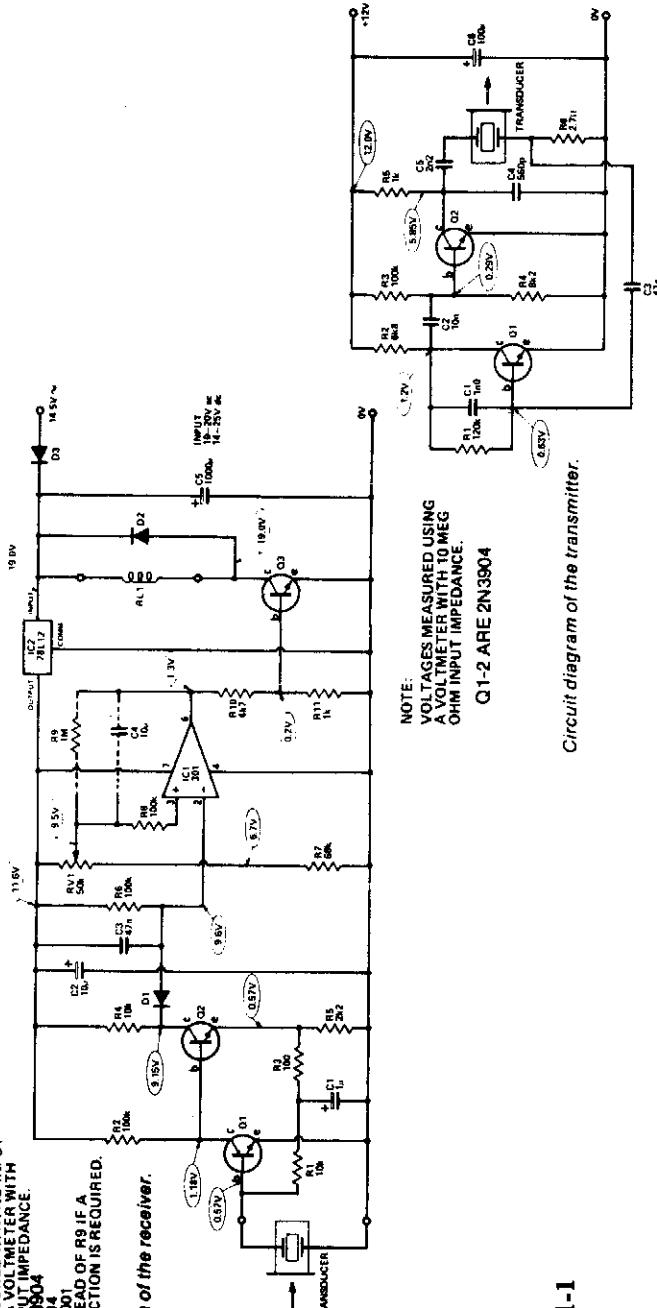


Fig. 91-1

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

Circuit Notes

ULTRASONIC BUG-CHASER

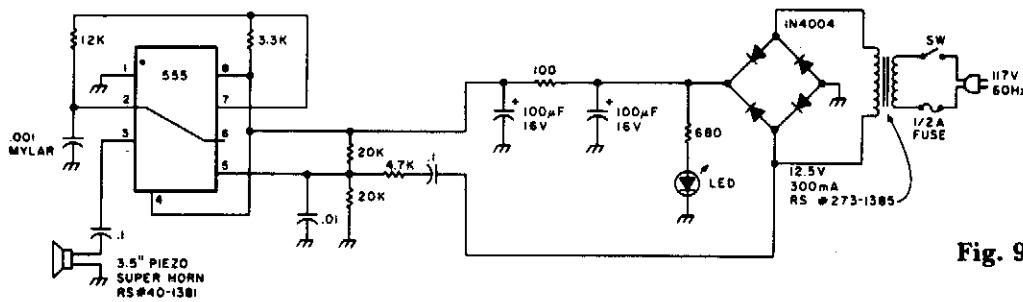


Fig. 91-2

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

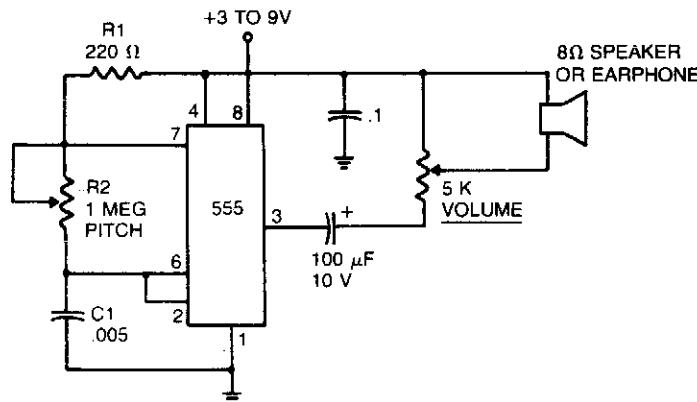


Fig. 91-3

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 minia-

ture speaker so that it will produce frequencies on the order of 20 kHz.

ULTRASONIC PEST REPELLER

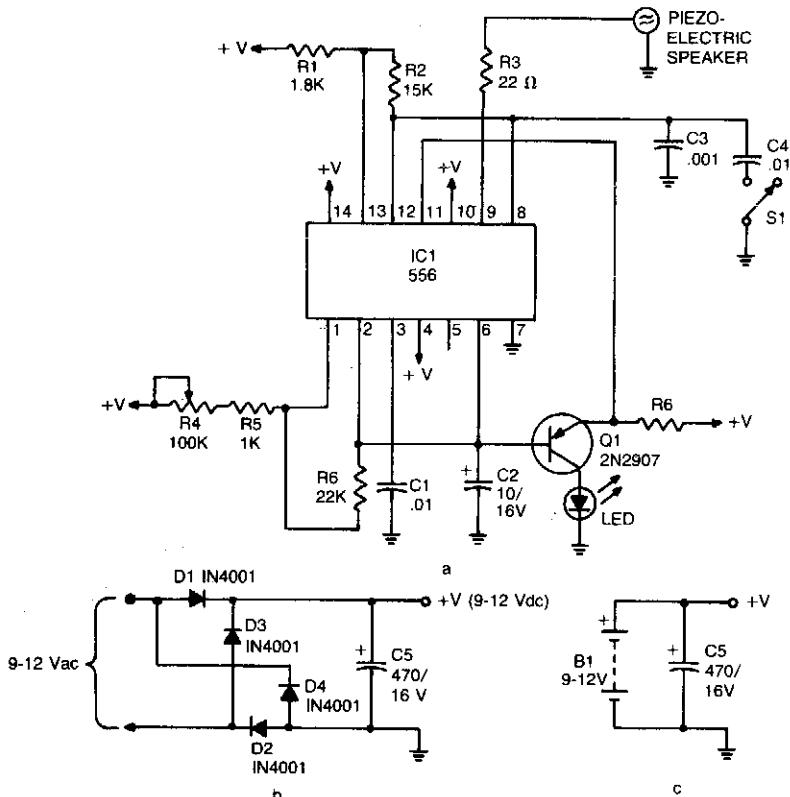


Fig. 91-4

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

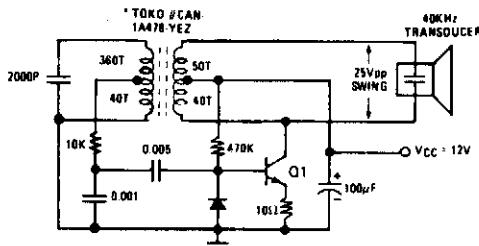


Fig. 91-5

92

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

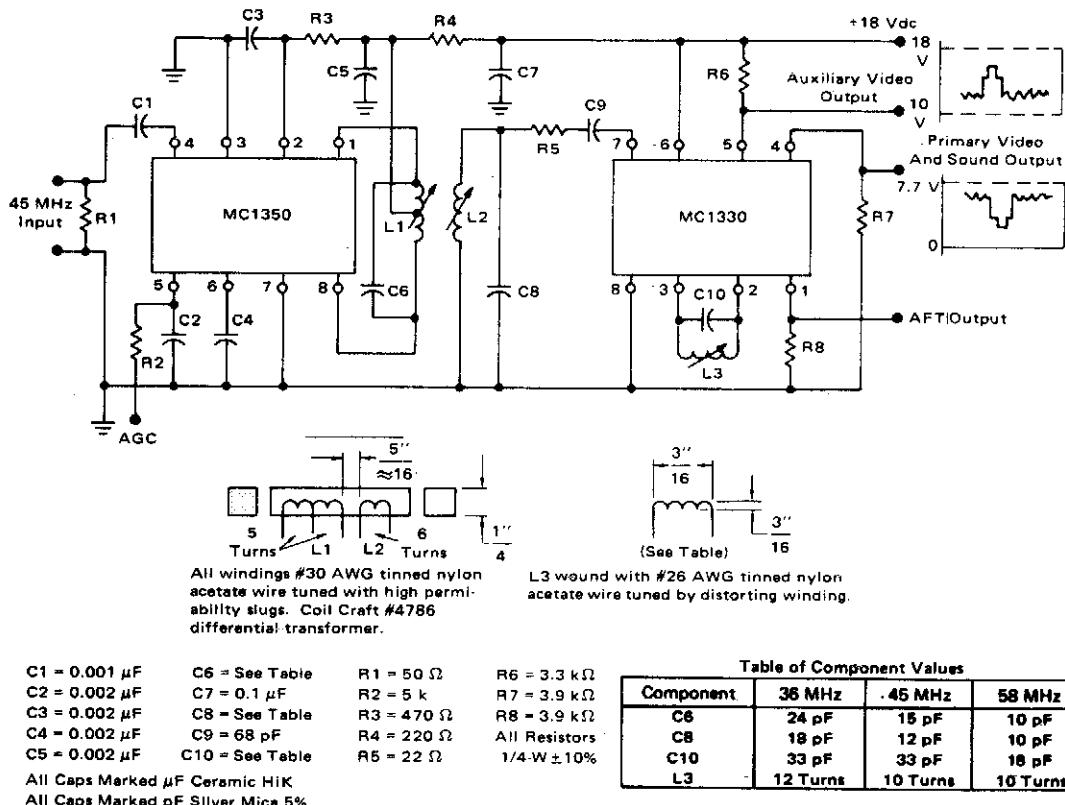


Fig. 92-1

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

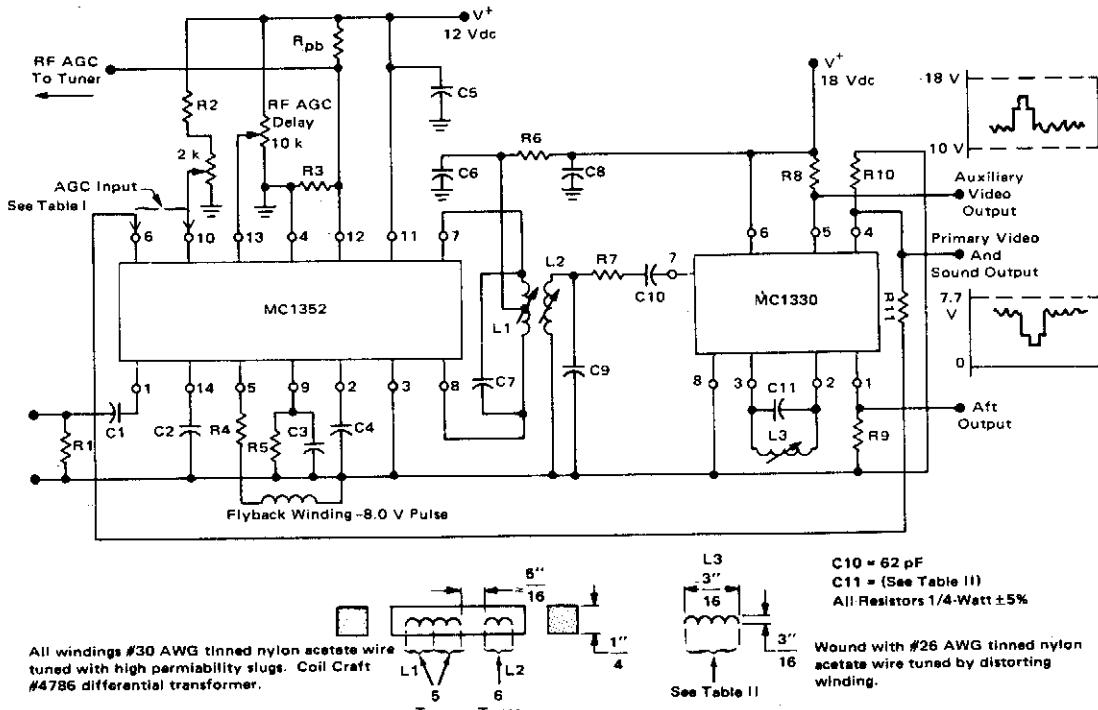


TABLE I

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	15 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)
 R1 = 50 Ω
 R2 = 3.9 k Ω
 R3 = (See Text)
 R4 = (See Table I)
 R5 = 220 k Ω
 R6 = 220 Ω
 R7 = 22 Ω
 R8 = 3.3 k Ω
 R9 = 3.9 k Ω
 R10 = 3.9 k Ω
 R11 = 4.7 k Ω
 C1 = 0.001 μ F
 C2 = 0.1 μ F
 C3 = 0.25 μ F
 C5 = 0.1 μ F
 C6 = 0.1 μ F
 C7 = (See Table II)
 C8 = 0.1 μ F
 C9 = (See Table III)

Fig. 92-2

TWO-STAGE WIDEBAND AMPLIFIER

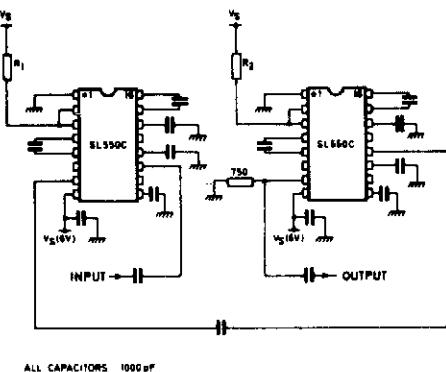


Fig. 92-3

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

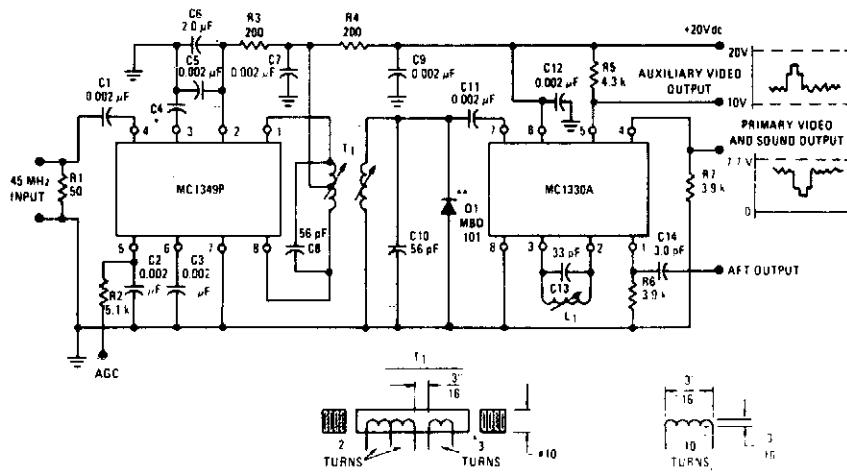


Fig. 92-4

TV SOUND IF OR FM IF AMPLIFIER WITH QUADRATURE DETECTOR

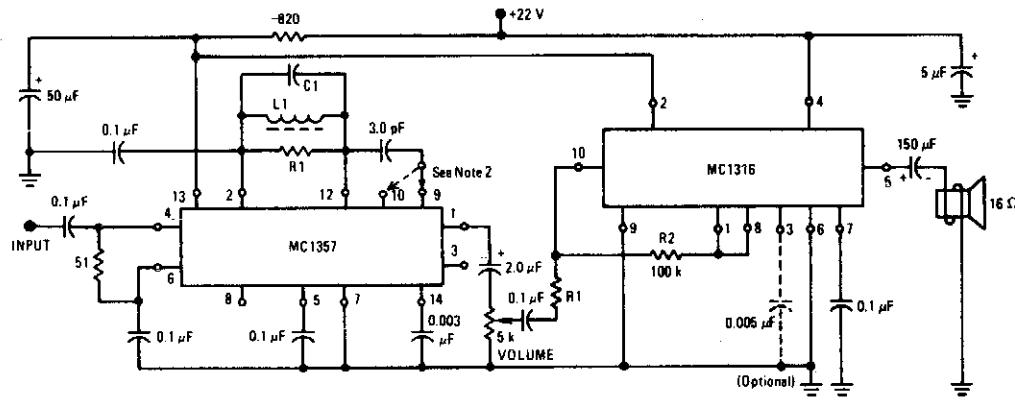
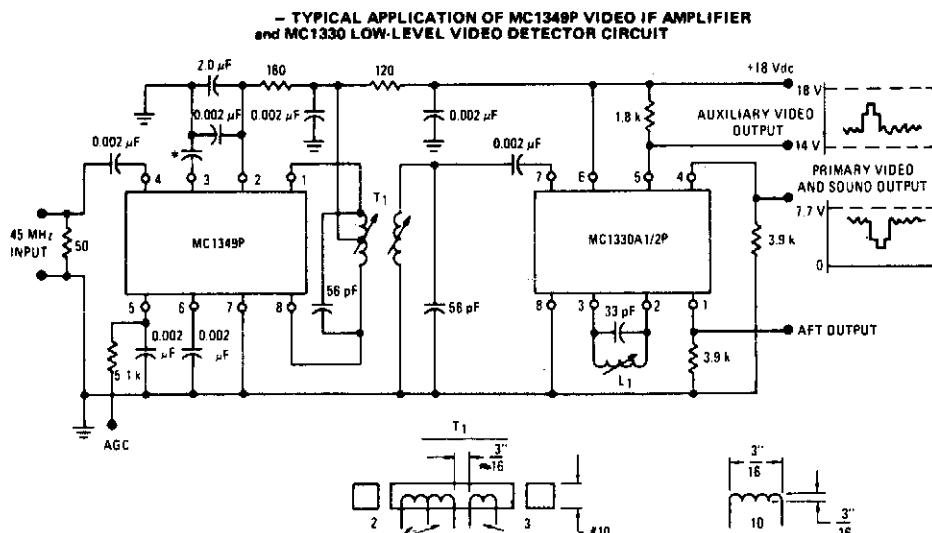


Fig. 92-5

IF AMPLIFIER



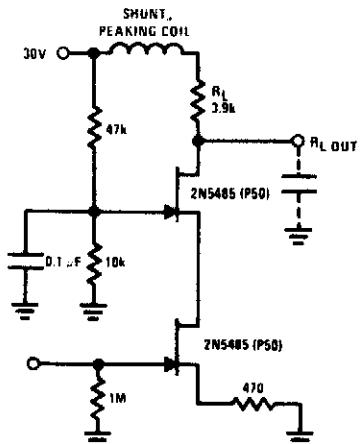
All windings #22 AWG tinned nylon
acetate wire tuned with Coilcraft #61
slugs, size 10-32, or equivalent.

*See Note 1 (page 3), and C4, Parts List (page 4) of this specification.

L1 wound with #26 AWG tinned 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

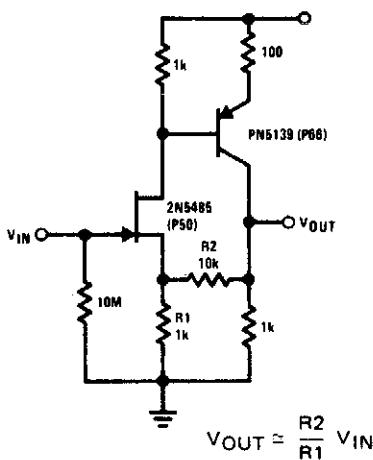
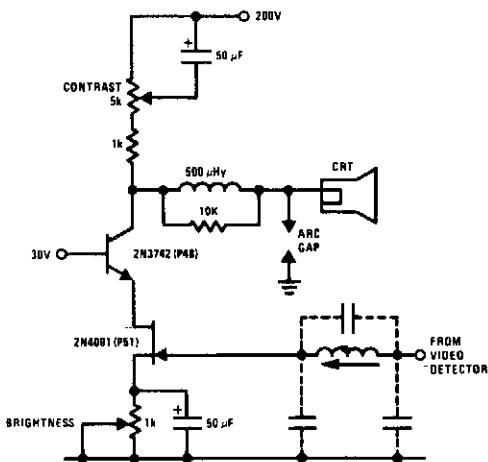


Fig. 92-8

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 2N4091 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

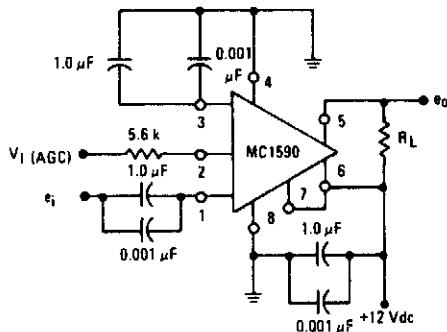


Fig. 92-10

VIDEO AMPLIFIER

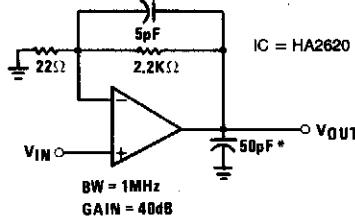


Fig. 92-11

*A small load capacitance of at least 30 pF (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
0 V to 20 V Power Reference
Programmable Voltage Source
Bilateral Current Source
Noninverting Bipolar Current Source
Voltage Reference
Low Voltage Adjustable Reference Supply
Voltage Reference
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

Inverting Bipolar Current Source
Precision Reference Micropower 10 V Reference
Precision Reference Low Noise Buffered Reference
Constant Current Source
Precision Dual Tracking Voltage References
Precision Reference Bipolar Output Reference
Precision Reference 0 V to 20 V Power Reference
Precision Reference Standard Cell Replacement

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.

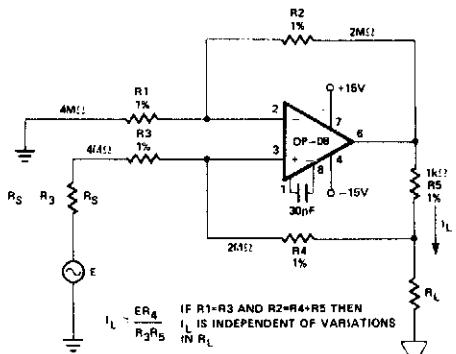


Fig. 93-1

0 V TO 20 V POWER REFERENCE

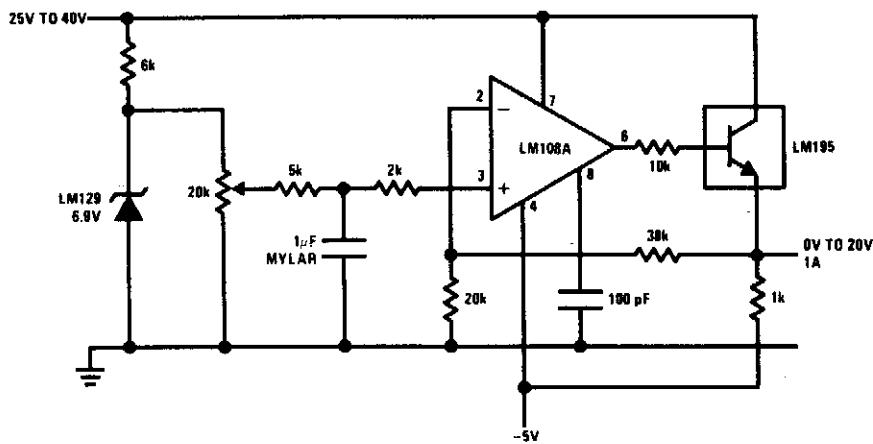


Fig. 93-2

PROGRAMMABLE VOLTAGE SOURCE

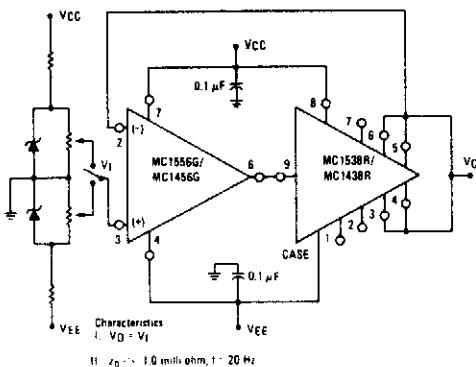


Fig. 93-3

BILATERAL CURRENT SOURCE

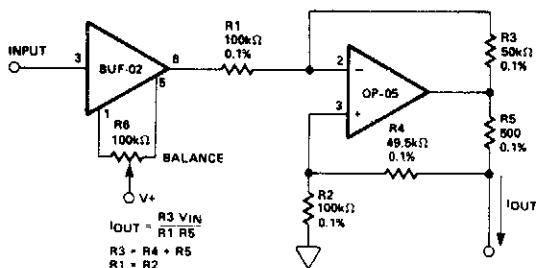


Fig. 93-4

LOW VOLTAGE ADJUSTABLE REFERENCE SUPPLY

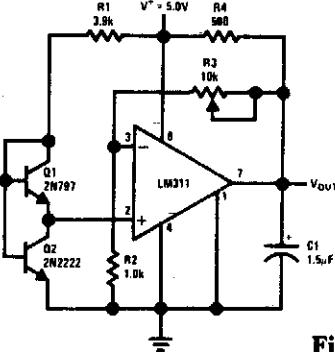


Fig. 93-7

NONINVERTING BIPOLAR CURRENT SOURCE

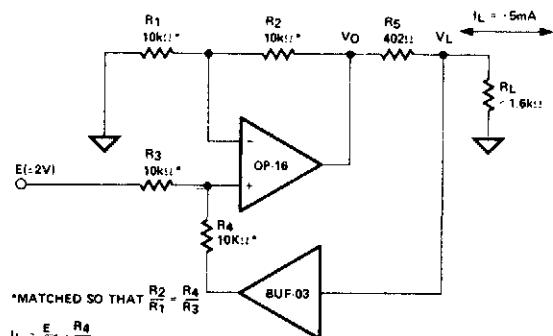


Fig. 93-5

COMPLIANCE OF ABOVE CIRCUIT (ΔV_L) IS -8V WHEN $E = -2V$ AND $R_L \leq 1.6k\Omega$. NOTE THAT V_O IS $\pm 10V$ UNDER THESE CONDITIONS.

VOLTAGE REFERENCE

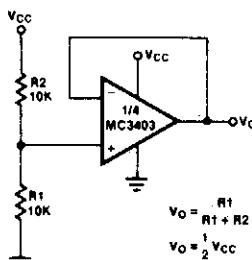


Fig. 93-6

LOW POWER REGULATOR REFERENCE

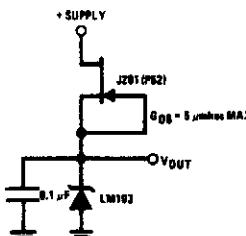


Fig. 93-9

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

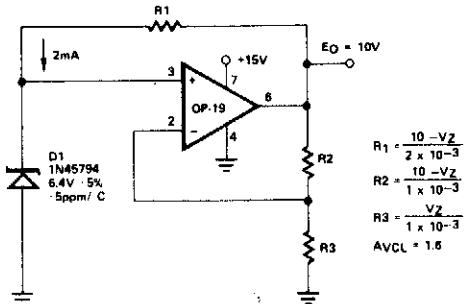


Fig. 93-10

ZENERLESS PRECISION MILLIVOLT SOURCE

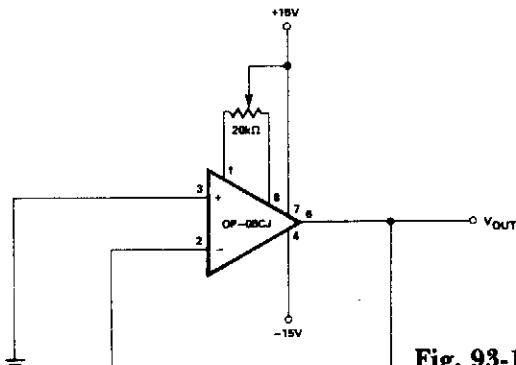


Fig. 93-13

± 3 V REFERENCE

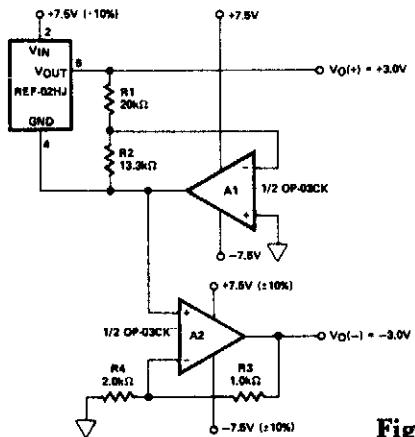


Fig. 93-11

± 10 V REFERENCE

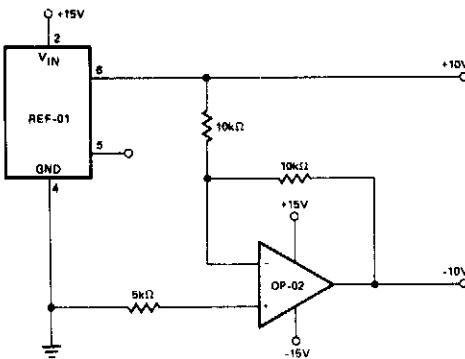


Fig. 93-14

± 5 V REFERENCE

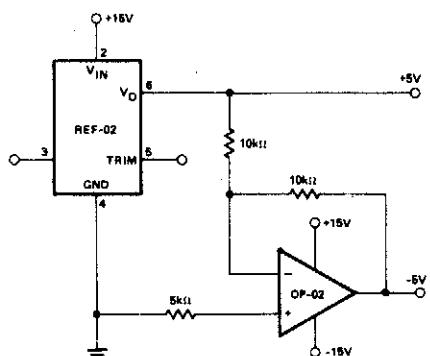


Fig. 93-12

PRECISION REFERENCE SQUARE WAVE VOLTAGE REFERENCE

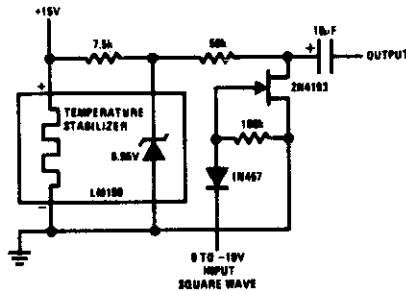
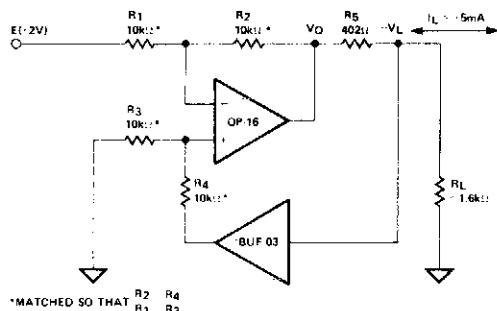


Fig. 93-15

INVERTING BIPOLAR CURRENT SOURCE (HIGH SPEED)

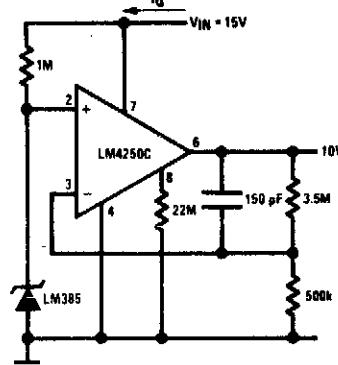


*MATCHED SO THAT $R_2 = R_4$
 $R_3 = R_1$

COMPLIANCE OF ABOVE CIRCUIT (V_{OL}) IS .8V
WHEN $E = 2V$ AND $R_L = 1.6k\Omega$. NOTE THAT
 $V_O = -10V$ UNDER THESE CONDITIONS.

Fig. 93-16

PRECISION REFERENCE MICROPOWER 10 V REFERENCE



* $I_Q = 20 \mu A$ standby current

Fig. 93-17

PRECISION REFERENCE LOW NOISE BUFFERED REFERENCE

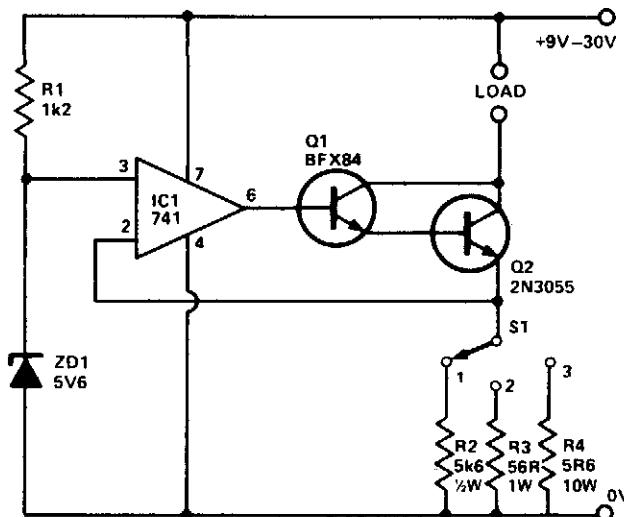


Fig. 93-18

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, 100 mA or 1 A can be selected. Q2 should be mounted on a suitable heatsink.

CONSTANT CURRENT SOURCE

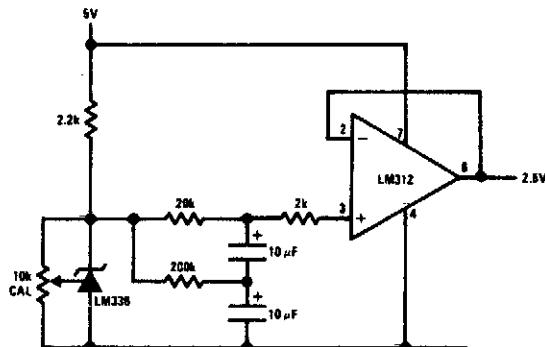


Fig. 93-19

PRECISION DUAL TRACKING VOLTAGE REFERENCES

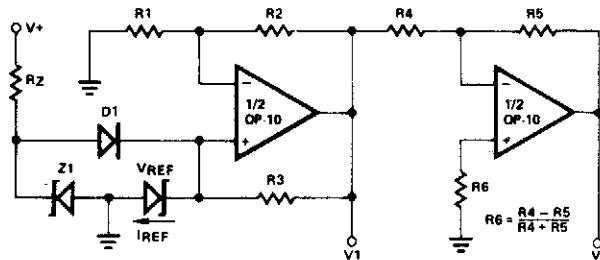


Fig. 93-20

PRECISION REFERENCE BIPOLAR OUTPUT REFERENCE

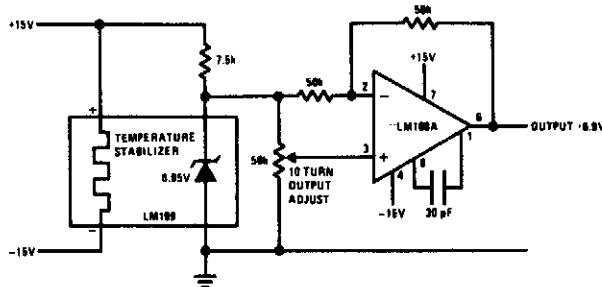


Fig. 93-21

PRECISION REFERENCE 0 V TO 20 V POWER REFERENCE

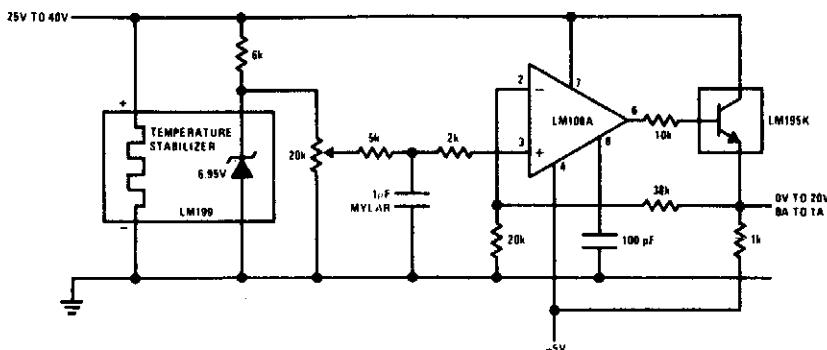


Fig. 93-22

PRECISION REFERENCE STANDARD CELL REPLACEMENT

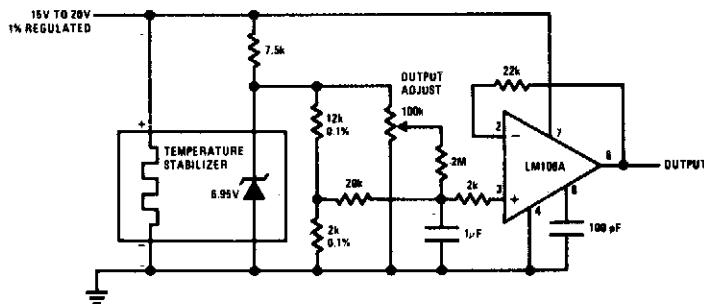


Fig. 93-23

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 Oscil-
lator
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

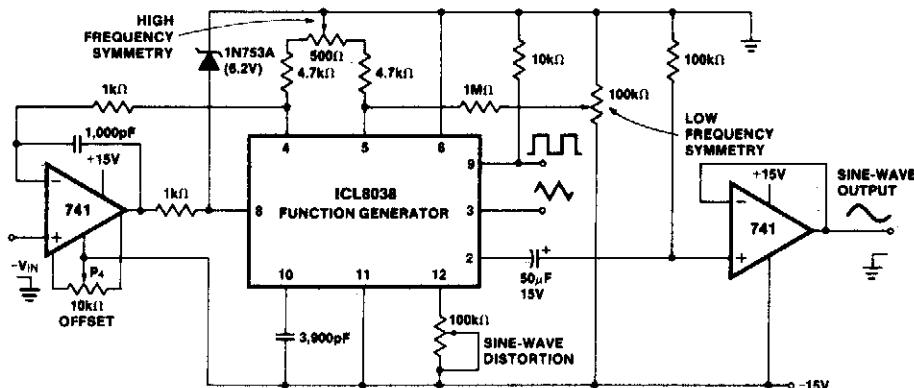


Fig. 94-1

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

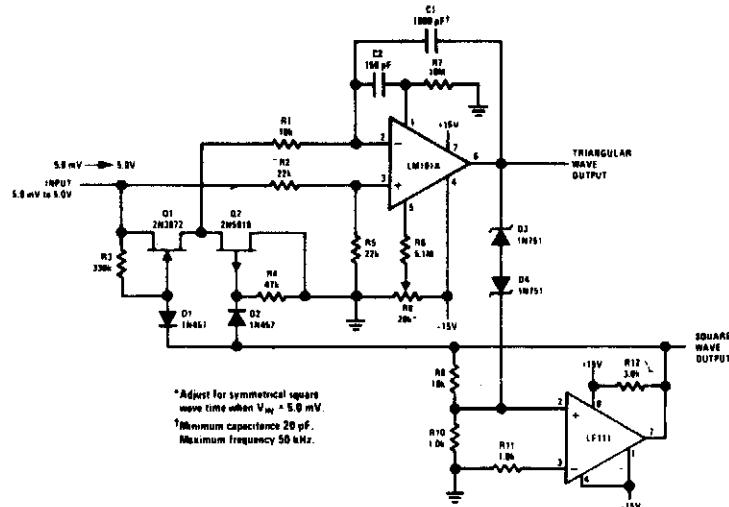


Fig. 94-2

PRECISION VOLTAGE CONTROLLED OSCILLATOR

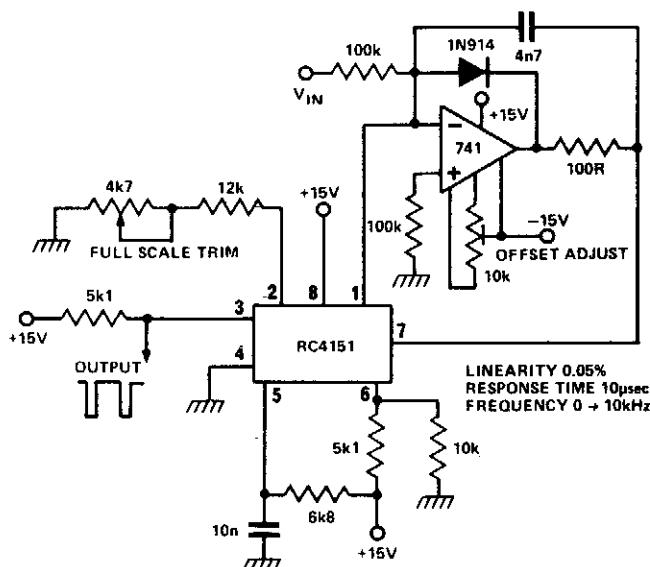
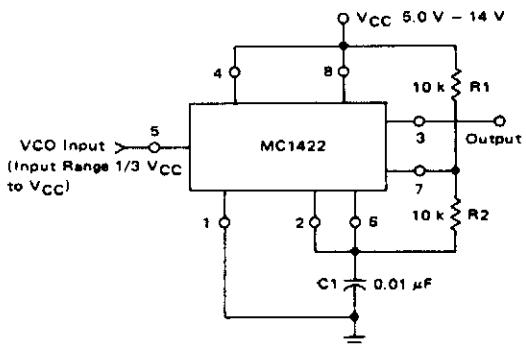


Fig. 94-3

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

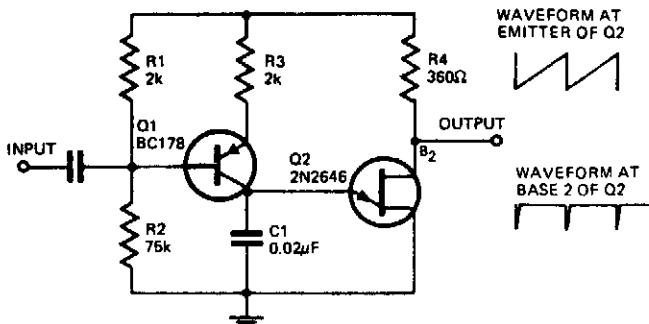


Fig. 94-5

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

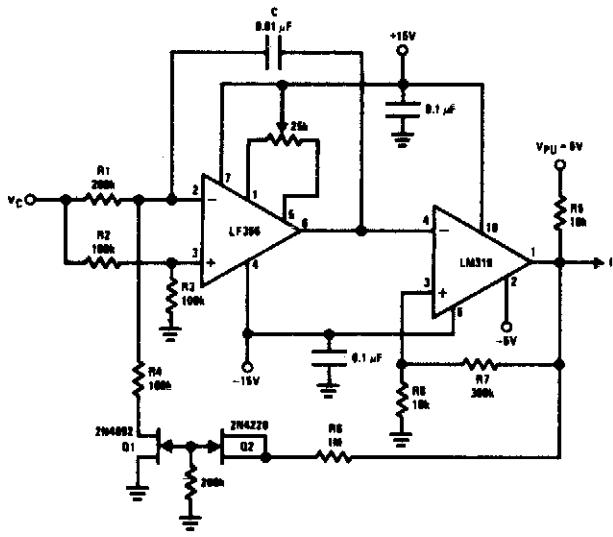


Fig. 94-6

$$f = \frac{V_C (R_8 + R_7)}{[8 V_{PU} R_8 R_1] C}, \quad 0 \leq V_C \leq 30V, \quad 10 \text{ Hz} \leq f \leq 10 \text{ kHz}$$

R1, R4 matched. Linearity 0.1% over 2 decades.

TWO-DECADE HIGH-FREQUENCY VCO

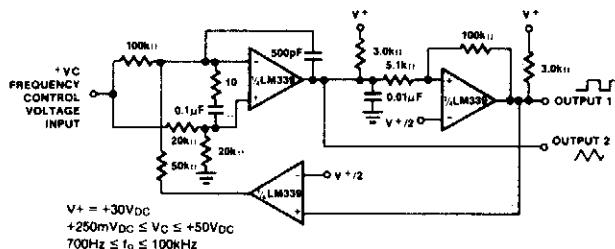


Fig. 94-7

VOLTAGE CONTROLLED OSCILLATOR

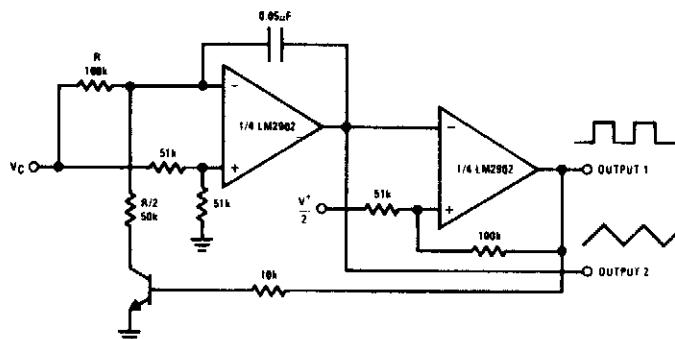
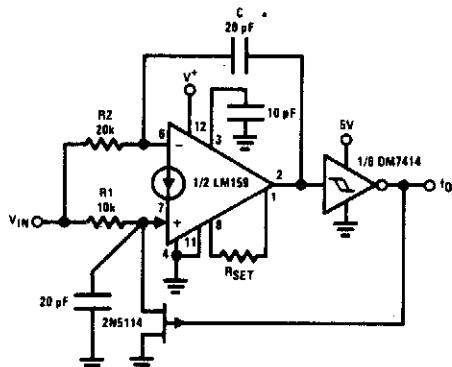


Fig. 94-8

VOLTAGE CONTROLLED OSCILLATOR



$$f_O = \frac{V_{IN} - \dagger}{4C\Delta V R_1}$$

where: $R_2 = 2R_1$

$\dagger = \text{amplifier input voltage} = 0.6\text{V}$

$\Delta V = \text{DM7414 hysteresis, typ } 1\text{V}$

- 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.

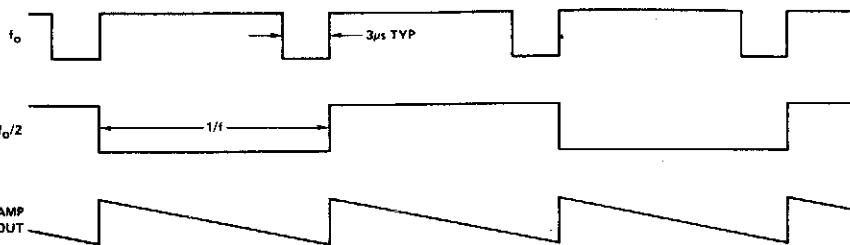
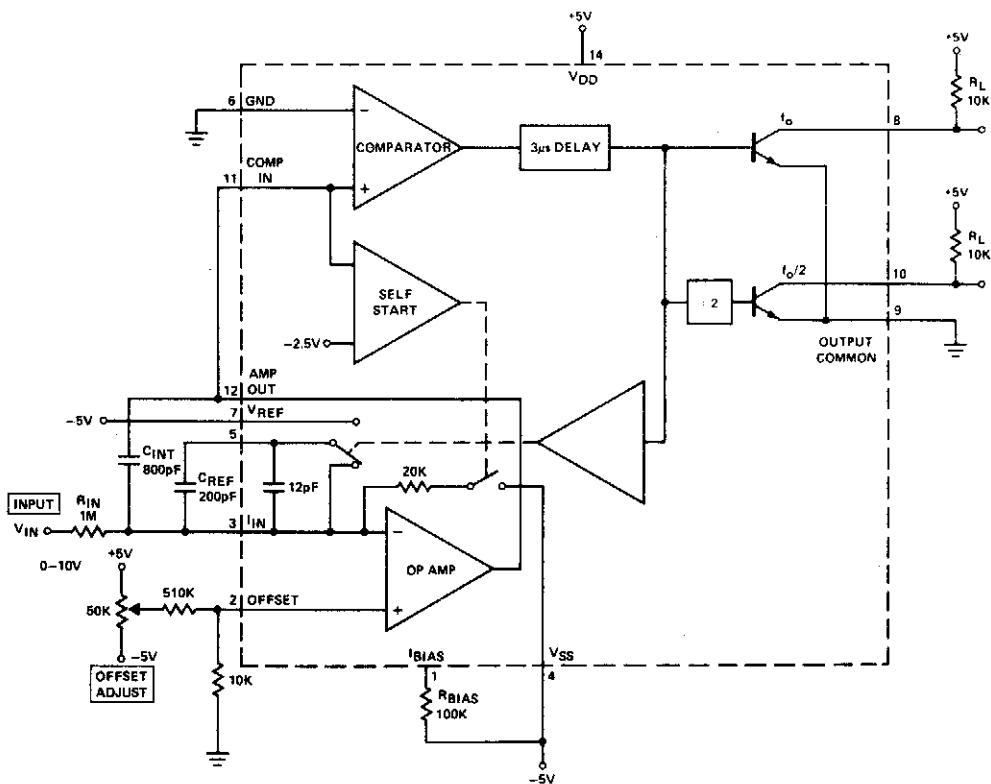
10 Hz to 10 kHz Voltage/Frequency Con-
verter

Voltage-to-Frequency Converter
V/F Conversion, Positive Input Voltage
Ultraprecision V/F Converter

Voltage-to-Frequency 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

VOLTAGE-TO-FREQUENCY CONVERTER

Circuit Notes

The D169 serves as a level detector and provides complementary outputs. The op amp is used to integrate the input signal V_{IN} with a time constant of R_1C_1 . The input (must be negative) causes a positive ramp at the output of the integrator which is summed with a negative zener voltage. When the ramp is positive enough D169 outputs change state and OUT 2 flips from negative to positive. The output pulse repetition rate f_o is directly proportional to the negative input voltage V_{IN} .

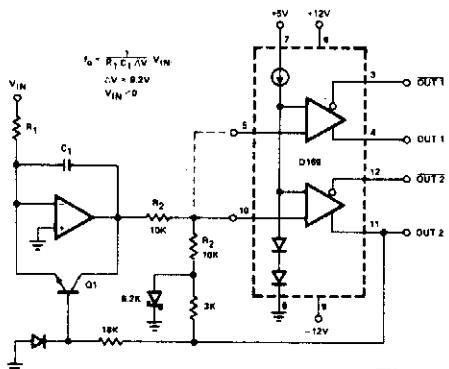


Fig. 95-2

VOLTAGE-TO-FREQUENCY CONVERTER

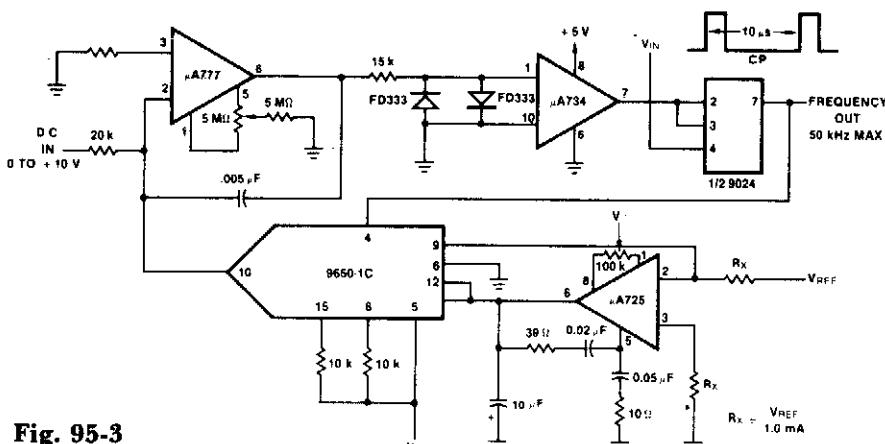


Fig. 95-3

V/F CONVERSION, POSITIVE INPUT VOLTAGE

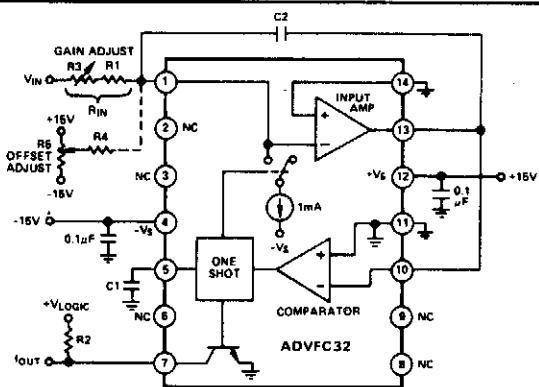
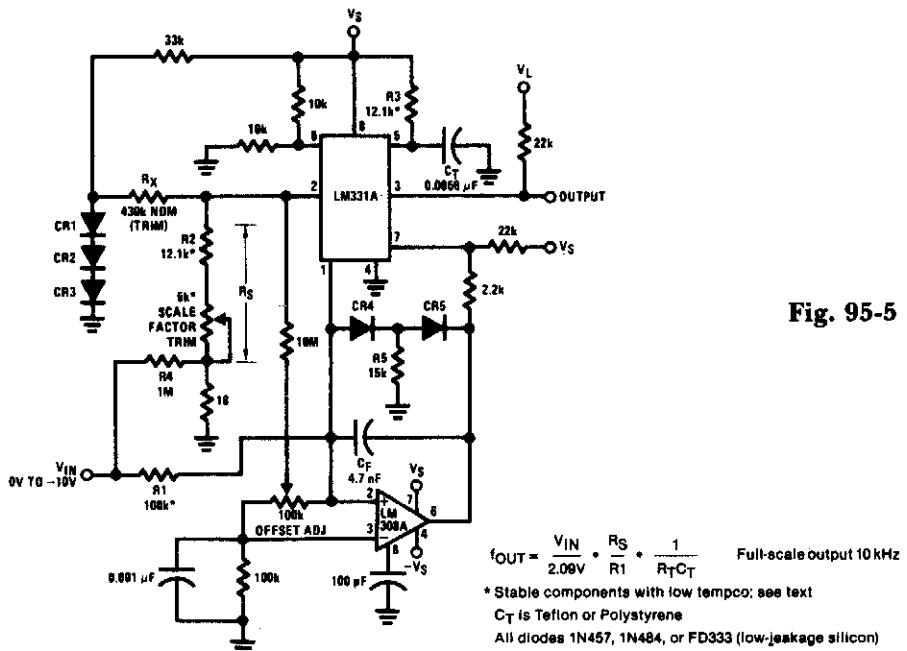


Fig. 95-4

ULTRAPRECISION V/F CONVERTER



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

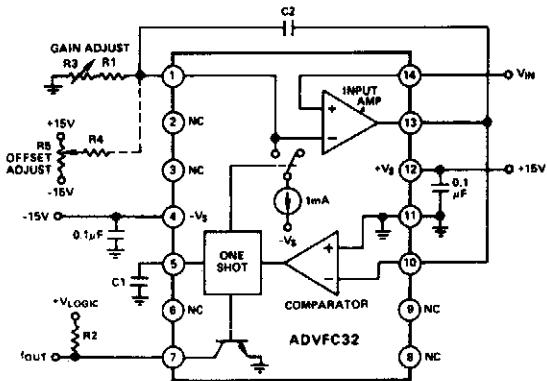


Fig. 95-6

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- $\frac{3}{4}$ Digit DVM, Four Decade, ± 0.4 V, ± 4 V, ± 40 V, and ± 400 V Full Scale
Automatic Nulling DVM
3- $\frac{1}{2}$ Digit True RMS AC Voltmeter
3- $\frac{1}{2}$ 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
4 $\frac{1}{2}$ Digit LCD-DVM
Sensitive Low Cost VTVM

**3 3/4 DIGIT DVM, FOUR DECADE,
 ± 0.4 V, ± 4 V, ± 40 V, AND ± 400 V FULL SCALE**

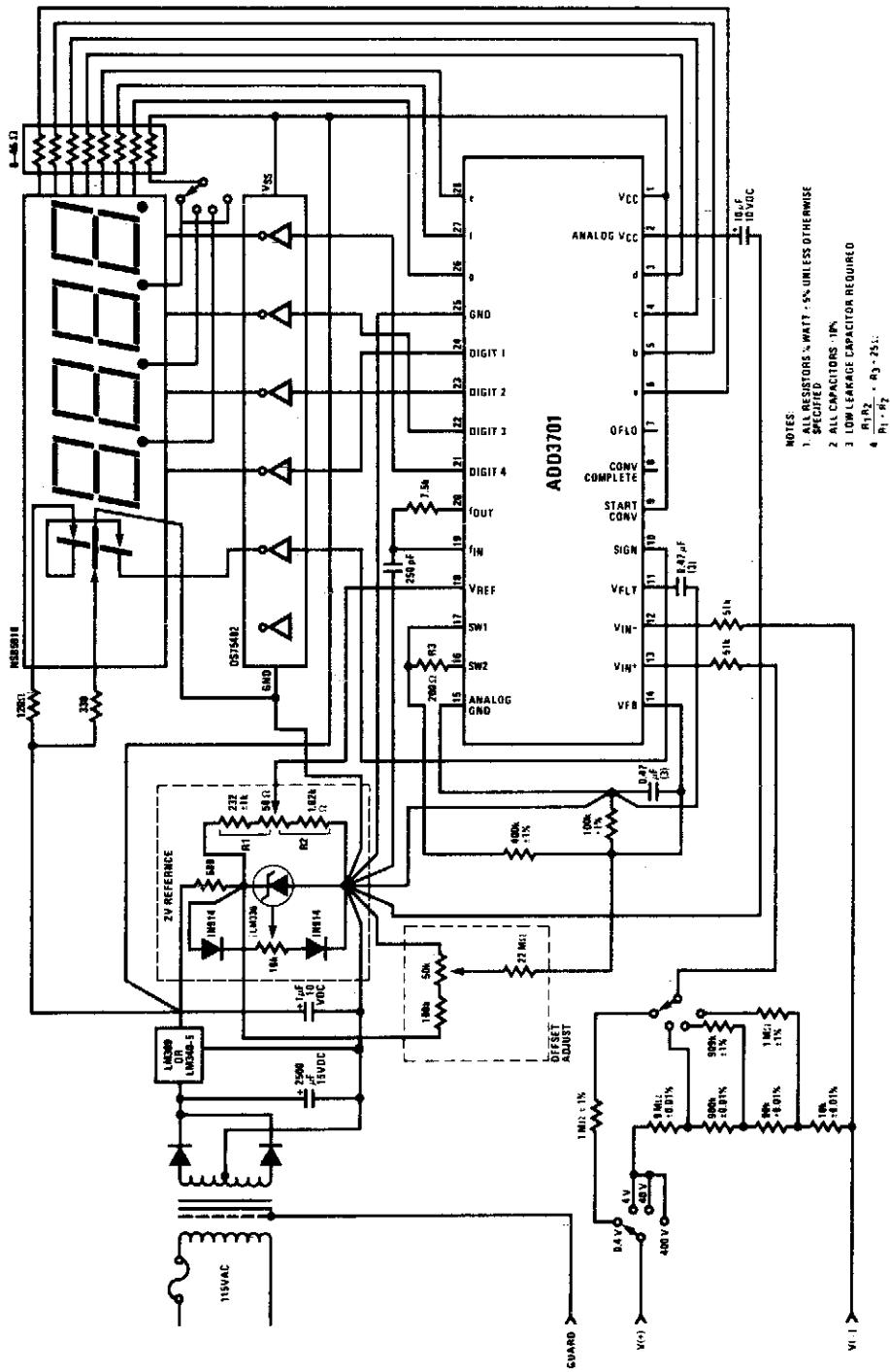


Fig. 96-1

AUTOMATIC NULLING DVM

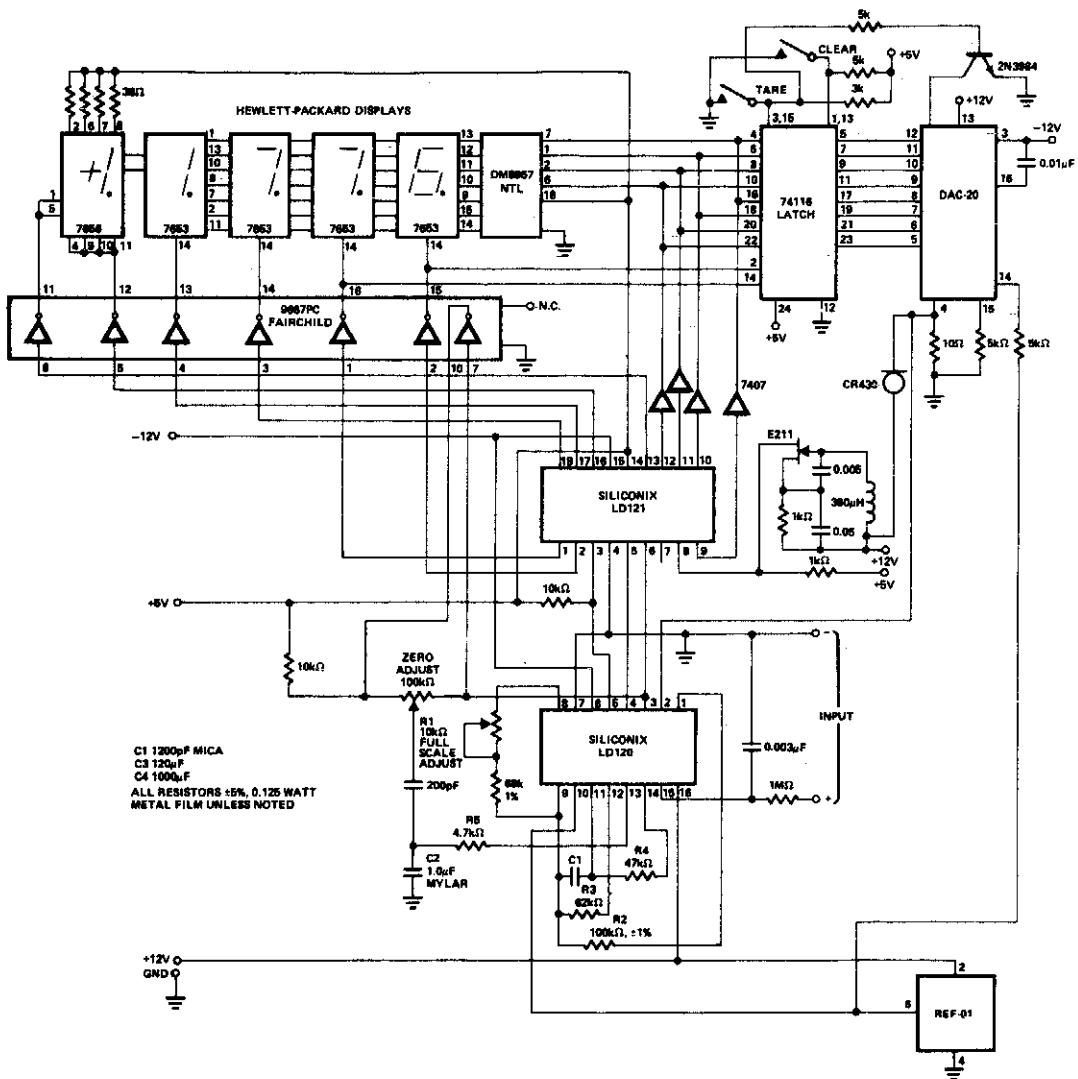


Fig. 96-2

3-½ DIGIT TRUE RMS AC VOLTMETER

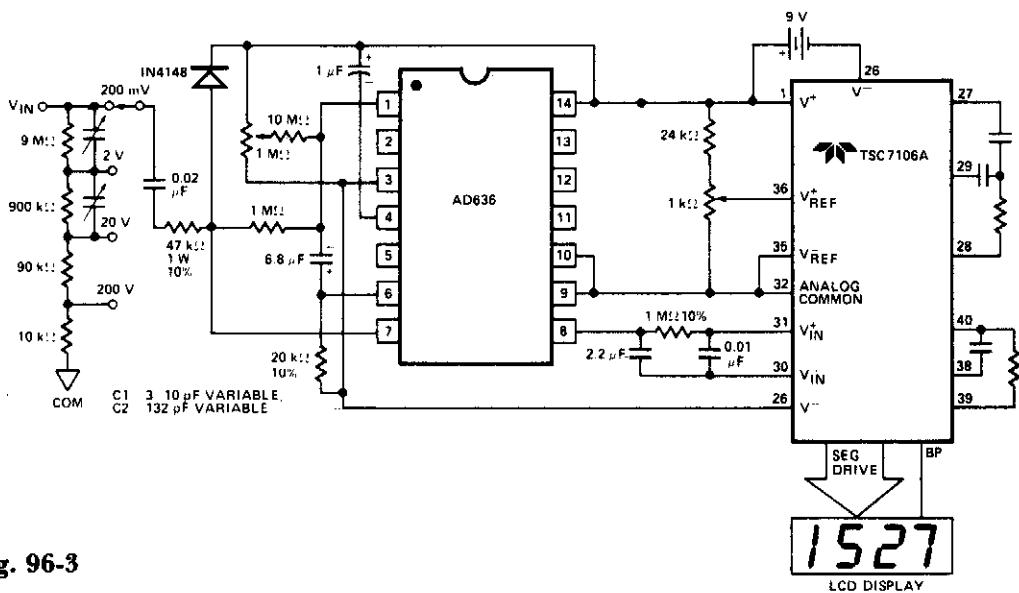


Fig. 96-3

3½ DIGIT DVM (± 200.0 mV) COMMON ANODE DISPLAY

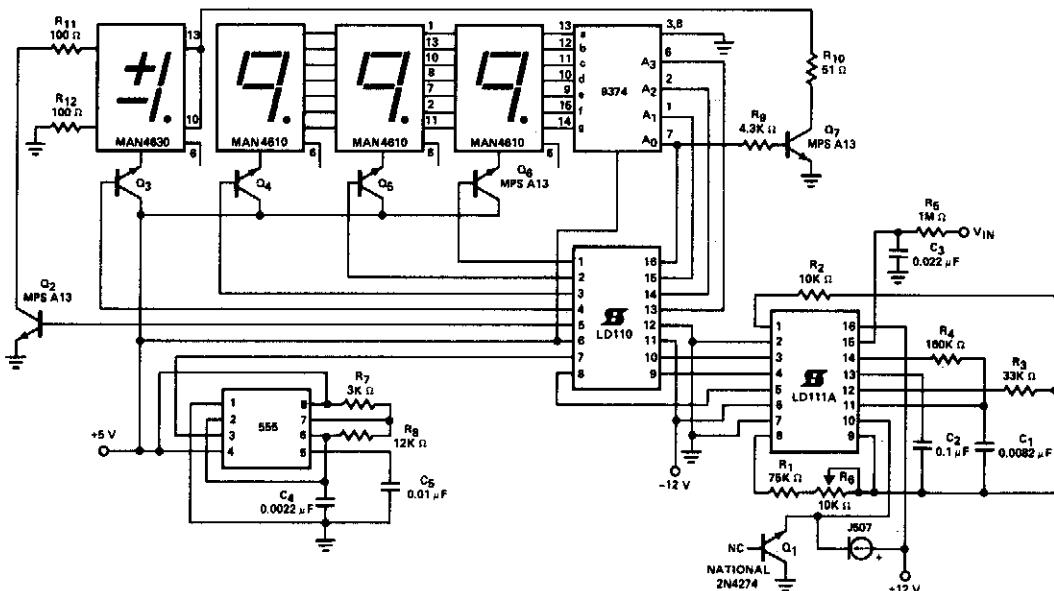


Fig. 96-4

DVM AUTO-CALIBRATE CIRCUIT

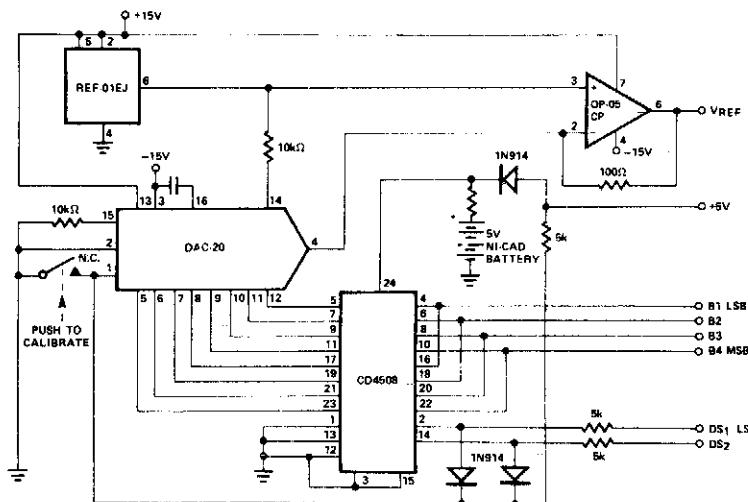


Fig. 96-5

FET VOLTMETER

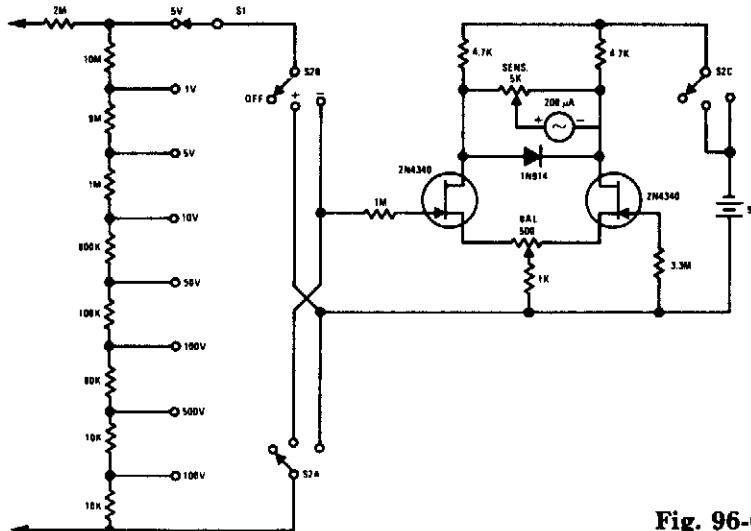


Fig. 96-6

Circuit Notes

This FETVM replaces the function of the VTVM while at the same time ridding the instrument of the usual line cord. In addition, drift rates are far superior to vacuum tube cir-

cuits allowing a 0.5 volt full scale range which is impractical with most vacuum tubes. The low-leakage, low-noise 2N4340 is an ideal device for this application.

EXTENDED RANGE VU METER (BAR MODE)

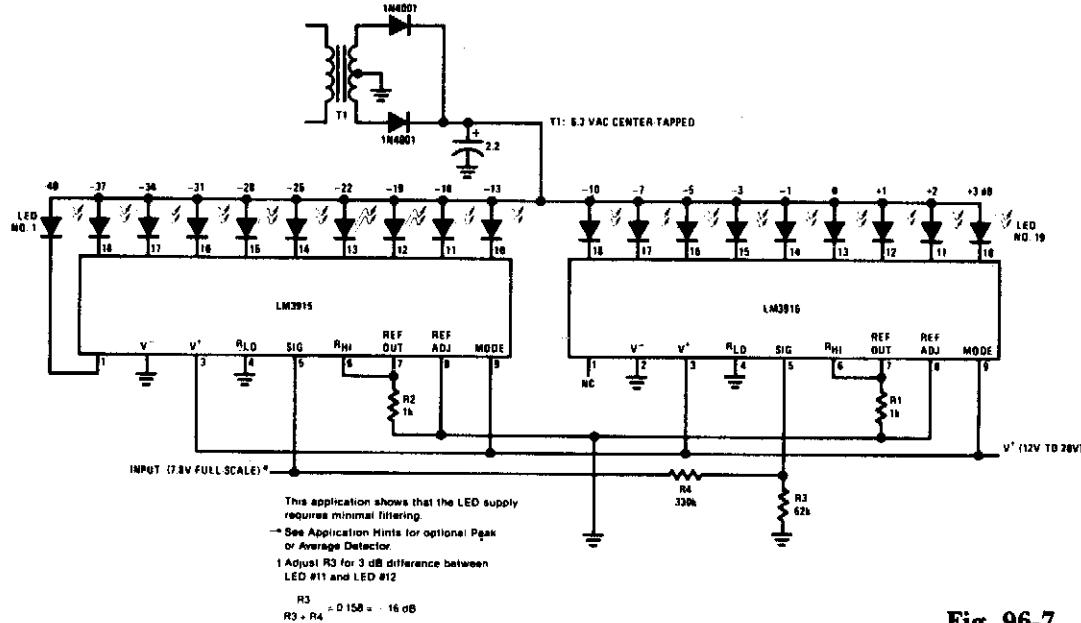


Fig. 96-7

HIGH INPUT IMPEDANCE MILLIVOLTMETER

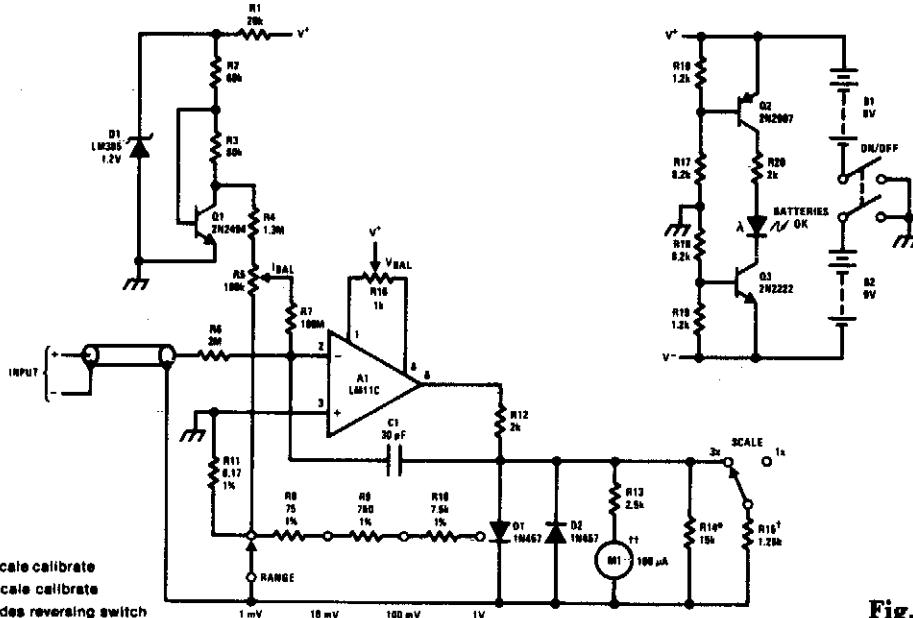
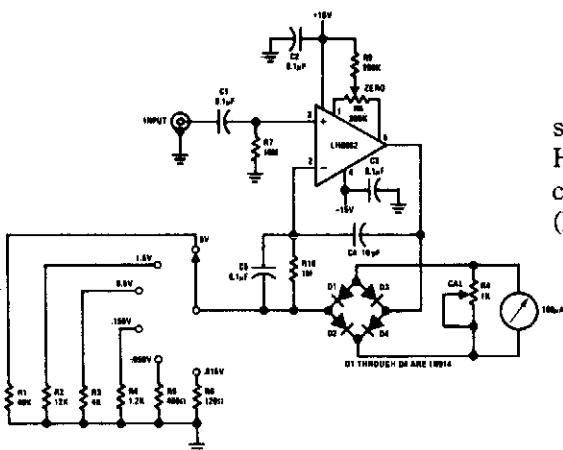


Fig. 96-8

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

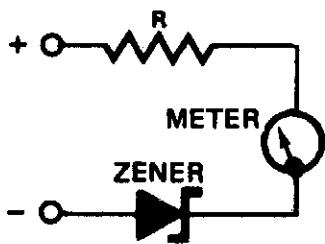


Fig. 96-10

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

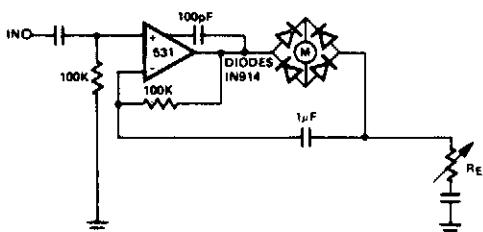


Fig. 96-11

4½ DIGIT LCD-DVM

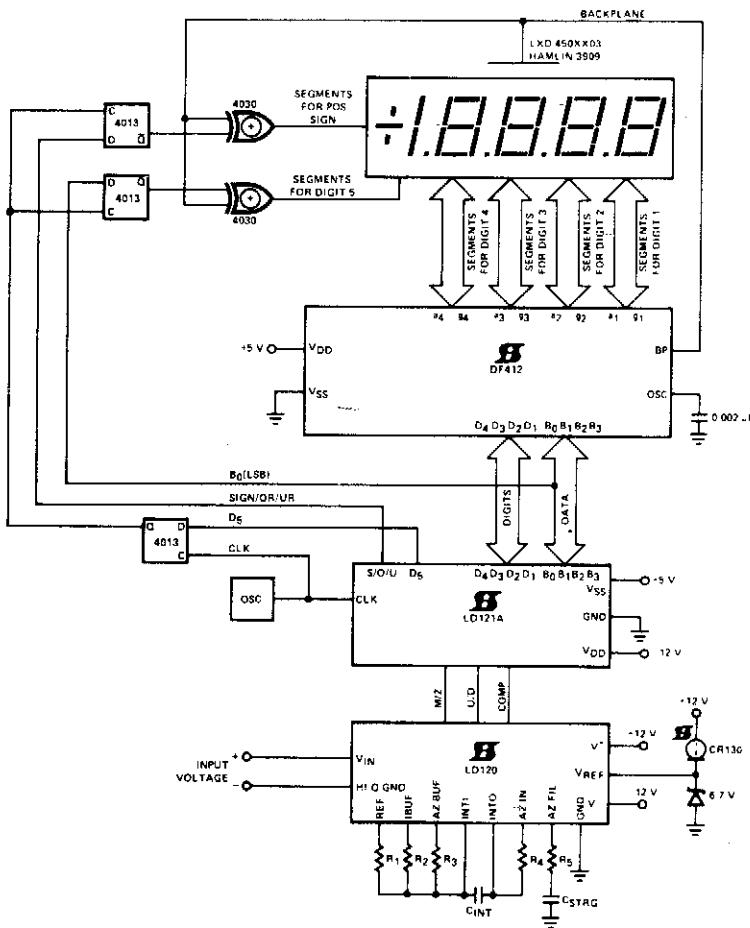


Fig. 96-12

SENSITIVE LOW COST "VTVM"

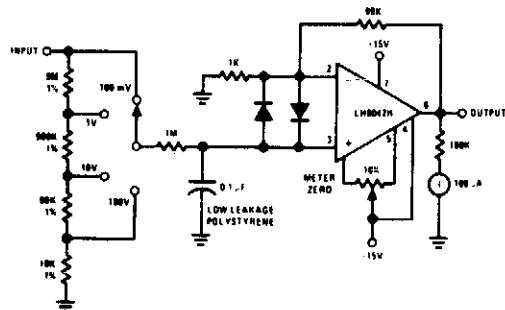


Fig. 96-13

97

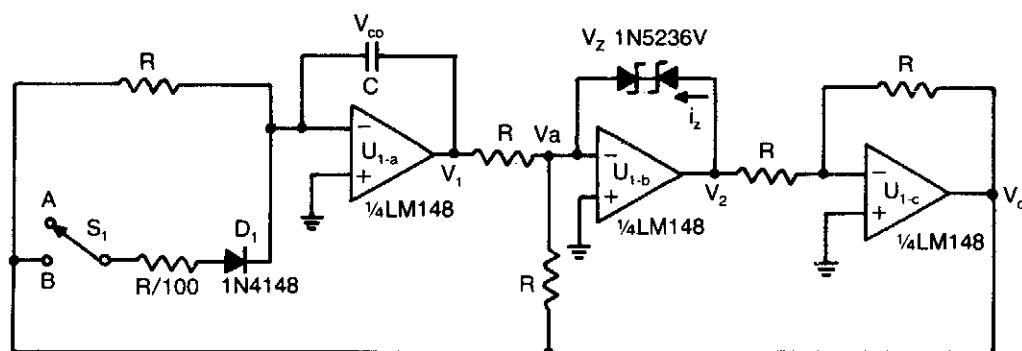
Waveform and Function Generators

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.

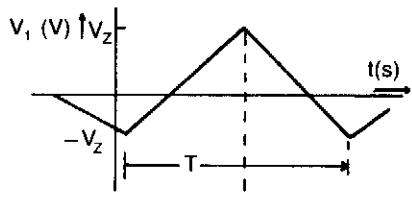
Low Cost Adjustable Function Generator
DAC Controlled Function Generator
Programmed Function Generator
100-kHz Quadrature Oscillator
Strobe-Tone Burst Generator
Low Cost High Frequency Generator
Tone-Burst Oscillator and Decoder
Triangle and Square Waveform Generator
10 kHz Oscillator
50 kHz Oscillator
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

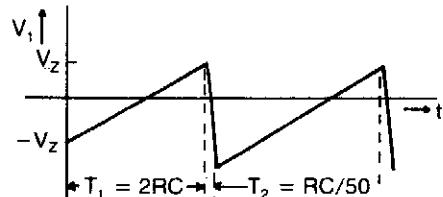
LOW COST ADJUSTABLE FUNCTION GENERATOR



(A)



(B)



(C)

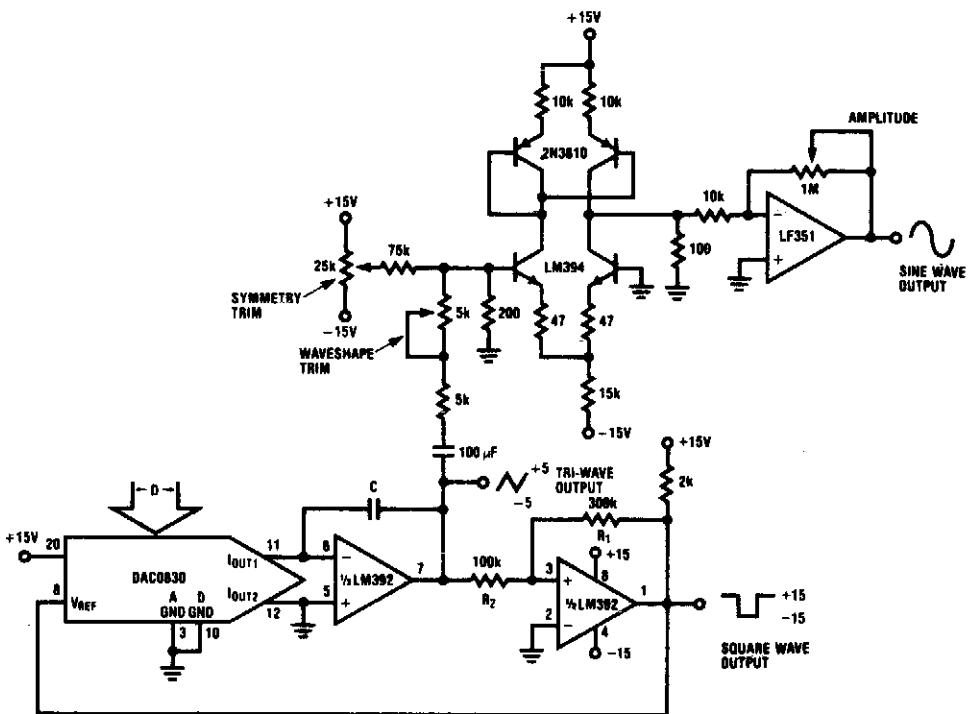
Fig. 97-1

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.

$$\bullet f = \frac{D}{256(20k)C} \text{ for } V_{OMAX} = V_{OMIN} \text{ of square wave output}$$

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

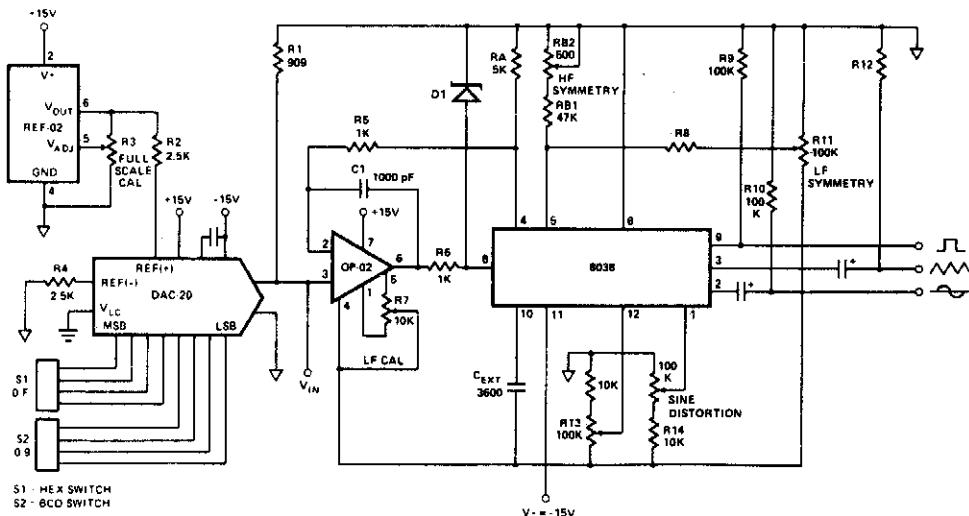
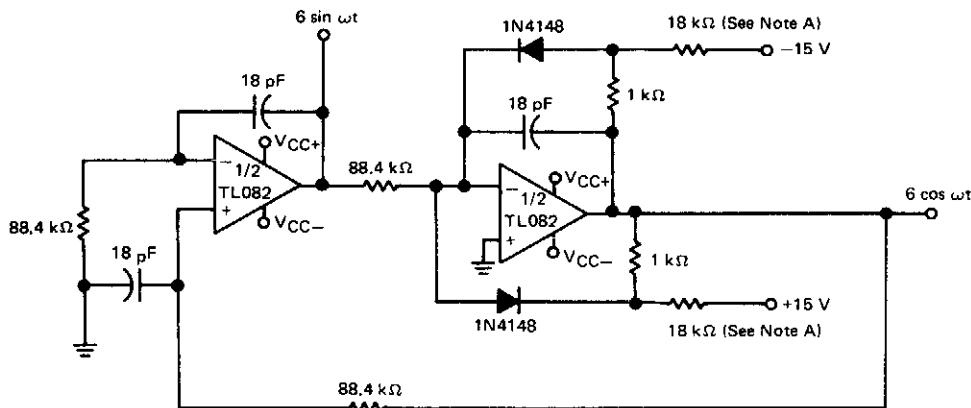


Fig. 97-3

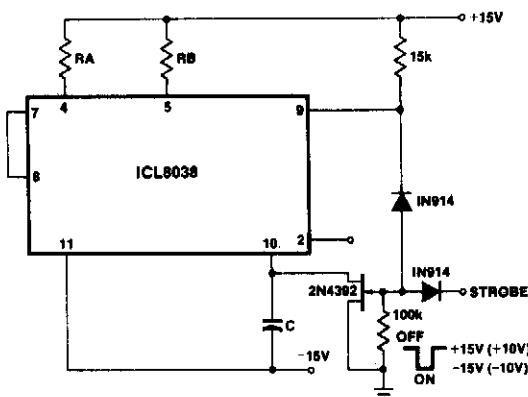
100-kHz QUADRATURE OSCILLATOR



Note A: These resistor values may be adjusted for a symmetrical output.

Fig. 97-4

STROBE-TONE BURST GENERATOR

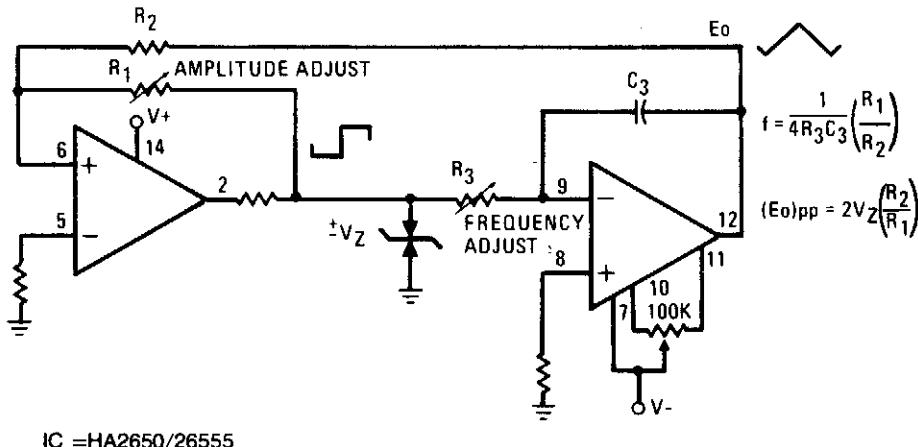


Circuit Notes

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

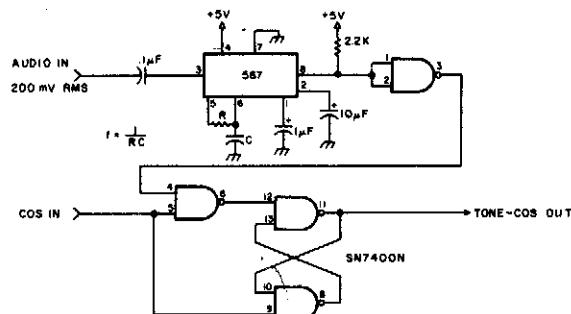
LOW COST HIGH FREQUENCY GENERATOR



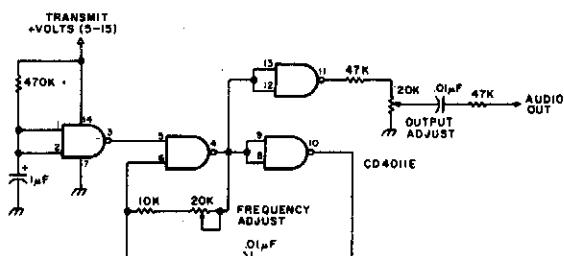
IC =HA2650/26555

Fig. 97-6

TONE-BURST OSCILLATOR AND DECODER



Decoder and logic.



Tone-burst oscillator.

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

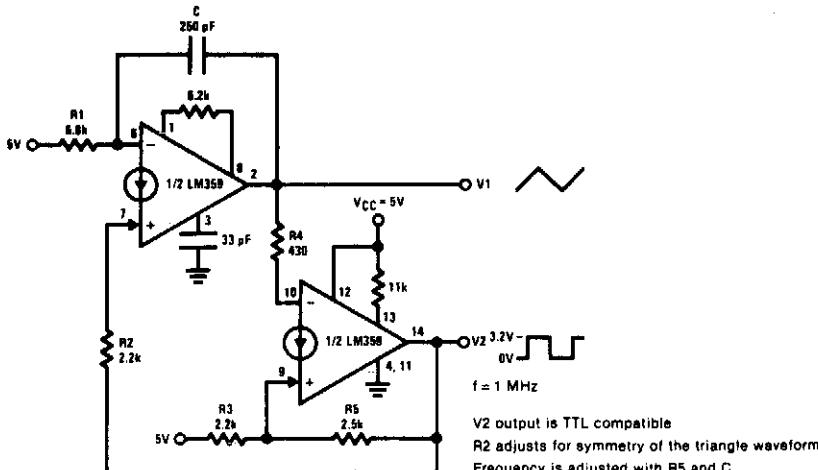
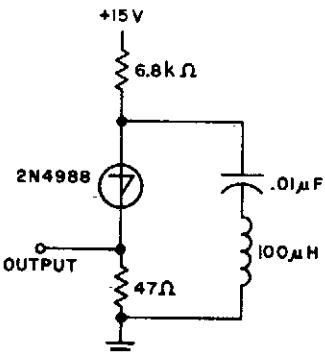


Fig. 97-8

V2 output is TTL compatible
R2 adjusts for symmetry of the triangle waveform
Frequency is adjusted with R5 and C

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

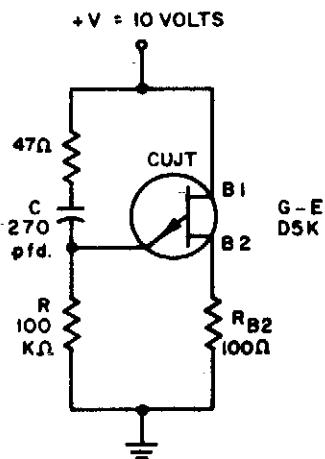


Fig. 97-10

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

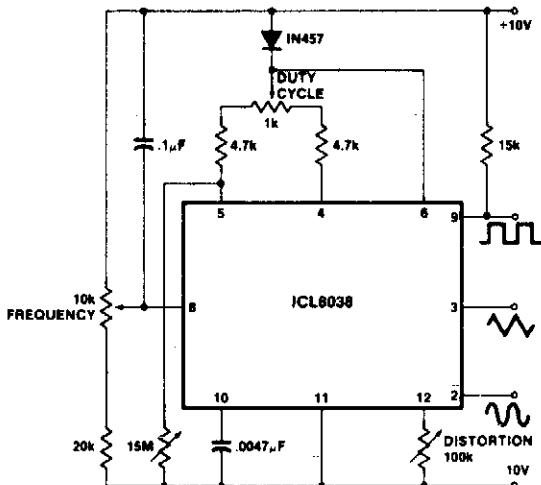
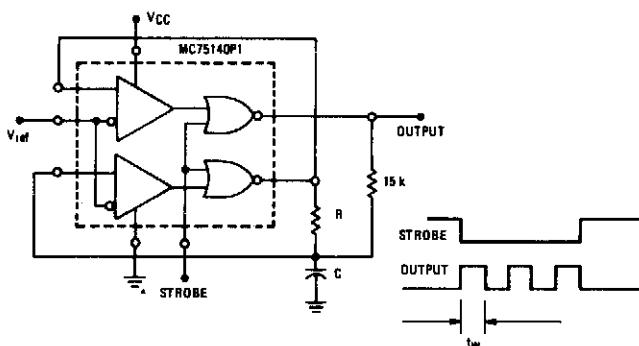


Fig. 97-11

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



GATE OSCILLATOR FREQUENCY
VERSUS RC TIME CONSTANT

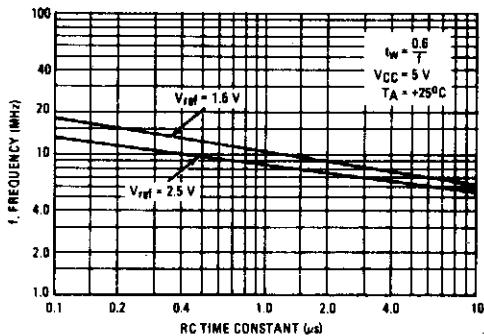
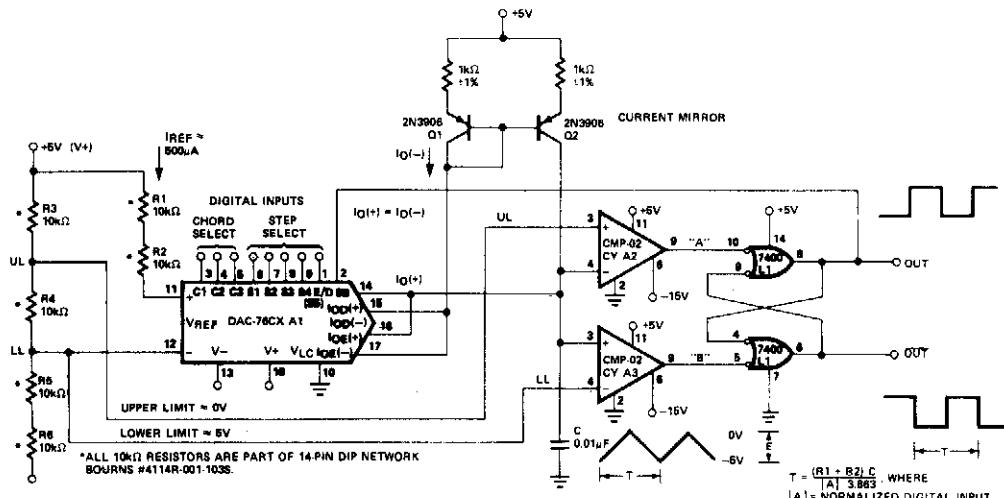


Fig. 97-12

EXPONENTIAL DIGITALLY-CONTROLLED OSCILLATOR



$$T = \frac{(R1 + R2)C}{|A| \cdot 3.863} \text{ WHERE } |A| = \text{NORMALIZED DIGITAL INPUT}$$

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 $+5 \pm 1\text{ V}$ and $-15 \pm 3\text{ V}$ supplies, and has the dynamic range of a 13-bit DAC.

FUNCTION GENERATOR

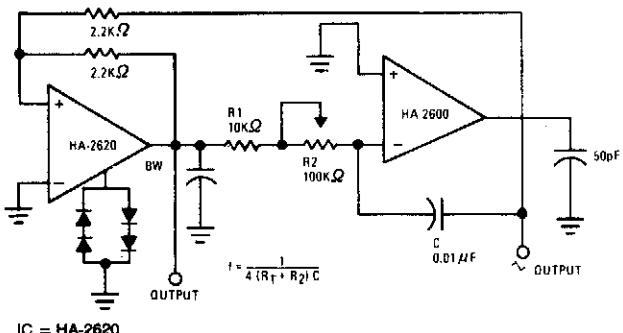
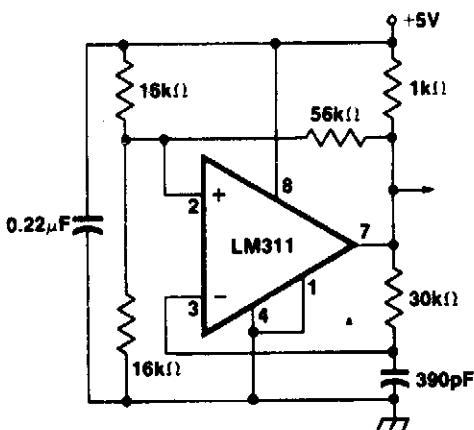


Fig. 97-14

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

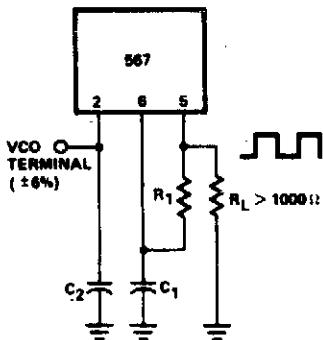


Fig. 97-16

OSCILLATOR WITH QUADRATURE OUTPUT

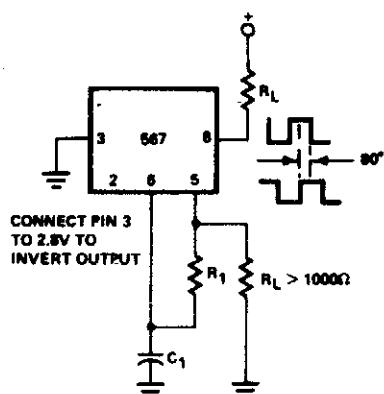


Fig. 97-17

WIDE RANGE VARIABLE OSCILLATOR

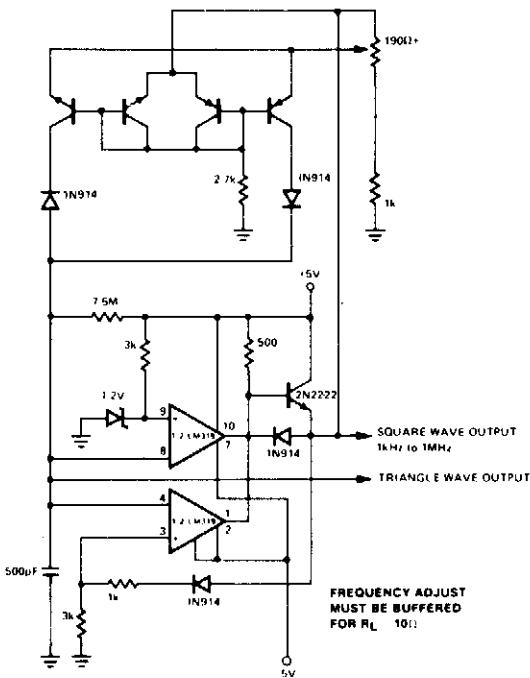
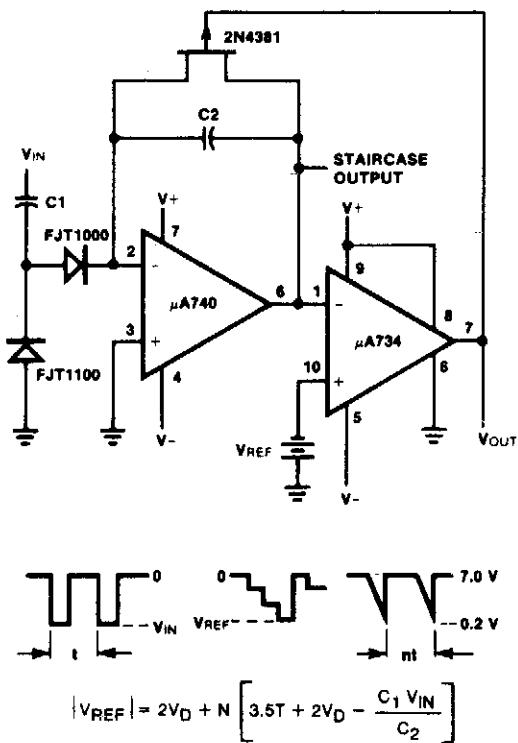


Fig. 97-18

FREQUENCY DIVIDER AND STAIRCASE GENERATOR



T in Seconds
 V_D for FJT 1000 ≈ 0.31 V

Fig. 97-19

PRECISION OSCILLATOR TO SWITCH 100 mA LOADS

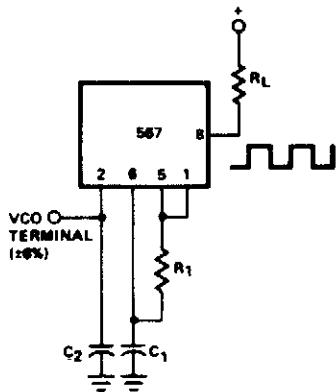


Fig. 97-20

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

Zero Crossing Detector

Sensor

Zero Crossing Detector

Zero Crossing Detector

Zero Crossing Detector

ZERO CROSSING SWITCH

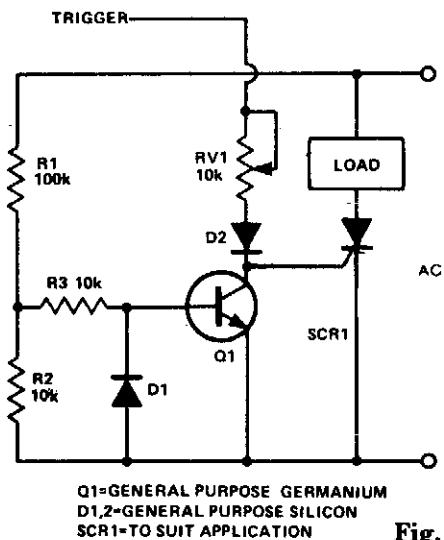


Fig. 98-1

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

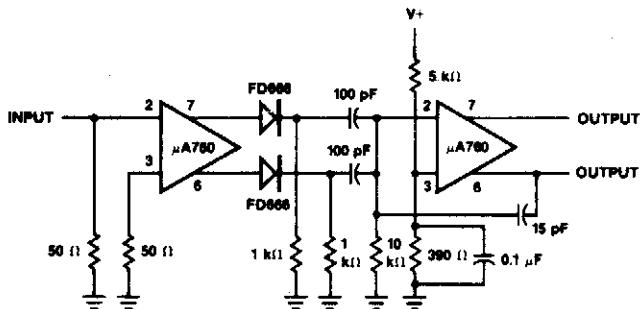


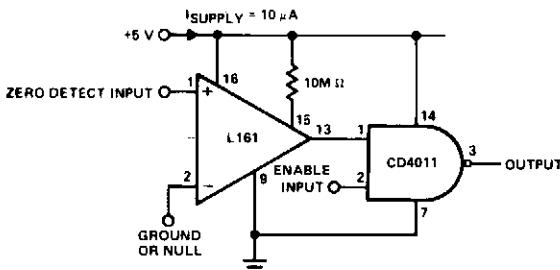
Fig. 98-2

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 μV .

Fig. 98-3

ZERO CROSSING DETECTOR WITH TEMPERATURE SENSOR

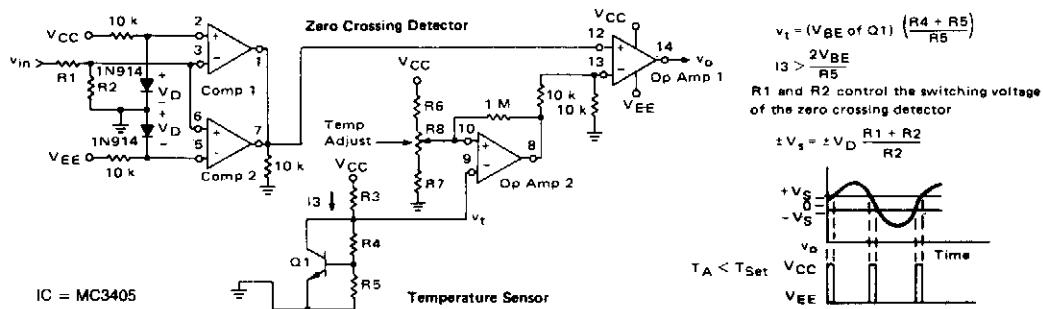


Fig. 98-4

ZERO-CROSSING DETECTOR

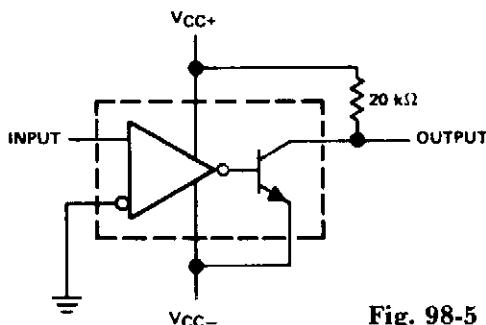


Fig. 98-5

ZERO CROSSING DETECTOR

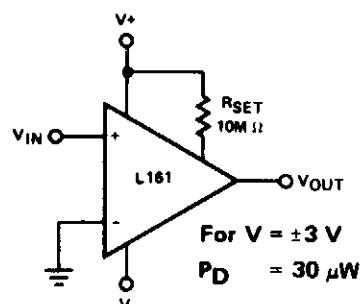


Fig. 98-6

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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of Fig. 19-29: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-31: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, Copyright © 1983, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc. r.f. Design, 5-6/83, p. 63.

Fig. 19-32: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCIL-

LATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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: CHRYSTAL OSCILLATOR CIRCUITS, Robert J. Matthey, 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, 1080, 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. 11-30.

Fig. 77-3: Reprinted with the permission of National Semiconductor Corp. *Transistor Databook*, 1982, p. 11-31.

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.

Fig. 85-4: *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.

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 permission 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.

Fig. 85-4: *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 Data-book, 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 Data-book, 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 Data-book, 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 Data-book, 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 Data-book, 1980, p. 14-53.
Fig. 93-22: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Data-book, 1980, p. 14-53.
Fig. 93-23: Reprinted with the permission of National Semiconductor Corp. Data Conversion/Acquisition Data-

book, 1980, p. 14-51.

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 Hz 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, cancellation 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 expandor, 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
 bargraph 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 oper-
 ated, 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 recov-
 ering, 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
 bucking 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
 bull 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
 reciever, 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 disconnector, 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
 commander, hi-fi, 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 10uV 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
 - 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
 - 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-446
 - 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

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

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

- 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®
 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 theremini, 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 two's 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
 3½ 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, Vpp 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-fi, 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
 fifth-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 generator, III-231
 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 beeper, 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
 preamplifier, 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 amplifier 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, programmable, III-226
 pulse, 2-ohm, III-231
 quad op amp, four simultaneous synchronized waveform, II-259
 ramp, variable reset level, II-267
 sawtooth and pulse, III-241
 signal, two-function, III-234
 sine/cosine (0.1-10 kHz), II-260
 single supply, II-273
 sine-wave/square-wave oscillator,
 tunable, III-232
 single-control, III-238
 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 generator)
 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
handalkies, 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 (*con't.*)

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 cancellation, II-328

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

photodiode 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
 pulsar, 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 disconnector, 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 hone 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
 subtracter, 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, programmed 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
 microvolt comparator
 dual limit, III-89
 hysteresis-including, III-88
 microvolt 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 cancellation 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-acutated 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
- N**
 N-phase motor drive, III-382
 NAB preamps
 record, III-673
 two-pole, III-673
- NAB tape playback pre-amp, III-38
 nano ammeter, I-202
 narrow band FM demodulator, carrier detect in, II-159
 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
 × 10, I-37
 × 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 amperes 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
rf, 5W, II-542
switching, I-33
two meter 10 W, I-562
walkman amplifier, II-456
power booster, I-28, I-33
power control, burst, III-362
power disconnector, 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 pnp 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 multiplexed 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
 preampl, 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, II-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
 push 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 beeper, 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
 radial, 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
 ratiomeric, 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

 x-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

 precison 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 tempera-
 ture, 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-55
 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
 sniffer
 heat, electronic, III-627
- rf, II-210
 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, tele-
 phone, 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, II-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, II-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
 photocell 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 sys-
tems, 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 oscilla-
tor, 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 transconductor, 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 ouput, 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 fre-
 quency 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, photographi, 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 handitalkies, 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 performance 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
bangraph 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 sourcebook 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. Valey

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*

Valey 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

Subtotal \$ _____

Charge my VISA MasterCard American Express

Postage and Handling

Acct. No. _____ Exp. _____

(\$3.00 in U.S., \$5.00 outside U.S.) \$ _____

Signature: _____

Add applicable state and local

sales tax \$ _____

Name: _____

TOTAL \$ _____

Address: _____

TAB Books catalog free with purchase; otherwise send \$1.00 in check
or money order and receive \$1.00 credit on your next purchase.

City: _____

Orders outside U.S. must pay with international money order in U.S. dollars.

State: _____ Zip: _____

TAB Guarantee: If for any reason you are not satisfied with the book(s)
you order, simply return it (them) within 15 days and receive a full
refund.

BC