

3138 *Encyclopedia of*
**ELECTRONIC
CIRCUITS**

Volume 2

Rudolf F. Graf



CONTENTS

	Introduction	vii
1	Alarm and Security Circuits	1
2	Amplifiers	5
3	Analog-to-Digital Converters	23
4	Annunciators	32
5	Audio Mixers, Crossovers and Distribution Circuits	35
6	Audio Signal Amplifiers	41
7	Automotive Circuits	48
8	Battery Chargers and Zappers	64
9	Battery Monitors	74
10	Bridge Circuits	80
11	Burst Generators	86
12	Capacitance Meters	91
13	Circuit Protection Circuits	95
14	Clock Circuits	100
15	Comparators	103
16	Computer Circuits	113
17	Converters	123

18	Counters	133
19	Crystal Oscillators	140
20	Current Meters	152
21	Demodulators	158
22	Descramblers and Decoders	162
23	Detectors	171
24	Digital-to-Analog Converters	179
25	Dip Meters	182
26	Display Circuits	184
27	Drive Circuits	189
28	Electronic Locks	194
29	Emulator Circuits	198
30	Fence Chargers	201
31	Fiberoptics Circuits	204
32	Field Strength Meters	208
33	Filter Circuits	213
34	Flashers and Blinkers	225
35	Flow Detectors	240
36	Fluid and Moisture Detectors	243
37	Frequency Meters	249
38	Frequency Multiplier and Divider Circuits	251
39	Frequency-to-Voltage Converters	255
40	Function Generator Circuits	258
41	Games	275
42	Gas and Smoke Detectors	278
43	Hall Effect Circuits	282
44	Humidity Sensors	285
45	Infrared Circuits	288
46	Instrumentation Amplifiers	293
47	Integrator Circuits	297
48	Intercom Circuits	301
49	Lamp-Control Circuits	304
50	Laser Circuits	313
51	Light-Controlled Circuits	318
52	Logic Amplifiers	332
53	LVDT Circuits	336
54	Measuring and Test Circuits	340
55	Medical Electronics Circuits	347
56	Metal Detectors	350
57	Metronomes	353

58	Miscellaneous Treasures	356
59	Modulator Circuits	368
60	Motor Control Circuits	373
61	Multiplier Circuits	391
62	Noise Reduction Circuits	393
63	Notch Filters	397
64	Operational Amplifier Circuits	404
65	Optically-Coupled Circuits	407
66	Oscillators	420
67	Oscilloscope Circuits	430
68	Peak Detector Circuits	434
69	Phase Sequence Circuits	437
70	Photography-Related Circuits	443
71	Power Amplifiers	450
72	Power Supply Circuits	460
73	Power Supply Circuits (High Voltage)	487
74	Power Supply Monitors	491
75	Probes	498
76	Proximity Sensors	505
77	Pulse Generators	508
78	Radiation Detectors	512
79	Radar Detectors	518
80	Ramp Generators	521
81	Receivers	524
82	Rectifier Circuits	527
83	Relay Circuits	529
84	Resistance/Continuity Meters	533
85	RF Amplifiers	537
86	RF Oscillators	550
87	Sample-and-Hold Circuits	552
88	Sine-Wave Oscillators	560
89	Sirens, Warblers and Wailers	571
90	Sound (Audio) Operated Circuits	580
91	Sound Effect Circuits	585
92	Square-Wave Generators	594
93	Staircase Generator Circuits	601
94	Stereo Balance Circuits	603
95	Strobe Circuits	606
96	Switch Circuits	611
97	Tape Recorder Circuits	613

98	Telephone-Related Circuits	616
99	Temperature Controls	636
100	Temperature Sensors	645
101	Temperature-to-Frequency Converters	651
102	Theremins	654
103	Thermometer Circuits	657
104	Tilt Meters	663
105	Time-Delay Circuits	667
106	Timers	671
107	Tone Control Circuits	682
108	Touch-Switch Circuits	690
	Sources	694
	Index	713

Introduction

Encyclopedia of Electronic Circuits—Volume 2, a companion to Volume 1 published in 1985, contains well over 1400 not-previously covered circuits organized into 108 chapters. For each reference, circuits are listed at the beginning of each chapter. The extensive index further enhances the usefulness of this new work. The browser, as well as the serious researcher looking for a very specific circuit, will be richly rewarded by the context of this volume. A brief explanatory text accompanies almost every entry. The original source for each item is also given so that the reader requiring additional data will know where to find it.

I am most grateful to William Sheets for his many and varied contributions to this book, and to Mrs. Stella Dillon for her fine work at the word processor. These friends and associates of long standing have my sincere thanks for contributing to the successful completion of this book.

1

Alarm and Security Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Auto Burglar Alarm
Multiple Alarm Circuit
Differential-Voltage or Current Alarm
Trouble Tone Alert
Photoelectric Alarm System
Alarm Circuit

AUTO BURGLAR ALARM

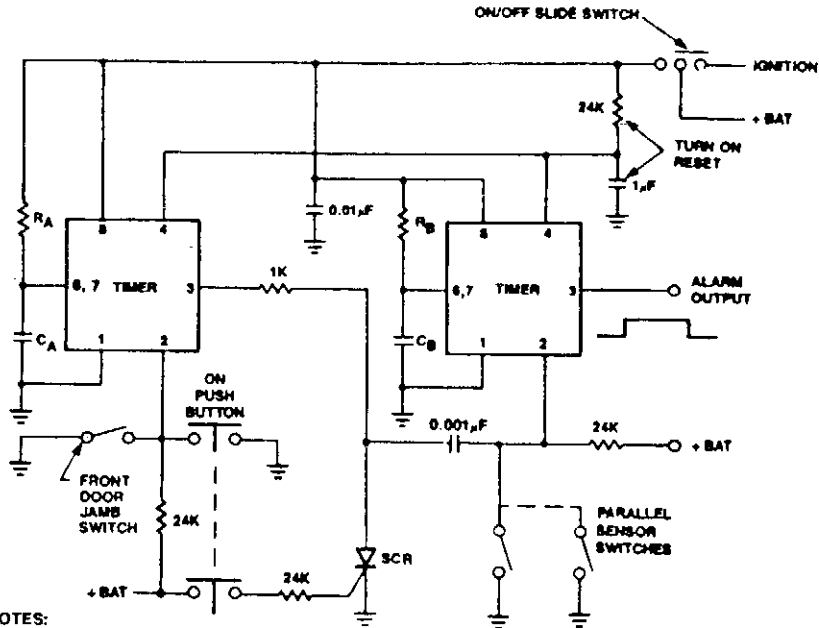


Fig. 1-1

SIGNETICS

NOTES:
Timer Signetics NE555
All resistor values in ohms

Circuit Notes

Timer A produces a safeguard delay, allowing the driver to disarm the alarm and eliminating a vulnerable outside control switch. The SCR prevents timer A from triggering timer B, unless timer B is triggered by strategically-located sensor switches.

MULTIPLE ALARM CIRCUIT

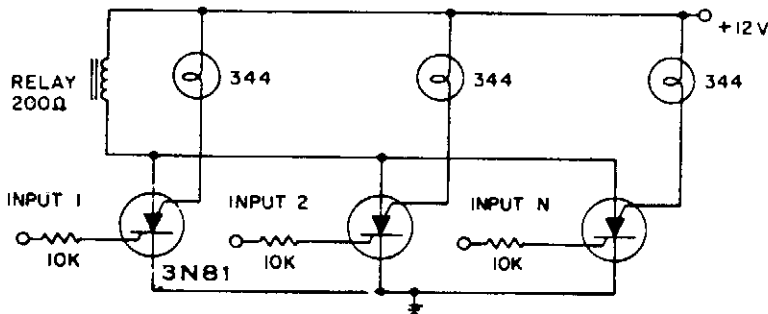


Fig. 1-2

GE

Circuit Notes

Any of several inputs pulls in the common alarm relay with lamps giving visual indication of triggering input. Low resistance lamps decrease input sensitivity.

DIFFERENTIAL VOLTAGE OR CURRENT ALARM

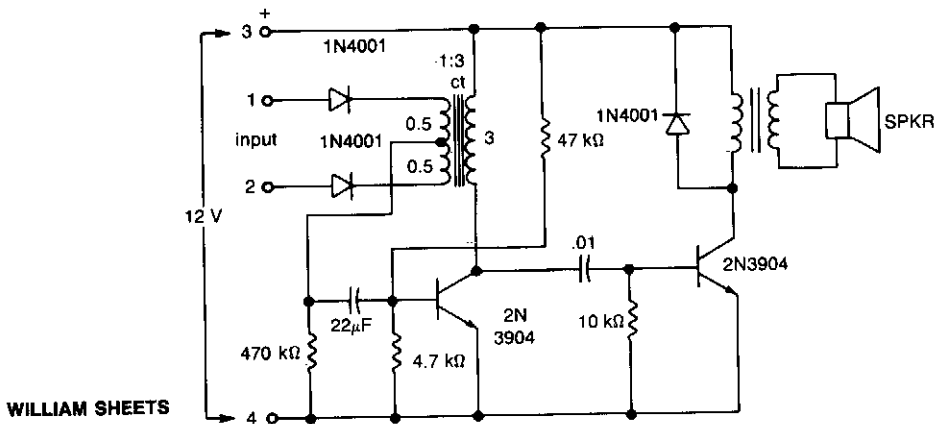


Fig. 1-3

Circuit Notes

The input may be dc or low frequency ac. The output is a distinctive series of audio beeps or a continuous tone, and occurs only when a selected polarity unbalance is present at the input.

TROUBLE TONE ALERT

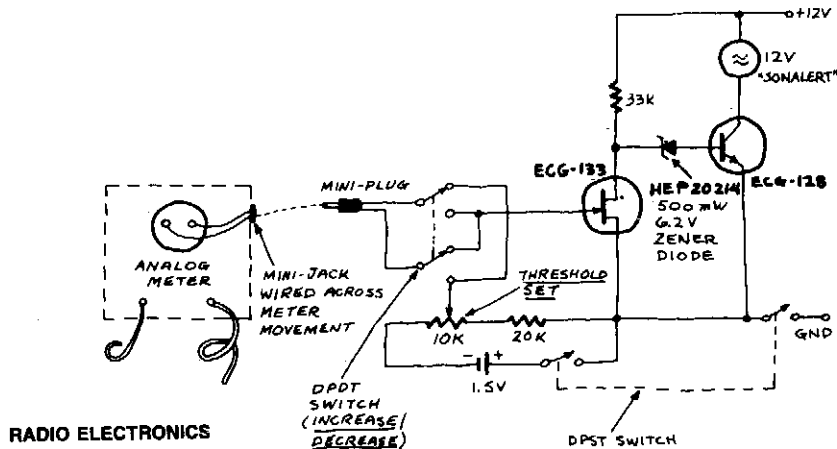


Fig. 1-4

Circuit Notes

The Trouble Tone Alert is intended for use with analog meters—just wire a “mini” earphone jack directly across the meter movement, plug it in, and you’re all set. This device reacts to the meter-movement driving voltage. It will respond to a change in ac or dc voltage, current, or in resistance. The circuit will respond to an increase or decrease selected by the DPDT switch and is adjusted with the threshold control until the tone from the Sonalert just disappears (with the meter in the circuit being tested, of course).

PHOTOELECTRIC ALARM SYSTEM

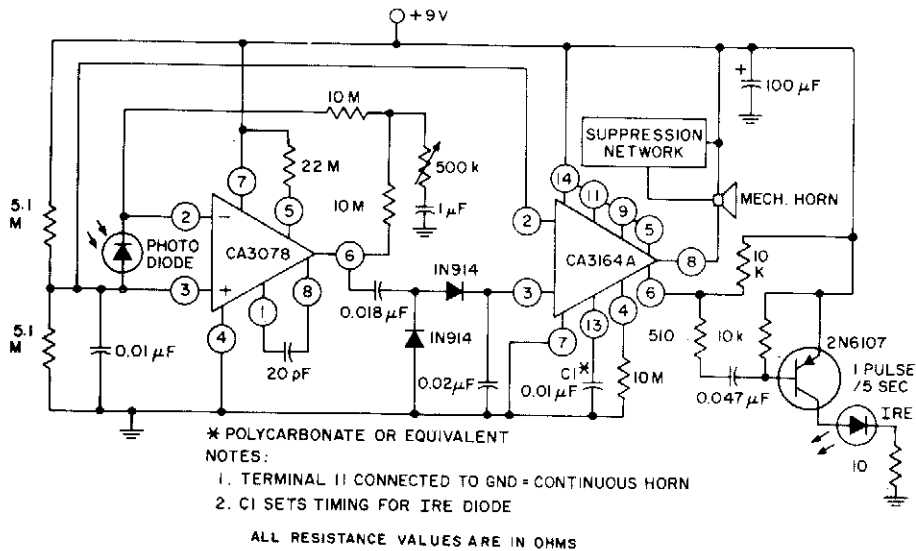


Fig. 1-5

GE/RCA

Circuit Notes

The CA3164A BiMOS detector alarm system and the CA3078 micropower op amp with a photodiode are used as an automatic switch for turning on a night light or sounding a mechanical horn.

ALARM CIRCUIT

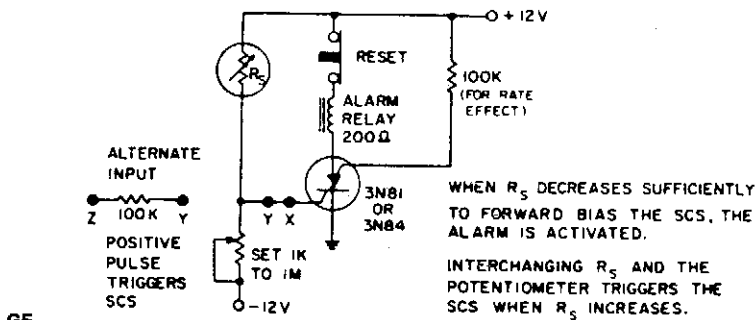


Fig. 1-6

GE

Circuit Notes

Temperature, light, or radiation sensitive resistors up to 1 megohm readily trigger the alarm when they drop below the value of the preset potentiometer. Alternately, 0.75 V at the input to the 100 kΩ triggers the alarm. Connecting SCS between ground and -12 V permits triggering on negative input to G_A .

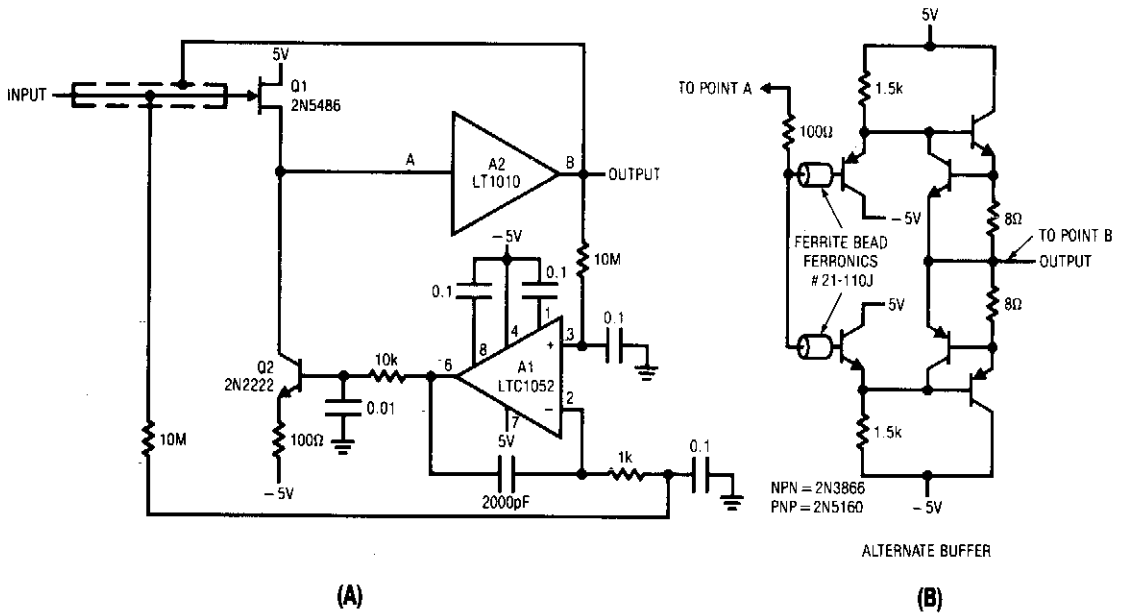
2

Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- | | |
|-------------------------------------------------------------------|---------------------------------------------|
| Stable Unity Gain Buffer with Good Speed and High Input Impedance | Hi-Fi Comander |
| Chopper Stabilized Amplifier | Two-Wire to Four-Wire Audio Converter |
| Ultra-Low-Leakage Preamplifier | Thermocouple Amplifier |
| FET Input Amplifier | Low-Distortion Audio Limiter |
| Ultra-High Z_{in} ac Unity Gain Amplifier | Speech Compressor |
| Logarithmic Amplifier | Speaker Overload Protector |
| Composite Amplifier | Audio Automatic Gain Control |
| Stereo Amplifier with Gain Control | Voltage Controlled Attenuator |
| Precision-Weighted Resistor Programmable-Gain Amplifier | High-Input-Impedance Differential Amplifier |
| Power GaAsFET Amplifier with Single Supply | Audio Q-Multiplier |
| Linear Amplifiers from CMOS Inverters | Automatic Level Control |
| Current-Collector Head-Amplifier | Pulse-Width Proportional-Controller Circuit |
| | Op Amp Clamping |

STABLE UNITY GAIN BUFFER WITH GOOD SPEED AND HIGH INPUT IMPEDANCE



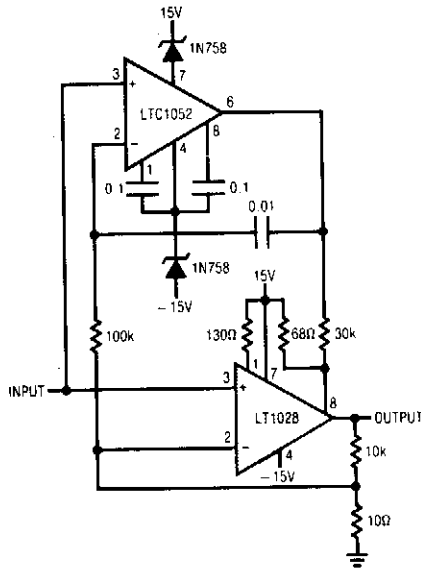
LINEAR TECHNOLOGY CORPORATION

Fig. 2-1

Circuit Notes

Q1 and Q2 constitute a simple, high speed FET input buffer. Q1 functions as a source follower, with the Q2 current source load setting the drain-source channel current. Normally, this open loop configuration would be quite drifty because there is no dc feedback. The LTC1052 contributes this function to stabilize the circuit by comparing the filtered circuit output to a similarly filtered version of the input signal. The amplified difference between these signals is used to set Q2's bias and hence Q1's channel current. This forces Q1's V_{GS} to whatever voltage is required to match the circuit's input and output potentials. The 2000 pF capacitor at A1 provides stable loop compensation. The RC network in A1's output prevents it from seeing high speed edges coupled through Q2's collector-base junction. A2's output is also fed back to the shield around Q1's gate lead, bootstrapping the circuit's effective input capacitance down to less than 1 pF. For very fast requirements, the alternate discrete component buffer shown will be useful. Although its output is current limited at 75 mA, the GHz range transistors employed provide exceptionally wide bandwidth, fast slewing and very little delay.

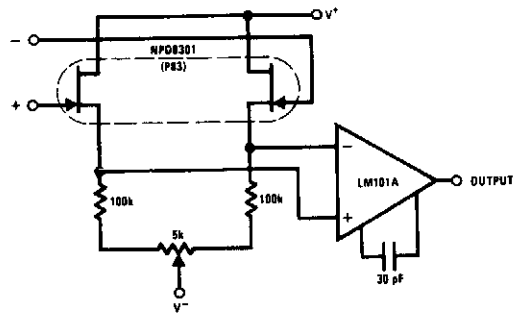
CHOPPER STABILIZED AMPLIFIER



LINEAR TECHNOLOGY CORP.

Fig. 2-2

FET INPUT AMPLIFIER



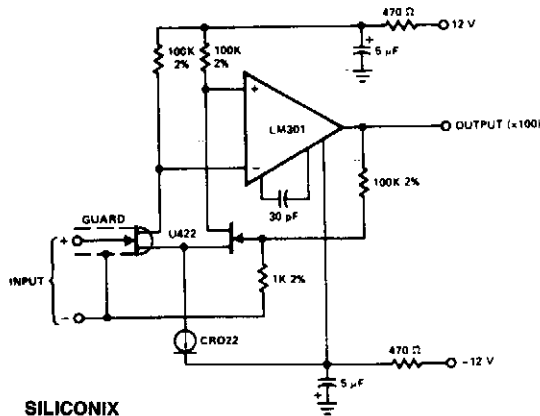
NATIONAL SEMICONDUCTOR CORP.

Circuit Notes

The NPD8301 monolithic-dual provides an ideal low offset, low drift buffer function for the LM101A op amp. The excellent matching characteristics of the NPD8301 track well over its bias current range, thus improving common-mode rejection.

Fig. 2-4

ULTRA-LOW-LEAKAGE PREAMPLIFIER



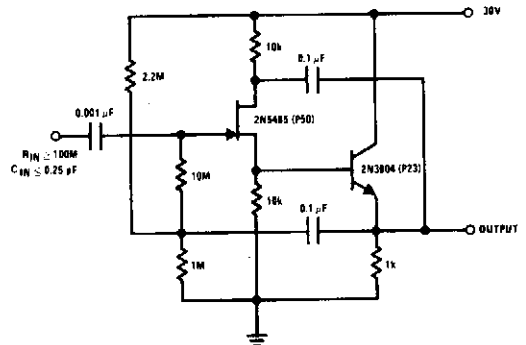
SILICONIX

Circuit Notes

The circuit has an input leakage of only 2 pA typical at 75°C and would be usable with 1 M ohm input resistance.

Fig. 2-3

ULTRA-HIGH Z_{in} AC UNITY GAIN AMPLIFIER



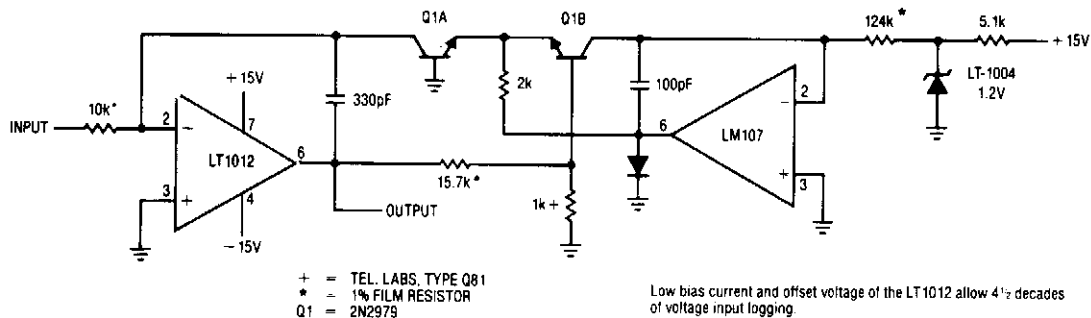
NATIONAL SEMICONDUCTOR CORP.

Circuit Notes

Nothing is left to chance in reducing input capacitance. The 2N5485, which has low capacitance in the first place, is operated as a source follower with bootstrapped gate bias resistor and drain.

Fig. 2-5

LOGARITHMIC AMPLIFIER



LINEAR TECHNOLOGY CORP.

Fig. 2-6

COMPOSITE AMPLIFIER

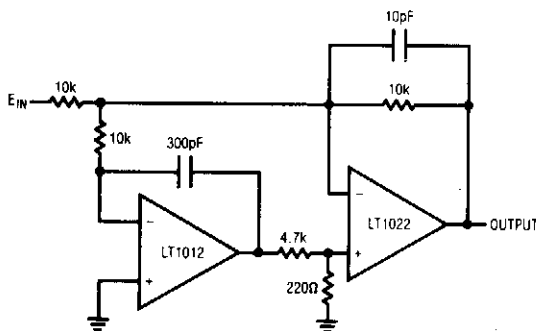


Fig. 2-7

LINEAR TECHNOLOGY CORPORATION

Circuit Notes

The circuit is made up of an LT1012 low drift device, and an LT1022 high speed amplifier. The overall circuit is a unity gain inverter, with the summing node located at the junction of three 10-k resistors. The LT1012 monitors this summing node, compares it to ground, and drives the LT1022's positive input, completing a dc stabilizing loop around the LT1022. The 10 k - 300 pF time constant at the LT1012 limits its response to low frequency signals. The LT1022 handles high frequency inputs while the LT1012 stabilizes the dc operating point. The 4.7 k - 220 ohm divider at the LT1022 prevents excessive input overdrive during start-up. This circuit combines the LT1012's 35 μ V offset and 1.5 V/ $^{\circ}$ C drift with the LT1022's 23 V/ μ s slew rate and 300 kHz full power bandwidth. Bias current, dominated by the LT1012, is about 100 pA.

STEREO AMPLIFIER WITH GAIN CONTROL

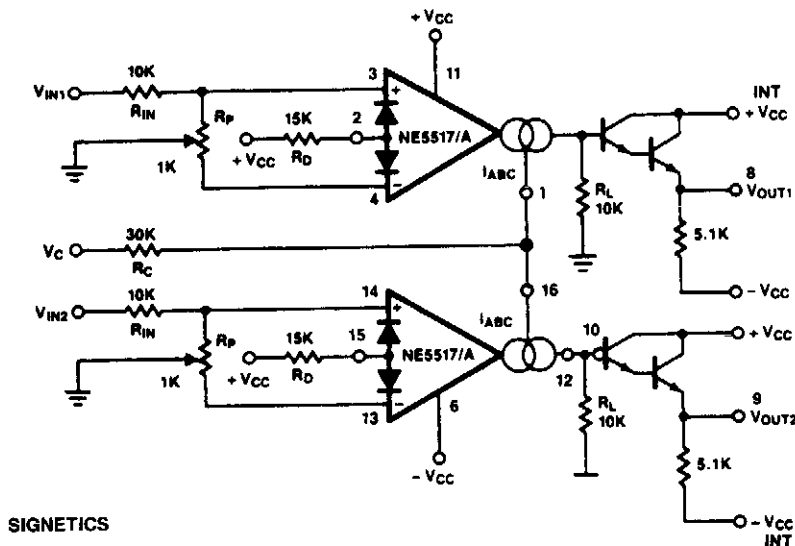


Fig. 2-8

Circuit Notes

Excellent tracking of typical 0.3 dB is easy to achieve. With the potentiometer, R_p , the offset can be adjusted. For ac-coupled amplifiers, the potentiometer may be replaced with two 5.1 k ohm resistors.

PRECISION-WEIGHTED RESISTOR PROGRAMMABLE-GAIN AMPLIFIER

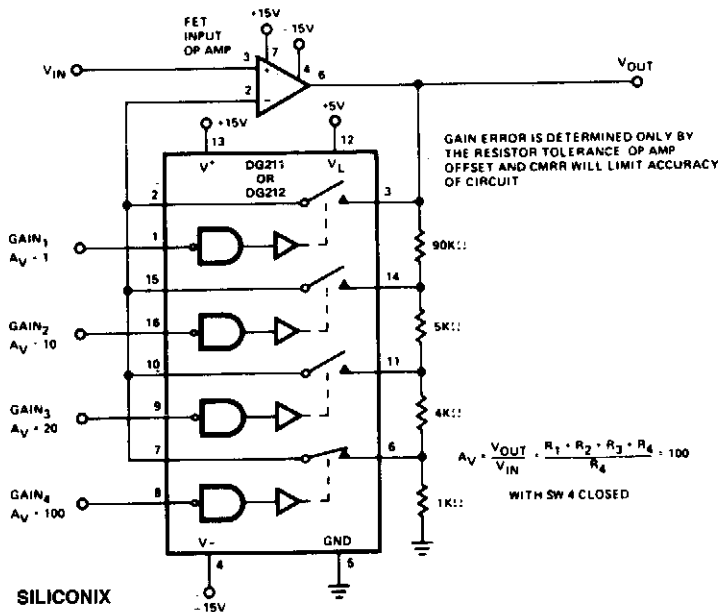
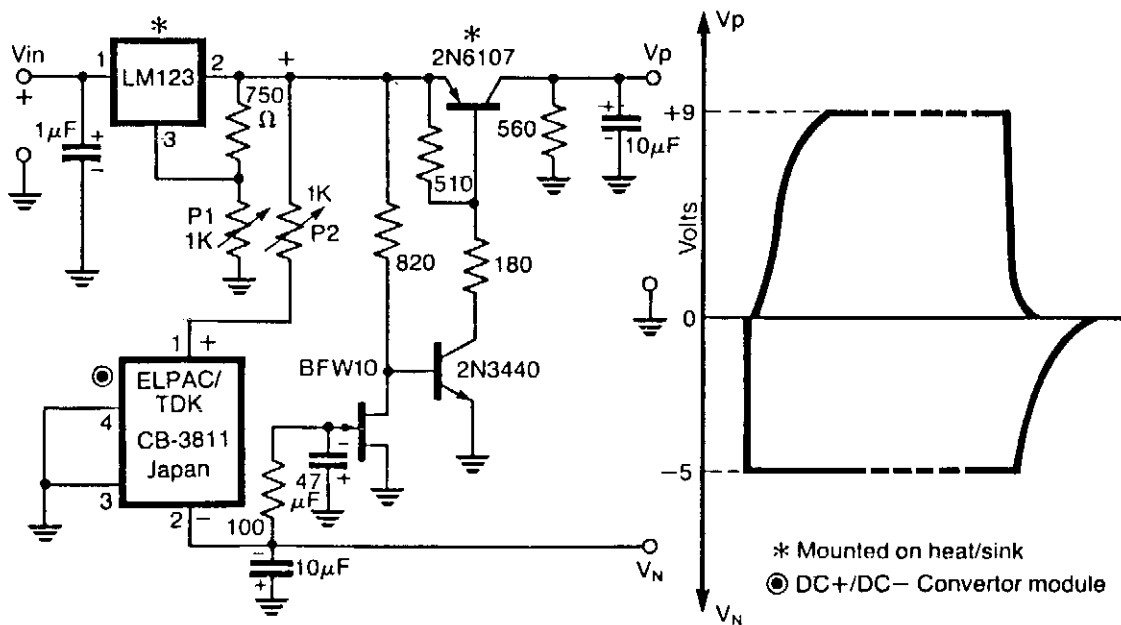


Fig. 2-9

POWER GaAsFET AMPLIFIER WITH SINGLE SUPPLY



ELECTRIC ENGINEERING

Fig. 2-10

Circuit Notes

The dual regulator circuit operates from a positive supply, which when switched ON powers the gate first, and when switched OFF shuts off the drain first as shown in the figure. This circuit incorporates the LM123, a three terminal positive regulator and a dc+ to dc- converter, the outputs of which power the drains and gates of the power GaAsFETs in a power amplifier relay. The output of the three terminal regulator drives a dc+ to dc- converter whose output biases an N-channel JFET suitably so as to pull the base of the series pass transistor 2N6107 to a level to turn it on. The circuit will turn off the drain supply whenever the negative potential on the Gate fails.

LINEAR AMPLIFIERS FROM CMOS INVERTERS

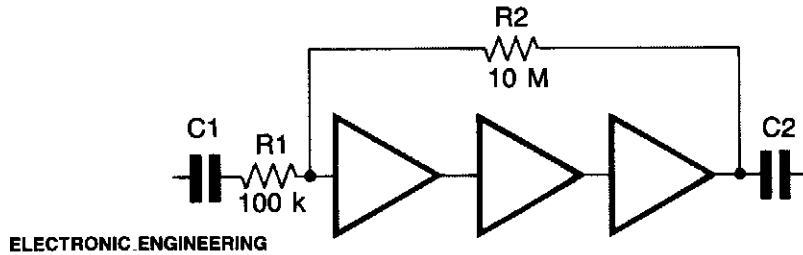


Fig. 2-11

Circuit Notes

CMOS inverters can be used as linear amplifiers if negative feedback is applied. Best linearity is obtained with feedback applied around three inverters which gives almost perfect linearity up to an output swing of 5 V p-p with a 10 V supply rail. The gain is set by the ratio of R1 and R2 and the values shown are typical for a gain of 100. The high frequency response with the values shown is almost flat to 20 kHz. The frequency response is determined by C1 and C2. This circuit is not suitable for low level signals because the signal-to-noise ratio is only approx. 50 dB with 5 V p-p output with the values shown.

CURRENT-COLLECTOR HEAD-AMPLIFIER

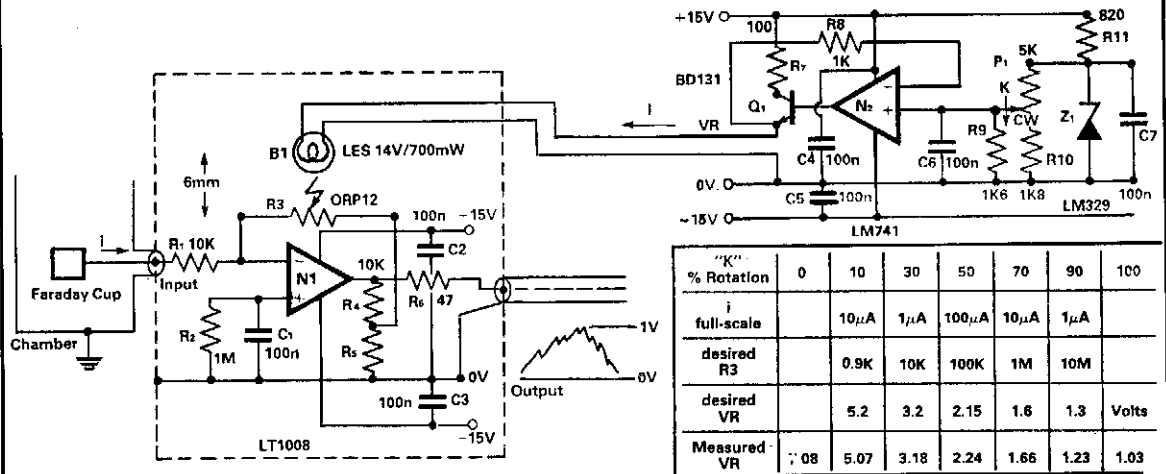


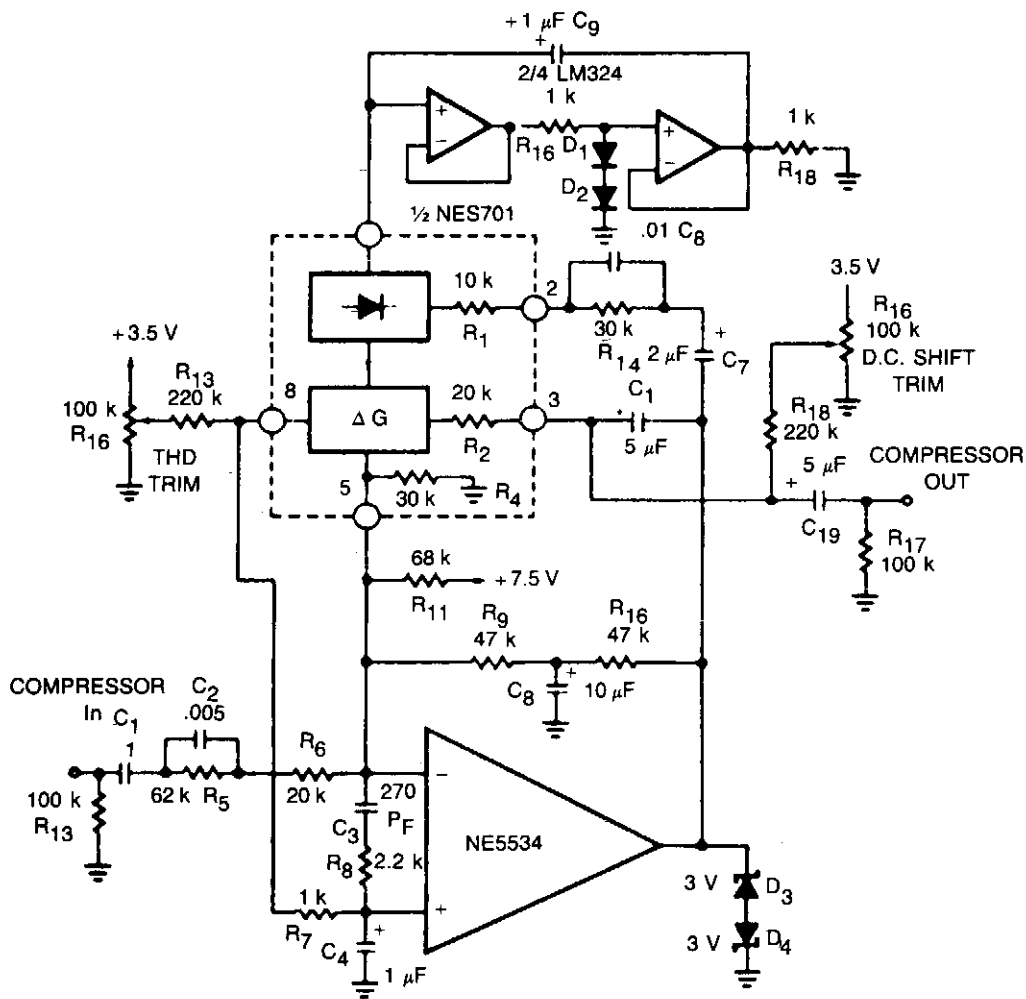
Fig. 2-12

Circuit Notes

To amplify small current signals such as from an electron-collector inside a vacuum chamber, it is convenient for reasons of noise and bandwidth to have a "head-amplifier" attached to the chamber. The op-amp N₁ is a precision bipolar device with extremely low bias current and offset voltage (1) as well as low noise, which allows the 100:1 feedback attenuator to be employed. The resistance of R₃ can be varied from above 10 M to below 1 k, and so the nominal 0 to 1 V-peak output signal corresponds to input current ranges of 1 nA to 10 μA.

"K" % Rotation	0	10	30	50	70	90	100
i full-scale		10 μA	1 μA	100 μA	10 μA	1 μA	
desired R ₃		0.9K	10K	100K	1M	10M	
desired VR		5.2	3.2	2.15	1.6	1.3	Volts
Measured VR	0.08	5.07	3.18	2.24	1.66	1.23	1.03

HI-FI COMPANDER



SIGNETICS

HI-FI Compressor With Pre-emphasis

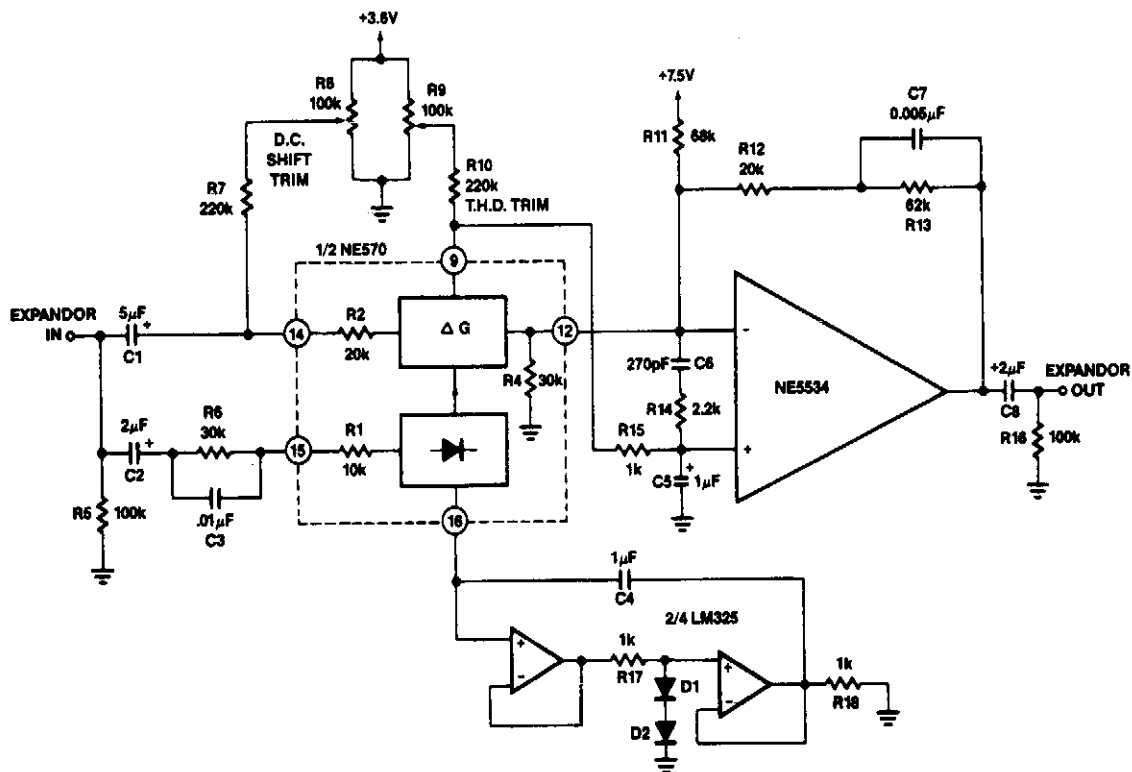
TC0721S

Fig. 2-13(A)

Circuit Notes

This circuit for a high fidelity compressor uses an external op amp, and has a high gain and wide bandwidth. An input compensation network is required for stability. The rectifier

capacitor (C_9) is not grounded, but is tied to the output of an op amp circuit. When a compressor is operating at high gain, (small input signal), and is suddenly hit with a signal, it will overload until



TC072505

Hi-Fi Expander With De-emphasis

Fig. 2-13(B)

it can reduce its gain. The time it takes for the compressor to recover from overload is determined by the rectifier capacitor C_9 . The expander to complement the compressor is shown in Fig. 2-13B. Here an external op amp is used for high slew rate. Both the compressor

and expander have unity gain levels of 0 dB. Trim networks are shown for distortion (THD) and dc shift. The distortion trim should be done first, with an input of 0 dB at 10 kHz. The dc shift should be adjusted for minimum envelope bounce with tone bursts.

TWO-WIRE TO FOUR-WIRE AUDIO CONVERTER

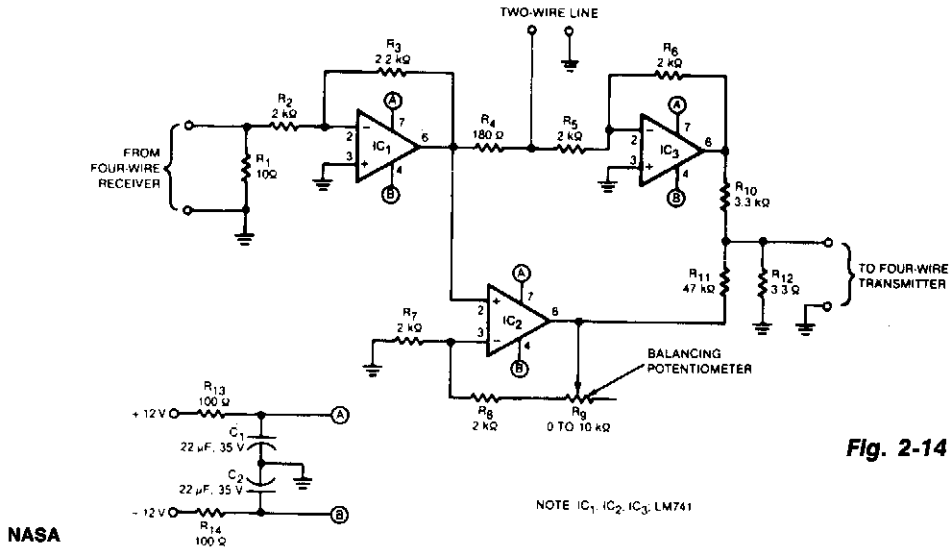


Fig. 2-14

Circuit Notes

This converter circuit maintains 40 dB of isolation between the input and output halves of a four-wire line while permitting a two-wire line to be connected. A balancing potentiometer, R_g , adjusts the gain of IC₂ to null the feed-through from the input to the output. The adjustment is done on the workbench just after assembly by inserting a 1 kHz tone into the four-wire input and setting R_g for minimum output signal. An 82 ohm dummy-load resistor is placed across the two wire terminals.

THERMOCOUPLE AMPLIFIER

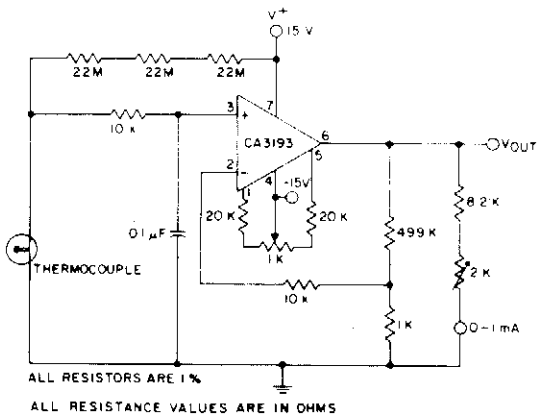
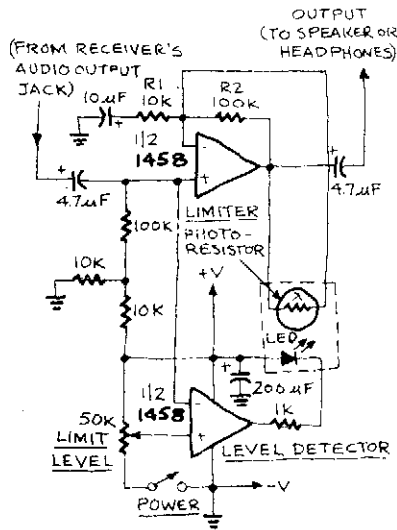


Fig. 2-15

Circuit Notes

The circuit uses a CA3193 BiMOS precision op amp to amplify the generated signal 500 times. Three 22-megohm resistors will provide full-scale output if the thermocouple opens.

LOW-DISTORTION AUDIO LIMITER



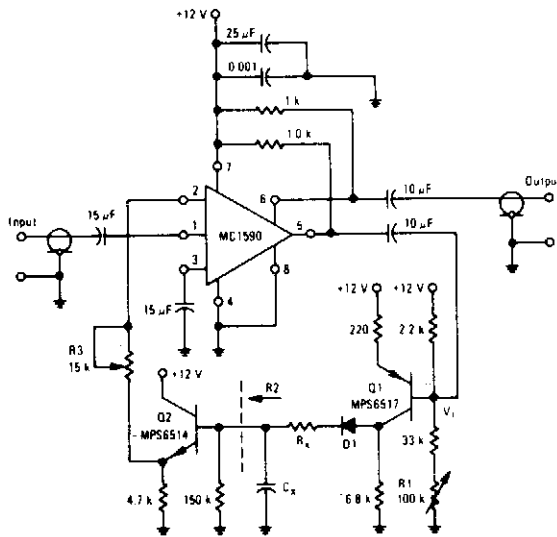
Circuit Notes

The level at which the audio limiter comes into action can be set with the LIMIT LEVEL trimmer potentiometer. When that level is exceeded, the output from the LIMITER-DETECTOR half of the op-amp (used as a comparator) turns the LED which causes the resistance of the photoresistor to decrease rapidly. That in turn causes the gain of the LIMITER half of the op-amp to decrease. When the signal drops below the desired limiting level, the LED turns off, the resistance of the photoresistor increases, and the gain of the LIMITER op-amp returns to its normal level—that set by the combination of resistors R1 and R2. A dual-polarity power supply (± 12 volts is desirable) is needed for the op-amp.

RADIO-ELECTRONICS

Fig. 2-16

SPEECH COMPRESSOR



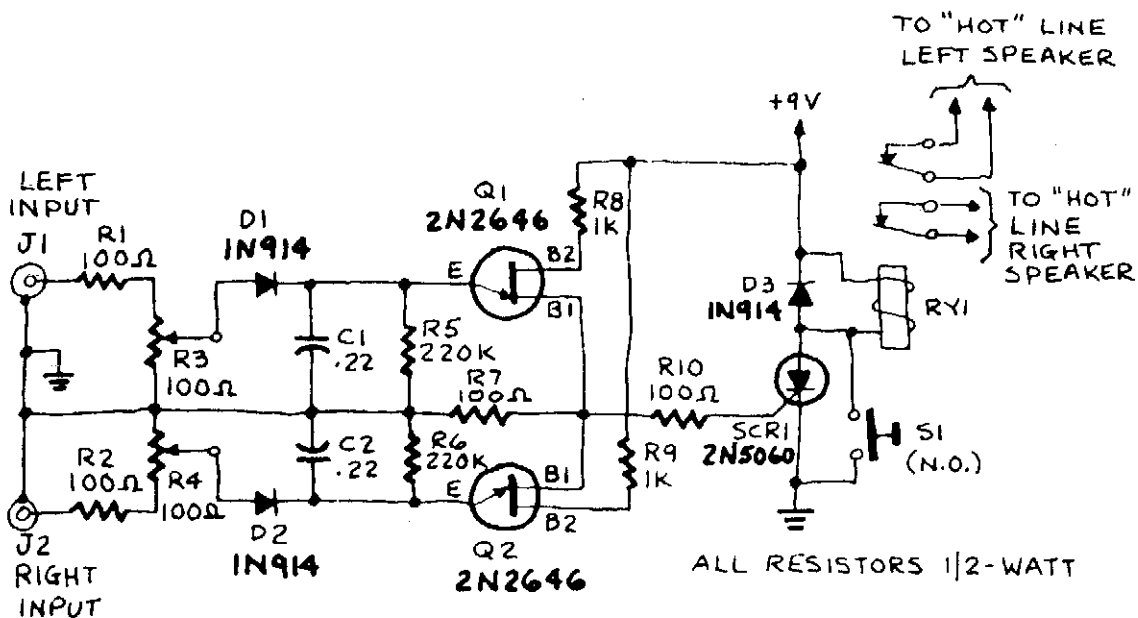
MOTOROLA INC.

Fig. 2-17

Circuit Notes

The amplifier drives the base of a pnp MPS6517 operating common-emitter with a voltage gain of approximately 20. The control R1 varies the quiescent Q point of this transistor so that varying amounts of signal exceed the level V_r . Diode D1 rectifies the positive peaks of Q1's output only when these peaks are greater than $V_r \approx 7.0$ volts. The resulting output is filtered C_x . R_x controls the charging time constant or attack time. C_x is involved in both charge and discharge. R2 (150 K, input resistance of the emitter-follower Q2) controls the decay time. Making the decay long and attack short is accomplished by making R_x small and R2 large. (A Darlington emitter-follower may be needed if extremely slow decay times are required.) The emitter-follower Q2 drives the AGC Pin 2 of the MC1590 and reduces the gain. R3 controls the slope of signal compression.

SPEAKER OVERLOAD PROTECTOR



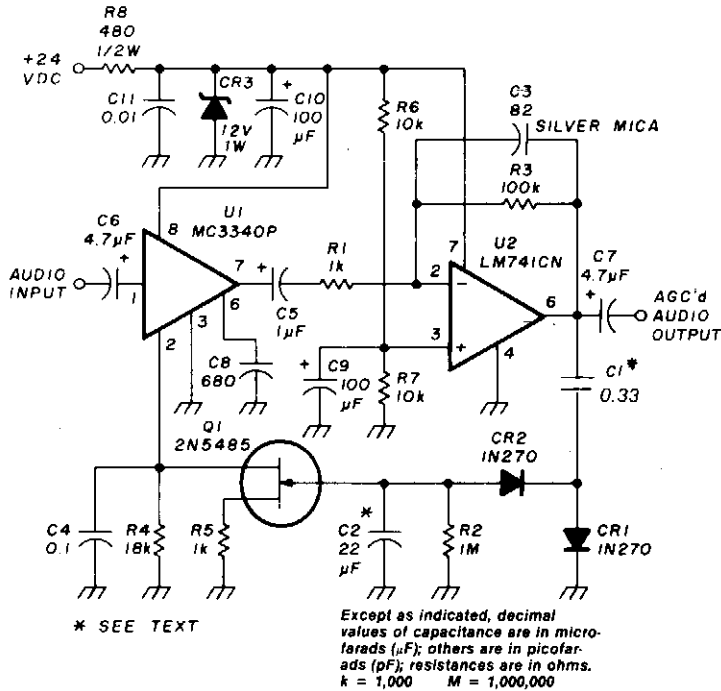
RADIO ELECTRONICS

Fig. 2-18

Circuit Notes

The input to the circuit is taken from the amplifier's speaker-output terminals or jacks. If the right-channel signal is sufficiently large to charge C1 to a potential that is greater than the breakdown voltage of Q1's emitter, a voltage pulse will appear across R7. Similarly, if the left-channel signal is sufficiently large to charge C2 to a potential that is greater than the breakdown voltage of Q2's emitter, a pulse will appear across R7. The pulse across R7 triggers SCR1, a sensitive gate SCR (I_{GT} less than 15 mA where I_{GT} is the gate trigger-current), that latches in a conducting state and energizes RY1. The action of the relay will interrupt both speaker circuits, and the resulting silence should alert you to the problem. Cut back the volume on your amplifier, then press and release S1 to reset the circuit and restore normal operation. The circuit can be adjusted to trip at any level from 15 to 150 watts RMS. To calibrate, deliberately feed an excessive signal to the right input of the speaker protector and adjust R3 until RY1 energizes. Do the same with the left channel, this time adjusting R4. The circuit is now calibrated and ready for use.

AUDIO AUTOMATIC GAIN CONTROL



HAM RADIO

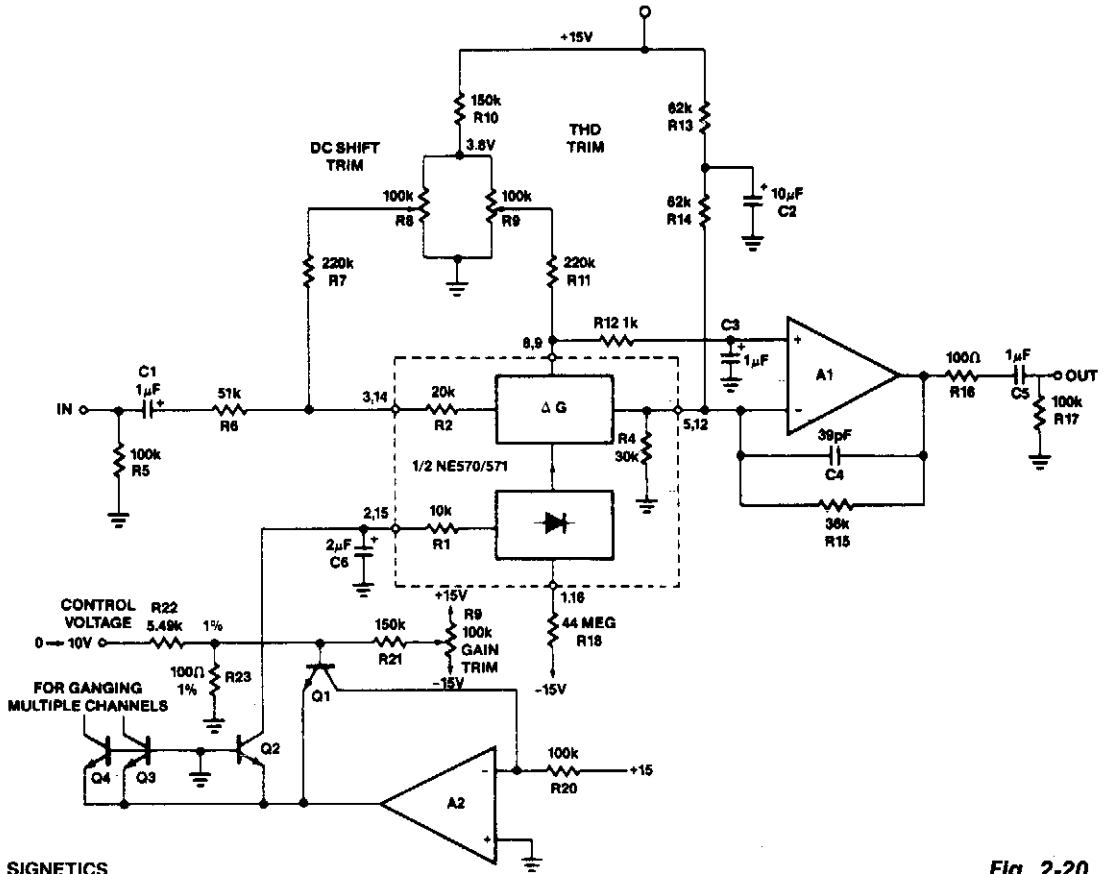
Fig. 2-19

Circuit Notes

An audio signal applied to U1 is passed through to the 741 operational amplifier, U2. After being amplified, the output signal of U2 is sampled and applied to a negative voltage doubler/rectifier circuit composed of diodes CR1 and CR2 along with capacitor C1. The resulting negative voltage is used as a control voltage that is applied to the gate of the 2N5485 JFET Q1. Capacitor C2 and resistor R2 form a smoothing filter for the rectified audio control voltage.

The JFET is connected from pin 2 of the MC3340P to ground through a 1 kilohm resistor. As the voltage applied to the gate of the JFET becomes more negative in magnitude, the channel resistance of the JFET increases causing the JFET to operate as a voltage controlled resistor. The MC3340P audio attenuator is the heart of the AGC. It is capable of 13 dB gain or nearly -80 dB of attenuation depending on the external resistance placed between pin 2 and ground. An increase of resistance decreases the gain achieved through the MC3340P. The circuit gain is not entirely a linear function of the external resistance but approximates such behavior over a good portion of the gain/attenuation range. An input signal applied to the AGC input will cause the gate voltage of the JFET to become proportionally negative. As a result the JFET increases the resistance from pin 2 to ground of the MC3340P causing a reduction in gain. In this way the AGC output is held at a nearly constant level.

VOLTAGE-CONTROLLED ATTENUATOR



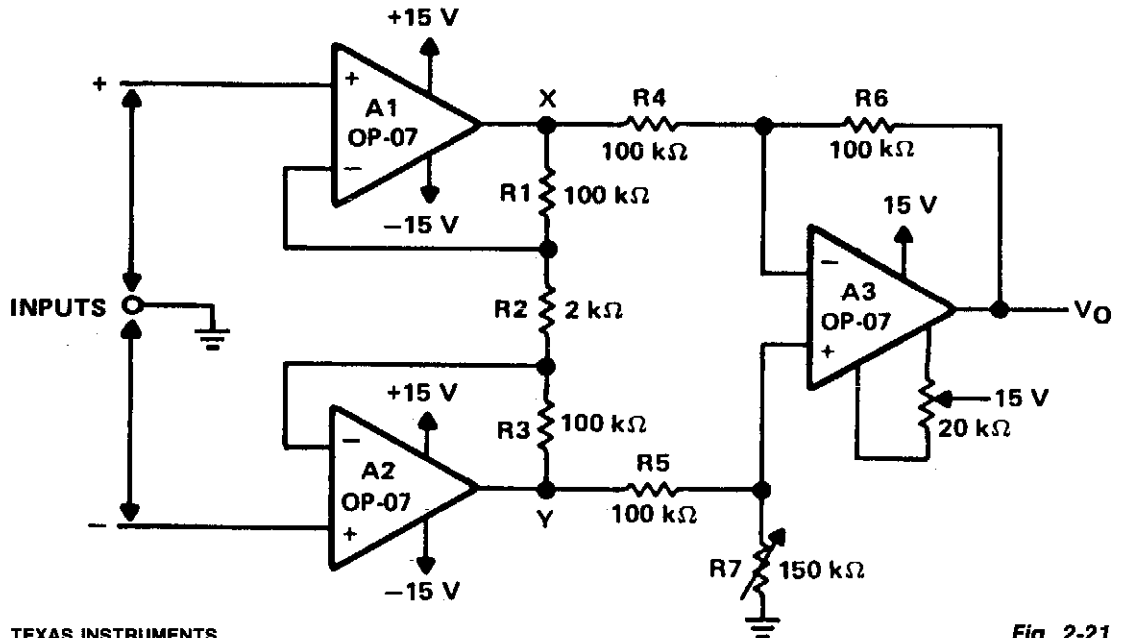
SIGNETICS

Fig. 2-20.

Circuit Notes

Op amp A₂ and transistors Q₁ and Q₂ form the exponential converter generating an exponential gain control current, which is fed into the rectifier. A reference current of 150 μ A, (15 V and R₂₀ = 100 k), is attenuated a factor of two (6 dB) for every volt increase in the control voltage. Capacitor C₆ slows down gain changes to a 20 ms time constant (C₆ \times R₁) so that an abrupt change in the control voltage will produce a smooth sounding gain change. R₁₈ ensures that for large control voltages the circuit will go to full attenuation. The rectifier bias current would normally limit the gain reduction to about 70 dB. R₁₆ draws excess current out of the rectifier. After approximately 50 dB of attenuation at a -6 dB/V slope, the slope steepens and attenuation becomes much more rapid until the circuit totally shuts off at about 9 V of control voltage. A₁ should be a low-noise high slew rate op amp. R₁₃ and R₁₄ establish approximately a 0 V bias at A₁'s output.

HIGH-INPUT-IMPEDANCE DIFFERENTIAL AMPLIFIER



TEXAS INSTRUMENTS

Fig. 2-21

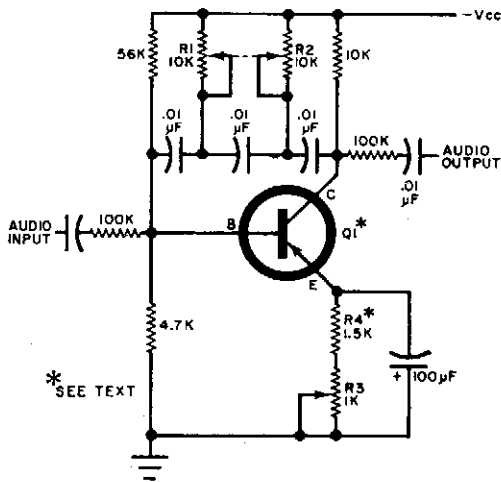
Circuit Notes

Operational amplifiers A1 and A2 are connected in a non-inverting configuration with their outputs driving amplifier A3. Operational amplifier A3 could be called a subtractor circuit which converts the differential signal floating between points X and Y into a single-ended output voltage. Although not mandatory, amplifier A3 is usually operated at unity gain and R4, R5, R6, and R7 are all equal.

The common-mode-rejection of amplifier A3 is a function of how closely the ratio R4:R5 matches the ratio R6:R7. For example, when using resistors with 0.1% tolerance, common-mode rejection is greater than 60 dB. Additional improvement can be attained by using a potentiometer (slightly higher in value than R6) for R7. The potentiometer can be adjusted for the best common-mode rejection. Input amplifiers A1 and A2 will have some differential gain but the common-mode input voltages will experience only unity gain. These voltages will not appear as differential signals at the input of amplifier A3 because, when they appear at equal levels on both ends of resistor R2, they are effectively canceled.

This type of low-level differential amplifier finds widespread use in signal processing. It is also useful for dc and low-frequency signals commonly received from a transducer or thermocouple output, which are amplified and transmitted in a single-ended mode. The amplifier is powered by ± 15 V supplies. It is only necessary to null the input offset voltage of the output amplifier A3.

AUDIO Q-MULTIPLIER



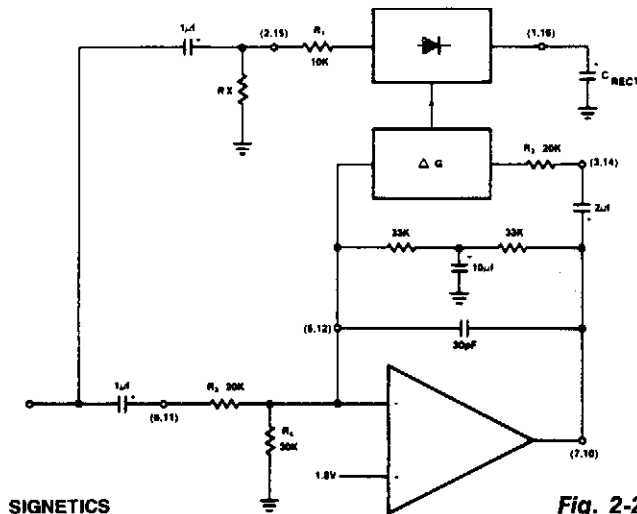
POPULAR ELECTRONICS

Fig. 2-22

Circuit Notes

This circuit is for selective tuning between two closely spaced audio tones. The selective frequency is dependent on the value of capacitors and resistors in the feedback circuit between the collector and base of Q1. With the values shown, the frequency can be "tuned" a hundred cycles or so around 650 Hz. R1 and R2 must be ganged. Emitter potentiometer R3 determines the sharpness of response curve. Any transistor having a beta greater than 50 can be used. Select a value for R4 so that the circuit will not oscillate when R3 is set for minimum bandwidth (sharpest tuning).

AUTOMATIC LEVEL CONTROL



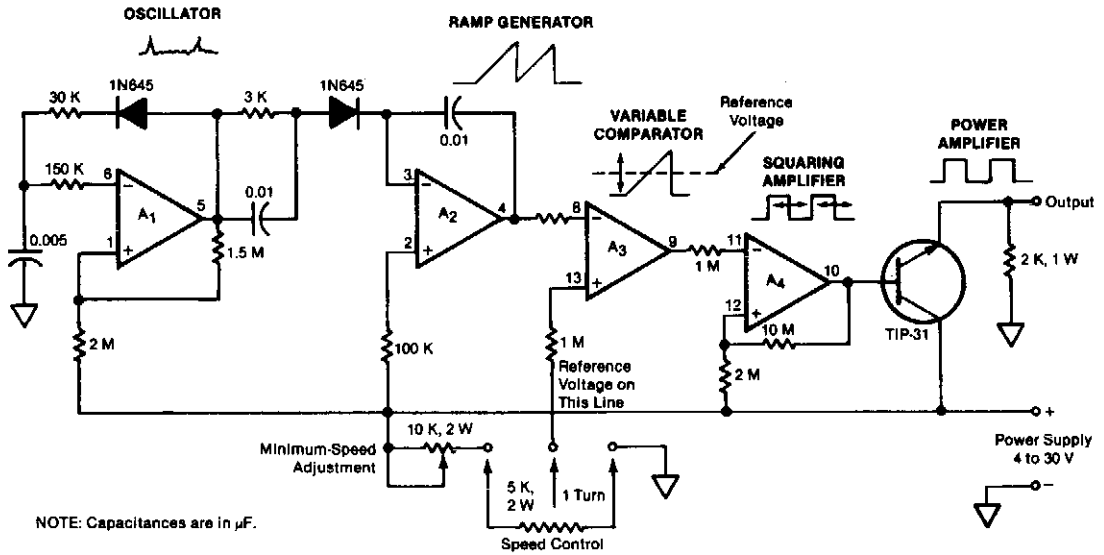
SIGNETICS

Fig. 2-23

Circuit Notes

The NE570 can be used to make a very high performance ALC compressor, except that the rectifier input is tied to the input. This makes gain inversely proportional to input level so that a 20 dB drop in input level will produce a 20 dB increase in gain. The output will remain fixed at a constant level. As shown, the circuit will maintain an output level of ± 1 dB for an input range of +14 to -43 dB at 1 kHz. Additional external components will allow the output level to be adjusted.

PULSE-WIDTH PROPORTIONAL-CONTROLLER CIRCUIT



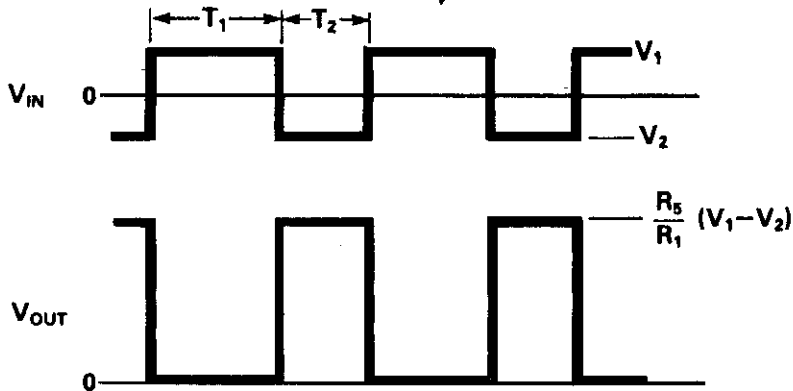
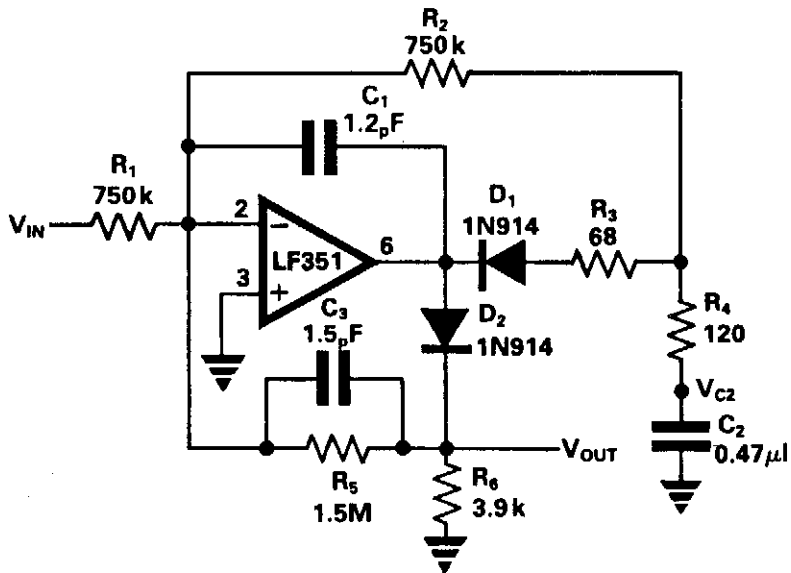
NASA

Fig. 2-24

Circuit Notes

The quad operational amplifier circuit yields full 0 to 100 percent pulse-width control. The controller uses an LM3900 that requires only a single supply voltage of 4 to 30 V. The pulse-repetition rate is set by a 1 kHz oscillator that incorporates amplifier A_1 . The oscillator feeds ramp generator A_2 , which generates a linear ramp voltage for each oscillator pulse. The ramp signal feeds the inverting input of comparator A_3 ; the speed-control voltage feeds the noninverting input. Thus, the output of the comparator is a 1 kHz pulse train, the pulse width of which changes linearly with the control voltage. The control voltage can be provided by an adjustable potentiometer or by an external source of feedback information such as a motor-speed sensing circuit. Depending on the control-voltage setting, the pulse duration can be set at any value from zero (for zero average dc voltage applied to the motor) to the full pulse-repetition period (for applied motor voltage equal to dc power-supply voltage). An amplifier stage (A_4) with a gain of 10 acts as a pulse-squaring circuit. A TIP-31 medium-power transistor is driven by A_4 and serves as a separate power-amplifier stage.

OP AMP CLAMPING



ELECTRONIC ENGINEERING

Fig. 2-25

Circuit Notes

The circuit clamps the most positive value of the input pulse signal to the zero base level. Additionally, the circuit inverts and amplifies the input signal by the factor of R_5/R_1 . The waveforms are shown in the bottom of Fig. 2-24.

3

Analog-to-Digital Converters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Successive Approximation A/D Converters
- 4 Digit (10,000 Count) A/D Converter
- 16-Bit A/D Converter
- Inexpensive, Fast 10-Bit Serial Output A/D
- 10-Bit A/D Converter
- High Speed 12-Bit A/D Converter
- Successive Approximation A/D Converter
- Cyclic A/D Converter
- Differential Input A/D System

SUCCESSIVE APPROXIMATION A/D CONVERTERS

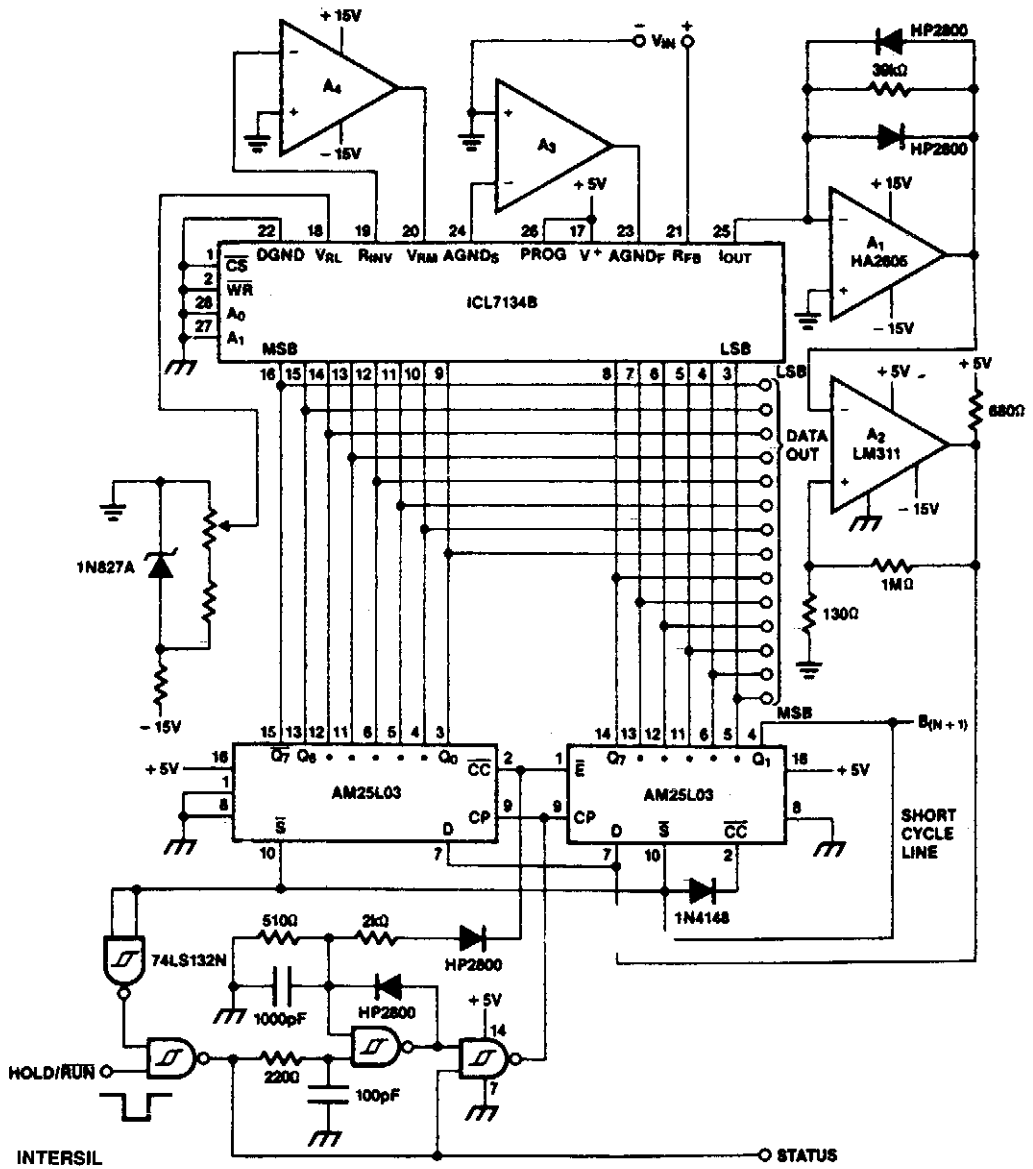


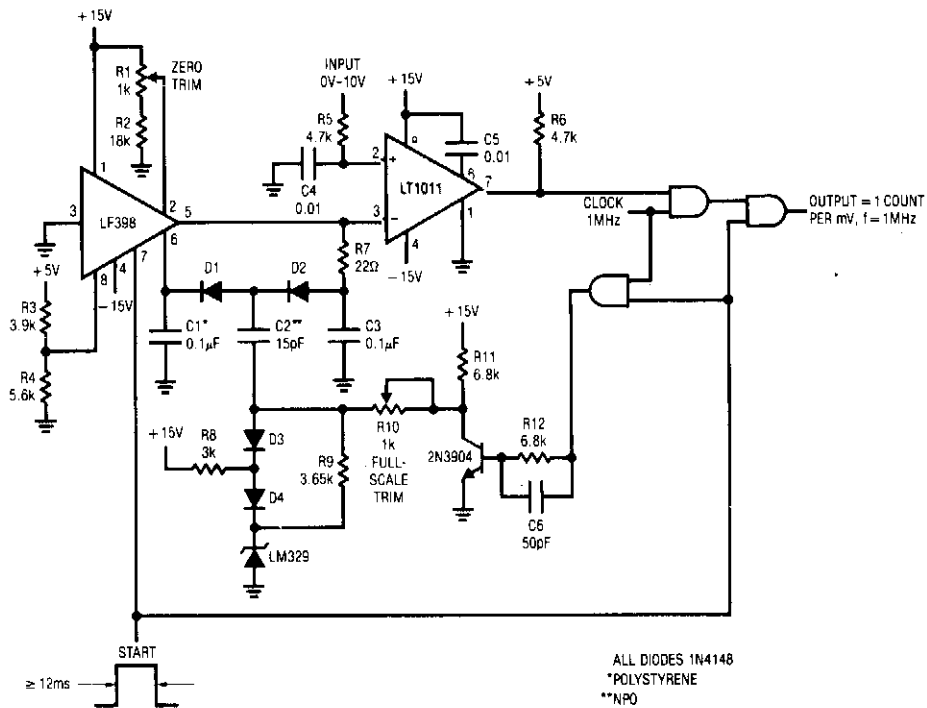
Fig. 3-1

SUCCESSIVE APPROXIMATION A/D CONVERTERS , Continued.

Circuit Notes

The ICL7134B-based circuit is for a bipolar-input high-speed A/D converter, using 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 (see A020). Careful offset-nulling of this amplifier is needed, and if wide temperature range operation is desired, an auto-null circuit using an ICL7650 is probably advisable (see A053). The clock, using two Schmitt trigger TTL gates, runs at a slower rate for the first 8 bits, where settling-time is most critical than for the last 6 bits. The short-cycle line is shown tied to the 15th bit; if fewer bits are required, it can be moved up accordingly. The circuit will free-run if the HOLD/RUN input is held low, but will stop after completing a conversion if the pin is high at that time. A low-going pulse will restart it. The STATUS output indicates when the device is operating, and the falling edge indicates the availability of new data. A unipolar version can be constructed by typing the MSB (D13) on an ICL7134U to pin 14 on the first AM25L03, deleting the reference inversion amplifier A4, and tying V_{RFL} to V_{RFL} .

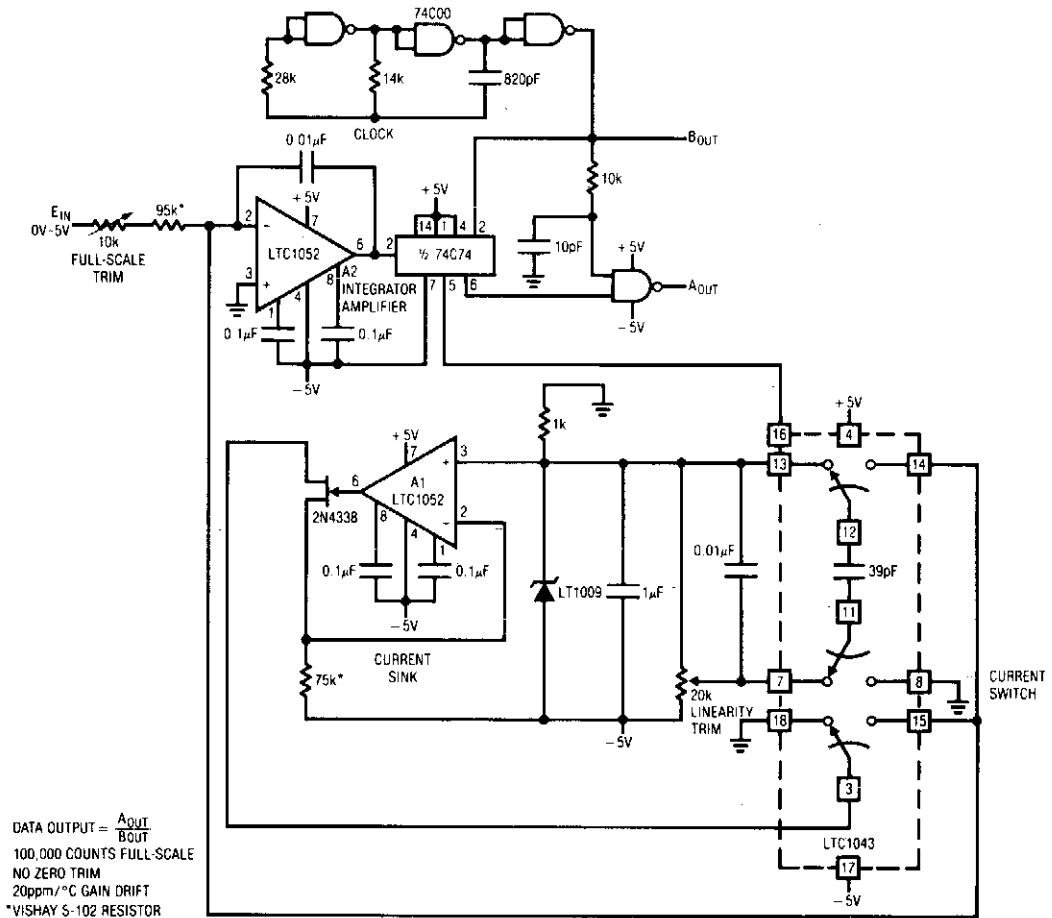
4 DIGIT (10,000 COUNT) A/D CONVERTER



LINEAR TECHNOLOGY CORP.

Fig. 3-2

16-BIT A/D CONVERTER



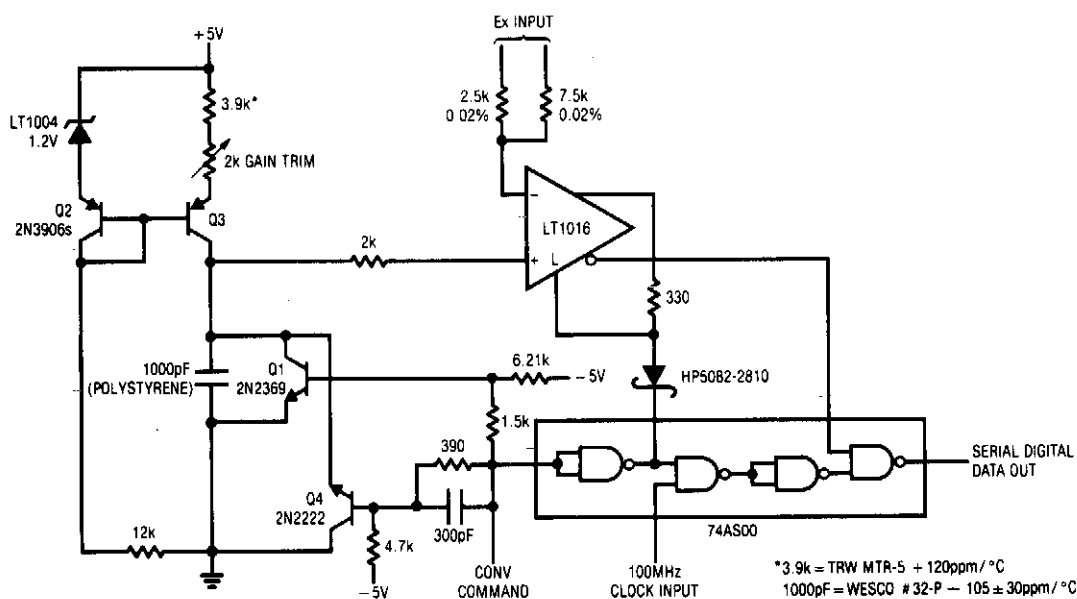
LINEAR TECHNOLOGY

Fig. 3-3

Circuit Notes

The A/D converter, made up of A2, a flip-flop, some gates and a current sink, is based on a current balancing technique. Once again, the chopper-stabilized LTC1052's 50 nV/°C input drift is required to eliminate offset errors in the A/D.

INEXPENSIVE, FAST 10-BIT SERIAL OUTPUT A/D



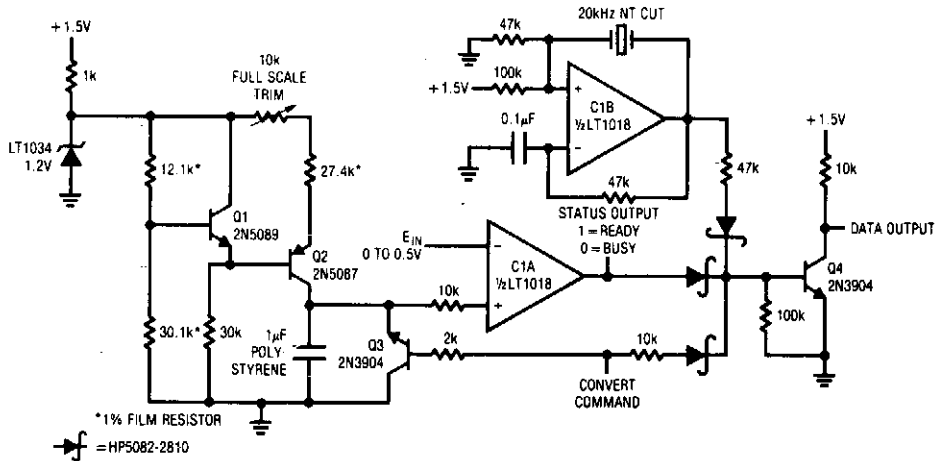
LINEAR TECHNOLOGY CORPORATION

Fig. 3-4

Circuit Notes

Everytime a pulse is applied to the convert command input, Q1 resets the 1000 pF capacitor to 0 V. This resetting action takes 200 ns of the falling edge of the convert command pulse, the capacitor begins to charge linearly. In precisely 10 microseconds, it charges to 2.5 V. The 10 microseconds ramp is applied to the LT1016's positive input. The LT1016 compares the ramp to Ex, the unknown, at its negative input. For a 0 V - 2.5 V range, Ex is applied to the 2.5 k ohm resistor. From a 0 V - 10 V range, the 2.5 k ohm resistor is grounded and Ex is applied to the 7.5 k ohm resistor. Output of the LT1016 is a pulse whose width is directly dependent on the value of Ex. This pulse width is used to gate a 100 MHz clock. The 100 MHz clock pulse bursts that appear at the output are proportional to Ex. For a 0 V - 10 V input, 1024 pulses appear at full-scale, 512 at 5.00 V, etc.

10-BIT A/D CONVERTER



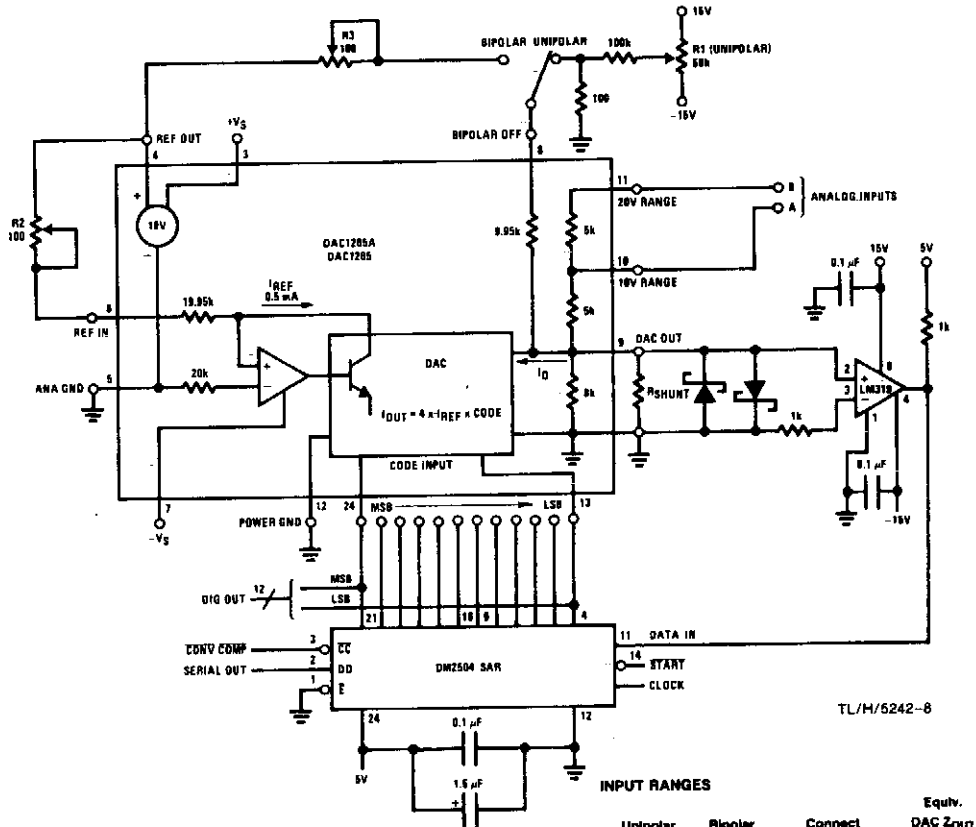
LINEAR TECHNOLOGY CORPORATION

Fig. 3-5

Circuit Notes

The converter has a 60 ms conversion time, consumes 460 μA from its 1.5 V supply and maintains 10 bit accuracy over a 15°C to 35°C temperature range. A pulse applied to the convert command line causes Q3, operating in inverted mode, to discharge through the 10 k Ω diode path, forcing its collector low. Q3's inverted mode switching results in a capacitor discharge within 1 mV of ground. During the time the ramps' value is below the input voltage, C1A's output is low. This allows pulses from C1B, a quartz stabilized oscillator, to modulate Q4. Output data appears at Q4's collector. When the ramp crosses the input voltages value C1A's output goes high, biasing Q4 and output data ceases. The number of pulses at the output is directly proportional to the input voltage. To calibrate apply 0.5 V to the input and trim the 10 k Ω potentiometer for exactly 1000 pulses out each time the convert command line is pulsed.

HIGH SPEED 12-BIT A/D CONVERTER



NATIONAL SEMICONDUCTOR CORP.

Fig. 3-6

Circuit Notes

This system completes a full 12-bit conversion in 10 μ s unipolar or bipolar. This converter will be accurate to $\pm 1/2$ LSB of 12 bits and have a typical gain TC of 10 ppm/ $^{\circ}$ C. In the unipolar mode, the system range is 0 V to 9.9976 V, with each bit having a value of 2.44 mV. For the true conversion accuracy, an A/D converter should be trimmed so that given bit code output results from input levels from $1/2$ LSB below to $1/2$ LSB above the exact voltage which that code represents. Therefore, the converter zero point should be trimmed with an input voltage of 1.22 mV; trim R1 until the LSB just begins to appear in the output code (all other bits "0"). For full-scale, use an input voltage of 9.9963 V (10 V-1 LSB- $1/2$ LSB); then trim R2 until the LSB just begins to appear (all other bits "1"). The bipolar signal range is -5.0 V to 4.9976 V. Bipolar offset trimming is done by applying a -4.9988 V input signal and trimming R3 for the LSB transition (all other bits "0"). Full-scale is set by applying 4.9963 V and trimming R2 for the LSB transition (all other bits "1").

INPUT RANGES			Eqv.
Unipolar	Bipolar	Connect	DAC Z_{out}
0 to 5	± 2.5	Input to A	1.60 k Ω
		B to DAC OUT	
0 to 10	± 5	Input to A	2.96 k Ω
0 to 20	± 10	Input to B	3.08 k Ω

SUCCESSIVE APPROXIMATION A/D CONVERTER

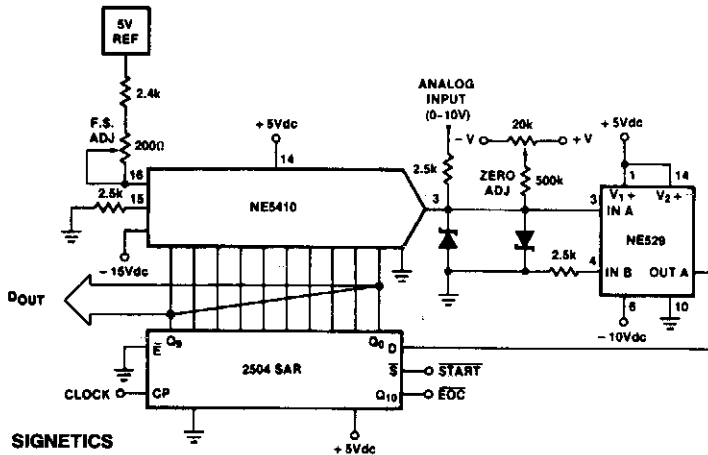
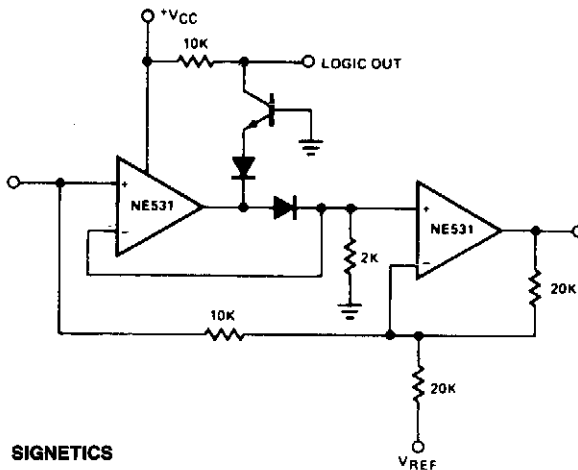


Fig. 3-7

Circuit Notes

The 10-bit conversion time is $3.3 \mu\text{s}$ with a 3 MHz clock. This converter uses a 2504 12-bit successive approximation register in the short cycle operating mode where the end of conversion signal is taken from the first unused bit of the SAR (Q_{10}).

CYCLIC A/D CONVERTER



SIGNETICS

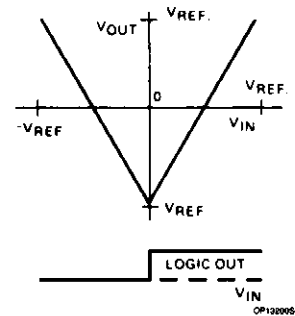
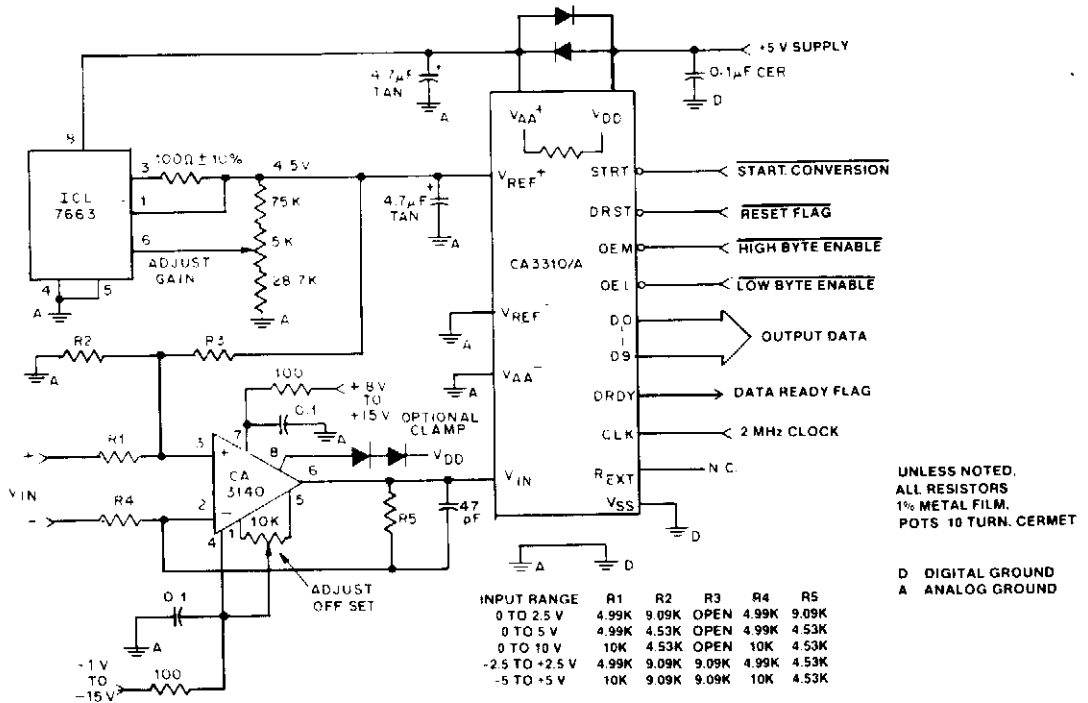


Fig. 3-8

Circuit Notes

The cyclic converter consists of a chain of identical stages, each of which senses the polarity of the input. The stage then subtracts V_{REF} from the input and doubles the remainder if the polarity was correct. The signal is full-wave rectified and the remainder of $V_{IN} - V_{REF}$ is doubled. A chain of these stages gives the gray code equivalent of the input voltage in digitized form related to the magnitude of V_{REF} . Possessing high potential accuracy, the circuit using NE531 devices settles in $5 \mu\text{s}$.

DIFFERENTIAL INPUT A/D SYSTEM



GENERAL ELECTRIC/RCA

Fig. 3-9

Circuit Notes

Using a CA3140 BiMOS op amp provides good slewing capability for high bandwidth input signals, and can quickly settle energy that the CA3310 outputs at its V_{IN} terminal. The CA3140 can also drive close to the negative supply rail. If system supply sequencing or an unknown input voltage is likely to cause the op amp to drive above the V_{DD} supply, a diode clamp can be added from pin 8 of the op amp to the V_{DD} supply.

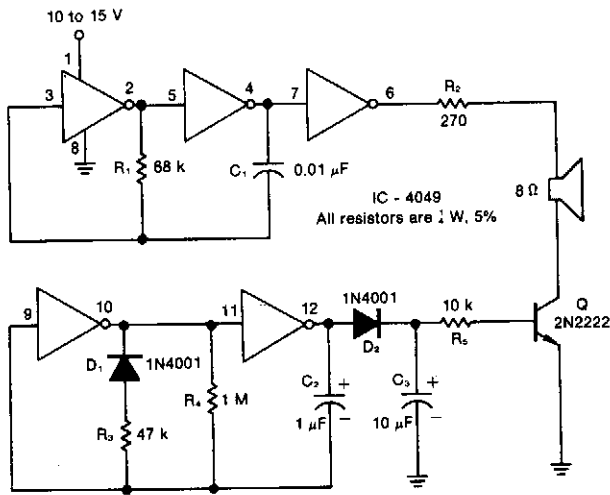
4

Annunciators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low-Cost Chime Circuit
Electronic Bell
Sliding-Tone Doorbell

LOW-COST CHIME CIRCUIT



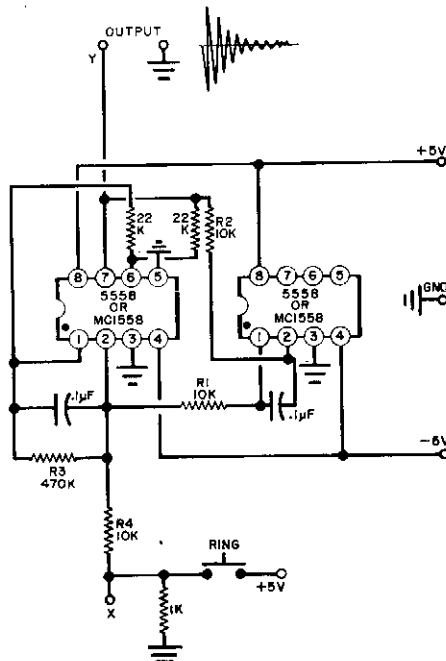
Circuit Notes

Resistor R1, capacitor C1, and two inverters form a square wave generator, which produces the basic tone. The generator is followed by an inverter that acts as both a buffer and a driver for the speaker. Resistor R2, which has a minimum value of 100 ohms, limits the current and controls the volume. Diode D1, capacitor C2, resistors R3 and R4, and two inverters create the pulse generator that determines the turn-on and decay times of the chime. The decay circuit—formed by D2, C3, R5, and Q—reduces the amplitude of the chime tone exponentially as a function of time.

ELECTRONIC DESIGN

Fig. 4-1

ELECTRONIC BELL



Circuit Notes

Coarse frequency is controlled by the capacitors which must be kept nearly identical in value to each other for best results. Fine tuning is accomplished with R1 and R2. The decay time is controlled by R3.

POPULAR ELECTRONICS

Fig. 4-2

SLIDING-TONE DOORBELL

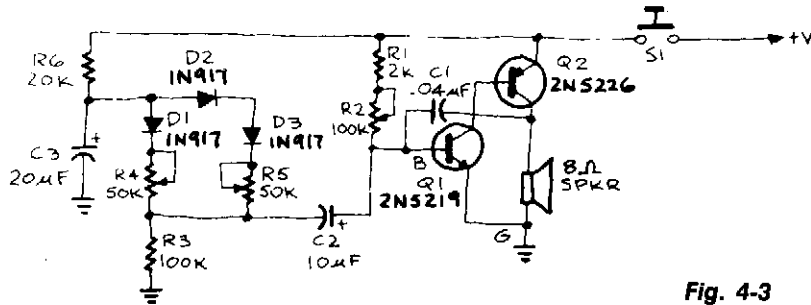


Fig. 4-3

RADIO ELECTRONICS

Circuit Notes

When the doorbell is pushed, you'll hear a low tone that will "slide up" to a higher frequency. The frequency of the AF oscillator is determined by coupling capacitor, C1 and the value of the resistance connected between the base of Q1 and ground. That resistance, R_{BG} is equal to $(R1 + R2) R3$. First, assume that S1 is closed and R2 has been adjusted to produce a pleasant, low-frequency tone. Capacitor C3 will charge through R6 until it reaches such a voltage that it will cause diode D1 to conduct. When that happens, the value of R_{BG} is paralleled by R4. Thus, because the total resistance R_{BG} decrease, the output tone slides up in frequency. Capacitor C3 will continue to charge until the voltage across D2 and D3 causes those diodes to conduct. Then R_{BG} is paralleled also by R5, the total resistance again decreases, and the oscillator's frequency again increases.

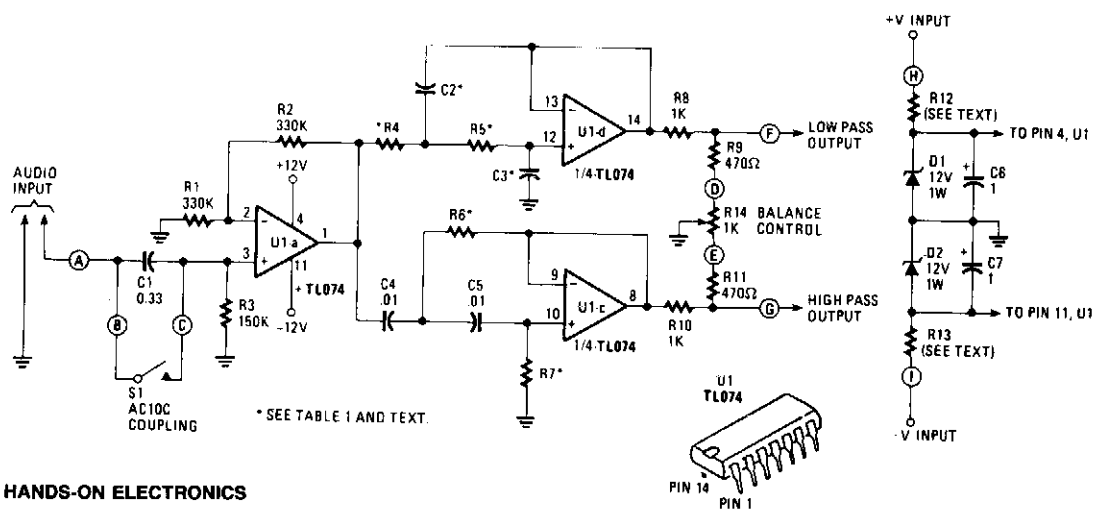
5

Audio Mixers, Crossovers and Distribution Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Electronic Crossover Circuit
Sound Mixer Amplifier
Microphone Mixer
Low Distortion Input Selector for Audio Use
Audio Distribution Amplifier
Four Channel Four Track Mixer

ELECTRONIC CROSSOVER CIRCUIT



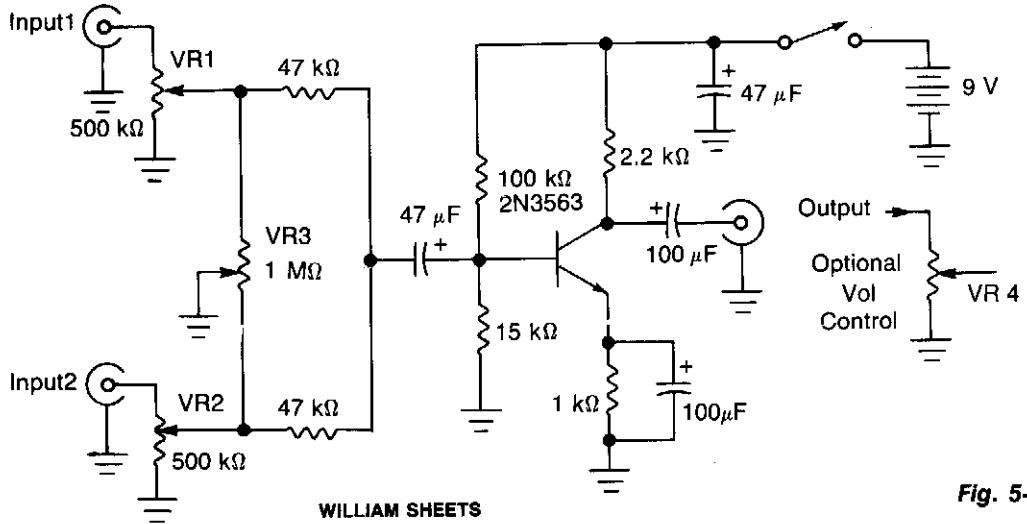
HANDS-ON ELECTRONICS

Fig. 5-1

Circuit Notes

An audio source, such as a mixer, preamplifier, equalizer, or recorder, is fed to the Electronic Crossover Circuit's input. That signal is either ac- or dc-coupled, depending on the setting of switch S1, to the non-inverting input of buffer-amplifier U1a, one section of a quad, BIFET, low-noise TL074 op amp made by Texas Instruments. That stage has a gain of 2, and its output is distributed to both a lowpass filter made by R4, R5, C2, C3, and op-amp U1d, and a highpass filter made by R6, R7, C4, C5, and op amp U1c. Those are 12 dB/octave Butterworth-type filters. The Butterworth filter response was chosen because it gives the best compromise between damping and phase shift. Values of capacitors and resistors will vary with the selected crossover at which your unit will operate. The filter's outputs are fed to a balancing network made by R8, R9, R10, R11 and balance potentiometer R14. When the potentiometer is at its mid-position, there is unity gain for the passbands of both the high and low filters. Dc power for the Electronic Crossover Circuit is regulated by R12, R13, D1, and D2, and decoupled by C6 and C7.

SOUND MIXER/AMPLIFIER



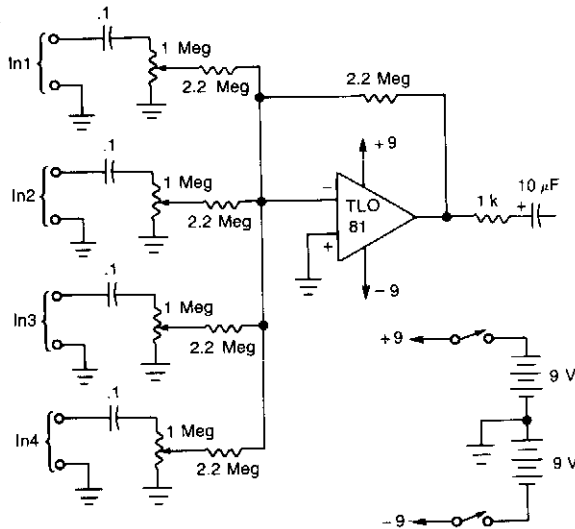
WILLIAM SHEETS

Fig. 5-2

Circuit Notes

Both input signals can be independently controlled by VR1 and VR2. The balance control VR3 is used to fade out one signal while simultaneously fading in the other. The transistor VR3 provides gain and the combined output signal level is controlled by VR4 (optional).

MICROPHONE MIXER



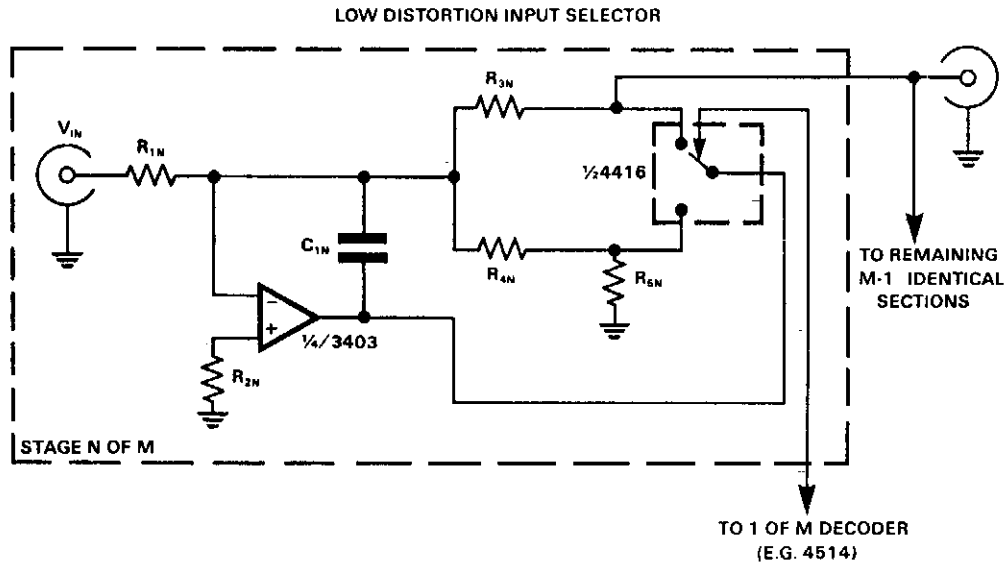
WILLIAM SHEETS

Fig. 5-3

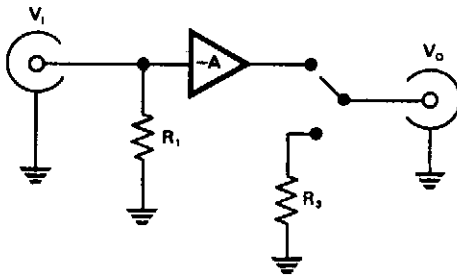
Circuit Notes

A TL081 op amp is used as a high-to-low impedance converter and signal mixer. The input impedance is approximately 1 megohm and the output impedance is about 1 kilohm. Two 9-volt batteries are used as the power source. Battery life should be several hundred hours with alkaline batteries.

LOW DISTORTION INPUT SELECTOR FOR AUDIO USE



EQUIVALENT CIRCUIT OF EACH STAGE:



$$R_{3N} = R_{4N} = AR_{1N}$$

$$R_{2N} = (R_{1N} + R_5) // R_{3N} // (R_{4N} + R_{5N})$$

$$\frac{1}{2\pi f_{MAX}} \gg R_{3N} C_{1N} \gg \tau_s$$

$$R_{5N} = \frac{1}{R_1^{-1} + \sum_{i=1}^M (R_{3i})^{-1}}$$

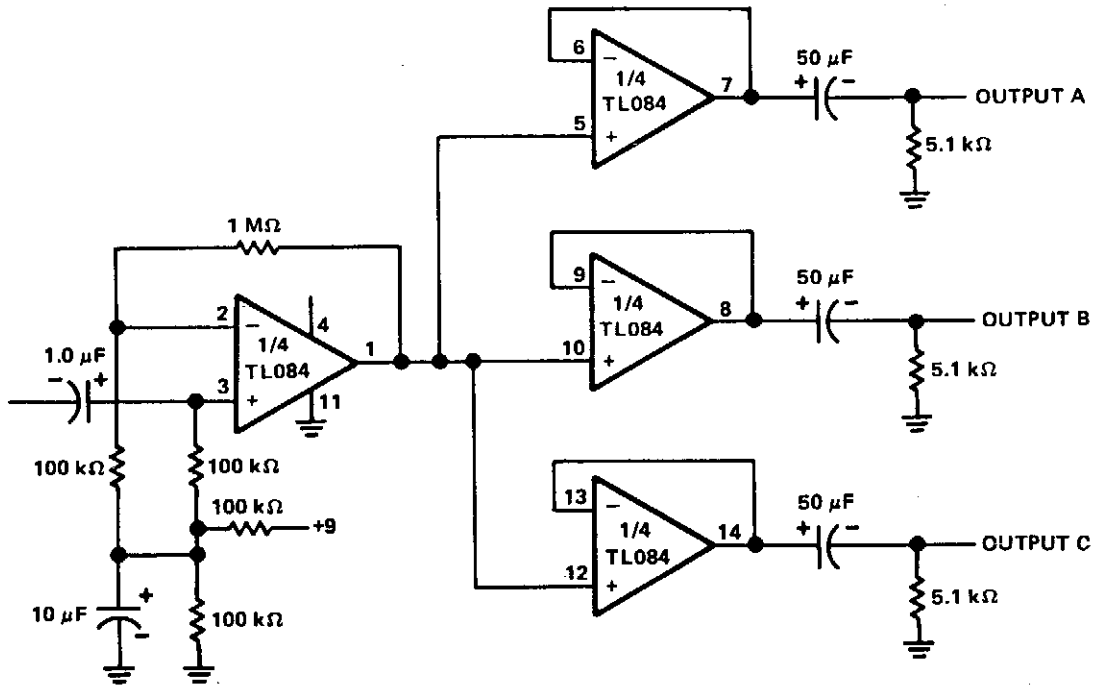
ELECTRONIC ENGINEERING

Fig. 5-4

Circuit Notes

CMOS switches are used directly to select inputs in audio circuits, this can introduce unacceptable levels of distortion, but if the switch is included in the feedback network of an op amp, the distortion due to the switch can be almost eliminated. The circuit uses a 4416 CMOS switch, arranged as two independent SPDT switches. If switching transients are unimportant, R₅ and C₁ can be omitted, and R₄ can be shorted out. However, a feedback path must be maintained, even when a channel is switched out, in order to keep the inverting input of the op amp at ground potential, and prevent excessive crosstalk between channels.

AUDIO DISTRIBUTION AMPLIFIER



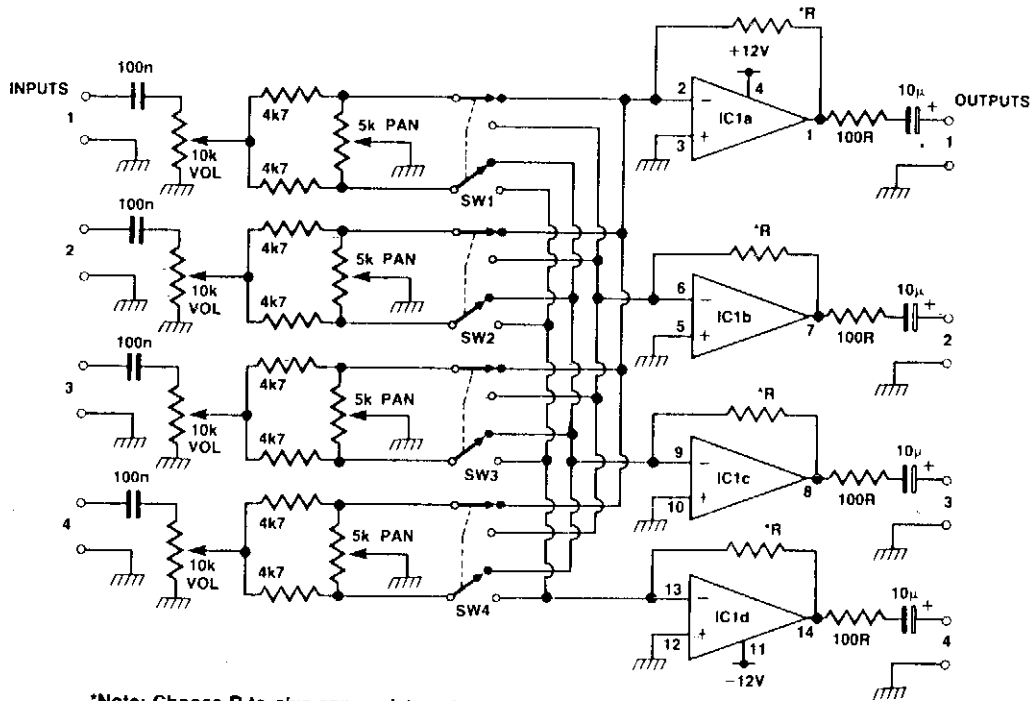
TEXAS INSTRUMENTS

Fig. 5-5

Circuit Notes

The three channel output distribution amplifier uses a single TL084. The first stage is capacitively coupled with a 1.0 μF electrolytic capacitor. The inputs are at 1/2 V_{CC} rail or 4.5 V. This makes it possible to use a single 9 V supply. A voltage gain of 10 (1 M ohm/100 k ohm) is obtained in the first stage, and the other three stages are connected as unity-gain voltage followers. Each output stage independently drives an amplifier through the 50 μF output capacitor to the 5.1 k ohm load resistor. The response is flat from 10 Hz to 30 kHz.

FOUR CHANNEL FOUR TRACK MIXER



*Note: Choose R to give appropriate gain.

ELECTRONICS TODAY INTERNATIONAL

Fig. 5-6

Circuit Notes

This circuit can be used as a stereo mixer as well as a four track. The quad op-amp IC gives a bit of gain for each track. The pan control allows panning between tracks one and two with the switch in the up position, and with the switch in the down position, it makes possible panning between tracks three and four. Extra channels can be added. A suitable op amp for IC1 is TL074 or similar.

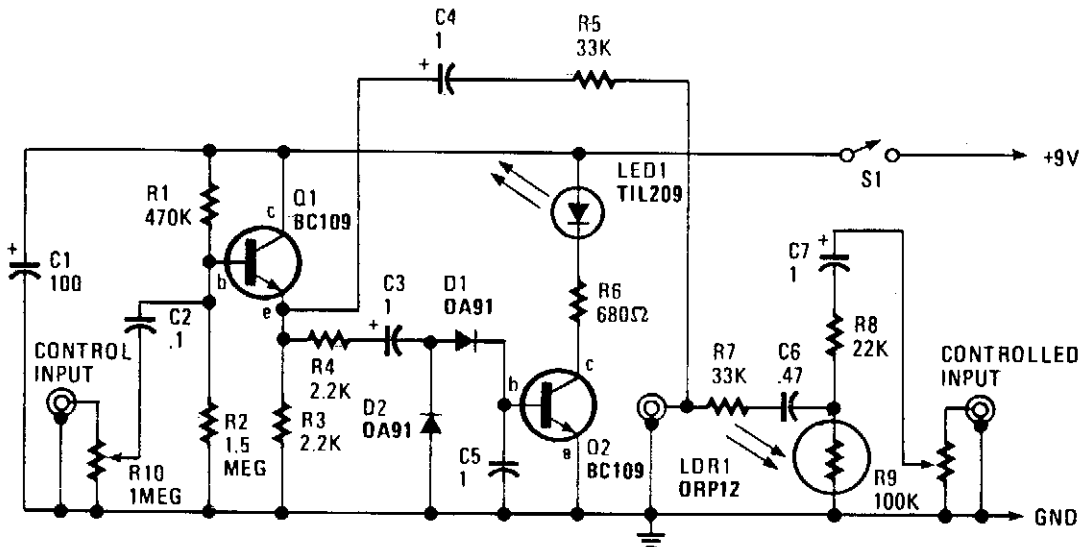
6

Audio Signal Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Auto Fade
Transistor Headphone Amplifier
Stereo Preamplifier
Audio Compressor
Micropower High-Input-Impedance 20-dB Amplifier
Stereo Preamplifier
Microphone Preamplifier
Volume, Balance, Loudness & Power Amps
Balance and Loudness Amplifier

AUTO FADE



TAB BOOKS INC.

Fig. 6-1

Circuit Notes

The automatic fader drops the level of the background music when the narration comes up. The control input goes through R10, a preset audio level control, to the input of an emitter-follower buffer stage (Q1). The buffer offers a high input impedance and makes sure that the source impedance is low enough to drive the rectifier and smoothing circuit, which consist of D1, D2, and C5. The smoothed output drives a simple LED circuit. R8 and LDR1 form an input attenuator across which the output is fed via C6 and C7 to the output jack. The output at the emitter of Q1 couples to this socket through C4 and R5. R5 and R7 are a passive mixer. With 200 mV or less at the input, there isn't sufficient voltage across C5 to make Q2 turn on. Over 200 mV, Q2 does turn on to a limit, and the LED gets power. That makes the LDR's resistance fall, and signal loss through the attenuator increases. Increase the input to 350 mV rms, and you get a signal reduction of better than 20 dB.

TRANSISTOR HEADPHONE AMPLIFIER

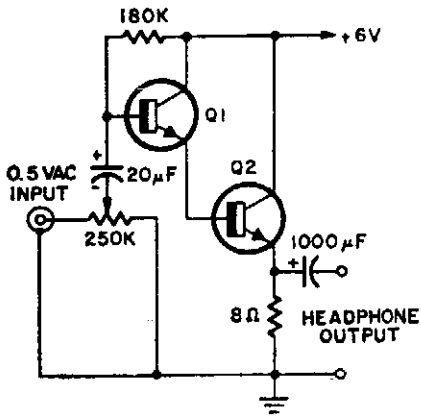
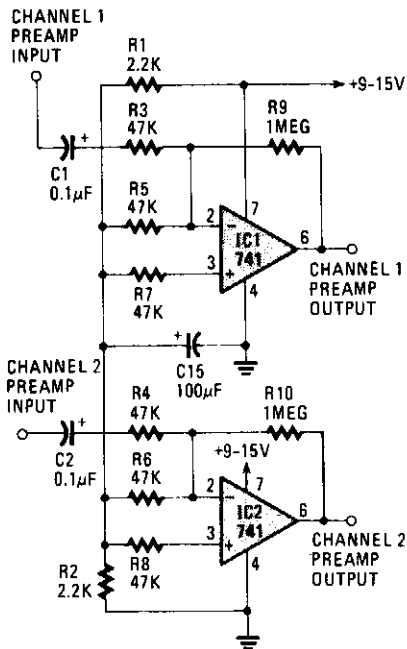


Fig. 6-2

RADIO ELECTRONICS

STEREO PREAMPLIFIER



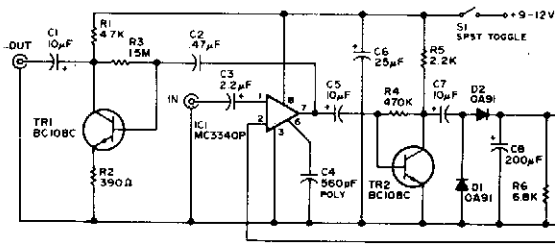
Circuit Notes

The circuit provides better than 20-dB gain in each channel. A better op-amp type will give a better noise figure and bandpass. In this circuit the roll-off is acute at 20,000 Hertz.

HANDS-ON ELECTRONICS

Fig. 6-2

AUDIO COMPRESSOR



RESISTORS - MINIATURE 1/4W, 5 OR 10%
 C1, C5, C6, C7 - ELECTROLYTIC, 16V WKG
 C3 - ELECTROLYTIC, 25V WKG
 C8 - ELECTROLYTIC, 5V WKG
 C2 - TYPE C280 (MULLARD)

Circuit Notes

A MC3340P is used as a variable gain amplifier. The output of TR2 is rectified and controls the gain of IC1.

73 MAGAZINE

Fig. 6-3

MICROPOWER HIGH-INPUT-IMPEDANCE 20-dB AMPLIFIER

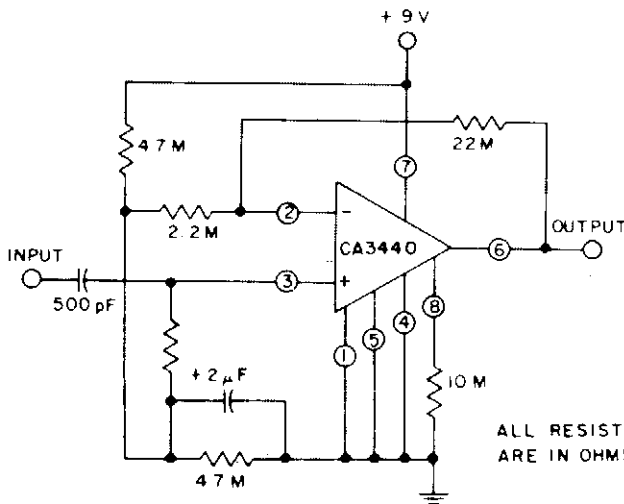


Fig. 6-4

ALL RESISTANCE VALUES
 ARE IN OHMS

$R_{in} > 20\text{ M}$
 STAND-BY POWER = $90\ \mu\text{W}$ 3 kHz UPPER 3 dB BANDWIDTH
 GAIN = 20 dB
 BW: 20-Hz TO 3-KHz
 SR = $0.016\ \text{V}/\mu\text{s}$

GENERAL ELECTRIC/RCA

Circuit Notes

This circuit takes advantage of low power drain, high input impedance, and the excellent frequency capability of the CA3440. Only a 500-pF input coupling capacitor is needed to achieve a 20 Hz, -3 dB low-frequency response.

STEREO PREAMPLIFIER

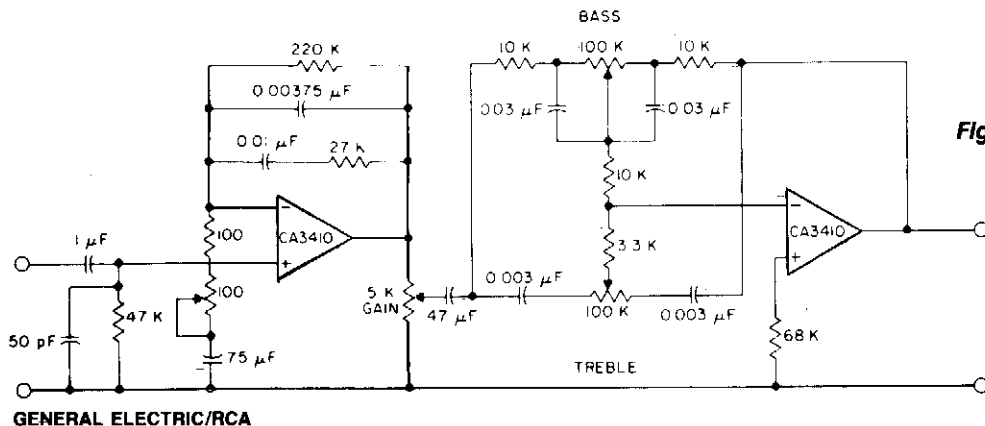


Fig. 6-5

Circuit Notes

This circuit has RIAA playback equalization, tone controls, and adequate gain to drive a majority of commercial power amplifiers, using the CA3410 BiMOS op amp. Total harmonic distortion, when driven to provide a 6-V output, is less than 0.035% in the audio-frequency range of 150 Hz to 40 kHz. Complete stereo preamplifier consists of duplicating this circuit using the two remaining CA3410 amplifiers.

MICROPHONE PREAMPLIFIER

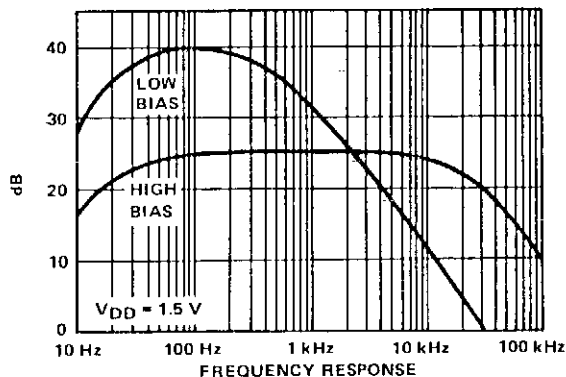
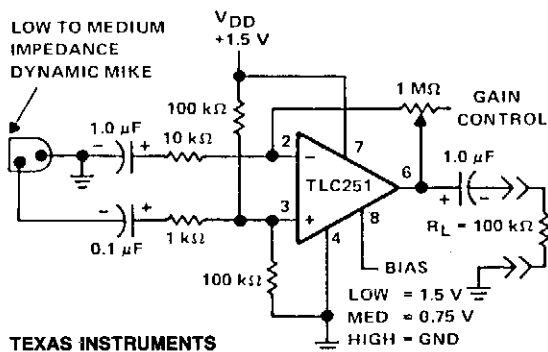
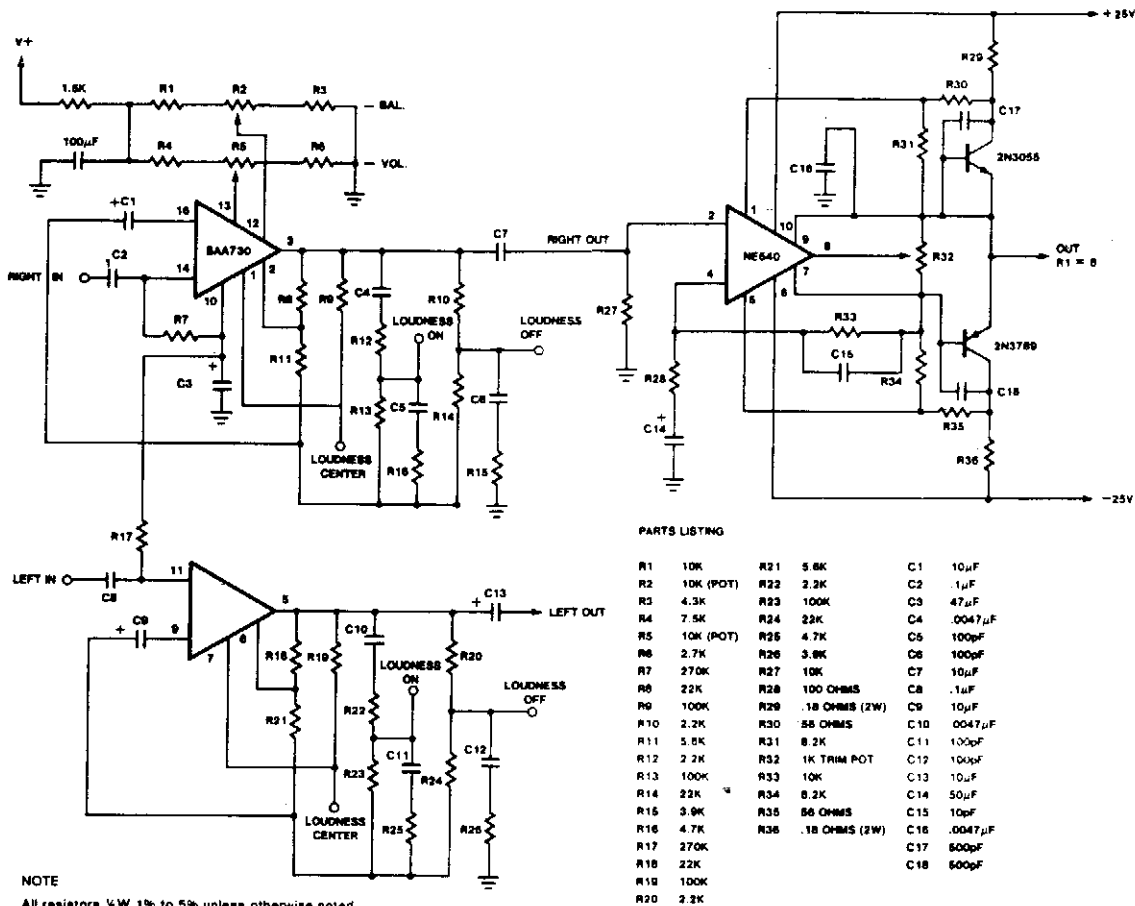


Fig. 6-6

Circuit Notes

A microphone preamplifier using a CMOS op amp complete with its own battery, is small enough to be put in a small mike case. The amplifier operates from a 1.5-V mercury cell battery at low supply currents. This preamplifier will operate at very low power levels and maintain a reasonable frequency response as well. The TLC251 operated in the low bias mode (operating at 1.5 V) draws a supply current of only 10 μ A and has a -3 dB frequency response of 27 Hz to 4.8 kHz. With pin 8 grounded, which is designated as the high bias condition, the upper limit increases to 25 kHz. Supply current is only 30 μ A under those conditions.

VOLUME, BALANCE, LOUDNESS & POWER AMPS



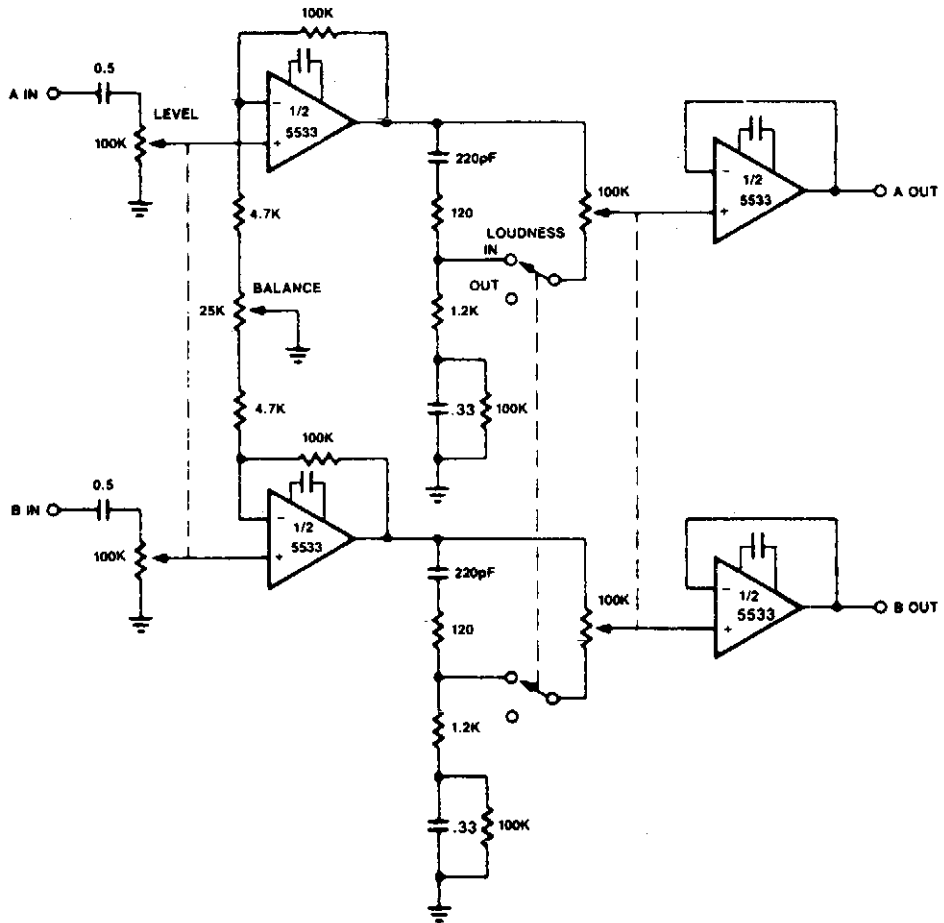
SIGNETICS

Fig. 6-7

Circuit Notes

This circuit should prove suitable as a design example for audio sound application.

BALANCE AND LOUDNESS AMPLIFIER



TC06660S

NOTE:
All resistor values are in ohms.

SIGNETICS

Fig. 6-7

Circuit Notes

The circuit shows a combination of balance and loudness controls. Due to the non-linearity of the human hearing system, the low frequencies must be boosted at low listening levels. Balance, level, and loudness controls provide all the listening controls to produce the desired music response.

7

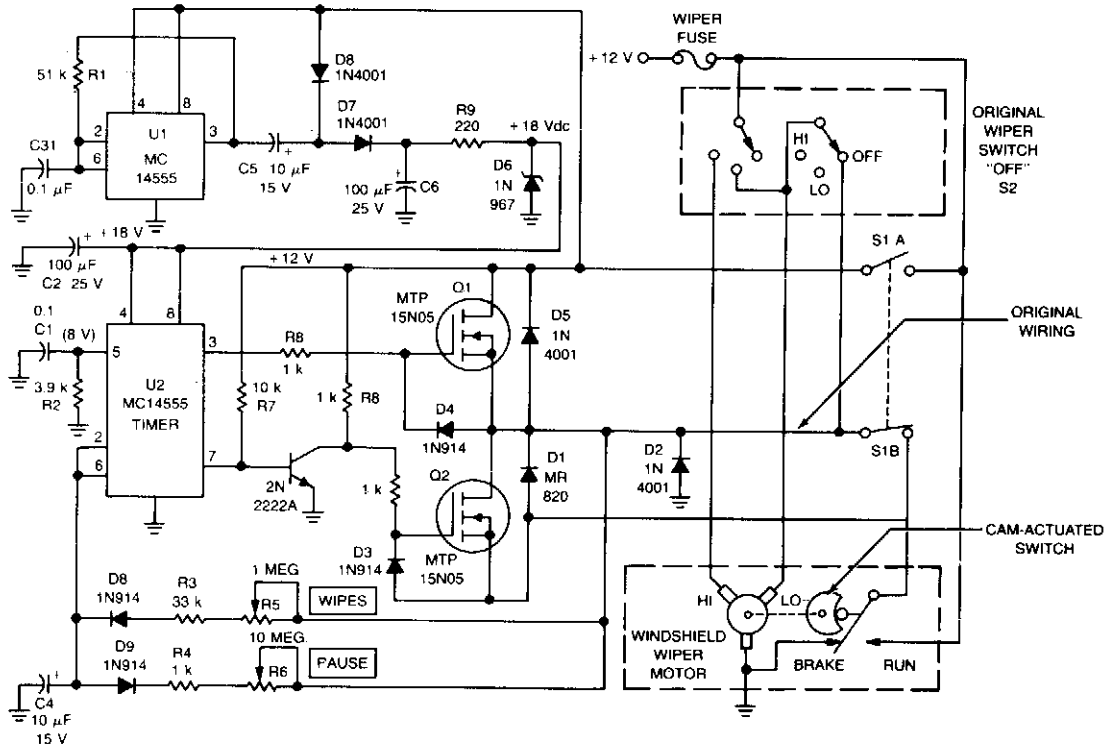
Automotive Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Intermittent Windshield Wiper with Dynamic
Braking
Immobilizer
Automotive Exhaust Emissions Analyzer
Glow Plug Driver
Garage Stop Light
Bar-Graph Voltmeter
Delayed-Action Windshield Wiper Control
Slow-Sweep Wiper Control
Automotive Lights On Warning

PTC Thermistor Automotive Temperature Indicator
Road Ice Alarm
Headlight Dimmer
Ice Formation Alarm
Delay Circuits for Headlights
Ignition Timing Light
Digi-Tach
Car-Wiper Control
Automatic Headlight Dimmer

INTERMITTENT WINDSHIELD WIPER WITH DYNAMIC BRAKING



MOTOROLA

Fig. 7-1

Circuit Notes

The circuit provides a delayed windshield wiping, and dynamic braking of wiper blades when they reach the rest position. This prevents the blades from overshooting, which might cause them to stop at a point where they interfere with the drivers' vision.

With the original wiper switch off, switch S1A turns on the delay circuit and S1B disconnects the original automotive wiring. When S1 is turned off, the original wiring controls the system and the delay circuit is bypassed.

Turning S1 on applies the +12-V battery to U1 which is a voltage doubler that produces +18 V. This higher voltage supply is necessary to ensure reliable turn on of Q1 by multivibrator U2. This arrangement provides about +18 V to the gate of Q1, whose source is +12 V minus the V_{DS} drop of Q1.

Q1 remains on for a time determined by the WIPES potentiometer. The interval between wipes is controlled by the PAUSE control. When C1 drops below +4 V, U2 fires, turning Q1 on and restarting the cycle.

IMMOBILIZER

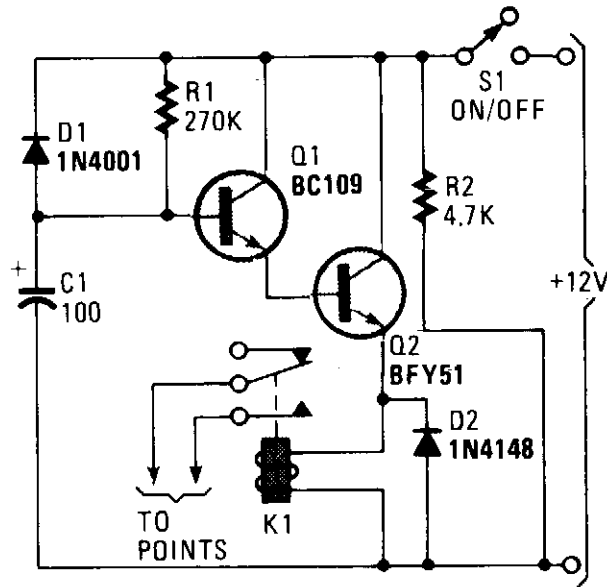


Fig. 7-2

HANDS-ON ELECTRONICS

Circuit Notes

A flip of S1 puts the circuit into action. Power for the circuit is picked up from the ignition switch, and the circuit receives no power until the ignition switch is closed. When power is turned on, capacitor C1 is not charged and the emitter-follower Darlington pair (formed by Q1 and Q2) are cutoff, thus no power is applied to the relay (K1), which serves as Q1's emitter load. The relay's normally-open contacts are connected across the vehicle's points. (At this time, the relay contacts are open and have no effect on the ignition system). C1 charges by way of R1, causing the voltage at the base of Q1 to rise steadily. That creates a similar rise in the voltage at the emitter of Q2. A Darlington pair is used to provide a high input-impedance, buffer stage so that the voltage across C2 is free to rise almost to the full supply potential. Loading effects do not limit the charge potential to just a few volts. Eventually, the voltage applied to the relay becomes sufficient to activate it. The contacts close and short out the points. The ignition system now doesn't act properly and the vehicle is disabled. If the ignition is switched off, power is removed from the circuit and diode D1, which was previously reverse-biased, is now forward biased by the charge on C1. D1 allows C1 to rapidly discharge through R2 (and any other dc paths across the supply lines). The circuit is ready to operate when the ignition is again turned on. The engine will operate, but not for very long. The values of R1 and C1 provides a delay of about 25 to 30 seconds. Increase R1's value to provide a longer delay.

AUTOMOTIVE EXHAUST EMISSIONS ANALYZER

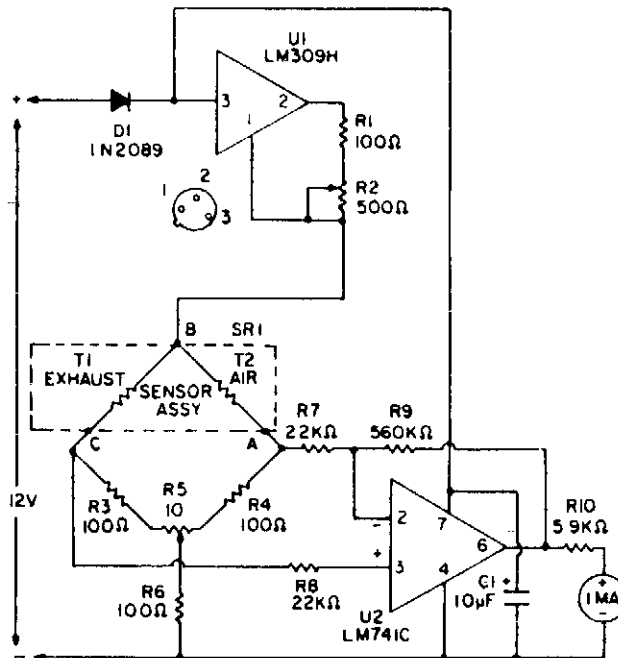


Fig. 7-3

- C1**—10- μ F, 25 volt electrolytic capacitor
D1—Silicon diode, general purpose, 1N2069 or equivalent
M1—0.1 ma ammeter
R1, R3, R4, R6—100-ohm 10% $\frac{1}{4}$ watt resistor (All resistors are 10%, $\frac{1}{4}$ watt)
R2—500-ohm potentiometer, PC mount
R5—10-ohm potentiometer, front panel mount
R7, R8—22,000-ohm resistor
R9—570,000-ohm resistor

- R10**—5,900-ohm resistor
SR1—thermister sensor assembly, part number 100-1648 from Heathkit model CI-1080, Heath Company Benton Harbor, MI, 49022
U1—LM309H 5-volt regulator integrated circuit
U2—LM741C op amp integrated circuit

Misc.—PC Board, screws, cabinet, solder, hardware, 10-foot plastic tube, etc.

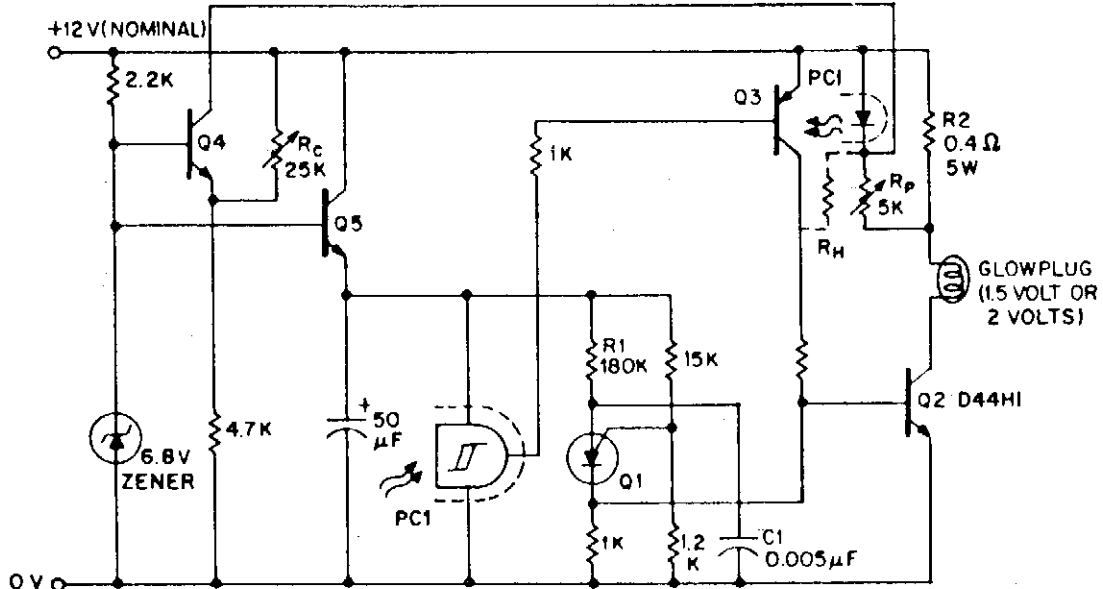
TAB BOOKS, INC.

Circuit Notes

A bridge circuit contains two 100-ohm resistors (R3 and R4), and two thermistors (T1 and T2). At room temperature the resistance of T1 and T2 is about 2000 ohms. When they are each heated to 150°C by a 10 mA current, the resistance value decreases to 100 ohms. Thus, the four elements comprise a bridge circuit. A characteristic of CO is that it conducts heat away from a thermistor at a different rate than air. One thermistor, T1, is exposed to the automobile exhaust while the other, T2, is isolated in a pure air environment. The difference in thermal conduction unbalances the bridge. A voltage difference is caused between points A and C. A differential amplifier, U1, amplifies this difference and drives the meter with sufficient current to read out the percentage of CO and the air-fuel ratio. A front panel balance control, R5, balances the bridge and calibrates the instrument. Calibration is performed when both thermistors are exposed to the outside air.

GLOW PLUG DRIVER

ALL RESISTORS 1/2W EXCEPT AS NOTED OTHERWISE



R_c - SUPPLY VOLTAGE COMPENSATION TRIM.

R_p - PLUG TEMPERATURE ADJUST.

Q1 - 2N6028

PC1 - H11L2.

Q3 - D29E2

Q4, Q5 - D33D1

GENERAL ELECTRIC

Fig. 7-4

Circuit Notes

Model airplanes, boats, and cars use glow plug ignitions for their miniature (0.8cc to 15cc) internal combustion engines. Such engines dispense with the heavy on-board batteries, H.T. coil, and "condenser" required for conventional spark ignition, while simultaneously developing much higher RPM (hence power) than the compression ignition (diesel) motors. The heart of a glow plug is a platinum alloy coil heated to incandescence for engine starting by an external battery, either 1.5 volts or 2 volts. Supplementing this battery, a second 12-volt power supply is frequently required for the engine starter, together with a third 6 volt type for the electrical fuel pump.

Rather than being burdened by all these multiple energy sources, the model builder would prefer to carry (and buy) a single 12-volt battery, deriving the lower voltages from this by use of suitable electronic step-down transformers (choppers). The glow driver illustrated does this and offers the additional benefit of (through negative feedback) maintaining constant plug temperature independent of engine flooding, or battery voltage while the starter is cranking.

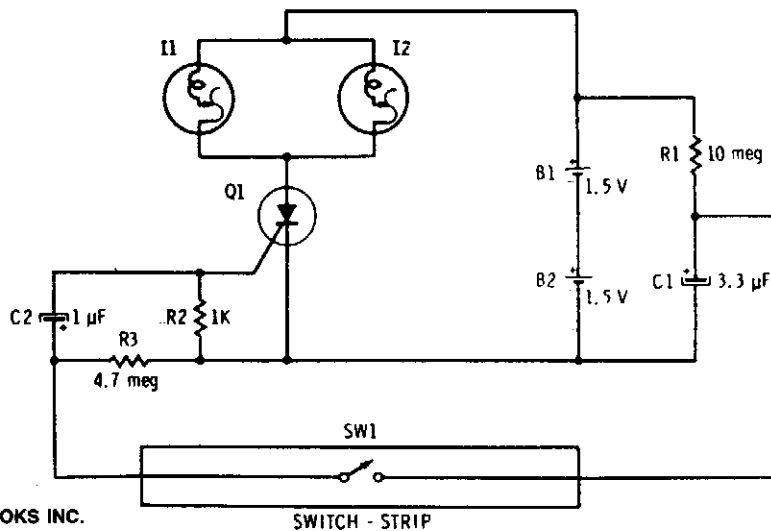
In this circuit, the PUT relaxation oscillator Q1 turns on the output chopper transistor Q2 at a fixed repetition rate determined by R1 and C1. Current then flows through the glow plug and the parallel combination of the current sense resistor R2 and the LED associated with the H11L Schmitt trigger. With the plug cold (low resistance), current

is high, the H11L is biased "on", and Q3 conducts to sustain base drive to Q2. Once the plug has attained optimum operating temperature, which can be monitored by its ohmic resistance, the H11L is programmed (via R_p) to switch off, removing base drive from Q3 and Q2.

However, since the H11L senses glow plug current, not resistance, this is only valid if supply voltage is constant, which is not always the case. Transistor Q4 provides suitable compensation in this case; if battery voltage falls (during cold cranking, for instance), the collector current of Q4 rises, causing additional current to flow through the LED, thus delaying the switch-off point for a given plug current. The circuit holds plug temperature relatively constant, with the plug either completely dry or thoroughly "wet", over an input voltage range of 8 to 16 volts. A similar configuration can be employed to maintain constant temperature for a full size truck diesel glow plug (28-volts supply, 12-volts glow plug); in this case, since plug temperature excursions are not so great, a hysteresis expansion resistor R_H may be required.

Fig. 7-4 Continued

GARAGE STOP LIGHT



TAB BOOKS INC.

SWITCH - STRIP

Fig. 7-5

Circuit Notes

Capacitor C1 is permanently connected across the 3-volt supply through 10 megohm resistor R1. The capacitor charges (relatively slowly) to 3 volts. The instant switch SW1 is closed, it connects the charged capacitor (C1) in series with C2 and R2. Capacitor C2 starts to charge, placing a positive-going voltage on the gate of the SCR and causing it to turn on. The two parallel-connected "self-flashing" bulbs I1 and I2 turn on. They flash and turn off the SCR and the circuit is off until car is driven off the switch and C1 can recharge.

BAR-GRAPH VOLTMETER

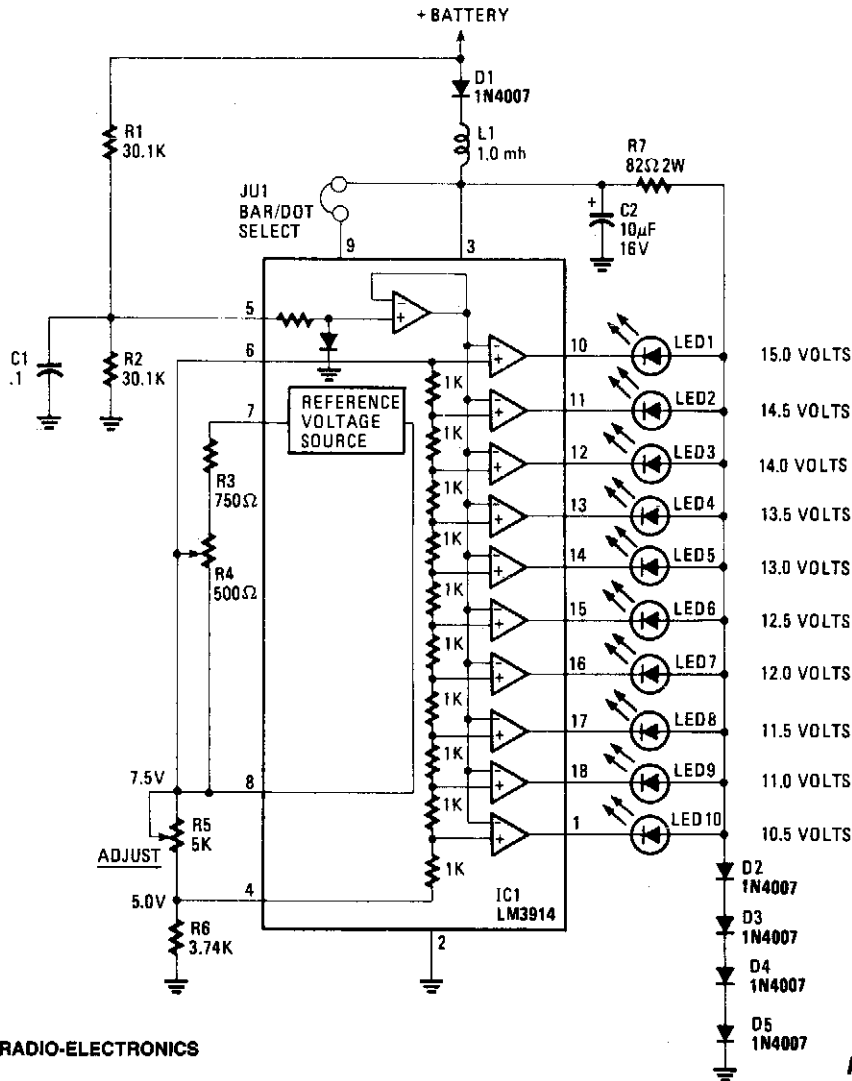


Fig. 7-6

Circuit Notes

This display uses ten LED's to display a voltage range from 10.5 to 15 volts. Each LED represents a 0.5-volt step in voltage. The heart of the circuit is the LM-3914 dot/bar display driver. Trimmer potentiometer R5 is adjusted so that 7.5 volts is applied to the top side of the divider. Resistor R7 and diodes D2 through D5 clamp the voltage applied to the LED's to about 3 volts. A lowpass filter made up of L1 and C2 guards against voltage spikes. Diode D1 is used to protect against reverse voltage in case the voltmeter is hooked up backward.

DELAYED-ACTION WINDSHIELD WIPER CONTROL

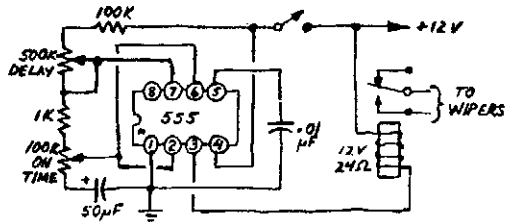
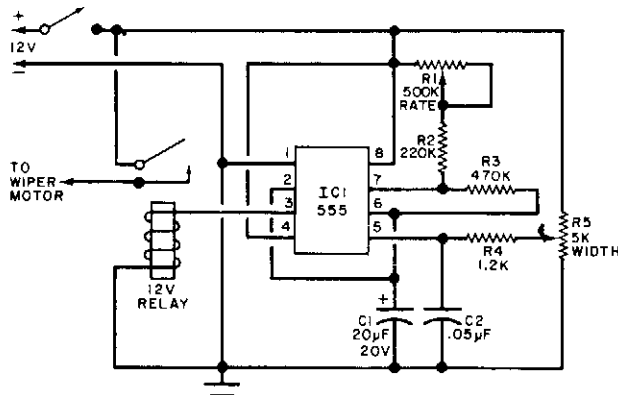


Fig. 7-7

POPULAR ELECTRONICS

SLOW-SWEEP WIPER CONTROL



Circuit Notes

The relay which applies power to the wiper motor is actuated at periodic intervals by the timer circuit, closing the wiper motor contacts. Potentiometer R1 serves as the pulse rate control and potentiometer R5 as the pulse width control. These two controls should be adjusted for optimum performance after the unit is installed in a car.

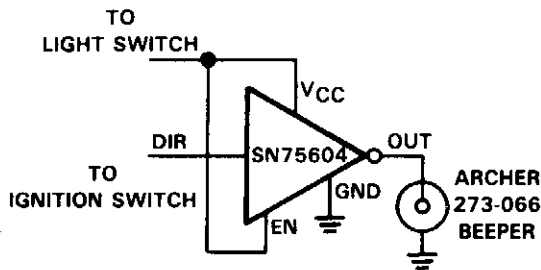
POPULAR ELECTRONICS

Fig. 7-8

AUTOMOTIVE LIGHTS ON WARNING

Circuit Notes

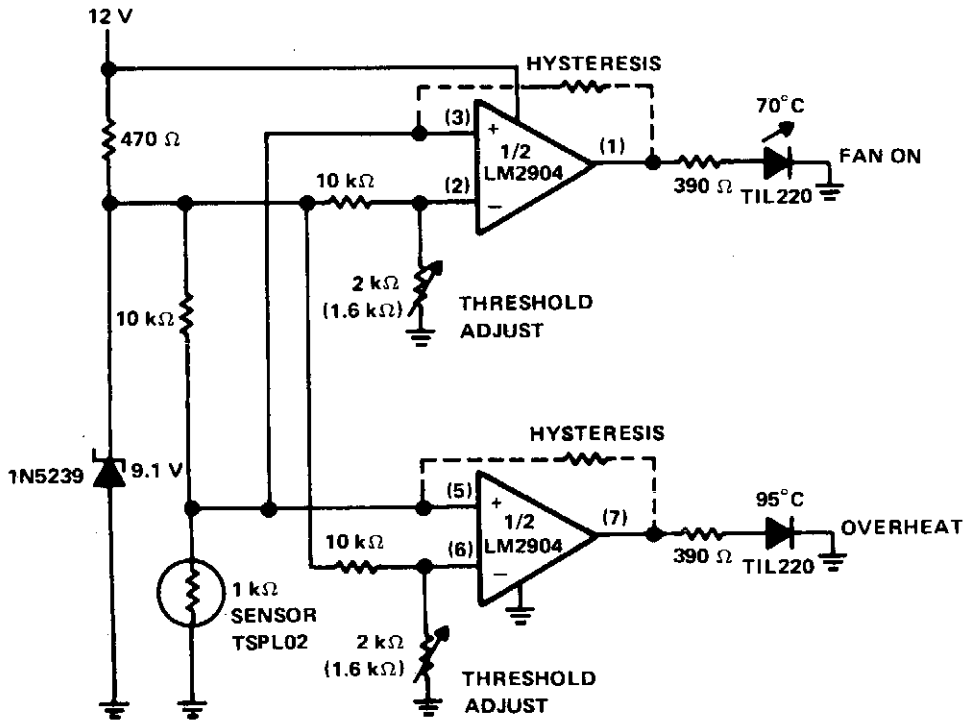
The SN75604, with input control logic but requiring only one supply rail, can be used in the "lights on" sensor and alarm driver. The device V_{CC} and enable inputs are connected to a voltage lead from the light switch. The direction control input is connected to a lead from the ignition switch. Only operation of the lights without the ignition will result in the alarm sounding. The beeper used in this application is an Archer 273-066 that will operate from 3 V to 28 V. At a typical 12 V level, it will produce a pulsating tone of about 95 dB at 30 cm. The alarm "on" current is about 12 mA when operating from a 12 V supply.



TEXAS INSTRUMENTS

Fig. 7-9

PTC THERMISTOR AUTOMOTIVE TEMPERATURE INDICATOR



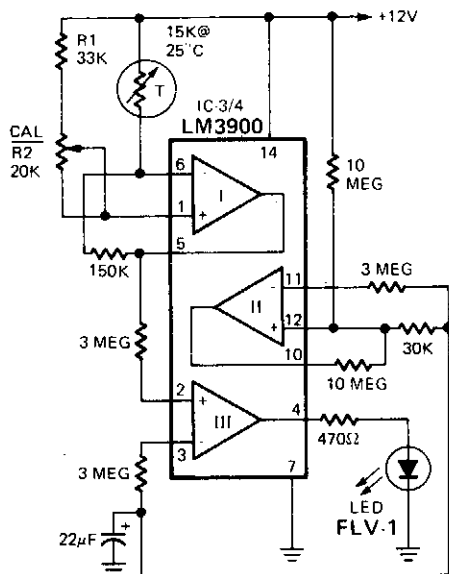
TEXAS INSTRUMENTS

Fig. 7-10

Circuit Notes

The circuit is used to indicate two different water temperature trip points by turning on LEDs when the temperatures are reached. The circuit is constructed around the LM2904 dual operational amplifier powered from the 12 V auto system. The thermistor is in series with a 10 k Ω resistor from ground to the positive 9.1 V point. The top of the thermistor is tied to both non-inverting inputs of the LM2904. The voltage at these inputs will change as the thermistor resistance changes with temperature. Each inverting input on the LM2904 has a reference, or threshold trip point, set by a 10 k Ω resistor and a 2 k Ω potentiometer in series across the 9.1 V regulated voltage. When this threshold is exceeded on the non-inverting input of LM2904, the TIL220 LED lights. The two trip points can be recalibrated or set to trip at different temperatures by adjusting the 2 k Ω potentiometer in each section. In addition to being used as warning lights as shown here, circuits can be added to turn on the fan motor or activate a relay.

ROAD ICE ALARM



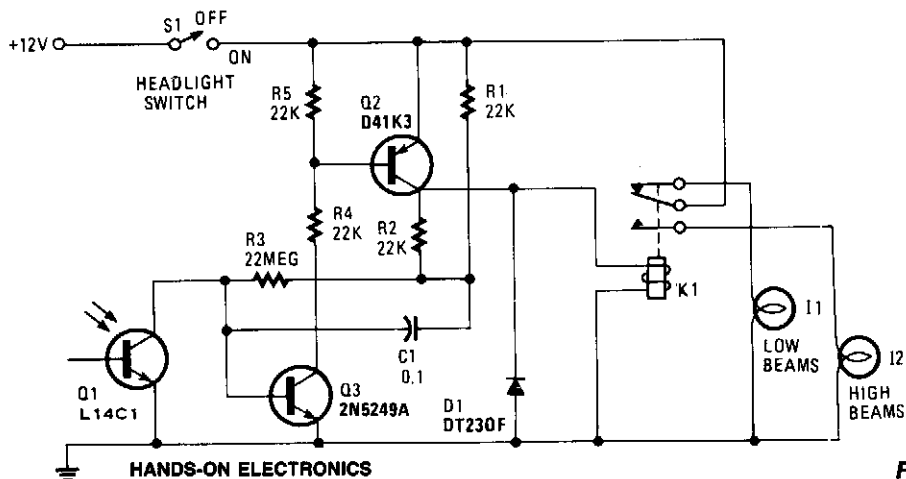
RADIO-ELECTRONICS

Fig. 7-11

Circuit Notes

The circuit uses a thermistor and three sections of a LM3900 quad op amp IC. When the temperature drops to 36°F the LED indicator flashes about once each second. The flashing rate increases as temperature drops to 32°F when the LED remains on. Amplifier I compares the thermistor's resistance to the resistance of the standard network connected to its noninverting input. Its output—fed to the noninverting input of op amp III—varies with temperature. Op amp II is a free-running multivibrator feeding a pulse signal of about 1 Hz to the inverting input of op amp III. This amplifier compares the outputs of op amps I and II and turns on the LED when the multivibrator's output level drops below op amp I. The monitor is calibrated by placing the thermistor in a mixture of crushed ice and water and adjusting the 20 kΩ pot so the LED stays on.

HEADLIGHT DIMMER



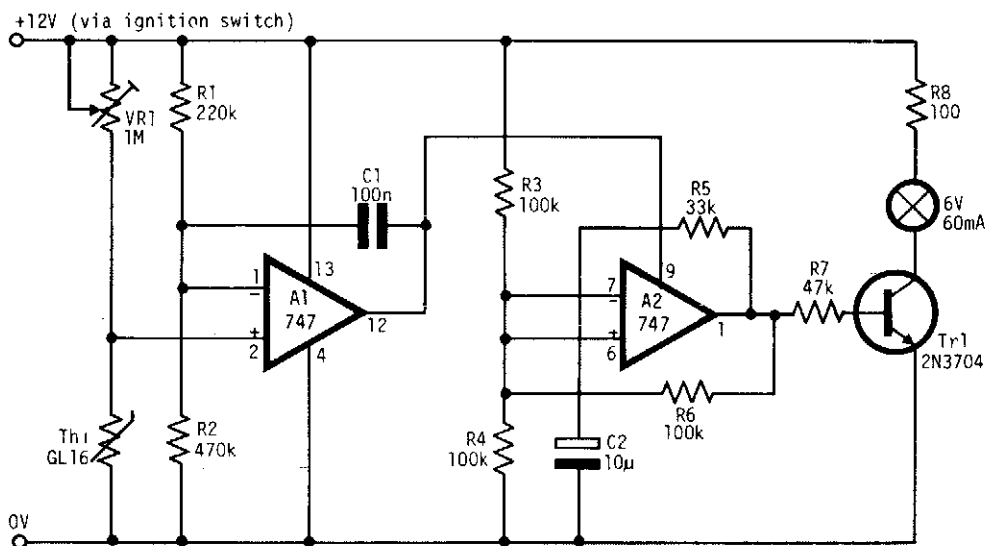
HANDS-ON ELECTRONICS

Fig. 7-12

Circuit Notes

When the lights of an on-coming car are sensed by photo-transistor Q1, things get going. Sensitivity is set by the 22-megohm resistor, R5, to about half a foot-candle. The relay used has a 12-volt, 0.3A coil. The L14C1 is complete with a lens that has a diameter of one inch for a 10° viewing angle.

ICE FORMATION ALARM



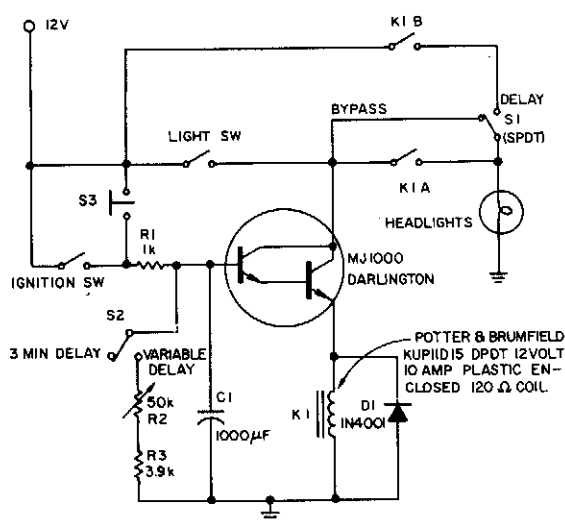
ELECTRONIC ENGINEERING

Fig. 7-13

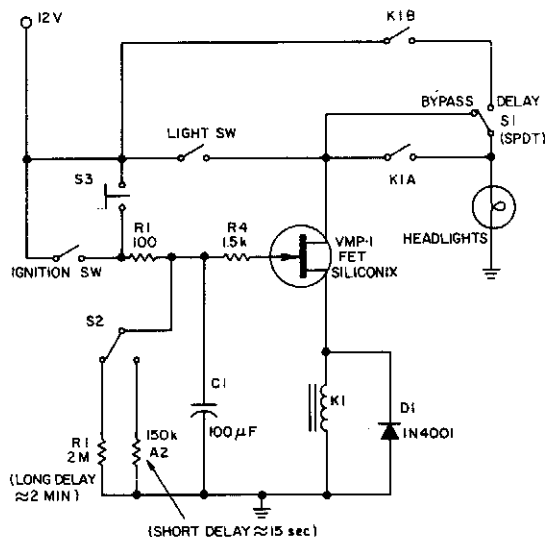
Circuit Notes

The circuit warns car drivers when the air temperature close to the ground approaches 0°C , thereby indicating possible formation of ice on the road surface. Op amp A1 is wired as a voltage level sensor. Op amp A2 is wired as an astable multivibrator which, by means of current buffer Tr1, flashes a filament lamp at about 1 Hz. As air temperature falls, a point is reached when the voltage at pin 2 just rises above the voltage at pin 1. The output of A1 is immediately driven into positive saturation, since it is operated open-loop. This positive output voltage powers A2 through its V + connection on pin 9, starting the oscillator. The thermistor is a glass bead type with a resistance of about $20\ \text{M}\Omega$ at 20°C . VR1 is adjusted so that the lamp starts flashing when the air temperature is 1 to 2°C .

DELAY CIRCUITS FOR HEADLIGHTS



1. Automobile headlights may be kept on up to 3 minutes after you leave the car with this Darlington time-delay circuit.



2. A FET version of the delay circuit allows the use of a smaller timing capacitor, C_1 , for a given delay, and almost instantaneous reset with S_3 ; the Darlington circuit needs almost 2 s.

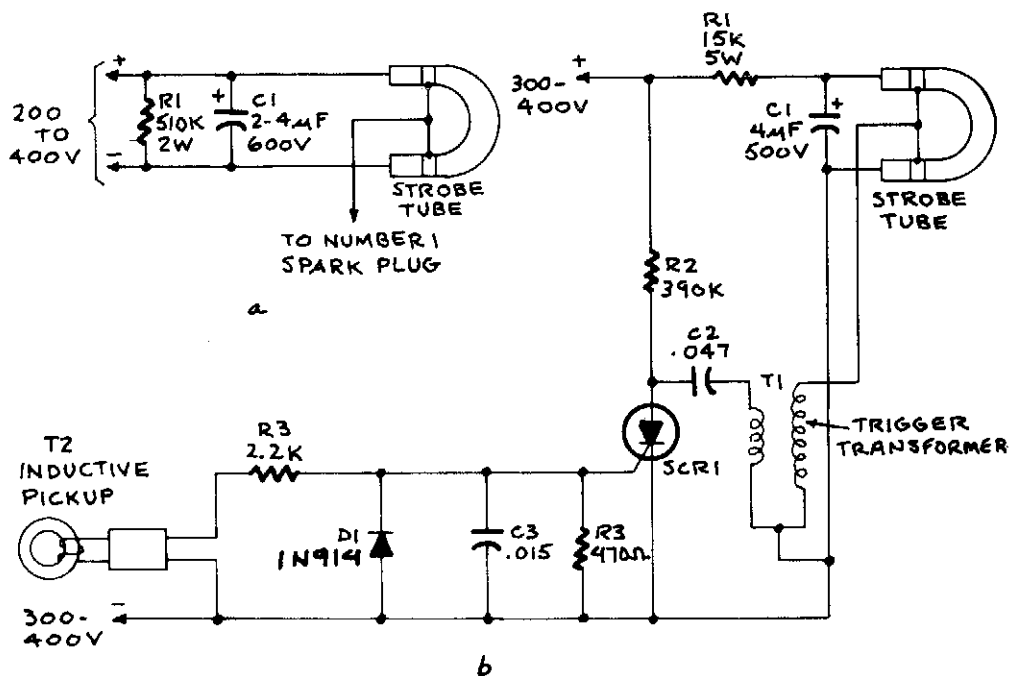
ELECTRONIC DESIGN

Fig. 7-14

Circuit Notes

This circuit keeps an automobile's headlights on temporarily. It also will turn the lights off, even if you forget to flip the light switch. The circuit's shut-off delay is actuated only after both the ignition and light switches have been on, and only if the ignition switch is turned off first. If the light switch is turned off first, no delay results. Parking and brake-light operation is not affected. The maximum time out can be up to 3 minutes in part 1 and hours with the circuit in part 2, depending on the relay selected and the value of R_2 . A switch S_2 can be used to permit selection of either a short or long delay. Momentary switch S_3 can restart circuit timing before the time-out is completed. A bypass switch, S_1 removes the delay action.

IGNITION TIMING LIGHT



RADIO-ELECTRONICS

Fig. 7-15

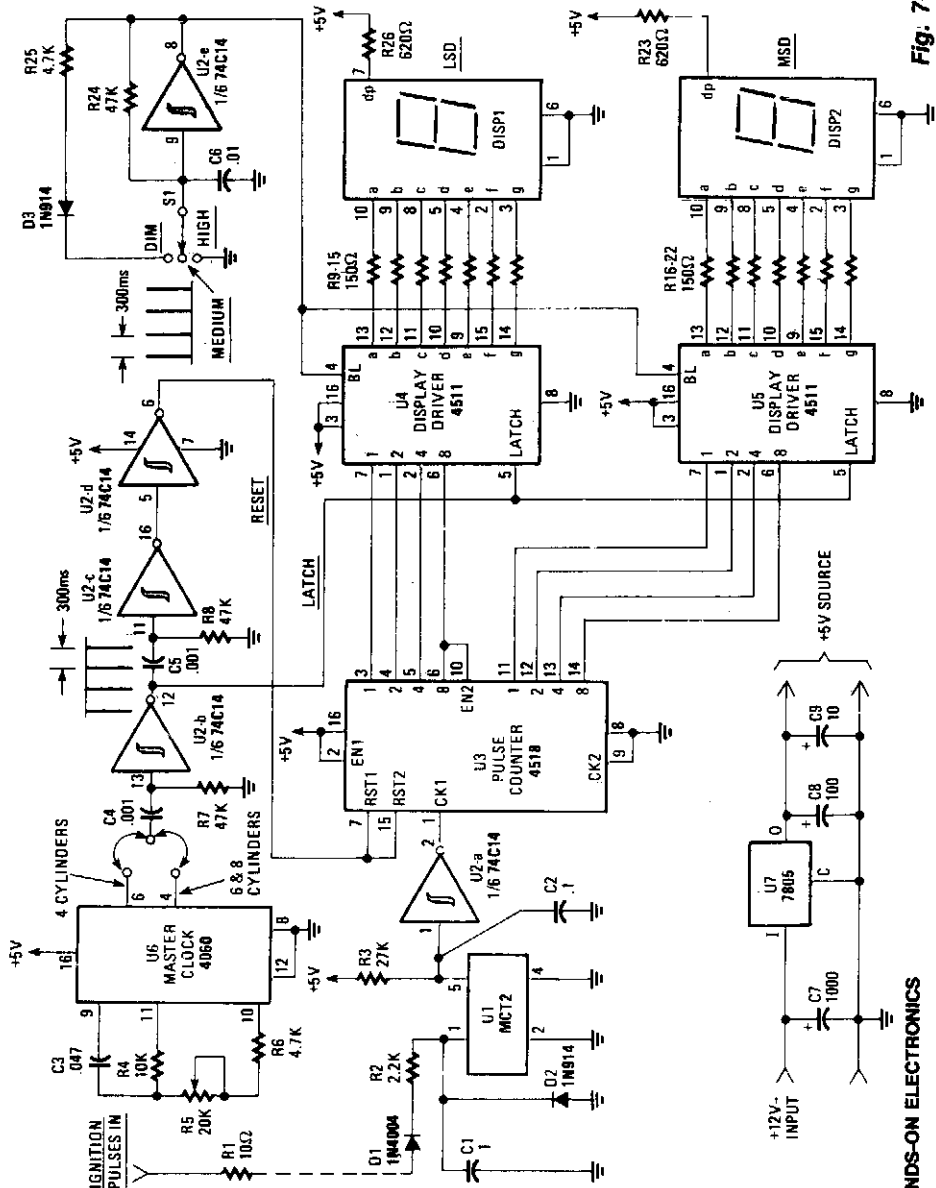
Circuit Notes

Figure A shows the circuit of a direct-trigger timing light. The trigger voltage is taken from the car's ignition circuit by a direct connection to a spark plug. A circuit using an inductive pickup is shown in Fig. B. A trigger transformer is used to develop the high-voltage pulse for triggering. The triggering circuit consists of T1, C1, SCR1, inductive pickup coil T2, and the waveshaping components in the SCR's gate circuit.

When the spark plug fires, it induces a pulse in pickup coil T2 that triggers the SCR gate. The SCR fires and discharges C2 through the primary of T1. The secondary of T1 feeds a high-voltage pulse to the trigger electrode of the flash tube. That pulse causes the gas—usually neon or xenon—to ionize. The ionized gas provides a low-resistance path for C1 to discharge, thereby creating a brilliant flash of light.

Resistor R1 limits current from the supply as the tube fires. When C1 is fully discharged the strobe tube cuts off and returns to its "high-resistance" state. The current through R2 is not enough to sustain conduction through SCR1, so it cuts off and remains off until it is re-triggered by a gate pulse.

DIGI-TACH



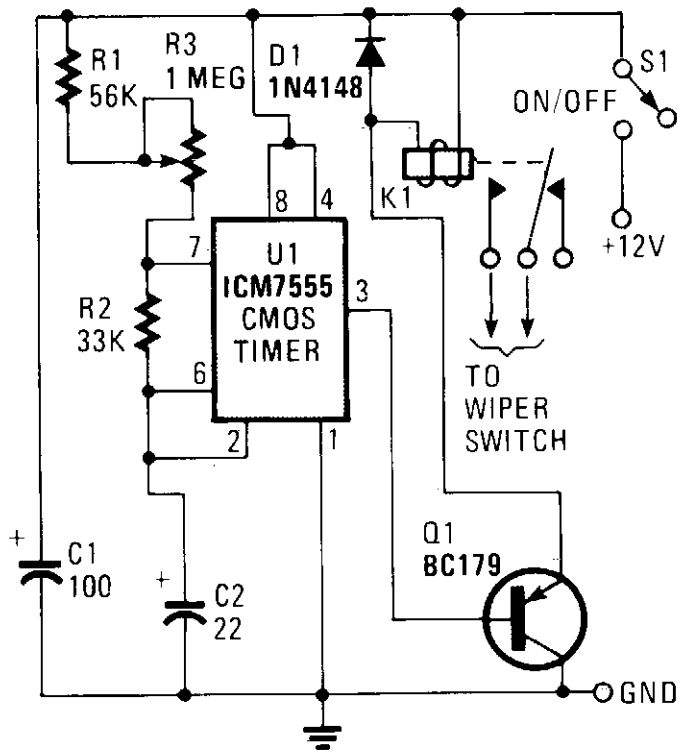
HANDS-ON ELECTRONICS

Circuit Notes

The Digi-Tach contains a master-clock circuits (U6), latch and reset pulse generators (U2-b-U2-d), input signal conditioner (U1, U2-a), pulse counter (U3), display and display drivers (DIS1, DIS2, U4, and U5), and a voltage regulator (U7). As an added feature, Digi-Tach contains a dimmer circuit (U2-e).

Fig. 7-16

CAR-WIPER CONTROL



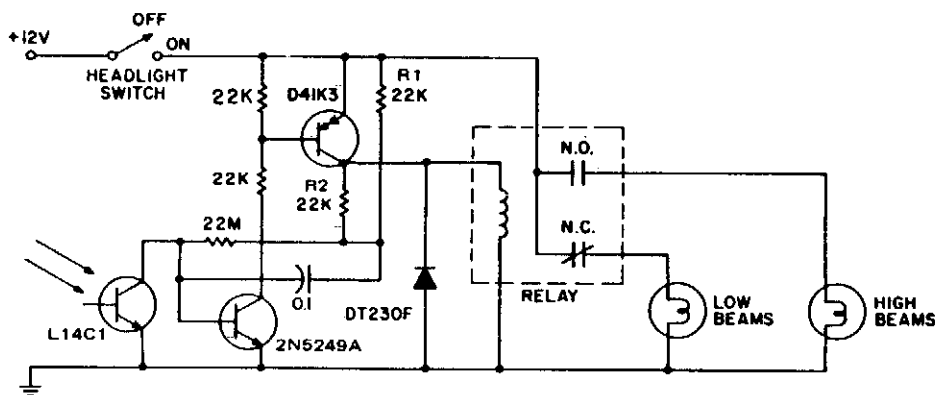
HANDS-ON ELECTRONICS

Fig. 7-17

Circuit Notes

U1 is configured to operate in the standard astable mode, providing a form of relaxation oscillator. When power is applied, C2 initially charges through R1, R2 and R3 to two-thirds of the supply voltage. At that point, U1 senses that its threshold voltage at pin 6 has been reached, and triggers the timer, causing its output at pin 3 to go high. That high, applied to the base of Q1, keeps the transistor in the off state. Now C2 begins to discharge through R2 to pin 7 of U1. When C2 has discharged to about one-third of the supply voltage, U1 is toggled back to its original state. C2 starts to charge again, as pin 3 of U1 goes low. The low at pin 3 causes Q1—which serves as an emitter-follower buffer stage—to turn on, allowing current to flow through the coil of relay K1. That, in turn, causes K1's contacts to close, applying power to the wipers. The charge time of capacitor C2 is determined by the setting of potentiometer R3. Capacitor C2 should be a tantalum type, and actually, almost any 12-volt coil relay with sufficiently heavy contacts should serve well.

AUTOMATIC HEADLIGHT DIMMER



RELAY: 12V, 0.3A COIL: 20A, FORM C, CONTACTS OR SOLID-STATE SWITCHING OF 16A STEADY-STATE 150A COLD FILAMENT SURGE, RATING.

LENS: MINIMUM 1" DIAMETER, POSITIONED FOR ABOUT 10° VIEW ANGLE.

GENERAL ELECTRIC

Fig. 7-18

Circuit Notes

This circuit switches car headlights to the low beam state when it senses the lights of an on-coming car. The received light is very low level and highly directional, indicating the use of a lens with the detector. A relatively large amount of hysteresis is built into the circuit to prevent "flashing lights." Sensitivity is set by the 22 megohm resistor to about 0.5 ft. candle at the transistor (0.01 at the lens), while hysteresis is determined by the R1, R2 resistor voltage divider, parallel to the D41K3 collector emitter, which drives the 22 megohm resistor; maximum switching rate is limited by the 0.1 μ F capacitor to 15/minute.

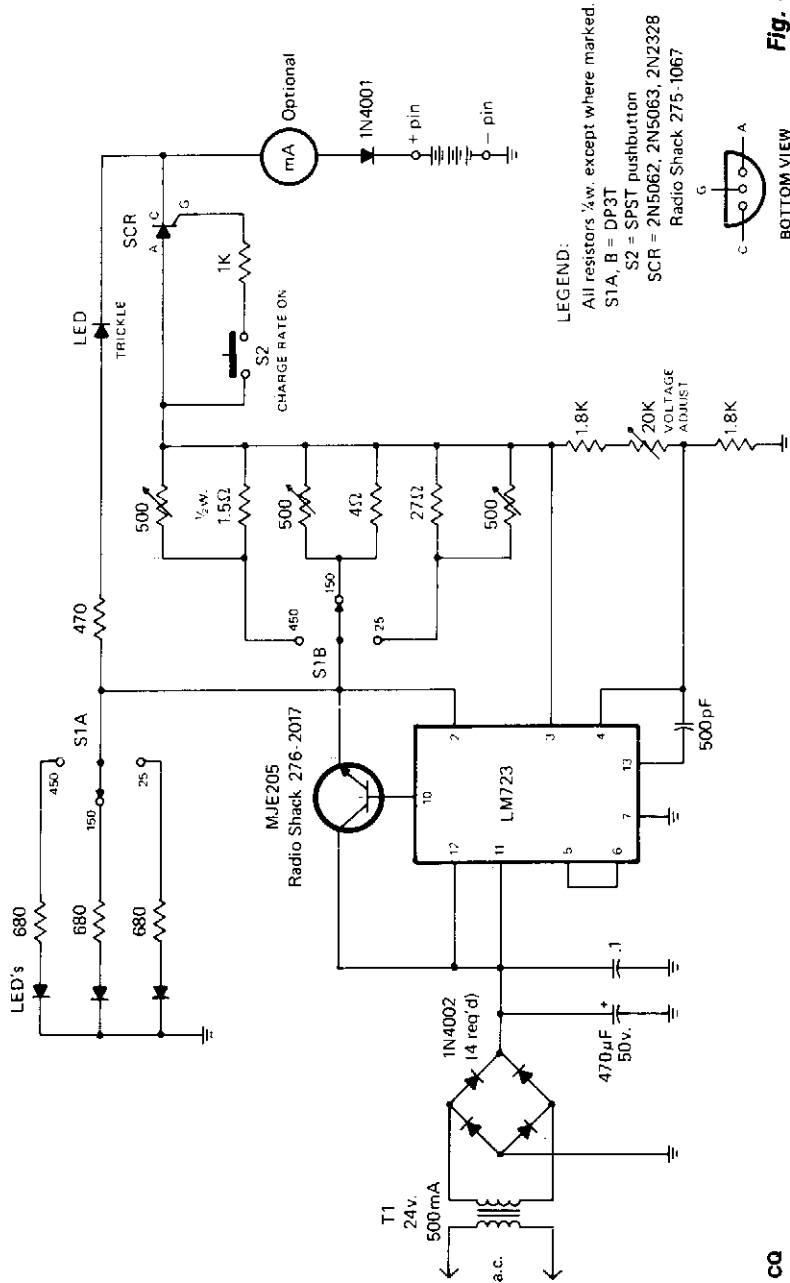
8

Battery Chargers and Zappers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Rapid Battery Charger for ICOM IC-2A
Gel Cell Charger
Ni-Cad Battery Zapper
Lithium Battery Charger
Thermally Controlled Ni-Cad Charger
Ni-Cad Battery Zapper II
Battery Charger
Wind Powered Battery Charger
Battery Charger Operates On Single Solar Cell
Versatile Battery Charger
14-Volt, 4-Amp Battery Charger/Power Supply

RAPID BATTERY CHARGER FOR ICOM IC-2A



LEGEND:
 All resistors 1/4w, except where marked.
 S1A, B = DP3T
 S2 = SPST pushbutton
 SCR = 2N5062, 2N5063, 2N2328
 Radio Shack 275-1067

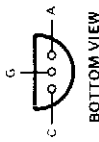


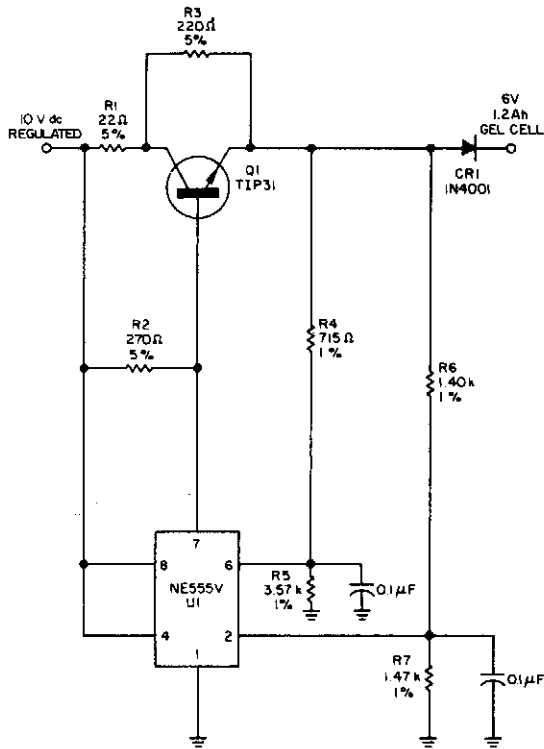
Fig. 8-1

Circuit Notes

Rectified and filtered voltage from the 24 Vac transformer is applied to the LM723 voltage regulator and the npn pass transistor set up for constant current supply. The 470 ohm resistor limits trickle current until the momentary pushbutton (S2) is depressed, the SCR turns on and current flows through the previously determined resistor network limiting the charging current. The SCR will turn off when the thermal cutout circuit inside the battery pack opens up.

CO

GEL CELL CHARGER



Circuit Notes

This circuit detects a full-charge state and automatically switches to a float condition—from 240 mA to 12 mA.

Fig. 8-2

ELECTRONIC DESIGN

Ni-CAD BATTERY ZAPPER

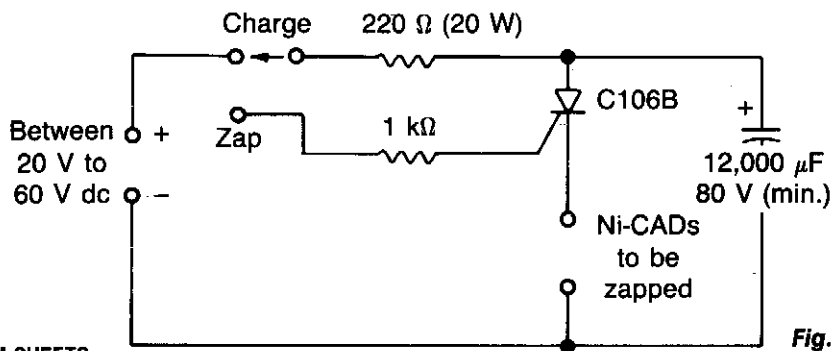


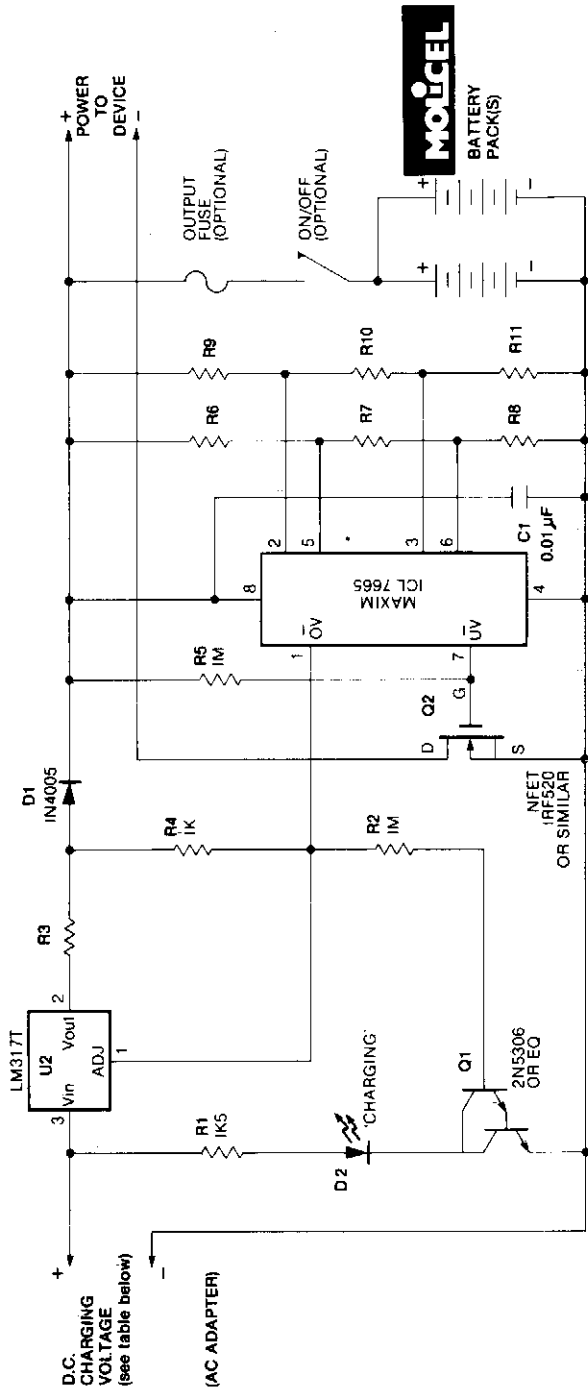
Fig. 8-3

WILLIAM SHEETS

Circuit Notes

The short in a Ni-Cad battery can be "burned off" with this zapper. Use of the SCR keeps heavy discharge current from damaging switch contacts.

LITHIUM BATTERY CHARGER



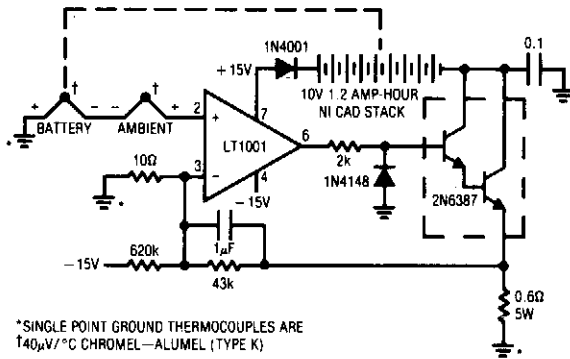
MOLJ ENERGY LIMITED

Circuit Notes

Charging is accomplished with a constant current of 60 mA for AA cells to a cutoff voltage of 2.4 V per cell at which point the charge must be terminated. The charging system shown is designed for multi-cell battery packs of 2 to 6 series-connected cells or series/parallel arrangements. It is essential that all cells assembled in the pack be at an identical state-of-charge (voltage) prior to charging. The maximum upper cut-off voltage is 15.6 volts ($6 \times 2.6 \text{ V}$).

Fig. 8-4

THERMALLY CONTROLLED NI-CAD CHARGER



*SINGLE POINT GROUND THERMOCOUPLES ARE
 $\uparrow 40\mu\text{V}/^\circ\text{C}$ CHROMEL—ALUMEL (TYPE K)

LINEAR TECHNOLOGY CORPORATION

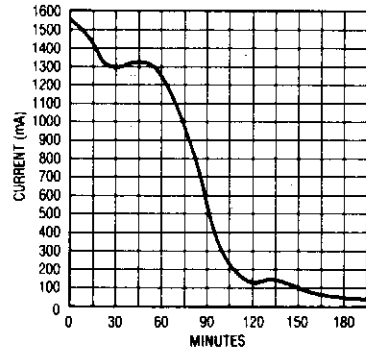
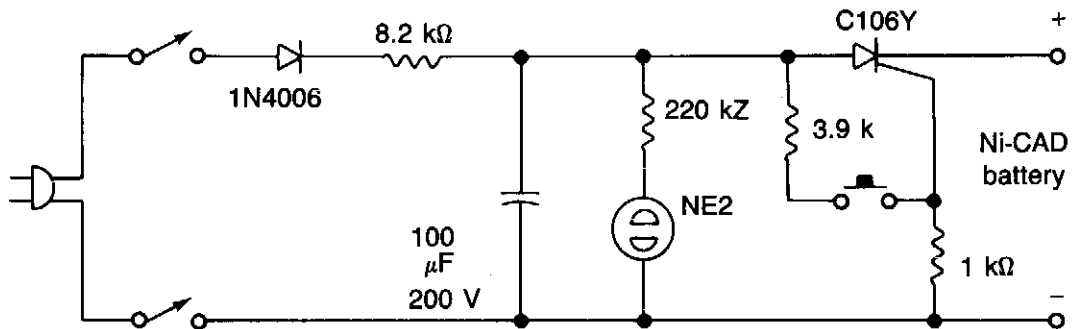


Fig. 8-5

Circuit Notes

One way to charge Ni-Cad batteries rapidly without abuse is to measure cell temperature and taper the charge accordingly. The circuit uses a thermocouple for this function. A second thermocouple nulls out the effects of ambient temperature. The temperature difference between the two thermocouples determines the voltage which appears at the amplifier's positive input. As battery temperature rises, this small negative voltage (1°C difference between the thermocouples equals $40\mu\text{V}$) becomes larger. The amplifier, operating at a gain of 4300, gradually reduces the current through the battery to maintain its inputs at balance. The battery charges at a high rate until heating occurs and the circuit then tapers the charge. The values given in the circuit limit the battery surface temperature rise over ambient to about 5°C .

NI-CAD BATTERY ZAPPER II



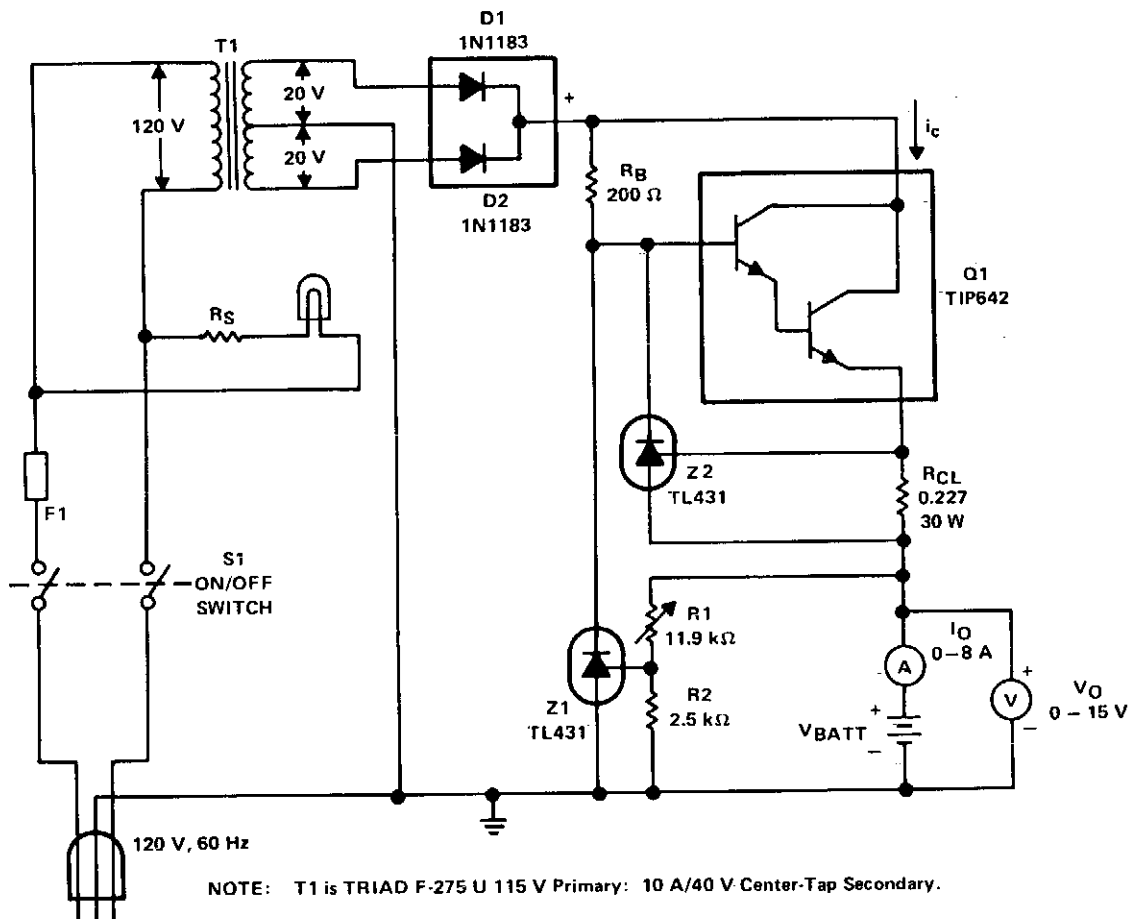
WILLIAM SHEETS

Fig. 8-6

Circuit Notes

This zapper clears internal short in nickel cadmium batteries by burning it away. **CAUTION:** The negative battery terminal is connected to one side of the ac line. For safety operation use a 1:1 isolation transformer.

BATTERY CHARGER



TEXAS INSTRUMENTS

Fig. 8-7

Circuit Notes

The charger is based on a charging voltage of 2.4 V per cell, in accordance with most manufacturers' recommendations. The circuit pulses the battery under charge with 14.4 V (6 cells \times 2.4 V per cell) at a rate of 120 Hz. The design provides current limiting to protect the charger's internal components while limiting the charging rate to prevent damaging severely discharged lead-acid batteries. The maximum recommended charging current is normally about one-fourth the ampere-hour rating of the battery. For example, the maximum charging current for an average 44 ampere-hour battery is 11 A. If the impedance of the load requires a charging current greater than the 11 A current limit, the circuit will go into current limiting. The amplitude of the charging pulses is controlled to maintain a maximum peak charging current of 11 A (8 A average).

WIND POWERED BATTERY CHARGER

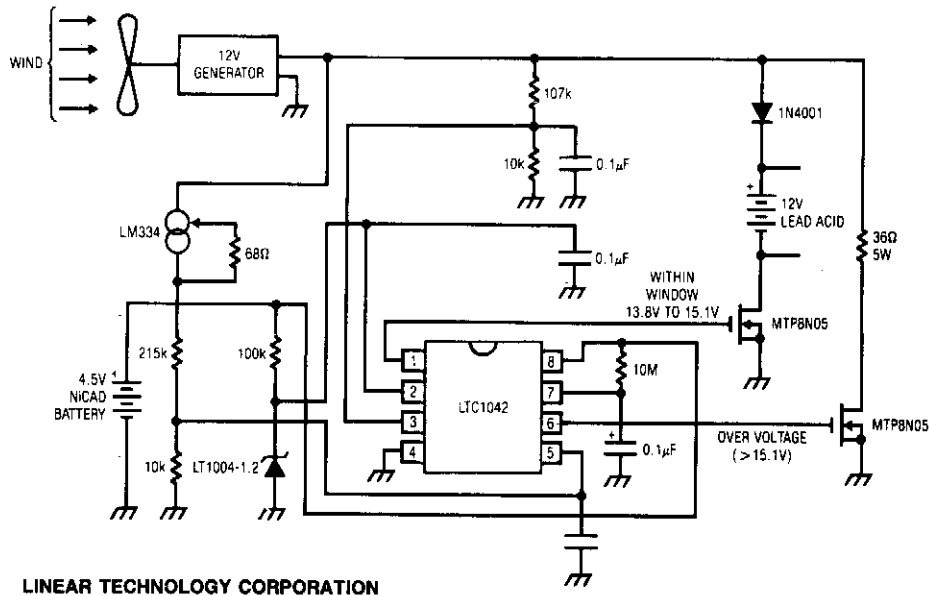


Fig. 8-8

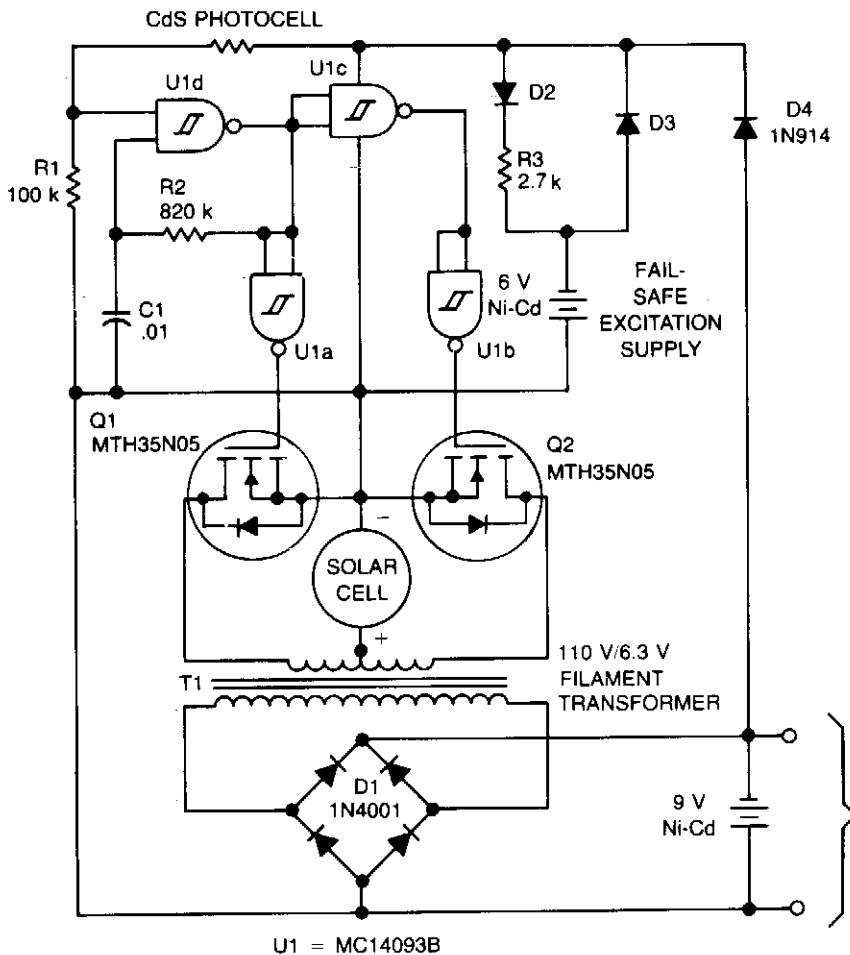
Circuit Notes

The dc motor is used as a generator with the voltage output being proportional to its rpm. The LTC1042 monitors the voltage output and provides the following control functions.

1. If generator voltage output is below 13.8 V, the control circuit is active and the Ni-Cad battery is charging through the LM334 current source. The lead acid battery is not being charged.
2. If the generator voltage output is between 13.8 V and 15.1 V, the 12 V lead acid battery is being charged at about 1 amp/hour rate (limited by the power FET).
3. If generator voltage exceeds 15.1 V (a condition caused by excessive wind speed or 12 V battery being fully charged) then a fixed load is connected limiting the generator rpm to prevent damage.

This charger can be used as a remote source of power where wind energy is plentiful such as on sailboats or remote radio repeater sites. Unlike solar powered panels, this system will function in bad weather and at night.

BATTERY CHARGER OPERATES ON SINGLE SOLAR CELL



MOTOROLA

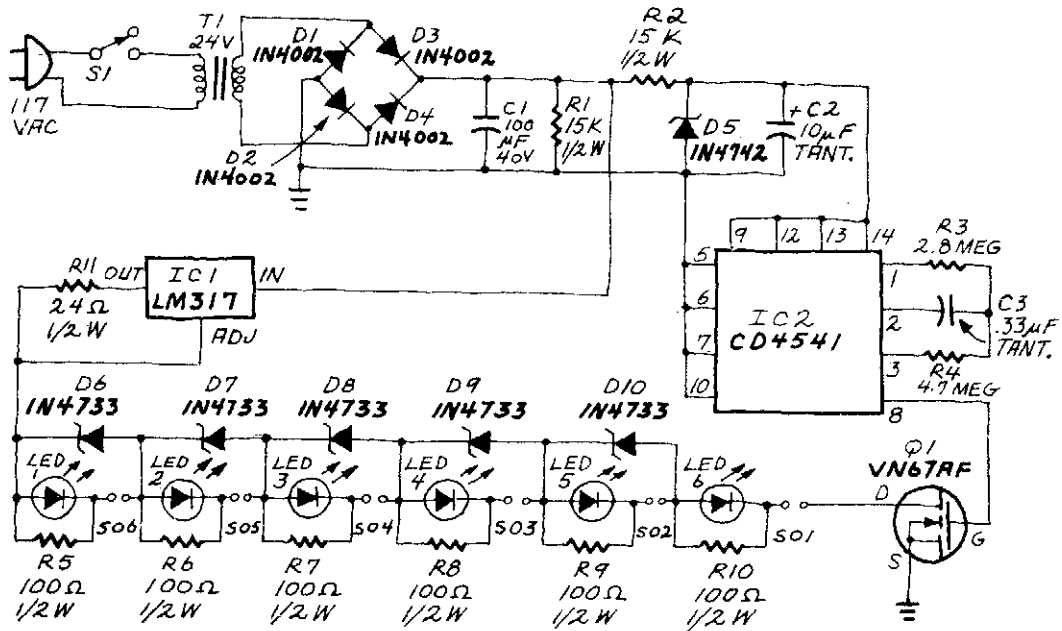
Fig. 8-9

Circuit Notes

The circuit charges a 9-V battery at about 30 mA per input ampere at 0.4 V. U1, a quad Schmitt trigger, operate as an astable multivibrator to drive push-pull TMOS devices Q1 and Q2. Power for U1 is derived from the 9-V battery via D4; power for Q1 and Q2 is supplied by the solar cell. The multivibrator frequency, determined by R2-C1, is set to 180 Hz for maximum efficiency from a 6.3-V filament transformer, T1. The secondary of the transformer is applied to a full wave bridge rectifier, D1, which is connected to the batteries being charged. The small Ni-Cad battery is a fail-safe excitation supply to allow the system to recover if the 9-V battery becomes fully discharged.

A CdS photocell shuts off the oscillator in darkness to preserve the fail-safe battery during shipping and storage, or prolonged darkness.

VERSATILE BATTERY CHARGER



RADIO ELECTRONICS

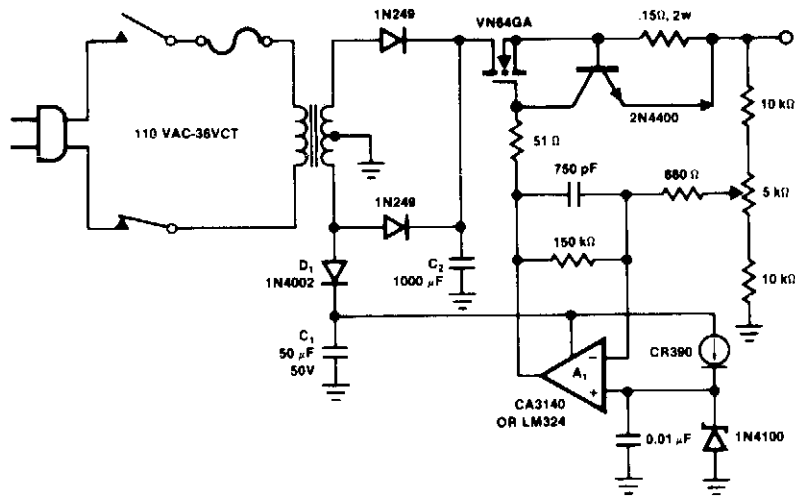
Fig. 8-10

Circuit Notes

An LM317 voltage regulator is configured as a constant-current source. It is used to supply the 50 mA charging current to S01-S06, an array of AA-cell battery holders. Each of the battery holders is wired in series with an LED and its associated shunt resistor. When the battery holder contains a battery, the LED glows during charging. Each battery holder/LED combination is paralleled by a 5.1-volt Zener diode. If the battery holder is empty, the Zener conducts the current around the holder.

A timing circuit prevents overcharging. When power is applied to the circuit, timing is initiated by IC2, a CD4541 oscillator/programmable timer. The output of IC2 is fed to Q1. When that output is high, the transistor is on, and the charging circuit is completed. When the output is low, the transistor is off, and the path to ground is interrupted.

14-VOLT, 4-AMP BATTERY CHARGER/POWER SUPPLY



SILICONIX, INC.

Fig. 8-11

Circuit Notes

Operation amplifier A1 directly drives the VN64GA with the error signal to control the output voltage. Peak rectifier D1, C1 supplies error amplifier A1 and the reference zener. This extra drive voltage must exceed its source voltage by several volts for the VN64GA to pass full load current. The output voltage is pulsating dc which is quite satisfactory for battery charging. To convert the system to a regulated dc supply, capacitor C2 is increased and another electrolytic capacitor is added across the load. The response time is very fast, being determined by the op-amp. The 2N4400 current limiter circuit prevents the output current from exceeding 4.5 A. However, maintaining a shorted condition for more than a second will cause the VN64GA to exceed its temperature ratings. A generous heat sink, on the order of 1°C/W, must be used.

9

Battery Monitors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dynamic, Constant Current Load for Fuel
Cell/Battery Testing
Voltage Detector Relay for Battery Charger
Battery Status Indicator
Low-Battery Indicator
A Lithium Battery's State-of-Charge Indicator
Step-Up Switching Regulator for 6-V Battery
Battery Voltage Monitor
Battery Monitor

DYNAMIC, CONSTANT CURRENT LOAD FOR FUEL CELL/BATTERY TESTING

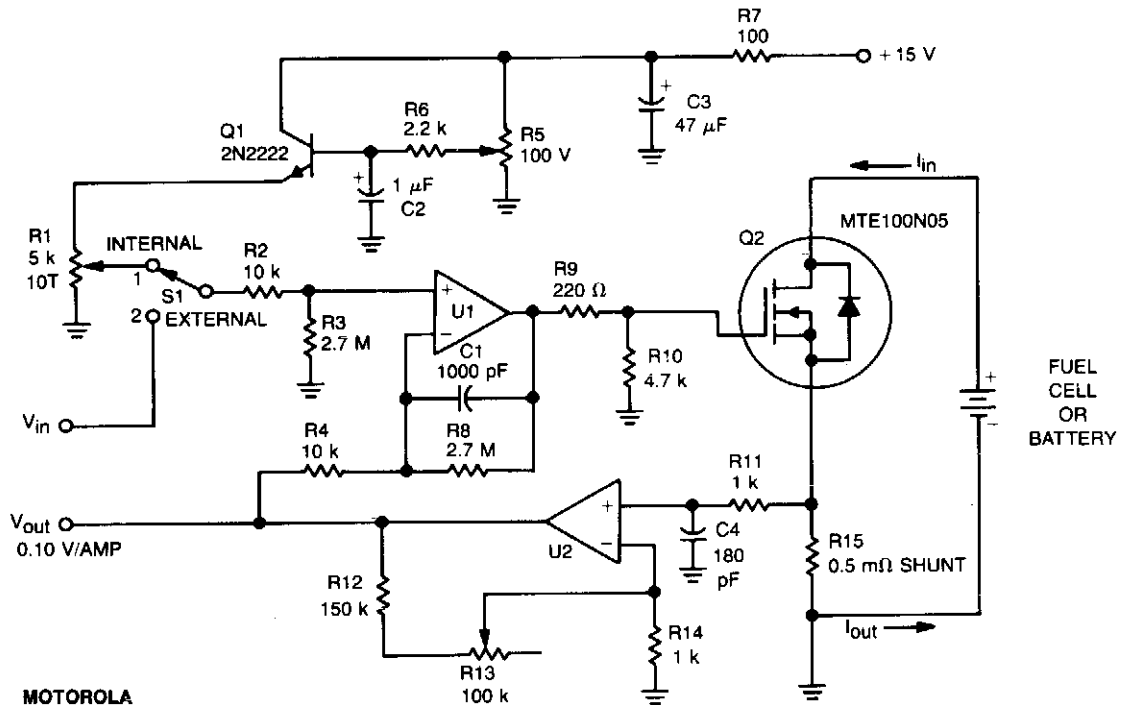


Fig. 9-1

Circuit Notes

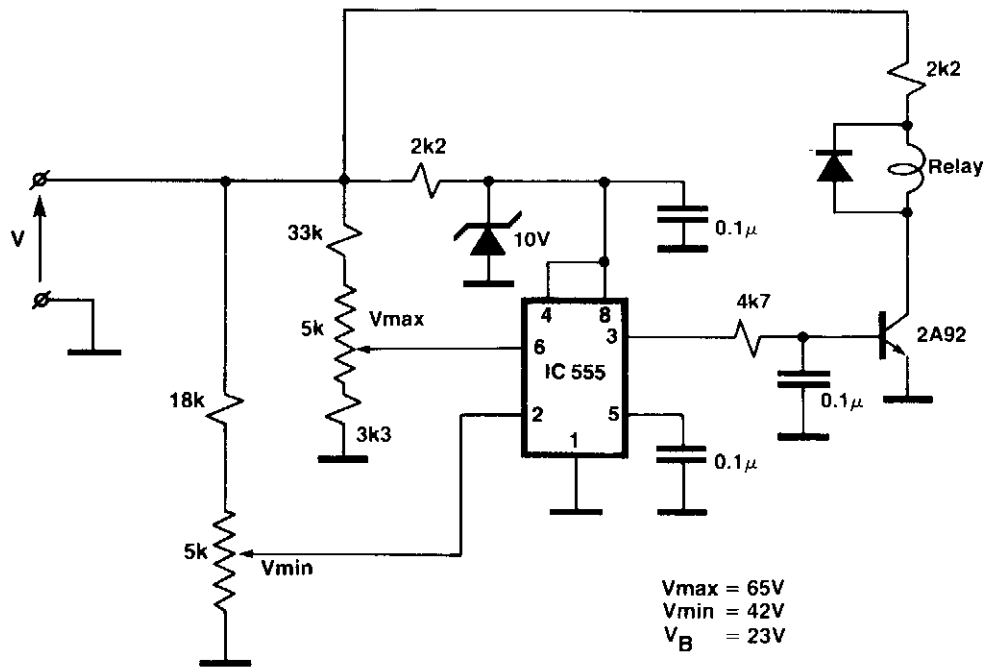
This circuit was designed for testing fuel cells, but it could also be used for testing batteries under a constant current load. It provides a dynamic, constant current load, eliminating the need to manually adjust the load to maintain a constant load.

For fuel cell application, the load must be able to absorb 20-40 A, and since a single cell develops only 0.5 to 1.0 V, bipolar power devices (such as a Darlington) are impractical. Therefore, this dynamic load was designed with a TMOS Power FET (Q2).

With switch S1 in position 1, emitter follower Q1 and R1 establish the current level for the load. In position 2, an external voltage can be applied to control the current level.

Operational amplifier U1 drives TMOS device Q1, which sets the load current seen by the fuel cell or battery. The voltage drop across R15, which is related to the load current, is then applied to U2, whose output is fed back to U1. Thus, if the voltage across R15 would tend to change, feedback to the minus input of U1 causes that voltage (and the load current) to remain constant. Adjustment of R13 controls the volts/amp of feedback. The V_{OUT} point is used to monitor the system.

VOLTAGE DETECTOR RELAY FOR BATTERY CHARGER



ELECTRONIC ENGINEERING

Fig. 9-2

Circuit Notes

While the battery is being charged, its voltage is measured at V. If the measured voltage is lower than the minimum the relay will be energized, that will connect the charger circuit. When the battery voltage runs over the maximum set point, the relay is deenergized and it will be held that way until the voltage decreases below the minimum when it will be connected again. The voltage is lower than a threshold V_B (low breaking voltage) the relay will be assumed that such a low voltage is due to one or several damaged battery components. Of course V_B is much lower than the minimum set point.

BATTERY STATUS INDICATOR

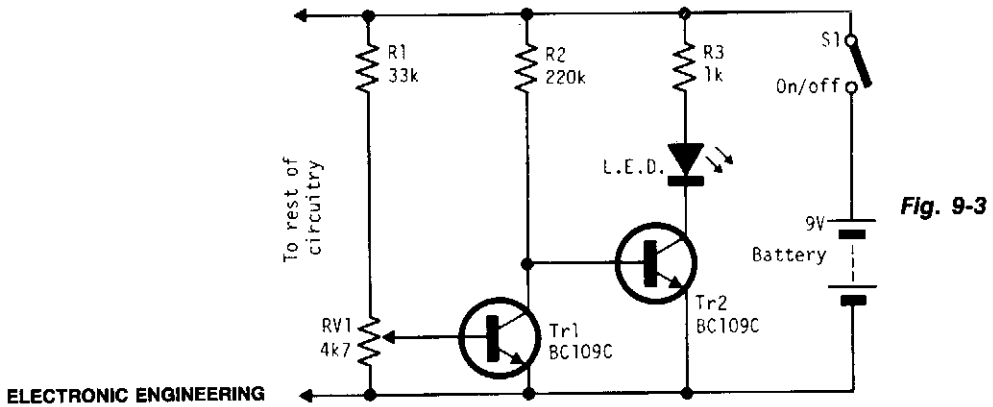
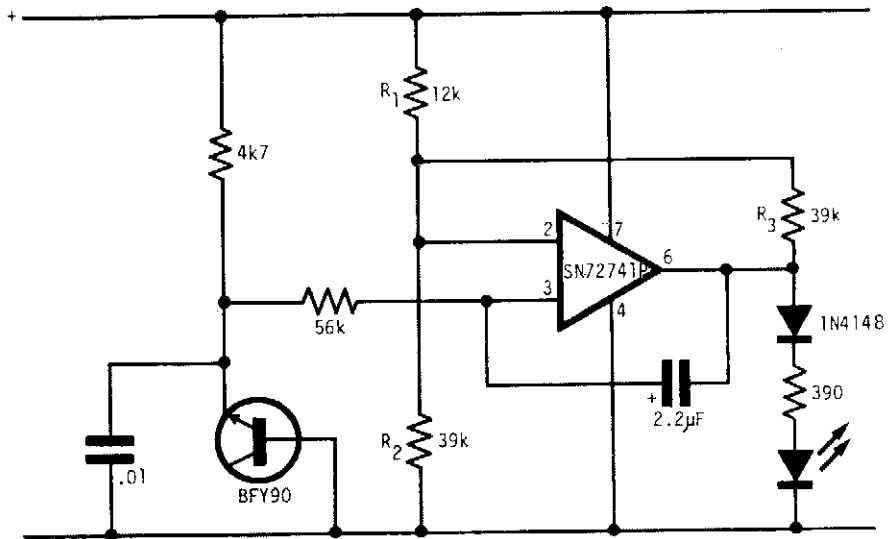


Fig. 9-3

Circuit Notes

Continually monitors battery voltage during use and consumes only about 250 μA (until the end point is reached). Near the end point Tr1 turns off, allowing Tr2 to illuminate the LED to increase current drain further leading to a distinct turn off point.

LOW-BATTERY INDICATOR



ELECTRONIC ENGINEERING

Fig. 9-4

Circuit Notes

Under good battery conditions the LED is off. As the battery voltage falls, the LED begins to flash until, in the low battery condition, the LED lights continuously. Designed for a 9-volt battery, with the values shown the LED flashes from 7.5 to 6.5 volts.

A LITHIUM BATTERY'S STATE-OF-CHARGE INDICATOR

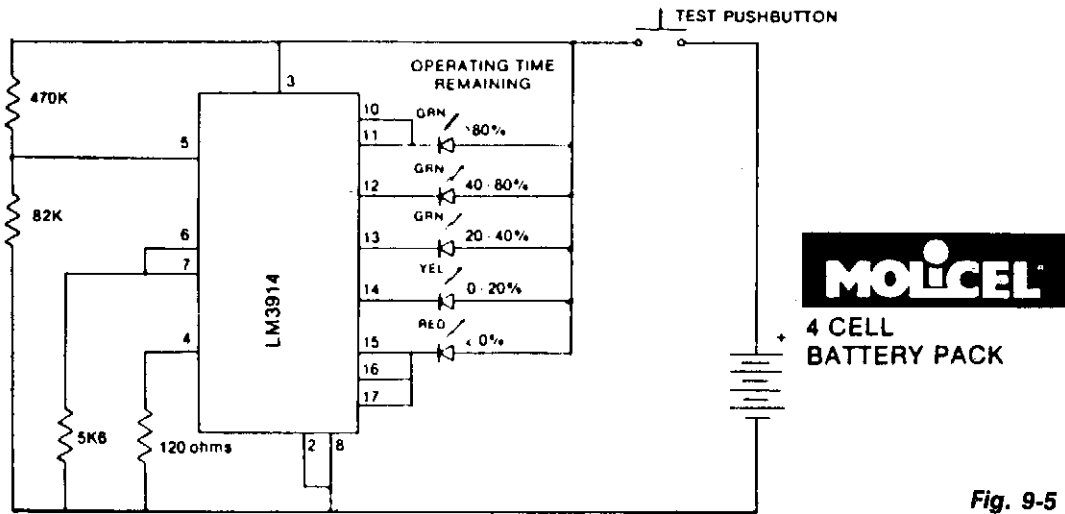


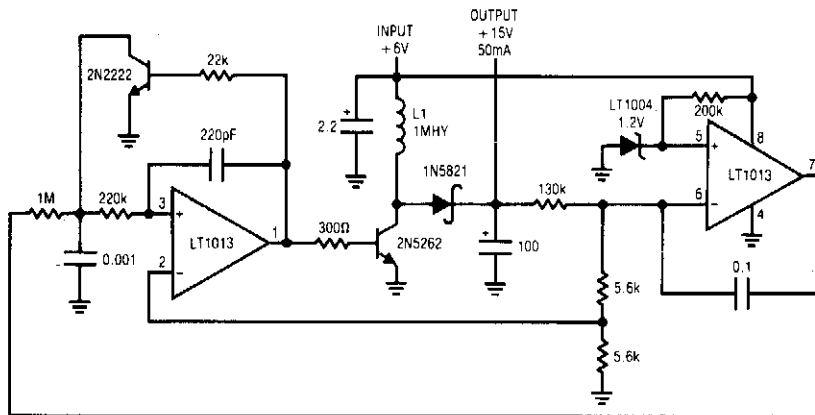
Fig. 9-5

MOLI ENERGY LIMITED

Circuit Notes

State-of-Charge indication of a sloping-voltage discharge can be used as a state-of-charge indicator. A typical voltage comparator circuit that gives a visual indication of state-of-charge is shown. Components identified are for a 4-cell input voltage of 9.6 to 5.2 volts.

STEP-UP SWITCHING REGULATOR FOR 6-V BATTERY

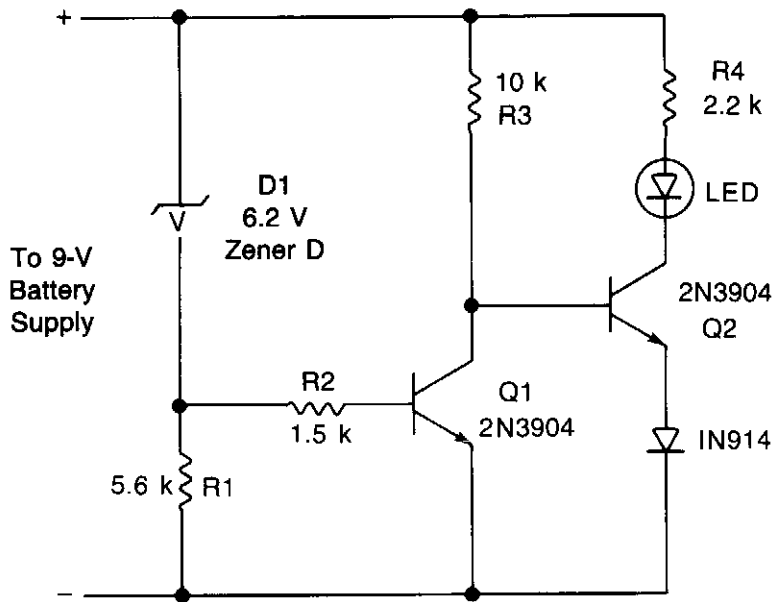


L1 = AIE-VERNITRON 24-104
78% EFFICIENCY

LINEAR TECHNOLOGY CORP.

Fig. 9-6

BATTERY VOLTAGE MONITOR



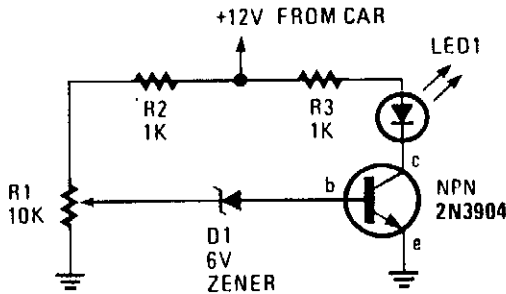
WILLIAM SHEETS

Fig. 9-7

Circuit Notes

This circuit gives an early warning of the discharge of batteries. Zener diode D1 is chosen for the voltage below which an indication is required (9 V). Should the supply drop to below 7 V, D1 will cease conducting causing Q1 to shut off. Its collector voltage will now increase causing Q2 to start conducting via LED1 and its limiting resistor R4.

BATTERY MONITOR



Circuit Notes

The circuit is quick and easy to put together and install, and tells you when battery voltage falls below the set limit as established by R1 (a 10,000-ohm potentiometer). It can indicate, via LED1, that the battery may be defective or in need of change if operating the starter causes the battery voltage to drop below the present limit.

TAB BOOKS, INC.

Fig. 9-8

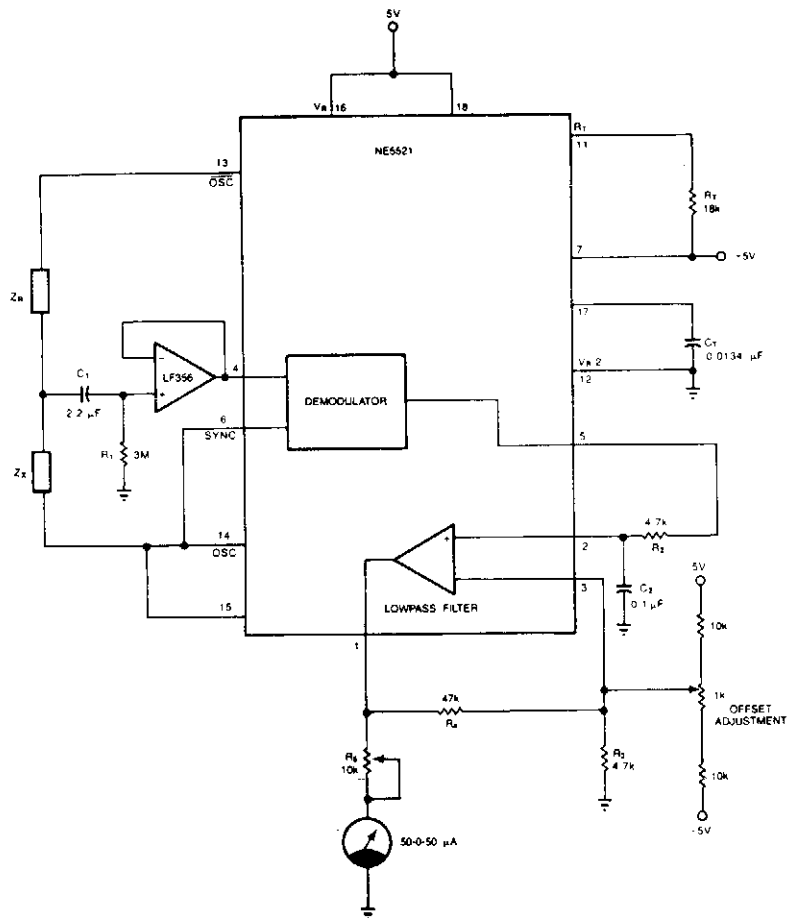
10

Bridge Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ac Bridge
Bridge-Balance Indicator
Bridge Circuit
Typical Two Op Amp Bridge-Type Differential
Amplifier
Low-Power Common Source Amplifier
Amplifier for Bridge Transducers
Strain Gage Bridge Signal Conditioner

AC BRIDGE



SIGNETICS

Fig. 10-1

Circuit Notes

The circuit provides a simple and cost-effective solution to matching resistors and capacitors. Impedances Z_R and Z_X form a half-bridge, while OSC and OSC-bar excite the bridge differentially. The external op amp is a FET input amplifier (LF356) with very low input bias current on the order of 30 pA (typical). C_1 allows ac coupling by blocking the dc common mode voltage from the bridge, while R_1 biases the output of LF356 to 0 V at dc. Use of FET input op amp insures that dc offset due to bias current through R_1 is negligible. Ac output of the demodulator is filtered via the uncommitted amp to provide dc voltage for the meter. The 10 k potentiometer, R_5 , limits the current into the meter to a safe level. Calibration begins by placing equal impedances at Z_R and Z_X , and the system offset is nulled by the offset adjust circuit so that Pin 1 is at 0 V. Next, known values are placed at Z_X and the meter deviations are calibrated. The bridge is now ready to measure an unknown impedance at Z_X with $\pm 0.05\%$ accuracy or better.

BRIDGE-BALANCE INDICATOR

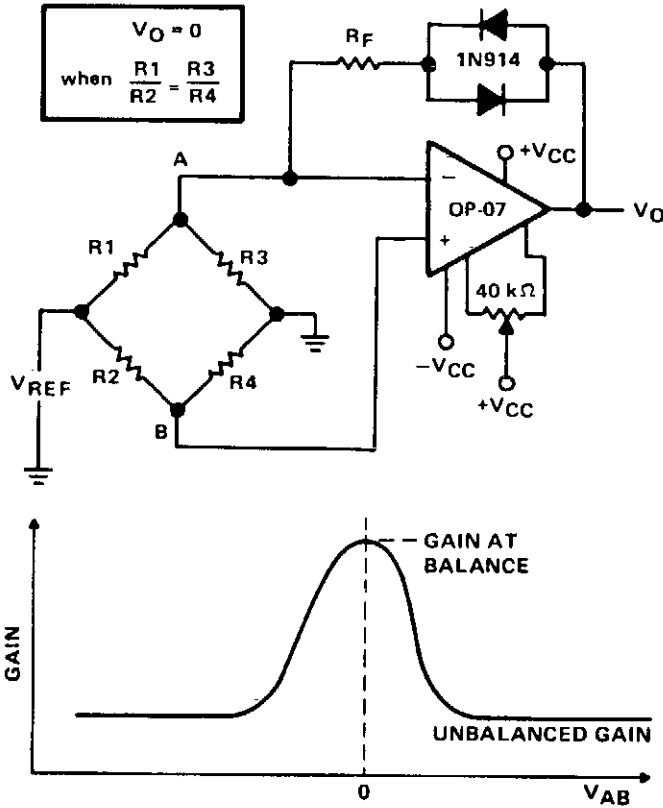


Fig. 10-2

TEXAS INSTRUMENTS

Circuit Notes

Indicator provides an accurate comparison of two voltages by indicating their degree of balance (or imbalance). Detecting small variations near the null point is difficult with the basic Wheatstone bridge alone. Amplification of voltage differences near the null point will improve circuit accuracy and ease of use.

The 1N914 diodes in the feedback loop result in high sensitivity near the point of balance ($R_1/R_2 = R_3/R_4$). When the bridge is unbalanced the amplifier's closed-loop gain is approximately R_F/r , where r is the parallel equivalent of R_1 and R_3 . The resulting gain equation is $G = R_F(1/R_1 + 1/R_3)$. During an unbalanced condition the voltage at point A is different from that at point B. This difference voltage (V_{AB}), amplified by the gain factor G , appears as an output voltage. As the bridge approaches a balanced condition ($R_1/R_2 = R_3/R_4$), V_{AB} approaches zero. As V_{AB} approaches zero the 1N914 diodes in the feedback loop lose their forward bias and their resistance increases, causing the total feedback resistance to increase. This increases circuit gain and accuracy in detecting a balanced condition. The figure shows the effect of approaching balance on circuit gain. The visual indicator used at the output of the OP-07 could be a sensitive voltmeter or oscilloscope.

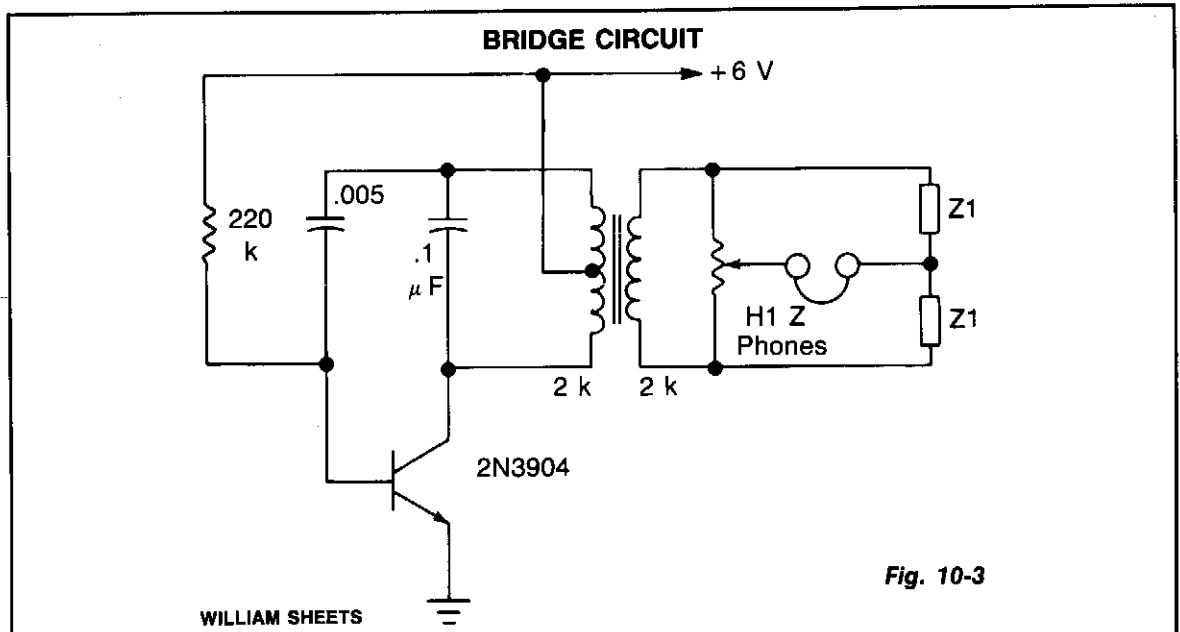
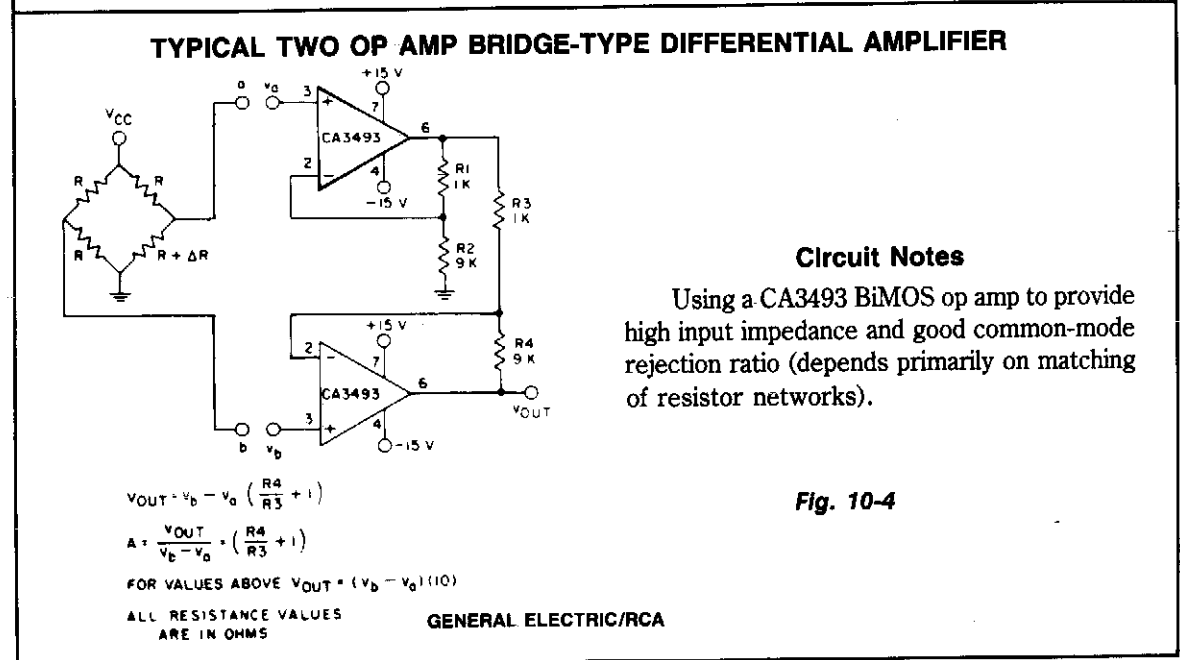


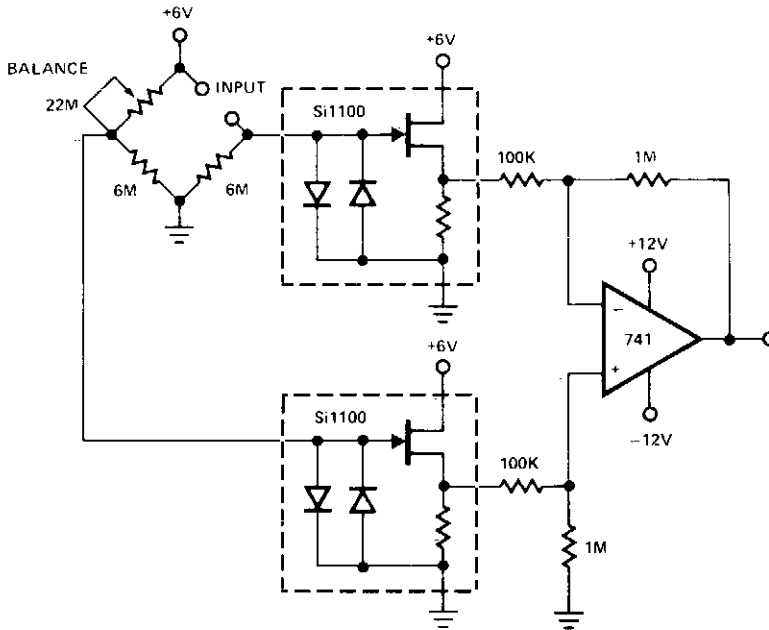
Fig. 10-3

Circuit Notes

The transistor is connected as an audio oscillator, using an audio transformer in the collector. The secondary goes to a linear pot. The ratio between the two parts of the pot from the slider is proportional to the values of Z1 and Z2 when no signal is heard in the phones.



LOW-POWER COMMON SOURCE AMPLIFIER



SILICONIX, INC.

Fig. 10-5

Circuit Notes

A circuit that will operate in the 10- to 20- microamp range at a 12-volt supply voltage. The diode protection is available in this configuration. The circuit voltage gain will be between 10 and 20, with extremely low power consumption (approximately $250 \mu\text{W}$). This is very desirable for remote or battery operation where minimum maintenance is important.

AMPLIFIER FOR BRIDGE TRANSDUCERS

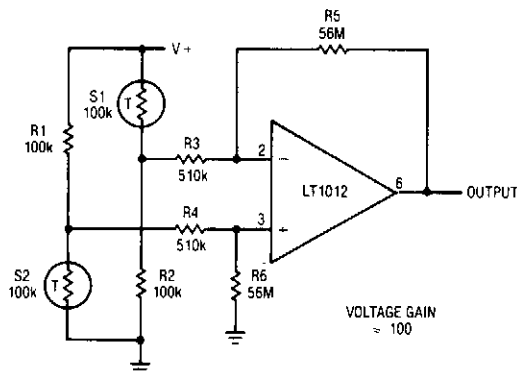
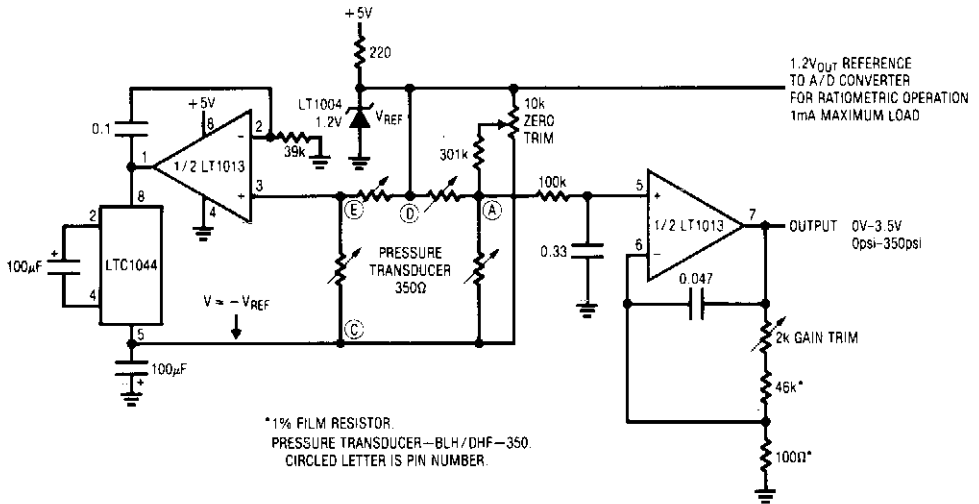


Fig. 10-6

LINEAR TECHNOLOGY CORP.

STRAIN GAUGE BRIDGE SIGNAL CONDITIONER



LINEAR TECHNOLOGY CORP.

Fig. 10-7

11

Burst Generators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Single-Tone Burst Generator
Square Waveform Multiburst Generator
Single-Timer IC Provides Square-Wave Tone Bursts
Strobe-Tone Burst Generator
Tone Burst Generator

SINGLE-TONE BURST GENERATOR

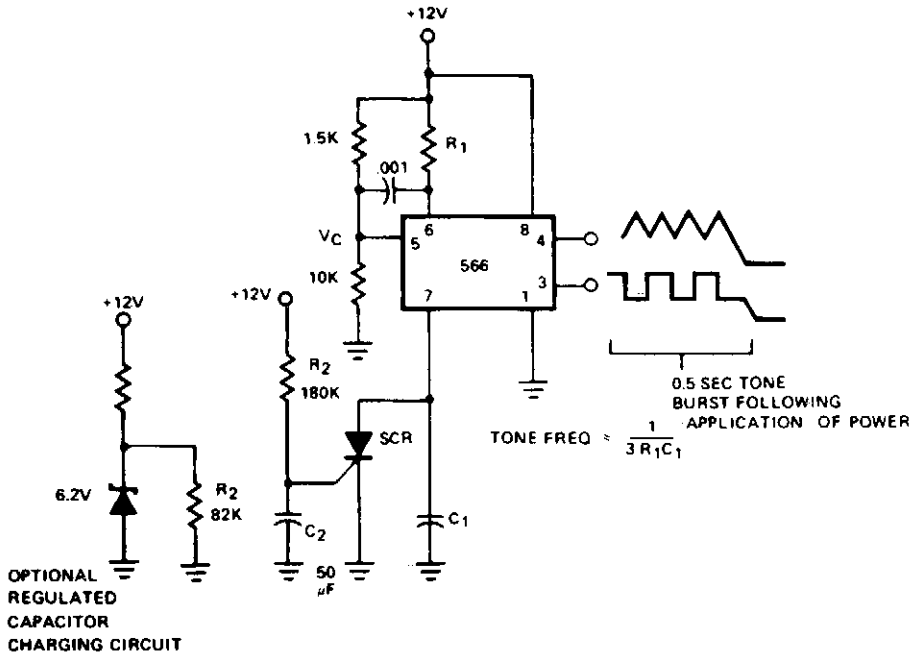
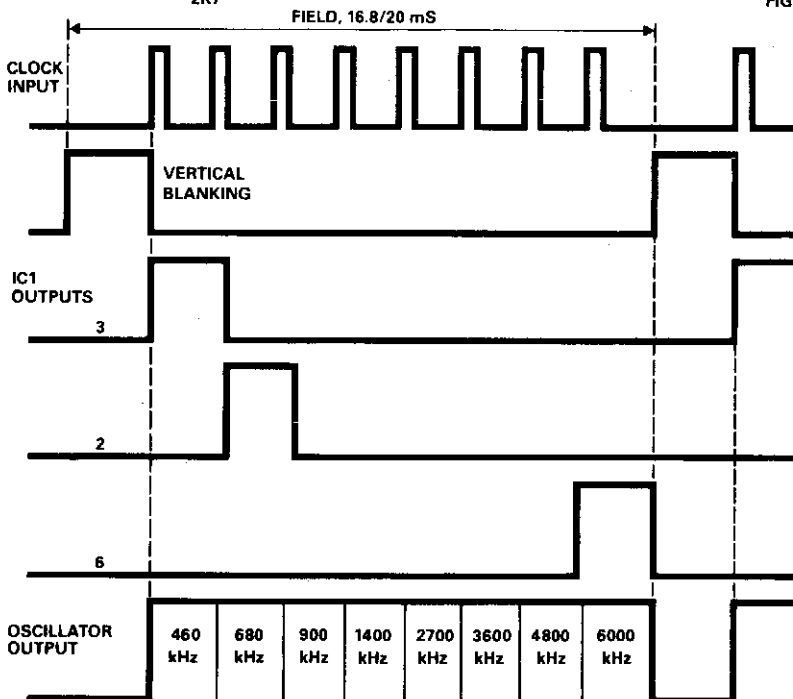
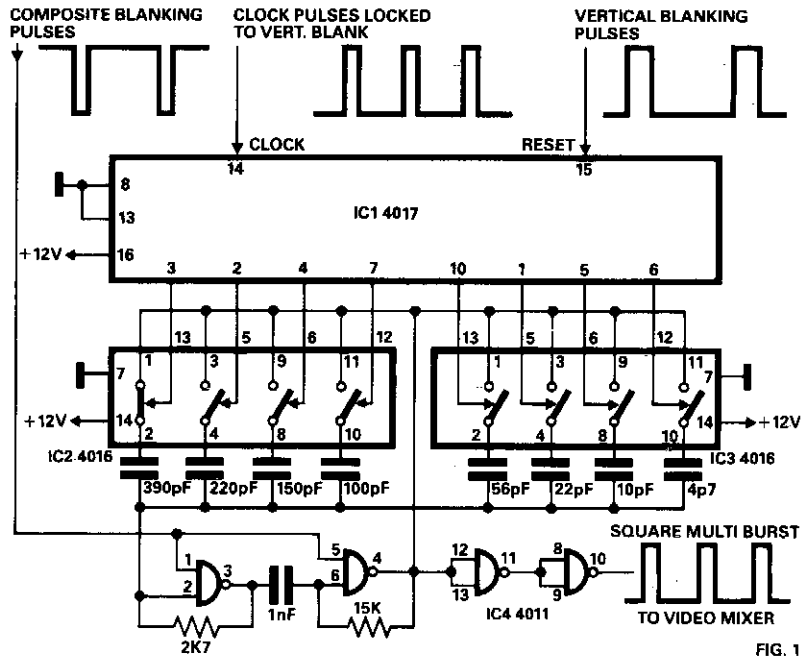


Fig. 11-1

Circuit Notes

The tone burst generator supplies a tone for one-half second after the power supply is activated; its intended use is a communications network alert signal. Cessation of the tone is accomplished at the SCR, which shunts the timing capacitor C1 charge current when activated. The SCR is gated on when C2 charges up to the gate voltage which occurs in 0.5 seconds. Since only 70 μ A are available for triggering, the SCR must be sensitive enough to trigger at this level. The triggering current can be increased, of course, by reducing R2 (and increasing C2 to keep the same time constant). If the tone duration must be constant under widely varying supply voltage conditions, the optional Zener regulator circuit can be added, along with the new value for R2 $R_2' = 82$ k Ω . If the SCR is replaced by an npn transistor, the tone can be switched on and off at will at the transistor base terminal.

SQUARE WAVEFORM MULTIBURST GENERATOR



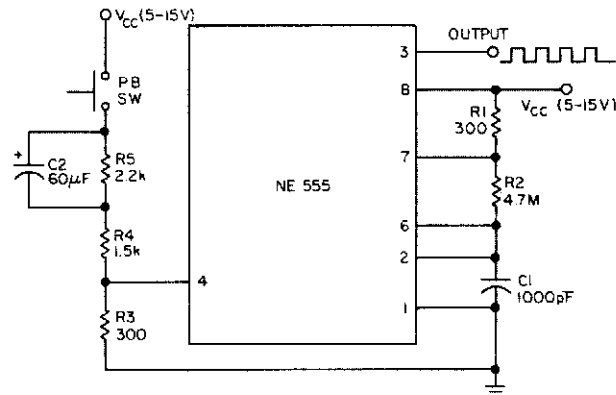
SQUARE WAVEFORM MULTIBURST GENERATOR, Continued.

Circuit Notes

The generator described here is intended for multiburst signal square waveform generation and can be used as a device for characterizing the response of TV monitor amplifiers as shown. The circuit is an RC oscillator with NAND gates (IC4-4011), with its capacitor C changed periodically by means of bilateral switches (IC2, IC3-4016). The control inputs of bilateral switches are driven by the outputs of a counter/decoder (IC1-4017) the operation of which is determined by generated clock pulses, so that they occur eight times at half-picture (field). These pulses are locked to vertical blank pulses.

Horizontal synchronization is achieved by means of composite blanking pulses (negative polarization) applied to pins 1 and 5 of IC4. The oscillator frequency changes in the following discrete steps: 460 kHz, 680 kHz, 900 kHz, 1400 kHz, 2700 kHz, 3600 kHz, for the time of one frame. The video signal is fed on a mixer where it is superimposed with a composite sync signal.

SINGLE-TIMER IC PROVIDES SQUARE-WAVE TONE BURSTS



ELECTRONIC DESIGN

Fig. 11-3

Circuit Notes

The tone-burst generator gives a 50-ms burst of 1.5 kHz square waves with each operation of the pushbutton and can source or sink 200 mA.

STROBE-TONE BURST GENERATOR

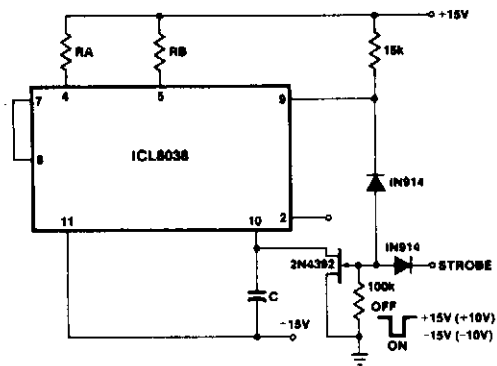
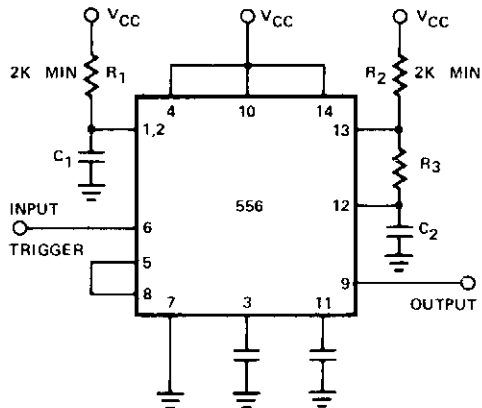


Fig. 11-4

INTERSIL

TONE BURST GENERATOR



Circuit Notes

The dual timer makes an excellent tone burst generator. The first half is connected as a one shot and the second half as an oscillator. The pulse established by the one shot turns on the oscillator allowing a burst of pulses to be generated.

SIGNETICS

Fig. 11-5

12

Capacitance Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Capacitance-to-Voltage Meter
Accurate Digital Capacitance Meter

CAPACITANCE-TO-VOLTAGE METER

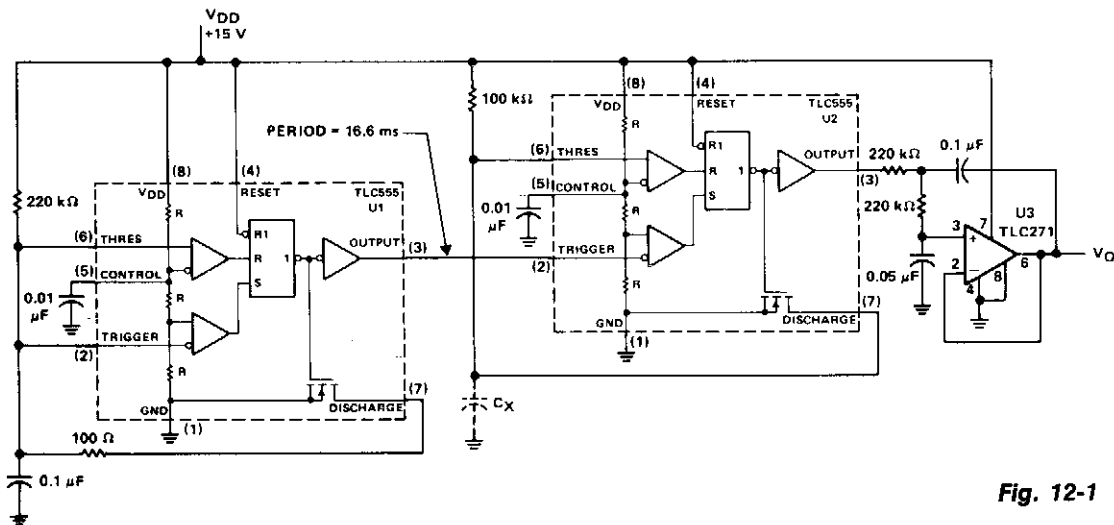


Fig. 12-1

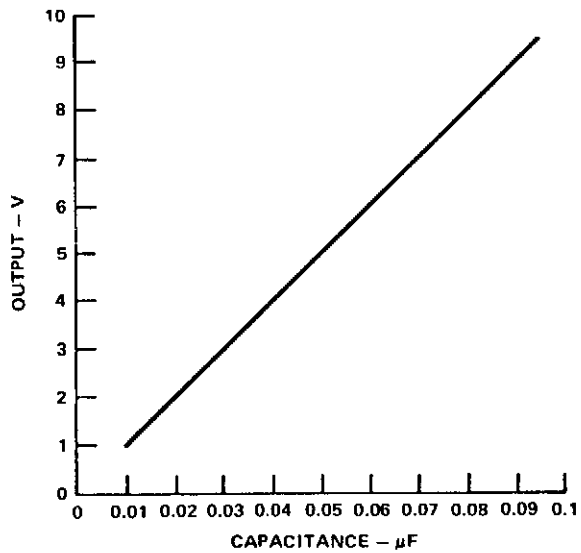
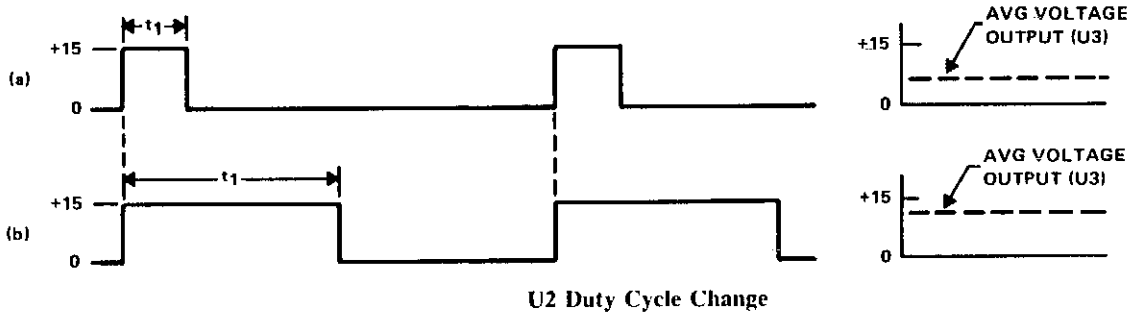
TEXAS INSTRUMENTS

Circuit Notes

Timer U1 operates as a free-running oscillator at 60 Hz, providing trigger pulses to timer U2 which operates in the monostable mode. Resistor R1 is fixed and capacitor Cx is the capacitor being measured. While the output of U2 is 60 Hz, the duty cycle depends on the value of Cx. U3 is a combination low-pass filter and unity-gain follower whose dc voltage output is the time-averaged amplitude of the output pulses of U2, as shown in the timing diagram.

The diagram shows when the value of Cx is small the duty cycle is relatively low. The output pulses are narrow and produce a lower average dc voltage level at the output of U3. As the capacitance value of Cx increases, the duty cycle increases making the output pulses at U2 wider and the average dc level output at U3 increases. The graph illustrates capacitance values of 0.01 μF to 0.1 μF plotted against the output voltage of U3. Notice the excellent linearity and direct one-to-one scale calibration of the meter. If this does not occur the 100 k ohm resistor, R1, can be replaced with a potentiometer which can be adjusted to the proper value for the meter being used.

CAPACITANCE-TO-VOLTAGE METER (CONT'D)



TEXAS INSTRUMENTS

Fig. 12-1

ACCURATE DIGITAL CAPACITANCE METER

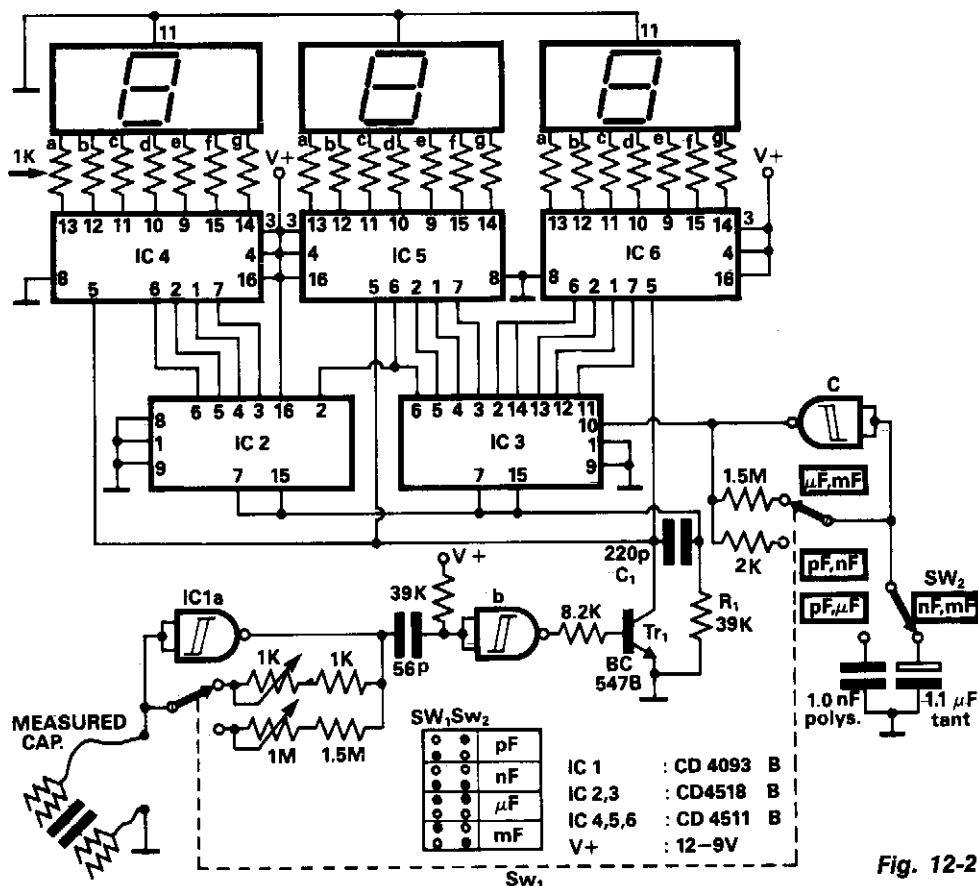


Fig. 12-2

ELECTRONIC ENGINEERING

Circuit Notes

The principle of operation is counting the pulse number derived from a constant frequency oscillator during a fixed time interval produced by another lower frequency oscillator. This oscillator uses the capacitor being measured as the timing. The capacitance measurement is proportional during pulse counting during a fixed time interval. The astable oscillator formed by IC1c produces a pulse train of constant frequency. Gate IC1a also forms an oscillator whose oscillation period is given approximately by the equation: $T = 0.7 RC$.

Period T is linearly dependent on the capacitance C . This period is used as the time interval for one measurement. The differentiator network following the oscillator creates the negative spikes shaped in narrow pulses by IC1b NAND Schmitt Trigger. The differentiator formed by R_1 and C_1 produces a negative spike which resets the counters. The display shows the number of high frequency oscillator pulses entering the counter during the measurement period.

13

Circuit Protection Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Overvoltage Protector
- High Speed Electronic Circuit Breaker
- 12 ns Circuit Breaker
- Low Voltage Power Disconnect
- Automatic Power-Down Protection Circuit
- Line Dropout Detector
- Electronic Crowbar

OVERVOLTAGE PROTECTOR

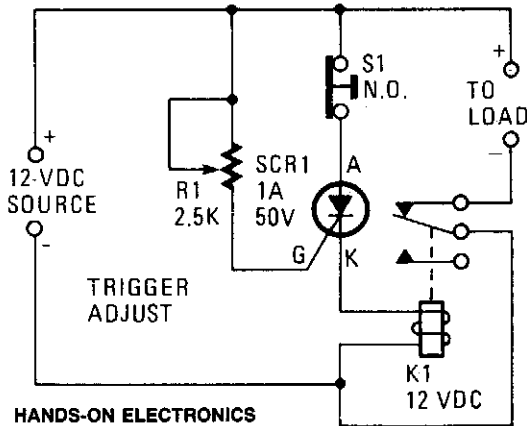


Fig. 13-1

Circuit Notes

A silicon-controlled rectifier is installed in parallel with the 12-V line and connected to a normally-closed 12-V relay, K1. The SCR's gate circuit is used to sample the applied voltage. As long as the applied voltage stays below a given value, SCR1 remains off and K1's contacts remain closed, thereby supplying power to the load. When the source voltage rises above 12 V, sufficient current is applied to the gate of SCR1 to trigger it into conduction. The trigger point of SCR1 is dependent on the setting of R1. Once SCR1 is triggered (activating the relay), K1's contacts open, halting current flow to the load.

HIGH SPEED ELECTRONIC CIRCUIT BREAKER

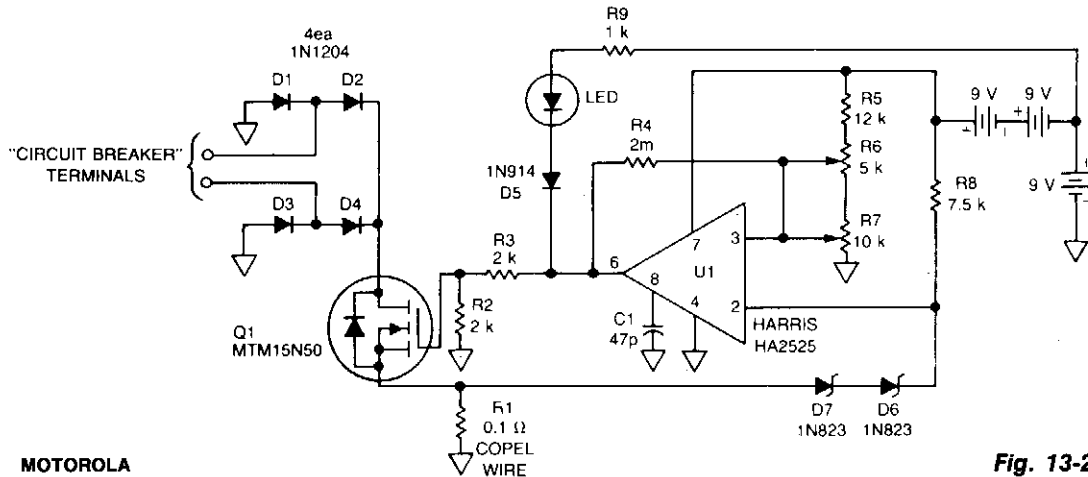


Fig. 13-2

Circuit Notes

This 115 Vac, electronic circuit breaker uses the low drive power, low on resistance and fast turn off of the TMOS MTM15N50. The trip point is adjustable, LED fault indication is provided and battery power provides complete circuit isolation.

The two "circuit breaker" terminals are across one leg of a full wave diode bridge consisting of D1-D4. Normally, Q1 is turned ON so that the circuit breaker looks like a very

low resistance. One input to comparator U1 is a fraction of the internal battery voltage and the other input is the drop across zeners D6 and D7 and the voltage drop across R1. If excessive current is drawn, the voltage drop across R1 increases beyond the comparator threshold (determined by the setting of R6), U1 output goes low, Q1 turns OFF, and the circuit breaker "opens." When this occurs, the LED fault indicator is illuminated.

12 ns CIRCUIT BREAKER

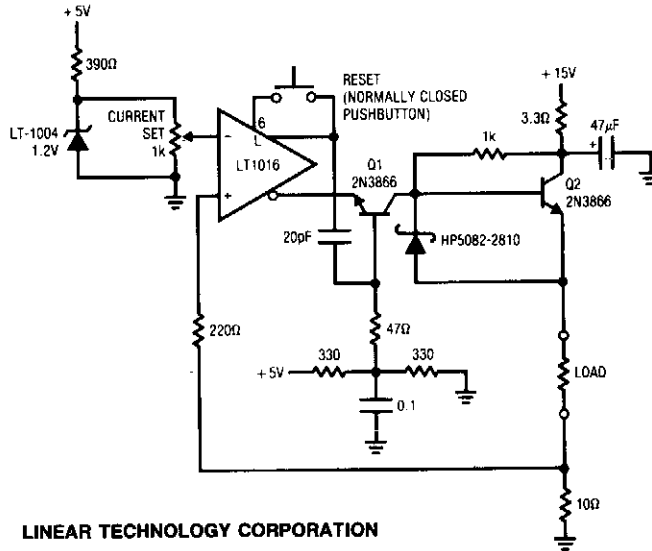


Fig. 13-3

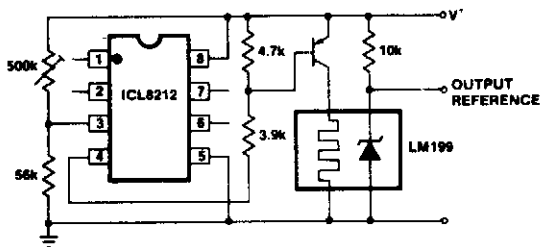
LINEAR TECHNOLOGY CORPORATION

Circuit Notes

This circuit will turn off current in a load 12 ns after it exceeds a preset value. Under normal conditions the voltage across the 10 ohm shunt is smaller than the potential at the LT1016's negative input. This keeps Q1 off and Q2 receives bias, driving the load. When an overload occurs the current through the 10 ohm sense resistor begins to increase. When this current exceeds the preset value, the LT1016's outputs reverse. This provides ideal turn-on drive for Q1 and it cuts off Q2 in 5 ns. The delay from the onset of excessive load current to complete shutdown is just 13 ns. Once the circuit has triggered, the LT1016 is held in its latched state by feedback from the non-inverting output. When the load fault has been cleared the pushbutton can be used to reset the circuit.

LOW VOLTAGE POWER DISCONNECTOR

Circuit Notes

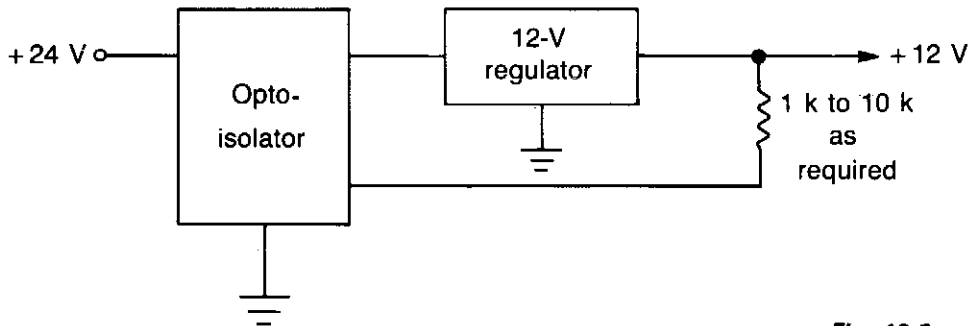


INTERSIL

Fig. 13-4

There are some classes of circuits that require the power supply to be disconnected if the power supply voltage falls below a certain value. As an example, the National LM199 precision reference has an on chip heater which malfunctions with supply voltages below 9 volts causing an excessive device temperature. The ICL8212 can be used to detect a power supply voltage of 9 volts and turn the power supply off to the LM199 heater section below that voltage.

AUTOMATIC POWER-DOWN PROTECTION CIRCUIT



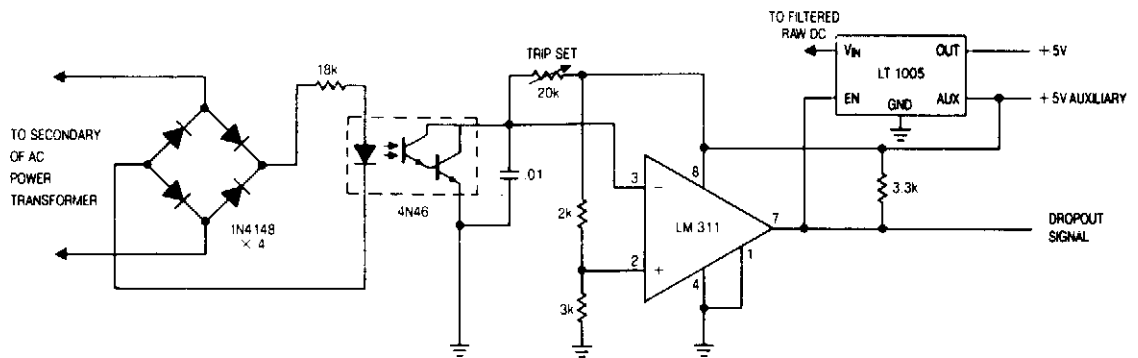
WILLIAM SHEETS

Fig. 13-5.

Circuit Notes

This circuit is faster than a fuse and automatically resets itself when a short is removed. The normal regulated dc input line is opened and the phototransistor of the opto isolator is connected in series with the source and regulator. Between the output of the regulator and ground is a LED and an associated current-limiting resistor, placed physically close to the surface of the photosensitive device. As long as the regulator is delivering its rated output, the LED glows and causes the photo device to have a low resistance. Full current is thus allowed to flow. If a short circuit occurs on the output side of the regulator, the LED goes dark, the resistance of the photo device increases, and the regulator shuts off. When the short is removed, the LED glows, and the regulator resumes operation.

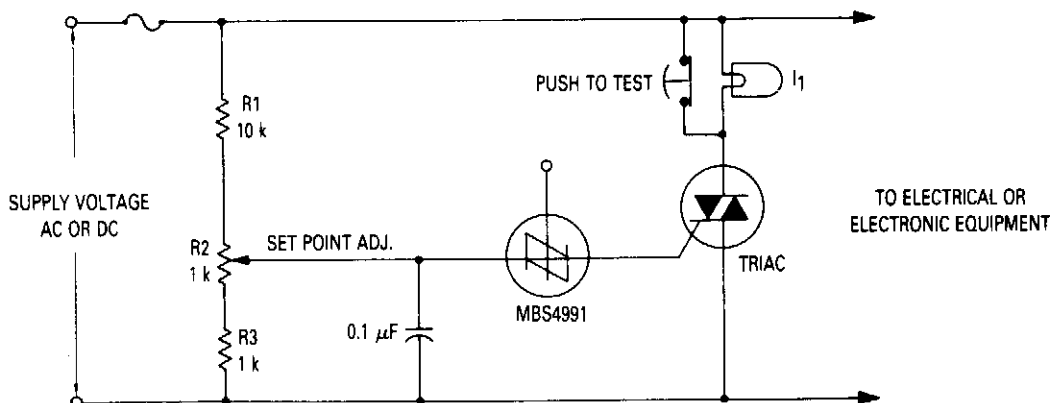
LINE DROPOUT DETECTOR



LINEAR TECHNOLOGY CORP.

Fig. 13-6

ELECTRONIC CROWBAR



MOTOROLA

Fig. 13-7

Circuit Notes

Where it is desirable to shut down equipment rather than allow it to operate on excessive supply voltage, an electronic "crowbar" circuit can be employed to quickly place a short-circuit across the power lines, thereby dropping the voltage across the protected device to near zero and blowing a fuse. Since the TRIAC and SBS are both bilateral devices, the circuit is equally useful on ac or dc supply lines. With the values shown for R1, R2 and R3, the crowbar operating point can be adjusted over the range of 60 to 120 volts dc or 42 to 84 volts ac. The resistor values can be changed to cover a different range of supply voltages. The voltage rating of the TRIAC must be greater than the highest operating point as set by R2. I₁ is a low power incandescent lamp with a voltage rating equal to the supply voltage. It may be used to check the set point and operation of the unit by opening the test switch and adjusting the input or set point to fire the SBS.

14

Clock Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Three Phase Clock From a Reference Clock
60 Hz Clock Pulse Generator

THREE PHASE CLOCK FROM A REFERENCE CLOCK

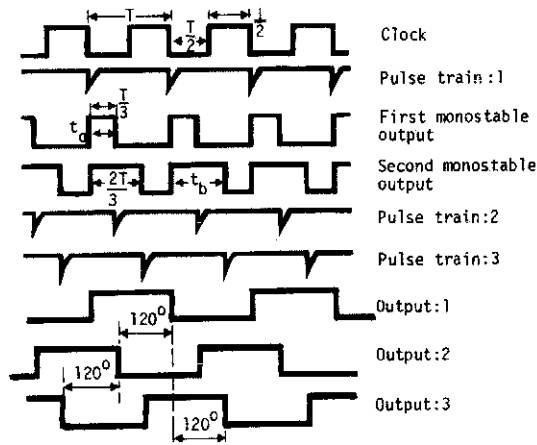
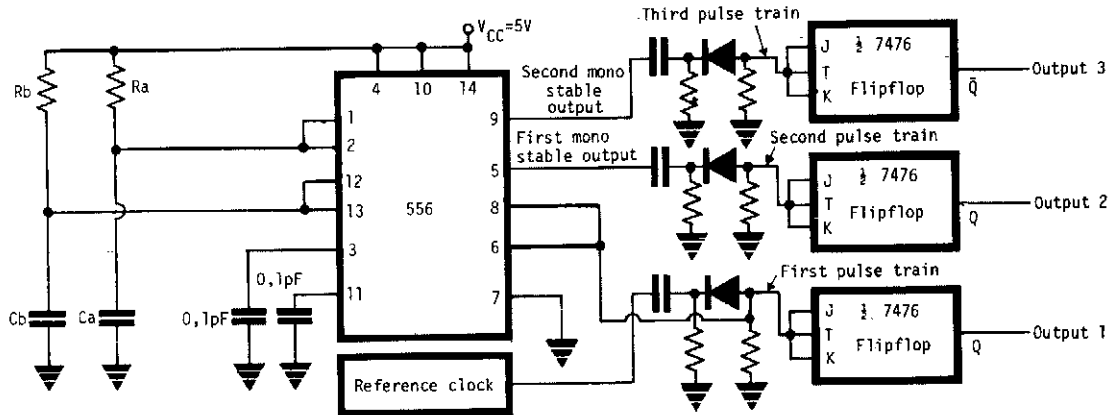


Fig. 14-1

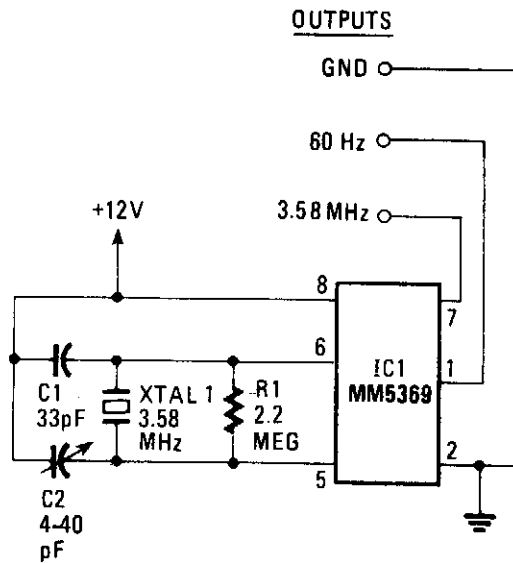


ELECTRONIC ENGINEERING

Circuit Notes

The circuit provides three square wave outputs with 120° of phase difference between each other. Reference clock frequency is twice that of the required frequency. This can be obtained from a crystal oscillator with a chain of dividers or by using LM 555 in 50% duty cycle astable mode. If $1/T$ is the frequency of the reference clock, the dual timer 556 is connected to give two mono-stable output pulses of duration $T/3$ and $2T/3$. The first timer R and C value are adjusted so that $t_a = 1.1RaCa = T/3$ and the second timer R and C values so that $t_b = 1.1RbCb = 2T/3$. For triggering the two monostables a negative pulse train (1st) is derived from the reference clock with a differentiator and a clipper combination as shown. The three pulse trains trigger three JK flip flops giving three phase square wave outputs.

60 Hz CLOCK PULSE GENERATOR



Circuit Notes

The circuit provides a clean, stable square wave and it will operate on anywhere from 6 to 15 volts. The IC and color-burst crystal are the kind used in TV receivers. The 3.58 MHz output makes a handy marker signal for shortwave bands.

HANDS-ON ELECTRONICS

Fig. 14-2

15

Comparators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- | | |
|----------------------------------------------------------------|-------------------------------------------|
| Low-Power Comparator with Less than 10 μ V Hysteresis | High-Low Level Comparator with One Op Amp |
| Voltage Monitor/Comparator | High-Input-Impedance Window Comparator |
| Limit Comparator | Frequency Comparator |
| Double-Ended Limit Comparator | Demonstration Comparator Circuit |
| Low-Cost Comparator and Display | LED Frequency Comparator |
| Window Comparator | TTL-Compatible Schmitt Trigger |
| Comparator Detects Power Supply Overvoltages, Catches Glitches | |

LOW-POWER COMPARATOR WITH LESS THAN 10 μV HYSTERESIS

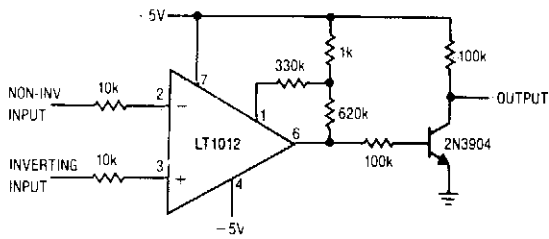
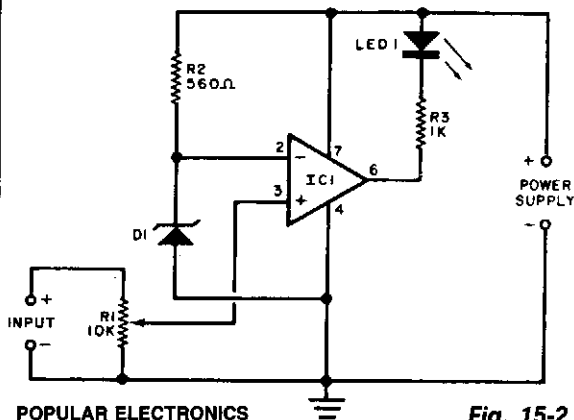


Fig. 15-1

LINEAR TECHNOLOGY CORP.

VOLTAGE MONITOR/COMPARATOR



POPULAR ELECTRONICS

Fig. 15-2

Circuit Notes

A portion of the monitored voltage (determined by R1's adjustment) is compared to a fixed voltage obtained from a zener reference network, R2-D1. As long as the monitored voltage remains at or above its present monitor point (determined by R1's setting), the output indicator, LED1, remains dark. If the voltage drops below this level, the LED goes on. D1 is a 3.3-V zener. A 12 Vdc power supply is suitable for monitoring input voltages of up to 12 volts.

LIMIT COMPARATOR

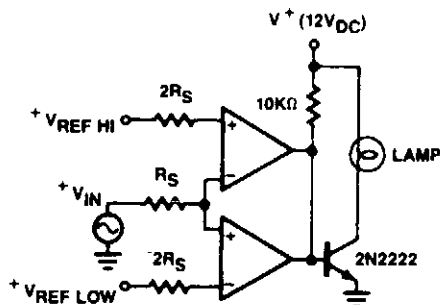


Fig. 15-3

SIGNETICS

DOUBLE-ENDED LIMIT COMPARATOR

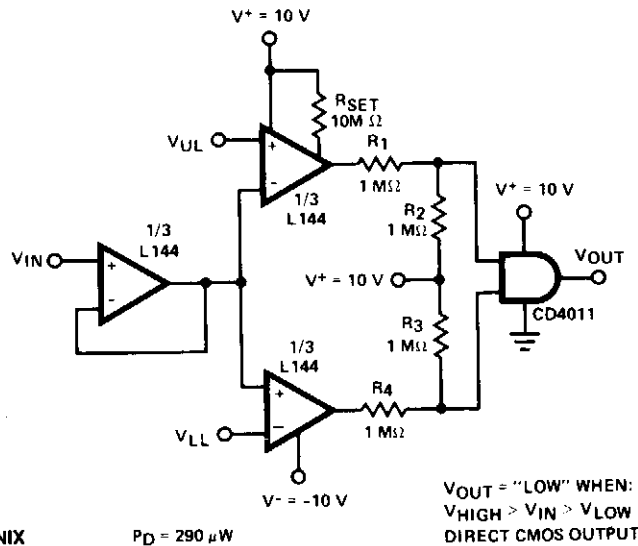


Fig. 15-4

LOW-COST COMPARATOR AND DISPLAY

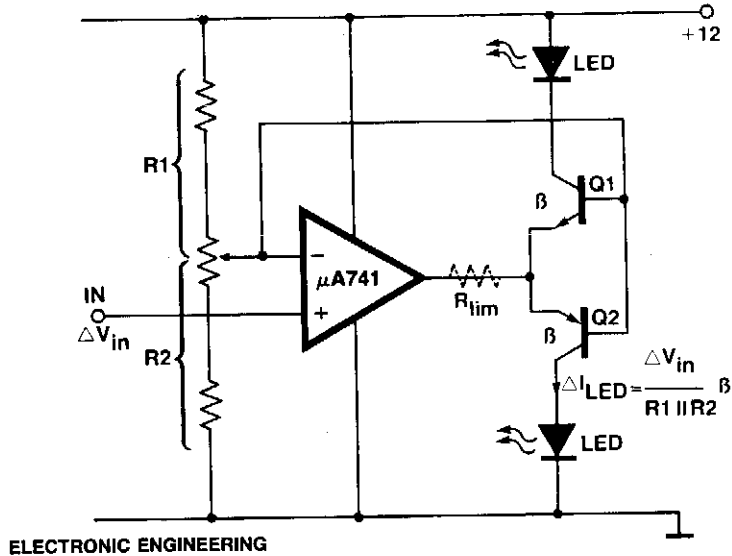


Fig. 15-5

Circuit Notes

An op amp is used as a comparator and a sink for LED current. The output voltage of the amplifier changes about 1.4 V depending on the direction of the current. Only one transistor is on at any time. Maximum LED current is limited to 25 mA by overcurrent protection of the $\mu A741$. If LEDs are not capable of carrying such a current or an alternative op amp is used and an additional resistor R_{lim} is necessary.

WINDOW COMPARATOR

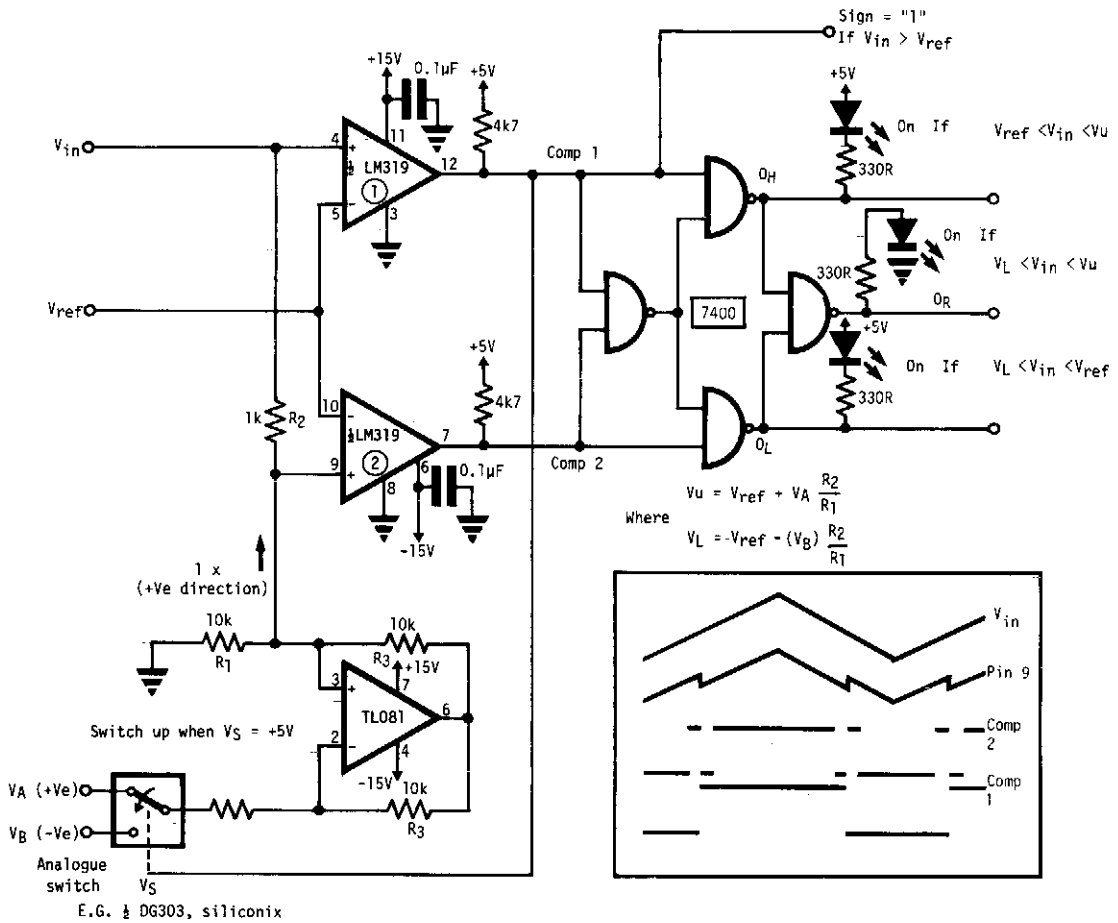


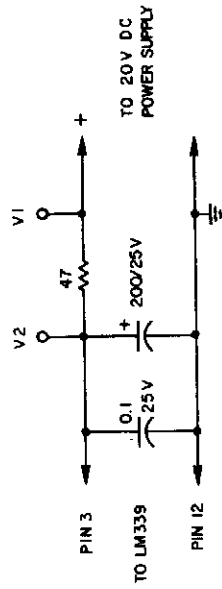
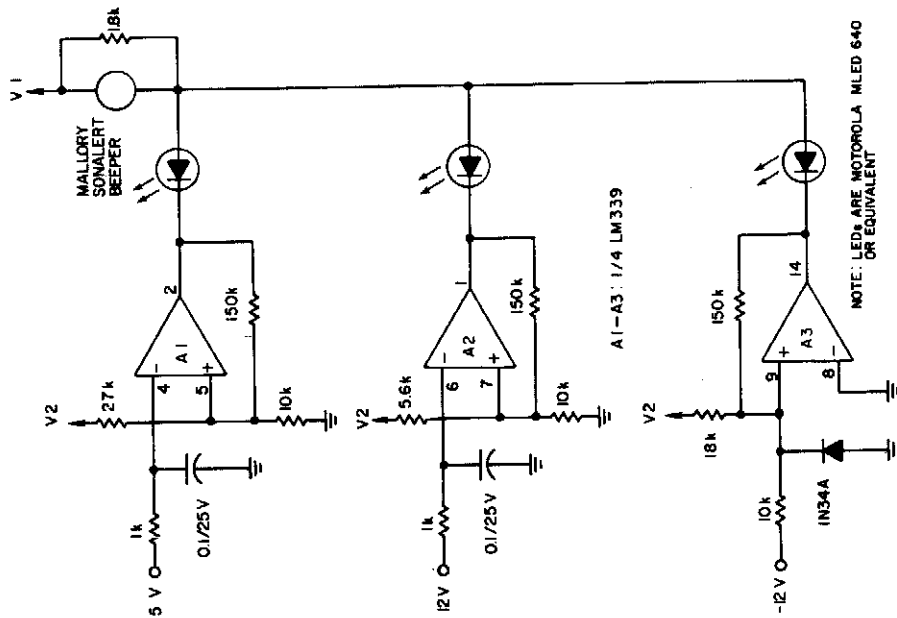
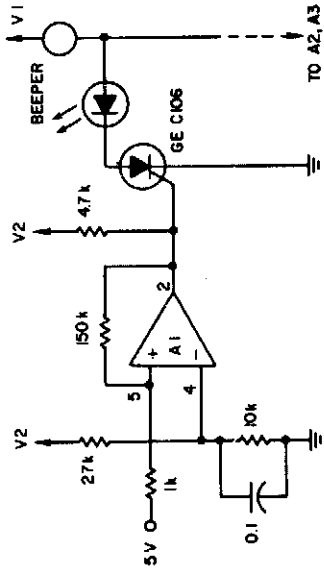
Fig. 15-6

ELECTRONIC ENGINEERING

Circuit Notes

This circuit provides independently adjustable upper and lower threshold settings, and has sign, in window range, in upper window, and in lower window digital outputs.

COMPARATOR DETECTS POWER SUPPLY OVERVOLTAGES, CATCHES GLITCHES



ALL RESISTORS 1/4 W 5%

Fig. 15-7.

Circuit Notes

- (A) To maintain an alarm condition when an overvoltage transient disappears, add an SCR to the comparator circuits. For SCR operation, voltages to the comparator inputs are inverted. (B) The triple-voltage monitoring circuit detects transient power-supply overvoltages. If excessive voltage momentarily appears at the 5, 12 and -12 V inputs, the LED for that circuit lights and the beeper sounds for as long as the overvoltage lasts.

ELECTRONIC DESIGN

NOTE: LED* ARE MOTOROLA MLED 640 OR EQUIVALENT

HIGH-LOW LEVEL COMPARATOR WITH ONE OP AMP

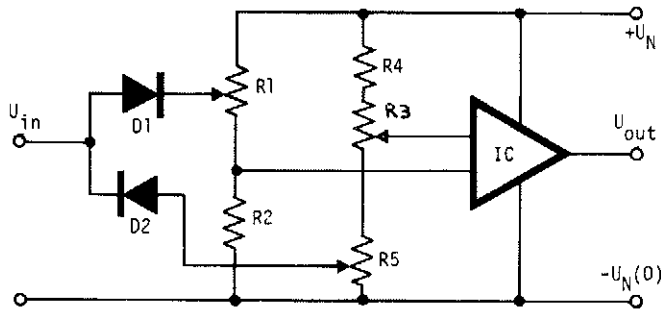


Fig. 15-8

ELECTRONIC ENGINEERING

Circuit Notes

The voltage to be compared is fed through diode D1 and D2 to the voltage dividers R1 and R5 where the low and high limits are present. When the voltage level of an input signal exceeds the high threshold limit set with potentiometer R1, the diode D1 becomes forward biased and the increased voltage on the inputs of the op amp drives it into positive saturation. Similarly, a decrease of the input voltage at the op amp inputs turns the op amp to positive saturation. Potentiometer R3 is used for zeroing the op amp in the off state.

HIGH-INPUT-IMPEDANCE WINDOW COMPARATOR

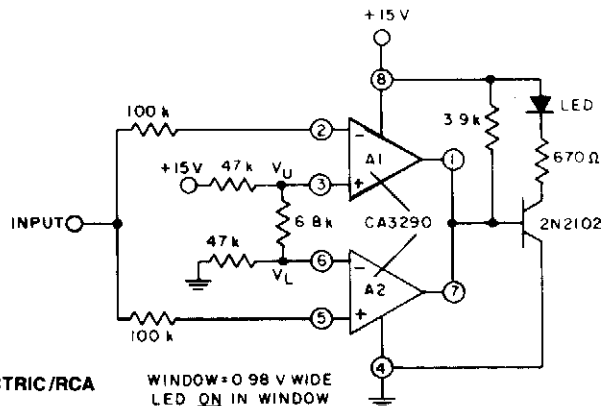


Fig. 15-9

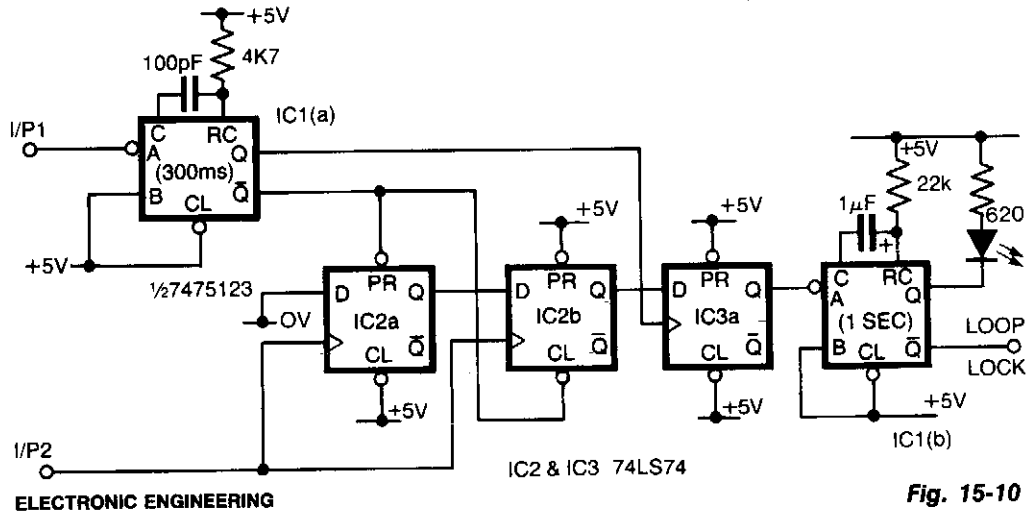
GENERAL ELECTRIC/RCA

WINDOW = 0.98 V WIDE
LED ON IN WINDOW

Circuit Notes

The circuit uses both halves of the CA3290 BiMOS dual voltage comparator. The LED will be turned "ON" whenever the input signal is above the lower limit (V_L) but below the upper limit (V_U).

FREQUENCY COMPARATOR

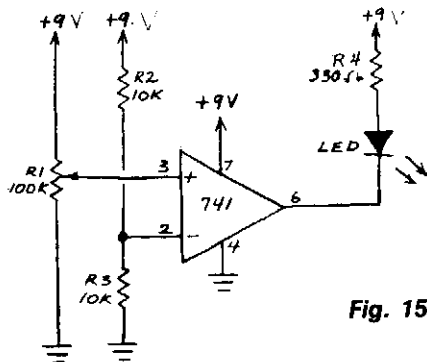


Circuit Notes

Input 1 is used as a gating period, during which a single rising edge on input 2 will cause a logic 1 output—any other number, indicating non-identical frequencies causes a logic 0 output.

IC1a converts input 1 to a narrow pulse which initializes IC2 which forms a two-stage shift register clocked by input 2. On the first edge of input 2 a logic 1 appears on the output of IC2b and for all subsequent inputs a logic 0 is present. At the end of the gating period this output is latched by IC3 forming the lock output. As this is only valid for one input period a monostable is added to the output to enable, for example, visual monitoring of the output. Either output from IC3 can be used depending on which state is most important. As connected the failure state is indicated.

DEMONSTRATION COMPARATOR CIRCUIT



Circuit Notes

This circuit is an op amp without a feedback resistor. R2 and R3 junction point sets the reference voltage. When the input voltage set by R1 is below the reference voltage the LED glows. If voltage is above reference, the LED goes off.

LED FREQUENCY COMPARATOR

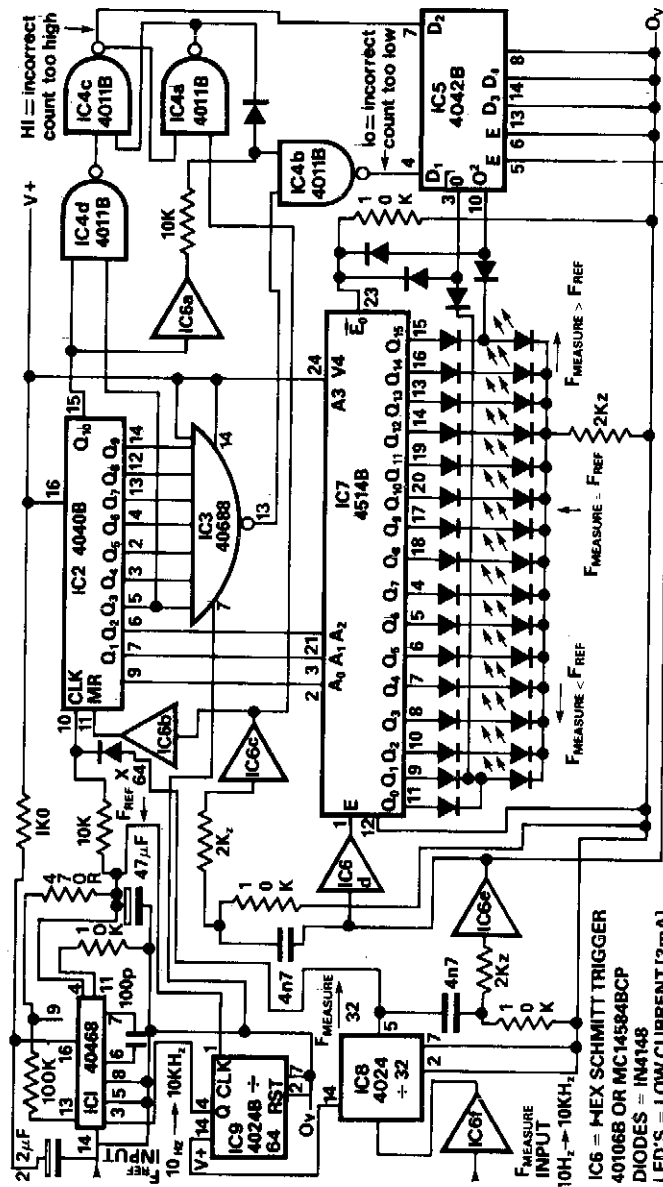


Fig. 15-12

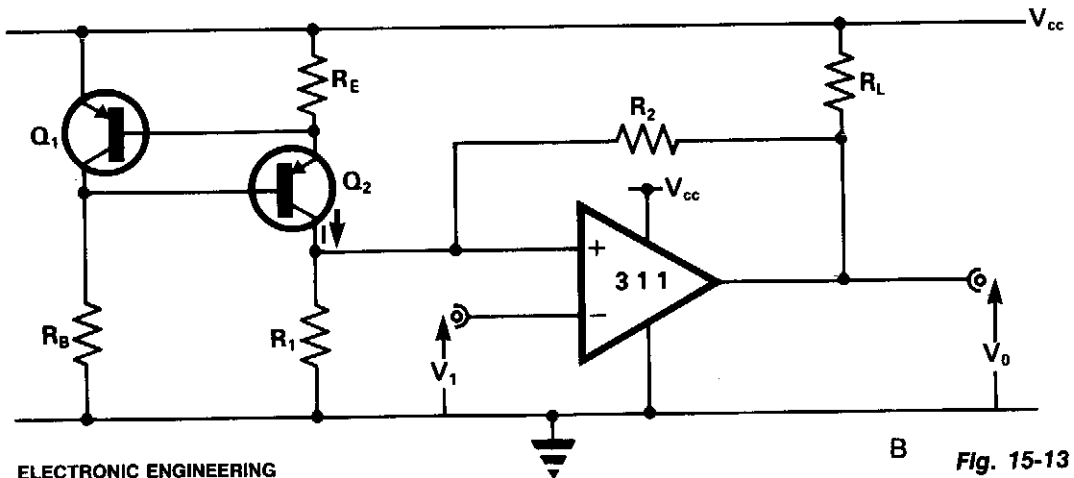
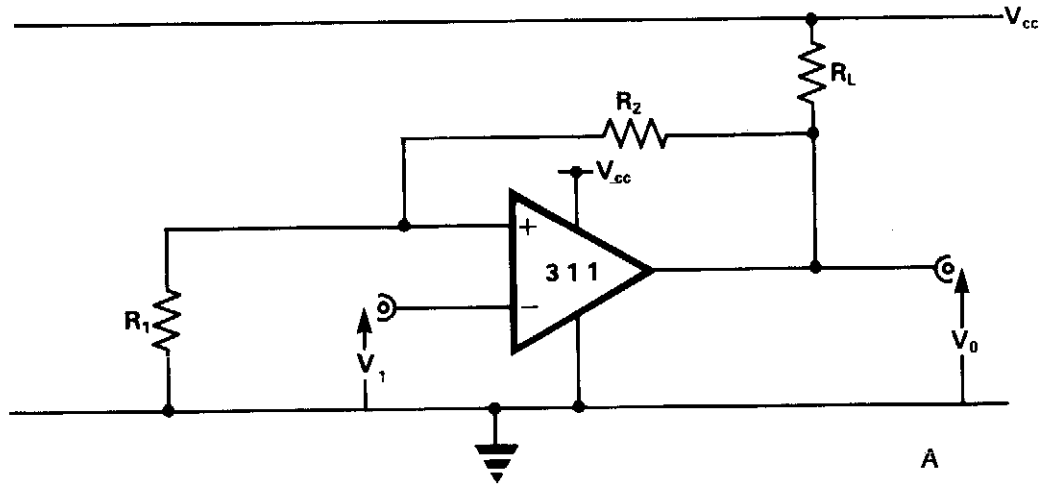
Circuit Notes

The circuit provides unambiguous LED + or - bar readout with steps of 0.1%. The reference frequency is multiplied by the PLLIC1 and divider IC9 to output $64 \times F_{(ref)}$ and this is then gated by dividing $F_{(measure)}$ by 32 in IC8 thus is $F_{(ref)} = (measure)$ then IC2 counts 1024 pulses. Should the count be more than 1031 than the latch IC4c/IC4a is set to indicate count too high ($F_{(measure)} > F_{(ref)}$) and if the count is less than 1017 then IC3/IC4b indicate count too low ($F_{(measure)} < F_{(ref)}$). These signals are latched by IC5 at the end of each period by the latch signal from IC6e.

When the two frequencies are within + or - 0.6% the LSB's of the counter IC2 are decoded and latched by IC5 and displayed on LED's of IC7. IC6c resets the counter after latching the data.

ELECTRONIC ENGINEERING

TTL-COMPATIBLE SCHMITT TRIGGER



ELECTRONIC ENGINEERING

B Fig. 15-13

Circuit Notes

The comparator has an output pull-up resistor R_L and is connected up to operate as a Schmitt trigger using the single rail supply V_{CC} . The feedback resistors R_1 and R_2 give upper and lower threshold levels V_{T+} , V_{T-} , respectively. V_{T+} is easily set by suitable resistor selection but there is little independent choice of V_{T-} because V_{T-} cannot exceed $V_{CE(SAT)}$. In Fig. 15-13B current-source, comprising the transistors R_E , R_B produces a current $I \sim (V_{EB}/R_E)$, V_{EB} (~ 0.65 V) being the emitter-base voltage of Q_1 and Q_2 . Fig. 15-13C shows the results of a practical test using the circuit of Fig. 15-13B, and the following operating and component data:

$V_{CC} = 5$ V; $R_L = 1$ K ohm; $R_1 = R_2 = 10$ K ohm;
 $R_B = 3.6$ K ohm; $R_E = 1$ K ohm + 10 K ohm pot;
 $Q_1 = ZTX500$; $Q_2 = ZTX500$.

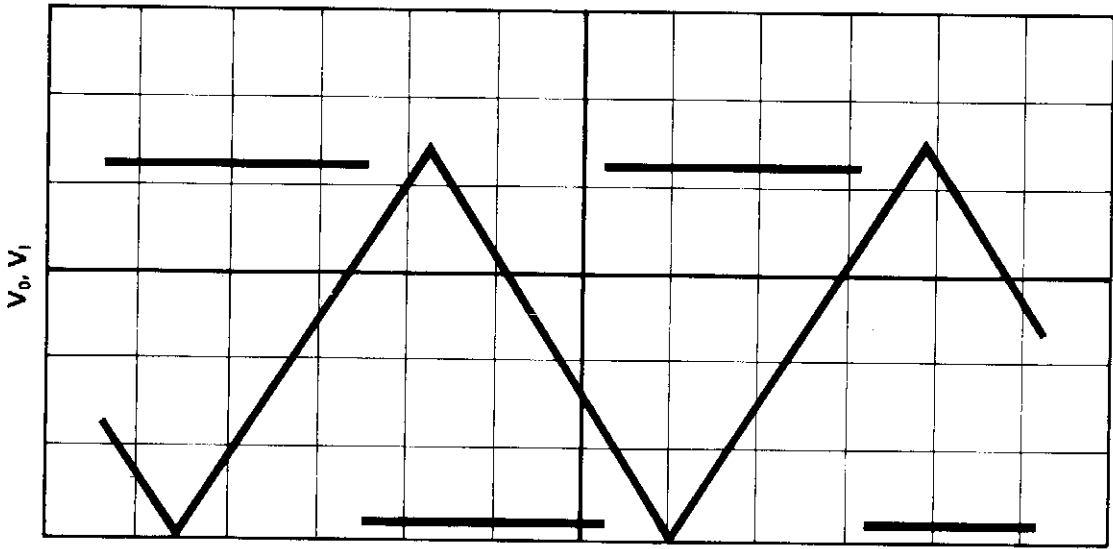


Fig. 15-13 Continued

C

16

Computer Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

8-Bit μ P Bus Interface

V_{PP} Generator for Eproms

Eight Channel Mux/Demux System

Microprocessor Selected Pulse Width Control

8048/IM80C48 Microcomputer with 8-Character

16-Segment ASCII Triplex Liquid Crystal Display

CMOS Data Acquisition System

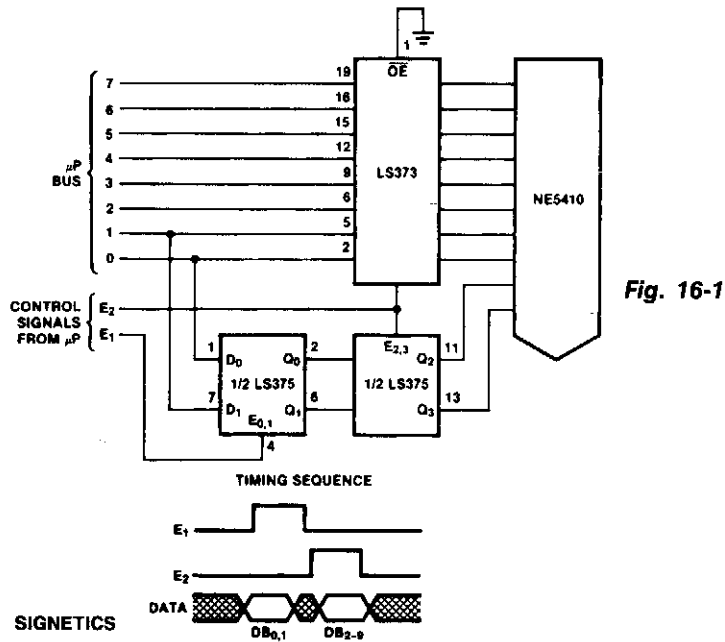
High Speed Data Acquisition System

Buffered Breakout Box

Z80 Clock

Data Separator for Floppy Disks

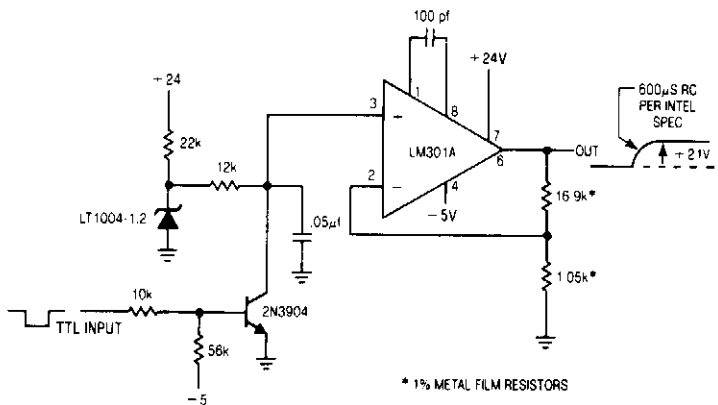
8-BIT μ P BUS INTERFACE



Circuit Notes

With this double latch technique, valid data will be latched to the DAC until updated with the E_2 pulse. Timing will depend on the processor used.

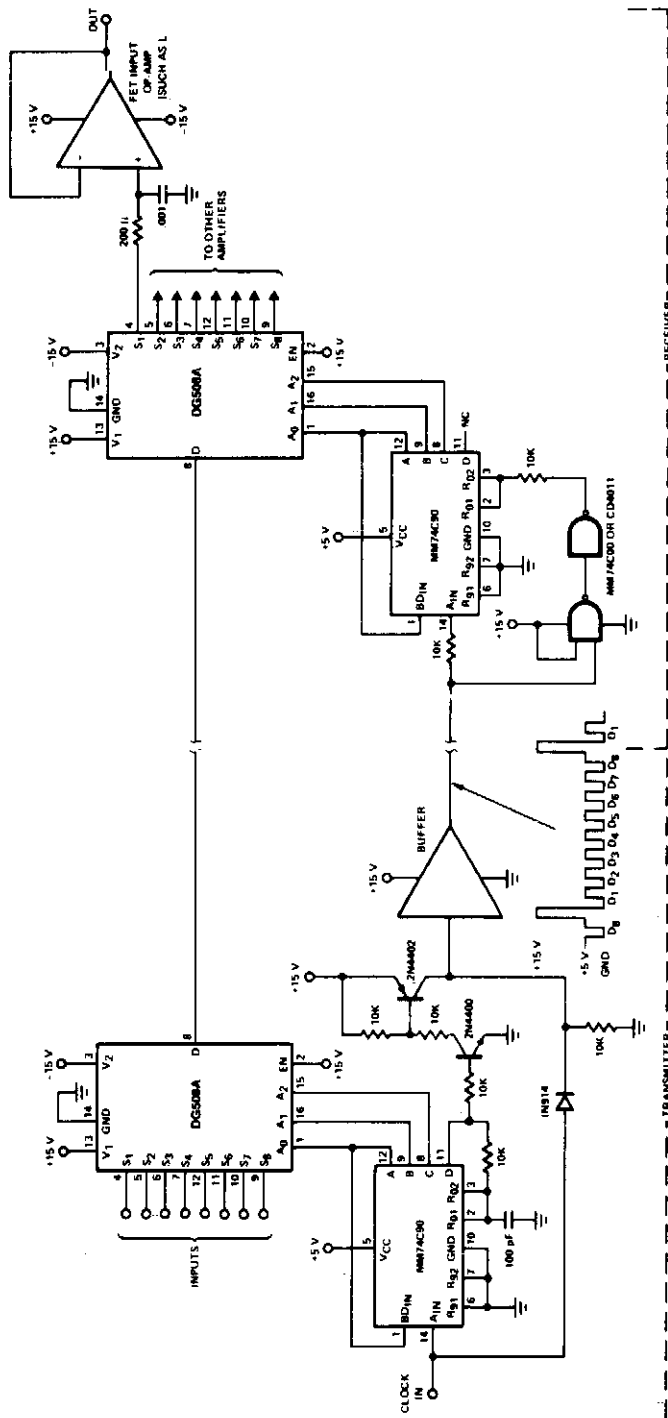
V_{PP} GENERATOR FOR EPROMS



LINEAR TECHNOLOGY CORP.

Fig. 16-2

EIGHT-CHANNEL MUX/DEMUX SYSTEM



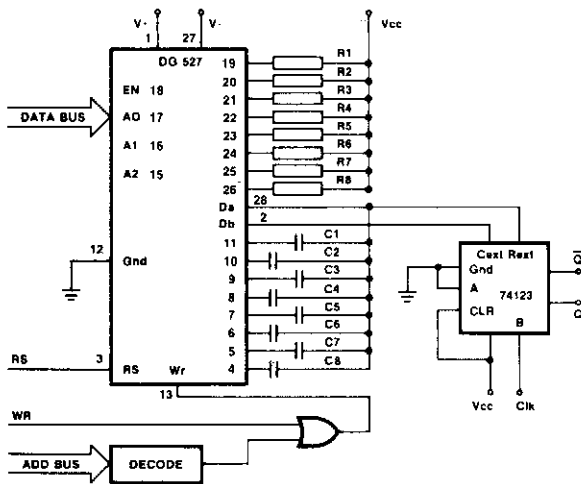
SILICONIX

Fig. 16-3

Circuit Notes

A number of signals may be sent between two points simultaneously by making a slight modification in the receiver circuit. A second DG508A is used as a demultiplexer, allowing all 8 channels to be monitored continuously.

MICROPROCESSOR SELECTED PULSE WIDTH CONTROL



Circuit Notes

Differential multiplexers are generally used in process control applications to eliminate errors due to common mode signals. In this circuit however, advantage is taken of the dual multiplexing capability of the switch. This is achieved by using the multiplexer to select pairs of RC networks to control the pulse width of the multivibrator. This can be a particularly useful feature in process control applications where there is a requirement for a variable width sample "window" for different control signals.

SILICONIX

Fig. 16-4

8048/IM80C48 MICROCOMPUTER WITH 8-CHARACTER 16-SEGMENT ASCII TRIPLEX LIQUID CRYSTAL DISPLAY

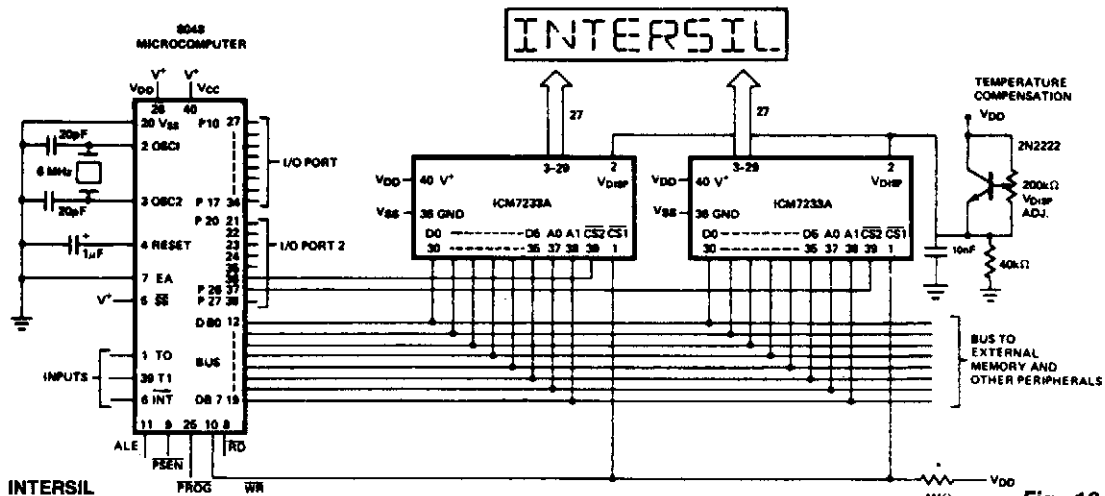


Fig. 16-5

Circuit Notes

The two bit character address is merged with the data and written to the display driver under the control of the WR line. Port lines are used to either select the target driver, or deselect all of them for other bus operations.

CMOS DATA ACQUISITION SYSTEM

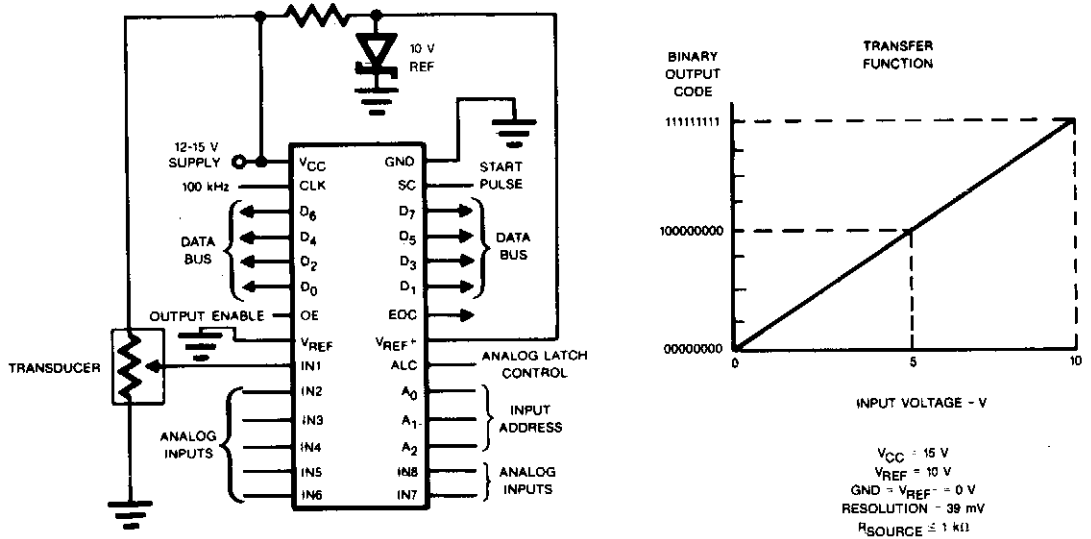


Fig. 16-6

SILICONIX

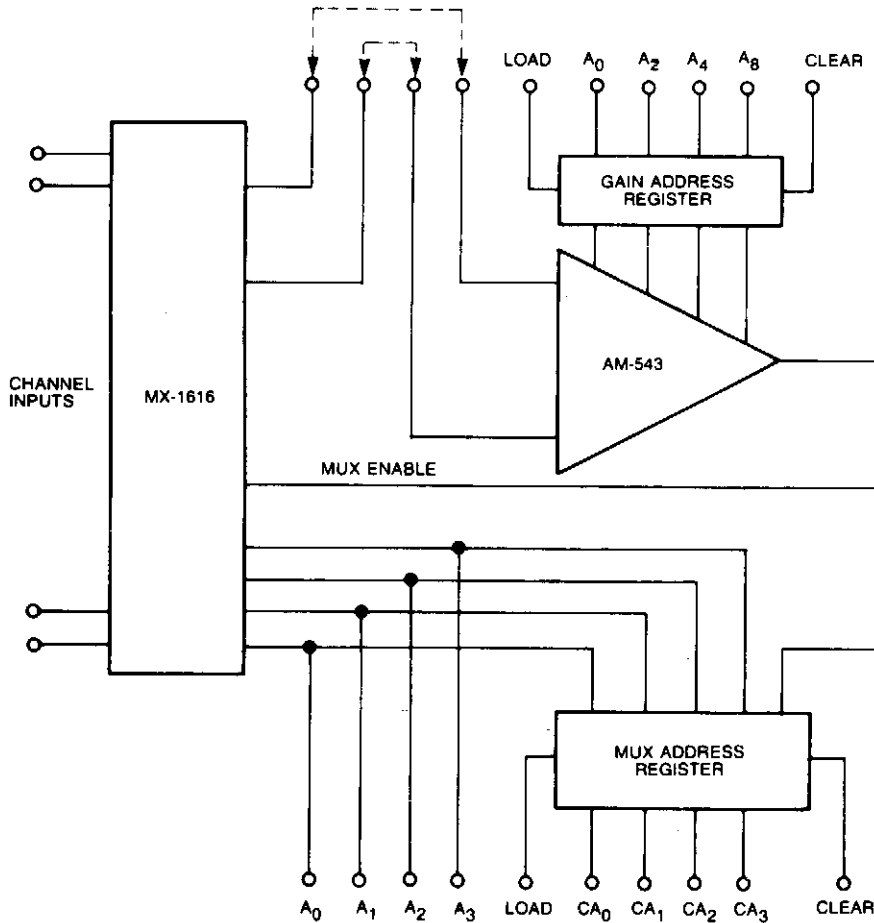
Circuit Notes

Charge redistribution to achieve A/D conversion. In typical applications, as a ratiometric conversion system for a microprocessor, V_{REF-} will be connected to ground and V_{REF+} will be connected to V_{CC} . The output will then be a simple proportional ratio between analog input voltage and V_{CC} . The general relationship is:

$$\frac{D_{OUT}}{2^8} = \frac{V_{IN}}{V_{REF+} - V_{REF-}}$$

Where D_{OUT} = Digital Output
 V_{IN} = Analog Input
 V_{REF+} = Positive Reference Potential
 V_{REF-} = Negative Reference Potential

HIGH SPEED DATA ACQUISITION SYSTEM

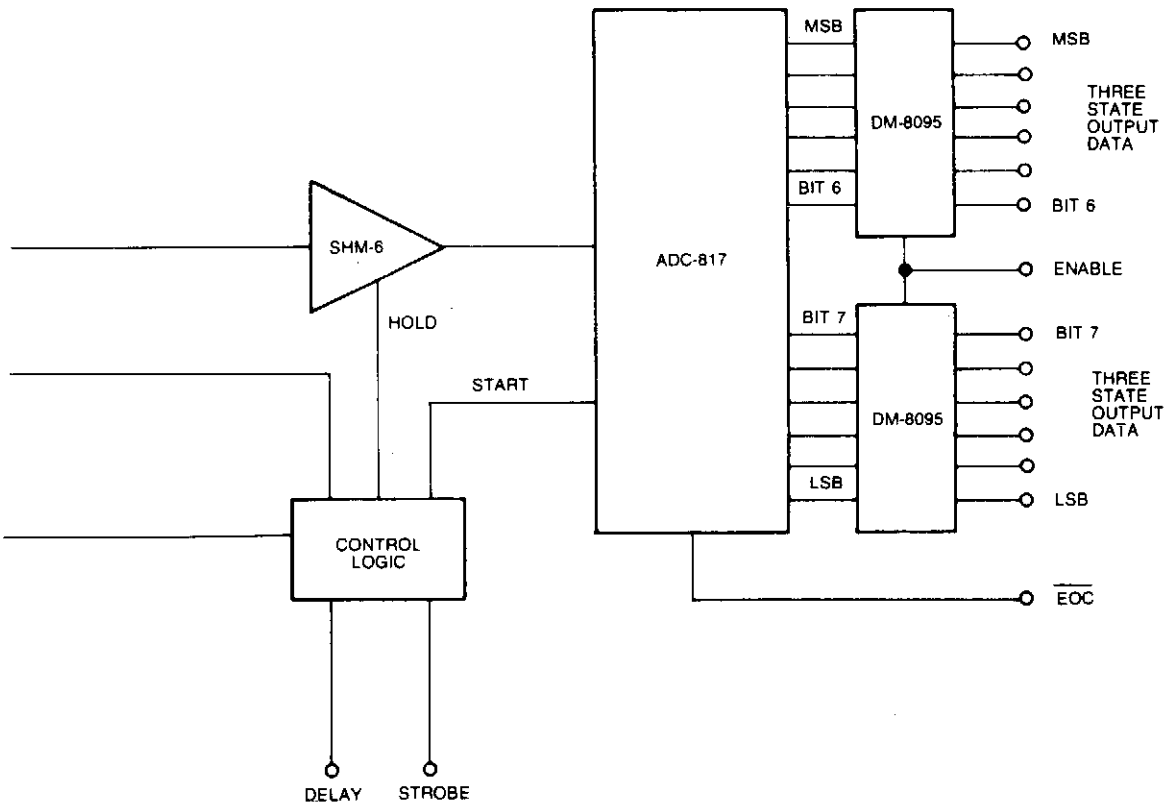


DATel

Fig. 16-7

Circuit Notes

This diagram shows a high-speed data acquisition system with 8 differential inputs and 12-bit resolution using the AM-543. If the control logic is timed so that the Sample-Hold-ADC section is converting one analog value while the mux-amplifier section is allowed to settle to the next input value, throughput rates greater than 156 KHz can be achieved. The AM-543 is used with Datel's ADV-817, a 12-bit hybrid A/D with a 2 μ sec conversion rate, the SHM-6, a 0.01%, 1 μ sec hybrid Sample-Hold, and the MX-1616,



a low cost, high-speed monolithic analog multiplexer. The system works as follows:

The μP selects a channel and initiates a conversion at $G=1$ and then looks at the MSB of the conversion result. If the $\text{MSB} = 1$, the μP will store the value. If the $\text{MSB} = 0$, the μP will select $G = 2$. The μP will repeat the cycle of gain incrementing, comparison, and analog-to-digital conversion until the $\text{MSB} = 1$. The μP will then test for an output of all 1's, as this is the full-scale output of the A/D. If the output is all 1's, the μP will decrement the gain by 1 step and perform the final conversion.

BUFFERED BREAKOUT BOX

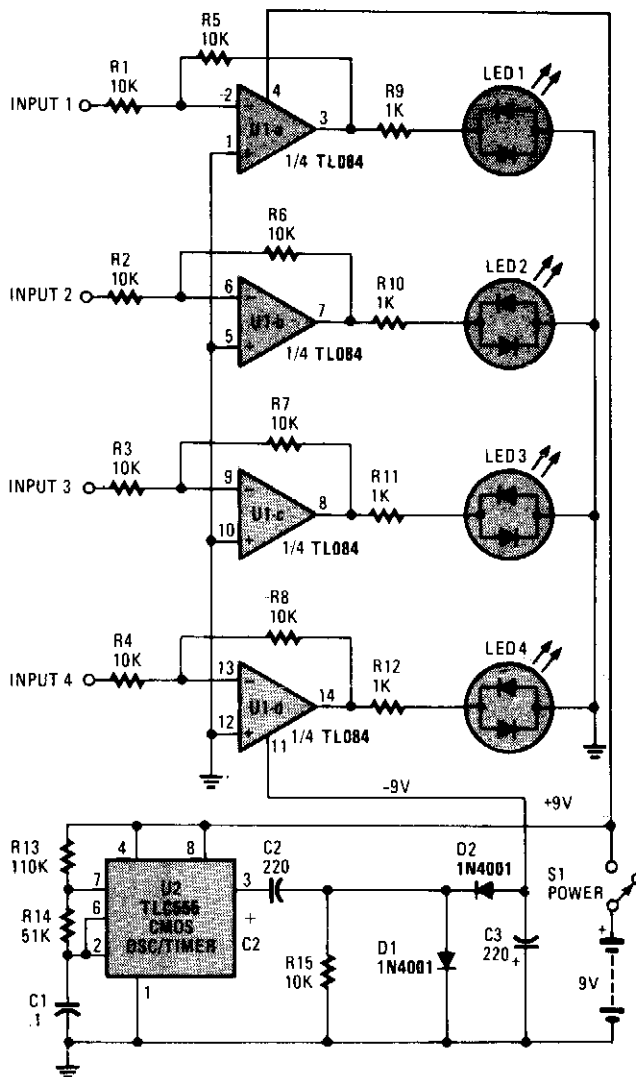


Fig. 16-8

HANDS-ON ELECTRONICS

Circuit Notes

The monitoring circuit consists of four tri-color LEDs driven by an equal number of op amps configured as gain-of-one inverting amplifiers. Each LED is wired in the circuit so that it glows red when the input to the op amp is high, and green when the input is low. The LED remains off when the input is disconnected from a circuit, when it's at ground potential, and when it's connected to a 3-state output that's in the high-impedance state. Each input has an impedance of 10,000 ohms preventing the circuit

BUFFERED BREAKOUT BOX, Continued.

from loading communication lines. The op amp requires both positive and negative supply voltages to properly drive the LEDs. Both voltages are supplied by a single, nine-volt battery. The battery supplies the positive source directly. The negative source is supplied via a CMOS 555 oscillator/timer that's configured as an astable oscillator, which is used to drive a standard diode/capacitor voltage doubler. When the 555 is connected to the monitoring circuit, the output voltage is not 18 volts (2×9), but a little under nine volts, due to loading. The circuit draws about 16 mA with all LEDs off; with all four on, it draws between 20 and 30 mA, depending on how many LEDs are high, and how many are low. The use of CMOS op amps reduces quiescent current drain considerably.

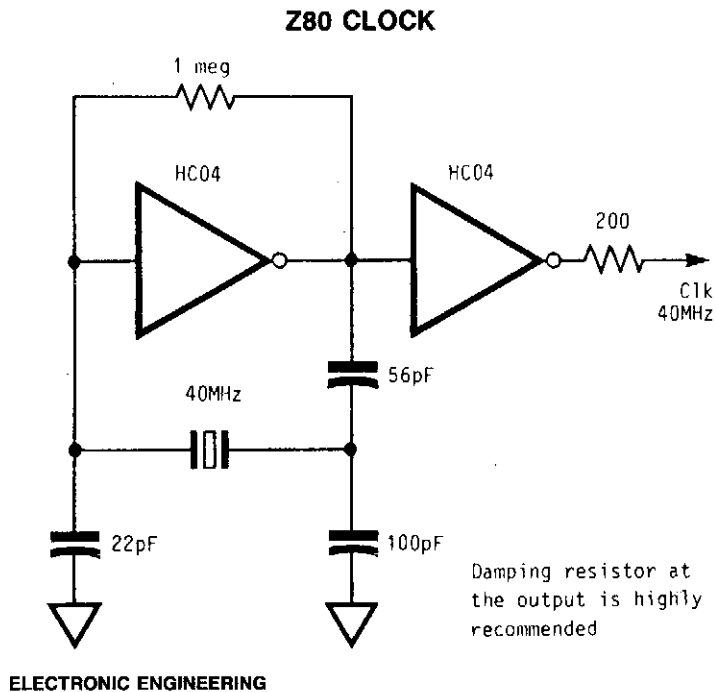
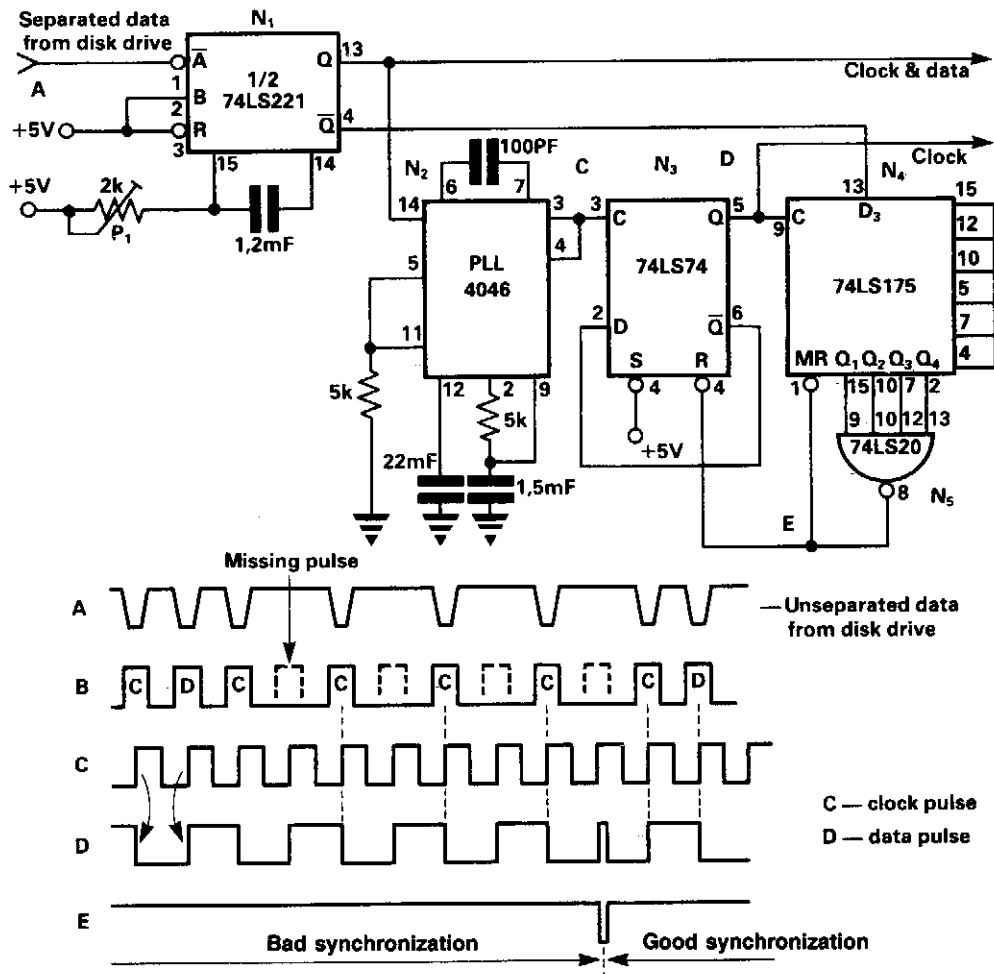


Fig. 16-9

Circuit Notes

The circuit will operate reliably from below 1 MHz to above 400 MHz. With $V_{CC} = 5\text{ V}$ the output of the second inverter essentially attains a full swing from 0 V to 5 V. Such large logic output levels and broad frequency range capabilities make this oscillator quite suitable for driving MOS components such as CPU, controller chip, peripheral devices, as well as other TTL products. A damping resistor in series between the clock output of the oscillator and the input of the device being driven will remove the undesirable undershoot and ringing caused by the high speed CMOS part.

DATA SEPARATOR FOR FLOPPY DISKS



ELECTRONIC ENGINEERING

Fig. 16-10

Circuit Notes

The data separator is intended for use with 8" flexible diskettes with IBM 3870 soft sectored format. The circuit delivers data and clock (B) and clock pulses (D). These two signals must be in such a sequence that the negative edge of the clock pulse is at the middle of a data cell.

Unseparated data (A) from the floppy unit is shaped with one shot N1. Trimmer P1 should be adjusted so that pulses (B) are 1 μ s wide. This signal synchronizes PLL N2 with a free running frequency adjusted to 500 kHz. The output of the PLL is 90° out of phase with its input. D-type flip-flop N3 is connected as a divider by two and changes state at each positive edge of (C). N4, connected as a shift register, looks for four consecutive missing pulses. When this happens, the circuit is resynchronized with (E) so that the negative edge of (D) is in the middle of a data cell.

17

Converters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Voltage-to-Pulse Duration Converter

Voltage-to-Current Converters

TTL-to-MOS Logic Converter

TTL Square Wave-to-Triangle Converter

A Regulated DC-to-DC Converter

Capacitance to Pulse Width Converter

Current-to-Voltage Converter with Grounded Bias
and Sensor

Triangle-to-Sine Converters

Precision Peak-to-Peak AC-DC Converter

Photodiode Current-to-Voltage Converter

Self Oscillating Flyback Converter

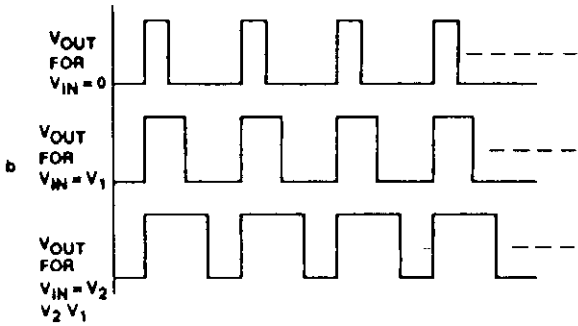
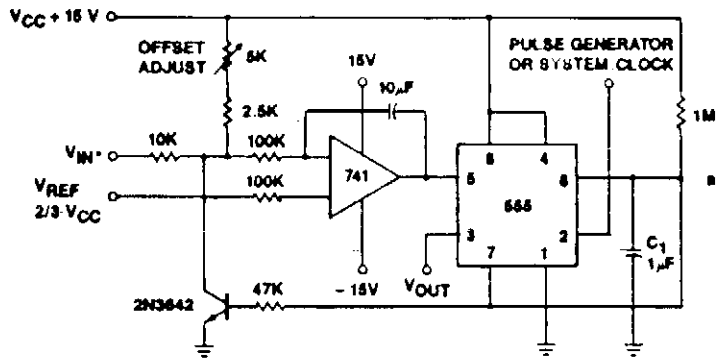
RMS-to-DC Converter

100 MHz Converter

Precision Voltage-to-Frequency Converter

Bipolar DC-DC Converter Requires No Inductor

VOLTAGE-TO-PULSE DURATION CONVERTER



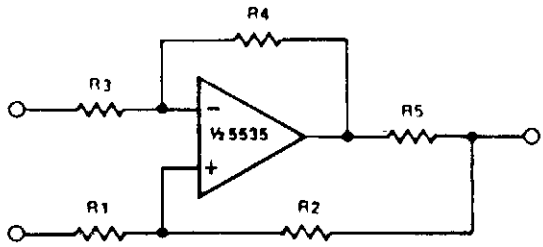
NOTES:
 All resistor values in ohms
 *VIN is limited to 2 diode drops within ground or below VCC

SIGNETICS Fig. 17-1.

Circuit Notes

Voltage levels can be converted to pulse durations by combining an op amp and a timer IC. Accuracies to better than 1% can be obtained with this circuit (a), and the output signals (b) still retain the original frequency, independent of the input voltage.

VOLTAGE-TO-CURRENT CONVERTERS



NOTES:
 $\frac{R_2}{R_1} = \frac{R_4}{R_3}$
 $I_{OUT} = \frac{V_{IN} \cdot R_2}{R_5 \cdot R_1}$

SIGNETICS

Circuit Notes

A simple voltage-to-current converter is shown in the figure. The current out is I_{OUT} or 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. 17-2

TTL-TO-MOS LOGIC CONVERTER

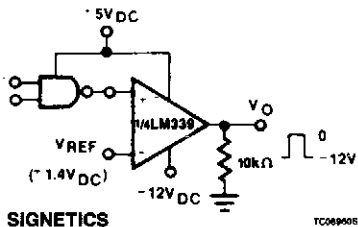
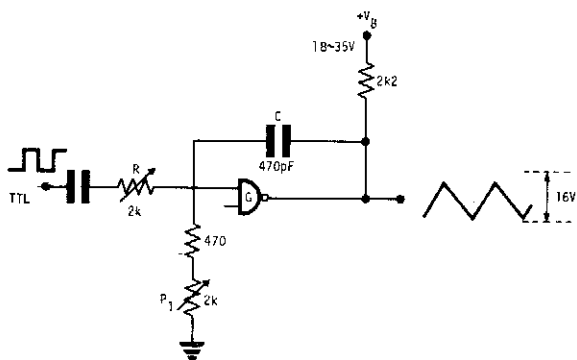


Fig. 17-3

TTL SQUARE WAVE-TO-TRIANGLE CONVERTER



Circuit Notes

This fixed frequency triangular waveform generator driven by a TTL square wave generates typically 16-V p-p triangles at frequencies up to several MHz. It uses only one NAND open collector gate, or one open collector inverter as a fast integrator with gain. Careful successive adjustments of R and P1 are needed. When correct adjustments are reached, output amplitude and linearity are largely independent of the value of V_B , from a minimum of 18 V up to 35 V. The value of C shown is for 100 kHz; at higher frequencies, it must be reduced in proportion.

ELECTRONIC ENGINEERING

Fig. 17-4

A REGULATED DC-TO-DC CONVERTER

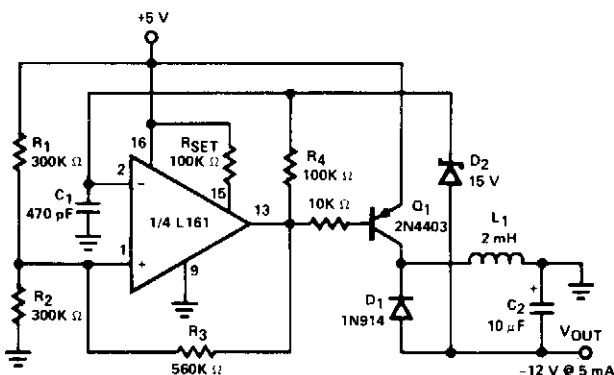


Fig. 17-5

SILICONIX

CAPACITANCE TO PULSE WIDTH CONVERTER

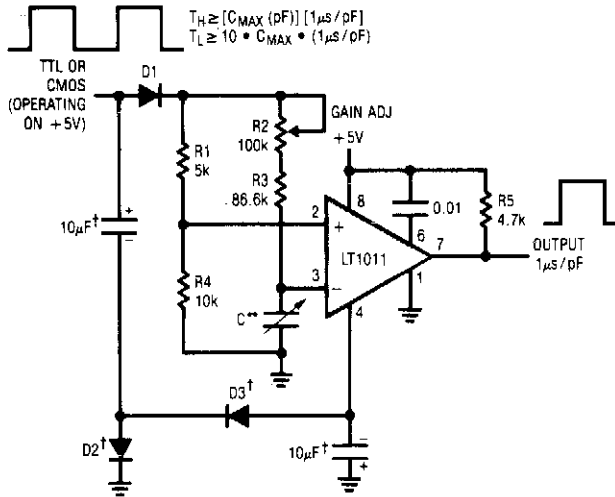


Fig. 17-6

$$*PW = (R2 + R3) \cdot C \left(\frac{R1 + R4}{R1} \right), \text{ INPUT CAPACITANCE OF}$$

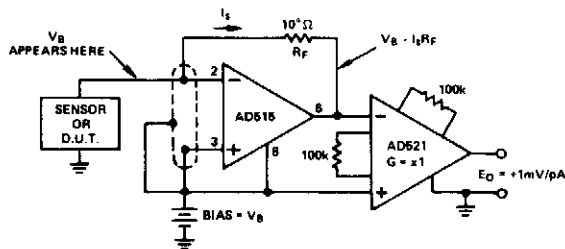
LT1011 IS $\approx 6\text{pF}$. THIS IS AN OFFSET TERM.

† THESE COMPONENTS MAY BE ELIMINATED IF NEGATIVE SUPPLY IS AVAILABLE (-1V TO -15V).

** TYPICAL 2 SECTIONS OF 365pF VARIABLE CAPACITOR WHEN USED AS SHAFT ANGLE INDICATION.

LINEAR TECHNOLOGY CORP.

CURRENT-TO-VOLTAGE CONVERTER WITH GROUNDED BIAS AND SENSOR



ANALOG DEVICES, INC.

Fig. 17-7

TRIANGLE-TO-SINE CONVERTERS

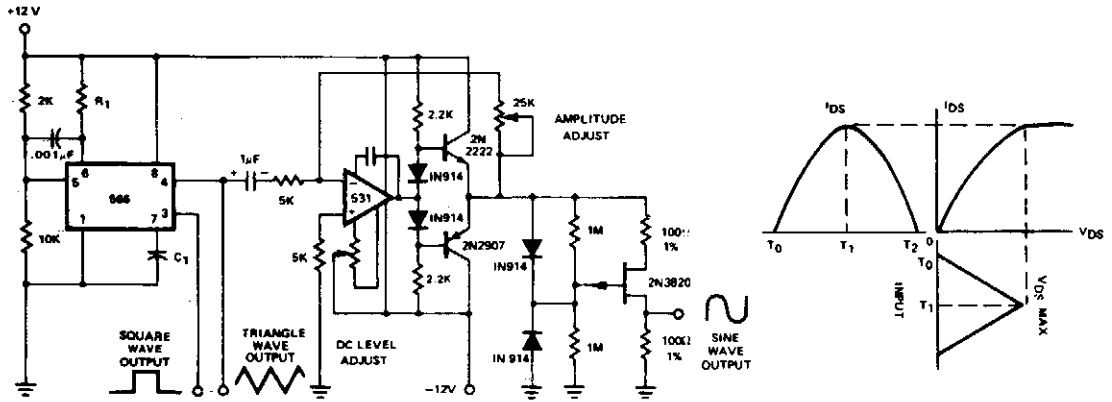


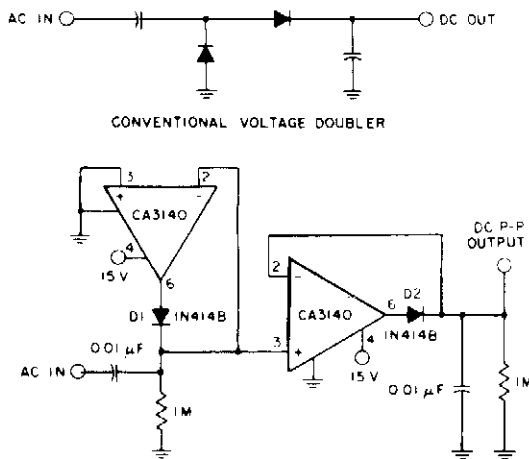
Fig. 17-8

$t_o = \frac{1}{3R_1C_1}$
SIGNETICS

Circuit Notes

Conversion of triangle wave shapes to sinusoids is usually accomplished by diode-resistor shaping networks, which accurately reconstruct the sine wave segment by segment. Two simpler and less costly methods may be used to shape the triangle waveform of the 566 into a sinusoid with less than 2% distortion. The non-linear $I_{DS}V_{DS}$ transfer characteristic of a P-channel junction FET is used to shape the triangle waveform. The amplitude of the triangle waveform is critical and must be carefully adjusted to achieve a low distortion sinusoidal output. Naturally, where additional waveform accuracy is needed, the diode-resistor shaping scheme can be applied to the 566 with excellent results since it has very good output amplitude stability when operated from a regulated supply.

PRECISION PEAK-TO-PEAK AC-DC CONVERTER



GENERAL ELECTRIC/RCA

Fig. 17-9

Circuit Notes

Using a CA3140 BiMOS op amp and a single positive supply converts a conventional voltage doubler with two precision diodes into a precision peak-to-peak ac-to-dc voltage converter having wide dynamic range and wide bandwidth.

ALL RESISTANCE VALUES ARE IN OHMS

"Reprinted with permission from Electronic Design, Vol. 25, No. 24, copyright Hayden Publishing Co., Inc. 1977"

PHOTODIODE CURRENT-TO-VOLTAGE CONVERTER

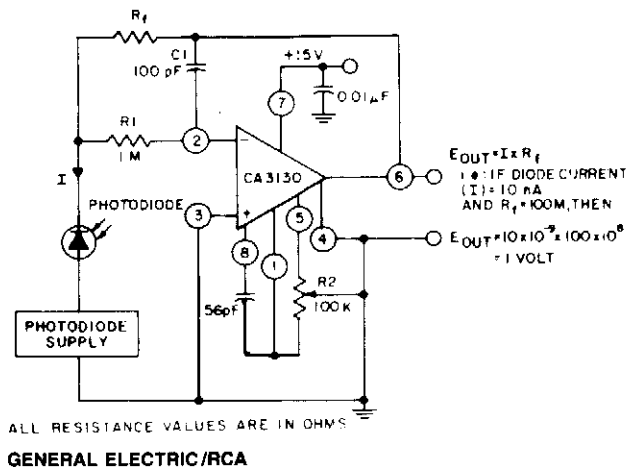
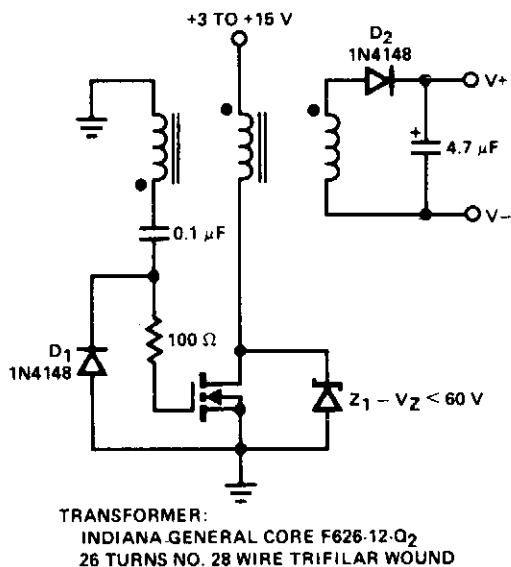


Fig. 17-10

Circuit Notes

The circuit uses three CA3130 BiMOS op amps in an application sensitive to sub-picoampere input currents. The circuit provides a ground-referenced output voltage proportional to input current flowing through the photodiode.

SELF OSCILLATING FLYBACK CONVERTER



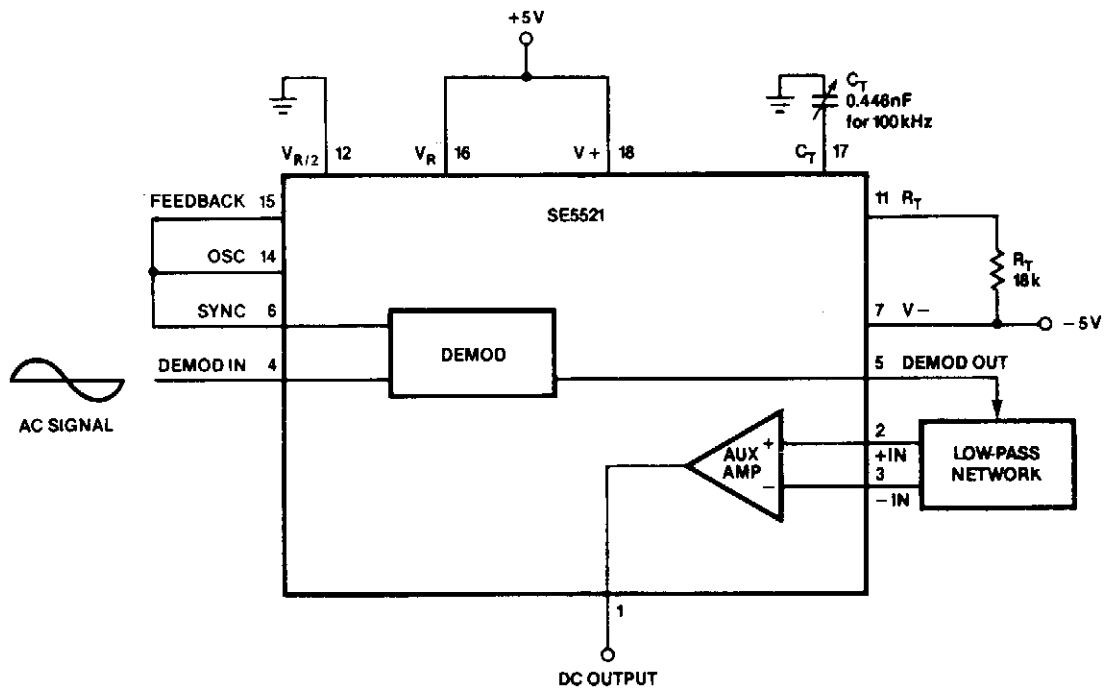
Circuit Notes

Low-power converter uses the core characteristics to determine frequency. With the transformer shown, operating frequency is 250 kHz. Diode D1 prevents negative spikes from occurring at the MOSFET gate, the 100 ohm resistor is a parasitic suppressor, and Z1 serves as a dissipative voltage regulator for the output and also clips the drain voltage to a level below the rated power FET breakdown voltage.

SILICONIX, INC.

Fig. 17-11

RMS-TO-DC CONVERTER



NOTE:

1. The DC output at Pin 1 varies linearly with the RMS input at Pin 4.
2. C_T is tweaked until the sync signal is in phase with the AC signal.

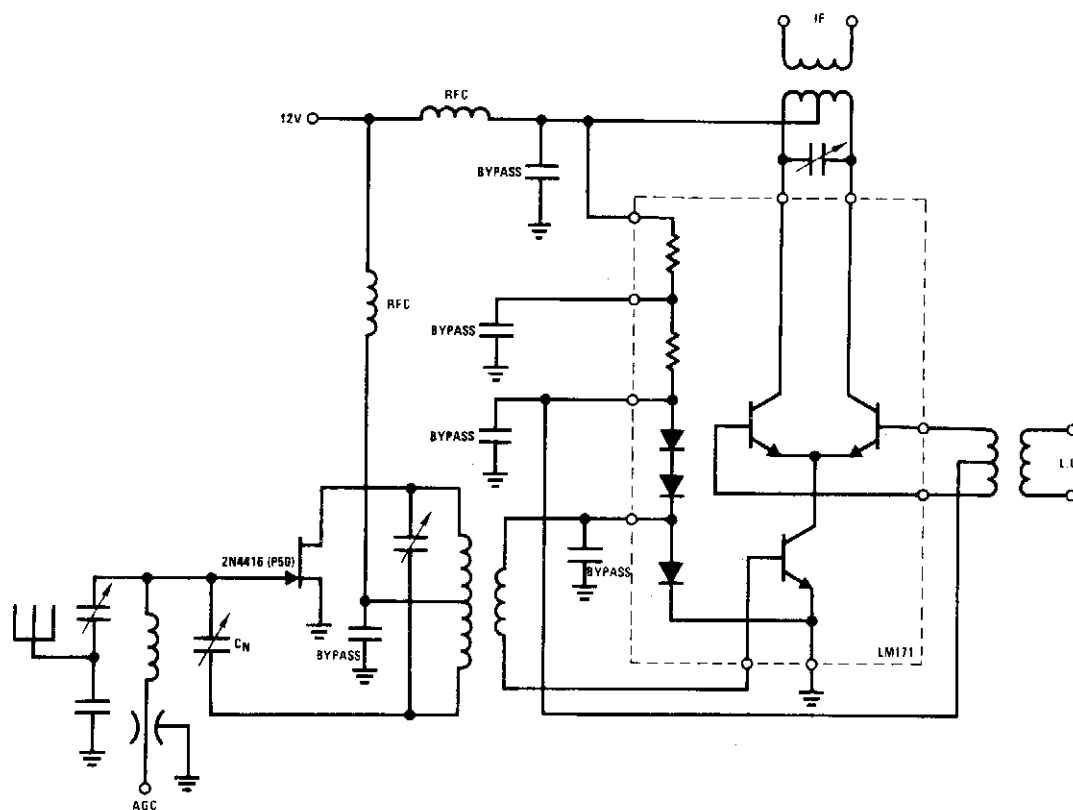
SIGNETICS

Fig. 17-12

Circuit Notes

An ac voltmeter may be easily constructed. Simplicity of the circuit and low component count make it particularly attractive. The demodulator output is a full-wave rectified signal from the ac input at Pin 4. The dc component on the rectified signal at Pin 5 varies linearly with the rms input at Pin 4 and thus provides an accurate rms-to-dc conversion at the output of the filter (Pin 1). C_T is a variable capacitor that is tweaked until the oscillator signal to the sync input of the demodulator is in phase with the ac signal at Pin 4.

100 MHz CONVERTER



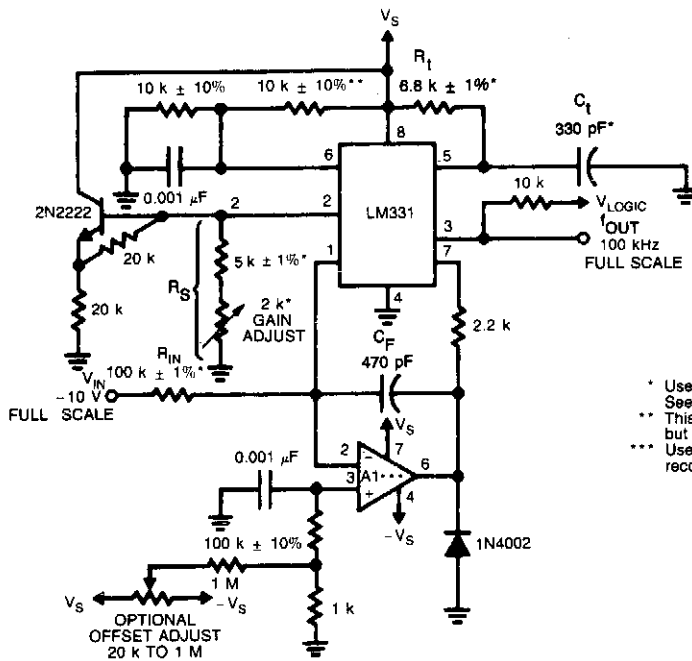
NATIONAL SEMICONDUCTOR CORP.

Fig. 17-13

Circuit Notes

The 2N4416 JFET will provide noise figures of less than 3 dB and power gain of greater than 20 dB. The JFET's outstanding low crossmodulation and low intermodulation distortion provides an ideal characteristic for an input stage. The output feeds into an LM171 used as a balanced mixer. This configuration greatly reduces local oscillator radiation both into the antenna and into the *if* strip and also reduces *rf* signal feedthrough.

PRECISION VOLTAGE-TO-FREQUENCY CONVERTER



- * Use stable components with low temperature coefficients. See Typical Applications section.
- ** This resistor can be 5 k Ω or 10 k Ω for $V_S = 8$ V to 22 V, but must be 10 k Ω = 4.5 V to 8 V.
- *** Use low offset voltage and low offset current op amps for A1; recommended types LF411A or LF356.

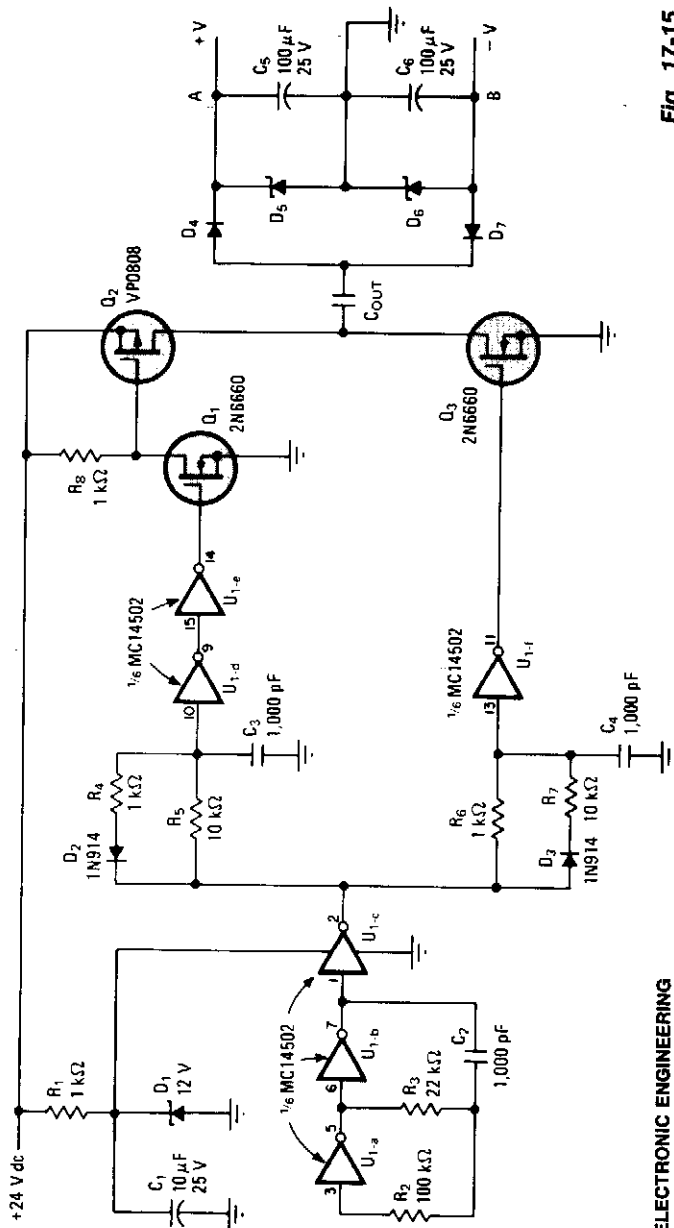
NATIONAL SEMICONDUCTOR CORP.

Fig. 17-14

Circuit Notes

In this circuit, integration is performed by using a conventional operational amplifier and feedback capacitor, C_F . When the integrator's output crosses the nominal threshold level at pin 6 of the LM131, the timing cycle is initiated. The average current fed into the op amp's summing point (pin 2) is $i \times (1.1 R_t C_t) \times f$ which is perfectly balanced with $-V_{IN}/R_{IN}$. In this circuit, the voltage offset of the LM131 input comparator does not affect the offset or accuracy of the V-to-F converter as it does in the stand-alone V-to-F converter, nor does the LM131 bias current or offset current. Instead, the offset voltage and offset current of the operational amplifier are the only limits on how small the signal can be accurately converted.

BIPOLAR DC-DC CONVERTER REQUIRES NO INDUCTOR



ELECTRONIC ENGINEERING

Circuit Notes

Inverters U1a and U1b form a 20-kilohertz oscillator whose square wave output—further shaped by D2, R4, and R5 and by D3, R6, and R7—drives power field-effect transistors Q2 and Q3. The p-channel and n-channel FETs conduct alternately, in a push-pull configuration. When Q2 conducts, the positive charge on C_{out} forces diode D4 to conduct as well, which produces a positive voltage, determined by zener diode D4 to terminal A. Similarly, when Q3, in its turn conducts, the negative charge on C_{out} forces D7 to do so as well. A negative voltage, therefore, develops at terminal B, whose level is set by D6.

Fig. 17-15

18

Counters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- 8-Digit Up/Down Counter
- Ring Counter with Variable Timing
- 20 kHz Ring Counter
- Binary Counter
- 100 MHz Frequency, Period Counter
- Analog Counter Circuit
- Attendance Counter
- 10 MHz Universal Counter

8-DIGIT UP/DOWN COUNTER

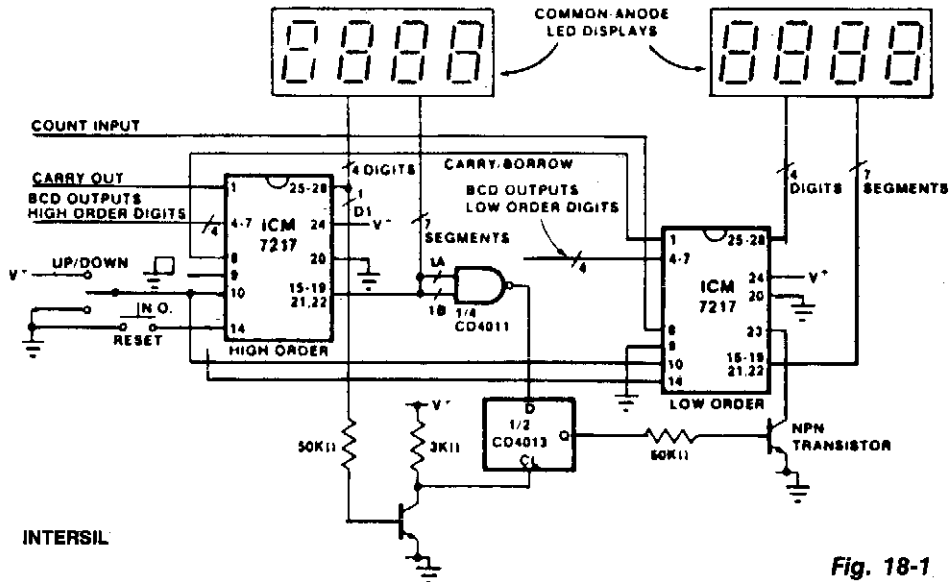
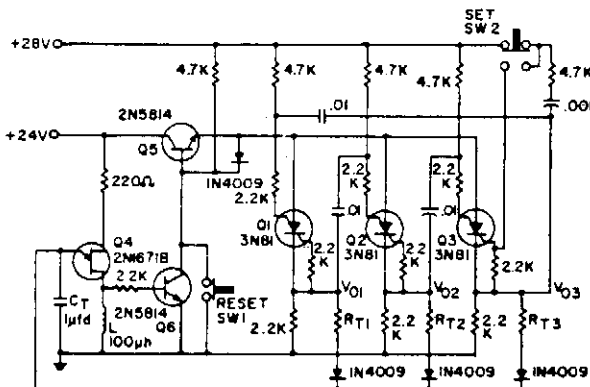


Fig. 18-1

Circuit Notes

This circuit shows how to cascade counters and retain correct leading zero blanking. The NAND gate detects whether a digit is active since one of the two segments a or b is active on any unblanked number. The flip flop is clocked by the least significant digit of the high order counter, and if this digit is not blanked, the Q output of the flip flop goes high and turns on the npn transistor, thereby inhibiting leading zero blanking on the low order counter.

RING COUNTER WITH VARIABLE TIMING



GENERAL ELECTRIC

Fig. 18-2

Circuit Notes

Shift pulses are generated by the unijunction transistors. The intervals between pulses are controlled by C_T and R_T . A different R_T can be selected for each stage of the counter as shown.

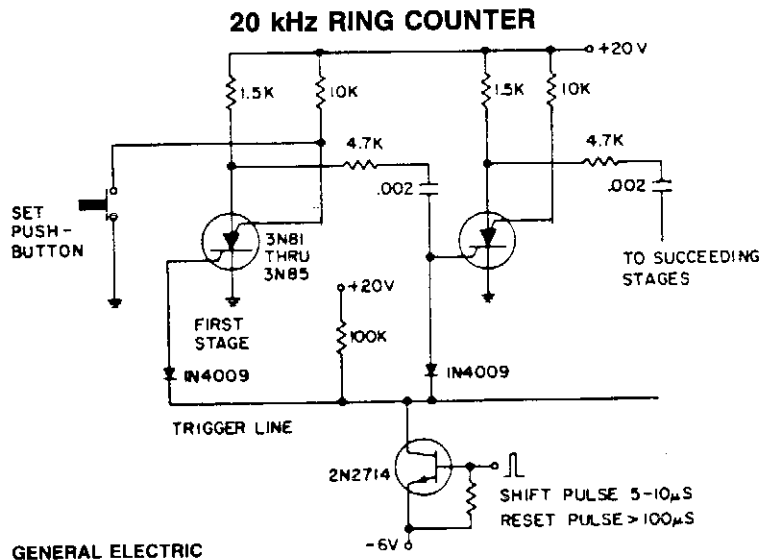


Fig. 18-3

Circuit Notes

The shift pulse turns off the conducting scs by reverse biasing the cathode gate. The charge stored on the coupling capacitor then triggers the next stage. An excessively long shift pulse charges up all the capacitors, turning off all stages. Grounding an anode gate will "set" that stage.

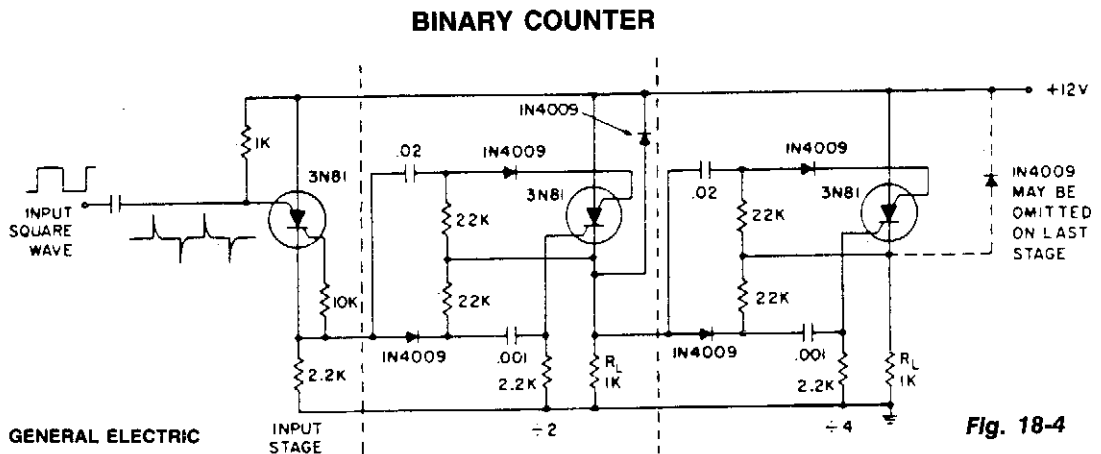
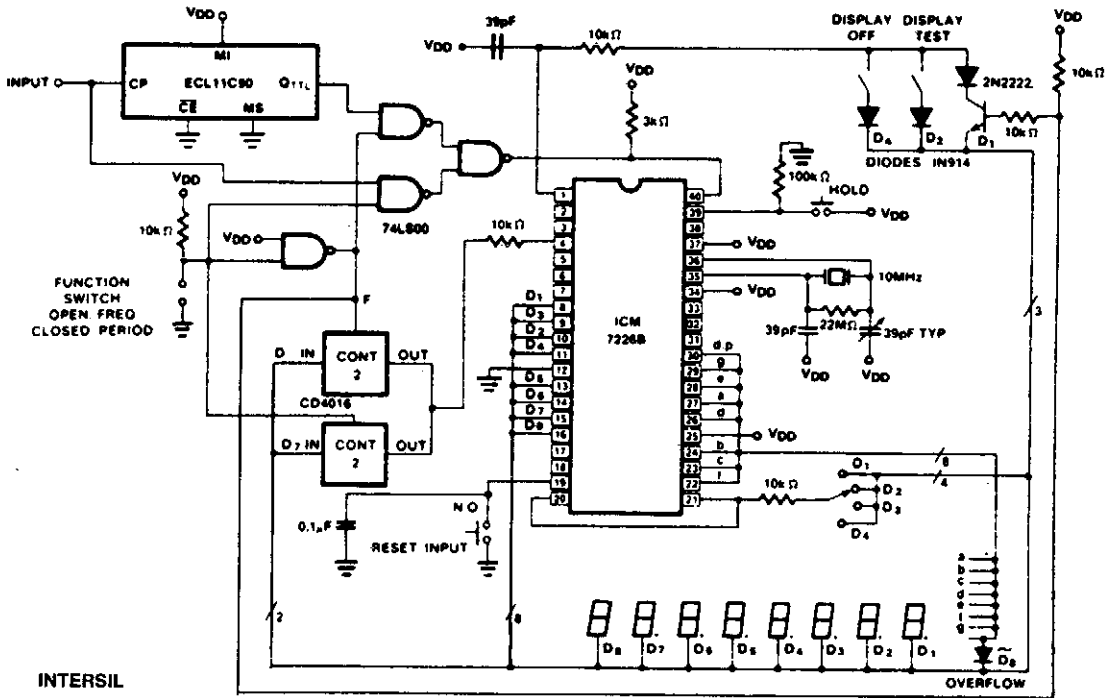


Fig. 18-4

Circuit Notes

Stages are triggered by the positive going edge. The scs is turned on at the cathode gate; turned off at the anode gate. The anode-to-cathode IN4009 suppresses positive transients while the scs is recovering. The input stage generates fast positive edges to trigger the counter.

100 MHz FREQUENCY, PERIOD COUNTER



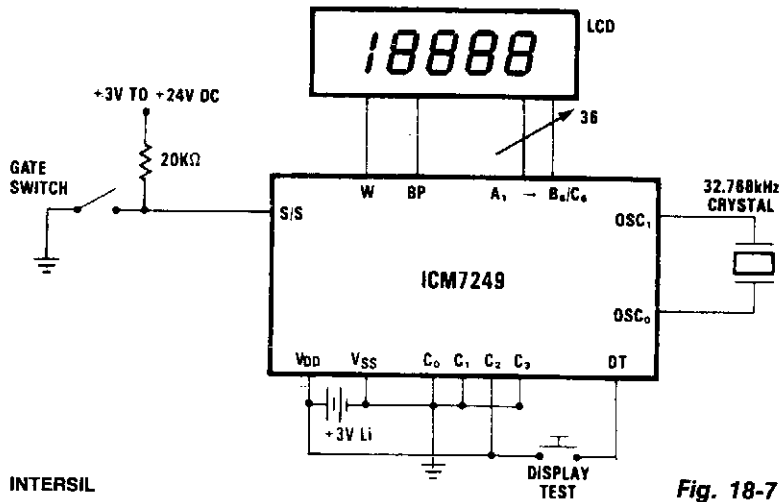
INTERSIL

Fig. 18-5

Circuit Notes

The figure shows the use of a CD4016 analog multiplex to multiplex the digital outputs back to the FUNCTION input. Since the CD4016 is a digitally controlled analog transmission gate, no level shifting of the digit output is required. The CD4051's or CD4052's could also be used to select the proper inputs for the multiplexed input on the ICM7226 from 2 or 3 bit digital inputs. These analog multiplexers may also be used in systems in which the mode of operation is controlled by a microprocessor rather than directly from front panel switches. TTL multiplexers such as the 74LS153 or 74LS251 may also be used, but some additional circuitry will be required to convert the digit output to TTL compatible logic levels.

ATTENDANCE COUNTER

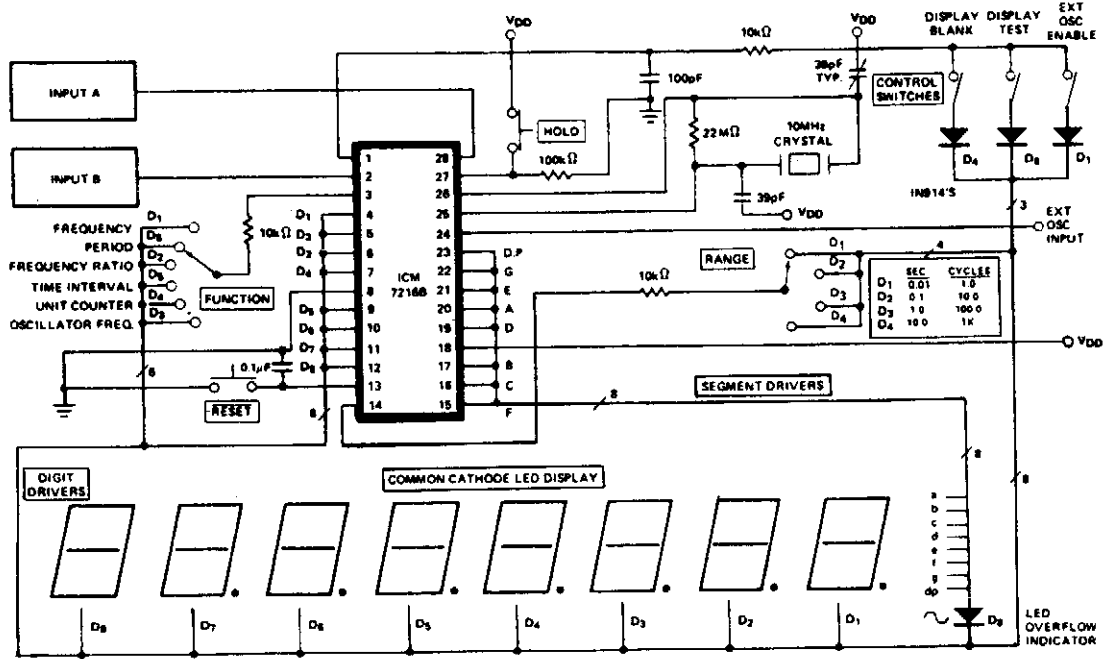


Circuit Notes

The display shows each increment. By using mode 2, external debouncing of the gate switch is unnecessary, provided the switch bounce is less than 35ms. The 3 V lithium battery can be replaced without disturbing operation if a suitable capacitor is connected in parallel with it. The display should be disconnected, if possible, during the procedure to minimize current drain. The capacitor should be large enough to store charge for the amount of time needed to physically replace the battery ($t = VC/I$). A 100 μF capacitor initially charged to 3 V will supply a current of 1.0 μA for 50 seconds before its voltage drops to 2.5 V, which is the minimum operating voltage for the ICM7249.

Before the battery is removed, the capacitor should be placed in parallel, across the V_{DD} and GND terminals. After the battery is replaced, the capacitor can be removed and the display reconnected.

10 MHz UNIVERSAL COUNTER



LC01801

INTERSIL

Fig. 18-8

Circuit Notes

The ICM7216A or B can be used as a minimum component complete Universal Counter. This circuit 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.

19

Crystal Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Varactor-Tuned 10 MHz Ceramic Resonator
Oscillator

10 MHz Crystal-Controlled Oscillator

Low Power, 5V Driven, Temperature Compensated
Crystal Oscillator (TXCO)

Crystal-Controlled LO for SSB Transmitter
Crystal Oscillator

Crystal Controlled Signal Source

1 MHz FET Crystal Oscillator

Pierce Crystal Oscillator

IC-Compatible Crystal Oscillator

Crystal Oscillator Provides Low Noise

Low-Frequency Crystal Oscillator—10 kHz–150 kHz

Overtone Crystal Oscillator

Colpitts Oscillator

Crystal-Controlled Oscillator

High-Frequency Crystal Oscillator

Crystal-Controlled Oscillator Operates from One
Mercury Cell

High-Frequency Signal Generator

Crystal Tester

Crystal Stabilized IC Timer can Provide
Subharmonic Frequencies

VARACTOR-TUNED 10 MHz CERAMIC RESONATOR OSCILLATOR

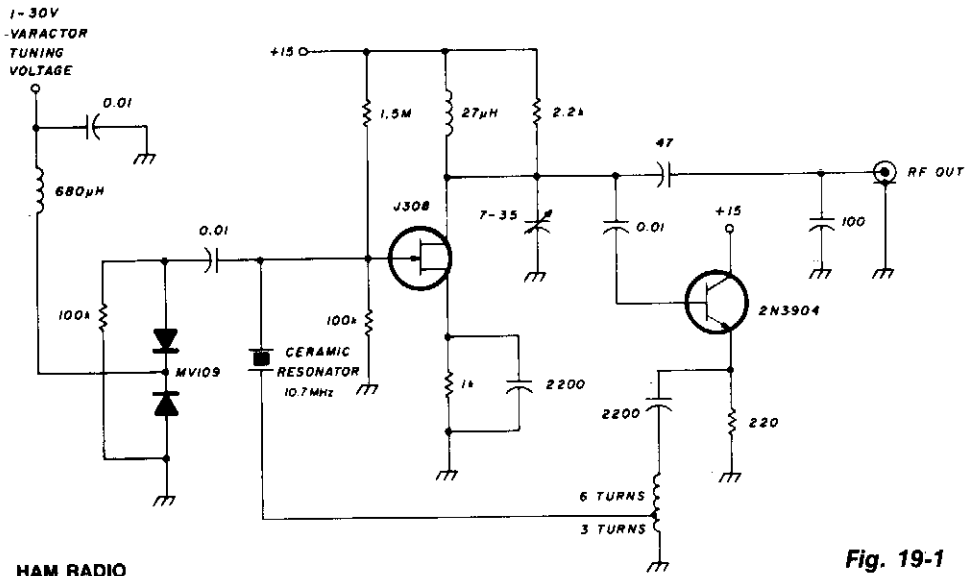
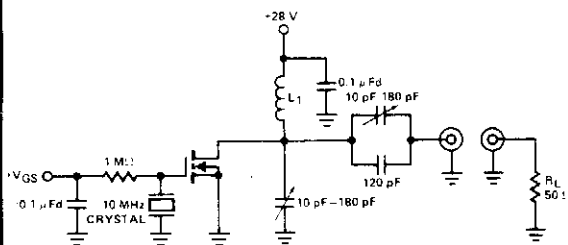


Fig. 19-1

Circuit Notes

The FET input amplifier has fixed bias with source feedback. This provides a very high input impedance with very low capacitance. The FET amplifier drives an emitter follower which, in spite of the fact that it has a low output impedance, feeds a transformer with a 3:1 turns ratio for a nine-fold impedance reduction. The result is an impedance at the ceramic resonator of a few ohms maximum. The varactor-tuned ceramic resonator oscillator has a significant frequency-temperature coefficient. The tuning range of the VCO is approximately 232 kHz, with a temperature coefficient of 350 Hz per degree centigrade. When using this circuit as a VCO, the entire 232 kHz range cannot be used because some of the tuning range must be sacrificed for the temperature dependence. If the required tuning range were 200 kHz, leaving 32 kHz for temperature variation, the resulting temperature variation would be more than 90°C.

10 MHz CRYSTAL OSCILLATOR



SILICONIX INC.

Fig. 19-2

Circuit Notes

This xtal oscillator is a FET equivalent of a vacuum tube tuned to plate-tuned grid xtal oscillator. Feedback is via the drain to gate capacitance.

Parts List

L₁ ~ 18 turns #22 enameled wire on micrometals T-50-6 torroid core. ≈ 1.0 µH.

CRYSTAL OSCILLATOR

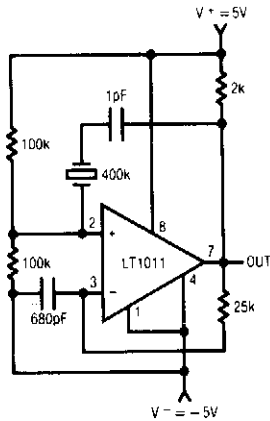


Fig. 19-5

LINEAR TECHNOLOGY CORPORATION

Circuit Notes

This circuit uses an LT1011 comparator biased in its linear mode and a crystal to establish its resonant frequency. This circuit can achieve a few hundred kHz, temperature independent clock frequency with nearly 50% duty cycle.

CRYSTAL-CONTROLLED SIGNAL SOURCE

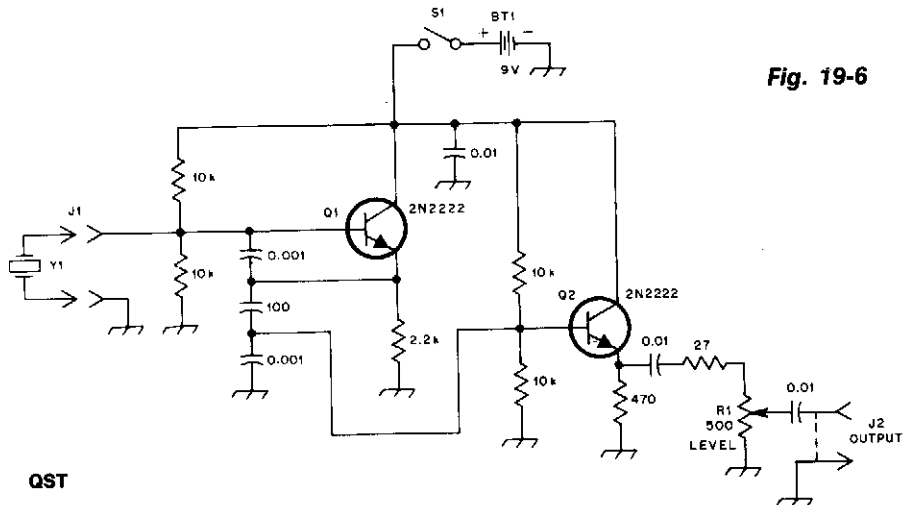


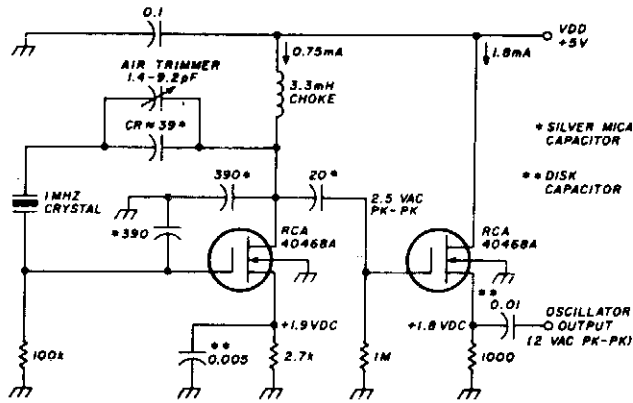
Fig. 19-6

QST

Circuit Notes

This general purpose signal source serves very well in signal-tracing applications. The output level is variable to more than 1 Vrms into a 50 Ω load. Almost any crystal in the 1 to 15 MHz range can be used. Q1 forms a Colpitts oscillator with the output taken from the emitter. A capacitive voltage divider (across the 2.2 K emitter resistor) reduces the voltage applied to the buffer amplifier, Q2. The buffer and emitter follower, provides the low input impedance necessary to drive 50 Ω loads.

1 MHz FET CRYSTAL OSCILLATOR



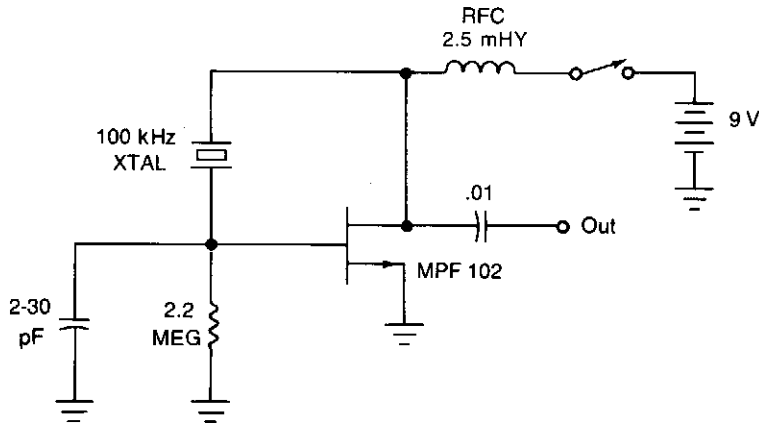
HAM RADIO

Fig. 19-7

Circuit Notes

This stable oscillator circuit exhibits less than 1 Hz frequency change over a V_{DD} range of 3-9 volts. Stability is attributed to the use of MOSFET devices and the use of stable capacitors.

PIERCE CRYSTAL OSCILLATOR



WILLIAM SHEETS

Fig. 19-8

Circuit Notes

The JFET Pierce oscillator is stable and simple. It can be the clock of a microprocessor, a digital timepiece or a calculator. With a probe at the output, it can be used as a precise injection oscillator for troubleshooting. Attach a small length of wire at the output and this circuit becomes a micropower transmitter.

IC-COMPATIBLE CRYSTAL OSCILLATOR

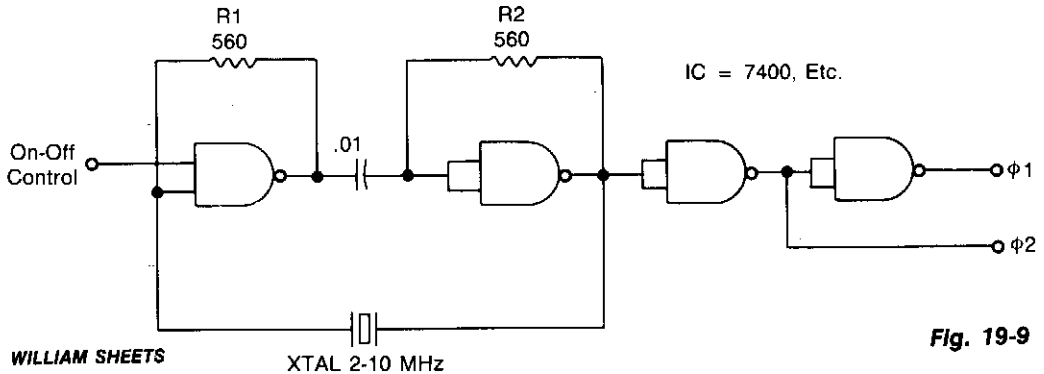


Fig. 19-9

Circuit Notes

Resistors R1 and R2 temperature-stabilize the NAND gates; they also ensure that the gates are in a linear region for starting. Capacitor C1 is a dc block; it must have less than $\frac{1}{10}$ ohm impedance at the operating frequency. The crystal runs in a series-resonant mode. Its series resistance must be low; AT-cut crystals for the 1- to 10-MHz range work well. The output waveshape has nearly a 50% duty cycle, with chip-limited rise times. The circuit starts well from 0° to 70°C.

CRYSTAL OSCILLATOR PROVIDES LOW NOISE

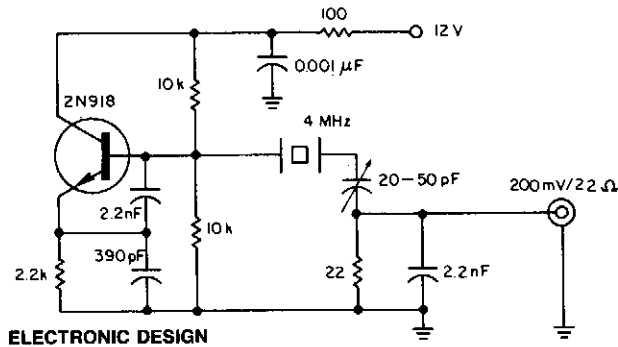


Fig. 19-10

Circuit Notes

The oscillator delivers an output of high spectral purity without any substantial sacrifice of the usual stability of a crystal oscillator. The crystal in addition to determining the oscillator's frequency, is used also as a low-pass filter for the unwanted harmonics and as a bandpass filter for the sideband noise. The noise bandwidth is limited to less than 100 Hz. All higher harmonics are substantially suppressed—60 dB down for the third harmonic of the 4-MHz fundamental oscillator frequency.

LOW-FREQUENCY CRYSTAL OSCILLATOR—10 kHz to 150 kHz

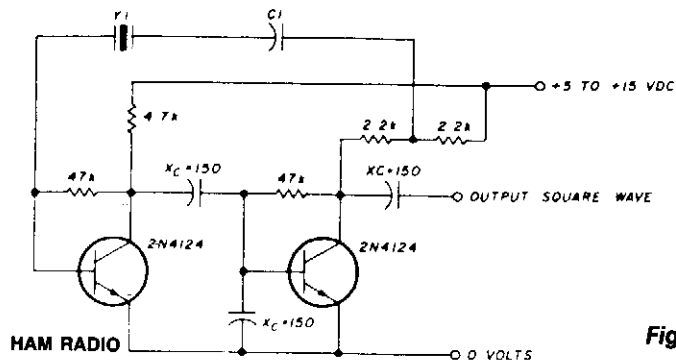
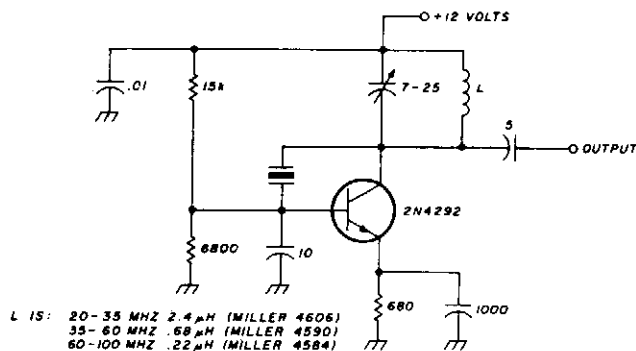


Fig. 19-11

Circuit Notes

C1 in series with the crystal may be used to adjust the oscillator output frequency. Value may range between 20 pF and 0.01 μ F, or may be a trimmer capacitor and will approximately equal the crystal load capacitance. X values are approximate and can vary for most circuits and frequencies; this is also true for resistance values. Adequate power supply decoupling is required; local decoupling capacitors near the oscillator are recommended. All leads should be extremely short in high frequency circuits.

OVERTONE CRYSTAL OSCILLATOR



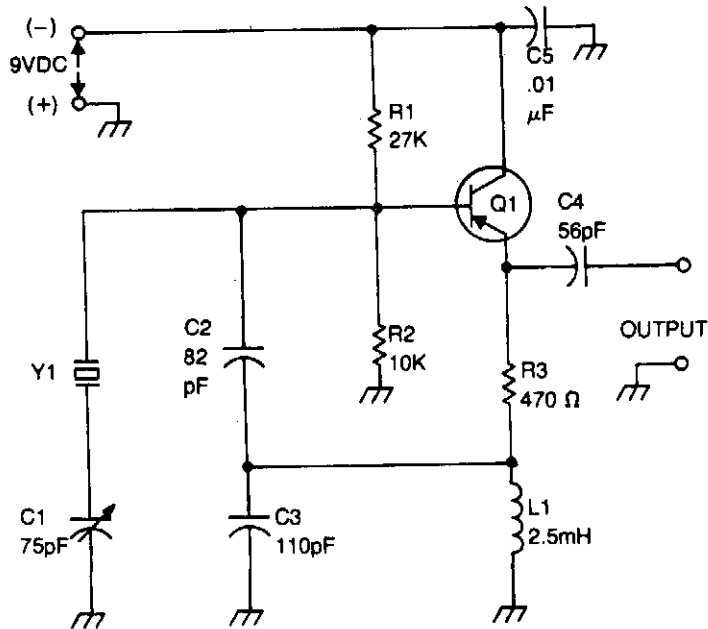
HAM RADIO

Fig. 19-12

Circuit Notes

This oscillator is designed for overtone crystals in the 20-100 MHz range operating in the third and fifth mode. Operating frequency is determined by the tuned circuit.

COLPITTS OSCILLATOR



TAB BOOKS, INC.

Fig. 19-13

Circuit Notes

Bias for the pnp bipolar transistor is provided by resistor voltage divider network R1/R2. The collector of the oscillator transistor is kept at ac ground by capacitor C5, placed close to the transistor. Feedback is provided by capacitor voltage divider C2/C3.

CRYSTAL-CONTROLLED OSCILLATOR

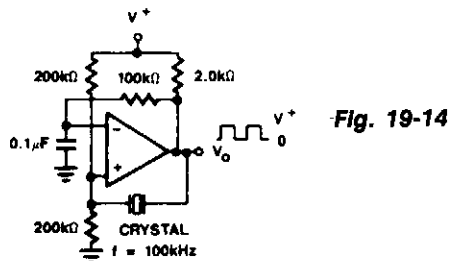
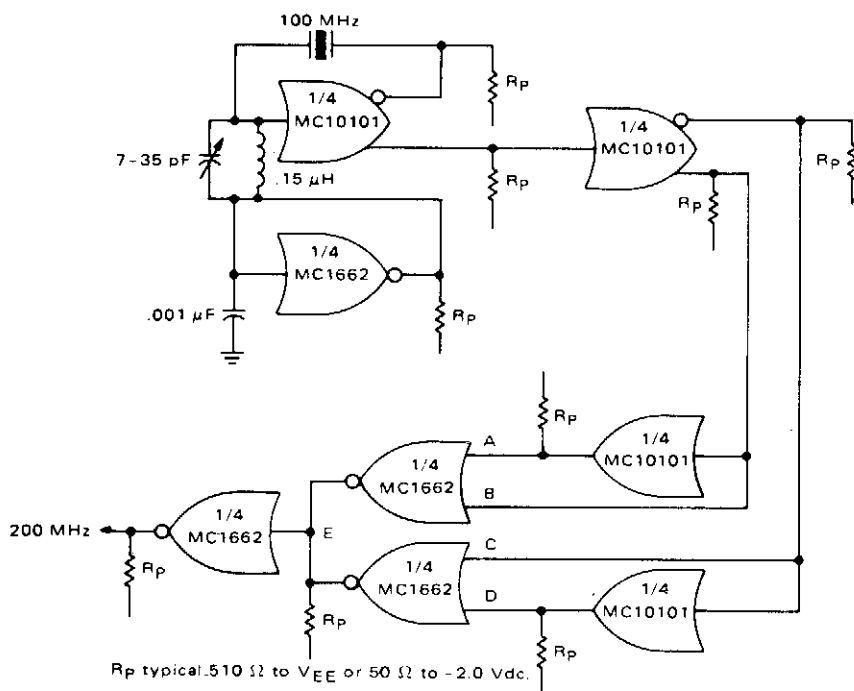


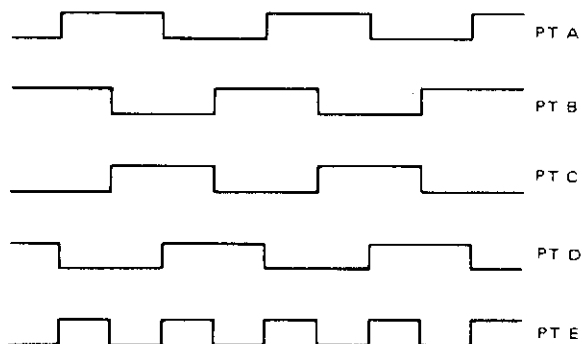
Fig. 19-14

SIGNETICS

HIGH-FREQUENCY CRYSTAL OSCILLATOR



200 MHz Crystal Oscillator



Frequency Doubler Waveforms

MOTOROLA, INC.

Fig. 19-15

HIGH-FREQUENCY CRYSTAL OSCILLATOR, Continued.

Circuit Notes

A high speed oscillator is possible by combining an MECL 10 K crystal oscillator with an MECL III frequency doubler as shown. 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. The gates are easier to incorporate and cause only a slight skew in output signal duty cycle. The MC1662 gates combine the 4 phase 100 MHz signals as shown in Figure B. The outputs of the MC1662's are wire-OR connected to give the 200 MHz signal. MECL III gates are used because of the bandwidth required for 200 MHz signals. One of the remaining MC1662 gates is used as a V_{BB} bias generator for the oscillator. By connecting the NOR output to the input, the circuit stays in the center of the logic swing or at V_{BB} . A 0.001 μF capacitor ensures the V_{BB} circuit does not oscillate.

CRYSTAL-CONTROLLED OSCILLATOR OPERATES FROM ONE MERCURY CELL

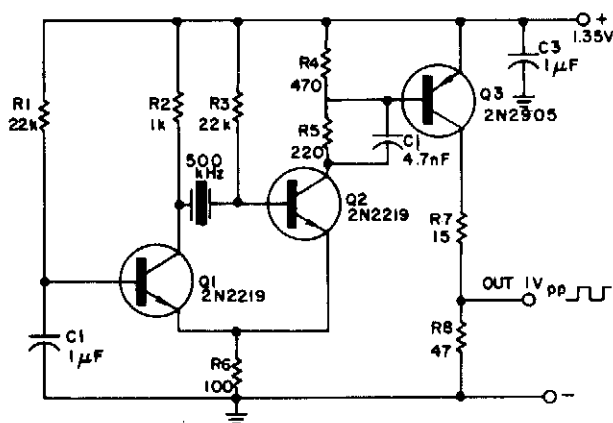


Fig. 19-16

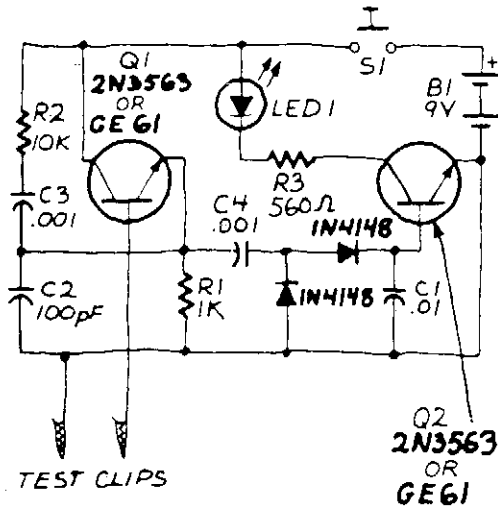
ELECTRONIC DESIGN

Inexpensive crystal controlled oscillator operates from a 1.35-volt source.

Circuit Notes

The circuit is powered by a single 1.35 V mercury cell and provides a 1 V square-wave output. As shown, the crystal is a tuned circuit between transistors Q1 and Q2, which are connected in the common-emitter configuration. Positive feedback provided by means of R permits oscillation. The signal at the collector of Q2 is squared by Q3, which switches between cutoff and saturation. R7 permits short-circuit-proof operation.

CRYSTAL TESTER



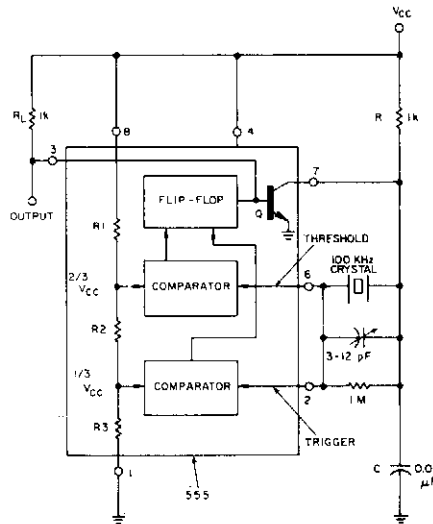
RADIO-ELECTRONICS

Fig. 19-18

Circuit Notes

Transistor Q1, a 2N3563, and its associated components form an oscillator circuit that will oscillate if, and only if, a good crystal is connected to the test clips. The output from the oscillator is then rectified by the two 1N4148 diodes and filtered by C1, a .01 μ F capacitor. The positive voltage developed across the capacitor is applied to the base of Q2, another 2N3563, causing it to conduct. When that happens, current flows through LED1, causing it to glow. Since only a good crystal will oscillate, a glowing LED indicates that the crystal is indeed OK. The circuit is powered by a standard nine-volt transistor-radio battery and the SPST pushbutton power-switch is included to prolong battery life.

CRYSTAL-STABILIZED IC TIMER CAN PROVIDE SUBHARMONIC FREQUENCIES



ELECTRONIC DESIGN

Fig. 19-19

The trimmer across the crystal can finely tune the circuit's oscillating frequency.

20

Current Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Ammeter with Six Decade Range
Current Sensing in Supply Rails
Pico Ammeter
Electrometer Amplifier with Overload Protection
Guarded Input Picoammeter Circuit
Ammeter with Six Decade Range
Picoammeter Circuit

PICO AMMETER

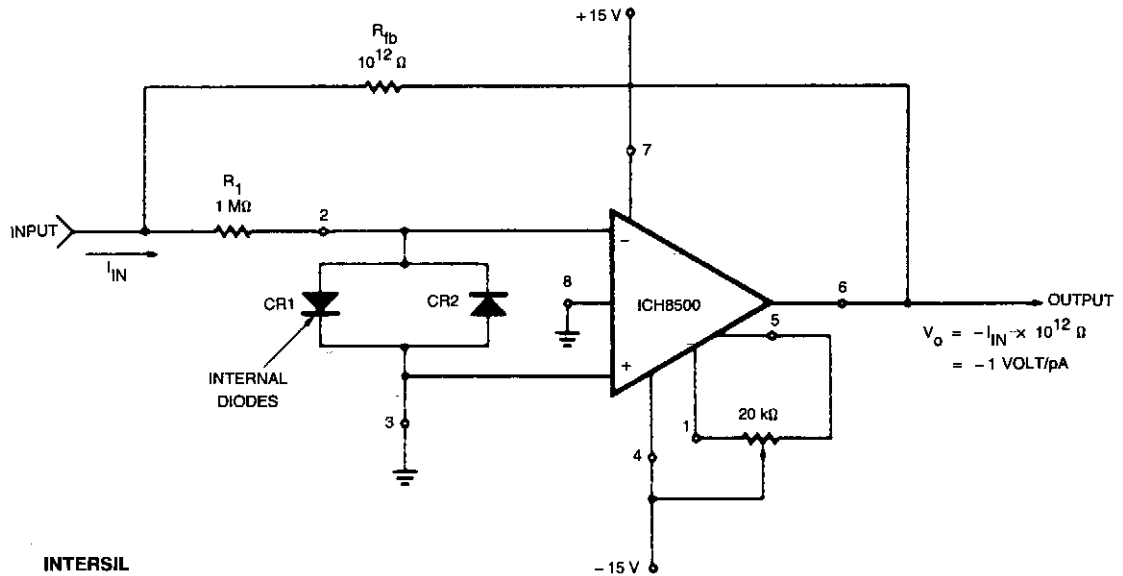
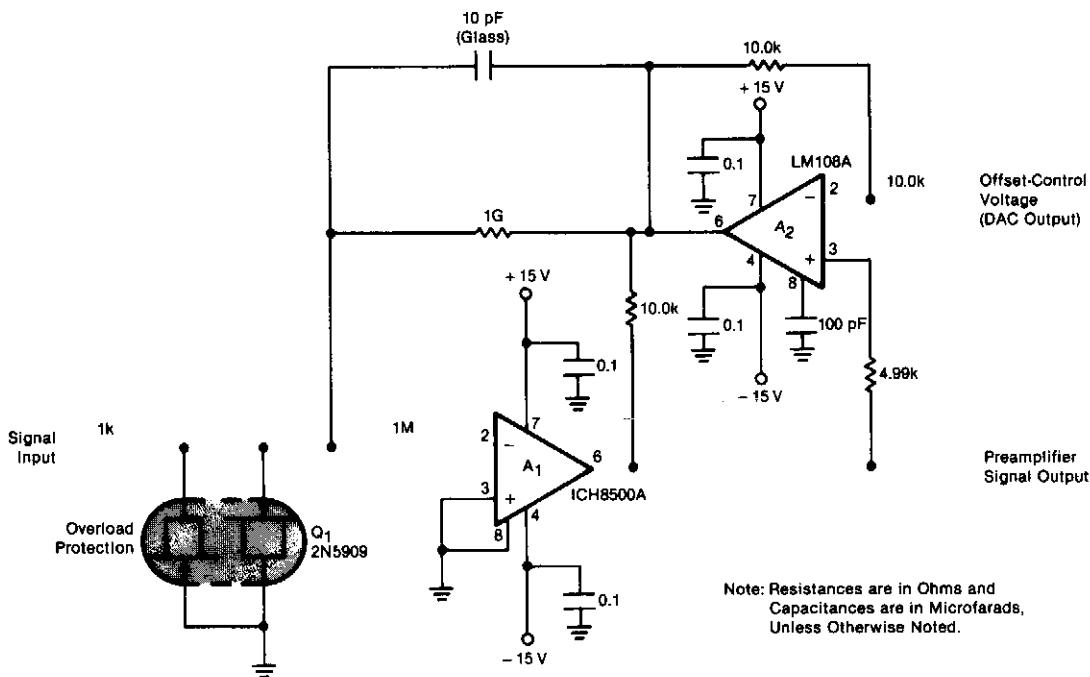


Fig. 20-3

Circuit Notes

Care must be taken to eliminate any stray currents from flowing into the current summing node. This can be accomplished by forcing all points surrounding the input to the same potential as the input. In this case the potential of the input is at virtual ground, or 0V. Therefore, the case of the device is grounded to intercept any stray leakage currents that may otherwise exist between the $\pm 15 \text{ V}$ input terminals and the inverting input summing junctions. Feedback capacitance should be kept to a minimum in order to maximize the response time of the circuit to step function input currents. The time constant of the circuit is approximately the produce of the feedback capacitance C_{fb} times the feedback resistor R_{fb} . For instance, the time constant of the circuit is 1 sec if $C_{fb} = 1 \text{ pF}$. Thus, it takes approximately 5 sec (5 time constants) for the circuit to stabilize to within 1% of its final output voltage after a step function of input current has been applied. C_{fb} of less than 0.2 to 0.3 pF can be achieved with proper circuit layout.

ELECTROMETER AMPLIFIER WITH OVERLOAD PROTECTION



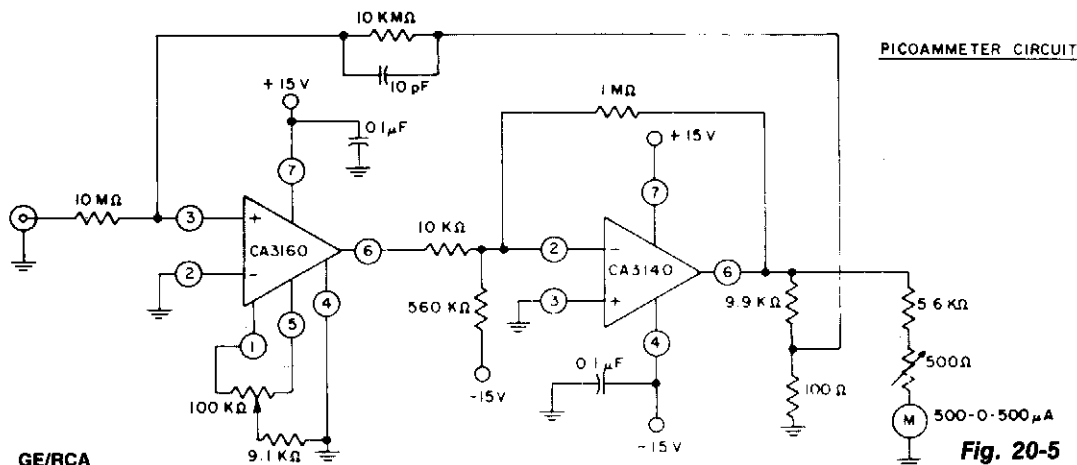
NASA TECH BRIEFS

Fig. 20-4

Circuit Notes

The preamplifier is protected from excessive input signals of either polarity by the 2N5909 junction field-effect transistor. A nulling circuit makes it possible to set the preamplifier output voltage to zero at a fixed low level (up to $\pm 10^{-8}$ A) of the input current. (This level is called the standing current and corresponds to the zero-signal level of the instrumentation.) The opposing (offset) current is generated in the 10^9 feedback resistor to buck the standing current. Different current ranges are reached by feeding the preamplifier output to low and high gain amplifier chains. To reduce noise, each chain includes a 1.5 Hz corner active filter.

GUARDED INPUT PICOAMMETER CIRCUIT



GE/RCA

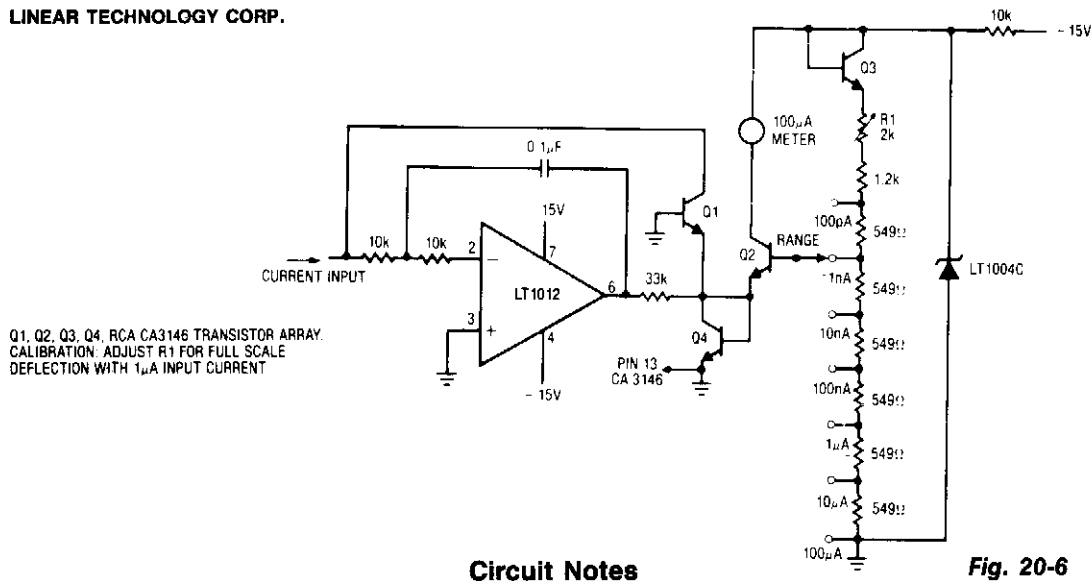
Fig. 20-5

Circuit Notes

The circuit utilizes CA3160 and CA3140 BiMOS op amps to provide a full-scale meter deflection of $\pm 3 \mu\text{A}$. The CA3140 serves as an X100 gain stage to provide the required plus and minus output swing for the meter and feedback network. Terminals 2 and 4 of the CA3160 are at ground potential, thus its input is operated in the "guarded mode."

AMMETER WITH SIX DECADE RANGE

LINEAR TECHNOLOGY CORP.



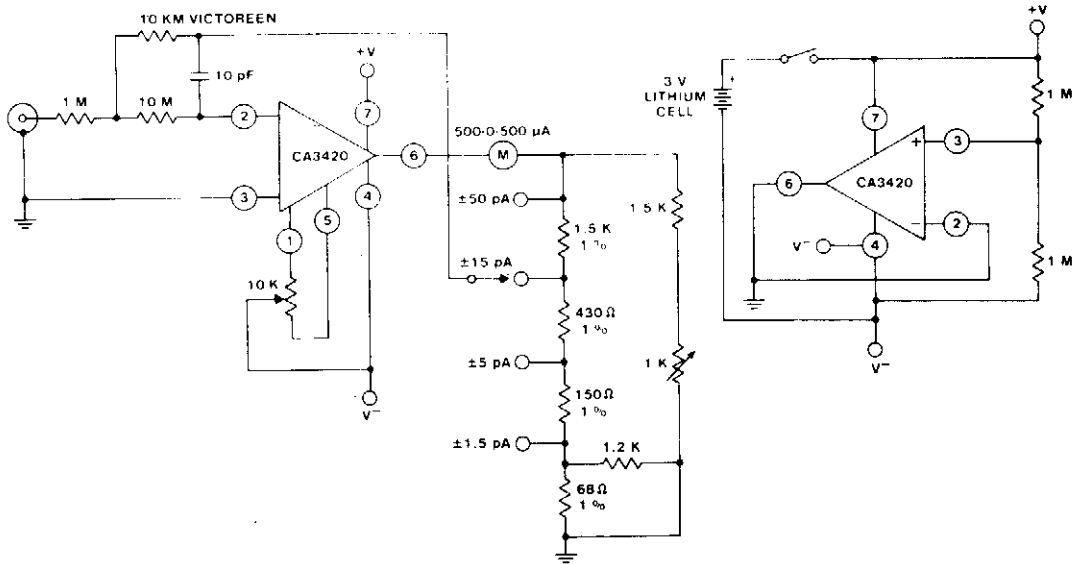
Q1, Q2, Q3, Q4, RCA CA3146 TRANSISTOR ARRAY.
CALIBRATION: ADJUST R1 FOR FULL SCALE
DEFLECTION WITH $1 \mu\text{A}$ INPUT CURRENT

Circuit Notes

Fig. 20-6

The Ammeter measures currents from 100 pA to $100 \mu\text{A}$ without the use of expensive high value resistors. Accuracy at $100 \mu\text{A}$ is limited by the offset voltage between Q1 and Q2 and, at 100 pA , by the inverting bias current of the LT1008.

PICOAMMETER CIRCUIT



GENERAL ELECTRIC /RCA

Fig. 20-7

Circuit Notes

The circuit uses the exceptionally low input current (0.1 pA) of the CA3420 BiMOS op amp. With only a single 10 megohm resistor, the circuit covers the range from ± 50 pA maximum to a full-scale sensitivity of ± 1.5 pA. Using an additional CA3420, a low-resistance center tap is obtained from a single 3-volt lithium battery.

21

Demodulators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Narrow Band FM Demodulator with Carrier Detect
Stereo Demodulator
AM Demodulator
FM Demodulator

NARROW BAND FM DEMODULATOR WITH CARRIER DETECT

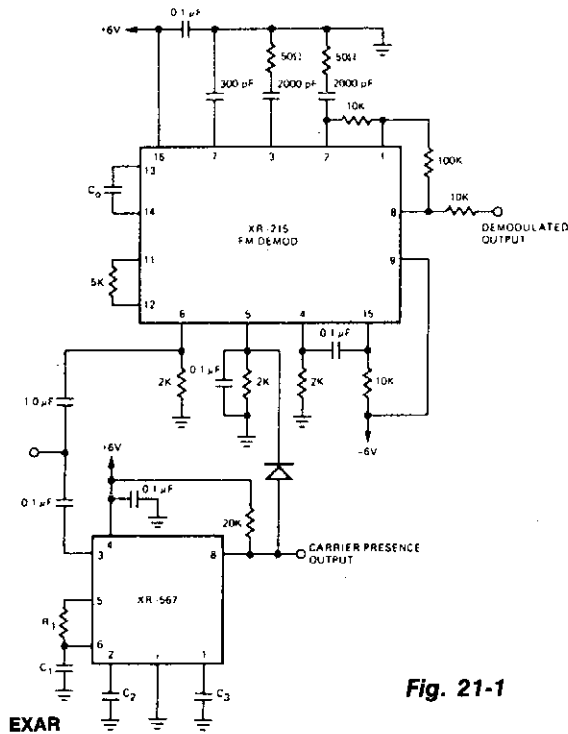


Fig. 21-1

Circuit Notes

For FM demodulation applications where the bandwidth is less than 10% of the carrier frequency, an XR-567 can be used to detect the presence of the carrier signal. The output of the XR-567 is used to turn off the FM demodulator when no carrier is present, thus acting as a squelch. In the circuit shown, an XR-215 FM demodulator is used because of its wide dynamic range, high signal/noise ratio and low distortion. The XR-567 will detect the presence of a carrier at frequencies up to 500 kHz.

STEREO DEMODULATOR

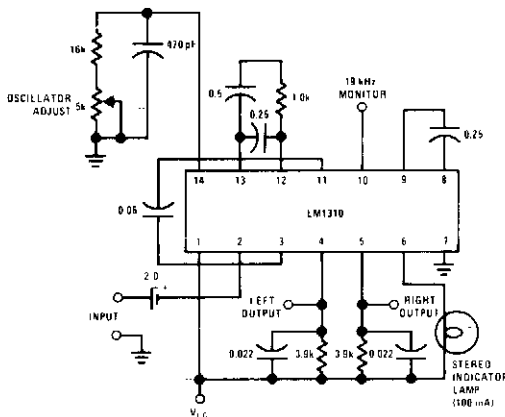


Fig. 21-2

Circuit Notes

This circuit uses a single IC LM1310 to provide left and right outputs from a composite MPX stereo signal. Oscillator adjust R1 is set for 76 kHz (19 kHz at pin 10). C1 should be a silver mica or NPO ceramic capacitor.

AM DEMODULATOR

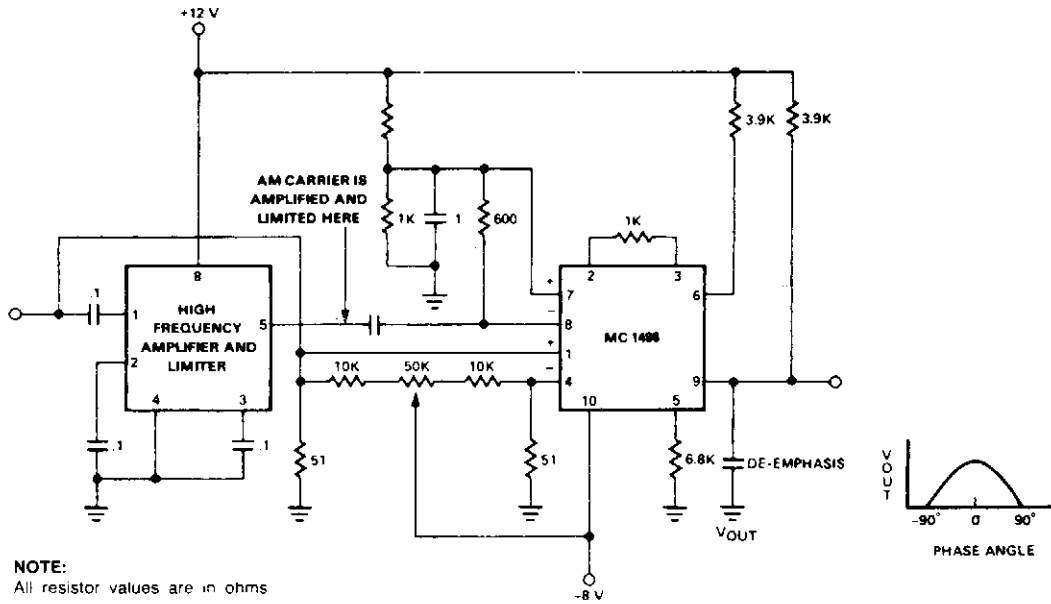


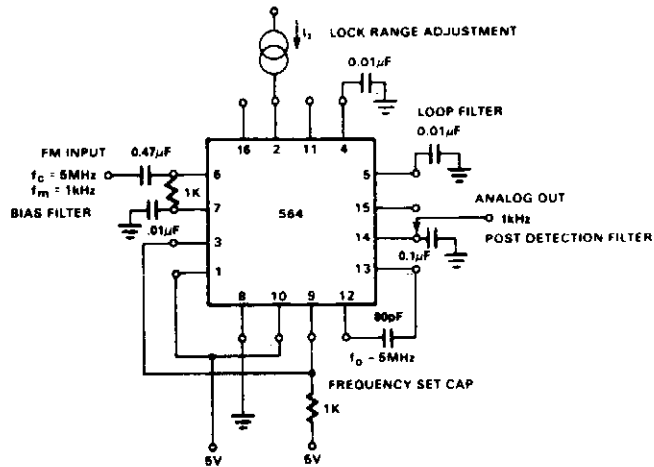
Fig. 21-3

SIGNETICS

Circuit Notes

Amplifying and limiting of the AM carrier is accomplished by the if gain block providing 55 dB of gain or higher with a limiting of 40 μ V. The limited carrier is then applied to the detector at the carrier ports to provide the desired switching function. The signal is then demodulated by the synchronous AM demodulator (1496) where the carrier frequency is attenuated due to the balanced nature of the device. Care must be taken not to overdrive the signal input so that distortion does not appear in the recorded audio. Maximum conversion gain is reached when the carrier signals are in phase as indicated by the phase-gain relationship. Output filtering is also necessary to remove high frequency sum components of the carrier from the audio signal.

FM DEMODULATOR



A

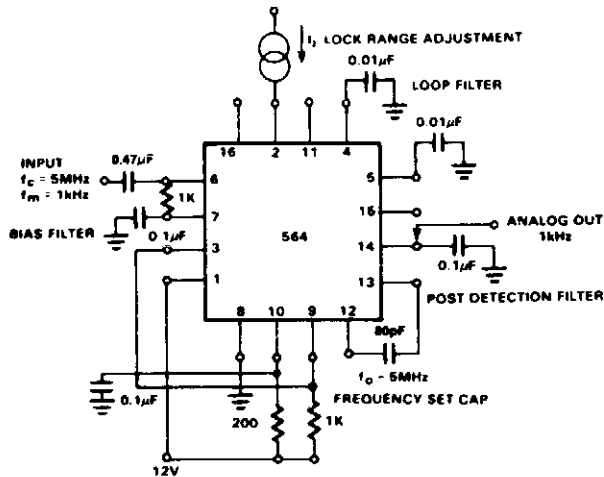


Fig. 21-4

B

SIGNETICS

Circuit Notes

The NE564 is used as an FM demodulator. The connections for operation at 5 V and 12 V are shown in Figures 21-4A and 21-4B. The input signal is ac coupled with the output signal being extracted at Pin 14. Loop filtering is provided by the capacitors at Pins 4 and 5 with additional filtering being provided by the capacitor at Pin 14. Since the conversion gain of the VCO is not very high, to obtain sufficient demodulated output signal the frequency deviation in the input signal should be 1% or higher.

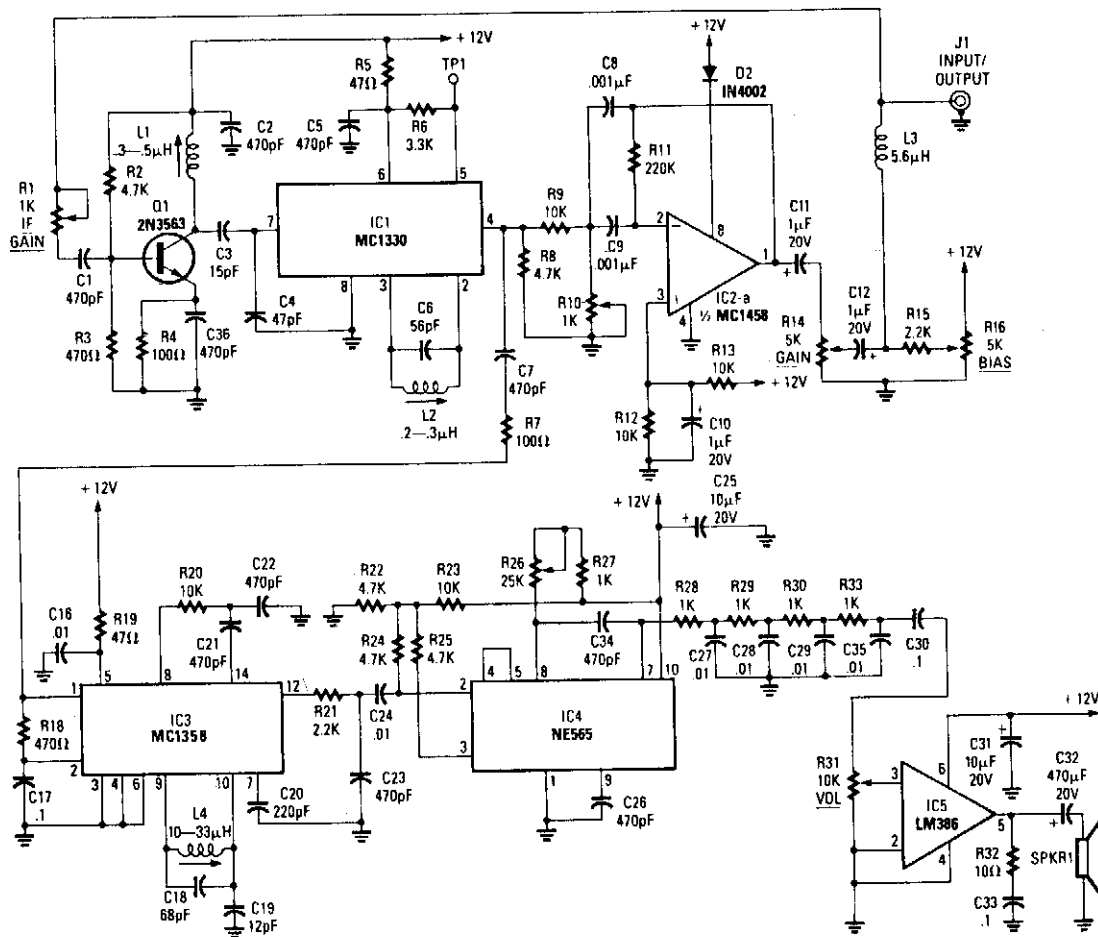
22

Descramblers and Decoders

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Sine Wave Descrambler
- Outband Descrambler
- Gated Pulse Descrambler
- SCA Decoder
- Dual Time Constant Tone-Decoder
- Stereo TV Decoder
- Time Division Multiplex (TDM) Stereo Decoder
- Frequency Division Multiplex (FDM) Stereo Decoder
- SCA (Background Music) Decoder

SINE WAVE DESCRAMBLER



—A COMPLETE SINEWAVE DESCRAMBLER. Easy to build, and relatively easy to align, this circuit completely removes the 15.75-kHz scrambling sinewave.

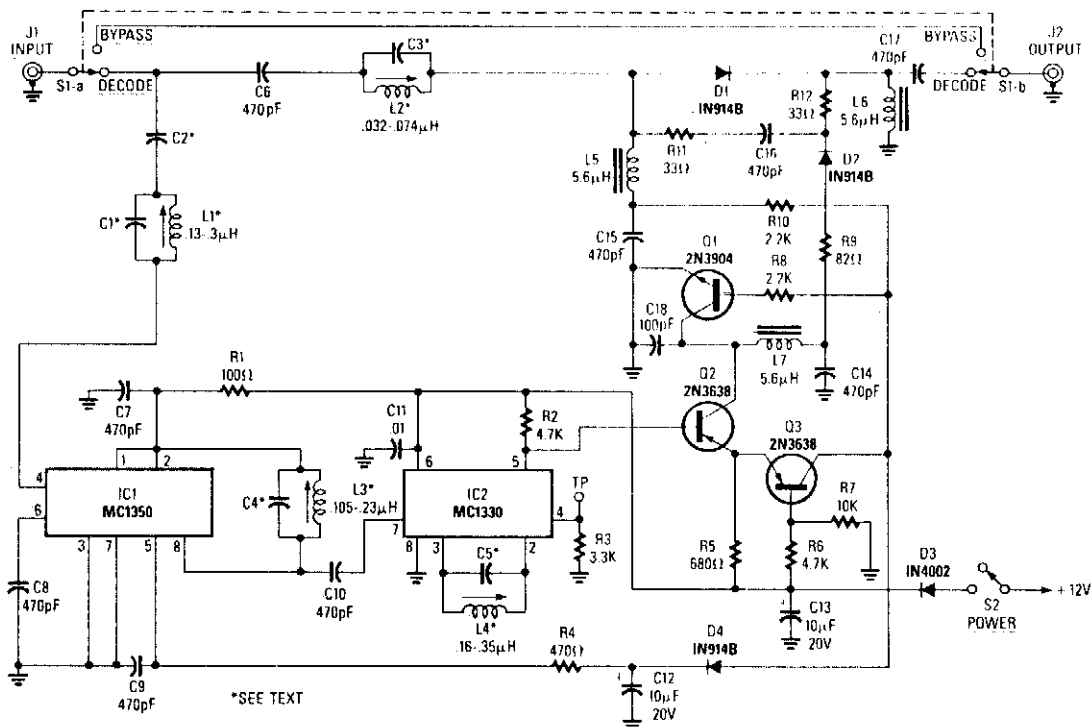
RADIO-ELECTRONICS

Fig. 22-1

Circuit Notes

This decoder features a sine wave recovery channel and uses a PIN diode attenuator driven by the sine wave recovery system to cancel out the sine wave sync suppression signal. Kit available from North Country Radio, P.O. Box 53, Wykagyl Station, New York 10804.

OUTBAND DESCRAMBLER



—FOR THE OUTBAND DECODER shown here to work, the cable company must provide at least a 1 millivolt signal. Values for C1-C5 and L1-L4 are found in Table 1.

TABLE 1—CAPACITOR AND COIL VALUES

	50 MHz	90-114 MHz
C1	5 pF	5 pF
C2	47 pF	12 pF
C3	200 pF	82 pF
C4	56 pF	12 pF
C5	56 pF	10 pF
L1	0.2 µH	0.2 µH
L2	0.05 µH	0.03 µH
L3	0.175 µH	0.2 µH
L4	0.175 µH	0.24 µH

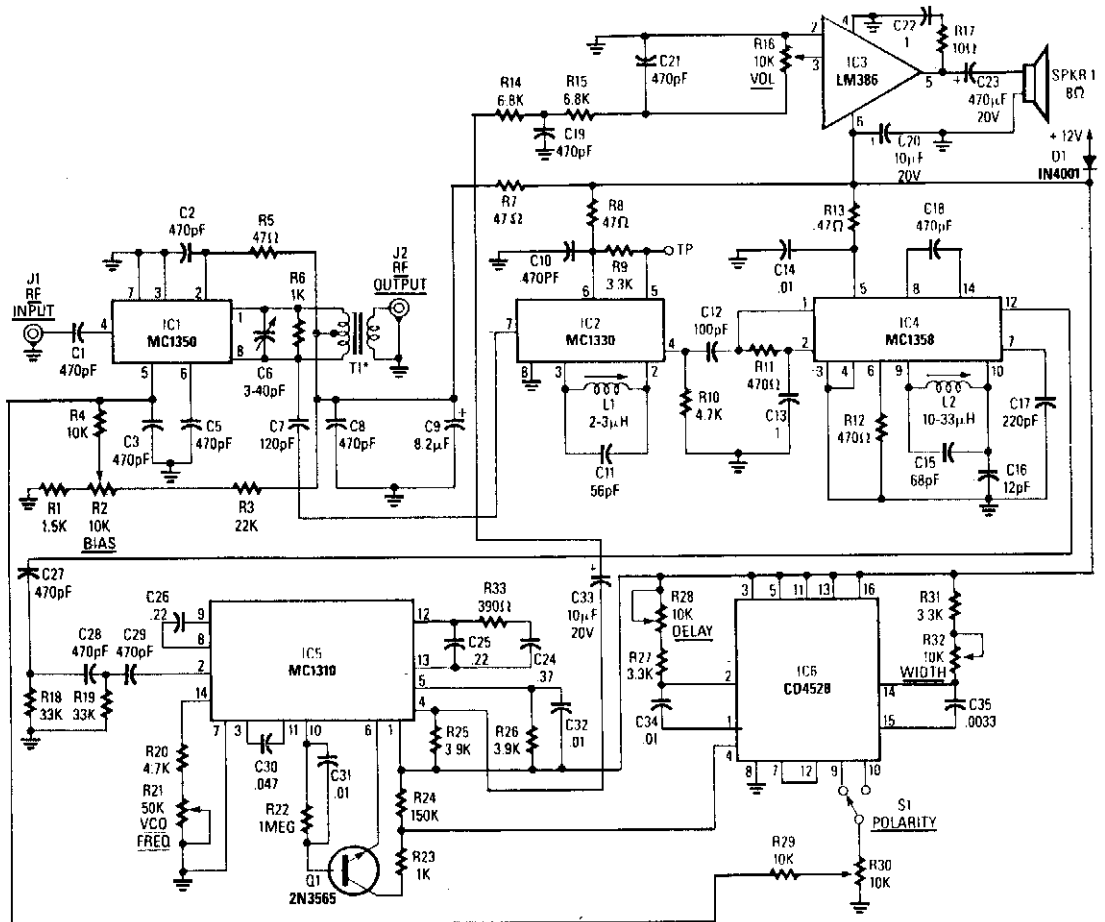
Fig. 22-2

RADIO-ELECTRONICS

Circuit Notes

This circuit consists of an amplifier for the synch channel and a video detector which controls an attenuator so that the gain of the systems is increased during synch intervals. Kit available from North Country Radio, P.O. Box 53, Wykagyl Station, New York 10804.

GATED PULSE DESCRAMBLER



—DESCRAMBLE GATED-PULSE SIGNALS using this easy-to-build circuit. Information for winding transformer T1 and coil L1 can be found in the text.

RADIO-ELECTRONICS

Fig. 22-3

Circuit Notes

This circuit consists of an amplifier and video detector with a second subcarrier detector for synch recovery purposes. A pulse-former circuit modulates the gain of the main channel increasing it during synch intervals. Provision for subcarrier audio descrambling is also provided. Kit available from North Country Radio, P.O. Box 53, Wykagyl Station, New York 10804.

SCA DECODER

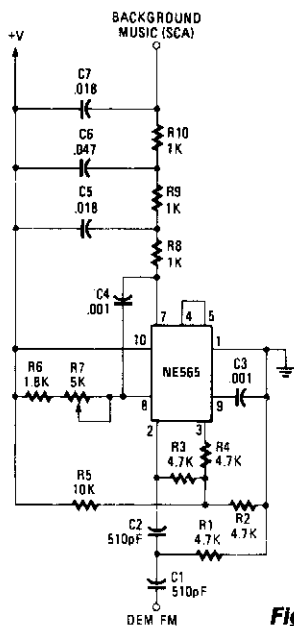


Fig. 22-4

RADIO-ELECTRONICS

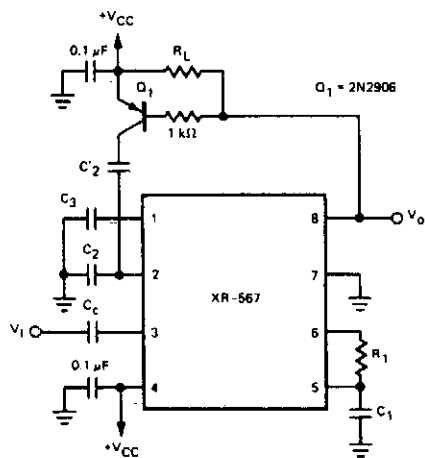
Circuit Notes

The circuit uses a Signetics NE565 PLL (Phase-Locked Loop) as a detector to recover the SCA signal. The input to the SCA decoder circuit is connected to an FM receiver at a point between the FM discriminator and the de-emphasis filter network. The PLL, IC1, is tuned to 67 kHz by R7, a 5 K potentiometer. Tuning need not be exact since the circuit will seek and lock onto the subcarrier. The demodulated signal from the FM receiver is fed to the input of the 565 through a high-pass filter consisting of two 510 pF capacitors (C1 and C2) and a 4.7 K resistor (R1). Its purpose is to serve as a coupling network and to attenuate some of the main channel spill. The demodulated SCA signal at pin 7 passes through a three-stage de-emphasis network as shown. The resulting signal is around 50 mV, with the response extending to around 7 kHz.

DUAL TIME CONSTANT TONE DECODER

Circuit Notes

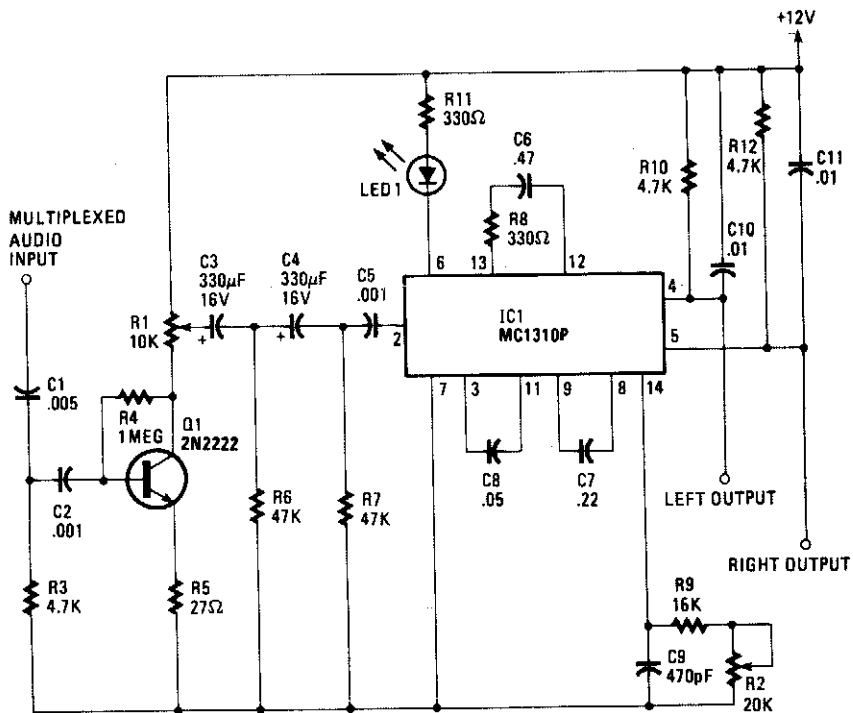
For some applications it is important to have a tone decoder with narrow bandwidth and fast response time. This can be accomplished by the dual time constant tone decoder circuit shown. The circuit has two low-pass loop filter capacitors, C_2 and C'_2 . With no input signal present, the output at pin 8 is high, transistor Q_1 is off, and C'_2 is switched out of the circuit. Thus, the loop low-pass filter is comprised of C_2 , which can be kept as small as possible for minimum response time. When an in-band signal is detected, the output at pin 8 will go low, Q_1 will turn on, and capacitor C'_2 will be switched in parallel with capacitor C_2 . The low-pass filter capacitance will then be $C_2 + C'_2$. The value of C'_2 can be quite large in order to achieve narrow bandwidth. During the time that no input signal is being received, the bandwidth is determined by capacitor C_2 .



EXAR

Fig. 22-5

STEREO TV DECODER



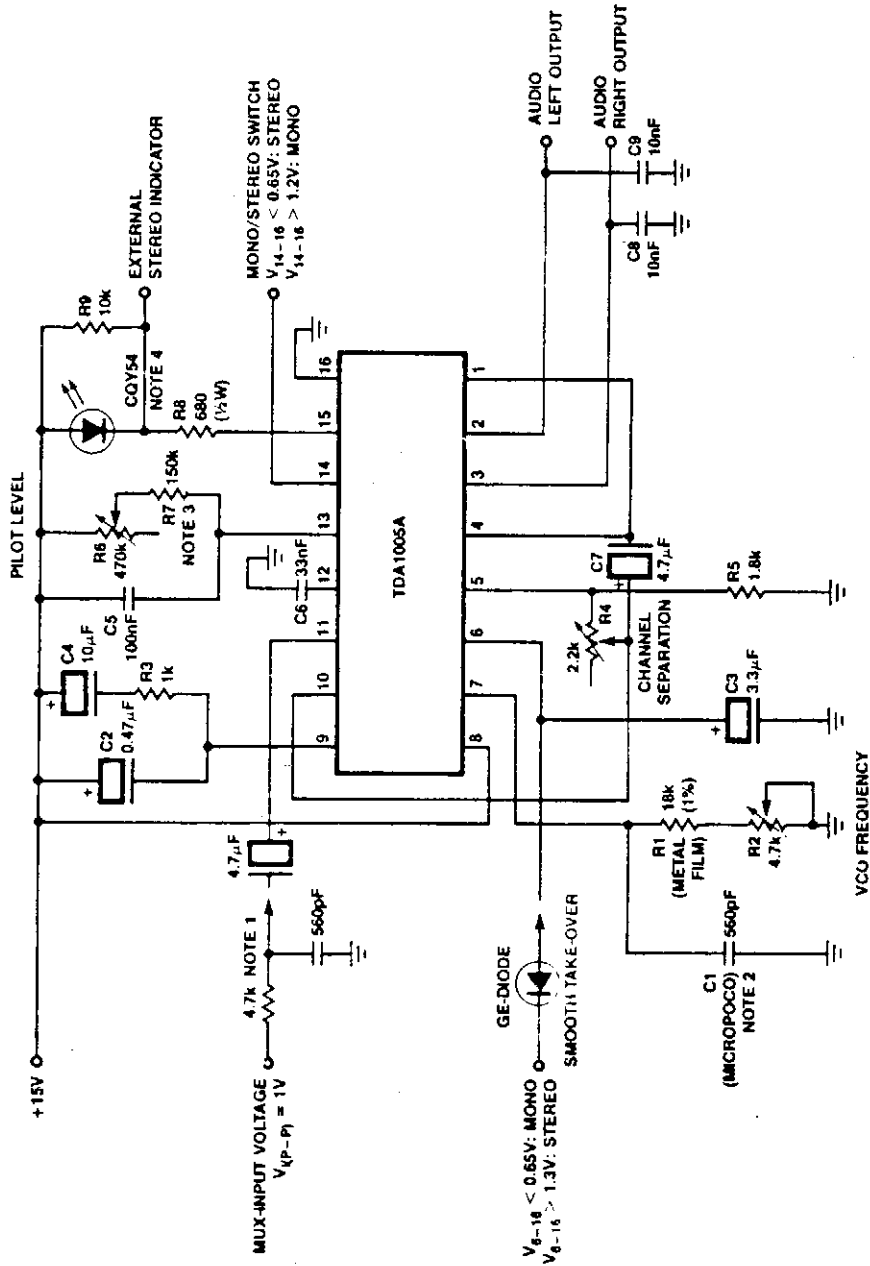
RADIO-ELECTRONICS

Fig. 22-6

Circuit Notes

The composite input signal is preamplified by transistor Q1 and is then coupled to the high-pass filter composed of C3, C4, R6, and R7. The filtered audio is then passed to IC1, an MC1310P "Coilless Stereo Demodulator." That IC is normally used to demodulate broadcast-band FM signals, but by changing the frequency of its on-board VCO (Voltage Controlled Oscillator) slightly (from 19 kHz to 15.734 kHz), we can use that IC to detect stereo-TV signals. A block diagram of the MC1310P is shown in Fig. 22-5. Notice that the components connected to pin 14 control the VCO's frequency, hence the pilot-detect and carrier frequencies. For use in an FM receiver, the VCO would run at four times the 19 kHz pilot frequency (76 kHz), but for our application, it will run at four times the 15.734 kHz pilot frequency of stereo TV, or 62.936 kHz. The MC1310P divides the master VCO signal by two in order to supply the 31.468 kHz carrier that is used to detect the L - R audio signal. The L - R signal undergoes normal FM detection, and at that point we've got two audio signals: L + R and L - R. The decoder block in the IC performs the addition and subtraction to produce the separate left and right signals. R10 and C10 form a de-emphasis network that compensates for the 75 μs pre-emphasis that the left channel underwent; R12 and C11 perform the same function for the right channel.

TIME DIVISION MULTIPLEX (TDM) STEREO DECODER



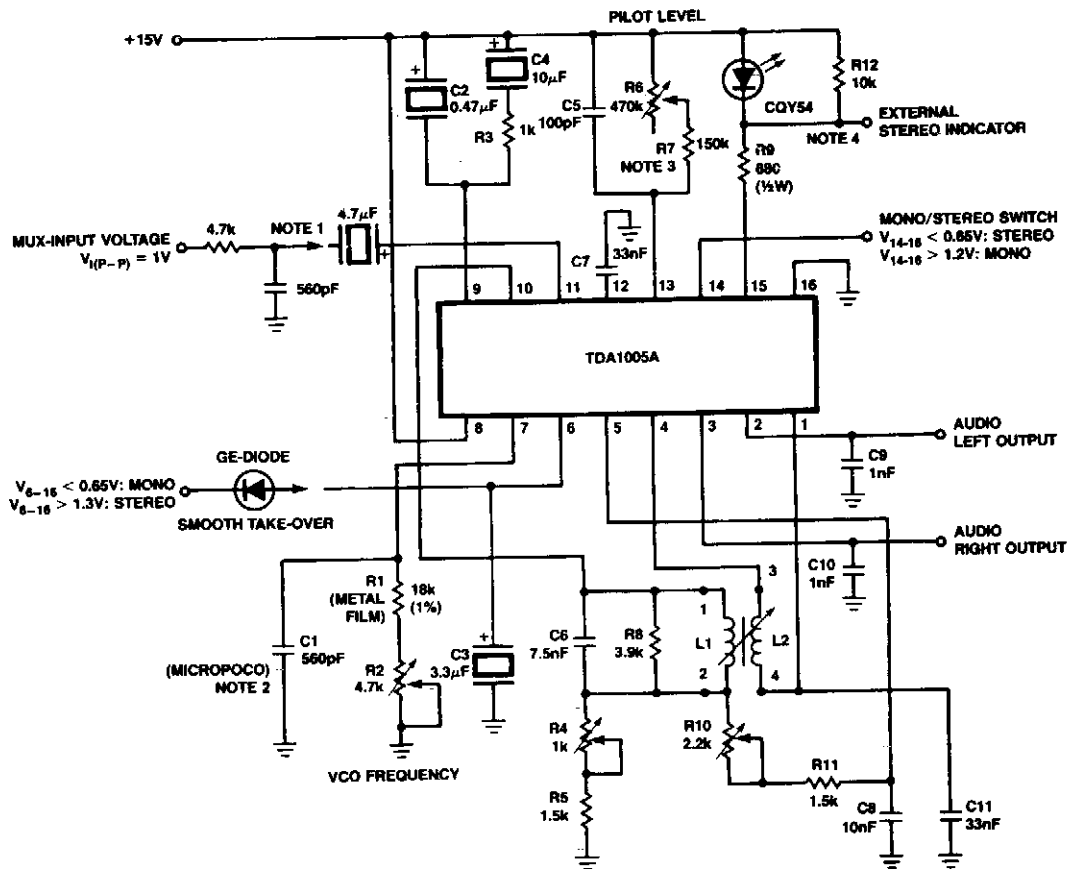
- NOTES:**
1. For other input structures see Figures 7 to 11, shown here with RC-filter (Figure 8).
 2. Micrococo capacitor has a temperature coefficient of $125 \cdot 10^{-6} \pm 60 \cdot 10^{-6} \cdot C^{-1}$.
 3. In simplified circuits a fixed resistor (e.g. 620k) can be used for a guaranteed switching level of $\leq 16mV$.
 4. Either the LED circuit or an external stereo indicator can be used.

SIGNETICS

Fig. 22-7

IC-28A

FREQUENCY DIVISION MULTIPLEX (FDM) STEREO DECODER



TC128105

Coil data:

$L_1, L_2 = 2.6\text{mH}$

$Q_{1,2} = 35; Q_{\text{MIN}} = 30$

$N_{1,2} = 357 \frac{1}{2}$ turns;

$N_{3,4} = 297 \frac{1}{2}$ turns; scrambled wound with wire diameter 0.09mm, $\frac{E_{3,4}}{E_{1,2}} \times 100\% = 82\%$

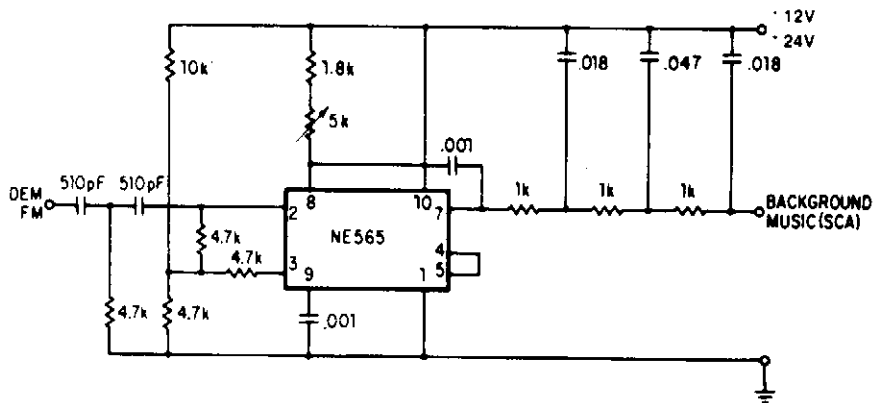
NOTES:

1. For other input structures see Figures 6 to 11; shown here with RC-filter (Figure 8).
2. The micropoco capacitor has a temperature coefficient of $125 \cdot 10^{-6} \pm 60 \cdot 10^{-8} \text{ k}^{-1}$.
3. In simplified circuits a fixed resistor (e.g. 620k) can be used for a guaranteed switching level of $\leq 16\text{mV}$.
4. Either the LED circuit or an external stereo indicator can be used.

SIGNETICS

Fig. 22-8

SCA (Background Music) DECODER



SIGNETICS

Fig. 22-9

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 ohm. 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. Note that no capacitor is provided directly at Pin 7; thus, the circuit is operating as a first-order loop. The demodulated output signal is in the order of 50 mV and the frequency response extends to 7 kHz.

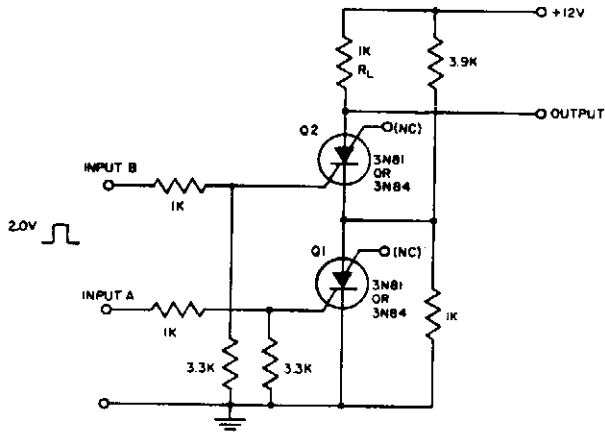
23

Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Pulse Sequence Detector
Voltage Level Detector
Zero-Crossing Detector
Peak Detector
Level Detector
High Frequency Peak Detector
Tachometer, Single Pulse Generator, Power Loss
Detector, Peak Detector
Phase Detector with 10-Bit Accuracy
Frequency Limit Detector
Pulse Coincidence Detector

PULSE SEQUENCE DETECTOR



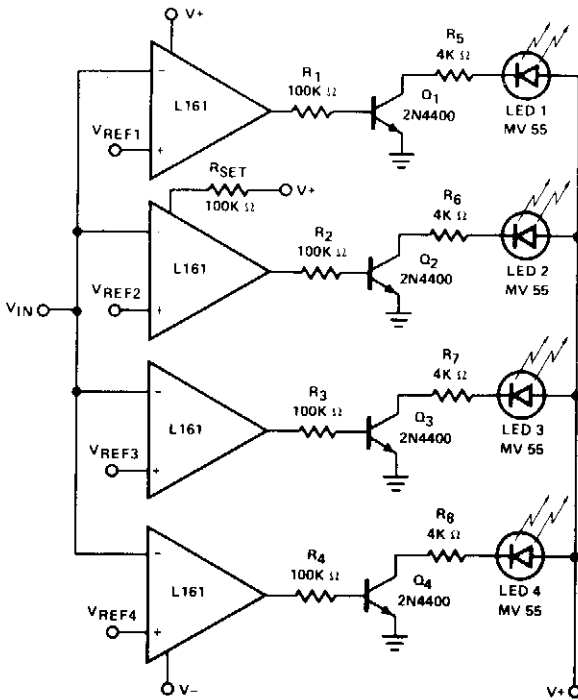
GENERAL ELECTRIC

Fig. 23-1

Circuit Notes

The resistor divider connected between Q1 and Q2 supplies I_H to Q1 after input A triggers it. It also prevents input B from triggering Q2 until Q1 conducts. Consequently, the first B input pulse after input A is applied will supply current to R_L .

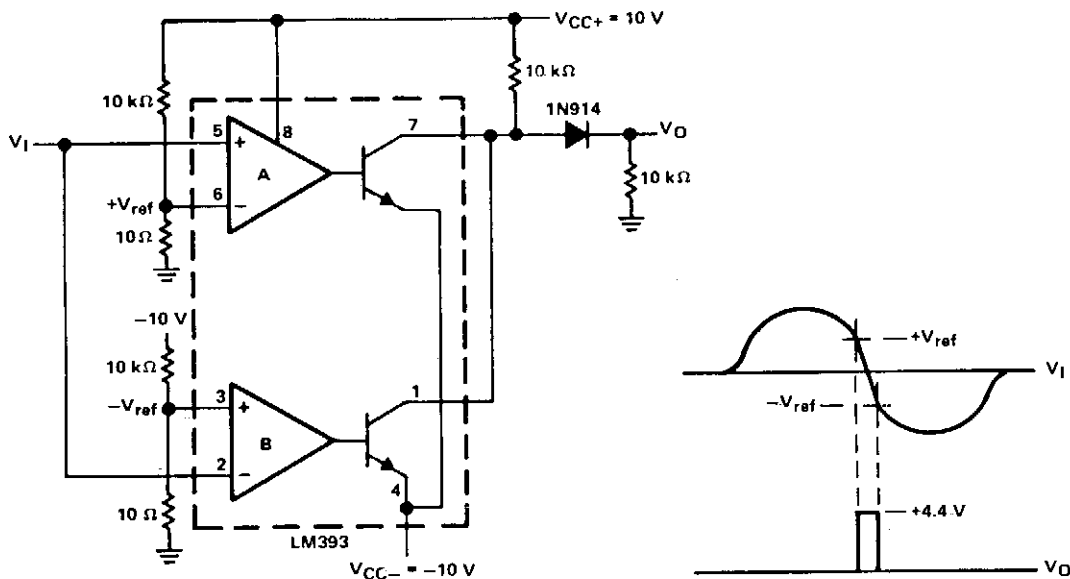
VOLTAGE LEVEL DETECTOR



SILICONIX

Fig. 23-2

ZERO-CROSSING DETECTOR



TEXAS INSTRUMENTS

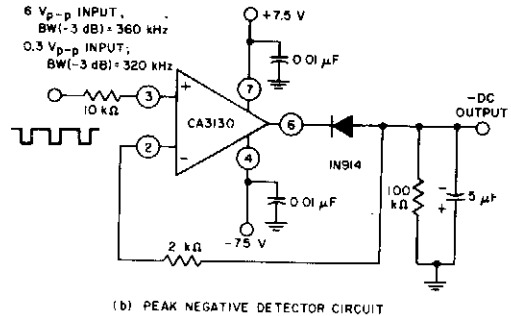
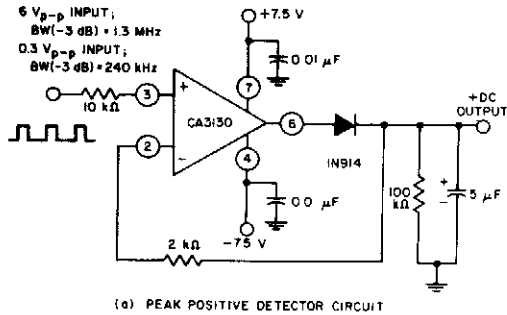
Fig. 23-3

Circuit Notes

This zero-crossing detector uses a dual LM393 comparator, and easily controls hysteresis by the reference levels which are set on the comparator inputs. The circuit illustrated is powered by $\pm 10\text{-V}$ power supplies. The input signal can be an ac signal level up to $+8\text{ V}$. The output will be a positive going pulse of about 4.4 V at the zero-crossover point. These parameters are compatible with TTL logic levels.

The input-signal is simultaneously applied to the non-inverting input of comparator A and the inverting input of comparator B. The inverting input of comparator A has a $+10\text{ mV}$ reference with respect to ground, while the non-inverting input of comparator B has a -10 mV reference with respect to ground. As the input signal swings positive (greater than $+10\text{ mV}$), the output of comparator "A" will be low while comparator "B" will have a high output. When the input signal swings negative (less than -10 mV), the reverse is true. The result of the combined outputs will be low in either case. On the other hand, when the input signal is between the threshold points ($\pm 10\text{ mV}$ around zero crossover), the output of both comparators will be high. If more hysteresis is needed, the $\pm 10\text{ mV}$ window may be made wider by increasing the reference voltages.

PEAK DETECTOR



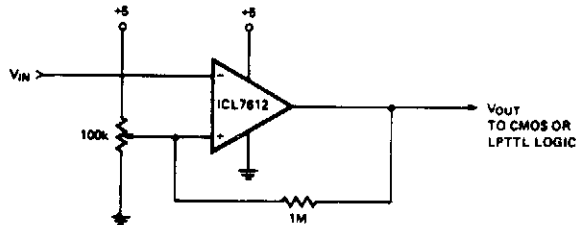
GENERAL ELECTRIC/RCA

Fig. 23-4

Circuit Notes

Circuits are easily implemented using the CA3130 BiMOS op amp. For large-signal inputs the bandwidth of the peak-negative circuit is less than that of the peak-positive circuit. The second stage of the CA3130 limits bandwidth in this case.

LEVEL DETECTOR



0307-31

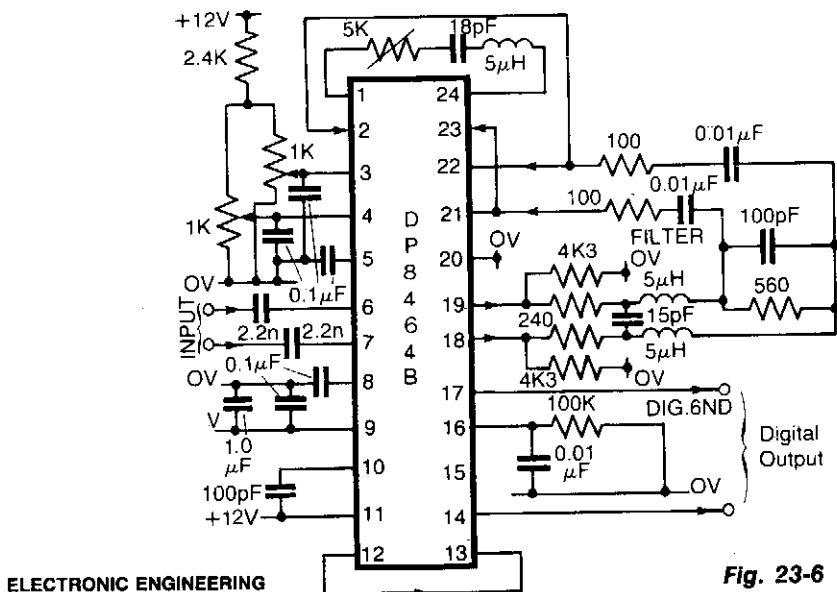
INTERSIL

Fig. 23-5

Circuit Notes

By using the ICL7612 in these applications, the circuits will follow rail to rail inputs.

HIGH FREQUENCY PEAK DETECTOR



ELECTRONIC ENGINEERING

Fig. 23-6

Circuit Notes

National Semiconductor's DP8464B is primarily intended for use in disk systems as a pulse detector. However it can be easily used as a general purpose peak detector for analogue signals up to 5 MHz. The chip can handle signals between 20 and 66 mV peak-to-peak. The circuit includes a filter with constant group delay characteristics to band limit the signal. Typically the -3 dB point for this filter will be at about 1.5 times the highest frequency of interest. This differentiator network between pins 1 and 24 can be as simple as a capacitor, or can be more complex to band limit the differentiator response.

TACHOMETER, SINGLE PULSE GENERATOR, POWER LOSS DETECTOR, PEAK DETECTOR

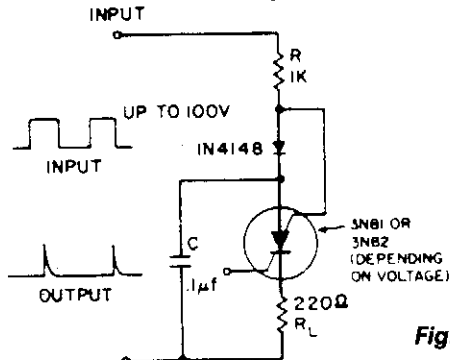
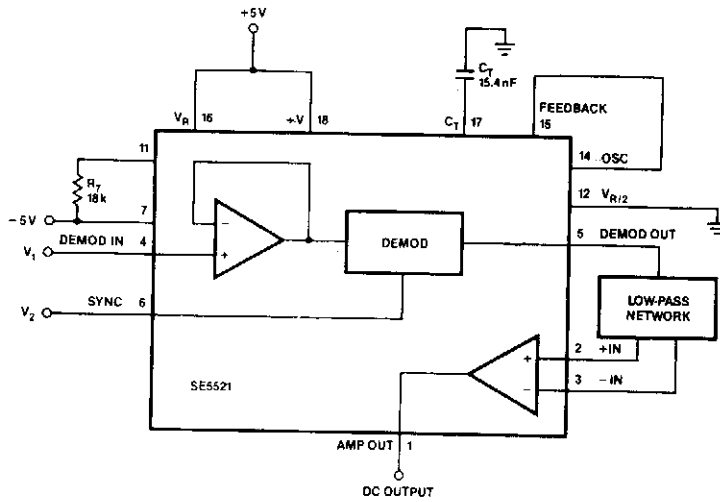


Fig. 23-7

GENERAL ELECTRIC

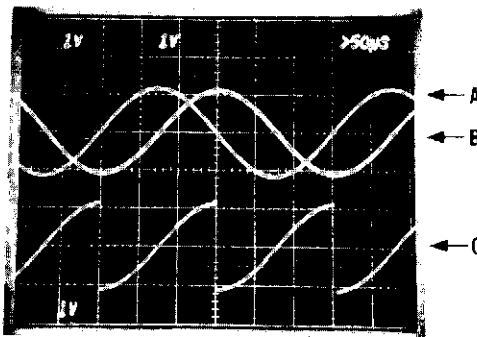
A positive going input charges C through the IN4148 and R. The diode keeps the scs off. A negative going input supplies anode-gate current triggering on the scs discharging C through R_L .

PHASE DETECTOR WITH 10-BIT ACCURACY



©1966905

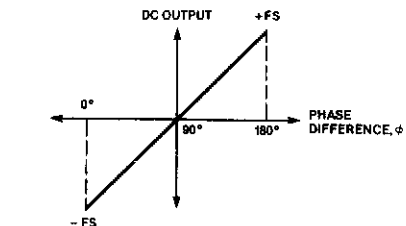
a. Phase Detector Measures Phase Difference Between Signals V_1 and V_2 and Provides dc Output at Pin 1



HF0214

b. When V_1 and V_2 in (a) are at Quadrature (Traces A and B), the DC Component of Demodulator Output (Trace C) is at 0V

SIGNETICS



UP-103505

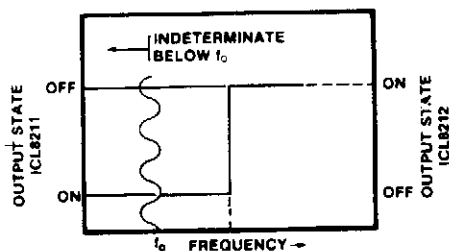
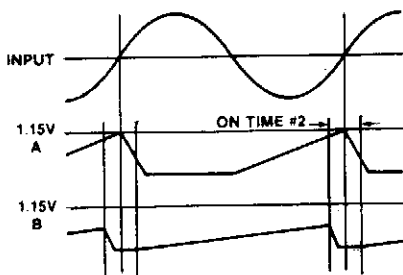
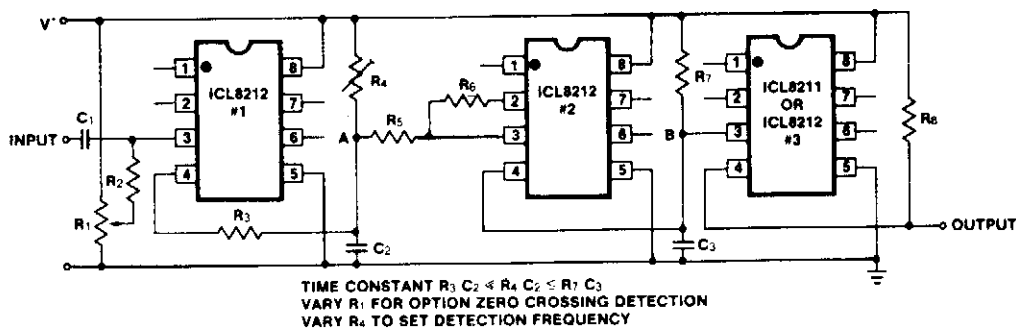
c. The dc Output and Phase Vary Linearly

Fig. 23-8

Circuit Notes

Signals of identical frequency are applied to sync input (Pin 6) and to the demodulator input (Pin 4), respectively, the demodulator functions as a phase detector with output dc component being proportional to phase difference between the two inputs. The signals must be referenced to 0 V for dual supply operation or to $V_R/2$ for single supply operation. At ± 5 -V supplies, the demodulator can easily handle 7-V peak-to-peak signals. The low-pass network configured with the uncommitted amplifier dc output at Pin 1 of the device. The dc output is maximum (+ full-scale) when V_1 and V_2 are 180° out of phase and minimum (- full-scale) when the signals are in phase.

FREQUENCY LIMIT DETECTOR



INTERSIL

Fig. 23-9

Circuit Notes

Simple frequency limit detectors providing a GO/NO-GO output for use with varying amplitude input signals may be conveniently implemented with the ICL8211/8212. In the application shown, the first ICL8212 is used as a zero-crossing detector. The output circuit consisting of R_3 , R_4 and C_2 results in a slow output positive ramp. The negative range is much faster than the positive range. R_5 and R_6 provide hysteresis so that under all circumstances the second ICL8212 is turned on for sufficient time to discharge C_3 . The time constant of $R_7 C_3$ is much greater than $R_4 C_2$. Depending upon the desired output polarities for low and high input frequencies, either an ICL8211 or an ICL8212 may be used as the output driver.

The circuit is sensitive to supply voltage variations and should be used with a stabilized power supply. At very low frequencies the output will switch at the input frequency.

PULSE COINCIDENCE DETECTOR

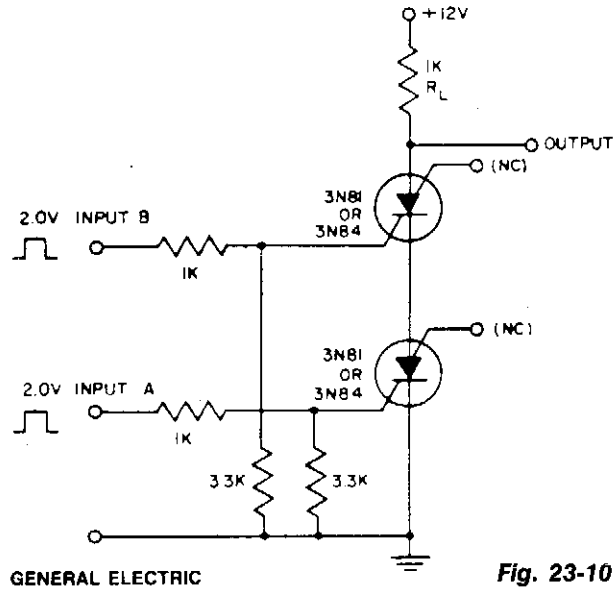


Fig. 23-10

Circuit Notes

Unless inputs A and B (2- to 3-V amplitude) occur simultaneously no voltage exists across R_L . Less than 1 microsecond overlap is sufficient to trigger the scs. Coincidence of negative inputs is detected with gates G_A instead of G_C by using the scs in a complementary SCR configuration.

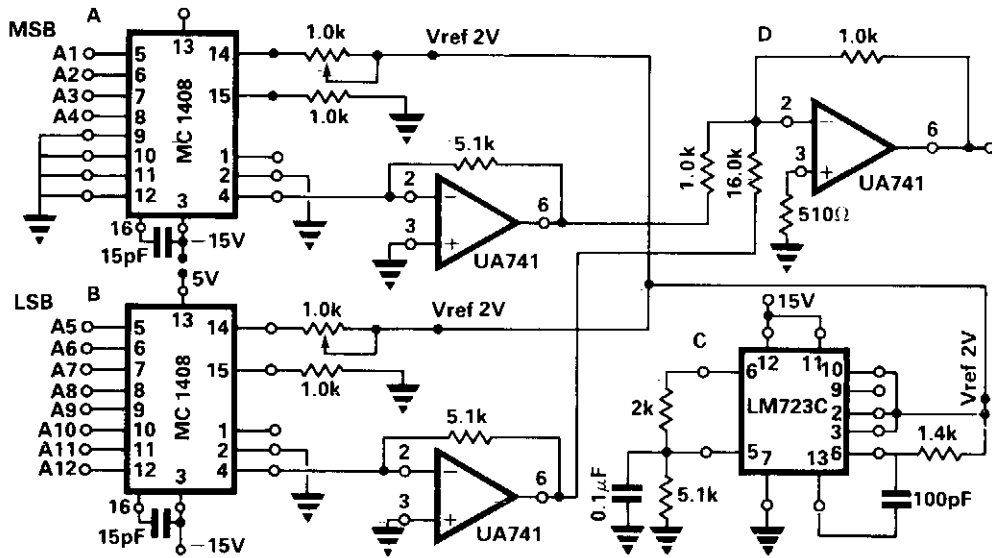
24

Digital-to-Analog Converters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Two 8-Bit DACs Make a 12-Bit DAC
12-Bit DAC with Variable Step Size

TWO 8-BIT DACS MAKE A 12-BIT DAC



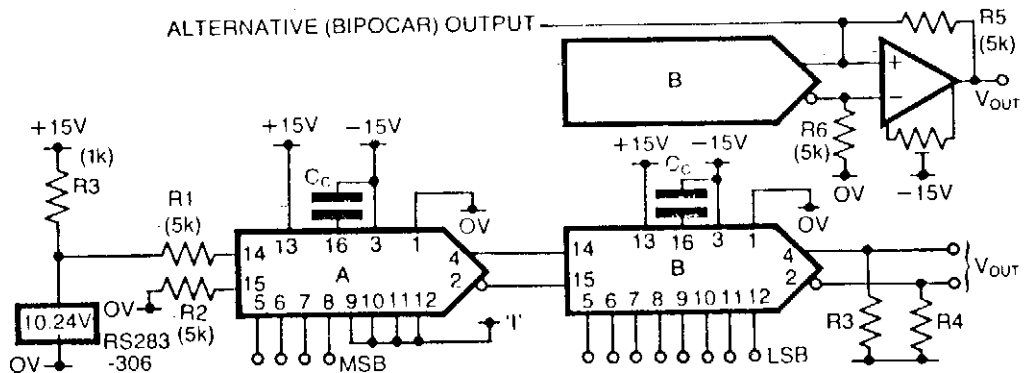
ELECTRONIC ENGINEERING

Fig. 24-1

Circuit Notes

Two MC1408—8-bit D/A converters, A and B in the circuit diagram, are used. The four least-significant bits of A are tied to zero. The four most significant bits of the 12-bit data are connected to the remaining four input pins. The eight least significant bits of the 12-bit data are connected to the eight input pins of B. The four most significant bits of the 12-bit data together have a weight of 16 relative to the remaining eight bits. Hence, the output from B is reduced by a factor of 16 and summed with the output from A using the summing op-amp configuration D. Voltage regulator chip, LM7236, is used to provide an accurate reference voltage, 2 V, for the MC1408. The full-scale voltage of the converter is $\frac{1}{16} \times 9.9609 + 1 \times (9.375)$ or 9.9976 V. The step size of the converter is 2.4 mV.

12-BIT DAC WITH VARIABLE STEP SIZE



ELECTRONIC ENGINEERING

Fig. 24-2

Circuit Notes

The step size of the converter is variable by selection of the high order data bits. The first DAC, A, has a stable reference current supplied via the 10.24 V reference IC and R1. R2 provides bias cancellation. As shown, only the first 4 MSB inputs are used, giving a step size of $225/256 \times 2.048/16 = 0.127 \text{ mA}$. This current supplies the reference for DAC B whose step size is then $0.1275/256 = 0.498 \text{ } \mu\text{A}$. Complementary voltage outputs are available for unipolar output and using $R3 = R4 = 10 \text{ K}$, V_{out} is $\pm 10.2 \text{ V}$ approximately, with a step size (1 LSB) of approximately 5 mV. If desired an op amp can be added to the output to provide a low impedance output with bipolar output symmetrical about ground, if $R5 = R6$ within 0.05%. Note that offset null is required, and all resistors except R2 and R3 should be 1% high stability types.

By using lower order address lines than illustrated for DAC A, a smaller step size (and therefore full-scale output) can be obtained. Unused high order bits can be manipulated high or low to change the relative position of the full-scale output.

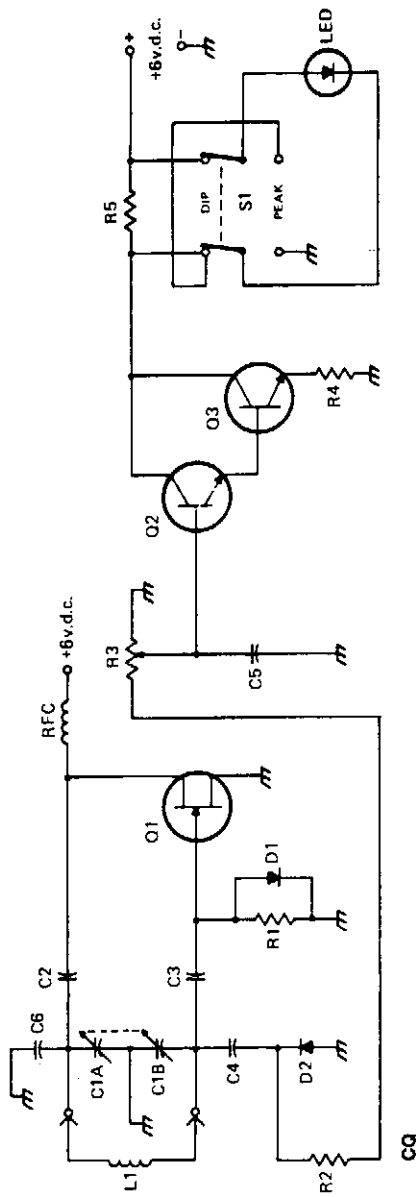
25

Dip Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Little Dipper

LITTLE DIPPER



Parts List

- L1—See coil data
 C1A, 1B—Dual capacitor 100 pF per section (ETCO SV409 or similar)
 C2, C3—100 pF mica, mylar, etc., low voltage
 C4—10 pF mica, mylar, etc., low voltage
 C5—01 uF ceramic, low voltage
 C6—5 pF mica, mylar, etc., low voltage
 D1, D2—1N914 silicon diode or similar
 R1—100 K ohms ¼ watt
 R2—220 K ohms ¼ watt
 R3—500 K ohms potentiometer
 R4—10 ohms ¼ watt
 R5—270 ohms ¼ watt
 Q1—MPF 102 FET
 Q2—Any general-purpose NPN transistor with a Beta (Hfe) of 40 or so (2N3904 or similar)
 Q3—Any general-purpose NPN transistor capable of 20 mA collector current or more. Beta 40 or so (2N3904, 2N2222 or similar)
 RFC—1 mH miniature ferrite core choke (value not critical)
 LED—Panel mounting LED Radio Shack 276-068 or similar.
 SW1—Sub-miniature DPDT slide switch or similar
 Miscellaneous—6 volt AC adapter (Radio Shack 273-1454A)
 Coaxial DC power jack (RS 274-1565)
 Calibrated Dial knob (RS 274-413)
 Dual phone jack (RS 274-332)

Fig. 25-1

Circuit Notes

The circuit consists of two basic circuits, the oscillator and the detector. The oscillator uses an FET in a Colpitts configuration. The energy circulating in the oscillator tank is coupled through C4 to the detector circuit, where a small diode (D2) rectifies it, feeding a dc voltage to the Darlington pair (Q2, A3) controlled by the sensitivity control (R3). Any small

variations in the bias of the amplifier will cause large variations of current through the LED indicator in the DIP mode; however, in the PEAK mode the current produces a corresponding voltage drop through R5 and the action of the LED is reversed. The circuit shown will work practically on any frequency from LF to VHF if the appropriate components are used.

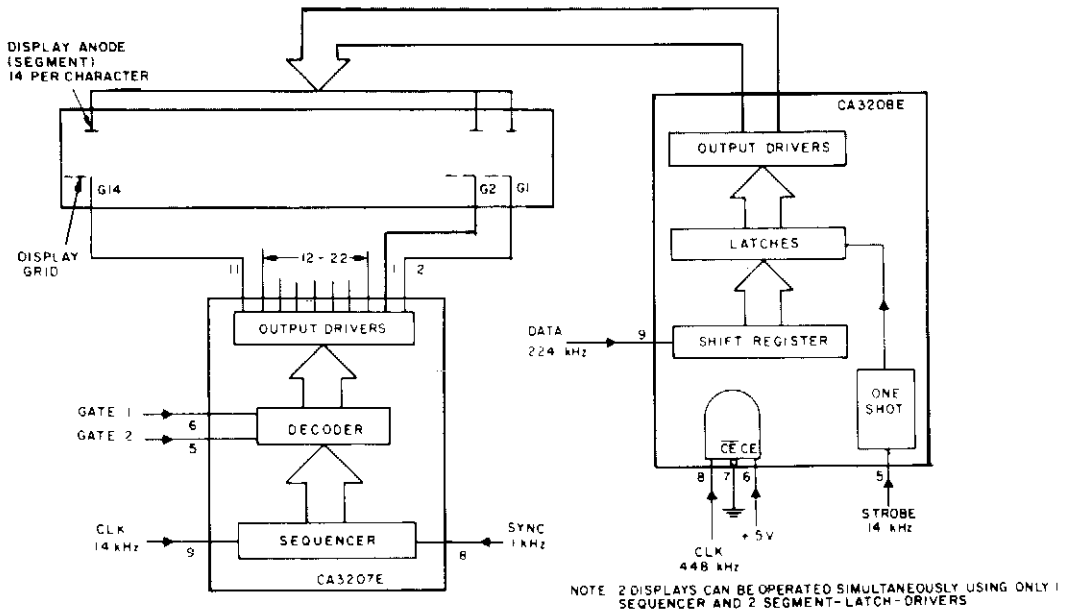
26

Display Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Vacuum Fluorescent Display
Expanded Scale Meter, Dot or Bar
Low-Cost Bar-Graph Indicator for ac Signals
LED Bar-Graph Driver

VACUUM FLUORESCENT DISPLAY

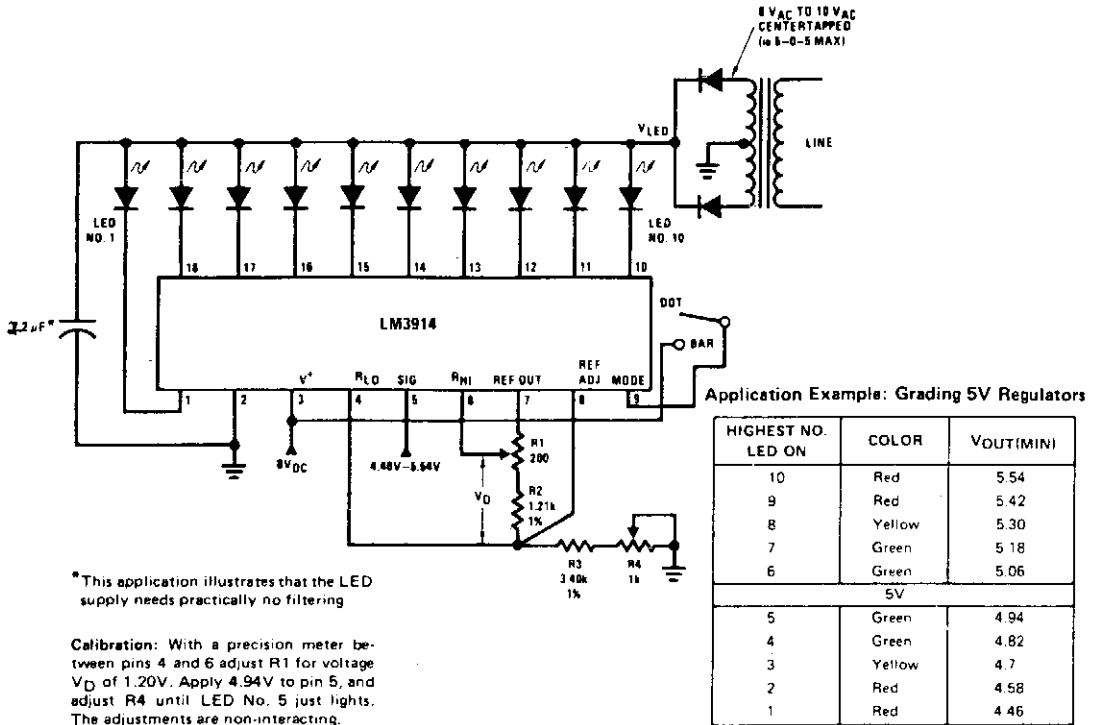


GENERAL ELECTRIC/RCA

Fig. 26-1

This circuit uses the CA3207 sequence driver and CA3208 segment latch-driver in combination to drive display devices of up to 14 segments with up to 14 characters of display. The CA3207 selects the digit or character to be displayed in sequence, CA3208 turns on the required alphanumeric segments.

EXPANDED SCALE METER, DOT OR BAR



NATIONAL SEMICONDUCTOR CORP.

Fig. 26-2

Circuit Notes

A bar graph driver IC LM314 drives an LED display. The LEDs may be separate or in a combined (integral) bar graph display.

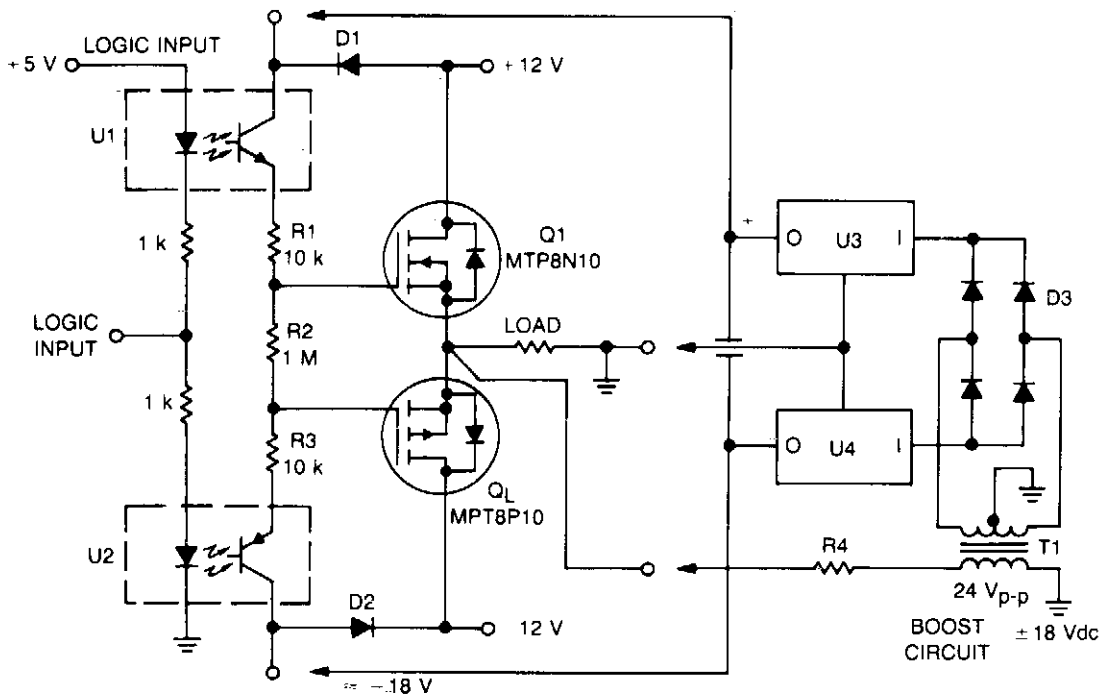
27

Drive Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source-entry in the Sources section.

Line Driver Provides Full Rail Excursions
Five Transistor Amplifier Boosts Fast Pulses into
50-Ohm Coaxial Cable
50-Ohm Transmission Line Driver
600-Ohm Balanced Driver for Line Signals
High Output 600-Ohm Line Driver

LINE DRIVER PROVIDES FULL RAIL EXCURSIONS



MOTOROLA

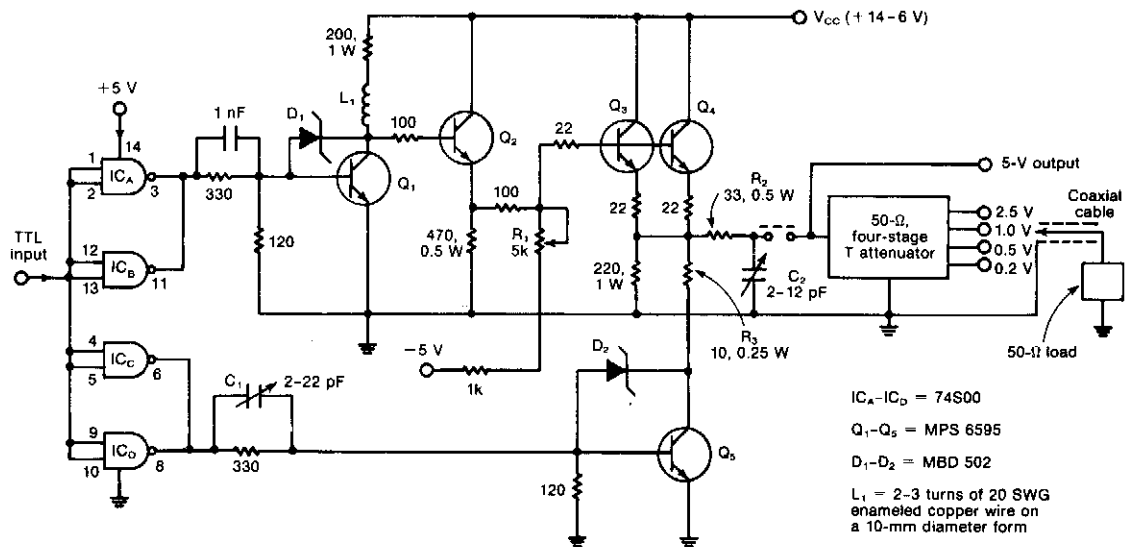
Fig. 27-1

Circuit Notes

The logic input is applied to optoisolators U1 and U2 with, respectively, npn and pnp emitter follower outputs. Dc balance is adjusted by potentiometer R2. The emitter followers drive the gates of Q1 and Q2, the complementary TMOS pairs. With a ± 12 V supply, the swing at the common source output point is about 12 V peak-to-peak.

By adding a ± 18 -V boost circuit, as shown, the output swing can approach the rail swing. This circuit applies the output to transformer T1, which is rectified by diode bridge D3, regulated by U3 and U4, and then applied to the collectors of U1 and U2. Diodes D1 and D2 are forward-biased when 12-V supplies are used, but they are back-biased when the 18-V boost is used.

FIVE-TRANSISTOR AMPLIFIER BOOSTS FAST PULSES INTO 50-OHM COAXIAL CABLE



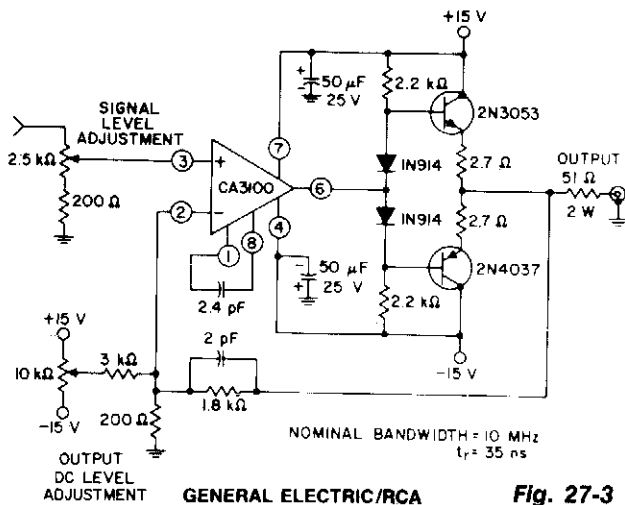
ELECTRONIC DESIGN

Fig. 27-2

Circuit Notes

The circuit works from dc to 50 MHz and will deliver pulses as short as 10 ns. It is driven by a TTL signal through a 740S00 quad Schottky NAND gate, IC_A through IC_D. Transistor Q₁, wired as a common-emitter amplifier, drives transistor Q₂, a simple emitter follower. Transistors Q₃ and Q₄, wired in parallel, also form an emitter follower and drive the output. When Q₃ and Q₄ are both turned off, transistor Q₅ works as a low-impedance sink. Schottky diodes D₁ and D₂ prevent Q₁ and Q₅ from becoming saturated. To adjust the circuit, potentiometer R₁ is set to optimize the output pulse's fall time. Inductor L₁, a peaking coil, should be adjusted to improve the rise time to within a permissible 5% overshoot. Likewise, capacitor C₁ can be varied to control preshooting. Further output pulse shaping is accomplished with the help of capacitor C₂. Resistors R₂ and R₃ ensure a proper 50-ohm impedance at the amplifier's output when the pulse is on or off, respectively.

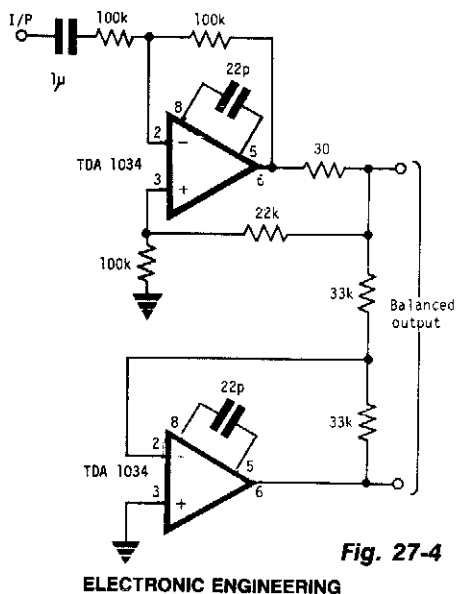
50-OHM TRANSMISSION LINE DRIVER



Circuit Notes

This circuit uses a wideband, high slew rate CA3100 BiMOS op amp. The slew rate for this amplifier is $28 \text{ V}/\mu\text{s}$. Output swing is 9 volts peak-to-peak into a terminated line, measured at the termination.

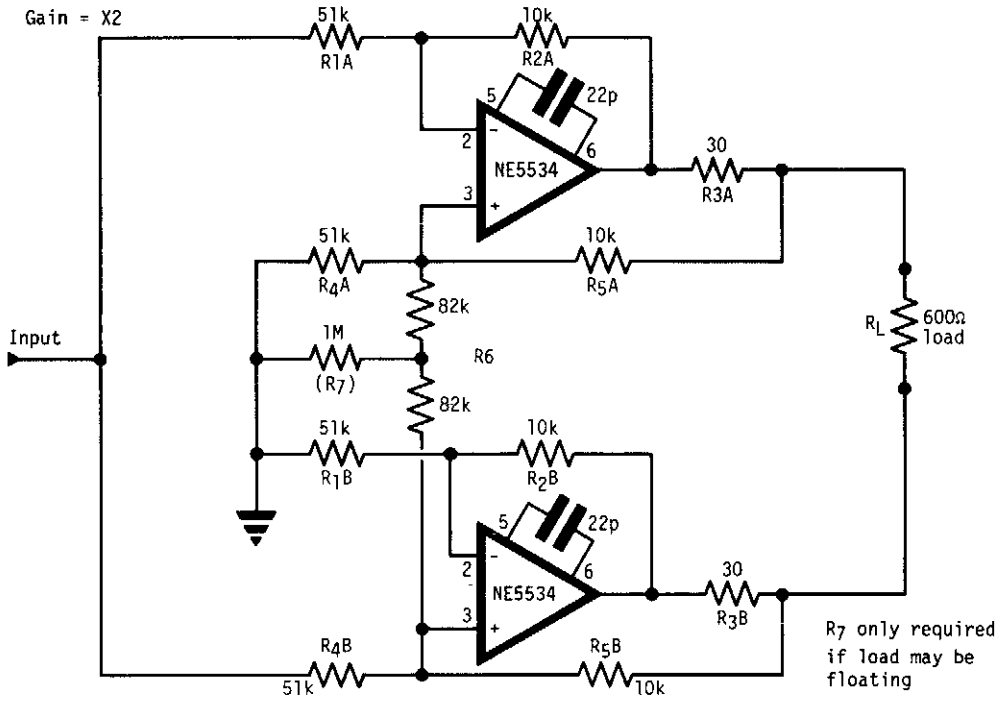
600-OHM BALANCED DRIVER FOR LINE SIGNALS



Circuit Notes

This circuit uses current and voltage feedback. This circuit will handle +24 dBm with ± 12 volts supply using TDA 1034s.

HIGH OUTPUT 600-OHM LINE DRIVER



ELECTRONIC ENGINEERING

Fig. 27-5

Circuit Notes

The circuit has a "floating" output, i.e., it behaves like an isolated transformer winding, with the output amplitude remaining unchanged whether the center or either end of the load is grounded. This is achieved by making Z -out, common mode, infinite. The circuit consists of two current-sources in push-pull. Since each has infinite output Z , the common mode output impedance is also infinite. Connecting a resistor between the non-inverting terminals of the op amps reduces the differential Z -out without affecting the Z -common-mode. Since the output is floating, if the load is also floating there is no output ground reference, which results in malfunction. This can be corrected by reducing the common-mode Z slightly. R7 fulfills this function. All resistors should be of close tolerance to give a good balance. The line driver provides +24 dB from ± 12 V or +16 dB from ± 6 V supplies.

28

Electronic Locks

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Three-Dial Combination Lock
Electronic Combination Lock

THREE-DIAL COMBINATION LOCK

C1—500- μ F, 25-VDC electrolytic capacitor

D1, D2—1N4002 diode

K1—relay with 6-volt coil rated @ 250-ohms, with SPST contacts

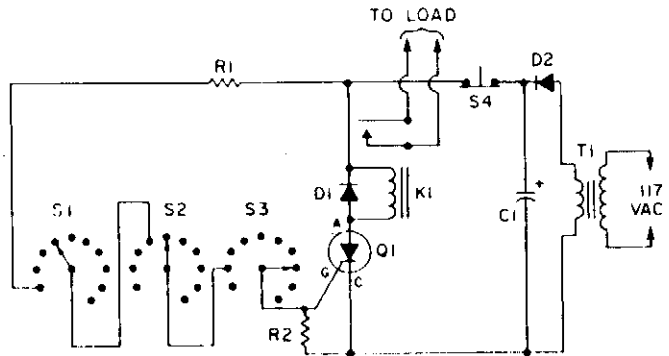
Q1—2N5050 SCR

R1, R2—4,700-ohm, $\frac{1}{2}$ -watt resistor, 5%

S1, S2, S3—single pole, 10-position rotary or thumbwheel switches

S4—normally closed SPST push-button switch

T1—120-VAC to 6.3-VAC @ 300mA power transformer



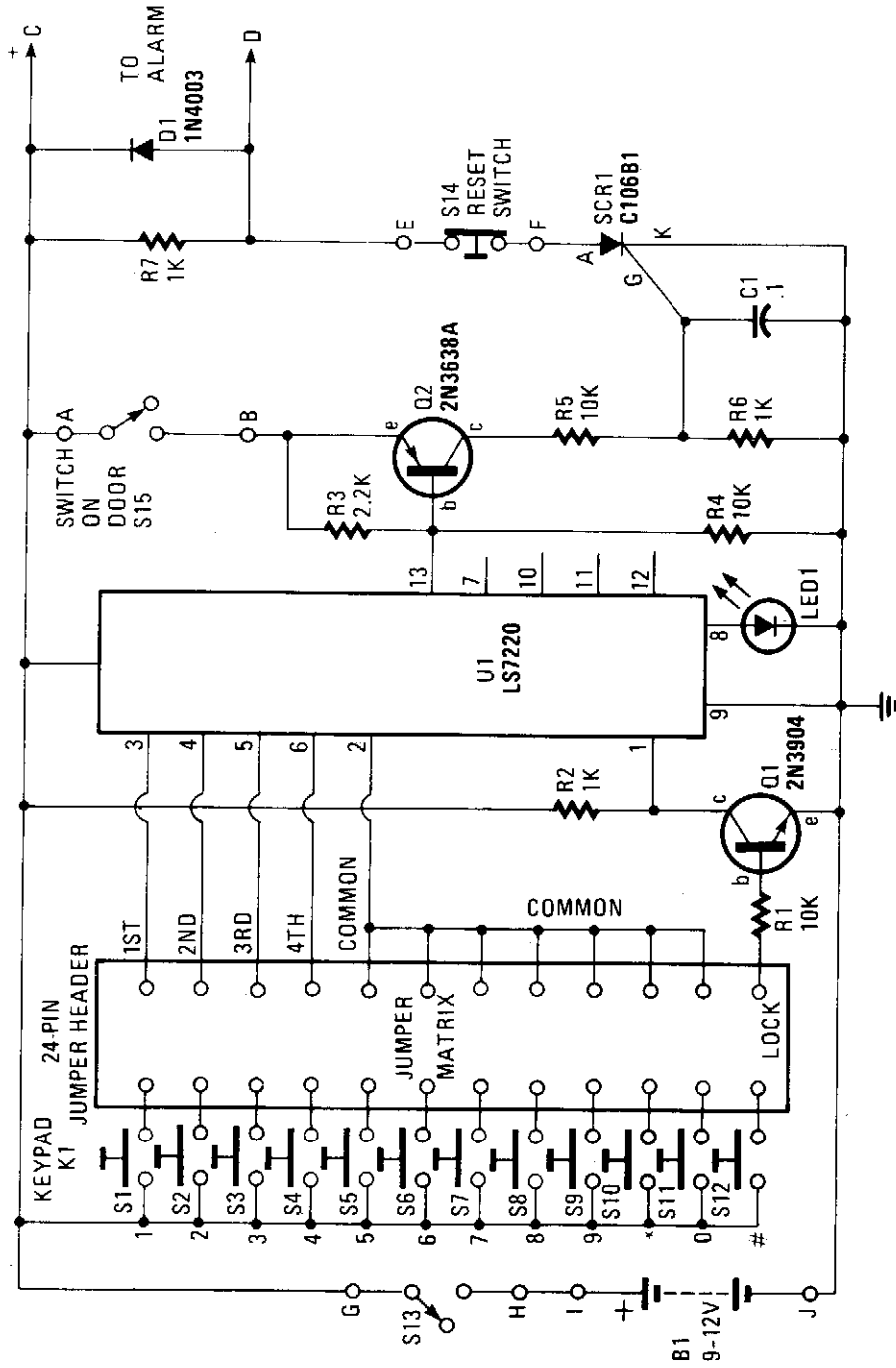
TAB BOOKS, INC.

Fig. 28-1

Circuit Notes

Here's an effective little combination lock that you can put together in one evening's time. To open the lock, simply dial in the correct combination on the three rotary or thumbwheel switches. With the correct combination entered, current flows through R1 into Q1's gate terminal, causing the SCR to latch in a conductive state. This sends a current through relay K1, which responds by closing its contacts and actuating whatever load is attached. After opening the lock, twirl the dials of S1 through S3 away from the correct combination so that nobody gets a look at it. The lock will remain open and your load will remain on because the SCR is latched on. To lock things up, it's only necessary to interrupt the flow of anode current through the SCR by pressing pushbutton S4.

ELECTRONIC COMBINATION LOCK



HANDS-ON ELECTRONICS

Fig. 28-2

Circuit Notes

When button S12 (#) is pressed, a positive voltage fed through R1 appears at the base of transistor Q1, turning it on. When Q1 is conducting, pin 1 of U1 is brought to ground (low) or the battery's negative terminal. With pin 1 low, two things occur: Pin 8 of U1 goes high (+9 volts dc), turning on LED 1—indicating that the circuit has been armed—and pin 13 goes from high to low. Transistor Q2 requires a low signal or negative voltage on its base in order to conduct. It also needs a positive voltage on its emitter and a negative voltage on the collector. As long as the door switch (S15) remains open (with the door itself closed), Q2's emitter will not receive the necessary positive voltage. If, however, an unauthorized person opens the door, thus closing switch S15 and placing a positive voltage on the emitter of Q1, the following sequence occurs:

1. Transistor Q2 conducts, receiving the necessary biasing current through a current-divider network consisting of resistors R3 and R4.
2. As Q2 conducts, a voltage drop is developed across the voltage dividers made up of resistors R5 and R6. With R5 at 10,000 ohms and R6 at 1000 ohms, approximately one volt appears at the gate of SCR1. That's enough voltage to trigger the SCR's gate.

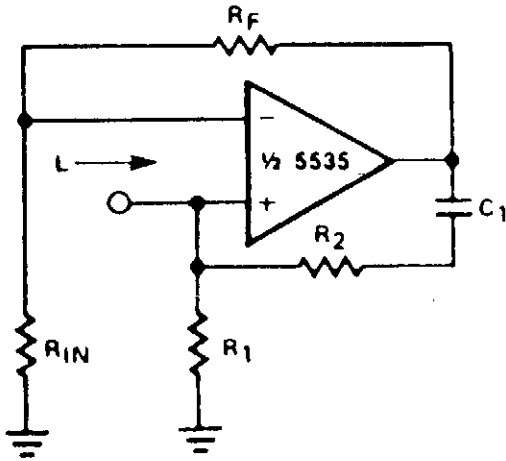
29

Emulator Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Simulated Inductor
Resistor Multiplier
Capacitor Multiplier
JFET ac Coupled Integrator

SIMULATED INDUCTOR



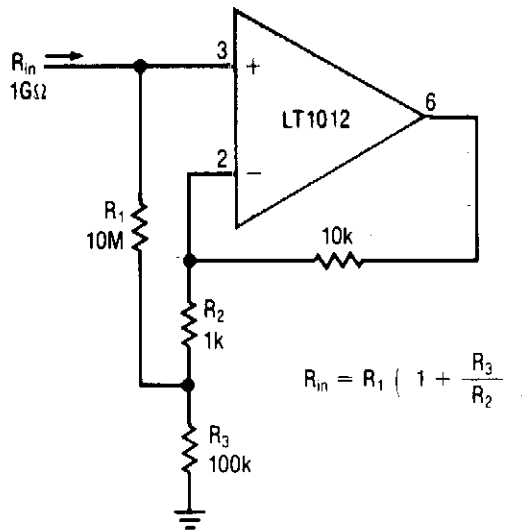
SIGNETICS

Fig. 29-1

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.

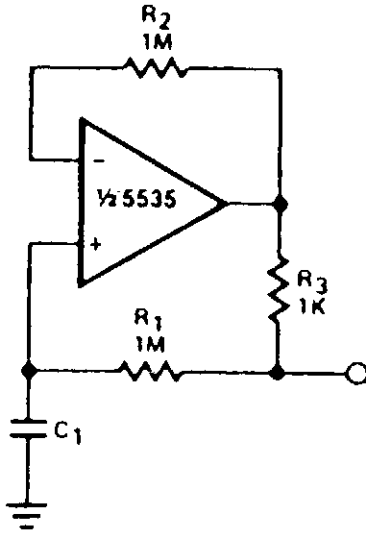
RESISTOR MULTIPLIER



LINEAR TECHNOLOGY CORP.

Fig. 29-2

CAPACITANCE MULTIPLIER



TC106205

Circuit Notes

The circuit can be used to simulate large capacitances using small value components. With the values shown and $C = 10 \mu\text{F}$, an effective capacitance of $10,000 \mu\text{F}$ was obtained. The Q available is limited by the effective series resistance. So $R1$ should be as large as practical.

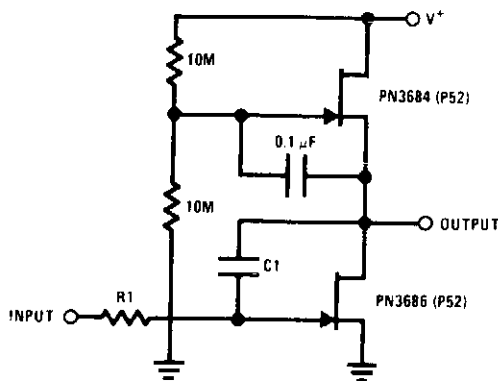
NOTE:

All resistor values are in ohms.

SIGNETICS

Fig. 29-3

JFET ac COUPLED INTEGRATOR



NATIONAL SEMICONDUCTOR CORP.

Fig. 29-4

Circuit Notes

This circuit utilizes the " μ -amp" technique to achieve very high voltage gain. Using $C1$ in the circuit as a Miller integrator, or capacitance multiplier, allows this simple circuit to handle very long time constants.

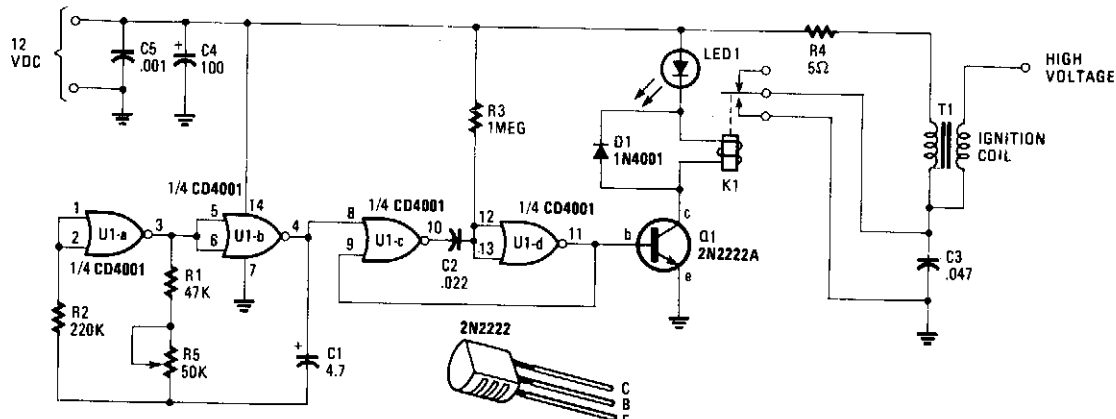
30

Fence Chargers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Battery-Powered Fence Charger
Solid-State Electric Fence Charger
Electric Fence Charger

BATTERY-POWERED FENCE CHARGER



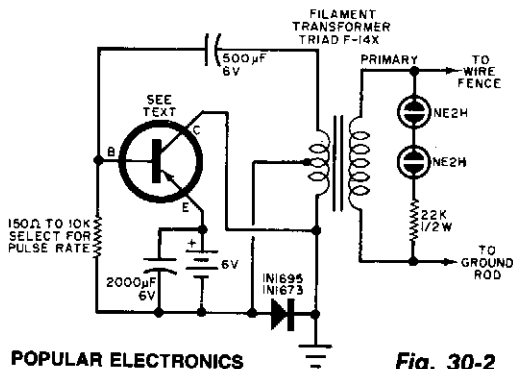
HANDS-ON ELECTRONICS

Fig. 30-1

Circuit Notes

In essence, the circuit is nothing more than an auto ignition coil and a set of points which accomplishes the same thing. A pulsing circuit made from a single CMOS NOR integrated circuit (U1), opens and closes the relay contacts to simulate the action of the original breaker points. The relay pulser is divided into two clocking functions. The first circuit is a free-running squarewave generator that determines the rate or frequency of the pulses that activate the relay. It is essentially a pair of NOR gates connected as inverters and placed in a feedback loop, they are U1-b. The oscillating period of the feedback loop is determined by timing components C1, R1, and variable resistor R5.

ELECTRIC FENCE CHARGER



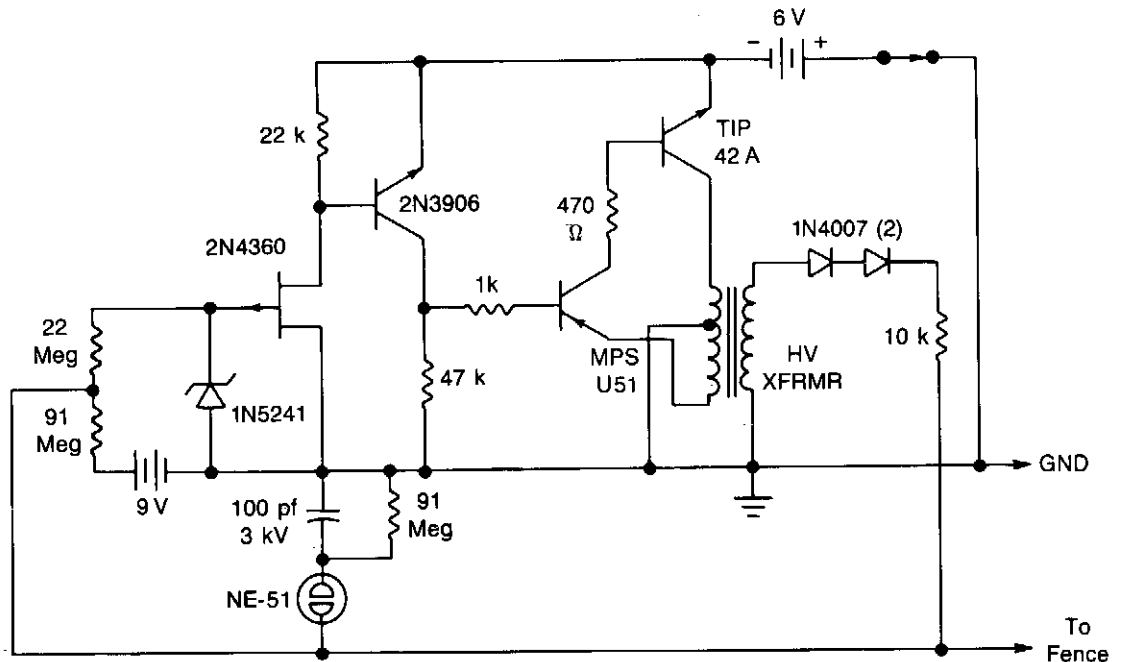
POPULAR ELECTRONICS

Fig. 30-2

Circuit Notes

Any good power transistor can be used in this circuit. The base resistor should be adjusted to obtain a pulse rate of about 50 pulses per minute. The range of values shown can go from 10 pulses to 100 pulses per minute. The single fence wire must be insulated at each supporting pole and should be mounted low enough to prevent an animal from crawling under the wire. The two neon lamps indicate when the unit is operating.

SOLID-STATE ELECTRIC FENCE CHARGER



WILLIAM SHEETS

Fig. 30-3

Circuit Notes

A touch-sensing circuit keeps the high-voltage generator cut off until something touches the fence wire. Contact with the fence sensing circuit wire starts the high-voltage generator which applies a series of 500 microsecond pulses at approximately 300 volts to the fence wire. Pulse repetition rate is determined by the intruder's resistance to earth ground. The lower the resistance, the higher the pulse rate. A ground rod is inserted several inches into the ground near the fence wire. In the sensing mode the neon lamp should not flicker or light. If it does, it indicates leakage between the fence wire and ground. If sensitivity is too great, it can be reduced by changing the 91 Meg resistor to 47 or 22 Meg as required.

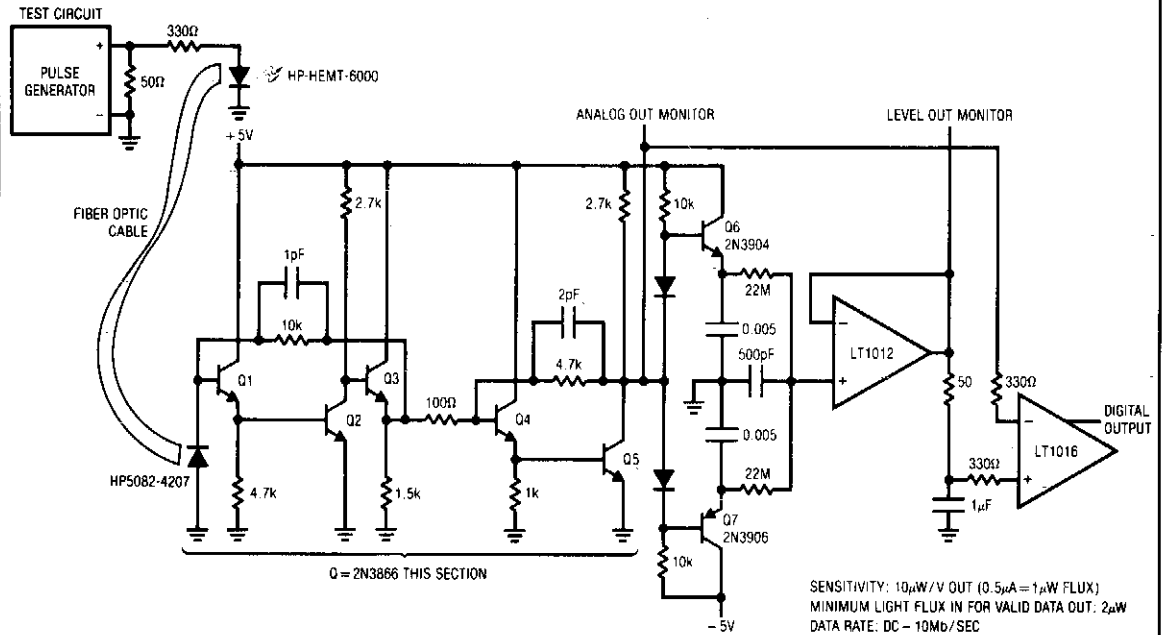
31

Fiberoptics Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Fiberoptic Interface
10 MHz Fiberoptic Receiver
DC Variable Speed Motor Control via Fiberoptics

10 MHz FIBEROPTIC RECEIVER



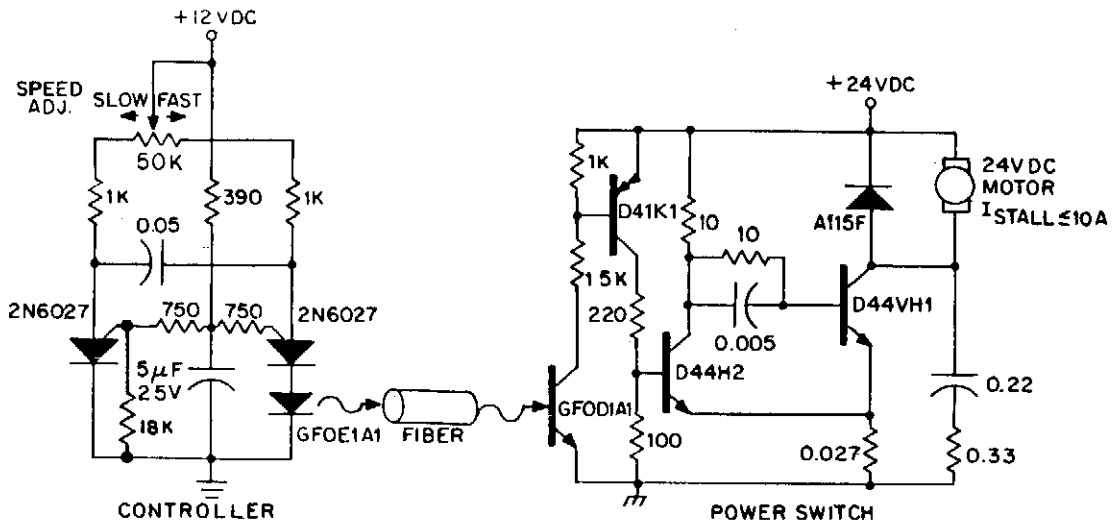
LINEAR TECHNOLOGY CORPORATION

Fig. 31-1

Circuit Notes

The receiver will accurately condition a wide range of light inputs at up to 10 MHz data rates. The optical signal is detected by the PIN photodiode and amplified by a broadband fed-back stage, Q1-Q3. A second, similar, stage gives further amplification. The output of this stage (Q5's collector) biases a 2-way peak detector (Q6-Q7). The maximum peak is stored in Q6's emitter capacitor while the minimum excursion is retained in Q7's emitter capacitor. The dc value of Q5's output signal's mid-point appears at the junction of the $0.005\ \mu\text{F}$ capacitor and the 22 M ohm unit. This point will always sit midway between the signal's excursions, regardless of absolute amplitude. This signal-adaptive voltage is buffered by the low bias LT1012 to set the trigger voltage at the LT1016's positive input. The LT1016's negative input is biased directly from Q5's collector.

DC VARIABLE SPEED MOTOR CONTROL VIA FIBEROPTICS



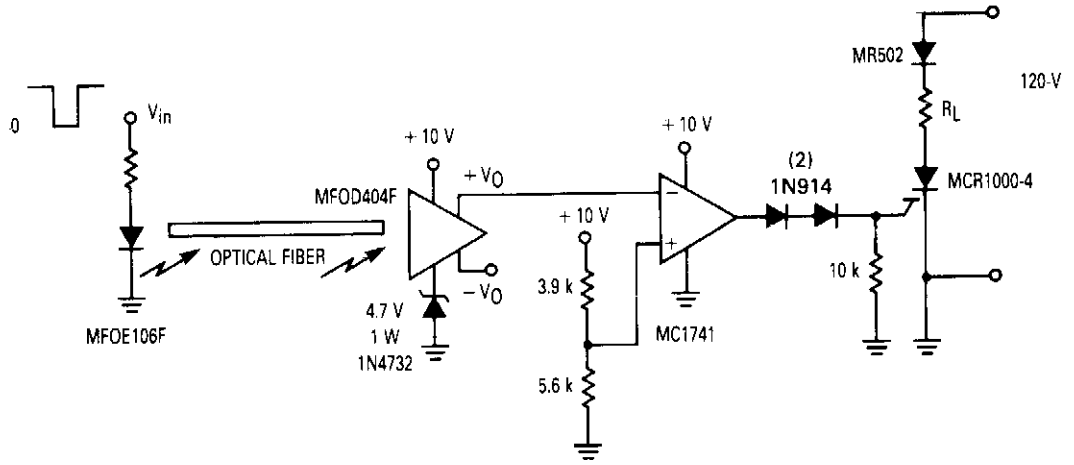
GENERAL ELECTRIC

Fig. 31-2

Circuit Notes

Dc power can also be controlled via fiber optics. The circuit provides an insulated speed control path for a small dc actuator motor ($\leq 1/2$ hp). Control logic is a self-contained module requiring about 300 mW at 12 V, which can be battery powered. The control module furnishes infrared pulses, at a rate of 160 Hz, with a duty cycle determined by the position of the speed adjust potentiometer. The programmable unijunction multivibrator provides approximately 10 mA pulses to the GFOE1A1 at duty cycles adjustable over a range of 1% to 99%. The infrared pulses are detected by the GFOD1A1, amplified by the D39C1 pnp Darlington, and supplied to the power drive switch, which is connected in a Schmitt trigger configuration to supply the motor voltage pulses during the infrared pulses. Thus, the motor's average supply voltage is pulse width modulated to the desired speed, while its current is maintained between pulses by the A115F free-wheeling diode. The snubber network connected in parallel with the power switch minimizes peak power dissipation in the output transistor, and enhancing reliability. Larger hp motors can be driven by adding another stage of current gain, while longer fiber range lengths can be obtained with an amplifier transistor driving the GFOE1A1.

FIBEROPTIC INTERFACE



MOTOROLA

Fig. 31-3

Circuit Notes

An op amp is used to interface between a fiberoptic system and the MOS SCR to multi-cycle, half-wave control of a load. This receiver has two complementary outputs, one at a quiescent level of about 0.6 V and the second at 3 V. By adding a 4.7 V zener in series with the return bus, the effective V_{CC} becomes 5.3 V and also the 0.6 V output level is translated up to about 5.3 V. This level is compatible with the reference input (5.9 V) of the single-ended powered op-amp acting as a comparator.

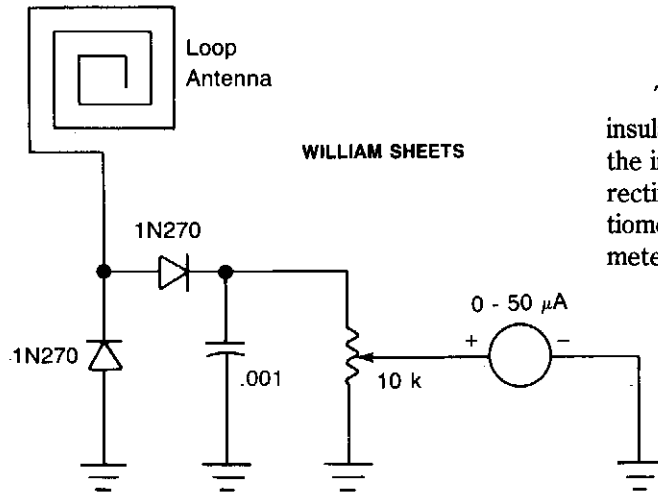
32

Field Strength Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Field Strength Meter
Field Strength Meter II
RF Sniffer
High Sensitivity Field Strength Meter
Transmission Indicator
LF or HF Field Strength Meter

FIELD-STRENGTH METER



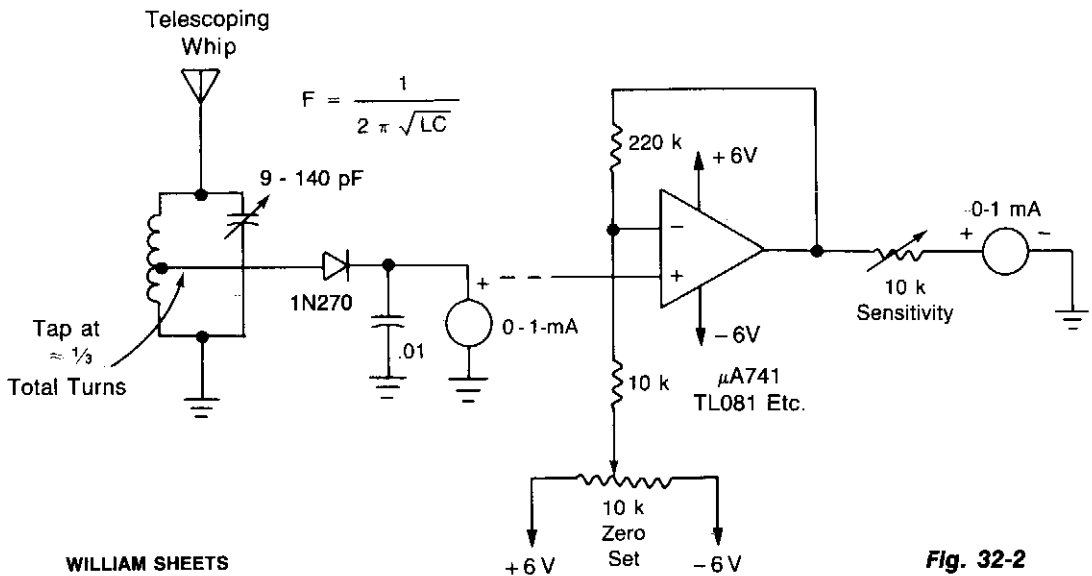
WILLIAM SHEETS

Circuit Notes

The antenna consists of about 20 cm of insulated stranded wire glued or taped around the inside of a small plastic box. RF current is rectified by two diodes, and a 10 k potentiometer provides variable attenuation for the meter.

Fig. 32-1

FIELD-STRENGTH METER II



WILLIAM SHEETS

$$F = \frac{1}{2\pi\sqrt{LC}}$$

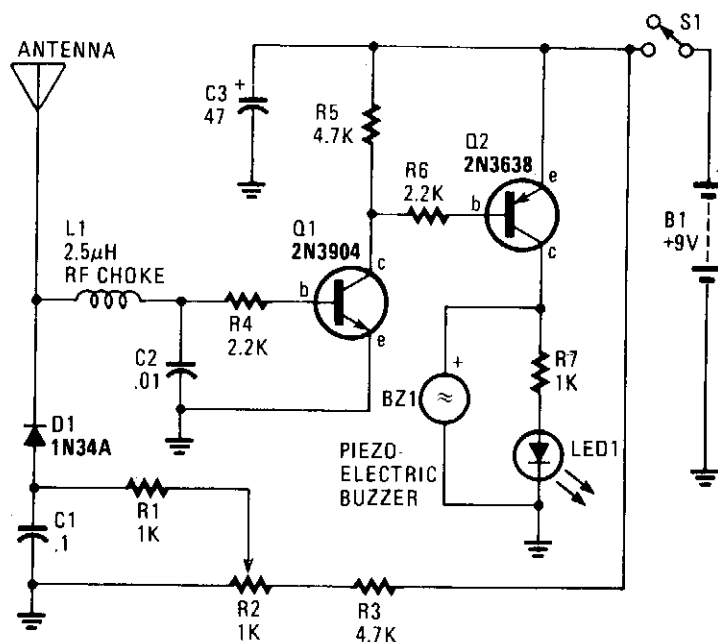
μA741
TL081 Etc.

Fig. 32-2

Circuit Notes

“Minimum-parts” field-strength meter is shown here. For more distant testing, add the dc amplifier.

RF SNIFFER



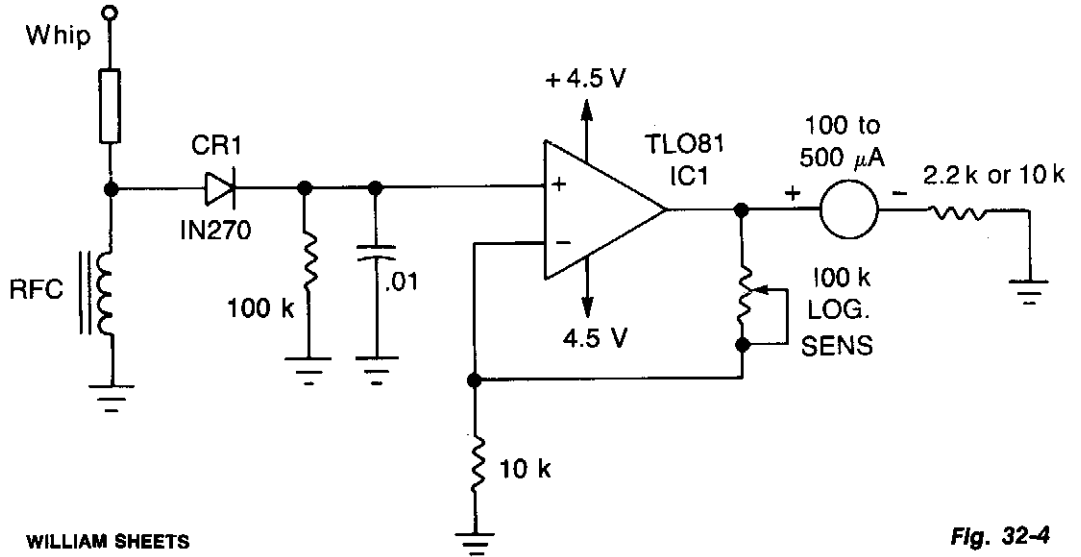
HANDS-ON ELECTRONICS

Fig. 32-3

Circuit Notes

This circuit responds to RF signals from below the standard broadcast band to well over 500 MHz, and provides a visual and audible indication when a signal is received. The circuit is designed to receive low-powered signals as well as strong sources of energy by adjusting the bias on the pick-up diode, D1, with R2. A very sensitive setting can be obtained by carefully adjusting R2 until the LED just begins to light and a faint sound is produced by the Piezo sounder.

HIGH-SENSIVITY FIELD STRENGTH METER



Circuit Notes

A TL081 (IC1 op amp) is used to increase sensitivity. RF signal is detected by CR1 and is then amplified by IC1. Full-scale sensitivity is set with the 100 K potentiometer.

TRANSMISSION INDICATOR

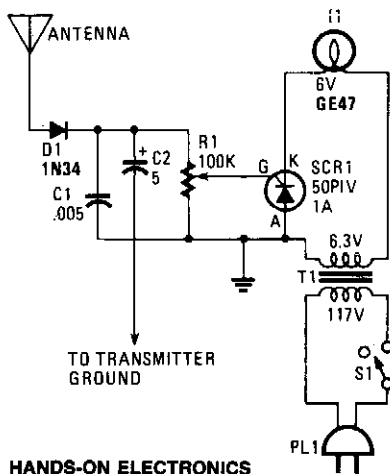


Fig. 32-5

Circuit Notes

Everytime the push-to-talk button is closed the light will go on. The antenna samples the output RF from the transmitter. That signal is then rectified (detected) by germanium diode D1, and used to charge capacitor C2. The dc output is used to trigger a small silicon-controlled rectifier (SCR1), which permits the current to flow through the small pilot lamp. For lower-power applications, such as CB radio, the antenna will have to be close-coupled to the antenna.

LF OR HF FIELD STRENGTH METER

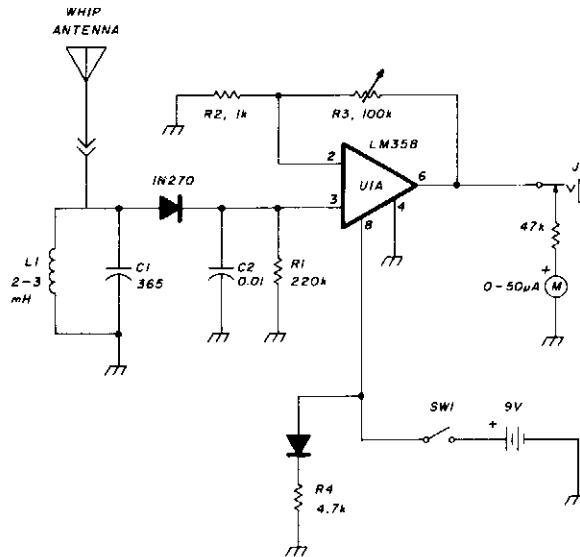


Table 1.

L1	C1 (variable)	Frequency Range	Ham Band
50 μ H	30-365 pF	1- 4 MHz	160, 80 meters
3 μ H	30-365 pF	5-16 MHz	40, 30, 20 meters
0.9 μ H	30-365 pF	9-30 MHz	30, 20, 15, 12, 10 meters
2.5 mH	—	Broadband at reduced gain	

HAM RADIO

Fig. 32-6

Circuit Notes

C1 and L1 resonate on the 1750 meter band, with coverage from 150 kHz to 500 kHz. L1 can be slug-tuned for 160-to-190 kHz coverage alone or a 2.5 mH choke can be used for L1, if desired, using C1 for tuning. A 1N270 germanium diode rectifies the RF signal and C2 is charged at the peak RF level. This dc level is amplified by an LM358. The gain is determined by R2 and R3, 1 100-kilohm linear potentiometer that varies the dc gain from 1 to 100, driving the 50 microampere meter. This field strength meter need not be limited to LF use. The Table shows the L1 and C1 values for HF operation and broadband operation.

33

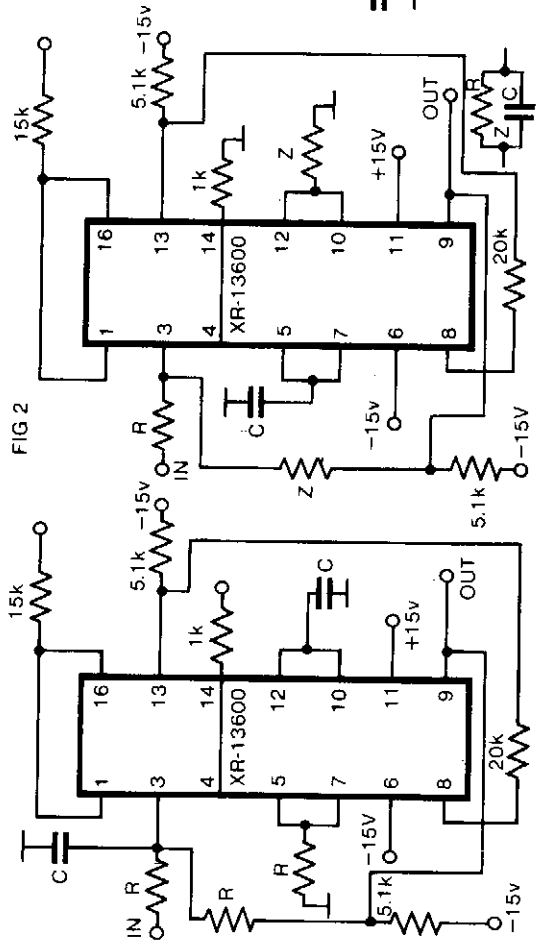
Filter Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Cost Universal Active Filter
State Variable Filter
Wideband Two-Pole High-Pass Filter
Active Low-Pass Filter with Digitally Selected Break
Frequency
Digitally Tuned Low Power Active Filter
Razor Sharp CW Filter
Fifth Order Chebyshev Multiple Feedback Low-Pass
Filter

Precision, Fast Settling Low-Pass Filter
Programmable Bandpass Using Twin-T Bridge
Active Bandpass Filter ($f_0 = 1000$ Hz)
Bandpass Filter
Active Bandpass Filter
Bandpass and Notch Filter
Multiple-Feedback Bandpass Filter

LOW COST UNIVERSAL ACTIVE FILTER



ELECTRONIC ENGINEERING

Circuit Notes

The circuit as shown in Fig. 1 gives the bandpass operation the transfer function calculated from

$$F_{BP}(s) = \frac{S/\omega_0}{K}$$

where $K = 1 + s/Q\omega_0 + s^2/\omega_0^2$. The cut-off frequency, ω_0 , and the Q-factor are given by

$$\omega_0 = g/C \text{ and } Q = gR/2$$

where g is the transconductance at room temperature.

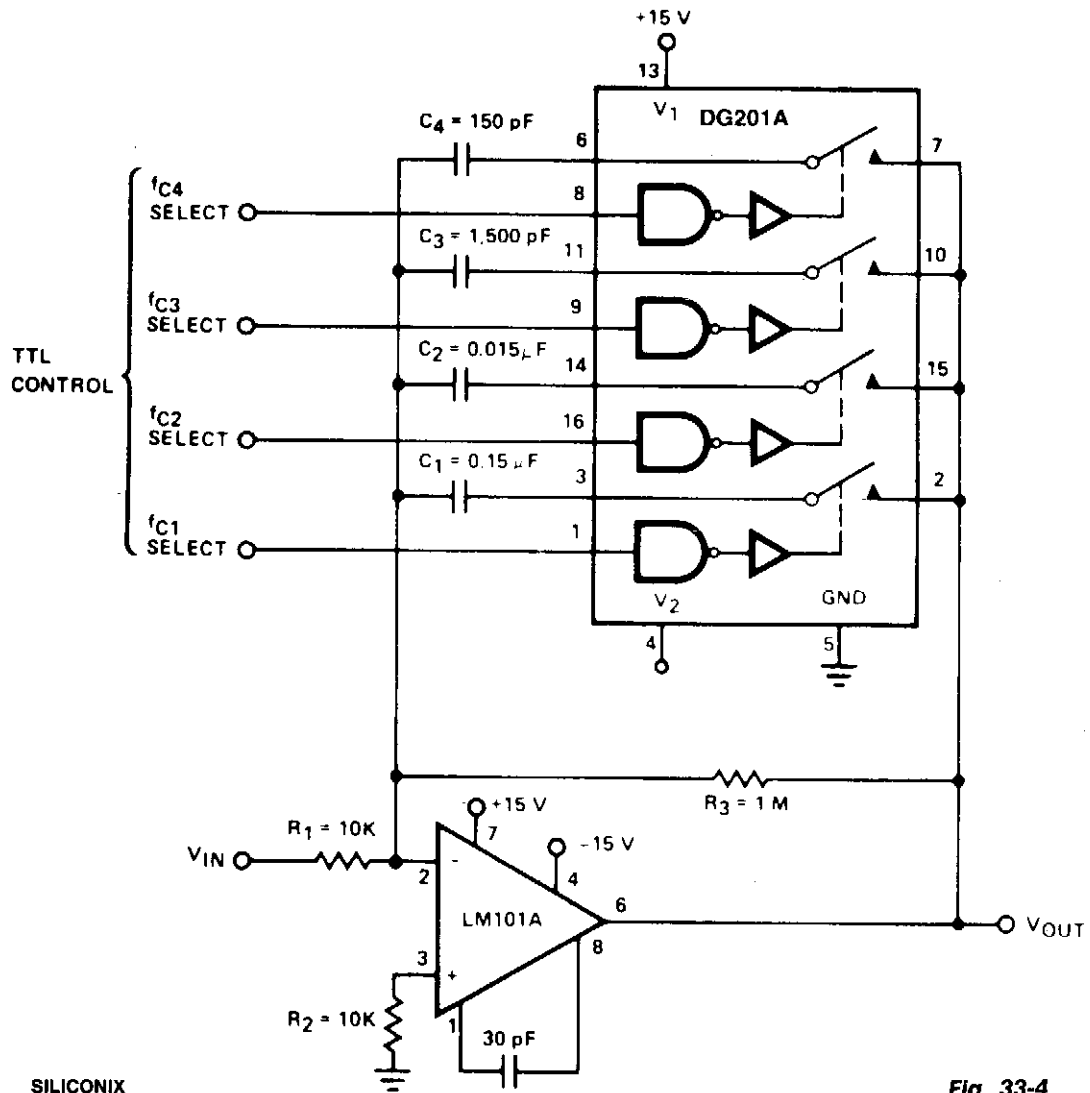
Interchanging the capacitor C with the resistor R at the input of the circuit high-pass operation is obtained. A low-pass filter is obtained by applying two parallel connections of R and C as shown in Fig. 2.

The low-pass operation may be much improved with the circuit as given in Fig. 3. Here the gain and Q may be set up separately with respect to the cut-off frequency according to the equations

$$Q = 1/fB = 1 + R_2/R_1, \\ A = Q^2 \text{ and } \omega_0 = g fB/C.$$

Fig. 33-1

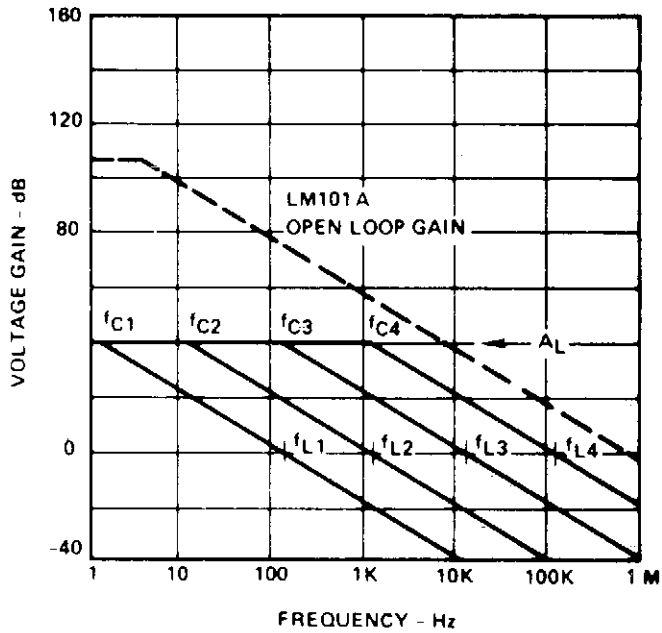
ACTIVE LOW-PASS FILTER WITH DIGITALLY SELECTED BREAK FREQUENCY



Circuit Notes

Variable low-pass filter has break frequencies at 1, 10, 100 Hz and 1 kHz. The break frequency is

$$1. \quad f_c = \frac{1}{2 \pi R_3 C_X}$$



A_L (VOLTAGE GAIN BELOW BREAK FREQUENCY)

$$= \frac{R_3}{R_1} = 100 \text{ (40 dB)}$$

$$f_c \text{ (BREAK FREQUENCY)} = \frac{1}{2\pi R_3 C_X}$$

$$f_L \text{ (UNITY GAIN FREQUENCY)} = \frac{1}{2\pi R_1 C_X}$$

$$\text{MAX ATTENUATION} = \frac{r_{DS(on)}}{10K} \approx -40 \text{ dB}$$

The low frequency gain is

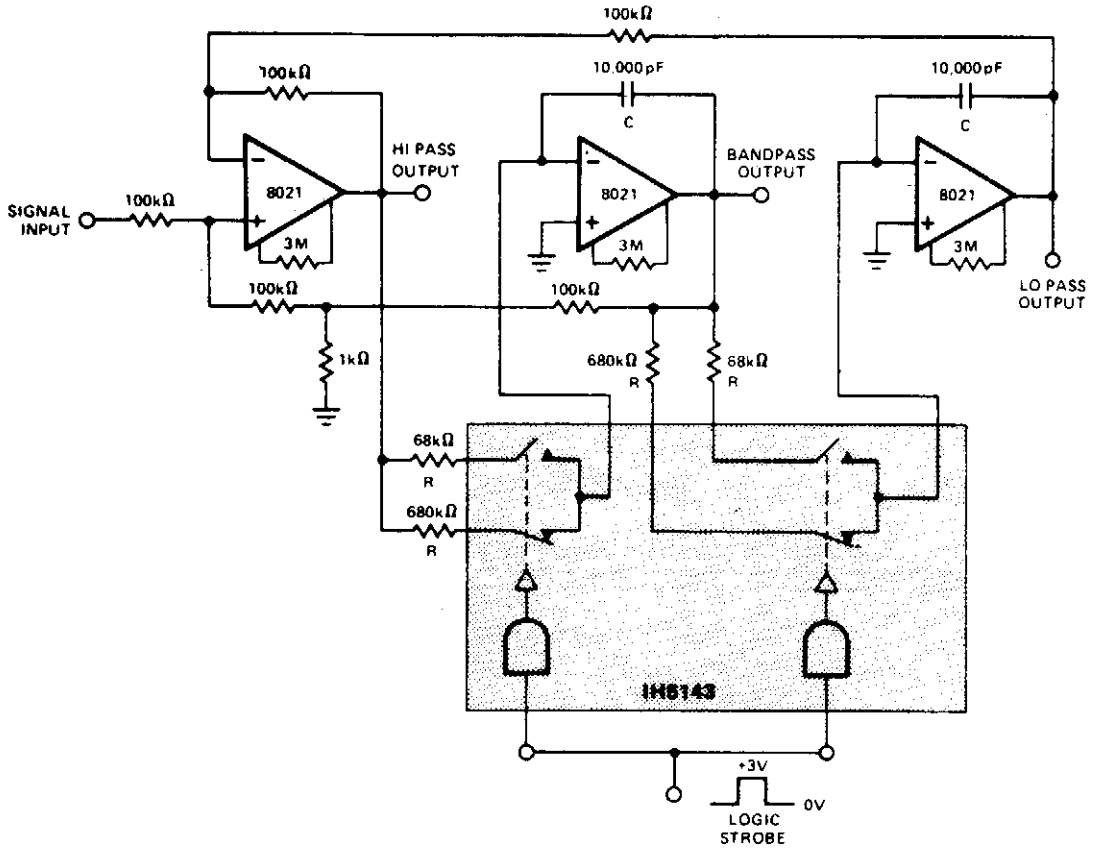
$$2. \quad A_L = \frac{R_3}{R_1} = 100 \text{ (40 dB)}$$

A second break frequency (a zero) is introduced by $r_{DS(on)}$ of the DG201A, causing the minimum gain to be

$$3. \quad A_{MIN} = \frac{r_{DS(on)}}{R_1} \approx \frac{100}{10K} = .01,$$

a maximum attenuation of 40 dB (80 dB relative to the low frequency gain).

DIGITALLY TUNED LOW POWER ACTIVE FILTER



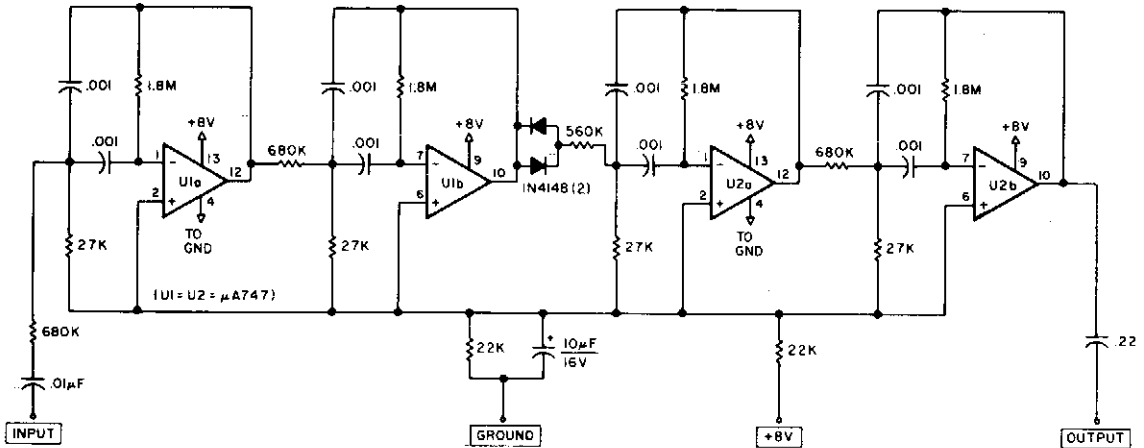
INTERSIL

Fig. 33-5

Circuit Notes

This constant gain, constant Q , variable frequency filter provides simultaneous low-pass, bandpass, and high-pass outputs with the component values shown, the center frequency will be 235 Hz and 23.5 Hz for high and low logic inputs respectively, $Q = 100$, and gain = 100.

RAZOR-SHARP CW FILTER



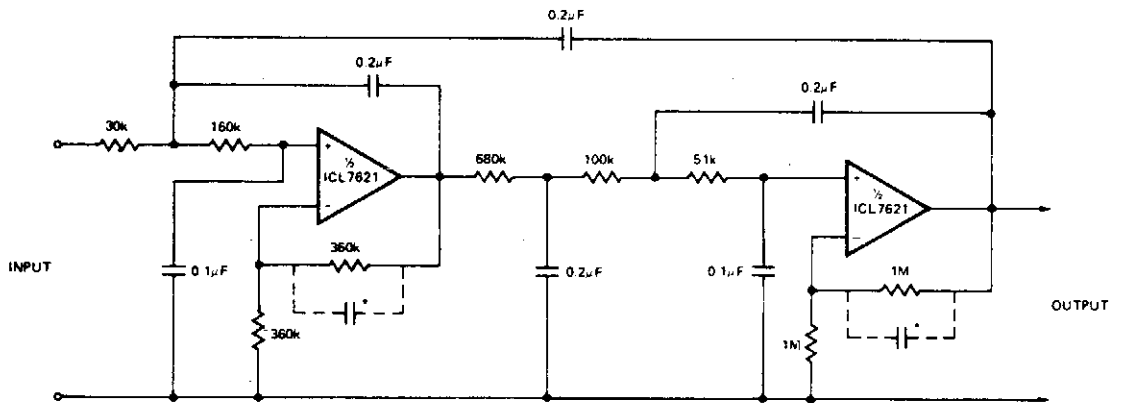
73 MAGAZINE

Fig. 33-6

Circuit Notes

The circuit consists of four stages of active bandpass filtering provided by two type- μ A747 integrated-circuit dual op amps and includes a simple threshold detector (diodes D1 and D2) between stages 2 and 3 to reduce low-level background noise. Each of the four filter stages acts as a narrow bandpass filter with an audio bandpass centered at 750 Hz. The actual measured 3-dB bandwidth is only 80 Hz wide.

FIFTH ORDER CHEBYSHEV MULTIPLE FEEDBACK LOW PASS FILTER



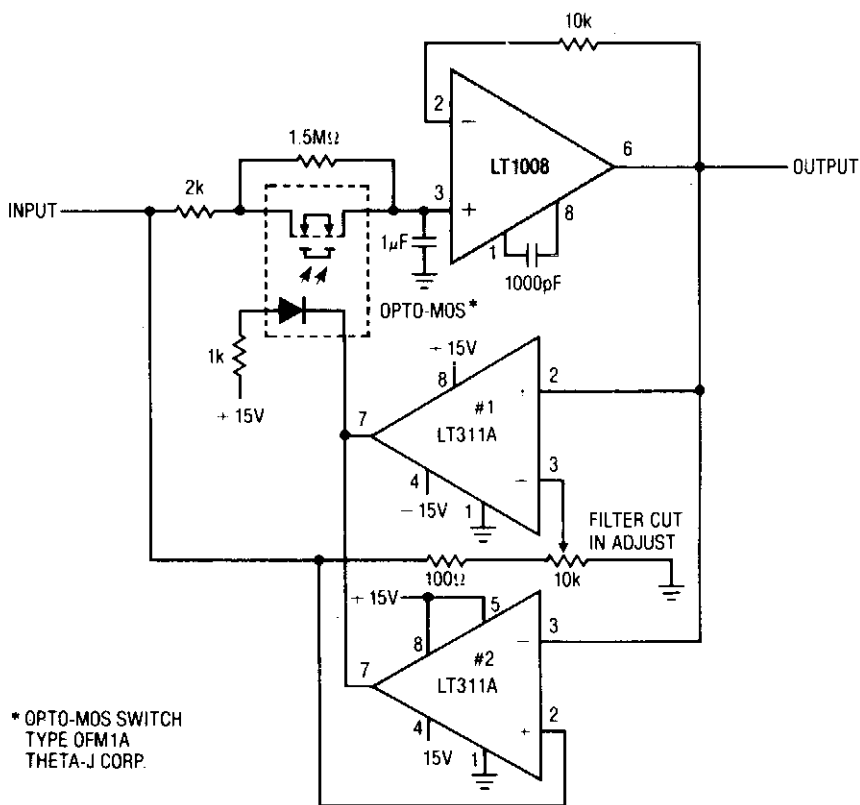
INTERSIL

Fig. 33-7

Circuit Notes

The low bias currents permit high resistance and low capacitance values to be used to achieve low frequency cutoff. $f_c = 10$ Hz, $A_{VCL} = 4$, Passband ripple = 0.1 dB. Note that small capacitors (25-50 pF) may be needed for stability in some cases.

PRECISION, FAST SETTLING, LOW-PASS FILTER



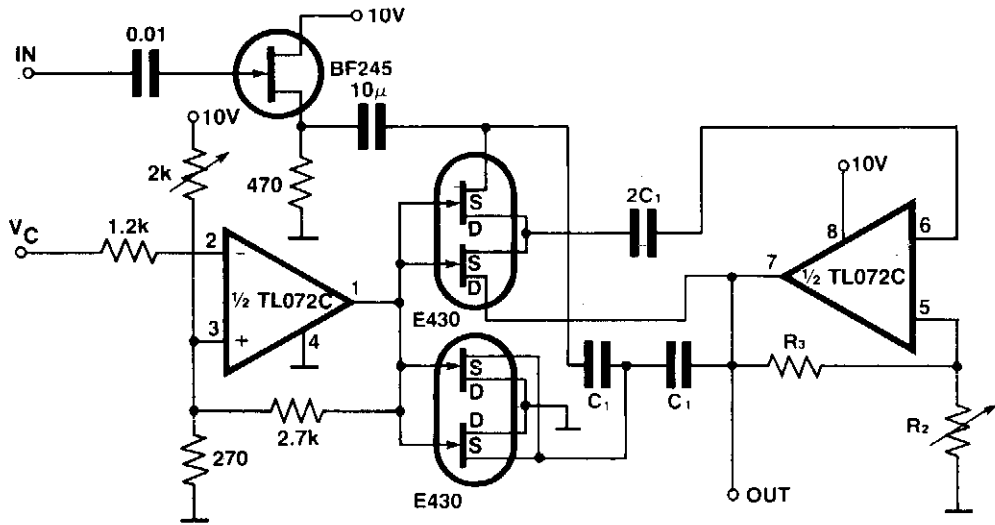
LINEAR TECHNOLOGY

Fig. 33-8

Circuit Notes

This circuit is useful where fast signal acquisition and high precision are required, as in electronic scales. The filter's time constant is set by the 2 K ohm resistor and the 1 μF capacitor until comparator No. 1 switches. The time constant is then set by the 1.5 M ohm resistor and the 1 μF capacitor. Comparator No. 2 provides a quick reset. The circuit settles to a final value three times as fast as a simple 1.5 M ohm—1 μF filter, with almost no dc error.

PROGRAMMABLE BANDPASS USING TWIN-T BRIDGE



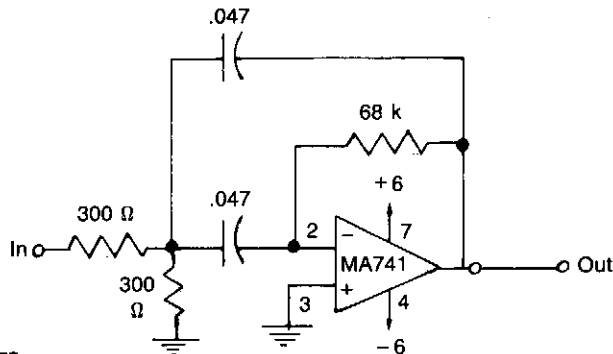
ELECTRONIC ENGINEERING

Fig. 33-9

Circuit Notes

The circuit gives a programmable bandpass where both the cut-over frequency and the gain, A , are controlled independently. In the twin-T bridge the resistors R and $R/2$ are replaced by two double FETs, E 430, the channel resistance of the first one in the series, the channel resistances of the second one are in parallel as to stimulate the resistance $R/2$. Both these resistors are controlled by V_c which ranges from 0 V to about 1 V. The gain of the circuit is set by means of the resistors R_2 and R_3 .

ACTIVE BANDPASS FILTER ($f_0 = 1000$ Hz)



WILLIAM SHEETS

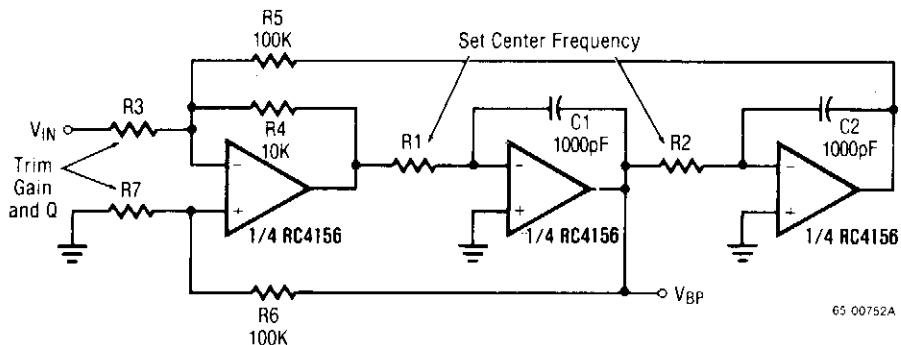
Fig. 33-10

Circuit Notes

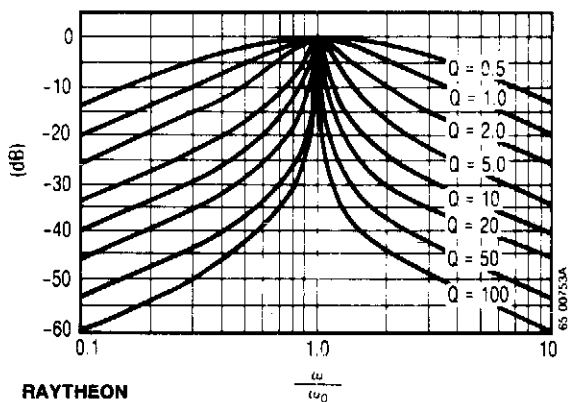
This filter has a bandpass centered around 1kHz, for applications such as bridge amplifiers, null detectors, etc.

The circuit uses a $\mu A741$ IC and standard 5% tolerance components.

BANDPASS FILTER



65 00752A



$$\frac{V_{BP}}{V_{IN}} = \frac{\frac{\omega}{\omega_0} \frac{1}{Q}}{\sqrt{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right]^2 + \left(\frac{1}{Q} \frac{\omega}{\omega_0}\right)^2}}$$

Fig. 33-11

Circuit Notes

The input signal is applied through R3 to the inverting input of the summing amplifier and the output is taken from the first integrator. The summing amplifier will maintain equal voltage at the inverting and non-inverting inputs. Defining $1/R1C1$ as ω_1 and $1/R2C2$ as ω_2 , this is now a convenient form to look at the center-frequency ω_0 and filter Q.

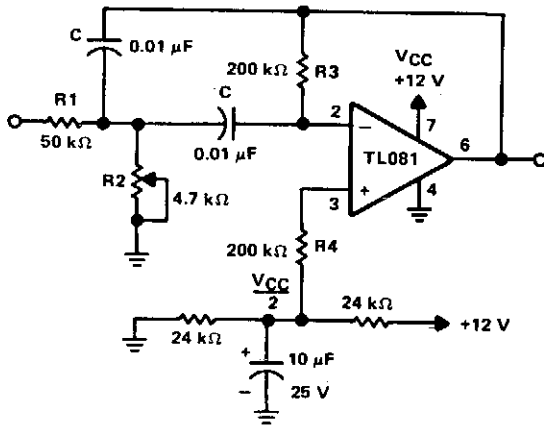
$$\omega_0 = \sqrt{0.1 \omega_1 \omega_2}$$

$$\text{and } Q = \frac{1 + \frac{10^5}{R7}}{1.1 + \frac{10^4}{R3}} \omega_0$$

$$= 10^{-9} \sqrt{0.1R1R2}$$

The frequency response for various values of Q is shown.

ACTIVE BANDPASS FILTER



Circuit Notes

The circuit is a two-pole active filter using a TL081 op amp. This type of circuit is usable only for Q s less than 10. The component values for this filter are calculated from the following equations.

$$R1 = \frac{Q}{2 fGC} \qquad R3 = \frac{2Q}{2fC}$$

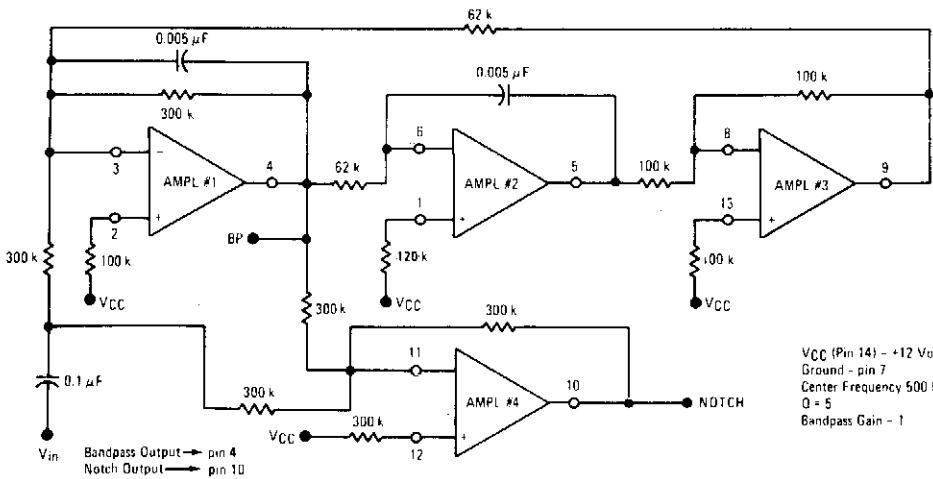
$$R2 = \frac{Q}{(2Q^2 - G)2fC} \qquad R4 = R3$$

TEXAS INSTRUMENTS

Fig. 33-12

The values shown are for a center frequency of 800 Hz.

BANDPASS AND NOTCH FILTER



MOTOROLA

V_{CC} (Pin 14) - +12 Volts
Ground - pin 7
Center Frequency 500 Hz
 $Q = 5$
Bandpass Gain - 1

Fig. 33-13

Circuit Notes

The Quad op amp MC4301 is used to configure a filter that will notch out a given frequency and produce that notched-out frequency at the BP terminal, useful in communications or measurement setups. By proper component selection any frequency filter up to a few tens of kilohertz can be obtained.

MULTIPLE-FEEDBACK BANDPASS FILTER

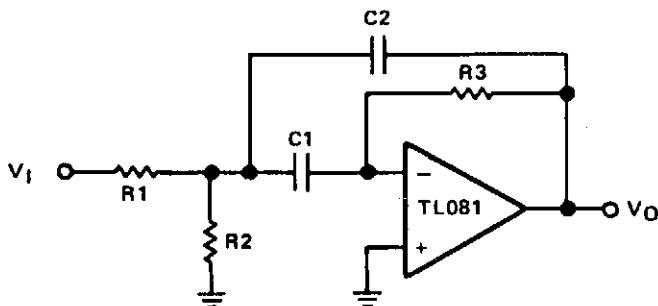


Fig. 33-14

TEXAS INSTRUMENTS

Circuit Notes

The op amp is connected in the inverting mode. Resistor R_3 from the output to the inverting input sets the gain and current through the frequency-determining capacitor, C_1 . Capacitor C_2 provides feedback from the output to the junction of R_1 and R_2 . C_1 and C_2 are always equal in value. Resistor R_2 may be made adjustable in order to adjust the center frequency which is determined from:

$$f_o = \frac{1}{2\pi C} \times \frac{1}{R_3} \times \frac{R_1 + R_2}{R_1 R_2}$$

When designing a filter of this type it is best to select a value for C_1 and C_2 , keeping them equal. Typical audio filters have capacitor values from $0.01 \mu\text{F}$ to $0.1 \mu\text{F}$ which will result in reasonable values for the resistors.

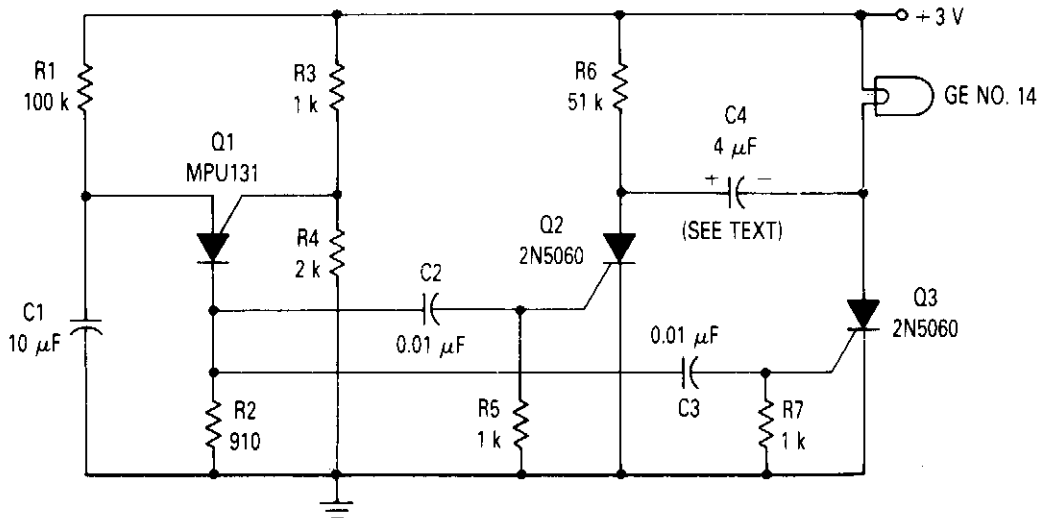
34

Flashers and Blinkers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Voltage Lamp Flasher	2 kW Flasher with Photoelectric Control
Miniature Transistorized Light Flasher	Sequential Flasher
Alternating Flasher	1 kW Flip-Flop Flasher Circuit
Electronic Light Flasher	Low Frequency Oscillator Flasher
High-Power Battery-Operated Flasher	High Drive Oscillator/Flasher
Series SCR Lamp Flasher Handles a Wide Range of Loads	Transistorized Flashers
SCR Relaxation Flasher	Sequential ac Flasher
Low Current Consumption Lamp Flasher	Astable Flip-Flop with Starter
LED Flasher Uses PUT	LED Flasher Uses UJT

LOW VOLTAGE LAMP FLASHER



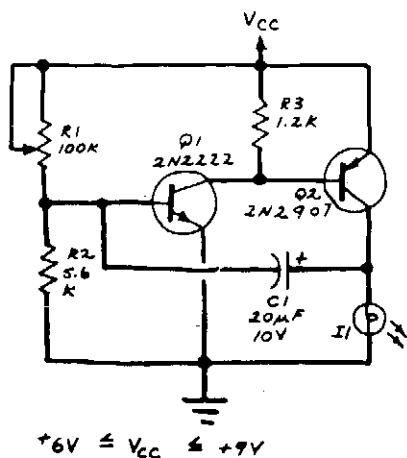
MOTOROLA

Fig. 34-1

Circuit Notes

The circuit is composed of a relaxation oscillator formed by Q1 and an SCR flip-flop formed by Q2 and Q3. With the supply voltage applied to the circuit, the timing capacitor C1 charges to the firing point of the PUT, 2 volts plus a diode drop. The output of the PUT is coupled through two 0.02 μF capacitors to the gate of Q2 and Q3. To clarify operation, assume that Q3 is on and capacitor C4 is charged plus to minus as shown in the figure. The next pulse from the PUT oscillator turns Q2 on. This places the voltage on C4 across Q3 which momentarily reverse biases Q3. This reverse voltage turns Q3 off. After discharging, C4 then charges with its polarity reversed to that shown. The next pulse from Q1 turns Q3 on and Q2 off. Note that C4 is a non-polarized capacitor. For the component values shown, the lamp is on for about ½ second and off the same amount of time.

MINIATURE TRANSISTORIZED LIGHT FLASHER



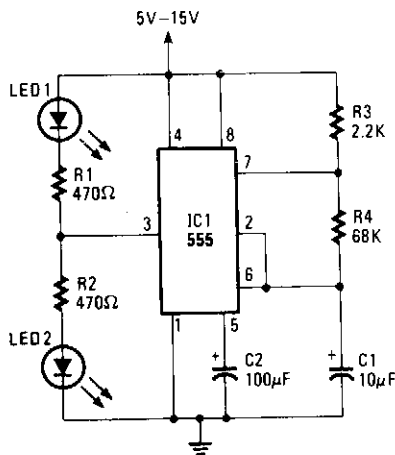
Circuit Notes

R1 adjusts the flash rate. The lamp should be a No. 122, No. 222 or other similar, miniature incandescent lamp.

POPULAR ELECTRONICS

Fig. 34-2

ALTERNATING FLASHER



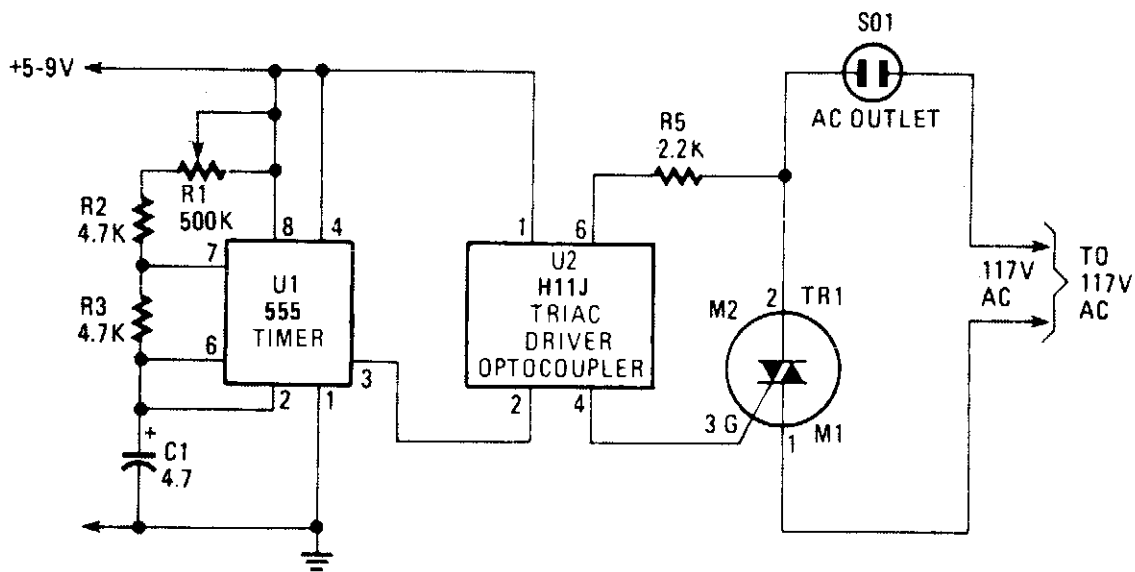
Circuit Notes

The LED's flash alternately. The flash rate is determined by C1 and R4.

HANDS-ON ELECTRONICS

Fig. 34-3

ELECTRONIC LIGHT FLASHER



HANDS-ON ELECTRONICS

Fig. 34-4

Circuit Notes

The blinking or flashing rate is determined by U1, a 555 timer integrated circuit. Its output, at pin 3, feeds U2, a H11J triac driver. That driver consists of an infrared LED that is coupled internally to a light-activated silicon bilateral switch (DIAC). When the LED internal to U2 is turned on by the timer, U1, its light triggers the DIAC; effectively closing the circuit between pins 4 and 6, and fires the Triac, TR1 through its gate circuit. When the Triac is firing, it acts as a closed circuit that turns on the light (or other device it may be controlling via S01). When the timer turns off, the LED, the DIAC and Triac stop conducting and the light turns off. The sequence then repeats. The flashing rate can be varied by means of R1, a 500,000 ohm potentiometer.

HIGH-POWER BATTERY-OPERATED FLASHER

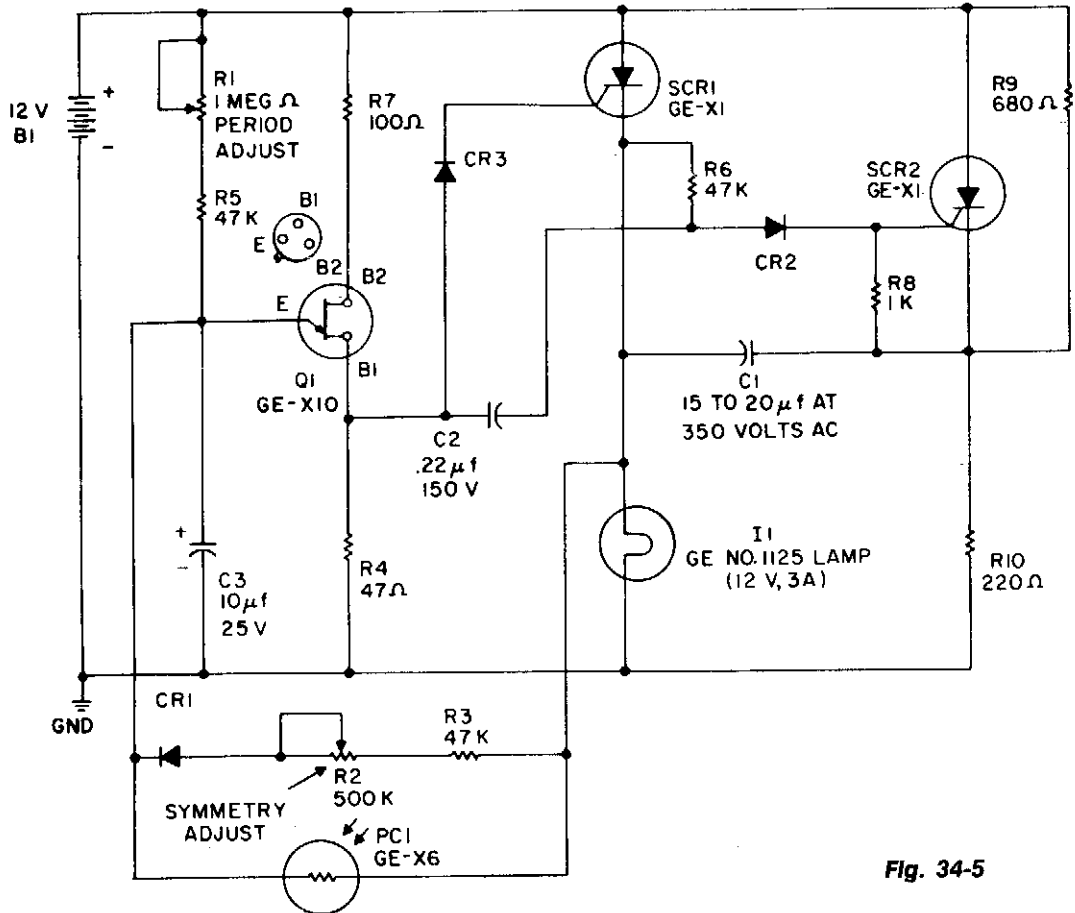


Fig. 34-5

GENERAL ELECTRIC

Circuit Notes

This flasher operates from a 12-volt car or boat battery. It offers 36 to 40-watts output, variable flash rate (up to 60 flashes per minute), independent control of both on and off cycles and photoelectric night and day control that turns the flasher on at night and shuts it off during the day for automatic operation. SCR1 and SCR2 form a basic dc flip-flop. The lamp load is the cathode leg of one SCR so that the other side of the load may be at ground (negative) potential (required in some applications). The flip-flop timing is controlled by a conventional UJT oscillator arrangement (Q1, R1, C3, etc.). Potentiometer R2 and diode CR1 provide on/off timing independence. Photoconductor PC1 locks out the UJT firing circuit during the daylight hours.

LOW CURRENT CONSUMPTION LAMP FLASHER

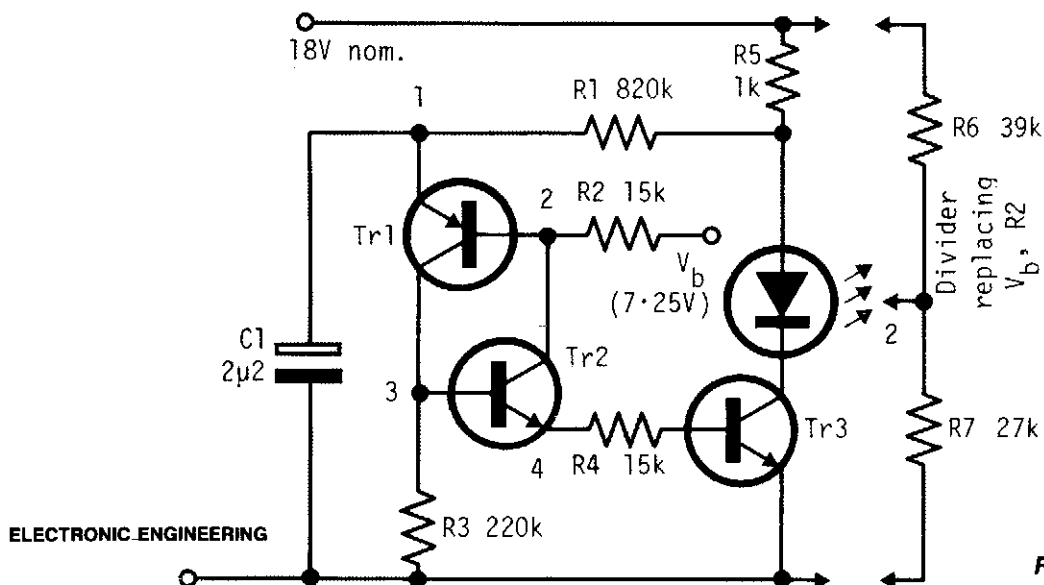


Fig. 34-8

Circuit Notes

The circuit is economical in components, and will work with virtually any transistors and is reliably self-starting. The voltage V_b can be taken from a divider, as shown at the right. If taken from a fixed source, flashing becomes slower as battery voltage falls. The lowest drive current into the base of Tr_3 is about $(V_b - 0.6 \text{ V}) / (R_2 + R_4)$. Resistor R_4 limits the initial current from C_1 and, as shown, R_2 and R_4 can be roughly equal when a divider is used for V_b . Resistor R_2 equals $R_6 R_7 / (R_6 + R_7)$. With the voltages shown, and with $R_2 = R_4$, the on-time is about $1.1 C_1 R_2$ and the off-time about $0.28 C_1 R_1$. Using the component values shown the period is about 0.55 sec. with a duty cycle of about 7% and a mean battery current including the V_b divider, about 1.5 mA.

LED FLASHER USES UJT

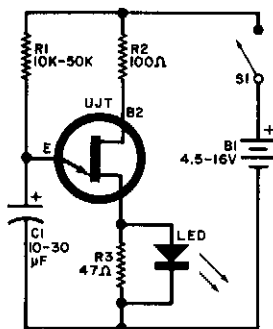


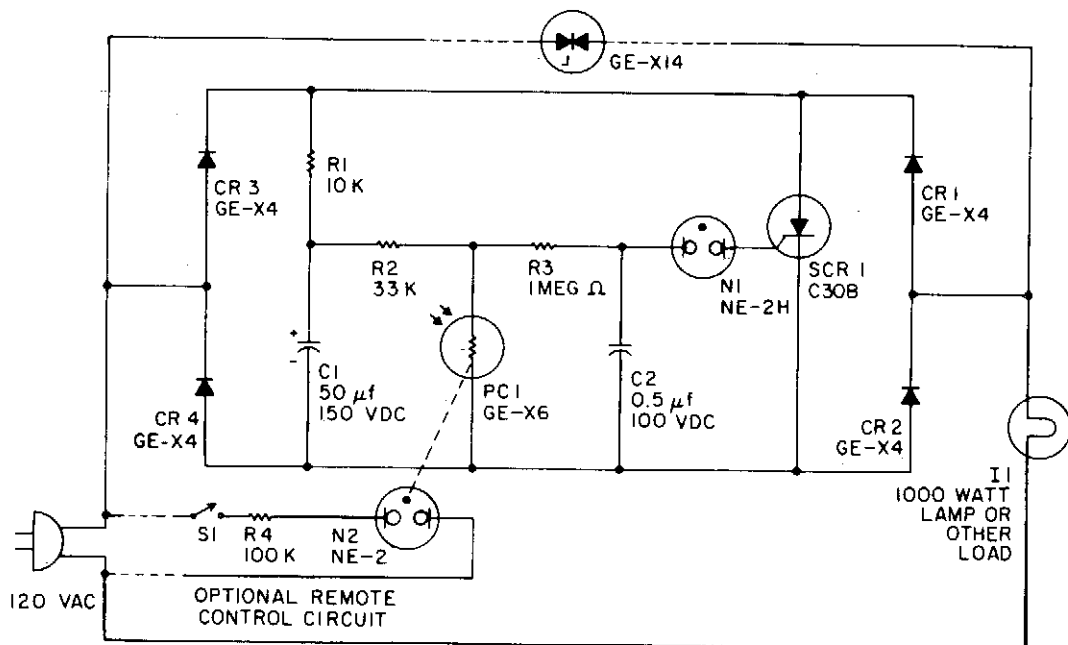
Fig. 34-9

Circuit Notes

A relaxation oscillator is used to flash an LED in the base circuit. C_1 is charged slowly through R_1 by the power source, then discharged periodically through R_3 and the LED by the UJT. Flashing rate is determined by the supply voltage and by R_1 - C_1 's time constant. UJT = 2N4871

POPULAR ELECTRONICS

2 kW FLASHER WITH PHOTOELECTRIC CONTROL



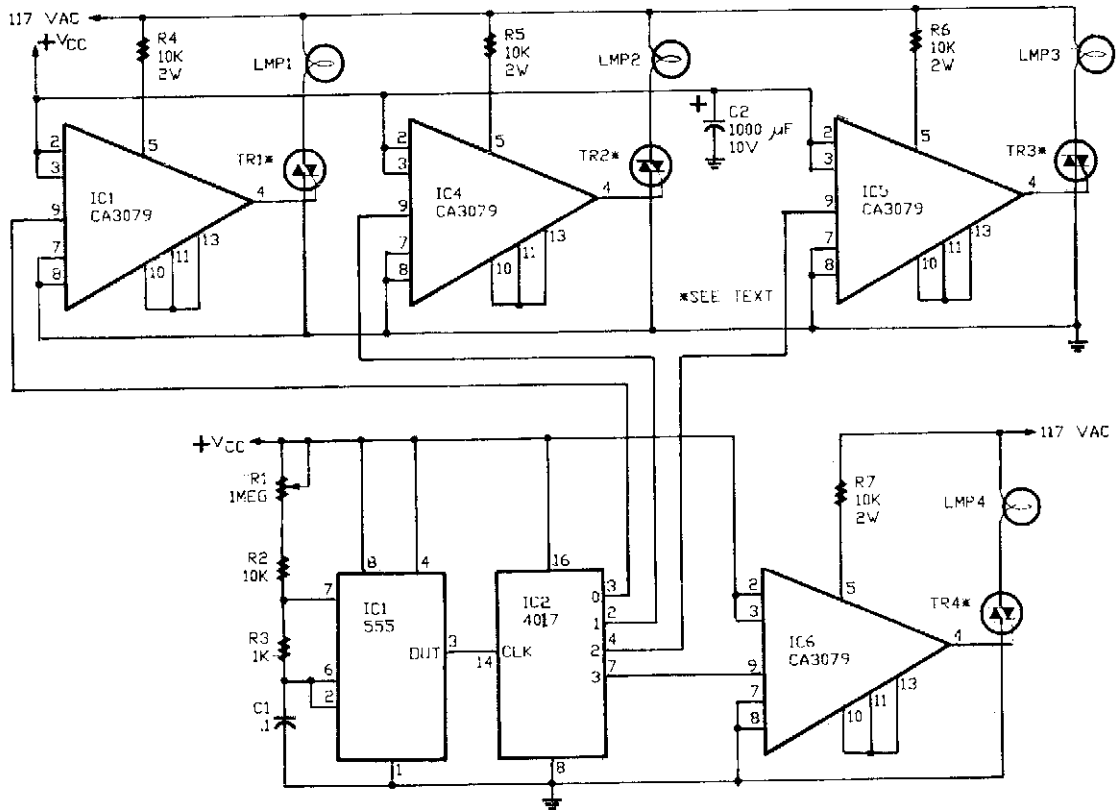
GENERAL ELECTRIC

Fig. 34-10

Circuit Notes

CR1, CR2, CR3, and CR4 form a bridge circuit with the SCR across the dc legs. With light on the photoconductor PC1, C1 charges through R1 to about 150 Vdc. The resistance of PC1 is low when illuminated, so very little voltage appears across it or C2. At about 90 volts C1 starts discharging through R1 and the SCR, but the SCR cannot turn off until C1 is almost completely discharged. When the SCR turns off during the interval line voltage is near zero, the full supply voltage again appears across the bridge, and C1 charges again to a high voltage. The voltage on C2 also starts rising until the neon lamp fires and the cycle repeats. An alternative remote control can be made by adding a second neon lamp, N2, and masking the photocell so it sees only N2. A very sensitive remote control is thus obtained that is completely isolated from the load circuit. For low-voltage remote control a flashlight lamp may be used instead of N2 and operated at about ½ its normal voltage thus giving exceptionally long life. Performance of the photoelectric control may be inverted (flash when the photoconductor is illuminated) by interchanging PC1, and R2. Sensitivity in either the normal or inverted modes can be decreased by partially masking PC1, and can be increased by increasing resistor R2 to about 470 K. To increase on time, increase C1; to increase off time, increase R3.

SEQUENTIAL FLASHER



RADIO-ELECTRONICS

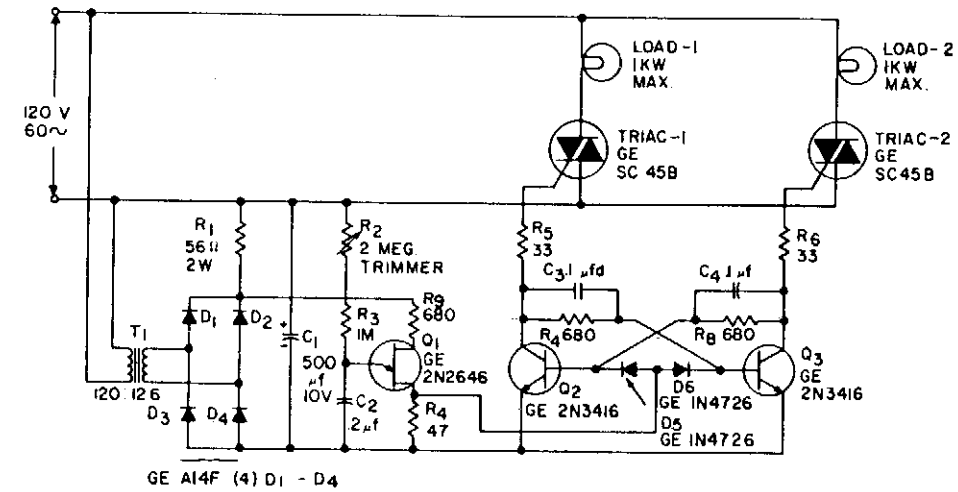
Fig. 34-11

Circuit Notes

A 555 timer, IC1, drives a 4017 CMOS decade counter. Each of the 4017's first four outputs drives a CA3079 zero-voltage switch. Pin 9 of the CA3079 is used to inhibit output from pin 4, thereby disabling the string of pulses that IC normally delivers. Those pulses occur every 8.3 ms, i.e., at a rate of 120 Hz. Each pulse has a width of 120 μ s. Due to the action of the CA3079, the lamps connected to the TRI-AC's turn on and off near the zero crossing of the ac waveform. Switching at that point increases lamp life by reducing the inrush of current that would happen if the lamp were turned on near the high point of the ac waveform. In addition, switching at the zero crossing reduces Radio-Frequency Interference (RFI) considerably.

CAUTION: The CA3079's are driven directly from the 117-volt ac power line, so use care.

1 KW FLIP-FLOP FLASHER CIRCUIT



GENERAL ELECTRIC

Fig. 34-12

Circuit Notes

This is an application of the static switch circuit where the control logic is a flip-flop which is controlled by the unijunction transistor. The flashing rate can be adjusted from about 0.1 second to a 10 second cycle time.

LOW FREQUENCY OSCILLATOR-FLASHER

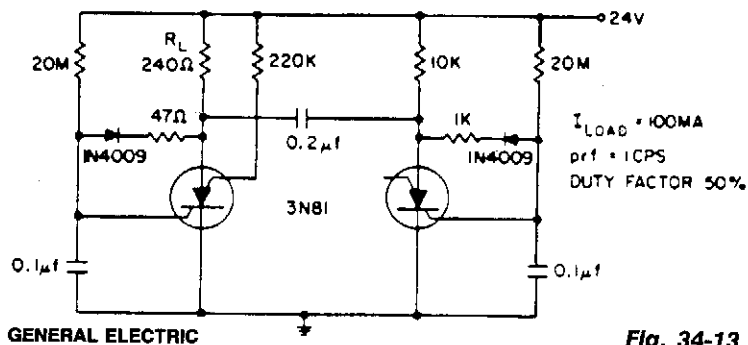
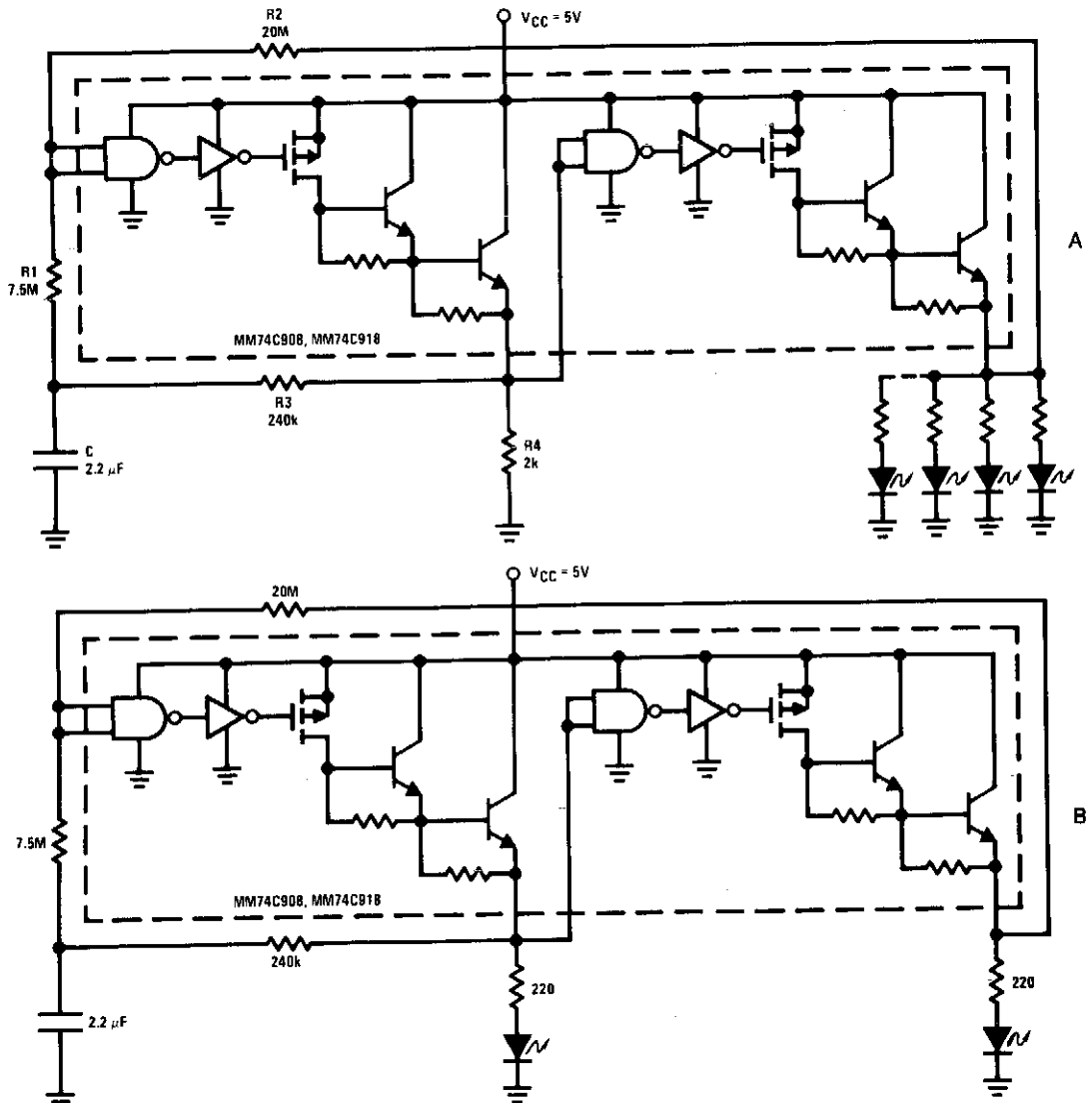


Fig. 34-13

Circuit Notes

Electrolytic capacitors are unnecessary to generate a 1 cps frequency. As an scs triggers on, the 0.2 μF commutating capacitor turns off the other one and charges its gate capacitor to a negative potential. The gate capacitor charges towards 24 volts through 20 M retriggering its scs. Battery power is delivered to the load with 88% efficiency. The 20 M resistors can be varied to change prf or duty factor.

HIGH DRIVE OSCILLATOR/FLASHER



NATIONAL SEMICONDUCTOR CORP.

Fig. 34-14

Circuit Notes

The driver in the package is connected as a Schmitt trigger oscillator (A) where R1 and R2 are used to generate hysteresis. R3 and C are the inverting feedback timing elements and R4 is the pull-down load for the first driver. Because of its current capability, the circuit can be used to drive an array of LEDs or lamps. If resistor R4 is replaced by an LED (plus a current limiting resistor), the circuit becomes a double flasher with the 2 LEDs flashing out of phase (B).

TRANSISTORIZED FLASHERS

AMBIENT TEMPERATURE

Flasher circuit performance as a function of temperature using limit sample transistors.

		AMBIENT TEMPERATURE		
		-40°F	77°F	212°F
CIRCUIT #1	Flashes per Minute	min. 58.0	60.0	59.6
		max. 56.7	59.6	58.7
	Flash Duration in %	min. 14.5	14.6	14.3
		max. 15.1	14.9	15.3
CIRCUIT #2	Flashes per Minute	min. 58.6	60.0	59.0
		max. 55.6	58.1	56.4
	Flash Duration in %	min. 26.3	27.5	22.2
		max. 28.8	29.1	29.6
CIRCUIT #3	Flashes per Minute	min. 59.0	60.0	61.5
		max. 55.4	57.7	55.2
	Flash Duration in %	min. 45.2	46.0	48.2
		max. 45.6	46.2	47.0

Circuit Notes

Transistors Q1 and Q2 are connected as a free running multivibrator. The output, at the emitter of Q2, drives the base of the common emitter amplifier Q3, which controls the lamp. This circuit configuration permits the flash duration, the interval between flashes, and the lamp type to be varied independently. Flash duration is proportional to the product of R2C2 while the off interval is proportional to the product of R3C1. Consequently, when the flash timing must be accurately maintained, these component tolerances will have to be held to similar limits.

All three circuits described are designed for barricade warning flasher lights such as used in highway construction. They differ only in flash duration which normally is 15%, 25%, or 50% of the flash rate. Performance has been checked at ambient temperatures of -40°F, 77°F, and 212°F. A GE 5 volt, 90 milliamper type No. 1850 lamp is used.

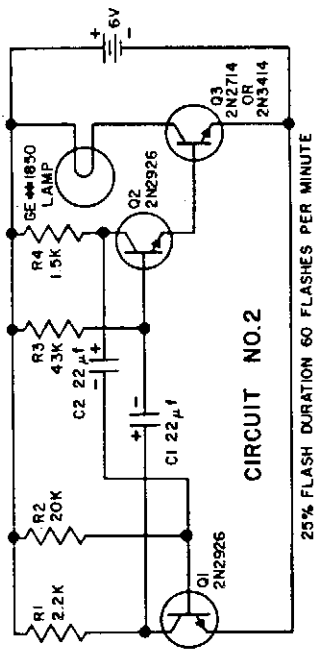
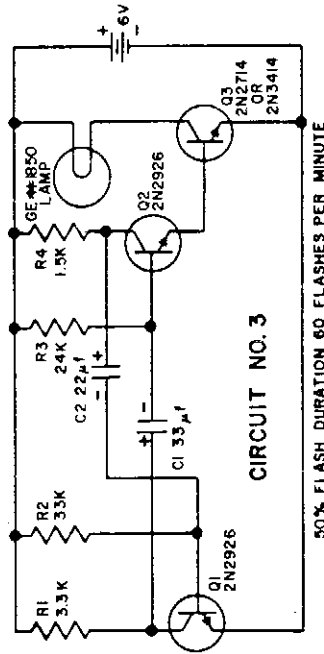
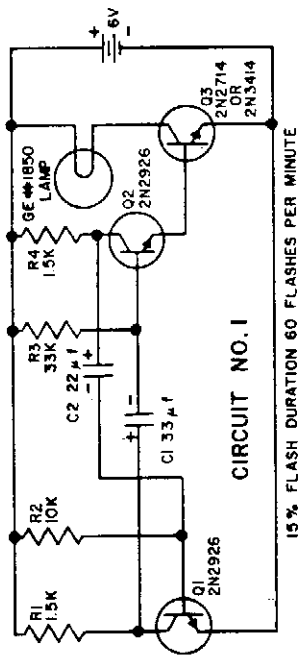


Fig. 34-15

GENERAL ELECTRIC

SEQUENTIAL AC FLASHER

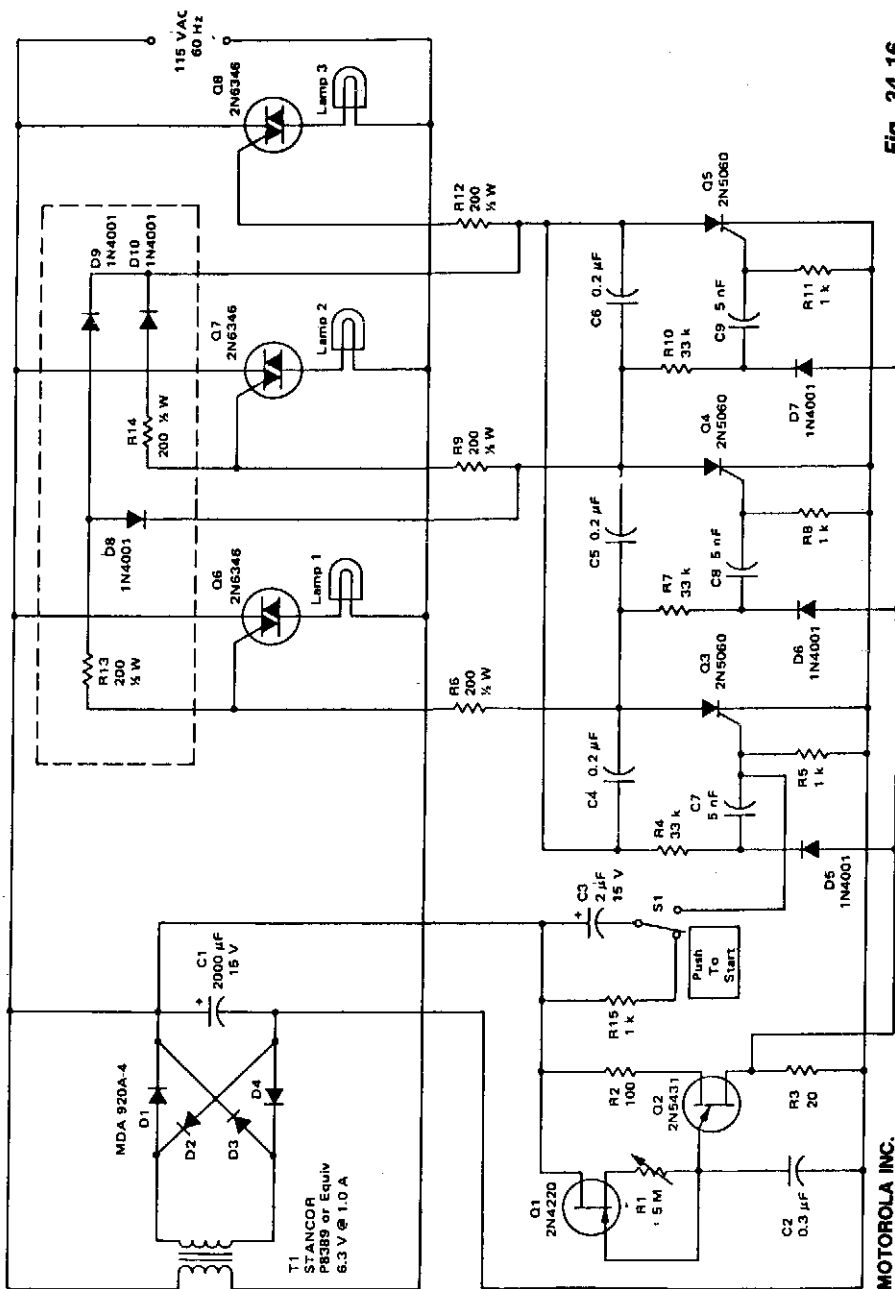


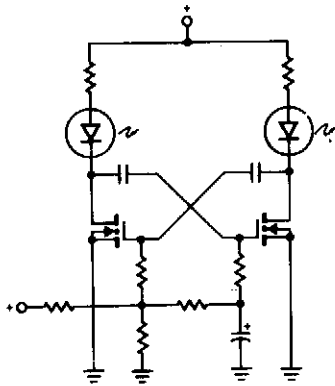
Fig. 34-16

Circuit Notes

This circuit uses a ring counter made up of Q3, Q4 and Q5. Q2 acts as an oscillator which triggers the SCRs Q3, Q4 and Q5 in sequence. When an SCR fires, a $0.2\mu\text{F}$ capacitor provides commutation, shutting off the previous stage. Triacs Q6, Q7 and Q8 control lamps 1, 2 and 3 respectively.

MOTOROLA INC.

ASTABLE FLIP-FLOP WITH STARTER



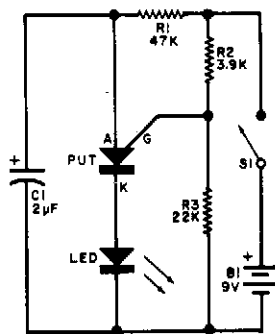
SILICONIX, INC.

Fig. 34-17

Circuit Notes

A pair of non-zenered MOSPOWER transistors, a pair of LEDs and a simple RC circuit make an easy sequential flasher with almost unlimited sequencing time—from momentary to several seconds. The infinite input resistance of the MOSFET gate allows for very long sequencing times that are impossible when using bipolars. One precaution, though, don't wire your circuit using phenolic or printed circuit boards when looking for slow sequencing (they exhibit too much leakage!).

LED FLASHER USES PUT



POPULAR ELECTRONICS

Fig. 34-18

Circuit Notes

This flasher circuit operates as a relaxation oscillator with C1 discharged periodically through the LED as the PUT switches on. The flashing rate is about 100/minute with the component values listed.

35

Flow Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Thermally Based Anemometer (Air Flowmeter)
Air Flow Detector

THERMALLY BASED ANEMOMETER (AIR FLOWMETER)

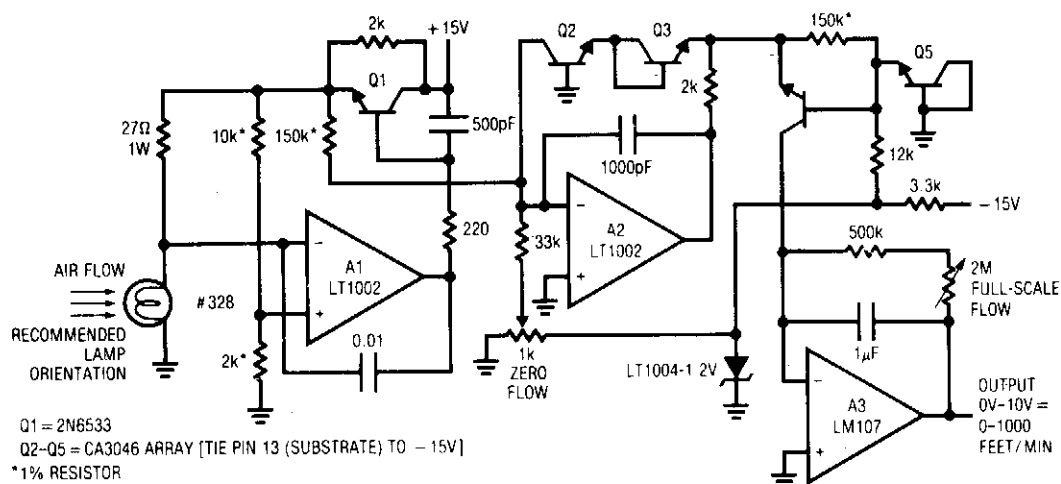


Fig. 35-1

LINEAR TECHNOLOGY CORPORATION

Circuit Notes

This design used to measure air or gas flow works by measuring the energy required to maintain a heated resistance wire at constant temperature. The positive temperature coefficient of a small lamp, in combination with its ready availability, makes it a good sensor. A type 328 lamp is modified for this circuit by removing its glass envelope. The lamp is placed in a bridge which is monitored by A1. A1's output is current amplified by Q1 and fed back to drive the bridge. When power is applied, the lamp is at a low resistance and Q1's emitter tries to come full on. As current flows through the lamp, its temperature quickly rises, forcing its resistance to increase. This action increases A1's negative input potential. Q1's emitter voltage decreases and the circuit finds a stable operating point. To keep the bridge balanced, A1 acts to force the lamp's resistance, hence its temperature, constant. The 20 k - 2 k bridge values have been chosen so that the lamp operates just below the incandescence point.

To use this circuit, place the lamp in the air flow so that its filament is at a 90° angle to the flow. Next, either shut off the air flow or shield the lamp from it and adjust the zero flow potentiometer for a circuit output of 0 V. Then, expose the lamp to air flow of 1000 feet/minute and trim the full flow potentiometer for 10 V output. Repeat these adjustments until both points are fixed. With this procedure completed, the air flowmeter is accurate within 3% over the entire 0-1000 foot/minute range.

AIR FLOW DETECTOR

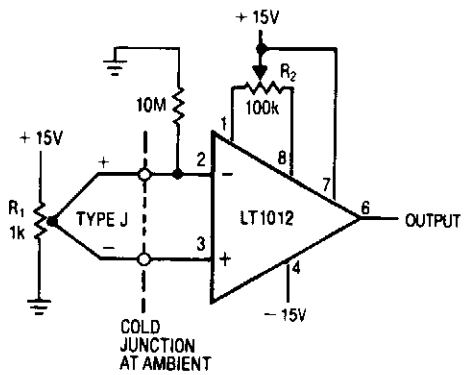


Fig. 35-2

Mount R₁ in airflow.
Adjust R₂ so output goes high when airflow stops.

LINEAR TECHNOLOGY CORP.

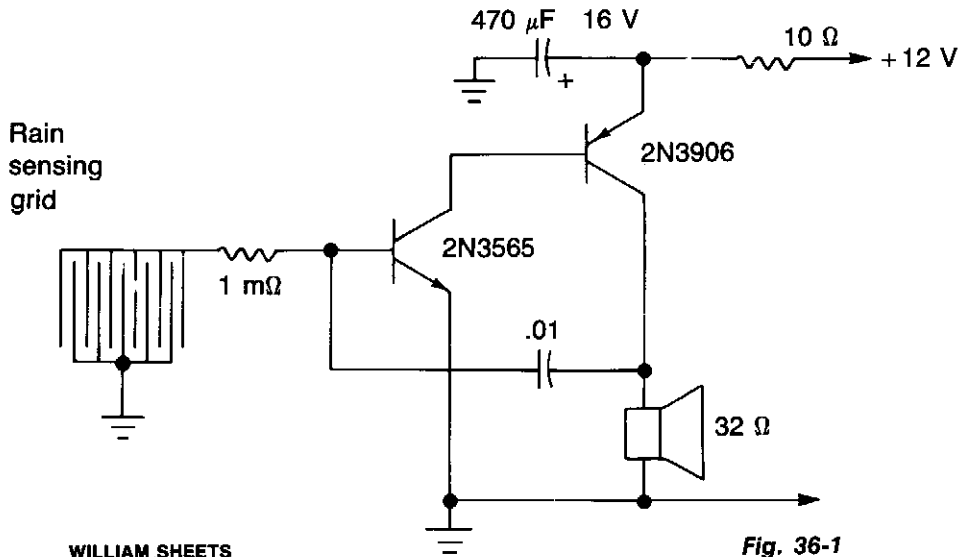
36

Fluid and Moisture Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Rain Warning Bleeper
Water-Level Indicator
Acid Rain Monitor
Plant-Water Monitor
Water-Level Sensing and Control
Single Chip Pump Controller
Plant-Water Gauge
Liquid Flowmeter

RAIN WARNING BLEEPER



Circuit Notes

One small spot of rain on the sense pad of this bleeper will start this audio warning. It can also be operated by rising water. The circuit has two transistors, with feedback via capacitor C1, but Tr1 cannot operate as long as the moisture sense pad is dry. When the pad conducts, Tr1 and Tr2 form an audio oscillatory circuit, the pitch depends somewhat on the resistance.

WATER-LEVEL INDICATOR

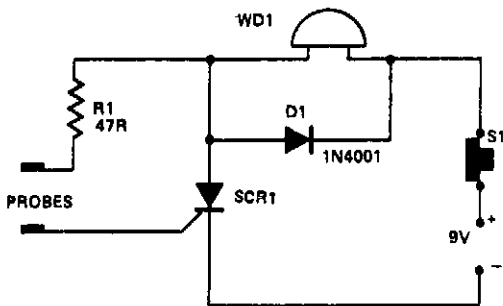
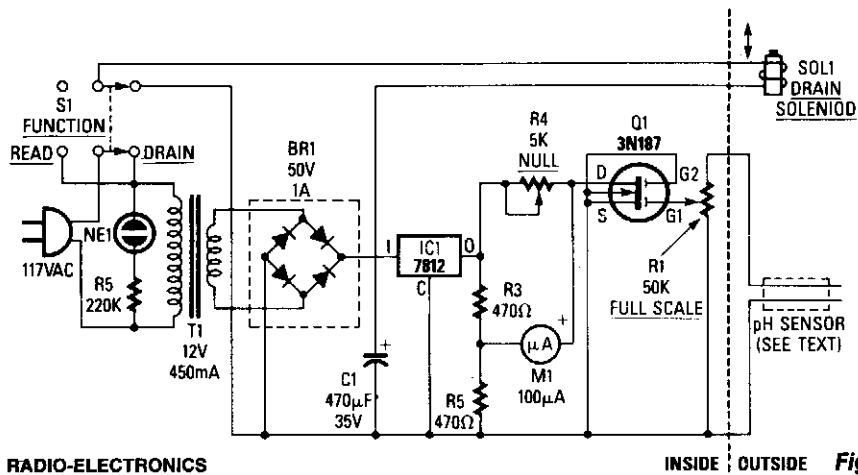


Fig. 36-2

Circuit Notes

In this a warning device WD1 is in series with SCR1. When the liquid level causes a conductive path between the probes, the SCR conducts sounding WD1. The warning device may be a Sonalert (TM), a lamp or a buzzer. D1 acts as a transient suppressor. Press S1 to reset the circuit.

ACID RAIN MONITOR



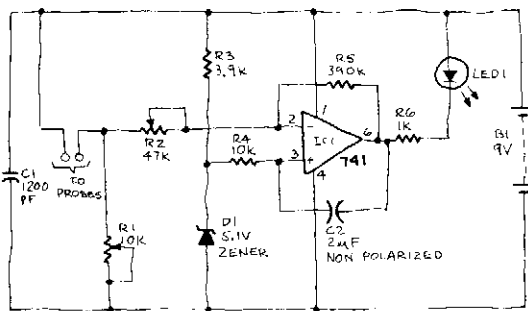
RADIO-ELECTRONICS

INSIDE | OUTSIDE Fig. 36-3

Circuit Notes

A bridge rectifier and 12-volt regulator powers the MOSFET sensing circuit. The unregulated output of the bridge rectifier operates the drain solenoid via switch S1. The sensor itself is built from two electrodes, one made of copper, the other of lead. In combination with the liquid trapped by the sensor, they form a miniature lead-acid cell whose output is amplified by MOSFET Q1. The maximum output produced by our prototype cell was about 50 μA . MOSFET Q1 serves as the fourth leg of a Wheatstone bridge. When acidity causes the sensor to generate a voltage, Q1 turns on slightly, so its drain-to-source resistance decreases. That resistance variation causes an imbalance in the bridge, and that imbalance is indicated by meter M1.

PLANT-WATER MONITOR



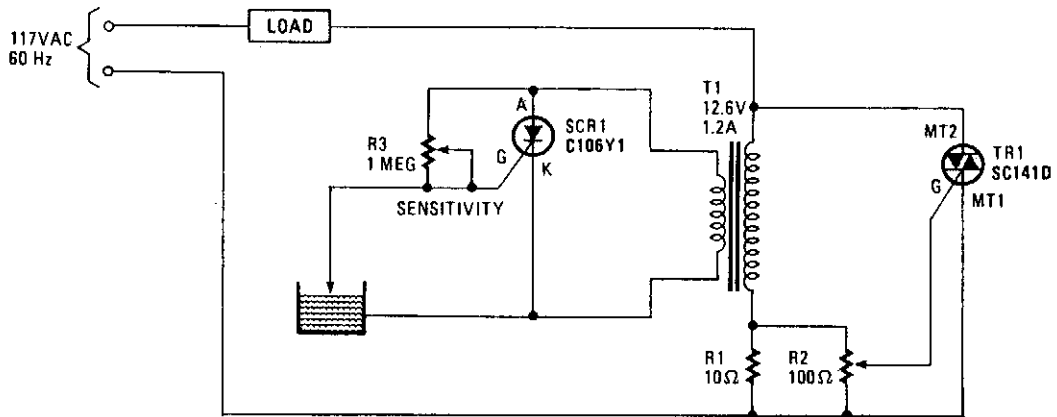
Circuit Notes

When the soil is moist, the LED glows. If the moisture falls below a certain predetermined level, the LED begins to flash. If there is still less moisture, the LED turns off. To calibrate, connect the battery and insert the probe into a container of dry soil. Set R1 to its maximum value then reduce that resistance until the LED begins to flash. The range over which the LED flashes before going out is adjusted using R2.

RADIO-ELECTRONICS

Fig. 36-4

WATER-LEVEL SENSING AND CONTROL



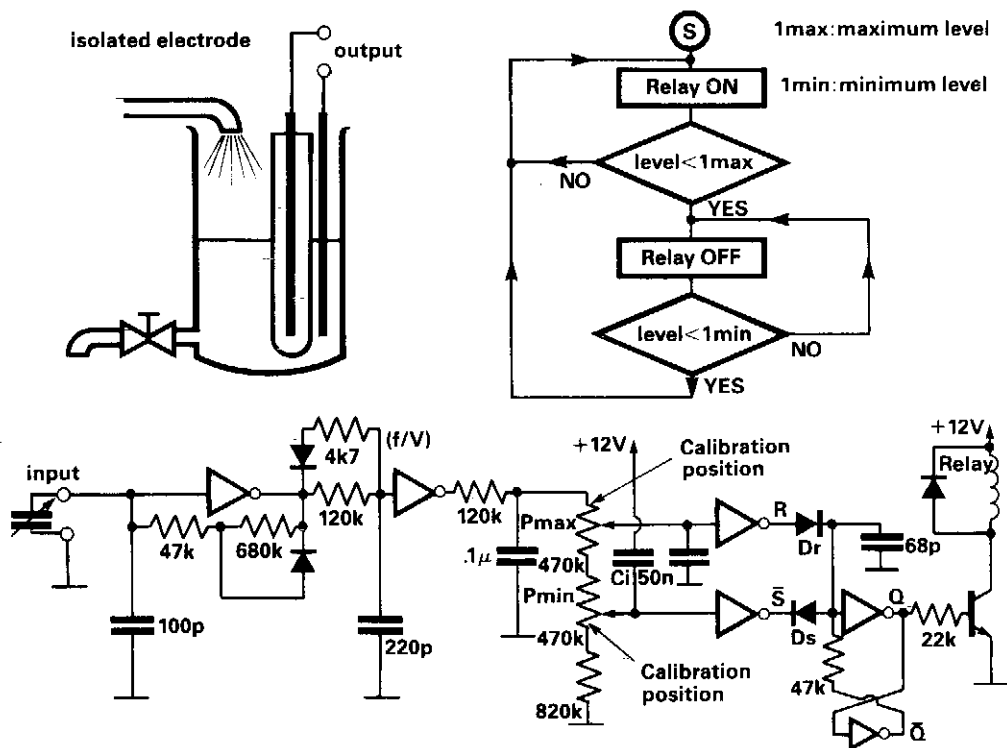
HANDS-ON ELECTRONICS

Fig. 36-5

Circuit Notes

The operation of the circuit is based on the difference in the primary impedance of a transformer when its secondary is loaded and when it is open-circuit. The impedance of the primary of T1 and resistor R1 are in series with the load. The triac's gate-control voltage is developed across parallel resistors R1 and R2. When the water level is low, the probe is out of the water and SCR1 is triggered on. It conducts and imposes a heavy load on transformer T1's secondary winding. That load is reflected back into the primary, gating triac TR1 on, which energizes the load. If the load is an electric valve in the water-supply line, it will open and remain open until the water rises and touches the probe, which shorts SCR1's gate and cathode, thereby turning off the SCR1, which effectively open-circuits the secondary. The open-circuit condition—when reflected back to the primary winding—removes the triac's trigger signal, thereby turning the water off. The load may range from a water valve, a relay controlling a pump supplying water for irrigation, or a solenoid valve controlling the water level in a garden lily pond.

SINGLE CHIP PUMP CONTROLLER



ELECTRONIC ENGINEERING

Fig. 36-6

Circuit Notes

This circuit controls the level of a tank using a bang-bang controlled electrical pump. The actual level of liquid is measured by a capacitive level-meter. The first inverter performs as a capacitance to frequency converter. It is a Schmitt oscillator and its frequency output decreases as the capacitance increases. The second inverter is a monostable which performs as a frequency to voltage converter (f/V). Its output is applied to the maximum and minimum level comparator inputs. Maximum and minimum liquid levels may be set by the potentiometers. The maximum level (1 max) may be preset between the limits: 65 pF less than C (1 max) less than 120 pF. The minimum level is presetable and the limits are: 0 less than C (1 min) less than 25 pF.

PLANT WATER GAUGE

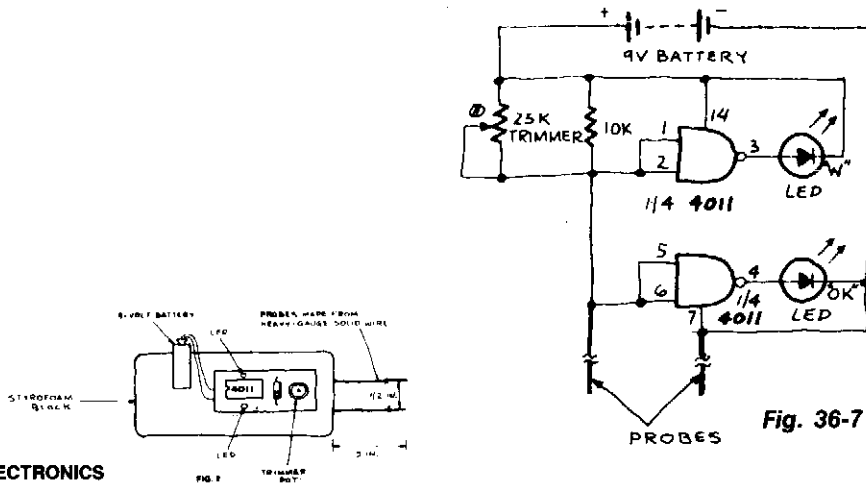


Fig. 36-7

RADIO-ELECTRONICS

Circuit Notes

To calibrate the gauge, connect the battery and press the probes gently into a pot containing a plant that is just on the verge of needing water (stick it in so that only an inch of the probe is left visible at the top). Turn the potentiometer until the "OK" LED lights and then turn it back to the point where that LED goes out and the "W", or "Water", LED just comes on. The device should now be properly adjusted.

LIQUID FLOWMETER

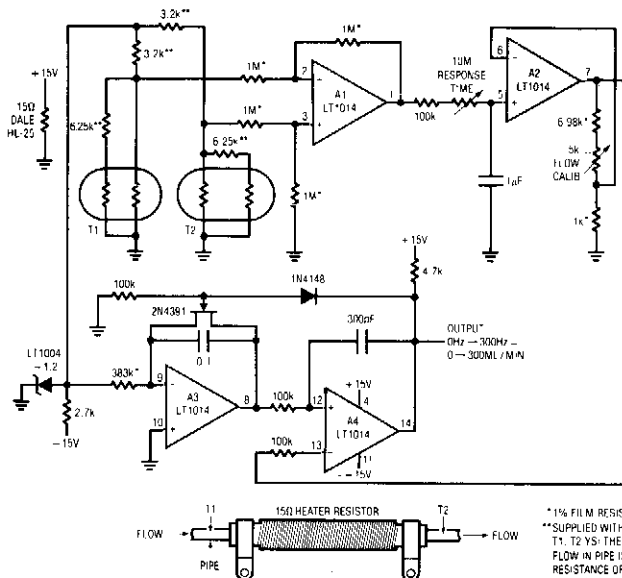


Fig. 36-8

LINEAR TECHNOLOGY CORP.

* 1% FILM RESISTOR
 ** SUPPLIED WITH YSI THERMISTOR NETWORK
 T1, T2 YSI THERMISTOR NETWORK - 44201
 FLOW IN PIPE IS INVERSELY PROPORTIONAL TO
 RESISTANCE OF T1-T2 TEMPERATURE DIFFERENCE.
 A1-A2 PROVIDE GAIN. A3, A4 PROVIDE LINEARIZED
 FREQUENCY OUTPUT.

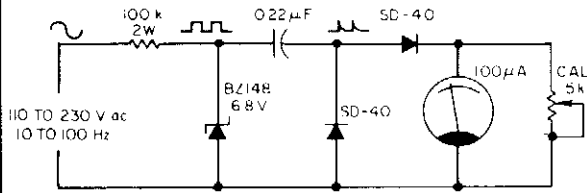
37

Frequency Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Power Frequency Meter
Low Cost Frequency Indicator

POWER-FREQUENCY METER



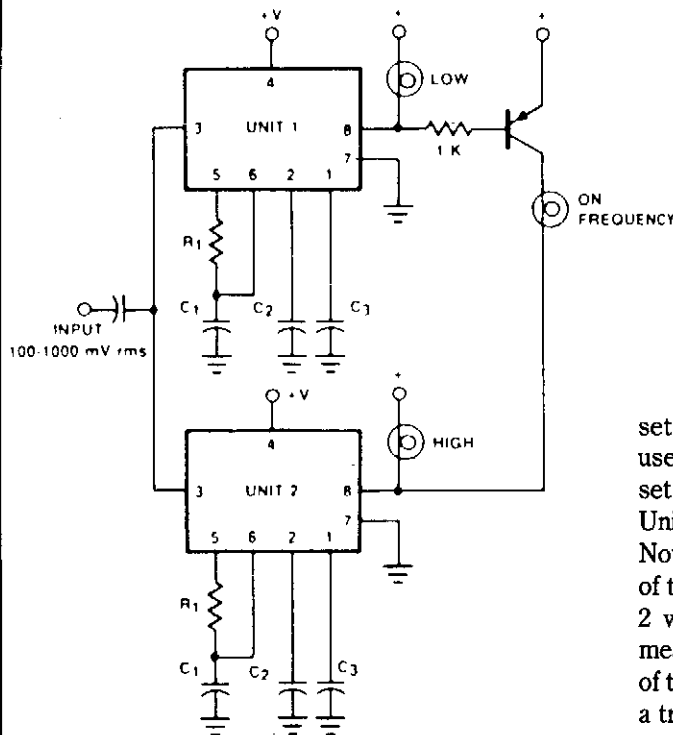
Circuit Notes

The meter uses a zener diode to form square waves from input sine waves. After calibration with the 5 k ohm potentiometer, the 100 μ A meter reads directly in hertz.

ELECTRONIC DESIGN

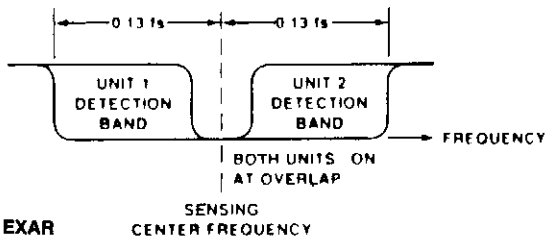
Fig. 37-1

LOW COST FREQUENCY INDICATOR



Circuit Notes

The circuit shows how two tone decoders set up with overlapping detection bands can be used for a go/no go frequency meter. Unit 1 is set 6% above the desired sensing frequency and Unit 2 is set 6% below the desired frequency. Now, if the incoming frequency is within 13% of the desired frequency, either Unit 1 or Unit 2 will give an output. If both units are on, it means that the incoming frequency is within 1% of the desired frequency. Three light bulbs and a transistor allow low cost read-out. The IC is an EXAR 567.



EXAR

Fig. 37-2

38

Frequency Multiplier and Divider Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Nonselective Frequency Tripler Uses Transistor
Saturation Characteristics
Frequency Doubler Works to 1 MHz
Low Frequency Divider
Frequency Divider

NONSELECTIVE FREQUENCY TRIPLER USES TRANSISTOR SATURATION CHARACTERISTICS

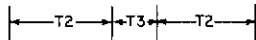
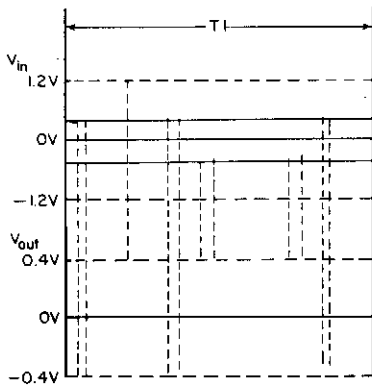
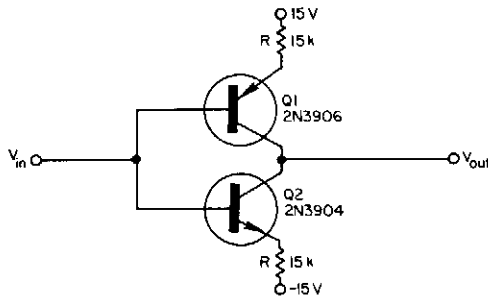


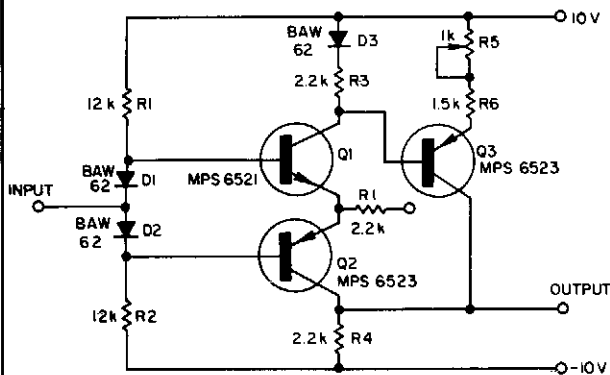
Fig. 38-1

ELECTRONIC DESIGN

Circuit Notes

The turn-on and turn-off characteristics of two complementary transistors can be combined to attain nonselective frequency tripling. The resulting circuit handles any periodic waveform with nonvertical sides. Each input signal peak produces three output signal peaks. The additional peaks occur where the input signal causes saturation of one of the two transistors. The circuit operates over a frequency range from dc to the upper limits of the complementary transistor pair. About the only disadvantage of the circuit is the lack of symmetry of the output signal peaks.

FREQUENCY DOUBLER WORKS TO 1 MHz



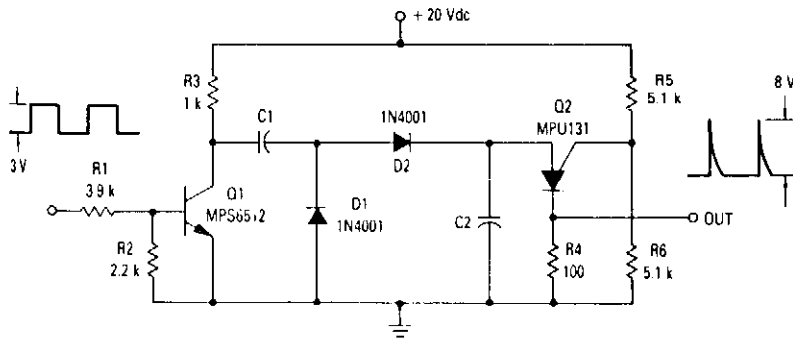
Circuit Notes

Adding components Q3, D3, and resistors R3 through R6 to a conventional complementary symmetry class AB buffer can double the frequency of an input sine wave.

ELECTRONIC DESIGN

Fig. 38-2

LOW FREQUENCY DIVIDER



TABLE

C ₁	C ₂	Division
0.01 μF	0.01 μF	2
0.01 μF	0.02 μF	3
0.01 μF	0.03 μF	4
0.01 μF	0.04 μF	5
0.01 μF	0.05 μF	6
0.01 μF	0.06 μF	7
0.01 μF	0.07 μF	8
0.01 μF	0.08 μF	9
0.01 μF	0.09 μF	10
0.01 μF	0.1 μF	11

MOTOROLA

Fig. 38-3

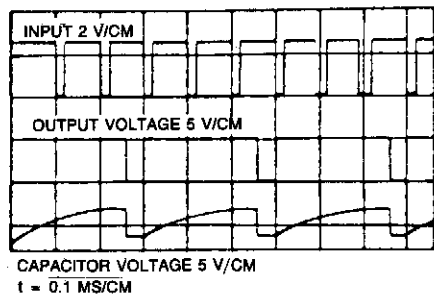
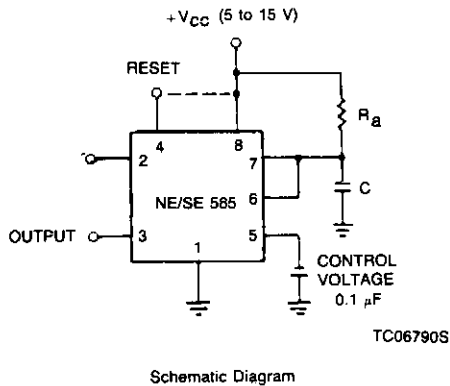
Circuit Notes

The ratio of capacitors C₁ and C₂ determines division. With a positive pulse applied to the base of Q₁, assume that C₁ = C₂ and that C₁ and C₂ are discharged. When Q₁ turns off, both C₁ and C₂ charge to 10 volts each through R₃. On the next pulse to the base of Q₁, C₁ is again discharged but C₂ remains charged to 10 volts. As Q₁ turns off this time, C₁ and C₂ again charge. This time C₂ charges to the peak point firing voltage of the PUT causing it to fire. This discharges capacitor C₂ and allows capacitor C₁ to charge to the line voltage. As soon as C₂ discharges and C₁ charges, the PUT turns off. The next cycle begins with another positive pulse on the base of Q₁ which again discharges C₁. The input and output frequency can be approximated by the equation

$$f_{in} = \frac{(C_1 = C_2)}{C_1} f_{out}$$

For a 10 kHz input frequency with an amplitude of 3 volts, the table shows the values for C₁ and C₂ needed to divide by 2 to 11.

FREQUENCY DIVIDER



SIGNETICS

Fig. 38-4

Circuit Notes

If the input frequency is known, the timer can easily be used as a frequency divider by adjusting the length of the timing cycle. Figure shows the waveforms of the timer when used as a divide-by-three circuit. This application makes use of the fact that this circuit cannot be retriggered during the timing cycle.

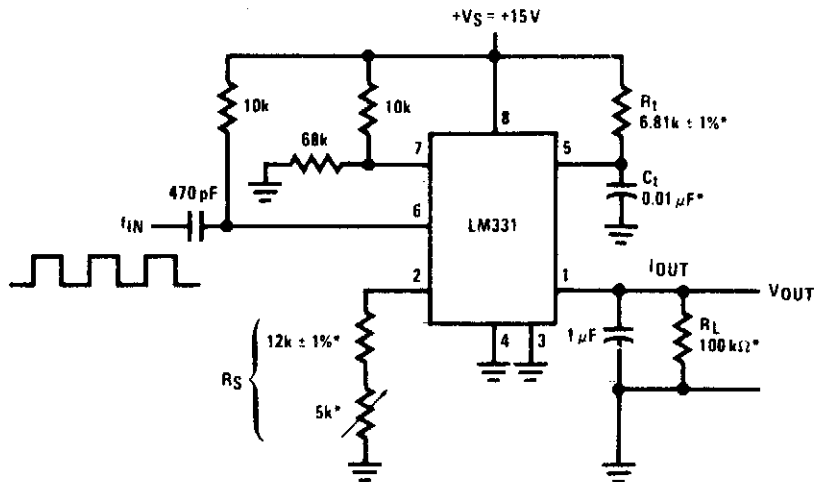
39

Frequency-to-Voltage Converters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Frequency-to-Voltage Converters

FREQUENCY-TO-VOLTAGE CONVERTERS



TL/H/5680-7

$$V_{OUT} = f_{IN} \times 2.09V \times \frac{R_L}{R_S} \times (R_1 C_1)$$

*Use stable components with low temperature coefficients.

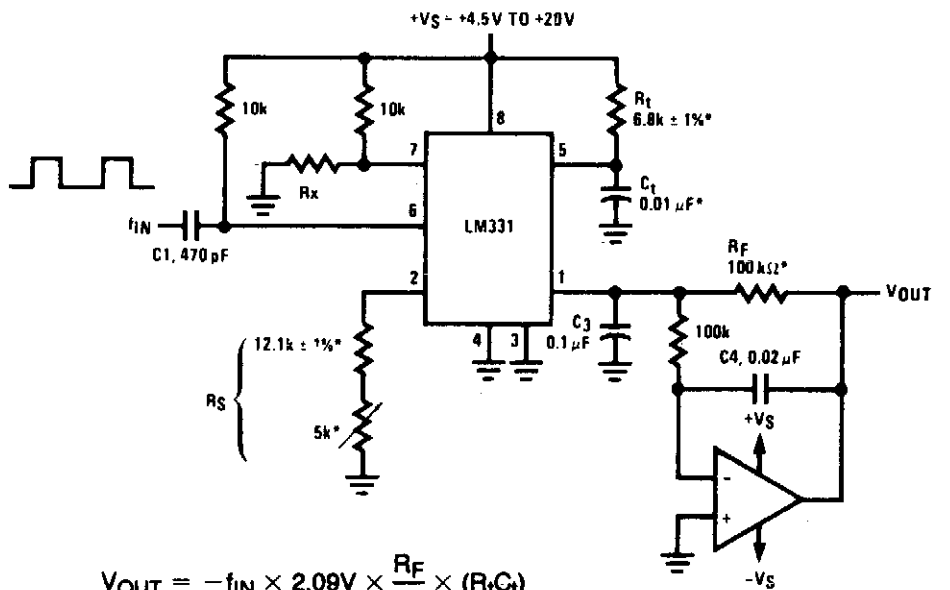
Simple Frequency-to-Voltage Converter, 10 kHz Full-Scale, $\pm 0.06\%$ Non-Linearity

NATIONAL SEMICONDUCTOR CORP.

Fig. 39-1

Circuit Notes

In these applications, a pulse input at f_{IN} is differentiated by a C-R network and the negative-going edge at pin 6 causes the input comparator to trigger the timer circuit. Just as with a V-to-F converter, the average current flowing out of pin 1 is $I_{AVERAGE} = i \times (1.1 R_1 C_1) \times f$. In this simple circuit, this current is filtered in the network R_L = 100 k ohm and 1 μ F. The ripple will be less than 10 mV peak, but the response will be slow, with a 0.1 second time constant, and settling of 0.7 second to 0.1%



$$V_{OUT} = -f_{IN} \times 2.09V \times \frac{R_F}{R_S} \times (R_t C_t)$$

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

TL/H/5680-8

*Use stable components with low temperature coefficients.

**Precision Frequency-to-Voltage Converter,
10 kHz Full-Scale with 2-Pole Filter, $\pm 0.01\%$
Non-Linearity Maximum**

accuracy. In the precision circuit, an operational amplifier provides a buffered output and also acts as a 2-pole filter. The ripple will be less than 5 mV peak for all frequencies above 1 kHz, and the response time will be much quicker than in Part 1. However, for input frequencies below 200 Hz, this circuit will have worse ripple than the figure. The engineering of the filter time-constants to get adequate response and small enough ripple simply requires a study of the compromises to be made. Inherently, V-to-F converter response can be fast, but F-to-V response cannot.

40

Function Generator Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Quad Op Amp Generates Four Different
Synchronized Waveforms Simultaneously
A Sine/Cosine Generator for 0.1-10 kHz
Oscillator or Amplifier with Wide Frequency Range
Linear Triangle/Square Wave VCO
Circuit for Multiplying Pulse Widths
Programmable Voltage Controlled Frequency
Synthesizer
Emitter-Coupled RC Oscillator
Voltage Controlled High Speed One Shot
Ramp Generator with Variable Reset Level

555 Astable with Low Duty Cycle
Monostable Using Video Amplifier and Comparator
UJT Monostable Circuit Insensitive to Change in
Bias Voltage
Astable Multivibrator
Waveform Generator
Linear Ramp Generator
Function Generator
Waveform Generator
Single Supply Function Generator
Precise Wave Generator

QUAD OP AMP GENERATES FOUR DIFFERENT SYNCHRONIZED WAVEFORMS SIMULTANEOUSLY

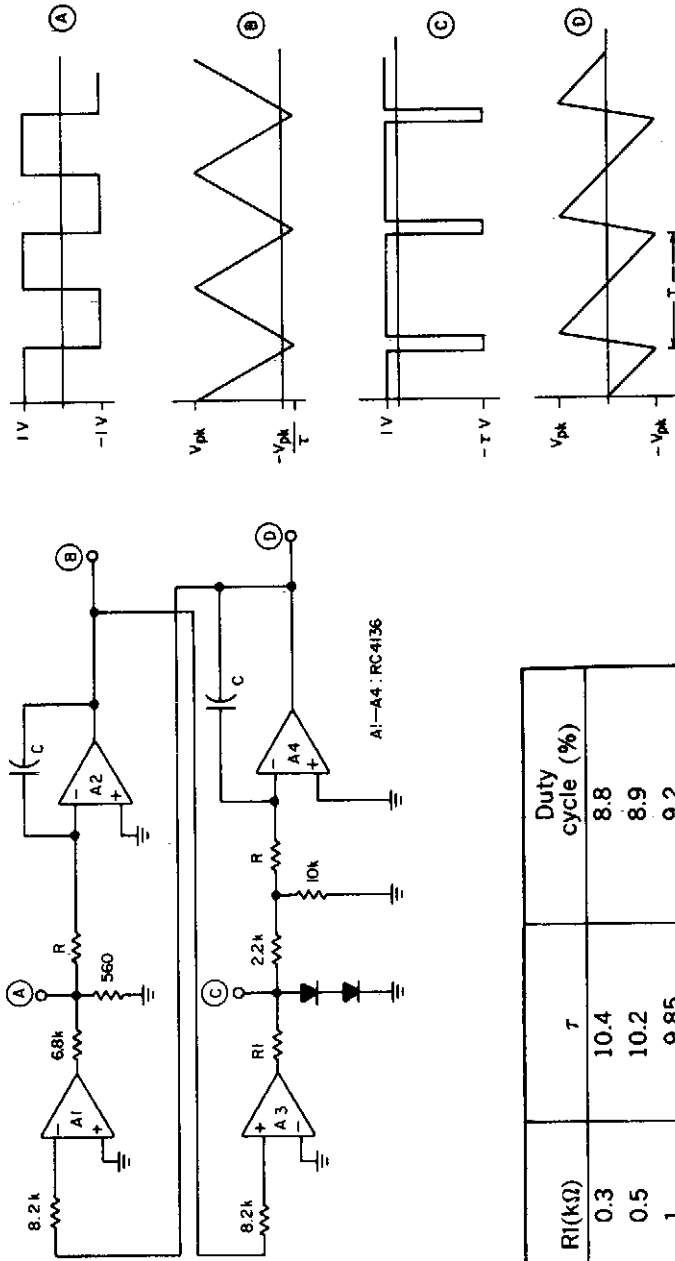


Fig. 40-1

ELECTRONIC DESIGN

Circuit Notes

A quad op amp can simultaneously generate four synchronized waveforms. The two comparators (A1 and A3) produce square and pulse waves, while the two integrators (A2 and A4) give triangular and sawtooth waves. Resistor R1 sets the duty cycle and the frequency, along with resistors R and capacitors C.

R1(k Ω)	T	Duty cycle (%)
0.3	10.4	8.8
0.5	10.2	8.9
1	9.85	9.2
4	8.0	11.1
10	5.86	14.6
20	4.04	19.84
50	2.09	32.4
100	1.16	46.30
117.8	1	50

A SINE/COSINE GENERATOR FOR 0.1 - 10 KHZ

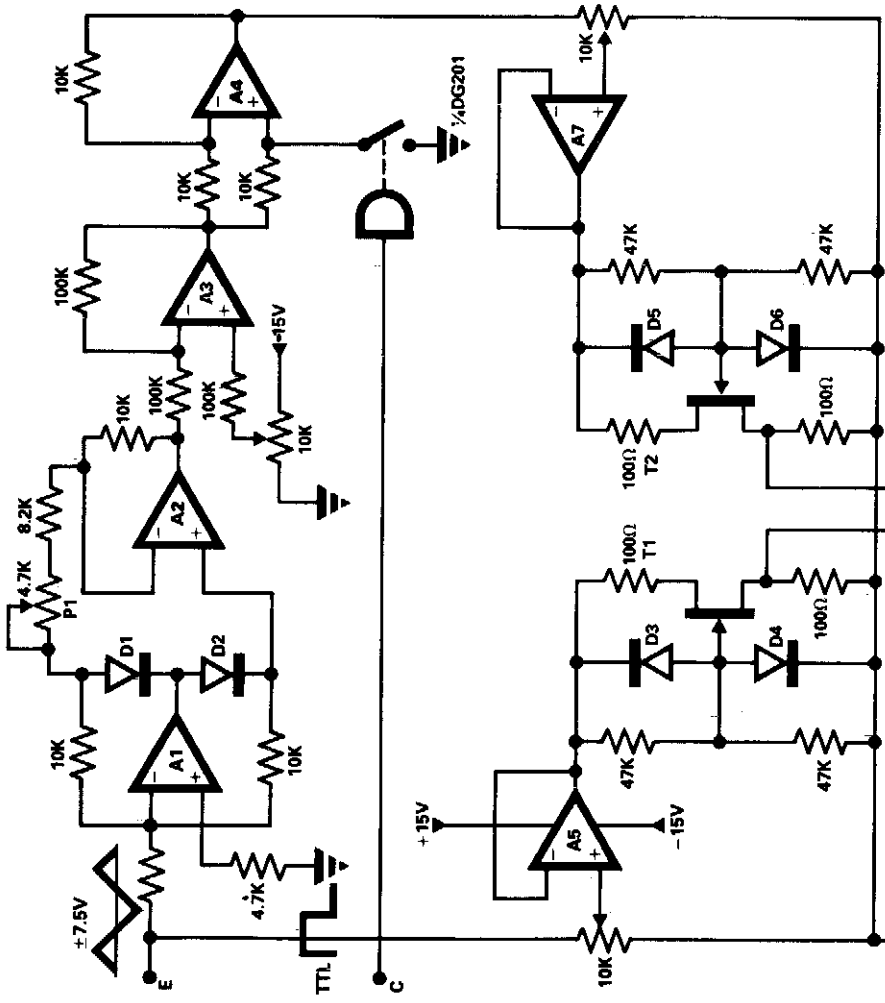


Fig: 1

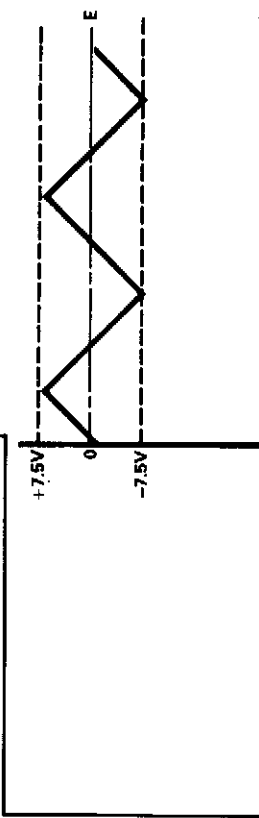


Fig. 40-2

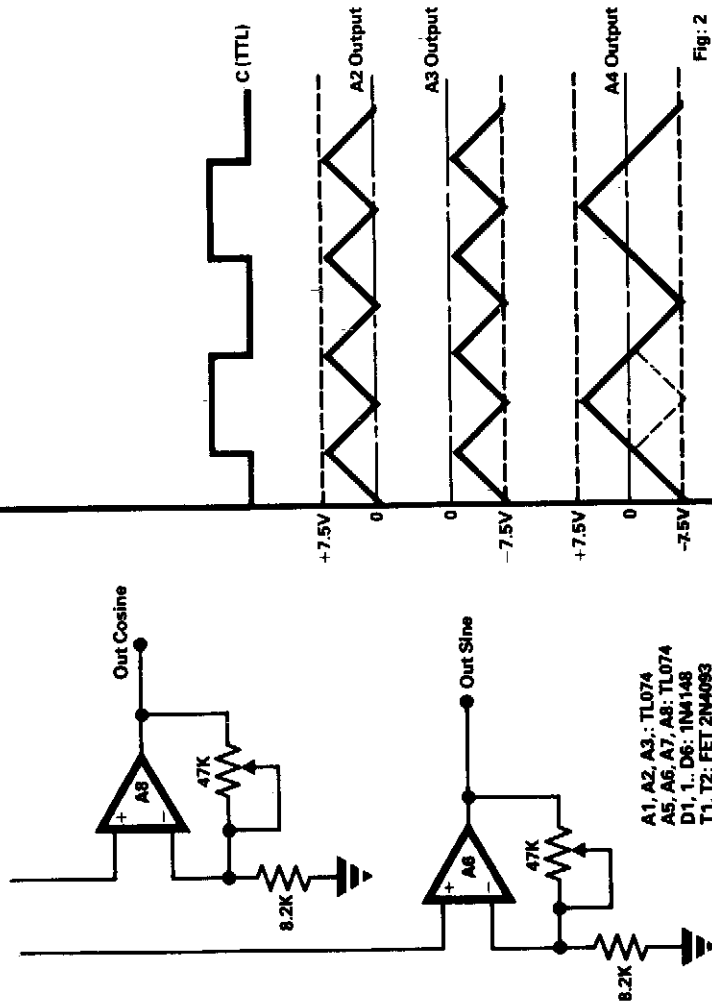


Fig: 2

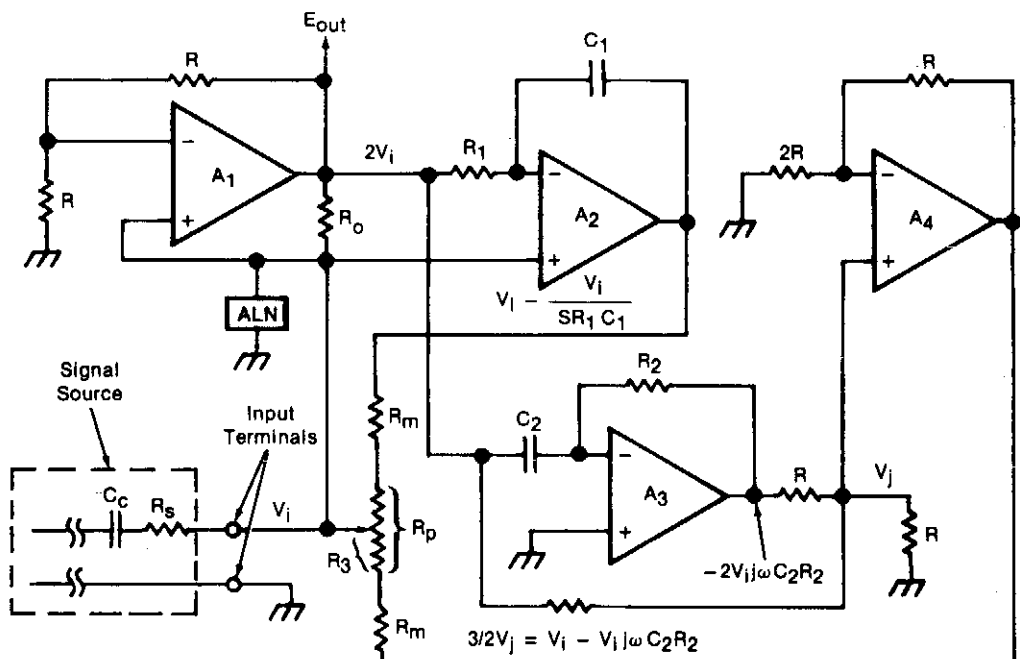
Circuit Notes

The scheme presented delivers waveforms from any function generator producing a triangular output and a synchronized TTL square wave. A1 and A2 act as a two-phase current rectifier by inverting the negative voltage appearing at the input of A1.

Positive input: Both A1 and A2 work as unity gain followers, D1 and D2 being in the off-state.

Negative input: A1 has a $-2/3$ gain (D1 off and D2 on), A2 has a $+1/2$ gain and the total voltage transfer is -1 between output and input. P1 allows a fine trimming of the -1 gain for the negative input signals. A3 adds a continuous voltage to the rectified positive signal in order to attack A4 which acts as a \pm multiplier commanded by the TTL input through the analog switch. The signal polarity is reconstructed and the output of A4 delivers a triangular waveform shifted by 90° with respect to the input signal, Fig. 2. The original and the shifted voltages are fed into the triangle to sine converters through A5 and A7 working as impedance converters. Over the frequency dynamic ranges from 0.1 Hz to 10 kHz, the phase shift is constant and the distortion on the sine voltage is less than 1%.

OSCILLATOR OR AMPLIFIER WITH WIDE FREQUENCY RANGE



NASA

NOTES: 1. A₁, A₂, A₃, and A₄ are operational amplifiers
 2. ALN = Amplitude-Limiting Network

Fig. 40-3

Circuit Notes

An oscillator/amplifier is resistively tunable over a wide frequency range. Feedback circuits containing operational amplifiers, resistors, and capacitors synthesize the electrical effects of an inductance and capacitance in parallel between the input terminals. The synthetic inductance and capacitance, and, therefore, the resonant frequency of the input admittance, are adjusted by changing a potentiometer setting. The input signal is introduced in parallel to the noninverting input terminals of operational amplifiers A₁ and A₂ and to the potentiometer cursor. The voltages produced by the feedback circuits in response to input voltage V_i are indicated at the various circuit nodes.

LINEAR TRIANGLE/SQUARE WAVE VCO

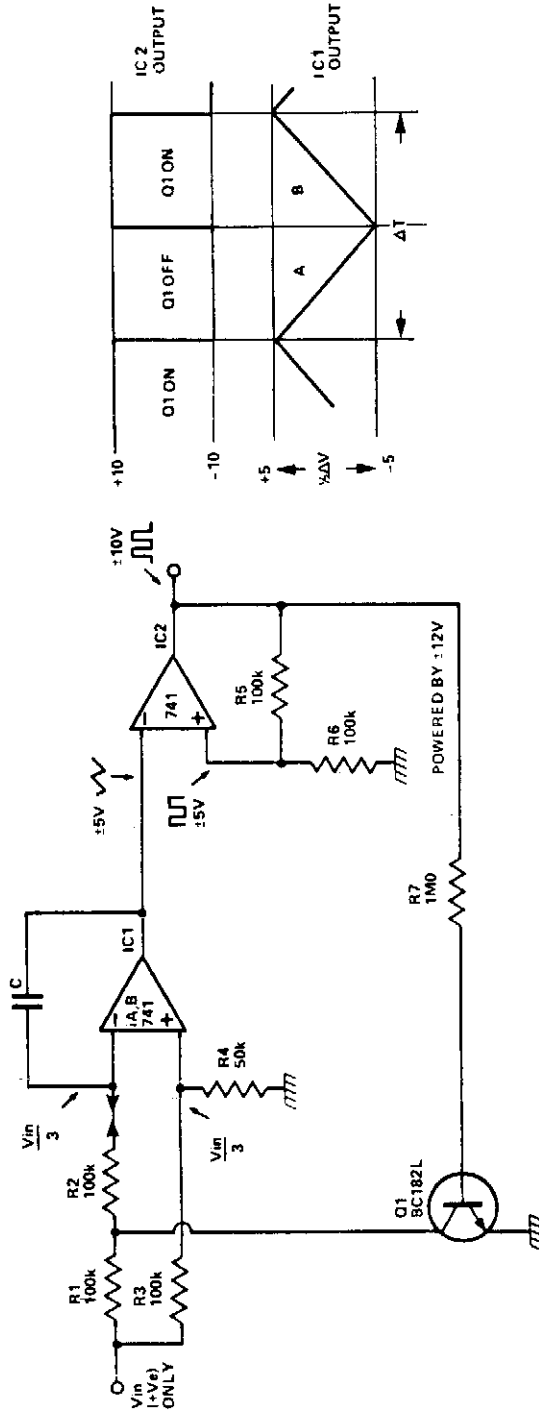


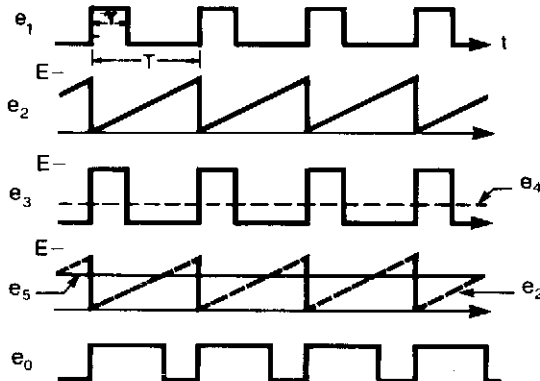
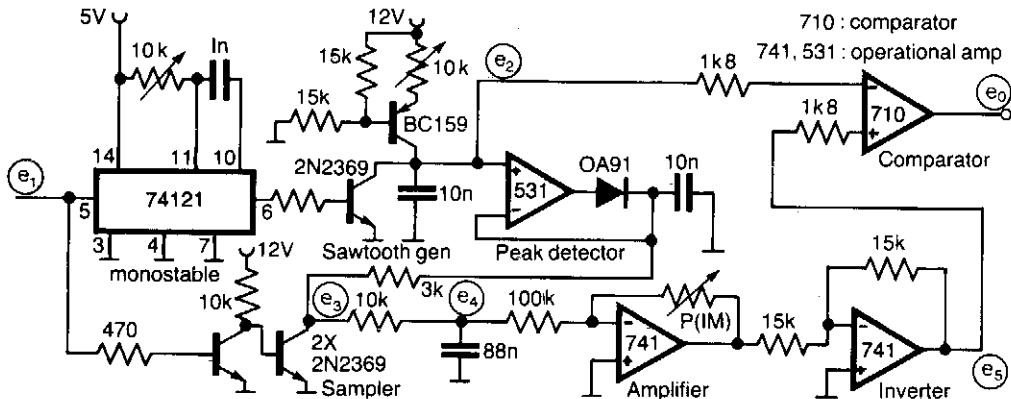
Fig. 40-4

ELECTRONICS TODAY INTERNATIONAL

Circuit Notes

The VCO has two buffered outputs; a triangle wave and a square wave. Frequency is dependent on the output voltage swing of the Schmitt trigger, IC2. Superior performance can be obtained by replacing Q1 with a switching FET. Fast FET op amps will improve high frequency performance.

CIRCUIT FOR MULTIPLYING PULSE WIDTHS



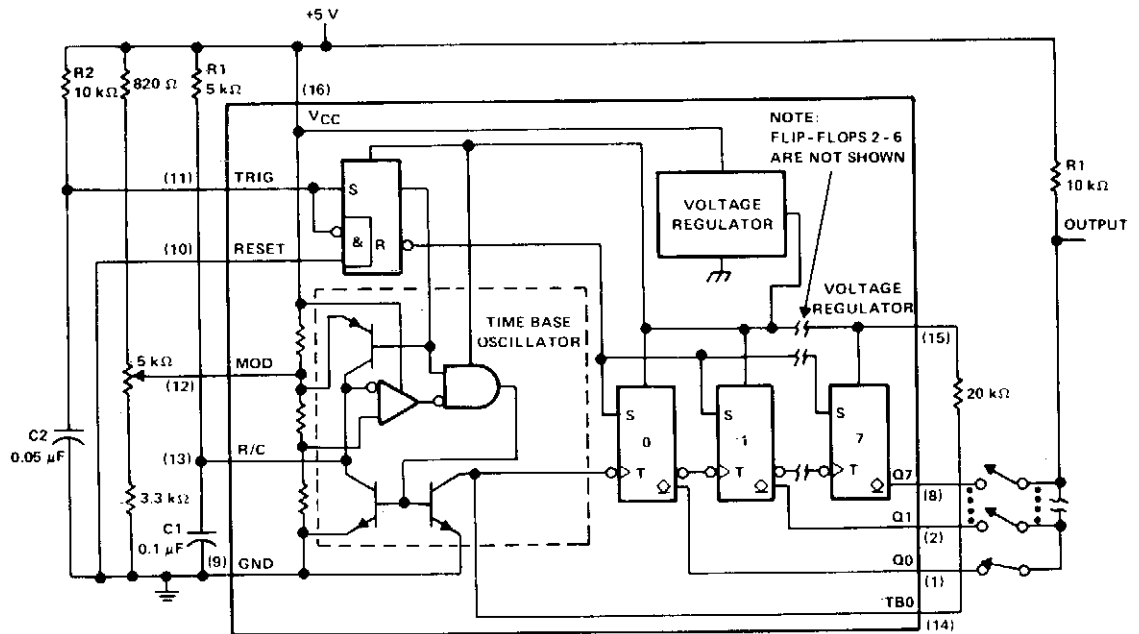
ELECTRONIC ENGINEERING

Fig. 40-5

Circuit Notes

A circuit for multiplying the width of incoming pulses by a factor greater or less than unity is simple to build and has the feature that the multiplying factor can be selected by adjusting one potentiometer only. The multiplying factor is determined by setting the potentiometer P in the feedback of a 741 amplifier. The input pulses e_1 of width τ and repetition period T is used to trigger a sawtooth generator at its rising edges to produce the waveform e_2 having a peak value of (E) volt. This peak value is then sampled by the input pulses to generate the pulse train e_3 having an average value of $e_4 (= E E \tau / T)$ which is proportional to τ and independent on T. The dc voltage e_4 is amplified by a factor k and compared with sawtooth waveform e_2 giving output pulses of duration k τ . The circuit is capable of operating over the frequency range 10 kHz - 100 kHz.

PROGRAMMABLE VOLTAGE CONTROLLED FREQUENCY SYNTHESIZER



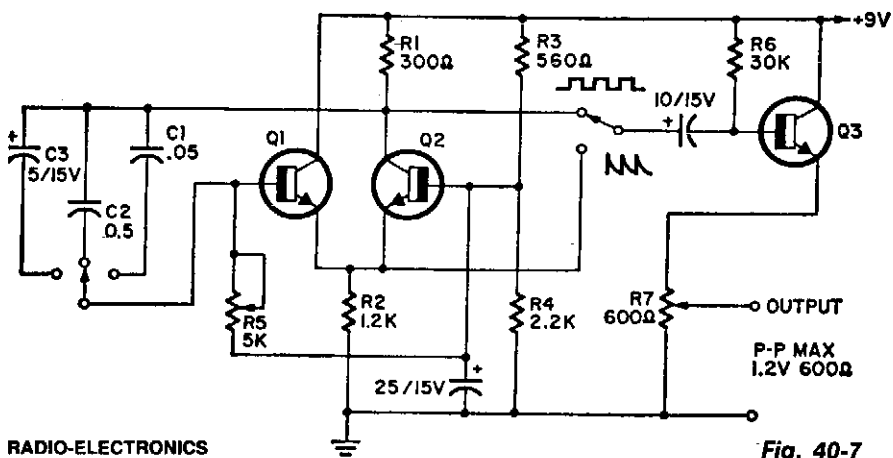
TEXAS INSTRUMENTS

Fig. 40-6

Circuit Notes

The $\mu A2240$ consists of four basic circuit elements: (1) a time-base oscillator, (2) an eight-bit counter, (3) a control flip-flop, and (4) a voltage regulator. The basic frequency of the time-base oscillator (TBO) is set by the external time constant determined by the values of R1 and C1 ($1/R1C1 = 2 \text{ kHz}$). The open-collector output of the TBO is connected to the regulator output via a 20 k ohm pull-up resistor, and drives the input to the eight-bit counter. At power-up, a positive trigger pulse is detected across C2 which starts the TBO and sets all counter outputs to a low state. Once the $\mu A2240$ is initially triggered, any further trigger inputs are ignored until it is reset. In this astable operation, the $\mu A2240$ will free-run from the time it is triggered until it receives an external reset signal. Up to 255 discrete frequencies can be synthesized by connecting different counter outputs.

EMITTER-COUPLED RC OSCILLATOR



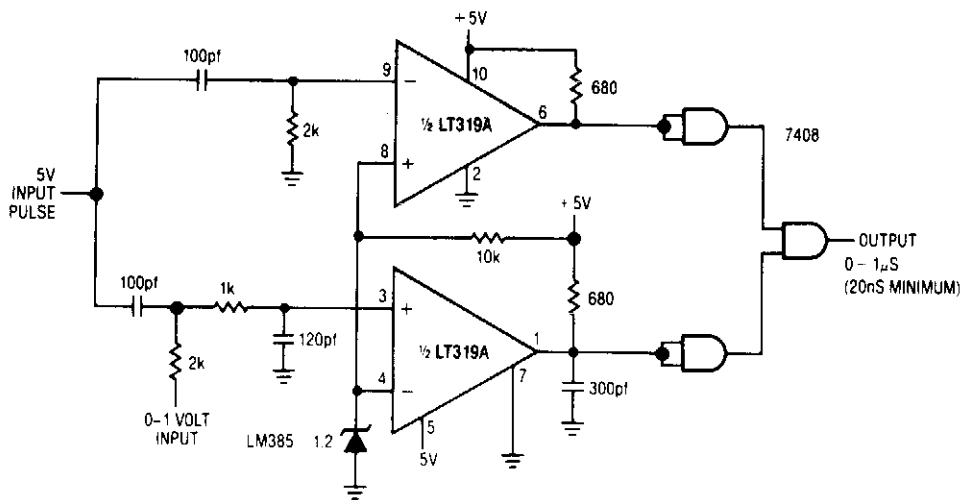
RADIO-ELECTRONICS

Fig. 40-7

Circuit Notes

The circuit covers 15 Hz-30 kHz and is useful as a function generator. The 2N2926 or equivalent transistors can be used.

VOLTAGE CONTROLLED HIGH SPEED ONE SHOT



LINEAR TECHNOLOGY CORP.

Fig. 40-8

RAMP GENERATOR WITH VARIABLE RESET LEVEL

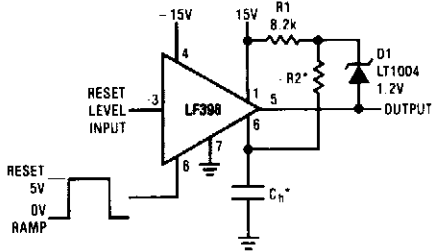


Fig. 40-9

*SELECT FOR RAMP RATE $\frac{\Delta V}{\Delta T} = \frac{1.2V}{R \geq 10k}$

LINEAR TECHNOLOGY CORP.

555 ASTABLE WITH LOW DUTY CYCLE

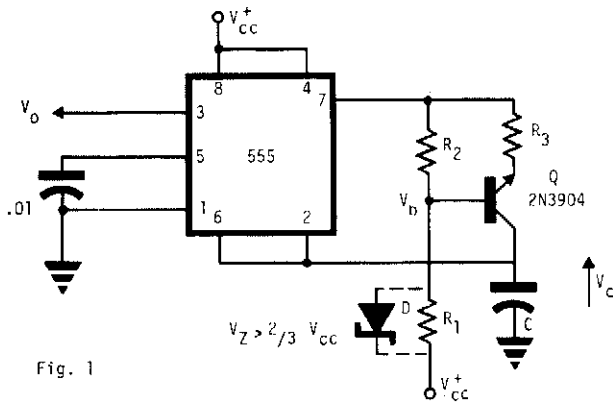


Fig. 1

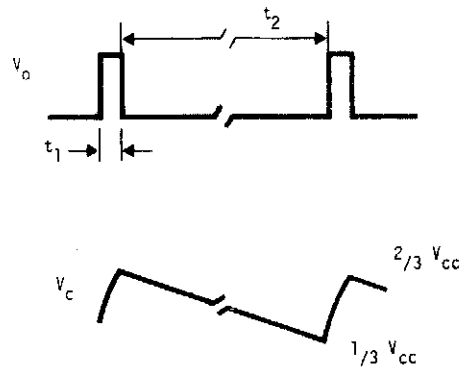


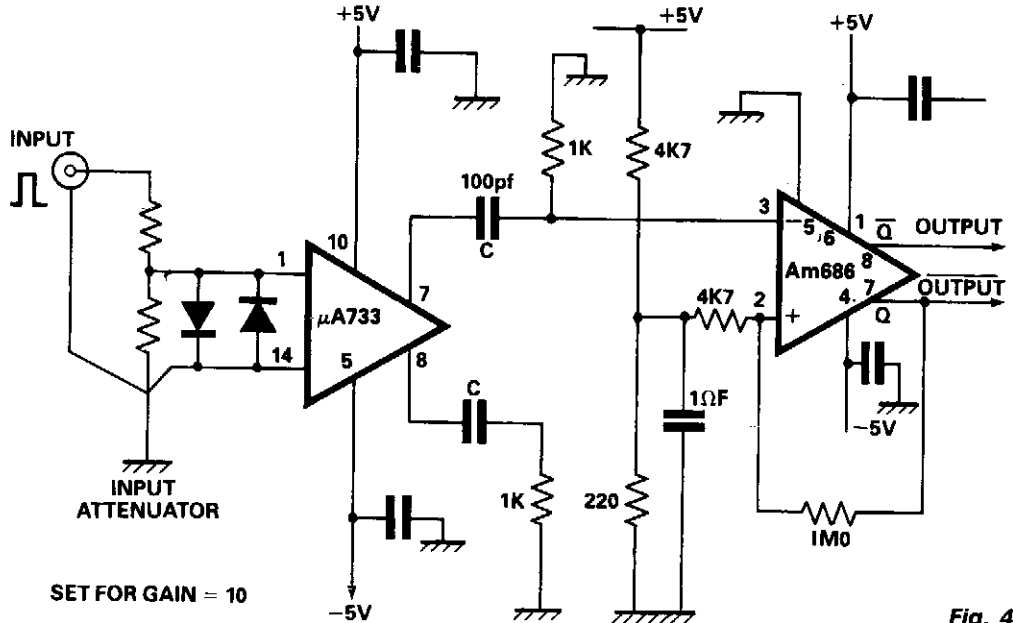
Fig. 40-10

ELECTRONIC ENGINEERING

Circuit Notes

This free-running multivibrator uses an external current sink to discharge the timing capacitor, C. Therefore, interval t_2 may easily be $1000 \times$ the pulse duration, t_1 , which defines a positive output. Capacitor voltage, V_C , is a negative going ramp with exponential rise during the pulse output periods.

MONOSTABLE USING VIDEO AMPLIFIER AND COMPARATOR



SET FOR GAIN = 10

ELECTRONIC ENGINEERING

Fig. 40-11

Circuit Notes

The output of a video amplifier is differentiated before being fed to a Schottky comparator. The propagation delay is reduced to typically 10ns. The output pulse width is set by the value of C, 100pf giving a pulse of about 90ns duration.

UJT MONOSTABLE CIRCUIT INSENSITIVE TO CHANGE IN BIAS VOLTAGE

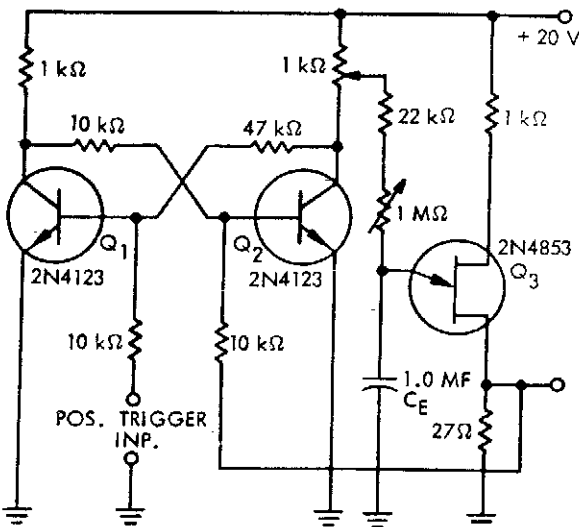


Fig. 40-12

MOTOROLA INC.

ASTABLE MULTIVIBRATOR

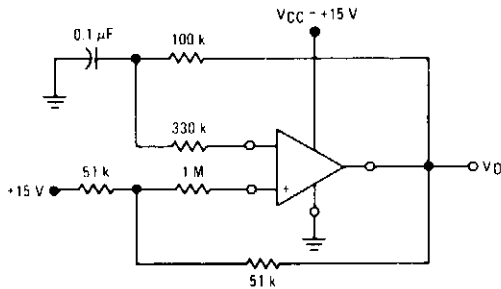
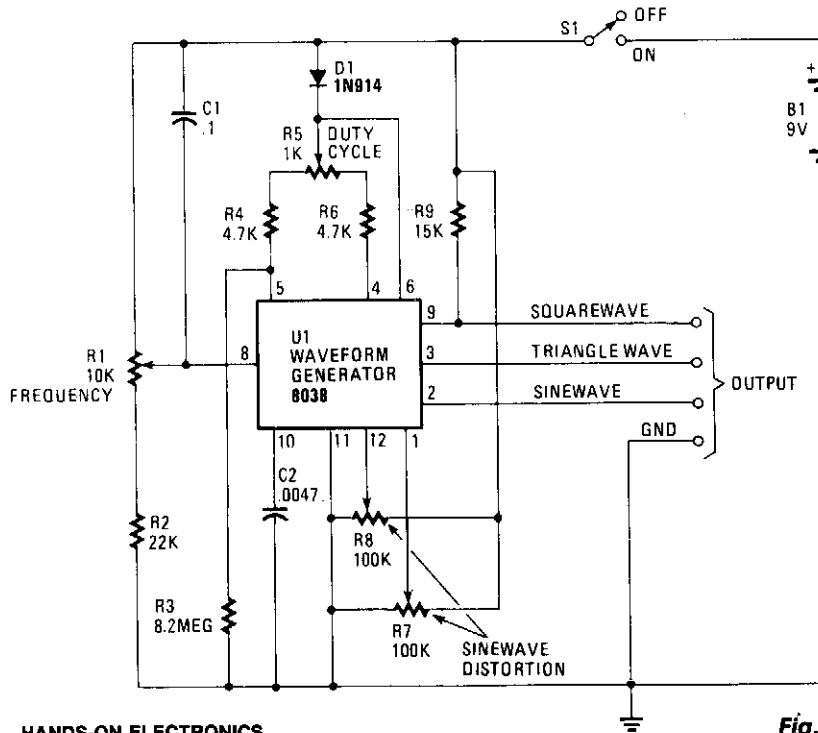


Fig. 40-13

IC = MC3301

MOTOROLA INC.

WAVEFORM GENERATOR



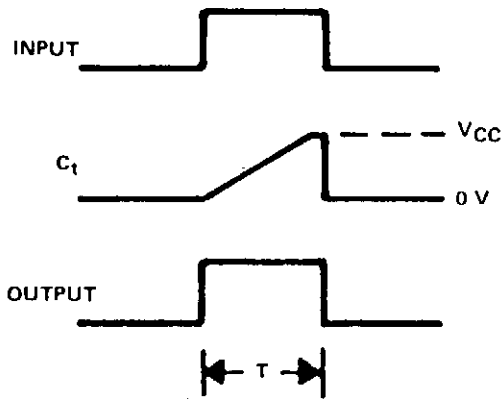
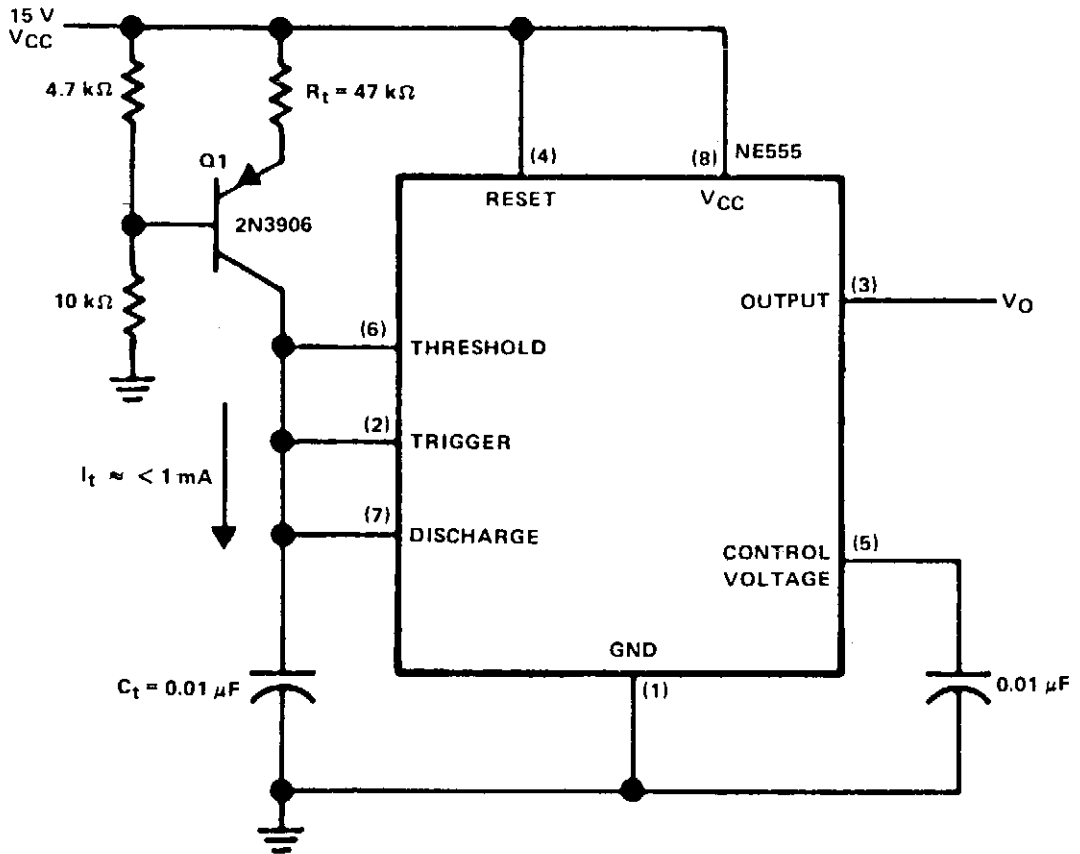
HANDS-ON ELECTRONICS

Fig. 40-14

Circuit Notes

The circuit is designed around the Intersil 8038CC. Frequency range is approximately 20 Hz to 20 kHz—a tuning range of 1000:1 with a single control. The output frequency depends on the value of C2 and on the setting of potentiometer R1. Other values of C2 change the frequency range. Increase the value of C2 to lower the frequency. The lowest possible frequency is around .001 Hz and the highest is around 300 kHz.

LINEAR RAMP GENERATOR



TEXAS INSTRUMENTS

Fig. 40-15

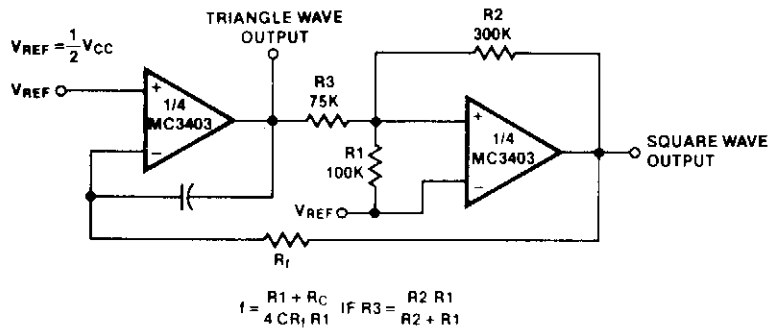
LINEAR RAMP GENERATOR, Continued.

Circuit Notes

The linear charging ramp is most useful where linear control of voltage is required. Some possible applications are a long period voltage controlled timer, a voltage to pulse width converter, or a linear pulse width modulator. Q1 is the current source transistor, supplying constant current to the timing capacitor C_t . When the timer is triggered, the clamp on C_t is removed and C_t charges linearly toward V_{CC} by virtue of the constant current supplied by Q1. The threshold at pin 6 is $\frac{2}{3} V_{CC}$; here, it is termed V_C . When the voltage across C_t reaches V_C volts, the timing cycle ends. The timing expression for output pulse with T is:

In general, I_t should be 1 mA value compatible with the NE555.

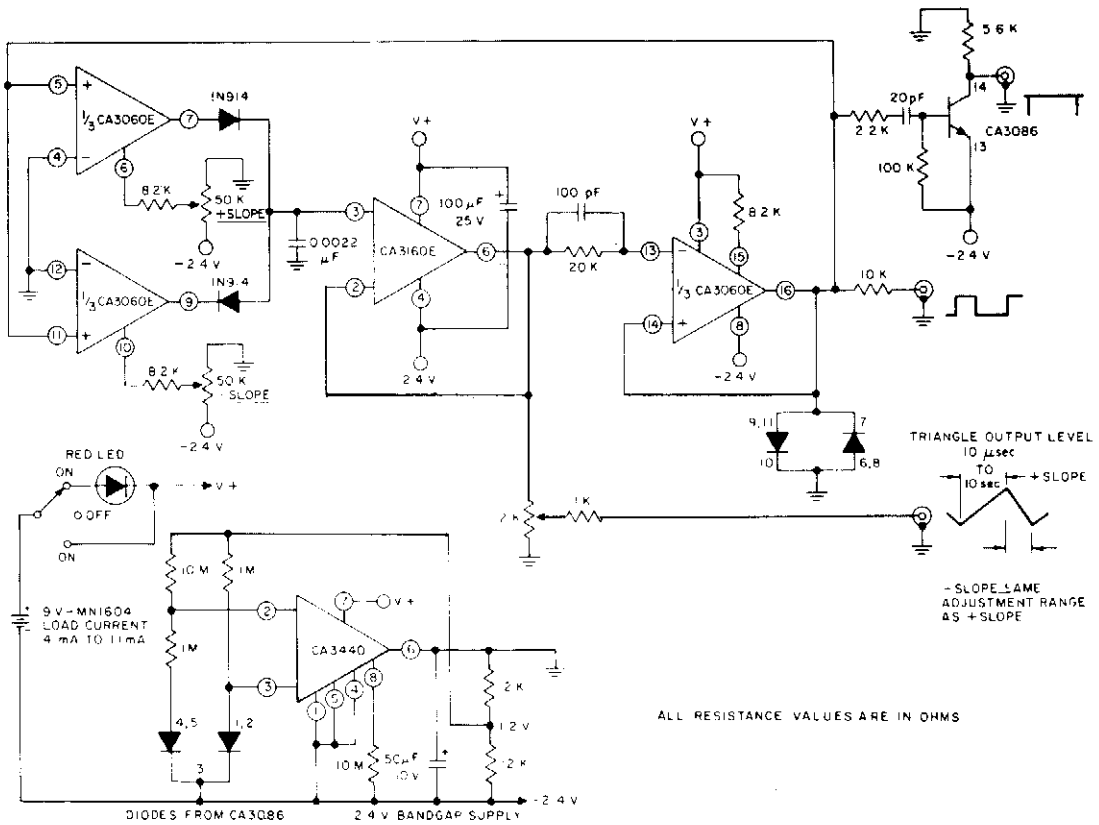
FUNCTION GENERATOR



SIGNETICS

Fig. 40-16

WAVEFORM GENERATOR



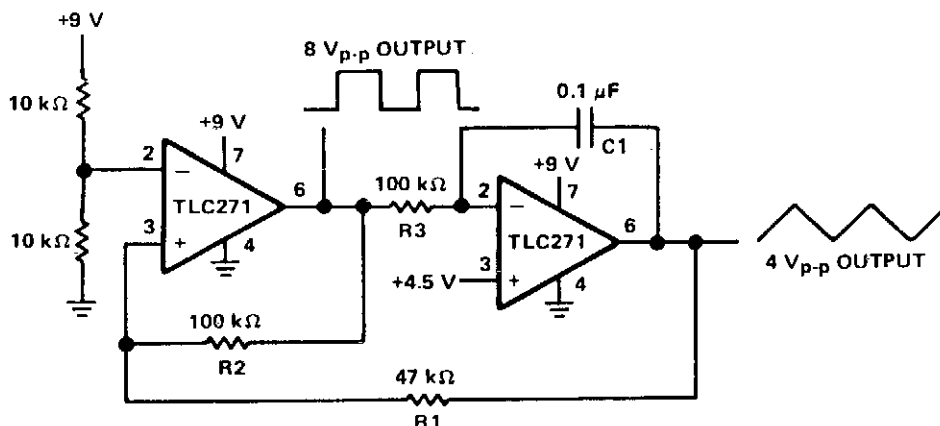
GENERAL ELECTRIC/RCA

Fig. 40-17

Circuit Notes

The circuit uses a CA3060 triple OTA (two units serve as switched current generators controlled by a third amplifier). A CA3160 BiMOS op amp serves as a voltage follower to buffer the 0.0022 μF integrating capacitor. The circuit has an adjustment range of 1,000,000:1 and a timing range of 20 μs to 20 sec. The "ON-OFF" switch actuates an LED that serves as both a pilot light and a low-battery indicator. The LED extends battery life, since it drops battery voltage to the circuit by approximately 1.2 volts, thus reducing supply current.

SINGLE SUPPLY FUNCTION GENERATOR



TEXAS INSTRUMENTS

Fig. 40-18

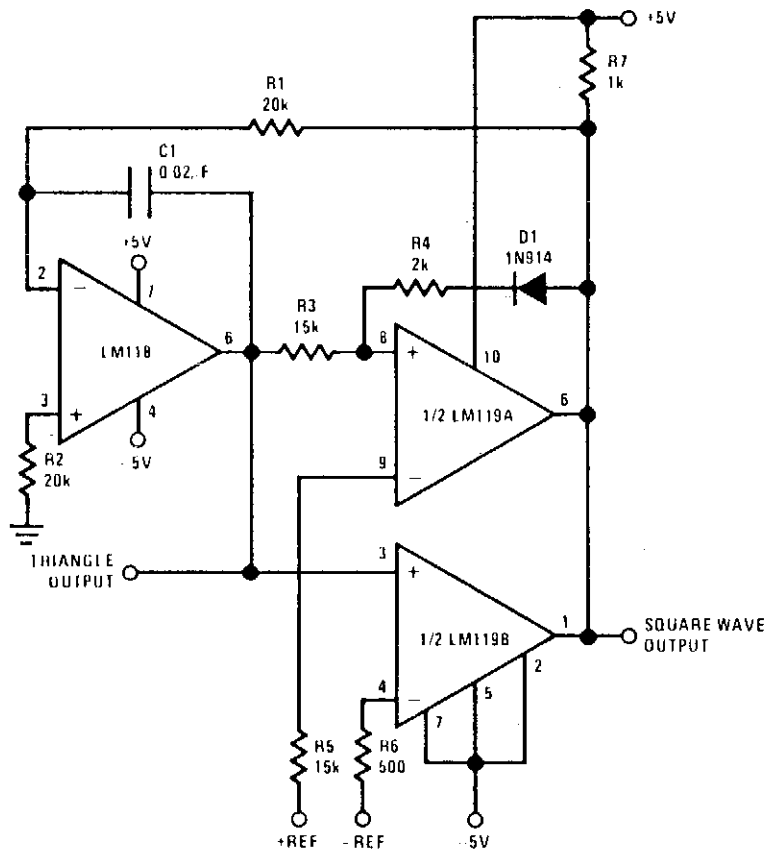
Circuit Notes

The circuit has both square-wave and triangle-wave output. The left section is similar in function to a comparator circuit that uses positive feedback for hysteresis. The inverting input is biased at one-half the V_{CC} voltage by resistors R4 and R5. The output is fed back to the non-inverting input of the first stage to control the frequency. The amplitude of the square wave is the output swing of the first stage, which is 8 V peak-to-peak. The second stage is basically an op amp integrator. The resistor R3 is the input element and capacitor C1 is the feedback element. The ratio $R1/R2$ sets the amplitude of the triangle wave, as referenced to the square-wave output. For both waveforms, the frequency of oscillation can be determined by the equation:

$$f_o = \frac{1}{4R3C1} \frac{R2}{R1}$$

The output frequency is approximately 50 Hz with the given components.

PRECISE WAVE GENERATOR



NATIONAL SEMICONDUCTOR

Fig. 40-19

Circuit Notes

The positive and negative peak amplitude is controllable to an accuracy of about ± 0.01 V by a dc input. Also, the output frequency and symmetry are easily adjustable. The oscillator consists of an integrator and two comparators—one comparator sets the positive peak and the other the negative peak of the triangle wave. If R1 is replaced by a potentiometer, the frequency can be varied over at least a 10 to 1 range without affecting amplitude. Symmetry is also adjustable by connecting a 50 k Ω resistor from the inverting input of the LM118 to the arm of the 1 k Ω potentiometer. The ends of the potentiometer are connected across the supplies. Current for the resistor either adds or subtracts from the current through R1, changing the ramp time.

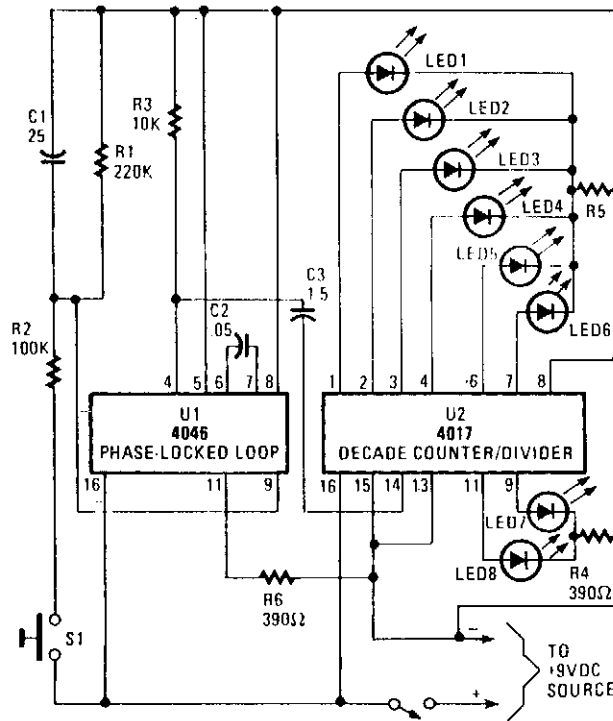
41

Games

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Electronic Roulette
Lie Detector

ELECTRONIC ROULETTE



TAB BOOKS, INC.

Fig. 41-1

Circuit Notes

U1 (a 4046 PLL containing a voltage controlled oscillator or VCO, two phase comparators, a source follower, and a Zener diode) is used to produce a low-frequency, pulsed output of about 40 Hz. The VCO's frequency range is determined by R6 and C2, which can be altered by varying the voltage at pin 9. The rising voltage causes the frequency to rise from zero to threshold and remain at that frequency as long as S1 is closed. When S1 is opened, C1 discharges slowly through R1 to ground and the voltage falls toward zero. That produces a decreasing pulse rate. The output of U1 at pin 4 is connected to the clock input of U2 (a 4017 decade decoder/driver) at pin 14 via C3. U2 sequentially advances through each of its ten outputs (0 to 9)—pins 1 to 7, and 9 to 11—with each input pulse. As each output goes high, its associated LED is lighted, and extinguished when it returns to the low state. Only eight outputs are used in the circuit, giving two numbers to the spinner of the house. The circuit can be set up so that the LED's lights sequence or you can use some staggered combination; the LEDs grouped in a straight line or a circle.

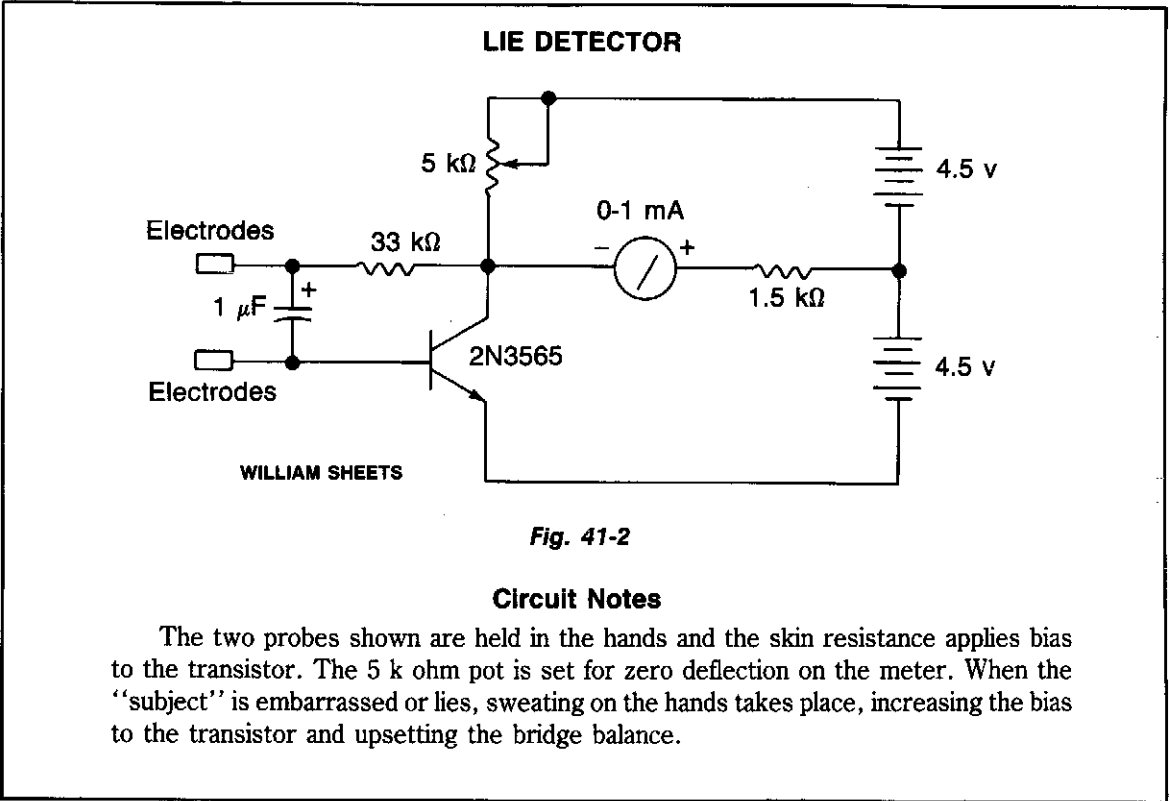


Fig. 41-2

Circuit Notes

The two probes shown are held in the hands and the skin resistance applies bias to the transistor. The 5 k ohm pot is set for zero deflection on the meter. When the "subject" is embarrassed or lies, sweating on the hands takes place, increasing the bias to the transistor and upsetting the bridge balance.

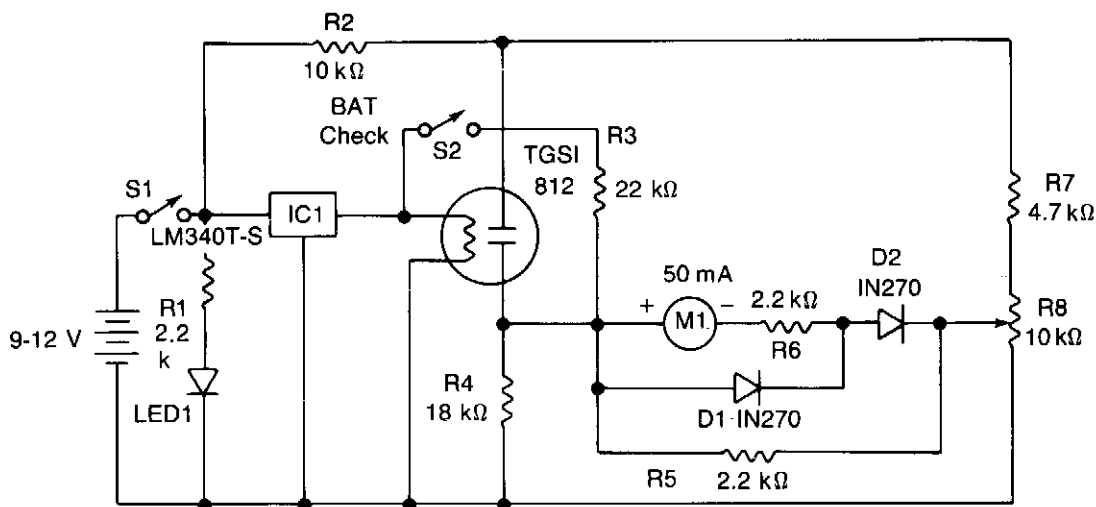
42

Gas and Smoke Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Gas and Vapor Detector
Toxic Gas Detector
Gas Analyzer

GAS AND VAPOR DETECTOR



WILLIAM SHEETS

Fig. 42-1

Circuit Notes

The power drain is approximately 150 mA. IC1 provides a regulated 5-volt supply for the filament heater of the sensor. The gas sensitive element is connected as one arm of a resistance bridge consisting of R4, R7, R8 and the meter M1 with its associated resistors R5 and R6. The bridge can be balanced by adjusting R8 so that no current flows through the meter. A change in the sensor's resistance, caused by detection of noxious gases, will unbalance the circuit and deflect the meter. Diodes D1, D2 and resistor R5 protect the meter from overload while R6 determines overall sensitivity. R2 limits the current through the sensor; R1 and LED1 indicate that the circuit is working, so that you do not drain the battery leaving the unit on inadvertently; R3 and S2 give a battery level check.

TOXIC GAS DETECTOR

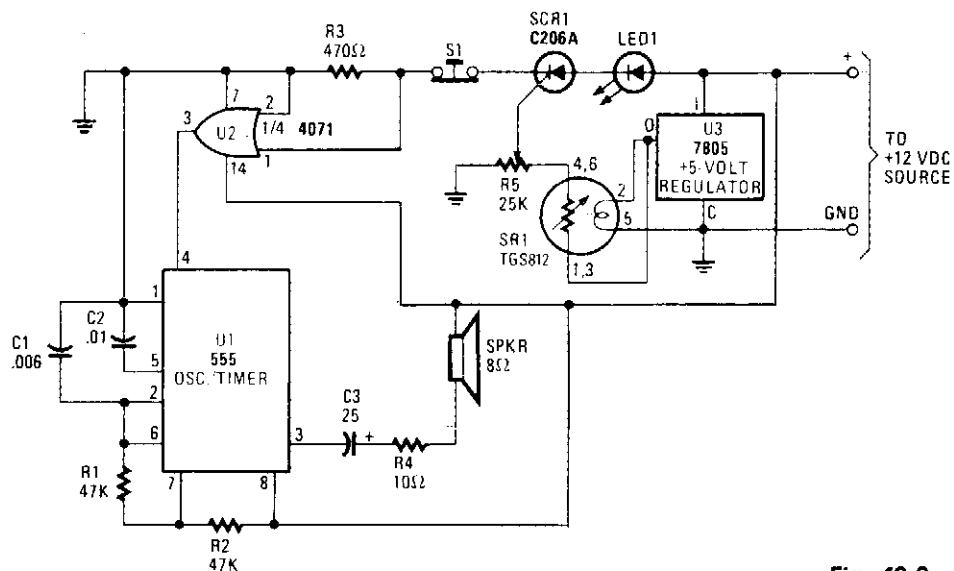


Fig. 42-2

HANDS-ON ELECTRONICS

Circuit Notes

The major device in the circuit is SR1 (a TGS812 toxic-gas sensor manufactured by Figaro Engineering Inc.) The gas-sensitive semiconductor (acting like a variable resistor in the presence of toxic gas) decreases in electrical resistance when gaseous toxins are absorbed from the sensor surface. A 25,000 ohm potentiometer (R5) connected to the sensor serves as a load, voltage-dividing network, and sensitivity control and has its center tap connected to the gate of SCR1. When toxic fumes come in contact with the sensor, decreasing its electrical resistance, current flows through the load (potentiometer R5). The voltage developed across the wiper of R5, which is connected to the gate of SCR1, triggers the SCR into conduction. With SCR1 now conducting, pin 1-volt supply for the semiconductor elements of the TGS812 in spite of the suggested 10 volts, thus reducing the standby current. A 7805 regulator is used to meet the 5-volt requirement for the heater and semiconductor elements.

GAS ANALYZER

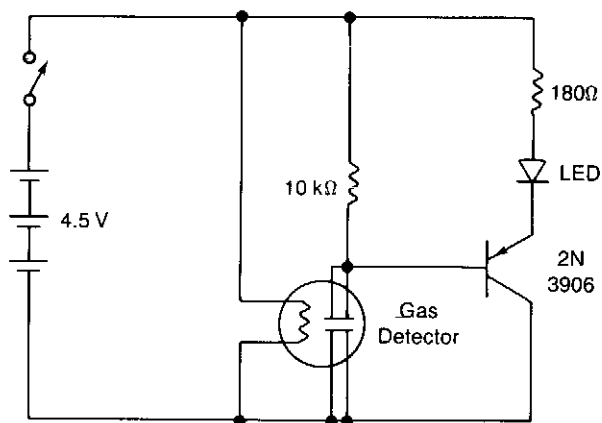


Fig. 42-3

WILLIAM SHEETS

Circuit Notes

The circuit shows a simple yes/no gas detector. Three 1.5-V D cells are used as a power supply, with S1 acting as an on/off switch. The heater is energized directly from the battery, while the electrodes are in series with a 10 k resistor. The voltage across this resistor is monitored by a pnp transistor. When the sensor is in clean air, the resistance between the electrodes is about 40 k, so that only about 0.9 V is dropped across the 10 k resistor. This is insufficient to turn on the transistor, because of the extra 1.6 V required to forward bias the light emitting diode (LED) in series with the emitter. When the sensor comes in contact with contaminated air, the resistance starts to fall, increasing the voltage dropped across the 10 k resistor. When the sensor resistance falls to about 10 k or less, the transistor starts to turn on, current passes through the LED, causing it to emit. The 180 ohm resistor limits the current through the LED to a safe value.

43

Hall Effect Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Angle of Rotation Detector
Door Open Alarm

ANGLE OF ROTATION DETECTOR

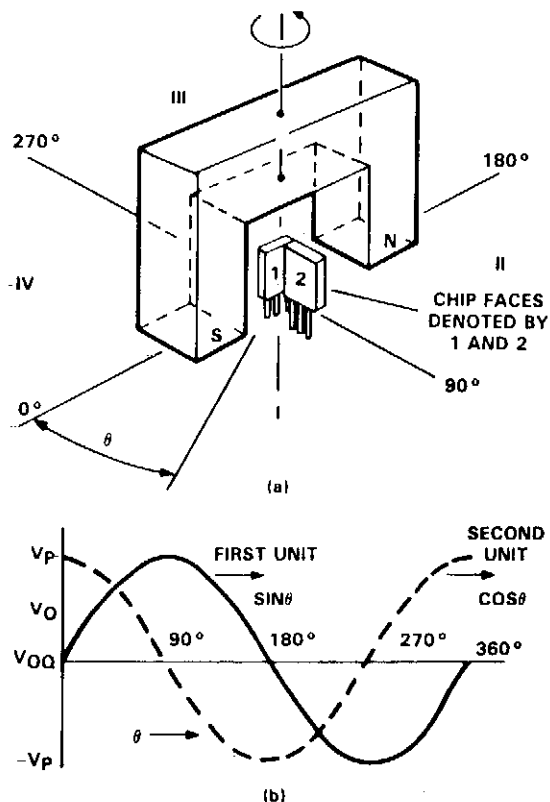
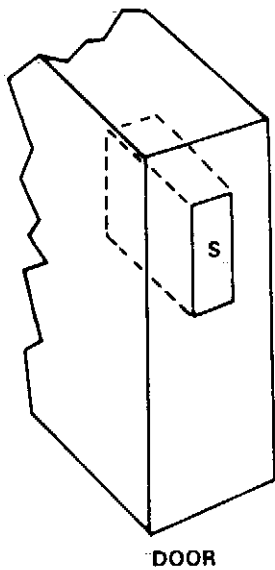


Fig. 43-1

TEXAS INSTRUMENTS

Circuit Notes

The figure shows two TL3103 linear Hall-effect devices used for detecting the angle of rotation. The TL3103s are centered in the gap of a U-shaped permanent magnet. The angle that the south pole makes with the chip face of unit #1 is defined as angle θ . Angle θ is set to 0° when the chip face of unit #1 is perpendicular to the south pole of the magnet. As the south pole of the magnet sweeps through a 0° to 90° angle, the output of the sensor increases from 0° . Sensor unit #2 decreases from its peak value of $+V_p$ at 0° to a value V_{0Q} at 90° . So, the output of sensor unit #1 is a sine function of θ and the output of unit #2 is a cosine function of θ as shown. Thus, the first sensor yields the angle of rotation and the second sensor indicates the quadrant location.



DOOR

TEXAS INSTRUMENTS

DOOR OPEN ALARM

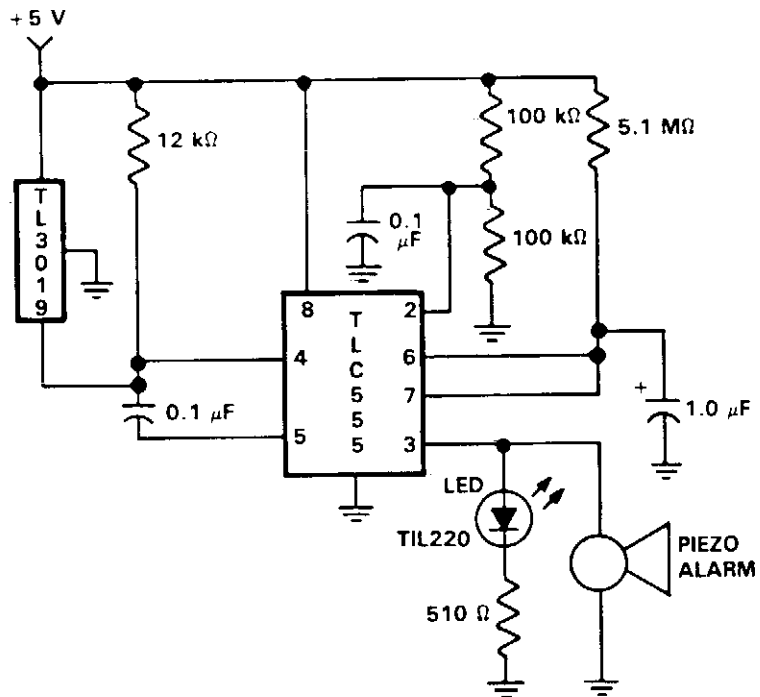


Fig. 43-2

Circuit Notes

Door open alarms are used chiefly in automotive, industrial, and appliance applications. This type of circuit can sense the opening of a refrigerator door. When the door opens, a triac could be activated to control the inside light. The figure shows a door position alarm. When the door is opened, an LED turns on and the piezo alarm sounds for approximately 5 seconds. This circuit uses a TL3019 Hall-effect device for the door sensor. This normally open switch is located in the door frame. The magnet is mounted in the door. When the door is in the closed position, the TL3019 output goes to logic low, and remains low until the door is opened. This design consists of a TLC555 monostable timer circuit. The 1 μF capacitor and 5.1 M ohm resistor on pins 6 and 7 set the monostable RC time constant. These values allow the LED and piezo alarm to remain on about 5 seconds when triggered. One unusual aspect of this circuit is the method of triggering. Usually a 555 timer circuit is triggered by taking the trigger, pin 2, low which produces a high at the output, pin 3. In this configuration with the door in the closed position, the TL3019 output is held low. The trigger, pin 2, is connected to ½ the supply voltage V_{CC} . When the door opens, a positive high pulse is applied to control pin 5 through a 0.1 μF capacitor and also to reset pin 4. This starts the timing cycle. Both the piezo alarm and the LED visual indicator are activated.

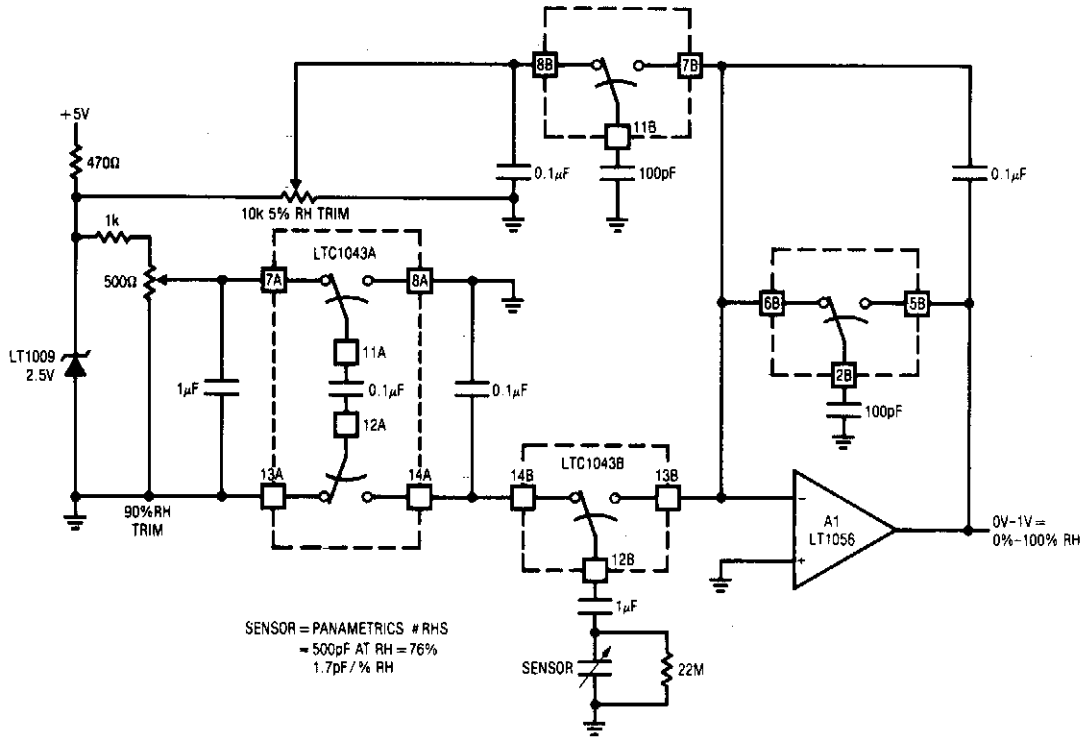
44

Humidity Sensors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Relative Humidity Sensor Signal Conditioner

RELATIVE HUMIDITY SENSOR SIGNAL CONDITIONER

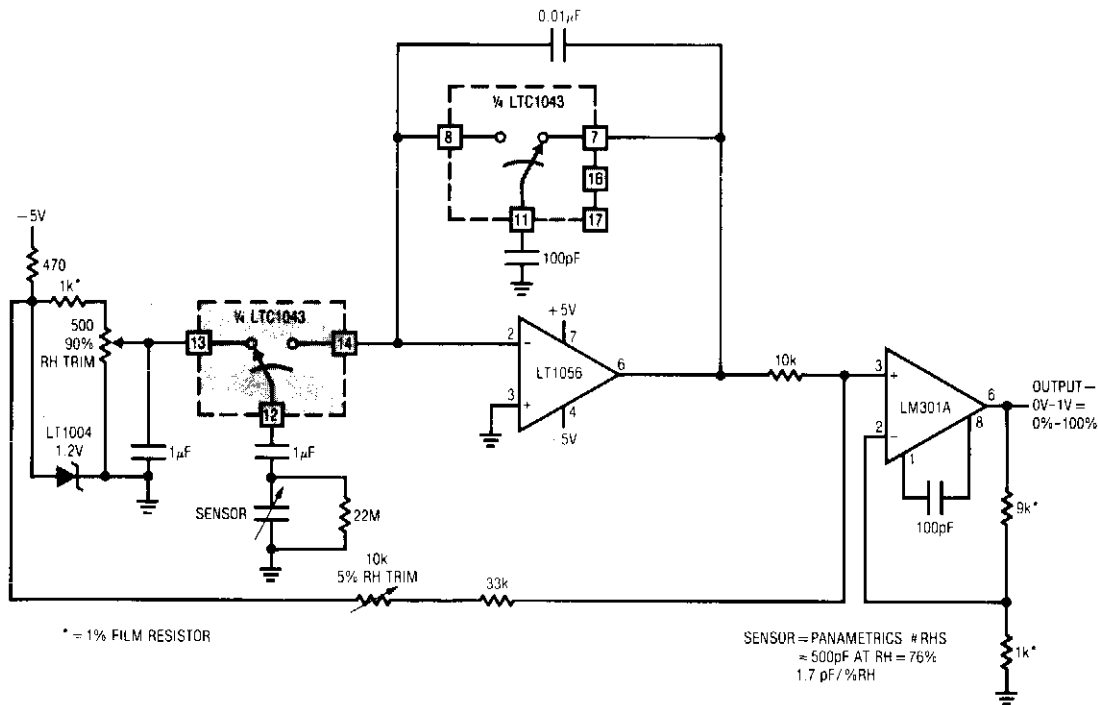


LINEAR TECHNOLOGY CORPORATION

Fig. 44-1

Circuit Notes

This circuit combines two LTC1043s with a based humidity transducer in a simple charge-pump based circuit. The sensor specified has a nominal 400 pF capacitance at RH = 76%, with a slope of 1.7 pF/% RH. The average voltage across this device must be zero. This provision prevents deleterious electrochemical migration in the sensor. The LTC1043A inverts a resistively scaled portion of the LT1009 reference, generating a negative potential at pin 14A. The LTC1043B alternately charges and discharges the humidity sensor via pins 12B, 13B, and 14B. With 14B and 12B connected, the sensor charges via the 1 μ F unit to the negative potential at pin 14A. When the 14B-12B pair



opens, 12B is connected to A1's summing point via 13B. The sensor now discharges into the summing point through the 1 μ F capacitor. Since the charge voltage is fixed, the average current into the summing point is determined by the sensor's humidity related value. The 1 μ F value ac couples the sensor to the charge-discharge path, maintaining the required zero average voltage across the device. The 22M resistor prevents accumulation of charge, which would stop current flow. The average current into A1's summing point is balanced by packets of charge delivered by the switched-capacitor gives A1 an integrator-like response, and its output is dc.

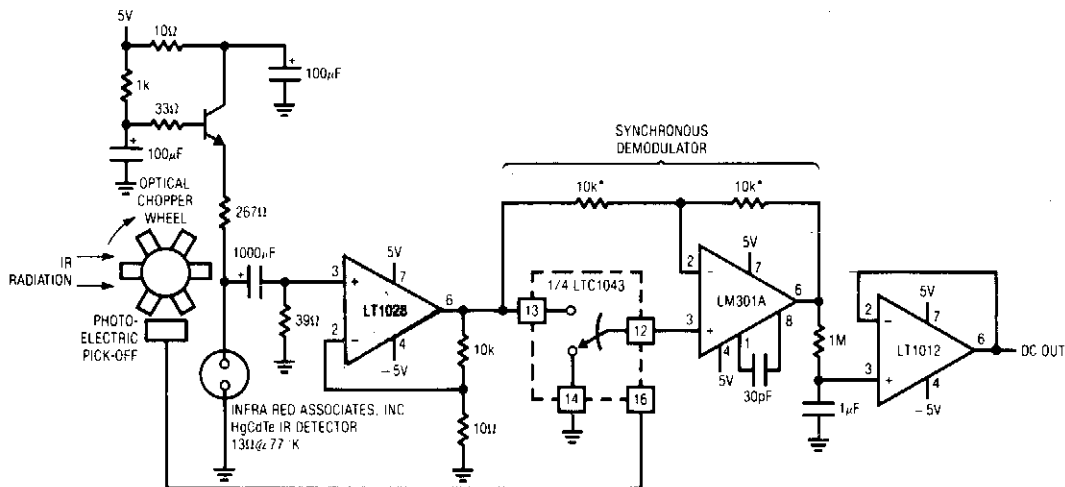
45

Infrared Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Noise Infrared Detector
Infrared Transmitter
Infrared Transmitter
Invisible Infrared Pulsed Laser Rifle
Infrared Receiver
Pulsed Infrared Diode Emitter Drive

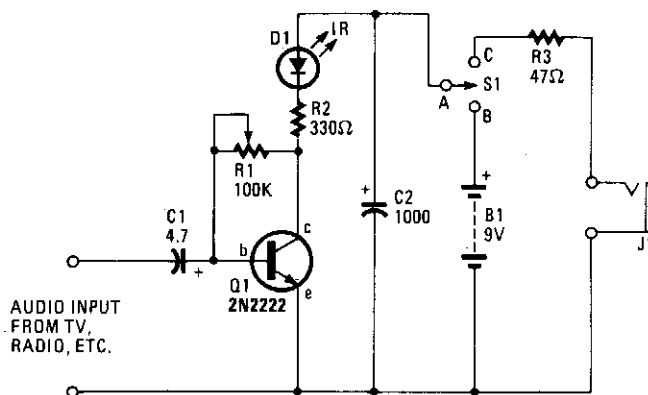
LOW NOISE INFRARED DETECTOR



LINEAR TECHNOLOGY CORP.

Fig. 45-1

INFRARED TRANSMITTER



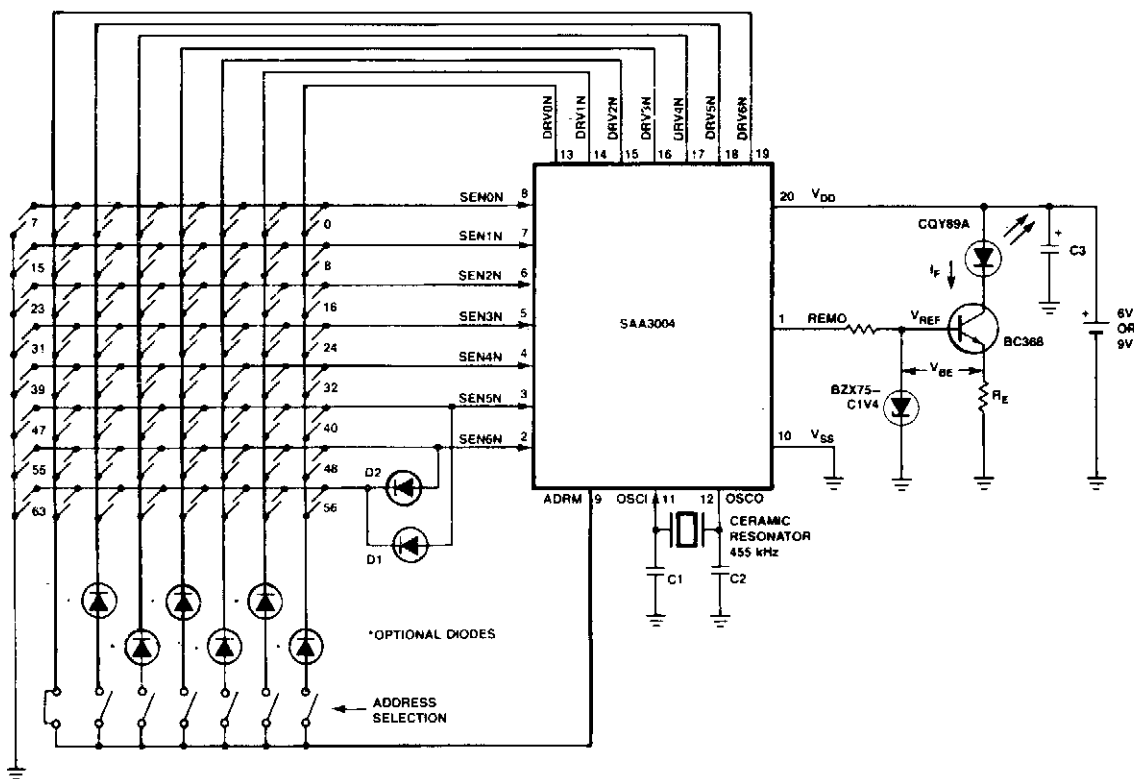
HANDS-ON ELECTRONICS

Fig. 45-2

Circuit Notes

The ultra-simple one-transistor, IR transmitter shown is designed to transmit the sound from any 8 or 16 ohm audio source, such as a TV, radio, or tape recorder on an infrared beam of light.

INFRARED TRANSMITTER



SIGNETICS

Fig. 45-3

Circuit Notes

The transmitter keyboard is arranged as a scanned matrix. The matrix consists of 7 driver outputs and 7 sense inputs. The driver outputs DRVON to DRV6N are open-drain n-channel transistors and they are conductive in the stand-by mode. The 7 sense inputs (SEN0N to SEN6N) enable the generation of 56 command codes. With 2 external diodes all 64 commands are addressable. The sense inputs have p-channel pull-up transistors, so that they are HIGH until they are pulled LOW by connecting them to an output via a key depression to initiate a code transmission.

INVISIBLE INFRARED PULSED LASER RIFLE

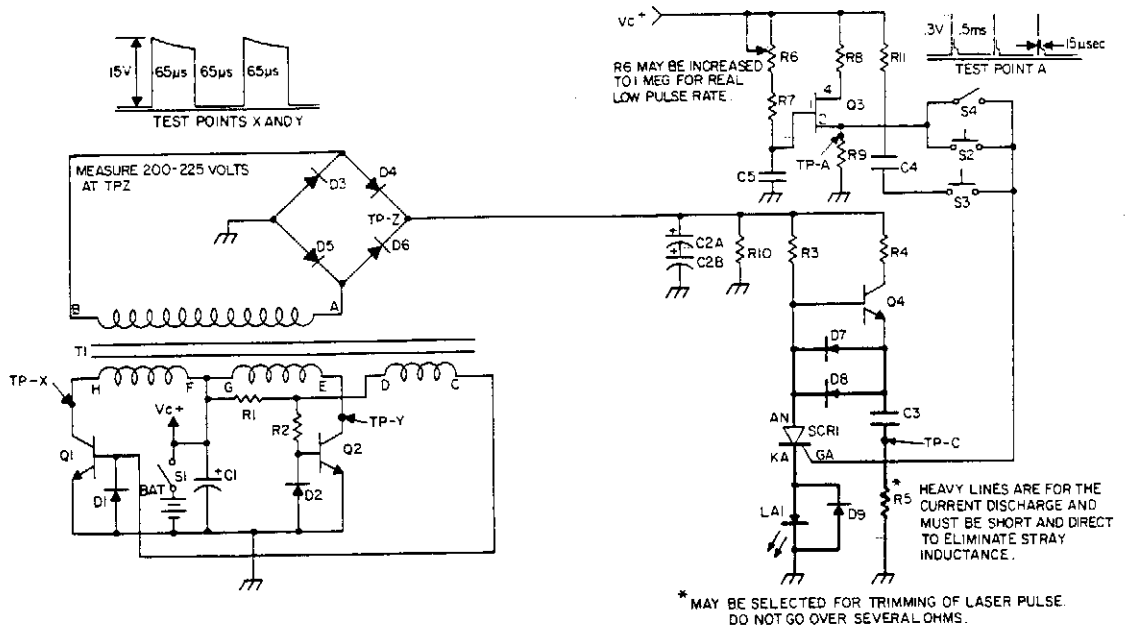


Fig. 45-4

TAB BOOKS INC.

Circuit Notes

The device generates an adjustable frequency of low to medium powered IR pulses of invisible energy and must be treated with care.

The portable battery pack is stepped up to 200 to 300 volts by the inverter circuit consisting of Q1, Q2, and T1. Q1 conducts until saturated, at which time, the base no longer can sustain it in an "on" state and Q1 turns "off," causing the magnetic field in its collector winding to collapse thus producing a voltage or proper phase in the base drive winding that turns on Q2 until saturated, repeating the above sequence of events in an "on/off" action. The diodes connected at the bases provide a return path for the base drive current. The stepped up squarewave voltage on the secondary of T1 is rectified and integrated on C2.

INFRARED RECEIVER

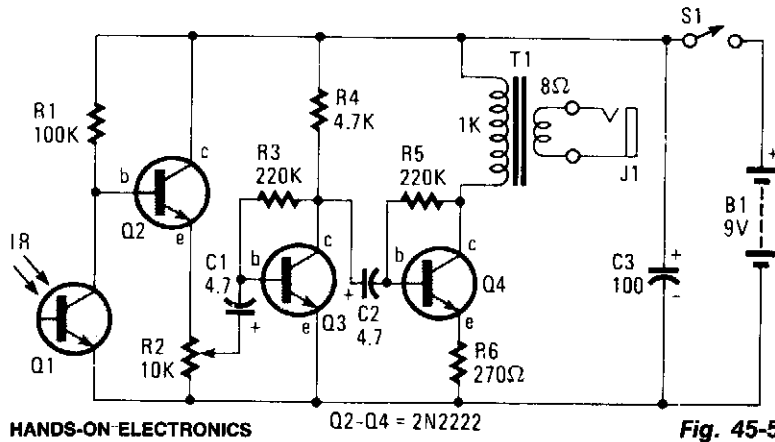


Fig. 45-5

Circuit Notes

The circuit consists of Q1—a phototransistor that responds to an intensity of amplitude-modulated IR light source—and a three-stage, high-gain audio amplifier. Transformer T1 is used to match the output impedance of the receiver to today's popular low-impedance (low-Z) headphones; but if a set of 1000-2000 ohm, magnetic (not crystal), high-impedance (high-Z) phones are to be used, remove T1 and connect the high-Z phones in place of T1's primary winding—the 1000-ohm winding.

PULSED INFRARED DIODE EMITTER DRIVE

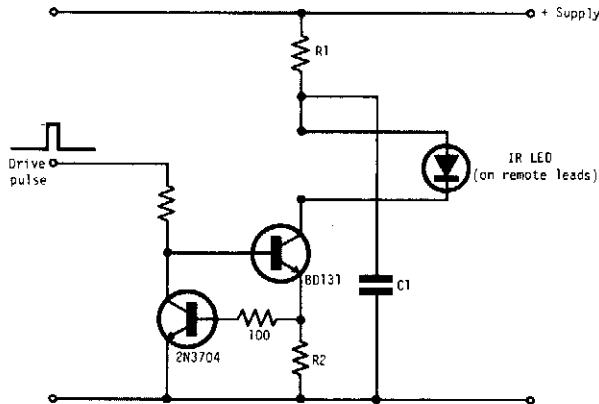


Fig. 45-6

Circuit Notes

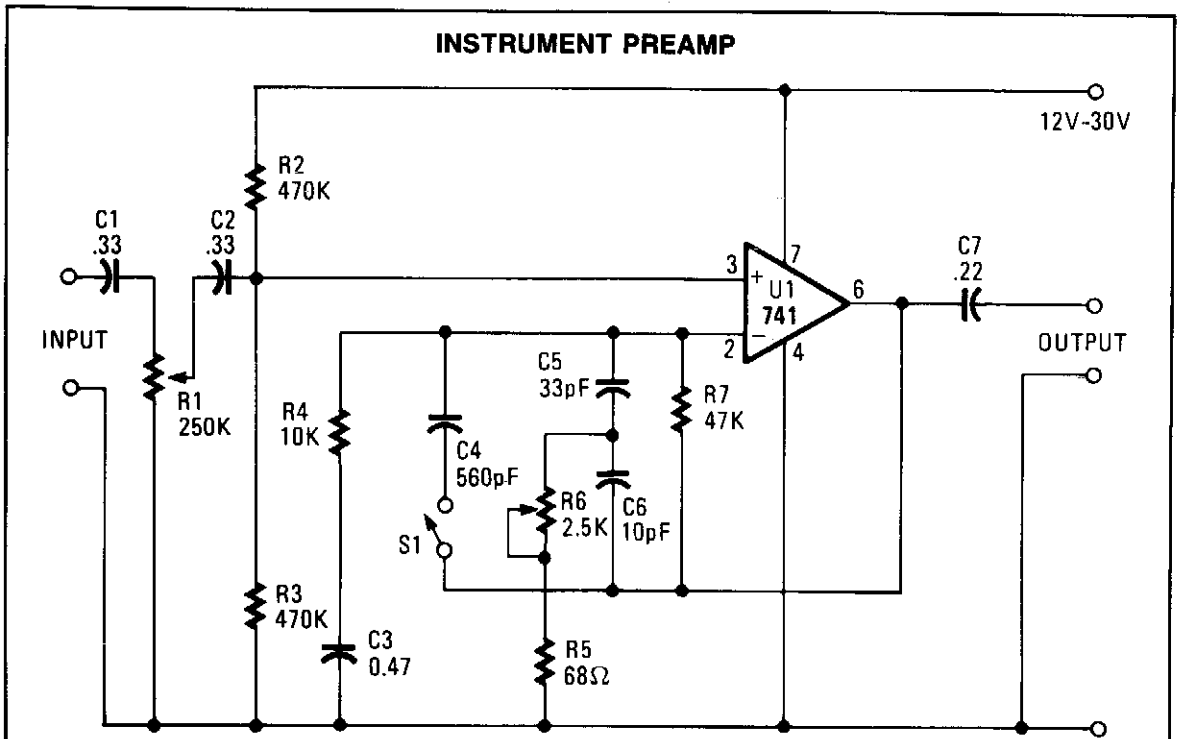
Q1 and Q2 form a constant current drive defined by R2. (I approximates to the reciprocal of R2 in the circuit shown for values of I greater than 1 amp). The pulse current is drawn from C1 which is recharged during the time between pulses via R1. The value of C1 is determined from the duration and magnitude of the peak current required, and the time constant R1 C1 is determined from the duration between pulses.

46

Instrumentation Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Instrument Preamp
Instrumentation Amplifier with ± 100 Volt Common
Mode Range
Current-Collector Head-Amplifier
Instrumentation Meter Driver
Saturated Standard Cell Amplifier



HANDS-ON ELECTRONICS

Fig. 46-1

Circuit Notes

The input impedance is the value of potentiometer R1. If your instrument has extra-deep bass, change capacitor C1 to 0.5 μ F. What appears to be an extra part in the feedback loop is a brightening tone control. The basic feedback from the op amp's output (pin 6) to the inverting input (pin 2) consists of resistor R7, and the series connection of resistor R4 and capacitor C3, which produce a voltage gain of almost 5 (almost 14 dB). That should be more extra oomph than usually needed. If the circuit is somewhat short on bass response, increase the value of capacitor C3 to 1 to 10 μ F. Start with 1 μ F and increase the value until you get the bass effect you want.

INSTRUMENTATION AMPLIFIER WITH ± 100 VOLT COMMON MODE RANGE

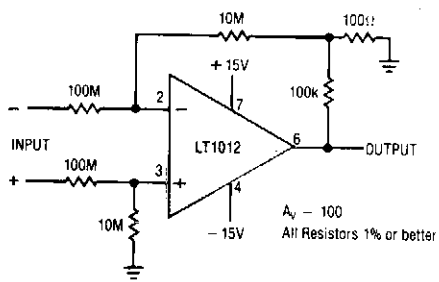


Fig. 46-2

LINEAR TECHNOLOGY CORP.

CURRENT-COLLECTOR HEAD-AMPLIFIER

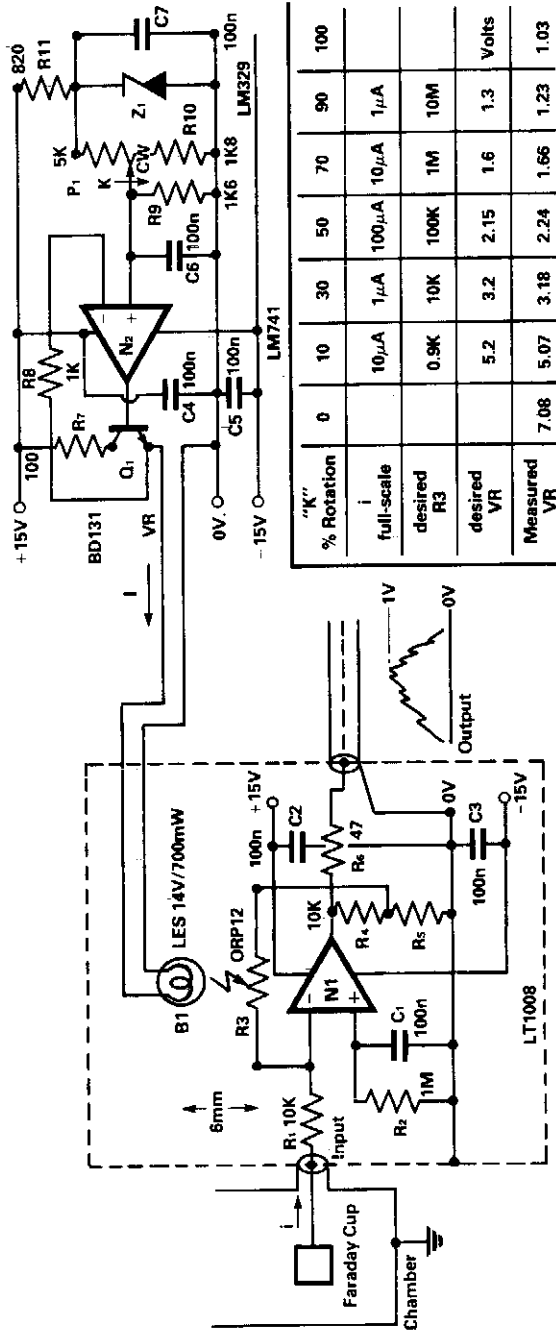


Fig. 46-3

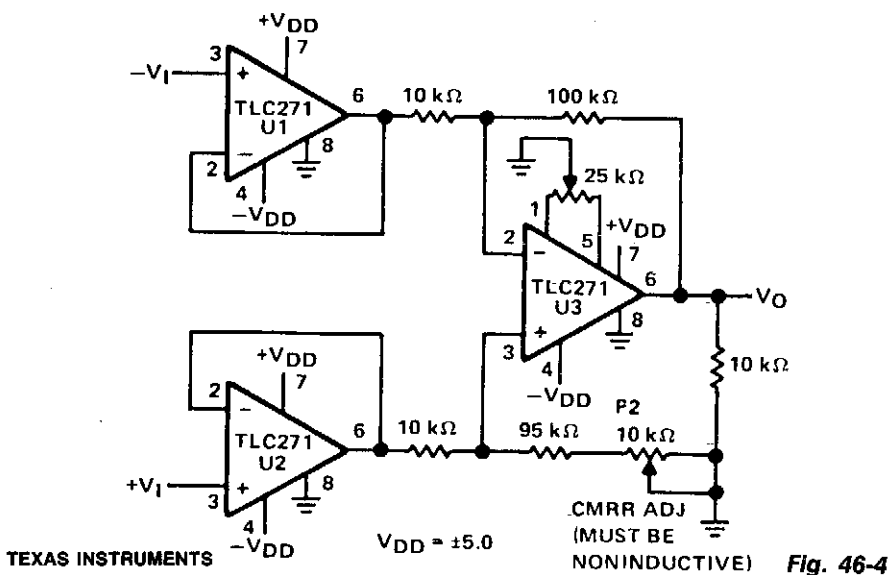
ELECTRONIC ENGINEERING

Circuit Notes

To amplify small current signals such as from an electron-collector inside a vacuum chamber, it is convenient for reasons of noise and bandwidth to have a "head-amplifier" attached to the chamber. The op amp N1 is a precision bipolar device with extremely low bias current and offset voltage (1) as well as low noise, which allows the 100:1 feedback attenuator R4:R5. The resistance of R3 can be varied from above 10M to below 1R, and so the nominal 0 to 1 V-peak output signal corresponds to input current ranges of 1 nA to 10 μ A; this current i enters via the protective resistor R1. Light from the bulb B1 shines on R3, and the filament current I is controlled by the op amp N2.

The reference voltage VR is "shaped" by the resistors R9:R10 so as to tailor the bulb and LDR characteristics to the desired current ranges. Thus, rotation of the calibrated knob K gives the appropriate resistance to R3 for the peak-current scale shown.

INSTRUMENTATION METER DRIVER



Circuit Notes

Three op amps U1, U2, and U3 are connected in the basic instrumentation amplifier configuration. Operating from ± 5 V, pin 8 of each op amp is connected directly to ground and provides the ac performance desired in this application (high bias mode). P1 is for offset error correction and P2 allows adjustment of the input common mode rejection ratio. The high input impedance allows megohms without loading. The resulting circuit frequency response is 200 kHz at -3 dB and has a slew rate of 4.5 V/ μ s.

SATURATED STANDARD CELL AMPLIFIER

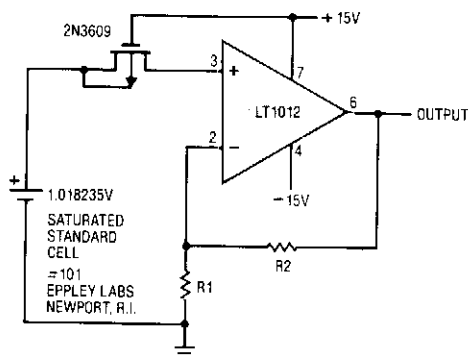


Fig. 46-5

The typical 30pA bias current of the LT1012 will degrade the standard cell by only 1 ppm/year. Noise is a fraction of a ppm. Unprotected gate MOSFET isolates standard cell on power down.

LINEAR TECHNOLOGY CORP.

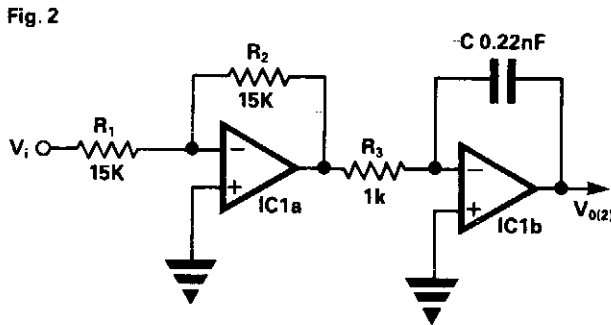
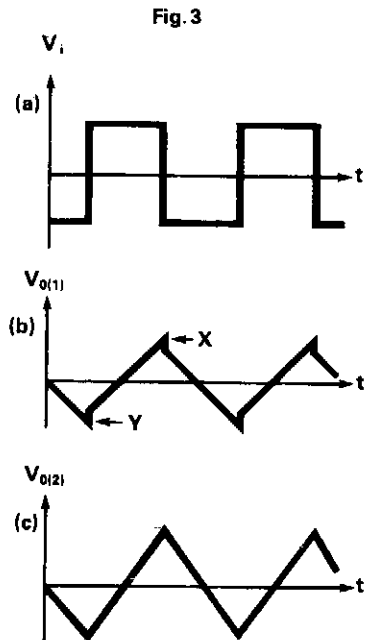
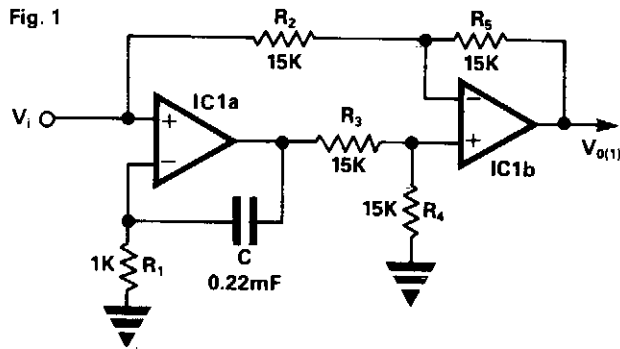
47

Integrator Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Improved Non-Inverting Integrator
Active Integrator with Inverting Buffer
Long Time Integrator

IMPROVED NON-INVERTING INTEGRATOR



ELECTRONIC ENGINEERING

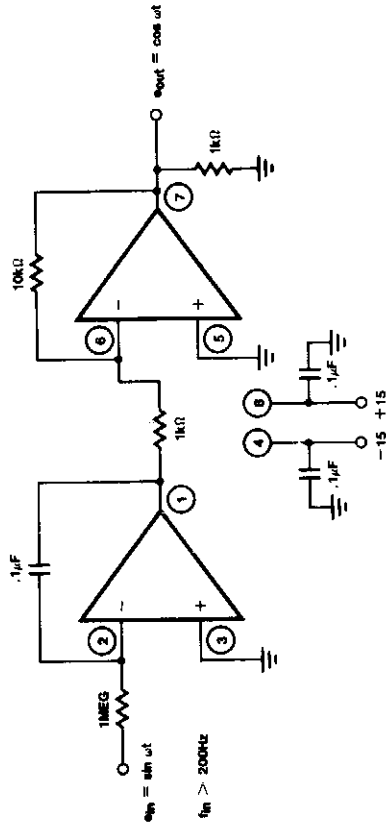
Fig. 47-1

Circuit Notes

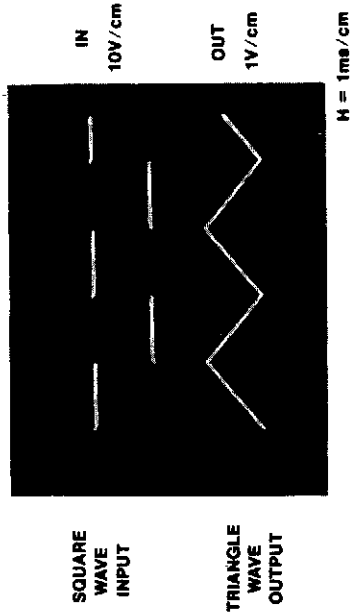
In the circuit in Fig. 1, IC1a produces the integral term required but also has the side effect of producing a proportional term not required, so this term is subtracted by IC1b leaving a pure integral. If the ratio R_2/R_5 does not exactly match the ratio of R_3/R_4 , the subtraction will not be complete and a small amount of the proportional term will reach the output. The result of this with a squarewave input is shown in Fig. 3a as small steps in the output waveform at points X and Y.

This effect can be completely removed by using the simplified circuit shown in Fig. 2. Here the signal is pre-inverted by IC1a, then fed to a standard inverting integrator IC1b. The result is a non-inverting integrator with the advantage that the unwanted proportional term is never produced, so it does not need to be subtracted.

ACTIVE INTEGRATOR WITH INVERTING BUFFER



INTEGRATOR WAVEFORMS



IC = NE/SE5512

SIGNETICS

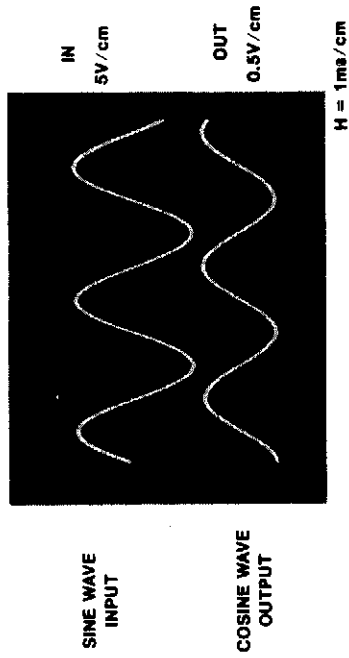


Fig. 47-2

LONG TIME INTEGRATOR

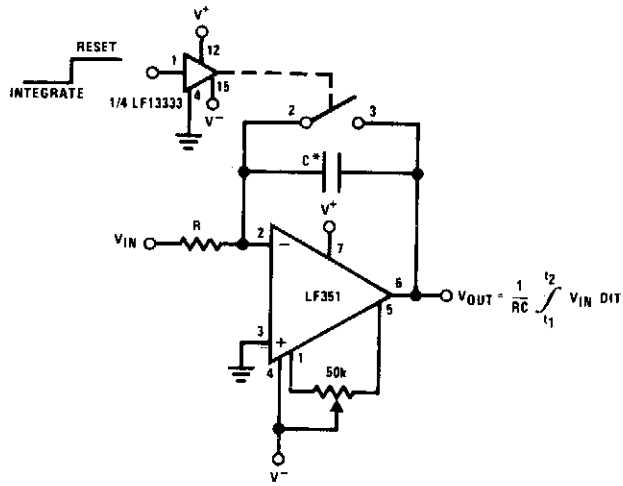


Fig. 47-3

- * Low leakage capacitor
- 50k pot used for less sensitive \$V_{OS}\$ adjust

NATIONAL SEMICONDUCTOR CORP.

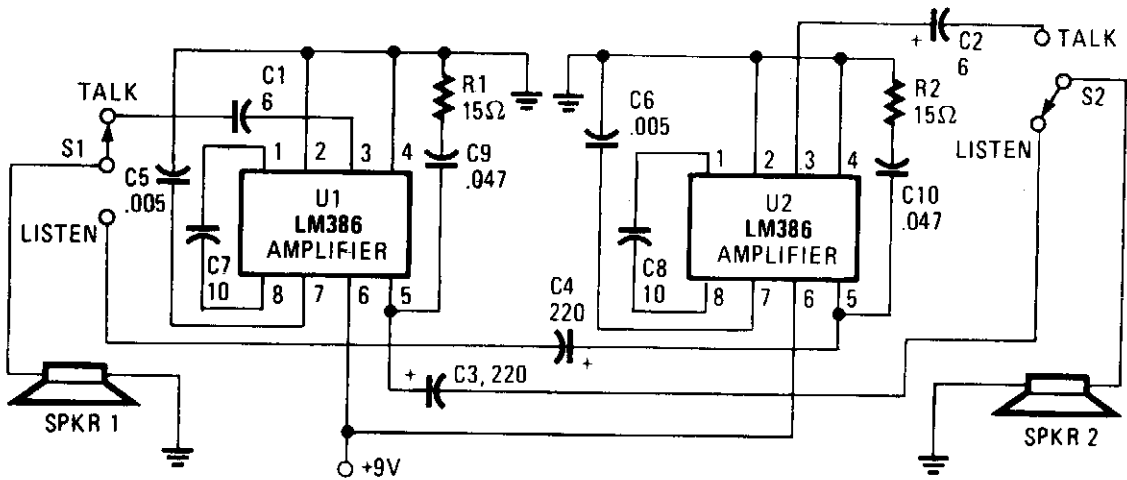
48

Intercom Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Intercom
Party-Line Intercom

INTERCOM



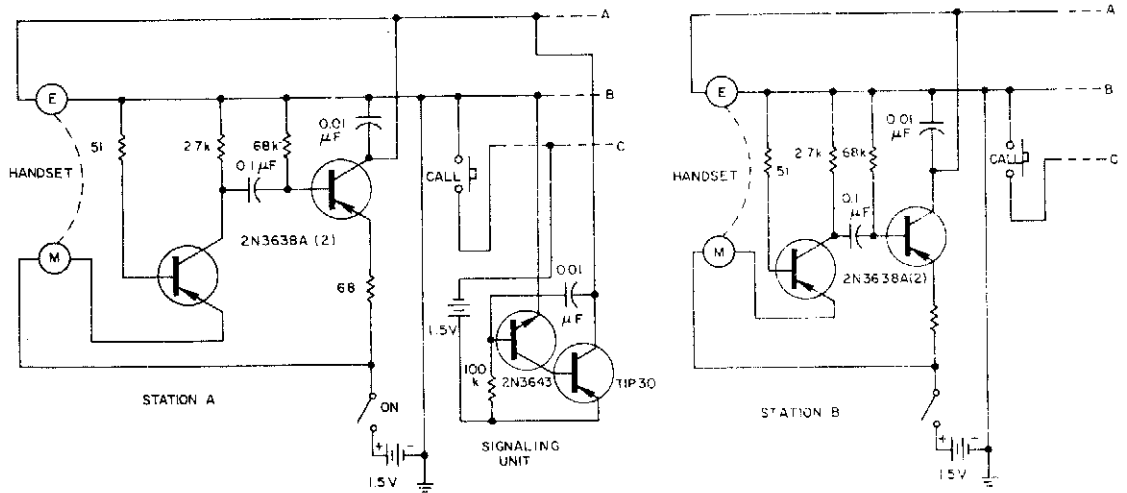
HANDS-ON ELECTRONICS

Fig. 48-1

Circuit Notes

The circuit consists of separate amplifiers—one for each station—rather than a single amplifier and a time sharing arrangement. U1 and U2 are low-voltage audio amplifiers, each of which operates as separate entities with switches at either station controlling which will transmit or receive. With capacitors C7 and C8 included in the circuit, the amplifiers have a gain of 200. Omitting those two components drops the gain to about 20. Other gain levels are available with the addition of a series-connected R/C combination connected between pin 1 and pin 8—for example, a 1000 ohm resistor and 10 μ F capacitor for a gain of about 150.

PARTY-LINE INTERCOM



ELECTRONIC DESIGN

Fig. 48-2

Circuit Notes

A large number of intercom stations can be tied together. All units are connected in parallel, and the entire system is buzzed by only one signaling circuit. Each unit is powered individually from 1.5-V cells for redundancy. For greater signal volume, 3-V sources can be used for the supplies without changing any other parts of the system. The carbon microphone of a standard telephone handset at each station feeds into a common-base amplifier, and a tandem high-gain common-emitter stage drives the intercom line. All phone earpieces are in parallel across the line. The signaling circuit, also connected across the line, is a simple oscillator that drives all the earpieces.

49

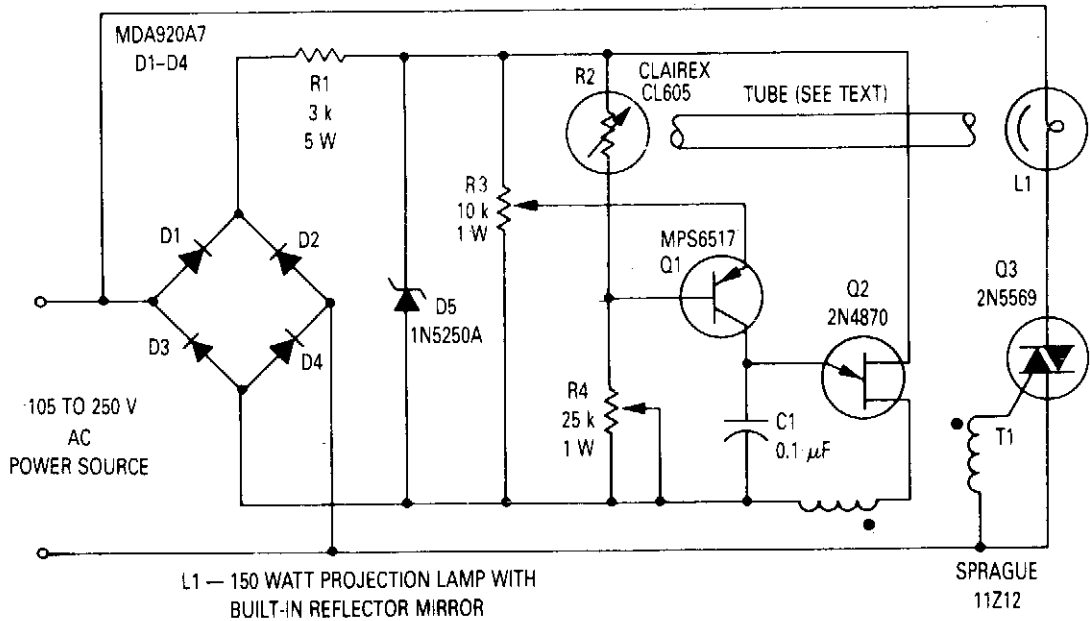
Lamp-Control Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Voltage Regulator for a Projection Lamp
Machine Vision Illumination Stabilizer
dc Lamp Dimmer
Automatic Light Controller for Carport
800 W Light-Dimmer

Lamp Dimmer
Rugged Lamp Driver is Short-Circuit Proof
TRIAC Lamp Dimmer
TRIAC Zero-Point Switch
Tandem Dimmer (Cross-Fader)

VOLTAGE REGULATOR FOR A PROJECTION LAMP



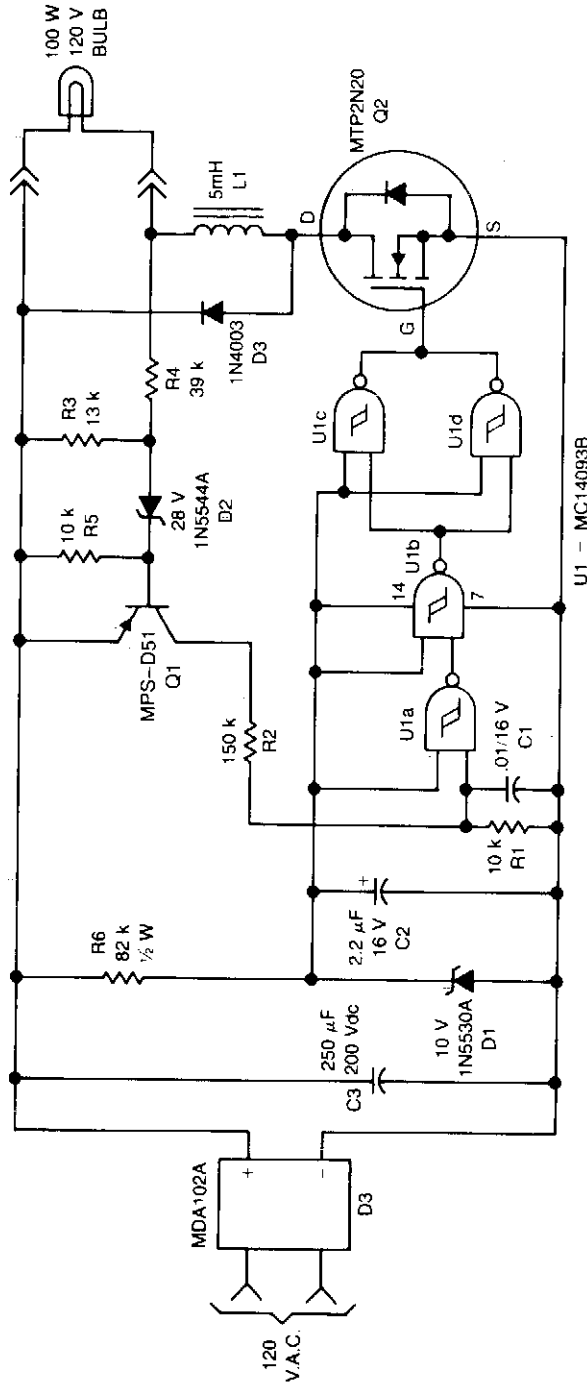
MOTOROLA

Fig. 49-1

Circuit Notes

The circuit will regulate the rms output voltage across the load (a projection lamp) to 100 volts $\pm 2\%$ for an input voltage between 105 and 250 volts ac. This is accomplished by indirectly sensing the light output of lamp L1 and applying this feedback signal to the firing circuit (Q1 and Q2) which controls the conduction angle of TRIAC Q3. The lamp voltage is provided by TRIAC Q3, whose conduction angle is set by the firing circuit for unijunction transistor Q2. The circuit is synchronized with the line through the full-wave bridge rectifier. The voltage to the firing circuit is limited by zener diode D5. Phase control of the supply voltage is set by the charging rate of capacitor C1. Q2 will fire when the voltage on C1 reaches approximately 0.65 times the zener voltage. The charging rate of C1 is set by the conduction of Q1, which is controlled by the resistance of photocell R2. Potentiometers R3 and R4 are used to set the lamp voltage to 100 volts when the line voltage is 105 volts and 250 volts, respectively.

MACHINE VISION ILLUMINATION STABILIZER



MOTOROLA

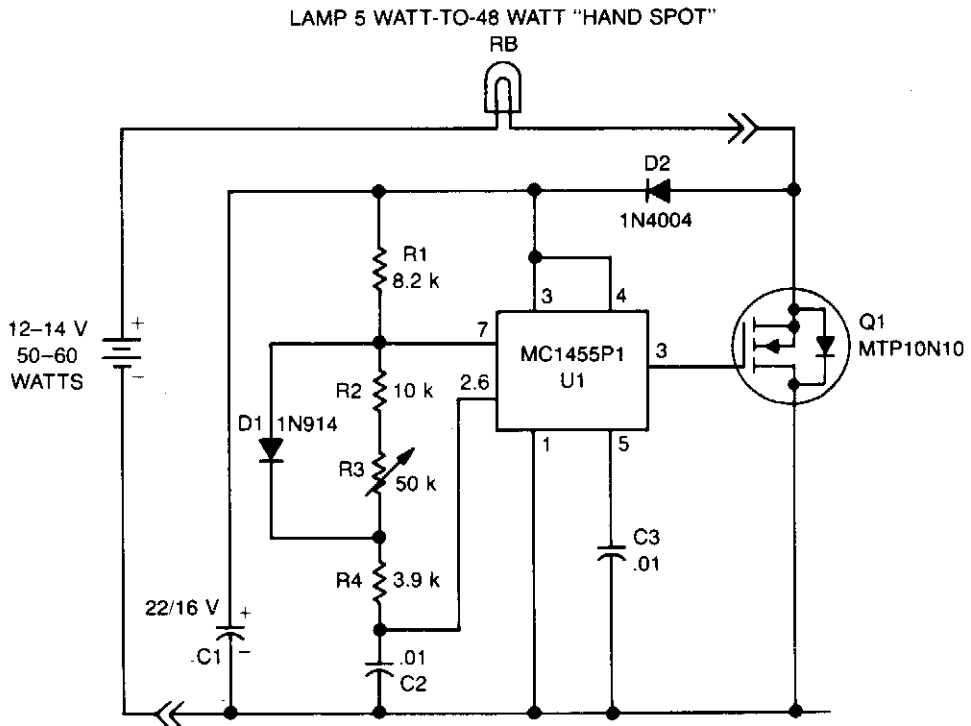
U1 - MC14093B

Fig. 49-2

Circuit Notes

The combination of Q1, Q2 and U1 form a hysteresis oscillator to stabilize lamp illumination. In operation, full wave bridge D3 operates directly from the ac line to supply unregulated dc to the lamp and also to the 10 V zener that provides power to the quad CMOS Schmitt trigger, U1. When the lamp supply exceeds 115 V, Q1 is turned ON, charging C1 through R2 to raise the input to U1a past the positive-going logic threshold. This drops the output voltage at U1c and U1d, which drives the gate of Q2, turning it OFF. Current then decays through the lamp, L1 and D3 until the lamp voltage falls below 115 V, at which time Q1 turns OFF and the cycle repeats.

DC LAMP DIMMER



MOTOROLA

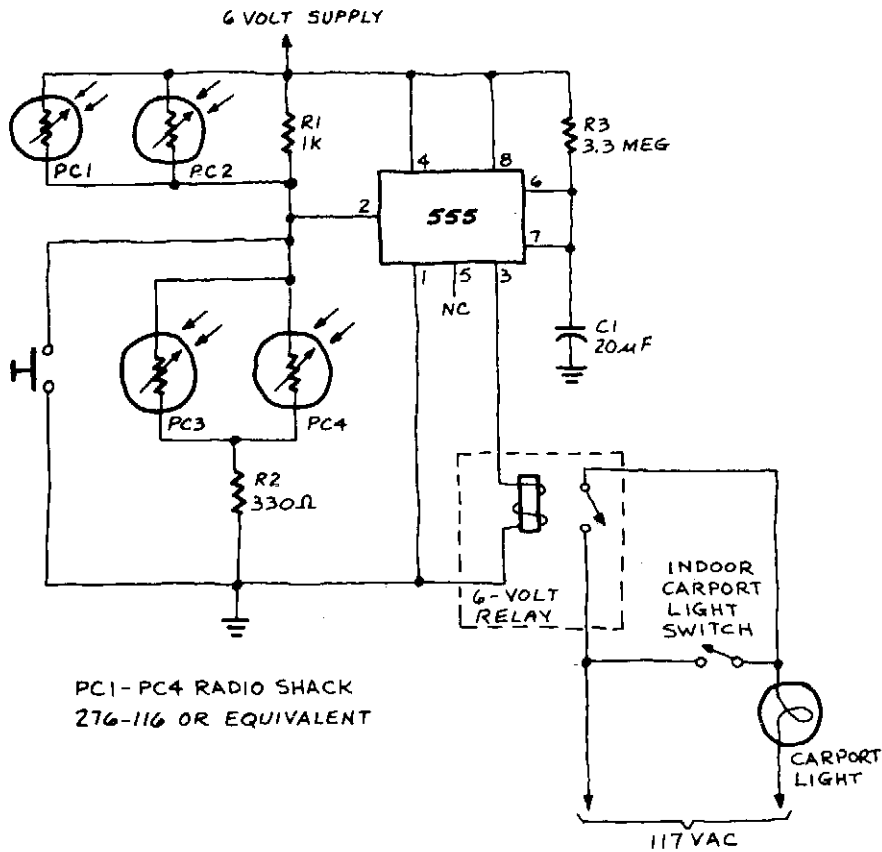
Fig. 49-3

Circuit Notes

A low power, low cost dc lamp dimmer for a two-wire portable "flashlight" can be realized with little or no heatsinking. In addition, a single potentiometer, R3 adjusts lamp brightness.

Battery power is stored in C1 for U1, which is a free-running multivibrator whose frequency is determined by R1, R2, R3, R4, and C2. U1 drives the gate of Q1, turning it and the lamp ON and OFF at a rate proportional to the multivibrator duty cycle.

AUTOMATIC LIGHT CONTROLLER FOR CARPORT



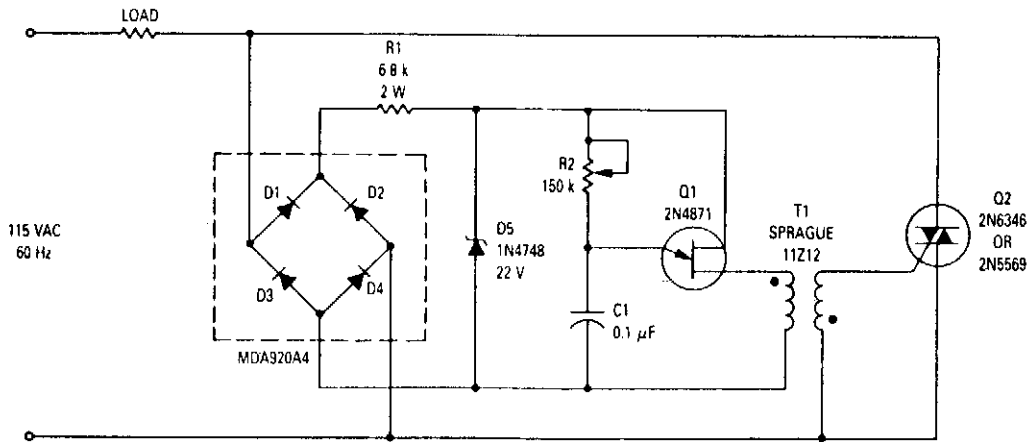
RADIO-ELECTRONICS

Fig. 49-4

Circuit Notes

A 555 timer IC, operating in the one-shot mode, is triggered by light striking photoresistors. These normally have a resistance of several megohms but, in the presence of light, that resistance drops to several hundred ohms, permitting current from the six-volt source to flow in the circuit. The R-C combination shown gives an on-time of about two minutes. Photoresistors PC3 and PC4 are mounted at headlight-height. When headlights illuminate the photoresistor, the timer starts. That actuates a relay, RY1, and the lights are turned on. The lights are automatically turned off when the timer's two minutes are up.

800 W LIGHT-DIMMER



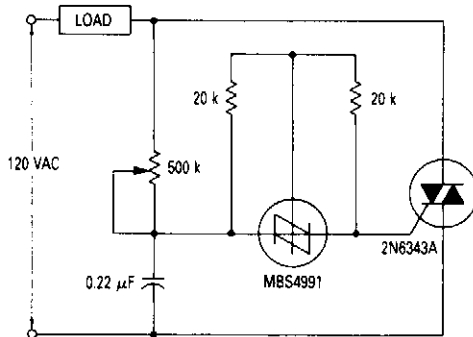
MOTOROLA

Fig. 49-5

Circuit Notes

This wide-range light dimmer circuit uses a unijunction transistor and a pulse transformer to provide phase control for the TRIAC. The circuit operates from a 115 volt, 60 Hz source and can control up to 800 watts of power to incandescent lights. The power to the lights is controlled by varying the conduction angle of the TRIAC from 0° to about 170°. The power available at 170° conduction is better than 97% of that at the full 180°.

LAMP DIMMER



MOTOROLA

Fig. 49-6

Circuit Notes

A full range power controller suitable for lamp dimming and similar applications operate from a 120 volt, 60 Hz ac source, and can control up to 1000 watts of power to incandescent bulbs. The power to the bulbs is varied by controlling the conduction angle of TRIAC Q1. At the end of each positive half-cycle when the applied voltage drops below that of the capacitor, gate current flows out of the SBS and it switches on, discharging the capacitor to near zero volts. The RC network shown across the TRIAC represents a typical snubber circuit that is normally adequate to prevent line transients from accidentally firing the TRIAC.

RUGGED LAMP DRIVER IS SHORT-CIRCUIT PROOF

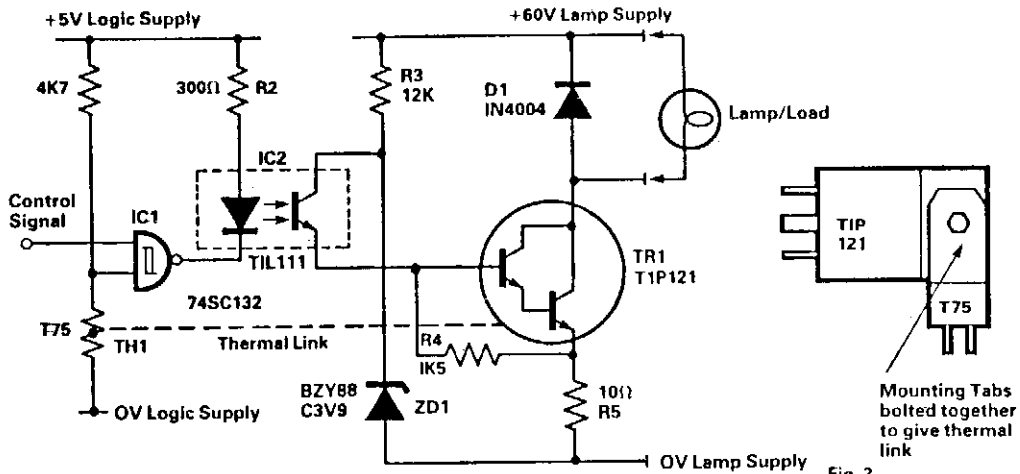


Fig. 1

ELECTRONIC ENGINEERING

Fig. 2

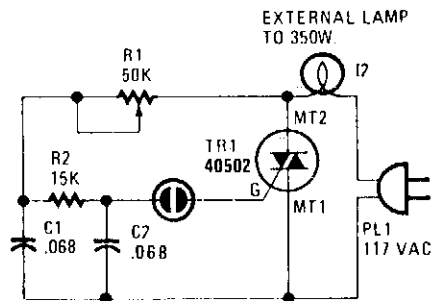
Fig. 49-7

Circuit Notes

This circuit is capable of driving filament lamps of nominal rating 200 mA at 60 V dc from a CMOS logic signal.

The lamp or load is connected in series with the Darlington transistor TR1 and emitter resistor R5. The Zener diode ZD1 establishes a soft reference voltage on the collector of the optocoupler IC2. When the logic control signal from the processor switches the optocoupler on via IC1, base drive is applied to TR1 and the lamp is switched on.

TRIAC LAMP DIMMER



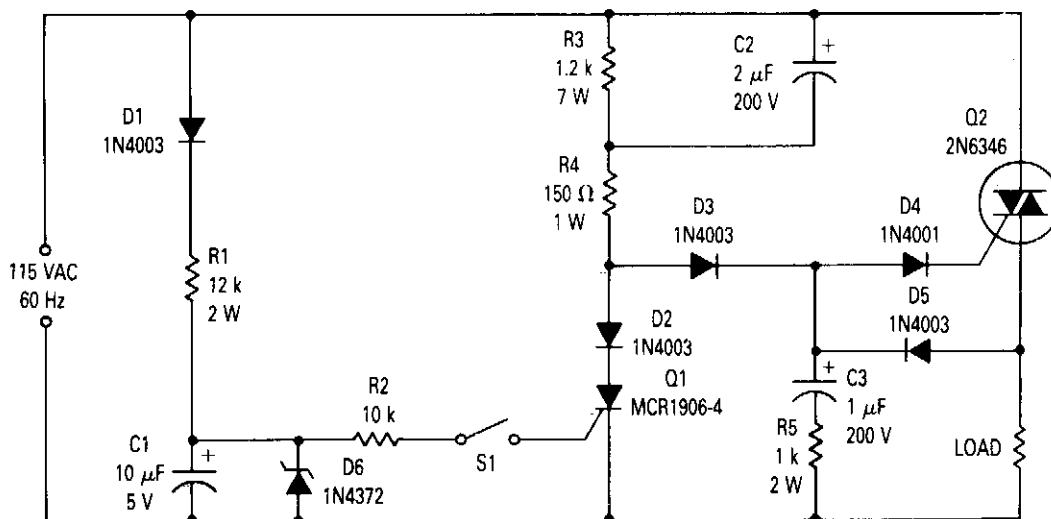
Circuit Notes

Using a heatsink, the TRIAC (TR1) can handle up to 350 watts. The neon lamp, I1, won't trip the gate until after it conducts and using R1, set the lighting wherever you want it.

TAB BOOKS, INC.

Fig. 49-8

TRIAC ZERO-POINT SWITCH



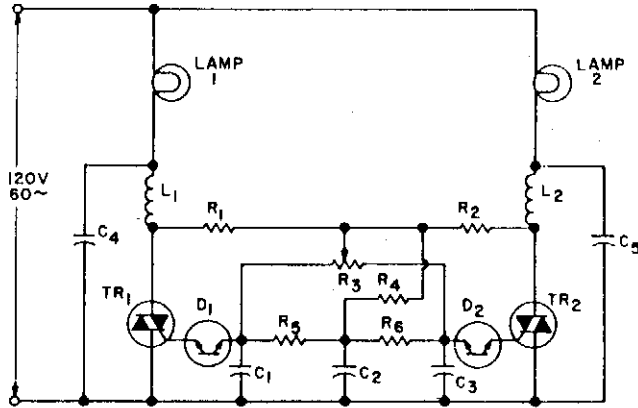
MOTOROLA

Fig. 49-9

Circuit Notes

On the initial part of the positive half cycle, the voltage is changing rapidly from zero causing a large current to flow into capacitor C2. The current through C2 flows through R4, D3, and D4 into the gate of the TRIAC Q2 causing it to turn on very close to zero voltage. Once Q2 turns on, capacitor C3 charges to the peak of the line voltage through D5. When the line voltage passes through the peak, D5 becomes reverse-biased and C3 begins to discharge through D4 and the gate of Q2. At this time the voltage on C3 lags the line voltage. When the line voltage goes through zero there is still some charge on C3 so that when the line voltage starts negative C3 is still discharging into the gate of Q2. Thus Q2 is also turned on near zero on the negative half cycle. This operation continues for each cycle until switch S1 is closed, at which time SCR Q1 is turned on. Q1 shunts the gate current away from Q2 during each positive half cycle keeping Q2 from turning on. Q2 cannot turn on during the negative cycle because C3 cannot charge unless Q2 is on during the positive half cycle.

TANDEM DIMMER (CROSS-FADER)



$R_1 = R_2 = 6800\Omega$, 1WATT
 $R_3 = 150K\Omega$ LINEAR POT. 1W
 $R_5 = R_6 = 22K\Omega$, 1/2W.
 $R_4 = 15K\Omega$, 1/2W.
 $TR_1 = TR_2 =$ TRIAC
 $D_1 = D_2 =$ GE ST-2 DIAC

$L_1 = L_2 = 60\mu\text{hy}$ (FERRITE CORE)
 $C_1 = C_2 = C_3 = 0.1\mu\text{f}$ 50V
 $C_4 = C_5 = 0.1\mu\text{f}$ 200 VOLTS

NOTE: TOTAL LIGHT LEVEL (SUM OF LAMPS 1+2) CONSTANT WITHIN 15%.

GENERAL ELECTRIC

Fig. 49-10

Circuit Notes

This cross fader circuit can be used for fading between two slide projectors. As R_3 is moved to either side of center, one triac is fired earlier in each half cycle, and the other later. The total light output of both lamps stays about the same for any control position.

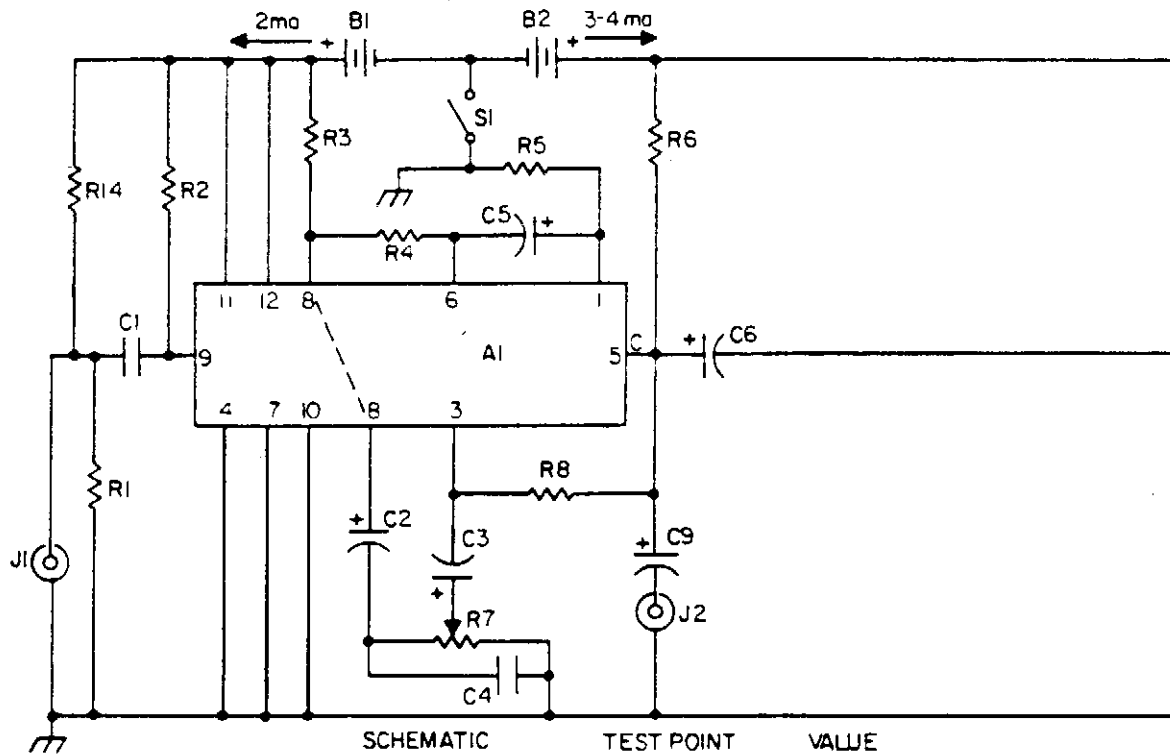
50

Laser Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Laser Light Detector
Stabilizing a Laser Discharge Current

LASER LIGHT DETECTOR

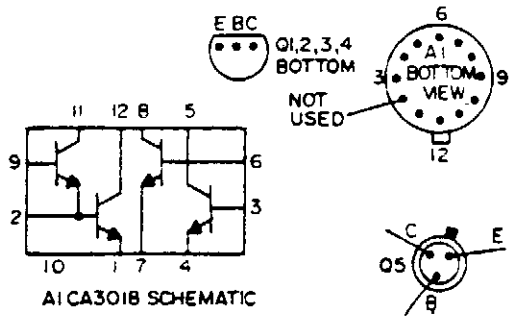


SCHEMATIC

TEST POINT VALUE

TEST POINT	VALUE
A	6-8V
B	4-5V
C	3-4V
D	0(.3)V
E	9(4.5)V
F	0(.3)V
G	0(.1)V
H	9(.2)V

VALUE IN PARENTHESIS ARE IN THE "ACTUATED" STATE AND ARE WITH A REALISTIC #CTR-43 RECORDER.

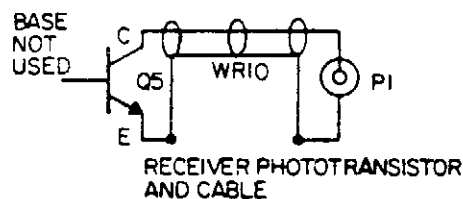
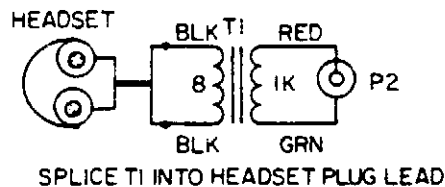
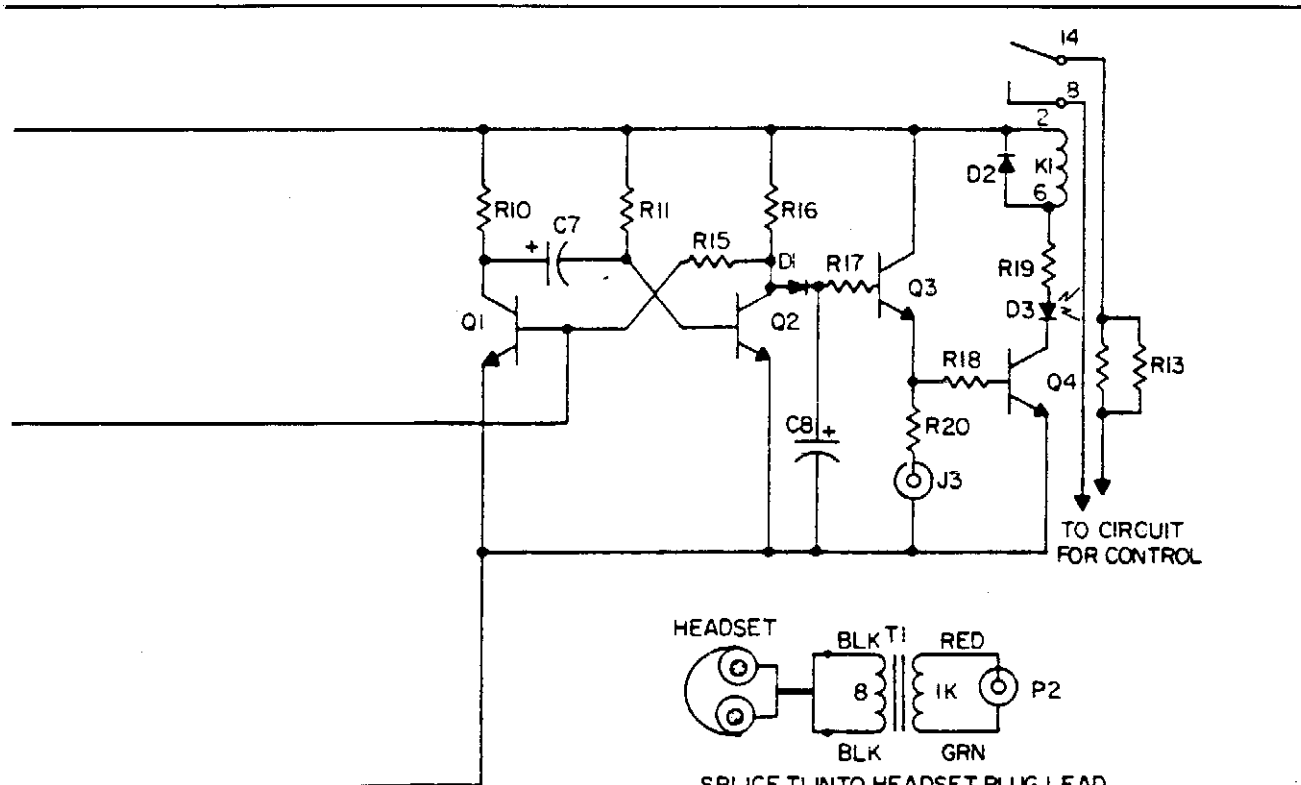


TAB BOOKS INC.

Fig. 50-1

Circuit Notes

The laser light detector utilizes a sensitive photo transistor (Q5) placed at the focal point of a lens (LE2). The output of Q5 is fed to a sensitive amplifier consisting of array (A1) and is biased via the voltage divider consisting of R14 and R1. The base is not used. Q5 is capacitively coupled to a Darlington pair for impedance transforming and is further fed to a capacitively coupled cascaded pair of common-emitter amplifiers for further signal



amplification. Sensitivity control (R7) controls base drive to the final transistor of the array and hence controls overall system sensitivity. Output of the amplifier array is capacitively coupled to a one-shot consisting of Q1 and Q2 in turn integrating the output pulses of Q2 onto capacitor C8 through D1. This dc level now drives relay drivers Q3 and Q4 activating K1 along with energizing indicator D3, consequently controlling the desired external circuitry. The contacts of K1 are in series with low ohm resistor R13 to prevent failure when switching capacitive loads. J2 allows "listening" to the intercepted light beam via headsets. This is especially useful when working with pulsed light sources such as GaAs lasers or any other varying periodic light source.

STABILIZING A LASER DISCHARGE CURRENT

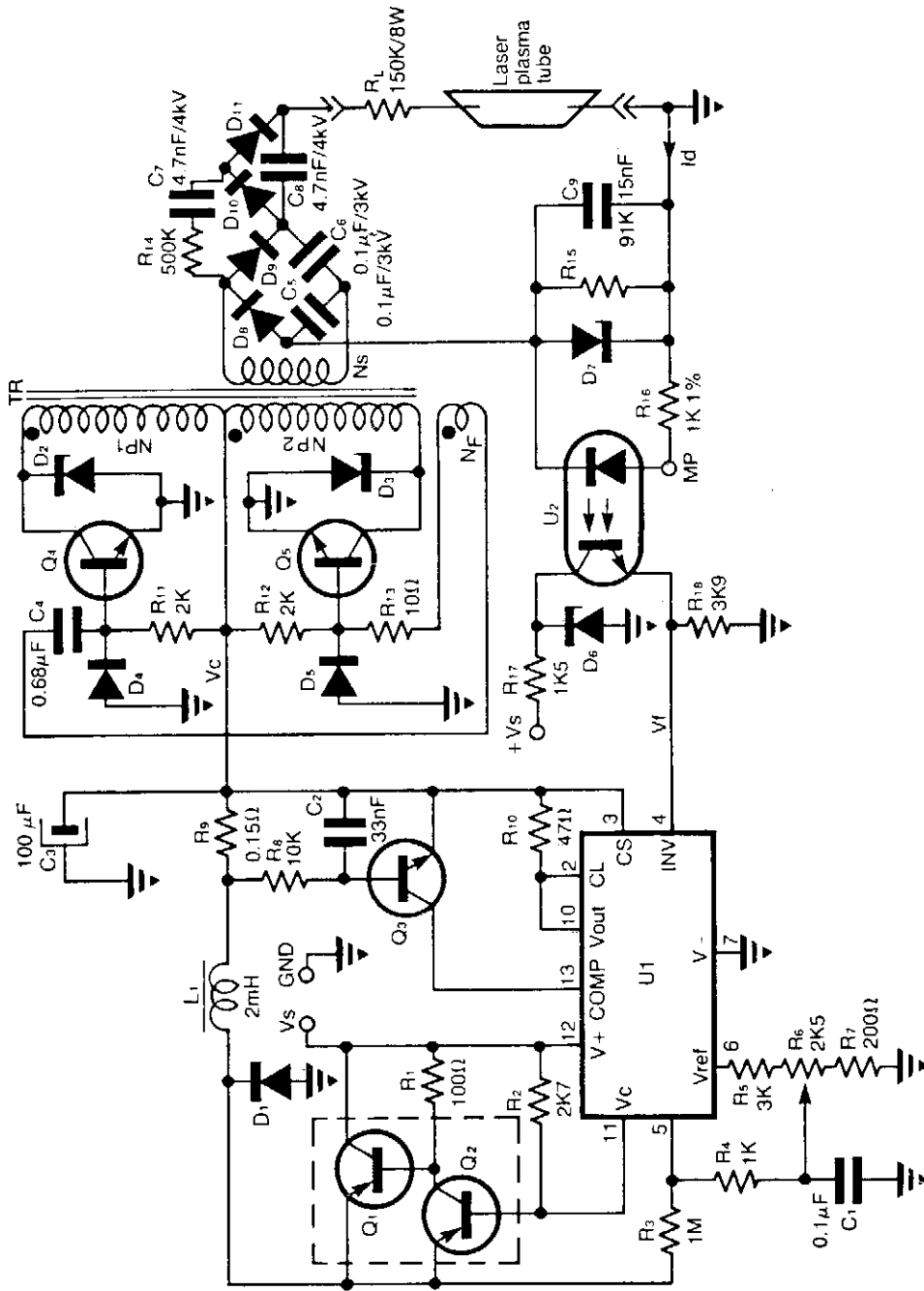


Fig. 50-2

U ₁	LM723	Np1 = Np2	8 turns	Q ₁	KD167	D ₁	BA159
U ₂	MB101	Ns	1100 turns	Q ₂	BD140	D ₂ : D ₃	PL33Z
		Nf	5 turns	Q ₃	BC173C	D ₄ : D ₅	1N4148
				Q ₄ : Q ₅	2N5496	O ₆	PL7V5
						D ₇	PL47Z
						D ₈ ...D ₁₁	LA40

Circuit Notes

The circuit uses a free-running push-pull dc to dc high voltage converter to get the necessary voltage for the laser plasma tube supply. The supply voltage V_C of this converter, is adjusted by a switch-mode power supply in order to keep the load current constant, at set value. The linear opto-electronic isolator U2, connected in series with the laser plasma tube, gives a voltage V_F proportional to the discharge current I_D across R18, having the correct polarity to drive directly the inverting input of U1, D7, R15 protects the optoisolator diode against damage produced by the high voltage ignition pulse.

Due to the high operating frequency of the high voltage converter (25 kHz) the ripple of the laser output power is less than $2 \cdot 10^{-4}$. The stability of I_D is better than 10^{-2} , for variations of supply voltage V_s is the range of $\pm 10\%$, and depends on the optoisolator sensitivity.

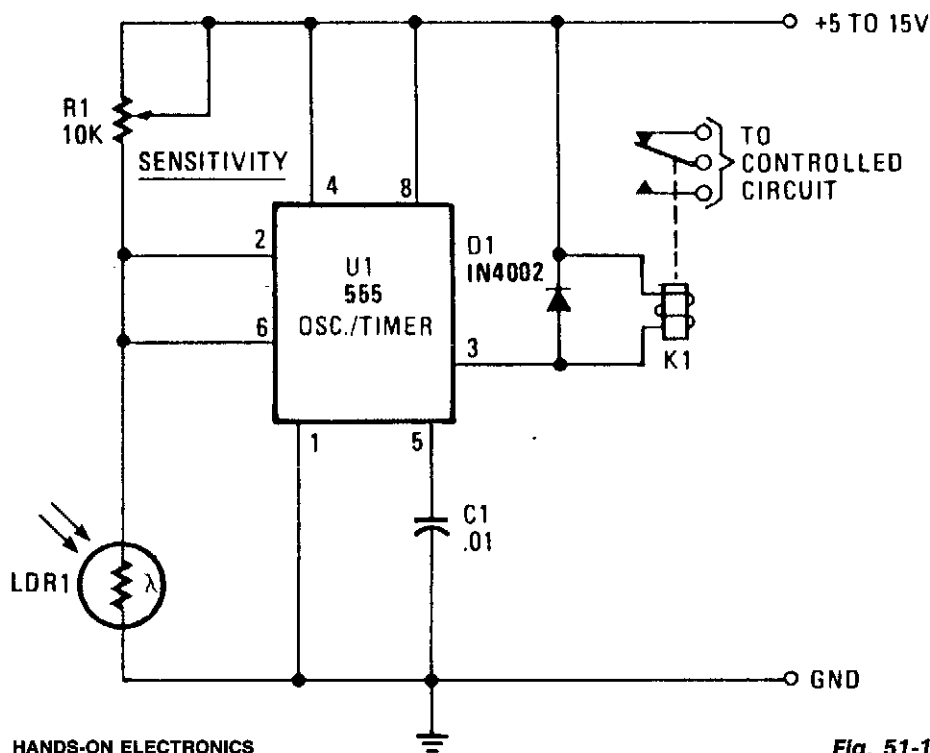
51

Light-Controlled Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Photo Alarm	Synchronous Photoelectric Switch
Warning Light Operates from Battery Power Supply	Photocurrent Integrator
Light Operated Switch	Robot Eyes
Photoelectric Switch	Modulated Light-Beam Circuit Cancels Ambient Light Effects
Back-Biased GaAsP LED Operates as Light Sensor	Monostable Photocell Circuit has Self-Adjusting Trigger Level
Twilight-Triggered Circuit	Thermally Stabilized PIN Photodiode Signal Conditioner
Automatic Mooring Light	
Electronic Wake-Up Call	
Photodiode Sensor Amplifier	
Light Seeking Robot	

PHOTO ALARM



Circuit Notes

LDR1, a cadmium sulphide (CDS) photoresistive cell is used as the lower leg of a voltage divider between V_{CC} and ground. The timer terminals 2 and 6 are connected to the junction of the photocell and SENSITIVITY control R1. The resistance of the photoresistive cell varies inversely as the light intensity; resistance is high when the illumination level is low; low in bright light. (The Radio Shack CDS cell 276-116 has a typically wide resistance range—about 3 megohms in darkness and 100 ohms in bright light.) When the light is interrupted or falls below a level set by SENSITIVITY control R1, the rise in LDR1's resistance causes the voltage on pins 2 and 6 to rise. If the control is set so the voltage rises above $\frac{2}{3} V_{CC}$, the relay pulls in. The relay drops out when the light level increases and the drop across the photocell falls below $\frac{1}{3} V_{CC}$. (The circuit can be modified by placing relay K1 and diode D1 between pin 3 and ground. In this case, the relay drops out when the voltage on pins 2 and 6 rises above $\frac{2}{3} V_{CC}$, and pulls in when it falls below $\frac{1}{3} V_{CC}$. This modification is valuable when the relay has single-throw contacts.) Opening and closing of the relay contacts occurs at different illumination levels. This $\frac{1}{3} V_{CC}$ hysteresis is an advantage that prevents the circuit from hunting and the relay from chattering when there are very small changes in illumination.

WARNING LIGHT OPERATES FROM BATTERY POWER SUPPLY

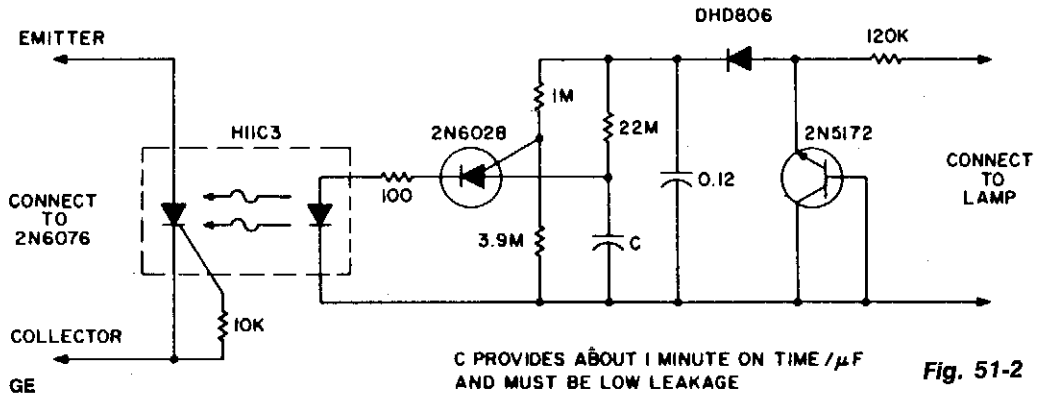
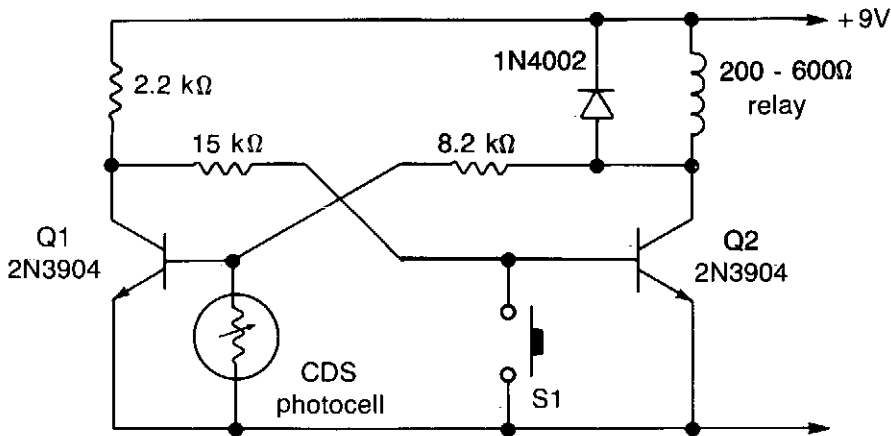


Fig. 51-2

Circuit Notes

The circuit provides illumination when darkness comes. By using the gain available in darlington transistors, this circuit is simplified to use just a photodarlington sensor, a darlington amplifier, and three resistors. The illumination level will be slightly lower than normal, and longer bulb life can be expected, since the D40K saturation voltage lowers the lamp operating voltage slightly.

LIGHT-OPERATED SWITCH



WILLIAM SHEETS

Fig. 51-3

Circuit Notes

This circuit uses a flip-flop arrangement of Q1 and Q2. Normally Q1 is conducting heavily. Light on CDS photocell causes Q1 bias to decrease, cutting it off, turning on Q2, removing the remaining bias from Q1. Reset is accomplished by depressing S1.

PHOTOELECTRIC SWITCH

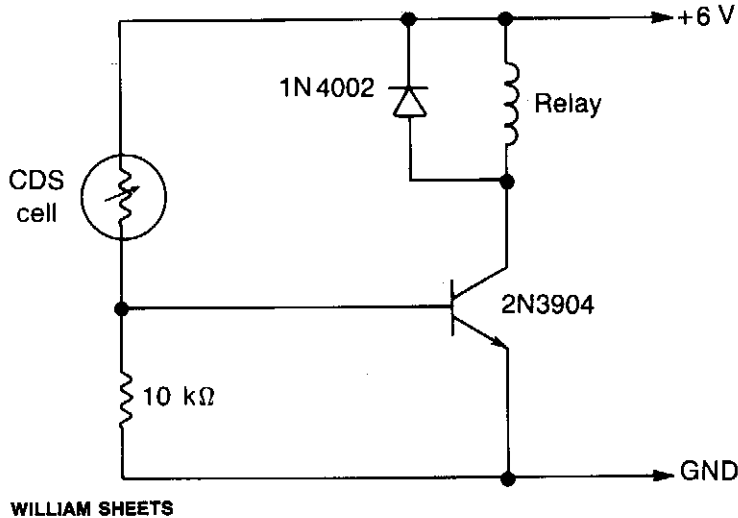


Fig. 51-4

Circuit Notes

The CDS cell resistance decreases in the presence of light, turning on the 2N3904 relay driver.

BACK-BIASED GaAsP LED OPERATES AS LIGHT SENSOR

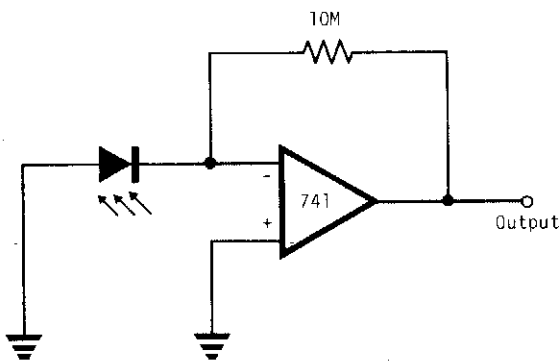
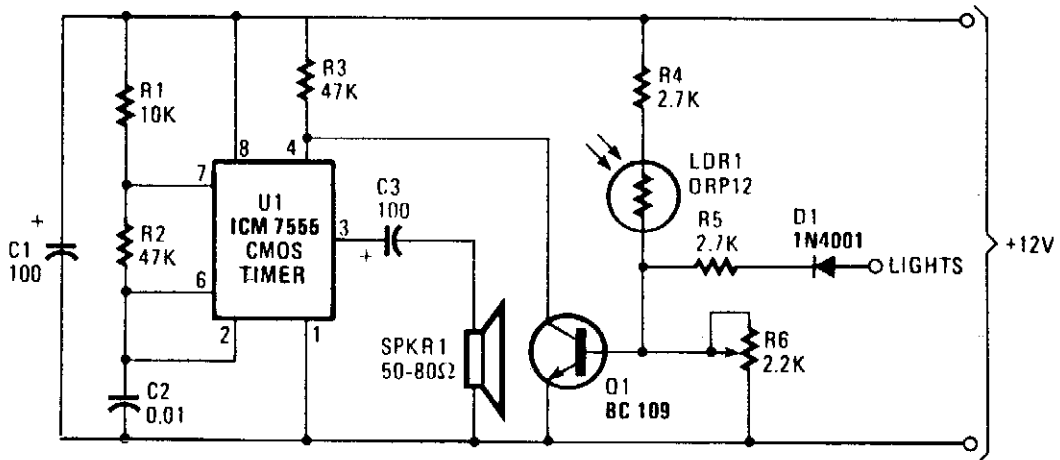


Fig. 51-5

Circuit Notes

Using a simple 741 amplifier connected as a current-to-voltage converter with the LED as the current source, the voltage at the output is proportional to incident light. The junction is biased only by the difference between the summing node junction potential and ground, preventing the possibility of reverse breakdown. The photon-generated current equals the short-circuit current of the junction, which is linearly related to incident light. The sensor requires a level of incident illumination that depends on the degree of opacity of the LED package.

TWILIGHT-TRIGGERED CIRCUIT



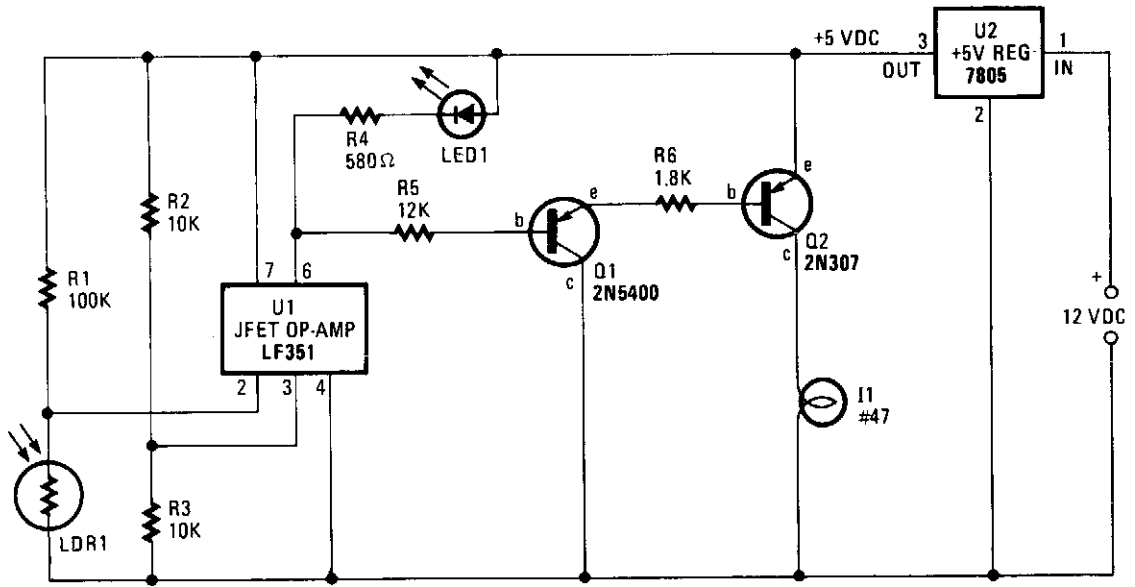
HANDS-ON ELECTRONICS

Fig. 51-6

Circuit Notes

As dusk begins to fall, the sensor (a cadmium-sulfide light-dependent resistor or LDR) operates a small horn to provide an audible reminder that it's time to turn on your lights. To turn the circuit off—simply turn your headlights on and the noise stops. The base of Q1 is fed through a voltage divider formed by R4, LDR1—a light-dependent resistor with an internal resistor of about 100 ohms under bright-light conditions and about 10 megohms in total darkness—potentiometer R6. Q1's base voltage depends on the light level received by LDR1 and the setting of R6. If LDR1 detects a high light level, its resistance decreases, thereby providing a greater base current for Q1, causing it to conduct. When Q1 conducts, pin 4 of U1 is pulled to near ground potential, muting the oscillator. If, on the other hand, LDR1 detects a low light level, its resistance increases (reducing base current to Q1), cutting off the transistor and enabling the oscillator. In actual practice, you set R6 so that at a suitable light level (dusk), the oscillator will sound. The anode of diode D1 connects to the light switch, where it connects to the vehicle's parking lights. With the lights switched off, that point is connected to the negative chassis by way of the parking lamp. That has no effect on the circuit, as D1 blocks any current flow to ground from Q1's base via R6 and the sidelight lamps. When the lights are switched on, the anode of D1 is connected to the positive supply via the parking lamp switch, thereby applying a voltage to the base of Q1, biasing it into conduction. With Q1 conducting, pin 4 of U1 is pulled virtually to ground, disabling the oscillator even though LDR1's resistance is not enough to do so.

AUTOMATIC MOORING LIGHT



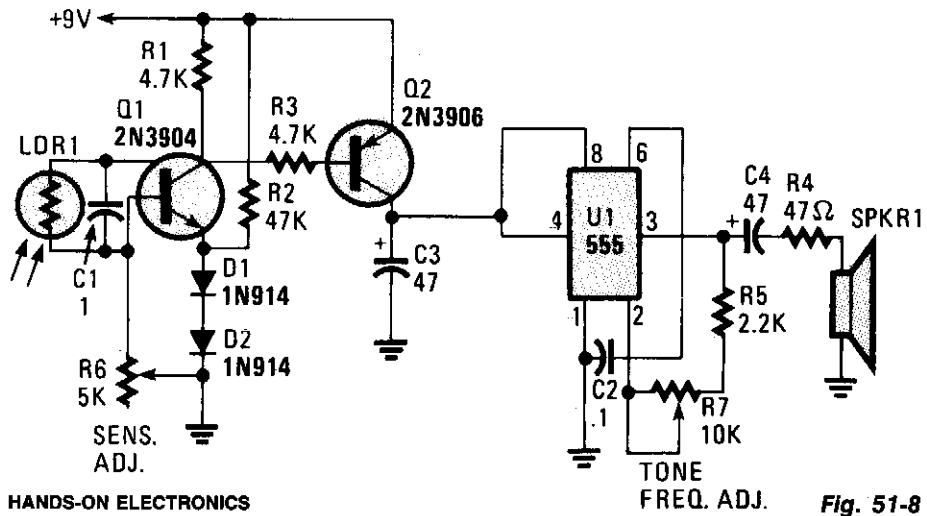
HANDS-ON ELECTRONICS

Fig. 51-7

Circuit Notes

Integrated-circuit U1—an LF351 or 741 op amp—is used as a comparator to control the light. Resistors R2 and R3 provide a reference voltage of about 2.5 volts at pin 3 of U1. When daylight falls on light-dependent resistor LDR1, its resistance is low: about 1000 ohms. In darkness, the LDR's resistance rises to about 1 megohm. Since R1 is 100,000 ohms, and the LDR in daylight is 1000 ohms, the voltage ratio is 100 to 1; the voltage drop across the LDR is less than the 2.5 volt reference voltage and pin 2 of U1 is held at that voltage. In that state, the output at pin 6 of U1 is positive at about 4.5 volts, a value that reverse-biases Q1 to cutoff, which in turn holds Q2 in cutoff, thereby keeping lamp I1 off. When darkness falls, the LDR's resistance rises above R1's value and the voltage at pin 2 of U1 rises above the reference voltage of 2.5 volts. U1's output terminal (pin 6) falls to less than a volt and Q1 is biased on. The base-to-emitter current flow turns Q2 on, which causes current to flow through the lamp. When daylight arrives, the LDR's resistance falls sharply, which causes the lamp to be turned off, ready to repeat the next night/day cycle.

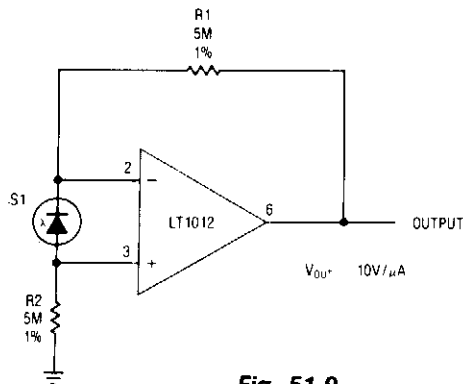
ELECTRONIC WAKE-UP CALL



Circuit Notes

A cadmium sulfide photocell (LDR1, which is a light-dependent resistor) is connected to the base and collector of an npn transistor, Q1. When light hits LDR1, the internal resistance goes from a very high (dark) value to a low (light) value, supplying base current to Q1, turning it on. The voltage across R1 produces a bias that turns Q2 on, which in turn, supplies the positive voltage to U1 at pin 8 (the positive-supply input) and pin 4 (the reset input), to operate the 555 audio oscillator circuit. The circuit's sensitivity to light can be set via R6 (a 50,000 ohm potentiometer). R7 sets the audio tone to the most desirable sound. The squarewave audio tone is fed from U1 pin 3 to a small speaker through coupling-capacitor C4 and current limiting resistor R4.

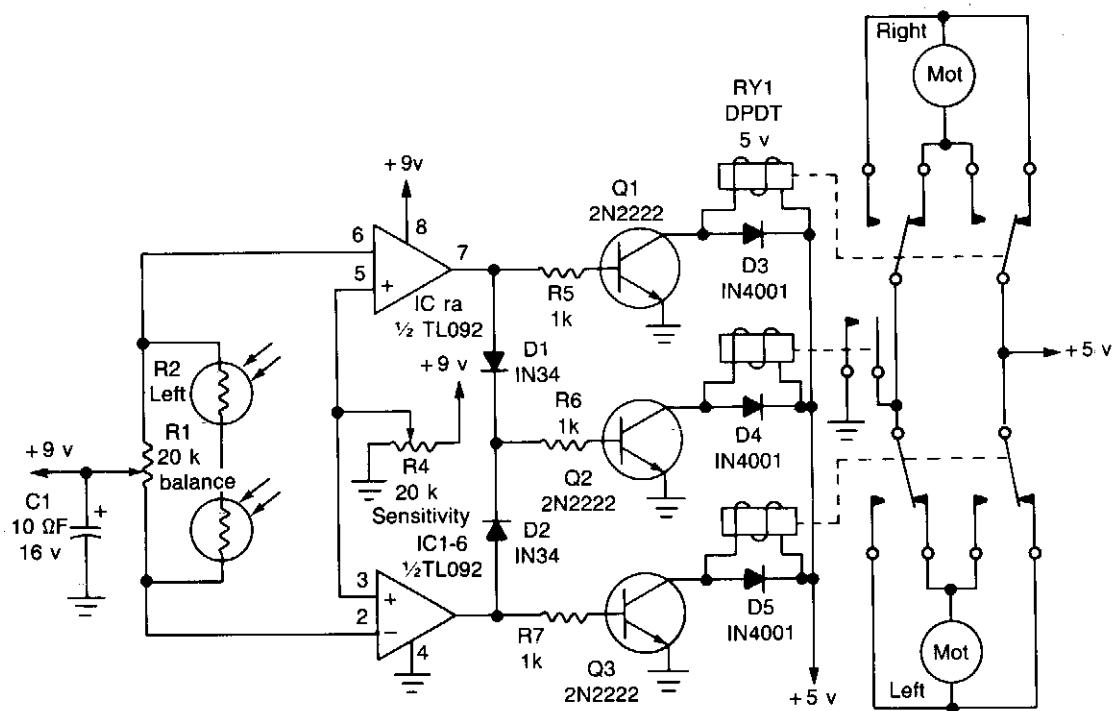
PHOTODIODE SENSOR AMPLIFIER



LINEAR TECHNOLOGY CORP.

Fig. 51-9

LIGHT-SEEKING ROBOT



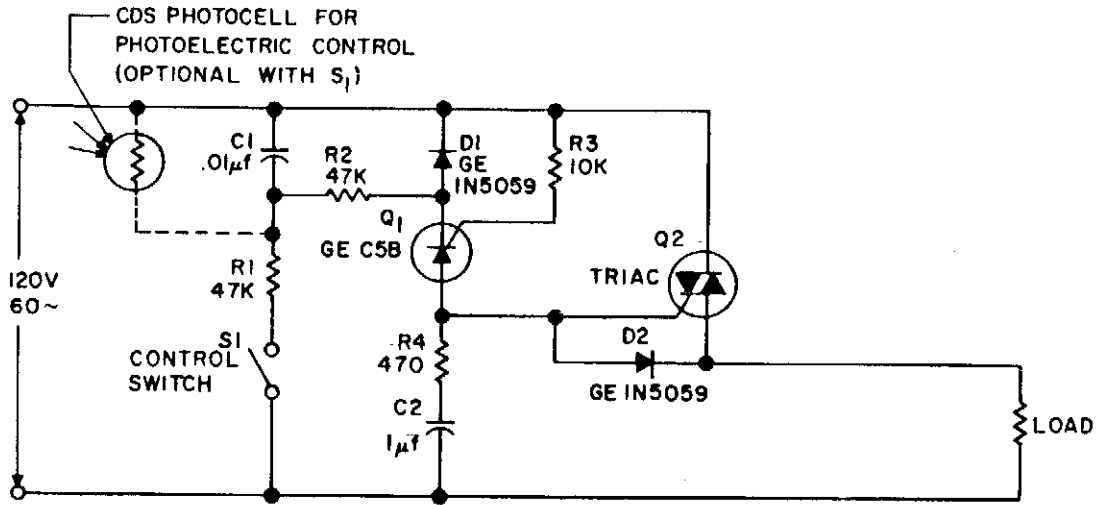
RADIO-ELECTRONICS

Fig. 51-10

Circuit Notes

The circuit is light seeking; it will follow a flashlight around a darkened room. A pair of photocells determine the direction in which the robot will move. Each photocell is connected to an op amp configured as a comparator. When sufficient light falls on photocell R2, the voltage at the inverting input (pin 6) of IC1-a will fall below the voltage at the non-inverting input (pin 5), so the output of the comparator will go high, and transistors Q1 and Q2 will turn on. That will enable relays RY1 and RY2, and thereby provide power for the right motor. The robot will then turn left. Likewise, when light falling on R3 lowers its resistance, Q2 and Q3 will turn on, the left motor will energize, and the robot will turn right.

SYNCHRONOUS PHOTOELECTRIC SWITCH



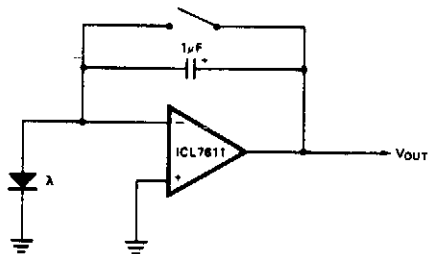
GENERAL ELECTRIC

Fig. 51-11

Circuit Notes

Synchronous switching is turning on only at the instant the ac supply voltage passes through zero, and turning off only when current passes through zero. This circuit provides this function in response to either a mechanical switch or a variable resistance such as a cadmium-sulfide photocell. This circuit produces the minimum disturbance to the power supply when switching, and always conducts an integral number of whole cycles. It is ideal for use wherever RFI and audio filtering is undesirable, where magnetizing inrush current of transformers causes nuisance fuse-blowing, and where sensitive equipment must operate in the vicinity of power switches.

PHOTOCURRENT INTEGRATOR



Circuit Notes

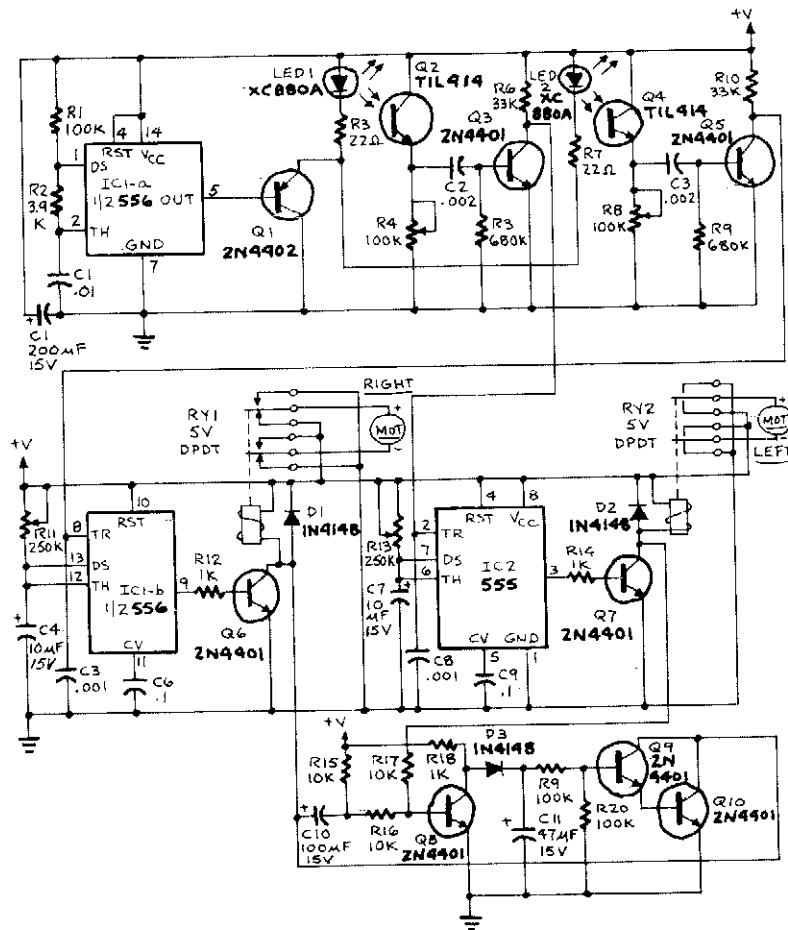
Low leakage currents allow integration times up to several hours.

0307-32

INTERSIL

Fig. 51-12

ROBOT EYES



RADIO ELECTRONICS

Fig. 51-13

Circuit Notes

An infrared LED and a phototransistor are used for each eye. Half of a 556 timer IC (IC1-a) functions as an astable multivibrator oscillating at a frequency of about 1 kHz. That IC drives transistor Q1 which in turn drives the two infrared LED's, LED1 and LED2. The right eye is composed of LED1 and Q2. If an obstacle appears in front of the right eye, pulses from LED1 are reflected by the obstacle and detected by Q2. The signal from Q2 is amplified by Q3, which triggers IC2, a 555. That IC operates in the monostable mode, and it provides a pulse output with a width of as much as 2.75 seconds, depending on the setting of R11. That pulse output energizes relay RY1, and that reverses the polarity of the voltage applied to the motor. Corresponding portions of the circuit of the left eye operate in the same fashion, using the unused half of the 556 (IC1-b). That action causes the robot to turn away from an obstacle.

MODULATED LIGHT-BEAM CIRCUIT CANCELS AMBIENT LIGHT EFFECTS

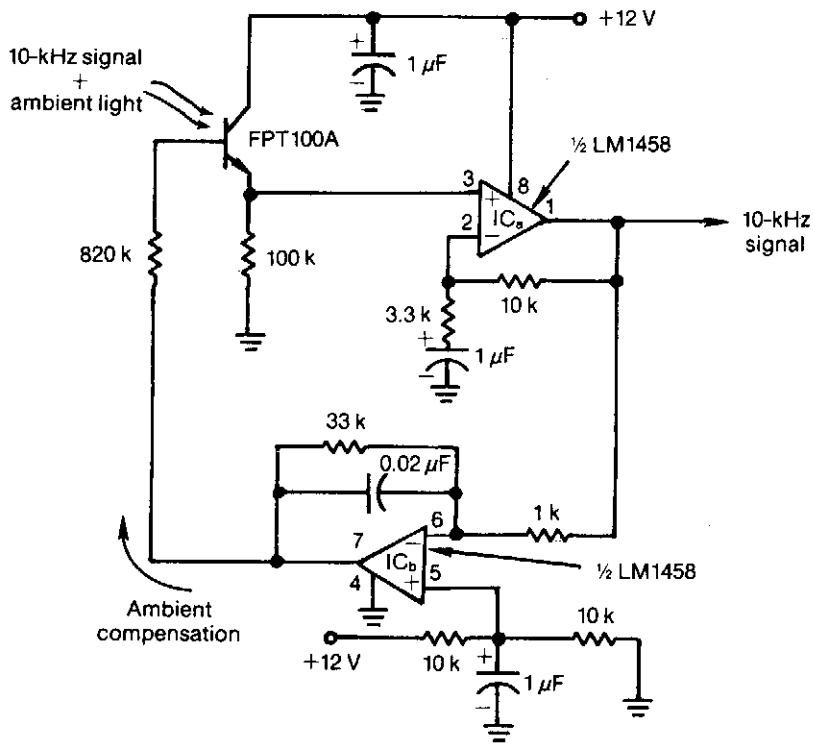


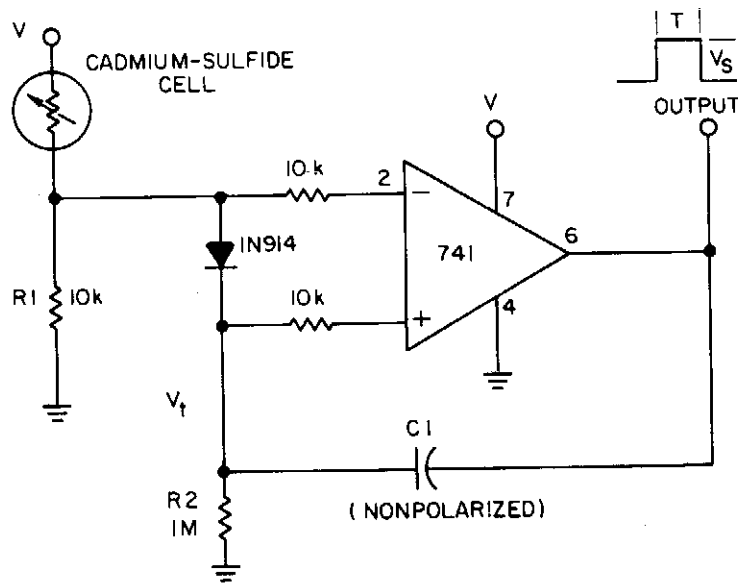
Fig. 51-14

ELECTRONIC DESIGN

Circuit Notes

Feedback control of the phototransistor in this optical detector helps negate the effects of varying ambient light sources. The output of a modulated visible-light LED is detected, amplified, buffered, and fed through a low-pass filter. Ambient light signals below the LED's 10-kHz modulating rate reach the detector's base out of phase with incoming ambient light and cancel the undesired effects.

MONOSTABLE PHOTOCELL CIRCUIT HAS SELF-ADJUSTING TRIGGER LEVEL



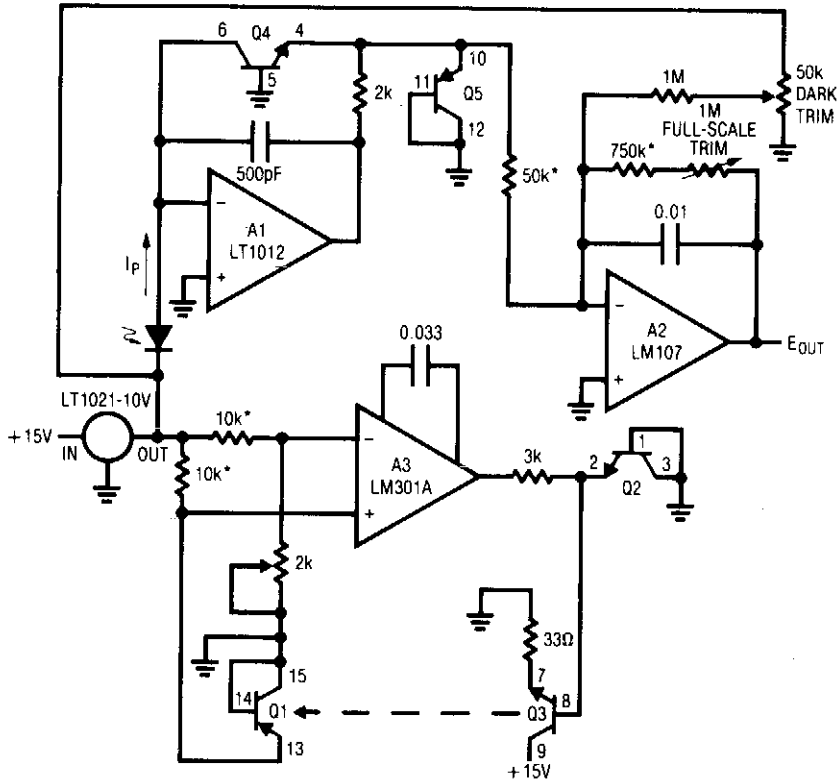
ELECTRONIC DESIGN

Fig. 51-15

Circuit Notes

A photocell circuit provides automatic threshold adjustment. Monostable action prevents undesired retriggering of the output. With only one op amp IC, the circuit offers: Automatic adjustment of its trigger level to accommodate various light sources, changes in ambient light and misalignments; A built-in monostable action to provide only a single output pulse during a preset time; Feedback action to raise the threshold level after triggering and to speed switching. The feedback also eliminates the circuit's tendency to oscillate during switching.

THERMALLY STABILIZED PIN PHOTODIODE SIGNAL CONDITIONER



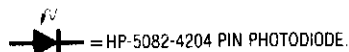
LINEAR TECHNOLOGY CORPORATION

Fig. 51-16

Circuit Notes

The photodiode specified responds linearly to light intensity over a 100 dB range. Digitizing the diode's linearly amplified output would require an A-D converter with 17 bits of range. This requirement can be eliminated by logarithmically compressing the diode's output in the signal conditioning circuitry. A1 and Q4 convert the diode's photocurrent to voltage output with a logarithmic transfer function. A2 provides offsetting and additional gain. A3 and its associated components form a temperature control loop

LIGHT (900 μ M)	RESPONSE DATA	
	DIODE CURRENT	CIRCUIT OUTPUT
1mW	350 μ A	10.0V
100 μ W	35 μ A	7.85V
10 μ W	3.5 μ A	5.70V
1 μ W	350nA	3.55V
100nW	35nA	1.40V
10nW	3.5nA	-0.75V



= HP-5082-4204 PIN PHOTODIODE.

Q1-Q5 = CA3096.

CONNECT SUBSTRATE OF CA3096

ARRAY TO Q4'S EMITTER.

* 1% RESISTOR

which maintains Q4 at constant temperature (all transistors in this circuit are part of a CA3096 monolithic array). The 0.033 μ F value at A3's compensation pins gives good loop damping if the circuit is built using the array's transistors in the location shown. Because of the array die's small size, response is quick and clean. A full-scale step requires only 250 ms to settle to final value. To use this circuit, first set the thermal control loop. To do this, ground Q3's base and set the 2 k pot so A3's negative input voltage is 55 mV above its positive input. This places the servo's setpoint at about 50°C (25°C ambient + (2.2 mV/°C \times 25°C rise = 55 mV = 50°C). Unground Q3's base and the array will come to temperature. Next, place the photodiode in a completely dark environment and adjust the "dark trim" so A2's output is 0 V. Finally, apply or electrically simulate 1 mW of light and set the "full-scale" trim for 10 V out. Once adjusted, this circuit responds logarithmically to light inputs from 10nW to 1mW with an accuracy limited by the diode's 1% error.

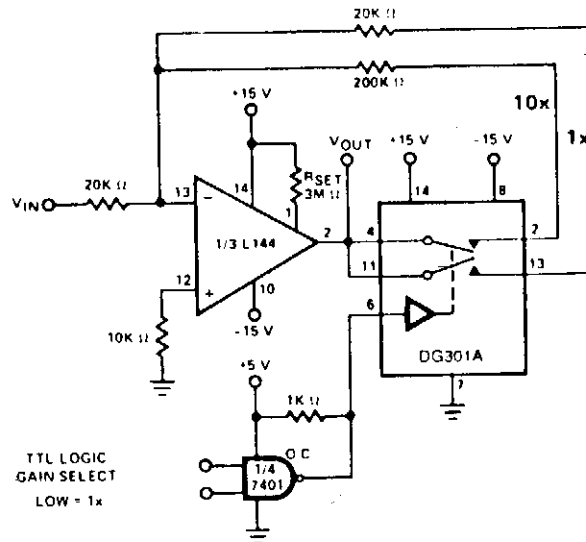
52

Logic Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- Low Power Inverting Amplifier with Digitally Selectable Gain
- Low Power Binary to 10^N Gain Low Frequency Amplifier
- Low Power Non-Inverting Amplifier with Digitally Selectable Inputs and Gain
- Programmable Amplifier
- A Precision Amplifier with Digitally Programmable Inputs and Gains

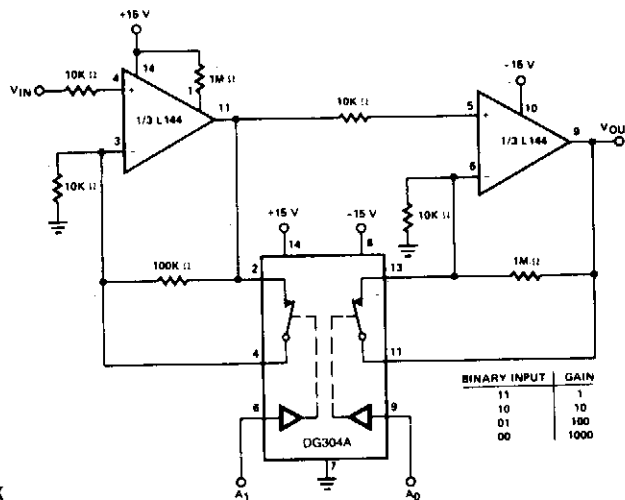
LOW POWER INVERTING AMPLIFIER WITH DIGITALLY SELECTABLE GAIN



SILICONIX

Fig. 52-1

LOW POWER BINARY TO 10^n GAIN LOW FREQUENCY AMPLIFIER



SILICONIX

Fig. 52-2

Circuit Notes

Gain increases by decades as the binary input decreases from 1,1 to 0,0. Minimum gain is 1 and maximum gain is 1000. Since the switch is static in this type of amplifier the power dissipation of the switch will be less than a tenth of a milliwatt.

LOW POWER NON-INVERTING AMPLIFIER WITH DIGITALLY SELECTABLE INPUTS AND GAIN

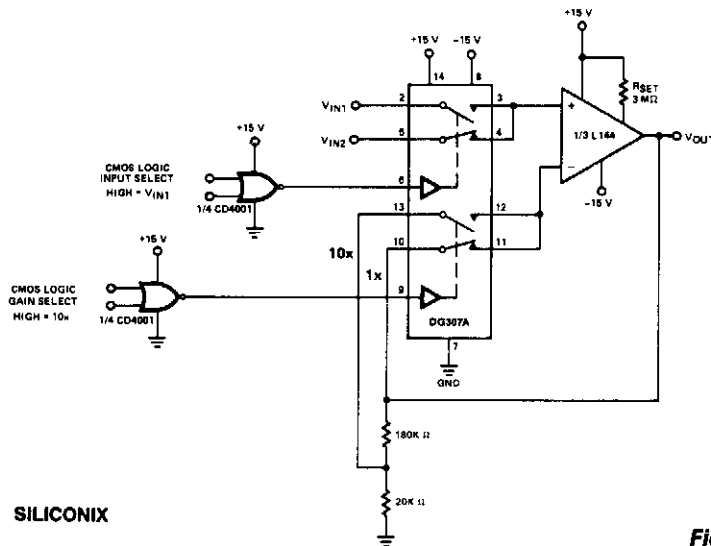


Fig. 52-3

PROGRAMMABLE AMPLIFIER

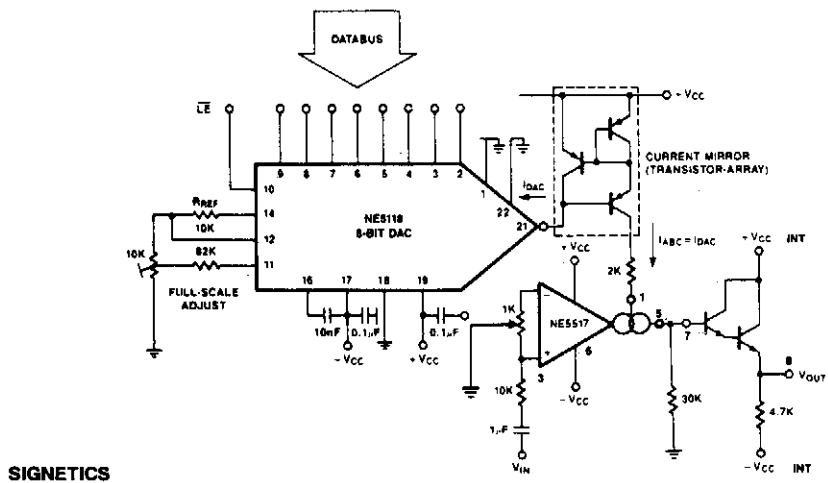
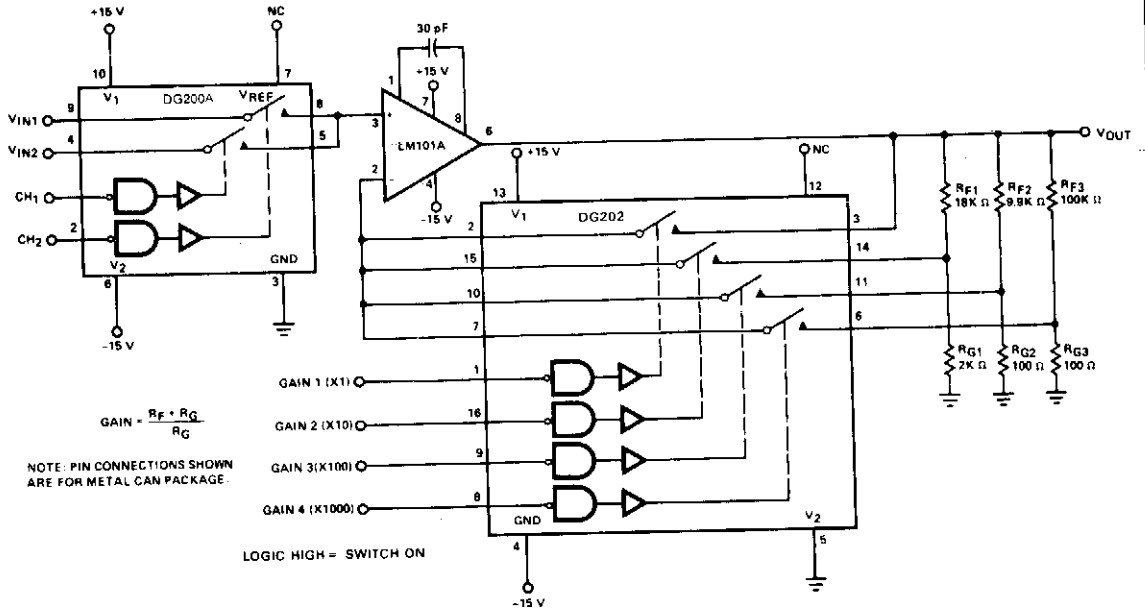


Fig. 52-4

Circuit Notes

The intention of the following application shows how the NE5517 works in connection with a DAC. In the application, the NE5118 is used—an 8-bit DAC with current output—its input register making this device fully μ P-compatible. The circuit consists of three functional blocks; the NE5118 which generates a control current equivalent to the applied data byte, a current mirror, and the NE5517.

A PRECISION AMPLIFIER WITH DIGITALLY PROGRAMMABLE INPUTS AND GAIN



SILICONIX

Fig. 52-5

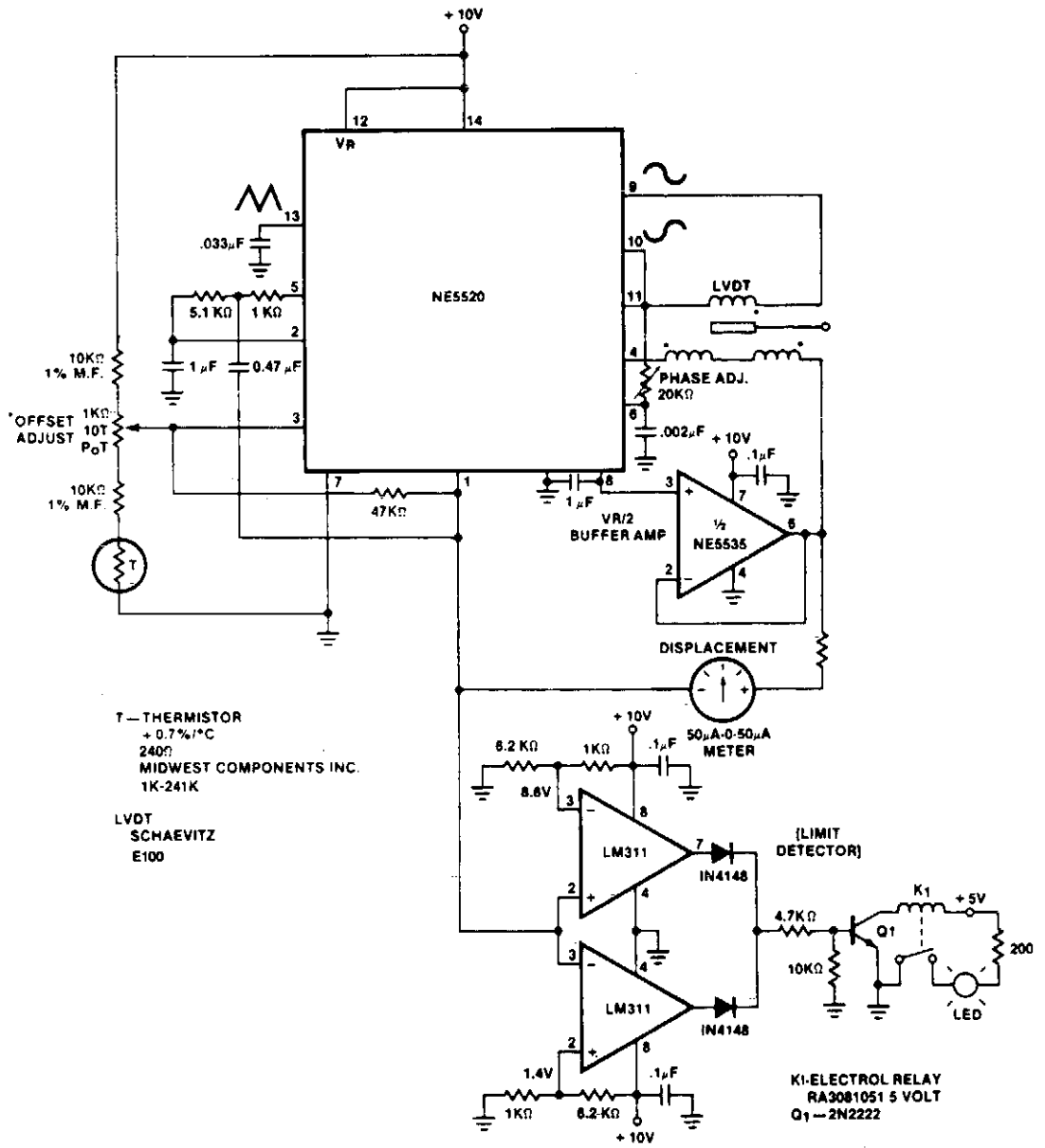
53

LVDT Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

LVDT Driver Demodulator
Linear Variable Differential Transformer Signal
Conditioner

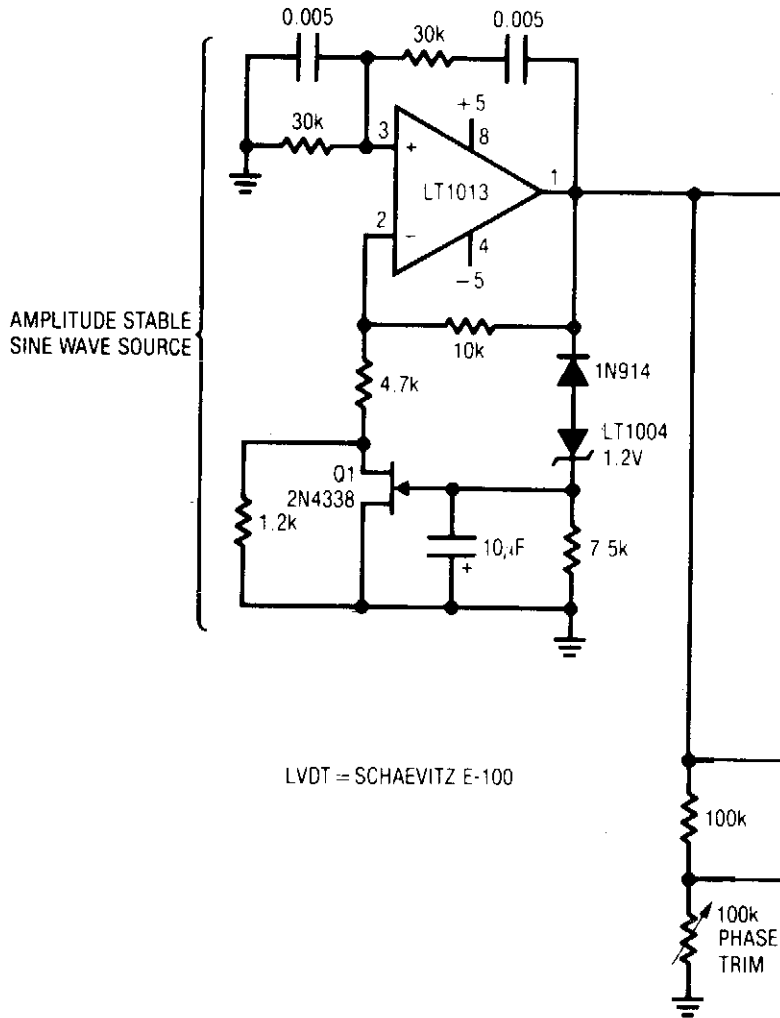
LVDT DRIVER DEMODULATOR



SIGNETICS

Fig. 53-1

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER SIGNAL CONDITIONER

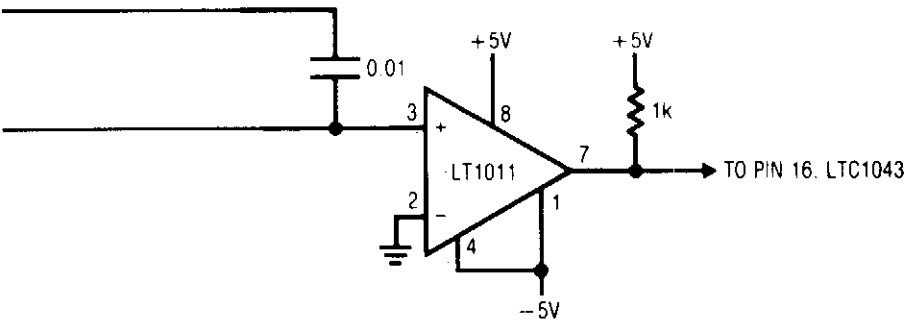
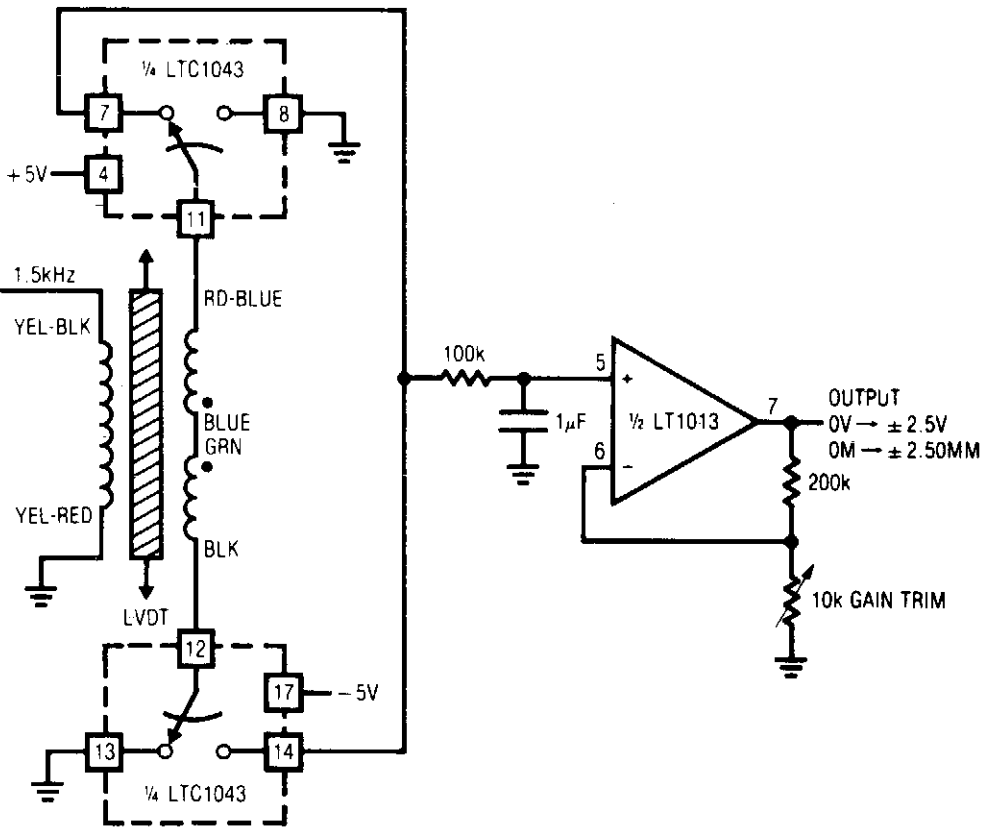


LINEAR TECHNOLOGY CORPORATION

Fig. 53-2

Circuit Notes

A1 and its associated components furnish an amplitude stable sine wave source. A1's positive feedback path is a Wein bridge, tuned for 1.5 kHz, Q1, the LT1004 reference, and additional components in A1's negative loop unity-gain stabilize the amplifier. A1's output an amplitude stable sine wave, drives the LVDT. C1 detects zero crossings and feeds the LTC1043 clock pin. A speed-up network at C1's input compensates LVDT phase shift, synchronizing the LTC1043's clock to the transformer's output zero



crossings. The LTC1043 alternately connects each end of the transformer to ground, resulting in positive half-wave rectification at pins 7 and 14. These points are summed at a low-pass filter which feeds A2. A2 furnishes gain scaling and the circuit's output. The LTC1043's synchronized clocking means the information presented to the low-pass filter is amplitude and phase sensitive. The circuit output indicates how far the core is from center and on which side. To calibrate this circuit, center the LVDT core in the transformer and adjust the phase trim for 0 V output. Next, move the core to either extreme position and set the gain trim for 2.50 V output.

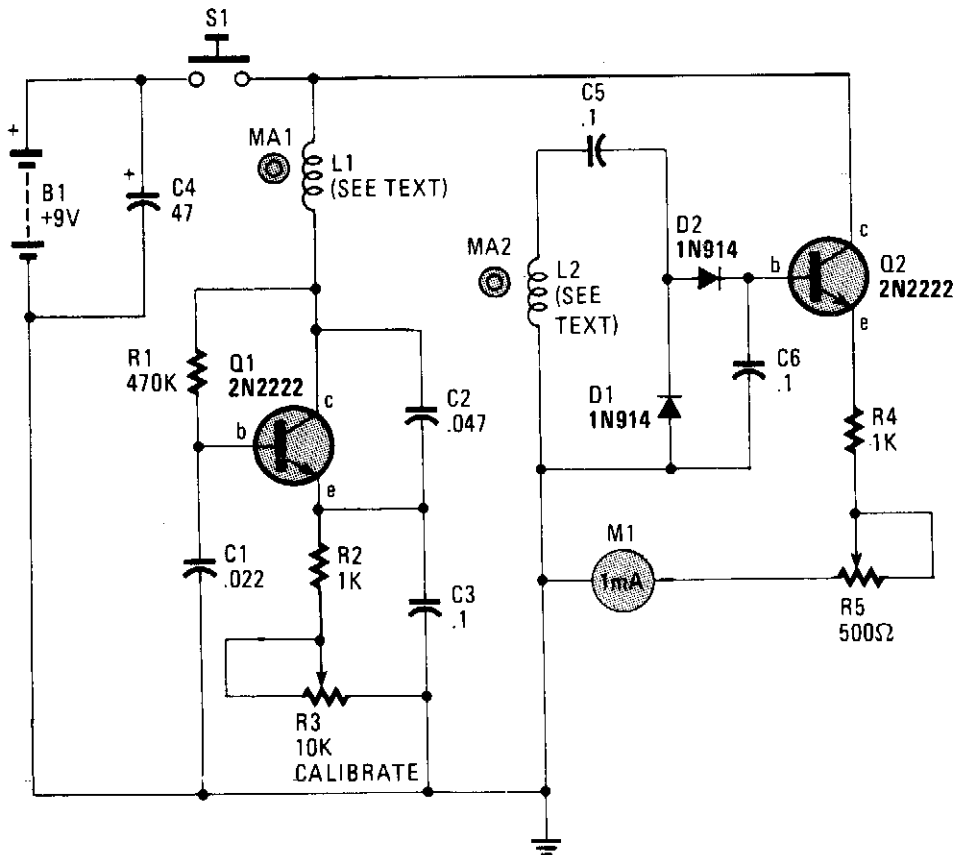
54

Measuring and Test Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Magnetometer
Resistance-Ratio Detector
Continuity Tester for PCB's
Wire Tracer
Diode Testing
Measuring Phase Difference from 0° to $\pm 180^\circ$
Ground Tester
Making Slow Logic Pulses Audible
Unidirectional Motion Sensor

MAGNETOMETER



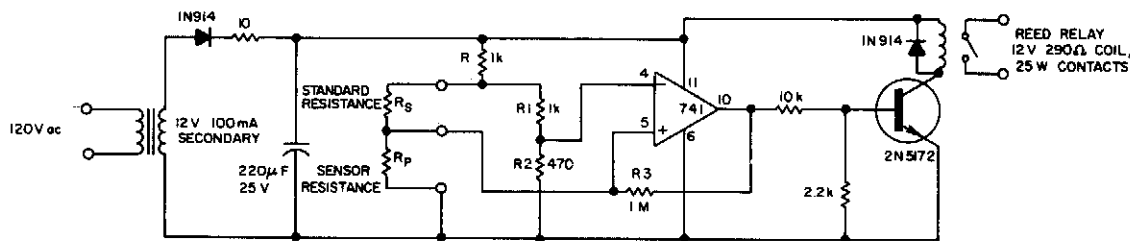
HANDS-ON ELECTRONICS

Fig. 54-1

Circuit Notes

The circuit uses two general-purpose npn transistors, Q1 and Q2, and a special hand-wound, dual-coil probe ferrets out the magnetism. Q1 and its associated components form a simple VLF oscillator circuit, with L1, C2, and C3 setting the frequency. The VLF signal received by the pickup coil, L2, is passed through C5 and rectified by diodes D1 and D2. The small dc signal output from the rectifier is fed to the base of Q2 (configured as an emitter follower), which is then fed to a 0-1 mA meter, M1.

RESISTANCE-RATIO DETECTOR



ELECTRONIC DESIGN

Fig. 54-2

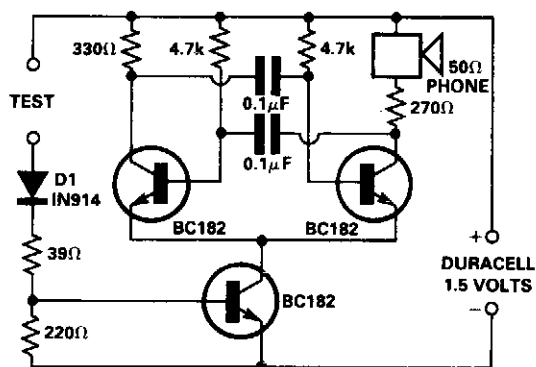
Circuit Notes

Applications such as photoelectric control, temperature detection and moisture sensing require a circuit that can accurately detect a given resistance ratio. A simple technique that uses an op amp as a sensing element can provide 0.5% accuracy with low parts cost. The reed-relay contacts close when the resistance of the sensor R_p equals 47% of the standard R_s . Adjusting either R_1 or R_2 provides a variable threshold; the threshold is controlled by varying R_3 . For the most part, the type of resistors used for R_1 and R_2 determines the accuracy and stability of the circuit. With metal-film resistors, less than 0.5% change in ratio sensing occurs over the commercial temperature range (0 to 70 C) with ac input variations from 105 to 135 V.

CONTINUITY TESTER FOR PCB'S

Circuit Notes

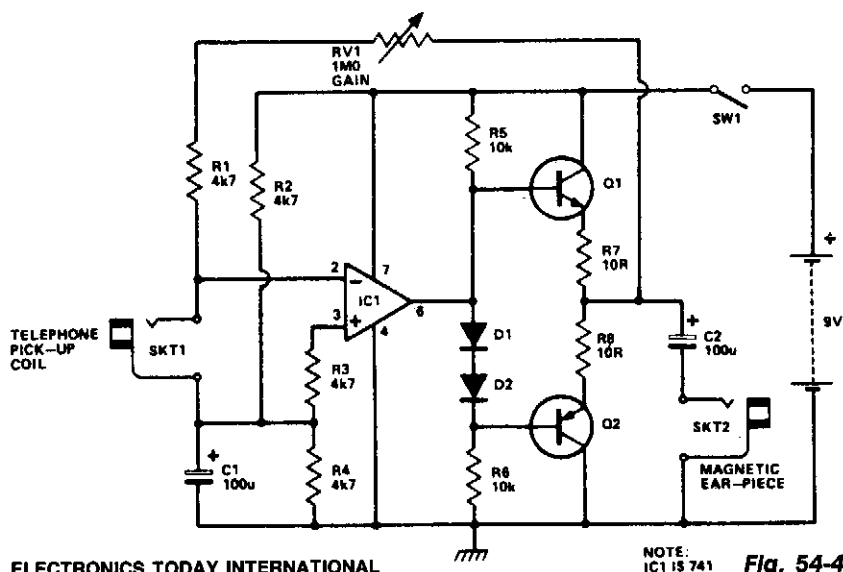
The continuity tester is for tracing wiring on printed circuit boards. It only consumes any appreciable power when the test leads are shorted, so no On/Off switch is used or required. The applied voltage at the test terminals is insufficient to turn on diodes or other semiconductors. Resistors below 50 ohms act as short circuit; above 100 ohms as open circuit. The circuit is a simple multivibrator—T1 and T2, which are switched on by transistor T3. The components in the base of T3 are D1, R1, R2, and the test resistance. With a 1.5 volt supply, there is insufficient voltage to turn on a semiconductor connected to the test terminals. The phone is a telephone earpiece but a 30 ohm speaker would work equally as well.



ELECTRONIC ENGINEERING

Fig. 54-3

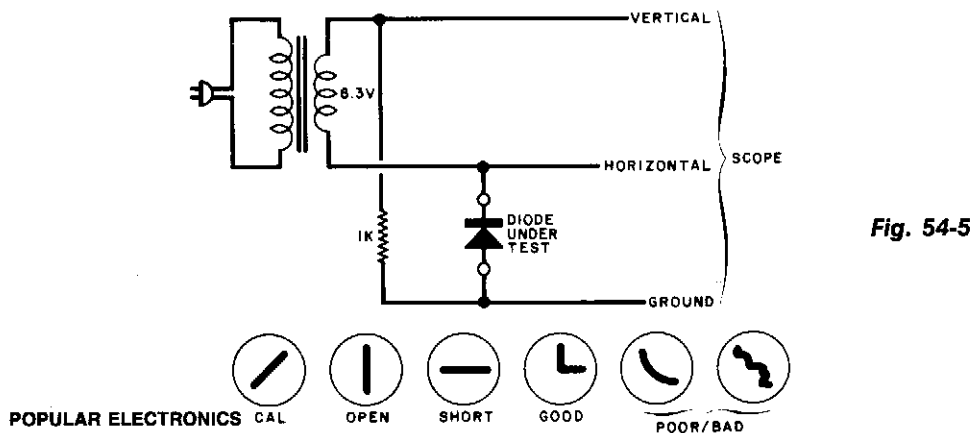
WIRE TRACER



Circuit Notes

The tracer detects the weak magnetic field of any current-carrying house wiring and amplifies this signal to a level that is adequate for driving a magnetic earpiece. The unit uses a telephone pick-up coil to detect the magnetic field.

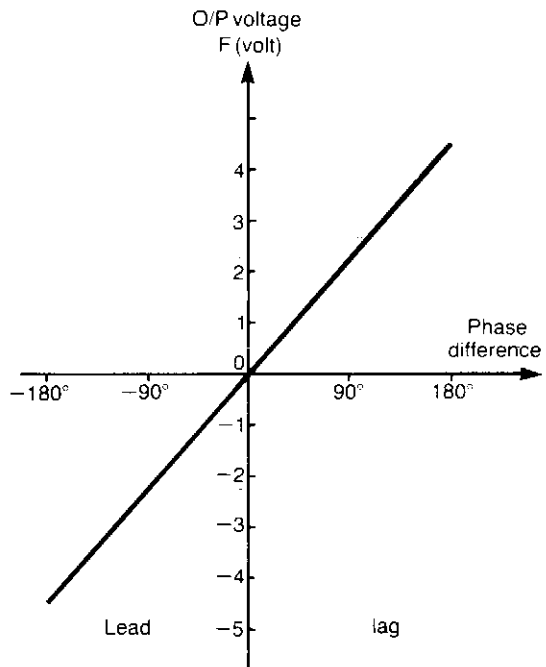
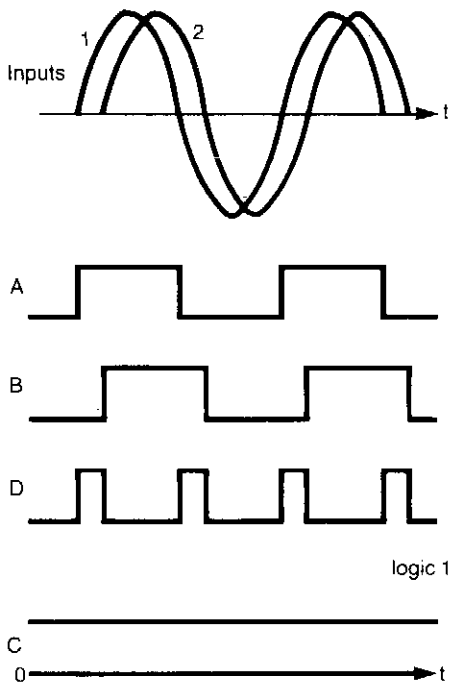
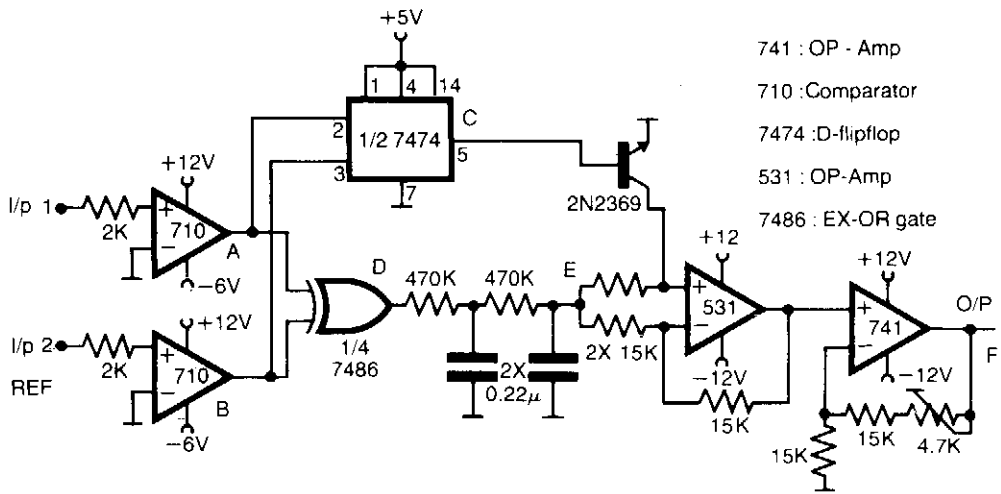
DIODE TESTING



Circuit Notes

The circuit will display curves on a scope, contingent on the state of the diode. To "calibrate," substitute a 1000-ohm resistor for the diode and adjust the scope gains for a 45-degree line. The drawings show some expected results.

MEASURING PHASE DIFFERENCE FROM 0° to $\pm 180^\circ$

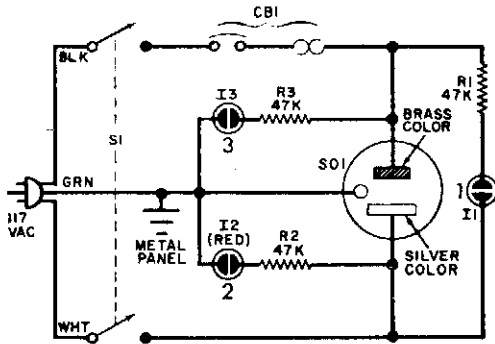


MEASURING PHASE DIFFERENCE FROM 0° to ±180°, Continued.

Circuit Notes

This method is capable of measuring phase between 0 to ±180°. The generated square waves A and B are fed to a D flip-flop which gives an output C equal to logic 1 when input 1 leads input 2 and equal to logic 0 in case of lagging. When C = logic 0, the output of the amplifier F will be positive proportional to the average value E of the output of the EX-OR. When C = logic 1, F will be negative and also proportional to E by the same factor. Hence, the output of the meter is positive in case of lagging and negative for leading. The circuit is tested for sinusoidal inputs and indicates a linearity within 1%. Measurements are unaffected by the frequency of the inputs up to 75 kHz.

GROUND TESTER



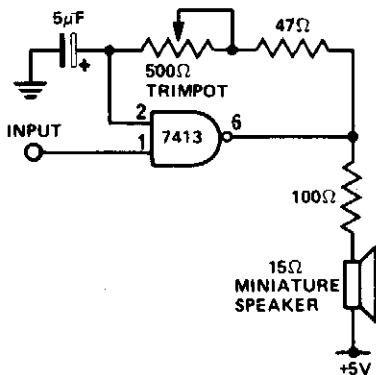
Circuit Notes

The circuit is simple and foolproof if wired correctly. Under normal conditions, only lamps 1 and 3 should be lit. If lamp 2 comes on, the cold lead is 117 volts above ground.

POPULAR ELECTRONICS

Fig. 54-7

MAKING SLOW LOGIC PULSES AUDIBLE



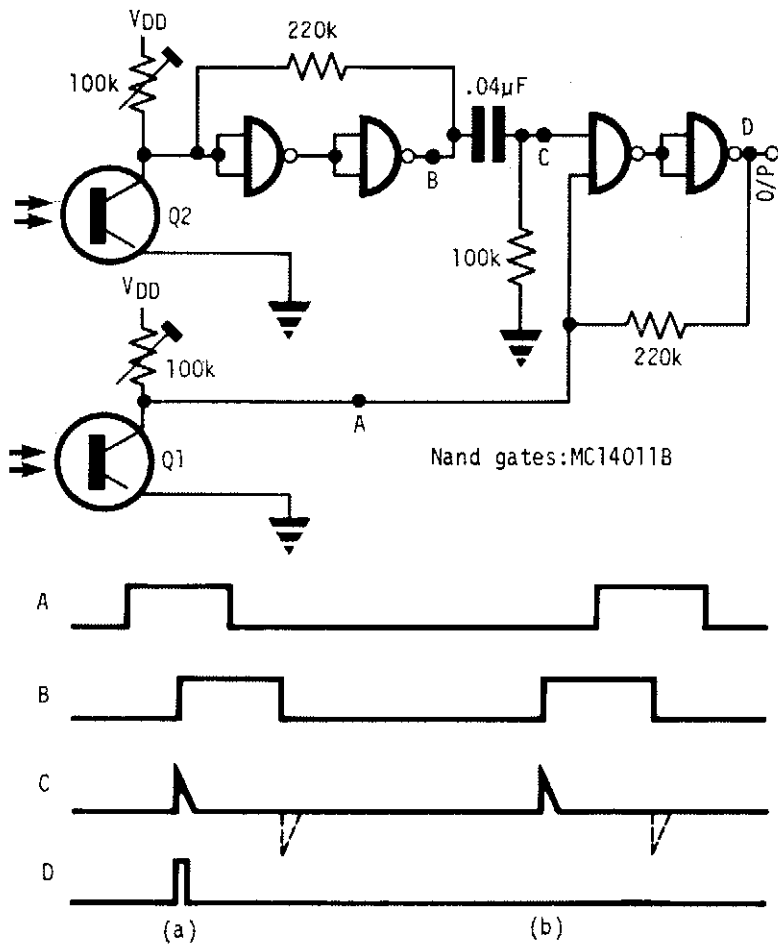
Circuit Notes

This circuit is useful for monitoring slow logic pulses as a keying monitor or digital clock alarm. The Schmitt trigger is connected as an oscillator. The trimpot controls the pitch of the output. When the input goes high, the circuit will oscillate.

ELECTRONICS TODAY INTERNATIONAL

Fig. 54-8

UNIDIRECTIONAL MOTION SENSOR



ELECTRONIC ENGINEERING

Fig. 54-9

Circuit Notes

This circuit detects an object passing in one direction but ignores it going the opposite way. Two sensors define the sense of direction. The object blocks the light to phototransistor Q1 or Q2 first dependent on the direction of approach. When the object passes Q1 then Q2, an output pulse is generated at D; while no pulse is seen at D as the object passes Q2 then Q1. Object length (measured along the direction of the two sensors) should be greater than the separation of the two sensors Q1 and Q2.

55

Medical Electronics Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Heart Rate Monitor
Medical Instrument Preamplifier

HEART RATE MONITOR

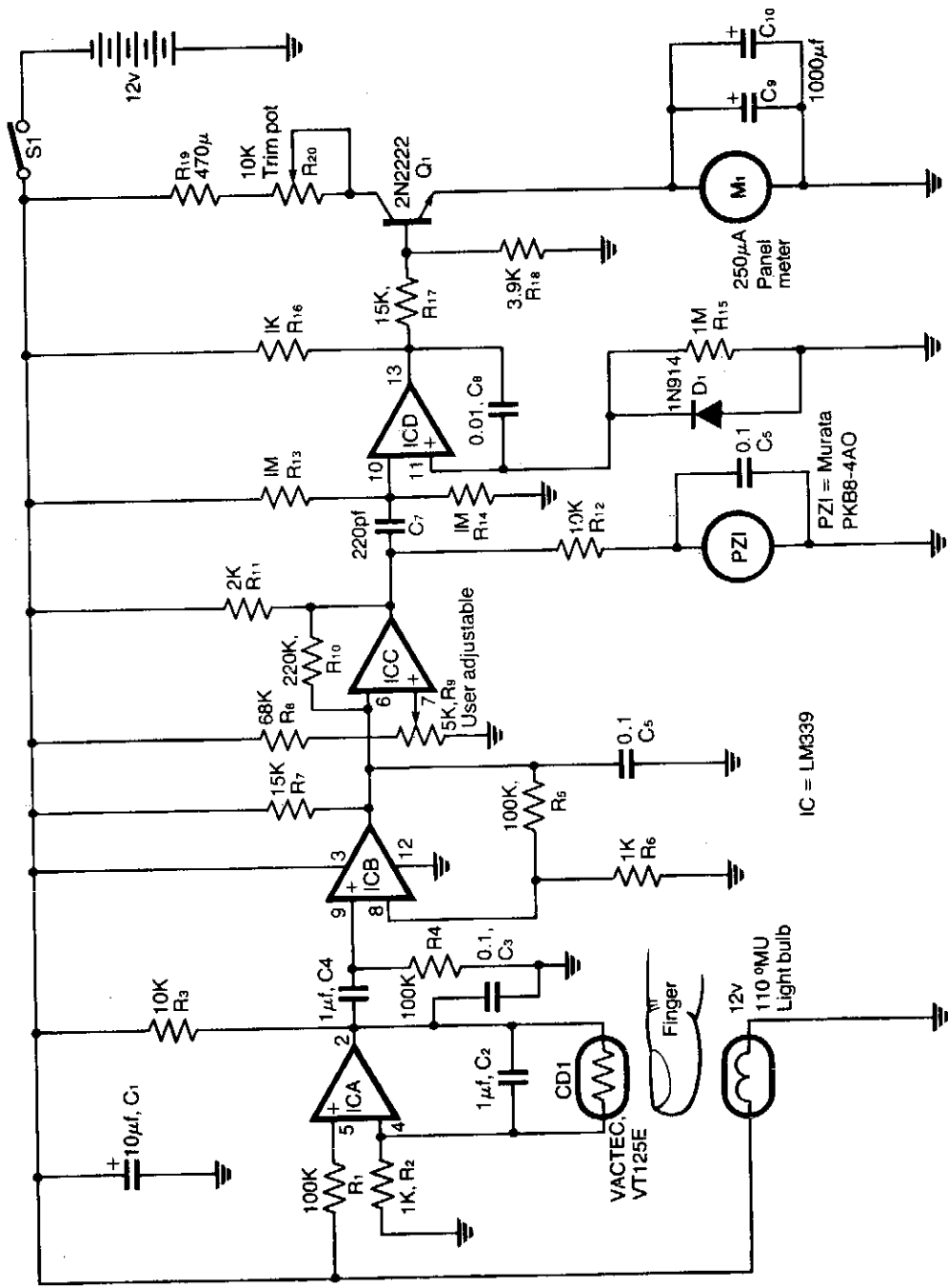


Fig. 55-1

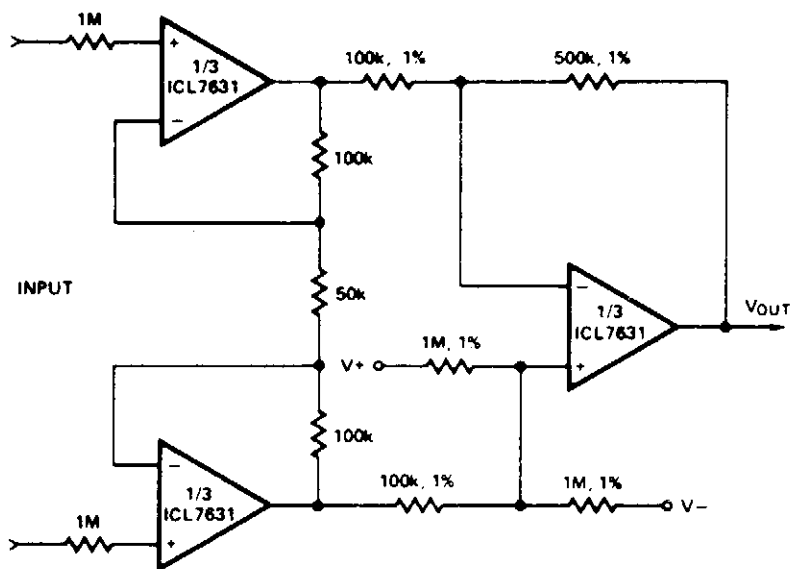
ELECTRONIC ENGINEERING

HEART RATE MONITOR, Continued.

Circuit Notes

Light filtering through the finger tip is detected by the cadmium sulphide photoresistor CD1 which forms the feedback network for transducer amplifier section ICA producing a weak signal which is further amplified by ICB. This signal is now compared against a user adjusted threshold, comparator ICD triggers gating on the piezoelectric buzzer PZ1. On each falling edge of the comparator's output signal one-shot multivibrator ICD produces a $2 \mu\text{s}$ pulse which is inverted by Q1 and averaged by the RC network consisting of M1, C6 and C7. The 10 K trimpot R20 in Q1's collector circuit sets the scale factor for M_1 where full scale is 150 beats per minute.

MEDICAL INSTRUMENT PREAMPLIFIER



INTERSIL

Fig. 55-2

Circuit Notes

Note that $A_{VOL} = 25$; single Ni-cad battery operation. Input current (from sensors connected to the patient) is limited to less than $5 \mu\text{A}$ under fault conditions.

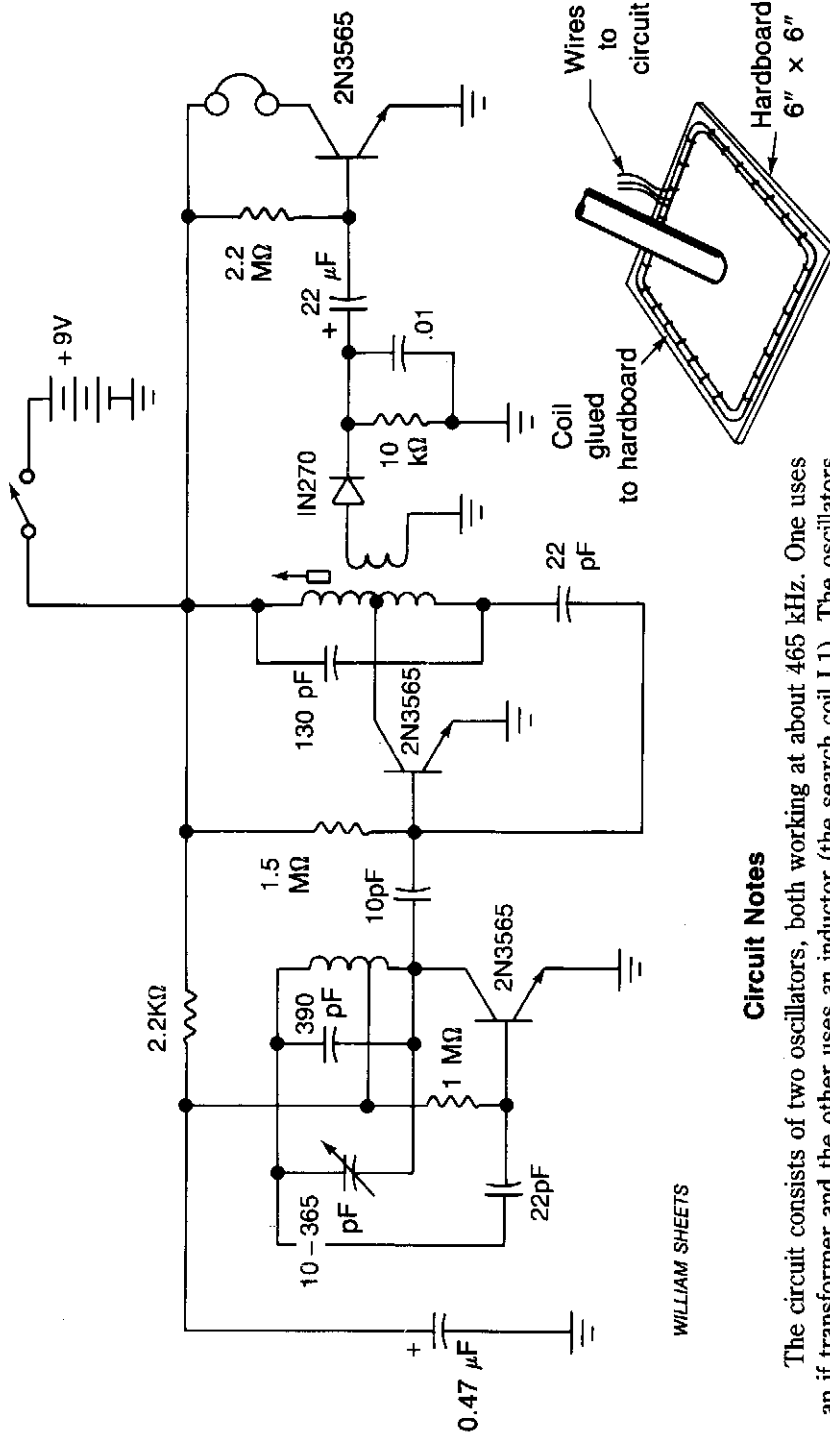
56

Metal Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Metal Locator II
Metal Locator

METAL LOCATOR II



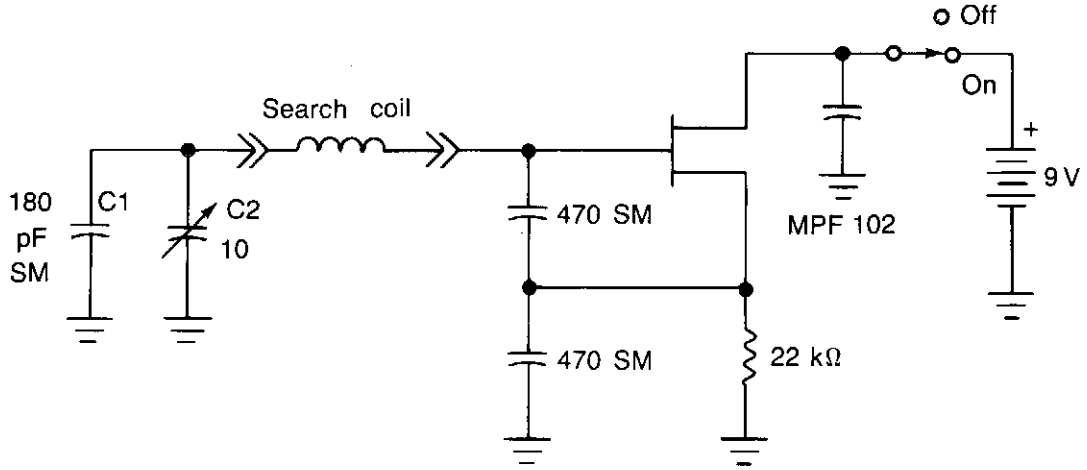
WILLIAM SHEETS

Circuit Notes

The circuit consists of two oscillators, both working at about 465 kHz. One uses an if transformer and the other uses an inductor (the search coil L1). The oscillators are coupled by a capacitor (10 pF). A beat note (produced if the two oscillators are working closely together) is detected by the diode and fed to the headphone amplifier and the 22 μF capacitor. The search coil oscillator is tuned by a 10-365 pf variable capacitor. The search coil comprises 22 turns of wire (any gauge between 24 swg and 36 swg enamel) center tapped. The wire should be wound on a temporary form then taped and glued to a piece of hardboard. The coil size should be about 6" x 6". Headphones should be high impedance.

Fig. 56-1

METAL LOCATOR



WILLIAM SHEETS

Fig. 56-2

Circuit Notes

The search coil, C1 and C2 form a tuned circuit for the oscillator which is tuned near the center of the broadcast band. Tune a portable radio to a station near the middle of the band, then tune C2 until a squeal is heard as the two signals mix to produce a beat (heterodyne) note. Metal near the search coil will detune the circuit slightly, changing the pitch of the squeal. The search coil is 20 turns of number 30 enameled wire, wound on a 6" × 8" wood or plastic form. It is affixed at the end of a 30" to 40" wooden or plastic pole, and connected to the remainder of the metal detector circuit through a coaxial cable.

57

Metronomes

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Simple Metronome
Metronome I
Ac-Line Operated Unijunction Metronome
Metronome II

SIMPLE METRONOME

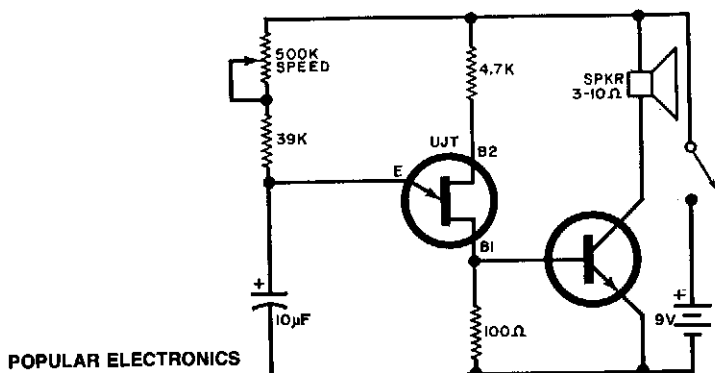


Fig. 57-1

POPULAR ELECTRONICS

Circuit Notes

Adjustable from 15 to 240 beats per minute. The UJT oscillator output is applied to a general purpose npn transistor which drives the speaker.

UJT = 2N4871

NPNxistor = TIP31

METRONOME I

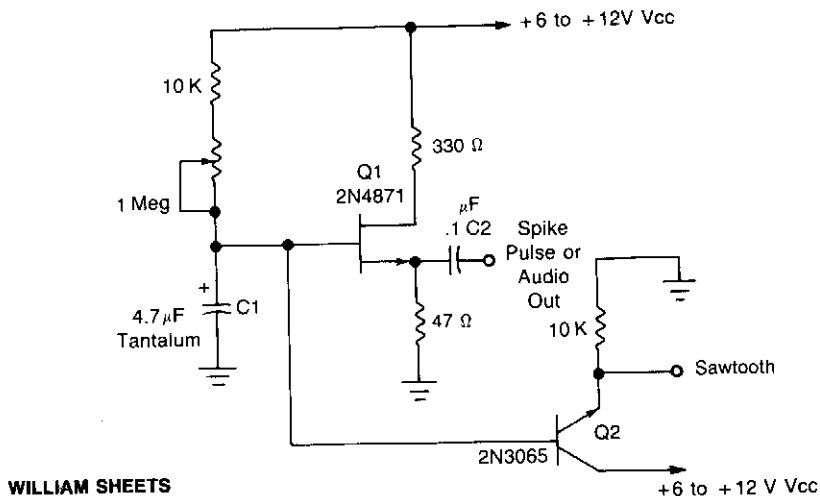


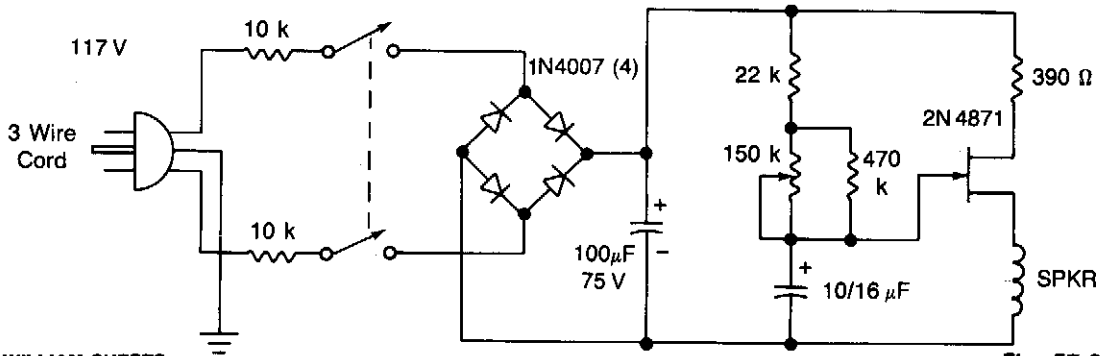
Fig. 57-2

WILLIAM SHEETS

Circuit Notes

This simple oscillator uses a 2N4871 UJT to give pulses from 0.2 to about 20 Hz. A spike is available at C2, a sawtooth at the emitter of Q2 of about 2-3 V p-p, depending on V_{CC} .

AC-LINE OPERATED UNIJUNCTION METRONOME



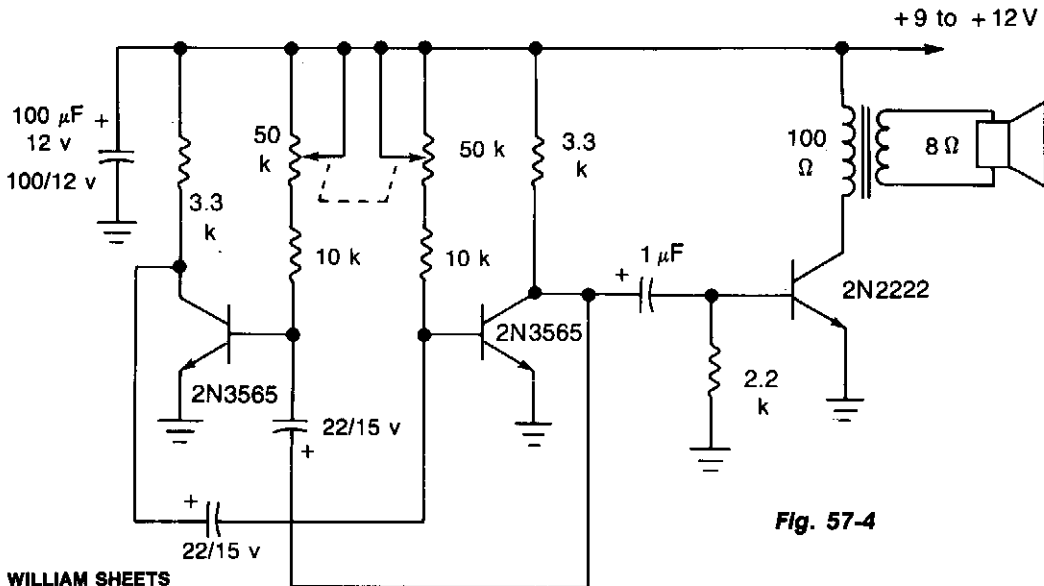
WILLIAM SHEETS

Fig. 57-3

Circuit Notes

The UJT-oscillator frequency is determined by the 100 μF capacitor and the effective resistance of the 22 K and 470 K resistors and the potentiometer. Rate can be varied from 42 to 208 beats/minute. The circuit should be housed in an insulated box for safety, or use ground (3-wire cord).

METRONOME II



WILLIAM SHEETS

Fig. 57-4

Circuit Notes

This simple circuit uses a multivibrator to generate the beats and a subsequent audio amplifier stage to increase the output level. Range of adjustment is approximately from 40 to 200 beats per minute set by the gauged potentiometer.

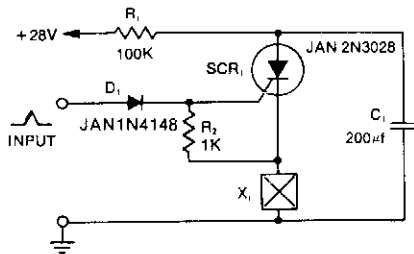
58

Miscellaneous Treasures

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Squib-Firing Circuit (I)	4-Channel Commutator
Squib-Firing Circuit (II)	Two-Wire Tone Encoder
Model Rocket Launcher	Differential Hold
Push-On/Push Off Electronic Switch	5 MHz Phase-Encoded Data Read Circuitry
Game Feeder Controller	Shift Register
Single LED Can Indicate Four Logic States	Power-On Reset
Inexpensive Radio-Control Uses Only SCR	Noise Immune 60 Hz Line Sync
Guitar and Bass Tuner	DC Static Switch (SCR Flip-Flop)

SQUIB-FIRING CIRCUIT (I)



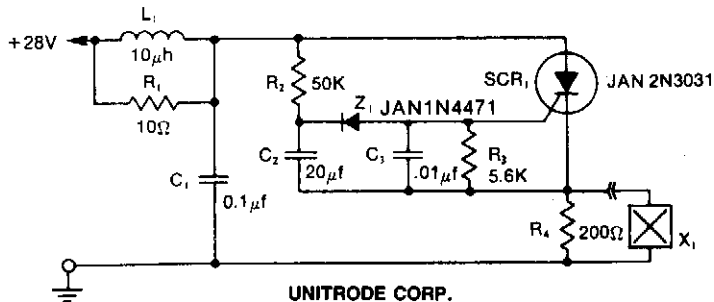
UNITRODE CORP.

Fig. 58-1

Circuit Notes

Capacitor C1 is charged to +28 V through R1 and stores energy for firing the squib. A positive pulse of 1 mA applied to the gate of SCR1 will cause it to conduct, discharging C1 into the squib load X1. With the load in the cathode circuit, the cathode rises immediately to +28 V as soon as the SCR is triggered on. Diode D1 decouples the gate from the gate trigger source, allowing the gate to rise in potential along with the cathode so that the negative gate-to-cathode voltage rating is not exceeded. This circuit will reset itself after test firing, since the available current through R1 is less than the holding current of the SCR. After C1 has been discharged, the SCR automatically turns off—allowing C1 to recharge.

SQUIB-FIRING CIRCUIT (II)



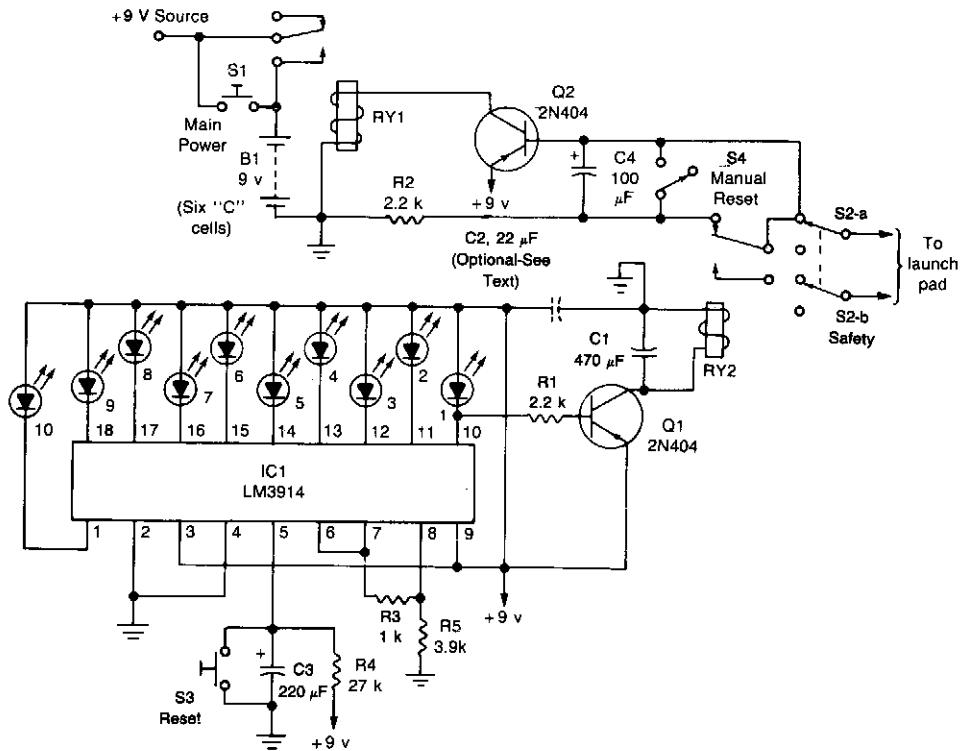
UNITRODE CORP.

Fig. 58-2

Circuit Notes

The LRC input network limits the anode dv/dt to a safe value—below $30 V/\mu s$. R1 provides critical damping to prevent voltage overshoot. While a simple RC filter section could be used, the high current required by the squib would dictate a small value of resistance and a much larger capacitor. Resistor R3 provides dc bias stabilization, while C3 provides stiff gate bias during the transient interval when anode voltage is applied. The SCR is fired one second after arming by means of the simple R2C2Z1 time delay network. R4 provides a load for the SCR for testing the circuit with the squib disconnected—limiting the current to a level well within the continuous rating of the SCR. The circuit can be reset by opening the +28 V supply and then re-arming.

MODEL ROCKET LAUNCHER



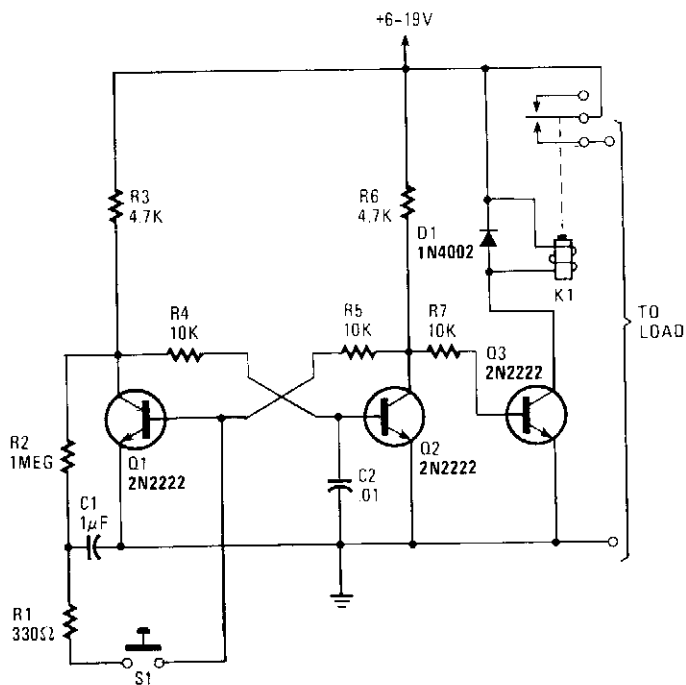
RADIO ELECTRONICS

Fig. 58-3

Circuit Notes

The circuit consists of the launch timer itself and an automatic-off timer. When power is applied to that IC, the countdown LED's sequence is on until they are all lit. When the last one LED1, is fully lit, transistor Q1 saturates, energizing RY2. When that happens, a circuit between the lantern battery at the launch pad and the nickel-chromium wire is completed; the wire heats up as before, and the rocket is launched. Resistor R4 and capacitor C3 determine the countdown timing; with the values shown it should be approximately 10 seconds. Resistors R3 and R5 set the LED brightness. Safety is of the utmost importance. That's the purpose of the second half of the circuit. When RY2 opens, the current flow to Q2 is disrupted. But, because of the presence of R2 and C4, the transistor remains saturated for about 3 seconds. After that, however, the transistor stops conducting and RY1 is de-energized. That cuts off the power to the rest of the circuit, and RY2 de-energizes again, breaking the circuit to the launch pad. Switch S3 is used to reset the countdown. Once that is done, pressing S1 starts the launch sequence; the rest is automatic. Switch S4 is used to latch RY1 manually if needed.

PUSH-ON/PUSH-OFF ELECTRONIC SWITCH



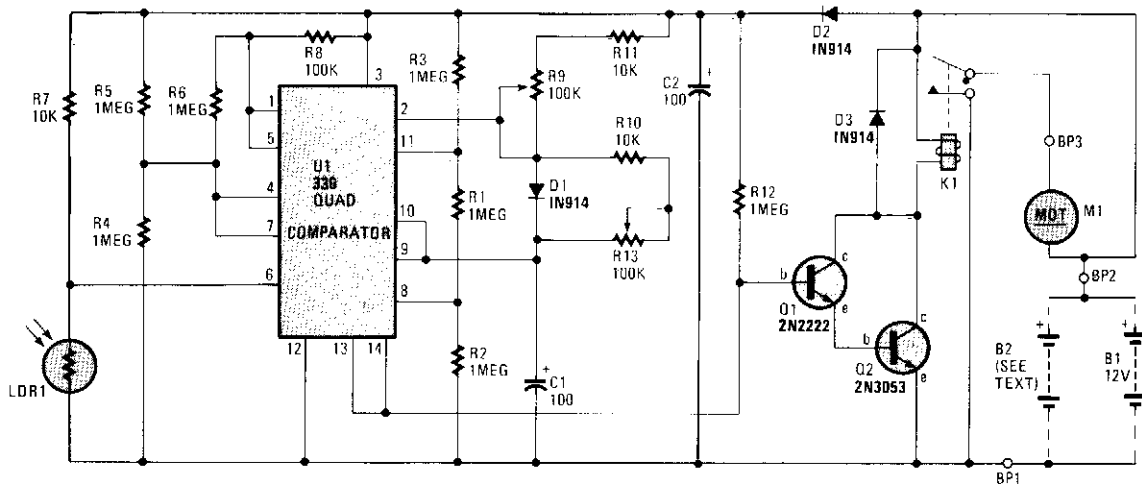
HANDS-ON ELECTRONICS

Fig. 58-4

Circuit Notes

Transistors Q1 and Q2 make up the flip-flop while Q3 drives a reed relay. When power is first applied to the circuit, Q1 and Q3 are conducting and Q2 is cut off. Momentarily closing S1 causes the flip-flop to switch states—Q1 cuts off and Q2 conducts. When Q2 is conducting, its collector drops to around 0.6 volt. That prevents base current from flowing into Q3 so it is cut off, de-energizing relay K1. The flip-flop changes state every time S1 is pressed. Capacitors C1 and C2 ensure that Q1 is always the transistor that turns on when power is first applied to the circuit. When power is first applied to the basic flip-flop, the initial status is random—Q1 and Q2 both try to conduct and, usually, the transistor with the higher gain will take control, reaching full conduction and cutting off the other one. However, differences in the values of the collector and coupling resistors will also influence the initial state at power-on. With C2 in the circuit, it and R4 form an R-C network that slightly delays the rise in Q2's base voltage. That gives Q1 sufficient time to reach saturation and thus take control.

GAME FEEDER CONTROLLER



HANDS-ON ELECTRONICS

Fig. 58-5

Circuit Notes

The circuit is built around an LM339 quad comparator, U1, which forms the basis of a Schmitt trigger, timer circuit, and a window comparator. One comparator within the LM339 (pins 1, 7, 6), plus LDR1, R4, R5, R6 and R8, is used as a Schmitt trigger. The timer circuit (which receives its input from the Schmitt trigger) consists of R9, R10, R11, R13. The last two-fourth's of U1 (pins 8, 9, 10, 11, 13 and 14) are wired as a window comparator. The two inputs to the window comparator are derived from the charge on capacitor C1—which is fed to pins 9 and 10 of U1. The other inputs are picked from two points along a voltage-divider network, consisting of R1, R2, and R3. Diode D1 is used as a blocking diode, forcing capacitor C1 to discharge through R10 and R13. The window comparator looks for any voltage falling between one-third and two-thirds of the supply voltage. When the voltage falls between those two points, the output of the window comparator (pins 13/14) goes high. Transistors Q1, and Q2 are turned on, when the pins 13/14 junction goes high, energizing the relay, K1. The energized relay provides a dc path to ground, activating the motor, M1, which reloads the feeder. The timer circuit also provides immunity from triggering, due to lightning. The on-time of relay K1 is determined by the charge cycle of C1, R11, and R9 or the discharge cycle of C1, R10, and R13. Changing the value of either a resistor or the capacitor, changes the timing cycle.

SINGLE LED CAN INDICATE FOUR LOGIC STATES

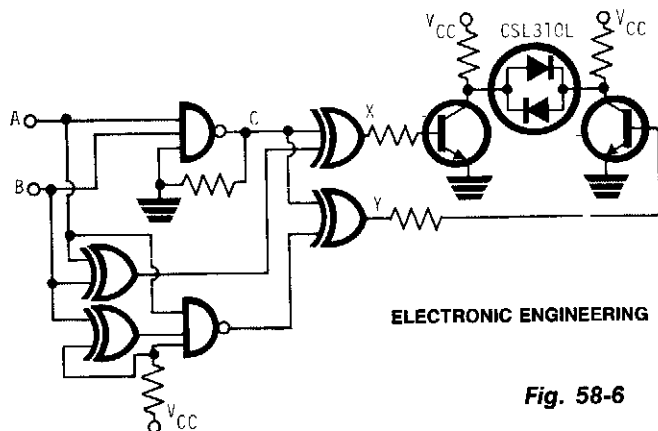


Fig. 58-6

Circuit Notes

The LED is the CSL310L which contains a red LED and a green LED connected back to back and mounted close together in a single moulding. The LED can emit red or green light by controlling the polarity of the applied voltage and if the polarity is switched at a rate of several hundred Hertz the emitted light appears yellow. The four combinations of inputs A and B can therefore be converted to four LED states—red, green, yellow and off. The truth table shows the LED colors corresponding to the combinations of A and B levels.

Truth Table

A	B	X	Y	LED color
0	0	1	0	red
0	1	0	0	off
1	0	0	1	green
1	1	C	C	yellow

INEXPENSIVE RADIO-CONTROL USES ONLY ONE SCR

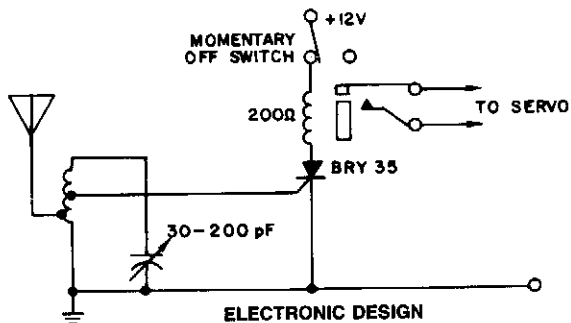
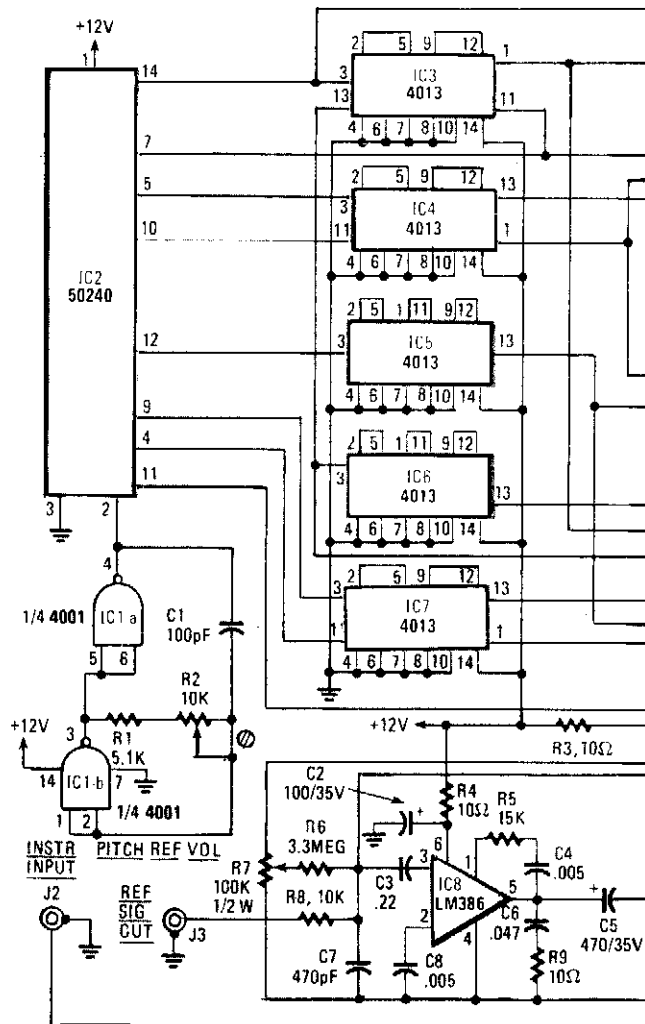


Fig. 58-7

Circuit Notes

A simple and effective receiver for actuating garage doors, alarms, warning systems, etc. The SCR, which has a very low trigger current $30 \mu\text{A}$ is typical—it requires an input power of only $30 \mu\text{W}$ to activate the relay. A high Q tuned antenna circuit assures rejection of spurious signals. A whip or wire antenna is adequate up to 100 feet from a low power transistor transmitter. A momentary-off switch resets the circuit.

GUITAR AND BASS TUNER

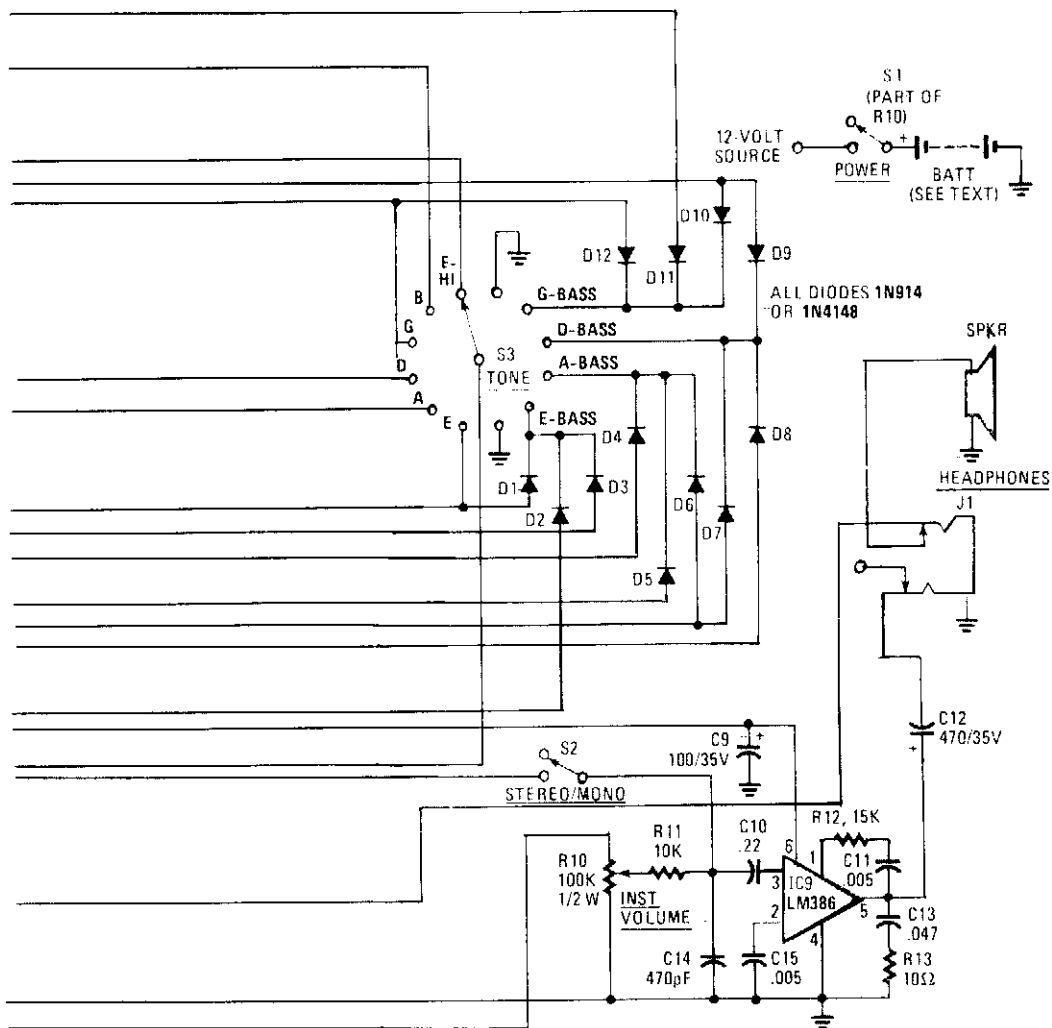


RADIO-ELECTRONICS

Fig. 58-8

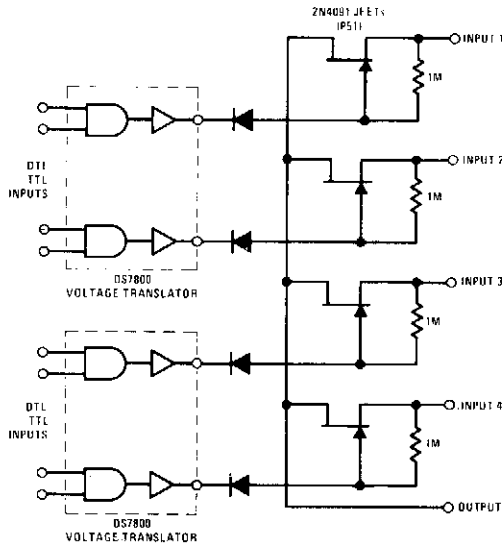
Circuit Notes

The heart of the circuit is IC2, a 50240 top-octave generator. That device uses a single input-frequency to generate all twelve notes of the musical scale. The input signal is provided by IC1, a 4001 quad 2-input NOR gate. Two sections of that IC are used to form an oscillator that runs at approximately 2 MHz. The frequency can be adjusted by trimmer potentiometer R2. Dual D flip-flops, IC3-IC7, are used as frequency dividers. They divide down the upper-octave frequencies from IC2, thus generating the lower-frequency notes required for the pitch references. The chords for the bass pitch-references are composed of three notes each. Those notes are taken from various outputs



of IC2-IC7 through isolation diodes D1-D12. All signals are routed to the TONE switch, S3. The wiper arm of that switch is connected through R7 to the input of audio power-amplifier IC8, an LM386. The resistor acts as a volume control for the pitch reference. Another LM386, IC9, serves as an amplifier for the instrument being tuned, with R10 acting as its volume control. The outputs of IC8 and IC9 are coupled, through C5 and C12 respectively, to the headphone jack, J1. Switch S2 STEREO/MONO is used to mix the reference and instrument signals at IC9 for mono operation. Power is supplied by eight "AA" cells connected in series.

4-CHANNEL COMMUTATOR



Circuit Notes

This 4-channel commutator used the 2N4091 to achieve low channel on resistance (< 30 ohm) and low off current leakage. The DS7800 voltage translator is a monolithic device that provides from 10 V to -20 V gate drive to the JFETs while at the same time providing DTL/TTL logic compatibility.

Fig. 58-9

NATIONAL SEMICONDUCTOR CORP.

TWO-WIRE TONE ENCODER

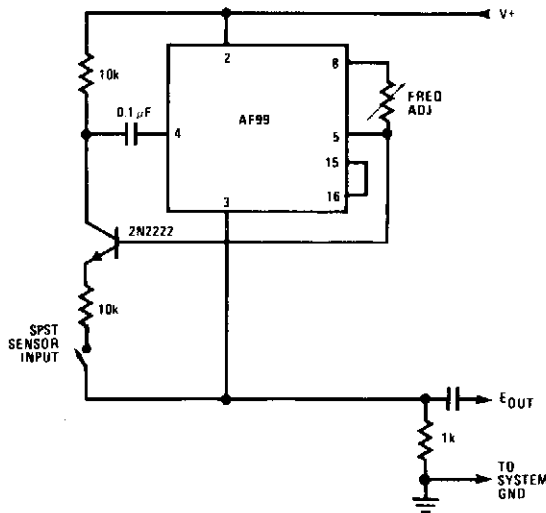


Fig. 58-10

NATIONAL SEMICONDUCTOR CORP.

DIFFERENTIAL HOLD

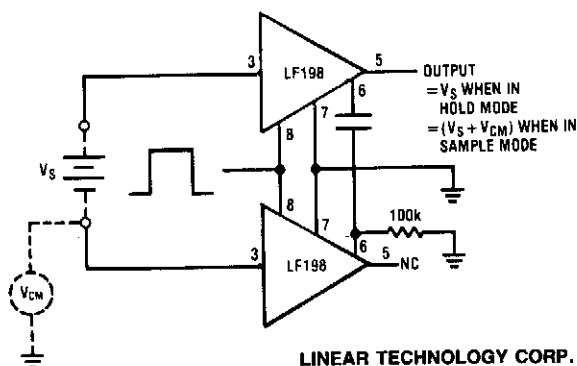
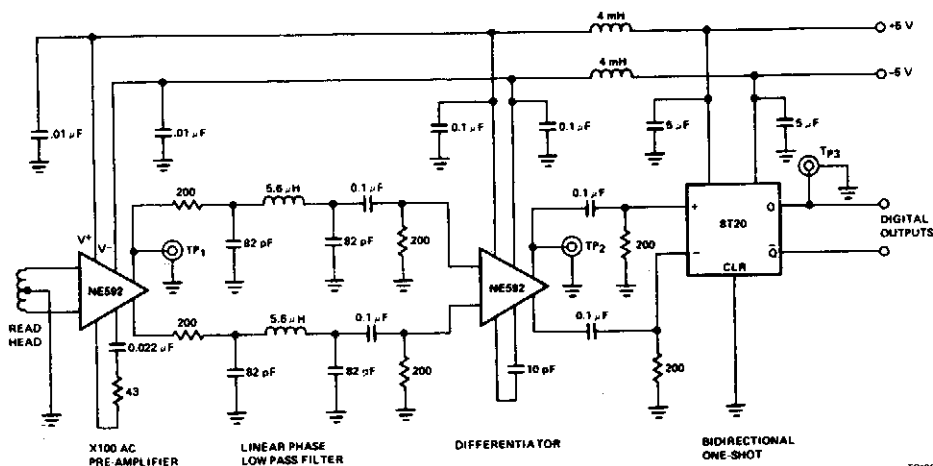


Fig. 58-11

5 MHz PHASE-ENCODED DATA READ CIRCUITRY



NOTE:
All resistor values are in ohms

SIGNETICS

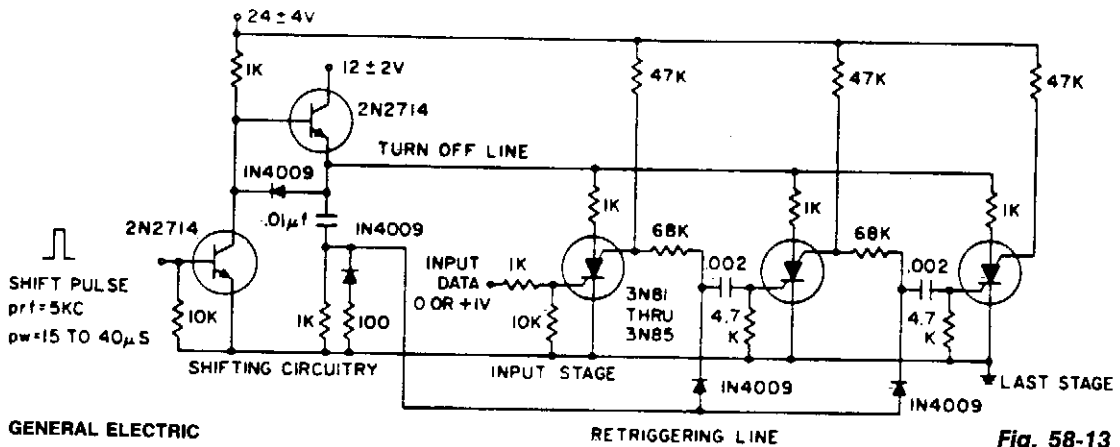
TC10065

Fig. 58-12

Circuit Notes

Readback data is applied directly to the input of the first NE592. This amplifier functions as a wide-band ac coupled amplifier with a gain of 100. By direct coupling of the readback head to the amplifier, no matched terminating resistors are required and the excellent common-mode rejection ratio of the amplifier is preserved. The dc components are also rejected because the NE592 has no gain at dc due to the capacitance across the gain select terminals. The output of the first stage amplifier is routed to a linear phase shift low-pass filter, with a characteristic impedance of 200 ohms. The second NE592 is utilized as a low noise differentiator/amplifier stage. The output of the differentiator/amplifier is connected to the 8T20 bidirectional monostable unit to provide the proper pulses at the zero-crossing points of the differentiator.

SHIFT REGISTER



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 triggering 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 retriggered.

POWER-ON RESET

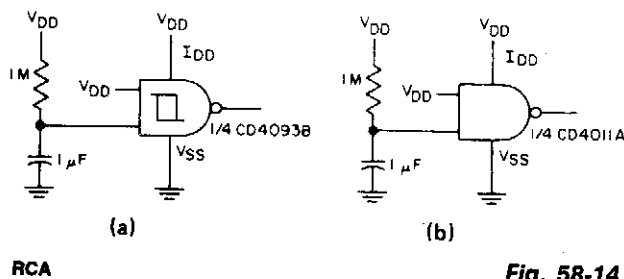
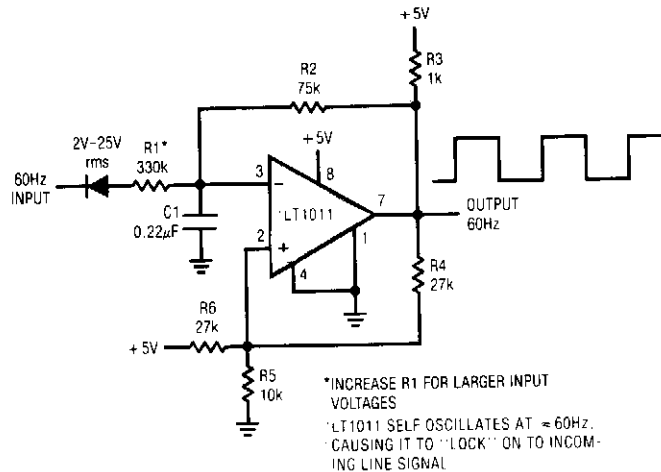


Fig. 58-14

Circuit Notes

A reset pulse is often required at power-on in a digital system. This type of reset pulse is ideally provided by this circuit. Because of the high input impedance of the Schmitt trigger, long reset pulse times may be achieved without the excess dissipation that results when both output devices are on simultaneously, as in an ordinary gate device (B).

NOISE IMMUNE 60 Hz LINE SYNC



LINEAR TECHNOLOGY CORP.

Fig. 58-15

DC STATIC SWITCH (SCR FIIP-FLOP)

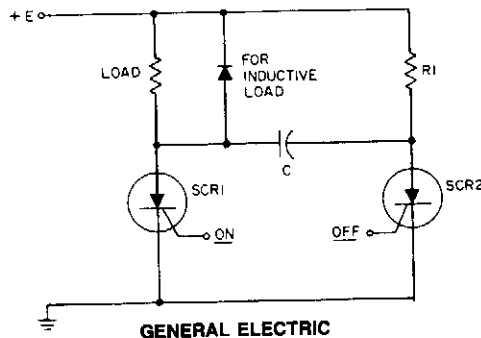


Fig. 58-16

Circuit Notes

This circuit is a static SCR switch for use in a dc circuit. When a low power signal is applied to the gate of SCR1, this SCR is triggered and voltage is applied to the load. The right hand plate of C charges positively with respect to the left hand plate through R1. When SCR2 is triggered on, capacitor C is connected across SCR1, so that this SCR is momentarily reverse biased between anode and cathode. This reverse voltage turns SCR1 off provided the gate signal is not applied simultaneously to both gates. The current through the load will decrease to zero in an exponential fashion as C becomes charged.

59

Modulator Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Double Sideband, Suppressed Carrier RF Modulator
Low-Distortion Low Level Amplitude Modulator
Video Modulator Circuit
Video Modulator
TTL Oscillator Interfaces Data for Display by a
Television Set

DOUBLE SIDEBAND, SUPPRESSED CARRIER RF MODULATOR

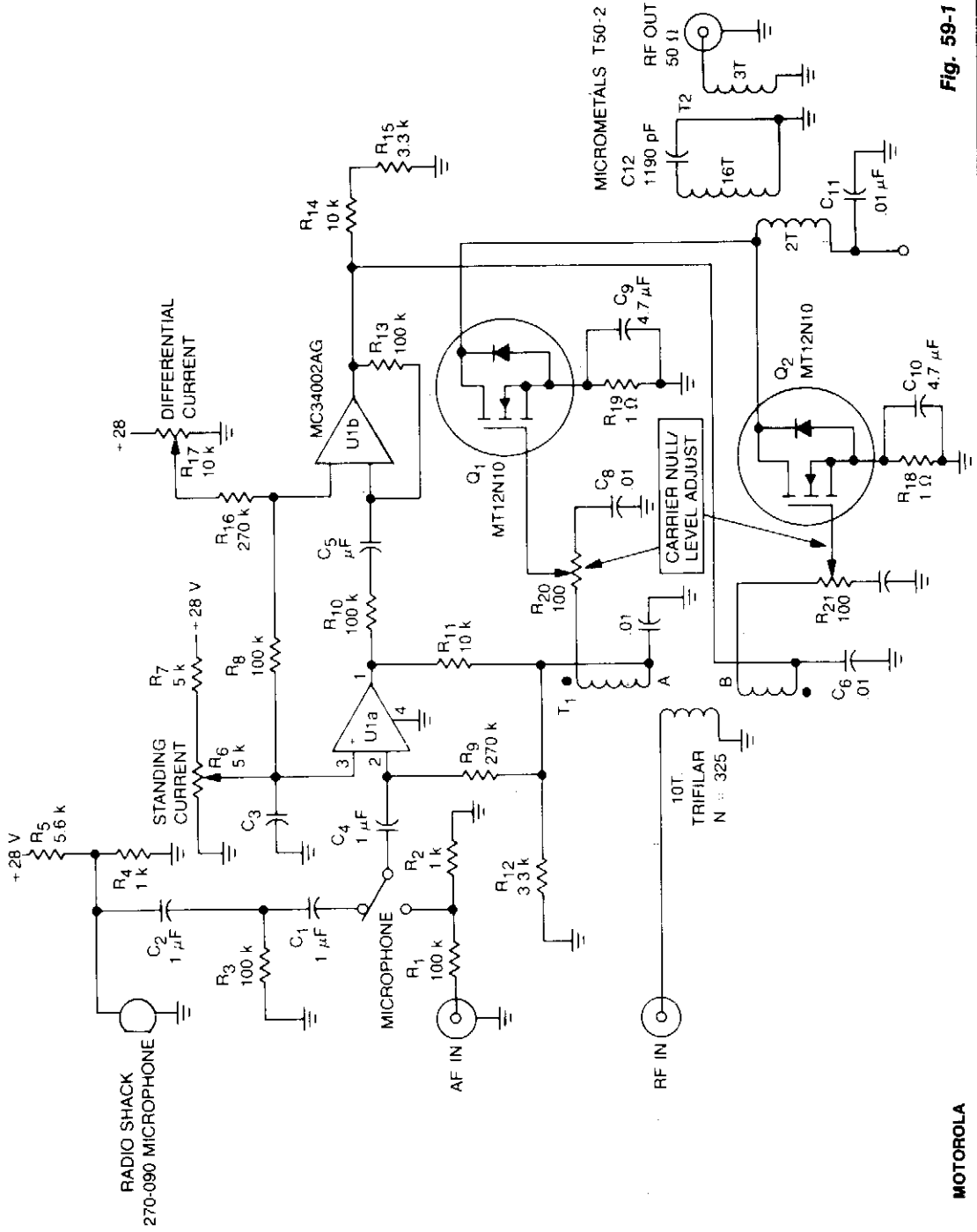


Fig. 59-1

MOTOROLA

DOUBLE SIDEBAND, SUPPRESSED CARRIER RF MODULATOR , Continued.

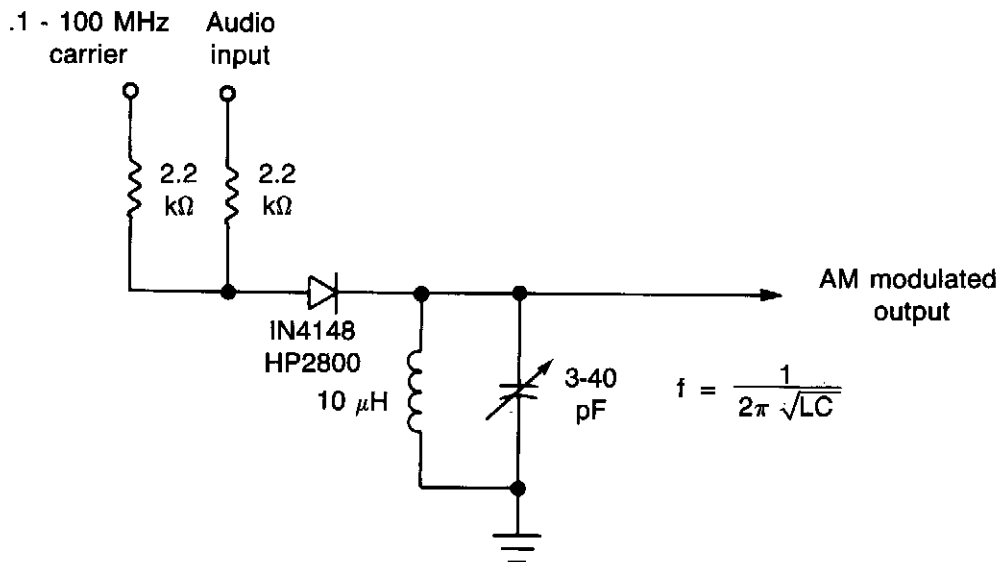
Circuit Notes

An RF input is applied to the primary of T1, which applies equal amplitude, opposite phase RF drive for output FETs Q1 and Q2. With no AF modulation at points A and B, the opposite phase RF signals cancel each other and no output appears at the 50 V output connector.

When AF modulation is applied to points A and B, a modulated RF output is obtained. The dc stability and low frequency gain are improved by source resistors R18 and R19.

A phase inverter consisting of a dual op amp (U1a and U1b) produces the out-of-phase, equal amplitude AF modulation signals.

LOW-DISTORTION LOW-LEVEL AMPLITUDE MODULATOR



WILLIAM SHEETS

Fig. 59-2

Circuit Notes

This simple diode modulator delivers excellent results when used for high percentage modulation at low signal levels. Constants are shown for a carrier frequency of about 10 MHz, but, with a suitable tank, the circuit will give good results at any frequency at which the diode approximates a good switch. To extend frequency above that for which the IN4148 is suited, a hot-carrier diode (HP2800, etc.) can be substituted. A shunt resistor across the tank circuit can be used to reduce the circuit Q so as to permit high percentage modulation without appreciable distortion.

VIDEO MODULATOR CIRCUIT

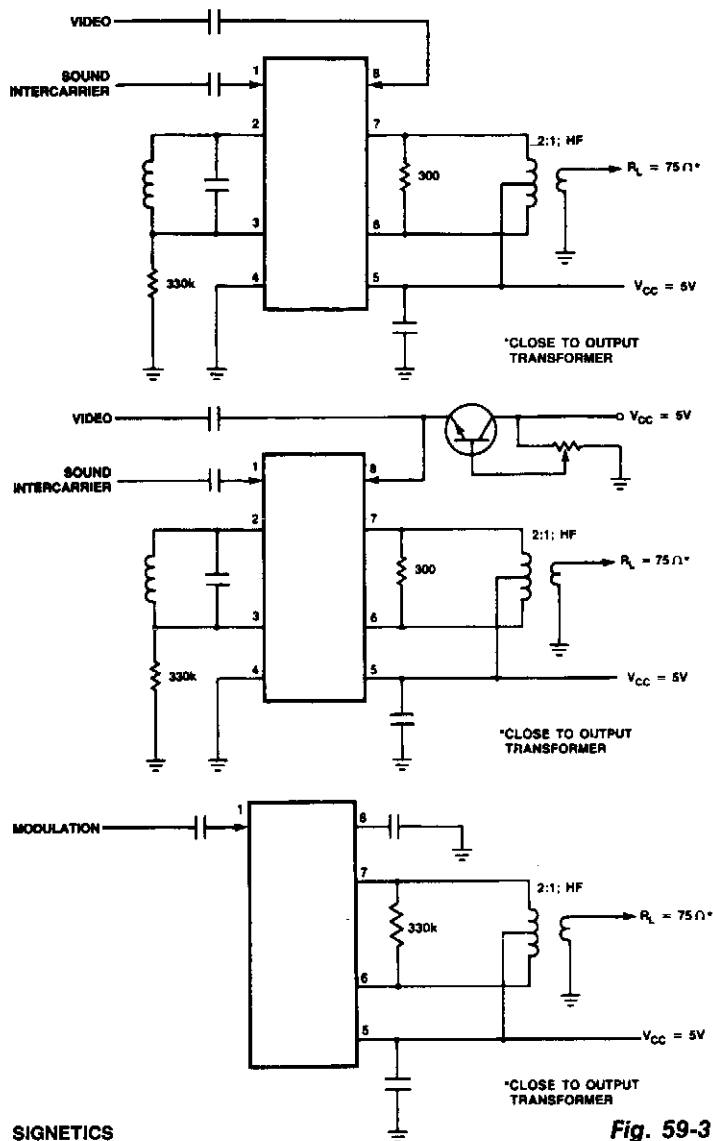


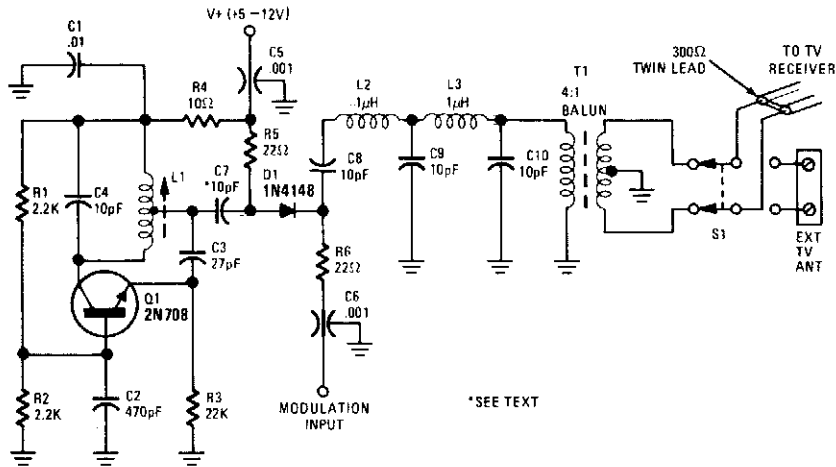
Fig. 59-3

SIGNETICS

Circuit Notes

These are modulator circuits for modulation of video signals on a VHF/UHF carrier. The circuits require a 5 V power supply and few external components for the negative modulation mode. For positive modulation an external clamp circuit is required. The circuits can be used as general-purpose modulators without additional external components. The IC is TDA6800.

VIDEO MODULATOR



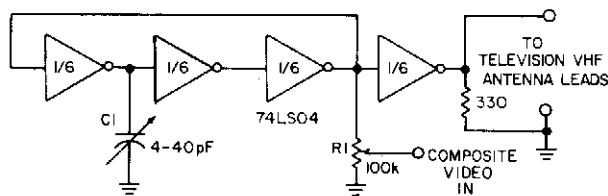
RADIO-ELECTRONICS

Fig. 59-4

Circuit Notes

This circuit permits direct connection of composite video signals from video games and microcomputers to the antenna terminals of TV sets. The output signal level is controlled by the modulation input.

TTL OSCILLATOR INTERFACES DATA FOR DISPLAY BY A TELEVISION SET



ELECTRONIC DESIGN

Fig. 59-5

Circuit Notes

Three gates of a 74LS04 form the oscillator circuit. Capacitor C1 allows fine-frequency adjustment to a specific television channel and helps stabilize the circuit. Potentiometer R1 acts as the mixing input and provides adjustment of the contrast ratio for the best viewing. A fourth gate buffers and helps stabilize the oscillator.

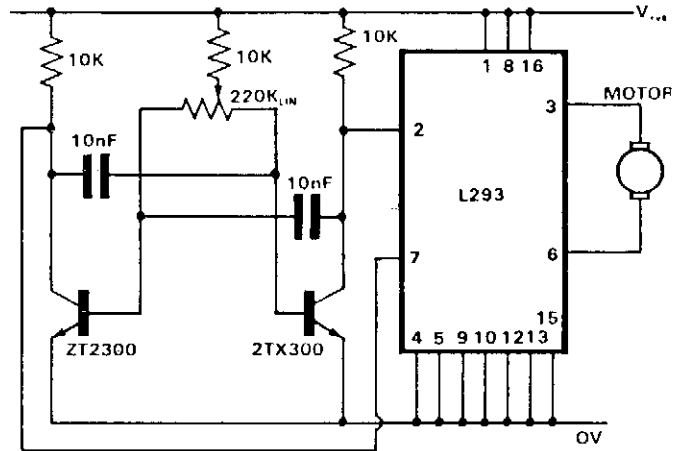
60

Motor Control Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Bi-Directional Proportional Motor Control	DC Motor Speed Control
AC Motor Control	Reversing Motor Drive, DC Control Signal
PWM Motor Speed Control	N-Phase Motor Drivers
Stepping Motor Driver	Servo Motor Drive Amplifier
Low-Cost Speed Regulator For DC Motors	DC Servo Drive Employs Bipolar Control Input
Motor Speed Control Circuit	400 Hz Servo Amplifier
Constant Speed Motor Control Using Tachometer Feedback	Three-Phase Power-Factor Controller
Back EMF PM Motor Speed Control	Motor/Tachometer Speed Control
	Closed Loop, Tachometer Feedback Control

BI-DIRECTIONAL PROPORTIONAL MOTOR CONTROL



ELECTRONIC ENGINEERING

Fig. 60-1

Circuit Notes

The control of both direction and of proportional motor speed is achieved by rotation of a single potentiometer. The motor driver is an SGS integrated circuit L293 which will drive up to 1 amp in either direction, depending on the logic state of input 1 and input 2 as per table.

<u>I/P 1</u>	<u>I/P 2</u>	<u>Function</u>
High	Low	Motor turns one way
Low	High	Motor reverses

By applying a variable M/S ratio flip-flop to these inputs, both speed and direction will be controlled. With RV1 in its center position the M/S will be 1:1 whereby the motor will remain stationary due to its inability to track at the flip-flop frequency. Movement of RV1 in either direction will gradually alter the M/S ratio and provide an average voltage bias in one direction proportional to the M/S ratio.

AC MOTOR CONTROL

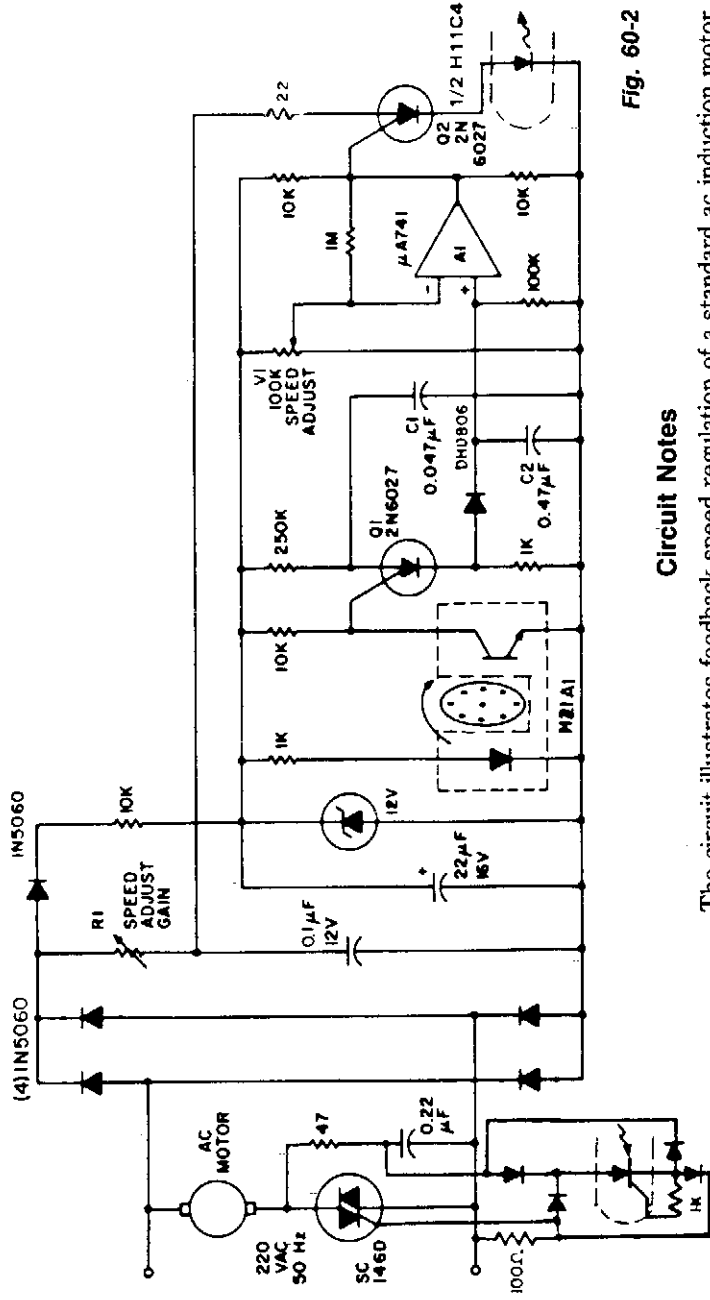


Fig. 60-2

Circuit Notes

The circuit illustrates feedback regulation of a standard ac induction motor, a function difficult to accomplish other than with a costly, generator type, precision tachometer. When the apertured disc attached to the motor shaft allows the light beam to cross the interrupter module, the programmable unijunction transistor, Q1, discharges capacitor, C1, into the much larger storage capacitor, C2. The voltage on C2 is a direct function of the rotational speed of the motor. Subsequently, this speed-related potential is compared against an adjustable reference voltage, V1, through the monolithic operational amplifier, A1, whose output, in turn, establishes a dc control input to the second P.U.T. (Q2). This latter device is synchronized to the ac supply frequency and furnishes trigger pulses in the conventional manner to the triac at a phase angle determined by the speed control, R1, and by the actual speed of the motor.

GENERAL ELECTRIC
1/2 H11C4 (4)1N5060

PWM MOTOR SPEED CONTROL

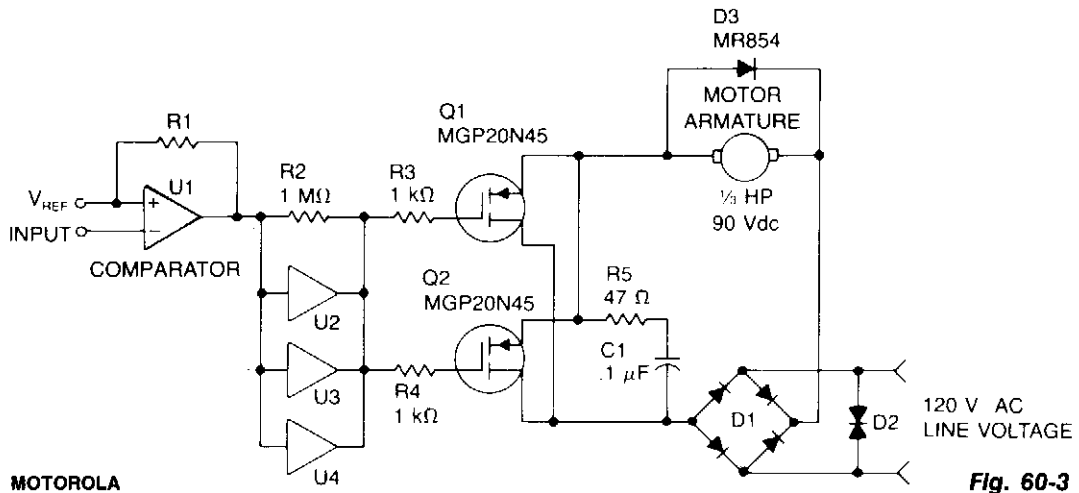


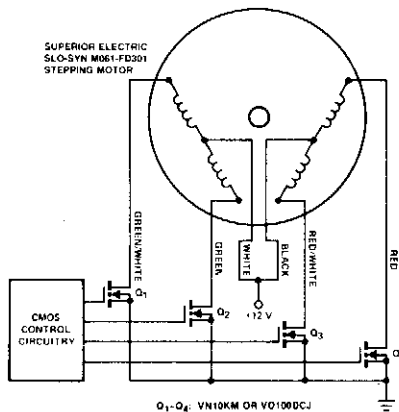
Fig. 60-3

Circuit Notes

Speed control is accomplished by pulse width modulating the gates of two MGP20N45 TMOS devices. Therefore, motor speed is proportional to the pulse width of the incoming digital signal, which can be generated by a microprocessor or digital logic.

The incoming signal is applied to comparator U1, then to paralleled inverters U2, U3, and U4 that drive the two TMOS devices, which, in turn, control power applied to the motor armature. Bridge rectifier D1 supplies fullwave power that is filtered by R5 and C1. Free-wheeling diode D3 (MR854) prevents high voltage across Q1 and Q2. A back-to-back zener diode, D2, protects against transients and high voltage surges.

STEPPING MOTOR DRIVER



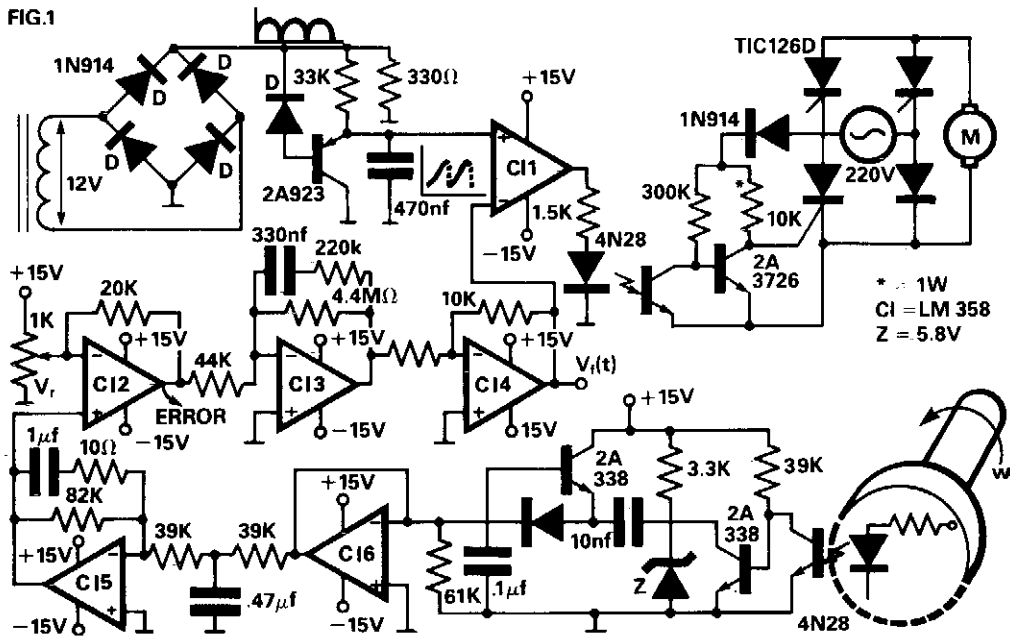
SILCONIX, INC.

Fig. 60-4

Circuit Notes

Stepping motors find wide use in disk drives and machine control. MOSPOWER transistors are ideal motor drivers because of their freedom from second breakdown. Note that snubbing networks are not used because load line shaping is not necessary with MOSPOWER and the inductance of the motor is fairly low so that the inductive spike is small. The MOSFET gates are tied directly to the outputs of the CMOS control circuitry. The logic is arranged to sequence the motor in accordance with the needs of the application.

LOW-COST SPEED REGULATOR FOR DC MOTORS



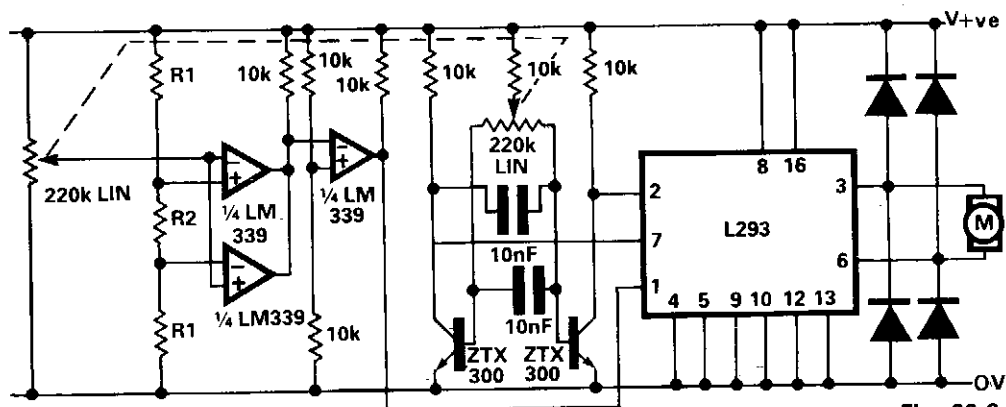
ELECTRONIC ENGINEERING

Fig. 60-5

Circuit Notes

A four thyristor controlled bridge is used for operation in two quadrants of the torque-speed characteristics. In the trigger circuits the usual pulse transformers were replaced by self biased circuits which minimize gate power consumption and increase noise immunity. Electrical isolation is guaranteed by the use of optocouplers. The trigger pulses are generated by the comparison between an error signal, previously processed and amplified, and a line synchronism signal. The converter's output is a dc voltage proportional to the speed, which after being compared with a reference signal, becomes the error signal.

MOTOR SPEED CONTROL CIRCUIT



ELECTRONIC ENGINEERING

Fig. 60-6

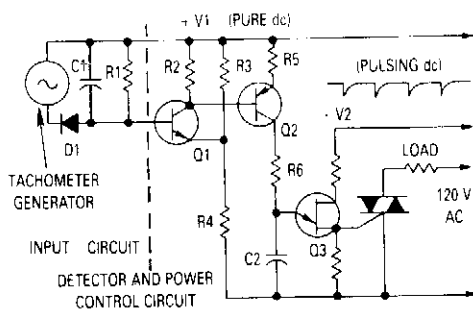
Circuit Notes

A shortcoming of the above bi-directional proportional motor control circuit is that with the potentiometer in its center position the motor does not stop, but creeps due to the difficulty in setting the potentiometer for an exact 1:1 mark-space ratio from the flip-flop. This modified circuit uses a second potentiometer, ganged with the first used to inhibit drive to the motor near the center position. This potentiometer is connected between the supply lines and feeds a window comparator which in turn drives the inhibit input of the L293.

CONSTANT SPEED MOTOR CONTROL USING TACHOMETER FEEDBACK

Circuit Notes

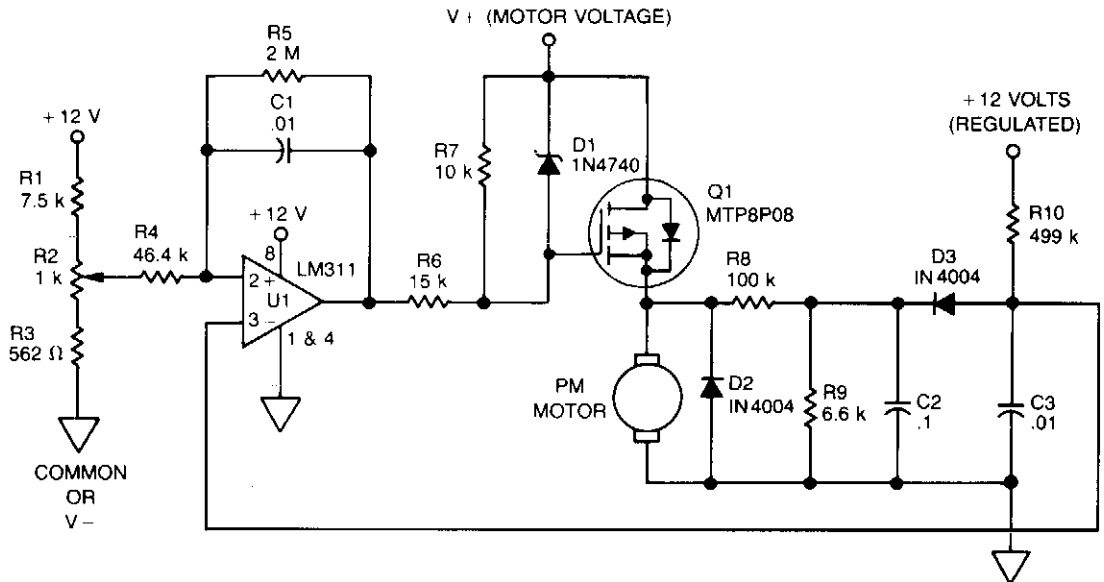
The generator output is rectified then filtered and applied between the positive supply voltage and the base of the detector transistor. This provides a negative voltage which reduces the base-voltage when the speed increases. In normal operation, if the tachometer voltage is less than desired, the detector transistor is turned on, then turns on Q2 which causes the timing capacitor for the unijunction transistor to charge quickly. As the tachometer output approaches the voltage desired, the base-emitter voltage is reduced to the point at which Q1 is almost cut off. Thereby, the collector current which charges the unijunction timing capacitor is reduced, causing that capacitor to charge slowly and trigger the thyristor later in the half cycle. In this manner, the average power to the motor is reduced until just enough power to maintain the desired motor speed is allowed to flow.



MOTOROLA

Fig. 60-7

BACK EMF PM MOTOR SPEED CONTROL



MOTOROLA

Fig. 60-8

Circuit Notes

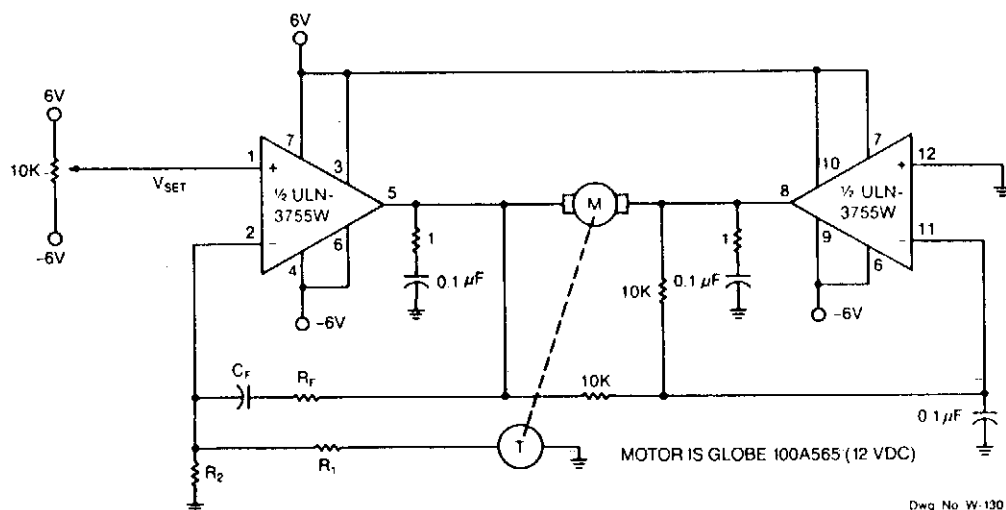
The use of power MOSFETs allows a direct interface between logic and motor power, which permits circuit simplicity as well as high efficiency. This speed control circuit can be packaged on a 22-pin, double-sided, 3.5 × 4-in. pc board.

A 12 V control supply and a TRW BL11, 30 V motor are used; with minor changes other motor and control voltages can be accommodated. For example, a single 24 V rail could supply both control and motor voltages. Motor and control voltages are kept separate here because CMOS logic is used to start, stop, reverse and oscillate the motor with a variable delay between motor reversals.

Motor speed is established by potentiometer R2, which applies a corresponding dc voltage to the + input of comparator U1, whose output is then applied to TMOS device MTP8P08 (Q1). Zener diode D1 limits the drive to Q1. The output of Q1 drives the permanent magnet motor.

Back emf is obtained from the motor via the network consisting of R8, R9, R10, C2, C3 and D3; it is applied to—input of comparator U1.

DC MOTOR SPEED CONTROL



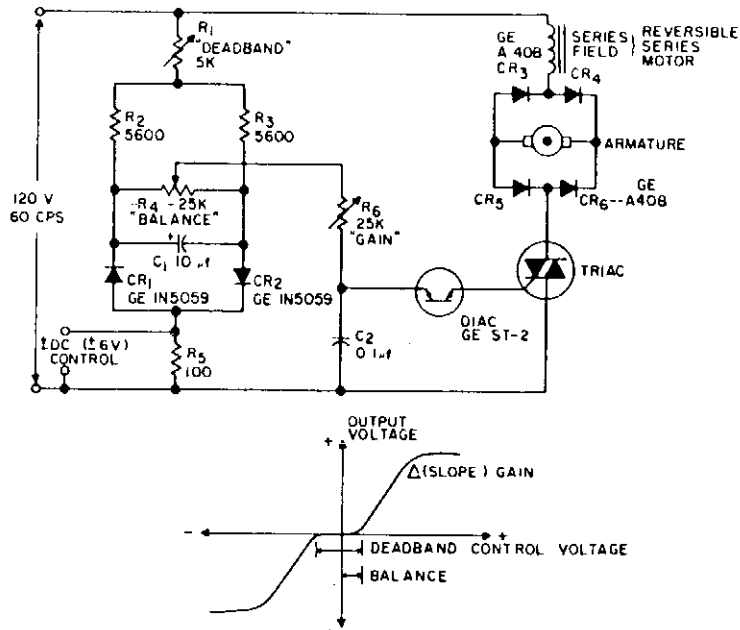
SPRAGUE ELECTRIC CO.

Fig. 60-9

Circuit Notes

Power op amps provide accurate speed control for dc motors. The circuit provides bidirectional speed control. The amplifiers' push-pull configuration ensures a full rail-to-rail voltage swing (minus the output stages' saturation drops) across the motor in either direction. The circuit uses a mechanically-coupled tachometer to provide speed-stabilizing feedback to the first amplifier section. The motor's speed and direction of rotation is set by adjusting the 10 k ohm potentiometer at the amplifier's noninverting input. The RFCF feedback network prevents oscillation by compensating for the inherent dynamic mechanical lag of the motor. Select the RFCF time constant to match the particular motor's characteristics.

REVERSING MOTOR DRIVE, DC CONTROL SIGNAL



GENERAL ELECTRIC

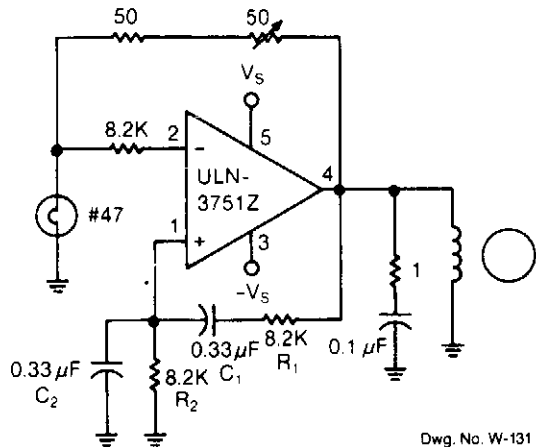
Fig. 60-10

Circuit Notes

This is a positioning servo drive featuring adjustment of balance, gain, and deadband. In addition to control from a dc signal, mechanical input can be fed into the balance control, or that control could be replaced by a pair of resistance transducers for control by light or by temperature.

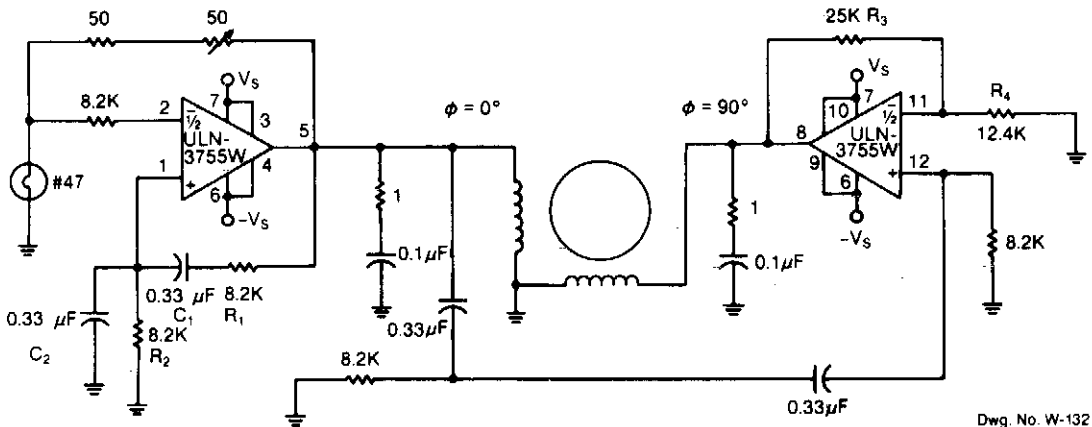
N-PHASE MOTOR DRIVERS

SINGLE-PHASE AC MOTOR DRIVER



Dwg. No. W-131

TWO-PHASE AC MOTOR DRIVER



Dwg. No. W-132

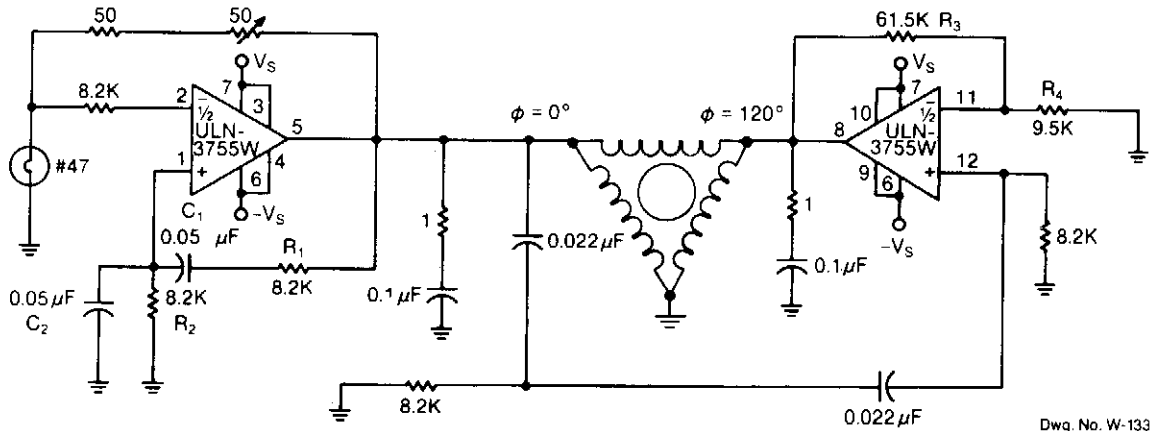
SPRAGUE ELECTRIC CO.

Fig. 60-11

Circuit Notes

Because of its high amplification factor and built-in power-output stage, an integrated power operational amplifier makes a convenient driver for ac motors. One op amp can be configured as an oscillator to generate the required ac signal. The power-output stage, of course, supplies the high-current drive to the motor. The controlling op amp is

THREE-PHASE AC MOTOR DRIVER



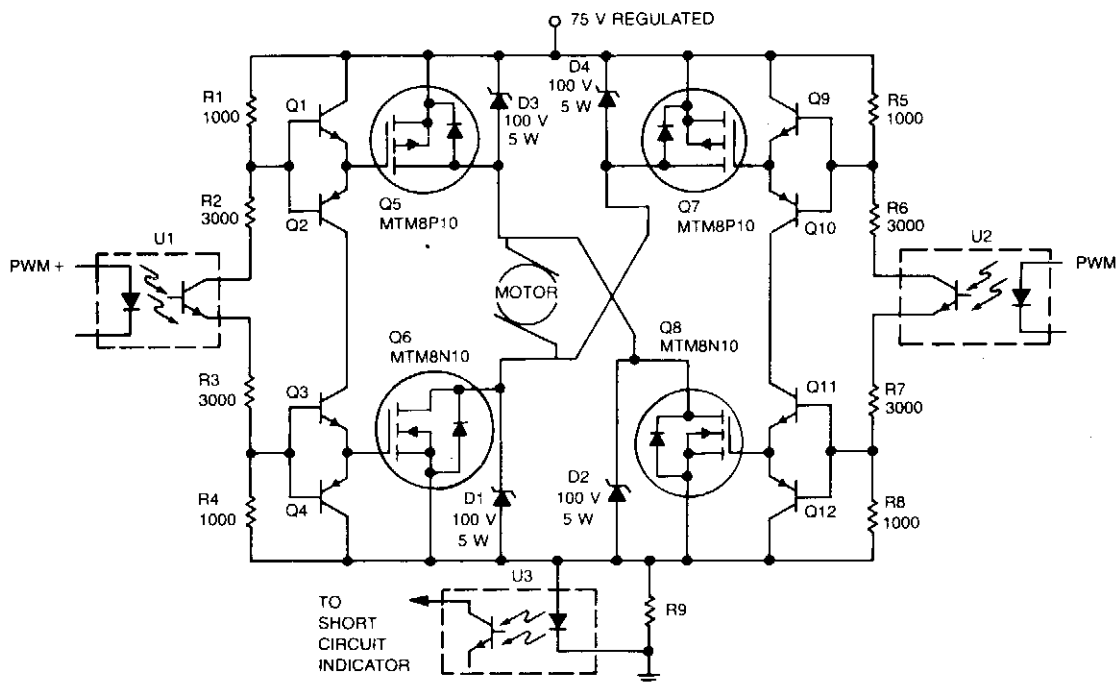
Dwg. No. W-133

configured as a Wein bridge oscillator. The R_1C_1 , R_2C_2 feedback networks determine the oscillation frequency, according to the following expression:

$$f_o = \frac{1}{(2 \pi \sqrt{R_1 R_2 C_1 C_2})}$$

By varying either R_1 or R_2 , the oscillation frequency can be adjusted over a narrow range. The R_3/R_4 ratio sets the second amplifier's gain to compensate for signal attenuation occurring in the phase shifters. The circuits can be driven from an external source, such as a pulse or square wave, setting the gain of the left-hand amplifier to a level less than that required for oscillation. The RC feedback networks then function as an active filter causing the outputs to be sinusoidal.

SERVO MOTOR DRIVE AMPLIFIER



MOTOROLA

Fig. 60-12

Circuit Notes

Digital ICs and opto-isolators provide the drive for this T MOS servo amplifier, resulting in fewer analog circuits and less drift. Fast and consistent turn-on and turn-off characteristics also enable accurate analog output results directly from the digital signal without the need for analog feedback.

An "H" bridge configuration is employed for the servo amplifier, which obtains complementary PWM inputs from digital control circuits. The PWM inputs are applied via opto-isolators, which keep the digital control logic isolated from the 75 V supply used for the amplifier. A short circuit indicator is provided by opto-isolator U3; if there is a short, the drop across R9 increases to a value sufficient to activate the isolator and send a short indication to the digital control logic.

DC SERVO DRIVE EMPLOYS BIPOLAR CONTROL INPUT

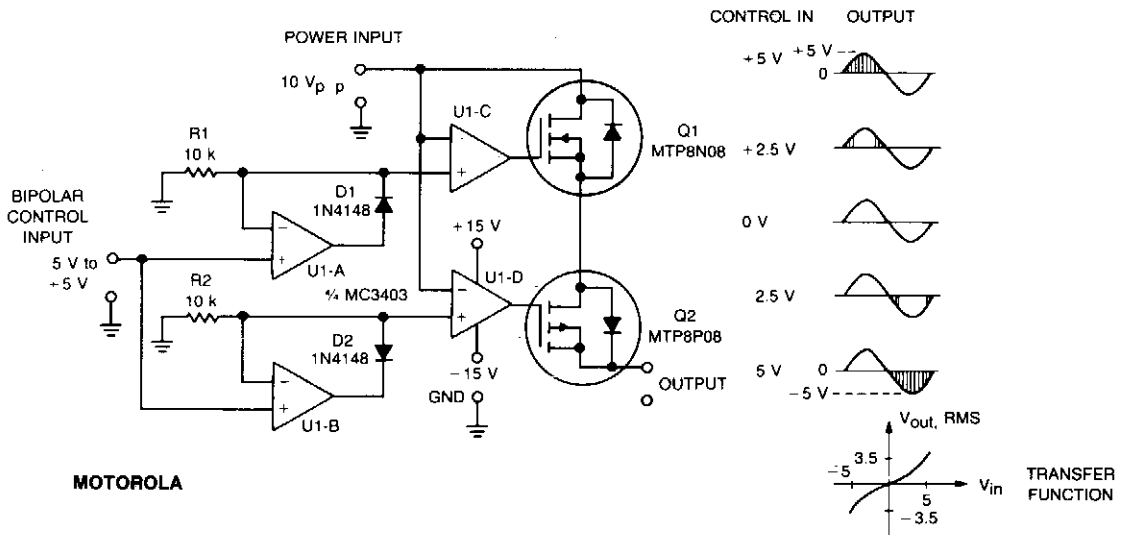


Fig. 60-13

Circuit Notes

This circuit accepts bipolar control inputs of $\pm 5 V$ and provides a phase-chopped output to a dc load (such as a servo motor) of the same polarity as the input. The rms voltage of the output is closely proportional to the control input voltage.

N-channel and p-channel T MOS devices, Q1 and Q2, are connected in anti-series to form a bidirectional switch through which current can flow in either the forward or reverse direction. Control circuits turn Q1 and Q2 on when they are reverse biased, bypassing their reverse rectifier and increasing circuit efficiency. Each device is allowed to turn off only when forward biased.

The Q1-Q2 switch connects the ac power source to the load when its instantaneous voltage is the same polarity and less than the control voltage. U1a is configured as an ideal positive rectifier whose output follows the control voltage when it is positive, and is zero otherwise. Similarly, U1b is a negative rectifier. U1c turns Q1 on whenever the ac input voltage is lower than the positive rectifier output. For negative control voltages, Q1 is turned on only during the negative half-cycle. For positive control voltages, Q1 is turned on during the end portions of the positive half-cycle. Similarly, U1d turns Q2 on whenever the ac input voltage is higher than the output of the negative rectifier.

400 Hz SERVO AMPLIFIER

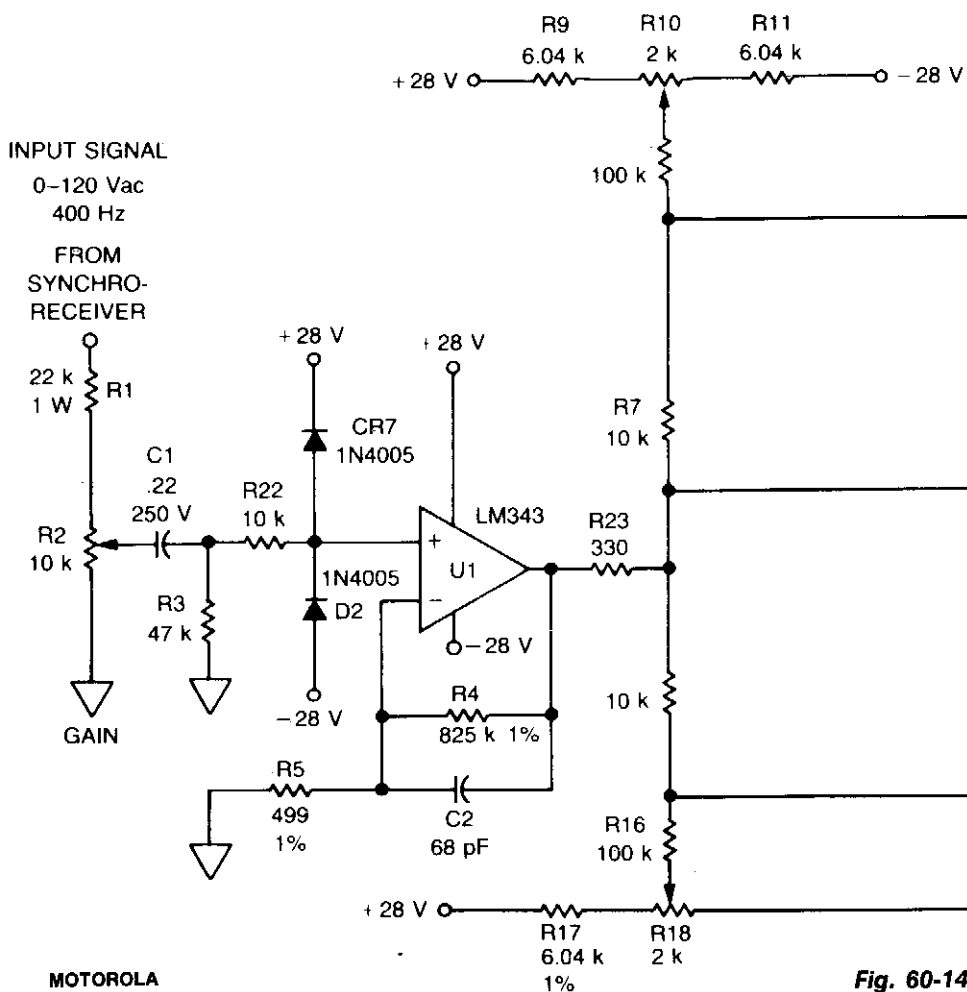
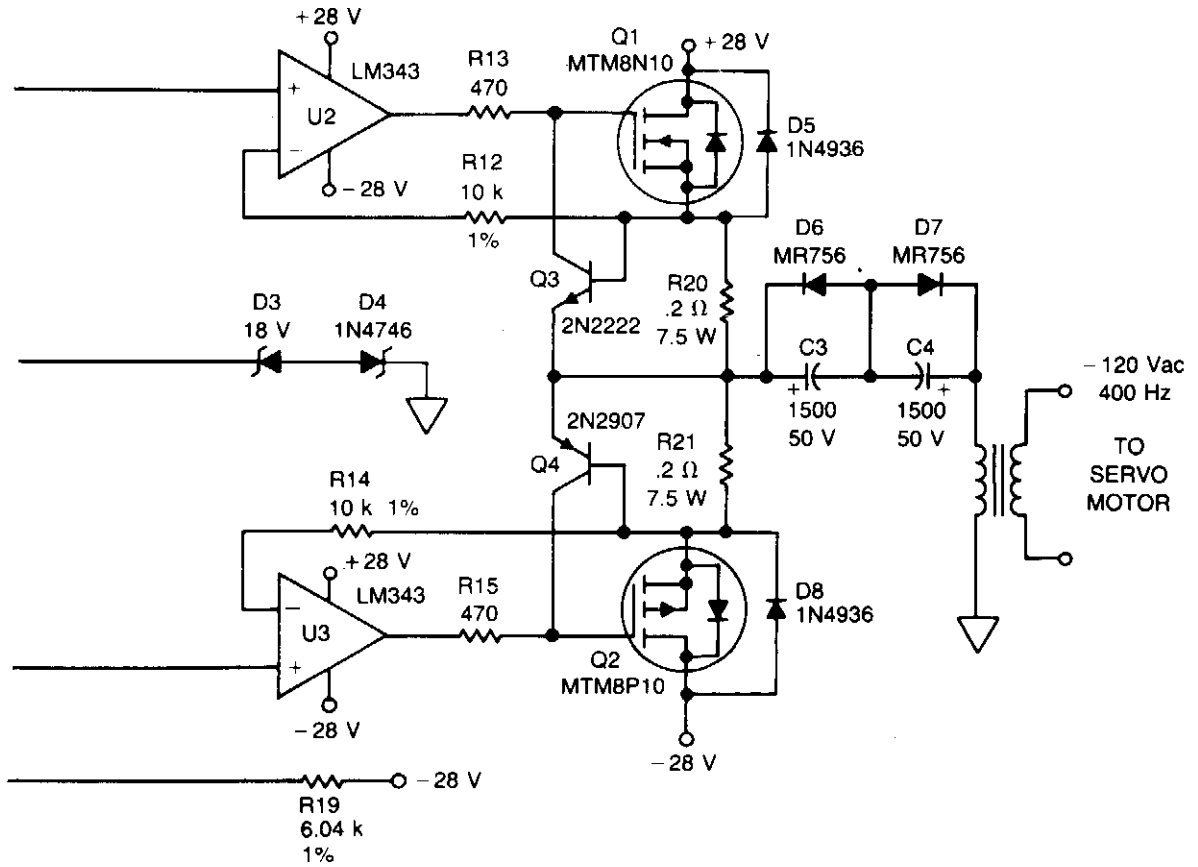


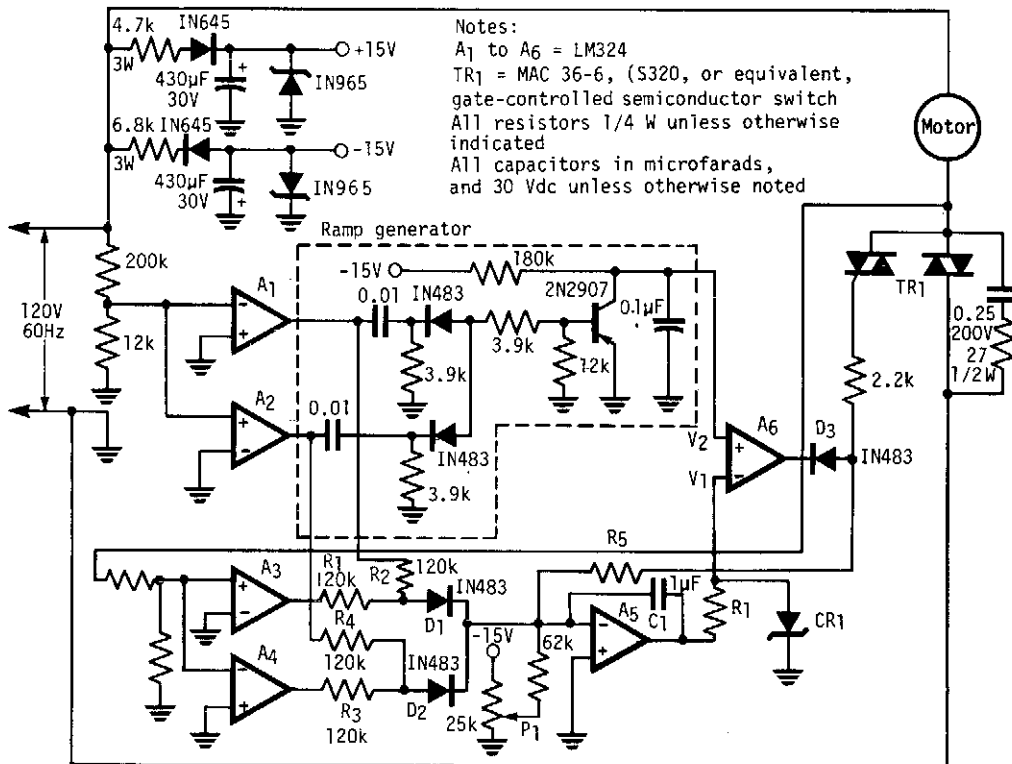
Fig. 60-14

Circuit Notes

The signal from a synchro receiver or a variable resistive cam follower (potentiometer) is boosted by operational amplifier U1, whose output swing is limited by back-to-back zeners D3 and D4. The signal is then applied to operational amplifiers U2 and U3, which drive the gates of Q1 and Q2 respectively. The npn transistor (Q3) is a fast current limiter for the n-channel MTM8N10; a pnp transistor (Q4) performs the same function for the p-channel MTM8P10. Capacitors C3 and C4 eliminate the need for accurate dc offset zeroing. T1 steps up the output voltage to 120 V for the 400 Hz servo motor.



THREE-PHASE POWER-FACTOR CONTROLLER



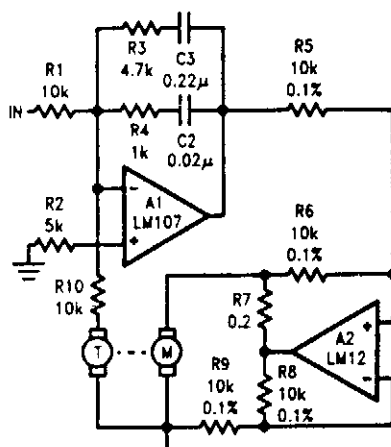
ELECTRONIC ENGINEERING

Fig. 60-15

Circuit Notes

The modified power-factor controller, developed at the Marshall Space Flight Center, employs a phase detector for each of the three phase-windings of a delta-connected induction motor. The phase-difference sum is the basis for control. Instabilities of earlier systems are overcome with improved feedback control incorporating a 20Hz bandwidth signal.

MOTOR/TACHOMETER SPEED CONTROL



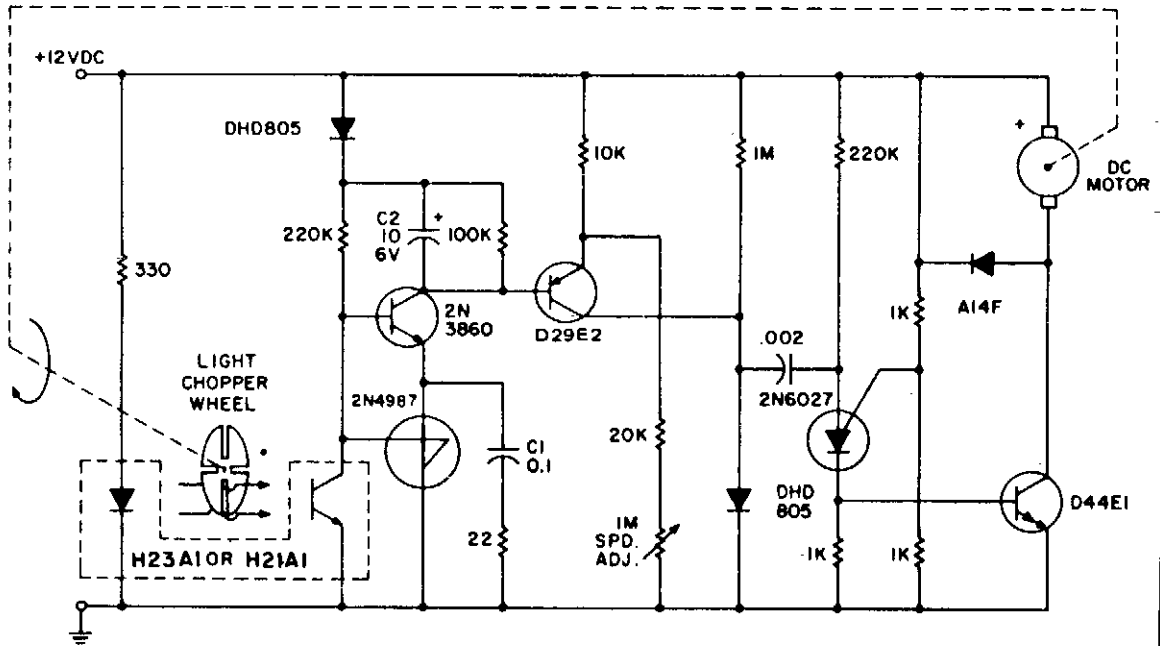
NATIONAL SEMICONDUCTOR CORP.

Fig. 60-16

Circuit Notes

The tachometer, on the same shaft as the dc motor, is simply a generator. It gives a dc output voltage proportional to the speed of the motor. A summing amplifier, A1, controls its output so that the tachometer voltage equals the input voltage, but of opposite sign. With current drive to the motor, phase lag to the tachometer is 90° , before the second order effects come in. Compensation on A1 is designed to give less than 90° phase shift over the range of frequencies where the servo loop goes through unity gain. Should response time be of less concern, a power op amp could be substituted for A1 to drive the motor directly. Lowering break frequencies of the compensation would, of course, be necessary. The circuit could also be used as a position servo. All that is needed is a voltage indicating the sense and magnitude of the motor shaft displacement from a desired position. This error signal is connected to the input, and the servo works to make it zero. The tachometer is still required to develop a phase-correcting rate signal because the error signal lags the motor drive by 180° .

CLOSED LOOP, TACHOMETER FEEDBACK CONTROL



GENERAL ELECTRIC

Fig. 60-17

Circuit Notes

The system utilizes the H21A1 and a chopper disc to provide superior speed regulation when the dynamic characteristics of the motor system and the feedback system are matched to provide stability. The tachometer feedback system illustrated was designed around specific motor/load combinations and may require modification to prevent hunting or oscillation with other combinations. This dc motor control utilizes the optachometer circuit previously shown to control a P.U.T. pulse generator that drives the D44E1 darlington transistor which powers the motor.

61

Multiplier Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Analog Multiplier

0.01% Analog Multiplier

ANALOG MULTIPLIER

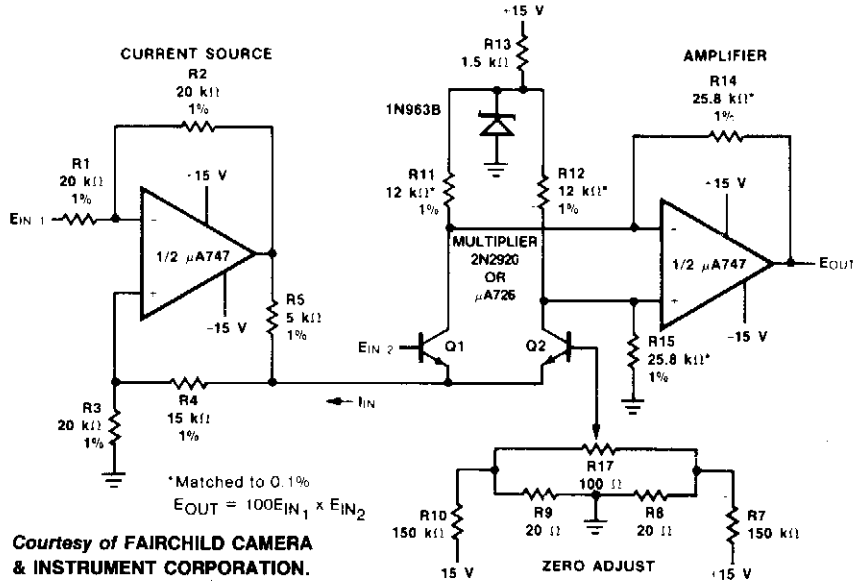


Fig. 61-1

0.01% ANALOG MULTIPLIER

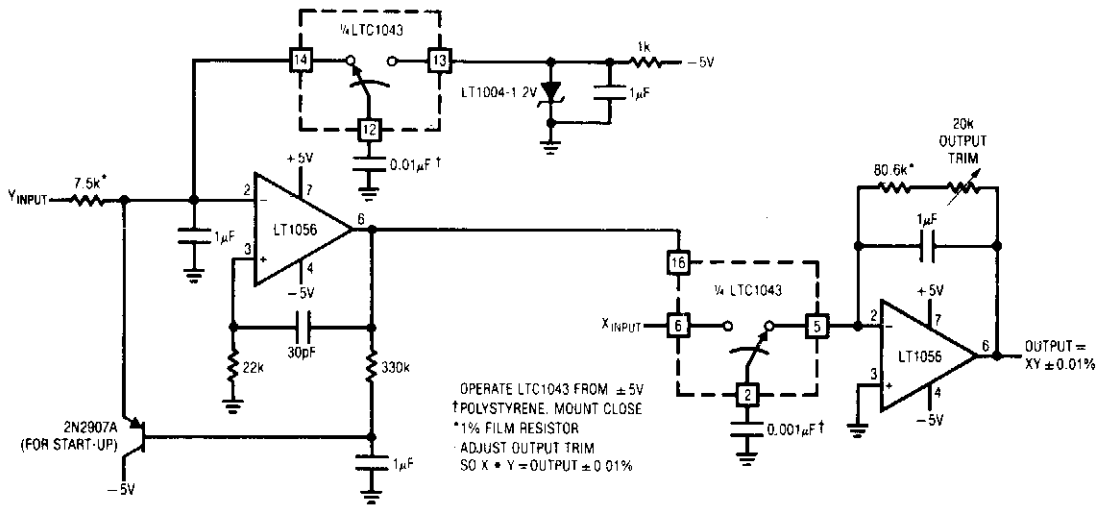


Fig. 61-2

Circuit Notes

The F → V input frequency is locked to the V → F output because the LTC1043's clock is common to both sections. The F → V's reference is used as one input of the multiplier, while the V → F furnishes the other. To calibrate, short the X and Y inputs to 1.7320 V and trim for a 3-V output.

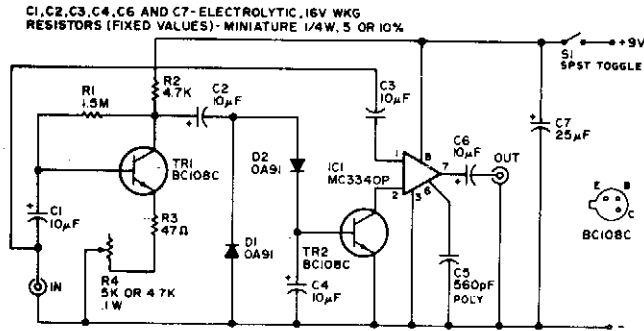
62

Noise Reduction Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Audio Squelch Circuit
Precise Audio Clipper
Balance Amplifier with Loudness Control
Noise Limiter
Audio-Powered Noise Clipper

AUDIO SQUELCH CIRCUIT



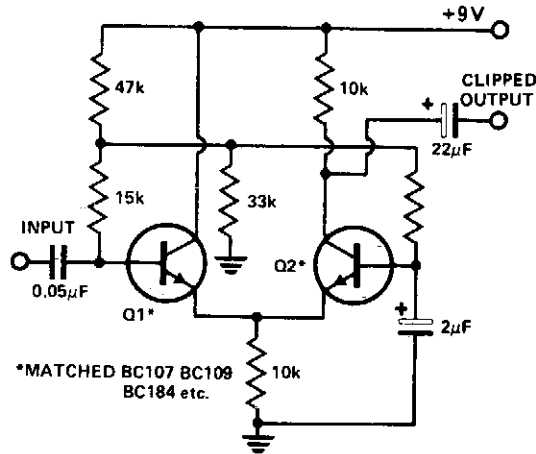
73 MAGAZINE

Fig. 62-1

Circuit Notes

This simple audio squelch unit suppresses all input signals below a preset threshold.

PRECISE AUDIO CLIPPER



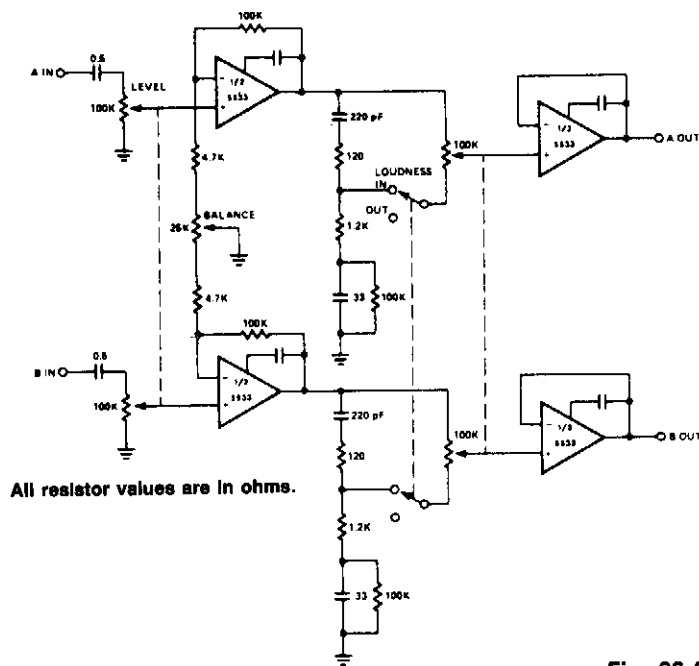
ELECTRONICS INTERNATIONAL TODAY

Fig. 62-2

Circuit Notes

A differential amplifier makes an excellent audio clipper and can provide precise, symmetrical clipping. The circuit shown commences clipping at an input of 100 mV. The output commences clipping at ± 3 V. Matching Q1 and Q2 is necessary for good symmetrical clipping. (If some asymmetry can be tolerated, this need not be done.)

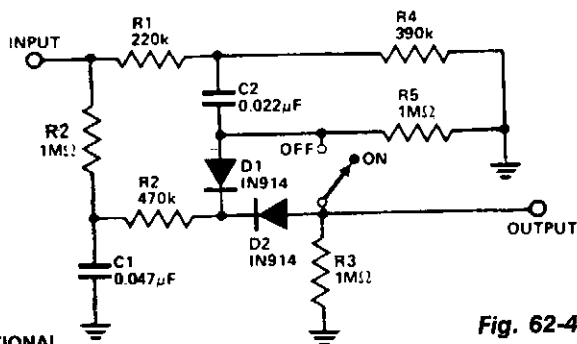
BALANCE AMPLIFIER WITH LOUDNESS CONTROL



SIGNETICS

Fig. 62-3

NOISE LIMITER



ELECTRONICS TODAY INTERNATIONAL

Fig. 62-4

Circuit Notes

This limiter improves signal-to-noise ratio. It is connected between the detector output and the audio input (if high impedance) or at some relatively high-impedance section between two audio stages—preferably the low level stages. D1 and D2 can be any diode having relatively low forward resistance and very high back resistance. The circuit is excellent for receivers having bandwidths down to 2 or 3 kHz. Increase the value of C1 for receivers having narrower bandwidths.

AUDIO-POWERED NOISE CLIPPER

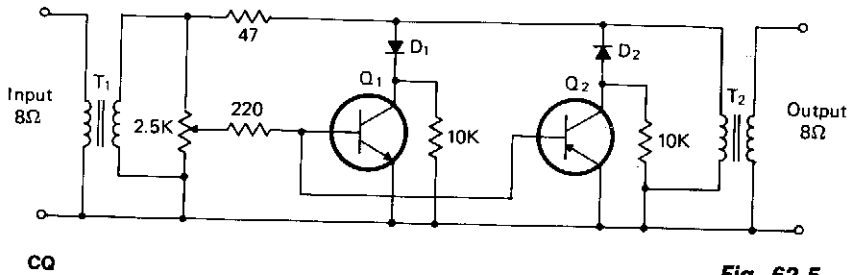


Fig. 62-5

Circuit Notes

T₁ and T₂ are 600 to 8 ohm transformers (any transistor radio output transformers with 500 to 4 ohm impedance may be used). Q₁ is a 2N2222 npn transistor, and Q₂ is a 2N2907 pnp transistor. D₁ and D₂ 1N270 signal diodes (HEP 134 or 135). Two transistors, powered by the audio power contained within the signal, will clip signal peaks which exceed the threshold established by the 2.5 K potentiometer. The diodes isolate the positive and negative clipping circuits represented by the npn and pnp transistors, respectively. A desired audio operating level can be established and the potentiometer needs little or no further adjustment.

63

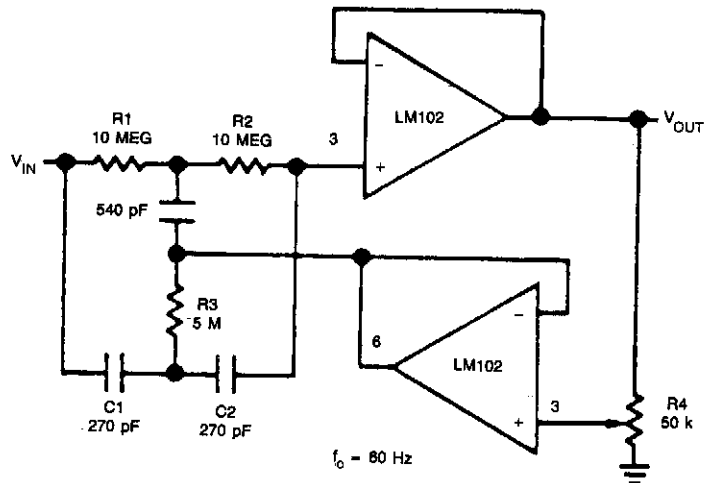
Notch Filters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Adjustable Q Notch Filter
1800 Hz Notch Filter
550 Hz Notch Filter
Tunable Audio Notch Filter Circuit
Audio Notch Filter

Tunable Notch Filter Uses an Operational Amplifier
Active Band-Reject Filter
Wien Bridge Notch Filter
Tunable Audio Filter
Passive Bridged, Differentiator Tunable Notch Filter

ADJUSTABLE Q NOTCH FILTER



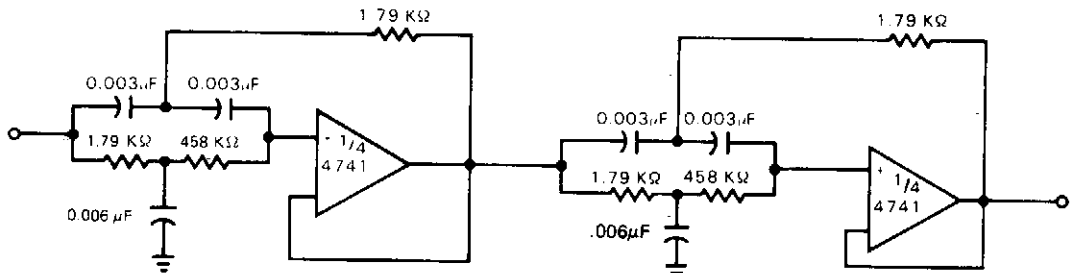
NATIONAL SEMICONDUCTOR CORP.

Fig. 63-1

Circuit Notes

In applications where the rejected signal might deviate slightly from the null on the notch network, it is advantageous to lower the Q of the network. This insures some rejection over a wider range of input frequencies. The figure shows a circuit where the Q may be varied from 0.3 to 50. A fraction of the output is fed back to R3 and C3 by a second voltage follower, and the notch Q is dependent on the amount of signal fed back. A second follower is necessary to drive the twin "T" from a low-resistance source so that the notch frequency and depth will not change with the potentiometer setting.

1800 Hz NOTCH FILTER



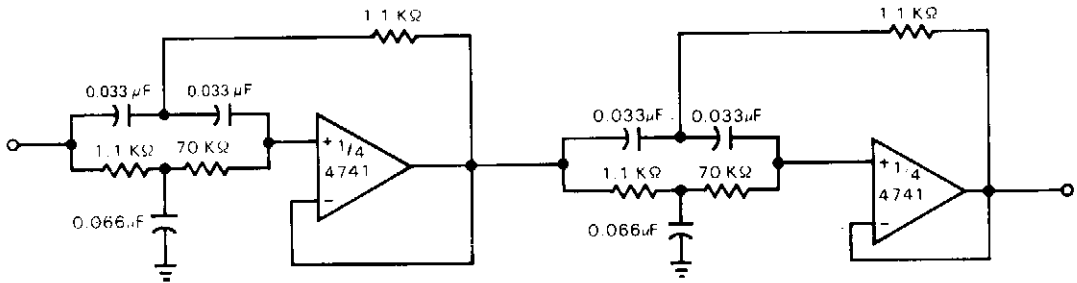
EXAR

Fig. 63-2

Circuit Notes

The circuit produces at least 60 dB of attenuation of the notch frequency.

550 Hz NOTCH FILTER



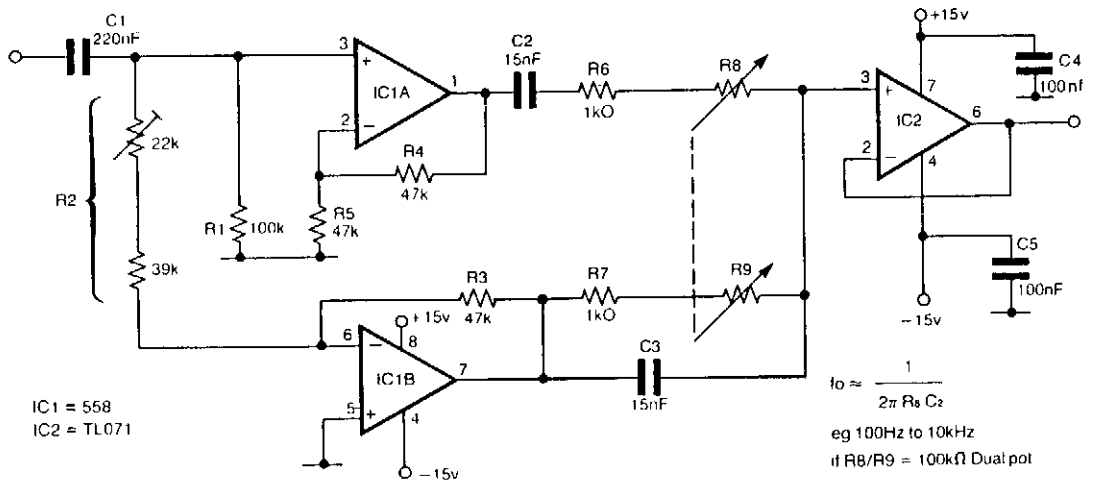
EXAR

Fig. 63-3

Circuit Notes

The circuit produces at least 60 dB of attenuation of the notch frequency.

TUNABLE AUDIO NOTCH FILTER CIRCUIT



IC1 = 558
IC2 = TL071

$$f_0 \approx \frac{1}{2\pi R_8 C_2}$$

eg 100Hz to 10kHz
if R8/R9 = 100kΩ Dual pot

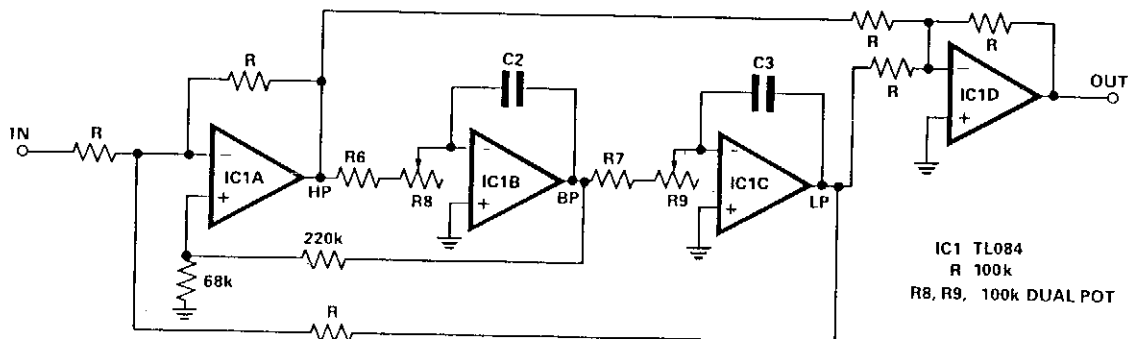
ELECTRONIC ENGINEERING

Fig. 63-4

Circuit Notes

The circuit requires only one dual-ganged potentiometer to tune over a wide range; if necessary over the entire audio range in one sweep. The principle used is that of the Wien bridge, fed from anti-phase inputs. The output should be buffered as shown with a FET input op amp, particularly if a high value pot is used. An op amp with differential outputs (eg., MC1445) may be used in place of the driver ICs; R2 may be made trimmable to optimize the notch.

AUDIO NOTCH FILTER



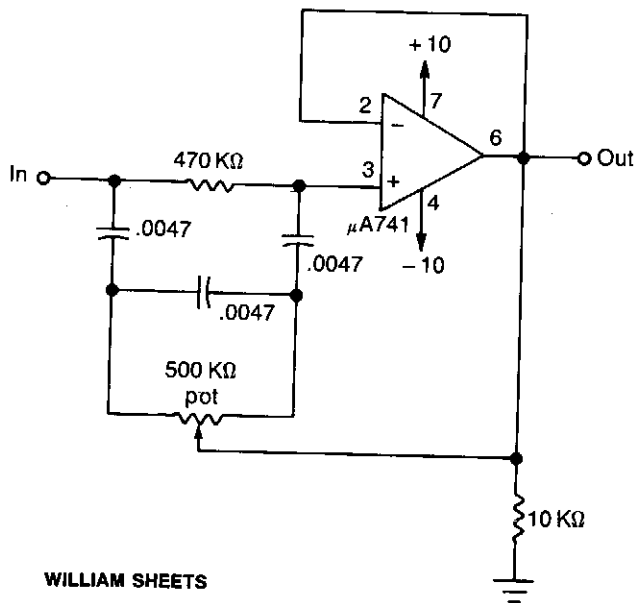
ELECTRONIC ENGINEERING

Fig. 63-5

Circuit Notes

With the circuit shown here the response at one octave off tune is within 10% of the far out response: notch sharpness may be increased or reduced by reducing or increasing respectively the 68 K ohm resistor. Linearity tracking of R8 and R9 has no effect on notch depth. The signals at HP and LP are always in antiphase, notch will always be very deep at the tuned frequency, despite tolerance variations in R6-9 and C2, C3.

TUNABLE NOTCH FILTER USES AN OPERATIONAL AMPLIFIER



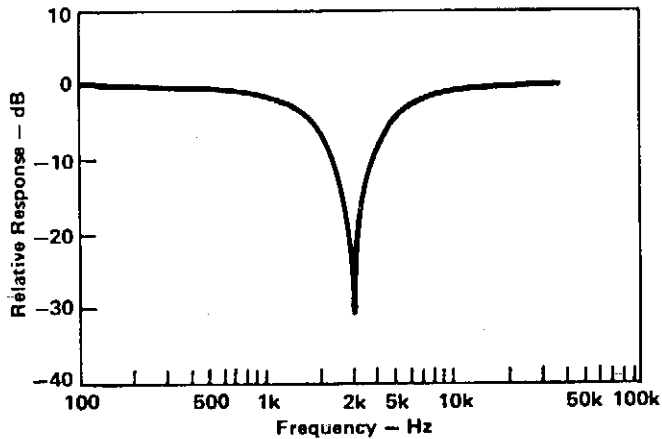
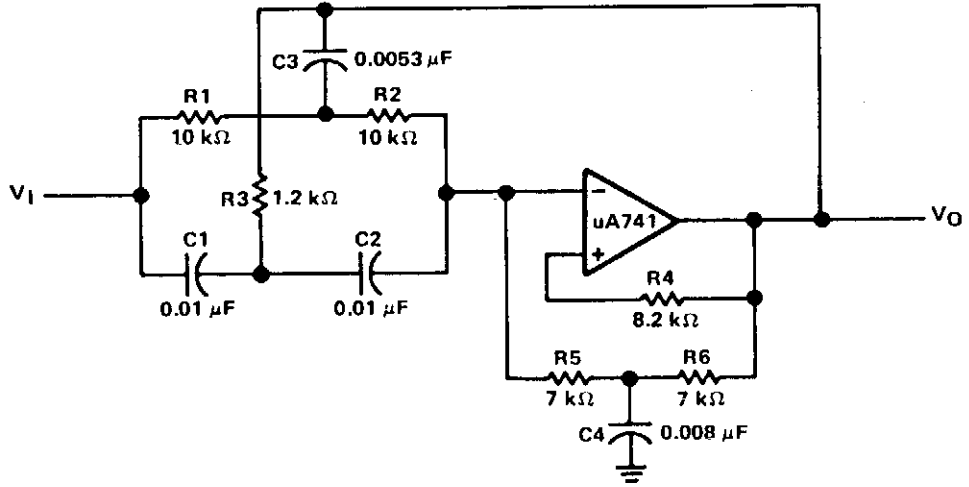
WILLIAM SHEETS

Fig. 63-6

Circuit Notes

This notch filter is useful for tunable band-reject applications in the audio range. The values shown will give a tuning range of about 300-1500 Hz.

ACTIVE BAND-REJECT FILTER



TEXAS INSTRUMENTS

Fig. 63-7

Circuit Notes

A filter with a band-reject characteristic is frequently referred to as a notch filter. A typical circuit using a μ A 741 is the unity-gain configuration for this type of active filter shown. The filter response curve shown is a second-order band-reject filter with a notch frequency of 3 kHz. The resulting Q of this filter is about 23, with a notch depth of -31 dB. Although three passive T networks are used in this application, the operational amplifier has become a sharply tuned low-frequency filter without the use of inductors or large-value capacitors.

WIEN BRIDGE NOTCH FILTER

WILLIAM SHEETS

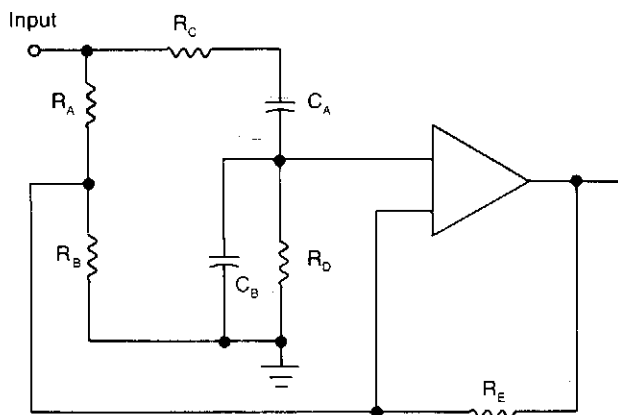
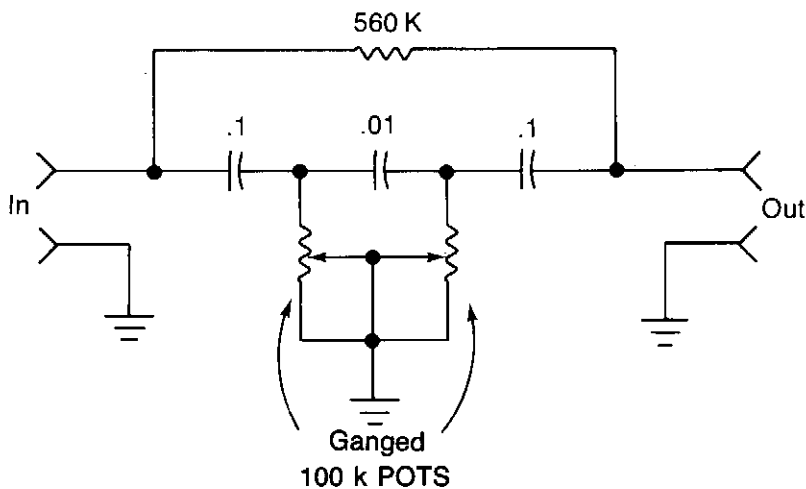


Fig. 63-8

if $R_A = R_B = R_C = R_D = R_E = R$ and $C_A = C_B = C$

$$f_{\text{null}} = \frac{1}{6.28 RC} \begin{matrix} R \text{ megohm} \\ C \text{ microfarad} \\ f \text{ Hertz} \end{matrix}$$

TUNABLE AUDIO FILTER



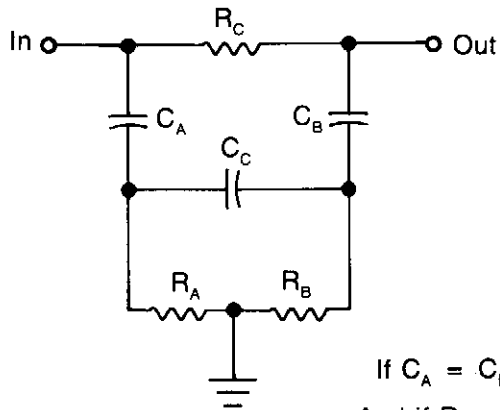
WILLIAM SHEETS.

Fig. 63-9

Circuit Notes

This filter covers the upper part of the audio passband and can be used to eliminate unwanted high frequencies from audio signals.

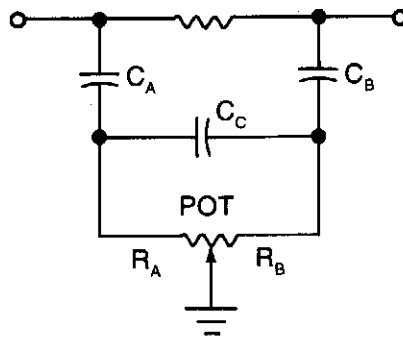
PASSIVE BRIDGED, DIFFERENTIATOR TUNABLE NOTCH FILTER



If $C_A = C_B = C_C = C$
 And if $R_3 = 6(R_A + R_B)$

$$\text{Then } \left\{ \begin{array}{l} \text{Notch} \\ \text{freq} \end{array} \right\} = \frac{1}{6.28 C \sqrt{3R_A R_B}}$$

If R_A and R_B is made a potentiometer
 then the filter can be variable.



WILLIAM SHEETS

Fig. 63-10

R_A and R_B are sections of potentiometer.

64

Operational Amplifier Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Variable Gain and Sign Op Amp Circuit
Single Potentiometer Adjusts Op Amp's Gain Over
Bipolar Range

VARIABLE GAIN AND SIGN OF AMP CIRCUIT

Fig.1

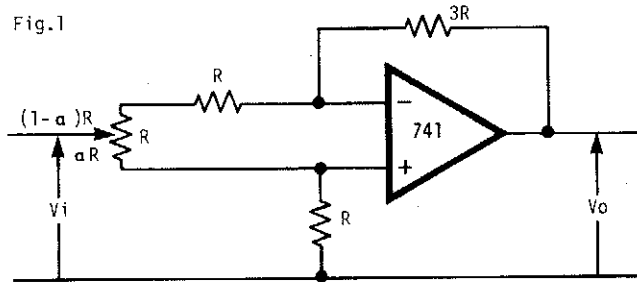
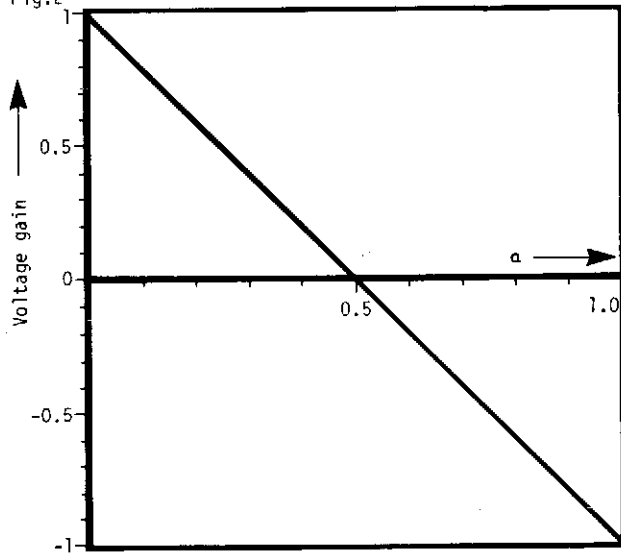


Fig.2



ELECTRONIC ENGINEERING

Fig. 64-1

Circuit Notes

The gain of the amplifier is smoothly-controllable between the limits of +1 to -1. It is adjustable over this range using a single potentiometer. The voltage gain of the arrangement is given by:

$$\frac{V_o}{V_i} = \frac{2(1-2\alpha)}{(1+\alpha)(2-\alpha)}$$

Where α represents the fractional rotation of the potentiometer, R.

SINGLE POTENTIOMETER ADJUSTS OP AMP'S GAIN OVER BIPOLAR RANGE

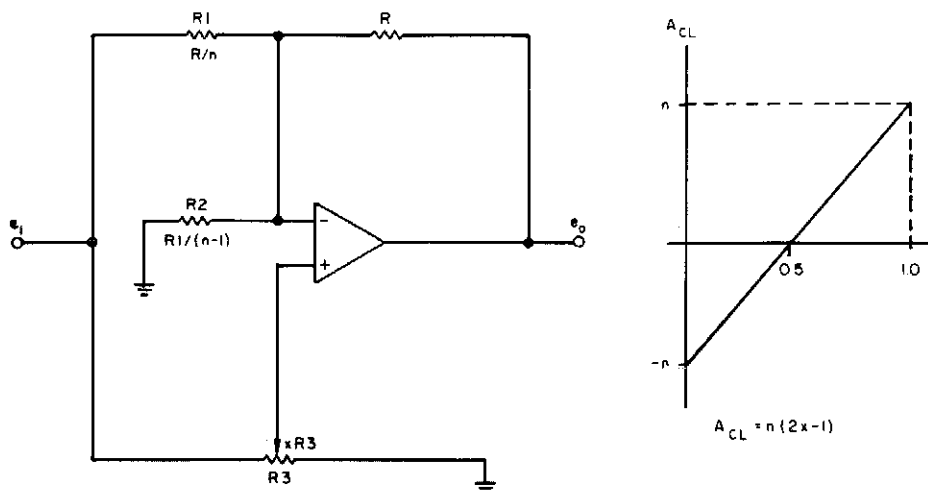


Fig. 64-2

ELECTRONIC DESIGN

Circuit Notes

An op amp's gain level can be adjusted over its full inverting and noninverting gain range. R_3 varies the signal applied to both the inverting and noninverting amplifier inputs. When the wiper position (denoted by x) equals zero, the noninverting amplifier input is grounded. This also holds the voltage across R_2 at zero, so R_2 has no effect on operation. Now only R_1 and R carry feedback current, and the amplifier operates at a gain of $-n$. At the other pot extreme, where $x = 1$, the input signal is connected directly to the noninverting input. Since feedback maintains a near-zero voltage between the amplifier inputs, the amplifier's inverting input will also be near the input signal level, thus little voltage is across R_1 , also now the gain is $+n$. The amplifier should be driven from a low impedance source to minimize source loading error, low offset op amps should be used.

65

Optically-Coupled Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Three-Phase Switch for Inductive Load

Integrated Solid State Relay

Stable Optocoupler

Microprocessor Triac Array Driver

DC Linear Coupler

Linear AC Analog Coupler

Simple AC Relay Using Two Photon Couplers

Linear Analog Coupler

High Sensitivity, Normally Open, Two Terminal,

Zero Voltage Switching Half-Wave Contact
Circuit

High Speed Paper Tape Reader

Digital Transmission Isolator

Isolation and Zero Voltage Switching Logic

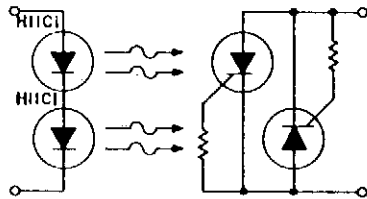
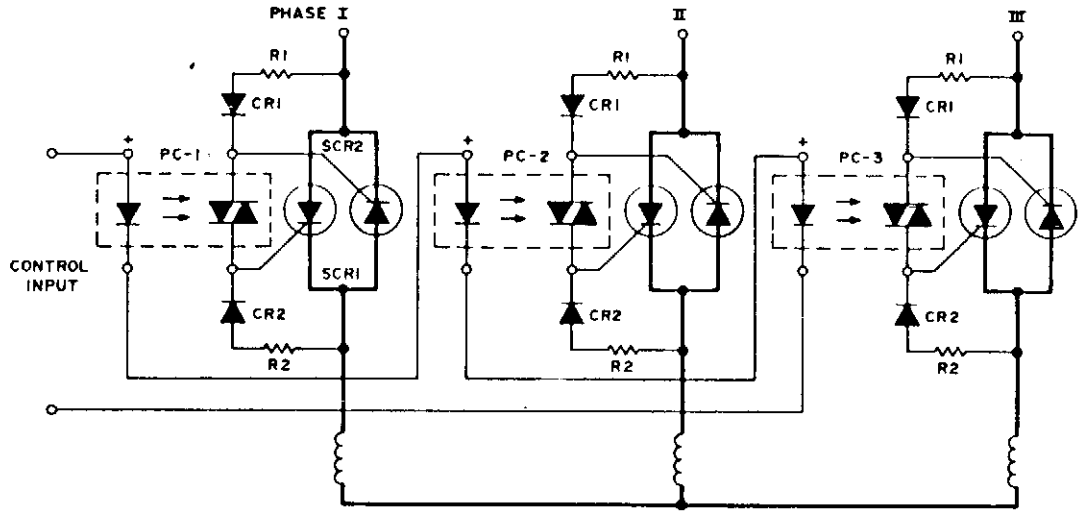
Optical Communication System

Linear Optocoupler Circuit for Instrumentation

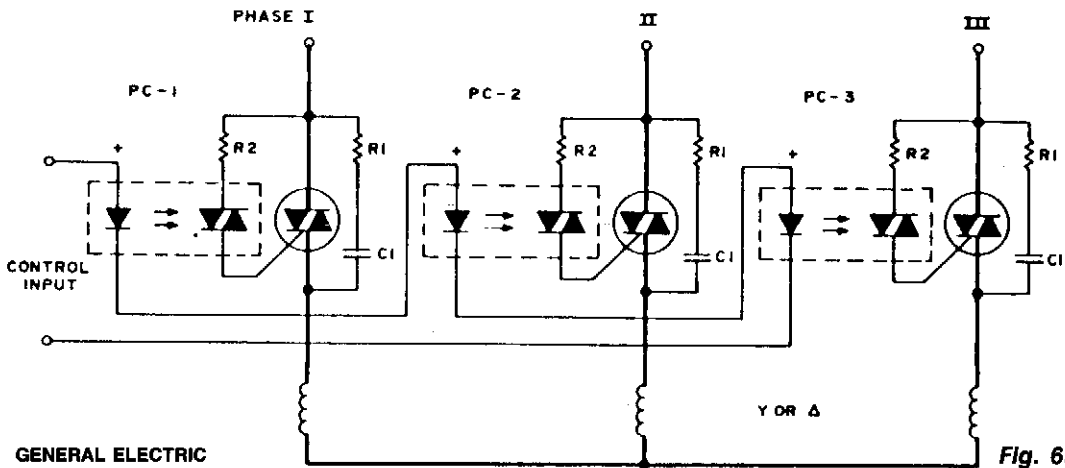
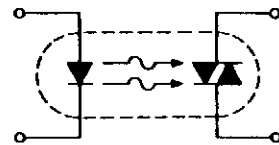
50 kHz Center Frequency FM Optical Transmitter

Receiver for 50 kHz FM Optical Transmitter

THREE-PHASE SWITCH FOR INDUCTIVE LOAD



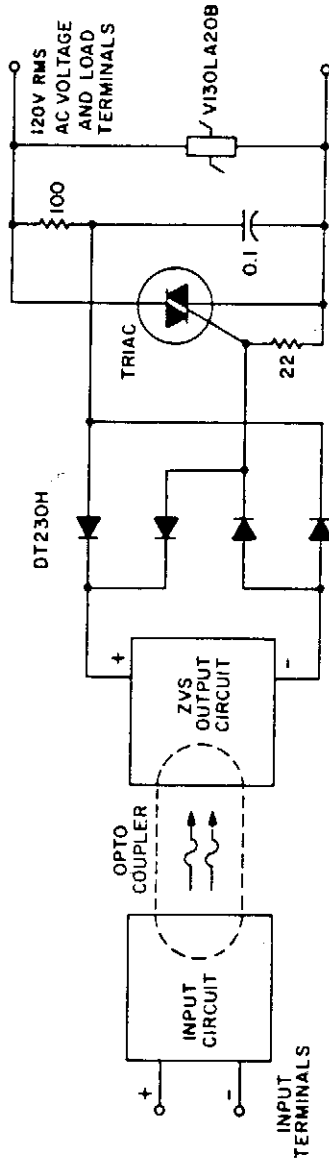
BECOMES



Circuit Notes

The following are three-phase switches for low voltage. Higher currents can be obtained by using inverse parallel SCRs which would be triggered as shown. To simplify the following schematics and facilitate easy understanding of the principles involved, the following schematic substitution is used (Note the triac driver is of limited use at 3 ϕ voltage levels).

INTEGRATED SOLID STATE RELAY



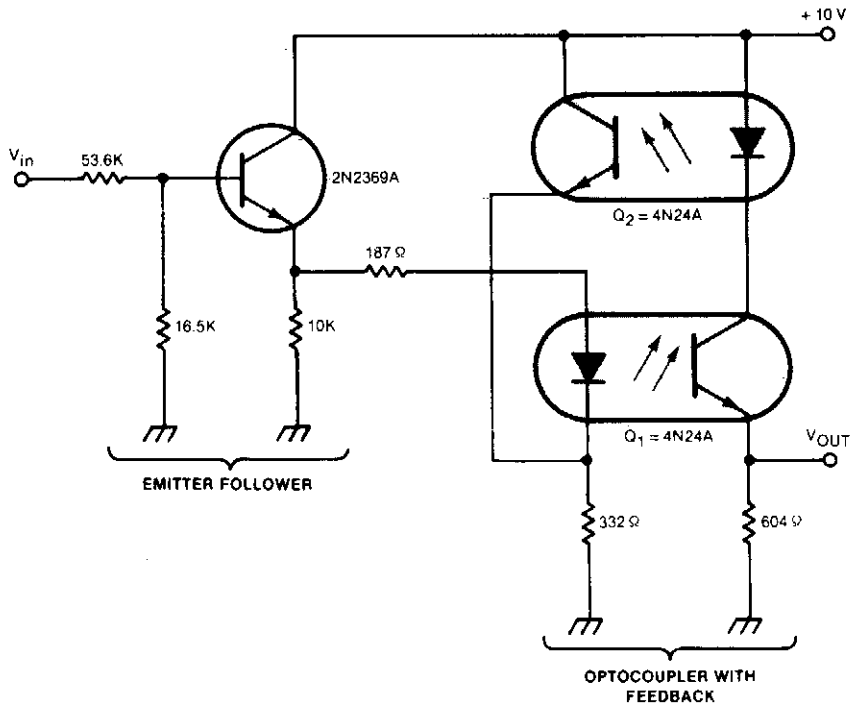
GENERAL ELECTRIC

Fig. 65-2

Circuit Notes

A complete zero-voltage switch solid-state relay contains an input circuit, an output circuit, and the power thyristor. The circuit illustrates a triac power thyristor with snubber circuit and GE-MOVR II Varistor transient over-voltage protection. The 22 ohm resistor shunts di/dt currents, passing through the bridge diode capacitances, from the triac gate, while the 100 ohm resistor limits surge and gate currents to safe levels. Although the circuits illustrated are for 120-V rms operation, relays that operate on 220 V require higher voltage ratings on the MOV, rectifier diodes, triac, and pilot SCR. The voltage divider that senses zero crossing must also be selected to minimize power dissipation in the transistor optisolator circuit for 220-V operation.

STABLE OPTOCOUPLER



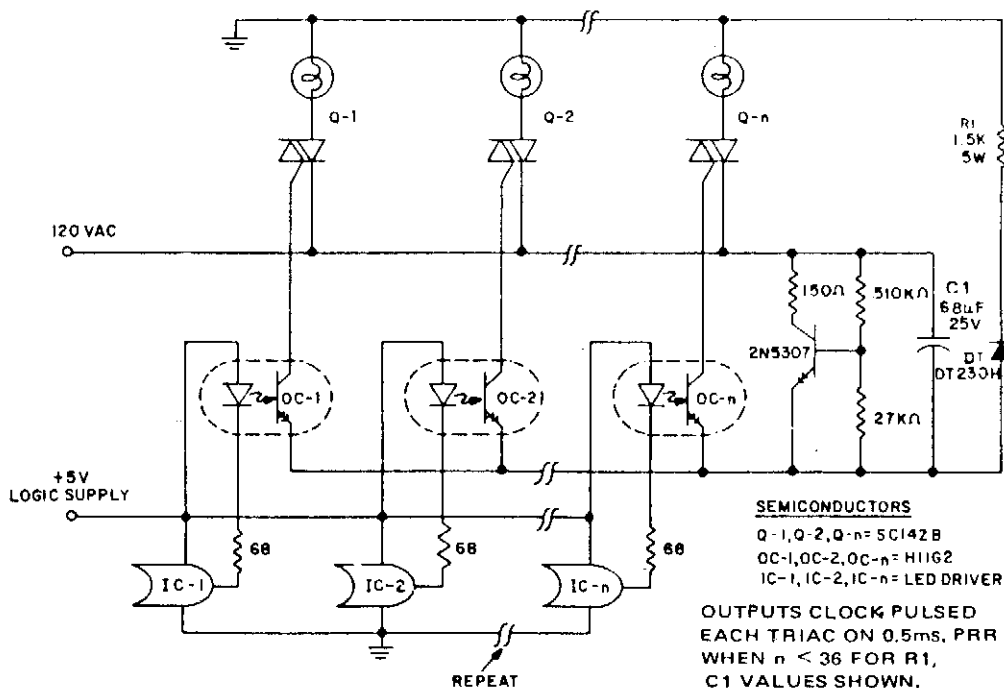
NASA

Fig. 65-3

Circuit Notes

A circuit stabilizes the current-transfer ratio (CTR) of an optically coupled isolator used as a linear transducer. The optocoupler produces a voltage output that is proportional to—but electrically isolated from—the voltage input. However, the output voltage is directly affected by changes in the CTR, and the CTR can change substantially with temperature and current. To a lesser extent the CTR changes with time over the life of the optocoupler. The circuit employs a feedback circuit containing a second optocoupler. The feedback signal tends to oppose changes in the overall CTR.

MICROPROCESSOR TRIAC ARRAY DRIVER



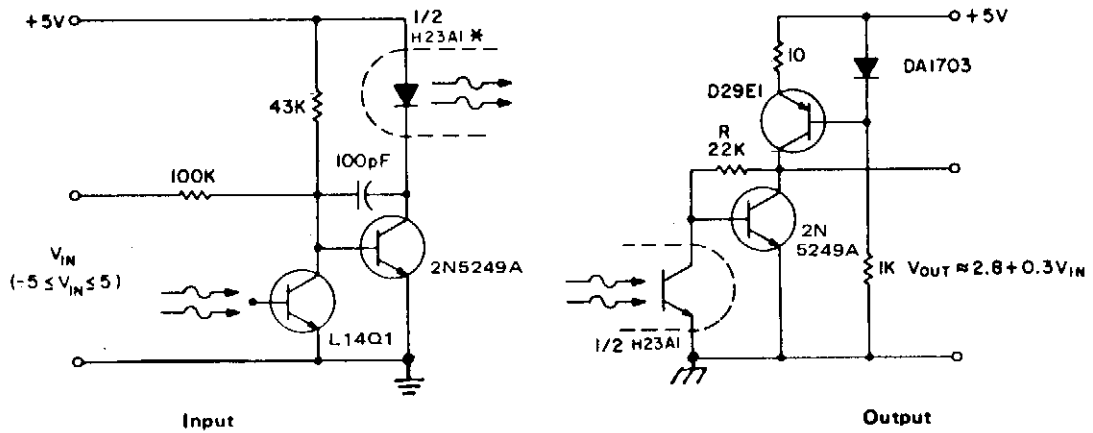
GENERAL ELECTRIC

Fig. 65-4

Circuit Notes

In microprocessor control of multiple loads, the minimum cost per load is critical. A typical application example is a large display involving driving arrays of incandescent lamps. This circuit provides minimal component cost per stage and optocoupler triggering of triac power switches from logic outputs. The minimal component cost is attained by using more complex software in the logic. A darlington output optocoupler provides gate current pulses to the triac, with cost advantages gained from eliminating the current limiting resistor and from the low cost coupler. The trigger current source is a dipped tantalum capacitor, charged from the line via a series resistor with coarse voltage regulation being provided by the darlington signal transistor. The resistor and capacitor are shared by all the darlington-triac pairs and are small in size and cost due to the low duty cycle of pulsing. Coupler IRED current pulses are supplied for the duration of one logic clock pulse (2-10 μ sec), at 0.4 to 1 msec intervals, from a LED driver I.C. The pulse timing is derived from the clock waveform when the logic system requires triac conduction. A current limiting resistor is not used, which prevents Miller effect slowdown of the H11G2 switching speed to the extent the triac is supplied insufficient current to trigger. Optodarlington power dissipation is controlled by the low duty cycle and the capacitor supply characteristics.

DC LINEAR COUPLER



LINEAR OPTICAL COUPLER CIRCUIT

*Closely positioned to illuminate L14Q1 and H23A1 Detector, such that $V_{OUT} \approx 2.8V$ at $V_{IN} = 0$.

GENERAL ELECTRIC

Fig. 65-5

Circuit Notes

The accuracy of direct linear coupling of analog current signals via an optocoupler is determined by the coupler linearity and its temperature coefficient. Use of an additional coupler for feedback can provide linearity only if the two couplers are perfectly matched and identically biased. These are not practical constraints in most equipment designs and indicate the need for a different design approach. One of the most successful solutions to this problem can be illustrated by using a H23 emitter-detector pair and a L14H4. The H23 detector and L14H4 are placed so both are illuminated by the H23 IRED emitter. Ideally, the circuit is mechanically designed such that the H23 emitter may be positioned to provide $V_{OUT} = 2.8V$ when $V_{IN} = 0$, thereby insuring collector current matching in the detectors. Then all three devices are locked in position relative to each other. Otherwise, R may be adjusted to provide the proper null level, although temperature tracking should prove worse when R is adjusted. Note that the input bias is dependent on power supply voltage, although the output is relatively independent of supply variations. Testing indicated linearity was better than could be resolved, due to alignment motion caused by using plastic tape to lock positions. The concept of feedback control of IRED power output is useful for both information transmission and sensing circuitry.

LINEAR AC ANALOG COUPLER

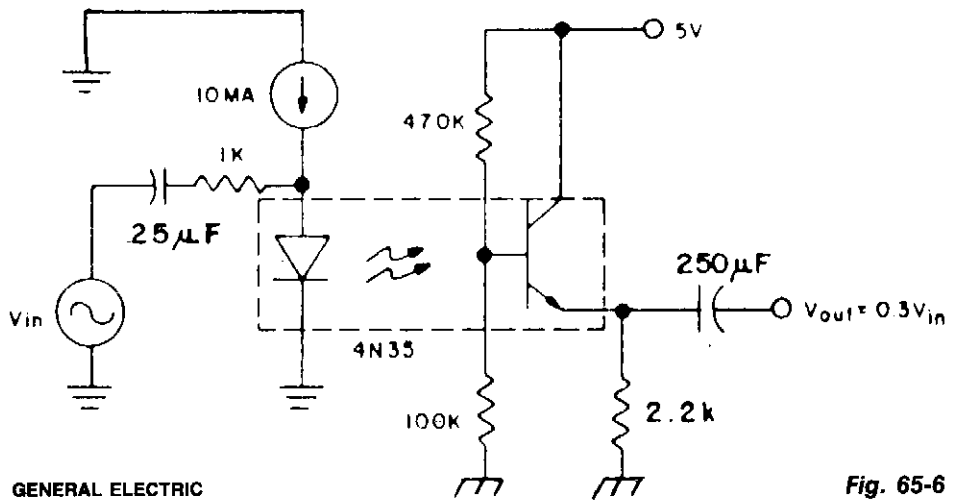


Fig. 65-6

Circuit Notes

With the coupler biased in the linear region by the 10 mA dc bias on the IRED and the voltage divider on the phototransistor base, photodiode current flows out of the base into the voltage divider, producing an ac voltage proportional to the ac current in the IRED. The transistor is biased as an emitter follower and requires less than 10% of the photodiode current to produce the low impedance ac output across the emitter resistor. Note that the H11AV1 may be substituted for the 4N35 to provide VDE line voltage rated isolation of less than 0.5 pF.

SIMPLE AC RELAY USING TWO PHOTON COUPLERS

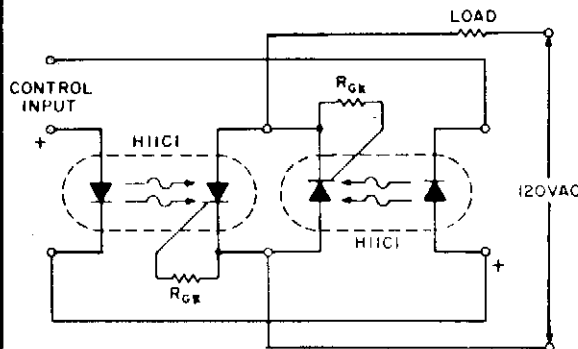
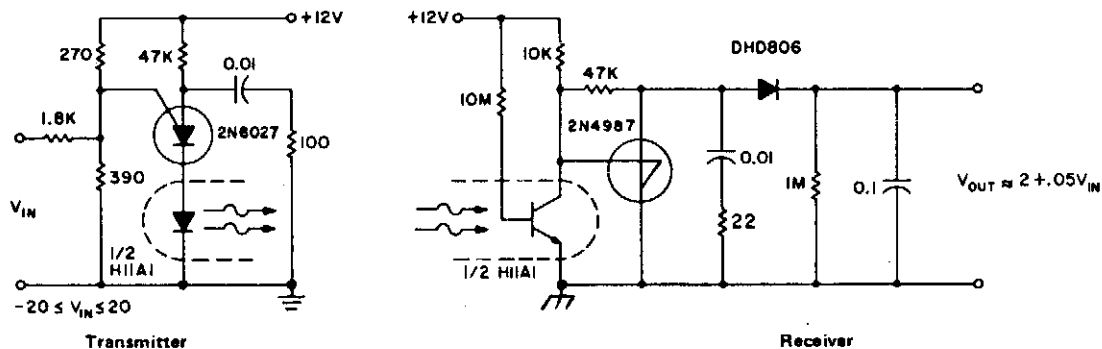


Fig. 65-7

Circuit Notes

If load current requirements are relatively low (i.e. maximum forward rms current 500 mA), an ac solid state relay can be constructed quite simply by the connection of two H11C optically coupled SCRs in a back-to-back configuration as illustrated.

LINEAR ANALOG COUPLER



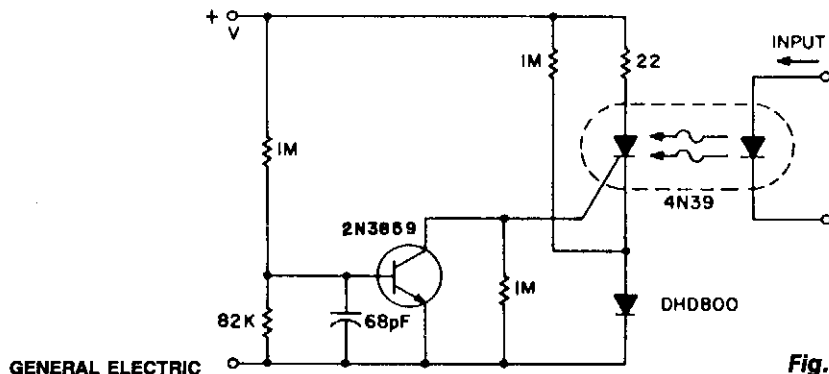
GENERAL ELECTRIC

Fig. 65-8

Circuit Notes

The minimum parts count version of this system provides isolated, linear signal transfer useful at shorter distances or with an optocoupler for linear information transfer. Although the output is low level and cannot be loaded significantly without harming accuracy, a single I.C. operational or instrumentation amplifier can supply both the linear gain and buffering for use with a variety of loads.

HIGH SENSITIVITY, NORMALLY OPEN, TWO TERMINAL, ZERO VOLTAGE SWITCHING, HALF-WAVE CONTACT CIRCUIT



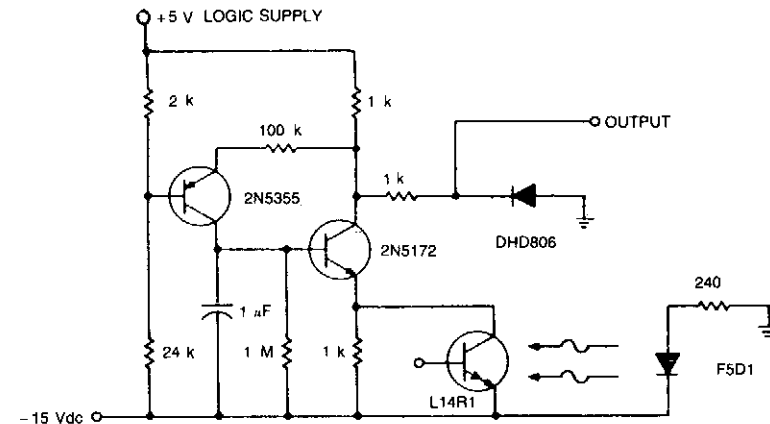
GENERAL ELECTRIC

Fig. 65-9

Circuit Notes

The SCR coupler circuit provides higher sensitivity to input signals as illustrated. This allows the lower cost 4N39 (H11C3) to be used with the > 7 mA drive currents supplied by the input circuit.

HIGH SPEED PAPER TAPE READER



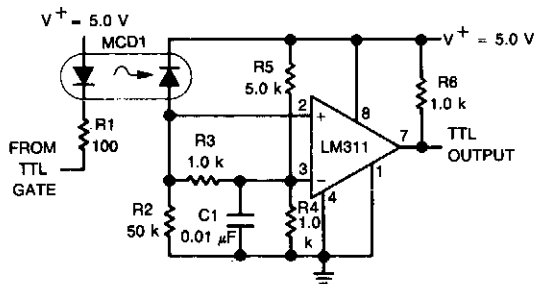
GENERAL ELECTRIC

Fig. 65-10

Circuit Notes

When computer peripheral equipment is interfaced, it is convenient to work with logic signal levels. With a nominal 4 V at the output dropping to -0.6 V on illumination, this circuit reflects the requirements of a high-speed, paper tape optical reader system. The circuit operates at rates of up to 1000 bits per second. It will also operate at tape translucency such that 50% of the incident light is transmitted to the sensor, and provide a fixed threshold signal to the logic circuit, all at low cost. Several circuit tricks are required. Photodarlington speed is enhanced by cascode constant voltage biasing. The output threshold and tape translucency requirements are provided for by sensing the output voltage and operating to 2000 bits per second at ambient light levels equal to signal levels.

DIGITAL TRANSMISSION ISOLATOR



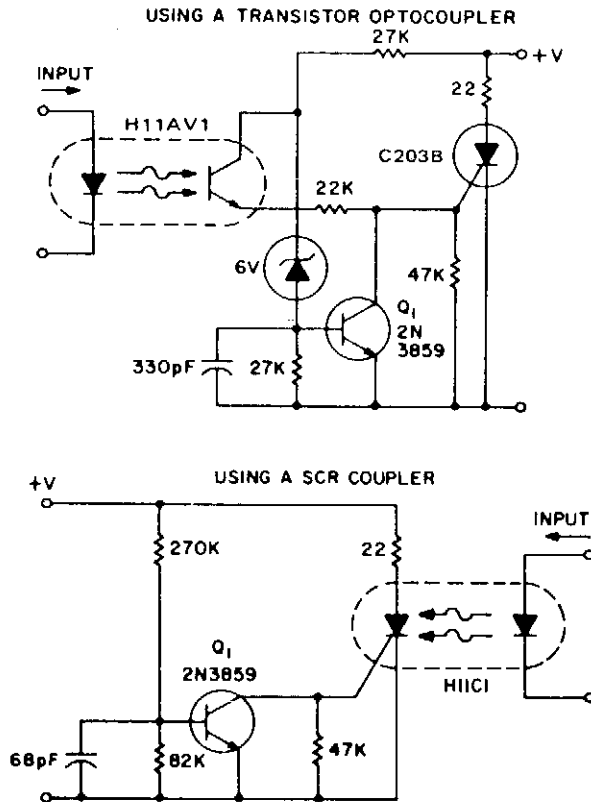
National Semiconductor Corp.

Fig. 65-11

Circuit Notes

An optoelectronics device is used to couple a digital (TTL) signal to another system. The photodiode in the optocoupler drives an LM311 set up to produce a TTL compatible output. It is useful where grounds are not able to be connected for any reason.

ISOLATION AND ZERO VOLTAGE SWITCHING LOGIC



NORMALLY OPEN, TWO TERMINAL, ZERO VOLTAGE SWITCHING HALF WAVE CONTACT CIRCUITS

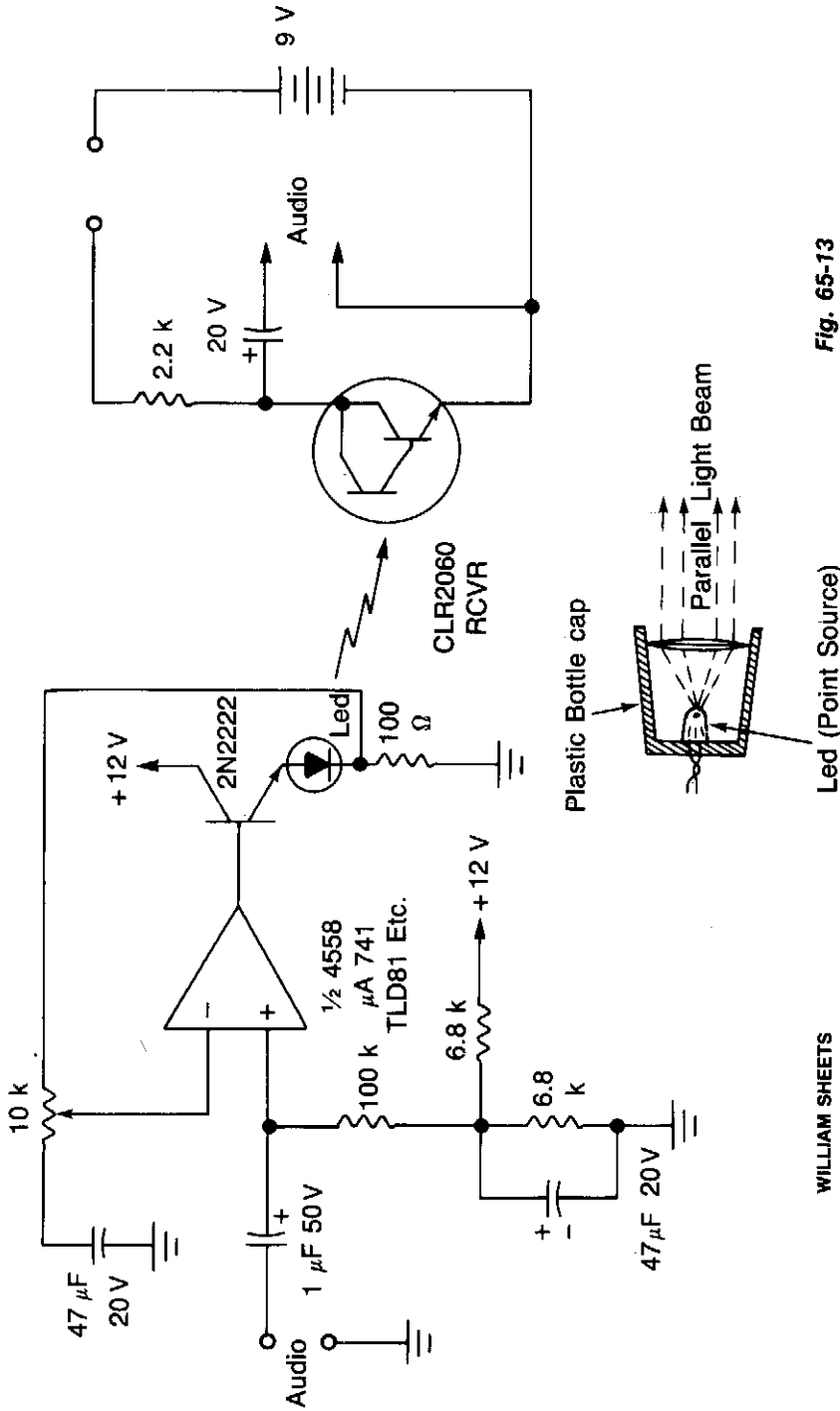
GENERAL ELECTRIC

Fig. 65-12

Circuit Notes

These two simple circuits provide zero voltage switching. They can be used with full wave bridges or in antiparallel to provide full wave control and are normally used to trigger power thyristors. If an input signal is present during the time the ac voltage is between 0 to 7 V, the SCR will turn on. But, if the ac voltage has risen above this range and the input signal is then applied, the transistor, Q1, will be biased to the "on" state and will hold the SCR and, consequently, the relay "off" until the next zero crossing.

OPTICAL COMMUNICATION SYSTEM



WILLIAM SHEETS

Fig. 65-13

Circuit Notes

The circuit will modulate the light from the LED using a crystal microphone or a loudspeaker output. To obtain the maximum range, the optical system must be efficient (see example). Either a convex lens or a concave mirror can be used to convert the LED output into a parallel beam. The received light is concentrated onto a sensitive photodarlington transistor. At short range the signal across the load resistor is adequate to drive a crystal earpiece, for longer range an amplifier and a loudspeaker are needed.

50 KHz CENTER FREQUENCY FM OPTICAL TRANSMITTER

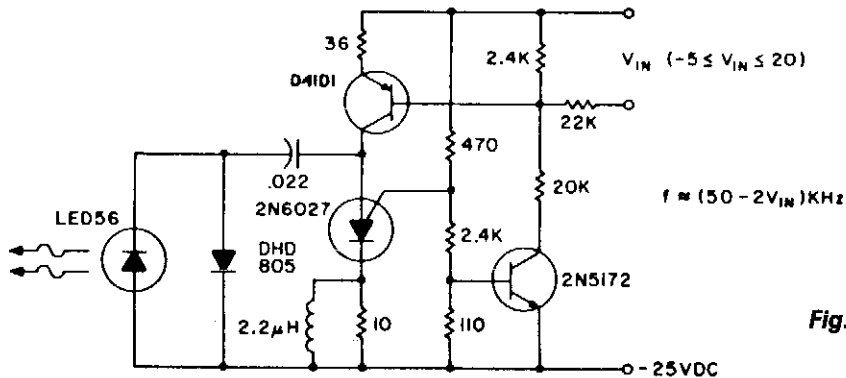


Fig. 65-14

GENERAL ELECTRIC

Circuit Notes

The pulse repetition rate is relatively insensitive to temperature, and power supply voltage and is a linear function of V_{IN} , the modulating voltage. Useful information transfer was obtained in free air ranges of 12 feet ($\approx 4m$). Lenses or reflectors at the light emitter and detector increases range and minimizes stray light noise effects. Greater range can also be obtained by using a higher power output IRED such as the F5D1 in combination with the L14P2 phototransistor. Average power consumption of the transmitter circuit is less than 3 watts.

LINEAR OPTOCOUPLER CIRCUIT FOR INSTRUMENTATION

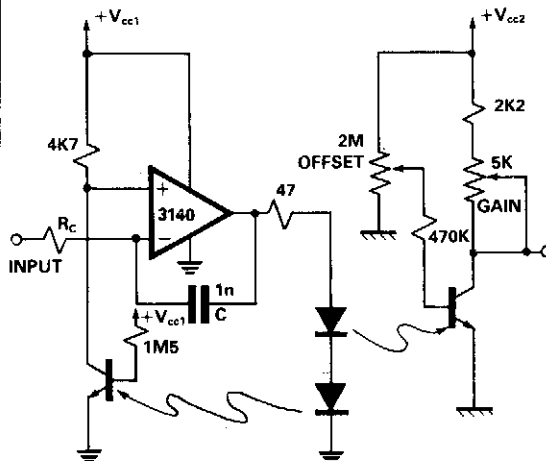


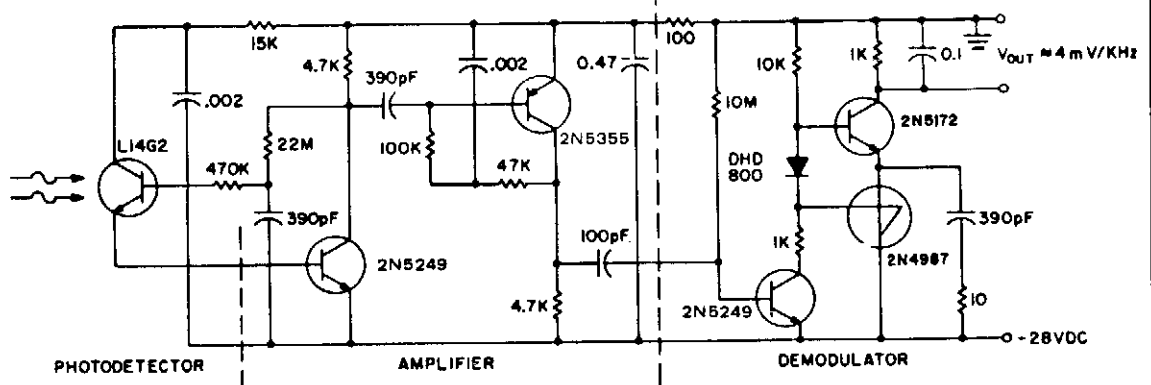
Fig. 65-15

ELECTRONIC ENGINEERING

Circuit Notes

A dual optocoupler is used in a configuration which has the same current throughout as the LEDs. Assuming similar optocoupler features the output voltage must be equal to the non-inverting input voltage. Since the op amp is within a closed loop the output voltage becomes equal to the input voltage. R_C and C perform as a compensation network to prevent oscillations.

RECEIVER FOR 50 kHz FM OPTICAL TRANSMITTER



GENERAL ELECTRIC

Fig. 65-16

Circuit Notes

For maximum range, the receiver must be designed in the same manner as a radio receiver front end, since the received signals will be similar in both frequency component and in amplitude of the photodiode current. The major constraint on the receiver performance is signal to noise ratio, followed by e.m. shielding, stability, bias points, parts layout, etc. These become significant details in the final design. This receiver circuit consists of a L14G2 detector, two stages of gain, and a FM demodulator which is the tachometer circuit, modified to operate up to 100 kHz. Better sensitivity can be obtained using more stages of stabilized gain with AGC, lower cost and sensitivity may be obtained by using an H23A1 emitter-detector pair and/or by eliminating amplifier stages. For some applications, additional filtering of the output voltage may be desired.

66

Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

RF-Genie

Emitter-Coupled Big Loop Oscillator

Simple Triangle Square Wave Oscillator

Oscillator Adjustable over 10:1 Range

One Second, 1 kHz Oscillator

Single Control Four-Decade Variable Oscillator

Tunable Frequency Oscillators

Resistance Controlled Digital Oscillator

Cassette Bias Oscillator

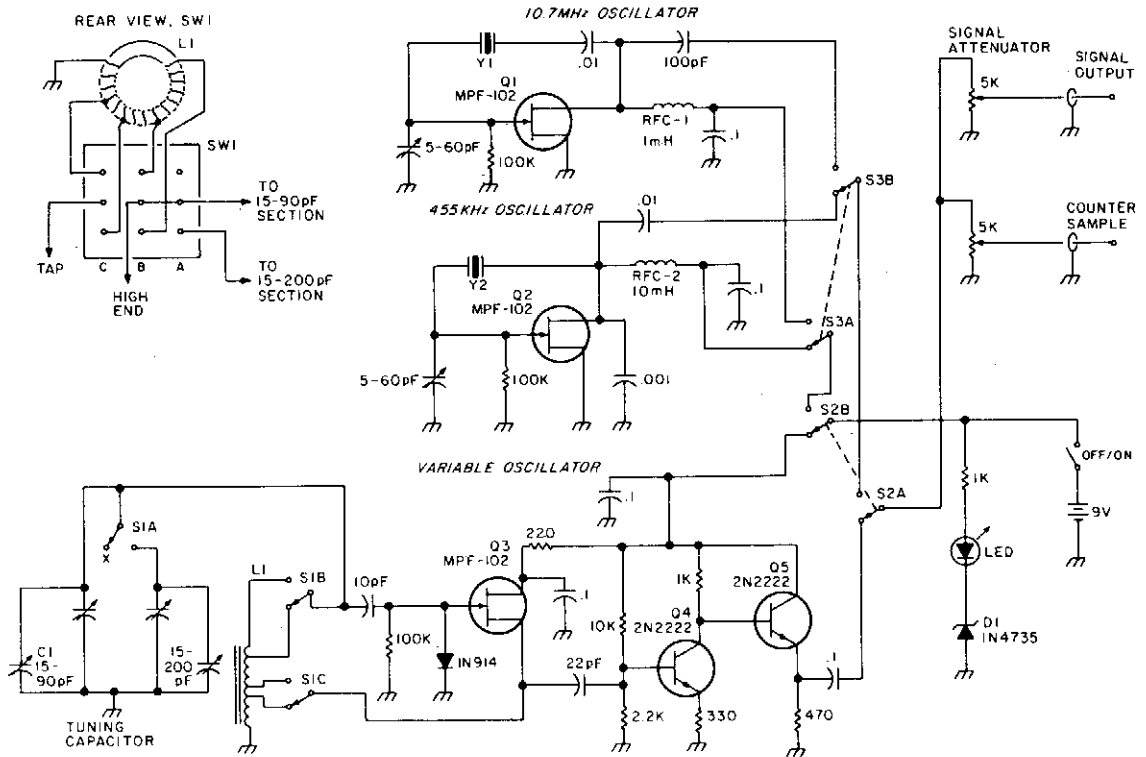
1 kHz Oscillator

Inexpensive Oscillator is Temperature Stable

Code Practice Oscillator

Wide Range Variable Oscillator

RF-GENIE



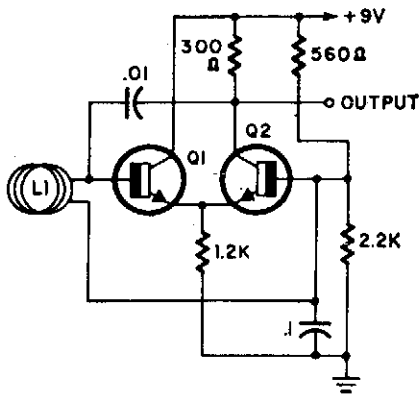
73 MAGAZINE

Fig. 66-1

Circuit Notes

A variable oscillator covers 3.2 to 22 MHz in two bands—providing coverage of 80 through 15 meters plus most crystal-filter frequencies. Optional 455 kHz and 10.7 MHz crystal oscillators can be switched on-line for precise *if* alignment. Generator output is on the order of 4 volts p-p into a 500 ohm load. A simple voltage-divider attenuator controls the generator's output level, and a second output provides sufficient drive for an external frequency counter.

EMITTER-COUPLED BIG LOOP OSCILLATOR



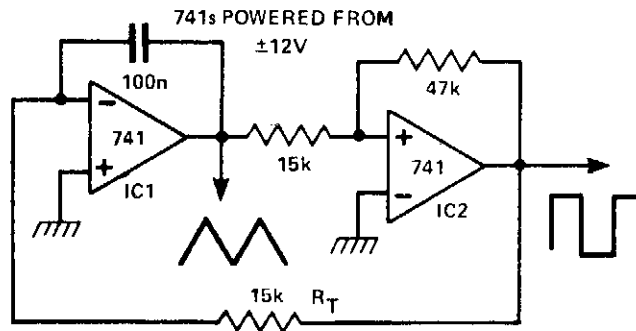
RADIO-ELECTRONICS

Fig. 66-2

Circuit Notes

L1 is a loop of 10 to 20 turns of insulated wire with a diameter anywhere between 4" to 4'. Oscillator frequency (7 to 30 MHz) shifts substantially when a person comes near or into the loop. This oscillator together with a resonant detector might make a very good anti-personnel alarm. Transistors are 2N2926 or equivalent.

SIMPLE TRIANGLE SQUARE WAVE OSCILLATOR



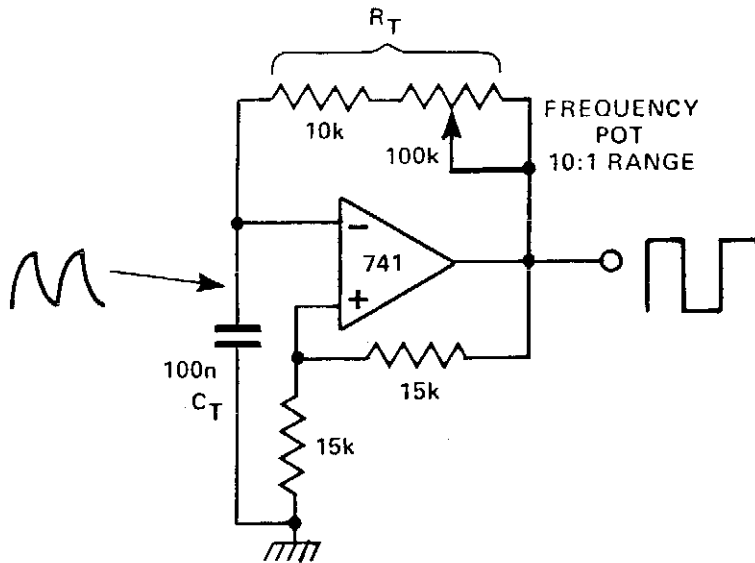
ELECTRONICS TODAY INTERNATIONAL

Fig. 66-3

Circuit Notes

This circuit generates simultaneously, a triangle and a square waveform. It is self starting and has no latch up problems. IC1 is an integrator with a slew rate determined by CT and RT and IC2 is a Schmitt trigger. The output of IC1 ramps up and down between the hysteresis levels of the Schmitt, the output of which drives the integrator. By making RT variable, it is possible to alter the operating frequency over a 100 to 1 range. Three resistors, one capacitor, and a dual op amp is all that is needed to make a versatile triangle and square wave oscillator with a possible frequency range of 0.1 Hz to 100 kHz.

OSCILLATOR ADJUSTABLE OVER 10:1 RANGE



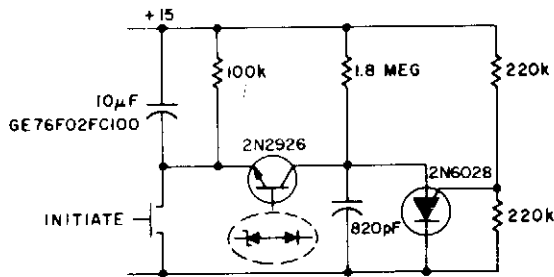
ELECTRONICS TODAY INTERNATIONAL

Fig. 66-4

Circuit Notes

In this circuit, there are two feedback paths around an op amp. One is positive dc feedback which forms a Schmitt trigger. The other is a CR timing network. Imagine that the output voltage is +10 V. The voltage at the noninverting terminal is +15 V. The voltage at the inverting terminal is a rising voltage with a time constant of $C_T R_T$. When this voltage exceeds +5 V, the op amp's output will go low and the Schmitt trigger action will make it snap into its negative state. Now the output is -10 V and the voltage at the inverting terminal falls with the time constant as before. By changing this time constant with a variable resistor, a variable frequency oscillation may be produced.

ONE SECOND, 1 kHz OSCILLATOR



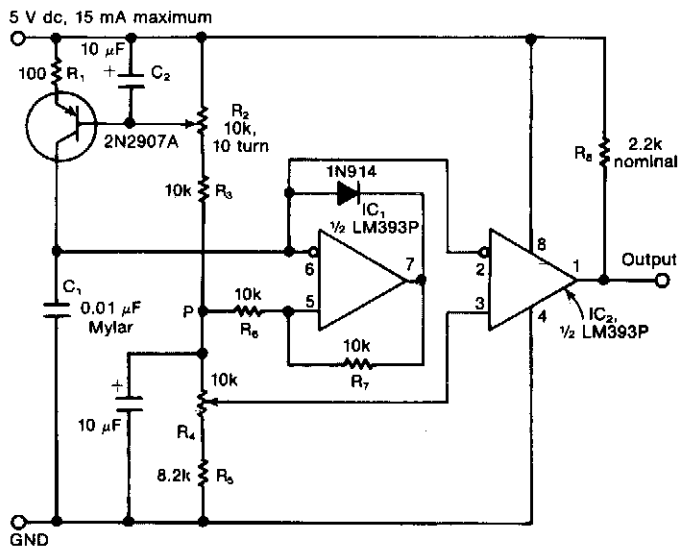
GENERAL ELECTRIC

Fig. 66-5

Circuit Notes

This circuit operates as an oscillator and a timer. The 2N6028 is normally on due to excess holding current through the 100 k resistor. When the switch is momentarily closed, the 10 μ F capacitor is charged to a full 15 volts and 2N2926 starts oscillating (1.8 M and 820 pF). The circuit latches when 2N2926 zener breaks down again.

SINGLE CONTROL FOUR-DECADE VARIABLE OSCILLATOR



ELECTRONIC DESIGN

Fig. 66-6

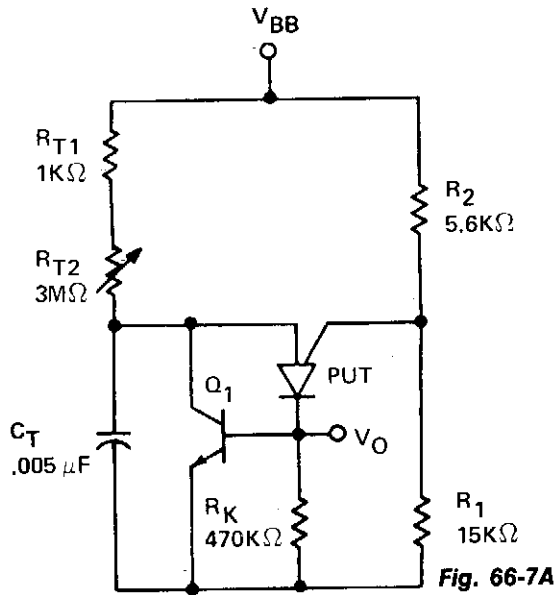
Circuit Notes

The circuit consists of a variable current source that charges a capacitor, which is rapidly discharged by a Schmitt-trigger comparator. The sawtooth waveform thus produced is fed to another comparator, one with a variable switching level. The output from the second comparator is a pulse train with an independently adjustable frequency and duty cycle. The variable-frequency ramp generator consists of capacitor C1, which is charged by a variable and nonlinear current source. The latter comprises a 2N2907A pnp transistor, plus resistor R1 and the potentiometer R2. Capacitor C2 eliminates any ripple or noise at the base of the transistor that might cause frequency jitter at the output.

TUNABLE FREQUENCY OSCILLATORS

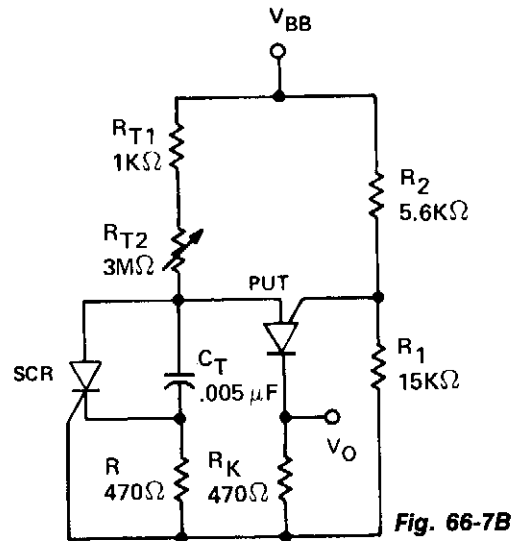
FREQUENCY RANGE
40 Hz to 65 kHz

OUTPUT PULSE
Rise time ~ 200 nsec.
Pulse width ~ 10 μ sec.
Recovery time < 200 nsec.



FREQUENCY RANGE
40 Hz to 40 kHz

OUTPUT PULSE
Width ~ 5 μ sec.

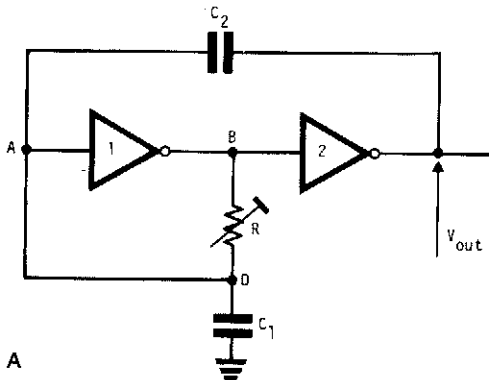


UNITRODE CORPORATION

Circuit Notes

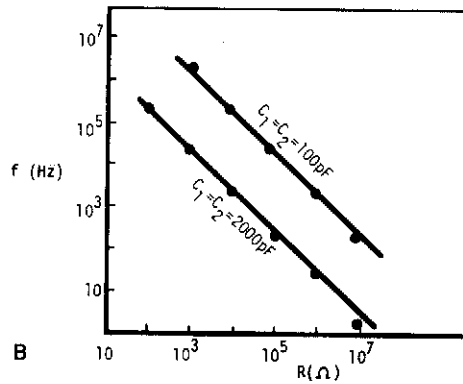
The variable oscillator circuit includes active elements for discharging the timing capacitor C_T shown in Fig. 66-7A. A second method is given as in Fig. 66-7B.

RESISTANCE CONTROLLED DIGITAL OSCILLATOR



A

ELECTRONIC ENGINEERING



B

Fig. 66-8

Circuit Notes

This very simple, low cost oscillator, is built with two CMOS buffer inverters, two capacitors and a variable resistance. The circuit can work with voltages ranging from 4 V up to 18 V. If $C_1 = C_2$, the frequency of oscillation, (ignoring the output and input impedance) is given by:

$$f = \frac{1}{4\pi\sqrt{2RC}}$$

The graph in Fig. B shows how the output frequency varies with resistance when $C_1 = C_2 = 100$ pF and $C_1 = C_2 = 2000$ pF.

CASSETTE BIAS OSCILLATOR

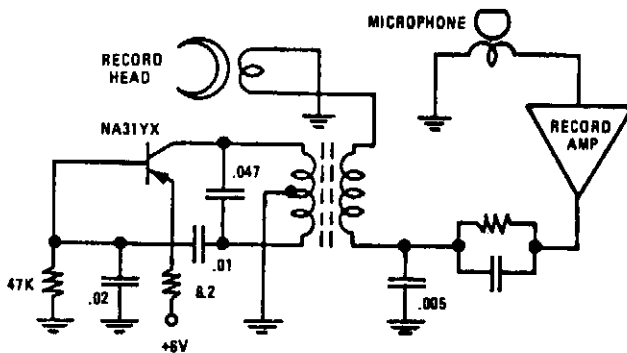
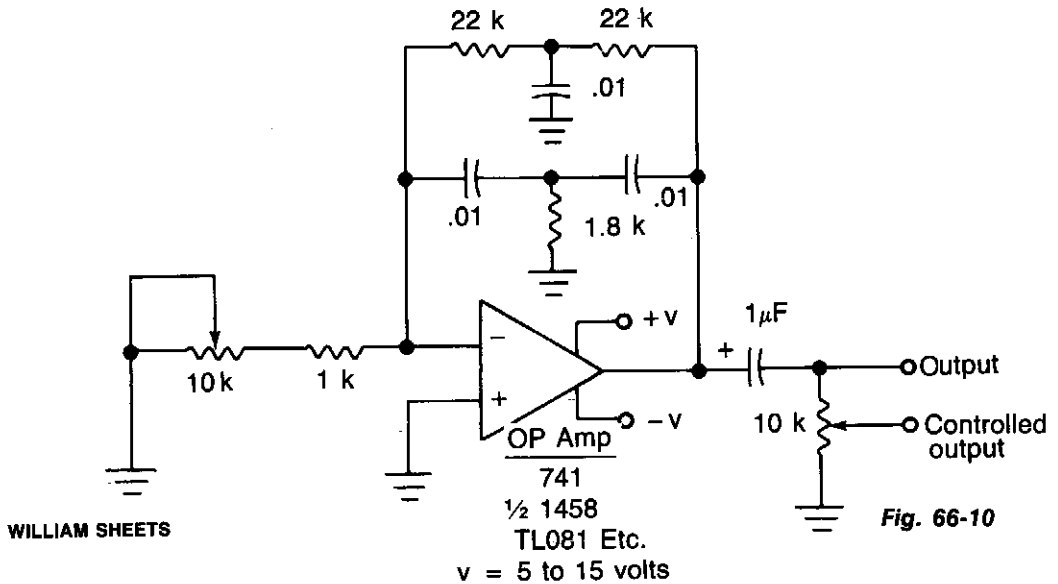


Fig. 66-9

NATIONAL SEMICONDUCTOR

1 kHz OSCILLATOR



Circuit Notes

If fine output control is desired, add the 10 K potentiometer. When the oscillator is connected to a dc circuit then connect a dc blocking capacitor in series with the potentiometer's wiper arm.

INEXPENSIVE OSCILLATOR IS TEMPERATURE STABLE

Circuit Notes

The Colpitts sinusoidal oscillator provides stable output amplitude and frequency from 0°F to +150°F. In addition, output amplitude is large and harmonic distortion is low. Oscillation is sustained by feedback from the collector tank circuit to the emitter. The oscillator's frequency is determined by:

$$f = \frac{1}{2\pi \sqrt{\frac{L_1 C_1 C_2}{C_1 + C_2}}}$$

Potentiometer R3 is an output level control. Control R1 may be used to adjust base bias for maximum-amplitude output. The circuit was operated at 50 kHz with L1 = 10mH, C1 = 3500 pF, and C2 = 1500 pF.

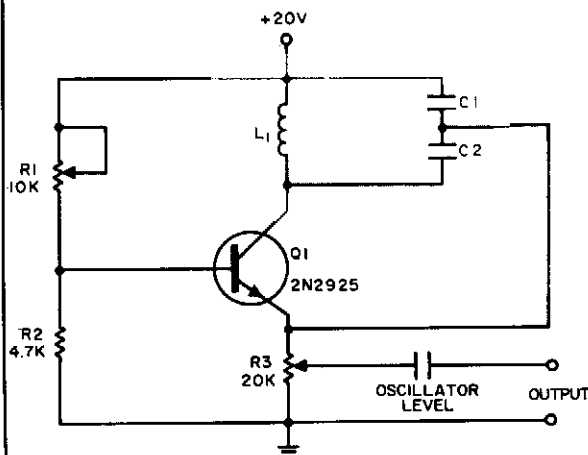
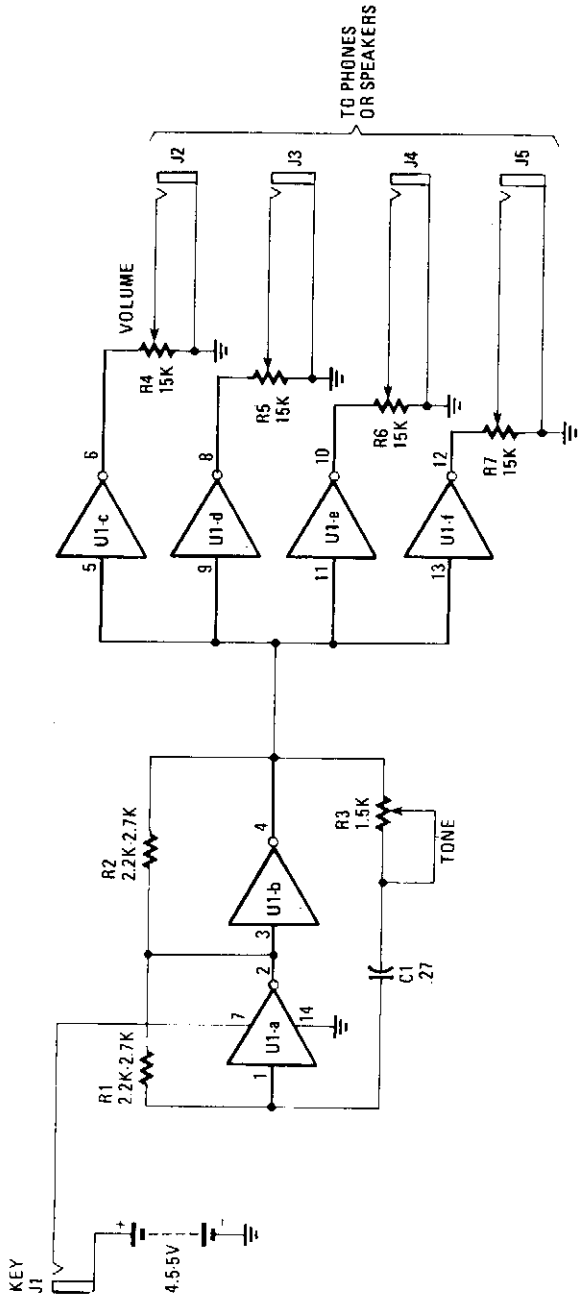


Fig. 66-11

ELECTRONIC DESIGN

CODE PRACTICE OSCILLATOR



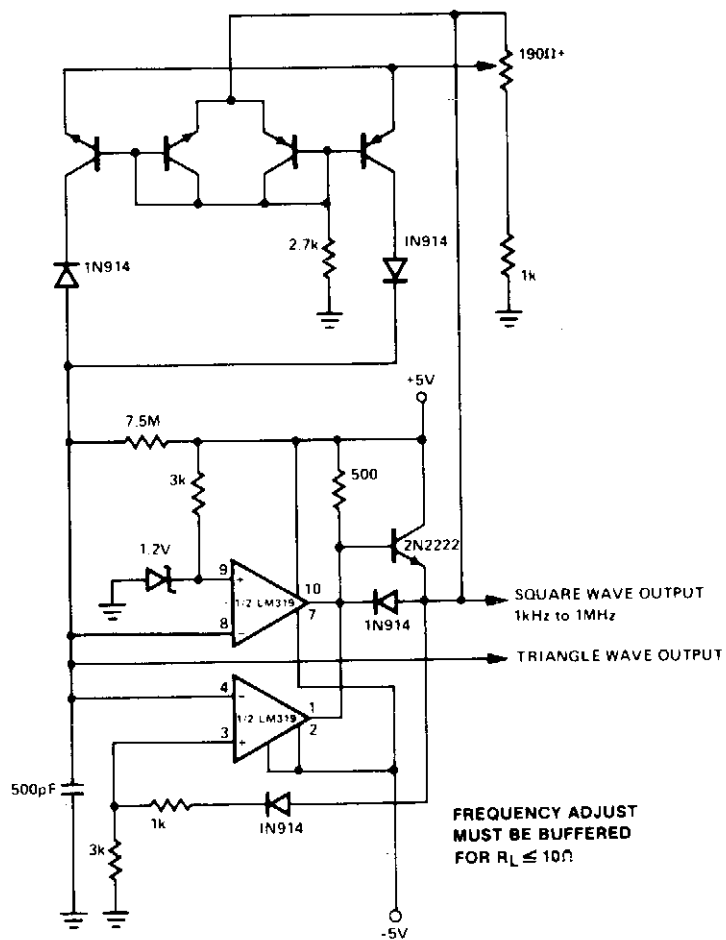
HANDS-ON ELECTRONICS

Circuit Notes

The inexpensive 7404 hex-inverter has enough amplification to handle a wide range of transducers. Closing the key completes the battery circuit and applies four to five volts to the 7404. Bias for the first two inverter amps (U1a and U1b) comes from the two resistors, R1 and R2, connected between their inputs and outputs. The capacitor and rheostat (R3/C1) close the feedback loop from the input to the properly-phased output. The signal leaving U1b drives the remaining four inverter amplifiers, U1c through U1f; they, in turn, drive the phones or speakers. The volume control potentiometers, R4-R7, may have any value from 1500 ohms to 10,000 ohms. The smaller values work best when speakers, or low impedance phones, are used.

Fig. 66-12

WIDE RANGE VARIABLE OSCILLATOR



SIGNETICS

Fig. 66-13

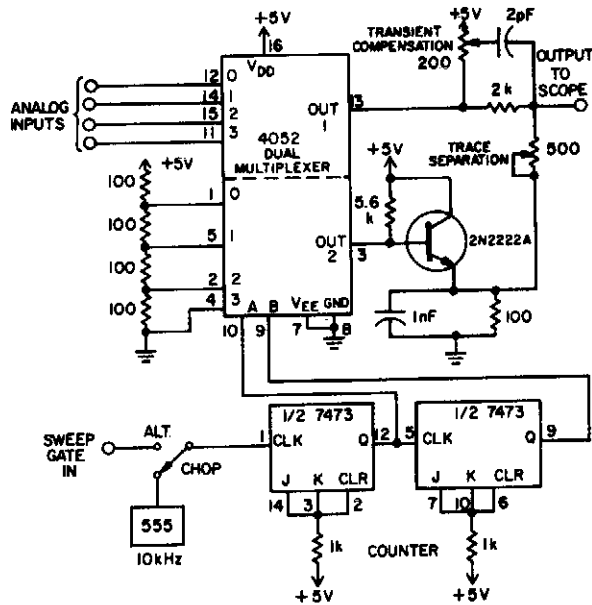
67

Oscilloscope Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Analog Multiplexer Converts Single-Trace Scope to
Four-Trace
FET Dual-Trace Scope Switch
Scope Calibrator

ANALOG MULTIPLEXER CONVERTS SINGLE-TRACE SCOPE TO FOUR-TRACE



ELECTRONIC DESIGN

Fig. 67-1

Circuit Notes

This adapter circuit, based on a dual four-channel analog multiplexer handles digital signals to at least 1 MHz, and analog signals at least through the audio range. The dual multiplexer's upper half selects one input for display. The lower half generates a staircase to offset the baselines of each channel, keeping them separate on the screen. The emitter-follower buffers the staircase, which is then summed with the selected signal. A two-bit binary counter addresses the CMOS 4052 multiplexer.

FET DUAL-TRACE SCOPE SWITCH

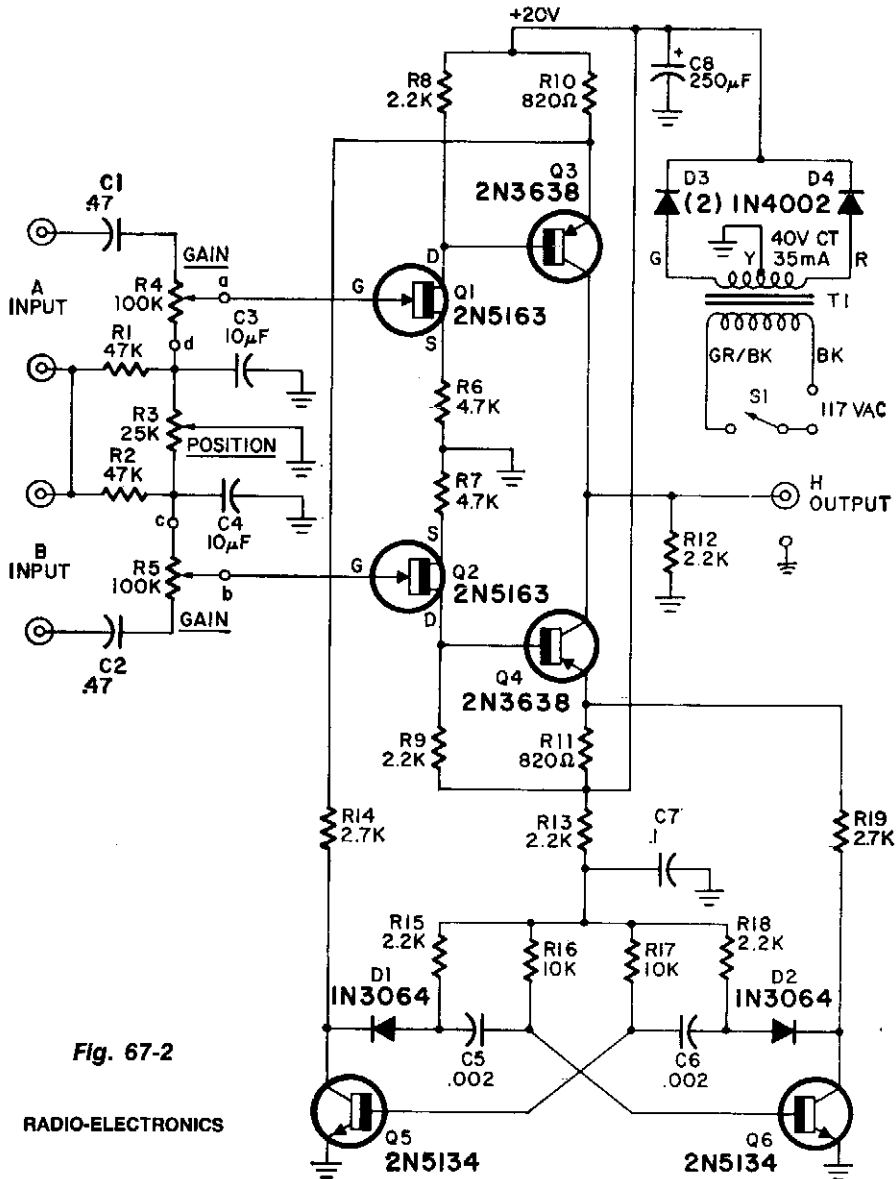


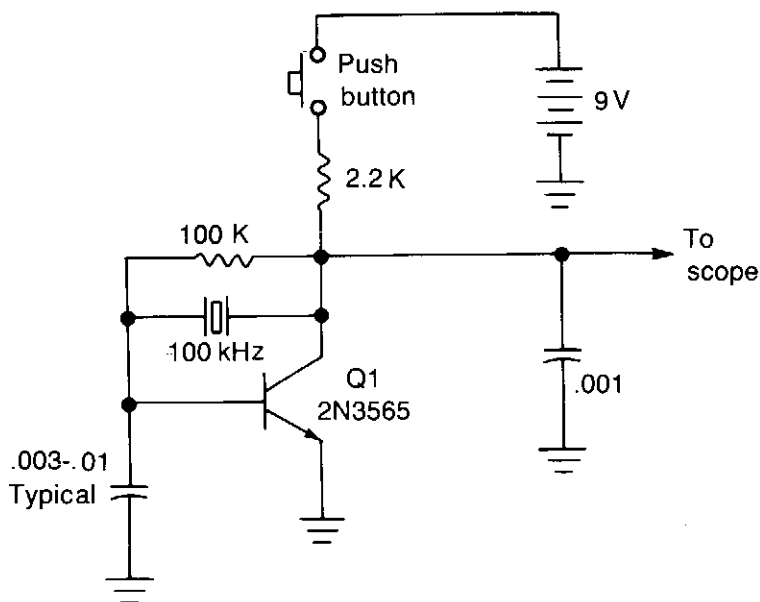
Fig. 67-2

RADIO-ELECTRONICS

Circuit Notes

The switcher output goes to the single vertical input of the scope, and a sync line from one of the inputs is taken to the scope's external-sync input. Frequency response of the input amplifiers is 300 kHz over the range of the gain controls. With the gain controls wide open so no attenuation of the signal takes place, the frequency response is up to 1 MHz.

SCOPE CALIBRATOR



WILLIAM SHEETS

Fig. 67-3

Circuit Notes

The calibrator operates on exactly 100 kHz providing a reference for calibrating the variable time base oscillator of general purpose scopes. For example, if the scope is set so that one cycle of the signal fills exactly 10 graticule divisions then each division represents 1 MHz, or 1 microsecond. If the scope is adjusted for 10 cycles on 10 graticule divisions. (1 cycle per division) then each division represents 100 kHz or 10 microseconds.

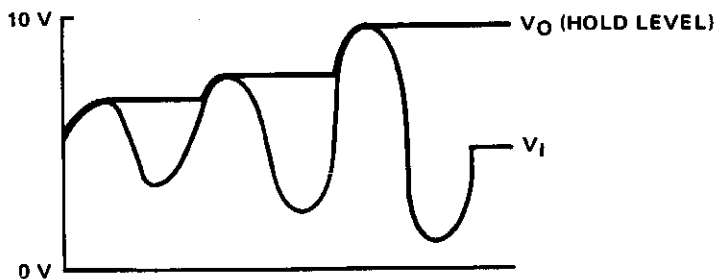
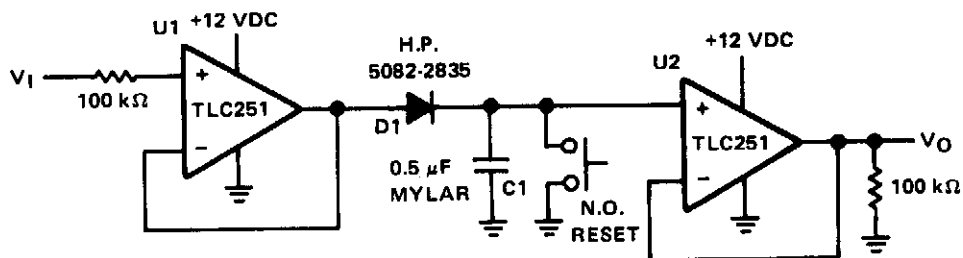
68

Peak Detector Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Positive Peak Detector
Peak Detector

POSITIVE PEAK DETECTOR



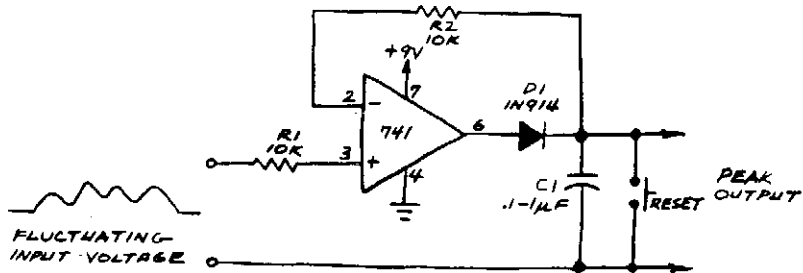
TEXAS INSTRUMENTS

Fig. 68-1

Circuit Notes

The purpose of the circuit is to hold the peak of the input voltage on capacitor C1, and read the value, V_O , at the output of U2. Op amps U1 and U2 are connected as voltage followers. When a signal is applied to V_I , C1 will charge to this same voltage through diode D1. This positive peak voltage on C1 will maintain V_O at this level until the capacitor is reset (shorted). Of course, higher positive peaks will raise this level while lower power peaks will be ignored. C1 can be reset manually with a switch, or electronically with an FET that is normally off. The capacitor specified for C1 should have low leakage and low dielectric absorption. Diode D1 should also have low leakage. Peak values of negative polarity signals may be detected by reversing D1.

PEAK DETECTOR



POPULAR ELECTRONICS

Fig. 68-2

Circuit Notes

The comparator will charge C1 until the voltage across the capacitor equals the input voltage. If subsequent input voltage exceeds that stored in C1, the comparator voltage will go high and charge C1 to new higher peak voltage.

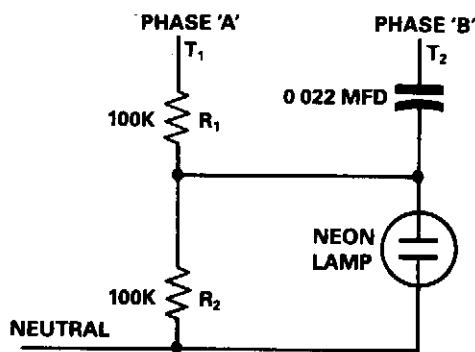
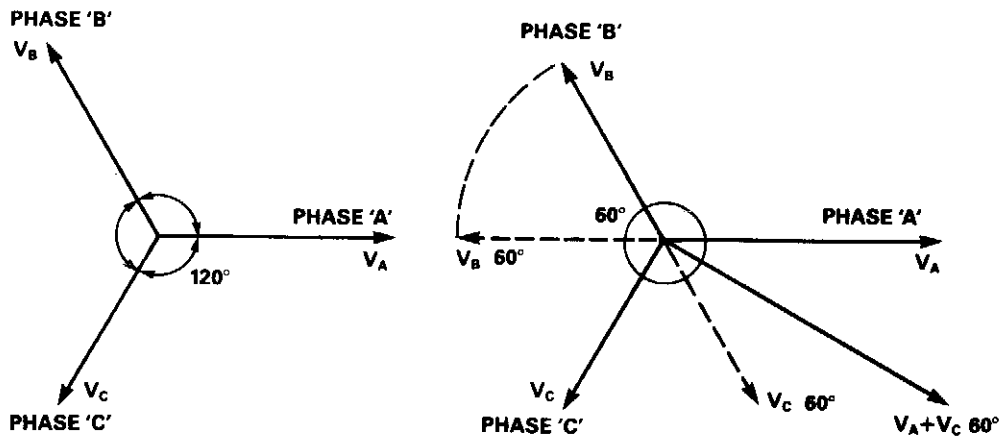
69

Phase Sequence Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

RC Circuit Detects Phase Sequence Reversal
Phase Indicator
Phase Sequence Detector
Three Phase Tester
Phase Sequence Detector II
Simple Phase Detector Circuit

RC CIRCUIT DETECTS PHASE SEQUENCE REVERSAL



TABLE

PHASE SEQUENCE	NEON INDICATOR	MOTOR MOTION
$V_A V_B V_C$	OFF	FORWARD
$V_A V_C V_B$	ON	REVERSE
$V_B V_A V_C$	ON	REVERSE
$V_B V_C V_A$	OFF	FORWARD
$V_C V_A V_B$	OFF	FORWARD
$V_C V_B V_A$	ON	REVERSE

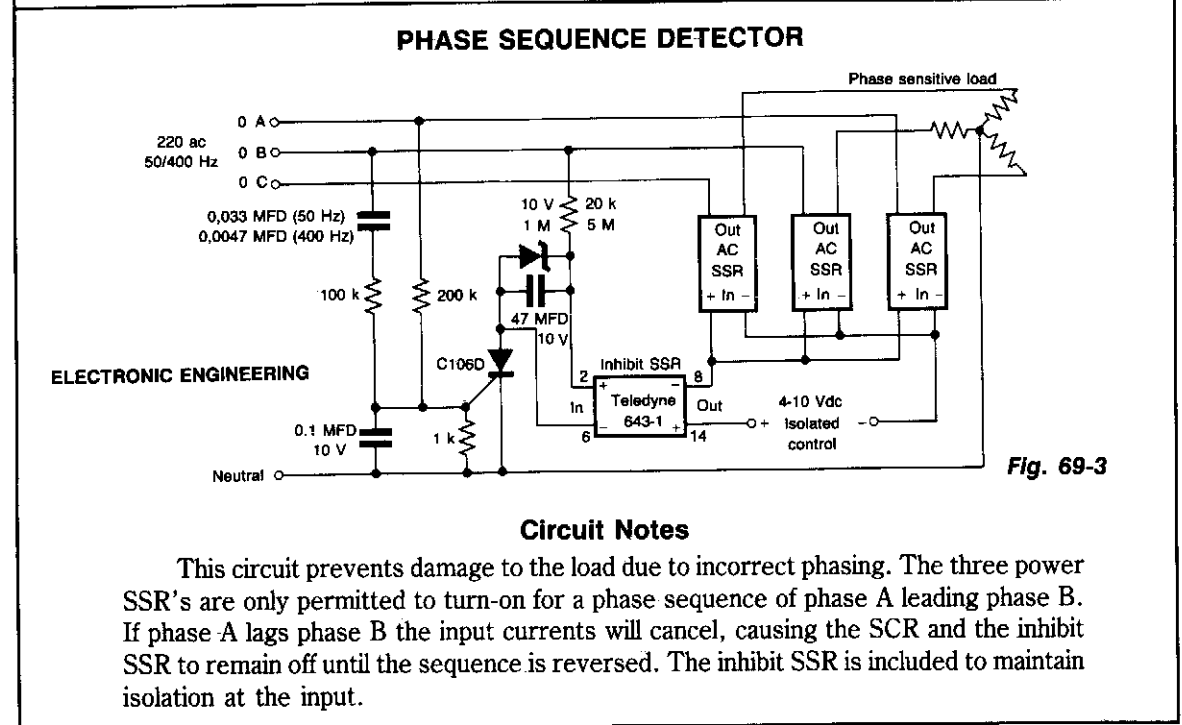
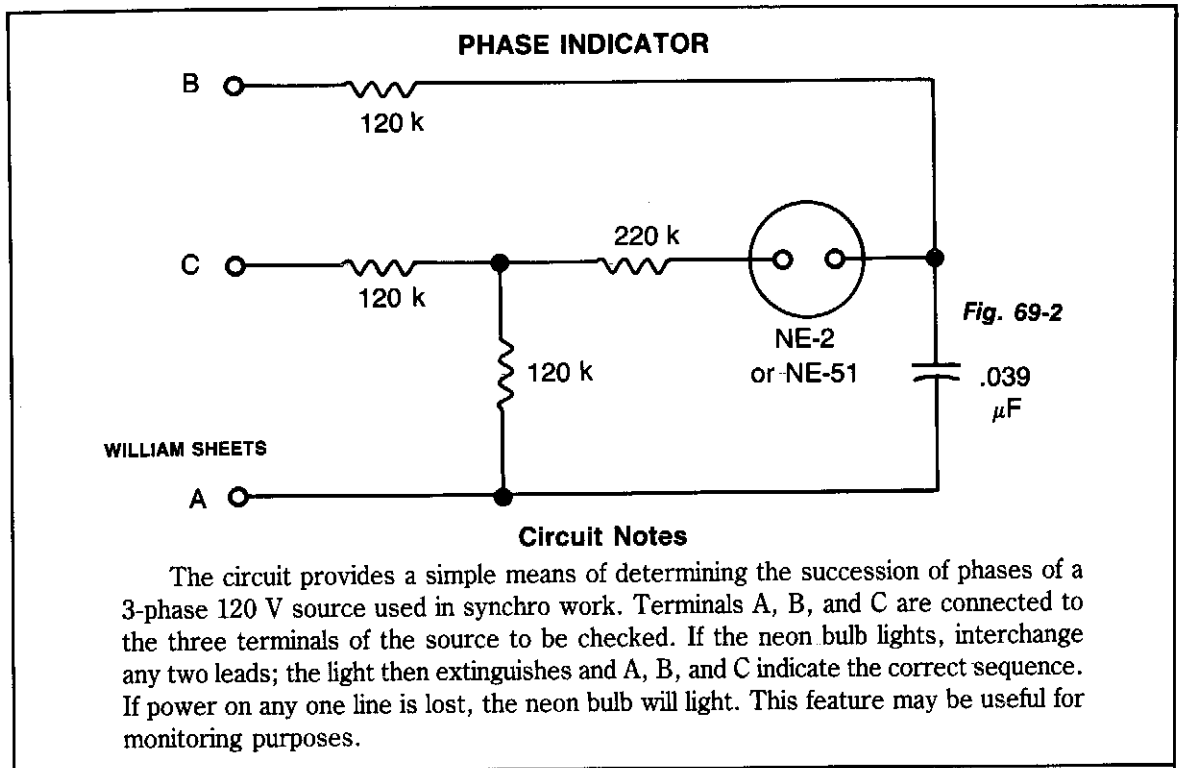
ELECTRONIC ENGINEERING

Fig. 69-1

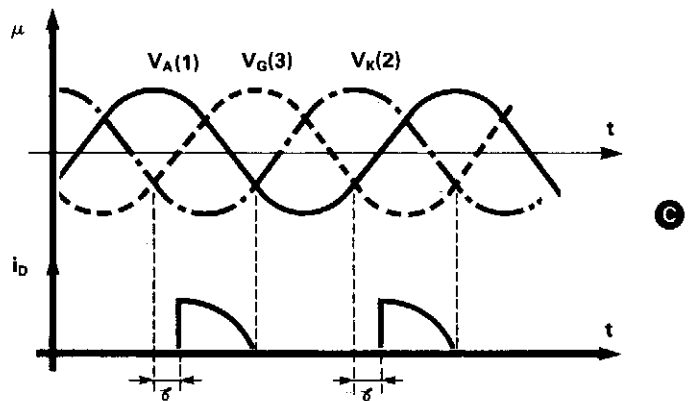
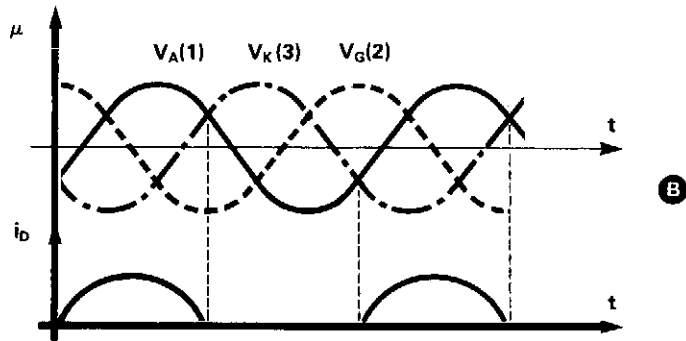
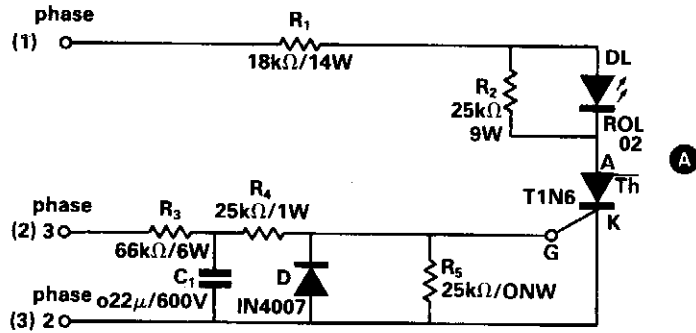
Circuit Notes

Assume the correct phase sequence to be V_A - V_B - V_C . The circuit terminals are connected such that T1 gets connected to phase A and T2 to phase B. The capacitor advances the voltage developed across R2 due to phase "B" by $\sim 60^\circ$, while the voltages developed across it by phase "A" is in phase with V_A as shown in Fig. 69-1. The net voltage developed across R2 \sim zero, the neon lamp is not energized, thereby signaling correct phase sequence. If terminal T2 gets connected to phase C, a large voltage, $K(V_A + V_C 60^\circ)$, gets developed across R2, energizing the neon indicator to signal reverse phase sequence.

The motor terminals can be connected to the three phases in six different combinations. A three-phase motor will run in the forward direction for three such combinations, while for the other three it will operate in the reverse direction. As shown in the table, the circuit detects all three reverse combinations. This circuit can be wired into any existing motor starter where the operator can see whether the phase sequence has been altered, before starting the machine.



THREE PHASE TESTER



THREE PHASE TESTER, Continued.

Circuit Notes

This simple three-phase tester, uses only a small current thyristor as a main element for testing the right or wrong succession of the three phases, and there is no need for a supplementary power supply.

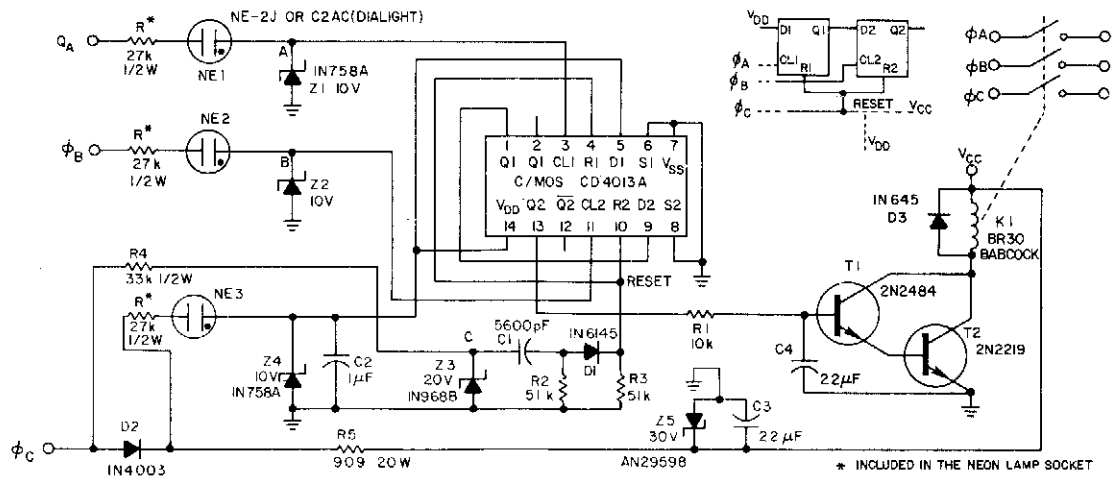
The basic circuit is shown in Fig. 69-4A. When connecting to the thyristor anode, grid, and cathode the three phases of the supply network in the sequence phase 1, phase 3, phase 2, are considered as correct, the mean value of the current through the thyristor is relatively high (since it is turned on during an entire half-period of one phase). The result is that the LED will emit a normal light.

The wave shapes for the three voltages and the current through the LED for this situation are shown in Fig. 69-4B.

If the three phases are not correctly connected—phase 1 to the anode, phase 2 to the grid, and phase 3 to the cathode, for instance—the thyristor will be turned on for a very short time and the LED will produce a very poor light. The wave shapes for this case are shown in Fig. 69-4C. The delay time is given by the R3-R1-R4 group.

When any of the three phases is missing, there is no current through the thyristor and the LED will emit no light.

PHASE-SEQUENCE DETECTOR II



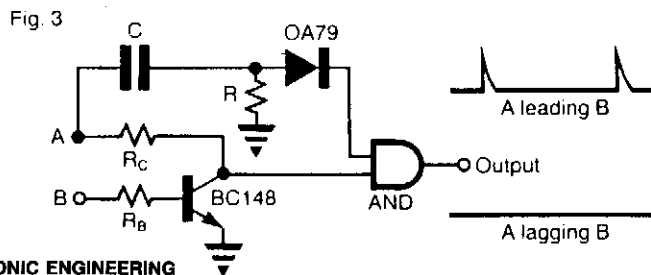
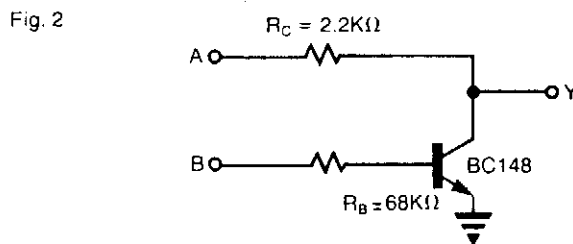
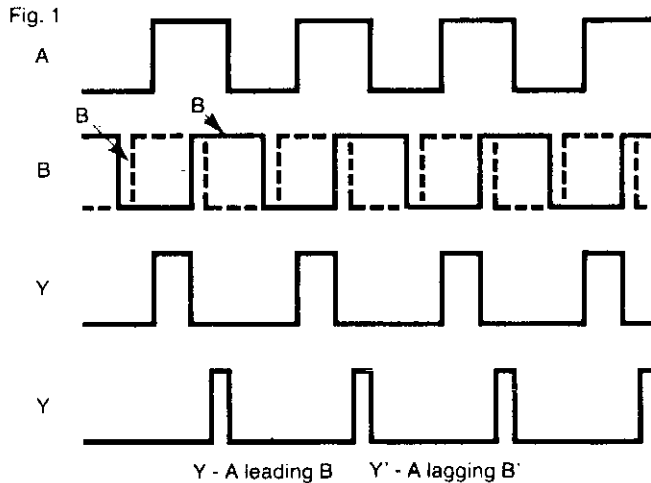
ELECTRONIC-DESIGN

Fig. 69-5

Circuit Notes

This circuit derives its supply voltage, V_{CC} and V_{DD} from ϕ_C . This factor, together with the neon lamps and zener diodes in the phase inputs, establishes 50% threshold that detects low voltage or absence of one or more phases. Relay K1 energizes for correct phase volts.

SIMPLE PHASE DETECTOR CIRCUIT



Circuit Notes

The operation of the circuit is like an enabled inverter, that is, the output $Y=B$ provided A is high. If A is low, output is low (independent of the state of B). When the signals A and B or B1 are connected to the inputs A and B of this gate the output Y is a pulse train signal (shown a Y or Y1) which has a pulse duration equal to the phase difference between the two signals. The circuit is directly suitable for phase difference measurement from zero to 180° . This performance is similar to the circuits like the Exclusive OR gate used for this purpose. With this method leading and lagging positions of the signals can also be found using an AND gate. Phase difference measured along with the leading and lagging information gives complete information about the phases of the two signals between zero and 360° .

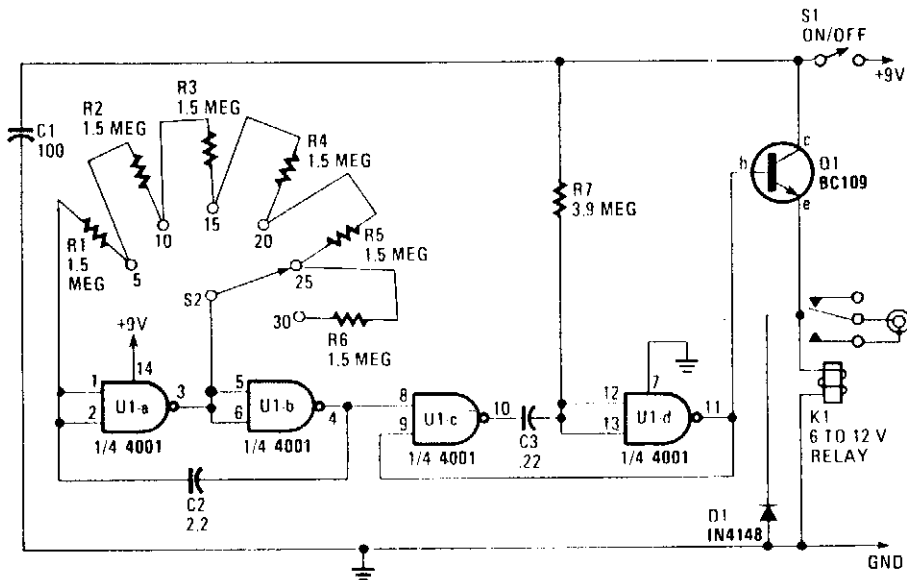
70

Photography-Related Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Auto-Advance Projector
Shutter-Speed Tester
Enlarger Timer
Contrast Meter
Electronic Flash Trigger
Sound Trigger for Flash Unit

AUTO-ADVANCE PROJECTOR



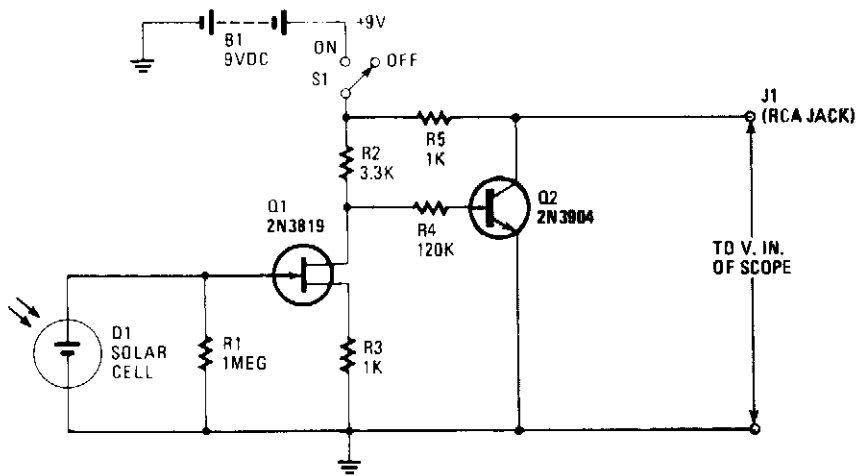
HANDS-ON ELECTRONICS

Fig. 70-1

Circuit Notes

The circuit is built around a 4001 quad two-input NOR gate, it provides switch selectable auto-advance times of 5, 10, 15, 20, 25 or 30 seconds through the remote-control socket of your projector. U1a and U1b form an astable multivibrator, with its operating frequency dependent on the number of timing resistors switched into the circuit via S2. The frequency is about one cycle for every five seconds with a single timing resistor, one every ten seconds with two resistors, etc., providing six switched time intervals. The output of the astable at pin 4 of U1b is fed to the input of a monostable multivibrator, consisting of the second pair of gates, U1c and U1d. R7 and C3 are the timing components; they set the length of the (positive) output pulse of the monostable at a little more than half a second. The monostable is triggered by each positive-going input it receives from the astable. The output from the monostable therefore, consists of a series of short pulses, the interval between the pulses being controlled using S2. The output of the monostable (at pin 11) controls a relay by way of Q1, which is configured as an emitter-follower buffer stage. The projector is controlled via the normally-open contacts of relay K1. When the output of the monostable goes positive, the relay contacts close, triggering the slide-change mechanism of the projector. The monostable assures that the power to the relay is applied only briefly by the timer, so that multiple operation of the projector is avoided.

SHUTTER-SPEED TESTER



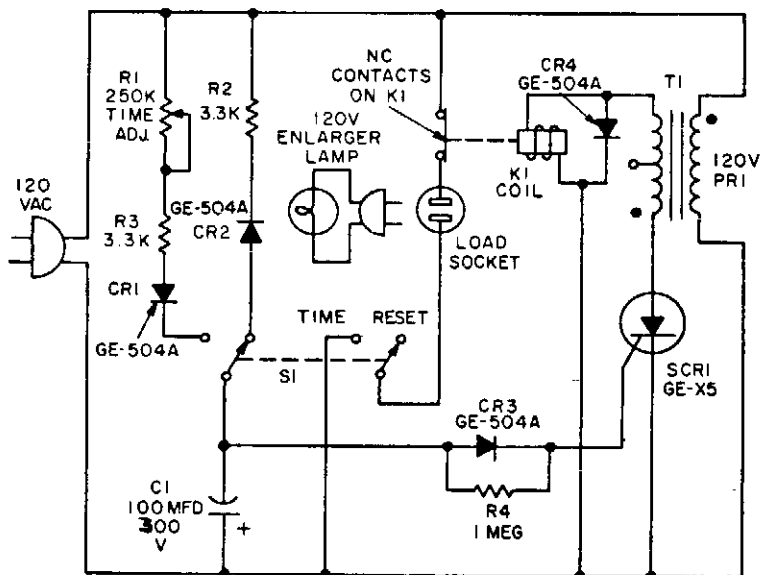
HANDS-ON ELECTRONICS

Fig. 70-2

Circuit Notes

The solar cell is connected across the input of the FET (field-effect transistor), Q1, so that it will produce positive dc voltage to the gate when activated by light shining through the open shutter, decreasing the negative gate-source bias already established by the source resistor, and causes an increase in drain current. The drain voltage goes more negative which causes a decrease in Q2's base current. Q2's collector current decreases, and its collector voltage becomes more positive. There is an amplified positive-going voltage output at the collector, and it's applied directly to the oscilloscope's vertical input, producing a waveform that is displaced vertically whenever light strikes the cell.

ENLARGER TIMER



Parts List

- | | |
|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <i>C1</i> — 100-mfd, 300-volt electrolytic capacitor | <i>R4</i> — 1-megohm, 1/2-watt resistor |
| <i>CR1</i> thru <i>CR4</i> — GE-504A rectifier diode | <i>S1</i> — DPDT toggle switch |
| <i>K1</i> — 12 -volt a-c relay (Potter & Brumfield No. MR5A, or equivalent) | <i>SCR1</i> — GE-X5 silicon controlled rectifier |
| <i>R1</i> — 250K-ohm, 2-watt potentiometer | <i>T1</i> — Filament transformer: primary, 120-volts a-c; secondary, 12.6-volts center tapped (Triad F25X, or equivalent) |
| <i>R2</i> , <i>R3</i> — 3.3K-ohm, 1/2-watt resistor | Line cord, vectorboard, minibox etc. |

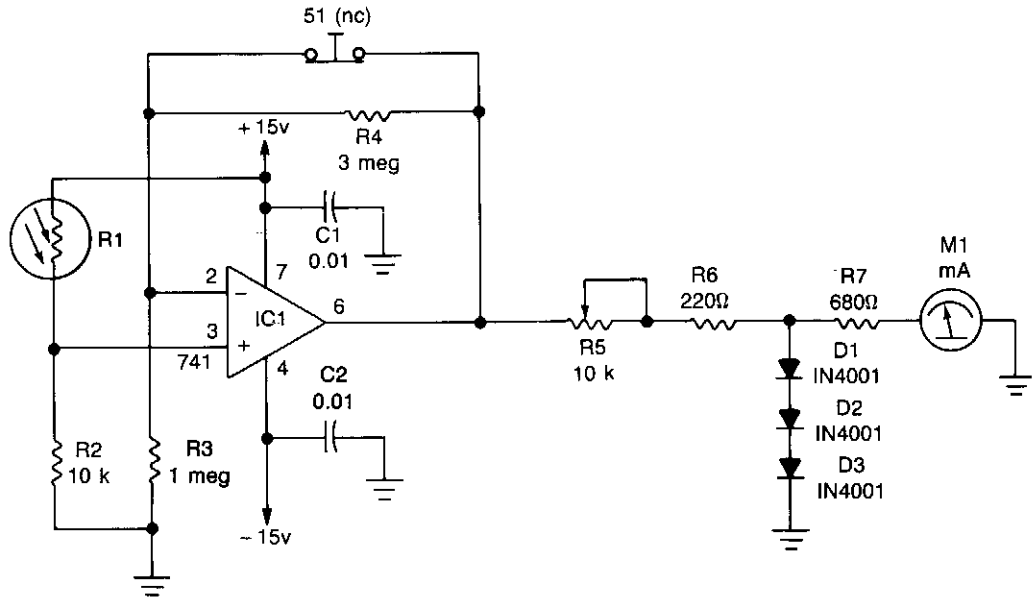
GENERAL ELECTRIC

Fig. 70-3

Circuit Notes

This precision, solid state, time delay circuit has delayed *off* and delayed *on* switching functions that are interchangeably available by simply interchanging the relay contacts.

CONTRAST METER



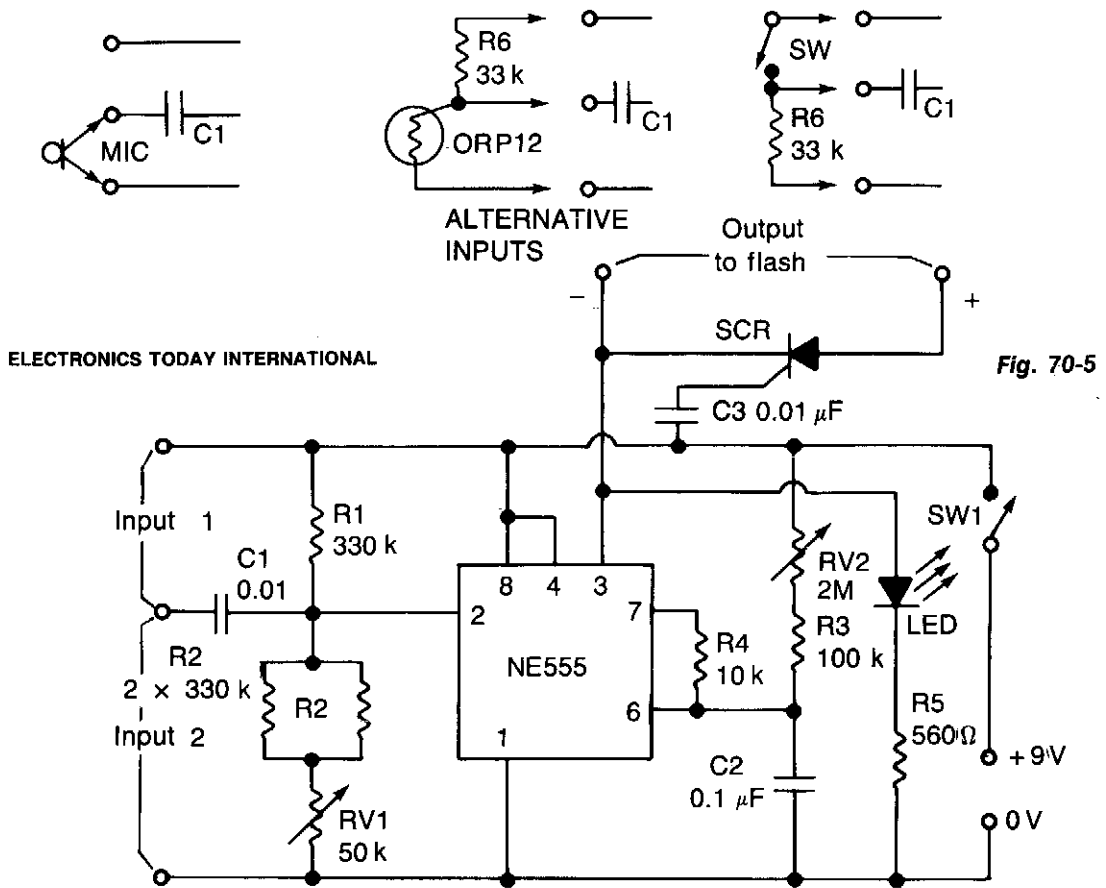
RADIO ELECTRONICS

Fig. 70-4

Circuit Notes

One leg of the photocell (R1) is tied to the +15 volt supply and the other end is connected to ground through resistor R2, forming a voltage-divider network. The non-inverting input of the 741 op amp, IC1, is tied to the junction formed by R1 and R2, while its inverting input is grounded through resistor R3. When switch S1 is pressed, another divider network is formed, reducing the voltage applied to the inverting input of the op amp. When light hits the photocell its resistance begins to decrease causing a greater voltage drop across R2 and a higher voltage to be presented to the non-inverting input of IC1. This causes IC1 to output a voltage proportional to the two inputs. The circuit gives a meter reading that depends on the intensity of light hitting photocell R1; therefore, R1 should be mounted in a bottle cap so that the light must pass through a 3/16 inch hole. Potentiometer R5 is used to adjust the circuit for the negative you're working with.

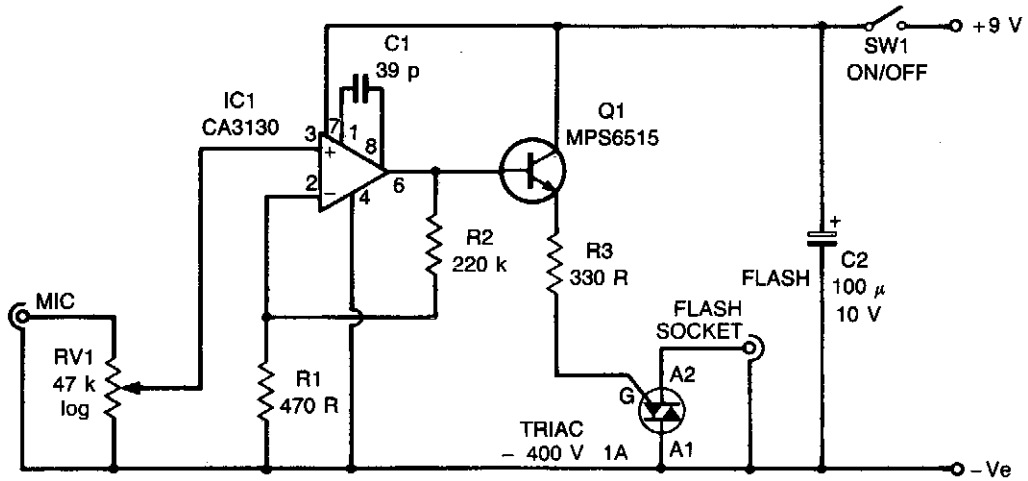
ELECTRONIC FLASH TRIGGER



Circuit Notes

A negative pulse at the input is fed via capacitor C1 to the input pin (2) of the IC. Pin 2 is held slightly above its triggering voltage of $1/3 V_{cc}$ by the voltage divider comprising R1, R2 and RV1. The negative pulse triggers the IC and the output (pin 3) goes high for a time period controlled by RV2, R3 and C2. When the output goes low again at the end of the time interval, capacitor C3 charges through the gate cathode circuit of the SCR switching it on and firing the flash. Capacitor C1 isolates the input from the voltage divider so that the unit isn't sensitive to the dc level at the input. RV1 acts as a sensitivity control by allowing the voltage to be adjusted to a suitable level so that the input signal will trigger the IC. Resistor R4 limits the discharge current from C2 at the end of the timing cycle protecting the IC. The LED and its protective resistor R5 act as an indicator to show that the unit has triggered, simplifying the setting up process and minimizing the number of times the strobe has to be fired. This means that the strobe needn't be fired until a photo is to be taken.

SOUND TRIGGER FOR FLASH UNIT



ELECTRONICS TODAY INTERNATIONAL

Fig. 70-6

Circuit Notes

The circuit is based on operational amplifier IC1 used in the noninverting amplifier mode. R1 and 2 set the gain at about 500. RV1 (sensitivity) biases the noninverting input to the negative supply. Q1 provides the relatively high trigger current required by the triac. When a signal is received by the microphone, the signals are amplified (by IC1). The triac is triggered and a low resistance appears across its A1 and A2 terminals which are connected via the flashlead to the strobe. The circuit operates almost instantly, giving very little delay between the commencement of the sound and the flashgun being triggered.

71

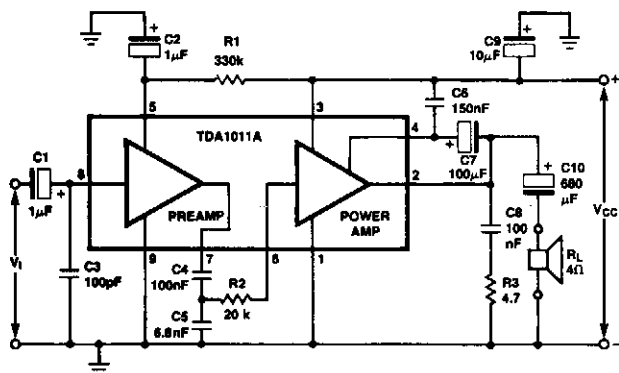
Power Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

2 To 6 W Audio Amplifier with Preamplifier
Audio Power Amplifier
25 Watt Amplifier
Bull Horn
Low Power Audio Amplifier
Audio Booster

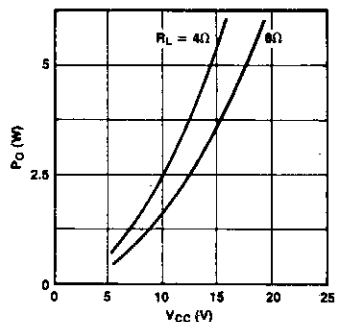
Walkman Amplifier
Rear Speaker Ambience (4-Channel) Amplifier
90 W Audio Power Amplifier with Safe Area
Protection
Power Amplifier

2 TO 6 W AUDIO AMPLIFIER WITH PREAMPLIFIER



SIGNETICS

Fig. 71-1



OP107803

NOTES:

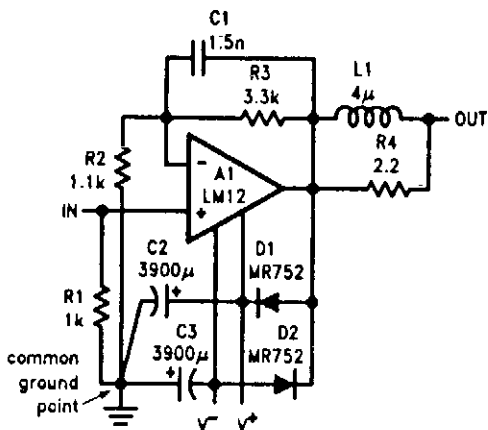
$d_{TOT} = 10\%$; typical values. The available output power is 5% higher when measured at Pin 2 (due to series resistance of C1).

Output Power Across R_L
as a Function of Supply
Voltage with Bootstrap

Circuit Notes

The monolithic integrated audio amplifier circuit is especially designed for portable radio and recorder applications and delivers up to 4 W in a 4 ohm load impedance.

AUDIO POWER AMPLIFIER



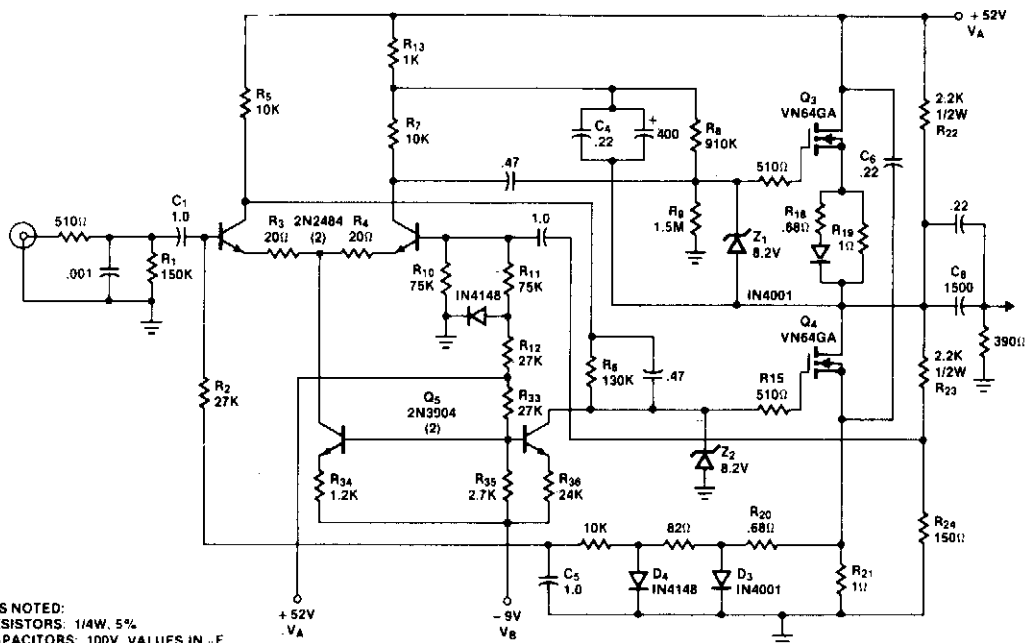
NATIONAL SEMICONDUCTOR CORP.

Fig. 71-2

Circuit Notes

Output-clamp diodes are mandatory because loudspeakers are inductive loads. Output LR isolation is also used because audio amplifiers are usually expected to handle up to $2 \mu\text{F}$ load capacitance. Large, supply-bypass capacitors located close to the IC are used so that the rectified load current in the supply leads does not get back into the amplifier, increasing high-frequency distortion. Single-point grounding for all internal leads plus the signal source and load is recommended to avoid ground loops that can increase distortion.

25 WATT AMPLIFIER



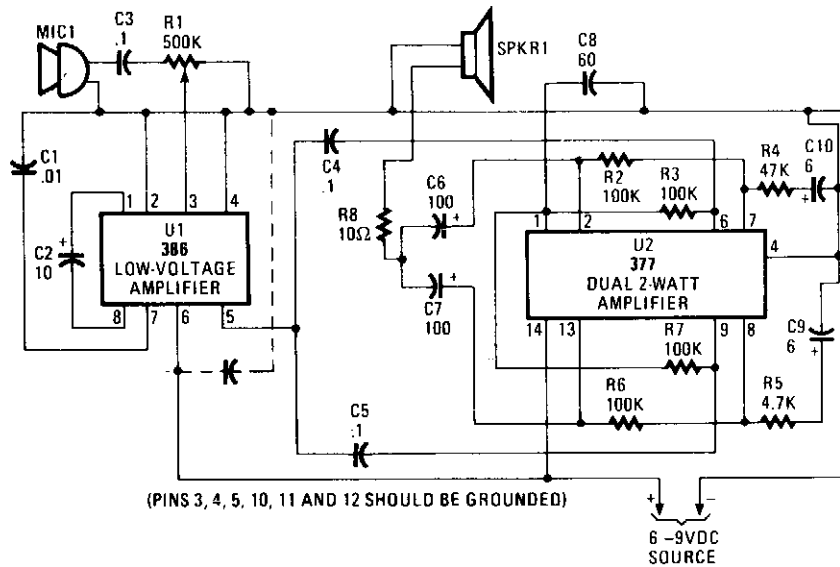
SILICONIX, INC.

Fig. 71-3

Circuit Notes

Transistors are used for current sources. Base drive for these transistors is derived from the main power supply V_A , so that their collector current is proportional to the rail voltage. This feature holds the voltage on the diff-amp collectors close to $V_A/2$. The sensitivity of I_Q to V_A is about 3.4 mA/volt when V_B is held constant; the sensitivity of I_Q to V_B is -15 mA/volt when V_A is held constant. In a practical amplifier with a non-regulated supply, variations in power output will cause fluctuations in V_A , but will not affect V_B ; therefore, having I_Q increase slightly with power output will tend to compensate for the 3.4 mA/volt $I_Q V_A$ sensitivity. In the case of line voltage variations, since V_A is about five times V_B , the sensitivities tend to cancel, leaving a net sensitivity of about 2 mA/volt.

BULL HORN



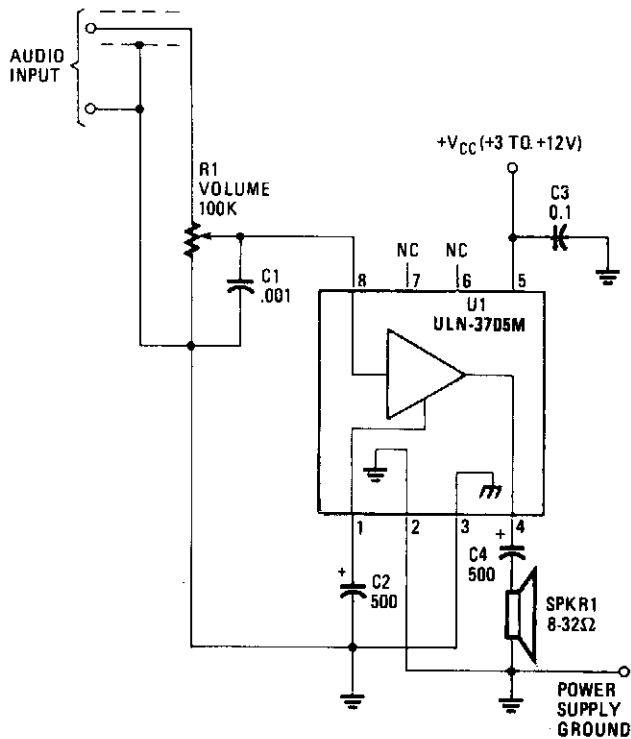
HANDS-ON ELECTRONICS

Fig. 71-4

Circuit Notes

The input audio signal is fed to pin 3 of U1, an LM386 low-voltage amplifier, via C3 and R1. Potentiometer R1 sets the drive or volume level. U1, which serves as a driver stage, can be set for a gain of from 20 to 200. The output of U1 at pin 5 is fed to U2—a 377 dual two-watt amplifier connected in parallel to produce about four watts of output power—at pins 6 and 9 via C4 and C5. Frequency stability is determined by R2, R4, and C10 on one side, and the corresponding components R6, R5, and C9 on the other side. The outputs of the two amplifiers (at pins 2 and 13) are capacitively coupled to SPKR1 through C6 and C7.

LOW POWER AUDIO AMPLIFIER



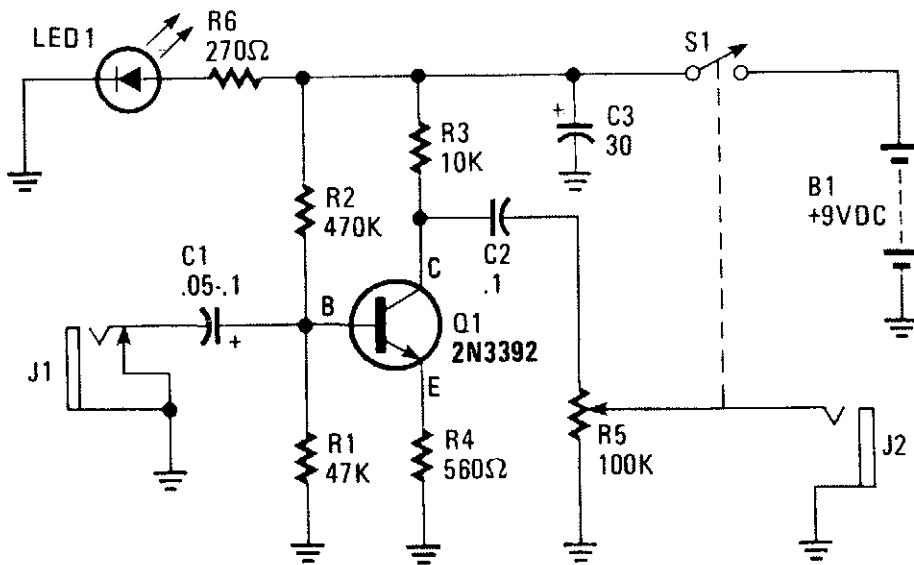
HANDS-ON ELECTRONICS

Fig. 71-5

Circuit Notes

The amplifier operates from supplies ranging up to 12 volts, and operates (with reduced volume) from supply voltages as low as 1.8 volts without having distortion rise to unacceptable levels. (Its power requirements make it suitable for solar-cell application.) Components external to the integrated circuit, U1, consist of four capacitors and a potentiometer for volume control. Capacitor C3 is for decoupling, low-frequency roll-off, and power-supply ripple rejection. Capacitor C4 is an electrolytic type that couples the audio output to an 8 to 32 ohm speaker that is efficient.

AUDIO BOOSTER



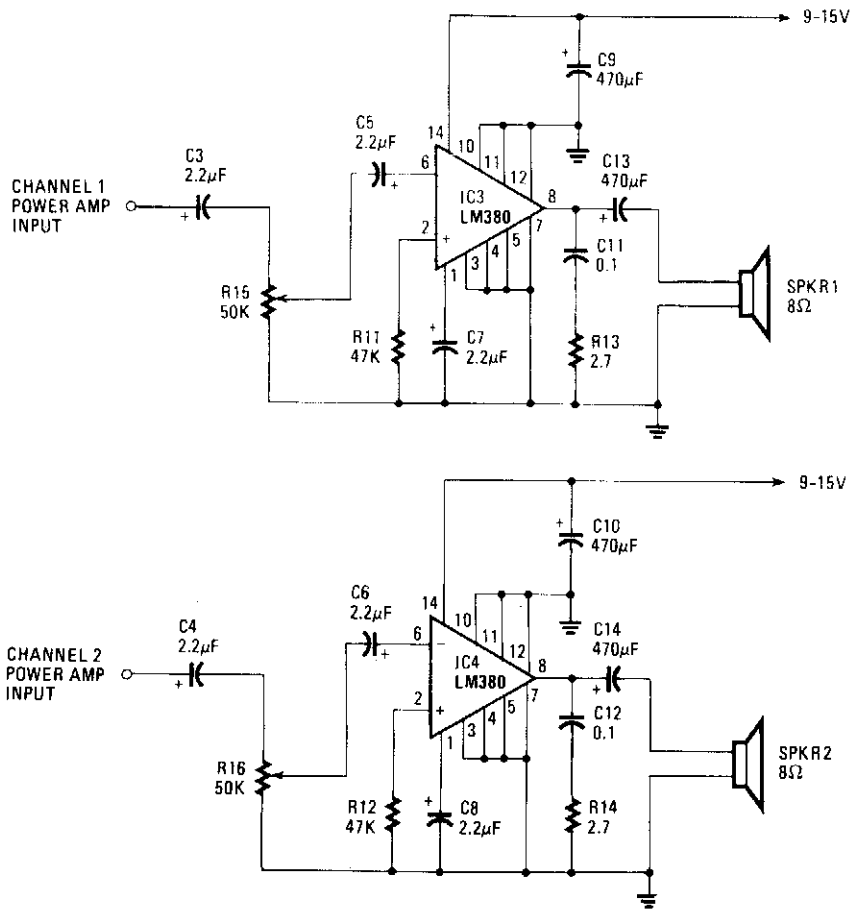
HANDS-ON ELECTRONICS

Fig. 71-6

Circuit Notes

The amplifier's gain is nominally 20 dB. Its frequency response is determined primarily by the value of just a few components—primarily C1 and R1. The values of the schematic diagram provide a response of ± 3.0 dB from about 120 Hz to better than 20,000 Hz. Actually, the frequency response is ruler flat from about 170 Hz to well over 20,000 Hz; it's the low end that deviates from a flat frequency response. The low end's roll-off is primarily a function of capacitor C1 (since R1's resistive value is fixed). If C1's value is changed to 0.1 μ F, the low end's corner frequency—the frequency at which the low-end roll-off starts—is reduced to about 70 Hz. If you need an even deeper low-end roll-off, change C1 to a 1.0 μ F capacitor; if it's an electrolytic type, make certain that it's installed into the circuit with the correct polarity, with the positive terminal connected to Q1's base terminal.

WALKMAN AMPLIFIER



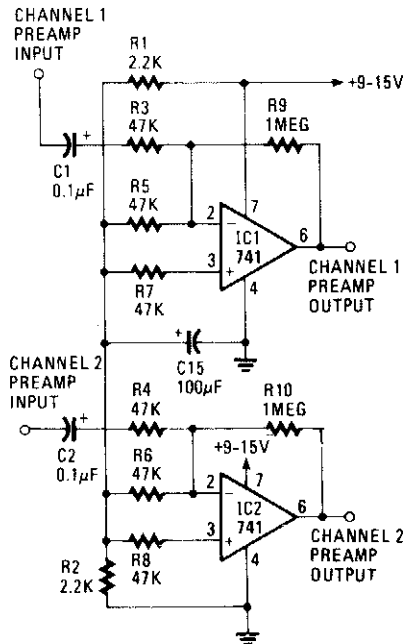
RADIO-ELECTRONICS

Fig. 71-7

Circuit Notes

The gain of the low-cost IC is internally fixed so that it is not less than 34 dB (50 times). A unique input stage allows input signals to be referenced to ground. The output is automatically self centering to one half the supply voltage. The output is also short-circuit proof with internal thermal limiting. With a maximum supply of 15 volts and an 8 ohm load, the output is around 1.5 watts per channel. The input stage is usable with signals from 50 mV to 500 mV rms. If the amplifier is to be used with a source other

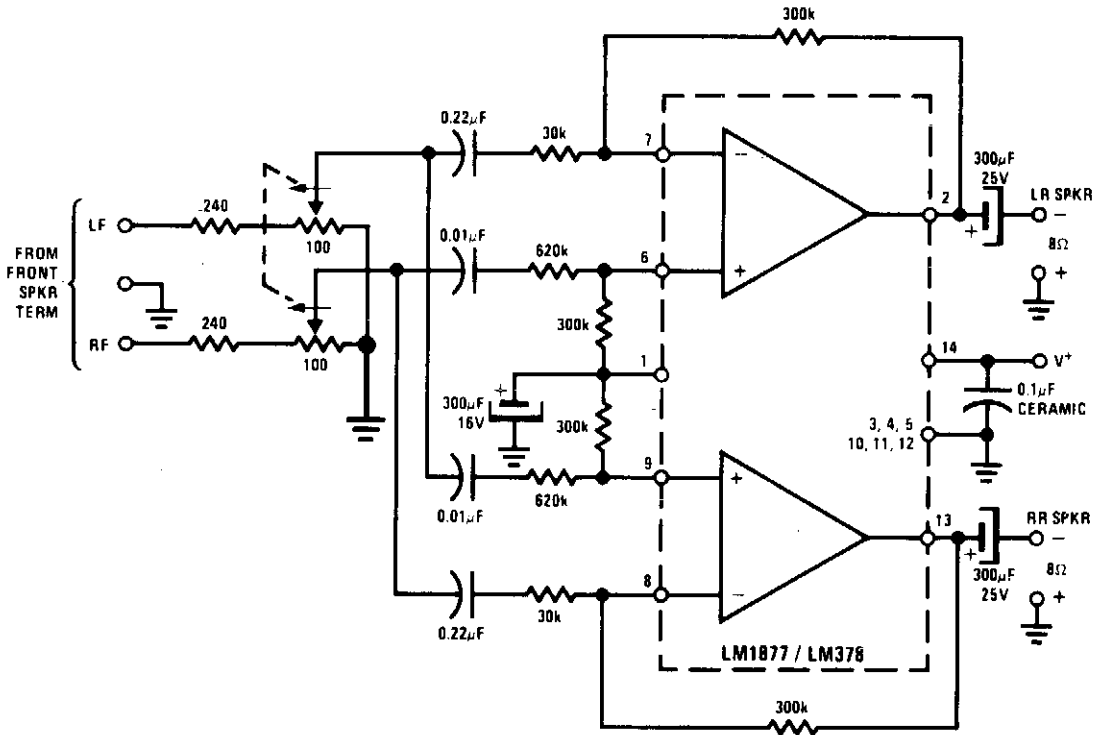
WALKMAN AMPLIFIER, Continued.



-THE PREAMP. If you wish to amplify low-level signals, such as the output of a turntable, the signal will first have to be fed to the preamp shown here.

than a personal stereo, such as a phonograph or an electric guitar, some type of preamplifier is required. A suitable circuit is shown. In that circuit, two 741 op amps have been configured as input amplifiers. Their input stages referenced to a common point—half the supply voltage. That voltage is derived from a voltage divider made up of R1 and R2, two 2.2 k resistors. The gain of each of the 741's has been fixed at 21 by the input resistors (R9, R10). Input capacitors, C1 and C2, are used to filter out any dc component from the input signal.

REAR SPEAKER AMBIENCE (4-CHANNEL) AMPLIFIER



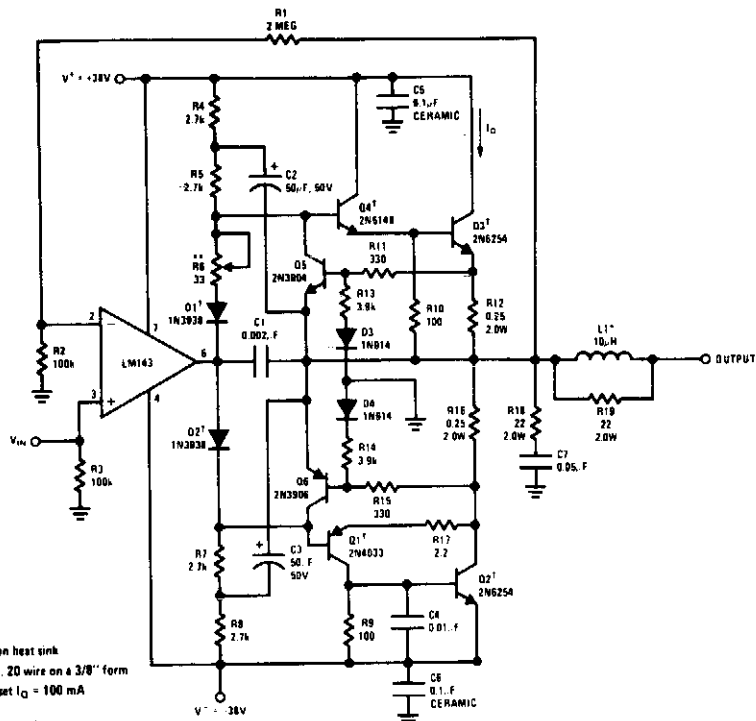
NATIONAL SEMICONDUCTOR CORP.

Fig. 71-8

Circuit Notes

Rear channel "ambience" can be added to an existing stereo system to extract a difference signal (R - L or L - R) which, when combined with some direct signal (R or L), adds fullness, or "concert hall realism" to the reproduction of recorded music. Very little power is required at the rear channels, hence an LM1877 suffices for most "ambience" applications. The inputs are merely connected to the existing speaker output terminals of a stereo set, and two more speakers are connected to the ambience circuit outputs. The rear speakers should be connected in the opposite phase to those of the front speakers, as indicated by the +/- signs.

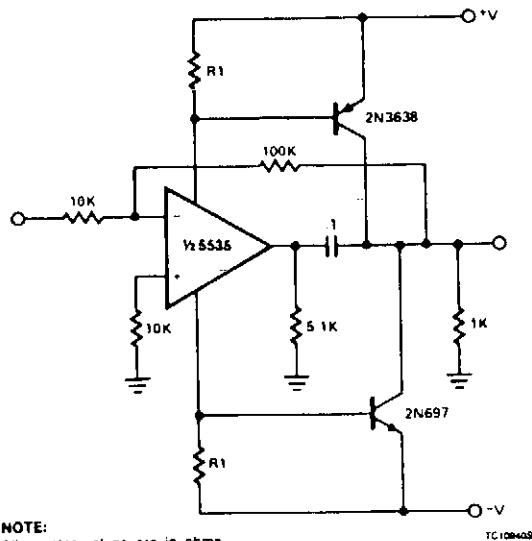
90 W AUDIO POWER AMPLIFIER WITH SAFE AREA PROTECTION



NATIONAL SEMICONDUCTOR

Fig. 71-9

POWER AMPLIFIER



NOTE:
All resistor values are in ohms.

SIGNETICS

Fig. 71-10

Circuit Notes

For most applications, the available power from op amps is sufficient. There are times when more power handling capability is necessary. A simple power booster capable of driving moderate loads uses an NE5535 device. Other amplifiers may be substituted only if R1 values are changed because of the I_{CC} current required by the amplifier. R1 should be calculated from the expression

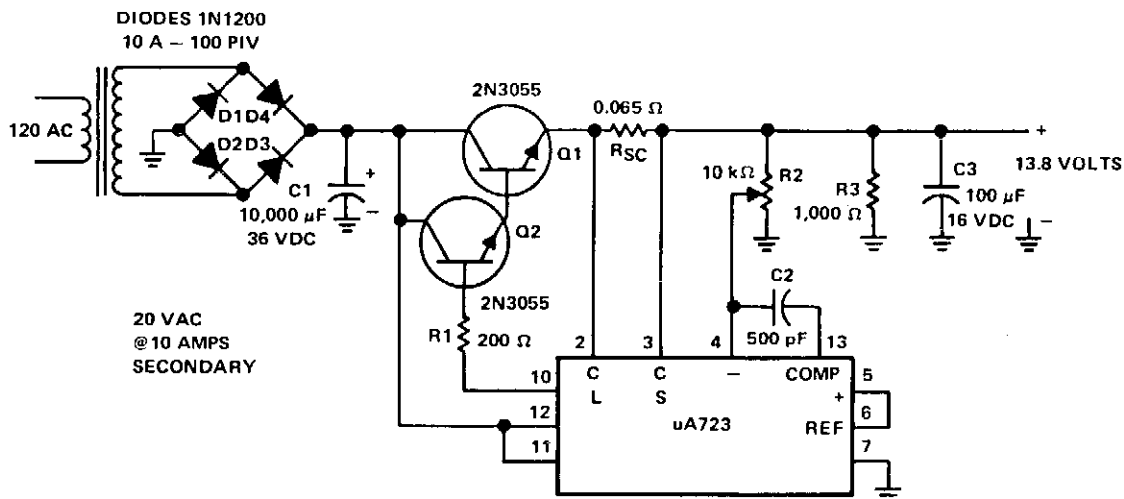
$$R1 = \frac{600 \text{ mV}}{I_{CC}}$$

Power Supply Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

- | | |
|--------------------------------------------------------------------------|-------------------------------------------------------------------|
| 8 Amp Regulated Power Supply for Operating Mobile Equipment | Protection |
| Uninterruptible Power Supply for Personal Computers | Bipolar Power Supply for Battery Instruments |
| 5 V Supply Including Stabilized Momentary Backup Power-Switching Circuit | Power Supply for 25-Watt Arc Lamp |
| Radiation-Hardened, 125 A Linear Regulator | Stand-by Power for Non-Volatile CMOS RAMs |
| Switch Mode Power Supply | HV Regulator with Foldback Current Limiting |
| Micropower Bandgap Reference Supply | 90 V rms Voltage Regulator Using a PUT |
| Variable Current Source, 100 mA to 2 Amp | 12-14 V Regulated 3 A Power Supply |
| Basic Single-Supply Voltage Regulator | DC-to-DC SMPS Variable 18 V to 30 V out at 0.2 A |
| Bench Top Power Supply | Off-Line Flyback Regulator |
| 400-Volt, 60-Watt Push-Pull Power Supply | SCR Preregulator Fits Any Power Supply Voltage Regulator |
| 500 kHz Switching Inverter for 12 V Systems | Zener Diode Increase Fixed PNP Regulator's Output Voltage Ratings |
| 10-Amp Regulator with Current and Thermal | Increasing the Power Rating of Zener Diodes |
| | Memory Save on Power-Down |

8-AMP REGULATED POWER SUPPLY FOR OPERATING MOBILE EQUIPMENT



TEXAS INSTRUMENTS

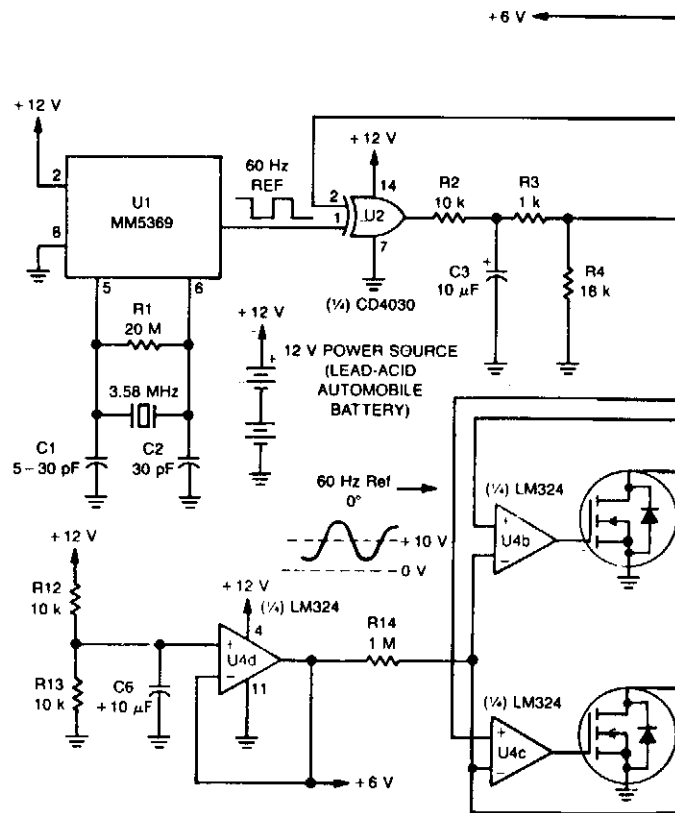
Fig. 72-1

Circuit Notes

This supply is powered by a transformer operating from 120 Vac on the primary and providing approximately 20 Vac on the secondary, and providing approximately 20 Vac on the secondary. Four 10-A diodes with a 100 PIV rating are used in a full-wave bridge rectifier. A 10,000 $\mu\text{F}/36\text{ Vdc}$ capacitor completes the filtering, providing 28 Vdc. The dc voltage is fed to the collectors of the Darlington connected 2N3055's. Base drive for the pass transistors is from pin 10 of the $\mu\text{A}723$ through a 200 ohm current limiting resistor, R1. The reference terminal (pin 6) is tied directly to the non-inverting input of the error amplifier (pin 5), providing 7.15 V for comparison.

The inverting input to the error amplifier (pin 4) is fed from the center arm of a 10 k ohm potentiometer connected across the output of the supply. This control is set for the desired output voltage of 13.8 V. Compensation of the error amplifier is accomplished with a 500 pF capacitor connected from pin 13 to pin 4. If the power supply should exceed 8 A or develop a short circuit, the $\mu\text{A}723$ regulator will bias the transistors to cutoff and the output voltage will drop to near zero until the short circuit condition is corrected.

UNINTERRUPTIBLE POWER SUPPLY FOR PERSONAL COMPUTERS



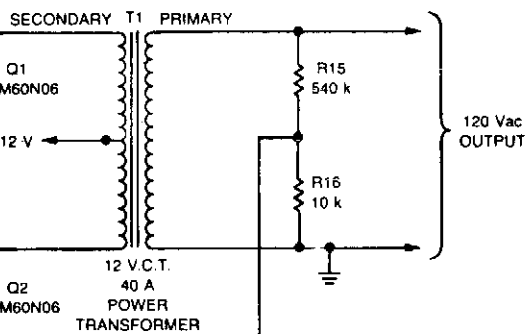
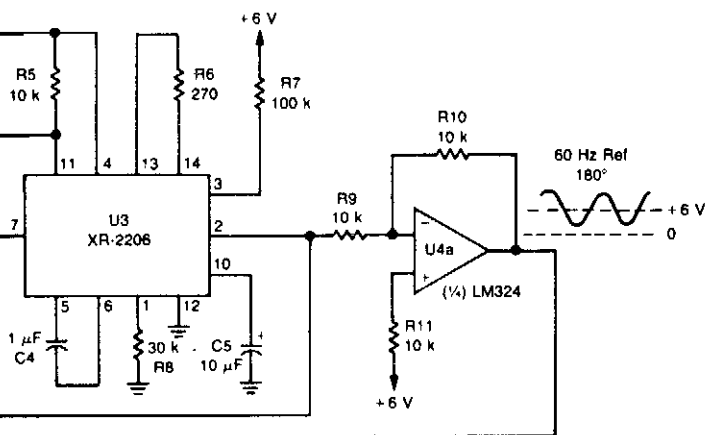
MOTOROLA

Fig. 72-2

Circuit Notes

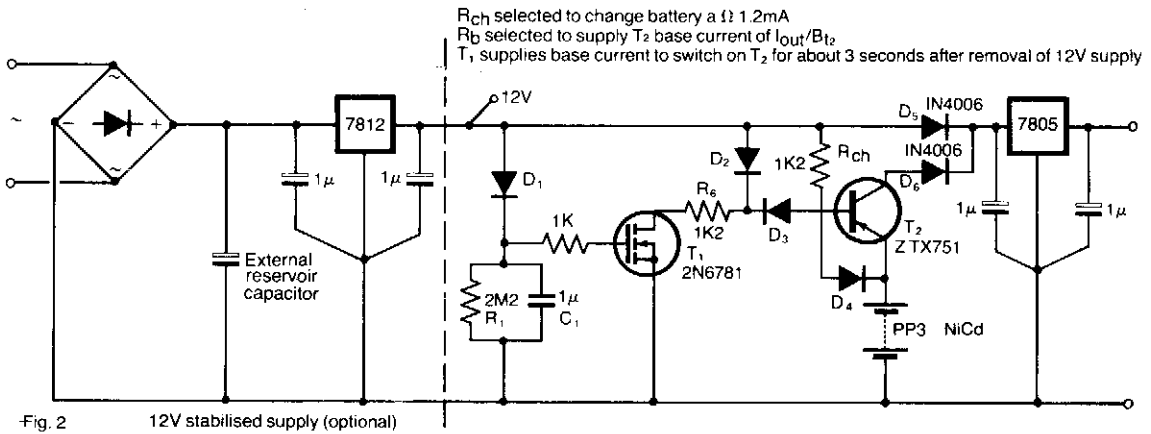
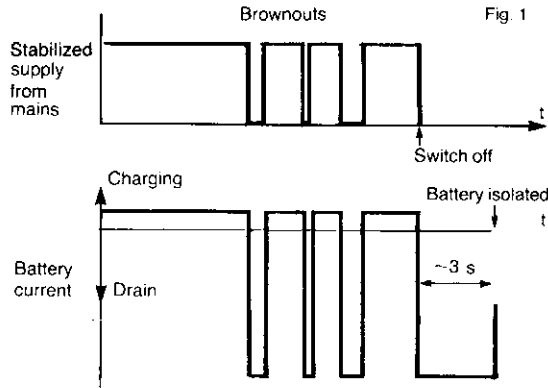
The UPS is basically an ac inverter that is powered by a 12-V, lead-acid automobile battery. During power outages, it can supply several minutes of power for an average personal computer. It incorporates a crystal-controlled 60 Hz time base, so that a computer with a real time clock can maintain its accuracy. It isolates the ac line from the computer, so it can be used to operate sensitive electronic equipment on noisy power sources.

Two MTM60N06 Power FETs (Q1 and Q2) alternately switch current through a center-tapped 120-V to 12-V filament transformer (T1) with its primary and secondary reversed. The 120-V output is compared with a 60 Hz reference in a closed-loop configuration that maintains a constant output at optimum efficiency.



A 60 Hz reference frequency is derived from a crystal oscillator and divider circuit, U1. An inexpensive 3.58 MHz color burst crystal provides the time base that can be accurately adjusted by C1. The 60 Hz output from U1 is applied to the exclusive-OR gate, U2, and then to the XR-2206 function generator (U3) that converts the square wave into a sine wave. U2 and U3 form a phase-locked loop that synchronizes the sine wave output of U3 with the 60 Hz square wave reference of U1. The sine wave is then inverted by op amp U4a, so that two signals 180 out of phase can be applied to U4b and U4c that drive Q1 and Q2. Due to the closed-loop configuration of the drive circuits, Q1 and Q2 conduct only during the upper half of the sine wave. Therefore, one TMOS device conducts during the first half of the sine wave and the other conducts during the second half.

5 V SUPPLY INCLUDING STABILIZED MOMENTARY BACKUP



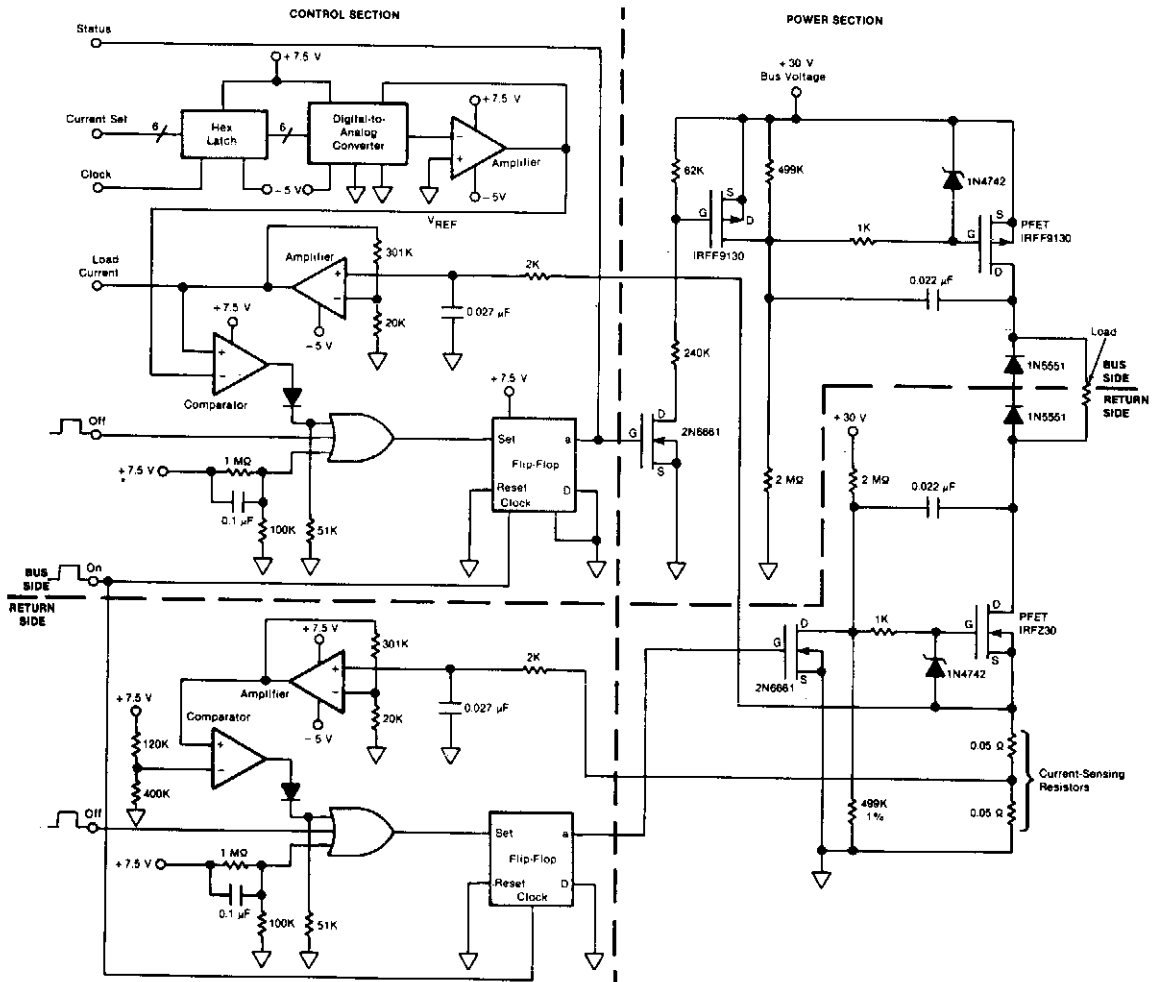
5 V SUPPLY INCLUDING STABILIZED MOMENTARY BACKUP , Continued.

Circuit Notes

This circuit protects microprocessor systems from "brownouts" without the expense of an uninterruptible power supply. Designed around a small 9-V nickel cadmium battery the circuit continues to provide a constant 5-V output during brownouts of up to a few seconds. Load currents of up to 500 mA may be drawn using the components shown. With this mains-derived supply present, D5 is forward biased so that the stabilized supply powers the 5-V regulator and hence the circuitry to be protected. FET T_1 is held on by D1, its drain current being provided from the dc supply via R_b and D2. Diode D3 is reverse-biased so that T2 is off, and the battery is isolated from D6. R_{CH} and D4 serve to trickle charge the battery with approximately 1.2 mA.

When the 12-V supply is removed, R1 and C1 initially keep T1 switched on. D3 is now forward biased, so that T1 drain current is drawn via R_b , D3 and T2 from the battery. This switches T2 on, allowing the load circuitry to draw current from the battery via D6 and the 5-V regulator. After a few seconds C1 has discharged (via R1) such that V_{gs} falls below the threshold value for the FET, and T1 switches off. There is then no path for T2 base current, so that it also switches off, isolating the battery.

POWER-SWITCHING CIRCUIT



NASA

Fig. 72-4

POWER-SWITCHING CIRCUIT, Continued.

Circuit Notes

This circuit provides on/off switching, soft starting, current monitoring, current tripping, and protection against overcurrent for a 30 Vdc power supply at normal load currents up to 2 A. The switch is turned on by an "on" command pulse; it is turned off by an "off" command pulse. An overcurrent trip can also be set on the bus side by a 6-digit binary signal, which is converted to an analog voltage and compared with the amplified voltage developed across a load-current-sensing resistor. Resistor/capacitor combinations ($0.027 \mu\text{F}$, $2 \text{ k}\Omega$) at the inputs of the current-sensing amplifiers act as low-pass filters: this introduces a few hundred μs of delay in the response to overcurrent, thereby providing some immunity to noise. The $0.022 \mu\text{F}$ capacitors connected to the drain terminals of the PFETs provide a Miller effect, which reduces the rate of change of the drain voltage and therefore the rate of rise of current at turn-on. The soft-turn-on time depends upon the load impedance and is typically 100 to 200 ms.

RADIATION-HARDENED, 125 A LINEAR REGULATOR

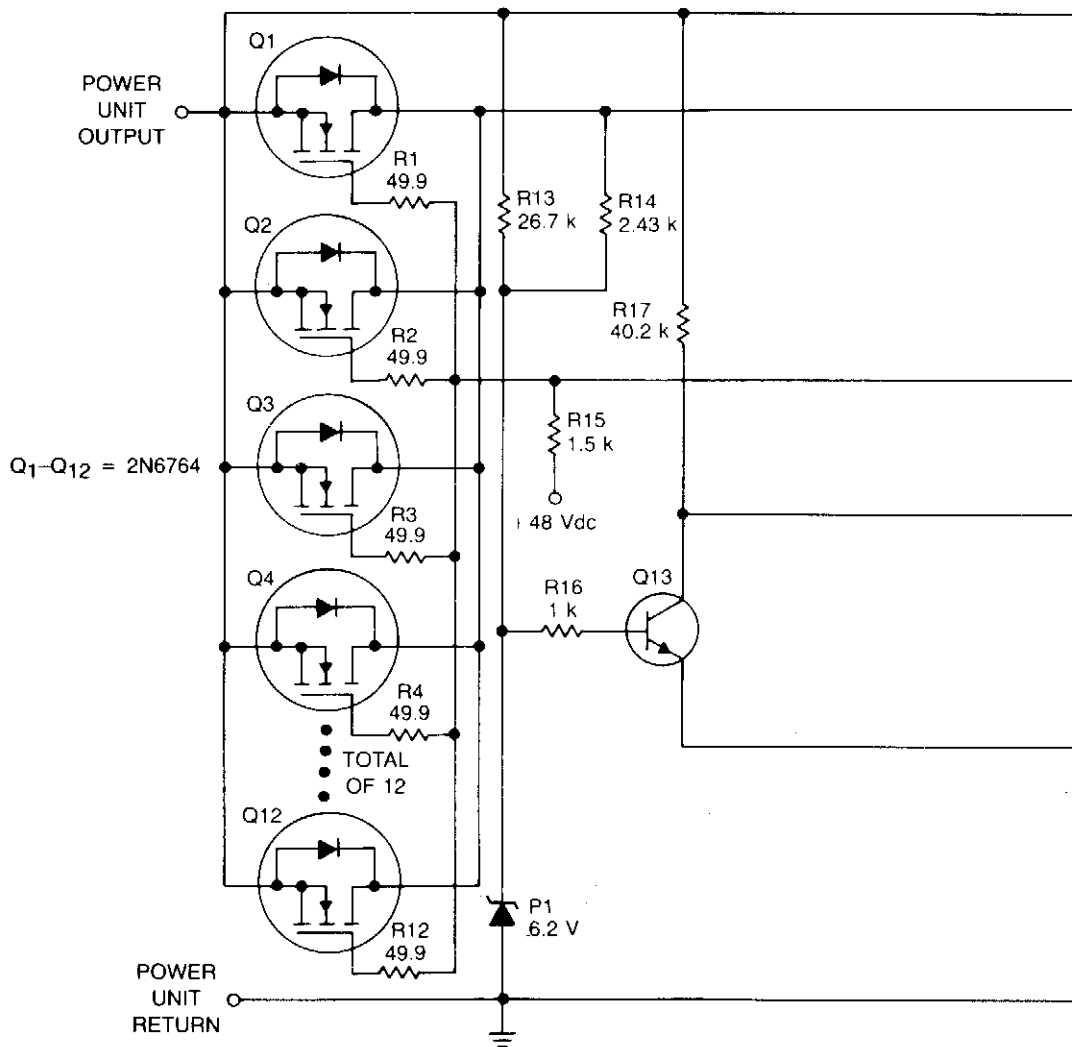


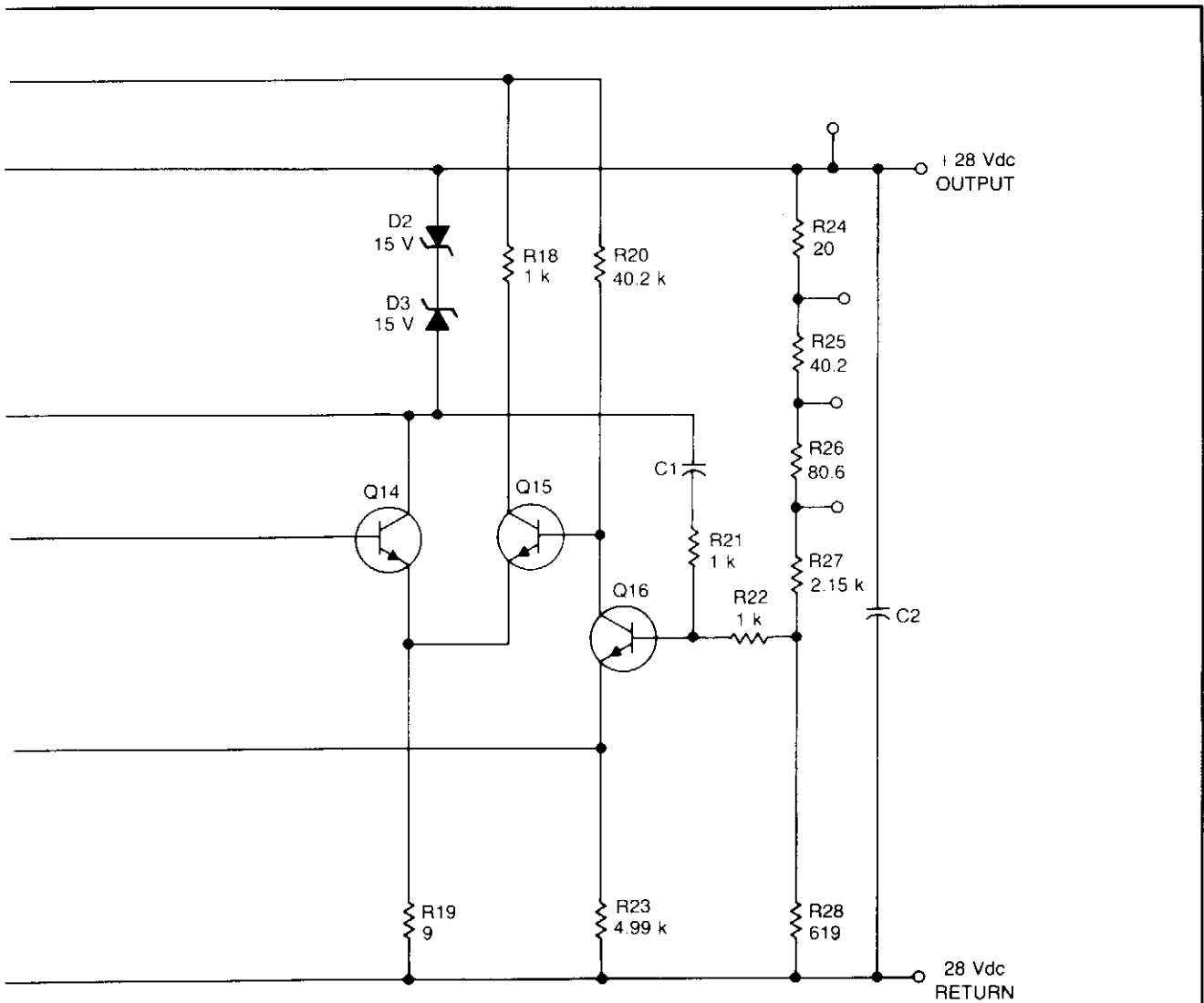
Fig. 72-5

MOTOROLA

Circuit Notes

Intended for extreme temperature, radiation-hardened environments, this linear supply is capable of supplying 28 Vdc at 125 A from an ac-driven power unit.

In operation, power supply output voltage is sensed by the voltage divider consisting of R24 to R28 and fed to one input of a discrete differential amplifier composed of Q13



through Q16. The other input of the amplifier is connected to a radiation-hardened zener diode, D1. Local feedback using R21 and C1 produces gain to phase shift that are independent of individual component parameters, which provides stable operation into the required loads.

SWITCH MODE POWER SUPPLY

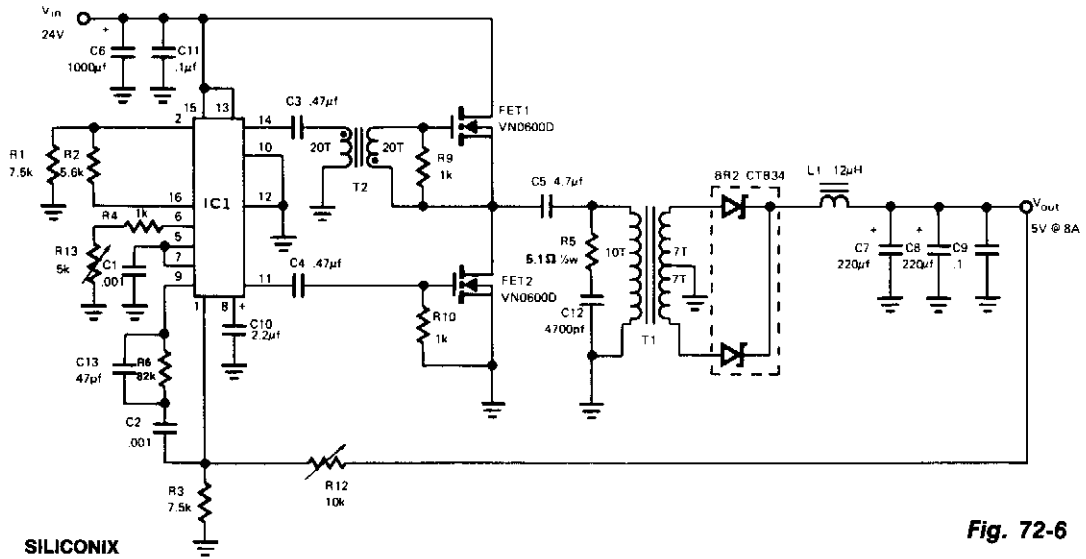


Fig. 72-6

Circuit Notes

This buck-derived circuit provides up to 8 A at 5 Vdc operating off 24 to 32 Vdc. The two power MOSFETs in the circuit conduct alternately for equal periods. Switching frequency is 150 kHz, set by the PWM125 controller. Output of the two MOSFETs is transformed to a low-voltage level, then rectified. Efficiency of the circuit is 75% when operated in a 22 to 32 V range. Efficiency approaches 90% with higher voltage inputs.

MICROPOWER BANDGAP REFERENCE SUPPLY

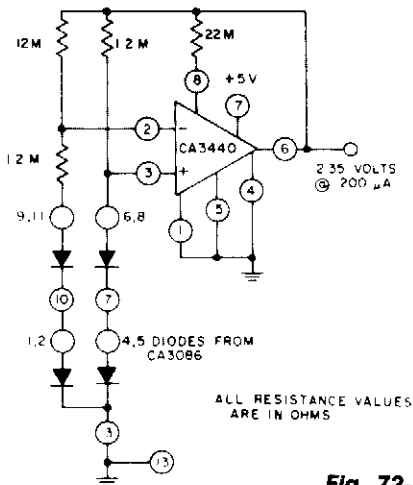


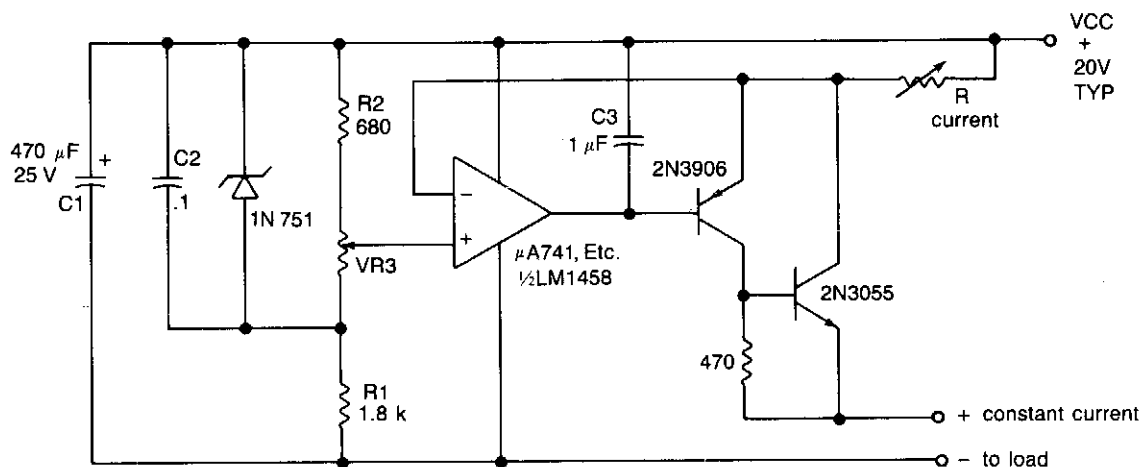
Fig. 72-7

GENERAL ELECTRIC/RCA

Circuit Notes

The circuit uses a CA3440 BiMOS op amp and CA3086 transistor array. The no-load current from 5-volt supply is 1.5 μ A. Load current can go as high as 200 μ A and still maintain output voltage regulation within 0.05%.

VARIABLE CURRENT SOURCE, 100 mA TO 2 AMP



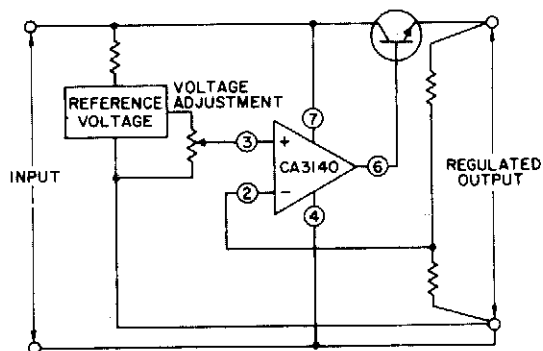
WILLIAM SHEETS

Fig. 72-8

Circuit Notes

The output current is set by the resistor R in the collector of Tr_2 , which may be varied to offer a range of output currents from 100 mA to 2 A with fine control by means of VR_3 which varies the reference voltage to the non-inverting input of the op amp. The feedback path from the output to the inverting input of the op amp maintains a constant voltage across R , equal to $(V_{CC} - V_{IN})$ and hence a constant current to the load given by $(V_{CC} - V_{IN})/R$.

BASIC SINGLE-SUPPLY VOLTAGE REGULATOR



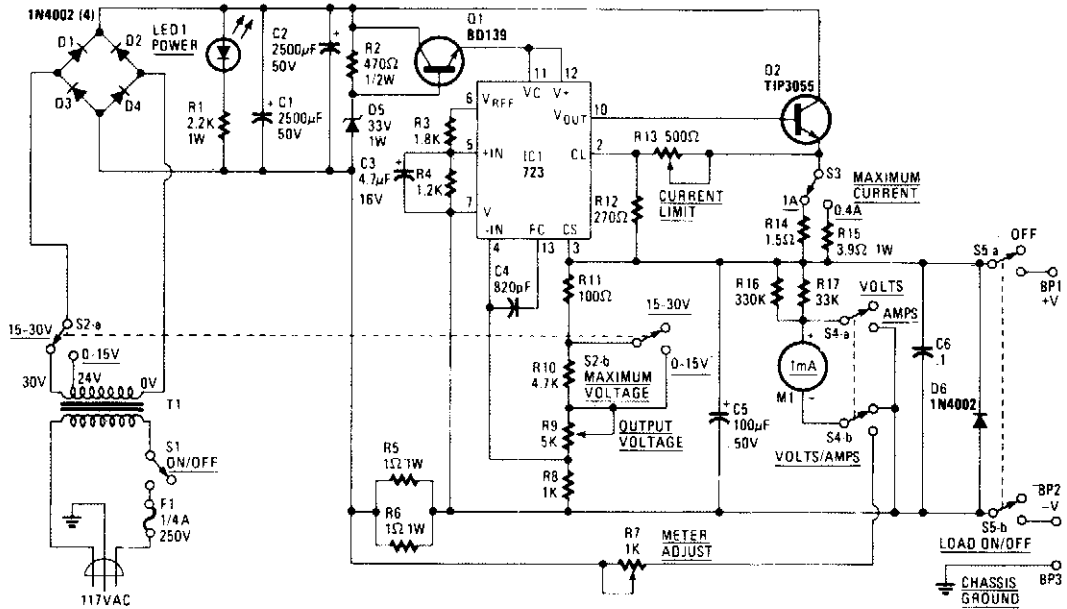
GENERAL ELECTRIC/RCA

Fig. 72-9

Circuit Notes

The circuit uses a CA3140 BiMOS op amp capable of supplying a regulated output that can be adjusted from essentially 0 to 24 volts.

BENCH TOP POWER SUPPLY



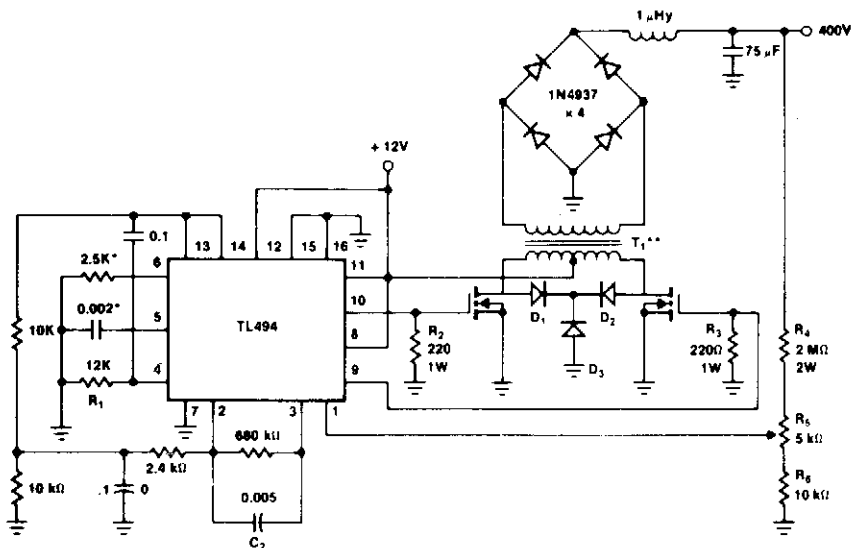
RADIO-ELECTRONICS

Fig. 72-10

Circuit Notes

A tapped transformer drives a diode bridge (D1-D4) and two 2500 μ F filter capacitors (C1 and C2), that provide a no-load voltage of 37 or 47 volts, depending upon the position of switch S2a. The unregulated dc is then fed to a pre-regulator stage composed of Q1 and D5. Those components protect IC1 (the 723) from an over-voltage condition; the 723 can't handle more than 40 volts. The LED (LED1) and its 2.2 k current-limiting resistor (R1) provide on/off indication. The current through the LED varies slightly according to the transformer tap selected, but that's of no real consequence. The series-pass transistor in IC1 drives voltage-follower Q2, providing current amplification. The transistor can handle lots of power. It has a maximum collector current of 15 amps and a maximum V_{CE} of 70 V, both of which are more than adequate for our supply.

400-VOLT, 60-WATT PUSH-PULL POWER SUPPLY



- NOTES**
 UNLESS OTHERWISE NOTED.
 ALL RESISTORS 5%, 1/4 W
 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: 275T, NO 24 AWG
 CORE: IND GEN 8231-1

SILICONIX, INC.

Fig. 72-11

Circuit Notes

The design delivers a regulated 400-V, 60-W output. The TL494 switching regulator governs the operating frequency and regulates output voltage. R1 and C1 determine switching frequency, which is approximately 0.5RC—100 kHz for the values shown. The TL494 directly drives the FET's gates with a voltage-controlled, pulse-width-modulated signal. After full-wave rectification, the output waveform is filtered by a choke-input arrangement. The 1 μH, 75 μF filter accomplishes the job nicely at 100 kHz. A feedback scheme using R4, R5 and R6 provides for output-voltage regulation adjustment, with loop compensation handled by C2. Diodes D1 and D2 provide isolation and steering for the 33-V zener transient clamp, D3. Output regulation is typically 1.25% from no-load to the full 60-W design rating. Regulation is essentially determined by the TL494. Output noise and ripple consists mainly of positive and negative 0.8-V spikes occurring when the output stage switches.

500 kHz SWITCHING INVERTER FOR 12 V SYSTEMS

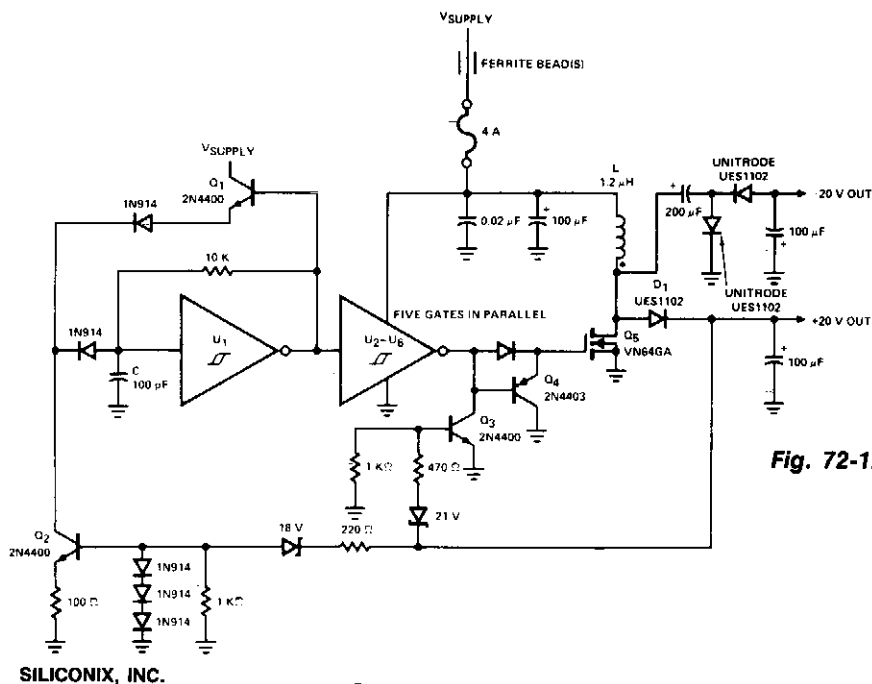


Fig. 72-12

Circuit Notes

This PWM control circuit provides the control pulse to the DMOS Power Switch in the flyback circuit. The output of the PWM is a pulse whose width is proportional to the input control voltage and whose repetition rate is determined by an external clock signal. To provide the control input to the PWM and to prevent the output voltage from soaring or sagging as the load changes the error amplifier and reference voltage complete the design. They act as the feedback loop in this control circuit much like that of a servo control system.

10 AMP-REGULATOR WITH CURRENT AND THERMAL PROTECTION

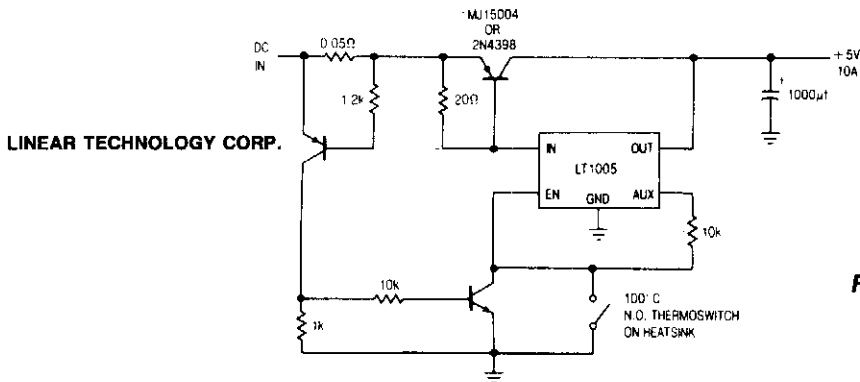


Fig. 72-13

BIPOLAR POWER SUPPLY FOR BATTERY INSTRUMENTS

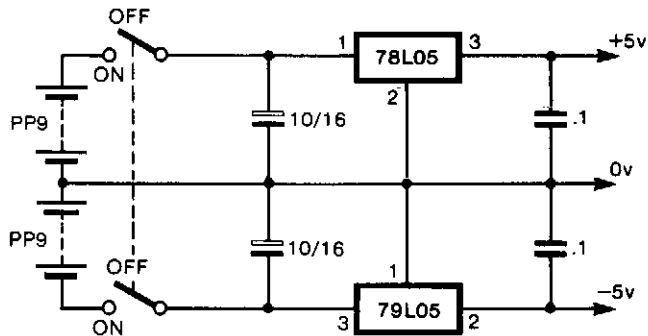


Fig. 1

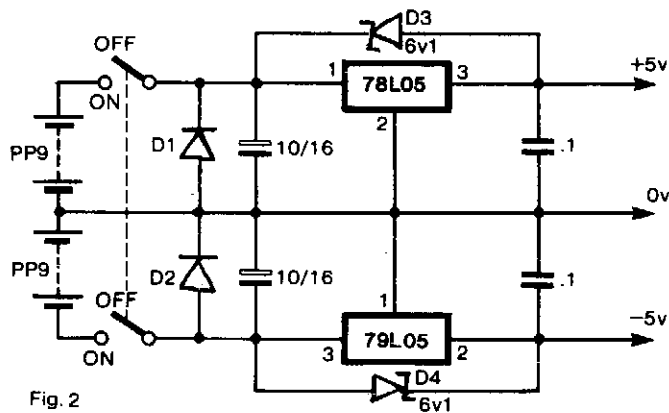


Fig. 2

ELECTRONIC ENGINEERING

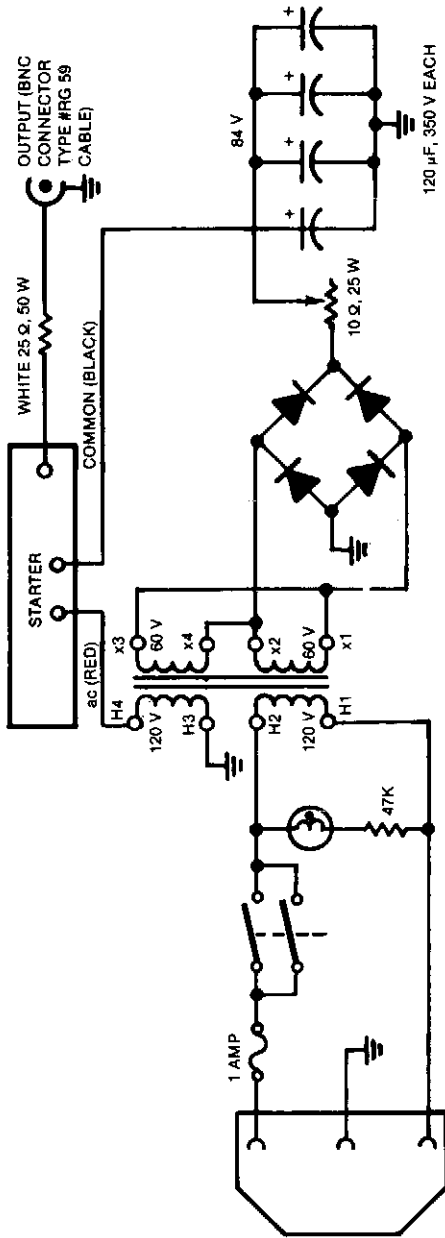
Fig. 72-14

Circuit Notes

To generate regulated $\pm 5\text{-V}$ supplies from a pair of dry batteries, the circuit of Fig. 1 is commonly used. In order to give protection from inadvertent reverse connection of a battery, a diode in series with each battery would produce an unacceptable voltage drop. The more effective approach is to fit diodes D1 and D2 as shown in Fig. 2, in parallel with each battery.

When the supply is switched off, there is the risk of a reverse bias being applied across the regulators, if there is significant inductance or capacitance in the load circuit. Diodes across the regulators prevent damage. When the power supply is switched on, the two switches do not act in unison. There is a probability that one or the other regulators will be latched hard off by the other. To prevent this, D3 and D4 are Zener diodes so that $\pm 5\text{-V}$ rails are pulled up by the batteries until the regulators establish the correct levels.

POWER SUPPLY FOR 25-WATT ARC LAMP



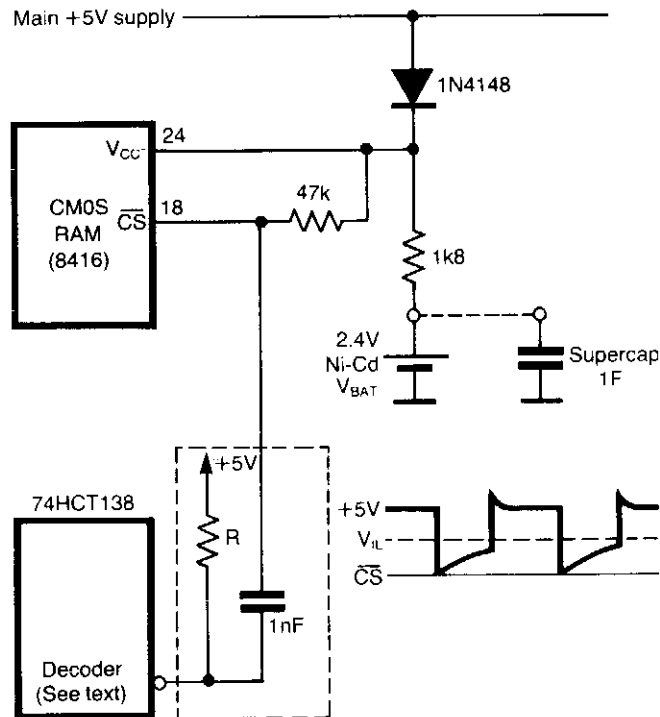
NASA

Fig. 72-15

Circuit Notes

A dual-voltage circuitry both strikes and maintains the arc. The lamps require a starting voltage in excess of 1,000 volts. Once stabilized, the voltage drop across the lamp is near 20 volts. Power supply consists of two main sections. The first section, the low-voltage power supply section, is an 84-volt starter circuit. This supply powers the stabilized arc. Current is limited by the 10 ohm adjustable and 25 ohm fixed resistance. The second section, the high-voltage starter circuit, is a Cockcroft-Walton voltage multiplier. With no load, the output voltage is 2,036 volts. However, when the arc is established, the heavy current drain maintains a forward bias on all of the diodes, and the circuit becomes a straight path with a voltage drop of 7.2 volts. The small value of the capacitors used in the multiplier guarantees that the diodes will be forward-biased once the arc is established.

STAND-BY POWER FOR NON-VOLATILE CMOS RAMs



ELECTRONIC ENGINEERING

Fig. 72-16

Circuit Notes

To prevent loss of data when a CMOS RAM is switched from normal operation ($V_{CC} = 5$ volts) to stand-by mode ($V_{CC} = V_{BAT}$) it must be ensured that the CS pin goes near the V_{CC} rail at all times. Ac coupling to the chip select is made through capacitor C, breaking the dc current path between V_{CC} (and hence V_{BAT}) and the decoder output. So, whatever the impedance state of the decoder in power down, the battery will provide current only for the RAM, low enough to keep the voltage at CS near to V_{CC} .

HV REGULATOR WITH FOLDBACK CURRENT LIMITING

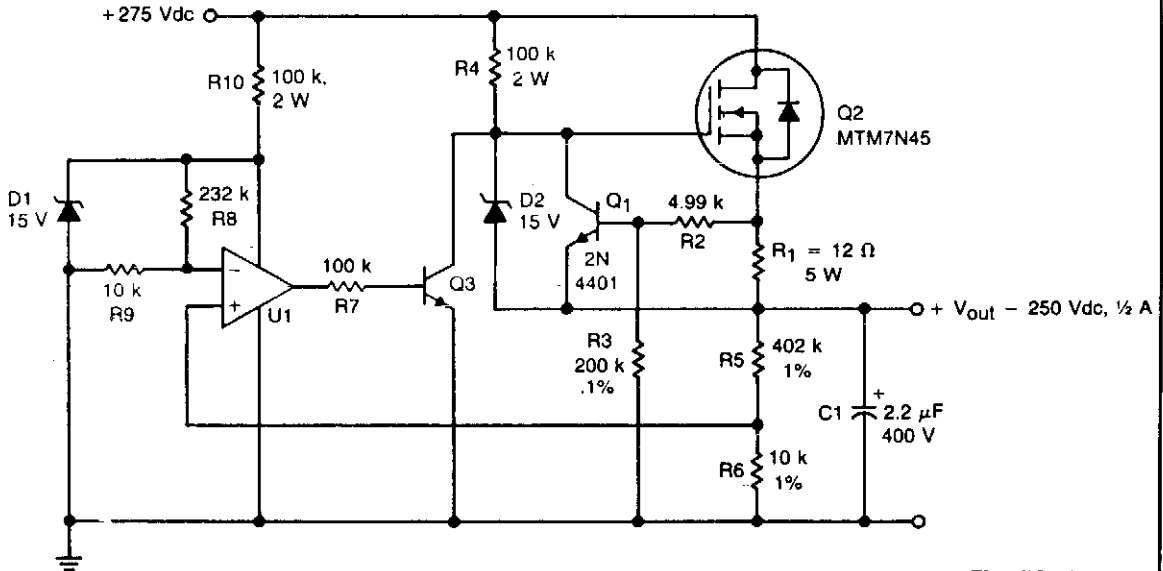


Fig. 72-17

MOTOROLA

Circuit Notes

A TMOS MTM7N45 (Q2) is used as a series pass element in a linear high voltage supply that accepts +275-V unregulated and produces 250 V regulated with foldback current limiting.

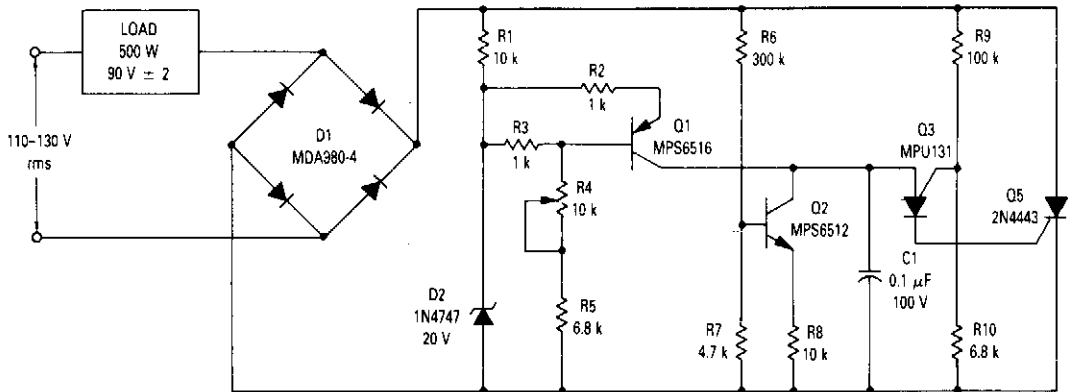
A 15-V zener, D1, provides the dc reference for operational amplifier U1, whose other input is obtained from a fraction of the output voltage. U1 drives Q3, which drives the gate of Q2. Foldback current limiting is achieved by R1, R2, R3, R4, Q1, and D2. The formula to establish the current "knee" for limiting is:

$$I_{\text{KNEE}} = \frac{V_{\text{OUT}}(R2/R2 + R3) + 0.5 \text{ V}}{R1}$$

Short circuit current is:

$$I_{\text{SC}} = \frac{0.5 \text{ V}}{R1}$$

90 V rms VOLTAGE REGULATOR USING A PUT



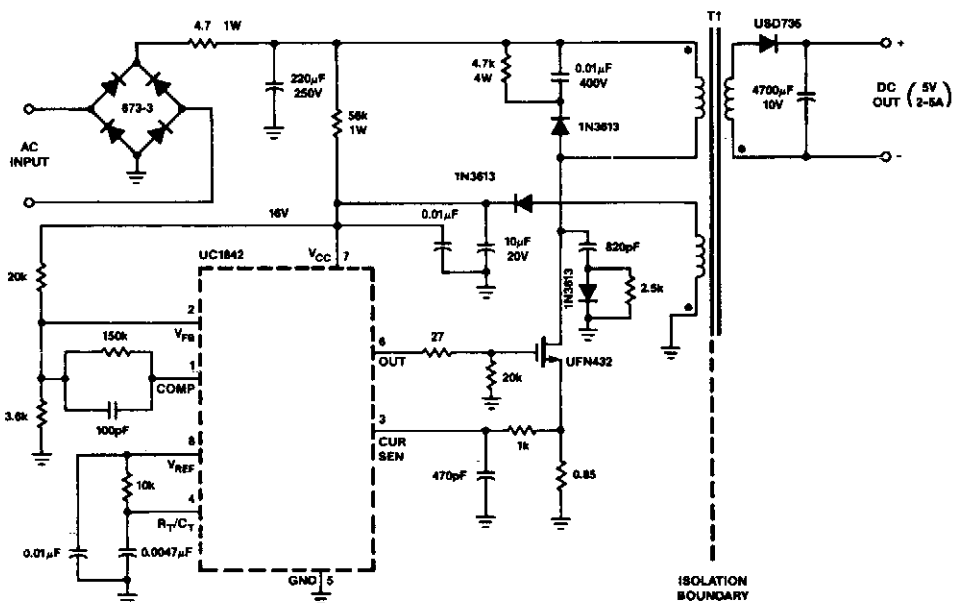
MOTOROLA

Fig. 72-18

Circuit Notes

The circuit is an open loop rms voltage regulator that will provide 500 watts of power at 90 V rms with good regulation for an input voltage range of 110-130 V rms. With the input voltage applied, capacitor C1 charges until the firing point of Q3 is reached causing it to fire. This turns Q5 on which allows current to flow through the load. As the input voltage increases, the voltage across R10 increases which increases the firing point of Q3. This delays the firing of Q3 because C1 now has to charge to a higher voltage before the peak-point voltage is reached. Thus the output voltage is held fairly constant by delaying the firing of Q5 as the input voltage increases. For a decrease in the input voltage, the reverse occurs.

OFF-LINE FLYBACK REGULATOR



NOTES:

T1: Colcraft E-4140-B
 Primary - 97 turns
 single AWG 24
 Secondary - 4 turns
 4 parallel AWG 22
 Control - 9 turns
 3 parallel AWG 28

SPECIFICATIONS

Input line voltage:	90V _{AC} to 130V _{AC}	Efficiency @ 25 W,	
Input frequency:	50 or 60Hz	V _{IN} = 90V _{AC} :	70%
Switching frequency:	40kHz ± 10%	V _{IN} = 130V _{AC} :	65%
Output power:	25W maximum	Output short-circuit current:	2.5A average
Output voltage:	5V ± 5%		
Output current:	2 to 5A		
Line regulation:	0.01%/V		
Load regulation:	8%/A		

SIGNETICS

Fig. 72-21

Circuit Notes

This circuit uses a low-cost feedback scheme in which the dc voltage developed from the primary-side control winding is sensed by the UC1842 error amplifier. Load regulation is therefore dependent on the coupling between secondary and control windings, and on transformer leakage inductance. For applications requiring better load regulation, a UC1901 Isolated Feedback Generator can be used to directly sense the output voltage.

Circuit Notes

This SCR pre-regulator keeps the filter capacitor V_c in a variable output power supply, a few volts above the output voltage V_o . The benefits include: less heat dissipated by the pass transistor and therefore small heatsink, cooler operation and higher efficiency, especially at low output voltages.

Q1, R1, R2, D1 and D2 form a constant current source for zener Z1, so that the contribution to the output current is always a few mA (2 - 3 mA).

The Darlington pair Q2, Q3 keeps the SCR off. The voltage V_c decreases until $V_c = V_o = V$ at which point the Darlington pair fires the SCR, charging the filter capacitor to a higher voltage V_c^1 in less than half the period of the input voltage. The component values, shown are for a 0 - 250-V, 3-A power supply.

VOLTAGE REGULATOR

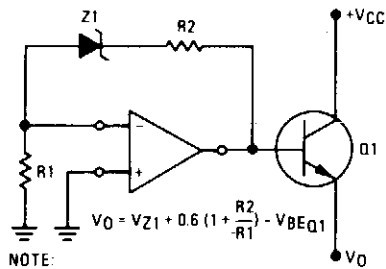


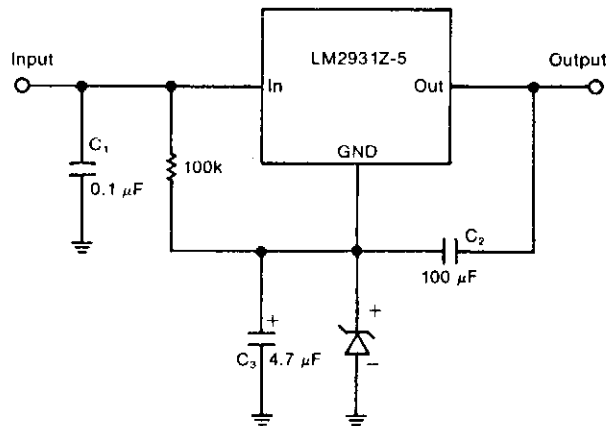
Fig. 72-23

NOTE:

For positive T_C zeners R2 and R1 can be selected to give 0 T_C output.

MOTOROLA, INC.

ZENER DIODE INCREASE FIXED PNP REGULATOR'S OUTPUT VOLTAGE RATINGS



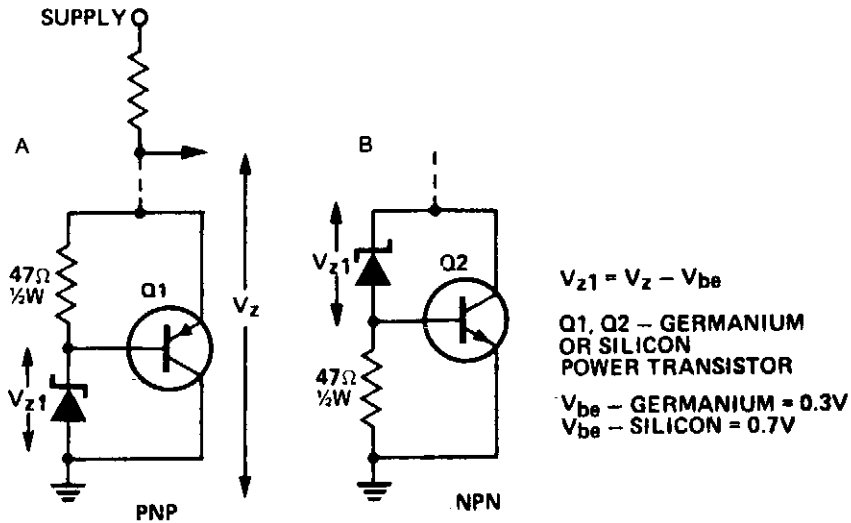
ELECTRONIC DESIGN

Fig. 72-24

Circuit Notes

A zener diode in the ground lead of a fixed pnp regulator varies the voltage output of that device without a significant sacrifice in regulation. The technique also allows the regulator to operate with output voltages beyond its rated limit.

INCREASING THE POWER RATING OF ZENER DIODES



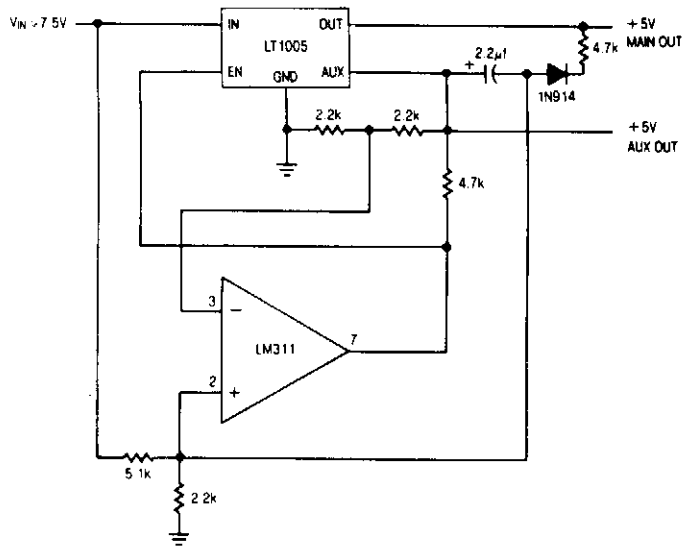
ELECTRONICS TODAY INTERNATIONAL

Fig. 72-25

Circuit Notes

A power transistor can be used to provide a high powered zener voltage from a low wattage zener. A 400 mW zener can be used where a 10 watt zener is required or a 1 W zener can be used where a 50 to 80 watt zener is required by using appropriate transistors for Q1 and Q2 in the circuits shown. Where low rating is required, Q1 would be an ASZ 15 (germanium) or an AY9140 (silicon). Q2 could be a 2N2955 (silicon). For higher powers, Q1 should be an ASZ18 (germanium) or a 2N2955 (silicon) and Q2 a 2N3055 (silicon) or an AY8149 (silicon). A heatsink on the transistor is required. The circuit in A has the advantage that power transistors can be bolted directly on to a chassis which may serve as a heatsink.

MEMORY SAVE ON POWER-DOWN



LINEAR TECHNOLOGY

Fig. 72-26

Circuit Notes

The auxiliary output powers the memory, while the main output powers the system and is connected to the memory store pin. When power goes down, the main output goes low, commanding the memory to store. The auxiliary output then drops out.

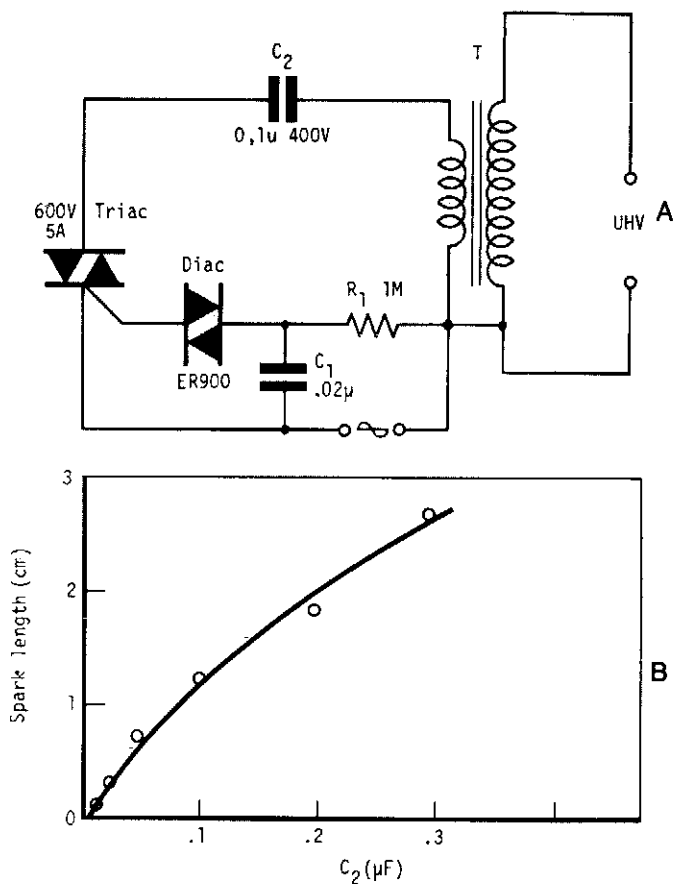
73

Power Supply Circuits (High Voltage)

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Cost Ultra High Generator
Simple High-Voltage Supply
High Voltage Geiger Counter Supply
High Voltage Supply

LOW COST ULTRA HIGH VOLTAGE GENERATOR



ELECTRONIC ENGINEERING

Fig. 73-1

Circuit Notes

By repetitively charging and discharging a capacitor through the primary of an induction coil with a high voltage, an ultra high emf is induced in the secondary. Switching is performed by the triac, triggered by the disc at times set by C₁ and R₁. With a 12 V car ignition coil for example, the length of sparkgap obtained is 12 mm of air for C₂ = 0.1 μF. If the dielectric strength of air is assumed to be 3 kV/mm, this spark-gap length corresponds to 36 kV. From the curve shown in Fig. B, care must be taken in keeping the value of C₂ below 1 μF as the coil is liable to be seriously damaged at this value of C₂. Power consumption is only about one watt.

SIMPLE HIGH-VOLTAGE SUPPLY

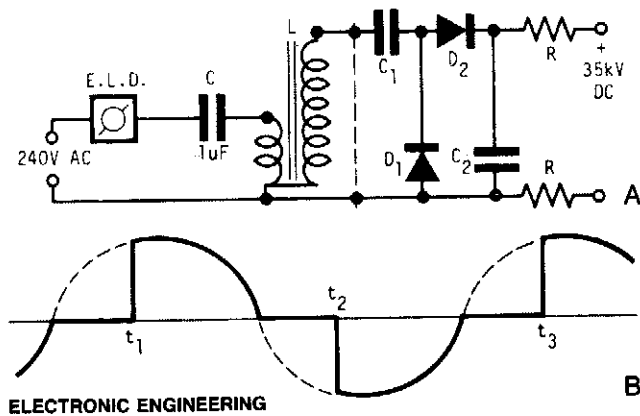


Fig. 73-2

Circuit Notes

A light dimmer, a 1 μF capacitor and a 12 V car ignition coil form the simple line powered HV generator. The current in the dimmer is shown in Fig. B. At times t_1 , t_2 , . . . , set by the dimmer switch, the inner triac of the dimmer switches on, and a very high and very fast current pulse charges the capacitor through the primary of the induction coil. Then at a rate of 120 times per second for a 60 Hz line, a very high voltage pulse appears at the secondary of the coil. To obtain an HV dc output, use a voltage doubler. D1 and D2 are selenium rectifiers (TV 18 Siemens or ITT) used for the supply of television sets. High value output shock protection resistors, R, are recommended when suitable.

HIGH VOLTAGE GEIGER COUNTER SUPPLY

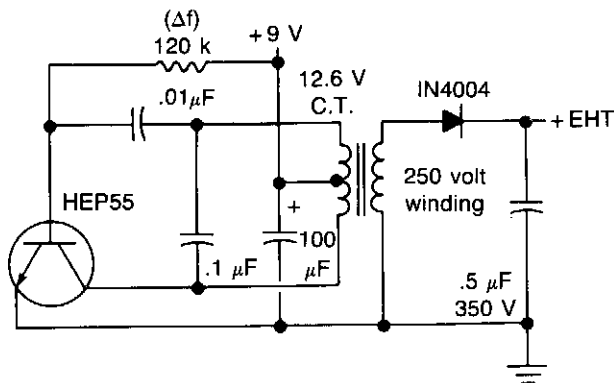
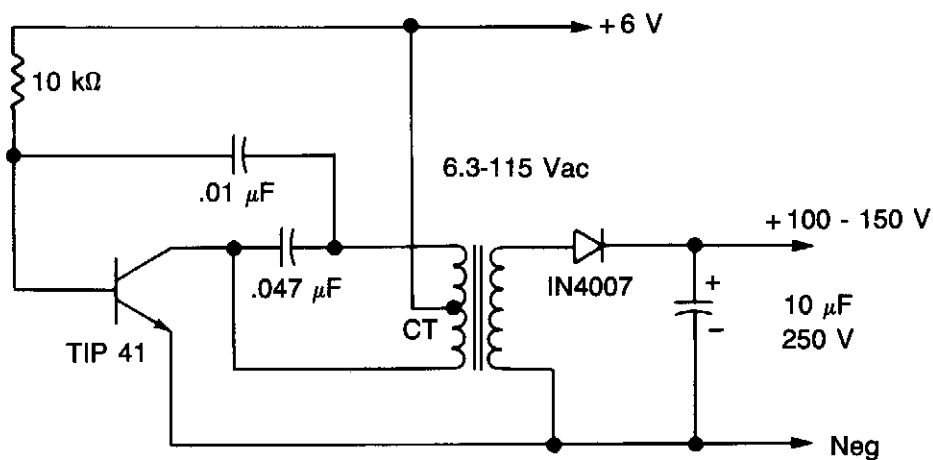


Fig. 73-3

Circuit Notes

This circuit will generate about 300 volts dc—at a very low current, but enough for a GM tube.

HIGH VOLTAGE SUPPLY



WILLIAM SHEETS

Fig. 73-4

Circuit Notes

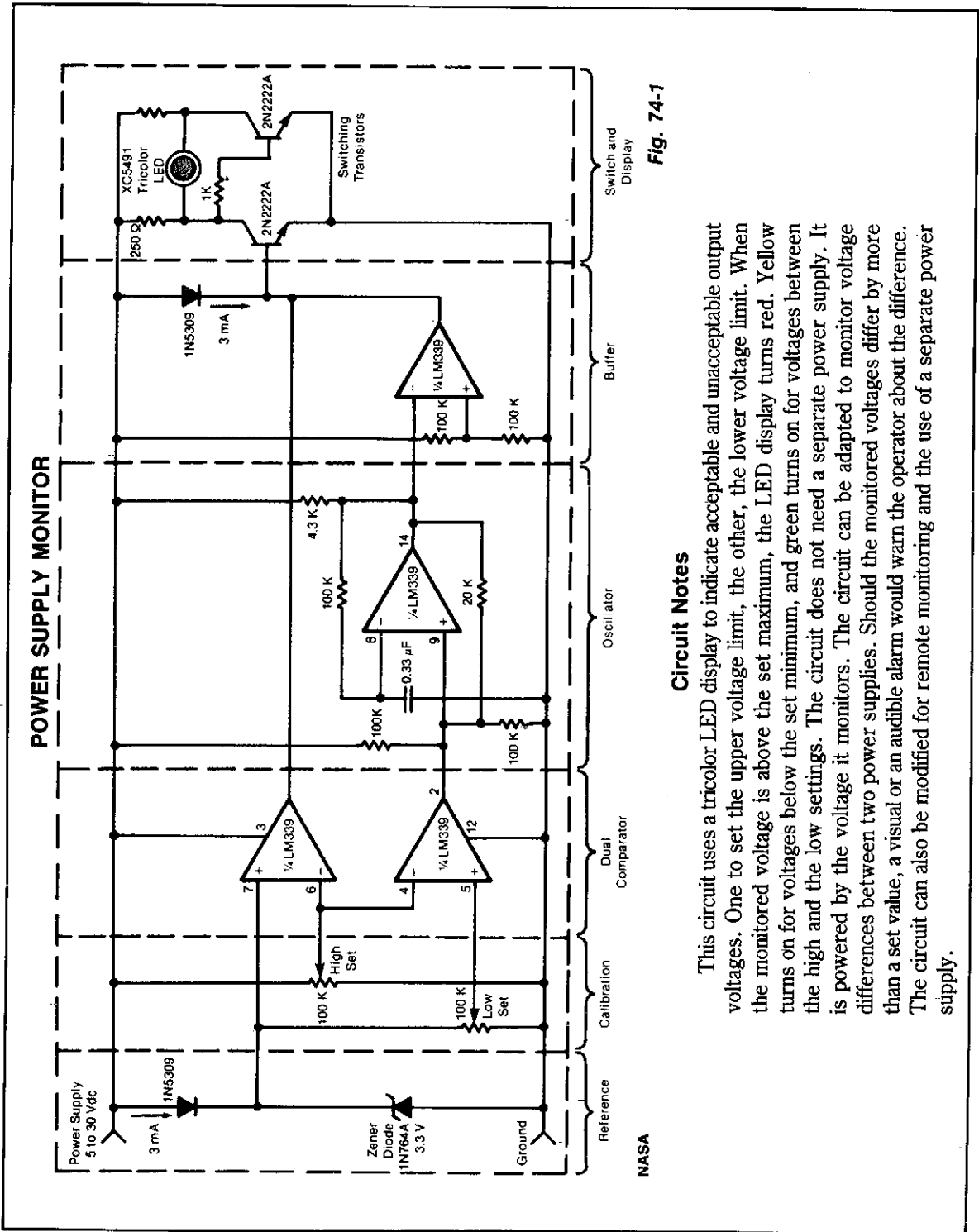
A 6 V battery can provide 100-150 Vdc center-tapped at a high internal impedance (not dangerous though it can inflict an unpleasant jolt). A 6.3 V transformer is connected "in reverse" with a transistor used in a Hartley oscillator configuration. The frequency of operation may be controlled by varying the value of the 10 K ohm resistor. The 10 μF capacitor must have a working voltage of at least 250 Vdc.

74

Power Supply Monitors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Power Supply Monitor
Low-Volts Alarm
Microprocessor Power Supply Watchdog
Overvoltage Protection Circuit (SCR Crowbar)
Power Supply Protection Circuit

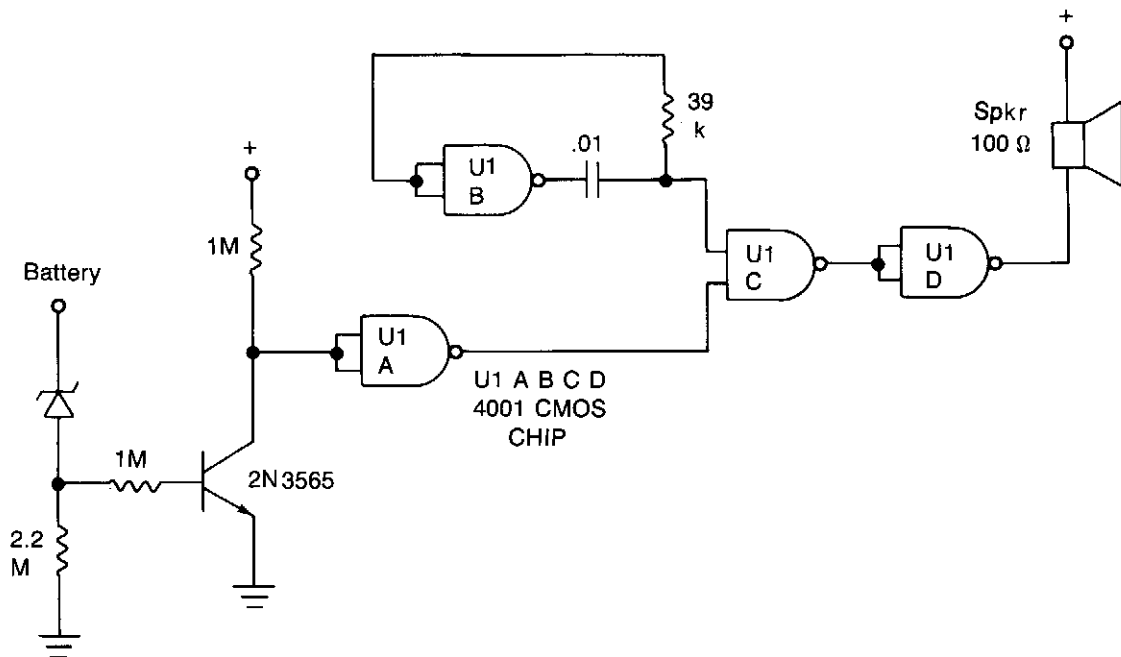


Circuit Notes

This circuit uses a tricolor LED display to indicate acceptable and unacceptable output voltages. One to set the upper voltage limit, the other, the lower voltage limit. When the monitored voltage is above the set maximum, the LED display turns red. Yellow turns on for voltages below the set minimum, and green turns on for voltages between the high and the low settings. The circuit does not need a separate power supply. It is powered by the voltage it monitors. The circuit can be adapted to monitor voltage differences between two power supplies. Should the monitored voltages differ by more than a set value, a visual or an audible alarm would warn the operator about the difference. The circuit can also be modified for remote monitoring and the use of a separate power supply.

NASA

LOW-VOLTS ALARM



WILLIAM SHEETS

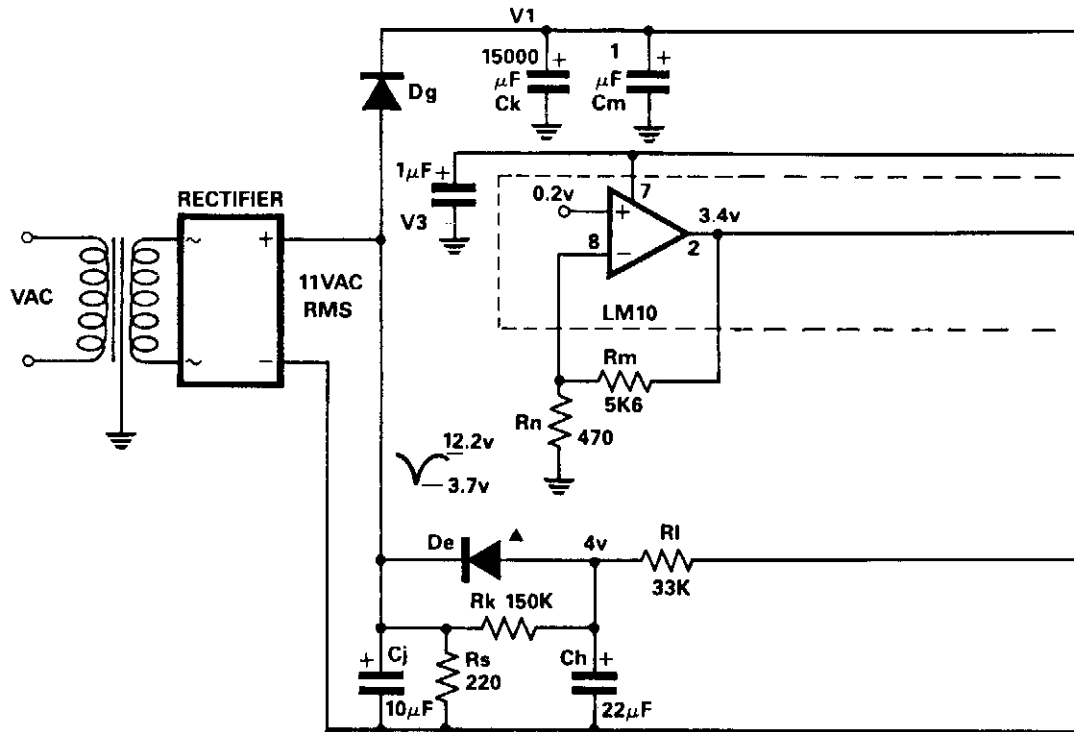
Fig. 74-2

Circuit Notes

This inexpensive dc supply-voltage monitor sounds a warning when the voltage falls below a preset value. It is ideal for monitoring rechargeable batteries since it draws only a few microamperes when not sounding. The voltage at which the alarm sounds is determined by the zener diode. When the voltage falls below the zener voltage, the alarm sounds. The alarm tone is determined by the RC time constant of the 39 k resistor and 0.01 mf capacitor.

MICROPROCESSOR POWER SUPPLY WATCHDOG

Fig 1

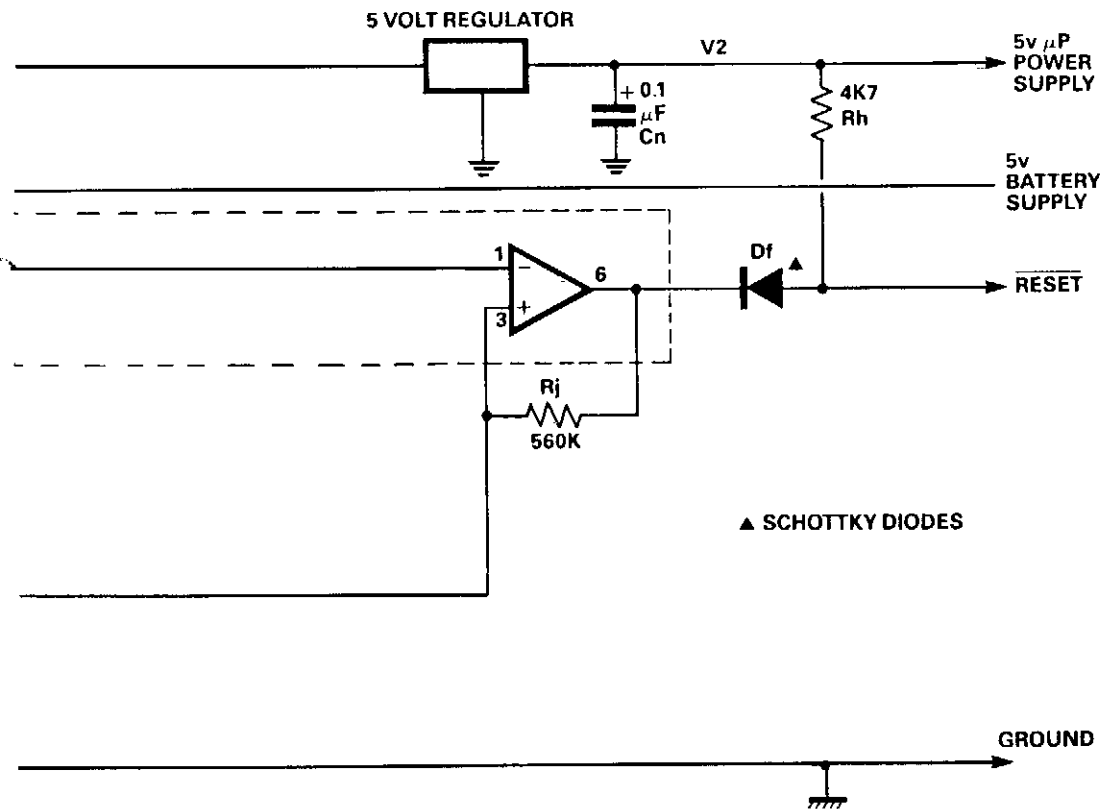


ELECTRONIC ENGINEERING

Fig. 74-3

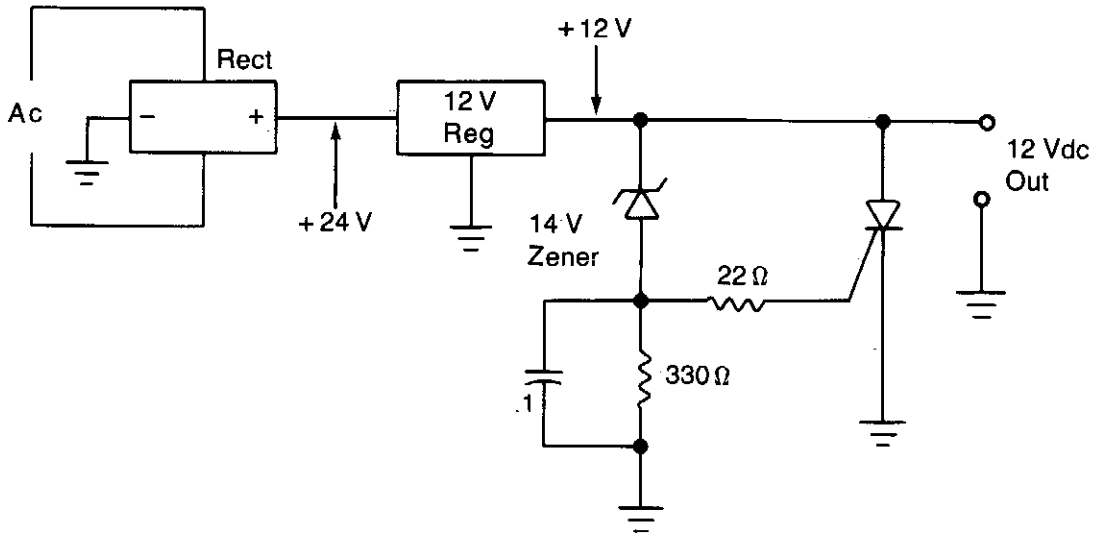
Circuit Notes

The circuit monitors the input to the microprocessor 5 V regulated supply for voltage drops and initiates a reset sequence before supply regulation is lost. In operation, the resistor capacitor combination R_s and C_j form a short time constant smoothing network for the output of the fullwave bridge rectifier. An approximately triangular, voltage waveform appears across C and R_s and it is the minimum excursion of this that initiates



the reset. Diode D_g prevents charge sharing between capacitors C_j and C_k . Resistors R_n and R_m form a feedback network around the voltage reference section of the LM10C, setting a threshold voltage of 3.4 volts. The threshold voltage is set at 90% of the minimum voltage of the triangular waveform. When the triangular wave trough, at the comparator's non-inverting input, dips below the threshold, the comparator output is driven low. This presents a reset to the microprocessor. Capacitor C_h is charged slowly through resistor R_k and discharged rapidly through diode D_e .

OVERVOLTAGE PROTECTION CIRCUIT (SCR CROWBAR)



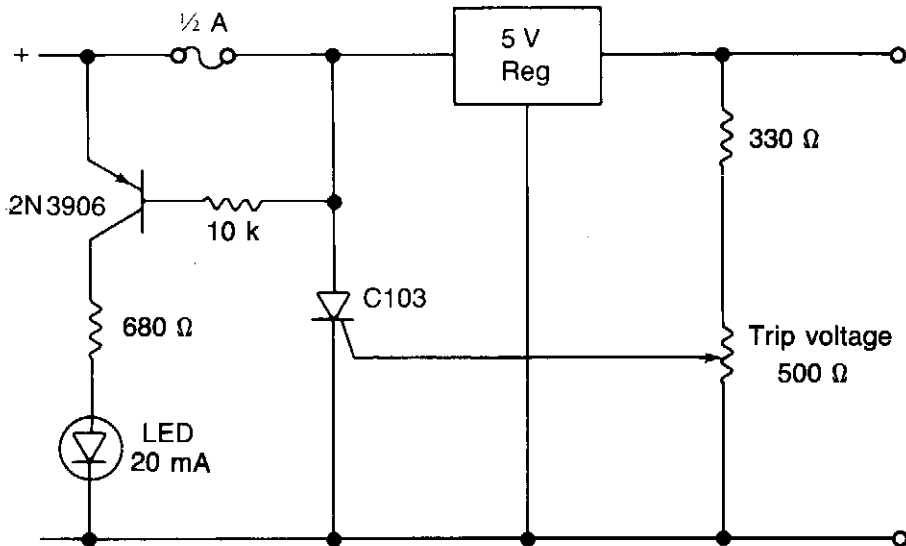
WILLIAM SHEETS

Fig. 74-4

Circuit Notes

The silicon controlled rectifier (SCR) is rated to handle at least the current of the power supply. It is connected in parallel across the 12 V dc output lines, but remains inert until a voltage appears at the gate terminal. This triggering voltage is supplied by the zener diode. At potentials less than 14 V the zener will not conduct current. But, at potentials greater than 14 Vdc the zener conducts and creates a voltage drop across the 330 ohm resistor that will fire the SCR. When the SCR turns on, the output lines of the power supply are shorted to ground. This will blow the primary fuse or burn out the transformer if there is no primary fuse.

POWER SUPPLY PROTECTION CIRCUIT



WILLIAM SHEETS

Fig. 74-5

Circuit Notes

When using a regulated supply to reduce a supply voltage there is always the danger of component failure in the supply and consequent damage to the equipment. A fuse will protect when excess current is drawn, but might be too slow to cope with overvoltage conditions. The values shown are for a 12 V supply being dropped to 5 V. The trip voltage is set to 5.7 V to protect the equipment in the event of a regulator fault. The 330 ohm resistor and the 500 ohm potentiometer form a potential divider which samples the output voltage as set by adjustment of the potentiometer. The SCR is selected to carry at least twice the fuse rating. The full supply voltage is connected to the input of the regulator. The 2N3906 is held bias off by the 10 k resistor and the SCR so that the LED is held off. If the output voltage rises above a set trip value then the SCR will conduct, the fuse will blow, and the 2N3906 will be supplied with base current via the 10 k resistor, and the LED will light up.

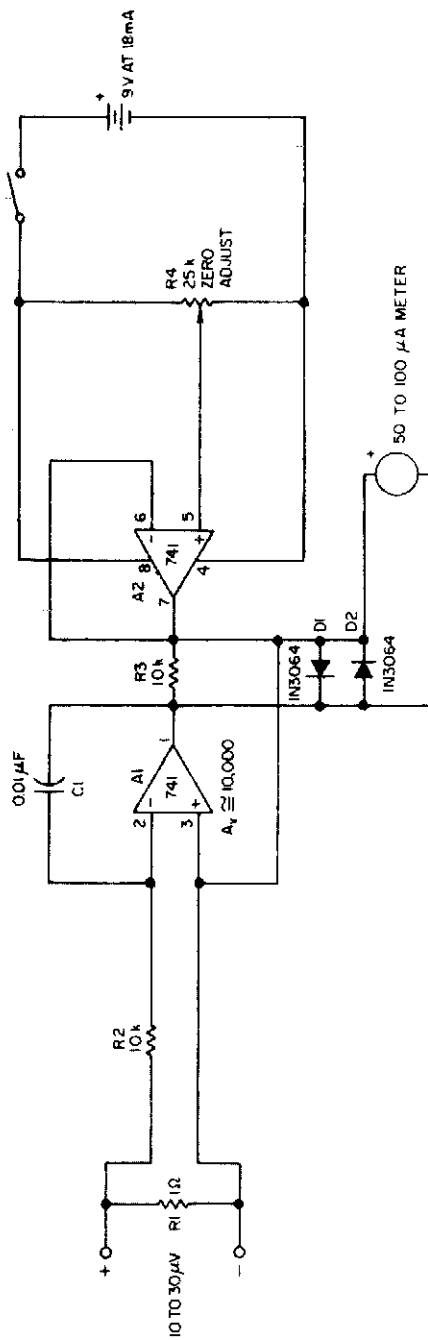
75

Probes

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Microvolt Probe
Single Injector-Tracer
General Purpose RF Detector
Clamp-on-Current Probe Compensator
650 MHz Amplifying Prescaler Probe
Tone Probe for Testing Digital ICs

MICROVOLT PROBE



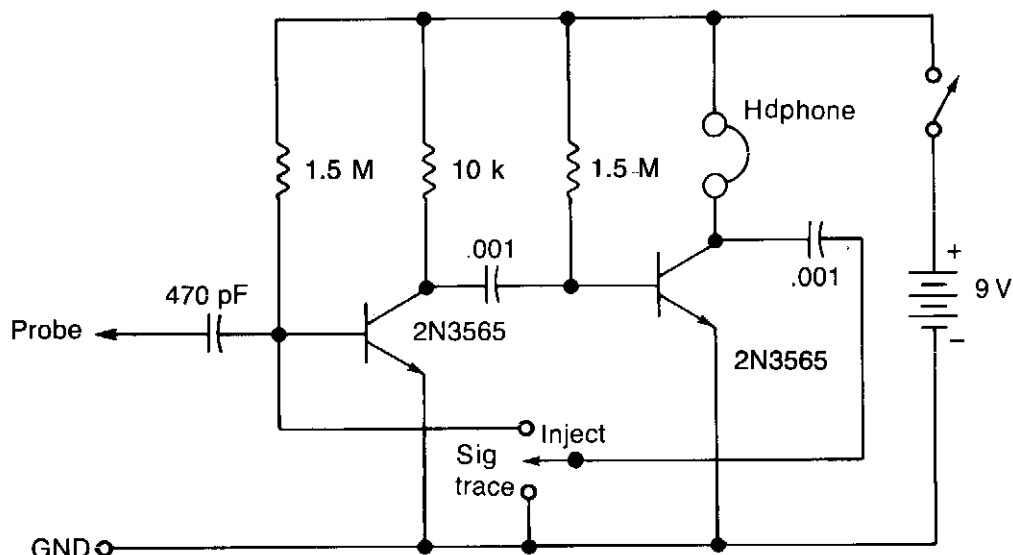
ELECTRONIC DESIGN

Fig. 75-1

Circuit Notes

The current tracer helps locate a defective IC that is loading down the power supply. The tracer amplifies the small voltage drop caused by current flow along a fraction of an inch of PC wiring and drives an ordinary microammeter. Needle-point test probes are used to contact the edge of a PC trace and to follow the current to determine which branch the current takes. One-half of a dual 741 op amp forms a dc amplifier with ac feedback to prevent oscillations and hum-pickup problems. It drives a 50-to-100 μA meter. The other op amp provides a center tap for the 9 V battery supply and zero adjustment with R4. Two diodes protect the meter. Resistor R1 eliminates the necessity for shorting the probes when the meter is zeroed. The value of 1 ohm is large when compared with the resistance of the meter leads plus the bridged portion of PC wiring.

SINGLE INJECTOR-TRACER



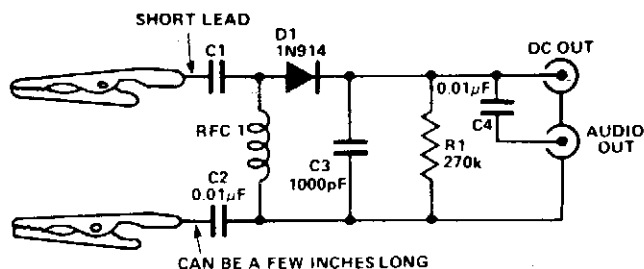
WILLIAM SHEETS

Fig. 75-2

Circuit Notes

This circuit will provide a nominal square wave output in the audio range in the "Inject" mode, the harmonics of which should be heard at several MHz. In the "Trace" mode the non-linear operation of the amplifier will detect modulated rf signals which will be filtered by the .001 μF capacitor and heard in the headphones.

GENERAL PURPOSE RF DETECTOR



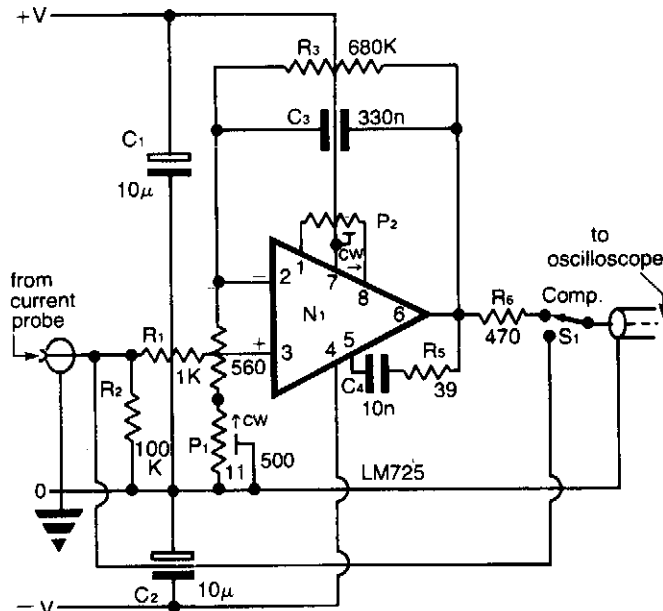
ELECTRONICS TODAY INTERNATIONAL

Fig. 75-3

Circuit Notes

This circuit provides a dc output to a meter and an audio output (if necessary) for checking transmitters or modulated signals. It can be used also as a field strength meter or transmitter monitor.

CLAMP-ON-CURRENT PROBE COMPENSATOR



Table

Tek P6021, on its own	with Tek amp. 134	with compensator
120Hz to 60MHz @ 10mA/mV	12Hz to 38MHz	1Hz to 100kHz @
450Hz to 60MHz @ 2mA/mV	(switched 1mA to 1A/div for 50mV/div output)	2mA/mV

ELECTRONIC ENGINEERING

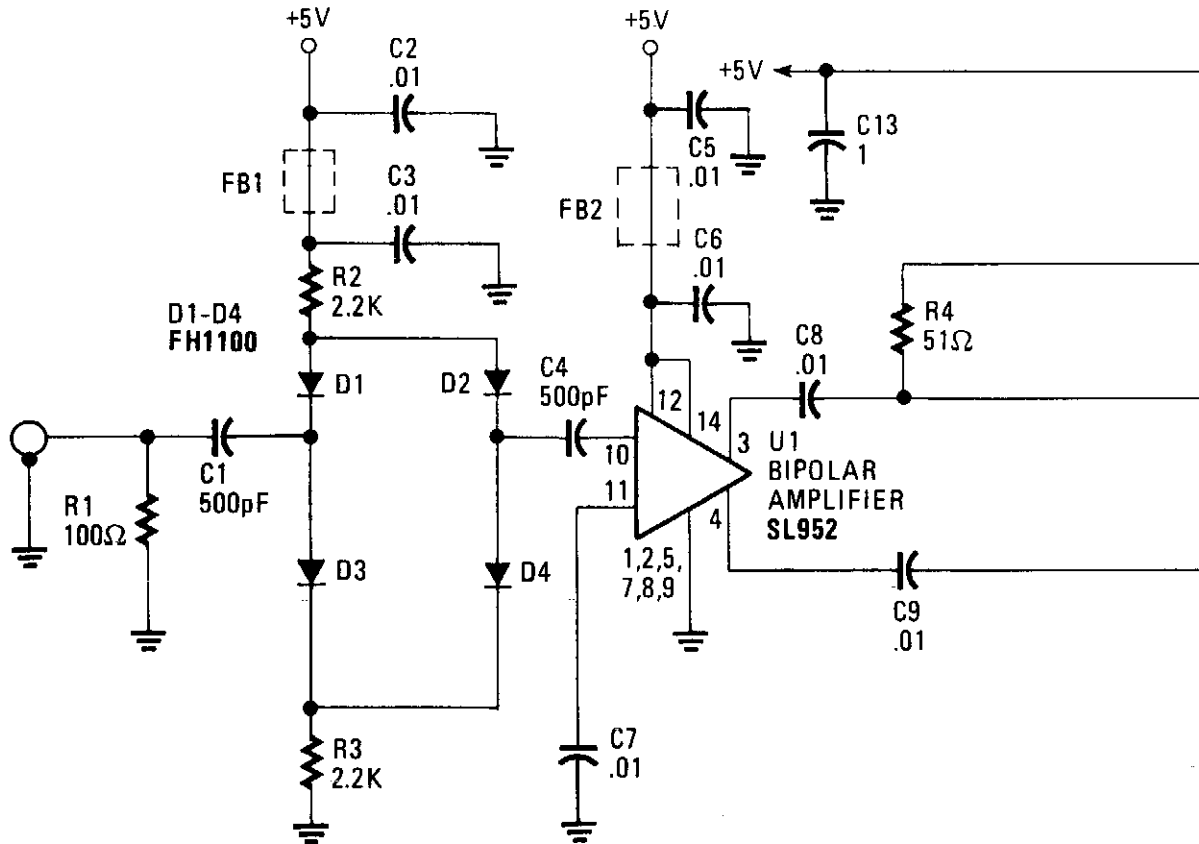
Fig. 75-4

Circuit Notes

A clamp-on "current probe" such as the Tektronix P6021 is a useful means of displaying current waveforms on an oscilloscope. Unfortunately, the low-frequency response is somewhat limited, as shown in the Table.

The more sensitive range on the P6021 is 2 mA/mV, but it has a roll-off of 6 dB per octave below 450 Hz. The compensator counteracts the low-frequency attenuation, and this is achieved by means of C3 and R4 + P1 in the feedback around op amp N1. The latter is a low-noise type, such as the LM725 shown, and even so it is necessary at some point to limit the increasing gain with decreasing frequency; otherwise amplifier noise and drift will overcome the signal. The values shown for C3R3 give a lower limit below 1 Hz. A test square wave of ± 10 mA is fed to the current probe so that P1 can be adjusted for minimum droop or overshoot in the output waveform. At high frequencies, the response begins to fall off at 100 kHz.

650 MHz AMPLIFYING PRESCALER PROBE

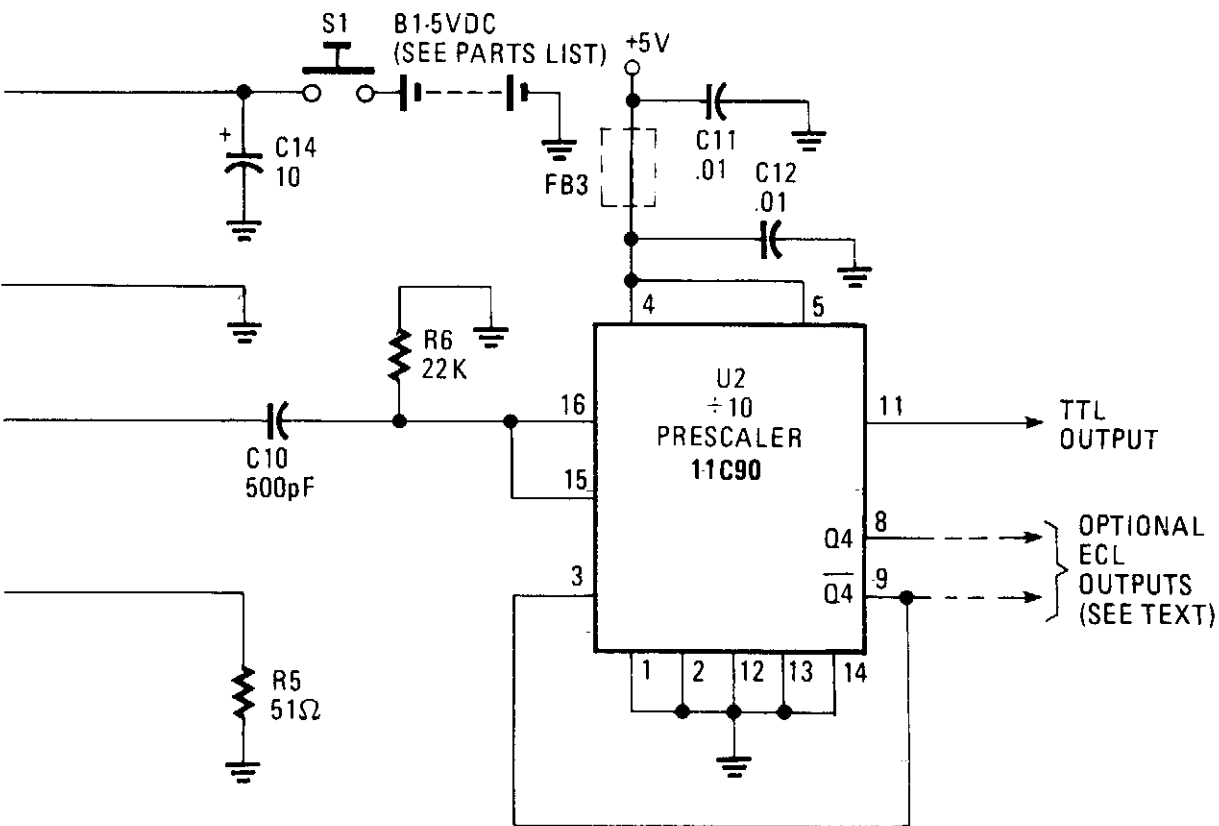


HANDS-ON ELECTRONICS

Fig. 75-5

Circuit Notes

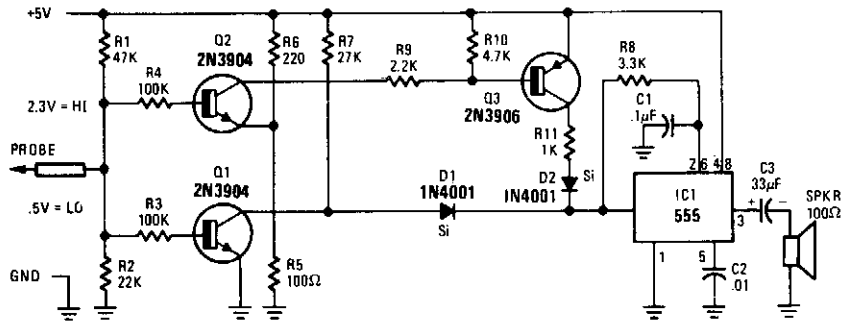
The 650 MHz Prescaler Probe's input is terminated by resistor R1 and is fed through C1 to the diode limiter composed of D1 through D4. Those diodes are forward-biased by the +5 volt supply for small-input signals and, in turn, feed the signal to U1. However, for larger input signals, diodes D1 through D4 will start to turn off, passing less of the signal, and, thus, attenuating it. But even in a full-off state, the FH1100-type diodes will always pass a small part of the input to U1 because of capacitive leakage within the diodes. Integrated circuit U1, a Plessey SL952 bipolar amplifier, capable of 1 GHz operation, provides 20 to 30 dB of gain. The input signal is supplied to pin 10, U1 with



the other input (pin 11) is bypassed to ground. The output signal is taken at pin 3 and pin 4, with pin 3 loaded by R4 and pin 4 by R5.

Integrated circuit 11C90, U2, is a high-speed prescaler capable of 650 MHz operation configured for a divide-by-10 format. A reference voltage internally generated appears at pin 15 and is tied to pin 16, the clock input. This centers the capacitive-coupled input voltage from U1 around the switching threshold-voltage level. An ECL-to-TTL converter in U1 provides level conversion to drive TTL input counters by tying pin 13 low. Therefore, no external ECL to TTL converter is required at the pin 11 output. On the other hand, ECL outputs are available at U2, pin 8 (Q4) and at pin 9 (Q4), if desired. In that circuit configuration, pin 13 is left open, and U2 will use less power.

TONE PROBE FOR TESTING DIGITAL ICs



RADIO-ELECTRONICS

Fig. 75-6

Circuit Notes

The tone probe uses sound to tell the status of the signal being probed. The probe's input circuit senses the condition of the signal and produces either a low-pitched tone for low-level signals (less than 0.8 V) or a high-pitched tone for high-level signals (greater than 2 V).

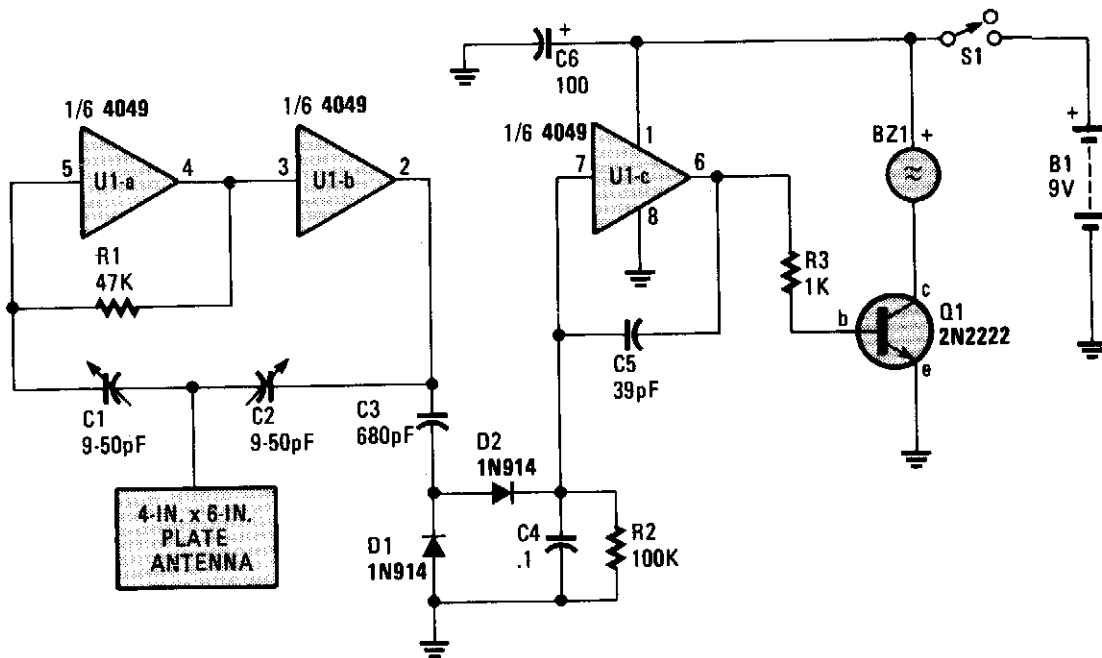
76

Proximity Sensors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Proximity Alarm
Field Disturbance Sensor/Alarm

PROXIMITY ALARM



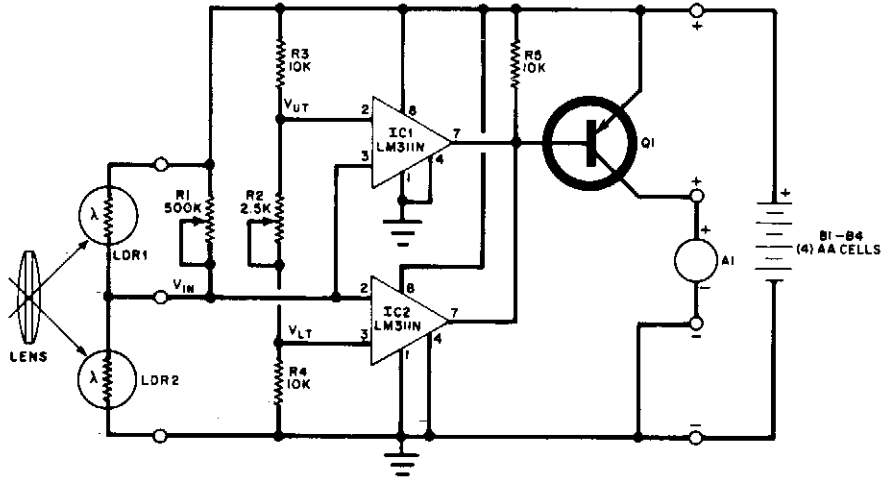
HANDS-ON ELECTRONICS

Fig. 76-1

Circuit Notes

Inverters U1a and U1b are connected in a simple RC oscillator circuit. The frequency is determined by the values of R1, C1, C2, and the internal characteristics of the integrated circuit. As long as the circuit is oscillating, a positive dc voltage is developed at the output of the voltage-coupler circuit: C3, D1, D2 and C4. The dc voltage is applied to the input of U1c—the third inverter amplifier—keeping its output in a low state, which keeps Q1 turned off so that no sound is produced by BZ1. With C1 and C2 adjusted to the most sensitive point, the pickup plate will detect a hand 3 to 5-inches away and sound an alert. Set C1 and C2 to approximately one-half of their maximum value and apply power to the circuit. The circuit should oscillate and no sound should be heard. Using a non-metallic screwdriver, carefully adjust C1 and C2, one at a time, to a lower value until the circuit just ceases oscillation: Buzzer BZ1 should sound off. Back off either C1 or C2 just a smidgen until the oscillator starts up again—that is the most sensitive setting of the circuit.

FIELD DISTURBANCE SENSOR/ALARM



POPULAR ELECTRONICS

Fig. 76-2

Circuit Notes

The change in ambient light triggers the alarm by changing resistance of LDR1 and LDR2.

Q1 = Radio Shack 276-2024

A1 = Mallory SC628P Sonalert

LDR1, LDR2 = Cadmium sulfide photocell, Radio Shack 276-116

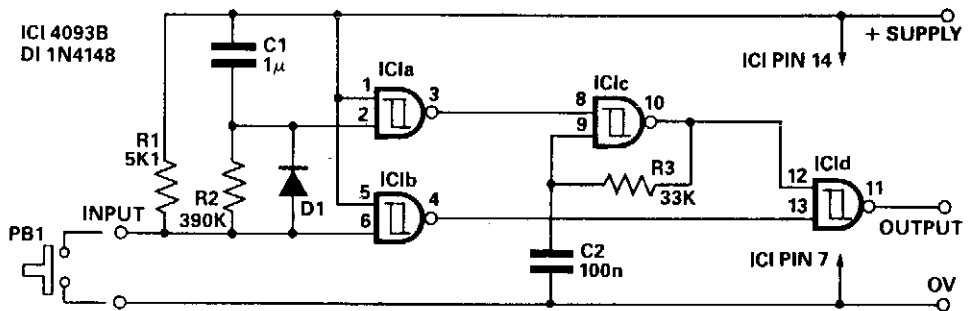
77

Pulse Generators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Delayed Pulse Generator
Pulse Generator (Astable Multivibrator)
Non-Integer Programmable Pulse Divider

DELAYED PULSE GENERATOR



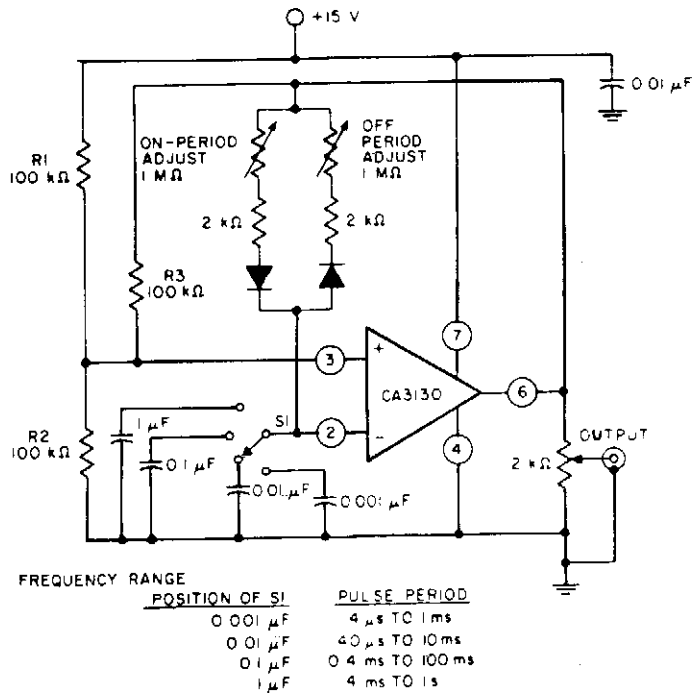
ELECTRONIC ENGINEERING

Fig. 77-1

Circuit Notes

The circuit offers independent control of initial delay and pulse rate. IC1c is connected as a pulse generator whose operation is inhibited by the normally low O/P of the IC1a. When the circuit input goes low i.e., by pressing PB1, IC1b O/P goes high and the circuit O/P goes low thus replicating the input. When the input is kept low capacitor C1 charges via R2 to a point where IC1a O/P goes low. This allows the pulse generator IC1c to start and "rapid fire" pulses appear at the circuit O/P. When the circuit input returns to the high state C1 is rapidly discharged via D1 and R1. The value of R2 and C1 control the initial delay while R3 and C2 control the pulse rate. The values given will give a delay of around 0.5 seconds and a pulse rate of 200/300 Hz depending on supply voltage. PB1 may be replaced by an open collector TTL gate or a common emitter transistor stage if required.

PULSE GENERATOR (ASTABLE MULTIVIBRATOR)



RCA

Fig. 77-2

Circuit Notes

Resistors R1 and R2 bias the CA3130 to the mid-point of the supply-voltage, and R3 is the feedback resistor. The pulse repetition rate is selected by positioning S1 to the desired position and the rate remains essentially constant when the resistors which determine on-period and off-period are adjusted.

NON-INTEGGER PROGRAMMABLE PULSE DIVIDER

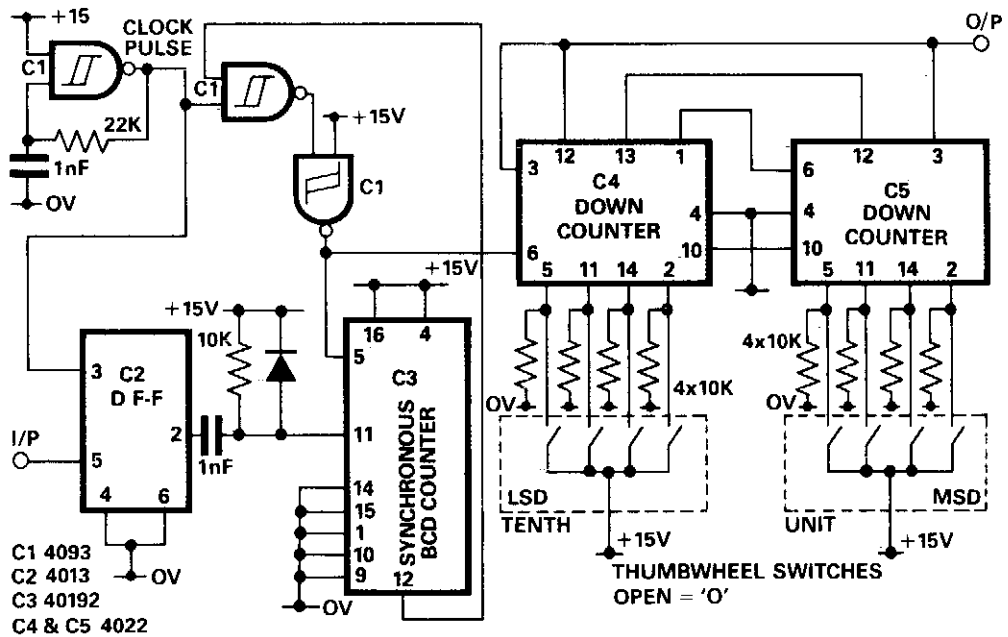


Fig. 77-3

ELECTRONIC ENGINEERING

Circuit Notes

In applications where the period of the input pulses is uneven and the divider is required to cover a wide range of frequencies, the non-integer programmable pulse divider shown can be used. The purpose of the D-type flip-flop (IC2) is to synchronize the input signal with the clock pulse. When the clock pulse changes from low to high and the input is high, IC2 output goes high. Subsequently, IC3 resets to zero and starts counting up. The number of pulses at the output of IC3 is ten times the input pulse. IC4 and IC5 are cascaded to form a two decade programmable down counter.

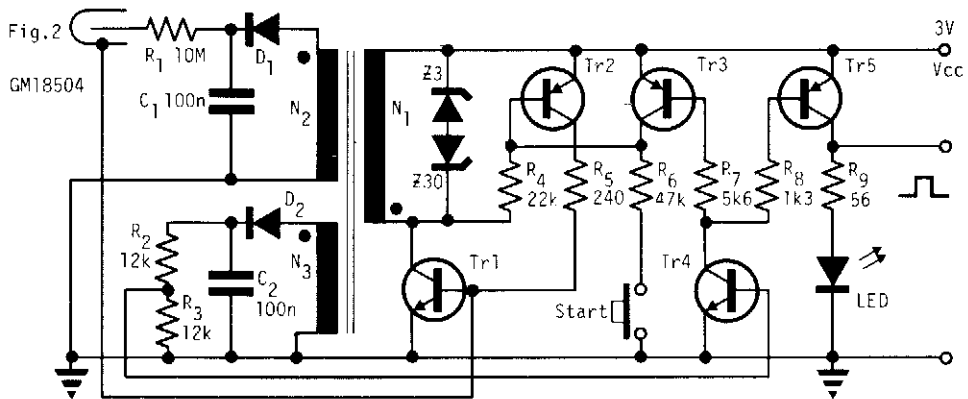
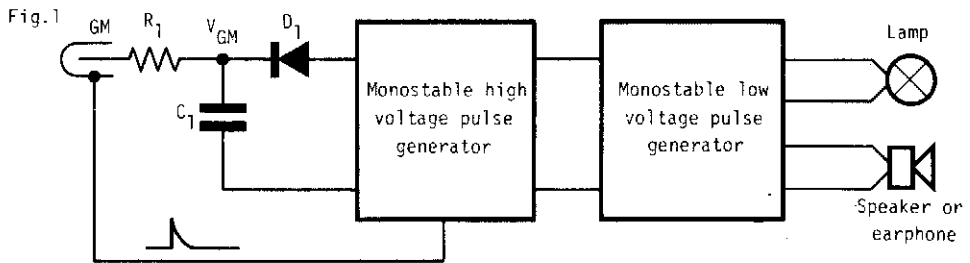
78

Radiation Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Micropower Radioactive Radiation Detector
Pocket-Sized Geiger Counter
Photomultiplier Output-Gating Circuit

MICROPOWER RADIOACTIVE RADIATION DETECTOR



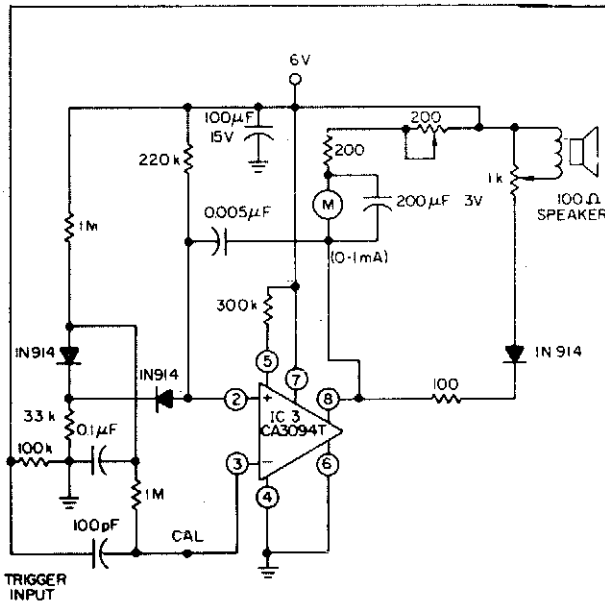
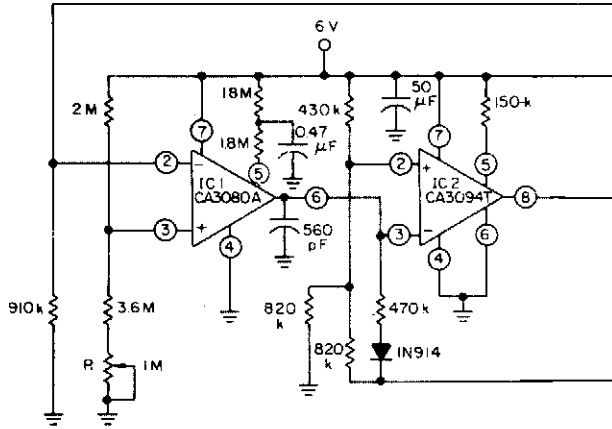
ELECTRONIC ENGINEERING

Fig. 78-1

Circuit Notes

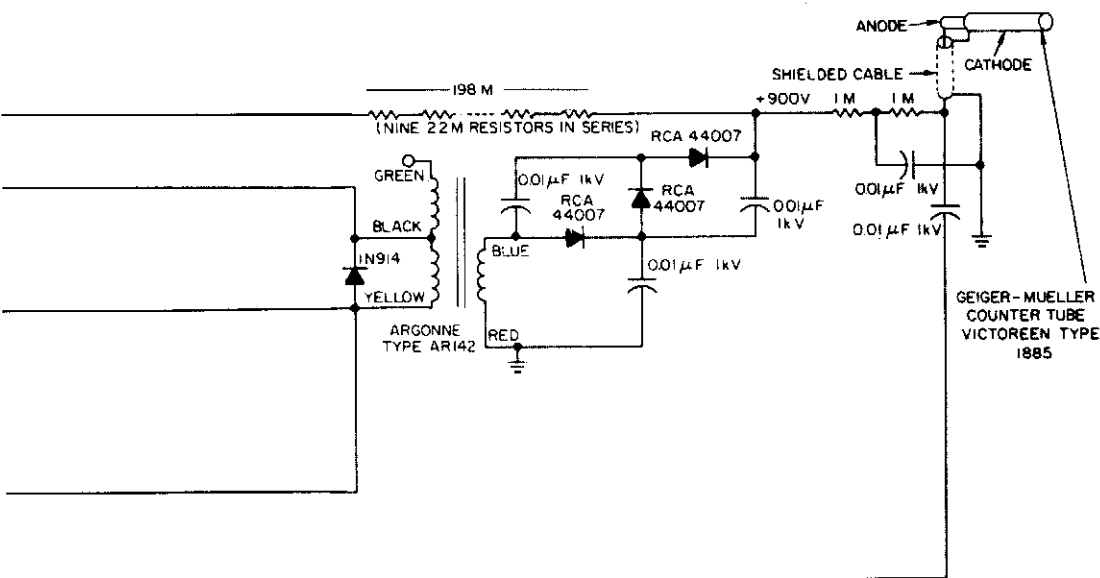
In the absence of radiation, no current is drawn. At normal background radiation levels the power consumption is extremely low. The instrument may be left on for several months without changing batteries. In this way the detector is always ready to indicate an increase in radiation. An LED is used as an indicator lamp. With background radiation it draws less than $50 \mu\text{A}$. A ferrite pot core is used for the transformer with $N_1 = 30$, $N_2 = 550$, and $N_3 = 7$. Using two 1.5V batteries with 0.5 Ah total capacity, the detector can work at background radiation levels for $0.5 \text{ Ah} \div 50 \mu\text{A} = 10,000$ hours, which is more than a year.

POCKET-SIZED GEIGER COUNTER



ELECTRONIC DESIGN

Fig. 78-2



Circuit Notes

A single 6.75 V mercury battery powers the counter, which features a 1 mA count-rate meter as well as an aural output. A regulated 900 V supply provides stable operation of the counter tube. A multivibrator, built around a differential power amplifier IC2, drives the step-up transformer. Comparator IC1 varies the multivibrator duty cycle to provide a constant 900 V. The entire regulated supply draws less than 2 mA. A one-shot multivibrator, built with IC3, provides output pulses that have constant width and amplitude. Thus the average current through the meter is directly proportional to the pulse-rate output from the counter tube. And the constant-width pulses also drive the speaker. Full-scale meter deflection (1 mA) represents 5000 counts/min, or 83.3 pulses/s. A convenient calibration checkpoint can be provided on the meter scale for 3600 ppm (60 pulses/s.)

PHOTOMULTIPLIER OUTPUT-GATING CIRCUIT

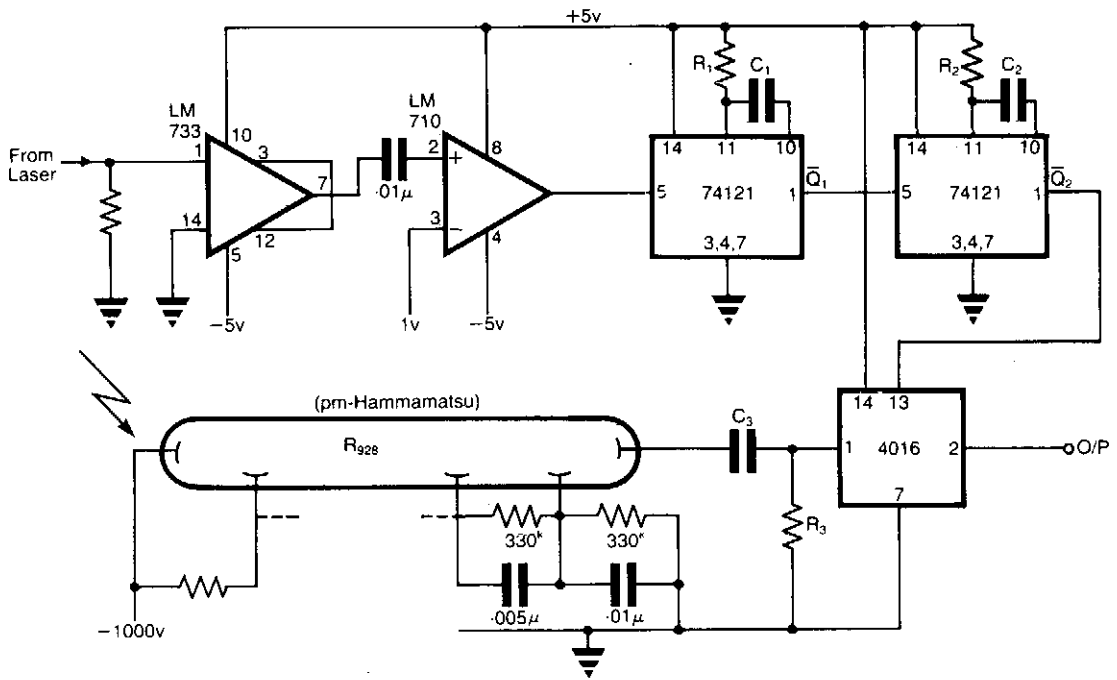


Fig. 78-3

ELECTRONIC ENGINEERING

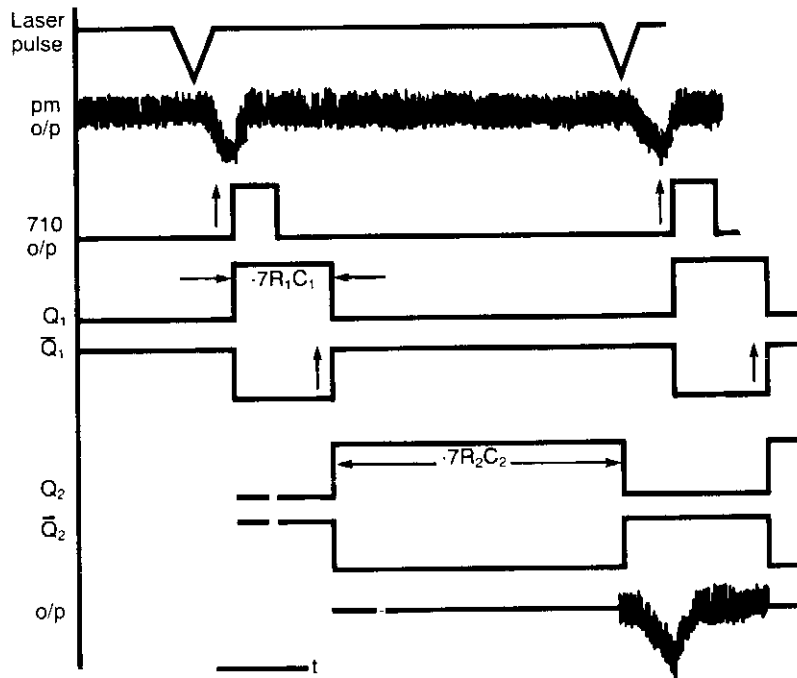


Fig 2

Circuit Notes

The application involves observing the light pulse emerging from a thick specimen after transillumination by a laser pulse. Pulses derived from the laser source are amplified using a Video Amplifier LM733. The reference level is set to 1 V in the comparator LM 710, to provide the necessary trigger pulses for the monostable multivibrator 74121. The laser pulses have a repetition frequency of 500 Hz and suitable values are as below:

$$R1 = 33 \text{ k ohm}, C1 = 22 \text{ pF}$$

$$R2 = 33 \text{ k ohm}, C2 = 68 \text{ nF}$$

The pulse width for each monostable is approximately given by $tw = 0.7 RC$. R3 and C3 is a high pass filter. The method therefore permits the use of low cost components having moderate response times for extracting the pulse of interest.

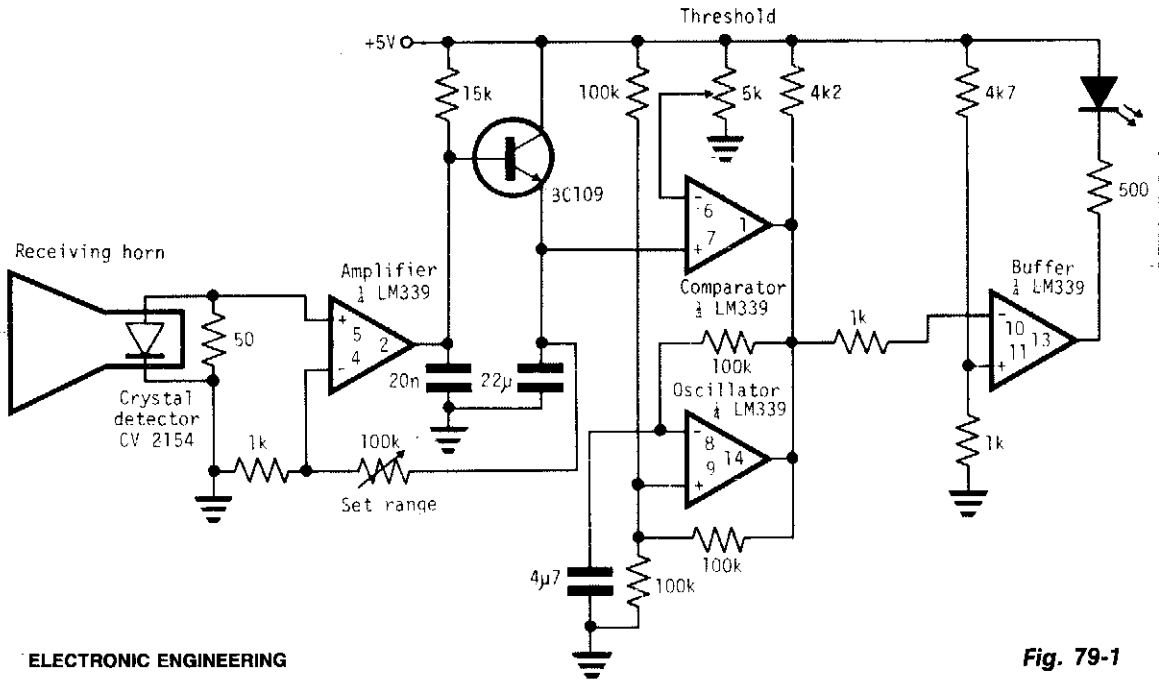
79

Radar Detectors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

One-Chip Radar Detection Circuit
Radar Signal Detector

ONE-CHIP RADAR DETECTION CIRCUIT



ELECTRONIC ENGINEERING

Fig. 79-1

Circuit Notes

A simple X-band radar detector is capable of indicating changes in rf radiation strength at levels down to 2 mW/cm^2 . Radiation falling on the detector diode, produces a voltage at the input of an amplifier whose gain may be adjusted to vary the range at which the warning is given. The amplifier output drives a voltage comparator with a variable threshold set to a level that avoids false alarms. The comparator output is connected in the wired-OR configuration with the open collector output of an oscillator running at a frequency of 2 Hz. In the absence of a signal, the comparator output level is low, inhibiting the oscillator output stage and holding the buffer so the lamp is off. When a signal appears, the comparator output goes high, removing the lock from the oscillator which free-runs, switching the lamp on and off at 2 Hz.

RADAR SIGNAL DETECTOR

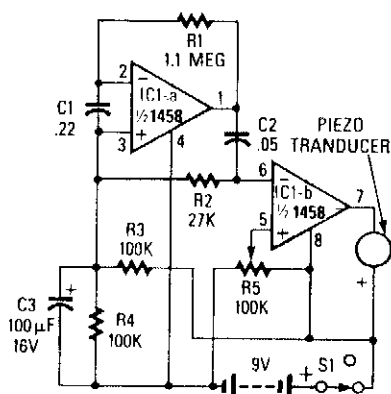


FIG. 1—THE ECONOMY RADAR DETECTOR needs only one IC and a few discrete components.

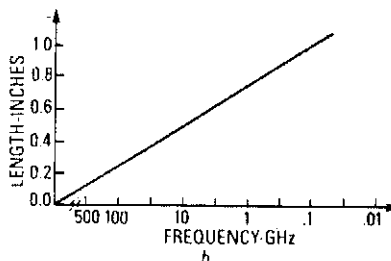
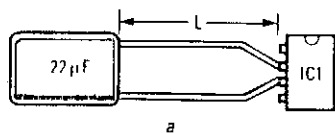


FIG. 3—VARY THE LEAD LENGTHS OF C1 to tune the input circuit.

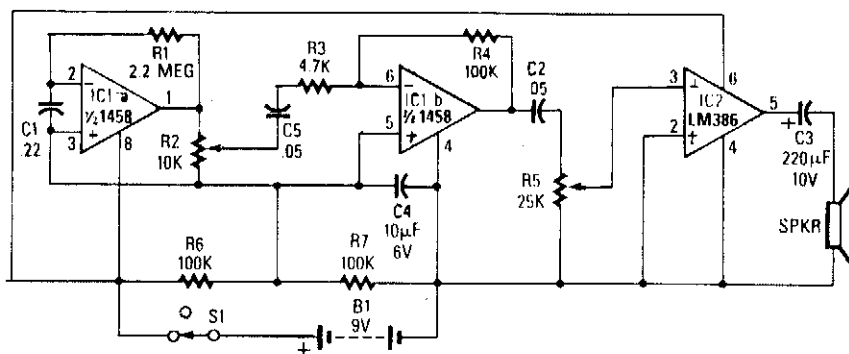


FIG. 2—DELUXE RADAR DETECTOR adds a buffer amplifier and an audio power amp to drive a speaker.

RADIO-ELECTRONICS

Fig. 79-2

Circuit Notes

The circuit can be tuned to respond to signals between 50 MHz and 500 GHz. The economy model is shown in Fig. 1, and the deluxe model is shown in Fig. 2. The first op amp in each circuit functions as a current-to-voltage converter. In the economy model IC1b buffers the output to drive the piezo buzzer. The deluxe model functions in a similar manner except that IC1b is configured as a $\times 20$ buffer amplifier to drive the LM386. In both circuits C1 functions as a "transmission line" that intercepts the incident radar signal. The response may be optimized by trimming C1's lead length for the desired frequency. Typically the capacitor's leads should be 0.5-0.6 inches long.

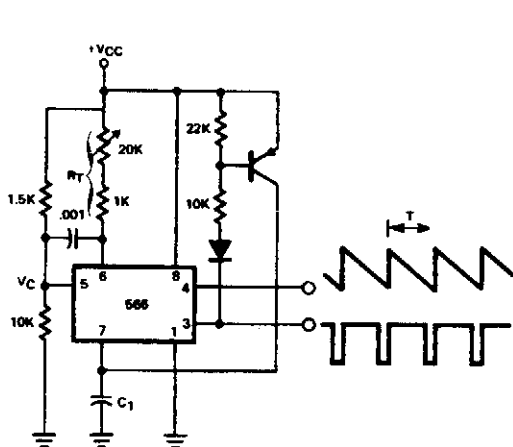
80

Ramp Generators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

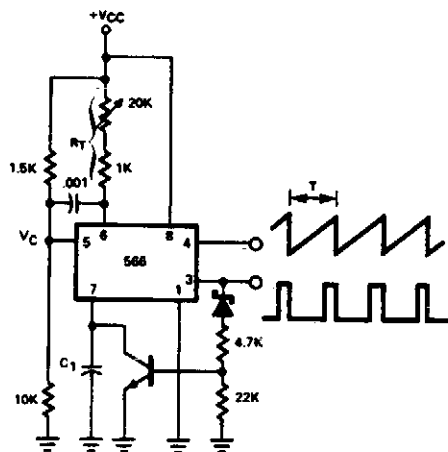
Ramp Generator
Voltage Controlled Ramp Generator

RAMP GENERATOR



a. Negative Ramp

TC078608



b. Positive Ramp

YC078708

SIGNETICS

Fig. 80-1

Circuit Notes

The 566 can be wired as a positive or negative ramp generator. In the positive ramp generator, the external transistor driven by the Pin 3 output rapidly discharges C1 at the end of the charging period so that charging can resume instantaneously. The pnp transistor of the negative ramp generator likewise rapidly charges the timing capacitor C1 at the end of the discharge period. Because the circuits are reset so quickly, the temperature stability of the ramp generator is excellent. The period

$$T \text{ is } \frac{1}{2f_o}$$

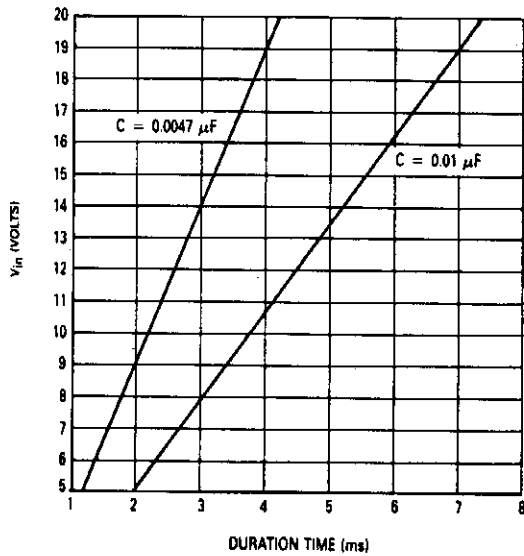
where f_o is the 566 free-running frequency in normal operation. Therefore,

$$T = \frac{1}{2f_o} = \frac{R_T C_1 V_{CC}}{5(V_{CC} - V_C)}$$

(1)

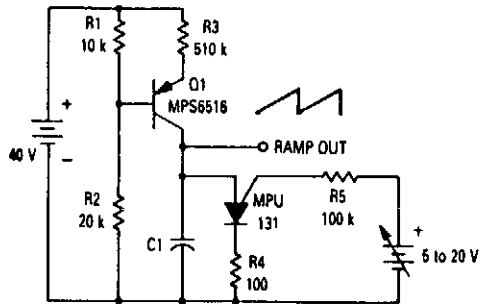
where V_C is the bias voltage at Pin 5 and R_T is the total resistance between Pin 6 and V_{CC} . Note that a short pulse is available at Pin 3. (Placing collector resistance in series with the external transistor collector will lengthen the pulse.)

VOLTAGE CONTROLLED RAMP GENERATOR



Voltage versus Ramp Duration Time of VCRG

MOTOROLA



Voltage Controlled Ramp Generator (VCRG)

Fig. 80-2

Circuit Notes

The current source formed by Q1 in conjunction with capacitor C1 set the duration time of the ramp. As the positive dc voltage at the gate is changed, the peak point firing voltage of the PUT is changed, which changes the duration time, i.e., increasing the supply voltage increases the peak point firing voltage causing the duration time to increase.

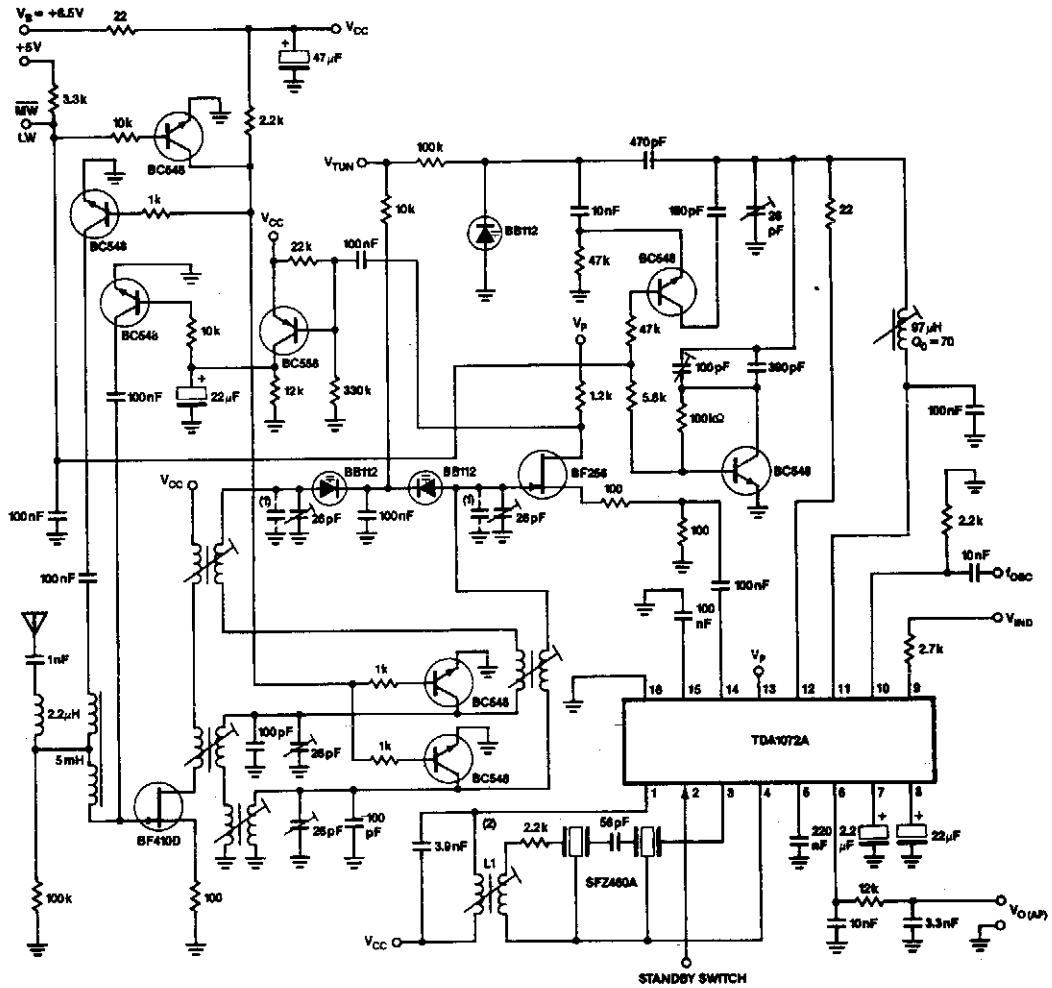
81

Receivers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Car Radio with Capacitive Diode Tuning and
Electronic MW/LW Switching
Receiver Monitor
PLL/BC Receiver

CAR RADIO WITH CAPACITIVE DIODE TUNING AND ELECTRONIC MW/LW SWITCHING



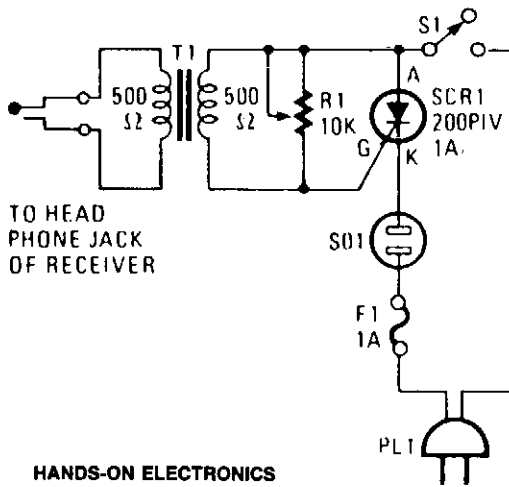
NOTES:

1. Values of capacitors depend on the selected group of capacitive diodes BB112.
2. For IF filter and coil data refer to Block Diagram.
3. The circuit includes pre-stage AGC optimized for good large-signal handling.

SIGNETICS

Fig. 81-1

RECEIVER MONITOR



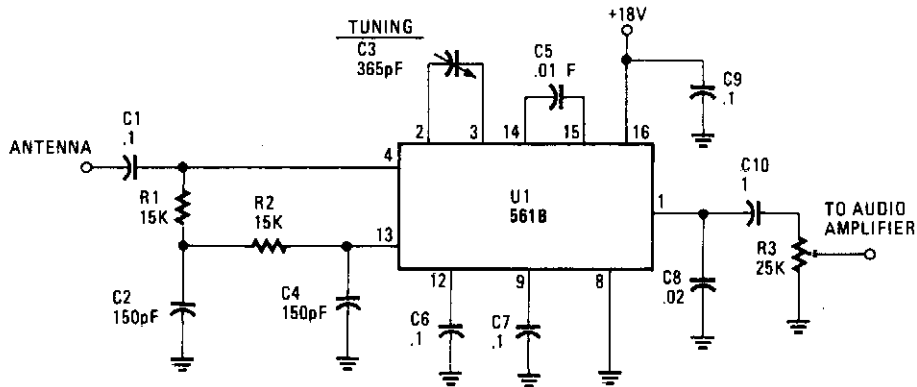
HANDS-ON ELECTRONICS

Fig. 81-2

Circuit Notes

The alarm plugs into the earphone jack on a receiver. Then when a signal (normally fed to the headphones) is detected and applied to the gate of SCR1, it conducts, sounding whatever alarm is connected to SO1. The signaling device can be an audible alarm or a lamp. Variable resistor R1 functions as a sensitivity control so that background noises won't trigger the alarm.

PLL/BC RECEIVER



HANDS-ON ELECTRONICS

Fig. 81-3

Circuit Notes

This simple AM circuit uses a 561B. There's no inductance/capacitance tuning circuit. The 365 pF capacitor connected between pins 2 and 3 does all the tuning. The circuit needs a good outside antenna and a solid ground. And if you want to further improve operation, stick a broadband amplifier in front of the receiver. Just make sure the input voltage does not climb over 0.5 volt rms.

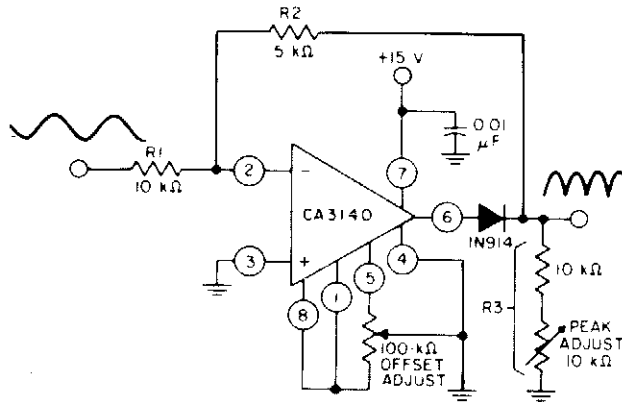
82

Rectifier Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Absolute-Value, "Ideal" Full-Wave Rectifier
Half-Wave Rectifier

ABSOLUTE-VALUE, "IDEAL" FULL-WAVE RECTIFIER



$$\text{GAIN} = \frac{R_2}{R_1} = X = \frac{R_3}{R_1 + R_2 + R_3}$$

$$R_3 = R_1 \left(\frac{X + X^2}{1 - X} \right)$$

$$\text{FOR } X = 0.5 \quad \frac{5 \text{ k}\Omega}{10 \text{ k}\Omega} = \frac{R_3}{R_1}$$

$$R_3 = 10 \text{ k}\Omega \left(\frac{0.75}{0.5} \right) = 15 \text{ k}\Omega$$

20 V p-p INPUT BW(−3dB) = 290 kHz, DC OUTPUT (AVG) = 3.2 V

GENERAL ELECTRIC / RCA

Fig. 82-1

Circuit Notes

The circuit uses a CA3140 BiMOS op amp in an inverting gain configuration. When equality of two equations shown in satisfied, full-wave output of circuit is symmetrical.

HALF-WAVE RECTIFIER

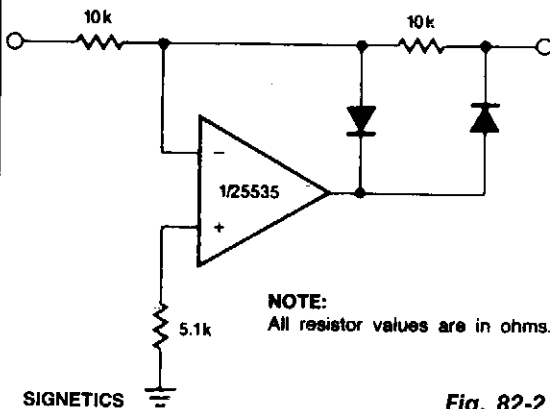


Fig. 82-2

Circuit Notes

The 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.

83

Relay Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Relay Driver Provides Delay and Controls Closure
Time
TRIAC Relay-Contact Protection
TR Circuit

RELAY DRIVER PROVIDES DELAY AND CONTROLS CLOSURE TIME

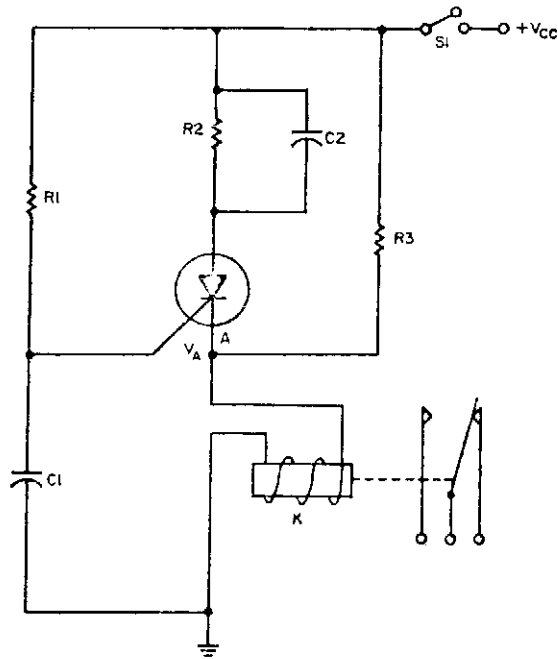


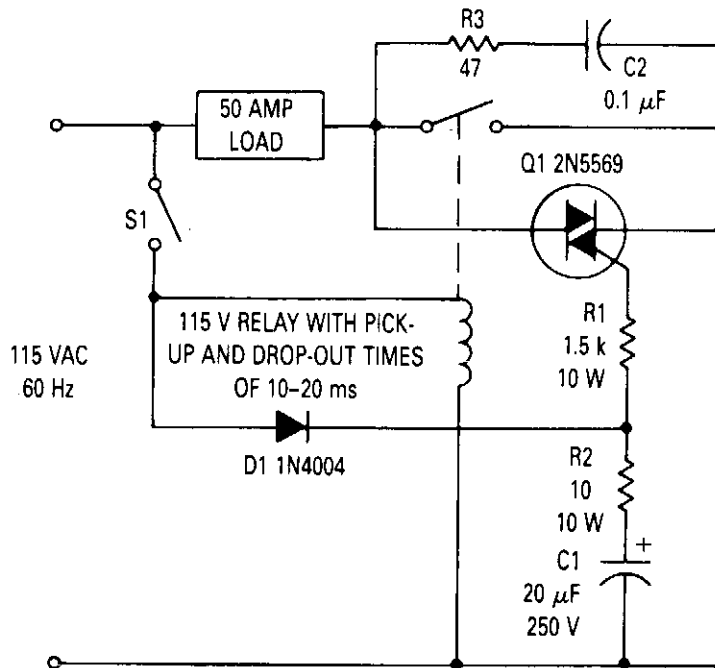
Fig. 83-1

ELECTRONIC DESIGN

Circuit Notes

The relay operates a certain time, t_d , after power is applied to it, and then it operates for a length of time, t_c . The SCR fires when the voltage on C_1 reaches V_A . This operates the relay, which stays activated until the current charging C_2 drops below the dropout current. To keep the relay in its activated position indefinitely ($t_c = \infty$), eliminate C_2 and choose R_2 just large enough to keep the relay coil current within its related limits. Typical component values for $t_d = 30$ seconds and $t_c = 2$ seconds are: $R_1 = 1.5$ megohms, $R_2 = 10$ k ohms, $R_3 = 3$ k ohms, $C_1 = 47 \mu\text{F}$, and $C_2 = 100 \mu\text{F}$. The SCR is a 2N1877 and the relay is a Potter Brumfield PW-5374. A value of 12 Vdc is assumed for V_{CC} .

TRIAC RELAY-CONTACT PROTECTION



MOTOROLA

Fig. 83-2

Circuit Notes

This circuit can be used to prevent relay contact arcing for loads up to 50 amperes. There is some delay between the time a relay coil is energized and the time the contacts close. There is also a delay between the time the coil is de-energized and the time the contacts open. For the relay used in this circuit both times are about 15 ms. The TRIAC across the relay contacts will turn on as soon as sufficient gate current is present to fire it. This occurs after switch S1 is closed but before the relay contacts close. When the contacts close, the load current passes through them, rather than through the TRIAC, even though the TRIAC is receiving gate current. If S1 should be closed during the negative half cycle of the ac line, the TRIAC will not turn on immediately but will wait until the voltage begins to go positive, at which time diode D1 conducts providing gate current through R1. The maximum time that could elapse before the TRIAC turns on is $8\frac{1}{2}$ ms for the 60 Hz supply. This is adequate to ensure that the TRIAC will be on before the relay contact closes.

TR CIRCUIT

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

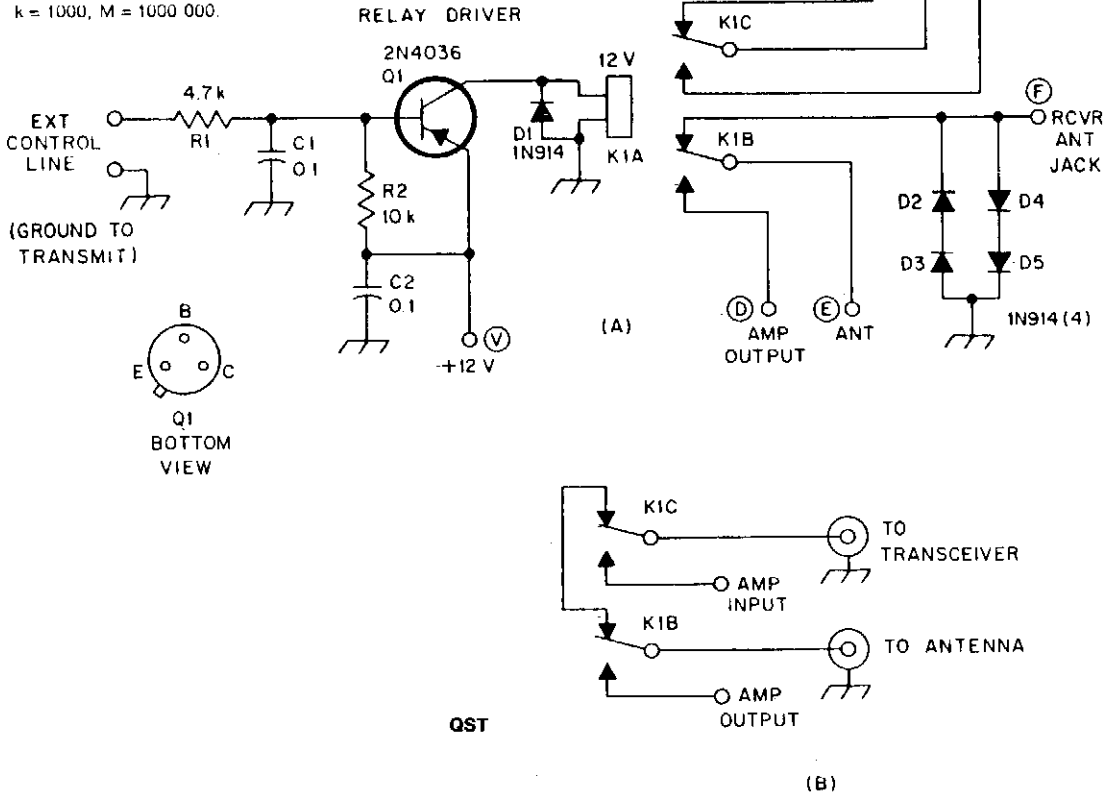


Fig. 83-3

Circuit Notes

C1 and C2 are disc ceramic. R1 and R2 are ¼ or ½ W carbon composition resistors. K1 is a 12 V DPDT DIP relay. Illustration A shows how to connect the relay contacts for use with a separate transmitter-receiver combination. The circuit at B is for amplifier use with a transceiver.

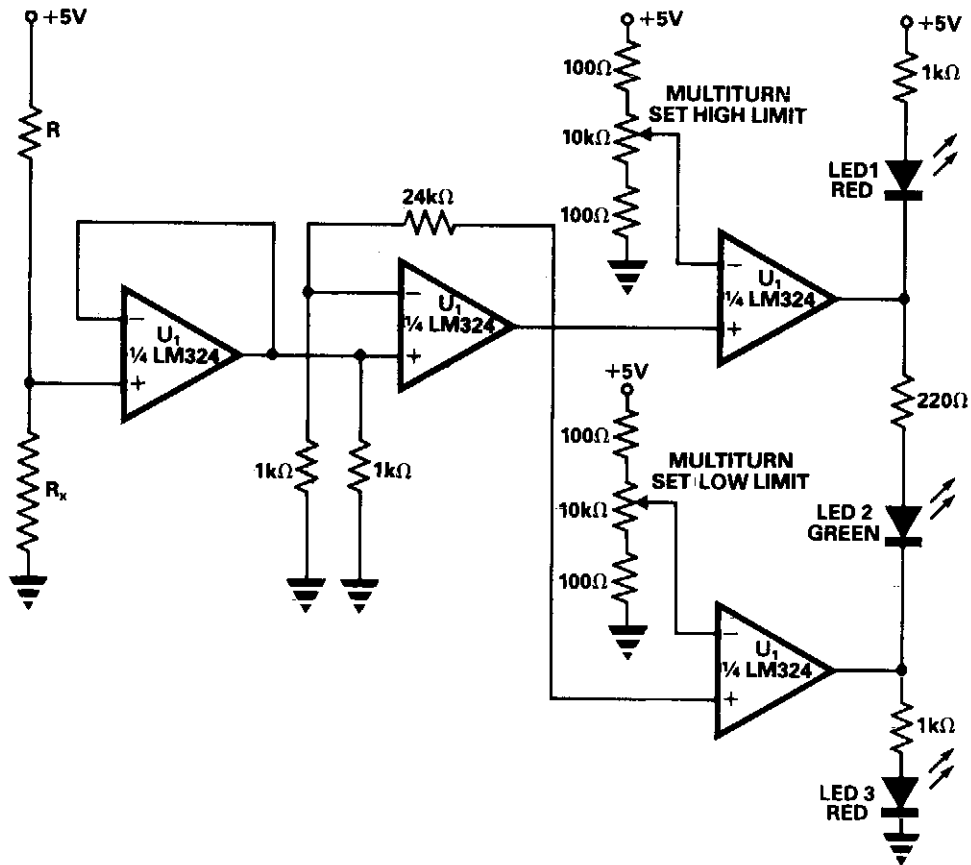
84

Resistance/Continuity Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Single Chip Checks Resistance
Simple Continuity Tester for PCB's
Simple Continuity Tester
Adjustable, Audible Continuity Tester for Delicate
Circuits

SINGLE CHIP CHECKS RESISTANCE



ELECTRONIC ENGINEERING

Fig. 84-1

Circuit Notes

A simple tester can be used for routine checks for resistance on production lines of relays, coils, or similar components where frequent changes in resistance to be tested are not required. The tester is built around a single quad op amp chip, the LM324. R , which is chosen to be around 80 times the resistance to be checked, and the 5 V supply form the current source. The first op amp buffers the voltage generated across the resistance under test, R_x . The second op amp amplifies this voltage. The third and fourth op amps compare the amplified voltage with high and low limits. The high and low limits are set on multiturn presets with high and low limit resistors connected in place of R_x . LED 1 (red) lights when the resistance is high. LED 2 (green) shows that the resistance is within limits. LED 3 (red) indicates that the resistance is low.

SIMPLE CONTINUITY TESTER FOR PCBs

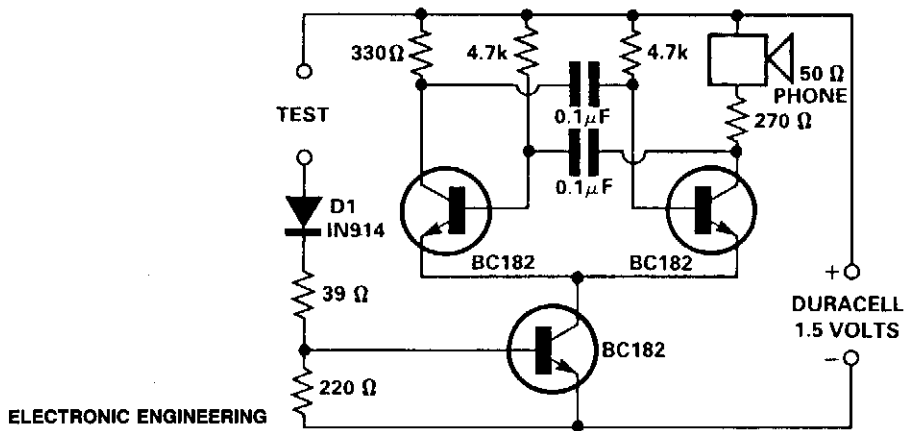


Fig. 84-2

Circuit Notes

This tester is for tracing wiring on Printed Circuit Boards. Resistors below 50 ohms act as a short circuit; above 100 ohms as an open circuit. The circuit is a simple multivibrator switched on by transistor T3. The components in the base of T3 are D1, R1, R2, and the test resistance. With a 1.5 volt supply, there is insufficient voltage to turn on a semiconductor connected to the test terminals.

SIMPLE CONTINUITY TESTER

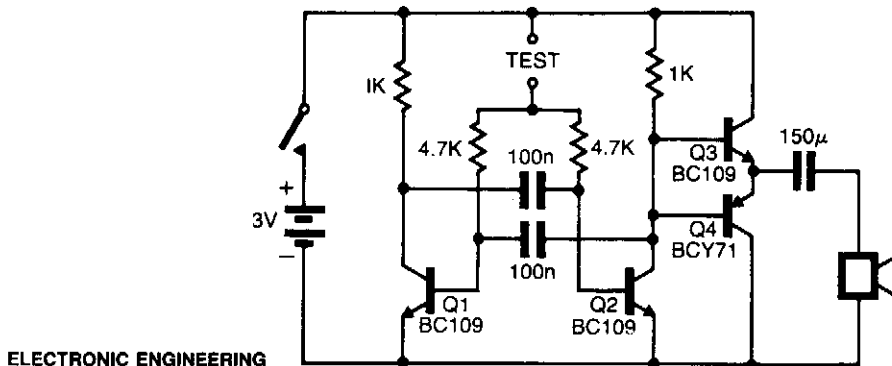


Fig. 84-3

Circuit Notes

The pitch of the tone is dependent upon the resistance under test. The tester will respond to resistance of hundreds of kilohms, yet it is possible to distinguish differences of just a few tens of ohms in low-resistance circuits. Q1 and Q2 form a multivibrator, the frequency of which is influenced by the resistance between the test points. The output stage Q3 and Q4 will drive a small loudspeaker or a telephone earpiece.

SIMPLE CONTINUITY TESTER FOR PCBs

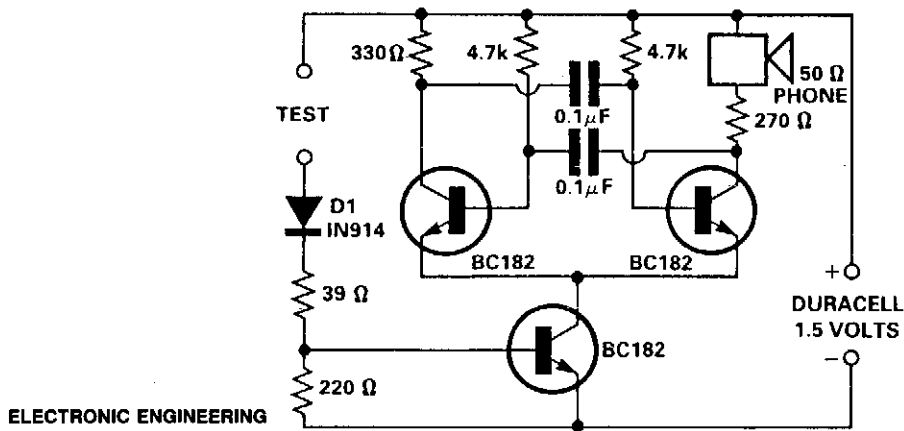


Fig. 84-2

Circuit Notes

This tester is for tracing wiring on Printed Circuit Boards. Resistors below 50 ohms act as a short circuit; above 100 ohms as an open circuit. The circuit is a simple multivibrator switched on by transistor T3. The components in the base of T3 are D1, R1, R2, and the test resistance. With a 1.5 volt supply, there is insufficient voltage to turn on a semiconductor connected to the test terminals.

SIMPLE CONTINUITY TESTER

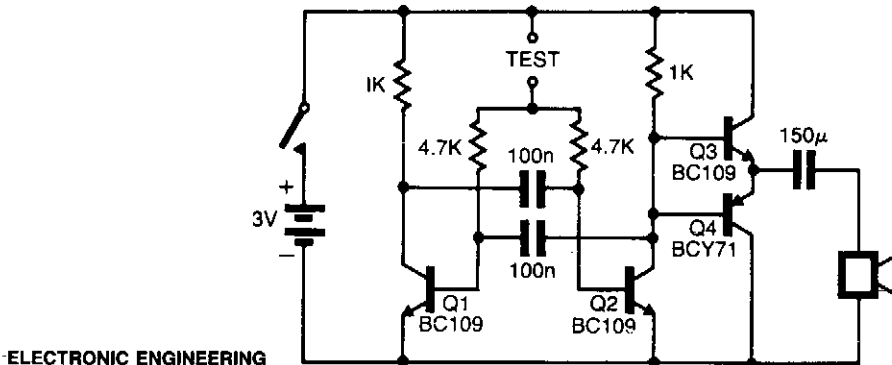
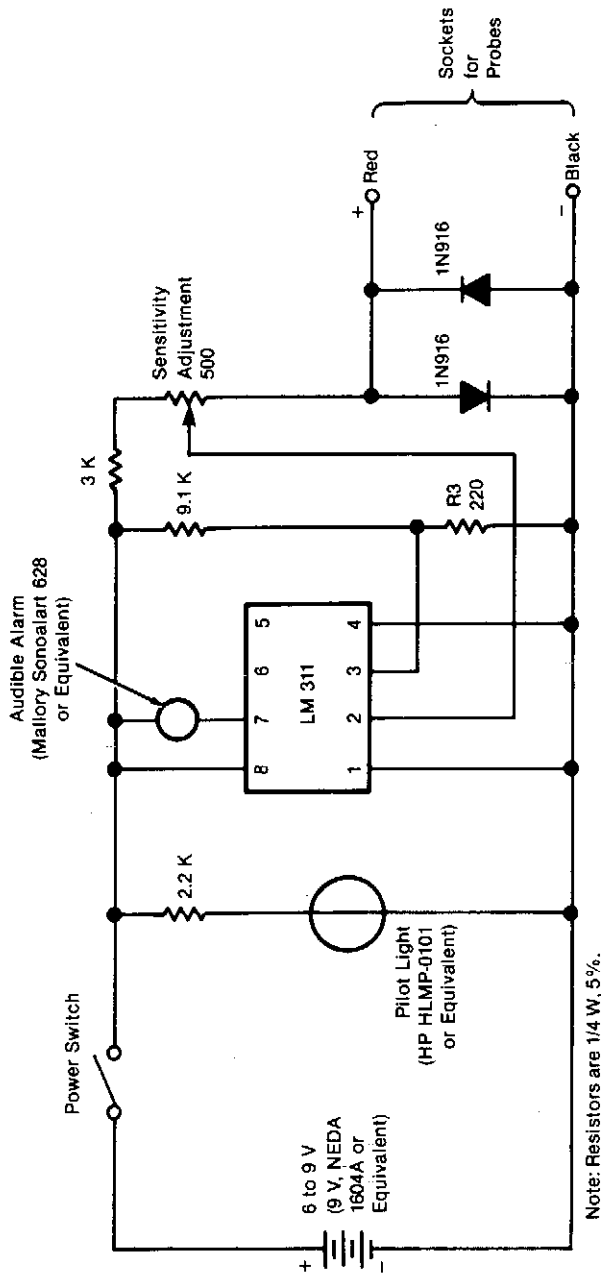


Fig. 84-3

Circuit Notes

The pitch of the tone is dependent upon the resistance under test. The tester will respond to resistance of hundreds of kilohms, yet it is possible to distinguish differences of just a few tens of ohms in low-resistance circuits. Q1 and Q2 form a multivibrator, the frequency of which is influenced by the resistance between the test points. The output stage Q3 and Q4 will drive a small loudspeaker or a telephone earpiece.

ADJUSTABLE, AUDIBLE CONTINUITY TESTER FOR DELICATE CIRCUITS



NASA

Fig. 84-4

Circuit Notes

The tester gives an audible indication, making it unnecessary for the user to look directly at the instrument to observe a meter reading. In addition, the current and voltage of the tester are strictly limited. It can apply no more than 0.6 volts dc and no more than 3 mA through the probes. It can therefore be used safely on circuit boards in which semiconductor components have been installed, and on complementary metal oxide/semiconductor integrated circuits, which are highly susceptible to damage during testing. The tester can be adjusted to indicate continuity below any resistance value up to 35 ohms. For example, if the user sets the tester to 30 ohms, the unit will emit an audible tone whenever the resistance between the probes is 30 ohms or less; if, for example, the resistance is 30.2 ohms, the unit will remain silent.

85

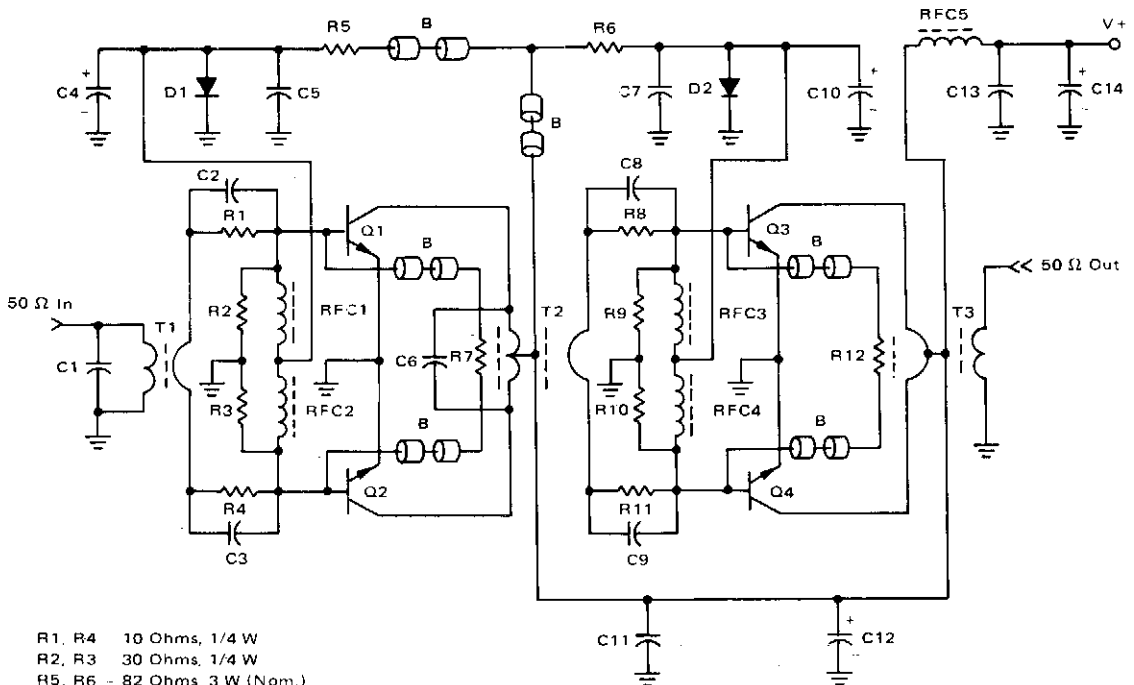
RF Amplifiers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low-Distortion 1.6 to 30 MHz SSB Driver
1 Watt, 2.3 GHz Amplifier
5-W RF Power Amplifier
6-Meter Preamplifier Provides 20 dB Gain and Low
NF

125 Watt 150 MHz Amplifier
6-Meter Kilowatt Amplifier
Broadcast-Band RF Amplifier
Improved RF Isolation Amplifier
A 10 Watt 225-400 MHz Amplifier

LOW-DISTORTION 1.6 TO 30 MHz SSB DRIVER



- R1, R4 - 10 Ohms, 1/4 W
 R2, R3 - 30 Ohms, 1/4 W
 R5, R6 - 82 Ohms, 3 W (Nom.)
 R7 - 47 Ohms, 1/4 W
 R8, R11 - 6.8 Ohms, 1/4 W
 R9, R10 - 15 Ohms, 1/4 W
 R12 - 130 Ohms, 1/4 W
 C1 - 39 pF Dipped Mica
 C2, C3 - 680 pF Ceramic Disc
 C4, C10 - 220 μ F, 4 V, Tantalum
 C5, C7, C11, C13 - 0.1 μ F Ceramic Disc
 C6 - 56 pF Dipped Mica
 C8, C9 - 1200 pF Ceramic Disc
 C12, C14 - 10 μ F, 25 V Tantalum

- RFC5 - Ferroxcube VK200 19/4B
 RFC1, 2, 3, 4 - 10 μ H Molded Choke
 B - Ferrite Beads (Fair-Rite Prod. Corp. #2643000101 or Ferroxcube #56 590 65/3B)
 D1, D2 - 1N4001
 Q1, Q2 - MRF476
 Q3, Q4 - MRF475
 T1, T2 - 4:1 Impedance Transformer
 T3 - 1:4 Impedance Transformer

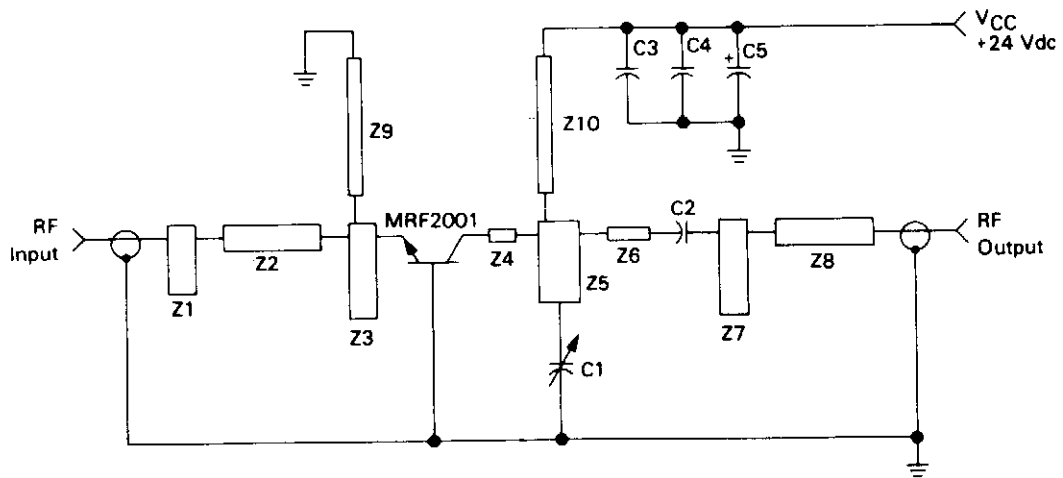
MOTOROLA

Fig. 85-1

Circuit Notes

The amplifier provides a total power gain of about 25 dB, and the construction technique allows the use of inexpensive components throughout. The MRF476 is specified as a 3 watt device and the MRF475 has an output power of 12 watts. Both are extremely tolerant to overdrive and load mismatches, even under CW conditions. Typical IMD numbers are better than -35 dB, and the power gains are 18 dB and 12 dB, respectively, at 30 MHz. The bias currents of each stage are individually adjustable with R5 and R6. Capacitors C4 and C10 function as audio-frequency bypasses to further reduce the source impedance at the frequencies of modulation. Gain leveling across the band is achieved with simple RC networks in series with the bases, in conjunction with negative feedback. The amplitude of the out-of-phase voltages at the bases is inversely proportional to the frequency as a result of the series inductance in the feedback loop and the increasing input impedance of the transistor at low frequencies. Conversely, the negative feedback lowers the effective input impedance presented to the source (not the input impedance of the device itself) and with proper voltage slope would equalize it. With this technique, it is possible to maintain an input VSWR of 1.5:1 or less than 1.6 to 30 MHz.

1 WATT, 2.3 GHz AMPLIFIER



C1 — 0.4-2.5 pF Johanson 7285*

C2, C3 — 68 pF, 50 mil ATC**

C4 — 0.1 μ F, 50 V

C5 — 4.7 μ F, 50 V Tantalum

Z1-Z10 — Microstrip; see Photomaster, Figure 3

Board Material — 0.0625" 3M Glass Teflon,***

$\epsilon_r = 2.5 \pm 0.05$

*Johanson Manufacturing Corp., 400 Rockaway Valley Road, Boonton, NJ 07005

**American Technical Ceramics, One Norden Lane, Huntington Station, NY 11746

***Registered Trademark of Du Pont

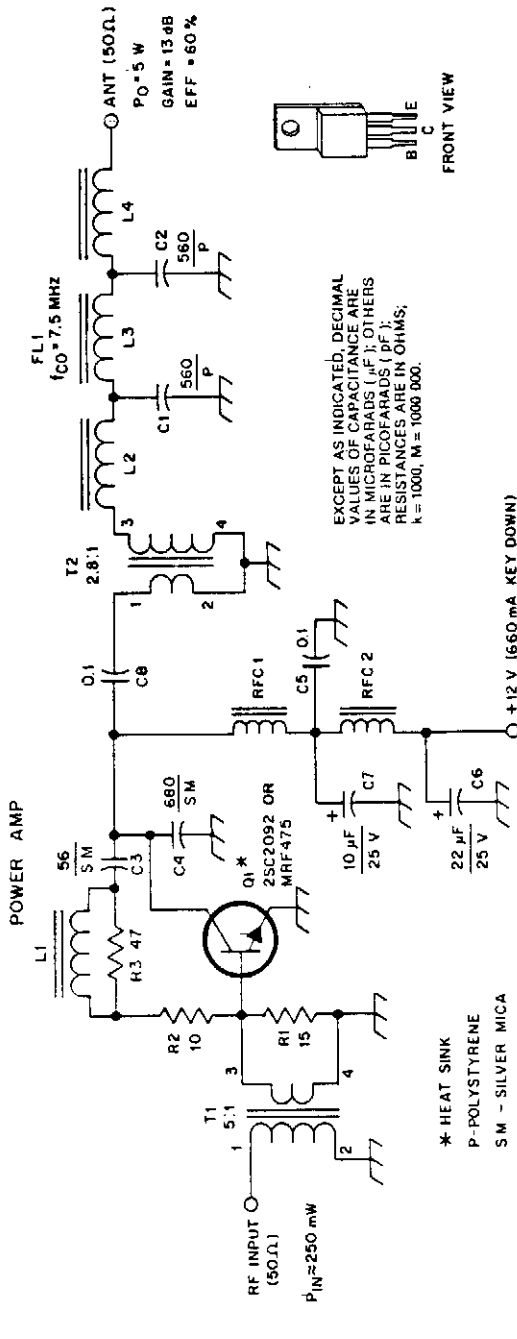
MOTOROLA

Fig. 85-2

Circuit Notes

Simplicity and repeatability are featured in this 1 watt S-band amplifier design. The design uses an MRF2001 transistor as a common base, Class C amplifier. The amplifier delivers 1 watt output with 8 dB minimum gain at 24 V, and is tunable from 2.25 to 2.35 GHz. Applications include microwave communications equipment and other systems requiring medium power, narrow band amplification. The amplifier circuitry consists almost entirely of distributed microstrip elements. A total of six additional components, including the MRF2001, are required to build a working amplifier. The input and output impedances of the transistor are matched to 50 ohms by double section low pass networks. The networks are designed to provide about 3% 1 dB power bandwidth while maintaining a collector efficiency of approximately 30%. There is one tuning adjustment in the amplifier—C1 in the output network. Ceramic chip capacitors, C2 and C3, are used for dc blocking and power supply decoupling. Additional low frequency decoupling is provided by capacitors C4 and C5.

5-W RF POWER AMPLIFIER



L1—0.22-μH inductor. Small RF choke or 8 turns of no. 24 enam wire on an Amidon T-37-6 toroid.
 L2, L4—0.8-μH inductor. 12 turns of no. 24 enam wire on an Amidon T-50-2 toroid.
 L3—1.67-μH inductor. 18 turns of no. 24 enam wire on an Amidon T-50-2 toroid.

RFC1—2.8 μH choke. 24 turns of no. 26 enam wire on an Amidon T-50-2 toroid.
 RFC2—42 μH choke. 10 turns of no. 26 enam wire on an Amidon FT-37-43 toroid.
 T1—Primary has 16 turns of no. 26 enam wire on an Amidon FT-37-43 toroid

Secondary has 6 turns of no. 26 enam wire.
 T2—Primary (Q1 side) has 9 turns of no. 24 enam wire on an Amidon FT-50-43 toroid. Secondary has 15 turns of no. 24 enam wire.

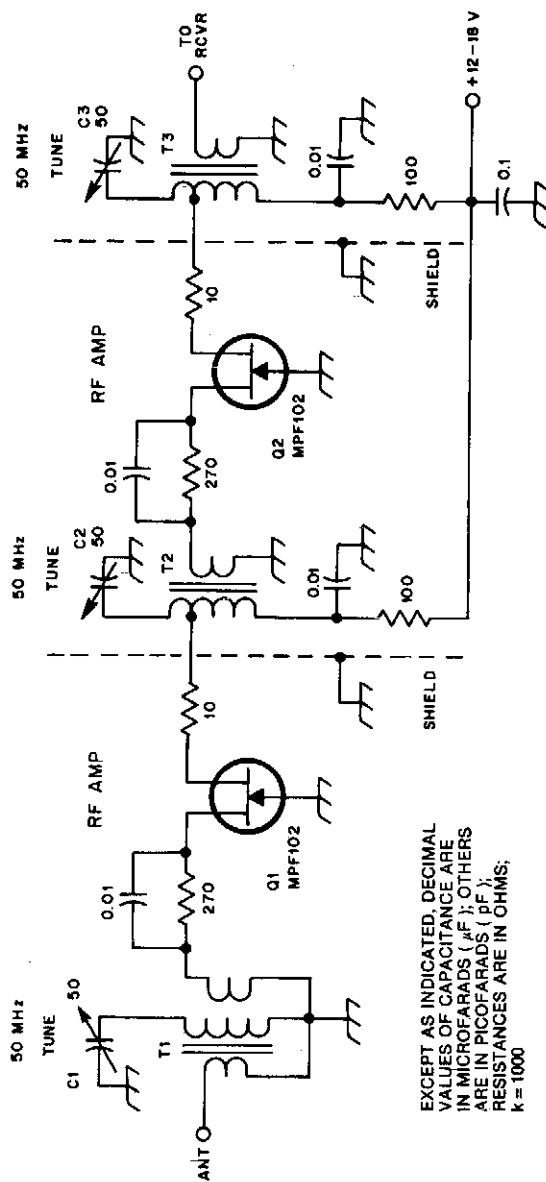
QST

Fig. 85-3

Circuit Notes

Numbered components are so designated for PC-board layout purposes. C5 and C8 are disc ceramic. C6 and C7 are tantalum or electrolytic. R1, R2 and R3 are ½ W carbon composition resistors. Silver-mica capacitors may be substituted for polystyrene (P) types. Impedance transformation ratios are shown above T1 and T2.

6-METER PREAMPLIFIER PROVIDES 20 dB GAIN AND LOW NF



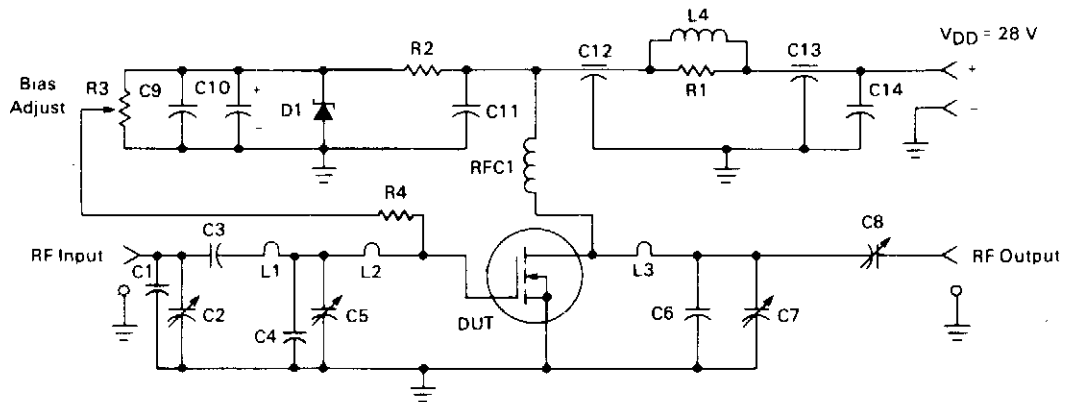
GST

Fig. 85-4

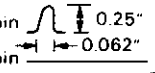
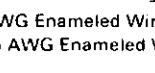
Circuit Notes

C1, C2, and C3 are miniature ceramic or plastic trimmers. T1 (main winding) is 0.34 μH. Use of 11 turns of no. 24 enameled wire on a T37-10 toroid core. The antenna winding has one turn, and Q1 the source winding has three turns. T2 primary consists of 11 turns of no. 24 enameled wire on a T37-10 toroid. Tap Q1 drain is three turns from C2 the end of the winding. The secondary has three turns. T3 is the same as T2, except its secondary has one turn.

125 WATT 150 MHz AMPLIFIER



C1 — 35 pF Unleco
 C2, C5 — Arco 462, 5–80 pF
 C3 — 100 pF Unleco
 C4 — 25 pF Unleco
 C6 — 40 pF Unleco
 C7 — Arco 461, 2.7–30 pF
 C8 — Arco 463, 9–180 pF
 C9, C11, C14 — 0.1 μ F Erie Redcap
 C10 — 50 μ F, 50 V
 C12, C13 — 680 pF Feedthru
 D1 — 1N5925A Motorola Zener

L1 — #16 AWG, 1-1/4 Turns, 0.213" ID
 L2 — #16 AWG, Hairpin 
 L3 — #14 AWG, Hairpin 
 L4 — 10 Turns #16 AWG Enameled Wire on R1
 RFC1 — 18 Turns #16 AWG Enameled Wire, 0.3" ID
 R1 — 10 Ω , 2.0 W
 R2 — 1.8 k Ω , 1/2 W
 R3 — 10 k Ω , 10 Turn Bourns
 R4 — 10 k Ω , 1/4 W

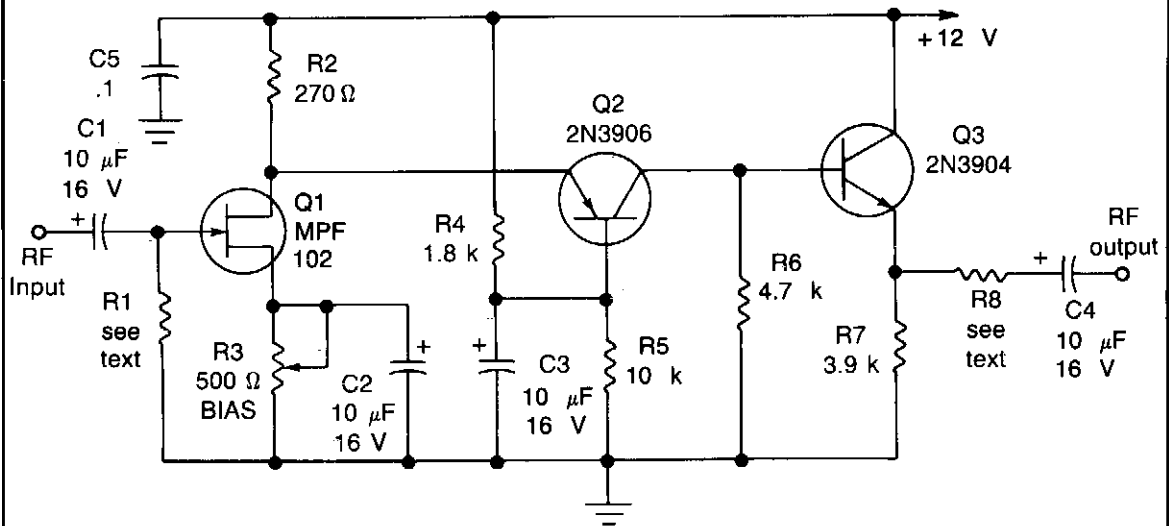
MOTOROLA

Fig. 85-5

Circuit Notes

This amplifier operates from a 28 Vdc supply. It has a typical gain of 12 dB, and can survive operation into a 30:1 VSWR load at any phase angle with no damage. The amplifier has an AGC range in excess of 20 dB. This means that with input power held constant at the level that provides 125 watts output, the output power may be reduced to less than 1.0 watt continuously by driving the dc gate voltage negative from its I_{DQ} value.

BROADCAST-BAND RF AMPLIFIER



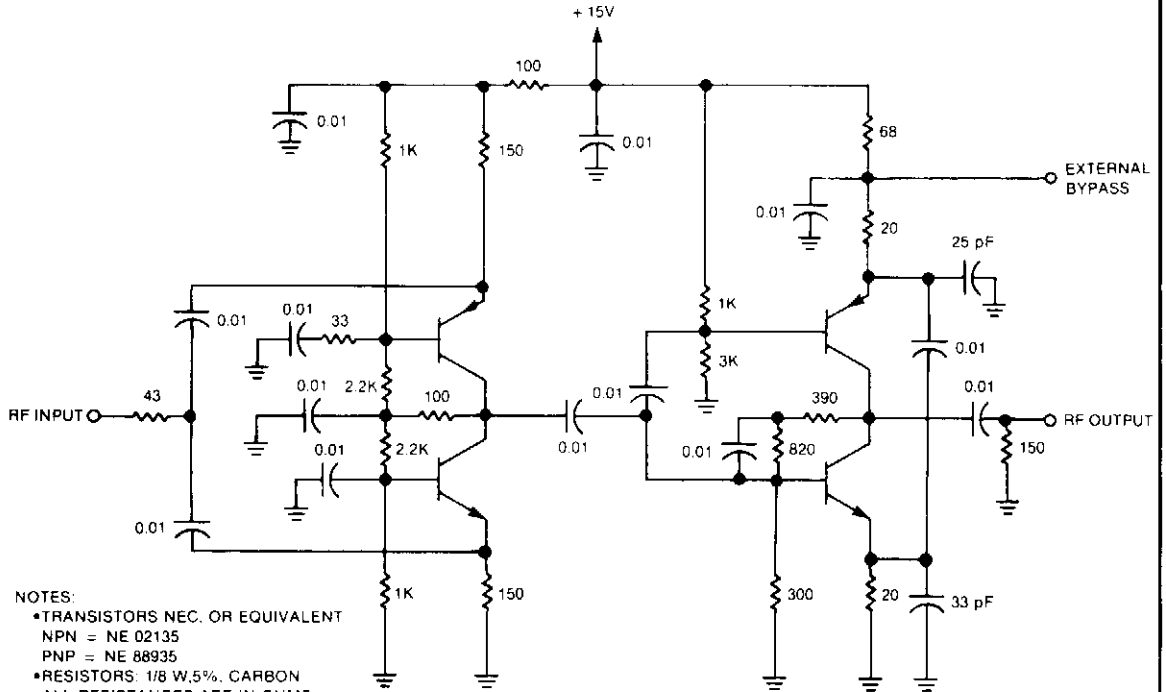
RADIO-ELECTRONICS

Fig. 85-7

Circuit Notes

The circuit has a frequency response ranging from 100 Hz to 3 MHz; gain is about 30 dB. Field-effect transistor Q1 is configured in the common-source self-biased mode; optional resistor R1 sets the input impedance to any desired value. Commonly, it will be 50 ohms. The signal is then direct-coupled to Q2, a common-base circuit that isolates the input and output stages and provides the amplifier's exceptional stability. Q3 functions as an emitter follower, to provide low output impedance (about 50 ohms). For higher output impedance, include resistor R8. It will affect impedance according to this formula: $R8 \sim R_{out} - 50$. Otherwise, connect output capacitor C4 directly to the emitter of Q3.

IMPROVED RF ISOLATION AMPLIFIER



NOTES:

- TRANSISTORS NEC. OR EQUIVALENT
NPN = NE 02135
PNP = NE 88935
- RESISTORS: 1/8 W, 5% CARBON
ALL RESISTANCES ARE IN OHMS
UNLESS OTHERWISE NOTED.
- ALL CAPACITANCES ARE IN MICROFARADS
UNLESS OTHERWISE NOTED.

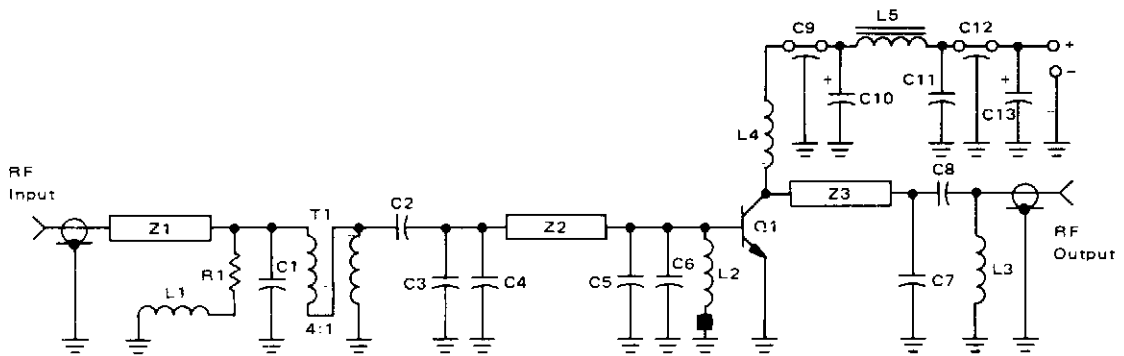
NASA

Fig. 85-8

Circuit Notes

This wideband RF isolation amplifier has a frequency response of 0.5 to 400 MHz \pm 0.5-dB. This two stage amplifier can be used in applications requiring high reverse isolation, such as receiver intermediate-frequency (IF) strips and frequency distribution systems. Both stages use complementary-symmetry transistor arrangements. The input stage is a common-base connection for the complementary circuit. The output stage, which supplies the positive gain, is a common-emitter circuit using emitter degeneration and collector-base feedback for impedance control.

A 10 WATT 225-400 MHz AMPLIFIER



C1 - 8.2 pF Chip*
 C2 - 270 pF Chip*
 C3 - 36 pF Chip*
 C4, C7 - 15 pF Chip*
 C5, C6 - 50 pF Chip*
 C8 - 82 pF Chip*
 C9, C12 - 680 pF Feedthru
 C10, C13 - 1.0 μ F 50 V Tantalum
 C11 - 0.1 μ F Erie Redcap

L1, L3 - 3 Turns #22 AWG 1/8" (3.175 mm) ID
 L2 - 0.15 μ H Molded Choke
 L4 - 0.15 μ H Molded Choke with Ferroxcube Bead
 (Ferroxcube 56 590-65/4B on Ground End
 of Choke)
 L5 - Ferroxcube VK200-19/4B

*100 mil A.C.I. Chip Capacitors

MOTOROLA

R1 - 36 Ω 1/4 Watt

T1 - 25 Ω Subminiature Coax (Type UT34 25) -
 1.75 inches (44.45 mm) long

Z1 - Microstrip Line
 720 mils L X 162 mils W
 18.29 mm L X 4.115 mm W

Z2 - Microstrip Line
 680 mils L X 162 mils W
 17.27 mm L X 4.115 mm W

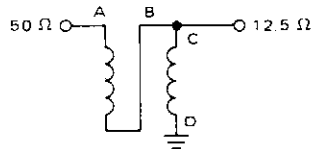
Z3 - Microstrip Line
 2200 mils L X 50 mils W
 55.88 mm L X 1.27 mm W

Board - 0.0625" (1.588 mm) Glass Teflon,
 $\epsilon_r = 2.56$

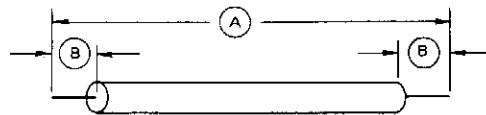
Q1 - MRF331

Fig. 85-9

SCHEMATIC REPRESENTATION



ASSEMBLY AND PICTORIAL



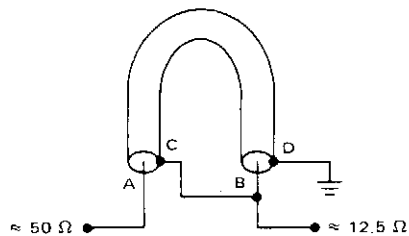
Transformer Dimensions
 (not to scale)

(A) - 1.75 inches (4.445 cm)

(B) - 0.1875 inch (0.476 cm)

A 10 WATT 225-400 MHz AMPLIFIER, Continued.

Transformer Connections



Circuit Notes

This broadband amplifier covers the 225-400 MHz military communications band producing 10 watt RF output power and operating from a 28 volt supply. The amplifier can be used as a driver for higher power devices such as 2N6439 and MRF327. The circuit is designed to be driven by a 50 ohm source and operate into a nominal 50 ohm load. The input matching network consists of a section composed of C3, C4, Z2, C5 and C6. C2 is a dc blocking capacitor, and T1 is a 4:1 impedance ratio coaxial transformer. Z1 is a 50 ohm transmission line. A compensation network consisting of R1, C1, and L1 is used to improve the input VSWR and flatten the gain response of the amplifier. L2 and a small ferrite bead make up the base bias choke. The output network is made up of a microstrip L-section consisting of Z3 and C7, and a high pass section consisting of C8 and L3. C8 also serves as a dc blocking capacitor. Collector decoupling is accomplished through the use of L4, L5, C9, C10, C11, C12, and C13.

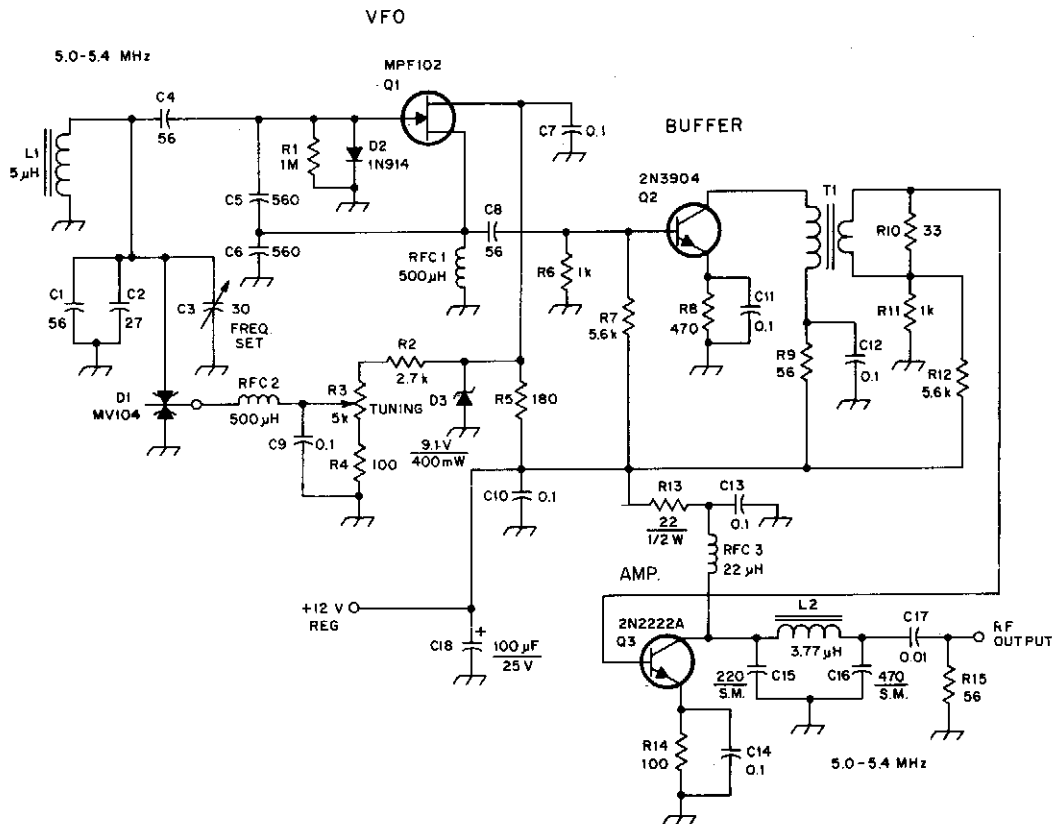
86

RF Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

5 MHz VFO

5 MHz VFO



QST

Fig. 86-1

Circuit Notes

A JFET (Q1) serves as the oscillator. D2 helps to stabilize the transistor by limiting positive sinewave peaks and stabilizing the bias. Output from Q1 is supplied to a class A buffer, Q2. It operates as a broadband amplifier by means of T1, which is untuned. Output amplifier Q3 is also a class A stage. A low-pass, single-section filter is used at the output of Q3 to remove some of the harmonic currents generated within the system. The filter output impedance is 50 ohms. The injection level to the mixer is 600 mV p-p.

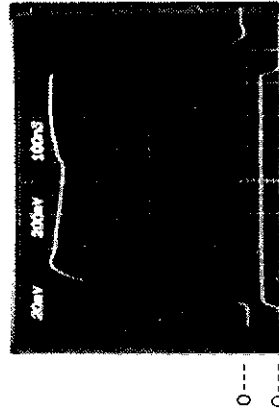
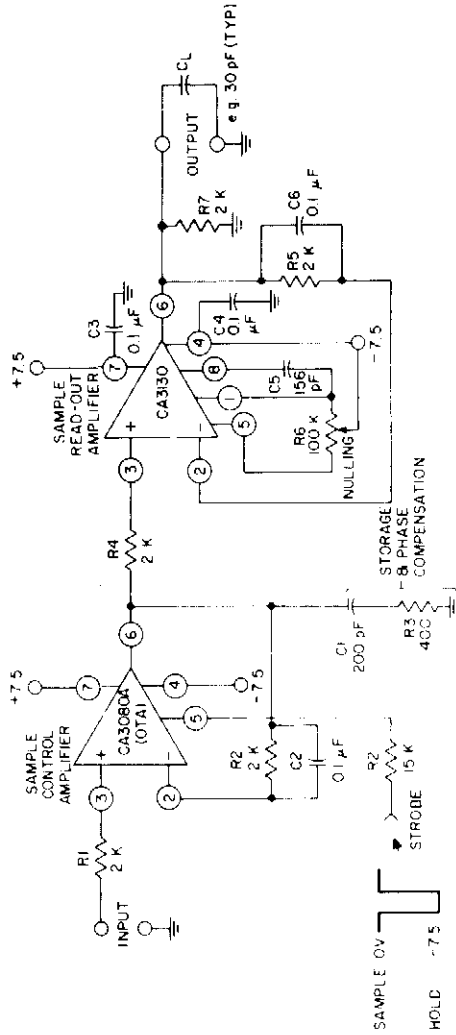
87

Sample-and-Hold Circuits

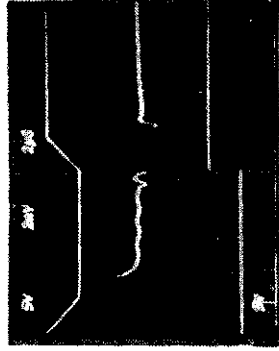
The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Sample-and-Hold Circuit
Sample and Hold Circuit II
Fast, Precision Sample-Hold
High Performance Sample and Hold
Infinite Sample and Hold Amplifier
Charge Compensated Sample and Hold

SAMPLE-AND-HOLD CIRCUIT



TOP TRACE: OUTPUT—20 mV/DIV. & 100 ns/DIV.
 BOTTOM TRACE: INPUT—200 mV/DIV. & 100 ns/DIV.



TOP TRACE: OUTPUT—5 V/DIV. & 2 μ s/DIV.
 CENTER TRACE: DIFFERENTIAL COMPARISON OF
 INPUT & OUTPUT—2 mV/DIV. & 2 μ s/DIV.
 BOTTOM TRACE: INPUT—5 V/DIV. & 2 μ s/DIV.

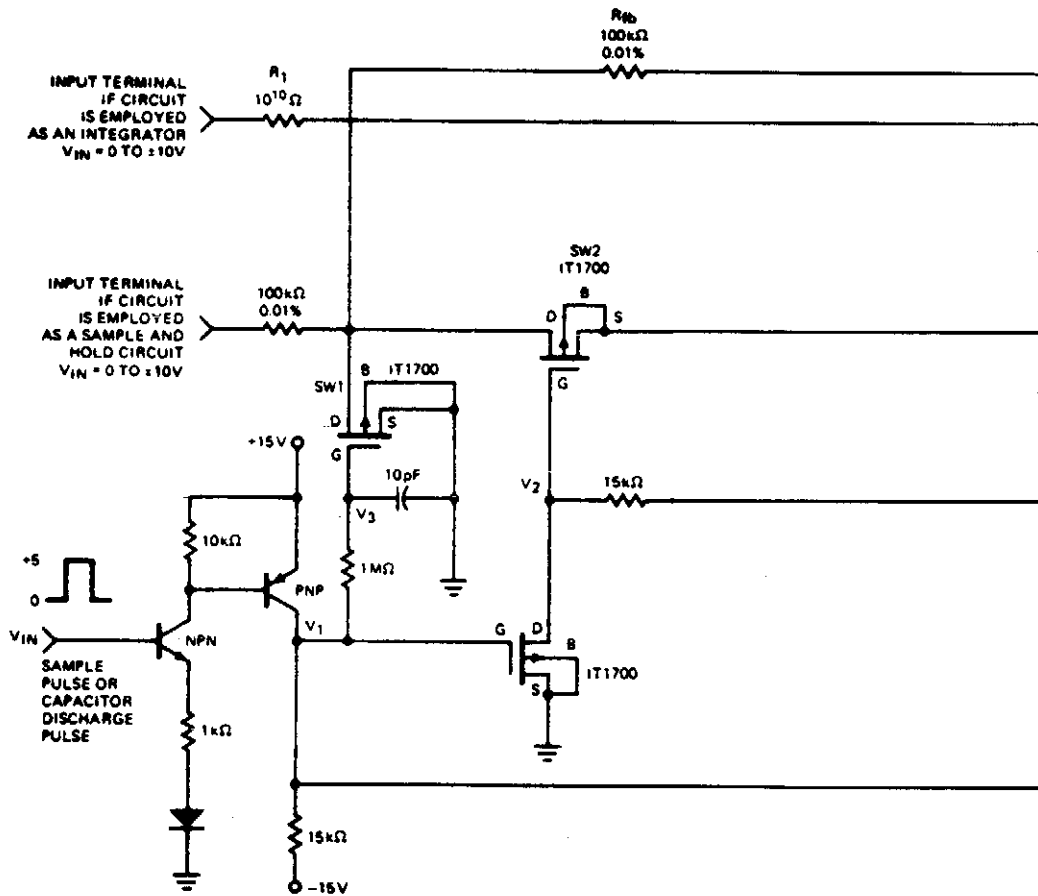
GENERAL ELECTRIC / RCA

Fig. 87-1

Circuit Notes

The circuit uses a CA3130 BiMOS op amp as the sample-readout amplifier for the storage (sample-holding) capacitor C1, and a CA3080A as the sample-control amplifier. Applications in linear systems to temporarily store analog data include DVM systems, industrial process-control, multiplex systems, and A-D converters.

SAMPLE AND HOLD CIRCUIT II



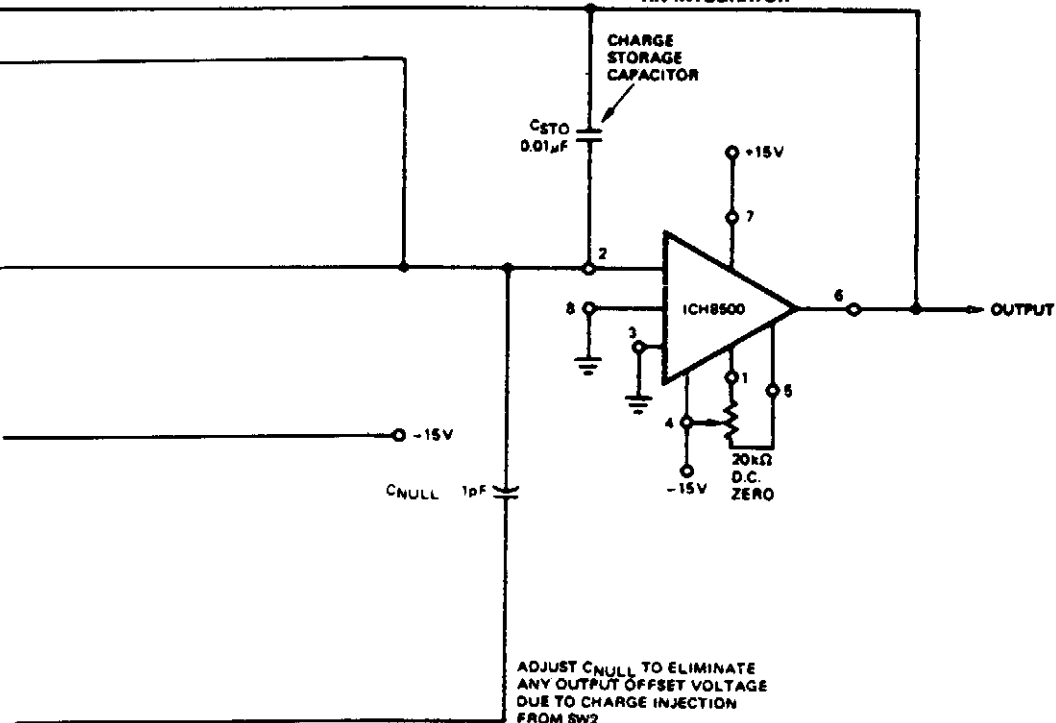
INTESIL

Fig. 87-2

Circuit Notes

This circuit rapidly charges capacitor C_{STO} to a voltage equal to an input signal. The input signal is then electrically disconnected from the capacitor with the charge still remaining on C_{STO} . Since C_{STO} is in the negative feedback loop of the operational amplifier, the output voltage of the amplifier is equal to the voltage across the capacitor. Ideally, the voltage across C_{STO} should remain constant causing the output of the amplifier to remain constant as well. However, the voltage across C_{STO} will decay at a rate proportional to the current being injected or taken out of the current summing node of the amplifier. This current can come from four sources: leakage resistance of

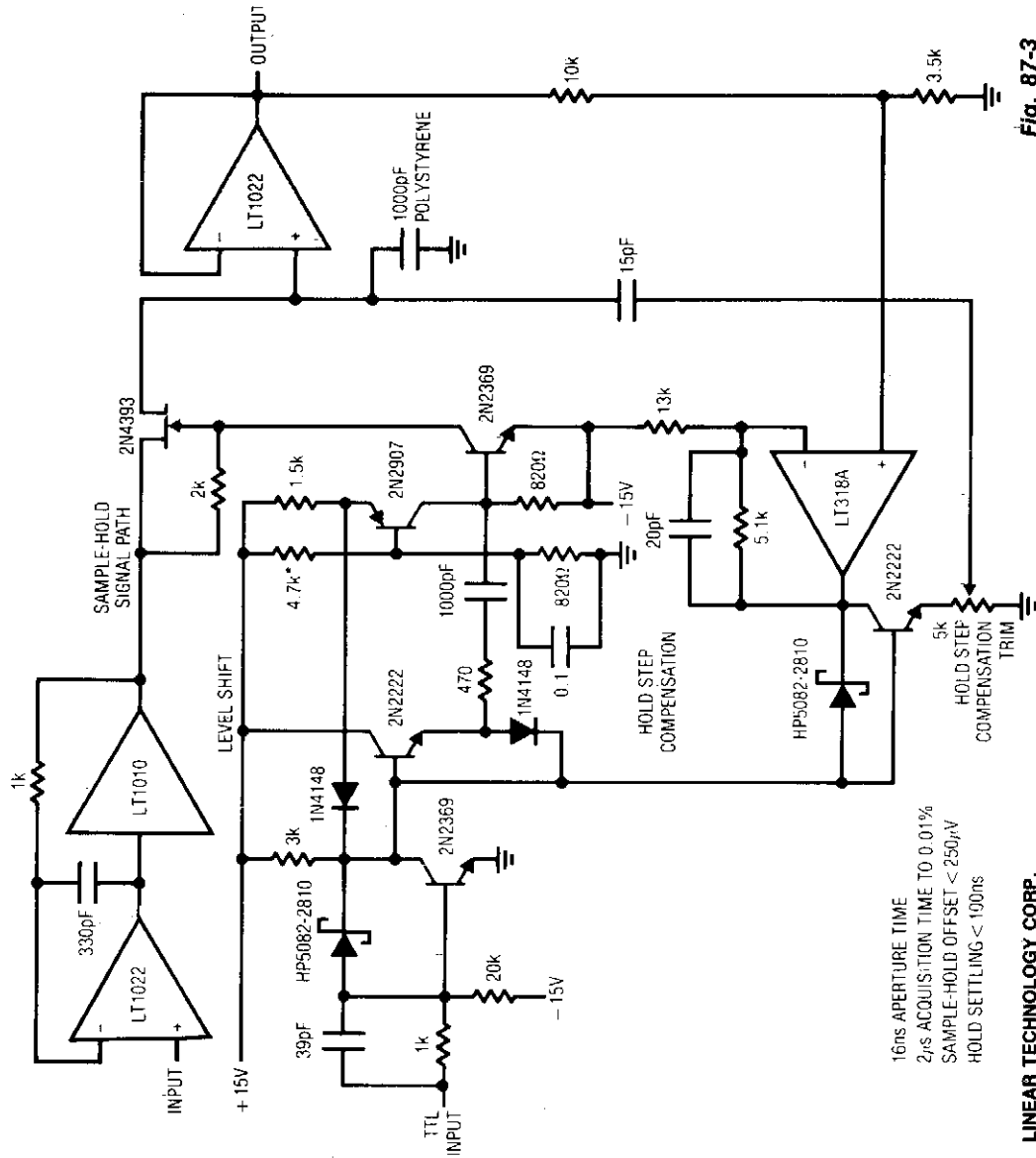
R_{ID} CAN BE REDUCED TO 10K
IF CIRCUIT IS EMPLOYED AS
AN INTEGRATOR



C_{STO} , leakage current due to the solid state switch SW2, currents due to high resistance paths on the circuit fixture, and most important, bias current of the operational amplifier. If the ICH8500A operational amplifier is employed, this bias current is almost non-existent (less than 0.01pA). Note that the voltages on the source, drain and gate of switch SW2 are zero or near zero when the circuit is in the hold mode. Careful construction will eliminate stray resistance paths and capacitor resistance can be eliminated if a quality capacitor is selected. The net result is a low drift sample and hold circuit.

The circuit can double as an integrator. In this application the input voltage is applied to the integrator input terminal. The time constant of the circuit is the product of R_1 and C_{STO} .

FAST, PRECISION SAMPLE-HOLD

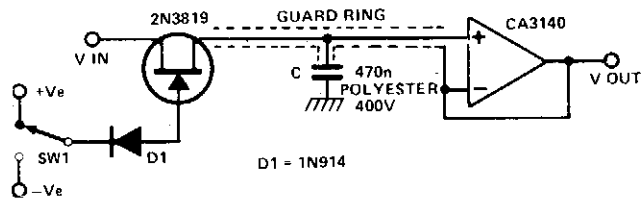


16ns APERTURE TIME
 2ns ACQUISITION TIME TO 0.01%
 SAMPLE-HOLD OFFSET < 250µV
 HOLD SETTLING < 100ns

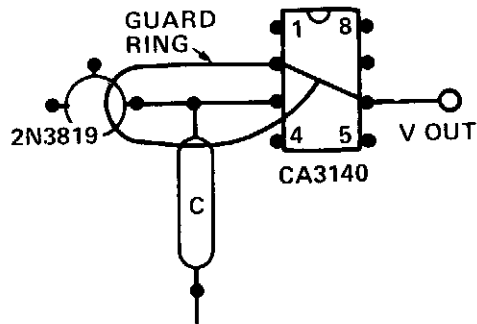
Fig. 87-3

LINEAR TECHNOLOGY CORP.

HIGH PERFORMANCE SAMPLE AND HOLD



PRINTED CIRCUIT BOARD LAYOUT



ELECTRONICS TODAY INTERNATIONAL

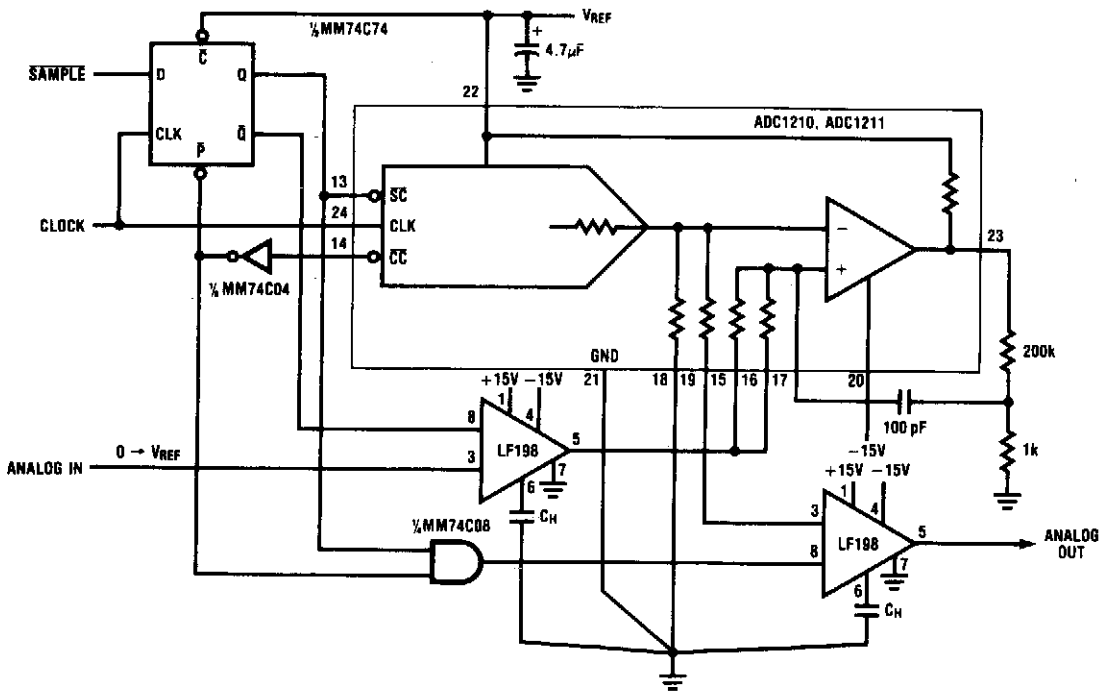
Fig. 87-4

Circuit Notes

When switch SW1 is positive, the FET is turned on, and has a resistance of about 400 ohm. The input voltage charges up the capacitor through the FET. When SW1 is negative, the FET is turned off (pinched off). To get a long storage time, the op amp must have a very low input bias current. For the CA3140, this current is about 10 pico amps. The rate at which the capacitor will be discharged by this current is based on the equation, $C (dv/dt) = i$ where dv/dt is the rate of change of voltage on the capacitor. Therefore:

$$\frac{dv}{dt} = \frac{i}{C} = \frac{10^{-11}}{0.47 \times 10^{-6}} = 22 \mu\text{V/s}$$

INFINITE SAMPLE AND HOLD AMPLIFIER



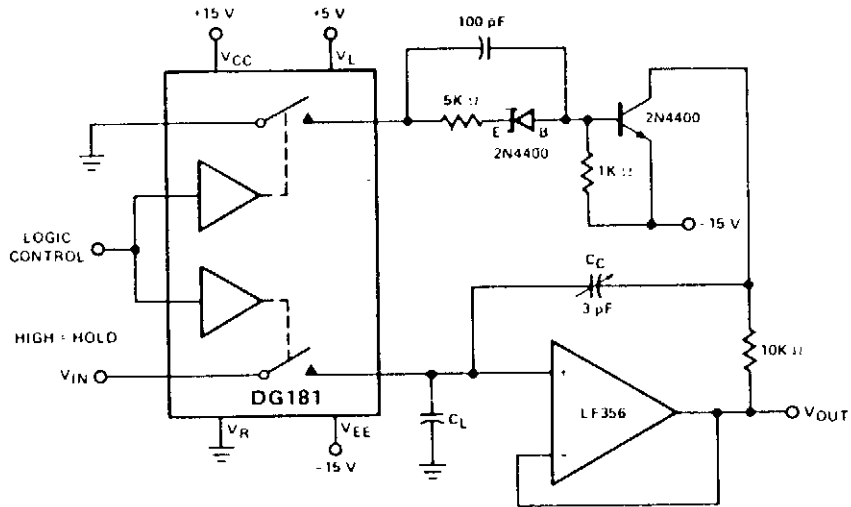
NATIONAL SEMICONDUCTOR CORP.

Fig. 87-5

Circuit Notes

During normal "hold" mode, the replicated analog voltage is buffered straight through the S/H amplifier to the output. Upon issuance of a **SAMPLE** signal, the S/H amplifier is placed in the hold mode, holding the voltage until the new analog voltage is valid. The same **SAMPLE** signal triggers an update to the input sample-and-hold amplifier. The most current analog voltage is captured and held for conversion. The previously determined voltage is held stable at the output during the conversion cycle while the SAR/D-to-A converter continuously adjusts to replicate the new input voltage. At the end of the conversion, the output sample-and-hold amplifier is once again placed in the track mode. The new analog voltage is then regenerated.

CHARGE COMPENSATED SAMPLE AND HOLD



(< 5 mV of Sample to Hold-Offset when $C_L = 1000 \text{ pF}$)

SILICONIX

Fig. 87-6

Circuit Notes

Less than $\pm 5 \text{ pC}$ charge transfer (less than 5 mV sample-to-hold offset when $C_L = 1000 \text{ pF}$).

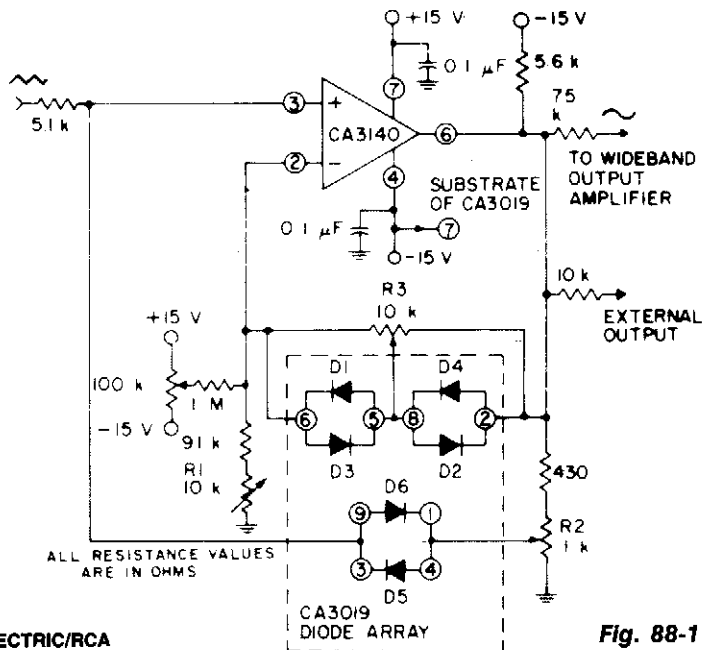
Sine-Wave Oscillators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Sine-Wave Shaper
Low Distortion Sine-Wave Oscillator
Audio Oscillator
Simple Audio Sine-Wave Generator
Low Cost Wien Bridge Oscillator
Modified UJT Relaxation Oscillator Produces Clean
Audio Sinusoids

A 555 Used as an RC Audio Oscillator
Wien Bridge Oscillator Uses CMOS Chip
Adjustable Sine-wave Audio Oscillator
One-IC Audio Generator
Simple Two-Tone Generator

SINE-WAVE SHAPER



GENERAL ELECTRIC/RCA

Fig. 88-1

Circuit Notes

Uses a CA3140 BiMOS op amp as voltage follower, together with diodes from a CA3019 array, to convert a triangular signal (such as obtained from a function generator) to a sine-wave output with typical THD less than 2%.

LOW DISTORTION SINE-WAVE OSCILLATOR

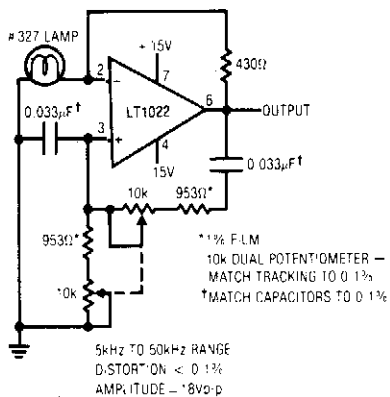
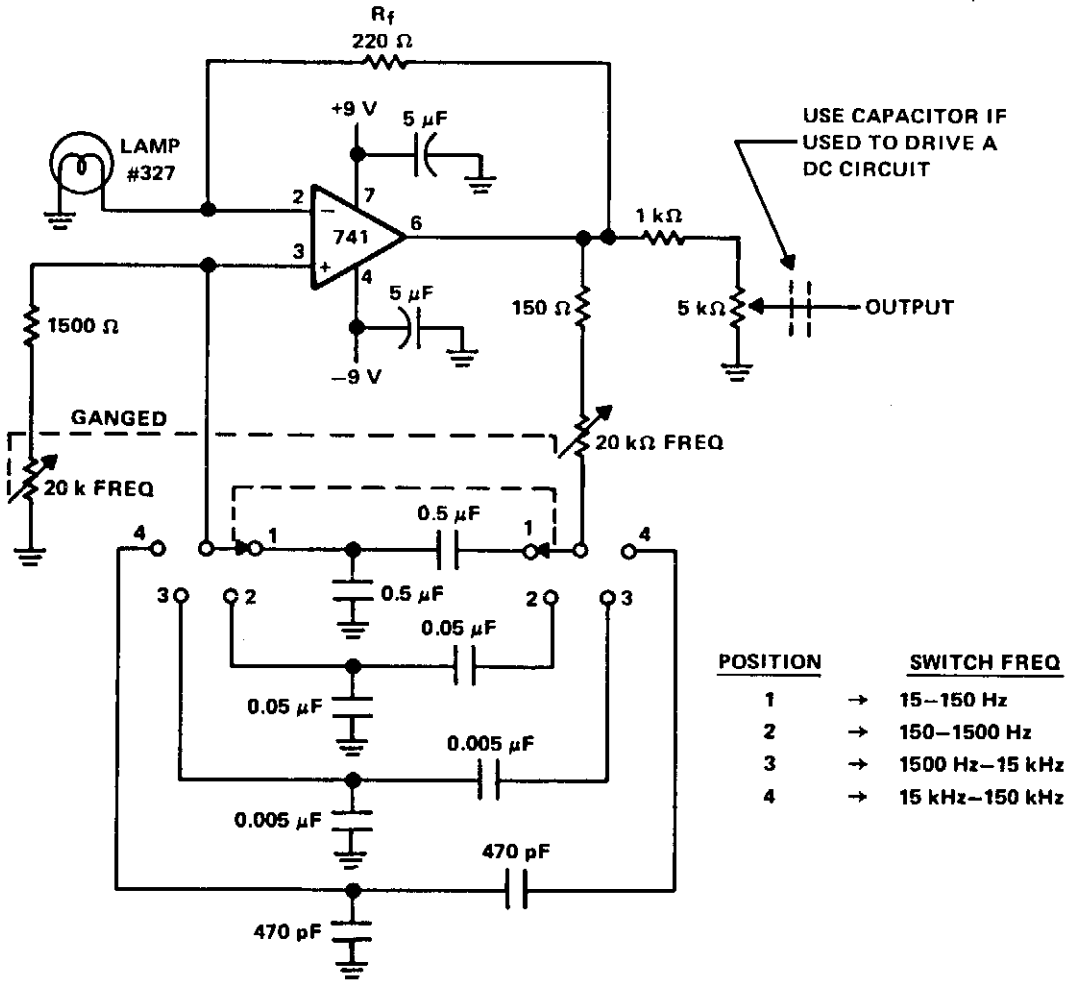


Fig. 88-2

LINEAR TECHNOLOGY CORP.

AUDIO OSCILLATOR



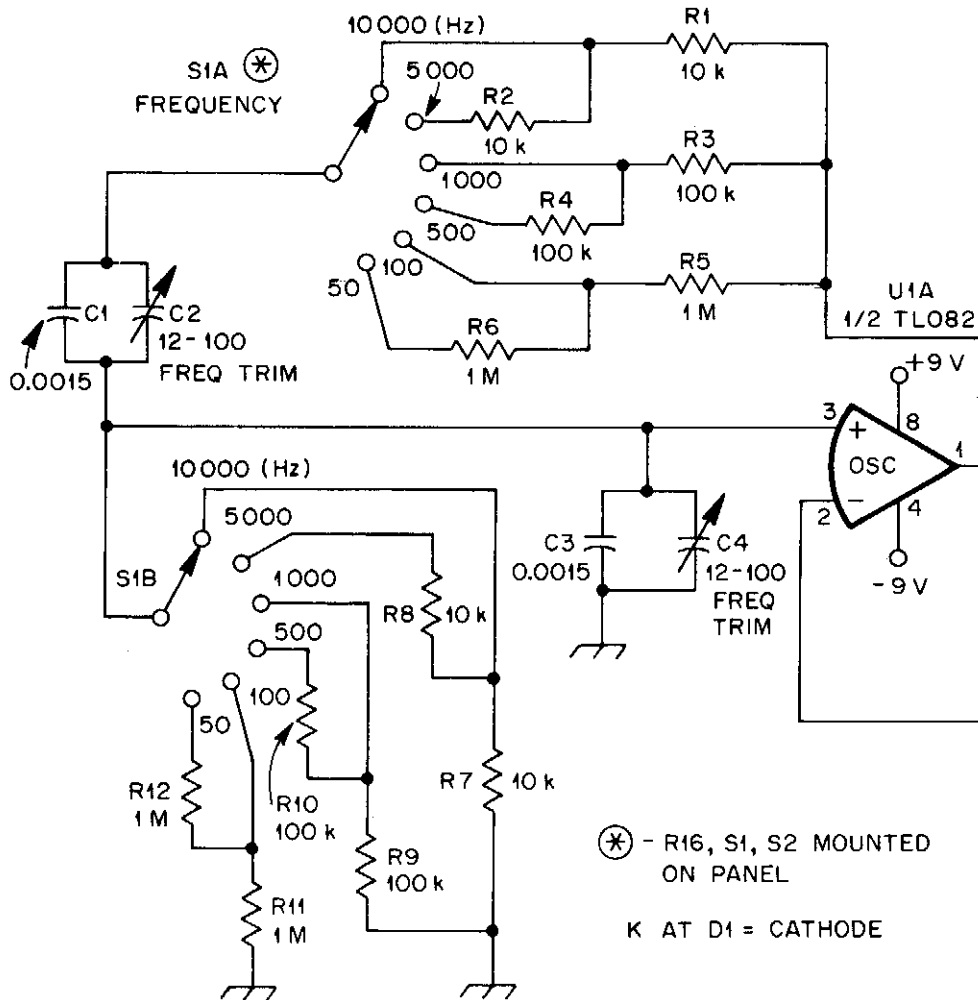
TEXAS INSTRUMENTS

Fig. 88-3

Circuit Notes

A Wien bridge oscillator produces sine waves with very low distortion level. The Wien bridge oscillator produces zero phase shift at only one frequency ($f = \frac{1}{2} \pi RC$) which will be the oscillation frequency. Stable oscillation can occur only if the loop gain remains at unity at the oscillation frequency. The circuit achieves this control by using the positive temperature coefficient of a small lamp to regulate gain (R_f/R_{LAMP}) as the oscillator attempts to vary its output. The oscillator shown here has four frequency bands covering about 15 Hz to 150 kHz. The frequency is continuously variable within each frequency range with ganged 20 k ohm potentiometers. The oscillator draws only about 4.0 mA from the 9-V batteries. Its output is from 4 to 5 V with a 10 k ohm load and the R_f (feedback resistor) is set at about 5% below the point of clipping. As shown, the center arm of the 5 k ohm output potentiometer is the output terminal. To couple the oscillator to a dc type circuit, a capacitor should be inserted in series with the output lead.

SIMPLE AUDIO SINE-WAVE GENERATOR

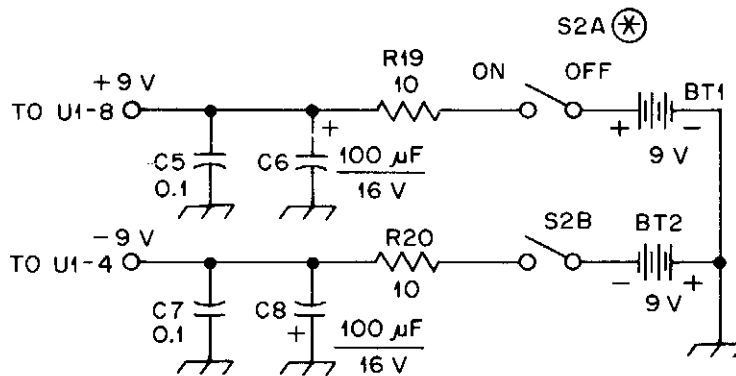


QST

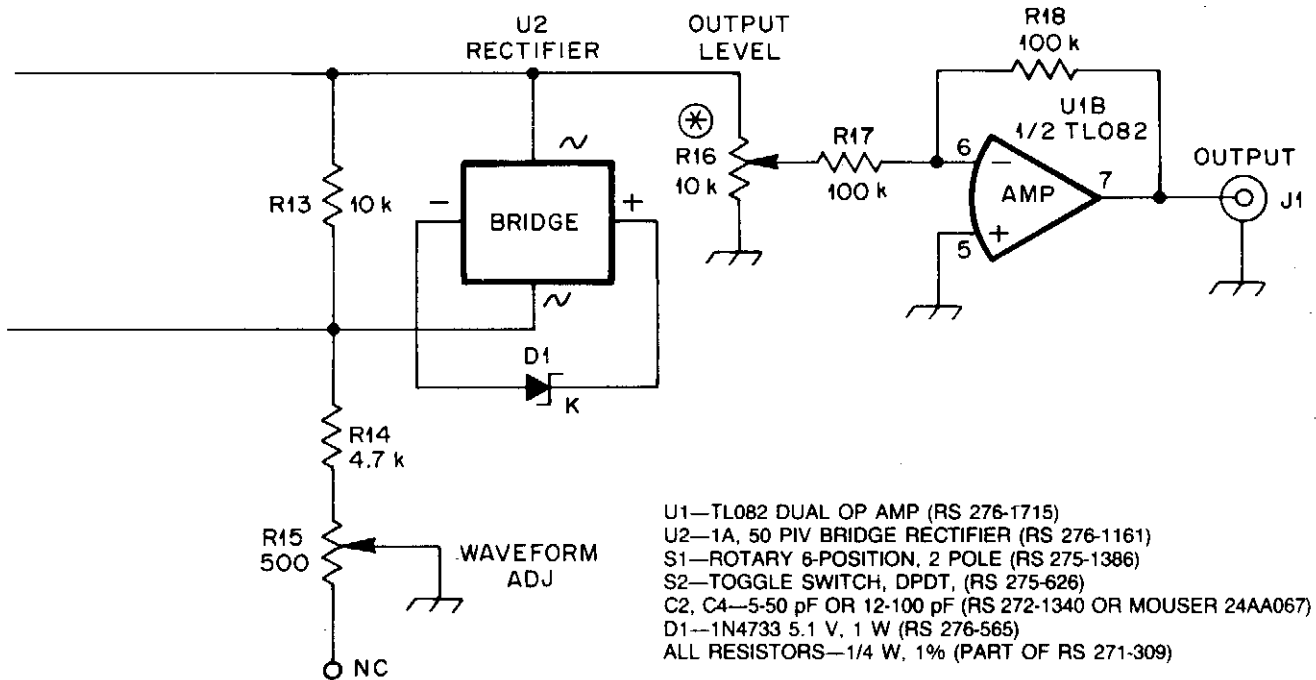
Fig. 88-4

Circuit Notes

U1A, an op amp, oscillates at the frequency at which the phase shift in the Wien bridge network is exactly zero degrees. Changing bridge component values changes the oscillator frequency. In this circuit, we need change only the two resistors to do this. S1A chooses a value among R1 through R6, and S1B similarly selects a value from R7 through R12. U1A must provide enough gain to overcome losses in the bridge, but not so much gain that oscillation builds up to the point of overload and distortion. U2 and



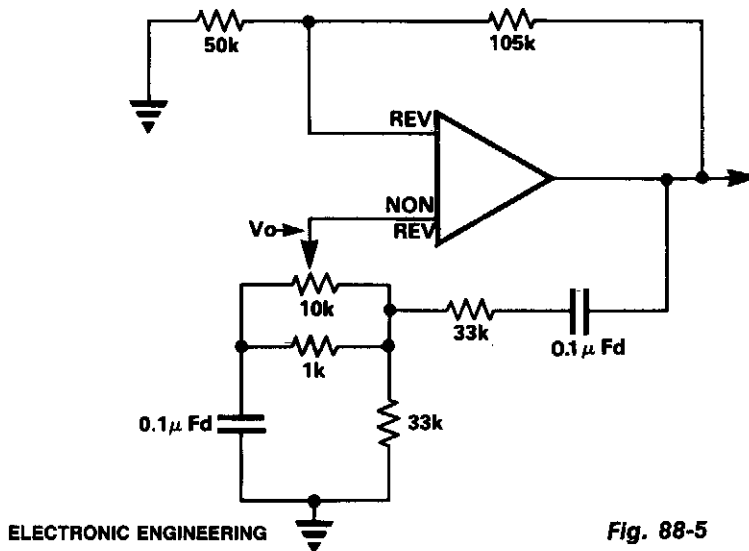
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICO FARADS (pF); RESISTANCES ARE IN OHMS; $k = 1000$, $M = 1000\ 000$.



- U1—TL082 DUAL OP AMP (RS 276-1715)
- U2—1A, 50 PIV BRIDGE RECTIFIER (RS 276-1161)
- S1—ROTARY 6-POSITION, 2 POLE (RS 275-1386)
- S2—TOGGLE SWITCH, DPDT, (RS 275-626)
- C2, C4—5-50 pF OR 12-100 pF (RS 272-1340 OR MOUSER 24AA067)
- D1—1N4733 5.1 V, 1 W (RS 276-565)
- ALL RESISTORS—1/4 W, 1% (PART OF RS 271-309)

C1 automatically regulate circuit gain to maintain oscillation. U2 places D1 across R13 with the proper polarity on both positive and negative alterations of the signal at pin 1 of U1. As the voltage at pin 1 of U1 approaches its peak value, D1 enters its Zener breakdown region, effectively shunting R13 with a resistive load. This increases the amount of negative feedback around U1, reducing its gain. R15, WAVEFORM ADJ, allows you to optimize circuit operation for lowest distortion. U1B provides isolation between oscillator and load. With the values shown for R17 and R18, U1B operates at unity gain.

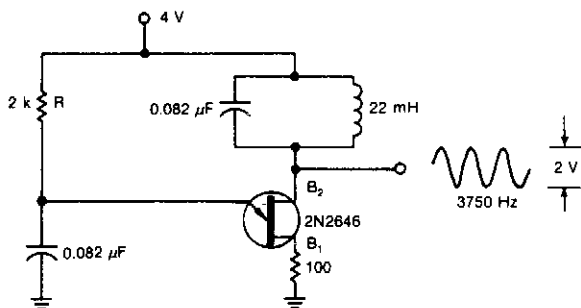
LOW COST WIEN BRIDGE OSCILLATOR



Circuit Notes

In the circuit the frequency trimming component is arranged so that the voltage across it is in quadrature with the voltage V_o from the bridge so that as it is adjusted the attenuation of the bridge only changes a little, avoiding the need for a two gang component. The range of variation of frequency is very limited. By using a high gain amplifier and metal film feedback resistors the loop gain can be set so that the unit just oscillates and the use of an automatic gain setting component, a thermistor for example, is eliminated.

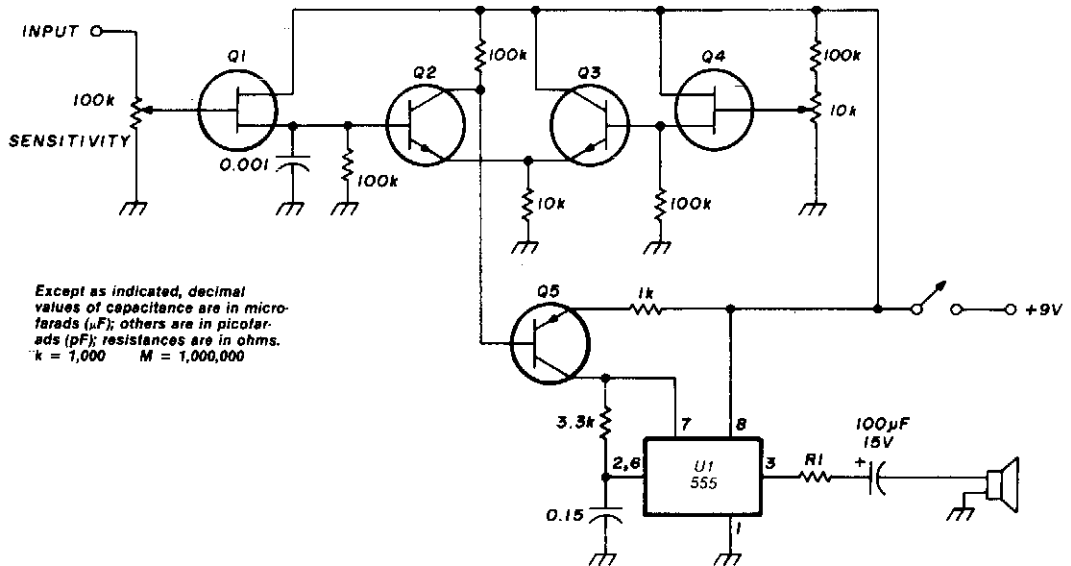
MODIFIED UJT RELAXATION OSCILLATOR PRODUCES CLEAN AUDIO SINUSOIDS



Circuit Notes

By placing a tuned circuit in the UJT oscillator's current-pulse path, a 3750-Hz sinusoid can be created at B2 with the component values shown.

A 555 USED AS AN RC AUDIO OSCILLATOR



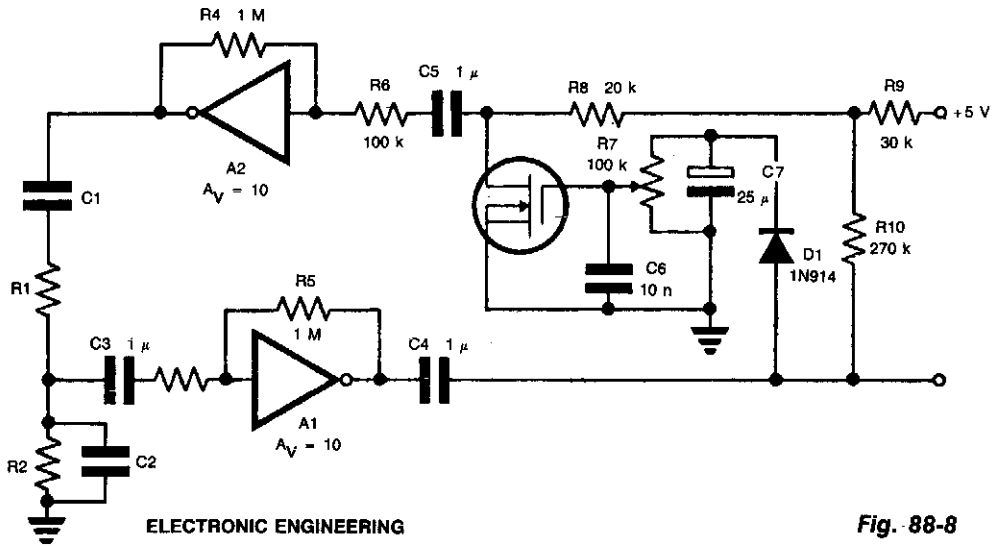
HAM RADIO

Fig. 88-7

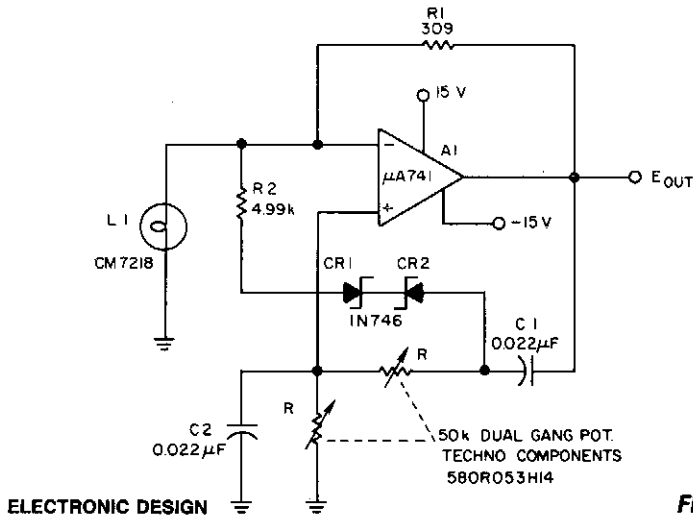
Circuit Notes

Transistor Q5 and the 1000 ohm resistor form the variable element needed for controlling the frequency of VCO by limiting the charging current flowing into the 0.15 μF timing capacitor according to the forward bias being applied to Q5. As the voltage on pins 2 and 6 of U1 reach $\frac{2}{3} V_{CC}$ (about 6 volts with a 9-volt supply) the timer will fire and pin 3 will be pulled low. Pin 7, an open collector output, goes low and begins to discharge the timing capacitor—through the 3.3 kilohm resistor. The discharge time provided by this resistor assures a reasonable, although asymmetrical, waveform for the aural signal generated by U1. At $\frac{1}{3} V_{CC}$ the internal flip-flop resets, the output on pin 3 goes high, the open collector output on pin 7 floats, and the timing cycle begins again.

WIEN BRIDGE OSCILLATOR USES CMOS CHIP



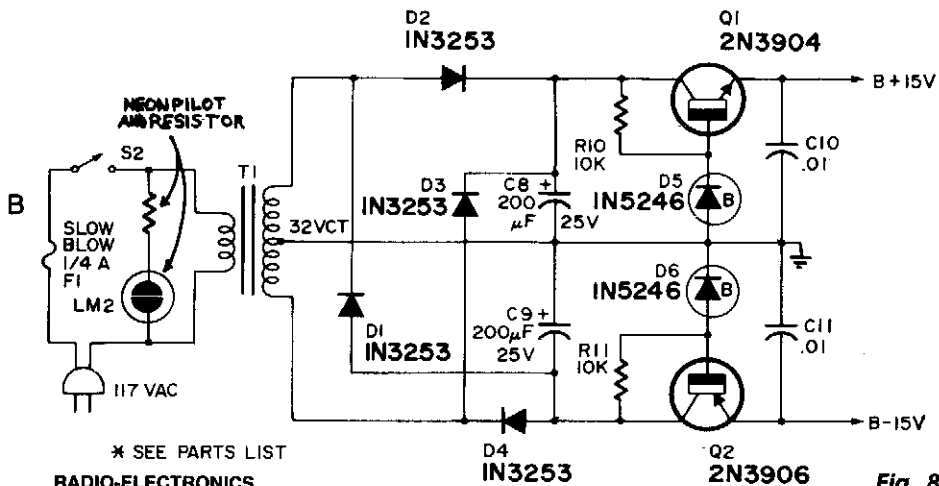
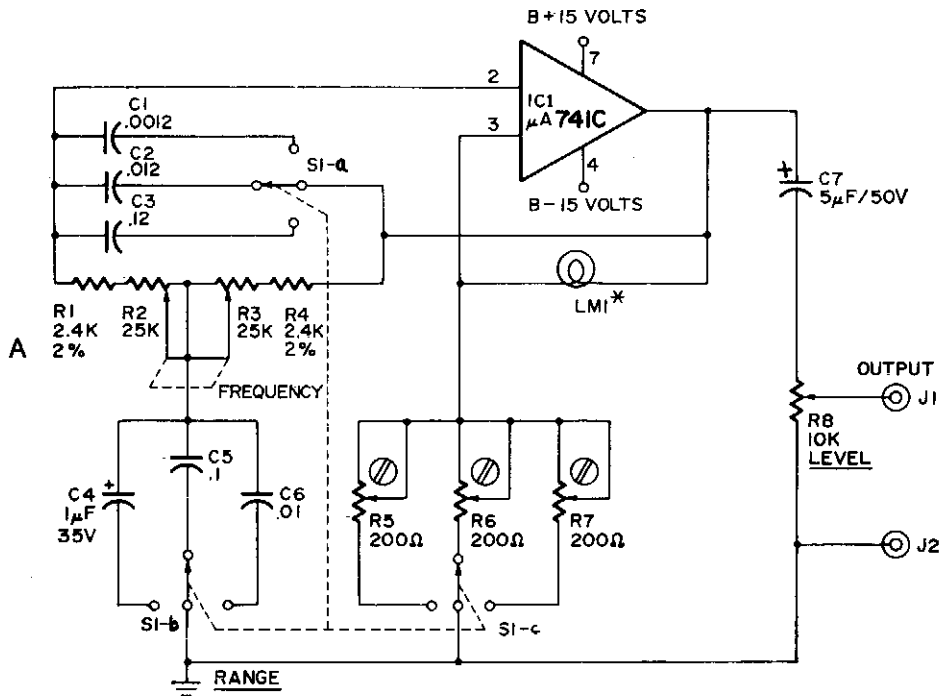
ADJUSTABLE SINE-WAVE AUDIO OSCILLATOR



Circuit Notes

Waveform purity at low frequencies for a Wien bridge oscillator is enhanced by diode limiting. Lamp L1 stabilizes the loop gain at higher frequencies while the limiting action of R2, CR1, and CR2 prevents clipping at low frequencies and increases the frequency adjustment range from about 3:1 to greater than 10:1.

ONE-IC AUDIO GENERATOR



* SEE PARTS LIST

RADIO-ELECTRONICS

Fig. 88-10

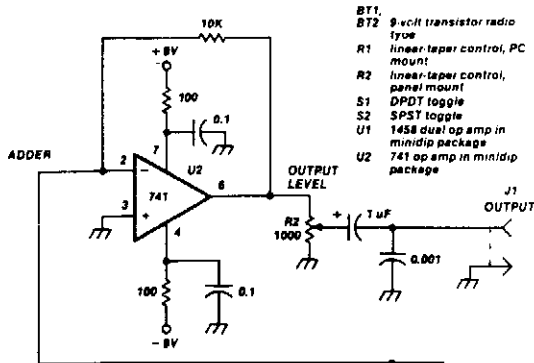
Circuit Notes

This high-quality low-cost generator covers 20 Hz to 20 kHz in three bands with less than 1% distortion. LM1—10 V, 14 mA (344, 1869, 914) or 10 V, 10 mA (913, 367).

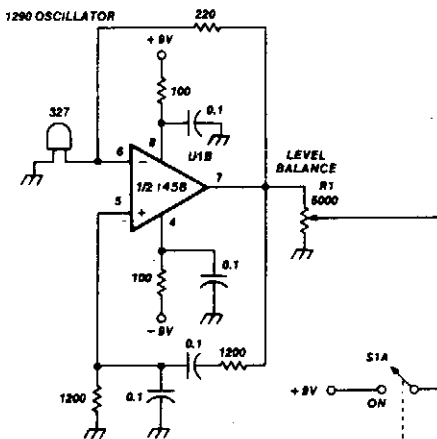
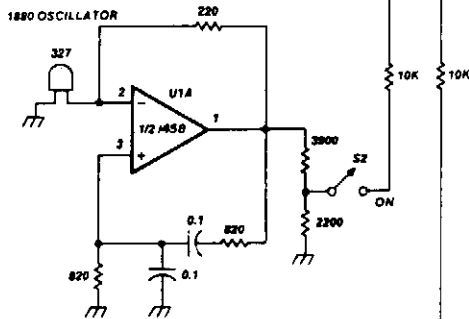
A = oscillator

B = power supply

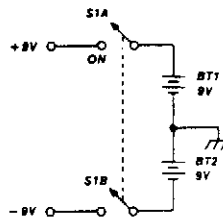
SIMPLE TWO-TONE GENERATOR



- BT1 9-watt transistor radio type
- BT2 9-watt transistor radio type
- R1 linear-taper control, PC mount
- R2 linear-taper control, panel mount
- S1 DPDT toggle
- S2 SPST toggle
- U1 1458 dual op amp in minidip package
- U2 741 op amp in minidip package



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

Two 741 operational amplifiers are used for the active element in this Wien bridge oscillator. (The 1458 is the dual version of the 741.) Frequencies of the two oscillators were chosen to fit standard component values. Other frequencies between 500 and 2000 Hz can be employed. They should not be harmonically related. The output level of U1A is set by a resistive divider, while the output of U1B is adjustable through R1. The output of the two oscillators is combined in U2, an op-amp adder with unity gain. The output from U2 can be adjusted using R2.

Fig. 88-11

Sirens, Warblers and Wailers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Warble Generator

Wailing Alarm

Warble-Tone Alarm

Warbling Tone Generator

Multifunction Siren System

7400 Siren

Toy Siren

Siren Uses TTL Gates

Electronic Ship Siren

Siren Alarm Simulates Star Trek Red Alert

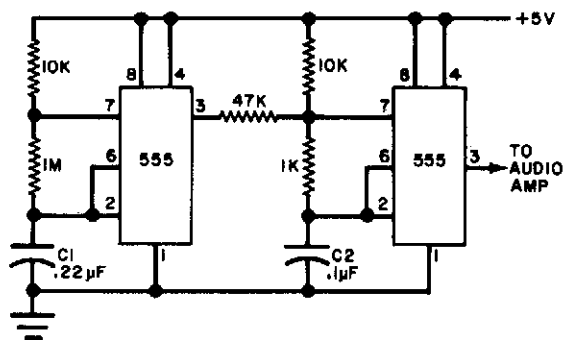
Yelp Oscillator

High Power Siren

“Hee-Haw” Two-Tone Siren

Varying Frequency Warning Alarm

WARBLE GENERATOR



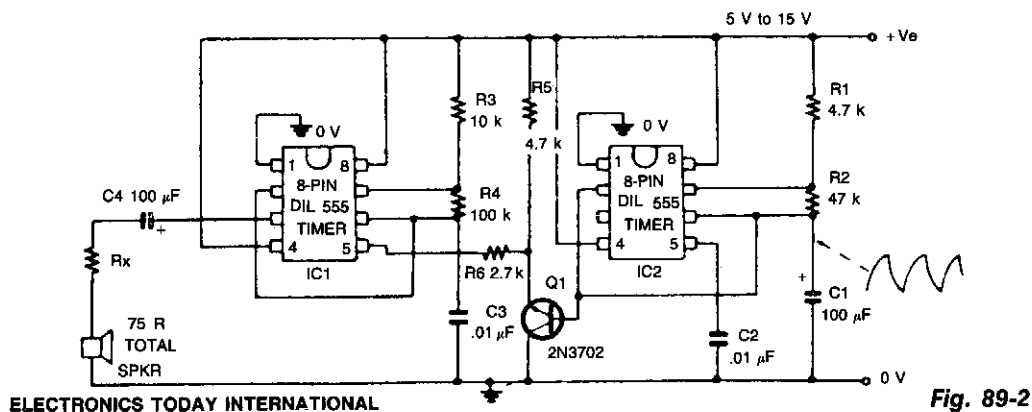
POPULAR ELECTRONICS

Fig. 89-1

Circuit Notes

The circuit uses a pair of 555 timers or a single dual timer. Capacitor C1 controls the speed of the warble, while C2 determines the pitch. The values shown should produce quite a distinctive signal.

WAILING ALARM



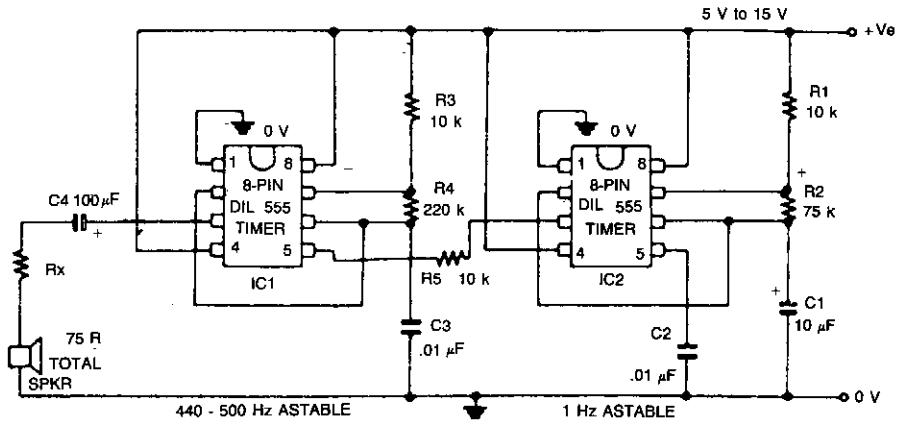
ELECTRONICS TODAY INTERNATIONAL

Fig. 89-2

Circuit Notes

This circuit simulates the sound of an American police siren. IC2 is wired as a low frequency astable that has a cycling period of about 6 seconds. The slowly varying ramp waveform on C1 is fed to pnp emitter follower Q1, and is then used to frequency modulate alarm generator IC1 via R6. IC1 has a natural center frequency of about 800Hz. Circuit action is such that the alarm output signal starts at a low frequency, rises for 3 seconds to a high frequency, then falls over 3 seconds to a low frequency again, and so on ad infinitum.

WARBLE-TONE ALARM



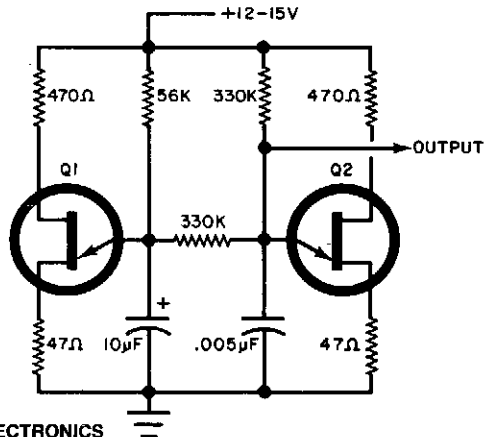
ELECTRONICS TODAY INTERNATIONAL

Fig. 89-3

Circuit Notes

The circuit generates a warble-tone alarm signal that simulates the sound of a British police siren. IC1 is wired as an alarm generator and IC2 is wired as a 1 Hz astable multivibrator. The output of IC2 is used to frequency modulate IC1 via R5. The action is such that the output frequency of IC1 alternates symmetrically between 500 Hz and 440 Hz, taking one sound to complete each alternating cycle.

WARBLING TONE GENERATOR



POPULAR ELECTRONICS

Fig. 89-4

Circuit Notes

The circuit uses two unijunction transistors. The low-frequency sawtooth generated by Q1 modulates the high-frequency tone generated by Q2. The output should feed into a high-impedance amplifier. Q1 = Q2 = 2N4871.

MULTIFUNCTION SIREN SYSTEM

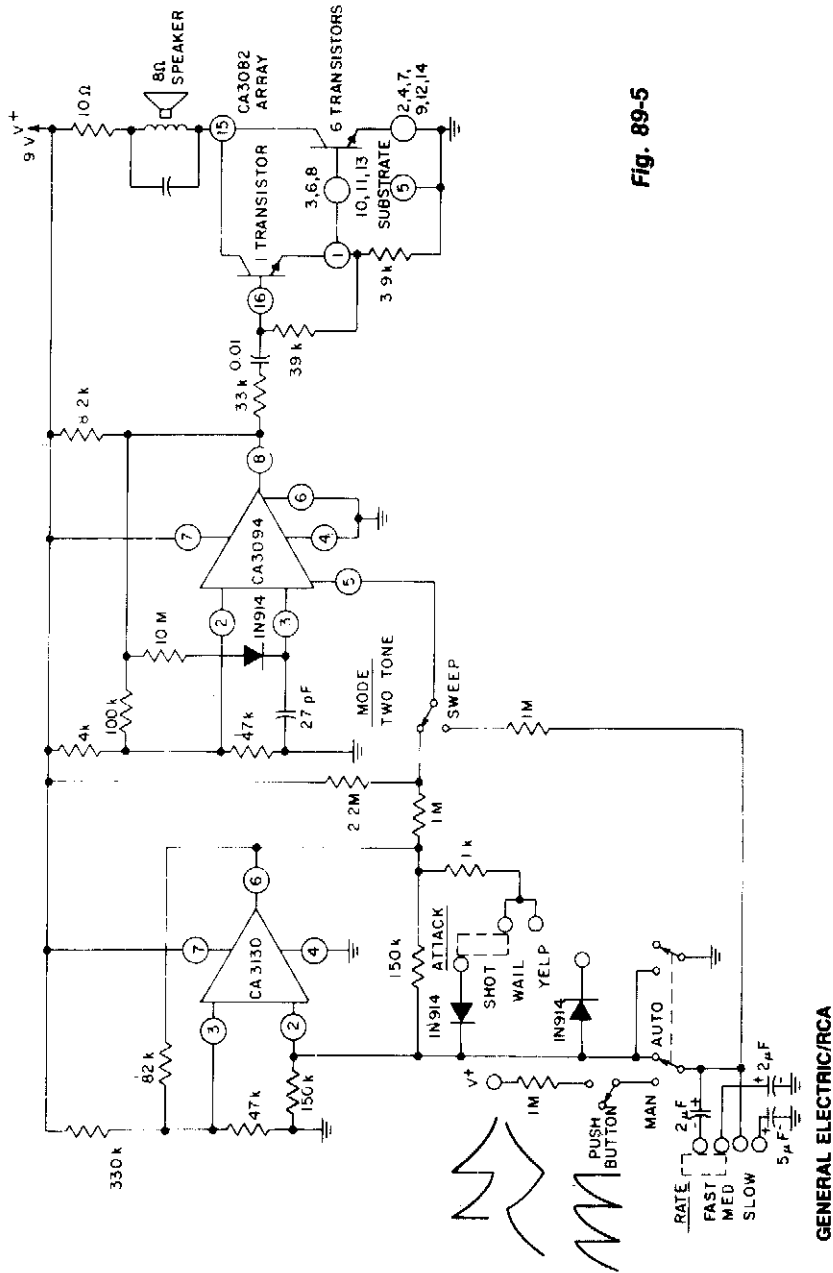
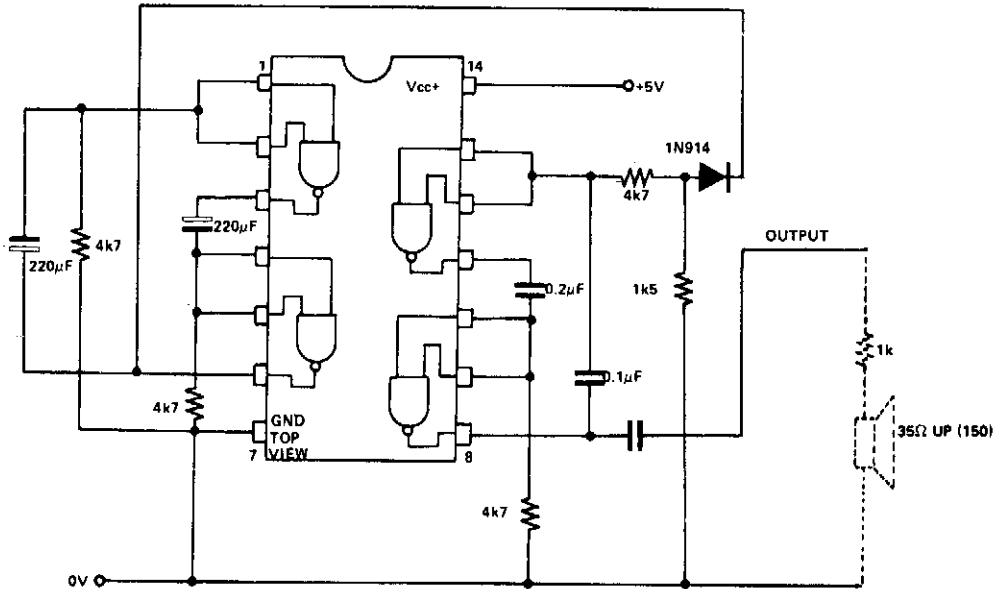


Fig. 89-5

Circuit Notes

The circuit uses a CA3130 BiMOS op amp as a multivibrator to control the siren's rate. A CA3094 used as a VCO is followed by a CA3082 transistor array used to drive a speaker. A "Manual" or "Auto" mode switch allows the user to select either intermittent or continuous siren operation, respectively. In addition, three switches are available that control "Mode", "Attack", and "Rate".

7400 SIREN



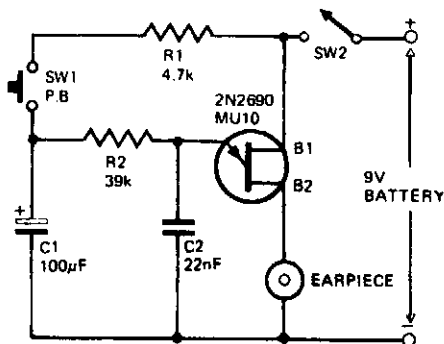
ELECTRONICS TODAY INTERNATIONAL

Fig. 89-6

Circuit Notes

Two NAND gates are used for the oscillator, and two as the control. If the two-tone speed needs to be altered, the 220 μ F capacitors can be changed (larger for slower operation). If the frequency of the oscillator is to be changed, the 0.2 and 0.1 μ F capacitors can be varied and the value of R1 can be increased. To change frequency range between the two notes, alter the 1.5 k (1,500) resistor.

TOY SIREN



ELECTRONICS TODAY INTERNATIONAL

Fig. 89-7

Circuit Notes

This circuit can be built small enough to fit inside a toy. The circuit consists of a relaxation oscillator utilizing one unijunction transistor (2N2646, MU10, TIS43). R2 and C2 determine the frequency of the tone. Pushing the button, SW1 charges up the capacitor and the potential at the junction of R2 and C2 rises, causing an upswing in the frequency of oscillation. On releasing the pushbutton the charge on C2 will drop slowly with a proportional reduction in the frequency of oscillation. Manual operation of the button at intervals of approximately 2 seconds will produce a siren sound.

SIREN USES TTL GATES

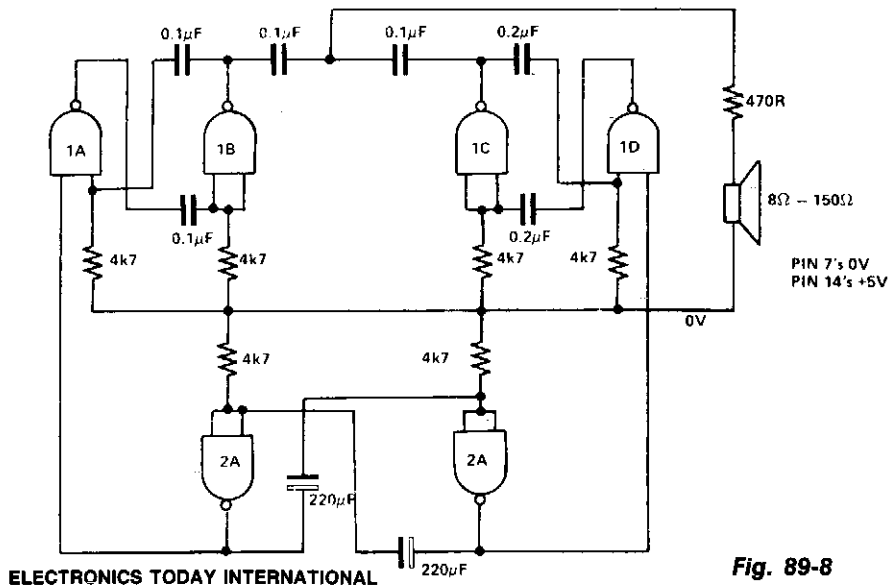


Fig. 89-8

Circuit Notes

The siren consists of two oscillators which generate the tones. A third oscillator is used to switch the others on and off alternately, giving the two-tone effect. By changing the capacitor values different tones can be produced.

ELECTRONIC SHIP SIREN

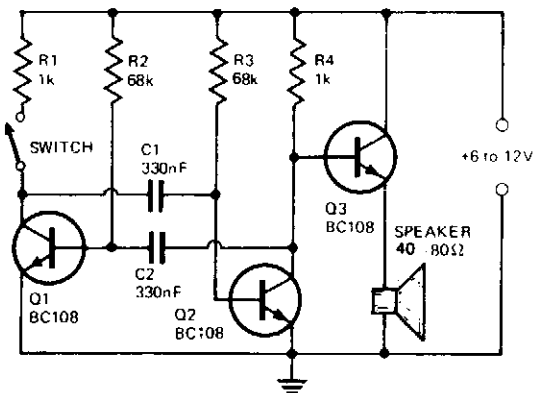
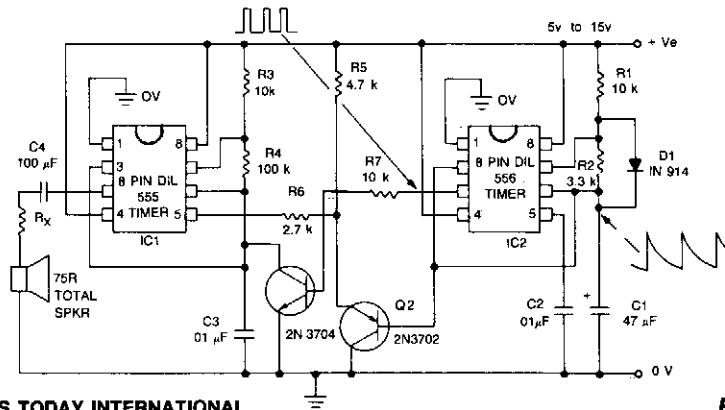


Fig. 89-9

Circuit Notes

The circuit consists of a multivibrator (Q1 & Q2), and a low power output stage Q3. The speaker should have an impedance in the region of 40 to 80 ohms. To use a low impedance speaker, connect an output transformer from the emitter of Q3 to ground. C1 and C2 determine the pitch of the siren and the values specified will provide a tone of about 300 Hz. Quiescent current is negligible. The output at the collector of Q2 can also be fed into an amplifier input via a 1 µF electrolytic, in series with a 12 k resistor.

SIREN ALARM SIMULATES STAR TREK RED ALERT



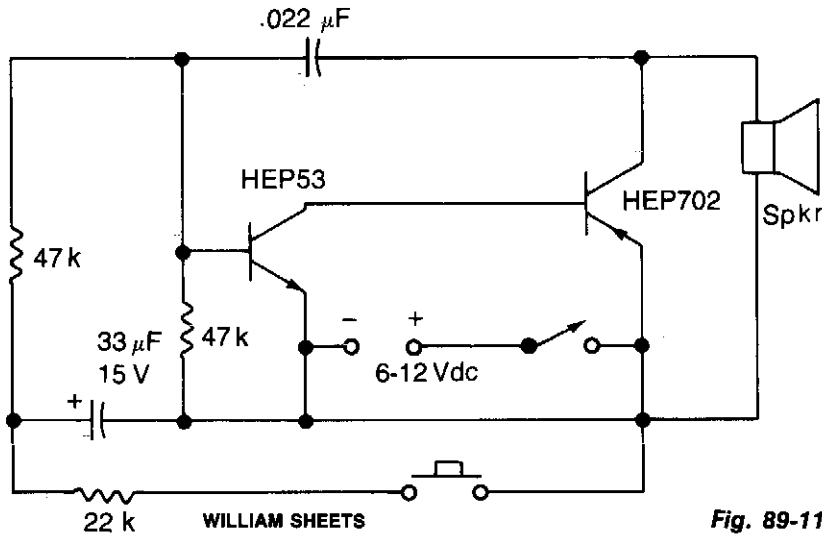
ELECTRONICS TODAY INTERNATIONAL

Fig. 89-10

Circuit Notes

The signal starts at a low frequency, rises for about 1.15 seconds to a high frequency, ceases for about 0.35 seconds, then starts rising again from a low frequency, and so on ad infinitum.

YELP OSCILLATOR



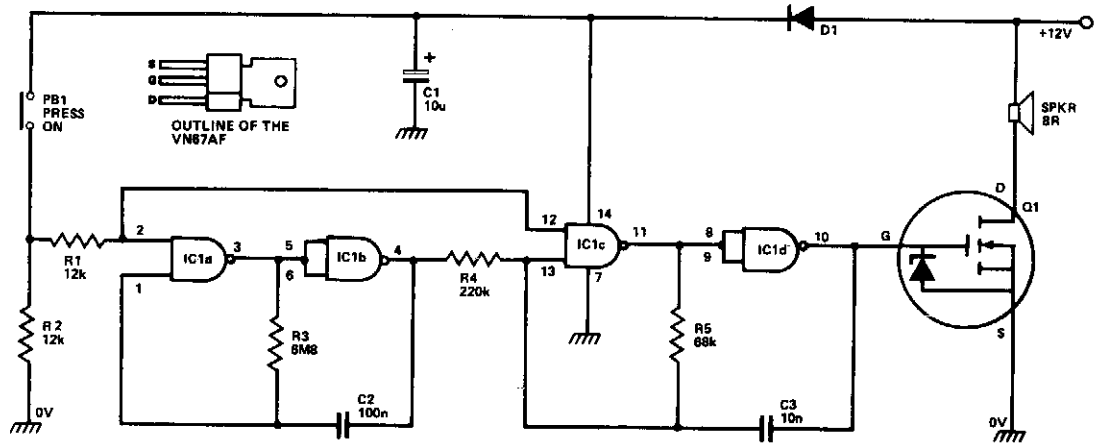
WILLIAM SHEETS

Fig. 89-11

Circuit Notes

Close the pushbutton switch and the circuit starts the siren up-shifting to a higher frequency. Release it and the tone slides down until S2 is closed again. Tone quality is adjusted by changing the 0.022 µF capacitor.

HIGH POWER SIREN



ELECTRONICS TODAY INTERNATIONAL

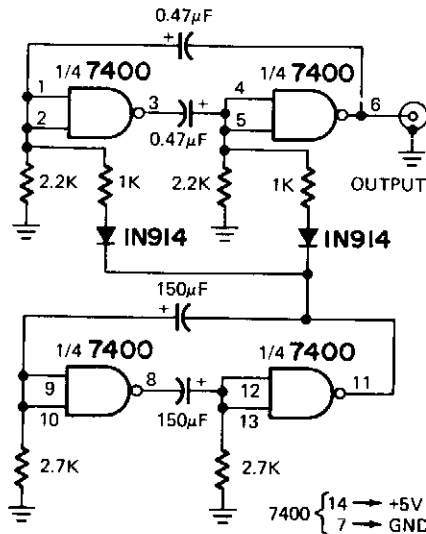
Fig. 89-12

NOTES:
D1 IS 1N4001
Q1 IS VN67AF
IC1 IS CD4011B

Circuit Notes

IC1a and IC1b are wired as a slow astable multivibrator and IC1c-IC1d are wired as a fast astable. Both are "gated" types, which can be turned on and off via PB1. The output of the slow astable modulates the frequency of the fast astable, and the output of the fast astable is fed to the external speaker via the Q1 VMOS power FET amplifier stage.

"HEE-HAW" TWO-TONE SIREN



RADIO-ELECTRONICS

Fig. 89-13

Circuit Notes

The circuit uses two gates of a 7400 IC cross-connected to form an astable multivibrator driven by the 1-pulse per second output of the digital clock IC. The hee-haw circuit has a low frequency astable modulator added to make a self-contained European-type siren. Tone and rate can be varied as desired by changing capacitor values. If the tone is too harsh, a simple R-C filter will remove the harmonic content—the multivibrator output is almost a square wave. With the resistor values shown, no start-up problems occur; but if the 2.2 k or 2.7 k resistors are changed too much, latch-up can be a problem.

VARYING-FREQUENCY WARNING ALARM

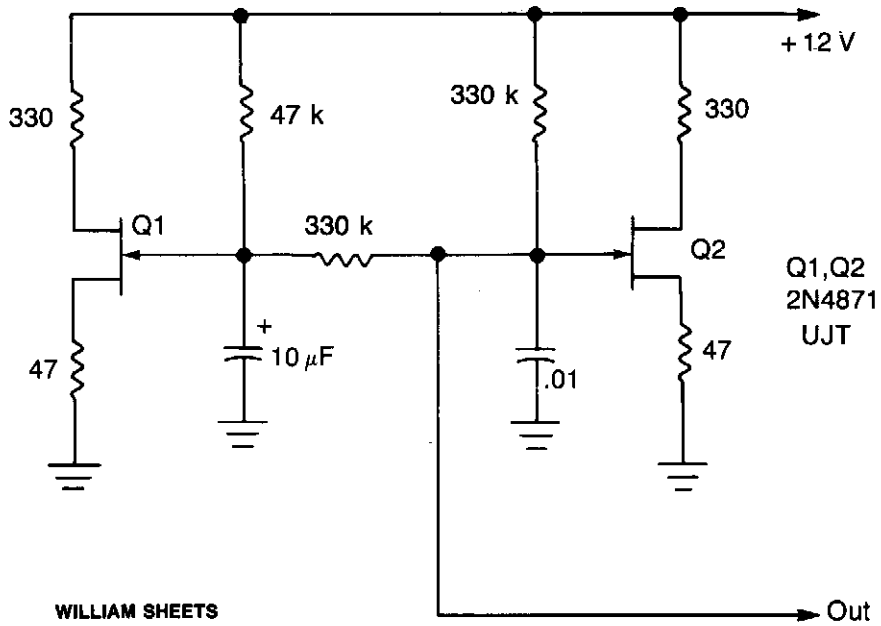


Fig. 89-14

Circuit Notes

The output frequency changes continuously. Low frequency oscillator (Q1) modulates high frequency oscillator Q2 and its associated timing capacitor.

90

Sound (Audio) Operated Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Sound-Activated Switch
Sound-Activated ac Switch
VOX Box
Color Organ
Basic Color Organ

SOUND-ACTIVATED SWITCH

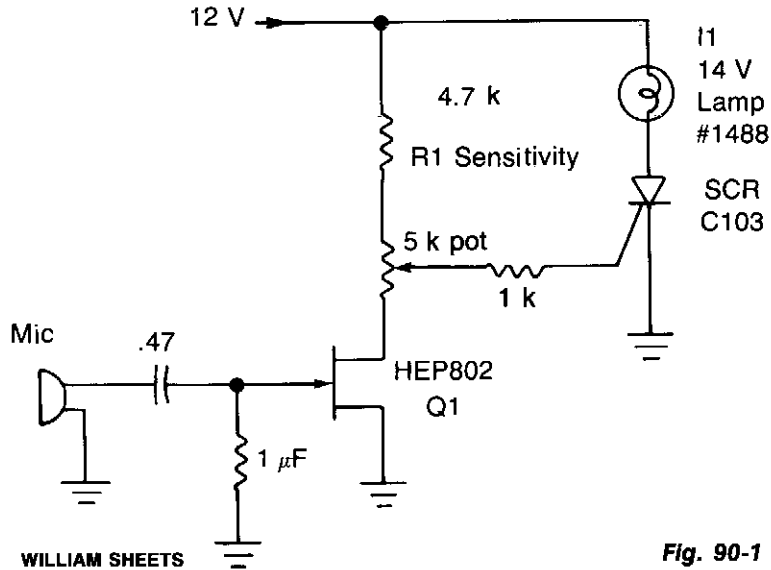


Fig. 90-1

Circuit Notes

The audio from Mic is amplified by Q1. Peaks of signal (adjusted by R1) greater than about 0.7 volts trigger the SCR and light lamp I1.

SOUND-ACTIVATED ac SWITCH

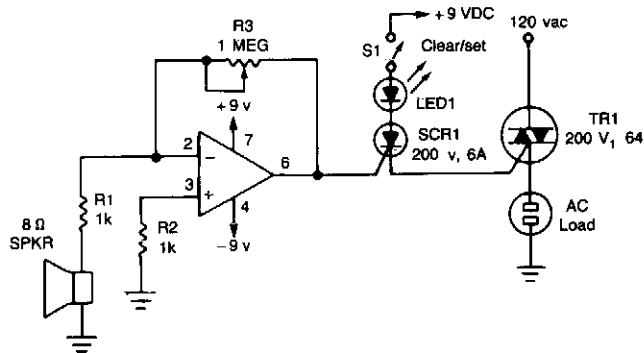
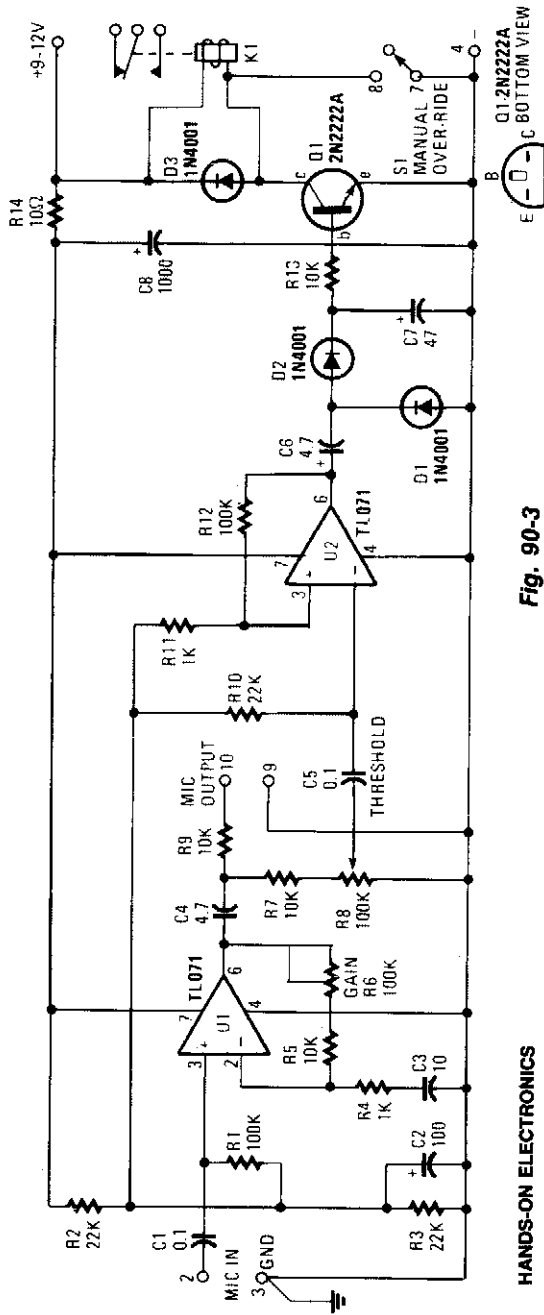


Fig. 90-2

Circuit Notes

The circuit uses a 741 op amp operating as an inverting amplifier to amplify the voltage produced by an 8-ohm speaker used to detect any sounds. The feedback resistor R3, a 1-megohm potentiometer used to vary the gain of the amplifier determines the sensitivity of the circuit. When S1 is closed in the (SET) position and a sound is applied to the speaker, SCR1 is turned on. It will remain in conduction until the anode voltage is removed by opening S1, putting it in its RESET position. (Once an SCR is turned on, the gate or trigger has no control over the circuit.) As long as the SCR conducts, the Triac, TR1, will remain on and supply voltage to the load.

VOX BOX



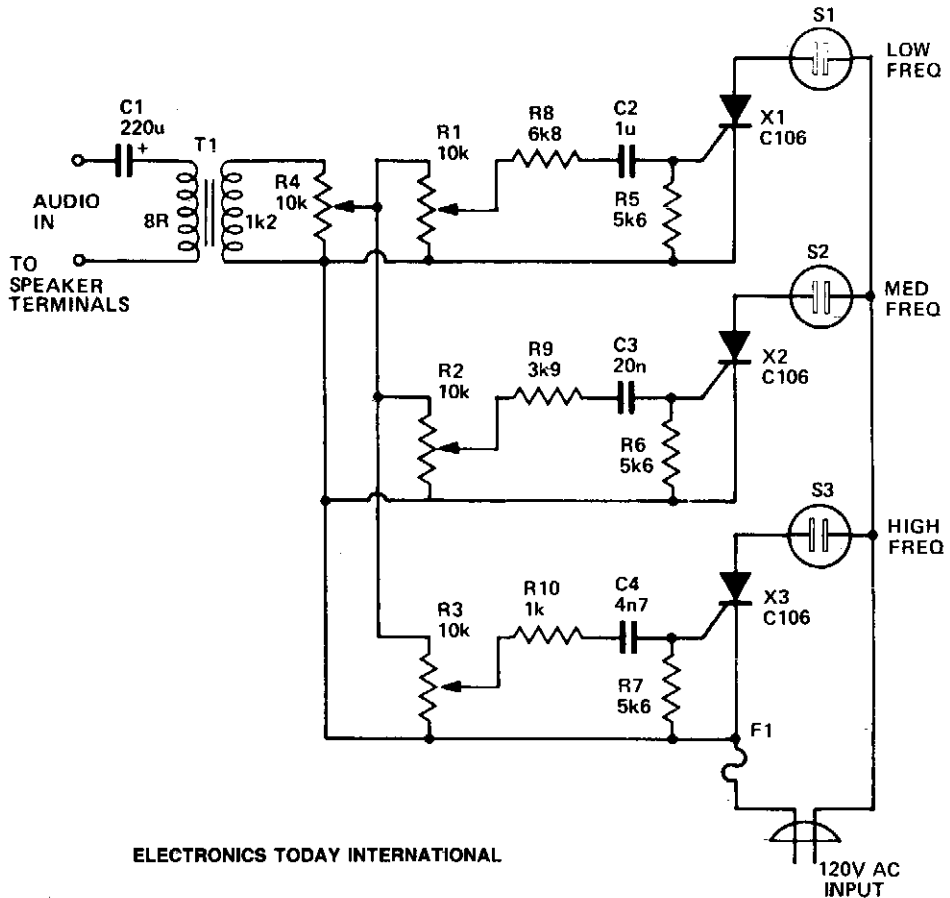
HANDS-ON ELECTRONICS

Fig. 90-3

Circuit Notes

The electronic circuit in the VOX Box consists of three parts: a microphone preamplifier, a Schmitt trigger, and a relay driver. Input signals (MIC INPUT terminals) to the microphone preamplifier (U1) are amplified and fed to a THRESHOLD control (R8). When the preselected threshold voltage level is exceeded, the output of the Schmitt trigger (U2) immediately goes high. The signal from U2 is rectified and the voltage developed across C7 turns on the relay energizer transistor (Q1). That transistor action passes pull-down current through the coil of relay K1. The changing of the relay SPDT contacts can be used to either make or break an external ac or dc circuit.

COLOR ORGAN



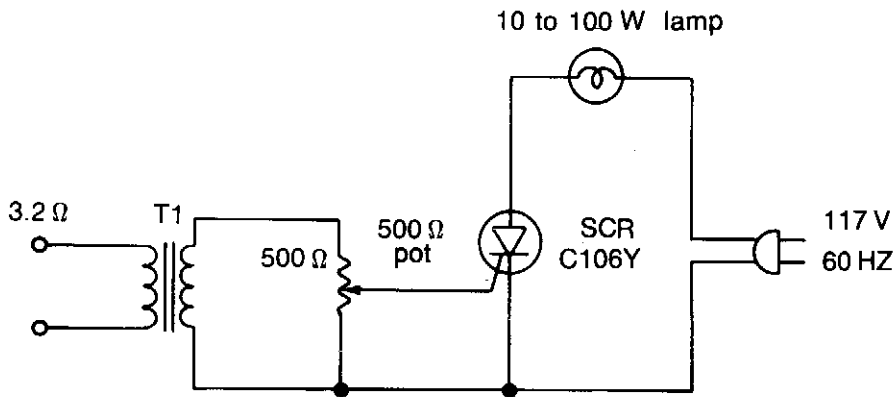
ELECTRONICS TODAY INTERNATIONAL

Fig. 90-4

Circuit Notes

Three lights are controlled by the three channels. One light will pulse in response to the bass, another illuminates with mid-range sounds, and the last lights for high notes. Four level controls allow adjustment of overall light level and each channel individually. Up to 200 watts per channel can be handled.

BASIC COLOR ORGAN



WILLIAM SHEETS

Fig. 90-5

Circuit Notes

Transformer T1 can be any matching transistor type in the range of 500/500 to 2500/2500 ohms. No connections from the SCR or its components are connected to ground. For safety's sake, keep the 117-V line voltage from the amplifier connections—that is the reason for using T1. To adjust, set potentiometer R1 "off" and adjust the amplifier volume control for a normal listening level. Then adjust the potentiometer until the lamp starts to throb in step with the beat.

91

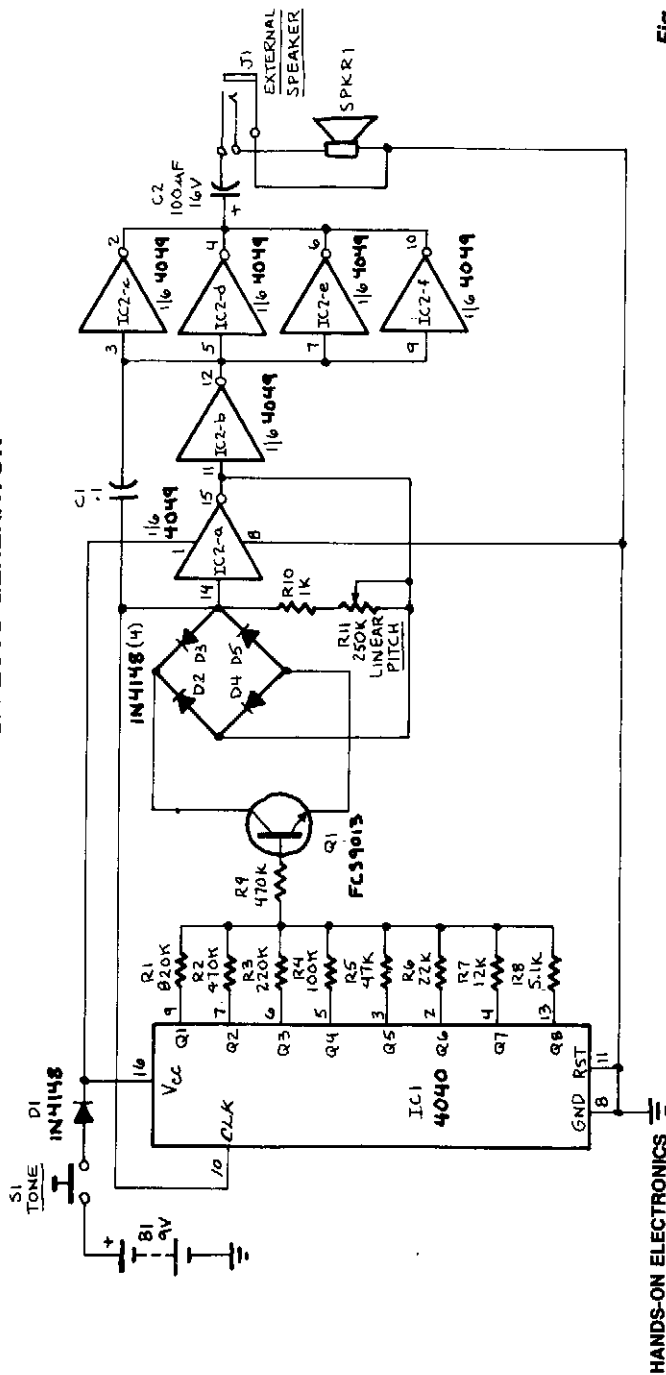
Sound Effect Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure-number contained in the box of each circuit correlates to the source entry in the Sources section.

Sound Effects Generator
Electronic Bongos
Train Chuffer
Bird Chirp
Steam Locomotive Whistle
WAA-WAA Circuit

Unusual Fuzz
Autodrum
Twang-Twang Circuit
Steam Train/Prop Plane
Funk Box

SOUND EFFECTS GENERATOR



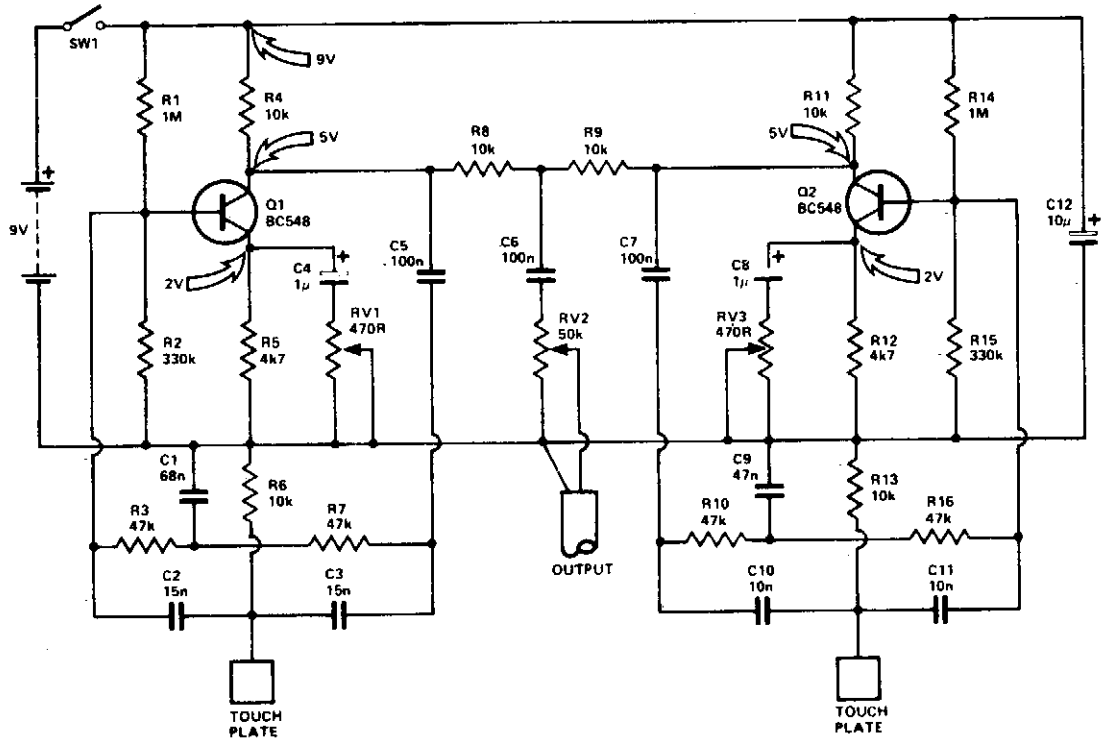
HANDS-ON ELECTRONICS

Fig. 91-1

Circuit Notes

This circuit can generate a European police-car siren, bird noises, spaceship sounds, etc. In addition, it can be put to use as a doorbell, an alarm, etc. The circuit consists of four parts: a binary counter, a D/A converter, a VCO, and an audio output amplifier. The initial frequency of oscillation is determined by potentiometer R11. The VCO first oscillates at a relatively low frequency, and gradually picks up speed as the control voltage supplied by the D/A converter increases. The D/A converter is the group of resistors R1-R8. When none of IC1's outputs is active, little current will flow into the base of Q1, so the VCO's control voltage will be low. As more and more counter outputs become active, base current increases, and thereby so does the VCO's frequency of oscillation. The VCO itself is composed of IC2-a, IC2-b, Q1, and the timing network comprising D1-D4, C1, R10, and R11. The buffer amplifier is made up of the four remaining gates from IC2, all wired in parallel.

ELECTRONIC BONGOS

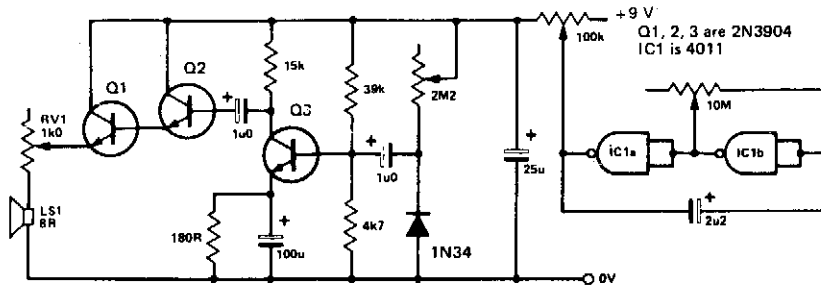


ELECTRONICS TODAY INTERNATIONAL

Circuit Notes

This circuit consists of twin-T sine-wave oscillators. Each oscillator has a filter in the feedback loop. If the loop gain is greater than unity, the circuit will oscillate. Gain is adjusted to be just less than unity. Touching the touch plate starts the oscillator, but the moment your finger is removed from the touch plate the oscillations will die away. The rate of decay is a function of circuit gain and controlled by RV1 (and RV3).

TRAIN CHUFFER



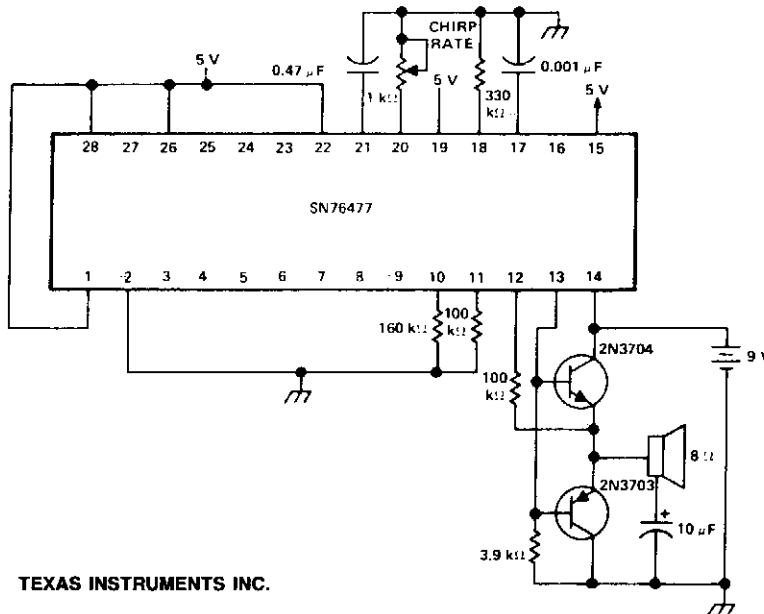
ELECTRONICS TODAY INTERNATIONAL

Fig. 91-3

Circuit Notes

The circuit consists of a white noise generator which only switches on with the high part of the square wave output from the clock circuit. The frequency of the clock is adjusted with the 10 M pot and the output voltage of the clock is adjusted by the 100 k pot (rate and volume of chuff respectively). The 2M2 pot controls the amount of noise produced and the 1 k pot on the speaker controls the pitch of the average noise.

BIRD CHIRP



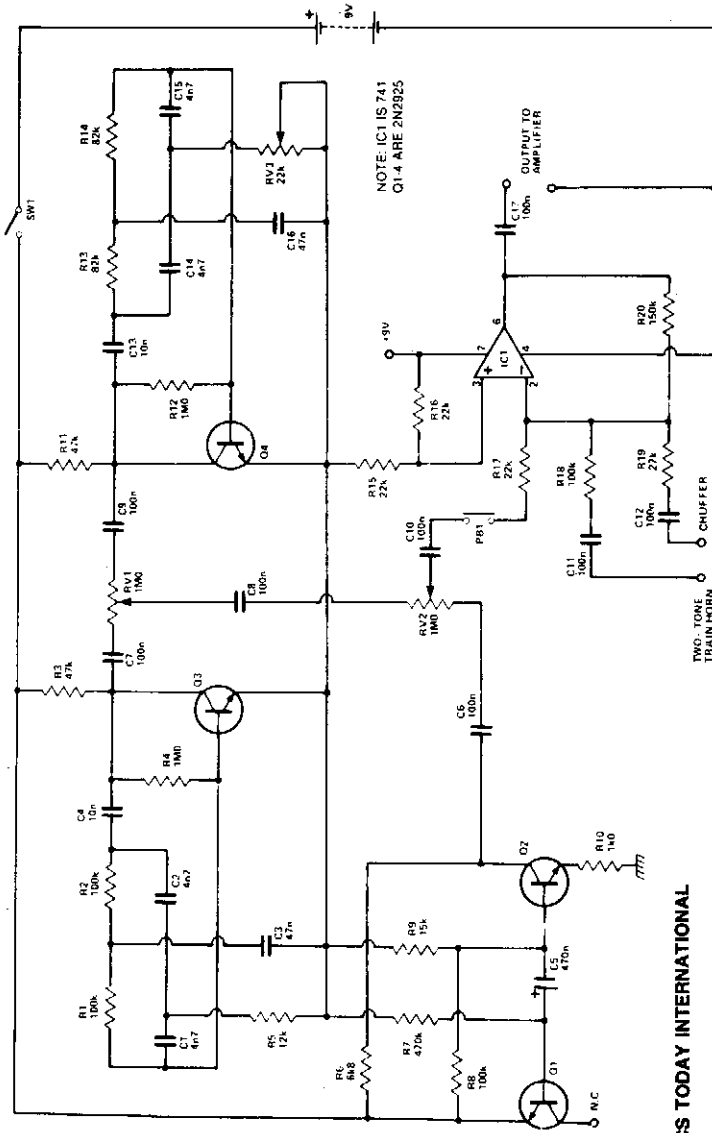
TEXAS INSTRUMENTS INC.

Fig. 91-4

Circuit Notes

For a barking dog, the capacitor at pin 17 is changed to 15 pF to increase the frequency of the VCO.

STEAM LOCOMOTIVE WHISTLE



ELECTRONICS TODAY INTERNATIONAL

Circuit Notes

The waveform of a steam whistle is a complex combination of white noise and an audio frequency oscillation. The noise generator is a transistor (Q1) biased into zener mode. The audio frequency oscillation is a straightforward mixture of two similar (but not identical) sine waves, which after their addition produce a more complex waveshape. The sine wave generators are twin-t oscillators. Preset RV1 mixes the two sine waves so that an appropriate waveform is obtained. Preset RV2 mixes this waveform with the white noise. Adjustment of all three presets will result in the required sound. Integrated circuit IC1 is an operational amplifier used as a simple mixer/amplifier which combines the steam whistle, chuffer, (generated elsewhere) and two-tone horn sounds into one, suitable for amplification by an external amplifier.

Fig. 91-5

WAA-WAA CIRCUIT

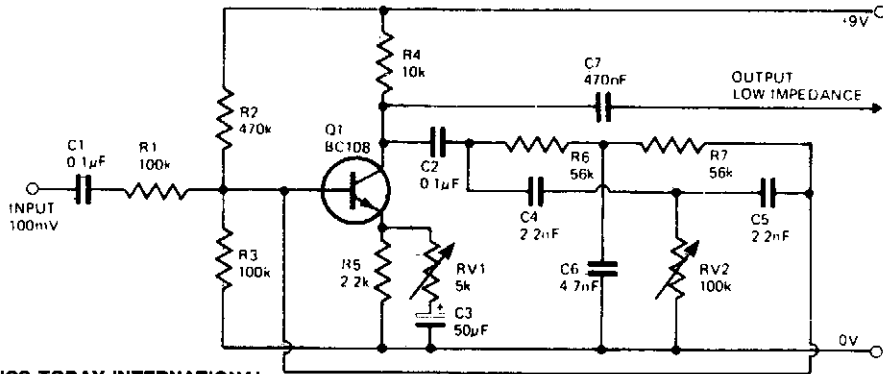


Fig. 91-6

ELECTRONICS TODAY INTERNATIONAL

Circuit Notes

The waa-waa effect is achieved as certain frequencies are amplified more than others. A phase shift RC oscillator makes up the basic circuit. Negative feedback is obtained by feeding part of the signal back to the base. When adjusting initially, RV1 is turned to minimum. RV2 is adjusted to a point at which an audible whistle appears indicating oscillation. RV1 is then adjusted till the oscillation just disappears. It should be possible to set RV2 to any value without any oscillation, this should also be achieved with the minimum possible value of RV1.

UNUSUAL FUZZ

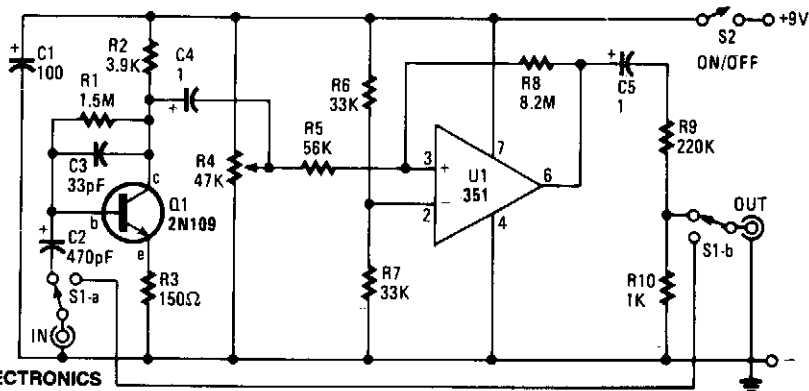


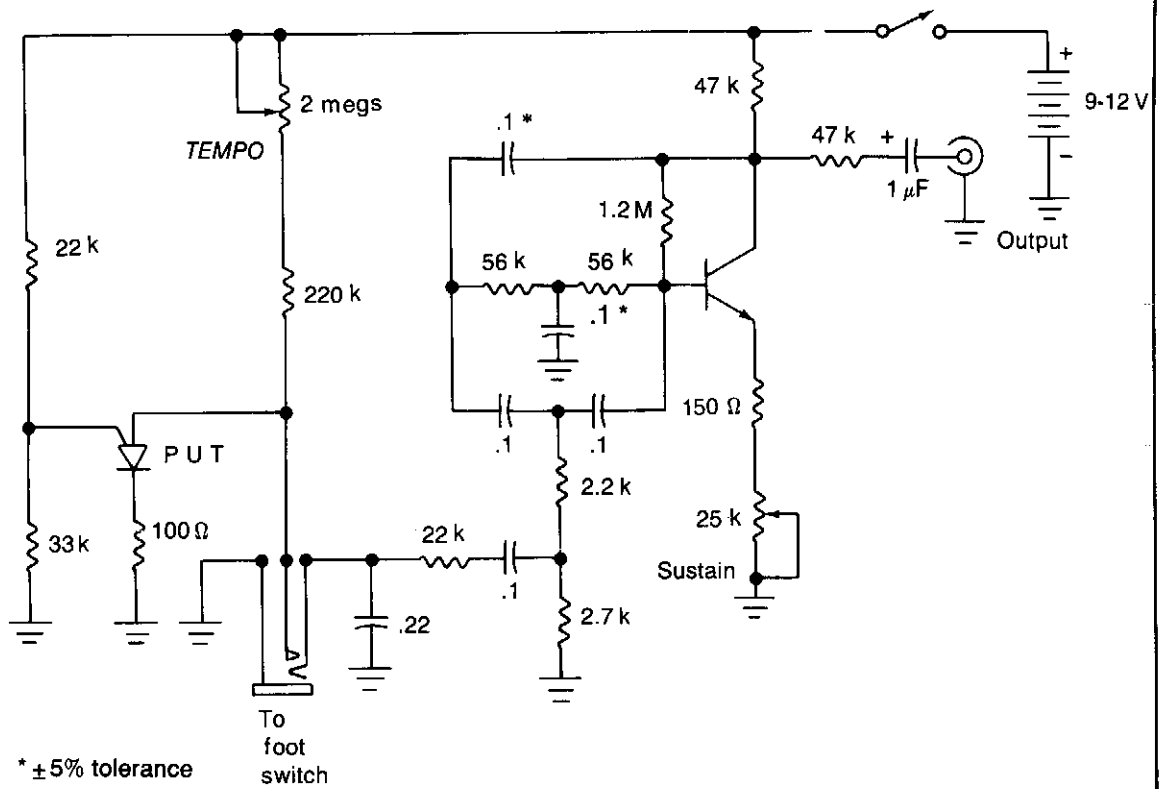
Fig. 91-7

HANDS-ON ELECTRONICS

Circuit Notes

It seems that guitar fuzz boxes have been around since the beginning of rock, and have seen little improvement over the years. This one is somewhat different because rather than simply distorting the sound, it also pulses in step with the peaks of the waveform from the pickup because of the Schmitt trigger op amp circuit. Capacitor C2 requires some explanation. It should normally be a 1- or 2- μ F electrolytic capacitor. However, we show the value as 470 pF because it's recommended as an experimental value giving far out effects.

AUTODRUM



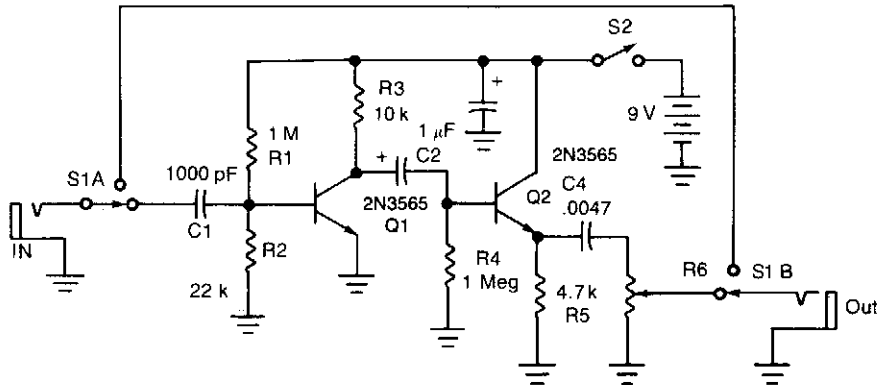
WILLIAM SHEETS

Fig. 91-8

Circuit Notes

This unit generates a drum-like damped oscillation that sounds best when fed into a higher power amplifier. The beat rate may be determined by operating a foot pedal in much the same manner as for a real drum, or by means of an internal oscillator, the speed of which may be preset.

TWANG-TWANG CIRCUIT



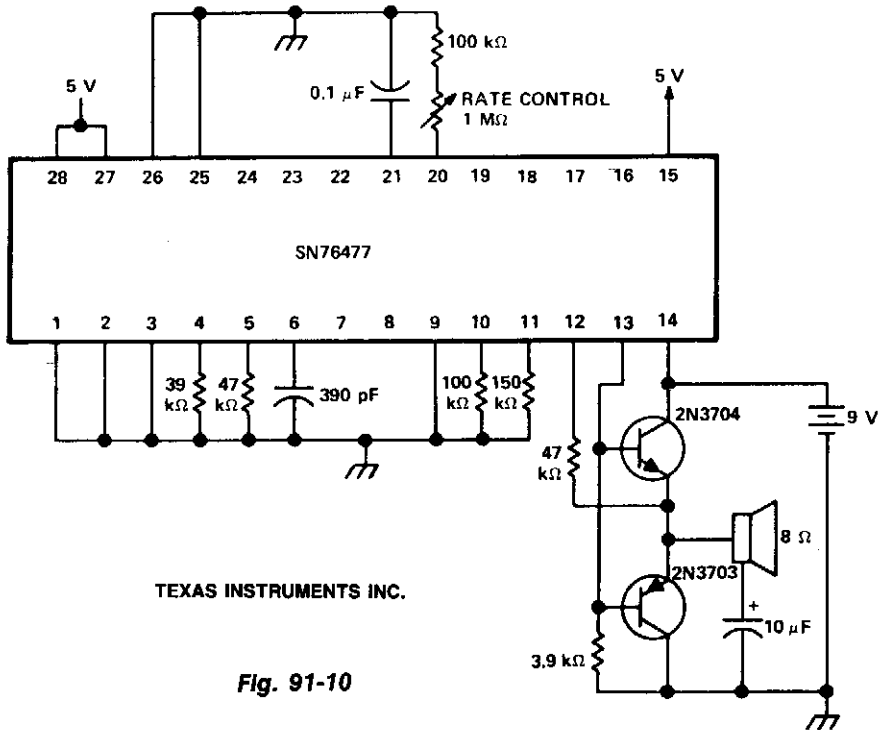
WILLIAM SHEETS

Fig. 91-9

Circuit Notes

Twang is a guitar sound that more or less approximates a banjo or mandolin. The circuit produces unusual sounds from an ordinary electric guitar by cutting the bass, severely distorting the midband and highs, and then amplifying the distortion. S1 cuts the effect in and out, S2 turns the unit on and off.

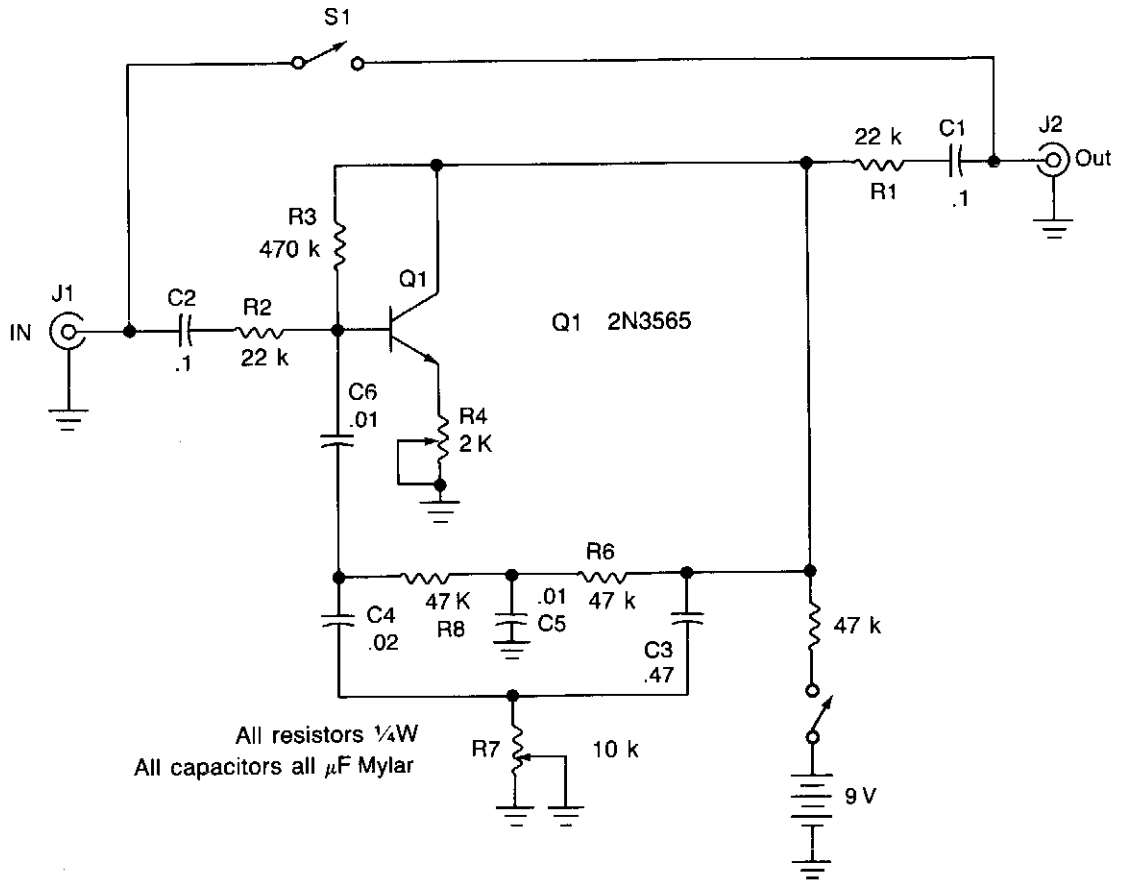
STEAM TRAIN/PROP PLANE



TEXAS INSTRUMENTS INC.

Fig. 91-10

FUNK BOX



WILLIAM SHEETS

Fig. 91-11

Circuit Notes

Adjusting potentiometer R7 adds extra twang from way down low to way up high. To set the unit, adjust potentiometer R4 until you hear a whistle (oscillation); then back off R4 until the oscillation just ceases. The effect can be varied from bass to treble by R7.

92

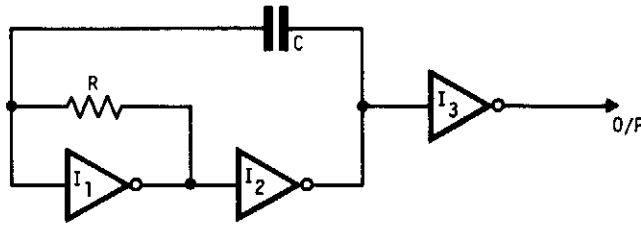
Square-Wave Generators

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Low Frequency TTL Oscillator
Square-Wave Generator Using a 555 Timer
Oscillator with Frequency Doubled Output
CMOS 555 Astable Generates True Rail-to-Rail
Square Waves
Square-Wave Oscillator

Astable Multivibrator
Two-MHz Square-Wave Generator Uses Two TTL
Gates
Phase Tracking Three-Phase Generator
Line Frequency Square-Wave Generator
Three Phase Square-Wave Output Generator

LOW FREQUENCY TTL OSCILLATOR



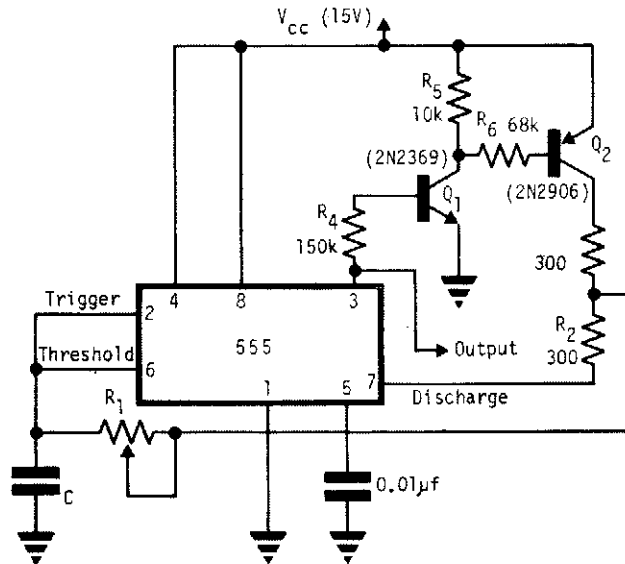
ELECTRONIC ENGINEERING

Fig. 92-1

Circuit Notes

This oscillator uses standard inverters, one resistor and one capacitor, and has no minimum operating frequency. R and C must be chosen such that currents into the gates are below recommended operating limits and that leakage current into the gates and into C are small in comparison with the current in R also the output should be buffered (I3) to prevent variations in load affecting frequency. This circuit may also be used to square up slowly changing logic levels by use of multi input gates (NANDS, NORS Etc).

SQUARE-WAVE GENERATOR USING A 555 TIMER



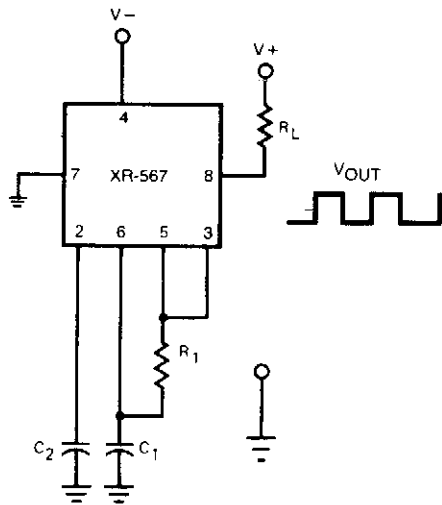
ELECTRONIC ENGINEERING

Fig. 92-2

Circuit Notes

A single timing resistor ensures that the output is a square (50% duty cycle) wave at all frequency settings.

OSCILLATOR WITH FREQUENCY DOUBLED OUTPUT



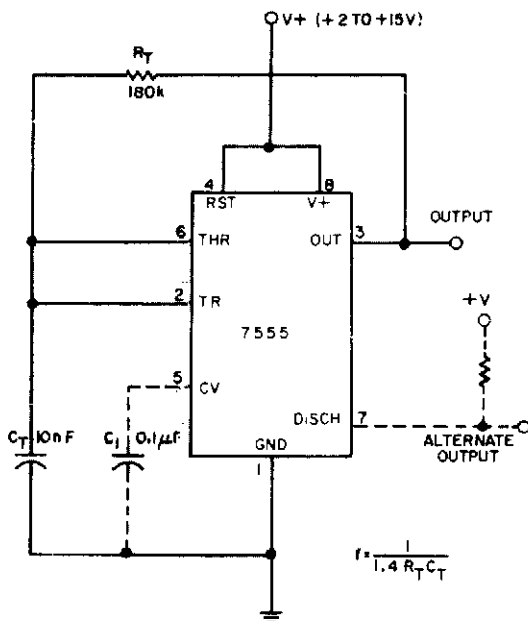
EXAR

Fig. 92-3

Circuit Notes

The current-controlled oscillator frequency can be doubled by applying a portion of the square-wave output at pin 5 back to the input at pin 3, as shown. In this manner, the quadrature detector functions as a frequency doubler and produces an output of $2 f_0$ at pin 8.

CMOS 555 ASTABLE GENERATES TRUE RAIL-TO-RAIL SQUARE WAVES



ELECTRONIC DESIGN

Fig. 92-4

Circuit Notes

A CMOS timer generates true square waves because, unlike the bipolar 555, its output swings from rail to rail. The component values shown give a frequency of about 400 Hz.

SQUARE-WAVE OSCILLATOR

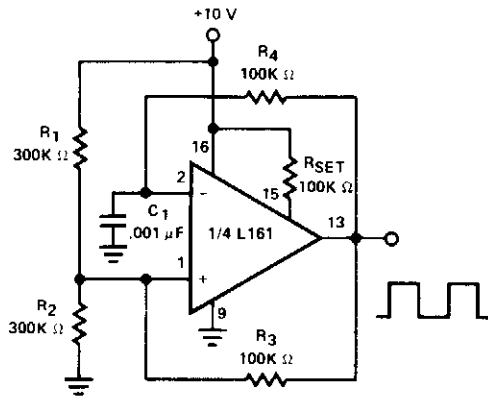
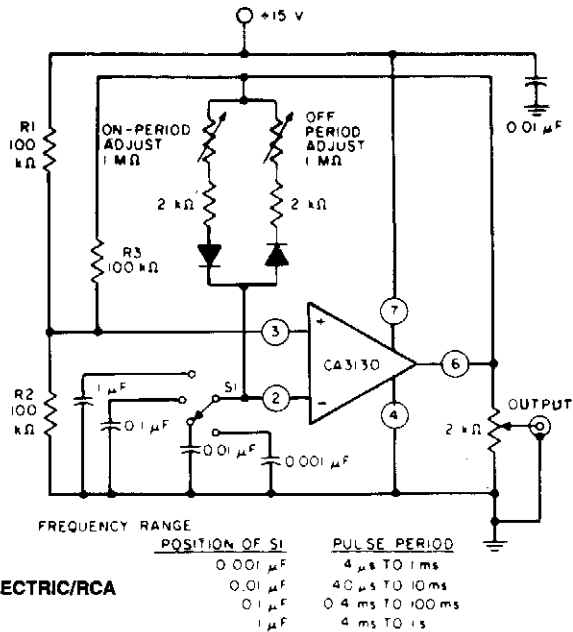


Fig. 92-5

SILICONIX

ASTABLE MULTIVIBRATOR



GENERAL ELECTRIC/RCA

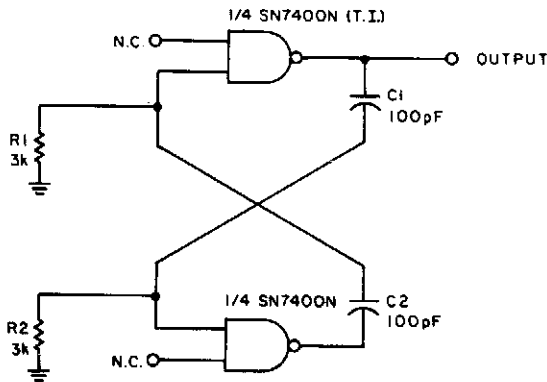
Fig. 92-6

Circuit Notes

The circuit with independent control of "ON" and "OFF" periods uses the CA3130 BiMOS op amp for filters, oscillators, and long-duration timers. With input current at 50 pA, oscillators can utilize large-resistor/small-capacitor combinations without loading effects.

TWO-MHz SQUARE-WAVE GENERATOR USES TWO TTL GATES

N.C. = NO CONNECTION



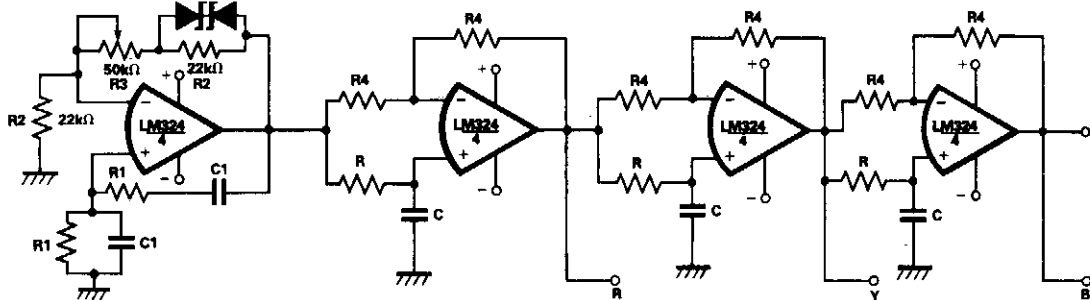
Circuit Notes

With the values shown the circuit generates a 2-MHz symmetrical square wave. Changing capacitors C1 and C2 to 0.01 μF results in a frequency of 500 Hz. For the particular integrated circuits and power supply voltages (5.0 V), the reliable operating range of $R1 = R2$ is 2 k ohm to 4 k ohm.

ELECTRONIC DESIGN

Fig. 92-7

PHASE TRACKING THREE-PHASE GENERATOR



ELECTRONIC ENGINEERING

Fig. 92-8

Circuit Notes

Using a single chip LM324 can, with active R-C networks, reduce the size of a 3-phase waveform generator, and prove useful in compact and stable 3-phase inverters. One quarter of an LM324 is used as a Wien bridge oscillator generating a pure sinusoidal waveform while the remaining parts of the LM324 are used as three 120° fixed phase shifters. Initially potentiometer R3 should be varied to adjust the loop gain of the oscillator in order to start the oscillator.

LINE FREQUENCY SQUARE-WAVE GENERATOR

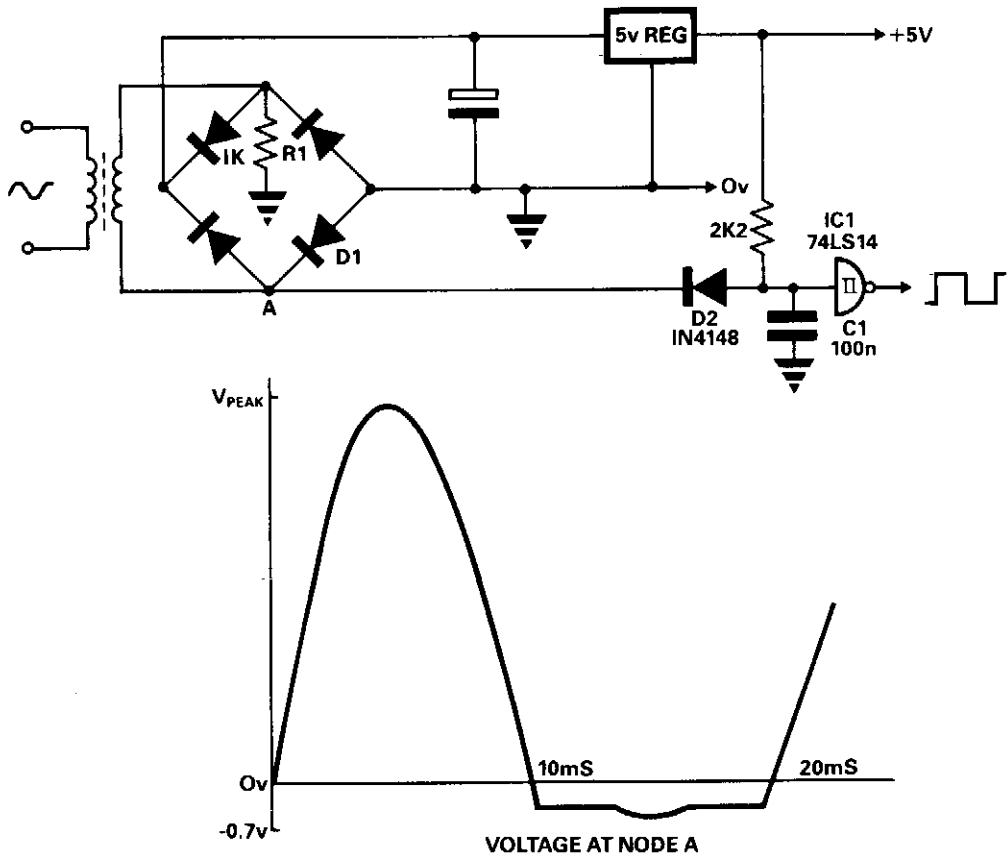


Fig. 92-9

ELECTRONIC ENGINEERING

Circuit Notes

With only three components and a buffer, a line frequency square wave having a 1:1 duty cycle may be derived from the power supply. During the alternate half-cycle, however, A is effectively clamped to -0.7 V by D1 in the bridge which offsets the forward voltage across D2 giving an input to IC1 of approximately 0 V. When A rises above +5 V, D2 is reverse biased and remains at +5 V. R1 is needed to load the transformer secondary maintaining a distortion-free waveform at A during the time the diode bridge is not conducting. C1 although not essential may be required to remove transients.

THREE PHASE SQUARE-WAVE OUTPUT GENERATOR

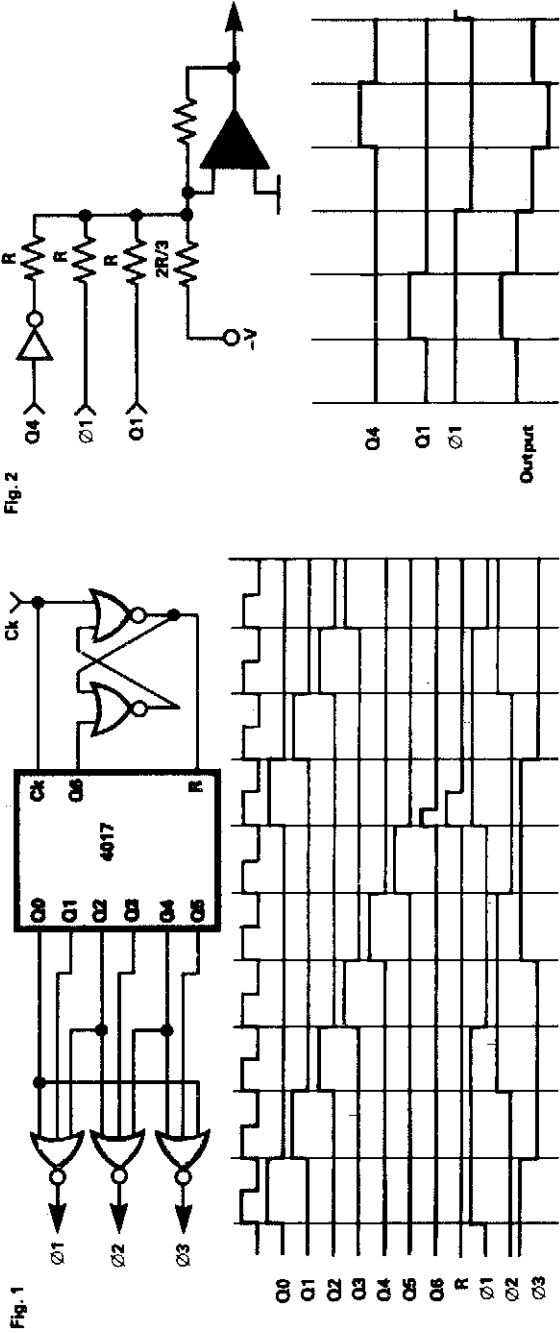


Fig. 92-10

Circuit Notes

This circuit gives a 3 phase square-wave output for a variable speed motor drive. Operation is straightforward, the 4017 counter is synchronously reset after six clock inputs. The six outputs are combined to give the required waveforms. It is interesting to note that although NOR gates are shown, OR gates will give effectively the same result. The circuit can be extended as shown in Fig. 2 to give pseudo-sine waves if that is required, but that will diminish the simplicity of the circuit.

ELECTRONIC ENGINEERING

93

Staircase Generator Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Staircase Generator
Staircase Generator II

STAIRCASE GENERATOR

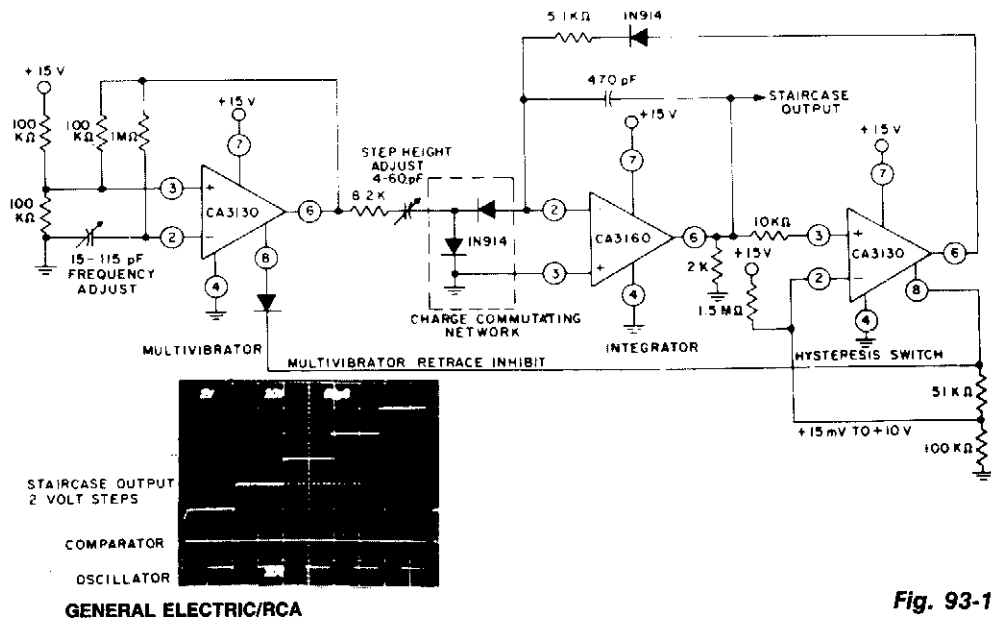
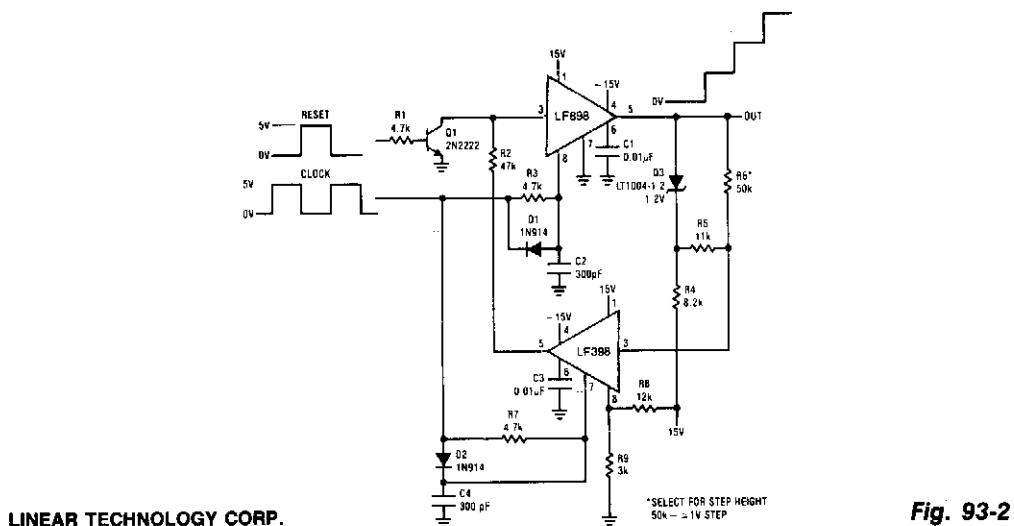


Fig. 93-1

Circuit Notes

The circuit uses three BiMOS op amps. Two CA3130's are used, one as a multivibrator and the other as a hysteresis switch. The third amplifier, a CA3160, is used as a linear staircase generator.

STAIRCASE GENERATOR II



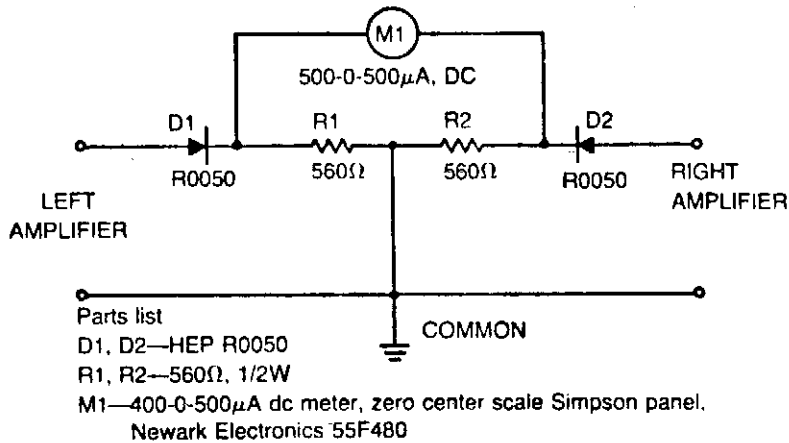
94

Stereo Balance Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Stereo Balance Tester
Stereo Balance Meter

STEREO BALANCE TESTER



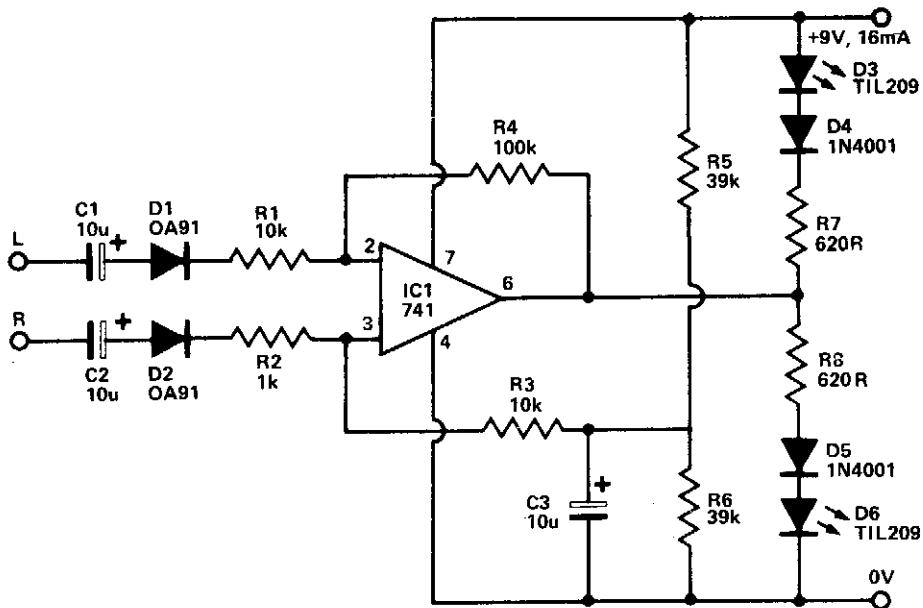
TAB BOOKS INC.

Fig. 94-1

Circuit Notes

The meter will show volume and tone control balance between left and right stereo amplifiers. For maximum convenience the meter is a zero-center type. Resistors are five percent or better and the diodes a matched pair. Optimum stereo level and phase balance occurs for matched speakers when the meter indicates zero. If the meter indicates either side of zero, the levels are not matched or the wires are incorrectly phased. Check phasing by making certain the meter leads are connected to the amplifier hot terminals and the common leads go to ground.

STEREO BALANCE METER



ELECTRONICS TODAY INTERNATIONAL

Fig. 94-2

Circuit Notes

To use the indicator, switch the amplifier to mono mode and adjust the balance control until both LEDs are equally illuminated. The amplifier is now in perfect stereo mode balance.

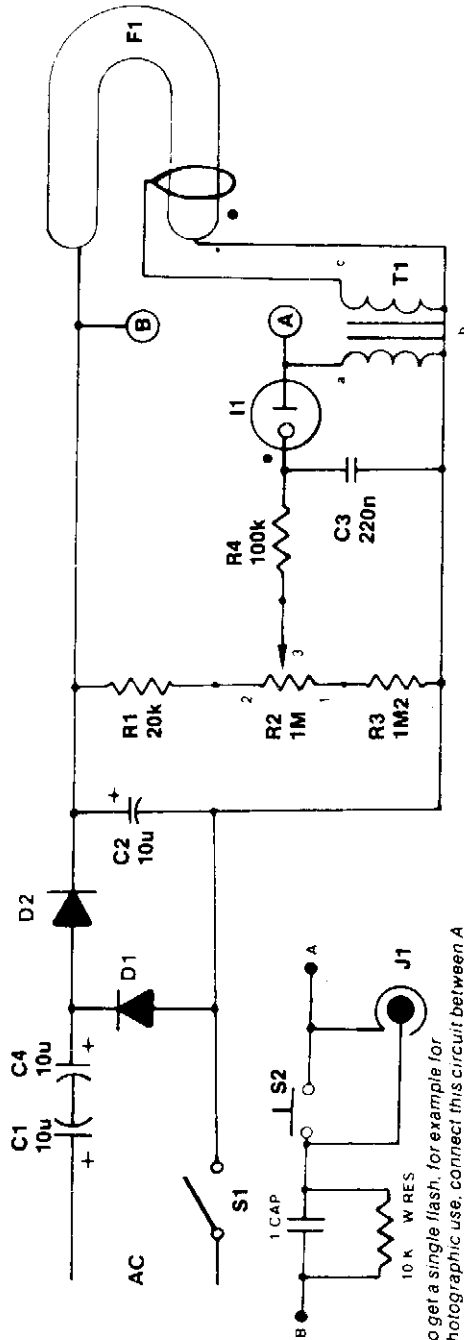
95

Strobe Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Simple Strobe
Safety Flare
Disco-Strobe Light

SIMPLE STROBE



To get a single flash, for example for photographic use, connect this circuit between A and B in the main circuit. With R2 in the position for slowest flash rate (ie no flashes!) S2 will provide the desired single flash. Alternatively J1 can be used to allow the camera's flash contacts to trigger the strobe.

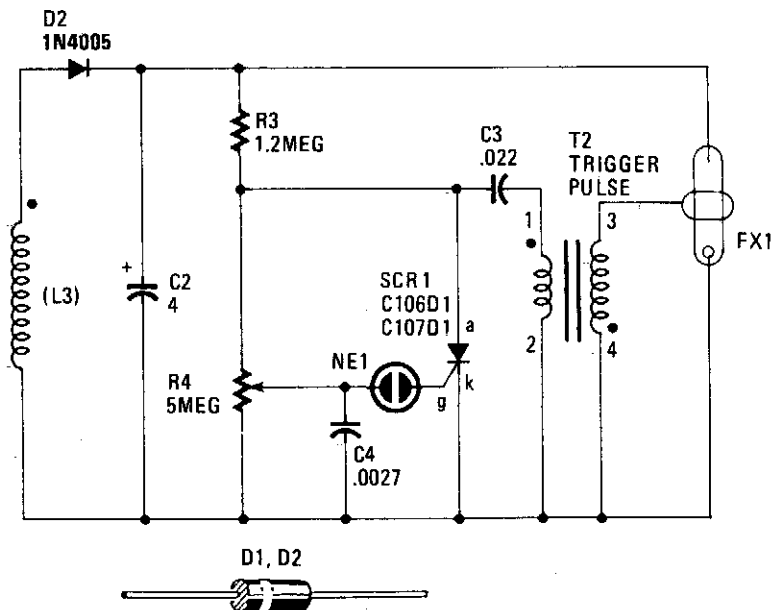
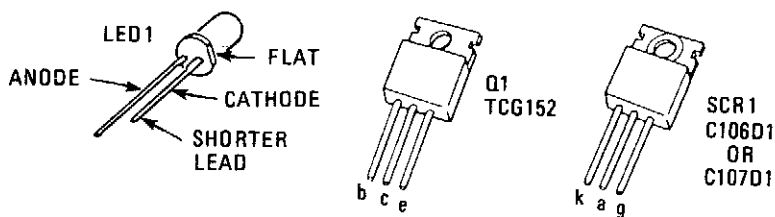
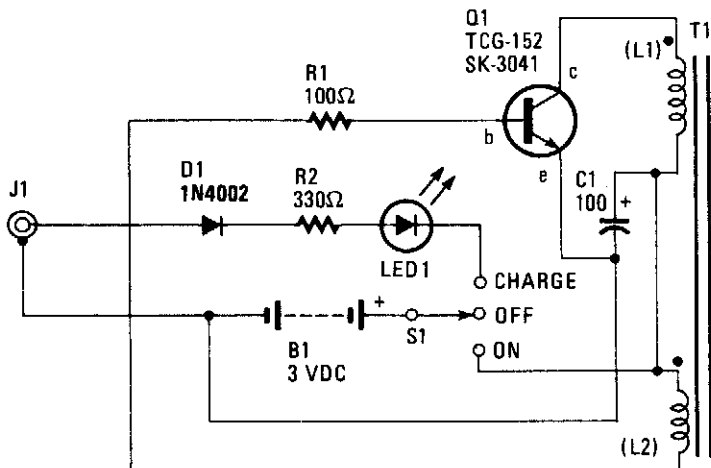
ELECTRONICS TODAY INTERNATIONAL

Fig. 95-1

Circuit Notes

Initially the neon and xenon lamps are not conducting and act like a very high (almost infinite) resistance. Capacitors C1 and C4 in conjunction with D1 and D2 form a voltage doubler circuit, which can charge C2 up to about 300 Vdc after several ac cycles. Voltage increases as current is supplied through R1 and R2. Neon bulb I1 will all of a sudden start to conduct when the voltage across C3 reaches I1's ionization potential. While conducting, the resistance of the bulb will be relative low. Due to this sudden conduction, a pulse of current will pass through the primary of T1. The turns ratio is such that about 400 V will be developed at the secondary of T1. The turns ratio is to the neon bulb in that it produces light when the gas ionizes and conducts. However, it is designed so that an external signal (the 4 kV on the metal ring around the tube) ionizes the gas and initiates the conduction. When F1 conducts, it discharges C2. At this point, the whole cycle starts over again. The purpose of R2 is to vary the rate at which C3 charges, and hence the repetition rate of the strobe.

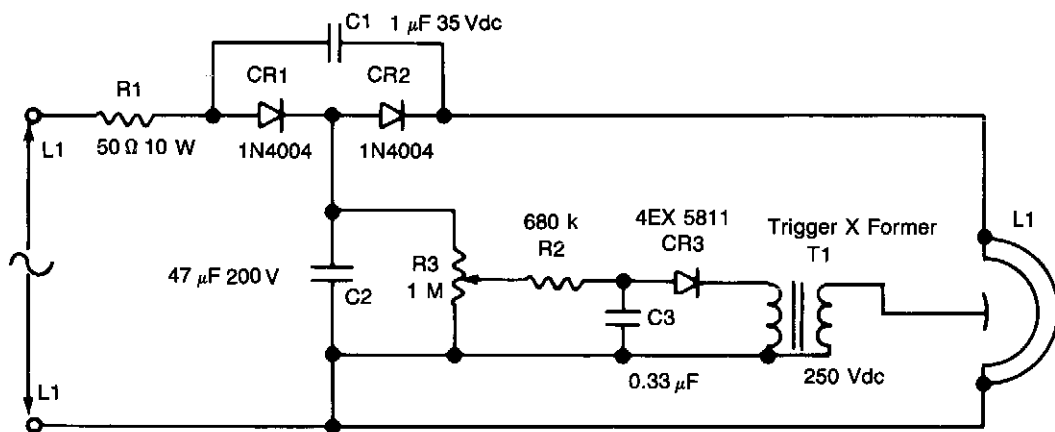
SAFETY FLARE



Circuit Notes

When S1 is on, power is applied to an oscillator composed of Q1, R1, C1, L1, and L2. Coil L1 is the primary winding of T1, and L2 is the feedback winding. When Q1 turns on, its collector current saturates T1's ferrite core. That, in turn, removes the base drive to Q1 through L2. Transistor Q1 then turns off. As the field around L1 and L2 decays, Q1 will eventually turn on again, and the cycle repeats over, and over. Transformer T1 is a step-up, ferrite-core, potted-type unit whose secondary-winding (L3) output is rectified by D2 and filtered by C2. That capacitor charges up to around 250 to 300 volts, which is applied to the resistor divider composed of R3 and R4, along with the flash tube FX1. Capacitors C3 and C4 will charge up to around 200 and 100 volts, through R3 and R4, respectively. Flash rate is adjustable via R4. When the charge on C4 gets to around 100 volts, neon lamp NE1 fires discharging C4 into the gate circuit of silicon control rectifier SCR1. The SCR1 turns on discharging C3 into the primary winding of trigger-pulse transformer T2. Transformer T2 is another step-up, pulse-type unit providing an output of around 4 kW across transformer T2's secondary winding. The xenon gas inside FX1 is ionized and a bright flash is emitted. Finally, C3 quickly discharges through L4, and the cycle repeats over, and over.

DISCO-STROBE LIGHT



WILLIAM SHEETS

Fig. 95-3

Circuit Notes

This circuit uses a voltage doubler CR1 and CR2 to obtain about 280 V dc across C1. C2 and R3 form a voltage divider to obtain a dc voltage to charge C3 thru R2. When CR3 fires, a high voltage is generated in T1, firing L1.

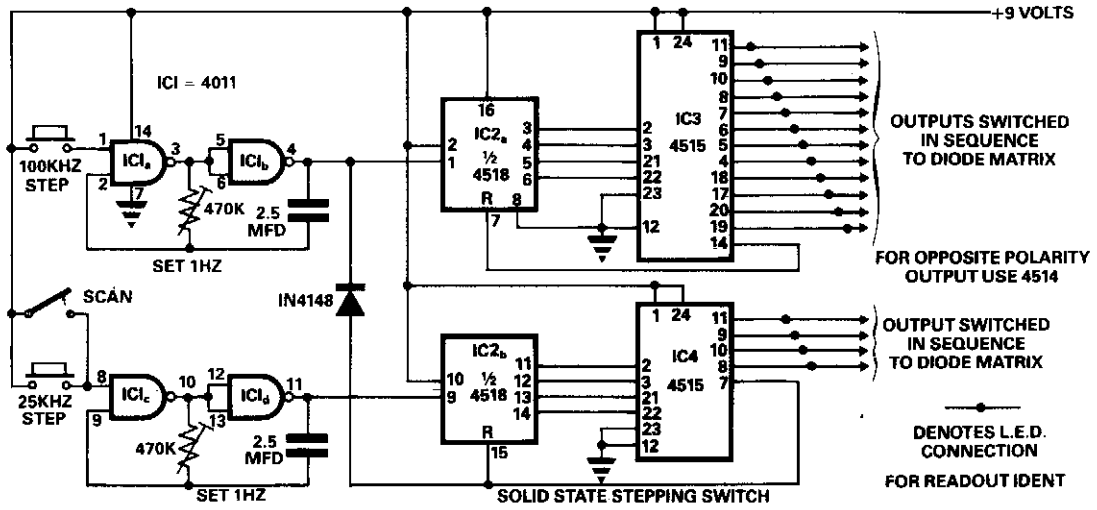
96

Switch Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Solid State Stepping Switch
AC-Static SPDT Switch

SOLID STATE STEPPING SWITCH



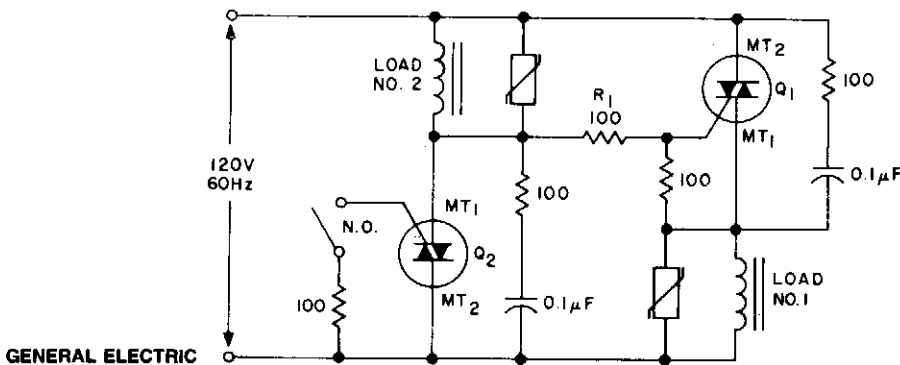
ELECTRONIC ENGINEERING

Fig. 96-1

Circuit Notes

This circuit was designed to make switching of a 48-channel mobile transceiver safe to operate while mobile. The oscillators allow for single-stepping or a scanning function. The scan facility allows for stepping through all 48 channels to check for occupancy or otherwise, and each output is indicated with an LED and labeled accordingly, so at-a-glance indication is possible. With full scope of this circuit it is possible to scan 256 channels and by adding more 4 to 16 line encoders etc. you could switch to any required number.

AC-STATIC SPDT SWITCH



GENERAL ELECTRIC

Fig. 96-2

Circuit Notes

An SPDT solid state relay is shown. When voltage is applied Q1 will turn on, activating load #1, because the full line voltage appears across Q2, supplying gate current through R1. When S1 is closed, Q2 turns on removing the gate drive from Q1 and activating load #2.

97

Tape Recorder Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Tape Recorder Interface
Tape Recorder Position Indicator/Controller

TAPE RECORDER INTERFACE

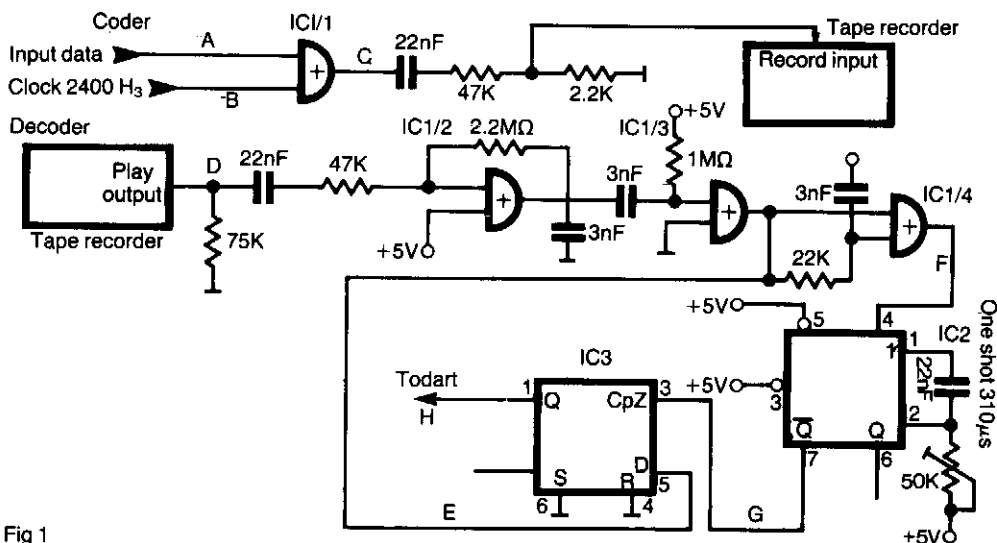


Fig 1

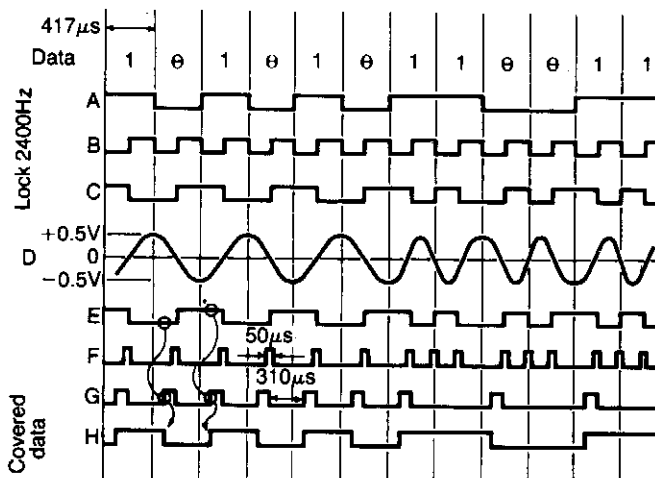


Fig 2

ELECTRONIC ENGINEERING

Fig. 97-1

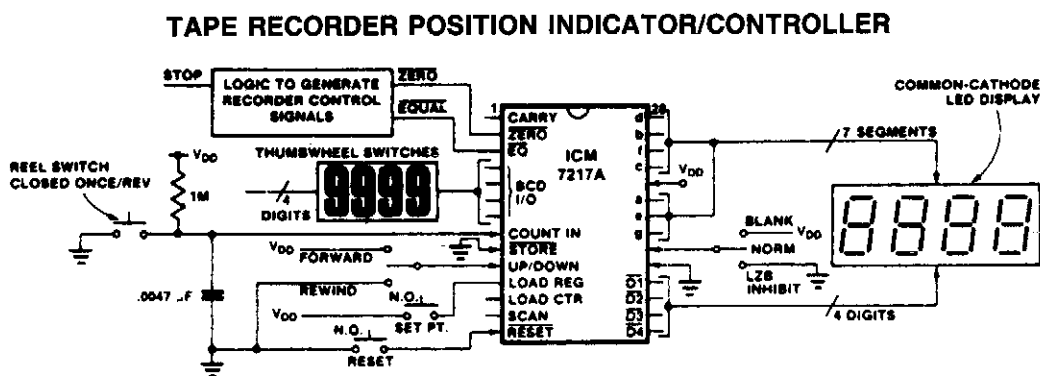
Circuit Notes

The interface allows data to be saved on an ordinary tape recorder at a speed of 2400 bit/s.

The serial stream of data Fig. 1 (A) is coded with a clock of 2400 Hz (B), by means of XOR gate IC 1/1. Logical "high" and "low" appear as shown in Fig. 2 (C). These impulses are lowered in amplitude and feed into the record input of a low cost tape recorder.

TAPE RECORDER INTERFACE, Continued.

During the playback, pulses (D) are amplified with CMOS gate IC 1/2 connected as a linear amplifier, and providing a TTL level signal shown in (E). On both positive and negative transitions IC 1/4 forms short pulses as shown in (F) (approx. 50 μ s) that triggers one shot IC2. A monostable one shot pulse width is adjusted to be $\frac{3}{4}$ of bit length (310 μ s). A change from "high" to "low" in a coded stream generates a "low" pulse width of one bit cell. The same is for change from "low" to "high" that generates a "high" pulse of the same width. During this pulse one shot latches the state of line E in D type flip-flop IC3 (G). When a stream consists of multiple "ones" or "zeros," the one shot is retriggered before it comes to the end of the quasistable state and the state of the flip-flop remains unchanged. The original data stream is available at the output of the flip-flop (H). Z80 the DUART that receives these pulses is programmed so that the receiver clock is 16 times the data rate (38.4 kHz).



INTERSIL

Fig. 97-2

Circuit Notes

This circuit is representative of the many applications of up/down counting in monitoring dimensional position. In the tape recorder application, the LOAD REGISTER, EQUAL, and ZERO outputs are used to control the recorder. To make the recorder stop at a particular point on the tape, the register can be set with the stop at a particular point on the tape, the register can be set with the stop point and the EQUAL output used to stop the recorder either on fast forward, play or rewind.

To make the recorder stop before the tape comes free of the reel on rewind, a leader should be used. Resetting the counter at the starting point of the tape, a few feet from the end of the leader, allows the ZERO output to be used to stop the recorder on rewind, leaving the leader on the reel. The 1 M ohm resistor and .0047 μ F capacitor on the COUNT INPUT provide a time constant of about 5 ms to debounce the reel switch. The Schmitt trigger on the COUNT INPUT of the ICM7217 squares up the signal before applying it to the counter. This technique may be used to debounce switchclosure inputs in other applications.

98

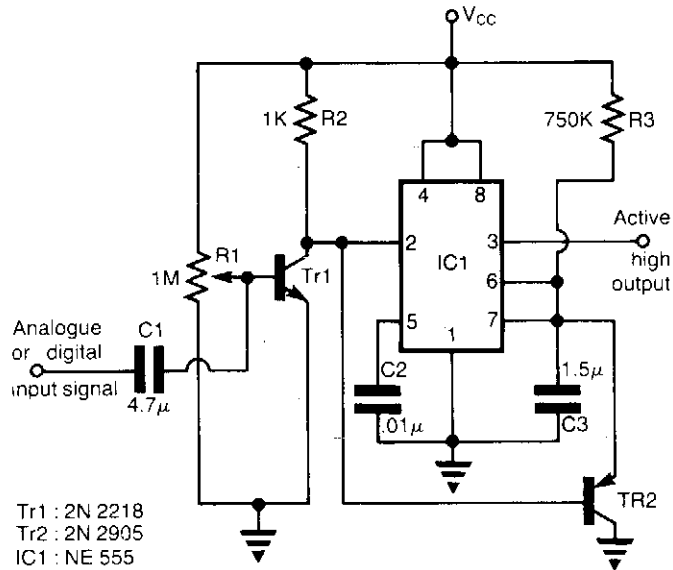
Telephone-Related Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Speech Activity Detector for Telephone Lines
Scramble Phone
Musical Telephone Ringer
Dual Tone Decoding
Automatic Telephone Recording Device
Telephone Ringing Detector, Frequency and Volume Controlled
Music on Hold
Circuit Monitors Blinking Phone Lights
Phone Light
High Isolation Telephone Ringer

Remote Telephone Monitor
Plug-In Remote Telephone Ringer
Telephone Hold Button
Telephone Blinker
Telephone "In Use" Indicator
Tone Ringer
Tone Ringer II
Speakerphone
Speech Network
Programmable Multi-Tone Telephone Ringer

SPEECH ACTIVITY DETECTOR FOR TELEPHONE LINES



ELECTRONIC ENGINEERING

Fig. 98-1

Circuit Notes

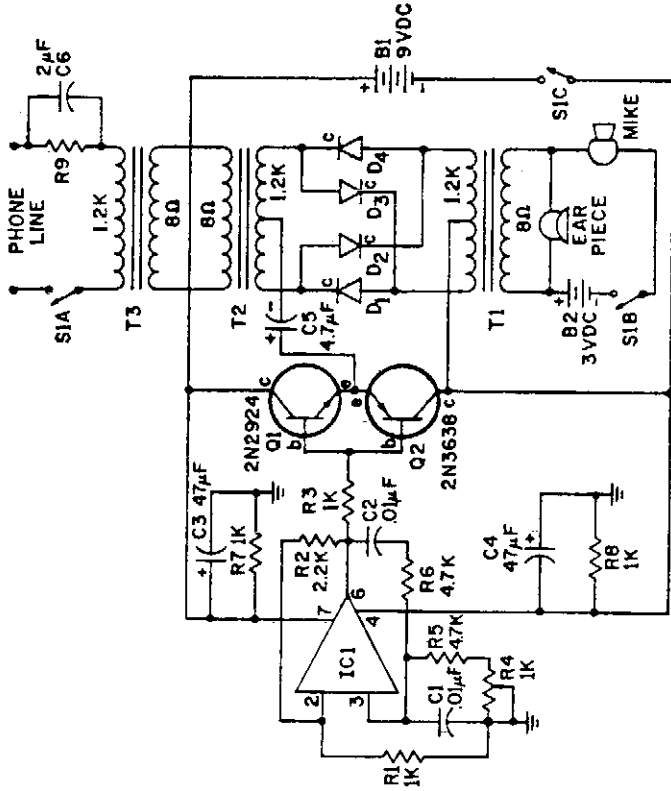
The circuit can be used in telephone lines for speech activity detection purposes. This detection is very useful in the case of half-duplex conversation between two stations, in the case of simultaneous transmission of voice and data over the same pair of cables by the method of interspersion data on voice traffic, and also in echo suppressor devices. The circuit consists of a class-A amplifier in order to amplify the weak analog signals (in the range 25-400 mW of an analog telephone line).

The IC1 is connected as a retriggerable monostable multivibrator with the Tr2 discharging the timing capacitor C3, if the pulse train reaches the trigger input 2 of IC1 with period less than the time:

$$T_{\text{high}} = 1.1 (R3 C3)$$

The output 3 of IC1 is active ON when an analog or digital signal is presented at the output and it drops to low level, T_{high} seconds after the input signal has ceased to exist.

SCRAMBLE PHONE



Circuit Notes

IC-1 and the associated circuitry form a stable audio tone generator that feeds a buffer amplifier, Q1 and Q2. The tone output is taken from the emitters of the transistor pair to supply a carrier voltage for a balanced modulator made up of four diodes—D1 through D4—and T1 and T2. If the two transformers and the four diodes are perfectly matched (which is almost impossible to achieve and not necessary in any case) no carrier will appear at the input or output of T1 or T2. In a practical circuit, a small amount of unbalance will occur and produce a low-level carrier tone at the input and output of the balanced modulator. A telephone carbon mike and earpiece are connected to the low impedance winding of T1, with a three volt battery supplying the necessary mike current. Trim potentiometer R4 is used to make a fine frequency adjustment of the oscillator so that two scrambler units may be synchronized to the same carrier frequency. Rg limits line current to 25 mA.

- B1—9-volt battery, Eveready 216 or equiv.
- B2—3-volt battery, two AA penlight cells in series
- C1, C2—0.01 μ F polystyrene capacitor, 100 VDC or better
- C3, C4—47 μ F electrolytic capacitor, 25 VDC or better
- C5—4.7 μ F electrolytic capacitor, 25 VDC or better
- C6—2 μ F paper or mylar capacitor, 50 VDC or better
- D1 to D4—Diode, IN914, HEP-156
- IC1—Integrated circuit, Signetics N5741K or equiv.
- Q1—NPN transistor, 2N2924, HEP-724

- Q2—PNP transistor, 2N3638, HEP-716
- R1, R3, R7, R8—1000-ohm, 1/2-watt resistor
- R2—2,200-ohm 1/2-watt resistor
- R4—1000-ohm potentiometer
- R5, R6—4,700-ohm, 1/2-watt resistor
- R9—Limit line current to 25mA (see text)
- S1A, S1B, S1C—Phone hook switch (see text)
- T1 to T3—Small transistor audio transformer; 8-ohm primary, 1,200-ohm center tapped secondary.
- Misc.—Surplus telephone (see Lafayette, Radio Shack, EDI, BA catalogs), battery holders, hardware, knob, wire, solder, etc.

TAB BOOKS, INC.

Fig. 98-2

MUSICAL TELEPHONE RINGER

Circuit Notes

The heart of the circuit is IC1, General Instrument's AY-3-1350 melody-synthesizer IC. IC2 is a TCM1512 telephone ring detector IC that is powered by the telephone line. The circuit's operation begins when IC2 senses a ring pulse on the telephone line. The detector (internally) rectifies the ring signal and then outputs a voltage to relay RY1 (an SPST reed-type relay with 5 volt contacts), causing its contacts to close. That pulls pin 12 (the ON/OFF control) of IC1 low (logic '0'), causing it to output a signal—the selected tune—to transistor amplifier Q2. The amplified signal is then fed to the speaker. The melody continues to play either until the tune is finished (at which time IC1 returns to the standby mode), or until someone takes the phone off the hook. Taking the phone off the hook discontinues the ring pulses to IC2, which opens RY1. When the relay contacts open, pin 12 of IC1 goes high, returning the circuit to the standby mode to wait for the next incoming phone call.

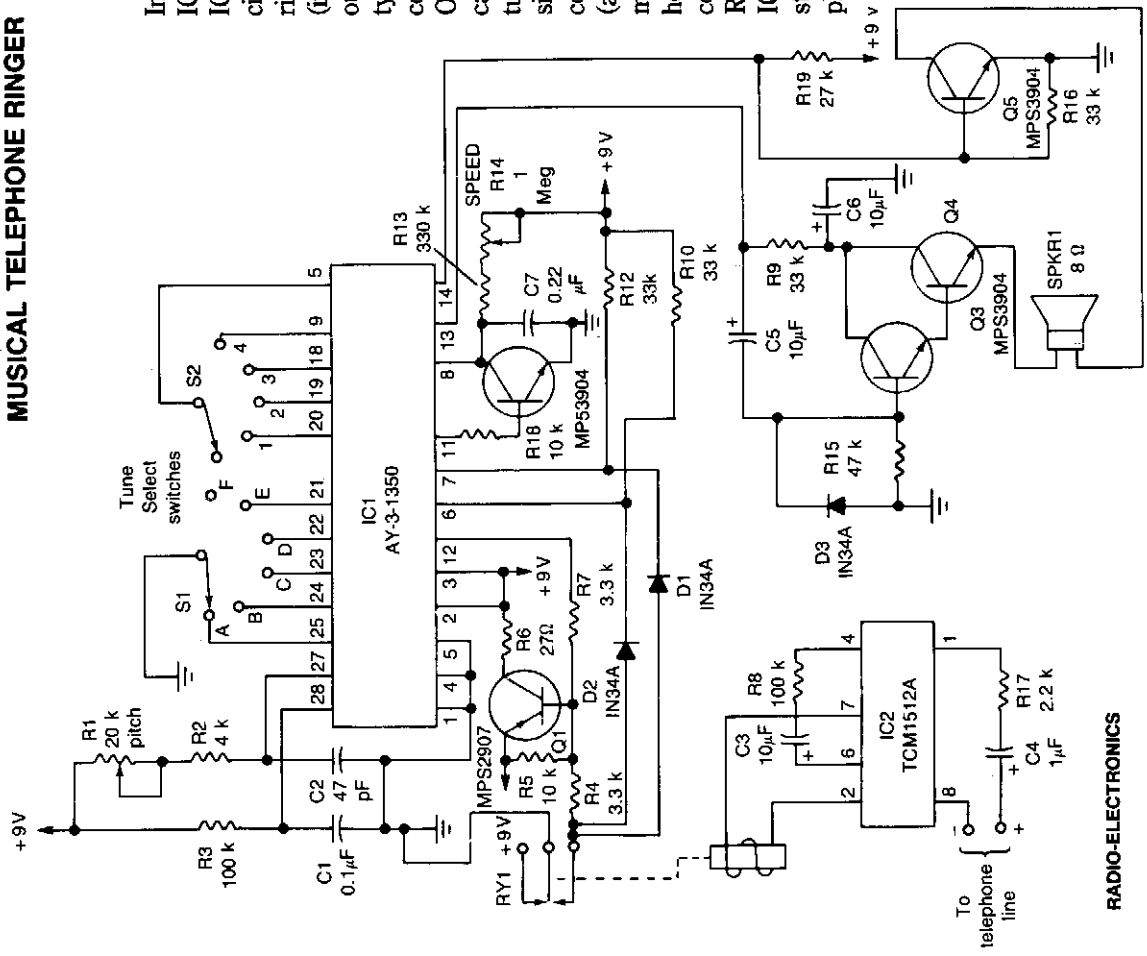


Fig. 98-3

RADIO-ELECTRONICS

DUAL TONE DECODING

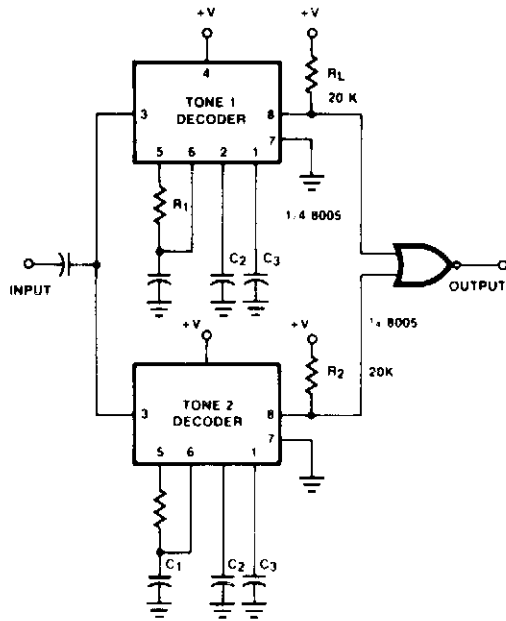


Figure 1A. Detection of Two Simultaneous or Sequential Tones

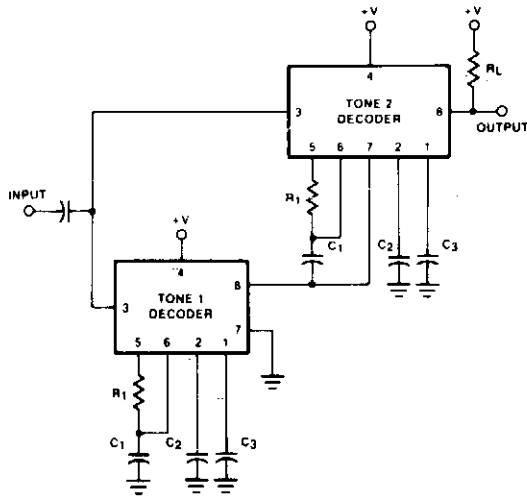


Figure 1C

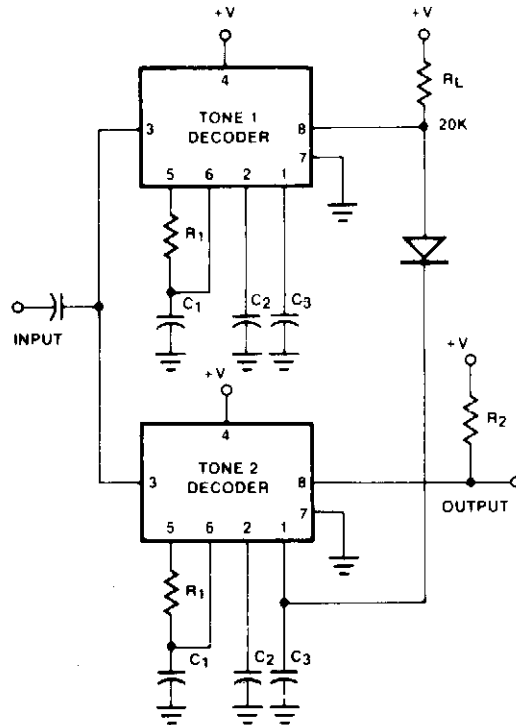


Figure 1B

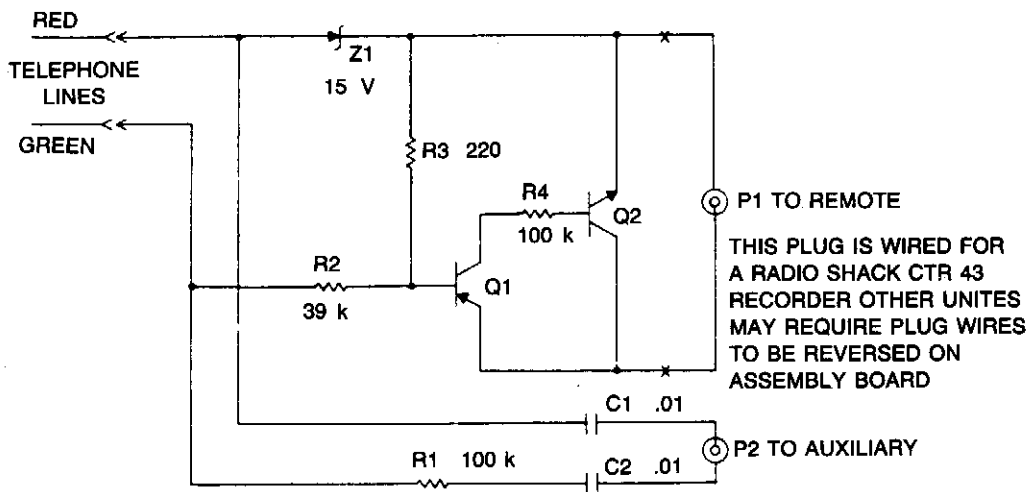
EXAR

Fig. 98-4

Circuit Notes

Two integrated tone decoders, XR-567 units, can be connected (as shown in Fig. 1A) to permit decoding of simultaneous or sequential tones. Both units must be on before an output is given. R_1C_1 and R_1C_1 are chosen, respectively, for Tones 1 and 2. If sequential tones (1 followed by 2) are to be decoded, then C_3 is made very large to delay turn-off of Unit 1 until Unit 2 has turned on and the NOR gate is activated. Note that the wrong sequence (2 followed by 1) will not provide an output since Unit 2 will turn off before Unit 1 comes on. Figure 1B shows a circuit variation which eliminates the NOR gate. The output is taken from Unit 2, but the Unit 2 output stage is biased off by R_2 and C_1 until activated by Tone 1. A further variation is given in Fig. 1C. Here, Unit 2 is turned on by the Unit 1 output when Tone 1 appears, reducing the standby power to half. Thus, when Unit 2 is on, Tone 1 is or was present. If Tone 2 is now present, Unit 2 comes on also and an output is given. Since a transient output pulse may appear at Unit 1 turn-on, even if Tone 2 is not present, the load must be slow in response to avoid a false output due to Tone 1 alone. The XR-267 Dual Tone Decoder can replace two integrated tone decoders in this application.

AUTOMATIC TELEPHONE RECORDING DEVICE



CONNECT TO ANY CONVENIENT PHONE JACK OR WHEREVER ACCESS TO WIRES IS AVAILABLE. MAY BE CONNECTED VIA ALLIGATOR CLIPS, PLUGS OR MODULAR PLUG.

SPECIAL NOTE
SEE TEXT

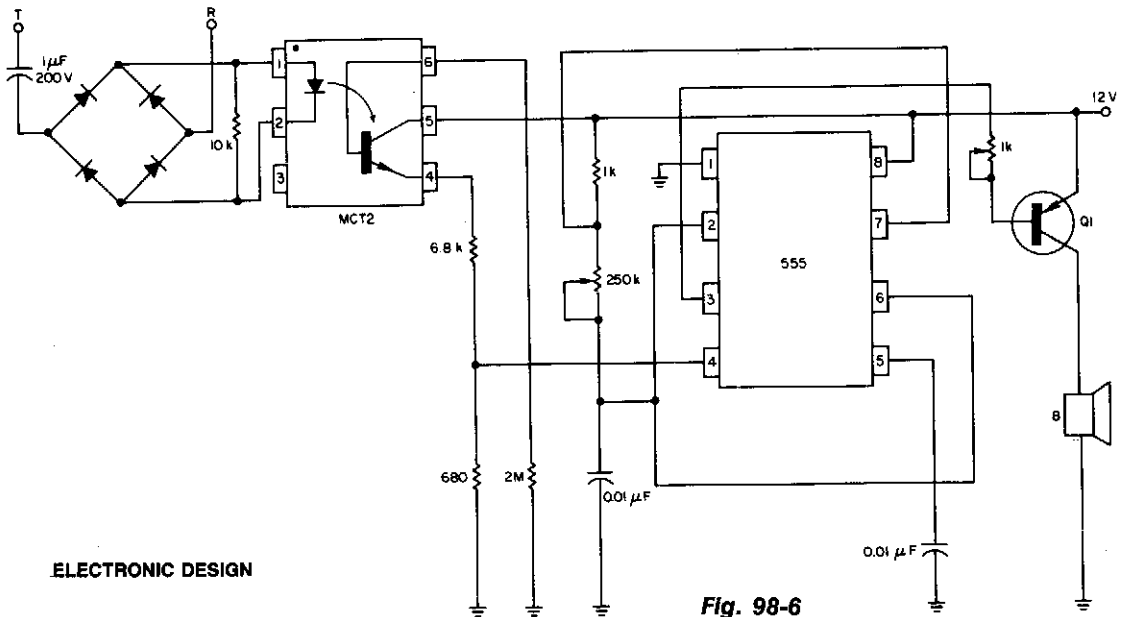
TAB BOOKS, INC.

Fig. 98-5

Circuit Notes

The device is a dc switch that is normally on via the forward biasing of Q1 via R3. Q1 now clamps Q2 into a forward state by biasing its complement well into a saturated state via R4. The dc switch is turned off via a negative voltage above that of the zener (D1). This voltage is usually about 48 and is the on-hook value of the phone line. This negative voltage overrides the effect of R3 and keeps the circuit "off." When the phone is off the hook, the 48 volts drops to 10 volts, that is below the zener voltage of D1 and R3 now turns the circuit on. The audio signal is via attenuator resistor R1 and dc isolating capacitors C1, C2. The device is a high impedance switch that isolates the recording controlled device from the phone line via some relatively simple electronic circuitry. It requires no battery and obtains power for operating via the remote jack that in most recorders is a source of 6 volts. When clamped to ground it initiates recorder operation. The unit interfaces with most portable cassette recorders providing they contain a remote control jack.

TELEPHONE RINGING DETECTOR, FREQUENCY AND VOLUME CONTROLLED



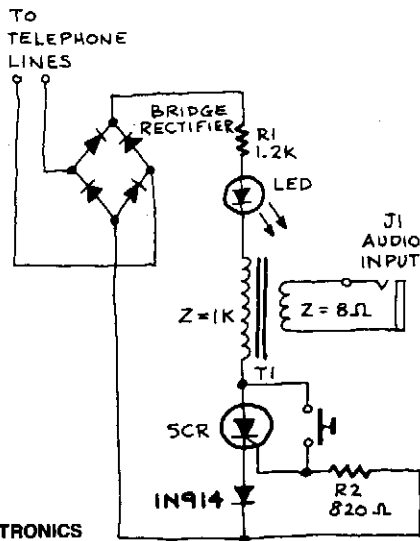
ELECTRONIC DESIGN

Fig. 98-6

Circuit Notes

With the 555 timer connected as a multivibrator and an opto-isolator, a remote speaker can be driven.

MUSIC ON HOLD



RADIO-ELECTRONICS

Fig. 98-7

Circuit Notes

With this music-on-hold device, you can answer the phone in one room, place the caller on hold, and then pick up the phone again at another location. When you pick up the phone the second time, you automatically deactivate the music-on-hold feature and can continue your conversation.

CIRCUIT MONITORS BLINKING PHONE LIGHTS

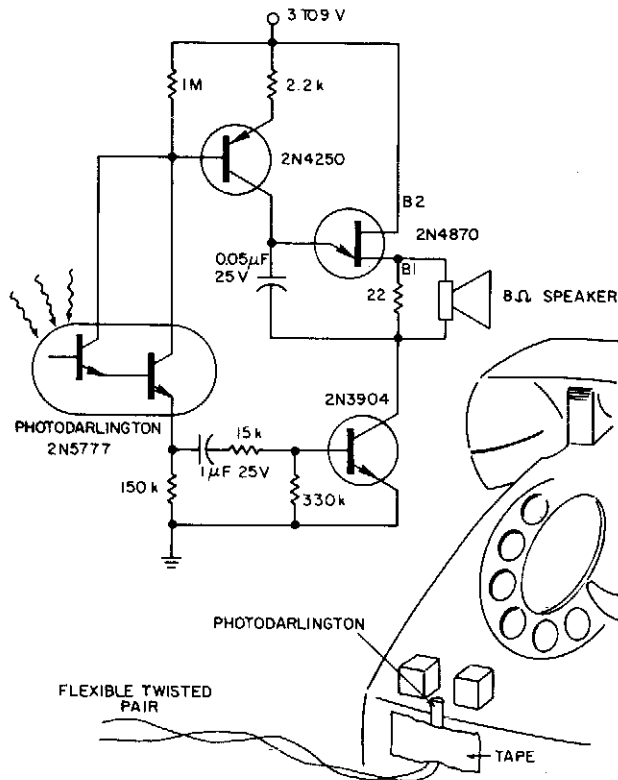
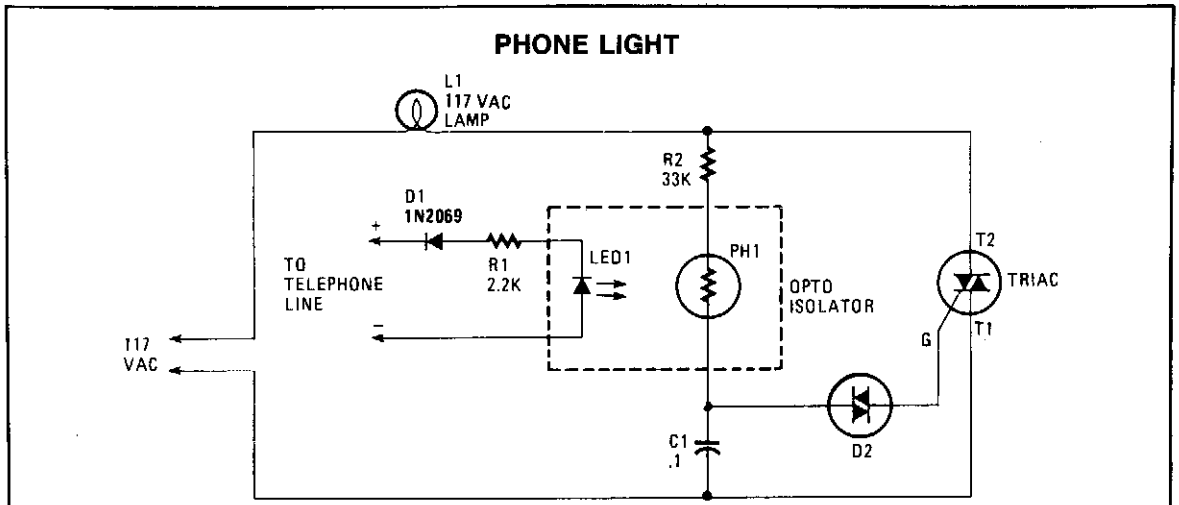


Fig. 98-8

ELECTRONIC DESIGN

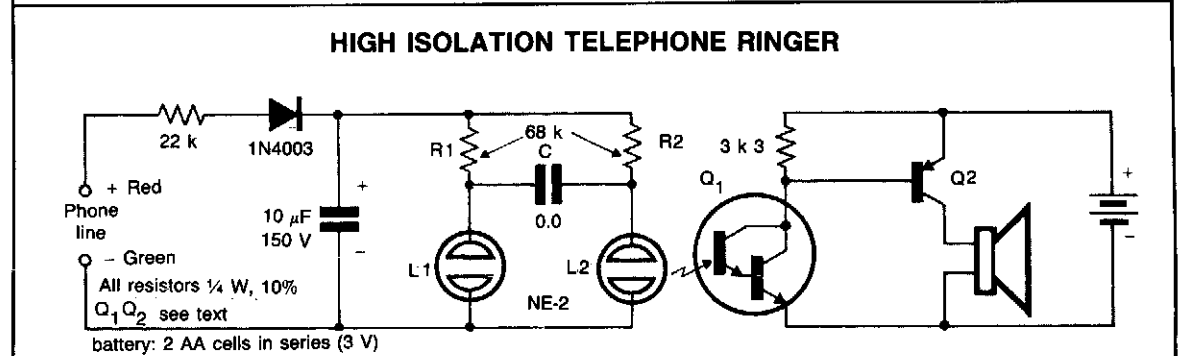
Circuit Notes

A 2N5777 photo-Darlington cell picks up blinking light from the transparent plastic buttons. The power is switched ON and OFF by a hi-beta 2N3904 transistor. The circuit's 9 V battery can be left continuously connected. Less than a micro-ampere is drawn—even with normal, office ambient light and the phone lights not flashing. For noisy locations, the tone can be made louder with an output transformer (ratio of 250:8) or a 100 ohm speaker that replaces the 22 ohm resistor in the output.



Circuit Notes

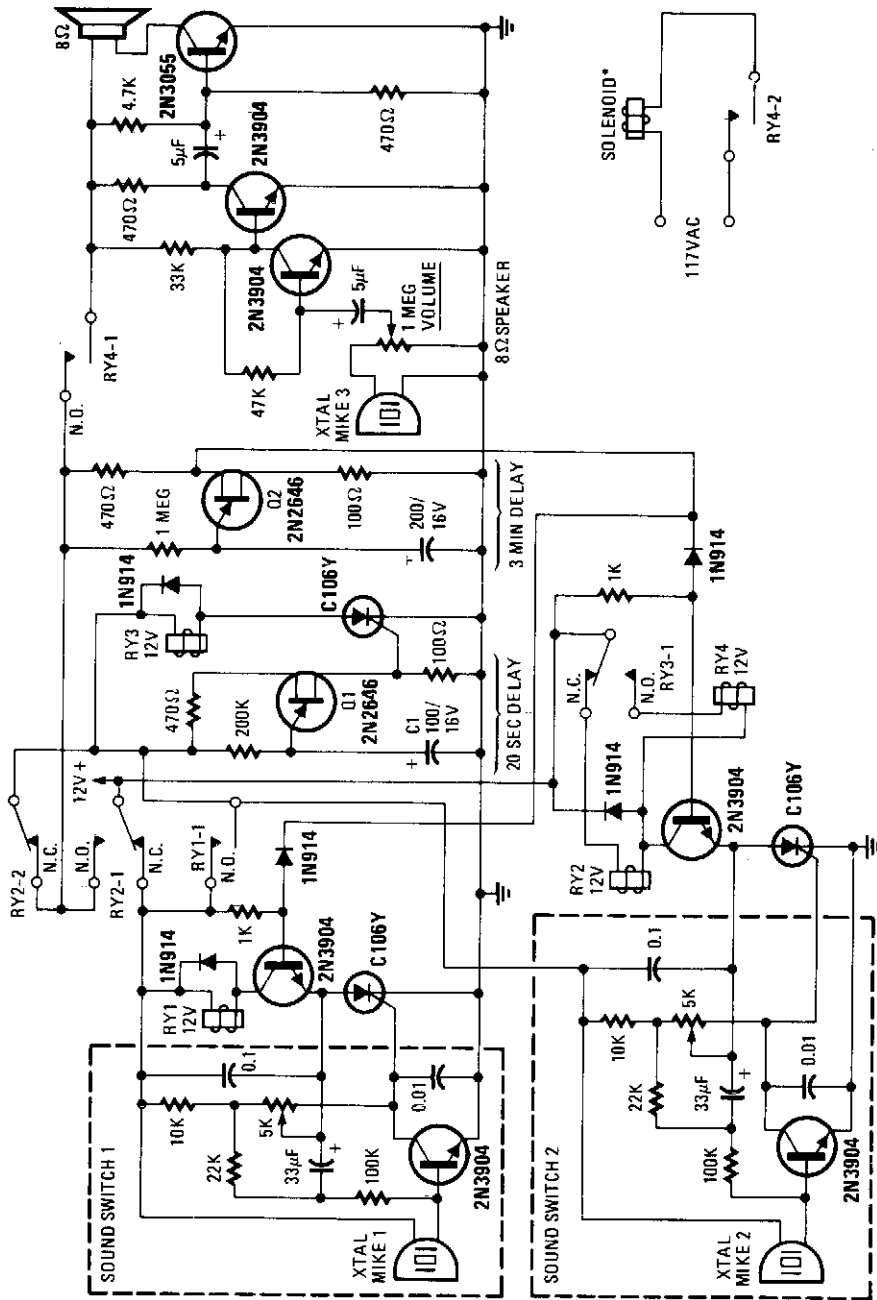
When the phone does ring the triac is triggered into conduction by a signal applied to its gate (G) through a bilateral switch (diac), D2. The triac acts as a switch, conducting only when a signal is present at the gate.



Circuit Notes

The diode rectifies the ringing signal to supply the operating power to the audio relaxation oscillator made up of L1, L2, R1, R2, and C. Moreover, L2 together with Q1 acts as an opto-isolator, totally isolating the telephone line from the rest of the circuit. The oscillator audio frequency is optically coupled to the photo-Darlington which drives Q2 and thus the speaker. The 10 μF capacitor is not large enough to smooth the ringing ripple completely. This results in frequency modulation of the audio oscillator giving it an attention-getting warble.

REMOTE TELEPHONE MONITOR



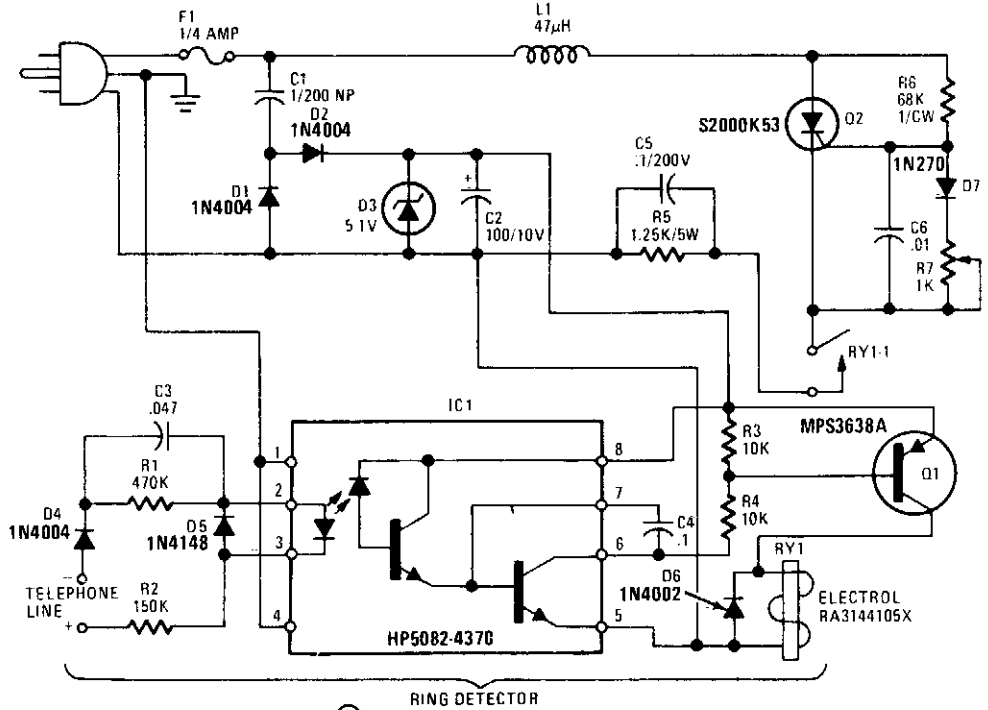
RADIO-ELECTRONICS

Circuit Notes

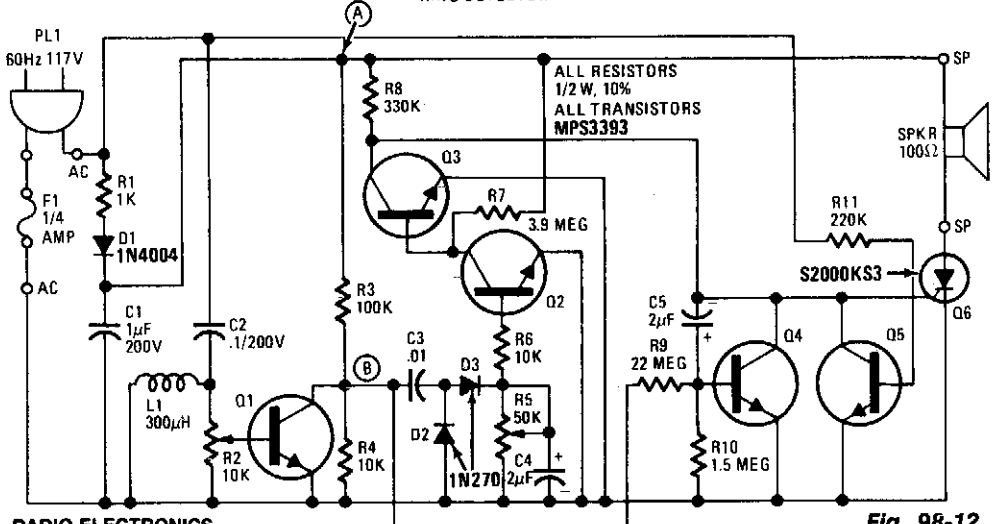
This device monitors sounds in home or office when a telephone is called from a remote location.

Fig. 98-11

PLUG-IN REMOTE TELEPHONE RINGER



RING DETECTOR



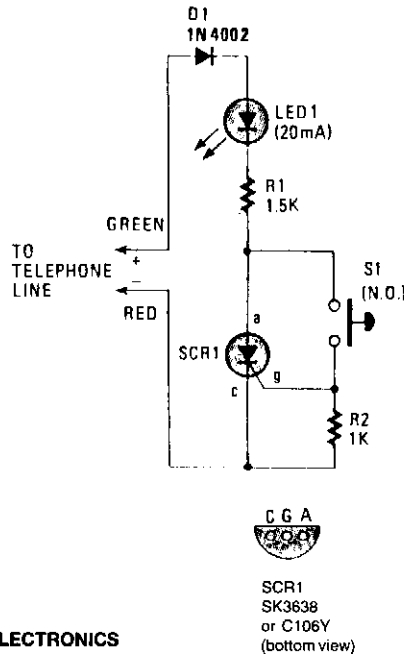
RADIO-ELECTRONICS

Fig. 98-12

Circuit Notes

This device consists of a ring detector connected to the telephone line. When the telephone rings, the ring detector impresses high-frequency pulses on the ac power line. A receiver placed anywhere on the same power line detects these pulses and emits an audible tone in synchronization with the telephone signal.

TELEPHONE HOLD BUTTON



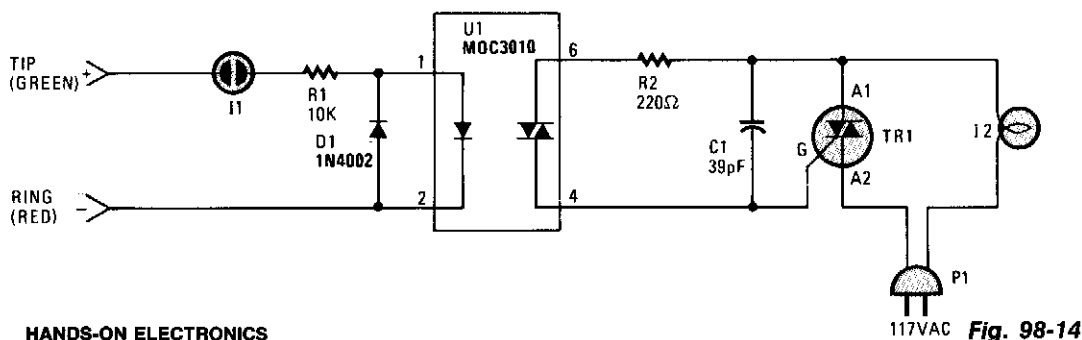
HANDS-ON ELECTRONICS

Fig. 98-13

Circuit Notes

The on-hook (no load) voltage across the red-green wires will be 48 V or slightly less when all telephones are on-hook (disconnected). When any telephone goes off-hook the load current flowing in the telephone causes the voltage to fall below 5 volts dc. Although the telephone hold is connected across the red-green wires, silicon control rectifier SCR1 is open; so there is no current path across the telephone line. To hold the call, depress normally-open switch S1 and hang up the telephone (still depressing S1). When the phone goes on-hook the red-green voltage jumps to 48 volts dc. Since switch S1 is closed, a positive voltage is applied to SCR1's gate, which causes SCR1 to conduct, thereby completing the circuit across the telephone line through D1, LED1, R1, and SCR1. The current that flows through those components also causes the LED to light up—indicating that the telephone line is being held. The effective load across the red-green wires is the 1500 ohm value of R1, which is sufficient to seize the line while limiting the current through the LED to a safe value. When the telephone, or an extension, is once again placed off-hook the red-green voltage falls to 5 volts or less. But diode D1 has a normal voltage drop—called the breakover voltage—of 0.7 volts, and the LED has a forward drop of 2.0 volts. Excluding the voltage drop across R1 there is a maximum of 2.3 volts available for SCR1, which is too low to maintain conduction; so SCR1 automatically opens the hold circuit when any telephone goes off-hook.

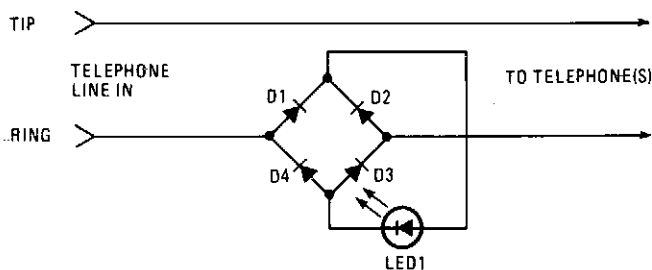
TELEPHONE BLINKER



Circuit Notes

A small neon lamp is triggered into conduction by the telephone's ringing voltage, passes just enough current to activate the LED in optocoupler U1, which in turn triggers the 6-A Triac that controls I2—a 117-Vac lamp or bell. (Capacitor C1 is necessary only when the circuit is used to drive a bell.) The lamp will flash off-and-on at the ringing rate, which is normally around 20 Hz. If a 117 Vac bell is used, connect it in place of the lamp.

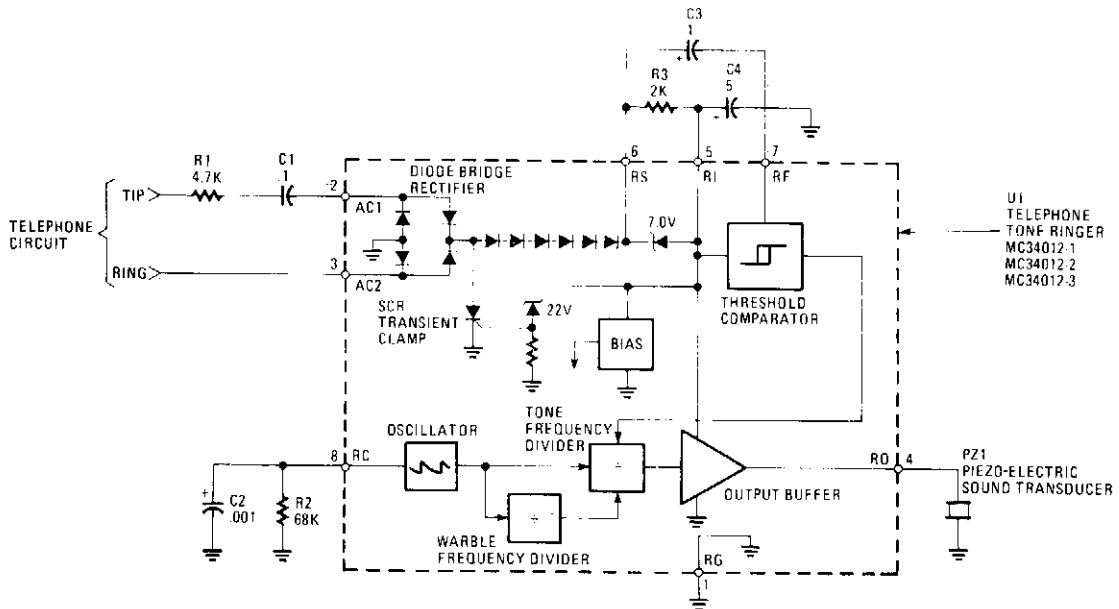
TELEPHONE "IN USE" INDICATOR



Circuit Notes

This circuit functions as a line-current sensor and can be connected in series with either of the phone lines. For the circuit to indicate an "in use" status for all phones on a single line, it must be connected in series with the phone line before, or ahead of all phones on the line. Since the power for the circuit is supplied by the phone company, a circuit could be added to each phone as an off-hook indicator.

TONE RINGER



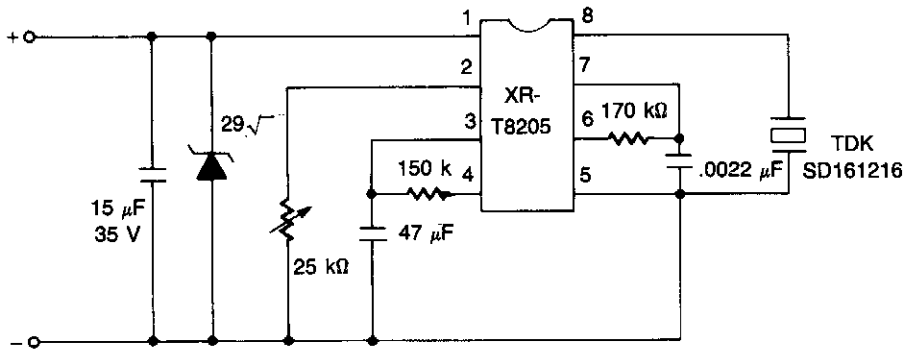
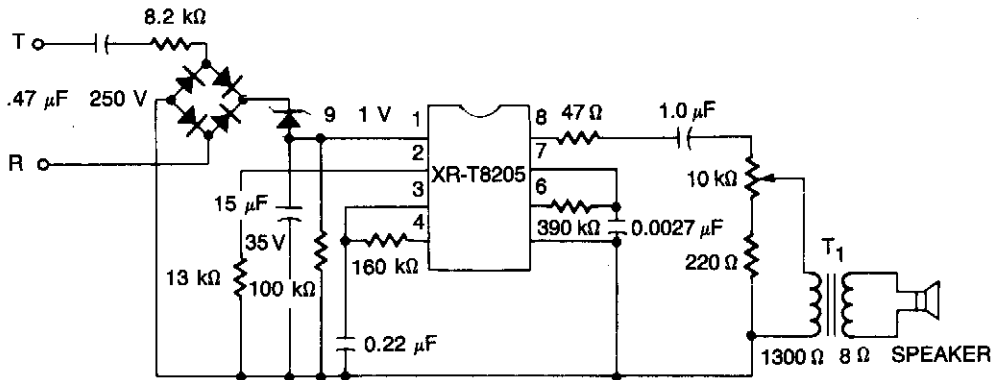
HANDS-ON ELECTRONICS

Fig. 98-16

Circuit Notes

The MC34012 tone-ringer chip derives its power by rectifying the ac ringing signal. That signal is normally at 20 Hz and measures between 70 and 130 volts rms. It uses that power for the tone generator and to drive the piezoelectric transducer. The sound that is produced is a warble that varies between two frequencies, $f_o/4$ ($f_o - 4$) $f_o/5$. The clock, or fundamental, frequency, f_o , is generated by a relaxation oscillator. That oscillator has R2 and C2 as its frequency setting components providing a selectable range of 1 kHz to 10 kHz. Selecting different values for R2 and/or C2 changes the clock frequency, which in turn varies the warble frequencies. The MC34012 chip comes in three different warble rates at which the warble frequencies ($f_o/4$, $f_o/5$) are varied. These warble rates are $f_o/320$, $f_o/640$, or $f_o/160$ and the different chips are designated as MC34012-1, -2, and -3, respectively. For example: with a 4.40 kHz oscillator frequency, the MC34012-1 produces 800 Hz and 1000 Hz tones with a 12.5 Hz warble rate. The MC34012-2 generates 1600 Hz and 2000 Hz tones with a similar 12.5 Hz warble frequency from an 8.0 kHz oscillator frequency. MC34012-3 will produce 400 Hz and 500 Hz tones with a 12.5 warble rate from a 2.0 kHz oscillator frequency.

TONE RINGER II

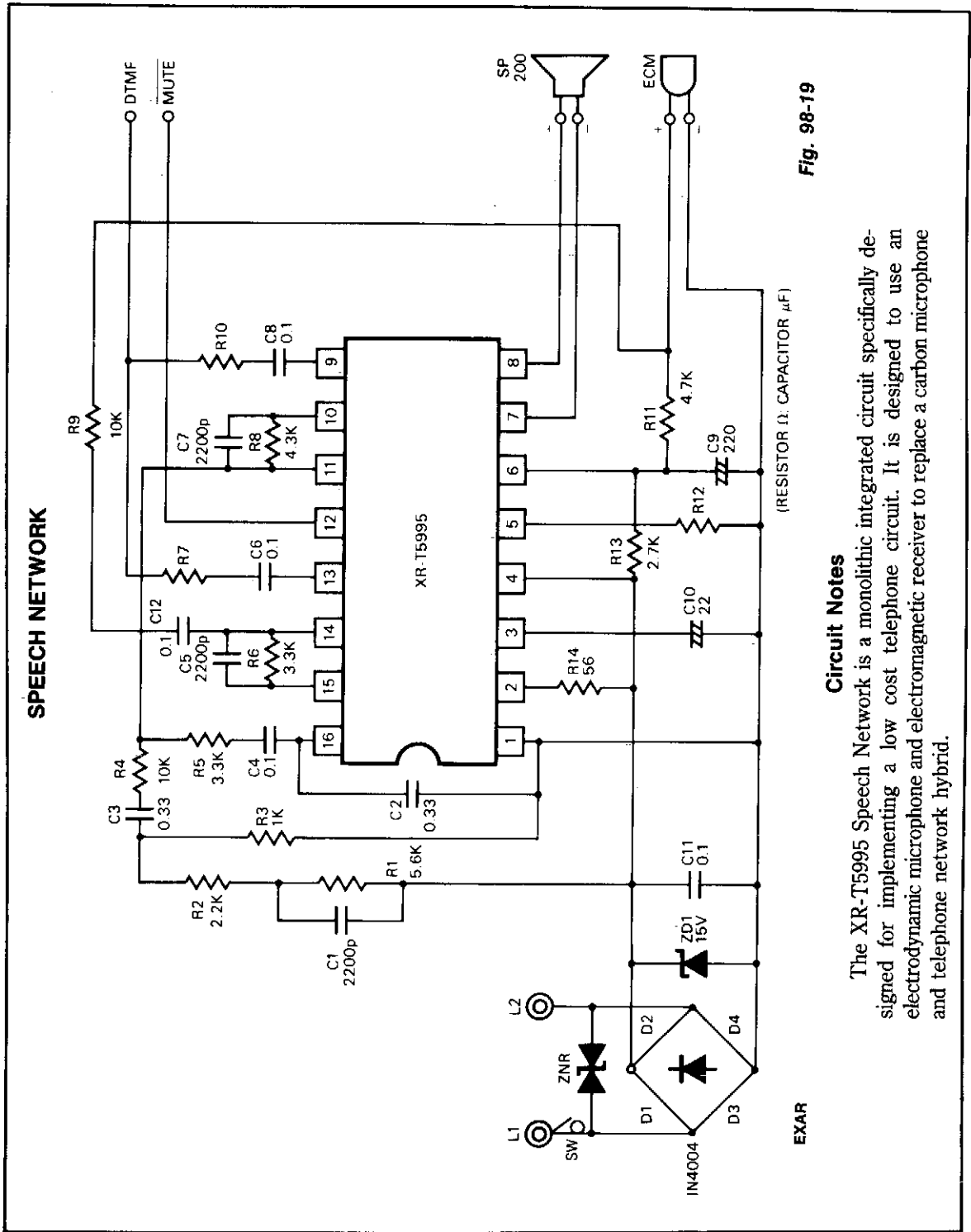


EXAR

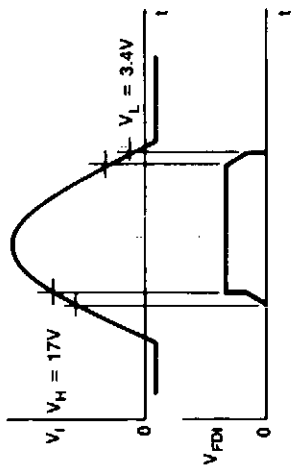
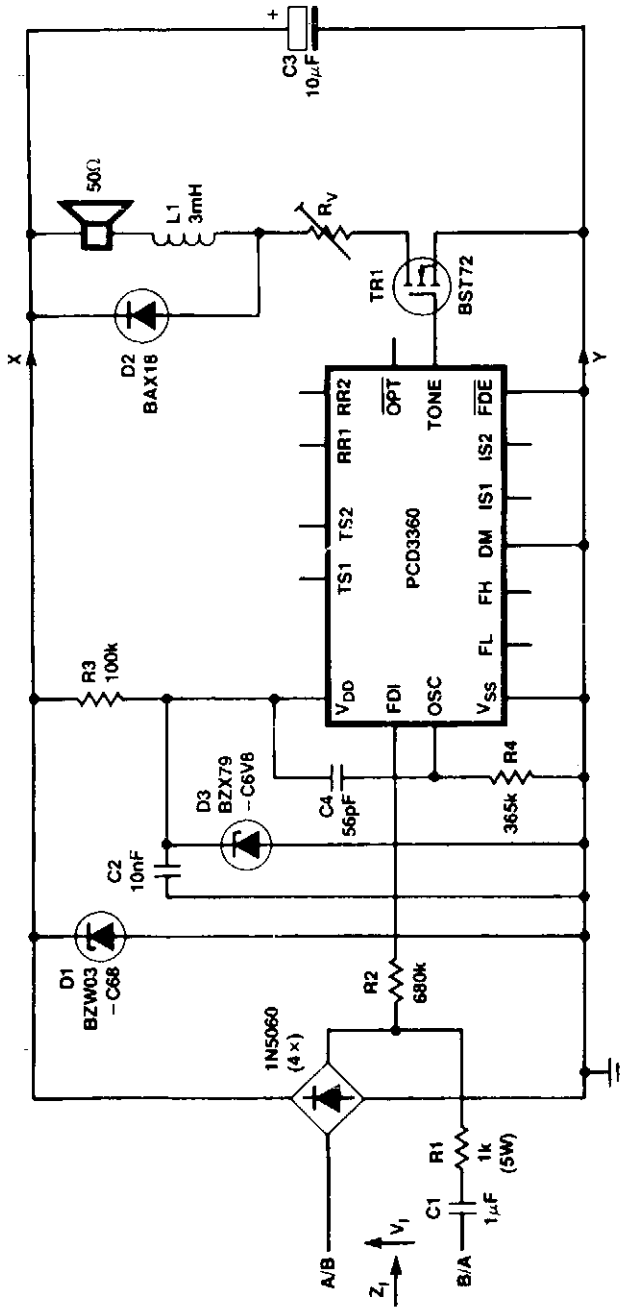
Fig. 98-17

Circuit Notes

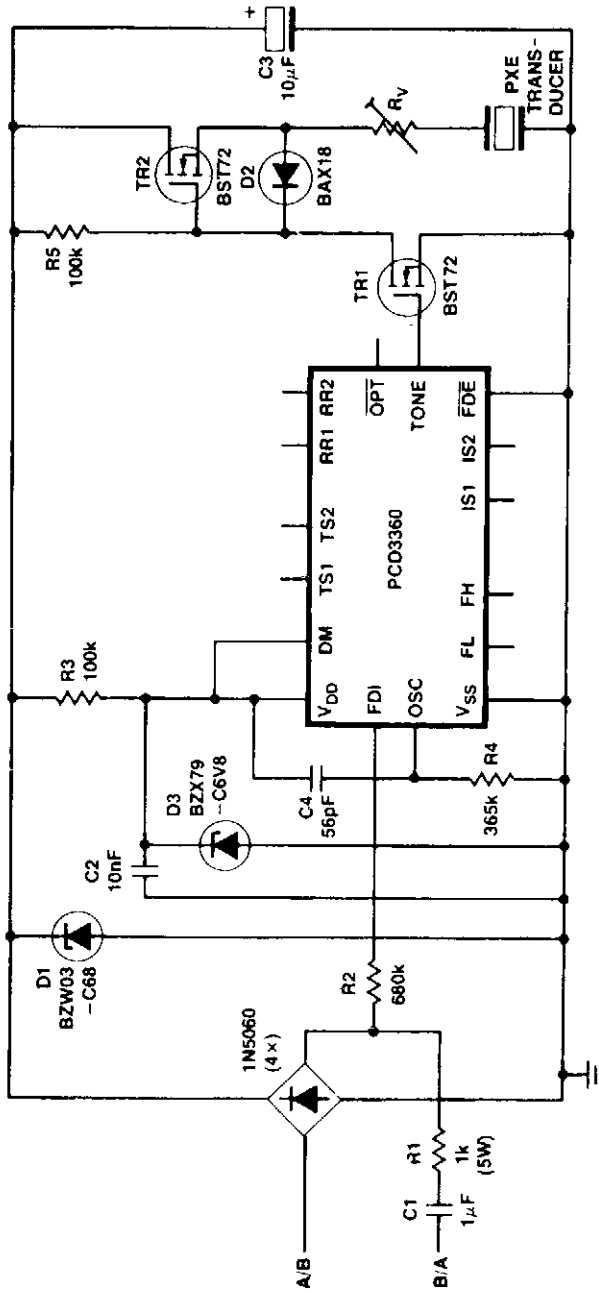
The XR-T8205 Tone Ringer is primarily intended as a replacement for the mechanical telephone bell. The device can be powered directly from telephone ac ringing voltage or from a separate dc supply. An adjustable trigger level is provided with an external resistor. The circuit is designed for nominal 15 volt operation.



PROGRAMMABLE MULTI-TONE TELEPHONE RINGER



Transformerless Electronic Ringer With PCD3360 and a Loudspeaker



PCD3360 Ringer With PXE Transducer

SIGNETICS

Fig. 98-20

Circuit Notes

Two BST72 transistors provide an output voltage swing almost equal to the voltage at C3. Pins IS1 and IS2 are inoperative because DM = HIGH. Volume control is possible using resistor R_v .

99

Temperature Controls

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Temperature-Controlling Circuit

Temperature Control

Low-Cost Temperature Controller

Precision, Linearized Platinum RTD Signal Conditioner

Low Power Zero Voltage Switch Temperature Controller

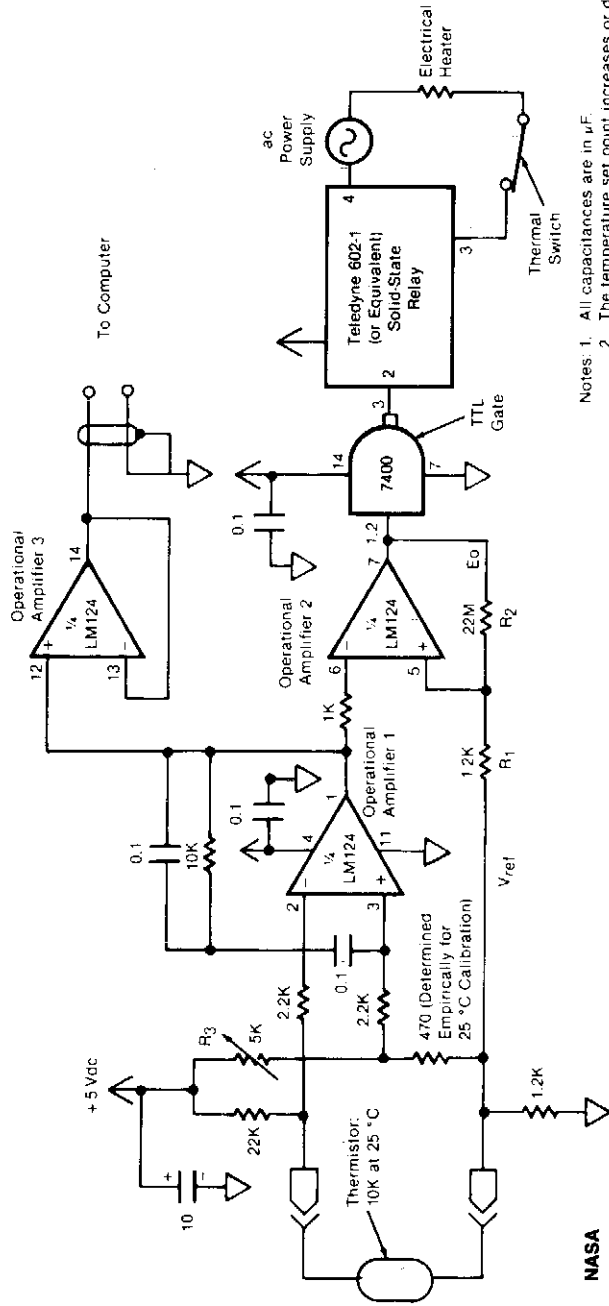
Heater Element Temperature Controller

Dual-Time Chip Controls Temperature While Monitoring Liquid Level

Temperature Alarm

Adjustable Threshold Temperature Alarm

TEMPERATURE-CONTROLLING CIRCUIT



NASA

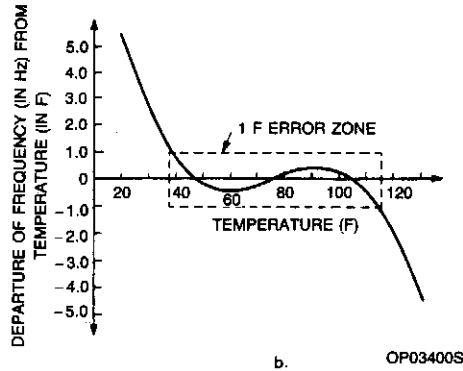
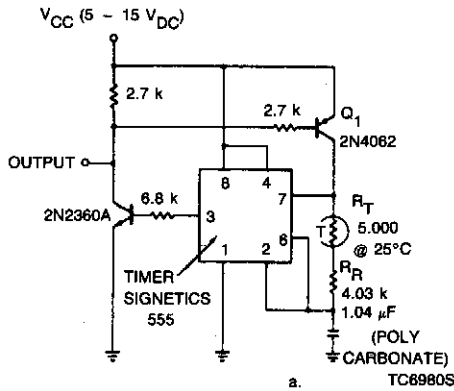
Fig. 99-1

- Notes: 1. All capacitances are in μF .
 2. The temperature set point increases or decreases with R_3 , which is set at 2.17K for 25 °C.
 3. The upper and lower tripping voltages of operational amplifier 2 are given by $V_{\text{trip}} = V_{\text{ref}} \pm E_0 R_1 / (R_1 + R_2)$, where V_{ref} = the reference voltage and E_0 = the output voltage of the operational amplifier.

Circuit Notes

The circuit switches the current to an electrical heater on and off to maintain the temperature of a room at $25 \pm 0.5^\circ\text{C}$. The temperature sensor is a thermistor which provides a differential input (for reduced noise) to an operational amplifier. A 5 kilohm potentiometer is used to adjust the set point through a voltage divider; a value of 2.17 kilohms yields the 25°C setting. A second operational amplifier is connected as an inverting differential-input comparator. The output of operational amplifier 2 controls the electrical heater through a zero-crossing solid-state relay. A transistor/transistor-logic (TTL) gate adjusts the output to the proper level for the relay. A thermal switch is placed in series with the heater and the ac supply for safety in case of thermal runaway. A third operational amplifier monitors the output of the thermistor, providing a signal to a computer for data logging.

TEMPERATURE CONTROL



NOTE:
All resistor values are in ohms.

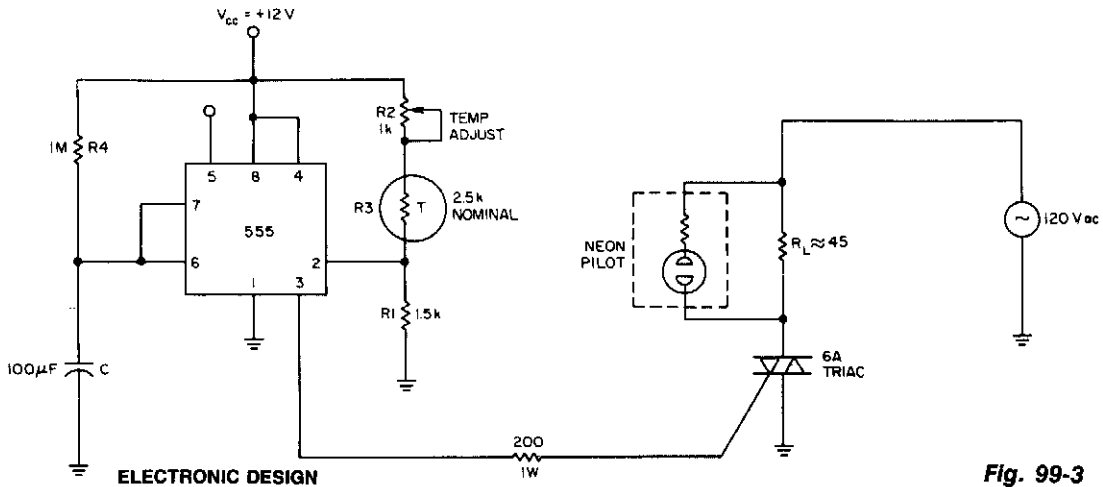
SIGNETICS

Fig. 99-2

Circuit Notes

A couple of transistors and a thermistor in the charging network of the 555 type timer enable this device to sense temperature and produce a corresponding frequency output. The circuit is accurate to within ± 1 Hz over a 78°F temperature range.

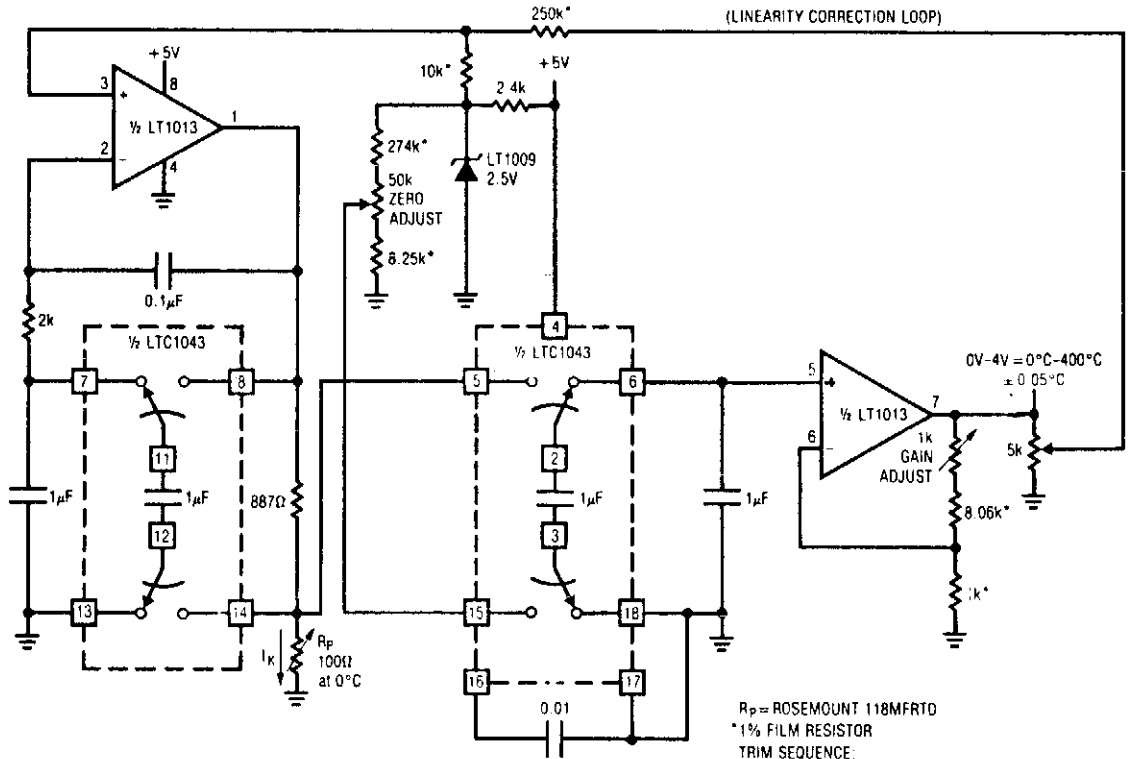
LOW-COST TEMPERATURE CONTROLLER



Circuit Notes

The internal comparator of the 555 timer, combined with a thermistor, makes a low-cost temperature controller. Resistor R2 sets the temperature trip point.

PRECISION, LINEARIZED PLATINUM RTD SIGNAL CONDITIONER



R_p = ROSEMOUNT 118MFRTD
 * 1% FILM RESISTOR
 TRIM SEQUENCE:
 SET SENSOR TO 0°C VALUE. ADJUST ZERO FOR 0V OUT. SET SENSOR TO 100°C VALUE. ADJUST GAIN FOR 1.000V OUT. SET SENSOR TO 400°C VALUE. ADJUST LINEARITY FOR 4.000V OUT. REPEAT AS REQUIRED.

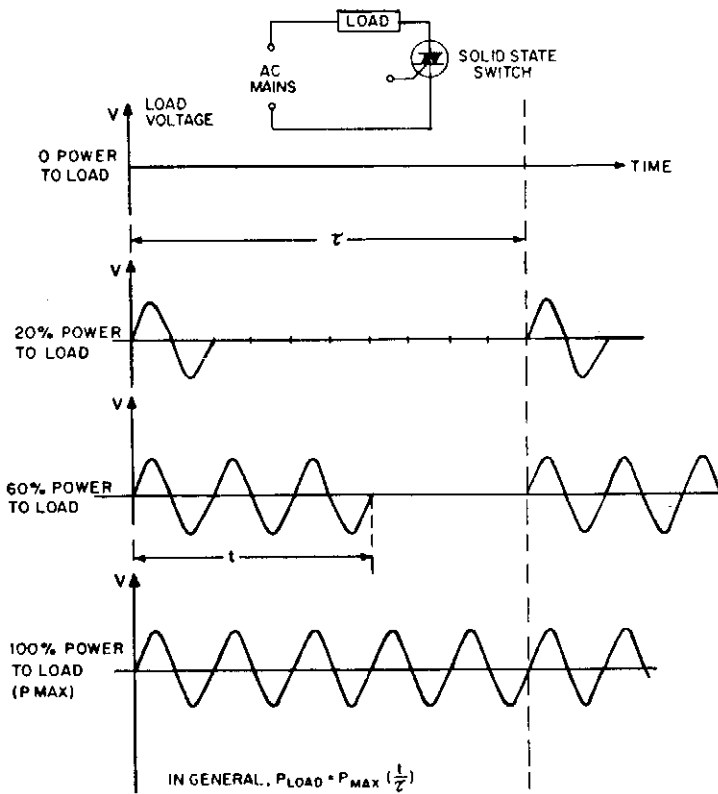
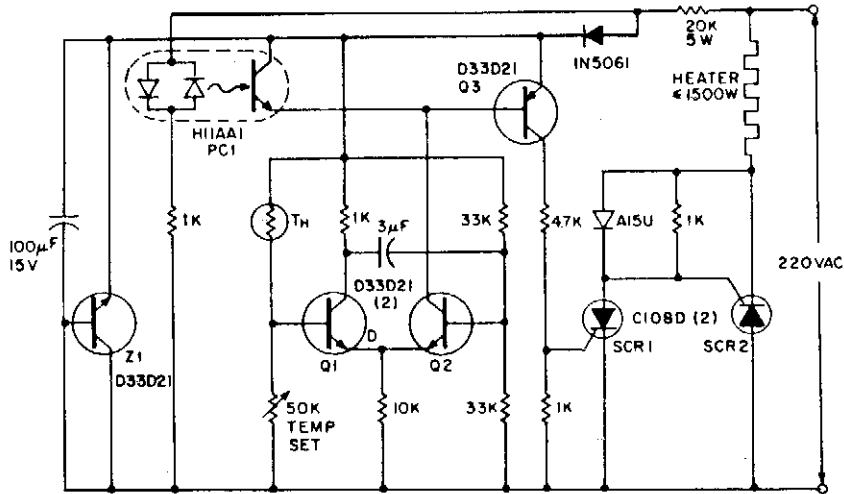
LINEAR TECHNOLOGY CORPORATION

Fig. 99-4

Circuit Notes

The circuit provides complete, linearized signal conditioning for a platinum RTD. This LTC1043 based circuit is considerably simpler than instrumentation or multi-amplifier based designs, and will operate from a single 5 V supply. A1 serves as a voltage-controlled ground referred current source by differentially sensing the voltage across the 998 phm feedback resistor. The LTC1043 section which does this presents a single-ended signal to A1's negative input, closing a loop. The 2 k 0.1 μF combination sets amplifier roll-off well below the LTC1043's switching frequency and the configuration is stable. Because A1's loop forces a fixed voltage across the 887 ohm resistor, the current through R_p is constant. A1's operating point is primarily fixed by the 2.5 V LT1009 voltage reference.

LOW POWER ZERO VOLTAGE SWITCH TEMPERATURE CONTROLLER



GENERAL ELECTRIC

Fig. 99-5

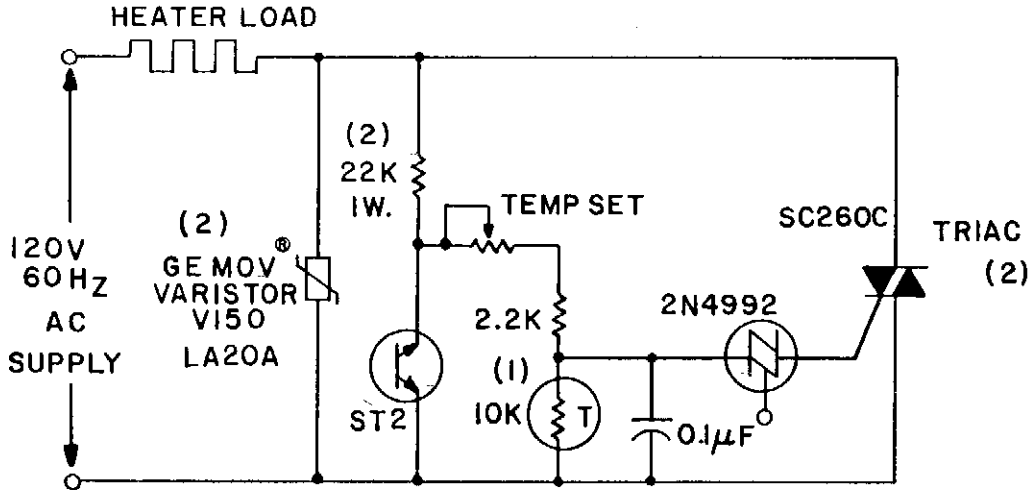
Circuit Notes

The "zero voltage switching" technique is widely used to modulate heating and similar types of ac loads where the time constant associated with the load (tens of seconds to minutes) is sufficiently long to allow smooth proportional modulation by time ratio control, using one complete cycle of the ac input voltage as the minimum switching movement. Despite its attractions, the traditional triac-based ZVS is virtually unusable for the control of very low power loads, especially from 220 volt ac inputs due to the triac's reluctance to latch-on into the near-zero instantaneous currents that flow through it and the load near the ac voltage zero crossover points. The circuit side-steps the latching problem by employing a pair of very sensitive low current reverse blocking thyristors (C106) connected in antiparallel; these are triggered by a simple thermistor modulated differential amplifier (Q1, Q2), with zero voltage logic furnished by an H11AA1 ac input optocoupler. With the NTC thermistor TH calling for heat, transistor Q1 is cut off and Q2 is on, which would normally provide continuous base drive to Q3, with consequent triggering of either SCR, or of SCR 2 via SCR1, depending on phasing of the ac input.

Note that when the ac input voltage is positive with respect to SCR 2, SCR 1 is reverse biased and, in the presence of "gate" current from Q3, behaves as a remote base transistor, whose output provides via blocking diode CR1, positive gate trigger current for SCR 2. When the ac input polarity is reversed (SCR 1's anode positive), SCR 1 behaves as a direct fired conventional thyristor. "Trigger" current to SCR 1, however, is not continuous, even when TH is calling for heat and Q2 is delivering base current to Q3. In this situation, Q3 is inhibited from conduction by the clamping action of PC1, an H11AA photocoupler, except during those brief instants when the ac input voltage is near zero and the coupler input diodes are deprived of current.

Triggering of either SCR can occur only at ac voltage crossing points, and RFI-less operation results. The proportional control feature is injected via the positive feedback action of capacitor CM, which converts the differential amplifier Q1, Q2 into a simple multivibrator, whose duty cycle varies from one to 99 percent according to the resistance of TH. Zener diode Z1 is operational, being preferred when maximum immunity from ac voltage induced temperature drift is desired.

HEATER ELEMENT TEMPERATURE CONTROLLER



- NOTES: 1. Thermistor National Lead type 1D101, or equivalent.
 2. Component values for 220V operation:
 Resistor - 47K, 2W
 GE-MOV® Varistor - V275LA20A
 Triac - SC260E

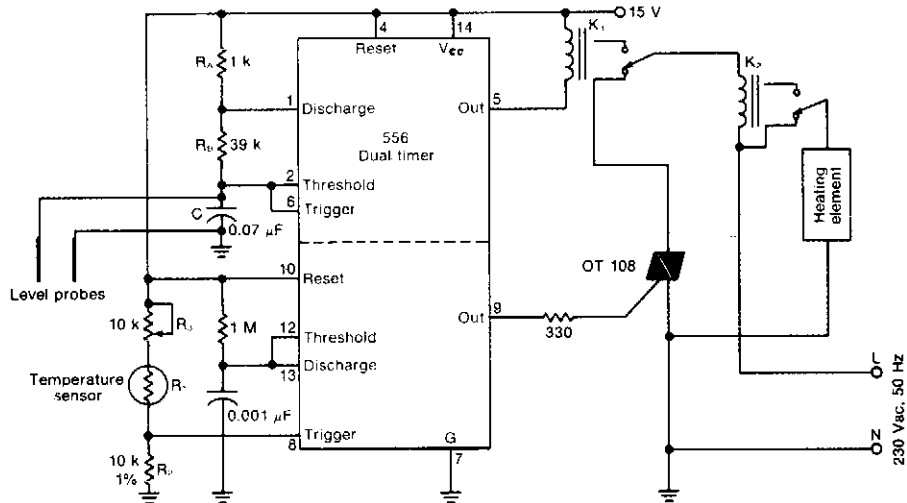
GENERAL ELECTRIC

Fig. 99-6

Circuit Notes

The circuit can control up to 6 kW of heating, with moderate gain, using a 25-amp triac (SC260D). Feedback is provided by the negative temperature co-efficient (NTC) thermistor, which is mounted adjacent to the environment being temperature controlled. The temperature set potentiometer is initially adjusted to the desired heating level. As the thermistor becomes heated by the load, its resistance drops, phasing back the conduction angle of the triac, so the load voltage is reduced. The ST2 diac is used as a back-to-back zener diode. Its negative resistance-region in its E-I characteristic provides a degree of line voltage stabilization. As the input line voltage increases, the diac triggers earlier in the cycle and, hence, the average charging voltage to the 0.1 µF capacitor, decreases.

DUAL-TIMER CHIP CONTROLS TEMPERATURE WHILE MONITORING LIQUID LEVEL



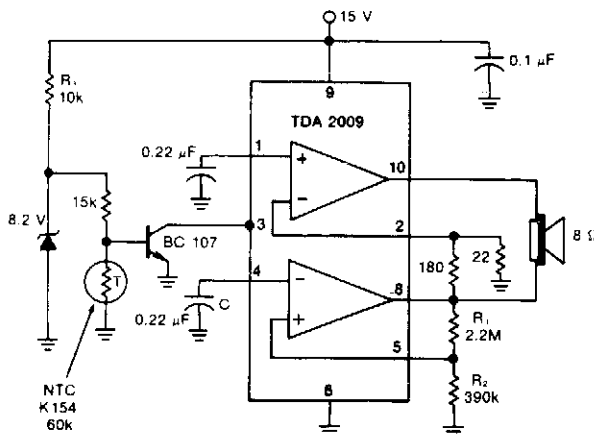
ELECTRONIC DESIGN

Fig. 99-7

Circuit Notes

One-half of a 556 dual timer monitors the temperature of a liquid bath, controlling a heating element that maintains temperature within $\pm 2^\circ\text{C}$ over a $32^\circ - 200^\circ\text{C}$ range. The other half monitors the liquid level, disconnecting the heater when the level drops below a preset point.

TEMPERATURE ALARM



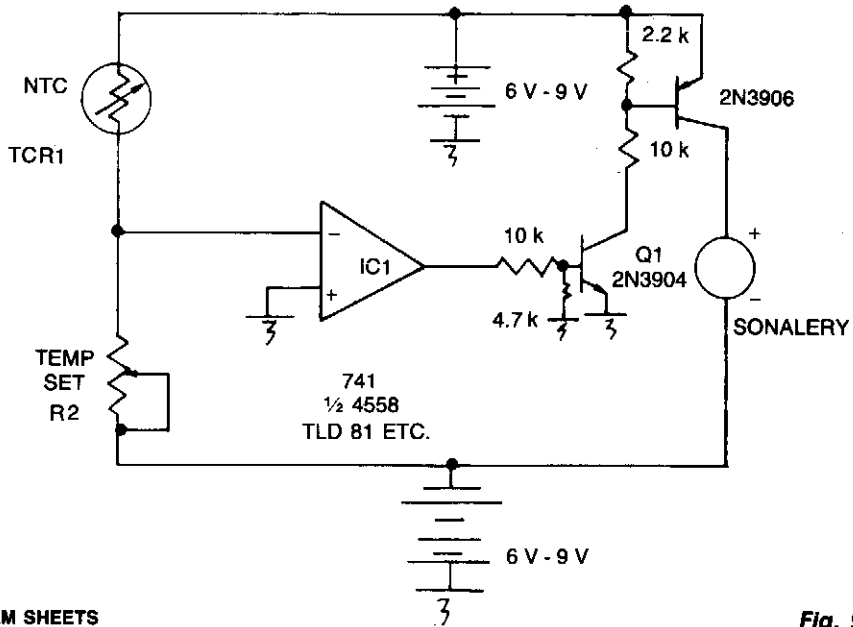
ELECTRONIC DESIGN

Fig. 99-8

Circuit Notes

The mute pin of this dual audio amplifier is used as the trigger for a one chip high-temperature alarm. One-half of the IC is connected as an oscillator and the other boosts the audio alarm outputs to 10W.

ADJUSTABLE THRESHOLD TEMPERATURE ALARM



WILLIAM SHEETS

Fig. 99-9

Circuit Notes

When R1 increases as temp decreases, the output of IC1 goes positive, turning on Q1. Q1 conducts and causes Q2 to conduct, turning on the audible alarm. The threshold is set with potentiometer R2.

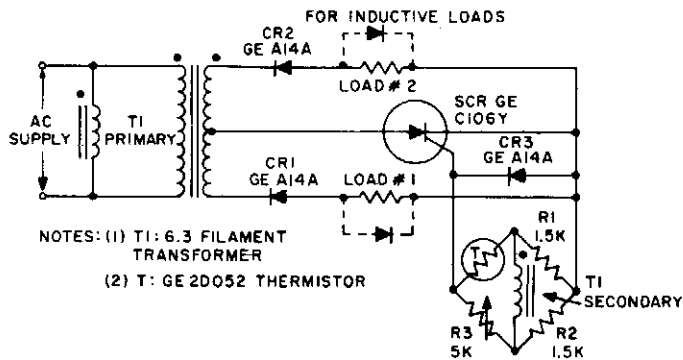
100

Temperature Sensors

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Dual Output, Over-Under Temperature Monitor
Temperature Sensor and DVM Interface
Curvature Corrected Platinum RD Thermometer
Thermocouple Amplifier with Cold Junction Compensation
5-V Powered, Linearized Platinum RTD Signal
Conditioner
HI LO Temperature Sensor

DUAL OUTPUT, OVER-UNDER TEMPERATURE MONITOR



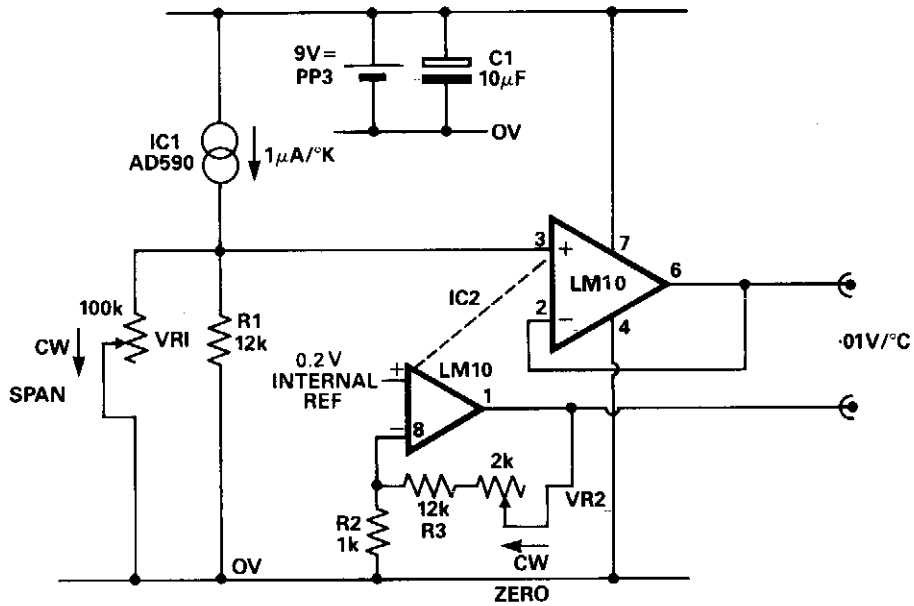
GENERAL ELECTRIC

Fig. 100-1

Circuit Notes

This circuit is ideal for use as an over-under temperature monitor, where its dual output feature can be used to drive HIGH and LOW temperature indicator lamps, relays, etc. T1 is a 6.3 volt filament transformer whose secondary winding is connected inside a four arm bridge. When the bridge is balanced, ac output is zero, and C5 (or C7) receives no gate signal. If the bridge is unbalanced by raising or lowering the thermistor's ambient temperature, and ac voltage will appear across the SCR's gate cathode terminals. Depending in which sense the bridge is unbalanced, the positive gate voltage will be in phase with, or 180° out of phase with the ac supply. If the positive gate voltage is in phase, the SCR will deliver load current through diode CR1 to load (1), diode CR2 blocking current to load (2). Conversely, if positive gate voltage is 180° out of phase, diode CR2 will conduct and deliver power to load (2), CR1 being reverse biased under these conditions. With the component values shown, the circuit will respond to changes in temperature of approximately 1-2°C. Substitution of other variable-resistance sensors, such as cadmium sulfide light dependent resistors (LDR) or strain gauge elements, for the thermistor shown is permissible.

TEMPERATURE SENSOR AND DVM INTERFACE



ELECTRONIC ENGINEERING

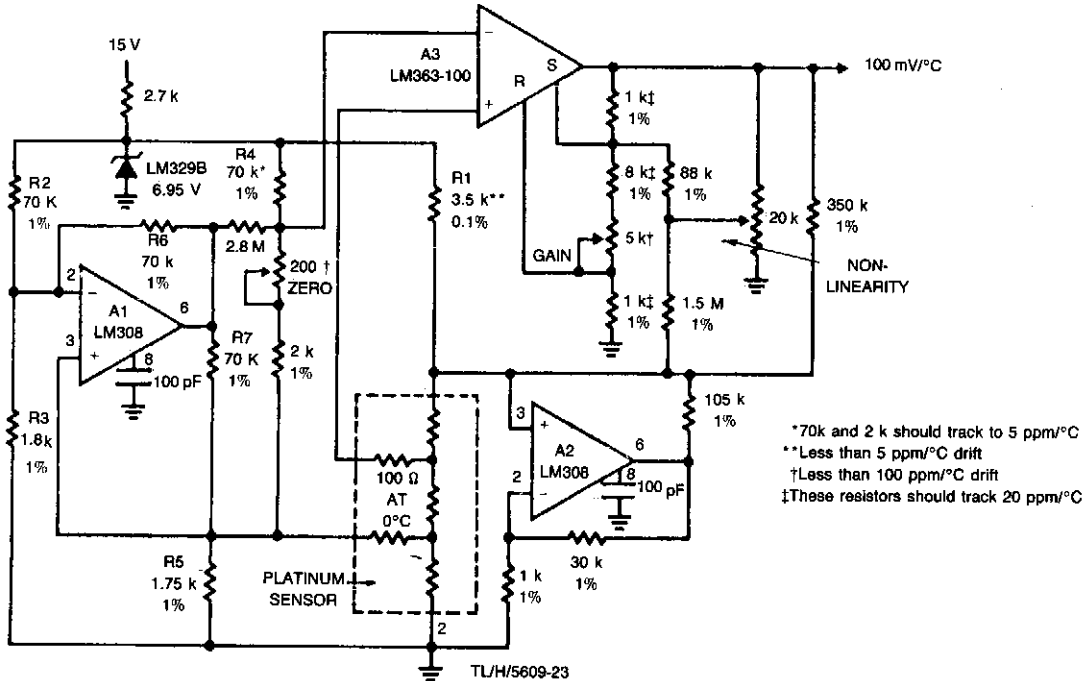
Fig. 100-2

Circuit Notes

The DVM gives a direct indication of the temperature of the sensor in degrees Centigrade. The temperature sensor IC1 gives a nominal $1\ \mu\text{A}$ per degree Kelvin which is converted to 10 mV per degree Kelvin by R1 and VR1. IC2 is a micropower, low input drift op amp with internal voltage reference and amplifier. The main op amp in IC1 is connected as a voltage follower to buffer the sensor voltage at R1.

The second amplifier in IC1 is used to amplify the .2 V internal reference up to 2.73 V in order to offset the 273 degrees below 0°C . The output voltage of the unit is the differential output of the two op amps and is thus equal to 0.01 V per $^\circ\text{C}$.

CURVATURE CORRECTED PLATINUM RTD THERMOMETER



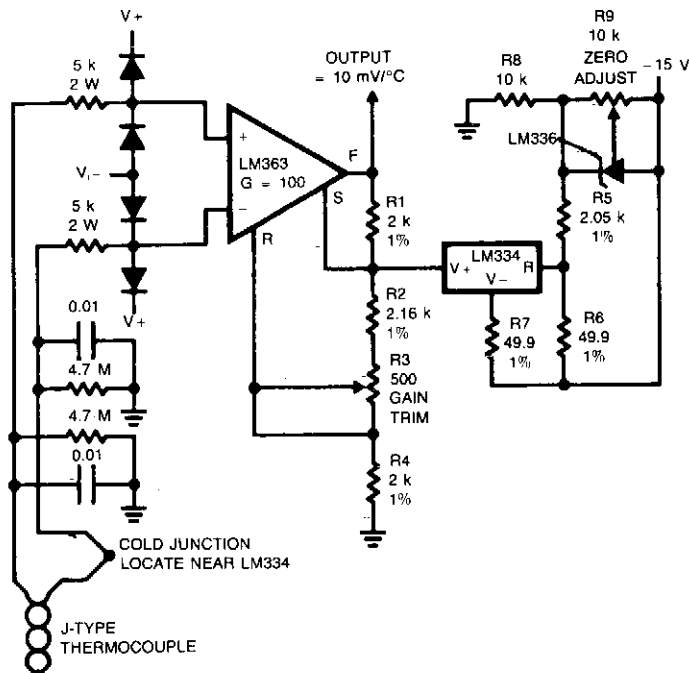
NATIONAL SEMICONDUCTOR CORP.

Fig. 100-3

Circuit Notes

This thermometer is capable of 0.01°C accuracy over -50°C to +150°C. A unique trim arrangement eliminates cumbersome trim interactions so that zero gain, and nonlinearity correction can be trimmed in one even trip. Extra op amps provide full Kelvin sensing on the sensor without adding drift and offset terms found in other designs. A1 is configured as a Howland current pump, biasing the sensor with a fixed current. Resistors R2, R3, R4 and R5 form a bridge driven into balance by A1. In balance, both inputs of A2 are at the same voltage. Since R6 = R7, A1 draws equal currents from both legs of the bridge. Any loading of the R4/R5 leg by the sensor would unbalance the bridge; therefore, both bridge taps are given to the sensor open circuit voltage and no current is drawn.

THERMOCOUPLE AMPLIFIER WITH COLD JUNCTION COMPENSATION



NATIONAL SEMICONDUCTOR CORP.

Fig. 100-4

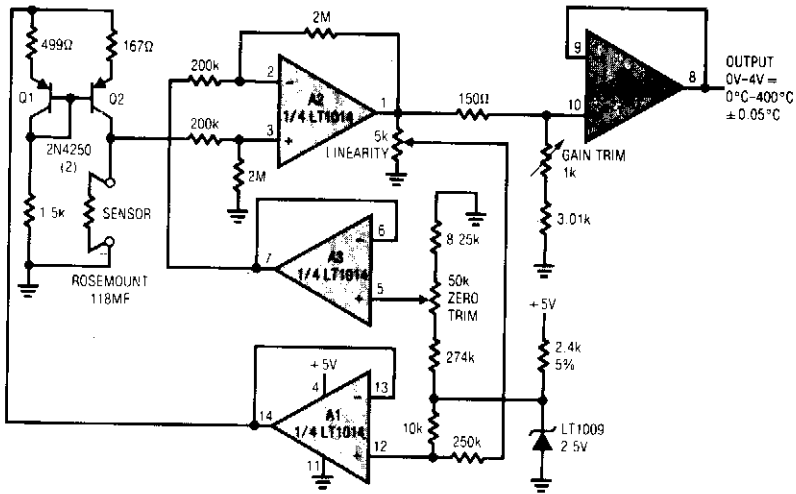
Circuit Notes

Input protection circuitry allows thermocouple to short to 120 Vac without damaging the amplifier.

Calibration:

1. Apply a 50 mV signal in place of the thermocouple. Trim R3 for $V_{OUT} = 12.25$ V.
2. Reconnect the thermocouple. Trim R9 for correct output.

5-V POWERED, LINEARIZED PLATINUM RTD SIGNAL CONDITIONER

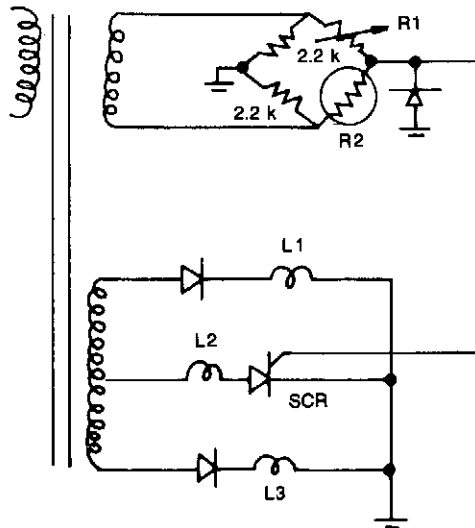


LINEAR TECHNOLOGY CORP.

ALL RESISTORS ARE TRW-MAR-6 METAL FILM.
 RATIO MATCH 2M 200k ± 0.01%.
 TRIM SEQUENCE
 SET SENSOR TO 0 °C VALUE
 ADJUST ZERO FOR 0V OUT

Fig. 100-5

HI LO TEMPERATURE SENSOR



WILLIAM SHEETS

Fig. 100-6

Circuit Notes

Resistors R1, R2, and the two 2.2 k resistors form a bridge circuit. R2 is a thermistor, and R1 sets the temperature at which L2 lights. Lower or higher temperatures light L1 or L3 to indicate an over- or under-temperature condition.

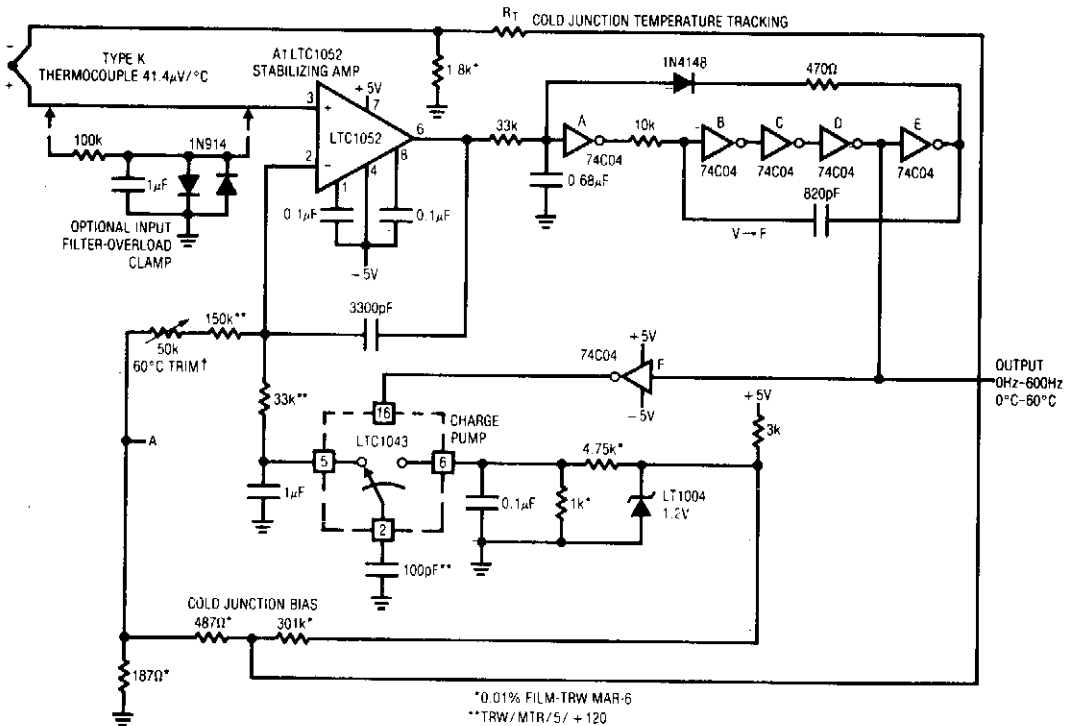
101

Temperature-to-Frequency Converters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Temperature-to-Frequency Converter
Digital Temperature Measuring Circuit

TEMPERATURE-TO-FREQUENCY CONVERTER



*0.01% FILM-TRW MAR-6
 **TRW/MTR/5/+120
 R_T = YELLOW SPRINGS INST. # 44007
 100pF = POLYSTYRENE
 † FOR GENERAL PURPOSE (1mV FULL-SCALE) 10-BIT A TO D. REMOVE THERMOCOUPLE - COLD JUNCTION NETWORK. GROUND POINT A, AND DRIVE LTC1052 POSITIVE INPUT.

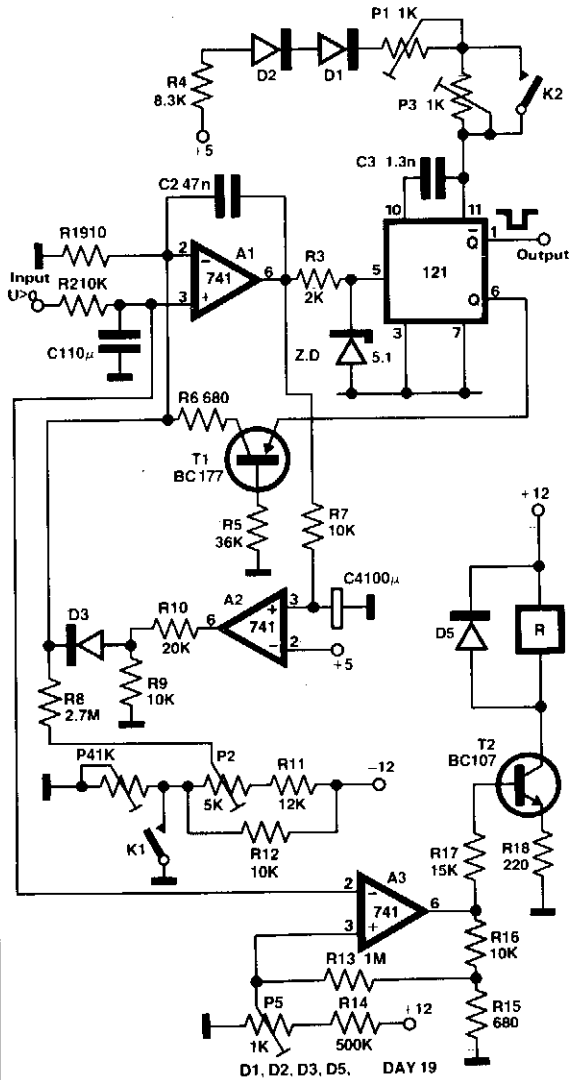
LINEAR TECHNOLOGY CORPORATION

Fig. 101-1

Circuit Notes

A1's positive input is biased by the thermocouple. A1's output drives a crude $V \rightarrow F$ converter, comprised of the 74C04 inverters and associated components. Each $V \rightarrow F$ output pulse causes a fixed quantity of charge to be dispensed into the $1 \mu F$ capacitor from the 100 pF capacitor via the LT1043 switch. The larger capacitor integrates the packets of charge, producing a dc voltage at A1's negative input. A1's output forces the $V \rightarrow F$ converter to run at whatever frequency is required to balance the amplifier's inputs. This feedback action eliminates drift and nonlinearities in the $V \rightarrow F$ converter as an error item and the output frequency is solely a function of the dc conditions at A1's inputs. The 3300 pF capacitor forms a dominant response pole at A1, stabilizing the loop.

DIGITAL TEMPERATURE MEASURING CIRCUIT



Circuit Notes

The output voltage of a thermocouple is converted into frequency measured by a digital frequency meter. The measuring set connected with Ni-NiCr thermocouple permits you to measure the temperatures within the range of 5°C - 800°C with $\pm 1^\circ\text{C}$ error. The output thermocouple signal is proportional to the temperature difference between the hot junction and the thermostat kept at 0°C, it drives the voltage-to-frequency converter changing the analogue input signal into the output frequency with the conversion ratio adjusted in such a way, that the frequency is equal to the measured temperature in Celsius degrees, e.g., for 350°C the frequency value is 350 Hz.

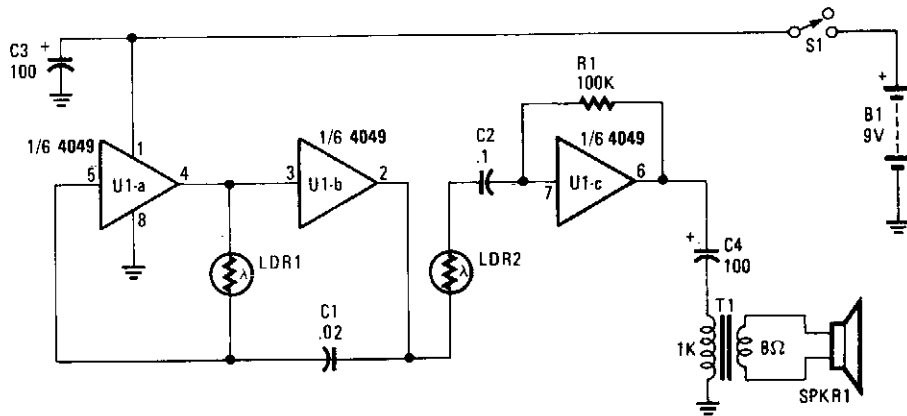
102

Theremins

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Electronic Theremin
Digital Theremin

ELECTRONIC THEREMIN



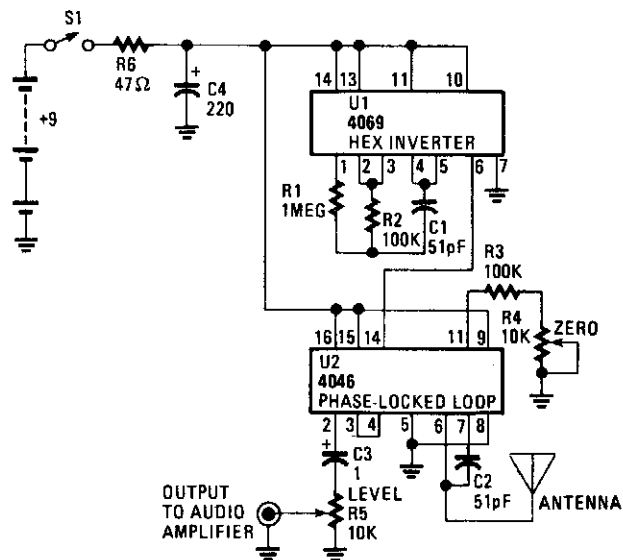
HANDS-ON ELECTRONICS

Fig. 102-1

Circuit Notes

This circuit has the CMOS IC doing double-duty performance. The first two inverters operate as a digital audio oscillator; the third operates as a low-gain linear audio amplifier. As the intensity of the light falling on photoresistor LDR1 increases the oscillator's frequency increases; similarly, the illumination falling on photoresistor LDR2 determines the volume level from the loudspeaker: The more illumination the more volume. If you flop and wave your hands between the two photocells and a light source, a special kind of electronic music will be produced.

DIGITAL THEREMIN



HANDS-ON ELECTRONICS

Fig. 102-2

Circuit Notes

The CD4069 or 74C04 hex inverter—is used as a fixed-frequency oscillator centered around 100 kHz. U2 contains the variable frequency oscillator and balanced modulator. The CD4046 is a phase-locked loop and R3, R4, and C2 determine the center frequency of the on-chip oscillator. The antenna forms a parallel capacitance with C2, which allows the frequency to be shifted several kilohertz by bringing a hand near the antenna. R4, the ZERO control, allows the variable oscillator to be set to the same frequency as the fixed oscillator. When the difference frequency is below 15 Hz, it is below the lower frequency limit of the ear. By setting both oscillators to the same frequency, the Theremin remains silent until the performer brings his or her hand near the antenna. The oscillators are mixed by an exclusive OR gate inside the 4046. That gate acts as a digital balanced modulator, which produces the sum and difference frequencies. The output of the gate is then ac coupled by C3 to LEVEL control R5 and an output jack for connection to an audio amplifier or stereo receiver.

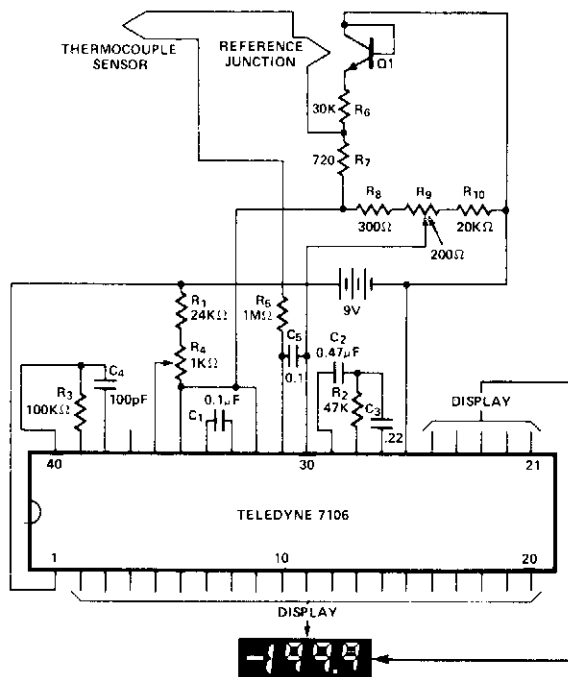
103

Thermometer Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Digital Thermocouple Thermometer
Remote Thermometer
Electronic Thermometer
Differential Thermometer
Basic Digital Thermometer, Kelvin Scale with Zero
Adjust
Centigrade Thermometer (0°C-100°C)

DIGITAL THERMOCOUPLE THERMOMETER



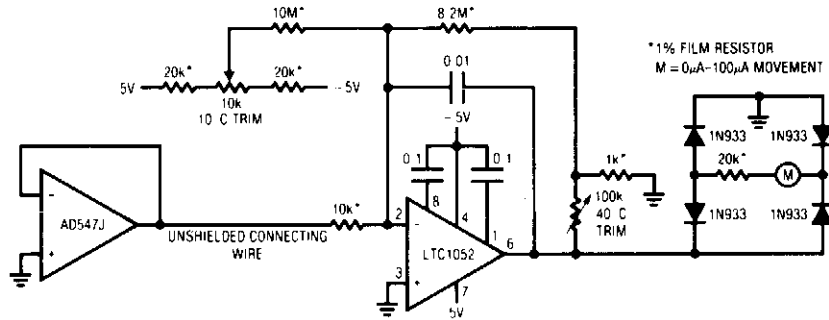
TELEDYNE SEMICONDUCTOR

Fig. 103-1

Circuit Notes

This digital thermocouple thermometer uses one active component and 15 passive components. With this circuit, both type J and type K thermocouples may be used. The type J will measure over the temperature range of 10 to 530°C with a conformity of $\pm 2^\circ\text{C}$. The type K will measure over a temperature range of 0°C to 1000°C with a conformity of $\pm 3^\circ\text{C}$.

REMOTE THERMOMETER



LINEAR TECHNOLOGY

Fig. 103-2

Circuit Notes

The low output impedance of a closed loop op amp gives ideal line-noise immunity, while the op amp's offset voltage drift provides a temperature sensor. Using the op amp in this way requires no external components and has the additional advantages of a hermetic package and unit-to-unit mechanical uniformity if replacement is ever required. The op amp's offset drift is amplified to drive the meter by the LTC1052. The diode bridge connection allows either positive or negative op amp temperature sensor offsets to interface directly with the circuit. In this case, the circuit is arranged for a +10°C to +40°C output, although other ranges are easily accommodated. To calibrate this circuit, subject the op amp sensor to a +10°C environment and adjust the 10°C trim for an appropriate meter indication. Next, place the op amp sensor in a +40°C environment and trim the 40°C adjustment for the proper reading. Repeat this procedure until both points are fixed. Once calibrated, this circuit will typically provide accuracy within $\pm 2^\circ\text{C}$, even in high noise environments.

ELECTRONIC THERMOMETER

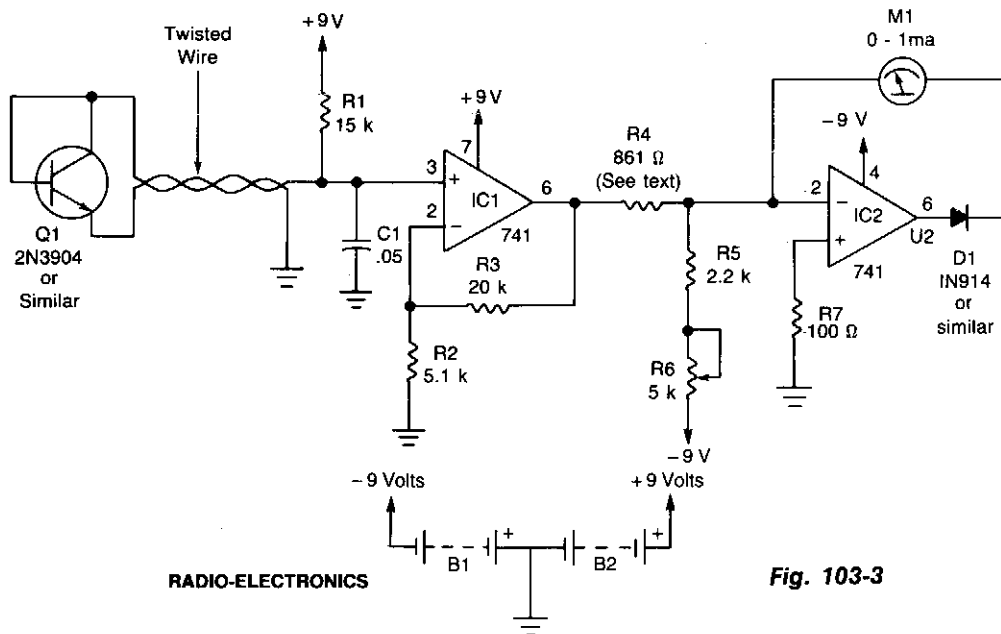


Fig. 103-3

Circuit Notes

An inexpensive electronic thermometer is capable of measuring temperatures over a range of from -30°F to $+120^{\circ}\text{F}$. A diode-connected 2N3904 transistor used as the temperature sensor forms a voltage divider with R1. As temperature increases, the voltage drop across the transistor changes by approximately -1.166 millivolts-per $^{\circ}\text{F}$. As a result, the current at pin 3 of IC1, a 741 op amp with a gain of 5, decreases as the temperature measured by the sensor increases.

A second 741 op amp, IC2 is configured as an inverting amplifier. Resistors R5 and R6 calibrate the circuit. Calibration is also straightforward. When properly done, a temperature of -30°F will result in a meter reading of 0 milliamps, while a temperature of 120°F will result in a meter reading of 1 milliamp. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. The calibration is completed by placing the sensor in an environment with a known temperature, such as an ice-point bath. Place the sensor in the bath and adjust R6 until you get the correct meter reading.

CENTIGRADE THERMOMETER (0°C-100°C)

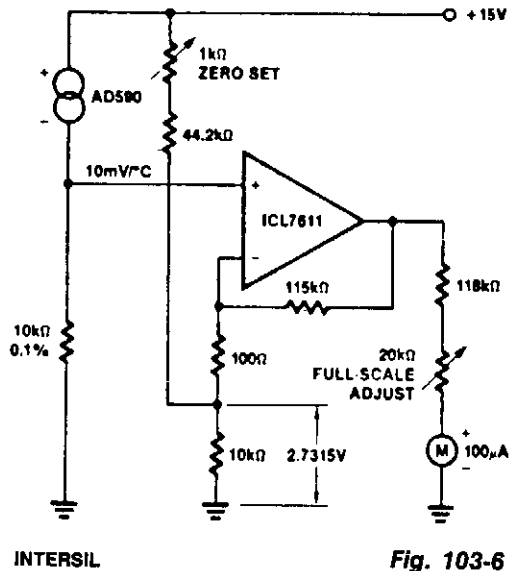


Fig. 103-6

Circuit Notes

The ultra-low bias current of the ICL7611 allows the use of large-value gain-resistors, keeping meter-current error under ½%, and therefore saving the expense of an extra meter-driving amplifier.

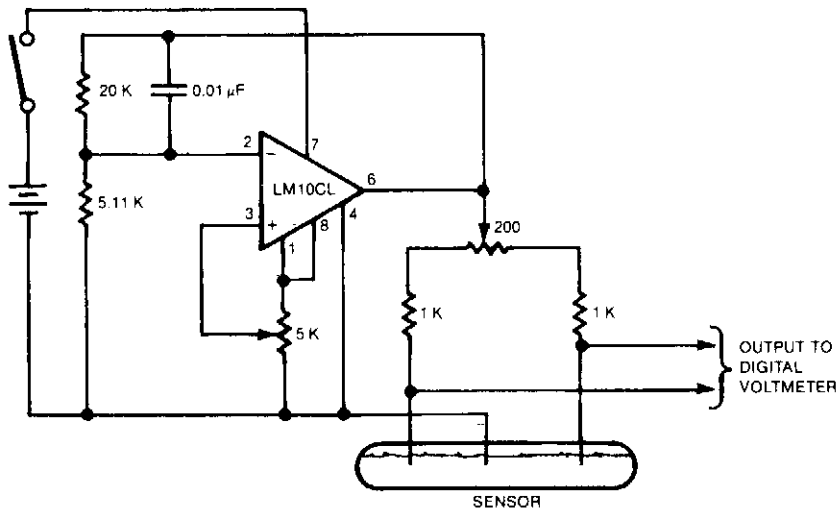
104

Tilt Meters

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Tiltmeter Indicates Sense of Slope
Differential Capacitance Measurement Circuit
Ultra-Simple Level

TILTMETER INDICATES SENSE OF SLOPE



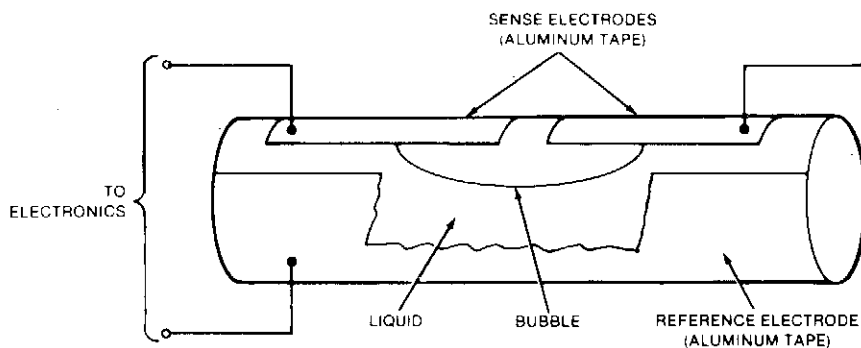
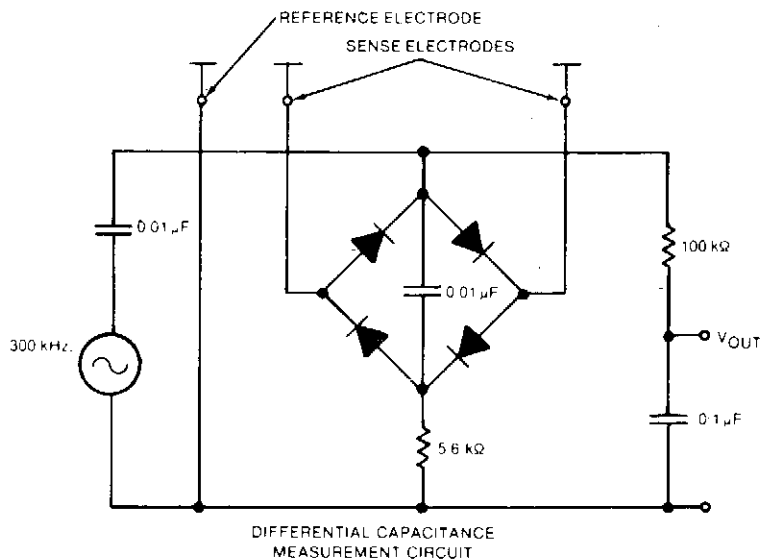
NASA

Fig. 104-1

Circuit Notes

Electrodes are immersed in an electrolyte that remains level while the sensor follows the tilt of the body on which it is placed, more of one outer electrode and less of the other are immersed and their resistances fall or rise, respectively. The resistance change causes a change in the output voltage of the bridge circuit. The sensor forms the two lower legs of the bridge, and two 1000 ohm metal film resistors and a 200 ohm cermet balance potentiometer form the two upper legs. In preparation for use, the bridge is balanced by adjusting the balance potentiometer so that the bridge output voltage is zero when the sensor is level. The bridge input voltage (dc excitation) is adjusted to provide about 10 millivolts output per degree of slope, the polarity indicating the sense of the slope. This scaling factor allows the multimeter to read directly in-degrees if the user makes a mental shift of the meter decimal point. The scaling-factor calibration is done at several angles to determine the curve of output voltage versus angle.

DIFFERENTIAL CAPACITANCE MEASUREMENT CIRCUIT



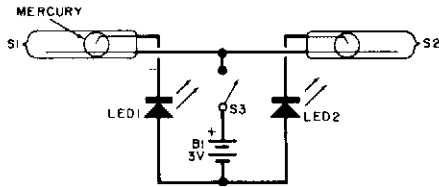
NASA

Fig. 104-2

Circuit Notes

A bubble vial with external aluminum-foil electrodes is the sensing element for a simple indicating tiltmeter. To measure bubble displacement, a bridge circuit detects the difference in capacitance between the two sensing electrodes and the reference electrode. Using this circuit, a tiltmeter level vial with 2 mm deflection for 5 arc-seconds of tilt easily resolves 0.05 arc-second. The four diodes are CA3039, or equivalent.

ULTRA-SIMPLE LEVEL



POPULAR ELECTRONICS

Fig. 104-3

Circuit Notes

This electronic level uses two LED indicators instead of an air bubble. If the surface is tilted to the right, one LED lights; if it's tilted to the left, the other LED lights. When the surface is level, both LEDs light. It uses two unidirectional mercury switches, S1 and S2. The unidirectional mercury switch has one long electrode and one short, angled electrode. The pool of mercury "rides" on the long electrode and makes contact between the two electrodes if the unit is held in a horizontal position.

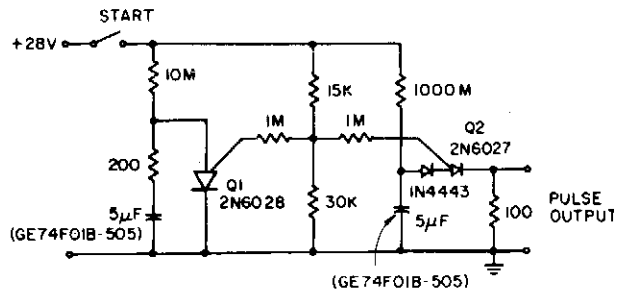
105

Time-Delay Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Hour Time-Delay Sampling Circuit
Time Delay With Constant Current Charging
Low-Cost Integrator Multiplies 555 Timer's Delay
Simple Time-Delay Circuit Using Two SCRs

HOUR TIME-DELAY SAMPLING CIRCUIT



GENERAL ELECTRIC

Fig. 105-1

Circuit Notes

The circuit lowers the effective peak current of the output PUT, Q2. By allowing the capacitor to charge with high gate voltage and periodically lowering gate voltage, when Q1 fires, the timing resistor can be a value which supplies a much lower current than I_p . The triggering requirement here is that minimum charge to trigger flow through the timing resistor during the period of the Q1 oscillator. This is not capacitor size dependent, only capacitor leakage and stability dependent.

TIME DELAY WITH CONSTANT CURRENT CHARGING

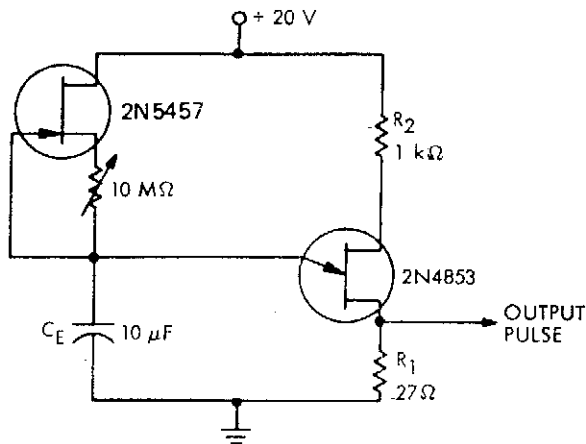
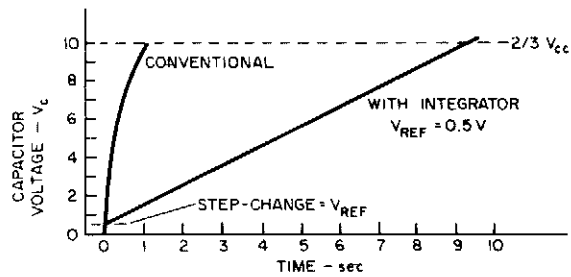
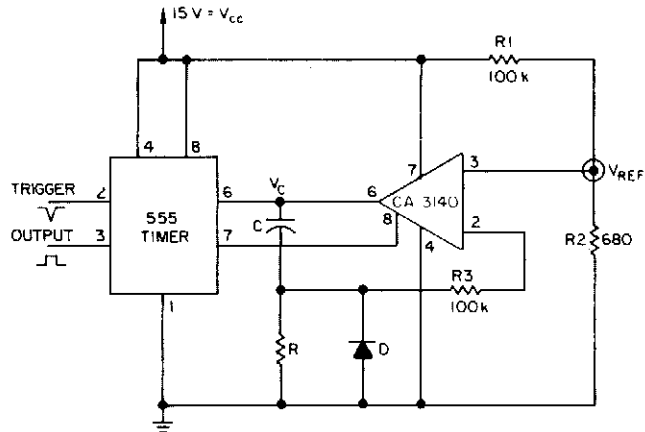


Fig. 105-2

MOTOROLA INC.

LOW-COST INTEGRATOR MULTIPLIES 555 TIMER'S DELAY



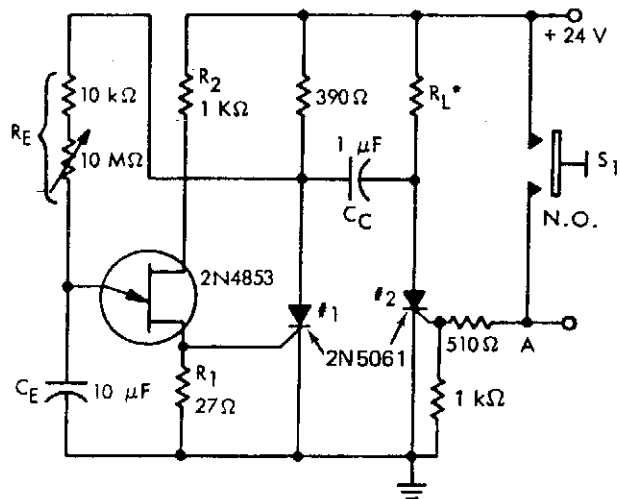
ELECTRONIC DESIGN

Fig. 105-3

Circuit Notes

Long delay times can be derived from a 555 timer with reasonably sized capacitors if an integrator circuit is used. The capacitor's charging time with an integrator circuit can be much longer than with a conventional 555-timer configuration.

SIMPLE TIME-DELAY CIRCUIT USING TWO SCRs



*Value of R_L must be low enough to allow hold current to flow in the SCR.

MOTOROLA INC.

Fig. 105-4

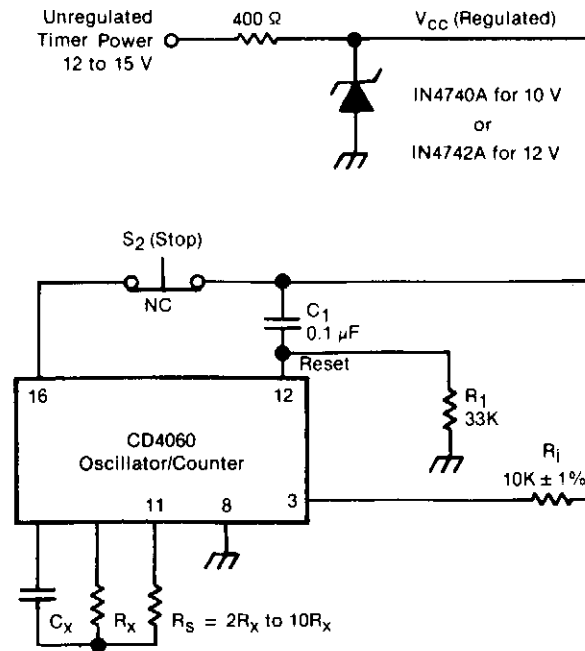
106

Timers

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Long-Term Electronic Timer
Timer with Alarm
Timer Circuit
PUT Long Duration Timer
Programmable Voltage Controlled Timer
Low Power Microprocessor Programmable Interval
Timer
Precision Elapsed Time/Countdown Timer
Adjustable AC Timer .2 to 10 sec.

LONG-TERM ELECTRONIC TIMER

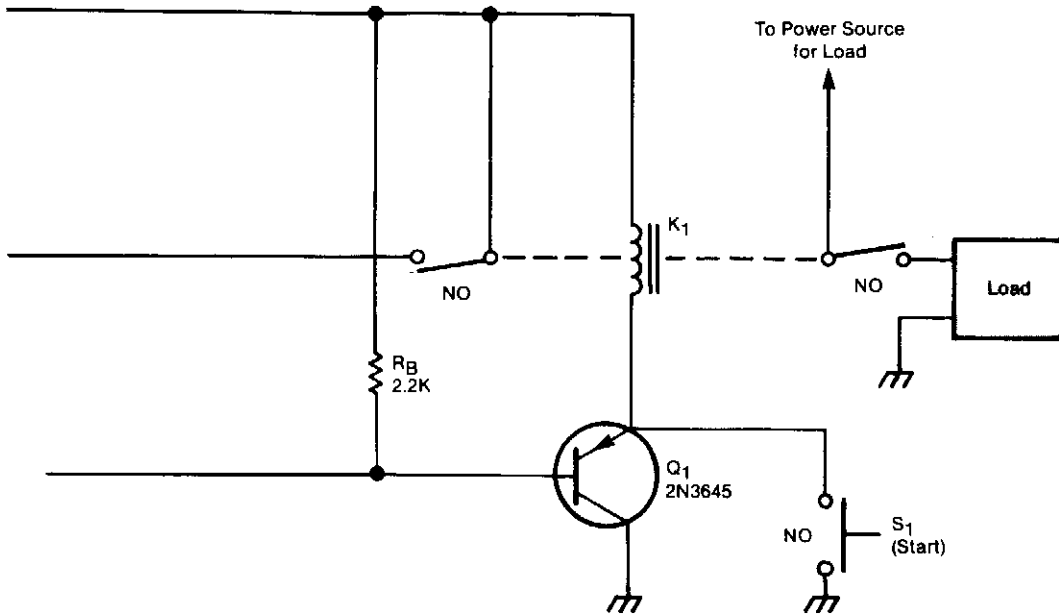


NASA

Fig. 106-1

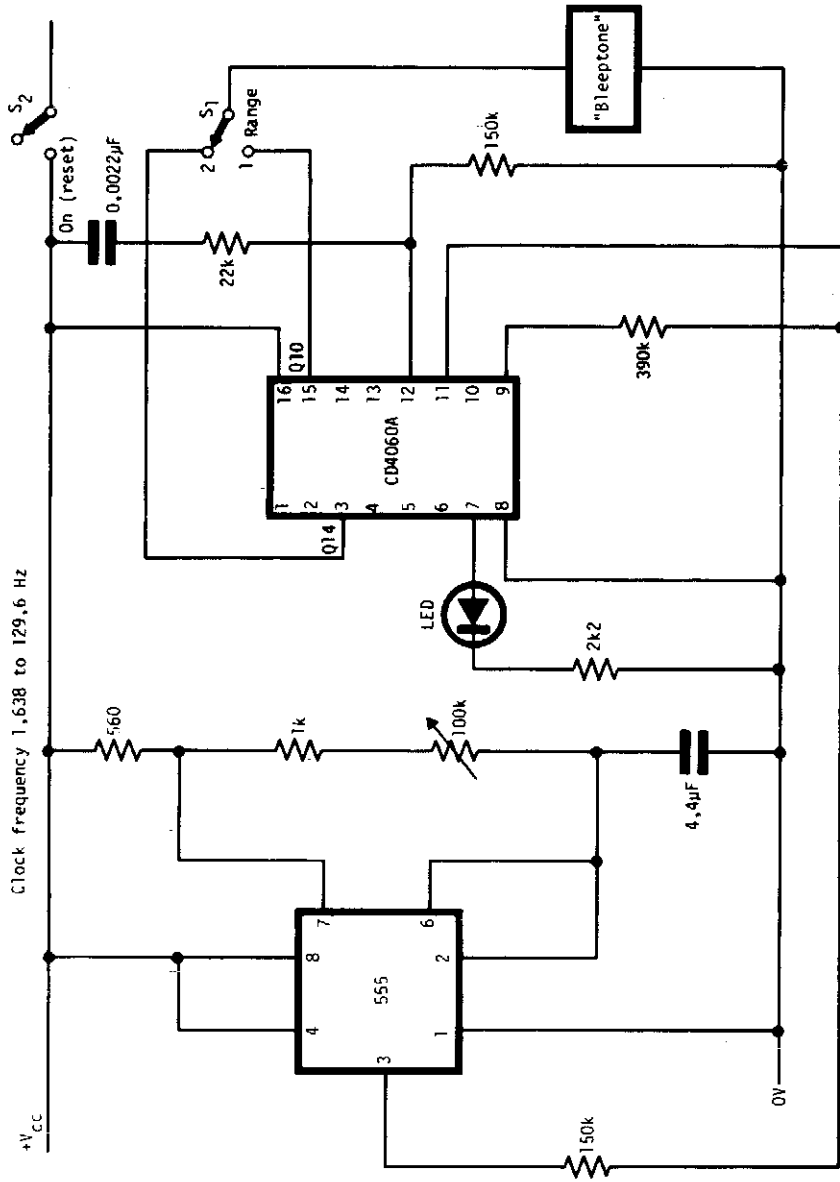
Circuit Notes

The timer includes an oscillator and a counter in an integrated circuit. The timing interval equals the oscillator period multiplied by the number of cycles to be counted. The oscillator frequency depends upon resistor R_S and capacitor C_X . The number of oscillator cycles to be counted before the counter output changes state is determined by the selection of the counter output terminal, shown here as pin 3. The interval can be set anywhere in the range from fractions of a second to months; it is given by $T = 0.55 R_S C_X^{2^n}$, where n is an integer determined by the counter-output selection. Operation is initiated by the closure of momentary switch S_1 (or by a command signal having a similar effect). This grounds one side of relay K_1 , thereby activating the relay



and causing the closure of the switches that supply power to the timer and to the load. The turn-on of V_{CC} at the timer is coupled through C1 to the counter-reset terminal, thus resetting the counter. The initial reset voltage transient is then drained away through R1 to permit normal operation. During the first half cycle of the counter operation, the counter output voltage (at pin 3 in this case) is low. This turns on transistor Q1 so that relay K1 latches on, enabling the timer to continue running even though switch S1 has opened. The oscillator runs while the relay is on. When the number of oscillator cycles reaches the limit, the counter output voltage at pin 3 goes high. This turns off Q1, thereby turning off the relay and returning the system to the original "power-off" state to await the next starting command. The timing cycle can also be interrupted and the system turned off by opening normally-closed switch S2.

TIMER WITH ALARM



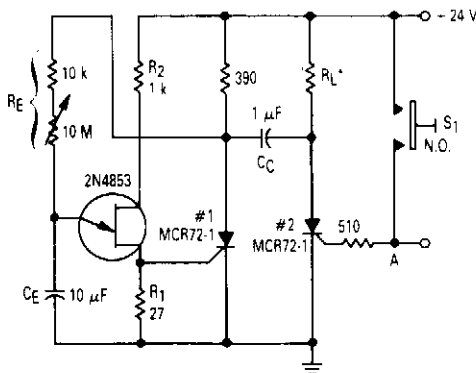
ELECTRONIC ENGINEERING

Fig. 106-2

Circuit Notes

The circuit has two ranges: 10 secs to 5 mins and 1 min to 80 mins. It can be powered by a 9-V battery. With the LED connected as shown a reasonable frequency of flashing occurs throughout the range of operation. This circuit is reset when S2 is closed.

TIMER CIRCUIT



*VALUE OF R_L MUST BE LOW ENOUGH TO ALLOW HOLD CURRENT TO FLOW IN THE SCR.

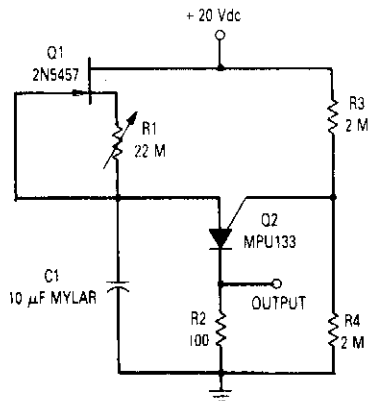
MOTOROLA

Fig. 106-3

Circuit Notes

After one cycle of operation, SCR 1 will be on, and a low value of voltage is applied to the UJT emitter circuit, interrupting the timing function. When pushbutton S1 is pushed, or a positive going pulse is applied at point A, SCR 2 will turn on, and SCR 1 will be turned off by commutating capacitor CC. With SCR 1 off, the supply voltage will be applied to RE and the circuit will begin timing again. After a period of time determined by the setting of RE, the UJT will fire and turn SCR 1 on and commutate SCR 2 off. The time delay is determined by the charge time of the capacitor.

PUT LONG DURATION TIMER



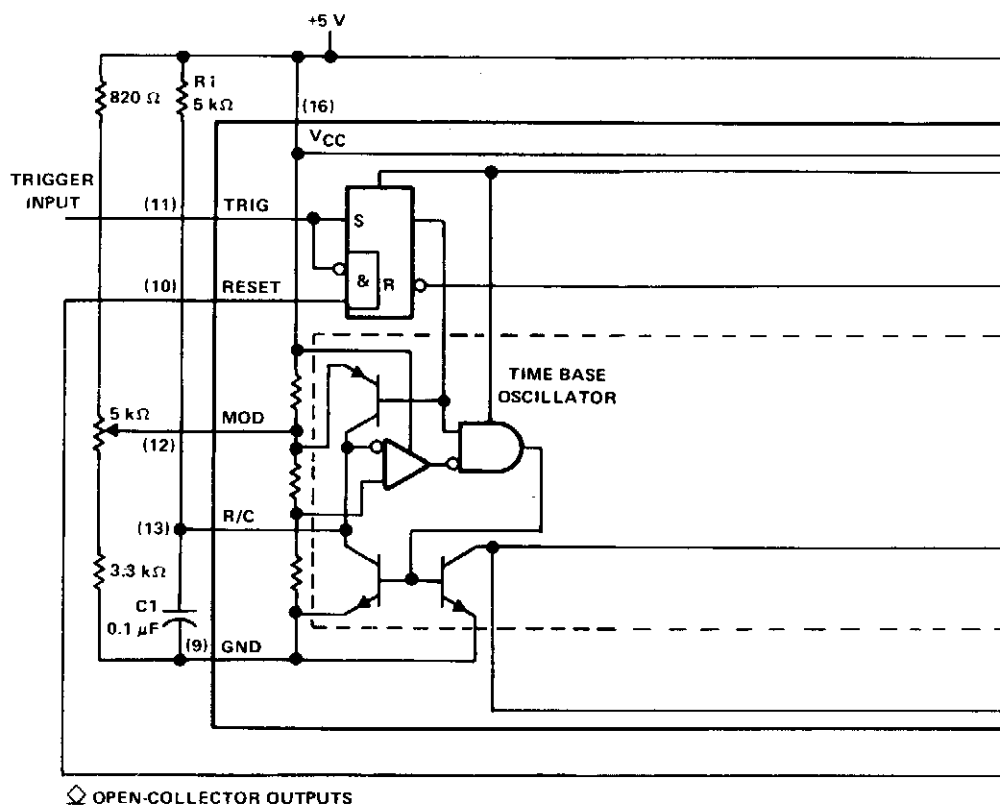
Circuit Notes

The time circuit can provide a time delay of up to 20 minutes. The circuit is a standard relaxation oscillator with a FET current source in which resistor R1 is used to provide reverse bias on the gate-to-source of the JFET. This turns the JFET off and increases the charging time of C1. C1 should be a low leakage capacitor such as a mylar type.

MOTOROLA

Fig. 106-4

PROGRAMMABLE VOLTAGE CONTROLLED TIMER

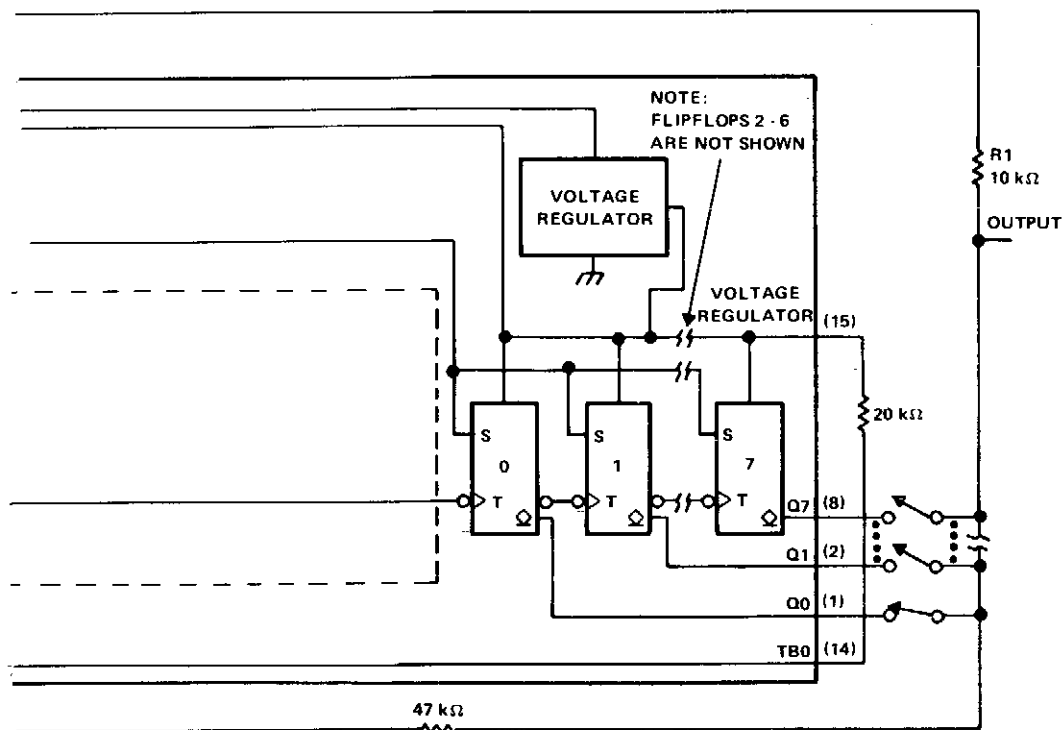


TEXAS INSTRUMENTS

Fig. 106-5

Circuit Notes

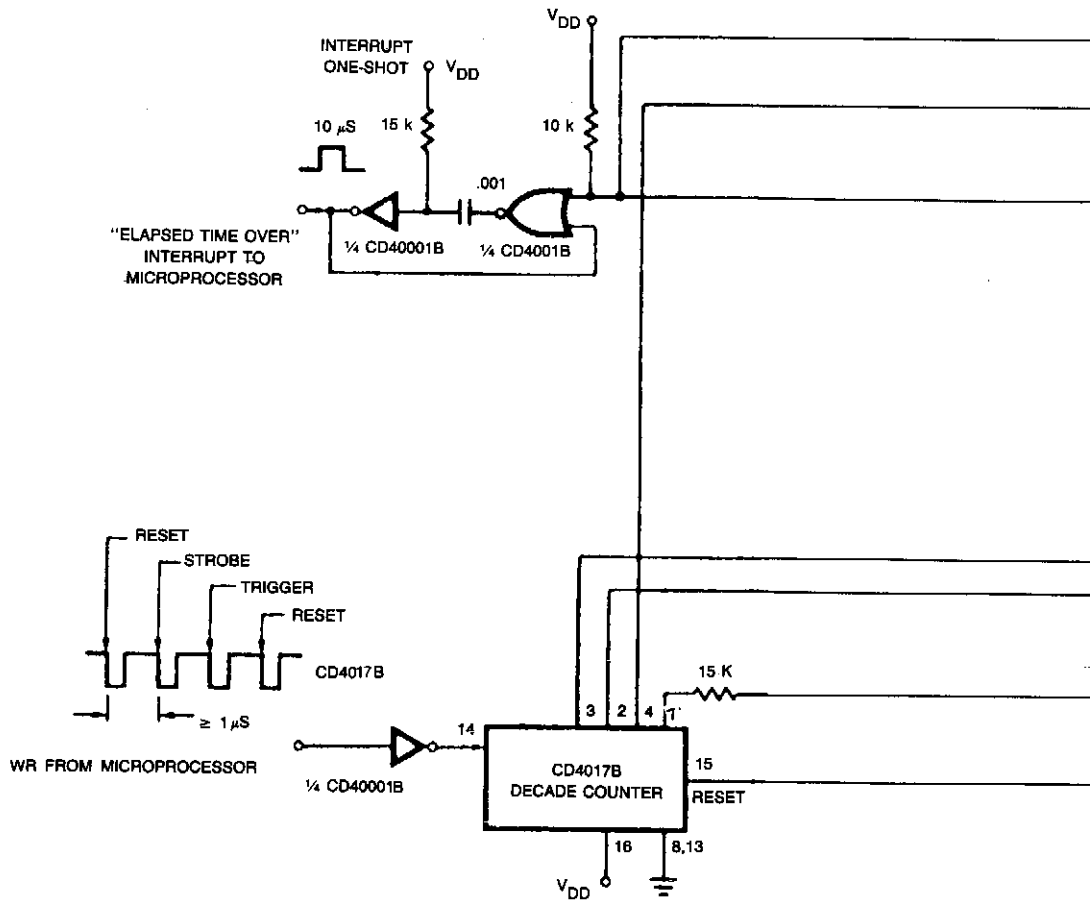
The $\mu\text{A}2240$ may easily be configured as a programmable voltage controlled timer with a minimum number of external components. The modulation input (pin 12), which allows external adjustment of the input threshold level. A variable voltage is applied from the arm of a 10 k ohm potentiometer connected from V_{CC} to ground. A change in the modulation input voltage will result in a change in the time base oscillator frequency and the period of the time base output (TBO). The TBO has an open-collector output that



is connected to the regulator output via a 10 k ohm pull-up resistor. The output of the TBO drives the input to the 8-stage counter section.

At start-up, a positive trigger pulse starts the TBO and sets all counter outputs to a low state. The binary outputs are open-collector stages that may be connected together to the 10 k ohm pull-up resistor to provide a "wired-OR" output function. This circuit may be used to generate 255 discrete time delays that are integer multiples of the time-base period. The total delay is the sum of the number of time-base periods, which is the binary sum of the Q outputs connected. Delays from 200 μ s to 0.223 s are possible with this configuration.

LOW POWER MICROPROCESSOR PROGRAMMABLE INTERVAL TIMER

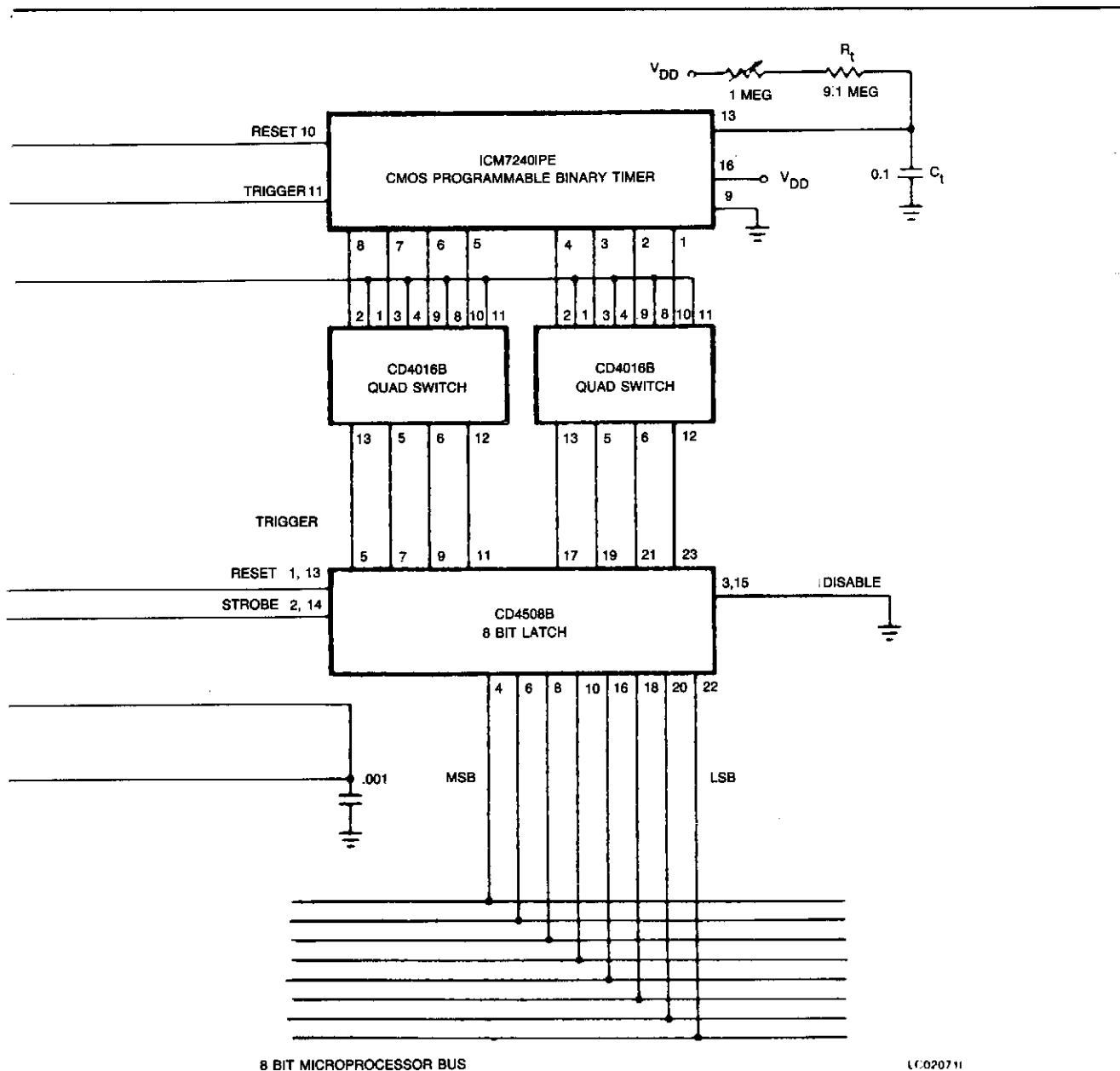


INTERSIL

Fig. 106-6

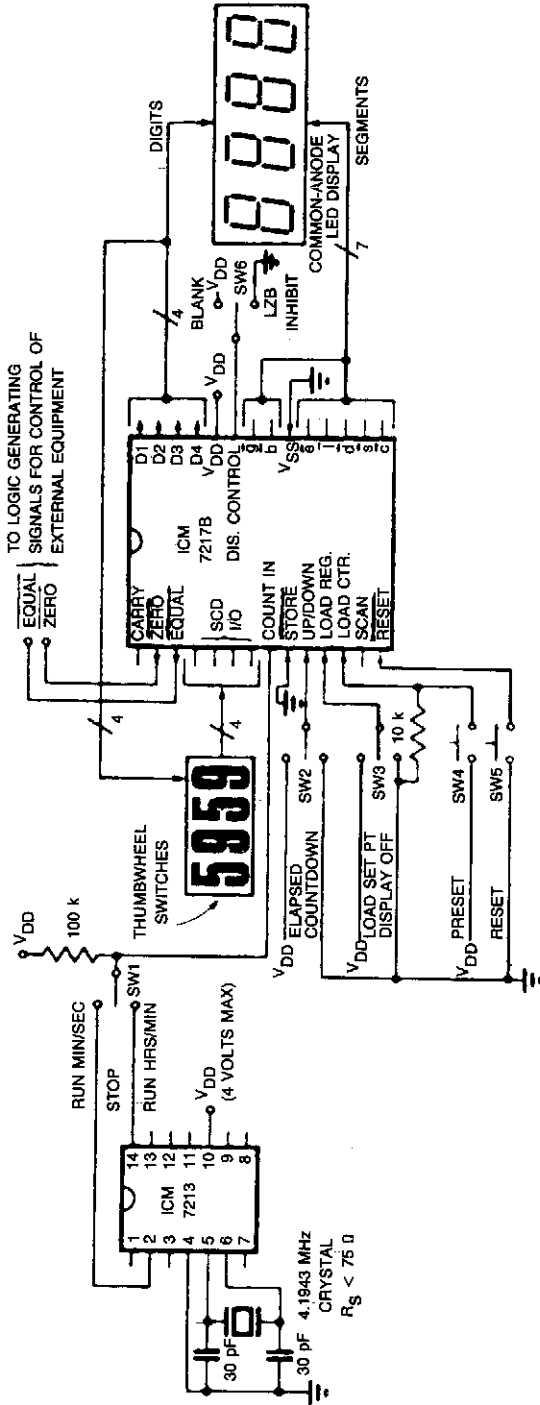
Circuit Notes

The microprocessor sends out an 8-bit binary code on its 8-bit I/O bus (the binary value needed to program the ICM7240), followed by four WRITE pulses into the CD4017B decade counter. The first pulse resets the 8-bit latch, the second strobes the binary value into the 8-bit latch, the third triggers the ICM7240 to begin its timing cycle and the fourth resets the decade counter. The ICM7240 then counts the interval of time



determined by the R-C value on pin 13, and the programmed binary count on pins 1 through 8. At the end of the programmed time interval, the interrupt one-shot is triggered, informing the microprocessor that the programmed time interval is over. With a resistor of approximately 10 M ohm and a capacitor of 0.1 μF , the time base of the ICM7240 is one second. Thus, a time of 1-255 seconds can be programmed by the microprocessor, and by varying R or C, longer or shorter time bases can be selected.

PRECISION ELAPSED TIME/COUNTDOWN TIMER



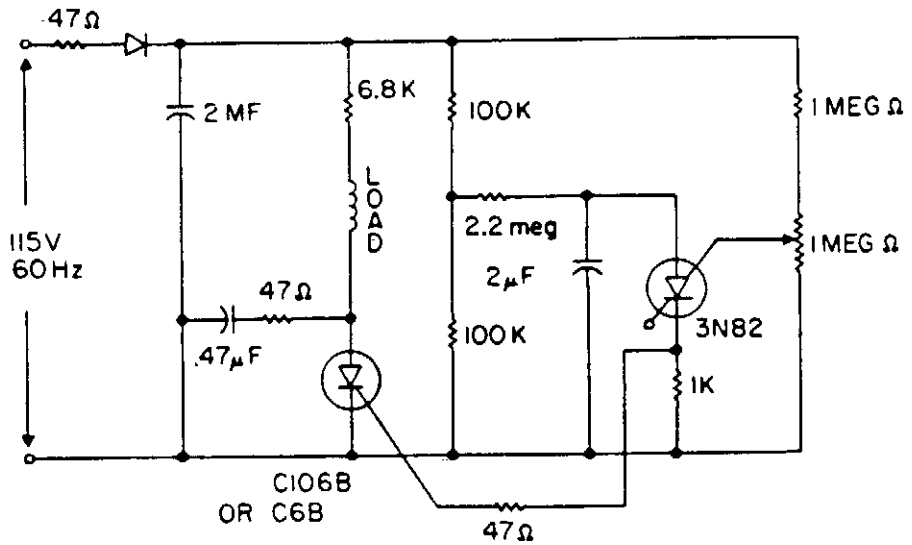
INTERSIL

Fig. 106-7

Circuit Notes

The circuit uses an ICM7213 precision one minute/one second timebase generator using a 4.1943 MHz crystal for generating pulses counted by an ICM7217B. The thumbwheel switches allow a starting time to be entered into the counter for a preset-countdown type timer, and allow the register to be set for compare functions. For instance, to make a 24-hour clock with BCD output the register can be preset with 2400 and the EQUAL output used to reset the counter. Note the 10 k resistor connected between the LOAD COUNTER terminal and ground. This resistor pulls the LOAD COUNTER input low when not loading, thereby inhibiting the BCD output drivers. This resistor should be eliminated and SW4 replaced with an SPDT center-off switch if the BCD outputs are to be used.

ADJUSTABLE AC TIMER .2 TO 10 SEC.



GENERAL ELECTRIC

Fig. 106-8

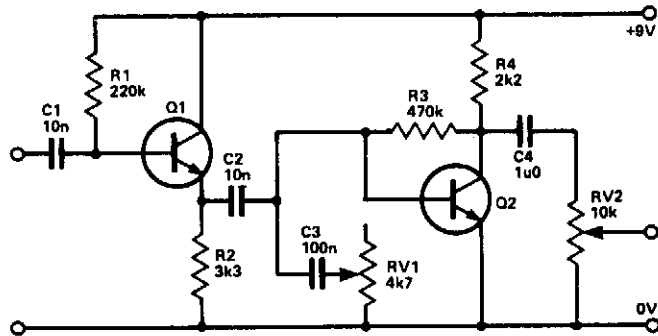
107

Tone Control Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Guitar Treble Boost
Tone Control
Ten Band Graphic Equalizer, Using Active Filters
Tone-Control Audio Amplifier
Mike Preamp with Tone Control
Low Cost High-Level Preamp and Tone Control
Circuit
Passive Tone-Control Circuit

GUITAR TREBLE BOOST



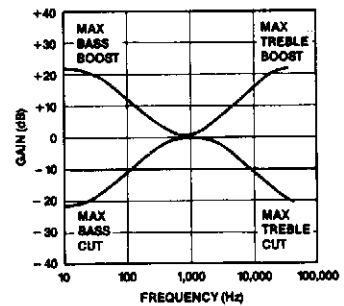
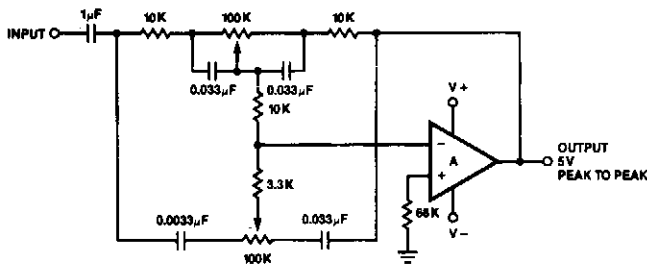
ELECTRONICS TODAY INTERNATIONAL

Fig. 107-1

Circuit Notes

Q1 is connected as an emitter follower in order to present a high input impedance to the guitar. C2, being a relatively low capacitance, cuts out most of the bass, and C3 with RV1 acts as a simple tone control to cut the treble, and hence the amount of treble boost can be altered. Q2 is a simple preamp to recover signal losses in C2, C3, and RV1.

TONE CONTROL



NOTES:

1. Amplifier A may be a NE531 or 301. Frequency compensation, as for unity gain non-inverting amplifiers, must be used.
2. Turn-over frequency — 1kHz.
3. Bass boost +20dB at 20Hz, bass cut -20dB at 20Hz, treble boost +19dB at 20Hz, treble cut -19dB at 20Hz.

All resistor values are in ohms.

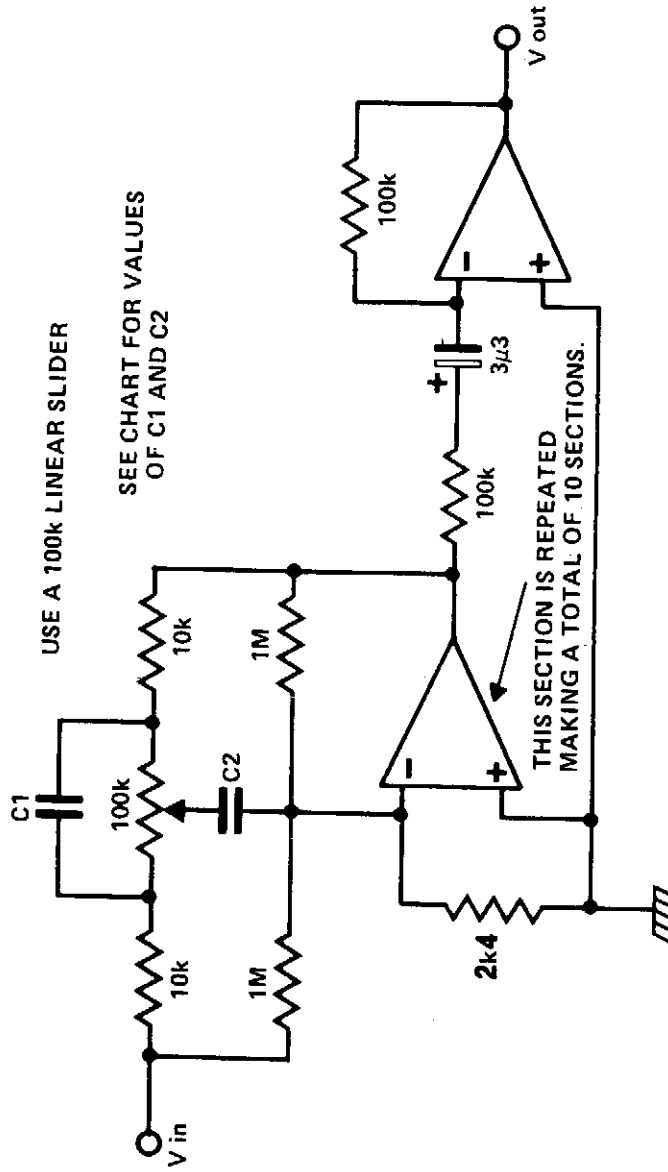
SIGNETICS

Fig. 107-2

Circuit Notes

Tone control of audio systems involves altering the flat response in order to attain more low frequencies or more high ones, dependent upon listener preference. The circuit provides 20 dB of bass or treble boost or cut as set by the variable resistance. The actual response of the circuit is shown also.

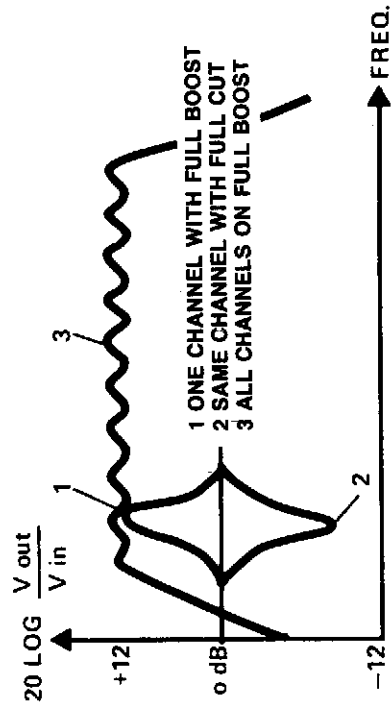
TEN BAND GRAPHIC EQUALIZER, USING ACTIVE FILTERS



ELECTRONICS TODAY INTERNATIONAL

Fig. 107-3

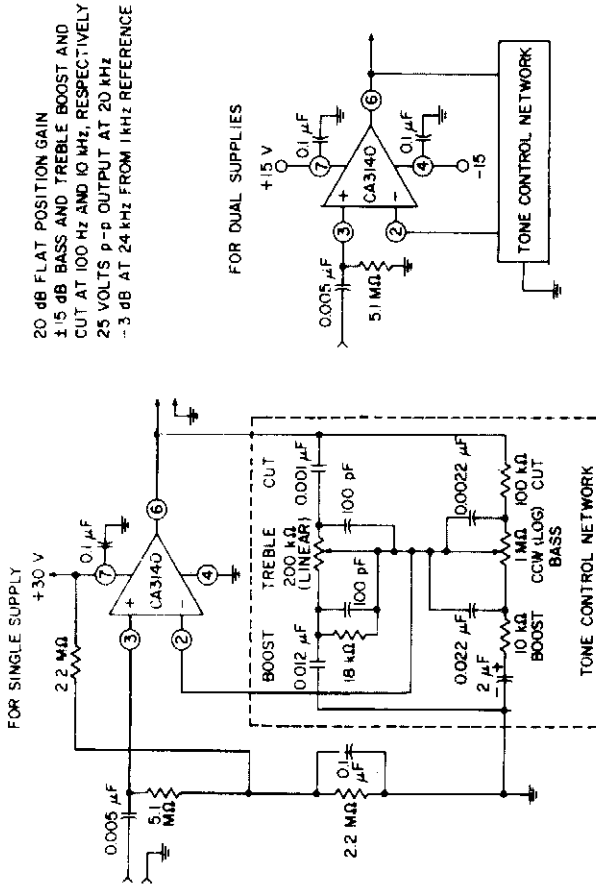
CHANNEL CENTRE FREQ. IN Hz	C1	C2
32	180n	18n
64	100n	10n
125	47n	4n7
250	22n	2n2
500	12n	1n2
1000	5n6	560p
2000	2n7	270p
4000	1n5	150p
8000	680p	68p
16000	360p	36p



Circuit Notes

The above circuit is repeated ten times. Use the table to calculate values.

TONE-CONTROL AUDIO AMPLIFIER

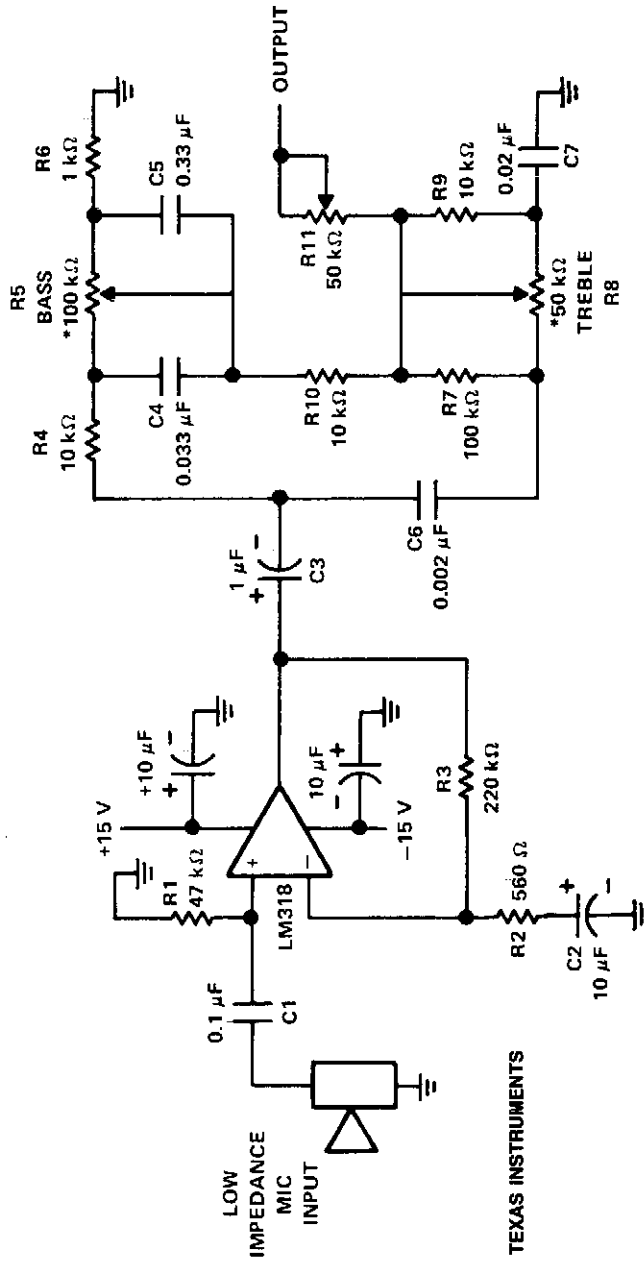


Circuit Notes

The circuit makes excellent use of the high slew rate, wide bandwidth, high input impedance, and high-output voltage capability of the CA3140 BiMOS op amp. The wideband gain of this circuit is equal to the ultimate boost or cut plus one, in this case a gain of eleven. For 20-dB boost or cut, input loading is essentially equal to the resistance from terminal 3 to ground.

Fig. 107-4

MIKE PREAMP WITH TONE CONTROL



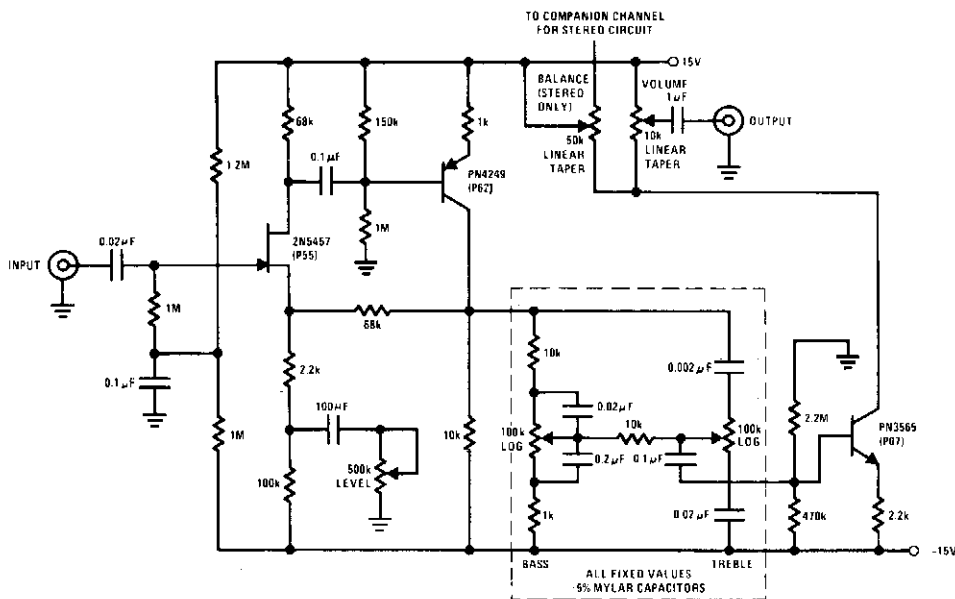
*THE TONE CONTROLS ARE AUDIO TAPER (LOG) POTENTIOMETERS.

Fig. 107-5

Circuit Notes

The LM318 op amp is operated as a standard non-inverting amplifier. Resistor R1 (47 k ohm) provides an input path to ground for the bias current of the non-inverting input. The combination of R2 (560 ohm) and C2 (10 μ F) provides a frequency roll-off below 30 Hz. At 30 Hz and above the gain is relatively flat at about 50 dB, set by the ratio R3/R2. R3 (200 k ohm) furnishes negative feedback from the output to the inverting input of the op amp. C3 (1.0 μ F electrolytic) ac couples the preamp to the tone control section. The top half of the tone control section is the bass control. The bottom half controls the treble frequency response. These tone controls (R5 and R8) require audio taper (logarithmic) potentiometers. The 50 k ohm potentiometer on the output can be used to set the output or gain of the preamp.

LOW COST HIGH-LEVEL PREAMP AND TONE CONTROL CIRCUIT



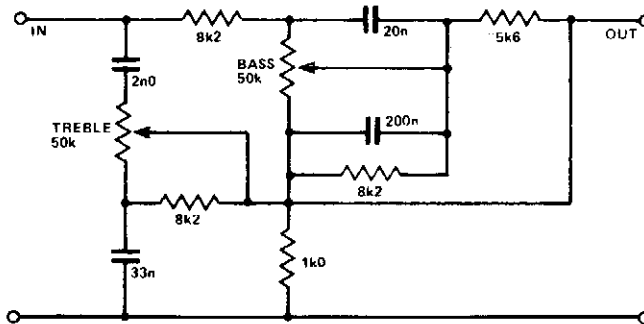
NATIONAL SEMICONDUCTOR CORP.

Fig. 107-6

Circuit Notes

This preamp and tone control uses the JFET to its best advantage; as a low noise high input impedance device. All device parameters are noncritical, yet the circuit achieves harmonic distortion levels of less than 0.05% with a S/N ratio of over 85 dB. The tone controls allow 18 dB of cut and boost; the amplifier has a 1-V output for 100-mV input at maximum level.

PASSIVE TONE-CONTROL CIRCUIT



ELECTRONICS TODAY INTERNATIONAL

Fig. 107-7

Circuit Notes

A simple circuit using two potentiometers and easily available standard value components provides tone control. The impedance level is suitable for low-level transistor or op amp circuitry.

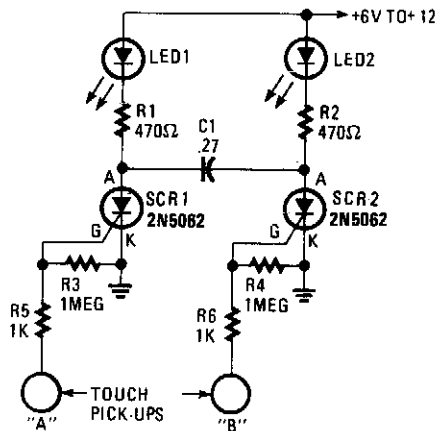
108

Touch-Switch Circuits

The sources of the following circuits are contained in the Sources section beginning on page 694. The figure number contained in the box of each circuit correlates to the source entry in the Sources section.

Touch On/Off Switch
Touch Switch
Touchomatic

TOUCH ON/OFF SWITCH



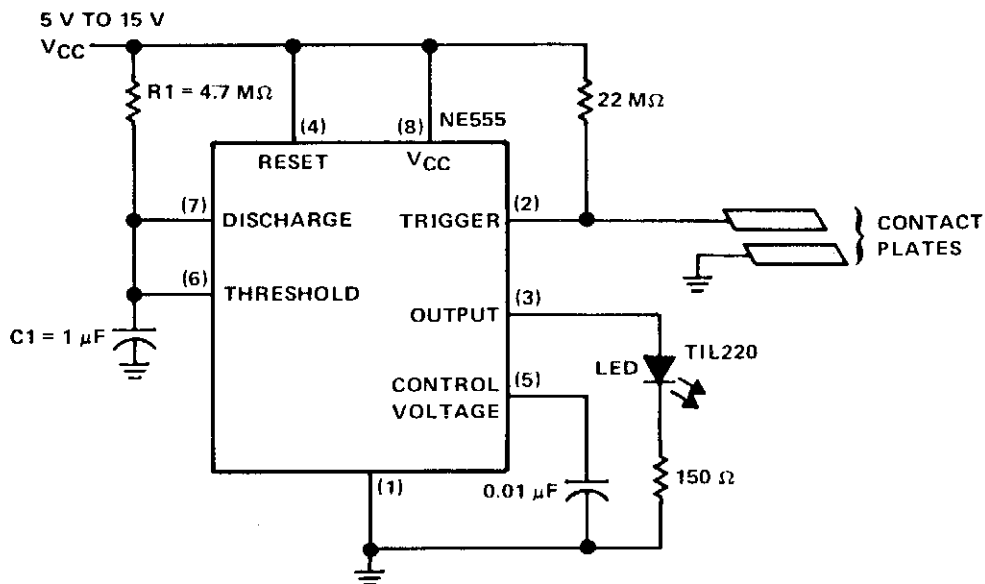
HANDS-ON ELECTRONICS

Fig. 108-1

Circuit Notes

If a Touch On/Off Switch is desired, this circuit fills the bill. Two sensitive gate SCRs are interconnected, so that when one of the devices is turned on, the other (if on) is forced off. That toggling effect gives an on/off circuit condition for each of the LEDs in the SCR-anode circuits. To turn LED1 on and LED2 off, simply touch the "A" terminal, and to turn LED1 off and LED2 on, the "B" pick-up must be touched. It is possible to simultaneously touch both terminals, causing both SCRs to turn on together. To reset the circuit to the normal one-on/one-off condition, momentarily interrupt the circuit's dc power source. Additional circuitry can be connected to the anode circuit of either or both SCRs to be controlled by the on/off function of the touch switch.

TOUCH SWITCH



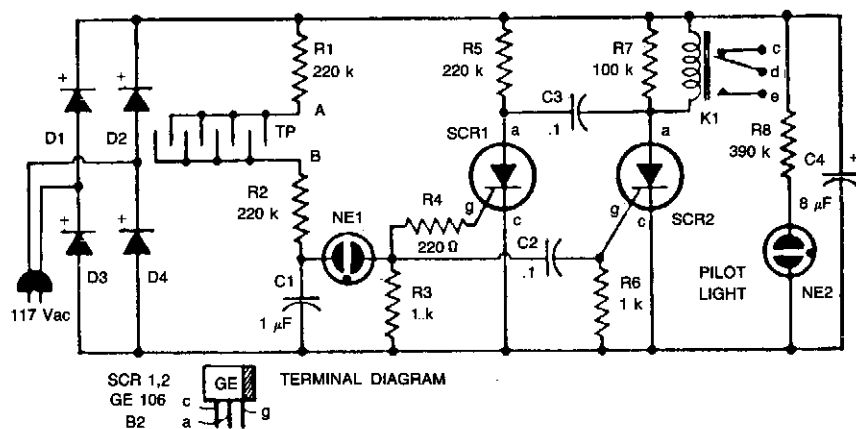
TEXAS INSTRUMENTS

Fig. 108-2

Circuit Notes

The circuit is basically a NE555 monostable, the only major difference being its method of triggering. The trigger input is biased to a high value by the 22 M ohm resistor. When the contact plates are touched, the skin resistance of the operator will lower the overall impedance from pin 2 to ground. This action will reduce the voltage at the trigger input to below the $\frac{1}{3} V_{CC}$ trigger threshold and the timer will start. The output pulse width will be $T = 1.1 R_1 C_1$, in this circuit about 5 seconds. A relay connected from pin 3 to ground instead of the LED and resistor could be used to perform a switching function.

TOUCHOMATIC



TAB BOOKS, INC.

Fig. 108-3

Circuit Notes

When someone touches the touchplate (TP), the resistance of his finger across points A and B is added in series to the combination of R1 and R2, the capacitor C2 begins to charge. When the voltage across C1 is finally sufficient to fire NE1, C1 will begin to discharge. When NE1 fires, it produces a short between its terminals. Since R3 is connected across C1, they are effectively in series after NE1 fires. A voltage spike will then be passed by C2 and this will act as a positive triggering pulse. The pulse is fed to both SCR gates: SCR2 conducts, thereby closing relay K1. With a finger no longer on the touchplate, no more pulses are forthcoming because the C1 charge path is open. The next contact with the touchplate will produce a pulse which triggers SCR1. SCR2 is now off by capacitor C3 which was charged by current passing through R6 and SCR2. The firing of SCR1 in this way places a negative voltage across SCR2 which momentarily drops the relay current to a point below the holding current value of SCR2. (Holding current is the minimum current an SCR requires to remain in a conducting state once its gate voltage is removed.) With SCR2 turned off, the relay will open and SCR1 will turn off due to the large resistance in series with its anode. Starved in this way SCR1 turns off because of a forced lack of holding current.

Sources Index

Chapter 1

Fig. 1-1. Signetics 1987 Linear Data Manual Vol. 2, 2/87, p.7-65.

Fig. 1-2. General Electric Application Note 90.16, p. 25.

Fig. 1-3. Courtesy, William Sheets.

Fig. 1-4. General Electric Application Note 90.16, p. 25.

Fig. 1-5. General Electric/RCA, B1MOS Operational Amplifiers Circuit Ideas, 1987, p. 27.

Fig. 1-6. R-E Experimenters Handbook, p. 157.

Chapter 2

Fig. 2-1. Linear Technology Corporation, Linear Applications Handbook, 1987, p. AN21-2

Fig. 2-2. Linear Technology Corporation, Linear Databook Supplement, 1988, p. S2-34.

Fig. 2-3. Siliconix, Integrated Circuits Data Book, 3/85, p. 10-154.

Fig. 2-4. Linear Technology Corp., Linear Databook, 1986, p. 2-83.

Fig. 2-5. National Semiconductor Corp., Transistor Databook, 1982, p. 11-23.

Fig. 2-6. Linear Technology Corp., Linear Applications Handbook, 1987, p. AN21-1.

Fig. 2-7. Signetics, 1987 Linear Data Manual, Vol. 2: Industrial, 10/86, p. 4-260.

Fig. 2-8. Electronic Engineering, 11/86, p. 40.

Fig. 2-9. National Semiconductor Corp., Transistor Databook, 1982, p. 11-25.

Fig. 2-10. Siliconix, Integrated Circuits Data Book, 3/85, p. 2-112.

Fig. 2-11. Electronics Engineering, 9/78, p. 17.

Fig. 2-12. Electronics Engineering, 9/84, p. 33.

Fig. 2-13. Signetics, 1987 Linear Data Manual, Vol. 1: Communications, 8/87, p. 4-346.

Fig. 2-14. NASA Tech Briefs, Spring 1983, p. 244.

Fig. 2-15. Radio Electronics, 7/83, p. 74.

Fig. 2-16. Motorola Inc., Linear Integrated Circuits, 1979, p. 6-58.

Fig. 2-17. MR-E Experimenters Handbook, p. 158.

- Fig. 2-19. *Popular Electronics*, 8/68.
 Fig. 2-20. *Ham Radio*, 9/84, p. 24.
 Fig. 2-21. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 20.
 Fig. 2-22. *Texas Instruments, Linear and Interface Circuits Applications*, Vol. 1, 1985, p. 3-2, 3-4.
 Fig. 2-23. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 3/87, p. 4-345.
 Fig. 2-24. *Electronic Engineering*, 11/85, p. 32.
 Fig. 2-25. *NASA Tech Briefs*, Sept/Oct 1986, p. 43.

Chapter 3

- Fig. 3-1. *Intersil, Component Data Catalog*, 1987, p. 4-43.
 Fig. 3-2. *Linear Technology, Application Note 9*, p. 16.
 Fig. 3-3. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 26.
 Fig. 3-4. *Linear Technology Corp., Linear Applications Handbook*, 1987, p. AN15-2.
 Fig. 3-5. *Linear Technology Corp., Linear Databook*, 1986, p. 5-17.
 Fig. 3-6. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 11/86, p. 5-215.
 Fig. 3-7. *National Semiconductor Corp., 1984 Linear Supplement Databook*, p. S5-126.
 Fig. 3-8. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 12/86, p. 4-67.

Chapter 4

- Fig. 4-1. *Electronic Design*, 5/82, p. 214.
 Fig. 4-2. *R-E Experimenters Handbook*, p. 160.
 Fig. 4-3. *Popular Electronics*, 11/73, p. 50.

Chapter 5

- Fig. 5-1. *Hands-On Electronics, Summer 1984*, p. 77.
 Fig. 5-2. *Courtesy, William Sheets*.
 Fig. 5-3. *Courtesy, William Sheets*.
 Fig. 5-4. *Electronic Engineering*, 5/84, p. 44
 Fig. 5-5. *Texas Instruments, Linear and Interface Circuits Applications*, vol. 1, 1985, p. 3-13.

- Fig. 5-6. *Electronics Today International*, 4/85, p. 82.

Chapter 6

- Fig. 6-1. *Tab Books Inc., 101 Sound, Light, and Power IC Projects*.
 Fig. 6-2. *Radio Electronics*, 7/70, p. 38.
 Fig. 6-3. *Hands-On Electronics, Jul/Aug 1986*, p. 16.
 Fig. 6-4. *73 Magazine*, 12/76, p. 170.
 Fig. 6-5. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 21.
 Fig. 6-6. *Ibid.*
 Fig. 6-7. *Texas Instruments, Linear and Interface Circuits Applications*, Vol. 1, 1985, p. 3-17.
 Fig. 6-8. *Signetics, Analog Data Manual*, 1982, p. 3-90.

Chapter 7

- Fig. 7-1. *Motorola, CMOS Power FET Design Ideas*, 1985.
 Fig. 7-2. *Hands-On Electronics*, 4/87, p. 95.
 Fig. 7-3. *Tab Books, Inc., The Giant book of Easy-To-Build Electronics Projects*, 1982, p. 196.
 Fig. 7-4. *General Electric, Optoelectronics, Third Edition*, p. 151.
 Fig. 7-5. *Tab Books, Inc., The Build-It Book of Electronic Projects*, No. 1498, p. 28.
 Fig. 7-6. *Radio-Electronics*, 6/85, p. 60.
 Fig. 7-7. *Popular Electronics*, 12/74, p. 6.
 Fig. 7-8. *Popular Electronics*, 4/75, p. 68.
 Fig. 7-9. *Texas Instruments, Linear and Interface Circuits Applications*, 1987, p. 10-21.
 Fig. 7-10. *Texas Instruments, Linear and Interface Circuits Applications*, 1985, vol. 1, p. 3-5.
 Fig. 7-11. *Radio-Electronics*, 1979.
 Fig. 7-12. *Hands-On Electronics*, 1/87, p. 30.
 Fig. 7-13. *Electronic Engineering*, 12/75, p. 9.
 Fig. 7-14. *Electronic Design* 18, 9/76, p. 114.
 Fig. 7-15. *Radio-Electronics*, 5/87, p. 10.
 Fig. 7-16. *Hands-On Electronics, Fall 1984*, p. 45.
 Fig. 7-17. *Hands-On Electronics*, 4/87, p. 92.
 Fig. 7-18. *General Electric, Optoelectronics, Third Edition*, p. 105.

Chapter 8

- Fig. 8-1. CQ, 7/82, p. 18.
Fig. 8-2. *Electronics Design*, 7/76, p. 120.
Fig. 8-3. Courtesy, William Sheets.
Fig. 8-4. Moli Energy Limited.
Fig. 8-5. Linear Technology Corp., *Linear Applications Handbook*, 1987, p. AN6-3.
Fig. 8-6. Courtesy, William Sheets.
Fig. 8-7. Texas Instruments, *Linear and Interface Circuits Applications, Vol. 1*, p. 6-24.
Fig. 8-8. Linear Technology Corp., *Linear Databook Supplement*, 1988, p. S5-11.
Fig. 8-9. Motorola, *TMOS Power FET Design Ideas*, 1985, p. 8.
Fig. 8-10. *Radio Electronics*, 9/85, p. 44.
Fig. 8-11. Siliconix, *MOSpower Applications Handbook*, p. 6-176.

Chapter 9

- Fig. 9-1. Motorola, *TMOS Power FET Ideas*, 1985, p. 7.
Fig. 9-2. *Electronic Engineering*, 2/85, p. 45.
Fig. 9-3. *Electronic Engineering*, 10/70, p. 17.
Fig. 9-4. *Electronic Engineering*, Mid5/78, p. 11.
Fig. 9-5. Moli Energy Limited, Publication MEL-126.
Fig. 9-6. Linear Technology Corp., *Linear Databook*, 1986, p. 2-104.
Fig. 9-7. Courtesy, William Sheets.
Fig. 9-8. Tab Books, Inc., *101 Sound, Light, and Power IC Projects*.

Chapter 10

- Fig. 10-1. Signetics, 1987 *Linear Data Manual, Vol. 2: Industrial*, 2/87, p. 5-367.
Fig. 10-2. Texas Instruments, *Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 3-3, 3-4.
Fig. 10-3. Courtesy, William Sheets.
Fig. 10-4. General Electric/RCA, *BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 17.
Fig. 10-5. Siliconix, *Small-Signal FET Data Book*, 1/86, p. 7-29.
Fig. 10-6. Linear Technology Corp., *Linear Databook*, 1986, p. 2-83.
Fig. 10-7. Linear Technology Corp., *Linear Databook*, 1986, p. 2-101.

Chapter 11

- Fig. 11-1. Signetics, 1987 *Linear Data Manual, Vol. 1: Communications*, 2/87, p. 4-312.
Fig. 11-2. *Electronic Engineering*, 5/86, p. 50.
Fig. 11-3. *Electronic Design*, 9/73, p. 148.
Fig. 11-4. Intersil, *Component Data Catalog*, 1987, p. 6-28.
Fig. 11-5. Signetics, *555 Timers*, 1973, p. 19.

Chapter 12

- Fig. 12-1. Texas Instruments, *Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 7-21.
Fig. 12-2. *Electronic Engineering*, 2/85, p. 34.

Chapter 13

- Fig. 13-1. *Hands-On Electronics*, 3/87, p. 25.
Fig. 13-2. Motorola, *TMOS Power FET-Design Ideas*, 1985, p. 17.
Fig. 13-3. Linear Technology Corp., *Linear Applications Handbook*, 1987, p. AN13-23.
Fig. 13-4. Intersil, *Component Data Catalog*, 1987, p. 5-113.
Fig. 13-5. Courtesy, William Sheets.
Fig. 13-6. Linear Technology Corp., *Linear Databook*, 1986, p. 3-23.
Fig. 13-7. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-57.

Chapter 14

- Fig. 14-1. *Electronic Engineering*, 3/78, p. 38.
Fig. 14-2. *Hands-On Electronics, Nov/Dec* 1985, p. 4.

Chapter 15

- Fig. 15-1. Linear Technology Corp., *Linear Databook*, 1986, p. 2-82.
Fig. 15-2. *Popular Electronics*, 9/77, p. 92.
Fig. 15-3. Signetics, 1987 *Linear Data Manual Vol. 2: Industrial*, 11/86, p. 5-269.
Fig. 15-4. Siliconix, *Integrated Circuits Data Book*, 3/85, p. 5-8.
Fig. 15-5. *Electronic Engineering*, 2/85, p. 45.
Fig. 15-6. *Electronic Engineering*, 2/84, p. 36.
Fig. 15-7. *Electronic Design* 15, 7/79, p. 120.
Fig. 15-8. *Electronic Engineering*, 12/78, p. 17.

- Fig. 15-9. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 23.
- Fig. 15-10. *Electronic Engineering*, 11/86, p. 39.
- Fig. 15-11. *Popular Electronics*, 3/79, p. 77.
- Fig. 15-12. *Electronic Engineering*, 7/86, p. 27.
- Fig. 15-13. *Electronic Engineering*, 1/86, p. 37.

Chapter 16

- Fig. 16-1. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 5-215.
- Fig. 16-2. *Linear Technology Corp., Linear Databook*, 1986, p. 4-15.
- Fig. 16-3. *Siliconix, Integrated Circuits Data Book*, 3/85, p. 2-207.
- Fig. 16-4. *Siliconix, Integrated Circuits Data Book*, 3/85, p. 2-231.
- Fig. 16-5. *Intersil, Component Data Catalog*, 1987, p. 13-51.
- Fig. 16-6. *Siliconix, Integrated Circuits Data Book*, 3/85, p. 3-62.
- Fig. 16-7. *Datel, Data Conversion Components*, p. 4-37.

Chapter 17

- Fig. 17-1. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 2/87, p. 7-62.
- Fig. 17-2. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 4-136.
- Fig. 17-3. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 5-269.
- Fig. 17-4. *Electronic Engineering*, 12/77, p. 19.
- Fig. 17-5. *Siliconix, Integrated Circuits Data Book*, 3/85, p. 5-17.
- Fig. 17-6. *Linear Technology Corp., Linear Databook*, 1986, p. 5-17.
- Fig. 17-7. *Analog Devices, Data Acquisition Databook*, 1982, p. 4-56.
- Fig. 17-8. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 2/87, p. 4-311.
- Fig. 17-9. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 20.
- Fig. 17-10. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 11.

- Fig. 17-11. *Siliconix, MOSpower Applications Handbook*, p. 6-178.
- Fig. 17-12. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 2/87, p. 5-368.
- Fig. 17-13. *National Semiconductor Corp., Transistor Databook*, 1982, p. 7-27.
- Fig. 17-14. *National Semiconductor Corp., 1984 Linear Supplemental Databook*, p. S5-142.
- Fig. 17-15. *Electronic Engineering*, 8/83, p. 141.

Chapter 18

- Fig. 18-1. *Intersil, Component Data catalog*, 1987, p. 14-70.
- Fig. 18-2. *General Electric, Application Note 90.16*, p. 29.
- Fig. 18-3. *General Electric, Application Note 90.16*, p. 29.
- Fig. 18-4. *General Electric, Application Note 90.16*, p. 28.
- Fig. 18-5. *Intersil, Component Data Catalog*, 1987, p. 14-91.
- Fig. 18-6. *Intersil, Component Data Catalog*, 1987, p. 7-96.
- Fig. 18-7. *Intersil, Component Data Catalog*, 1987, p. 14-121.
- Fig. 18-8. *Intersil, Databook 1987*, p. 7-47.

Chapter 19

- Fig. 19-1. *Ham Radio*, 6/85, p. 23.
- Fig. 19-2. *Siliconix, MOSpower Design Catalog*, 1/83, p. 5-27.
- Fig. 19-3. *Linear Technology Corp., Linear Databook*, 1986, p. 2-104.
- Fig. 19-4. *QST*, 12/85, p. 38.
- Fig. 19-5. *Linear Technology Corp., Linear Applications Handbook 1987*, p. AN20-12.
- Fig. 19-6. *QST*, 2/28, p. 43.
- Fig. 19-7. *Ham Radio*, 2/79, p. 40.
- Fig. 19-8. *Courtesy, William Sheets*.
- Fig. 19-9. *Courtesy, William Sheets*.
- Fig. 19-10. *Electronic Design* 21, 10/75, p. 98.
- Fig. 19-11. *Ham Radio*, 2/79, p. 40.
- Fig. 19-12. *Ham Radio*, 2/79, p. 42.
- Fig. 19-13. *Tab Books, Inc., The Complete Handbook of Amplifiers, Oscillators, and Multivibrators*, No. 1230, p. 328.
- Fig. 19-14. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 5-269.

- Fig. 19-15. Motorola, *MECL System Design Handbook*, 1983, p. 227.
- Fig. 19-16. *Electronic Design*, 11/69, p. 109.
- Fig. 19-17. *QST*, 1/86, p. 40.
- Fig. 19-18. *R-E Experimenters Handbook*, p. 157.
- Fig. 19-19. *Electronic Design* 23, 11/74, p. 148.

Chapter 20

- Fig. 20-1. *Linear Technology Corp., 1986 Linear Databook*, p. 2-57.
- Fig. 20-2. *Linear Technology Corp., Linear Applications Handbook*, 1987, p. AN3-13.
- Fig. 20-3. *Intersil, Component Data Catalog*, 1987, p. 7-4.
- Fig. 20-4. *NASA Tech Briefs, Jul/Aug 1986*, p. 37.
- Fig. 20-5. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 17.
- Fig. 20-6. *Linear Technology Corp., Linear Databook*, 1986, p. 2-85.
- Fig. 20-7. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 14.

Chapter 21

- Fig. 21-1. *EXAR, Telecommunications Databook*, 1986, p. 9-23.
- Fig. 21-2. *National Semiconductor Corp., Audio/Radio Handbook*, 1980, p. 3-17.
- Fig. 21-3. *Signetics, 1987 Linear Data Manual, Vol. 1: Communications*, 2/87, p. 4-66.
- Fig. 21-4. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 11/86, p. 4-263.

Chapter 22

- Fig. 22-1. *Radio-Electronics*, 12/86, p. 57.
- Fig. 22-2. *Radio-Electronics*, 8/87, p. 63.
- Fig. 22-3. *Radio-Electronics*, 8/87, p. 53.
- Fig. 22-4. *Radio-Electronics*, 6/87, p. 12.
- Fig. 22-5. *EXAR, Telecommunications Databook*, 1986, p. 9-23.
- Fig. 22-6. *Radio-Electronics*, 3/86, p. 51.
- Fig. 22-7. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 11/86, p. 7-123.

- Fig. 22-8. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 11/86, p. 7-123.
- Fig. 22-9. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 11/86, p. 4-295.

Chapter 23

- Fig. 23-1. *General Electric, Application Note 90.16*, p. 26.
- Fig. 23-2. *Siliconix, Integrated Circuits Data Book*, 3/85, p. 5-16.
- Fig. 23-3. *Texas Instruments, Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 3-23.
- Fig. 23-4. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 18.
- Fig. 23-5. *Intersil, Component Data Catalog*, 1987, p. 7-44.
- Fig. 23-6. *Electronic Engineering*, 11/86, p. 39.
- Fig. 23-7. *General Electric, Application Note 90.16*, p. 27.
- Fig. 23-8. *Signetics, 1987 Linear Data Manual Vol. 2: Industrial*, 2/87, p. 5-367.
- Fig. 23-9. *Intersil, Component Data Catalog*, 1987, p. 5-112.
- Fig. 23-10. *GENERAL Electric, Application Note 90.16*, p. 26.

Chapter 24

- Fig. 24-1. *Electronic Engineering*, 8/85, p. 30.
- Fig. 24-2. *Electronic Engineering*, 11/86, p. 40.

Chapter 25

- Fig. 25-1. *CQ*, 1/87, p. 36.

Chapter 26

- Fig. 26-1. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 26.
- Fig. 26-2. *National Semiconductor Corp., Linear Databook*, 1982, p. 171.
- Fig. 26-3. *Electronic Engineering*, 9/84, p. 30.
- Fig. 26-4. *GENERAL Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 12.

Chapter 27

- Fig. 27-1. Motorola, *TMOS Power FET Design Ideas*, 1985, p. 18.
Fig. 27-2. *Electronic Design*, 12/87, p. 67.
Fig. 27-3. General Electric/RCA, *BIMOS Operational Amplifiers Circuit Ideas*, 1987, p. 22.
Fig. 27-4. *Electronic Engineering*, 6/78, p. 32.
Fig. 27-5. *Electronic Engineering*, 2/83, p. 37.

Chapter 28

- Fig. 28-1. Tab Books, Inc., *The Giant Book of Easy-To-Build Electronic Projects*, 1982, p. 53.
Fig. 28-2. *Hands-On Electronics*, 2/87, p. 38.

Chapter 29

- Fig. 29-1. Signetics, *1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 4-135.
Fig. 29-2. Linear Technology Corp., *Linear Databook*, 1986, p. 2-82.
Fig. 29-3. Signetics, *1987 Linear Data Manual Vol. 2: Industrial*, 11/86, p. 4-135.
Fig. 29-4. *Transistor Databook*, 1982, p. 11-25.

Chapter 30

- Fig. 30-1. *Hands-On Electronics*, May/June 1986, p. 52.
Fig. 30-2. *Popular Electronics*, 3/67.
Fig. 30-3. Courtesy, William Sheets.

Chapter 31

- Fig. 31-1. Linear Technology Corp., *Linear Applications Handbook*, 1987, p. AN13-22.
Fig. 31-2. General Electric, *Optoelectronics*, Third Edition, p. 149.
Fig. 31-3. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-39.

Chapter 32

- Fig. 32-1. Courtesy, William Sheets.
Fig. 32-2. Courtesy, William Sheets.
Fig. 32-3. *Hands-On Electronics*, 8/87, p. 65.
Fig. 32-4. Courtesy, William Sheets.
Fig. 32-5. *Hands-On Electronics*, 3/87, p. 27.
Fig. 32-6. *Ham Radio*, 9/86, p. 67.

Chapter 33

- Fig. 33-1. *Electronic Engineering*, 10/48, p. 45.
Fig. 33-2. *Electronics Today International*, 10/78, p. 26.
Fig. 33-3. *Hybrid Products Databook*, 1982, p. 17-131.
Fig. 33-4. Siliconix, *Integrated Circuits Data Book*, 3/85, p. 10-62.
Fig. 33-5. Intersil, *Component Data Catalog*, 1987, p. 8-102.
Fig. 33-6. *73 for Radio Amateurs*, 2/86, p. 10.
Fig. 33-7. Intersil, *Component Data Catalog*, 1987, p. 7-45.
Fig. 33-8. Linear Technology Corp., *1986 Linear Databook*, p. 2-56.
Fig. 33-9. *Electronic Engineering*, 2/47, p. 47.
Fig. 33-10. Courtesy, William Sheets.
Fig. 33-11. Raytheon, *Linear and Integrated Circuits*, 1984, p. 6-205.
Fig. 33-12. Texas Instruments, *Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 3-7.
Fig. 33-13. Motorola, *Linear Integrated Circuits*, 1979, p. 3-147.
Fig. 33-14. Texas Instruments, *Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 3-9.

Chapter 34

- Fig. 34-1. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-52.
Fig. 34-2. *Popular Electronics*, 3/81, p. 100.
Fig. 34-3. *Hands-On Electronics*, Spring 1986, p. 4.
Fig. 34-4. *Hands-On Electronics*, Fall 1984, p. 61.
Fig. 34-5. General Electric, *SCR Manual, Fourth Edition*, p. 85.
Fig. 34-6. *Electronic Design* 65, 3/73, p. 84.
Fig. 34-7. *Electronic Design*, 3/69, p. 96.
Fig. 34-8. *Electronic Engineering*, 6/76, p. 32.
Fig. 34-9. *Popular Electronics*, 3/75, p. 78.
Fig. 34-10. General Electric, *Optoelectronics*, Third Edition.
Fig. 34-11. *Radio-Electronics*, 2/87, p. 36.
Fig. 34-12. General Electric, *Application Note 200.35*, p. 16.
Fig. 34-13. General Electric, *Application Note 90.16*, p. 27.

Fig. 34-14. National Semiconductor Corp., CMOS Databook, 1981, p. 8-45.

Fig. 34-15. General Electric, Application Note 90-25.

Fig. 34-16. Motorola, Circuit Applications for the Trian (AN-466), p. 11.

Fig. 34-17. Siliconix, MOSpower Applications Handbook, p. 6-181.

Fig. 34-18. Popular Electronics, 3/75, p. 78.

Chapter 35

Fig. 35-1. Linear Technology Corp., Linear Applications Handbook, 1987, p. AN5-6.

Fig. 35-2. Linear Technology Corp., Linear Databook, 1986, p. 2-82.

Chapter 36

Fig. 36-1. Courtesy, William Sheets.

Fig. 36-2. Electronics Today International, 6/76, p. 43.

Fig. 36-3. Radio-Electronics, 4/87, p. 48.

Fig. 36-4. Radio-Electronics, 2/84, p. 97.

Fig. 36-5. Hands-On Electronics, Sep/Oct 1986, p. 24.

Fig. 36-6. Electronic Engineering, 9/86, p. 37.

Fig. 36-7. R-E Experimenters Handbook, p. 162.

Fig. 36-8. Linear Technology Corp., Linear Databook, 1986, p. 2-96.

Chapter 37

Fig. 37-1. Electronic Design, 3/75, p. 68.

Fig. 37-2. EXAR, Telecommunications Databook, 1986, p. 11-38.

Chapter 38

Fig. 38-1. Electronic Design, 8/73, p. 86.

Fig. 38-2. Electronic Design, 12/78, p. 98.

Fig. 38-3. Motorola, Thyristor Device Data, SEries A, 1985, p. 1-6-53.

Fig. 38-4. Signetics, 1987 Linear Data Manual Vol. 2: Industrial, 2/87, p. 7-59.

Chapter 39

Fig. 39-1. National Semiconductor Corp., 1984 Linear Supplement Databook, p. S5-143.

Chapter 40

Fig. 40-1. Electronic Design, 6/79, p. 122.

Fig. 40-2. Electronic Engineering, 9/84, p. 37.

Fig. 40-3. NASA Tech Briefs, 6/87, p. 26.

Fig. 40-4. Electronics Today International, 6/80, p. 68.

Fig. 40-5. Electronic Engineering, 9/87, p. 27.

Fig. 40-6. Texas Instruments, Linear and Interface Circuits Applications, Vol. 1, 1985, p. 7-25.

Fig. 40-7. Radio-Electronics, 5/70, p. 33.

Fig. 40-8. Linear Technology Corp., Linear Databook, 1986, p. 5-78.

Fig. 40-9. Linear Technology Corp., Linear Databook, 1986, p. 8-40.

Fig. 40-10. Electronic Engineering, 2/79, p. 23.

Fig. 40-11. Electronic Engineering, 7/86, p. 30.

Fig. 40-12. Motorola, Application Note AN-294, p. 6.

Fig. 40-13. Motorola, Linear Integrated Circuits, p. 3-139.

Fig. 40-14. Hands-On Electronics, Winter 1985, p. 60.

Fig. 40-15. Texas Instruments, Linear and Interface Circuits Applications, Vol. 1, 1985, p. 7-16.

Fig. 40-16. Signetics, Analog Data Manual, 1982, p. 3-39.

Fig. 40-17. General Electric/RCA, BiMOS Operational Amplifier Circuit Ideas, 1987, p. 10.

Fig. 40-18. Texas Instruments, Linear and Interface Circuits Applications, Vol. 1, 1985, p. 3-20.

Fig. 40-19. National Semiconductor, Linear Brief 23.

Chapter 41

Fig. 41-1. Tab Books, Inc., 101 Sound, Light, and Power IC Projects.

Fig. 41-2. Courtesy, William Sheets.

Chapter 42

Fig. 42-1. Courtesy, William Sheets.

Fig. 42-2. Hands-On Electronics, Sep/Oct 1986, p. 85.

Fig. 42-3. Courtesy, William Sheets.

Chapter 43

- Fig. 43-1. Texas Instruments, *Linear and Interface Circuits Applications*, 1987, p. 12-8.
- Fig. 43-2. Texas Instruments, *Linear and Interface Circuits Applications*, 1987, p. 12-10.

Chapter 44

- Fig. 44-1. Linear Technology Corp., *Linear Applications Handbook*, 1987, p. AN3-7.

Chapter 45

- Fig. 45-1. Linear Technology Corp., *Linear Databook Supplement*, 1988, p. S2-34.
- Fig. 45-2. *Hands-On Electronics*, Jul/Aug 1986, p. 86.
- Fig. 45-3. Signetics, *Linear Data Manual Vol. 3: Video*, p. 5-15.
- Fig. 45-4. Tab Books, Inc. *Build Your Own Laser, Phaser, Ion Ray Gun*, 1983, p. 29.
- Fig. 45-5. *Hands-On Electronics*, Jul/Aug 1986, p. 86.
- Fig. 45-6. *Electronic Engineering*, 8/78, p. 24.

Chapter 46

- Fig. 46-1. *Hands-On Electronics*, 12/86, p. 42.
- Fig. 46-2. Linear Technology Corp., *Linear Databook*, 1986, p. 2-82.
- Fig. 46-3. *Electronic Engineering*, 9/84, p. 33.
- Fig. 46-4. Texas Instruments, *Linear and Interface Circuits Applications Vol. 1*, 1985, p. 3-18.
- Fig. 46-5. Linear Technology Corp., *Linear Databook*, 1986, p. 2-83.

Chapter 47

- Fig. 47-1. *Electronic Engineering*, 7/86, p. 30.
- Fig. 47-2. Signetics, *Analog Data Manual*, 1982, p. 3-73.
- Fig. 47-3. National Semiconductor Corp., *Data Conversion/Acquisition Databook*, 1980, p. 3-30.

Chapter 48

- Fig. 48-1. *Hands-On Electronics*, 5/87, p. 95.
- Fig. 48-2. *Electronic Design* 16, 8/76, p. 76.

Chapter 49

- Fig. 49-1. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-50.

Fig. 49-2. Motorola, *TMOS Power FET Design Ideas*, 1985, p. 20.

Fig. 49-3. Motorola, *TMOS Power FET Design Ideas*, 1985, p. 21.

Fig. 49-4. *R-E Experimenters Handbook*, p. 156.

Fig. 49-5. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-48.

Fig. 49-6. Motorola, *Thyristor Device Data, Series A*, 1985, 1-6-55.

Fig. 49-7. *Electronic Engineering*, 9/84, p. 38.

Fig. 49-8. Tab Books, Inc., *101 Sound, Light, and Power IC Projects*.

Fig. 49-9. Motorola, *Thyristor Device Data, Series A*, 1985, p. 1-6-60.

Fig. 49-10. General Electric, *Application Note 200.35*, p. 17.

Chapter 50

- Fig. 50-1. Tab Books, Inc., *Build Your Own Laser, Phaser, Ion Ray Gun*, 1983, p. 104.
- Fig. 50-2. *Electric Engineering*, 12/84, p. 34.

Chapter 51

- Fig. 51-1. *Hands-On Electronics*, Sep/Oct 1986, p. 26.
- Fig. 51-2. General Electric, *Optoelectronics, Third Edition*, p. 107.
- Fig. 51-3. Courtesy, William Sheets.
- Fig. 51-4. Courtesy, William Sheets.
- Fig. 51-5. *Electronic Engineering*, 12/75, p. 15.
- Fig. 51-6. *Hands-On Electronics*, 4/87, p. 94.
- Fig. 51-7. *Hands-On Electronics*, 2/87, p. 87.
- Fig. 51-8. *Hands-On Electronics*, 10/87, p. 92.
- Fig. 51-9. Linear Technology Corp., *Linear Databook*, 1986, p. 2-83.
- Fig. 51-10. *Radio-Electronics*, 11/86, p. 38.
- Fig. 51-11. General Electric, *Application Note 200.35*, p. 15.
- Fig. 51-12. Intersil, *Component Data Catalog*, 1987, p. 7-44.
- Fig. 51-13. *Radio Electronics*, 3/86, p. 32.
- Fig. 51-14. *Electronic Design*, 11/82, p. 172.
- Fig. 51-15. *Electronic Design*, 6/76, p. 120.
- Fig. 51-16. Linear Technology Corp., *Linear Application Handbook*, 1987, p. AN5-3.

Chapter 52

- Fig. 52-1. Siliconix, *Integrated Circuit Data Book*, 3/85, p. 10-85.

- Fig. 52-2. *Siliconix, Integrated Circuit Data Book*, 3/85, p. 10-79.
- Fig. 52-3. *Siliconix, Integrated Circuit Data Book*, 3/85, p. 2-144.
- Fig. 52-4. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 10/86, p. 4-261.
- Fig. 52-5. *Siliconix, Integrated Circuit Data Book*, 3/85, p. 2-103.

Chapter 53

- Fig. 53-1. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 2/87, p. 5-350.
- Fig. 53-2. *Linear Technology Corp., Linear Application Handbook*, 1987, p. AN3-9.

Chapter 54

- Fig. 54-1. *Hands-On Electronics*, May/June 1986, p. 63.
- Fig. 54-2. *Electronic Design*, 10/73, p. 114.
- Fig. 54-3. *Electronic Engineering*, 7/85, p. 44.
- Fig. 54-4. *Electronics Today International*, 3/80, p. 25.
- Fig. 54-5. *Popular Electronics*, 1/82, p. 76.
- Fig. 54-6. *Electronic Engineering*, 6/87, p. 28.
- Fig. 54-7. *Popular Electronics*, 8/69, p. 71.
- Fig. 54-8. *Electronics Today International*, 1/76, p. 52.
- Fig. 54-9. *Electronic Engineering*, 9/78, p. 20.

Chapter 55

- Fig. 55-1. *Electronic Engineering*, 1/85, p. 39.
- Fig. 55-2. *Intersil, Component Data Catalog*, 1987, p. 7-44.

Chapter 56

- Fig. 56-1. *Courtesy, William Sheets*.
- Fig. 56-2. *Courtesy, William Sheets*.

Chapter 57

- Fig. 57-1. *Popular Electronics*, 6/73.
- Fig. 57-2. *Courtesy, William Sheets*.
- Fig. 57-3. *Courtesy, William Sheets*.
- Fig. 57-4. *Courtesy, William Sheets*.

Chapter 58

- Fig. 58-1. *Unitrode Corp.*, 10/86, p. 332.
- Fig. 58-2. *Unitrode Corp.*, 10/86, p. 332.
- Fig. 58-3. *Radio Electronics*, 8/82, p. 36.
- Fig. 58-4. *Hands-On Electronics, Winter 1985*, p. 93.
- Fig. 58-5. *Hands-On Electronics*, 9/87, p. 71.

- Fig. 58-6. *Electronic Engineering*, 10/77, p. 23.
- Fig. 58-7. *Electronic Design*, 11/8/69, p. 109.
- Fig. 58-8. *Radio-Electronics*, 11/82, p. 79.
- Fig. 58-9. *National Semiconductor Corp., Transistor Databook*, 1982, p. 11-34.
- Fig. 58-10. *National Semiconductor Corp., Data Conversion/Acquisition Databook*, 1980, p. 2-5.

- Fig. 58-11. *Linear Technology Corp., Linear Databook*, 1986, p. 8-42.
- Fig. 58-12. *Signetics, Linear Data Manual Vol. 3: Video*, p. 11-120.
- Fig. 58-13. *General Electric, Application Note 90.16*, p. 28.
- Fig. 58-14. *RCA, Digital Integrated Circuits Application Note ICAN-6346*, p. 5.
- Fig. 58-15. *Linear Technology Corp., Linear Databook*, 1986, p. 5-15.
- Fig. 58-16. *General Electric, SCR Manual, Sixth Edition*, 1979, p. 204.

Chapter 59

- Fig. 59-1. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 45.
- Fig. 59-2. *Courtesy, William Sheets*.
- Fig. 59-3. *Signetics, Linear Data Manual, Vol. 3: Video*, p. 11-3.
- Fig. 59-4. *Radio-Electronics*, 8/77, p. 33.
- Fig. 59-5. *Electronic Design*, 3/77, p. 76.

Chapter 60

- Fig. 60-1. *Electronic Engineering*, 5/84, p. 43.
- Fig. 60-2. *General Electric, Optoelectronics, Third Edition*, p. 114.
- Fig. 60-3. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 32.
- Fig. 60-4. *Siliconix, MOSpower Applications Handbook*, p. 6-186.
- Fig. 60-5. *Electronic Engineering*, 7/86, p. 34.
- Fig. 60-6. *Electronic Engineering*, 4/85, p. 47.
- Fig. 60-7. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-8.
- Fig. 60-8. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 31.
- Fig. 60-9. *Sprague Electric Co., Integrated Circuits Databook WR504*, p. 4-159.
- Fig. 60-10. *General Electric, Application Note 200.35*, p. 18.
- Fig. 60-11. *Sprague Electric Co., Integrated Circuits Databook WR504*, p. 4-160.

- Fig. 60-12. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 55.
- Fig. 60-13. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 54.
- Fig. 60-14. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 51.
- Fig. 60-15. *Electronic Engineering*, 2/84, p. 23.
- Fig. 60-16. *National Semiconductor Corp., Linear Application Databook*, p. 1066.
- Fig. 60-17. *General Electric, Optoelectronics, Third Edition*, p. 113.

Chapter 61

- Fig. 61-1. *Fairchild Corp., Linear Databook*, 1982, p. 4-72.
- Fig. 61-2. *Linear Technology Corp., Linear Applications Handbook*, 1987, p. AN3-14.

Chapter 62

- Fig. 62-1. *73 Magazine*, 12/76, p. 170.
- Fig. 62-2. *Electronics International Today*, 1/76, p. 44.
- Fig. 62-3. *Signetics Analog Data Manual*, 1983, p. 10-93.
- Fig. 62-4. *Electronics Today International*, 9/75, p. 66.
- Fig. 62-5. *CQ*, 5/76, p. 26.

Chapter 63

- Fig. 63-1. *National Semiconductor Corp., Linear Applications Databook*, p. 1096.
- Fig. 63-2. *EXAR, Telecommunications Databook*, 1986, p. 7-24.
- Fig. 63-3. *EXAR, Telecommunications Databook*, 1986, p. 7-24.
- Fig. 63-4. *Electronic Engineering*, 12/84, p. 33.
- Fig. 63-5. *Electronic Engineering*, 11/85, p. 31.
- Fig. 63-6. *Courtesy, William Sheets*.
- Fig. 63-7. *Texas Instruments, Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 2-11.
- Fig. 63-8. *Courtesy, William Sheets*.
- Fig. 63-9. *Courtesy, William Sheets*.
- Fig. 63-10. *Courtesy, William Sheets*.

Chapter 64

- Fig. 64-1. *Electronic Engineering*, 6/83, p. 31.
- Fig. 64-2. *Electronic Design* 15, 7/75, p. 68.

Chapter 65

- Fig. 65-1. *General Electric, Optoelectronics, Third Edition*, p. 135.
- Fig. 65-2. *NASA, Tech Briefs, Summer 1984*, p. 446.
- Fig. 65-3. *General Electric, Optoelectronics, Third Edition*, p. 140.
- Fig. 65-4. *General Electric, Optoelectronics, Third Edition*, p. 121.
- Fig. 65-5. *General Electric, Optoelectronics, Third Edition*, p. 120.
- Fig. 65-6. *General Electric, Optoelectronics, Third Edition*, p. 139.
- Fig. 65-7. *General Electric, Optoelectronics, Third Edition*, p. 120.
- Fig. 65-8. *General Electric, Optoelectronics, Third Edition*, p. 134.
- Fig. 65-9. *General Electric, Optoelectronics, Third Edition*, p. 112.
- Fig. 65-10. *National Semiconductor Corp., Data Conversion/Acquisition Databook*, 1980, p. 13-46.
- Fig. 65-11. *General Electric, Optoelectronics, Third Edition*, p. 133.
- Fig. 65-12. *Courtesy, William Sheets*.
- Fig. 65-13. *General Electric, Optoelectronics, Third Edition*, p. 117.
- Fig. 65-14. *Electronic Engineering*, 8/86, p. 36.
- Fig. 65-15. *General Electric, Optoelectronics, Third Edition*, p. 118.

Chapter 66

- Fig. 66-1. *73 For Radio Amateurs*, 11/85, p. 32.
- Fig. 66-2. *Radio-Electronics*, 5/70, p. 35.
- Fig. 66-3. *Electronics Today International*, 7/78, p. 16.
- Fig. 66-4. *Electronics Today International*, 12/78, p. 15.
- Fig. 66-5. *General Electric, Semiconductor Data Handbook, Third Edition*, p. 513.
- Fig. 66-6. *Electronic Design*, 11/29/84, p. 281.
- Fig. 66-7. *Unitrode Corp., Databook 1986*, p. 51.
- Fig. 66-8. *Electronic Engineering*, 5/77, p. 27.
- Fig. 66-9. *National Semiconductor Corp., Transistor Databook*, 1982, p. 7-19.
- Fig. 66-10. *Courtesy, William Sheets*.
- Fig. 66-11. *Electronic Design*, 10/65.

Fig. 66-12. *Hands-On Electronics*, Summer 1984, p. 43.

Fig. 66-13. *Signetics, Analog Data Manual*, 1982, p. 8-10.

Chapter 67

Fig. 67-1. *Electronic Design*, 5/79, p. 102.

Fig. 67-2. *Radio-Electronics*, 7/70, p. 36.

Fig. 67-3. Courtesy, William Sheets.

Chapter 68

Fig. 68-1. *Texas Instruments, Linear and Interface Circuits Applications*, Vol. 1, 1985, p. 3-18.

Fig. 68-2. *Popular Electronics*, 3/79, p. 78.

Chapter 69

Fig. 69-1. *Electronic Engineering*, 2/86, p. 38.

Fig. 69-2. Courtesy, William Sheets.

Fig. 69-3. *Electronic Engineering*, 4/77, p. 13.

Fig. 69-4. *Electronic Engineering*, 7/85, p. 34.

Fig. 69-5. *Electronic Design*, 3/77, p. 106.

Fig. 69-6. *Electric Engineering*, 1/87, p. 25.

Chapter 70

Fig. 70-1. *Hands-On Electronics*, 10/87, p. 96.

Fig. 70-2. *Hands-On Electronics*, Spring 1985, p. 82.

Fig. 70-3. *General Electric Project G4*, p. 131.

Fig. 70-4. *Radio Electronics*, 12/84, p. 77.

Fig. 70-5. *Electronics Today International*, 6/75, p. 42.

Fig. 70-6. *Electronics Today International*, 9/82, p. 42.

Chapter 71

Fig. 71-1. *Signetics, 1987 Linear Data Manual Vol. 1: Communications*, 11/86, p. 7-251.

Fig. 71-2. *National Semiconductor Corp., Linear Applications Databook*, p. 1065.

Fig. 71-3. *Siliconix, MOSpower Applications Handbook*, p. 6-101.

Fig. 71-4. *Hands-On Electronics*, 5/87, p. 96.

Fig. 71-5. *Hands-On Electronics*, Spring 1985, p. 36.

Fig. 71-6. *Hands-On Electronics*, Summer 1984, p. 74.

Fig. 71-7. *Radio-Electronics*, 3/86, p. 59.

Fig. 71-8. *National Semiconductor Corp., Audio/Radio Handbook*, 1980, p. 4-20.

Fig. 71-9. *National Semiconductor Corp., Linear Databook*, 1982, p. 3-187.

Fig. 71-10. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 11/86, p. 4-135.

Chapter 72

Fig. 72-1. *Texas Instruments, Linear and Interface Circuits Applications*, Vol. 1, 1985, p. 6-35.

Fig. 72-2. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 43.

Fig. 72-3. *Electronic Engineering*, 12/84, p. 41.

Fig. 72-4. *NASA, Tech Briefs*, 9/87, p. 21.

Fig. 72-5. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 37.

Fig. 72-6. *Siliconix, MOSpower Applications Handbook*, p. 6-51.

Fig. 72-7. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 24.

Fig. 72-8. Courtesy, William Sheets.

Fig. 72-9. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 24.

Fig. 72-10. *Radio-Electronics*, 6/86, p. 52.

Fig. 72-11. *Siliconix, MOSpower Applications Handbook*, p. 6-177.

Fig. 72-12. *Siliconix, MOSpower Applications Handbook*, p. 6-59.

Fig. 72-13. *Linear Technology Corp., Linear Databook*, 1986, p. 3-23.

Fig. 72-14. *Electronic Engineering*, 10/84, p. 38.

Fig. 72-15. *NASA Tech Briefs, Summer 1985*, p. 32.

Fig. 72-16. *Electronic Engineering*, 1/87, p. 22.

Fig. 72-17. *Motorola, TMOS Power FET Design Ideas*, 1985, p. 42.

Fig. 72-18. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-55.

Fig. 72-19. *73 Magazine*, 12/70, p. 170.

Fig. 72-20. *Signetics, Analog Data Manual*, 1983, p. 12-27.

Fig. 72-21. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 2/87, p. 8-223.

Fig. 72-22. *Electronic Engineering*, 1/85, p. 45.

Fig. 72-23. *Motorola, Linear Integrated Circuits*, p. 3-138.

Fig. 72-24. *Electronic Design*, 11/29/84, p. 282.

Fig. 72-25. *Electronics Today International*, 1/70, p. 45.

Fig. 72-26. *Linear Technology*, 1986 *Linear Databook*, p. 3-22.

Chapter 73

Fig. 73-1. *Electronic Engineering*, 10/76, p. 17.

Fig. 73-2. *Electronic Engineering*, 7/77, p. 26.

Fig. 73-3. *Popular Electronics*, 5/74, p. 24.

Fig. 73-4. Courtesy, William Sheets.

Chapter 74

Fig. 74-1. *NASA, Tech Briefs*, Winter 1985, p. 52.

Fig. 74-2. Courtesy, William Sheets.

Fig. 74-3. *Electronic Engineering*, 3/86, p. 34.

Fig. 74-4. Courtesy, William Sheets.

Fig. 74-5. Courtesy, William Sheets.

Chapter 75

Fig. 75-1. *Electronic Design* 25, 1275, p. 90.

Fig. 75-2. Courtesy, William Sheets.

Fig. 75-3. *Electronics Today International*, 9/75, p. 66.

Fig. 75-4. *Electronic Engineering*, 1/85, p. 41.

Fig. 75-5. *Hands-On Electronics*, Fall 1984, p. 66.

Fig. 75-6. *Radio-Electronics*, 3/77, p. 76.

Chapter 76

Fig. 76-1. *Hands-On Electronics*, 11/86, p. 92.

Fig. 76-2. *Popular Electronics*, 11/77, p. 62.

Chapter 77

Fig. 77-1. *Electronic Engineering*, 9/86, p. 38.

Fig. 77-2. *RCA, Design Guide for Fire Detection Systems*, Publication 2M1189, p. 27.

Fig. 77-3. *Electronic Engineering*, 9/86, p. 34.

Chapter 78

Fig. 78-1. *Electronic Engineering*, 5/76, p. 17.

Fig. 78-2. *Electronic Design*, 4/74, p. 114.

Fig. 78-3. *Electronic Engineering*, 10/86, p. 41.

Chapter 79

Fig. 79-1. *Electronic Engineering*, 12/75, p. 15.

Fig. 79-2. *Radio-Electronics, Experimenters Handbook*, p. 122.

Chapter 80

Fig. 80-1. *Signetics*, 1987 *Linear Data Manual*, Vol. 1: *Communications*, 2/87, p. 4-310.

Fig. 80-2. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-52.

Chapter 81

Fig. 81-1. *Signetics*, 1987 *Linear Data Manual*, Vol. 1: *Communications*, 11/86, p. 7-14.

Fig. 81-2. *Hands-On Electronics*, 3/87, p. 28.

Fig. 81-3. *Hands-On Electronics*, 12/86, p. 22.

Chapter 82

Fig. 82-1. *General Electric/RCA, BIMOS Operational Amplifiers Circuit Ideas*, 1987, p. 11.

Fig. 82-2. *Signetics*, 1987 *Linear Data Manual*, Vol. 2: *Industrial*, 11/86, p. 4-135.

Chapter 83

Fig. 83-1. *Electronic Design*, 9/69, p. 106.

Fig. 83-2. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-61.

Fig. 83-3. *QST*, 7/87, p. 32.

Chapter 84

Fig. 84-1. *Electronic Engineering*, 4/86, p. 34.

Fig. 84-2. *Electronic Engineering*, 7/85, p. 44.

Fig. 84-3. *Electronic Engineering*, 11/86, p. 34.

Fig. 84-4. *NASA, Tech Briefs*, 1/88, p. 18.

Chapter 85

Fig. 85-1. *Motorola, RF Data Manual*, 1986, p. 6-141.

Fig. 85-2. *Motorola, RF Data Manual*, 1986, p. 6-240.

Fig. 85-3. *QST*, 7/87, p. 31.

Fig. 85-4. *QST*, 5-86, p. 23.

Fig. 85-5. *Motorola, RF Data Manual*, 1986, p. 6-181.

Fig. 85-6. *Ham Radio*, 7/86, p. 50.

Fig. 85-7. *Radio Electronics*, 3/87, p. 42.

Fig. 85-8. *NASA, Tech Briefs*, Spring 1984, p. 322.

Fig. 85-9. *Motorola, RF Data Manual*, 1986, p. 6-232.

Chapter 86

Fig. 86-1. QST, 12/85, p. 39.

Chapter 87

Fig. 87-1. General Electric/RCA, BiMOS Operational Amplifiers circuit Ideas, 1987, p. 14.

Fig. 87-2. Intersil, Component Data Catalog, 1987, p. 7-5.

Fig. 87-3. Linear Technology Corp., Linear Databook, 1986, p. 2-113.

Fig. 87-4. Electronics Today International, 3/78, p. 51.

Fig. 87-5. National Semiconductor Corp., Hybrid Products Databook, 1982, p. 17-149.

Fig. 87-6. Siliconix, Integrated Circuits Data Book, 3/85, p. 10-58.

Chapter 88

Fig. 88-1. General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas, 1987, p. 8.

Fig. 88-2. Linear Technology Corp., Linear Databook, 1986, p. 2-113.

Fig. 88-3. Texas Instruments, Linear and Interface Circuits Applications, Vol. 1, 1985, p. 3-15, 3-16.

Fig. 88-4. QST, 4/87, p. 48.

Fig. 88-5. Electronic Engineering, 5/85, p. 38.

Fig. 88-6. Electronic Design, 6/81, p. 250.

Fig. 88-7. Ham Radio, 1/87, p. 97.

Fig. 88-8. Electronic Engineering, 2/76, p. 17.

Fig. 88-9. Electronic Design, 2/73, p. 82.

Fig. 88-10. Radio-Electronics, 2/71, p. 37.

Fig. 88-11. Ham Radio, 6/82, p. 33.

Chapter 89

Fig. 89-1. Popular Electronics, 12/74, p. 68.

Fig. 89-2. Electronics Today International, 1/77, p. 49.

Fig. 89-3. Electronics Today International, 1/77, p. 49.

Fig. 89-4. Popular Electronics, 8/74, p. 98.

Fig. 89-5. General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas, 1987, p. 28.

Fig. 89-6. Electronics Today International, 11/76, p. 45.

Fig. 89-7. Electronics Today International, 2/75, p. 66.

Fig. 89-8. Electronics Today International, 1/77, p. 85.

Fig. 89-9. Electronics Today International, 6/75, p. 63.

Fig. 89-10. Electronics Today International, 1/77, p. 49.

Fig. 89-11. Courtesy, William Sheets.

Fig. 89-12. Electronics Today International, 11/80, p. 43.

Fig. 89-13. Radio-Electronics, 2/75, p. 42.

Fig. 89-14. Courtesy, William Sheets.

Chapter 90

Fig. 90-1. Courtesy, William Sheets.

Fig. 90-2. Radio-Electronics, 12/83, p. 38.

Fig. 90-3. Hands-On Electronics, 8/87, p. 77.

Fig. 90-4. Electronics today International, 6/79, p. 27.

Fig. 90-5. Courtesy, William Sheets.

Chapter 91

Fig. 91-1. Hands-On Electronics, 6/87, p. 40.

Fig. 91-2. Electronics Today International, 8/77, p. 25.

Fig. 91-3. Electronics Today International, 11/80.

Fig. 91-4. Texas Instruments, Complex Sound Generator, Bulletin No. DL-12612, p. 13.

Fig. 91-5. Electronics Today International, 4/82, p. 34.

Fig. 91-6. Electronics Today International, 2/75, p. 66.

Fig. 91-7. Hands-On Electronics, 12/86, p. 42.

Fig. 91-8. Courtesy, William Sheets.

Fig. 91-9. Courtesy, William Sheets.

Fig. 91-10. Texas Instruments, complex Sound Generator, Bulletin No. DL-S 12612, p. 11.

Fig. 91-11. Courtesy, William Sheets.

Chapter 92

Fig. 92-1. Electronic Engineering, 3/82, p. 29.

Fig. 92-2. Electronic Engineering, 1078, p. 17.

Fig. 92-3. EXAR, Telecommunications Databook, 1986, p. 9-24.

Fig. 92-4. Electronic Design, 5/79, p. 100.

Fig. 92-5. Siliconix, Integrated Circuits Data Book, 3/85, p. 5-17.

Fig. 92-6. General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas, 1987, p. 7.

- Fig. 92-7. *Electronic Design*, 6/69, p. 126.
 Fig. 92-8. *Electronic Engineering*, 8/84, p. 27.
 Fig. 92-9. *Electronic Engineering*, 12/85, p. 35.
 Fig. 92-10. *Electronic Engineering*, 8/84, p. 29.

Chapter 93

- Fig. 93-1. *General Electric/RCA, Operational Amplifiers Circuit Ideas*, 1987, p. 10.
 Fig. 93-2. *Linear Technology Corp., Linear Databook*, 1986, p. 8-42.

Chapter 94

- Fig. 94-1. *Tab Books, Inc. 303 Dynamic Electronic Circuits*, p. 169.
 Fig. 94-2. *Electronics Today International*, 12/77, p. 86.

Chapter 95

- Fig. 95-1. *Electronics Today International*, 10/78, p. 46.
 Fig. 95-2. *Hands-On Electronics, Fall 1984*, p. 65.
 Fig. 95-3. *Courtesy, William Sheets.*

Chapter 96

- Fig. 96-1. *Electronic Engineering*, 6/86, p. 35.
 Fig. 96-2. *General Electric, SCR Manual, Sixth Edition*, 1979, p. 200.

Chapter 97

- Fig. 97-1. *Electronic Engineering*, 9/87, p. 32.
 Fig. 97-2. *Intersil, Component Data Catalog*, 1987, p. 14-67.

Chapter 98

- Fig. 98-1. *Electronic Engineering*, 2/87, p. 40.
 Fig. 98-2. *Tab Books, Inc. The Giant Book of Easy-To-Build Electronic Projects*, 1982, p. 1.
 Fig. 98-3. *Radio-Electronics*, 2/85, p. 90.
 Fig. 98-4. *EXAR, Telecommunications Databook*, 1986, p. 11-38.
 Fig. 98-5. *Tab Books, Inc. build Your Own Laser, Phaser, Ion gun*, 1983, p. 305.
 Fig. 98-6. *Electronic Design*, 12/78, p. 95.
 Fig. 98-7. *Radio-Electronics*, 11/79, p. 53.
 Fig. 98-8. *Electronic Design*, 10/76, p. 194.
 Fig. 98-9. *Hands-On Electronics*, 12/86, p. 22.

- Fig. 98-10. *Electronics Engineering*, 1/79, p. 17.

- Fig. 98-11. *Radio-Electronics*, 12/78, p. 67.
 Fig. 98-12. *Radio-Electronics*, 11/77, p. 45.
 Fig. 98-13. *Hands-On Electronics, Summer 1985*, p. 74.
 Fig. 98-14. *Hands-On Electronics, Sep/Oct 1986*, p. 88.
 Fig. 98-15. *Hands-On Electronics, Sep/Oct 1986*, p. 105.
 Fig. 98-16. *Hands-On Electronics, Summer 1984*, p. 39.
 Fig. 98-17. *EXAR, Telecommunications Databook*, 1986, p. 4-19.
 Fig. 98-18. *EXAR, Telecommunications Databook*, 1986, p. 5-14.
 Fig. 98-19. *EXAR, Telecommunications Databook*, 1986, p. 4-15.
 Fig. 98-20. *Signetics, 1987 Linear Data Manual, Vol. 1: Communications*, 12/2/86, p. 6-50.

Chapter 99

- Fig. 99-1. *NASA, Tech Briefs*, 12/87, p. 28.
 Fig. 99-2. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 2/87, p. 7-67.
 Fig. 99-3. *Electronic Design*, 8/75, p. 82.
 Fig. 99-4. *Linear Technology Corp., Linear Application Handbook*, 1987, p. AN3-6.
 Fig. 99-5. *General Electric, Optoelectronics, Third Edition*, p. 153.
 Fig. 99-6. *General Electric, Application Note 200.85*, p. 18.
 Fig. 99-7. *Electronic Design*, 8/82, p. 217.
 Fig. 99-8. *Electronic Design*, 8/83, p. 230.
 Fig. 99-9. *Courtesy, William Sheets.*

Chapter 100

- Fig. 100-1. *General Electric, SCR Manual, Sixth Edition*, 1979, p. 222.
 Fig. 100-2. *Electronic Engineering*, 9/85, p. 30.
 Fig. 100-3. *National Semiconductor Corp., 1984 Linear Supplement Databook*, p. S1-41.
 Fig. 100-4. *National Semiconductor Corp., 1984 Linear Supplement Databook*, p. S1-42.
 Fig. 100-5. *Linear Technology Corp., Linear Databook*, 1986, p. 2-101.
 Fig. 100-6. *Courtesy, William Sheets.*

Chapter 101

- Fig. 101-1. *Linear Technology Corp., Linear Applications Handbook*, 1987, p. AN7-2.
Fig. 101-2. *Electric Engineering*, 7/84, p. 31.

Chapter 102

- Fig. 102-1. *Hands-On Electronics*, 11/86, p. 93.
Fig. 102-2. *Hands-On Electronics*, 9/87, p. 32.

Chapter 103

- Fig. 103-1. *Teledyne Semiconductor, Data & Design Manual*, 1981, p. 7-17.
Fig. 103-2. *Linear Technology Corp., Application Note 9*, p. 18.
Fig. 103-3. *Radio-Electronics*, 9/82, p. 42.
Fig. 103-4. *Intersil, Component Data Catalog*, 1987, p. 6-8.
Fig. 103-5. *Intersil, Component Data Catalog*, 1987, p. 6-11.
Fig. 103-6. *Intersil, Component Data Catalog*, 1987, p. 6-8.

Chapter 104

- Fig. 104-1. *NASA, Tech Briefs, Spring 1985*, p. 40.
Fig. 104-2. *NASA, Tech Briefs, Fall/Winter 1981*, p. 319.
Fig. 104-3. *Popular Electronics*, 12/82, p. 82.

Chapter 105

- Fig. 105-1. *General Electric, Semiconductor Data Handbook, Third Edition*, p. 513.
Fig. 105-2. *Motorola, Application Note AN294*.
Fig. 105-3. *Electronic Design*, 4/77, p. 120.
Fig. 105-4. *Motorola, Application Note AN294*.

Chapter 106

- Fig. 106-1. *NASA, Tech Briefs, Sep/Oct 1986*, p. 36.

Fig. 106-2. *Electronic Engineering*, 9/77, p. 37.

Fig. 106-3. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-51.

Fig. 106-4. *Motorola, Thyristor Device Data, Series A*, 1985, p. 1-6-54.

Fig. 106-5. *Texas Instruments, Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 7-23.

Fig. 106-6. *Intersil, Databook*, 1987, p. 7-102.

Fig. 106-7. *Intersil, Component Data Catalog*, 1987, p. 14-67.

Fig. 106-8. *General Electric, Application Note 90.16*, p. 30.

Chapter 107

Fig. 107-1. *Electronics Today International*, 11/80.

Fig. 107-2. *Signetics, 1987 Linear Data Manual, Vol. 2: Industrial*, 2/87, p. 4-107.

Fig. 107-3. *Electronics Today International*, 9/77, p. 55.

Fig. 107-4. *General Electric/RCA, BiMOS Operational Amplifiers Circuit Ideas*, 1987, p. 21.

Fig. 107-5. *Texas Instruments, Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 3-11.

Fig. 107-6. *National Semiconductor Corp., Transistor Databook*, 1982, p. 11-35.

Fig. 107-7. *Electronics Today International*, 6/82, p. 61.

Chapter 108

Fig. 108-1. *Hands-On Electronics*, 9/87, p. 88.

Fig. 108-2. *Texas Instruments, Linear and Interface Circuits Applications, Vol. 1*, 1985, p. 7-15.

Fig. 108-3. *Tab Books, Inc., The Giant book of Easy-To-Build Electronics Projects*, 1982, p. 31.

Index

Numbers preceded by a "I," "II," "III," or "IV" are from *Encyclopedia of Electronic Circuits* Vol. I, II, III, or IV, respectively.

A

- absolute-value amplifier, I-31
- absolute-value circuit, I-37, IV-274
- absolute-value full wave rectifier, II-528
- absolute-value Norton amplifier, III-11
- ac bridge circuit, II-81
- ac flasher, III-196
- ac linear coupler, analog, II-412
- ac motor
 - control for, II-375
 - three-phase driver, II-383
 - two-phase driver, II-382
- ac sequential flasher, II-238
- ac switcher, high-voltage optically coupled, III-408
- ac timer, .2 to 10 seconds, adjustable, II-681
- ac-coupled amplifiers, dynamic, III-17
- ac/dc indicator, IV-214
- ac-to-dc converter, I-165
 - fixed power supplies, IV-395
 - full-wave, IV-120
 - high-impedance precision rectifier, I-164
- acid rain monitor, II-245, III-361
- acoustic-sound receiver/transmitter, IV-311
- active antennas, III-1-2, IV-1-4
 - basic designs, IV-3
 - wideband rod, IV-4
 - with gain, IV-2
- active clamp-limiting amplifiers, III-15
- active crossover networks, I-172-173
- active filters (*see also* filter circuits)
 - band reject, II-401
 - bandpass, II-221, II-223, III-190
 - digitally tuned low power, II-218
 - five pole, I-279
 - high-pass, second-order, I-297
 - low-pass, digitally selected break frequency, II-216
 - low-power, digitally selectable center frequency, III-186
 - low-power, digitally tuned, I-279
 - programmable, III-185
 - RC, up to 150 kHz, I-294
 - state-variable, III-189
 - ten-band graphic equalizer using, II-684
 - three-amplifier, I-289
 - tunable, I-294
 - universal, II-214
 - variable bandwidth bandpass, I-286
- active integrator, inverting buffer, II-299
- adapters
 - dc transceiver, hand-held, III-461
 - program, second-audio, III-142
 - traveller's shaver, I-495
- adder, III-327
- AGC, II-17
- AGC amplifiers
 - AGC system for CA3028 IF amplifier, IV-458
 - rf, wideband adjustable, III-545
 - squelch control, III-33
 - wideband, III-15
- air conditioner, auto, smart clutch for, III-46
- air flow detector, I-235, II-242, III-364
- air flow meter (*see* anemometer)
- air-pressure change detector, IV-144
- air-motion detector, III-364
- airplane propeller sound effect, II-592
- alarms (*see also* detectors; indicators; monitors; sensors; sirens), III-3-9, IV-84-87

- alarms (*cont.*)
- auto burglar, II-2, I-3, III-4, I-7, I-10, IV-53
 - auto burglar, CMOS low-current design, IV-56
 - auto burglar, horn as loudspeaker, IV-54
 - auto burglar, single-IC design, IV-55
 - auto burglar, single-IC, III-7
 - auto-arming automotive alarm, IV-50
 - automatic turn-off after 8-minute delay, automotive, IV-52
 - automatic turn-off with delay, IV-54
 - blown fuse, I-10
 - boat, I-9
 - burglar, III-8, III-9, IV-86
 - burglar, latching circuit, I-8, I-12
 - burglar, NC and NO switches, IV-87
 - burglar, NC switches, IV-87
 - burglar, one-chip, III-5
 - burglar, self-latching, IV-85
 - burglar, timed shutoff, IV-85
 - camera triggered, III-444
 - capacitive sensor, III-515
 - current monitor and, III-338
 - differential voltage or current, II-3
 - digital clock circuit with, III-84
 - door-ajar, II-284
 - door-ajar, Hall-effect circuit, III-256
 - doorbell, rain, I-443
 - fail-safe, semiconductor, III-6
 - field disturbance, II-507
 - flasher, bar display, I-252
 - flood, III-206, I-390, IV-188
 - freezer meltdown, I-13
 - headlights-on, III-52
 - high/low limit, I-151
 - home-security system, IV-87
 - ice formation, II-58
 - infrared wireless security system, IV-222-223
 - low-battery disconnect and, III-65
 - low-battery warning, III-59
 - low volts, II-493
 - mains-failure indicator, IV-216
 - motion-actuated car, I-9
 - motion-actuated motorcycle, I-9
 - multiple circuit for, II-2
 - one-chip, III-5
 - photoelectric, II-4, II-319
 - piezoelectric, I-12
 - power failure, III-511, I-581, I-582
 - printer-error, IV-106
 - proximity, II-506, III-517
 - pulsed-tone, I-11
 - purse-snatcher, capacitance operated, I-134
 - rain, I-442, I-443, IV-189
 - road ice, II-57
 - security, I-4
 - self-arming, I-2
 - shutoff, automatic, I-4
 - signal-reception, receivers, III-270
 - smoke, photoelectric, line-operated, I-596
 - smoke, SCR, III-251
 - solar powered, I-13
 - sonic defenders, IV-324
 - speed, I-95
 - Star Trek red alert, II-577
 - strobe flasher alarm, IV-180
 - tamperproof burglar, I-8
 - temperature, II-643
 - temperature, light, radiation sensitive, II-4
 - timer, II-674
 - trouble tone alert, II-3
 - varying-frequency warning, II-579
 - wailing, II-572
 - warbling, II-573
 - watchdog timer/alarm, IV-584
 - water-leakage, IV-190
 - water level, I-389
 - allophone generator, III-733
 - alternators
 - battery-alternator monitor, automotive, III-63
 - AM demodulator, II-160
 - AM microphone, wireless, I-679
 - AM radio, I-544
 - AM radio
 - AM car-radio to short-wave radio converter, IV-500
 - broadcast-band signal generator, IV-302
 - envelope detector, IV-142
 - modulation monitor, IV-299
 - power amplifier for, I-77
 - receivers, III-529, IV-455
 - receivers, carrier-current, III-81
 - receivers, integrated, III-535
 - AM/FM
 - clock radio, II-543, III-1
 - squelch circuit for, II-547, III-1
 - amateur radio
 - linear amp, 2-30 MHz 140-W, III-260
 - receiver, III-534
 - signal-identifier, programmable, IV-326
 - transmitter, 80-M, III-675
 - ambience amplifier, rear speaker, II-458
 - ammeter, I-201
 - nano, I-202
 - pico, II-154, I-202
 - pico, circuit for, II-157
 - pico, guarded input circuit, II-156
 - six decade range, II-153, II-156
 - amplifiers, II-5-22, III-10-21
 - 1 watt/2.3 GHz, II-540
 - 2 to 6 W, with preamp, II-451
 - 25-watt, II-452
 - 30 MHz, I-567
 - 40 dB gain design, IV-36
 - 60 MHz, I-567
 - 135-175 MHz, I-564
 - absolute value, I-31
 - ac servo, bridge type, III-387
 - AGC, II-17
 - AGC, squelch control, III-33
 - AGC, wide-band, III-15
 - adjustable-gain, noninverting, I-91
 - ambience, rear speaker, II-458
 - amateur radio, linear, 2-30 MHz, 140W, I-555
 - AM radio power, I-77
 - attenuator, digitally controlled, I-53
 - audio (*see* audio amplifiers)
 - audio converter, two-wire to four-wire, II-14
 - audio limiter, low-distortion, II-15
 - audio power amplifiers, IV-28-33
 - audio signal amplifiers, IV-34-42
 - auto fade circuit for, II-42
 - automatic level control for, II-20
 - automotive audio amplifier, IV-66
 - balance, II-46
 - balance, loudness control, II-47, II-395
 - balancing circuit, inverting, I-33
 - bass tone control, stereo phono-graph, I-670
 - bridge, I-74
 - bridge, 4W, I-79
 - bridge, 16 W, I-82
 - bridge, ac servo, I-458
 - bridge, audio power, I-81
 - bridge, high-impedance, I-353
 - bridge transducer, III-71, II-84, I-351
 - broadband, low-noise, I-562
 - broadband, PEP, 160W, I-556
 - broadband/linear, PEP, 80W, I-557
 - buffer, 10x, I-128
 - buffer, 100x, I-128
 - buffer, ac, single-supply, I-126
 - buffer, battery-powered, standard cell, I-351
 - buffer, rf amplifiers with modulator, IV-490
 - buffer, sinewave output, I-126
 - buffer, unity-gain, stable design, II-6
 - cascade, III-13
 - cascade, 80 MHz, I-567
 - cascode, rf amplifiers, IV-488
 - CD4049 audio signal amplifiers, IV-40
 - chopper, \pm 15V, III-12
 - chopper channel, I-350

chopper stabilized, II-7
 clamp-limiting, active, III-15
 color video, I-34, III-724
 common-source, 450 MHz, I-568
 common-source, low power, II-84
 complementary-symmetry, I-78
 composite, II-8, III-13
 compressor/amplifier, low-distortion, IV-24
 constant-bandwidth, III-21
 current-shunt, III-21
 current collector head, II-11, II-295
 current-to-voltage, high-speed, I-35
 dc servo, I-457
 dc-stabilized, fast action, III-18
 dc-to-video log, I-38
 detector, MC1330/MC1352, television IF, I-688
 differential, III-14, I-38
 differential, high-impedance, I-27, I-354
 differential, high-input high-impedance, II-19
 differential, instrumentation, I-347, III-283
 differential, instrumentation, biomedical, III-282
 differential, programmable gain, III-507
 differential, two op amp bridge type, II-83
 dynamic, ac-coupled, III-17
 electrometer, overload protected, III-155
 FET input, II-7
 flat response, I-92, III-673
 forward-current booster, III-17
 four-quadrant photo-conductive detector, I-359
 gain, 10-dB, III-543
 gain-controlled, III-34
 gate, I-36
 guitars, matching audio signal amplifiers, IV-38
 hi-fi compander, II-12
 hi-fi expander, II-13
 high-frequency, III-259-265
 high-impedance/high gain/high-frequency, I-41
 high-impedance/low capacitance, I-691
 IF (*see* IF amplifiers)
 input/output buffer for analog multiplexers, III-11
 instrumentation, I-346, I-348, I-349, I-352, I-354, III-278-284, IV-229-234
 instrumentation, differential, high-gain, I-353
 instrumentation, high-impedance, low-drift, I-355
 instrumentation, high-speed, I-354
 instrumentation, low-signal/high-impedance, I-350
 instrumentation, precision FET input, I-355
 instrumentation, triple op-amp design, I-347
 instrumentation, variable gain, differential input, I-349
 instrumentation, very high-impedance, I-354
 inverting, I-42, II-41, III-14
 inverting, ac, high-gain, I-92
 inverting, gain of 2, lag-lead compensation, UHF, I-566
 inverting, power, I-79
 inverting, unity gain, I-80
 isolation, capacitive load, I-34
 isolation, level-shifting, I-348
 isolation, medical telemetry, I-352
 isolation, rf, II-547
 JFET bipolar cascade video, I-692
 line amplifier, universal design, IV-39
 linear, CMOS inverter in, II-11
 line-operated, III-37
 line-type, duplex, telephone, III-616
 load line protected, 75W audio, I-73
 logarithmic, II-8
 logic (*see* logic amplifier)
 log ratio, I-42
 loudness control, II-46
 low-noise design, IV-37
 low-level video detector circuit, I-687
 medical telemetry, isolation, I-352
 meter-driver, rf, 1-MHz, III-545
 micro-powered, high-input/high-impedance, 20 dB, II-44
 micro-sized, III-36
 microphone, III-34, I-87
 microphone, electronically balanced input, I-86
 microwave, IV-315-319
 monostable, II-268
 neutralized common source, 100 MHz/400MHz, I-565
 neutralized common source, 200 MHz, I-568
 noninverting, I-32, I-33, I-41, III-14
 noninverting, ac power, I-79
 noninverting, single-supply, I-75
 noninverting, split-supply, I-75
 Norton, absolute value, III-11
 op amp (*see also* operational amplifiers)
 op amp, x10, I-37
 op amp, x100, I-37
 op amp, clamping circuit, II-22
 op amp, intrinsically safe-protected, III-12
 oscilloscope sensitivity, III-436
 output, four-channel D/A, III-165
 phono, I-80, I-81
 phono, magnetic pickup, I-89
 photodiode, I-361, II-324, III-672
 photodiode, low-noise, III-19
 playback, tape, III-672
 polarity-reversing low-power, III-16
 power (*see also* power amps), II-46, II-451, III-450-456
 power, 10-W, I-76
 power, 12-W, low distortion, I-76
 power, 90-W, safe area protection, II-459
 power, GaAsFET with single supply, II-10
 power, rf power, 600 W, I-559
 pre-amps (*see* pre-amplifiers)
 precision, I-40
 programmable, II-334, III-504-508
 programmable gain, weighted resistors, II-9
 pulse-width proportional controller circuit, II-21
 push-pull, PEP, 100W, 420-450 MHz, I-554
 PWM servo, III-379
 reference voltage, I-36
 remote, I-91
 rf (*see* rf amplifiers)
 sample and hold, high-speed, I-587
 sample and hold, infinite range, II-558
 selectable input, programmable gain, I-32
 servo, 400 Hz, II-386
 servo motor, I-452
 servo motor drive, II-384
 signal distribution, I-39
 sound-activated, gain-controlled amp, IV-528
 sound mixer, II-37
 speaker, hand-held transceivers, III-39
 speaker, overload protector for, II-16
 speech compressor, II-15
 standard cell, saturated, II-296
 stereo, Av/200, I-77
 stereo, gain control, II-9
 summing, I-37, III-16
 summing, fast action, I-36
 summing, precision design, I-36
 switching power, I-33
 tape playback, I-92, IV-36
 tape recording, I-90
 telephone, III-621, IV-555, IV-560

- amplifiers (*cont.*)
- thermocouple, I-654, III-14
 - thermocouple, cold junction compensation, II-649
 - thermocouple, high-stability, I-355
 - transducer, I-86, III-669-673
 - transformerless, 6W 8-ohm output, I-75
 - transistorized, basic design, I-85
 - transistorized, headphone, II-43
 - tremolo circuit, voltage-controlled, I-598
 - tube amplifier, high-voltage isolation, IV-426
 - TV audio, III-39
 - two-meter, 5W output, I-567
 - two-meter, 10W power, I-562
 - UHF, I-565
 - UHF, wideband, high-performance FET, I-560
 - unity gain, I-27
 - unity gain, ultra-high Z, ac, II-7
 - VHF, single-device, 80W/50-ohm, I-558
 - video, I-692, III-708-712
 - video, FET cascade, I-691
 - video, loop-through amplifier, IV-616
 - voice activated switch, I-608
 - voltage, differential-to-single-ended, III-670
 - voltage-controlled, IV-20
 - voltage-follower, signal-supply operation, III-20
 - voltage-controlled (*see* voltage-controlled amplifiers)
 - volume, II-46
 - walkman, II-456
 - weighted-resistor programmable gain, precision design, II-9
 - wideband (*see* wideband amplifiers)
 - wide frequency range, III-262
 - write, III-18
- amplitude modulator, low distortion low level, II-370
- analog counter circuit, II-137
- analog delay line, echo and reverb effects, IV-21
- analog multiplexers
- buffered input/output, III-396
 - single-trace to four-trace scope converter, II-431
- analog multiplier, II-392
- 0/01 percent, II-392
- analog-to-digital buffer, high-speed 6-bit, I-127
- analog-to-digital converters, II-23-31, III-22-26, IV-5-6
- 3-bit, high-speed, I-50
 - 8-bit, I-44, I-46
 - 8-bit successive approximation, I-47
 - 10-bit, II-28
 - 10-bit serial output, II-27
 - 12-bit, high-speed, II-29
 - 16-bit, II-26
 - board design, IV-6
 - capacitance meter, $3^{1/2}$ digit, III-76
 - cyclic, II-30
 - differential input system, II-31
 - fast precision, I-49
 - four-digit (10,000 count), II-25
 - half-flash, III-26
 - IC, low cost, I-50
 - LCD 3.5-digit display, I-49
 - logarithmic, three-decade, I-48
 - precision design, I-49
 - successive approximation, I-45, II-24, II-30
 - switched-capacitor, III-23
 - three-IC, low-cost, I-50
 - tracking, III-24
 - video converter, IV-610-611
- analyzer, gas, II-281
- AND gate, I-395
- large fan-in, I-395
- anemometers
- hot-wire, III-342
 - thermally based, II-241
- angle-of-rotation detector, II-283
- annunciators, II-32-34, III-27-28, IV-710
- ac line-voltage, III-730
 - bell, electronic, IV-9
 - chime circuit, low-cost, II-33
 - door buzzer, IV-8
 - door buzzer, electronic, IV-8
 - electronic bell, II-33
 - large fan-in, I-395
 - SCR circuit, self-interrupting load, IV-9
 - sliding tone doorbell, II-34
 - two-door annunciator, IV-10
- answering machines, beeper, IV-559
- antennas, IV-11-14
- active, III-1-2
 - active antenna, wideband rod, IV-4
 - active antenna, with gain, IV-2
 - active antennas, IV-1-4
 - loop, 3.5 MHz, IV-12-13
 - selector switch, IV-538-539
 - tuner, 1-to-30 MHz, IV-14
- antitheft device, I-7
- arc lamp, 25W, power supply for, II-476
- arc welding inverter, ultrasonic, 20 KHz, III-700
- arc-jet power supply, starting circuit, III-479
- astable flip-flop with starter, II-239
- astable multivibrators, II-269, II-510, III-196, III-233, III-238
- op amp, III-224
 - programmable-frequency, III-237
 - square wave generation with, II-597
- attendance counter, II-138
- attenuators, III-29-31
- analog signals, microprocessor-controlled, III-101
 - digitally programmable, III-30
 - digitally selectable, precision design, I-52
 - programmable, I-53, III-30
 - programmable (1 to 0.00001), I-53
 - rf, IV-322
 - variable, I-52
 - voltage-controlled, II-18, III-31
- audio amplifiers, III-32-39
- AGC, squelch control, III-33
 - automotive stereo systems, high-power, IV-66
 - balance indicator, IV-215
 - Baxandall tone-control, IV-588
 - booster, 20 dB, III-35
 - circuit bridge load drive, III-35
 - complementary-symmetry, I-78
 - distribution, I-39, II-39
 - fixed power supplies, ± 35 V ac, IV-398
 - fixed power supplies, ± 35 V, 5 A, mobile, IV-407
 - high-slew rate power op amp, I-82
 - gain-controlled, stereo, III-34
 - line-operated, III-37
 - load line protection, 75W, I-73
 - low-power, II-454
 - micro-sized, III-36
 - microphone, III-34
 - mini-stereo, III-38
 - pre-amp, NAB tape playback, professional, III-38
 - pre-amp, phono, magnetic, III-37
 - pre-amp, RIAA, III-38
 - Q-multiplier, II-20
 - signal, II-41-47
 - speaker, hand-held transceivers, III-39
 - television type, III-39
 - tone control, II-686
 - ultra-high gain, I-87
 - volume indicator, IV-212
- audio circuits
- audio-rf signal tracer probe, I-527
 - automatic gain control, II-17
 - booster, II-455, III-35
 - biquad filter, III-185
 - bridge load drive, III-35
 - carrier-current transmitter, III-79
 - clipper, precise, II-394
 - compressor, II-44

- continuity tester, I-550
- converter, two-wire to four-wire, II-14
- distribution amplifier, II-39, I-39
- filters (*see* audio filters)
- frequency meter, I-311
- generators (*see* sound generators)
- LED bar peak program meter display, I-254
- limiter, low distortion, II-15
- millivoltmeter, III-767, III-769
- mixers (*see* mixers)
- notch filter, II-400
- power meter, I-488
- Q multiplier, II-20
- sine wave generator, II-564
- squelch, II-394
- switching/mixing, silent, I-59
- waveform generators, precision, III-230
- audio effects circuits (*see* sound generators)
- audio equalizer, IV-18
- audio fader, IV-17
- audio filters
 - analyzer circuit, IV-309
 - biquad filter, III-185
 - notch filter, II-400
 - tunable, IV-169
- audio generators (*see* sound generators)
- audio-operated circuits (*see* sound-operated circuits)
- audio oscillators, I-64, II-24, III-427, IV-374, IV-375
 - 20Hz to 20kHz, variable, I-727
 - light-sensitive, III-315
 - sine wave, II-562
- audio power amplifier, II-451, III-454, IV-28-33
 - 20-W, III-456
 - 50-W, III-451
 - 6-W, with preamp, III-454
- audio amplifier, IV-32
- audio amplifier, 8-W, IV-32
- bridge, I-81
- bull horn, IV-31
- general-purpose, 5 W, ac power supply, IV-30
- op amp, simple design, IV-33
- receiver audio circuit, IV-31
- stereo amp, 12-V/20-W, IV-29
- audio scramblers, IV-25-27
 - voice scrambler/descrambler, IV-26
 - voice scrambler/disguiser, IV-27
- audio signal amplifiers, II-41-47, IV-34-42
 - 40 dB gain design, IV-36
 - audio compressor, II-44
 - auto fade, II-42
 - balance, II-46
 - balance and loudness amplifier, II-47
 - CD4049 design, IV-40
 - electric guitar, matching amplifier, IV-38
 - line amplifier, universal design, IV-39
 - loudness, II-46
 - low-noise design, IV-37
 - microphone preamp, II-45
 - micropower high-input-impedance 20-dB amplifier, II-44
 - power, II-46
 - preamplifier, 1000x, low-noise design, IV-37
 - preamplifier, general-purpose design, IV-42
 - preamplifier, impedance-matching, IV-37
 - preamplifier, low-noise, IV-41
 - preamplifier, magnetic phono cartridges, IV-35
 - preamplifier, microphone, IV-37, IV-42
 - preamplifier, microphone, low-impedance, IV-41
 - preamplifier, phono, low-noise, IV-36
 - preamplifier, phono, magnetic, ultra-low-noise, IV-36
 - stereo preamplifier, II-43, II-45
 - tape playback amplifiers, IV-36
 - transistor headphone amplifier, II-43
 - volume, II-46
- audio-frequency doubler, IV-16-17
- audio/video switcher circuit, IV-540-541
- auto-advance projector, II-444
- autodrum sound effect, II-591
- auto-fade circuit, II-42
- auto-flasher, I-299
- auto-zeroing scale bridge circuits, III-69
- automotive circuits, II-48-63, III-40-52, IV-43-67
 - alarms, automatic-arming, IV-50
 - alarms, automatic turn-off after 8-minute delay, IV-52
 - alarms, automatic turn-off with delay, IV-54
 - alarms, CMOS design, low-current, IV-56
 - alarms, horn as loudspeaker, IV-54
 - alarm, motion actuated, I-9
 - alarms, single-IC design, IV-55
 - air conditioner smart clutch, III-46
 - AM-radio to short-wave radio converter, IV-500
 - analog expanded-scale meter, IV-46
 - audio-amplifier, high-power, IV-66
 - automatic headlight dimmer, II-63
 - automobile locator, III-43
 - automotive exhaust emissions analyzer, II-51
 - back-up beeper, III-49, IV-51, IV-56
 - bar-graph voltmeter, II-54
 - battery charger, ni-cad, I-115
 - battery condition checker, I-108
 - battery current analyzer, I-104
 - battery monitor, I-106
 - battery supply circuit, ± 15 V and 5 V, IV-391
 - battery-alternator monitor, III-63
 - brake lights, delayed extra, III-44
 - brake lights, flashing third, III-51
 - brake light, night-safety light for parked cars, IV-61
 - brake light, third brake light, IV-60
 - burglar alarm, I-3, I-7, I-10, II-2, III-4, III-7, IV-53
 - cassette-recorder power circuit, IV-548
 - courtesy light delay switch, III-42
 - courtesy light extender, III-50
 - delayed-action windshield wiper control, II-55
 - digi-tach, II-61
 - directional signals monitor, III-48
 - door ajar monitor, III-46
 - electric vehicles, battery saver, III-67
 - electrical tester, IV-45
 - electronic circuits, IV-63-67
 - fog light controller with delay, IV-59
 - fuel gauge, digital readout, IV-46
 - exhaust-gas emissions analyzer, II-51
 - garage stop light, II-53
 - glow plug driver, II-52
 - headlight alarm, I-109, III-52
 - headlight automatic-off controller, IV-61
 - headlight delay circuit, II-59, III-49
 - headlight dimmer, II-57
 - high-speed warning device, I-101
 - horn, III-50
 - ice formation alarm, II-58
 - ignition circuit, electronic ignition, IV-65
 - ignition cut-off, IV-53
 - ignition substitute, III-41
 - ignition timing light, II-60
 - immobilizer, II-50
 - intermittent windshield wiper with dynamic braking, II-49
 - light circuits, IV-57-62
 - lights-on warning, II-55, III-42, IV-58, IV-60, IV-62
 - night-safety light for parked cars, IV-61
 - oil-pressure gauge, digital readout, IV-44, IV-47

automotive circuits (*cont.*)

PTC thermistor automotive temperature indicator, II-56
radio, receiver for, II-525
read-head pre-amplifier, III-44
road ice alarm, II-57
security system, I-5, IV-49-56
tachometer, set point, III-47
tachometer/dwell meter, III-45
temperature gauge, digital readout, IV-48
temperature indicator, PTC thermistor, II-56
turn signals, sequential flasher, II-109, III-1
vacuum gauge, digital readout, IV-45
voltage gauge, IV-47
voltage regulator, III-48, IV-67
voltmeter, bargraph, I-99
water-temperature gauge, IV-44
wiper control, II-55, II-62
wiper delay, solid-state, IV-64
wiper interval controller, IV-67

B

B-field measurer, IV-272
back-biased GaAs LED light sensor, II-321
back-EMF PM motor speed control, II-379
backup-light beeper, automotive, IV-51, IV-56
bagpipe sound effect, IV-521
balance indicator, audio amplifiers, IV-215
balancer, stereo, I-619
barricade flasher, I-299
battery charge/discharge indicator, I-122
battery charger, automatic shut-off, II-113
balance amplifiers, III-46
 loudness control, II-47, II-395
balance indicator, bridge circuit, II-82
bandpass filters (*see also* filter circuits), II-222
 0.1 to 10 Hz bandpass, I-296
 160 Hz, I-296
 active, II-221, II-223, III-190
 active, with 60dB gain, I-284
 active, 1 kHz, I-284
 active, 20 kHz, I-297
 active, variable bandwidth, I-286
 biquad, RC active, I-285
 biquad, second-order, III-188
 Chebyshev, fourth-order, III-191
 high Q, I-287
 MPFB, multichannel tone decoder, I-288
 multiple feedback, I-285, II-224
 multiple feedback, 1.0 kHz, I-297
 notch, II-223
 Sallen-Key, 500 Hz, I-291
 second-order biquad, III-188
 state variable, I-290
 tunable, IV-171
band reject filters, active (*see also* filter circuits), II-401
bang-bang power controllers, IV-389
bar-code scanner, III-363
bar-expanded scale meter, II-186
bar graphs
 ac signal indicator, II-187
 voltmeter, II-54
 voltmeter, automotive, I-99
barometer, IV-273
bass tuners, II-362
 12 V, I-111
 200 mA-hour, 12V ni-cad, I-114
 automatic shutoff for, I-113
batteries
 fixed power supply, 12-VDC/120-VAC, III-464
 high-voltage generator, III-482
 zapper, simple ni-cad, I-116
battery chargers, I-113, II-64, II-69, III-53-59, IV-68-72
 12-V charger, IV-70
 battery-life extender, lead-acid batteries, IV-72
 constant-voltage, current limited charger, I-115
 control for 12V, I-112
 current limited 6V, I-118, IV-70
 gel cell, II-66
 lead/acid, III-55
 lithium, II-67
 low-battery detector, lead-acid, III-56
 low-battery warning, III-59
 low-cost trickle for 12V storage, I-117
 mobile battery charger, +12-Vdc, IV-71
 ni-cad, I-118
 ni-cad, portable, III-57, IV-69
 ni-cad, temperature-sensing charger, IV-77
 ni-cad, zapper, II-66
 power supply and, 14V, III-4A, II-73
 PUT, III-54
 regulator, I-117
 simpli-cad, I-112
 solar cell, II-71
 thermally controlled ni-cad, II-68
 UJT, III-56
 universal, III-56, III-58
 versatile design, II-72
 voltage detector relay, II-76

wind powered, II-70
zapper, simple ni-cad, I-116
battery monitors, I-106, II-74-79, III-60-67, IV-73-80
analyzer, ni-cad batteries, III-64
automatic shutoff, battery-powered projects, III-61
battery saver, electric vehicles, III-67
battery-life extender, 9 V, III-62
battery life-extender, disconnect switch, IV-75
capacity tester, III-66
condition checker, I-108, I-121
converter, dc-to-dc +3-to-+5 V, IV-119
disconnect switch, life-extender circuit, IV-75
dynamic, constant current load fuel cell/battery tester, II-75
internal resistance tester, IV-74
level indicator, II-124
lithium battery, state of charge indicator, II-78
low-battery detector, III-63, IV-76
low-battery indicator, I-124, II-77, IV-80
low-battery protector, III-65
low-battery warning/disconnect, III-65
protection circuit, ni-cad batteries, III-62
sensor, quick-deactivating, III-61
splitter, III-66
status indicator, II-77
step-up switching regulator for 6V, II-78
temperature-sensing battery charger, ni-cad batteries, IV-77
test circuit, IV-78
test circuit, ni-cad batteries, IV-79
threshold indicator, I-124
undervoltage indicator for, I-123
voltage, II-79
voltage detector relay in, II-76
voltage gauge, automotive battery, IV-47
voltage indicator, solid-state, I-120
voltage measuring regulator, IV-77
voltage monitor, II-79
voltage monitor, HTS, I-122
voltage-level indicator, IV-80
battery-life extender, 9 V, III-62, IV-75
battery-operated equipment
 ac power control switch, battery-triggered, IV-387
 automatic shutoff, III-61
 automotive battery supply, ± 15 V and 5 V, IV-391
 automotive cassette-deck power

- circuit, IV-548
- bipolar power supply for, II-475
- buffer amplifier for standard cell, I-351
- fence charger, II-202
- flasher, high powered, II-229
- lantern circuit, I-380
- light, capacitance operated, I-131
- On indicator, IV-217
- undervoltage indicator for, I-123
- warning light, II-320
- Baxandall tone-control audio amplifier, IV-588
- BCD-to-analog converter, I-160
- BCD-to-parallel converter, multiplexed, I-169
- beacon transmitter, III-683
- beep transformer, III-555, III-566
- beepers
 - back-up, automotive circuits, III-49
 - repeater, I-19
- bells
 - electronic, II-33, IV-9
 - electronic phone, I-636
- benchtop power supply, II-472
- bicycle speedometer, IV-271, IV-282
- bilateral current source, III-469
- binary counter, II-135
- biomedical instrumentation differential amplifier, III-282
- bipolar dc-dc converter with no inductor, II-132
- bipolar power supply, II-475
- bipolar voltage reference source, III-774
- biquad audio filter, I-292-293, III-185
- second-order bandpass, III-188
- RC active bandpass, I-285
- bird-chirp sound effect, II-588, III-577
- bistable multivibrator, touch-triggered, I-133
- bit grabber, computer circuits, IV-105
- blinkers (*see* flashers and blinkers)
- blown-fuse alarm, I-10
- boiler control, I-638
- bongos, electronic, II-587
- boosters
 - 12ns, II-97
 - audio, III-35, II-455
 - booster/buffer for reference current boost, IV-425
 - electronic, high-speed, II-96
 - forward-current, III-17
 - LED, I-307
 - power booster, op-amp design, IV-358
 - rf amplifiers, broadcast band booster, IV-487
 - shortwave FET, I-561
- bootstrapping, cable, I-34
- brake lights
 - extra, delayed, III-44
 - flashing, extra, III-51
- brake, PWM speed control/energy recovering, III-380
- breakers
 - 12ns, II-97
 - high-speed electronic, II-96
- breaker power dwell meter, I-102
- breakout box, buffer, II-120
- breath alert alcohol tester, III-359
- breath monitor, III-350
- bridge balance indicator, II-82
- bridge circuits, I-552, II-80-85, III-68-71, IV-81-83
 - ac, II-81
 - ac servo amplifier with, III-387
 - accurate null/variable gain circuit, III-69
 - air-flow sensing thermistor bridge, IV-82
 - auto-zeroing scale, III-69
 - balance indicator, II-82
 - bridge transducer amplifier, III-71
 - crystal-controlled bridge oscillator, IV-127
 - differential amplifier, two op-amp, II-83
 - inductance bridge, IV-83
 - load driver, audio circuits, III-35
 - low power common source amplifier, II-84
 - one-power supply design, IV-83
 - QRP SWR, III-336
 - rectifier, fixed power supplies, IV-398
 - remote sensor loop transmitter, III-70
 - strain gauge signal conditioner, II-85, III-71
 - transducer, amplifier for, II-84
 - Wien bridge, variable oscillator, III-424
 - Wien-bridge filter, III-659
 - Wien-bridge oscillator, III-429
 - Wien-bridge oscillator, low-distortion, thermally stable, III-557
 - Wien-bridge oscillator, low-voltage, III-432
 - Wien-bridge oscillator, single-supply, III-558
- brightness controls, III-308
 - LED, I-250
 - low loss, I-377
- broadband communications
 - ac active rectifier, IV-271
- broadcast-band rf amplifier, II-546, III-264
- buck converter, 5V/0.5A, I-494
- buck/boost converter, III-113
- buckling regulator, high-voltages, III-481
- buffers, IV-88-90
 - ac, single-supply, high-speed, I-127-128
 - ADC input, high-resolution, I-127
 - A/D, 6-bit, high-speed, I-127
 - booster/buffer for reference current boost, IV-425
 - capacitance, stabilized low-input, III-502
 - input/output, for analog multiplexers, III-11
 - inverting bistable buffer, IV-90
 - oscillator buffers, IV-89
 - precision-increasing design, IV-89
 - rf amplifiers, buffer amplifier with modulator, IV-490
 - stable, high-impedance, I-128
 - unity gain, stable, good speed and high-input impedance, II-6
 - video, low-distortion, III-712
 - wideband, high-impedance/low-capacitance I-127
- buffer amplifiers
 - 10x, I-128
 - 100x, I-128
 - ac, single-supply, I-126
 - battery-powered, standard cell, I-351
 - sinewave output, I-126
 - unity-gain, stable design, II-6
- buffered breakout box, II-120
- bug detector, III-365
- bug tracer, III-358
- bull horn, II-453, IV-31
- burglar alarms (*see* alarms)
- burst generators (*see also* function generators; sound generators; waveform generators), II-86-90, III-72-74
 - multi-, square waveform, II-88
 - rf, portable, III-73
 - single timer IC square wave, II-89
 - single-tone, II-87
 - strobe-tone, I-725, II-90
 - tone, II-90
 - tone burst, European repeaters, III-74
- burst power control, III-362
- bus interface, eight bit uP, II-114
- Butler oscillators
 - aperiodic, I-196
 - common base, I-191
 - emitter follower, II-190-191, II-194
- Butterworth filter, high-pass, fourth-order, I-280
- buzzers
 - door buzzer, IV-8

buzzers (*cont.*)

- continuous tone 2kHz, I-11
- gated 2kHz, I-12

C

- cable bootstrapping, I-34
- cable tester, III-539
- calibrated circuit, DVM auto, I-714
- calibrated tachometer, III-598
- calibration standard, precision, I-406
- calibrators
 - crystal, 100 kHz, I-185
 - electrolytic-capacitor reforming circuit, IV-276
 - ESR measurer, IV-279
 - oscilloscope, II-433, III-436
 - portable, I-644
 - square-wave, 5 V, I-423
 - tester, IV-265
 - wave-shaping circuits, high slew rates, IV-650
- cameras (*see* photography-related circuits; television-related circuits; video circuits)
- canceller, central image, III-358
- capacitance buffers
 - low-input, III-498
 - low-input, stabilized, III-502
- capacitance meters, I-400, II-91-94, III-75-77
 - A/D, three-and-a-half digit, III-76
 - capacitance-to-voltage, II-92
 - digital, II-94
- capacitance multiplier, I-416, II-200
- capacitance relay, I-130
- capacitance switched light, I-132
- capacitance-to-pulse width converter, II-126
- capacitance-to-voltage meter, II-92
- capacitor discharge
 - high-voltage generator, III-485
 - ignition system, II-103
- capacity tester, battery, III-66
- car port, automatic light controller, II-308
- cars (*see* automotive circuits)
- carrier-current circuits, III-78-82, IV-91-93
 - AM receiver, III-81
 - audio transmitter, III-79
 - data receiver, IV-93
 - data transmitter, IV-92
 - FM receiver, III-80
 - intercom, I-146
 - power-line modem, III-82
 - receiver, I-143
 - receiver, single transistor, I-145
 - receiver, IC, I-146
 - remote control, I-146
 - transmitter, I-144
 - transmitter, integrated circuit, I-145
- carrier-operated relay (COR), IV-461
- carrier system receiver, I-141
- carrier transmitter with on/off 200kHz line, I-142
- cascaded amplifier, III-13
- cassette bias oscillator, II-426
- cassette interface, telephone, III-618
- cassette-recorders (*see* tape-recorder circuits)
- centigrade thermometer, I-655, II-648, II-662
- central image canceller, III-358
- charge pool power supply, III-469
- charge pumps
 - positive input/negative output, I-418, III-360
 - regulated for fixed power supplies, IV-396
- chargers (*see* battery charger)
- chase circuit, I-326, III-197
- Chebyshev filters (*see also* filter circuits)
 - bandpass, fourth-order, III-191
 - fifth-order multiple feedback low-pass, II-219
 - high-pass, fourth-order, III-191
- chime circuit, low-cost, II-33
- chopper amplifier, I-350, II-7, III-12
- checkers
 - buzz box continuity and coil, I-551
 - car battery condition, I-108
 - crystal, I-178, I-186
 - zener diode, I-406
- chroma demodulator with RGB matrix, III-716
- chug-chug sound generator, III-576
- circuit breakers (*see also* protection circuits)
 - 12ns, II-97
 - ac, III-512
 - high-speed electronic, II-96
 - trip circuit, IV-423
- circuit protection (*see* protection circuits)
- clamp-on-current probe compensator, II-501
- clamp-limiting amplifiers, active, III-15
- clamping circuits
 - video signal, III-726
 - video summing amplifier and, III-710
- class-D power amplifier, III-453
- clippers, II-394, IV-648
 - audio-powered noise, II-396
 - audio clipper/limiter, IV-355
 - zener-design, fast and symmetrical, IV-329
- clock circuits, II-100-102, III-83-85
 - 60Hz clock pulse generator, II-102
 - adjustable TTL, I-614
 - comparator, I-156
 - crystal oscillators, micropower design, IV-122
 - digital, with alarm, III-84
 - gas discharge displays, 12-hour, I-253
 - oscillator/clock generator, III-85
 - phase lock, 20-Mhz to Nubus, III-105
 - run-down clock for games, IV-205
 - sensor touch switch and clock, IV-591
 - single op amp, III-85
 - source, clock source, I-729
 - three-phase from reference, II-101
 - TTL, wide-frequency, III-85
 - Z80 computer, II-121
- clock generators
 - oscillator, I-615, III-85
 - precision, I-193
 - pulse generator, 60 Hz, II-102
- clock radio, I-542
 - AM/FM, I-543
- CMOS circuits
 - 555 astable true rail to rail square wave generator, II-596
 - 9-bit, III-167
 - coupler, optical, III-414
 - crystal oscillator, III-134
 - data acquisition system, II-117
 - flasher, III-199
 - inverter, linear amplifier from, II-11
 - mixer, I-57
 - optical coupler, III-414
 - oscillator, III-429, III-430
 - short-pulse generator, III-523
 - timer, programmable, precision, III-652
 - touch switch, I-137
 - universal logic probe, III-499
- coaxial cable, five-transistor pulse booster, II-191
- Cockcroft-Walton cascaded voltage doubler, IV-635
- code-practice oscillator, I-15, I-20, I-22, II-428-431, IV-373, IV-375, IV-376
- coil drivers, current-limiting, III-173
- coin flipper circuit, III-244
- color amplifier, video, III-724
- color-bar generator, IV-614
- color organ, II-583, II-584
- color video amplifier, I-34
- Colpitts crystal oscillator, I-194, I-572, II-147
 - 1-to-20 MHz, IV-123
 - frequency checker, IV-301

harmonic, I-189-190
 two-frequency, IV-127
 combination locks
 electronic, II-196
 electronic, three-dial, II-195
 commutator, four-channel, II-364
 comparators (*see* compressor/expander circuits)
 comparators, I-157, II-103-112, III-86-90
 demonstration circuit, II-109
 diode feedback, I-150
 display and, II-105
 double-ended limit, I-156, II-105
 dual limit, I-151
 four-channel, III-90
 frequency, II-109
 frequency-detecting, III-88
 high-impedance, I-157
 high-input impedance window comparator, II-108
 high-low level comparator with one op amp, II-108
 latch and, III-88
 LED frequency, II-110
 limit, II-104, I-156
 low-power, less than 10uV hysteresis, II-104
 microvolt, dual limit, III-89
 microvolt, with hysteresis, III-88
 monostable using, II-268
 opposite polarity input voltage, I-155
 oscillator, tunable signal, I-69
 power supply overvoltage, glitch detection with, II-107
 precision, balanced input/variable offset, III-89
 precision, photodiode, I-360, I-384
 time-out, I-153
 TTL-compatible Schmitt trigger, II-111
 three-input and gate comparator, op-amp design, IV-363
 variable hysteresis, I-149
 voltage comparator, IV-659
 voltage monitor, II-104
 window, I-152, I-154, II-106, III-87, III-90, III-776-781, IV-656-658
 with hysteresis, I-157
 with hysteresis, inverting, I-154
 with hysteresis, noninverting, I-153
 compass
 digital design, IV-147
 Hall-effect, III-258
 compensator, clamp-on-current probe, II-501
 composite amplifier, II-8, III-13
 composite-video signal text adder, III-716

compressor/expander circuits, III-91-95, IV-94-97
 amplifier/compressor, low-distortion, IV-24
 audio, II-44
 audio compressor/audio-band splitter, IV-95
 clock circuit, I-156
 guitar, sound-effect circuit, IV-519
 hi-fi, II-12, II-13
 hi-fi, de-emphasis, III-95
 hi-fi, pre-emphasis, III-93
 low-voltage, III-92
 protector circuit, IV-351
 speech, II-2
 universal design, IV-96-97
 variable slope, III-94
 computalarm, I-2
 computer circuits (*see also* interfaces), II-113-122, III-96-108, IV-98-109
 analog signal attenuator, III-101
 alarm, I-2
 ASCII triplex LCD, 8048/IM80C48 8-char/16-seg, II-116
 bit grabber, IV-105
 buffered breakout box, II-120
 bus interface, 8-bit uP, II-114
 clock phase lock, 20-Mhz-to-Nubus, III-105
 CMOS data acquisition system, II-117
 CPU interface, one-shot design, IV-239
 data separator for floppy disks, II-122
 degitcher, IV-109
 display, eight-digit, III-106
 dual 8051s execute in lock-step circuit, IV-99
 EEPROM pulse generator, 5V-powered, III-99
 eight-channel mux/demux system, II-115
 eight-digit microprocessor display, III-106
 flip-flop inverter, spare, III-103
 high-speed data acquisition system, II-118
 interface, 680x, 650x, 8080 families, III-98
 interval timer, programmable, II-678
 keyboard matrix interface, IV-240
 line protectors, 3 uP I/O, IV-101
 logic-level translators, IV-242
 logic line monitor, III-108
 long delay line, logic signals, III-107
 memory/protector power supply monitor, IV-425
 memory saving power supply for, II-486

microprocessor selected pulse width control, II-116
 multiple inputs detector, III-102
 one-of-eight channel transmission system, III-100
 oscilloscope digital-levels, IV-108
 power supply watchdog, II-494
 pulse width control, II-116
 printer-error alarm, IV-106
 reset protection, IV-100
 reset switch, child-proof, IV-107
 RGB blue box, III-99
 RS-232 dataselector, automatic, III-97
 RS-232C line-driven CMOS circuits, IV-104
 RS-232-to-CMOS line receiver, III-102
 RS-232C LED circuit, III-103
 short-circuit sensor, remote data lines, IV-102
 signal attenuator, analog, microprocessor-controlled, III-101
 socket debugger, coprocessor, III-104
 speech synthesizer, III-732
 stalled-output detector, IV-109
 switch debouncer, IV-105
 switch debouncer, auto-repeat, IV-106
 triac array driver, II-410
 uninterruptible power supply, II-462
 Vpp generator for EPROMs, II-114
 XOR gate, IV-107
 XOR gate up/down counter, III-105
 Z-80 bus monitor/debugger, IV-103
 Z80 clock, II-121
 contact switch, I-136
 continuity testers, II-533, II-535, III-345, III-538-540, IV-287, IV-289, IV-296
 audible, adjustable, II-536
 cable tester, III-539
 latching design, IV-295
 PCB, II-342, II-535
 contrast meters, II-447
 automatic, I-472
 control circuits (*see also* alarms; detectors; indicators; monitors; motor control circuits; sensors), III-378-390
 ac servo amplifier, bridge-type, III-387
 boiler, I-638
 brightness, low-loss, I-377
 fan speed, III-382
 feedback speed, I-447
 floodlamp power, I-373
 fluid level, I-387

- control circuits (*cont.*)
 full-wave SCR, I-375
 heater, I-639
 hi-fi tone, high-Z input, I-676
 high-power, sensitive contacts for, I-371
 LED brightness, I-250
 light-level, I-380
 light-level, 860 W limited-range low-cost, I-376
 light-level, brightness, low-loss, I-377
 liquid level, I-388
 model train and/or car, I-453, I-455
 motor controllers (*see* motor control circuits)
 on/off, I-665
 phase control, hysteresis-free, I-373
 power tool torque, I-458
 sensitive contact, high power, I-371
 servo system, III-384
 single-setpoint temperature, I-641
 speed control (*see* speed controllers)
 switching, III-383
 temperature, I-641-643
 temperature-sensitive heater, I-640
 three-phase power-factor, II-388
 tone control (*see* tone controls)
 voltage-control, pulse generator and, III-524
 water-level sensing, I-389
 windshield wiper, I-105
- conversion and converters, I-503, II-123-132, III-109-122, IV-110-120
 3-5 V regulated output, III-739
 4-18 MHz, III-114
 4-to-20-mA current loop, IV-111
 5V-to-isolated 5V at 20MA, III-474
 5V/0.5A buck, I-494
 9-to-5 V converter, IV-119
 12 V- to 9-, 7.5-, or 6-V, I-508
 12-to-16 V, III-747
 +50V feed forward switch mode, I-495
 +50 V push-pull switched mode, I-494
 100 MHz, II-130
 100 V/10.25 A switch mode, I-501
 ac-to-dc, I-165
 ac-to-dc, high-impedance precision rectifier, I-164
 analog-to-digital (*see* analog-to-digital conversion)
 ATV rf receiver/converter, IV-420
 MHz, low-noise, IV-496, IV-497
 BCD-to-analog, I-160
 BCD-to-parallel, multiplexed, I-169
 buck/boost, III-113
 calculator-to-stopwatch, I-153
 capacitance-to-pulse width, II-126
 current-to-frequency, IV-113
 current-to-frequency, wide-range, I-164
 current-to-voltage, I-162, I-165
 current-to-voltage, grounded bias and sensor, II-126
 current-to-voltage, photodiode, II-128
 dc-dc, 3-25 V, III-744, IV-118
 dc-to-dc, +3-to- +5 V battery, IV-119
 dc-to-dc, 1-to-5 V, IV-119
 dc-to-dc, bipolar, no inductor, II-132
 dc-to-dc, fixed 3- to 15-V supplies, IV-400
 dc-to-dc, isolated +15V., III-115
 dc-to-dc, push-pull, 400 V, 60 W, I-210
 dc-to-dc, regulating, I-210, I-211, II-125, III-121
 dc-to-dc, step up-step down, III-118
 digital-to-analog (*see* digital-to-analog conversion)
 fixed power supply, III-470
 flyback, I-211
 flyback, self oscillating, I-170, II-128
 flyback, voltage, high-efficiency, III-744
 frequency, I-159
 frequency-to-voltage (*see* frequency-to-voltage conversion)
 high-to-low impedance, I-41
 intermittent converter, power-saving design, IV-112
 light intensity-to-frequency, I-167
 logarithmic, fast-action, I-169
 low-frequency, III-111
 ohms-to-volts, I-168
 oscilloscope, I-471
 period-to-voltage, IV-115
 pico-ampere, 70 voltage with gain, I-170
 PIN photodiode-to-frequency, III-120
 polarity, I-166
 positive-to-negative, III-112, III-113
 peak-to-peak, ac-dc, precision, II-127
 pulse height-to-width, III-119
 pulse train-to-sinusoid, III-122
 pulse width-to-voltage, III-117
 radio beacon converter, IV-495
 rectangular-to-triangular waveform, IV-116-117
 regulated 15-Vout 6-V driven, III-745
 resistance-to-voltage, I-161-162
 RGB-composite video signals, III-714
 RMS-to-dc, II-129, I-167
 RMS-to-dc, 50-MHz thermal, III-117
 RGB-to-NTSC, IV-611
 sawtooth wave converter, IV-114
 shortwave, III-114
 simple LF, I-546
 sine-to-square wave, I-170, IV-120
 square-to-sine wave, III-118
 square-to-triangle wave, TTL, II-125
 temperature-to-frequency, I-168
 temperature-to-time, III-632-633
 triangle-to-sine wave, II-127
 TTL-to-MOS logic, II-125, I-170
 two-wire to four-wire audio, II-14
 unipolar-to-dual voltage supply, III-743
 video, a/d and d/a, IV-610-611
 video, RGB-to-NTSC, IV-611
 VLF, I-547
 VLF, rf converter, IV-497
 voltage ratio-to-frequency, III-116
 voltage, III-742-748, III-742
 voltage, negative voltage, μ P-controlled, IV-117
 voltage, offline, 1.5-W, III-746
 voltage-to-current, I-166, II-124, III-110, IV-118
 voltage-to-current, power, I-163
 voltage-to-current, zero IB error, III-120
 voltage-to-frequency (*see* voltage-to-frequency conversion)
 voltage-to-pulse duration, II-124
 WWV-to-SW rf converter, IV-499
 coprocessor socket debugger, III-104
 countdown timer, II-680
 counters, II-133-139, III-123-130
 analog circuit, II-137
 attendance, II-138
 binary, II-135
 divide-by-N, CMOS programmable, I-257
 divide-by- n , 1+ GHz, IV-155
 divide-by-odd-number, IV-153
 frequency, III-340, III-768, IV-300
 frequency, 1.2 GHz, III-129
 frequency, 10-MHz, III-126
 frequency, 100 MHz, periodic, II-136
 frequency, low-cost, III-124
 frequency, preamp, III-128
 frequency, tachometer and, I-310
 geiger, I-536-537
 microfarad counter, IV-275
 odd-number divider and, III-217
 preamplifier, oscilloscope, III-438
 precision frequency, I-253
 programmable, low-power wide-range, III-126
 ring, 20 kHz, II-135
 ring, incandescent lamp, I-301
 ring, low cost, I-301
 ring, low-power pulse circuit, IV-437

- ring, SCR, III-195
- ring, variable timing, II-134
- time base , function generators, 1 Hz, IV-201
- universal, 10 MHz, I-255, II-139
- universal, 40-MHz, III-127
- up/down, 8-digit, II-134
- up/down, extreme count freezer, III-125
- up/down, XOR gate, III-105
- couplers
 - linear, ac analog, II-412
 - linear, analog, II-413
 - linear, dc, II-411
 - optical, CMOS design, III-414
 - optical, TTL design, III-416
 - photon, II-412
 - transmitter oscilloscope for CB signals, I-473
- courtesy light delay/extender, I-98, III-42, III-50
- CRO doubler, III-439
- cross-fader, II-312
- cross-hatch generator, color TV, III-724
- crossover networks, II-35
 - 5V, I-518
 - ac/dc lines, electronic, I-515
 - active, I-172
 - active, asymmetrical third order Butterworth, I-173
 - electronic circuit for, II-36
- crowbars, I-516
 - electric, III-510
 - electronic, II-99
 - SCR, II-496
- crystal oscillators (*see also* oscillators),
 - I-180, I-183-185, I-195, I-198, II-140-151, III-131-140, IV-121-128
 - 1-to-20 MHz, TTL design, IV-127
 - 1-to-4 MHz, CMOS design, IV-125
 - 10 MHz, II-141
 - 10-to-150 kHz, IV-125
 - 10-to-80 MHz, IV-125
 - 50-to-150 MHz, IV-126
 - 96 MHz, I-179
 - 150-to-30,000 kHz, IV-126
 - 330 MHz, IV-125
 - aperiodic, parallel-mode, I-196
 - bridge, crystal-controlled, IV-127
 - Butler oscillator, I-182
 - calibrator, 100 kHz, I-185, IV-124
 - ceramic, 10 MHz, varactor tuned, II-141
 - clock, micropower design, IV-122
 - CMOS, I-187, III-134
 - CMOS, 1-to-4 MHz, IV-125
 - Colpitts, II-147
 - Colpitts, 1-to-20 MHz, IV-123
 - Colpitts, frequency checker, IV-301
 - Colpitts, two-frequency, IV-127
 - crystal-controlled oscillator as, II-147
 - crystal-stabilized IC timer for subharmonic frequencies, II-151
 - crystal tester, I-178, I-186, II-151
 - doubler and, I-184
 - easy start-up, III-132
 - FET, 1 MHz, II-144
 - fundamental-frequency, III-132
 - high-frequency, I-175, II-148
 - high-frequency signal generator as, II-150
 - IC-compatible, II-145
 - LO for SSB transmitter controlled by, II-142
 - low-frequency, I-184, II-146
 - low-frequency, 10 kHz to 150 kHz, II-146
 - low-noise, II-145
 - OF-1 HI oscillator, international, I-197
 - OF-1 LO oscillator, international, I-189
 - overtone, I-176, I-180, I-183, II-146
 - overtone, 100 MHz, IV-124
 - marker generator, III-138
 - mercury cell crystal-controlled oscillator as, II-149
 - overtone, I-176, I-177, I-180, I-186, III-146
 - Pierce, II-144
 - Pierce, 1-MHz, III-134
 - Pierce, JFET, I-198
 - Pierce, low-frequency, III-133
 - quartz, two-gate, III-136
 - reflection oscillator, crystal-controlled, III-136
 - Schmitt trigger, I-181
 - signal source controlled by, II-143
 - sine-wave oscillator, I-198
 - stable low frequency, I-198
 - standard, 1 MHz, I-197
 - temperature-compensated, I-187, III-137
 - temperature-compensated, 5V driven, low-power, II-142
 - third-overtone, I-186, IV-123
 - time base, economical design, IV-128
 - TTL design, I-179
 - TTL design, 1-to-20 MHz, IV-127
 - TTL-compatible, I-197
 - transistorized, I-188
 - tube-type, I-192
 - VHF, 20-MHz, III-138
 - VHF, 50-MHz, III-140
 - VHF, 100-MHz, III-139
 - voltage-controlled, III-135, IV-124
 - crystal switching, overtone oscillator with, I-183
 - current analyzer, auto battery, I-104
 - current booster, I-30, I-35
 - current collector head amplifier, II-11, II-295
 - current loop, 4-to-20-mA converter, IV-111
 - current meters and monitors, I-203, II-152-157, III-338
 - ac current indicator, IV-290
 - current sensing in supply rails, II-153
 - electrometer amplifier with overload protection, II-155
 - Hall-effect circuit, III-255
 - Hall-sensor, IV-284
 - high-gain current sensor, IV-291
 - pico ammeter, II-154, II-157
 - pico ammeter, guarded input, II-156
 - range ammeter, six-decade, II-153, II-156
 - current readout, rf, I-22
 - current sensing, supply rails, II-153
 - current sink, I-206
 - 1 mA for fixed power supplies, IV-402
 - voltage-controlled, IV-629
 - current sources, I-205, I-697
 - 0-to-200-nA, IV-327
 - bilateral, III-469, I-694-695
 - bipolar, inverting, I-697
 - bipolar, noninverting, I-695
 - constant, I-697, III-472
 - fixed power supplies, bootstrapped amp, IV-406
 - fixed power supplies, differential-input, fast-acting, IV-405
 - low-current source, fixed power supplies, IV-399
 - precision, I-205
 - precision, 1mA to 1mA, I-206
 - regulator, variable power supply, III-490
 - variable power supplies, voltage-programmable, IV-420
 - voltage-controlled, grounded source/load, III-468
 - current-loop controller, SCR design, IV-387
 - current-shunt amplifiers, III-21
 - current-to-frequency converter, IV-113
 - wide range, I-164
 - current-to-voltage amplifier, high-speed, I-35
 - current-to-voltage converter, I-162, I-165
 - grounded bias and sensor in, II-126
 - photodiode, II-128
 - curve tracer
 - diodes, IV-274
 - FET, I-397
 - CW radio communications

CW radio communications (*cont.*)

filter, razor sharp, II-219
keying circuits, IV-244
offset indicator, IV-213
SSB/CW product detector, IV-139
transceiver, 5 W, 80-meter, IV-602
transmitter, 1-W, III-678
transmitter, 40-M, III-684
transmitter, 902-MHz, III-686
transmitter, HF low-power, IV-601
transmitter, QRP, III-690
cyclic A/D converter, II-30

D

darkroom equipment (*see* photography-related circuits)
Darlington regulator, variable power supplies, IV-421
data-manipulation circuits, IV-129-133
acquisition circuits, CMOS system, II-117
acquisition circuits, four-channel, I-421
acquisition circuits, high-speed system, II-118
analog-signal transmission isolator, IV-133
data-acquisition systems, IV-131
link, IR type, I-341
prescaler, low-frequency, IV-132
read-type circuit, 5 MHz, phase-encoded, II-365
receiver/message demuxer, three-wire, IV-130
selector, RS-232, III-97
separator, floppy disk, II-122
data transmission
receiver, carrier-current circuit design, IV-93
transmitter, carrier-current circuit design, IV-92
dc adapter/transceiver, hand-held, III-461
dc generators, high-voltage, III-481
dc restorer, video, III-723
dc servo drive, bipolar control input, II-385
dc static switch, II-367
dc-to-dc converters, IV-118
1-to-5 V, IV-119
3-25 V, III-744
bipolar, no inductor, II-132
dual output \pm 12-15 V, III-746
fixed power supplies, 3-to-15 V, IV-400
isolated +15 V, III-115
push-pull, 400 V, 60 W, I-210

regulated, I-210, I-211, II-125, III-121
step up/step down, III-118
dc-to-dc SMPS variable power supply, II-480
debouncer, III-592, IV-105
auto-repeat, IV-106
flip-flop, IV-108
debugger, coprocessor sockets, III-104
decibel level detector, audio, with meter driver, III-154
decoders, II-162, III-141-145
10.8 MHz FSK, I-214
24-percent bandwidth tone, I-215
direction detector, III-144
dual-tone, I-215
encoder and, III-144
frequency division multiplex stereo, II-169
PAL/NTSC, with RGB input, III-717
radio control receiver, I-574
SCA, I-214, III-166, III-170
second-audio program adapter, III-142
sound-activated, III-145
stereo TV, II-167
time division multiplex stereo, II-168
tone alert, I-213
tone dial, I-631
tone dial sequence, I-630
tone, I-231, III-143
tone, dual time constant, II-166
tone, relay output, I-213
video, NTSC-to-RGB, IV-613
weather-alert detector/decoder, IV-140
degitcher circuit, computer circuits, IV-109
delay circuits/ delay units, III-146-148
adjustable, III-148
door chimes, I-218
headlights, I-107, II-59
leading-edge, III-147
long duration time, I-217, I-220
precision solid state, I-664
pulse, dual-edge trigger, III-147
time delay, constant-current charging, II-668
time delay, simple design, I-668, II-220
windshield wiper delay, I-97, II-55
delay line, analog, echo and reverb effects, IV-21
delayed pulse generator, II-509
delay relay, ultra-precise long time, II-211
demodulators, II-158-160, III-149-150
5V FM, I-233

12V FM, I-233
565 SCA, III-150
AM, II-160
chroma, with RGB matrix, III-716
FM, II-161
FM, narrow-band, carrier detect, II-159
linear variable differential transformer driver, I-403
LVDT circuit, III-323-324, III-323
LVDT driver, II-337
stereo, II-159
telemetry, I-229
demonstration comparator circuit, II-109
demultiplexer, III-394
descramblers, II-162
gated pulse, II-165
outband, II-164
sine wave, II-163
derived center-channel stereo system, IV-23
detect-and-hold circuit, peak, I-585
detection switch, adjustable light, I-362
detectors (*see also* alarms; control circuits; indicators; monitors; sensors), II-171-178, III-151-162, IV-134-145
air flow, I-235, II-240-242
air motion, I-222, III-364
air-pressure change, IV-144
amplifier, four quadrant photoconductive, I-359
angle of rotation, II-283
bug, III-365
controller circuit, IV-142
decibel level, audio, with meter driver, III-154
direction detector, thermally operated, IV-135
double-ended limit, I-230, I-233
duty-cycle, IV-144
edge, III-157, I-226
electrostatic, III-337
envelope detector, III-155
envelope detector, AM signals, IV-142
envelope detector, low-level diodes, IV-141
flame, III-313
flow, III-202-203
flow, low-rate thermal, III-203
fluid and moisture, II-243, II-248, III-204-210, IV-184-191
frequency limit, II-177
frequency window, III-777
frequency, digital, III-158
frequency-boundary, III-156

gas, II-278, III-246-253
 gas and smoke, I-332
 gas and vapor, II-279
 ground-fault Hall detector, IV-208-209
 high-frequency peak, II-175
 high-speed peak, I-232
 IC product detector, IV-143
 infrared, II-289, III-276, IV-224
 IR, long-range objects, III-273
 level, II-174
 level, with hysteresis, I-235
 lie detector, IV-206
 light detector, IV-369
 light interruption, I-364
 light level, III-316
 light level, level drop, III-313
 line-current, optically coupled, III-414
 liquid level, I-388, I-390
 low-level video, video IF amplifier, I-687-689
 low-line loading ring, I-634
 low-voltage, I-224
 magnet, permanent-magnet detector, IV-281
 magnetic transducer, I-233
 MC1330/MC1352 television IF amplifier, I-688
 metal, II-350-352, IV-137
 missing pulse, I-232, III-159
 moisture, I-442
 motion, IV-341-346
 motion, UHF, III-516
 multiple-input, computer circuit, III-102
 negative peak, I-234
 nuclear particle, I-537
 null, I-148, III-162
 peak program, III-771
 peak, II-174, II-175, IV-138, IV-143
 peak, analog, with digital hold, III-153
 peak, digital, III-160
 peak, high-bandwidth, III-161
 peak, low-drift, III-156
 peak, negative, I-225
 peak, op amp, IV-145
 peak, positive, III-169
 peak, wide-bandwidth, III-162
 peak, wide-range, III-152
 peak voltage, precision, I-226
 people-detector, infrared-activated, IV-225
 pH level, probe and, III-501
 phase, III-440-442
 phase, 10-bit accuracy, II-176
 photodiode level, precision, I-365
 positive peak, I-225, I-235
 power loss, II-175
 product, I-223, I-861
 proximity, I-344, II-135, II-136, IV-341-346
 pulse coincidence, II-178
 pulse sequence, II-172
 pulse-width, out-of-bounds, III-158
 radar (*see* radar detector)
 radiation (*see* radiation detector)
 resistance ratio, II-342
 rf, II-500, IV-139
 rf detector probe, IV-433
 Schmitt trigger, III-153
 smoke, II-278, III-246-253, IV-140
 smoke, ionization chamber, I-332-333
 smoke, operated ionization type, I-596
 smoke, photoelectric, I-595
 speech activity on phone lines, II-617, III-615
 SSB/CW product detectors, IV-139
 stalled computer-output detector, IV-109
 static detector, IV-276
 telephone ring, III-619, IV-564
 telephone ring, optically interfaced, III-611
 threshold, precision, III-157
 tone, 500-Hz, III-154
 toxic gas, II-280
 true rms, I-228
 TV sound IF/FM IF amplifier with quadrature, I-690
 two-sheets in printer detector, IV-136
 ultra-low drift peak, I-227
 undervoltage detector, IV-138
 video, low-level video IF amplifier, I-687-689
 voltage level, I-8, II-172
 weather-alert decoder, IV-140
 window, I-235, III-776-781, IV-658
 zero crossing, I-732, I-733, II-173
 zero crossing, with temperature sensor, I-733
 deviation meter, IV-303
 dial pulse indicator, telephone, III-613
 dialers, telephone
 pulse-dialing telephone, III-610
 pulse/tone, single-chip, III-603
 telephone-line powered repertory, I-633
 tone-dialing telephone, III-607
 dice, electronic, I-325, III-245, IV-207
 differential amplifiers, I-38, III-14
 high-impedance, I-27, I-354
 high-input high-impedance, II-19
 instrumentation, I-347, III-283
 instrumentation, biomedical, III-282
 programmable gain, III-507
 two op amp bridge type, II-83
 differential analog switch, I-622
 differential capacitance measurement circuit, II-665
 differential hold, I-589, II-365
 differential multiplexers
 demultiplexer/, I-425
 wide band, I-428
 differential thermometer, II-661, III-638
 differential voltage or current alarm, II-3
 differentiators, I-423
 negative-edge, I-419
 positive-edge, I-420
 digital-capacitance meter, II-94
 digital-IC, tone probe for testing, II-504
 digital-frequency meter, III-344
 digital-logic probe, III-497
 digital audio tape (DAT)
 dithering circuit, IV-23
 digital multimeter (DMM)
 high-resistance-measuring, IV-291
 digital oscillator, resistance controlled, II-426
 digital transmission isolator, II-414
 digital voltmeters (DVM)
 3.5-digit, common anode display, I-713
 3.5-digit, full-scale, four-decade, III-761
 3.75-digit, I-711
 4.5-digit, III-760
 4.5-digit, LCD display, I-717
 auto-calibrate circuit, I-714
 automatic nulling, I-712
 interface and temperature sensor, II-647
 digital-to-analog converters, I-241, II-179-181, III-163-169
 0-to -5V output, resistor terminated, I-239
 3-digit, BCD, I-239
 8-bit, I-240-241
 8-bit, high-speed, I-240
 8-bit, output current to voltage, I-243
 8-bit to 12-bit, two, II-180
 9-bit, CMOS, III-167
 10-bit, I-238
 10-bit, 4-quad, offset binary coding, multiplying, I-241
 + 10V full scale bipolar, I-242
 + 10V full scale unipolar, I-244
 12-bit, binary two's complement, III-166

- digital-to-analog converters (*cont.*)
 - 12-bit, precision, I-242
 - 12-bit, variable step size, II-181
 - 14-bit binary, I-237
 - 16-bit binary, I-243
 - fast voltage output, I-238
 - high-speed voltage output, I-244
 - multiplying, III-168
 - output amplifier, four-channel, III-165
 - video converter, IV-610-611
- digitizer, tilt meter, III-644-646
- dimmers (*see* lights/light-activated and controlled circuits)
- diode emitter driver, pulsed infrared, II-292
- diode tester, II-343, III-402
 - go/no-go, I-401
 - zener diodes, I-406
- diode-matching circuit, IV-280
- dip meters, I-247, II-182-183
 - basic grid, I-247
 - dual gate IGFET, I-246
 - little dipper, II-183
 - varicap tuned FET, I-246
- diplexer/mixer, IV-335
- direction detector, thermally operated, IV-135
- direction detector decoder, III-144
- direction finders, IV-146-149
 - compass, digital design, IV-147
 - radio-signal direction finder, IV-148-149
- direction-of-rotation circuit, III-335
- directional-signals monitor, auto, III-48
- disco strobe light, II-610
- discrete current booster, II-30
- discrete sequence oscillator, III-421
- discriminators
 - multiple-aperture, window, III-781
 - pulse amplitude, III-356
 - pulse width, II-227
 - window, III-776-781
- display circuits, II-184-188, III-170-171
 - 3¹/₂ digit DVM common anode, II-713
 - 60-dB dot mode, II-252
 - audio, LED bar peak program meter, II-254
 - bar-graph indicator, ac signals, II-187
 - brightness control, III-316
 - comparator and, II-105
 - exclamation point, II-254
 - expanded scale meter, dot or bar, II-186
 - LED bar graph driver, II-188
 - LED matrix, two-variable, III-171
 - oscilloscope, eight-channel voltage, III-435
 - dissolver, lamp, solid-state, III-304
- distribution circuits, II-35
- distribution amplifiers
 - audio, I-39, II-39
 - signal, I-39
- dividers, IV-150-156
 - 1 + GHz divide-by-*n* counter, IV-155
 - 7490-divided-by-*n* circuits, IV-154
 - binary chain, I-258
 - counter, divide-by-odd-number, IV-153
 - divide-by-2-or-3 circuit, IV-154
 - divide-by-*n* + 1/2 circuit, IV-156
 - frequency, I-258, II-254, III-213-218
 - frequency divider, clock input, IV-151
 - frequency, decade, I-259
 - frequency, divide-by-1¹/₂, III-216
 - frequency, low frequency, II-253
 - frequency divider, programmable, IV-152-153
 - mathematical, one trim, III-326
 - odd-number counter and, III-217
 - pulse, non-integer programmable, II-511, III-226
- Dolby noise reduction circuits, III-399
- decode mode, III-401
- encode mode, III-400
- door bells/chimes, I-218, I-443, IV-8
 - buzzer, two-door, IV-10
 - musical-tone, IV-522
 - rain alarm, I-443
 - single-chip design, IV-524
 - sliding tone, II-34
- door-open alarm, II-284, III-46
 - Hall-effect circuit, III-256
- door opener, III-366
- dot-expanded scale meter, II-186
- double-sideband suppressed-carrier modulator, III-377
- double-sideband suppressed-carrier rf, II-366
- doublers
 - 0 to 1MHz, II-252
 - 150 to 300 MHz, I-314
 - audio-frequency doubler, IV-16-17
 - broadband frequency, I-313
 - CRO, oscilloscope, III-439
 - crystal oscillator, I-184
 - frequency, I-313, III-215
 - frequency, digital, III-216
 - frequency, GASFET design, IV-324
 - frequency, single-chip, III-218
 - low-frequency, I-314
 - voltage, III-459
 - voltage, triac-controlled, III-468
- downbeat-emphasized metronome, III-353-354
- drivers and drive circuits, I-260, II-189-193, III-172-175, IV-157-160
 - 50 ohm, I-262
- bar-graph driver, transistorized, IV-213
- BIFET cable, I-264
- bridge loads, audio circuits, III-35
- capacitive load, I-263
- coaxial cable, I-266, I-560
- coaxial cable, five-transistor pulse boost, II-191
- coil, current-limiting, III-173
- CRT deflection yoke, I-265
- demodulator, linear variable differential transformer, I-403
- fiber optic, 50-Mb/s, III-178
- flash slave, I-483
- glow plug, II-52
- high-impedance meter, I-265
- instrumentation meter, II-296
- lamp, I-380
- lamp, flip-flop independent, IV-160
- lamp, low-frequency flasher/relay, I-300
- lamp, optically coupled, III-413
- lamp, short-circuit proof, II-310
- laser diode, high-speed, I-263
- LED, bar graph, II-188
- LED, emitter/follower, IV-159
- line signals, 600-ohm balanced, II-192
- line, I-262
- line, 50-ohm transmission, II-192
- line, full rail excursions in, II-190
- line-synchronized, III-174
- load, timing threshold, III-648
- LVDI demodulator and, II-337, III-323-324
- meter-driver rf amplifier, 1-MHz, III-545
- microprocessor triac array, II-410
- motor drivers (*see* motor control, drivers)
- multiplexer, high-speed line, I-264
- neon lamp, I-379
- op amp power driver, IV-158-159
- optoisolated, high-voltage, III-482
- power driver, op amp, IV-158-159
- pulsed infrared diode emitter, II-292
- relay, I-264
- relay, delay and controls closure time, II-530
- relay, with strobe, I-266
- RS-232C, low-power, III-175
- shift register, I-418
- solenoid, I-265, III-571-573
- SSB, low distortion 1.6 to 30MH, II-538
- stepping motor, II-376
- totem-pole, with bootstrapping, III-175
- two-phase motor, I-456

VCO driver, op-amp design, IV-362
 drop-voltage recovery for long-line systems, IV-328
 drum sound effect, II-591
 dual-tone decoding, II-620
 dual-tracking regulator, III-462
 duplex line amplifier, III-616
 duty-cycle detector, IV-144
 duty-cycle meter, IV-275
 duty-cycle monitor, III-329
 duty-cycle multivibrator, 50-percent, III-584
 duty-cycle oscillators
 50-percent, III-426
 variable, fixed-frequency, III-422
 dwell meters
 breaker point, I-102
 digital, III-45

E

eavesdropper, telephone, wireless, III-620
 echo effect, analog delay line, IV-21
 edge detector, I-266, III-157
 EEPROM pulse generator, 5V-powered, III-99
 EKG simulator, three-chip, III-350
 elapsed-time timer, II-680
 electric-fence charger, II-202
 electric-vehicle battery saver, III-67
 electrolytic-capacitor reforming circuit, IV-276
 electrometer, IV-277
 electrometer amplifier, overload protected, II-155
 electronic dice, IV-207
 electronic locks, II-194-197, IV-161-163
 combination, I-583, II-196
 digital entry lock, IV-162
 keyless design, IV-163
 three-dial combination, II-195
 electronic music, III-360
 electronic roulette, II-276, IV-205
 electronic chip siren, II-576
 electronic switch, push on/off, II-359
 electronic theremin, II-655
 electronic thermometer, II-660
 electronic wake-up call, II-324
 electrostatic detector, III-337
 emergency lantern/flasher, I-308
 emergency light, I-378, IV-250
 emissions analyzer, automotive exhaust, II-51
 emulators, II-198-200
 capacitance multiplier, II-200
 JFET ac coupled integrator, II-200
 resistor multiplier, II-199
 simulated inductor, II-199

encoders
 decoder and, III-14
 telephone handset tone dial, I-634, III-613
 tone, I-67, I-629
 tone, two-wire, II-364
 engine tachometer, I-94
 enlarger timer, II-446, III-445
 envelope detectors, III-155
 AM signals, IV-142
 low-level diodes, IV-141
 envelope generator/modulator, musical, IV-22
 EPROM, Vpp generator for, II-114
 equalizers, I-671, IV-18
 ten-band, graphic, active filter in, II-684
 ten-band, octave, III-658
 equipment-on reminder, I-121
 exhaust emissions analyzer, II-51
 expanded-scale meters
 analog, III-774
 dot or bar, II-186
 expander circuits (*see* compressor/expander circuits)
 extended-play circuit, tape-recorders, III-600
 extractor, square-wave pulse, III-584

F

555 timer
 astable, low duty cycle, II-267
 beep transformer, III-566
 integrator to multiply, II-669
 RC audio oscillator from, II-567
 square wave generator using, II-595
 fader, audio fader, IV-17
 fail-safe semiconductor alarm, III-6
 fans
 infrared heat-controlled fan, IV-226
 speed controller, automatic, III-382
 Fahrenheit thermometer, I-658
 fault monitor, single-supply, III-495
 fax/telephone switch, remote-controlled, IV-552-553
 feedback oscillator, I-67
 fence charger, II-201-203
 battery-powered, II-202
 electric, II-202
 solid-state, II-203
 FET circuits
 dual-trace scope switch, II-432
 input amplifier, II-7
 probe, III-501
 voltmeter, III-765, III-770
 fiber optics, II-204-207, III-176-181
 driver, LED, 50-Mb/s, III-178
 interface for, II-207
 link, I-268, I-269, I-270, III-179

motor control, dc, II-206
 receiver, 10 MHz, II-205
 receiver, 50-Mb/s, III-181
 receiver, digital, III-178
 receiver, high-sensitivity, 30mw, I-270
 receiver, low-cost, 100-M baud rate, III-180
 receiver, low-sensitivity, 300nW, I-271
 receiver, very-high sensitivity, low speed, 3nW, I-269
 repeater, I-270
 speed control, II-206
 transmitter, III-177
 field disturbance sensor/alarm, II-507
 field-strength meters, II-208-212, III-182-183, IV-164-166
 1.5-150 MHz, I-275
 adjustable sensitivity indicator, I-274
 high-sensitivity, II-211
 LF or HF, II-212
 microwave, low-cost, I-273
 rf sniffer, II-210
 sensitive, I-274, III-183
 signal-strength meter, IV-166
 transmission indicator, II-211
 tuned, I-276
 UHF fields, IV-165
 untuned, I-276
 filter circuits, II-213-224, III-184-192, IV-167-177
 active (*see* active filters)
 antialiasing/sync-compensation, IV-173
 audio, biquad, III-185
 audio, tunable, IV-169
 bandpass (*see* bandpass filters)
 band-reject, active, II-401
 biquad, I-292-293
 biquad, audio, III-185
 biquad, RC active bandpass, I-285
 bridge filter, twin-T, programmable, II-221
 Butterworth, high-pass, fourth-order, I-280
 Chebyshev (*see* Chebyshev filters)
 CW, razor-sharp, II-219
 full wave rectifier and averaging, I-229
 high-pass (*see* high-pass filters)
 low-pass (*see* low-pass filters)
 networks of, I-291
 noise, dynamic, III-190
 noisy signals, III-188
 notch (*see* notch filters)
 programmable, twin-T bridge, II-221
 rejection, I-283
 ripple suppressor, IV-175

- filter circuits (*cont.*)
- rumble, III-192, IV-175
 - rumble, LM387 in, I-297
 - rumble filter, turntable, IV-170
 - rumble/scratch, III-660
 - Sallen-Key, 500 Hz bandpass, I-291
 - Sallen-key, low-pass, active, IV-177
 - Sallen-Key, low-pass, equal component, I-292
 - Sallen-Key, low-pass, second order, I-289
 - scratch, III-189, IV-175
 - scratch, LM287 in, I-297
 - speech, bandpass, 300 Hz 3kHz, I-295
 - speech filter, second-order, 300-to-3,400 Hz, IV-174
 - speech filter, two-section, 300-to-3,000 Hz, IV-174
 - state-variable, II-215
 - state-variable, multiple outputs, III-190
 - state-variable, second-order, 1kHz, Q/10, I-293
 - state-variable, universal, I-290
 - turbo, glitch free, III-186
 - twin-T bridge filter, II-221
 - Wien-bridge, III-659
 - voltage-controlled, III-187
 - voltage-controlled, 1,000:1 tuning, IV-176
- fixed power supplies, III-457-477, IV-390-408
- 12-VDC battery-operated 120-VAC, III-464
 - +24 V, 1.5 A supply from +12 V source, IV-401
 - 15 V isolated to 2,500 V supply, IV-407
 - audio amplifier supply, ± 35 V ac, IV-398
 - audio amplifier supply, ± 35 V, 5 A, mobile, IV-407
 - automotive battery supply, ± 15 V and 5 V, IV-391
 - auxiliary supply, IV-394
 - bias/reference applications, auxiliary negative dc supply, IV-404
 - bilateral current source, III-469
 - bridge rectifier, IV-398
 - charge pool, III-469
 - charge pump, regulated, IV-396
 - constant-current source, safe, III-472
 - converter, III-470
 - converter, 5V-to-isolated 5V at 20mA, III-474
 - converter, ac-to-dc, IV-395
 - converter, dc-to-dc, 3-to-15 V, IV-400
 - current sink, 1 mA, IV-402
 - current source, bootstrapped amp, IV-406
 - current source, differential-input, fast-acting, IV-405
 - dc adapter/transceiver, hand-held, III-461
 - dual-tracking regulator, III-462
 - GASFET power supply, IV-405
 - general-purpose, III-465
 - inverter, 12 V input, IV-395
 - isolated feedback, III-460
 - LCD display power supply, IV-392, IV-403
 - linear regulator, low cost, low dropout, III-459
 - low-current source, IV-399
 - low-power inverter, III-466
 - negative rail, GET, with CMOS gates, IV-408
 - negative supply from +12 V source, IV-401
 - negative voltage from positive supply, IV-397
 - output stabilizer, IV-393
 - portable-radio 3 V power supply, IV-397
 - positive and negative voltage power supplies, IV-402
 - pnp regulator, zener increases voltage output, II-484
 - programmable, III-467
 - rectifier, bridge rectifier, IV-398
 - rectifier, low forward-drop, III-471
 - regulated 1 A, 12 V, IV-401
 - régulated +15V 1-A, III-462
 - regulated -15V 1-A, III-463
 - regulator, 15V slow turn-on, III-477
 - regulator, positive with PNP boost, III-471
 - regulator, positive, with NPN/PNP boost, III-475
 - regulator, switching, 3-A, III-472
 - regulator, switching, high-current inductorless, III-476
 - ripple suppressor, IV-396
 - RTTY machine current supply, IV-400
 - stabilizer, CMOS diode network, IV-406
 - switching, III-458
 - switching, 5- and ± 12 V, ac-powered, IV-404
 - switching, 50-W off-line, III-473
 - switching, positive and negative voltage, IV-403
 - switching regulator, 3 A, IV-408
 - three-rail, III-466
 - uninterruptible +5V, III-477
 - voltage doubler, III-459
 - voltage doubler, triac-controlled, III-468
 - voltage regulator, 10V, high stability, III-468
 - voltage regulator, 5-V low-dropout, III-461
 - voltage regulator, ac, III-477
 - voltage regulator, negative, III-474
 - voltage-controlled current source/grounded source/load, III-468
 - fixed-frequency generator, III-231
 - flame ignitor, III-362
 - flame monitor, III-313
 - flash/flashbulb circuits (*see* photography-related circuits)
 - flashers and blinkers (*see also* photography-related circuits), I-304, II-225, III-193-210, IV-178-183
 - 1.5 V, minimum power, I-308
 - 1 kW flip-flop, II-234
 - 1A lamp, I-306
 - 2 kW, photoelectric control in, II-232
 - 3V, I-306
 - ac, III-196
 - alternating, I-307, II-227
 - astable multivibrator, III-196
 - auto, I-299
 - automatic safety, I-302
 - automotive turn signal, sequential, I-109
 - bar display with alarm, I-252
 - barricade, I-299
 - boat, I-299
 - CMOS, III-199
 - dc, adjustable on/off timer, I-305
 - dual LED CMOS, I-302
 - electronic, II-228
 - emergency lantern, I-308
 - fast-action, I-306
 - flash light, 60-W, III-200
 - flicker light, IV-183
 - flip-flop, I-299
 - four-parallel LED, I-307
 - high efficiency parallel circuit, I-308
 - high-voltage, safe, I-307
 - high-power battery operated, II-229
 - incandescent bulb, III-198, I-306
 - LED, IV-181
 - LED, alternating, III-198, III-200
 - LED, control circuit, IV-183
 - LED, multivibrator design, IV-182
 - LED, PUT used in, II-239
 - LED, ring-around, III-194
 - LED flasher, sequential, reversible-direction, IV-182
 - LED, three-year, III-194
 - LED, UJT used in, II-231
 - low-current consumption, II-231

- low-voltage, I-305, II-226
- miniature transistorized, II-227
- minimum-component, III-201
- neon, I-303
- neon, five-lamp, III-198
- neon, two-state oscillator, III-200
- neon, tube, I-304
- oscillator and, high drive, II-235
- oscillator and, low frequency, II-234
- photographic slave-flash trigger, SCR design, IV-380, IV-382
- photographic time-delay flash trigger, IV-380
- relay driver, low-frequency lamp, I-300
- SCR design, II-230, III-197
- SCR chaser, III-197
- SCR relaxation, II-230
- SCR ring counter, III-195
- sequential, II-233, IV-181
- sequential, ac, II-238
- sequencer, pseudorandom simulated, IV-179
- single-lamp, III-196
- strobe alarm, IV-180
- telephone, II-629, IV-558, IV-559, IV-561
- telephone-message flasher, IV-556
- transistorized, III-200, I-303
- transistorized, table of, II-236
- variable, I-308
- xenon light, IV-180
- flashlight finder, I-300
- flip-flops
 - astable, with starter, II-239
 - debouncer switch, IV-108
 - flasher circuit, 1 kW, use of, II-234
 - inverter, III-103
 - SCR, II-367
 - wave-shaping circuits, S/R, IV-651
- flood alarm, I-390, III-206, IV-188
- flow detectors, II-240-242, III-202-203
 - air, II-242
 - low-rate thermal, III-203
 - thermally based anemometer, II-241
- flowmeter, liquid, II-248
- fluid and moisture detectors, I-388, I-390, I-442, II-243-248, III-204-210, IV-184-191
 - acid rain monitor, II-245
 - checker, III-209
 - control, I-388, III-206
 - cryogenic fluid-level sensor, I-386
 - dual, III-207
 - flood alarm, III-206, IV-188
 - fluid-level control, III-205
 - full-bathtub indicator, IV-187
 - full-cup detector for the blind, IV-189
 - indicator, II-244
 - liquid flow meter, II-248
 - liquid-level checker, III-209
 - liquid-level monitor, III-210
 - liquid-level sensor, IV-186
 - liquid-level, dual, III-207
 - moisture detector, IV-188
 - monitor, III-210
 - plant water, II-245, II-248
 - pump controller, single-chip, II-247
 - rain alarm, IV-189
 - rain warning bleeper, II-244
 - sensor and control, II-246
 - soil moisture, III-208
 - temperature monitor, II-643, III-206
 - water-leak alarm, IV-190
 - water-level, III-206, IV-186, IV-191
 - water-level, indicator, II-244
 - water-level, sensing and control, II-246, IV-190
 - windshield-washer level, I-107
- fluid-level controller, I-387, III-205
- fluorescent display, vacuum, II-185
- fluorescent lamps
 - high-voltage power supplies, cold-cathode design, IV-411
 - inverter, 8-W, III-306
- flyback converters, I-211
 - self oscillating, I-170, II-128, III-748
 - voltage, high-efficiency, III-744
- flyback regulator, off-line, II-481
- FM transmissions
 - 5 V, I-233
 - 12 V, I-233
 - clock radio, AM/FM, I-543
 - demodulators, I-544, II-161
 - IF amplifier with quadrature detector, TV sound IF, I-690
 - generators, low-frequency, III-228
 - radio, I-545
 - receivers, carrier-current circuit, III-80
 - receivers, MPX/SCA receiver, III-530
 - receivers, narrow-band, III-532
 - receivers optical receiver/transmitter, 50 kHz, I-361
 - receivers, zero center indicator, I-338
 - snooper, III-680
 - speakers, remote, carrier-current system, I-140
 - squelch circuit for AM, I-547
 - stereo demodulation system, I-544
 - transmitters, I-681
 - transmitters, infrared, voice-modulated pulse, IV-228
 - transmitters, multiplex, III-688
 - transmitters, one-transistor, III-687
 - transmitters, optical, 50 kHz center frequency, II-417
 - transmitters, optical receiver/transmitter, 50 kHz, I-361
 - transmitters, optical (PRM), I-367
 - transmitters, voice, III-678
 - tuner, I-231, III-529
 - wireless microphone, III-682, III-685, III-691
- FM/AM clock radio, I-543
- fog-light controller, automotive, IV-59
- foldback current, HV regulator limiting, II-478
- followers, III-211-212
 - inverting, high-frequency, III-212
 - noninverting, high-frequency, III-212
 - source, photodiode, III-419
 - unity gain, I-27
 - voltage, III-212
- forward-current booster, III-17
- free-running multivibrators
 - 100 kHz, I-465
 - programmable-frequency, III-235
- free-running oscillators, I-531
 - square wave, I-615
- freezer, voltage, III-763
- freezer-meltdown alarm, I-13
- frequency comparators, II-109
 - LED, II-110
- frequency control, telephone, II-623
- frequency converter, I-159
- frequency counters, III-340, III-768, IV-300
 - 1.2 GHz, III-129
 - 10-MHz, III-126
 - 100 MHz, period and, II-136
 - low-cost, III-124
 - preamp, III-128
 - precision, I-253
 - tachometer and, I-310
- frequency detectors, II-177, III-158
 - boundary detector, III-156
 - comparator, III-88
- frequency dividers, I-258, II-251, II-254
 - clock input, IV-151
 - decade, I-259
 - low, II-253
 - programmable, IV-152-153
 - staircase generator and, I-730
- frequency-division multiplex stereo decoder, II-169
- frequency doublers, I-313
 - broadband, I-313
 - GASFET design, IV-324
- frequency generators, fixed-frequency, III-231
- frequency indicators, beat, I-336
- frequency inverters, variable frequency, complementary output, III-297

- frequency meters, II-249-250, IV-282
 - audio, I-311
 - linear, I-310
 - low cost, II-250
 - power, II-250
 - power-line, I-311
 - frequency multipliers/dividers, II-251, III-213-218
 - counter, odd-number, III-217
 - divide-by- $1\frac{1}{2}$, III-216
 - doubler, III-215
 - doubler, digital, III-216
 - doubler, to 1MHz, II-252
 - doubler, single-chip, III-218
 - nonselective tripler, II-252
 - pulse-width, III-214
 - frequency-boundary detector, III-156
 - frequency-detecting comparator, III-88
 - frequency oscillator, tunable, II-425
 - frequency-ratio monitoring circuit, IV-202
 - frequency-shift key (FSK) communications
 - data receiver, III-533
 - decoder, 10.8 MHz, I-214
 - generator, low-cost design, III-227
 - keying circuits, IV-245
 - frequency synthesizer, programmable voltage controlled, II-265
 - frequency-to-voltage converter, I-318, II-255-257, III-219-220
 - dc, 10kHz, I-316
 - digital meter, I-317
 - optocoupler input, IV-193
 - sample-and-hold circuit, IV-194
 - single-supply design, IV-195
 - zener regulated, I-317
 - fuel gauge, automotive, IV-46
 - full-wave rectifiers, IV-328, IV-650
 - absolute value, II-528
 - precision, I-234, III-537
 - function generators (*see also* burst generators; sound generators; waveform generators), I-729, II-271, III-221-242, III-258-274, IV-196-202
 - 555 astable, low duty cycle, II-267
 - astable multivibrator, II-269, III-233, III-238
 - astable multivibrator, op amp, III-224
 - astable multivibrator, programmable-frequency, III-237
 - audio function generator, IV-197
 - clock generator, I-193
 - clock generator/oscillator, I-615
 - complementary signals, XOR gate, III-226
 - DAC controlled, I-722
 - emitter-coupled RC oscillator, II-266
 - fixed-frequency, III-231
 - FM, low-frequency, III-228
 - free-running multivibrator, programmable-frequency, III-235
 - frequency-ratio monitoring circuit, IV-202
 - frequency synthesizer, programmable voltage controlled, II-265
 - FSK, low-cost, III-227
 - harmonics, III-228
 - linear ramp, II-270
 - linear triangle/square wave VCO, II-263
 - monostable operation, III-235
 - monostable multivibrator, III-230
 - monostable multivibrator, linear-ramp, III-237
 - monostable multivibrator, positive-triggered, III-229
 - monostable multivibrator, video amplifier and comparator, II-268
 - multiplying pulse width circuit, II-264
 - multivibrator, low-frequency, III-237
 - multivibrator, single-supply, III-232
 - nonlinear potentiometer outputs, IV-198
 - one-shot, precision, III-222
 - one-shot, retriggerable, III-238
 - oscillator/amplifier, wide frequency range, II-262
 - potentiometer-position V/F converter, IV-200
 - precise wave, II-274
 - programmed, I-724
 - pulse divider, noninteger, programmable, III-226
 - pulse train, IV-202
 - pulse, 2-ohm, III-231
 - quad op amp, four simultaneous synchronized waveform, II-259
 - ramp, variable reset level, II-267
 - sawtooth and pulse, III-241
 - signal, two-function, III-234
 - sine/cosine (0.1-10 kHz), II-260
 - single supply, II-273
 - sine-wave/square-wave oscillator, tunable, III-232
 - single-control, III-238
 - timebase, 1 Hz, for readout and counter applications, IV-201
 - time-delay generator, I-217-218
 - triangle-square wave, programmable, III-225
 - triangle-wave, III-234
 - triangle-wave timer, linear, III-222
 - triangle-wave/square-wave, III-239
 - triangle-wave/square-wave, precision, III-242
 - triangle-wave/square-wave, wide-range, III-242
 - tunable, wide-range, III-241
 - UJT monostable circuit insensitive to changing bias voltage, II-268
 - variable duty cycle timer output, III-240
 - voltage controlled high-speed one shot, II-266
 - waveform, II-269, II-272
 - waveform, four-output, III-223
 - white noise generator, IV-201
 - funk box, II-593
 - furnace exhaust gas/smoke detector, temp monitor/low supply detection, III-248
 - fuzz box, III-575
 - fuzz sound effect, II-590
- ## G
- GaAsFET amplifier, power, with single supply, II-10
 - gain block, video, III-712
 - gain control, automatic, audio, II-17
 - gain-controlled stereo amplifier, II-9, III-34
 - game feeder controller, II-360
 - game roller, I-326
 - games, II-275-277, III-243-245, IV-203-207
 - coin flipper, III-244
 - electronic dice, III-245, IV-207
 - electronic roulette, II-276, IV-205
 - lie detector, II-277, IV-206
 - reaction timer, IV-204
 - run-down clock/sound generator, IV-205
 - Wheel-of-Fortune, IV-206
 - who's first, III-244
 - garage stop light, II-53
 - gas analyzer, II-281
 - gas/smoke detectors (*see also* smoke alarms and detectors), II-278-279, III-246-253, III-246
 - analyzer and, II-281
 - furnace exhaust, temp monitor/low-supply detection, III-248
 - methane concentration, linearized output, III-250
 - toxic, II-280
 - SCR, III-251
 - smoke/gas/vapor detector, III-250
- GASFET fixed power supplies, IV-405
- gated oscillator, last-cycle completing, III-427
- gated-pulse descrambler, II-165
- gates
 - programmable, I-394
 - XOR gate, IV-107

geiger counters, I-536-537
 high-voltage supply, II-489
 pocket-sized, II-514
 gel cell charger, II-66
 generators, electric-power
 corona-wind generator, IV-633
 high-voltage generator, IV-413
 high-voltage generator, battery-powered, III-482
 high-voltage generator, capacitor-discharge, III-485
 high-voltage generator, dc voltage, III-481
 high-voltage generator, negative-ions, IV-634
 high-voltage generator, ultra-high voltages, II-488
 glitch-detector, comparator, II-107
 glow plug driver, II-52
 graphic equalizer, ten-band, active filter in, II-684
 grid-dip meter, bandswitched, IV-298
 ground tester, II-345
 ground-fault Hall detector, IV-208-209
 ground-noise probe, battery-powered, III-500
 guitars
 compressor, sound-effect circuit, IV-519
 matching audio signal amplifiers, IV-38
 treble boost for, II-683
 tuner, II-362
 gun, laser, visible red and continuous, III-310

H

half-duplex information transmission link, III-679
 half-flash analog-to-digital converters, III-26
 half-wave ac phase controlled circuit, I-377
 half-wave rectifiers, I-230, III-528, IV-325
 fast, I-228
 Hall-effect circuits, II-282-284, III-254-258
 angle of rotation detector, II-283
 compass, III-258
 current monitor, III-255, IV-284
 door open alarm, II-284
 ground-fault detector, IV-208-209
 security door-ajar alarm, III-256
 switches using, III-257, IV-539
 halogen lamps, dimmer for, III-300
 handtalkies, I-19
 two-meter preamplifier for, I-19

hands-free telephone, III-605
 hands-off intercom, III-291
 handset encoder, telephone, III-613
 harmonic generators, I-24, III-228, IV-649
 Hartley oscillator, I-571
 HC-based oscillators, III-423
 HCU/HTC-based oscillator, III-426
 headlight alarm, III-52
 headlight delay unit, I-107, III-49
 headlight dimmer, II-63
 headphones, amplifier for, II-43
 heart rate monitor, II-348, II-349
 heat sniffer, electronic, III-627
 heater, induction, ultrasonic, 120-KHz 500-W, III-704
 heater controls, I-639
 element controller, II-642
 protector circuit, servo-sensed, III-624
 temperature sensitive, I-640
 hee-haw siren, II-578, III-565
 hi-fi circuits
 comparer, II-12
 compressor, pre-emphasis and, III-93
 expander, II-13
 expander, de-emphasis, III-95
 tone control circuit, high Z input, I-676
 high-frequency amplifiers, III-259-265
 29-MHz, III-262
 3-30 MHz, 80-W, 12.5-13.6 V, III-261
 amateur radio, linear, 2-30 MHz 140-W, III-260
 noninverting, 28-dB, III-263
 RF, broadcast band, III-264
 UHF, wideband with high-performance FETs, III-264
 wideband, hybrid, 500 kHz-1GHz, III-265
 wideband, miniature, III-265
 high-frequency oscillator, III-426
 crystal, I-175, II-148
 high-frequency peak detector, II-175
 high-frequency signal generator, II-150
 high-input-high-impedance amplifiers, II-19, II-44
 high-pass filters, I-296
 active, I-296
 active, second-order, I-297
 Butterworth, fourth-order, I-280
 Chebyshev, fourth-order, III-191
 fourth-order, 100-Hz, IV-174
 second-order, 100-Hz, IV-175
 sixth-order elliptical, III-191
 wideband two-pole, II-215
 high-voltage power supplies (*see also* generators, electrical power), II-

487-490, III-486, IV-409-413
 10,000 V dc supply, IV-633
 arc-jet power supply, starting circuit, III-479
 battery-powered generator, III-482
 bucking regulator, III-481
 dc generator, III-481
 fluorescent-lamp supply, cold-cathode design, IV-411
 geiger counter supply, II-489
 generators (*see* generators, electrical power)
 inverter, III-484
 inverter, 40 W, 120 V ac, IV-410-411
 negative-ion generator, IV-634
 optoisolated driver, III-482
 preregulated, III-480
 pulse supply, IV-412
 regulator, III-485
 regulator, foldback-current limiting, II-478
 solid-state, remote adjustable, III-486
 strobe power supply, IV-413
 tube amplifier, high-volt isolation, IV-426
 ultra high-voltage generator, II-488
 hobby circuits (*see* model and hobby circuits)
 hold button, telephone, 612, II-628
 home security systems, IV-87
 lights-on warning, IV-250
 monitor, I-6
 horn, auto, electronic, III-50
 hot-wire anemometer, III-342
 hour/time delay sampling circuit, II-668
 Howland current pump, II-648
 humidity sensor, II-285-287, III-266-267
 HV regulator, foldback current limiting, II-478
 hybrid power amplifier, III-455

IC product detectors, IV-143
 IC timer, crystal-stabilized, subharmonic frequencies for, II-151
 ice alarm, automotive, II-57
 ice formation alarm, II-58
 ice warning and lights reminder, I-106
 ICOM IC-2A battery charger, II-65
 IF amplifiers, I-690, IV-459
 AGC system, IV-458
 AGC system, CA3028-amplifiers, IV-458
 preamp, IV-460
 preamp, 30-MHz, IV-460
 receiver, IV-459
 two-stage, 60 MHz, I-563

- ignition circuit, electronic, automotive, IV-65
- ignition cut-off circuit, automotive, IV-53
- ignition substitute, automotive, III-41
- ignition system, capacitor discharger, I-103
- ignition timing light, II-60
- ignitor, III-362
- illumination stabilizer, machine vision, II-306
- image canceller, III-358
- immobilizer, II-50
- impedance converter, high to low, I-41
- incandescent light flasher, III-198
- indicators (*see also* alarms; control circuits; detectors; monitors; sensors), III-268-270, IV-210-218
 - ac-current indicator, IV-290
 - ac-power indicator, LED display, IV-214
 - ac/dc indicator, IV-214
 - alarm and, I-337
 - automotive-temperature indicator, PTC thermistor, II-56
 - balance indicator, IV-215
 - bar-graph driver, transistorized, IV-213
 - battery charge/discharge, I-122
 - battery condition, I-121
 - battery level, I-124
 - battery threshold, I-124
 - battery voltage, solid-state, I-120
 - beat frequency, I-336
 - CW offset indicator, IV-213
 - dial pulse, III-613
 - field-strength (*see* field-strength meters)
 - in-use indicator, telephone, II-629
 - infrared detector, low-noise, II-289
 - lamp driver, optically coupled, III-413
 - level, three-step, I-336
 - low-battery, I-124
 - low-voltage, III-769
 - mains-failure indicator, IV-216
 - On indicator, IV-217
 - on-the-air, III-270
 - overspeed, I-108
 - overvoltage/undervoltage, I-150
 - peak level, I-402
 - phase sequence, I-476
 - receiver-signal alarm, III-270
 - rf output, IV-299
 - rf-actuated relay, III-270
 - simulated, I-417
 - sound sensor, IV-218
 - stereo-reception, III-269
 - SWR warning, I-22
 - telephone, in-use indicator, II-629, IV-560, IV-563
 - telephone, off-hook, I-633
 - temperature indicator, IV-570
 - transmitter-output indicator, IV-218
 - undervoltage, battery operated equipment, I-123
 - visual modulation, I-430
 - visual level, III-269
 - voltage, III-758-772
 - voltage, visible, I-338, III-772
 - voltage-level, I-718, III-759
 - voltage-level, five step, I-337
 - voltage-level, ten-step, I-335
 - volume indicator, audio amplifier, IV-212
 - VU meter, LED display, IV-211
 - zero center, FM receivers, I-338
- in-use indicator, telephone, II-629
- induction heater, ultrasonic, 120-KHz 500-W, III-704
- inductors
 - active, I-417
 - simulated, II-199
- infrared circuits, II-288-292, III-271-277, IV-219-228
 - data link, I-341
 - detector, III-276, IV-224
 - detector, low-noise, II-289
 - emitter drive, pulsed, II-292
 - fan controller, IV-226
 - laser rifle, invisible pulsed, II-291
 - loudspeaker link, remote, I-343
 - low-noise detector for, II-289
 - object detector, long-range, III-273
 - people-detector, IV-225
 - proximity switch, infrared-activated, IV-345
 - receivers, I-342, II-292, III-274, IV-220-221
 - receivers, remote-control, I-342
 - remote controller, IV-224
 - remote-control tester, IV-228
 - remote-extender, IV-227
 - transmitter, I-343, II-289, II-290, III-274, III-276, III-277, IV-226-227
 - transmitter, digital, III-275
 - transmitter, remote-control, I-342
 - transmitter, voice-modulated pulse FM, IV-228
 - wireless speaker system, III-272
- injectors
 - three-in-one set: logic probe, signal tracer, injector, IV-429
- injector-tracers, I-522
 - single, II-500
 - signal, I-521
- input selectors, audio, low distortion, II-38
- input/output buffer, analog multiplexers, III-11
- instrumentation amplifiers, I-346, I-348, I-349, I-352, II-293-295, III-278-284, IV-229-234
 - ± 100 V common mode range, III-294
 - current collector head amplifier, II-295
 - differential, I-347, I-354, III-283
 - differential, biomedical, III-282
 - differential, high-gain, I-353
 - differential, input, I-354
 - differential, variable gain, I-349
 - extended common-mode design, IV-234
 - high-impedance low drift, I-355
 - high-speed, I-354
 - low-drift/low-noise dc amplifier, IV-232
 - low-signal level/high-impedance, I-350
 - low-power, III-284
 - meter driver, II-296
 - preamp, oscilloscope, IV-230-231
- re-amp, thermocouple, III-283
- precision FET input, I-355
- saturated standard cell amplifier, II-296
- strain gauge, III-280
- triple op amp, I-347
- ultra-precision, III-279
- variable gain, differential input, I-349
- very high-impedance, I-354
- wideband, III-281
- instrumentation meter driver, II-296
- integrators, II-297-300, III-285-286
 - active, inverting buffer, II-299
 - JFET ac coupled, II-200
 - gamma ray pulse, I-536
 - long time, II-300
 - low drift, I-423
 - noninverting, improved, II-298
 - photocurrent, II-326
 - programmable reset level, III-286
 - ramp generator, initial condition reset, III-527
 - resettable, III-286
- intercoms, I-415, II-301-303, III-287-292
 - bidirectional, III-290
 - carrier current, I-146
 - hands-off, III-291
 - party-line, II-303
 - pocket pager, III-288
 - telephone-intercoms, IV-557
 - two-way, III-292
 - two-wire design, IV-235-237
- interfaces (*see also* computer circuits), IV-238-242
 - 680x, 650x, 8080 families, III-98

cassette-to-telephone, III-618
 CPU interface, one-shot design, IV-239
 DVM, temperature sensor and, II-647
 FET driver, low-level power FET, IV-241
 fiber optic, II-207
 keyboard matrix interface, IV-240
 logic-level translators, IV-242
 optical sensor-to-TTL, III-314
 process control, precision, I-30
 tape recorder, II-614
 interrupter, ground fault, I-580
 interval timer, low-power, microprocessor programmable, II-678
 inverters, III-293-298
 dc-to-dc/ac, I-208
 fast, I-422
 fixed power supplies, 12 V input, IV-395
 flip-flop, III-103
 fluorescent lamp, 8-W, III-306
 high-voltage, III-484
 high-voltage power supplies, 40 W, 120 V ac, IV-410-411
 low-power, fixed power supplies, III-466
 on/off switch, III-594
 picture, video circuits, III-722
 power, III-298
 power, 12 VDC-to-117 VAC at 60 Hz, III-294
 power, medium, III-296
 power, MOSFET, III-295
 rectifier/inverter, programmable op-amp design, IV-364
 ultrasonic, arc welding, 20 KHz, III-700
 variable frequency, complementary output, III-297
 voltage, precision, III-298
 inverting amplifiers, I-41-42, III-14
 balancing circuit in, I-33
 low power, digitally selectable gain, II-333
 power amplifier, I-79
 programmable-gain, III-505
 unity gain amplifier, I-80
 wideband unity gain, I-35
 inverting buffers, active integrator using, II-299
 inverting comparators, hysteresis in, I-154
 inverting followers, high-frequency, III-212
 isolated feedback power supply, III-460
 isolation amplifiers
 capacitive load, I-34

level shifter, I-348
 medical telemetry, I-352
 rf, II-547
 isolation and zero voltage switching logic, II-415
 isolators
 analog data-signal transmission, IV-133
 digital transmission, II-414
 stimulus, III-351

J
 JFET ac coupled integrator, III-200

K
 Kelvin thermometer, I-655
 zero adjust, III-661
 keying circuits, IV-243-245
 automatic operation, II-15
 automatic TTL morse code, I-25
 CW keyer, IV-244
 electronic, I-20
 frequency-shift keyer, IV-245
 negative key line keyer, IV-244

L
 lamp-control circuits (*see* lights/light-activated and controlled circuits)
 laser circuits (*see also* lights/light-activated and controlled circuits; optical circuits), II-313-317, III-309-311
 diode sensor, IV-321
 discharge current stabilizer, II-316
 gun, visible red, III-310
 light detector, II-314
 power supply, IV-636
 pulsers, laser diode, III-311, I-416
 receiver, IV-368
 rifle, invisible IR pulsed, II-291
 latches
 12-V, solenoid driver, III-572
 comparator and, III-88
 latching relays, dc, optically coupled, III-417
 latching switches
 double touchbutton, I-138
 SCR-replacing, III-593
 LCD display, fixed power supply, IV-392, IV-403
 lead-acid batteries
 battery chargers, III-55
 life-extender and charger, IV-72
 low-battery detector, III-56
 leading-edge delay circuit, III-147
 LED circuits
 ac-power indicator, IV-214

alternating flasher, III-198, III-200
 bar graph driver, II-188
 driver, emitter/follower, IV-159
 flasher, IV-181
 flasher, control circuit, IV-183
 flasher, multivibrator design, IV-182
 flasher, PUT, II-239
 flasher, sequential, reversible-direction, IV-182
 flasher, UJT, II-231
 frequency comparator, II-110
 matrix display, two-variable, III-171
 millivoltmeter readout, IV-294
 multiplexed common-cathode display ADC, III-764
 panel meter, III-347
 peakmeter, III-333
 ring-around flasher, III-194
 RS-232C, computer circuit, III-103
 three-year flasher, III-194
 voltmeter, IV-286
 VU meter, IV-211
 level, electronic, II-666, IV-329
 level controllers/indicators/monitors, II-174
 alarm, water, I-389
 audio, automatic, II-20
 cryogenic fluid, I-386
 fluid, I-387
 hysteresis in, I-235
 liquid, I-388, I-389, I-390
 meter, LED bar/dot, I-251
 peak, I-402
 sound, I-403
 three-step, I-336
 visual, III-269
 warning, audio output, low, I-391
 warning, high-level, I-387
 water, I-389
 level shifter, negative-to-positive supply, I-394
 LF or HF field strength meter, II-212
 LF receiver, IV-451
 lie detector, II-277, IV-206
 lights/light-activated and controlled circuits (*see also* laser circuits; optical circuits), II-304-312, II-318-331, III-312-319
 860 W limited-range light control, I-376
 ambient-light cancellization circuit, II-328
 audio oscillator, light-sensitive, III-315
 battery-powered light, capacitance operated, I-131
 brightness control, lighted displays, III-316
 carport light, automatic, II-308

- lights/light-activated and controlled circuits (*cont.*)
 - chaser lights, sequential activation, IV-251, IV-252
 - Christmas light driver, IV-254
 - complementary, I-372
 - controller, IV-252
 - cross fader, II-312
 - detectors, detection switch, adjustable, I-362
 - dimmer, I-369, II-309, IV-247, IV-249
 - dimmer, 800 W, II-309
 - dimmer, dc lamp, II-307
 - dimmer, four-quadrant, IV-248-249
 - dimmer, halogen lamps, III-300
 - dimmer, headlight, II-57, II-63
 - dimmer, low-cost, I-373
 - dimmer, soft-start, 800-W, I-376, III-304
 - dimmer, tandem, II-312
 - dimmer, triac, I-375, II-310, III-303
 - dissolver, solid-state, III-304
 - drivers, I-380
 - drivers, flip-flop independent design, IV-160
 - drivers, indicator-lamps, optical coupling, III-413
 - drivers, neon lamps, I-379
 - drivers, short-circuit-proof, II-310
 - emergency light, I-378, I-581, II-320, III-317, III-415, IV-250
 - flame monitor, III-313
 - fluorescent-lamp high-voltage power supplies, cold-cathode design, IV-411
 - indicator-lamp driver, optically coupled, III-413
 - interruption detector, I-364
 - inverter, fluorescent, 8-W, III-306
 - level controller, I-380
 - level detector, I-367, III-316
 - level detector, low-light level drop detector, III-313
 - life-extender for lightbulbs, III-302
 - light-bulb changer, "automatic" design, IV-253
 - lights-on warning, IV-58, IV-62, IV-250
 - light-seeking robot, II-325
 - logic circuit, I-393
 - machine vision illumination stabilizer, II-306
 - marker light, III-317
 - meters, light-meters, I-382, I-383
 - modulator, III-302
 - monostable photocell, self-adjust trigger, II-329
 - mooring light, automatic, II-323
 - night light, automatic, I-360, III-306
 - night light, telephone-controlled, III-604
 - on/off relay, I-366
 - on/off reminder, automotive lights, I-109
 - on/off reminder, with ice alarm, I-106
 - one-shot timer, III-317
 - phase control, II-303, II-305
 - photo alarm, II-319
 - photocell, monostable, self-adjust trigger, II-329
 - photocurrent integrator, II-326
 - photodiode sensor amplifier, II-324
 - photoelectric controller, IV-369
 - photoelectric switches, II-321, II-326, III-319
 - projector-lamp voltage regulator, II-305
 - power outage light, line-operated, III-415
 - pulse-generation interruption, I-357
 - relay, on/off, I-366
 - remote-controller, I-370
 - robot, eyes, II-327
 - robot, light-seeking robot, II-325
 - sensor, ambient-light ignoring, III-413
 - sensor, back-biased GaAs LED, II-321
 - sensor, logarithmic, I-366
 - sensor, optical sensor-to-TTL interface, III-314
 - sequencer, pseudorandom, III-301
 - short-circuit proof lamp driver, II-310
 - signal conditioner, photodiode design, II-330
 - sound-controlled lights, I-609
 - speed controller, IV-247
 - strobe, high-voltage power supplies, IV-413
 - strobe, variable, III-589-590
 - sun tracker, III-318
 - switch, II-320, III-314
 - switch, capacitance switch, I-132
 - switch, light-controlled, IV-320, III-314
 - switch, photoelectric, II-321, II-326, III-319
 - switch, solar triggered, III-318
 - switch, zero-point triac, II-311
 - tarry light, I-579
 - telephone in-use light, II-625
 - three-way light control, IV-251
 - touch lamp, three-way, IV-247
 - triac switch, inductive load, IV-253
 - turn-off circuit, SCR capacitor design, IV-254
 - twilight-triggered circuit, II-322
 - voltage regulator for projection lamp, II-305
 - wake-up call light, II-324
 - warning lights, II-320, III-317
 - light-seeking robot, II-325
 - lights-on warning, automotive, II-55, III-42
 - limit alarm, high/low, I-151
 - limit comparator, I-156, III-106
 - double ended, I-156, II-105
 - limit detectors
 - double ended, I-230, I-233
 - micropower double ended, I-155
 - limiters, III-320-322, IV-255-257
 - audio, low distortion, II-15
 - audio clipper/limiter, IV-355
 - dynamic noise reduction circuit, III-321
 - hold-current, solenoid driver, III-573
 - noise, III-321, II-395
 - one-zener design, IV-257
 - output, III-322
 - power-consumption, III-572
 - transmit-time limiter/timer, IV-580
 - voltage limiter, adjustable, IV-256
 - line amplifier
 - duplex, telephone, III-616
 - universal design, IV-39
 - line drivers
 - 50-ohm transmission, II-192
 - 600-ohm balanced, II-192
 - full rail excursions, II-190
 - high output 600-ohm, II-193
 - video amplifier, III-710
 - line-dropout detector, II-98
 - line-frequency square wave generator, II-599
 - line receivers
 - digital data, III-534
 - low-cost, III-532
 - line-sync, noise immune 60 Hz, II-367
 - line-current detector, optically coupled, III-414
 - line-current monitor, III-341
 - line-hum touch switch, III-664
 - line-synchronized driver circuit, III-174
 - line-voltage announcer, ac, III-730
 - line-voltage monitor, III-511
 - linear amplifiers
 - 2-30MHz, 140W PEP amateur radio, I-555
 - 100 W PEP 420-450 MHz push-pull, I-554
 - 160 W PEP broadband, I-556
 - amateur radio, 2-30 MHz 140-W, III-260
 - CMOS inverter, II-11
 - rf amplifiers, 6-m, 100 W, IV-480-481
 - rf amplifiers, 903 MHz, IV-484-485
 - rf amplifiers, ATV, 10-to-15 W, IV-481

- linear couplers
 - analog, II-413
 - analog ac, II-412
 - dc, II-411
 - linear IC siren, III-564
 - linear optocoupler, instrumentation, II-417
 - linear ramp generator, II-270
 - linear regulators
 - fixed power supply, low dropout low cost, III-459
 - radiation-hardened 125A, II-468
 - link, fiber optic, III-179
 - liquid flowmeter, II-248
 - liquid-level detectors (*see* fluid and moisture detectors)
 - lithium batteries
 - charger for, II-67
 - state of charge indicator for, II-78
 - little dipper dip meter, II-183
 - locator, lo-parts treasure, I-409
 - locks, electronic, II-194-197, IV-161-163
 - combination, I-583, II-196
 - digital entry lock, IV-162
 - keyless design, IV-163
 - three-dial combination, II-195
 - locomotive whistle, II-589
 - logarithmic amplifiers, I-29, I-35, II-8
 - dc to video, I-38
 - log-ratio amplifier, I-42
 - logarithmic converter, fast, I-169
 - logarithmic light sensor, I-366
 - logarithmic sweep VCO, III-738
 - logic/logic circuits
 - audible pulses, II-345
 - four-state, single LED indicator, II-361
 - isolation and zero voltage switching, II-415
 - light-activated, I-393
 - line monitor, III-108
 - overvoltage protection, I-517
 - probes (*see* logic probes)
 - pulse generator for logic-troubleshooting, IV-436
 - pulser, III-520
 - signals, long delay line for, III-107
 - tester, audible, III-343
 - tester, TTL, I-527
 - translators, logic-level translators, IV-242
 - logic amplifiers, II-332-335
 - low power binary, to 10n gain low frequency, II-333
 - low power inverting, digitally selectable gain, II-333
 - low power noninverting, digitally selectable input and gain, II-334
 - precision, digitally programmable input and gain, II-335
 - programmable amplifier, II-334
 - logic converter, TTL to MOS, I-170
 - logic level shifter, negative-to-positive supply, I-394
 - logic probes, I-520, I-525, I-526, IV-430-431, IV-434
 - CMOS, I-523, I-526, III-499
 - digital, III-497
 - four-way operation, IV-432
 - memory-tester, installed, I-525
 - single-IC design, IV-433
 - three-in-one test set: probe, signal tracer, injector, IV-429
 - long-duration timer, PUT, II-675
 - long-range object detector, III-273
 - long-term electronic timer, II-672
 - long-time integrator, II-300
 - long-time timer, III-653
 - loop antenna, 3.5 MHz, IV-12-13
 - loop transmitter, remote sensors, III-70
 - loop-thru video amplifier, IV-616
 - loudness amplifier, II-46
 - loudness control, balance amplifier with, II-395
 - loudspeaker coupling circuit, I-78
 - low-current measurement system, III-345
 - low-distortion audio limiter, II-15
 - low-distortion input selector for audio use, II-38
 - low-distortion low level amplitude modulator, II-370
 - low-distortion sine wave oscillator, II-561
 - low-frequency oscillators, III-428
 - crystal, I-184, II-146
 - oscillator/flasher, II-234
 - Pierce oscillator, III-133
 - TTL oscillator, II-595
 - low-pass filters, I-287
 - active, digitally selected break frequency, II-216
 - Chebyshev, fifth-order, multi-feed-back, II-219
 - pole-active, I-295
 - fast-response, fast settling, IV-168-169
 - fast-settling, precision, II-220
 - precision, fast settling, II-220
 - Sallen-Key, 10 kHz, I-279
 - Sallen-key, active, IV-177
 - Sallen-Key, equal component, I-292
 - low-voltage alarm/indicator, II-493, III-769
 - low-voltage power disconnecter, II-97
 - LVDT circuits, II-336-339, III-323-324
 - driver demodulator, II-337
 - signal conditioner, II-338
- M**
- machine vision, illumination stabilizer for, II-306
 - magnetic current low-power sensor, III-341
 - magnetic phono preamplifier, I-91
 - magnetic pickup phone preamplifier, I-89
 - magnetometer, II-341
 - magnets, permanent-magnet detector, IV-281
 - mains-failure indicator, IV-216
 - marker generator, III-138
 - marker light, III-317
 - mathematical circuits, III-325-327, IV-258-263
 - adder, III-327
 - adder, binary, fast-action, IV-260-261
 - divide/multiply, one trim, III-326
 - multiplier, precise commutating amp, IV-262-263
 - slope integrator, programmable, IV-259
 - subtractor, III-327
 - measurement/test circuits (*see also* detectors; indicators; meters), II-340, III-328-348, IV-264-311
 - 3-in-1 test set, III-330
 - absolute-value circuit, IV-274
 - acoustic-sound receiver, IV-311
 - acoustic-sound transmitter, IV-311
 - anemometer/, hot-wire, III-342
 - audible logic tester, III-343
 - automotive electrical tester, IV-45
 - B-field measurer, IV-272
 - barometer, IV-273
 - battery internal-resistance, IV-74
 - battery tester, IV-78
 - battery tester, ni-cad batteries, IV-79
 - breath alert alcohol tester, III-359
 - broadband ac active rectifier, IV-271
 - cable tester, III-539
 - capacitor tester, IV-265
 - capacitor-ESR measurer, IV-279
 - continuity tester, I-550, I-551, II-342, III-345, III-540, IV-287, IV-289, IV-296
 - continuity tester, latching, IV-295
 - crystal tester, II-151
 - current indicator, ac current, IV-290
 - current monitor, Hall-sensor, IV-284
 - current monitor/alarm, III-338
 - current sensor, high-gain, IV-291
 - deviation meter, IV-303
 - digital frequency meter, III-344

- measurement/test circuits (*cont.*)
- digital multimeter (DMM), high-resistance measuring, IV-291
 - diode, I-402, II-343
 - direction-of-rotation circuit, III-335
 - diode-curve tracer, IV-274
 - diode-matching circuit, IV-280
 - duty-cycle measurer, IV-265
 - duty-cycle meter, IV-275
 - duty-cycle monitor, III-329
 - E, T, and R measurement/test circuits, IV-283-296
 - electrolytic-capacitor reforming circuit, IV-276
 - electrometer, IV-277
 - electrostatic detector, III-337
 - filter analyzer, audio filters, IV-309
 - frequency checker, crystal oscillator, precision design, IV-301
 - frequency counter, III-340, IV-300
 - frequency meter, IV-282
 - frequency shift keyer tone generator, I-723
 - go/no-go, diode, I-401
 - go/no-go, dual-limit, I-157
 - grid-dip meter, bandswitched, IV-298
 - ground, I-580, II-345
 - injectors, IV-429
 - high-frequency and rf, IV-297-303
 - LC checker, III-334
 - LED panel meter, III-347
 - line-current monitor, III-341
 - logic probes (*see* logic probes)
 - logic-pulses, slow pulse test, II-345
 - low-current measurement, III-345
 - low-ohms adapter, IV-290
 - magnet, permanent-magnet detector, IV-281
 - magnetic current sensor, low-power, III-341
 - magnetic-field meter, IV-266
 - magnetometer, II-341
 - measuring gauge, linear variable differential transformer, I-404
 - meter tester, IV-270
 - microammeter, dc, four-range, IV-292
 - microfarad counter, IV-275
 - millivoltmeter, dc, IV-295
 - millivoltmeter, four-range, IV-289
 - millivoltmeter, LED readout, IV-294
 - modulation monitor, IV-299
 - mono audio-level meter, IV-310
 - motion sensor, unidirectional, II-346
 - motor hour, III-340
 - multiconductor-cable tester, IV-288
 - multimeter shunt, IV-293
 - noise generator, IV-308
 - ohmmeter, linear, III-540
 - ohmmeter, linear-scale, five-range, IV-290
 - oscilloscope adapter, four-trace, IV-267
 - paper sheet discriminator, copying machines, III-339
 - peak-dB meter, III-348
 - peakmeter, LED, III-333
 - phase difference from 0 to 180 degrees, II-344
 - phase meter, digital VOM, IV-277
 - picoammeter, III-338
 - power gain, 60 MHz, I-489
 - power supply test load, constant-current, IV-424
 - probes, 4-to-220 V, III-499
 - pulse-width, very short, III-336
 - QRP SWR bridge, III-336
 - remote-control infrared device, IV-228
 - resistance measurement, synchronous system, IV-285
 - resistance ratio detector, II-342
 - resistance/continuity meters, III-538-540
 - rf output indicator, IV-299
 - rf power, wide-range, III-332
 - SCR tester, III-344
 - shutter, I-485
 - signal generator, AM broadcast-band, IV-302
 - signal generator, AM/IF, 455 kHz, IV-301
 - signal strength (S), III-342
 - signal tracer, IV-429
 - sound-level meter, III-346, IV-305, IV-307
 - sound-test circuits (*see also* sound generators), IV-304
 - speedometer, bike, IV-271, IV-282
 - static detector, IV-276
 - stereo audio-level meter, IV-310
 - stereo audio-power meter, IV-306
 - stereo power meter, III-331
 - stud finder, III-339
 - SWR meter, IV-269
 - tachometer, III-335, III-340
 - tachometer, optical pick-up, III-347
 - tachometer, analog readout, IV-280
 - tachometer, digital readout, IV-278
 - tachometer, digital, IV-268-269
 - temperature measurement, transistorized, IV-572
 - test probe, 4-220 V, III-499
 - thermometers, III-637-643
 - three-in-one set, logic probe, signal tracer, injector, IV-429
 - three-phase tester, II-440
 - transistor, I-401, IV-281
 - TTL logic, I-527
 - universal test probe, IV-431
 - UHF source dipper, IV-299
 - voltmeter, digital LED readout, IV-286
 - VOM, phase meter, digital readout, IV-277
 - VOR signal simulator, IV-273
 - water-level measurement circuit, IV-191
 - wavemeter, tuned RF, IV-302
 - wideband test amplifier, IV-303
 - wire tracer, II-343
 - zener, I-400
- medical electronic circuits, II-347-349, III-349-352
- biomedical instrumentation differential amp, III-282
 - breath monitor, III-350
 - EKG simulator, three-chip, III-350
 - heart rate monitor, II-348, II-349
 - preamplifier for, II-349
 - stimulator, constant-current, III-352
 - stimulus isolator, III-351
 - thermometer, implantable/ingestible, III-641
- melody generator, single-chip design, IV-520
- memory-related circuits
- EEPROM pulse generator, 5V-powered, III-99
 - memory protector/power supply monitor, IV-425
 - memory-saving power supply, II-486
- metal detectors, II-350-352, IV-137
- micropower, I-408
- meters (*see also* measurement/test circuits)
- ac voltmeters, III-765
 - analog, expanded-scale, IV-46
 - analog, expanded-scale, voltage reference, III-774
 - anemometer/, hot-wire, III-342
 - audio frequency, I-311
 - audio millivolt, III-767, III-769
 - audio power, I-488
 - automatic contrast, I-479
 - basic grid dip, I-247
 - breaker point dwell, I-102
 - capacitance, I-400
 - dc voltmeter, III-763
 - dc voltmeter, high-input resistance, III-762
 - deviation meter, IV-303
 - digital frequency, III-344
 - digital multimeter (DMM), high-resistance measuring, IV-291
 - dip, I-247
 - dip, dual-gate IGFET in, I-246

- dosage rate, I-534
- duty-cycle meter, IV-275
- electrometer, IV-277
- extended range VU, I-715, III-487
- FET voltmeter, III-765, III-770
- field-strength meters (*see* field-strength meters)
- flash exposure, I-484, III-446
- frequency meter, IV-282
- grid-dip meter, bandswitched, IV-298
- LED bar/dot level, I-251
- LED panel, III-347
- light, I-383
- linear frequency, I-310
- linear light, I-382
- logarithmic light, I-382
- magnetic-field meter, IV-266
- meter-driver rf amplifier, 1-MHz, III-545
- microammeter, dc, four-range, IV-292
- microwave field strength, I-273
- millivoltmeter, dc, IV-295
- millivoltmeter, four-range, IV-289
- millivoltmeter, LED readout, IV-294
- mono audio-level meter, IV-310
- motor hour, III-340
- multimeter shunt, IV-293
- ohmmeter, linear, III-540
- ohmmeters, linear-scale, five-range, IV-290
- peak decibels, III-348
- peak, LED, III-333
- pH, I-399
- phase, I-406
- picoammeter, III-338
- power line frequency, I-311
- power, I-489
- resistance/continuity, III-538-540
- rf power, I-16
- rf power, wide-range, III-332
- rf voltmeter, III-766
- signal strength (S), III-342, IV-166
- soil moisture, III-208
- sound-level meter, IV-305, IV-307
- sound level, telephone, III-614
- sound level, III-346
- speedometer, bicycle, IV-271, IV-282
- stereo audio-level meter, IV-310
- stereo audio-power meter, IV-306
- stereo balance, I-618-619
- stereo power, III-331
- suppressed zero, I-716
- SWR power, I-16, IV-269
- tachometer, III-335, III-340, III-347
- tachometer, analog readout, IV-280
- tachometer, digital readout, IV-278
- temperature, I-647
- tester, IV-270
- thermometers, III-637-643
- tilt meter, III-644-646
- varicap tuned FET DIP, I-246
- vibration, I-404
- voltage, III-758-77
- voltmeters, ac wide-range, III-772
- voltmeters, digital, 3.5-digit, full-scale four-decade, III-761
- voltmeters, digital, 4.5-digit, III-760
- voltmeters, high-input resistance, III-768
- VOM field strength, I-276
- VOM/phase meter, digital readout, IV-277
- wavemeter, tuned RF, IV-302
- methane concentration detector, linearized output, III-250
- metronomes, I-413, II-353-355, III-353-354, IV-312-314
 - ac-line operated unijunction, II-355
 - accentuated beat, I-411
 - downbeat-emphasized, III-353-354
 - electronic, IV-313
 - low-power design, IV-313
 - novel design, IV-314
 - sight and sound, I-412
 - simple, II-354
 - version II, II-355
- microammeter, dc, four-range, IV-292
- microcontroller, musical organ, preprogrammed single-chip, I-600
- micro-sized amplifiers, III-36
- microphone circuits
 - amplifiers for, I-87, III-34
 - amplifiers for, electronic balanced input, I-86
 - FM wireless, III-682, III-685, III-691
 - mixer, II-37
 - preamp for, II-45, IV-37, IV-42
 - preamp, low-impedance design, IV-41
 - preamp for, low-noise transformerless balanced, I-88
 - preamp for, tone control in, I-675, II-687
 - wireless, IV-652-654
 - wireless AM, I-679
- microprocessors (*see* computer circuits)
- microvolt comparators
 - dual limit, III-89
 - hysteresis-including, III-88
- microvolt probe, II-499
- microwave amplifier circuits, IV-315-319
 - 5.7 GHz, IV-317
 - bias supply for preamp, IV-318
 - preamplifier, 2.3 GHz, IV-316
 - preamplifier, 3.4 GHz, IV-316
- preamplifier, single-stage, 10 GHz, IV-317
- preamplifiers, bias supply, IV-318
- preamplifiers, two-stage, 10 GHz, IV-319
- Miller oscillator, I-193
- millivoltmeters (*see also* meters; voltmeters)
 - ac, I-716
 - audio, III-767, III-769
 - high-input impedance, I-715
- mini-stereo audio amplifiers, III-38
- mixers, III-367-370, IV-330-336
 - 1-MHz, I-427
 - audio, I-23, II-35, IV-335
 - audio, one-transistor design, I-59
 - CMOS, I-57
 - common-source, I-427
 - digital mixer, IV-334
 - diplexer, IV-335
 - doubly balanced, I-427
 - dynamic audio mixer, IV-331
 - four-channel, I-60, III-369, IV-333
 - four-channel, four-track, II-40
 - four-channel, high level, I-56
 - four-input, stereo, I-55
 - four-input, unity-gain, IV-334
 - HF transceiver/mixer, IV-457
 - hybrid, I-60
 - input-buffered, III-369
 - microphone, II-37
 - multiplexer, I-427
 - one-transistor design, I-59
 - passive, I-58
 - preamplifier with tone control, I-58
 - signal combiner, III-368
 - silent audio switching, I-59
 - sound amplifier and, II-37
 - stereo mixer, pan controls, IV-332
 - unity-gain, four-input, IV-334
 - utility-design mixer, IV-336
 - universal stage, III-370
 - video, high-performance operation, IV-609
- mobile equipment, 8-amp regulated power supply, II-461
- model and hobby circuits, IV-337-340
 - controller, model-train and/or slot-car, IV-338-340
- model rocket launcher, II-358
- modems, power-line, carrier-current circuit, III-82
- modulated light beam circuit, ambient light effect cancellation with, II-328
- modulated readback systems, disc/tape phase, I-89
- modulation indicator/monitor, I-430
- CB, I-431

- modulators, I-437, II-368-372, III-371-377
 - +12V dc single supply, balanced, I-437
 - AM, I-438
 - amplitude, low-distortion low level, II-370
 - balanced, III-376
 - balanced, phase detector-selector/sync rectifier, III-441
 - double-sideband suppressed-carrier, III-377
 - linear pulse-width, I-437
 - monitor for, III-375
 - musical envelope generator, I-601
 - pulse-position, I-435, III-375
 - pulse-width, I-435, I-436, I-438-440, III-376, IV-326
 - rf, I-436, III-372, III-374
 - rf, double sideband, suppressed carrier, II-369
 - saw oscillator, III-373
 - TTL oscillator for television display, II-372
 - TV, I-439, II-433, II-434
 - VHF, I-440, III-684
 - video, I-437, II-371, II-372
- moisture detector (*see* fluid and moisture detectors)
- monitors (*see also* alarms; control circuits; detectors; indicators; sensors), III-378-390
 - acid rain, III-361
 - battery, III-60-67
 - battery-alternator, automotive, III-63
 - blinking phone light, II-624
 - breath monitor, III-350
 - current, alarm and, III-338
 - directional signals, auto, III-48
 - door-ajar, automotive circuits, III-46
 - duty cycle, III-329
 - flames, III-313
 - home security system, I-6
 - line-current, III-341
 - line-voltage, III-511
 - logic line, III-108
 - modulation, III-375
 - overvoltage, III-762
 - power monitor, SCR design, IV-385
 - power-supply monitors (*see* power-supply monitors)
 - power-line connections, ac, III-510
 - precision battery voltage, HTS, I-122
 - receiver, II-526
 - sound level, telephone, III-614
 - telephone status, optoisolator in, I-625
 - telephone, remote, II-626
 - thermal monitor, IV-569
 - undervoltage, III-762
 - voltage, III-767
 - voltage, III-758-772
- monostable circuit, I-464, II-460
- monostable multivibrators, I-465, III-230, III-235
 - input lockout, I-464
 - linear-ramp, III-237
 - positive-triggered, III-229
- monostable photocell, self-adjust trigger, II-329
- monostable TTL, I-464
- monostable UJT, I-463
- mooring light, automatic, II-323
- MOSFETs
 - power control switch, IV-386
 - power inverter, III-295
- mosquito repelling circuit, I-684
- motion sensors
 - acoustic Doppler motion detector, IV-343
 - auto alarm, I-9
 - low-current-drain design, IV-342-343
 - motorcycle alarm, I-9
 - UHF, III-516, IV-344
 - unidirectional, II-346
- motor control circuits, IV-347-353
 - 400 Hz servo amplifier, II-386
 - ac motors, II-375
 - bidirectional proportional, II-374
 - compressor protector, IV-351
 - direction control, dc motors, I-452
 - direction control, series-wound motors, I-448
 - direction control, shunt-wound motors, I-456
 - direction control, stepper motor, IV-350
 - driver control, ac, three-phase, II-383
 - driver control, ac, two-phase, II-382
 - driver control, constant-speed, III-386
 - driver control, dc, fixed speed, III-387
 - driver control, dc, servo, bipolar control input, II-385
 - driver control, dc, speed-controlled reversible, III-388
 - driver control, N-phase motor, II-382
 - driver control, reversing, dc control signals, II-381
 - driver control, servo motor amplifier, I-452, II-384
 - driver control, stepper motors, III-390
 - driver control, stepper motor, half-step, IV-349
 - driver control, stepper motor, quar-
- ter-step, IV-350
- driver control, two-phase, II-456
- fiber-optic, dc, variable, II-206
- hours-in-use meter, III-340
- induction motor, I-454
- load-dependent, universal motor, I-451
- mini-drill control, IV-348
- power brake, ac, II-451
- power-factor controller, three-phase, II-388
- PWM motor controller, III-389
- PWM servo amplifier, III-379
- PWM speed control, II-376
- PWM speed control/energy-recovering brake, III-380
- self-timing control, built-in, universal motor, I-451
- servo motor amplifier, I-452, II-384
- speed control (*see* speed controllers)
- start-and-run motor circuit, III-382
- stepper motors, half-step, IV-349
- stepper motors, quarter-step, IV-350
- stepper motors, speed and direction, IV-350
- tachometer feedback control, II-378
- tachometer feedback control, closed loop, II-390
- motorcycle alarm, motion actuated, II-9
- multiburst generator, square waveform, II-88
- multimeters, shunt, IV-293
- multiple-input detector, III-102
- multiplexed common-cathode LED-display ADC, III-764
- multiplexers, III-391-397
 - 1-of-8 channel transmission system, III-395
 - analog, II-392
 - analog, 0/01-percent, II-392
 - analog, buffered input and output, III-396
 - analog, input/output buffer for, III-11
 - analog, single- to four-trace converter, II-431
 - capacitance, II-200, II-416
 - de-, III-394
 - four-channel, low-cost, III-394
 - frequency, III-213-218
 - mathematical, one trim, III-326
 - oscilloscopes, add-on, III-437
 - pulse-width, III-214
 - resistor, II-199
 - sample-and-hold, three-channel, III-396
 - two-level, III-392
 - video, 1-of-15 cascaded, III-393
- wideband differential, II-428
- multipliers, low-frequency multiplier, IV-325

multiplying D/A converter, III-168
 multiplying pulse width circuit, II-264
 multivibrators
 100 kHz free running, II-485
 astable, I-461, II-269, II-510, III-196, III-224, III-233, III-238
 astable, digital-control, II-462
 astable, dual, II-463
 astable, programmable-frequency, III-237
 bistable, II-465
 bistable, touch-triggered, I-133
 car battery, II-106
 CB modulation, II-431
 current, II-203
 duty-cycle, 50-percent, III-584
 free-running, programmable-frequency, III-235
 low-frequency, III-237
 low-voltage, II-123
 modulation, II-430
 monostable, II-465, III-229, III-230, III-235, III-237
 monostable, input lock-out, II-464
 one-shot, II-465
 oscilloscope, II-474
 single-supply, III-232
 sound level, II-403
 square-wave generators, IV-536
 telephone line, II-628
 wideband radiation, II-535
 music circuits (*see* sound generators)
 musical envelope generator/modulator, IV-22
 mux/demux systems
 differential, I-425
 eight-channel, I-426, II-115

N

N-phase motor drive, III-382
 NAB preamps
 record, III-673
 two-pole, III-673
 NAB tape playback pre-amp, III-38
 nano ammeter, I-202
 narrow-band FM demodulator, carrier detect in, II-159
 negative-ion generator, IV-634
 neon flashers
 five-lamp, III-198
 two-state oscillator, III-200
 networks
 filter, I-291
 speech, telephone, II-633
 ni-cad batteries
 analyzer for, III-64
 charger, I-112, I-116, III-57
 charger, 12 v, 200 mA per hour, I-114

charger, current and voltage limiting, I-114
 charger, fast-acting, I-118
 charger, portable, IV-69
 charger, temperature-sensing, IV-77
 charger, thermally controlled, II-68
 packs, automotive charger for, I-115
 protection circuit, III-62
 test circuit, IV-79
 zappers, I-6, II-68
 night lights (*see* lights/light-activated and controlled circuits)
 noise generators (*see* sound generators)
 noise reduction circuits, II-393-396, III-398-401, IV-354-356
 audio clipper/limiter, IV-355
 audio shunt noise limiter, IV-355
 audio squelch, II-394
 balance amplifier with loudness control, II-395
 blinker, IV-356
 clipper, II-394
 clipper, audio-powered, III-396
 Dolby B, decode mode, III-401
 Dolby B, encode mode, III-400
 Dolby B/C, III-399
 dynamic noise reduction, III-321
 filter, III-188
 filter, dynamic filter, III-190
 limiter, II-395, III-321
 noninverting amplifiers, I-41, III-14
 adjustable gain, I-91
 comparator with hysteresis in, I-153
 high-frequency, 28-dB, III-263
 hysteresis in, I-153
 low power, digitally selectable input and gain, II-334
 power, I-79
 programmable-gain, III-505
 single supply, I-74
 split supply, I-75
 noninverting integrator, improved design, II-298
 noninverting voltage followers, I-33
 high-frequency, III-212
 nonselective frequency tripler, transistor saturation, II-252
 Norton amplifier, absolute value, III-11
 notch filters (*see also* filter circuits), I-283, II-397-403, III-402-404
 4.5 MHz, I-282
 550 Hz, II-399
 1800 Hz, II-398
 active band reject, II-401
 adjustable Q, II-398
 audio, II-400
 bandpass and, II-223
 high-Q, III-404
 selectable bandwidth, I-281

three-amplifier design, I-281
 tunable, II-399, II-402
 tunable, passive-bridged differentiator, II-403
 tunable, hum-suppressing, I-280
 tunable, op amp, II-400
 twin-T, III-403
 Wien bridge, II-402
 NTSC-to-RGB video decoder, IV-613
 null circuit, variable gain, accurate, III-69
 null detector, I-148, III-162

O

ohmmeters, I-549
 linear, III-540
 linear scale, I-549
 linear-scale, five-range, IV-290
 ohms-to-volts converter, I-168
 oil-pressure gauge, automotive, IV-44, IV-47
 on/off inverter, III-594
 on/off touch switches, II-691, III-663
 one-of-eight channel transmission system, III-100
 one-shot function generators, I-465
 digitally controlled, I-720
 precision, III-222
 retriggerable, III-238
 one-shot timers, III-654
 light-controlled, III-317
 voltage-controlled high-speed, II-266
 op amps, II-404-406, III-405-406, IV-357-364
 x10, I-37
 x100, I-37
 astable multivibrator, III-224
 audio amplifier, IV-33
 bidirectional compound op amp, IV-361
 clamping for, II-22
 clock circuit using, III-85
 comparator, three-input and gate comparator, IV-363
 compound op-amp, IV-364
 feedback-stabilized amplifier, IV-360
 gain-controlled op amp, IV-361
 intrinsically safe protected, III-12
 inverter/rectifier, programmable, IV-364
 on/off switch, transistorized, IV-546
 power booster, IV-358
 power driver circuit, IV-158-159
 quad, simultaneous waveform generator using, II-259
 single potentiometer to adjust gain over bipolar range, II-406
 swing rail-ray, LM324, IV-363

- op amps (*cont.*)
 - tunable notch filter with, II-400
 - variable gain and sign, II-405
 - VCO driver, IV-362
 - video op amp circuits, IV-615
 - optical circuits (*see also* lasers; lights/light-activated and controlled circuits), II-407-419, IV-365-369
 - 50 kHz center frequency FM transmitter, II-417
 - ac relay, III-418
 - ac relay using two photon couplers, II-412
 - ac switcher, high-voltage, III-408
 - ambient light ignoring optical sensor, III-413
 - CMOS coupler, III-414
 - communication system, II-416
 - dc linear coupler, II-411
 - dc latching relay, III-417
 - digital transmission isolator, II-414
 - high-sensitivity, NO, two-terminal zero voltage switch, II-414
 - indicator lamp driver, III-413
 - integrated solid state relay, II-408
 - interruption sensor, IV-366
 - isolation and zero voltage switching logic, II-415
 - light-detector, IV-369
 - line-current detector, III-414
 - linear ac analog coupler, II-412
 - linear analog coupler, II-413
 - linear optocoupler for instrumentation, II-417
 - microprocessor triac array driver, II-410
 - optoisolator relay circuit, IV-475
 - paper tape reader, II-414
 - photoelectric light controller, IV-369
 - power outage light, line-operated, III-415
 - probe, IV-369
 - receiver, 50 kHz FM optical transmitter, II-418
 - receiver, light receiver, IV-367
 - receiver, optical or laser light, IV-368
 - relays, dc solid-state, open/closed, III-412
 - source follower, photodiode, III-419
 - stable optocoupler, II-409
 - telephone ring detector, III-611
 - transmitter, light transmitter, IV-368
 - triggering SCR series, III-411
 - TTL coupler, optical, III-416
 - zero-voltage switching, closed half-wave, III-412
 - zero-voltage switching, solid-state, III-410
 - zero-voltage switching, solid-state relay, III-416
- optical communication system, I-358, II-416
 - optical pyrometer, I-654
 - optical receiver, I-364, II-418
 - optical Schmitt trigger, I-362
 - optical sensor, ambient light ignoring, III-413
 - optical sensor-to-TTL interface, III-314
 - optical transmitters, I-363
 - FM (PRM), I-367
 - optocouplers
 - linear, instrumentation, II-417
 - stable, II-409
 - optoisolators, IV-475
 - driver, high-voltage, III-482
 - telephone status monitor using, I-626
 - OR gate, I-395
 - organ, musical, I-415
 - preprogrammed single chip microcontroller for, I-600
 - stylus, I-420
 - oscillators, II-420-429, III-420-432, IV-370-377
 - 1 kHz, II-427
 - 1.0 MHz, I-571
 - 2MHz, II-571
 - 5-V, III-432
 - 50 kHz, I-727
 - 400 MHz, I-571
 - 500 MHz, I-570
 - 800 Hz, I-68
 - adjustable over 10:1 range, II-423
 - astable, I-462
 - audio, I-245, III-427, IV-374, IV-375
 - audio, light-sensitive, III-315
 - beat-frequency audio generator, IV-371
 - buffer circuits, IV-89
 - Butler, aperiodic, I-196
 - Butler, common base, I-191
 - Butler, emitter follower, II-190-191, II-194
 - cassette bias, II-426
 - clock generator, I-615, III-85
 - CMOS, I-615
 - CMOS, 1 MHz to 4MHz, I-199
 - CMOS, crystal, I-187
 - code practice, I-15, I-20, I-22, II-428, III-431, IV-373, IV-375, IV-376
 - Colpitts, I-194, I-572, II-147
 - Colpitts, harmonic, I-189-190
 - crystal (*see* crystal oscillators)
 - double frequency output, I-314
 - discrete sequence, III-421
 - duty-cycle, 50-percent, III-426
 - emitter-coupled, big loop, II-422
 - emitter-coupled, RC, II-266
 - exponential digitally controlled, I-728
 - feedback, I-67
 - flasher and, high drive, II-235
 - flasher and, low frequency, II-234
 - free-running, I-531
 - free-running, square wave, I-615
 - frequency doubled output from, II-596
 - gated, I-728
 - gated, last-cycle completing, III-427
 - Hartley, I-571
 - hc-based, III-423
 - HCU/HCT-based, III-426
 - high-current, square-wave generator, III-585
 - high-frequency, III-426
 - high-frequency, crystal, I-175, II-148
 - load-switching, 100 mA, I-730
 - low-distortion, I-570
 - low-duty-cycle pulse circuit, IV-439
 - low-frequency, III-428
 - low-frequency, crystal, I-184, II-146
 - low-frequency, TTL, II-595
 - low-noise crystal, II-145
 - Miller, I-193
 - neon flasher, two-state, III-200
 - one-second, 1 kHz, II-423
 - one-shot, voltage-controlled high-speed, II-266
 - overtone, 50 MHz to 100 MHz, I-181
 - overtone, crystal, I-176, I-180, II-146, IV-123
 - overtone, crystal switching, I-183
 - overtone, fifth overtone, I-182
 - phase-locked, 20-MHz, IV-374
 - Pierce, I-195
 - Pierce, crystal, II-144
 - Pierce, harmonic, I-199, II-192
 - quadrature, III-428
 - quadrature-output, I-729
 - quadrature-output, square-wave generator, III-585
 - R/C, I-612
 - reflection, crystal-controlled, III-136
 - relaxation, IV-376
 - relaxation, SCR, III-430
 - resistance-controlled digital, II-426
 - rf (*see also* rf oscillator), II-550, I-572
 - rf-genie, II-421
 - rf-powered sidetone, I-24
 - RLC, III-423
 - sawtooth wave, modulator, III-373
 - Schmitt trigger crystal, I-181
 - sine-wave (*see* sine-wave oscillators)
 - sine-wave/square wave, easily tuned, I-65
 - sine-wave/square-wave, tunable, III-232
 - single op amp, I-529
 - square-wave, II-597, I-613-614, II-

616, IV-532, IV-533
square-wave, 0.5 Hz, I-616
square-wave, 1kHz, I-612
start-stop oscillator pulse circuit, IV-438
switching, 20 ns, I-729
temperature-compensated, low power 5v-driven, II-142
temperature-stable, II-427
temperature-compensated crystal, I-187
timer, 500 timer, I-531
tone-burst, decoder and, I-726
transmitter and, 27 MHz and 49 MHz rf, I-680
triangle/square wave, I-616, II-422
TTL, I-179, I-613
TTL, 1MHz to 10MHz, I-178
TTL, television display using, II-372
TTL-compatible crystal, I-197
tube type crystal, I-192
tunable frequency, II-425
tunable single comparator, I-69
varactor tuned 10 MHz ceramic resonator, II-141
variable, II-421
variable, audio, 20Hz to 20kHz, II-727
variable, four-decade, single control for, II-424
variable, wide range, II-429
variable-duty cycle, fixed-frequency, III-422
voltage-controlled (*see* voltage-controlled oscillators)
wide-frequency range, II-262
wide-range, I-69, III-425
wide-range, variable, I-730
Wien-bridge (*see* Wien-bridge oscillators)
XOR-gate, III-429
yelp, II-577

oscilloscopes, II-430-433, III-433-439
analog multiplexer, single- to four-trace scope converter, II-431
beam splitter, I-474
calibrator, II-433, III-436
converter, I-471
CRO doubler, III-439
eight-channel voltage display, III-435
extender, III-434
FET dual-trace switch for, II-432
four-trace oscilloscope adapter, IV-267
monitor, I-474
multiplexer, add-on, III-437
preamplifier, III-437
preamplifier, counter, III-438
preamplifier, instrumentation amplifiers, IV-230-231

sensitivity amplifier, III-436
triggered sweep, III-438
voltage-level dual readout, IV-108
outband descrambler, II-164
out-of-bounds pulse-width detector, III-158
output limiter, III-322
output-gating circuit, photomultiplier, II-516
output-stage booster, III-452
over/under temperature monitor, dual output, II-646
overload protector, speaker, II-16
overspeed indicator, I-108
overtone crystal oscillators, II-146
50 MHz to 100 MHz, I-181
100 MHz, IV-124
crystal, I-176, I-180, II-146
crystal switching, I-183
fifth overtone, I-182
third-overtone oscillator, IV-123
overvoltage detection and protection, IV-389
comparator to detect, II-107
monitor for, III-762
protection circuit, II-96, II-496, III-513
undervoltage and, indicator, I-150

P

pager, pocket-size, III-288
PAL/NTSC decoder, RGB input, III-717
palette, video, III-720
panning circuit, two-channel, I-57
paper-sheet discriminator, copying machines, III-339
paper-tape reader, II-414
parallel connections, telephone, III-611
party-line intercom, II-303
passive bridge, differentiator tunable notch filter, II-403
passive mixer, II-58
PCB continuity tester, II-342
peak decibel meter, III-348
peak detectors, II-174, II-175, II-434-436, IV-138, IV-143
analog, with digital hold, III-153
digital, III-160
high-bandwidth, III-161
high-frequency, II-175
high-speed, I-232
low-drift, III-156
negative, I-225, I-234
op amp, IV-145
positive, I-225, I-235, II-435, III-169
ultra-low drift, I-227
voltage, precision, I-226
wide-bandwidth, III-162
wide-range, III-152

peak meter, LED, III-333
peak program detector, III-771
peak-to-peak converter, precision ac/dc, II-127
people-detector, infrared-activated, IV-225
period counter, 100 MHz, frequency and, II-136
period-to-voltage converter, IV-115
pest-repeller, ultrasonic, III-699, III-706, III-707, IV-605-606
pH meter, I-399
pH probe, I-399, III-501
phase detectors, III-440-442
10-bit accuracy, II-176
phase selector/sync rectifier/balanced modulator, III-441
phase sequence, III-441
phase difference, 0- to 180-degree, II-344
phase indicator, II-439
phase meter, I-406
digital VOM, IV-277
phase selector, detector/sync rectifier/balanced modulator, III-441
phase sequence circuits, II-437-442
detector, II-439, II-441, II-442, III-441
indicator, I-476, II-439
rc circuit, phase sequence reversal detection, II-438
reversal, rc circuit to detect, II-438
three-phase tester, II-440
phase shifters, IV-647
0-180 degree, I-477
0-360 degree, I-477
single transistor, I-476
phase splitter, precision, III-582
phase tracking, three-phase square wave generator, II-598
phasor gun, I-606, IV-523
phono amplifiers, I-80-81
magnetic pickup, I-89
stereo, bass tone control, I-670
phono preamps, I-91
equalized, III-671
LM382, I-90
low-noise design, IV-36
magnetic, I-91, III-37
magnetic, ultra-low-noise, IV-36
photo-conductive detector amplifier, four quadrant, I-359
photo memory switch for ac power control, I-363
photo stop action, I-481
photocell, monostable, self-adjust trigger, II-329
photocurrent integrator, II-326
photodiode circuits
amplifier, III-672

- photodiode circuits amplifier (*cont.*)
 - amplifier, low-noise, III-19
 - current-to-voltage converter, II-128
 - sensor amplifier, II-324
 - amplifier, I-361
 - comparator, precision, I-360
 - level detector, precision, I-365
 - PIN, thermally stabilized signal conditioner with, II-330
 - PIN-to-frequency converters, III-120
 - source follower, III-419
 - photoelectric circuits
 - ac power switch, III-319
 - alarm system, II-4
 - controlled flasher, II-232
 - light controller, IV-369
 - smoke alarm, line operated, I-596
 - smoke detector, I-595
 - switch, II-321
 - switch, synchronous, II-326
 - photoflash, electronic, III-449
 - photography-related circuits, II-443-449, III-443-449, IV-378-382
 - auto-advance projector, II-444
 - camera alarm trigger, III-444
 - camera trip circuit, IV-381
 - contrast meter, II-447
 - darkroom enlarger timer, III-445
 - electronic flash trigger, II-448
 - enlarger timer, II-446
 - exposure meter, I-484
 - flash meter, III-446
 - flash slave driver, I-483
 - flash trigger, electronic, II-448
 - flash trigger, remote, I-484
 - flash trigger, sound-triggered, II-449
 - flash trigger, xenon flash, III-447
 - photo-event timer, IV-379
 - photoflash, electronic, III-449
 - shutter speed tester, II-445
 - slave-flash unit trigger, SCR design, IV-380, IV-382
 - slide projector auto advance, IV-381
 - slide timer, III-448
 - slide-show timer, III-444
 - sound trigger for flash unit, II-449, IV-382
 - time-delay flash trigger, IV-380
 - timer, I-485
 - xenon flash trigger, slave, III-447
- photomultiplier output-gating circuit, II-516
- picoammeters, I-202, II-154, III-338
- circuit for, II-157
 - guarded input circuit, II-156
- picture fixer/inverter, III-722
- Pierce crystal oscillator, I-195, II-144
- 1-MHz, III-134
 - harmonic, I-199, II-192
 - low-frequency, III-133
- piezoelectric alarm, I-12
- piezoelectric fan-based temperature controller, III-627
- PIN photodiode-to-frequency converters, III-120
- pink noise generator, I-468
- plant watering gauge, II-248
- plant watering monitor, II-245
- plant waterer, I-443
- playback amplifier, tape, I-77
- PLL/BC receiver, II-526
- pocket pager, III-288
- polarity converter, I-166
- polarity-protection relay, IV-427
- polarity-reversing amplifiers, low-power, III-16
- portable-radio 3 V fixed power supplies, IV-397
- position indicator/controller, tape recorder, II-615
- positive input/negative output charge pump, III-360
- positive peak detector, II-435
- positive regulator, NPN/PNP boost, III-475
- power amps, II-450-459, III-450-456
- 2- to 6-watt audio amplifier with preamp, II-451
 - 10 W, I-76
 - 12 W low distortion, I-76
 - 25 W, II-452
 - 90 W, safe area protection, II-459
 - am radio, I-77
 - audio, II-451, III-454, IV-28-33
 - audio, 20-W, III-456
 - audio, 50-W, III-451
 - audio, 6-W, with preamp, III-454
 - audio, booster, II-455
 - bridge audio, I-81
 - bull horn, II-453
 - class-D, III-453
 - hybrid, III-455
 - inverting, I-79
 - low-distortion, 12 W, I-76
 - low-power audio, II-454
 - noninverting, I-79
 - noninverting, ac, I-79
 - output-stage booster, III-452
 - portable, III-452
 - rear speaker ambience amplifier, II-458
 - rf, 1296-MHz solid state, III-542
 - rf, 5W, II-542
 - switching, I-33
 - two-meter 10 W, I-562
 - walkman amplifier, II-456
- power booster, I-28, I-33
- power control, burst, III-362
- power disconnecter, low-voltage, II-97
- power factor controller, three-phase, II-388
- power failure alarm, I-581-582
- power gain test circuit, 60 MHz, I-489
- power inverters, III-298
- 12 VDC-to-117 VAC at 60 Hz, III-294
 - medium, III-296
 - MOSFET, III-295
- power loss detector, II-175
- power meters, I-489
- audio, I-488
 - frequency and, II-250
 - rf, I-16
 - SWR, I-16
- power op amp/audio amp, high slew rate, I-82
- power outage light, line-operated, III-415
- power pack for battery operated devices, I-509
- power protection circuit, I-515
- power reference, 0-to-20 V, I-694
- power supplies, II-460-486, III-464
- 5V including momentary backup, II-464
 - 5V, 0.5A, I-491
 - 8-amp regulated, mobile equipment operation, II-461
 - 10 A regulator, current and thermal protection, II-474
 - 12-14 V regulated 3A, II-480
 - 90 V rms voltage regulator with PUT, II-479
 - 500 kHz switching inverter for 12V, II-474
 - 2,000 V low-current supply, IV-636-637
 - adjustable current limit and output voltage, I-505
 - arc lamp, 25W, II-476
 - arc-jet, starting circuit, III-479
 - backup supply, drop-in main-activated, IV-424
 - balance indicator, III-494
 - battery charger and, 14V, 4A, II-73
 - bench top, II-472
 - benchtop, dual output, I-505
 - bipolar, battery instruments, II-475
 - charge pool, III-469
 - dc-to-dc SMPS variable 18V to 30 V out at 0.2A, II-480
 - dual polarity, I-497
 - fault monitor, single-supply, III-495
 - fixed power supplies (*see* fixed power supplies)
 - general-purpose, III-465
 - glitches in, comparator to detect, II-107

- high-voltage (*see* high-voltage power supplies)
- increasing zener diode power rating, II-485
- isolated feedback, III-460
- laser power supply, voltage multiplier circuits, IV-636
- low-ripple, I-500
- low-volts alarm, II-493
- memory save on power-down, II-486
- micropower bandgap reference, II-470
- microprocessor power supply watchdog, II-494
- monitors (*see* power-supply monitors)
- off-line flyback regulator, II-481
- overvoltage protection circuit, II-496
- overvoltages in, comparator to detect, II-107
- power-switching circuit, II-466
- programmable, III-467
- protection circuit, II-497
- protection circuit, fast acting, I-518
- push-pull, 400V/60W, II-473
- radiation-hardened 125A linear regulator, II-468
- regulated, +15V 1-A, III-462
- regulated, -15V 1-A, III-463
- regulated, split, I-492
- SCR preregulator for, II-482
- single supply voltage regulator, II-471
- split, I-512
- stand-by, non-volatile CMOS RAMs, II-477
- switching, II-470, III-458
- switching, 50-W off-line, III-473
- switching, variable, 100-KHz multiple-output, III-488
- three-rail, III-466
- uninterruptible, +5V, III-477
- uninterruptible, personal computer, II-462
- variable (*see* variable power supplies)
- voltage regulator, II-484
- power-consumption limiters, III-572
- power-control circuits, IV-383-389
 - ac switch, battery-triggered, IV-387
 - bang-bang controllers, IV-389
 - current-loop control, SCR design, IV-387
 - high-side switches, 5 V supplies, IV-384, IV-385
 - monitor, SCR design, IV-385
 - MOSFET switch, IV-386
 - overvoltage protector, IV-389
 - power controller, universal design, IV-388
 - pushbutton switch, IV-388
- power-down protection
 - alarm, III-511
 - memory save power supply for, II-486
 - protection circuit, II-98
- power-line connections monitor, ac, III-510
- power-line modem, III-82
- power-on reset, II-366
- power-supply monitors, II-491-497, III-493-495, IV-422-427
 - backup supply, drop-in main-activated, IV-424
 - balance monitor, III-494
 - booster/buffer, boosts reference current, IV-425
 - circuit breaker, trip circuit, IV-423
 - fault monitor, single-supply, III-495
 - memory protector/supply monitor, IV-425
 - polarity-protection relay, IV-427
 - test load, constant-current, IV-424
 - triac for ac-voltage control, IV-426
 - tube amplifier, high-voltage isolation, IV-426
 - voltage sensor, IV-423
- power-switching circuit, II-466
 - complementary ac, I-379
- power/frequency meter, II-250
- preamplifiers, I-41
 - 6-meter, 20 dB gain and low NF, II-543
 - 1000x, low-noise design, IV-37
 - audio amplifier, 2- to 6-watt, II-451
 - audio amplifier, 6-W and, III-454
 - equalized, for magnetic phono cartridges, III-671
 - frequency counter, III-128
 - general purpose, I-84
 - general-purpose design, audio signal amplifiers, IV-42
 - handtalkies, two-meter, I-19
 - IF, 30 MHz, IV-460
 - impedance-matching, IV-37
 - LM382 phono, I-91
 - low-noise, IV-41
 - low-noise 30MHz, I-561
 - low-noise transformerless balanced microphone, I-88
 - magnetic phono, I-91, III-673, IV-35
 - medical instrument, II-349
 - microphone, II-45, IV-37, IV-42
 - microphone, low-impedance, IV-41
 - microphone, tone control for, II-687
 - microphone, transformerless, unbalanced input, I-88
 - microwave, 2.3 GHz, IV-316
 - microwave, 3.4 GHz, IV-316
 - microwave, bias supply, IV-318
 - microwave, single-stage, 10 GHz, IV-317
- microwave, two-stage, 10 GHz, IV-319
- NAB, tape playback, professional, III-38
- NAB, record, III-673
- NAB, two-pole, III-673
- oscilloscope, III-437
- oscilloscope, instrumentation amplifiers, IV-230-231
- oscilloscope/counter, III-438
- phono, I-91
 - phono, low-noise, IV-36
 - phono, magnetic, ultra-low-noise, IV-36
 - phono, magnetic, III-37
- read-head, automotive circuits, III-44
- RIAA, III-38
- RIAA/NAB compensation, I-92
- stereo, II-43, II-45
- tape, I-90
- thermocouple instrumentation amplifier, III-283
- tone control, I-675
- tone control, high-level, II-688
- tone control, IC, I-673, III-657
- tone control, mixer, I-58
- UHF-TV, III-546
- ultra-low leakage, I-38, II-7
- VHF, I-560
- precision amplifier, I-40
 - digitally programmable input and gain, II-335
- preregulators
 - high-voltage power supplies, III-480
 - tracking, III-492
- prescaler, data circuits, low-frequency, IV-132
- prescaler probe, amplifying, 650 MHz, II-502
- preselectors
 - rf amplifiers, JFET, IV-485
 - rf amplifiers, JFET, double-tuned, IV-483
 - rf amplifiers, varactor-tuned, IV-488
- printer-error alarm, computer circuits, IV-106
- printers
 - printer-error alarm, IV-106
 - two-sheets in printer detector, IV-136
- probes, II-498-504, III-496-503, IV-428-434
 - 100 K megaohm dc, I-524
 - ac hot wire, I-581
 - audible TTL, I-524
 - audio-rf signal tracer, I-527
 - capacitance buffer, low-input, III-498
 - capacitance buffer, stabilized low-input, III-502

- probes (*cont.*)
- clamp-on-current compensator, II-501
 - CMOS logic, I-523
 - FET, III-501
 - general purpose rf detector, II-500
 - ground-noise, battery-powered, III-500
 - logic probes (*see* logic probes)
 - microvolt, II-499
 - optical light probe, IV-369
 - pH, I-399, III-501
 - prescaler, 650 MHz amplifying, II-502
 - rf, I-523, III-498, III-502, IV-433
 - single injector-tracer, II-500
 - test, 4-220V, III-499
 - three-in-one test set: logic probe, signal tracer, IV-429
 - tone, digital IC testing, II-504
 - universal test probe, IV-431
 - process control interface, I-30
 - processor, CW signal, I-18
 - product detector, I-223
 - programmable amplifiers, II-334, III-504-508
 - differential-input, programmable gain, III-507
 - inverting, programmable-gain, III-505
 - noninverting, programmable-gain, III-505
 - precision, digital control, III-506
 - precision, digitally programmable, III-506
 - programmable-gain, selectable input, I-32
 - variable-gain, wide-range digital control, III-506
 - projectors (*see* photography-related circuits)
 - proportional temperature controller, III-626
 - protection circuits, II-95-99, III-509-513
 - 12ns circuit breaker, II-97
 - automatic power down, II-98
 - circuit breaker, ac, III-512
 - circuit breaker, electronic, high-speed, II-96
 - compressor protector, IV-351
 - crowbars, electronic, II-99, III-510
 - heater protector, servo-sensed, III-624
 - line protectors, computer I/O, 3 uP, IV-101
 - line dropout detector, II-98
 - line-voltage monitor, III-511
 - low-voltage power disconnecter, II-97
 - overvoltage, II-96, IV-389
 - overvoltage, fast, III-513
 - overvoltage, logic, I-517
 - polarity-protection relay for power supplies, IV-427
 - power-down, II-98
 - power-failure alarm, III-511
 - power-line connections monitor, ac, III-510
 - power supply, II-497, I-518
 - reset-protection for computers, IV-100
 - proximity sensors, I-135-136, I-344, II-505-507, III-514-518, IV-341-346
 - alarm for, II-506
 - capacitive, III-515
 - field disturbance sensor/alarm, II-507
 - infrared-reflection switch, IV-345
 - relay-output, IV-345
 - SCR alarm, III-517
 - self-biased, changing field, I-135
 - switch, III-517
 - UHF movement detector, III-516
 - pseudorandom sequencer, III-301
 - pulse circuits, IV-435-440
 - amplitude discriminator, III-356
 - coincidence detector, II-178
 - counter, ring counter, low-power, IV-437
 - delay, dual-edge trigger, III-147
 - detector, missing-pulse, III-159
 - divider, non-integer programmable, III-226, II-511
 - extractor, square-wave, III-584
 - generator, 555-circuit, IV-439
 - generator, delayed-pulse generator, IV-440
 - generator, free-running, IV-438
 - generator, logic troubleshooting applications, IV-436
 - generator, transistorized design, IV-437
 - height-to-width converters, III-119
 - oscillator, fast, low duty-cycle, IV-439
 - oscillator, start-stop, stable design, IV-438
 - pulse train-to-sinusoid converters, III-122
 - sequence detector, II-172
 - stretcher, IV-440
 - stretcher, negative pulse stretcher, IV-436
 - stretcher, positive pulse stretcher, IV-438
 - pulse generators, II-508-511
 - 2-ohm, III-231
 - 300-V, III-521
 - astable multivibrator, II-510
 - clock, 60Hz, II-102
 - CMOS short-pulse, III-523
 - delayed, II-509
 - EEPROM, 5V-powered, III-99
 - interrupting pulse-generation, I-357
 - logic, III-520
 - programmable, I-529
 - sawtooth-wave generator and, III-241
 - single, II-175
 - two-phase pulse, I-532
 - unijunction transistor design, I-530
 - very low duty-cycle, III-521
 - voltage-controller and, III-524
 - wide-ranging, III-522
 - pulse supply, high-voltage power supplies, IV-412
 - pulse-dialing telephone, III-610
 - pulse-position modulator, III-375
 - pulse-width-to-voltage converters, III-117
 - pulse-width modulators (PWM), IV-326
 - brightness controller, III-307
 - control, microprocessor selected, II-116
 - modulator, III-376
 - motor speed control, II-376, III-389
 - multiplier circuit, II-264, III-214
 - out-of-bounds detector, III-158
 - proportional-controller circuit, II-21
 - servo amplifier, III-379
 - speed control/energy-recovering brake, III-380
 - very short, measurement circuit, III-336
 - pulse/tone dialer, single-chip, III-603
 - pulsers, laser diode, III-311
 - pump circuits
 - controller, single chip, II-247
 - positive input/negative output charge, I-418
 - push switch, on/off, electronic, II-359
 - push-pull power supply, 400V/60W, II-473
 - pushbutton power control switch, IV-388
 - PUT battery chargers, III-54
 - PUT long-duration timer, II-675
 - pyrometer, optical, I-654

Q

 - Q-multipliers
 - audio, II-20
 - transistorized, I-566
 - QRP CW transmitter, III-690
 - QRP SWR bridge, III-336
 - quad op amp, simultaneous waveform generator using, II-259
 - quadrature oscillators, III-428
 - square-wave generator, III-585
 - quartz crystal oscillator, two-gate, III-136

quick-deactivating battery sensor, III-61

R

- race-car motor/crash sound generator, III-578
- radar detectors, II-518-520, IV-441-442
one-chip, II-519
- radiation detectors, II-512-517
alarm, II-4
micropower, II-513
monitor, wideband, I-535
photomultiplier output-gating circuit, II-516
pocket-sized Geiger counter, II-514
radiation-hardened 125A linear regulator, II-468
- radio
- AM car-radio to short-wave radio converter, IV-500
 - AM demodulator, II-160
 - AM radio, power amplifier, I-77
 - AM radio, receivers, III-81, III-529, III-535
 - AM/FM, clock radio, I-543
 - AM/FM, squelch circuit, II-547, III-1
 - amateur radio, III-260, III-534, III-675
 - automotive, receiver for, II-525
 - clock, I-542
 - direction finder, radio signals, IV-148-149
 - FM (*see* FM transmissions)
 - portable-radio 3 V fixed power supplies, IV-397
 - radio beacon converter, IV-495
 - receiver, AM radio, IV-455
 - receiver, old-time design, IV-453
 - receiver, reflex radio receiver, IV-452
 - receiver, short-wave receiver, IV-454
 - receiver, TRF radio receiver, IV-452
- radio beacon converter, IV-495
- radio-control circuits
- audio oscillator, II-567, III-555
 - motor speed controller, I-576
 - phase sequence reversal by, II-438
 - oscillator, emitter-coupled, II-266
 - receiver/decoder, I-574
 - single-SCR design, II-361
- radioactivity (*see* radiation detectors)
- rain warning beeper, II-244, IV-189
- RAM, non-volatile CMOS, stand-by power supply, II-477
- ramp generators, I-540, II-521-523, III-525-527, IV-443-447
- accurate, III-526
 - integrator, initial condition reset, III-527
 - linear, II-270
 - variable reset level, II-267
 - voltage-controlled, II-523
- ranging system, ultrasonic, III-697
- reaction timer, IV-204
- read-head pre-amplifier, automotive circuits, III-44
- readback system, disc/tape phase modulated, I-89
- readout, rf current, I-22
- receiver audio circuit, IV-31
- receivers and receiving circuits (*see also* transceivers; transmitters), II-524-526, III-528-535, IV-448-461
- 50kHz FM optical transmitter, I-361
 - acoustic-sound receiver, IV-311
 - AGC system for CA3028 IF amplifier, IV-458
 - AM, III-529, IV-455
 - AM, carrier-current circuit, III-81
 - AM, integrated, III-535
 - analog, I-545
 - ATV rf receiver/converter, 420 MHz, low-noise, IV-496, IV-497
 - car radio, capacitive diode tuning/electronic MW/LW switching, II-525
 - carrier current, I-143, I-146
 - carrier current, single transistor, I-145
 - carrier system, I-141
 - carrier-operated relay (COR), IV-461
 - CMOS line, I-546
 - data receiver/message demuxer, three-wire design, IV-130
 - fiber optic, 10 MHz, II-205
 - fiber optic, 50-Mb/s, III-181
 - fiber optic, digital, III-178
 - fiber optic, high-sensitivity, 30nW, I-270
 - fiber optic, low-cost, 100-M baud rate, III-180
 - fiber optic, low-sensitivity, 300nW, I-271
 - fiber optic, very high-sensitivity, low speed 3nW, I-269
 - FM, carrier-current circuit, III-80
 - FM, MPX/SCA, III-530
 - FM, narrow-band, III-532
 - FM, tuner, III-529
 - FM, zero center indicator, I-338
 - FSK data, III-533
 - ham-band, III-534
 - IF amplifier, IV-459
 - IF amplifier, preamp, 30 MHz, IV-460
 - IF amplifier/receiver, IV-459
 - infrared, I-342, II-292, III-274, IV-220-221
 - laser, IV-368
 - LF receiver, IV-451
 - line-type, digital data, III-534
 - line-type, low-cost, III-532
 - monitor for, II-526
 - optical, I-364, II-418
 - optical light receiver, IV-367, IV-368
 - PLL/BC, II-526
 - pulse-frequency modulated, IV-453
 - radio control, decoder and, I-574
 - radio receiver, AM, IV-455
 - radio receiver, old-time design, IV-453
 - radio receiver, reflex, IV-452
 - radio receiver, TRF, IV-452
 - regenerative receiver, one-transistor design, IV-449
 - RS-232 to CMOS, III-102
 - short-wave receiver, IV-454
 - signal-reception alarm, III-270
 - superheterodyne receiver, 3.5-to-10 MHz, IV-450-451
 - tracer, III-357
 - transceiver/mixer, HF, IV-457
 - ultrasonic, III-698, III-705
 - zero center indicator for FM, I-338
- recording amplifier, I-90
- recording devices (*see* tape-recorder circuits)
- rectangular-to-triangular waveform converter, IV-116-117
- rectifiers, II-527-528, III-536-537
- absolute value, ideal full wave, II-528
 - averaging filter, I-229
 - bridge rectifier, fixed power supplies, IV-398
 - broadband ac active, IV-271
 - diodeless, precision, III-537
 - full-wave, I-234, III-537, IV-328, IV-650
 - half-wave, I-230, II-528, IV-325
 - half-wave, fast, I-228
 - high-impedance precision, for ac/dc converter, I-164
 - inverter/rectifier, programmable op-amp design, IV-364
 - low forward-drop, III-471
 - precision, I-422
 - synchronous, phase detector-selector/balanced modulator, III-441
- redial, electronic telephone set with, III-606
- reference voltages, I-695, III-773-775
- $\pm 10V$, I-696
 - $\pm 3V$, I-696
 - $\pm 5V$, I-696
 - 0- to 20 V power, I-694, I-699
- amplifier, I-36
- bipolar output, precision, I-698

- reference voltages (*cont.*)
 - dual tracking voltage, precision, I-698
 - high-stability, I-696
 - low-noise buffered, precision, I-698
 - low-power regulator, I-695
 - micropower 10 V, precision, I-697
 - square wave voltage, precision, I-696
 - standard cell replacement, precision, I-699
 - variable-voltage reference source, IV-327
- reference clock, three phase clock from, II-101
- reference supply, low-voltage adjustable, I-695
- reflection oscillator, crystal-controlled, III-136
- reflectometer, I-16
- regenerative receiver, one-transistor design, IV-449
- registers, shift, I-380, II-366
 - driver, I-418
- regulated power supplies
 - 8-amp, II-461
 - 12 to 14V at 3 A, II-480
 - +15V 1-A, III-462
 - 15V 1-A, III-463
 - split power supplies, I-492
- regulators (*see* voltage regulators)
- rejection filter, I-283
- relaxation oscillator, III-430, IV-376
- relays, II-529-532, IV-471-475
 - ac, optically coupled, III-418
 - ac, photon coupler in, II-412
 - ac, solid-state latching, IV-472
 - audio operated, I-608
 - bidirectional switch, IV-472
 - capacitance, I-130
 - carrier operated, I-575
 - carrier-operated relay (COR), IV-461
 - dc latching, optically coupled, III-417
 - delay-off circuit, IV-473
 - driver, delay and controls closure time, II-530
 - light-beam operated on/off, I-366
 - monostable relay, low-consumption design, IV-473
 - optically coupled, ac, III-418
 - optically coupled, dc latching, III-417
 - optoisolator, IV-475
 - polarity-protection for power supplies, IV-427
 - rf-actuated, III-270
 - ringer, telephone, III-606
 - solid-state, III-569-570, IV-474
 - solid-state, 10 A 25 Vdc, I-623
 - solid-state, ac, III-570
 - solid-state, ac, latching, IV-472
- solid-state, dc, normally open/closed, III-412
 - solid-state, integrated, II-408
 - solid-state, light-isolated, I-365
 - solid-state, ZVS, antiparallel SCR output, III-416
 - sound actuated, I-576, I-610
 - telephone, I-631
 - time delayed, I-663
 - time delayed, ultra-precise, I-219
 - tone actuated, I-576
 - TR circuit, II-532
 - triac, contact protection, II-531
- remote control devices
 - amplifier, I-99
 - carrier, current, I-146
 - drop-voltage recovery for long-line systems, IV-328
 - extender, infrared, IV-227
 - fax/telephone switch, IV-552-553
 - infrared circuit, IV-224
 - lamp or appliance, I-370
 - loudspeaker via IR link, I-343
 - on/off switch, I-577
 - ringer, telephone, III-614
 - sensor, temperature transducer, I-649
 - servo system, I-575
 - telephone monitor, II-626
 - temperature sensor, II-654
 - tester, infrared, IV-228
 - thermometer, II-659
 - transmitter/receiver, IR, I-342
 - video switch, IV-619-621
- repeaters
 - European-type, tone burst generator for, III-74
 - fiber optic link, I-270
 - telephone, III-607
- repeater beeper, I-19
- reset buttons
 - child-proof computer reset, IV-107
 - power-on, II-366
 - protection circuit for computer, IV-100
- resistance/continuity meters, II-533, III-538-540
 - cable tester, III-539
 - continuity tester, III-540
 - ohmmeter, linear, III-540
 - resistance-ratio detector, II-342
 - single chip checker, II-534
- resistance measurement, low parts count ratiometric, I-550
- resistance-to-voltage converter, I-161-162
- resistor multiplier, II-199
- resonator oscillator, varactor tuned 10 MHz ceramic, II-141
- restorer, video dc, III-723
- reverb effect, analog delay line, IV-21
- reverb system, stereo, I-602, I-606
- reversing motor drive, dc control signal, II-381
- rf amplifiers, II-537-549, III-542-547, IV-476-493
 - 1 W, 2.3 GHz, II-540
 - 10 W, 225-400 MHz, II-548
 - 10 dB-gain, III-543
 - 2- to 30 MHz, III-544
 - 4 W amp for 900 MHz, IV-477
 - 5 W 150-MHz, III-546
 - 5 W power, II-542
 - 6-meter kilowatt, II-545
 - 6-meter preamp, 20dB gain and low NF, II-543
 - 60 W 225-400 MHz, III-547
 - 125 W, 150 MHz, II-544
 - 500 MHz, IV-491
 - 1,296 MHz, IV-486
 - 1,500 W, IV-478-479
 - AGC, wideband adjustable, III-545
 - broadcast-band, III-264, II-546
 - broadcast-band booster, IV-487
 - buffer amplifier with modulator, IV-490
 - cascode amplifier, IV-488
 - common-gate, 450-MHz, III-544
 - isolation amplifier, II-547
 - linear amplifier, 903 MHz, IV-484-485
 - linear amplifier, 6-m, 100 W, IV-480-481
 - linear amplifier, ATV, 10-to-15 W, IV-481
 - low distortion 1.6 to 30MHz SSB driver, II-538
 - meter-driver, 1-MHz, III-545
 - MOSFET rf-amp stage, dual-gate, IV-489
 - power, 600 W, I-559
 - power amp, 1296-MHz solid-state, III-542
 - preselector, JFET, IV-485
 - preselector, JFET, double-tuned, IV-483
 - preselector, varactor-tuned, IV-488
 - UHF-TV preamp, III-546
 - UHF TV-line amplifier, IV-482, IV-483
 - wideband amplifier, IV-479, IV-489, IV-490
 - wideband amplifier, HF, IV-492
 - wideband amplifier, JFET, IV-493
 - wideband amplifier, MOSFET, IV-492
 - wideband amplifier, two-CA3100 op

- amp design, IV-491
 - rf circuits
 - attenuator, IV-322
 - burst generators, portable, III-73
 - converters, IV-494-501
 - converters, ATV receiver/converter, 420 MHz, low-noise, IV-496, IV-497
 - converters, radio beacon converter, IV-495
 - converters, receiver frequency-converter stage, IV-499
 - converters, SW converter for AM car radio, IV-500
 - converters, two-meter, IV-498
 - converters, up-converter, TVRO subcarrier reception, IV-501
 - converters, VLF converter, IV-497
 - converters, WWV-to-SW converter, IV-499
 - converters, receiving converter, 220 MHz, IV-500
 - current readout, I-22
 - detector, II-500
 - detector probe, IV-433
 - genie, II-421
 - measurement/test circuits, IV-297-303
 - modulators, I-436, III-372, III-374
 - modulators, double sideband suppressed carrier, II-369
 - oscillators, I-550-551, I-572
 - oscillators, 5 MHz VFO, II-551
 - oscillators, transmitter and, 27MHz and 49MHz, I-680
 - output indicator, IV-299
 - power meter, I-16
 - power meter, sidetone oscillator, I-24
 - power meter, switch, III-592
 - power meter, wide-range, III-332
 - probe, I-523, III-498, III-502
 - signal tracer probe, audio, I-527
 - sniffer, II-210
 - switch, low-cost, III-361
 - VHF/UHF diode switch, IV-544
 - voltmeter, I-405, III-766
 - RGB video amplifier, III-709
 - RGB-composite video signal converter, III-714
 - RGB-to-NTSC converter, IV-611
 - ring counters
 - 20 kHz, II-135
 - incandescent lamps, I-301
 - low cost, I-301
 - pulse circuit, low-power, IV-437
 - SCR, III-195
 - variable timing, II-134
 - ring detectors
 - low line loading, I-634
 - telephone, II-623, III-619
 - telephone, auto-answer, I-635
 - telephone, optically interfaced, III-611
 - ring-around flasher, LED, III-194
 - ringers, telephone, I-628, IV-556
 - extension-phone ringer, IV-561
 - high isolation, II-625
 - multi-tone, remote programmable, II-634
 - musical, II-619
 - piezoelectric, I-636
 - plug-in, remote, II-627
 - relay, III-606
 - remote, II-627, III-614, IV-562
 - silencer, IV-557
 - tone, I-627, I-628, II-630, II-631
 - ripple suppressor, IV-175
 - fixed power supplies, IV-396
 - RLC oscillator, III-423
 - rms-to-dc converter, I-167, II-129
 - thermal, 50-MHz, III-117
 - road ice alarm, II-57
 - robots
 - eyes for, II-327
 - light-seeking, II-325
 - rocket launcher, II-358
 - rotation detector, II-283
 - roulette, electronic, II-276, IV-205
 - RS-232 interface
 - CMOS-to, line receiver, III-102
 - dataselector, automatic, III-97
 - drive circuit, low-power, III-175
 - LED circuit, III-103
 - line-driven CMOS circuits, IV-104
 - RS flip-flop, I-395
 - RTD signal conditioners
 - 5V powered linearized platinum, II-650
 - precision, linearized platinum, II-639
 - RTTY machines, fixed current supply, IV-400
 - rumble filters, I-297, III-192, III-660, IV-170, IV-175
- S**
- S meter, III-342
 - safe area protection, power amplifier with, III-459
 - safety flare, II-608
 - Sallen-Key filters
 - .500 Hz bandpass, I-291
 - low-pass, active, IV-177
 - low-pass, equal component, I-292
 - low-pass, second order, I-289
 - sample-and-hold circuits, I-590, II-552-559, III-548-553, IV-502-503
 - x 1000, I-589
 - charge-compensated, II-559
 - fast and precise, II-556
 - filtered, III-550
 - frequency-to-voltage conversion, IV-194
 - high-accuracy, I-590
 - high-performance, II-557
 - high-speed amplifier, I-587
 - high-speed, I-587-588, I-590, III-550
 - infinite, II-558
 - inverting, III-552
 - JFET, I-586
 - low-drift, I-586
 - offset adjustment for, I-588
 - three-channel multiplexer with, III-396
 - track-and-hold, III-552
 - track-and-hold, basic, III-549
 - sampling circuit, hour time delay, II-668
 - saturated standard cell amplifier, II-296
 - sawtooth waves
 - converter, IV-114
 - generator, digital design, IV-444, IV-446
 - oscillator modulator, III-373
 - pulse generator and, III-241
 - SCA decoder, I-214, II-166, II-170
 - SCA demodulator, II-150, III-565
 - scale, digital weight, I-398
 - scaler, inverse, I-422
 - scanner, bar codes, III-363
 - Schmitt triggers, I-593, III-153
 - crystal oscillator, I-181
 - programmable hysteresis, I-592
 - TTL-compatible, II-111
 - without hysteresis, I-592
 - SCR circuits
 - annunciator, self-interrupting load, IV-9
 - chaser, III-197
 - crowbar, II-496
 - flasher, III-197
 - flip-flop, II-367
 - gas/smoke detector, III-251
 - preregulator, II-482
 - proximity alarm, III-517
 - radio control using, II-361
 - relaxation flasher, II-230
 - relaxation oscillator, III-430
 - ring counter, III-195
 - tester, III-344
 - time delay circuit with, II-670
 - triggering series, optically coupled, III-411
 - scramblers, audio (*see also* sound generators; voice-activated circuits), IV-25-27

- scramblers, audio (*cont.*)
 telephone, II-618
 voice scrambler/descrambler, IV-26
 voice scrambler/disguiser, IV-27
- scratch filters, III-189, IV-175
 LM287 in, I-297
- second-audio program adapter, III-142
- security circuits, I-4, III-3-9
 automotive security system, I-5, IV-49-56
 home system, I-6, IV-87
 infrared, wireless, IV-222-223
- sense-of-slope tilt meter, II-664
- sensors (*see also* alarms; control circuits; detectors; indicators; monitors)
 0-50 C, four-channel temperature, I-648
 air-flow sensor, thermistor bridge, IV-82
 ambient light ignoring optical, III-413
 capacitive, alarm for, III-515
 cryogenic fluid level, I-386
 differential temperature, I-655
 humidity, II-285-287, III-266-267
 IC temperature, I-649
 isolated temperature, I-651
 light level, I-367
 light, back-biased GaAs LED, II-321
 logarithmic light, I-366
 magnetic current, low-power, III-341
 motion, IV-341-346
 motion, unidirectional, II-346
 nanoampere, 100 megohm input impedance, I-203
 optical interruption sensor, IV-366
 photodiode amplifier for, II-324
 precision temperature transducer with remote, I-649
 proximity, II-505, III-514-518, IV-341-346
 remote, loop transmitter for, III-70
 remote temperature, I-654
 self-biased proximity, detected changing field, I-135
 short-circuit sensor, computer remote data lines, IV-102
 simple differential temperature, I-654
 temperature (*see also* temperature sensor), II-645, I-648, I-657
 temperature, III-629-631, III-629
 voltage regulators, LM317 design, IV-466
 voltage sensor, power supplies, IV-423
 voltage-level, III-770
 water level, I-389
 zero crossing detector with temperature, I-733
- sequence indicator, phase, I-476
- sequencer, pseudorandom, III-301
- sequential flasher, II-233
 ac, II-238
 automotive turn signals, I-109
- sequential timer, III-651
- series connectors, telephone, III-609
- servo amplifiers
 400 Hz, II-386
 bridge type ac, I-458
 dc, I-457
- servo motor drive amplifier, II-384
- servo systems
 controller, III-384
 remote control, I-575
- shaper, sine wave, II-561
- shift registers, I-380, II-366
 driver for, I-418
- shifter, phase (*see* phase shifter)
- ship siren, electronic, II-576
- short-circuit proof lamp driver, II-310
- shortwave transmissions
 converters, III-114
 converter, AM car radio, IV-500
 FET booster, I-561
 receiver, IV-454
- short-circuit sensor, computer remote data lines, IV-102
- shunt, multimeter shunt, IV-293
- shutoff, automatic, battery-powered projects, III-61
- shutter speed tester, II-445
- sidetone oscillator, rf-powered, I-24
- signal amplifiers, audio, IV-34-42
- signal attenuator, analog, microprocessor-controlled, III-101
- signal combiner, III-368
- signal conditioners, IV-649
 5V powered linearized platinum RTD, II-650
 bridge circuit, strain gauge, II-85
 linearized RTD, precision design, II-639
 LVDT, II-338
 thermally stabilized PIN photodiode, II-330
- signal distribution amplifier, I-39
- signal generators (*see also* function generators; sound generators; waveform generators)
 AM broadcast-band, IV-302
 AM/IF, 455 kHz, IV-301
 high-frequency, II-150
 square-wave, III-583-585
 staircase, III-586-588
 two-function, III-234
- signal injectors, III-554-555
- signal sources, crystal-controlled, II-143
- signal tracer, three-in-one set: logic probe, signal tracer, injector, IV-429
- signal-strength meters, III-342, IV-166
- signal-supply, voltage-follower amplifiers, III-20
- simulated inductor, II-199
- simulators
 EKG, three-chip, III-350
 VOR signals, IV-273
- sine-to-square wave converter, IV-120
- sine-wave descrambler, II-163
- sine-wave generators, square-wave and, tunable oscillator, III-232
- sine-wave oscillators, I-65, II-560-570, III-556-559, III-560, IV-504-513
 555 used as RC audio oscillator, II-567
 adjustable, II-568
 audio, II-562
 audio, generator, III-559
 audio, simple generator for, II-564
 generator, IV-505
 generator, LC sine-wave, IV-507
 generator, LF, IV-512
 generator, pure sine-wave, IV-506
 generator, VLF audio tone, IV-508
 generators, 60 Hz, IV-507
 LC oscillator, low-frequency, IV-509
 low distortion, II-561
 one-IC audio generator, II-569
 phase-shift, audio ranging, IV-510
 programmable-frequency, III-424
 relaxation, modified UJT for clean audio sinusoids, II-566
 sine wave shaper, II-561
 sine/square wave TTL oscillator, IV-512
 two-tone generator, II-570
 two-transistor design, IV-508
 variable, super low-distortion, III-558
 very-low distortion design, IV-509
 Wien bridge, I-66, I-70, II-566, IV-511
 Wien bridge, CMOS chip in, II-568
 Wien-bridge, low-distortion, thermal stable, III-557
 Wien-bridge, single-supply, III-558
 Wien-bridge, three-decade 15 Hz to 15 kHz, IV-510
 Wien-bridge, very-low distortion, IV-513
- sine-wave output buffer amplifier, I-126
- sine-wave to square-wave converter, I-170
- sine/cosine generator, 0.1 to 10 kHz, II-260
- sine/square wave oscillators, I-65
 easily tuned, I-65
 TTL design, IV-512

- tunable, III-232
- single-pulse generator, II-175
- single-sideband (SSB) communications
 - CW/SSB product detector, IV-139
 - driver, low distortion 1.6 to 30MHz, II-538
 - generators, IV-323
 - transmitter, crystal-controlled LO for, II-142
- sirens (*see also* alarms; sound generators), I-606, II-571, III-560-568
 - alarm using, II-572, II-573, IV-514-517
 - 7400, II-575
 - adjustable-rate programmable-frequency, III-563
 - electronic, III-566, IV-515, IV-517
 - generator for, II-572
 - hee-haw, III-565, II-578
 - high power, II-578
 - linear IC, III-564
 - low-cost design, IV-516
 - multifunction system for, II-574
 - ship, electronic, II-576
 - sonic defender, IV-324
 - Star Trek red alert, II-577
 - tone generator, II-573
 - toy, II-575
 - TTL gates in, II-576
 - two-state, III-567
 - two-tone, III-562
 - varying frequency warning alarm, II-579
 - wailing, III-563
 - warble-tone siren, 6 W, IV-516
 - warble-tone siren, alternate tone, IV-515
 - whooper, IV-517
 - yelp oscillator, II-577, III-562
- slave-flash trigger, IV-380, IV-382
- slide timer, III-448
- slide-show timer, III-444
- sliding tone doorbell, II-34
- smart clutch, auto air conditioner, III-46
- smoke alarms and detectors, II-278, III-246-253
 - gas, I-332
 - ionization chamber, I-332-333
 - line-operated, IV-140
 - operated ionization type, I-596
 - photoelectric, I-595, I-596
- sniffers (*see also* detectors; monitors)
 - heat, electronic, III-627
 - rf, II-210
- snooper, FM, III-680
- socket debugger, coprocessor, III-104
- soldering station, IR-controlled, IV-225
- soil moisture meter, III-208
- solar-powered battery charger, II-71
- solar-triggered switch, III-318
- solenoid drivers, III-571-573
 - 12-V latch, III-572
 - hold-current limiter, III-573
 - power-consumption limiter, III-572
- solid-state devices
 - ac relay, III-570
 - electric fence charger, II-203
 - high-voltage supply, remote adjustable, III-486
 - relays, III-569-570
 - stepping switch, II-612
 - switch, line-activated, telephone, III-617
- sonic defender, IV-324
- sound-activated circuits (*see* sound-operated circuits)
- sound generators (*see also* burst generators; function generators; sirens; waveform generators), I-605, II-585-593, III-559-568, III-575, IV-15-24, IV-518-524
 - amplifier, voltage-controlled, IV-20
 - amplifier/compressor, low-distortion, IV-24
 - allophone, III-733
 - audio tone generator, VLF, IV-508
 - autodrum, II-591
 - bagpipes, electronic, III-561, IV-521
 - beat-frequency, IV-371
 - bird chirp, I-605, II-588, III-577
 - bongos, II-587
 - chime generator, II-604
 - chime generator, single-chip design, IV-524
 - chug-chug, III-576
 - dial tone, I-629, III-609
 - ditherizing circuit, digital audio use, IV-23
 - doorbell, musical tones, IV-522
 - doubler, audio-frequency doubler, IV-16-17
 - echo and reverb, analog delay line, IV-21
 - electronic, III-360
 - envelope generator/modulator, II-601
 - equalizer, IV-18
 - fader, IV-17
 - frequency-shift keyer, tone-generator test circuit, I-723
 - funk box, II-593
 - fuzz box, III-575
 - guitar compressor, IV-519
 - harmonic generator, I-24, IV-649
 - high-frequency signal, III-150
 - hold for telephone, II-623
 - melody generator, single-chip design, IV-520
- music maker circuit, IV-521
- musical chimes, I-640
- musical envelope, modulator, I-601, IV-22
- noise generators, I-467, I-468, I-469, IV-308
- octave-shifter for musical effects, IV-523
- one-IC design, II-569
- phasor sound generator, IV-523
- pink noise, I-468
- portable, I-625
- race-car motor/crash, III-578
- run-down clock for games, IV-205
- sound effects, III-574-578
- steam locomotive whistle, II-589, III-568
- steam train/prop plane, II-592
- stereo system, derived center-channel, IV-23
- super, III-564
- synthesizer, II-599
- telephone call-tone generator, IV-562
- telephone ringer, II-619
- tone generator, burst, I-604
- tone generator, portable design, I-625
- Touchtone dial-tone, telephone, III-609
- train chuffer, II-588
- tremolo circuits, III-692-695, IV-589
- twang-twang, II-592
- two-tone, II-570
- ultrasonic sound source, IV-605
- unusual fuzz, II-590
- warbling tone, II-573
- white noise, IV-201
- very-low frequency, I-64
- vocal eliminator, IV-19
- voice circuits, III-729-734
- waa-waa circuit, II-590
- white noise, IV-201
- sound-level meters, III-346, IV-305, IV-307
 - meter/monitor, telephone, III-614
- sound-operated circuits (*see also* ultrasonic circuits; voice-operated circuits), II-580-584, III-579-580, IV-525-528
 - amplifier, gain-controlled, IV-528
 - color organ, II-583, II-584
 - decoder, III-145
 - flash triggers, I-481, II-449, IV-382
 - lights, I-609
 - noise clipper, I-396
 - relay, I-608, I-610
 - switch, II-581, III-580, III-600, III-601, IV-526-527
 - switch, ac, II-581

- sound-operated circuits (*cont.*)
 - switch, two-way, I-610
 - switch, voice-operated, III-580
 - switch, voice-activated, microphone-controlled, IV-527
 - speech activity detector, telephone, III-615
 - voice-operated switch, III-580
 - vox box, II-582
- sources (*see* current sources; voltage sources)
- source follower, photodiode, III-419
- SPDT switch, ac-static, II-612
- space war, I-606
- speaker systems
 - FM carrier current remote, I-140
 - hand-held transceiver amplifiers, III-39
 - overload protector for, II-16
 - wireless, IR, III-272
- speakerphone, II-611, III-608
- speech-activity detector, II-617, III-619
- speech compressor, II-15
- speech filter
 - 300 Hz-3kHz bandpass, I-295
 - second-order, 300-to-3,400 Hz, IV-174
 - two-section, 300-to-3,000 Hz, IV-174
- speech network, II-633
- speed alarm, I-95
- speed controllers, I-450, I-453, II-378, II-379, II-455
 - back EMF PM, II-379
 - cassette-deck motor speed calibrator, IV-353
 - closed-loop, III-385
 - fans, automatic, III-382
 - dc motors, I-452, I-454, III-377, III-380
 - dc motor, direction control and, I-452
 - dc variable, fiber optic, II-206
 - feedback, I-447
 - fixed, III-387
 - high-efficiency, III-390
 - high-torque motor, I-449
 - light-activated/controlled, IV-247
 - load-dependent, I-451
 - model trains and/or cars, I-455, IV-338-340
 - motor, I-450, I-453
 - motor, dc, reversible, driver and, III-388
 - motor, high-efficiency, III-390
 - PWM, II-376
 - PWM, energy-recovering brake, III-380
 - radio-controlled, I-576
 - series-wound motors, I-448, II-456
 - shunt-wound motors, II-456
 - stepper motors, direction and speed control, IV-350
 - switched-mode, III-384
 - tachless, III-386
 - tachometer, II-378, II-389
 - tachometerless, IV-349
 - tools and appliances, I-446
 - universal motors, I-457
 - universal motors, load-dependent, II-451
- speed warning device, I-96, I-101
- speedometers, bicycle, IV-271, IV-282
- splitters, III-581-582
 - battery, III-66
 - phase, precision, III-582
 - precision phase, I-477
 - voltage, III-738, III-743
 - wideband, III-582
- squarer, precision, I-615
- square-wave generators, II-594-600, III-583-585, IV-529-536
 - 1 kHz, IV-536
 - 2 MHz using two TTL gates, II-598
 - 555 timer, II-595
 - astable circuit, IV-534
 - astable multivibrator, II-597
 - CMOS 555 astable, true rail-to-rail, II-596
 - duty-cycle multivibrator, III-50-percent, III-584
 - four-decade design, IV-535
 - high-current oscillator, III-585
 - line frequency, II-599
 - low-frequency TTL oscillator, II-595
 - multiburst generator, II-88
 - multivibrator, IV-536
 - oscillator, II-597, IV-532, IV-533
 - oscillator, with frequency doubled output, II-596
 - phase-tracking, three-phase, II-598
 - pulse extractor, III-584
 - quadrature-outputs oscillator, III-585
 - sine-wave, tunable oscillator, III-232
 - three-phase, II-600
 - tone-burst generator, single timer IC, II-89
 - triangle-wave, III-239
 - triangle-wave, precision, III-242
 - triangle-wave, programmable, III-225
 - triangle-wave, wide-range, III-242
 - TTL, LSTTL, CMOS designs, IV-530-532
 - variable duty-cycle, IV-533
 - variable-frequency, IV-535
- square-wave oscillators, I-613-614, II-597, II-616, IV-532, IV-533
 - 0.5 Hz, I-616
 - 1kHz, I-612
- square-to-sine wave converters, III-118
- squelch circuits, II-394
 - AM/FM, I-547
 - voice-activated circuits, IV-624
- squib firing circuits, II-357
- stabilizer
 - fixed power supplies, CMOS diode network, IV-406
 - fixed power supplies, output stabilizer, IV-393
- staircase generators, (*see also* waveform generators), II-601-602, III-586-588, IV-443-447
 - UA2240, III-587
- stand-by power supply, non-volatile CMOS RAMs, II-477
- standard, precision calibration, I-406
- standard-cell amplifier, saturated, II-296
- standing wave ratio (SWR)
 - meter, IV-269
 - power meter, I-16
 - QRP bridge, III-336
 - warning indicator, I-22
- Star Trek red alert siren, II-577
- start-and-run motor circuit, III-382
- state-of-charge indicator, lithium battery, II-78
- state-variable filters, II-215, III-189
 - multiple outputs, III-190
 - second-order, 1kHz, Q/10, I-293
 - universal, I-290
 - steam locomotive sound effects, II-589, II-592, III-568
- static detector, IV-276
- step-up switching regulator, 6V battery, II-78
- step-up/step-down dc-dc converters, III-118
- stepping motor driver, II-376, III-390
- stepping switch, solid state, II-612
- stereo circuits
 - amplifier, 12-V/20-W, IV-29
 - amplifier, Av/200, I-77
 - amplifier, bass tone control, I-670
 - audio-level meter, IV-310
 - audio-power meter, IV-306
 - balance circuit, II-603-605
 - balance meter, II-605, I-618-619
 - balance tester, II-604
 - decoder, frequency division multiplex, II-169
 - decoder, time division multiplex, II-18
 - decoder, TV-stereo, II-167
 - demodulator, II-159
 - demodulator, FM, I-544
 - derived center-channel system, IV-23
 - mixer, four-input, I-55
 - power meter, III-331

preamplifier, II-43, II-45
 reception indicator, III-269
 reverb systems, I-602, I-606
 reverb systems, gain control in, II-9
 TV-stereo decoder, II-167
 stimulator, constant-current, III-352
 stimulus isolator, III-351
 stop light, garage, II-53
 strain gauges
 bridge excitation, III-71
 bridge signal conditioner, II-85
 instrumentation amplifier, III-280
 strobe circuits, II-606-610
 disco-, II-610
 high-voltage power supplies, IV-413
 safety flare, II-608
 simple, II-607
 tone burst generator, II-90
 trip switch, sound activated, I-483
 variable strobe, III-589-590
 stud finder, III-339
 subharmonic frequencies, crystal-stabilized IC timer, II-151
 subtractor circuit, III-327
 successive-approximation A/D converter, II-24, II-30
 summing amplifiers, III-16
 precision design, I-36
 video, clamping circuit and, III-710
 sun tracker, III-318
 superheterodyne receiver, 3.5-to-10 MHz, IV-450-451
 supply rails, current sensing in, II-153
 suppressed-carrier, double-sideband, modulator, III-377
 sweep generators
 10.7 MHz, I-472
 add-on triggered, I-472
 oscilloscope-triggered, III-438
 switches and switching circuits, II-611-612, III-591-594, IV-537
 ac switch, battery-triggered, IV-387
 analog, buffered, DTL-TTL-controlled, I-621
 analog, differential, I-622
 analog, high-toggle/high-frequency, I-621
 analog, one MOSPOWER FET, III-593
 antenna selector, electronic, IV-538-539
 audio/video switcher circuit, IV-540-541
 auto-repeat switch, bounce-free, IV-545
 bidirectional relay switch, IV-472
 bistable switch, mechanically controlled, IV-545
 contact, I-136

dc static, II-367
 debouncer, III-592
 debouncer, computer switches, IV-105
 debouncer, computer switches, auto-repeat, IV-106
 debouncer, computer switches, flip-flop, IV-108
 delay, auto courtesy light, III-42
 DTL-TTL controlled buffered analog, I-621
 fax/telephone switch, IV-552-553
 FET dual-trace (oscilloscope), II-432
 Hall-effect, III-257, IV-539
 high-frequency, I-622
 high-side power control switch, 5 V supply, IV-384, IV-385
 infrared-activated, IV-345
 latching, SCR-replacing, III-593
 light-operated, II-320, III-314
 light-operated, adjustable, I-362
 MOSFET power control switch, IV-386
 on/off inverter, III-594
 on/off switch, IV-543
 on/off switch, transistorized op-amp on/off switch, IV-546
 optically coupled, high-voltage ac, III-408
 optically coupled, zero-voltage, solid-state, III-410
 over-temperature switch, IV-571
 photocell memory, ac power control, I-363
 photoelectric, II-321
 photoelectric, ac power, II-326
 photoelectric, synchronous, II-326
 proximity, III-517
 push on/off, II-359
 pushbutton power control switch, IV-388
 remote, on/off, I-577
 remote, ring extender, I-630
 rf, low-cost, III-361
 rf, power switch, III-592
 satellite TV audio switcher, IV-543
 solar-triggered, III-318
 solid-state stepping, II-612
 sonar transducer/, III-703
 sound-activated, II-581, III-580, III-600, III-601, IV-526-527
 sound-activated, two-way, I-610
 speed, I-104
 SPDT, ac-static, II-612
 switching controller, III-383
 temperature control, low-power, zero-voltage, II-640
 tone switch, narrowband, IV-542
 touch switches (*see* touch switches)
 touchomatic, II-693

triac, inductive load, IV-253
 triac, zero point, II-311
 triac, zero voltage, I-623
 two-channel, I-623
 ultrasonic, I-683
 under-temperature switch, IV-570
 VHF/UHF diode rf switch, IV-544
 video, IV-618-621
 video, automatic, III-727
 video, general purpose, III-725
 video, high-performance, III-728
 video, very-high off isolation, III-719
 voice-operated, I-608, III-580
 voice-operated, microphone-controlled, IV-527
 zero crossing, I-732
 zero point, I-373, II-311
 zero-voltage switching, closed contact half-wave, III-412
 zero-voltage switching, solid-state, optically coupled, III-410
 zero-voltage switching, triac design, I-623
 switched-mode power supplies, II-470, III-458
 50 W, off-line, III-473
 100 kHz, multiple-output, III-488
 converter, +50V push pull, I-494
 switched light, capacitance, I-132
 switching inverter, 500 kHz, 12 V systems, II-474
 switching power amplifier, I-33
 switching regulators
 3 A, III-472
 5 V, 6 A, 25 uHz, separate ultra-stable reference, I-497
 6 A variable output, I-513
 200 kHz, I-491
 application circuit, 3W, I-492
 fixed power supplies, 3 A, IV-408
 high-current inductorless, III-476
 low-power, III-490
 multiple output MPU, I-513
 positive, I-498
 step-down, I-493
 step-up, 6V battery, II-78
 switching/mixing, silent audio, I-59
 sync separators
 single-supply wide-range, III-715
 video circuits, IV-616
 synthesizers
 four-channel, I-603
 frequency, programmable voltage-controlled, II-265
 music, I-599

T
 tachometers, I-100, I-102, II-175, III-335, III-340, III-595-598

- tachometers (*cont.*)
 analog readout, IV-280
 calibrated, III-598
 closed-loop, feedback control, II-390
 digital, II-61, III-45, IV-268-269, IV-278
 frequency counter, I-310
 gasoline engine, I-94
 low-frequency, III-596
 minimum component, I-405
 motor speed control, II-378, II-389
 optical pick-up, III-347
 set point, III-47
- tandem dimmer, II-312
 tap, telephone, III-622
 tape-recorder circuits, I-21, I-419, III-599-601, IV-547-548
 amplifier, I-90
 amplifier, playback mode, IV-36
 audio-powered controller, IV-548
 automatic tape-recording switch, I-21, II-21
 automotive-battery power circuit, IV-548
 cassette-deck motor speed calibrator, IV-353
 extended-play circuit, III-600
 flat-response amplifier, III-673
 interface for, II-614
 playback amplifier, III-672, IV-36
 position indicator/controller, II-615
 preamplifier, I-90
 sound-activated switch, III-600, III-601
 starter switch, telephone-activated, I-632
 telephone-activated starter switch, I-632, II-622, III-616
 telephone-to-cassette interface, III-618
- telemetry demodulator, I-229
 telephone-related circuits, II-616-635, III-602-622, IV-549-564
 amplifier, III-621, IV-560
 answering machine beeper, IV-559
 auto answer and ring indicator, I-635
 automatic recording device, II-622
 blinking phone light monitor, II-624, II-629
 call-tone generator, IV-562
 cassette interface, III-618
 decoder, touch-tone, IV-555
 dial pulse indicator, III-613
 dialed-phone number vocalizer, III-731
 dialer, pulse/tone, single-chip, III-603
 dual tone decoding, II-620
 duplex audio link, IV-554
 duplex line amplifier, III-616
- eavesdropper, wireless, III-620
 fax-machine switch, remote-controlled, IV-552-553
 flasher, phone-message, IV-556
 flasher, tell-a-bell, IV-558
 flasher, visual ring indicator, IV-559, IV-561
 frequency and volume controller, II-623
 hands-free telephone, III-605
 handset encoder, I-634, III-613
 hold button, II-628, III-612
 in-use indicator, II-629, IV-560, IV-563
 intercom, IV-557
 light for, II-625
 line interface, autopatch, I-635
 line monitor, I-628
 message-taker, IV-563
 musical hold, II-623
 musical ringer, II-619
 night light, telephone controlled, III-604
 off-hook indicator, I-633
 optoisolator status monitor, I-626
 parallel connection, III-611
 piezoelectric ringer, I-636
 power switch, ac, IV-550
 pulse-dialing, III-610
 recording calls, I-632, III-616
 recording calls, auto-record switch, IV-558
 recording calls, telemonitor, IV-553
 redial, III-606
 relay, I-631
 remote monitor for, II-626
 repeater, III-607
 repertory dialer, line powered, I-633
 ring detector, II-623, III-619, IV-564
 ring detector, optically interfaced, III-611
 ringers, IV-556
 ringers, extension-phone ringer, IV-561
 ringers, high isolation, II-625
 ringers, multi-tone, remote programmable, II-634
 ringers, musical, II-619
 ringers, piezoelectric, I-636
 ringers, plug-in, remote, II-627
 ringers, relay, III-606
 ringers, remote, II-627, III-614, IV-562
 ringers, tone, I-627, I-628, II-630, II-631
 scrambler, II-618
 series connection, III-609
 silencer, IV-557
 sound level meter monitor, III-614
- speaker amplifier, IV-555
 speakerphone, II-632, III-608
 speech activity detector, II-617, III-615
 speech network, II-633
 status monitor using optoisolator, I-626
 switch, solid-state, line-activated, III-617
 tap, III-622
 tape-recorder starter controlled by, I-632
 toll-totalizer, IV-551
 tone-dialing, III-607
 tone ringers, I-627, I-628, II-630, II-631
 Touchtone generator, III-609
 touch-tone decoder, IV-555
 vocalizer, dialed-phone number, III-731
- television-related circuits (*see also* video circuits)
 amplifier, audio, III-39
 amplifier, IF detector, MC130/MC1352, I-688
 amplifier, IF/FM IF, quadrature, I-690
 amplifier, RF, UHF TV-line amplifier, IV-482, IV-483
 audio/video switcher circuit, IV-540-541
 automatic turn-off, I-577
 cross-hatch generator, III-724
 data interface, TTL oscillator, II-372
 decoder, stereo TV, II-167
 IF detector, amplifier, MC130/MC1352, I-688
 modulators, I-439, II-433, II-434
 preamplifier, UHF, III-546
 rf up-converter for TVRO subcarrier reception, IV-501
 satellite TV audio switcher, IV-543
 stereo-sound decoder, II-167
 transmitter, III-676
 transmitter, amateur TV, IV-599
- temperature-related circuits (*see also* thermometers), IV-565-572
 alarms, II-4, II-643
 alarms, adjustable threshold, II-644
 automotive temperature indicator, II-56, IV-48
 automotive water-temperature gauge, IV-44
 Centigrade thermometer, II-648
 control circuits, I-641-643, II-636-644, III-623-628, IV-567
 control circuits, defrost cycle, IV-566
 control circuits, heater element, II-642

- control circuits, heater protector, servo-sensed, III-624
- control circuits, heat sniffer, electronic, III-627
- control circuits, liquid-level monitor, II-643
- control circuits, low-power, zero-voltage switch, II-640
- control circuits, piezoelectric fan-based, III-627
- control circuits, proportional, III-626
- control circuits, signal conditioners, II-639
- control circuits, single setpoint, I-641
- control circuits, thermocoupled, IV-567
- control circuits, zero-point switching, III-624
- converters, temperature-to-frequency, I-646, I-168, I-656, II-651-653
- converters, temperature-to-time, III-632-633
- defrost cycle and control, IV-566
- heater control, I-640, II-642, III-624
- heat sniffer, III-627
- hi/lo sensor, II-650
- indicator, IV-570
- indicator, automotive temperature, PTC thermistor, II-56
- measuring circuit, digital, II-653
- measuring sensor, transistorized, IV-572
- meter, I-647
- monitor, III-206
- monitor, thermal monitor, IV-569
- oscillators, crystal, temperature-compensated, I-187
- oscillators, temperature-stable, II-427
- over-temperature switch, IV-571
- over/under sensor, dual output, II-646
- remote sensors, I-649, I-654
- sensors, I-648, I-657, II-645-650, III-629-631, IV-568-572
- sensors, 0-50-degree C four channel, I-648
- sensors, 0-63 degrees C, III-631
- sensors, 5 V powered linearized platinum RTD signal conditioner, II-650
- sensors, automotive-temperature indicator, PTC thermistor, II-56
- sensors, Centigrade thermometer, II-648
- sensors, coefficient resistor, positive, I-657
- sensors, differential, I-654, I-655
- sensors, over/under, dual output, II-646
- sensors, DVM interface, II-647
- sensors, hi/lo, II-650
- sensors, integrated circuit, I-649
- sensors, isolated, I-651, III-631
- sensors, remote, I-654
- sensors, thermal monitor, IV-569
- sensors, thermocouple amplifier, cold junction compensation, II-649
- sensors, thermocouple multiplex system, III-630
- sensors, zero-crossing detector, I-733
- signal conditioners, II-639
- thermocouple amplifier, cold junction compensation, II-649
- thermocouple control, IV-567
- thermocouple multiplex system, III-630
- transducer, temperature-to-frequency, linear, I-646
- transducer, temperature-transducer with remote sensor, I-649
- under-temperature switch, IV-570
- zero-crossing detector, I-733
- temperature-to-frequency converter, I-168, I-656, II-651-653
- temperature-to-frequency transducer, linear, I-646
- temperature-to-time converters, III-632-633
- ten-band graphic equalizer, active filter, II-684
- Tesla coils, III-634-636
- test circuits (*see* measurement/test circuits)
- text adder, composite-video signal, III-716
- theremins, II-654-656
- digital, II-656
- electronic, II-655
- thermal flowmeter, low-rate flow, III-203
- thermocouple circuits
 - digital thermometer using, II-658
 - multiplex, temperature sensor system, III-630
 - pre-amp using, III-283
 - thermometer, centigrade calibrated, I-650
- thermocouple amplifiers, I-654, II-14
- cold junction compensation, II-649
- high stability, I-355
- thermometers, II-657-662, III-637-643, IV-573-577
- 0-50 degree F, I-656
- 0-100 degree C, I-656
- adapter, III-642
- add-on for DMM digital voltmeter, III-640
- centigrade, I-655, II-648, II-662
- centigrade, calibrated, I-650
- centigrade, ground-referred, I-657
- differential, I-652, II-661, III-638
- digital, I-651, I-658
- digital, temperature-reporting, III-638
- digital, thermocouple, II-658
- digital, uP controlled, I-650
- electronic, II-660, III-639, IV-575, IV-576
- Fahrenheit, I-658
- Fahrenheit, ground-referred, I-656
- high-accuracy design, IV-577
- implantable/ingestible, III-641
- kelvin, zero adjust, I-653, II-661
- kelvin, ground-referred, I-655
- linear, III-642, IV-574
- low-power, I-655
- meter, trimmed output, I-655
- remote, II-659
- single-dc supply, IV-575
- variable offset, I-652
- thermostats
 - electronic, remote ac, two-wire, I-639
 - electronic, three-wire, I-640
- three-in-one test set, III-330
- three-minute timer, III-654
- three-rail power supply, III-466
- threshold detectors, precision, III-157
- tilt meter, II-663-666, III-644-646
 - differential capacitance measurement circuit, II-665
 - sense-of-slope, II-664
 - ultra-simple level, II-666
- time base
 - crystal oscillator, III-133, IV-128
 - function generators, 1 Hz, for read-out and counter applications, IV-201
- time delays, I-668, II-220, II-667-670, III-647-649
 - circuit, precision solid state, I-664
 - constant current charging, II-668
 - electronic, III-648
 - generator, I-218
 - hour sampling circuit, II-668
 - integrator to multiply 555 timers, low-cost, II-669
 - long-duration, I-220
 - relay, I-663
 - relay, ultra precise long, I-219
 - timing threshold and load driver, III-648
 - two-SCR design, II-670
- time division multiplex stereo decoder, II-168

timers, I-666, I-668, II-671-681, III-650-655, IV-578-586
0.1 to 90 second, I-663
741 timer, I-667
adjustable, IV-585
adjustable ac .2 to 10 seconds, II-681
alarm, II-674
appliance-cutoff timer, IV-583
CMOS, programmable precision, III-652
circuit, II-675
darkroom, I-480
elapsed time/counter timer, II-680
electronic egg, I-665
IC, crystal-stabilized, II-151
interval, programmable, II-678
interval, programmable, thumbwheel, I-660
long-delay, PUT, I-219
long-duration, PUT, II-675
long-duration, time delay, IV-585
long-interval, programmable, IV-581, IV-582
long-interval, RC, I-667
long-term electronic, II-672
long-time, III-653
mains-powered, IV-579
one-shot, III-654
photographic, I-485
photographic, darkroom enlarger, III-445
photographic, photo-event timer, IV-379
reaction timer, game circuit, IV-204
SCR design, IV-583
sequential, I-661-662, I-663, III-651
sequential UJT, I-662
slide-show, III-444
slides, photographic, III-448
solid-state, industrial applications, I-664
ten-minute ID timer, IV-584
three-minute, III-654
thumbwheel-type, programmable interval, I-660
time-out circuit, IV-586
transmit-time limiter, IV-580
triangle-wave generator, linear, III-222
variable duty-cycle output, III-240
voltage-controlled, programmable, II-676
washer, I-668
watchdog timer/alarm, IV-584
timing light, ignition, II-60
timing threshold and load driver, III-648
tone alert decoder, I-213
tone annunciator, transformerless, III-27-28
tone burst generators, I-604, II-90
European repeaters, III-74
tone controls (*see also* sound generators), I-677, II-682-689, III-656-660, IV-587-589
active bass and treble, with buffer, I-674
active control, IV-588
audio amplifier, II-686
Baxandall tone-control audio amplifier, IV-588
equalizer, ten-band octave, III-658
equalizer, ten-band graphic, active filter, II-684
guitar treble booster, II-683
high-quality, I-675
high-z input, hi fi, I-676
microphone preamp, I-675, II-687
mixer preamp, I-58
passive circuit, II-689
preamplifier, high-level, II-688
preamplifier, IC, I-673, III-657
preamplifier, microphone, I-675, II-687
preamplifier, mixer, I-58
rumble/scratch filter, III-660
three-band active, I-676, III-658
three-channel, I-672
tremolo circuit, IV-589
Wien-bridge filter, III-659
tone decoders, I-231, III-143
dual time constant, II-166
24 percent bandwidth, I-215
relay output, I-213
tone-dial decoder, I-631
tone detectors, 500-Hz, III-154
tone-dial decoder, I-630, I-631
tone-dial encoder, I-629
tone-dial generator, I-629
tone-dialing telephone, III-607
tone encoder, I-67
subaudible, I-23
tone-dial encoder, I-629
two-wire, II-364
tone generators (*see* sound generators)
tone probe, digital IC testing with, II-504
tone ringer, telephone, II-630, II-631
totem-pole driver, bootstrapping, III-175
touch circuit, I-137
touch switches, I-131, I-135-136, II-690-693, III-661-665, IV-590-594
CMOS, I-137
bistable multivibrator, touch-triggered, I-133
double-button latching, I-138
hum-detecting touch sensor, IV-594
lamp control, three-way, IV-247
low-current, I-132
On/Off, II-691, III-663, IV-593
line-hum, III-664
momentary operation, I-133
negative-triggered, III-662
positive-triggered, III-662
sensor switch and clock, IV-591
time-on touch switch, IV-594
touchomatic, II-693
two-terminal, III-663
Touchtone generator, telephone, III-609
toxic gas detector, II-280
toy siren, II-575
TR circuit, II-532
tracers
audio reference signal, probe, I-527
bug, III-358
closed-loop, III-356
receiver, III-357
track-and-hold circuits, III-667
sample-and-hold circuit, III-549, III-552
signal, III-668
tracking circuits, III-666-668
positive/negative voltage reference, III-667
preregulator, III-492
track-and-hold, III-667
track-and-hold, signal, III-668
train chuffer sound effect, II-588
transceivers (*see also* receivers; transmitters), IV-595-603
CE, 20-m, IV-596-598
CW, 5 W, 80-meter, IV-602
hand-held, dc adapter, III-461
hand-held, speaker amplifiers, III-39
HF transceiver/mixer, IV-457
ultrasonic, III-702, III-704
transducer amplifiers, III-669-673
flat-response, tape, III-673
NAB preamp, record, III-673
NAB preamp, two-pole, III-673
photodiode amplifier, III-672
preamp, magnetic phono, III-671, III-673
tape playback, III-672
voltage, differential-to-single-ended, III-670
transducers, I-86
bridge type, amplifier, II-84, III-71
detector, magnetic transducer, I-233
sonar, switch and, III-703
temperature, remote sensor, I-649
transistors and transistorized circuits
flashers, II-236, III-200
frequency tripler, nonselective, saturated, II-252
headphone amplifier, II-43

- on/off switch for op amp, IV-546
 - pulse generator, IV-437
 - sorter, I-401
 - tester, I-401, IV-281
 - transmission indicator, II-211
 - transmitters (*see also* receivers; transceivers), III-674-691, IV-595-603
 - 2-meter, IV-600-601
 - acoustic-sound transmitter, IV-311
 - amateur radio, 80-M, III-675
 - amateur TV, IV-599
 - beacon, III-683, IV-603
 - broadcast, 1-to-2 MHz, I-680
 - carrier current, I-144, I-145, III-79
 - computer circuit, 1-of-8 channel, III-100
 - CW, 1 W, III-678
 - CW, 10 W, one-tube, I-681
 - CW, 40 M, III-684
 - CW, 902 MHz, III-686
 - CW, HF low-power, IV-601
 - CW, QRP, III-690
 - fiber optic, III-177
 - FM, I-681
 - FM, infrared, voice-modulated pulse, IV-228
 - FM, multiplex, III-688
 - FM, one-transistor, III-687
 - FM, (PRM) optical, I-367
 - FM, snoopier, III-680
 - FM, voice, III-678
 - FM, wireless microphone, III-682, III-685, III-691
 - half-duplex information transmission link, low-cost, III-679
 - HF, low-power, IV-598
 - infrared, I-343, II-289, II-290, III-277, IV-226-227
 - infrared, digital, III-275
 - infrared, FM, voice-modulated pulse, IV-228
 - infrared, remote control with receiver, I-342
 - line-carrier, with on/off, 200 kHz, I-142
 - low-frequency, III-682
 - multiplexed, 1-of-8 channel, III-395
 - negative key-line keyer, IV-244
 - optical, I-363, IV-368
 - optical, FM, 50 kHz center frequency, II-417
 - optical, receiver for, II-418
 - oscillator and, 27 and 49 MHz, I-680
 - output indicator, IV-218
 - remote sensors, loop-type, III-70
 - television, III-676
 - ultrasonic, 40 kHz, I-685
 - VHF, modulator, III-684
 - VHF, tone, III-681
 - treasure locator, lo-parts, I-409
 - treble booster, guitar, II-683
 - tremolo circuits, I-59, III-692-695, IV-589
 - voltage-controlled amplifier, I-598
 - triac circuits
 - ac-voltage controller, IV-426
 - contact protection, II-531
 - dimmer switch, II-310, III-303
 - dimmer switch, 800W, I-375
 - drive interface, direct dc, I-266
 - microprocessor array, II-410
 - relay-contact protection with, II-531
 - switch, inductive load, IV-253
 - trigger, I-421
 - voltage doubler, III-468
 - zero point switch, II-311
 - zero voltage, I-623
 - triangle-to-sine converter, II-127
 - triangle/square wave oscillator, II-422
 - triangle-wave generators, III-234
 - square-wave, III-225, III-239
 - square-wave, precision, III-242
 - square-wave, wide-range, III-242
 - timer, linear, III-222
 - trickle charger, 12 V battery, I-117
 - triggers
 - 50-MHz, III-364
 - camera alarm, III-444
 - flash, photography, xenon flash, III-447
 - optical Schmitt, I-362
 - oscilloscope-triggered sweep, III-438
 - remote flash, I-484
 - SCR series, optically coupled, III-411
 - sound/light flash, I-482
 - triac, I-421
 - triggered sweep, add-on, I-472
 - tripler, nonselective, transistor saturation, II-252
 - trouble tone alert, II-3
 - TTL circuits
 - clock, wide-frequency, III-85
 - coupler, optical, III-416
 - gates, siren using, II-576
 - Morse code keyer, II-25
 - square wave to triangle wave converter, II-125
 - TTL to MOS logic converter, II-125
 - TTL oscillators, I-179, I-613
 - 1MHz to 10MHz, I-178
 - television display using, II-372
 - crystal, I-197
 - sine/square wave oscillator, IV-512
 - tube amplifier, high-voltage isolation, IV-426
 - tuners
 - antenna tuner, 1-to-30 MHz, IV-14
 - FM, I-231
 - guitar and bass, II-362
 - turbo circuits, glitch free, III-186
 - twang-twang circuit, II-592
 - twilight-triggered circuit, II-322
 - twin-T notch filters, III-403
 - two-state siren, III-567
 - two-tone generator, II-570
 - two-tone siren, III-562
 - two-way intercom, III-292
 - two's complement, D/A conversion system, binary, 12-bit, III-166
- ## U
- UA2240 staircase generator, III-587
 - UHF transmissions
 - field-strength meters, IV-165
 - rf amplifiers, UHF TV-line amplifier, IV-482, IV-483
 - source dipper, IV-299
 - TV preamplifier, III-546
 - VHF/UHF rf diode switch, IV-544
 - wideband amplifier, high performance FETs, III-264
 - UJT circuits
 - battery chargers, III-56
 - metronome, II-355
 - monostable circuit, bias voltage change insensitive, II-268
 - ultrasonic circuits (*see also* sound-operated circuits), III-696-707, IV-604-606
 - arc welding inverter, 20 KHz, III-700
 - induction heater, 120-KHz 500-W, III-704
 - pest-controller, III-706, III-707
 - pest-repeller, I-684, II-685, III-699, IV-605-606
 - ranging system, III-697
 - receiver, III-698, III-705
 - sonar transducer/switch, III-703
 - sound source, IV-605
 - switch, I-683
 - transceiver, III-702, III-704
 - transmitter, I-685
 - undervoltage detector, IV-138
 - undervoltage monitor, III-762
 - uninterruptible power supply, II-462 + 5V, III-477
 - unity-gain amplifiers
 - inverting, I-80
 - inverting, wideband, I-35
 - ultra high Z, ac, II-7
 - unity-gain buffer
 - stable, with good speed and high-input impedance, II-6
 - unity-gain follower, I-27
 - universal counters
 - 10 MHz, II-139

universal counters (*cont.*)

40-MHz, III-127

universal mixer stage, III-370

universal power supply, 3-30V, III-489
up/down counter, extreme count
freezer, III-125

V

vacuum fluorescent display circuit, II-185

vacuum gauge, automotive, IV-45

vapor detector, II-279

varactor-tuned 10 MHz ceramic resonator oscillator, II-141

variable current source, 100 mA to 2A, II-471

variable duty-cycle oscillator, fixed-frequency, III-422

variable-frequency inverter, complementary output, III-297

variable-gain amplifier, voltage-controlled, I-28-29

variable-gain and sign op amp, II-405

variable-gain circuit, accurate null and, III-69

variable oscillators, II-421

audio, 20Hz to 20kHz, II-727

four-decade, single control for, II-424

sine-wave oscillator, super low-

distortion, III-558

wide range, II-429

variable power supplies, III-487-492, IV-414-421

adjustable 10-A regulator, III-492
current source, voltage-programmable, IV-420

dc supply, SCR variable, IV-418

dc supply, step variable, IV-418

dual universal supply, 0-to-50 V, 5 A, IV-416-417

regulated supply, 2.5 A, 1.25-to-25 V

regulator, Darlington, IV-421

regulator, variable, 0-to-50 V, IV-421

regulator/current source, III-490

switch-selected fixed-voltage supply, IV-419

switching regulator, low-power, III-490

switching, 100-KHz multiple-output, III-488

tracking preregulator, III-492

transformerless supply, IV-420

universal 3-30V, III-489

variable current source, 100mA to 2A, II-471

voltage regulator, III-491

vehicles (*see* automotive circuits)

VFO, 5 MHz, II-551

VHF transmissions

crystal oscillator, 20-MHz, III-138

crystal oscillator, 50-MHz, III-140

crystal oscillator, 100-MHz, III-139

modulator, I-440, III-684

tone transmitter, III-681

VHF/UHF diode rf switch, IV-544

video amplifiers, III-708-712

75-ohm video pulse, III-711

buffer, low-distortion, III-712

color, I-34, III-724

dc gain-control, III-711

FET cascade, I-691

gain block, III-712

IF, low-level video detector circuit, I-689, II-687

JFET bipolar cascade, I-692

line driving, III-710

log amplifier, I-38

RGB, III-709

summing, clamping circuit and, III-710

video circuits (*see also* television-related circuits), III-713-728, IV-607-621

audio/video switcher circuit, IV-540-541

camera-image tracker, analog voltage, IV-608-609

camera link, wireless, III-718

chroma demodulator with RGB

matrix, III-716

color amplifier, III-724

color-bar generator, IV-614

composite-video signal text adder, III-716

converter, RGB-to-NTSC, IV-611

converter, video a/d and d/a, IV-610-611

cross-hatch generator, color TV, III-724

dc restorer, III-723

decoder, NTSC-to-RGB, IV-613

high-performance video switch, III-728

line pulse extractor, IV-612

loop-thru amplifier, IV-616

mixer, high-performance video mixer, IV-609

modulators, I-437, II-371, II-372

monitors, RGB, blue box, III-99

monochrome-pattern generator, IV-617

multiplexer, cascaded, 1-of-15, III-393

PAL/NTSC decoder with RGB input, III-717

palette, III-720

picture fixer/inverter, III-722

RGB-composite converter, III-714

signal clamp, III-726

switching circuits, IV-618-621

switching circuits, remote selection switch, IV-619

switching circuits, remote-controlled switch, IV-619-621

sync separator, IV-616

sync separator, single-supply wide-range, III-715

video op amp circuits, IV-615

video switch, automatic, III-727

video switch, general purpose, III-725

video switch, very-high off isolation, III-719

wireless camera link, III-71

vocal eliminator, IV-19

voice scrambler/descrambler, IV-26

voice scrambler/disguiser, IV-27

voice substitute, electronic, III-734

voice-activated circuits (*see also* sound-operated circuits), III-729-734, IV-622-624

ac line-voltage announcer, III-730

allophone generator, III-733

amplifier/switch, I-608

computer speech synthesizer, III-732

dialed phone number vocalizer, III-731

scanner voice squelch, IV-624

switch, III-580

switch, microphone-controlled, IV-527

switch/amplifier, I-608

voice substitute, electronic, III-734

VOX circuit, IV-623

voltage amplifiers

differential-to-single-ended, III-670

reference, I-36

voltage-controlled amplifier, I-31, I-598

attenuator for, II-18

tremolo circuit, I-598

variable gain, I-28-29

voltage-controlled filter, III-187

1,000:1 tuning, IV-176

voltage-controlled high-speed one shot, II-266

voltage-controlled ramp generator, II-523

voltage-controlled resistor, I-422

voltage-controlled timer, programmable, II-676

voltage-controlled amplifier, IV-20

tremolo circuit or, I-598

voltage-controlled oscillators, I-702-

704, II-702, III-735, IV-625-630

3-5 V regulated output converter, III-739

10Hz to 10kHz, I-701, III-735-741

555-VCO, IV-627
 audio-frequency VCO, IV-626
 crystal oscillator, III-135, IV-124
 current sink, voltage-controlled, IV-629
 driver, op-amp design, IV-362
 linear, I-701, IV-628
 linear triangle/square wave, II-263
 logarithmic sweep, III-738
 precision, I-702, III-431
 restricted-range, IV-627
 stable, IV-372-373
 supply voltage splitter, III-738
 three-decade, I-703
 TMOS, balanced, III-736
 two-decade, high-frequency, I-704
 varactorless, IV-630
 variable-capacitance diode-sparked, III-737
 VHF oscillator, voltage-tuned, IV-628
 waveform generator, III-737
 wide-range, IV-629
 wide-range, biphasic, IV-629
 wide-range, gate, IV-627
 voltage-controller, pulse generator, III-524
 voltage converters, III-742-748
 12-to-16 V, III-747
 dc-to-dc, 3-25 V, III-744
 dc-to-dc, dual output \pm 12-15 V, III-746
 flyback, high-efficiency, III-744
 flyback-switching, self-oscillating, III-748
 negative voltage, uP-controlled, IV-117
 offline, 1.5-W, III-746
 regulated 15-Vout 6-V driven, III-745
 splitter, III-743
 unipolar-to-dual supply, III-743
 voltage detector relay, battery charger, II-76
 voltage followers, I-40, III-212
 fast, I-34
 noninverting, I-33
 signal-supply operation, amplifier, III-20
 voltage inverters, precision, III-298
 voltage meters/monitors/indicators, III-758-772
 ac voltmeter, III-765
 ac voltmeter, wide-range, III-772
 audio millivoltmeter, III-767, III-769
 automotive battery voltage gauge, IV-47
 battery-voltage measuring regulator, IV-77
 comparator and, II-104
 dc voltmeter, III-763
 dc voltmeter, resistance, high-input, III-762
 DVM, 3.5-digit, full-scale 4-decade, III-761
 DVM, 4.5-digit, III-760
 FET voltmeter, III-765, III-770
 five-step level detector, I-337
 frequency counter, III-768
 high-input resistance voltmeter, III-768
 HTS, precision, I-122
 level detectors, I-338, II-172, III-759, III-770
 low-voltage indicator, III-769
 multiplexed common-cathode LED ADC, III-764
 over/under monitor, III-762
 peak program detector, III-771
 rf voltmeter, III-766
 solid-state battery, I-120
 ten-step level detector, I-335
 visible, I-338, III-772
 voltage freezer, III-763
 voltage multipliers, IV-631-637
 2,000 V low-current supply, IV-636-637
 10,000 V dc supply, IV-633
 corona wind generator, IV-633
 doublers, III-459, IV-635
 doubler, cascaded, Cockcroft-Walton, IV-635
 doublers, triac-controlled, III-468
 laser power supply, IV-636
 negative-ion generator, high-voltage, IV-634
 tripler, low-current, IV-637
 voltage ratio-to-frequency converter, III-116
 voltage references, III-773-775
 bipolar source, III-774
 digitally controlled, III-775
 expanded-scale analog meter, III-774
 positive/negative, tracker for, III-667
 variable-voltage reference source, IV-327
 voltage regulators, I-501, I-511, II-484
 0- to 10-V at 3A, adjustable, I-511
 0- to 22-V, I-510
 0- to 30-V, I-510
 5 V, low-dropout, III-461
 5 V, 1 A, I-500
 6 A, variable output switching, I-513
 10 A, I-510
 10 A, adjustable, III-492
 10 V, high stability, III-468
 15 V, 1 A, remote sense, I-499
 15 V, slow turn-on, III-477
 -15 V negative, I-499
 45 V, 1 A switching, I-499
 100 Vrms, I-496
 ac, III-477
 adjustable output, I-506, I-512
 automotive circuits, III-48, IV-67
 battery charging, I-117
 bucking, high-voltage, III-481
 common hot-lead regulator, IV-467
 constant voltage/constant current, I-508
 current and thermal protection, 10 amp, II-474
 dual-tracking, III-462
 efficiency-improving switching, IV-464
 fixed pnp, zener diode increases output, II-484
 fixed-current regulator, IV-467
 fixed-voltages, IV-462-467
 flyback, off-line, II-481
 high- or low-input regulator, IV-466
 high-stability, I-499
 high-stability, 1 A, I-502
 high-stability, 10 V, III-468
 high-voltage, III-485
 high-voltage, foldback-current limiting, II-478
 high-voltage, precision, I-509
 low-dropout, 5-V, III-461
 low-voltage, I-502, I-511
 linear, low-dropout, III-459
 linear, radiation-hardened 125 A, II-468
 mobile, I-498
 negative, III-474, IV-465
 negative, -15 V, I-499
 negative, floating, I-498
 negative, switching, I-498
 negative, voltage, I-499
 positive, floating, I-498
 positive, switching, I-498
 positive, with NPN/PNP boost, III-475
 positive, with PNP boost, III-471
 pre-, SCR, II-482
 pre-, tracking, III-492
 projection lamp, II-305
 PUT, 90 V rms, II-479
 remote shutdown, I-510
 negative, IV-465
 sensor, LM317 regulator sensing, IV-466
 short-circuit protection, low-voltage, I-502
 single-ended, I-493
 single-supply, II-471
 slow turn-on 15 V, I-499
 switch-mode, IV-463
 switching, 3-A, III-472
 switching, 3 W, application circuit, I-492

- voltage regulators (*cont.*)
 - switching, 5 V, 6 A 25kHz, separate ultrastable reference, I-497
 - switching, 6 A, variable output, I-513
 - switching, 200 kHz, I-491
 - switching, multiple output, for use with MPU, I-513
 - switching, step down, I-493
 - switching, high-current inductorless, III-476
 - switching, low-power, III-490
 - variable, III-491, IV-468-470
 - variable, current source, III-490
 - zener design, programmable, IV-470
- voltage sources
 - millivolt, zenerless, I-696
 - programmable, I-694
- voltage splitter, III-738
- voltage-to-current converter, I-166, II-124, III-110, IV-118
 - power, I-163
 - zero IB error, III-120
- voltage-to-frequency converters, I-707, III-749-757, IV-638-642
 - 1 Hz-to-10MHz, III-754
 - 1 Hz-to-30 MHz, III-750
 - 1Hz-to-1.25 MHz, III-755
 - 5 KHz-to-2MHz, III-752
 - 10Hz to 10 kHz, I-706, III-110
 - accurate, III-756
 - differential-input, III-750
 - function generators, potentiometer-position, IV-200
 - low-cost, III-751
 - low-frequency converter, IV-641
 - negative input, I-708
 - optocoupler, IV-642
 - positive input, I-707
 - precision, II-131
 - preserved input, III-753
 - ultraprecision, I-708
 - wide-range, III-751, III-752
- voltage-to-pulse duration converter, II-124
- voltmeters
 - 3 $\frac{1}{2}$ digit, I-710
 - 3 $\frac{1}{2}$ digital true rms ac, I-713
 - 5-digit, III-760
 - ac, III-765
 - ac, wide-range, III-772
 - add-on thermometer for, III-640
 - bar-graph, I-99, II-54
 - dc, III-763
 - dc, high-input resistance, III-762
 - digital, III-4
 - digital, 3.5-digit, full-scale, four-decade, III-761
 - digital, LED readout, IV-286
 - FET, I-714, III-765, III-770
 - high-input resistance, III-768
 - millivoltmeters (*see* millivoltmeters)
 - rf, I-405, III-766
 - wide-band ac, I-716
 - voltohmeter, phase meter, digital readout, IV-277
 - volume amplifier, II-46
 - volume control circuits, IV-643-645
 - telephone, II-623
 - volume indicator, audio amplifier, IV-212
 - VOR signal simulator, IV-273
 - vox box, II-582, IV-623
 - Vpp generator, EPROM, II-114
 - VU meters
 - extended range, II-487, I-715
 - LED display, IV-211

W

 - waa-waa circuit, II-590
 - wailers (*see* alarms; sirens)
 - wake-up call, electronic, II-324
 - walkman amplifier, II-456
 - warblers (*see* alarms; sirens)
 - warning devices
 - auto lights-on warning, II-55
 - high-level, I-387
 - high-speed, I-101
 - light, III-317
 - light, battery-powered, II-320
 - low-level, audio output, I-391
 - speed, I-96
 - varying-frequency alarm, II-579
 - water-level sensors (*see* fluid and moisture detectors)
 - water-temperature gauge, automotive, IV-44
 - wattmeter, I-17
 - wave-shaping circuits (*see also* waveform generators), IV-646-651
 - capacitor for high slew rates, IV-650
 - clipper, glitch-free, IV-648
 - flip-flop, S/R, IV-651
 - harmonic generator, IV-649
 - phase shifter, IV-647
 - rectifier, full-wave, IV-650
 - signal conditioner, IV-649
 - waveform generators (*see also* burst generators; function generators; sound generators; square-wave generators; wave-shaping circuits), II-269, II-272
 - audio, precision, III-230
 - four-output, III-223
 - harmonic generator, IV-649
 - high-speed generator, I-723
 - precise, II-274
 - ramp generators, IV-443-447
 - sawtooth generator, digital, IV-444, IV-446
 - sine-wave, IV-505, IV-506
 - sine-wave, 60 Hz, IV-507
 - sine-wave, audio, II-564
 - sine-wave, LC, IV-507
 - sine-wave, LF, IV-512
 - sine-wave oscillator, audio, III-559
 - staircase generators, IV-443-447
 - staircase generator/frequency divider, I-730
 - stepped waveforms, IV-447
 - triangle and square waveform, I-726
 - VCO and, III-737
 - wavemeter, tuned RF, IV-302
 - weather-alert decoder, IV-140
 - weight scale, digital, II-398
 - Wheel-of-Fortune game, IV-206
 - whistle, steam locomotive, II-589, III-568
 - who's first game circuit, III-244
 - wide-range oscillators, I-69, III-425
 - variable, I-730
 - wide-range peak detectors, III-152
 - hybrid, 500 kHz-1 GHz, III-265
 - instrumentation, III-281
 - miniature, III-265
 - UHF amplifiers, high-performance FETs, III-264
 - wideband amplifiers
 - low-noise/low drift, I-38
 - two-stage, I-689
 - rf, IV-489, IV-490, IV-491
 - rf, HF, IV-492
 - rf, JFET, IV-493
 - rf, MOSFET, IV-492
 - rf, two-CA3100 op amp design, IV-491
 - unity gain inverting, I-35
 - wideband signal splitter, III-582
 - wideband two-pole high pass filter, II-215
 - Wien-bridge filter, III-659
 - notch filter, II-402
 - Wien-bridge oscillators, I-62-63, I-70, III-429, IV-371, IV-377, IV-511
 - CMOS chip in, II-568
 - low-distortion, thermally stable, III-557
 - low-voltage, III-432
 - sine wave, I-66, I-70, II-566
 - sine-wave, three-decade, IV-510
 - sine-wave, very-low distortion, IV-513
 - single-supply, III-558
 - variable, III-424
 - wind-powered battery charger, II-70
 - windicator, I-330
 - window circuits, II-106, III-90, III-776-

781, IV-655-659
comparator, IV-658
comparator, low-cost design, IV-656-657
comparator, voltage comparator, IV-659
detector, IV-658
digital frequency window, III-777
discriminator, multiple-aperture, III-781
generator, IV-657
high-input-impedance, II-108
windshield wiper circuits
control circuit, I-103, I-105, II-62
delay circuit, II-55
delay circuit, solid-state, IV-64
hesitation control unit, I-105
intermittent, dynamic braking, II-49
interval controller, IV-67
slow-sweep control, II-55
windshield washer fluid watcher, I-107
wire tracer, II-343

wireless microphones (*see* micro-phones), IV-652
wireless speaker system, IR, III-272
write amplifiers, III-18

X

xenon flash trigger, slave, III-447
XOR gates, IV-107
complementary signals generator, III-226
oscillator, III-429
up/down counter, III-105

Y

yelp oscillator/siren, II-577, III-562

Z

Z80 clock, II-121

zappers, battery, II-64
ni-cad battery, II-66
ni-cad battery, version II, II-68
zener diodes
clipper, fast and symmetrical, IV-329
increasing power rating, I-496, II-485
limiter using one-zener design, IV-257
tester, I-400
variable, I-507
voltage regulator, programmable, IV-470
zero-crossing detector, II-173
zero meter, suppressed, I-716
zero-point switches
temperature control, III-624
triac, II-311
zero-voltage switches
closed contact half-wave, III-412
solid-state, optically coupled, III-410
solid-state, relay, antiparallel SCR output, III-416

Other Bestsellers of Related Interest

ENCYCLOPEDIA OF ELECTRONIC CIRCUITS

Vol. 1—Rudolf F. Graf

“... schematics that encompass virtually the entire spectrum of electronics technology . . . This is a well worthwhile book to have handy.” —Modern Electronics

Discover hundreds of the most versatile electronic and integrated circuit designs, all available at the turn of a page. You'll find circuit diagrams and schematics for a wide variety of practical applications. Many entries also include clear, concise explanations of the circuit configurations and functions. 768 pages, 1,762 illustrations. Book No. 1938, \$32.95 paperback, \$60.00 hardcover

THE ILLUSTRATED DICTIONARY OF ELECTRONICS—5th Edition

—Rufus P. Turner and Stan Gibilisco

This completely revised and updated edition defines more than 27,000 practical electronics terms, acronyms, and abbreviations. Find up-to-date information on basic electronics, computers, mathematics, electricity, communications, and state-of-the-art applications—all discussed in a nontechnical style. The author also includes 360 new definitions and 125 illustrations and diagrams. 736 pages, 650 illustrations. Book No. 3345, \$26.95 paperback

ELECTRONIC CONVERSIONS: Symbols and Formulas—2nd Edition

—Rufus P. Turner and Stan Gibilisco

This revised and updated edition supplies all the formulas, symbols, tables, and conversion factors commonly used in electronics. Exceptionally easy to use, the material is organized by subject matter. Its format is ideal and you can save time by directly accessing specific information. Topics cover only the most-needed facts about the most often used conversions, symbols, formulas, and tables. 280 pages, 94 illustrations. Book No. 2865, \$14.95 paperback only

ELECTRONIC DATABOOK—4th Edition

—Rudolf F. Graf

If it's electronic, it's here—current, detailed, and comprehensive! Use this book to broaden your electronics information base. Revised and expanded to include all up-to-date information, this fourth edition makes any electronic job easier and less time-consuming. You'll find information that will aid in the design of local area networks, computer interfacing structure, and more! 528 pages, 131 illustrations. Book No. 2958, \$24.95 paperback only

BUILD YOUR OWN TEST EQUIPMENT

—Homer L. Davidson

Build more than 30 common electronic testing devices, ranging from simple continuity and polarity testers to signal injectors and power supplies. Also learn how test instruments work, how they are used, and how to save money. Each project includes a complete parts list with exact-part numbers. 300 pages, 324 illustrations. Book No. 3475, \$17.95 paperback, \$27.95 hardcover

ELECTRONIC SIGNALS AND SYSTEMS:

Television, Stereo, Satellite TV, and Automotive—Stan Prentiss

Study signal analysis as it applies to the operation and signal-generating capabilities of today's most advanced electronic devices with this handbook. It explains the composition and use of a wide variety of test instruments, transmission media, satellite systems, stereo broadcast and reception facilities, antennas, television equipment, and even automotive electrical systems. You'll find coverage of C- and Ku-band video, satellite master TV systems, high-definition television, C-QUAM® AM stereo transmission and reception, and more. 328 pages, 186 illustrations. Book No. 3557, \$19.95 paperback, \$29.95 hardcover

Prices Subject to Change Without Notice.

Look for These and Other TAB Books at Your Local Bookstore

To Order Call Toll Free 1-800-822-8158

(in PA, AK, and Canada call 717-794-2191)

or write to TAB Books, Blue Ridge Summit, PA 17294-0840.

Title	Product No.	Quantity	Price

Check or money order made payable to TAB Books

Subtotal \$ _____

Charge my VISA MasterCard American Express

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

Acct. No. _____ Exp. _____

Add applicable state and local
sales tax \$ _____

Signature: _____

TOTAL \$ _____

Name: _____

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

Address: _____

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

City: _____

**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**

State: _____ Zip: _____