

WITH  
CUMULATIVE INDEX

Rudolf F. Graf  
&  
William Sheets

Encyclopedia of  
**ELECTRONIC  
CIRCUITS**

Volume 5

Encyclopedia of

# **ELECTRONIC CIRCUITS**

Volume 5

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## **NAZIR MATNI ELECTRONICS**

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

TEL:+963-11-2221161

FAX:+963-11-2239468

E-Mail: [nazir@matni.com](mailto:nazir@matni.com)

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E.mail:nazir@matni.com

www.matni.com

Encyclopedia of

# **ELECTRONIC CIRCUITS**

Volume 5

Rudolf F. Graf  
&  
William Sheets

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# Contents

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<b>Introduction</b>	<b><i>xi</i></b>
<b>1 Alarm and Security Circuits</b>	<b>1</b>
<b>2 Amplifier Circuits</b>	<b>17</b>
<b>3 Analog-to-Digital Converter Circuits</b>	<b>27</b>
<b>4 Antenna Circuits</b>	<b>31</b>
<b>5 Audio Power Amplifier Circuits</b>	<b>39</b>
<b>6 Audio Signal Amplifier Circuits</b>	<b>52</b>
<b>7 Automatic Level Control Circuits</b>	<b>60</b>
<b>8 Automotive Circuits</b>	<b>63</b>
<b>9 Battery Charger Circuits</b>	<b>78</b>
<b>10 Battery Test and Monitor Circuits</b>	<b>82</b>
<b>11 Buffer Circuits</b>	<b>90</b>
<b>12 Carrier-Current Circuits</b>	<b>94</b>
<b>13 Clock Circuit</b>	<b>97</b>
<b>14 Code Practice Circuits</b>	<b>100</b>
<b>15 Color Organ Circuit</b>	<b>104</b>

<b>16</b>	Computer Circuits	<b>106</b>
<b>17</b>	Control Circuits	<b>111</b>
<b>18</b>	Converter Circuits	<b>116</b>
<b>19</b>	Counter Circuits	<b>129</b>
<b>20</b>	Crystal Oscillator and Test Circuits	<b>134</b>
<b>21</b>	Current Source Circuits	<b>141</b>
<b>22</b>	Current Limiter and Control Circuits	<b>144</b>
<b>23</b>	Delay Circuit	<b>147</b>
<b>24</b>	Detector, Demodulator, and Discriminator Circuits	<b>149</b>
<b>25</b>	Digital Circuits	<b>156</b>
<b>26</b>	Display Circuits	<b>161</b>
<b>27</b>	Doorbell Circuits	<b>168</b>
<b>28</b>	Fax Circuit	<b>171</b>
<b>29</b>	Field-Strength Meter Circuits	<b>174</b>
<b>30</b>	Filter Circuits	<b>177</b>
<b>31</b>	Flasher Circuits	<b>192</b>
<b>32</b>	Frequency Multiplier Circuit	<b>198</b>
<b>33</b>	Function and Signal Generator Circuits	<b>200</b>
<b>34</b>	Game Circuits	<b>208</b>
<b>35</b>	Gas Detector Circuits	<b>212</b>
<b>36</b>	Gate Circuit	<b>215</b>
<b>37</b>	Geiger Counter Circuits	<b>217</b>
<b>38</b>	Hall Effect Circuits	<b>220</b>
<b>39</b>	Infrared Circuits	<b>223</b>
<b>40</b>	Indicator Circuits	<b>230</b>
<b>41</b>	Instrumentation Amplifier Circuits	<b>233</b>
<b>42</b>	Integrator Circuit	<b>236</b>
<b>43</b>	Intercom Circuits	<b>238</b>
<b>44</b>	Interface Circuits	<b>241</b>
<b>45</b>	Inverter Circuits	<b>245</b>

<b>46</b>	<b>Ion Generator Circuit</b>	<b>248</b>
<b>47</b>	<b>Laser Circuits</b>	<b>250</b>
<b>48</b>	<b>Lie Detector Circuit</b>	<b>255</b>
<b>49</b>	<b>Light-Beam Communication Circuits</b>	<b>257</b>
<b>50</b>	<b>Light-Control Circuits</b>	<b>262</b>
<b>51</b>	<b>Light-Controlled Circuits</b>	<b>272</b>
<b>52</b>	<b>Light Sources Circuits</b>	<b>280</b>
<b>53</b>	<b>Load-Sensing Circuits</b>	<b>284</b>
<b>54</b>	<b>Mathematical Circuits</b>	<b>286</b>
<b>55</b>	<b>Measuring and Test Circuits</b>	<b>289</b>
<b>56</b>	<b>Metal Detector Circuits</b>	<b>322</b>
<b>57</b>	<b>Miscellaneous Treasures</b>	<b>325</b>
<b>58</b>	<b>Mixer Circuits</b>	<b>359</b>
<b>59</b>	<b>Modulator Circuits</b>	<b>365</b>
<b>60</b>	<b>Monitor Circuits</b>	<b>368</b>
<b>61</b>	<b>Moisture &amp; Fluid Detector Circuits</b>	<b>373</b>
<b>62</b>	<b>Motion Detector Circuits</b>	<b>376</b>
<b>63</b>	<b>Motor Control Circuits</b>	<b>378</b>
<b>64</b>	<b>Multiplexer Circuit</b>	<b>382</b>
<b>65</b>	<b>Multivibrator Circuits</b>	<b>384</b>
<b>66</b>	<b>Musical Circuits</b>	<b>389</b>
<b>67</b>	<b>Noise-Generator Circuit</b>	<b>394</b>
<b>68</b>	<b>Noise-Limiting Circuits</b>	<b>396</b>
<b>69</b>	<b>Operational Amplifier Circuits</b>	<b>399</b>
<b>70</b>	<b>Optical Circuits</b>	<b>404</b>
<b>71</b>	<b>Oscillator Circuits</b>	<b>410</b>
<b>72</b>	<b>Oscilloscope Circuits</b>	<b>422</b>
<b>73</b>	<b>Pest Control Circuits</b>	<b>427</b>
<b>74</b>	<b>Phase-Shifter Circuits</b>	<b>429</b>
<b>75</b>	<b>Photography Related Circuits</b>	<b>432</b>

<b>76</b>	Piezo Circuits	<b>439</b>
<b>77</b>	Power Supply Circuits—High Voltage	<b>442</b>
<b>78</b>	Power Supply Circuits—Low Voltage	<b>448</b>
<b>79</b>	Probe Circuits	<b>473</b>
<b>80</b>	Protection Circuits	<b>475</b>
<b>81</b>	Proximity Circuits	<b>484</b>
<b>82</b>	Pulse-Generator Circuits	<b>487</b>
<b>83</b>	Receiver Circuits	<b>493</b>
<b>84</b>	Relay Circuits	<b>504</b>
<b>85</b>	Remote-Control Circuits	<b>508</b>
<b>86</b>	RF Amplifier Circuits	<b>514</b>
<b>87</b>	RF Oscillator Circuits	<b>528</b>
<b>88</b>	Sample-and-Hold Circuits	<b>533</b>
<b>89</b>	SCA Circuit	<b>535</b>
<b>90</b>	Shutdown Circuits	<b>537</b>
<b>91</b>	Sine-Wave Oscillator Circuits	<b>539</b>
<b>92</b>	Sound- and Voice-Controlled Circuits	<b>545</b>
<b>93</b>	Sound-Effects Circuits	<b>556</b>
<b>94</b>	Square-Wave Generator Circuits	<b>568</b>
<b>95</b>	Stepper Motor Circuits	<b>571</b>
<b>96</b>	Stereo Circuits	<b>574</b>
<b>97</b>	Switching Circuits	<b>585</b>
<b>98</b>	Synch Circuits	<b>594</b>
<b>99</b>	Tachometer Circuits	<b>596</b>
<b>100</b>	Telephone-Related Circuits	<b>599</b>
<b>101</b>	Temperature-Related Circuits	<b>616</b>
<b>102</b>	Timer Circuits	<b>621</b>
<b>103</b>	Tone Circuits	<b>628</b>
<b>104</b>	Tone-Control Circuits	<b>630</b>
<b>105</b>	Touch-Control Circuits	<b>632</b>

<b>106</b>	Transmitter Circuits	<b>636</b>
<b>107</b>	Ultrasonic Circuits	<b>650</b>
<b>108</b>	Video Circuits	<b>654</b>
<b>109</b>	Voltage-Controlled Oscillator Circuits	<b>663</b>
<b>110</b>	Voltage-Converter/Inverter Circuits	<b>668</b>
<b>111</b>	Voltage Multiplier Circuits	<b>670</b>
<b>112</b>	Window Comparator and Discriminator Circuits	<b>673</b>
	<b>Sources</b>	<b>675</b>
	<b>Index</b>	<b>699</b>

# Introduction

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The *Encyclopedia of Electronic Circuits, Volume V* adds approximately 1000 new circuits to the treasury of carefully chosen circuits that cover nearly every phase of today's electronic technology. These five volumes contain a wealth of new ideas and up-to-date circuits garnered from prestigious industry sources. Also included are some of the authors' original designs.

Each circuit is accompanied by a brief explanation of how it works, unless the circuit's operation is either obvious or too complex to describe in a few words. In the latter case, the reader should consult the original source listed in the back of the book. The index includes all entries from Volumes I to V. This provides instant access to about 5000 circuits, which make up the most extensive collection of carefully categorized modern circuits available anywhere.

Once again, the authors wish to extend their thanks to Ms. Loretta Gonsalves, whose virtuoso performance at the word processor contributed so much to the successful completion of the manuscript for this work. We look forward to the pleasure of working with her on Volume VI, which is now under development.

Rudolf F. Graf and William Sheets

# 1

## Alarm and Security Circuits

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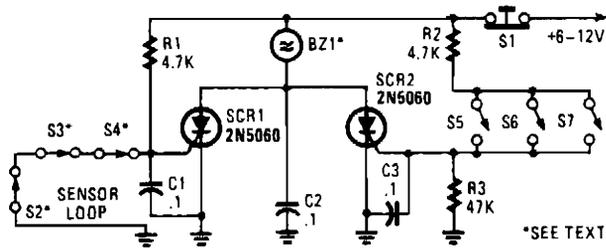
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

High-Power Alarm Driver	Exit Delay for Burglar Alarms
Multi-Loop Parallel Alarm	555-Based Alarm
Series/Parallel Loop Alarm	Light-Beam Alarm for Intrusion Detection
Parallel Loop Alarm	Light-Activated Alarm with Latch
Closed-Loop Alarm	Precision Light-Activated Alarm
Delayed Alarm	Dark-Activated Alarm with Pulsed Tone Output
Door Minder	Light-Beam Alarm Preamplifier
Strobe Alert System	Precision Light Alarm with Hysteresis
Warble Alarm	High-Output Pulsed-Tone/Light-Activated Alarm
Audio Alarm	Self-Latching Light Alarm with Tone Output
No-Doze Alarm	Alarm Sounder for Flex Switch
Heat- or Light-Activated Alarm	Burglar Chaser
Piezoelectric Alarm	Silent Alarm



## SERIES/PARALLEL LOOP ALARM

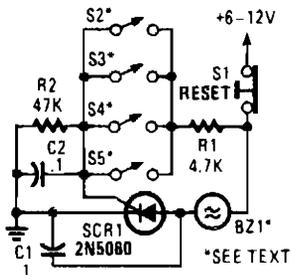


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FIG. 1-3

Two SCRs are used with two sensor loops. One loop uses series switches, the other loop parallel switches. When a switch actuation occurs, the SCR triggers. The alarm should be a noninterrupting type.

### PARALLEL LOOP ALARM

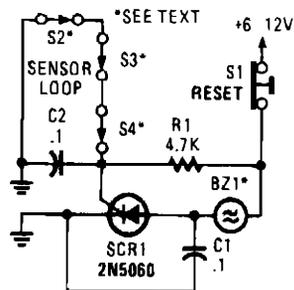


POPULAR ELECTRONICS

FIG. 1-4

Four parallel switches are used to monitor four positions. When a closure occurs on any switch, SCR1 triggers, which sounds the alarm. The alarm should be of the noninterrupting type.

### CLOSED-LOOP ALARM



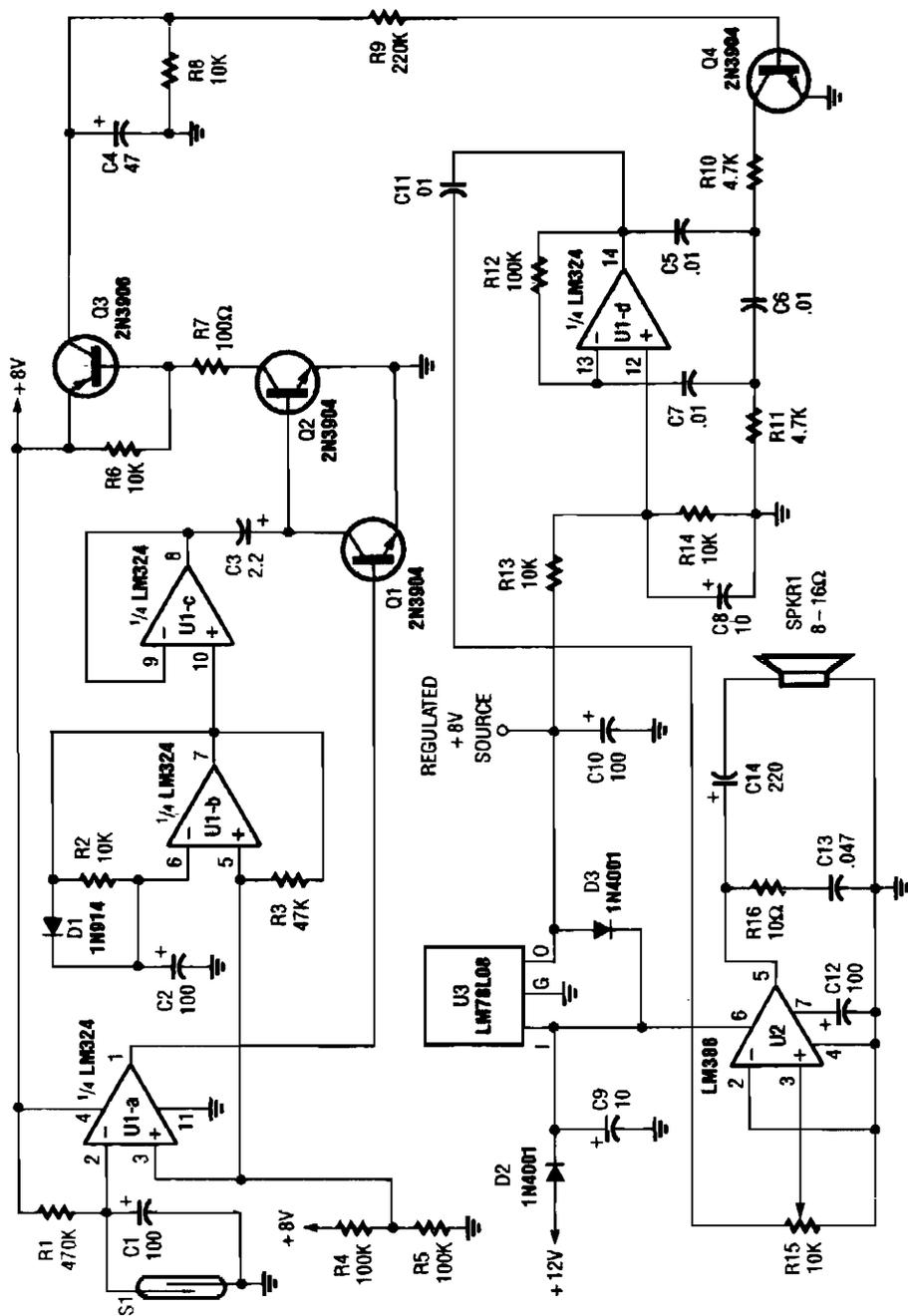
POPULAR ELECTRONICS

FIG. 1-5

A string of three series-connected, normally closed switches are connected across the gate of an SCR. When one opens, the SCR triggers via R1, sounding an alarm. The alarm should be of the noninterrupting type.



# DOOR MINDER

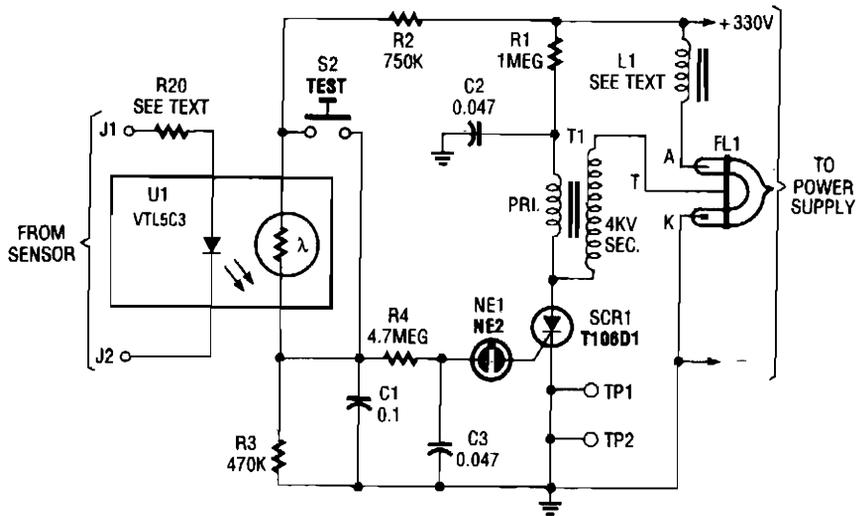


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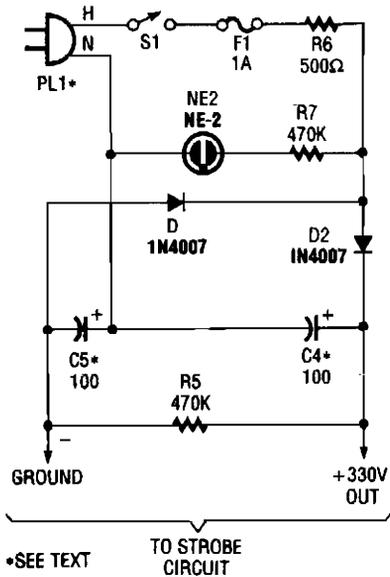
FIG. 1-7

This circuit monitors a door to determine if it has been left open. After 24 seconds, the alarm sounds, the alarm sounds, the alarm sounds. S1 is a magnetic sensor. The alarm is an electronic chime sound that is struck once per second.

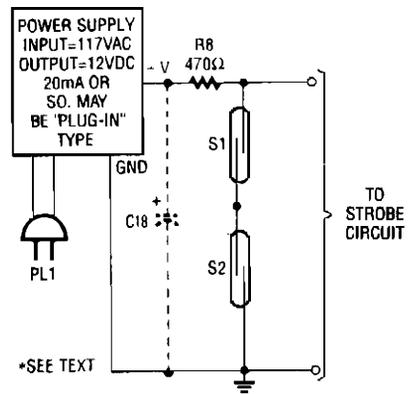
## STROBE ALERT SYSTEM



**A**



**B**



**C**

The circuit is activated by an LED/photoresistor isolator (U1), which is a combination of a light-dependent resistor (LDR) and an LED in a single package. That device was chosen because of its high isolation (2000 V) characteristic, which is necessary because the strobe part of the circuit is directly connected to the ac line.

## STROBE ALERT SYSTEM (Cont.)

The voltage divider is formed by R2, U1's internal resistance, and R3. When U1's internal LED is off, U1's internal LDR has a very high resistance—on the order of 10 M $\Omega$ . The voltage applied to NE1 is considerably below its ignition voltage of approximately 90 Vdc.

The optoisolator's internal LED is activated by a dc signal supplying 20 mA. The external sensor(s) that supply the signal are connected to the strobe part of the circuit at J1 and J2.

When the internal LED lights, the LDR's resistance decreases to around 5 k $\Omega$ . Under that condition, about 125 Vdc is applied across C1, R4, and C2. The neon lamp periodically fires and extinguishes as capacitor C3 charges through R4, and discharges via NE1 and the SCR gate.

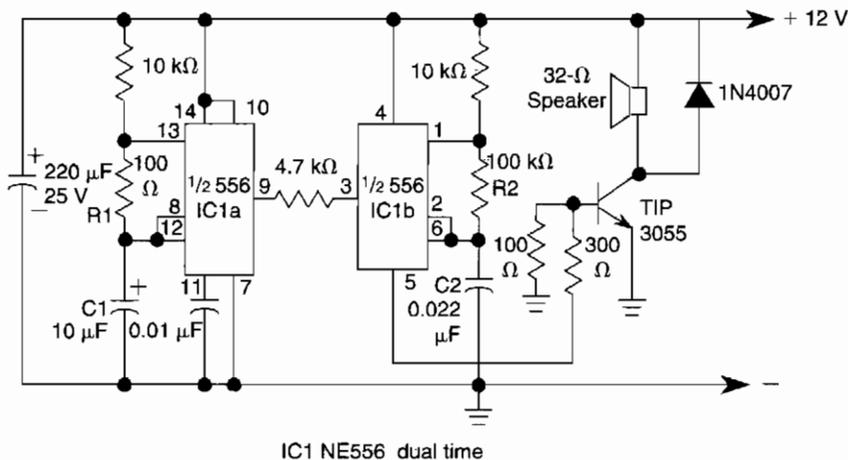
Resistor R4 restricts the current input to C3, and thereby controls the firing rate of NE1—about three times per second. The discharge through NE1 is applied to the gate of SCR1.

SCR1, a sensitive-gate unit, snaps on immediately when NE1 conducts, which completes the ground circuit for transformer T1 (a 4-kV trigger transformer). As SCR1 toggles on and off in time with the firing of NE1, capacitor C2 (connected in parallel with T1's primary) charges via R1, and then discharges very rapidly through T1's primary winding. A voltage pulse is applied to the trigger input of FL1, a Xenon flash lamp.

It is important to remember that the circuit is connected directly to the ac line. Resistor R6 is included to limit the amount of line current available to the circuit. The value of R6 can be decreased if you intend to modify the circuit for more flash power.

**Warning:** Even though the circuit is fusc-protected, it can still be dangerous if handled carelessly.

## WARBLE ALARM



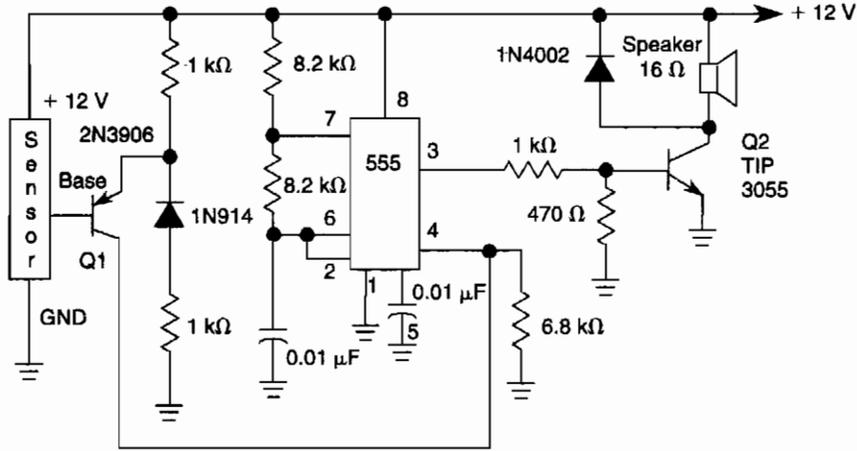
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FIG. 1-9

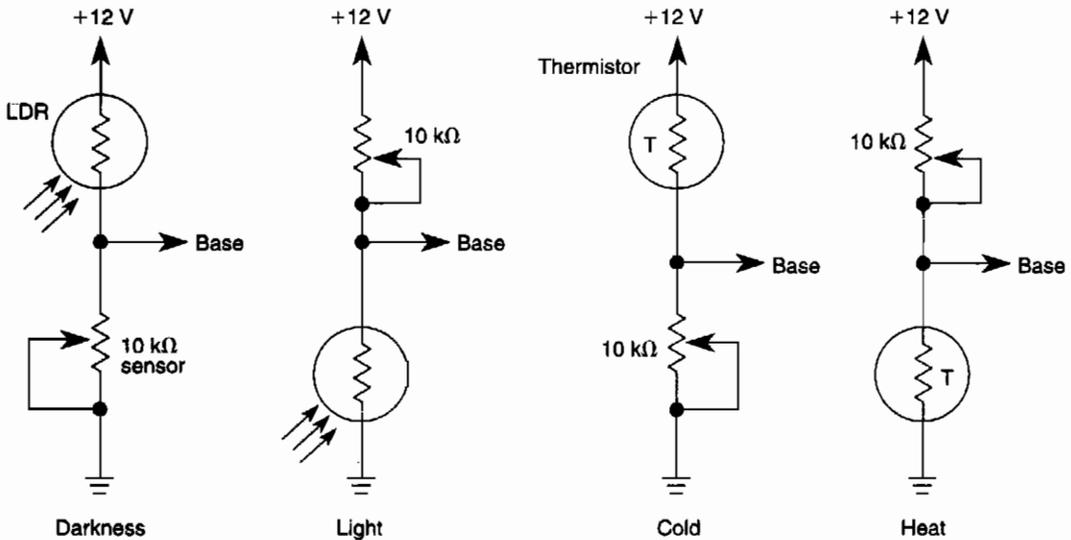
This circuit uses a 556 to first generate a low frequency square wave, that is modulated to produce two alternate tones of about 400 and 500 Hz. Circuit generates warble alarm of European emergency vehicles. The frequencies of the oscillators are determined by the values of R1, C1 and R2, C2.



## HEAT- OR LIGHT-ACTIVATED ALARM



### SENSOR CIRCUITS

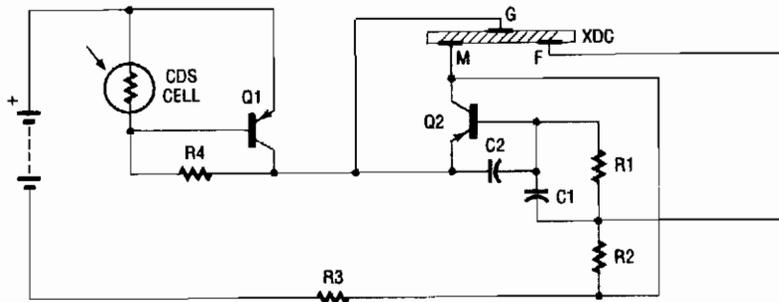


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FIG. 1-12

The tone generated by a 555 oscillator can be turned on (activated) by heat or light. That causes Q1 to conduct transistor W2 (TIP 3055). Q2 (TIP 3055) acts as an audio amplifier and speaker driver.

## PIEZOELECTRIC ALARM



- C1,C2..... .047 Disc Capacitor
- Q1,Q2..... 2N3906 Transistor
- R1..... 6.8K Resistor
- R2..... 33K Resistor
- R3..... 200 ohm Resistor
- R4..... 75K Resistor
- XDC..... Piezoelectric transducer

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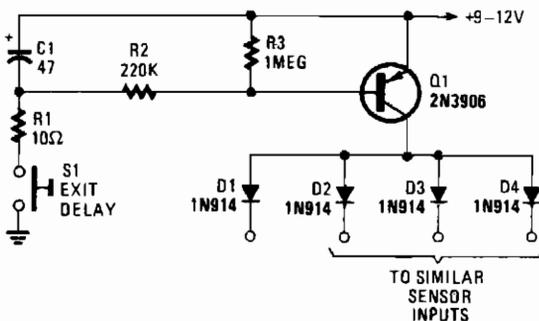
**FIG. 1-13**

The alarm uses a fixed-frequency piezoelectric buzzer in conjunction with the cadmium-sulfide (CDS) cell and the two-transistor circuit to provide a unique effect. Whenever light reaches the CDS photo-electric cell, the alarm is silent. But when no light strikes the cell, transistor Q1 turns on, and the circuit emits a high-pitched tone.

The alarm consists of a piezoelectric disk that oscillates at the fixed frequency of 3.137 kHz, created by transistor Q2, capacitor C1 and C2, and resistors R1 through R3. Transistor Q1 is used as a switch. It is forward-biased "on" by R4; however, the CDS cell turns Q1 "off" when the light is striking it.

A CDS photo cell is made from cadmium sulfide, a semiconductor material that changes resistance when the light strikes it. The greater the amount of light, the lower the resistance. The low resistance conducts positive voltage to the base of pnp transistor Q1, keeping it turned "off" when the light shines on the CDS cell. As soon as the light is removed, the CDS cell provides a resistance of over 100 kΩ. That causes Q1 to turn "on," allowing a positive voltage to reach the emitter lead of Q2, which then begins to oscillate. That then causes the piezoelectric element (transducer) to produce a loud signal.

## EXIT DELAY FOR BURGLAR ALARMS

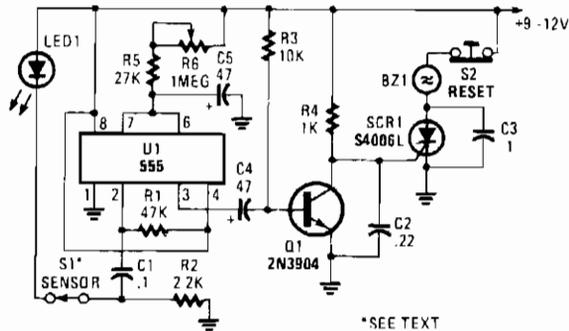


Depressing S1 charges C1 to the supply voltage. This biases Q1 on via bias resistors R2 and R3. A voltage is available for the duration of the delay period, to hold off the alarm circuit. C1 can be increased or decreased in value to alter the delay times.

POPULAR ELECTRONICS

**FIG. 1-14**

## 555-BASED ALARM



POPULAR ELECTRONICS

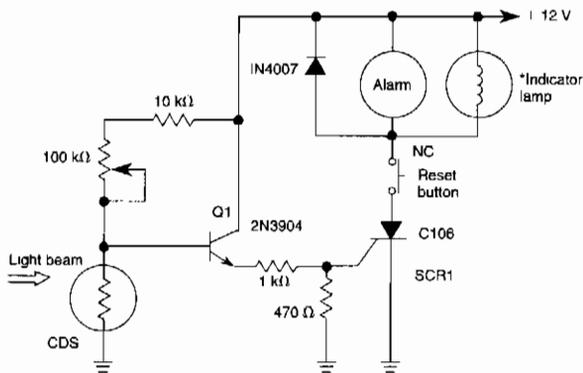
FIG. 1-15

The alarm circuit has a single 555 oscillator/timer (U1) performing double duty; serving both in the alarm-trigger circuit and the entry-delay circuit. In this application, the trigger input of U1 at pin 2 is held high via R1. A normally-closed sensor switch, S1, supplies a positive voltage to the junction of R2 and C1, and lights LED1. With both ends of C1 tied high, there is no charge on C1. But when S1 opens, C1 (initially acting as a short) momentarily pulls pin 2 of U1 low, triggering the timed delay circle.

At the beginning of the timing cycle, U1 produces a positive voltage at pin 3, which charges C4 to near the positive voltage at pin 3, which charges C4 to near the positive supply voltage. Transistor Q1 is heavily biased on by R3, keeping its collector at near ground level. With Q1 on, SCR1's gate is clamped to ground, holding it off. When the delay circuit times out, pin 3 of U1 goes low and ties the positive end of C4 to ground. That turns Q1 off.

When Q1 turns off, the voltage at the gate of SCR goes positive, turning on the SCR and sounding the alarm. The delay time is adjustable from just a few seconds (R6 set to its minimum resistance) to about one minute (R6 adjusted to its maximum resistance).

## LIGHT-BEAM ALARM FOR INTRUSION DETECTION



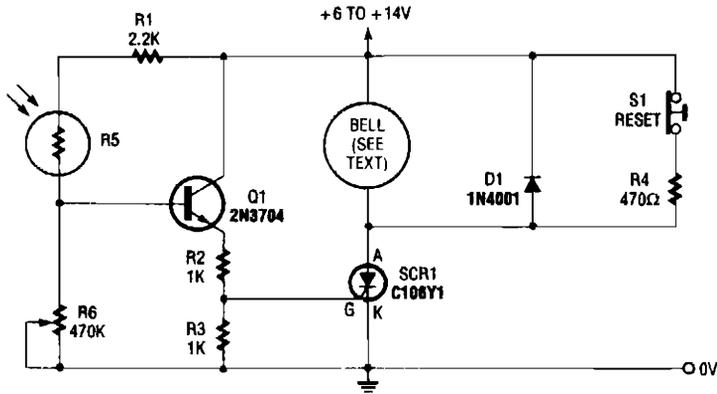
\* Lamp should draw at least 100 mA to sensure SCR1 remaining on during alarm cycle

When the light beam that falls in the CDS photocell is interrupted, transistor (EN3904) conducts thereby triggering SCR1 (C106) and activating alarm bell. S1 resets the SCR. The alarm bell should be a self-interrupting electro-mechanical type.

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FIG. 1-16

## LIGHT-ACTIVATED ALARM WITH LATCH

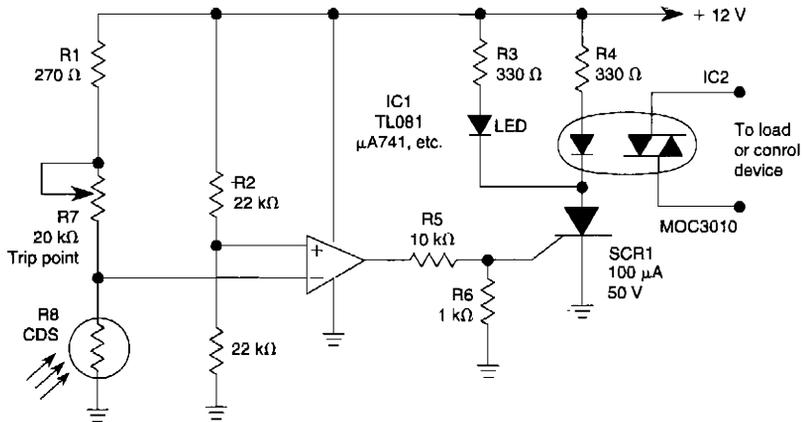


ELECTRONICS NOW

FIG. 1-17

In this circuit, light causes R5 to conduct forward-biasing Q1. R6 sets sensitivity. SCR1 is triggered from the emitter voltage on Q1, sounding the alarm bell. When S1 is depressed, SCR1 unlatches. Be sure that a self-interrupting alarm (electromechanical buzzer or bell) is used.

## PRECISION LIGHT-ACTIVATED ALARM

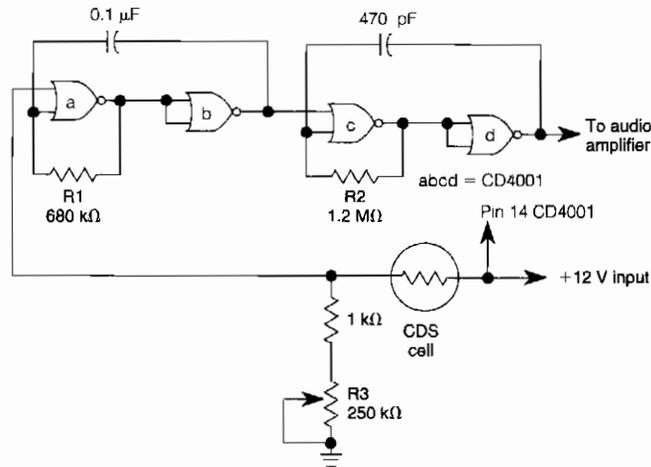


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FIG. 1-18

The light-sensitive CDS cell R8 configured in a bridge circuit with IC1 as a comparator causes IC1's output to go high when light strikes the CDS cell R8, triggering SCR1. This lights LED1 and turns on opto isolator IC2, which switches the load.

## DARK-ACTIVATED ALARM WITH PULSED TONE OUTPUT

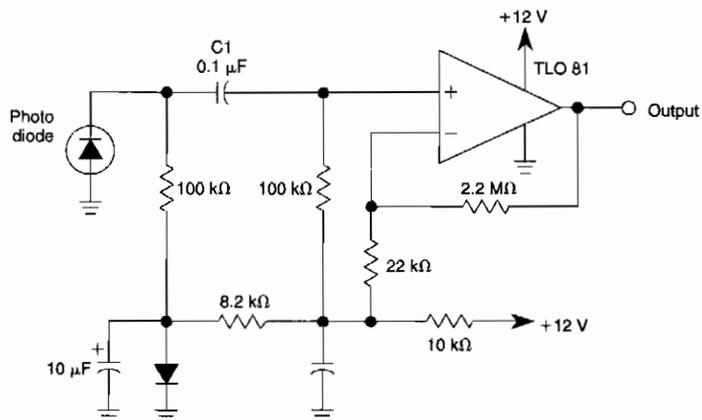


WILLIAM SHEETS

FIG. 1-19

NOR gates a and b form a low-frequency oscillator that is activated when the CDS cell, under dark conditions, causes NOR gate a to see a logic zero at one input. This low-frequency (10 Hz) gates a high-frequency oscillator (c and d) to oscillate at around 1000 Hz. R1 can be varied to change the pulse rate and R2 to change the tone. R3 sets the trigger point.

## LIGHT-BEAM ALARM PREAMPLIFIER

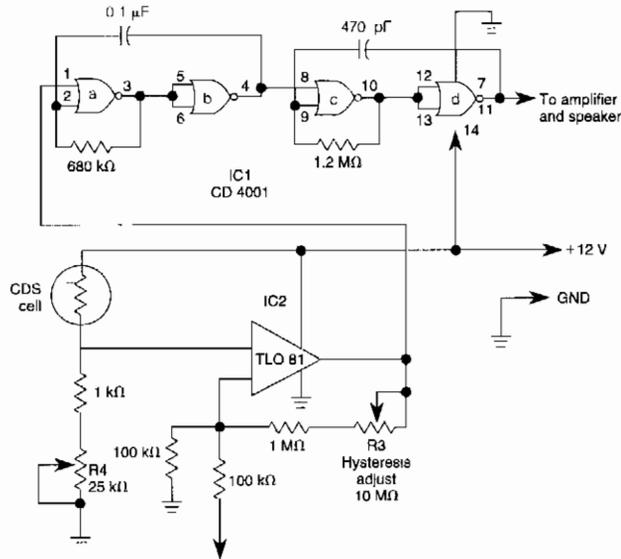


WILLIAM SHEETS

FIG. 1-20

This circuit can be used for light beams to 20 kHz. The gain of the operational amplifier is set for a 40-dB gain.

## PRECISION LIGHT ALARM WITH HYSTERESIS

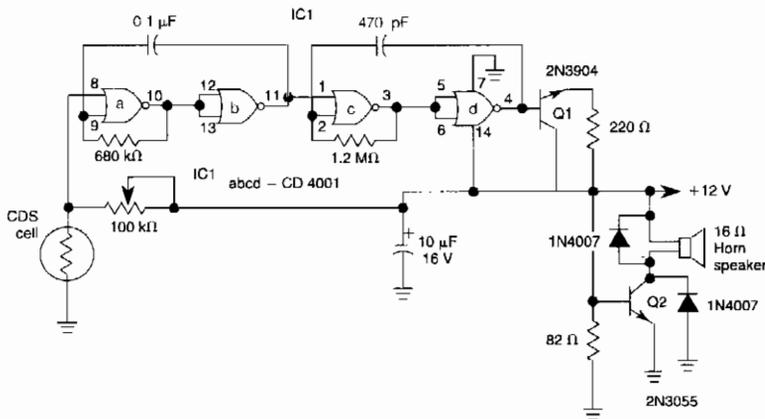


WILLIAM SHEETS

FIG. 1-21

The TL081 is used as a comparator in a Wheatstone bridge circuit. When the CDS cell resistance decreases due to exposure to light, the output from IC2 cause the low-frequency oscillator (a) and (b) to generate a 10-Hz square wave, gating the 1000 Hz oscillator (c) and (d) on and off. This signal drives an amplifier. R3 controls hysteresis, which reduces on-off triggering near the threshold set by R4.

## HIGH-OUTPUT PULSED-TONE/LIGHT-ACTIVATED ALARM

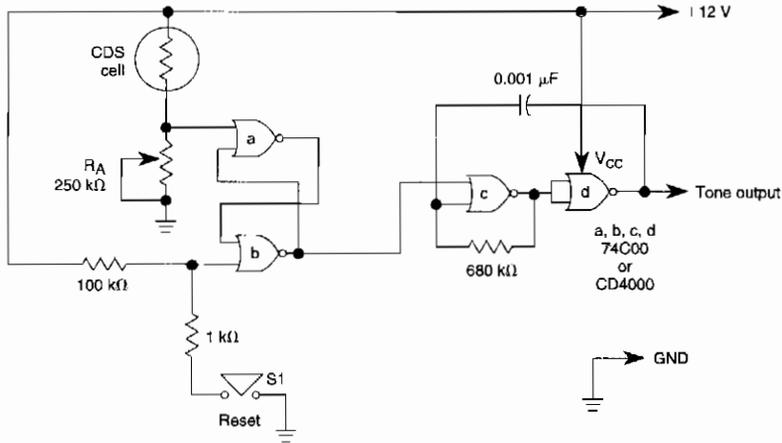


WILLIAM SHEETS

FIG. 1-22

This circuit can produce up to 1 W of audio power to drive a speaker or horn. When the CDS cell is struck by light, its resistance decreases thus activating NOR gate (a) thereby causing (a) and (b) to produce a low-frequency (10-Hz) square wave. This pulses the 1-kHz oscillator (c) and (d), causing it to generate a pulsed 1-kHz tone at a 10-Hz rate. Q1 and Q2 amplify this signal. Q2 (2N3055) drives the speaker.

## SELF-LATCHING LIGHT ALARM WITH TONE OUTPUT

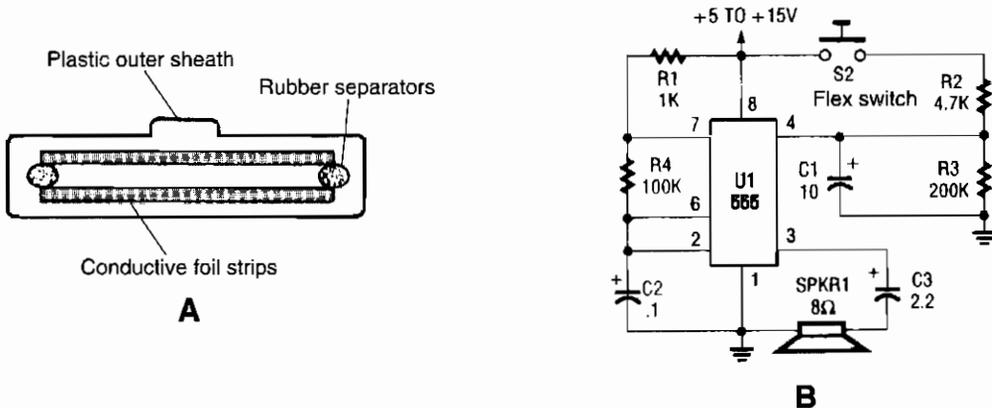


WILLIAM SHEETS

FIG. 1-23

A decrease in the resistance of the CDS cell when light strikes it activates latch a and b, enabling tone oscillator c and d which produces an output of about 1000 Hz.  $R_A$  sets the trip level. S1 resets the circuit.

## ALARM SOUNDER FOR FLEX SWITCH

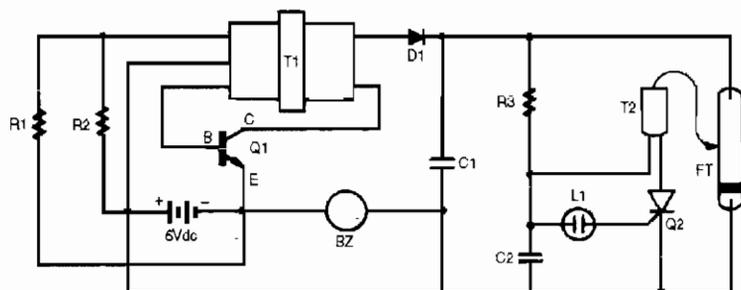


POPULAR ELECTRONICS

FIG. 1-24

This is a cross-sectional diagram of a flex switch. They can be used as pushbutton or even position sensors. This schematic diagram shows an oscillator, which is used as an alarm sounder, triggered by a flex switch.

## BURGLAR CHASER



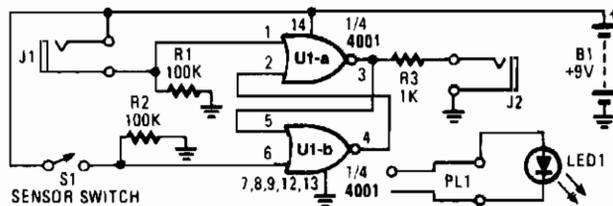
BZ.....	Metal Horn Buzzer
C1.....	.5 $\mu$ F 250 volts Capacitor
C2.....	.022 $\mu$ F Green Cap (223 K5K)
D1.....	.1N4007 Diode
FT.....	Micro Strobe Tube/Reflector
L1.....	Neon Lamp
Q1.....	C1740 SW Transistor
Q2.....	106 SCR
R1.....	200 ohm Resistor
R2.....	820 ohm Resistor
R3.....	10 meg Resistor
T1.....	Inverter Transformer
T2.....	4 kV Trigger Coll

1991 PE HOBBYIST HANDBOOK

FIG. 1-25

The burglar chaser makes a great accessory for any alarm system. It creates brilliant flashes of white light and a loud, irritating sound from a metal horn buzzer. Transformer T1 is connected to Q1, R1, and R2 to form a blocking oscillator. This creates a 6-Vac signal on the primary of T1. Because of T1's large ratio of turns from primary to secondary, the 6-Vac signal is stepped up to a level of over 200 Vac, which is then rectified by D1. The resultant dc voltage is applied to storage capacitor C1 and the neon relaxation oscillator made up of R3, C2, and L1. Each time C2 charges up to a sufficient level, it ionizes L1, which causes SCR Q2 to fire. The firing SCR causes the charge on C2 to be applied to the trigger coil. The trigger coil converts the 200 V into the 4000-V pulse that is needed to fire micro xenon strobe tube/reflector FT. The cycle repeats itself after the strobe tube flashes.

## SILENT ALARM



POPULAR ELECTRONICS

FIG. 1-26

A sensor switch triggers a set-reset flip flop and lights an LED.

## 2

# Amplifier Circuits

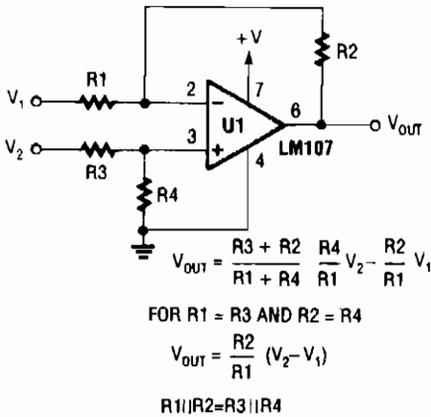
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Difference Amplifier	Electret Mike Preamp
Fast-Inverting Amplifier with High Input Impedance	Difference Amplifier
Noninverting ac Amplifier	General-Purpose JFET Preamp
Inverting Summing Amplifier	FET Amplifier with Offset Gate Bias
Noninverting ac Amplifier	Push-Pull Darlington Amplifier
Fast High-Impedance Input-Inverting Amplifier	Noninverted Unity-Gain Amplifier
Nonlinear Operational Amplifier with Temperature-Compensated Breakpoint	500 M $\Omega$ Input Impedance with JFET Amp
MOSFET High-Impedance Biasing Method	Discrete Current-Booster Amplifier
Inverting Summing Amplifier	Frequency Counter Preamp
Bootstrapped Source Follower	Audio to UHF Preamp
30 M $\Omega$ JFET Source Follower	V- & I-Protected Intrinsically Safe Op Amp
JFET Source Follower	Current Feedback Amp Delivers 100 mA @ 100 MHz
Unity-Gain Noninverting Amplifier	General-Purpose Preamplifier
JFET Amp with Current Source Biasing	Test Bench Amplifier

### DIFFERENCE AMPLIFIER

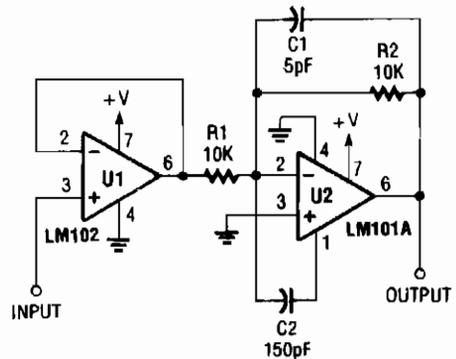


POPULAR ELECTRONICS

FIG. 2-1

By using two inputs as shown, a difference amplifier yielding the differential between U1 and U2, times a gain factor results.

### FAST-INVERTING AMPLIFIER WITH HIGH INPUT IMPEDANCE

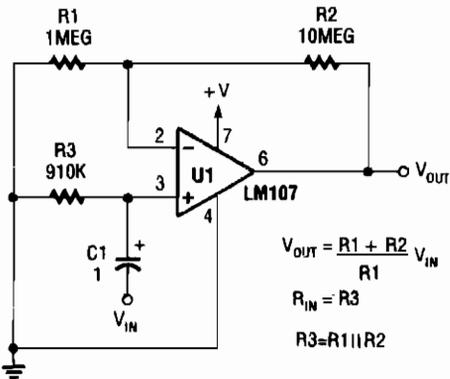


POPULAR ELECTRONICS

FIG. 2-2

U1 is used as a voltage follower to feed inverter U2. Because U1 is in the voltage-follower configuration, it exhibits a high input impedance.

### NONINVERTING ac AMPLIFIER

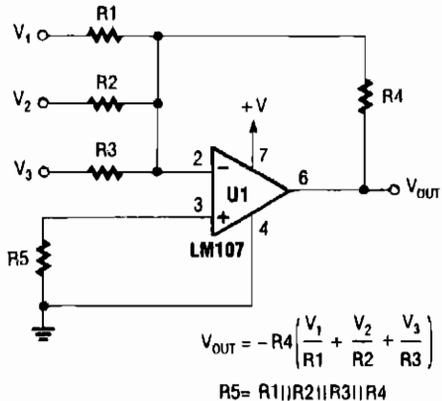


POPULAR ELECTRONICS

FIG. 2-3

A general-purpose noninverting ac amplifier for audio or other low-frequency applications is shown. Design equations are in the figure. Almost any general-purpose op amp can be used for U1.

### INVERTING SUMMING AMPLIFIER

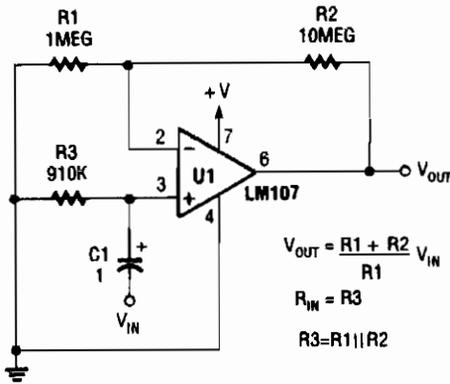


POPULAR ELECTRONICS

FIG. 2-4

The output of U1 is the sum of  $V_1$ ,  $V_2$ , and  $V_3$ , multiplied by  $R_1/R_4$ ,  $R_2/R_4$ , and respectively.  $R_1$ ,  $R_2$ ,  $R_3$  are selected as required for individual gains.  $R_4$  affects gain of all these inputs.

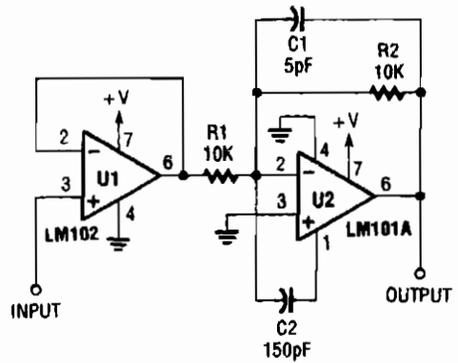
### NONINVERTING ac AMPLIFIER



POPULAR ELECTRONICS

FIG. 2-5

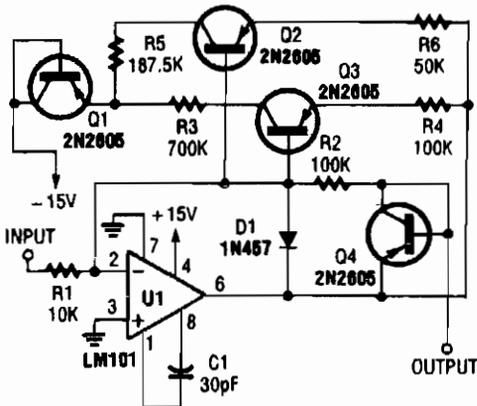
### FAST HIGH-IMPEDANCE INPUT-INVERTING AMPLIFIER



POPULAR ELECTRONICS

FIG. 2-6

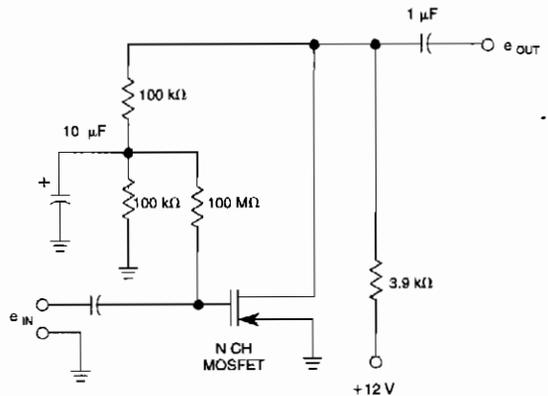
### NONLINEAR OPERATIONAL AMPLIFIER WITH TEMPERATURE COMPENSATED-BREAKPOINT



POPULAR ELECTRONICS

FIG. 2-7

### MOSFET HIGH-IMPEDANCE BIASING METHOD

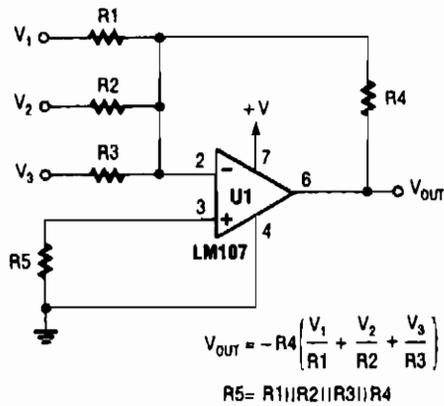


WILLIAM SHEETS

FIG. 2-8

High-impedance biasing method for an N-channel MOSFET to form a linear-inverting amplifier.

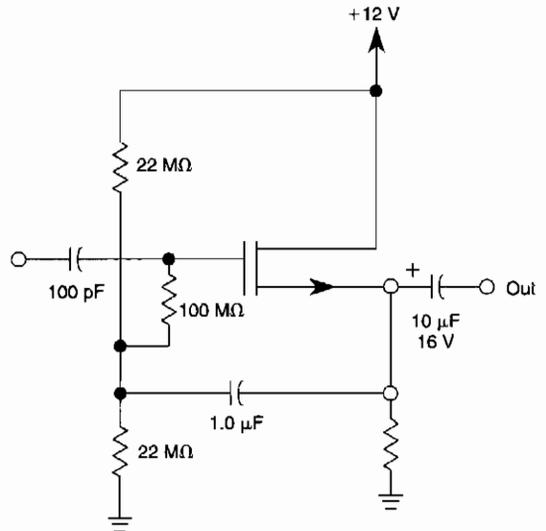
### INVERTING SUMMING AMPLIFIER



POPULAR ELECTRONICS

FIG. 2-9

### BOOTSTRAPPED SOURCE FOLLOWER

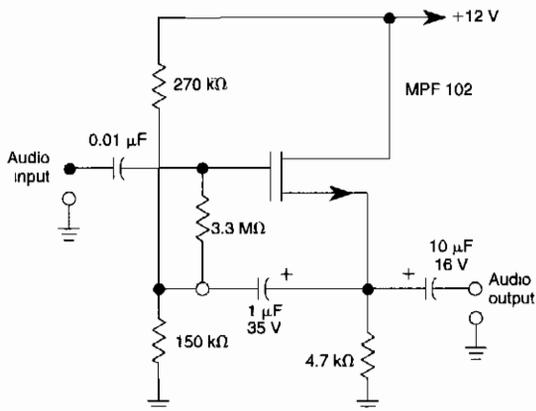


WILLIAM SHEETS

FIG. 2-10

This bootstrapped source follower uses an N-channel MOSFET. It has a high input impedance.

### 30-MΩ JFET SOURCE FOLLOWER

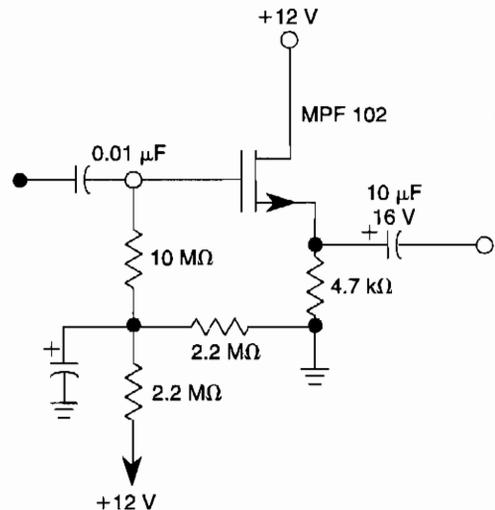


WILLIAM SHEETS

FIG. 2-11

This JFET source-follower uses an MPF102 with offset biasing. It has an input impedance of >30 MΩ.

### JFET SOURCE FOLLOWER

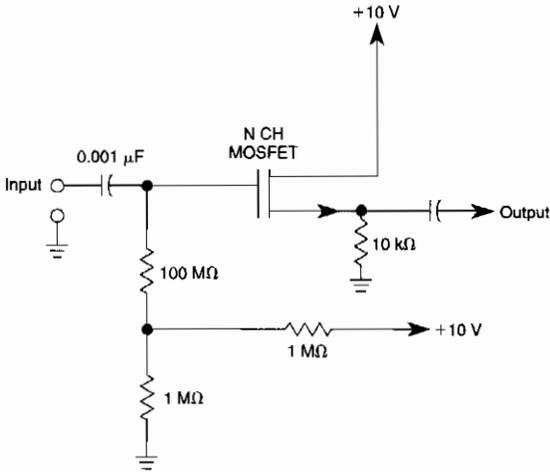


WILLIAM SHEETS

FIG. 2-12

The circuit uses positive gate bias to improve the operating point for better dynamic range.

### UNITY-GAIN NONINVERTING AMPLIFIER

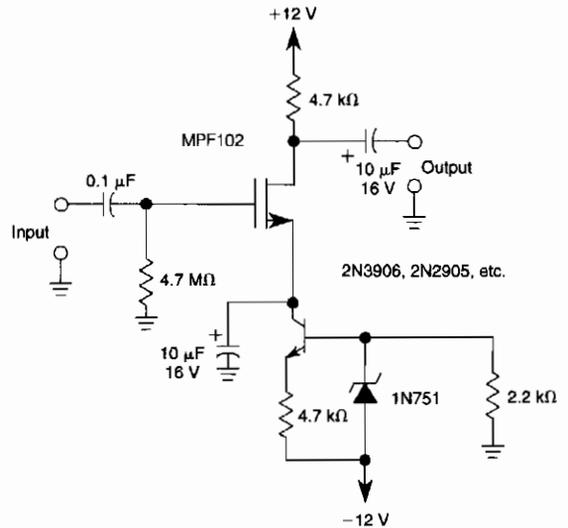


WILLIAM SHEETS

FIG. 2-13

Biasing methods for an N-channel MOSFET to form a unity-gain noninverting amplifier or source-follower.

### JFET AMP WITH CURRENT SOURCE BIASING

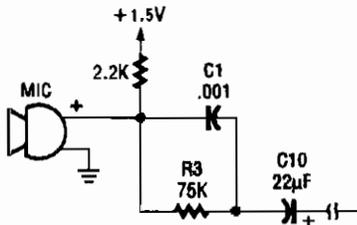


WILLIAM SHEETS

FIG. 2-14

A current source (MPF102) in the source lead of bipolar transistor 2N3906 permits accurate control of drain current.

### ELECTRET MIKE PREAMP

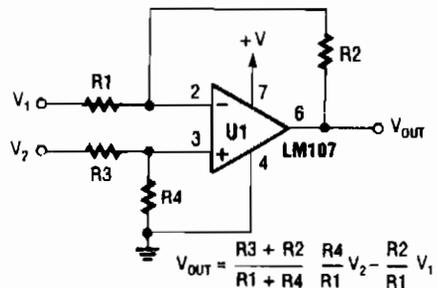


ELECTRONICS NOW

FIG. 2-15

This circuit is suitable for using an electret microphone for many applications. A 1.5-V battery is used. C1 and R3 provide treble boost/bass cut; they can be eliminated, if desired.

### DIFFERENCE AMPLIFIER



$$V_{OUT} = \frac{R3 + R2}{R1 + R4} \frac{R4}{R1} V_2 - \frac{R2}{R1} V_1$$

$$\text{FOR } R1 = R3 \text{ AND } R2 = R4$$

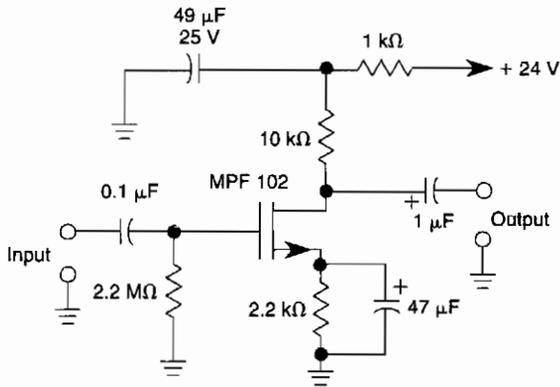
$$V_{OUT} = \frac{R2}{R1} (V_2 - V_1)$$

$$R1 || R2 = R3 || R4$$

POPULAR ELECTRONICS

FIG. 2-16

### GENERAL-PURPOSE JFET PREAMP

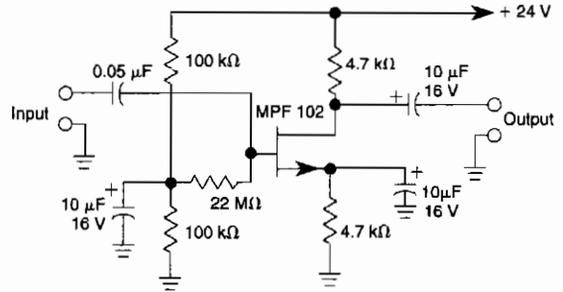


WILLIAM SHEETS

FIG. 2-17

This JFET preamplifier has a gain of about 20 dB and a bandwidth of over 100 kHz. It is useful as a low-level audio amplifier for high-impedance sources.

### FET AMPLIFIER WITH OFFSET GATE BIAS

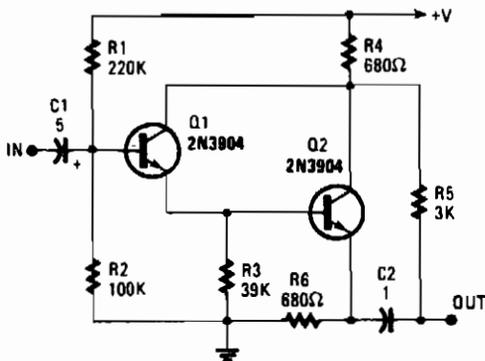


WILLIAM SHEETS

FIG. 2-18

In this amplifier circuit, the gate of the MPF102 is biased with an external voltage. This circuit achieves tighter control of the operating point and biasing conditions.

### PUSH-PULL DARLINGTON AMPLIFIER

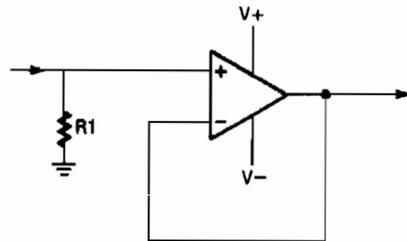


POPULAR ELECTRONICS

FIG. 2-19

This circuit has a high-Z input and push-pull output via the output taken across R4 and R6.

### NONINVERTED UNITY-GAIN AMPLIFIER

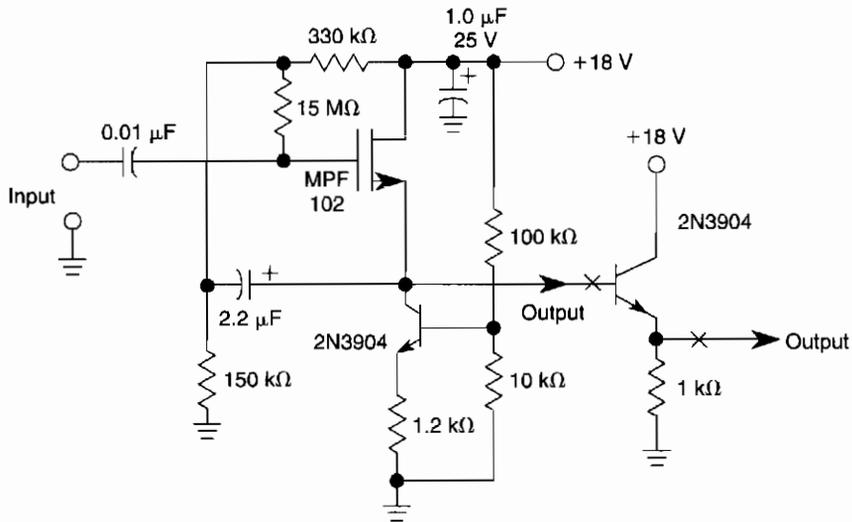


WILLIAM SHEETS

FIG. 2-20

An op amp can be used as a unity gain amplifier by connecting its output to its inverting input as shown. R1 should be low enough so the bias current of the op amp does not cause an appreciable offset.

## 500-M $\Omega$ INPUT IMPEDANCE WITH JFET AMP

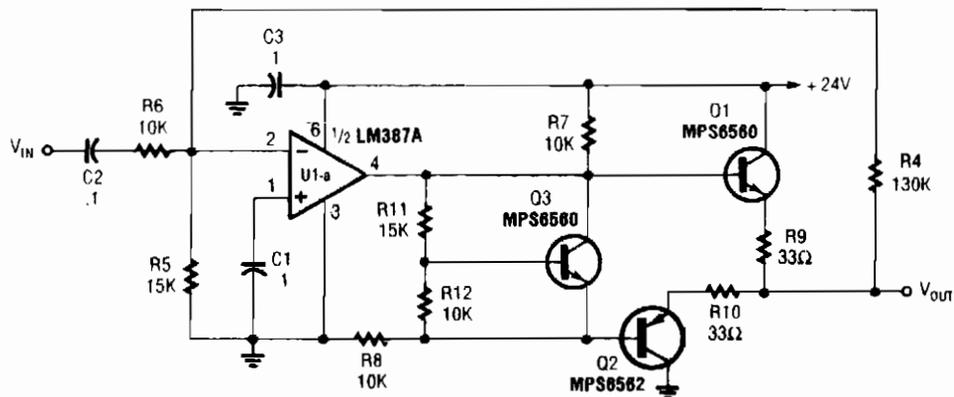


WILLIAM SHEETS

FIG. 2-21

A current source using a 2N3904 transistor plus bootstrapping, achieves an input impedance of 500 M $\Omega$ . A second 2N3904 transistor can be added at X to lower the output impedance.

## DISCRETE CURRENT-BOOSTER AMPLIFIER

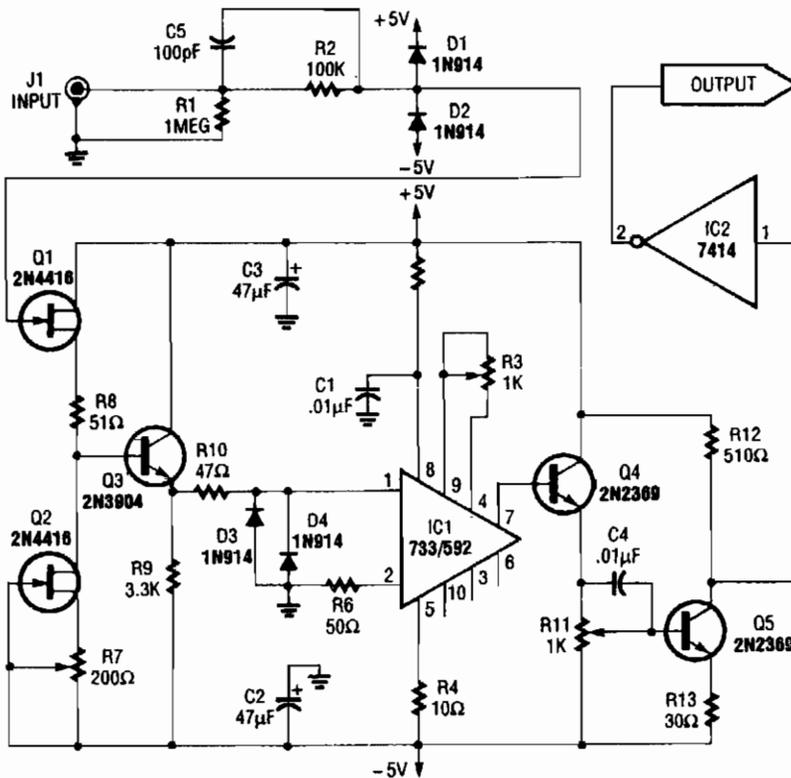


POPULAR ELECTRONICS

FIG. 2-22

Suitable as a line driver, this circuit is useable in many similar audio applications.

## FREQUENCY COUNTER PREAMP

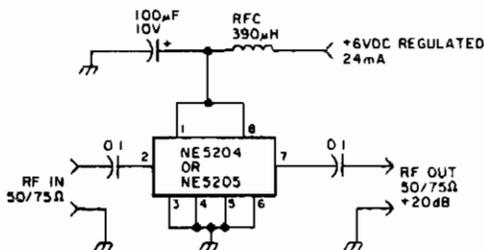


RADIO-ELECTRONICS

FIG. 2-23

Based on the LM733 or NE592, the preamp shown has a bandwidth of 100 MHz. The FET inputs provide about  $1\text{-M}\Omega$  input impedance. Q4, Q5, and IC2 provide signal conditioning.

## AUDIO TO UHF PREAMP

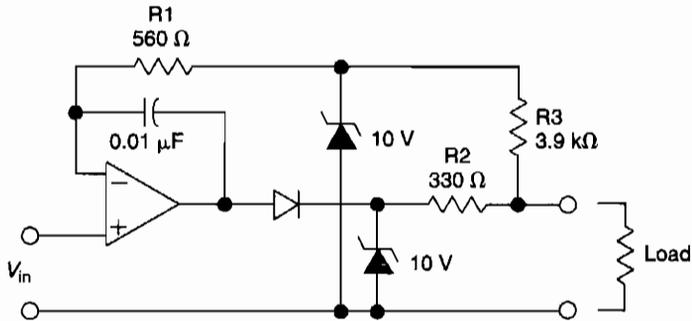


The Signetics NE5204 or NE5205 can be used in this AF to 350-MHz ( $-30$  dB) preamp. If 600 MHz @ 3 dB is needed, use the NE5205. The noise figure is 4.8 dB at  $75\ \Omega$ , 6 dB at  $50\ \Omega$ . Gain is approximately +20 dB over the passband.

73 AMATEUR RADIO TODAY

FIG. 2-24

## V- & I-PROTECTED INTRINSICALLY SAFE OP AMP



WILLIAM SHEETS

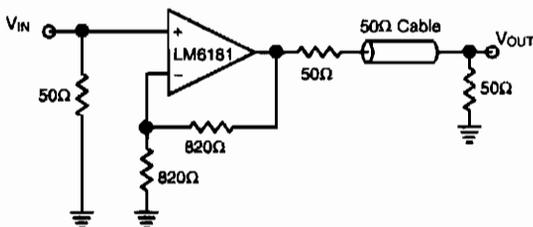
FIG. 2-25

The circuit is designed to drive an external load. A fault condition in the external load circuit could feed excessive current or voltage back into the line drive circuit. If excessive voltage appears from the load, the two zener diodes will clamp that voltage to a safe level, which in this case is 10 V.

The current in the zener diodes, op amp, and the remainder of the circuitry is limited to a safe level by resistors R1, R2, and R3. D1 protects the op-amp output stage from 10 V appearing across the clamp diodes under a fault condition.

The advantage of this circuit is that, although it's designed as unity gain buffer, the same techniques can be applied to inverting, noninverting, or differential gain stages.

## CURRENT FEEDBACK AMP DELIVERS 100 mA @ 100 MHz

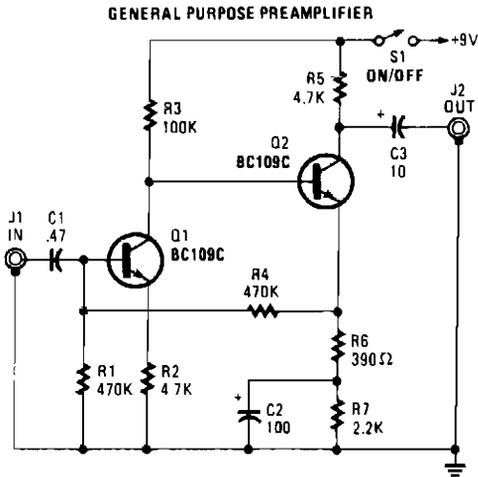


Using a NS LM6181, this IC is useful in cable drivers. The supply voltage is  $\pm 5$  V to  $\pm 15$  V.

NATIONAL SEMICONDUCTOR

FIG. 2-26

## GENERAL-PURPOSE PREAMPLIFIER

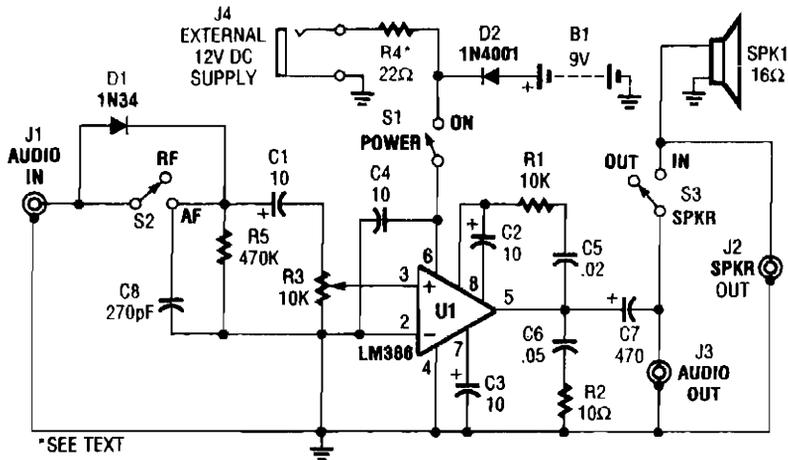


Suitable for general audio use, the preamp circuit uses a feedback pair. Current gain is set by the ratio of  $(R_4 + R_6)/R_4$ .

POPULAR ELECTRONICS

FIG. 2-27

## TEST BENCH AMPLIFIER



POPULAR ELECTRONICS

FIG. 2-28

This amplifier might be useful in servicing or bench testing as a signal tracer or as a building block in various systems.

# 3

## Analog-to-Digital Converter Circuits

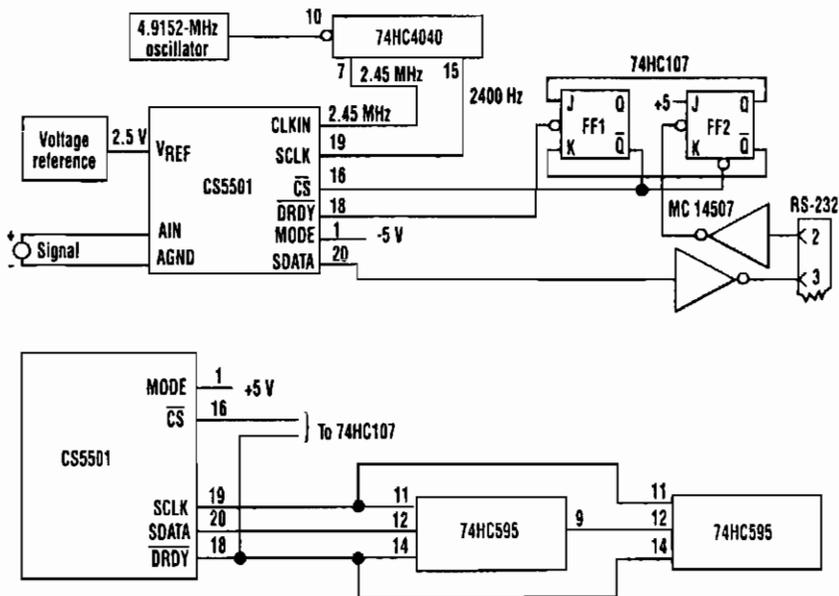
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

ADC Poller  
8-Channel A/D Converter for PC Clones

## ADC POLLER



ELECTRONIC DESIGN

FIG. 3-1

Because the CS5501 16-bit-delta-sigma analog-to-digital converter lacks a “start convert” command, it converts continuously, outputting conversion words to its output register every 1024 cycles of its master clock. However, by incorporating a standard dual J-K flip-flop into the circuit, the ADC can be configured to output a single-conversion word only when it is polled.

The CS5501 converter can be operated in its asynchronous communication mode (UART) to transmit one 16-bit conversion word when it is polled over an RS-232 serial line (see figure). A null character (all zeros) is transmitted to the circuit and sets the flip-flop FF2. The CS5501 can then output a single-conversion word, which is transmitted over the RS-232 line as two bytes with start and stop bits.

The baud rate can be chosen by selecting the appropriate clock divider rate on the 74HC4040 counter/divider as the serial port clock (SLCK) for the ADC. This type of polled-mode operation is also useful when the ADC’s output register is configured to operate in the synchronous-serial clock (SSC) mode. In this case, the converter will load one output word into a 16-bit serial-to-parallel register (two 74HC595 8-bit registers) when polled to do so (see figure).

## 8-CHANNEL A/D CONVERTER FOR PC CLONES

The following program causes the A-D converter to perform eight sequential conversions and display the result. It's written in Turbo BASIC/Power BASIC source code but it will run under the GWBASIC interpreter if you replace the delay statements with FOR/NEXT loops, and add line numbers as shown in the second highlighting. These loop statements are available on the 73 BBS under the filename: ADC-Turbo.BAS and ADGW.BAS.

```

INITIALIZE: 'marks follow the apostrophe
screen 0
color 14,0
cls
clear
toggle%:=2
oddsign%:=0

MINILOOP:
while not inat
out 880,1
delay 1
out 880,0
delay 054
for ch%:=0 to 7
out 888,8
out 888,0
out 880,2
out 890,0
for slow%:=0 to 1:next slow%
out 880,1
out 888,2
out 890,0
for slow%:=0 to 1:next slow%
out 880,1
out 888,oddsign%
out 890,0
for slow%:=0 to 1:next slow%
out 888,select1%
out 890,0
for slow%:=0 to 1:next slow%
out 888,select0%
out 890,0
for slow%:=0 to 1:next slow%
out 880,1
READBITS:
for bit%:=7 to 0 step -1
out 890,0
for slow%:=0 to 1:next slow%
out 890,1
if ar%<120 then byte%:=byte%+(2*bit%)
if bit% then
select1%:=0: select0%:=0: ch7volts:=byte%/51
if ch%:=1 then
select1%:=0: select0%:=2: ch7volts:=byte%/51
if ch%:=2 then
select1%:=0: select0%:=2: ch7volts:=byte%/51
if ch%:=3 then
select1%:=2: select0%:=0: ch7volts:=byte%/51
if ch%:=4 then
select1%:=2: select0%:=0: ch7volts:=byte%/51
if ch%:=5 then
select1%:=2: select0%:=2: ch7volts:=byte%/51
if ch%:=6 then
select1%:=2: select0%:=2: ch7volts:=byte%/51
if ch%:=7 then
select1%:=0: select0%:=0: ch7volts:=byte%/51
next ch%
next bit%
print using "##.#" ch7volts, ch1volts, ch2volts, ch4volts, ch5volts, ch6volts, ch7volts
wend
  
```

### GWBASIC Version

```

10 ' The following program causes the A-D converter to perform eight
20 ' sequential conversions and display the result.
30 SCREEN 0
40 COLOR 14,0
50 CLS
60 TOGGLE%:=2
80 ODDSIGN%:=0
90 IF INKEY$="" THEN END
100 OUT 888,1
120 FOR WP%:=0 TO 500:NEXT WP%
130 FOR CH%:=0 TO 7
140 OUT 888,8
150 OUT 888,0
170 OUT 890,0
180 FOR SLOW%:=0 TO 1:NEXT SLOW%
190 OUT 880,1
200 OUT 888,2
210 OUT 890,0
220 FOR SLOW%:=0 TO 1:NEXT SLOW%
230 OUT 880,1
240 OUT 888,ODDSIGN%
250 SWAP ODDSIGN%,TOGGLE%
260 OUT 880,0
270 OUT 890,0
280 OUT 888,SELECT1%
290 OUT 888,SELECT1%
300 OUT 890,0
310 FOR SLOW%:=0 TO 1:NEXT SLOW%
320 OUT 880,1
330 OUT 888,SELECT0%
340 OUT 890,0
350 FOR SLOW%:=0 TO 1:NEXT SLOW%
360 OUT 890,1
370 REM
380 FOR BIT%:=7 TO 0 STEP -1
390 OUT 890,0
400 FOR SLOW%:=0 TO 1:NEXT SLOW%
410 OUT 890,1
430 IF AD%<120 THEN BYTE%:=BYTE%+(2*BIT%)
440 NEXT BIT%
450 IF CH%:=0 THEN SELECT1%:=0: SELECT0%:=0: CH7VOLTS=BYTE%/51
460 IF CH%:=1 THEN SELECT1%:=0: SELECT0%:=2: CH7VOLTS=BYTE%/51
470 IF CH%:=2 THEN SELECT1%:=0: SELECT0%:=2: CH7VOLTS=BYTE%/51
480 IF CH%:=3 THEN SELECT1%:=2: SELECT0%:=0: CH7VOLTS=BYTE%/51
490 IF CH%:=4 THEN SELECT1%:=2: SELECT0%:=0: CH7VOLTS=BYTE%/51
500 IF CH%:=5 THEN SELECT1%:=2: SELECT0%:=2: CH7VOLTS=BYTE%/51
510 IF CH%:=6 THEN SELECT1%:=2: SELECT0%:=2: CH7VOLTS=BYTE%/51
520 IF CH%:=7 THEN SELECT1%:=0: SELECT0%:=0: CH7VOLTS=BYTE%/51
530 BYTE%=0
540 next ch%
550 PRINT USING"##.#"CH7VOLTS,CH1VOLTS,CH2VOLTS,CH4VOLTS,CH5VOLTS,CH6VOLTS,CH7VOLTS
  
```

73 AMATEUR RADIO TODAY

FIG. 3-2



# 4

## Antenna Circuits

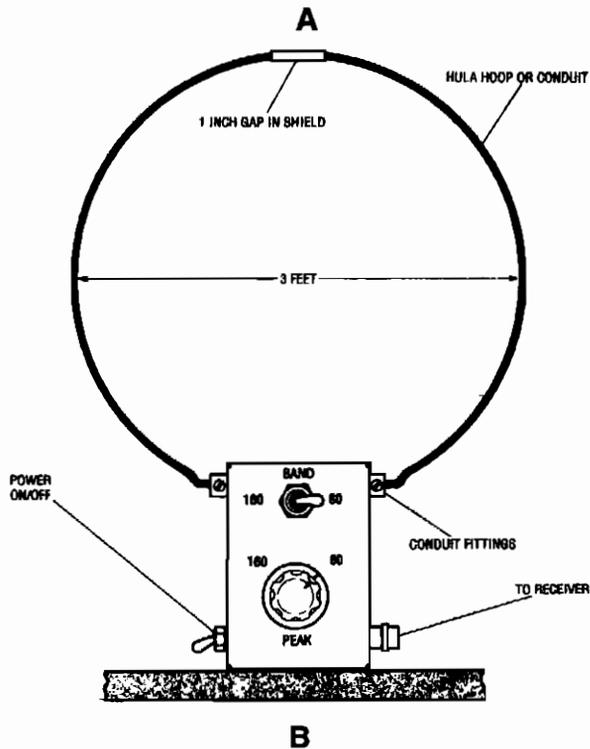
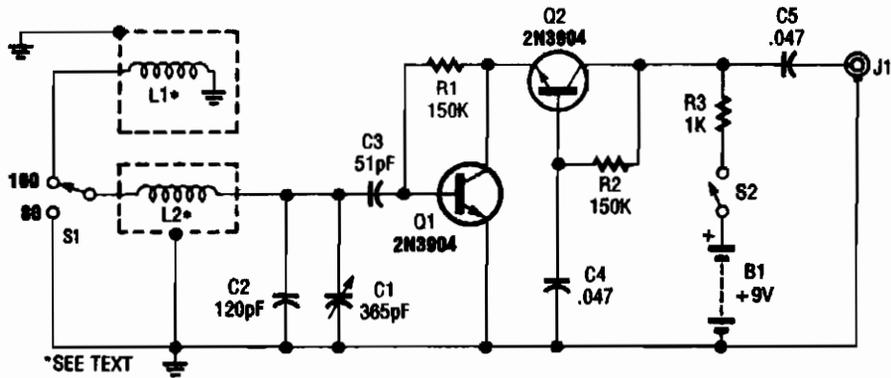
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Dual-Band Loop Antenna For 80 & 160 m  
VLF-VHF Wideband Low-Noise Active Antenna  
VLF 60-kHz Antenna/Preamp  
Simple Balun  
Wideband Antenna Preamplifier  
HF Broadband Antenna Preamp  
Automatic TR Switch  
Low-Power Antenna Tuner  
Loop Antenna Preamplifier

## DUAL-BAND LOOP ANTENNA FOR 80 & 160 m



POPULAR ELECTRONICS

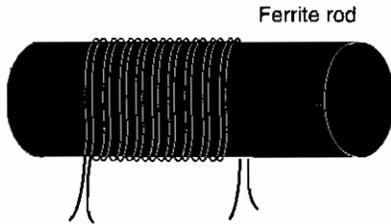
FIG. 4-1

This antenna might help to reduce power-line noise. A plastic "hula hoop" or conduit 3 feet in diameter, covered with aluminum foil as a shield is used for L1 and L2. L1 is two turns and L2 is one turn, threaded through the loop. S1 selects 160- or 80-m operation. Q1 and Q2 form a preamplifier for the loop antenna. Do not transmit with this antenna—it is for receiving only.



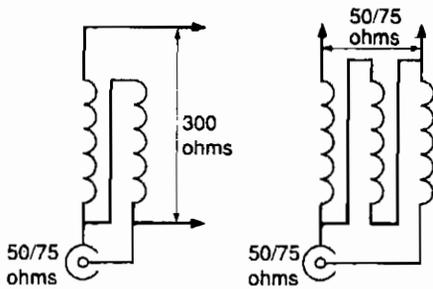
## SIMPLE BALUN

The wires must be bound tightly together, but windings may be slightly spaced if necessary. The diagram shows a bifilar balun with two coils.



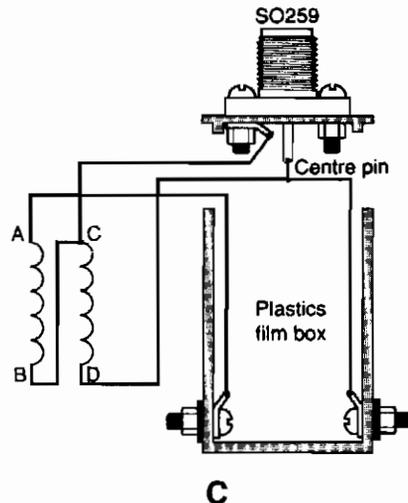
**A**

An example of a 4:1 bifilar (a), and (b) a 1:1 trifilar balun.



**B**

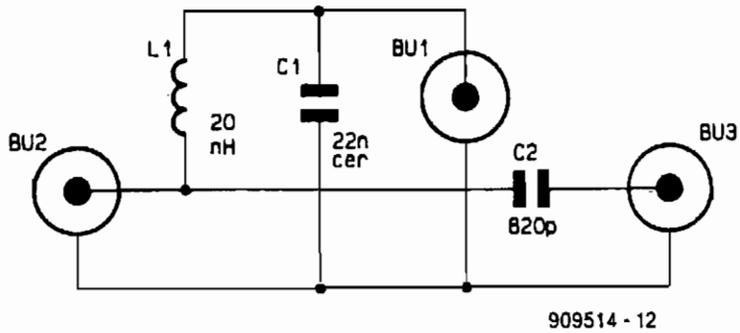
The wire connections for the 4:1 balun. After connecting up and testing, the coils and ferrite rod may be located inside the plastics film container.



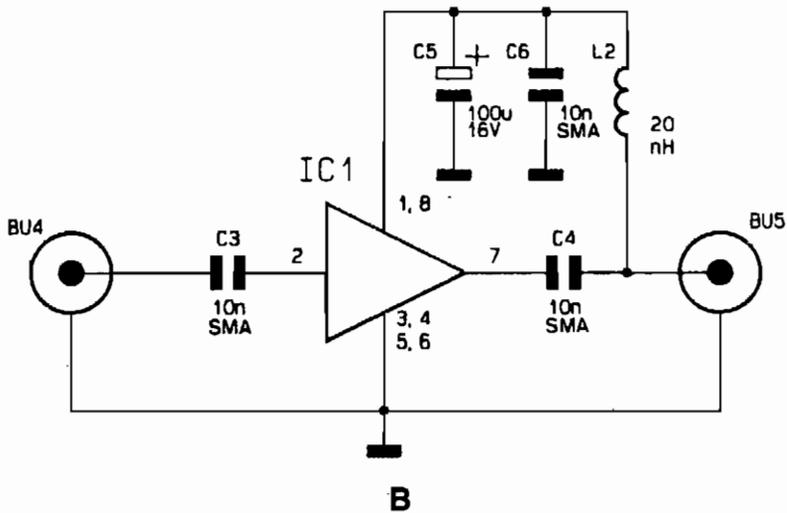
**C**

An old ferrite rod from a junked broadcast receiver can be used to construct an antenna balun, as shown.

## WIDEBAND ANTENNA PREAMPLIFIER



**A**

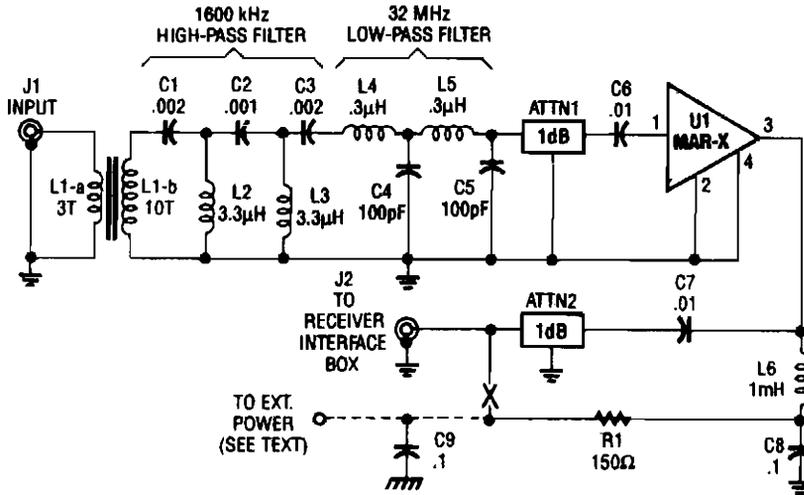


ELEKTOR ELECTRONICS

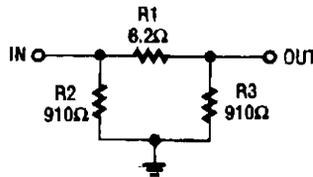
FIG. 4-5

This wideband antenna preamplifier has a gain of around 20 dB from 40 to 860 MHz, covering the entire VHF, FM, commercial, and UHF bands. A phantom power supply provides dc to the pre-amp via the coaxial cable feeding the unit.

## HF BROADBAND ANTENNA PREAMP



A

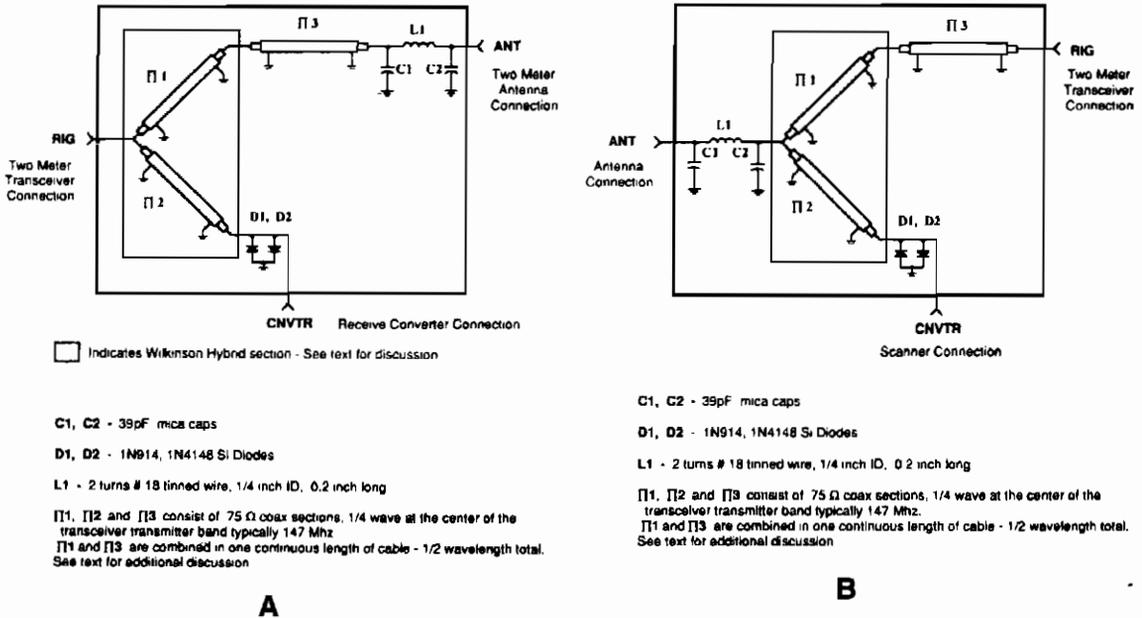


B

The HF/SW receiver preamplifier is comprised of a broadband toroidal transformer (L1-a and L1-b), LC network (comprised of a 1600-kHz, high-pass filter and a 32-MHz, low-pass filter), L2 and L3 (26 turns of #26 enameled wire wound on an Amidon Associates T-50-2, red, toroidal core), a pair of resistive attenuators (ATTN1 and ATTN2), and a MAR-x device.

Shown here is the composition of a basic 1-dB pi-network resistor attenuator. This is the method of supplying dc power to a preamplifier using only the RF coax cable.

## AUTOMATIC TR SWITCH



C1, C2 - 39pF mica caps

D1, D2 - 1N914, 1N4148 Si Diodes

L1 - 2 turns # 18 tinned wire, 1/4 inch ID, 0.2 inch long

Π1, Π2 and Π3 consist of 75 Ω coax sections, 1/4 wave at the center of the transceiver transmitter band typically 147 Mhz  
 Π1 and Π3 are combined in one continuous length of cable - 1/2 wavelength total.  
 See text for additional discussion

C1, C2 - 39pF mica caps

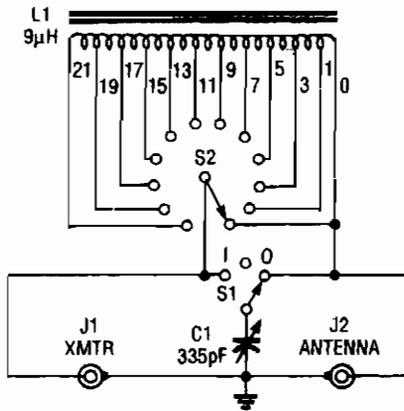
D1, D2 - 1N914, 1N4148 Si Diodes

L1 - 2 turns # 18 tinned wire, 1/4 inch ID, 0.2 inch long

Π1, Π2 and Π3 consist of 75 Ω coax sections, 1/4 wave at the center of the transceiver transmitter band typically 147 Mhz.  
 Π1 and Π3 are combined in one continuous length of cable - 1/2 wavelength total.  
 See text for additional discussion

A pair of diodes and a quarter-wave transmission line are used as an automatic TR switch. D1 and D2 conduct during transmit periods, short-circuiting the scanner input. In this mode, the 1/4-wave line appears as an open circuit. In receive, the circuit acts as a Wilkinson power divider.

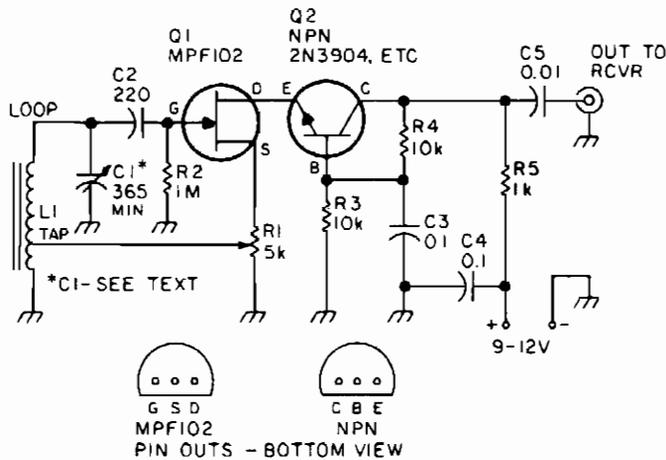
## LOW-POWER ANTENNA TUNER



This antenna tuner is suitable for use with low-power (less than 5 W) transmitters or SW receivers. S2 selects inductance and S2 connects the 365-pF capacitor to either the transmitter or the side of the inductor. The tiny tuner is comprised of a tapped inductor (L1) and a variable capacitor (C1), which is connected to the inductor through a center-off SPDT switch (S1). That switch arrangement permits the capacitor to be connected to either the input or the output of the circuit.

1993 ELECTRONICS HOBBYISTS HANDBOOK FIG. 4-8

## LOOP ANTENNA PREAMPLIFIER



73 AMATEUR RADIO TODAY

FIG. 4-9

This preamplifier has a built-in regeneration control boost gain selectivity. C1 is a single or multi-gang AM broadcast-band tuning capacitor. L1 is a ferrite loop antenna, tapped at about 15 to 25% of total turns. This circuit should prove useful for low-frequency (up to 3 MHz) reception, where a loop would be advantageous to reduce man-made noise pickup.

# 5

## Audio Power Amplifier Circuits

---

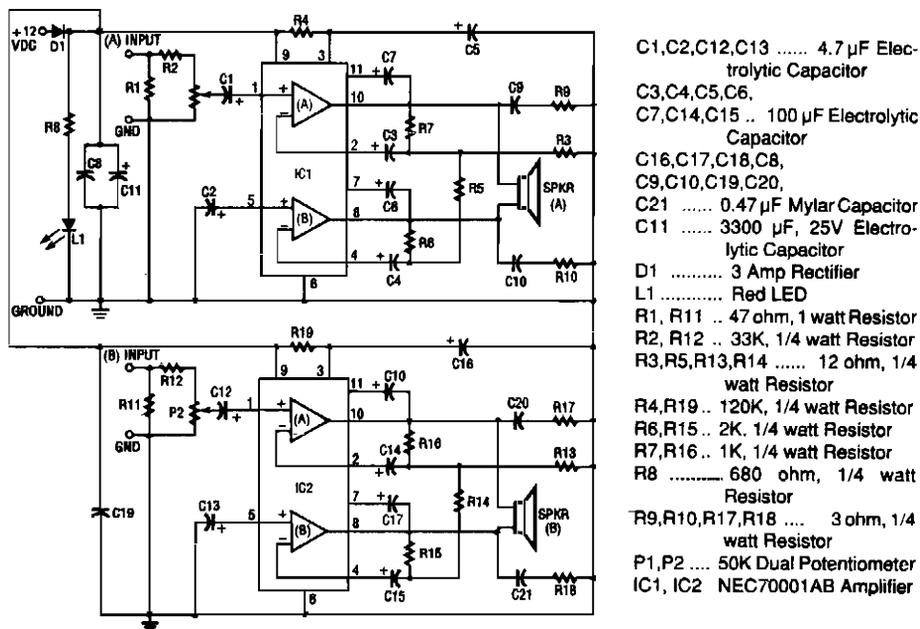
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

20-W + 20-W Stereo Amplifier  
40-W Amplifier  
Half-Watt Single-Channel Audio Amplifier  
Dual Audio Amplifier  
A 70-W Composite Amplifier  
A 33-W Bridge Composite Amplifier  
MOSFET Power Amplifier  
10-W Noninverting Composite Amplifier

10-W Inverting Composite Amplifier  
LM380 Personal Stereo Amplifier  
Subwoofer Amplifier  
18-W Bridge Audio Amplifier  
Subwoofer Crossover Amplifier  
Audio Power Amplifier  
Fast High-Voltage Linear Power Amp  
Single-Chip 40-W Amplifier

## 20-W + 20-W STEREO AMPLIFIER

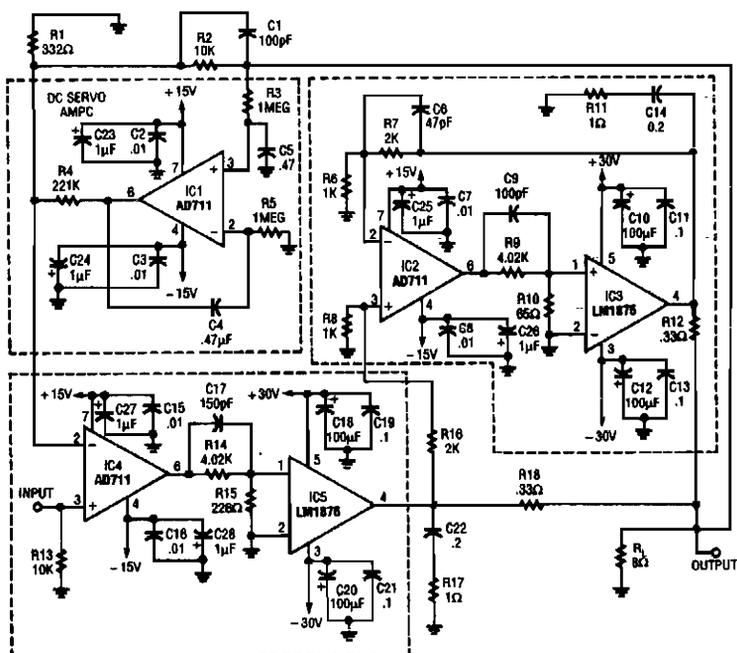


The 20-W + 20-W stereo amp consists of two complete, separate 20-W RMS bridge-type amplifiers. The input signal source is brought into the amplifier through the voltage divider network, which is made up of R1, R2, and P1. Resistor R1 provides a load impedance between the signal source and ground. Resistor R2 couples that signal to potentiometer P1.

The signal is coupled by capacitor C1 to the noninverting (+) input (pin 1) of internal amplifier (A) of IC1, where the signal is greatly amplified. Capacitor C2 couples the (+) input of the other (B) internal amplifier of IC1 to ground. That causes the input signal, which is referenced to ground, to be coupled to both amplifiers because both the inputs and outputs of IC1 (A) and IC1 (B) are connected in a bridge configuration. Notice that the output of IC1 (A) from pin 10 is connected to one side of the speaker and the output of IC1 (B) from pin 8 is connected to the other side of the speaker. That is why the speakers used cannot have one side connected to ground. Resistors R6 and R7 set the gain of the amplifier. Resistors R9 and R10 and capacitors C9 and C10 provide frequency stability and prevent oscillation. Capacitors C6 and C7 provide "bootstrapping," which prevents distortion at low frequencies. LED L1 lights up by way of a series resistor connected from the anode to +12 Vdc when power is applied.

Power for both IC1 and IC2 is brought in through D1 (to protect amplifiers from reverse polarity). Capacitor C11 provides additional power supply line filtering. This booster is capable of producing 20 W RMS output out of each channel.

## 40-W AMPLIFIER

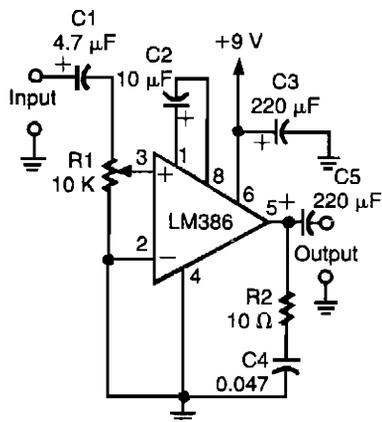


ELECTRONICS NOW

FIG. 5-2

This circuit uses two LM1875 devices and a dc servo loop. This circuit provides 40-W output. IC3 and IC5 must be heatsinked.

## HALF-WATT SINGLE-CHANNEL AUDIO AMPLIFIER

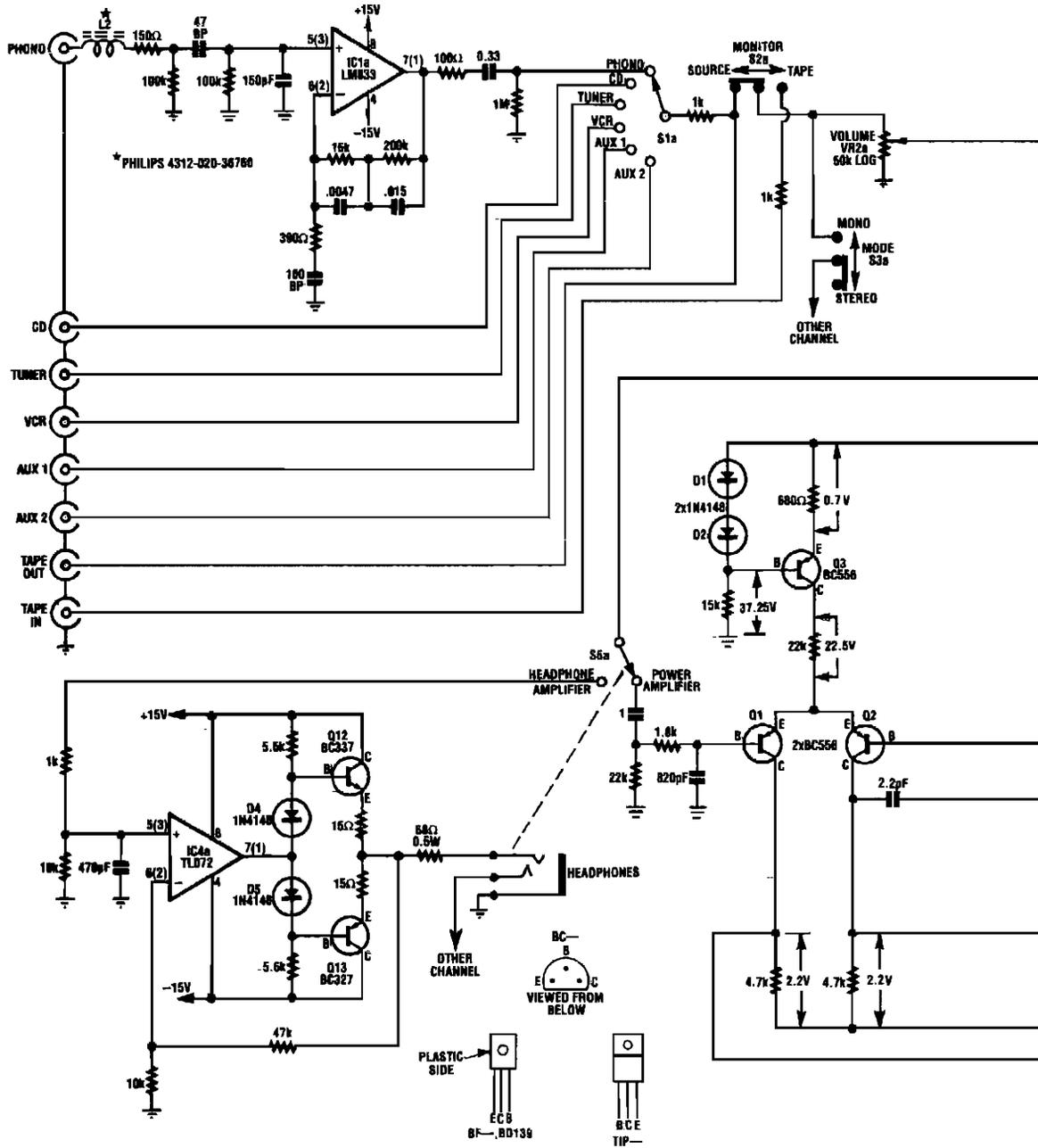


This circuit uses an LM386 IC and will work from 6- to 12-V battery sources. Output is about 0.5 W into 8 Ω.

ELECTRONICS NOW

FIG. 5-3

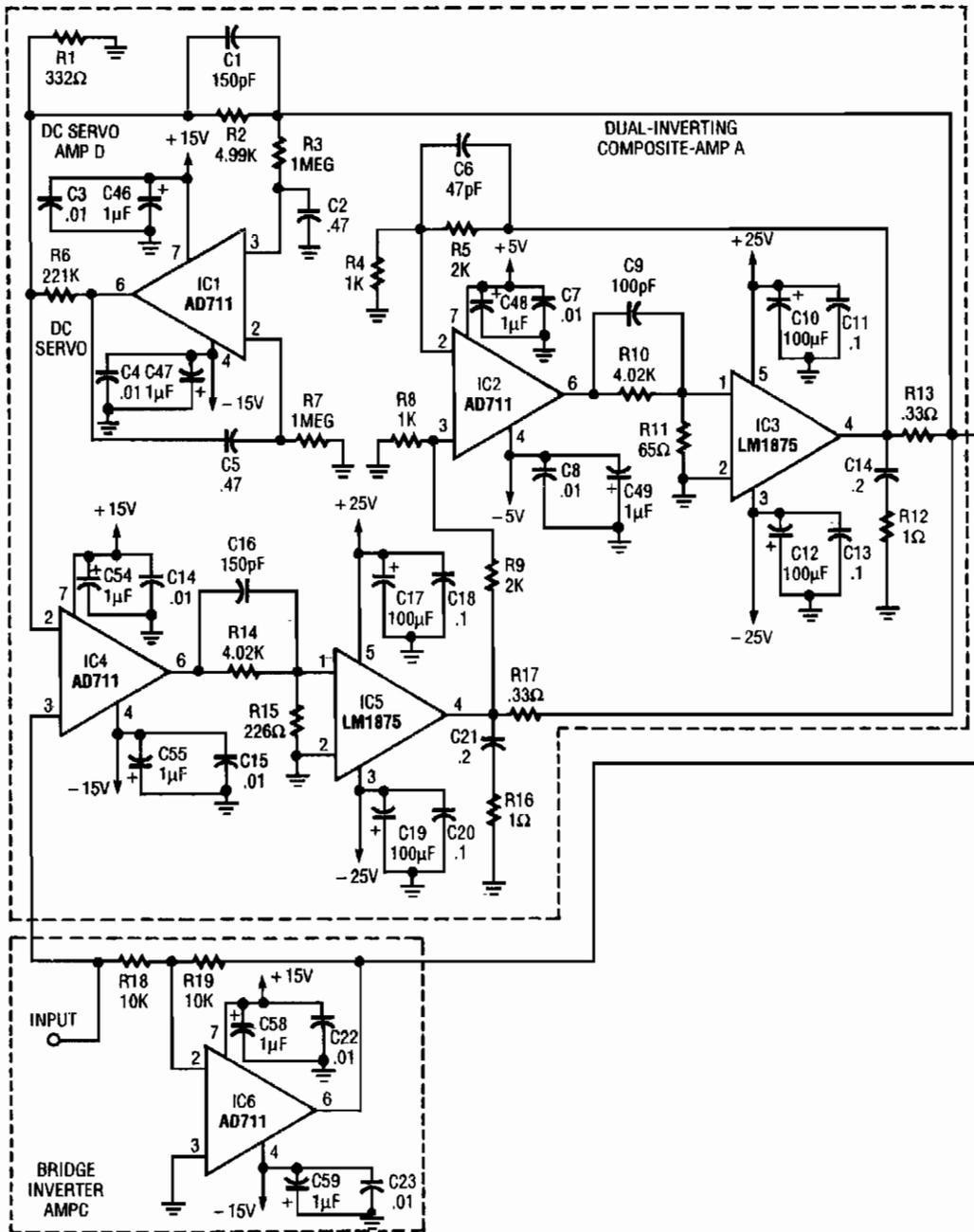
# DUAL AUDIO AMPLIFIER

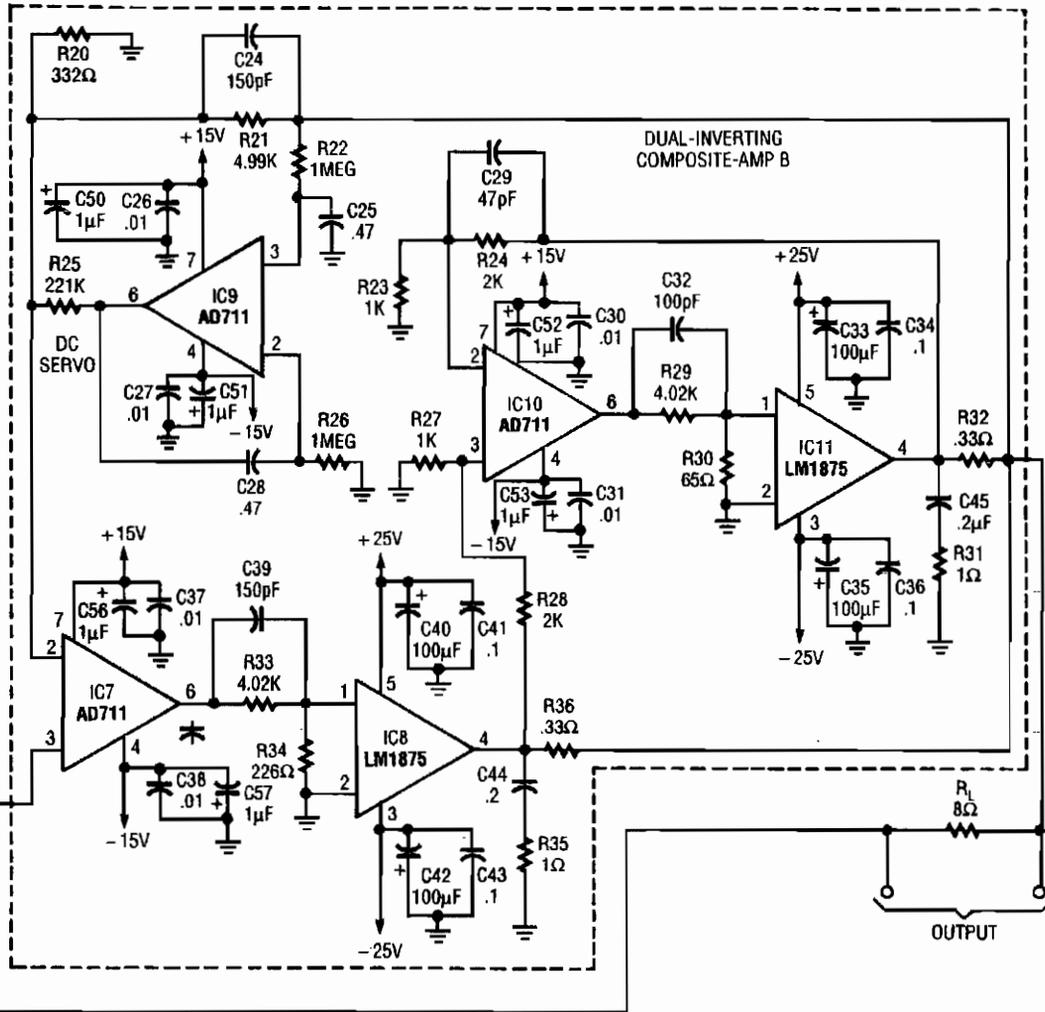


SILICON CHIP



## A 70-W COMPOSITE AMPLIFIER



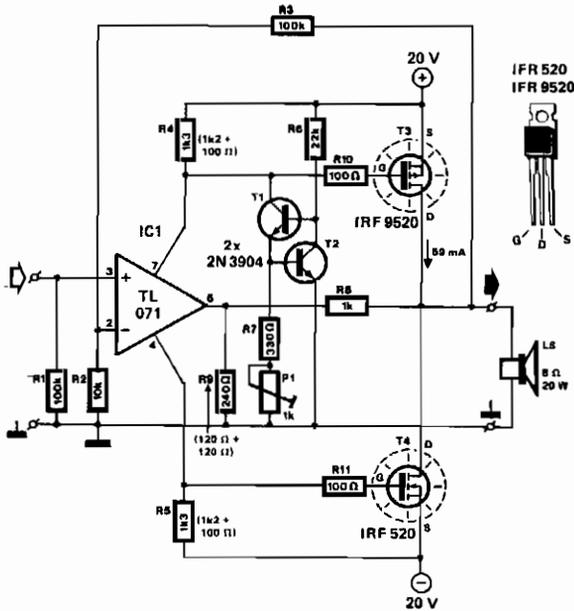


Four LM1875 devices, suitably heatsinked, and a  $\pm 25\text{-V}$  supply, 70 W of output are available from this circuit. IC6 is a phase inverter.

FIG. 5-5



## MOSFET POWER AMPLIFIER

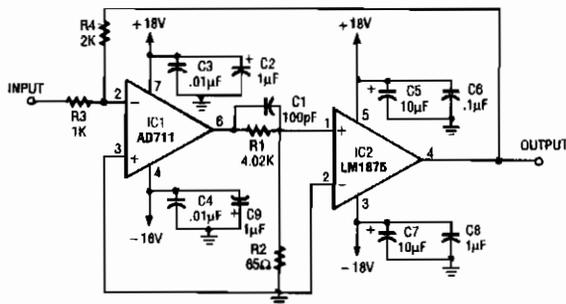


Two complementary MOSFETs are used to deliver 20 W into 8 Ω. A TL071 op amp is used as an input amplifier. The MOSFETs should be heatsinked with a heatsink of better than 5°C/W capability. THD is less than 0.15% from 100 Hz to 10 kHz.

303 CIRCUITS

FIG. 5-7

## 10-W NONINVERTING COMPOSITE AMPLIFIER

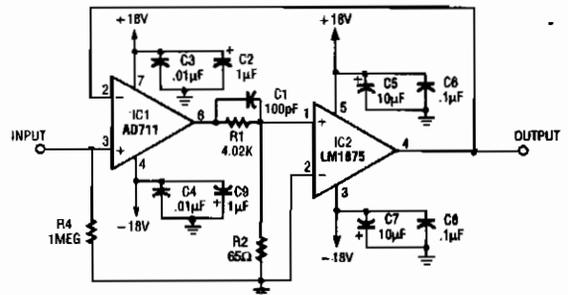


ELECTRONICS NOW

FIG. 5-8

By using an LM1875, suitably heatsinked, a 10-W amplifier that uses two IC devices can be built. IC2 must be heatsinked.

## 10-W INVERTING COMPOSITE AMPLIFIER

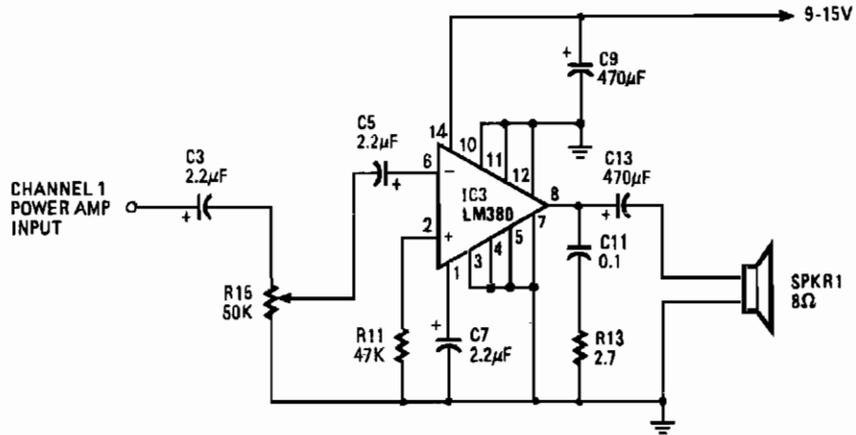


ELECTRONICS NOW

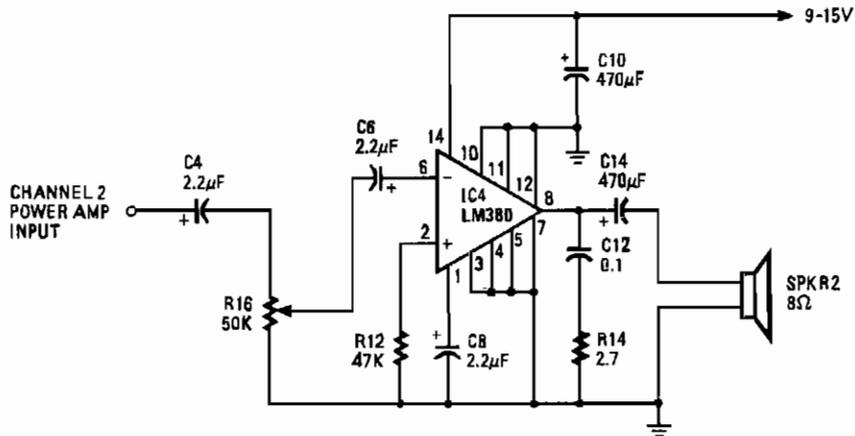
FIG. 5-9

Using an LM1875, a 10-W amplifier can be built using just two IC devices. The gain =  $R_4/R_3$ . Note that IC2 must be heatsinked.

## LM380 PERSONAL STEREO AMPLIFIER



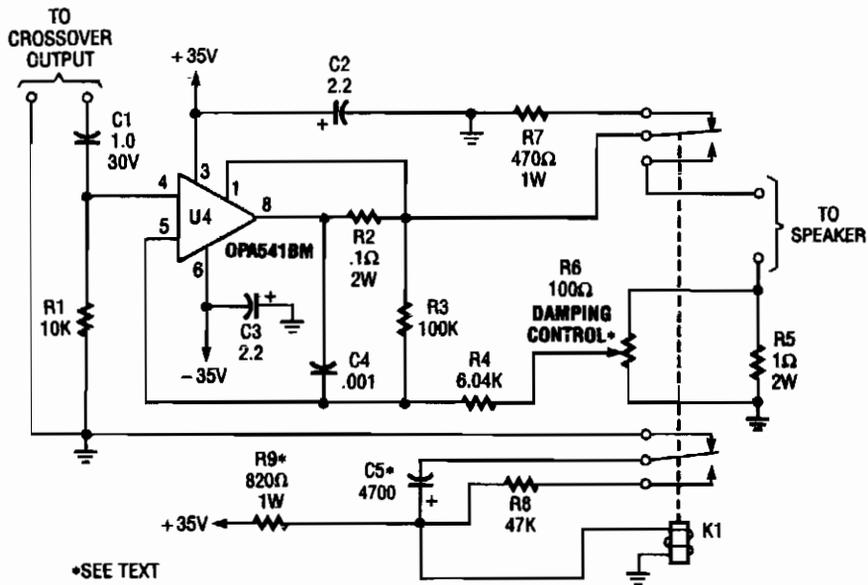
A



B

With the simple circuit, you can use your personal stereo to drive standard 8-Ω speakers.

## SUBWOOFER AMPLIFIER

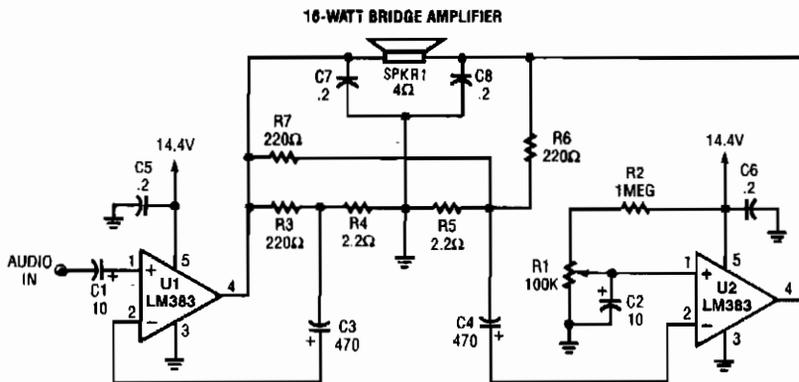


POPULAR ELECTRONICS

FIG. 5-11

Designed to feed a low-frequency subwoofer speaker system, the amplifier is capable of up to 100 W into an 8- $\Omega$  load. The OPA541BM op amp requires heatsinking and is manufactured by Burr-Brown Corporation. A damping control and a relay to eliminate turn-on and turn-off thump in the speaker is included.

## 18-W BRIDGE AUDIO AMPLIFIER

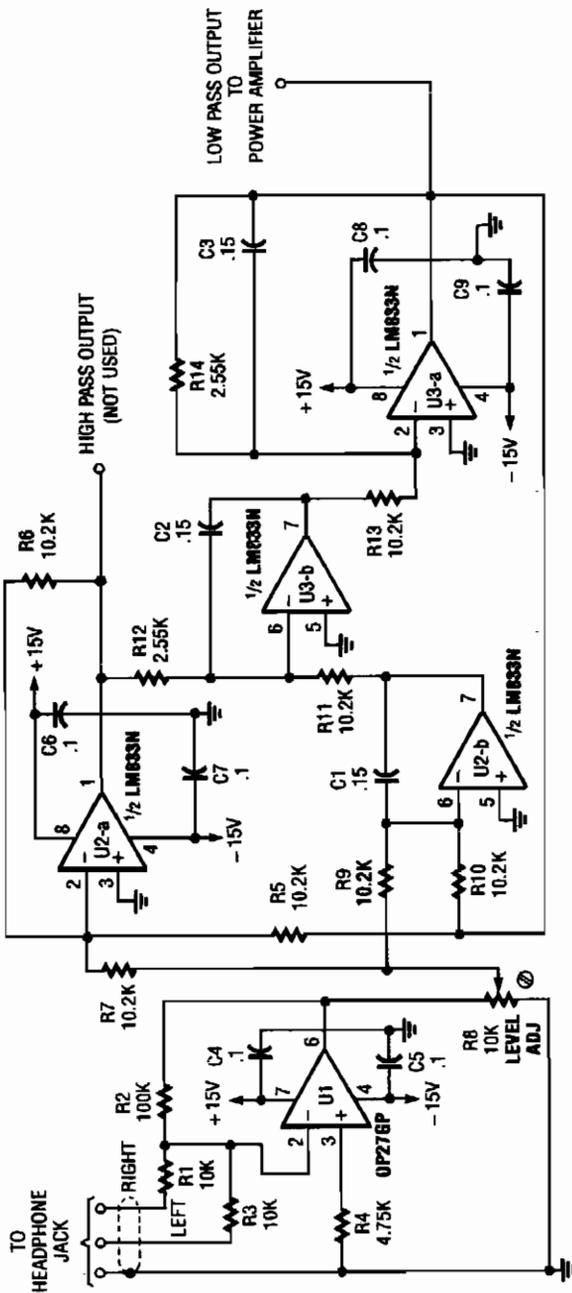


POPULAR ELECTRONICS

FIG. 5-12

Two LM383 IC devices are used in a bridge circuit that is useful for auto sound applications.

### SUBWOOFER CROSSOVER AMPLIFIER

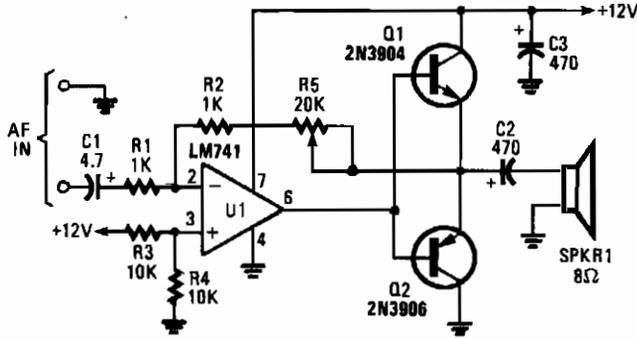


RADIO-ELECTRONICS

FIG. 5-13

The electronic-crossover circuit contains a summing amplifier that combines the left and right channels from a stereo's headphone jack. Originally used in a subwoofer system, the above circuit might be useful in similar audio applications.

## AUDIO POWER AMPLIFIER

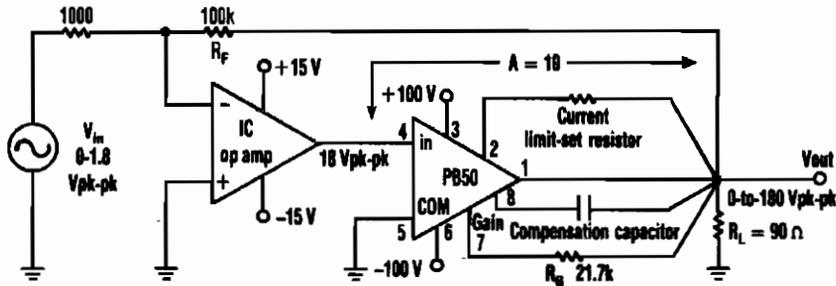


POPULAR ELECTRONICS

FIG. 5-14

The circuit, built around an LM741 op amp configured as an inverting amplifier, is used to drive complementary transistors (Q1 and Q2). The op amp's feedback loop includes the base-emitter junctions of both transistors—an arrangement that helps to reduce crossover distortion that would normally occur as a result of the emitter-to-base junction voltage drop of about 0.6 V. Potentiometer R5 varies the amplifier's voltage gain from 1 to about 20. As much as 0.5 W can be obtained from the circuit if a heatsink is added to the transistors.

## FAST HIGH-VOLTAGE LINEAR POWER AMP



ELECTRONIC DESIGN

FIG. 5-15

An Apex PB50 Booster Amplifier, plus an IC op amp, can be used in a high-voltage op amp that converts a small analog signal to a 180-V p-p signal.

Apex Microtechnology manufactures a number of power op amps. The above circuit uses a PB50 booster amplifier to deliver a 180-V p-p signal into a 90-Ω load, from a ±100-V supply.

# 6

## Audio Signal Amplifier Circuits

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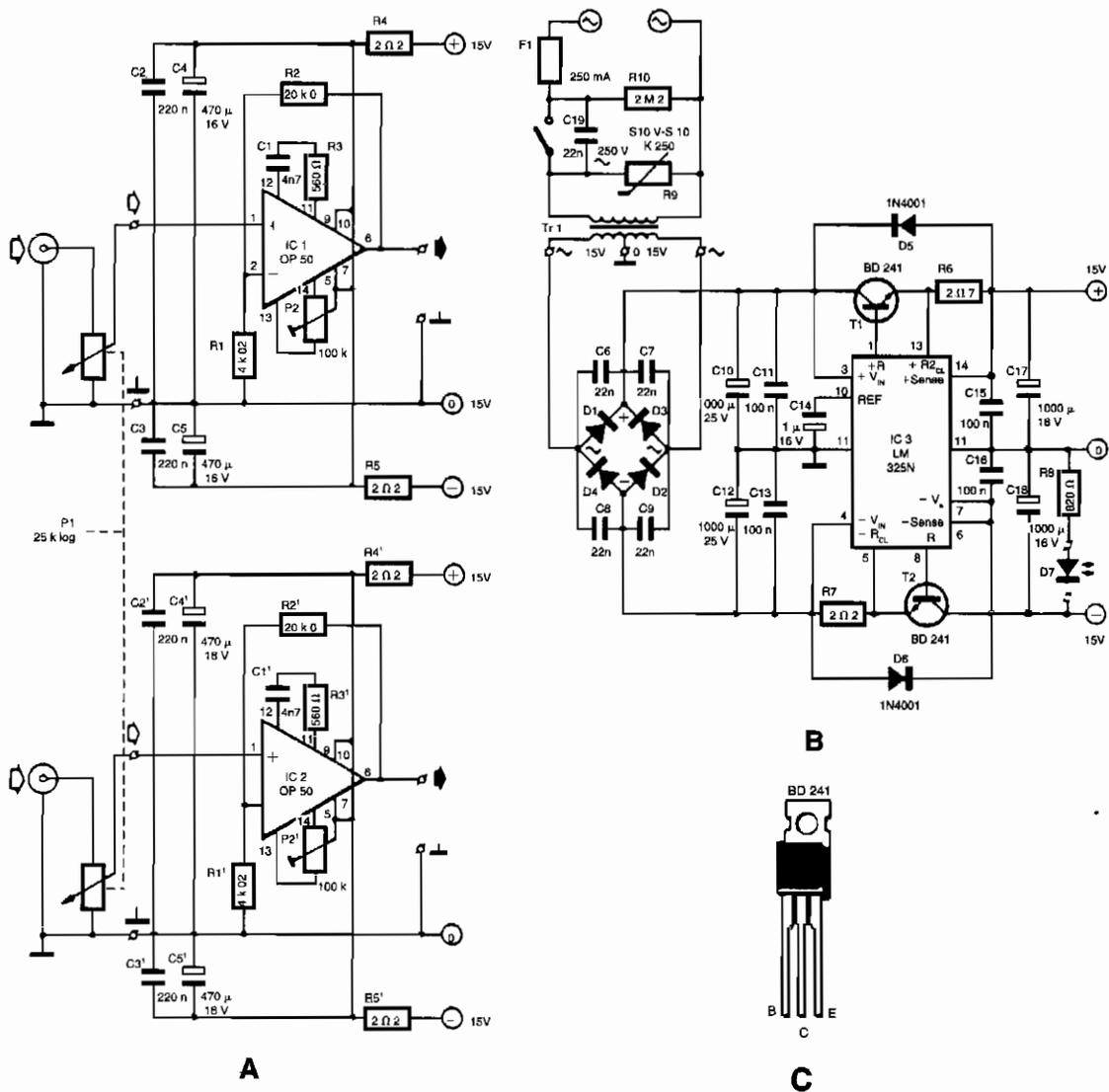
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Headphone Amplifier  
Audio Line Driver  
Constant-Volume Amplifier  
Mini Amplifier Using LM1895N  
Audio Amplifier with Tuneable Filter  
Audio Compressor

JFET Headphone Amplifier  
Dual Preamp  
Magnetic Pickup Phono Amplifier  
Audio Booster  
Audio Volume Limiter  
Audio Distribution Amplifier

## HEADPHONE AMPLIFIER

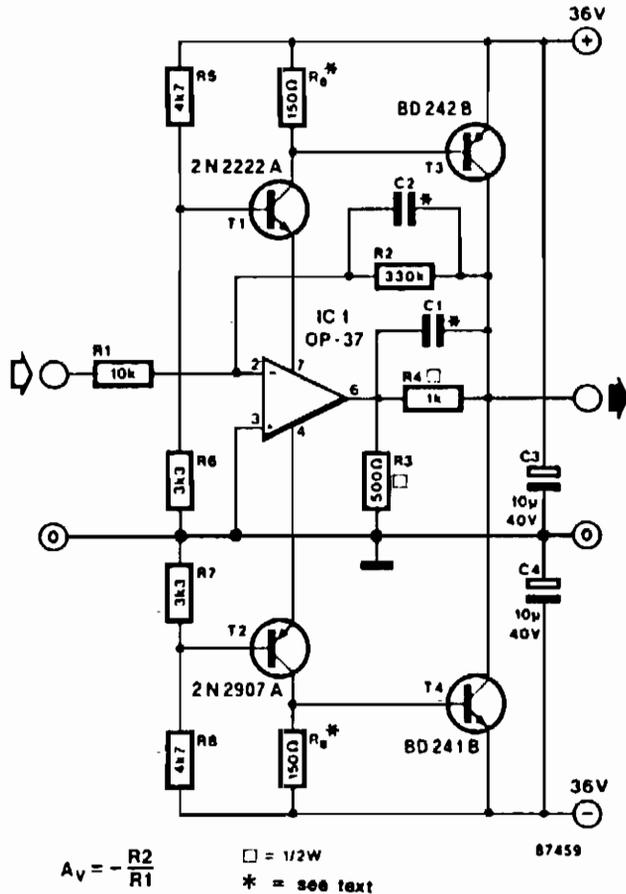


303 CIRCUITS

FIG. 6-1

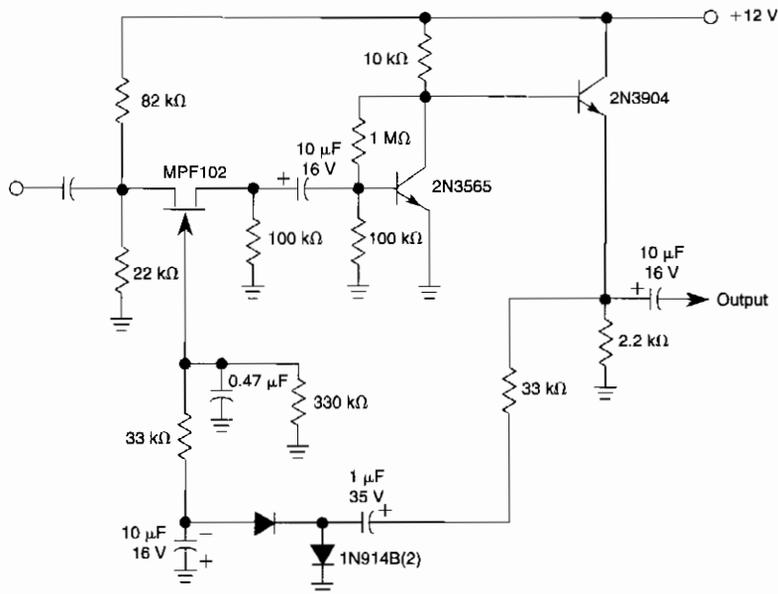
Built around Precision Monolithics Inc. OP-50 op amps, this amplifier will drive 100-Ω to 1-kΩ headphone, is flat within 0.4 dB from 10 Hz to 20 kHz, and has a THD of less than 0.01% over most of the audio range. Amplification factor is about 6X.

## AUDIO LINE DRIVER



This line driver can drive low-impedance lines with up to 70 V p-p max. IC1 is a low-noise op amp suitable for  $\pm 15$ -V operation. T1 and T2 are regulators for the power supply for IC1. T3 and T4 form a complementary power output stage. Frequency response is flat up to 100 kHz.

### CONSTANT-VOLUME AMPLIFIER

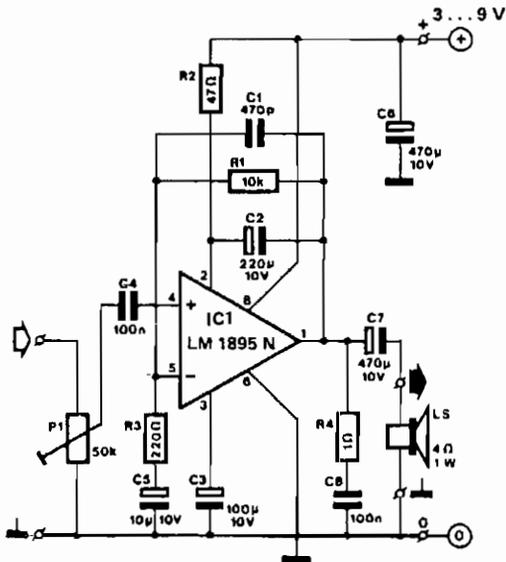


WILLIAM SHEETS

FIG. 6-3

The amplifier has an output level that shifts about 6 dB for a 40-dB input variation.

### MINI AMPLIFIER USING LM1895N

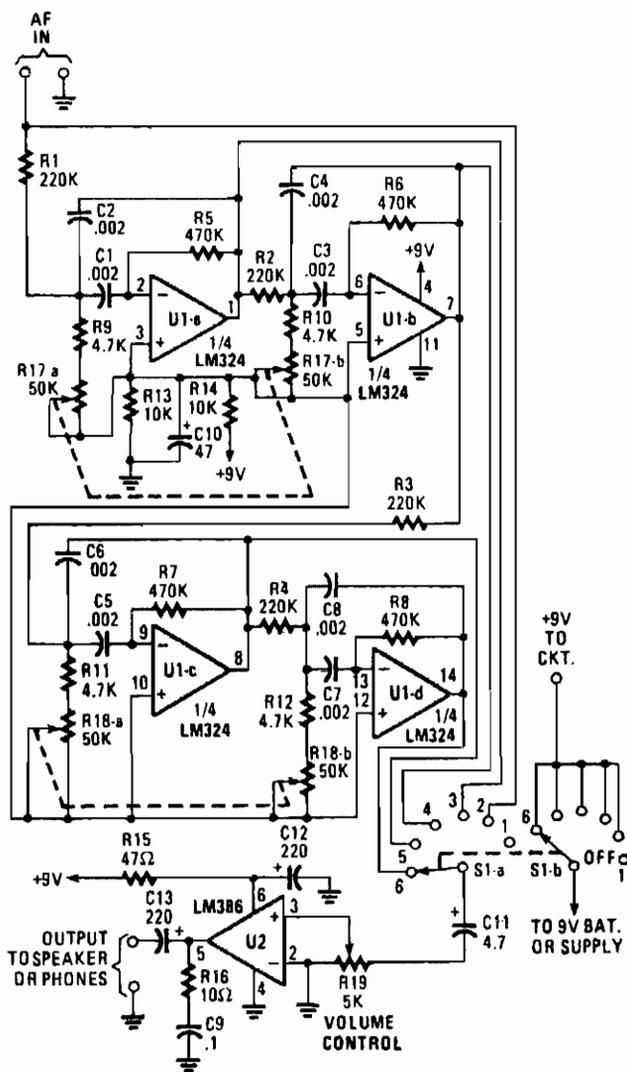


With 3-V to 9-V supplies, this amplifier can provide from 100-mW to 1-W output into a 4 Ω and bandwidth is approximately 20 kHz @ 3 dB. This circuit is useful for low-power and battery applications. Drain is 80 mA @ 3 V or 270 mA @ 9 V at maximum signal conditions.

303 CIRCUITS

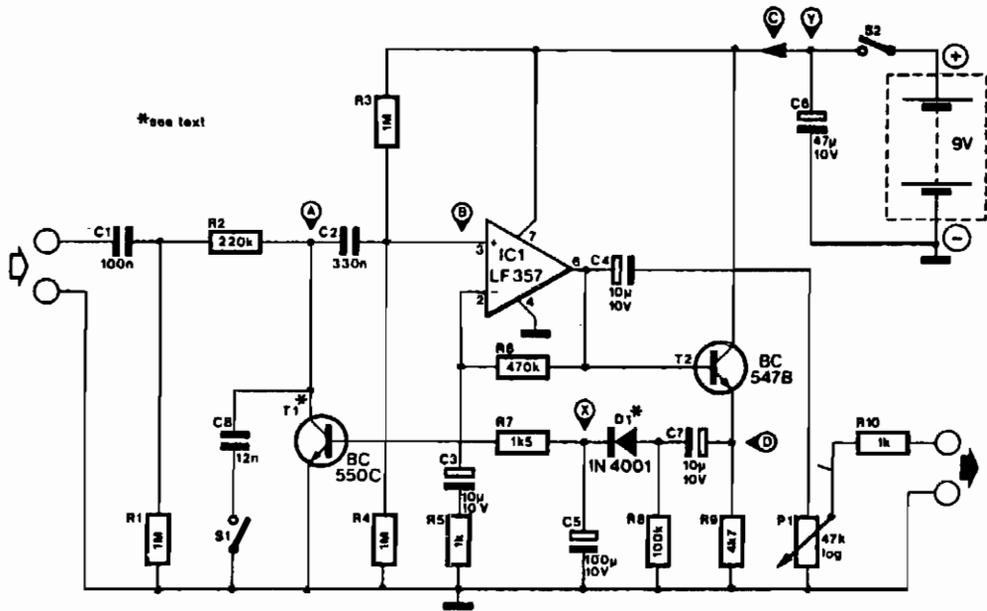
FIG. 6-4

## AUDIO AMPLIFIER WITH TUNEABLE FILTER



This audio amplifier can tune from 500 to 1500 Hz and will drive a speaker or headphones. Useful for CW reception or other receiver applications, only two IC devices are needed.

## AUDIO COMPRESSOR

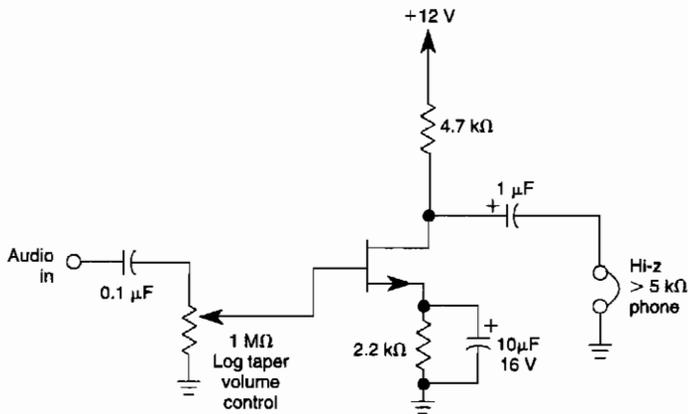


303 CIRCUITS

FIG. 6-6

This compressor will compress a 25-mV p-p to 20-V p-p audio output to input levels remaining between 1.5 V p-p to 3.5 V p-p, and has a frequency response of 7 Hz to 67 kHz. It is suitable for audio and communications applications.

## JFET HEADPHONE AMPLIFIER

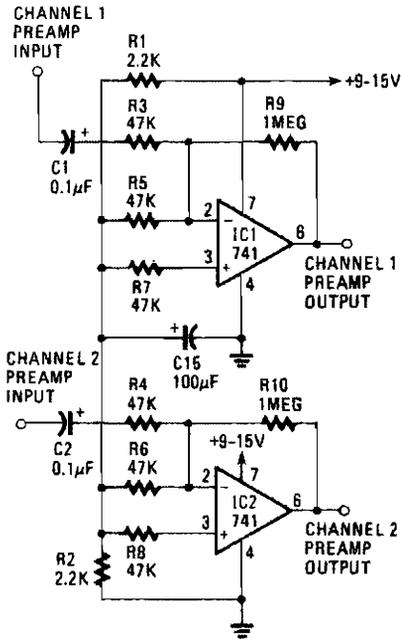


WILLIAM SHEETS

FIG. 6-7

This circuit can drive high-impedance headphones from a low impedance low-level source. Gain is about 5X to 10X depending on headphone impedance. A volume control is included.

## DUAL PREAMP

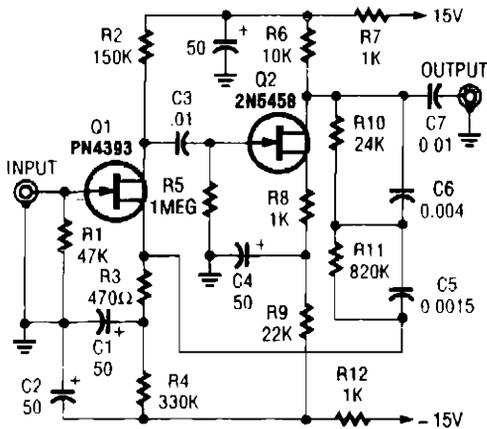


If you wish to amplify low-level signals, such as the output of a turntable, the signal must first be fed to this preamp.

1987 R-E EXPERIMENTERS HANDBOOK

FIG. 6-8

### MAGNETIC PICKUP PHONO AMPLIFIER

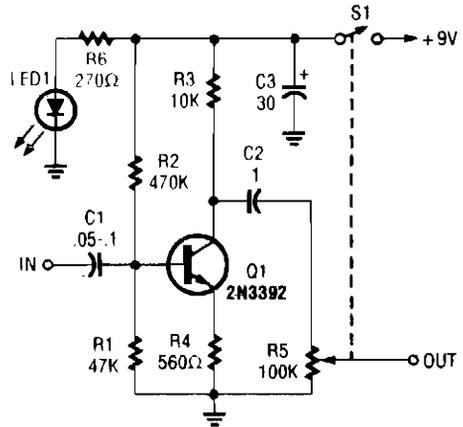


POPULAR ELECTRONICS

FIG. 6-9

This preamp is RAA compensated for use with magnetic phone cartridges.

### AUDIO BOOSTER

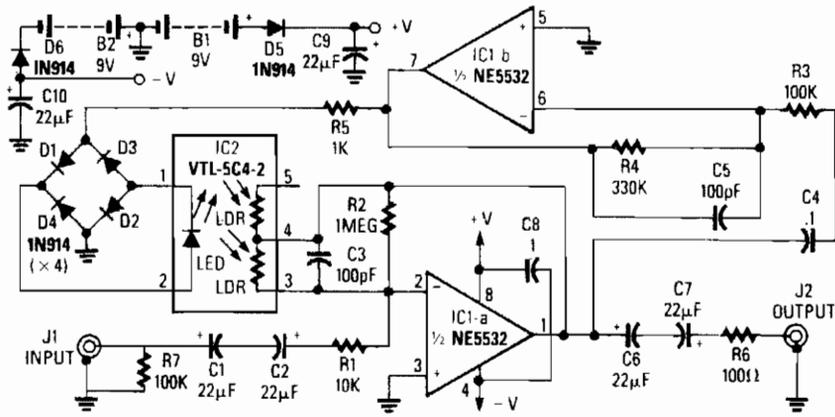


POPULAR ELECTRONICS

FIG. 6-10

This circuit has a maximum gain of about 22 dB (voltage gain), and it can be used for miscellaneous audio circuits.

## AUDIO VOLUME LIMITER

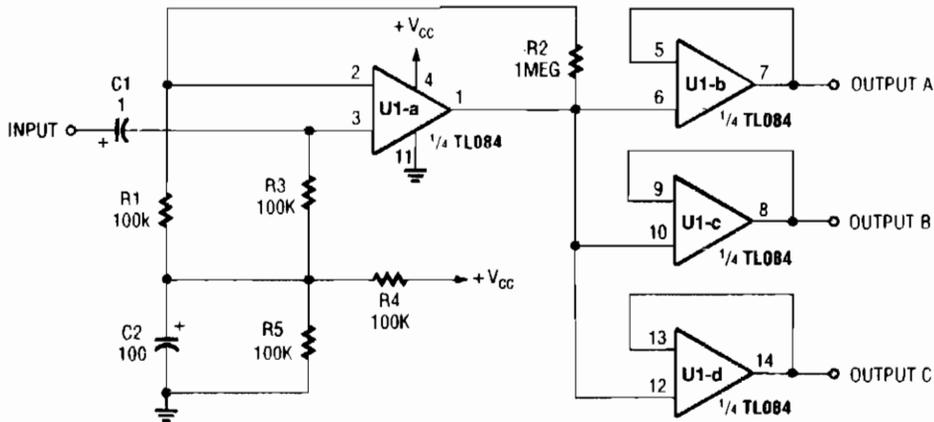


1992 R-E EXPERIMENTERS HANDBOOK

FIG. 6-11

IC1-a is connected as an inverting amplifier whose gain is controlled by the LDR portion of an optocoupler.

## AUDIO DISTRIBUTION AMPLIFIER



POPULAR ELECTRONICS

FIG. 6-12

Three low-Z audio outputs are available from this circuit, using a quad TL084 FET amplifier. The input is high impedance.  $V_{CC}$  can be 6 to 12 V for typical applications.

# 7

## Automatic Level Control Circuits

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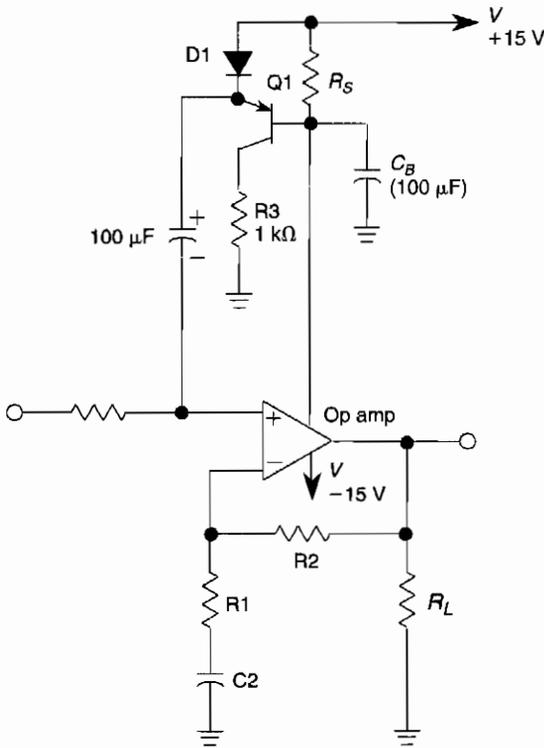
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Digital Automatic Level Control (ALC)  
AGC System for Audio Signals  
ALC (Automatic Level Control)



## AGC SYSTEM FOR AUDIO SIGNALS



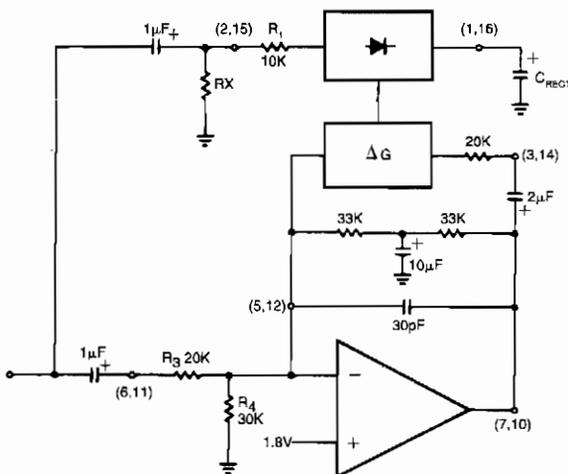
WILLIAM SHEETS

FIG. 7-2

This circuit is an AGC system for audio-frequency signals. AGC systems usually consist of three parts: an amplifier, rectifier, and controlled impedance. In this circuit the functions of an amplifier and a rectifier are performed by a single op amp. This makes the system simple and cheap.

The rectifier is made with the output push-pull cascade of the op amp and  $R_s$ ,  $R_L$ , and  $C_B$ . The transistor Q1 and D1 are used as a voltage-controlled resistance ( $Z$ ). The input signal is  $(Z + R_1)/Z$  times, diminished by the voltage divider and  $1 + R_2/R_1$  times, amplified by the op amp.  $C_2$  eliminates influence of dc bias voltage.  $R_3$  protects Q1 and D1 from excessive current.

## ALC (AUTOMATIC LEVEL CONTROL)



1989 RF COMMUNICATIONS HANDBOOK

FIG. 7-3

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. The circuit will maintain an output level of  $\pm 1$  dB for an input range of +14 to -43 dB at 1 kHz. Additional external components will allow the output-level to be adjusted.

# 8

## Automotive Circuits

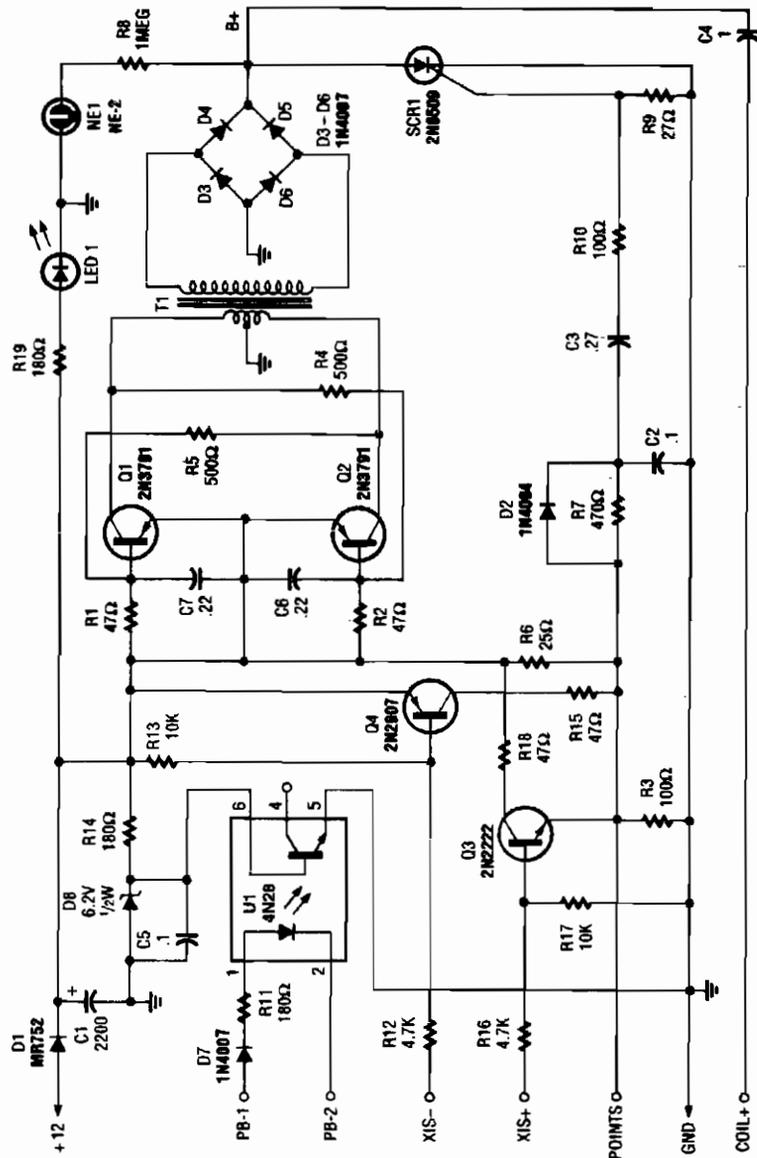
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

CD Ignition System for Autos	Headlight Flasher
Brake and Turn-Signal Light Circuit	Automotive Audible-Turn Indicator
Vehicular Tachometer Circuit	Engine Block Heater Minder
Smart Turn Signal	Headlights-On Reminder
Manual Headlight/Spotlight Control for Autos	Brake and Turn Indicator
Thermostat Switch for Automotive Electric Fans	Lamp-Switching Circuit
Flashing Brake Light	Automatic Turn-Off Control for Automobiles
Power Controller (for Automotive Accessories)	Alternator Regulator
Automotive Power Adapter for dc-Operated Devices	Auto Generator Regulator
Time-Delay Auto-Kill Switch	Lights-On Reminder
Booster Amplifier for Car Stereo Use	Auto Fuse Monitor
Auto Turn-Signal Reminder	Headlight Alarm

# CD IGNITION SYSTEM FOR AUTOS



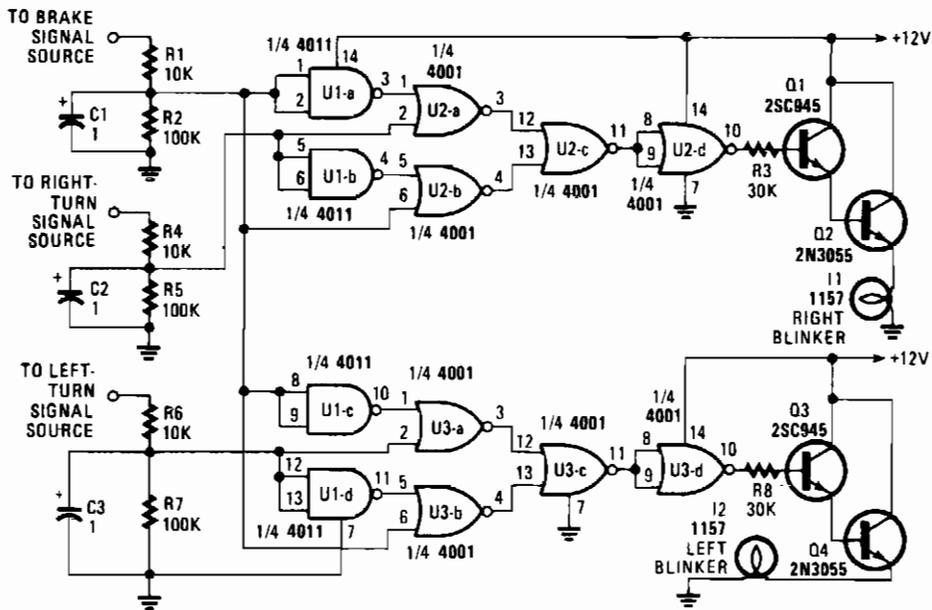
POPULAR ELECTRONICS

FIG. 8-1

At the heart of the CD4-MX is an astable multivibrator, built around Q1 and Q2, that feeds step-up transformer T1. The output of T1 is rectified by D3 to D6 and used to charge capacitor C4. When the points close, a small voltage is fed to the gate of SCR1, causing it to fire, dumping the charge of C4 to the vehicle's ignition coil. The circuit also contains optional subcircuits to accommodate different types of auto ignitions.

$X_{15+}$  and  $X_{15-}$  are alternative trigger configurations for nonpoint breaker ignition systems. R6 is not used for these systems and must be removed. Optocoupler U1 can be used (pin 4) in conjunction with  $X_{15-}$  or  $X_{15+}$  depending on polarity of sensor. Note that 60 to 70 kV is available from this system, so observe suitable safety precautions.

## BRAKE AND TURN-SIGNAL LIGHT CIRCUIT

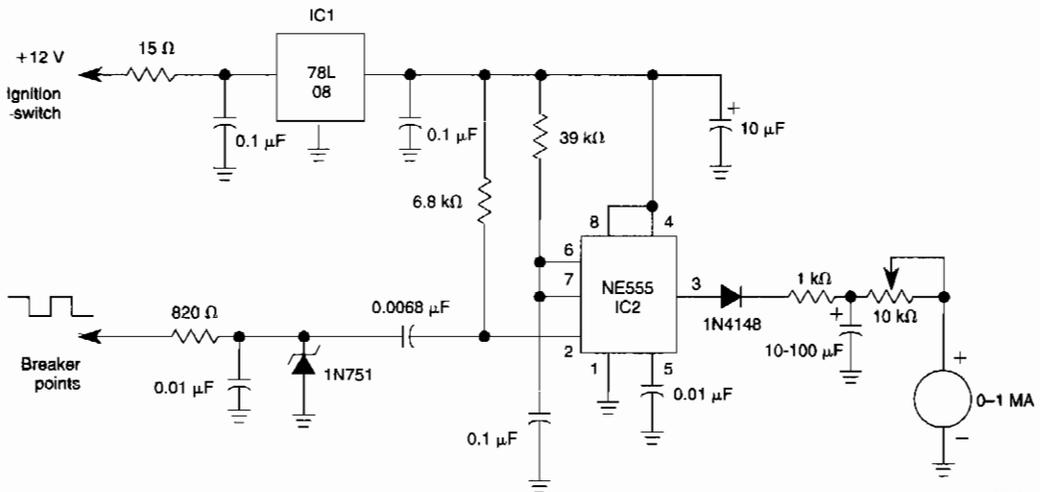


POPULAR ELECTRONICS

FIG. 8-2

This circuit enables single-filament tail lights to serve as combination brake lights and turn signals.

## VEHICULAR TACHOMETER CIRCUIT

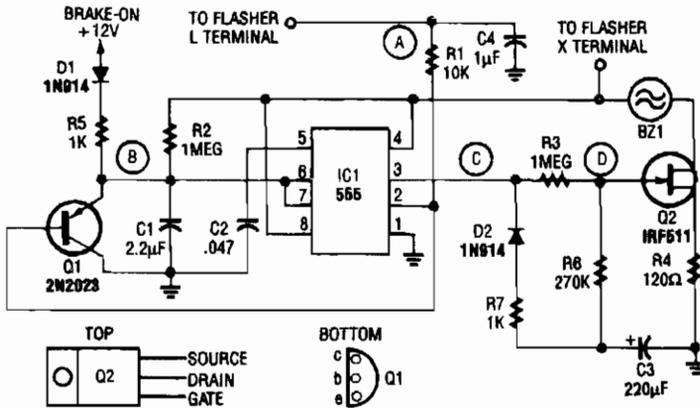


WILLIAM SHEETS

FIG. 8-3

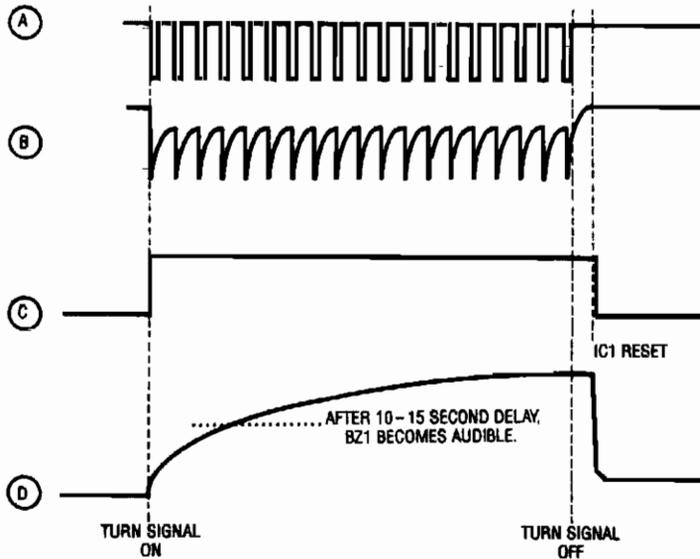
In this automotive application, the 555 is a pulse counter. IC1 regulator provides proper operating voltage for IC2. This circuit is for vehicles with conventional breaker points.

## SMART TURN SIGNAL



STS schematic. The Q2 gate voltage increases with the charge on C3. After 15 seconds of charging, the buzzer will warble. As the charging continues, the sound will grow louder.

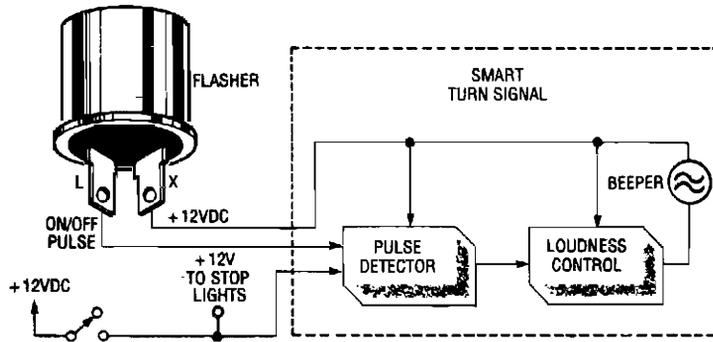
A



Circuit waveforms. Point A shows the signal from the flasher. The voltage at point D will increase as long as the pin-3 output of IC1 (point C) remains high. The C1-R2 time constant (point B) determines how long the output will be high.

B

## SMART TURN SIGNAL (Cont.)

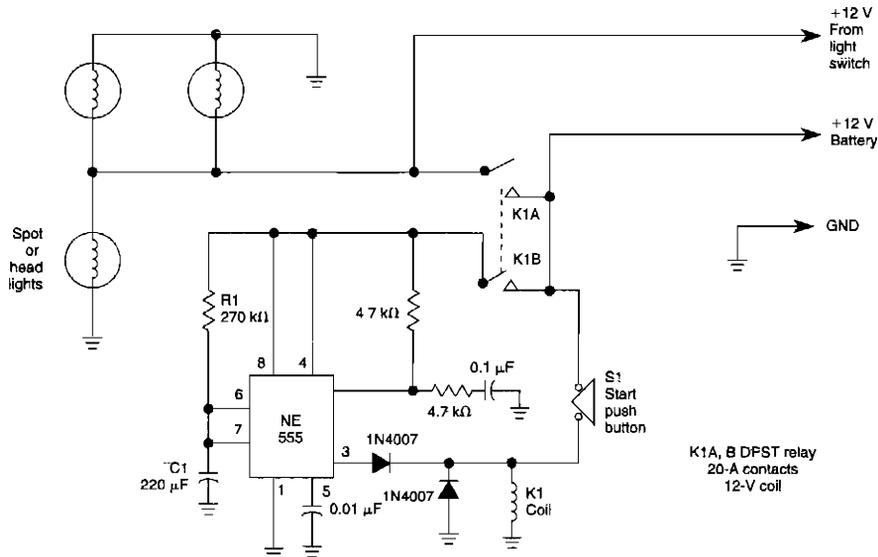


Flasher terminal L connects to the load and X connects to the 12-volt supply. When the driver engages the turn signal, the L terminal voltage varies with the blinking lights. The STS senses the changing voltage and, after 15 seconds, it applies power to a buzzer through a current-limiting device to control loudness.

**C**

This circuit reminds a driver that his turn signal has been left on for more than 15 seconds. When stopped for a light, the brake-on signal holds the warning off.

## MANUAL HEADLIGHT/SPOTLIGHT CONTROL FOR AUTOS



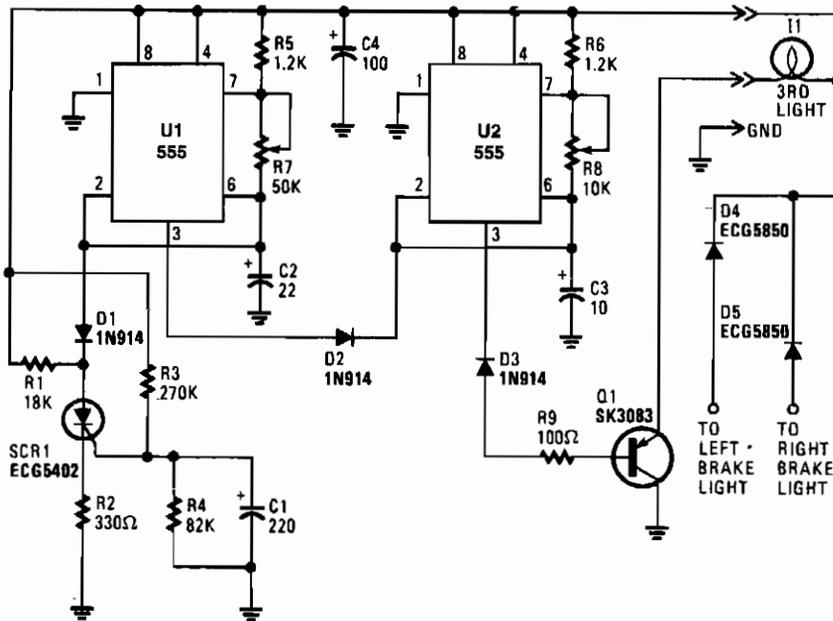
WILLIAM SHEETS

FIG. 8-5

Pressing the START pushbutton turns on either the headlights or spotlights for a predetermined time. After 1 minute (R1 and C1 determine this), the lights will shut off as the NE555 completes its cycle.



## FLASHING BRAKE LIGHT

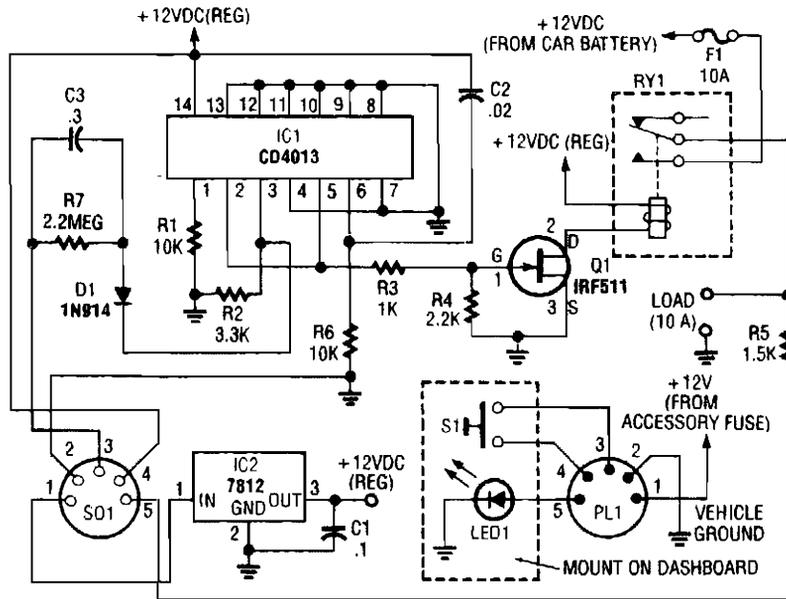


When power is first applied, three things happen: the light-driving transistor (Q1) is switched on because of a low output from U2, pin 3; timer U1 begins its timing cycle, with the output (pin 3) going high, inhibiting U2's trigger (pin 2) via D2; and charge current begins to move through R3 and R4 to C1.

When U1's output goes low, the inhibiting bias on U2 pin 2 is removed, so U2 begins to oscillate, flashing the third light via Q1, at a rate determined by R8, R6, and C3. Oscillation continues until the gate-threshold voltage of SCR1 is reached, causing it to fire and pull U1's trigger (pin 2) low. With its trigger low, U1's output is forced high, disabling U2's triggering. With triggering inhibited, U2's output switches to a low state, which makes Q1 conduct, turning on I1 until the brakes are released. Removing power from the circuits resets SCR1, but the RC network consisting of R4 and C1 will not discharge immediately and will trigger SCR1 earlier. So, frequent brake use means fewer flashes.

Bear in mind that the collector/emitter voltage drop across Q1, along with the loss across the series-fed diodes, reduces the maximum available light output. If the electrical system is functioning properly (at 13 to 14 V for most vehicles), those losses will be negligible.

## POWER CONTROLLER (FOR AUTOMOTIVE ACCESSORIES)

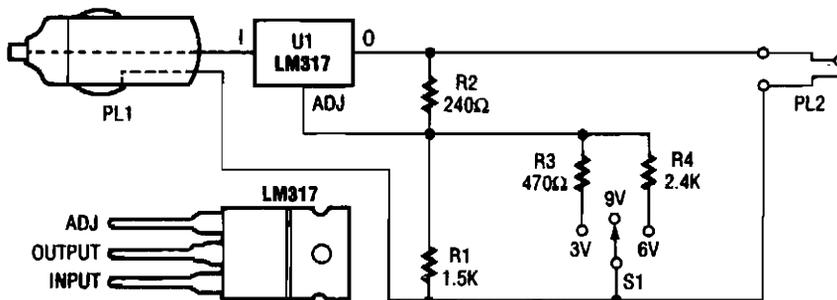


ELECTRONICS NOW

FIG. 8-8

Because the power controller is powered from the vehicle's accessory switch, the load can receive power only when the ignition key is on. Using half of a dual flip-flop (CD4013), a load of up to 10 A is controlled by a momentary pushbutton. This circuit was originally intended for automotive power control, but could have other applications as well.

## AUTOMOTIVE POWER ADAPTER FOR dc-OPERATED DEVICES



1993 ELECTRONICS HOBBYIST HANDBOOK

FIG. 8-9

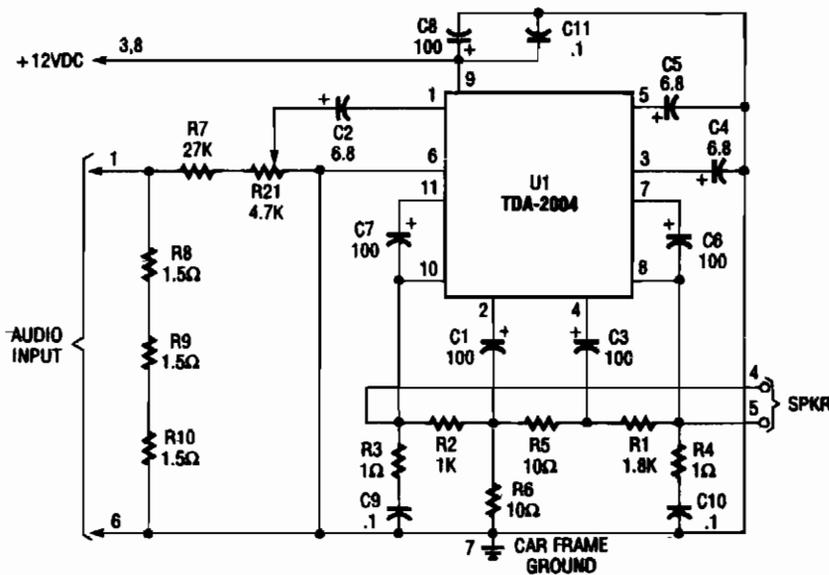
In the schematic diagram for the car-power adapter, note how the value of  $R_B$  (which is R1 and S1 in the center position) is changed by putting R3 or R4 in parallel with R1.



## TIME-DELAY AUTO-KILL SWITCH (Cont.)

The automobile delayed kill switch is simple in concept. When you get out of your car, a secretly located pushbutton switch is pressed. Nothing apparently happens, but at the end of a predetermined time, a relay is pulled in and locked. When the relay is pulled in, contacts open, and the hot lead from the ignition to the coil and the hot wire from the key switch to the starter solenoid is opened or disconnected. If the engine is running, it stops immediately and the starter will not operate. When you get into the car, another pushbutton switch is pressed and the relay drops out and everything goes back to normal.

## BOOSTER AMPLIFIER FOR CAR STEREO USE



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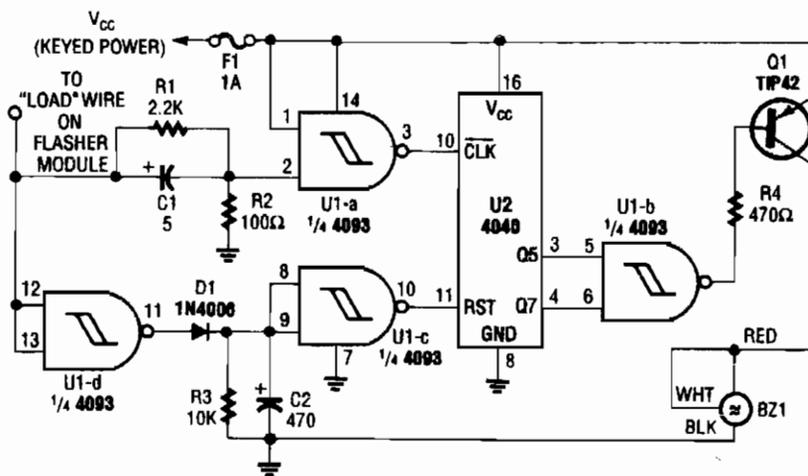
FIG. 8-11

Only one channel of this circuit is shown. The other is practically a carbon copy.

The input to the circuit, taken from your car radio's speaker output, is divided along two paths; in one path, a high-power divider network (consisting of R8 through R10) provides 4.5-ohm resistance to make the circuit's input impedance compatible with the output impedance of the car radio. In the other path, the signal is fed to the input of U1 through resistor R7, trimmer potentiometer R21, and capacitor C2. Together, R7 and R21 offer a minimum resistance of 27,000 ohm.

Integrated circuit U1 (a TDA-2004 audio power amplifier) amplifies the signal, which is then output at pins 8 and 10 and fed to the loudspeaker. Note: This amp is designed for use only with car radios whose speaker outputs are referenced to ground; do not use it with radios that have balanced outputs.

## AUTO TURN-SIGNAL REMINDER

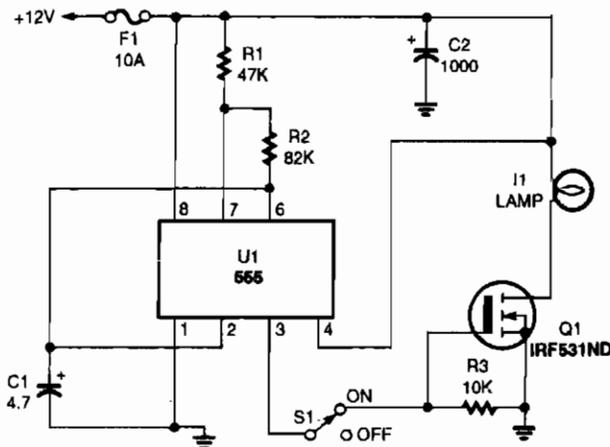


POPULAR ELECTRONICS

FIG. 8-12

This circuit counts turn signal flashes. At the end of about 70 flashes, a chime sounds to remind the driver to turn off the turn signal. By using various taps on U2, the period can be changed if desired. BZ1 is a buzzer or chime module.

## HEADLIGHT FLASHER

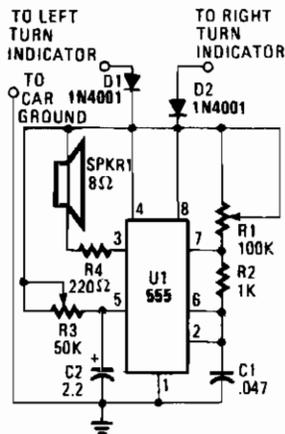


POPULAR ELECTRONICS

FIG. 8-13

The headlight flasher is nothing more than a 555 oscillator/timer that's configured as an astable multivibrator (oscillator). Its input is used to drive the gate of an IRF531ND hexFET, which, in turn, acts like an on/off switch, turning the lamp on and off at the oscillating frequency (1 Hz).

## AUTOMOTIVE AUDIBLE-TURN INDICATOR

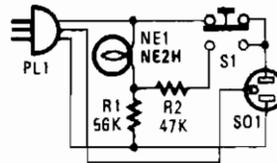


POPULAR ELECTRONICS

FIG. 8-14

This little circuit should be useful to the hearing impaired. It produces a tone each time a dashboard turn indicator lights. The tone drops in frequency for as long as the indicator is lit.

## ENGINE BLOCK HEATER MINDER

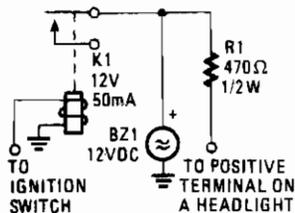


POPULAR ELECTRONICS

FIG. 8-15

If you live in the frozen north, knowing your engine-block heater is working is a comfort. This device will let you know if yours is okay. Plug in PL1 to your power outlet. NE1 should light. Then, plug in the block heater. Depressing S1 should cause the indicator to get brighter. If not, your block heater might be open and inoperative.

## HEADLIGHTS-ON REMINDER

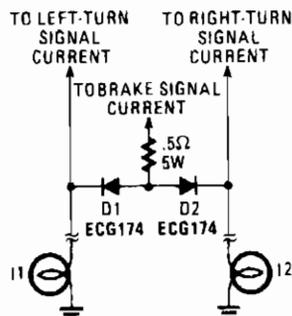


POPULAR ELECTRONICS

FIG. 8-16

This circuit will sound alarm BZ1 if the ignition is turned off with the headlights on.

## BRAKE AND TURN INDICATOR

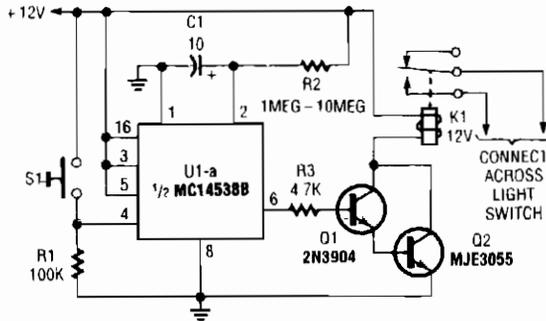


POPULAR ELECTRONICS

FIG. 8-17

This might be a quick solution to getting the two-wire truck harness to support both turn and braking indications.

## LAMP-SWITCHING CIRCUIT



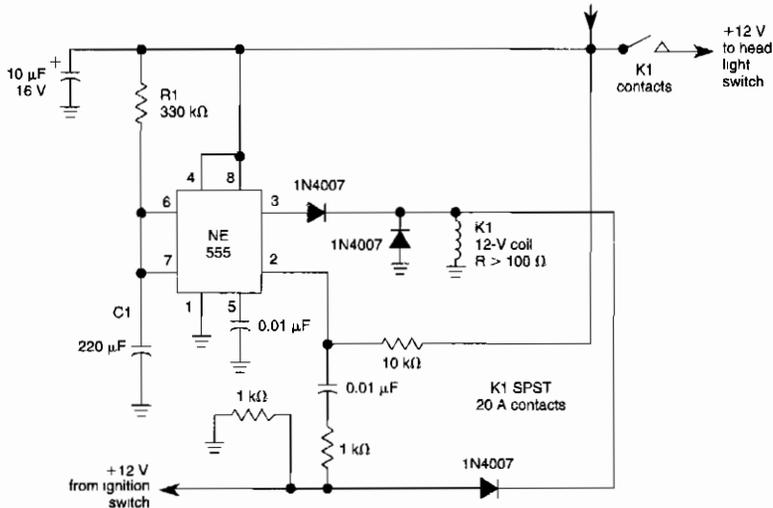
POPULAR ELECTRONICS

FIG. 8-18

A normally open pushbutton switch (S1) delivers a positive input pulse to pin 4 of U1, triggering the IC into action. The output of U1 at pin 6 supplies base-drive current to a Darlington pair comprised of Q1 and Q2, activating K1. A 10- $\mu\text{F}$  capacitor and any resistor value of from 1 to 10 M $\Omega$  can be used as the timing components.

To use the circuit on an auto's headlights, connect the relay's normally open contacts across the car's headlight switch and press S1 to extend the on time. In connecting the circuit to control an ac-operated lamp, turn off the ac power and connect the relay contacts in parallel with the lamp's power switch contacts.

## AUTOMATIC TURN-OFF CONTROL FOR AUTOMOBILES

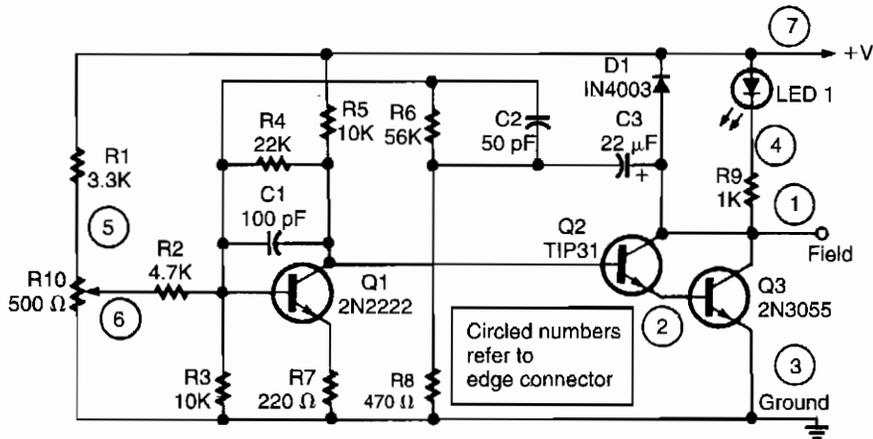


WILLIAM SHEETS

FIG. 8-19

When the ignition switch is on, relay K1 is energized continuously, and the headlights can be turned on. Turning off the ignition turns on timer IC1, which keeps IC1 energized for a time determined by R1 and C1. With the values shown approximately a 1 minute delay will result. The values of R1 or C1 can be changed to vary this delay time.

## ALTERNATOR REGULATOR

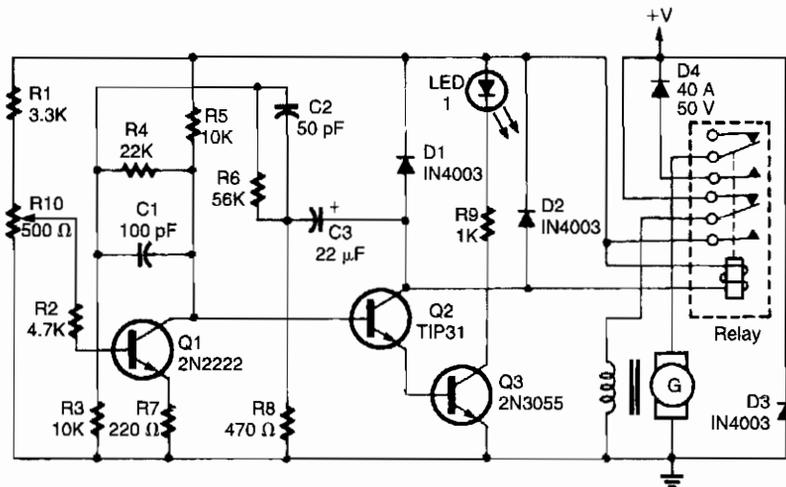


RADIO-ELECTRONICS

FIG. 8-20

This alternator regulator uses a 3-transistor dc amplifier, and is designed for a “pulled up” field system, where one side of the alternate field returns to the +12-V supply, and the other end is pulled toward ground. The circuit monitors the state of the battery through a resistive divider and causes the voltage to change at the field terminal.

## AUTO GENERATOR REGULATOR

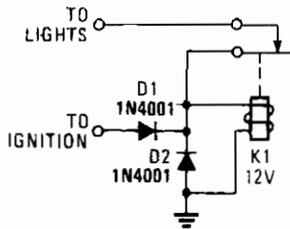


RADIO-ELECTRONICS

FIG. 8-21

This regulator is for the purpose of controlling a dc generator. The field configuration is that one side of the field is grounded. D4 prevents the battery from discharging through the generator and takes the place of the mechanical cut-out relay. R10 adjusts the system voltage setting.

## LIGHTS-ON REMINDER

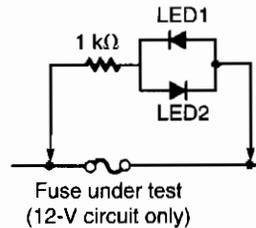


POPULAR ELECTRONICS

FIG. 8-22

A relay and two diodes are all that is needed—the relay performs the job of a buzzer so no annunciator is required. When the lights are left on, but the ignition is off, the normally closed relay contacts are in series with the relay coil. That means the relay interrupts its own power each time it becomes active, so it chatters and acts like a buzzer. This is a real minimalistic headlight reminder. It doesn't even require an annunciator because the relay acts as buzzer.

## AUTO FUSE MONITOR

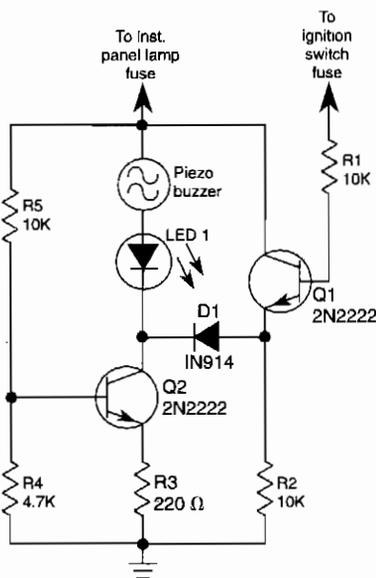


WILLIAM SHEETS

FIG. 8-23

This circuit can quickly check a fuse in an automobile circuit. Connect across suspected fuse—either LED glows, fuse is blown. The circuit must be live for this test to work.

## HEADLIGHT ALARM



1989 R-E EXPERIMENTERS HANDBOOK

FIG. 8-24

The base of Q1 is connected to the car's ignition circuit; the easiest point to make that connection is at the ignition switch fuse in the car's fuse panel. Also, one side of the piezoelectric buzzer is connected to the instrument-panel light fuse; when the headlights or parking lights are on, the instrument panel is lit, too. When the headlights are off, no current reaches the buzzer. Therefore, nothing happens. What happens when the headlights are on depends on the state of the ignition switch. When the ignition switch is on, transistors Q1 and Q2 are biased on, effectively removing the buzzer and the LED from the circuit.

When the ignition switch is turned off, but the headlight switch remains on, transistor Q1 is turned off, but transistor Q2 continues to be biased on. The result is that the voltage across the piezoelectric buzzer and the LED is sufficient to cause the buzzer to sound loudly and the LED to light.

# 9

## Battery Charger Circuits

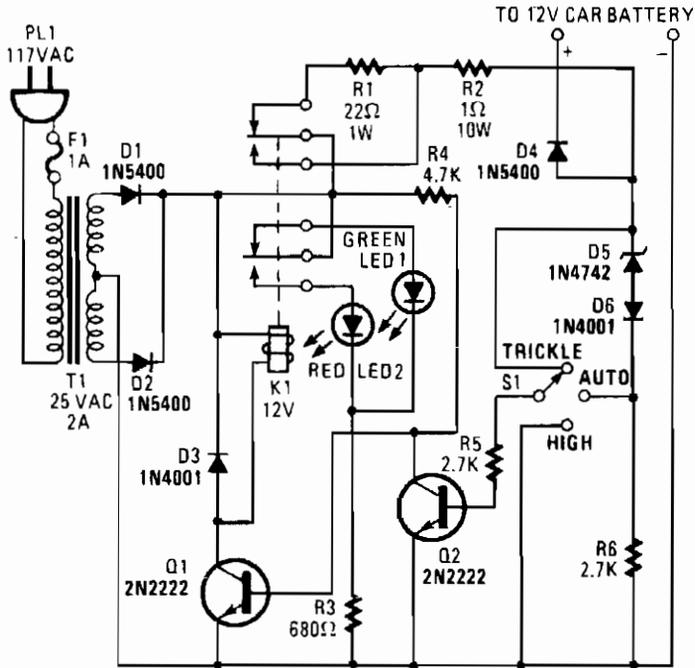
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Lead-Acid Trickle Charger
- RF-Type Battery Charger
- Battery Charger
- Solar-Powered Battery Charger
- Intelligent Battery-Charging Circuit



## BATTERY CHARGER



POPULAR ELECTRONICS

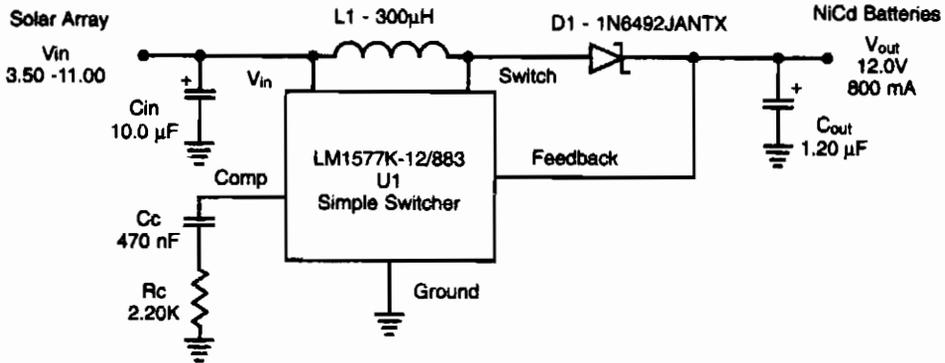
FIG. 9-3

The circuit is capable of supplying either a trickle (50 mA) or high-current (1-A) charge. You can select either charging method or an automatic mode that will first trickle charge a battery if it is particularly low before switching to high-current charging.

If the battery's voltage is low, Zener-diode D5 will not conduct sufficient current to produce a voltage drop across R6 to turn Q2 on. With Q2 off, R4 pulls the base of Q1 high, turning it on. That activates K1. With K1 active, the only thing between the battery and the power supply is R2 and D4 (which prevents current from flowing through the circuit from the battery).

Once the battery charges a bit, the current through D5 increases, causing a voltage drop across R6 that is of sufficient magnitude to turn on Q2. Transistor Q2, in turn, grounds the base of Q1, keeping it off. With Q1 off, K1 remains in its normally closed state. That places R1 in series with the battery, thereby reducing the current to a trickle.

## SOLAR-POWERED BATTERY CHARGER

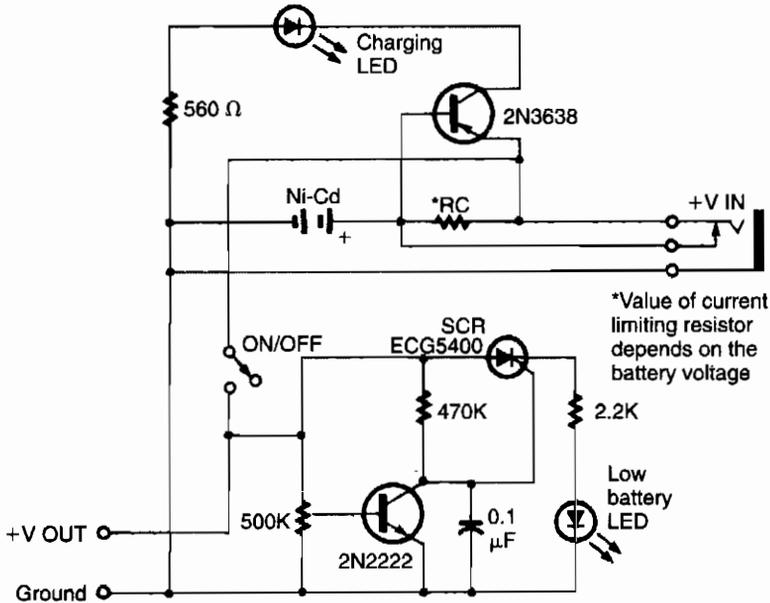


NATIONAL SEMICONDUCTOR

FIG. 9-4

A National Semiconductor LM1577 IC is used in a step-up regulator to charge Nicad batteries from a solar panel.

## INTELLIGENT BATTERY-CHARGING CIRCUIT



RADIO-ELECTRONICS

FIG. 9-5

Intended for a Nicad application this charging circuit can be used with a wide range of batteries. A low-battery detector is intended. The trip voltage is set via the 500-k $\Omega$  pot. Select  $R_c$  for the battery you intend to use.

# 10

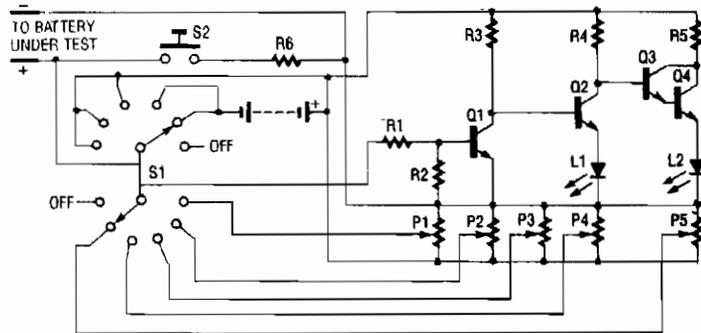
## Battery Test and Monitor Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Battery Tester
- Car Battery Tester for Cranking Amps
- Supply Voltage Monitor
- Battery Watchdog
- Battery Test Circuit
- Battery Voltage Monitor
- Battery Saver Circuit
- 0–2-A Battery Current Monitor with Digital Output
- Car Battery and Alternator Monitor
- Relay Fuse for Battery Charges
- Bargraph LED Battery Tester

## BATTERY TESTER



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FIG. 10-1

The battery tester uses four transistors and two LEDs to indicate the condition of any battery you want to test. Q3 and Q4 are connected in a Darlington configuration that has extremely high gain. LED L2 lights when a small positive potential appears on the base of Q3. Transistors Q1 and Q2 form a direct-coupled dc-amplifier circuit. The output of this stage drives the red LED L1. Rotary switch S1 is used to select different ranges (which have been previously set by adjusting trimmer resistors P1 through P5).

The positive (+) lead goes through the selected contacts of S1 to the biasing resistors R3, R4, and R5. The negative (-) lead of the battery under test goes to the ground or common lead of the circuit and the (+) side to one side of P1 through P5.

L1	Red LED
L2	Green LED
P1 through P5	5-k $\Omega$ trimmer resistor
R1	100 k $\Omega$
R2, R3	33 k $\Omega$
R4, R5	470 $\Omega$
R6	12 $\Omega$ 1 W
S1	2 P6 position NS rotary switch
S2	NO pushbutton switch

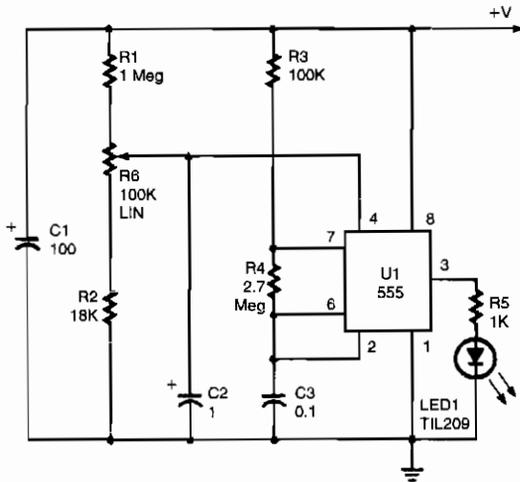
Depending on the position of S1, a particular trimmer resistor (wiper lead) is selected. That lead goes through the contact on S1 to resistor R1 and into the base of npn transistor Q1. If the battery is good enough, (+) voltage goes to the base of Q1, turning it on. This turns Q2 off, which then allows Q3 to turn on. That causes Q4 to turn on and light green LED L2.

If the battery is weak, Q1 will not turn on, which will cause Q2 to be biased on by R3, which in turn lights red LED L1. When Q1 is on, it biases the base of Q3 negative, and causes Q3 to be turned off. That prevents L2 from turning on.

The circuit operates in the same manner for all ranges except the first two, where a 9-V battery has been added by S1 to be in series with the input voltage to allow for testing of very low voltage batteries. That is because at voltages below 2 Vdc, LEDs will not light and the circuit would be unable to set a low-voltage (<2-V) battery without the additional internal-battery voltage. A load resistor has also been included; it allows the battery under test to be connected to a load to give a better indication of its condition. That load resistor is connected across the battery when normally open (NO) switch S2 is depressed.



## SUPPLY VOLTAGE MONITOR

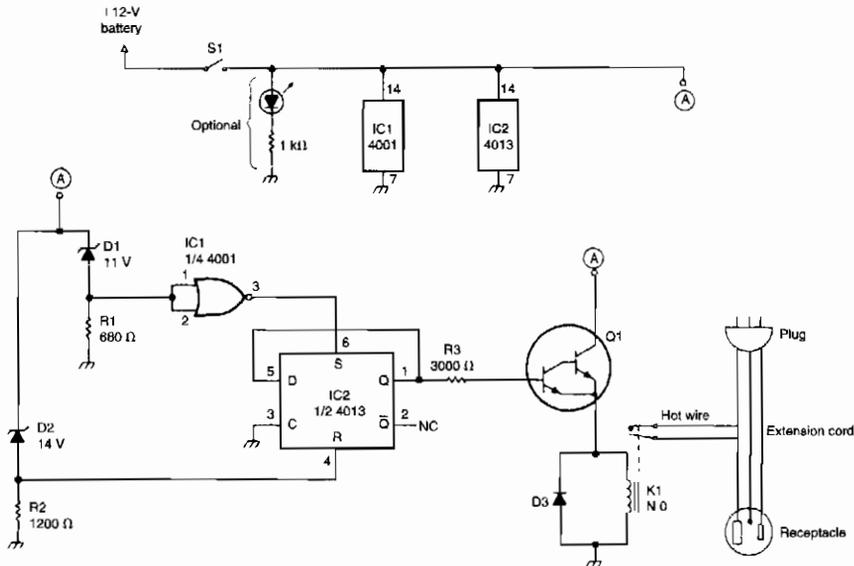


When supply voltage exceeds a preset level, the 555 oscillates, and flashes LED1. The flash rate is controlled by varying C3.

POPULAR ELECTRONICS

FIG. 10-3

## BATTERY WATCHDOG

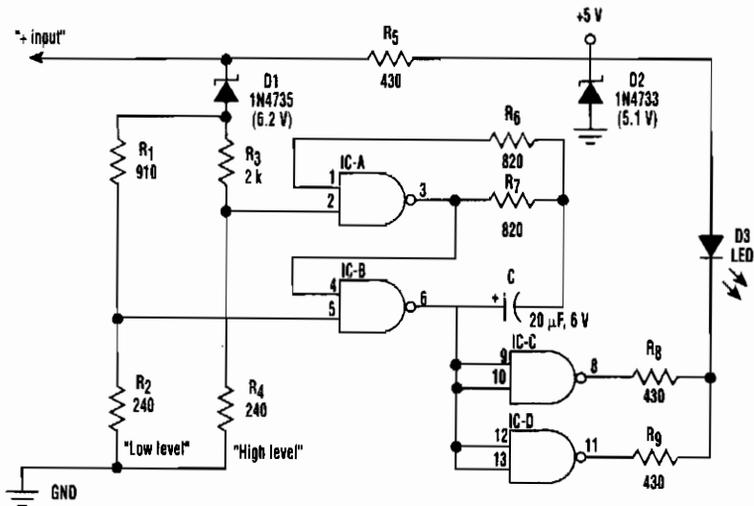


73 AMATEUR RADIO TODAY

FIG. 10-4

This circuit uses a pair of Zener diodes to monitor battery voltage of a 12-V battery. If below 11 V, D1 ceases to conduct, pin 3 of IC2 goes high, setting FF IC2 turning on Q1, K1, and the battery charger. At excess of 14-V-battery voltage (full charge), D2 conducts, resetting FF IC2, and cutting off the battery charger.

## BATTERY TEST CIRCUIT

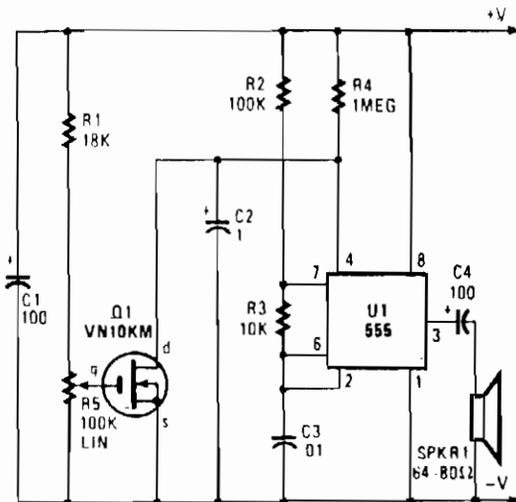


ELECTRONIC DESIGN

FIG. 10-5

Using this circuit, three levels of voltage can be displayed—normal (11 to 15 V), high (>15 V), and low (<11 V). When the voltage is low, the LED glows steadily. In the normal range, the LED is off. When the voltage is high, the LED blinks at a 1-Hz rate. This circuit is useful for assuring proper electrical system operation.

## BATTERY VOLTAGE MONITOR

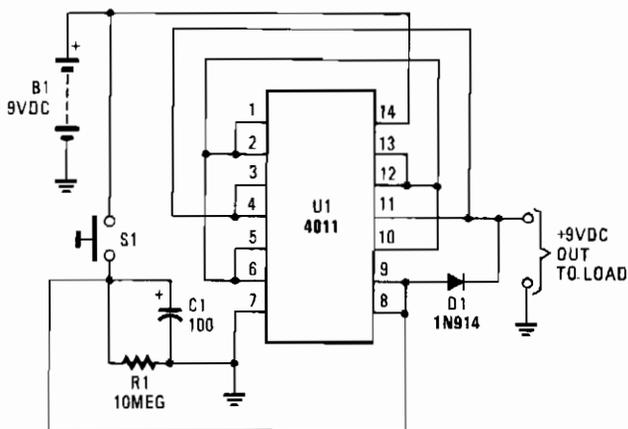


When battery voltage goes low, pin 4 of U1 goes high as Q1 fails to conduct. This activates oscillator U1 and generates audio tone. R5 sets level at which the circuit activates.

POPULAR ELECTRONICS

FIG. 10-6

## BATTERY SAVER CIRCUIT



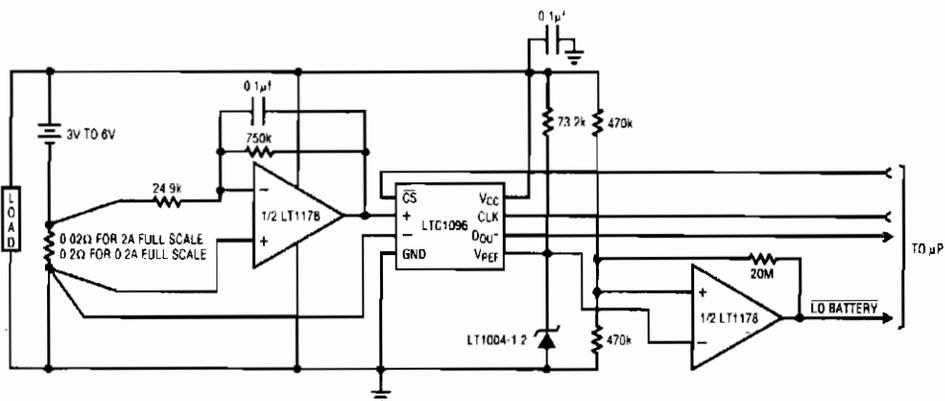
POPULAR ELECTRONICS

FIG. 10-7

This battery saver circuit can automatically turn off a small piece of test equipment after a desired period of time, allowing you to leave your shop worry free.

This circuit uses a CD4011 IC to act as a simple timer. One section acts as an RC discharge timer (pin 7). This causes its output to go low, holding the three other outputs high acting as a 9-V source. After C1/R1 discharges approximately 10 minutes, the output drops to zero. S1 resets the circuit.

## 0-2-A BATTERY CURRENT MONITOR WITH DIGITAL OUTPUT

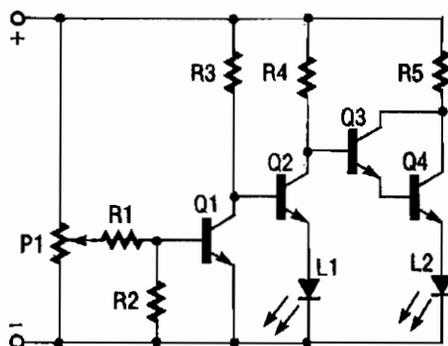


LINEAR TECHNOLOGY

FIG. 10-8

IC devices by Linear Technology make up this current monitor circuit. Drain is only 70μA from a 3- to 6-V battery.

## CAR BATTERY AND ALTERNATOR MONITOR



L1	Red LED
L2	Green LED
P1	2.5-k $\Omega$ trimmer resistor
Q1-Q4	2N3904 transistor
R1	100-k $\Omega$ resistor
R2, R3	33-k $\Omega$ resistor
R4, R5	470- $\Omega$ resistor
Misc.	PC board, wire

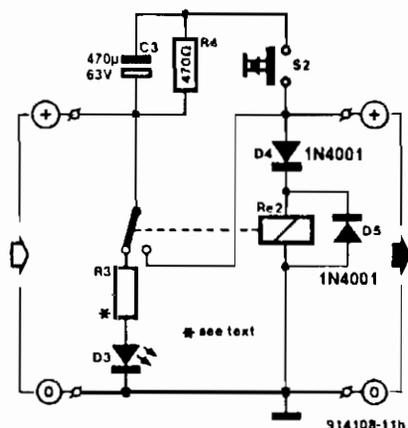
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FIG. 10-9

The monitor is a simple voltage comparator in which a car battery serves as the battery for operation. The input voltage to the comparator is set by adjustment potentiometer P1, which must be adjusted so that the green LED L2 is on when the alternator is operating properly and red LED L1 is on when the alternator is inoperative.

The circuit operates as follows: When the alternator operates properly, the battery voltage is higher and P1 is set so that transistor Q1 causes Q2 to be off. That results in Q3 and Q4 being fully on, thus applying current to green LED L2. If the battery voltage is lowered (alternator inoperative), transistor Q1 is turned off. That allows transistor Q2 to turn fully on, applying current to red LED L1, indicating trouble. Once Q2 is on, it causes Q3 and Q4 to go out of conduction.

## RELAY FUSE FOR BATTERY CHARGES

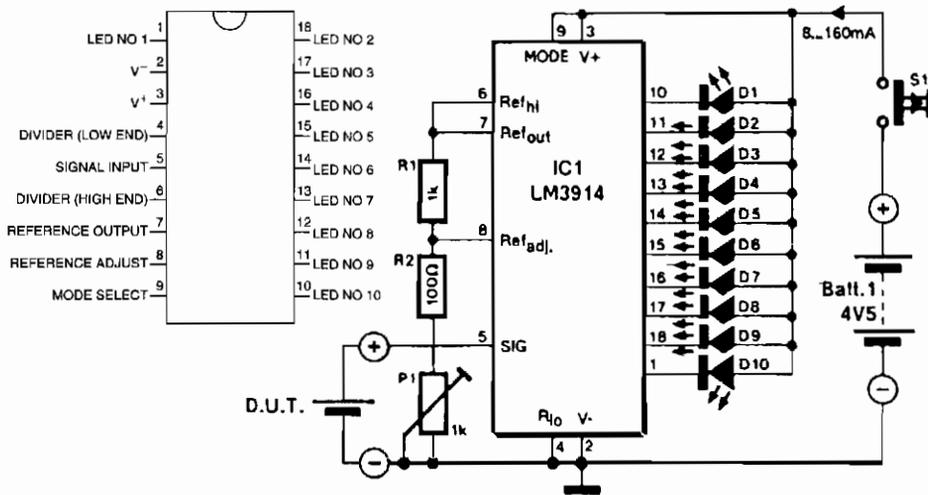


Charged capacitor C3 and momentary push-button switch S2 are used to momentarily energize relay RE2. The battery under charge energizes the relay to hold it closed. S2 will energize the relay even if the battery is too far discharged initially to energize it.

ELEKTOR ELECTRONICS

FIG. 10-10

## BARGRAPH LED BATTERY TESTER



ELEKTOR ELECTRONICS USA

FIG. 10-11

The LM3914A bargraph LED is used here as a voltmeter for battery testing. The circuit is powered by a 4.5-V battery and compares the battery under test with an internally derived reference, set by R1/R2/P1. Each LED of the 10 represent 10% of full scale. For best results, the battery (D.U.T.) should be loaded with an appropriate resistor.

# 11

## Buffer Circuits

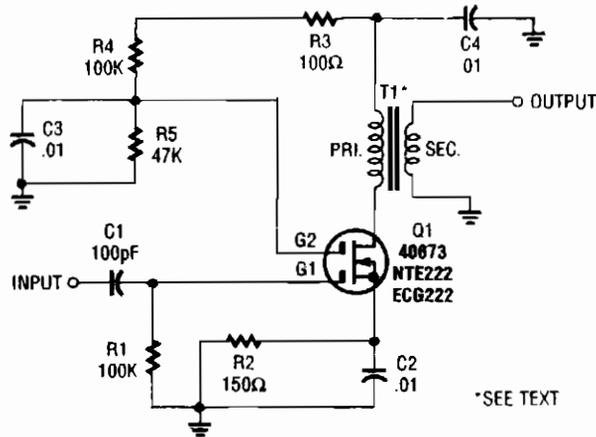
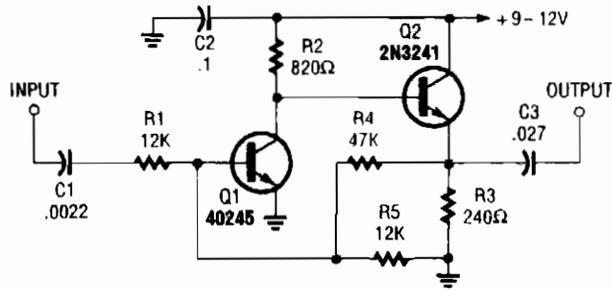
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

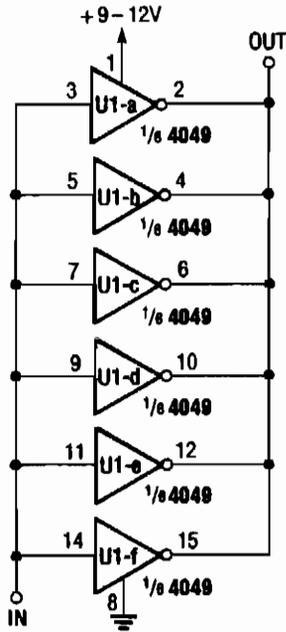
Buffer/Amplifiers  
High Current Buffer  
VFO Buffer Amplifier  
MOSFET Buffer Amplifier  
3-V Rail-to-Rail Single-Supply Buffer  
Simple Video Buffer  
Low-Offset Simple Video Buffer

## BUFFER/AMPLIFIERS



These two buffer/amplifiers that have been successfully used with VFOs: one (shown in A) is based on a pair of bipolar npn transistors, and the other (shown in B) is built around a dual-gate MOSFET.

## HIGH CURRENT BUFFER

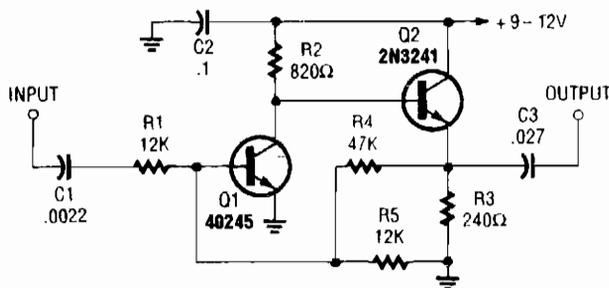


By parallel connecting all six gates of this 4049 hex inverting buffer, you can obtain a much higher output current than would otherwise be available.

POPULAR ELECTRONICS

FIG. 11-2

## VFO BUFFER AMPLIFIER

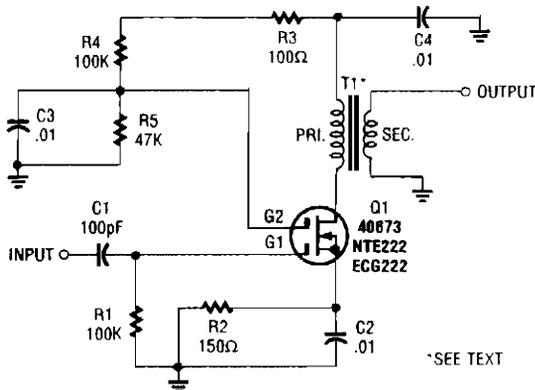


POPULAR ELECTRONICS

FIG. 11-3

A two-transistor feedback pair provides broadband operation. The gain is approximately  $R_4/R_1$ .

### MOSFET BUFFER AMPLIFIER

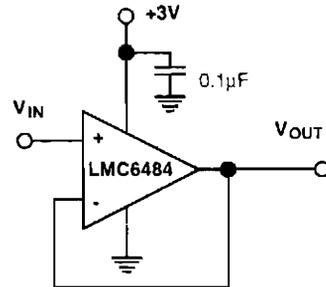


POPULAR ELECTRONICS

FIG. 11-4

A MOSFET is used as a wideband buffer amplifier. T1 is wound on a toroid of approximately ½" diameter, with material suitable for frequency (usually 1- to 20-MHz range). The turns ratio should be about 4:1 depending on load impedance. Typically, at 4 MHz, there are 18 turns on the primary, 4 turns on the secondary, and the stage gain is about 14-dB voltage ( $Z_L = 50 \Omega$ ).

### 3-V RAIL-TO-RAIL SINGLE-SUPPLY BUFFER

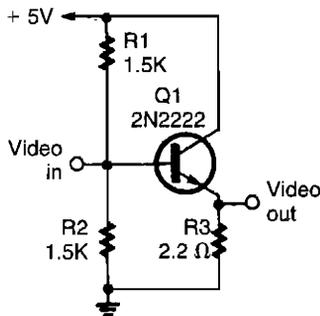


NATIONAL SEMICONDUCTOR

FIG. 11-5

The LMC6484 provides a 3-V p-p rail-to-rail buffer with a +3-V supply commonly used for logic systems.

### SIMPLE VIDEO BUFFER

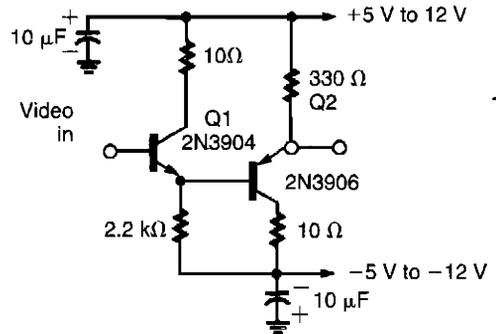


ELECTRONICS NOW

FIG. 11-6

This simple emitter follower can be used as a video buffer.

### LOW-OFFSET SIMPLE VIDEO BUFFER



WILLIAM SHEETS

FIG. 11-7

This circuit has proved to be an effective video buffer and will easily drive a 75-Ω load to 1.5-V p-p output. BW is better than 20 MHz and there is less than 0.05-V dc offset, which is the difference in  $V_{BE}$  of Q1 and Q2. The supply lines should be well bypassed,  $\pm 5$  V or more.

# 12

## Carrier-Current Circuits

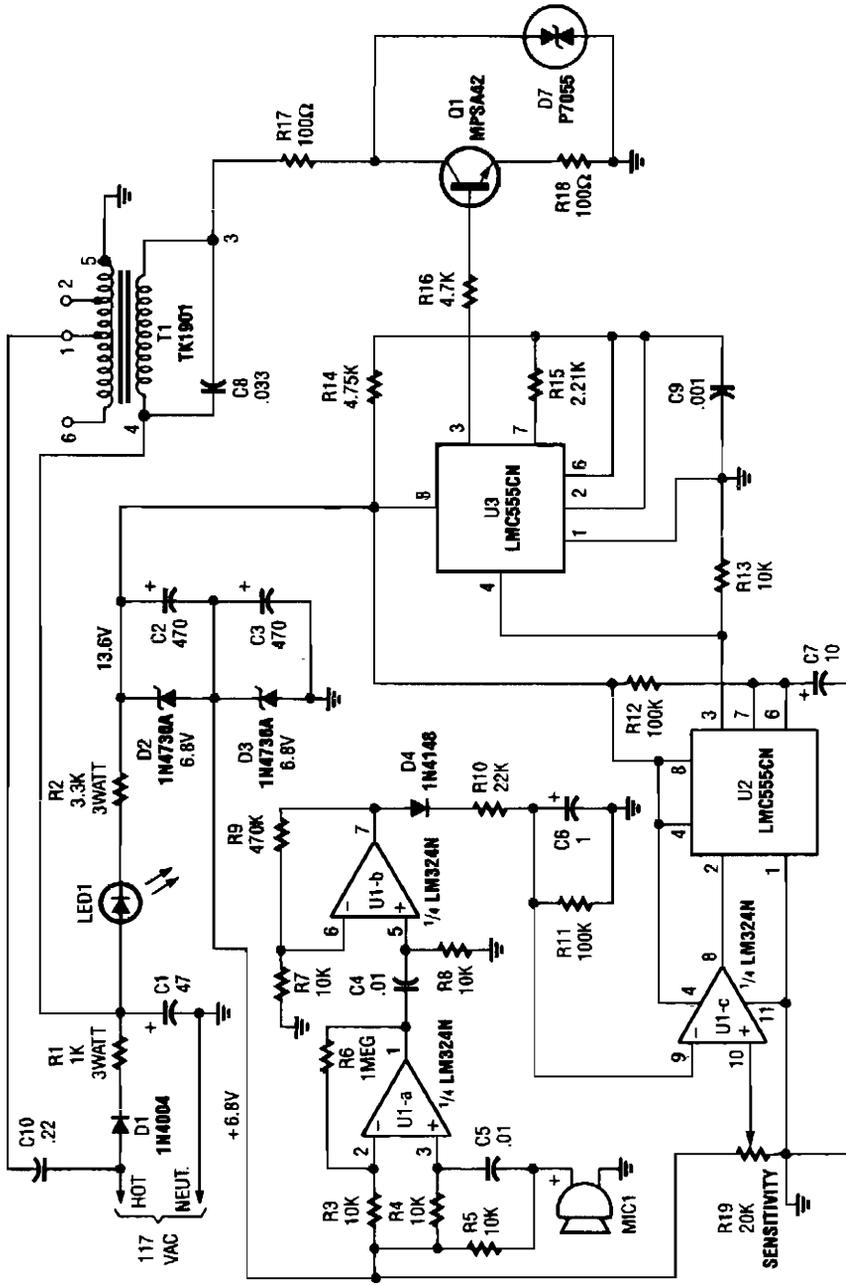
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Carrier-Current Baby-Alert Transmitter  
Carrier-Current Baby-Alert Receiver

# CARRIER-CURRENT BABY-ALERT TRANSMITTER

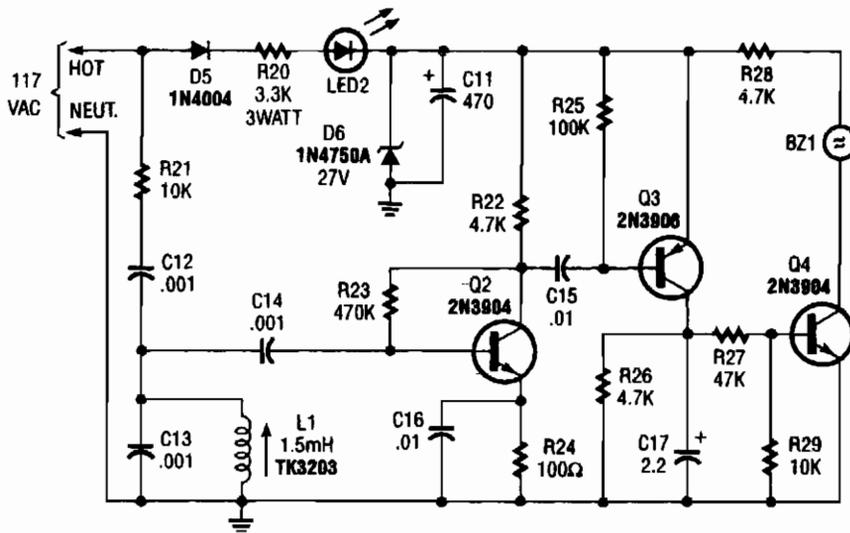


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FIG. 12-1

The baby-alert transmitter is built around an LM324 quad op amp (U1), two LMC555CM CMOS oscillator/timers (U2 and U3), and a few support components. The transmitter sends a signal on receipt of a sound at MIC1. It has a frequency of around 125 kHz and can be used to trigger an alarm receiver.

## CARRIER-CURRENT BABY-ALERT RECEIVER



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FIG. 12-2

The baby-alert receiver is comprised of three transistors: Q2, which is configured as a high-gain linear amplifier; Q3, which serves as both an amplifier and detector; and Q4, which is essentially used as a switch; and a few additional components. It sounds an alarm BZ1 on receipt of a 125-kHz signal from an alarm transmitter via the 120-V power lines.

# 13

## Clock Circuit

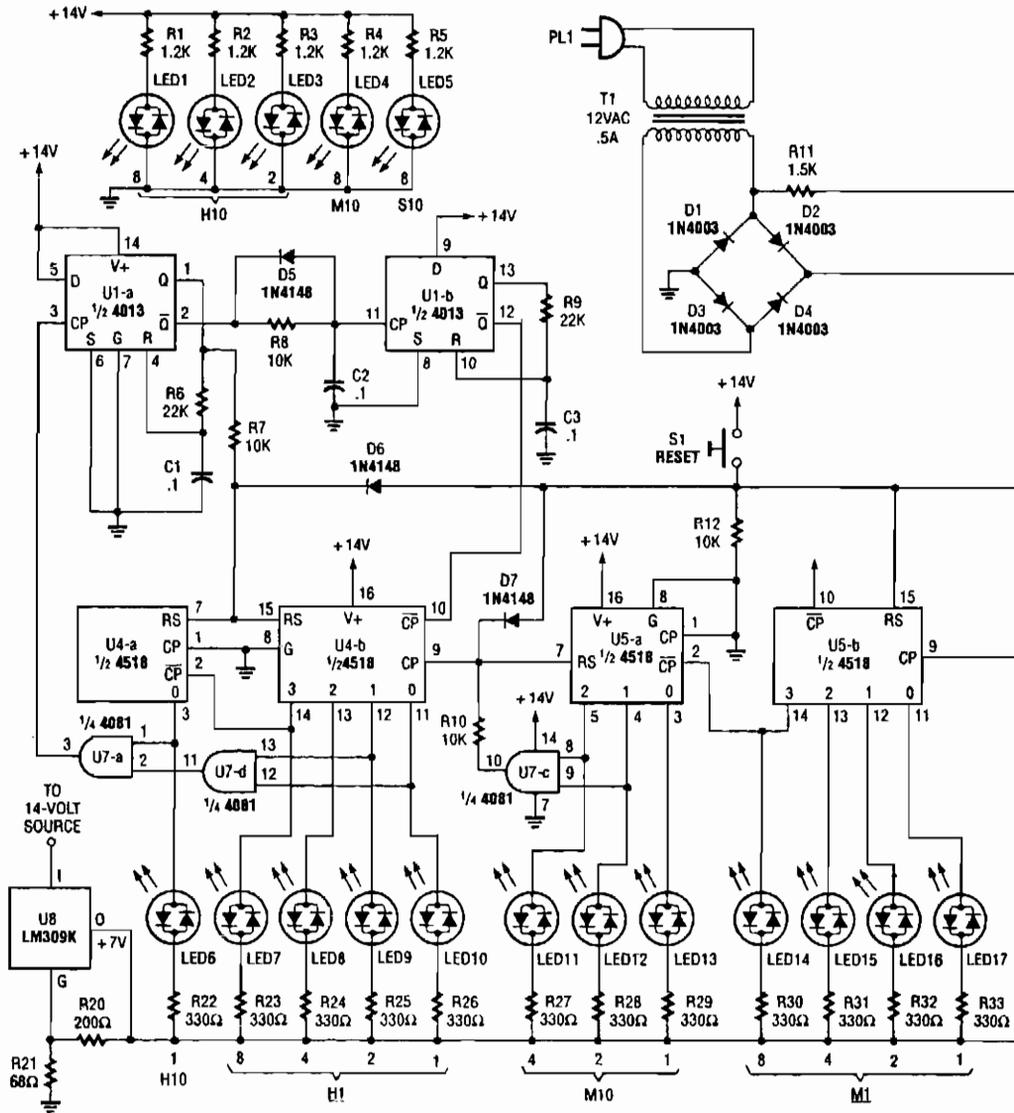
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Binary Clock

## BINARY CLOCK



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This circuit is an unusual clock in that the LEDs are bi-color red/green displays that indicate the time in binary coded decimal form.

LEDs 21 through 24 read out seconds

LEDs 5, 18, 19, and 20 read out 105 seconds

LEDs 14 through 17 read out in minutes

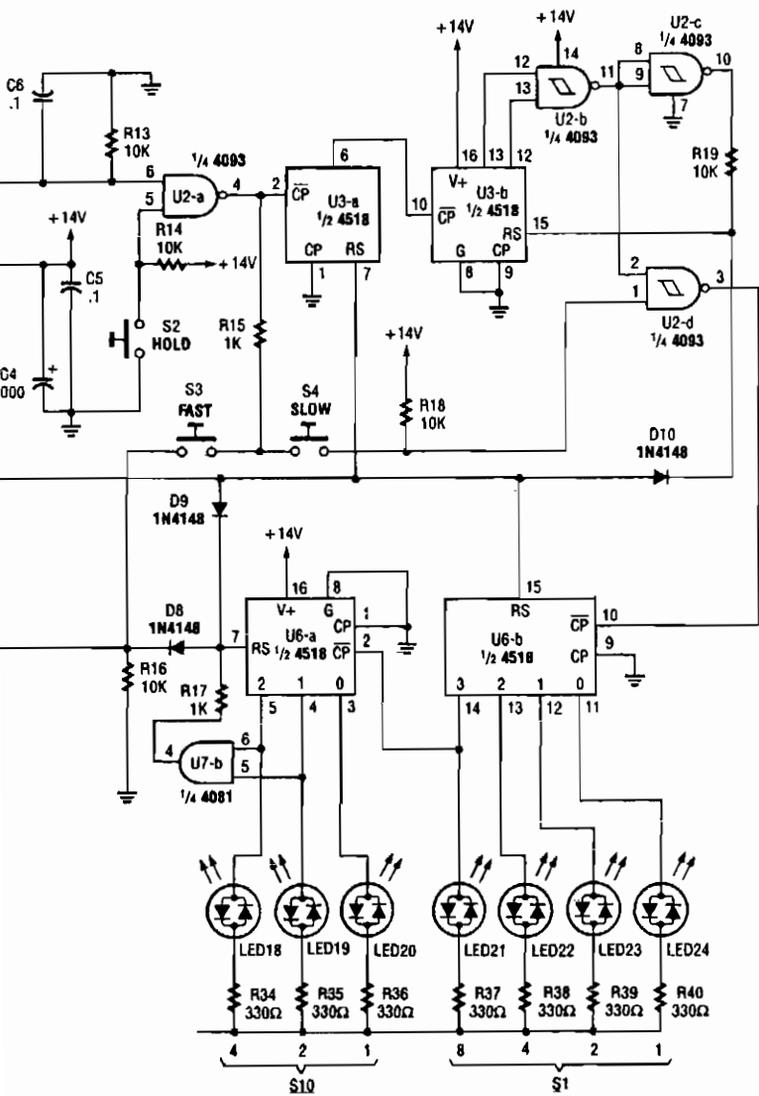


FIG. 13-1

LEDs 4, 11, 12, and 13 read out in 105 minutes  
 LEDs 7 through 10 read out the hours  
 LEDs 1, 2, 3, and 6 read out tens of hours  
 The 60-Hz line is used as a timebase.

# 14

## Code Practice Circuits

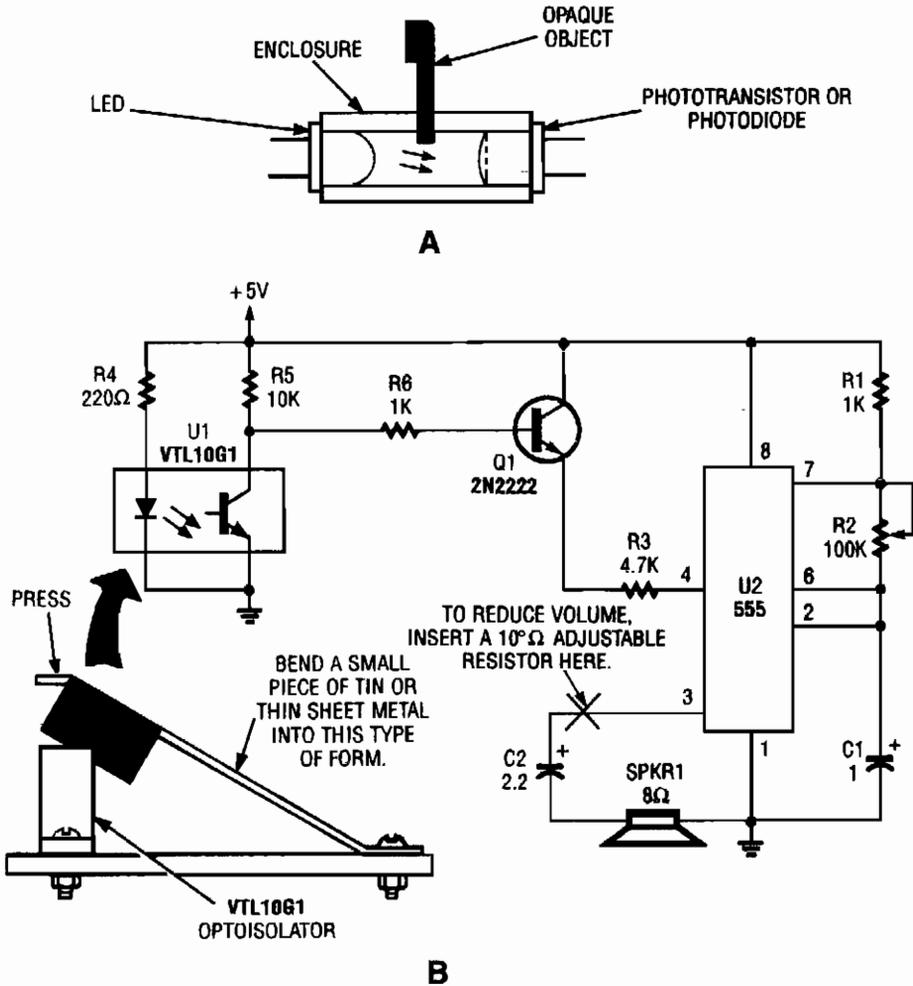
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The source of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

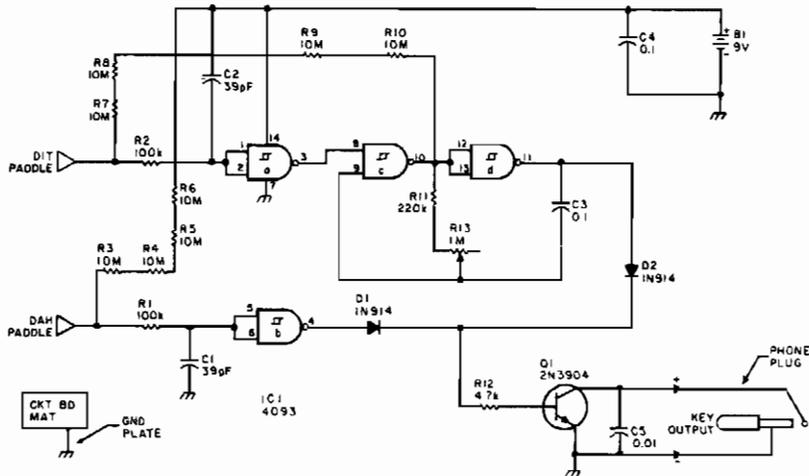
Code Practice Oscillator Uses Optoisolator  
Electronic CW “Bug” Keyer  
QRP Sidetone Generator/Code Practice Oscillator  
Morse Practice Oscillator  
Code Practice Oscillator  
Variable Frequency Code Practice Oscillator  
Single-Transistor Code Practice Oscillator

## CODE PRACTICE OSCILLATOR USES OPTOISOLATOR



A slotted-pair isolator (A) is effectively an enclosed-pair isolator with a slit that will allow an obstacle to interrupt the light path. That could be useful for building a code key (B).

## ELECTRONIC CW "BUG" KEYS

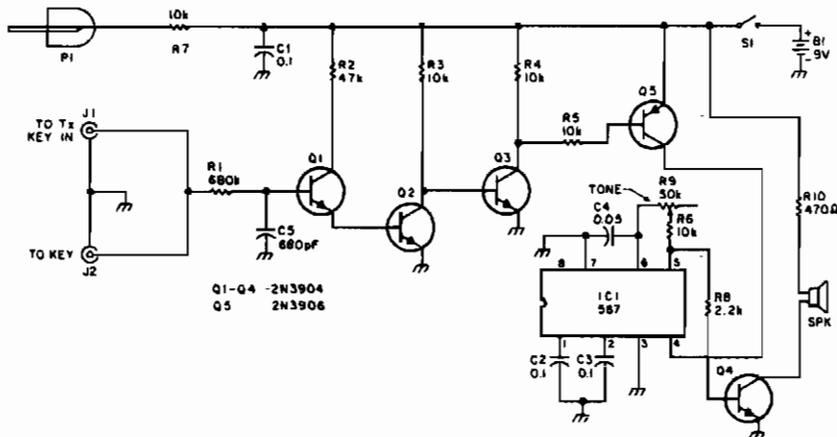


73 AMATEUR RADIO TODAY

FIG. 14-2

This keyer uses skin conductivity to simulate the old-fashioned mechanical CW bug keyer. When the "dit" paddle is touched the bias on the inverter, IC1-a is shunted to ground, and it produces a logic high, causing oscillator sections C&D to generate a low-frequency square wave keying Q1 for a series of "dits." When the "dah" paddle is touched, section b produces a logic high, driving keyer Q1 on.

## QRP SIDETONE GENERATOR/CODE PRACTICE OSCILLATOR

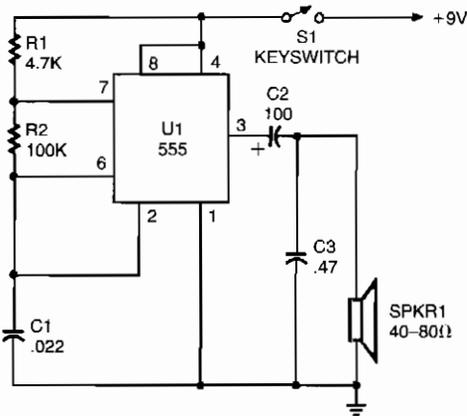


73 AMATEUR RADIO TODAY

FIG. 14-3

For use with low-power transmitters with a positive keying voltage. Q1/Q2/Q3 form a switching amplifier. When the key is pressed, the collector of Q3 goes to ground, turning on Q5 and activating IC1, an audio oscillator. Q4 drives the speaker. For use as a code practice oscillator, insert P1 and J1 and a key in J2.

### MORSE PRACTICE OSCILLATOR

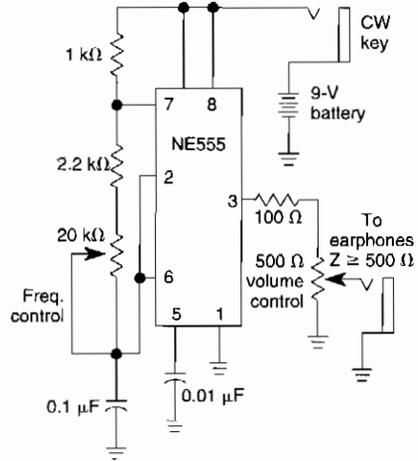


POPULAR ELECTRONICS

FIG. 14-4

A 555 timer configured as an astable multivibrator is used in this circuit to generate an audio note. C1 can be changed to vary the audio note as desired.

### CODE PRACTICE OSCILLATOR

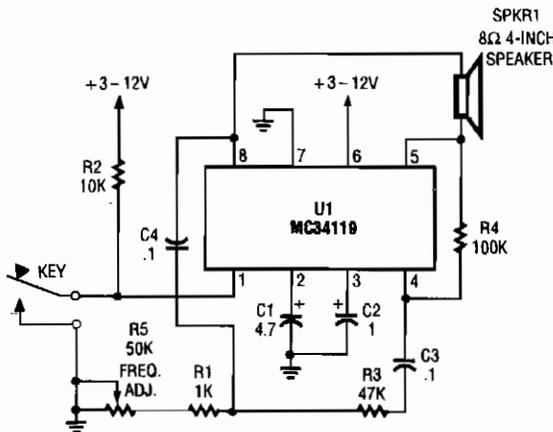


WILLIAM SHEETS

FIG. 14-5

The tone and volume of the sound produced when the telegraph key is depressed can be varied in this code practice oscillator.

### VARIABLE FREQUENCY CODE PRACTICE OSCILLATOR

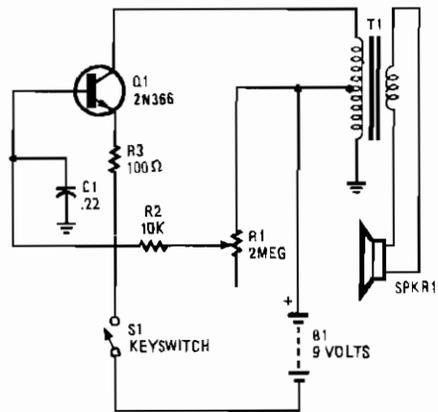


POPULAR ELECTRONICS

FIG. 14-6

The variable frequency audio oscillator can be used as a low-level alarm sounder or a code-practice oscillator.

### SINGLE-TRANSISTOR CODE PRACTICE OSCILLATOR



POPULAR ELECTRONICS

FIG. 14-7

A 2N366 is configured as an audio feedback oscillator using an audio transformer is shown. Adjust R1 for proper operation and desired audio note.

# 15

## Color Organ Circuit

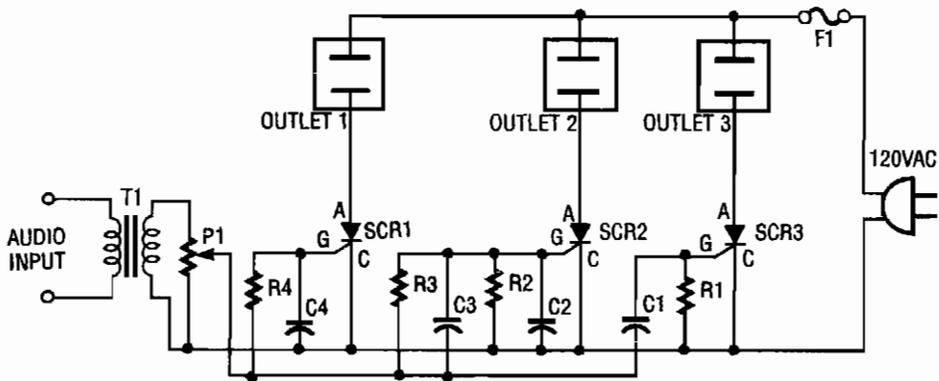
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

3-Channel Color Organ

### 3-CHANNEL COLOR ORGAN



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FIG. 15-1

The ac line power is brought back into the circuit through F1, a protective 5-A fuse. One side of the ac line is connected to one side of each ac outlet. The other side of the ac line is connected to each SCR or silicon-controlled rectifier. Each SCR is, in turn, connected to the other side of each ac outlet.

An audio signal is brought into the circuit from a stereo speaker by transformer T1. This transformer has 500- $\Omega$  impedance on the primary and 8- $\Omega$  impedance on its secondary. Connect T1 so that the 8- $\Omega$  side is connected to the speaker and the 500- $\Omega$  side is connected to potentiometer P1.

Potentiometer P1 is used as a level or sensitivity control. The signal from its wiper lead is applied to each RC filter stage. Because each SCR has a different RC (resistor/capacitor) filter on its gate lead, each will respond to different frequencies. The greater the capacitance in the filter, the lower the frequency that the SCR will respond to.

# 16

## Computer Circuits

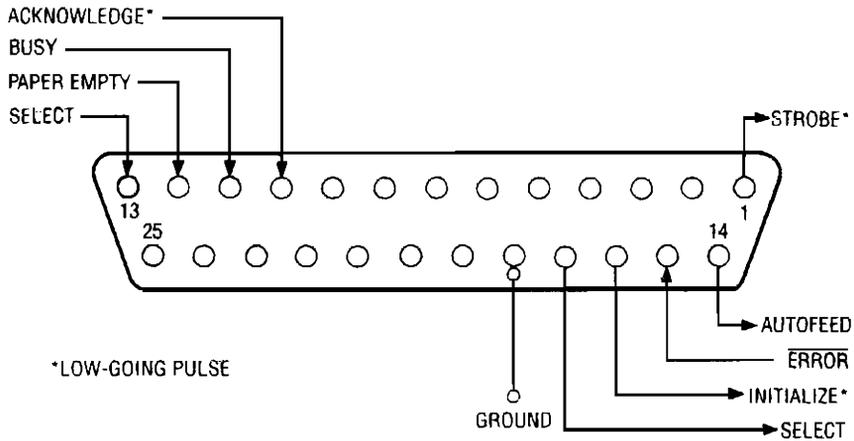
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Printer Sentry  
PC Password Protection  
Buffer I<sup>2</sup>C Data and Clock Lines



## PRINTER SENTRY (Cont.)

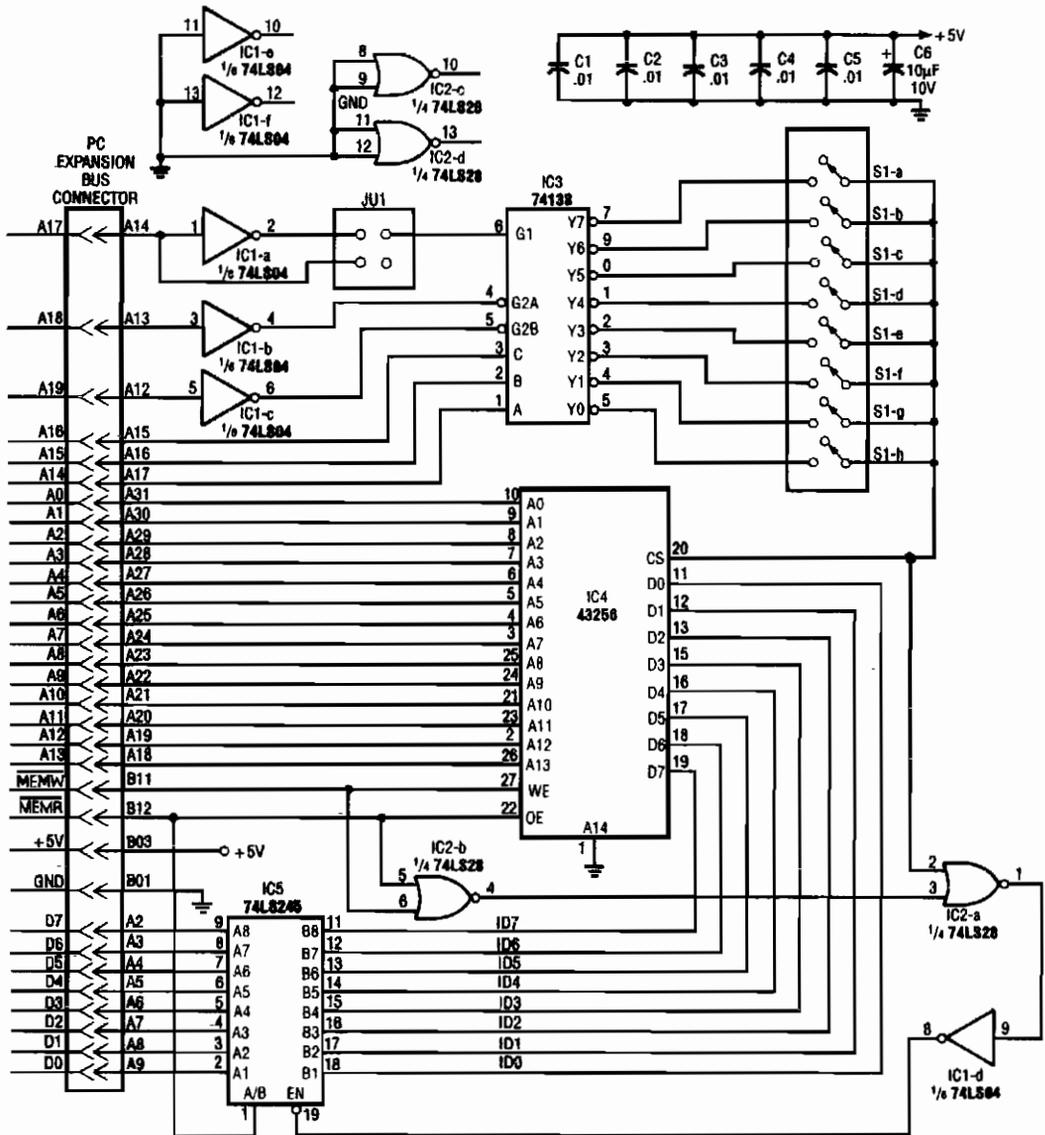


**TABLE 1—PIN CORRESPONDENCE**

DB-25 Connector	Centronics- Style Connector
1	1
10	10
11	11
12	12
13	13
14	14
15	32
16	31
17	36
18	19

Handy for monitoring printers, this circuit displays all the signals on a parallel link. It monitors the status of the lines, enabling remote monitoring of the operation of a printer, and it also gives an indication of troubles (paper empty, busy, etc.).

## PC PASSWORD PROTECTION

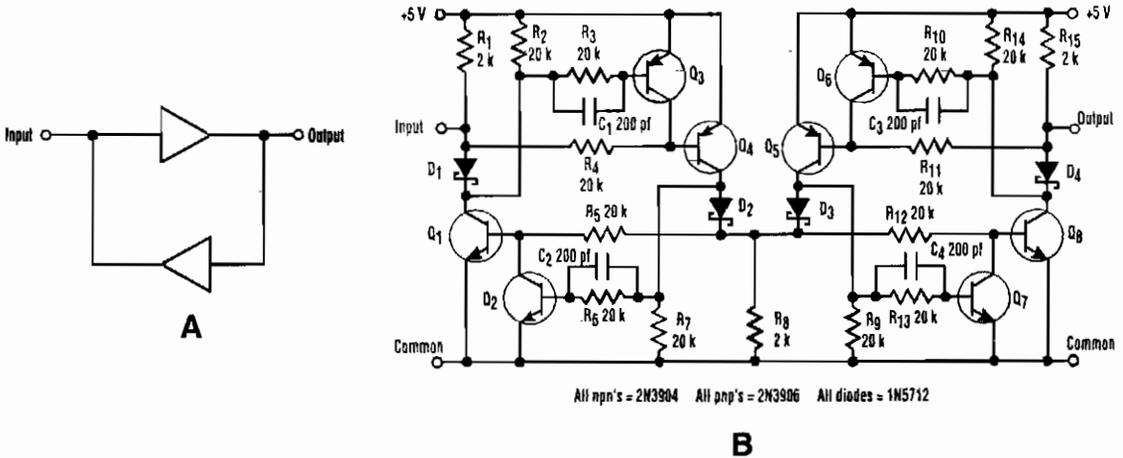


ELECTRONICS NOW

FIG. 16-2

With this circuit, a PC will be protected, requiring a password to boot. After three times, the computer will have to have a cold reboot and the password tried again. Software for this system is available—consult the reference for further details.

## BUFFER I<sup>2</sup>C DATA AND CLOCK LINES



ELECTRONIC DESIGN

FIG. 16-3

The I<sup>2</sup>C serial bus is a popular two-wire bus for small-area networks. I<sup>2</sup>C Clock and Data lines have open collector (or drain) outputs for each device on the network. Only a single pull-up resistor is needed. With this architecture, each device can “talk” on the network, rather than just “listen.” In some circumstances, it might be desirable to buffer these lines to expand the network, which can sometimes be a tricky task. The obvious approach (Fig. 1) won't work because it latches in either the higher or lower state. A circuit for a noninverting nonlatching buffer is also shown.

The circuit is symmetrical about its center so that the input and output can be swapped. Q1 and Q8 are the output open collector drivers. Q2, Q3, Q6, and Q7 provide the nonlatching functions. The capacitors prevent switching glitches by ensuring the inhibit transistors turn off before the output transistors do.

Operation can be best explained by example: if the input is high, Q4 turns off, and the voltage across R8 goes to zero. This turns off Q1 and Q8. The output then goes high, which is the circuit's normal resting place. If the input is pulled low, Q4 is turned on.

Diode D1 remains reverse-biased, preventing Q3 from turning off Q4. With Q4 on, current is supplied to both Q2 and Q1 to turn them on, but Q2 turns on first to keep Q1 off. This prevents the input from latching. Q4 also turns on Q8. D4 is now forward-biased, so Q6 turns on, and thus turns off Q5. With Q5 off, Q7 will not turn on. The output remains low. Even with both the input and the output externally driven low, the circuit will not latch. The circuit, using the values shown in Fig. 2, reached a clock rate of 80 kHz with a V<sub>OH</sub> of 5.0 V and a V<sub>OL</sub> of 0.5 V.

# 17

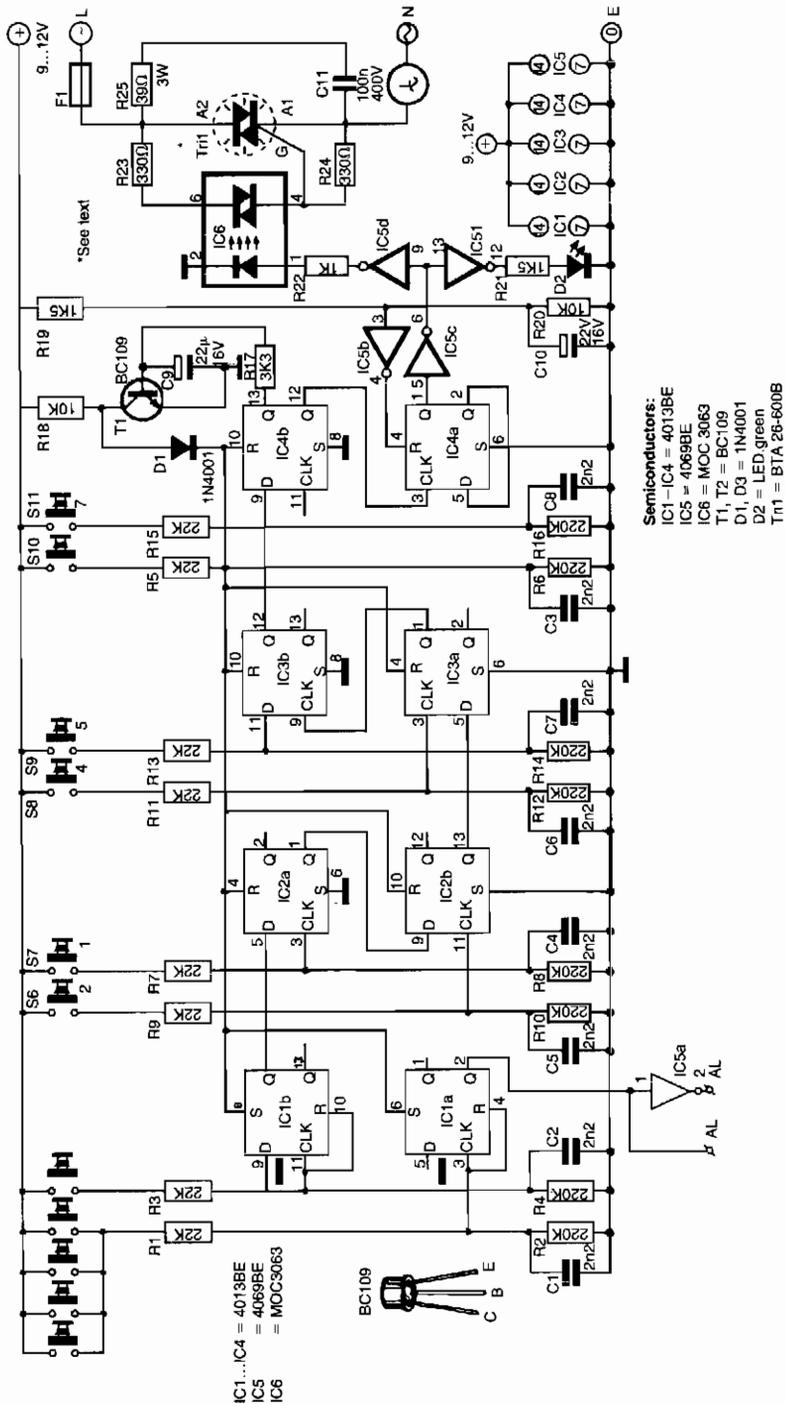
## Control Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

6-Digit Coded ac Power Switch  
VCR TV On/Off Control  
Simple Power Down Circuit  
Simple ac Voltage Control  
Dual-Control Switch Uses ac Signals

### 6-DIGIT CODED ac POWER SWITCH

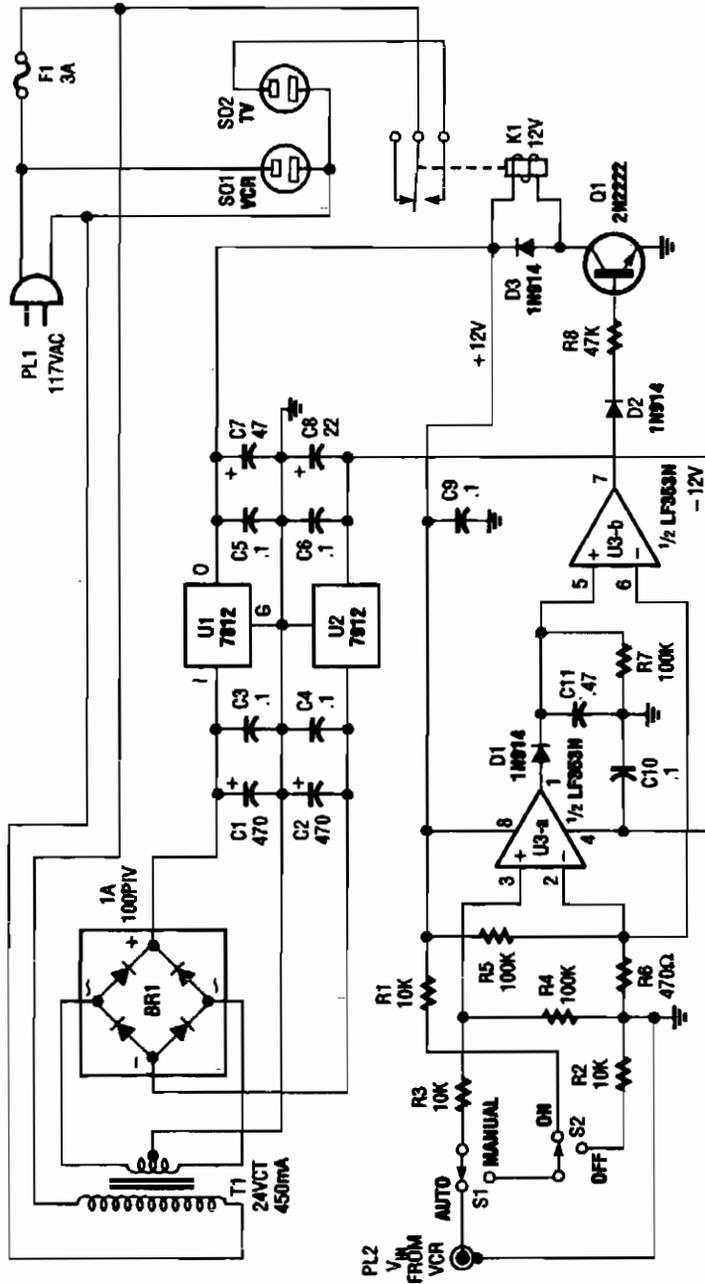


ELEKTOR ELECTRONICS

FIG. 17-1

This switch uses four CD4013 BE dual flip-flops, an inverter, and an optoisolator to drive a triac. The circuit can switch 25-A ac load current. A standard 4 x 3 telephone keyboard is used to enter a 6-digit code. In case of a wrong code, a signal is available to activate an alarm. The disarming method is a secret reset button that can be any number on the keyboard.

### VCR TV ON/OFF CONTROL

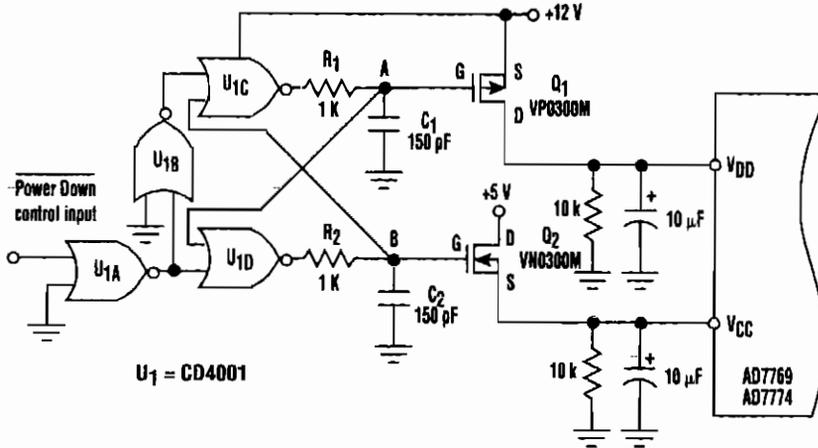


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FIG. 17-2

This circuit senses the video from the VCR. When the VCR is turned on, video signal is amplified by U3A and B to drive Q1, activating K1. In this manner, it is not necessary to turn on and off two video devices every time. In many cases, this avoids the use of a cable box, the cable-ready VCR performing this function.

## SIMPLE POWER DOWN CIRCUIT



**FIG. 17-3**

**ELECTRONIC DESIGN**

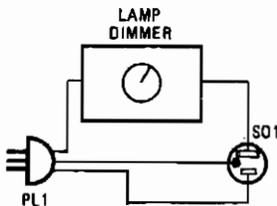
This circuit adds a power-down function to analog I/O ports (for example, the AD7769 and AD7774). Moreover, the diodes ordinarily needed to protect the devices against power-supply missequencing can be eliminated (see the figure).

In the circuit, MOSFETs Q1 and Q2 switch the +5- and +12-V supplies, respectively, in a sequence controlled by two cross-coupled CD4001 CMOS NOR gates (U1C and U1D). The sequence in which power is applied is important: The controlled circuits may be damaged anytime  $V_{CC}$  exceeds  $V_{DD} + 0.3$  V. Consequently, the NOR gates must be powered from a 12-V supply throughout the power-down sequence.

Bringing the power down control high (+5 V) applies power to the controlled circuit by turning on all MOSFETs. Specifically, raising the power-down brings the output of U1C low, causing capacitor C1 to discharge  $V_{OL}$  exponentially with time constant  $R_1 C_1$ . As the voltage on C1 falls, two events occur. First, it puts a negative gate-source voltage on P-channel Q1, turning it on.

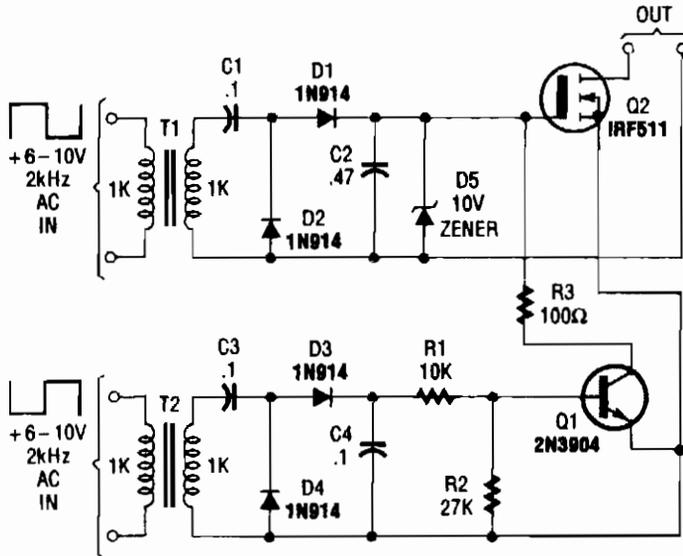
Second, it causes output gate U1D to go high. With the output of U1D high, capacitor C2 charges exponentially to  $V_{OH}$ —about 12-V—applying a positive gate-source voltage to turn on Q2. In the power down mode, the Power Down control is brought low and the RC circuits and their delays work in reverse. Consequently, capacitor C2 discharges to the logic input of U1C before C1 can charge. Hence, Q2 turns off before Q1.

## SIMPLE ac VOLTAGE CONTROL



Lamp dimmers can be used for more than just controlling lights. Just provide one with an ac line cord and a socket, and discover just how useful they can be.

## DUAL-CONTROL SWITCH USES ac SIGNALS



POPULAR ELECTRONICS

FIG. 17-5

The Dual-Control Switch uses two 6-10-Vac sources to trigger the circuit on and off; one source for each function.

# 18

## Converter Circuits

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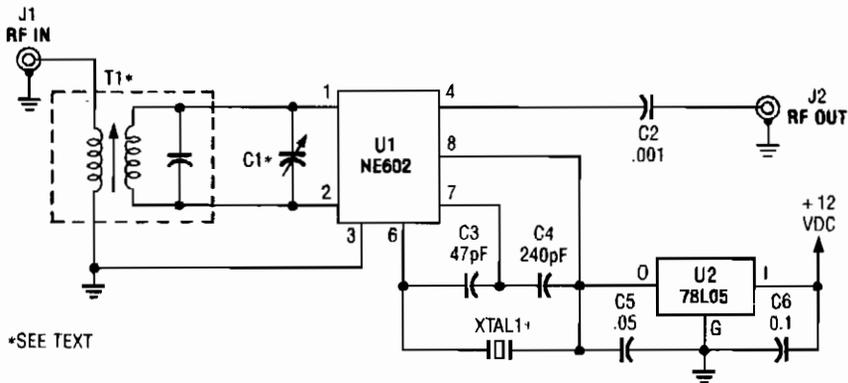
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

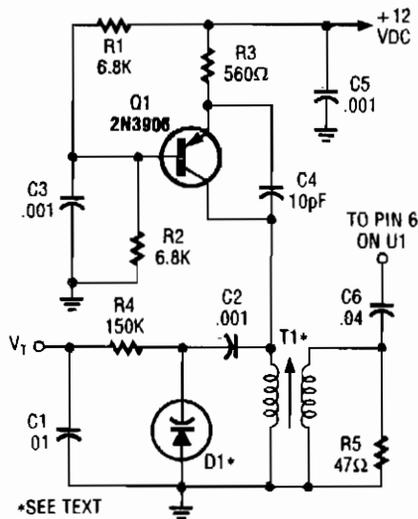
One-Chip Crystal-Controlled Converter  
High-Performance Shortwave Converter  
3-A dc-dc Converter Needs No Heatsink  
Simple WWV Converter for Auto Radios  
Digital-to-Analog Converter  
Temperature-to-Frequency Converter  
VLF Converter  
800- to 1000-MHz Scanner Converter  
Crystal-Controlled Frequency  
Converter Using MOSFET  
Temperature-to-Digital Converter

Simple 2-m-6-m Transverter  
Sine- to Square-Wave Converter  
439.25-MHz ATV Downconverter  
Sine-Wave-to-Square-Wave Converter  
ATV Downconverter  
28-Vdc to 5-Vdc Converter  
Current-to-Voltage Converter  
Temperature-Compensated One-Quadrant  
Logarithmic Converter  
dc/dc Converter Circuit with 3.3-V  
and 5-V Outputs

## ONE-CHIP CRYSTAL-CONTROLLED CONVERTER



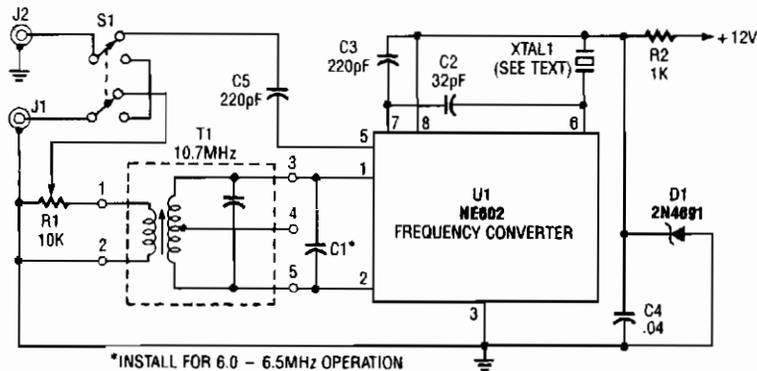
A



B

This circuit can work over a wide range of frequencies. XTAL 1 is a fundamental-frequency crystal. T1 and C1 are tuned to the input frequency. An application of this circuit is a simple shortwave converter for AM radios, etc. A tuneable oscillator can also be used, as shown.

## HIGH-PERFORMANCE SHORTWAVE CONVERTER



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FIG. 18-2

The NE602 chip, U1, contains oscillator and mixer stages. The mixer combines the oscillator signal with the input RF signal to produce signals whose frequencies are the sum and difference of the input frequencies. For example, an 8.5-MHz oscillator and a 10-MHz incoming signal will give output signals at 18.5 MHz (10 + 8.5) and 1.5 MHz (10 - 8.5). Recall that 1.5 MHz is 1500 kHz and an ordinary AM radio will tune to it.

The choice of crystal depends on what shortwave band you want to hear. The 9.5- to 10-MHz band is less crowded and includes the time-signal station WWV. For that band, you'll need a crystal of 8.5 to 8.9 MHz. There is no standard microprocessor crystal in that range, but you can use an amateur radio crystal, have a crystal custom-made, or use a CB crystal.

Transformer T1 rejects signals that are outside the band you are interested in. Transformer T1 should pass signals from 9 to 11 MHz and attenuate all others.

The transformer, T1, used in the circuit is a 10.7-MHz IF transformer salvaged from an FM radio. They are fairly easy to obtain new from parts stores and mail-order houses. Most 10.7-MHz IF transformers will tune across the 9.5- to 10-MHz band without modification; all you need to do is turn its tuning slug. To receive the 6.0- to 6.5-MHz shortwave band, you'll have to add a 150-pF capacitor.

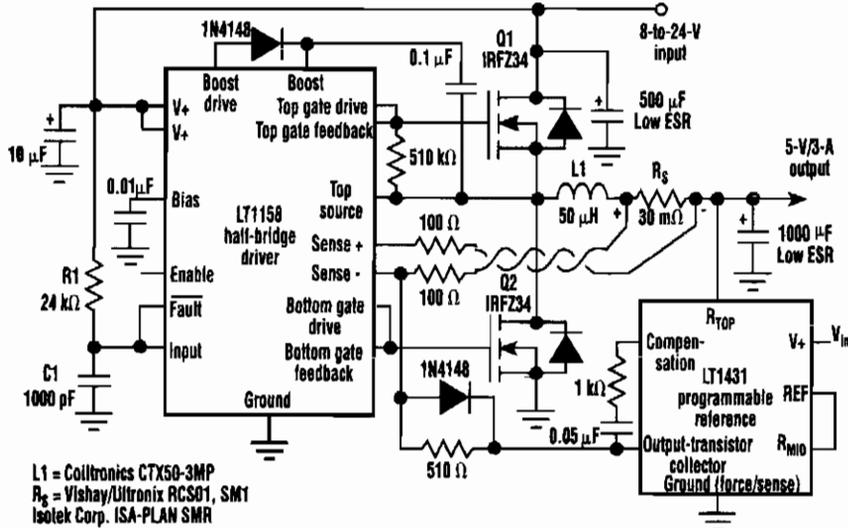
### Capacitors

- C1 150-pF, ceramic disc (see text)
- C2 32-pF, ceramic disc
- C3, C5 220-pF, ceramic disc
- C4 0.04 or 0.05- $\mu$ F, ceramic disc

### Additional Parts and Materials

- U1 NE602N frequency-converter integrated circuit
- D1 6.2-V, 0.4 or 1-W Zener diode
- R1 10,000- $\Omega$  panel-mount potentiometer
- R2 1000- $\Omega$ , 1/4-W, 5% resistor
- J1, J2 RCA phono jack
- S1 DPDT, toggle switch, panel mount
- T1 10.7-MHz IF transformer (green color coded)
- XTAL 1 8.5-MHz crystal or CB channel-5 receiving crystal (see text)
- XTAL 2 5.0-MHz microprocessor crystal for 6-MHz band

### 3-A dc-dc CONVERTER NEEDS NO HEATSINK

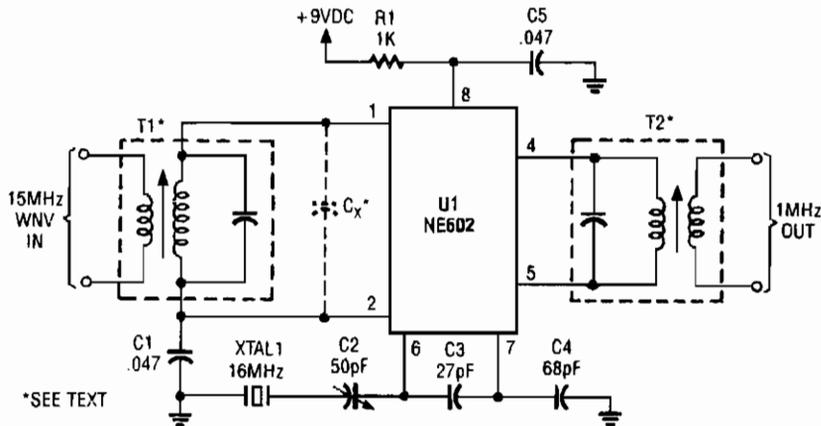


ELECTRONICS DESIGN

FIG. 18-3

This regulator delivers 90% efficiency at 12-V input, 5-V output. It uses an LT1158 and LT1431 by Linear Technology, Inc. High efficiency is obtained by synchronously switching two power MOSFETs in a step-down switching regulator. The LT1431 voltage reference combines with the LT1158 half-bridge driver to form a constant off-time current mode loop.

### SIMPLE WWV CONVERTER FOR AUTO RADIOS

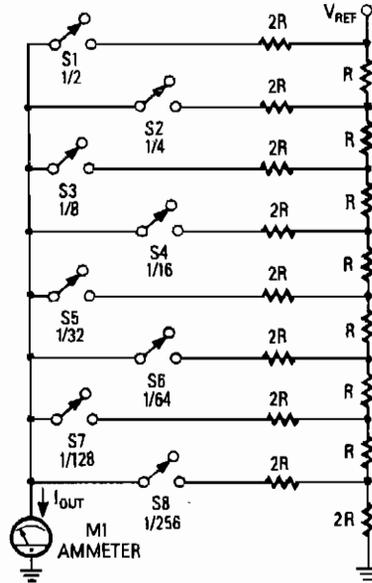


POPULAR ELECTRONICS

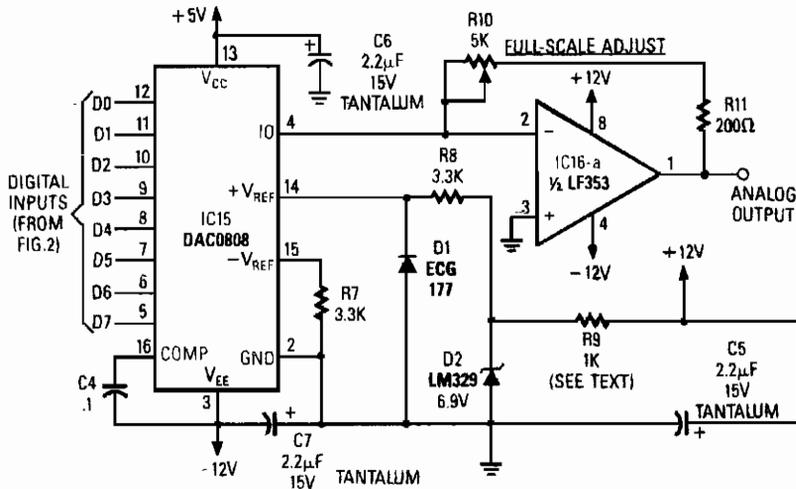
FIG. 18-4

This simple frequency converter mixes the 15-MHz WWV/WWH signal with a 16-MHz signal from the LO to convert it down to 1 MHz so that it can be heard on AM-band receiver.

## DIGITAL-TO-ANALOG CONVERTER



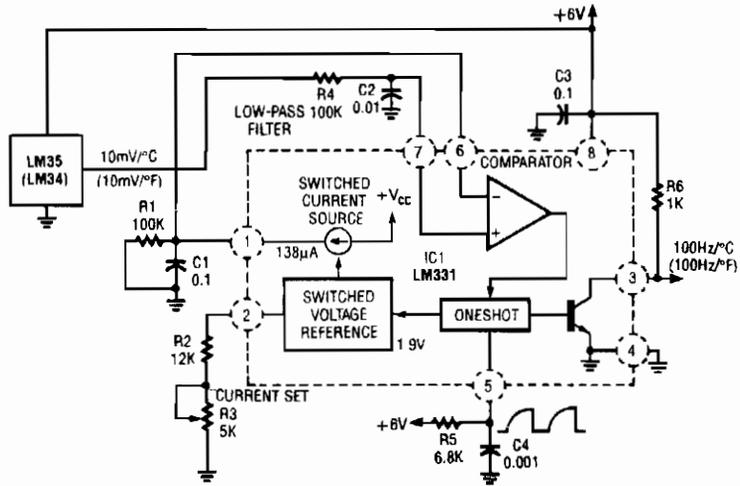
A



B

Figure A is an  $R/2R$  resistor ladder. Each switch that is closed increases the amount of current at  $I_{out}$ . A simple channel A/D converter is shown in Fig. B. The voltage reference (D2) is common to all channels, but the value of the dropping resistor (R9) varies as the number of DACs installed in the system. IC15 is a DAC0808 A/D converter chip. IC16A is an op amp to interface the output current from the D/A convert to an analog voltage output.

## TEMPERATURE-TO-FREQUENCY CONVERTER

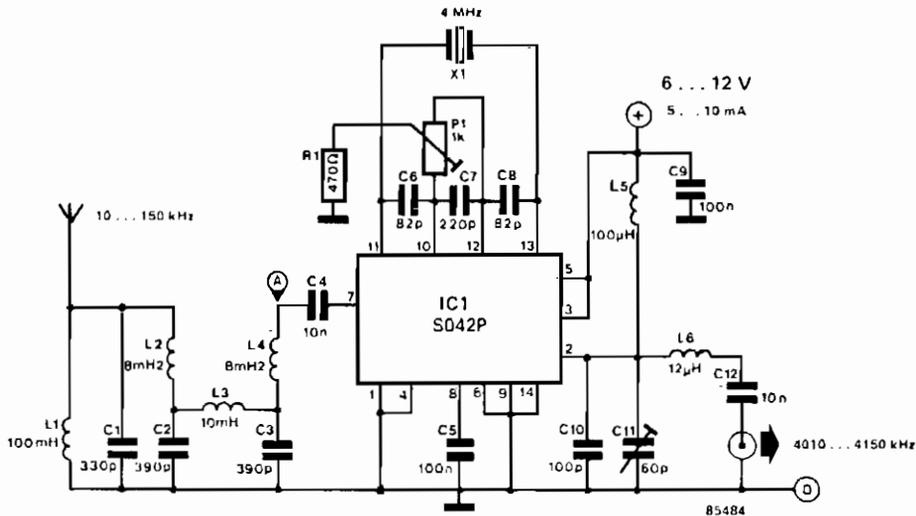


RADIO-ELECTRONICS

**FIG. 18-6**

In this circuit an LM34 or LM35 produces a frequency proportional to temperature. Reference current ( $138\ \mu\text{A}$ ) is set via R3. The output can be used to drive a display, frequency counter, or other indicating device for temperature readout.

## VLF CONVERTER

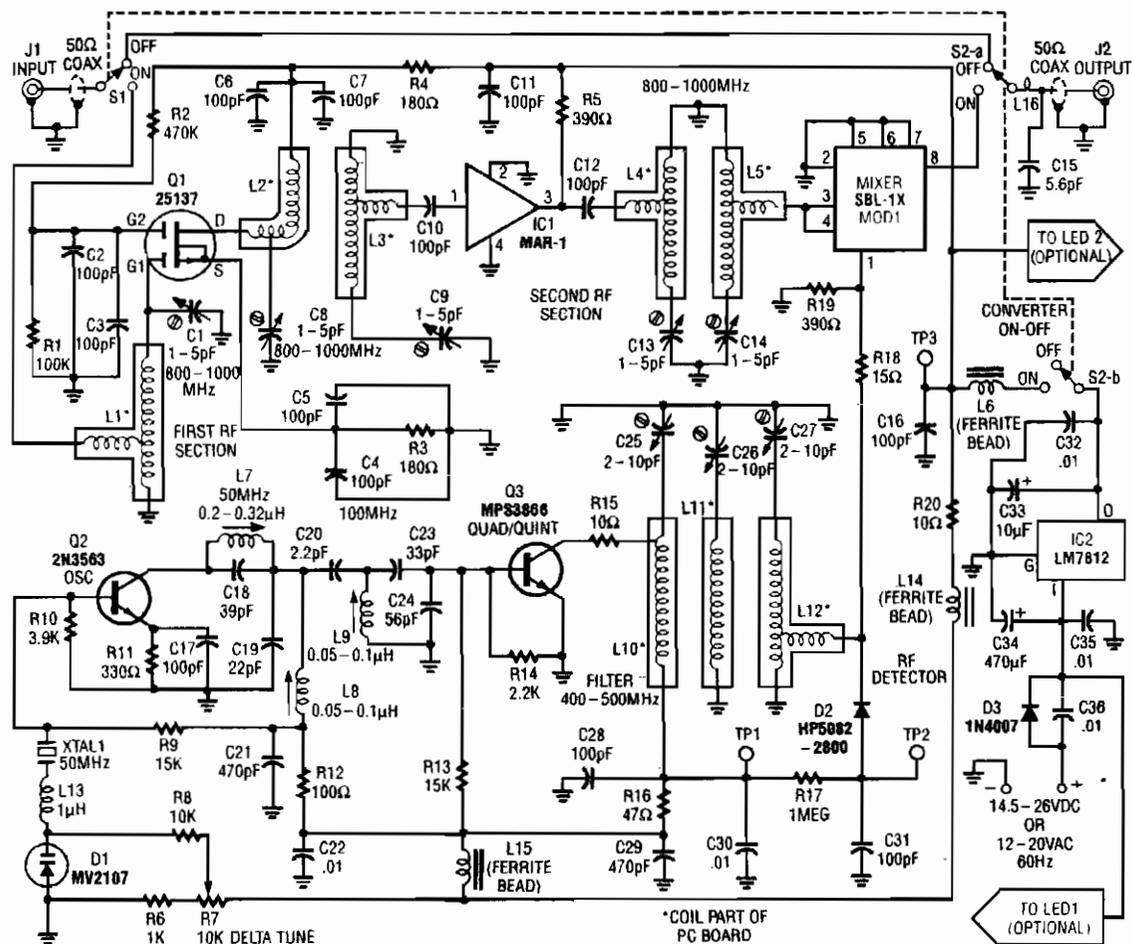


303 CIRCUITS

**FIG. 18-7**

This converter converts 10 kHz to 150 kHz to 4.01 to 4.15 MHz for use with a shortwave receiver for VLF reception. A 4-MHz L.O. frequency is used. X1 can be a microprocessor XTAL or another suitable type. The antenna should be as long as possible.

## 800- TO 1000-MHz SCANNER CONVERTER



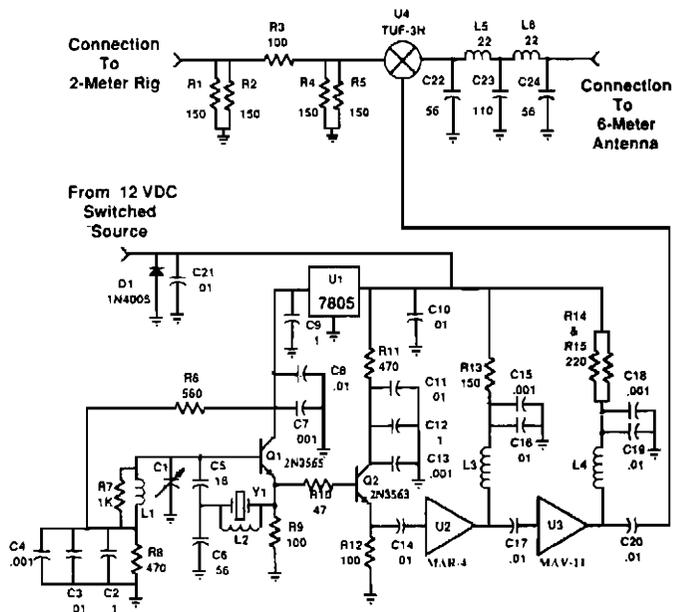
RADIO-ELECTRONICS

FIG. 18-8

This converter enables reception of 800 to 1000 MHz on any scanner covering the 400 to 500-MHz range. The converter can be set up to cover either 800 to 900 MHz or by readjustment 900 to 1000 MHz. Sensitivity is very high because of the GASFET front end. For best results, the scanner should be of a programmable variety. A complete kit is available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804.



## SIMPLE 2-m-6-m TRANSVERTER

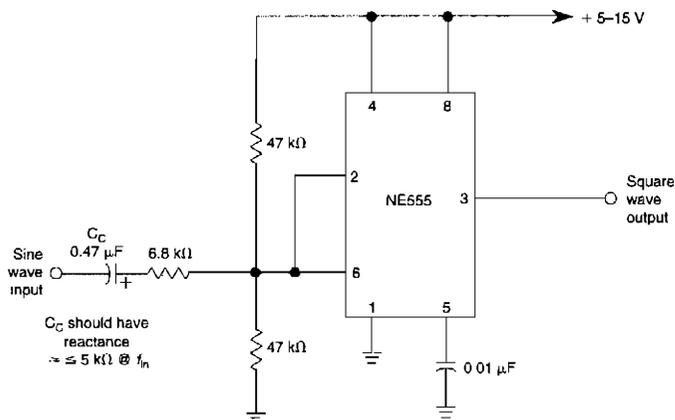


73 AMATEUR RADIO TODAY

FIG. 18-11

Using the bilateral properties of a balanced mixer this transverter will produce 6-m output with 2-m inputs. Y1 is a 90-MHz crystal. Note that the input on 2 m is 143 to 144 MHz for 53 to 54-MHz output. This avoids possibility of extraneous 2-m reception during receive periods. If your radio will not transmit below 144 MHz, then use a 93- or 94-MHz crystal frequency.

## SINE- TO SQUARE-WAVE CONVERTER

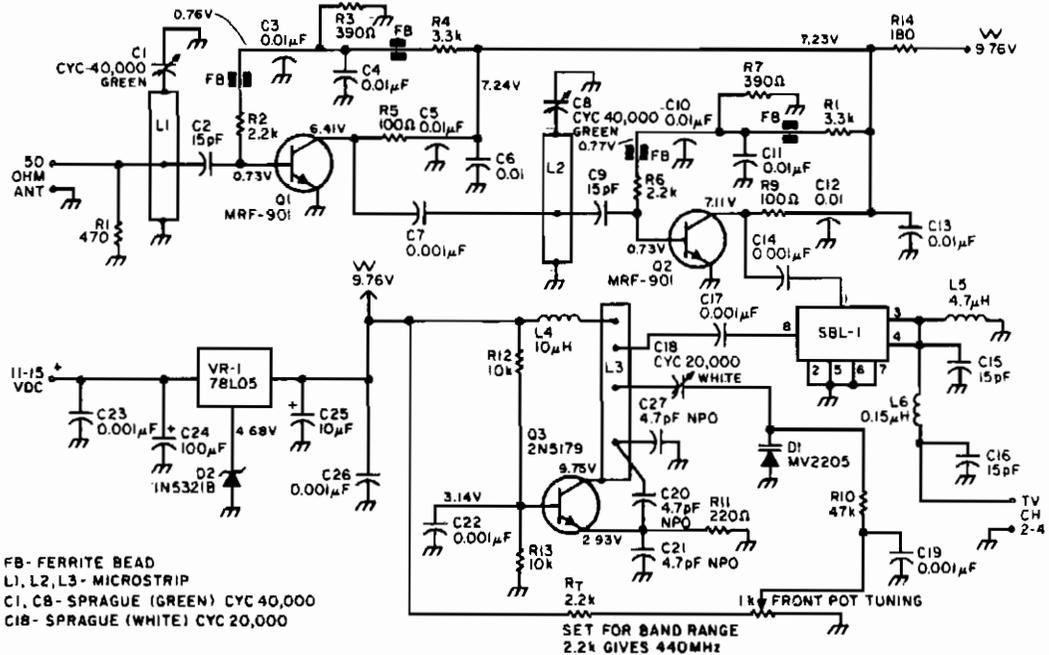


This 555-based Schmitt trigger circuit is useful for creating clock pulses from analog signals since it readily converts sine waves into square waves.

WILLIAM SHEETS

FIG. 18-12

## 439.25-MHz ATV DOWNCONVERTER

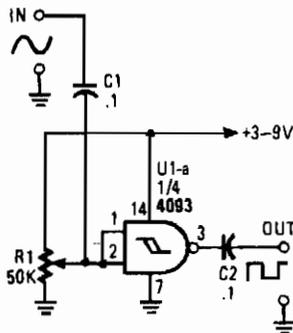


73 AMATEUR RADIO TODAY

FIG. 18-13

Most ATV (Amateur Television) transmitters transmit a DSB signal and commercial television stations use a VSB (Vestigial Sideband) signal. This fact is made use of in this converter to use the lower sideband. This results in less interference from repeaters that occupy the 440- to 445-MHz portion of the band. However, this approach might suffer from VHF image responses from channel 29, if that channel is active in your area.

## SINE-WAVE-TO-SQUARE-WAVE CONVERTER



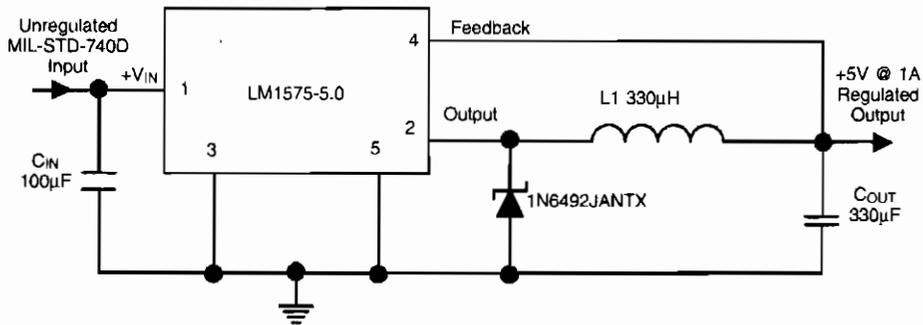
This circuit turns a sine wave into a square wave. It is comprised of a single 2-input NAND Schmitt trigger that's configured as an inverter with a trigger level adjustment at its input. As the input voltage rises above the gate's trigger point, the output snaps to its alternate state, producing a square-wave output.

POPULAR ELECTRONICS

FIG. 18-14



## 28-Vdc TO 5-Vdc CONVERTER

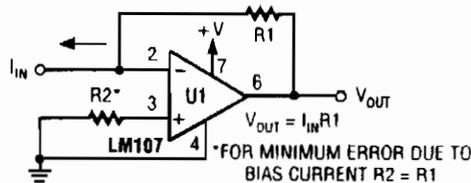


NATIONAL SEMICONDUCTOR

FIG. 18-16

The National Semiconductor LM1575-5.0 allows a very simple switching regulator, with >80% efficiency, operating as a 5-V source @ 1A from a +28-V bus.

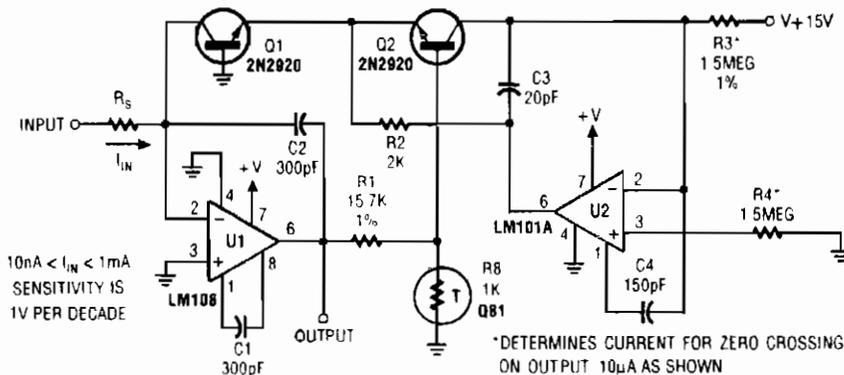
## CURRENT-TO-VOLTAGE CONVERTER



POPULAR ELECTRONICS

FIG. 18-17

## TEMPERATURE-COMPENSATED ONE-QUADRANT LOGARITHMIC CONVERTER

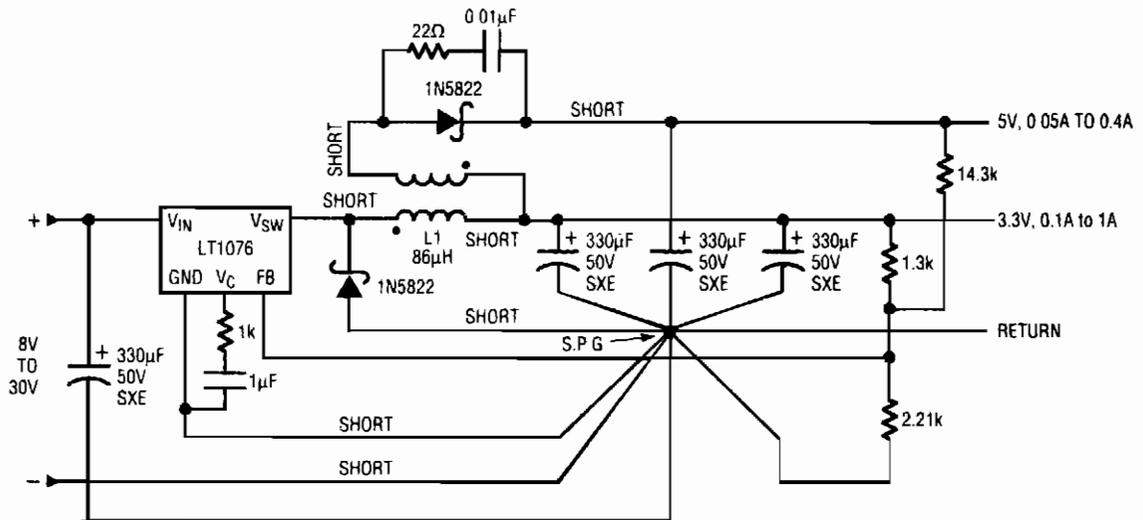


POPULAR ELECTRONICS

FIG. 18-18

A logarithmic converter used to produce an output voltage that is proportional to the logarithm of an input current is shown.  $R_s$  is the input impedance of the input source.

## dc/dc CONVERTER CIRCUIT WITH 3.3-V AND 5-V OUTPUTS



S.P.G. SINGLE POINT GROUND, (STAR GROUND)  
 DARK LINES INDICATE HIGH CURRENT PATHS (SEE TEXT)  
 L1 = HURRICANE LABS HL8685  
 = COILTRONICS CTX01-11959  
 ALL ELECTROLYTIC CAPACITORS, UNITED CHEMICON SXE SERIES

LINEAR TECHNOLOGY CORPORATION 1993

FIG. 18-19

Input voltages can range from 8 V to 30 V. The load range on the 5 V is 0.05 A to 5 A while the 3.3-V load range is 0.1 A to 1 A. The circuit is self-protected under no-load conditions. Over all load and line conditions, including cross regulation, the 3.3-V output varies from 3.25 V to 3.27 V. The 5-V output varies from 4.81 V to 5.19 V under the same conditions.

In a typical application to 0.5 A on the 3.3 V and 0.25 A on the 5 V, efficiency is typically 76%. With an input voltage of 30 V and a full-load condition, the efficiency drops to 66%. In normal operating regions, efficiency is always better than 70%. The 5-V ripple is less than 75 mV and the 3.3-V ripple less than 50 mV over all line and load conditions.

# 19

## Counter Circuits

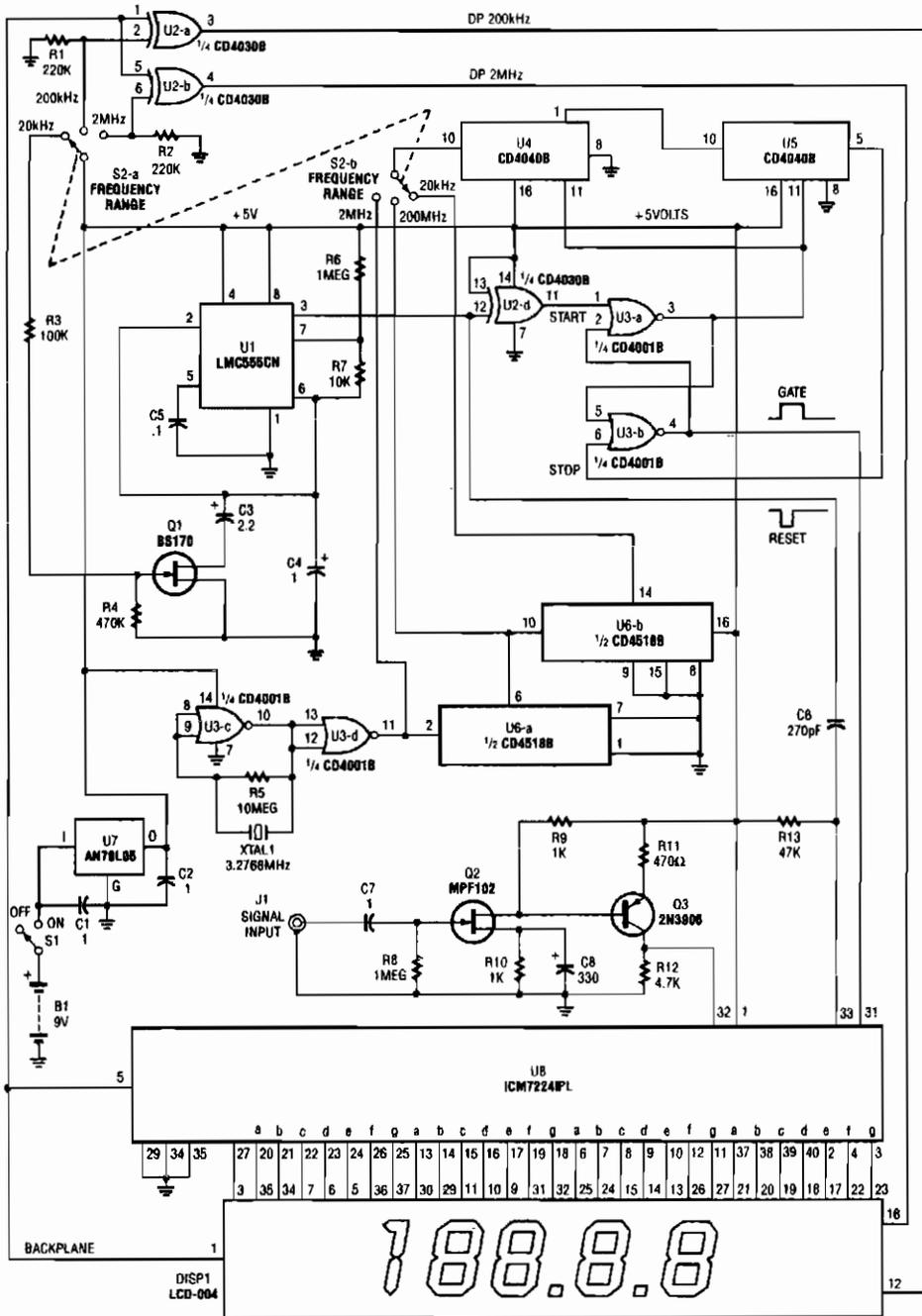
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

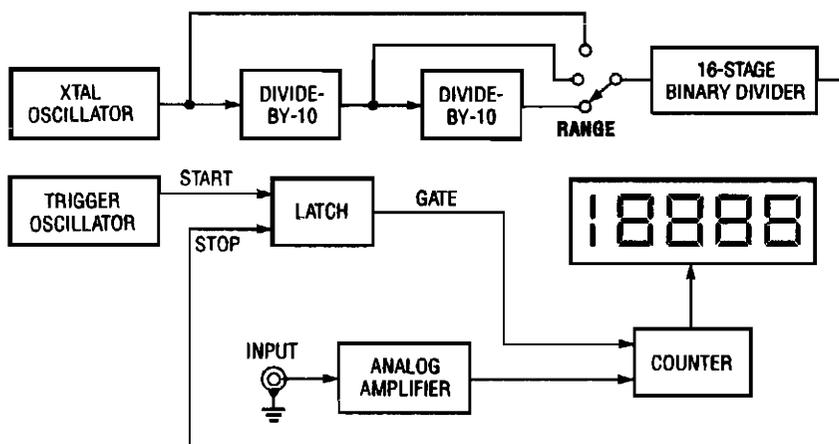
2-MHz Frequency Counter

10-MHz Frequency Counter

## 2-MHz FREQUENCY COUNTER



## 2-MHz FREQUENCY COUNTER (Cont.)

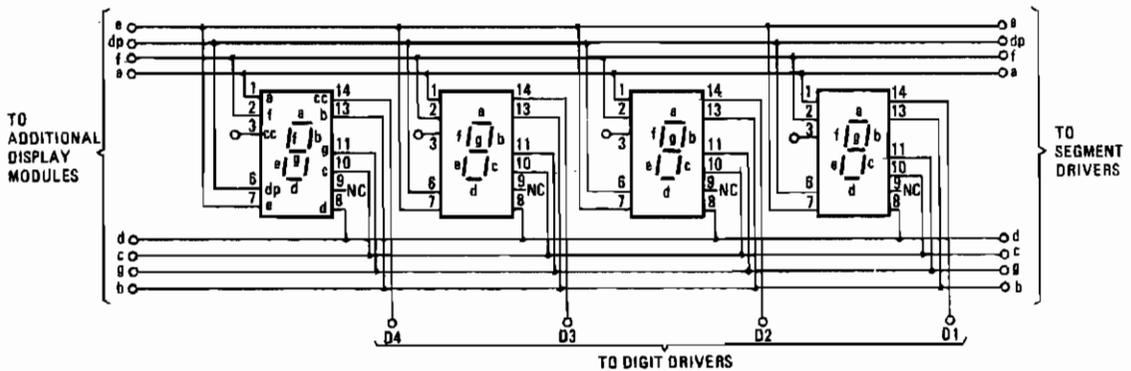
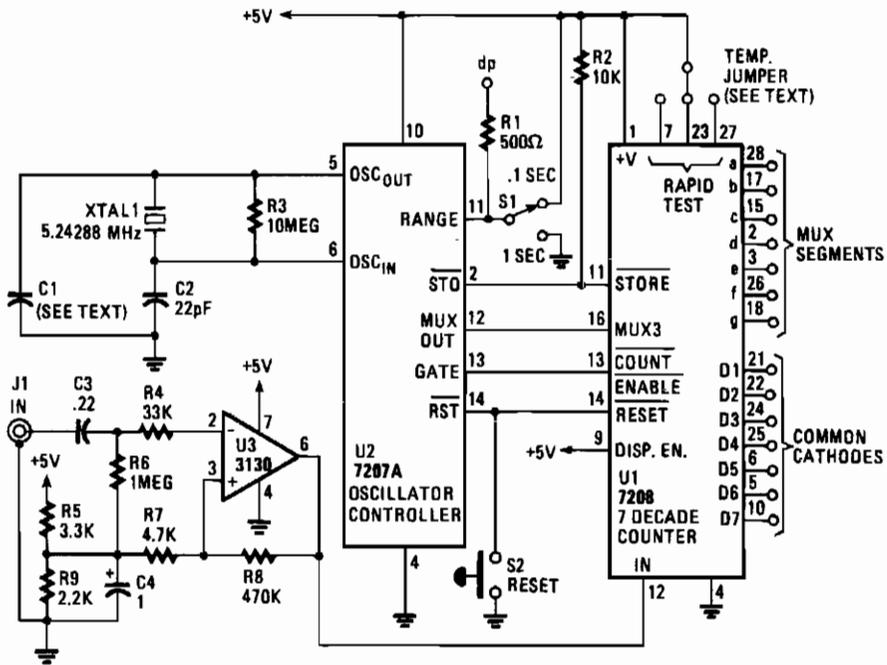


1993 ELECTRONICS HOBBYIST HANDBOOK

This is a schematic and block diagram of a 2-MHz frequency counter. It uses an LSI counter/display driver, LCD readout, and a few logic chips for timebase and timing pulse circuitry. Q2 and Q3 form a signal (input) amplifier.

The circuit contains a crystal oscillator built around U3-c and XTAL1, which provides the primary timing-reference signal. That signal is then divided twice to provide two additional timing references, giving the circuitry three selectable timing references. The ICM7224IPL is an integrated circuit that consists of the counter and display driver to drive the LCD-004 display.

## 10-MHZ FREQUENCY COUNTER



## 10-MHz FREQUENCY COUNTER (*Cont.*)

The circuit consists of an ICM7208 seven-decade counter (U1), an ICM7207A oscillator controller (U2), and a CA3130 biFET op amp (U3). Integrated circuit U1 counts input signals, decodes them to 7-segment format, and outputs signals that are used to drive a 7-digit display. Integrated circuit U2 provides the timing for U1, while U3 conditions the input signal to provide a suitable waveform for input to U1. The 5.24288-MHz crystal frequency is divided by U2 to produce a 1280-Hz multiplexing signal at pin 12 of U2. That signal is input to U1 at pin 16 and is used to scan the display digits in sequence. The cathodes of each digit are taken to ground several times each second, activating any segments of the digits whose anodes are high as the result of decoding by U1. The crystal frequency is further divided to produce a short “store” pulse at pin 2 of U2, followed (after about 0.4 ms) by a short “reset” pulse at pin 14 of U2. The frequency of the pulses is determined by the state of U2 pin 11.

When pin 11 of U2 is taken to ground through S1, the pulses occur every 2 seconds and cause U2 pin to go high for one second, which prevents additional input signals from entering U1. That causes the count latched in U1’s internal counters to be transferred to the display.

Integrated circuit U2 pin 13 then goes low for one second, allowing a new count to be entered into the seven decade counters of U1. That cycle is repeated, continuously updating the display every two seconds.

When U2 pin 11 is taken to the positive supply rail (+5 V), the “store” and “reset” pulses occur at 0.2-s intervals, resulting in a 0.1-s count-period. Ten input pulses must be counted in order for a “1” to appear on the first digit, D1, so that the frequency being measured is obviously 10 times larger than the frequency that is shown on the display. In that mode, the decimal points are driven by M and visually indicate that the 0.1-s count period is being used.

The display must have at least seven 7-segment common-cathode multiplexed LED digits. Any common-cathode seven-segment display can be used; no particular display is specified.

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## 20

# Crystal Oscillator and Test Circuits

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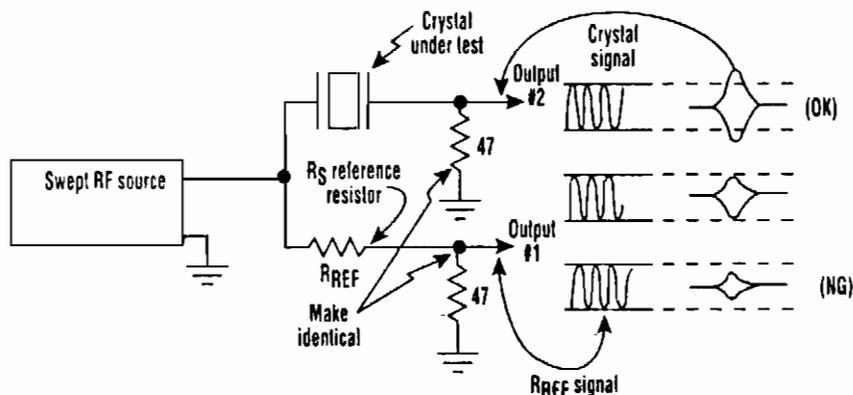
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Low-Frequency Crystal Oscillator
- Crystal Oscillator
- Easy Crystal Impedance Checker
- Hex Buffer Crystal Oscillator
- Multi-Output Timebase
- Crystal Activity Tester
- 10- to 1-Hz Timebase
- Crystal Tester
- Wide-Range Crystal Oscillator
- Pierce Oscillator
- Crystal-Controlled Hartley Oscillator



## EASY CRYSTAL IMPEDANCE CHECKER



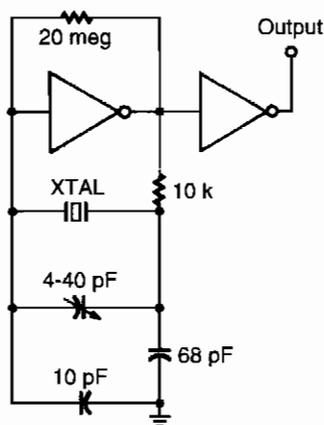
ELECTRONIC DESIGN

FIG. 20-3

On occasion, microprocessors/microcomputers and microprocessor crystals just aren't compatible with each other. Many microprocessor data sheets specify maximum values for a crystal's equivalent series resistance ( $R_S$ ) that aren't met by some crystals advertised for microprocessor/microcomputer use. As a result, a crystal with an  $R_S$  value greater than the maximum specified for the chip might cause problems, such as a balky or even inoperative clock oscillator.

To tackle this problem, a suspected crystal can be given a quick check for  $R_S$  with a simple test setup that consists of a sweep generator, oscilloscope, and three resistors (see the figure). When the frequency source is brought to the crystal's frequency, output 2 will maximize. If it exceeds the amplitude of output 1, the crystal's  $R_S$  value will be less than the  $R_S$  reference resistor's value. If it doesn't exceed output 1's amplitude, the crystal's  $R_S$  value is too large.

## HEX BUFFER CRYSTAL OSCILLATOR

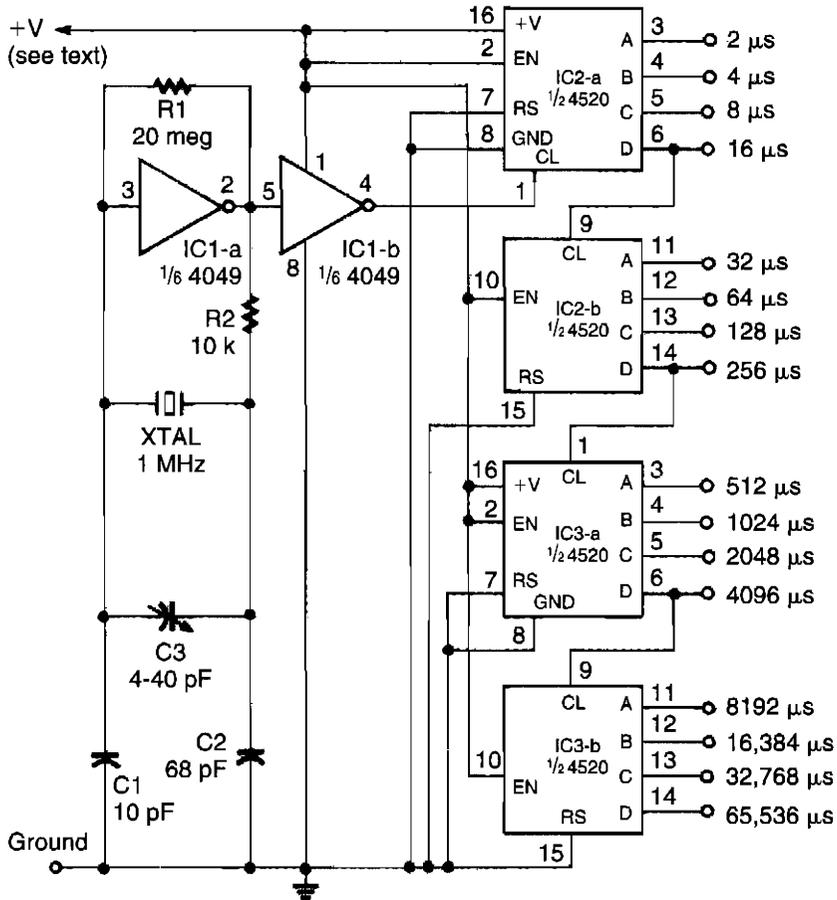


A 4049 single section acts as a crystal oscillator, driving another section as a buffer, leaving four sections for other use. Use a 32- or 20-pF parallel resonant fundamental crystal.

ELECTRONICS NOW

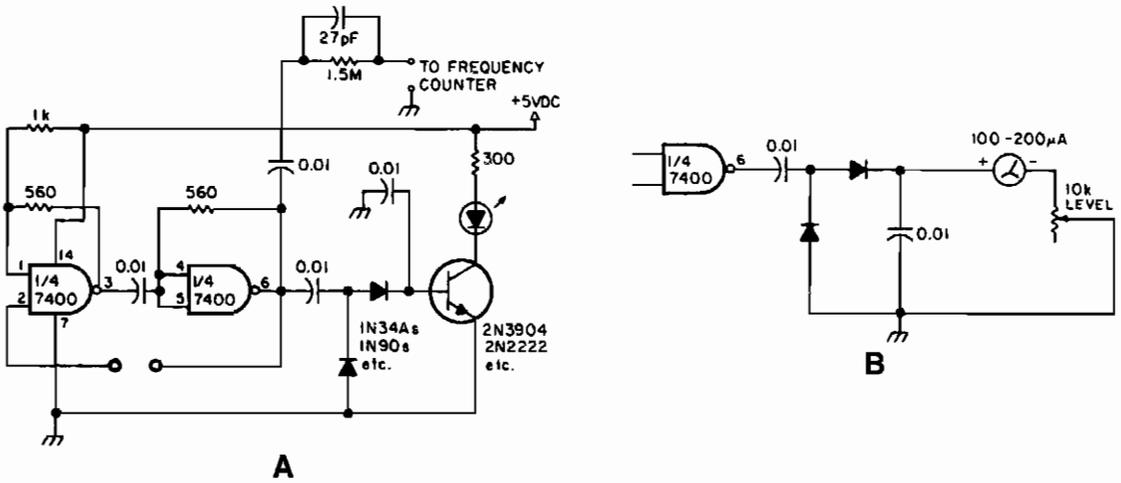
FIG. 20-4

## MULTI-OUTPUT TIMEBASE



A 1-MHz oscillator drives a binary counter to produce pulse widths from 2 to 65,536 ms.  $V+$  is any CMOS suitable level (5 to 15 V, etc.).

## CRYSTAL ACTIVITY TESTER

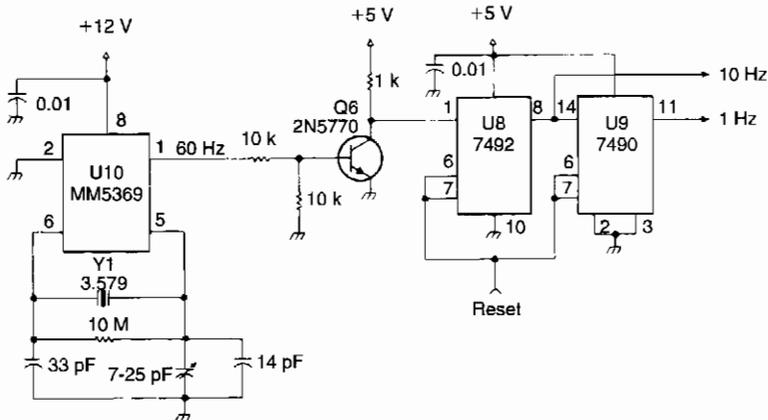


73 AMATEUR RADIO TODAY

FIG. 20-6

This circuit will check a crystal for activity. Two sections of a 7400 act as an oscillator and its output is rectified and drives an npn transistor that switches an LED (Fig. A). In Fig. B, a meter replaces the LED.

## 10- TO 1-Hz TIMEBASE

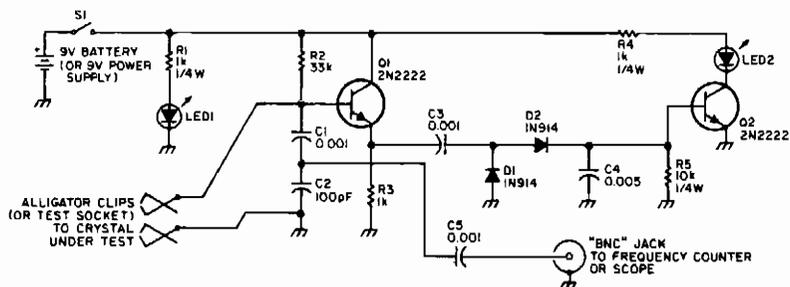


73 AMATEUR RADIO TODAY

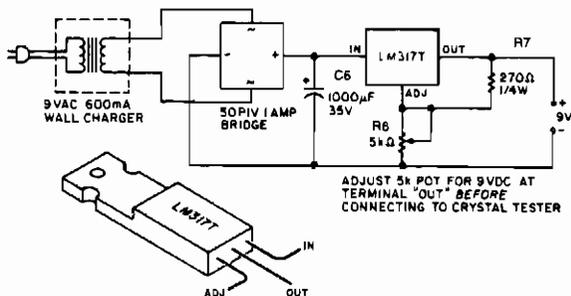
FIG. 20-7

This system uses an MM5369 IC to derive a 60-Hz signal from a TV burst crystal (3579 MHz). V8 and V9 produce a 10-Hz and 1-Hz signal from this 60-Hz signal. Y1 can be any parallel-mode 3.579-MHz crystal.

## CRYSTAL TESTER



**A**



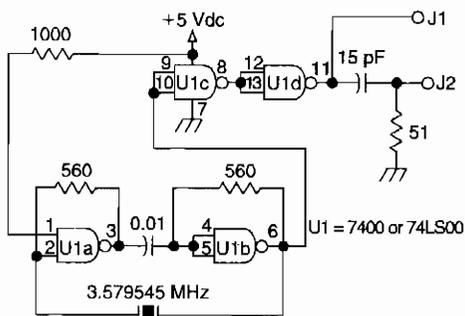
**B**

73 AMATEUR RADIO TODAY

FIG. 20-8

Q1 acts as a Colpitts crystal oscillator, and if the crystal under test is operational, the RF signal is rectified by D1 and D2, turning on Q2 and lighting indicator LED2. LED1 is a power indicator.

## WIDE-RANGE CRYSTAL OSCILLATOR

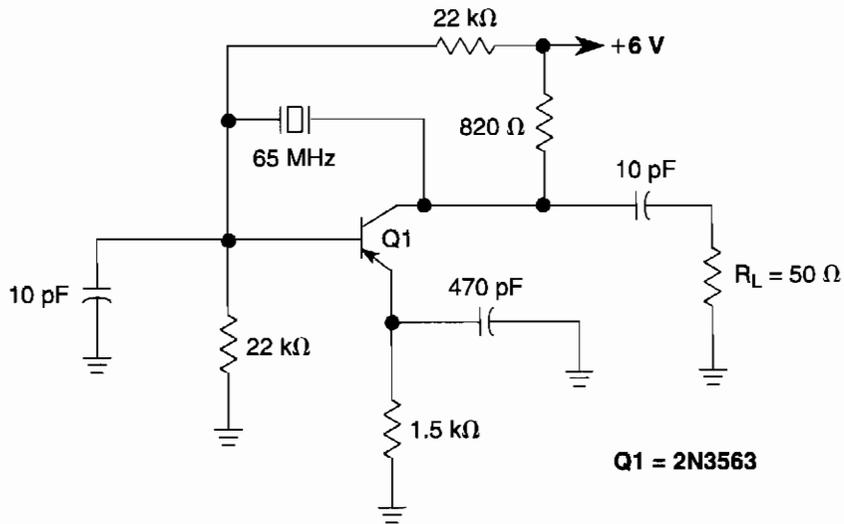


A circuit using one 7400 TTL IC can use crystals of the fundamental type, from 1 to about 13 MHz. Output is rich in harmonics, making this oscillator useful for calibrations and test applications.

73 AMATEUR RADIO TODAY

FIG. 20-9

## PIERCE OSCILLATOR

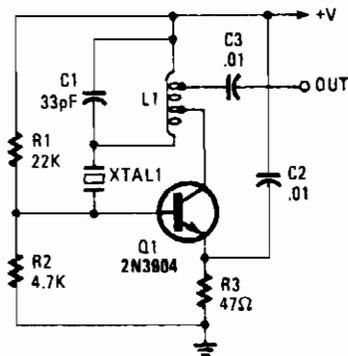


WILLIAM SHEETS

FIG. 20-10

This Pierce oscillator uses a fundamental-mode 65-MHz crystal.

## CRYSTAL-CONTROLLED HARTLEY OSCILLATOR



POPULAR ELECTRONICS

FIG. 20-11

# 21

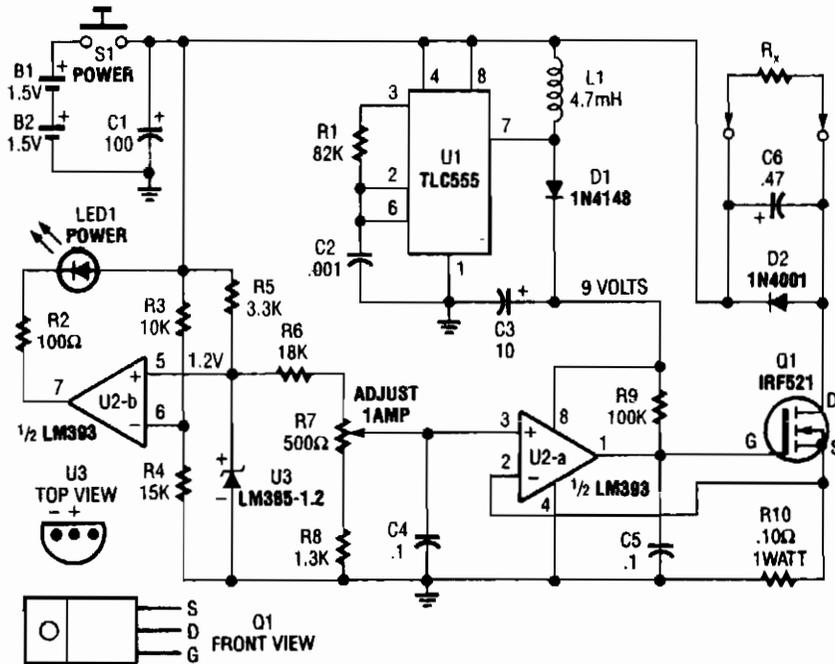
## Current-Source Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Current Source for Low-Resistance Measurements  
Precision Positive Current Source  
Bilateral Current Source  
Precision Negative Current Source

## CURRENT SOURCE FOR LOW-RESISTANCE MEASUREMENTS

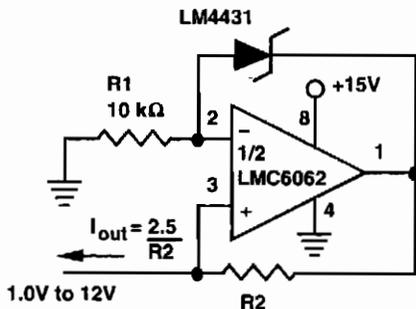


1993 ELECTRONICS HOBBYISTS HANDBOOK

FIG. 21-1

Useful for low-resistance measurements, this 1-A current source will produce 1 A in unknown resistance  $R_x$ . For best results,  $R_x$  should be less than 1 to 2  $\Omega$ , because only 3 V are available. U1 is a flyback converter to generate 9 V for U2.

## PRECISION POSITIVE CURRENT SOURCE

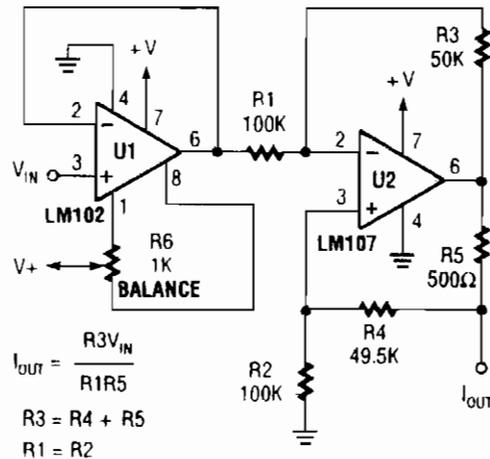


An LM4431 precision 2.5-V reference and an LMC6062 op amp to make a positive current source, from 1 mA to 10 mA.

NATIONAL SEMICONDUCTOR

FIG. 21-2

## BILATERAL CURRENT SOURCE

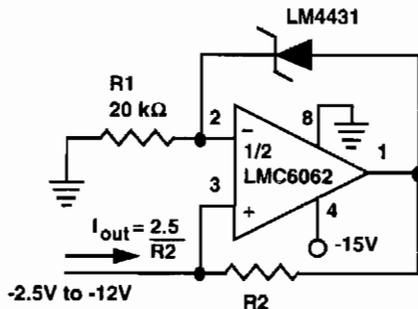


POPULAR ELECTRONICS

FIG. 21-3

Using two op amps, this circuit produces current proportional to  $V_{IN}$ .

## PRECISION NEGATIVE CURRENT SOURCE



A National Semiconductor LM4431 reference and an LMC6062 op amp make up a negative current source. Current range is 1  $\mu$ A to 1 mA.

NATIONAL SEMICONDUCTOR

FIG. 21-4

# 22

## Current Limiter and Control Circuits

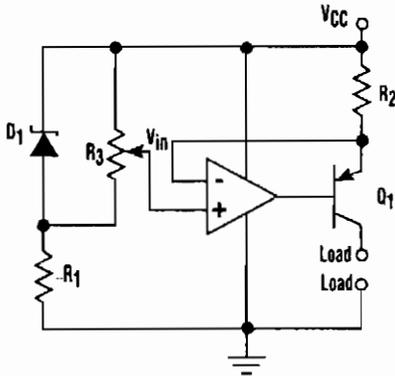
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

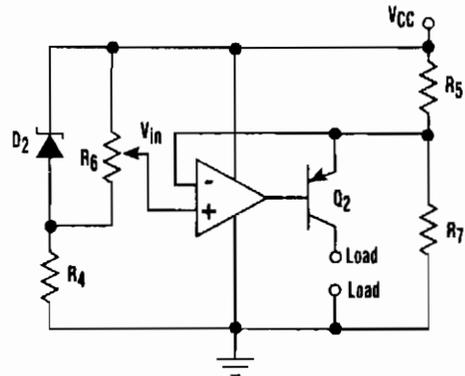
Offset-Adjusting Current Source  
Inrush Current Limiter

## OFFSET-ADJUSTING CURRENT SOURCE



1. Though this setup can act as a cost-effective current source with an output accurate to 1%, the voltage offset will turn on the current source even when  $V_{CC}$  equals  $V_{in}$ .

**A**



2. Modifying the configuration of Figure 1 can rectify the problem of the current source being turned on by the voltage offset. The addition of  $R_7$  allows an adjustment that guarantees turn-off for any op-amp offset specification.

**B**

**FIG. 22-1**

By carefully choosing components, you can create a cost effective circuit for a current source with an output that's accurate to 1% (Fig. A).  $I_{OUT}$  (the current flowing from the collector of Q1) is  $V_{CC} - V_{IN}$  (the voltage at the wiper of R3) divided by the value of  $R_2$ .

In some instances, it's important to be able to turn off the current source (within the limits of  $I_{CEO}$  for Q1). Unfortunately, in about half of these cases, the offset voltage ( $V_{OS}$ ) of the op amp will turn the current source on even when  $V_{CC} = V_{IN}$ . That's because the offset voltage (when the noninverting input needs to be at a higher potential than the inverting input to get an output of 0 V from the op amp) is impressed across R2. This offset voltage forces Q1 to turn on enough to yield a collector current of  $V_{OS}$  divided by  $R_2$ .

Figure B offers a fix for this predicament. The addition of R7 presents the emitter of Q2 with a Thevenin equivalent voltage and resistance represented by:

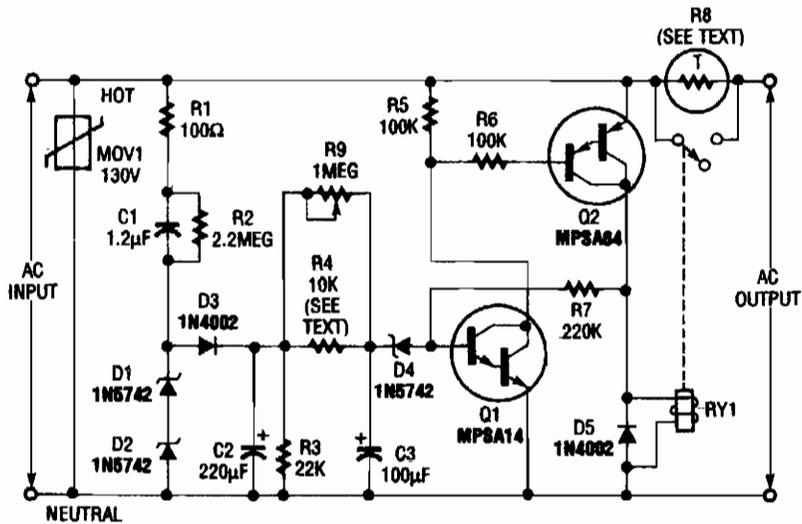
$$V_{TH} = \frac{V_{CC} (1 - R_5)}{R_5 + R_7}$$

$$R_{TH} = \frac{R_5 \times R_7}{R_5 + R_7}$$

The difference between  $V_{CC}$  and  $V_{TH}$  is  $V_{CC} (R_5/R_5 + R_7)$ . If  $V_{CC} (R_5/R_5 + R_7)$  is set equal to the maximum  $V_{OS}$  spec for the op amp in question, the circuit is then guaranteed to turn off. This circuit has an output current of  $V_{TH} - V_{IN}$  divided by  $R_{TH}$ .

The compromise of Fig. B does present another error term in the circuit. The term  $(V_{TH} - V_{IN})$  will have to be  $2 \times V_{OS}$  to guarantee a current output for whole population of the op amp chosen. This error can be made arbitrarily small (but not zero) by increasing the voltage of D2 and  $V_{CC}$  while raising the value of D2 and  $V_{CC}$  while also raising the value of the equivalent resistance  $R_{TH}$ .

## INRUSH CURRENT LIMITER



ELECTRONICS NOW

FIG. 22-2

Q1 is an npn Darlington and Q2 is a pnp Darlington. MOV1 is a metal-oxide varistor and R8 is an NTC thermistor for limiting inrush current.

This circuit limits ac line current to a load. When a predetermined interval has passed, RY1 shorts out thermistor or resistance R8. R4 can be 150 kΩ if R9 is not used. If power is removed, the circuit is ready for immediate restart.

# 23

## Delay Circuit

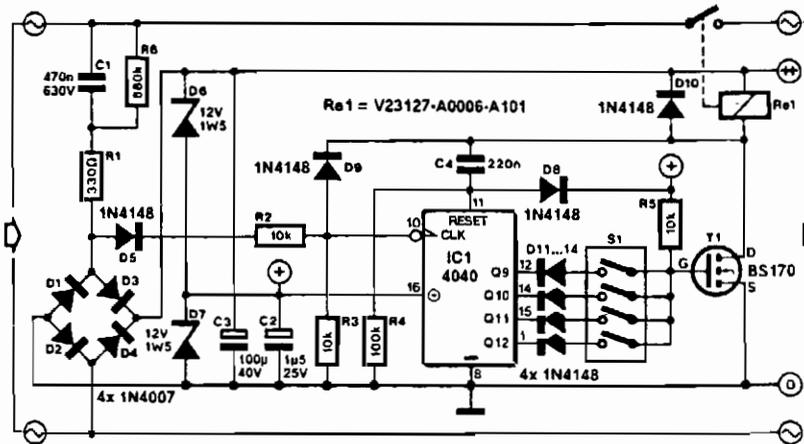
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Power-On Delay Circuit

## POWER-ON DELAY CIRCUIT



DELAY TIMES				
Switches S <sub>1</sub>				Time (s)
1	2	3	4	
0	0	0	0	0.0
0	0	0	1	5.1
0	0	1	0	10.2
0	0	1	1	15.4
0	1	0	0	20.5
0	1	0	1	25.6
0	1	1	0	30.7
0	1	1	1	35.8
1	0	0	0	41.0
1	0	0	1	46.1
1	0	1	0	51.2
1	0	1	1	56.3
1	1	0	0	61.4
1	1	0	1	66.6
1	1	1	0	71.7
1	1	1	1	76.8

ELEKTOR ELECTRONICS

FIG. 23-1

Using an IC to count ac mains pulses, the circuit produces 16 various delay times, where ac power is applied to a load after a preset interval.

# 24

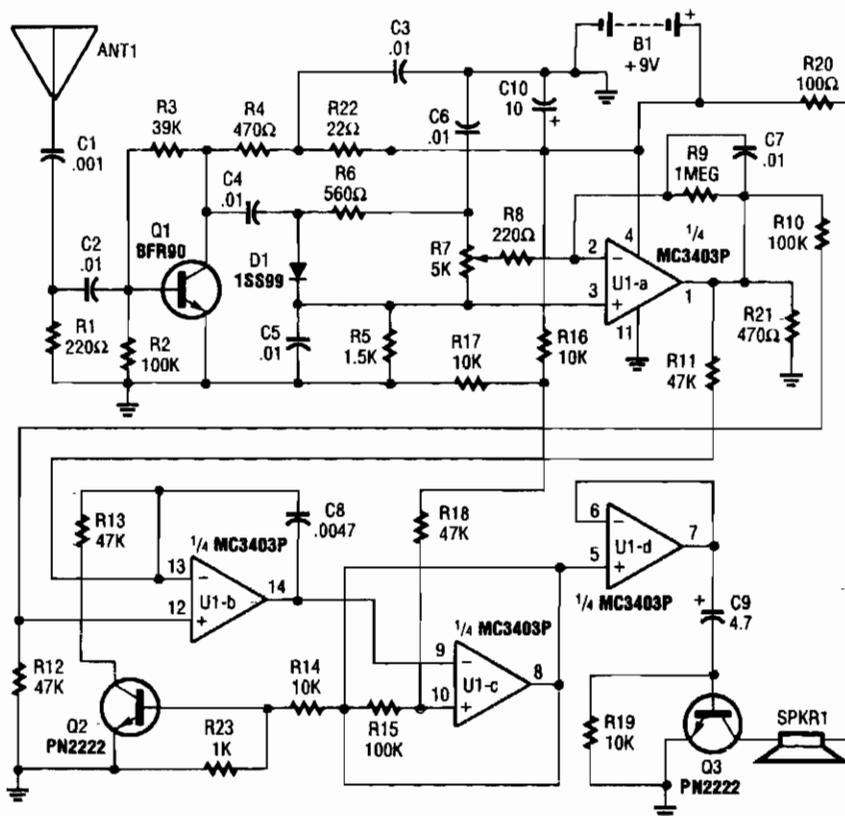
## Detector, Demodulator, and Discriminator Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Bug Detector
- FM Demodulator
- 555 Missing Pulse Detector
- Simple Full-Wave Envelope Detector
- Open-Loop Peak Detector
- Closed-Loop Peak Detector
- Fast Pulse Detector
- Air-Flow Detector
- Negative Peak Detector
- Low-Drift Peak Detector
- 455-kHz FM Demodulator

## BUG DETECTOR



1992 PE HOBBYIST HANDBOOK

FIG. 24-1

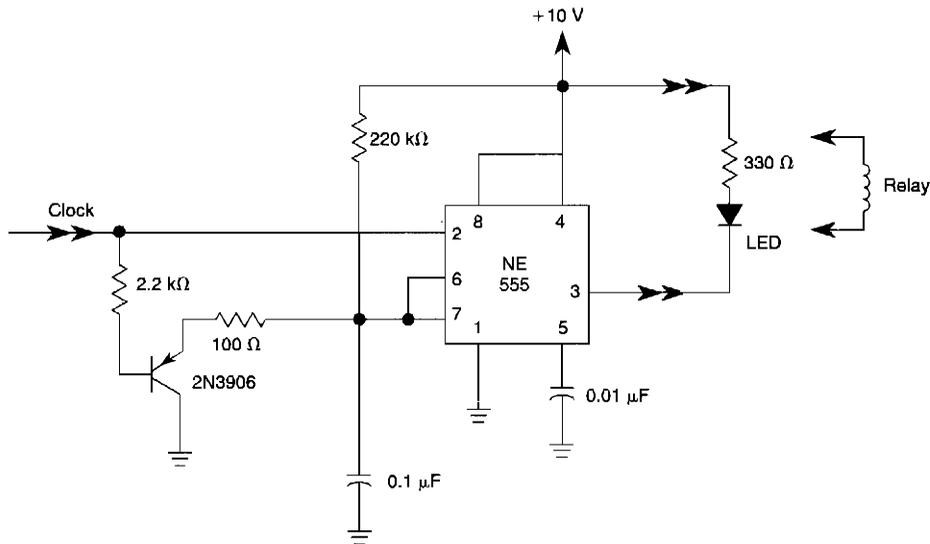
The circuit, built around a single integrated circuit (U1, an MC3403P quad op amp), three transistors (Q1-Q3), and a few support components, receives its input from the antenna (ANT1). The signal is fed through a high-pass filter, formed by C1, C2, and R1, which eliminates bothersome 60-Hz pickup from any nearby power lines or line cords located in and around buildings and homes.

From the high-pass filter, the signal is applied to transistor Q1 (which provides a 10-dB gain for frequencies in the 1- to 2000-MHz range) for amplification. Resistors R2, R3, and R4 form the biasing network for Q1. The amplified signal is then ac coupled, via capacitor C4 and resistor R7's (the sensitivity control) wiper, to the inverting input (pin 2) of U1-a. Op amp U1-a is configured as a very high gain amplifier. With no signal input from ANT1, the output of U1-a at pin 1 is near ground potential.

When a signal from the antenna is applied to the base of Q1, it turns on, producing a negative-going voltage at the cathode of D1. That voltage is applied to pin 1 of U1-a, which amplifies and inverts the signal, producing a positive-going output at pin 1. Op amps U1-b and U1-c along with C8, R10 through R18, and Q2 are arranged to form a voltage-controlled oscillator (VCO) that operates over the audio-frequency range. As the output of U1-a increases, the frequency of the VCO increases. The VCO output, at pin 8 of U1-c, is fed to the input of U1-d, which is configured as a noninverting, unity-gain (buffer) amplifier. The output of U1-d is used to drive Q3, which, in turn, drives the output speaker.



## 555 MISSING PULSE DETECTOR

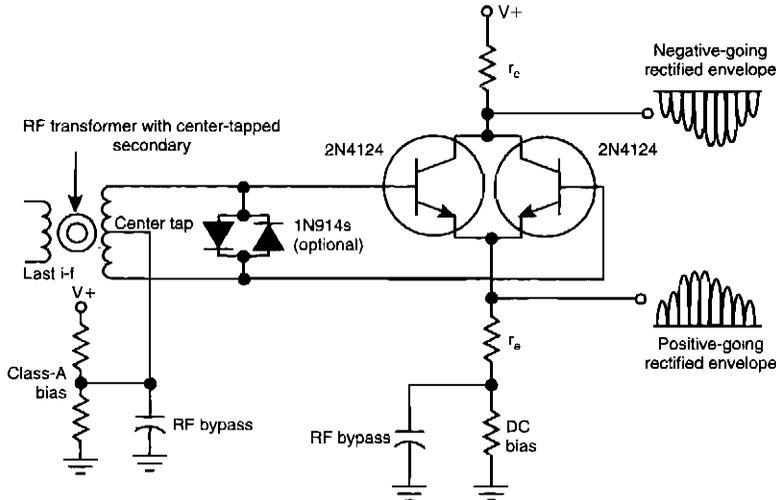


WILLIAM SHEETS

FIG. 24-3

This missing pulse detector can use an LED or relay output.

## SIMPLE FULL-WAVE ENVELOPE DETECTOR

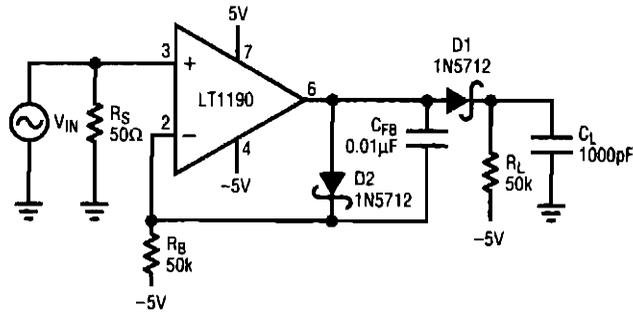


ELECTRONIC DESIGN

FIG. 24-4

Simple, yet sensitive, this amplifying full-wave detector circuit has an almost zero rectification threshold. It presents a highly linear RF load to the final IF stage. The gain for the collector output is given (approximately) by  $r_c/r_e$ . The emitter output gain is slightly less than unity.

## OPEN-LOOP PEAK DETECTOR

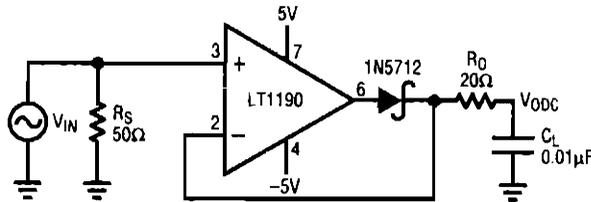


LINEAR TECHNOLOGY

FIG. 24-5

In this open-loop design, the detector diode is  $D1$ , and a level shifting or compensating diode is  $D2$ . Load resistor  $R_L$  is connected to  $-5$  V, and an identical bias resistor  $R_L$  is connected to  $-5$  V, and identical bias resistor  $R_B$  is used to bias the compensating diode. Resistors with equal values ensure that the diode drops are equal. Low values of  $R_L$  and  $R_B$  (1 k $\Omega$  to 10 k $\Omega$ ) provide fast response, but at the expense of poor low-frequency accuracy. High values of  $R_L$  and  $R_B$  provide good low-frequency accuracy, but cause the amplifier to slew rate limit, resulting in poor high-frequency accuracy. A good compromise can be made by adding a feedback capacitor  $C_{FB}$ , which enhances the negative slew rate on the (-) input.

## CLOSED-LOOP PEAK DETECTOR

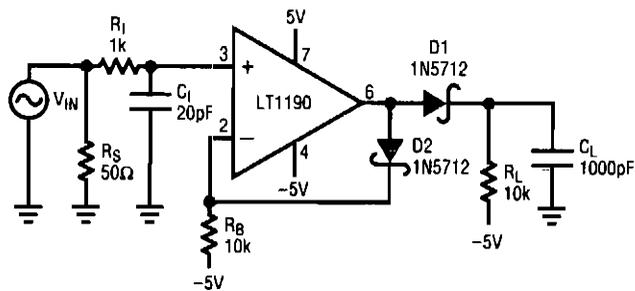


LINEAR TECHNOLOGY

FIG. 24-6

This closed-loop peak detector circuit uses a Schottky diode inside feedback loop to obtain good accuracy. The 20- $\Omega$  resistance  $R_O$  isolates the 0.01- $\mu$ F load and prevents oscillation. The dc value is read with a DVM. At a low frequency, the error is small and dominated by the decay of the detector capacitor between cycles. As the frequency rises, the error increases because capacitor charging time decreases. During this time, the overdrive becomes a very small portion of a sine-wave cycle. Finally, at approximately 4 MHz, the error rises rapidly because of the slew-rate limitation of the op amp.

## FAST PULSE DETECTOR

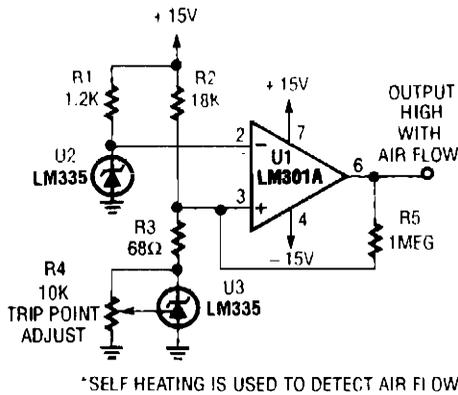


LINEAR TECHNOLOGY

FIG. 24-7

A fast pulse detector can be made with this circuit. A very fast input pulse will exceed the amplifier slew rate and cause a long overload recovery time. Some amount of  $dv/dt$  limiting on the input can help this overload condition, however this will delay the response.

### AIR-FLOW DETECTOR

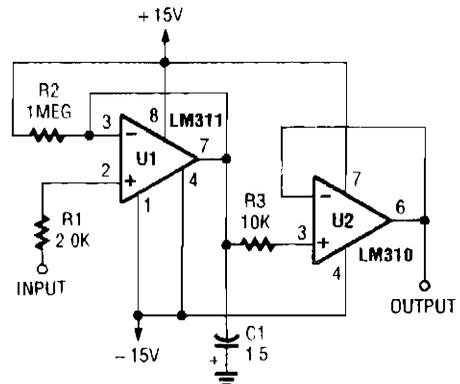


POPULAR ELECTRONICS

FIG. 24-8

Two precision temperature sensors are used to detect a small temperature difference. When air flow occurs, self-heating of the LM335 is reduced, and the output of the two temperature sensors is unequal. This is amplified by U1.

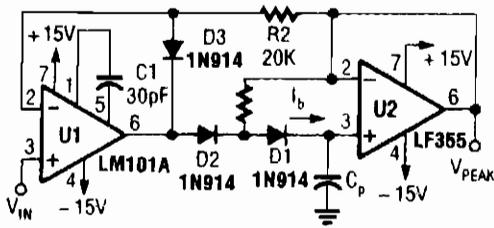
### NEGATIVE PEAK DETECTOR



POPULAR ELECTRONICS

FIG. 24-9

## LOW-DRIFT PEAK DETECTOR



Leakage of D2 is provided by feedback path through  $R_f$ .

Leakage of circuit is essentially  $I_b$  (LF155, LF156) plus capacitor leakage of  $C_p$ .

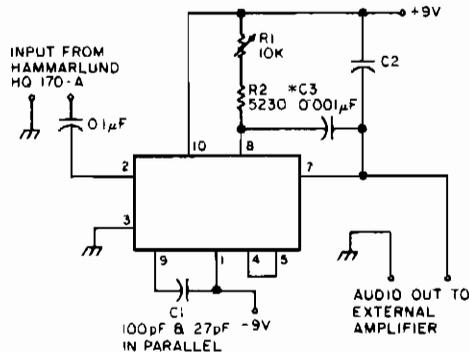
Diode D3 clamps  $V_{out}$  (A1) to  $V_{in} - V_{D3}$  to improve speed and to limit reverse bias of D2.

Maximum input frequency should be  $\ll \frac{1}{2} \pi R_f C_{D2}$ , where  $C_{D2}$  is shunt capacitance of D2.

POPULAR ELECTRONICS

FIG. 24-10

## 455-kHz FM DEMODULATOR



\*C3 IS REQUIRED TO ELIMINATE POSSIBLE OSCILLATION IN THE CONTROL CURRENT SOURCE

73 AMATEUR RADIO

FIG. 24-11

Free-running frequency of VCO:  $f_o = 1.2/4 (R_1) (C_1)$

lock range  $f_1 = \pm 8f_o \sqrt{V_{CC}}$

capture range  $f_c = \pm \frac{1}{2} \pi \sqrt{\frac{2\pi F^2 L}{r}}$

where  $r = (3.6 \times 10^3) (C2)$

Useful for NBFM reception on older shortwave receivers lacking this capability, this circuit uses a PLL IC, an N565N, to achieve this. It was originally used with an old Hammarlund HQ-170 receiver, for both 6- and 10-m FM reception.

# 25

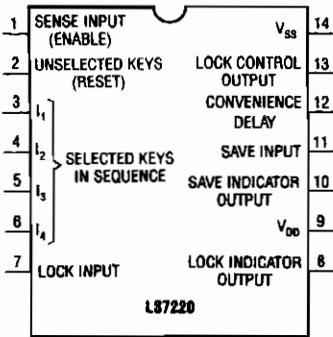
## Digital Circuits

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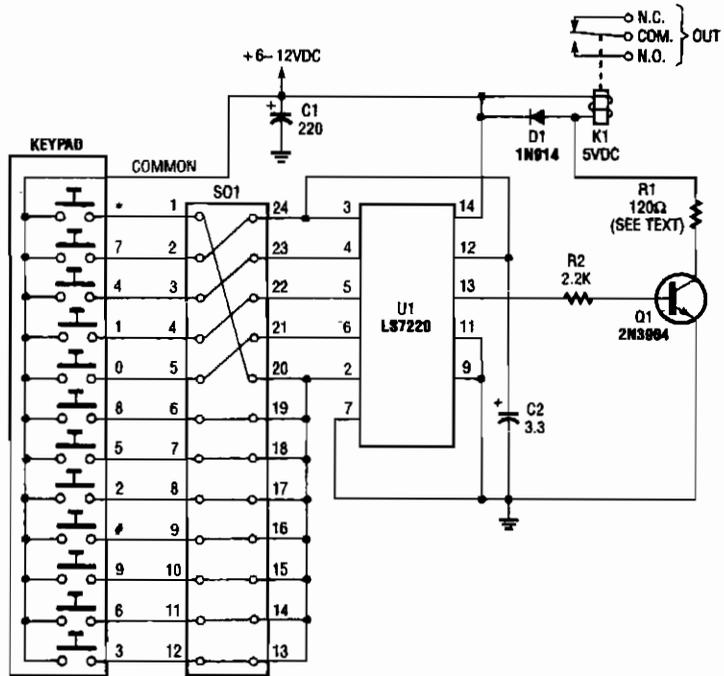
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Digital Entry Lock
- Digital Audio Selector
- Digital Multiple-Gang Potentiometer Control
- Digital Resistance Control
- Digital Capacitance Control
- BCD Rotary Switch

## DIGITAL ENTRY LOCK



The LS7220 keyless lock (a pinout of which is shown here) is a special-purpose IC designed to accept a four-digit code.



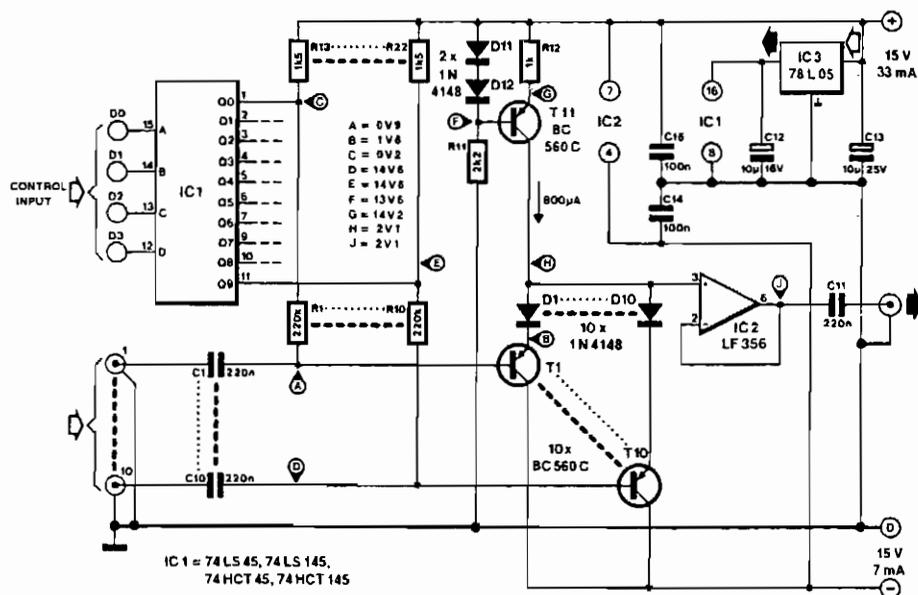
A block pinout diagram of the LS7220 keyless-lock IC is shown. The keypad must provide each key with a contact to a common connection. In this case, the common connection goes to the positive supply rail so that when a key is pressed, a positive voltage is passed through to the wire associated with that key. Each of the 12 keys are brought out to separate wires, and each wire is connected to a different pin of a 24-pin socket (SO1).

To activate (unlock) the circuit, a preprogrammed four-digit access code must be entered in the proper sequence. The four-digit access code must be entered in the proper sequence. The four-digit access is programmed into the circuit by connecting jumpers between terminals of a 24-pin plug-in header.

When the correct access code is entered (in the proper sequence), positive voltages appear at pins 3, 4, 5, and 6 of U1. That causes U1 to output a positive voltage at pin 13, which is fed through resistor R2 to the base of Q1, causing it to conduct. With Q1 conducting, its collector is pulled to ground potential, energizing relay K1. The normally open relay contacts close, switching on any external device.

Capacitor C2 controls the total time that the output of U1 at pin 13 is positive after the release of the first key. With a value of 3.3  $\mu$ F for C2, active time after release of the first key is about two seconds, assuming a 6-V supply or four seconds with a 12-V supply. Therefore, if you push the subsequent keys too slowly, the relay might not close at all! To increase the time allotted for code entry, you will have to increase the capacitance of C2.

## DIGITAL AUDIO SELECTOR

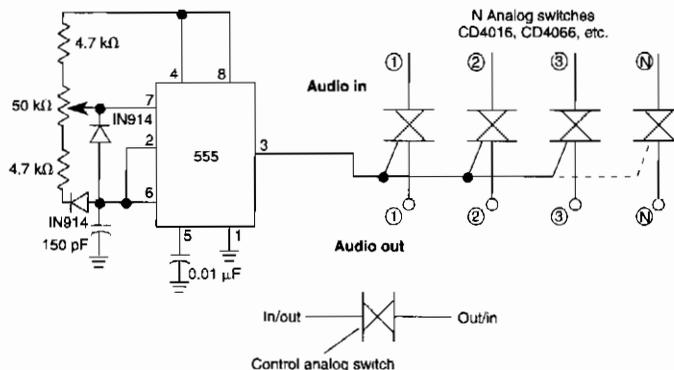


303 CIRCUITS

FIG. 25-2

This circuit uses switched emitter followers, rather than the usual analog switch CMOS chips. This yields better reduction of crosstalk between channels. This circuit can handle up to  $4 V_{\text{rms}}$  with less than  $-80\text{-dB}$  crosstalk.

## DIGITAL MULTIPLE-GANG POTENTIOMETER CONTROL

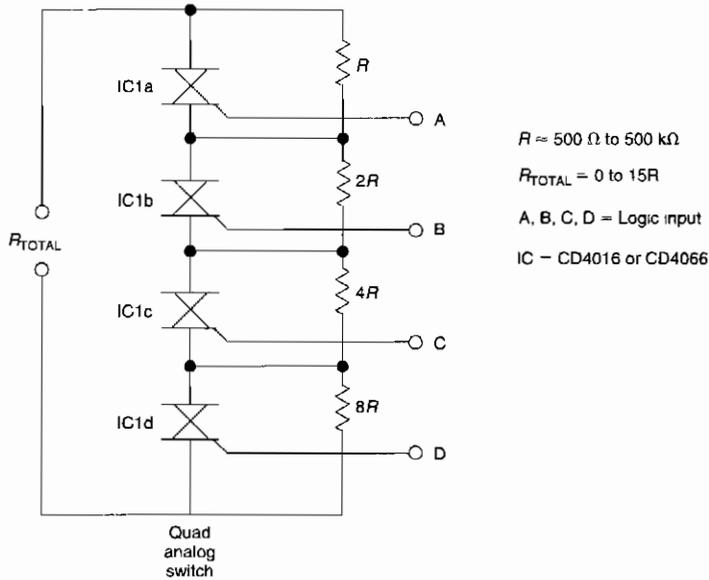


WILLIAM SHEETS

FIG. 25-3

A 555 timer can be configured to simulate a multi-gang potentiometer by controlling the mark-space ratio. The switching rate should be at least twice the maximum expected signal frequency the potentiometer has to handle.

## DIGITAL RESISTANCE CONTROL

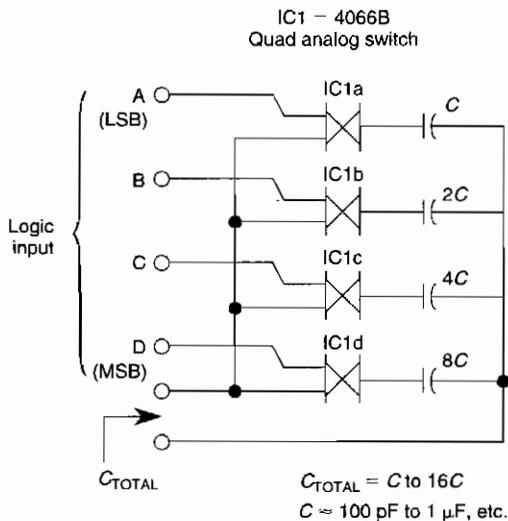


WILLIAM SHEETS

FIG. 25-4

Digital resistance control is possible with bilateral switches. Do not forget that analog switches have "on" resistance.

## DIGITAL CAPACITANCE CONTROL

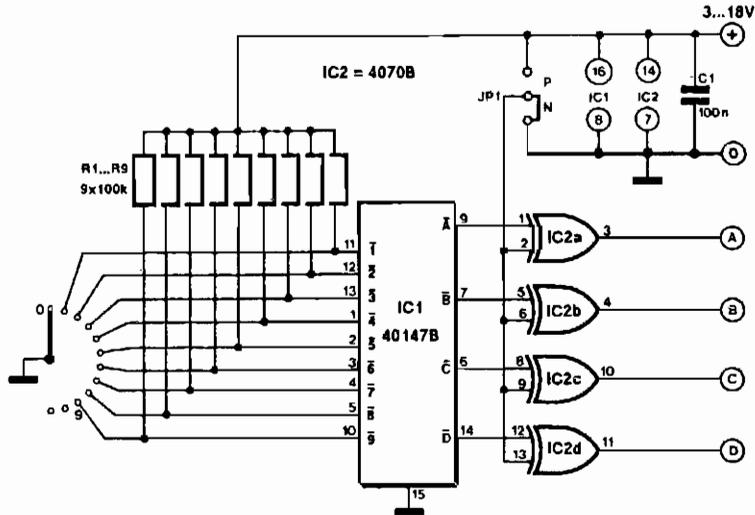


Digital capacitance control is possible with bilateral switches. Do not forget to consider "ON" resistance of the analog switches.

WILLIAM SHEETS

FIG. 25-5

## BCD ROTARY SWITCH



ELEKTOR ELECTRONICS USA

FIG. 25-6

This circuit allows a simple rotary switch to emulate a BCD switch. The circuit draws about 200 mA. A 10-position rotary switch is used.

# 26

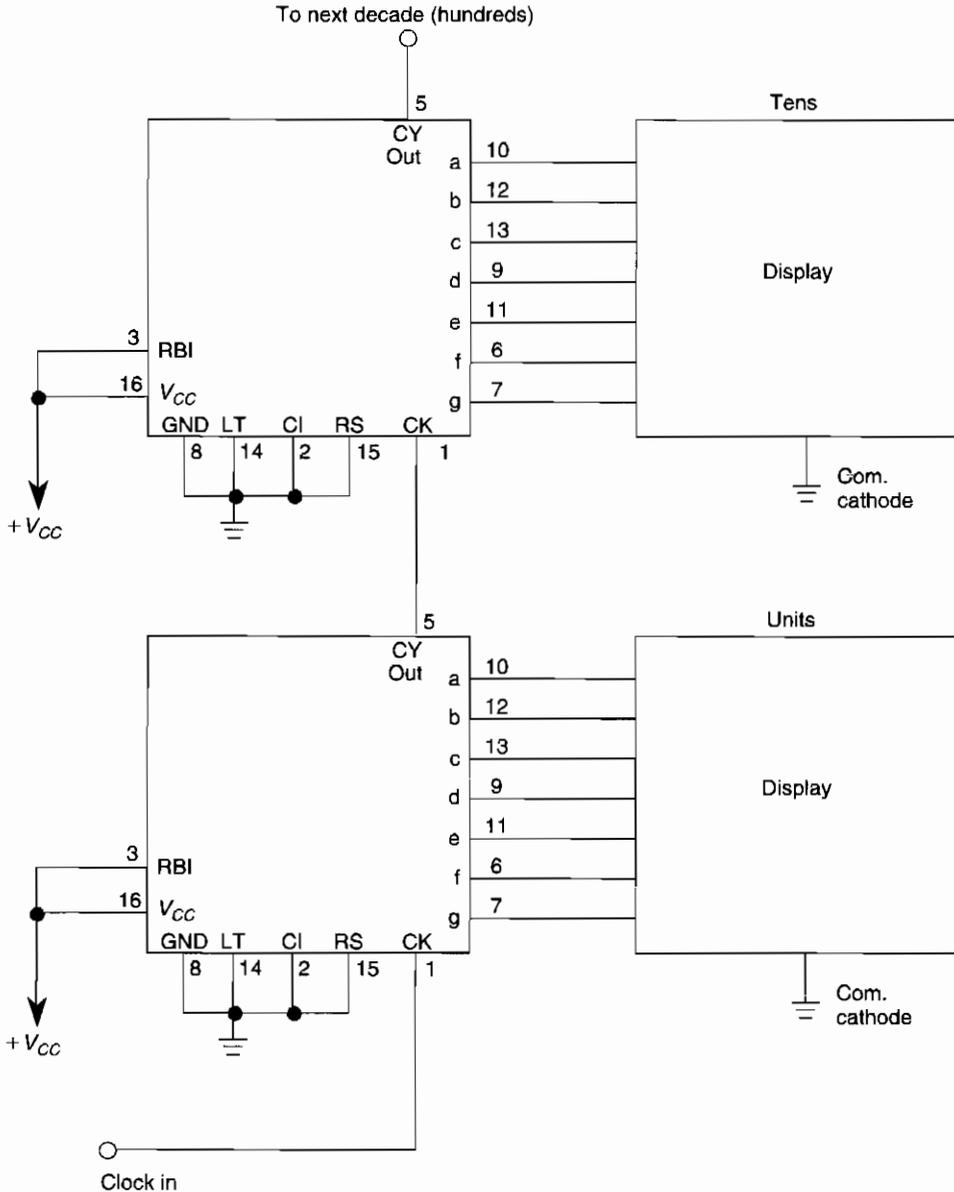
## Display Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

4033 Display Circuitry Common Cathode  
Cascaded 4026B Counter/Display Driver Circuit  
Large LCD Display Buffering Driver  
7-Segment LCD Driver  
LED Display Leading-Zero Suppressor  
7-Segment Common-Cathode LED Display Driver  
7-Segment (LED) Display Driver  
4543B 7-Segment LCD Driver  
Gas Discharge Tube or Display Driver  
4511B Common-Anode Display Driver  
Fluorescent Tube Display Driver  
4543B Common-Cathode LED Driver

## 4033 DISPLAY CIRCUITRY COMMON CATHODE

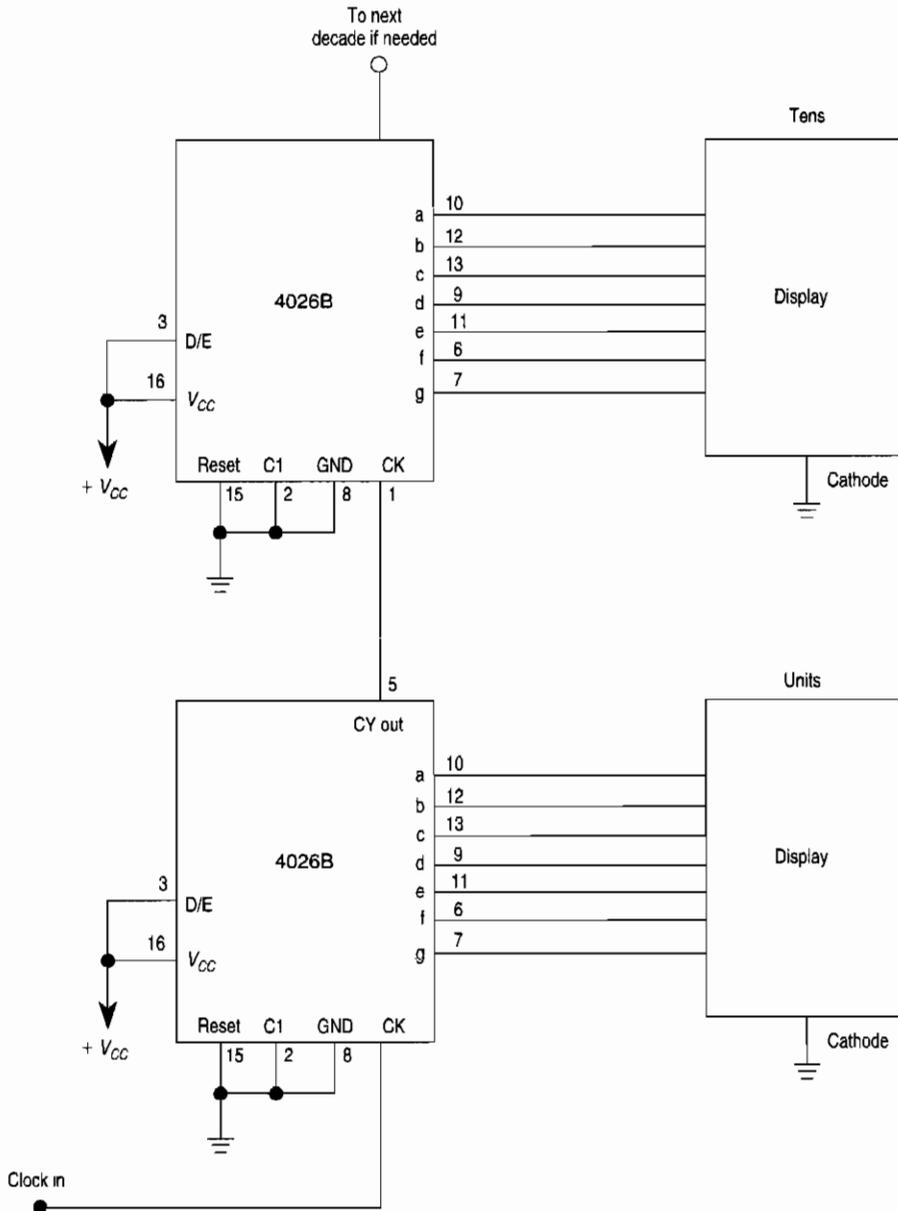


WILLIAM SHEETS

FIG. 26-1

To drive two or more common-cathode displays two or more 4033 decode counters can be cascaded.

## CASCADED 4026B COUNTER/DISPLAY DRIVER CIRCUIT

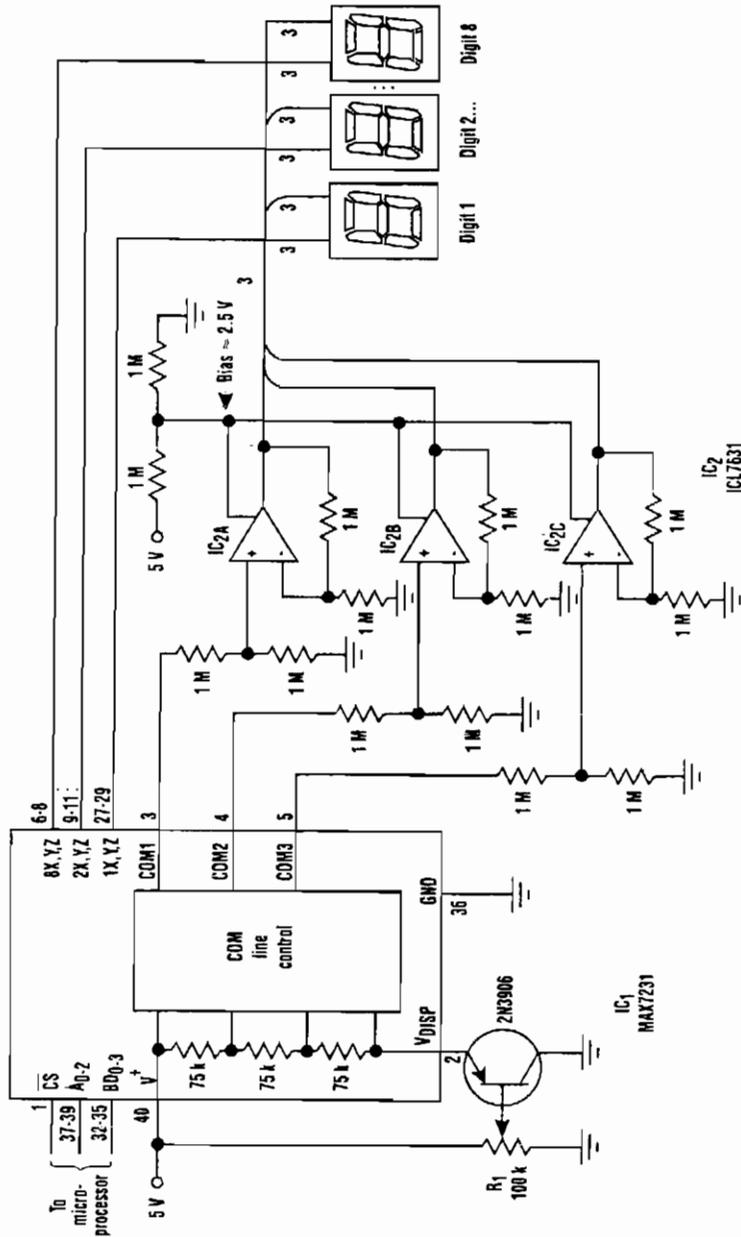


WILLIAM SHEETS

FIG. 26-2

Two or more 4026B counters can be cascaded as shown to give a multiple-digit display. Two, three or more displays can thus be connected.

## LARGE LCD DISPLAY BUFFERING DRIVER



**ELECTRONIC DESIGN**

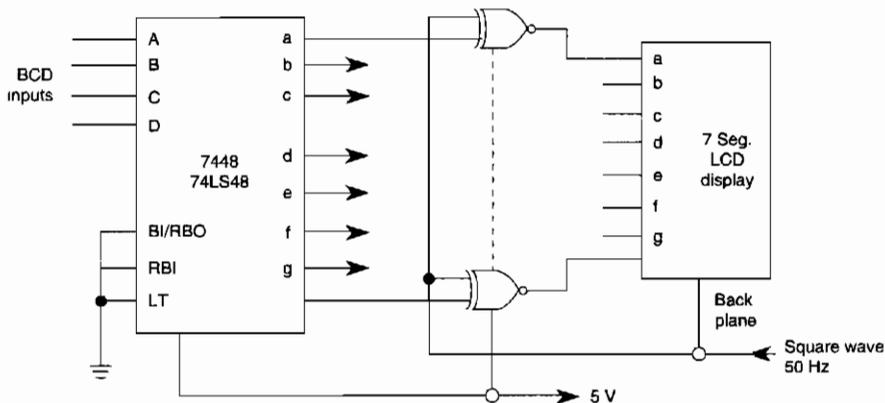
**FIG. 26-3**

Large LCD devices of 1" or more exhibit a large driving capacitance to the driver circuits. To solve this problem, the drive circuit shown (see the figure) introduces a buffer amplifier for each of the three common lines. Each amplifier can be programmed independently for a quiescent current of 10, 100, or 1000  $\mu\text{A}$ . In this application, the bias network applies a voltage that sets the three quiescent currents to 100  $\mu\text{A}$ .

The display driver and triple op amp operate between 5 V and ground, and the COM signals range from 5 V to  $\approx 1$  V. To ensure that these signals remain within the amplifiers' common-mode range, the signals are attenuated by one-half and the buffers operate at a gain of two. The circuit drives eight 1-inch displays, and is suitable for ambient temperature variations of 15°F or less. At the highest expected temperature, R1 should be adjusted so that no "off" segments are visible.

## 7-SEGMENT LCD DRIVER

2 Required  
7486, 74LS86, etc.  
exclusive OR gates or equivalent

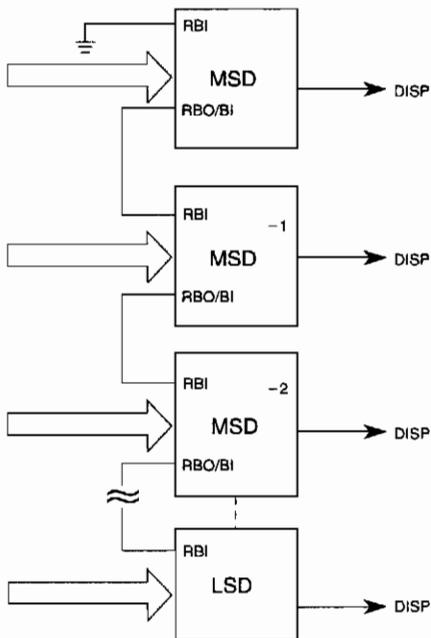


WILLIAM SHEETS

**FIG. 26-4**

This circuit shows how a 7448 IC is used to drive a 7-segment LCD display. An external 50-Hz square wave supplies necessary phase signals to the back plane of the display.

## LED DISPLAY LEADING-ZERO SUPPRESSOR

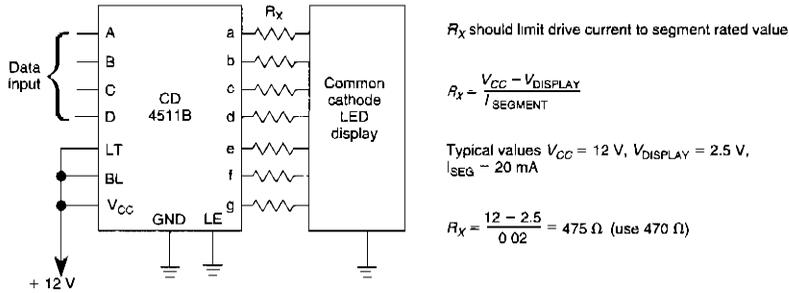


The diagram shows how to connect 7447-type IC devices for leading-zero suppression in an LED display.

WILLIAM SHEETS

**FIG. 26-5**

## 7-SEGMENT COMMON-CATHODE LED DISPLAY DRIVER

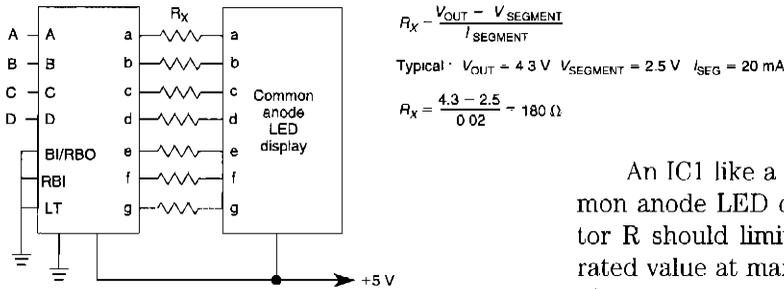


WILLIAM SHEETS

FIG. 26-6

A CD4511B CMOS LED display driver can be used to drive a common cathode LED display. Current limiting resistors limit the segment current to the rated value at maximum supply voltage. A sample calculation is shown.

## 7-SEGMENT (LED) DISPLAY DRIVER

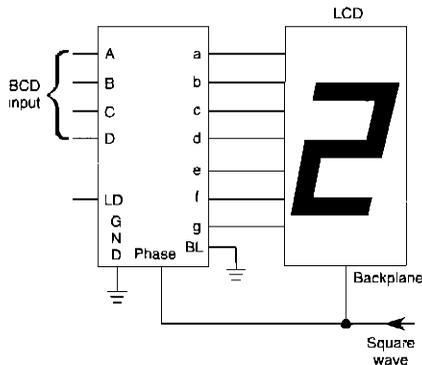


WILLIAM SHEETS

FIG. 26-7

An IC1 like a 7447 drives a 7-segment common anode LED display. Current limiting resistor R should limit the segment current to the rated value at maximum supply voltage. A sample calculation is shown.

## 4543B 7-SEGMENT LCD DRIVER



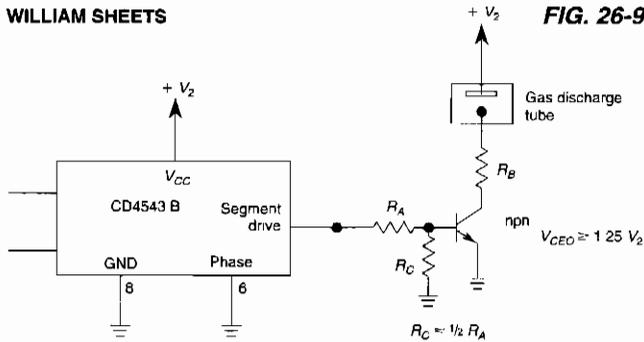
The circuit shows a frequently-used method of driving an LCD display. A square-wave drive is necessary for this application.

WILLIAM SHEETS

FIG. 26-8

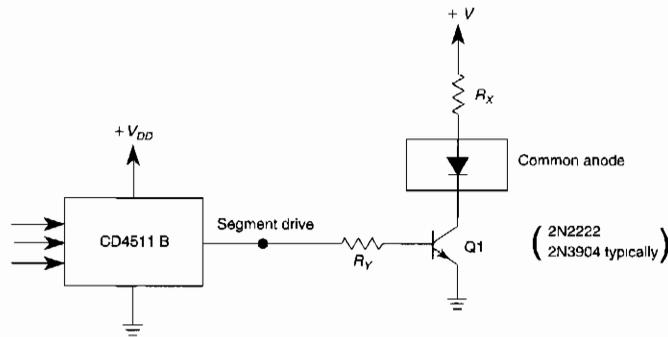
## GAS DISCHARGE TUBE OR DISPLAY DRIVER

WILLIAM SHEETS



To drive the display,  $R_A$  should provide a drive of about 1 mA to the gas discharge tube.  $R_B$  is a current-limiting resistor.

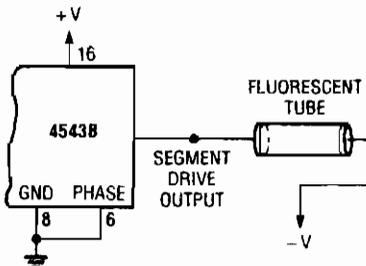
## 4511B COMMON-ANODE DISPLAY DRIVER



The use of a switching transistor (like a 2N2222 or 2N3904) allows use of the CD4511B with a common-anode display.  $R_y$  should be chosen to provide about 1 mA to drive Q1 and  $R_x$  should provide enough current to drive the display. For this circuit, the transistor gain ( $H_{FE}$ ) should be at least the ratio of the segment drive current to the current through  $R_y$ .

WILLIAM SHEETS

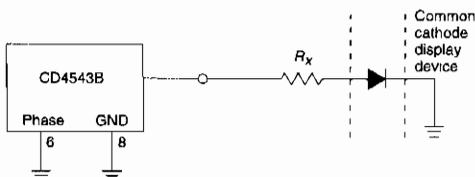
## FLUORESCENT TUBE DISPLAY DRIVER



A fluorescent tube or display can be driven with a 4543B IC, as shown.

RADIO-ELECTRONICS

## 4543B COMMON-CATHODE LED DRIVER



This circuit shows a way of driving a common-cathode display segment or an LED with a CD4543B.

WILLIAM SHEETS

# 27

## Doorbell Circuits

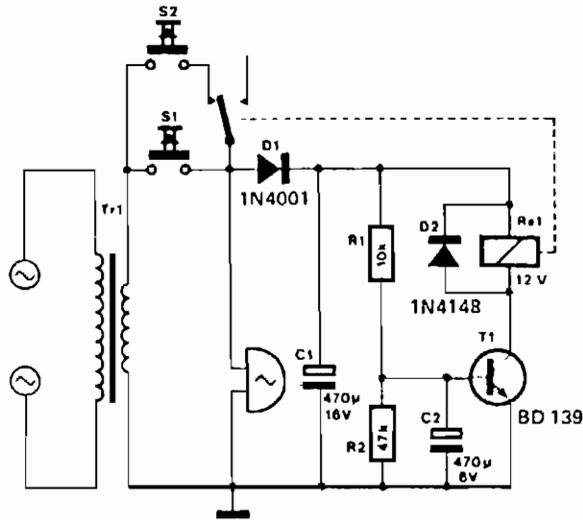
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Electronic Doorbell  
Twin Bell Circuit  
Electronic Door Buzzer



## TWIN BELL CIRCUIT



Tr1 = bell transformer

FIG. 27-2

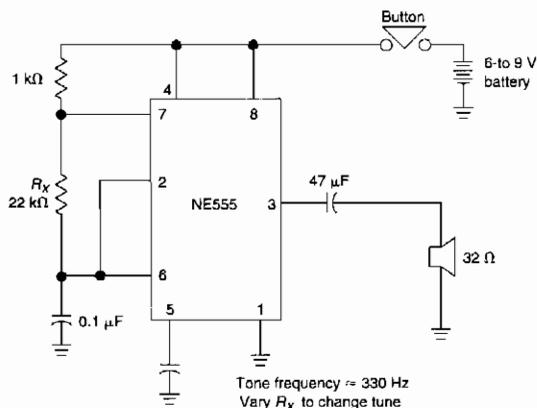
### 303 CIRCUITS

It is often desirable for a single doorbell to be operated by two buttons, for instance, one at the front door and the other at the back door.

The additional button, S2 in series with the break contact of relay Re1, is connected in parallel with the original bell-push, S1. When S2 is pressed, the bell voltage is rectified by D1 and smoothed by C1. After a time,  $t = R_1 R_2 C_2$ , the direct voltage across C2 has risen to a level here T1 switches on. Relay Re1 is then energized and its contact breaks the circuit of S2 so that the bell stops ringing. After a short time, C1 and C2 are discharged, the relay returns to its quiescent state and the bell rings again.

In this way, S1 will cause the bell to ring continuously, while S2 makes it ring in short bursts, so that it is immediately clear which button is pushed.

## ELECTRONIC DOOR BUZZER



This simple electronic door buzzer draws no quiescent current. When S1 is pressed the speaker produces a tone. The NE555 (U1) generates signal.

# 28

## Fax Circuit

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Fax Mate

# FAX MATE

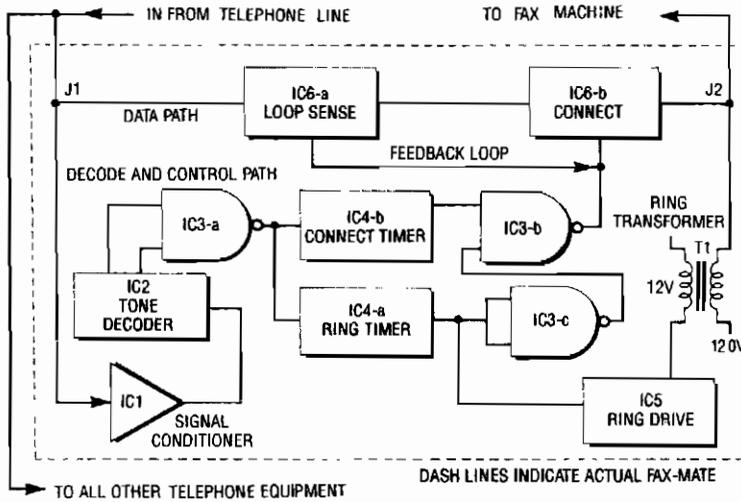


FIG. 1—BLOCK DIAGRAM for the Fax-Mate. The upper path is for data, and the lower one is the decode and control path.

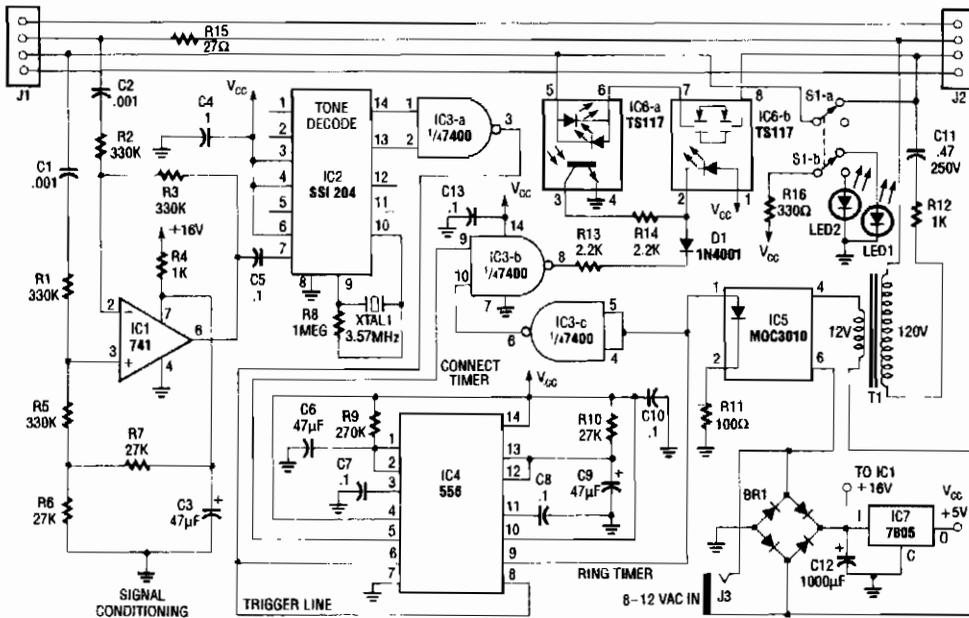


FIG. 2—SCHEMATIC for the Fax-Mate. Notice how it closely resembles the block diagram.

## FAX MATE(Cont.)

The fax mate separates the fax machine from the phone line, rings the fax machine on command, connects equipment to incoming lines, and senses the end of the message. When a touch tone pound signal (#) is detected, it actuates a ring greater and driver for the fax machine (the # signal is not used in ordinary dialing). The connect signal is inhibited for this time (ring cycle). IC46 runs for 15 s and drives part of the connect IC. Then the fax or modem has fired up and is sending out a handshake tone. IC6 connects the equipment for initial hookup and keeps the connect section powered. When the fax machine hangs up, the loop current detector turns off, and resets the system.

---

## 29

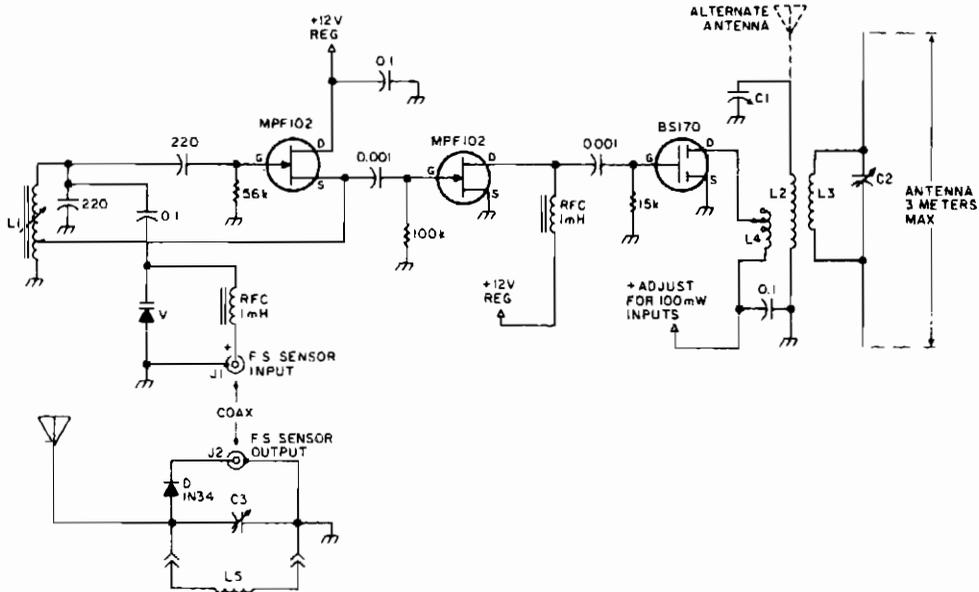
# Field-Strength Meter Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Remote Field Strength Meter  
Amplified Field Strength Meter  
Simple Amplified Field Strength Meter  
Simple Field Strength Meter I  
Simple Field Strength Meter II

## REMOTE FIELD STRENGTH METER

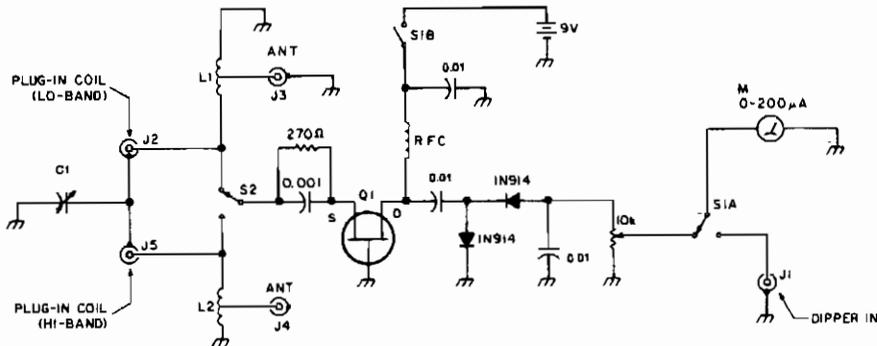


73 AMATEUR RADIO TODAY

FIG. 29-1

This field strength meter consists of a tuned crystal detector producing a dc output voltage from a transmitted signal. The dc voltage is used to shift the frequency of a transmitter of 100-mW power operating at 1650 kHz. The frequency shift is proportional to the received field strength. This unit has a range of several hundred feet and is operated under FCC part 15 rules (100-mW max power into a 2-m-long antenna between 510 and 1705 kHz).

## AMPLIFIED FIELD STRENGTH METER

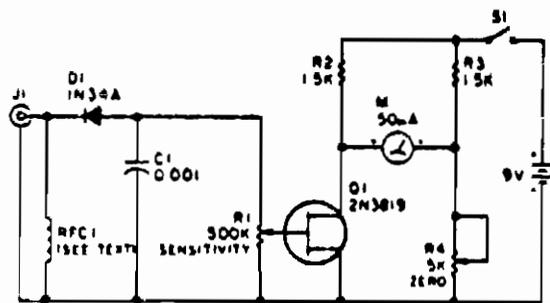


73 AMATEUR RADIO TODAY

FIG. 29-2

FET Q1 acts as an RF amplifier to boost sensitivity of the usual diode detector field strength meter.

## SIMPLE AMPLIFIED FIELD STRENGTH METER

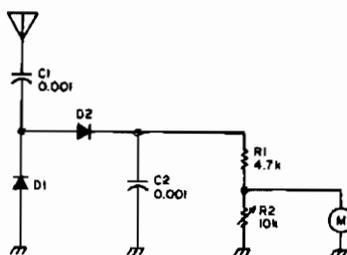


This circuit uses a FET as a dc amplifier in a bridge circuit. R4 is set for meter null with J1 short circuited. Any surplus 50-mA meter can serve in this circuit. RFC1 is any suitable RF choke for the band in use. A 2.5-mH RF choke will do for broadband operation. R1 is a sensitivity control. The antenna can be any small whip antenna (2 ft or less).

73 AMATEUR RADIO TODAY

FIG. 29-3

## SIMPLE FIELD STRENGTH METER I

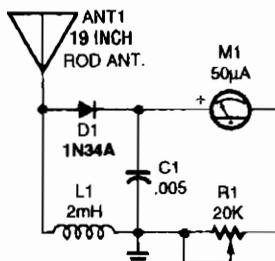


Useful for checking transmitters and antennas, this circuit uses a voltage-doubling detector D1 and D2 (HP 5082-2800 hot carrier types). D1 and D2 can also be type 1N34 or 1N82. M is a 100-mA meter movement.

73 AMATEUR RADIO TODAY

FIG. 29-4

## SIMPLE FIELD STRENGTH METER II



This simple field-strength meter provides a cheap way to monitor an amateur radio or CB transmitter (or even an antenna system) for maximum output.

POPULAR ELECTRONICS

FIG. 29-5

# 30

## Filter Circuits

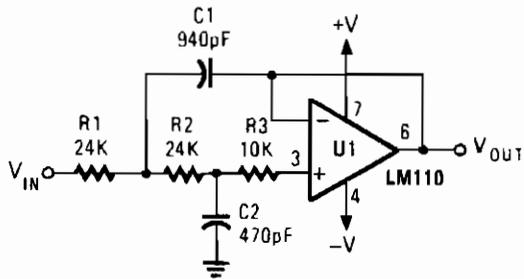
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- |   |  |
|---|--|
| Active Low-Pass Filter                    | Audio Notch Filter for Shortwave Receivers                       |
| High Q Notch Filter                       | Active Second-Order Bandpass Filter                              |
| Universal Stale Variable Filter           | Variable-Frequency Audio BP Filter                               |
| Adjustable Q Notch Filter                 | Variable Low-Pass Filter   |
| Fourth Order High-Pass Butterworth Filter | Variable High-Pass Filter  |
| Tunable Notch Filter                      | 1-mV Offset, Clock-Tunable,<br>Monolithic 5-Pole Low-Pass Filter |
| High Q Bandpass Filter                    | Unity-Gain Second-Order High-Pass Filter                         |
| Simulated Inductor                        | Active Unity-Gain Second-Order Low-Pass Filter                   |
| Bandpass Filter                           | Active Fourth-Order High-Pass Filter for 50 Hz                   |
| Fourth Order Low-Pass Butterworth Filter  | Simple High-Pass (HP) Active Filter for 1 kHz                    |
| Active High-Pass Filter                   | Equal Second-Order HP Filter                                     |
| 400-Hz Low-Pass Butterworth Filter        | Second-Order Low-Pass Filter for 10 kHz                          |
| Bandpass Filter                           | Simple Low-Pass (LP) Active Filter for 1 kHz                     |
| Active Low-Pass RC Filter                 | Current-Driven Sallen Key Filter                                 |
| Passive L Filter Configurations           | 455-kHz Narrow-Band IF Filter                                    |
| Passive Pi Filter Configurations          | Audio-Range Filter   |
| Four-Output Filter                        | BI-Quad RC Bandpass Filter                                       |
| Variable Q Filter for 400 Hz              | Passive T Filter Configurations                                  |
| Twin T Notch Filter for 1 kHz             | Full-Wave Rectifier/Averaging Filter                             |
| Variable Bandpass Audio Filter            | 1-kHz Tone Filter  |
| Active Fourth-Order Low-Pass Filter       |  |

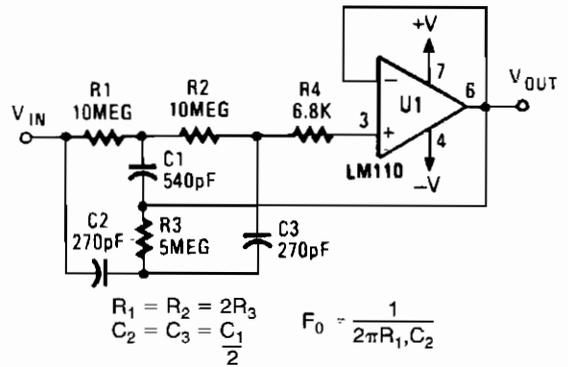
### ACTIVE LOW-PASS FILTER



POPULAR ELECTRONICS

FIG. 30-1

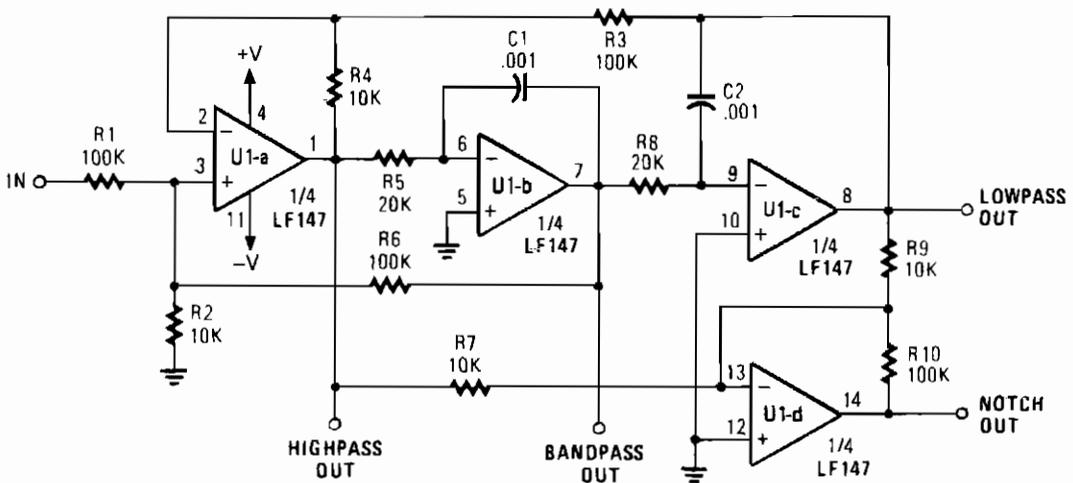
### HIGH Q NOTCH FILTER



POPULAR ELECTRONICS

FIG. 30-2

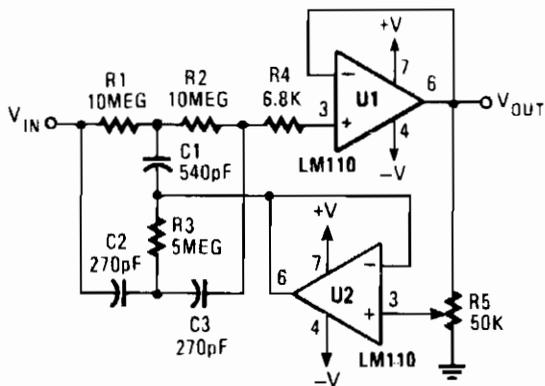
### UNIVERSAL STATE VARIABLE FILTER



POPULAR ELECTRONICS

FIG. 30-3

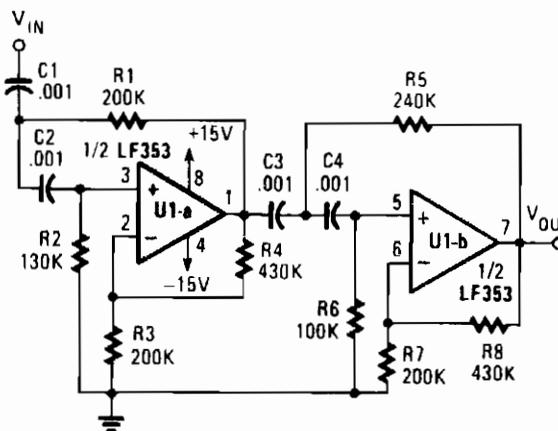
### ADJUSTABLE Q NOTCH FILTER



POPULAR ELECTRONICS

FIG. 30-4

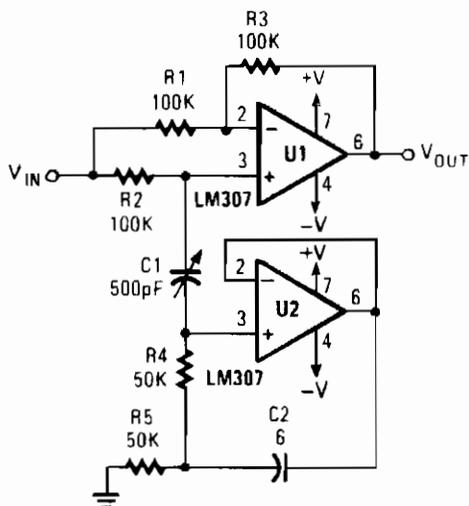
### FOURTH ORDER HIGH-PASS BUTTERWORTH FILTER



POPULAR ELECTRONICS

FIG. 30-5

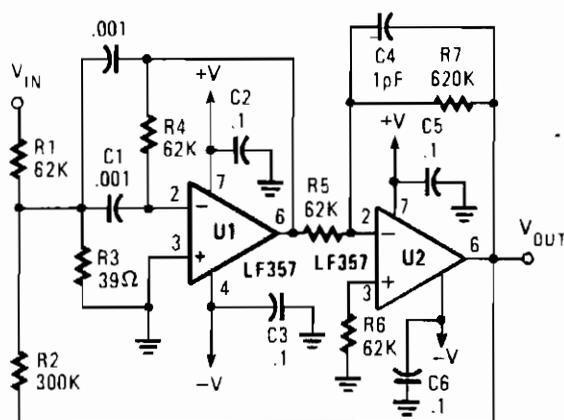
### TUNABLE NOTCH FILTER



POPULAR ELECTRONICS

FIG. 30-6

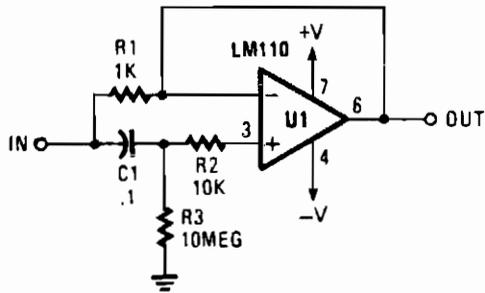
### HIGH Q BANDPASS FILTER



POPULAR ELECTRONICS

FIG. 30-7

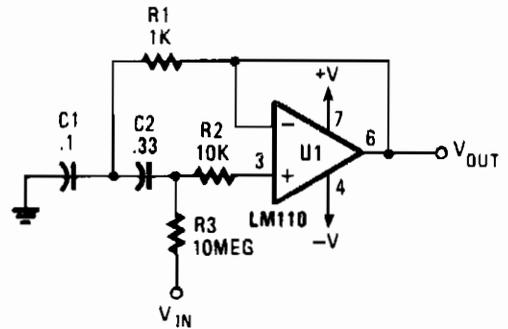
### SIMULATED INDUCTOR



POPULAR ELECTRONICS

FIG. 30-8

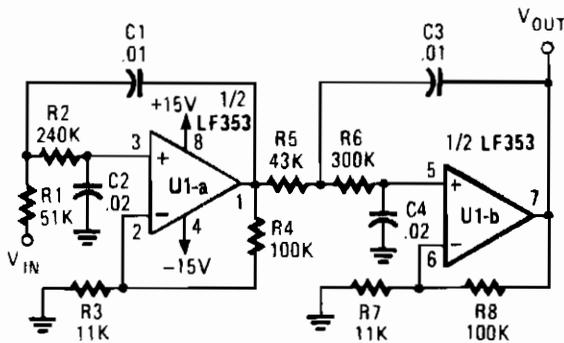
### BANDPASS FILTER



POPULAR ELECTRONICS

FIG. 30-9

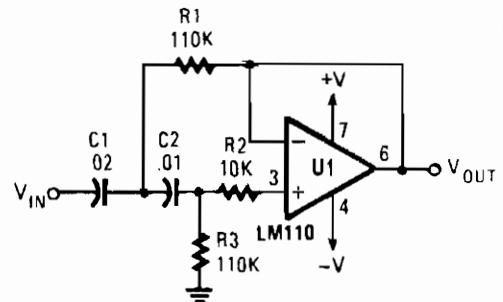
### FOURTH ORDER LOW-PASS BUTTERWORTH FILTER



POPULAR ELECTRONICS

FIG. 30-10

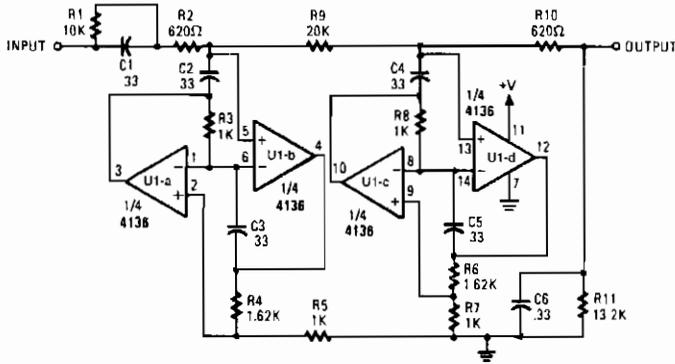
### ACTIVE HIGH-PASS FILTER



POPULAR ELECTRONICS

FIG. 30-11

## 400-Hz LOW-PASS BUTTERWORTH FILTER

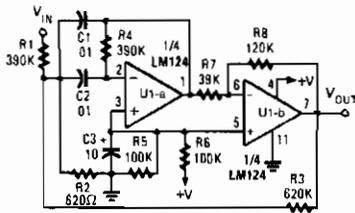


POPULAR ELECTRONICS

FIG. 30-12

Designed for a 400-Hz cutoff frequency, the cutoff can be scaled by varying the element values proportionally to frequency

### BANDPASS FILTER



POPULAR ELECTRONICS

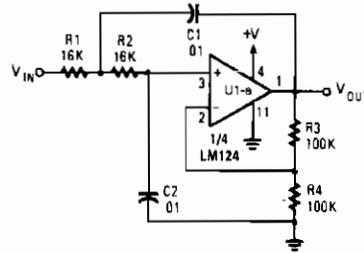
FIG. 30-13

Appropriate center frequency of this circuit is:

$$\frac{1}{R_4 C_2}$$

$$C_1 = C_2, R_1 = R_4$$

### ACTIVE LOW-PASS RC FILTER

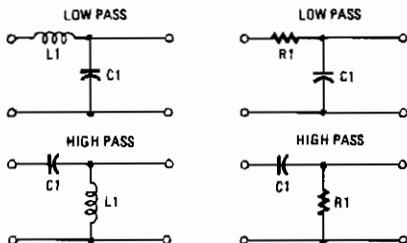


POPULAR ELECTRONICS

FIG. 30-14

The circuit shown has a cutoff frequency at about 1 kHz. R1, R2, C1, and C2 can be scaled to change this to any other desired frequency.

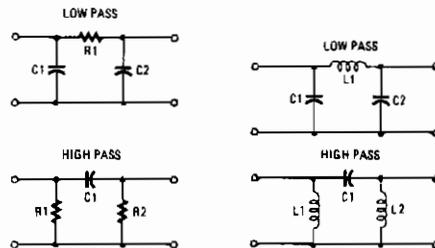
### PASSIVE L FILTER CONFIGURATIONS



POPULAR ELECTRONICS

FIG. 30-15

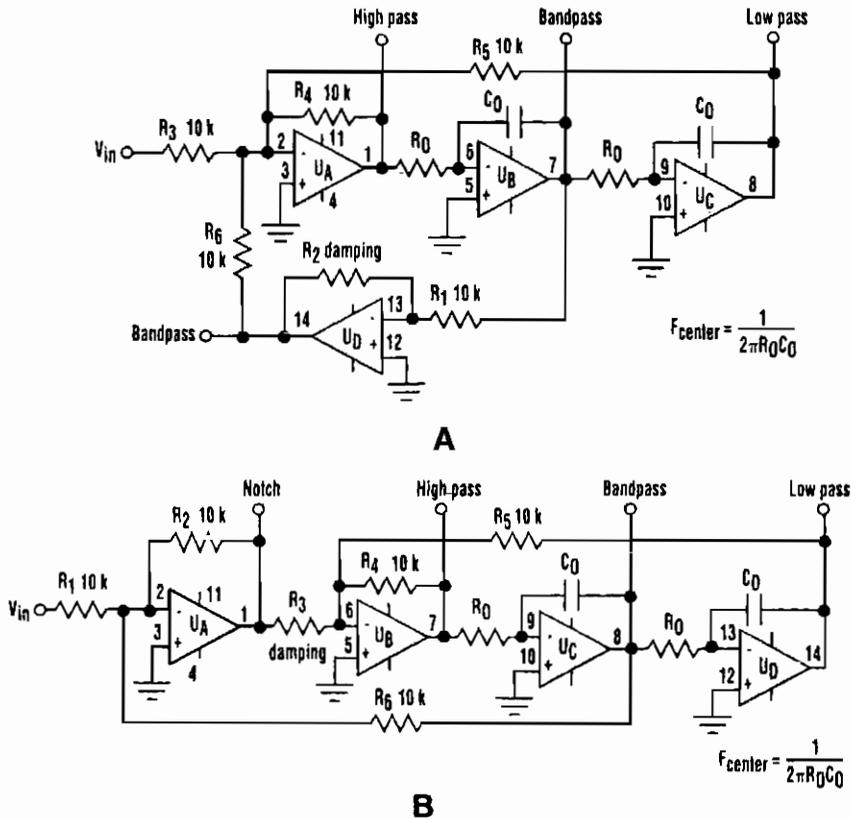
### PASSIVE PI FILTER CONFIGURATIONS



POPULAR ELECTRONICS

FIG. 30-16

## FOUR-OUTPUT FILTER



$$f_{center} = \frac{1}{2\pi R_0 C_0}$$

$$f_{center} = \frac{1}{2\pi R_0 C_0}$$

### ELECTRONIC DESIGN

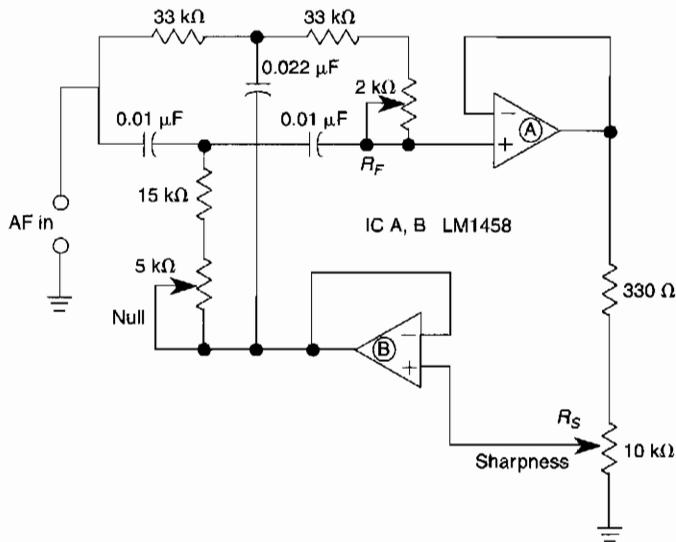
**FIG. 30-17**

The classic “state-variable” (two-integrator) filter (see Fig. A) is famous for its insensitivity to device parameter tolerances, as well as its ability to provide three simultaneous separate outputs: high pass, bandpass, and low pass. These advantages often offset the fact that a quad operational amplifier is needed to implement the circuit.

A modification of the classic scheme that applies the input voltage via amplifier  $U_D$ , rather than  $U_A$  provides a bandpass output with a fixed peak gain that doesn't depend on the  $Q$  of the filter. It was found by using that configuration, a fourth notch-filter output can be obtained if  $R_1 = R_6$  (see Fig. B).

If  $R_1 = R_6 = R_2$ , the gains of both the notch and bandpass outputs are unity, regardless of the  $Q$  factor, as determined by  $R_3$ ,  $R_1$ ,  $R_2$ ,  $R_4$ ,  $R_5$ , and  $R_6$ . The resonant (or cutoff) frequency is given by  $\omega_c = 1/R_0 \times C_0$ . Depending on the capacitor values and frequency  $\omega$ , resistance  $R_0$  might also share the same monolithic network for maximum space economy. As with the classic configuration, resonant frequency  $\omega$  can be electrically controlled by switching resistors  $R_0$ , or by using analog multipliers in series with the integrators.

### VARIABLE Q FILTER FOR 400 Hz

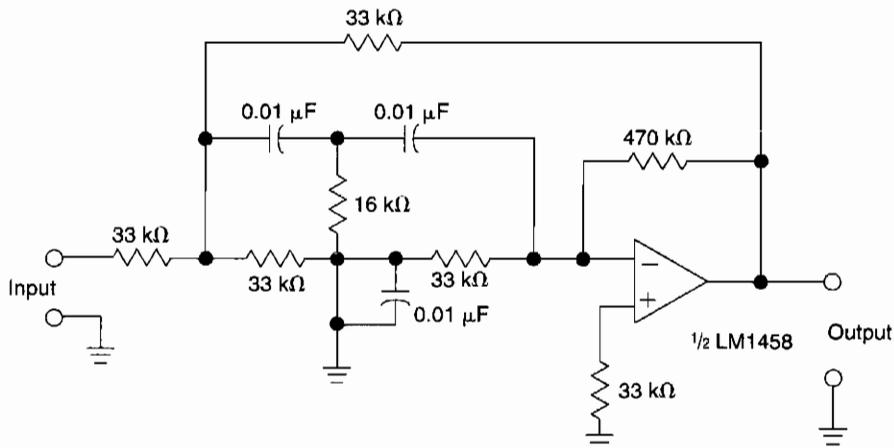


WILLIAM SHEETS

FIG. 30-18

A bootstrapped twin T notch filter in this circuit can yield an effective  $Q$  of up to 10.  $R_S$  adjusts the feedback, hence the  $Q$ . Values of  $C_1$  and  $C_2$  can be changed to alter the frequency.  $R_F$  is a fine-tune null control.

### TWIN T NOTCH FILTER FOR 1 kHz

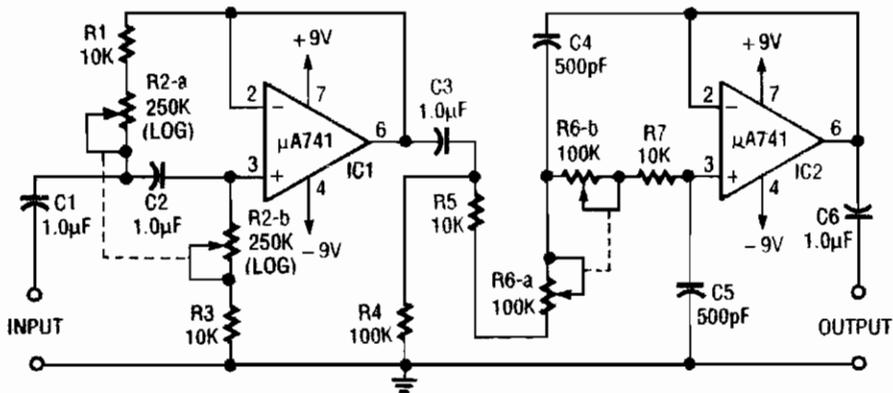


WILLIAM SHEETS

FIG. 30-19

The circuit shown uses a twin T notch filter and an amplifier. Used to remove unwanted frequency.

### VARIABLE BANDPASS AUDIO FILTER

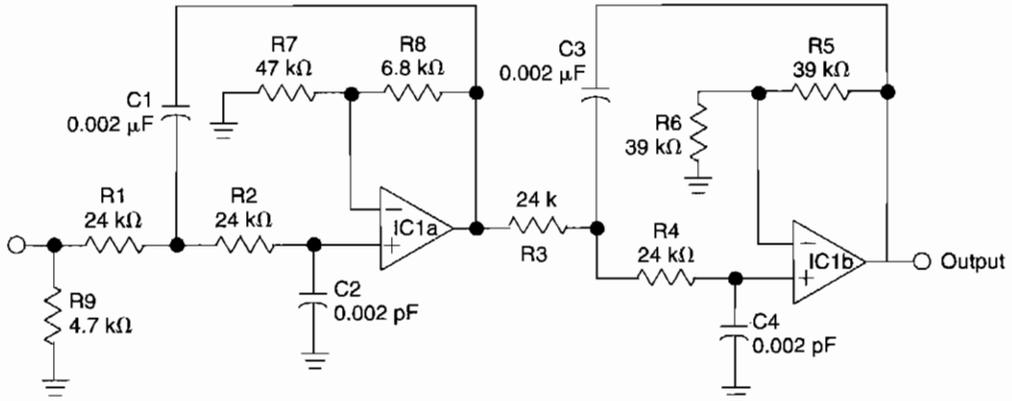


ELECTRONICS NOW

FIG. 30-20

This circuit is a variable audio bandpass filter that has a low cutoff variable from about 25 Hz to 700 Hz and a high cutoff variable from 2.5 kHz to over 20 kHz. Rolloff is 12 dB/octave on both high and low ends. R2-a-b and R6-a-b are ganged potentiometers for setting lower and upper cutoff frequencies, respectively.

### ACTIVE FOURTH-ORDER LOW-PASS FILTER



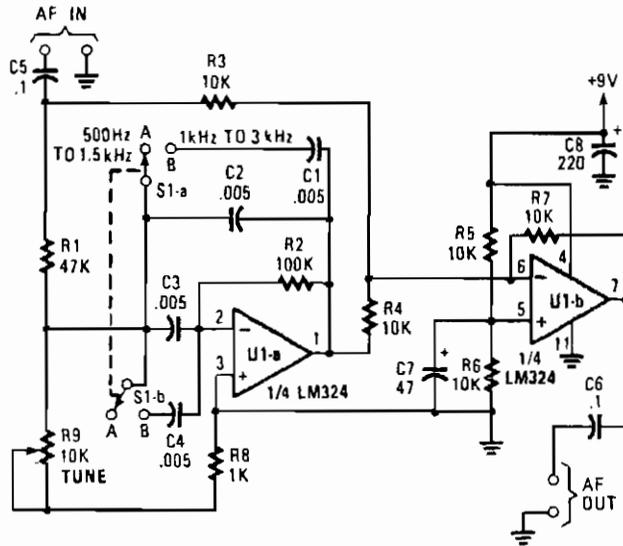
IC1 a, b op amp = LM1458

WILLIAM SHEETS

FIG. 30-21

This circuit is a fourth-order low-pass filter with values for kHz. The values of  $R_1$ ,  $R_2$ ,  $C_1$  and  $C_2$ , and  $R_3$ ,  $R_4$ ,  $C_3$  and  $C_4$  can be scaled for operation at other frequencies. Roll-off is 24 dB/octave.

## AUDIO NOTCH FILTER FOR SHORTWAVE RECEIVERS

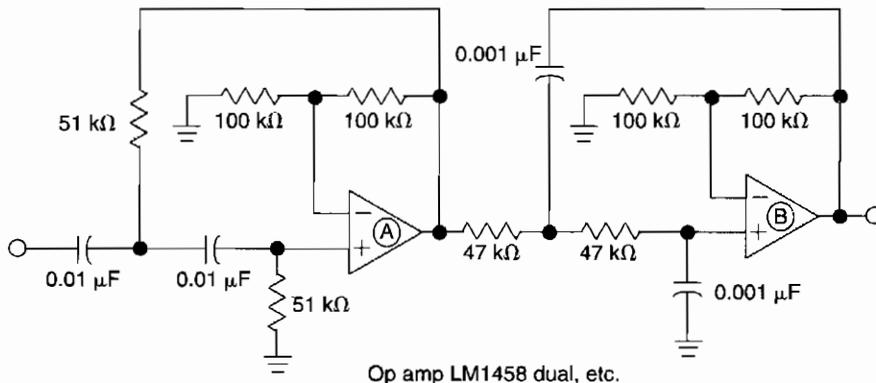


POPULAR ELECTRONICS

FIG. 30-22

The notch filter can be added to just about any receiver to attenuate a single frequency by more than 30 dB. This filter should be handy for reducing heterodynes and whistles.

## ACTIVE SECOND-ORDER BANDPASS FILTER FOR SPEECH RANGE

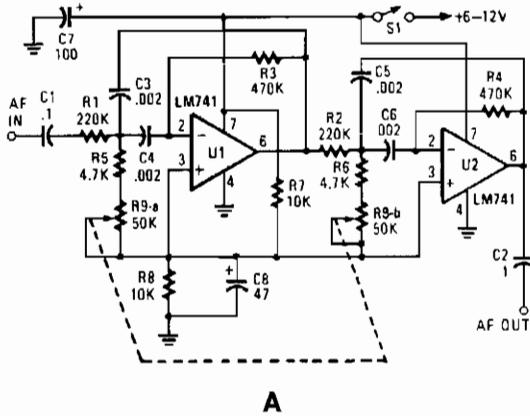


WILLIAM SHEETS

FIG. 30-23

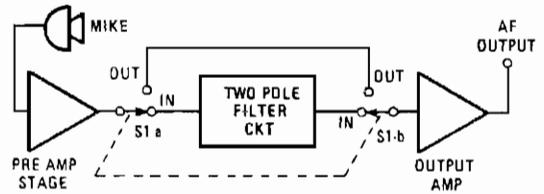
This filter circuit which uses LM1458 or similar op amp has a response of 300 Hz to 3.4 kHz with 12 dB/octave roll-off outside the pass band. Section A is the high-pass one, followed by low-pass section B. Values of either section can be scaled to alter the pass band.

## VARIABLE-FREQUENCY AUDIO BP FILTER



A

POPULAR ELECTRONICS

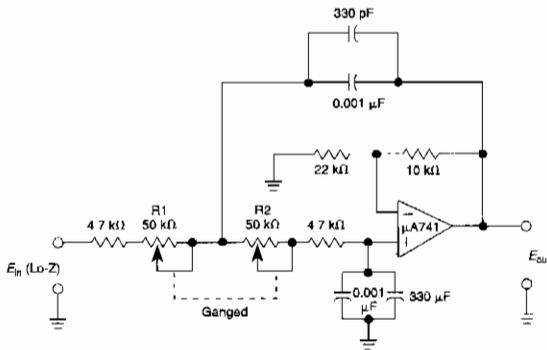


The filter can be wired into an existing amplifier by inserting the filter circuit between the amp's preamp and output stages as shown here.

FIG. 30-24

This variable-frequency, audio bandpass filter is built around two 741 op amps that are connected in cascade. Two 741 op amps are configured as identical RC active filters and are connected in cascade for better selectivity. The filter's tuning range is from 500-Hz to 1500 Hz. The overall voltage gain is slightly greater than 1 and the filter's is about 5. The circuit can handle input signals of 4 V peak-to-peak without being overdriven. The circuit's input impedance is over 200 k $\Omega$  and its output impedance is less than 1 k $\Omega$ .

## VARIABLE LOW-PASS FILTER

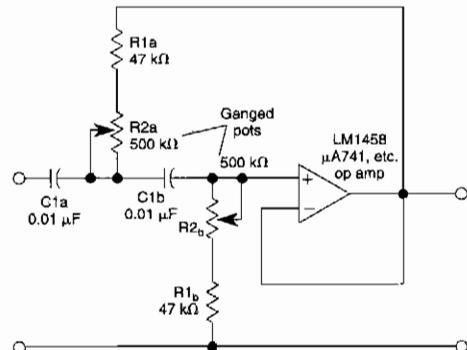


WILLIAM SHEETS

FIG. 30-25

This second-order low-pass filter uses a 741 op amp and is tuneable from 2.5 kHz to 25 kHz. This circuit is useful in audio and tone control applications. R1 and 2 are ganged potentiometers.

## VARIABLE HIGH-PASS FILTER



WILLIAM SHEETS

FIG. 30-26

This second order filter which should prove useful in audio applications uses an LM1458 or other similar of op amp. It is tuneable from 30 to 300 Hz cutoff. R2a, b are ganged log-taper potentiometers.

## 1-mV OFFSET, CLOCK-TUNABLE, MONOLITHIC 5-POLE LOW-PASS FILTER

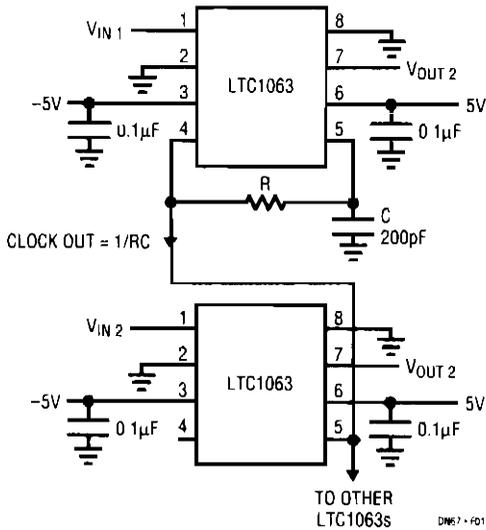


FIG. 30-27

LINEAR TECHNOLOGY CORP.

The LTC1063 is the first monolithic low-pass filter that simultaneously offers outstanding dc and ac performance. It features internal or external clock tunability, cutoff frequencies up to 50 kHz, 1-mV typical output dc offset, and a dynamic range in excess of 12 bits for over a decade of input voltage.

The LTC1063 approximates a 5-pole Butterworth low-pass filter. The unique internal architecture of the filter allows outstanding amplitude matching from device to device. Typical matching ranges from 0.01 dB-at 25% of the filter passband to 0.05 dB at 50% of the filter passband.

An internal or external clock programs the filter's cutoff frequency. The clock-to-cutoff frequency ratio is 100:1. In the absence of an external clock, the LTC1063's internal precision oscillator can be used. An external resistor and capacitor set the device's internal clock frequency.

### UNITY-GAIN SECOND-ORDER HIGH-PASS FILTER

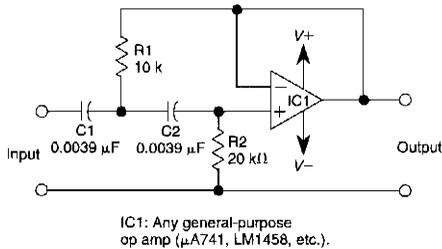


FIG. 30-28

WILLIAM SHEETS

This filter circuit has a cutoff frequency of 2900 Hz with the values shown.

$$f_{\text{cutoff}} = \frac{1}{2.83\pi RC}$$

$$\begin{aligned} R &= R_1 \\ R_2 &= 2R_1 \\ C &= C_1 = C_2 \end{aligned}$$

### ACTIVE UNITY-GAIN SECOND-ORDER LOW-PASS FILTER

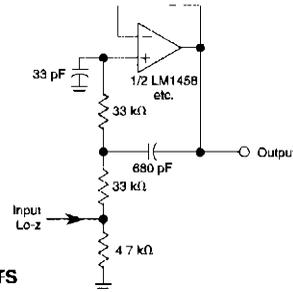


FIG. 30-29

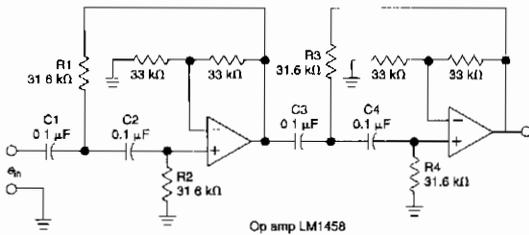
WILLIAM SHEETS

This second-order Butterworth filter cuts off near 10 kHz. The values of  $C_1$  and  $C_2$  can be changed to alter the frequency, or else calculated from the formula.

$$f_{\text{cutoff}} = \frac{1}{2.83\pi RC}$$

$$\begin{aligned} C_1 &= 2C_2 \\ R_2 &= R_3 = R \end{aligned}$$

## ACTIVE FOURTH-ORDER HIGH-PASS FILTER FOR 50 Hz

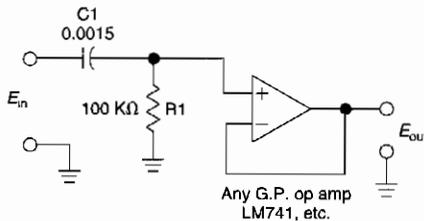


This circuit which uses an LM1458 or similar op amp is a fourth-order high-pass filter with a 24 dB/octave roll-off. The values of  $R_1/R_2$ ,  $R_3/R_4$ ,  $C_1/C_2$ ,  $C_3/C_4$  can be scaled to suit other cutoff frequencies.

WILLIAM SHEETS

FIG. 30-30

## SIMPLE HIGH-PASS (HP) ACTIVE FILTER FOR 1 kHz

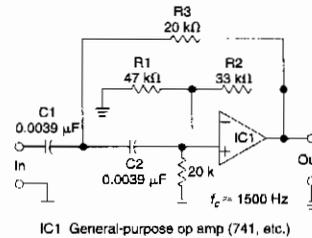


WILLIAM SHEETS

FIG. 30-31

This simple 1 kHz filter uses a voltage follower and an RC section for a filter element. For other frequencies  $f_3$  dB =  $1/6.28 R_1 C_1$ . The response drops 6 dB/octave below  $f_3$  dB.

## EQUAL COMPONENTS SECOND-ORDER HP FILTER



WILLIAM SHEETS

FIG. 30-32

This filter circuit uses equal value components and is shown for 1500 Hz. The values can be scaled for other frequencies.

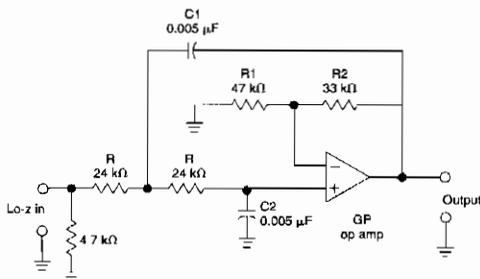
$$f_{\text{cutoff}} = \frac{1}{2.83\pi RC}$$

$$R = R_1$$

$$R_2 = 2R_1$$

$$C = C_1 = C_2$$

## SECOND-ORDER LOW-PASS FILTER FOR 10 kHz



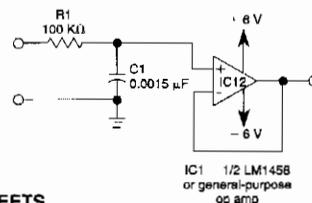
WILLIAM SHEETS

FIG. 30-33

This circuit uses equal value capacitors. The cutoff frequency ( $f_c$ ) is

$$f_c = \frac{1}{2.83\pi RC}$$

## SIMPLE LOW-PASS (LP) ACTIVE FILTER FOR 1 kHz

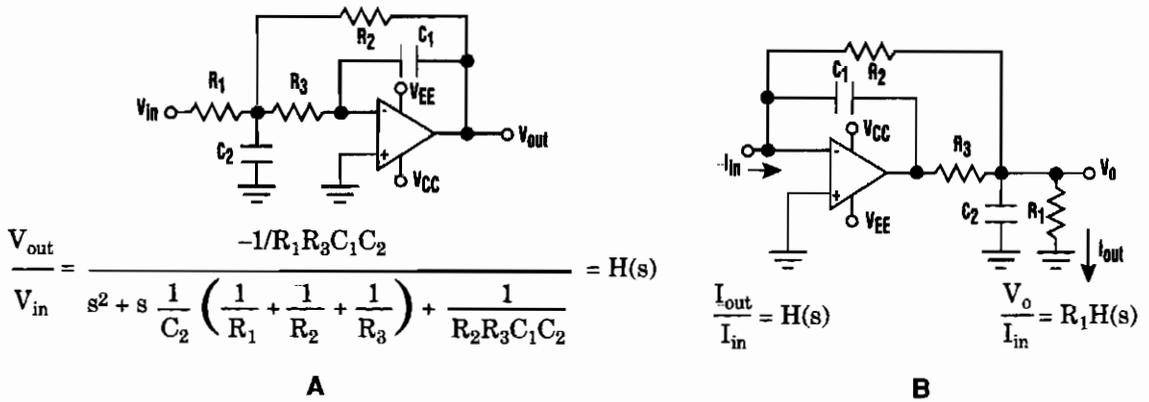


WILLIAM SHEETS

FIG. 30-34

This simple filter uses an RC section for a filter element, with a voltage follower for other frequencies  $f_3$  dB =  $1/6.28 R_1 C_1$ . Response drops 6 dB/octave above  $f_3$  dB.

## CURRENT-DRIVEN SALLEN KEY FILTER

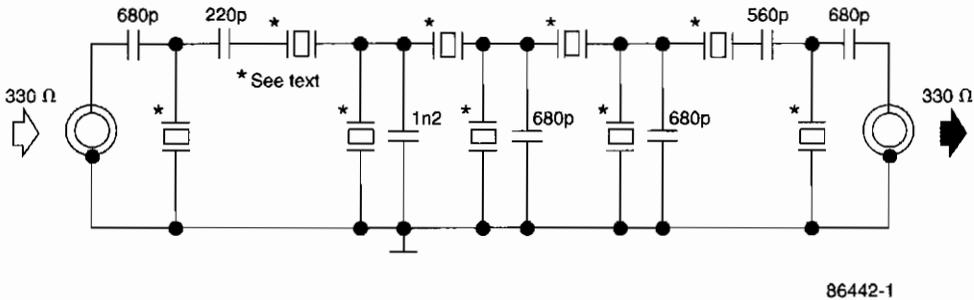


ELECTRONIC DESIGN

FIG. 30-35

The low-pass Sallen-Key filter is staple for designers because it contains few components (A). By redesigning the filter, a current to voltage conversion can be avoided when the input signal to be filtered is in current form (B).

## 455-KHz NARROW-BAND IF FILTER

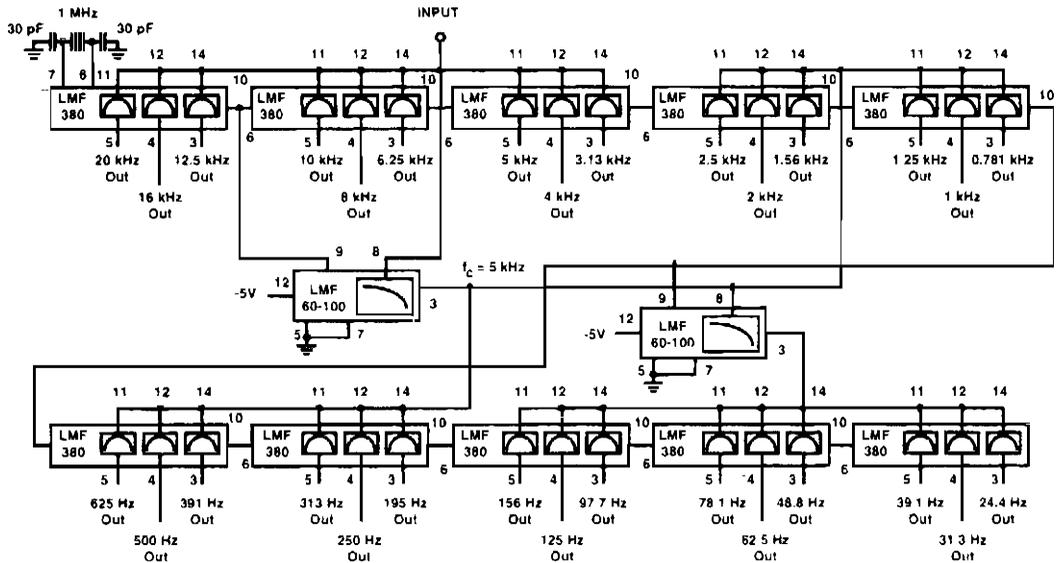


303 CIRCUITS

FIG. 30-36

This filter uses five 455-kHz ceramic resonators. The impedance is 330 Ω, the bandwidth is 800 Hz, and the ultimate rejection ≥60 dB. The ceramic resonators could be replaced by crystals.

## AUDIO-RANGE FILTER

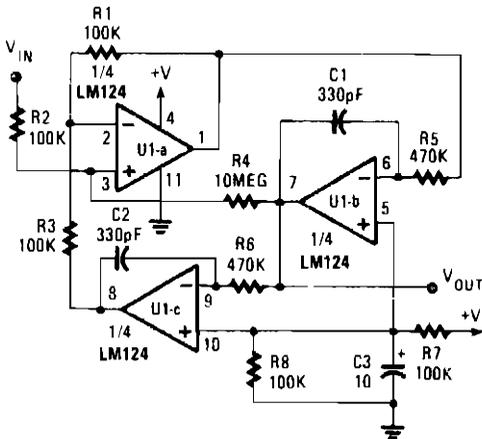


NATIONAL SEMICONDUCTOR

FIG. 30-37

The LMF380 switched audio filter by National Semiconductor is used here to obtain a third-octave filter set that covers the entire audio range.

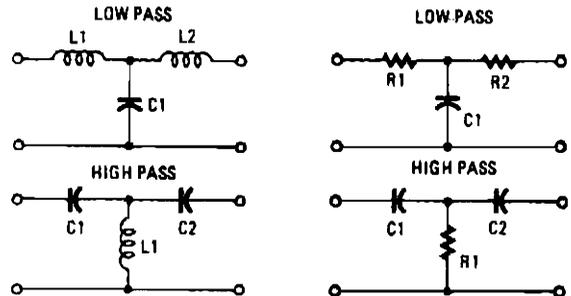
## BI-QUAD RC BANDPASS FILTER



POPULAR ELECTRONICS

FIG. 30-38

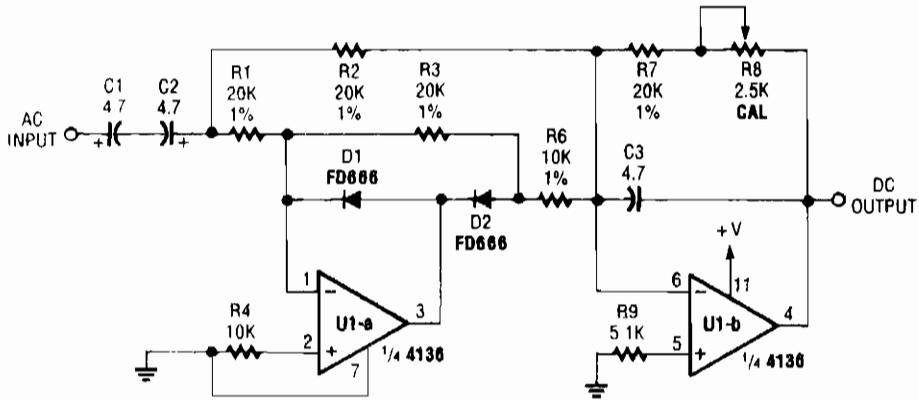
## PASSIVE T FILTER CONFIGURATIONS



POPULAR ELECTRONICS

FIG. 30-39

## FULL-WAVE RECTIFIER/AVERAGING FILTER

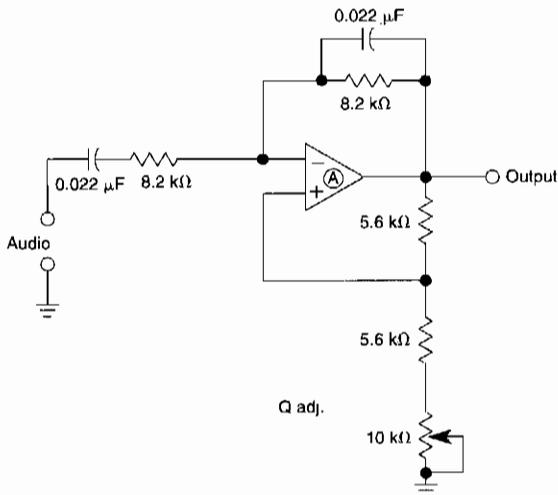


POPULAR ELECTRONICS

FIG. 30-40

The input signal is rectified by D1 and D2 on amp U1-a, and fed to output amp U2. R8 is set for correct circuit calibration.

## 1-kHz TONE FILTER



Ⓐ - Most any IC op amp LM1458, LM324, etc.

The Wien-bridge based filter has a variable bandwidth and a center frequency of 900 Hz. The circuit will oscillate if the 10-kΩ pot is set too low.

WILLIAM SHEETS

FIG. 30-41

# 31

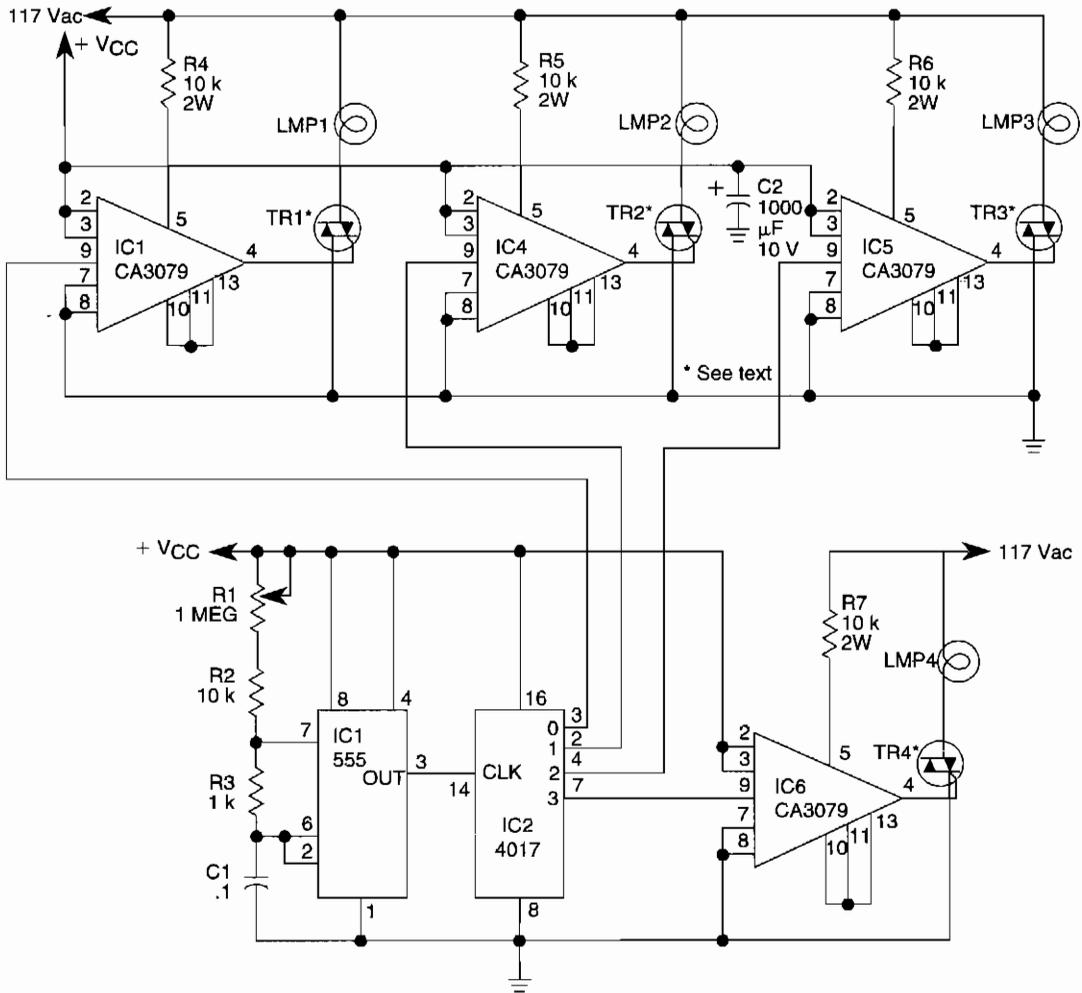
## Flasher Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Sequential Flasher
- 36 LED Flasher Driver
- LED Flashers
- Dark-Activated LED Flasher
- Super LED Flasher
- LED Flasher for 2 to 10 LEDs
- Flash Signal Alarm
- LED Christmas Tree Light Flasher

## SEQUENTIAL FLASHER



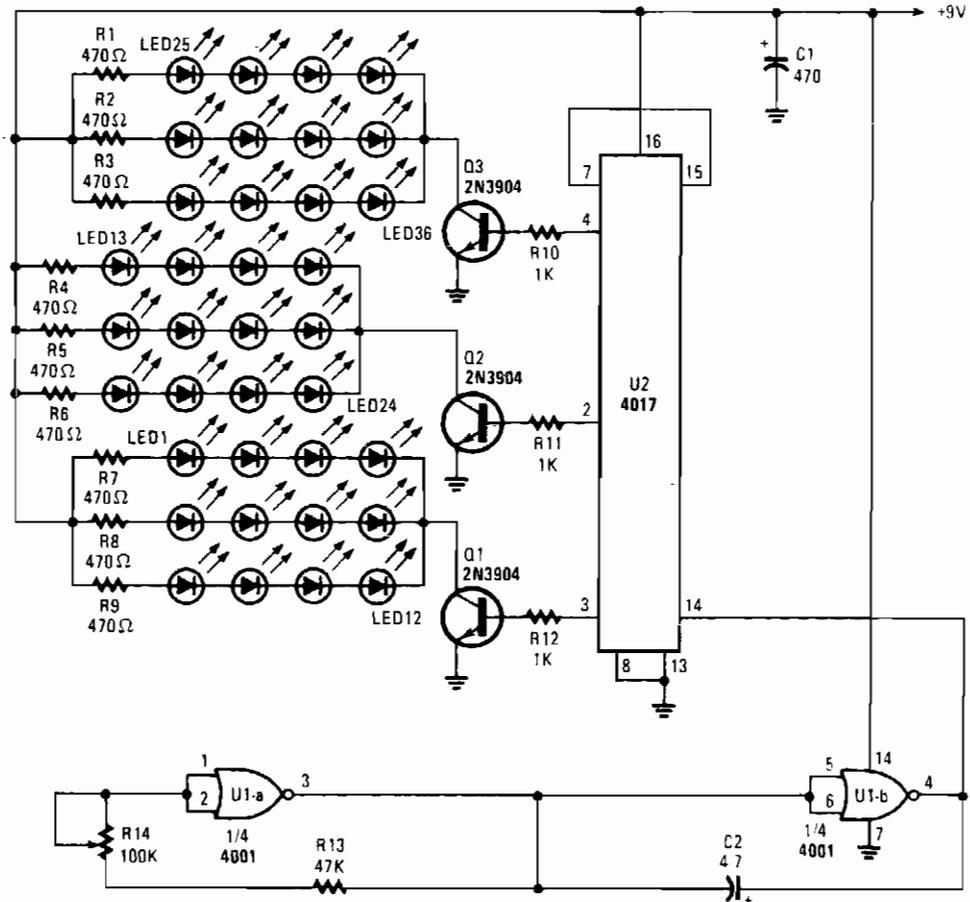
R-E EXPERIMENTERS HANDBOOK

FIG. 31-1

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 the 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  $\mu$ s.

Because of the action of the CA3079, the lamps connected to the triacs turn on and off near the zero crossing of the ac waveform. Switching at that point increases lamp life by reducing an 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 CA3079s are driven directly from the 117-Vac power line, so use care.

## 36 LED FLASHER DRIVER

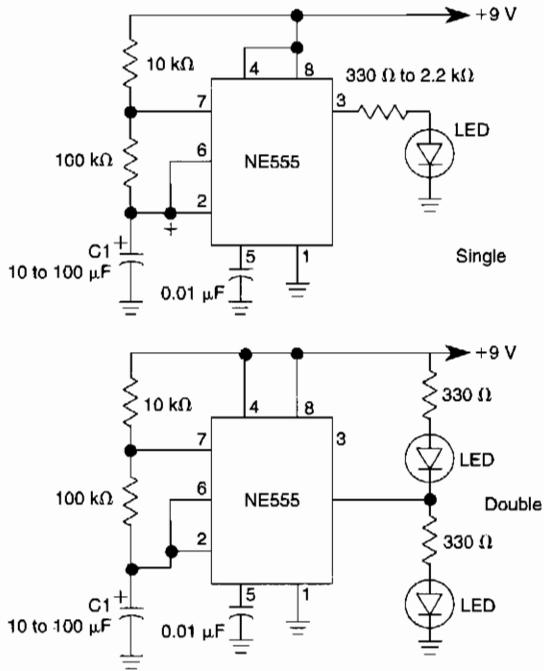


POPULAR ELECTRONICS

FIG. 31-2

Originally intended as a 3-bell animation circuit for Christmas decorations, the circuit can be used for many other purposes that require a flasher of this kind. By re-connecting U2 (see the data manual), more than three outputs can be obtained.

## LED FLASHERS

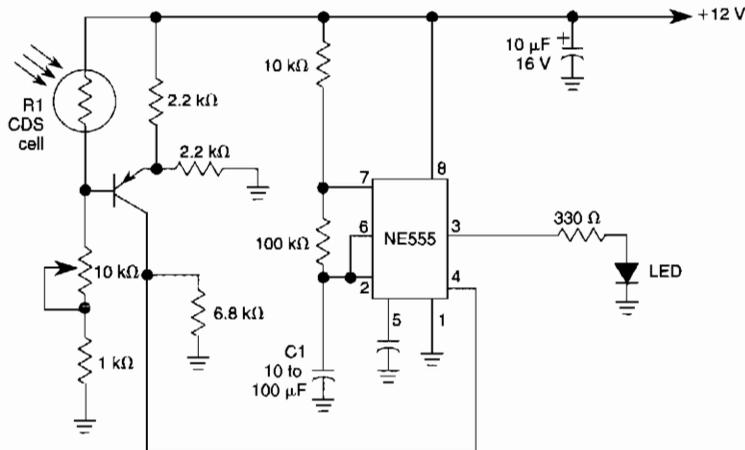


A 555 is used to switch an LED on and off. C1 determines the flash rate. Single ended (one LED) and double-ended (alternating) flashers are shown.

WILLIAM SHEETS

FIG. 31-3

## DARK-ACTIVATED LED FLASHER

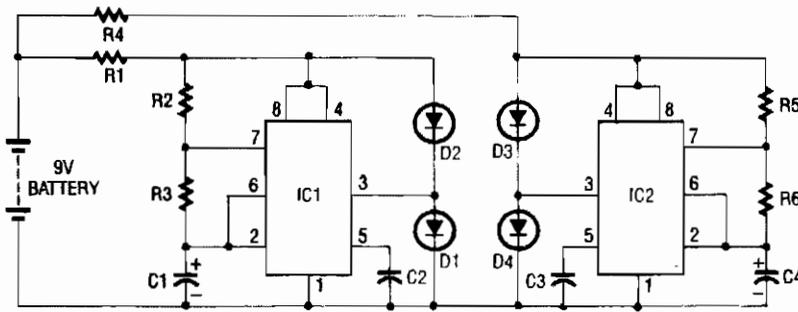


WILLIAM SHEETS

FIG. 31-4

This circuit can be used as a small beacon or marker light, and toys or novelty items. R1 is an LDR that has  $\geq 10$  k $\Omega$  dark-resistance, or a CDS photocell. C1 determines the flash rate.

## SUPER LED FLASHER



- C1, C4 .....4.7  $\mu$ F Electrolytic Capacitor
- C2, C3.....330 pF Disc Capacitor
- D1 ..... Yellow LED
- D2, D3 ..... Red LED
- D4 ..... Green LED
- IC1, IC2 ..... 555 Timer IC
- R1, R4 ..... 100 ohm Resistor
- R2, R5 ..... 82 k Resistor
- R3, R6 ..... 33 k Resistor

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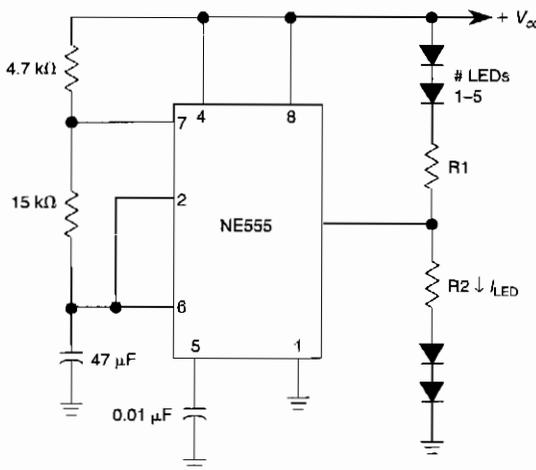
**FIG. 31-5**

The super LED flasher is actually two complete LED flasher circuits on one circuit board. The first LED flasher is made up of IC1 and LEDs D1 and D2. IC1 is a 555 timer IC configured as an astable (free-running) multivibrator with its output on pin 3.

The frequency of the 555's oscillation is controlled by R2, R3, and C1. Resistor R1 limits the input voltage to a low enough level to prevent damage to the IC. As the 555 IC oscillates, the output of pin 3 goes high (+) then low (-). When the output is high it supplies current to D1, which lights up. When it is low, pin 3 sinks current and D2 lights up. This happens because LEDs are polarity-sensitive (like all other diodes, they permit current flow in only one direction) and one lead of each LED has been connected to the respective polarity needed to light that LED.

The second LED flasher, made up of IC2 and LEDs D3 and D4, operates in the same way as the first LED flasher.

## LED FLASHER FOR 2 TO 10 LEDs



$$R_1, R_2 = \frac{V_{oc} - 2(\#LEDs)}{I_{LED}}$$

Typically  $V_{oc} = 12$  V  
 $\#LEDs = 2$   
 $I_{LED} = 30$  mA

(# LEDs 1 to 5 per side)

$$R_1, R_2 = \frac{12 - 2(2)}{0.03} = 267 \Omega$$

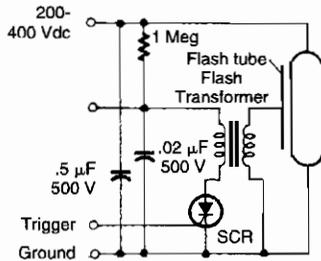
Use 270  $\Omega$

WILLIAM SHEETS

**FIG. 31-6**

This LED flasher has double-ended output connection. The circuit can be used with 1 to 5 LEDs on each side as indicated.

## FLASH SIGNAL ALARM



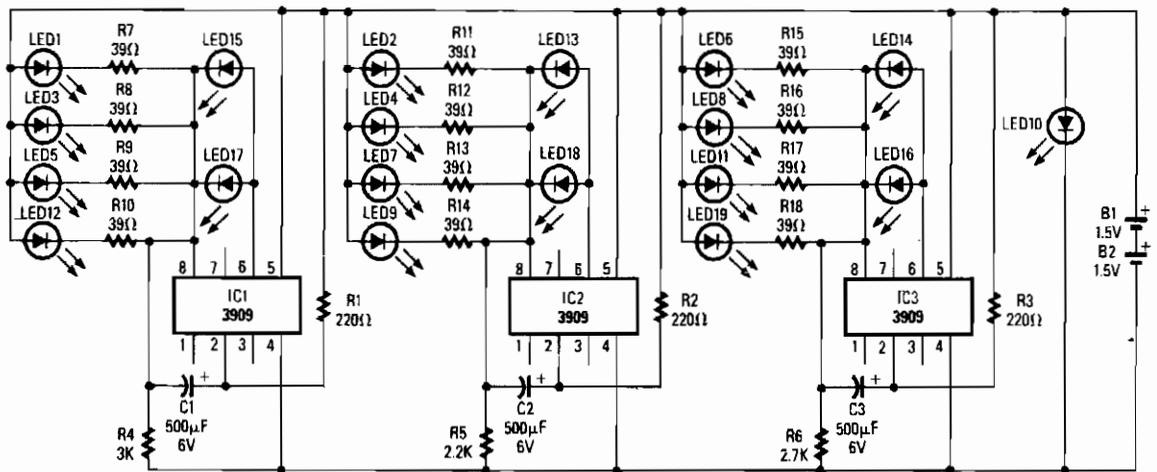
1. Choose an SCR with the proper power ratings
2. Be careful since high voltages are present at the flash tube

This circuit is useful if you need a low-energy flashing alarm. The 200 to 400-dc supply should have enough internal resistance to charge the 0.5  $\mu\text{F}$  capacitor between flashes, about 2 or 3 time constants, which means about 500  $\text{k}\Omega$  to 1  $\text{M}\Omega$  for a 1-s rate. Use lower values for higher rates.

RADIO-ELECTRONICS

FIG 31-7

## LED CHRISTMAS TREE LIGHT FLASHER



R-E EXPERIMENTERS HANDBOOK

FIG. 31-8

Three individual flashing circuits that use an LM3909 LED flasher/oscillator IC create the appearance of a pseudo-random firing order. The combination of  $C_1/R_4$ ,  $C_2/R_5$ , and  $C_3/R_6$  control the blink rate, which is between 0.3 and 0.8 s, and the inherent wide tolerance range ( $-20\%$  to  $+80\%$ ) of standard electrolytic capacitors add to the irregularities of the blink cycles. The continuous current drain is about 10 mA; however, if you decrease the values of  $R_4$  through  $R_6$  or  $C_1$  through  $C_3$  in order to increase the blink rate, the current will then increase proportionally.

Note in particular that external current-limiting resistors aren't needed for LED13 through LED18; the resistors are built into the ICs. LED10, which serves as the tree's "star," is a special kind of flashing LED that blinks continuously at a fixed rate.

# 32

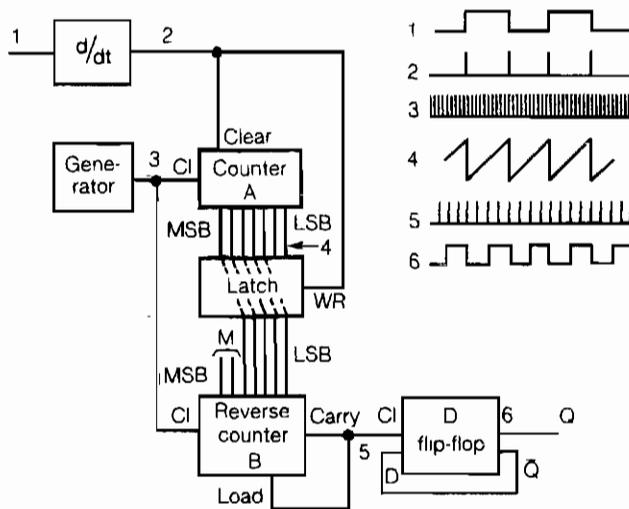
## Frequency Multiplier Circuit

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Frequency Multiplier Without PLL

## FREQUENCY MULTIPLIER WITHOUT PLL



ELECTRONIC ENGINEERING

FIG. 32-1

An input rectangular signal is differentiated and short impulses are formed from its edges. These impulses write the content of counter A to a latch that clears the counter after a very short time. Counter A counts impulses of the frequency  $f_o$  that are much greater than that of the input signal. The pulses come from an impulse generator. Thus, the number, which is written to the latch, expresses the number of these impulses between the edges of the input signal. The impulses from the same generator pass to (reverse) counter B. The carry impulse loads the content of the latch to counter B. The latch is connected with the reverse counter such that the number written to this counter is  $2M$  times smaller than the number introduced to the latch. This can be readily achieved by omitting  $M$  most significant bites of counter B. Because the number loaded to counter B is  $2M$  times smaller than the number in the latch, the carry impulses of counter B have frequency  $2M$  times greater than the frequency of the impulses at the output of the differentiator. The carry impulses are fed to a D flip-flop, which divides their frequency by two. In this way, the output frequency is  $2M$  greater than input frequency  $f_o$  as long as the frequency of impulse generator  $f_g$  is much greater than  $2Mf_o$ .

# 33

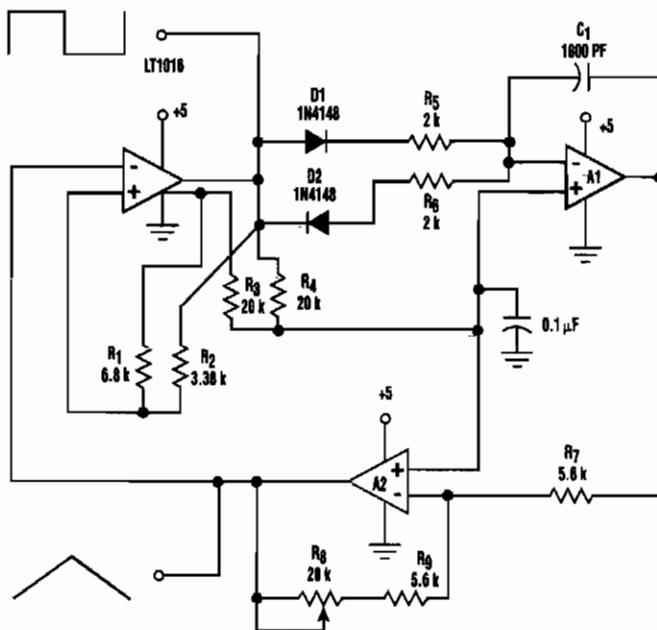
## Function and Signal Generator Circuits

---

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Function Generator
- 100-dB Dynamic-Range Log Generator
- Function Generator
- Fast Logarithm Generator
- Triangle-Wave Generator
- 555-Based Ramp Generator
- Triggered Sawtooth Generator
- Signal Generator
- Transistorized Schmitt Trigger
- Linear Sawtooth Generator
- Capacitance Multiplier
- Triangle-Wave Oscillator
- Clock-Driven Triangle-Wave Generator
- Triangle- and Square-Wave Generator
- Root Extractor

## FUNCTION GENERATOR

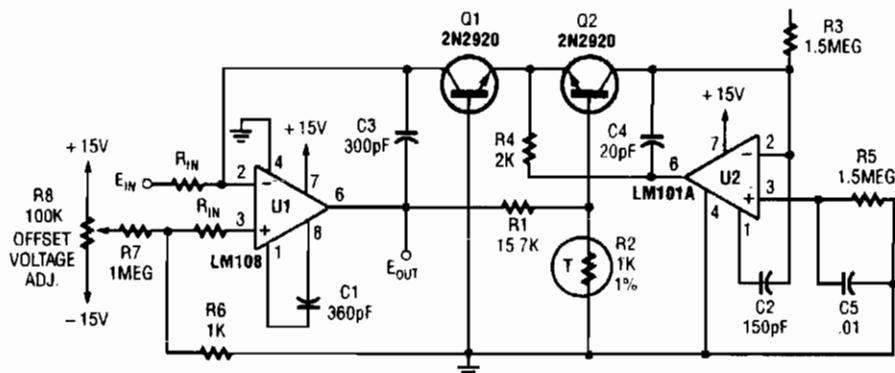


ELECTRONIC DESIGN

FIG. 33-1

This function generator, based on an LT1016 high-speed comparator, will generate from a single +5-V supply. The slow rate of the op amps used determines the maximum useable frequency of this circuit.

## 100-dB DYNAMIC-RANGE LOG GENERATOR

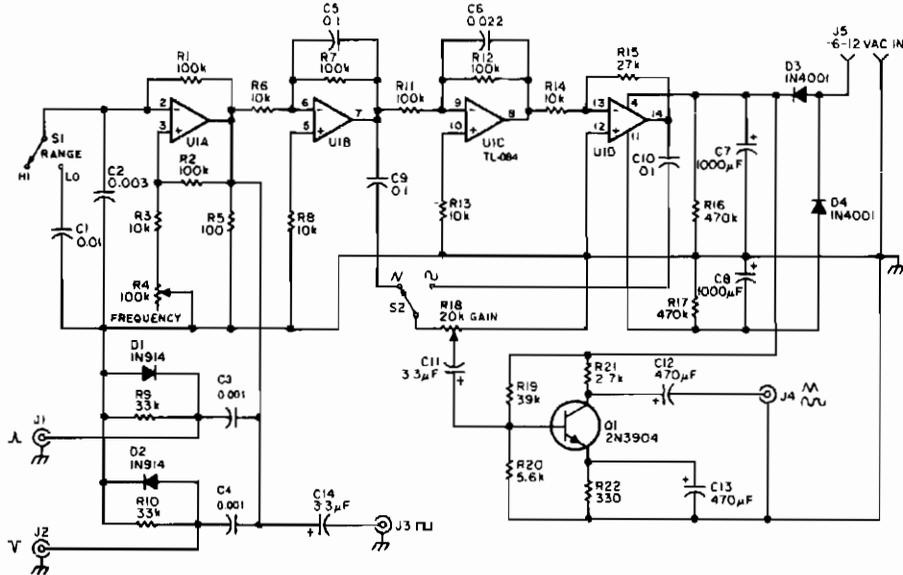


POPULAR ELECTRONICS

FIG. 33-2

$E_{OUT} = \text{constant} \times (\text{Log } E_{IN})$ . This circuit has 100-dB dynamic range, which is five decades of voltage change at the input.

## FUNCTION GENERATOR

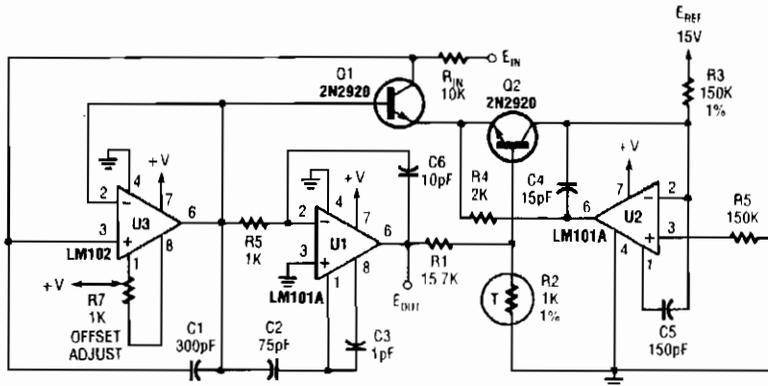


73 AMATEUR RADIO TODAY

FIG. 33-3

A quad op amp makes up the heart of this function generator. U1-a generates a square wave, and outputs this to J3. J1 and J2 are pulse outputs obtained by differentiating the square wave. Integrator U1-b generates a triangle-wave shaper to obtain a sine wave. Q1 is an output amplifier.

## FAST LOGARITHM GENERATOR

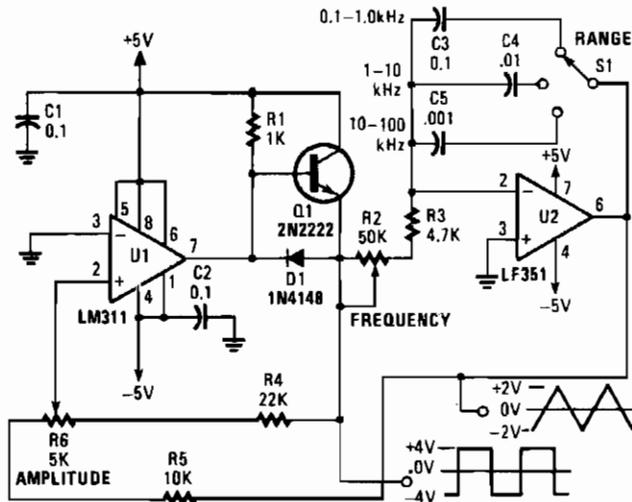


POPULAR ELECTRONICS

FIG. 33-4

In this circuit,  $E'_{\text{OUT}} = (\text{constant}) \times \log E_{\text{IN}}$ . The circuit should be useable with op amps other than the ones illustrated.

## TRIANGLE-WAVE GENERATOR

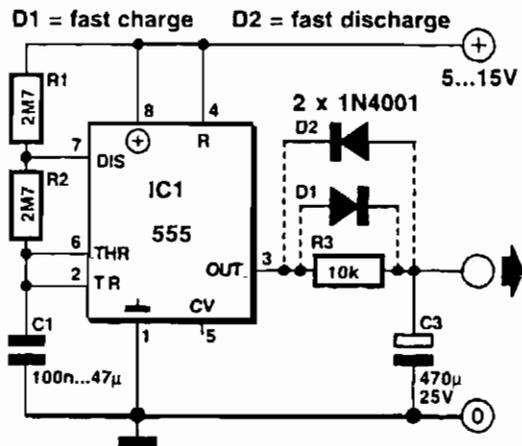


POPULAR ELECTRONICS

FIG. 33-5

This is a simple triangle-wave generator using two IC devices and a transistor. The triangle wave is used as feedback to the square-wave generator. S1 allows range switching in three ranges from 100 Hz to 100 kHz. Extra positions could be used to extend the range to lower frequencies, using larger values of capacitance.

## 555-BASED RAMP GENERATOR

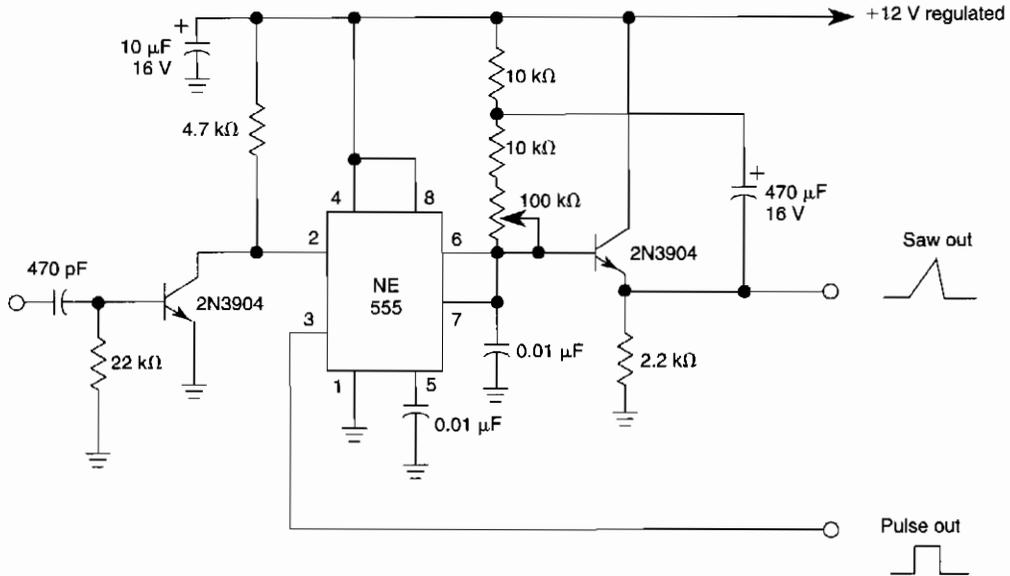


This circuit is used to generate a ramp voltage for tuning a radio receiver. An NE555, running at about 0.1 Hz, is used as an astable multivibrator.

ELEKTOR ELECTRONICS

FIG. 33-6

## TRIGGERED SAWTOOTH GENERATOR

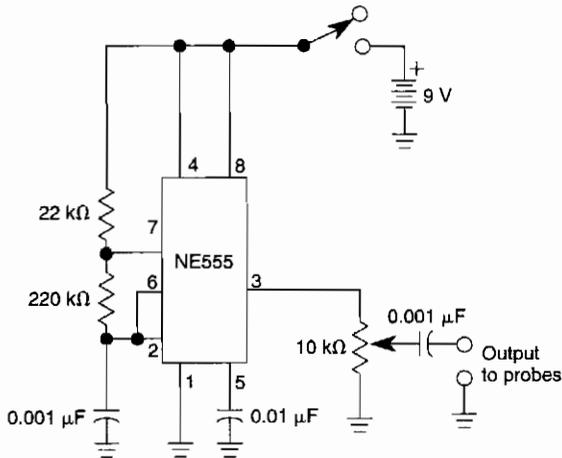


WILLIAM SHEETS

FIG. 33-7

Two 2N3904 transistors and a 555 form a triggered sawtooth generator. A sawtooth or other rising voltage input provides a pulse output when the trigger point is reached.

## SIGNAL GENERATOR

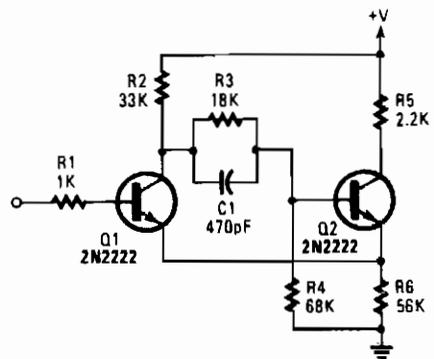


WILLIAM SHEETS

FIG. 33-8

This simple oscillator is rich in harmonics which make this circuit useful for signal tracing applications.

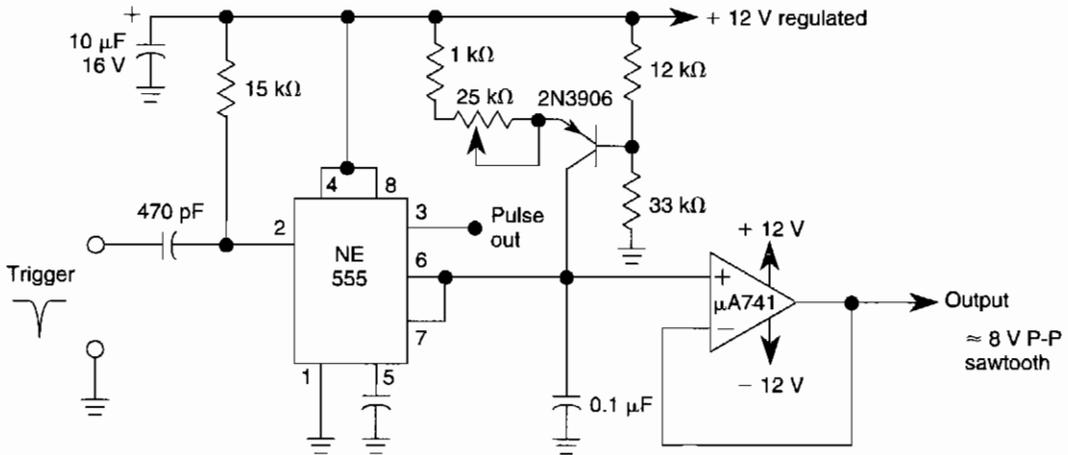
## TRANSISTORIZED SCHMITT TRIGGER



POPULAR ELECTRONICS

FIG. 33-9

## LINEAR SAWTOOTH GENERATOR

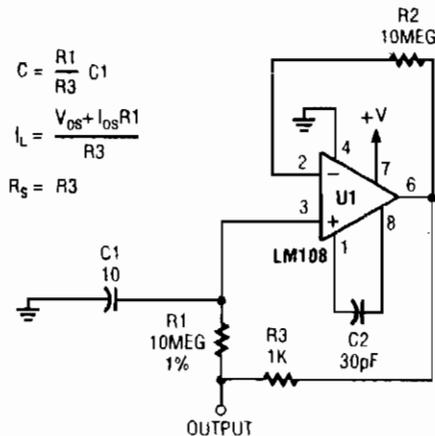


WILLIAM SHEETS

FIG. 33-10

The 2N3906 transistor is used as a constant-current source, to assure that the 555-based sawtooth generator generates a linear ramp waveform.

## CAPACITANCE MULTIPLIER

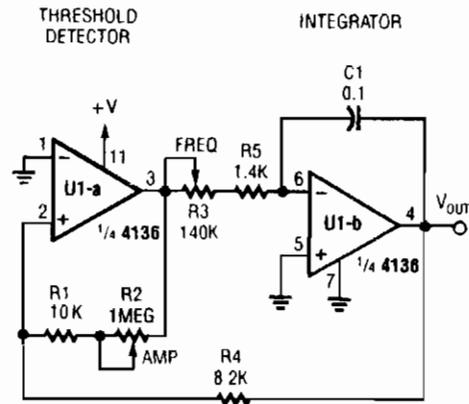


POPULAR ELECTRONICS

FIG. 33-11

Capacitance multiplier uses the gain of an op amp to produce an effective capacitance—in this case 100,000 µF.

## TRIANGLE-WAVE OSCILLATOR

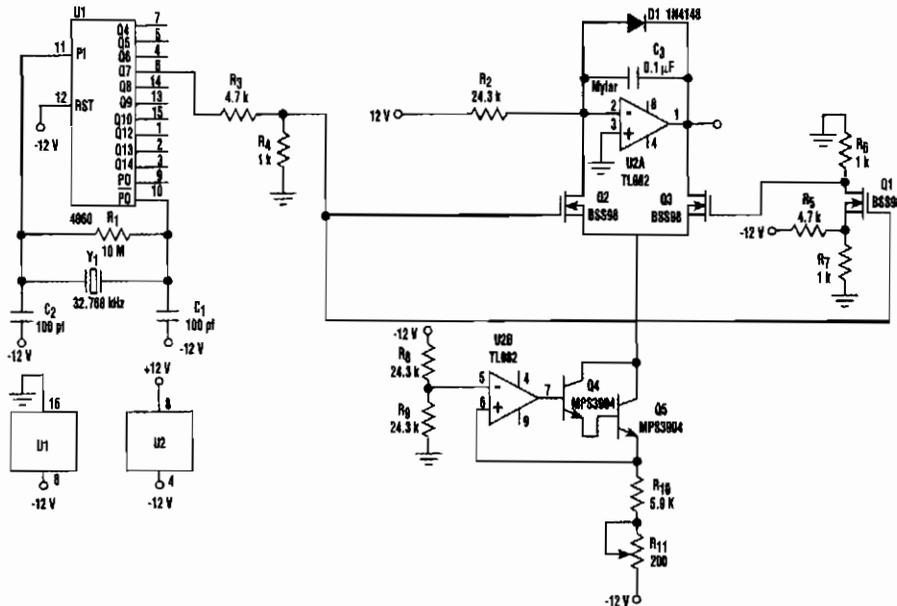


POPULAR ELECTRONICS

FIG. 33-12

U1-b acts as an integrator while U1-a is a threshold detector. R2 sets the trip level and therefore the amplitude. R3 controls charging current of C1 and the frequency.

## CLOCK-DRIVEN TRIANGLE-WAVE GENERATOR

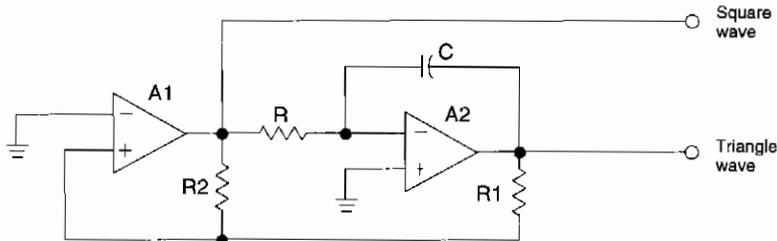


ELECTRONIC DESIGN

FIG. 33-13

U2-a, C3 and R2 operate as an integrator. Q2 and Q3 are alternately switched at 256 cycles. U2-b, Q4, Q5, and R8 through R11 are a constant current generator, and R11 is set for a symmetrical triangular waveform.

## TRIANGLE- AND SQUARE-WAVE GENERATOR



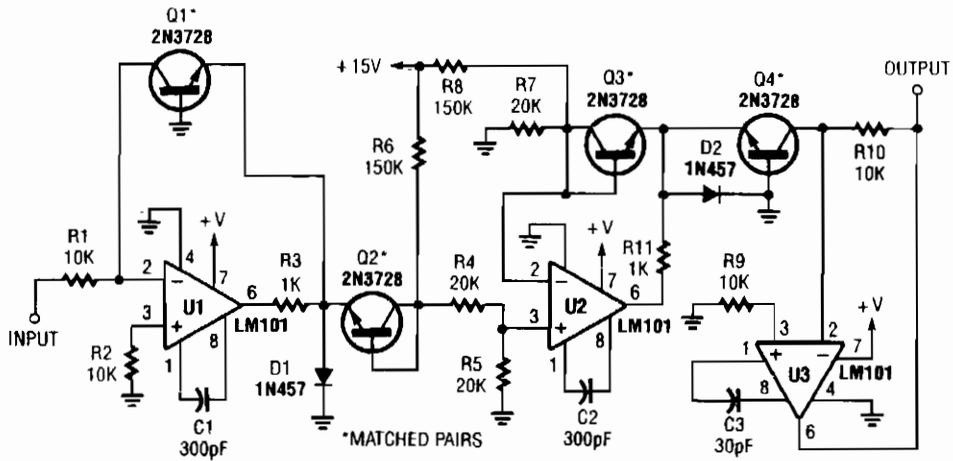
WILLIAM SHEETS

FIG. 33-14

The circuit will generate precision triangle and square waves. The output amplitude of the square wave is set by the output swing of op amp A1, and  $R_1/R_2$  sets the triangle amplitude. The frequency of oscillation in either case is approximately  $1/0.69RC$ .

The square wave will maintain 50% duty cycle—even if the amplitude of the oscillation is not symmetrical. The use of a fast op amp in this circuit will allow good square waves to be generated to quite high frequencies. Because the amplifier runs open-loop, compensation is not necessary. The triangle-generating amplifier should be a compensated type. A dual op amp, such as the MC1458, can be used for most applications.

## ROOT EXTRACTOR



POPULAR ELECTRONICS

FIG. 33-15

This circuit produces a voltage that is proportional to the root of the input. This gives a logarithmic response,  $\log V_{IN}^N = N \log V_{IN}$ .

# 34

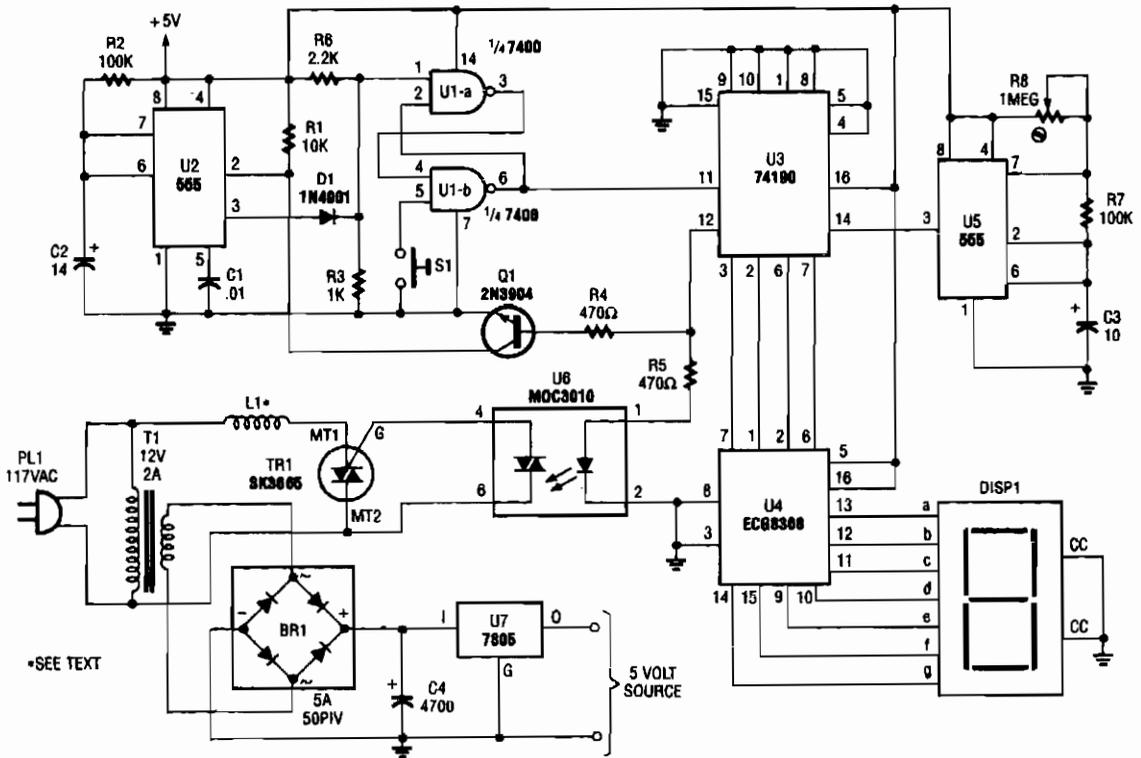
## Game Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Electromagnetic Ring Launcher  
Quiz Master  
Electronic Slot Machine

## ELECTROMAGNETIC RING LAUNCHER



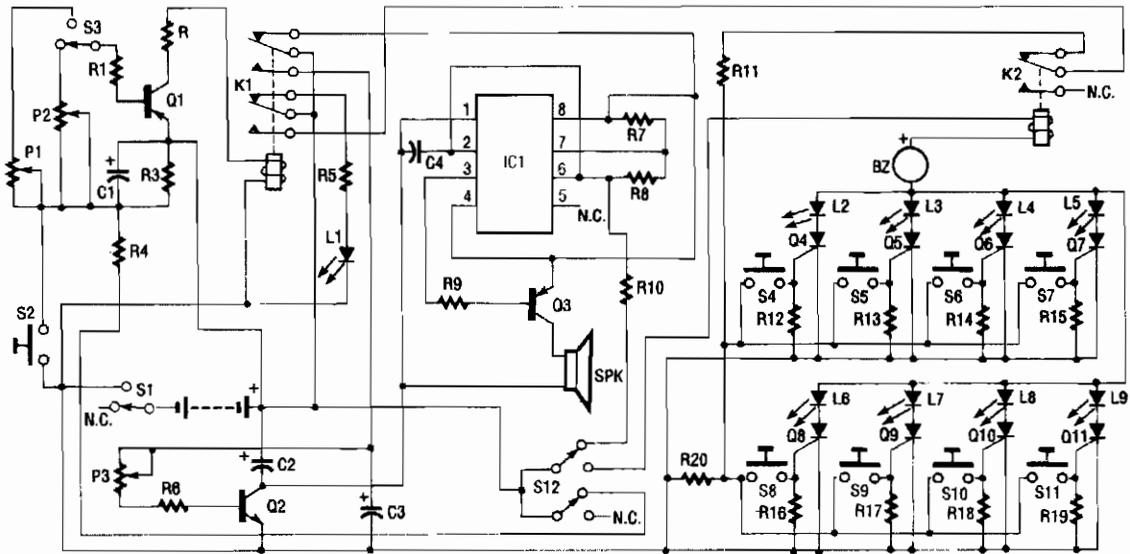
1993 ELECTRONICS HOBBYIST HANDBOOK

FIG. 34-1

The electromagnetic ring launcher is comprised of four subcircuits: a clock circuit (built around U5, a 555 oscillator/timer configured for astable operation), a count-down/display circuit (built around U3), a 74190 synchronous up/down counter with BCD outputs that is configured for count-down operation; U4, a ECG8368 BCD-to-7-segment latch/decoder/display driver; and DISP1, a common-cathode seven-segment display), a trigger circuit (comprised of U6), an MOC3010 optoisolator/coupler with Triac-driver output; TR1, an SK3665 200-PIV, 4-A Triac; and a few support components), and a reset circuit (comprised of U1, a 7400 quad 2-input NAND gate; U2, a second 555 oscillator/timer configured for monostable operation; and a few support components).

This circuit is that of a repulsion coil (L1) used to demonstrate the principle of electromagnetic repulsion by propelling a metal ring around the core of L1 through the air. A countdown circuit is provided to count seconds before launch.

## QUIZ MASTER



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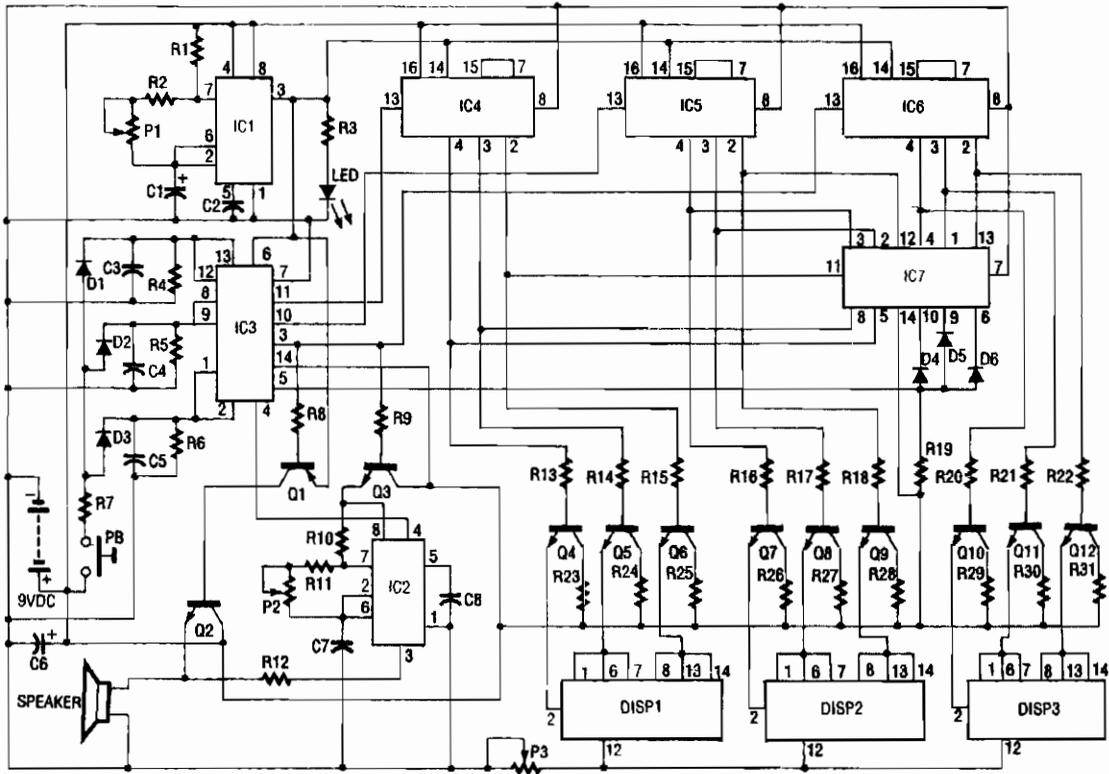
FIG. 34-2

Up to eight players each have their own answer button to press, corresponding to the four Red Team and four Green Team LEDs on the master control board. As soon as the first contestant who thinks that he knows the answer presses the button, a loud tone sounds, all other contestants are locked out, and the contestant's indicator LED lights on the control board so that it's obvious who locked in first.

The control board also features two selectable "time out" periods—each adjustable from 3 to 15 seconds, setting specified time intervals in which the player must answer before the "time's up!" tone sounds. Eight SCRs form the heart of the circuit. The anode of each SCR has a positive (+) bias on it by way of an LED and a negative (-) bias on each cathode. As soon as a contestant depresses his or her switch button (S4 through S11), a positive bias is applied to the respective SCR gate. That bias latches the contestant's SCR on, which in turn lights up the appropriate LED on the master control board. At the same time, the activity of the SCR latching on turns on the answer buzzer (BZ) and locks out all other contestants. The lockout occurs because relay K2 contacts operate to remove the availability of a bias voltage to the gate of the other SCRs.

The other circuitry consists of a timer circuit and a "time's-up" tone-generating circuit. The timer circuit consists of transistor Q1, capacitor C1, resistors R1 through R3, and trimmer resistors P1 and P2. Depending on the adjustment of the trimmer resistors and selection switch S3, a specific time period can be set. The time's-up tone-generating circuit is made up of IC1, transistors Q2 and Q3, and the associated resistors and capacitors. The "on" time of the tone can be set by P3. Relay K1, which is operated by the timer circuit, serves to reset the entire unit for the next question.

## ELECTRONIC SLOT MACHINE



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FIG. 34-3

The slot machine's realistic action is provided by seven ICs and three displays, as shown. Two 555 CMOS timer ICs generate pulses. IC1 is used to generate the clock pulses for the entire electronic slot machine. The pulses are coupled from the output (pin 3) to the clock inputs of IC4, IC5, and IC6, the display-driver ICs.

The displays are common-cathode 7-segment LED types. They are wired to display three different symbols, an "L," a "7," and "bar." When all three displays show the same symbols, IC7 (a 4023 triple 3-input NAND gate) decodes a winner and sends a signal to pin 5 of IC3. That IC is a 4001 CMOS NOR gate and it turns on IC2, a 555 timer IC. IC2 actually produces the winner tone on its output, pin 3.

Transistors Q4 through Q12 are used to drive the common-cathode displays. An LED is used to indicate the clock pulses, and a variable resistor is provided for each of these functions. Trimmer resistor P1 controls the overall clock rate, P2 controls the "winner" tone, and P3 controls the display brilliance.

# 35

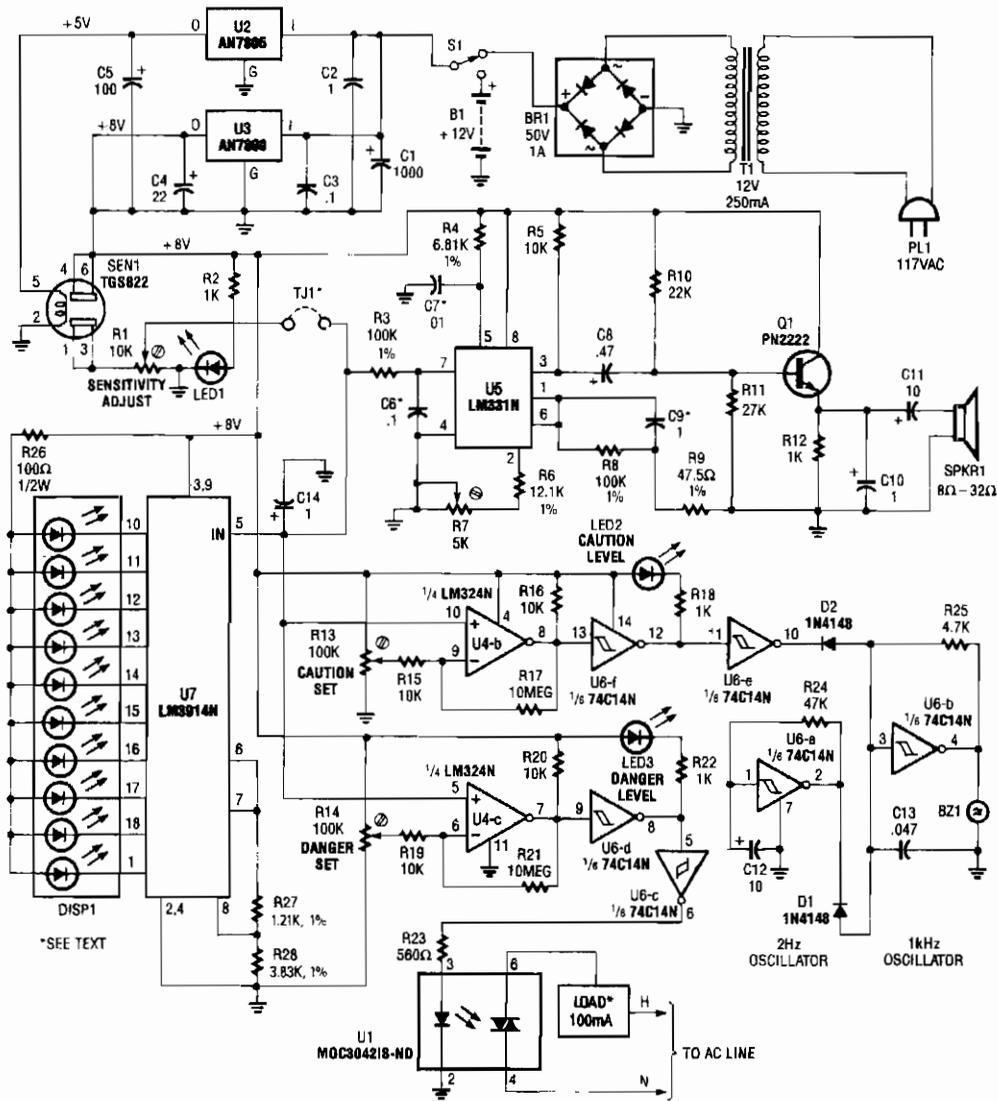
## Gas Detector Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

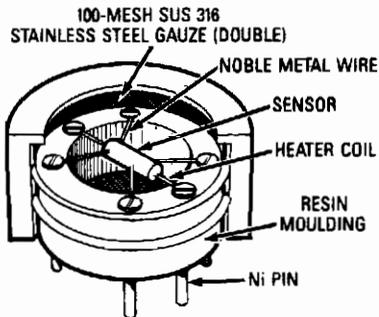
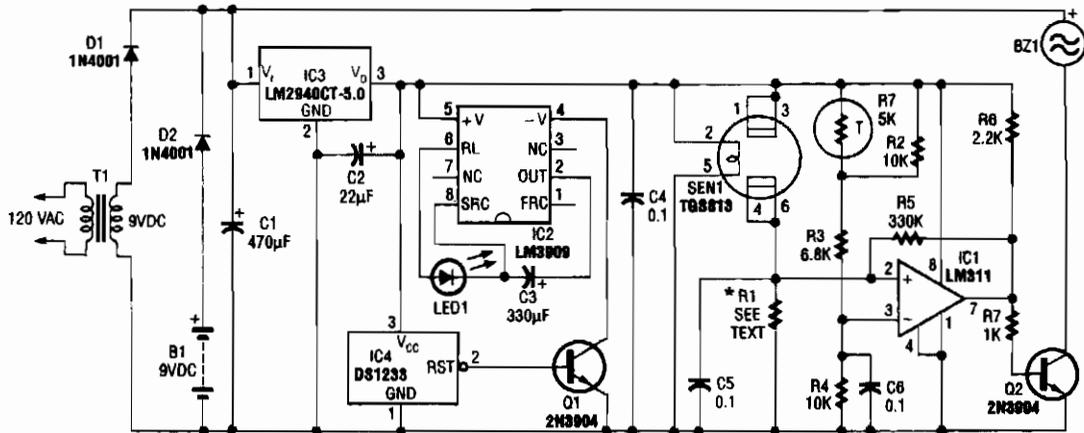
Explosive Gas Detector  
Combustible Gas Detector

## EXPLOSIVE GAS DETECTOR



A gas sensor (TGS823 from Allegro Electronics, Cornwall Bridge, CT 06754) conducts in the presence of explosive gases. U5 is a voltage-to-frequency converter that produces a frequency proportional to the sensor conductance. The output frequency ranges from 100 Hz in clean air to 8 kHz in a contaminated atmosphere. The dc voltage from the sensor also drives bar graph LED U7 and comparators U4-b and U4-c to sense present caution and danger levels. U1 drives an ac load up to 100 mA (relay, indicator, alarm, etc.).

## COMBUSTIBLE GAS DETECTOR



**THE GAS SENSOR** is mainly composed of tin dioxide on a ceramic base; the resistance of the sensor varies depending on the concentration of reducing gases in the air.

The circuit shown is useful for the detection of dangerous levels of combustible fumes or gases. It uses a comparator circuit to trigger an alarm buzzer. The sensor's resistant element is connected in series with resistor R1 to form a voltage-divider circuit; R1 is specifically matched to each gas sensor by the manufacturer.

# 36

## Gate Circuit

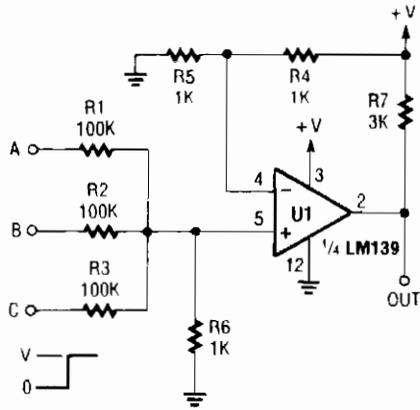
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

AND Gate

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## AND GATE



POPULAR ELECTRONICS

**FIG. 36-1**

A left-over section of a quad op amp can be used to save cost and eliminate an extra logic chip for this AND gate.

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# 37

## Geiger Counter Circuits

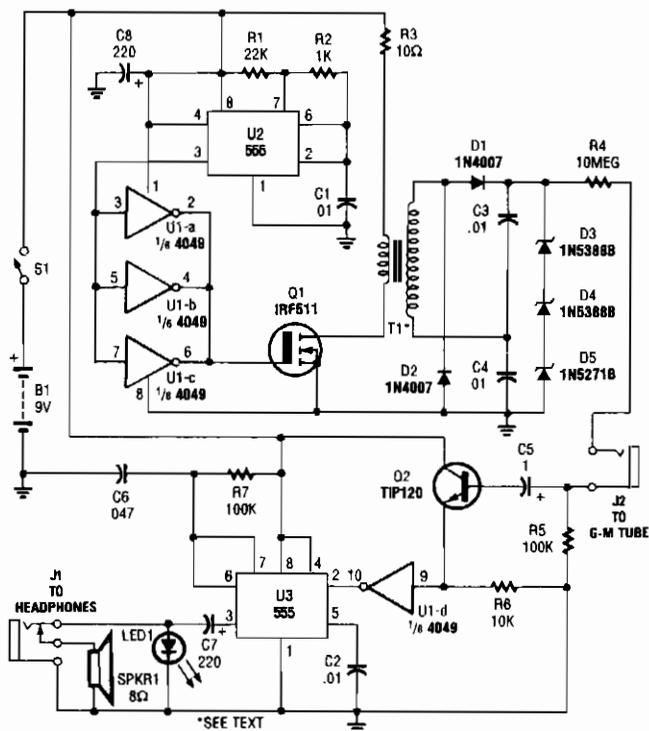
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Geiger Counter I  
Geiger Counter II

## GEIGER COUNTER I



POPULAR ELECTRONICS

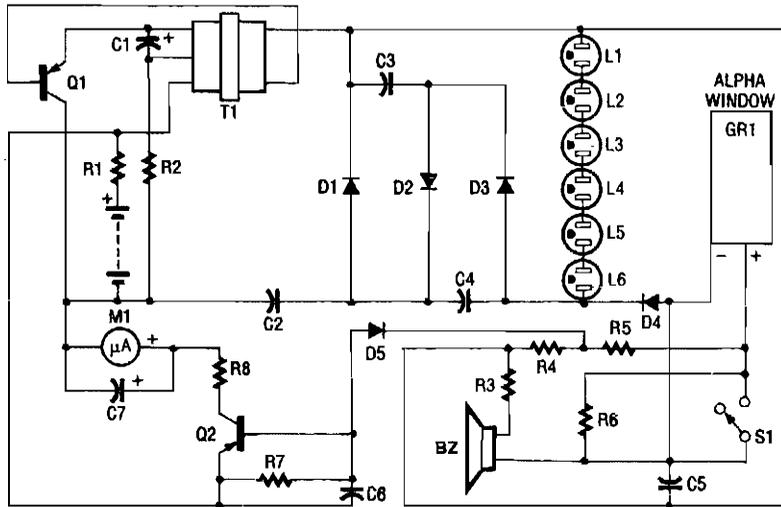
FIG. 37-1

The circuit is built around a 4049 hex inverter (U1), a pair of 555 oscillator/timers (U2 and U3), two transistors, a Geiger-Muller tube, and a few additional support components. The first 555 (U2) is configured for astable operation. The output of U2 (a series of negative-going pulses) at pin 3 is fed to three parallel-connected inverters (U1-a, U1-b, and U1-c). The positive-going output pulses of the inverters are fed to the gate of Q1, causing it to toggle on and off.

The output of Q1, which is connected in series with the primary of step-up transformer T1, produces a stepped-up series of pulses in T1's secondary. The output of T1 (approximately 300 V) is fed through a voltage doubler (consisting of D1, D2, C3, and C4), producing a voltage of around 600 V. Three series-connected Zener diodes (D3, D4, and D5) are placed across the output of the voltage doubler to regulate the output to 500 V, fed through R4 (a 10-M $\Omega$  current-limiting resistor) and J2 to the anode of the GM tube. The limiting resistor also allows the detection ionization to be quenched.

The cathode side of the tube is connected to ground through a 100-k $\Omega$  resistor, R5. When a particle is detected by the GM tube, the gases within the tube ionize, producing a pulse across R5. That pulse is also fed through C5 and applied to the base of Q2 (a TIP120 npn transistor), where it is amplified and clamped to 9 V. The output of Q2 is inverted by gate U1-d, then it is used to trigger U3 (the second 555, which is configured for monostable operation). The output of U3 at pin 3 causes LED1 to flash, and produces a click that can be heard through speaker SPKR1 or headphones. The circuit is powered by a 9-V alkaline battery and draws about 28 mA when not detecting radiation.

## GEIGER COUNTER II



- BZ .....Blue Piezo Buzzer  
 C1 ..... 4.6- $\mu$ F Electrolytic Ca-  
 pacitor  
 C2-C4 ...0.005- $\mu$ F 1-kV Disc Ca-  
 pacitor  
 C5 ..... 0.01- $\mu$ F 1-kV Disc Ca-  
 pacitor (103 M)  
 C6 ..... 1- $\mu$ F 100-V Mylar Ca-  
 pacitor (104 k)  
 C7 ..... 33- $\mu$ F Electrolytic Ca-  
 pacitor  
 D1-D5 ...1N4007 Diodes  
 GR1 ..... Alpha Window Geiger  
 Mueller Tube  
 L1-L6 .....Neon Lamps  
 M1 ..... 0-200 Microamp Meter  
 Q1 ..... 02-GE PNP Power Tran-  
 sistor  
 Q2 ..... 2N3906 Transistor  
 R1 ..... 47-ohm Resistor  
 R2, R3 ... 3.9-k Resistor  
 R4, R5 ... 4.7-Meg Resistor  
 R6 ..... 220-k Resistor  
 R7 ..... 27-k Resistor  
 R8 ..... 18-k $\Omega$  Resistor  
 S1 ..... SPDT Slide Switch  
 T1 ..... Inverter Transformer

Q1 is a pnp power transistor used in conjunction with a ferrite transformer to form a blocking-type oscillator. This oscillator is a fixed-frequency type, and the feedback to sustain oscillations is from capacitor C1. Because of the turns ratio of T1, the small ac voltage produced on its primary is converted to a large ac voltage on its secondary. That high-voltage ac is applied to the voltage tripler stage, which consists of capacitors C2, C3, and C4 and diodes D1, D2, and D3. The resultant voltage is now over 800 V and it is regulated by neon lamps L1 through L6. Diode D4 rectifies the high voltage and applies it to the cathode lead of the GM tube. The positive (+) bias on the GM tube is applied to the anode by way of load resistors R4 and R5. Each time a radioactive particle strikes the GM tube, it causes the gas inside to ionize. This ionization of the gas creates a pulse, which drives the piezo speaker and is also coupled by diode D5 to the base of Q2. Transistor Q2 is a pnp type and is used to "integrate" the pulses in conjunction with capacitor C6. That produces a dc voltage level, which is in proportion to the quantity of pulses arriving at the base of Q2. The collector of Q2 is connected through resistor R8 to the (+) terminal of the meter. The other side of the meter goes directly to (-) of the battery.

# 38

## Hall Effect Circuits

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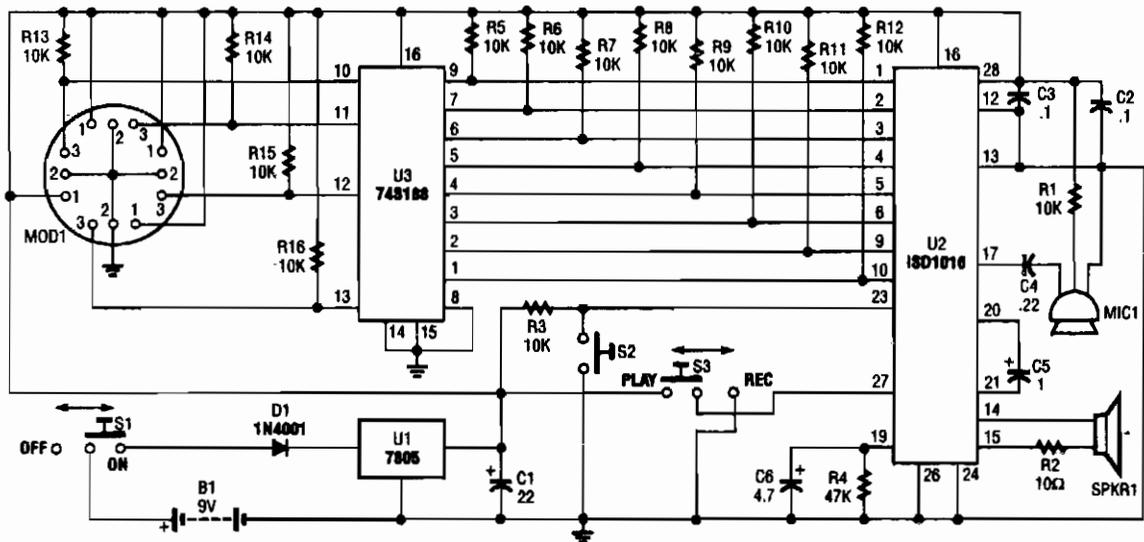
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

The Talking Compass  
Unusual Hall-Effect Oscillators

# THE TALKING COMPASS

TABLE 1—74S188 TRUTH TABLE

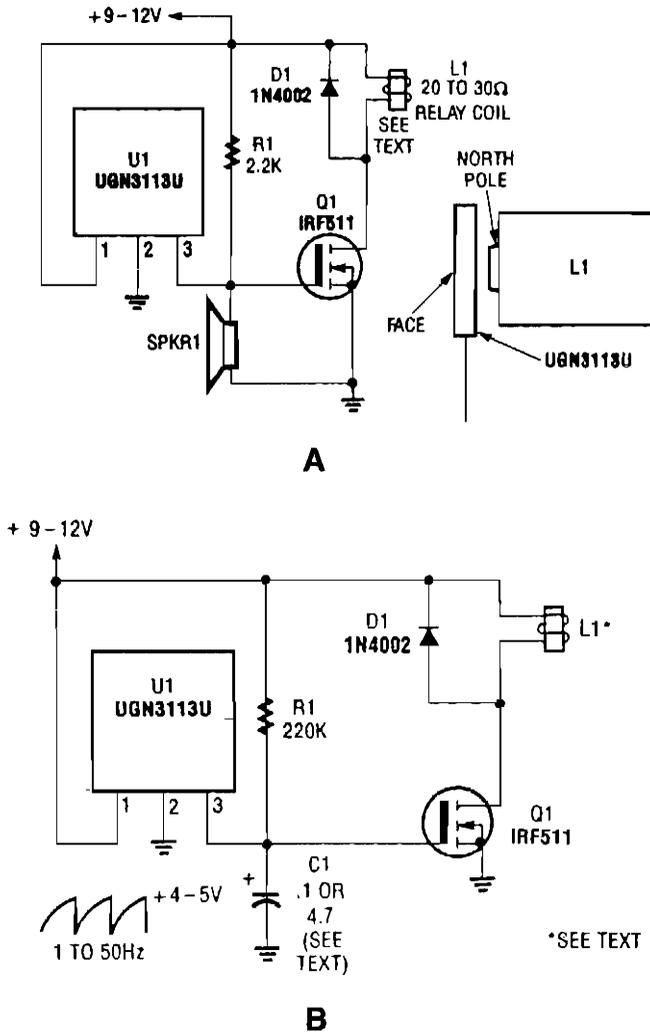
Directory	Input					Output								Decimal Equivalent
	A4	A3	A2	A1	A0	B0	B1	B2	B3	B4	B5	B6	B7	
North	L	H	L	H	H	0	0	0	0	0	0	0	1	1
N.W.	L	L	L	H	H	0	0	0	1	0	1	0	0	20
West	L	L	H	H	H	0	0	1	0	1	0	0	0	40
S.W.	L	L	H	H	L	0	0	1	1	1	1	0	0	60
South	L	H	H	H	L	0	1	0	1	0	0	0	0	80
S.E.	L	H	H	L	L	0	1	1	0	0	1	0	0	100
East	L	H	H	L	H	0	1	1	1	1	0	0	0	120
N.E.	L	H	L	L	H	1	0	0	0	1	1	0	0	140



A talking compass is made up using a Hall-effect direction sensor (MOD1) and an ISD1016 analog audio storage device. It is possible to program eight two-second announcements, for each of the eight main compass directions.

The Talking Compass is comprised of a digital compass (MOD1), and ISD1016 analog storage device (U2), a 74S188 preprogrammed PROM (U3), and a handful of additional components.

## UNUSUAL HALL-EFFECT OSCILLATORS



Although not intended for this application, Hall-effect switch can be used as the basis for a rather unusual oscillator. The oscillator can be reconfigured, as shown in Fig. B, to allow the circuit's oscillating frequency to be controlled via an RC network, comprised of R1 and C1.

# 39

## Infrared Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Remote-Control Analyzer

IR-Pulse-to-Audio Converter

IR-Controlled Remote A/B Switch

Simple IR Detector

Infrared Receiver

Selective Preamplifier for Infrared Photodiode

Wireless IR Headphone Transmitter

Wireless IR Headphone Receiver

Infrared Remote-Control Tester

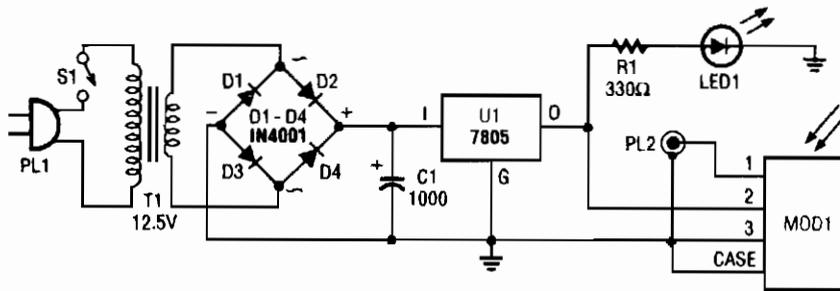
Pulsed Infrared Transmitter for On/Off Control

Very Simple IR Remote-Control Circuit

IR Receiver

Remote-Control Tester

## REMOTE-CONTROL ANALYZER



POPULAR ELECTRONICS

FIG. 39-1

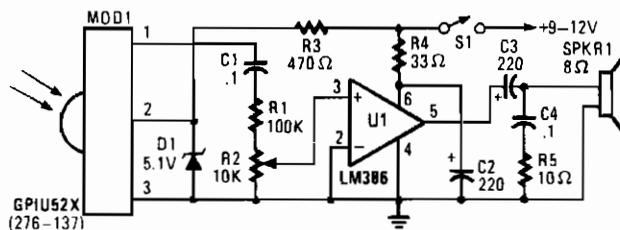
A schematic diagram for the remote analyzer is shown. The circuit is powered from a simple 5-V supply, consisting of PL1, S1, T1, a bridge rectifier (comprised of D1 through D4), capacitor C1, and a common 5-V regulator, U1. Switch S1 is the on/off control and is optional. The power-supply transformer used in the prototype is a 12.6-Vac unit, but any transformer that can supply at least 5.6-Vac will do. The 12.6-V unit was used solely because of its availability.

The output of T1 is full-wave rectified by diodes D1 through D4 and filtered by C1. The bumpy dc output from the capacitor is regulated down to 5 V by U1, a 7805 integrated regulator. LED1 acts as a power indicator to let you know that the circuit is active.

The 5-Vdc powers a GPIU52X infrared-detector module\* (MOD1), which demodulates the 40-kHz carrier used by most infrared remotes. After demodulation, the resulting logic pulses are sent to an oscilloscope via PL2, a BNC connector.

\*Radio Shack part #276-137

## IR-PULSE-TO-AUDIO CONVERTER

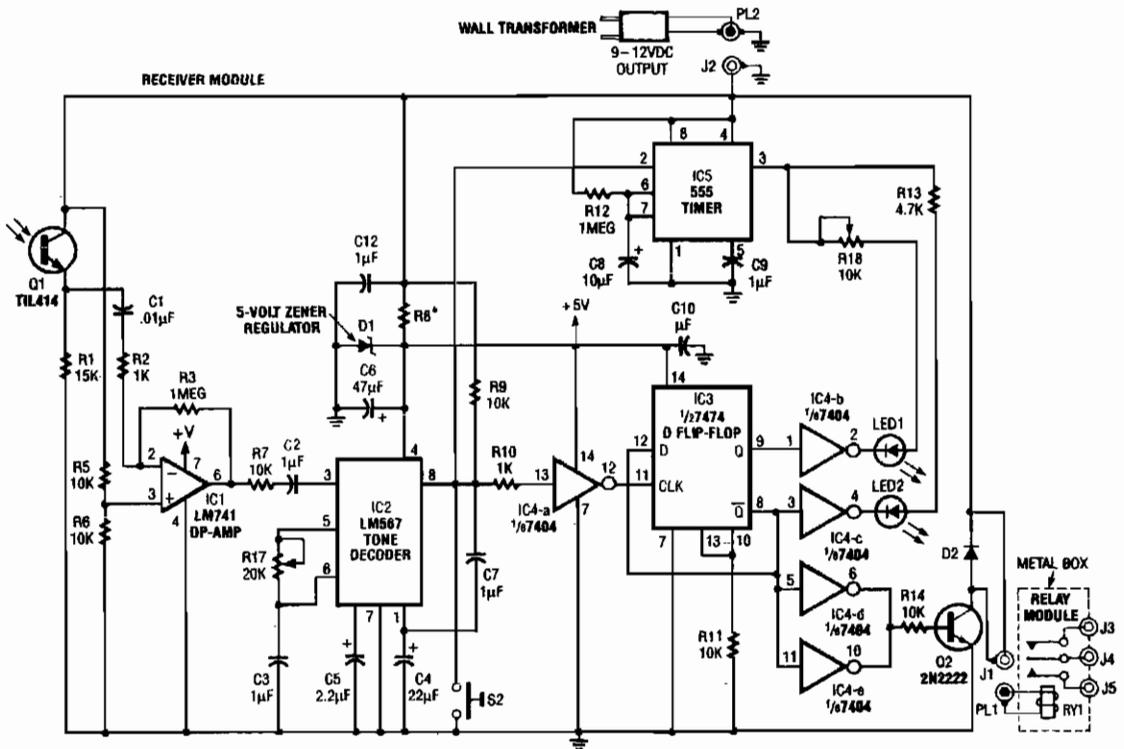


POPULAR ELECTRONICS

FIG. 39-2

If your ear is good, you can use this IR-pulse-to-audio converter to troubleshoot infrared remote-controls. It is also a good project for detecting infrared-light sources. A photo cell module (Radio Shack P/N 276-137) detects IR radiation and drives audio IC U1. This circuit is useful for troubleshooting IR remote controls.

## IR-CONTROLLED REMOTE A/B SWITCH

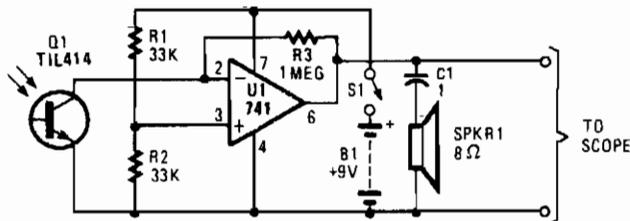


RADIO ELECTRONICS

FIG. 39-3

Useful for A/B control, the IR receiver shown controls a relay from an infrared beam that has a pulsed tone-modulated signal. Q1 is the photo receptor feeding op amp IC1, tone decoder IC2, and flip-flop IC3. IC5 turns off the indicator LEDs after about 15 seconds.

## SIMPLE IR DETECTOR

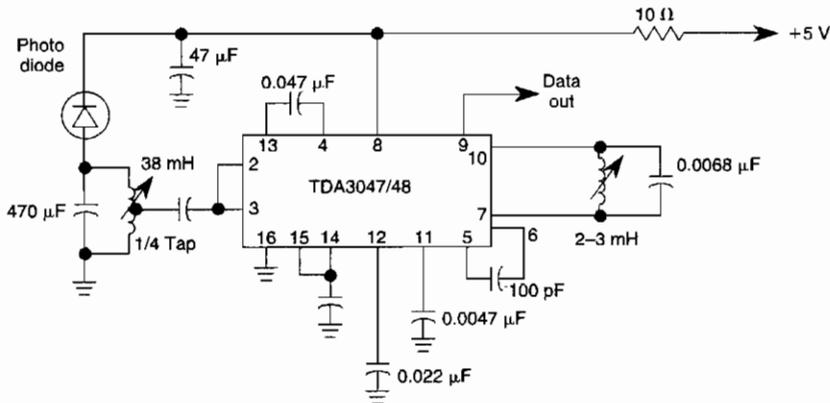


POPULAR ELECTRONICS

FIG. 39-4

Useful for IR detection, this circuit uses an op amp of the 741 family (or similar) to detect and amplify IR pulses.

## INFRARED RECEIVER

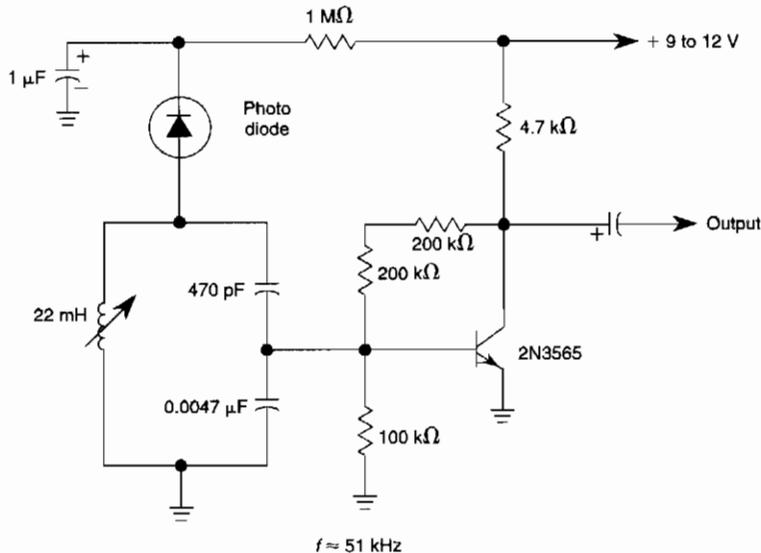


WILLIAM SHEETS

**FIG. 39-5**

The circuit operates from a 5-V supply and has a current consumption of 2 mA. The output is a current source that drives or suppresses a current of more than 75  $\mu\text{A}$  with a voltage swing of 4.5 V. The Q-killer circuit eliminates distortion of the output pulses because of the decay of the tuned input circuit at high input voltages. The input circuit is protected against signals of more than 600 mV by an input limiter. The typical input is an AM signal at a frequency of 36 kHz.

## SELECTIVE PREAMPLIFIER FOR INFRARED PHOTODIODE

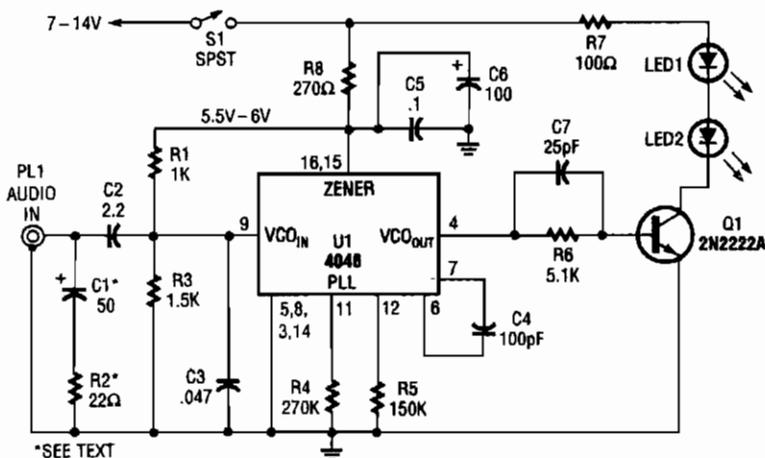


WILLIAM SHEETS

**FIG. 39-6**

The circuit uses a tuned circuit to achieve frequency selection. Values are for operation at about 51 kHz. The 2N3565 amplifies the output developed by the tuned circuit.

## WIRELESS IR HEADPHONE TRANSMITTER

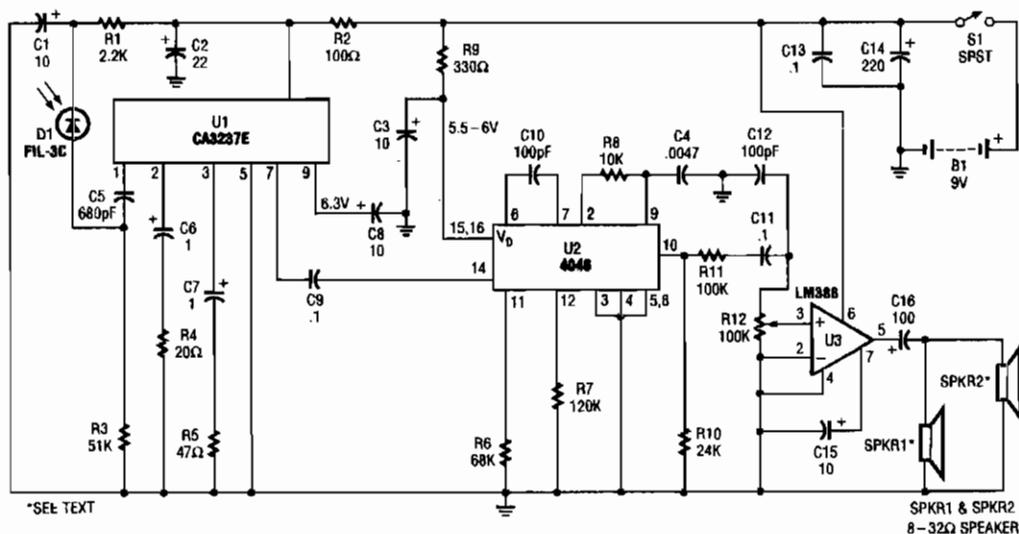


POPULAR ELECTRONICS

FIG. 39-7

The transmitter for the wireless headphones is built around a CD4046 CMOS phase-locked loop, coupled with a driver transistor, and a pair of infrared LEDs. Although the CD4046 is comprised of two phase comparators, a voltage-controlled oscillator (or VCO), a source follower, and a zener reference, only its VCO is used in this application.

## WIRELESS IR HEADPHONE RECEIVER

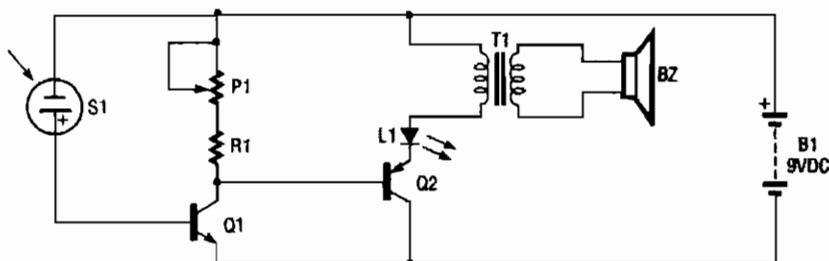


POPULAR ELECTRONICS

FIG. 39-8

IR detector diode D1 intercepts the IR signal at around 40 kHz and feeds it from U1, a high-gain preamp, to PLL, U2, a 4046 configured to serve as an FM detector. U3 is an audio amplifier that feeds a pair of headphones or a speaker.

## INFRARED REMOTE-CONTROL TESTER



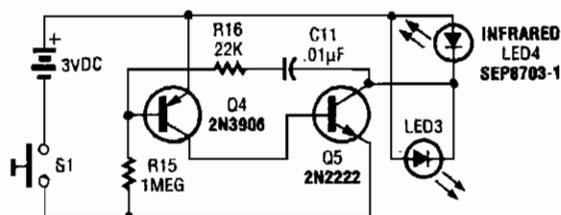
1991 PE HOBBYIST HANDBOOK

FIG. 39-9

The infrared remote-control tester uses a sensitive PN-type solar sensor that is connected directly to a Darlington amplifier made up of transistors Q1 and Q2. Biasing is provided by R1 and P1, a variable resistor that serves as a sensitivity control. The collector lead of Q1 is the output lead of the Darlington amp, and it is connected to a red LED and the primary of transformer T1. The function of T1 is to convert the low-voltage output signal to a level high enough to drive a small piezo disc. That disc makes a clicking sound when the sensor picks up an infrared signal that is varying in frequency or amplitude. The infrared sensor will also pick up visible light. The use of an IR filter (Wrattton #87) is recommended.

BZ	Piezo Disc
L1	Jumbo Red LED
P1	2-M $\Omega$ Trimmer Resistor
Q1	2N3904 Transistor
Q2	2N3906 Transistor
R1	270- $\Omega$ Resistor
S1	Solar Sensor
T1	Audio Transformer

## PULSED INFRARED TRANSMITTER FOR ON/OFF CONTROL

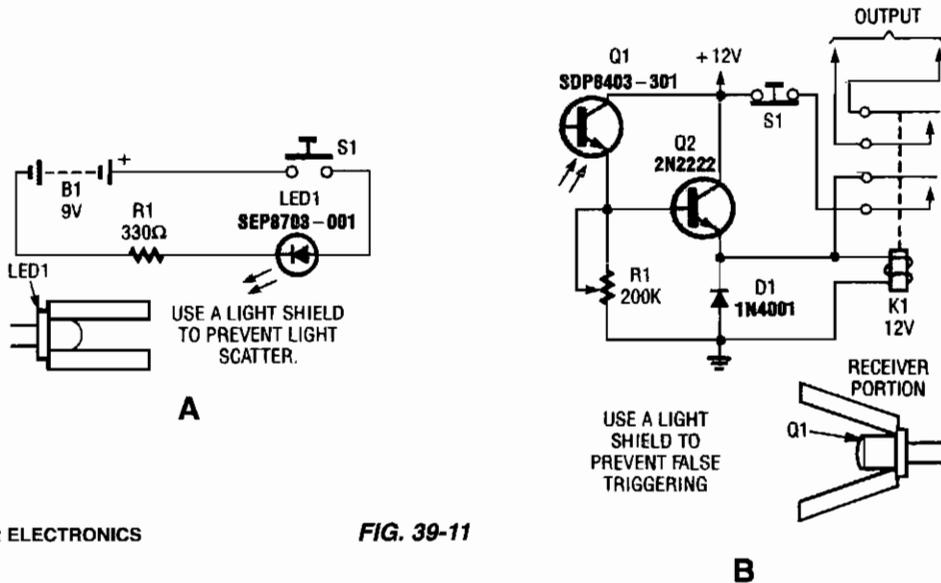


RADIO ELECTRONICS

FIG. 39-10

This transmitter consists of an oscillator and LEDs. It generates a pulsed tone of around 850 Hz.

## VERY SIMPLE IR REMOTE-CONTROL CIRCUIT

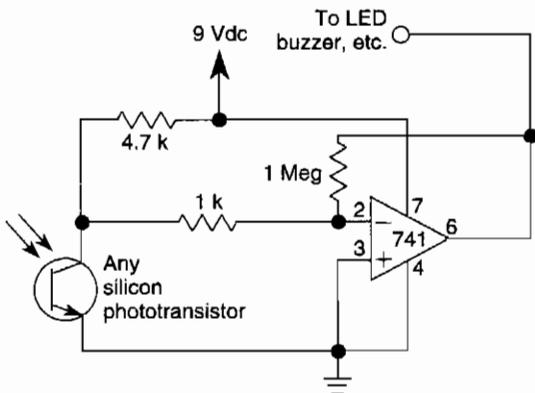


POPULAR ELECTRONICS

FIG. 39-11

Here is a complete IR remote-control system that consists of a simple transmitter (A) and an equally simple receiver (B).

### IR RECEIVER

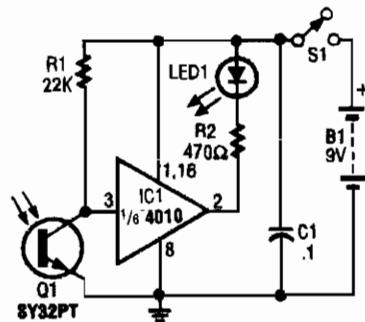


ELECTRONICS NOW

FIG. 39-12

This circuit is just about the simplest IR receiver you can build. The parts are cheap, the layout is not critical, and a 9-V battery will last a long time.

### REMOTE-CONTROL TESTER



ELECTRONICS NOW

FIG. 39-13

The IR Tester circuit lets you know if the button you press on a remote control is working. Q1 is a photo transistor that is activated by IR energy.

# 40

## Indicator Circuits

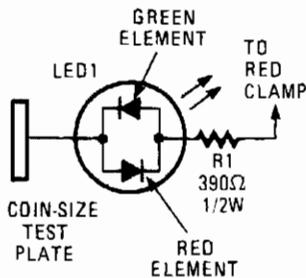
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Polarity Indicator  
Tri-Color Indicator

## POLARITY INDICATOR



POPULAR ELECTRONICS

FIG. 40-1

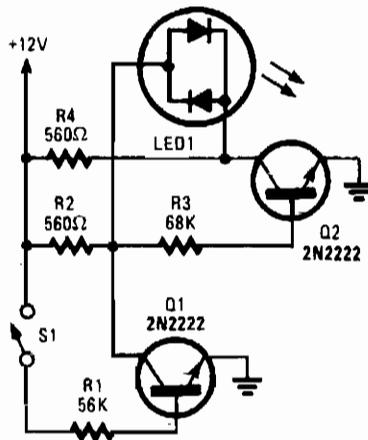
This circuit consists of a tri-color LED, a resistor, wire, and a coin-size test plate. You will have to build two such circuits—one for each black clamp on a set of auto battery jumper cables. The author installed the circuits inside the black clamps themselves using lengths of wire to make the connections to the red clamps.

The first step is to connect one red clamp to what you believe is the positive post on the okay battery. Then, touch the test plate on the black clamp at the end of the cable to the negative terminal on the good battery. The LED will light red if the red clamp is on the wrong terminal. If so move the clamp to the other post and check again. If all is well, the LED will light green. Pick up the other black clamp and connect it to the remaining post on the good battery.

Connect the remaining red clamp to what you assume to be the positive terminal on the bad battery. Now, touch the test plate on the remaining clamp to the engine block or a bare area on the dead car's frame. If the LED appears or doesn't glow, switch the red clamp to the other terminal and test again. When the LED glows green, attach the black clamp to the car's frame (which will prevent any sparks from occurring near the battery). When you remove the clamps, take the clamps off in reverse order to avoid sparks.

---

## BI-COLOR INDICATOR



POPULAR ELECTRONICS

FIG. 40:2

With S1 open, base bias is supplied to Q2 through a voltage divider (formed by R2 and R3), thus turning on the green element in the LED. That indicates that power is being supplied to the project. If you close S1, current through R1 biases Q1 on, thereby grounding the voltage divider and turning off Q2. That reverses the flow of current through the LED, which causes its red element to light. That indicates that the circuit is under power and S1 (really a DPDT switch), whose remaining section controls another circuit, is active. In this circuit, a bi-color LED is used to indicate when a circuit is under power and the status of S1. In that way, the LED does the job of two indicators.

# 41

## Instrumentation Amplifier Circuits

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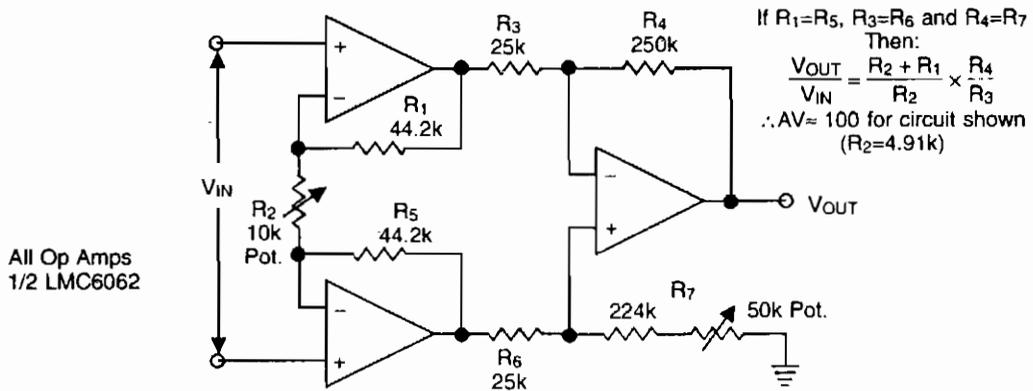
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

LMC6062 Instrumentation Amplifier

LM6218 High-Speed Instrumentation Amplifier

## LMC6062 INSTRUMENTATION AMPLIFIER

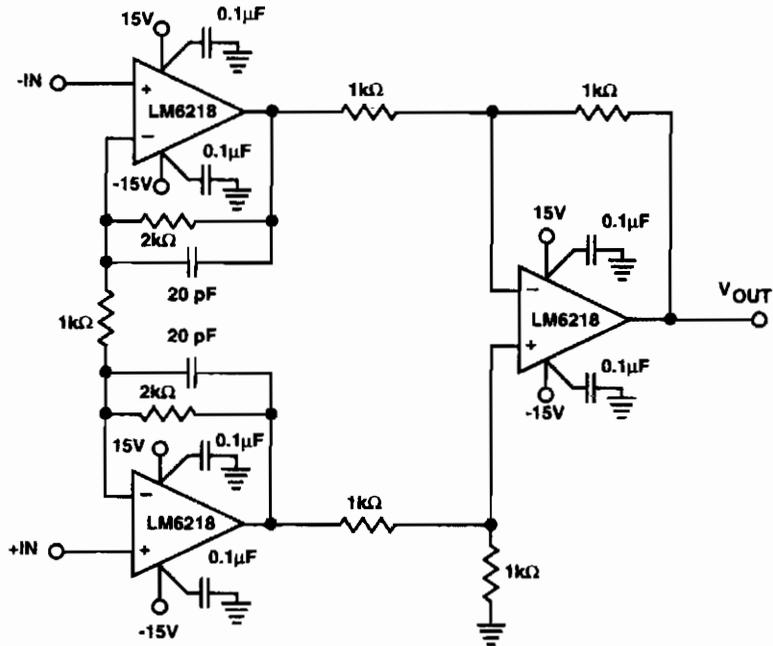


NATIONAL SEMICONDUCTOR

FIG. 41-1

Useful for +5-V single-supply applications, this op amp circuit features low drain (around 1 mA), high input resistance ( $10^{14} \Omega$ ), and low bias current ( $\approx 10^{-14} \text{A}$ ).

## LM6218 HIGH-SPEED INSTRUMENTATION AMPLIFIER



NATIONAL SEMICONDUCTOR

FIG. 41-2

This amplifier features 400-μsec settling time (to 0.01%), 140-V/μsec slew rate, and 17-MHz gain-bandwidth product. The supply voltage can be ±5 to ±20 V.

# 42

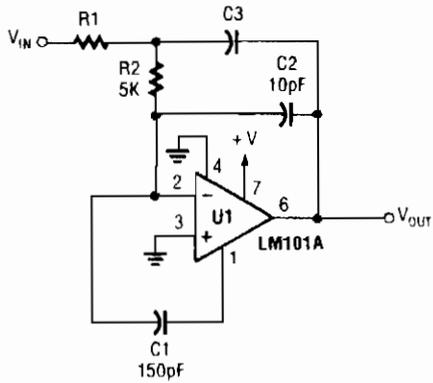
## Integrator Circuit

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Fast Integrator

## FAST INTEGRATOR



$V_{OUT}$  is the integral of  $V_{IN}$  in this circuit.

$$\frac{V_{OUT}}{V_{IN}} \approx \frac{1}{C_3} \frac{V_{IN}(A)}{R} dt.$$

# 43

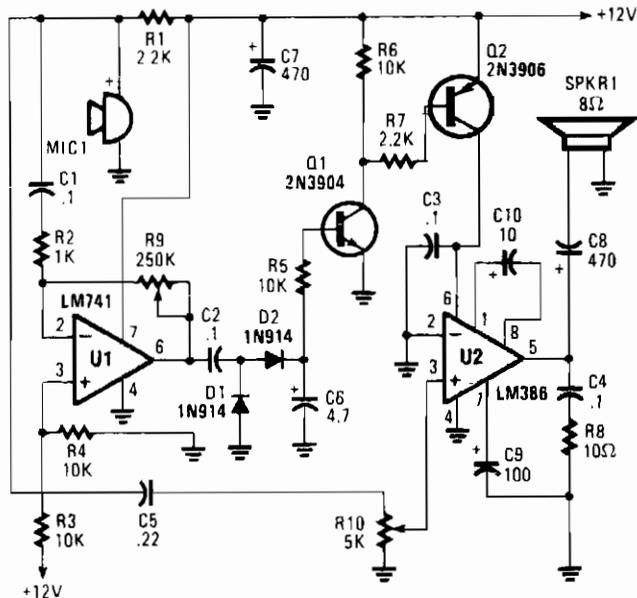
## Intercom Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

One-Way Voice-Activated Intercom  
Very Simple Telephone Intercom Circuit  
Telephone Intercom

## ONE-WAY VOICE-ACTIVATED INTERCOM

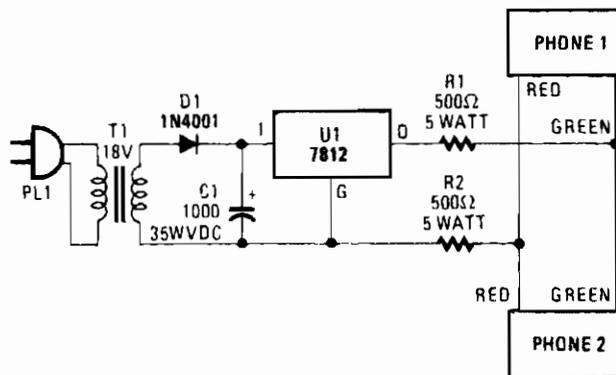


POPULAR ELECTRONICS

FIG. 43-1

An omnidirectional electret microphone can be used to pick up the sound and convert it into an electrical signal. The output of the microphone is fed along two paths. In the first path, the signal is sent to the inverting input at pin 6. In the second path, the microphone signal is fed to the non-inverting input of U2, where it is amplified and output to the speaker, SPKR1.

## VERY SIMPLE TELEPHONE INTERCOM CIRCUIT

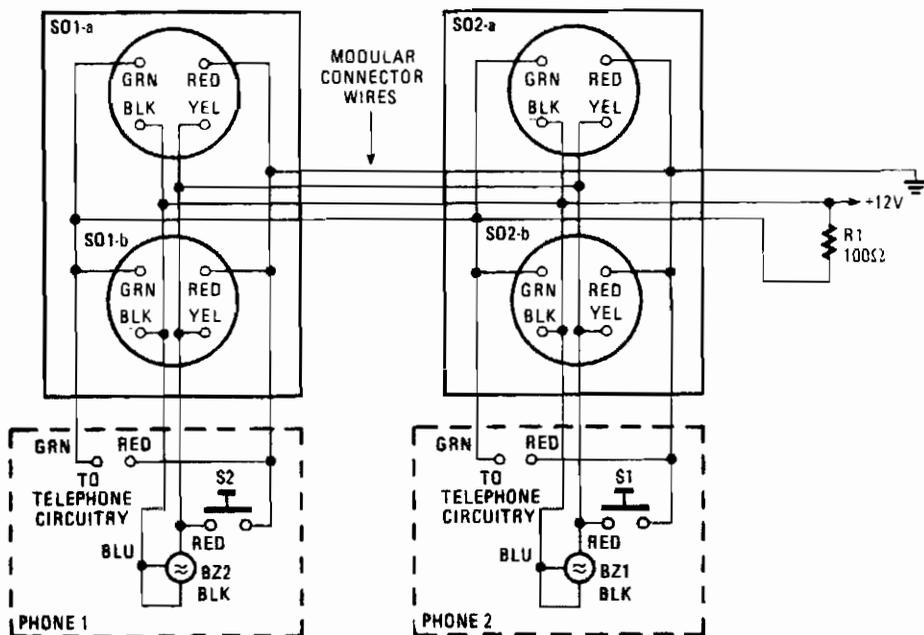


POPULAR ELECTRONICS

FIG. 43-2

Two telephones can be used as an intercom by using this circuit. Older style rotary phones that are nonelectronic might work best in this application. Also, handsets only might be powered this way.

## TELEPHONE INTERCOM



POPULAR ELECTRONICS

FIG. 43-3

An intercom using dual-modular wall jacks is shown in this circuit. If the wires are available in the home telephone cable, this system can be installed with little trouble.

# 44

## Interface Circuits

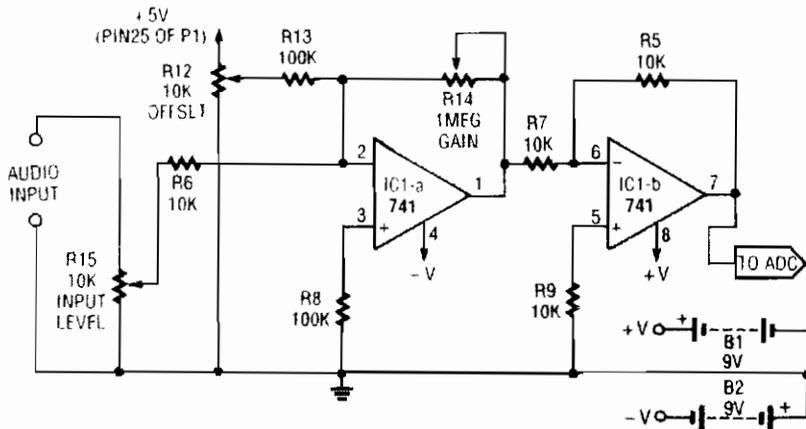
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio-to-ADC Interface  
Process-Control Interface  
Relay Interface for Amateur Radio Transceivers  
Receiver Interface Circuit for Preamps  
Microcomputer-to-Triac Interface

## AUDIO-TO-ADC INTERFACE

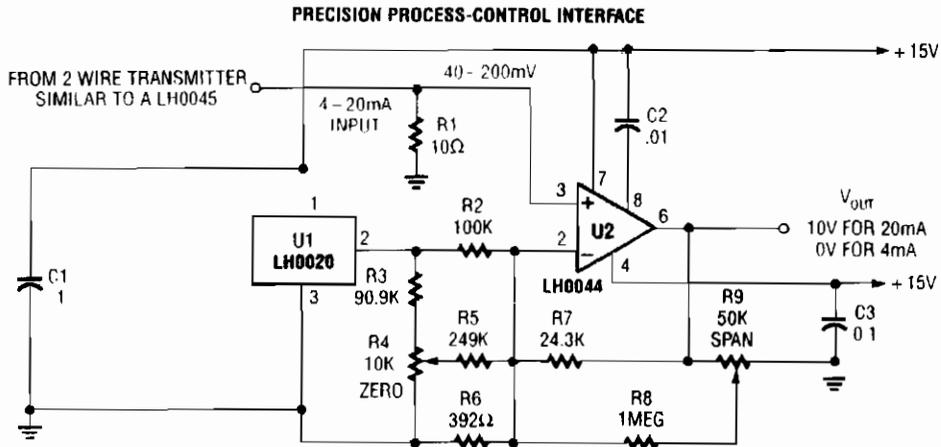


RADIO-ELECTRONICS

FIG. 44-1

This simple general-purpose driver for an analog/digital converter uses two 741 IC devices with adjustable gain and offset. Other op amps might be substituted, but some circuit adjustments might be needed.

## PROCESS-CONTROL INTERFACE



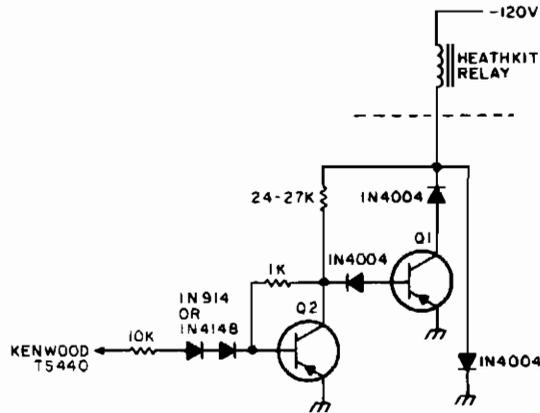
POPULAR ELECTRONICS

FIG. 44-2

This circuit can be used to interface a 2-wire transmitter/sensor combination to an external device or measurement setup.

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## RELAY INTERFACE FOR AMATEUR RADIO TRANSCEIVERS



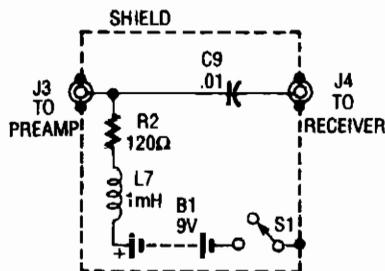
73 AMATEUR RADIO

FIG. 44-3

The relay power in the linear is obtained from the -120-V bias supply, and the transmit keying output from the Kenwood is +12 V at 10 mA maximum. The key ingredient in the circuit is the pnp driver transistor, which must be capable of handling at least 150 V at about 250 mA.

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## RECEIVER-INTERFACE CIRCUIT FOR PREAMPS

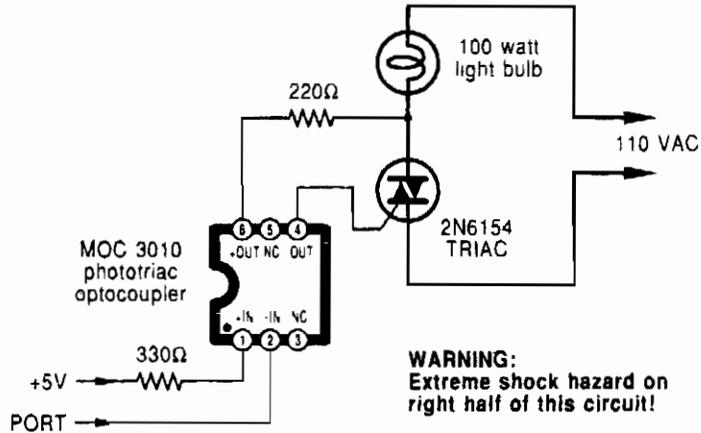


POPULAR ELECTRONICS

FIG. 44-4

The purpose of the receiver/interface circuit is to pass RF to the receiver through capacitor C9, while adding dc power to the feedline through R2 and RF choke L7.

## MICROCOMPUTER-TO-TRIAC INTERFACE



RADIO-ELECTRONICS

FIG. 44-5

A microcomputer-to-triac interface uses a phototriac optoisolator to let safety-isolated logic signals directly control high-power loads. Depending on the input waveforms and the load, this circuit can be used in either an on/off switch or a proportional phase control. A low input powers the lamp.

# 45

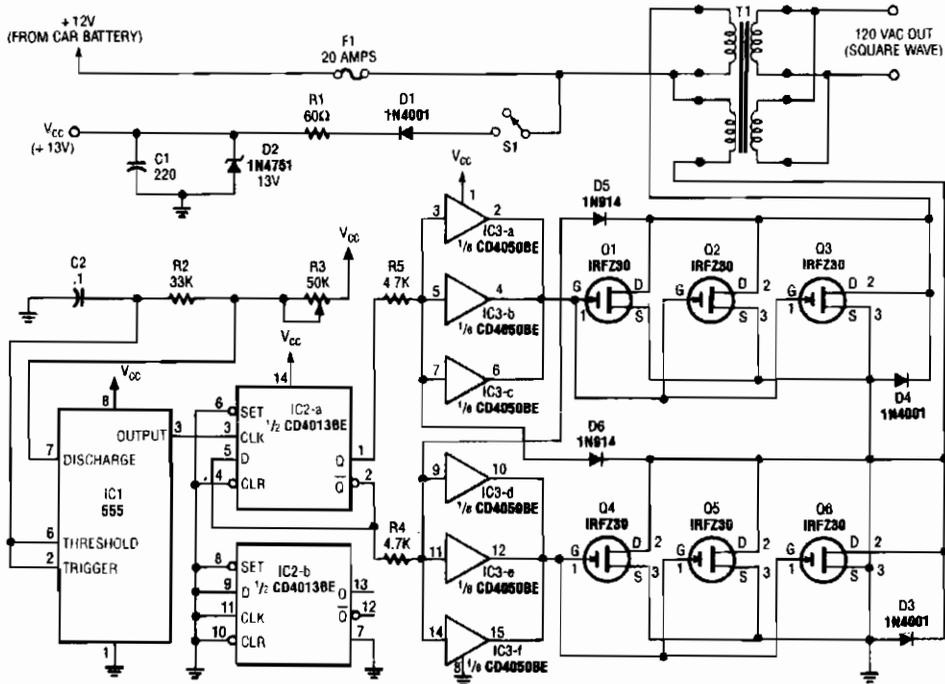
## Inverter Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

250-W Inverter  
Digital Inverter  
dc-to-ac Inverter  
Power MOSFET Inverter

## 250-W INVERTER

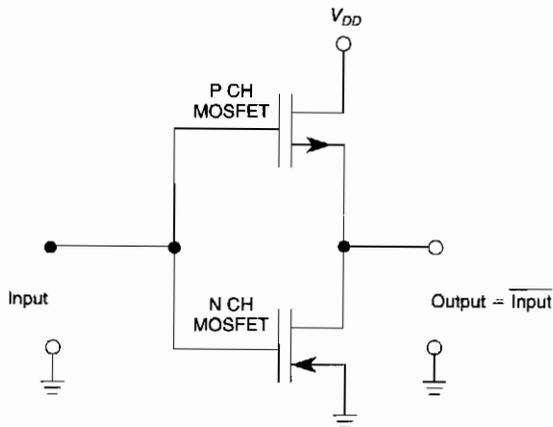


ELECTRONICS NOW

FIG. 45-1

A 555 timer (IC1) generates a 120-Hz signal that is fed to a CD4013BE flip-flop (IC1-a), which divides the input frequency by two to generate a 60-Hz clocking frequency for the FET array (Q1 through Q6). Transformer T1 is a 12-/24-V center-tapped 60-Hz transformer of suitable size.

## DIGITAL INVERTER

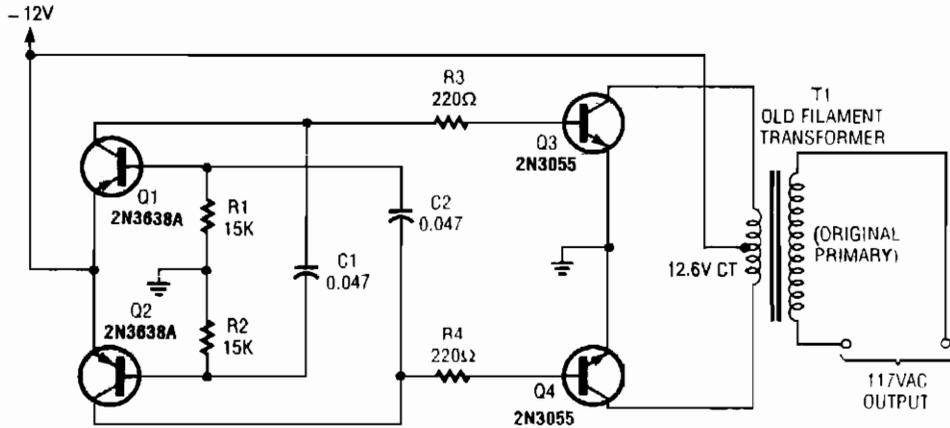


A CMOS digital inverter is formed by connecting two MOSFETS, as shown.

WILLIAM SHEETS

FIG. 45-2

## dc-to-ac INVERTER

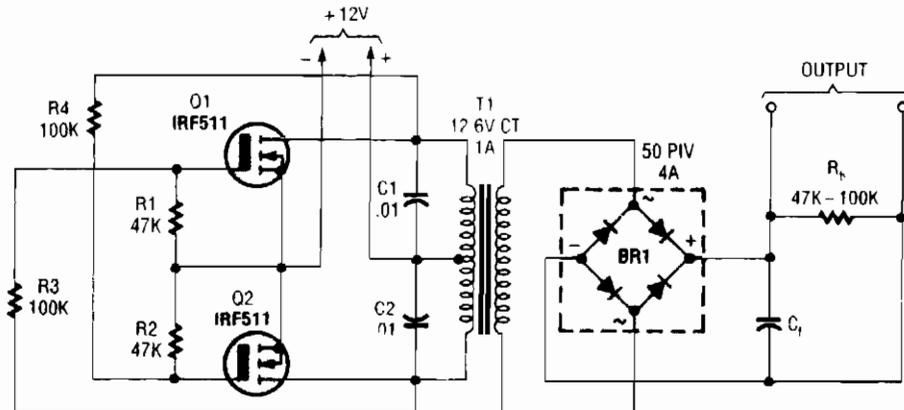


POPULAR ELECTRONICS

FIG. 45-3

A multivibrator circuit drives a pair of 2N3055 power transistors. T1 is a 12.6-V CT filament transformer with a 120-V primary.

## POWER MOSFET INVERTER



POPULAR ELECTRONICS

FIG. 45-4

T1 is a suitable transformer for the voltage desired, with a 12.6-V CT winding.

# 46

## Ion Generator Circuit

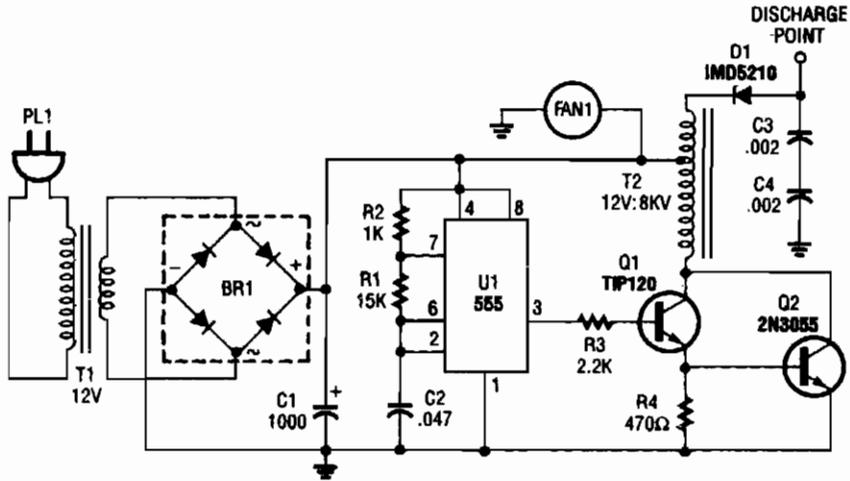
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Negative Ion Generator

# NEGATIVE ION GENERATOR



1983 ELECTRONICS HOBBYIST HANDBOOK

FIG. 46-1

This oscillator-driver induces a high voltage in the windings of T2.

# 47

## Laser Circuits

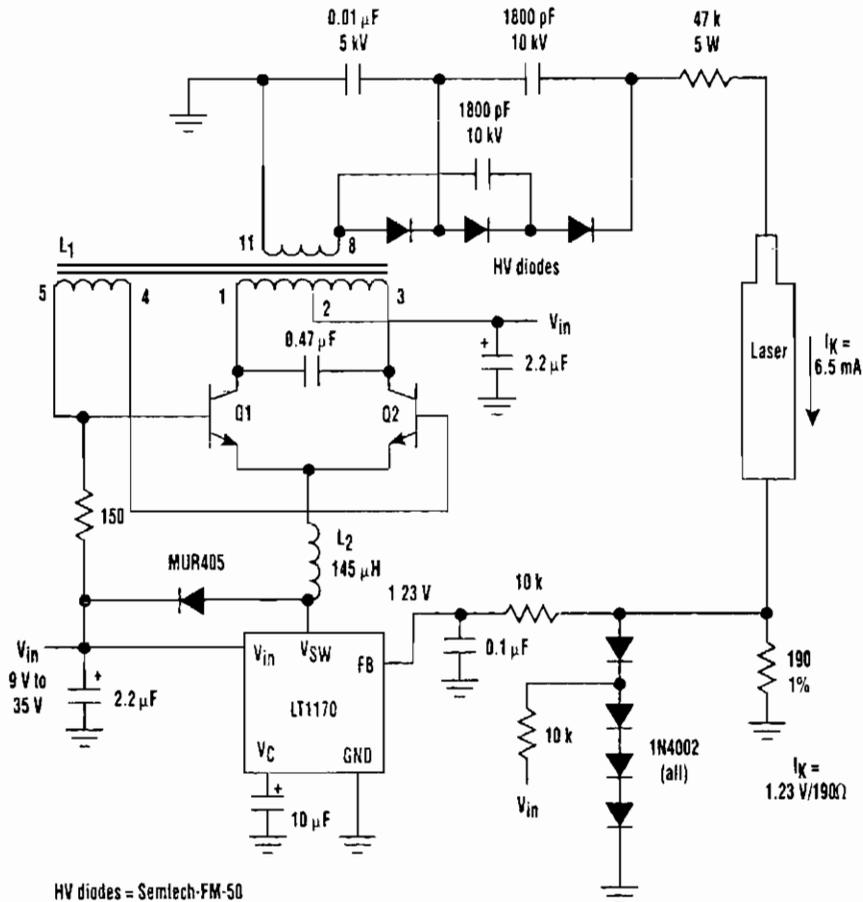
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Efficient Laser Supply
- Laser Power Supply and Starting Circuit
- Handheld Laser
- High-Voltage Power Supply
- Fantastic Simulated Laser
- Laser Power Supply

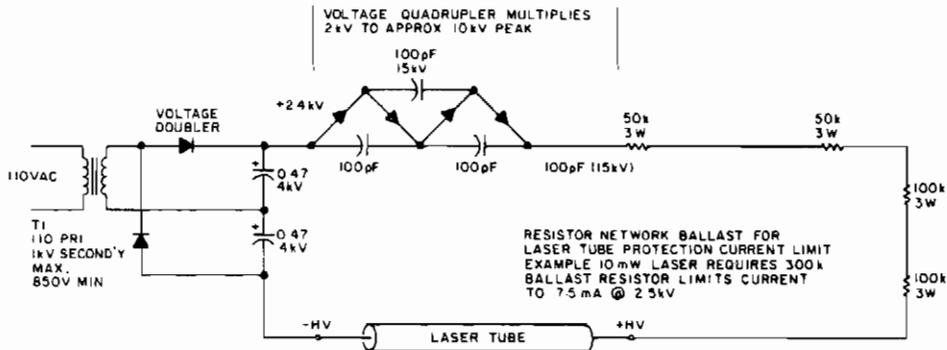
## EFFICIENT LASER SUPPLY



HV diodes = Semtech-FM-50  
 0.47 µF = Wima (Mannheim, Germany) 3 X 0.15 µF, type MKP-20  
 Q1, Q2 = Zetex ZTX-849  
 L<sub>1</sub> = Coiltronics CTX021128-2  
 L<sub>2</sub> = Pulse Engineering PE-92105  
 Laser = Hughes 3121 H-P, 6.5-mA beam current

Driving Helium-Neon Lasers can be simplified considerably using this power-supply configuration. When power is applied, the laser doesn't conduct and the voltage across the 190-Ω resistor is zero. However, a resonant circuit and a voltage tripler then produces over 10 kV to turn on the laser.

## LASER POWER SUPPLY AND STARTING CIRCUIT

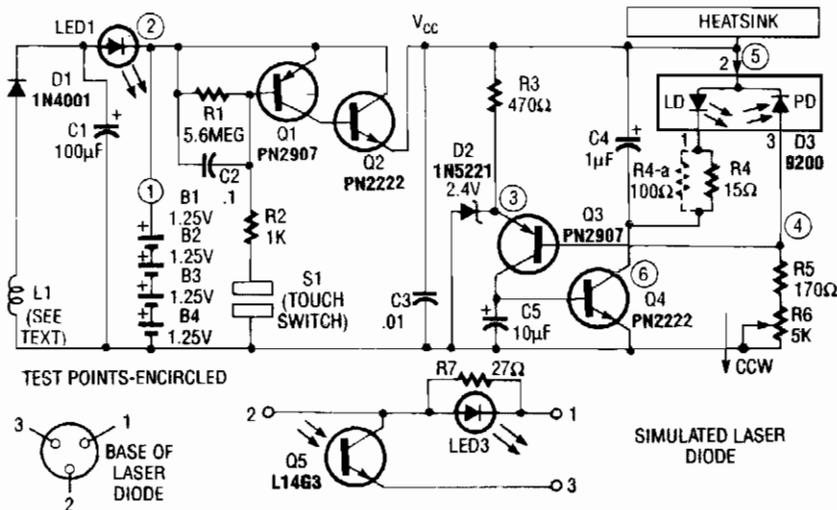


73 AMATEUR RADIO TODAY

FIG. 47-2

This circuit delivers 10 kV peak, then limits current to 7.5 mA @ 2 kV. The resistors shown provide ballasting. The starting circuit cannot maintain the 10 kV under load and appears as a series-pass circuit with little drop in voltage.

## HANDHELD LASER

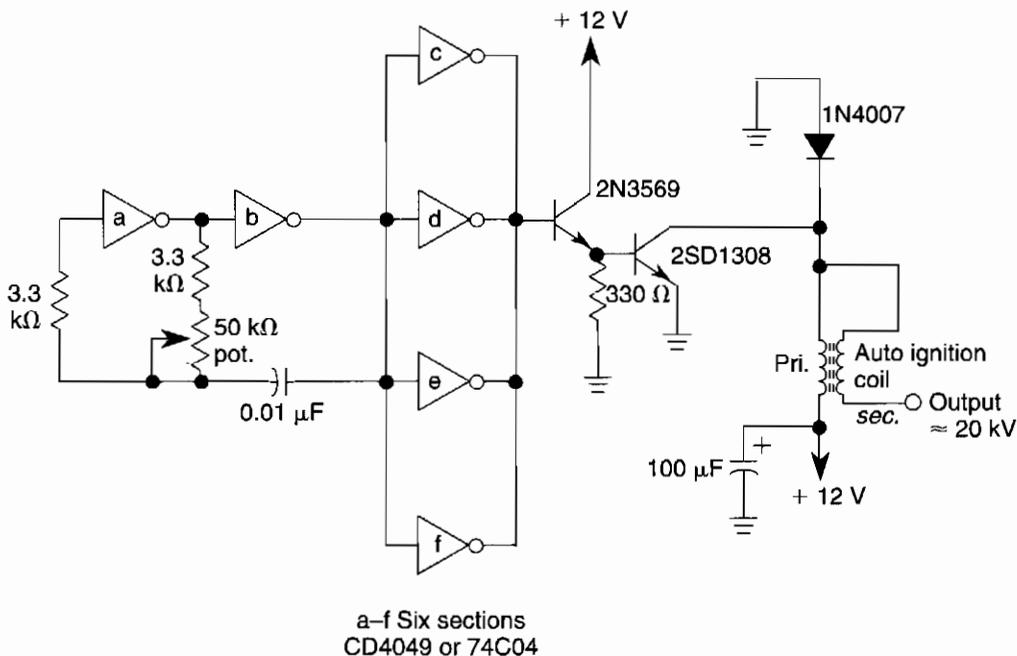


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FIG. 47-3

A laser diode TOLD9200 (Toshiba) is used as a source of laser light. Q3, Q2, and S1 form a touch switch to control the laser. L1 is an RF pickup coil to pick up energy from an RF-type battery charger. It is 10 turns of #18 wire on a 1/2" diameter.

## HIGH-VOLTAGE POWER SUPPLY

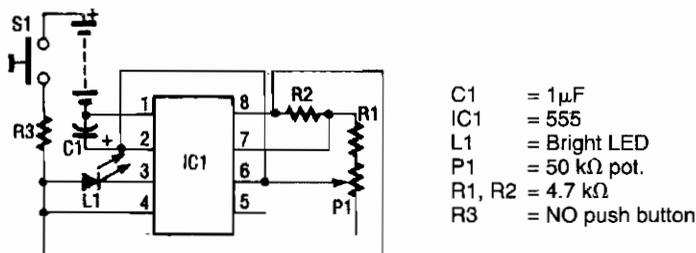


WILLIAM SHEETS

FIG. 47-4

The high-voltage power supply is a CMOS-based oscillator that pulses a high-voltage ignition transformer. The transformer output is around 20 kV.

## FANTASTIC SIMULATED LASER

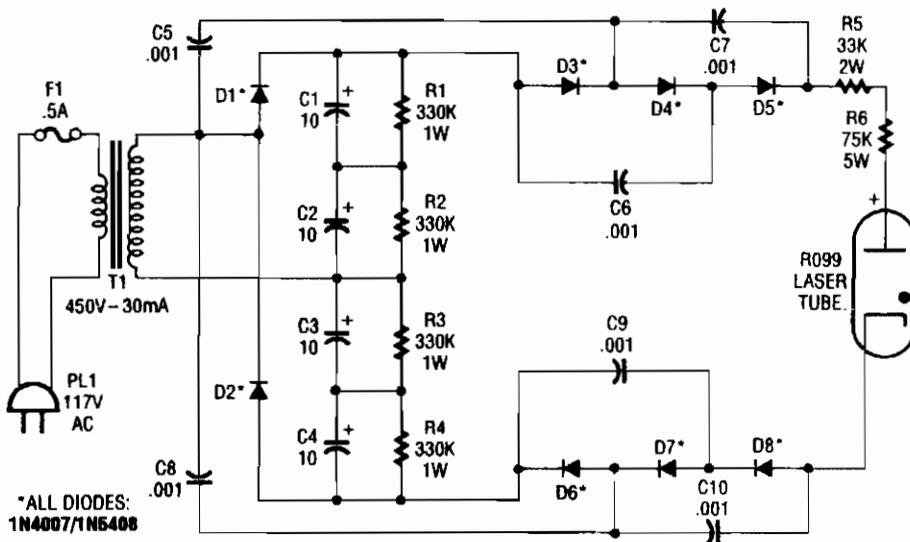


1991 PE HOBBYIST HANDBOOK

FIG. 47-5

The circuit uses a 555 timer IC to power an ultrabright LED. The output is a pulsing red light that can be projected using lenses. An ultrabright Stanley LED, capable of 300-millicandle output, is tied to pin 3 of the 555 timer IC. That IC has been configured as an astable multivibrator. The frequency of this multivibrator is controlled by R1, R2, C1, and P1. You can vary the frequency by adjusting P1, which changes the output from a slow blinking to a fast pulsating light. Resistor R3 is used to limit the current flowing into the circuit to a safe value, to prevent the LED and the IC from burning out. Switch S1 applies power to the circuit when its button is pressed.

## LASER POWER SUPPLY



POPULAR ELECTRONICS

FIG. 47-6

This supply generates an initial high voltage for ignition purposes. After ignition, the supply generates about 1300 to 1500 V. If a higher ignition voltage (than the 6000 V supplied) is necessary, more multiplier stages can be added to D5 and D8.

# 48

## Lie Detector Circuit

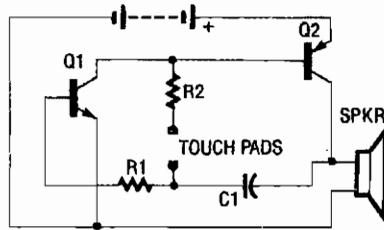
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Simple Lie Detector

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## SIMPLE LIE DETECTOR



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FIG. 48-1

The circuit uses a two-transistor direct-coupled oscillator that has a frequency determined by C1, R2, and the (skin) resistance across the touch pads. Since C1 and R2 are fixed values, only the skin resistance across the touch pads can vary the sound of the oscillator. To sustain oscillations, C1 feeds a portion of the output from Q2 back to the input of Q1 through resistor R1.

Transistor Q1 is an npn type and transistor Q2 is a pnp type. The output of Q2 is fed into a small speaker. The circuit relies on the fact that the human skin conducts electricity.

C1	0.01- $\mu$ F Capacitor
Q1	2N3904 Transistor
Q2	2N3906 Transistor
R1	4.7 k $\Omega$ Resistor
R2	82 k $\Omega$ Resistor

# 49

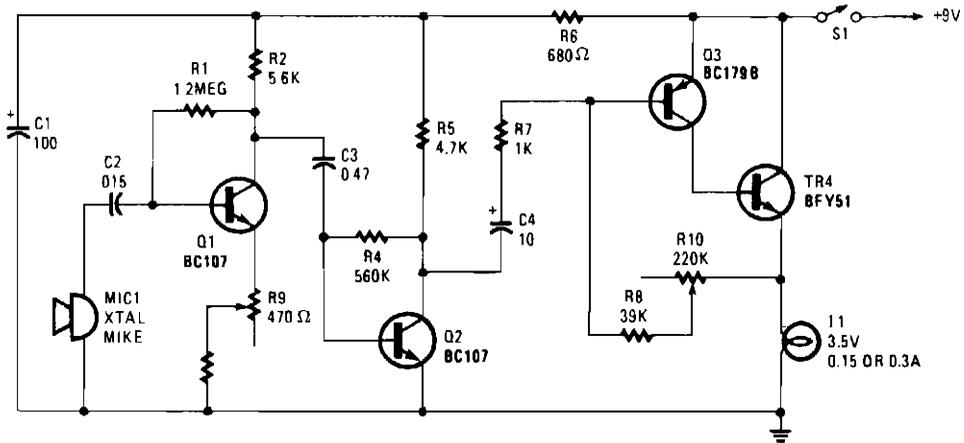
## Light Beam Communication Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Modulated Light Transmitter  
Modulated Light Receiver  
FM Light-Beam Receiver  
FM Light-Beam Transmitter  
Light-Wave Voice-Communication Transmitter  
Light-Wave Voice-Communication Receiver  
Visible-Light Audio Transmitter  
Visible-Light Receiver

## MODULATED LIGHT TRANSMITTER

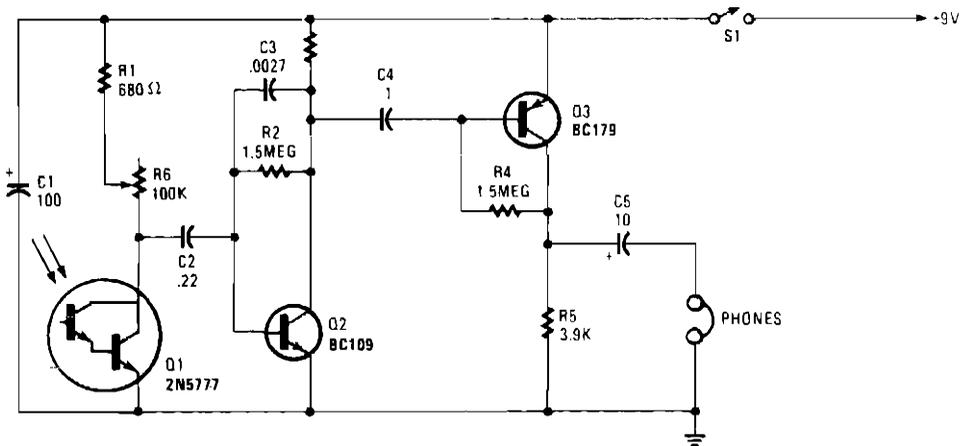


POPULAR ELECTRONICS

FIG. 49-1

A light-bulb filament can be modulated with audio as a method of optical transmission. Amplifier Q1/Q2/Q3 drives emitter-follower TR4. Adjust R10 for the Q point (light bulb) giving best results. It should have a filament with low thermal inertia for best audio responses.

## MODULATED LIGHT RECEIVER

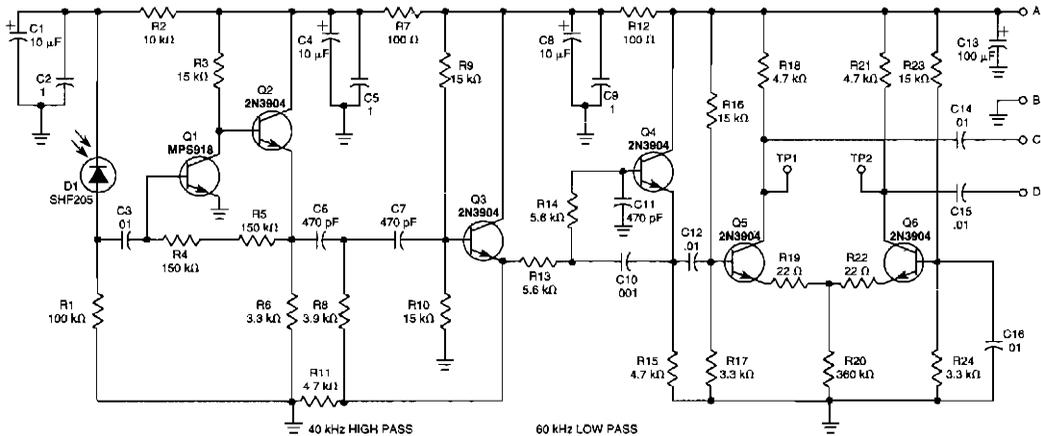


POPULAR ELECTRONICS

FIG. 49-2

Using a phototransistor, this receiver will detect and demodulate a modulated light beam. R6 affects sensitivity.

## FM LIGHT BEAM RECEIVER

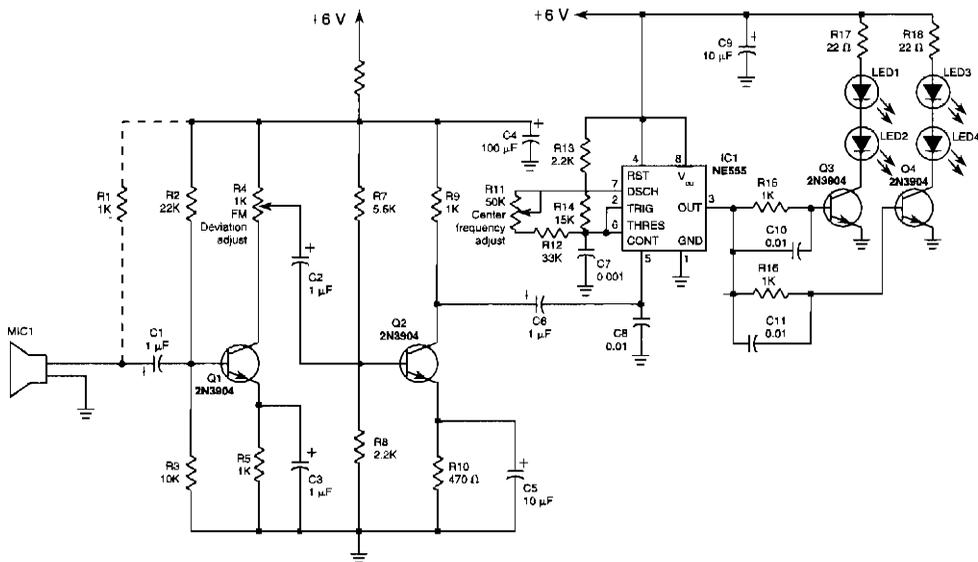


ELECTRONICS NOW

FIG. 49-3

This receiver will pick up IR or light beams that are frequency modulated on a 50-kHz carrier. Q2/Q1/Q3/Q4 from an active filter and amplifier and differential amp Q5/Q6 provide more gain.

## FM LIGHT-BEAM TRANSMITTER

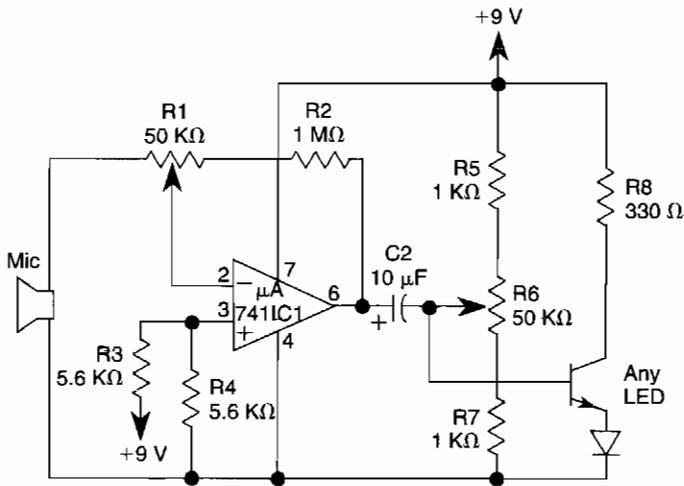


ELECTRONICS NOW

FIG. 49-4

This transmitter uses two-stage amplifier Q1/Q2 to frequency modulate an NE555 (configured as a VCO) operating at about 50 kHz. The resultant FM-modulated pulse train is converted to light pulses via LED1 through LED4, driven by Q3 and Q4.

## LIGHT-WAVE VOICE-COMMUNICATION TRANSMITTER

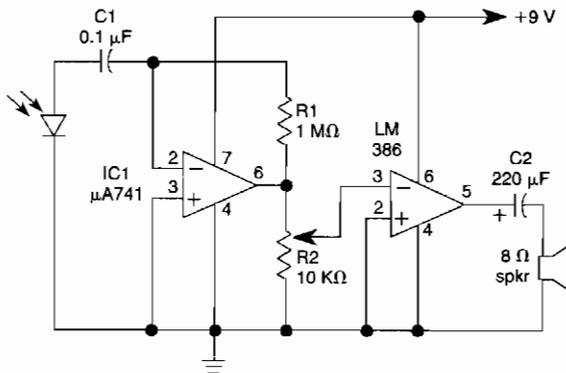


WILLIAM SHEETS

FIG. 49-5

This transmitter uses a 741 op amp as a high-gain audio amplifier, which is driven by a microphone. The output of the 741 is coupled to Q1, which serves as the driver for a LED. Potentiometer R1 is the amplifier's gain control. Miniature trimmer resistor R6 permits adjustment of the base bias of Q1 for best transmitter performance. Gain control R1 can be eliminated if C1 and R2 are connected directly to pin 2 of the 741. For maximum sensitivity, increase the value of R<sub>2</sub> from 1 to 10 MΩ and use a crystal microphone with a large diaphragm.

## LIGHT-WAVE VOICE-COMMUNICATION RECEIVER

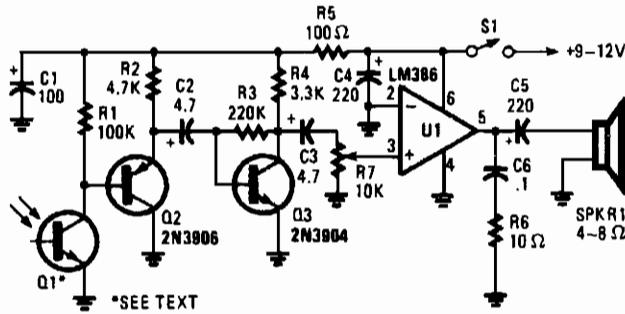


WILLIAM SHEETS

FIG. 49-6

This light-wave receiver consists of a 741 operated as a preamplifier and an LM386 operated as a power amplifier. Potentiometer R2 is the gain control. Various kinds of detectors can be used as the front end of the receiver. Phototransistors are very sensitive, but they do not work well in the presence of too much ambient light. A 100-kΩ series resistor is required if you use a phototransistor. Solar cells, photodiodes, and LEDs of the same semiconductor as the transmitter all work well in this circuit.

## VISIBLE-LIGHT RECEIVER

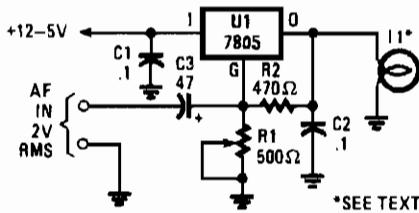


POPULAR ELECTRONICS

FIG. 49-7

This receiver for amplitude-modulated light signals uses phototransistor Q1 mounted in a parabolic reflector (to increase range). Any npn phototransistor should work. Emitter-follower Q2 drives amplifier Q3. The output from Q3 feeds volume control R7 and audio amplifier U1. A 9- to 12-V supply is recommended for the receiver.

## VISIBLE-LIGHT AUDIO TRANSMITTER



POPULAR ELECTRONICS

FIG. 49-8

In the visible-light transmitter, a 7805 voltage regulator is connected in a variable-voltage configuration, and an audio signal is fed to the common input, to modulate the output voltage. The modulated output voltage is used to transmit intelligence via an incandescent lamp.

# 50

## Light Control Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Light Sequencer

Holiday Light Sequencer

Automatic Porch-Light Control

Dimmer for Low Voltage Loads

Three-Power-Level Triac Controller

Phase-Controlled Dimmer

120-ac Shimmering Light

Simple Triac Circuit

Running Light Sequencer

MOS Lamp Driver

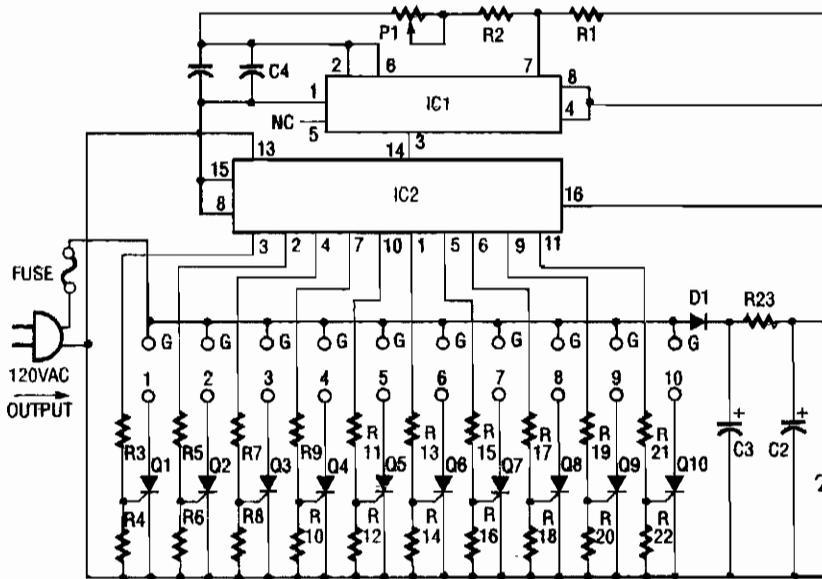
CMOS Touch Dimmer

Neon Lamp Driver for 9-V Supplies

Sensitive Triac Controller

Halogen Lamp Protector

## LIGHT SEQUENCER



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FIG. 50-1

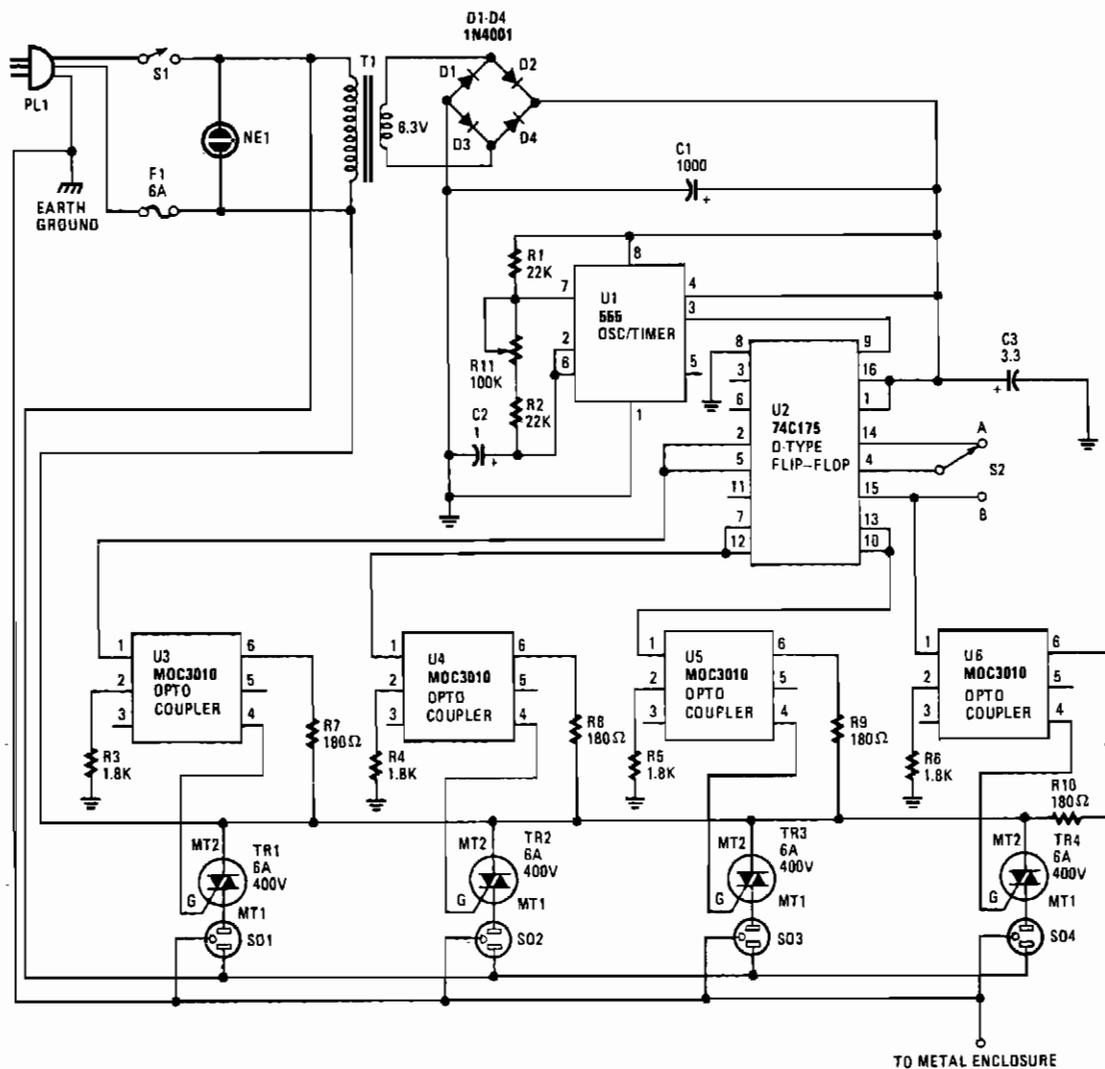
The light sequencer uses two ICs and 10 SCRs to create an ac sequencer. The first IC, a 555 timer, is used to provide clock pulses for IC2. The IC is configured as an astable multivibrator, and its output is on pin 3.

Capacitors C1 and C4, along with resistor R2 and potentiometer P1, control the frequency of the pulses. IC2 is a 4017 Johnson counter, which shifts a high-signal level to each one of its 10 output pins in sequence. Each output pin is resistively coupled to the gate lead on an SCR. When the respective output pin on the 4017 is high and the positive half of the ac cycle is on the anode lead of the SCR, it turns on. The lamp that is connected to its anode lights.

Power is brought into the PC board by the line cord, then the circuit is fuse-protected. Diode D1 changes the ac to pulsating, which is smoothed by C2 and C3. R23 limits the current, and zener diode D2 limits the dc voltage to 6 Vdc.

IC1, C4	0.1- $\mu$ F Capacitor	R2, R4, R6,	
C2	100- $\mu$ F Capacitor	R8, R10, R12,	
C3	47- $\mu$ F, 350-V Electrolytic Capacitor	R14, R16, R18	
D1	1N4007 Diode	R20, R22	100-k $\Omega$ Resistor
D2	6-V Zener (M747814)	R3, R5, R7	
IC1	555 Timer IC	R9, R11, R13	
IC2	4017 CMOS IC	R15, R17, R19	
P1	500-k $\Omega$ Potentiometer	R21	2.2-k $\Omega$ Resistor
Q1-Q10	106 SCR	R23	15-k $\Omega$ 7-W Resistor
R1	560- $\Omega$ Resistor		

## HOLIDAY LIGHT SEQUENCER



## HOLIDAY LIGHT SEQUENCER (*Cont.*)

Integrated circuit U1 (a 555 oscillator/timer) is wired as a conventional pulse generator. The frequency of the pulse generator is controlled by potentiometer R11. Resistor R2 puts a reasonable limit on the highest speed attainable.

The output of the pulse generator is fed to the common clock input of U2, a 74C175 quad D-type flip-flop. Each flip-flop is configured so that its Q output is coupled to the D input of the subsequent flip-flop.

Information on the D input of each flip-flop is transferred to the Q (and Q) outputs on the leading edge of each clock pulse. Switch S2 allows you to invert the information on the D input of the first flip-flop at any time during the cycle. This allows you to create a number of different sequences, which are determined by the state of the CQ output at the time of the switching.

Some of the possible sequences are:

- 1 through 4 on, 1 through 4 off;
- 1 of 4 on sequence;
- 1 of 4 off sequence;
- 2 of 4 on sequence;
- 1 and 3 on to 2 and 4 off;
- and other instances when the sequence of events is difficult to determine.

However, if S2 is switched to position B while all outputs are high or all are low (which seldom occurs), the sequence stops and the outputs remain either all on or all off. If that happens, you only need to switch back to position A for at least one pulse duration, then back to position B again.

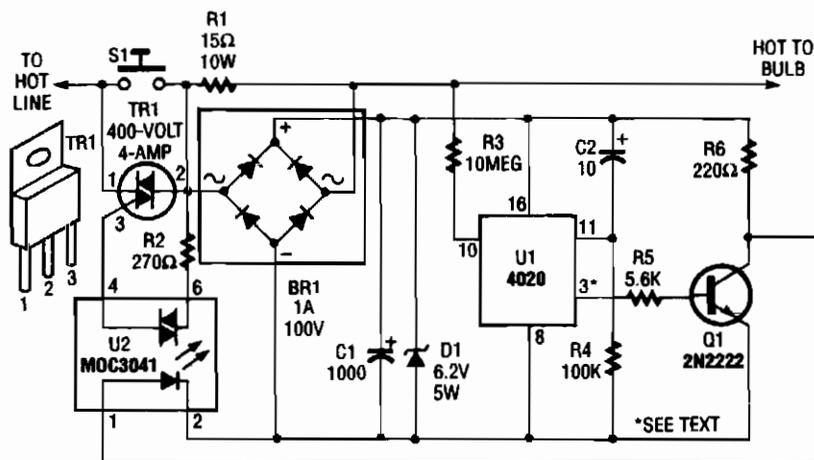
Likewise, S2 should be in position A (pin 4 connected to pin 14) each time the power is turned on. This is because the data on pin 4 must be a logic 1 in order to start a sequence; otherwise all outputs remain at logic 0, regardless of the clock pulses.

Each output of the sequencing circuit is connected to an MOC3010 optoisolator/coupler (U3 through U6), which contains an infrared-emitting diode with an infrared-sensitive diac (triac driver or trigger) in close proximity. The diac triggers the triac, which carries the 117-volts ac.

Each time that the infrared-emitting diode receives a logic 1, it turns on and causes the diac to conduct. With the optoisolator/coupler's internal diac conducting, the triac turns on, and power is supplied to whatever load is plugged into the corresponding ac socket. So, the sequencing circuit and the 117-V ac outputs are "optically coupled" and are effectively isolated from each other.

Power for the sequencing circuit is provided by a 6.3-V miniature transformer. The output of the transformer is rectified by a four-diode bridge circuit, the output of which is filtered by C1 (1000- $\mu$ F electrolytic capacitor). Capacitor C3 is added at the supply pin of U2 to suppress transients.

## AUTOMATIC PORCH-LIGHT CONTROL

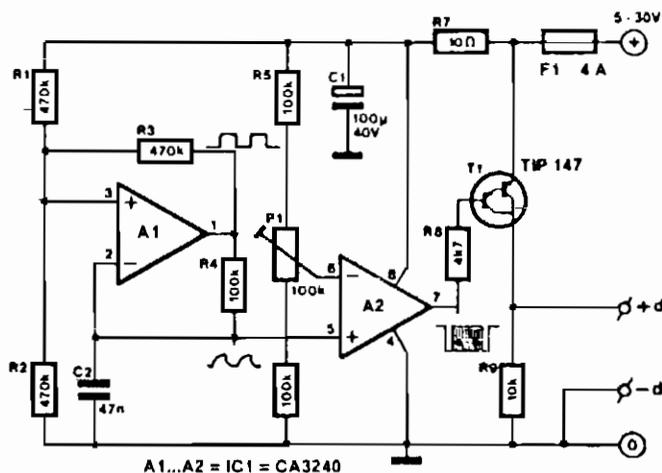


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FIG. 50-3

The automatic porch-light control circuit holds a triac on until a 4020 divider counts a number of 60-Hz powerline pulses. The circuit turns off a light after a predetermined time by using pins other than pin 3 of U1. Various times can be set. Consult the 4020 data sheet for information.

## DIMMER FOR LOW VOLTAGE LOADS

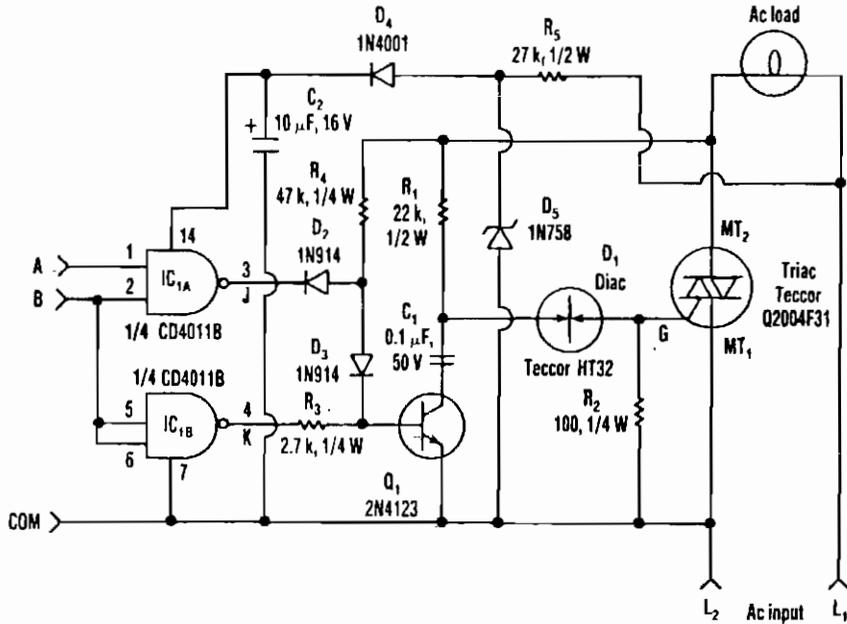


303 CIRCUITS

FIG. 50-4

This circuit controls a low voltage dc supply by pulse width modulation. The switching rate is 200 Hz. Input supply voltage should be +5 to +30 V. Up to 5 A can be controlled.

### THREE-POWER-LEVEL TRIAC CONTROLLER

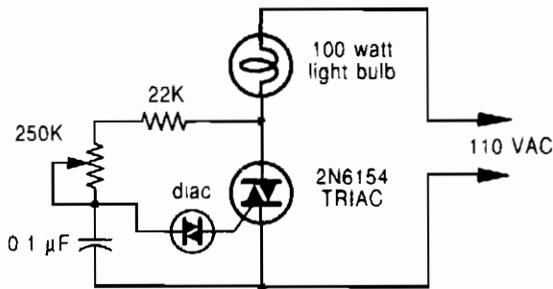


ELECTRONIC DESIGN

FIG. 50-5

Three power levels are supplied by the two logic inputs of this enhanced circuit. R5, D4, D5, and C2 form a power supply for the logic IC. They can be omitted if another source of low voltage is available.

### PHASE-CONTROLLED DIMMER



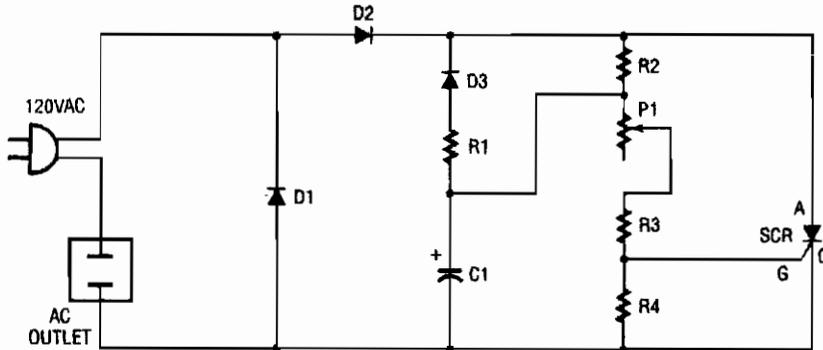
**WARNING: Extreme shock hazard!**

A phase-controlled dimmer delays the triac turn-on to a selected point in each successive ac half cycle. Use this circuit only for incandescent lamps, heaters, soldering irons, or "universal" motors that have brushes.

RADIO-ELECTRONICS

FIG. 50-6

## 120-ac SHIMMERING LIGHT



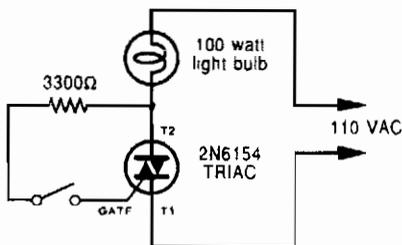
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FIG. 50-7

You can turn any ordinary household bulb into one that shimmers or blinks. This circuit works on any incandescent light up to 200 W, and runs on standard 120 Vac. The circuit uses an SCR to cause an ordinary lamp to shimmer. Note that one side of the lamp is connected directly to 120 Vac, and the other side of the lamp goes to the cathode of the SCR. As ac voltage is brought into the circuit through the line cord, it is full-wave rectified by diodes D1 and D2. That changes the ac to dc, and a portion of that dc voltage is applied to capacitor C1 through R2. Diode D3 blocks the (+) dc voltage so that only the voltage from the path of R1 and D3 is clear. That forms an oscillator, which has a frequency determined by the setting of potentiometer P1 (because the other components have fixed values).

Remember to use **extreme caution** when using a device that connects to the ac line. **Never** use it outside or near water and always mount the entire kit inside a wooden or plastic (insulated) box to prevent any contact with the ac voltage.

## SIMPLE TRIAC CIRCUIT



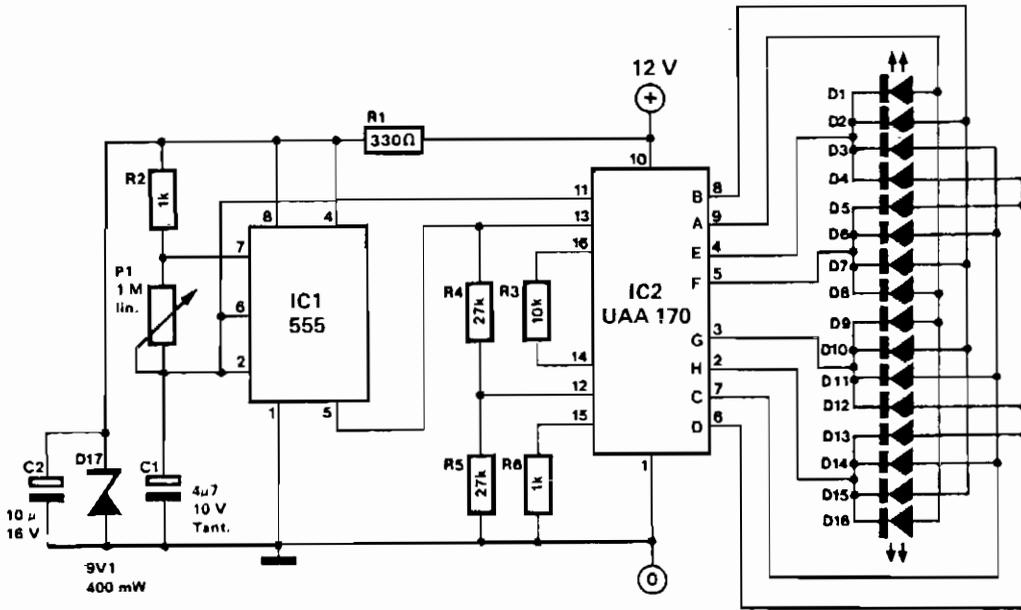
**WARNING: Extreme shock hazard!**

A triac can be used as a line-operated ac power switch that can directly control lamps, heaters, or motors. A brief and small current pulse into the gate turns the triac on; it remains on until the main current reverses.

RADIO-ELECTRONICS

FIG. 50-8

## RUNNING LIGHT SEQUENCE

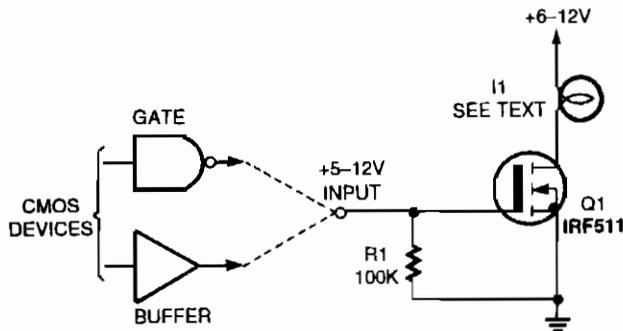


303 CIRCUITS

FIG. 50-9

This running light sequencer drives 16 LEDs and runs from a 12-V supply. C1 can be varied to alter the rate of operation.

## MOS LAMP DRIVER

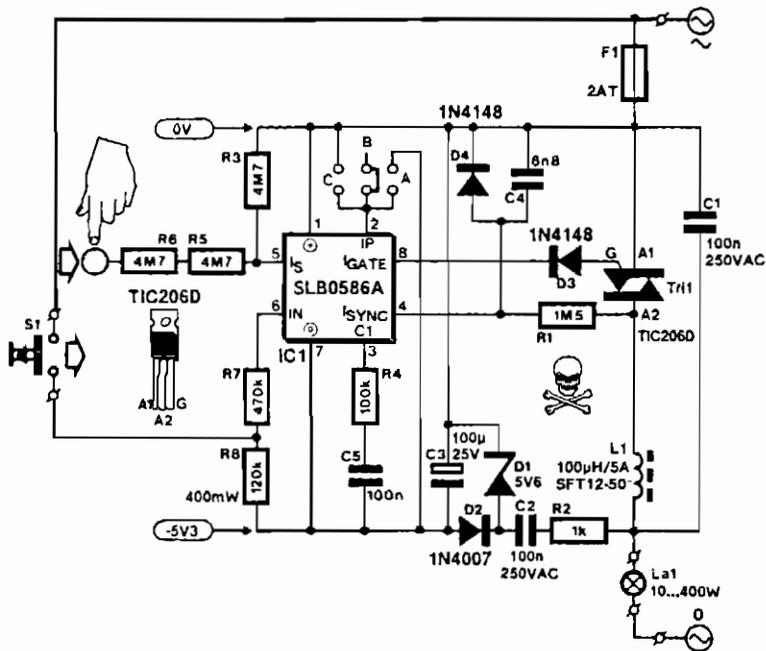


POPULAR ELECTRONICS

FIG. 50-10

The circuit shows a way of using a MOSFET as a load driver. I1 can be a lamp, or any other load, that does not exceed the current rating of Q1.

## CMOS TOUCH DIMMER

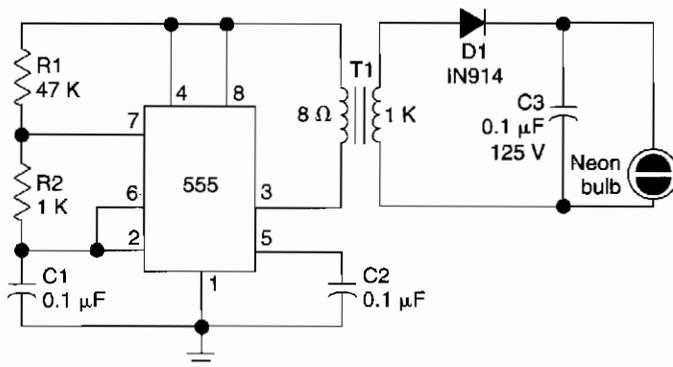


ELEKTOR ELECTRONICS

FIG. 50-11

A Siemens SLB0586A IC allows the construction of a simple touch-controlled dimmer circuit. The circuit controls a triac ac switch, which allows control of loads from 10 to 400 W.

## NEON LAMP DRIVER FOR 9-V SUPPLIES

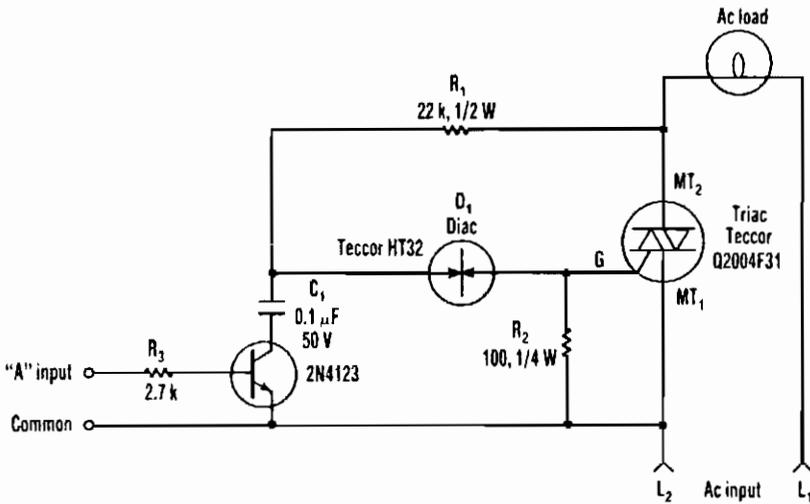


RADIO-ELECTRONICS

FIG. 50-12

This circuit is for driving a neon lamp from a 9-V supply. The 555 generates an ac signal (stepped up by T1), and lights the neon bulb. T1 is any small audio output transformer.

## SENSITIVE TRIAC CONTROLLER

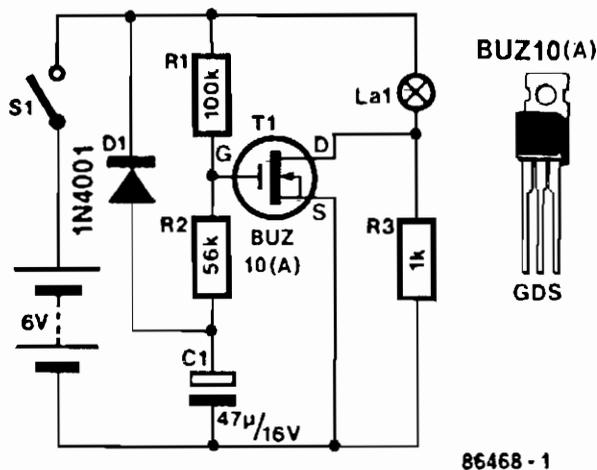


ELECTRONIC DESIGN

FIG. 50-13

The single transistor connected between the capacitor and the common side of the ac line allows a logic-level signal to control this triac power circuit. Resistor R2 prevents false triggering of the triac by the trickle current through the diac.

## HALOGEN LAMP PROTECTOR



86468 - 1

303 CIRCUITS

FIG. 50-14

This circuit produces a soft turn-on for halogen lamp filaments upon powering up. MOSFET used is a BUZ10, which has  $0.2 \Omega R_{DS}$  on. R1, R2, and C1 set the turn-on rate and D1 discharges C1 at turn-off.

# 51

## Light-Controlled Circuits

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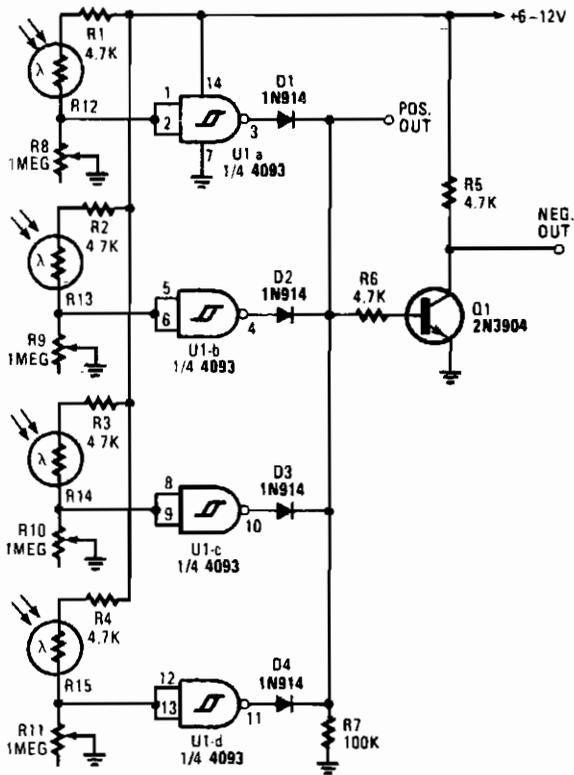
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Light-Dependent Sensor for Multiple Inputs  
Simple Light-Activated Alarm  
Precision Dark-Activated Switch with Hysteresis  
Combined Light-/Dark-Activated Switch  
Outdoor Light Controller  
Dark-Activated Relay with Hysteresis  
Porch Light Control  
Dark-Activated Switch

Photoelectric Sensor  
Precision Light-Sensitive Relay Switch  
Self-Latching Light-Activated Switch  
Simple Nonlatching Photocell Switch  
Light-Controlled Oscillator  
Phototransistor Circuits  
Dark-Activated Relay

## LIGHT-DEPENDENT SENSOR FOR MULTIPLE INPUTS

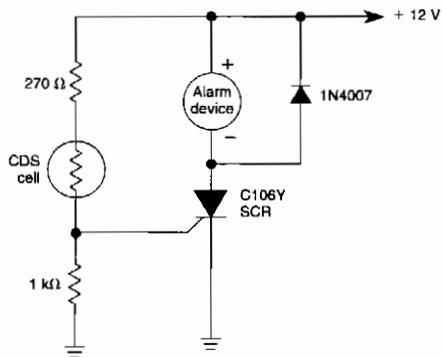


This light-dependent sensor uses LDRs to detect the presence or absence of light. As long as the light source striking the LDRs remains constant, the alarm does not sound. But when the light is interrupted, the alarm is triggered.

POPULAR ELECTRONICS

FIG. 51-1

## SIMPLE LIGHT-ACTIVATED ALARM

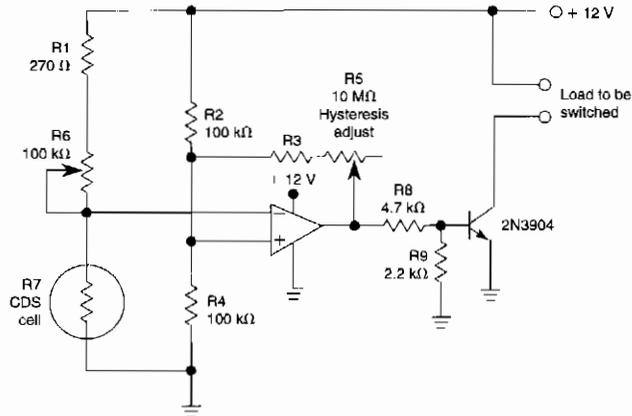


A cadmium-sulfide photocell conducts when a light beam strikes it. This triggers the SCR and activates the alarm device.

WILLIAM SHEETS

FIG. 51-2

## PRECISION DARK-ACTIVATED SWITCH WITH HYSTERESIS

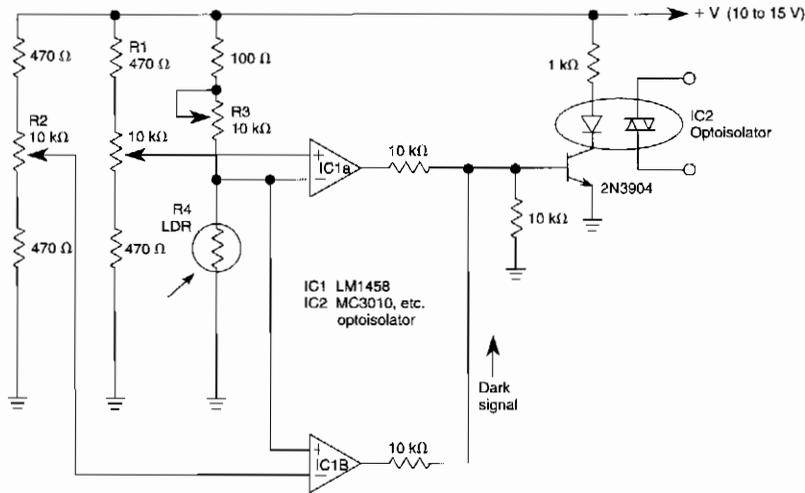


WILLIAM SHEETS

FIG. 51-3

A CdS cell is one leg of a bridge circuit. Potentiometer R6 in another leg sets the trip point. Potentiometer R5 provides hysteresis adjustment to prevent "chattering" or hunting of the relay. The light level has to increase noticeably before the 2N3904 turns off and the circuit deactivates.

## COMBINED LIGHT-/DARK-ACTIVATED SWITCH



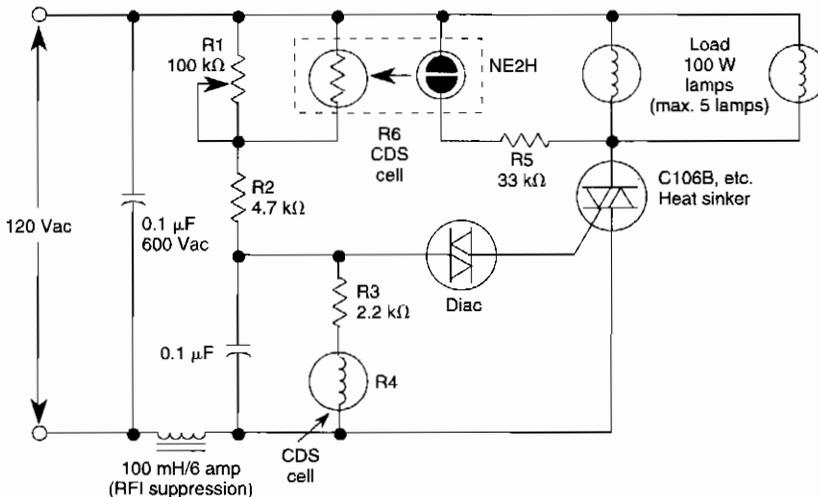
Set R4 so 1/2 of  $V_{CC}$  appears across R3.  
Set R2 for dark trip point.  
Set R1 for light trip point.

WILLIAM SHEETS

FIG. 51-4

Two op amps used in a bridge circuit configuration detect high and low light levels. Potentiometer R2 sets the dark level and R1 controls the light level. R3 is set so that about  $\frac{1}{2}$  the supply voltage appears across R4 at the desired light level. R1 and R2 set the trip point of the optoisolator IC2 at darker or lighter ambient levels, as required.

## OUTDOOR LIGHT CONTROLLER



WILLIAM SHEETS

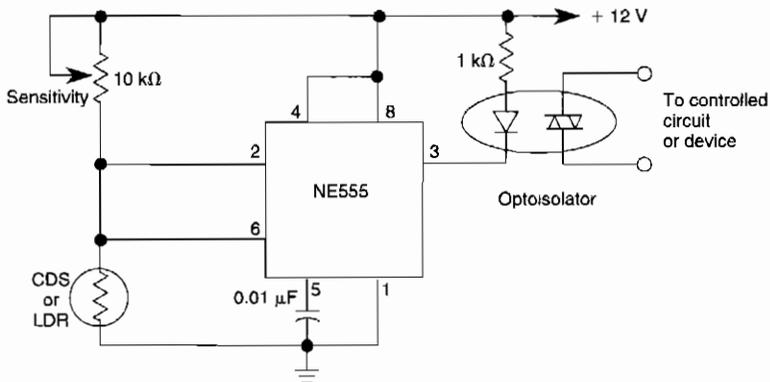
FIG. 51-5

A neon bulb and a CdS photocell enclosed in a light-tight enclosure form an optocoupler. A diac/triac combination is used to provide the snap-switch effect. A second CdS photocell acts as the main sensor.

As darkness approaches, the resistance of R4 begins to increase. At a threshold level, the diac triggers the triac and causes the neon bulb to light. This reduces the resistance of R6, causing the diac to trigger the triac, which lights the neon bulb and provides power to the load.

As morning light comes up, the process is reversed. The neon bulb goes out and the SCR turns off.

## DARK-ACTIVATED RELAY WITH HYSTERESIS

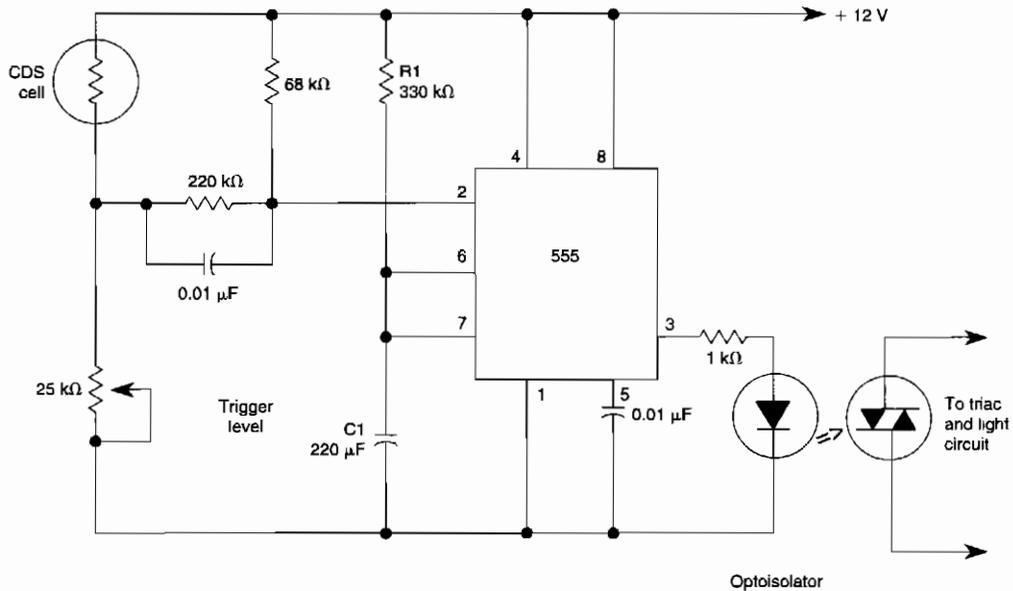


WILLIAM SHEETS

FIG. 51-6

The hysteresis of a 555 IC can be used to advantage for sensing a drop in light. An LDR or CDS cell with about 2 to 8 k resistance at desired light level should be used.

## PORCH LIGHT CONTROL

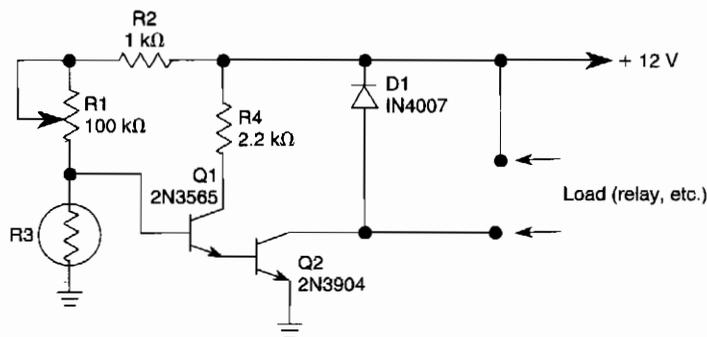


WILLIAM SHEETS

FIG. 51-7

This circuit can control the on/off cycle of a light via a CDS photocell, and turn it off after a pre-set period. The light can only be turned on when CDS cell is in darkness, and it stays on for a time determined by the 555 circuit. On time depends on R1 and C1 and is about 80 seconds with the values shown.

## DARK-ACTIVATED SWITCH

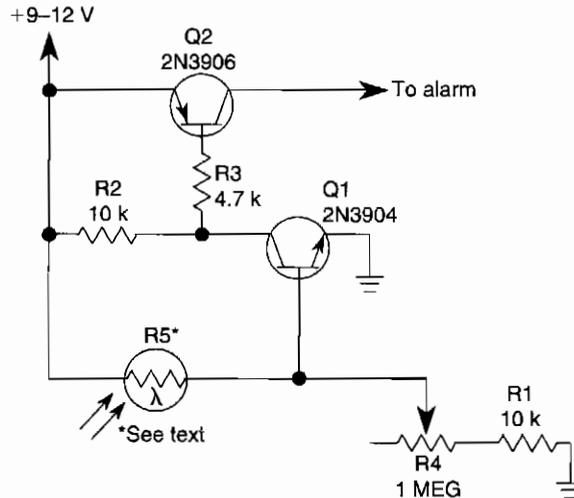


WILLIAM SHEETS

FIG. 51-8

In this circuit, lowering of the light level on the CDS cell turns on Q1 and Q2 which switches on the load which could be a relay, light, etc.

## PHOTOELECTRIC SENSOR



POPULAR ELECTRONICS

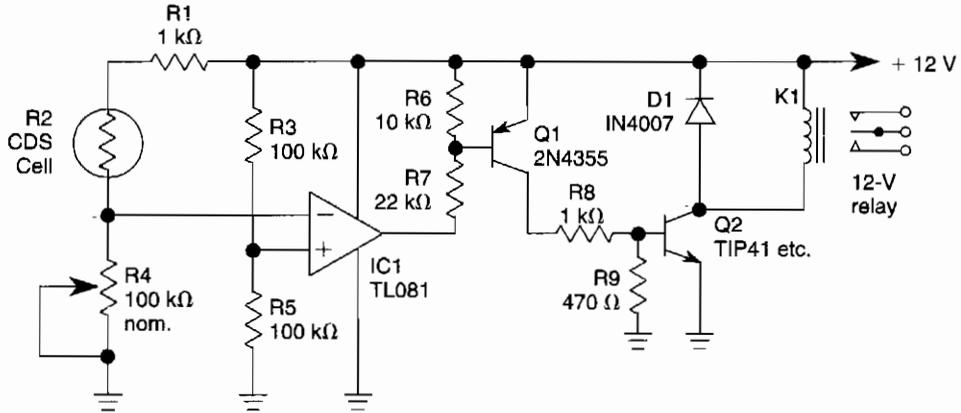
FIG. 51-9

The circuit can be used as a sensor that can trigger an alarm without direct contact being made by the intruder. In this circuit, a visible or invisible light source radiates on the sensor, keeping the detection loop in what could essentially be called a normally closed condition.

As long as the light source striking R5 remains uninterrupted, the switch remains closed. But if an intruder passes between the light source and the sensor, the circuit goes from closed to open, and triggers the alarm.

A light-dependent resistor (LDR), whose resistance varies inversely in with the amount of light hitting its sensitive surface, is used. A bright light aimed at R5 causes its internal resistance to drop as low as a few hundred ohms; in total darkness, the unit's resistance can rise to several megohms. The light-dependent resistor (R5) is connected between the +V supply and the base of Q1. As long as R5 detects light, it supplies ample base current to cause Q1's collector to saturate to near ground level. That also pulls the base of Q2 (a 2N3906 general-purpose pnp transistor) to near ground level, turning it on and clamping its collector to the +V rail.

## PRECISION LIGHT-SENSITIVE RELAY SWITCH

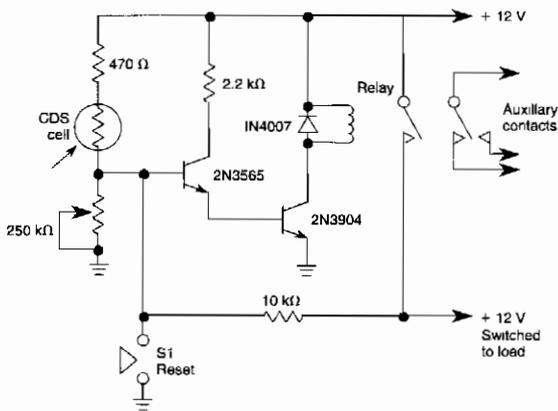


WILLIAM SHEETS

FIG. 51-10

A CDS cell in a bridge circuit with an op amp provides a simple means of operating a relay at a predetermined light level. Potentiometer R4 sets the sensitivity.

### SELF-LATCHING LIGHT-ACTIVATED SWITCH

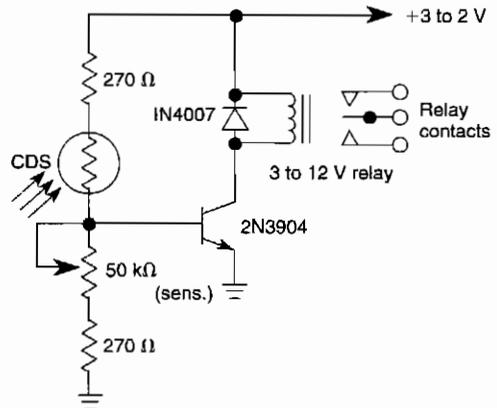


WILLIAM SHEETS

FIG. 51-11

When light strikes the CDS cell it turns on the transistors which activates the relay which latches. Depressing S1 grounds the base of the 2N3565 and the relay resets. The 250 k potentiometer adjusts the sensitivity of the circuit.

### SIMPLE NONLATCHING PHOTOCELL SWITCH

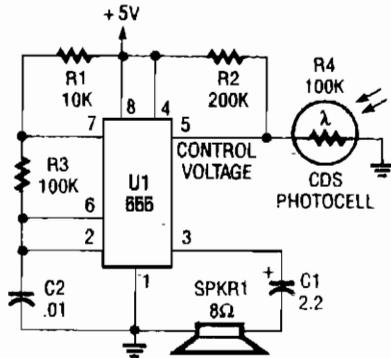


WILLIAM SHEETS

FIG. 51-12

A CDS photocell is used to drive the relay. The circuit operates from a +12 V supply.

## LIGHT-CONTROLLED OSCILLATOR

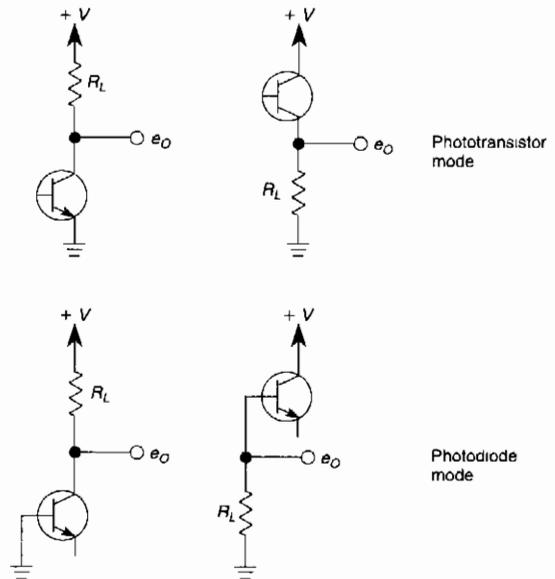


POPULAR ELECTRONICS

FIG. 51-13

This circuit can be used as a light detector and possibly as an aid for the visually handicapped. The frequency of the oscillator is determined by the amount of illumination striking LDR4.

## PHOTOTRANSISTOR CIRCUITS

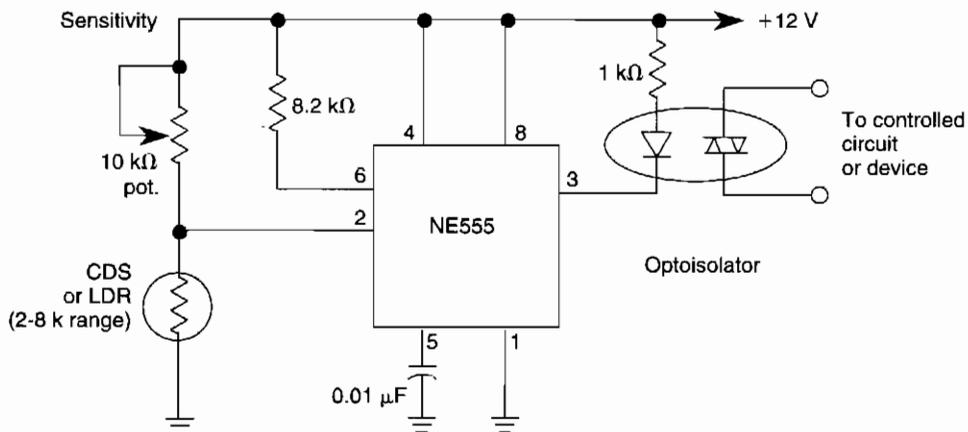


WILLIAM SHEETS

FIG. 51-14

Here are four ways to connect a phototransistor for general use in phototransistor circuits.

## DARK-ACTIVATED RELAY



WILLIAM SHEETS

FIG. 51-15

Configuring a 555 IC as shown yields a dark-activated relay with low hysteresis. CDS or LDR should be in the 2 k to 8 k range at desired light level.

# 52

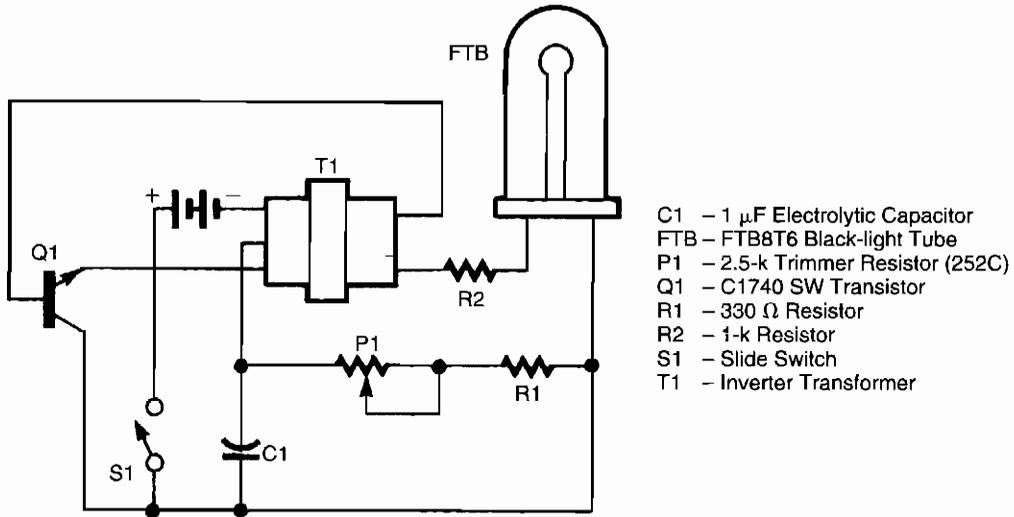
## Light Sources

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Battery-Operated Black Light  
Solid-State Light Sources

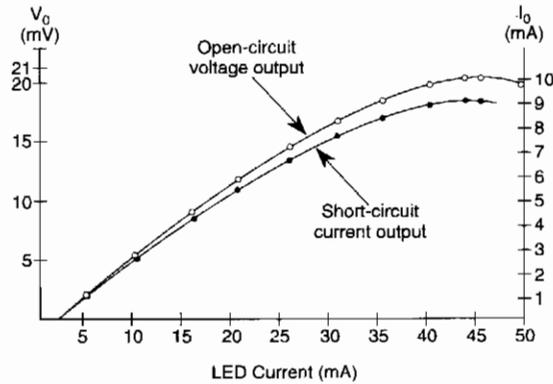
## BATTERY-OPERATED BLACK LIGHT



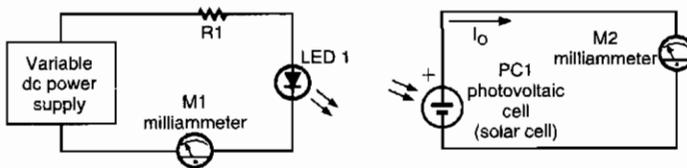
The battery-operated black light uses a “U”-shaped, unfiltered, black-light tube, which requires approximately 250 Vac to operate. To create the 250-Vac 6-V battery, the circuit uses a one-transistor blocking oscillator that drives a ferrite inverter transformer. A blocking oscillator turns itself off after one or more cycles. In this circuit, it consists of C1, P1, Q1, R1, and T1. The oscillations are sustained because the base of Q1 is connected to one of the windings on T1.

Transformer T1 is a step-up transformer that consists of a ferrite core, which has a few turns on the primary and many turns on the secondary. The oscillating (ac) output of Q1 is fed to T1, which, because of its large turns ratio, converts the low-voltage signal into a high-voltage alternating current, which is coupled through resistor R2 to the black-light tube. Resistor R1 and trimmer resistor P1 limit the current flowing through the circuit. As the control on P1 is rotated, more current flows in the circuit, producing a brighter light output.

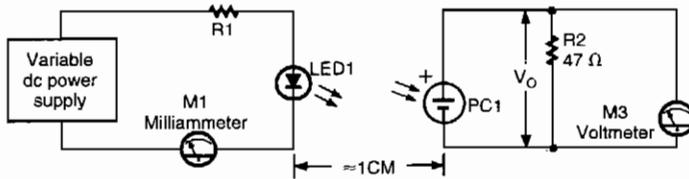
## SOLID-STATE LIGHT SOURCES



A

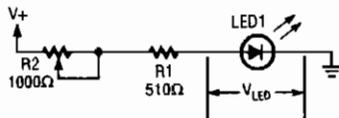


B

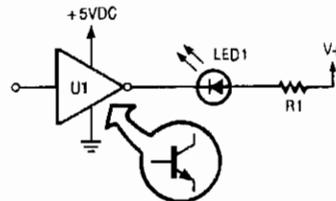


C

In A we show two LED output curves derived by experiment. The circuit in B was used to get the data for the short-circuit current plot, while the circuit in C yielded the data for the open-circuit voltage plot.

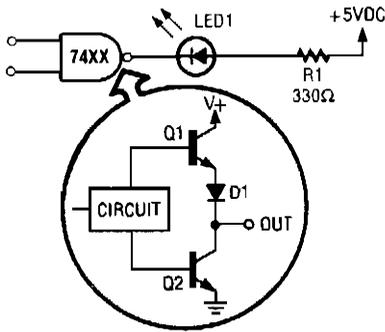


Since LED intensity is linearly related to the input current this circuit can be used to vary the LED's brightness via R2.



You can drive an LED with an open-collector TTL inverter. The inverter shown must ground the LED to turn it on.

The 12 LED circuits shown are useful for experiments and applications of LED devices. The captions are self-explanatory and illustrate many common LED applications.



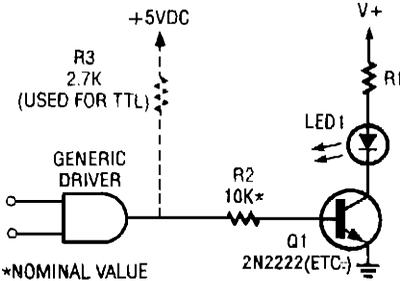
A totem-pole TTL output can drive an LED by grounding the LED's cathode, much like the open-collector driver.



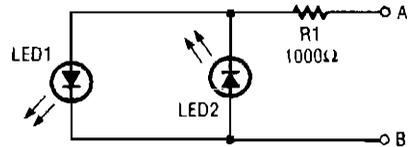
Unlike TTL devices, integrated circuits made with CMOS technology can source enough current to power an LED as shown here.



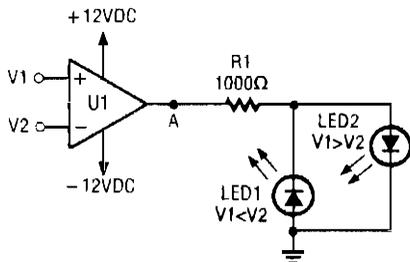
A CMOS-based gate can sink current much like a TTL gate in order to activate an LED.



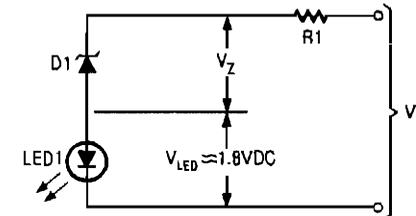
This driver circuit will work for either CMOS or TTL gates, but you don't need R3 in a CMOS-driven circuit.



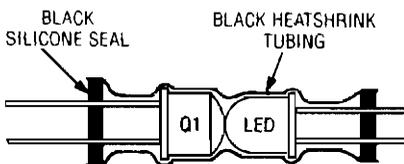
This simple polarity checker is easy to build and can be of help if you don't know much about a circuit's wiring or grounding convention.



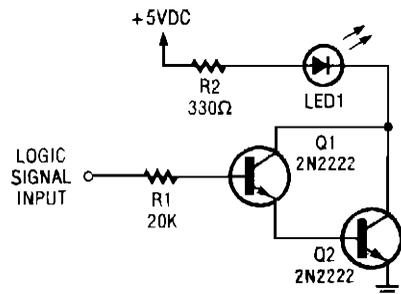
This is a bipolar output indicator that lets you know if one voltage is greater than, less than, or equal to another.



This is a simpler voltage-level sensor than that shown back in Fig. 9. To use it you have to know the polarity of the voltage it is to monitor.



You can "roll your own" optocoupler by using some heat-shrink tubing, an LED, and optical transistor, and silicon sealant as shown here.



This high sensitivity Darlington LED driver circuit can be used as a simple logic probe. You may have to vary the value of R1 to suit the circuit under test.

# 53

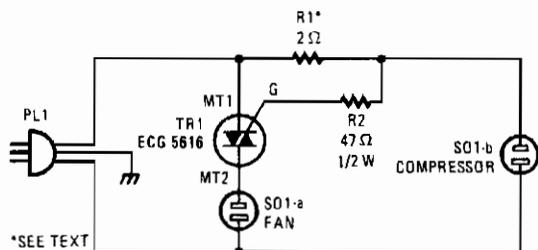
## Load-Sensing Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Load-Sensing Solid-State Switch  
Load-Sensing Trigger

## LOAD-SENSING SOLID-STATE SWITCH

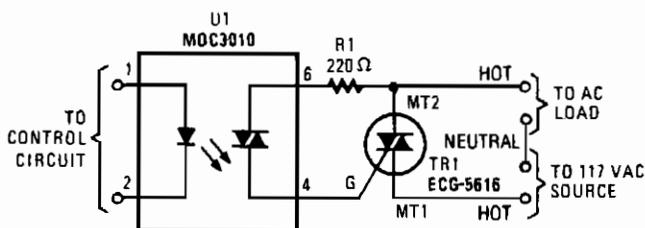


When this triac circuit senses current flow through SO1-a, it activates the device plugged into SO1-b. The values of the resistors must be chosen for the specific devices to be plugged in.

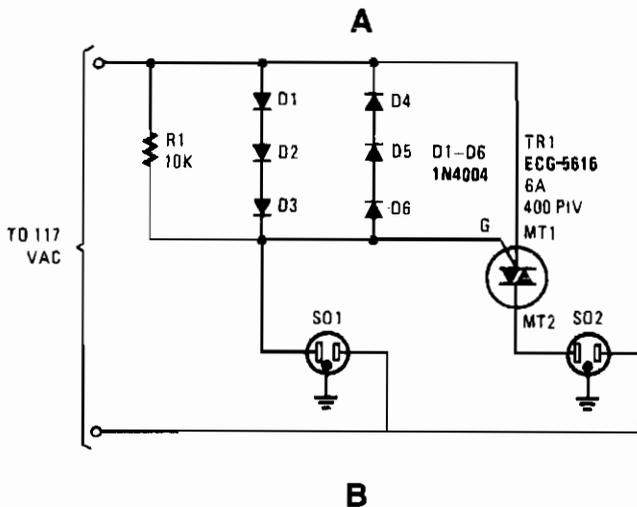
POPULAR ELECTRONICS

FIG. 53-1

## LOAD-SENSING TRIGGER



*Triacs can be controlled by low-power circuits through Triac-driver optoisolators as shown here.*



POPULAR ELECTRONICS

FIG. 53-2

A device plugged into SO1 causes a voltage-limited gate trigger for triac TR1, and causes power to be applied to SC2.

# 54

## Mathematical Circuits

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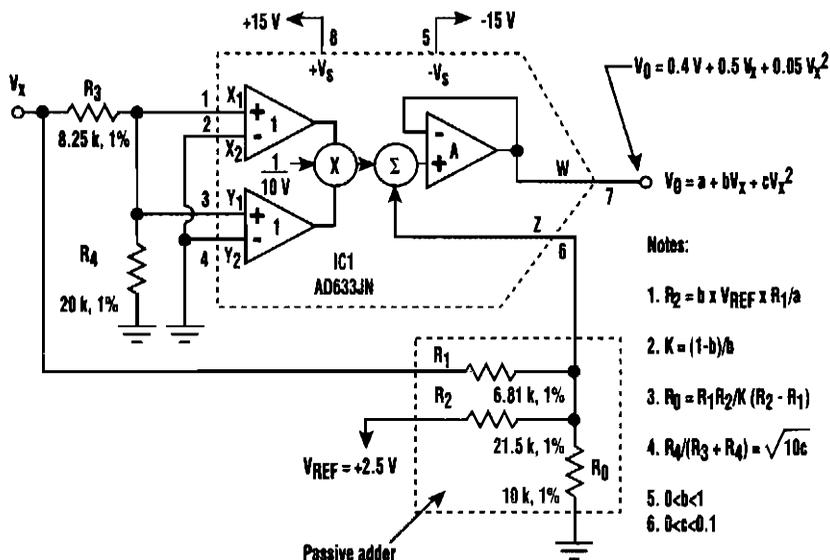
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Second-Order Polynomial Generator

Polar-to-Rectangular Converter and Pattern Generator for Radio Direction Finding

Root Extractor

## SECOND-ORDER POLYNOMIAL GENERATOR



ELECTRONIC DESIGN

FIG. 54-1

By using a circuit built with a single analog multiplier and five precision resistors, an output voltage ( $V_o$ ) can be made to create a second-order polynomial.

The circuit implements the following quadratic:

$$V_o = a + bV_x + cV_x^2$$

The input terminals of IC1 are connected to create a positive square term and present the  $V_x$  signal to the output with a 1-10-V scale factor. Incorporating the voltage-divider network (resistors  $R_3$  and  $R_4$ ) in the input signal path provides additional attenuation adjustment for the coefficient ( $c$ ) of the square term in the quadratic. Then, the passive adder (resistors  $R_1$ ,  $R_2$ , and  $R_0$ ) is wired to IC1's internal summing circuit to generate the polynomial's other two terms; the offset term ( $a$ ) and the linear coefficient ( $b$ ).



# 55

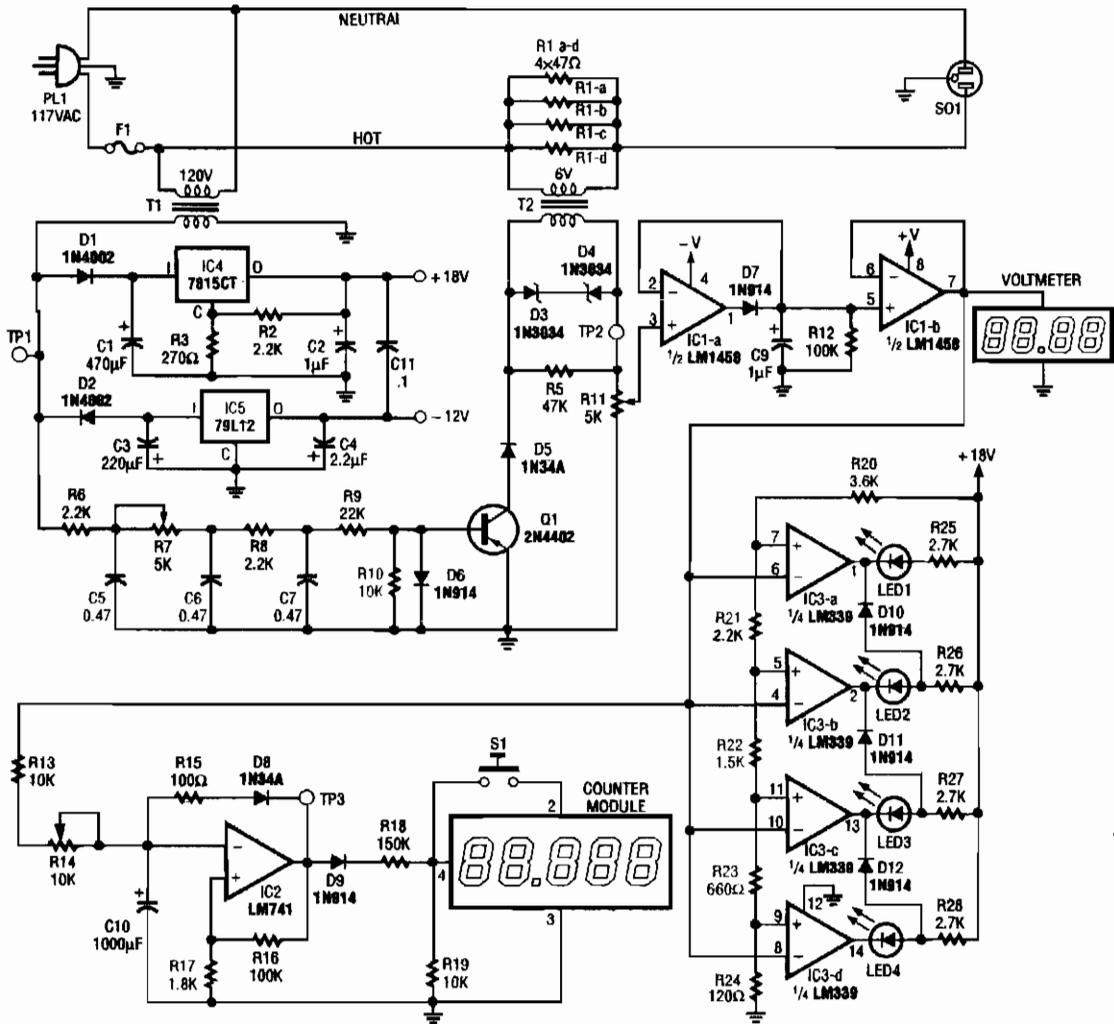
## Measuring and Test Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Energy Consumption Monitor	Signal Generator
Harmonic Distortion Analyzer	Simple Signal Tracer
Watch Tick Timer	DVM Adapter for PC
Visual Continuity Tester	Simple Digital Logic Probe
RC Decade Box	S Meter for Communications Receivers
Digital Altimeter	LED Expanded Scale Voltmeter
Electronic Scale	1-kHz Harmonic Distortion Meter
Radar Calibrator	Line Voltage-to-Multimeter Adapter
Cable Tester	Audible Logic Tester
Simple Curve Tracer	Short Tester for 120-V Equipment
Voltage Level Circuit	Digital Pressure Gauge
Low-Drift dc Voltmeter	Simple Short Finder
Light Meter	Voltage Monitor
Mercury Switch Tilt Detector	Linear Inductance Meter
50-MHz RF Bridge	DeBounce Circuit
ac Watts Calculator	ac Wiring Locator
Audio-Frequency Meter Circuit	Audible Continuity Tester
One-IC Capacitance Tester	ac Outlet Tester
Transistor Checker	JFET Voltmeter
Low-Current Ammeter	Check for Op-Amp dc Offset Shift
Analog Frequency Meter	Continuity Tester for Low-Resistance Circuits
Electromagnetic Field Sensor	Supply Voltage Monitor
Magnetic Proximity Sensor	Audio-Frequency Meter
High-Impedance Voltmeter	Zener Diode Test Set
Fast Video-Signal Amplitude Measurer	

## ENERGY CONSUMPTION MONITOR

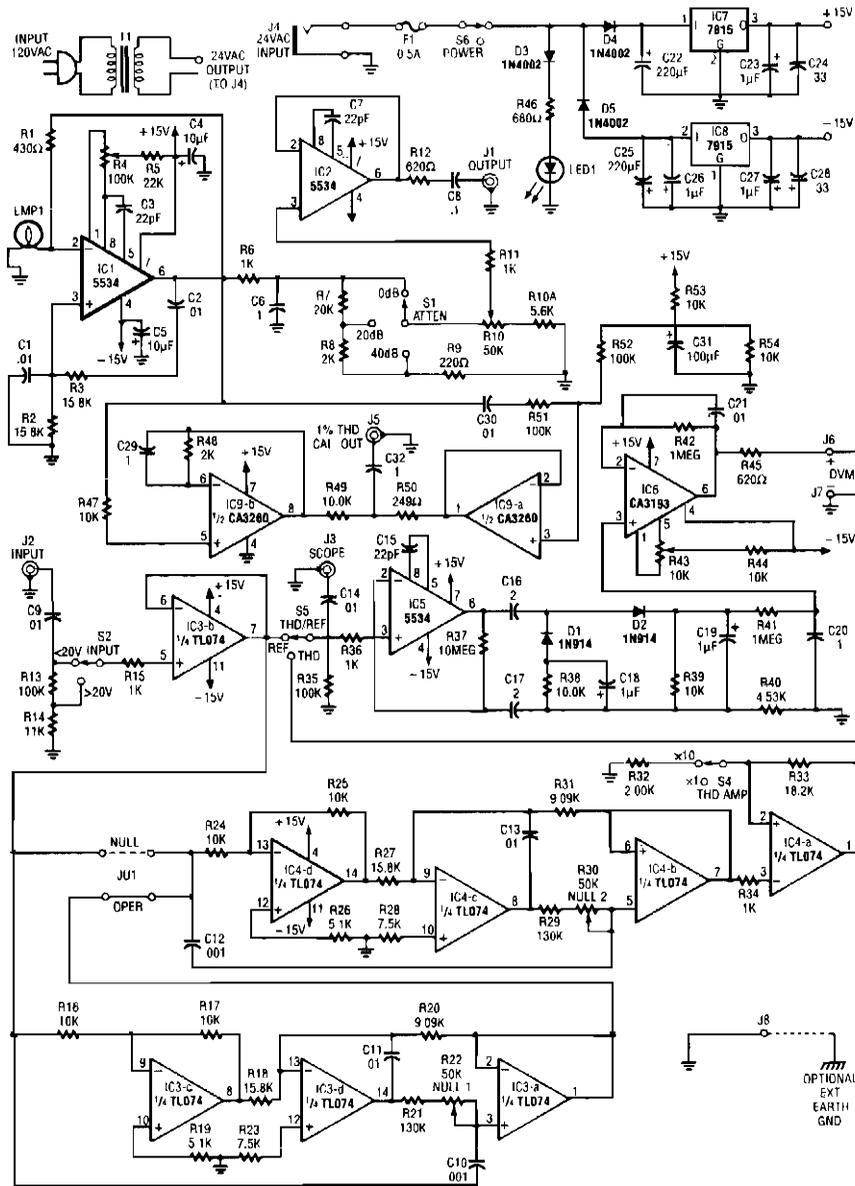


RADIO-ELECTRONICS

FIG. 55-1

The ECM circuit consists of four sections, as shown in the block diagram. A power converter generates a voltage that is proportional to the true or real power consumed by the load. That voltage feeds both a bargraph and a voltage-to-pulse converter. The bargraph gives an approximate indication of the amount of power used, and the voltage-to-pulse converter produces a pulse whose frequency is proportional to the power. The pulse triggers the counter module, which displays the cost of powering the monitored load.

# HARMONIC DISTORTION ANALYZER



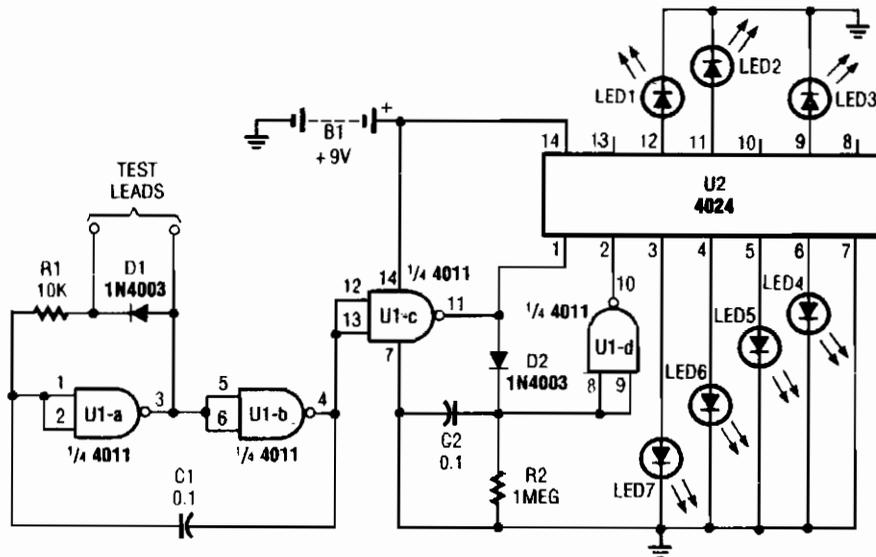
RADIO-ELECTRONICS

FIG. 55-2

The circuit includes a low-distortion, 1-kHz oscillator and will measure THD at a user selected voltage level for voltage amplifiers, or for checking amplifiers of power levels to 600 W. It will detect THD levels of .005% (-86 dB). A built-in one-percent THD calibrator is included. The output device is a digital multimeter (DMM).



## VISUAL CONTINUITY TESTER



POPULAR ELECTRONICS

FIG. 55-4

By judging the rate at which a particular LED flashes, you'll be able to estimate the resistance. The circuit consists of two IC's (1 4011 CMOS quad 2-input NAND gate, U1; and a 4024 binary counter, U2), seven LEDs, and a handful of additional components. All of the gates in U1 are wired as inverters.

Two of the inverters (U1-a and U1-b) comprise an astable-multivibrator (free-running oscillator) circuit, whose operating frequency depends on the amount of resistance detected between the test probes. Feedback from the output of the oscillator (at pin 4 of U1-b) back to the input of the circuit (at U1-a, pins 1 and 2) is provided via C1. Resistor, R1, along with the unknown resistance between the test probes, completes the RC timing circuit. The frequency of the oscillator decreases as the resistance between the test probes increases.

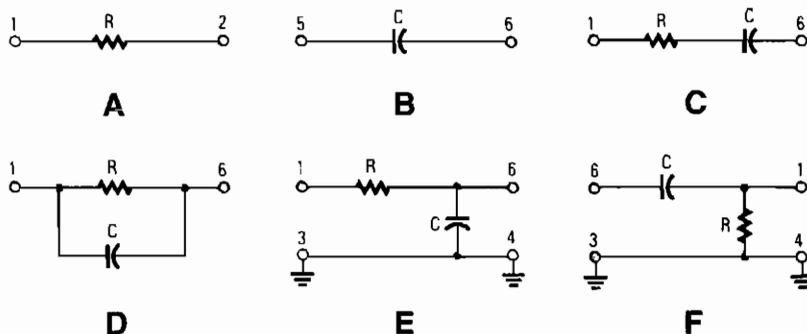
The output of the oscillator is fed to pin 12 and 13 of U1-c, the output of which then divides along two paths. In the first path, U1-c's output is applied to the clock input of U2 (a 4024 binary counter) at pin 1; in the other path, the signal is fed through D2 and across capacitor C2, causing it to begin charging. The charge on C2 is applied to U1-d at pins 8 and 9. The output of that inverter (U1-d) is fed to the reset terminal (pin 2) of U2. If there is continuity or a measurable resistance between the test probes, U2's reset terminal is pulled low, triggering the counter and allowing it to process the input pulses (count).

The rate of the count is proportional to the resistance between the test probes. If the resistance between the test probes is low, the counter advances slowly. The counter provides a 7-bit binary output that is wired to seven LEDs.

When the test probes are placed across a short circuit, LED7 flashes. If the tester is placed across a resistance of, for example, 2 MΩ, LED1 will flash. In either case, the LED whose assigned value most closely corresponds to the resistance connected between the two probes will flash continually at a steady pace, while the other LEDs will seem to flash intermittently.



## RC DECADE BOX (Cont.)



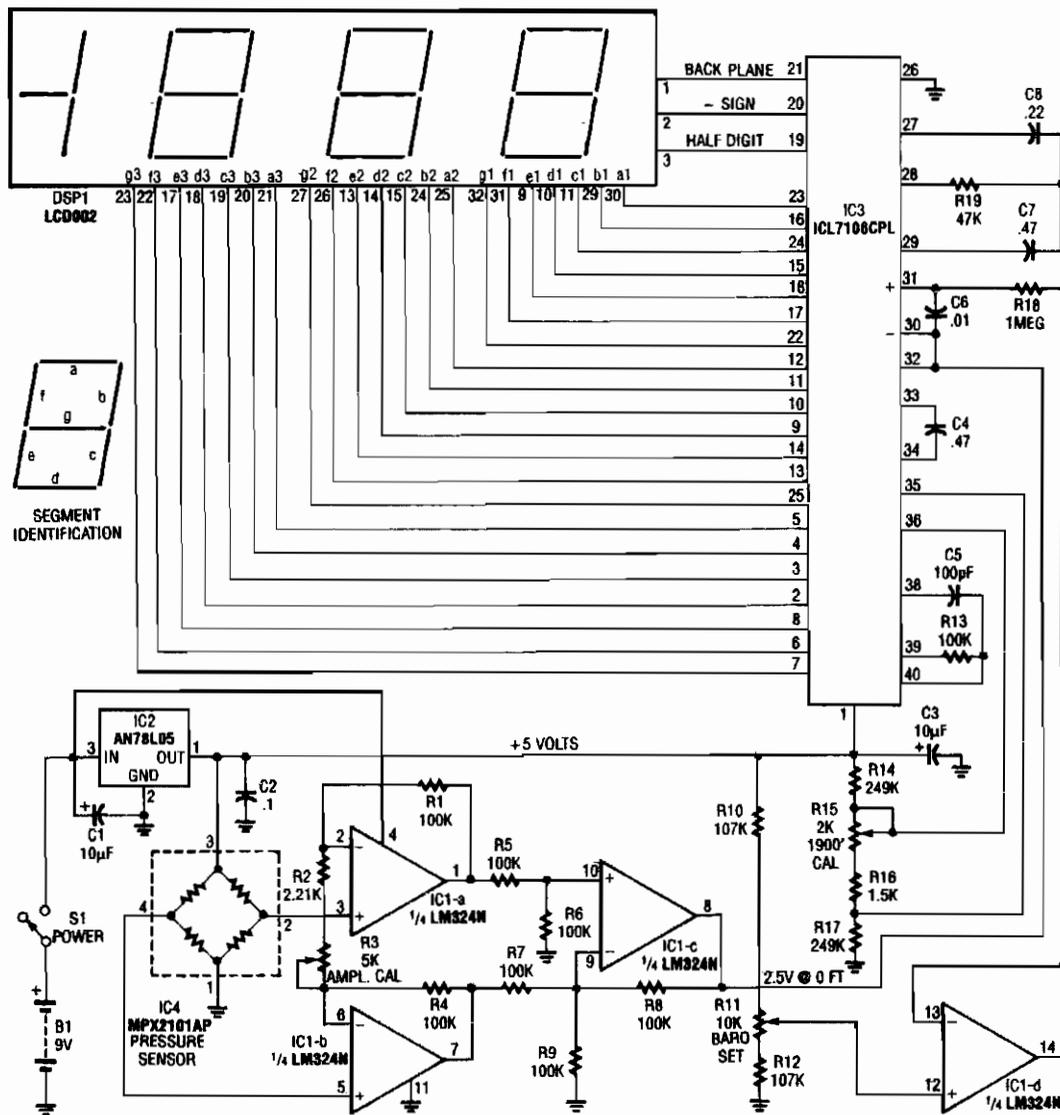
THE VARIOUS CONFIGURATIONS are set using S13: (a) resistor only and (b) capacitor only (both in position R/C); (c) series RC (position SER); (d) parallel RC (position PAR); (e) Low-Pass Filter (position LPF); and (f) High-Pass Filter (position HPF). The terminal numbers listed are those of binding-posts BP1–BP6.

**TABLE 1—DECABOX TERMINAL CONNECTIONS**

Configuration	S13 Position	IN/GND	OUT/GND
Resistance	R/C	IN: BP1	OUT: BP2
Capacitance	R/C	IN: BP5	OUT: BP6
Series RC	SER	IN: BP1	OUT: BP6
Parallel RC	PAR	IN: BP1	OUT: BP6
Low Pass Filter (Integrator)	LPF	IN: BP1 GND: BP3	OUT: BP6 GND: BP4
High Pass Filter (Differentiator)	HPF	IN: BP6 GND: BP3	OUT: BP1 GND: BP4

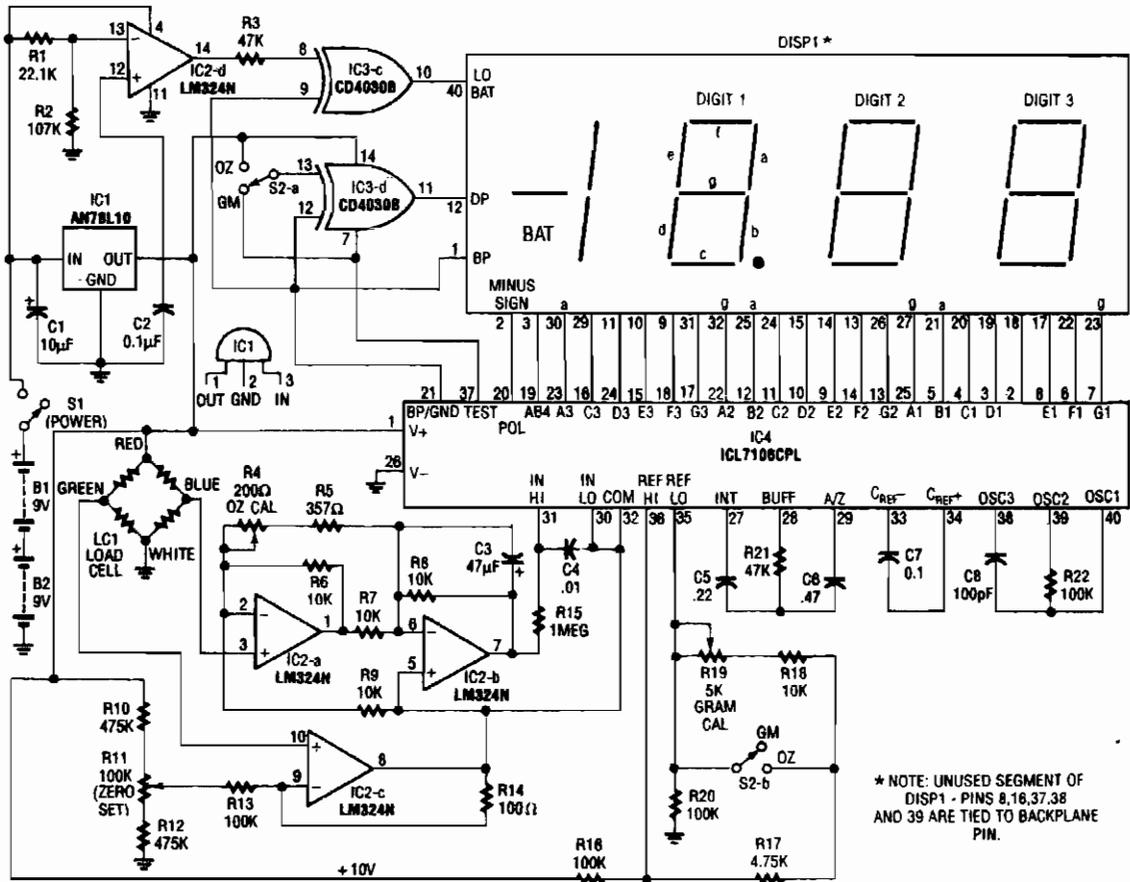
This decade box can be set for any resistance value between 10  $\Omega$  and 11.1 M $\Omega$  in 10- $\Omega$  steps. A switch can be used to configure several RC configurations. Use close tolerance components in the circuit. If possible, check components with an accurate bridge or other means to ensure accuracy.

# DIGITAL ALTIMETER



A pressure sensor (IC4) is used with a dc amplifier to convert the bridge output (IC4) to a single-ended voltage. IC1d provides a reference voltage for setting barometric pressure. IC3 is an A/D converter manufactured by Intersil. This drives an LCD module. Calibration reads out in fact. A vacuum pump and a water-based manometer can be used for sensor calibration.

## ELECTRONIC SCALE



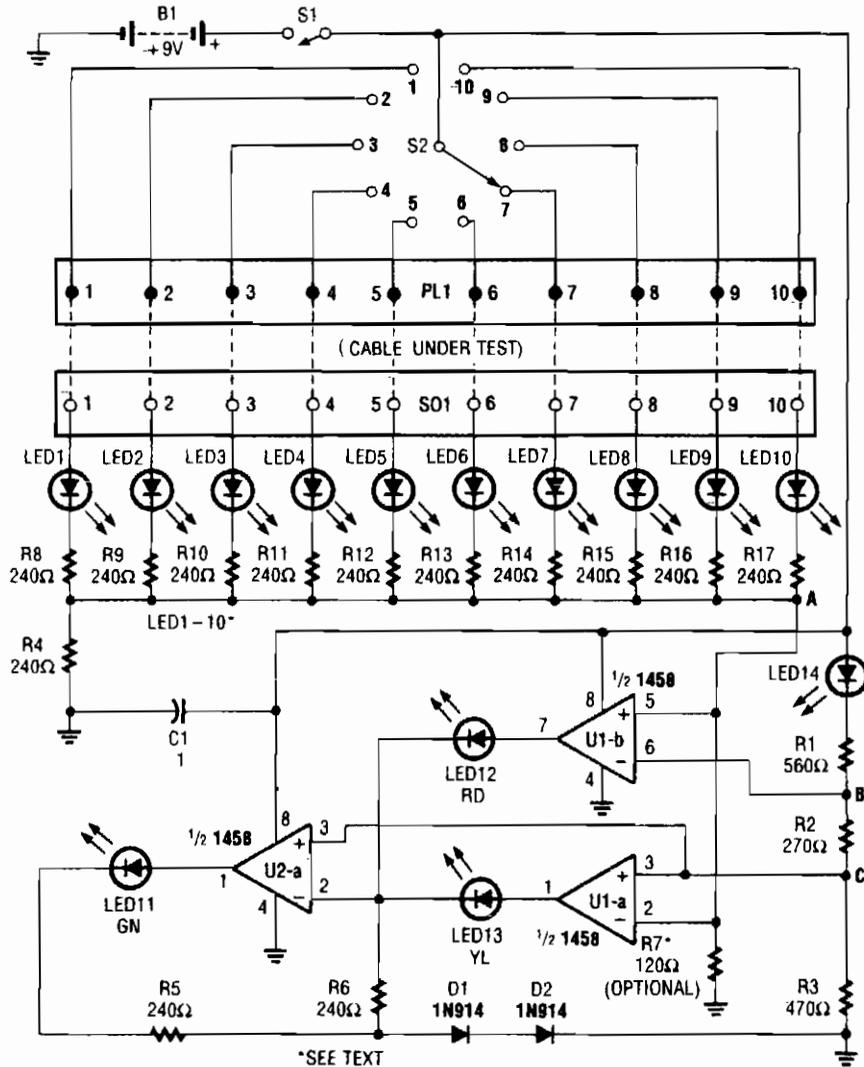
ELECTRONICS NOW

FIG. 55-7

An electronic scale using a pressure transducer (load cell) and an analog-digital (A/D) converter to drive a digital display is shown. The scale range depends on load cell. Display is calibrated in appropriate units. Components are on main circuit and display boards. The off-board controls are on the front panel and case. The cell in this scale is rated for 1.3 pounds (600 grams).



## CABLE TESTER

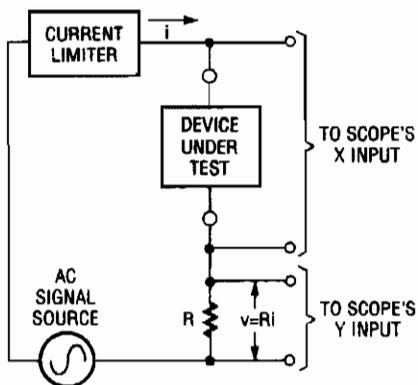


POPULAR ELECTRONICS

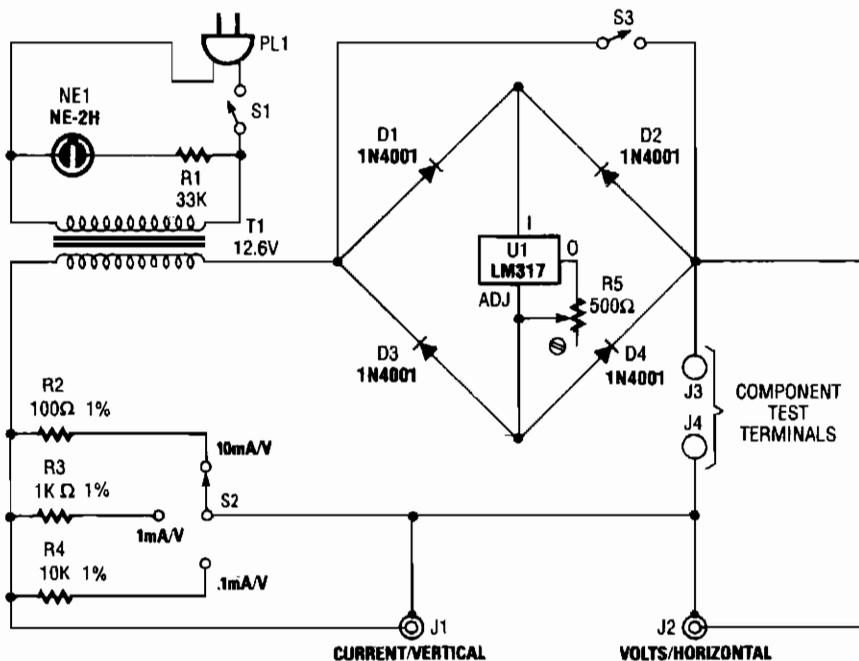
FIG. 55-9

At the heart of the cable tester are two op amps, which are used as a window comparator to indicate a short- or open-circuit condition. A third op-amp comparator is used to indicate a good circuit (i.e., neither open nor shorted). Colored LEDs are used to show the condition of individual conductors within the cable under test; a red one to indicate a short between conductors, a yellow one to identify an open conductor, and a green one to signify that the conductor is okay. Individual LEDs of a bar-graph display are used to show which conductor in the cable is being tested.

## SIMPLE CURVE TRACER

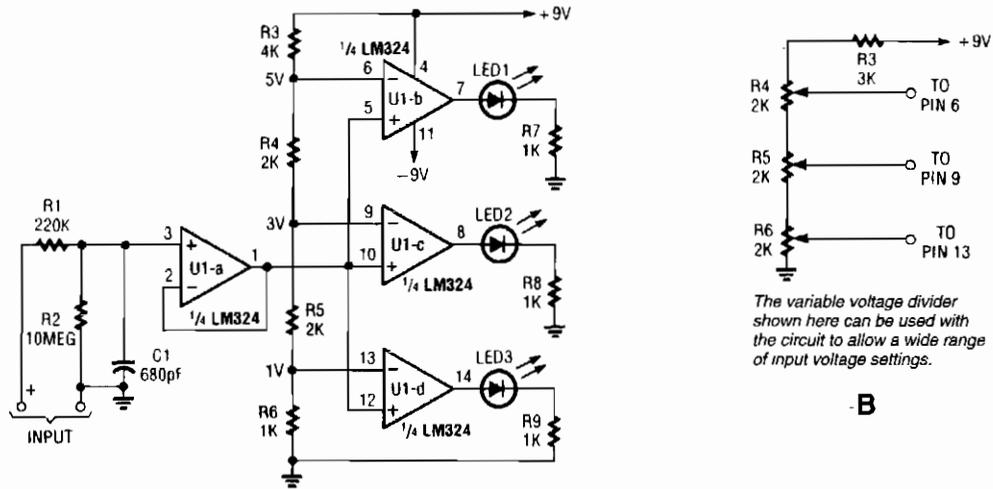


*This is a simple block diagram of the EZ-Curve. Current-limited AC signals are passed through both the device under test and a precision resistor to yield current and voltage readings.*



Useful for checking diodes, transistors, triacs, SCRs, resistors, and LEDs, this curve tracer should prove useful in the experimenter's lab. It displays the volt-ampere characteristic of a two-terminal device on an oscilloscope.

## VOLTAGE LEVEL CIRCUIT



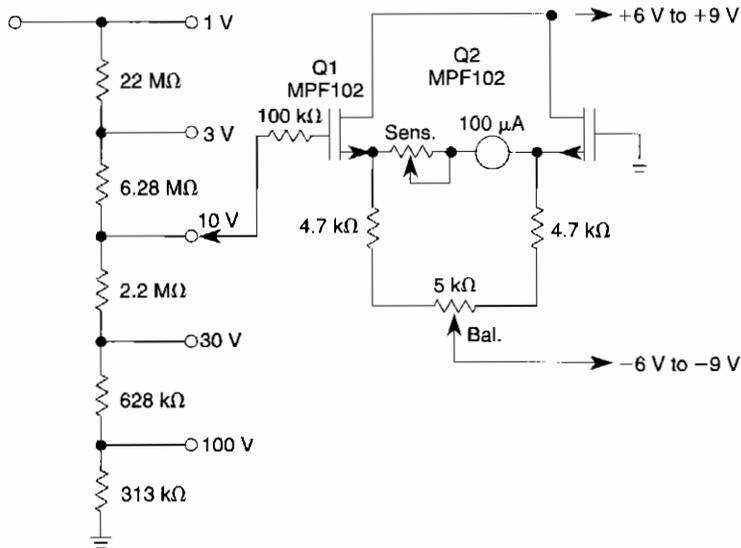
POPULAR ELECTRONICS

A

FIG. 55-11

A DC op amp and a comparator with a ladder reference divider allow a dc input voltage to light one or more LEDs, depending on voltage levels.

## LOW-DRIFT dc VOLTMETER

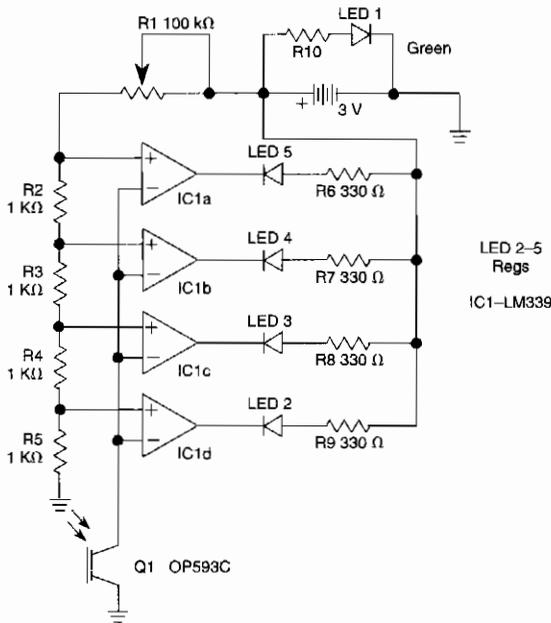


WILLIAM SHEETS

FIG. 55-12

This voltmeter uses a pair of JFETs in a balanced-bridge source-follower amplifier circuit. Q1 and Q2 should be matched within 10% for  $I_{DSS}$ . This minimizes meter drift and maintains bridge balance over temperature.

## LIGHT METER



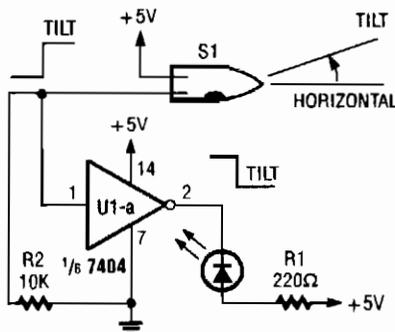
WILLIAM SHEETS

FIG. 55-13

The outputs from the comparators will swing, in sequence, from high to low as the input voltage rises above the reference voltage applied to each comparator. The output LEDs will then switch on in sequence as the voltage rises.

The inverting inputs of the comparators are connected in common to the collector of photo-transistor Q1. When Q1 is illuminated, its collector-emitter junction conducts, thereby placing all the inverting inputs within a few millivolts of ground. For most settings of R1, each of the four reference voltages exceeds the value. Therefore, when Q1 is illuminated, the output from each comparator is high and its respective indicator LED is off.

## MERCURY SWITCH TILT DETECTOR

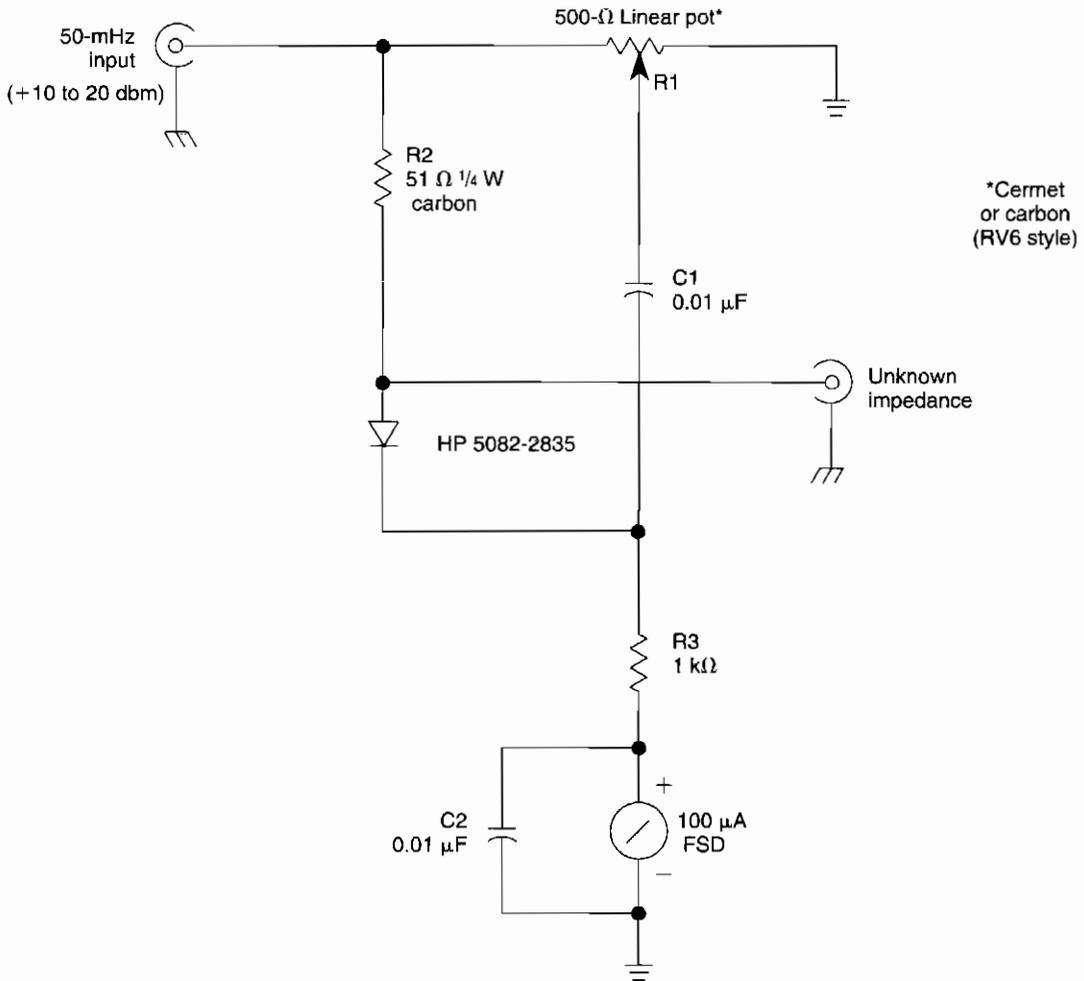


POPULAR ELECTRONICS

FIG. 55-14

If the mercury bulb in this circuit is tipped, U1-a will light LED1 by going low, indicating a "tilted" condition.

### 50-MHz RF BRIDGE

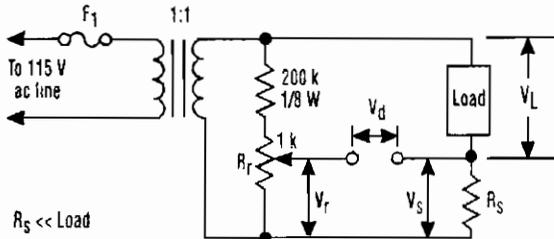


WILLIAM SHEETS

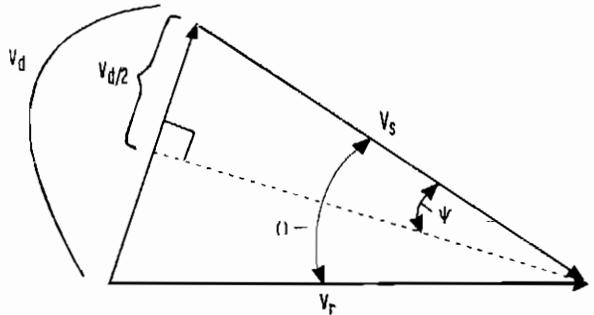
FIG. 55-15

The bridge shown was used for measurements on 50-MHz amateur radio antennas. R1 is a miniature 500  $\Omega$  linear potentiometer. The unknown impedance is compared to R2, a 51- $\Omega$  resistor. An external signal source is required.

## ac WATTS CALCULATOR



The load's power factor, which is the cosine of the phase angle between the voltage across the load current, can be calculated simply with this circuit. A 1:1 isolation transformer is used to prevent direct contact with the line



By properly adjusting  $R_r$ , the vector diagram of voltages  $V_s$ ,  $V_d$ , and  $V_r$  forms an isosceles triangle, which simplifies the power calculation.

ELECTRONIC DESIGN

FIG. 55-16

The method basically consists of determining the power factor of the load—the cosine of the phase angle between the voltage across the load and the load current. Using a simple circuit, that angle can be calculated quite simply.

This circuit uses a 1:1 isolation transformer to prevent direct contact with the line. It is wise to proceed with caution whenever voltages of this magnitude are utilized in a test setup, even though the voltages that will be measured are usually below 1 V.

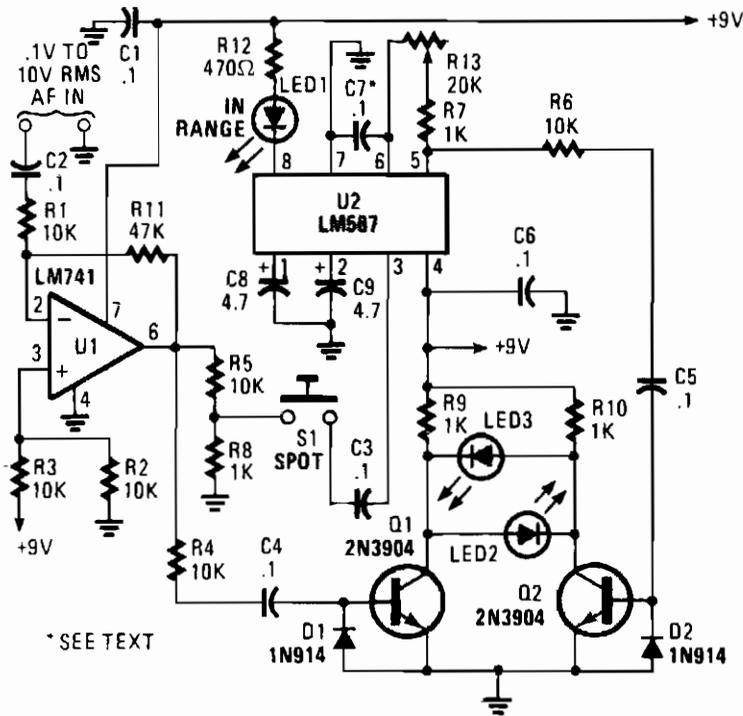
$R_s$  is a circuit-sense resistor and  $R_r$  is a multi-turn potentiometer. The voltage across  $R_r$  is approximately 0.5% of the line voltage, which should be sufficient for most applications.

$R_r$  is adjusted so that  $|V_r| = |V_s|$ ; then  $V_d$  is measured. In the vector diagram according to Kirchhoff's voltage law,  $V_s$ ,  $V_d$ , and  $V_r$  form a triangle, which becomes isosceles by adjusting  $R_r$ .  $V_s$  is in phase with the load current and  $V_r$  is essentially in phase with the load voltage.

The power delivered to the load can be calculated as follows:

$$\begin{aligned}
 P_L &= V_L \times I_L \times \cos \theta \\
 &= V_L \times (V_s/R_s) \times \cos [2 \sin^{-1} (V_d/2V_s)] \\
 [\theta &= 2 \psi = 2 \sin^{-1} (V_d/2V_s)]
 \end{aligned}$$

## AUDIO-FREQUENCY METER



POPULAR ELECTRONICS

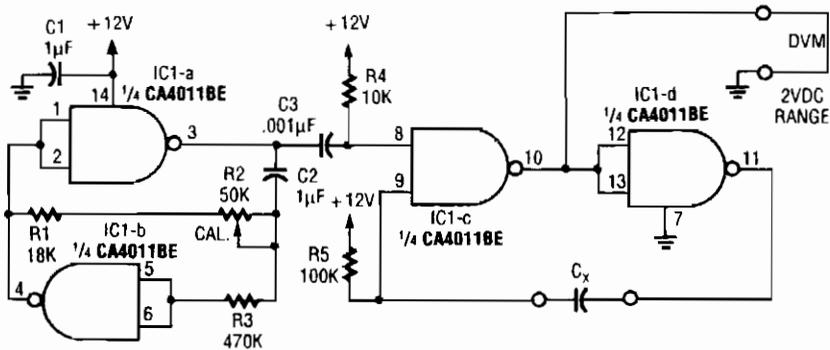
FIG. 55-17

This meter differs from the norm in that it does not use a D'Arsonval movement or digital display to give a reading of the input frequency. Instead, the measured frequency is read from a hand-calibrated dial.

Any audio signal applied to the circuit is amplified by U1 and the resulting output is divided along two paths. In one path, the output signal is applied to the mixer; in the other path, the signal is applied to the input of U2 through S1 (a normally open pushbutton switch).

The portion of the amplifier signal that is fed to the mixer is applied to the base of Q1, causing it to toggle on and off at the signal frequency. In the other path, when S1 is pressed, a portion of the op amp's output is applied to U2. If the signal is within the range of U2's internal oscillator's operating frequency, LED1 lights, and a signal is fed to the base of Q2. If the two signals arriving at the mixer do not match exactly, LED2 and LED3 light. That means that the circuit must be fine tuned, which is accomplished by releasing S1 and fine tuning R13 until LED2 and LED3 go out. The dial setting at that point gives the frequency of the input signal to within 1 Hz (or as close as the calibrated dial will allow).

## ONE-IC CAPACITANCE TESTER

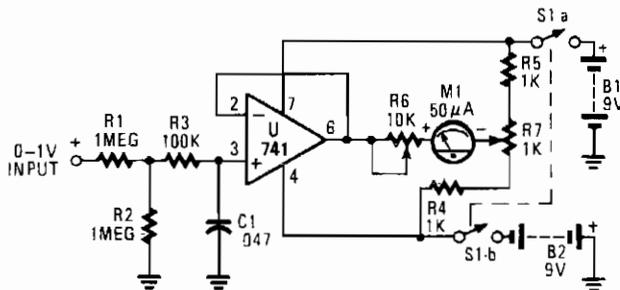


RADIO-ELECTRONICS

FIG. 55-18

This circuit can be used to match capacitors, etc. The dc output voltage is related to the capacitance values of  $C_x$ . The circuit values shown are for capacitors in the  $0.01\text{-}\mu\text{F}$  order of magnitude, but they can be changed for lower or higher values.

## TRANSISTOR CHECKER



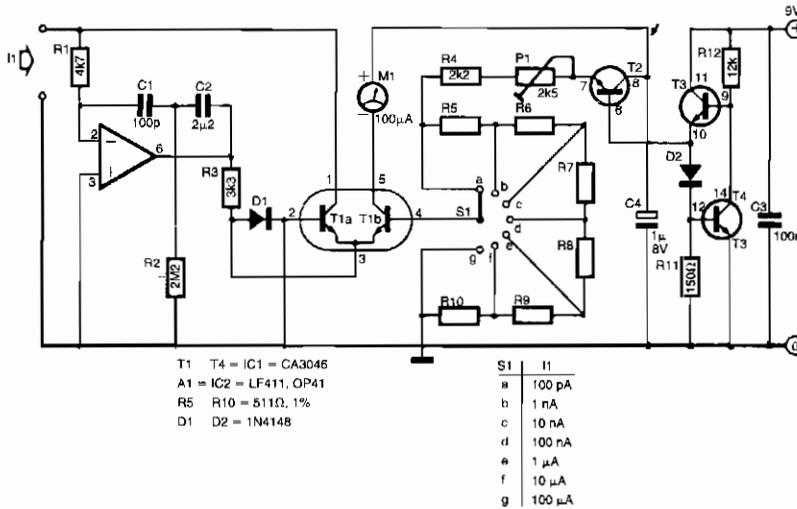
POPULAR ELECTRONICS

FIG. 55-19

The circuit is built around a 741 general-purpose op amp that is configured as a voltage follower; with the components shown, the op amp has a voltage gain of one. The output of the 741 is used to drive a  $50\text{-}\mu\text{A}$  meter movement. Potentiometer R7 is used to zero the meter and R6 sets the meter's full-scale reading.

Calibrating the meter is a snap. With no input applied to the circuit, set R6 to mid-position and adjust R7 to zero the meter. Once that is done, apply a positive 1-Vdc voltage to the input and adjust R6 for a full-scale reading. The voltmeter can be adjusted to read both positive and negative voltages by adjusting R7 for a center scale reading at the meter's zero position and a positive 1-V reading at the meter's full-scale position.

## LOW-CURRENT AMMETER

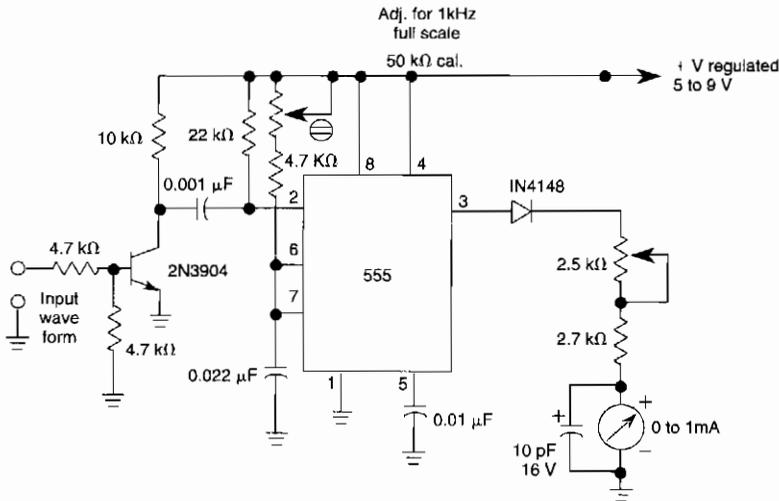


303 CIRCUITS

FIG. 55-20

Without using high-value precision resistors, this circuit uses a current mirror, T1a/T1b. Currents of 100 pA can be measured with this circuit. M1 is a 100-mA meter. Make sure to use a high-quality PC board and low-leakage circuit construction.

## ANALOG FREQUENCY METER

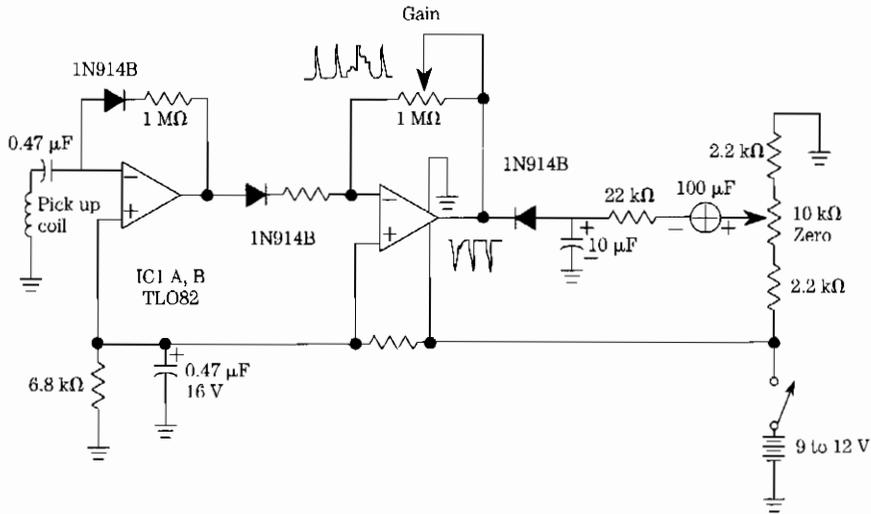


WILLIAM SHEETS

FIG. 55-21

This 1-kHz linear-scale analog frequency meter circuit uses the 555 as a pulse counter. Frequency is read on M1, (or 1 mA meter) which can be calibrated to read 0 to 1 kHz.

## ELECTROMAGNETIC FIELD SENSOR

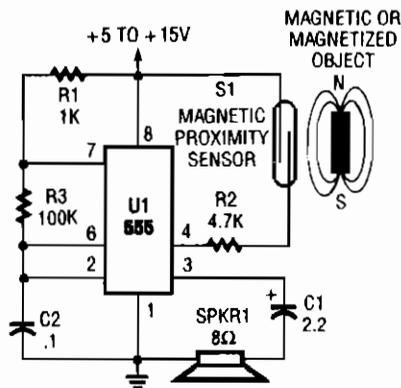


WILLIAM SHEETS

FIG. 55-22

A telephone pick-up coil is used as a sensing coil. Any 60-Hz hum picked up by the sensing coil is rectified, amplified, and detected, and then drives a meter.

### MAGNETIC PROXIMITY SENSOR

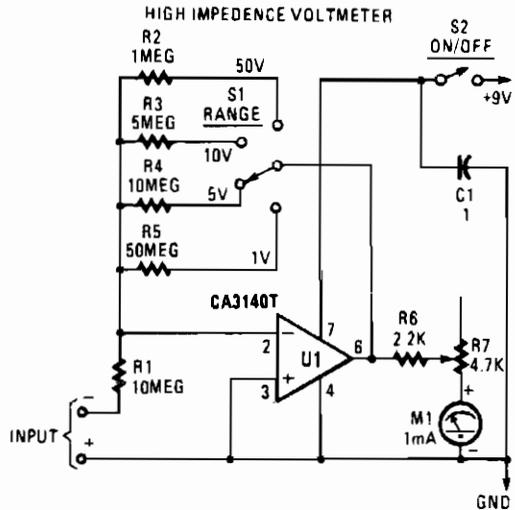


POPULAR ELECTRONICS

FIG. 55-23

A magnetic need switch enables a 555 oscillator, which drives a speaker. C2 can be varied for different tone frequencies.

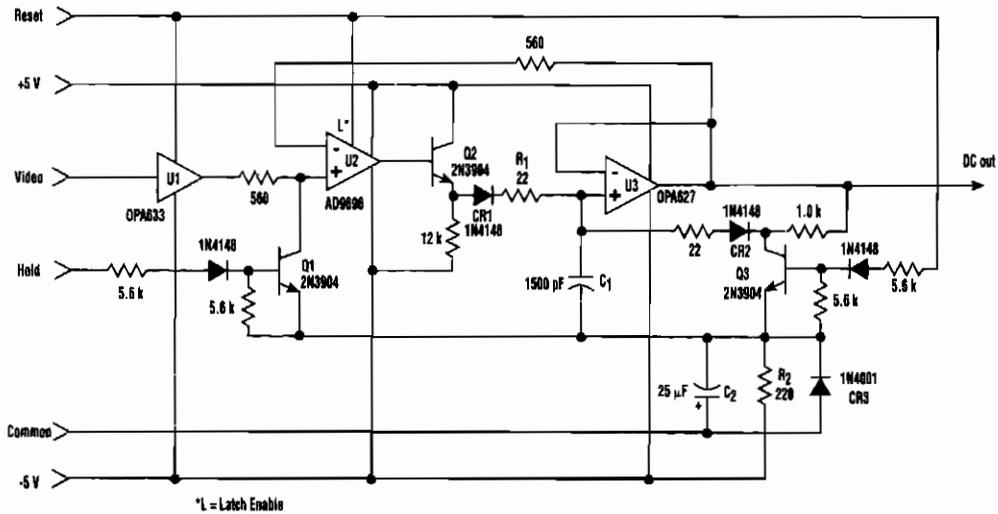
### HIGH-IMPEDANCE VOLTMETER



POPULAR ELECTRONICS

FIG. 55-24

## FAST VIDEO SIGNAL AMPLITUDE MEASURER

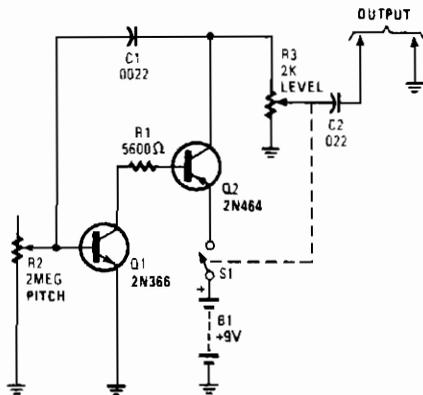


**ELECTRONIC DESIGN**

**FIG. 55-25**

Video-signal amplitude can be measured with this simple circuit, which is basically a modified standard peak detector. The device can verify RGB generated by video RAMDACs. U1 is a high-speed buffer and U2 is a latched comparator. C1 is a hold capacitor. Reset is performed by Q3. U2 has a latch that maintains the last comparator state. The reset holds the comparator output low during the reset operation. The dc output voltage is equal to the signal's maximum amplitude.

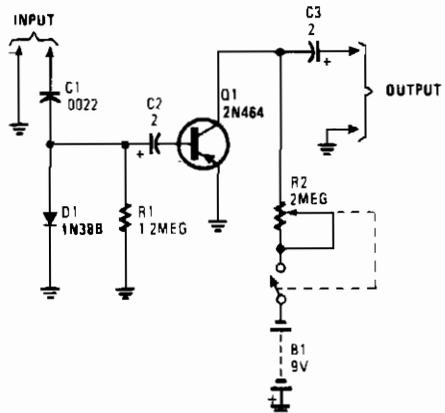
### SIGNAL GENERATOR



**POPULAR ELECTRONICS**

**FIG. 55-26**

### SIMPLE SIGNAL TRACER



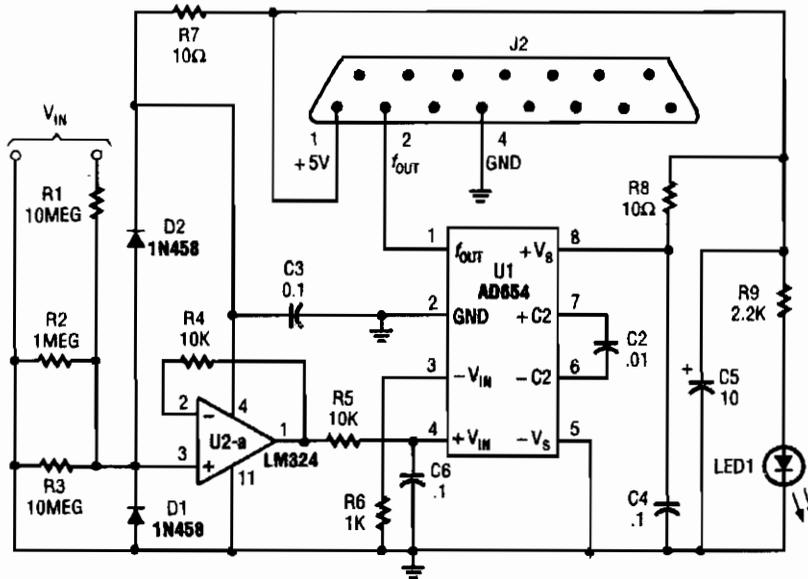
**POPULAR ELECTRONICS**

**FIG. 55-27**

Useful for troubleshooting audio, video, and lower frequency RF amplifiers, this circuit generates a signal that is rich in harmonics.

In this circuit, C1/D1/R1 form an envelope detector. C2 couples audio to the base of Q1. R2 can be adjusted for the desired gain.

## DVM ADAPTER FOR PC

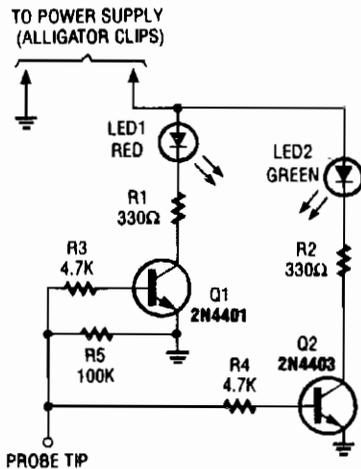


POPULAR ELECTRONICS

FIG. 55-28

The adapter consists of a voltage to frequency adapter with a signal conditioner and protection circuit. J2 connects to the game port of a PC. See reference listed for software for use with this circuit.

## SIMPLE DIGITAL LOGIC PROBE

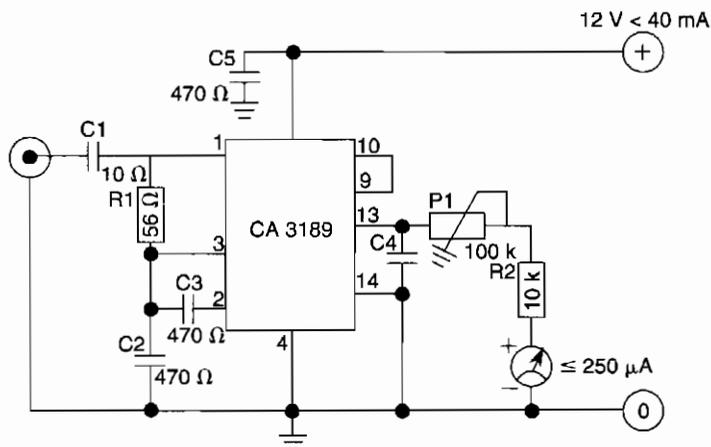


POPULAR ELECTRONICS

FIG. 55-29

The design of the digital logic probe centers around a pair of complementary bipolar transistors, which, in this application, are used as electronic switches.

## S METER FOR COMMUNICATIONS RECEIVERS



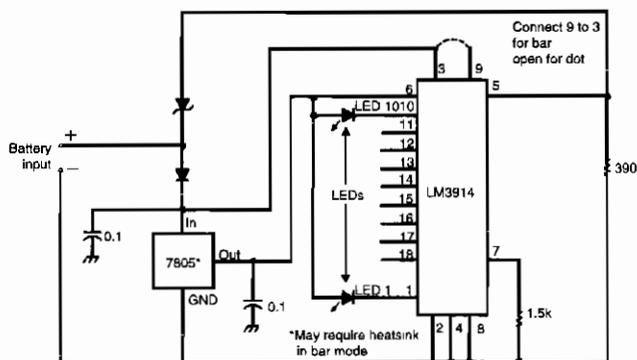
303 CIRCUITS

FIG. 55-30

Because many amateur receivers are fitted with an S meter that functions far from logarithmically, the proposed circuit should be a welcome extension of such receivers. Although ICs such as the CA3089 or the CA3189 are not in common use anymore, they serve a useful purpose in the meter circuit, because, apart from a symmetric limiter, a coincidence detector, and an AFC amplifier, they contain a very good logarithmic amplifier-detector.

As is seen, the circuit is fairly simple, but remember that these ICs operate up to about 30 MHz; the wiring of the meter and its connections in the receiver should be kept as short as possible.

## LED EXPANDED SCALE VOLTMETER

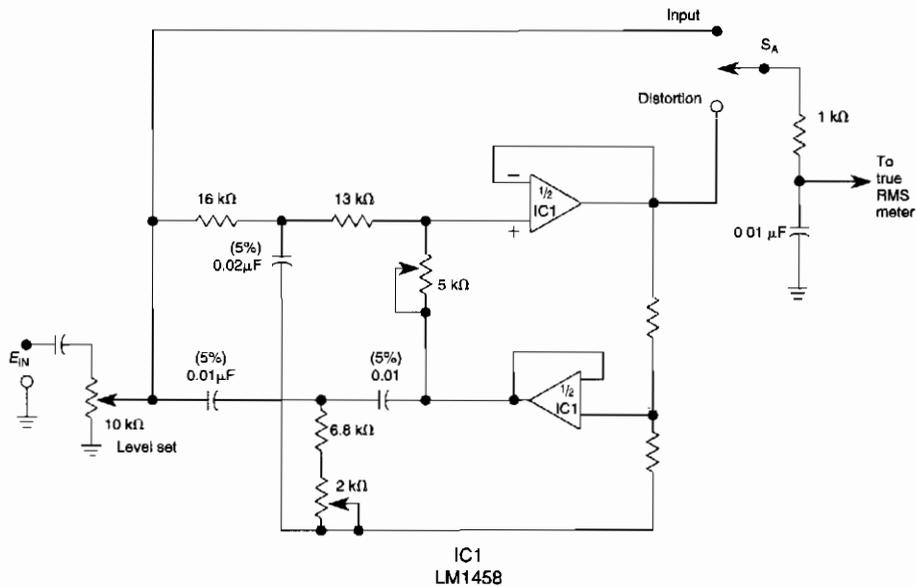


73 AMATEUR RADIO TODAY

FIG. 55-31

A 10-V zener diode is used to expand the scale of a 0- to 5-V voltmeter to a 10- to 15-V voltmeter. The LED bar graph lights one segment per 0.5-V input above 10 V. The 7805 IC provides a 5-V reference and 5 V for the bar graph LEDs.

## 1-KHz HARMONIC DISTORTION METER

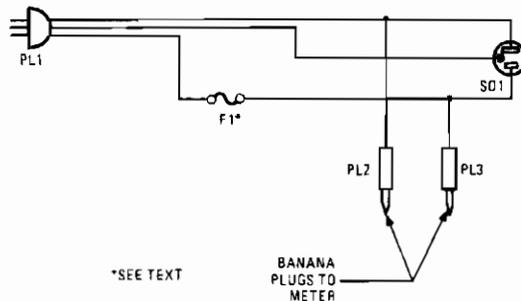


WILLIAM SHEETS

FIG. 55-32

The circuit useful for distortion measurements notches out the fundamental frequency of 1 kHz to allow measurement of the residual level of harmonics. First a true RMS meter is used to measure the 1-kHz input level  $E_{in}$  by setting  $S_A$  to the input position. Then,  $S_A$  is placed in the distortion position and the 2 k potentiometer is adjusted for a null. The residual reading is noted. The THD is then calculated based on the formula:

## LINE VOLTAGE-TO-MULTIMETER ADAPTER

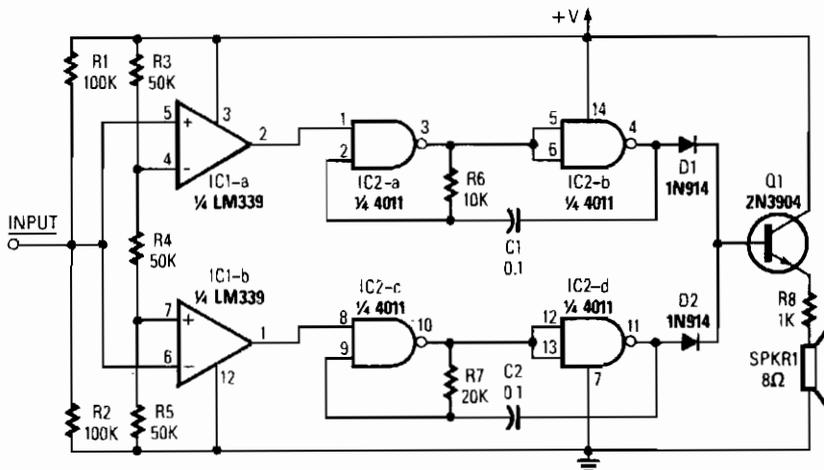


POPULAR ELECTRONICS

FIG. 55-33

This ac line-to-multimeter adapter can make checking line voltage safer. You can use it to find taxing loads on your household wiring.

## AUDIBLE LOGIC TESTER



1989 R-E EXPERIMENTERS HANDBOOK

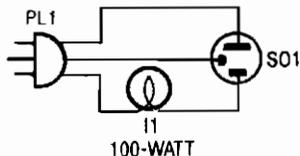
FIG. 55-34

The tester provides an audible indication of the logic level of the signal presented to its input. A logic high is indicated by a high tone, a logic low is indicated by a low tone, and oscillation is indicated by an alternating tone. The input is high impedance, so it will not load down the circuit under test. It can be used to troubleshoot TTL or CMOS logic.

The input section determines whether the logic level is high or low, and enables the appropriate tone generator; it consists of two sections of an LM339 quad comparator. One of the comparators (IC1-a) goes high when the input voltage exceeds 67% of the supply voltage. The other comparator goes high when the input drops below 33% of the supply. Resistors R1 and R2 ensure that neither comparator goes high when the input is floating or between the threshold levels.

The tone generators consist of two gated astable multivibrators. The generator built around IC2-a and IC2-b produces the high tone. The one built around IC2-c and IC2-d produces the low tone. Two diodes, D1 and D2, isolate the tone-generator outputs. Transistor Q1 is used to drive a low-impedance speaker.

## SHORT TESTER FOR 120-V EQUIPMENT

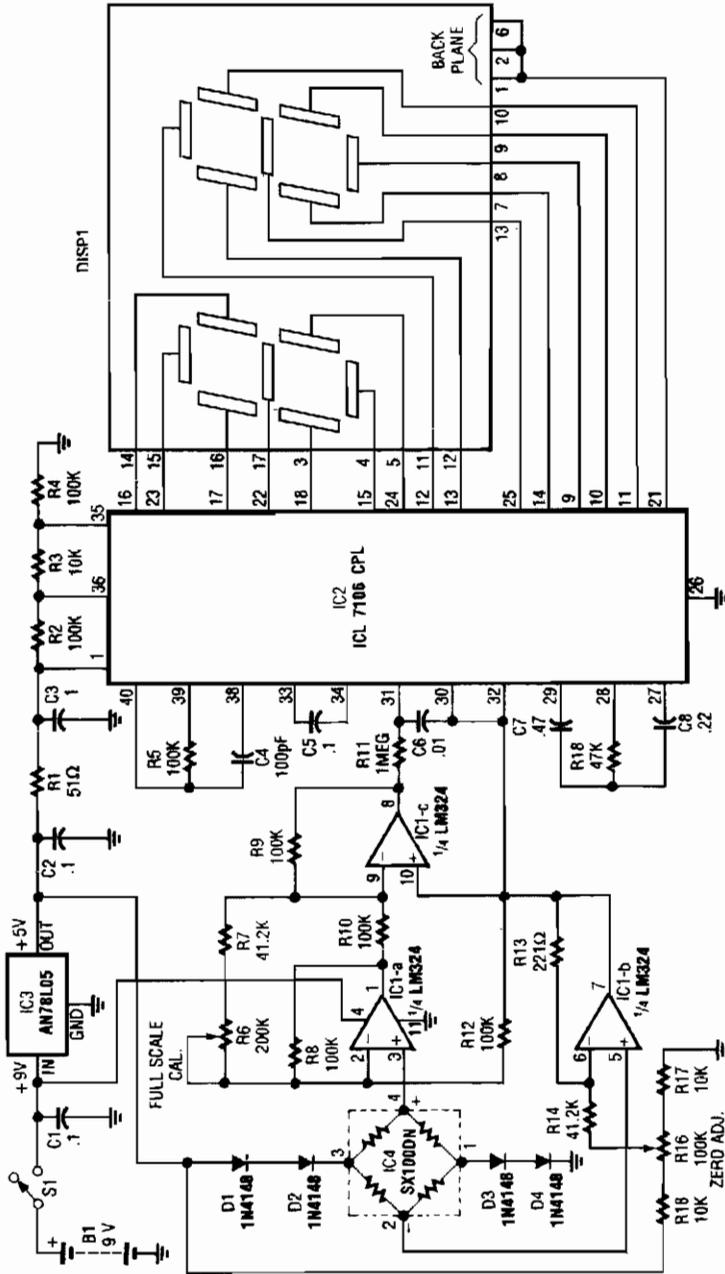


Do you deal with old equipment in unknown condition? If so, this little circuit could keep you from causing further harm to already shorted devices.

POPULAR ELECTRONICS

FIG. 55-35

## DIGITAL PRESSURE GAUGE

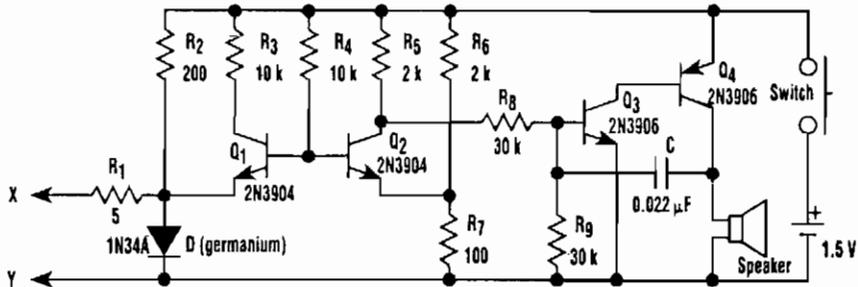


1992 R-E EXPERIMENTERS HANDBOOK

FIG. 55-36

This electronic pressure gauge uses a Wheatstone bridge-type pressure sensor to drive a 3½ digit A/D converter and a display. IC1 is a pump (quad) that interfaces the bridge sensor to the A/D converter. R16 provides zero adjustment and R6 provides full-scale calibration. D1 thru D4 provide temperature compensation.

### SIMPLE SHORT FINDER



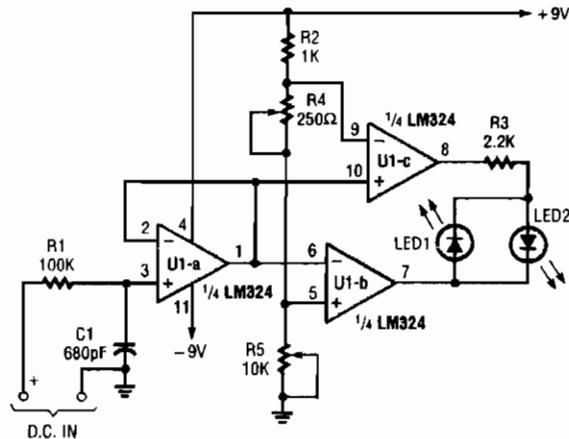
ELECTRONIC DESIGN

FIG. 55-37

Transistors Q1 and Q2, together with resistors R1 through R7, make up the input balancing stage, which senses the resistance between points X and Y. The input stage is essentially a bridge, consisting of R1, R2, R6, R7, and the resistance between points X and Y.

Transistors Q3 and Q4 and their associated passive components form a buzzer, which sounds when the tester detects a short. The buzzer is controlled by the output from Q2. When the input resistance is high (more than about 10  $\Omega$ ), Q2 turns on, so its collector potential is close to ground, and the buzzer remains off. When the input resistance is sufficiently low, Q2 turns off, and the buzzer sounds. The frequency of the sound, which is about 1000 Hz, can be adjusted by varying the value of capacitor (C).

### VOLTAGE MONITOR



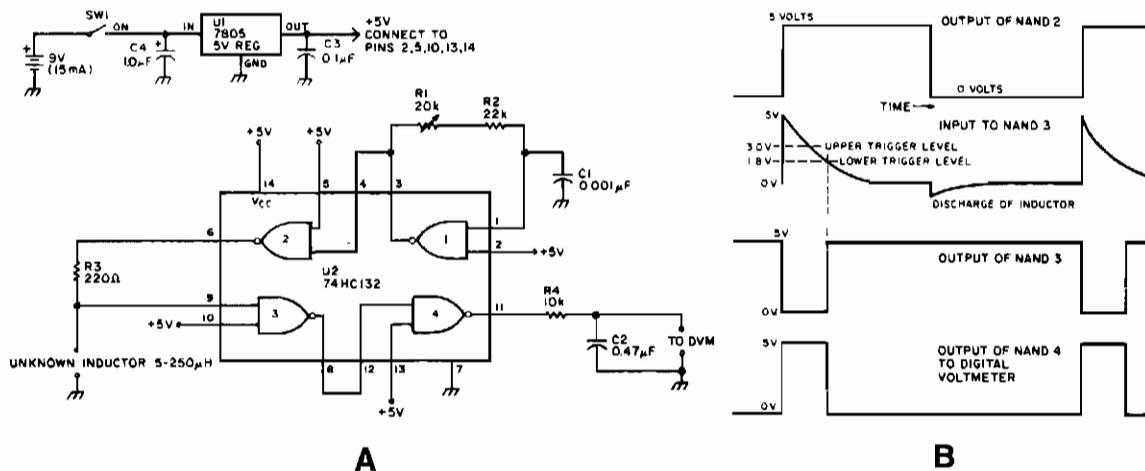
*The adjustable voltage monitor can be used to check whether the voltage in a circuit remains within a given range.*

POPULAR ELECTRONICS

FIG. 55-38

If the dc voltage is less than the voltage at pin 5 of U1-B, then LED 1 will light. If the voltage is over 5V, LED2 will light. If the voltage is within the window set by R4 and R5, neither LED will light. This circuit is useful as an under-or-over voltage monitor.

## LINEAR INDUCTANCE METER

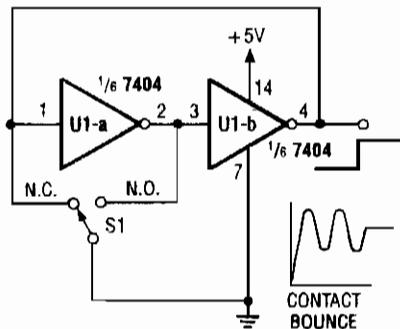


73 AMATEUR RADIO TODAY

FIG. 55-39

Using the fact that in an RL circuit, the pulse width seen across the inductor is proportional to the inductance, this circuit reads this indirectly on a DVM. The range is about 5 to 250 μH.

## DEBOUNCE CIRCUIT

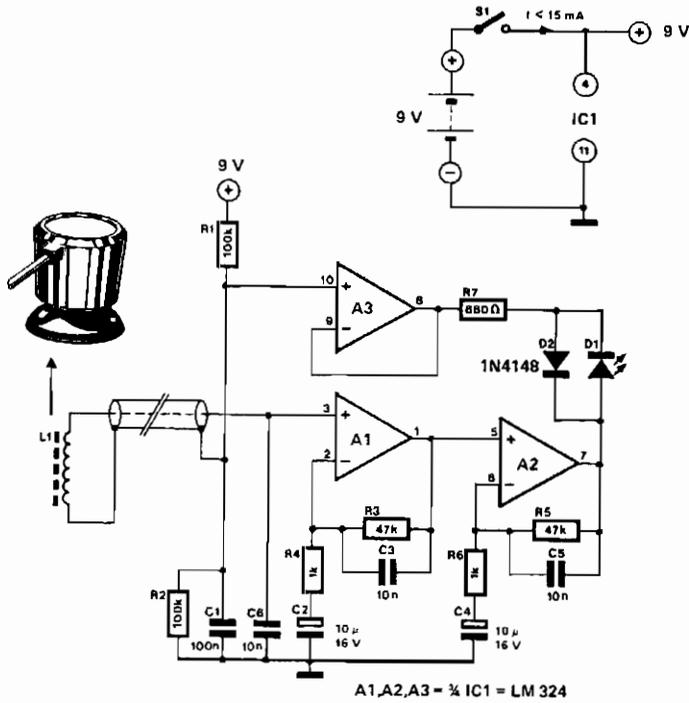


POPULAR ELECTRONICS

FIG. 55-40

This debounce circuit will keep the electrical noise generated by the mechanical switch (S1) from reaching the next circuit in line.

## ac WIRING LOCATOR

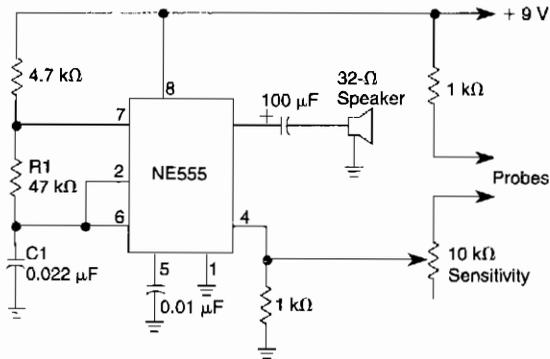


303 CIRCUITS

FIG. 55-41

This circuit uses a pick-up coil to sense the 50- or 60-Hz field around wiring carrying ac. L1 is a telephone pick-up coil with a suction pad. D1 (LED) lights during positive half waves, indicating that ac current is present.

## AUDIBLE CONTINUITY TESTER

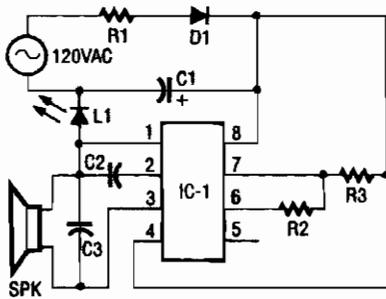


This 555 oscillator sounds a tone when continuity exists between the probes. Oscillator frequency is determined by the values of R1 and C1.

WILLIAM SHEETS

FIG. 55-42

## ac OUTLET TESTER



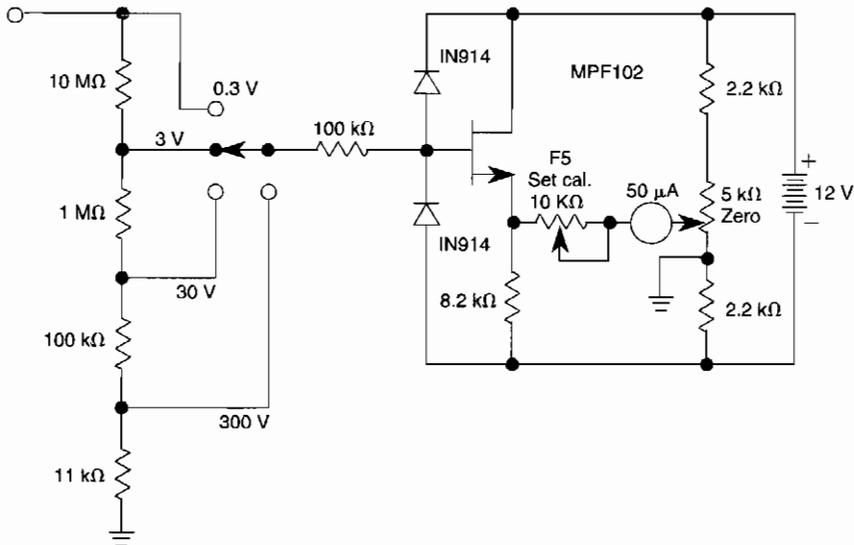
- C1 ..... 50  $\mu$ F Electrolytic Capacitor  
 C2,C3 .. .047  $\mu$ F Disc Capacitor  
 D1 ..... 1N4003 Diode  
 IC1 ..... 555 Timer IC  
 L1 ..... Jumbo Red LED  
 R1 ..... 3.9K, 1 watt Resistor  
 R2 ..... 2K, 1/4 watt Resistor  
 R3 ..... 4.7K, 1/4 watt Resistor  
 SPK ..... Piezoelectric Speaker

1991 PE HOBBYIST HANDBOOK

FIG. 55-43

The tester consists of a rectifier circuit and a multivibrator circuit. The ac voltage is half-wave rectified by diode D1 and stored in capacitor C1. Resistor R1 is used to limit the current through D1 to a safe value. The voltage stored across C1 supplies IC1 operating power. The IC, the versatile 555 timer, is configured to operate as a multivibrator whose operating frequency is determined by C2, R2, and R3. The output of IC1, on pin 3, is coupled to a piezoelectric speaker (SPK), which gives an indication of the presence of ac. An LED (L1) also lights when ac is present.

## JFET VOLTMETER

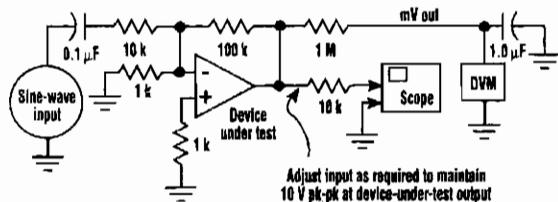


WILLIAM SHEETS

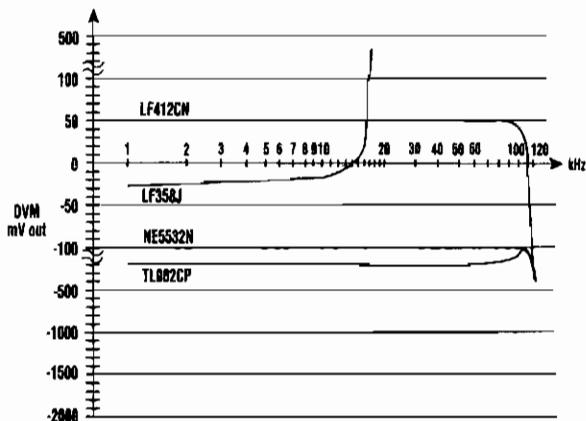
FIG. 55-44

This very simple voltmeter circuit uses a 50- $\mu$ A meter in a bridge circuit. It is useful for noncritical applications.

## CHECK FOR OP-AMP dc OFFSET SHIFT



LF412CN		LF356J		NE5532N		TL082CP	
kHz	mV out	kHz	mV out	kHz	mV out	kHz	mV out
1	51	1	-23	1	-191	1	-313
10	50	10	-14	10	-197	10	-314
100	44	12	-9	100	-109	50	-307
110	9	13	-4	110	-152	60	-296
115	-358	14	4	120	-378	70	-279
120	-502	15	7			80	-258
130	-1374	16	58			90	-227
140	-1741	17	119			100	-184
		17.5	158			110	-125
		18	494				



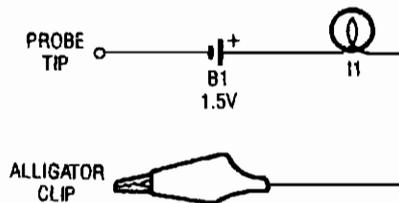
ELECTRONIC DESIGN

FIG. 55-45

The dc values of op-amp offsets can't always be taken for granted when delivering ac outputs. No device is ever exactly symmetrical for maximum positive slew rate versus maximum negative slew rate. Consequently, there is always some range of output slew rates in which the device used limits in one direction more severely than in the other. What results in rectification of the ac signal and an apparent shift of the dc offset.

This test circuit can check for the shift phenomenon. The accompanying table and graph illustrate the results obtained for four devices, all of different types. As frequency and slew rate are increased, the effect can be either relatively abrupt (LF412CN and NE5532N) or relatively gradual (LF356J and TL082CP).

## CONTINUITY TESTER FOR LOW-RESISTANCE CIRCUITS

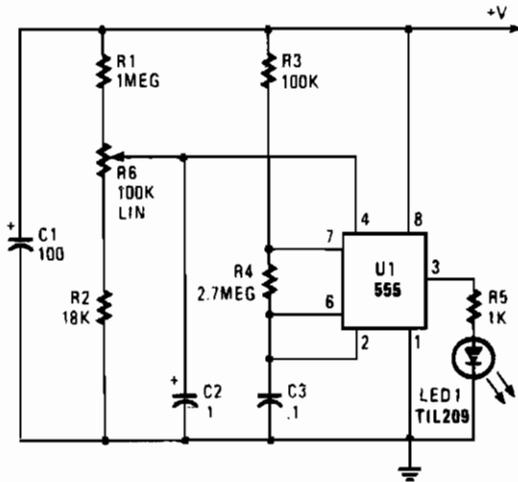


POPULAR ELECTRONICS

FIG. 55-46

The continuity tester is little more than a battery and a lamp connected in series, with one end of the string terminated in an alligator clip, and the other end connected to the probe tip.

## SUPPLY VOLTAGE MONITOR

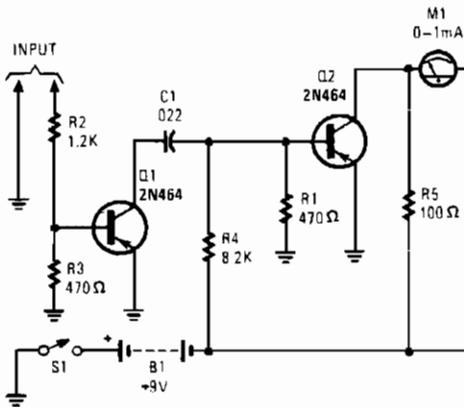


Excessive voltage causes U1 to oscillate, causing LED1 to flash. R6 sets the desired trip level.

POPULAR ELECTRONICS

FIG. 55-47

## AUDIO-FREQUENCY METER CIRCUIT



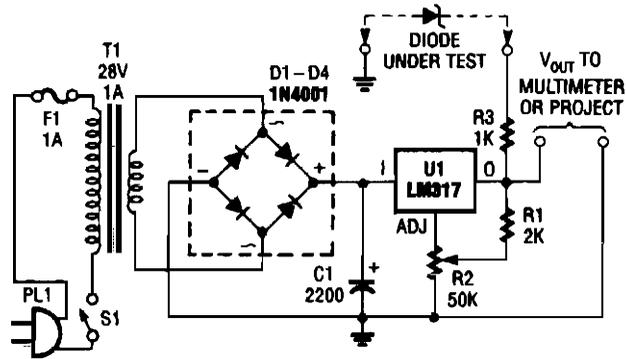
This simple tachometer circuit uses a pulse shaper Q1 to drive M1, a 0- to 1- $\mu$ A meter. C1 can be varied to optimize operation.

POPULAR ELECTRONICS

FIG. 55-48

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## ZENER DIODE TEST SET



POPULAR ELECTRONICS

FIG. 55-49

This versatile circuit can be used to test zener diodes or act as a stand-alone power supply. It requires a voltmeter to work as a zener tester.

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# 56

## Metal-Detector Circuits

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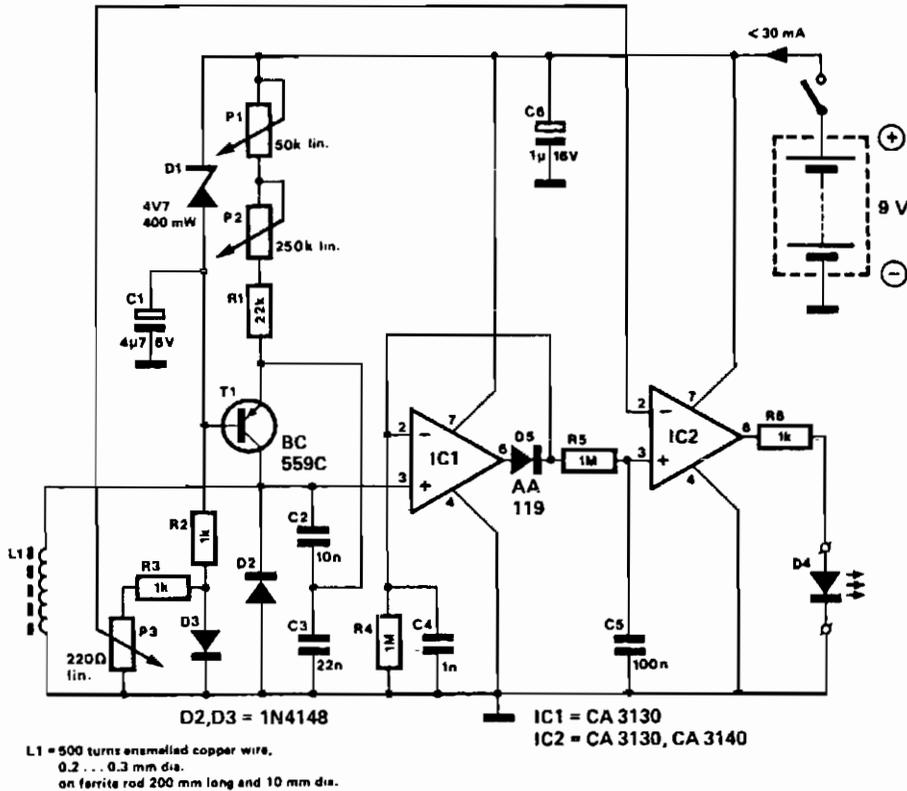
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Metal Pipe Detector

Low-Cost Metal Detector for Experimenters

Metal Locator

## METAL PIPE DETECTOR

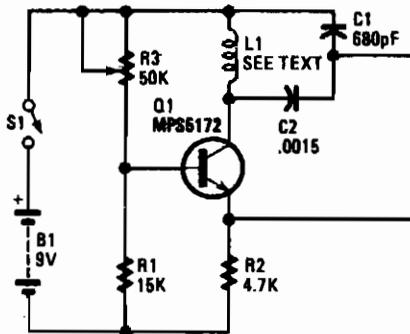


303 CIRCUITS

FIG. 56-1

This circuit uses a 15-kHz oscillator coil. When metal placed in the energy field is withdrawn, the oscillator voltage is rectified and compared to a reference. A drop in oscillator voltage therefore operates comparator IC2 and D4 (LED) extinguishes.

## LOW-COST METAL DETECTOR FOR EXPERIMENTERS

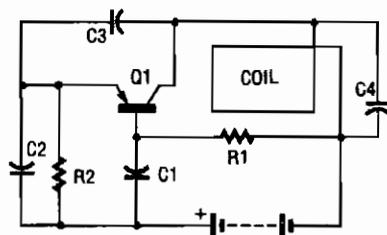


This circuit is an oscillator with L1 being a 4" diameter coil of 35 turns of #26 magnet wire. Metal in proximity to L1 will cause the oscillator to shift frequency. An AM transistor radio is used to detect the frequency shift.

POPULAR ELECTRONICS

FIG. 56-2

## METAL LOCATOR



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FIG. 56-3

The metal locator uses a one-transistor oscillator and an AM radio to detect metal. Transistor Q1 is a pnp transistor that is connected to an oscillator. Resistor R1 provides the correct base bias and capacitors C3 and C4 and the search coil determine the frequency of oscillation.

Capacitors C3 and C4 are fixed in value, but the search coil is an inductor that varies in inductance (and thus varies the oscillator frequency) as metal is brought near it. The oscillator frequency is rich in harmonics and its output falls within the AM broadcast band. The metal detector works by combining its output with the local oscillator of the AM radio. The resulting net output of the radio is a low-frequency audio tone that changes—gets higher or lower—as metal is brought near or taken away from the search coil. Commercial metal detectors use two oscillators, so they don't require an AM radio. This metal locator provides an inexpensive alternative to an expensive commercial metal locator.

C1, C2	0.01- $\mu$ F Capacitor (103)
C3, C4	0.001- $\mu$ F Capacitor
Q1	2N3906 Transistor
R1	47-k $\Omega$ Resistor
R2	100- $\Omega$ Resistor

# 57

## Miscellaneous Treasures

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Voice Disguiser	dc Output Chopper
Soldering Iron Control	ac Isolation Transformers Use
Furnace Fuel Miser	Inexpensive 12-V Transformers
Personal Message Recorder	ac Line Voltage Booster
Four-Input Minimum/Maximum Selector	Octal DA Converter
Soil Heater for Plants	1-dB Pad
Key Illuminator	Pseudo-Random Bit Sequence Generator
Radio Commercial Zapper	Simple External Microphone Circuit
Audio Limiter	for Transceivers
Analog De-Glitch Circuit	JFET Chopper Circuit
Acoustic Field Generator	Audio Memo Alert
Suppress Jitter with Hysteresis	Octave Equalizer
Heartbeat Monitor	Complementary or Bilateral ac
Self-Retriggering Timed-On Generator	Emitter-Follower Circuit
Frequency Divider for Measurements	Capacitor Hysteresis Compensator
Video, Power, and Channel-Select	Amplifier Cool-Down Circuit I
Signal Carrier	NE602 Input Circuits
7805 Turn-On Circuit	NE602 Output Circuits
AF Drive Indicator	Basic Latch Circuits
Phase-Locked Loop	Bootstrap Circuit
Capacitance Multiplier	Simple Schmitt Trigger
Practical Differentiator	Amplifier Cool-Down Circuit II
Hum Reducer for Direct-Conversion Receivers	NE602 dc Power Circuits
Preamp Transmit-Receive Sequencer	Inrush Current Limiter



## VOICE DISGUISER (Cont.)

The voice signal is then fed to the input of the first balanced modulator, which is comprised of U1-a, U1-b, U2-a, and U3-a. The output of the first 4-kHz oscillator, built around U3-f and U3-e, is fed to the carrier input of the first modulator. The frequency of the first oscillator is controlled by the setting of potentiometer R13. The modulator output—a double-sideband suppressed-carrier signal centered on 4 kHz—is then filtered by the first 5-kHz low-pass filter, formed by U2-b, which eliminates the upper-sideband signals.

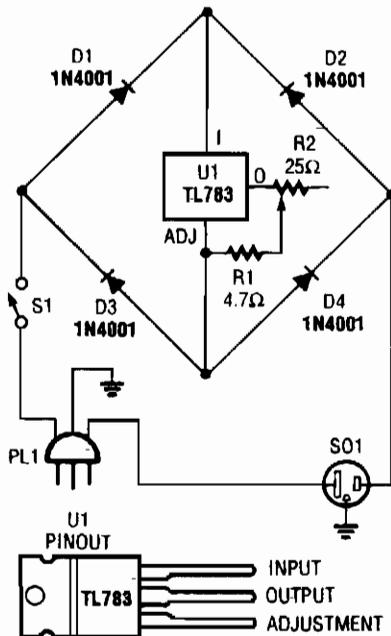
At this point, the voice frequency spectrum is inverted (e.g., the frequencies that were low now become high, and vice versa), making the voice signal completely unintelligible. The output of the first low-pass filter is fed to a second modulator formed by U1-c, U1-d, and U3-b, where it is frequency modulated with the output of the second carrier oscillator, comprised of U3-c and U3-d; the frequency of the second oscillator is controlled by potentiometer R36.

The output of the second modulator is filtered by the second low-pass filter, which consists of U2-d and few support components, and amplified by Q3. The voice output signal from Q3 is fed to U4 (an LM386 low-voltage, audio-power amplifier) through an impedance-matching transformer, T1. The output of U4 is then used to drive SPKR1 (an 8- $\Omega$  speaker).

In operation, if both carrier oscillators are set to the same frequency, the voice signal from the speaker will be an exact duplicate of the input signal from the microphone. However, if the frequency of the second oscillator is varied (via R36), the output voice signal also shifts in frequency. That makes the voice reproduced by the speaker sound higher- or lower-pitched than normal.

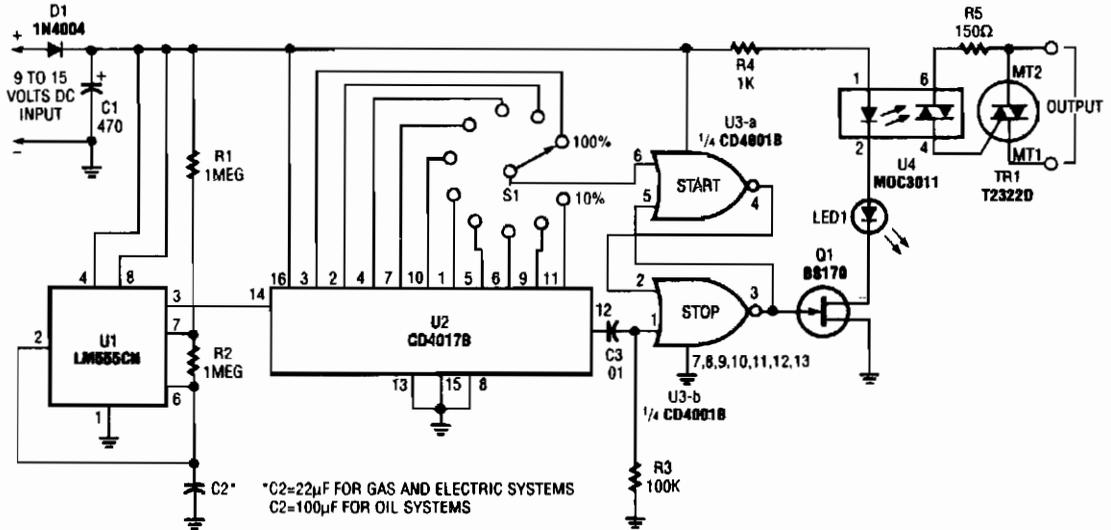
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## SOLDERING IRON CONTROL

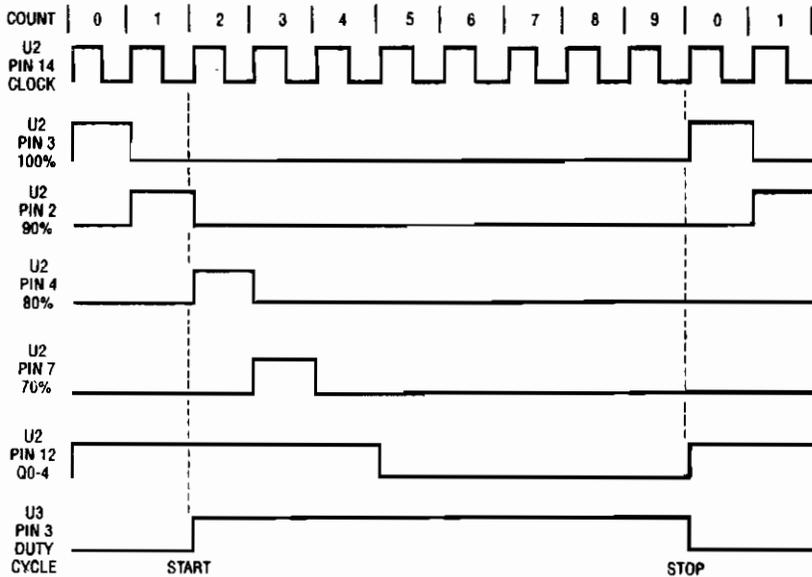


A current control to temperature regulate a soldering iron uses a high-voltage integrated regulator, TL783 (U1). With the component values specified, the circuit should be used with a soldering iron of 25 W or less.

## FURNACE FUEL MISER



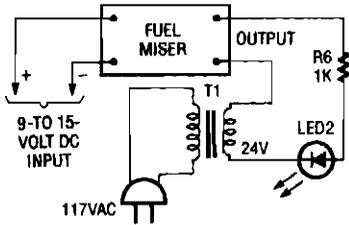
A



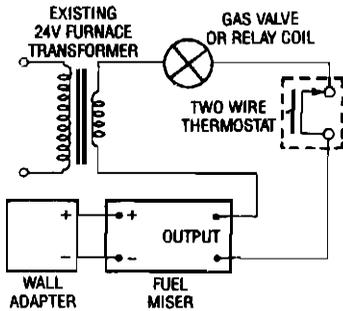
B

A timer (LM555CN) and decode counter is used to generate duty cycles from 10% to 100% to control the time a heating system can operate. V2 is a decode counter that can be switched from 10% to 100% duty cycle. V3A and B form a latch that drive A1, LED1, and V4. The triac TRI is used as an ac switch, in series with the thermostat that controls the heating system.

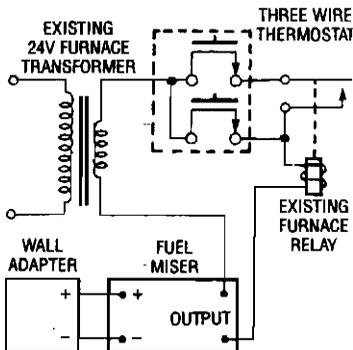
## FURNACE FUEL MISER (Cont.)



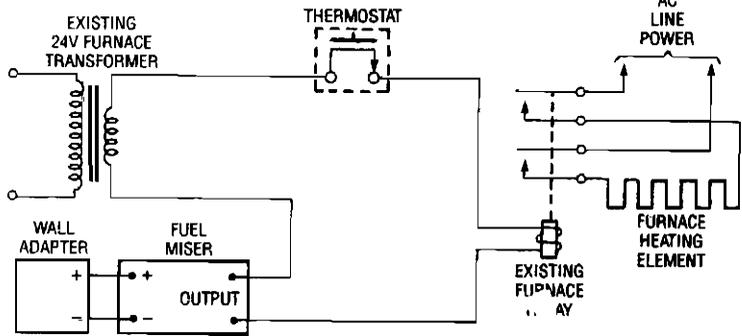
When the circuit is working properly, the output circuitry can be checked using a 24-volt step-down transformer, a 1k resistor, and an LED. Together those components simulate the load that the Fuel Miser sees during normal operation.



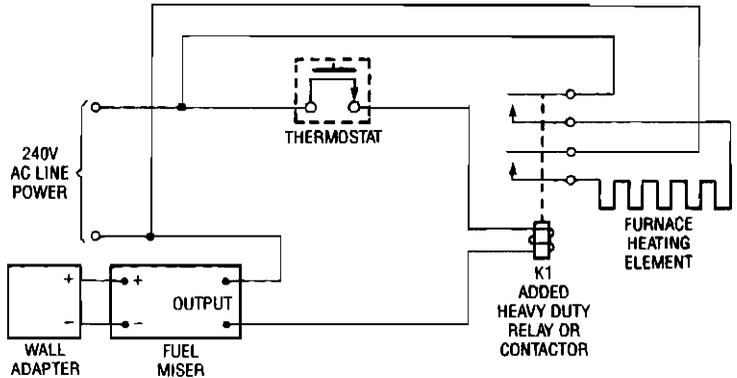
This drawing shows the Fuel Miser connected in series with the thermostat of a two-wire gas furnace that's powered by a 24-volt transformer.



Some oil-fired systems use three-wire thermostats to control the operation of the burner motor and ignition system by activating a relay. This is a typical installation for such systems.

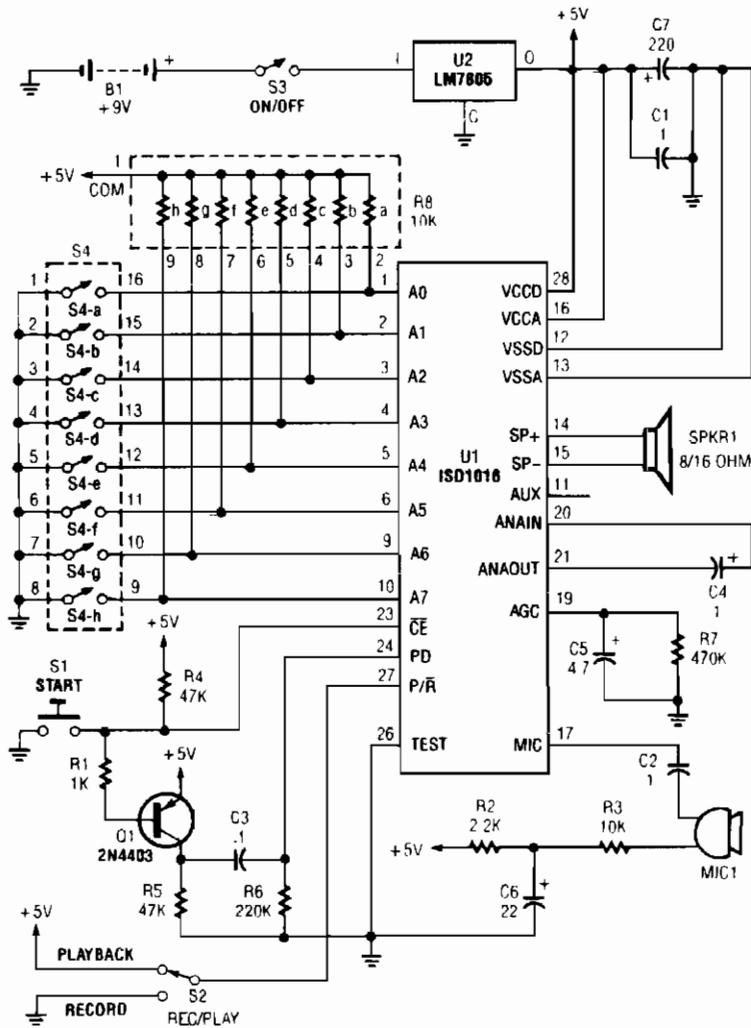


Electric-heating systems may or may not use a relay in the thermostat circuit. Those that do have a relay can be controlled by the Fuel Miser by wiring its output circuit in series with the relay coil connections as shown here.

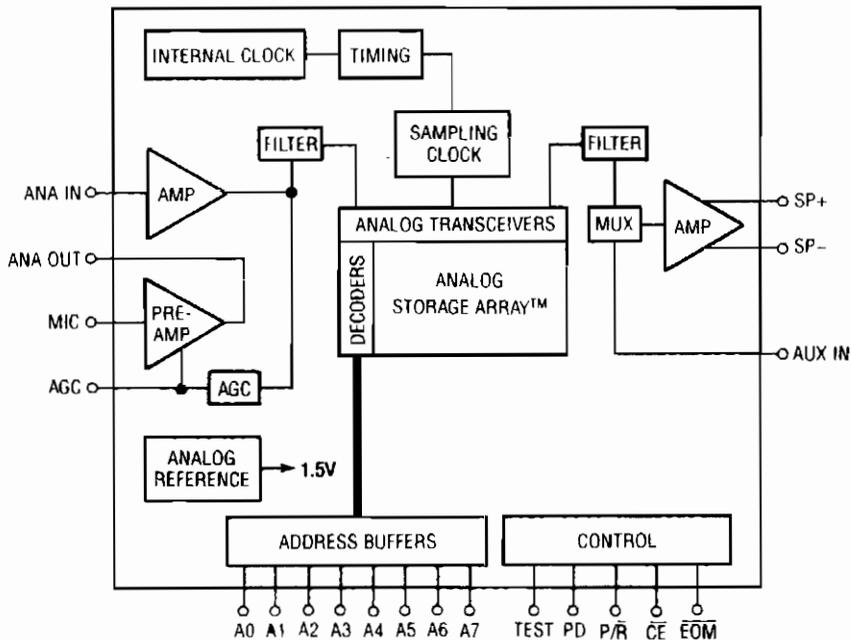


Electric-heating systems that do not contain a low-current thermostat (as in the previous installation), use a heavy-duty thermostat that directly feeds current to the heating element. For such systems, it will be necessary to install a heavy-duty relay (K1 in this example) to control the heavy heating-element current.

# PERSONAL MESSAGE RECORDER



## PERSONAL MESSAGE RECORDER (Cont.)



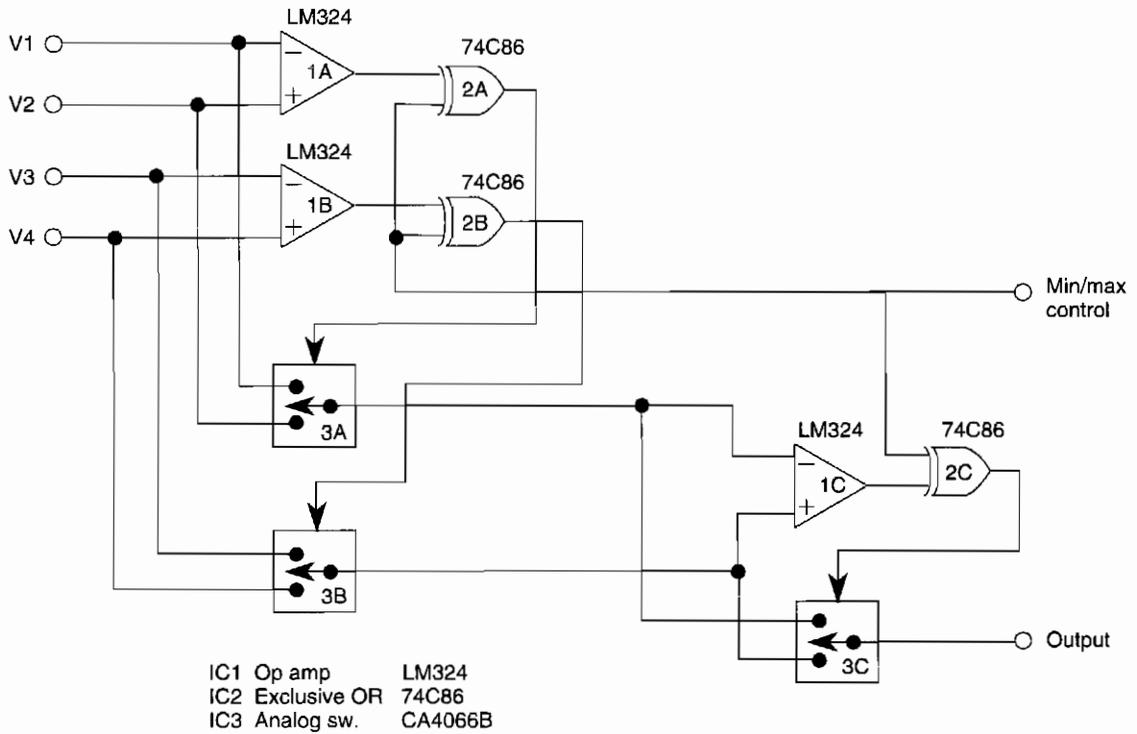
The personal message recorder is built around an ISD1016 CMOS voice messaging system, which does away with the cumbersome and expensive analog-to-digital and digital-to-analog conversion circuits.

A functional block diagram of the ISD1016 is shown. The ISD1016 contains all of the functions necessary for a complete message-storage system. The preamplifier stage accepts audio signals directly from an external microphone and routes the signals to the ANA OUT (analog out) terminal. An automatic-gain control (AGC) dynamically adjusts the preamplifier gain to extend the input signal range. Together, the preamp and AGC circuits provide a maximum gain of 24 dB. The internal clock samples the signal and, under the control of the address-decoding logic, writes the sampling to the analog-storage array. Eight external input lines allow the ISD1016's message space to be addressed in 160 equal segments, each with a 100-millisecond duration. When all address lines are held low, the storage array can hold a single, continuous, 16-second message.

However, there is a special addition to the POWER DOWN input (pin 24) of U1. If the internal memory becomes full during recording, an overflow condition is generated in order to trigger the next device. Once an overflow occurs, pin 24 must be taken high and then low again before a new playback of record operation can be started.

Transistor Q1, C3, R5, and R6 form a one-shot pulse generator that automatically clears any overflow condition each time that start switch (S1) is pressed. Switch S2 selects either the playback or the record mode. Switch S4—an 8-position (a-h) DIP switch—is included in the circuit to allow the circuit's record/playback time to be varied from 0 to 16 seconds. The maximum time available is when all 8 switch positions are closed (or set to the on position). Resistor network R8 (a-h) is included in the circuit to provide a pull-up function for the address lines, which thereby controls U1's record/playback time.

## FOUR-INPUT MINIMUM/MAXIMUM SELECTOR



WILLIAM SHEETS

FIG. 57-5

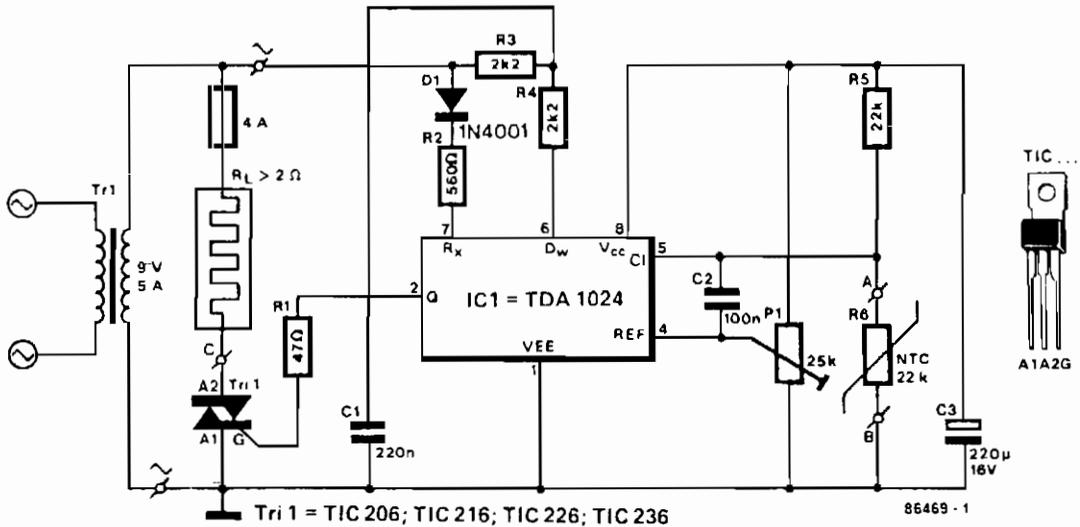
This circuit outputs the maximum (or the minimum) of the four input voltages  $V_1$ ,  $V_2$ ,  $V_3$ , and  $V_4$ . Each of these input voltages is in the range 0 to 5 V.

The output of the unit is the maximum of  $V_1$ ,  $V_2$ ,  $V_3$ , and  $V_4$  if the control voltage input is 5 V (i.e., logical 1). The output is the minimum of  $V_1$ ,  $V_2$ ,  $V_3$ , and  $V_4$  if the control is zero.

By cascading  $N$  such units, one can select the maximum (or the minimum) of  $3N + 1$  input voltages.

Thus if  $k$  is the number of input voltages, we need  $\lceil (k+1)/3 \rceil$  units.

## SOIL HEATER FOR PLANTS

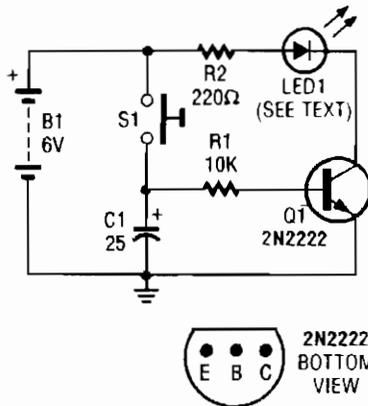


303 CIRCUITS

FIG. 57-6

A TDA1024 electronic thermostat senses soil temperature via thermistor R6. The circuit uses zero-crossing switching of the heater. The heater is made of elastic-coated steel wire. P1 is used to set the temperature. The heater should have 2 Ω or more resistance and operate from the 9-V transformer. About 40 W of heat is available.

## KEY ILLUMINATOR

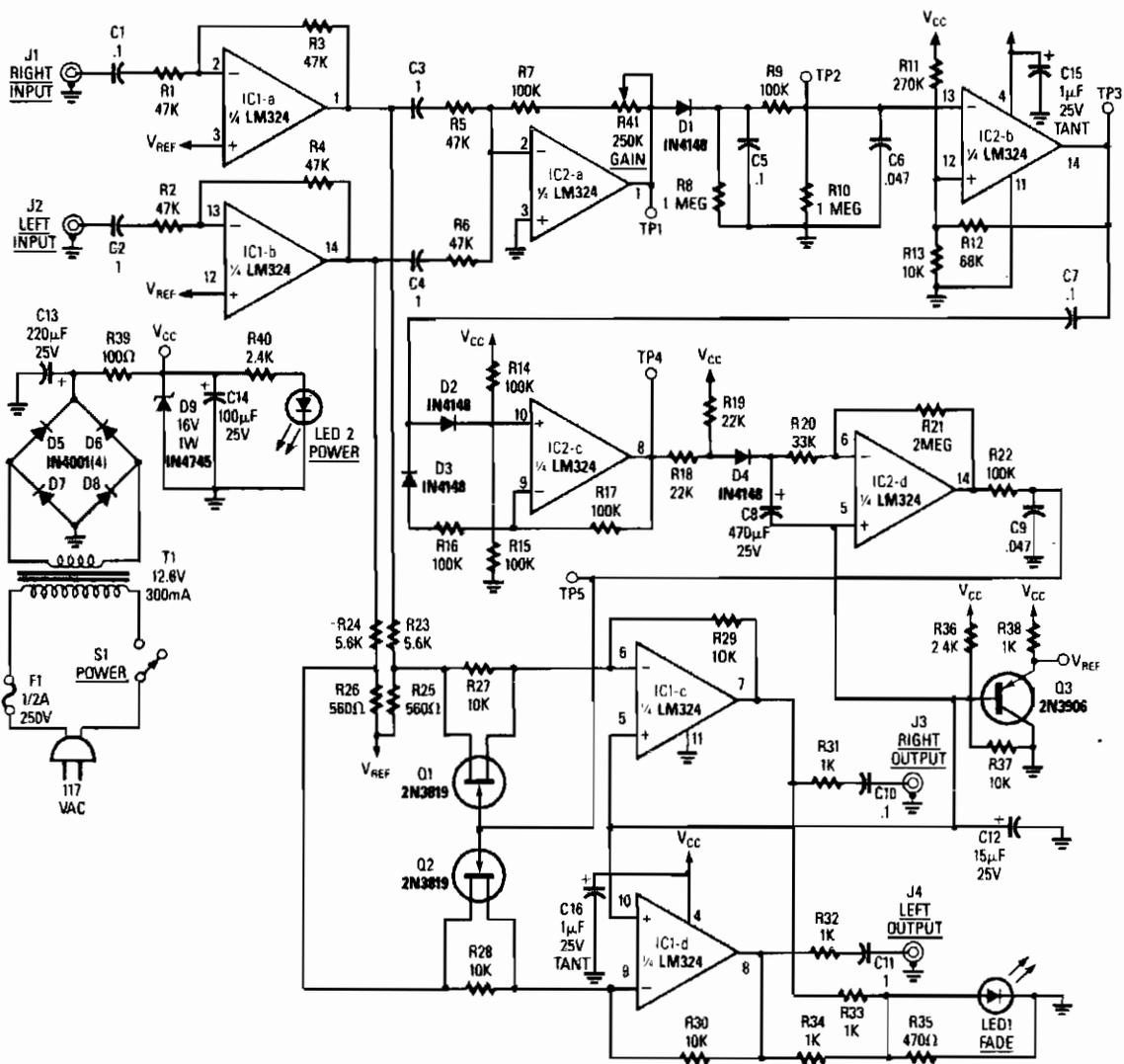


Used as a 10-second momentary illuminator, this circuit can be useful in other applications as well. Pressing S1 charges C1, which holds Q1 on and holds the LED lit for about 10 seconds.

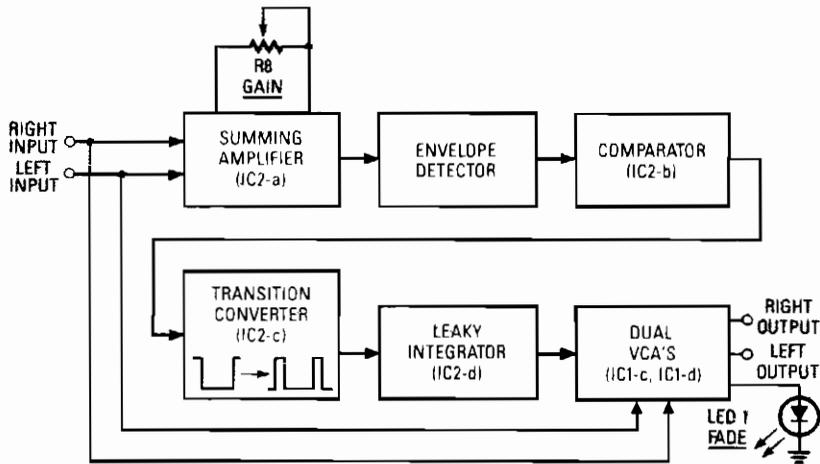
POPULAR ELECTRONICS

FIG. 57-7

## RADIO COMMERCIAL ZAPPER



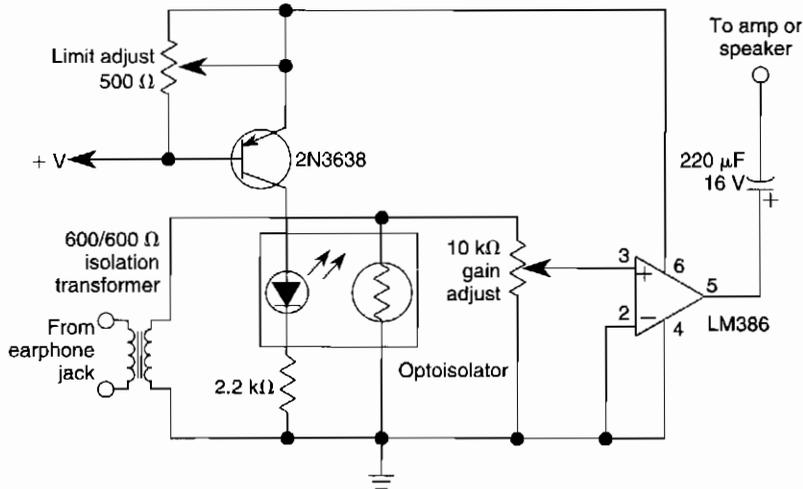
## RADIO COMMERCIAL ZAPPER (Cont.)



**BLOCK DIAGRAM OF THE COMMERCIAL KILLER:** The envelope of the signal is used to vary the pulse rate from IC2-c. The pulses are integrated; the resulting signal controls the gains of a pair of VCA's.

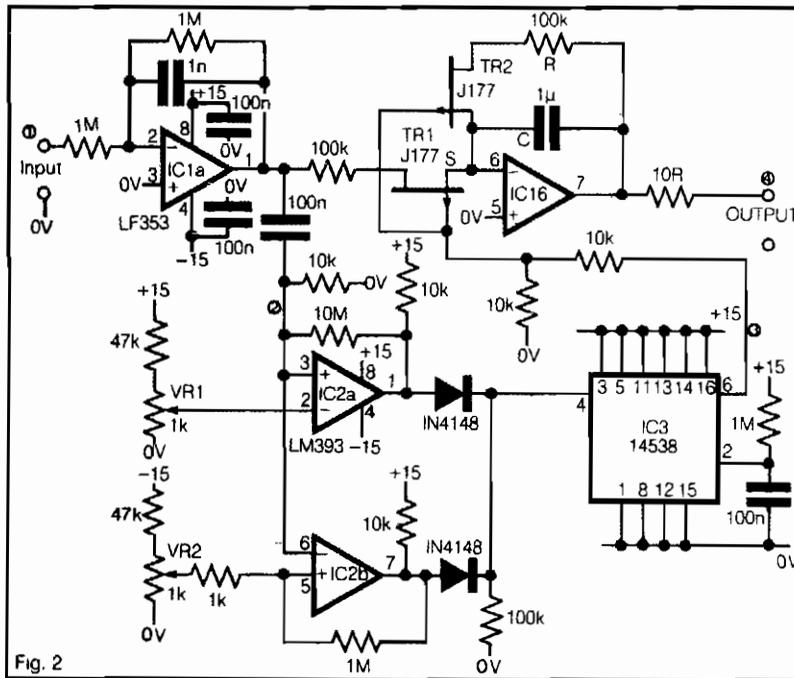
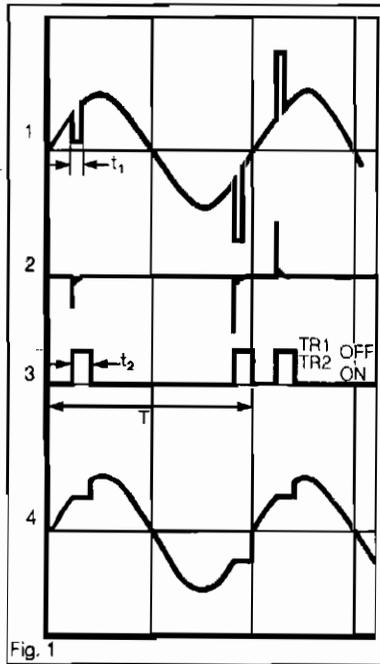
The L&R inputs are summed, dated and drive a comparator. The comparator senses level and generates a transition when audio inputs go above or below preset thresholds. The number of these transitions (corresponding to rapid volume changes) are integrated and feed voltage controlled amplifiers. This device actually senses dynamic range.

## AUDIO LIMITER



An optoisolator is used as an attenuator in this circuit. When the LM386 draws more current on audio signals, the 2N3638 turns on, which biases the optoisolator on, and reduces the volume.

# ANALOG DE-GLITCH CIRCUIT



## ANALOG DE-GLITCH CIRCUIT (Cont.)

Low-frequency signals produced by transducers, measurement equipment, or data loggers often appear like the first waveform in the figure. The circuit shown operates as a tracking sample-and-hold, and the transients are replaced in the output by the stored value of the current signal at the instant of the transient.

The input signal is buffered and inverted by IC1a, and the differentiated result shown at 2 applied to the inputs of two comparators IC2-a and IC2-b. VR1 and VR2 set levels to prevent false or unnecessary operation. Either comparator output triggers the mono IC3 from positive or negative signal transients. When IC3 has not been triggered, TR1 and TR2 'p' channel JFETs are on, and IC1b operates as an integrator with a high leakage, and tracks the input signal. When the mono is triggered as at 3, TR1 and TR2 turn off and the previous signal value is held constant, as shown at 4. The resulting output waveform can then be easily filtered to remove the harmonics from the restoring step at the end of the mono period, if needed.

The criteria for successful operation are:

$$t_2 > t_1 \text{ (mono period longer than glitch)}$$

$$t_2/T \text{ small (to optimize output waveform)}$$

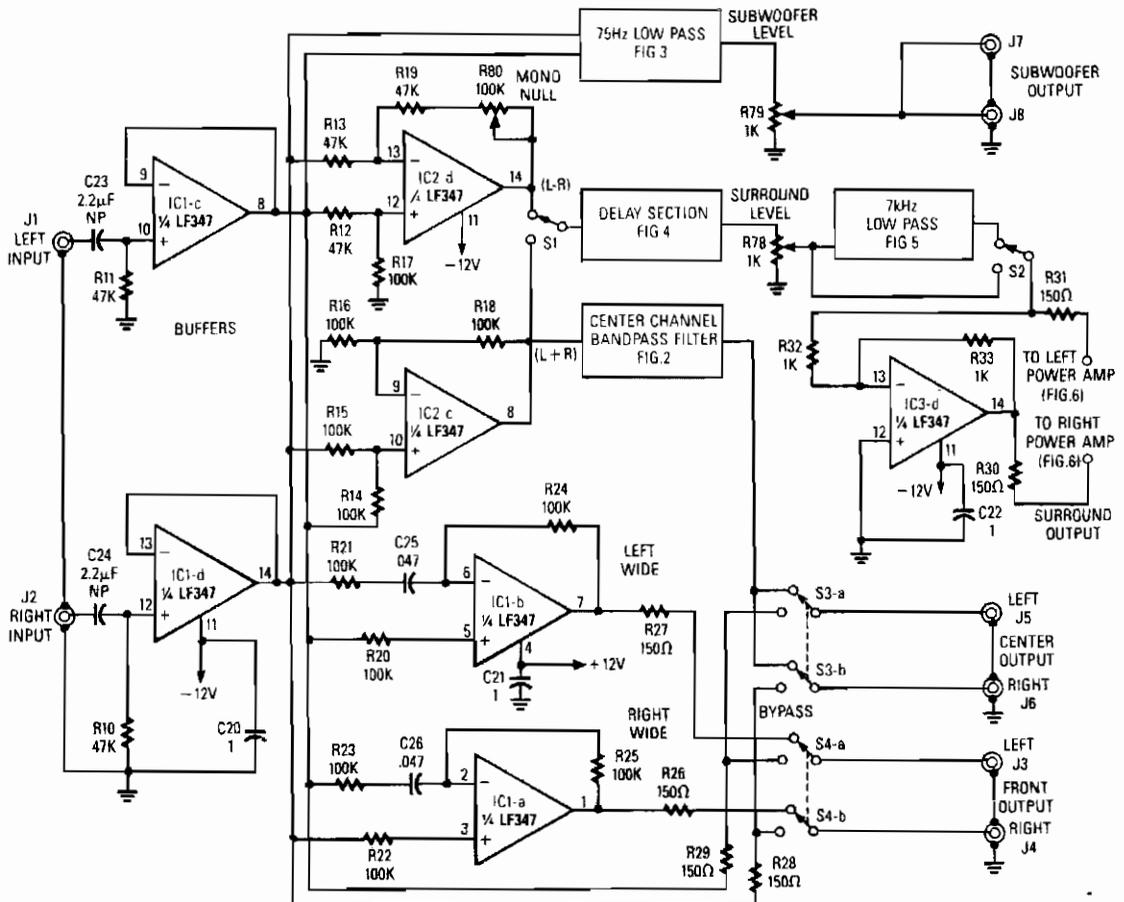
$$\text{Signal bandwidth } f_o = \frac{1}{2\pi CR}$$

$$\text{Signal phase } \theta = \tan^{-1} 2\pi fCR$$

The signal range is approximately  $\pm 5$  V, depending on the transient amplitude and polarity. The mono period shown is 100 mS, but this can be optimized in practical applications. The shorter the mono period in relation to the signal waveform, the better the quality of the result.

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## ACOUSTIC FIELD GENERATOR



THE AFG IS MADE UP OF 10 relatively simple circuit elements.

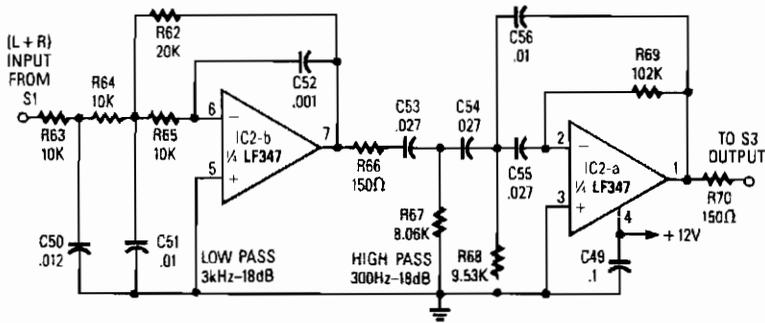
A

Referring to the simplified schematic in A, the AFG is made up of 10 relatively simple circuit elements. IC1-c and IC1-d are configured as unity-gain noninverting buffer amplifiers.

The summing ( $L+R$ ) amplifier, IC2-c, combines equal amounts of the left and right signals, via R14 and R15, to develop a total composite signal. Left- and right-channel signals are applied equally through R13 and R12 to IC2-d, the difference ( $L-R$ ) decoder. Any common to both channels is canceled by IC2-d, which exactly balances the inverting and noninverting gains of the amplifier for a perfect null.

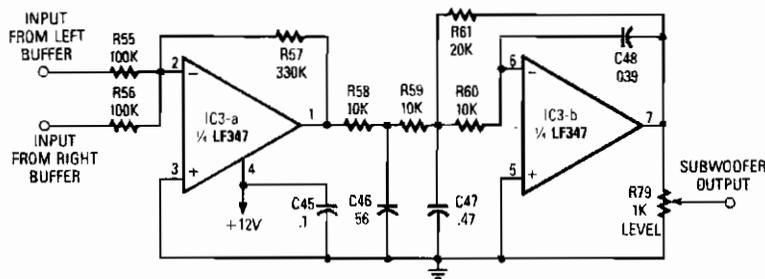
The stereo width-enhancement circuit made up from IC1-a and IC1-b works similarly to the ( $L-R$ ) decoder, except that C25 and C26 have been added in the inverting inputs of each op amp. IC1-b develops the "left wide" signal because its inverting and noninverting inputs are connected to the left

## ACOUSTIC FIELD GENERATOR (Cont.)



**THE CENTER-CHANNEL SPEECH FILTER is built by cascading a 3-kHz low-pass filter with a 300-Hz high-pass filter to form a band-pass filter.**

**B**



**AN ACTIVE CROSSOVER NETWORK for driving a high-power subwoofer system is made from IC3-a and IC3-b.**

**C**

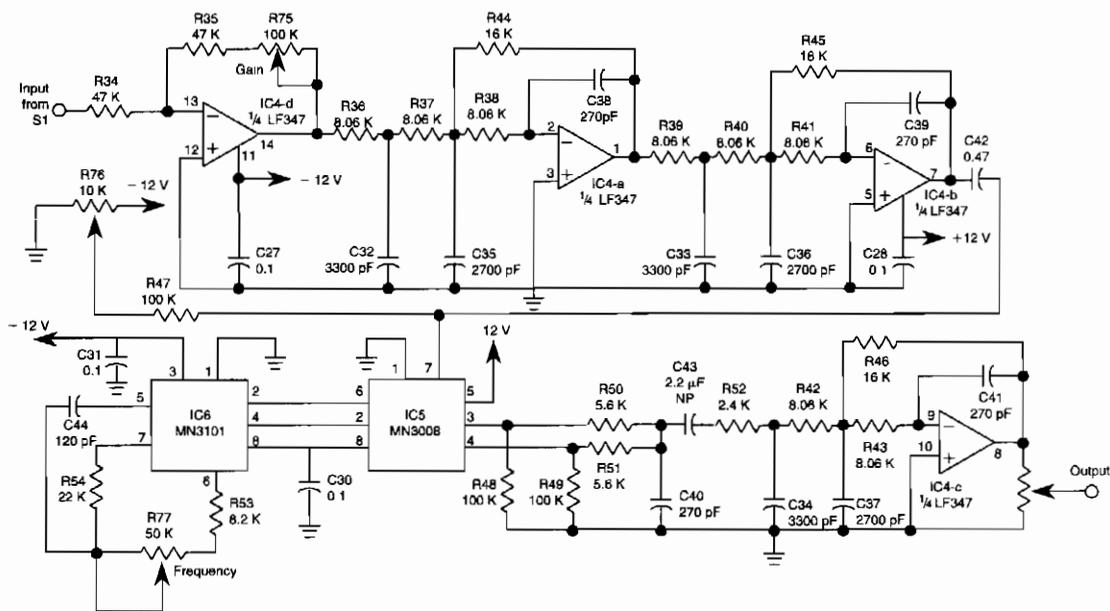
and right channels opposite that of IC1-a. The output of the width-enhancement circuit is routed to S4, which selects either the “wide” or the bypass signal for feeding the front-channel amplifier.

The center-channel dialogue filter is built by cascading a 3-kHz low-pass filter with a 3-Hz high-pass filter to form a band-pass filter. It has a sharp  $-18$  dB/octave cutoff, a flat voltage and power frequency response, and minimum phase change within the passband.

In C, IC3-a and IC3-b form an active crossover network for driving a subwoofer. IC3-a sums signals from the left- and right-channel buffer amps, it inverts the summed signal 180 degrees, and provides a low driving impedance for the following filter stage. IC3-b and its associated RC network form a 75-Hz, 3rd-order low-pass filter. The filter inverts the signal another 180 degrees, so the signal that appears across R79 (which is the output-level control) is back in phase with the original input signal.

The delay section of the AFG, shown in D, is built around the MN3008 bucket brigade device (BBD), and the MN3101 two-phase variable-frequency clock generator. The amount of delay required in this system varies between approximately 5 to 35 milliseconds. The delay time of a BBD is equal to the number of stages divided by twice the clock frequency. Values were chosen for R53, R54, R77, and C44, to produce a clock frequency, adjustable via R77, which varies from about 30 kHz to 130 kHz.

## ACOUSTIC FIELD GENERATOR (Cont.)

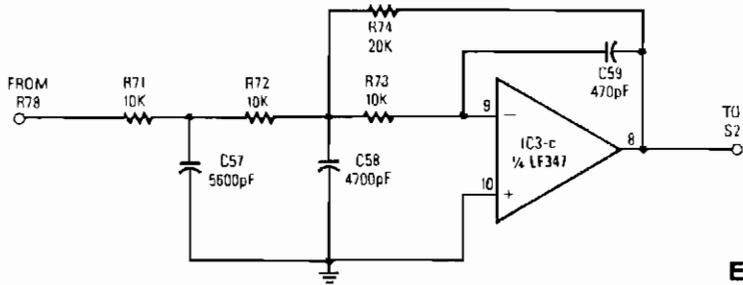


D

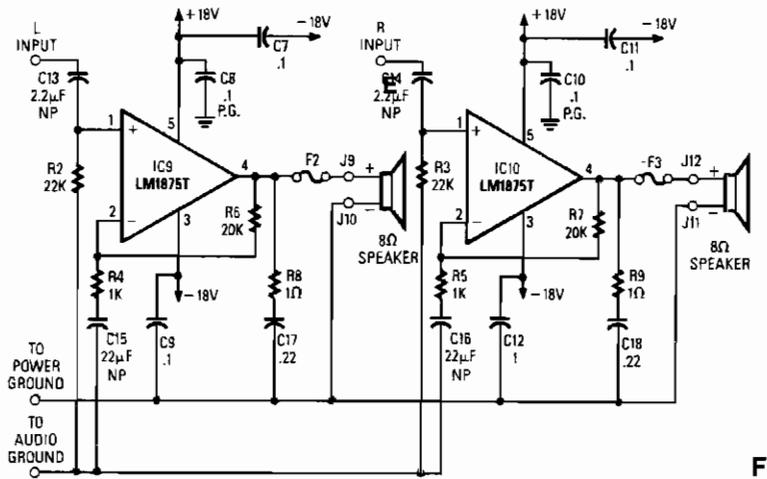
In A, S1 selects the signal to be delayed; either the difference signal ( $L-R$ ) from IC2-d in the matrix mode or the sum signal ( $L+R$ ) from IC2-c in the concert mode. The selected signal is fed from S1 to the delay section (D) where IC4-d is configured as an inverting amplifier; R75 adjusts the gain between unity and X3. Integrated circuits IC4-a and IC4-b, along with their associated RC networks, are identical 3rd-order 15-kHz low-pass filters. Cascading two filters produces a very sharp cut off ( $-36$  dB per octave). Potentiometer R76 adjusts the bias voltage required by the BBD to exactly one half the supply voltage, as required.

The power supply of the AFG, shown in G, is of conventional design. A 25-V center-tapped transformer, along with diodes D1 and D2, produces about  $\pm 18$ -V unregulated dc. Two 2200- $\mu$ F filter capacitors provide ample energy storage to meet the high-current demands of the audio output amplifier ICs during high output peaks.

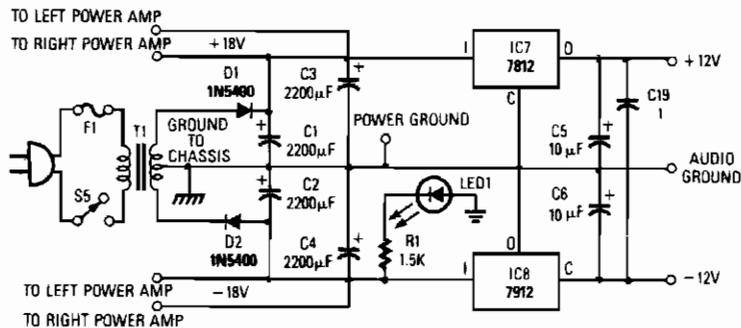
## ACOUSTIC FIELD GENERATOR (Cont.)



A 3rd-ORDER 7-kHz LOW-PASS FILTER is made from IC3-c and its associated RC network.

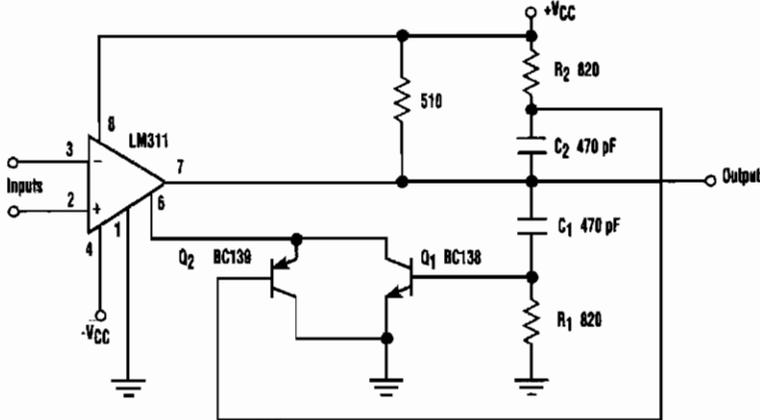


THE SURROUND CHANNEL POWER AMPLIFIERS are designed around a pair of LM1875 monolithic power-amplifier IC's.



THE POWER SUPPLY produces about  $\pm 18$ -volts unregulated DC.

## SUPPRESS JITTER WITH HYSTERESIS

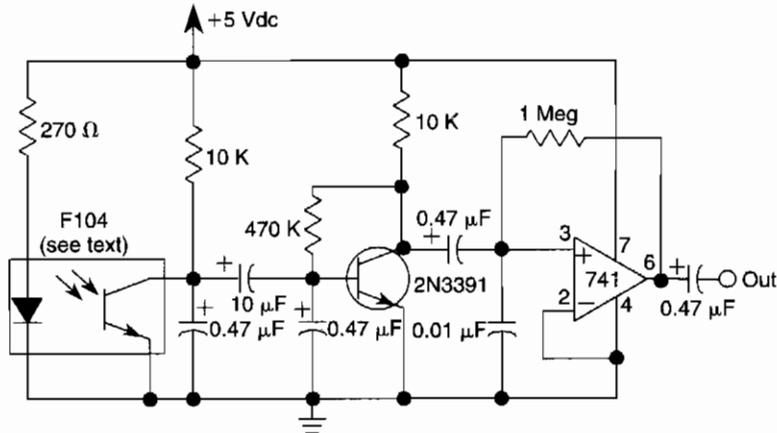


ELECTRONIC DESIGN

FIG. 57-12

When the comparator's output changes its state from low to high, the rising edge of the output pulse, differentiated by the C1/R1 chain, opens Q1. This blocks comparator M via its strobing input and sustains its output in the H state for a period of time, defined by the time constant  $R_1C_1$ . After C1 is charged by the current flowing through R1, Q1 is shut off and the comparator is released. When the comparator's output state changes from high to low, a similar process, involving elements R2, C2, and Q2, occurs. In many applications, the output transition in only one direction is of vital importance, and the elements, which provide temporal hysteresis for the opposite direction transition, can be omitted.

## HEARTBEAT MONITOR



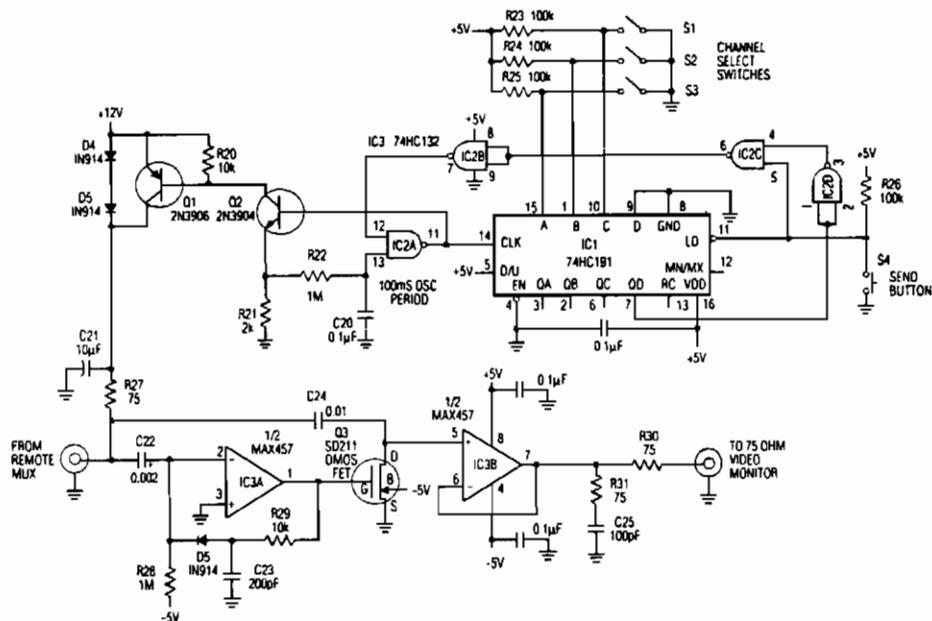
ELECTRONICS NOW

FIG. 57-13

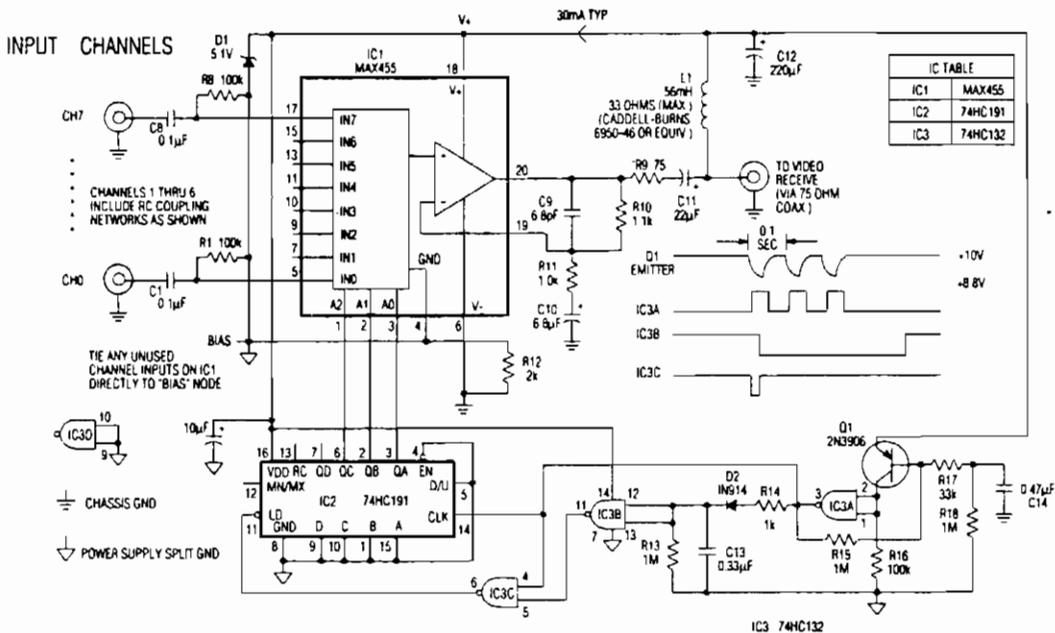
An IR photodiode, which senses IR skin reflectivity as a result of increased blood volume during the periods that the heart forcibly contracts, is used to pick up a signal that is correlated with the heartbeat. A transistor and op amp raise this to a level suitable to trigger logic circuitry or to be displayed on a scope.



# VIDEO, POWER, AND CHANNEL-SELECT SIGNAL CARRIER



**A**



**B**

## VIDEO, POWER, AND CHANNEL-SELECT SIGNAL CARRIER (Cont.)

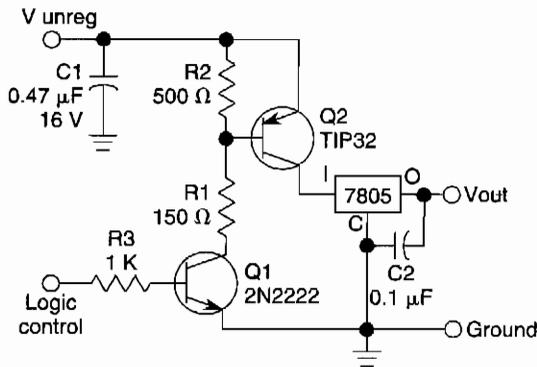
In the video system of Figs. A and B, a single coaxial cable carries power to the remote location, selects one of eight video channels, and returns the selected signal. The system can choose one of several remote surveillance-camera signals, for example, and display the picture on a monitor near the interface box.

The heart of the multiplexer box (A) is a combination 8-channel multiplexer and amplifier (IC1). C11 couples the multiplexer's baseband video output to the coax, and L1 decouples the video from dc power arriving on the same line. This power—approximately 30 mA at 10 V—supplies all circuitry in the multiplexer box.

In interface box (B), a desired channel is encoded by three bits, set either by switches as shown or by an applied digital input. Momentary depression of the send button triggers downconverter IC1 and gated oscillator IC2A to initiate a channel-selection burst.

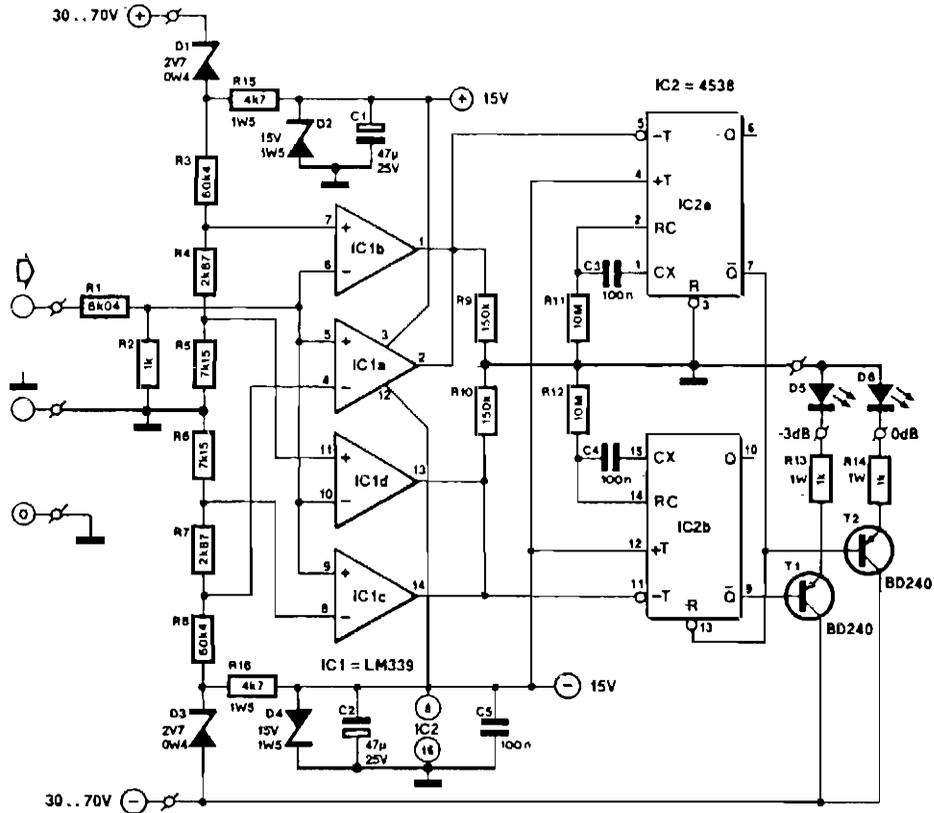
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### 7805 TURN-ON CIRCUIT



A logic level can control a 7805 regulator with this circuit. Q2 is a series switching transistor controlled by Q1. Q1 is turned on by a logic voltage to its base.

## AF DRIVE INDICATOR

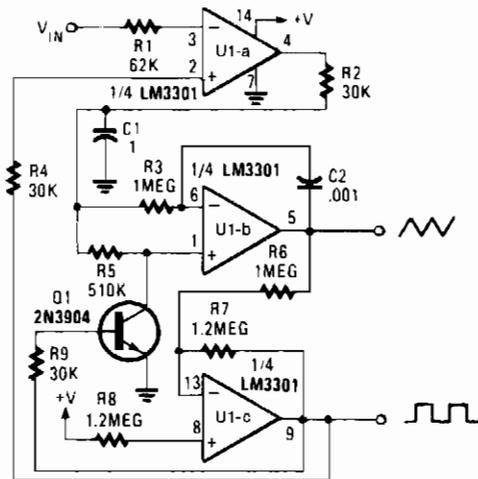


ELEKTOR ELECTRONICS

FIG. 57-18

This circuit was used with an audio power amplifier to detect the point at which output is  $-3$  dB from maximum, indicated by LED D5, and at clipping, shown by LED D6. The indicator can be used with any amplifier operating from a  $\pm 30$  to  $\pm 70$  V symmetrical supply.

### PHASE-LOCKED LOOP

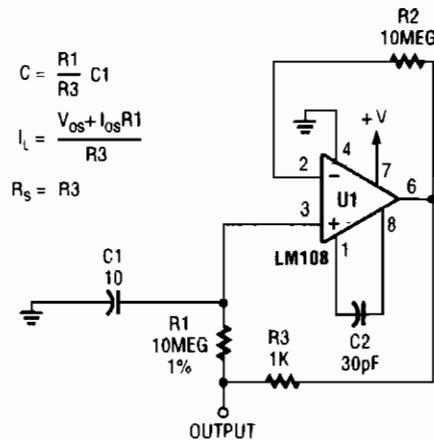


POPULAR ELECTRONICS

FIG. 57-19

The PLL will lock onto an input signal. Both triangle- and square-wave outputs are available. A quad op amp can be used in this circuit, which should be useful in the audio and LF radio region.

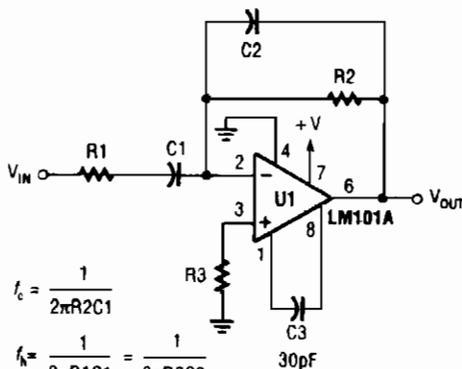
### CAPACITANCE MULTIPLIER



POPULAR ELECTRONICS

FIG. 57-20

### PRACTICAL DIFFERENTIATOR



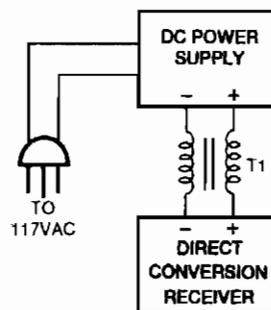
$f_c < f_h < \text{unity gain}$

POPULAR ELECTRONICS

FIG. 57-21

A differentiator has a high-pass characteristic. Components are chosen by using the design equations.

### HUM REDUCER FOR DIRECT-CONVERSION RECEIVERS

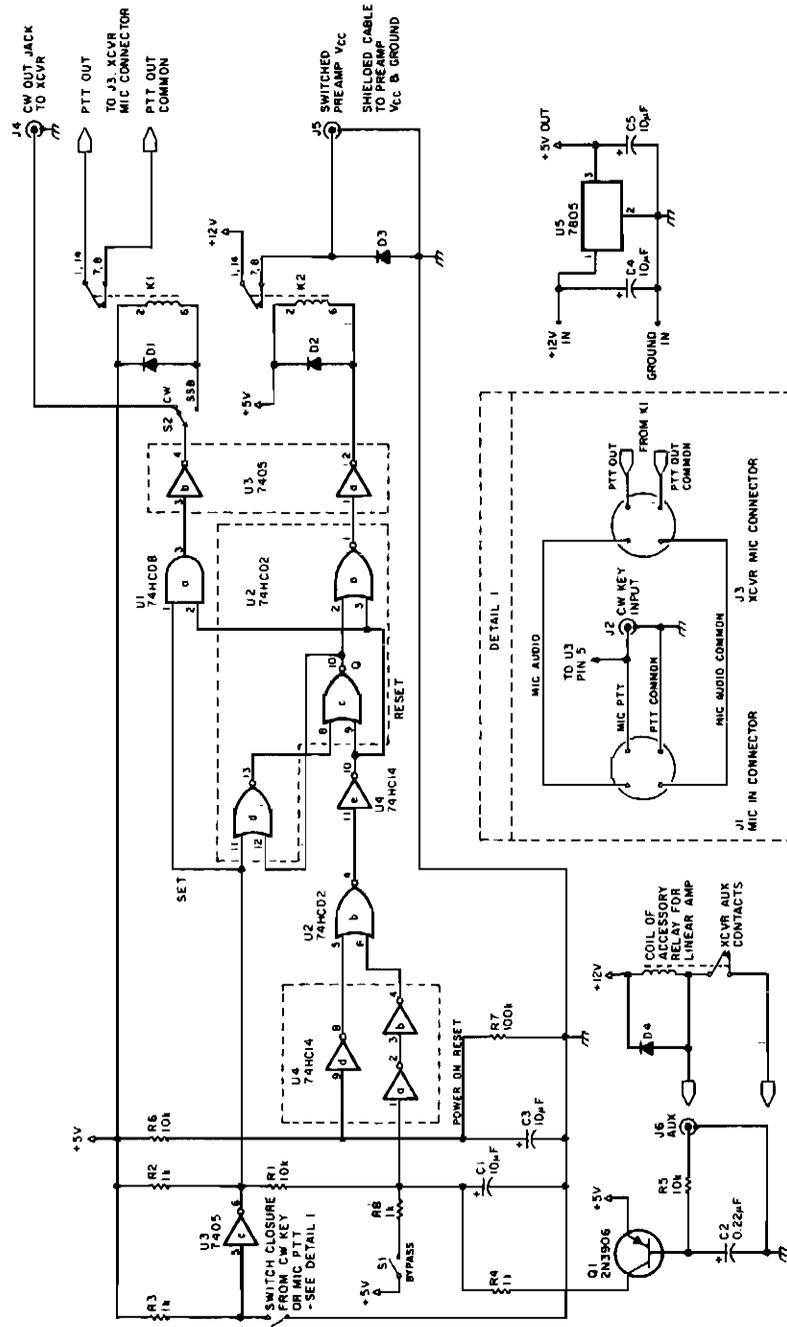


POPULAR ELECTRONICS

FIG. 57-22

One cure for ac power line hum and ripple (caused by leakage current) is to use a well-regulated and filtered 9- to 18-Vdc power supply with a balancing choke (T1 in this illustration) between the power supply and the DCR.

# PREAMP TRANSMIT-RECEIVE SEQUENCER

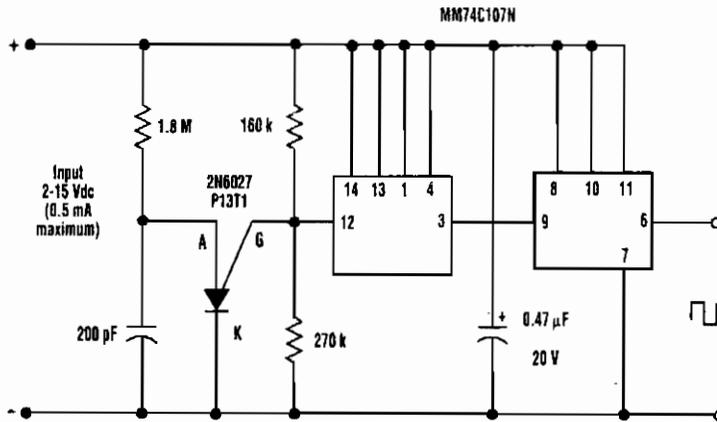


73 AMATEUR RADIO TODAY

FIG. 57-23

This circuit is useful in amateur radio VHF and UHF work where a mast-mounted antenna preamp is used for receiving. The kit controls T-R switching and change-over relay sequencing so that high RF levels are prevented from accidentally being applied to the preamplifier during switching intervals.

## dc OUTPUT CHOPPER



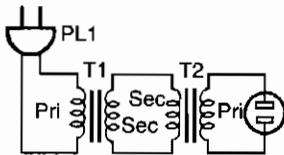
ELECTRONIC DESIGN

FIG. 57-24

Any dc voltage source in the 2- to 15-V range can be chopped into a unipolar square wave that has a peak amplitude nearly equal to the dc source voltage with circuit (lightly loaded CMOS will swing within a few millivolts of each rail at low frequencies). Depending on the actual voltage of the supply, the programmable-unijunction-transistor (PUT) relaxation oscillator produces 2000-Hz trigger pulses. These pulses operate the cascaded 74C107 flip-flop, producing a square wave.

## ac ISOLATION TRANSFORMERS USE INEXPENSIVE 12-V TRANSFORMERS

“Safety first” is a good motto to follow when you play with electricity. You can follow that adage more closely with this homebrew isolation transformer.

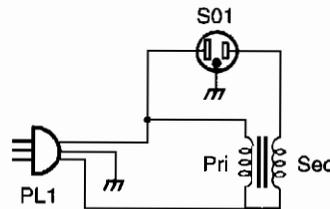


POPULAR ELECTRONICS

FIG. 57-25

## ac LINE VOLTAGE BOOSTER

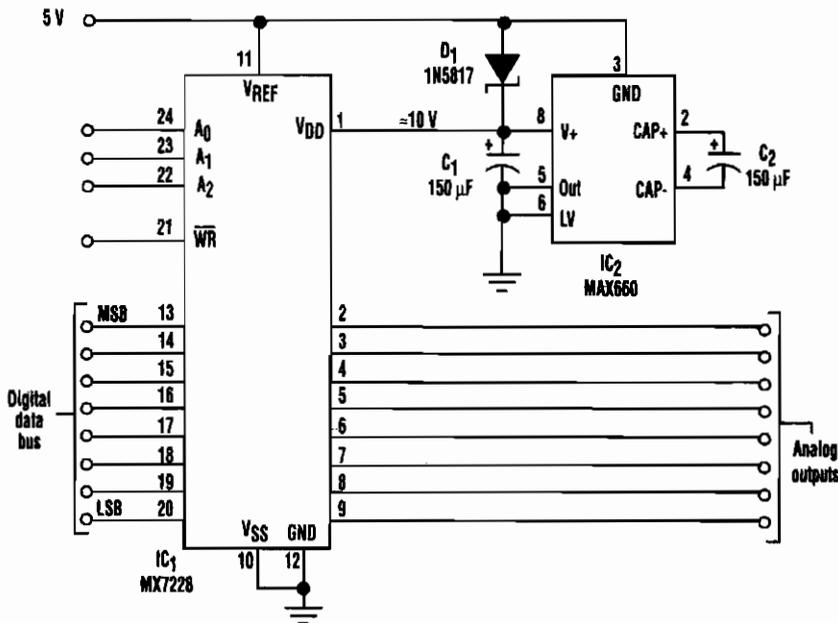
When incoming ac power drops, you can bring the voltage back up with this booster circuit. It adds the transformer's secondary voltage to the ac line voltage.



POPULAR ELECTRONICS

FIG. 57-26

## OCTAL D/A CONVERTER

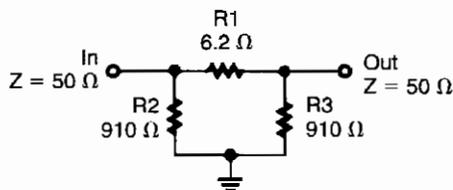


ELECTRONIC DESIGN

FIG. 57-27

This octal digital-to-analog converter operates on 5 V and provides eight output voltages, each digitally adjustable from supply rail to supply rail (0 to 5 V). Each output's resolution is 20 mV/LSB. The DAC chip (IC1) requires 3.5 V of "headroom" between its  $V_{DD}$  and reference voltages. However, a voltage-doubler charge pump (IC2) removes this limitation by generating an approximate 10-V supply for  $V_{DD}$ . All of the converter references are connected to the 5-V supply. IC2 doubles the 5-V input to an unregulated 10-V output that has an output impedance of less than 10  $\Omega$ . It can deliver 100 mA, which enables the eight DACs to issue their maximum output currents simultaneously ( $8 \times 5 \text{ mA} = 40 \text{ mA}$ ).

### 1-dB PAD

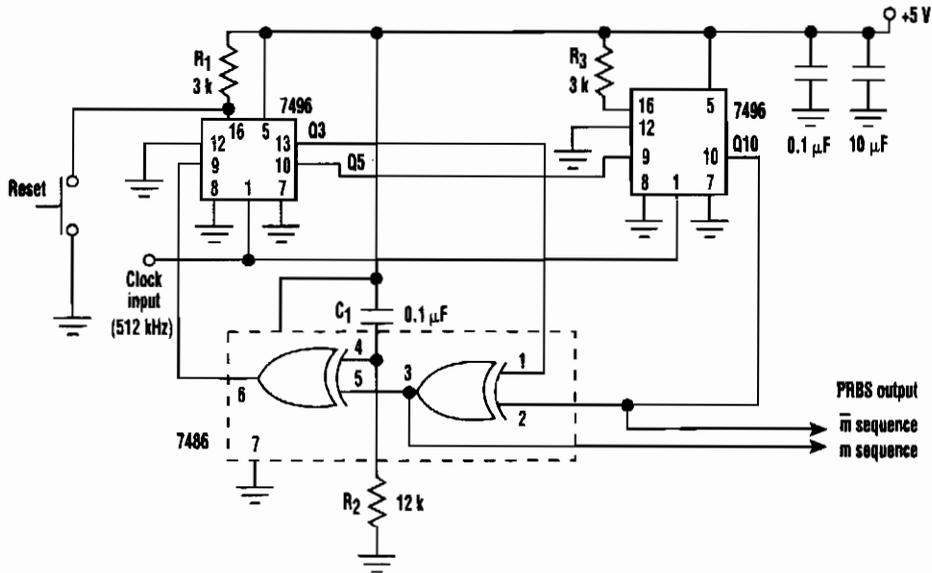


The 1-dB pad is useful as a termination in RF work to limit possible mismatch range between system blocks, etc.

POPULAR ELECTRONICS

FIG. 57-28

## PSEUDO-RANDOM BIT SEQUENCE GENERATOR



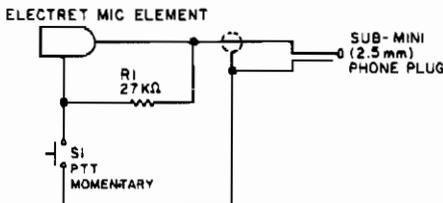
ELECTRONIC DESIGN

FIG. 57-29

In this circuit, an additional exclusive-OR gate is connected after the modulo-2 feedback, with C1 and R2 applying the supply turn-on ramp into the feedback loop. This provides sufficient transient signal so that the PRBS generator can self-start a power-up. A shift-register length  $n$  of 10 is shown with feedback at stages 3 and 10, providing true and inverted maximal length sequence outputs.

This technique applies an input directly to the feedback loop. Therefore, it's considered more reliable than applying an RC configuration to the shift-register reset input to create a random turn-on state.

## SIMPLE EXTERNAL MICROPHONE CIRCUIT FOR TRANSCEIVERS

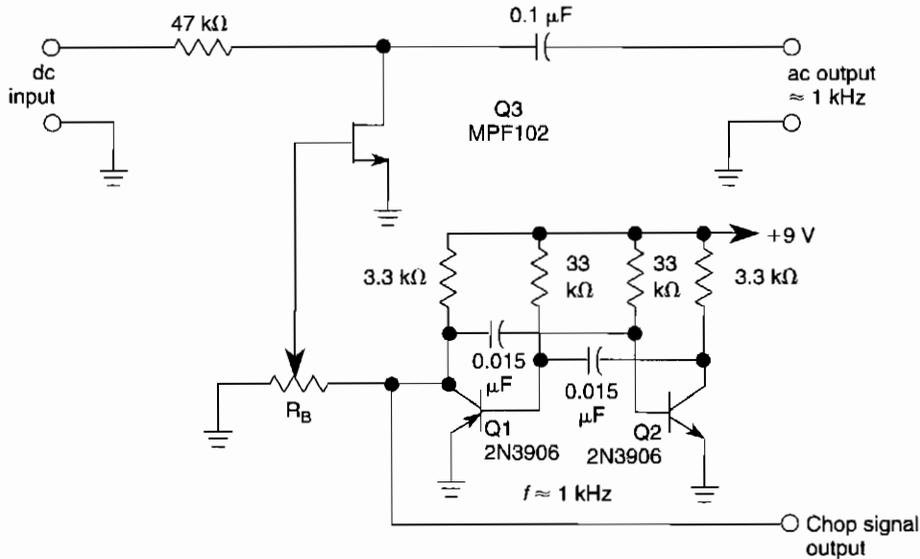


Used originally for an Icom IC2AT handie talkie, this circuit might prove useful in other applications.

73 AMATEUR RADIO

FIG. 57-30

## JFET CHOPPER CIRCUIT

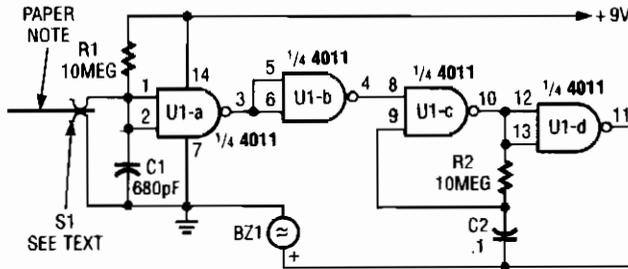


WILLIAM SHEETS

FIG. 57-31

A JFET (MPF102) is used to chop a dc signal for amplification in an ac coupled amplifier. Q3 is the chopper element and Q1-Q2 forms the multivibrator to derive a chopping signal.  $R_B$  sets the bias on the FET to keep the drive to MPF102 as low as possible.

## AUDIO MEMO ALERT

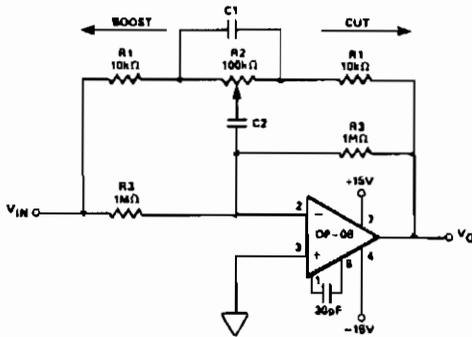


POPULAR ELECTRONICS

FIG. 57-32

This device prevents paper notes and memos from being overlooked. A paper note placed between two fingers made of a conducting material (metal or conductive plastic) breaks the circuit, allowing pair 1 of U1-a to go high. This causes U1-c & U1-d to act as an oscillator, pulsing piezo buzzer BZ1.

## OCTAVE EQUALIZER



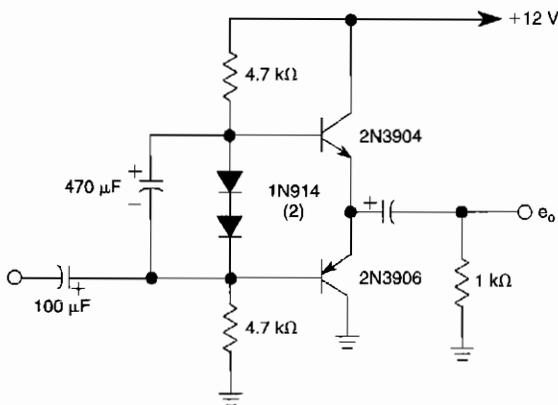
$f_o$ (Hz)	$C_1$	$C_2$
32	$0.18\mu\text{F}$	$0.018\mu\text{F}$
64	$0.1\mu\text{F}$	$0.01\mu\text{F}$
125	$0.047\mu\text{F}$	$0.0047\mu\text{F}$
250	$0.022\mu\text{F}$	$0.0022\mu\text{F}$
500	$0.012\mu\text{F}$	$0.0012\mu\text{F}$
1k	$0.0056\mu\text{F}$	560pF
2k	$0.0027\mu\text{F}$	270pF
4k	$0.0015\mu\text{F}$	150pF
8k	680pF	68pF
16k	360pF	36pF

PRECISION MONOLITHICS INC.

FIG. 57-33

This circuit is one section of an octave equalizer used in audio systems. The table shows the values of  $C_1$  and  $C_2$  that are needed to achieve the given center frequencies. This circuit is capable of 12 dB boost or cut, as determined by the position of  $R_2$ . Because of the low input bias current of the OP-08, the resistors could be scaled up by a factor of 10, and thereby reduce the values of  $C_1$  and  $C_2$  at the low-frequency end. In addition, 10 sections will only draw a combined supply current of 6 mA maximum.

### COMPLEMENTARY OR BILATERAL ac EMITTER-FOLLOWER CIRCUIT

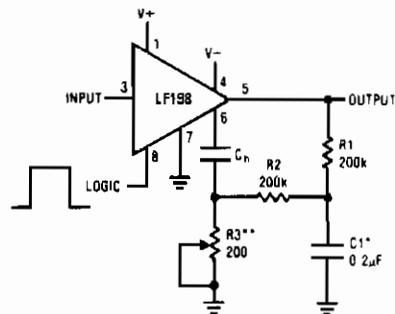


WILLIAM SHEETS

FIG. 57-34

This noninverting circuit uses a pair of complementary npn (2N3904) and pnp (2N3906) transistors.

### CAPACITOR HYSTERESIS COMPENSATOR



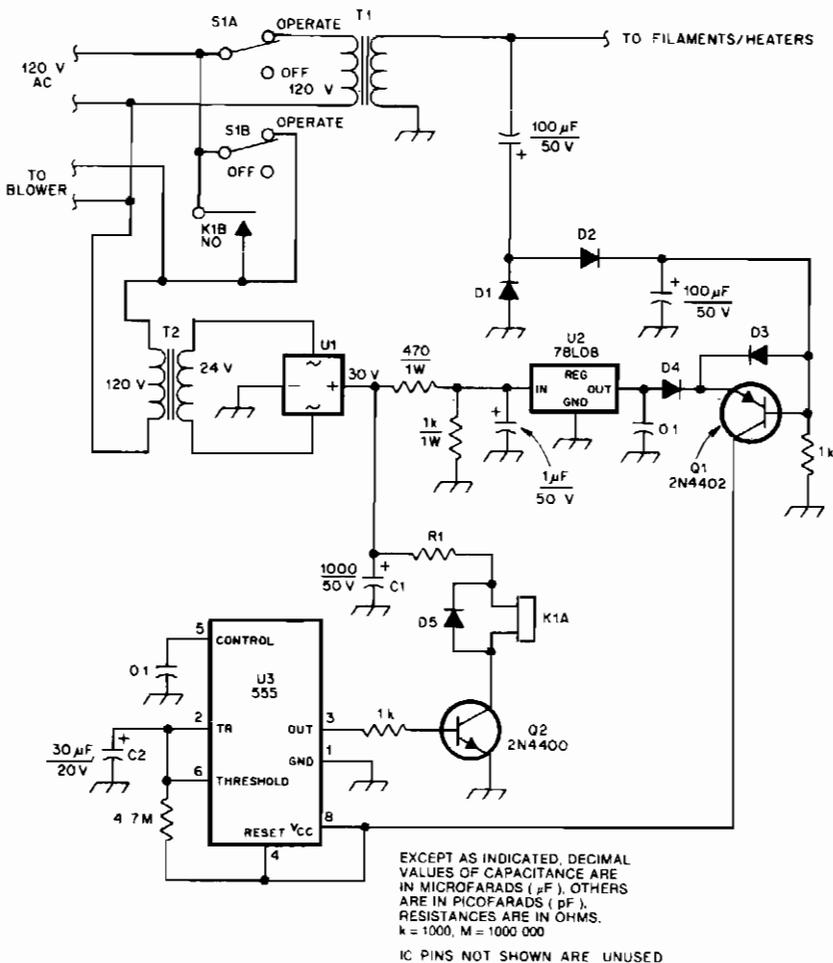
\*SELECT FOR TIME CONSTANT  $C_1 = \frac{\tau}{100k}$

\*\*ADJUST FOR AMPLITUDE

LINEAR DATABASE

FIG. 57-35

## AMPLIFIER COOL-DOWN CIRCUIT I

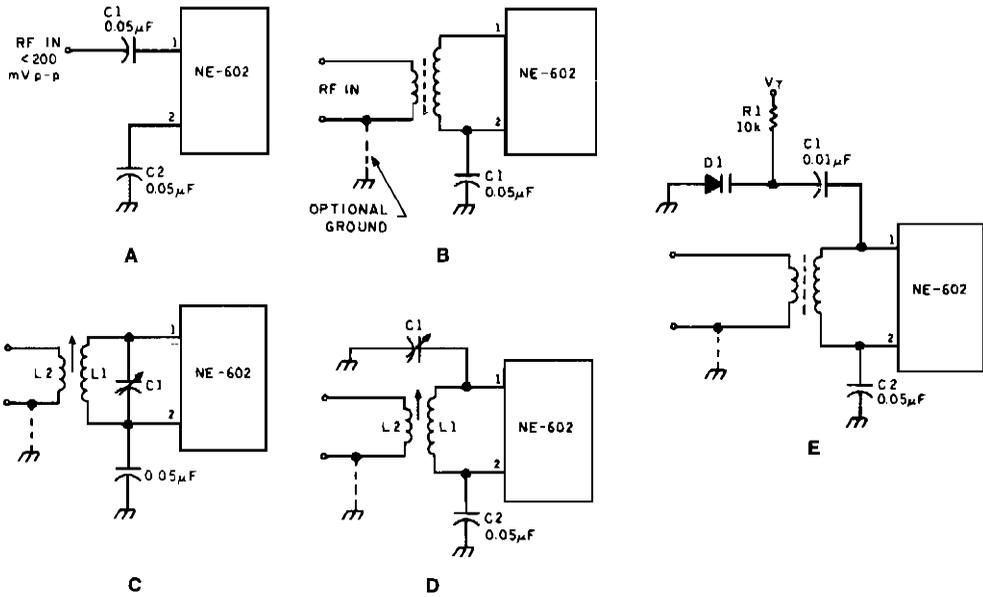


QST

FIG. 57-36

This cool-down relay circuit uses an IC timer to drive a relay, which keeps the blower on for a time delay from timer U3. The value of  $C_2$  can be changed to lengthen or shorten the time, as needed.

## NE602 INPUT CIRCUITS

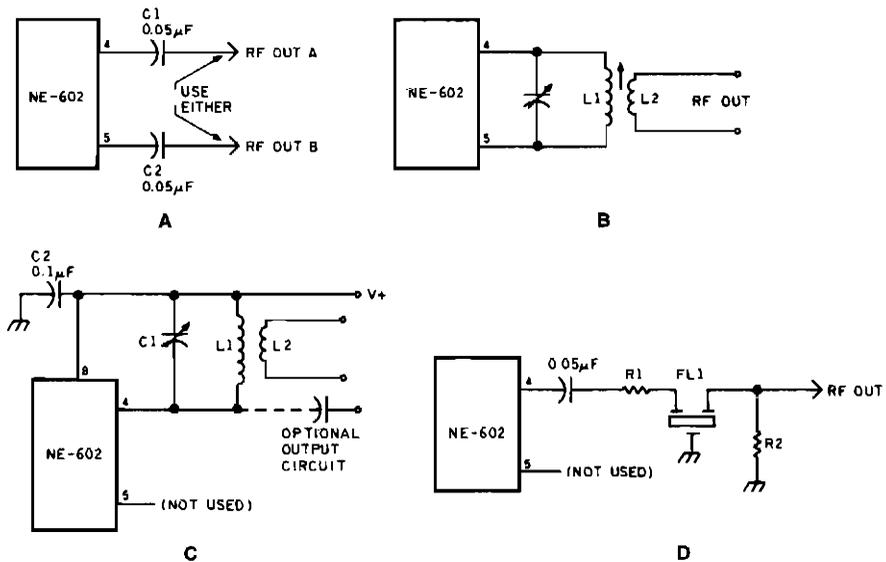


73 AMATEUR RADIO TODAY

FIG. 57-37

Input circuits for the NE-602.

## NE602 OUTPUT CIRCUITS

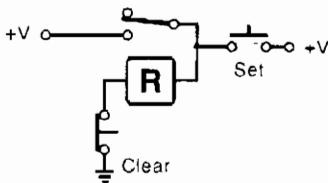


73 AMATEUR RADIO TODAY

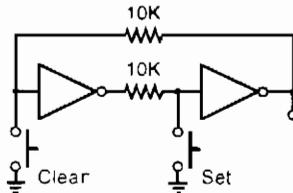
FIG. 57-38

Output circuits for the NE-602.

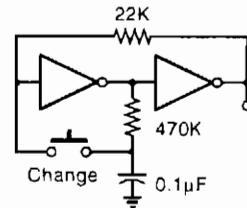
## BASIC LATCH CIRCUITS



(A) Relay converted to latch



(B) Inverter pair used as latch.



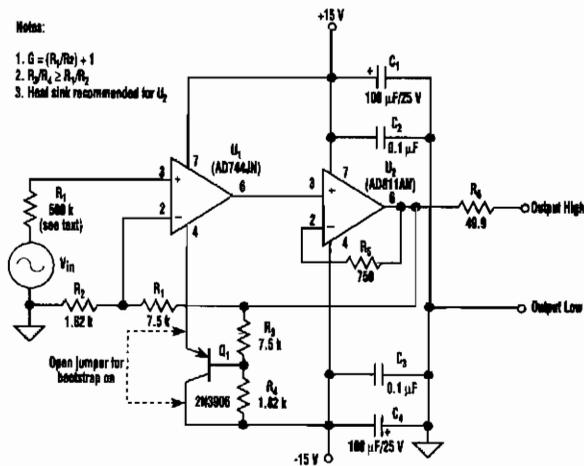
(C) Alternate action pushbutton.

ELECTRONICS NOW

FIG. 57-39

Some simple latches and alternate action circuits.

## BOOTSTRAP CIRCUIT

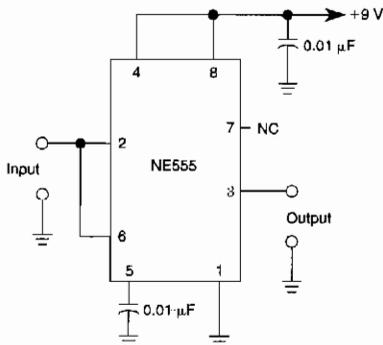


Bootstrapping the substrate of a JFET amplifier reduces the distortion caused by the nonlinearity of the JFET input capacitance. In the figure, a second feedback divider bootstraps the substrate of  $U_1$ . With  $R_1 = 500 \text{ k}\Omega$  (source impedance), THD at 10 kHz was reduced an order of magnitude.

ELECTRONIC DESIGN

FIG. 57-40

## SIMPLE SCHMITT TRIGGER

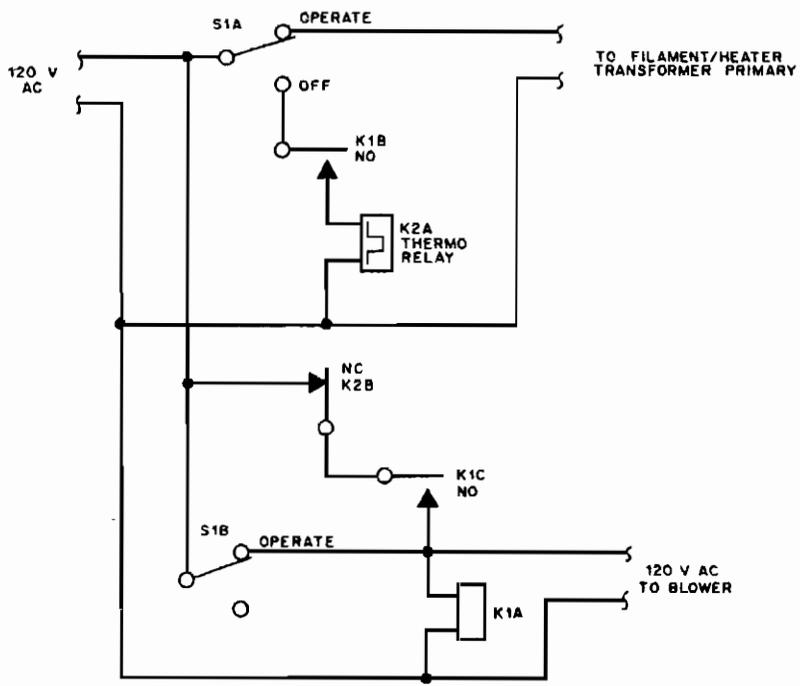
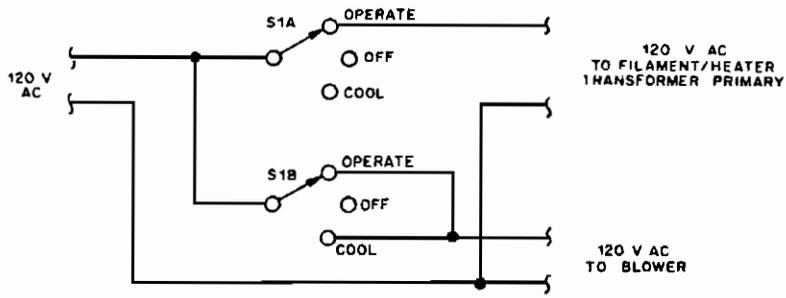


A 555 IC is shown configured to function as a Schmitt trigger. Inputs above and below the threshold level will turn the circuit on and off producing a square wave output.

WILLIAM SHEETS

FIG. 57-41

## AMPLIFIER COOL-DOWN CIRCUIT II

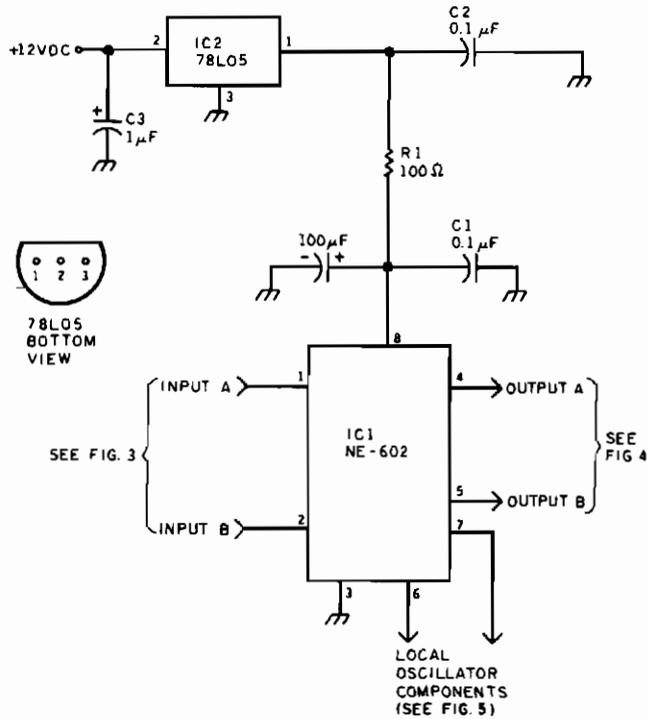


QST

**FIG. 57-42**

High-power amplifiers used in RF service, using vacuum tubes, often benefit from leaving the blower air flow on after removal of filament/heater voltage.

## NE602 dc POWER CIRCUITS

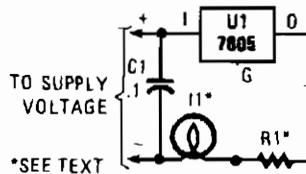


73 AMATEUR RADIO TODAY

FIG. 57-43

The dc power supply circuit for the NE-602.

## INRUSH CURRENT LIMITER



POPULAR ELECTRONICS

FIG. 57-44

A 7805 can be configured as a constant-current regulator, to serve as an inrush current limiter.  $R_1$  will have 5 V across it at all times so the total current through  $I_1$  will be  $5 V/R_1 + 5 \text{ mA}$ , the 5 mA being the regulator operating current. In this case,  $R_1 = 5 V/95 \text{ mA} = 52.6 \Omega$  for  $I_1$  current = 100 mA.

# 58

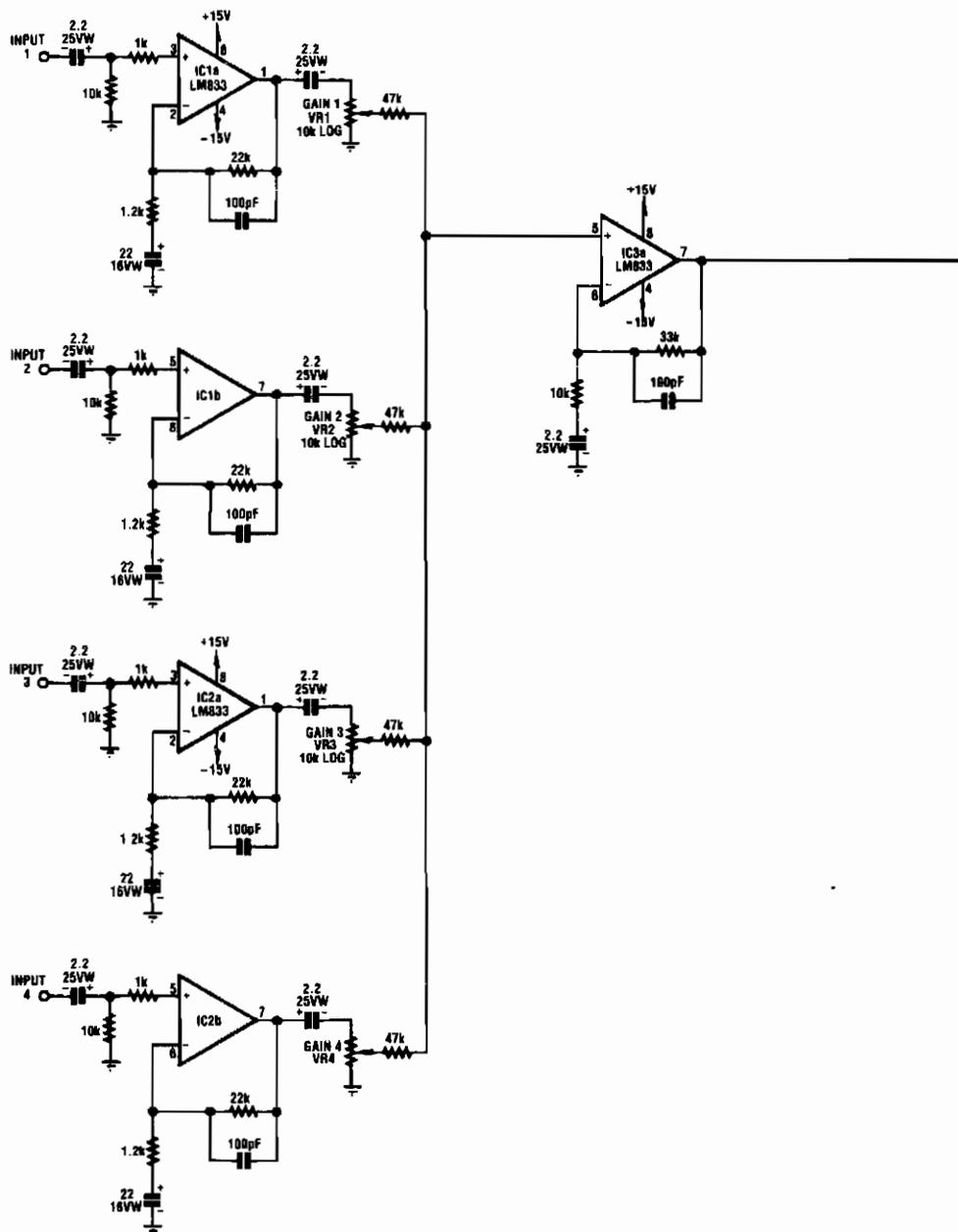
## Mixer Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Low-Noise 4-Channel Guitar Mixer  
Audio Mixer  
FET Microphone Mixer  
Unity-Gain Four-Input Audio Mixer  
FET Op Amp Microphone Mixer

## LOW-NOISE 4-CHANNEL GUITAR MIXER



### SILICON CHIP

IC1-a, IC1-b, IC2-a, and IC2-b all function with a gain of about 19. Their outputs are mixed via the level-control pots and the resulting signal amplified by IC3-a and fed to tone-control stage IC3-b. Finally, the output from IC3-b is fed to unity-gain buffer stage IC4-a via volume-control potentiometer VR8.

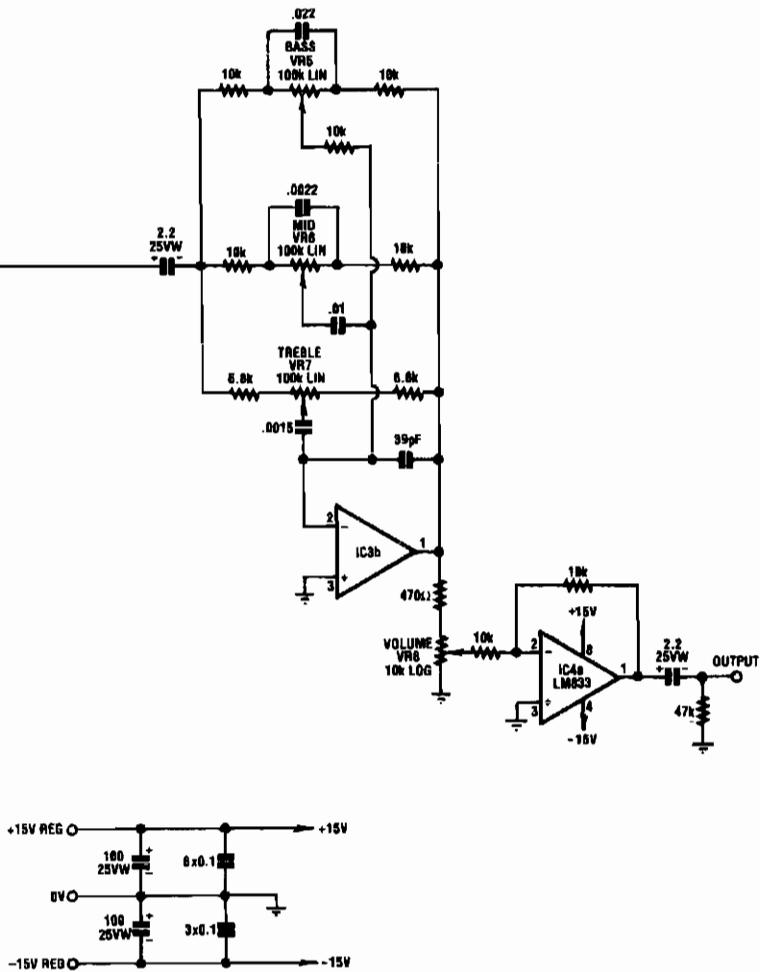
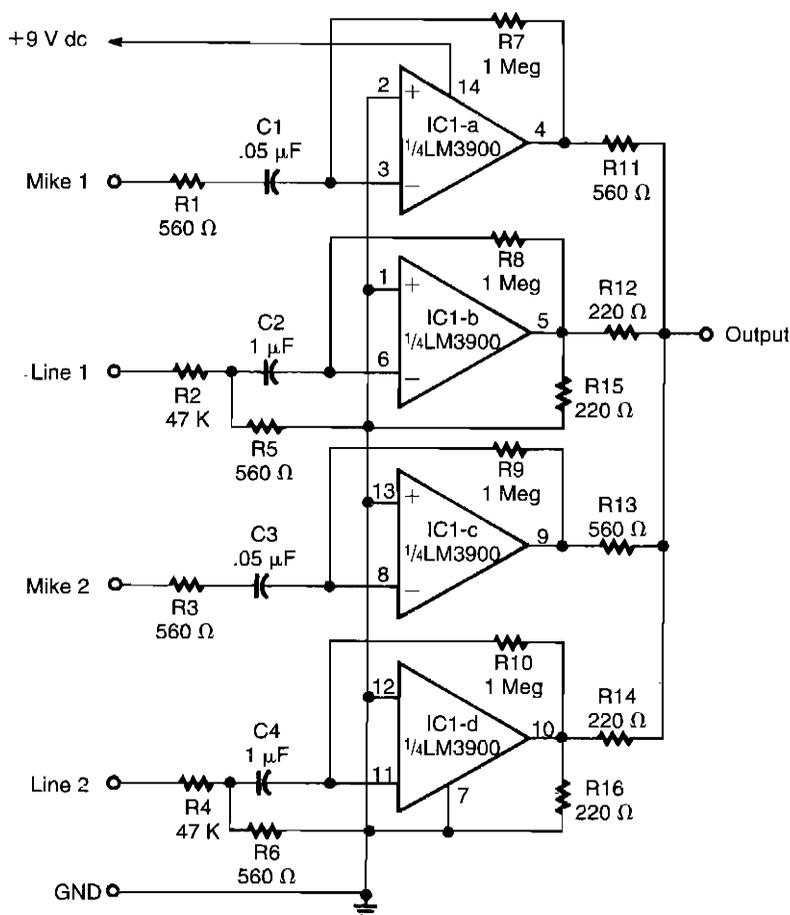


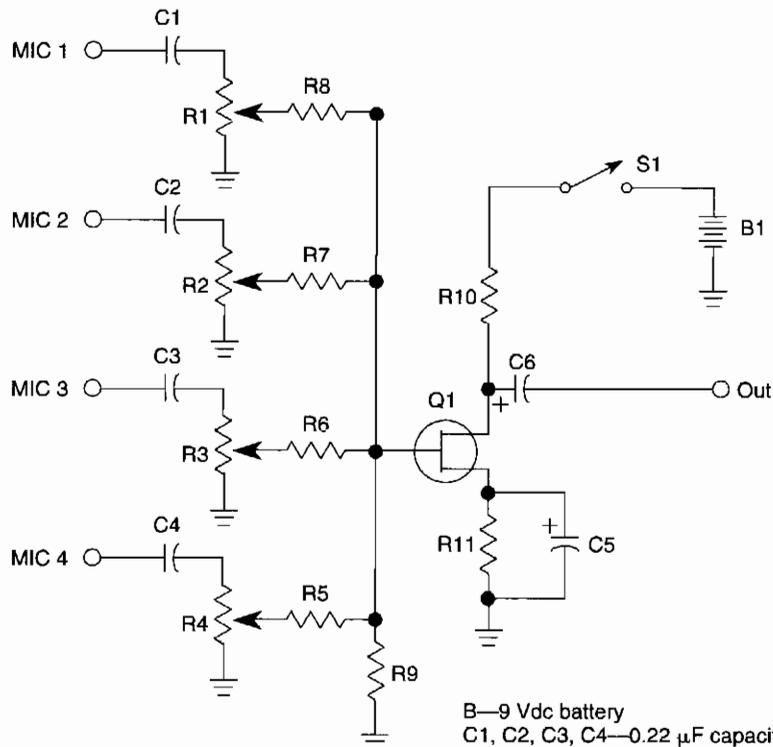
FIG. 58-1

## AUDIO MIXER



Designed around an LM3900 quad op amp, this mixer combines 2-line and 2-mike inputs and sums them at the output terminal. R7 through R10 can be changed to vary the gain (around +23 dB).

## FET MICROPHONE MIXER



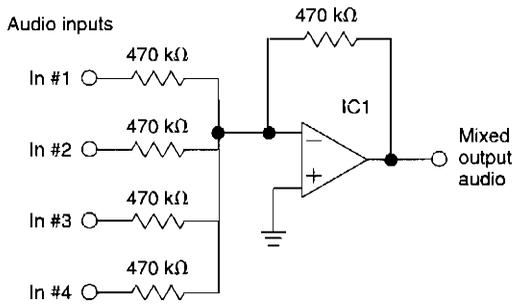
- B—9 Vdc battery
- C1, C2, C3, C4—0.22  $\mu$ F capacitor
- C5, C6—10- $\mu$ F capacitor
- R1, R2, R3, R4—500 k $\Omega$  potentiometer, audio taper
- R5, R6, R7, R8—2.2 M $\Omega$  resistor
- R9—10 M $\Omega$  resistor
- R10—2.2 k $\Omega$  resistor
- R11—470  $\Omega$  resistor
- Q1—FET (field effect resistor), MPF102
- S1—SPST switch

WILLIAM SHEETS

FIG. 58-3

A JFET transistor is used as a high-to-low impedance converter and signal mixer. Input impedance is approximately 500 k $\Omega$  but it can be increased by increasing R5 to R8 as high as 10 M $\Omega$ . Output Z is about 2 k $\Omega$ , but it can be increased or decreased by changing the value of R<sub>10</sub>. Use 560 or 680  $\Omega$  to feed a 600- $\Omega$  input; use 100 k $\Omega$  to 1 M $\Omega$  for high impedance.

## UNITY-GAIN FOUR-INPUT AUDIO MIXER



The circuit has four inputs. The voltage gain between each input and the output is held at unity by the relative values of the 470kΩ input resistor and the 470kΩ feedback resistor.

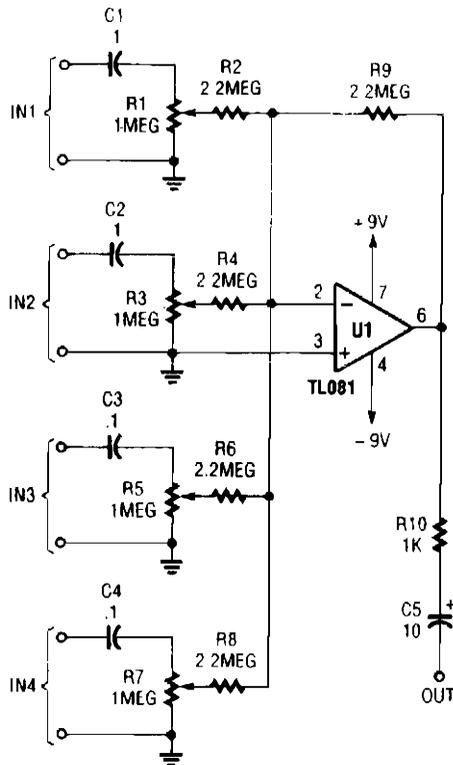
$$E_{OUT} = -(In \#1 + In \#2 + In \#3 + In \#4)$$

IC1 = LM741, etc.

WILLIAM SHEETS

**FIG. 58-4**

## FET OP AMP MICROPHONE MIXER



POPULAR ELECTRONICS

**FIG. 58-5**

# 59

## Modulator Circuits

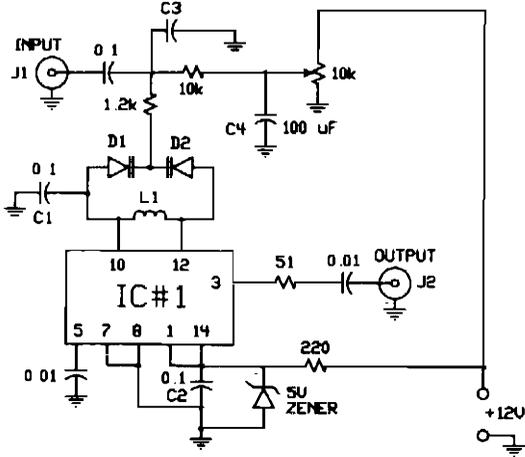
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

FM Modulator  
455-kHz Modulator  
555 FM Circuit

## FM MODULATOR

IC-1 - Motorola MC-1648P  
 All resistors 5%, 0.25 W  
 Zener - 5.1 V, 0.5 W  
 All 0.1 and 0.01  $\mu$ F capacitors ceramic, 16V  
 C4 - 100  $\mu$ F, 16 V electrolytic  
 D1, D2 - Motorola MV-209  
 L1 - airwound, 6 turns, 3/16" dia., 5/16" long, 20 AWG  
 C3 - 500 pF, silver mica

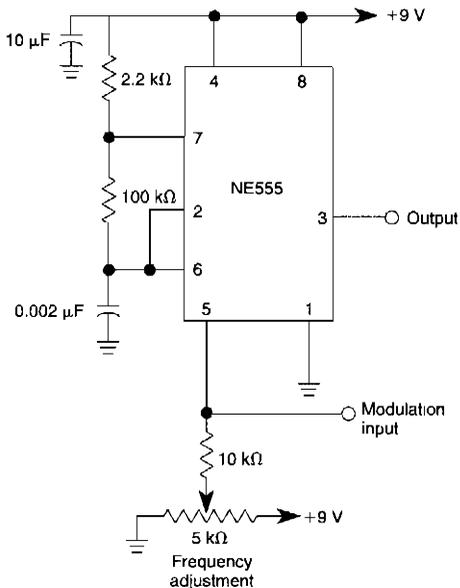


The FM modulator is built with a Motorola MC1648P oscillator. Two varactors, Motorola MV-209, are used to frequency modulate the oscillator. The 5000- $\Omega$  potentiometer is used to bias the varactors for best linearity. The output frequency of approximately 100 MHz can be adjusted by changing the value of the inductor. The output frequency can vary as much as 10 MHz on each side. The output level of the modulator is -5 dBm. In this prototype, the varactor bias was 7.5 V for best linearity; but this could be different with other varactors.

RF DESIGN

FIG. 59-1

## 455-kHz MODULATOR



This circuit shows how to frequency-modulate the oscillator using a 555. Oscillator frequency is set with the 5-k $\Omega$  potentiometer and the modulation signal is dc-coupled.

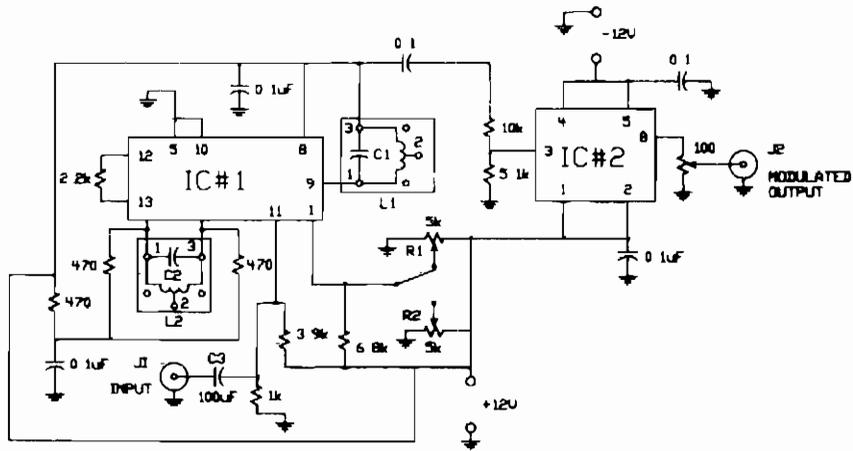
WILLIAM SHEETS

FIG. 59-2

## 555 FM CIRCUIT

IC-1 - Motorola MC-1374P  
 IC-2 - National LH0002C  
 L1, L2 - Mouser Electronics #4211F200  
 C1, C2 - silver mica, 300 pF  
 All 0.1 uF cap., ceramic disc, 16V  
 C3 - 100 uF, 10 V, electrolytic  
 All resistors 5%, 0.25 W

ADJUSTMENT: Adjust R1 for minimum carrier; signal from function generator should generate 500 mVpp at pin 8 of IC-2 (suppressed carrier double sideband). Adjust R2 and function generator level to achieve 800 mVpp at pin 8 of IC-2 (standard AM with carrier). Adjust L2 for 455 kHz. Adjust L1 for maximum output.



RF DESIGN

FIG. 59-3

Circuit for applying a dc-coupled FM or PPM to a 555 configured as an oscillator.

# 60

## Monitor Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Room Monitor  
Baby Monitor  
Bird Feeder Monitor  
Acid-Rain Monitor





## BABY MONITOR (Cont.)

**Transmitter operation.** Operating power for the transmitter circuit is derived directly from the ac line. The dc power to operate the circuit is generated in two stages, one for an RF power-amplifier stage, and the second for the remainder of the circuit.

The ac line voltage is applied to D1, which half-wave rectifies the ac input. The resulting dc voltage (approximately 30V under load) is fed across an RC filter (comprised of R1 and C1) and used to operate amplifier, Q1. The second stage of the power supply (composed of LED1, R2, D2, D3, C2, and C3, which forms a regulated +13.6-V, center-tapped supply) feeds the remainder of the circuit. LED1 is connected in series with R2 and is used as a visual power-on indicator for the transmitter.

An electret microphone element (MIC1) is used as the pick-up. The output of the microphone is ac coupled through C5 to U1-a (a noninverting op amp with a gain of about 100). The output of U1-a at pin 1 is ac coupled through C4 to the noninverting input of U1-b (which provides an additional gain of 48) at pin 5. The output of U1-b at pin 7 is then fed through D4 and R10, and across R11 and C6 to the inverting input of U1-c which is biased to a positive voltage that is set by SENSITIVITY-control R19. This represents a threshold voltage at which the output of U1-c switches from high to low.

During standby, the output of U1-c at pin 8 is held at about 12 V when the voltage developed across C6 is less than the bias-voltage setting at pin 10. When a sound of sufficient intensity and duration is detected, the voltage at pin 9 of U1-c exceeds the threshold level (set by R19), causing U1-c's output at pin 8 to go low. That low is applied to pin 2 of U2 (a 555 oscillator/timer configured as a monostable multivibrator). This causes the output of U2 to go high for about one second, as determined by the time constant of R12 and C7. The output of U2 at pin 3 is applied to pin 4 of U3 (a second 555 oscillator/timer that is configured for astable operation, with a frequency of about 125 kHz). That causes U3 to oscillate, producing a near square-wave output that is used to drive Q1 into conduction. The output of Q1 is applied across a parallel-tuned circuit composed of T1's primary and C8. The tuned circuit, in turn, reshapes the 125-kHz signal, causing a sine-wave-like signal to appear across both the primary and the secondary of T1.

The signal appearing at T1's secondary (about 1 or 2 V peak-to-peak) is impressed across the ac power line, and is then distributed throughout the building without affecting other electrical appliances connected to the line. Transient suppressor D7 is included in the circuit to help protect Q1 from voltage spikes that might appear across the power line and be coupled to the circuit through T1.

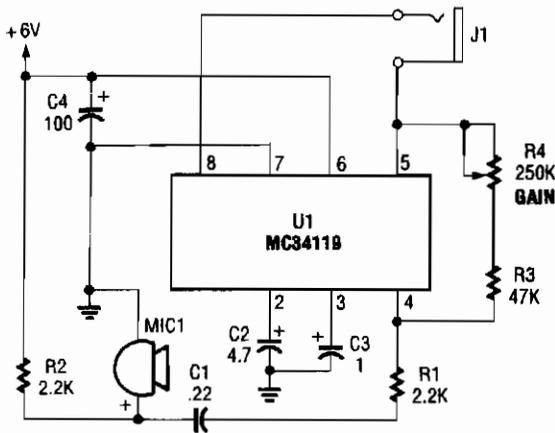
**Receiver operation.** Power for the receiver, as with the transmitter, is derived from a traditional half-wave rectifier (D5). The resulting dc voltage is regulated to 27 V by D6 and R20, and is then filtered by C11 to provide a relatively clean, dc power source for the circuit. A light-emitting diode, LED2, connected in series with R20 provides a visual indication that the circuit is powered and ready to receive a signal.

The 125-kHz signal is plucked from the ac line and coupled through R21 and C12 to a parallel-tuned LC circuit, consisting of C13 and L1. That LC circuit passes 125-kHz signals while attenuating all others. The 125-kHz signal is fed through C14 to the base of Q2 (which is configured as a high-gain linear amplifier), which boosts the relatively low amplitude of the 125-kHz signal. The RF output of Q2 is ac coupled to the base of Q3 through C15. Transistor Q3 acts as both an amplifier and detector. Because there is no bias voltage applied to the base of Q3, it remains cut off until driven by the amplified 125-kHz signal. When Q3 is forward biased, its collector voltage rises.

Capacitor C16, connected across Q3's collector resistor, filters the 125-kHz signal so that it is essentially dc. When the voltage at the collector of Q3 rises, Q4 is driven into conduction. That causes current to flow into piezo buzzer BZ1, producing a distinctive audio tone that alerts anyone within earshot that the baby needs attention.

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## BIRD FEEDER MONITOR



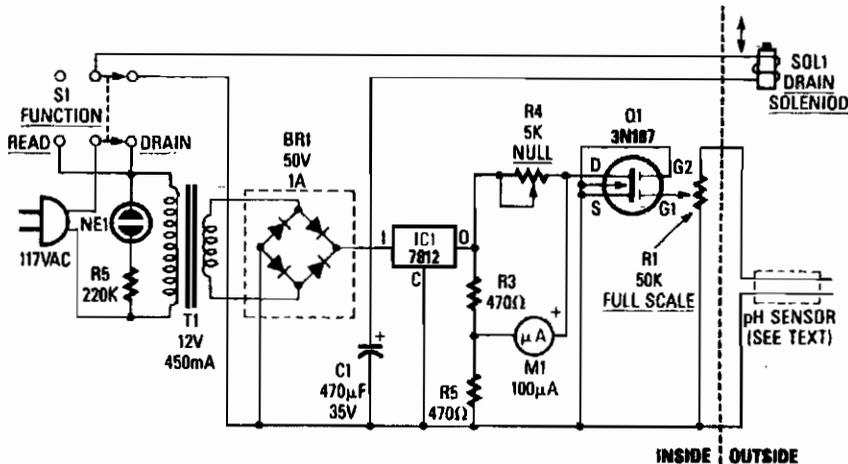
The first amplifier circuit is a bird phone. In this circuit, the electret mike (MIC1) is mounted in the neck of a large plastic funnel. The amplifier, built around an MC34119 (which is available from D.C. Electronics, P.O. Box 3203, Scottsdale, AZ 85271-3203; Tel. 800-467-7736, and elsewhere), is then placed outside of the funnel with the pick-up facing a nearby bird feeder. The output of the amplifier is then connected to a 16- $\Omega$  speaker.

The amplifier's voltage gain is determined by the values of the input resistor (R1) and the feed-back resistor (R3 and R4, respectively). The differential gain of the amplifier is given by:  $R_3 + R_4/R_1 \times 2$ . With the component values shown, the maximum voltage gain is about 270. This permits listening to the activity at the bird feeder.

POPULAR ELECTRONICS

FIG. 60-3

## ACID-RAIN MONITOR



R-E EXPERIMENTERS HANDBOOK

FIG. 60-4

The drain-to-source resistance of Q1 varies depending on the acidity of the sample presented to Q1's gate circuit. That variable resistance varies the current flowing through the bridge; that current is proportional to pH.

# 61

## Moisture- and Fluid-Detector Circuits

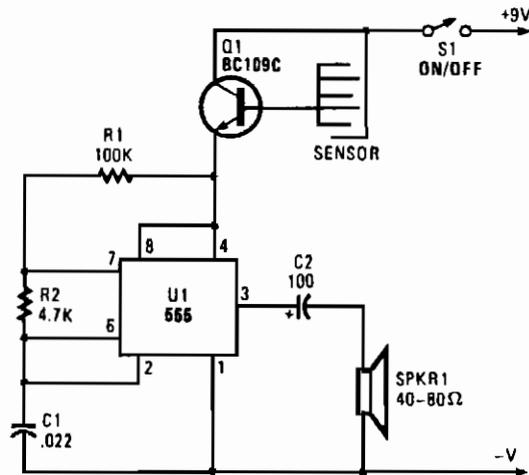
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Water-Activated Alarm  
Simple Flood Alarm  
Moisture Detector

## WATER-ACTIVATED ALARM

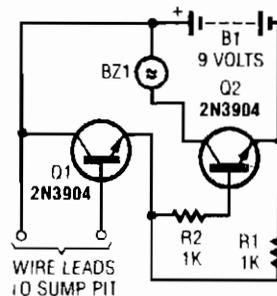


POPULAR ELECTRONICS

FIG. 61-1

When sensor gets wet, it conducts, forward-biases Q1, and activates audio oscillator U1. A tone is heard from the speaker.

## SIMPLE FLOOD ALARM



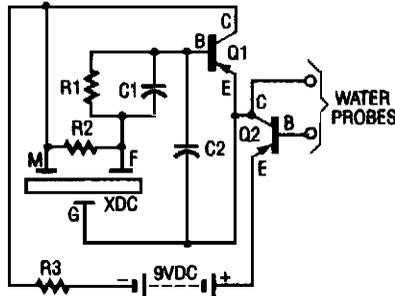
POPULAR ELECTRONICS

FIG. 61-2

A common collector amplifier drives a 2N3904 switch to sound alarm BZ1. The wire leads to water sensor or sump pit, level switch, etc. and used to allow the alarm to operate and be mounted in a dry place.

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## MOISTURE DETECTOR



1991 PE HOBBYIST HANDBOOK

FIG. 61-3

The moisture detector uses two transistors and a piezoelectric transducer to sound an alarm tone when water is present. Transistor Q1 forms a crystal-controlled oscillator, using a portion of piezoelectric transducer XDC—which contains two piezoelectric crystal regions—as the crystal. The transducer has three separate leads. One lead goes to each of the crystals, and the third lead is common to both.

The smaller internal crystal region sets the frequency of operation and the larger element is driven by Q1 (when it is biased “on”) to provide the loud tone output. To turn the pnp transistor Q1 (used as an oscillator) “on” pnp transistor Q2 (used here as a switch) must be on. To turn it “on” with the biasing that is normally connected, you would only need to connect a resistor from the collector of Q2 to the base, which gives the base a negative (–) bias. The resistor used is the water that is to be detected. That turns Q2 on, which, in turn, turns on Q1. The result when water touches the probe is that the transducer emits a loud sound.

C1, C2	0.1- $\mu$ F Mylar Capacitor
Q1, Q2	2N3906 Transistor
R1	6.8-k $\Omega$ Resistor
R2	33-k $\Omega$ Resistor
R3	200- $\Omega$ Resistor
XDC	Piezoelectric Transducer

# 62

## Motion Detector Circuit

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Microwave Motion Detector



# 63

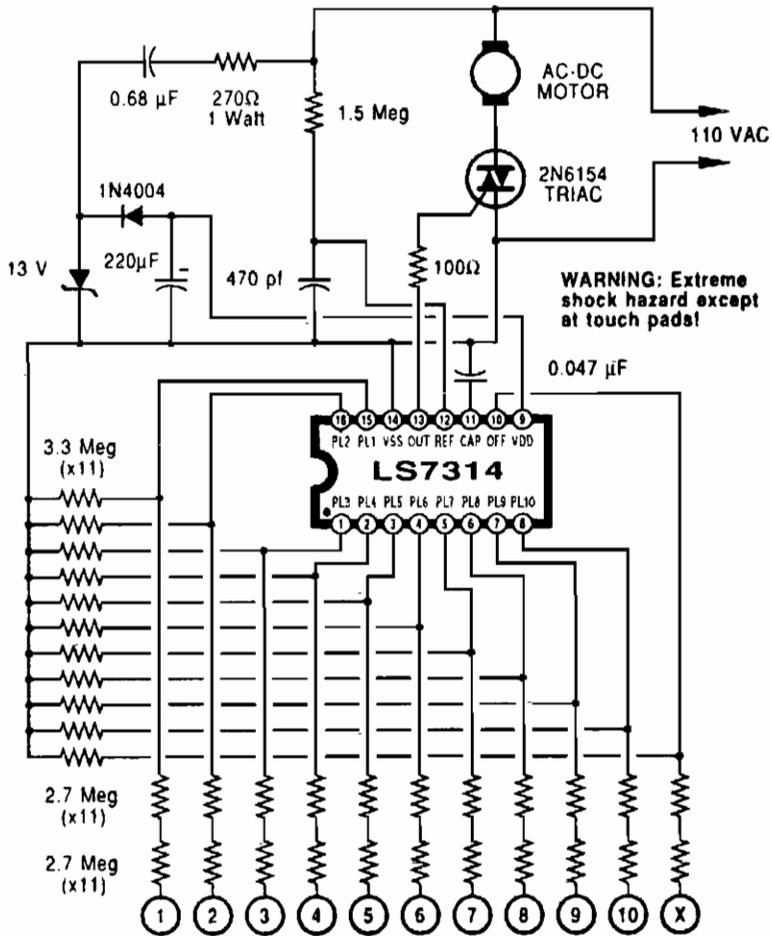
## Motor-Control Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Blender-Control Circuit
- PWM Motor-Drive Circuit
- Speed-Control Switch Circuit
- Piezo Motor Drive
- Pulse-Width-Modulated Motor-Speed Control
- Speed-Control Switch

## BLENDER-CONTROL CIRCUIT



RADIO-ELECTRONICS

**FIG. 63-1**

A 10-speed touch-control blender circuit that uses the low-cost LS314 chip by LSI Systems. The 11th touch pad is for power off.

## PWM MOTOR-DRIVE CIRCUIT

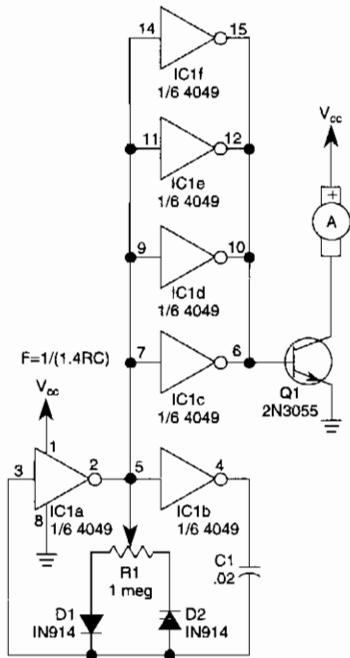


FIG. 63-2

RADIO-ELECTRONICS

This circuit will drive a small dc motor over a wide range of speeds without stalling by controlling the duty cycle of the motor, rather than the supply voltage.

## SPEED-CONTROL SWITCH CIRCUIT

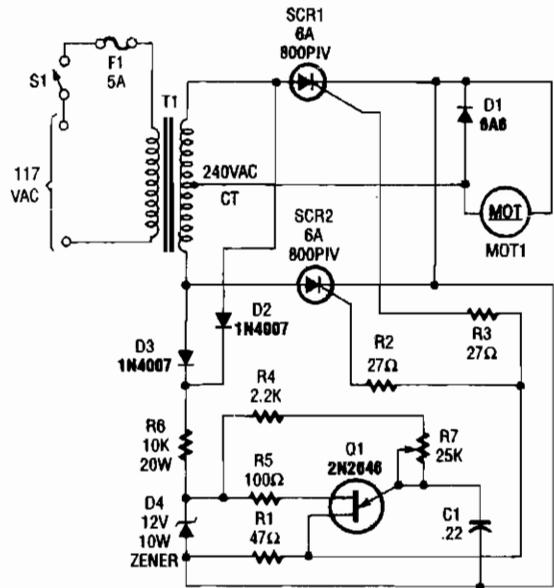


FIG. 63-3

POPULAR ELECTRONICS

A center-tapped 240-V transformer is used with two SCR devices to provide rectified ac (pulsating dc) to MOT1. Q1 is a UJT ramp generator used to generate trigger pulses for SCR1 and SCR2.

## PIEZO MOTOR DRIVE

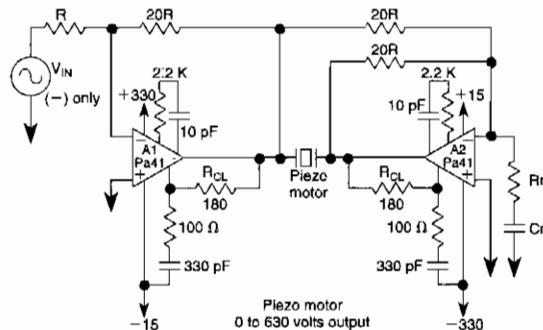


FIG. 63-4

ELECTRONIC DESIGN

Using two Apex Microtechnology PA41 devices in a bridge circuit, this piezo motor driver delivers 0- to 630-V output.



# 64

## Multiplexer Circuit

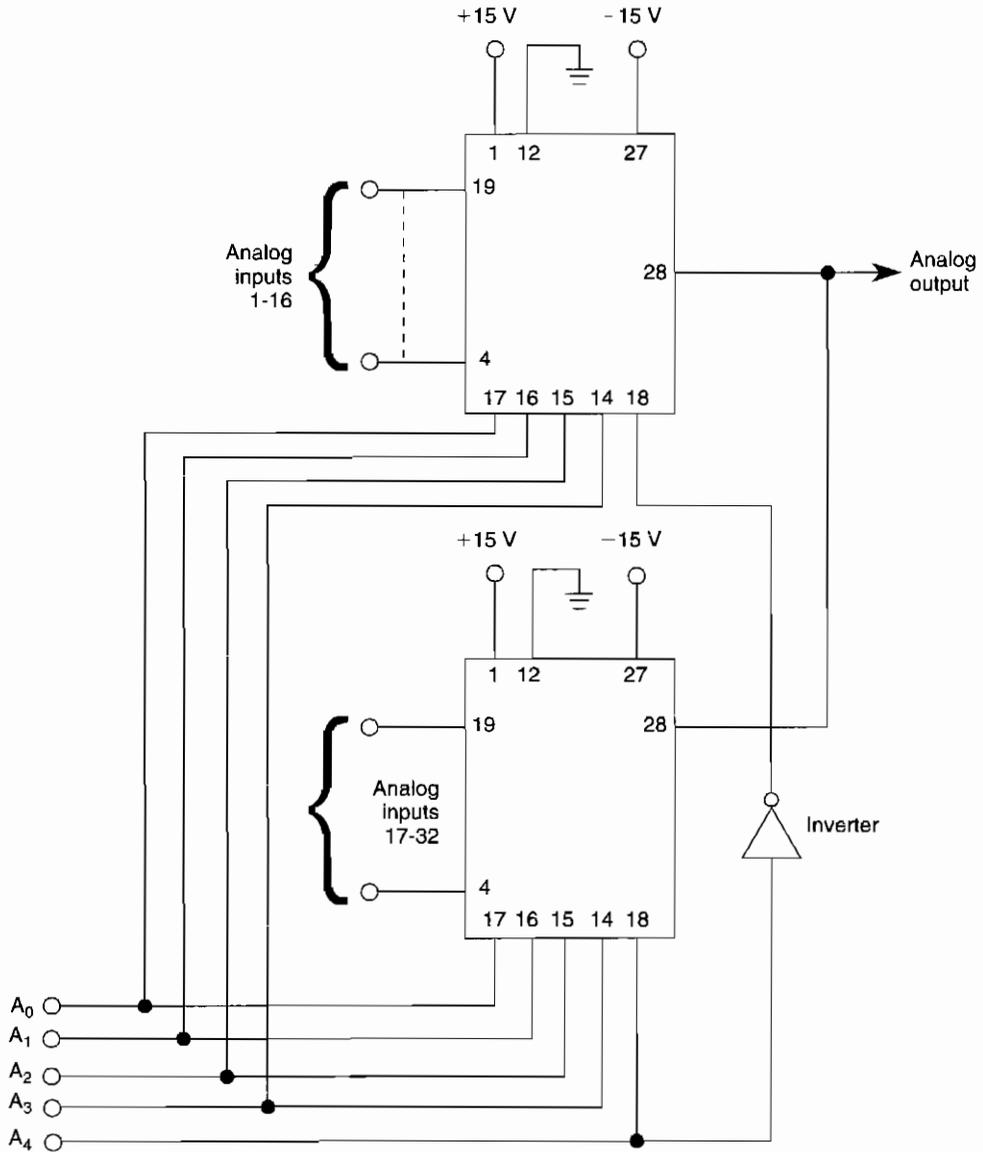
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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

32-Channel Analog Multiplexer

## 32-CHANNEL ANALOG MULTIPLEXER



WILLIAM SHEETS

FIG. 64-1

Using two Siliconix DG506 multiplexer chips, this 32-channel analog multiplexer selects 1 of 32 channels, depending on the data inputs  $A_0 - A_4$ .

# 65

## Multivibrator Circuits

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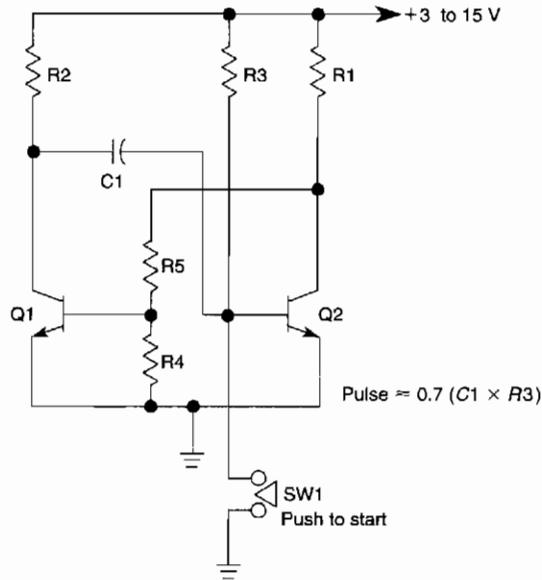
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Improved CMOS Multivibrator  
Very Low Frequency Multivibrator  
Monostable Multivibrator I  
Astable Multivibrator or Free-Running  
Square-Wave Oscillator  
Astable Multivibrator I

Monostable Multivibrator II  
Astable Multivibrator II  
One-Shot Multivibrator  
Flip-Flop or Bistable Multivibrator  
with Pushbutton Triggering  
Free-Running Multivibrator Using Op Amp



### MONOSTABLE MULTIVIBRATOR I

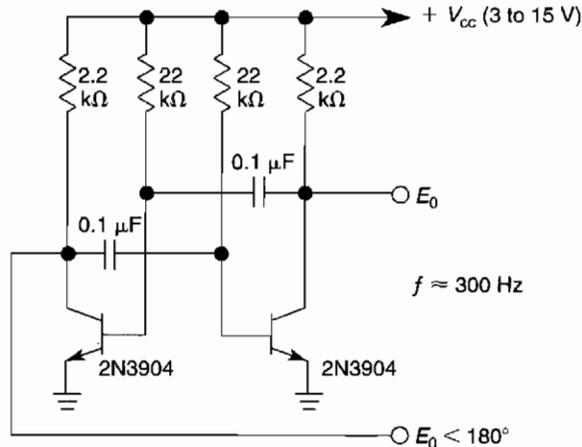


WILLIAM SHEETS

FIG. 65-3

This circuit is activated when SW1 is pushed to ground the base of transistor Q2. The pulse rate is approximately equal to  $0.7(R3 \times C1)$ .

### ASTABLE MULTIVIBRATOR OR FREE-RUNNING SQUARE-WAVE OSCILLATOR

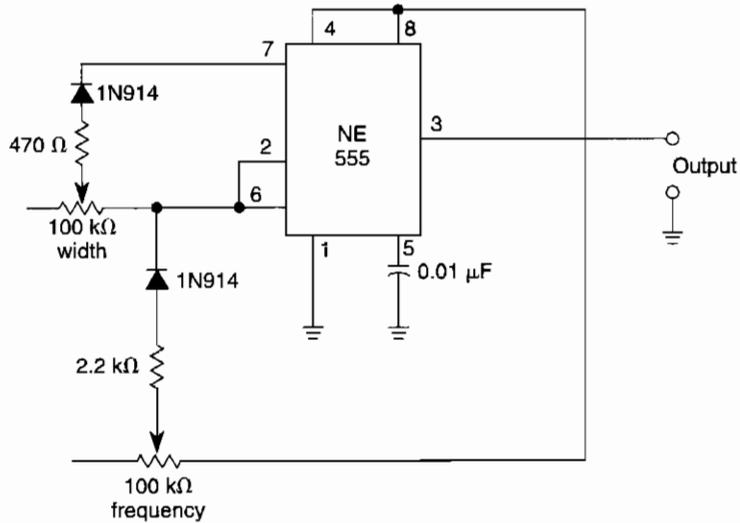


WILLIAM SHEETS

FIG. 65-4

This free-running square-wave oscillator uses two npn transistors. Output frequency is approximately 300 Hz with the values shown.

## ASTABLE MULTIVIBRATOR I

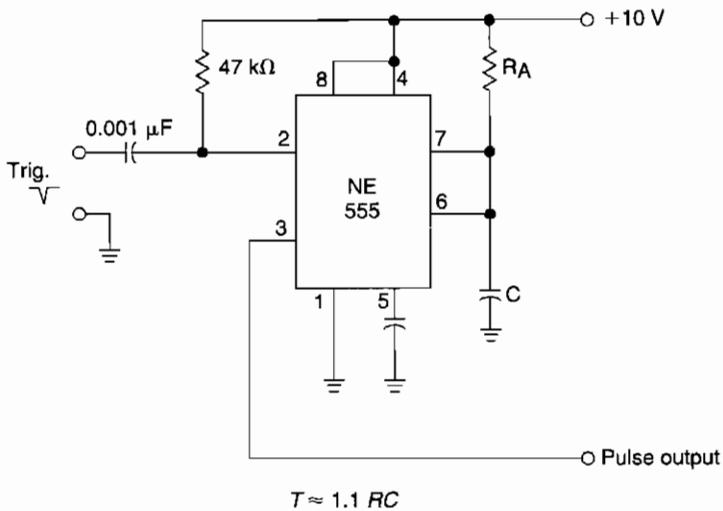


WILLIAM SHEETS

FIG. 65-5

In this multivibrator circuit frequency and pulse width can be separately controlled by using steering diodes (1N914) and two potentiometers.

## MONOSTABLE MULTIVIBRATOR II

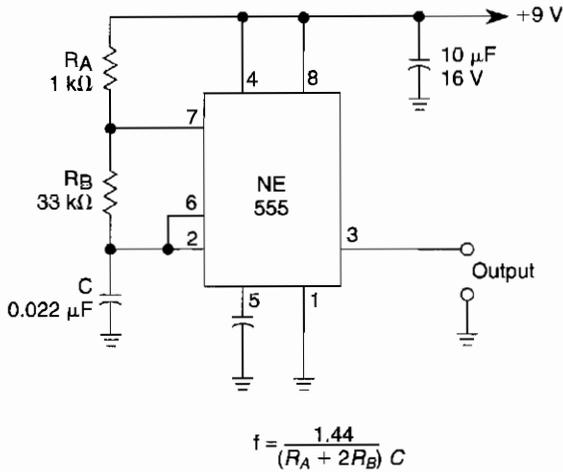


WILLIAM SHEETS

FIG. 65-6

The time constant of  $R_A C$  determines the period of the monostable multivibrator. A negative pulse at pin 2 of the 555 starts the cycle.

### ASTABLE MULTIVIBRATOR II

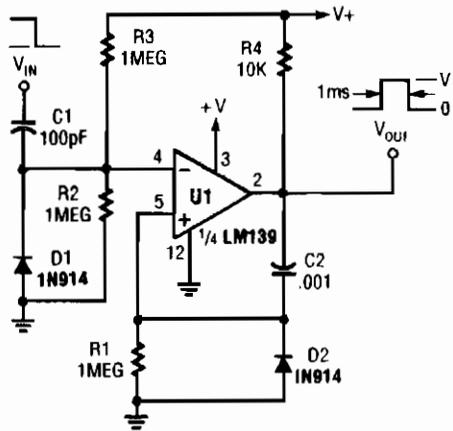


WILLIAM SHEETS

FIG. 65-7

An astable multivibrator based on the 555 is shown. Freq is approximately 975 Hz as determined by the values of  $R_B$  and  $C$ .

### ONE-SHOT MULTIVIBRATOR

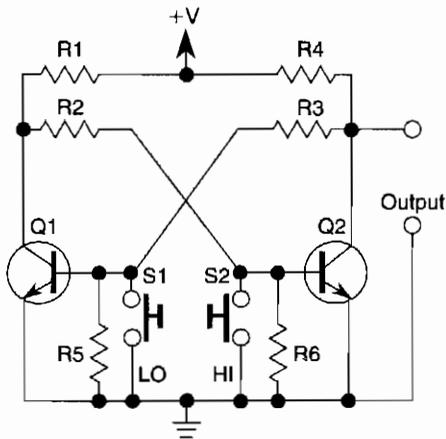


POPULAR ELECTRONICS

FIG. 65-8

A section of a quad LM139 is used here as a one-shot pulse former.

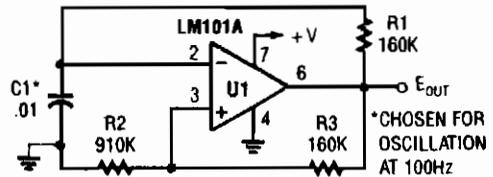
### FLIP-FLOP OR BISTABLE MULTIVIBRATOR WITH PUSHBUTTON TRIGGERING



ELECTRONICS NOW

FIG. 65-9

### FREE-RUNNING MULTIVIBRATOR USING OP AMP



POPULAR ELECTRONICS

FIG. 65-10

# 66

## Musical Circuits

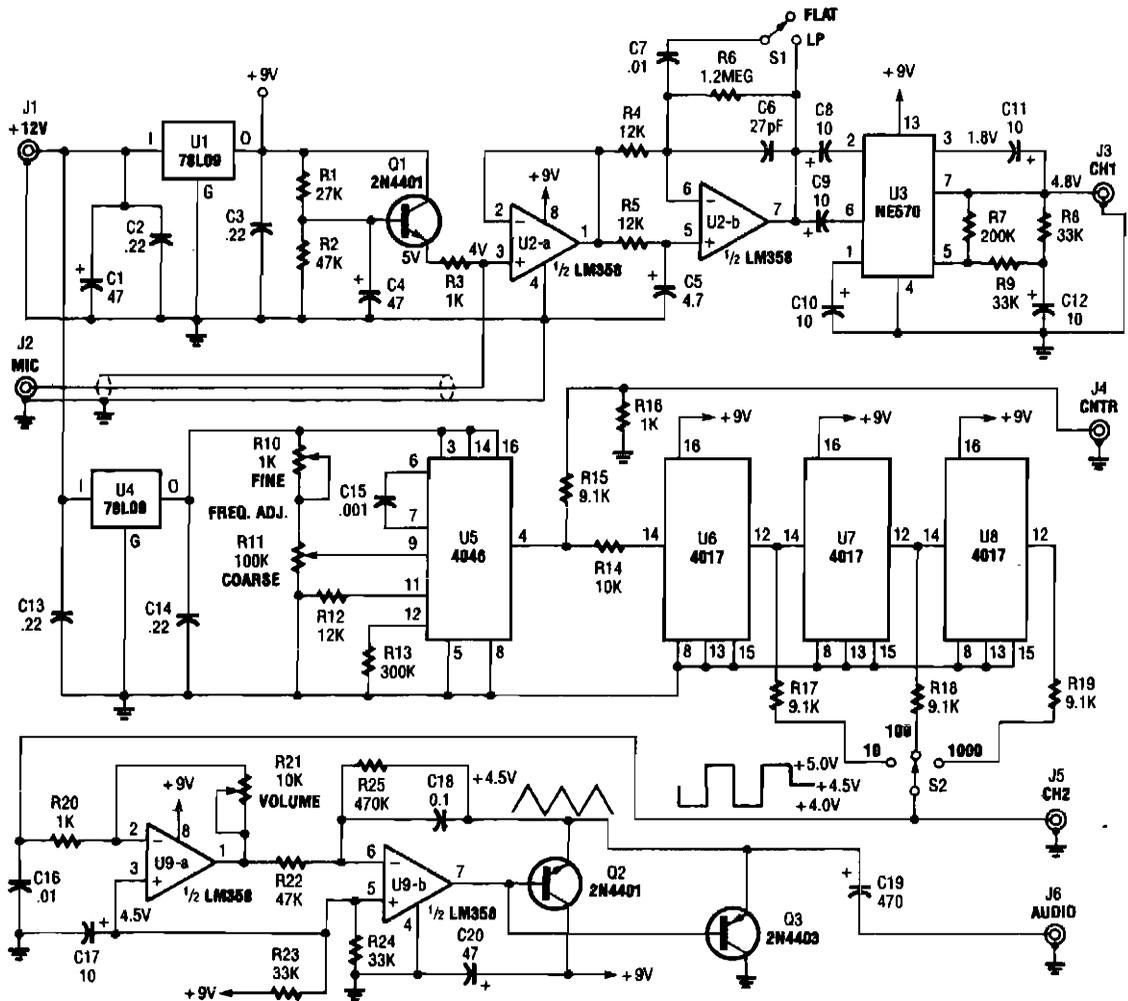
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The sources of the following circuits are contained in the Sources section, which begins on page 575. The figure number in the box of each circuit correlates to the entry in the Sources section.

Precision Audio Generator for Musical Instrument Tune-Up  
Perfect Pitch  
Musical Instrument Digital Interface (MIDI) Receiver  
Electronic Metronome  
Musical Instrument Digital Interface (MIDI) Transmitter  
Melody Circuit  
Top Octave Generator

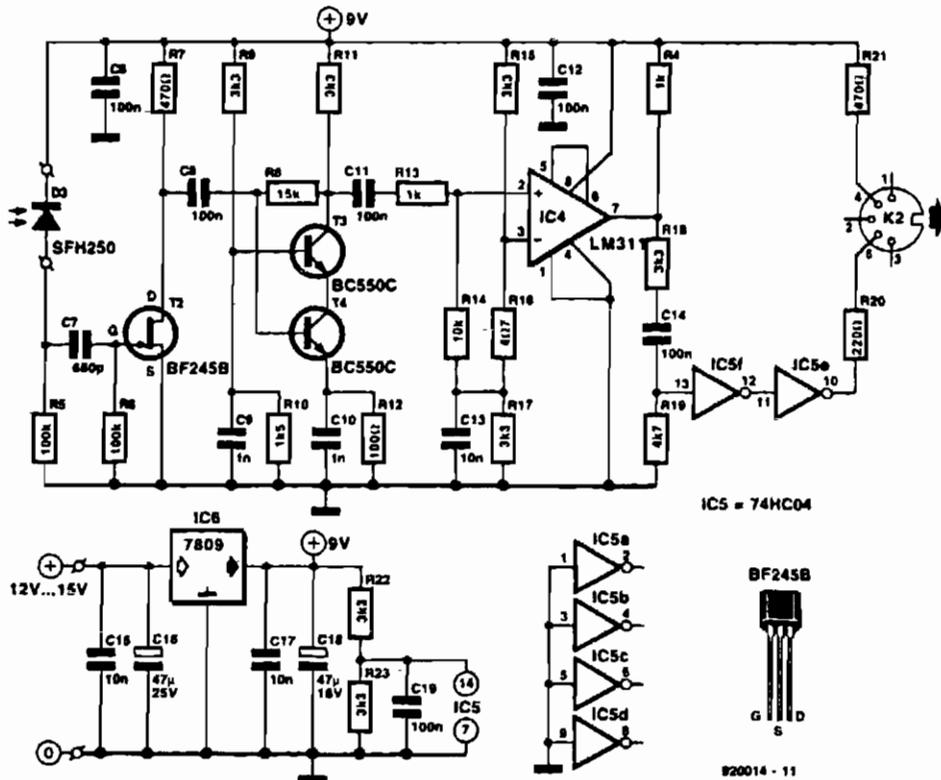
## PRECISION AUDIO GENERATOR FOR MUSICAL INSTRUMENT TUNE-UP



One section of the precision audio frequency generator uses an electret microphone element to pick up audio from the piano. That signal is then processed and sent to one channel of a dual-trace oscilloscope. The other section of the circuit is used to produce a variable-frequency signal that is fed to a digital frequency counter. After conditioning, the audio signal is presented to the second channel of the scope and output to a set of stereo headphones.



## MUSICAL INSTRUMENT DIGITAL INTERFACE (MIDI) RECEIVER



IC5 = 74HC04

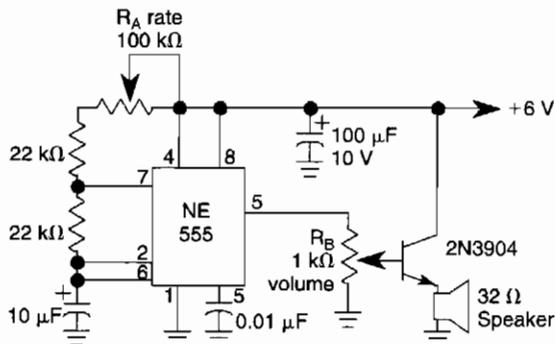


ELEKTOR ELECTRONICS

FIG. 66-3

Receiver photodiode SFH250 is used to convert optical data pulses at 32.5 Kb to electrical signals. Buffer T2 feeds the signals to cascade amplifier T3-T4, then to op amp IC4, and buffers IC5-f and IC5-e. IC6 supplies 9 V for the circuit.

## ELECTRONIC METRONOME



$R_A$  sets the rate while  $R_B$  sets the volume of clocks in the speaker. The 555 is configured as a low frequency oscillator. The circuit is powered by a 6 V battery.

ELECTRONICS NOW

FIG. 66-4



67

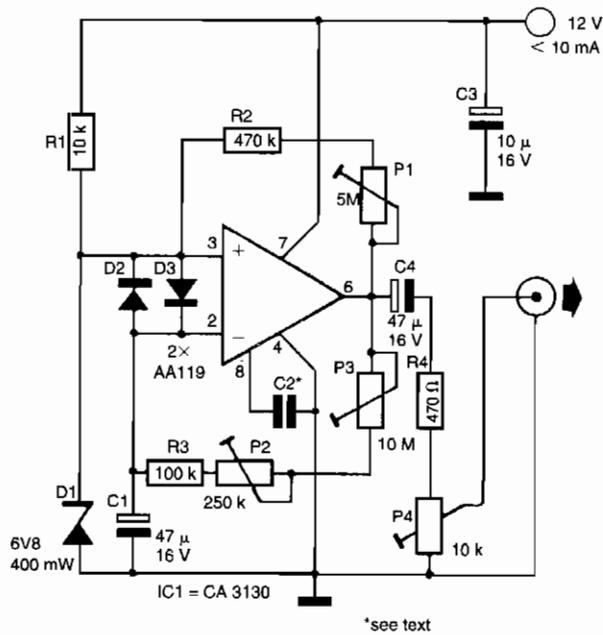
## Noise-Generator Circuits

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Noise Generator

## NOISE GENERATOR



303 CIRCUITS

FIG. 67-1

This circuit generates noise pulses that are suitable for test purposes, etc. A zener diode is used as a noise source. IC1 is a relaxation oscillator. P1 determines noise bandwidth, and P2 and P3 the noise amplification. Current consumption is 10 mA @ 12 Vdc.

# 68

## Noise-Limiting Circuits

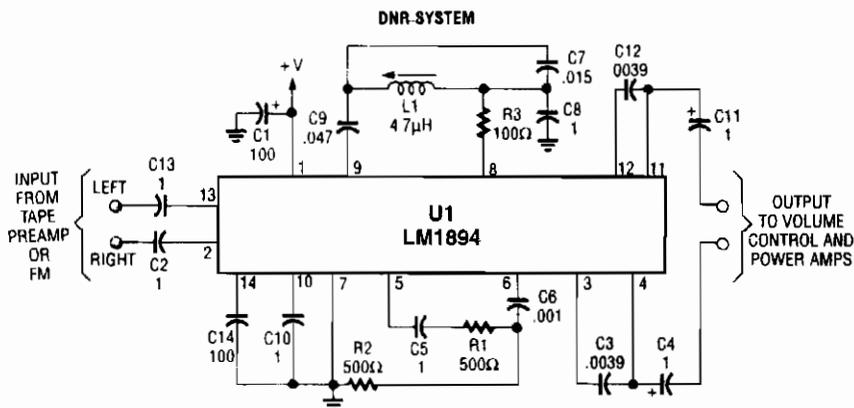
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Audio Dynamic Noise-Reduction System  
Amplified Noise Limiter for SW Receivers  
Receiver AF Noise Limiter for Low-Level Signals  
Simple Noise Limiter for Receivers

## AUDIO DYNAMIC NOISE-REDUCTION SYSTEM

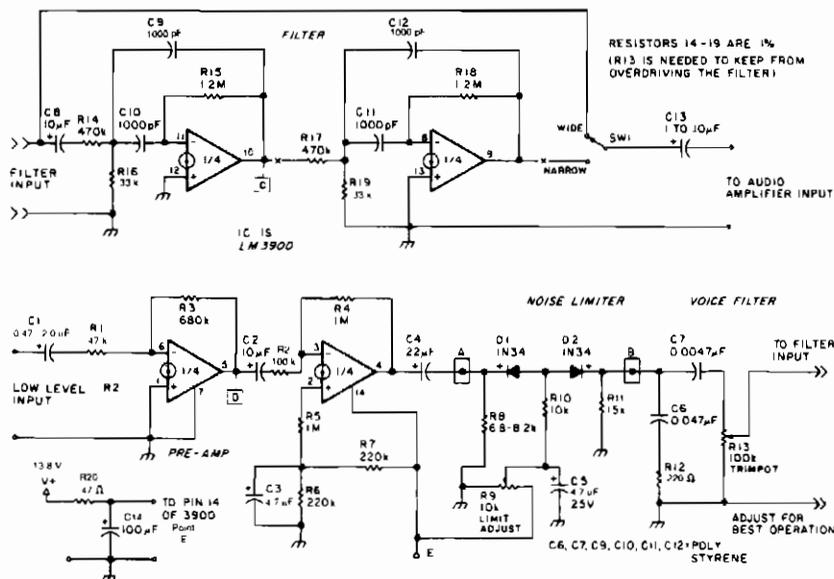


POPULAR ELECTRONICS

FIG. 68-1

U1 is a dedicated IC (National Semiconductor) that achieves up to 10 dB noise reduction by an adaptive bandwidth scheme and a psycho acoustic masking technique.

## AMPLIFIED NOISE LIMITER FOR SW RECEIVERS

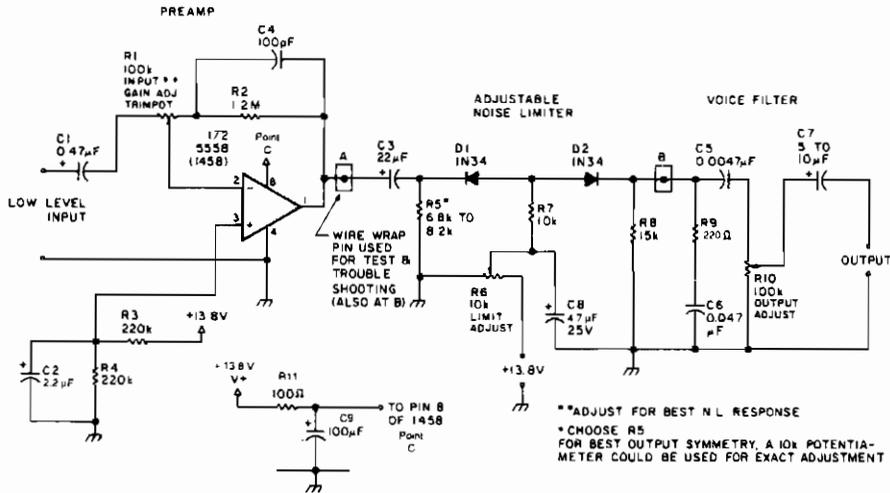


73 AMATEUR RADIO TODAY

FIG. 68-2

The noise limiter circuit has a preamplifier clipper, and a switchable audio bandpass filter. Audio levels in the 5- to 50-mV range are amplified in a preamp to several volts p-p, fed to a clipper, voice band filter, then to a narrow band active filter which can be switched in and out of the circuit.

## RECEIVER AF NOISE LIMITER FOR LOW-LEVEL SIGNALS

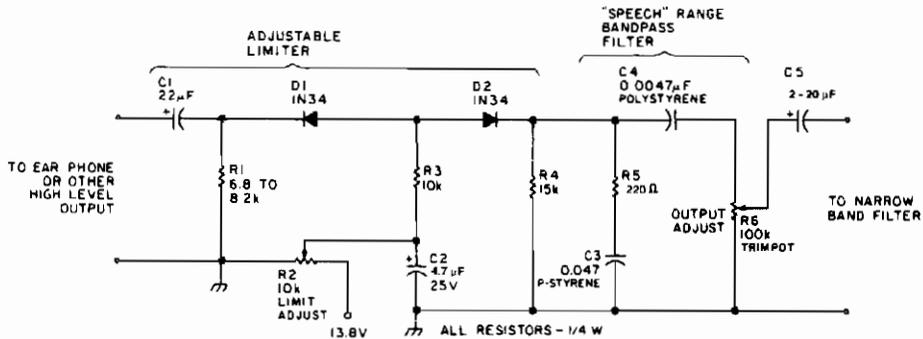


73 AMATEUR RADIO TODAY

FIG. 68-3

A preamplifier in the audio frequency range amplifies a noisy audio signal to drive a diode clipper. Suitable audio input levels would be in the 10-mV to 1-V range.

## SIMPLE NOISE LIMITER FOR RECEIVERS



73 AMATEUR RADIO TODAY

FIG. 68-4

This circuit uses a diode series clipper to limit noise peaks on a received signal. It is best used where several volts p-p of audio signal are available.

# 69

## Operational-Amplifier Circuits

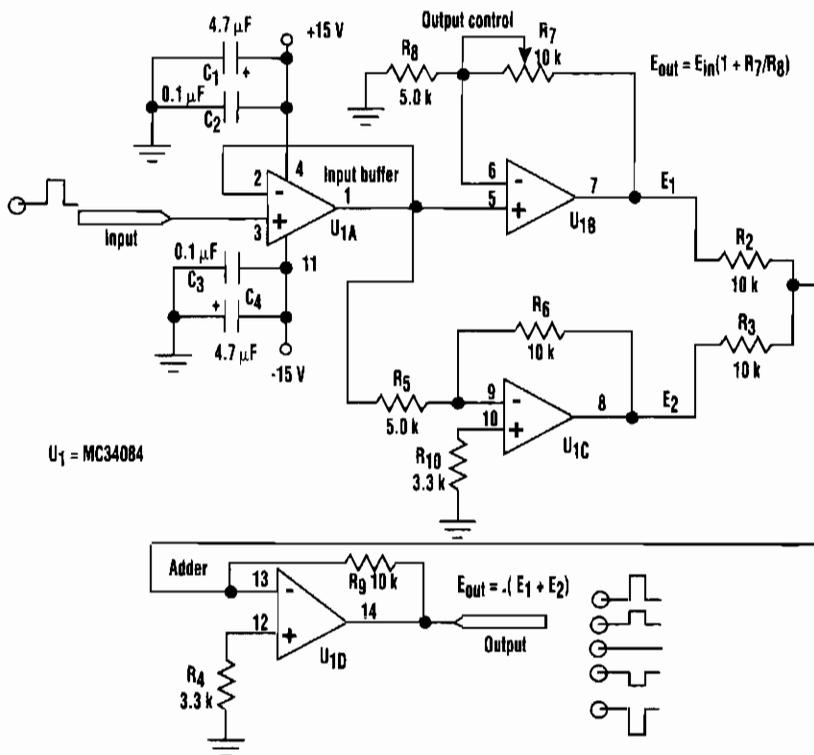
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Polarity Gain Adjustment  
Fast Composite Amplifier  
Non-Linear Operational Amplifier with  
Temperature-Compensated Breakpoints  
Power Op Amp  
Variable Gain Op-Amp Circuit  
Low Noise and Drift Composite Amp  
High-GBW Op Amp  
Single Op-Amp Full-Wave Rectifier

## POLARITY GAIN ADJUSTMENT



ELECTRONIC DESIGN

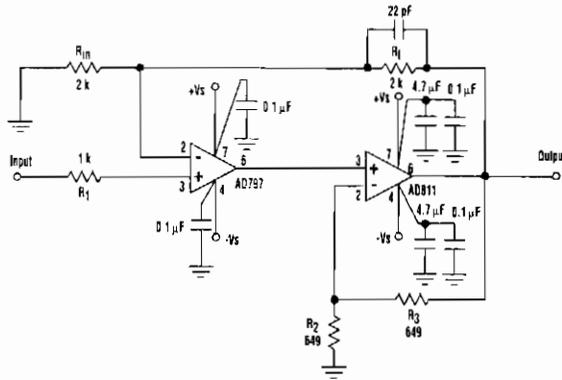
FIG. 69-1

By adjusting one potentiometer, this circuit's output can be varied from a positive-going version of the input signal, smoothly through zero output, then to a negative-going version of the input (see the figure). If the input signal is a positive pulse of, for example, +2-V peak, the output pulse amplitude can be smoothly varied from +2-V through ground (no output) to a -2-V peak.

Taking a closer look at the setup, assume that the signal has a +2-V peak input. The A section of the quad op amp is an input buffer, op amp C provides a fixed negative-going output of -4-V peak, and op amp B supplies a positive-going output that varies from +2-V to +6-V peak. The D section adds the B and C outputs. Thus, by varying the B output, the circuit output varies smoothly from -2-V to +2-V peak.

The circuit can, of course, also be used as a 0°/180° phase switcher. For instance, with a ground-centered sine-wave input of 4V p-p, the output varies from 4-V p-p in phase with the input, smoothly through 0 V, to 4V p-p 180° out of phase with the input.

## FAST COMPOSITE AMPLIFIER



ELECTRONIC DESIGN

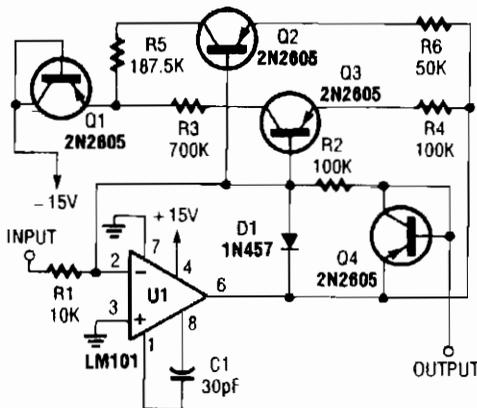
FIG. 69-2

An ultra-low-noise, low-distortion op amp—the AD797—is combined with the AD811 op amp, which offers a high bandwidth and a 100-mA output drive capability. The composite-amplifier circuit serves quite well when driving high resolution ADC's and ATE systems.

The fast AD811 operates at twice the gain of the AD797 so that the slower amplifier need only slew one-half of the total output swing. Using the component values shown, the circuit is capable of better than  $-90$  dB THD with a  $\pm 5$ -V, 500-kHz output signal. If a 100-kHz sine-wave input is used, the circuit will drive a 600- $\Omega$  load to a level of 7 V rms with less than  $-109$  dB THD, as well as a 10-k $\Omega$  load at less than  $-117$  dB THD.

The device can be modified to supply an overall gain of 5 by changing both the  $R_f/R_{in}$  ratio and  $R_3/R_2$  ratio to 4:1. This raises the gains of AD811 and the total circuit while maintaining the AD797 at unity gain. If only the  $R_f/R_{in}$  ratio is changed, the circuit might become unstable. In contrast, if only the  $R_3/R_2$  ratio is varied, the AD797 will then operate at gain. Subsequently, the circuit will have a lower overall bandwidth.  $R_1$  should be equal to the parallel combination of  $R_{in}$  and  $R_f$ .

## NONLINEAR OPERATIONAL AMPLIFIER WITH TEMPERATURE-COMPENSATED BREAKPOINTS

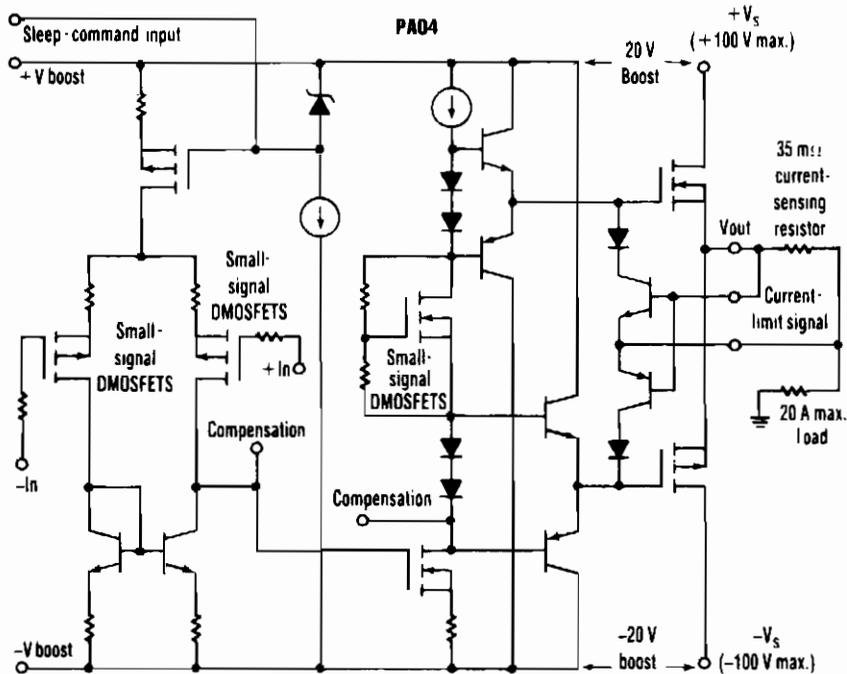


Using resistor and transistor feedback elements, this operational amplifier circuit can be used as a nonlinear amplifier. R4 and R6 can be varied to change breakpoints, as required.

POPULAR ELECTRONICS

FIG. 69-3

## POWER OP AMP

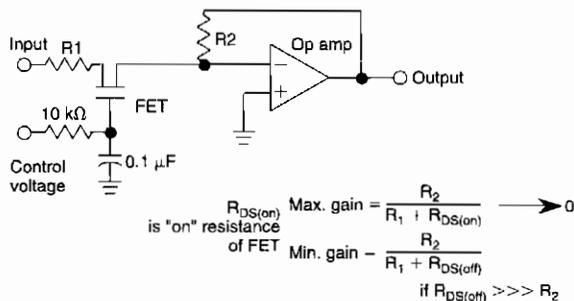


**ELECTRONIC DESIGN**

**FIG. 69-4**

This circuit from Apex Microtechnology can deliver 180 V p-p @ 90 kHz into a 4-Ω load. The PA04 can deliver 400-W RMS into an 8-Ω load with low THD at frequencies beyond 20 kHz.

## VARIABLE GAIN OP-AMP CIRCUIT



A JFET acts as a variable attenuator for this op amp. Maximum gain is:

$$\frac{R_2}{R_1 + R_{DS(ON)}}$$

**ELECTRONICS NOW**

**FIG. 69-5**



# 70

## Optical Circuits

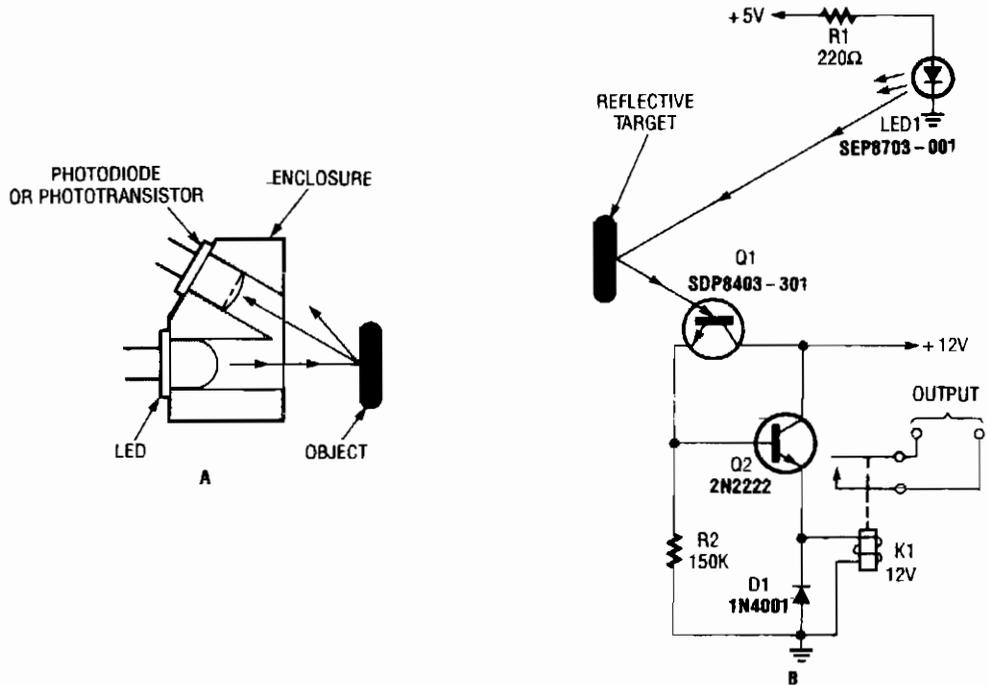
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Optical Proximity Detector
- Photoreceiver Optimized for Noise and Response
- Optoisolator and Optocoupler Interface Circuits
- Optocoupler Circuits
- Optical Direction Discriminator
- Optical Safety Circuit Switches
- Simple Amplifier for Phototransistors
- Variable-Sensitivity Phototransistor Circuit

## OPTICAL PROXIMITY DETECTOR

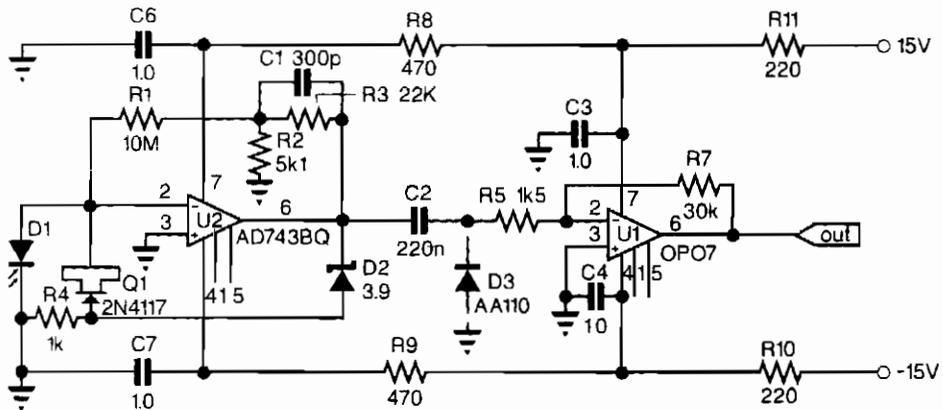


POPULAR ELECTRONICS

FIG. 70-1

A "reflector" isolator (A) detects the presence of an object by bouncing light off of it. This technique is useful in circuits that detect when an object is close enough to the sensor (B).

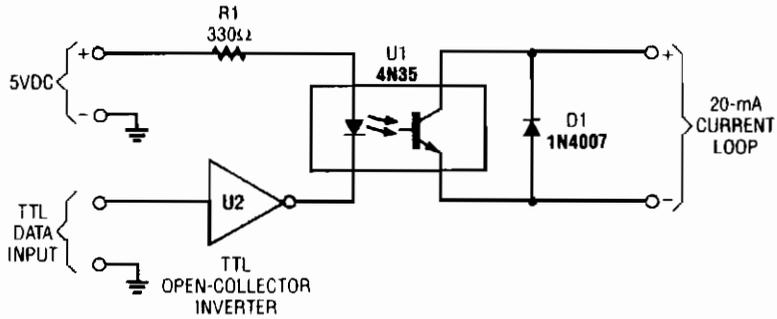
## PHOTORECEIVER OPTIMIZED FOR NOISE AND RESPONSE



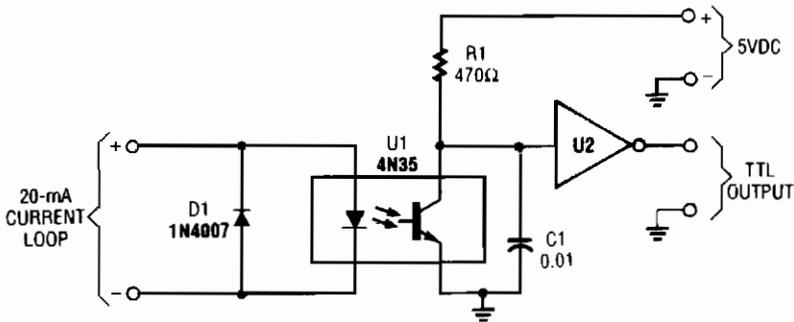
ELECTRONIC ENGINEERING

FIG. 70-2

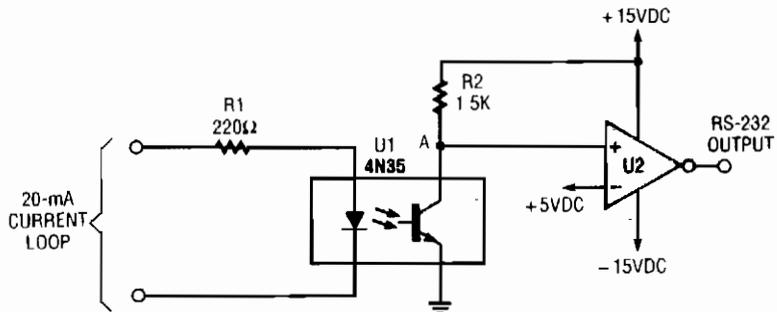
# OPTOISOLATOR AND OPTOCOUPLER INTERFACE CIRCUITS



**A**



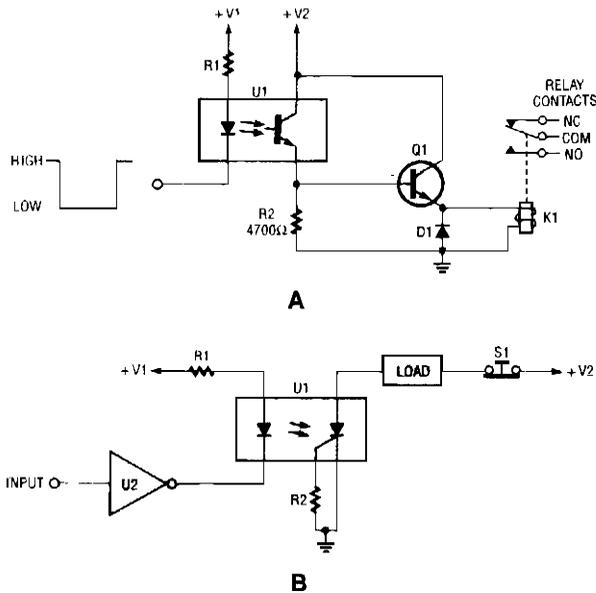
**B**



**C**

*Interfacing equipment, whether TTL, RS-232C, or 20-mA current-loop based, with optoisolators.*

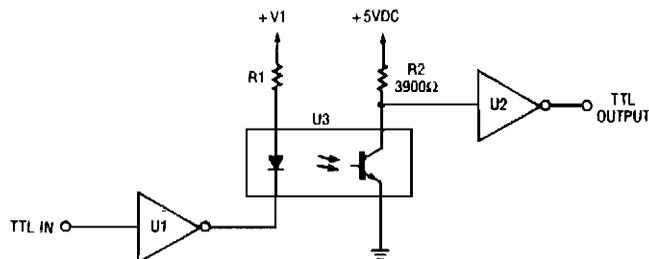
## OPTOISOLATOR AND OPTOCOUPLER INTERFACE CIRCUITS (Cont.)



*Very heavy loads, which can't be powered directly by an optoisolator, might require the use of a relay as shown in A. You can sometimes get away with using a circuit like that shown in B, but it won't turn itself off.*

A circuit for isolating a variable resistor is shown. An optoisolator that has an LED and a photoconductive cell (or photoresistor) is used. The current through the LED controls its brightness, which in turn determines the resistance between terminals A and B. The LED current is set by the voltage of the dc power supply and the value of the two resistors (R1 and R2). The fixed resistor (R1) is used to limit the current to a maximum of 20 mA (when the resistance of the potentiometer,  $R_2$ , is set to zero ohms), otherwise, the LED might burn out.

## OPTOCOUPLER CIRCUITS



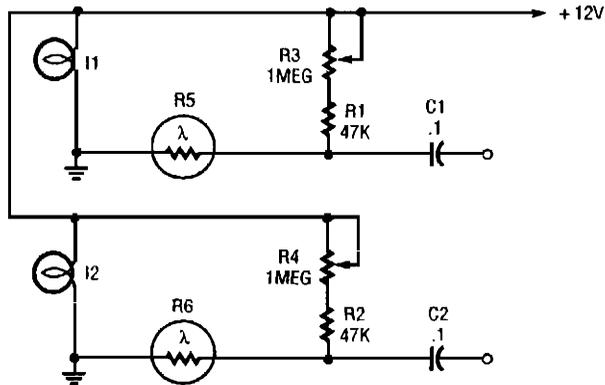
POPULAR ELECTRONICS

FIG. 70-4

This circuit is a TTL-to-TTL isolator circuit. The driver circuit is an open-collector TTL inverter (U1). When the input is high, then the output of the inverter is low. Thus, when the input is high, the output of U1 grounds the cathode end of the LED and causes the LED to turn on.



## OPTICAL SAFETY CIRCUIT SWITCHES

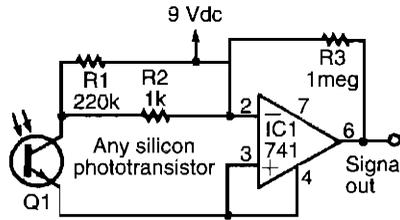


POPULAR ELECTRONICS

FIG. 70-6

Use of two LDR devices replaces the two pushbuttons used in safety switches. The lamps provide light sources for the LDR devices.

## SIMPLE AMPLIFIER FOR PHOTOTRANSISTORS

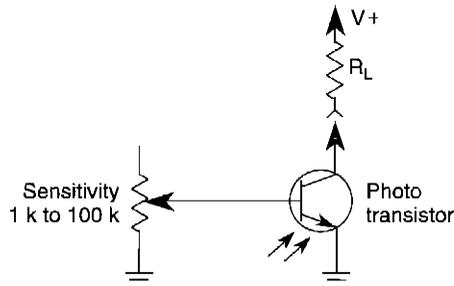


ELECTRONICS NOW

FIG. 70-7

This simple amplifier will work well with just about any phototransistor. The 741, although designed to operate with a split supply, will work with a single-sided supply as well.

## VARIABLE-SENSITIVITY PHOTOTRANSISTOR CIRCUIT



ELECTRONICS NOW

FIG. 70-8

A variable resistor is used to vary the light-level response of a phototransistor. Phototransistors are more light sensitive than photodiodes, but they generally have poorer frequency response.

# 71

## Oscillator Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

NE602 Local Oscillator Circuits

LC Audio Oscillator

Colpitts Oscillator

MOSFET Mixer-Oscillator Circuit for

AM Receivers

Simple RF Test Oscillator

AF Power Oscillator

Gated 1-kHz Oscillator (Normally Off)

Gated 1-kHz Oscillator (Normally On)

Precision LF Oscillator

Basic Oscillator Circuits

Variable Wien-Bridge Oscillator

Local Oscillator for Double Balanced Mixers

Precision Audio-Frequency Generator

CMOS VFO

Frequency Switcher

Precision Gated Oscillator

Wien-Bridge Audio Oscillator

Variable Duty-Cycle Oscillator

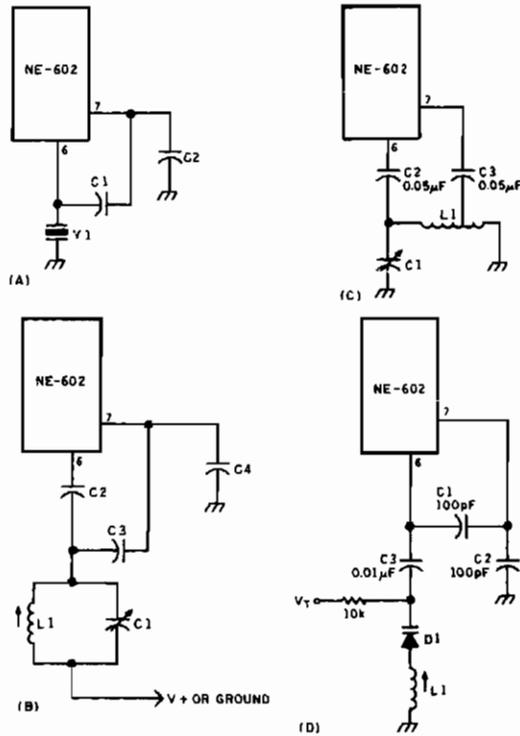
Adjustable VFO Temperature Compensator

4093 CMOS Astable Oscillator

Simple Audio Test Oscillator

4093 CMOS VFO

## NE602 LOCAL OSCILLATOR CIRCUITS

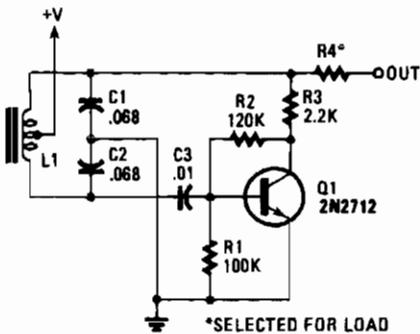


73 AMATEUR RADIO TODAY

FIG. 71-1

Local oscillator circuits for the NE602.

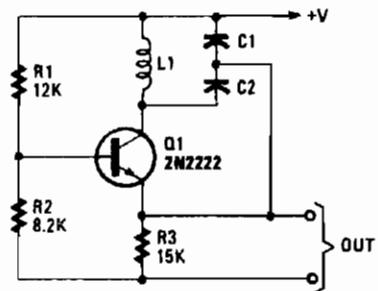
### LC AUDIO OSCILLATOR



POPULAR ELECTRONICS

FIG. 71-2

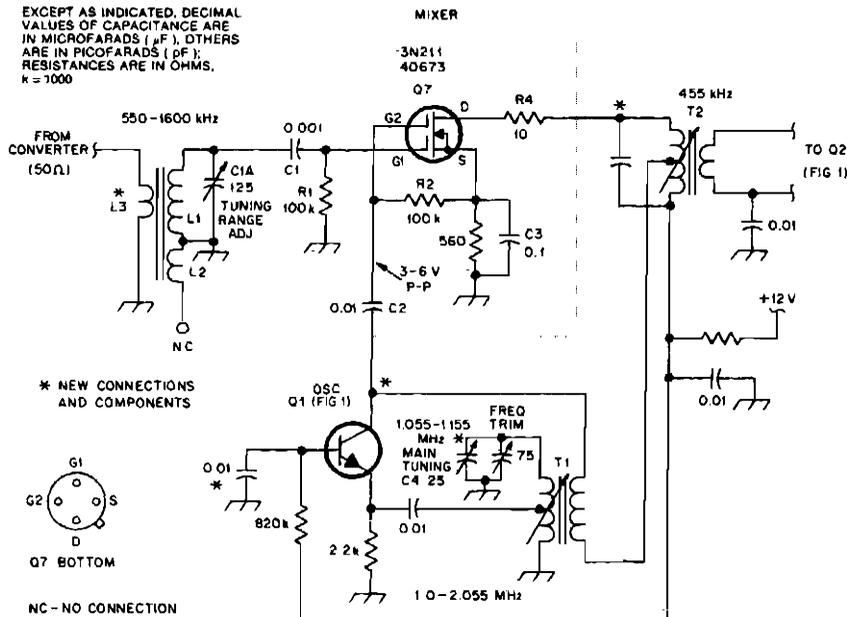
### COLPITTS OSCILLATOR



POPULAR ELECTRONICS

FIG. 71-3

## MOSFET MIXER-OSCILLATOR CIRCUIT FOR AM RECEIVERS

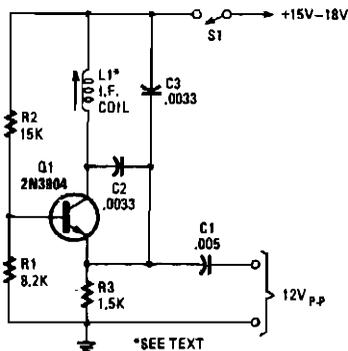


QST

FIG. 71-4

This circuit is an improved front end for upgrading a transistor AM receiver. This front end is useful when the radio is to be used as a tuneable IF amplifier with shortwave converters.

### SIMPLE RF TEST OSCILLATOR

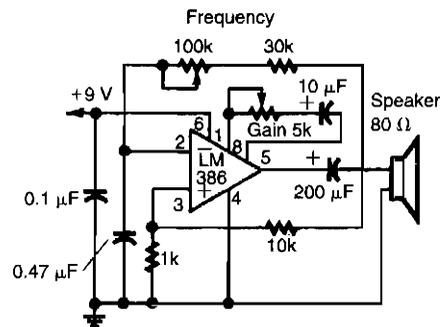


POPULAR ELECTRONICS

FIG. 71-5

A simple oscillator for IF alignment (455 kHz) can prove useful in field testing or where a standard signal generator is available. L1 should resonate at the desired output frequency with the series combination of C2 and C3.

### AF POWER OSCILLATOR

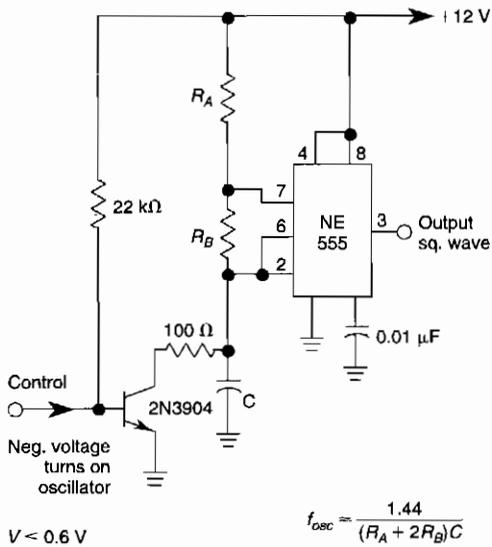


RADIO ELECTRONICS

FIG. 71-6

An LM386 audio power IC is set up as a feedback oscillator. Any supply from 6 to 12 V can be used. The circuit can drive a loudspeaker.

### GATED 1-kHz OSCILLATOR (NORMALLY OFF)

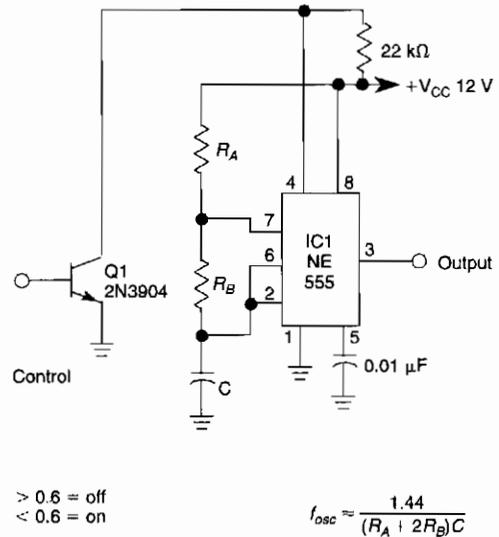


ELECTRONICS NOW

FIG. 71-7

This gated 1-kHz oscillator offers "press-to-turn-on" operation, A, and waveforms at the output of pin 3 and across C1, B.

### GATED 1-kHz OSCILLATOR (NORMALLY ON)

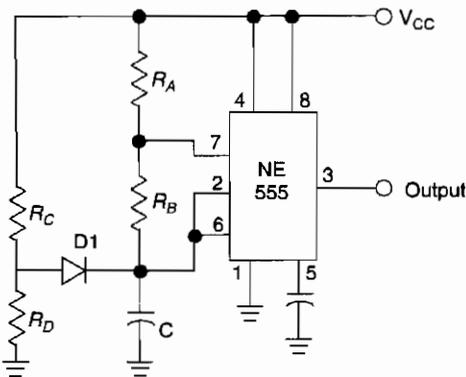


ELECTRONICS NOW

FIG. 71-8

This gated 1-kHz oscillator offers "press-to-turn-off" operation, A, and waveforms at the output of pin 3 and across C1, B.

### PRECISION LF OSCILLATOR



$$\frac{R_D}{R_C + R_D} = \left( \frac{V_{CC}}{3} + 0.6 \right)$$

$$R_C + R_D \ll R_A + R_B$$

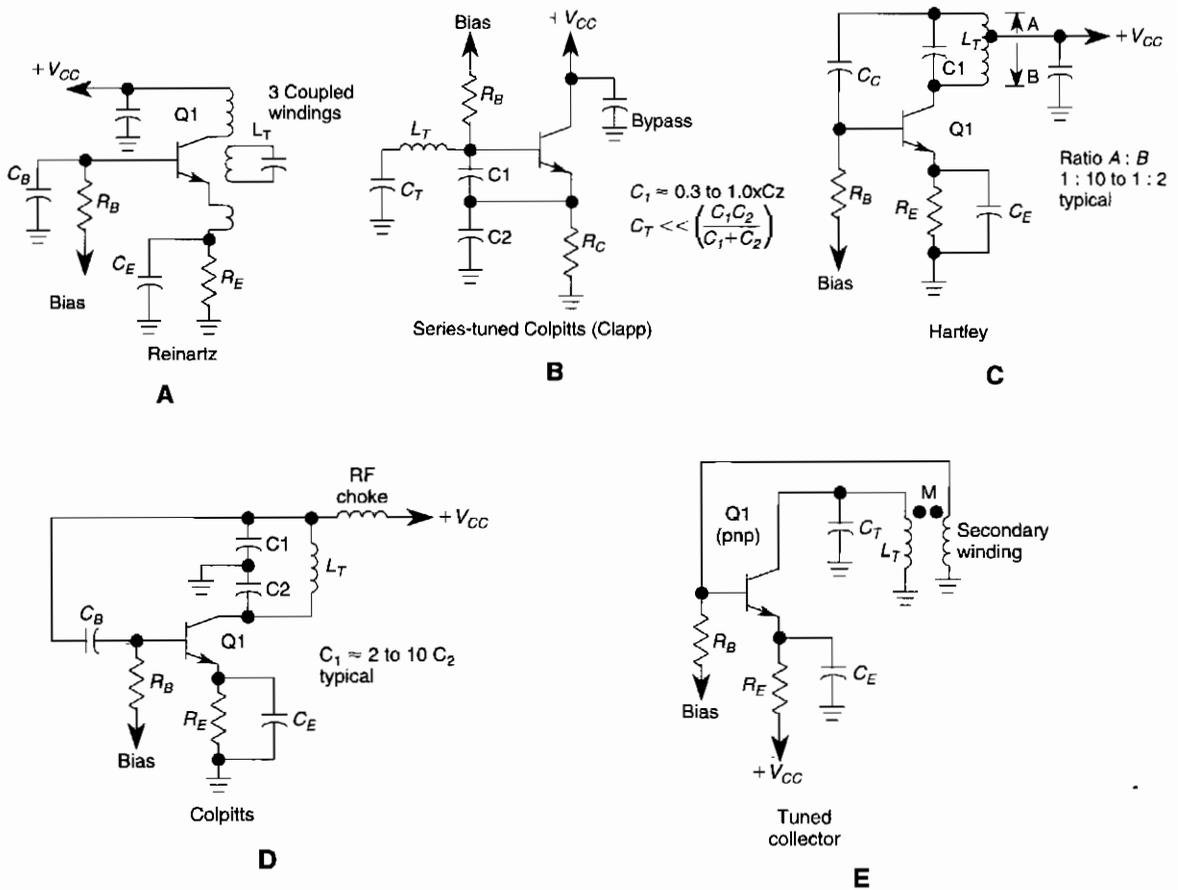
$$T \approx \frac{1.44}{(R_A + 2R_B)C}$$

ELECTRONICS NOW

FIG. 71-9

Using R1, R7, and D1 to preset C1 to one third of the supply voltage, this circuit avoids a longer first cycle period than subsequent cycles.

## BASIC OSCILLATOR CIRCUITS



ELECTRONICS NOW

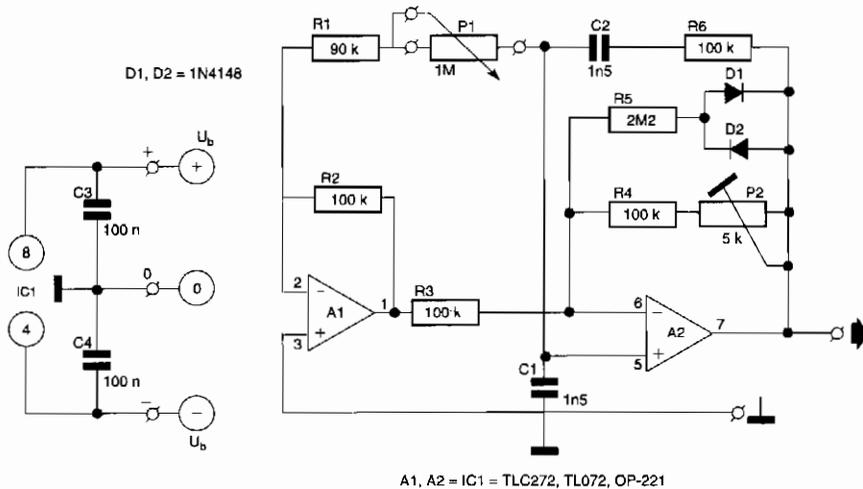
FIG. 71-10

Five basic types of LC oscillators are shown. The frequency can be changed by using the formula:

$$f = \frac{1}{2\pi L_{\text{effective}} C_{\text{effective}}}$$

where  $L_{\text{effective}}$  = equivalent inductance  
 $C_{\text{effective}}$  = equivalent capacitance

## VARIABLE WIEN-BRIDGE OSCILLATOR



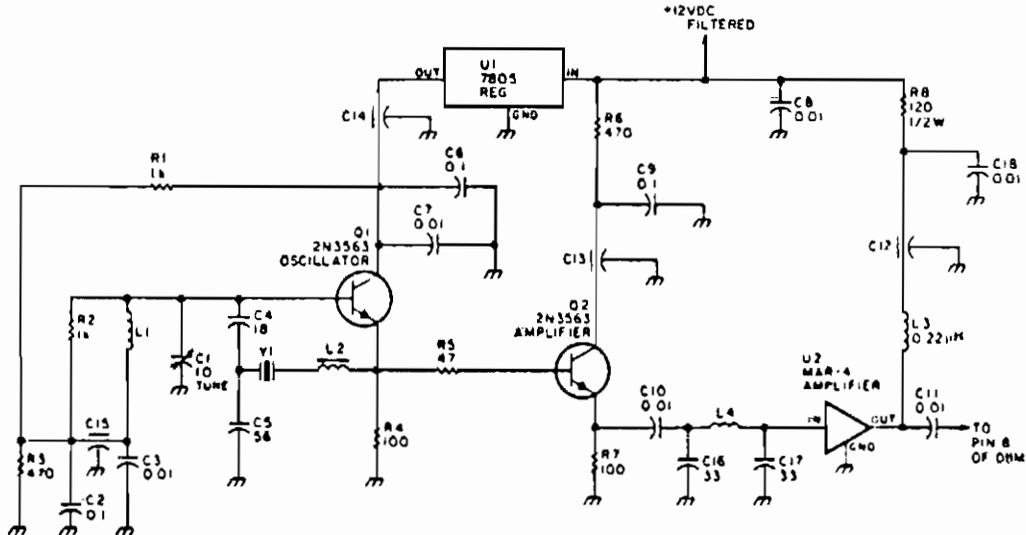
A1, A2 = IC1 = TLC272, TL072, OP-221

### 303 CIRCUITS

FIG. 71-11

This circuit uses a single potentiometer to tune a 300- to 3000-Hz range. A FET op amp is used at A1 and A2. The upper frequency limit is determined by the gain-bandwidth product of the op amps.

## LOCAL OSCILLATOR FOR DOUBLE BALANCED MIXERS

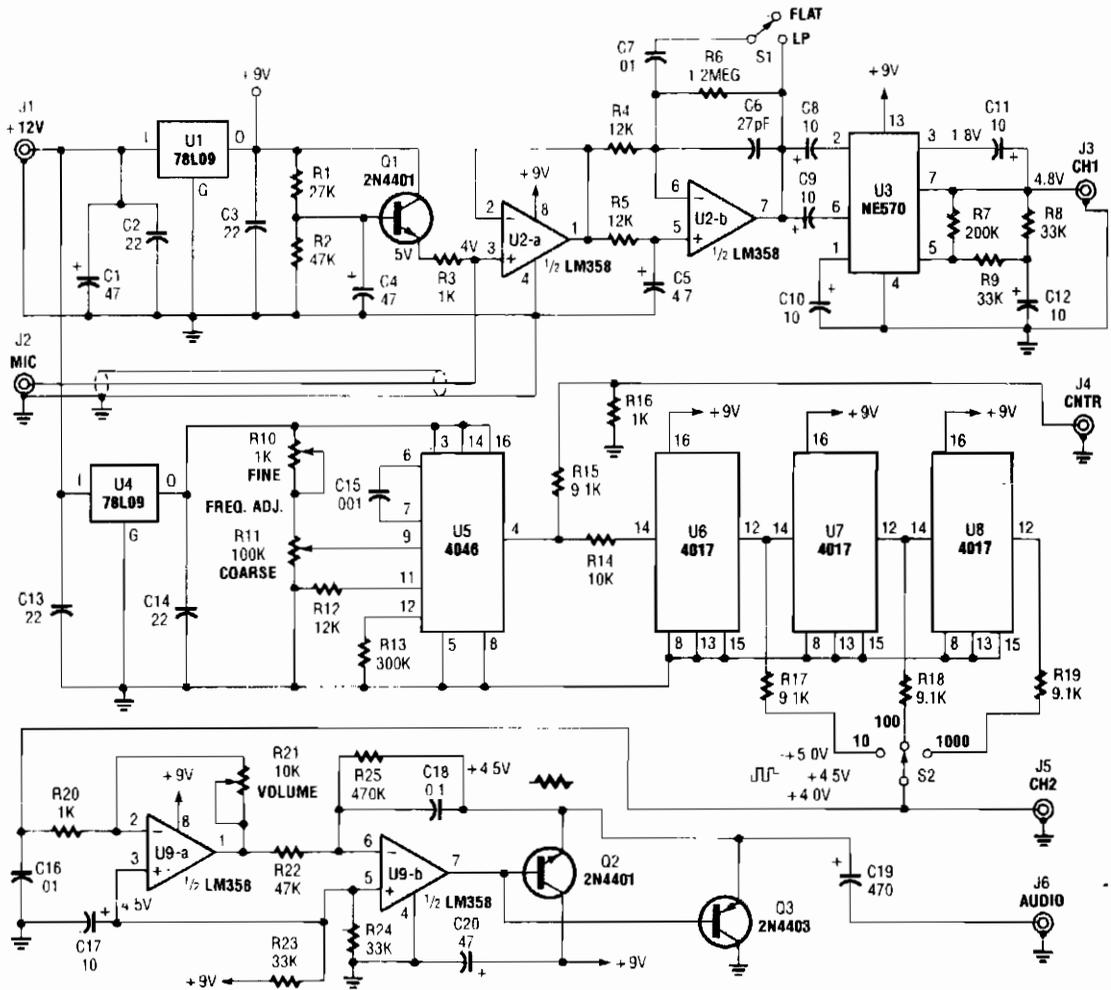


### 73 AMATEUR RADIO TODAY

FIG. 71-12

This circuit has an amplifier to supply +10 dBm to an SBL series (Mini-circuits) or similar type doubly-balanced mixer assembly. This circuit has values shown for  $\approx$ 80- to 90-MHz crystals, although values of oscillator circuit constants can be scaled for higher or lower frequencies.

## PRECISION AUDIO-FREQUENCY GENERATOR



POPULAR ELECTRONICS

FIG. 71-13A

The precision audio-frequency generator consists of several subcircuits—an audio-amplifier/filter circuit, an automatic level control, a variable voltage-controlled oscillator, a frequency divider circuit, an integrator, and an audio output amplifier.

An electret microphone element is used to pick up the audio tone produced by the instrument. That signal is then fed to an amplifier/filter/level-controlled circuit and output via channel 1 (CH1) to an oscilloscope for display.

The variable voltage-controlled oscillator (VCO) is used to produce a signal of from less than 10 kHz to more than 99 kHz. The VCO output is fed to a digital frequency counter for display, and is also routed to a chain of frequency dividers, where the signal is divided by 10, 100, or 1,000, depending on the setting of a selector switch.

## PRECISION AUDIO-FREQUENCY GENERATOR (Cont.)

Note/ Octave	Key#	Hertz	Stretch in Cents	Note/ Octave	Key#	Hertz	Stretch in Cents
A/0	1	27.184	-20	F/4	45	349.03	- 1
B $\flat$ /0	2	28.817	-19	G $\flat$ /4	46	369.78	- 1
B/0	3	30.548	-18	G/4	47	391.77	- 1
C/1	4	32.384	-17	A $\flat$ /4	48	415.07	- 1
D $\flat$ /1	5	34.329	-16	A/4	49	440.00	0
D/1	6	36.391	-15	B $\flat$ /4	50	466.16	0
E $\flat$ /1	7	38.578	-14	B/4	51	493.88	0
E/1	8	40.895	-13	C/5	52	523.25	0
F/1	9	43.352	-12	D $\flat$ /5	53	554.37	0
G $\flat$ /1	10	45.956	-11	D/5	54	587.33	0
G/1	11	48.717	-10	E $\flat$ /5	55	622.61	+ 1
A $\flat$ /1	12	51.644	- 9	E/5	56	659.64	+ 1
A/1	13	54.746	- 8	F/5	57	698.86	+ 1
B $\flat$ /1	14	58.035	- 7	G $\flat$ /5	58	740.42	+ 1
B/1	15	61.522	- 6	G/5	59	784.44	+ 1
C/2	16	65.180	- 6	A $\flat$ /5	60	831.57	+ 2
D $\flat$ /2	17	69.096	- 5	A/5	61	881.02	+ 2
D/2	18	73.204	- 5	B $\flat$ /5	62	933.41	+ 2
E $\flat$ /2	19	77.602	- 4	B/5	63	988.91	+ 2
E/2	20	82.217	- 4	C/6	64	1047.7	+ 2
F/2	21	87.106	- 4	D $\flat$ /6	65	1110.7	+ 3
G $\flat$ /2	22	92.285	- 4	D/6	66	1176.7	+ 3
G/2	23	97.773	- 4	E $\flat$ /6	67	1246.7	+ 3
A $\flat$ /2	24	103.65	- 3	E/6	68	1321.6	+ 4
A/2	25	109.81	- 3	F/6	69	1400.1	+ 4
B $\flat$ /2	26	116.34	- 3	G $\flat$ /6	70	1484.3	+ 5
B/2	27	123.26	- 3	G/6	71	1572.5	+ 5
C/3	28	130.59	- 3	A $\flat$ /6	72	1667.0	+ 6
D $\flat$ /3	29	138.35	- 3	A/6	73	1766.1	+ 6
D/3	30	146.58	- 3	B $\flat$ /6	74	1872.2	+ 7
E $\flat$ /3	31	155.29	- 3	B/6	75	1984.7	+ 8
E/3	32	164.53	- 3	C/7	76	2103.9	+ 9
F/3	33	174.31	- 3	D $\flat$ /7	77	2230.3	+10
G $\flat$ /3	34	184.73	- 2.5	D/7	78	2230.2	+10
G/3	35	195.71	- 2.5	E $\flat$ /7	79	2506.3	+12
A $\flat$ /3	36	207.41	- 2	E/7	80	2656.9	+13
A/3	37	219.75	- 2	F/7	81	2818.1	+15
B $\flat$ /3	38	232.81	- 2	G $\flat$ /7	82	2989.2	+17
B/3	39	246.66	- 2	G/7	83	3170.6	+19
C/4	40	261.32	- 2	A $\flat$ /7	84	3363.0	+21
D $\flat$ /4	41	276.86	- 2	A/7	85	3567.1	+23
D/4	42	293.33	- 2	B $\flat$ /7	86	3783.6	+25
E $\flat$ /4	43	310.86	- 1.5	B/7	87	4013.2	+27
E/4	44	329.44	- 1	C/8	88	4259.2	+30

•Standard pitch, A49= 440 Hz  
 Values shown are stretched for the average piano

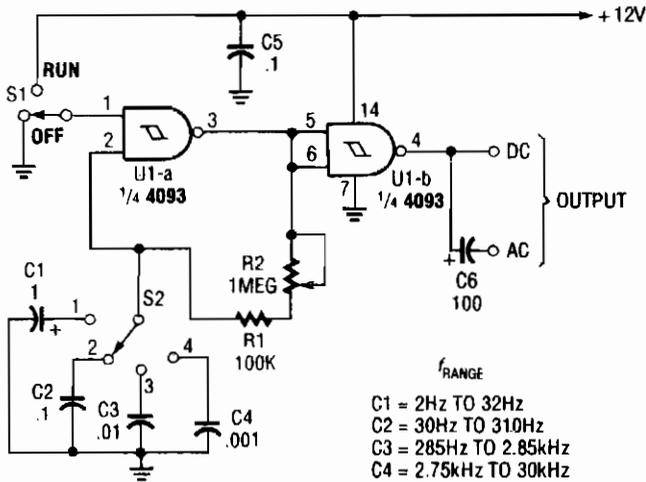
### POPULAR ELECTRONICS

**FIG. 71- 13B**

From there, the selected signal frequency divides along two paths; one going to CH2 (which feeds the oscilloscope's sweep synchronization input) and to an integrator that converts the square-wave output of the divider into a triangular waveform. The output of the integrator is then amplified and fed to a set of stereo headphones via an audio output jack.

One section of the precision audio-frequency generator uses an electret microphone element to pick up audio from the piano. That signal is then processed and sent to one channel of a dual-trace oscilloscope. The other section of the circuit is used to produce a variable-frequency signal that is fed to a digital frequency counter and, after conditioning, is presented to the second channel of the scope and output to a set of stereo headphones.

## CMOS VFO

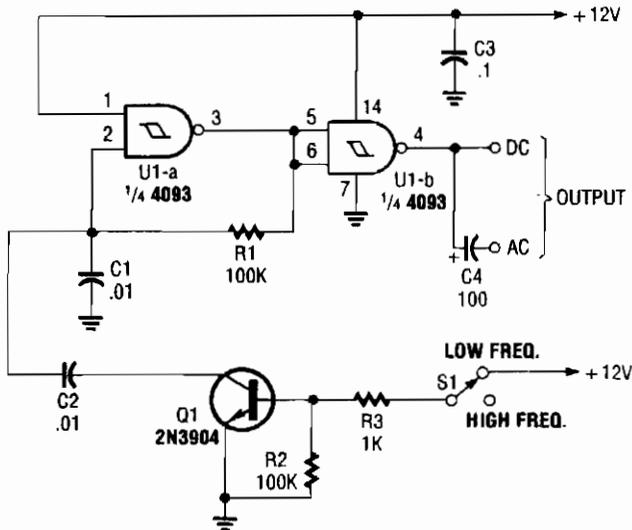


POPULAR ELECTRONICS

FIG. 71-14

The circuit shown has a frequency range of 2 Hz to 30 kHz. R2 is a linear or log potentiometer.

## FREQUENCY SWITCHER



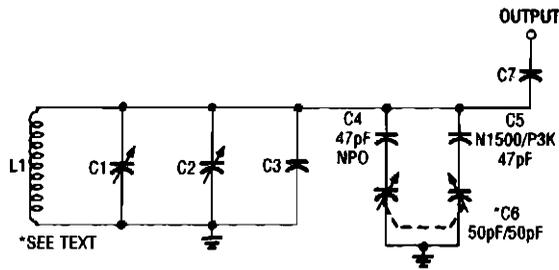
POPULAR ELECTRONICS

FIG. 71-15

This transistor can achieve frequency switching in this CMOS astable oscillator.



## ADJUSTABLE VFO TEMPERATURE COMPENSATOR

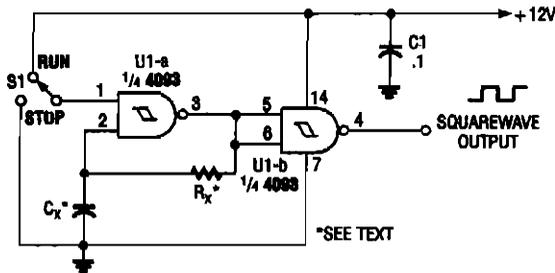


POPULAR ELECTRONICS

FIG. 71-19

Use of a differential capacitor allows temperature compensation of LC circuit using an NPO and N1500 ceramic. C6 is a differential capacitor that has two stators and one common rotor. When one capacitance (stator) is maximum, the other is minimum. L1, C1, C2, and C3 are tuning, trimming, and fixed capacitors, respectively.

## 4093 CMOS ASTABLE OSCILLATOR

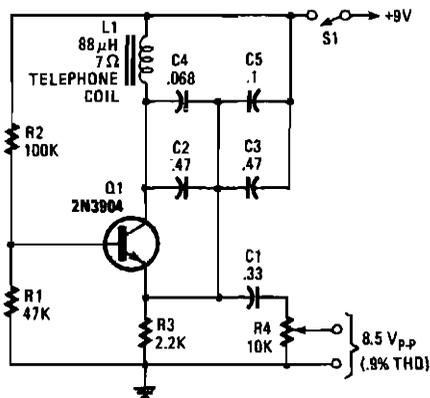


POPULAR ELECTRONICS

FIG. 71-20

Two gates of the Quad 4093 are used to make an oscillator.  $R_x$  can be from about  $5\text{ k}\Omega$  to around  $10\text{ M}\Omega$ .  $C_x$  can be from about  $10\text{ pF}$  to many  $\mu\text{F}$ , the limit being set by the leakage of the capacitor. Frequency is approximately  $2.8/R_x C_x$  ( $R\text{ M}\Omega$ ,  $C\text{ mfd}$ ).

## SIMPLE AUDIO TEST OSCILLATOR

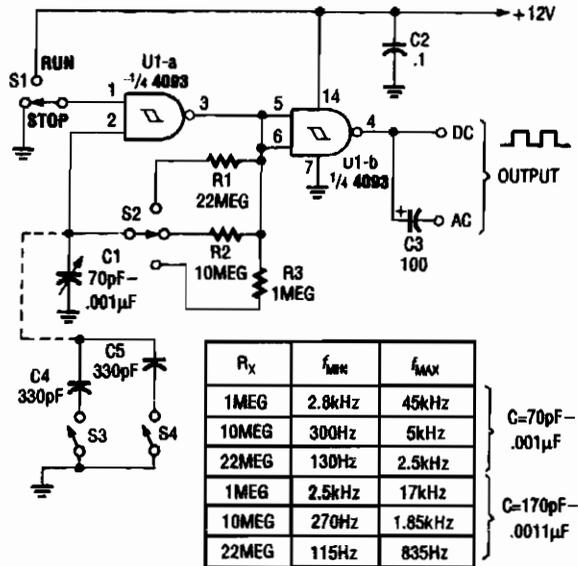


POPULAR ELECTRONICS

FIG. 71-21

An 88-mH surplus telephone toroidal coil is used in a 1-kHz oscillator. Up to 8 V p-p into a high-Z load is available. THD is 0.9%.

## 4093 CMOS VFO



POPULAR ELECTRONICS

**FIG. 71-22**

Two gates of a Quad 4093 are used in an astable multivibrator. C1 is a three-gang 365 pF variable capacitor with sections paralleled. S3 and S4 switch in optional extra capacitors.

# 72

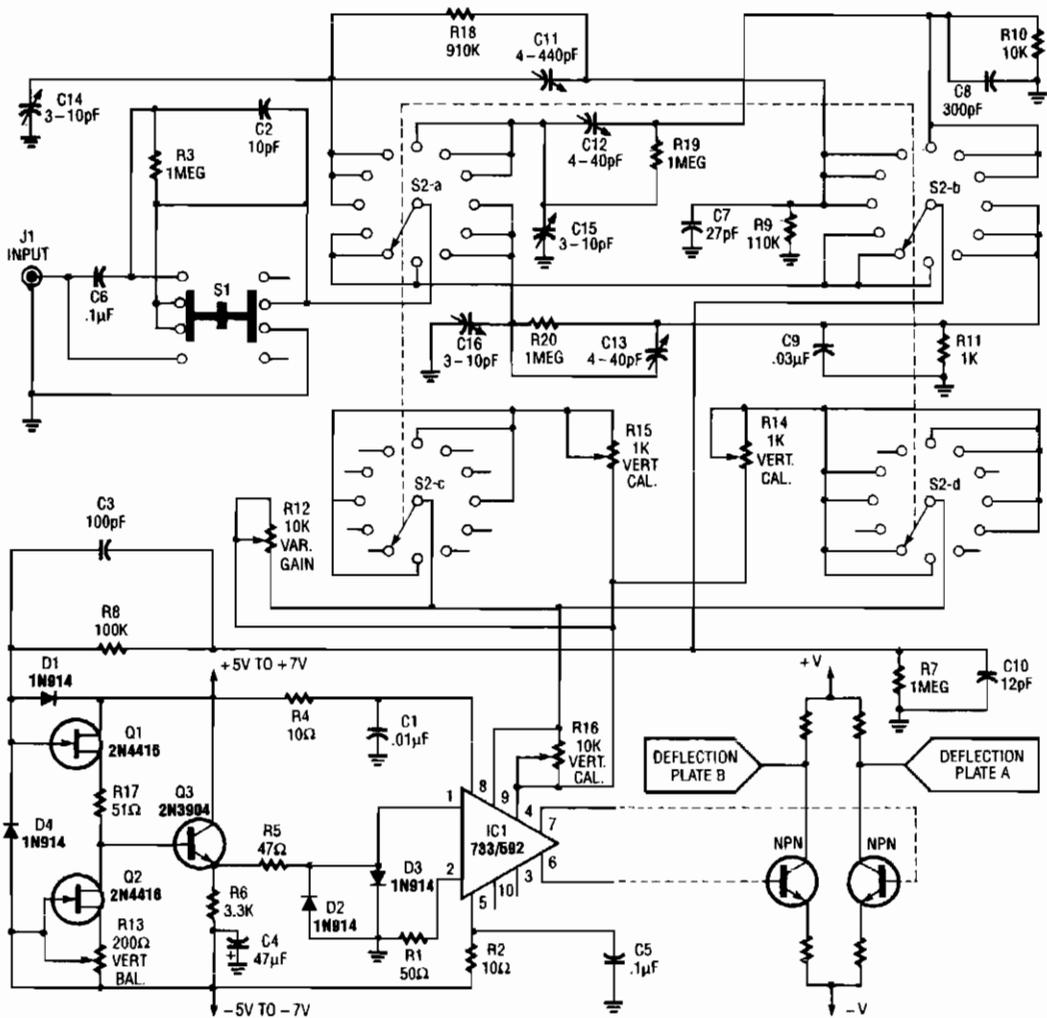
## Oscilloscope Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Oscilloscope Preamplifier  
Simple Spectrum Analyzer Adaptor for Scopes  
Simple Oscilloscope Timebase Generator  
Trigger Selection Circuit for Oscilloscope Timebase  
Variable Gain Amplifier

## OSCILLOSCOPE PREAMPLIFIER

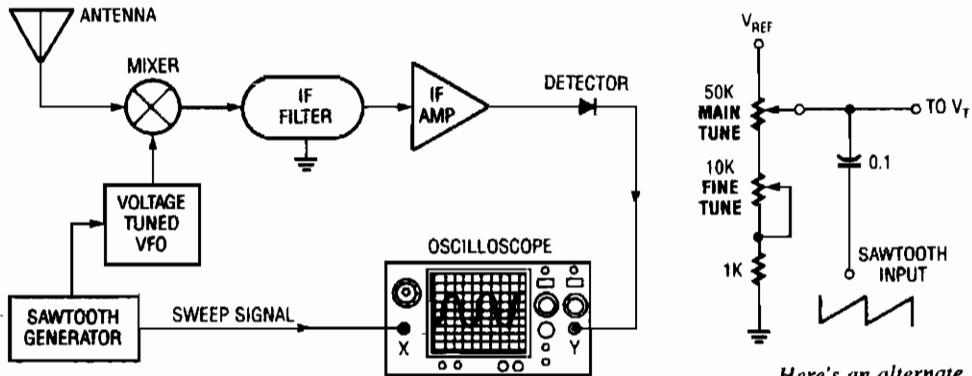


RADIO ELECTRONICS

FIG. 72-1

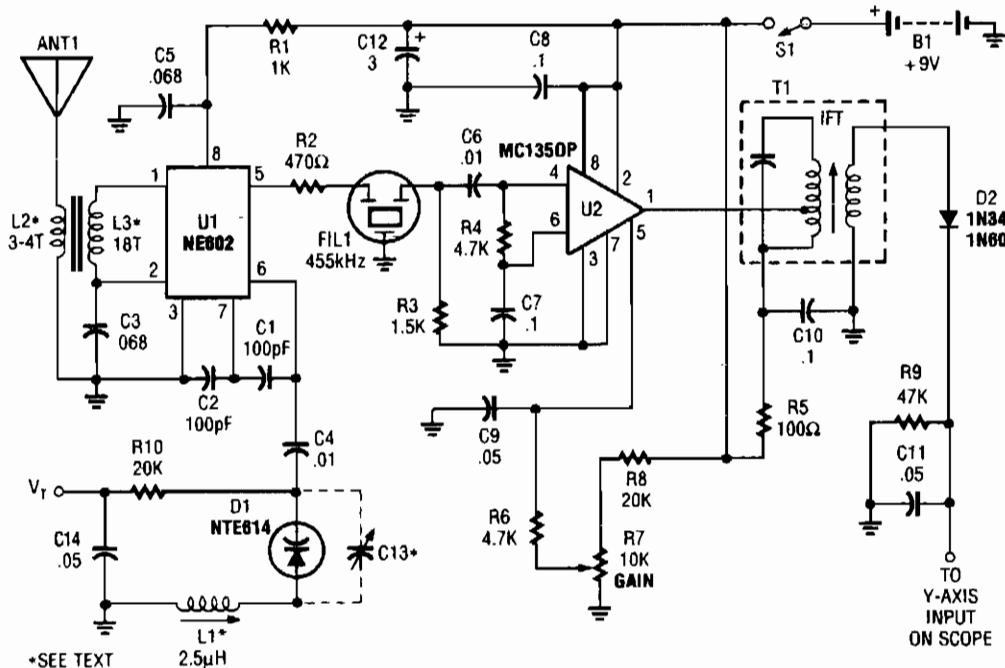
An oscilloscope front-end amplifier can be built with low-cost transistor and video amp ICs. This preamp uses a FET input and compensated attenuators, and has approximately 100-MHz bandwidth, which is adequate for most general-purpose oscilloscopes.

## SIMPLE SPECTRUM ANALYZER ADAPTOR FOR SCOPES



*Block diagram of a spectrum analyzer.*

*Here's an alternate tuning network for the spectrum analyzer.*

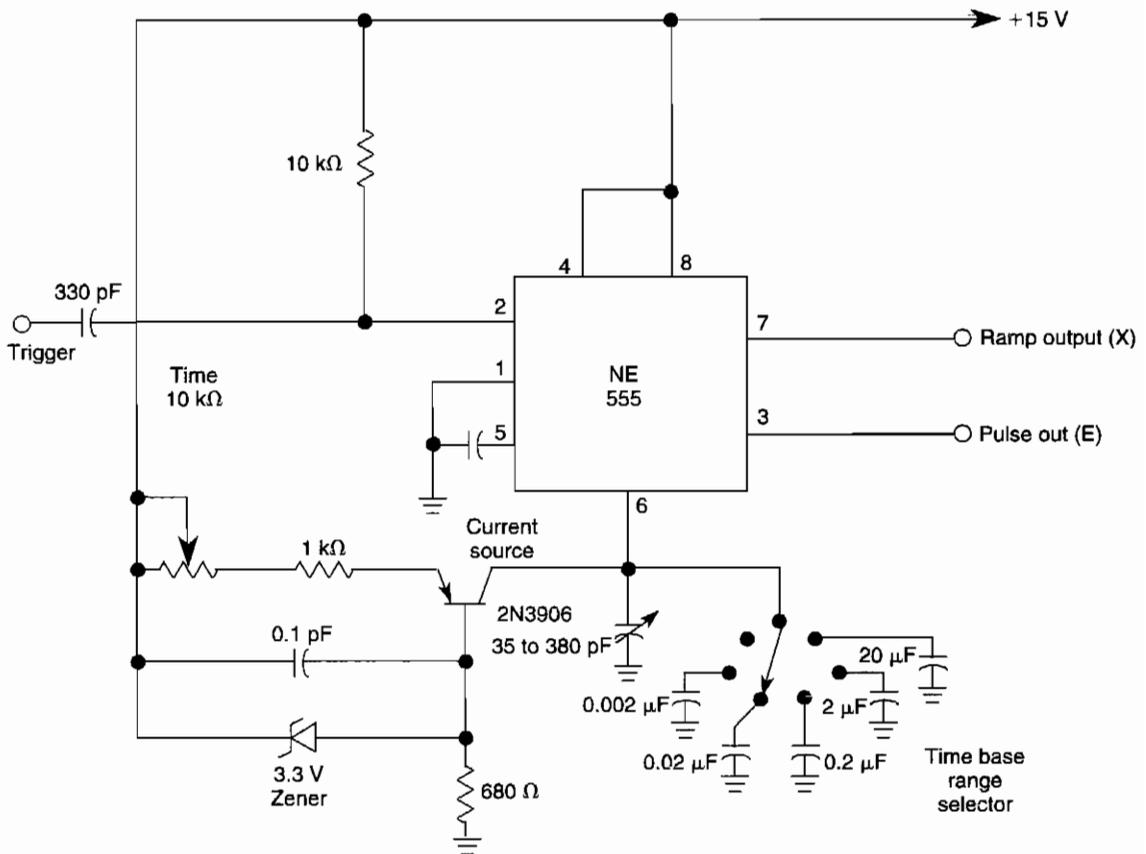


### POPULAR ELECTRONICS

**FIG. 72-2**

Suitable for monitoring an amateur band or a segment of the radio spectrum, this simple adaptor uses an NE602 mixer-oscillator chip to produce a 455-kHz IF signal, which U2 amplifies, then feeds to detector D2 and the Y axis of an oscilloscope.  $V_T$  is used to drive the horizontal axis input of a scope. L2 and L3 are coils suitable for the frequency range in use. For this circuit, coils are shown for the 10- to 15-MHz range. L2 and L3 are wound on Amidon Associates, T-37 or T-50 toroidal cores, and L1 is a commercial or homemade variable inductor, etc.

## SIMPLE OSCILLOSCOPE TIMEBASE GENERATOR

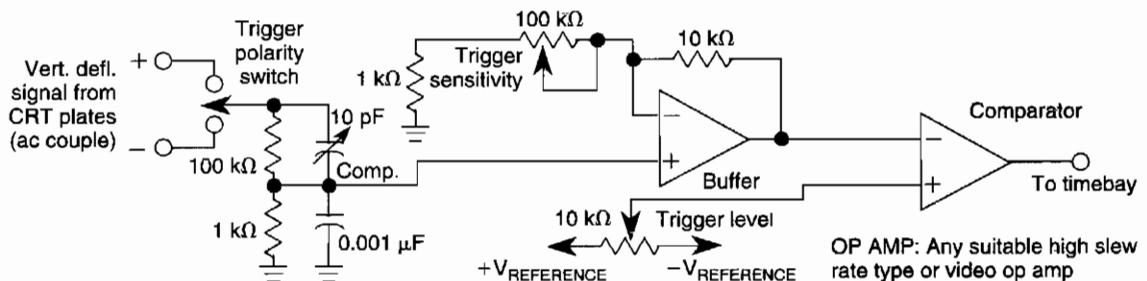


ELECTRONICS NOW

FIG. 72-3

The 555 timer generates both a linear ramp and an output for Z-axis modulations of the CRT electron beam.

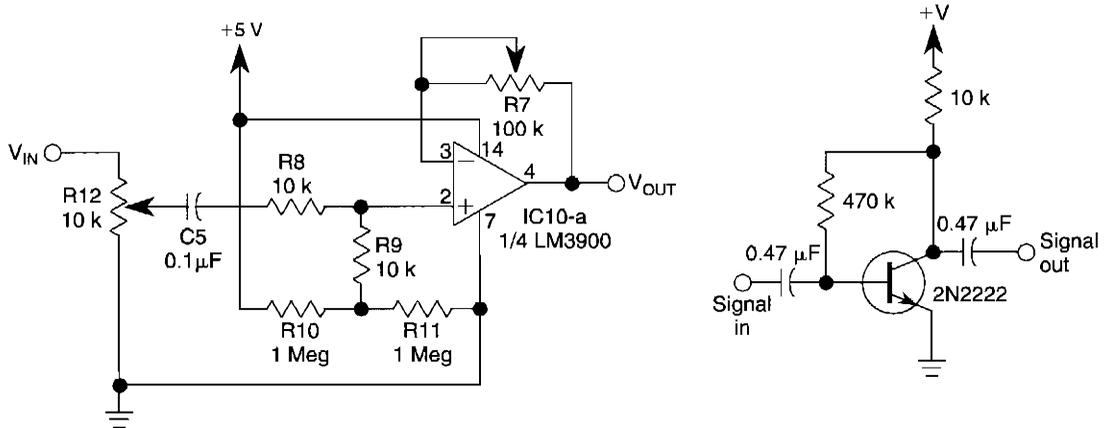
## TRIGGER SELECTION CIRCUIT FOR OSCILLOSCOPE TIMEBASE



ELECTRONICS NOW

FIG. 72-4

## VARIABLE GAIN AMPLIFIER



ELECTRONICS NOW

FIG. 72-5

This circuit uses ¼ of an LM3900 to build a simple variable-gain front end for an oscilloscope. R7 is the gain control. Also shown is a simple preamp if you need more than 10X of gain.

# 73

## Pest-Control Circuits

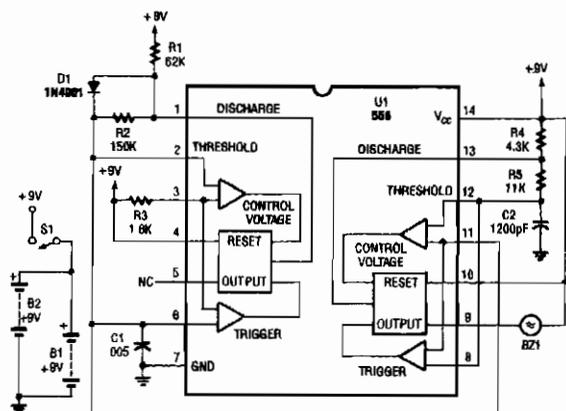
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Pest Repeller  
Ultrasonic Pest Repeller

## PEST REPELLER

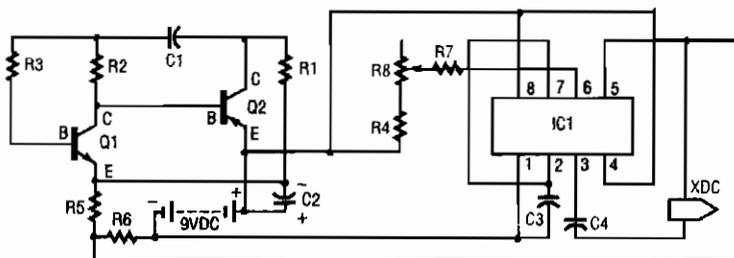


1992 PE HOBBYIST HANDBOOK

FIG. 73-1

The two timers in the bug repeller have some interesting characteristics. Both of them have their thresholds externally set; the oscillator on the left has a 50% duty cycle and the oscillator on the right acts as a VCO.

## ULTRASONIC PEST REPELLER



1991 PE HOBBYIST HANDBOOK

FIG. 73-2

This circuit uses two transistors and one IC (555 timer IC) to produce a pulsating ultrasonic frequency. Transistors Q1 and Q2 are connected in a direct-coupled oscillator. The frequency of that oscillator is set by capacitor C1. The oscillator output is taken from the emitter of Q2 to pin 7 of IC1. Transistor Q1 is an npn transistor, and Q2 is a pnp transistor. The signal of pin 7 on IC1 causes the output signal appearing on pin 3 to be modulated or varied by the audio frequency developed by Q1 and Q2. The IC itself is connected as a stable multivibrator with a frequency that is determined by C3. Capacitor C3 sets the basic frequency to be well above the human hearing range (ultrasonic). The combined modulated ultrasonic frequency appears on pin 3 of IC1, where it is coupled by capacitor C4 to the piezoelectric transducer.

C1, C2	0.1- $\mu$ F Mylar Capacitor	R2	3.3-M $\Omega$ Resistor
C2	1- $\mu$ F Electrolytic Capacitor	R3, R6	10-k $\Omega$ Resistor
C3	0.001- $\mu$ F Mylar Capacitor	R4, R5	100- $\Omega$ Resistor
IC1	555 timer IC	R7	18-k $\Omega$ Resistor
Q1	2N3904 Transistor	R8	Potentiometer
Q2	2N3906 Transistor	XDC	Piezoelectric Transducer Disc
R1	4.7-k $\Omega$ Resistor	Misc	IC Socket, 9-V Snap, PC Board

# 74

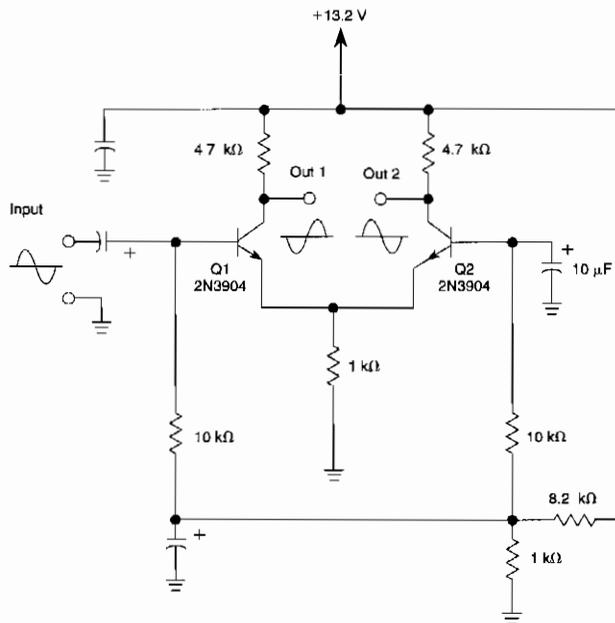
## Phase Shifter Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Long-Tailed Pair Phase-Splitter  
Phase-Splitter Circuit  
Phase Shifter with Eight Outputs

## LONG-TAILED PAIR PHASE-SPLITTER

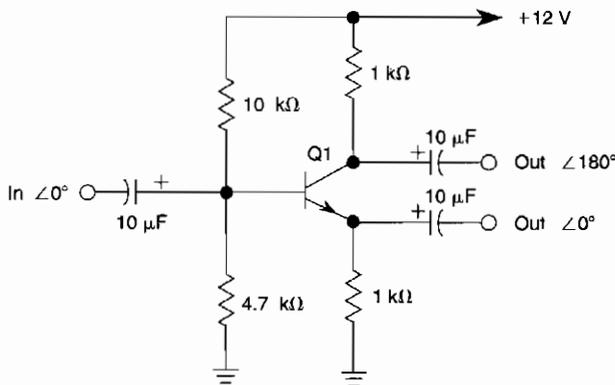


WILLIAM SHEETS

FIG. 74-1

The single-phase input produces out-of-phase outputs at the collectors of Q1 and Q2.

## PHASE-SPLITTER CIRCUIT



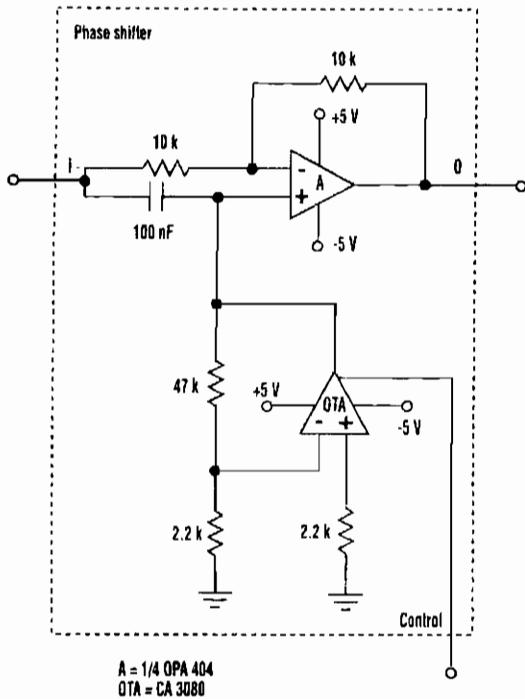
Q1: 2N2222, etc.

WILLIAM SHEETS

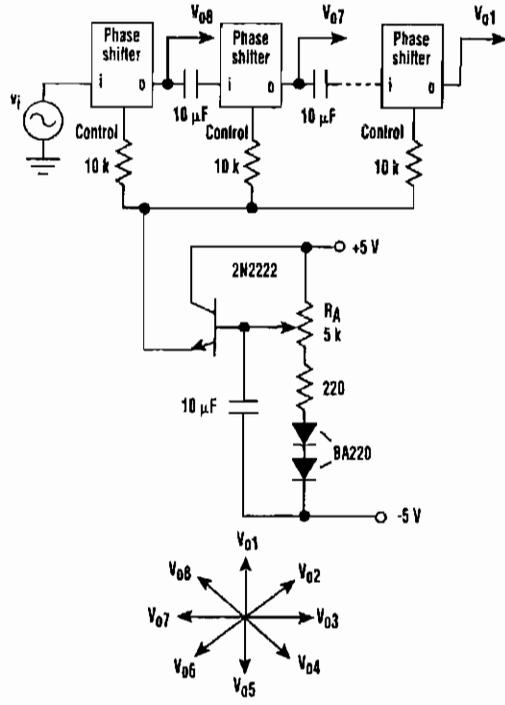
FIG. 74-2

This phase splitter uses a 2N2222 (or other general purpose npn transistor) to achieve outputs that are 180° out of phase.

## PHASE SHIFTER WITH EIGHT OUTPUTS



A = 1/A OPA 404  
OTA = CA 3080



### ELECTRONIC DESIGN

**FIG. 74-3**

The circuit consists of eight cascaded identical cells, each cell being a dc-controlled active phase shifter. Because the dc control is common for all shifters, the circuit is adjusted by trimming  $R_A$  so that the phase difference between  $V_{o1}$  and  $V_i$  is zero. As a result, each shifter will introduce a phase difference of exactly  $\pi/r$ . The eight signals for PSK are available at the op amps' outputs.

Phase accuracy is acceptable for 1%-tolerance resistors and 5%-tolerance 100-nF capacitors. Also, the amplitude of  $V_i$  (which is a 1700-Hz sine wave), should not exceed 1 V.

# 75

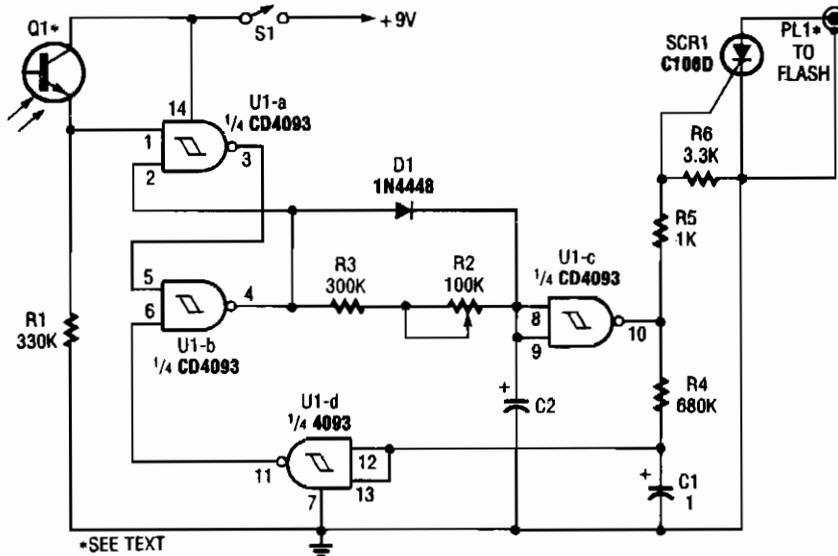
## Photography Related Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Time-Delay Flash-Trigger Circuit  
Photo Flash Slave Unit  
Enlarging Light Meter  
Photo Strobe  
Darkroom Timer  
Photo Strobe Slave Trigger  
Strobe Light  
Enlarger Exposure Meter

## TIME-DELAY FLASH-TRIGGER CIRCUIT

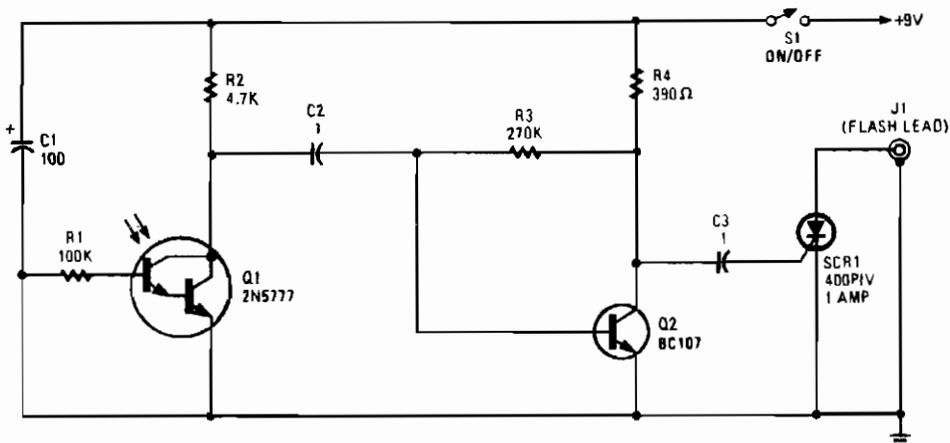


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FIG. 75-1

The circuit is built around a single 4093 quad 2-input NAND Schmitt trigger. Two gates from that quad package (U1-a and U1-b) are configured as a set-reset flip-flop.

## PHOTO FLASH SLAVE UNIT

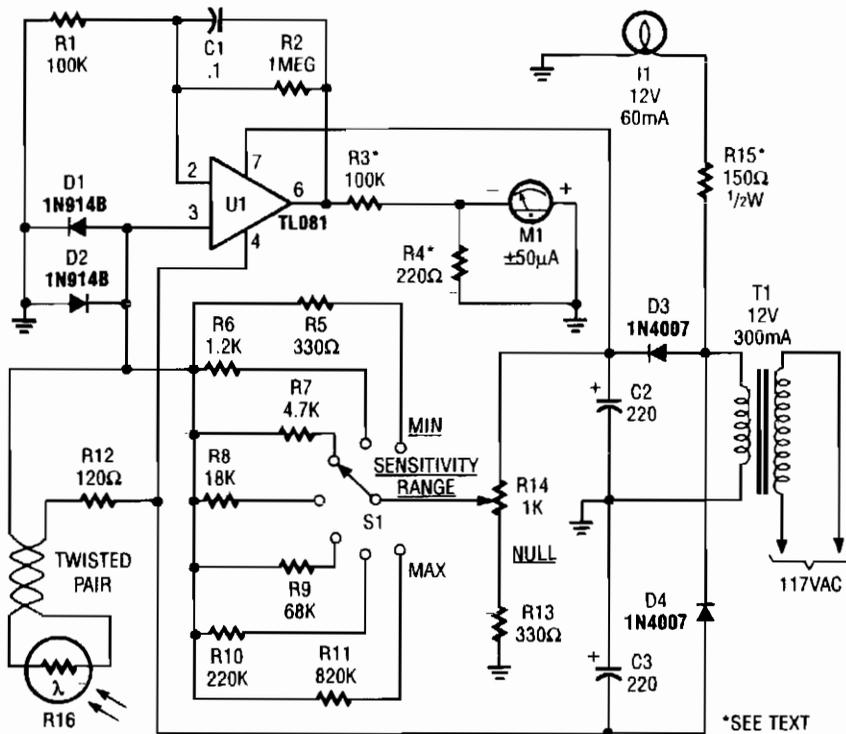


POPULAR ELECTRONICS

FIG. 75-2

Phototransistor Q1 receives a light pulse from a photoflash unit. The pulse is ac-coupled to amplifier Q2. It then triggers SCR1, which triggers a flash unit that is connected to J1.

## ENLARGING LIGHT METER



POPULAR ELECTRONICS

FIG. 75-3

Meter M1, a  $\pm 50\text{-}\mu\text{A}$  zero-center D'Arsonval meter movement is driven by U1, a TL081 FET op amp, through R3. The gain of U1 is set at 11 by R1 and R2, while capacitor C1 is used to restrict the bandwidth of U1 to 1.6 Hz. Power for the circuit is derived from a simple dual-polarity 12-V power supply (consisting of T1, D3, D4, C2, and C3).

A light-dependent resistor (LDR), R16 (which is a semiconductor element whose resistance decreases as it is exposed to increasing illumination), is used as a light-sensing device. One end of R16 is connected to the negative supply rail through R12, and the other end is connected to pin 3 of U1, applying a negative current to U1. A variable (over a 4:1 range) positive current determined by the settings of R14 and S1 (and derived from the positive supply rail) is also fed to pin 3 of U1.

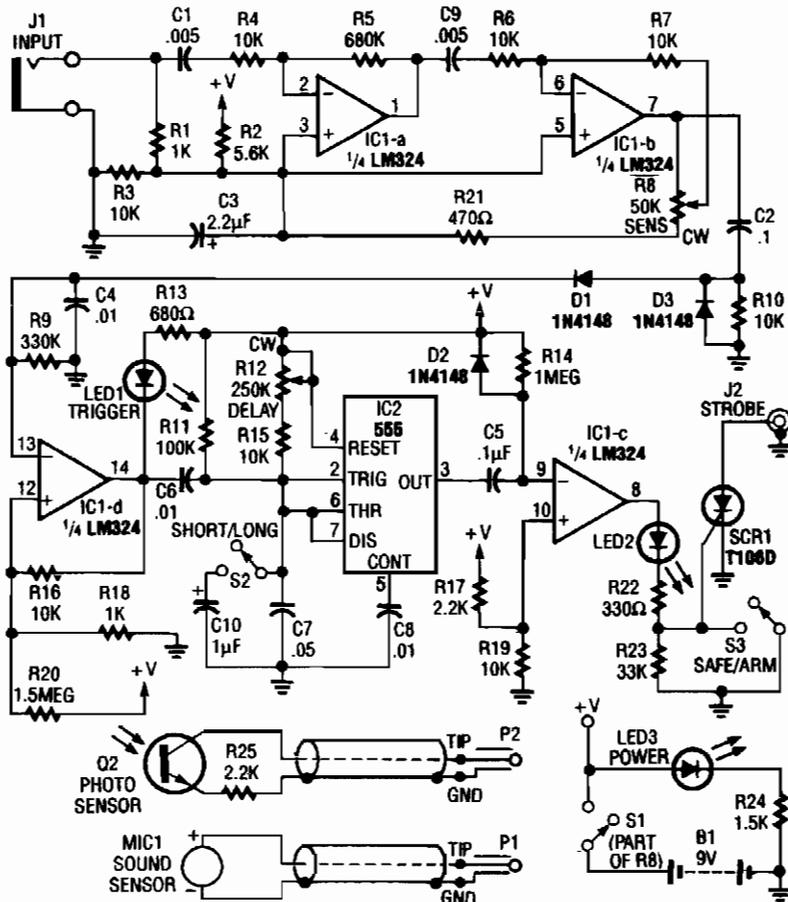
When the two currents (of opposite polarities) are equal, they cancel each other out, so effectively no current is applied to pin 3 of U1. With no current applied to pin 3, the output of U1 is zero and meter M1 registers accordingly, indicating a null. However, when light striking R16 causes its resistance to decrease, the current through the device increases, making the negative current greater than the positive current. Under that condition, the negative current causes the output of U1 to swing negative, causing the pointer to swing in the negative direction.

That indicates that the light intensity must be reduced by using a smaller lens opening on the enlarger (smaller  $f/\text{stop}$ ). The opposite occurs if the light is too dim. Lamp I1, a 12-V 60-mA "grain of wheat" unit, is used to illuminate the meter scale, and R15 is used to limit the meter's illumination to a faint glow that is just bright enough so that the face of M1 can be plainly seen in a photo darkroom.

## ENLARGING LIGHT METER (Cont.)

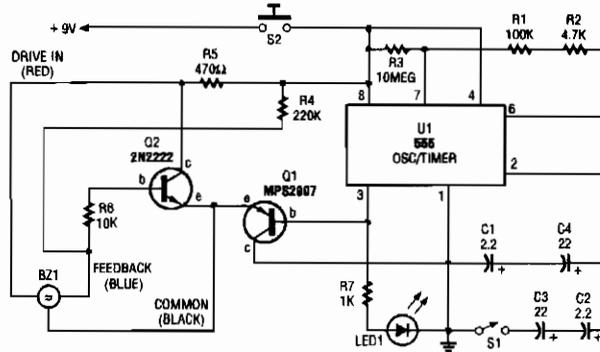
Resistors R3 and R4 should be selected for the meter used. With a dual supply of  $\pm 12$  V, U1 produces an output voltage of 10 V peak-to-peak. The resistance of R3 can be found by dividing the peak voltage (i.e., 10/2) by the full-scale meter current (in amps); i.e.,  $R_3 = (10/2)/0.0005 = 100,000 \Omega$ . R4, the shunt resistor, should be selected to have a value equal to the meter's internal resistance.

### PHOTO STROBE



Sound or light sensors connected to J2 produce a voltage that is amplified by IC1-a and IC1-b. A positive trigger voltage that is developed by D1 and D3 and amplified by IC1-d, drives IC2 and IC1 to trigger SCR1. SCR1 is connected to a strobe. This device is handy for photographic purposes to take pictures of events that involve sound, such as impacts, etc.

## DARKROOM TIMER



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FIG. 75-5

The electronic darkroom timer is built around a 555 oscillator/timer, a pair of general-purpose transistors, a buzzer, and an LED. The 555 (U1) is configured as an astable multivibrator (free-running oscillator). The frequency of the oscillator is determined by the values  $R_1$  through  $R_3$  and  $C_1$  through  $C_4$ .

Switch S1 is used to divide the capacitor network to vary the time interval between beeps; when S1 is closed, the circuit beeps at intervals of 30 seconds. With S1 closed, it beeps at 15-second intervals.

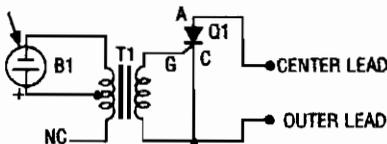
When power is applied to the circuit (by closing switch S2), the output of U1 at pin 3 is initially high. That high is applied to the base of transistor Q1 (an MPS2907 general-purpose pnp device), keeping it turned off. That high is also applied to the anode of LED1 (which is used as a power on indicator) through resistor R7, turning it on.

Timing capacitors C1 through C5 begin to charge through timing resistors R1 through R3. dc voltage is applied to BZ1's driver input through R5 and to its feedback terminal (through R4), which is also connected to Q2's base terminal. The  $V_+$  voltage that applied to Q2's base causes it to turn on, tying BZ1's common terminal high.

When the timing capacitors are sufficiently charged, a trigger pulse is applied to pin 2 (the trigger input) of U2, causing U1's output to momentarily go low. This causes LED1 to go out and transistor Q1 to turn on. That, in turn, grounds the common lead of buzzer BZ1, causing BZ1 to sound. Afterward, the output of U1 returns to the high state, turning off Q1, and turning on LED1, until another time interval has elapsed and the process is repeated.

The circuit is powered by a 9-Vac adapter, which plugs into a standard 117-V household outlet. Because the circuit draws only about 10 to 15 mA, a 9-V alkaline transistor-radio-battery can also be used to power the circuit.

## PHOTO STROBE SLAVE TRIGGER

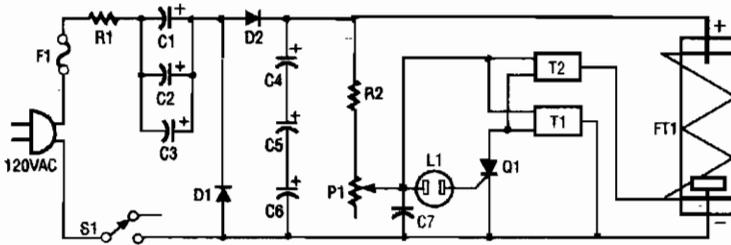


The photo strobe slave trigger circuit uses a solar cell and an SCR to flash any strobe when you trigger your "master" strobe. The tiny solar cell produces a very small voltage when light falls on its surface.

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FIG. 75-6

## STROBE LIGHT



- C1,C2,C3... 10  $\mu$ F 160V Electrolytic Capacitor  
 C4,C5,C6... 160  $\mu$ F 200V Electrolytic Capacitor  
 C7 ..... 0.5  $\mu$ F 250V Mylar Capacitor  
 D1, D2 .. 1N4004 Diodes  
 F1 ..... 1 Amp Pigtail Fuse  
 FT1 ..... Giant Xenon Strobe Tube  
 L1 ..... Neon Lamp  
 P1 ..... 10 Meg Potentiometer  
 Q1 ..... 106D1 SCR  
 R1 ..... 20 ohm 10 Watt Power Resistor  
 R2 ..... 270K 1/4 Watt Resistor  
 S1 ..... Slide Switch  
 T1, T2 .. Trigger Coil

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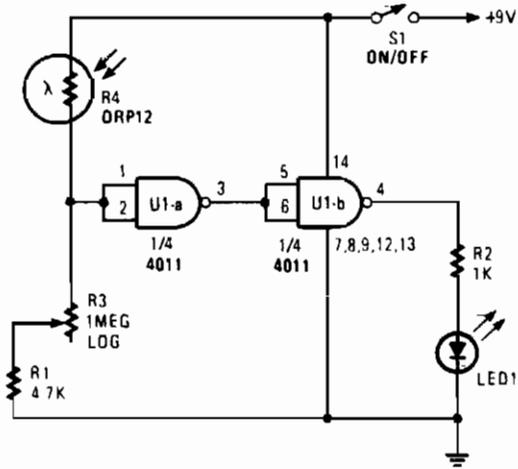
FIG. 75-7

This strobe light operates from standard 120-Vac power. R1 limits the amount of current applied to the voltage doubler stage, which is comprised of C1, C2, C3, D1, D2, C4, C5, and C6. Capacitors C1, C2, and C3 are connected in parallel and form a capacitance of 30  $\mu$ F at 160 V. Capacitors C4, C5, and C6 are connected in series and form an equivalent capacitor of about 53  $\mu$ F at 480 V. Diodes D1 and D2 not only rectify the ac voltage, but also complete the voltage doubler stage, which converts the incoming 120 Vac to the appropriately 300 V that are required by the xenon strobe tube.

The next stage of the circuit is the neon relaxation oscillator and trigger stage. This stage is made up of R2, P1, C7, L1, Q1, T1, and T2. As the storage capacitor (made up of C4, C5, and C6) reaches its full-capacity charge, the voltage divider (made up of R2 and P1) applies voltage to capacitor C7. As C7 charges up, it reaches a threshold voltage level, SCR Q1. When Q1 has a positive pulse on its gate, it fires (causes a short from anode to cathode). That firing action discharges most of the energy stored in C7 into trigger transformers T1 and T2 (which have secondaries connected in series to develop 8 kV). The frequency of the 8-kV pulses is determined by the setting of P1 and the value of C7. Because C7 is a fixed capacitor, only the setting of P1 adjusts the flash rate in this circuit.

As soon as an 8-kV pulse is applied from the secondary of T2 (trigger wire) to the trigger lead of FT1, it discharges storage capacitors C4, C5, and C6, which causes it to ionize (flash). The cycle then repeats itself until the power is removed from the circuit board by turning "off" S1 or removing the line cord.

## ENLARGER EXPOSURE METER



Two gates of a 4011 are used as a comparator. When the resistance of R4 decreases the voltage at pin 1 and 2 increases, producing a logic zero at pin 3, causing pin 4 to go high and activating the LED. R3 is calibrated in light units, or seconds exposure time. To calibrate, set pot R3 so as to just be on the LED ON/OFF threshold. With a light level that is suitable to correctly expose a photographic print, use a known enlarger and a known negative.

POPULAR ELECTRONICS

FIG. 75-8

# 76

## Piezo Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

CMOS Piezo Driver

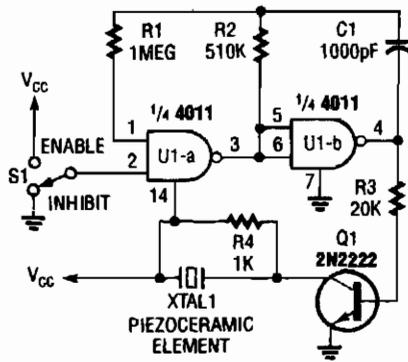
CMOS Piezo Driver Using 4049

Piezo Driver

Piezo Micropositioner Driver

555 Oscillator for Driving a Piezo Transducer

### CMOS PIEZO DRIVER



POPULAR ELECTRONICS

FIG. 76-1

A CMOS-gate and transistor buffer can be used as an effective driver for a piezoelectric transducer.

### CMOS PIEZO DRIVER USING 4049

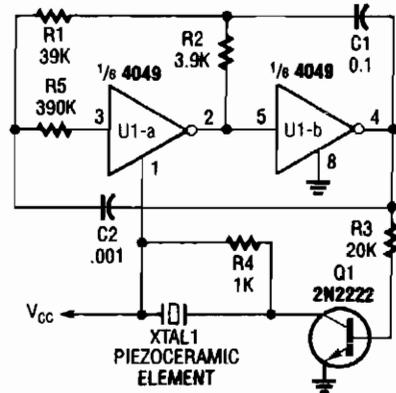
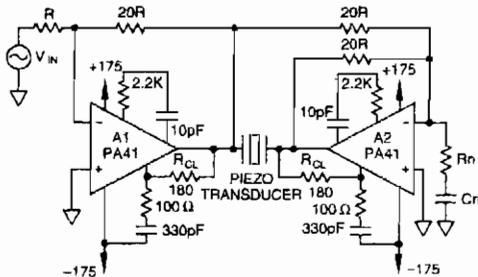


FIG 76-2

This circuit uses a 4049 IC to drive a 2N2222 switching transistor. The transistor drives crystal 1 a piezo transducer.

### PIEZO DRIVER

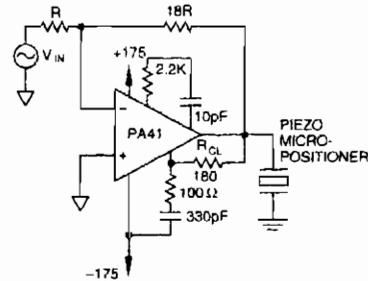


ELECTRONIC DESIGN

FIG. 76-3

Using a PA41 from Apex Microtechnology, this monolithic amplifier is capable of 350-V operation and delivers 660 V p-p in a bridge circuit.

### PIEZO MICROPOSITIONER DRIVER

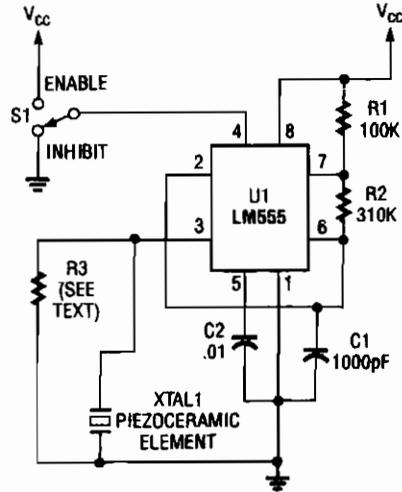


ELECTRONIC DESIGN

FIG. 76-4

The PA41 from Apex Microtechnology is used here to drive a piezoelectric micropositioner. The drive voltage is less than 20 V p-p at input.

## 555 OSCILLATOR FOR DRIVING A PIEZO TRANSDUCER



POPULAR ELECTRONICS

FIG. 76-5

A 555-timer oscillator is perhaps one of the most popular circuits for driving a piezoelectric transducer.

# 77

## Power Supply Circuits—High Voltage

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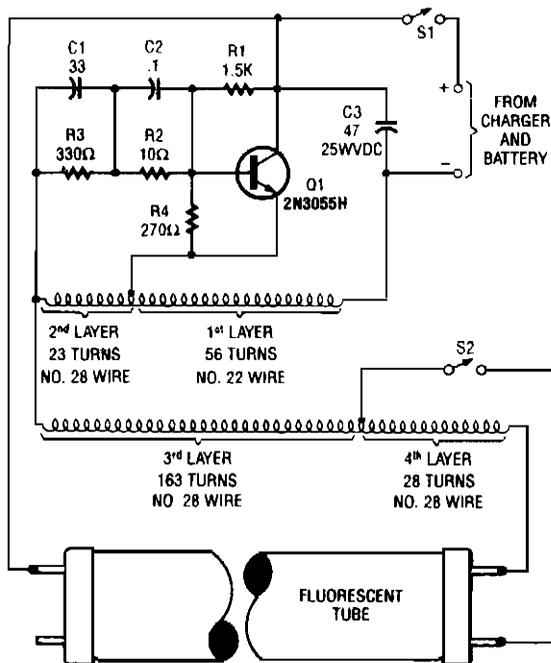
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

High-Voltage dc Generator  
Fluorescent Tube Power Supply  
Photomultiplier Supply  
Negative Voltage Supply  
Photomultiplier Circuit  
Single-Chip dc Supply for 120–240 Vac Operation  
High-Voltage Supply  
Cold-Cathode Fluorescent-Lamp Power Supply



## FLUORESCENT TUBE POWER SUPPLY

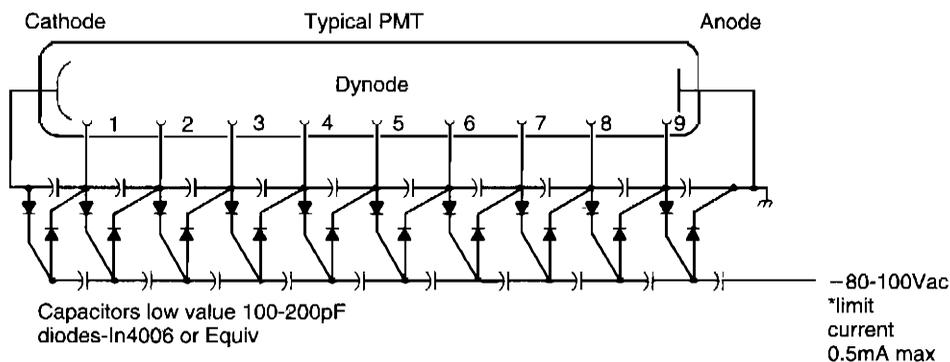


POPULAR ELECTRONICS

FIG. 77-2

A 2N3055 oscillator (Q1) drives a homemade transformer, wound on a  $\frac{5}{16} \times 1\frac{1}{8}$ " ferrite rod. S2 is used as a filament switch and it can be eliminated, if desired. A 20-W fluorescent tube is recommended. The supply is 12 V.

## PHOTOMULTIPLIER SUPPLY

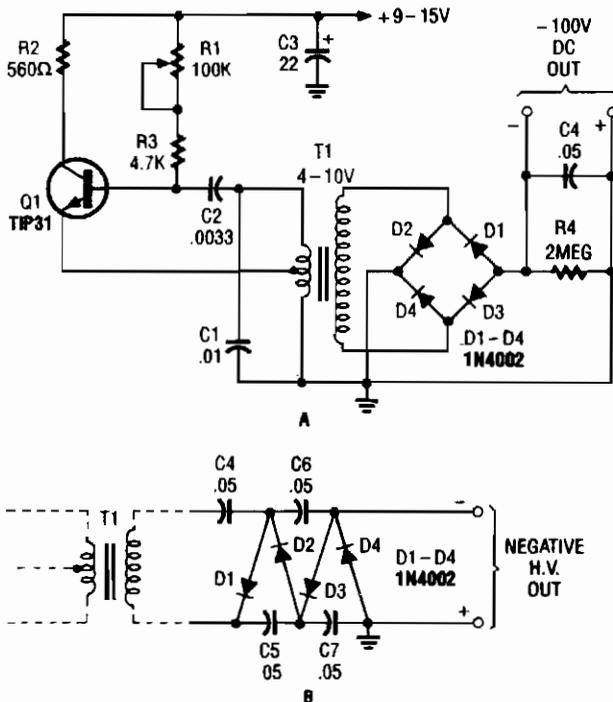


73 AMATEUR RADIO TODAY

FIG. 77-3

A Cockcroft-Walton voltage multiplier supplies the stepped voltage required for the dynodes of the PMT without the power-wasting voltage-divider resistor string that is traditionally used.

## NEGATIVE VOLTAGE SUPPLY

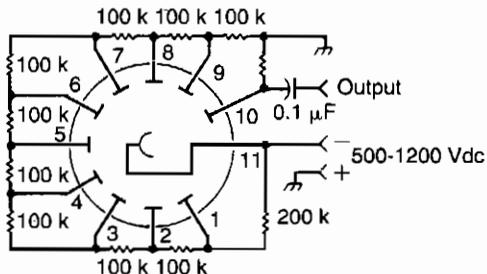


POPULAR ELECTRONICS

FIG. 77-4

The combination Hartley oscillator/step-up transformer shown in A can generate significant negative high voltage, especially if the voltage output of the transformer is multiplied by the circuit.

## PHOTOMULTIPLIER CIRCUIT

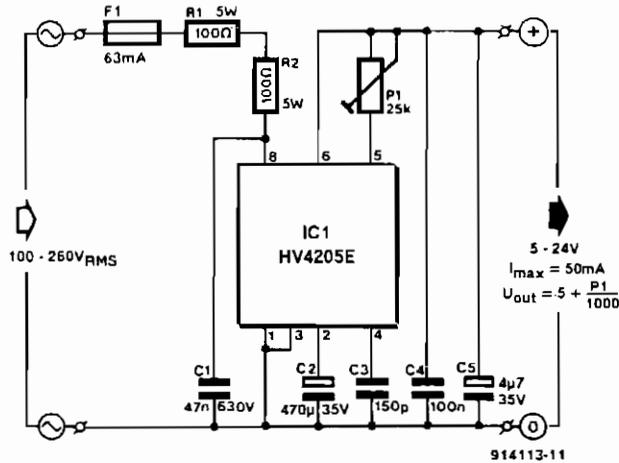


73 AMATEUR RADIO TODAY

FIG. 77-5

This circuit is typical of the way that a photomultiplier tube is used. The circuit shown is ac coupled, but if dc coupling is needed, the capacitor can be omitted and a suitable interfacing method used. A typical tube is the widely available 931/931A.

## SINGLE-CHIP dc SUPPLY FOR 120-TO 240-Vac OPERATION

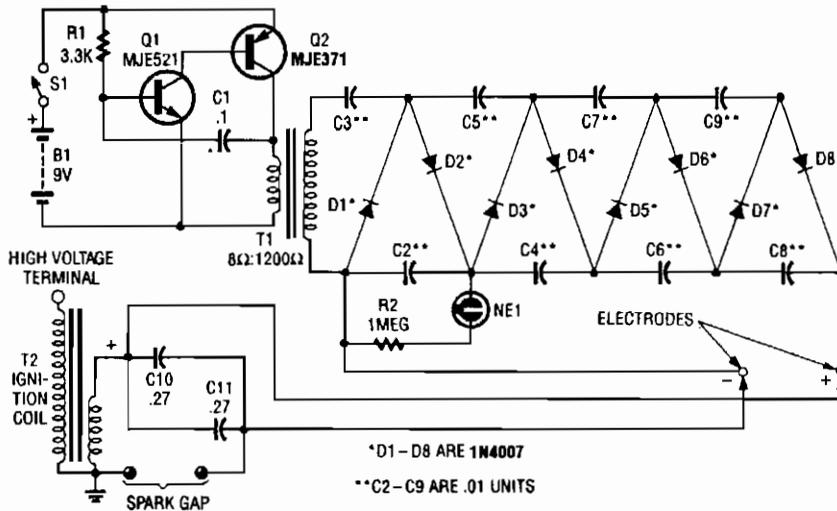


ELEKTOR ELECTRONICS

FIG. 77-6

Direct derivation of 5 to 24 Vdc from ac mains, without a transformer is possible with this circuit. Note that a direct mains connection to the dc output exists. *Suitable safety precautions must be taken.*

## HIGH-VOLTAGE SUPPLY



POPULAR ELECTRONICS

FIG. 77-7

This circuit uses a transistor oscillator and a voltage multiplier to charge C10 and C11 to a high voltage. When the spark gap breaks down, T2 produces a high-voltage pulse via the capacitance discharge of C10 and C11 into its primary. T2 is an auto ignition coil.



# 78

## Power Supply Circuits—Low Voltage

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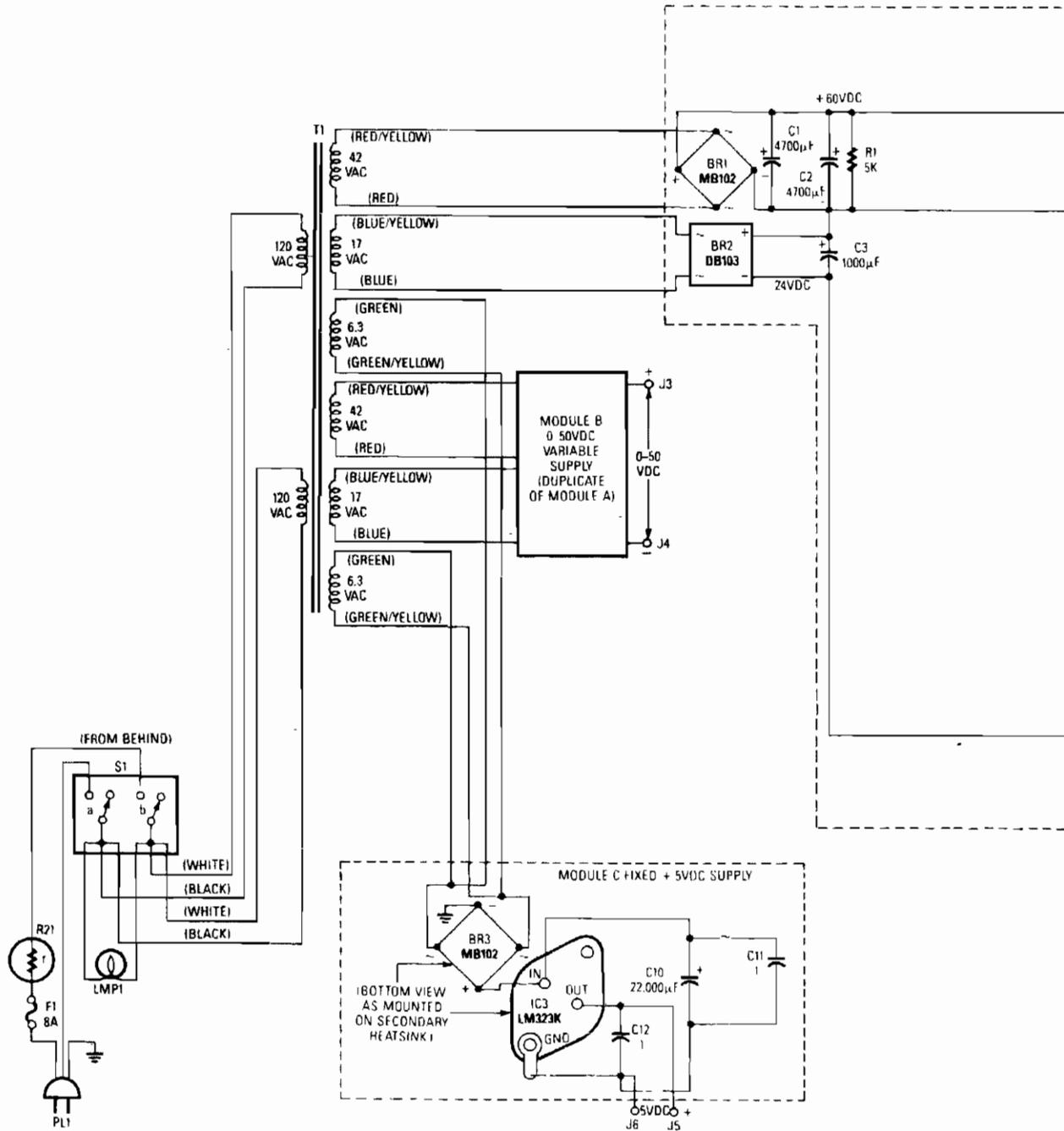
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

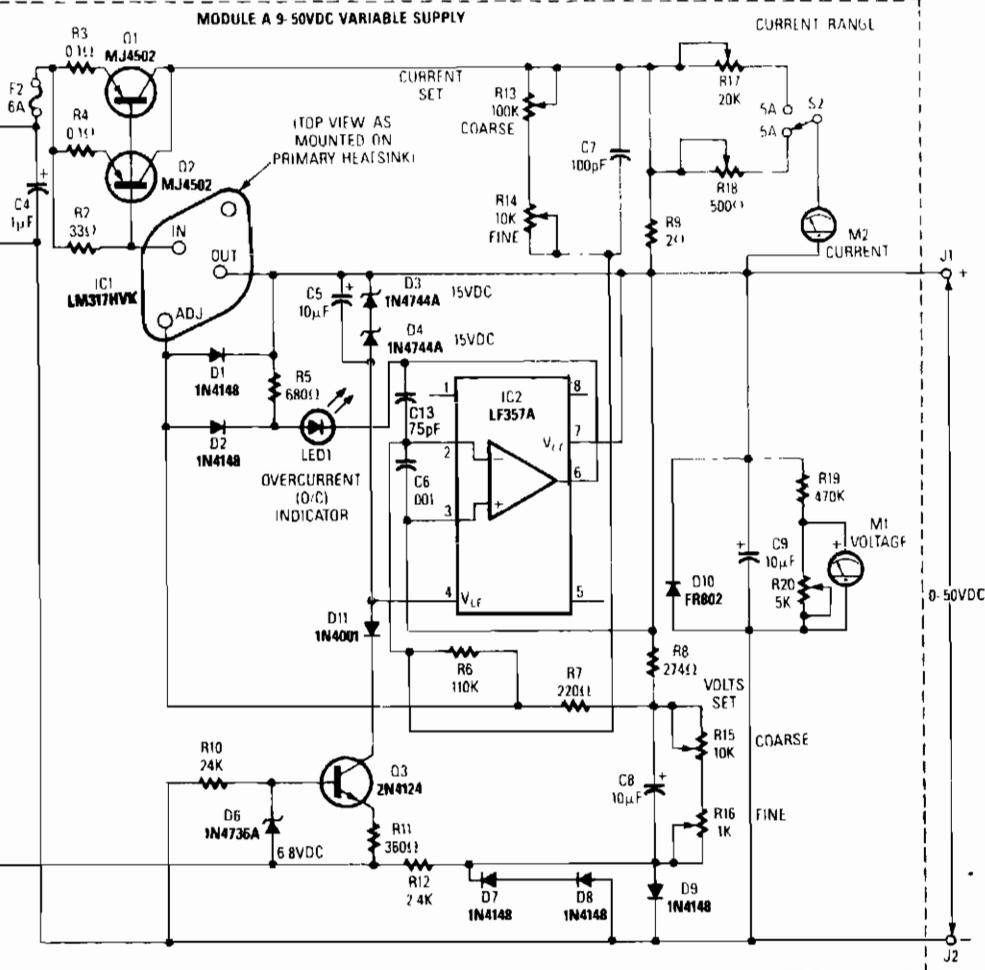
Tracking Double-Output Bipolar Supply	5-V to 3.3-V Switching Regulator
Universal Laboratory Power Supply	24-V to 3.3-V Switching Regulator
+5 V/+3.6 V from 4 AA Cells	Laptop Computer Power Supply
Inductorless Switching Regulator	Subwoofer Amplifier Power Supply
Single LTC Power Supply	Dual Voltage-Rectifier Circuit
Configurable Power Supply	Dual Audio Amplifier Power Supply
Combination Voltage and Current Regulator	Diodeless Rectifier
HV Power Supply with 9- to 15-Vdc Input	Regulator Loss Cutter
Inductorless Power Supply Converter	Synchronous Stepdown Switching
Simple Negative Supply for	Regulator with 90% Efficiency
Low-Current Applications	±5- to ±35-V Tracking Power Supply
Inverting Power Supply	8-V from 5-V Regulator
Multivoltage Power Supply	+1.5-V Supply for ZN416E Circuits
Current-Limiting Regulator	Antique Radio dc Filament Supply
Neon Lamp Driver for 5- to 15-V Supplies	Inexpensive Isolation Transformer
13.8-Vdc 2-A Regulated Power Supply	(Impromptu Setup)
0- to 12-V, 1-A Variable Power Supply	5-V UPS
Voltage Doubler Supply	+5-V Supply
Adjustable 20-V Supply	Add 12-V Output to 5-V Buck Regulator
Switching Regulator Converter	Telecom Converter -48 V to +5 V @ 1 A



# UNIVERSAL LABORATORY POWER SUPPLY



1992 R-E EXPERIMENTERS HANDBOOK



The value of the design lies in the use of IC1, an LM317HVK adjustable series-pass voltage regulator, for broad-range performance remainder supplies voltage-setting and current-limiting functions. The input to IC1 comes from the output of BR1, which is filtered by C1 and C2 to about +60 Vdc, and the input for current-sense comparator IC2 comes from BR2, which also acts as a negative bias supply for regulation down to ground. The output voltage is determined by:

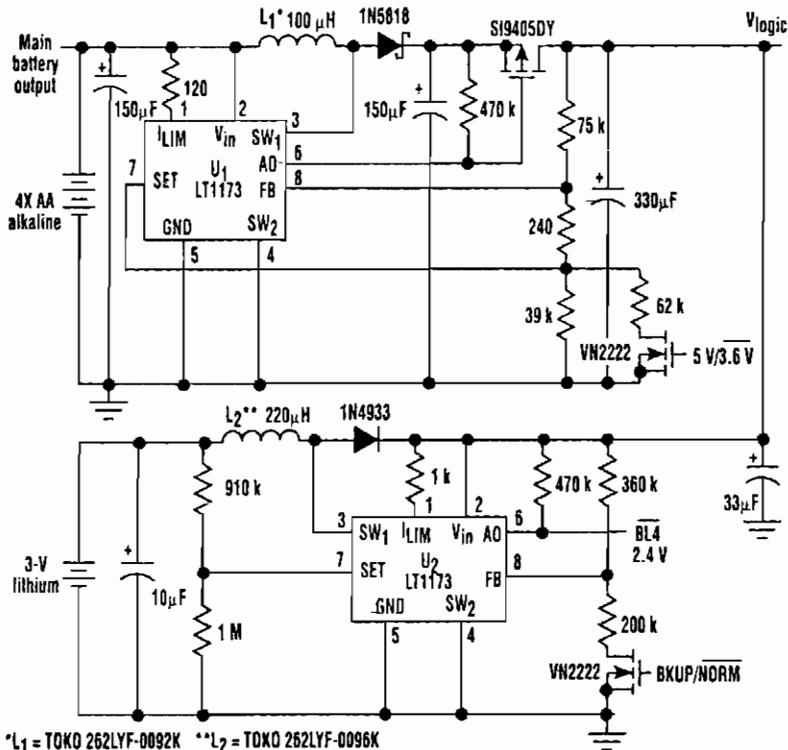
$$(V_{OUT} - 1.25 + 1.3)/(R_{15} + R_{16}) = 1.25/R_8.$$

Thus, the maximum value from each variable supply board is:

$$V_{OUT} = (1.25/R_8) \times (R_{15} + R_{16}) = 50.18 \text{ Vdc.}$$

**FIG. 78-2**

## +5 V/+3.6 V FROM 4 AA CELLS



ELECTRONIC DESIGN

FIG. 78-3

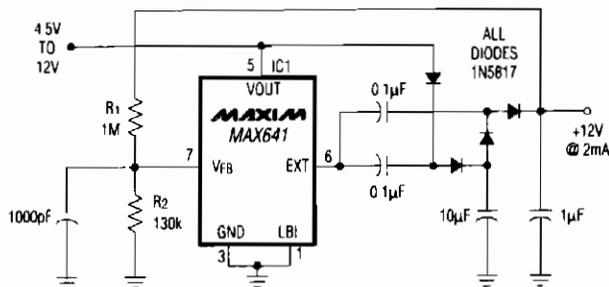
With this unique logic-power-converter design (see the figure), a switchable 3.6 or 5 V at 200 mA can be attained by using four AA cells. The supply incorporates a MOSFET switch that can switch to a lithium backup battery, providing a 3.4-V output when the main battery is dead or removed. The supply consumes only 380 μA under no-load conditions.

The circuit operates in a somewhat novel mode as a step-up/step-down converter. When the cells are fresh (from about 6 V to about 5.2 V), the LT1173's gain block drives the p-channel MOSFET, which turns the circuit into a linear voltage regulator. This might seem inefficient, but the batteries are quick to drop from 6 V to 5 V. With a 5-V input, the efficiency (for the 3.6-V output) is 3.6/5 or 72%, which is reasonable. As the battery-pack drops in voltage, efficiency increases, reaching greater than 90% with a 4.2-V input.

At a point below a 4-V input, the circuit switches to step-up mode. This mode squeezes the batteries for all of their available energy. In this case, efficiency runs between 83% at approximately a 4-V input to 73% at a 2.5-V input.

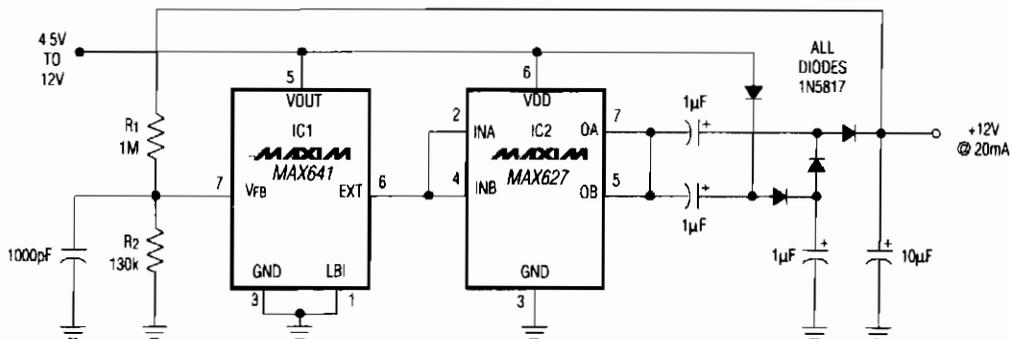
The supply can deliver 200 mA over its entire operational range. In its linear mode of operation, the supply has no current spikes that, because of the fairly high internal resistance of the alkaline cells, can reduce battery life. The topology delivers over 9.3 hours of 3.6-V 200-mA output power, compared to just 7 hours using the traditional flyback topology that is used in other designs.

## INDUCTORLESS SWITCHING REGULATOR



Substituting the diode-capacitor network shown for an inductor allows this switching-regulator IC to deliver 2mA at comparable line and load regulation, with somewhat reduced efficiency.

**A**



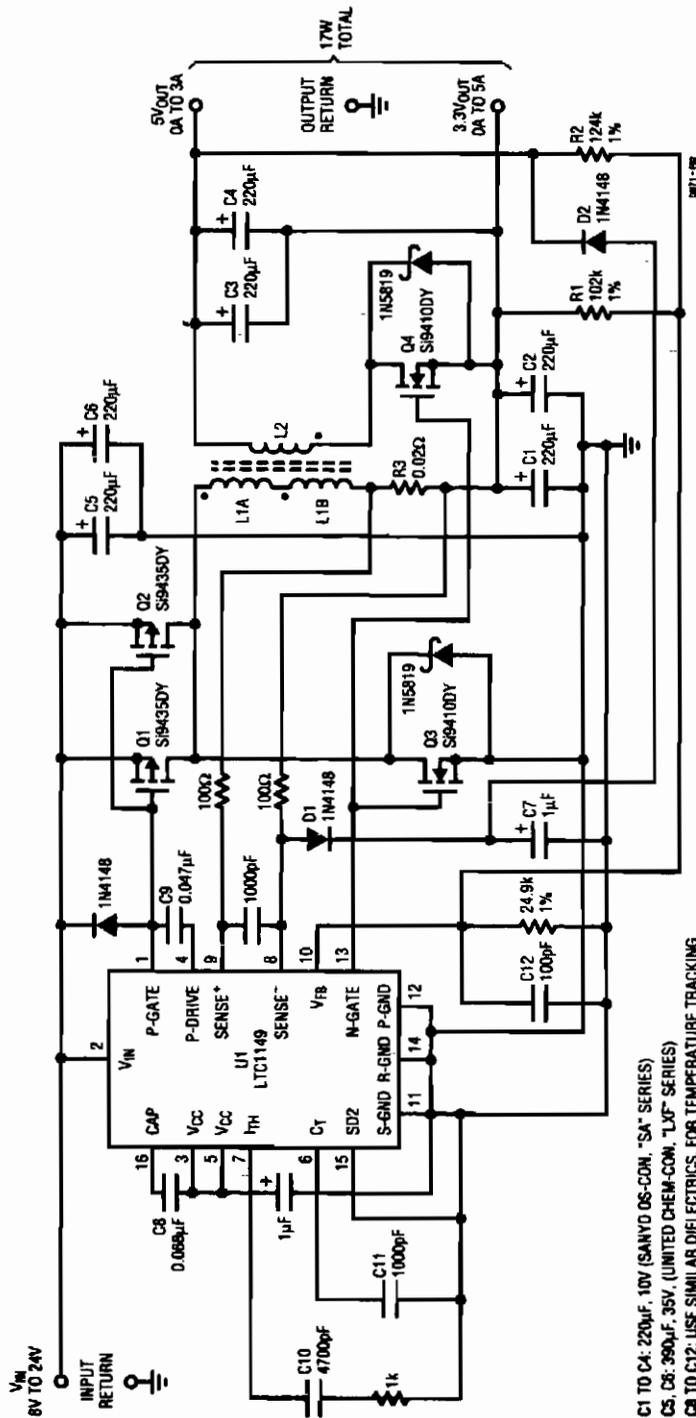
Introducing a MOS driver (IC<sub>2</sub>) enables the Figure 1 circuit to deliver as much as 20mA.

**B**

In conventional applications, switching-regulator ICs regulate  $V_{OUT}$  by controlling the current through an external inductor. The IC in A, however, driving a diode-capacitor network in place of the inductor, offers comparable performance for small loads. The network can double, triple, or quadruple the input voltage.

Feedback from the R1/R2 voltage divider enables IC1 to set the regulated-output level. (As shown, the circuit derives 12 V from a 5- to 12-V input and provides as much as 2 mA of output current.) Adding a noninverting MOS driver (B) boosts the available output current to 20 mA. Substituting the diode-capacitor network shown for an inductor allows this switching-regulator IC to deliver 2 mA at comparable line and load regulation, with somewhat reduced efficiency.

## SINGLE LTC POWER SUPPLY



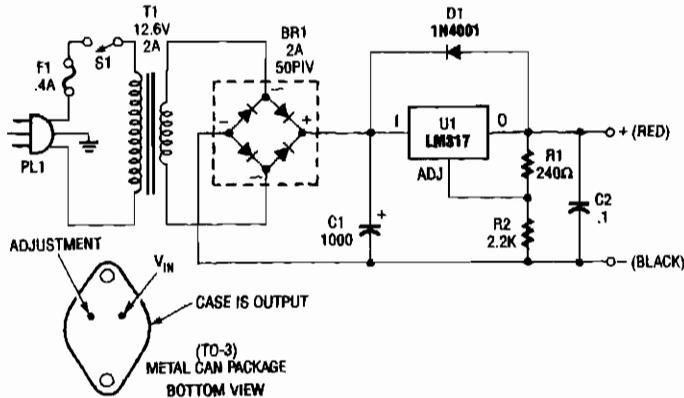
C1 TO C4: 220 $\mu$ F, 10V (SANYO OS-CON, "SA" SERIES)  
 C5, C6: 390 $\mu$ F, 35V, (LIMITED CHEM-CON, "LVF" SERIES)  
 C8 TO C12: USE SIMILAR DIELECTRICS, FOR TEMPERATURE TRACKING  
 (DO NOT USE TYPE Z5U CERAMIC CAPACITORS)  
 R3: 0.02 $\Omega$ , NONINDUCTIVE, IRC TYPE MSM-1-0.02 $\Omega$   $\pm$  5%.  
 L1A, L1B, L2: SEE TEXT  
 UNMARKED RESISTORS ARE 0.25W, 5%

## LINEAR TECHNOLOGY

FIG. 78-5

One LTC 1149 synchronous switching regulator can deliver both 3.3- and 5-V outputs. The design's simplicity, low cost, and high efficiency make it a strong contender for portable, battery-powered applications. The circuit described accepts input voltages from 8 to 24 V, to power any combination of 3.3-V and 5-V loads totalling 17 W or less. For input voltages in the 8-V to 16-V range, the LTC1148 may be used, reducing both quiescent current and cost.

## CONFIGURABLE POWER SUPPLY



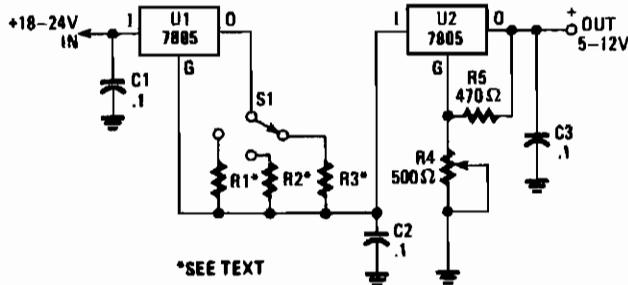
POPULAR ELECTRONICS

FIG. 78-6

The adjustable supply can easily be reconfigured by altering the value of  $V_2$  and beefing up some other components, as is necessary.

The output voltage is given by  $V_{OUT} = 1.25 (1 + R_2/R_1)$ .  $R_2$  can be changed, as is necessary.

## COMBINATION VOLTAGE AND CURRENT REGULATOR



POPULAR ELECTRONICS

FIG. 78-7

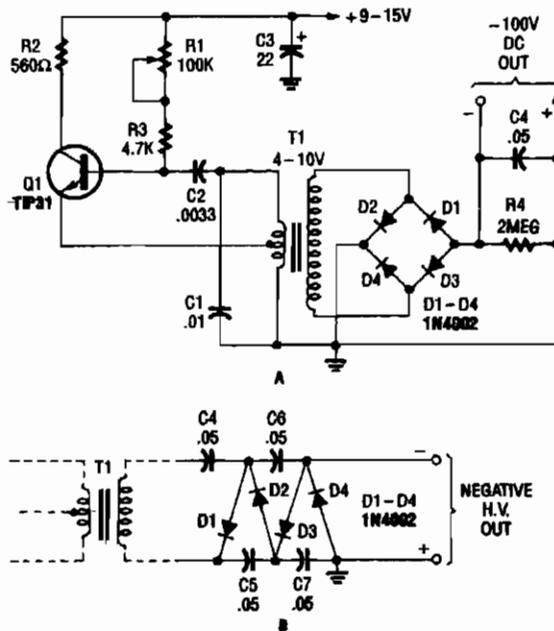
This voltage-regulator/current-limiter combination can be made from two 7805 regulators as shown.  $R_1$ ,  $R_2$ , and  $R_3$  should be selected for a 5-V drop at the maximum allowable current limit.  $S_1$  selects one of the three current values. Do not forget that  $U_1$  requires 5 mA to operate and this means that the minimum current limit setting should be 10 mA or more ( $R_1 = 1.25 \text{ k}\Omega$ ). Resistor values are as follows:

$$R_x \text{ (k}\Omega\text{)} = \frac{5 \text{ volts}}{\text{(current limit mA} - 5 \text{ mA)}}$$

For 100 mA,

$$R_x = \frac{5}{100-5} = \frac{5}{95} \text{ k}\Omega \text{ or } 52.5 \Omega$$

## HV POWER SUPPLY WITH 9-TO 15-Vdc INPUT

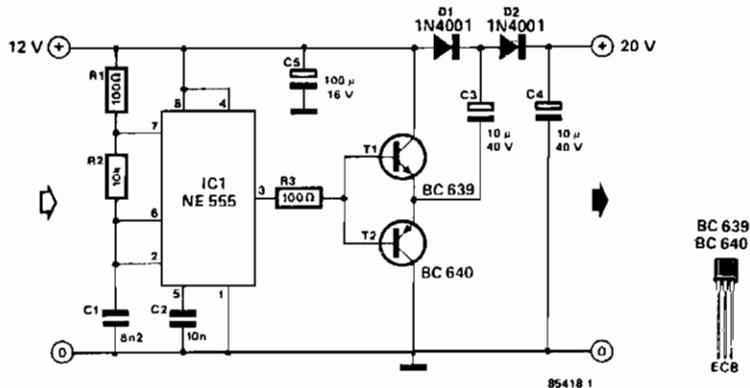


POPULAR ELECTRONICS

FIG. 78-8

The combination Hartley oscillator/step-up transformer shown in A can generate significant negative high voltage, especially if the voltage output of the transformer is multiplied by the circuit in B.

## INDUCTORLESS POWER SUPPLY CONVERTER

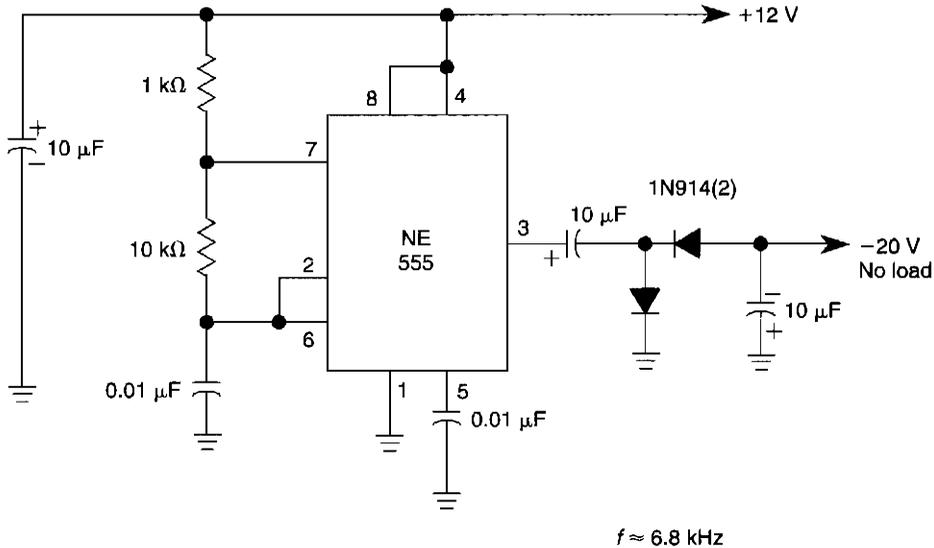


303 CIRCUITS

FIG. 78-9

Using a 555 timer and voltage doubler, this circuit will supply  $\geq 50$ mA at 20 Vdc. T1 and T2 act as power amplifiers to drive the voltage doubler. Frequency of operation is approximately 8.5 kHz.

## SIMPLE NEGATIVE SUPPLY FOR LOW-CURRENT APPLICATIONS

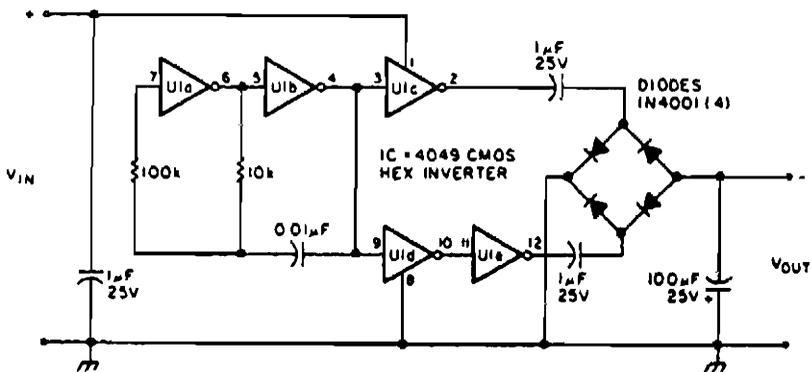


WILLIAM SHEETS

FIG. 78-10

This dc negative-voltage generator based on the 555 produces a negative output voltage equal to approximately 2x the dc supply voltage.

## INVERTING POWER SUPPLY

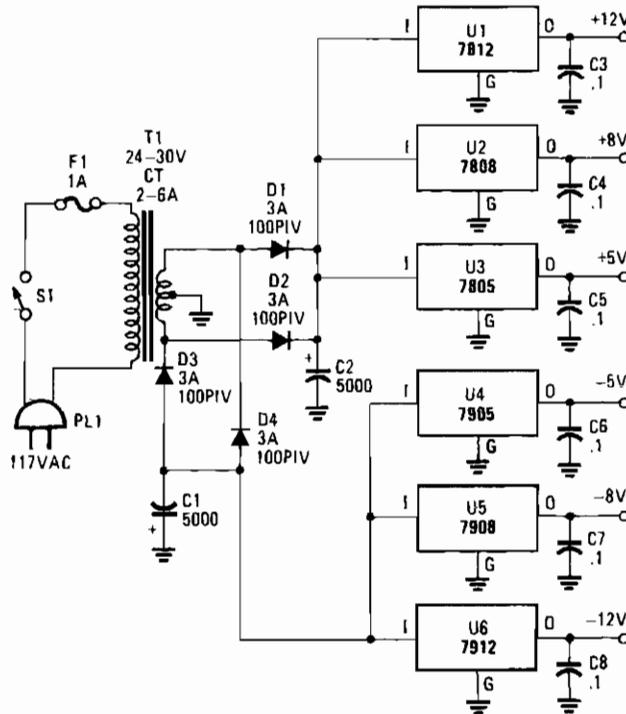


73 AMATEUR RADIO TODAY

FIG. 78-11

This circuit will provide a negative dc voltage that is approximately equal to the positive input voltage at no load and about 3 V less at 10 mA load.  $V_{IN}$  is from +5 to +15 Vdc. Do not exceed 15 V or U1 might be damaged.

## MULTIVOLTAGE POWER SUPPLY

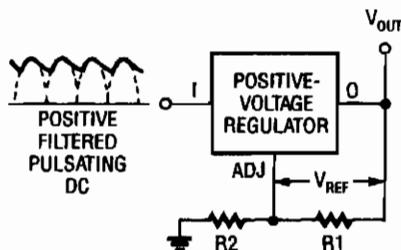


POPULAR ELECTRONICS

FIG. 78-12

This dual-polarity, multivoltage power supply can be built for a very small investment. The circuit is built around 78XX and 79XX series 1-A voltage regulators, four 3-A diodes, a 24-30-V 2-6-A transformer, and eight filter capacitors.

## CURRENT-LIMITING REGULATOR

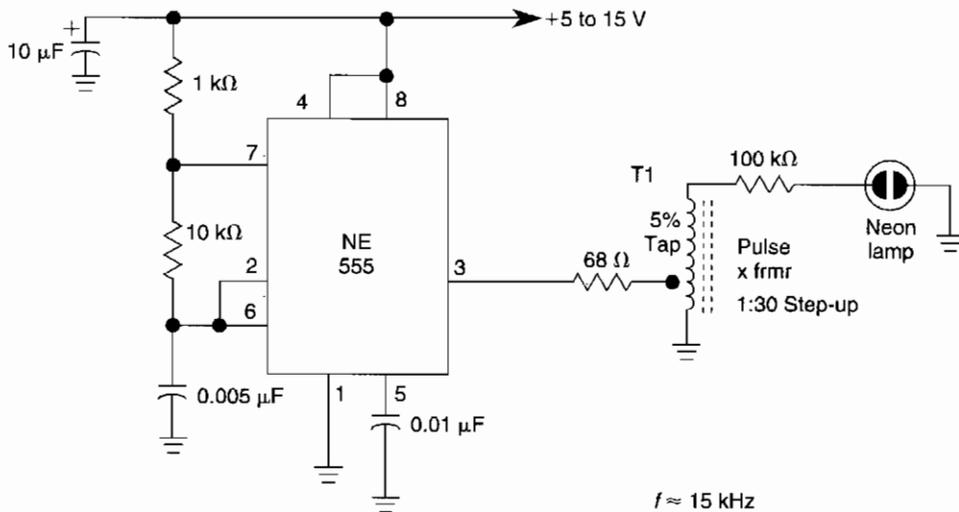


Floating adjustable regulators can be used as current limiters. Resistor R1 programs the current flowing through R2.

1993 ELECTRONICS HOBBYISTS HANDBOOK

FIG. 78-13

## NEON LAMP DRIVER FOR 5- TO 15-V SUPPLIES

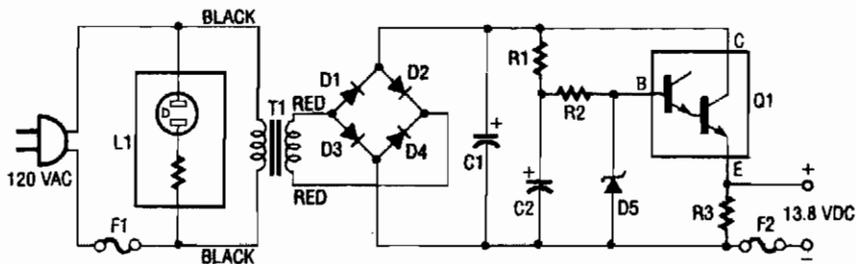


WILLIAM SHEETS

FIG. 78-14

This neon-lamp driver based on the 555 T1 can be wound on an old TV flyback transformer core.

## 13.8-Vdc 2-A REGULATED POWER SUPPLY

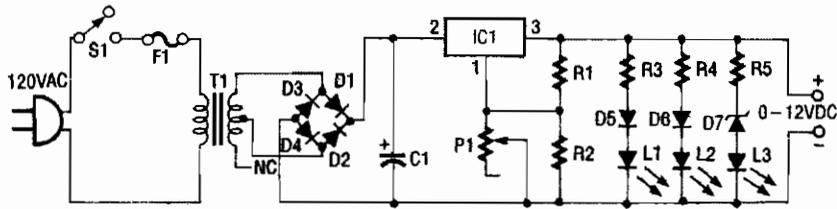


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FIG. 78-15

This regulated power supply consists of step-down transformer T1, a full-wave rectifier bridge (D1 through D4), and a filtering regulator circuit made up of C1, C2, R1, R2, R3, D5, and Q1. When 120 Vac is provided, the neon-lamp assembly L1 lights up, and transformer T1 changes 120 Vac to about 28 Vac. The rectifier bridge, D1 through D4, rectifies the ac into pulsating dc, which is then filtered by C1. Capacitor C1 acts as a storage capacitor. Zener diode D5 keeps the voltage constant across the base of Darlington regulator Q1, causing constant voltage across resistor R3 and the (+) and (-) output terminals, where the load is connected. Fuse F2 is used to open ("blow"), if the current through the output terminals is too high. Make sure to take proper precautions when using projects powered by 120 Vac.

## 0- TO 12-V, 1-A VARIABLE POWER SUPPLY



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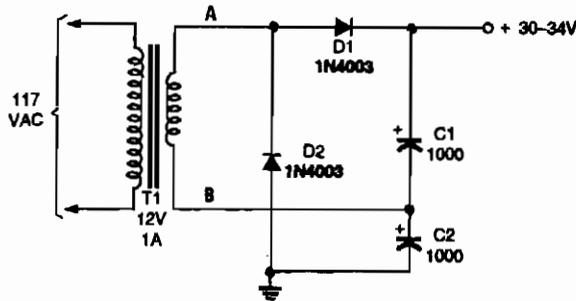
FIG. 78-16

This 0- to 12-Vdc variable power supply uses an IC voltage regulator and a heavy-duty transformer to provide a reliable dc power supply. Looking at the schematic shown, you can see that transformer T1 has a 120-V primary and a 28-V secondary.

Filtered dc is fed to the input (pin 2) of the LM317T voltage regulator, IC, which keeps the voltage at its output constant (pin 3) regardless (within limitations) of the input voltage. Pin 1 of the LM317T is the adjustment pin. Varying the voltage on pin 1 (via P1) varies the output voltage.

Diodes D5 through D7 and LEDs L1 through L3 give an approximate indication of the output voltage. Each LED/diode path has a limiting resistor to limit the current to a level that is safe for the LED.

## VOLTAGE DOUBLER SUPPLY

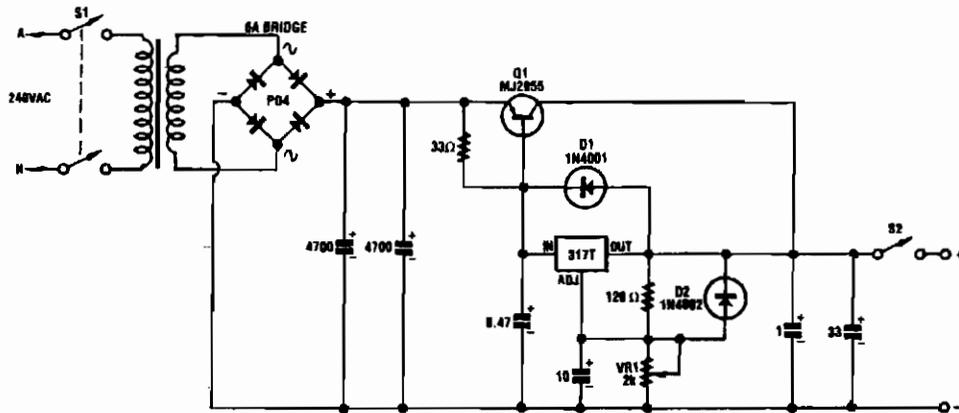


POPULAR ELECTRONICS

FIG. 78-17

The voltage doubler is built around a pair of diodes (D1 and D2) and a pair of capacitors (C1 and C2) that are fed from, in this case, a 12-V, 1-A step-down transformer (T1).

## ADJUSTABLE 20-V SUPPLY



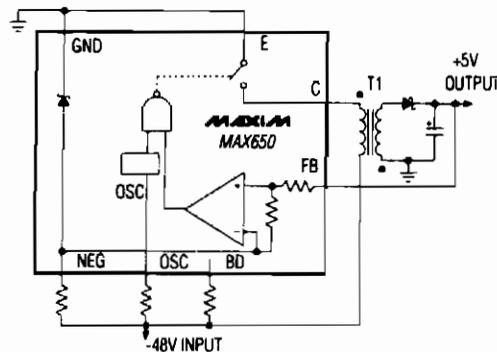
SILICON CHIP

FIG. 78-18

This circuit can deliver 3 A or more and a maximum dc voltage of a little over 20 V. It is designed around the readily available LM317T adjustable 3-terminal regulator and has a pnp power transistor to boost the current output.

The transformer has an 18-V secondary rated at 6 A; this feeds to bridge rectifier and two 4700- $\mu$ F capacitors to yield around 25 Vdc. This voltage is fed to the emitter of the MJ2955 transistor and to the input of the LM317 via a 33- $\Omega$  resistor.

## SWITCHING REGULATOR CONVERTER

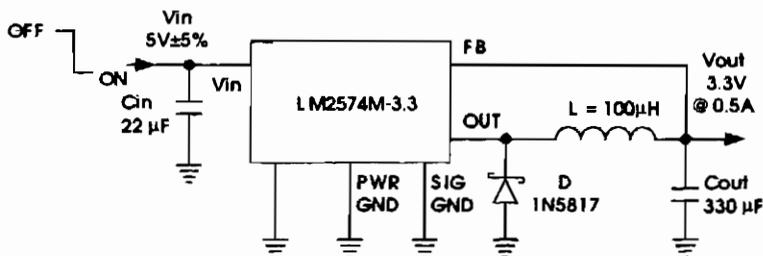


MAXIM ENGINEERING JOURNAL

FIG. 78-19

The Max650 switching regulator produces a regulated 5 V from large negative voltages, such as the -48 V found on telephone lines. The resulting power supply operates with several external components, including a transformer, and it delivers 250 mA. The device includes a 140-V 250-mA pnp transistor, short-circuit protection, and all necessary control circuitry.

### 5-V TO 3.3-V SWITCHING REGULATOR



NATIONAL SEMICONDUCTOR, LINEAR EDGE

FIG. 78-20

A National Semiconductor LM2574 is used to derive 3.3 V at 0.5 A from a 5-V logic bus. The duty cycle is:

$$\frac{V_{OUT} + V_D - V_{IND}}{V_{IN} - V_{SAT} + V_D - 2 V_{IND}}$$

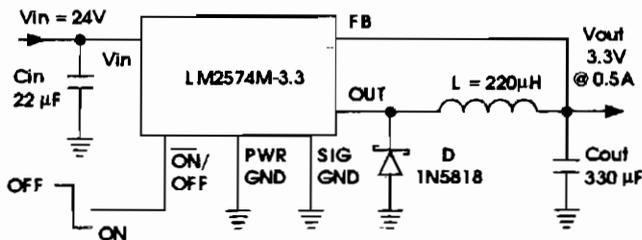
$V_D$  = diode drop (0.39)

$V_{IND}$  = inductor dc drop

$V_{SAT}$  = saturation voltage of LM2574 (0.9 V typical)

This circuit should be useful to derive 3.3 V for logic devices from existing +5-V buses.

### 24-V TO 3.3-V SWITCHING REGULATOR



NATIONAL SEMICONDUCTOR, LINEAR EDGE

FIG. 78-21

The National Semiconductor LM2574 delivers 3.3 V out at 0.5 A from a 24-V source. The duty cycle is:

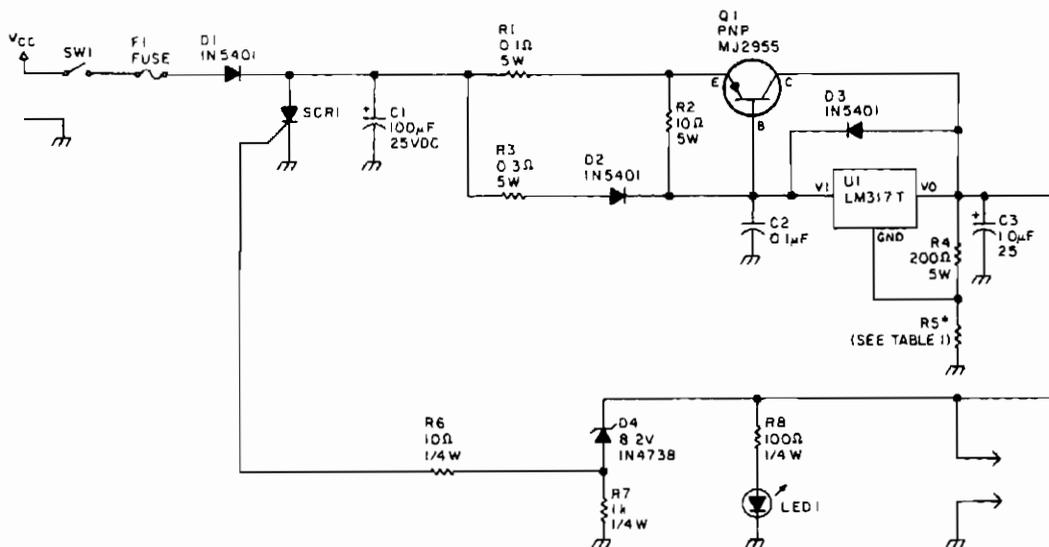
$$\frac{V_{OUT} + V_D - V_{IND}}{V_{IN} - V_{SAT} + V_D - 2 V_{IND}}$$

$V_D$  = diode drop (0.39)

$V_{IND}$  = inductor dc drop

$V_{SAT}$  = saturation voltage of LM2574 (0.9 V typical)

## LAPTOP COMPUTER POWER SUPPLY



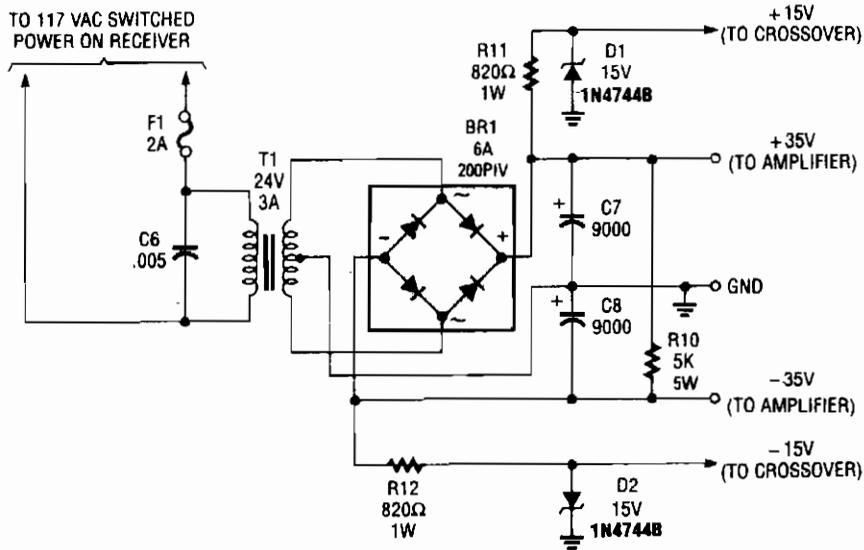
R5 Resistor Value	Voltage Out
750Ω	5V
910Ω	6V
1.2K	8V
1.5K	9V
1.8K	10V
2.0K	12V
2.7K	15V
3.3K	18V
3.6K	20V
4.3K	24V

Note: Any output voltage value greater than 10V requires a higher input voltage than 13.6V. In addition capacitor working voltage ratings will have to be increased accordingly. Allow a minimum of 2.5 times the voltage expected to appear across the capacitor as a standard for the working voltage.

Table 1. Resistor value/voltage matchup.

A laptop computer supply that has 9-V output, crowbar overvoltage protection, and operates from a 12-V supply is shown above. The supply voltage should be at least 3.6 V above the expected output voltage. Q1 should be heatsinked appropriately. R5 should have a value of 1.5 kΩ for 9-V output. Table 1 gives values for other voltages.

## SUBWOOFER AMPLIFIER POWER SUPPLY

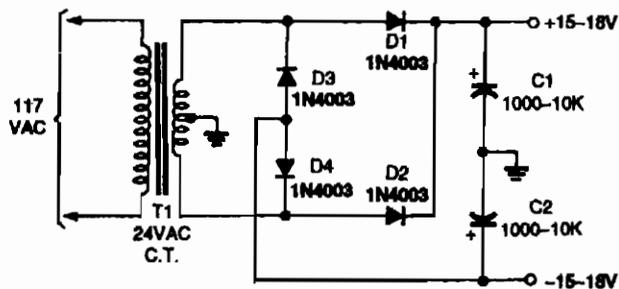


POPULAR ELECTRONICS

FIG. 78-23

Although intended to power a 100-W low-frequency amplifier, this power supply should handle many mono or stereo amplifiers in the medium power range that require  $\pm 30$  to 35 V.

## DUAL VOLTAGE-RECTIFIER CIRCUIT

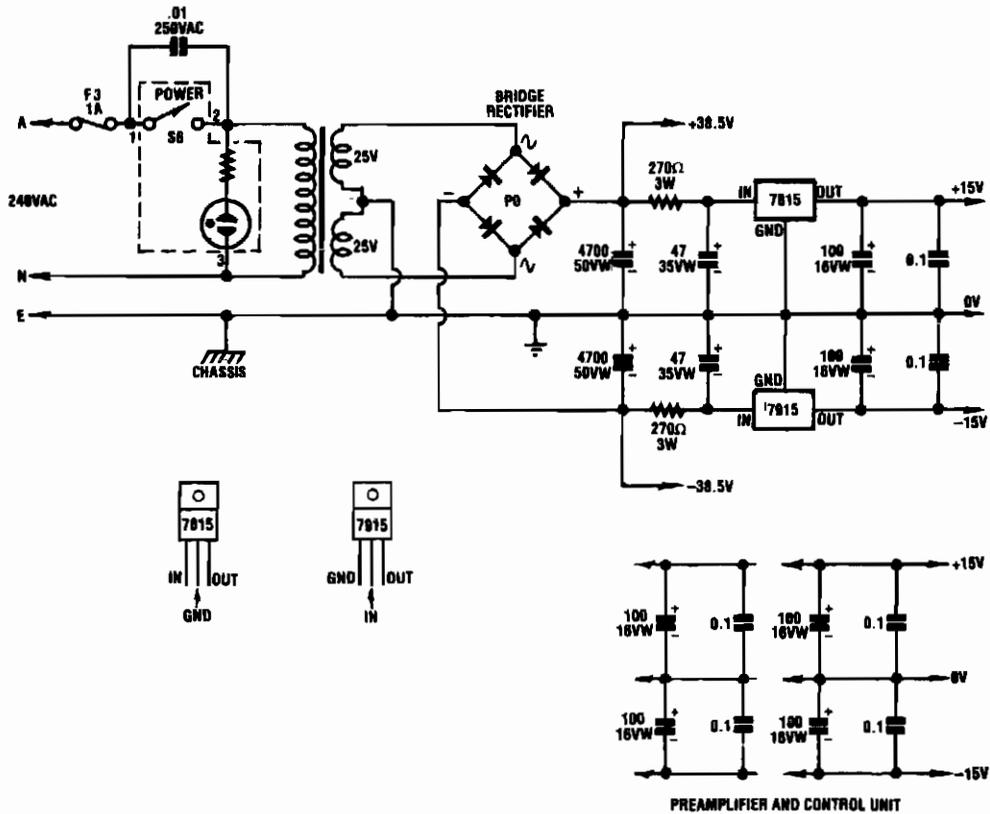


POPULAR ELECTRONICS

FIG. 78-24

This stepped-up dual voltage supply provides  $\pm 15$  to  $\pm 18$  V unregulated.

## DUAL AUDIO AMPLIFIER POWER SUPPLY

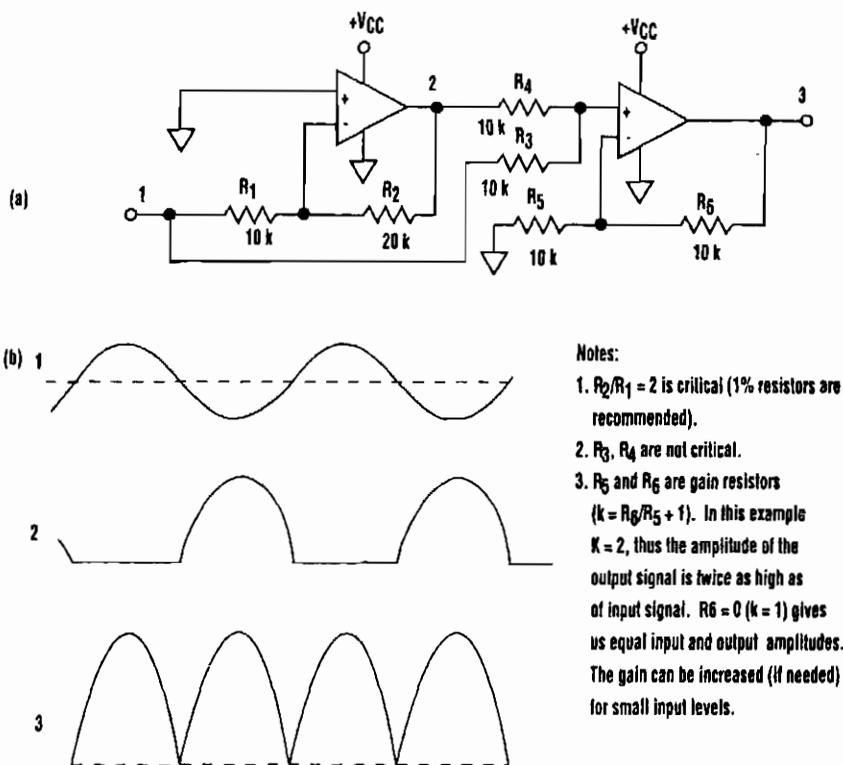


SILICON CHIP

FIG. 78-25

A dual audio amplifier that will deliver 50 W per channel is shown in the schematic. It includes preamp and tone controls, and also includes a headphone amplifier. The circuit depicts the power supply that supplies  $\pm 38.5$  V and  $\pm 15$  V regulated for the dual 50 watt.

## DIODELESS RECTIFIER



ELECTRONIC DESIGN

FIG. 78-26

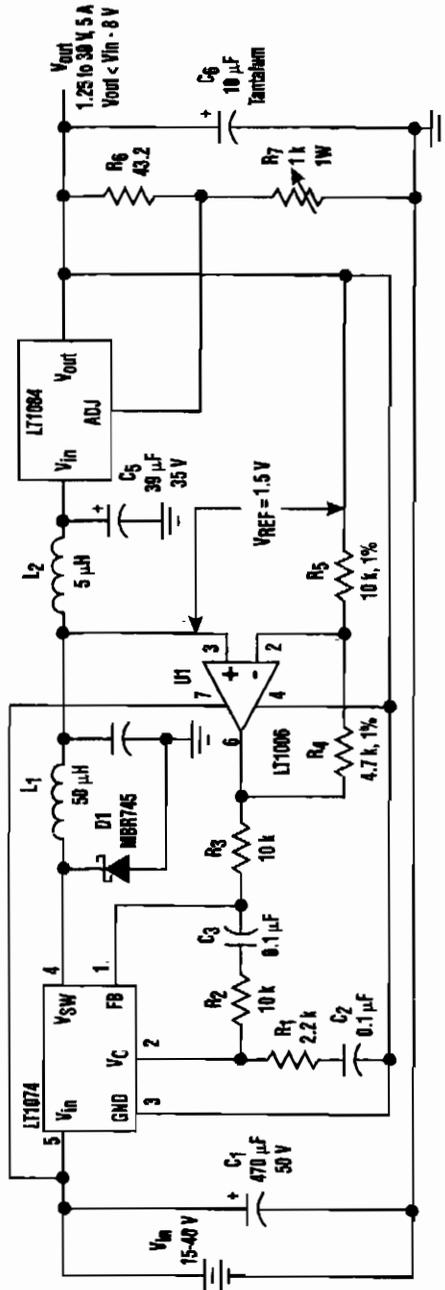
It's common knowledge that when working with single-supply op amps, implementing simple functions in a bipolar signal environment can be difficult. Sometimes additional op amps and other electronic components are required.

Taking that into consideration, can any advantage be attained from this mode? The answer lies in this simple circuit (A). Requiring no diodes, the circuit is a high-precision full-wave rectifier with a high-frequency limitation equalling that of the op amps themselves. Look at the circuit's timing diagram (B) to see the principle of operation.

The first amplifier rectifies negative input levels with an inverting gain of 2 and turns positive levels to zero. The second amp, a noninverting summing amplifier, adds the inverted negative signal from the first amplifier to the original input signal. The net result is the traditional waveform produced by full-wave rectification.

In spite of the limitation on the input signal amplitude (it must be less than  $V_{CC}/2$ ), this circuit can be useful in a variety of setups.

## REGULATOR LOSS CUTTER



$I_{out} < 1.5$  A: LT1076, LT1086  
 $I_{out} < 5$  A: LT1074, LT1084

$L_1$  = Coiltronics CTX50-5-52  
 $L_2$  = Coiltronics CTX5-S-FR

$C_1$  = Nichicon UPL1H471MRH  
 $C_2$  = Nichicon UPL1H331MRH  
 $C_3$  = Nichicon UPL1V350MEH

## ELECTRONIC DESIGN

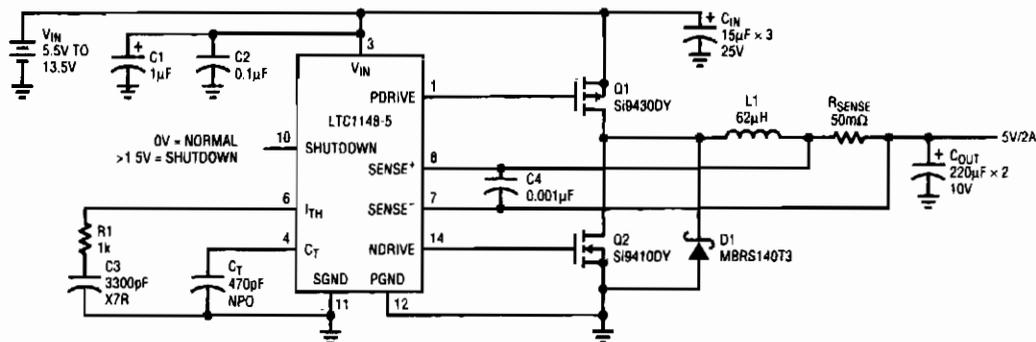
FIG. 78-27

Large input-to-output voltage differentials, caused by wide input voltage variations, reduce a linear regulator's efficiency and increase its power dissipation. A switching preregulator can reduce this power dissipation by minimizing the voltage drop across an adjustable linear regulator to a constant 1.5-V value.

The circuit operates the LT1084 at slightly above its dropout voltage. To minimize power dissipation, a low-dropout linear regulator was chosen. The LT1084 functions as a conventional adjustable linear regulator with an output voltage that can be varied from 1.25 to 30 V.

Without the preregulator (for a 40-V input and a 5-V output at 5 A), it would be virtually impossible to find a heatsink large enough to dissipate enough energy to keep the linear-regulator junction temperature below its maximum value. With the preregulator technique, however, the linear regulator will dissipate only 7.5 W under worst-case loading conditions for the entire input-voltage range of 15 to 40 V. Even under a short-circuit fault condition, the 1.5-V drop across the LT1084 is maintained.

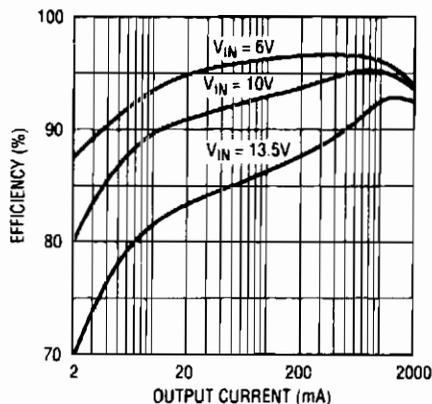
## SYNCHRONOUS STEPDOWN SWITCHING REGULATOR WITH 90% EFFICIENCY



C1 (TA)  
 $C_{IN}$  AVX (TA) TAJD156K025RLR, ESR = 0.3Ω,  $I_{RMS} = 0.707A$   
 $C_{OUT}$  AVX (TA) TAJE227K010RLR, ESR = 0.08Ω,  $I_{RMS} = 1.4A$   
 Q1 SILICONIX PMOS, BVDS = 20V,  $R_{DS(on)} = 0.1Ω$ ,  $C_{RSS} = 400pF$ ,  $Q_G = 50nC$   
 Q2 SILICONIX NMOS, BVDS = 30V,  $R_{DS(on)} = 0.05Ω$ ,  $C_{RSS} = 160pF$ ,  $Q_G = 30nC$

Q1 MOTOROLA SCHOTTKY, VBR = 40V  
 $R_{SENSE}$  IRC LR2512-01-R050J  $P_D = 1W$   
 L1 COILTRONICS CTX62-2-MP, DCR = 0.035Ω, MPP CORE (THROUGH HOLE)  
 L1-1 COILTRONICS CTX02-11715-2, DCR = 0.11Ω, FERRITE CORE (SURFACE MOUNT)  
 ALL OTHER CAPACITORS ARE CERAMIC

**A** LTC1148 (5.5V-13.5V to 5V/2A) surface mount



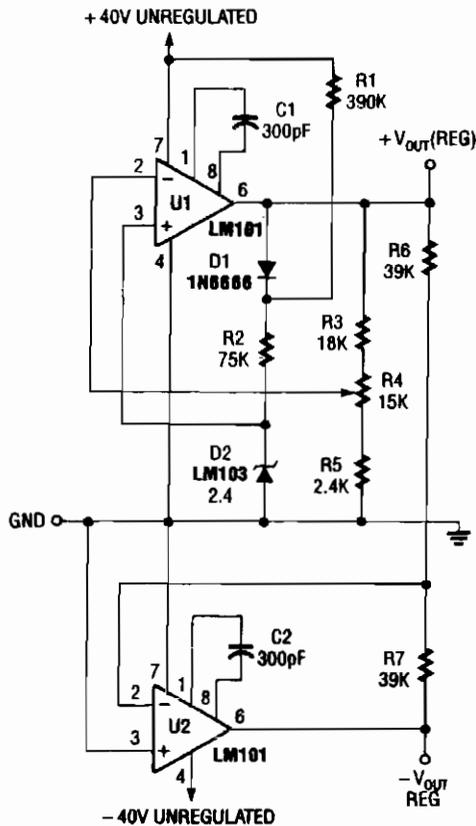
**B** LTC 1148-5: 5.5V to 13.5V efficiency

LINEAR TECHNOLOGY

FIG. 78-28

A shows a typical LTC1148 surface-mount application providing 5 V at 2 A from an input voltage of 5.5 V to 13.5 V. The operating efficiency, shown in B, peaks at 97% and exceeds 90% from 10 mA to 2 A with a 10-V input. Q1 and Q2 comprise the main switch and synchronous switch, respectively, and inductor current is measured via the voltage drop across the current shunt.  $R_{SENSE}$  is the key component used to set the output current capability according to the formula  $I_{OUT} = 100 \text{ mV}/R_{SENSE}$ . The advantages of current control include excellent line and load transient rejection, inherent short-circuit protection and controlled startup currents. Peak inductor current is limited to  $150 \text{ mV}/R_{SENSE}$  or 3 A for the circuit in A.

## ±5- TO ±35-V TRACKING POWER SUPPLY



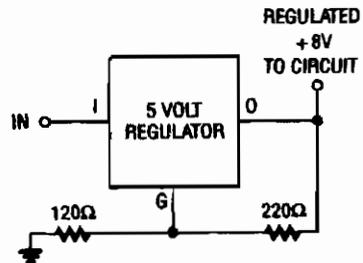
OUTPUT VOLTAGE IS VARIABLE FROM  $\pm 5\text{V}$  TO  $\pm 35\text{V}$ .  
 NEGATIVE OUTPUT TRACKS POSITIVE OUTPUT TO  
 WITHIN THE RATIO OF  $R_6$  TO  $R_7$ .

POPULAR ELECTRONICS

FIG. 78-29

This supply is designed to operate from a  $\pm 40\text{-V}$  nominal unregulated power source (bridge rectifier, etc.).

## 8-V FROM 5-V REGULATOR

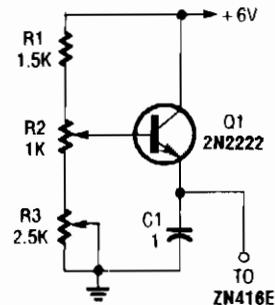


POPULAR ELECTRONICS

FIG. 78-30

If you have trouble locating an 8-V regulator, although they are commonly available, a 5-V unit can replace it by connecting the regulator, as is shown here.

## +1.5-V SUPPLY FOR ZN416E CIRCUITS

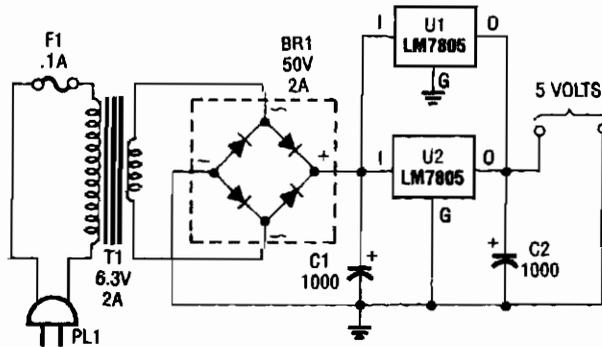


POPULAR ELECTRONICS

FIG. 78-31

This regulator can be used with a +6-V source to supply ZN416E low-voltage TRF radio-receiver IC the necessary +1.5 V.  $R_3$  sets output voltage.

## ANTIQUE RADIO dc FILAMENT SUPPLY

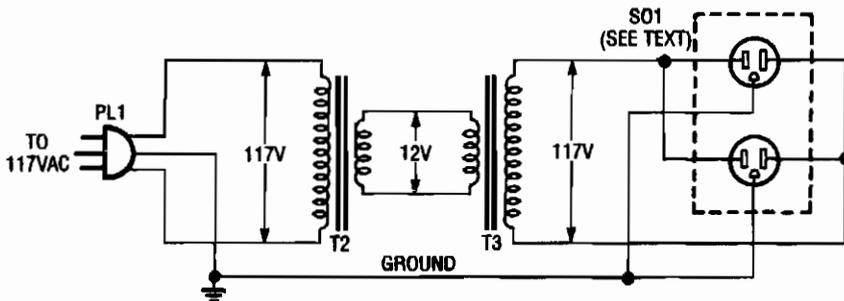


POPULAR ELECTRONICS

FIG. 78-32

This dc supply is great for operating battery-powered antique radios, because it is designed to prevent harming the tube filaments. The circuit is useful for powering filaments of 00-A, 01-A, 112A, and 71A tubes, which require 5V at 250 mA.

## INEXPENSIVE ISOLATION TRANSFORMER (IMPROMPTU SETUP)

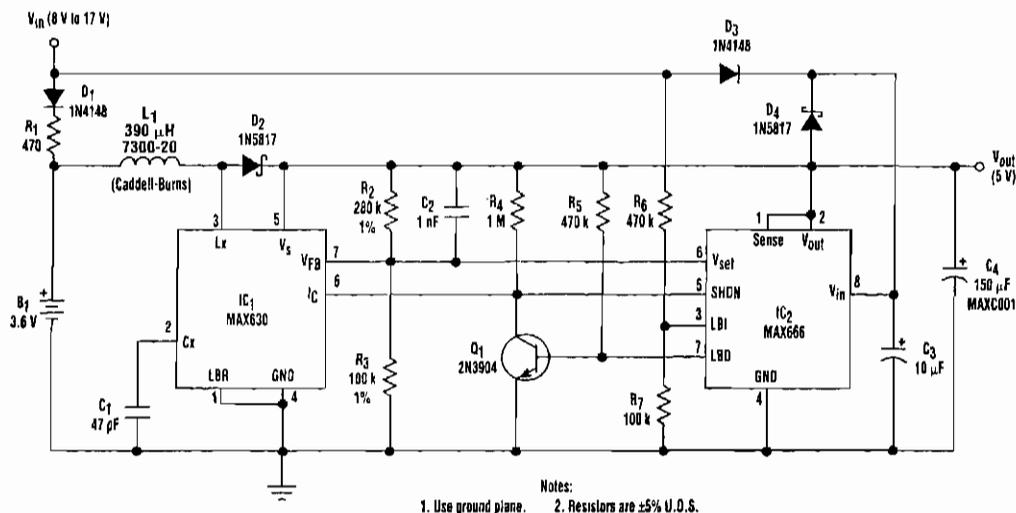


1993 ELECTRONICS HOBBYISTS HANDBOOK

FIG. 78-33

Using two 12-V filament or power transformers, an impromptu isolation transformer can be made for low-power (under 50 W) use in testing or servicing. S01 is an ordinary, duplex ac receptacle. Use heavy-wire connections between the 12-V windings because several amperes can flow.

## 5-V UPS



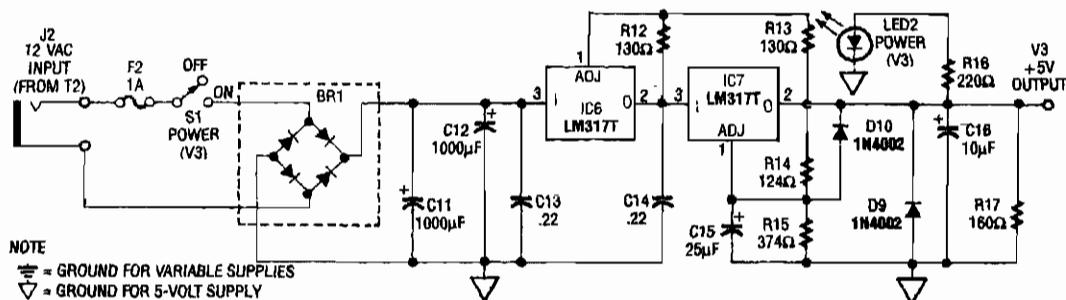
**FIG. 78-34**

### ELECTRONIC DESIGN

A 9-V wall adapter supplies  $V_{IN}$ . IC2 contains a low-battery detector circuit that senses  $V_{IN}$  by means of R6 and R7. The detector output (pin 7) drives an inverter (Q1), which in turn drives the shut-down inputs  $I_C$  of IC1 and SHDN of IC2. These inputs have opposite-polarity active levels. The common feedback resistors, R2 and R3 enable both regulators to sense the output voltage,  $V_{OUT}$ .

When IC2 shuts down, its output turns off. However, when IC1 shuts down, the whole chip assumes a low-power state and draws under 1  $\mu A$ . L1, D2, C1, C2, R2, and R3 are part of the 250-mW switching regulator. Diodes D3 and D4 wire-OR the power connection to IC2, and C3 improves the linear regulator's load regulation.

## +5-V SUPPLY

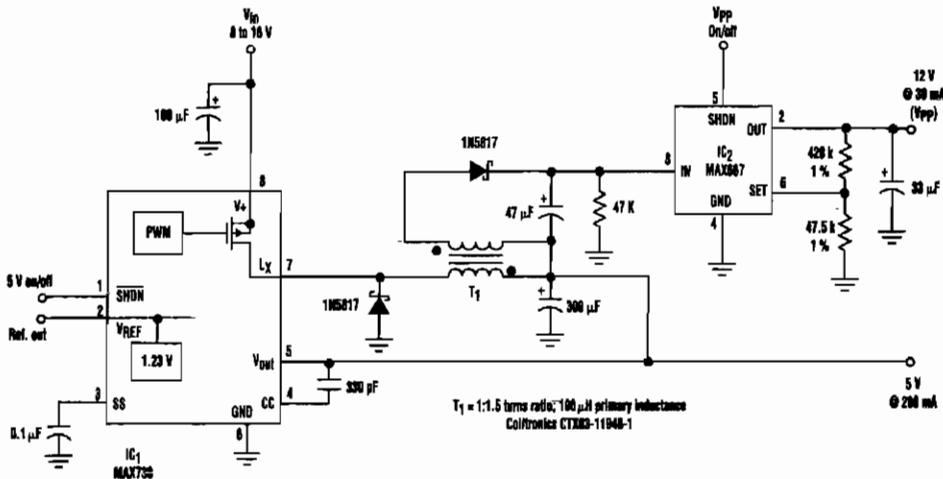


**FIG. 78-35**

### ELECTRONICS NOW

The power supply shown is designed to operate from a wall transformer. This circuit can be used in conjunction with a variable supply to test circuits in the lab, etc. T2 is a 12-V wall transformer.

## ADD 12-V OUTPUT TO 5-V BUCK REGULATOR

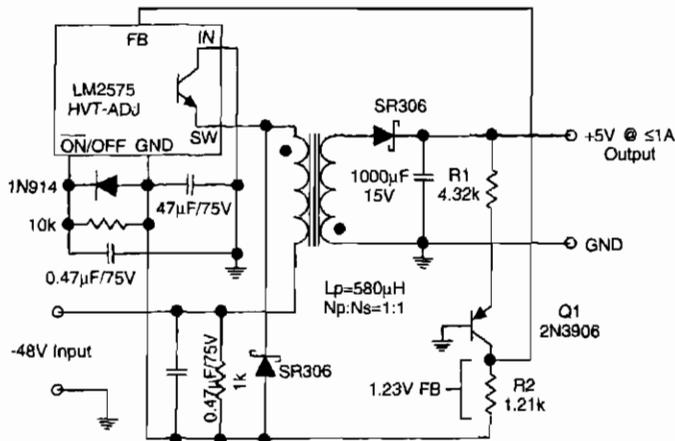


ELECTRONIC DESIGN

FIG. 78-36

By adding a flyback winding to a buck-regulator switching converter (see the figure), which is essentially a 5-V supply with a 200-mA output capability, a 12-V output ( $V_{pp}$ ) can be produced. The flyback winding on the main inductor (forming transformer T1) enables an additional low-dropout linear regulator (IC2) to create the 12-V output voltage that's needed to program EEPROMs. The required input voltage is 8 to 16 V.

## TELECOM CONVERTER -48 V TO +5 V @ 1 A



NATIONAL SEMICONDUCTOR, LINEAR EDGE

FIG. 78-37

The circuit supplies 1 A at +5 V from the -48-V supply commonly used in telephone equipment. The National Semiconductor LM2575 is a simple switching regulator.

# 79

## Probe Circuits

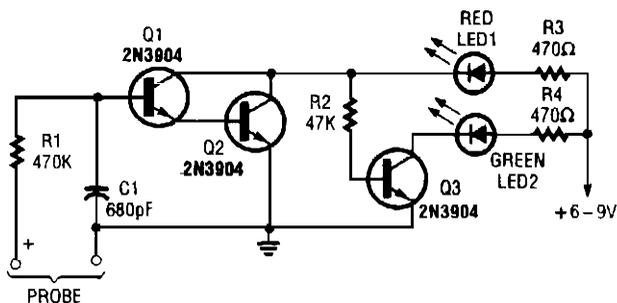
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple Voltage Probe  
ac Voltage Probe

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## SIMPLE VOLTAGE PROBE



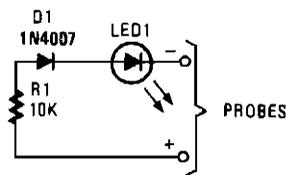
POPULAR ELECTRONICS

FIG. 79-1

This simple voltage probe can be helpful in checking and troubleshooting solid-state circuitry.

---

## ac VOLTAGE PROBE



POPULAR ELECTRONICS

FIG. 79-2

This simple probe can save your life by warning you of live circuitry. It's ideal for times when more than one person is working on a device.

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# 80

## Protection Circuits

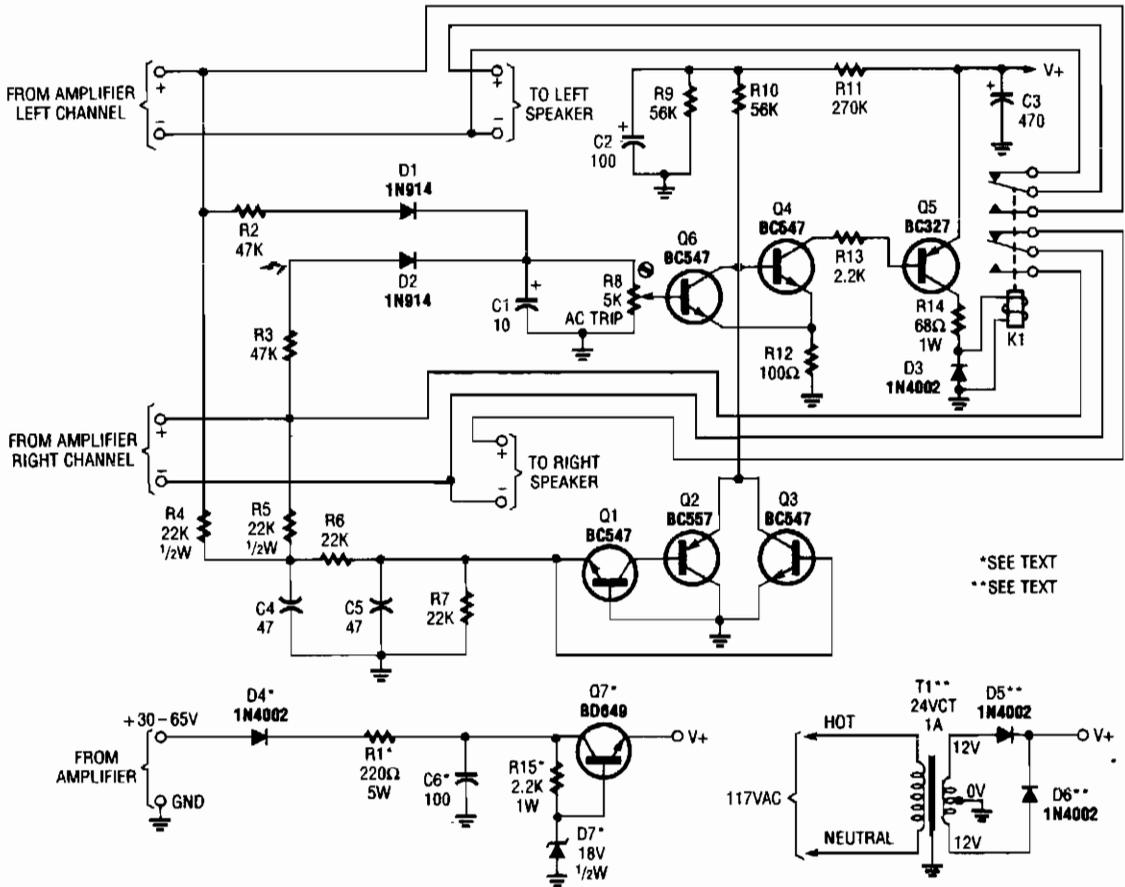
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Speaker Protector	Overvoltage Protection Circuit
Electronic Fuse	Timed Safety Circuit
Safety Circuit	Modem/Fax Protector for Two Computers
Overload Indicator	Ear Protector
Relay Fuse for Power Supplies	Loudspeaker Protector
Speaker Protector	Simple Safety Circuit
Modem Protector	

## SPEAKER PROTECTOR

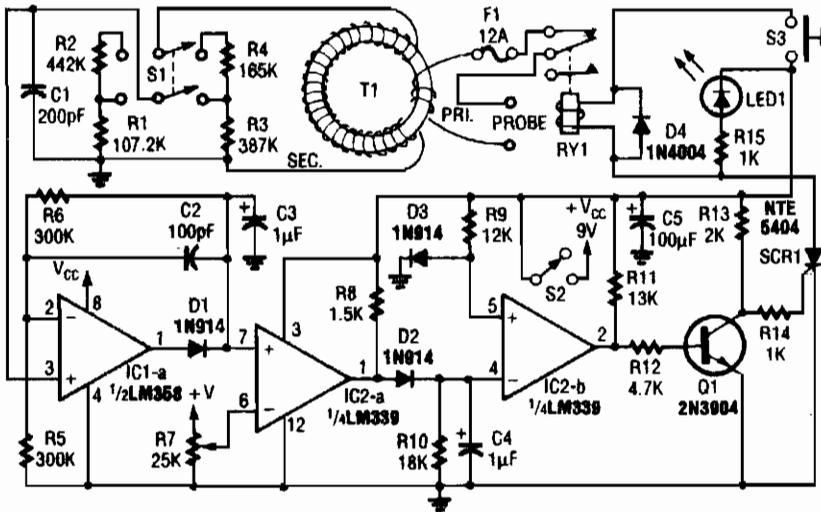


POPULAR ELECTRONICS

FIG. 80-1

Most of the transistors in this speaker protector function as switches. Normally, Q4, Q5, and K1 are on and the speakers are connected to the amplifier. However, if a large dc voltage appears at an amplifier output, either Q3, or Q1 and Q2 turn on, biasing Q4 off. That action turns Q5 off, de-energizes the relay, and disconnects the speakers from the amplifier. Components D1, D2, and Q6 form the overdrive-protection circuit.

## ELECTRONIC FUSE

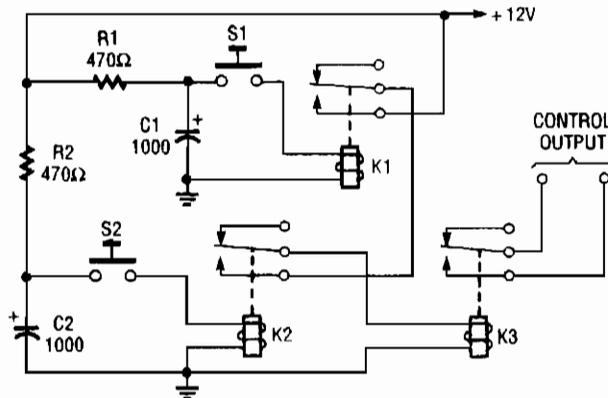


RADIO-ELECTRONICS

FIG. 80-2

Basically, this circuit is an adjustable electronic circuit breaker, containing a toroidal transformer that senses 60-Hz load current. T1 has a two-turn winding for primary, and 100 turns of #30 gauge wire for the secondary. A high-low range switch selects 0.1 to 6 A or 1 to 12 A. The primary winding of T1 carries full load current and voltage; should be suitably insulated, as should be RY1.

## SAFETY CIRCUIT

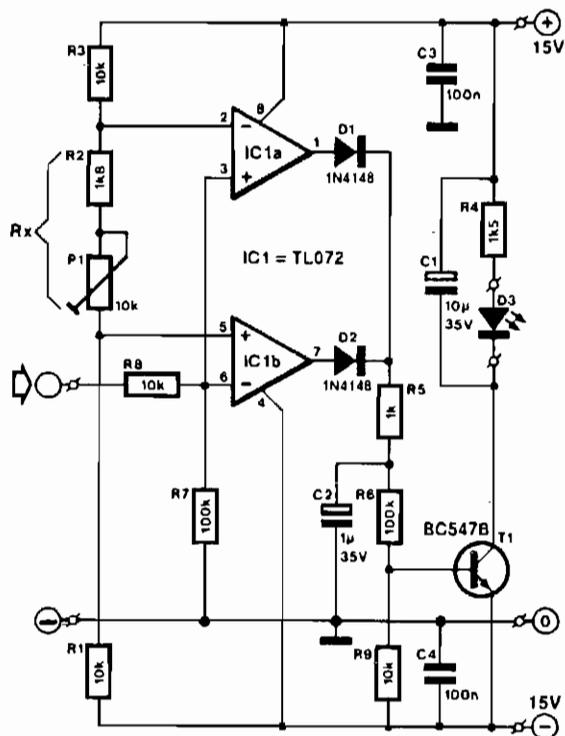


POPULAR ELECTRONICS

FIG. 80-3

Because of the finite hold-on time of delay circuits R1/C1 and R2/C2, both S1 and S2 must be pressed at the same time to power up the load.

## OVERLOAD INDICATOR

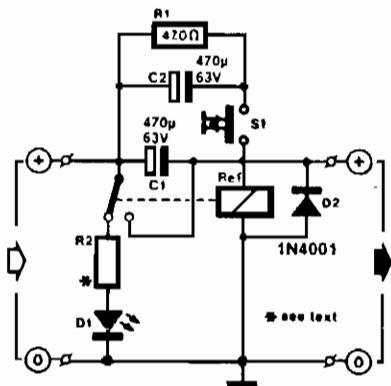


Two op amps are used as comparators to indicate excessive magnitude of an AF signal, either positive or negative, even if the signal is asymmetrical. P1 sets the reference voltage for both op amps. This circuit is useful for audio-amplifier and op-amp circuits using split power supplies.

ELEKTOR ELECTRONICS

FIG. 80-4

## RELAY FUSE FOR POWER SUPPLIES

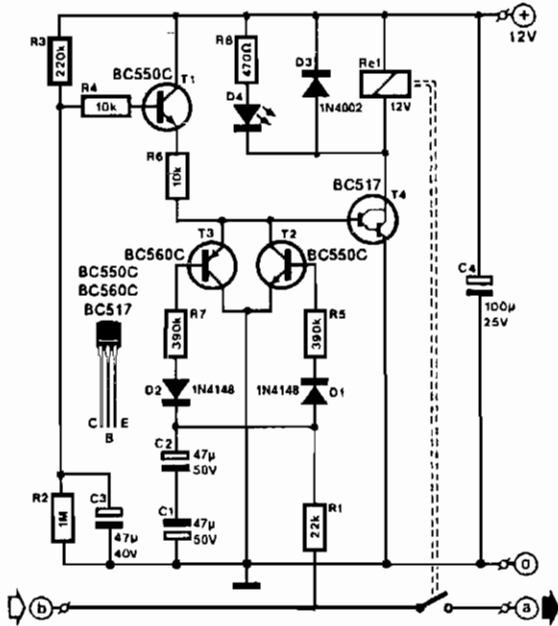


A method of adding overload protection to a power supply using a relay is shown. In each circuit, the relay must be reset by a momentary switch using a charge on capacitor C2. This prevents overload if the short still exists.

ELEKTOR ELECTRONICS

FIG. 80-5

## SPEAKER PROTECTOR

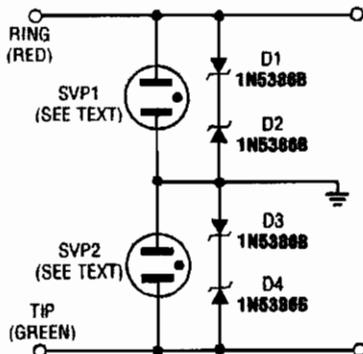


ELEKTOR ELECTRONICS

FIG. 80-6

A speaker system can be protected against amplifier failure when dc voltages (on speaker line a-b) are sensed by the circuit. Either positive or negative dc voltages are sensed. A relay opens in this case, removing the dc from the speakers. About 12 V at 50 mA is needed to power the circuit, depending on the relay.

## MODEM PROTECTOR

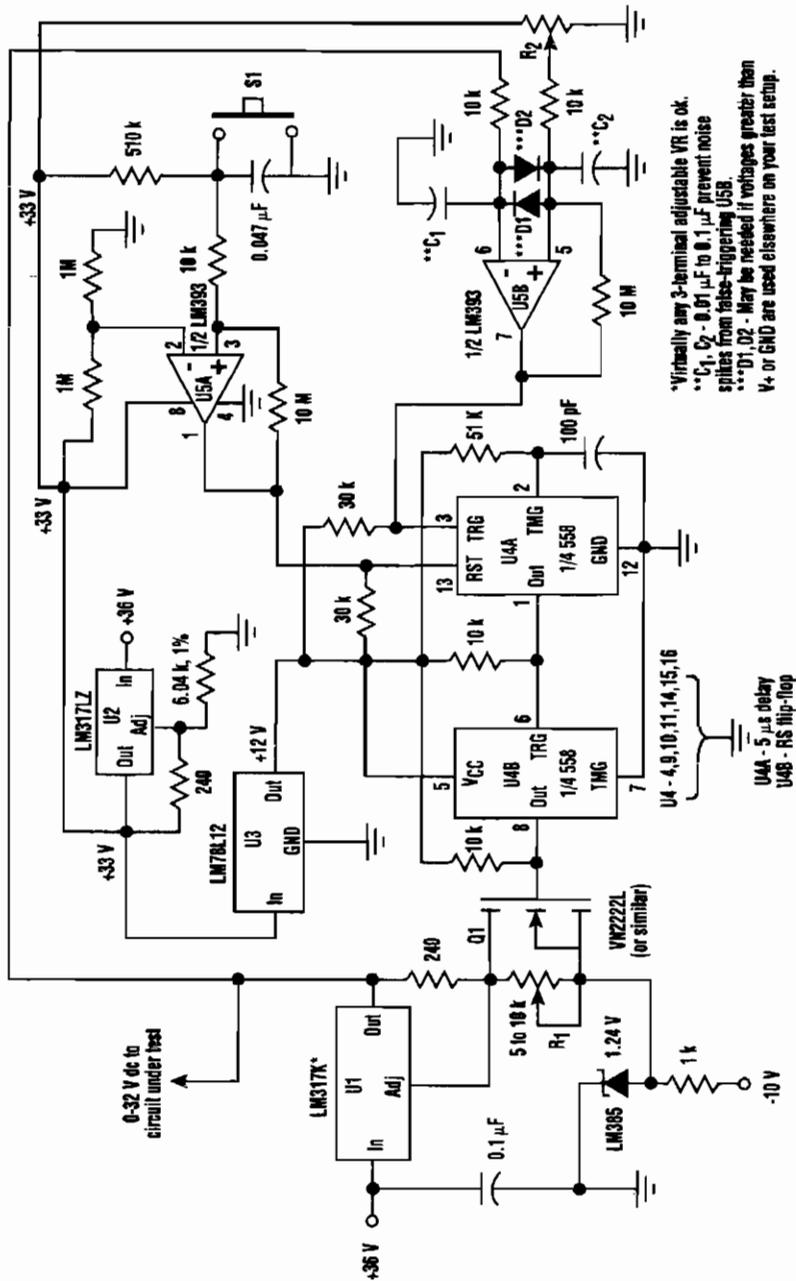


ELECTRONICS NOW

FIG. 80-7

This protector uses surge voltage protectors rated at 230-V breakdown. An effective ground should be used.

## OVERVOLTAGE PROTECTION CIRCUIT

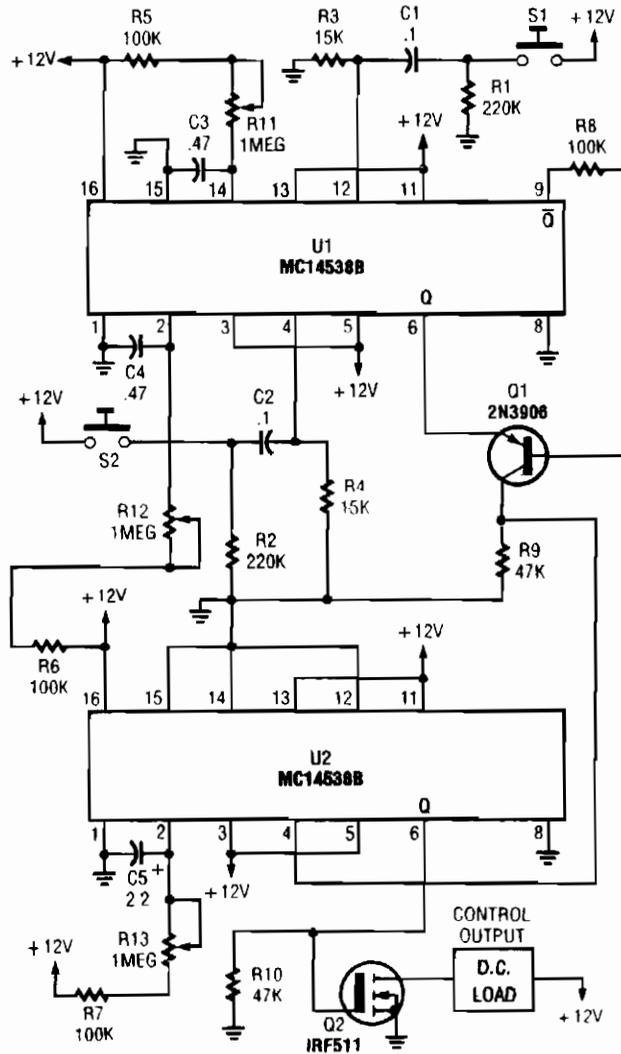


ELECTRONIC DESIGN

FIG. 80-8

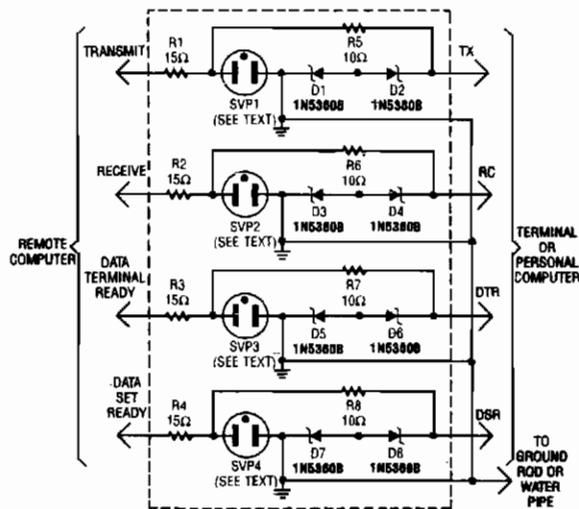
When testing a circuit, a source of voltage that is variable and has overvoltage shutdown is very useful. In this circuit, R1 is adjusted to 1 to 2 V below the eventual shutdown threshold. R2 sets the trip voltage. When this voltage is reached, the circuit shuts the voltage to the circuit under test down. To reset, reduce R1 below trip threshold and depress reset switch S1.

## TIMED SAFETY CIRCUIT



When S1 is closed, pin 9 of U1 goes low, turning on Q1 for a preset period. If S2 is closed during this period, Q2 is turned on for a preset period. R11 and R13 set the two time periods.

## MODEM/FAX PROTECTOR FOR TWO COMPUTERS



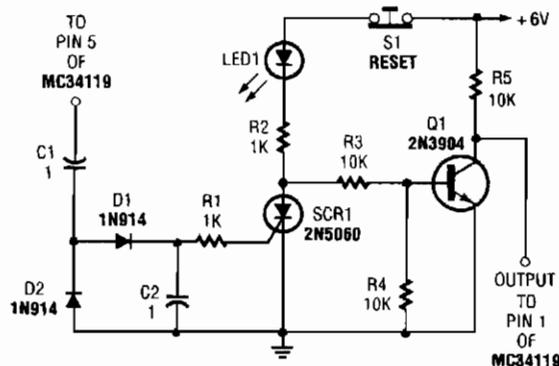
VARIAION OF THE MODEM/FAX PROTECTOR for use in telephone line connections between PC or terminal and larger distant computer.

ELECTRONICS NOW

FIG. 80-10

This modem/fax protector can be used in telephone-line connections between a PC or a terminal and a distant computer. In this circuit, the SVPs (surge voltage protectors) are rated at 230 V. A good ground is a must for effective operation.

## EAR PROTECTOR

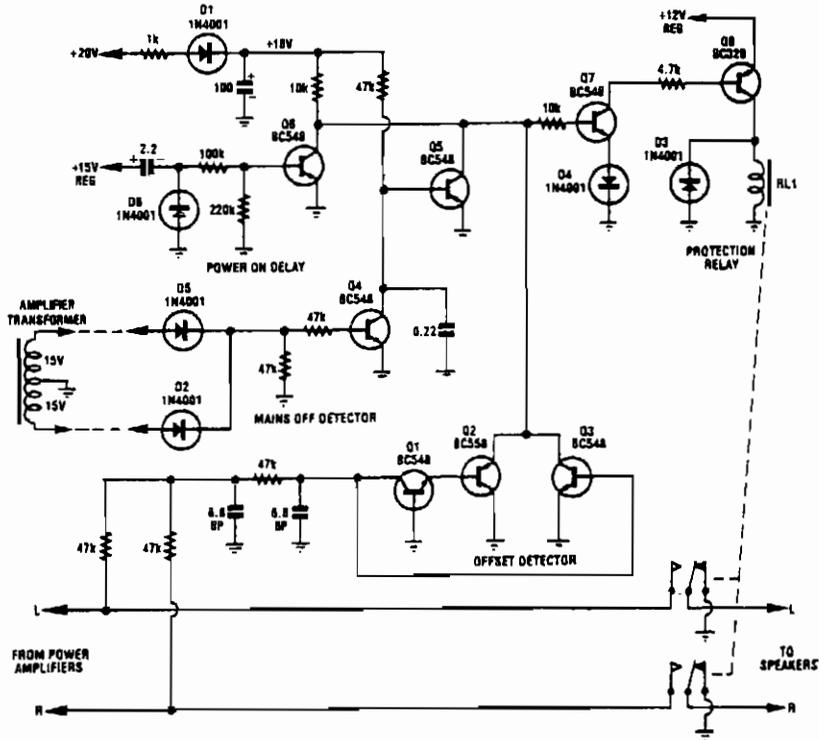


POPULAR ELECTRONICS

FIG. 80-11

The ear protector is actually a peak audio-detector/shutdown circuit that disables the amplifier through its chip-disable input when the output volume of an amplifier reaches the set level. The circuit, although intended for the MC34119 amplifier, should work with similar IC devices or applications.

## LOUDSPEAKER PROTECTOR

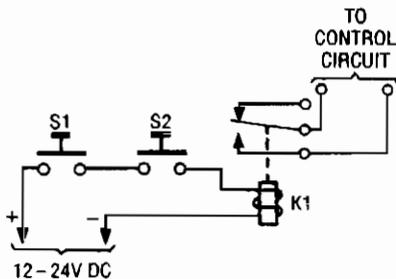


SILICON CHIP

FIG. 80-12

Transistors Q1, Q2, and Q3 monitor the two outputs of the stereo amplifier. If the offsets exceed  $\pm 2$  V, Q7 is turned off, which turns off Q8 and the normally on relay. Diodes D2 and D5, together with Q4, provide a mains voltage monitor. As soon as the ac input voltage disappears, as when the amplifier is turned off, Q4 turns off and Q5 turns on. This turns off Q7, Q8, and the relay. Hence, the loudspeakers are disconnected immediately after the amplifier is turned off.

## SIMPLE SAFETY CIRCUIT



The simple two-hand safety-control switch shown here is little more than two pushbutton switches connected in series; both must be depressed in order to energize the relay.

POPULAR ELECTRONICS

FIG. 80-13

# 81

## Proximity Circuits

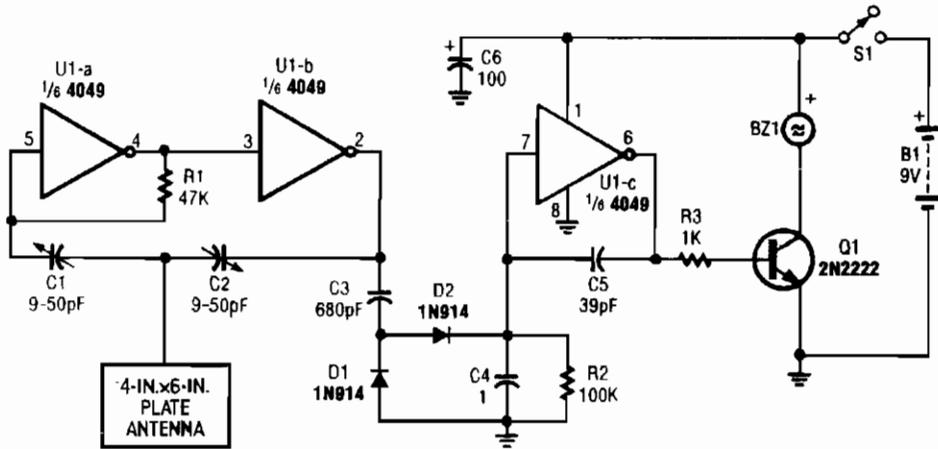
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Proximity Alarm I  
Proximity Alarm II



## PROXIMITY ALARM II



POPULAR ELECTRONICS

FIG. 81-2

A CMOS logic gate is used to make up this circuit. When an object is near the antenna, the change in oscillator output is detected by D1 and D2 and amplified by U1C, which drives Q1, sounding alarm BZ1.

# 82

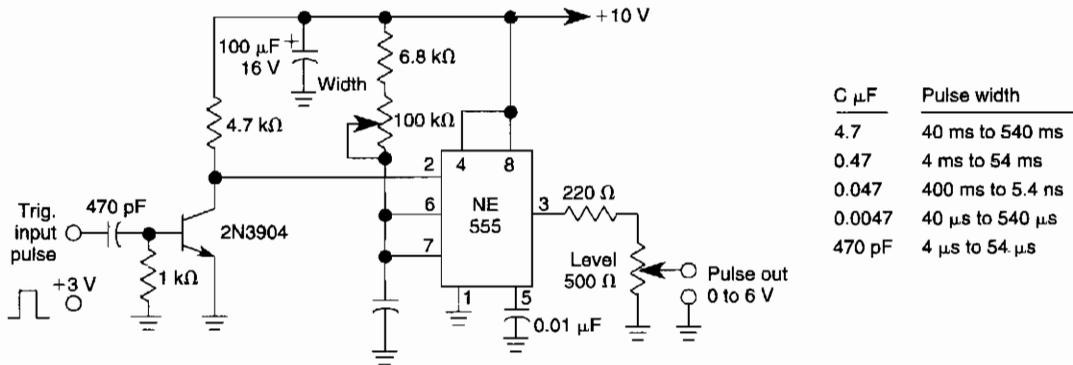
## Pulse-Generator Circuits

---

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

- Add-On Pulse Generator
- Pulse Generator
- Logic Pulser
- Precise One-Shot
- Digitally Controlled Sawtooth Pulse Generator
- Delayed Pulse Generator
- Pulse Generator with Variable Duty Cycle

## ADD-ON PULSE GENERATOR



WILLIAM SHEETS

**FIG. 82-1**

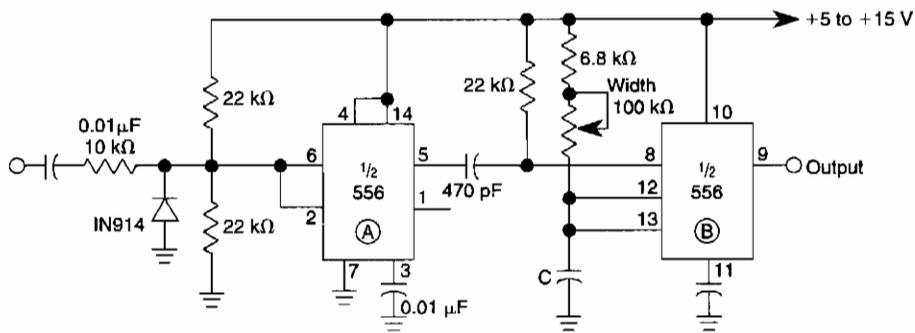
This pulse generator can supplement a standalone pulse generator. Using a transistor and a 555 timer, pulse widths of  $<5 \mu\text{s}$  to  $500 \mu\text{s}$  can be produced. The value of  $C_3$  is approximately found from the formula:

$$C_3 \mu\text{F} \approx 1.1 \times 10^{-5} T \quad \text{where } T \text{ is the shortest pulse width } (\mu\text{s}) \text{ desired in a 10:1 range}$$

( $T$  should be greater than  $5 \mu\text{s}$ )

The capacitor values and consequent pulse width range are shown.

## PULSE GENERATOR



$$\text{Pulsewidth } T \approx 1.1 RC$$

$$\text{In this circuit } T \approx 7.4 \times 10^{-3} C_{\mu\text{F}} \text{ to } 0.117 \times C_{\mu\text{F}} \text{ seconds}$$

$$\text{with } C = 0.1 \mu\text{F} \quad T = 740 \mu\text{s to } 11.7 \text{ ms}$$

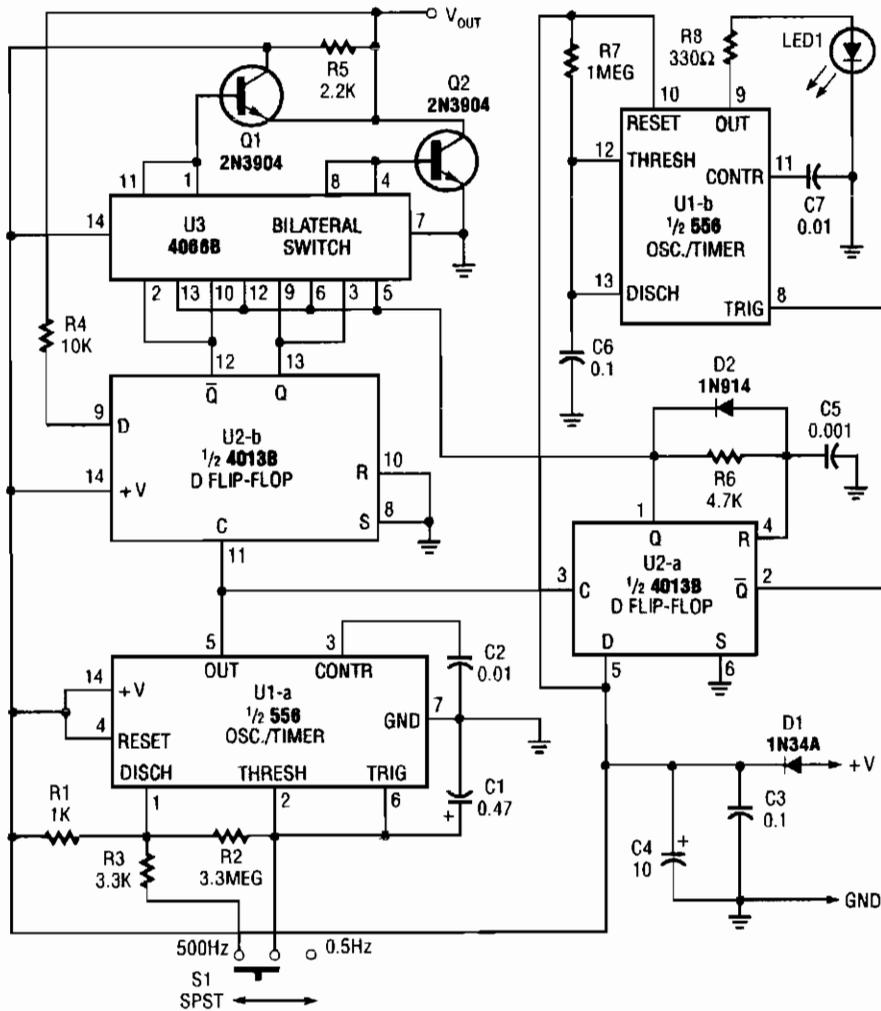
WILLIAM SHEETS

**FIG. 82-2**

By using a 556 dual timer with IC1A acting as a waveshaper and IC1B as a pulse generator, a 10:1 range of pulse widths can be generated.

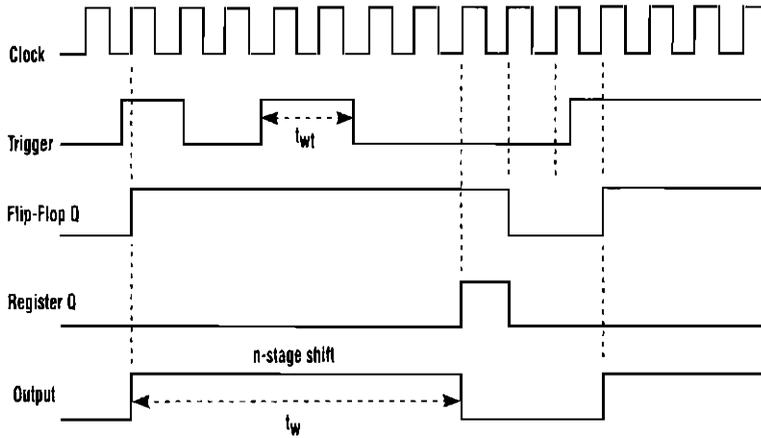
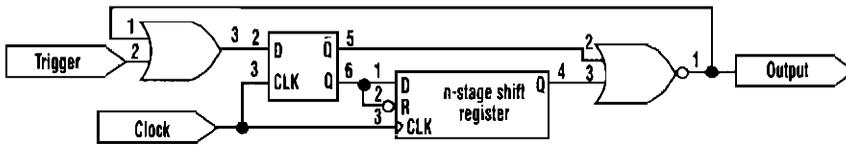
A sine wave can be used to trigger this circuit.

## LOGIC PULSER

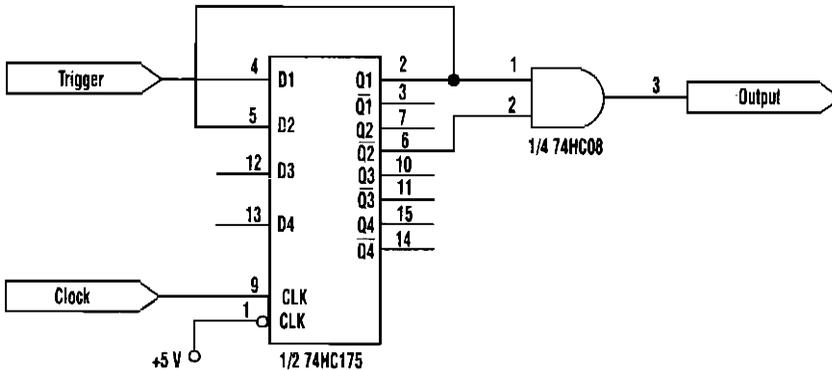


The logic pulser generates pulses at 500 Hz or 0.5 Hz. When the pulser's tip connects to an input that is already being driven high or low, the pulser senses the logic state and automatically pulses the input briefly to the opposite state.

## PRECISE ONE-SHOT



A more precise and stable one-shot pulse is generated by this circuit (a). When a trigger pulse is present, the flip-flop initiates a one-shot pulse whose width is a multiple of the clock period (b).



This simple one-shot circuit has a pulse width of one clock period and is more precise and stable than a multivibrator.

## PRECISE ONE-SHOT (Cont.)

This approach uses a flip-flop, a shift register, and two gates (A). Before the one-shot pulse, the output of the NOR gate is 0. Consequently, the data input of the D-type flip-flop is equivalent to the trigger. When a trigger pulse is present, the flip-flop initiates the one-shot pulse, and the n-stage shift register controls the pulse width,  $t_w$ , which is a multiple of the clock's period (B).

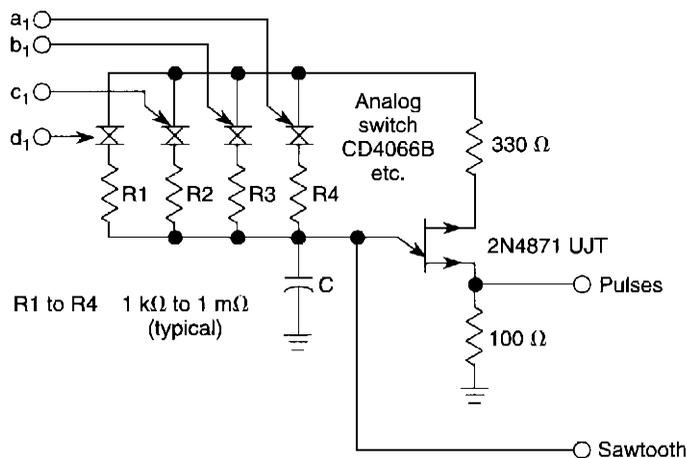
The precision of the one-shot pulse is determined by the clock period, which is inversely proportional to its frequency. For the circuit to work properly, the width of the trigger pulse,  $t_{wp}$ , should be greater than one clock period.

The OR gate masks the trigger's effect when the circuit is generating the desired pulse. The net result is a circuit that functions as a nonretriggerable multivibrator.

When the pulse needs to be only one-clock-period wide, the circuit can be simplified. All that's required are two D-type flip-flops and an AND gate. However, despite its simplicity, this circuit generates a more stable and precise one-shot pulse than a multivibrator.

---

## DIGITALLY CONTROLLED SAWTOOTH PULSE GENERATOR

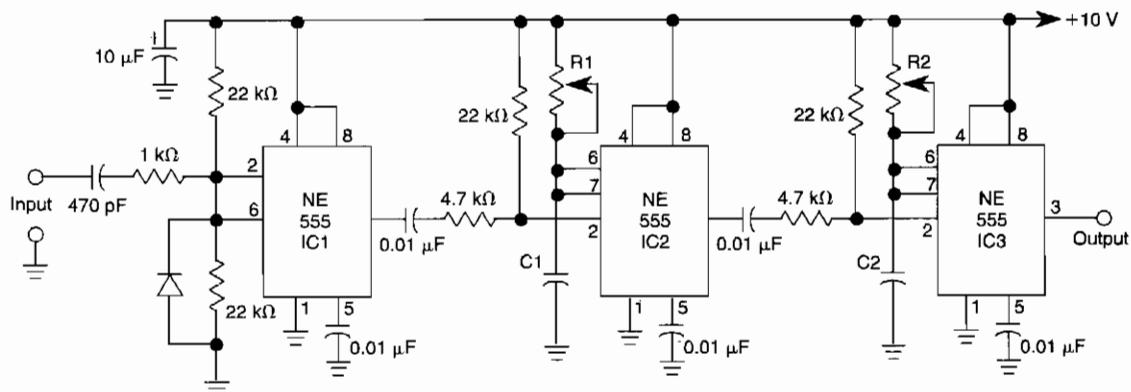


WILLIAM SHEETS

FIG. 82-5

Use of an analog switch as shown allows digital control of a UJT oscillator.

## DELAYED PULSE GENERATOR



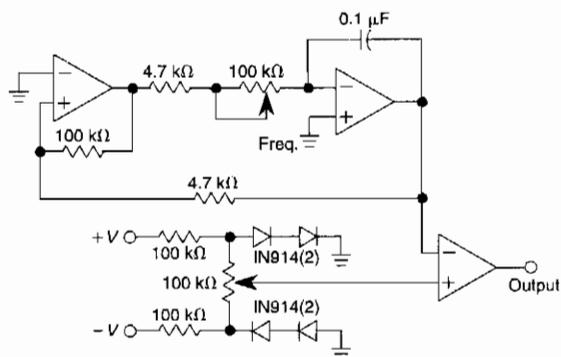
WILLIAM SHEETS

FIG. 82-6

Three 555 IC timers are used in this circuit to construct a simple delayed-pulse generator. IC1 acts as a waveform shaper to produce a rectangular waveform. IC2 produces a delaying pulse to trigger IC3 on the trailing edge of the delaying pulse. R1 controls delay time and R2 controls pulse width. As much as a 10:1 range can be generated.

$$\begin{aligned} \text{Delay:} & \quad C1 = 1.1 \times 10^{-5} T \text{ delay} \quad \text{c } \mu\text{F} \\ \text{Pulse:} & \quad C2 = 1.1 \times 10^{-5} T \text{ pulse} \quad \text{T } \mu\text{sec} \end{aligned}$$

## PULSE GENERATOR WITH VARIABLE DUTY CYCLE



WILLIAM SHEETS

FIG. 82-7

Using only one IC and six passive components, this pulse generator has a frequency range of 400 to 4000 Hz and an adjustable duty cycle of 1 to 99%. A threshold detector (ICA) and an integrator (ICB) generate a triangular waveform. A

positive voltage at the output of ICA causes the output of ICB to become a negative-going ramp. When the output of this ramp reaches a certain value, ICA, by virtue of its positive-feedback network, changes state; its output becomes negative, and the integrator generates positive ramp. This process continually repeats. A voltage follower (ICC) and a 100-k $\Omega$  potentiometer provide a variable  $\pm 0.18$ -V reference voltage. This reference voltage, along with the triangular waveform, feeds into the positive and negative inputs, respectively, of comparator ICD. You can set the comparator's trip voltage at any point on the triangular waveform; ICD's output changes at that point. Varying the reference voltage alters the duty cycle of the comparator's output by adjusting the potentiometer at the negative input of the integrator, thereby varying the integration time without altering the duty cycle.

# 83

## Receiver Circuits

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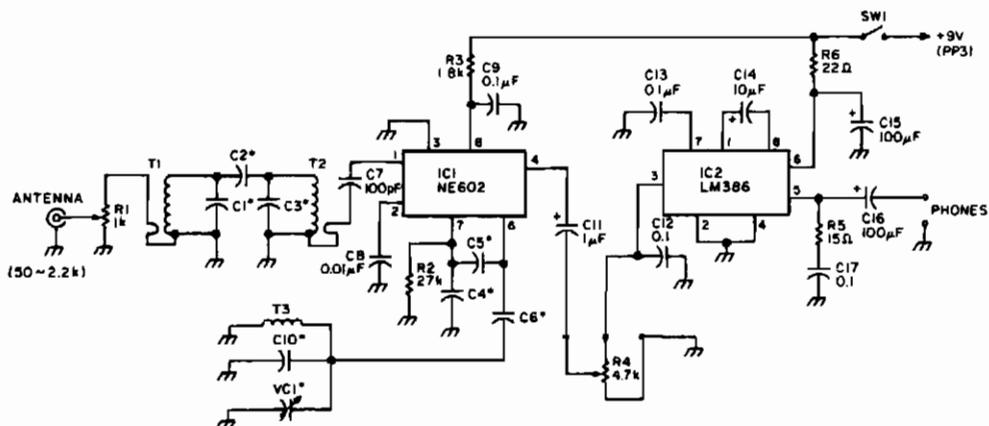
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple Direct-Conversion  
Receiver for 160 to 20 M  
27.145-MHz NBFM Receiver  
VLF Whistler Receiver  
Basic AM Receiver Circuit  
Simple 1.5-V AM Broadcast Receiver  
CMOS Line Receiver

NE602 Direct-Conversion Receiver  
80- and 40-M CW/SSB Receiver  
NE602 RF Input Circuits  
Super-Simple Shortwave Receiver  
Transistorized AM Radio  
NE602 Superhet Front End

## SIMPLE DIRECT-CONVERSION RECEIVER FOR 160 TO 20 M



**Table. Component Values for Different Bands**

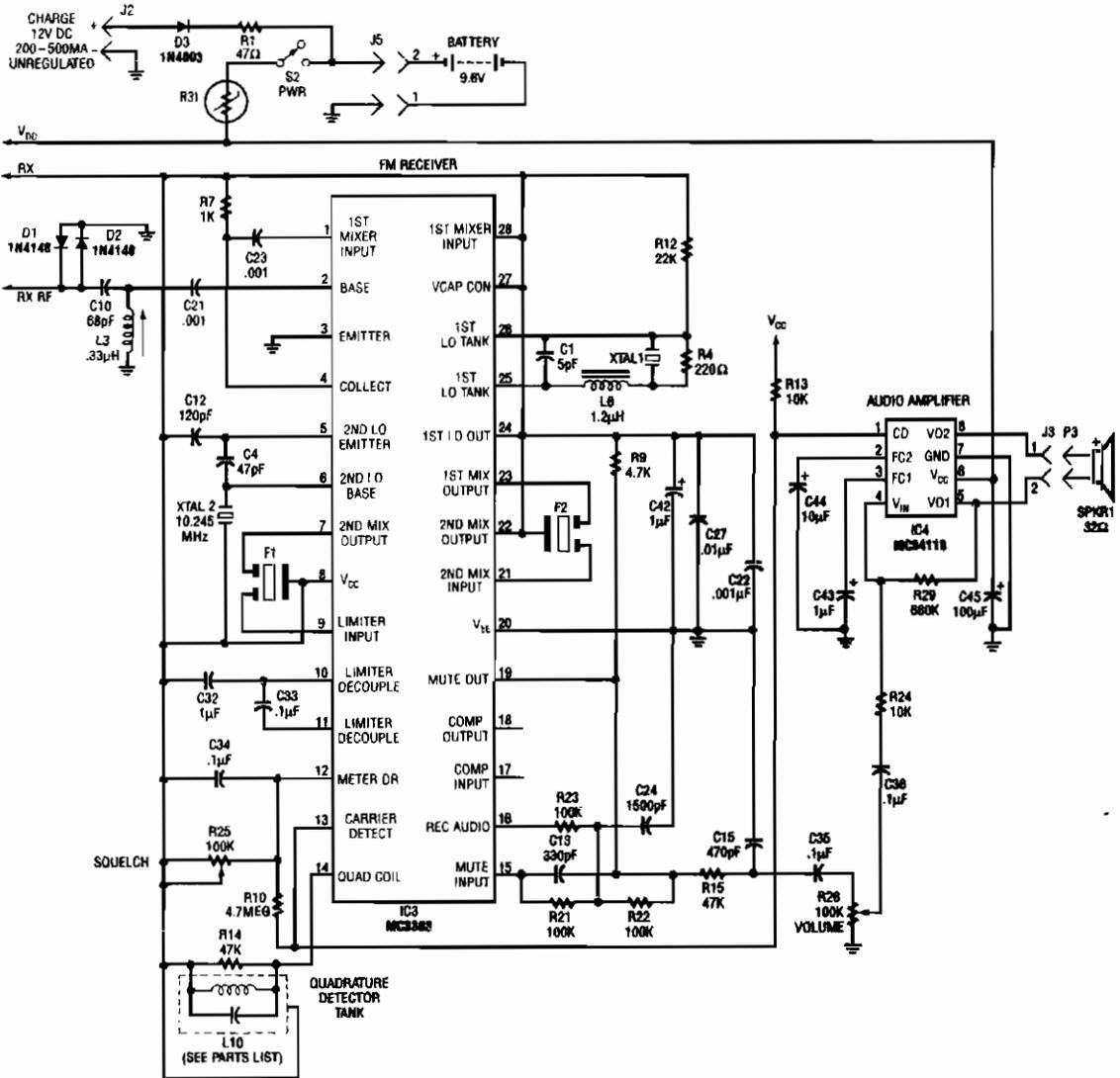
Band	C1	C2	C3	T1	T2
160	220 pF	10 pF	220 pF	BKXN-K3333R	BKXN-K3333R
80	47 pF	3 pF	47 pF	BKXN-K3333R	BKXN-K3333R
40	100 pF	8.2 pF	100 pF	BKXN-K3334R	BKXN-K3334R
30	47 pF	3 pF	47 pF	BKXN-K3334R	BKXN-K3334R
20	100 pF	3 pF	100 pF	BKXN-K3335R	BKXN-K3335R

VC1 + C10	C4	C5	C6	T3
All Sections + 100 pF	0.001 μF	0.001 μF	560 pF	BKXN-K3333R
All Sections + 100 pF	0.001 μF	0.001 μF	560 pF	BKXN-K3334R
1 Section + 47 pF	560 pF	560 pF	270 pF	BKXN-K4173AO
1 Section + 68 pF	680 pF	680 pF	220 pF	BKXN-K3335R
1 Section + 68 pF	220 pF	220 pF	68 pF	BKXN-K3335R

Note that T1 and T2 are TOKO, including part numbers for the coils T1 and T2. The direct-conversion receiver shown uses a double-tuned input network made from readily available TOKO coils. IC1, an NE602, acts as a VFO and mixer, with the output being an IF frequency in the audio range. IC2 is an audio amplifier, R4 is a volume control.

## 27.145-MHz NBFM RECEIVER

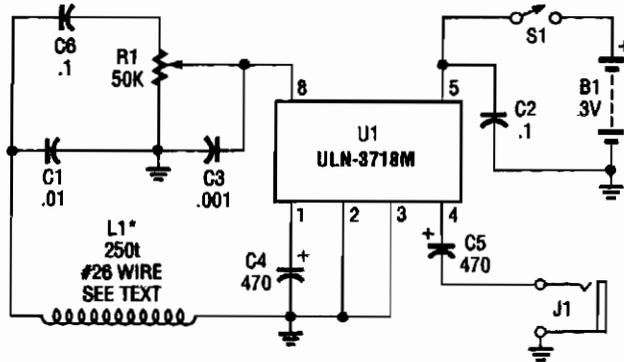


ELECTRONICS NOW

FIG. 83-2

Using a Motorola MC3363 LSI one-chip FM receiver, the circuit is a dual-conversion FM receiver with a 10.7-MHz IF chain. IC4 provides power to drive a small speaker.

## VLF WHISTLER RECEIVER

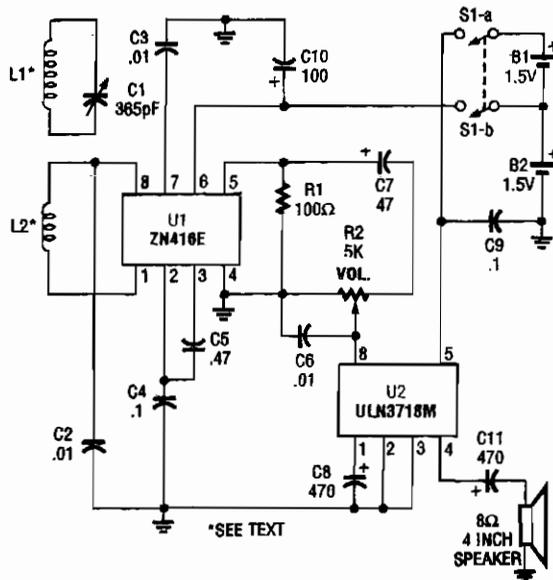


POPULAR ELECTRONICS

FIG. 83-3

The VLF whistler receiver is intended to listen to natural radio noise and signals that occur below 20 kHz. L1 is a large loop antenna that is 250 to 300 turns #26 gauge wire on a form 3' diameter. L1 should be mounted well away from power lines and is oriented for minimum 60- and 120-Hz pickup.

## BASIC AM RECEIVER CIRCUIT

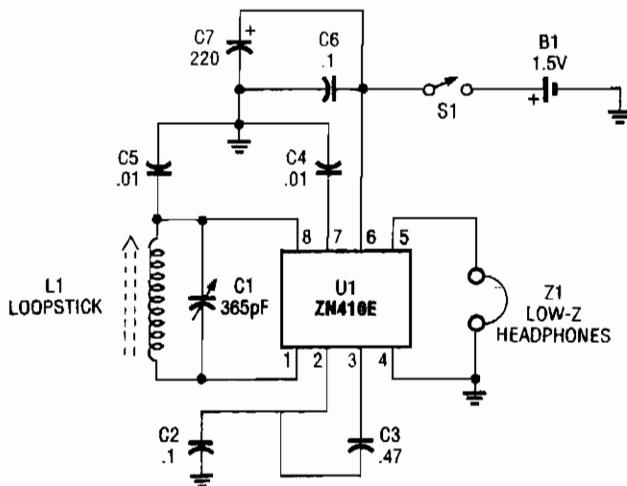


POPULAR ELECTRONICS

FIG. 83-4

Using a single ZN416E IC and a ULN3718M, this simple TRF receiver can drive a loudspeaker. Two 1.5-V cells power the circuit.

## SIMPLE 1.5-V AM BROADCAST RECEIVER

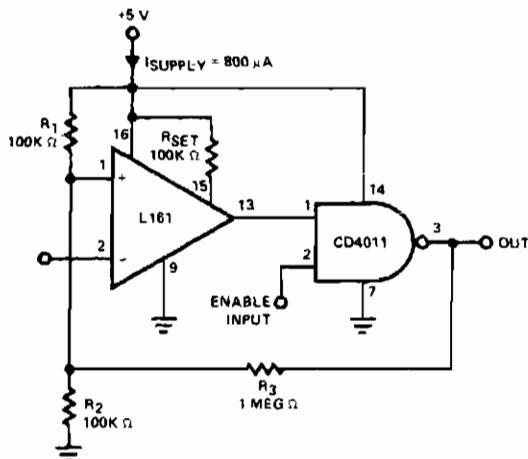


POPULAR ELECTRONICS

FIG. 83-5

This receiver uses the ZN416E made by GEC Plessey. The tuning is via C1.

## CMOS LINE RECEIVER



INTEGRATED CIRCUITS DATA BOOK

FIG. 83-6

This circuit will interface a line input to CMOS. The supply current is >1 mA at +5 V.

## NE602 DIRECT-CONVERSION RECEIVER

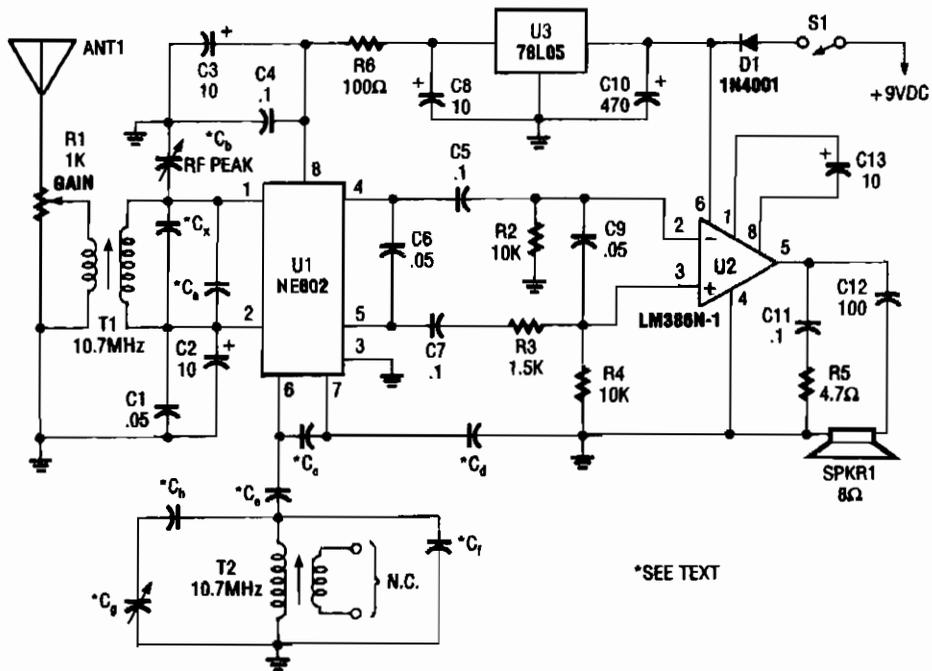
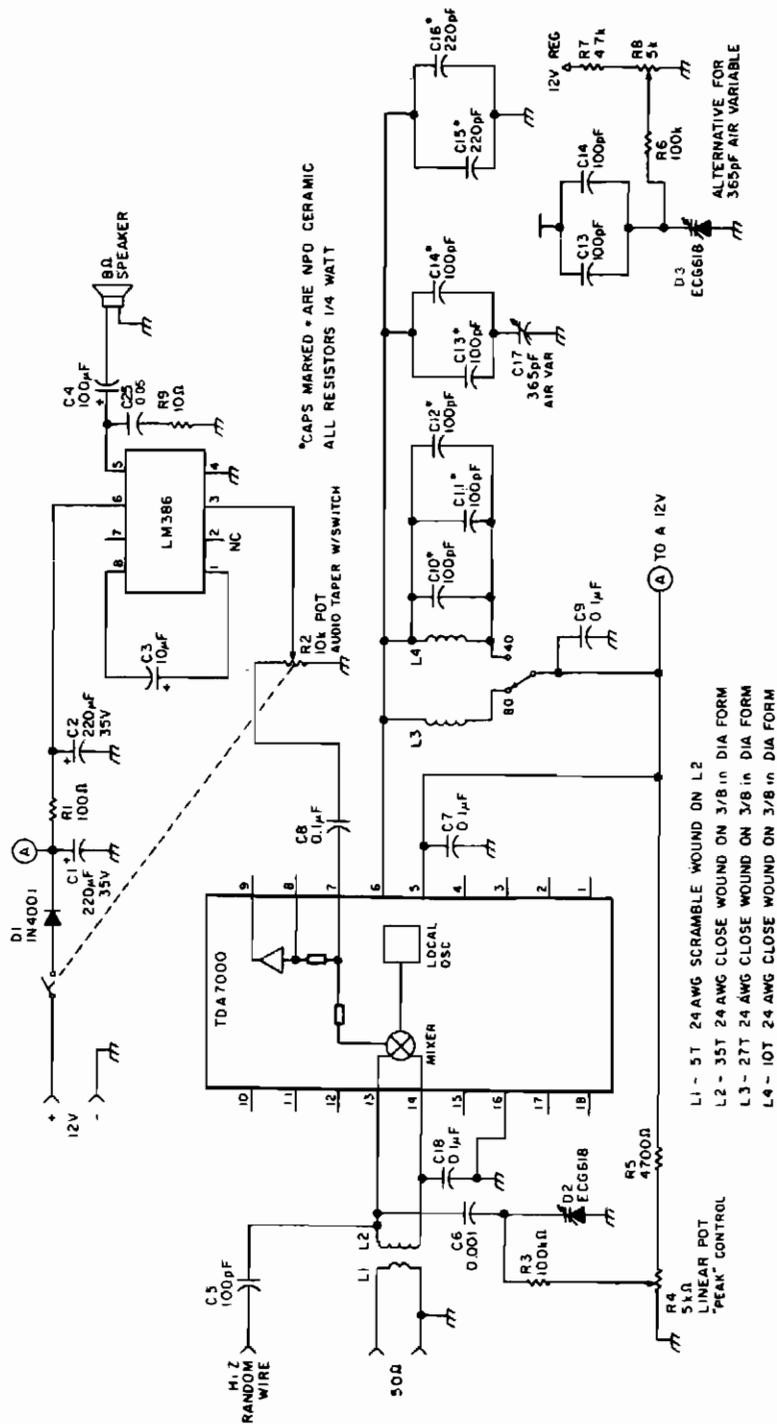


Table 1-- CAPACITOR SELECTION

Band (meters)	Capacitor values (picofarads)					
	Cc	Cd	Ce	Cf	Cg	Ch
75/80	1000	1000	470	120	365	270
40	330	330	120	150	365	68

An NEC602 is used as a mixer with a zero IF frequency output. U2 acts as an audio amplifier. This receiver is primarily for SSB and CW signals. T1 and T2 are 10.7-MHz IF coils used in AM/FM transistorized radios, etc. or in any similar indicator.

## 80- AND 40-M CW/SSB RECEIVER

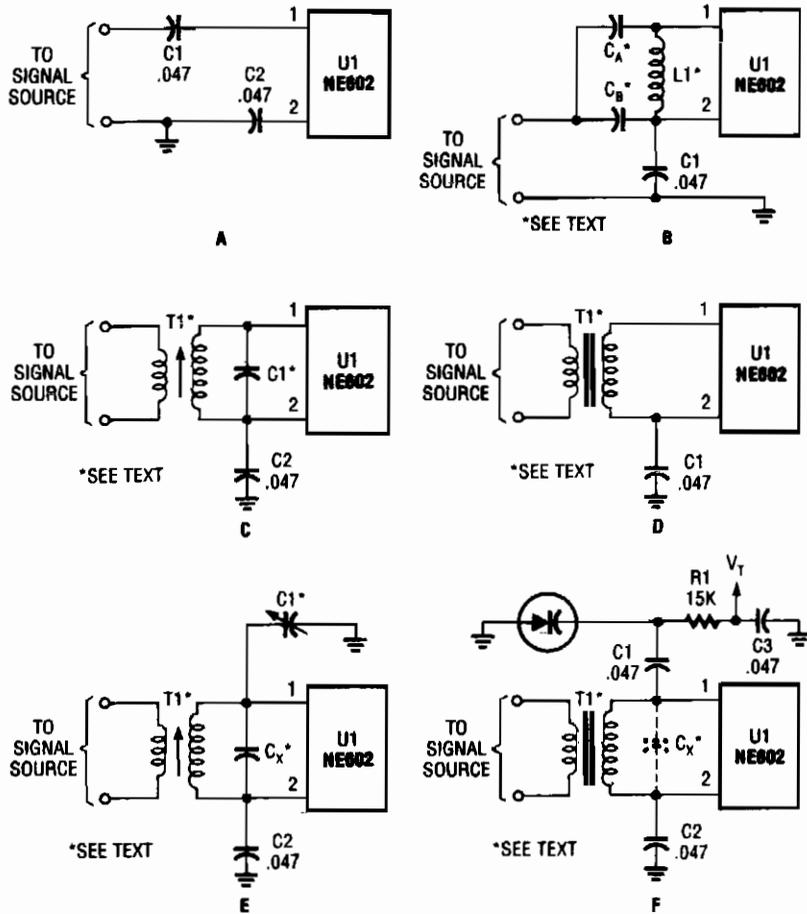


73 AMATEUR RADIO TODAY

FIG. 83-8

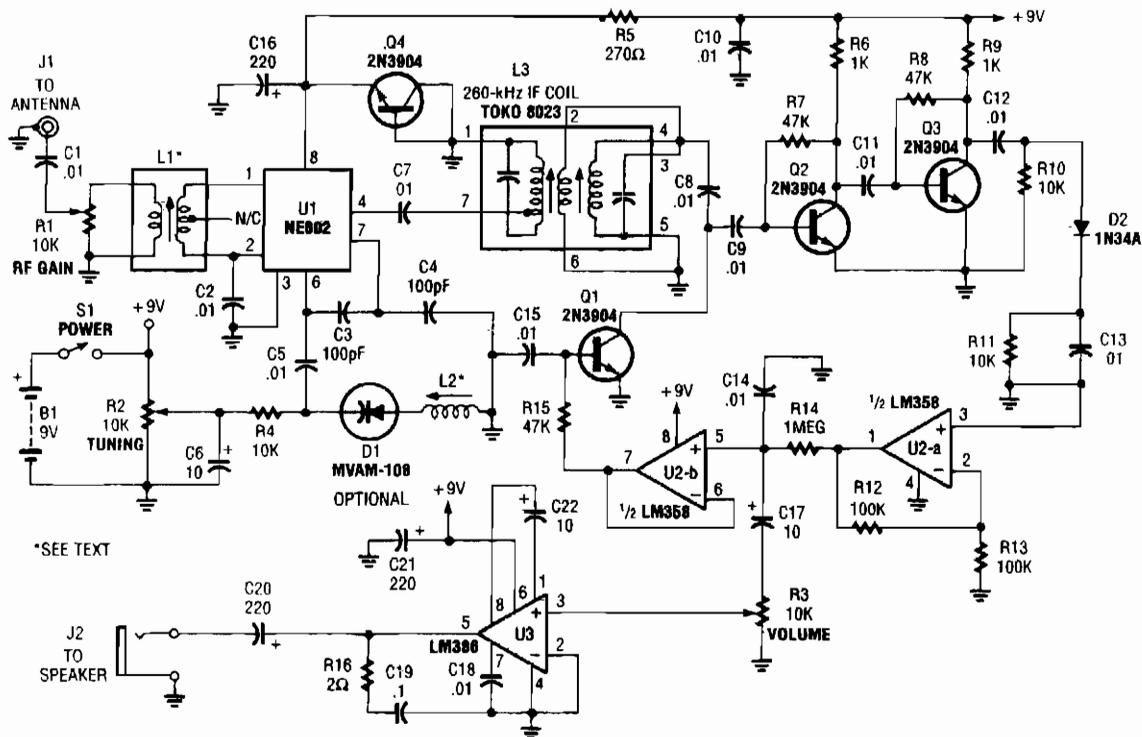
This direct-conversion receiver uses a TDA7000 IC and it drives an LM386 audio amplifier. The TDA7000 is used for its mixer and L.O. section. The frequency control can be either with an air variable capacitor or a varactor diode.

## NE602 RF INPUT CIRCUITS



Here are a few of the many possible RF input circuits for the NE602. Just about any tuned or broadband circuit will work.

## SUPER-SIMPLE SHORTWAVE RECEIVER



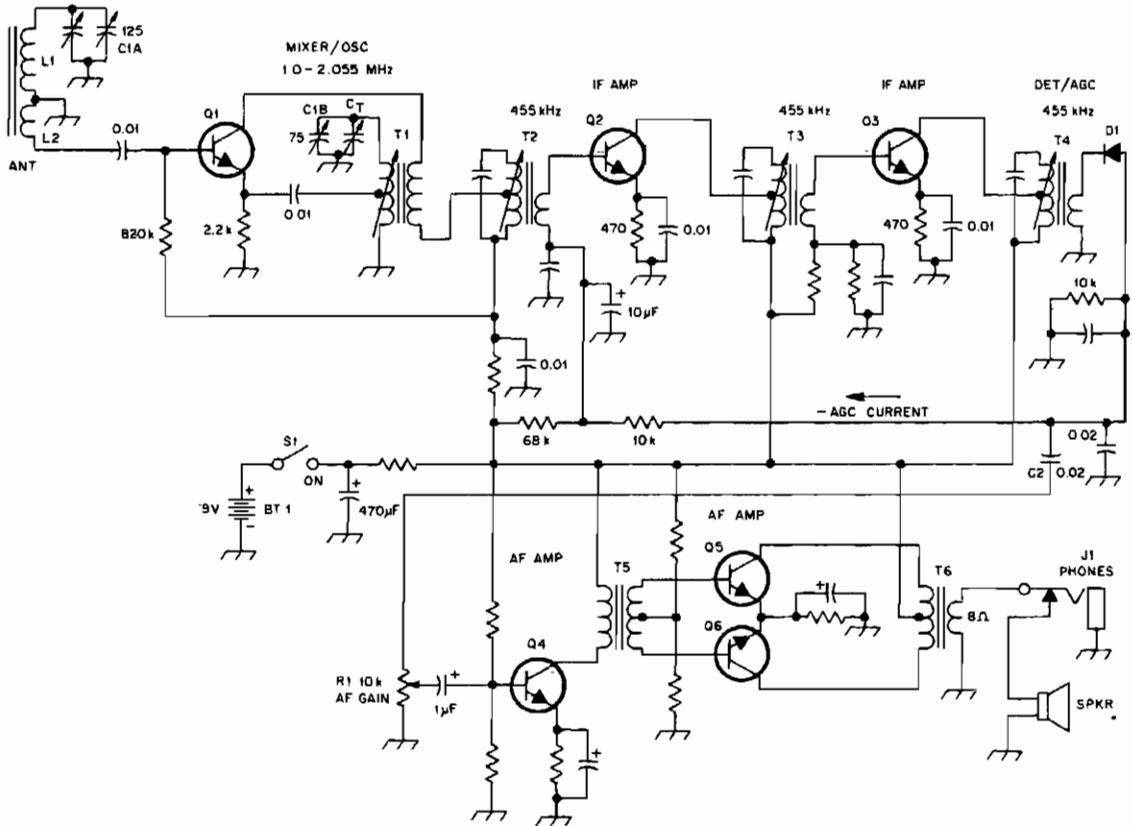
POPULAR ELECTRONICS

FIG. 83-10

Integrated circuit U1 (an NE602 double-balanced mixer) is a combination oscillator and frequency mixer. Signals from the antenna input (at J1) are fed through dc-blocking capacitor C1 to the RF-gain control, R1, and fed to the input of U1 at pins 1 and 2.

The local-oscillator frequency, which varies with the settings of R2 and L2, is mixed internally within U1, resulting in an output. The mixer output at pin 4 of U1 is applied to a tunable 260-kHz band-pass intermediate-frequency (IF) transformer, L3, through dc-blocking capacitor C7. Therefore, signals that are roughly 260 kHz above and below the local-oscillator frequency are passed while others are effectively blocked. The IF frequencies are now amplified by Q2 and Q3. The AM audio signal is detected by D2 and its associated components, which bypass the RF signals, and leave only the audio signals. The signals are preamplified by U1-a (half of an LM358 dual op amp). The audio is then boosted to speaker level by the LM386 low-voltage audio power amplifier, U3.

## TRANSISTORIZED AM RADIO

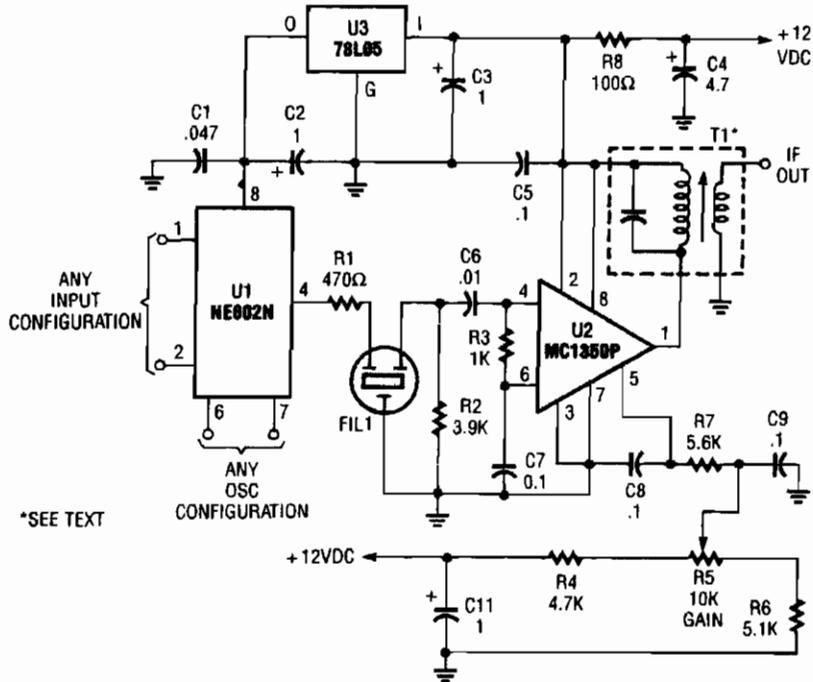


QST

FIG. 83-11

Shown is a schematic of a typical transistor AM radio. This circuit uses npn transistors. The circuit is "generic;" therefore, no specific values are given for some components. This circuit is for reference, to serve as a starting point for experimenters.

## NE602 SUPERHET FRONT END



POPULAR ELECTRONICS

FIG. 83-12

By using an NE602 with a filter and an MC1350P IC, a front end and an IF system for a basic superheterodyne receiver can be built with few parts. T1 is any suitable IF transformer for 262 kHz, 455 kHz, 10.7 MHz, etc.

# 84

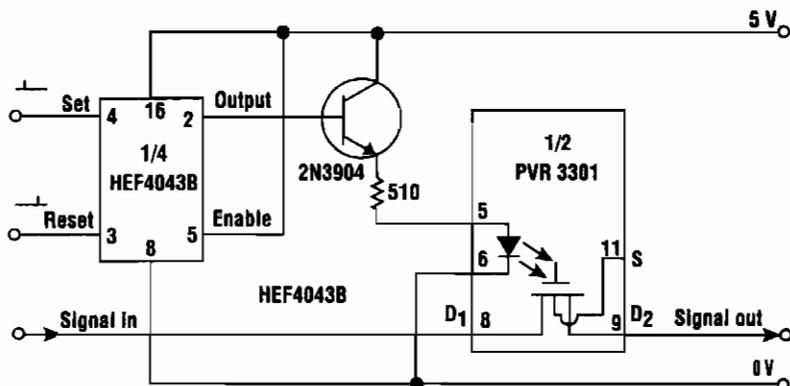
## Relay Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Solid-State Latching Relay  
Solid-State Relay Circuit  
Solid-State Relay Circuits  
Time Delay Relay  
Sensor-Activated Relay Pulser

## SOLID-STATE LATCHING RELAY



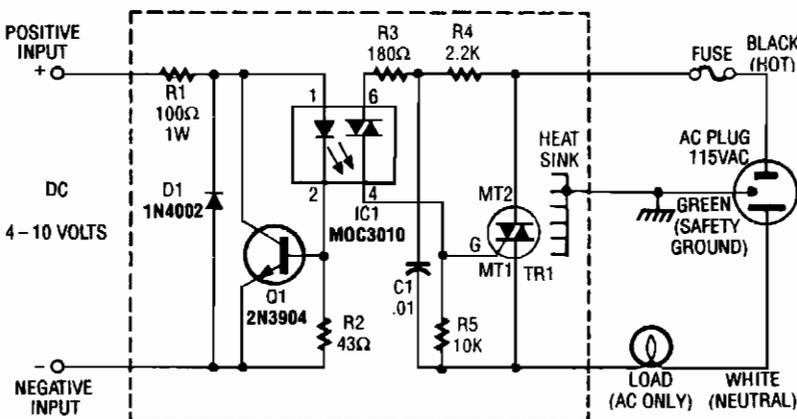
ELECTRONIC DESIGN

FIG. 84-1

This simple circuit provides a solid-state equivalent of the electromechanical latching relay (see the figure). What's more, the switching is clean, highly resistant to vibration and shock, and isn't sensitive to magnetic fields or position.

The circuit operates as follows: a set pulse to the 4043 RS latch takes its output high and turn on the 2N3904 transistor. Current will then flow through the photovoltaic relay's LED and the resistance between D1 and D2 will fall from several gigaohms to less than  $30\ \Omega$ . The PVR will remain in this state until a reset pulse is received by the 4043 RS latch.

## SOLID-STATE RELAY CIRCUIT

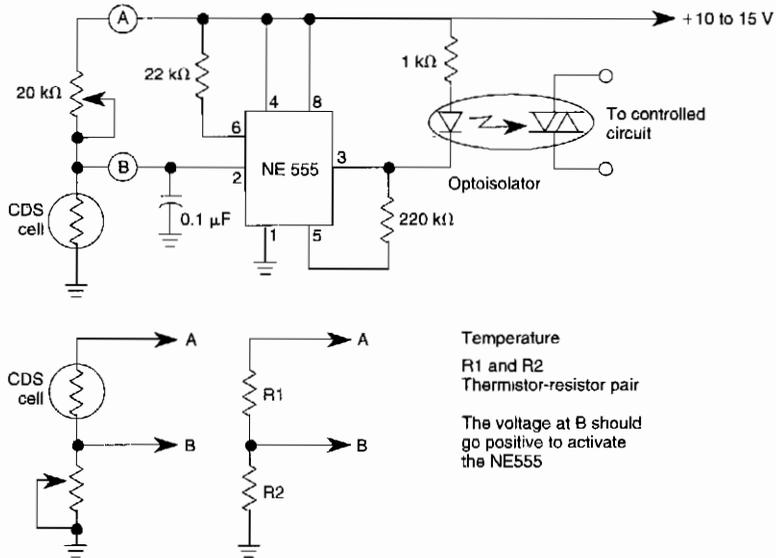


RADIO ELECTRONICS

FIG. 84-2

R1 limits input current while Q1 acts as a current sink to protect IC1. D1 serves as a polarity protector. IC1 provides a triac output to trigger the main triac, TR1.

## SOLID-STATE RELAY CIRCUITS

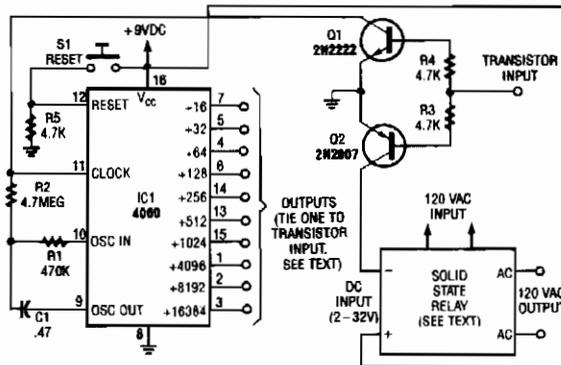


WILLIAM SHEETS

FIG. 84-3

This dark-activated relay switch can be used to turn on walkway or other outdoor lighting at dusk. By using alternate connections to A and B, increasing illumination, high and low temperatures can be sensed.

## TIME DELAY RELAY

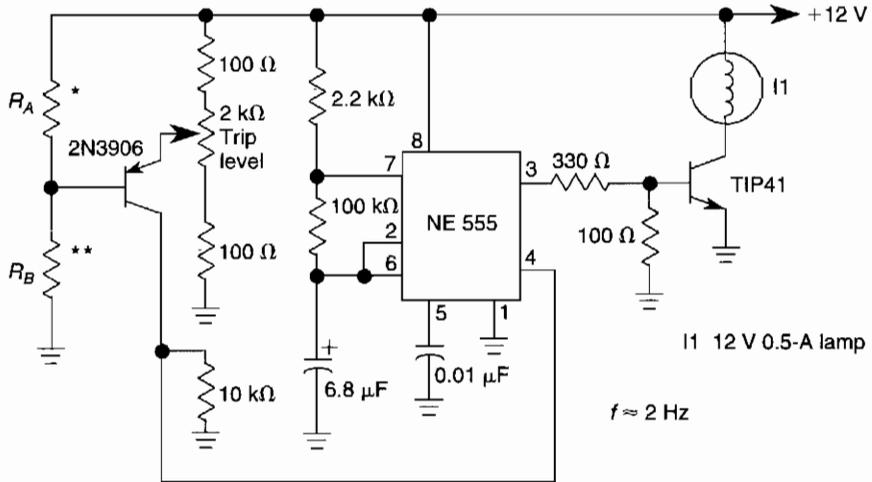


ELECTRONICS NOW

FIG. 84-4

Using a 4060 CMOS binary divider and built-in clock oscillator, a long-duration timer can be made very simply. The solid-state relay can be sized for your application, and can be replaced with a mechanical relay if a suitable power supply is available. With the components shown, a 4.5-Hz clock frequency is generated. Divided outputs are available from  $\div 4$  to 16384 (about 4 hours).

## SENSOR-ACTIVATED RELAY PULSER



Either  $R_A$  or  $R_B$  can be sensors, as desired. A decrease in  $R_B$  or an increase in  $R_A$  will cause the NE555 to flash I1.  $R_A$  and  $R_B$  should be  $\leq 100 \text{ k}\Omega$  max.

WILLIAM SHEETS

FIG. 84-5

A sensor turns on Q1 to activate the low-frequency 555 oscillator, which pulses LAMP I1. Sensor may be sensitive to changes in light or temperature.

# 85

## Remote-Control Circuits

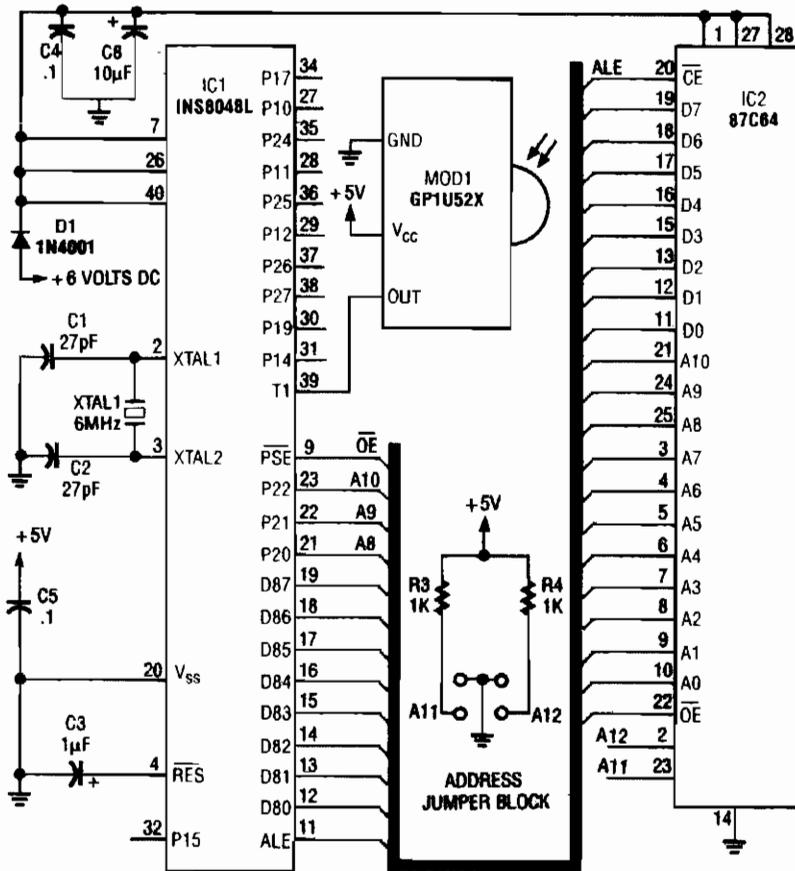
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Remote-Control Transmitter  
Remote-Control Receiver  
Interface Circuits for the Remote-Control Transmitter  
Remote-Control Extender  
Ultrasonic Remote-Control Transmitter  
Remote-Control Transmitter  
Ultrasonic Remote-Control Receiver

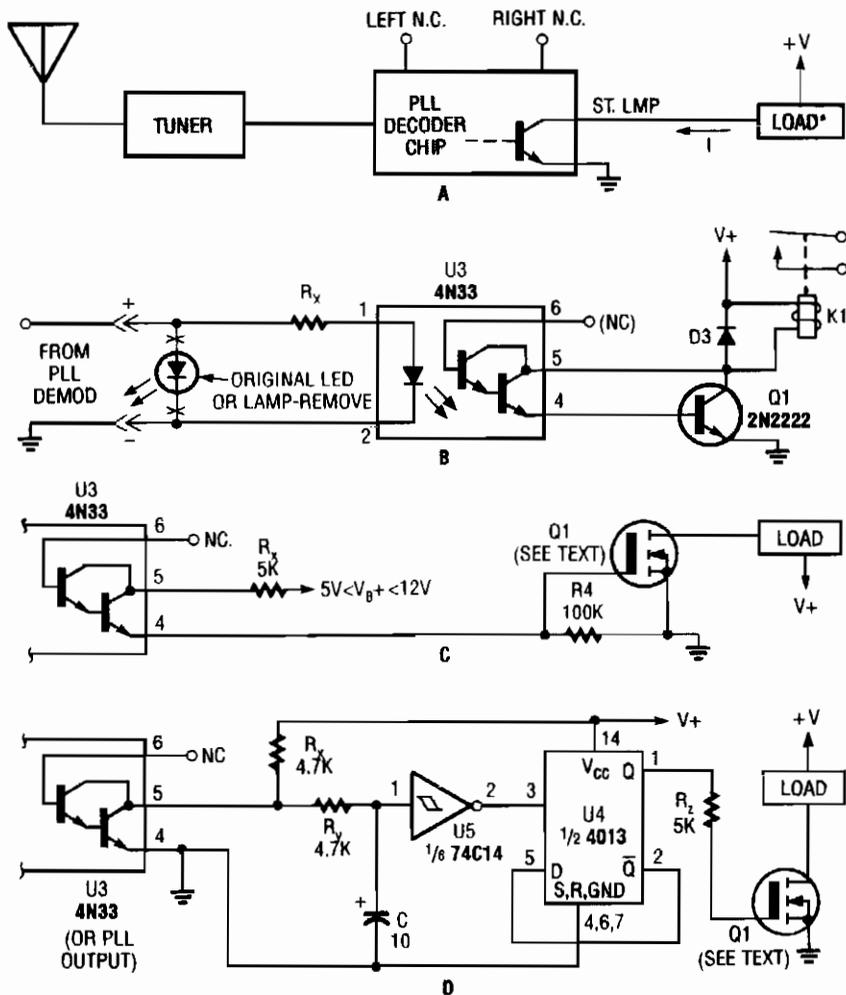


## REMOTE-CONTROL RECEIVER



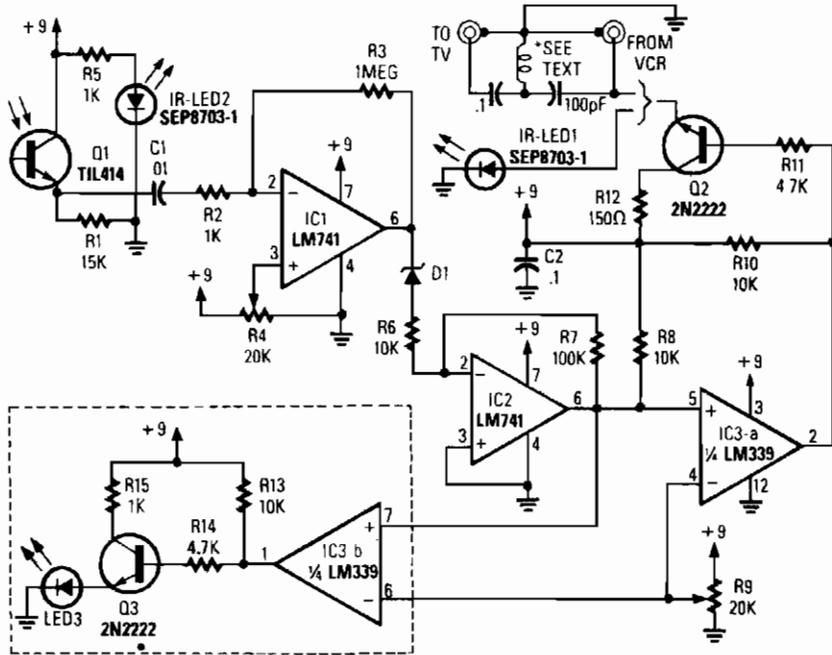
This circuit is based on the Sharp GP1U52X IR module and INS8048L microprocessor. The GP1U52X is a hybrid IC/infrared detector that provides a strong clean signal for later filtering and demodulation.

## INTERFACE CIRCUITS FOR THE REMOTE-CONTROL TRANSMITTER



Shown here are several possible interface circuits that can be used with the remote-control transmitter. The one in A illustrates a typical FM stereo MUX decoder with a load connected directly to the open-collector output of a TA7343 PLL. The circuit in B illustrates an optoisolator-coupler output driving a 12-V relay coil via a general-purpose transistor. C shows the gate of an N-channel power MOSFET connected to the output of a 4N33. The final circuit, D, is a toggle flip-flop that allows push-on/push-off control.

## REMOTE-CONTROL EXTENDER

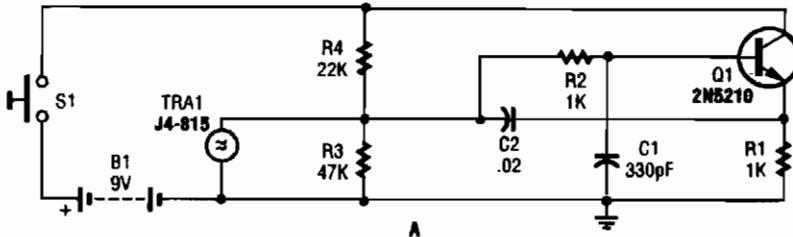


1991 R-E EXPERIMENTERS HANDBOOK

FIG. 85-4

A signal from an IR remote control is converted from IR radiation to a frequency pulse that can be transmitted through coaxial TV cable or any other two-conductor wire to another room, where it's converted back into an IR signal.

## ULTRASONIC REMOTE-CONTROL TRANSMITTER

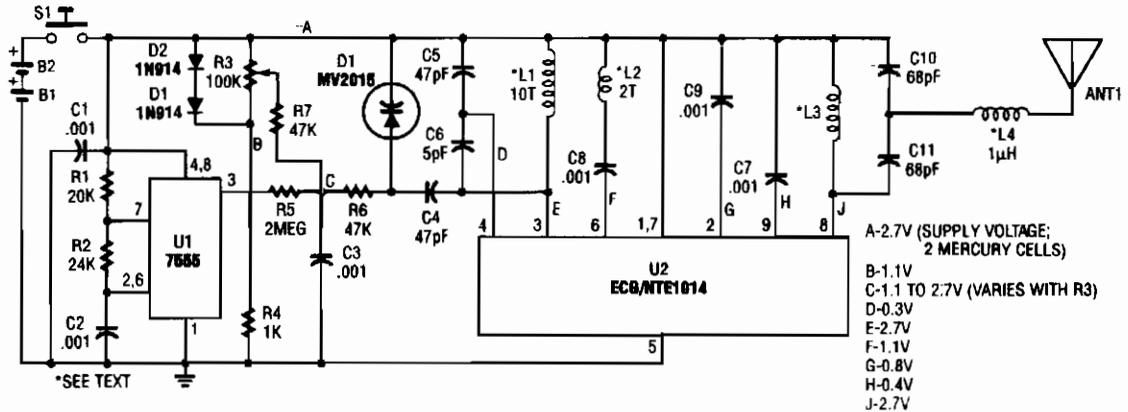


POPULAR ELECTRONICS

FIG. 85-5

A GC Electronic P/N J4-815 ultrasonic transducer is used in this 40-kHz transmitter for remote-control application.

## REMOTE-CONTROL TRANSMITTER

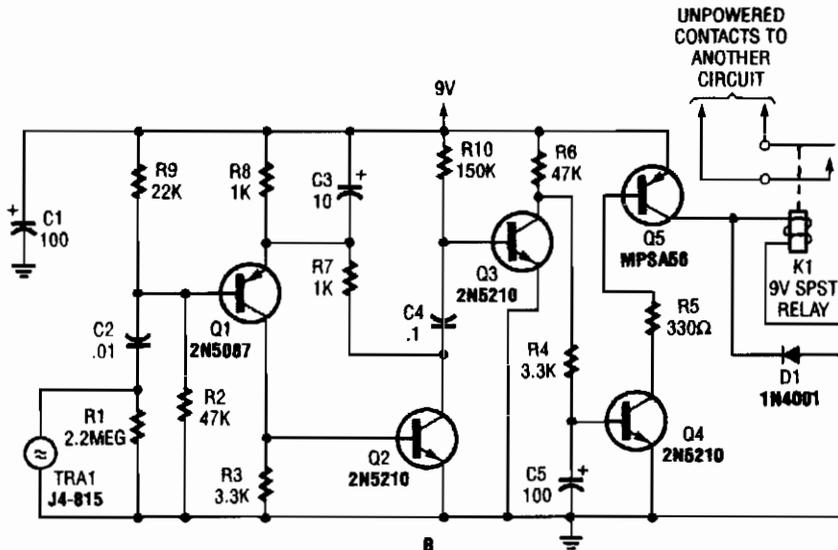


POPULAR ELECTRONICS

FIG. 85-6

This transmitter can be used for a variety of purposes. An INS8048L microprocessor generates various codes depending on keypad presses. The codes are modulated on a 40-kHz carrier. Q1 drives IR LEDs LED1 and LED2.

## ULTRASONIC REMOTE-CONTROL RECEIVER



POPULAR ELECTRONICS

FIG. 85-7

A GC Electronics P/N J4-815 transducer is used to receive 40-kHz acoustic remote-control signals. The receiver drives a relay for control of another circuit.

# 86

## RF Amplifier Circuits

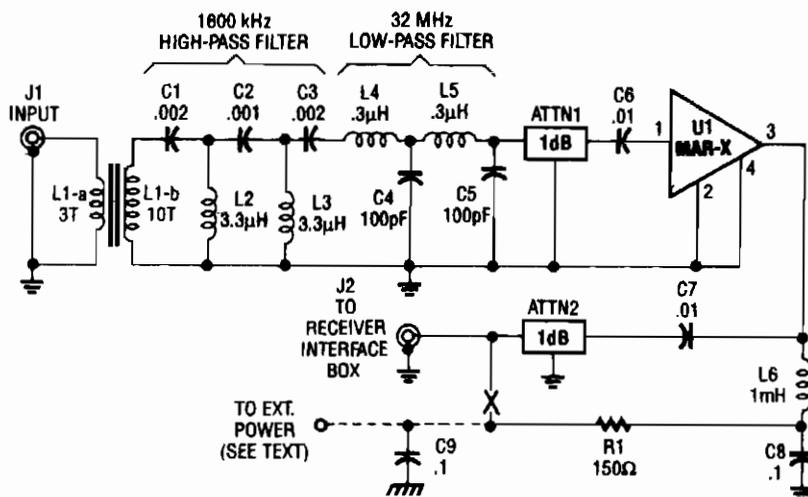
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

HF Preamplifier	Receiver/Scanner Preamp Using MAR-1 MMIC
VHF/UHF Preamp Using MAR-x	20-W 1296-MHz Amplifier Module
Broadband RF Amplifier	Simple 455-kHz IF Amplifier
Low-Noise GASFET Preamp for 435 MHz	UHF Amplifier
Broadcast-Band RF Amplifier	144- to 2304-MHz UHF Broadband Amplifier
70-MHz RF Power Amplifier	455-kHz IF Amplifier
Miniature Wideband Amplifier	Switchable HF/VHF Active Antenna
30-MHz Amplifier	455-kHz IF Amp for 1.5-V Operation
20-W 450-MHz Amplifier	5-W 7-MHz RF Power Amplifier
Wideband Power Amplifier	LC Tuned Amplifiers
TV Sound System	Wideband Preamp
10-W 10-Meter Linear Amplifier	RF Preamplifiers
2-Meter FET Power Amplifier for HTs	45-MHz IF Amplifier with crystal filter

## HF PREAMPLIFIER

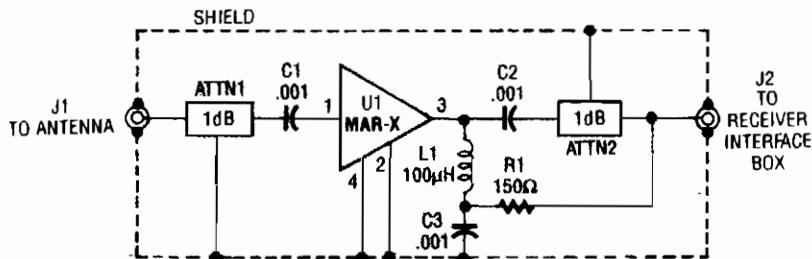


POPULAR ELECTRONICS

FIG. 86-1

This HF SW receiver preamplifier is comprised of a broadband toroidal transformer (L1-a and L1-b), a complex LC network (comprised of a 1600-kHz, high-pass filter and a 32-MHz, low-pass filter), L2 and L3 (26 turns of #26 enameled wire wound on an Amidon Associates T-50-2, red, toroidal core), a pair of resistive attenuators (ATTN1 and ATTN2), and of course, the MAR-x device. External power for the preamp can be 9 to 12 Vdc. R1 can be increased in value for higher voltages.

## VHF/UHF PREAMP USING MAR-x

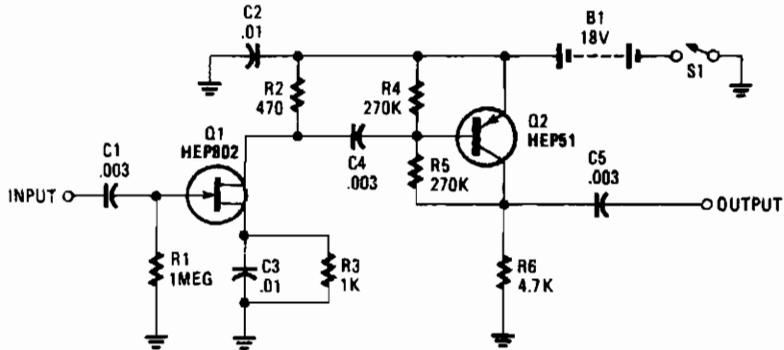


POPULAR ELECTRONICS

FIG. 86-2

The MAR-x preamp shown will cover up to 1.5 or 2 GHz with the correct MAR-x IC. ATTN1 should be omitted for low noise-figure applications. ATTN1 and ATTN2 provide a means of limiting possible termination range, for less chance of device instability.

## BROADBAND RF AMPLIFIER

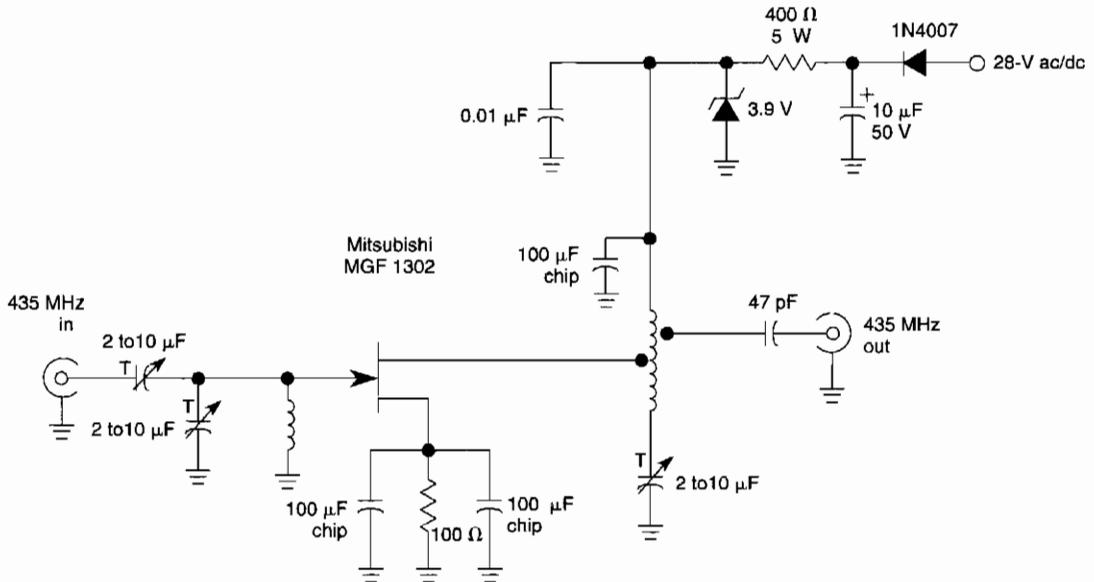


POPULAR ELECTRONICS

FIG. 86-3

The use of a FET gives this amplifier a high input impedance. The bandwidth should be adequate for LW through HF use (dc-30 MHz), as an active antenna preamplifier.

## LOW-NOISE GASFET PREAMP FOR 435 MHz

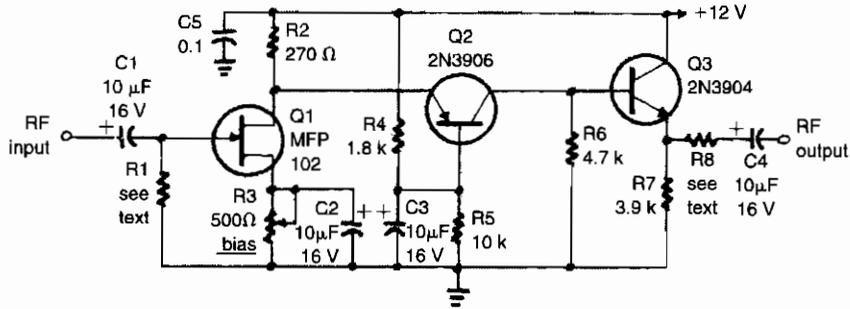


WILLIAM SHEETS

FIG. 86-4

This circuit is a low-noise preamplifier for the 435-MHz amateur satellite frequencies. The circuit uses a Mitsubishi MGF1302. A 28-Vdc source is shown, although by changing the 400- $\Omega$  5-W resistor lower voltages can be used.

## BROADCAST-BAND RF AMPLIFIER

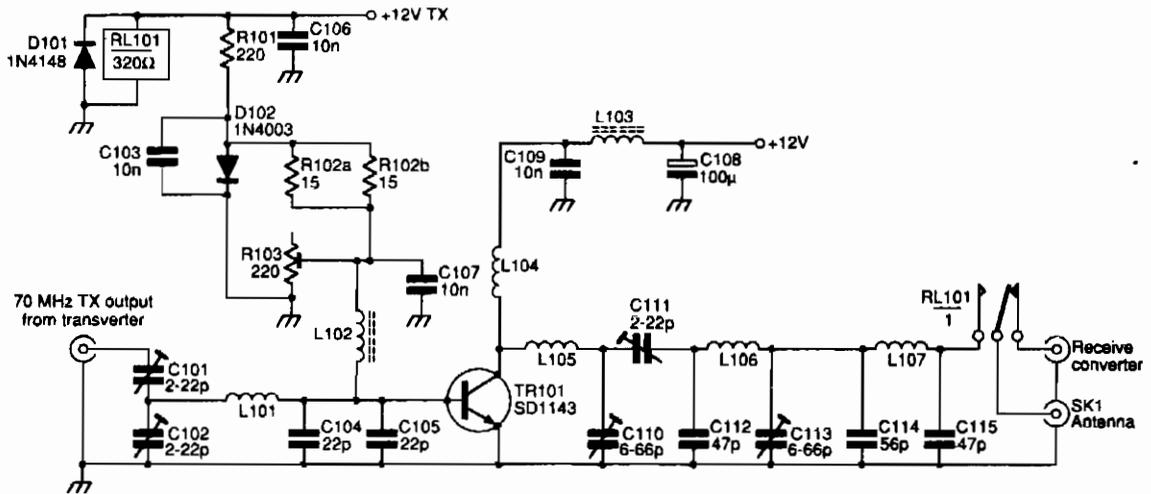


R-E EXPERIMENTERS HANDBOOK

FIG. 86-5

The circuit has a frequency response that ranges from 100 Hz to 3 MHz; the gain is about 30 dB. Field-effect transistor Q1 is configured in the common-source self-biased mode; optional resistor R1 allows you to set the input impedance to any desired value. Commonly, it will be 50 Ω. 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. Last, Q3 functions as an emitter-follower, to provide low output impedance (about 50 Ω). If you need higher output impedance, include resistor R8. It will affect impedance according to this formula:  $R_8 \approx R_{OUT} - 50$ . Otherwise, connect output capacitor C4 directly to the emitter of Q3.

## 70-MHz RF POWER AMPLIFIER

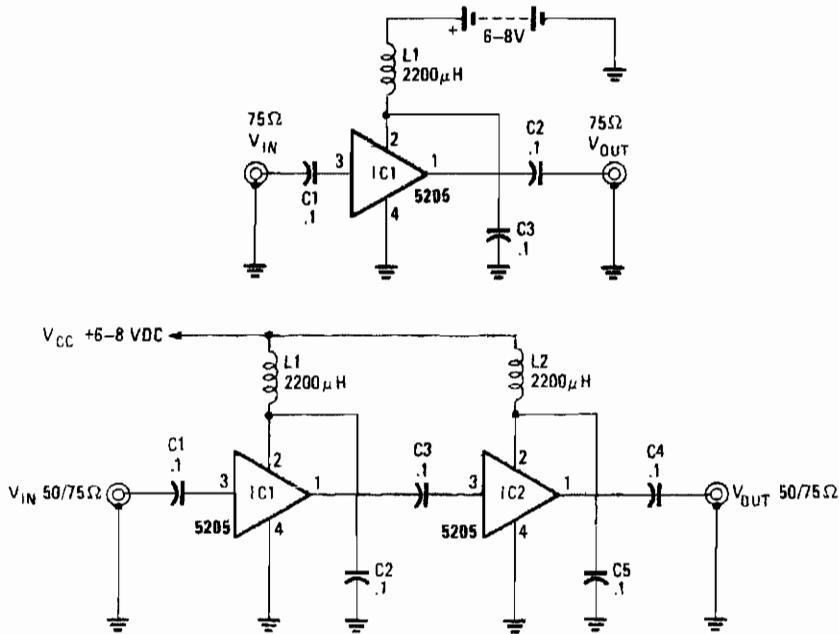


PRACTICAL WIRELESS

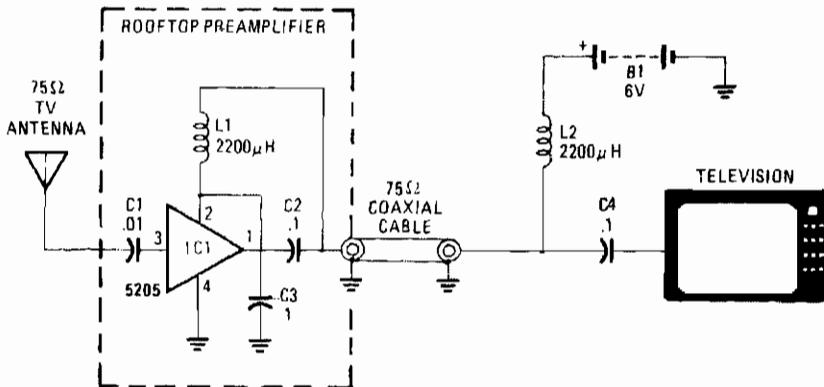
FIG. 86-6

The SD1143 transistor provides a gain of about 14 dB in this circuit. It uses the fact that a 175-MHz device has a much higher gain when used at lower frequencies. The amplifier was originally designed to be used with a transverter. The output is 8 to 10 W for a 300- to 500-mW input.

## MINIATURE WIDEBAND AMPLIFIER



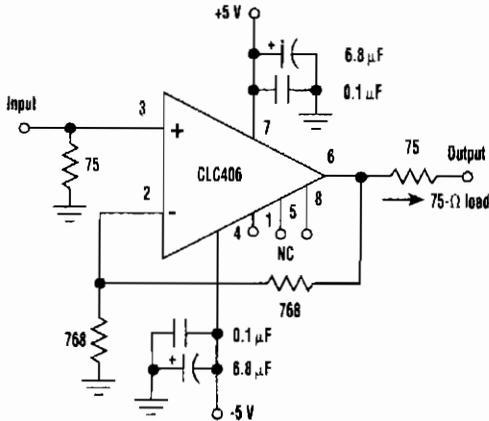
SINCE THE NE5205 FUNCTIONS as a gain block, two or more can be easily cascaded to provide additional amplification. In this circuit, which uses two NE5205s, the overall gain is  $\approx 0$  dB.



IF THE POWER SUPPLY is fed through the signal-carrying coaxial cable, the amplifier can be mounted in a weatherproof enclosure directly at the antenna.

Except for the coupling and decoupling capacitors, IC1 is a complete wideband amplifier that has a fixed gain of 20 dB to 450 MHz. No external compensation is required.

### 30-MHz AMPLIFIER

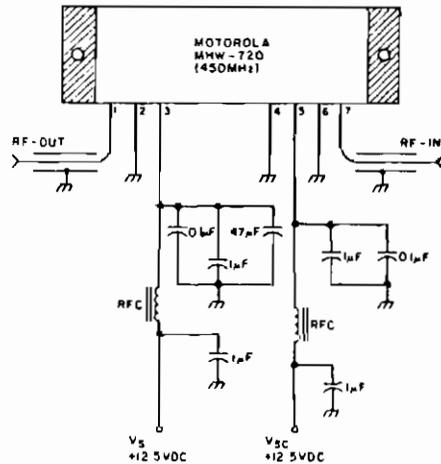


ELECTRONIC DESIGN

FIG. 86-8

Using a CLC406 op amp, this video amplifier has a voltage gain of +2 and is flat to 30 MHz. The circuit should be useable in video switching and interfacing applications.

### 20-W 450-MHz AMPLIFIER

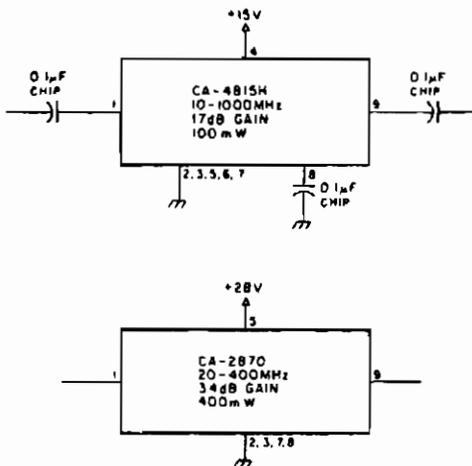


73 AMATEUR RADIO

FIG. 86-9

Delivering 20-W output, this amplifier has a gain of 21 dB at 450 MHz. A 12-V supply powers this circuit.

### WIDEBAND POWER AMPLIFIER

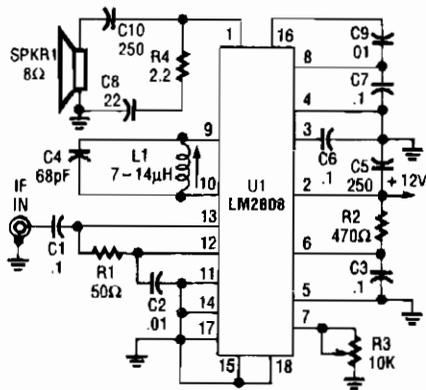


73 AMATEUR RADIO

FIG. 86-10

Using TRW P/N CA-815H, a 17-dB gain amplifier that delivers 100 mW over 10 to 1000 MHz can be constructed. The CA-2870 will yield 0.4 W with 34-dB gain from 20 to 400 MHz.

### TV SOUND SYSTEM



POPULAR ELECTRONICS

FIG. 86-11

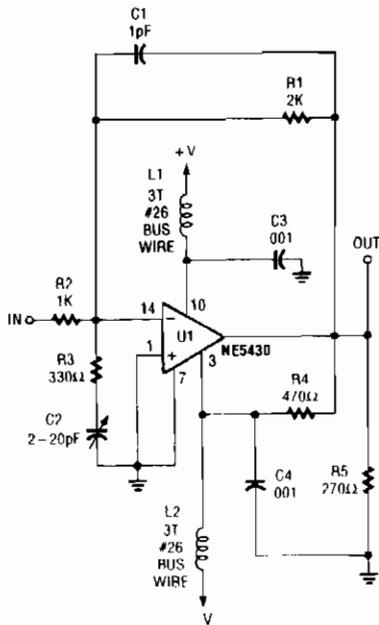
An LM2808 performs IF amplification of the 4.5-MHz sound subcarrier, limiting, detection, and audio amplification. If the center frequency must be changed, then change L1/C4. Audio output is 0.5 W. R3 is the volume control.







### UHF AMPLIFIER



NOTE  
RESISTORS-1/4 WATT CARBON  
L1 & L2 WOUND ON FERROXCUBE VK200 09/3B  
WIDEBAND THREADED CORE

POPULAR ELECTRONICS

FIG. 86-17

### 144- TO 2304-MHz UHF BROADBAND AMPLIFIER

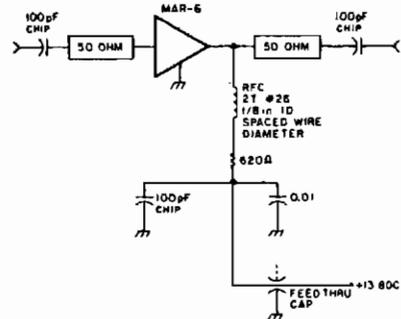
Table 1.

Device	Max. mA	Normal Current mA.	Approx. Gain 1-GHz
MAR-1	40	20-30 mA	18 dB
MAR-2	60	30-40 mA	13 dB
MAR-3	70	30-50 mA	12 dB
MAR-4	85	50-70 mA	8 dB
MAR-6	50	15-25 mA	17 dB
MAR-7	60	25-40 mA	13 dB
MAR-8	65	30-50 mA	23 dB

Table 2.

#### MMIC Amplifier Performance

144 MHz	18.2 dB	2.7 dB N/F
220 MHz	18.3 dB	2.6 dB N/F
432 MHz	16.5 dB	2.8 dB N/F
902 MHz	15.0 dB	2.9 dB N/F
1296 MHz	13.0 dB	3.5 dB N/F
2304 MHz	8.8 dB	4.2 dB N/F

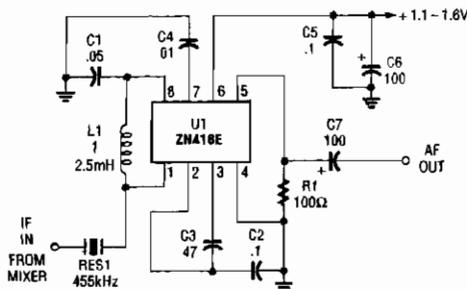


73 AMATEUR RADIO

FIG. 86-18

Based on an MAR-6 preamp, this circuit yields low noise figures and useful gain for the 144-MHz to 2304-MHz amateur bands.

### 455-kHz IF AMPLIFIER

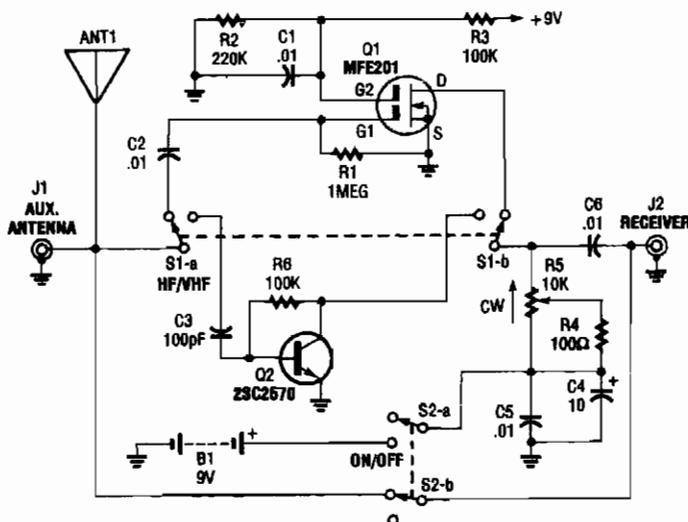


POPULAR ELECTRONICS

FIG. 86-19

Up to 60 dB of gain at 455 kHz is available with the MC1350P. RES1 is a ceramic resonator, LC, or crystal filter. Keep the leads to pins, 1, 2, 3, and 7 short.

## SWITCHABLE HF/VHF ACTIVE ANTENNA

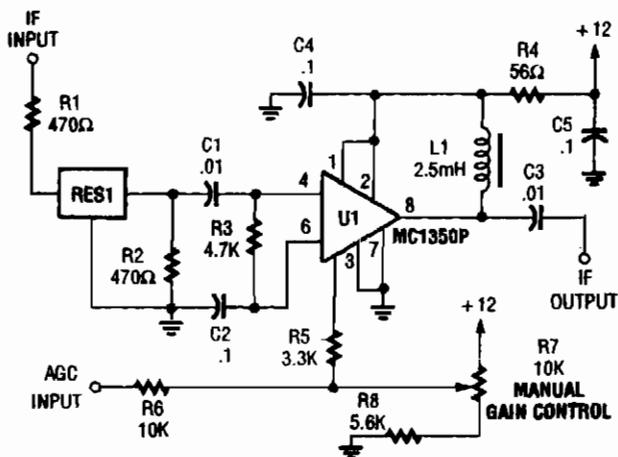


POPULAR ELECTRONICS

FIG. 86-20

The AA-7 active antenna contains only two active elements: Q1 (an MFE201 N-channel dual-gate FET) and Q2 (a 2SC2570 npn VHF silicon transistor), which provide the basis of two independent, switchable RF preamplifiers.

## 455-kHz IF AMP FOR 1.5-V OPERATION

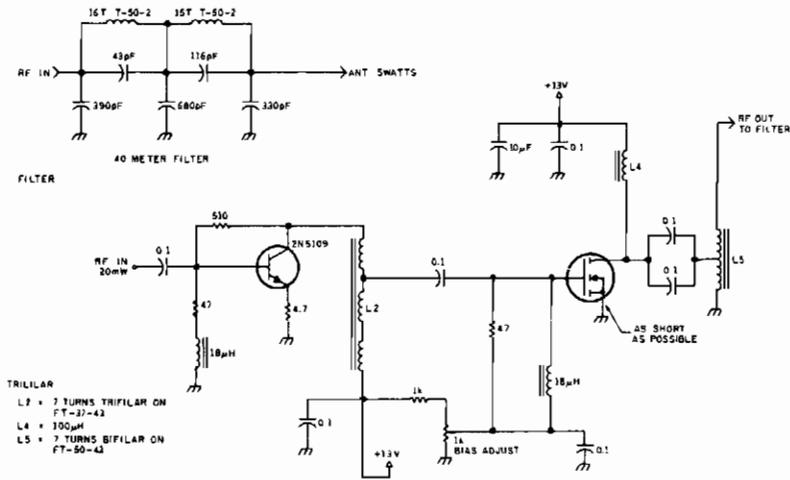


POPULAR ELECTRONICS

FIG. 86-21

The ZN416E can be configured as a simple 455-kHz IF amplifier. In this case, the circuit's center and bandwidth are set by RES1 (a Murata CSB455E ceramic resonator).

## 5-W 7-MHz RF POWER AMPLIFIER

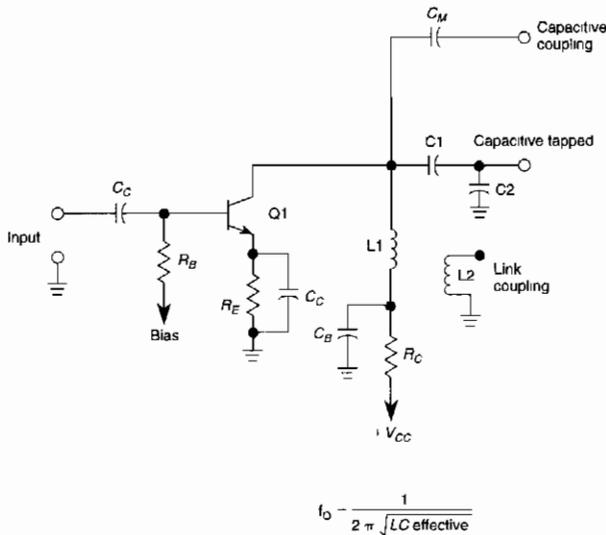


73 AMATEUR RADIO TODAY

FIG. 86-22

The circuit shown will produce up to 5-W RF output in the 40-m (7 MHz) amateur band. The coils shown are wound on toroidal cores (Armdon Associates Inc.). The part numbers are given in the schematic. The circuit requires about 20-mW drive and a 13-V supply.

## LC TUNED AMPLIFIERS



WILLIAM SHEETS

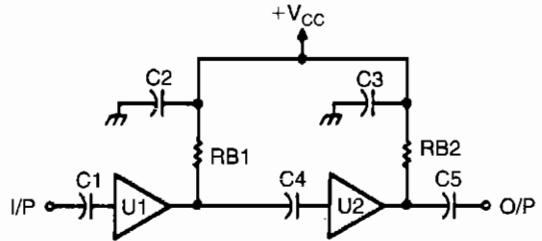
FIG. 86-23

This basic tuned LC amplifier can be used with three output coupling methods. They are capacitive coupling output, capacitive tapped output, or link-coupled output.

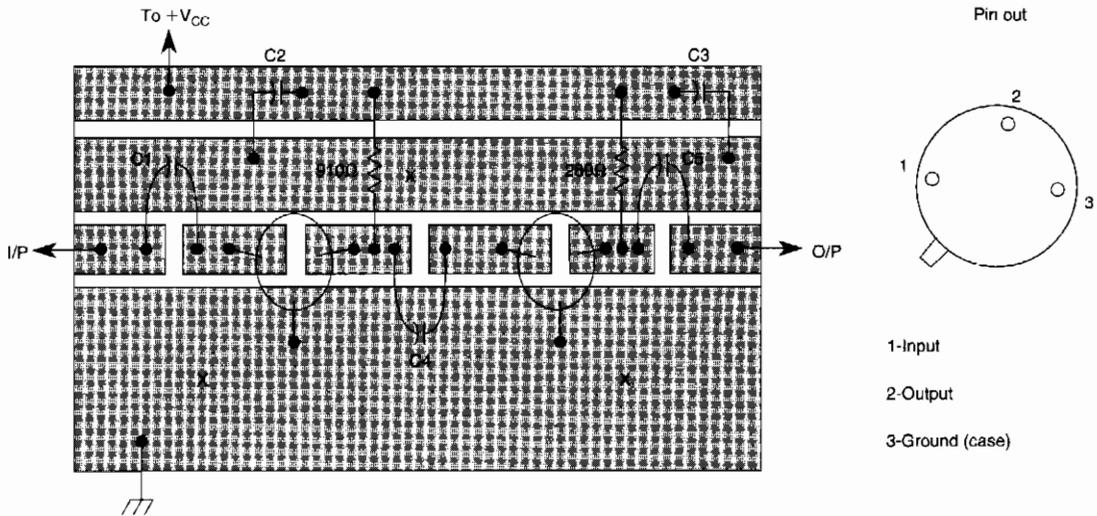
## WIDEBAND PREAMP

**Table 1.**

	V <sub>CC</sub>	V <sub>d</sub>	I <sub>d</sub>	R <sub>b</sub>
MWA110	5 V <sub>DC</sub>	2.9 V <sub>DC</sub>	10 mA	210Ω
	6			310Ω
	12			910Ω
MWA120	5	5.0	25	1Ω
	6			40Ω
	12			280Ω
MWA130	5	3.2	25	85Ω
	6			120Ω
	12			360Ω



V<sub>CC</sub> = 12 V<sub>DC</sub>; C1 to C5 = 0.1 μF; RB1 = 910Ω;  
RB2 = 280Ω; U1 = MWA110; U2 = MWA120



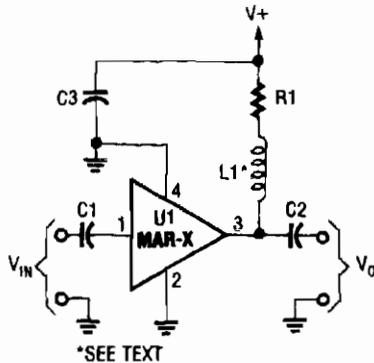
PC board layout (shading represents copper) and parts layout. "X" is the feedthrough wire to the ground plane. All capacitors are 0.1 μF. Keep all leads short.

Motorola MWA 110, 120, or 130 are wideband amplifier ICs. This wideband preamp circuit can be used in many applications. Keep the leads short when constructing the circuitry.

## RF PREAMPLIFIERS

**TABLE 1—MAR-X CAPABILITIES**

DEVICE	MAX. FREQ. (MHz)	GAIN (100/50/1000 MHz)	N.F.	COLOR
MAR-1	1,000	18.5/17.5/15.5	5	Brown
MAR-2	2,000	13/12.8/12.5	6.5	Red
MAR-3	2,000	13/12.8/12.5	6	Orange
MAR-4	1,000	8.2/8.2/8	7	Yellow
MAR-6	2,000	20/19/16	2.8	White
MAR-7	2,000	13.5/13.1/12.5	5	Violet
MAR-8	1,000	33/28/23	3.5	Blue

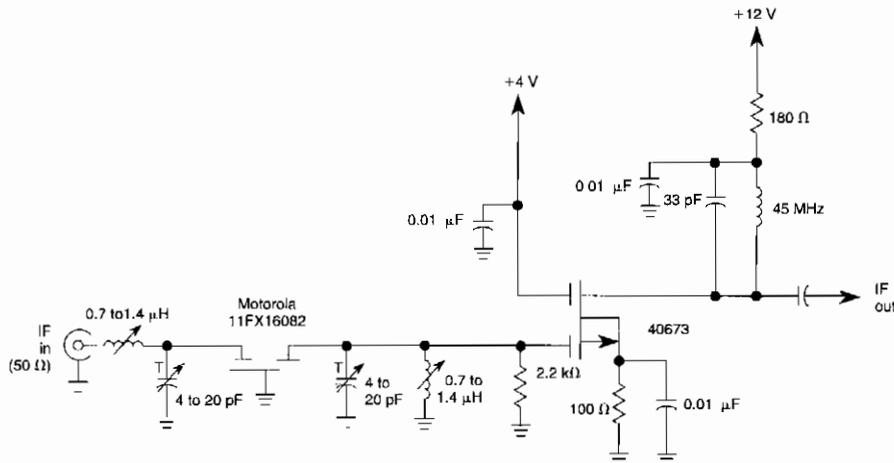


In this basic MAR-x-based circuit, both the input and output are comprised of a single dc-blocking capacitor (C1 and C2 for the input and output, respectively). The dc power-supply network (comprised of L1 and R1) is attached to the MAR-x via the RF-output terminal (lead 3).

POPULAR ELECTRONICS

**FIG. 86-25**

### 45-MHz IF AMPLIFIER WITH CRYSTAL FILTER



WILLIAM SHEETS

**FIG. 86-26**

A 40673 dual-gate MOSFET is matched to a crystal filter at 45 MHz. The filter impedance is around 2kΩ. The +4-V source can be made variable for gain control (about +4 to -4V.)

# 87

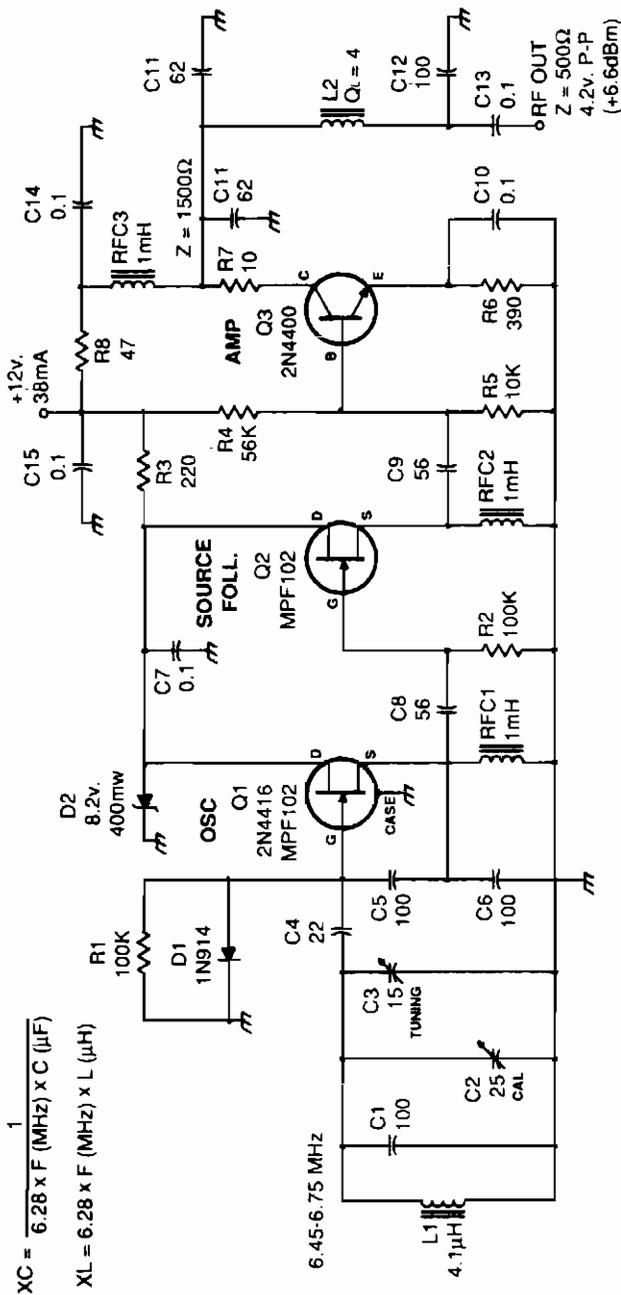
## RF Oscillator Circuits

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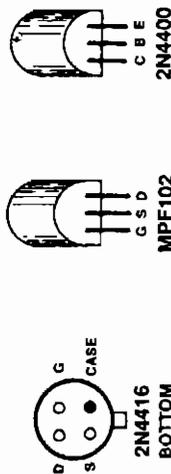
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

6.5-MHz VFO  
RF Signal Generator  
NE602 RF Oscillator Circuits  
A Shortwave Pulsed-Marker Oscillator  
Ham Band VFO

## 6.5-MHz VFO



Schematic diagram of the VFO. Fixed-value capacitors are disc ceramic. C1, C4, C5, C6, and C8 are NPO ceramic or polystyrene. C2 is a 25-pF ceramic trimmer and C3 is a 15-pF ceramic or polystyrene. C7 is a 25-pF ceramic trimmer and C11 is a 15-pF miniature air variable. Resistors are 1/4 watt carbon film or composition. The RF chokes are miniature Mouser Electronics No. 43LR103 units. For L1 use 32 turns of No. 28 enamel wire on an Amidon Assoc. T50-6 (yellow) toroid. L2 has 25 turns of No. 28 enamel wire on an Amidon FT-37-61 ferrite toroid.

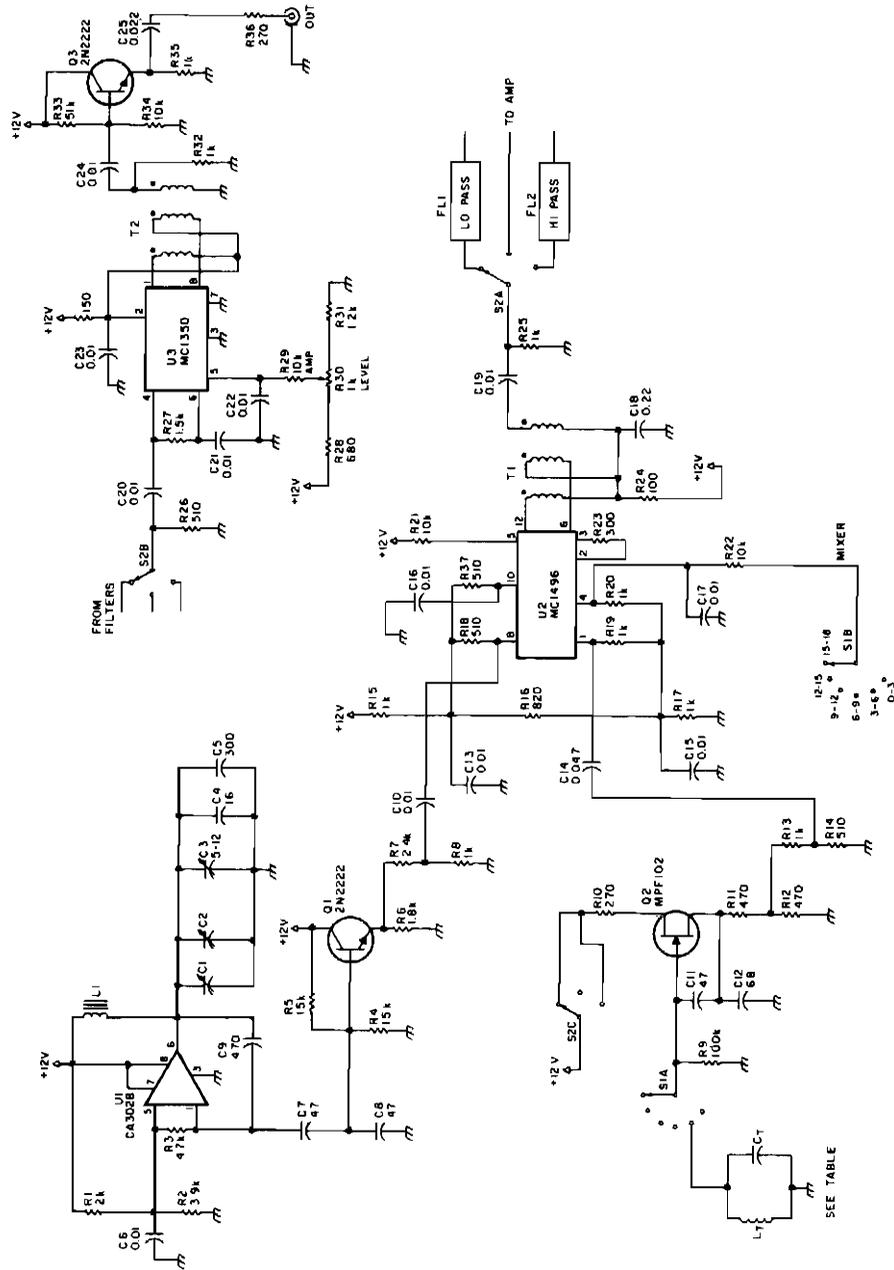


QST

FIG. 87-1

Fixed-value capacitors are disc ceramics. C1, C4, C5, C6, and C8 are NPO ceramic or polystyrene. C2 is a 25-pF ceramic trimmer and C3 is a 15-pF miniature air variable capacitor. The resistors are 1/4-W carbon film or composition. The RF chokes are miniature Mouser Electronics No. 43LR103 units. For L1, use 32 turns of #28 enamel wire on an Amidon Assoc. T50-6 (yellow) toroid. L2 has 25 turns of #28 enamel wire on an Amidon Ft-37-61 ferrite toroid.

RF SIGNAL GENERATOR

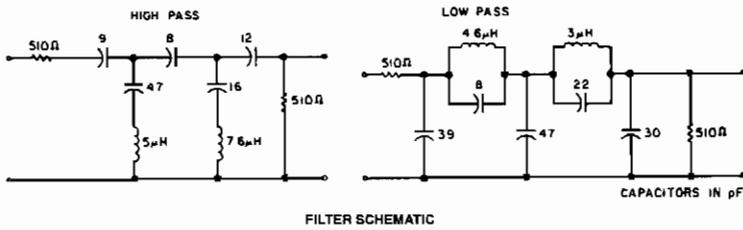


73 AMATEUR RADIO TODAY

FIG. 87-2A

This circuit uses a VFO operating from 15 to 18 MHz (U1), which feeds a balanced mixer (U2). A fixed oscillator signal is mixed with this signal to generate an output from 0.4 to 33 MHz. FL1 and FL2 are low- and high-pass filters that are used to eliminate undesired mixer products. Amplifier U3/Q3 supplies up to 200 mV rms to the output jack.

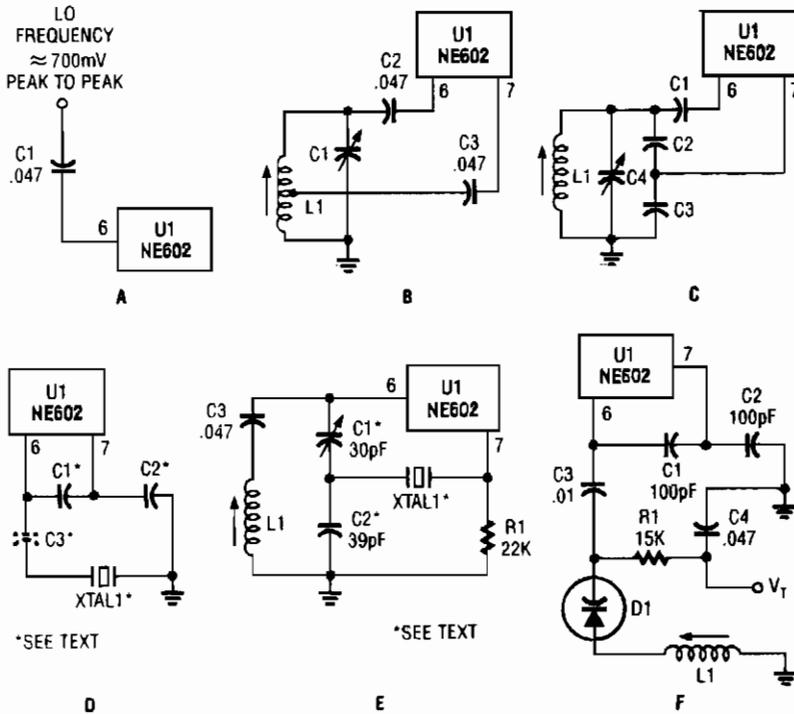
## RF SIGNAL GENERATOR (Cont.)



73 AMATEUR RADIO TODAY

FIG. 87-2B

## NE602 RF OSCILLATOR CIRCUITS

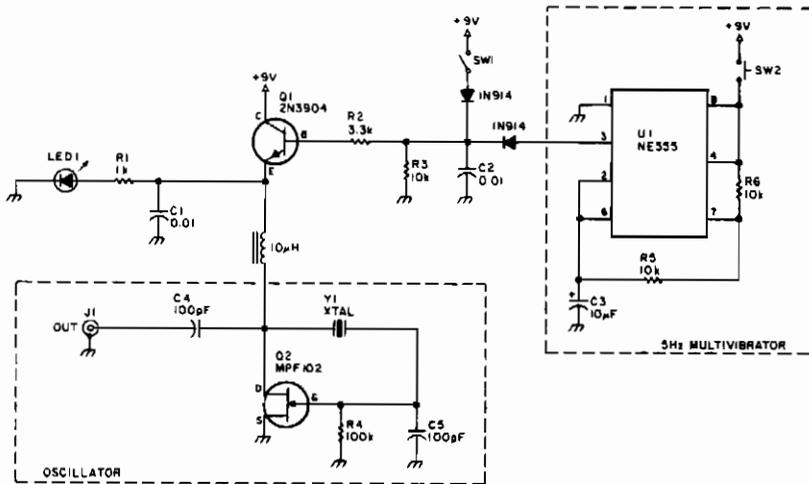


POPULAR ELECTRONICS

FIG. 87-3

Just about any standard oscillator (such as a Colpitts or Hartley configuration) can be used to generate the LO (local oscillator) frequency needed by the NE602.

## A SHORTWAVE PULSED-MARKER OSCILLATOR

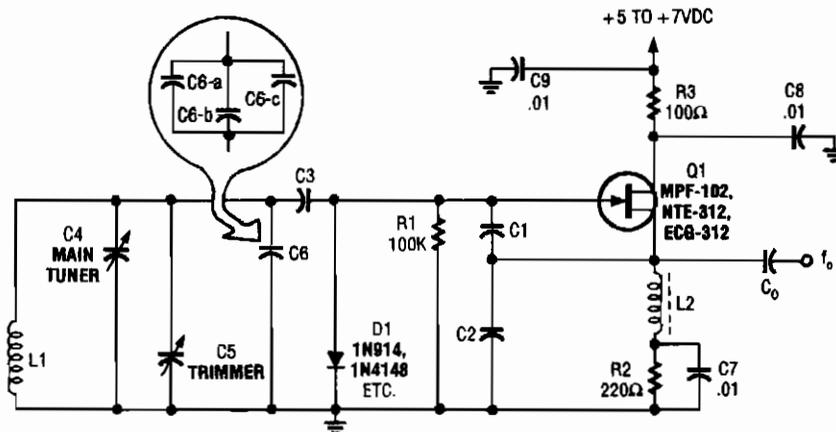


73 AMATEUR RADIO TODAY

FIG. 87-4

A useful marker oscillator can be made using an NE555 to pulse the oscillator at an audio rate. This makes it easy to find the signal in the presence of interference. The crystal can be any suitable frequency from 1 to 30 MHz.

## HAM BAND VFO



POPULAR ELECTRONICS

FIG. 87-5

This basic VFO for the 3- to 6-MHz range is commonly used in amateur applications, using a Colpitts circuit. For 5 to 5.5 MHz,  $C_1 = C_2 = 70$  pF and for 3.5 to 4.0 MHz, use 1000 pF.  $C_3$  is typically 10 to 220 pF, depending on the frequency.  $C_4$ ,  $C_5$ , and  $C_6$ , together with  $L_1$ , determine the frequency along with  $L_1$ .  $C_6$  can be made up of several smaller values, paralleled to get the exact required value.

# 88

## Sample-and-Hold Circuits

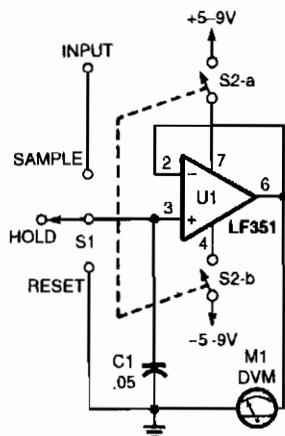
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sample-and-Hold Circuit I  
Sample-and-Hold Circuit II

## SAMPLE-AND-HOLD CIRCUIT I

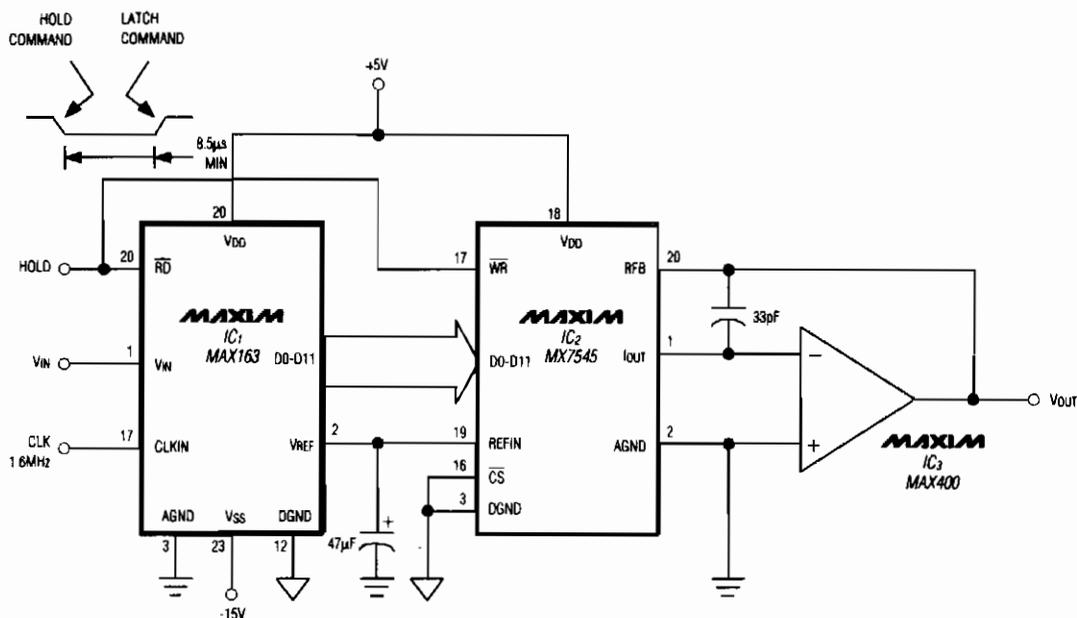


This circuit demonstrates the principle of the sample-and-hold circuit. S1 can be replaced by electronic switches (FET, etc.) in an actual application.

POPULAR ELECTRONICS

FIG. 88-1

## SAMPLE-AND-HOLD CIRCUIT II



MAXIM ENGINEERING JOURNAL

FIG. 88-2

Driving a D/A converter with an A/D converter provides an overall analog-hold function, which though limited in output resolution, offers zero voltage droop and infinite hold time. The A/D converter shown (IC1) includes a 12-bit compatible track/hold at its input. The track/hold specifies a 6-MHz full-power bandwidth, a 30-ns aperture delay, and a 50-ps aperture jitter. The direct connections shown allow the D/A converter to reconstruct signal levels within the input range of 0 to 5 V.

**89**

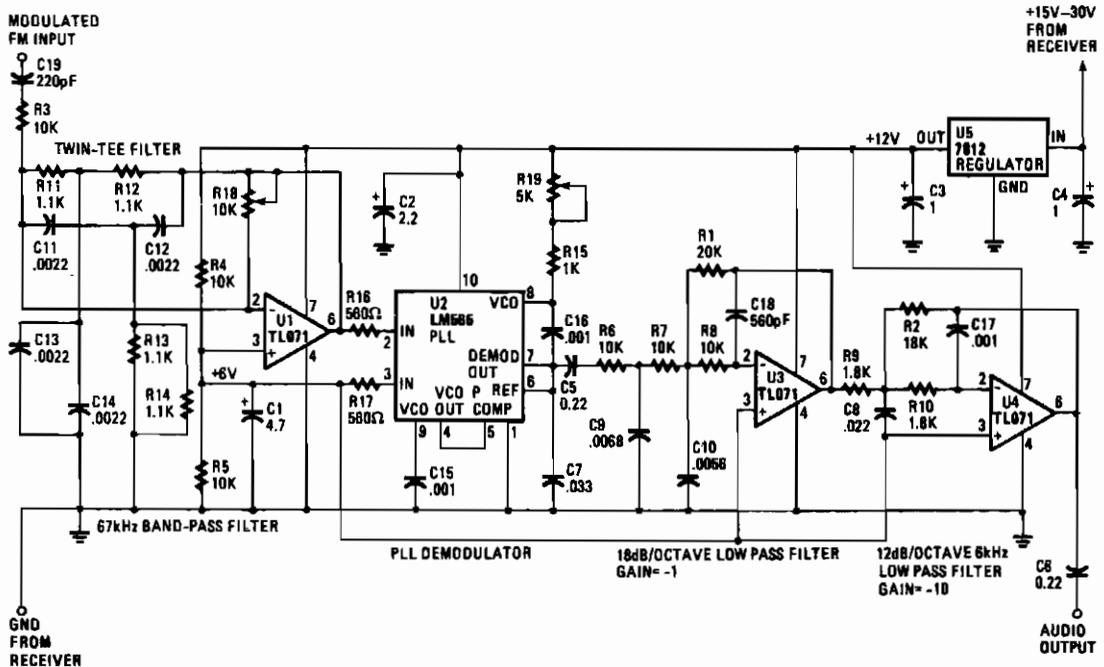
## **SCA Circuit**

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The source of the following circuit is contained in the Sources section, which begins on page 675. The figure number in the box of the circuit correlates to the entry in the Sources section.

Subcarrier Adapter for FM Tuners

## SUBCARRIER ADAPTER FOR FM TUNERS



1990 PE HOBBYIST HANDBOOK

FIG. 89-1

Op amp U1 and its associated components comprise the 67-kHz bandpass filter. A twin-T network, comprised of four 1100-Ω resistors and four 0.0022-μF capacitors, is connected in the feedback network of the op amp. That gives some gain at 67 kHz and heavy attenuation for frequencies above and below that frequency.

An additional passive filter at the input to the twin-T network (containing a 220-pF capacitor and a 10,000-Ω resistor) provides some additional roll-off for frequencies below 67 kHz.

In practice, the bandpass-filter action covers a frequency range of about 10 kHz above and below the 67-kHz center frequency. Resistor R18 sets the gain of the bandpass-filter stage.

Integrated-circuit U2 is a National LM565 phase-locked loop that modulates the 67-kHz frequency-modulated (FM) signal from U1. The LM565 PLL consists of a voltage-controlled oscillator (VCO) set to 67 kHz, and a comparator that compares the incoming frequency-modulated 67-kHz signal at pin 2 with the VCO signal that is fed into pin 5.

The output of the comparator represents the phase difference between the incoming signal and the VCO signal. Therefore, the output is the audio modulated by the subcarrier. A treble deemphasis of 150 μs is provided by a 0.033-μF capacitor (at pin 7).

The free-running VCO frequency is determined by the 0.001-μF capacitor at pin 9 and by the resistance between the positive rail and pin 8 (100 Ω in series with R19). Variable-resistor R19 adjusts the oscillator frequency (also known as the *center frequency*) so that the incoming signal is within the lock range of the PLL.

**90**

## **Shutdown Circuits**

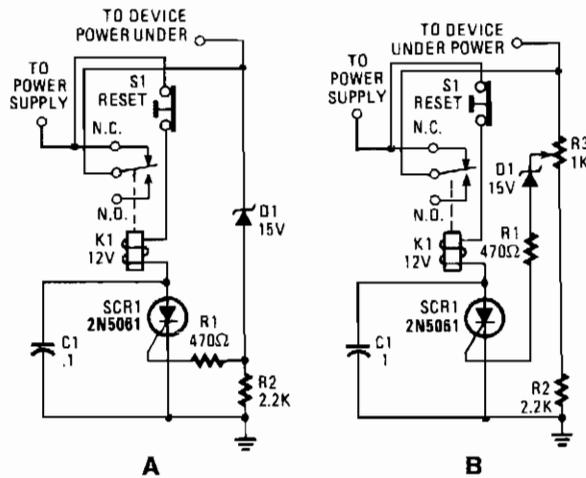
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Resettable Shutdown Circuits  
Shutdown Circuit

## RESETTABLE SHUTDOWN CIRCUITS



POPULAR ELECTRONICS

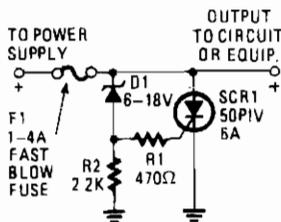
FIG. 90-1

If your circuits experience frequency overvoltage conditions, continually replacing blown fuses can get pretty expensive. However, this shutdown circuit overcomes that deficiency by replacing the fuse with a relay and a low-current SCR.

When the input voltage rises above the threshold set by the Zener diode (D1), a current of sufficient magnitude is applied to the gate of SCR1, which turns it on. That draws current through the relay coil and energizes it, which swings its commutator to its normally open contact, and disrupts power to the circuit under power. Switch S1, a normally closed pushbutton switch, is used to reset the circuit; it does so by interrupting power to the relay. When S1 is pressed, the relay's wiper arm returns to the normally closed position, restoring power to the connected circuit.

If you deal with a number of circuits that have different burn-out levels, try the circuit in B. That circuit variation, a variable trip-point shutdown circuit, allows you to adjust the shutdown threshold to whatever level you desire. The circuit adjustment allows for the 30% variance in the trip point. The zener diode should be selected to have a voltage rating that is slightly lower than the minimum desired threshold voltage.

## SHUTDOWN CIRCUIT



POPULAR ELECTRONICS

FIG. 90-2

Many modern devices have shutdown circuits that are designed to remove power from the device under power when the voltage rises above a predetermined threshold. This one blows a fuse to protect the device under power.

# 91

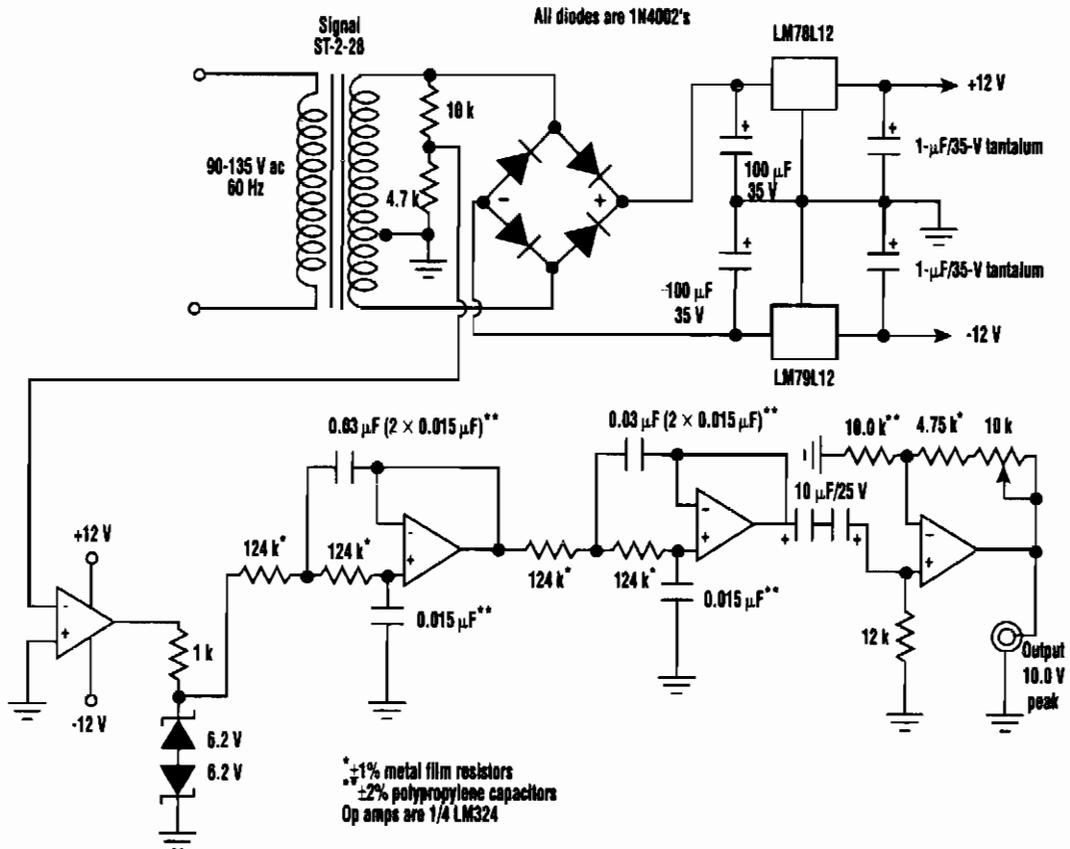
## Sine-Wave Oscillator Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

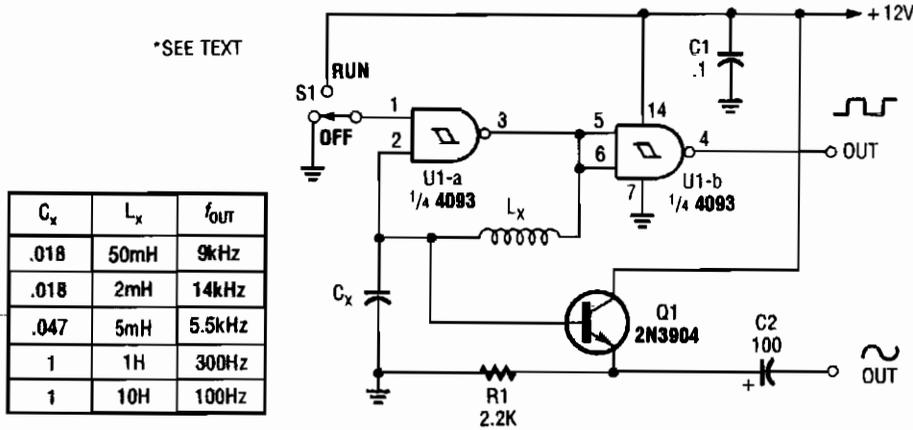
Highly Stable 60-Hz Sine-Wave Source  
Simple Sine-Wave Oscillator  
Wien-Bridge Sine-Wave Oscillator  
Battery-Powered Sine-Wave Generator  
1-Hz Sine-Wave Oscillator  
Simple Sine-Wave Generator  
Sinc-Wave Generator  
Sine-Wave Shaper  
Pure Sine-Wave Generator

## HIGHLY STABLE 60-Hz SINE-WAVE SOURCE



A highly-stable 60-Hz sine wave can be delivered with this circuit, which offers a different and much simpler approach to gaining a stable amplitude. Capacitor coupling the last stage removes any dc component caused by unequal zener voltages in the clipping circuit that follows the comparator.

## SIMPLE SINE-WAVE OSCILLATOR

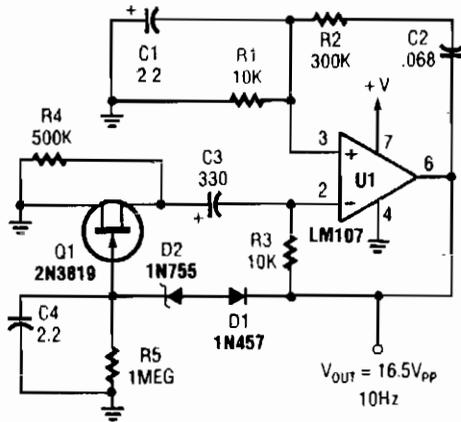


POPULAR ELECTRONICS

FIG. 91-2

Using an LC circuit, this CMOS oscillator generates sine waves.

## WIEN-BRIDGE SINE-WAVE OSCILLATOR

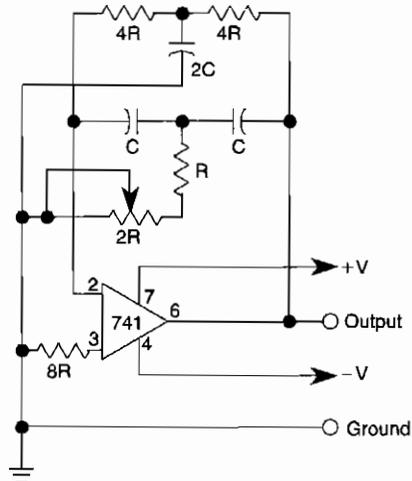


POPULAR ELECTRONICS

FIG. 91-3

This Wien-bridge sine-wave oscillator uses a 2N3819 as an amplitude stabilizer. The 2N3819 acts as a variable-resistance element in the Wien bridge.

## BATTERY-POWERED SINE-WAVE GENERATOR



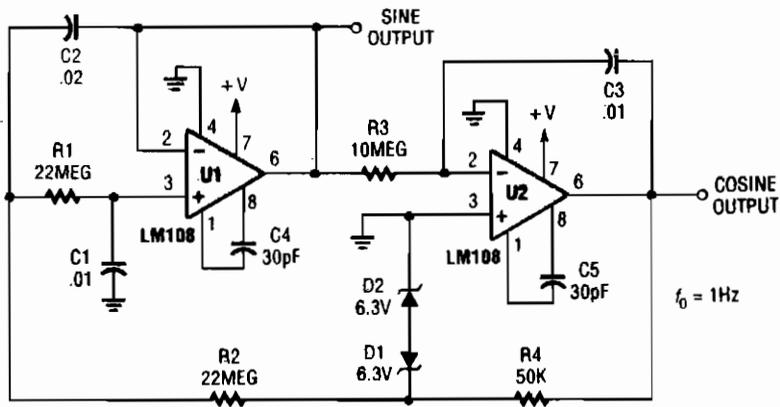
ELECTRONICS NOW

FIG. 91-4

The quality of the sine wave depends on how closely you match the components in the twin-T network in the op amp's feedback loop.

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

## 1-Hz SINE-WAVE OSCILLATOR

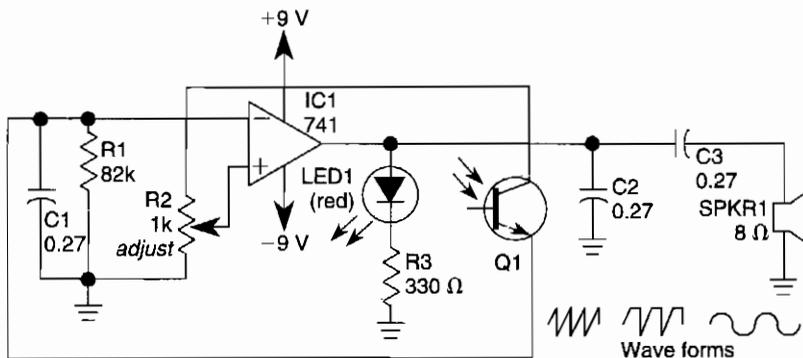


POPULAR ELECTRONICS

FIG. 91-5

This circuit produces a 1-Hz sine wave using two op amps. A single-chip dual op amp could be used as well.

## SIMPLE SINE-WAVE GENERATOR



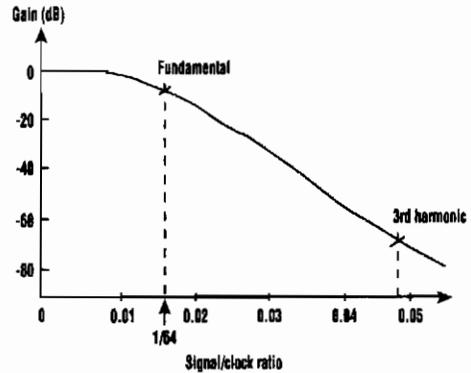
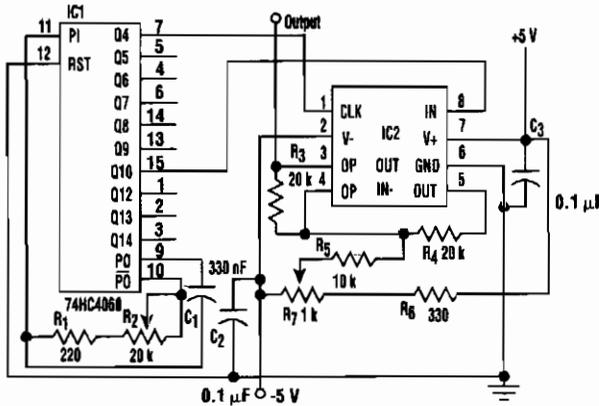
R-E EXPERIMENTERS HANDBOOK

FIG. 91-6

A 555 timer operating in the astable mode generates the driving pulses and two 4518 dual BCD (binary coded decimal) counters provide the square waves. A TL081 op amp serves as an output buffer-amplifier, and potentiometers R1 and R2 are used in order to control the pulse's frequency and amplitude, respectively.

The output-frequency range can be varied by changing  $C_x$ . For example, a value of 0.1  $\mu\text{F}$  gives a range from about 0.1 to 30 Hz, and a value of 470 pF gives a range from about 10 Hz to 1.5 kHz. The maximum output frequency is 30 kHz.

## SINE-WAVE GENERATOR

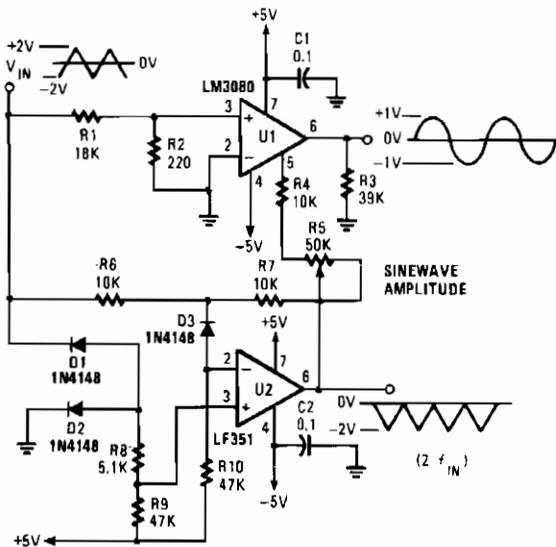


ELECTRONIC DESIGN

FIG. 91-7

In this circuit, a square wave is filtered by a high-order low-pass filter so that a  $-3$ -dB frequency will eliminate most harmonics of the waveform. As a result, the filter outputs a fundamental sine wave. This method is applied to generate a sine wave by using a switched-capacitor filter (MAX292) (see the figure). This circuit offers wide frequency range (0.1 Hz to 25 kHz), low distortion, and constant output amplitude throughout the whole frequency range.

## SINE-WAVE SHAPER

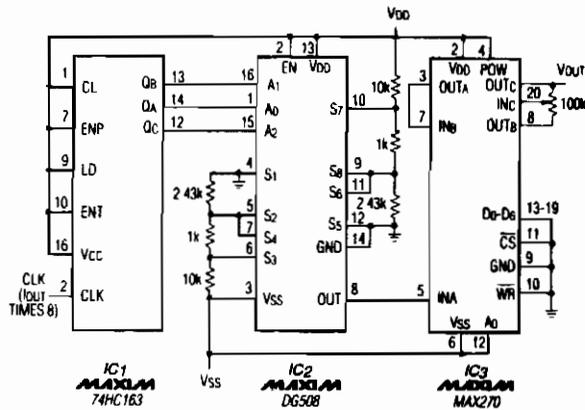


Unlike most sine-wave shapers, this circuit is temperature stable. It varies the gain of a transconductance amplifier to transform an input triangle wave into a good sine-wave approximation.

POPULAR ELECTRONICS

FIG. 91-8

## PURE SINE-WAVE GENERATOR



**NOTES:**  
 VDD TYPICALLY IS 5V  
 VSS TYPICALLY IS -5V

A TTL counter, an 8-channel analog multiplexer, and a fourth-order low-pass filter can generate 10- to 25-kHz sine waves with a THD better than -80 dB. The circuit cascades the two second-order, continuous-time Sallen-Key filters within IC3 to implement the fourth-order low-pass filter.

To operate the circuit, choose the filter's cutoff frequency,  $f_C$ , by tying IC3's  $D_0$  through  $D_6$  inputs to 5 V or ground. The cutoff frequency can be at 128 possible levels between 1 and 25 kHz, depending on those seven digital input levels. Because the circuit ties  $D_0$  through  $D_6$  to ground,  $f_C$  equals 1 kHz. The 100-kΩ potentiometer adjusts the output level between  $V_{DD} - 1.5$  V and  $V_{SS} + 1.5$  V.

## Sound- and Voice-Controlled Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Vocal Stripper  
Sleep-Mode Circuit  
Sonic Kaleidoscope  
Automatic Fader  
Voice Identifier for Ham Radio Use  
Whistle Switch  
Audio Light  
Voice-Activated Switch and Amplifier  
Audio-Controlled Switch  
Speech Scrambler  
Audio-Controlled Mains Switch

# VOCAL STRIPPER

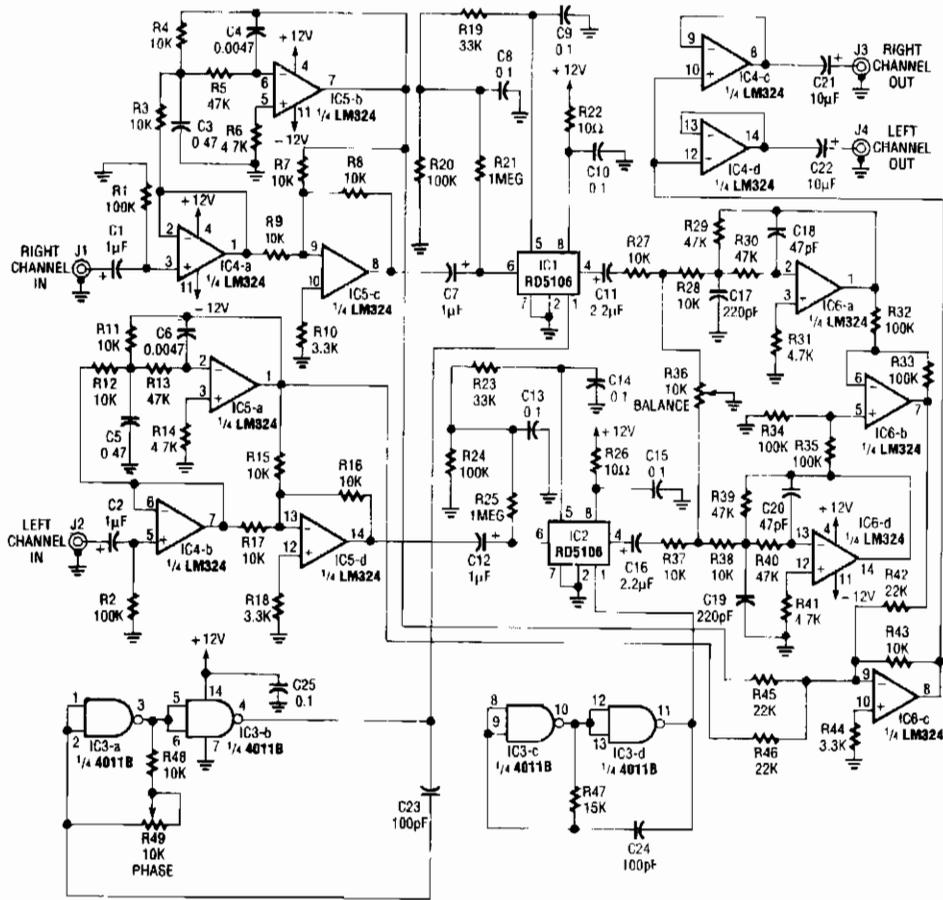


FIG. 92-1A

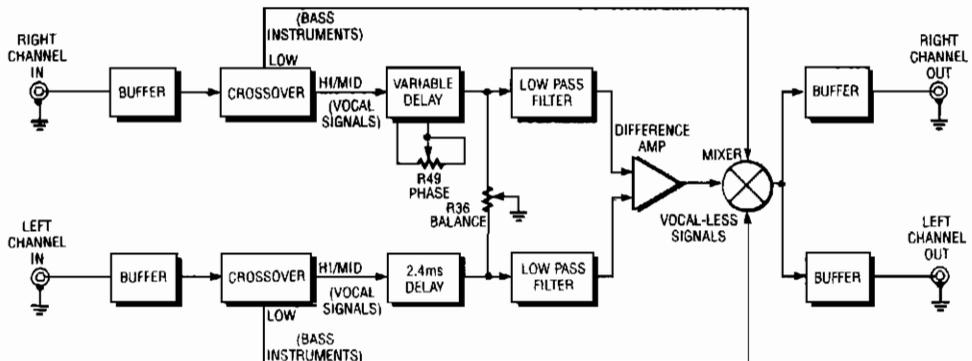
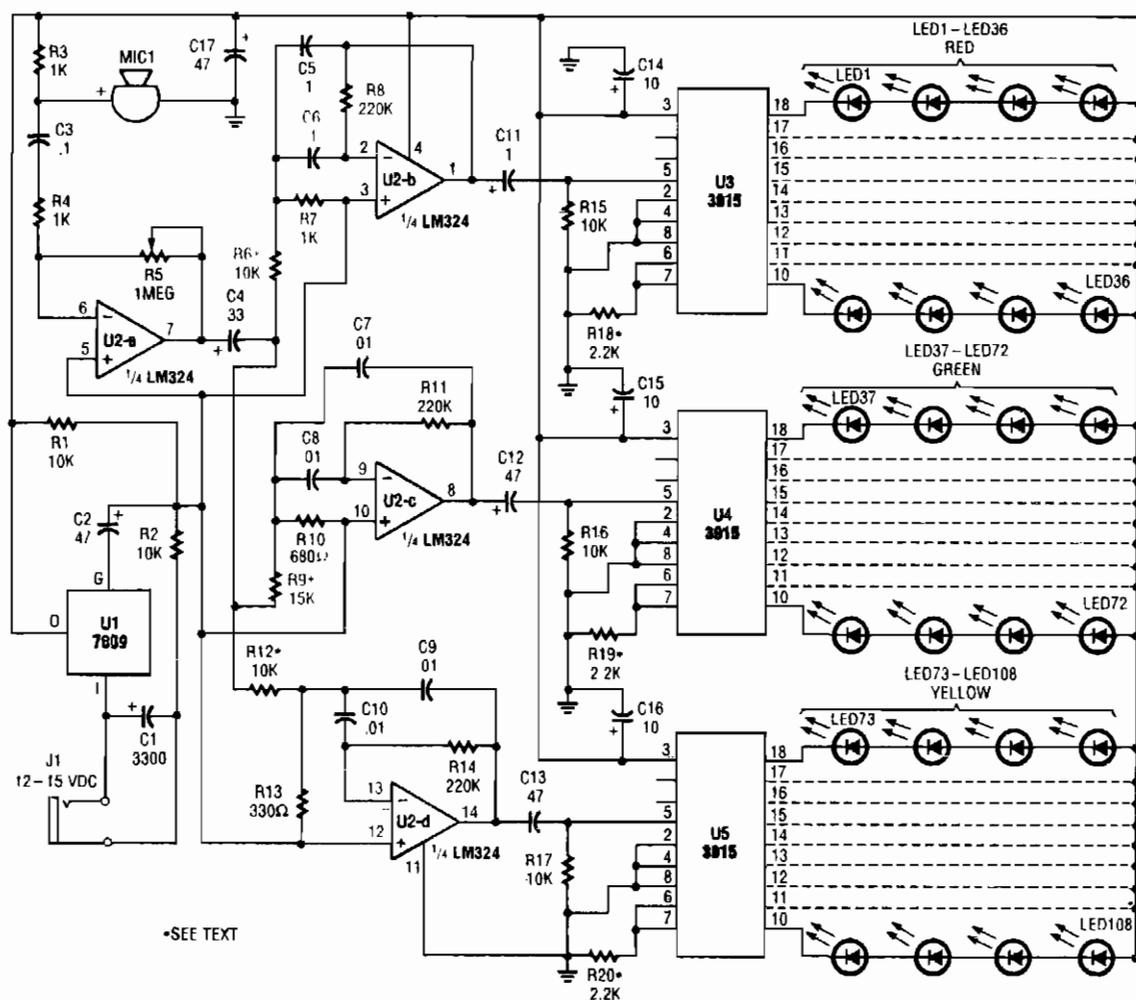


FIG. 92-1B



## SONIC KALEIDOSCOPE



POPULAR ELECTRONICS

FIG. 92-3

The microphone input, MIC1, is fed through C3 and R4 to inverting amplifier U2-a; the gain of U2-a is controlled by potentiometer R5. The output of U2-a is fed through C4 to the remaining op-amps (U2-b, U2-c, U2-d), which are all configured as band-pass filters. Each filter is tuned to pass a different range of frequencies by its resistor/capacitor combination. With the values shown, U2-b, U2-c, and U2-d have center frequencies of roughly 100, 1000 and 1500 Hz, respectively.

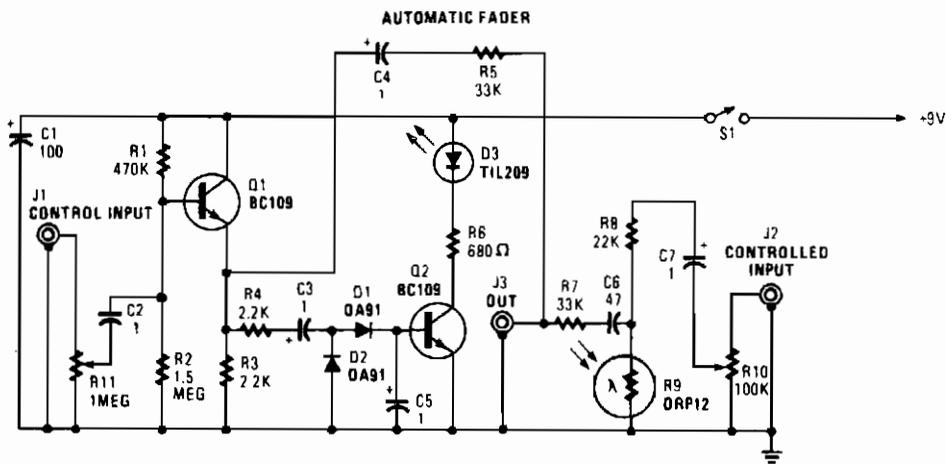
Resistors R6, R9, R12 control the bandwidth and gain of their respective filter circuits, and can range in value from 10 to 15 k $\Omega$ . The output of U2-b is capacitively coupled via C11 to the input of U3, with R15 serving as the load resistor for U2-b. That resistor also keeps U3's outputs from "floating" in the absence of a signal. Connected as shown, U3 uses its own internal voltage reference to make a full-scale display of 1.2 V.

## SONIC KALEIDOSCOPE (Cont.)

Each of the nine outputs of U3 (output 1 is not used) sinks four, series-connected (red) LEDs. Op amps U2-c and U2-d are similarly connected to U4 and U5, respectively, driving green and yellow LED strings. Resistors R18, R19, and R20 control the brightness of their corresponding LED arrays, and they must be adjusted accordingly; different colors of LEDs usually vary in brightness. A lower value of resistance will make the LEDs glow brighter.

Power for the circuit is supplied by a 500 mA, 12–15-Vdc wall-pack transformer, via J1. The output of the transformer is filtered by C1 and is regulated by U1; regulation is necessary to keep power-line ripple from affecting the display. The supply pins of U2 through U5 are bypassed by capacitors C14 through C17 to further ensure stability. An on/off switch was deemed unnecessary because the power supply should be unplugged when the unit is not in use.

## AUTOMATIC FADER

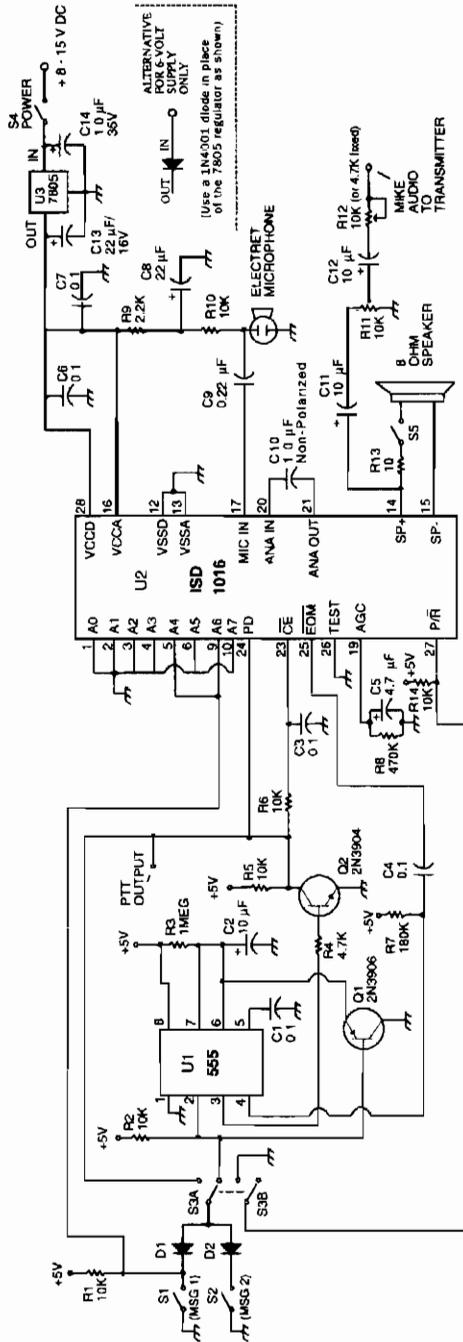


POPULAR ELECTRONICS

FIG. 92-4

In this circuit, audio fed to the control channel is amplified and rectified by D1 and D2. This dc level activates LED D3 via Q2. The light from D3 causes R9, a light-dependent resistor to decrease resistance. As R11 (audio gain) is set higher, more audio is present at the output of Q1. Audio fed into J2 is shunted to ground via R9 and less of this audio appears at J3. Therefore, audio at J1 controls the audio level fed to J3 from J2 and produces a fade effect.

### VOICE IDENTIFIER FOR HAM RADIO USE

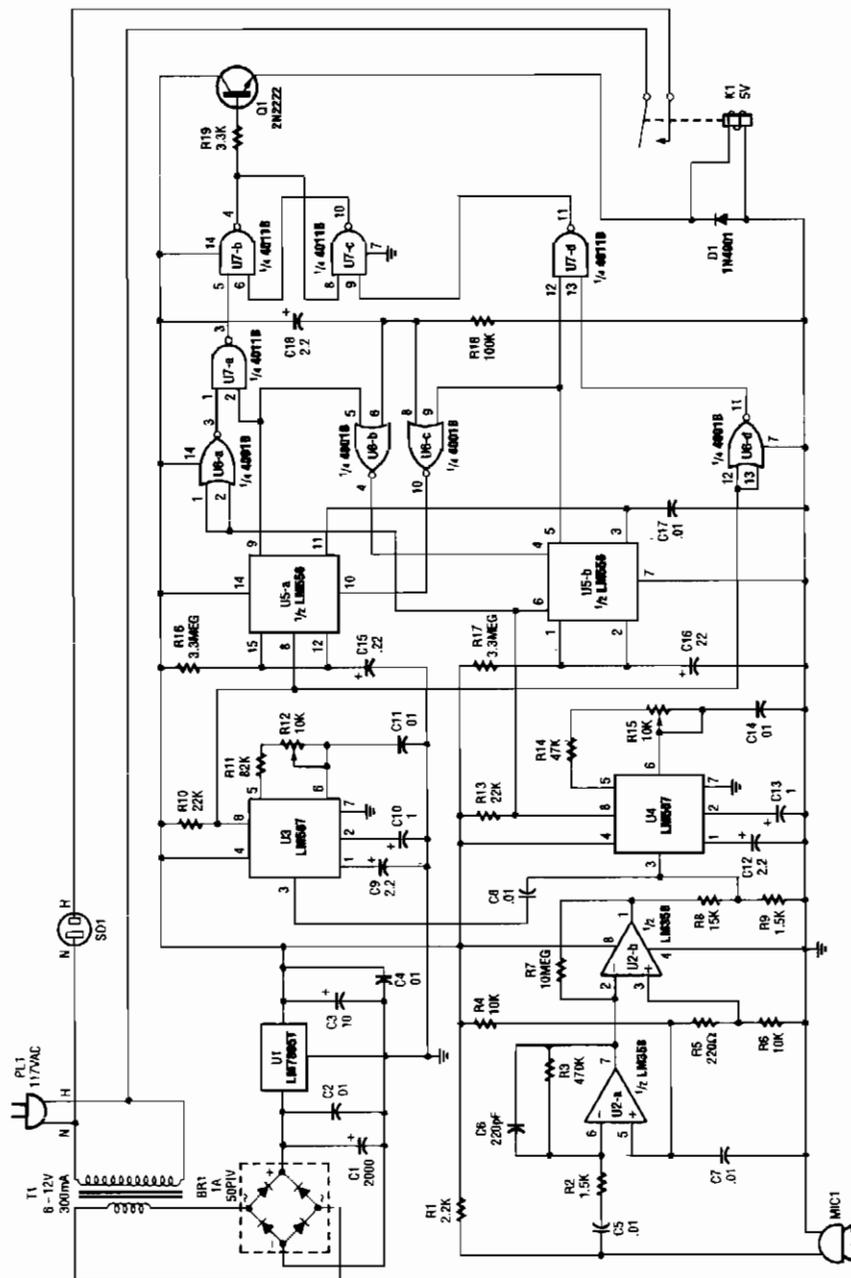


73 AMATEUR RADIO TODAY

FIG. 92-5

Using an ISD1016 audio record/playback chip (Information Storage Devices, Inc.), this circuit records and plays back messages on command. Although intended for use with transmitters, it can be used as an electronic notepad, etc. Consult the ISD1016 data sheet for other applications.

## WHISTLE SWITCH

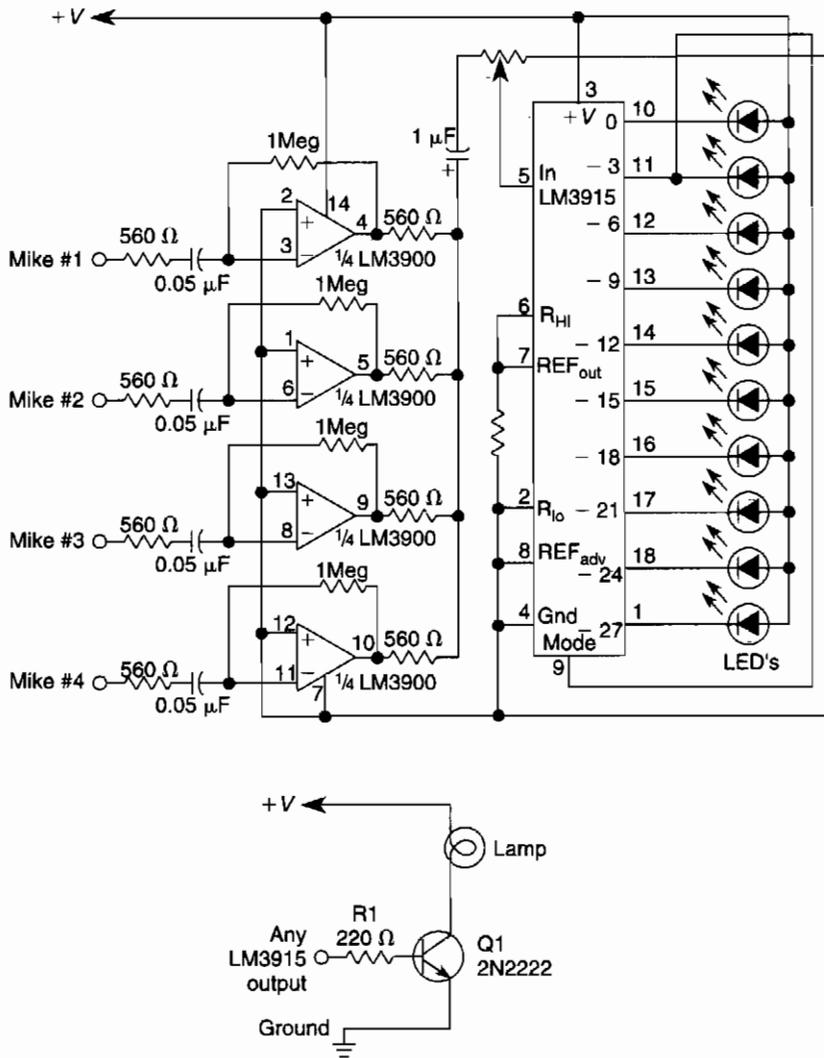


### POPULAR ELECTRONICS

FIG. 92-6

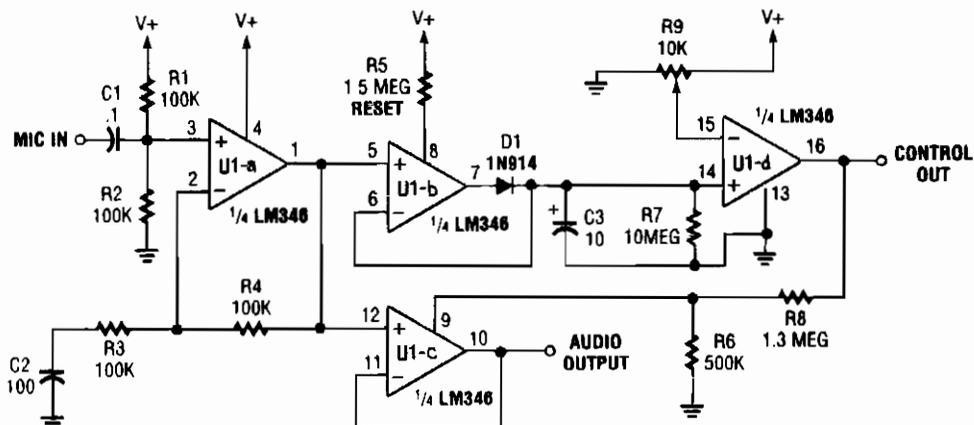
At the heart of the whistle switch are a pair of tone detectors, each of which is built around an LM567 tone decoder, which are supported by a minimum of additional components. This whistle switch is designed to respond to only two or more occurrences of a specific tone, or sequence of tones, within a specified period to prevent false triggering. Depending on the relay used, various ac loads can be controlled. Microphone MIC1 picks up the sound and U5-a and U5-b and the logic circuits that drive relay K1. These devices trigger U5-a and U5-b and the logic circuits that drive relay K1.

## AUDIO LIGHT



This circuit will produce an output when the sound exceeds a preset level. The LM3915 is a log-output bar graph driver. Use the transistor driver shown for higher current loads. To drive heavy-current loads with an LM3915 output, you must add a transistor, as shown in B.

## VOICE-ACTIVATED SWITCH AND AMPLIFIER

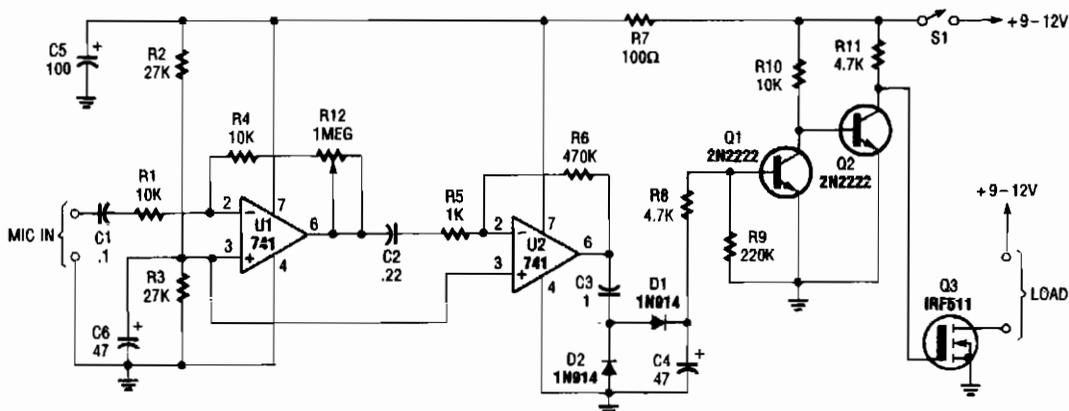


POPULAR ELECTRONICS

FIG. 92-8

In certain applications, such as transmitter or other communications and control applications, this circuit should be useful. Both audio output and dc control outputs are provided. R9 sets the control threshold.

## AUDIO-CONTROLLED SWITCH

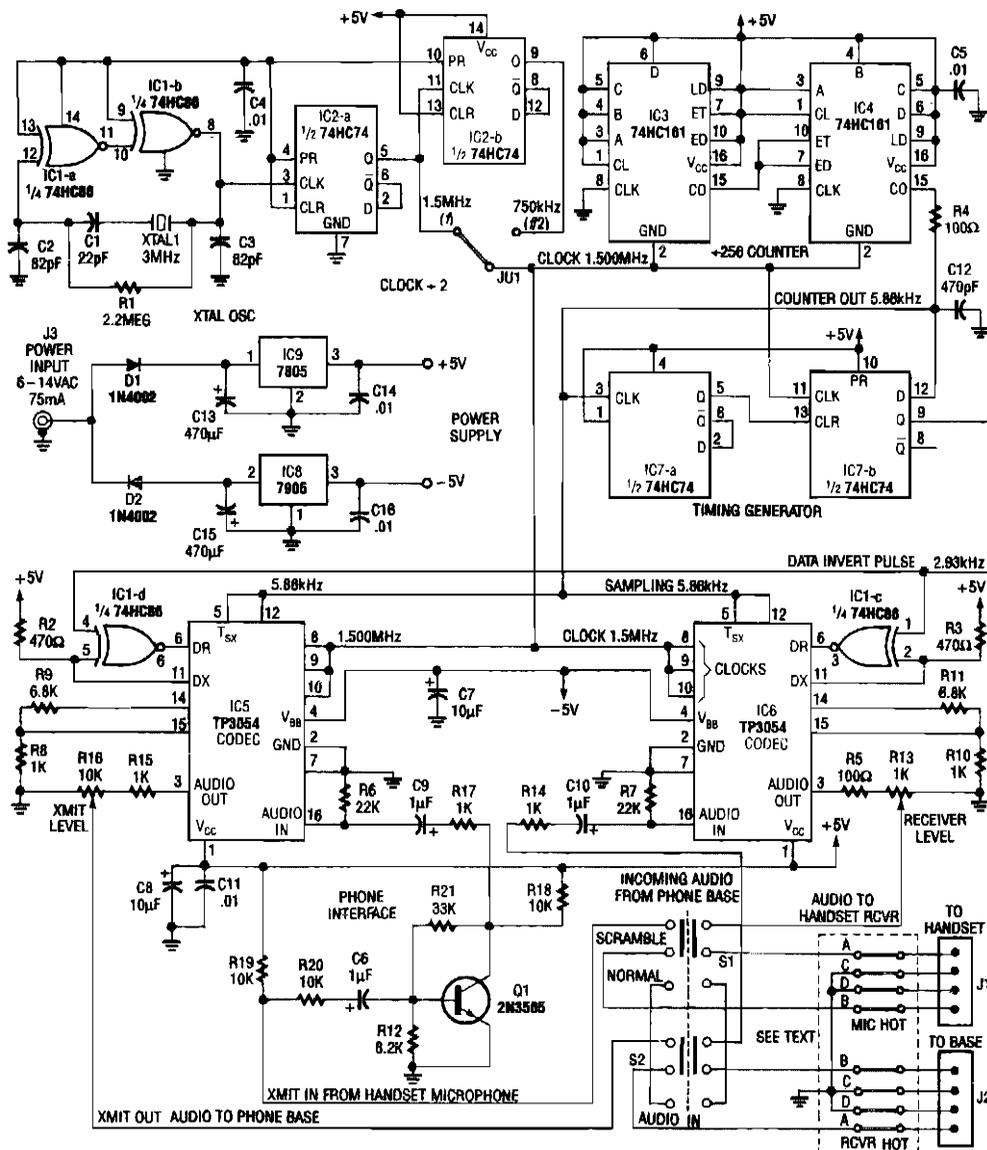


POPULAR ELECTRONICS

FIG. 92-9

The audio-controlled switch combines a pair of 741 op amps, two 2N2222 general-purpose transistors, a hexFET, and a few support components to a circuit that can be used to turn on a tape recorder, a transmitter, or just about anything that uses sound.

## SPEECH SCRAMBLER



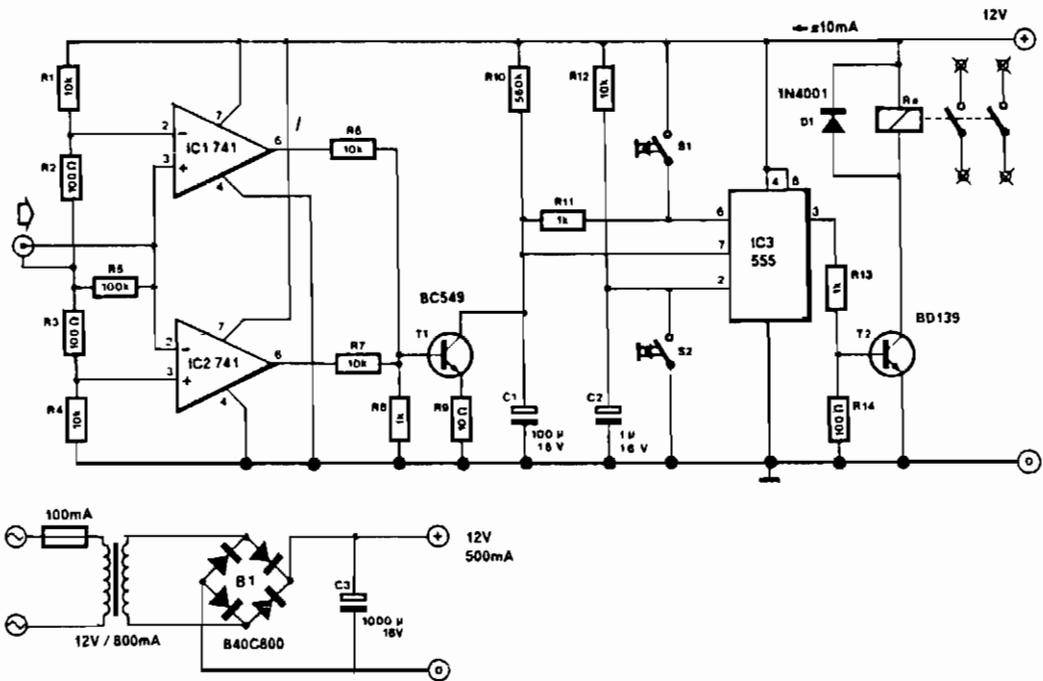
ELECTRONICS NOW

FIG. 92-10

Using digital techniques, this circuit accomplishes the frequency-inversion algorithm via digitization of the audio, inversion of the sign of every alternate sample, and D/A conversion of the resultant data. The result is an inverted frequency spectrum. Because the circuit has two channels, this system can be used in a full duplex two-way telephone scrambler.

A complete kit of parts is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804-0053A.

## AUDIO-CONTROLLED MAINS SWITCH



303 CIRCUITS

FIG. 92-11

This circuit will switch off the line supply to audio or video equipment if there has been no input signal for about 2 seconds. S1 provides manual operation and S2 acts as a reset. This circuit allows for time to change a tape or compact disc. About 50 mV of audio signal is necessary.

# 93

## Sound-Effects Circuits

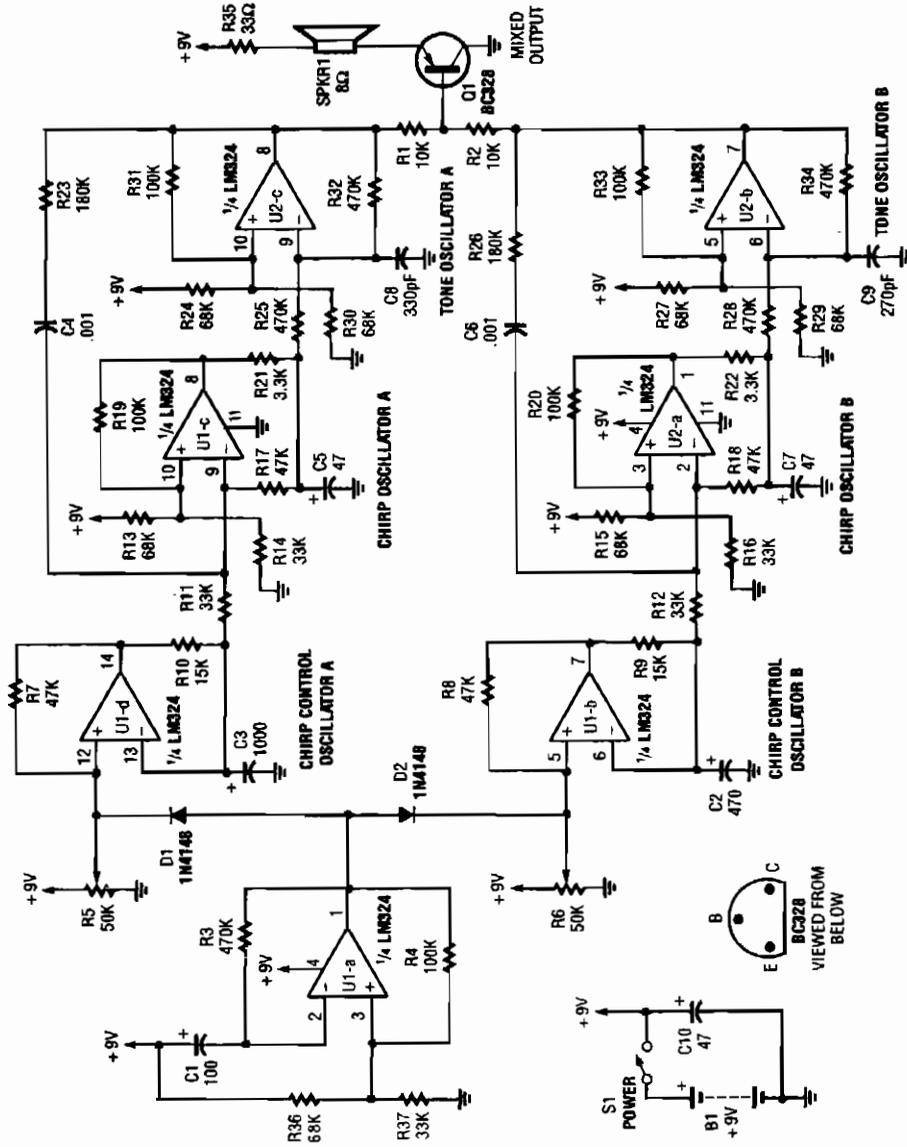
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Canary Sound Simulator  
110-dB Beeper  
Siren Alarm  
1000-Hz Pulsed-Tone Alarm  
Tone Chime  
Spaceship Alarm  
10-Note Sound Synthesizer  
Spacc-Age Sound Machine

Electronic Gong  
Alarm Tone Generator  
Dual-Tone Sounder  
Low-Level Sounder  
Sound-Effects Generator  
Siren  
Simple Multi-Tone Generator  
Siren Oscillator

# CANARY SOUND SIMULATOR

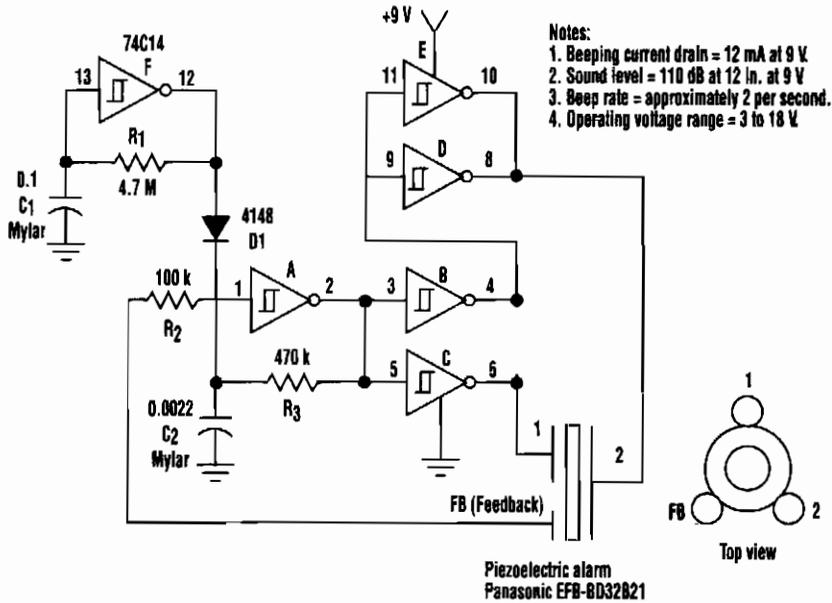


POPULAR ELECTRONICS

FIG. 93-1

This circuit generates the sound of two canaries singing in a cage. Two LM324 quad amps make up seven oscillators. One oscillator is an on/off control, the other six generate the sounds of two canaries. A 9-V supply powers the circuit.

## 110-dB BEEPER



ELECTRONIC DESIGN

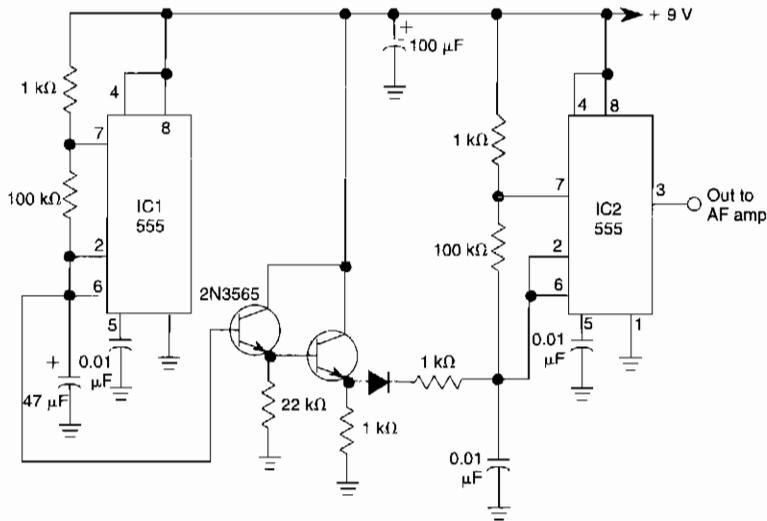
FIG. 93-2

This circuit will generate an ear-splitting 110 dB from 9 V. The setup uses a single 74C14 (CD40106B) CMOS hex inverting Schmitt-trigger IC, which must be used with a piezoelectric device with a feedback terminal. The feedback terminal is attached to a central region on the piezoelectric wafer. When the beeper is driven at resonance, the feedback signal peaks.

One inverter of the 74C14 is wired as an astable oscillator. The frequency is chosen to be 5 times lower than the 3.2 kHz resonant frequency of the piezoelectric device. Feedback from the third pin of the beeper reinforces the correct drive frequency to ensure maximum sound output.

Four other inverter sections of the IC are wired to form two separate drivers. The output of one section is cross-wired to the input of the second section. The differential drive signal that results produces about 18-V p-p when measured across the beeper. The last inverter section is wired as a second astable oscillator with a frequency of about 2 Hz. It gates the main oscillator on and off through a diode. For a continuous tone, the modulation circuit can be deleted.

## SIREN ALARM

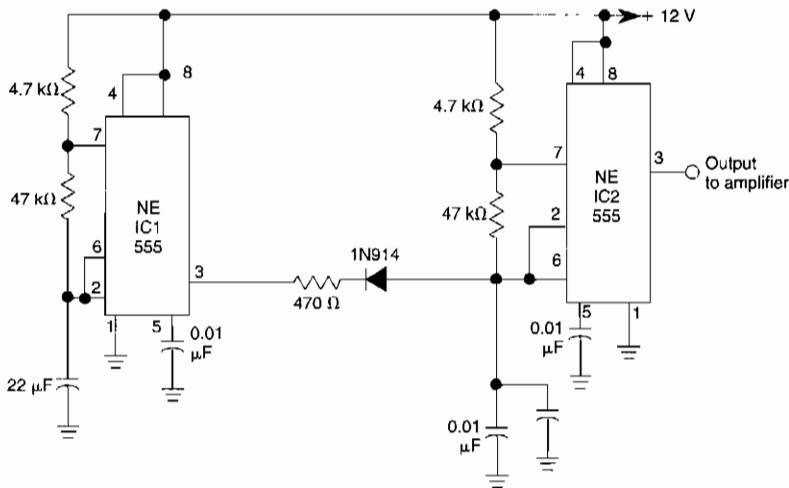


WILLIAM SHEETS

FIG. 93-3

The ramp voltage from the low frequency oscillator IC1 modulates IC2 thereby producing a rising and falling tone like the siren wail of police cars.

## 1000-Hz PULSED-TONE ALARM

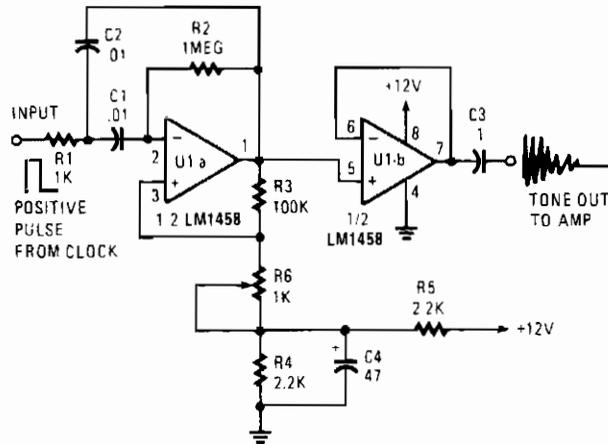


WILLIAM SHEETS

FIG. 93-4

IC1 generates a pulse that modulates the 1000-Hz tone generated by IC2. This circuit can be used to generate warning or alert signals.

## TONE CHIME

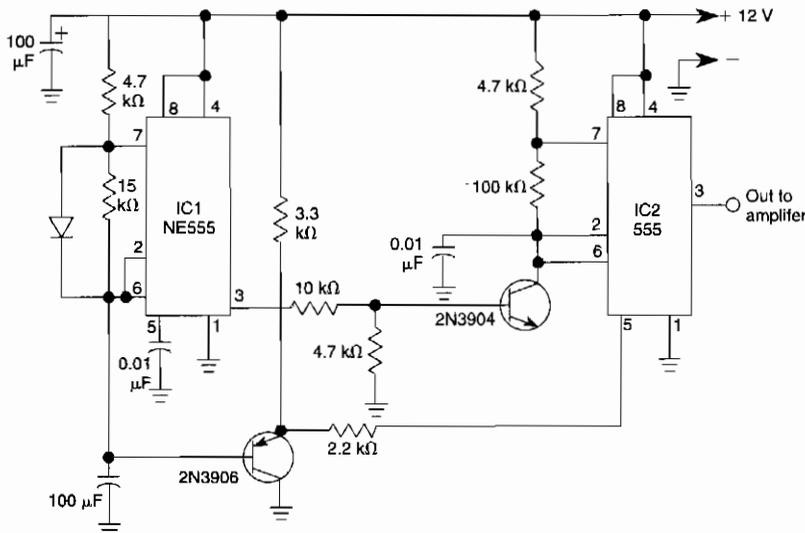


POPULAR ELECTRONICS

FIG. 93-5

A positive pulse input to R1 causes the active filter U1-a to “ring.” If the gain is set too high (R6), the circuit will oscillate. R6 controls the positive feedback and the Q of the circuit. C1 and C2 can be changed to adjust the tone frequency.

## SPACESHIP ALARM

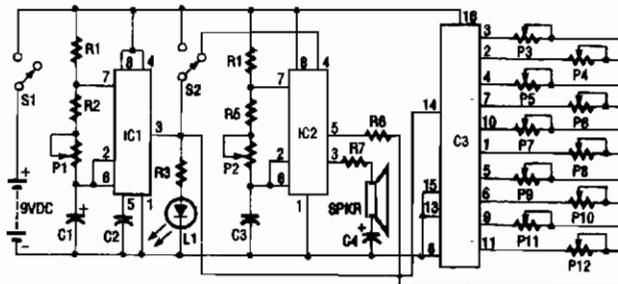


WILLIAM SHEETS

FIG. 93-6

By using two 555 timers this circuit produces a low frequency tone that rises to a high frequency tone in a little over 1 second. Then the sound stops for about 0.3 seconds, thereafter the cycle repeats. To produce the alarm sound of the Star Trek spaceship.

## 10-NOTE SOUND SYNTHESIZER

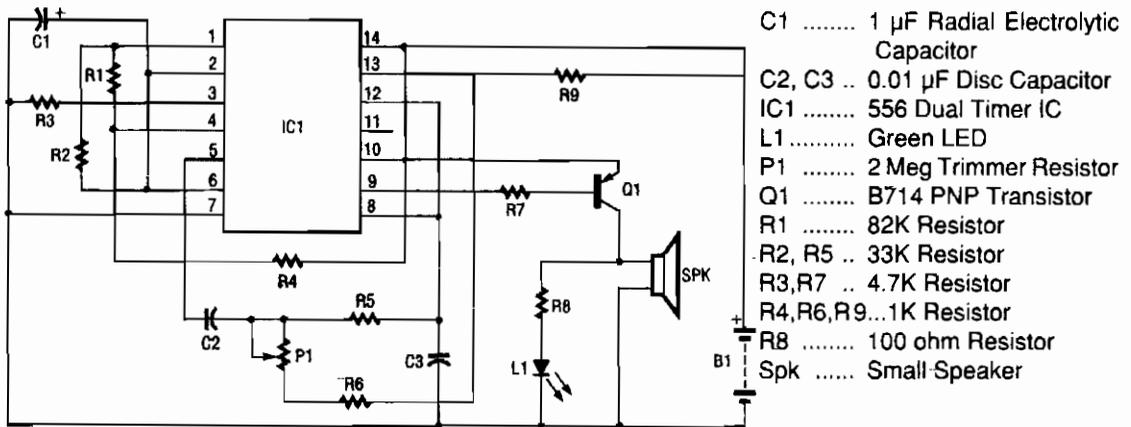


C1	.....	22 $\mu$ F	Electrolytic Capacitor
C2	.....	0.01 $\mu$ F	Capacitor
C3	.....	0.1 $\mu$ F	Capacitor (104k)
C4	.....	10 $\mu$ F	Capacitor
IC1, IC2	.....		555 Timer IC
IC3	.....		4017 IC
L1	.....		Red LED
P1-P12	.....		5k Trimmer Resistor
R1, R3, R4	.....		1k Resistor
R2	.....		200-ohm Resistor
R5	.....		4.7k Resistor
R6	.....		100-ohm Resistor
R7	.....		15-ohm Resistor
S1, S2	.....		SPDT Switch

As shown, three ICs are used to produce the sounds. IC1 is a 555 timer that generates clock pulses. It is configured as an astable multivibrator. The frequency of the clock pulses is set by trimmer potentiometer P1. These clock pulses are coupled to the input of IC3 (a 4017 CMOS Johnson counter) on its clock input pin 14. Each clock pulse causes IC3 to shift a "high" to each of its output pins in sequence. A trimmer resistor, which can be adjusted to set a different frequency for each note, is connected to each of IC3's output pins. One side of each of the trimmers is connected to pin 5 (the control voltage pin) of IC2.

IC2, another 555 timer IC, creates the tone; the overall pitch of the tone can be varied by P2. As the output sequences from the 4017, that tone, which is changed in frequency by each output shift is applied to a small speaker from pin 3 of IC2. An LED, which flashes with each clock pulse, is connected to pin 3 of IC1. Switch S2 is used to vary the sound between "flowing" and distinct notes.

## SPACE-AGE SOUND MACHINE

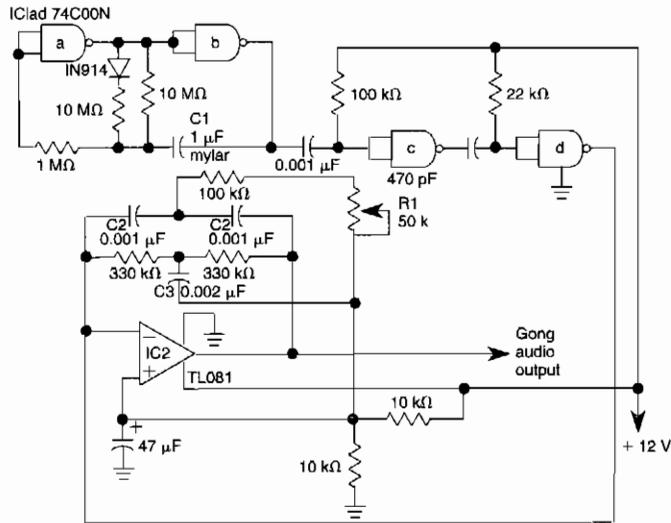


The space-age sound device uses a 556 dual-timer IC to produce a phasor sound. That IC is actually two 555 timer ICs in one 14-pin package, as shown in the schematic. Each timer inside the 556 is connected in an astable multivibrator mode.

The first timer has its frequency set by R1, R2, and C1. Its output appears on pin 5 and it is coupled through C2 and R5 into the trigger input of the second timer. The second timer has an adjustable frequency that is controlled by P1, R6, and C3.

In the second timer, the first frequency mixes with the second frequency and produces the phasor-like sounds. The output of the second timer, which has the two signals mixed together, is brought from pin 9 through limiting resistor R7 to the input of Q1. The function of pnp germanium power transistor Q1 is to amplify the signal to the level that is needed to drive the speaker. The green LED, L1, converts electrons directly into visible photons (light) in time with the pulses from the speaker. The purpose of resistor R8 is to limit the current through the LED to a safe level.

## ELECTRONIC GONG

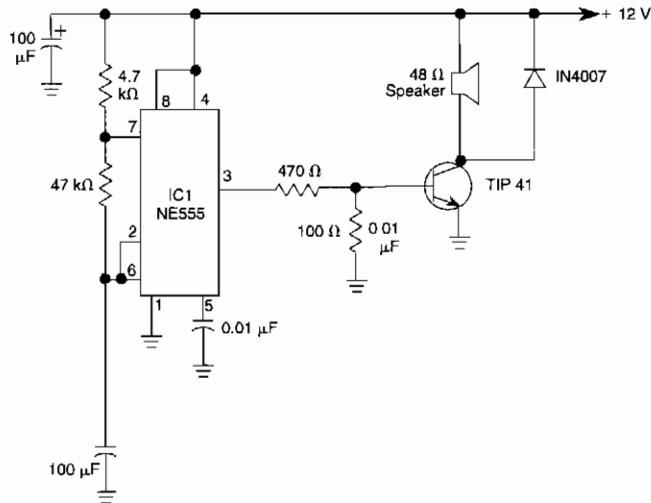


WILLIAM SHEETS

FIG. 93-9

The electronic gong is comprised of an oscillator (built around half of a 74C00N quad 2-input NAND gate), an active twin-T filter (built around a TL081), and will drive an audio amplifier IC such as an LM386N. Pulses from astable multivibrator IC1 cause the twin-tee active filter U2 to ring, producing a damped sinusoidal output. C1 varies rate and C2-C3 vary gong frequency. Adjust R1 for best "tone" sound.

## ALARM TONE GENERATOR

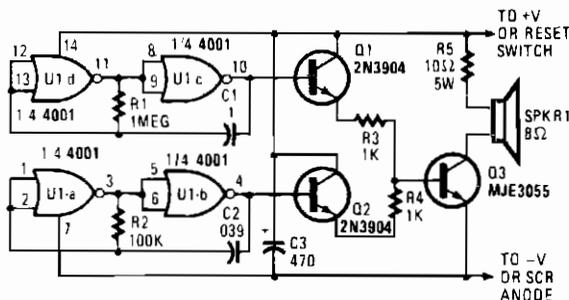


WILLIAM SHEETS

FIG. 93-10

In this alarm tone generator, a TIP41 transistor is used as a speaker driver. R1, R2, and C1 determines the frequency which is 1400 Hz with the values shown.

## DUAL-TONE SOUNDER



POPULAR ELECTRONICS

FIG. 93-11

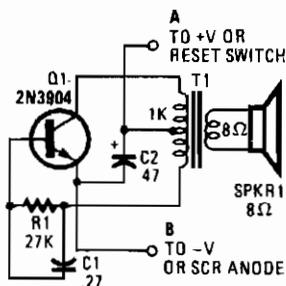
An outside horn-type speaker works best with the circuit. However, such devices require a great deal of power, so this sounder should only be used in alarm circuits where at least a 6-A SCR is used as the sounder driver.

A single CMOS 4001 quad 2-input NOR gate, two 2N3904 general-purpose npn transistors, and a single MJE3055 power transistor combine to generate a two-tone output. Gates U1-a and U1-b are configured as a simple feedback oscillator with R2 and C2 setting the oscillator's frequency. With the values shown, the circuit oscillates at about 500 Hz.

Gates U1-c and U1-d are connected in a similar oscillator circuit, but they operate at a much lower frequency. The oscillator frequencies (and thus the tones that they produce) can be altered by increasing or decreasing the values of R<sub>1</sub> and C<sub>1</sub> for the low-frequency oscillator and R<sub>2</sub> and C<sub>2</sub> for the high-frequency oscillator. Decreasing the values of those components will increase the frequency; increasing their values will decrease the frequency.

The two oscillator outputs are connected to separate amplifiers (configured as emitter followers), whose outputs are used to drive a single power transistor (Q3, an MJE3055). A 10- $\Omega$ , 5-W resistor, R5, is used to limit the current through the speaker and Q3 to a safe level. To boost the sound level, R5 can be replaced with another speaker.

## LOW-LEVEL SOUNDER



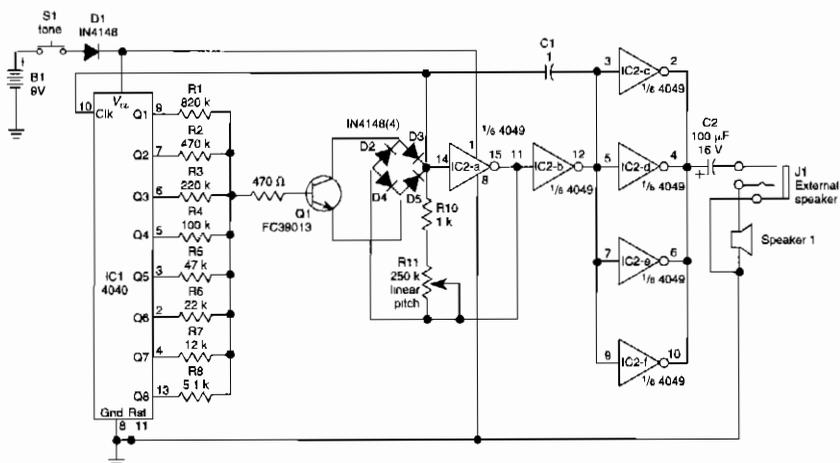
POPULAR ELECTRONICS

FIG. 93-12

This is a simple low-level noise maker that's ideally suited to certain alarm applications. When the sounder is located in another part of the building, the sound level is loud enough to be heard, but is not loud enough to warn off an intruder. A single 2N3904 npn transistor is connected in a Hartley audio oscillator, with a 1 k $\Omega$  to 8- $\Omega$  transistor-output transformer doing double duty.

The circuit produces a single-frequency tone that can be varied in frequency by changing the value of either or both R<sub>1</sub> and C<sub>1</sub>. Increasing the value of either component will lower the output frequency and decreasing their values will raise the frequency. Don't go below 4.7 k $\Omega$  for R1 because you could easily destroy Q1.

## SOUND-EFFECTS GENERATOR



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FIG. 93-13

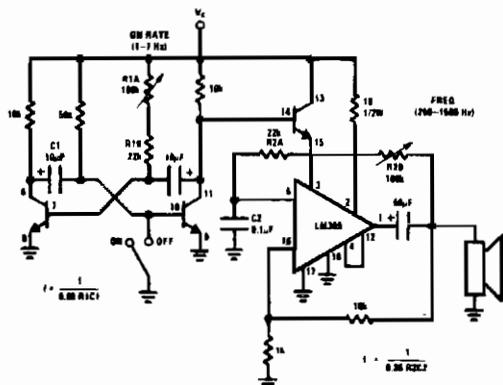
The circuit consists of four parts: a binary counter, a D/A converter, a VCO, and an audio output amplifier. The speed at which the counter counts depends on the frequency of the output of the VCO, which in turn is determined by the output of the counter. That feedback loop gives this circuit its characteristic output.

The initial frequency of oscillation is determined by potentiometer R11. The VCO first oscillates at a relatively low frequency, and it gradually picks up speed as the control voltage supplied by the D/A converter increases.

The D/A converter is simply the group of resistors R1 through 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 so does the VCO's frequency of oscillation.

The VCO itself is composed of IC2-a, IC2-b, and Q1; the timing network is D1 through D4, C1, R10, and R11. The diode bridge functions basically as a voltage-controlled resistor. The buffer amplifier is made up of the four remaining gates from IC2, all wired in parallel. The volume is sufficient for experimental purposes, but you might want to add an amplifier, speaker, or both.

## SIREN

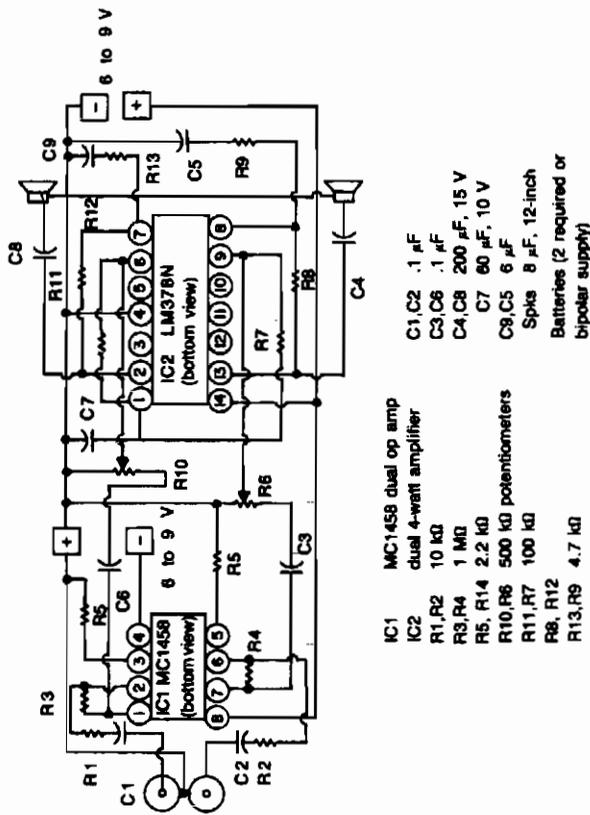


An LM380 audio IC is configured as a feedback audio oscillator. A transistor astable modulates this oscillator at a low frequency, which produces a siren tone.

NATIONAL SEMICONDUCTOR

FIG. 93-14

## ALTERNATE TONE ALARM



1989 R-E EXPERIMENTERS HANDBOOK

FIG. 93-15

A two-tone generator that is alternately switched ON provides a high/low output as might be heard from a traffic vehicle like a police car or ambulance.

IC1, CD4011, quad 2-input NAND gate is a two-tone oscillator in which each side, pins 1 through 7 and 8 through 13 set the tone frequencies. Changing the values of  $C_2$  and  $C_1$  determines the high/low tones. The output frequencies are coupled to IC2, CD4011, of which one side (pins 1 through 6) acts as a buffer. The buffer is necessary to prevent loading on the outputs that would occur if one tried to go directly to the LM386 amplifier. The other side of IC2, pins 8 through 13, is a slow pulse oscillator of approximately 8 Hz per second. The output at pin 10 is connected to IC4 as a clock.

IC4, CD4027, is a dual J-K master-slave flip-flop that is wired to perform as a toggle switch in which Q1 and 15, and Q1 (NOT) pin 14, go high and low alternately (flip-flop). The clock input from IC2 pin 10 is connected to pin 13 of IC4, and the outputs at pins 15 and 14 changes the flip/flop state with each positive pulse transition. The CD4027 functions in toggle mode when the set and reset inputs, pins 9 and 12, are held low or grounded. Also, J-K inputs, pins 10 and 11, must be held high or to the positive. The outputs Q1 and Q1 (NOT), pins 15 and 14 are connected to pins 13 and 1 respectively of IC1 that enables or disables. Thus, each tone oscillator is turned on and off alternately. IC3 is a straightforward low-voltage audio amplifier.



# 94

## Square-Wave Generator Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Square-Wave Oscillator

Schmitt Trigger or Sine-to-Square Wave Converter

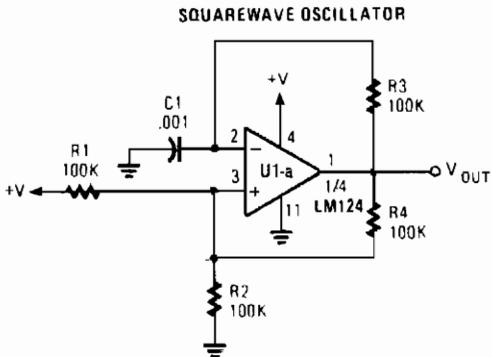
60-Hz Square-Wave Generator

Square-Wave Oscillator

Schmitt Trigger SineSquare Generator

10-Hz to 10-kHz VCO with Square- and Triangle-Wave Outputs

## SQUARE-WAVE OSCILLATOR



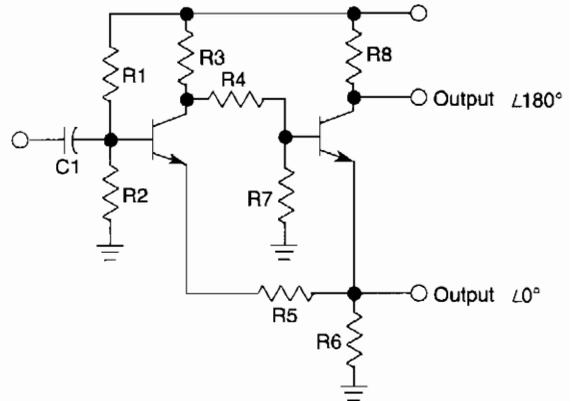
POPULAR ELECTRONICS

FIG. 94-1

An op amp with positive feedback generates a square wave. The period of the oscillator is determined by  $R_3$  and  $C_1$ .

$$T = T_1 + T_2 \approx 0.69 \times 2 (R_3 C_1) \quad T_1 = T_2$$

## SCHMITT TRIGGER OR SINE-TO-SQUARE-WAVE CONVERTER

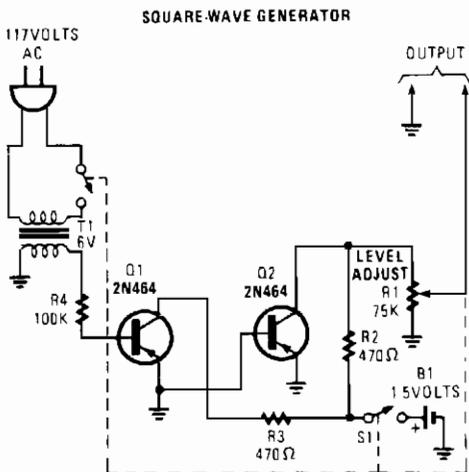


WILLIAM SHEETS

FIG. 94-2

This sine-wave triggered circuit produces two square-wave outputs that are  $180^\circ$  out of phase.

## 60-Hz SQUARE-WAVE GENERATOR

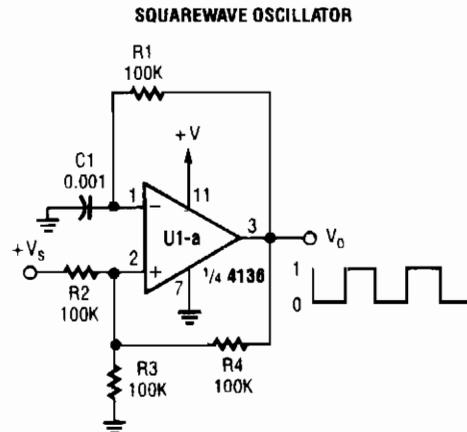


POPULAR ELECTRONICS

FIG. 94-3

This generator circuit uses an overdriven amplifier to produce a 60-Hz square wave from the 60-Hz ac line. The circuit can be used in line-operated applications as a clock source.

## SQUARE-WAVE OSCILLATOR

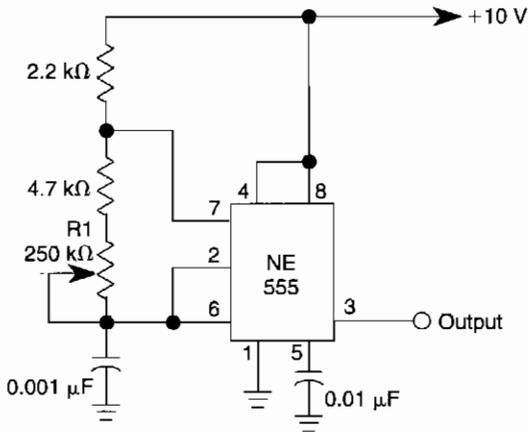


POPULAR ELECTRONICS

FIG. 94-4

Positive feedback is via  $R_3$  and  $R_4$  and  $R_1$  and  $C_1$  determine period.

### VARIABLE-FREQUENCY SQUARE-WAVE GENERATOR

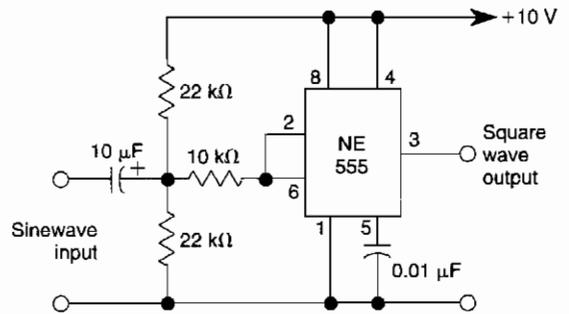


WILLIAM SHEETS

FIG. 94-5

This simple square-wave generator produces a variable frequency output of 2800 Hz to 80 kHz with the values shown. Frequency is adjusted with potentiometer R1.

### SCHMITT TRIGGER SINE-/SQUARE-WAVE GENERATOR

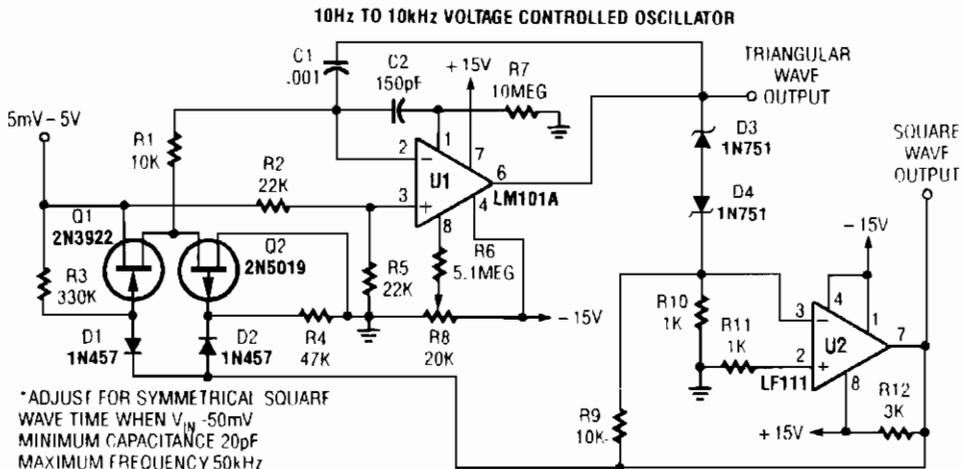


WILLIAM SHEETS

FIG. 94-6

A sine wave input can produce a square wave output by this Schmitt trigger circuit based on a 555 IC.

### 10-Hz TO 10-kHz VCO WITH SQUARE- AND TRIANGLE-WAVE OUTPUTS



POPULAR ELECTRONICS

FIG. 94-7

# 95

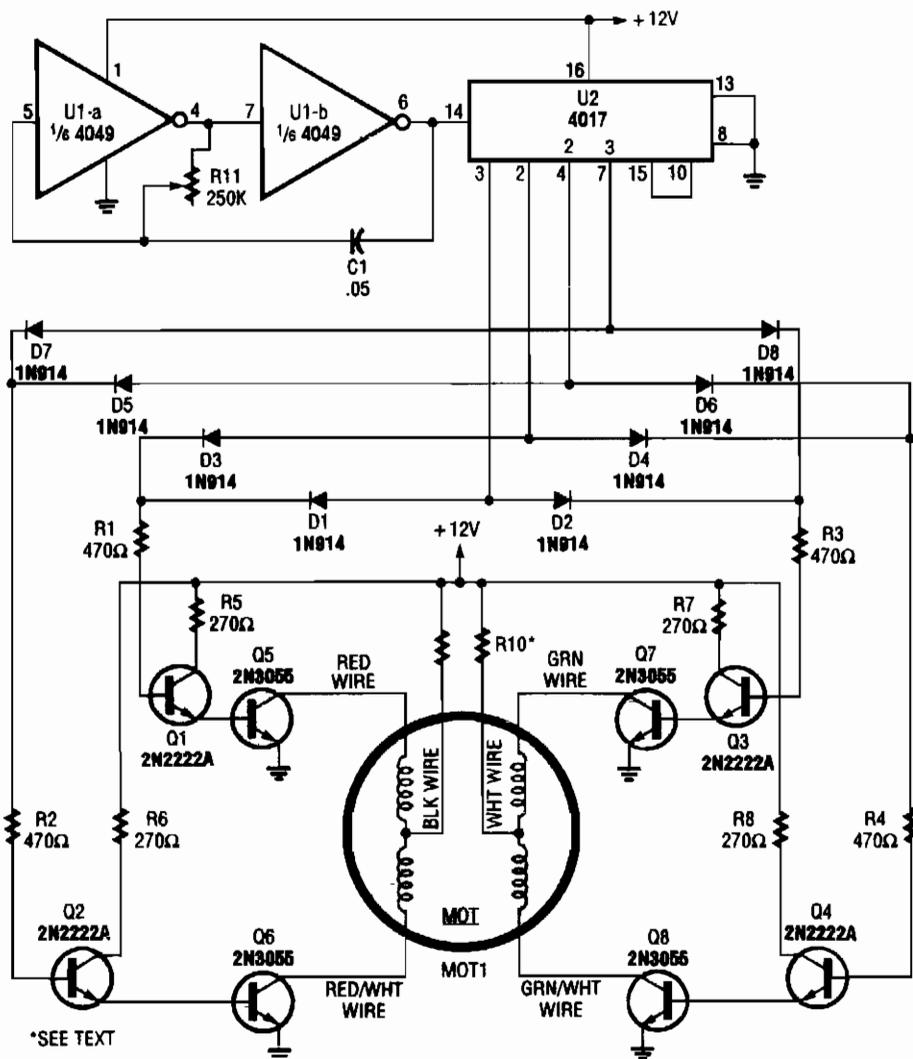
## Stepper Motor Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

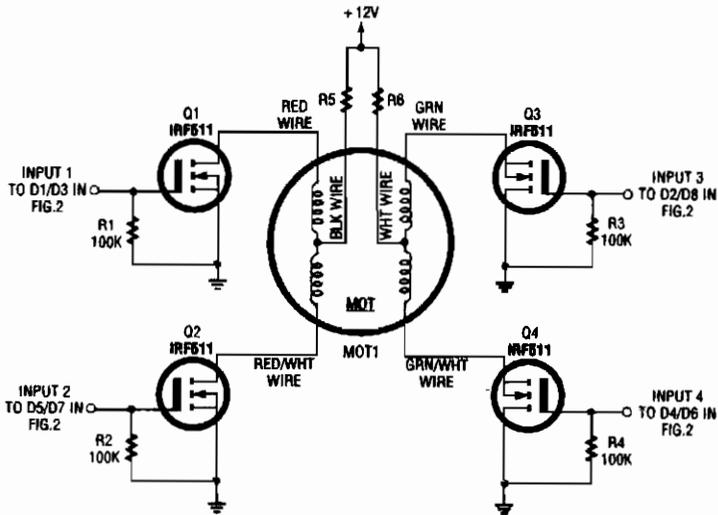
Bipolar Stepper Motor Drive Circuit  
Stepper Motor Circuit with FET Drivers  
Dual Clock Circuit for Stepper Motors

## BIPOLAR STEPPER MOTOR DRIVE CIRCUIT



A 4017 decade counter/divider driven from a low-frequency oscillator (U1-a and U1-b) is used to drive transistor switches to sequence the windings, as is needed. MOT1 is a 12-V stepper motor. R9 and R10 are selected for the motor's current rating. A 3.3-Hz signal from U1 will cause the motor to run at 1 rpm, a 33-Hz signal will result in 10 rpm, etc.

## STEPPER MOTOR CIRCUIT WITH FET DRIVERS

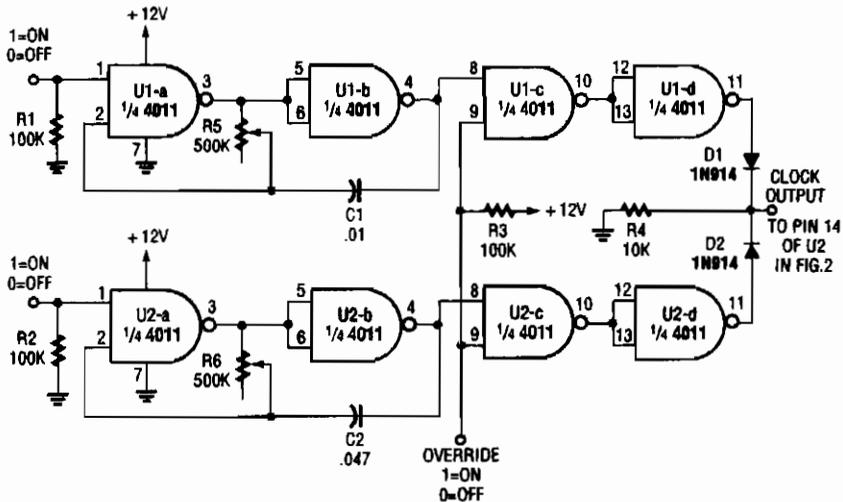


POPULAR ELECTRONICS

FIG. 95-2

This motor-driver circuit replaces the eight bipolar transistors of the previous circuit with four IFR511 power hexFET's (Q1 through Q4).

## DUAL CLOCK CIRCUIT FOR STEPPER MOTORS



POPULAR ELECTRONICS

FIG. 95-3

This oscillator can be used to drive a stepper motor circuit at two preset speeds with override to shut the motors off.

# 96

## Stereo Circuits

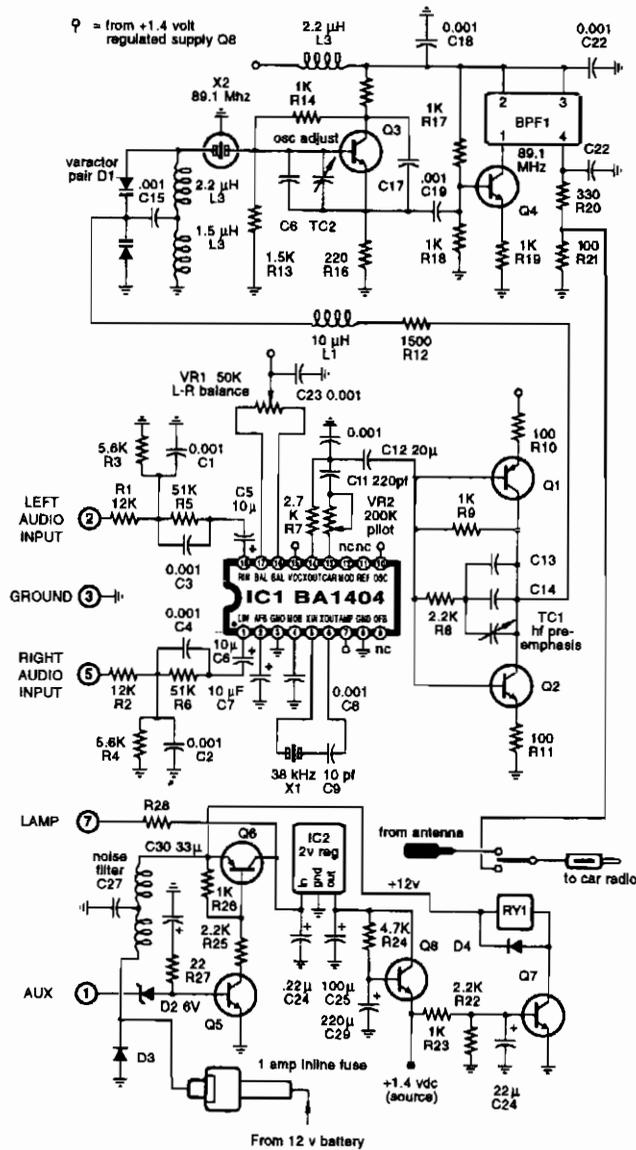
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

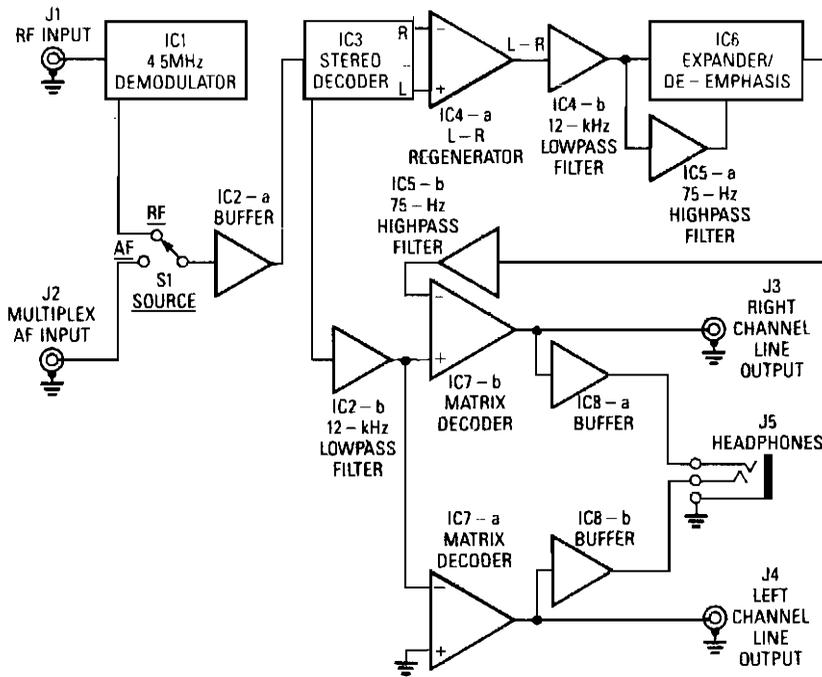
FM Stereo Transmitter  
Stereo TV Decoder  
Crystal-Controlled FM Stereo Transmitter  
Stereo TV Decoder  
One-Chip Stereo Preamp with Tone Control  
Audio Expander  
Mini Stereo Amplifier  
Stereo Balance Meter  
Stereo Preamplifier  
Stereo Phono Amplifier with Bass Tone Control

## FM STEREO TRANSMITTER



A BA1404 IC is used to generate a complete FM MPX signal. The chip contains all of the necessary circuitry. C1 and R3, and R4 and C4 provide pre-emphasis. The transmitter runs on a single AA cell. L3 is 3 turns of #20 wire on a  $\frac{1}{16}$ " drill (for a form). L3 is  $\frac{1}{4}$ " long. L4 is 4 turns #20 wire on  $\frac{1}{16}$ " drill bit, spaced to  $\frac{3}{8}$ ". If monophonic operation is wanted, omit C5 and the 38-kHz oscillator components.

## STEREO TV DECODER



A block diagram of the stereo-TV decoder is shown in A. It shows the overall relationships between the separate sections of the circuit; B through E show the details of each subsection. The decoder section centers around IC1, a standard 4.5-MHz audio demodulator. The output of IC1 is routed to S1, which allows you to choose between the internally demodulated signal and an externally demodulated one. Buffer amplifier IC2-a then provides a low-impedance source to drive IC3, an LM1800 stereo demodulator.

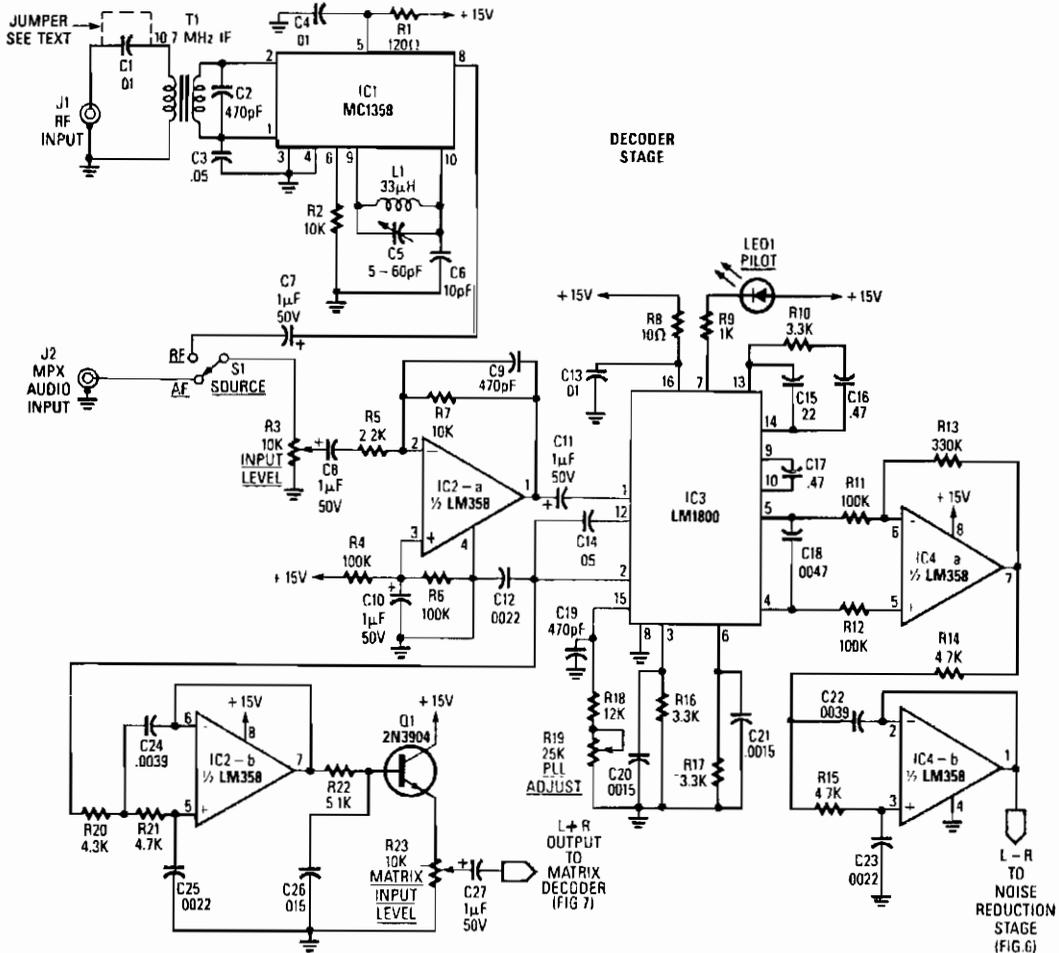
When IC3 is locked on a stereo signal, the outputs presented at pins 4 and 5 are discrete left- and right-channel signals, respectively. In order to provide noise reduction to the  $L - R$  signal, you must recombine the discrete outputs into sum and difference signals. Op amp IC4-a is used to regenerate the  $L - R$  signal. It is wired as a difference amplifier, wherein the inputs are summed together ( $+L - R$ ). Capacitor C18 bridges the left- and right-channel outputs of the demodulator. Although it decreases high-frequency separation slightly, it also reduces high-frequency distortion.

The  $L + R$  signal is taken from the LM1800 at pin 2, where it appears at the output of an internal buffer amplifier. The raw  $L - R$  signal is applied to IC4-b, a 12-kHz lowpass filter. The  $L + R$  signal is also fed through a 12-kHz low pass filter in order to keep the phase shift undergone by both signals equal.

Next, the  $L - R$  signal is fed to Q2. It allows you to add a level control to the  $L - R$  signal path; it provides a low source impedance for driving the following circuits, and it inverts the signal 180°. Inversion is necessary to compensate for the 180° inversion in the compander.

Next comes the expander stage. At the collector of Q2 is a 75- $\mu$ s de-emphasis network (R27 and C29) that functions just like the network that is associated with Q1. Note that Q2 feeds both Q3 and

## STEREO TV DECODER (Cont.)



THE DECODER STAGE converts the multiplexed audio signal into L + R and L - R signals.

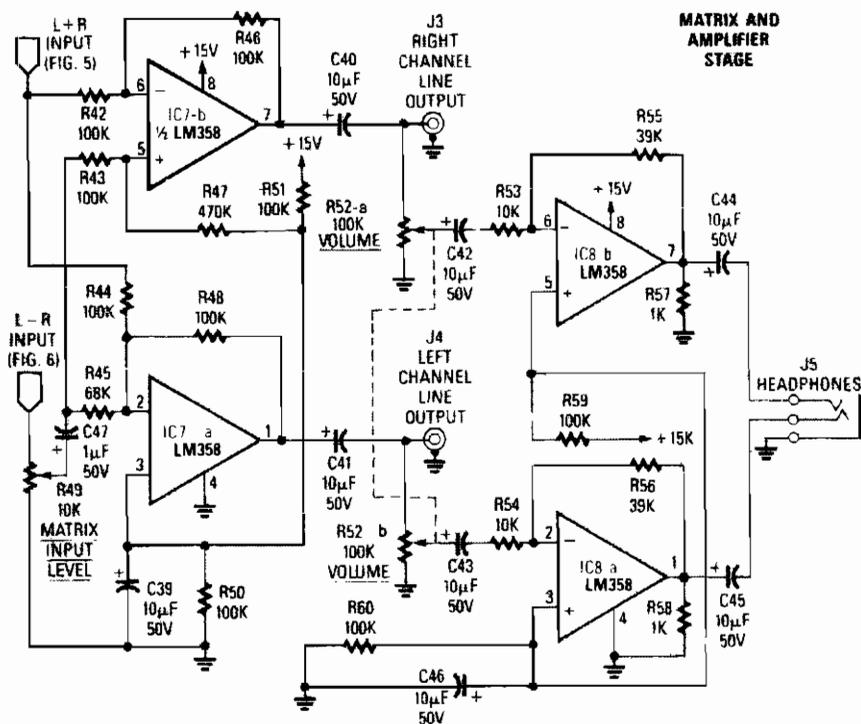
IC5-a, a  $-12$ -dB per octave high-pass filter. The output of that filter drives the rectifier input of IC6, an NE570. The  $75$ -Hz high-pass filter at the rectifier input helps to prevent hum,  $60$ -Hz sych buzz, and other low-frequency noise in the  $L - R$  signal from causing pumping or breathing.

The NE570 contains an on-board op amp; its inverting input is available directly at pin 5 and via a  $20$ -k $\Omega$  series resistor at pin 6. The  $18$ -k $\Omega$  resistor (R30) combines with the internal resistor and C32 ( $0.01 \mu\text{F}$ ) to form a first-order filter with a  $390$ - $\mu\text{s}$  time constant. Because the internal op amp operates in the inverting mode, the  $-(L - R)$  signal is restored to the proper  $(L - R)$  form.

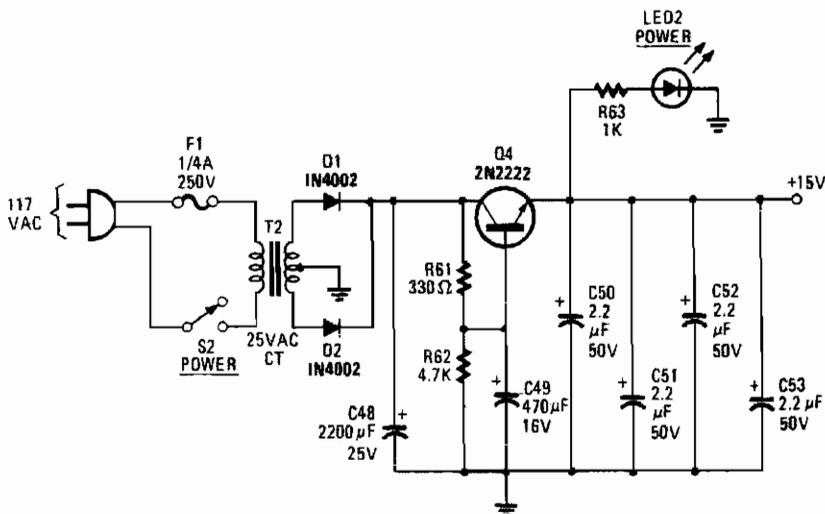
The output of the expander drives another  $75$ -Hz high-pass filter, but this one is a third-order type that provides  $-18$  dB per octave rolloff. It is used to keep low-frequency noise from showing up at the output of the decoder. At this point, the  $(L - R)$  signal has been restored, more or less, to the condition it was in before it was dBx companded at the transmitter.



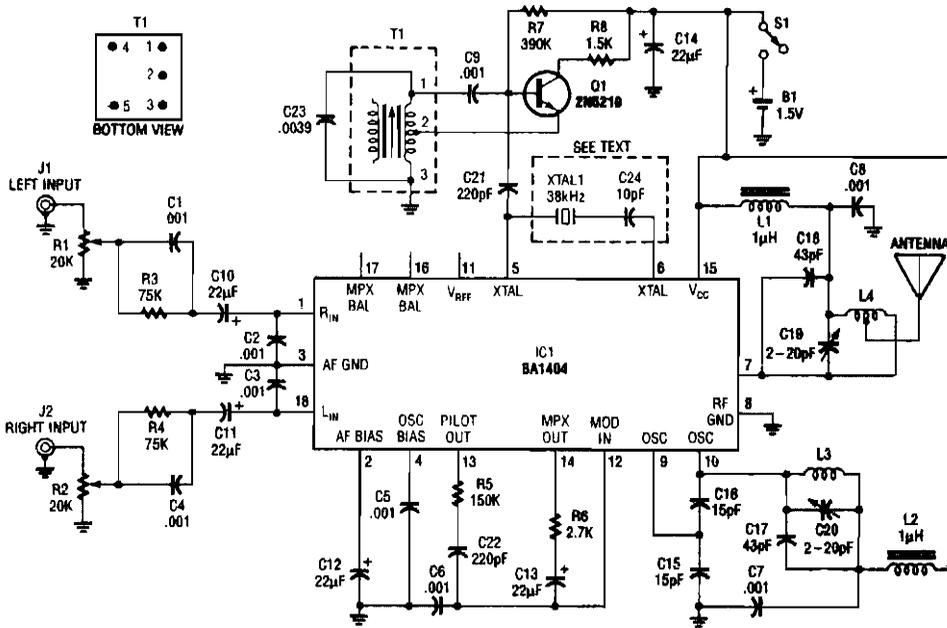
## STEREO TV DECODER (Cont.)



THE MATRIX STAGE separates the L + R and L - R signals into the left- and right-channel components. Op-amp IC8 and associated components provide an optional headphone output. If you do not wish to drive a pair of headphones, or plan to use your amplifier's headphone jack for that purpose, all components to the right of jacks J3 and J4 can be deleted.



## CRYSTAL-CONTROLLED FM STEREO TRANSMITTER

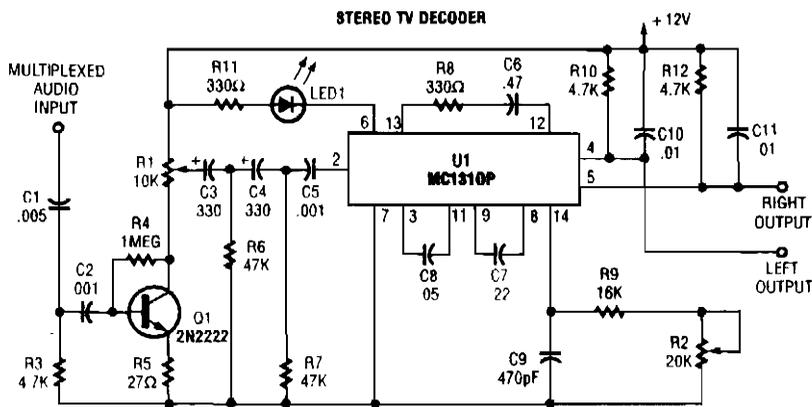


ELECTRONICS NOW

FIG. 96-3

In this application, a BA1404 is used to generate an FM MPX baseband signal. This modulates a crystal oscillator (Q3) via a dual varactor series modulator. This transmitter can be used to play CD audio on an existing FM auto radio.

## STEREO TV DECODER

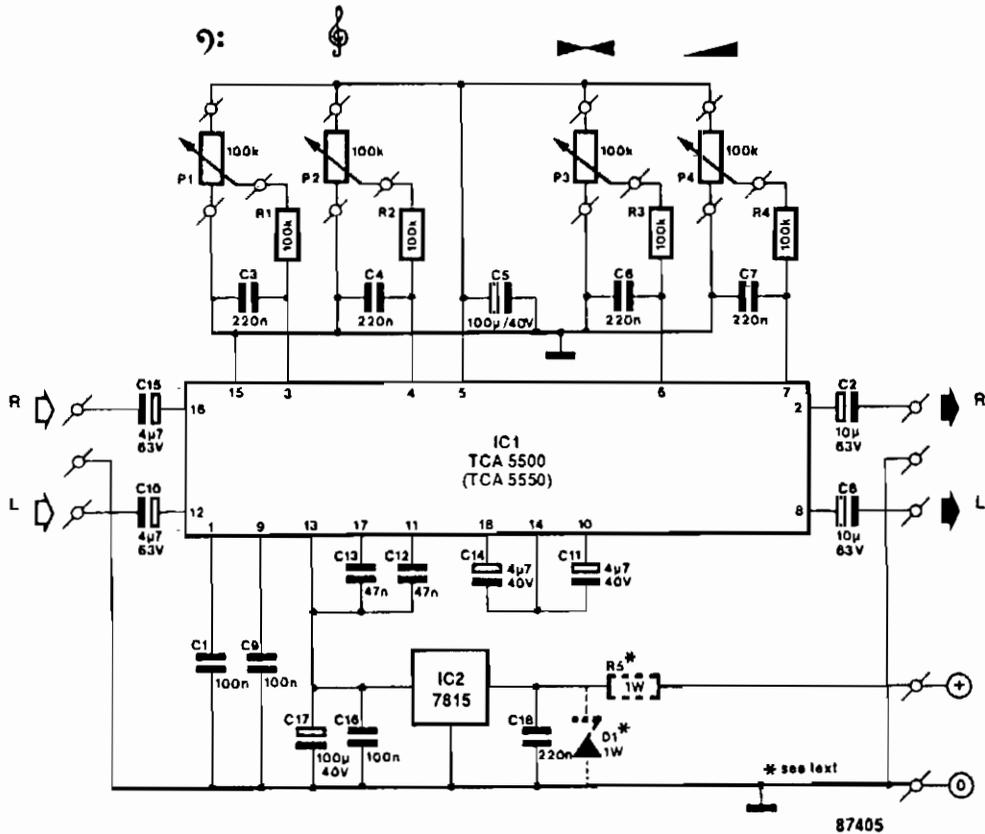


POPULAR ELECTRONICS

FIG. 96-4

Q1 is an audio amplifier and U1 is used as a 31.5-kHz subcarrier, which is similar to 38-kHz FM MPX. Pilot frequency is 15.734 kHz.

## ONE CHIP STEREO PREAMP WITH TONE CONTROL



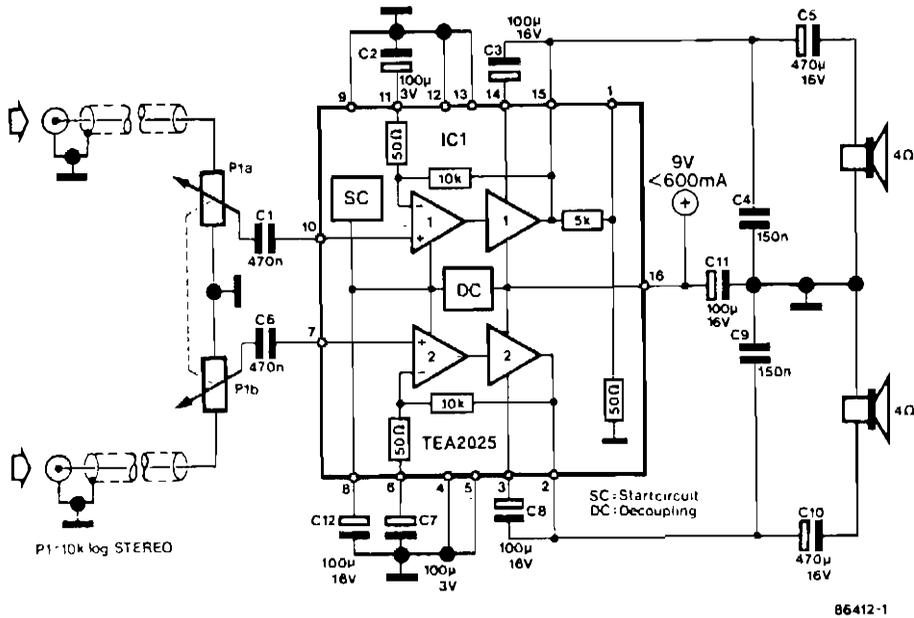
303 CIRCUITS

FIG. 96-5

A Motorola TCA5500 or TCA5550 can provide a stereo preamplifier system with tone controls. This circuit provides a gain of about 10X, a 14-dB tone-control range, a 75-dB volume control range, and it can operate from 8 to 18 Vdc. IC2 provides 15 V for IC1, and the input of IC2 can be supplied from the power amplifier's power supply (+) rail. D1 and R5 should be used if over 30 V input will be used.



## MINI STEREO AMPLIFIER



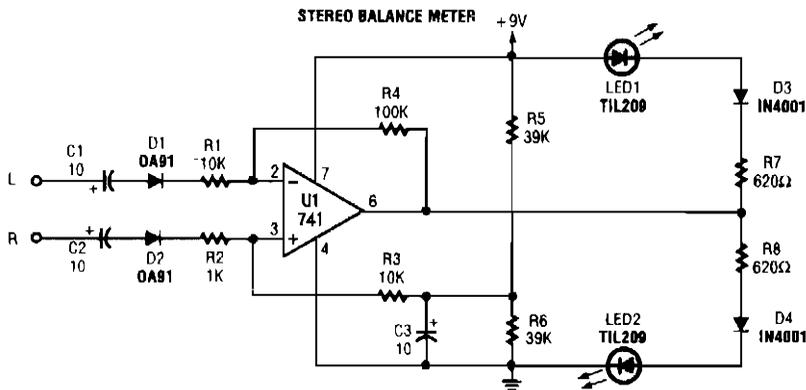
86412-1

303 CIRCUITS

FIG. 96-7

Using a Thomson TEA2025, this stereo amplifier provides 1 W per channel into 4  $\Omega$  with a 9-V supply. Input sensitivity is 25 mV p-p for full output. Note that pins 4, 5, 12, and 13 of IC1 should be effectively grounded to a ground plane and heatsinked.

## STEREO BALANCE METER

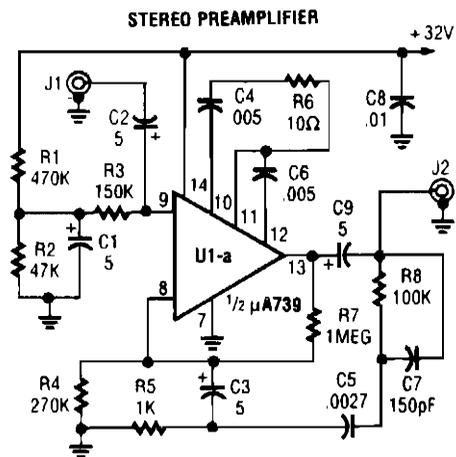


POPULAR ELECTRONICS

FIG. 96-8

When L & R signals are equal, no output is present from U1, and pin 6 is at a steady 4.5 V. Unbalanced audio causes the LEDs to vary in brightness, which causes a difference that corresponds to unbalance between channels.

## STEREO PREAMPLIFIER



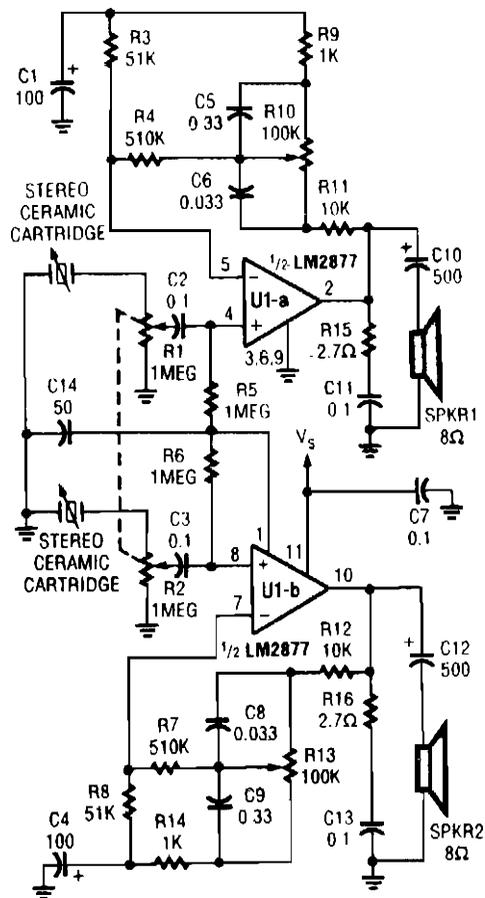
POPULAR ELECTRONICS

FIG. 96-9

A building block for audio work, the circuit can be used as a general-purpose preamp. Use two circuits for stereo applications.

## STEREO PHONO AMPLIFIER WITH BASS TONE CONTROL

### STEREO PHONOGRAPH AMPLIFIER WITH BASS TONE CONTROL



POPULAR ELECTRONICS

FIG. 96-10

# 97

## Switching Circuits

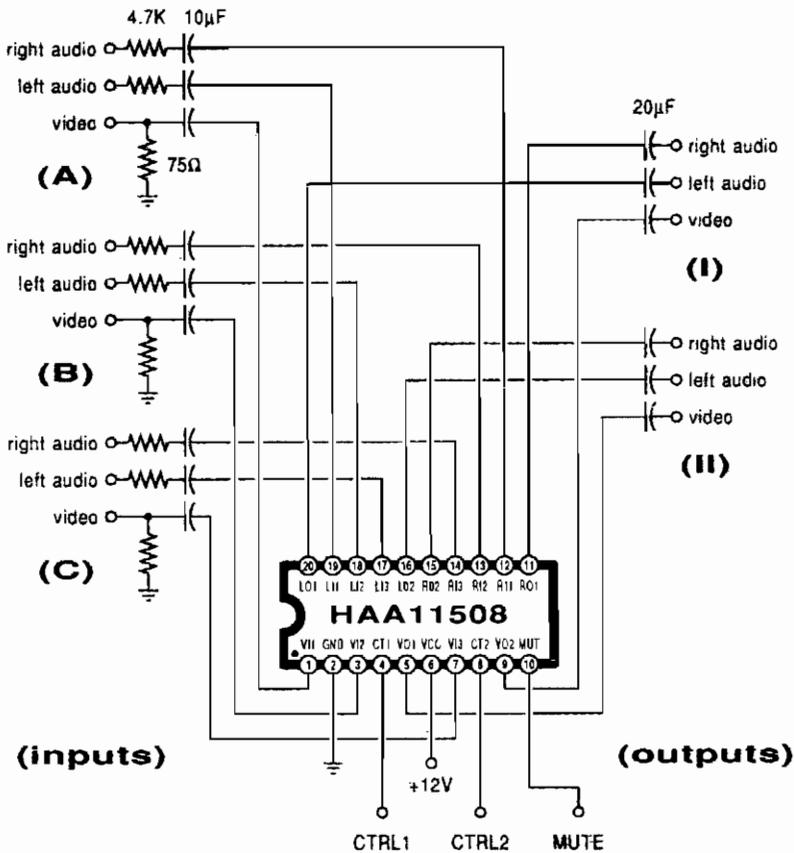
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Simple Video/Audio Switcher  
dc-Controlled Switch Using Optoisolator  
Wideband Video Switch for RGB Signals  
Eight-Channel Audio Switcher  
Electronic Safety Switch  
Audio-Controlled Switch  
Oscillator Triggered Switch

Load-Disconnect Switch  
Typical Two-Way Switch Wiring  
HexFET Switch  
dc-Controlled FET Switch  
Remote Two Way ac Switch Hookup  
Dual-Control HexFET Switch

## SIMPLE VIDEO/AUDIO SWITCHER

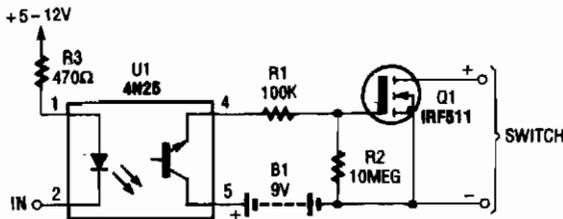


RADIO ELECTRONICS

FIG. 97-1

This channel selector selects video and stereo audio from any one of three different sources. The circuit should be constructed on a PC board with plenty of ground plane to minimize noise.

## dc-CONTROLLED SWITCH USING OPTOISOLATOR

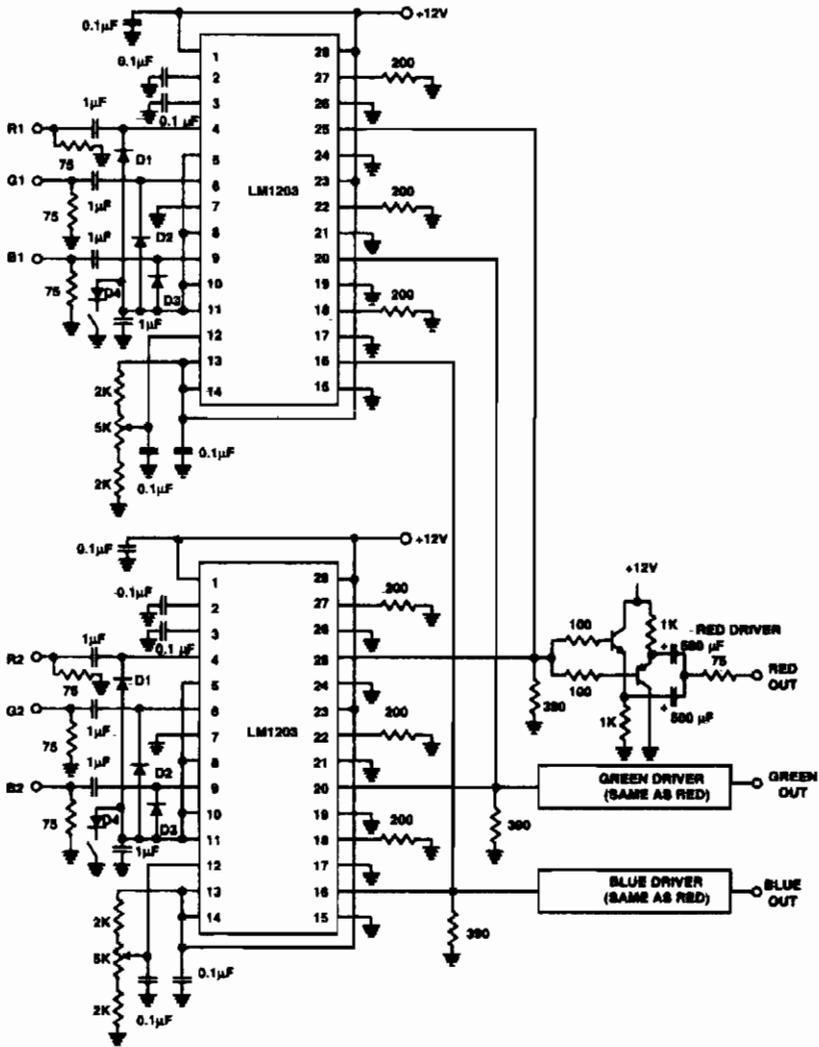


This dc-controlled switch uses an optoisolator/coupler, U1, to electrically isolate the input signal from the output-control device.

POPULAR ELECTRONICS

FIG. 97-2

## WIDEBAND VIDEO SWITCH FOR RGB SIGNALS

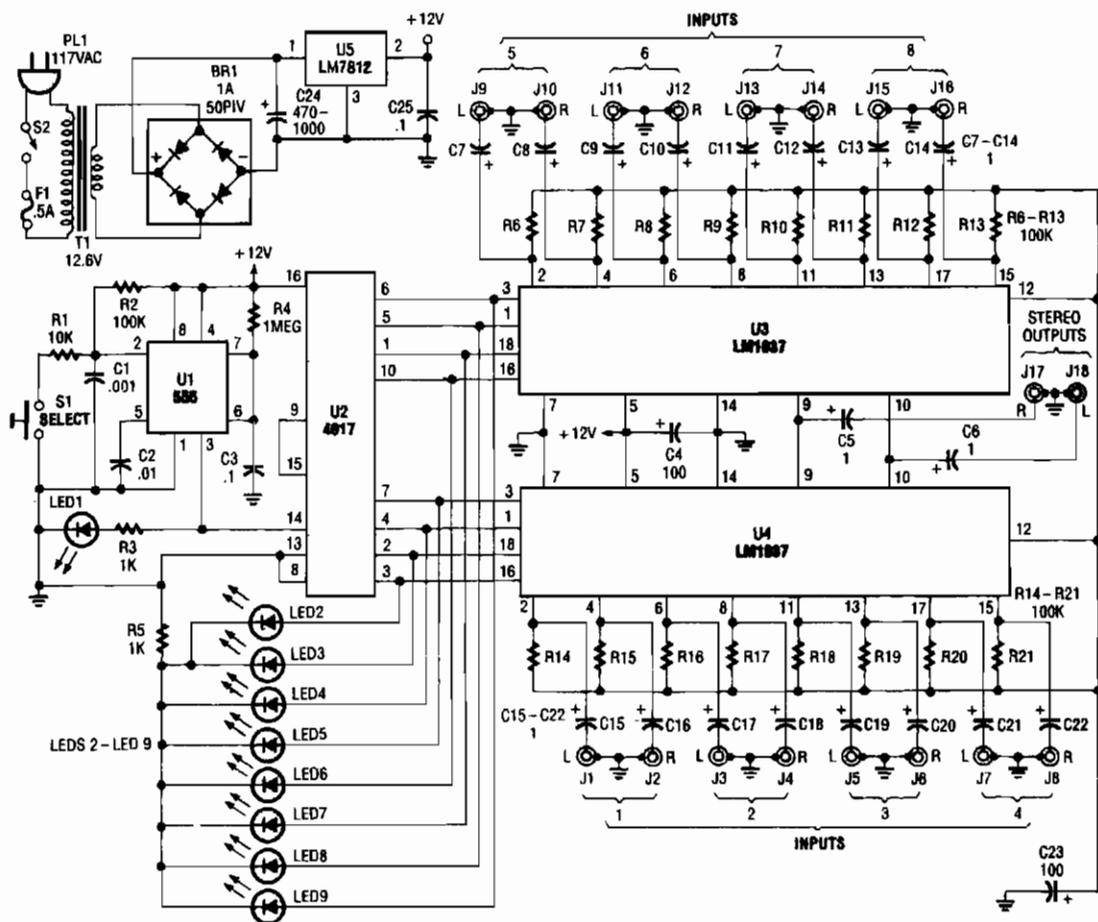


NATIONAL SEMICONDUCTOR

FIG. 97-3

The switch shown selects 1 to 2 inputs and uses a National LM1203. The slew rate is 4-V p-p into 390 Ω in 5 to 7 ns.

## EIGHT-CHANNEL AUDIO SWITCHER



POPULAR ELECTRONICS

FIG. 97-4

This source is selected by pressing momentary-contact pushbutton switch S1. Switch S1 is connected to the trigger of a 555 oscillator/limer (U1) configured as a monostable multivibrator, which generates one short output pulse for each press of S1. That pulse turns on LED1 to give a visible indication that the 555 is working correctly. That pulse is also used to clock U2 (a 4017 CMOS divide-by-1-counter/divider).

Both LED1 and its associated current-limiting resistor R3 are optional and can be left out of the finished project without any affect on circuit operation. The 4017 advances by one clock pulse each time S1 is pressed, turning on its corresponding output. Pin 9 (corresponding to output 8) of U2 is directly connected to its own reset terminal at pin 15. This allows the counter to count from zero to seven, and then reset to zero on the eighth count.

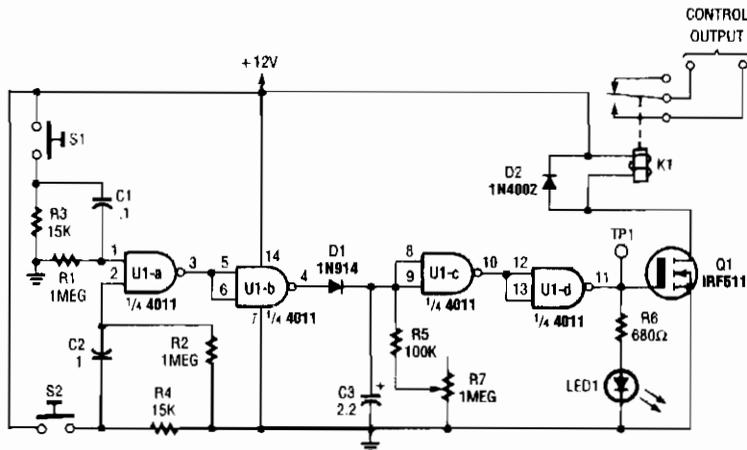
## EIGHT-CHANNEL AUDIO SWITCHER (Cont.)

Pin 13, the enable input of U2, is tied to ground to allow the counter to operate. Outputs zero through seven are connected to eight indicator LEDs and the control pins of the two LM1037s (U3 and U4). When an output is selected, its LED lights and the corresponding control input on the LM1037 is brought high.

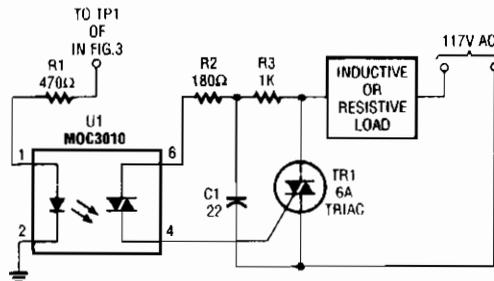
The LM1037 has extremely high-impedance inputs and low-impedance outputs, so interconnection between various types and brands of equipment should not be a problem. That, together with a wide-frequency response and low distortion, makes it ideal for use with good-quality, home-entertainment systems. The prototype of the audio switcher has a usable frequency response of from just a few hertz to over 100 kHz.

Power for the switcher is provided by a rather simple circuit. Because the switcher only draws between 20 and 30 mA, a simple circuit using the popular 7812 or 78L12 (a low-power version) voltage regulator works quite well.

## ELECTRONIC SAFETY SWITCH



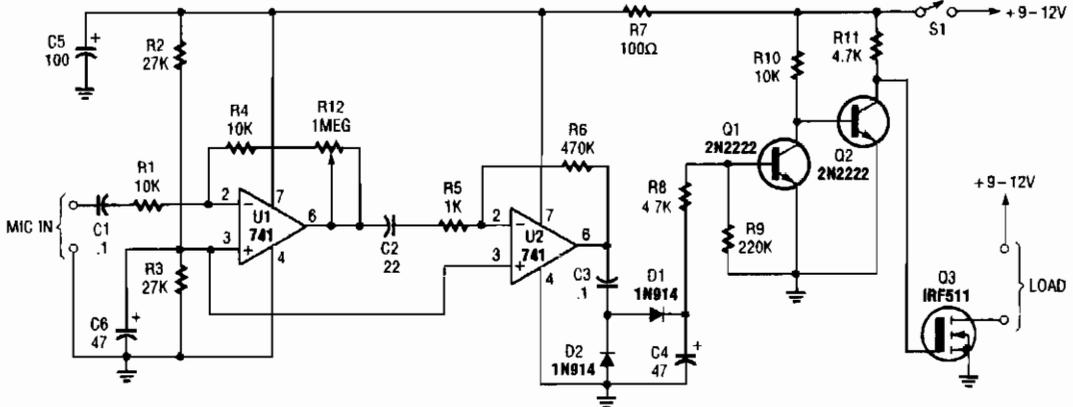
The electronic safety-control is built around a 4011 quad two-input NAND gate and an IRF511 hexFET.



The relay-replacement circuit (shown here) can be used to operate inductive or resistive loads.

S1 and S2 must be depressed within 200 ms of each other to activate K1. The hold time is adjustable via R7. S1 and S2 overlap time can be changed by changing C1 and C2 or R1 and R2.

## AUDIO-CONTROLLED SWITCH

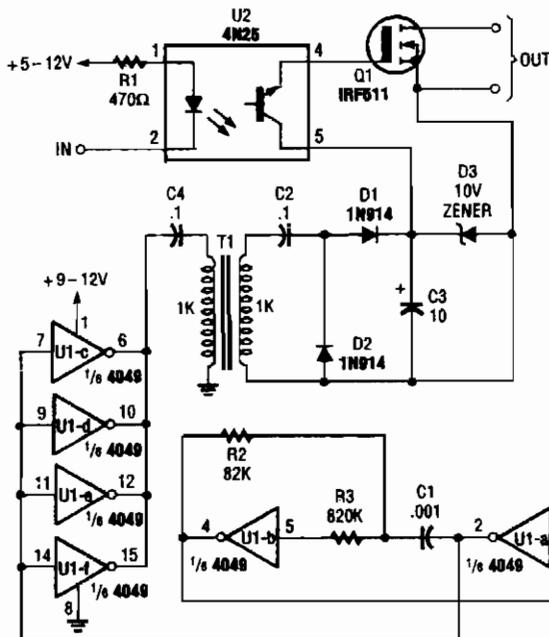


POPULAR ELECTRONICS

FIG. 97-6

This audio-controlled switch combines a pair of 741 op amps, two 2N2222 general-purpose transistors, a hcxFET, and a few support components to a circuit that can be used to turn on a tape recorder, a transmitter, or just about anything that uses sound.

## OSCILLATOR TRIGGERED SWITCH

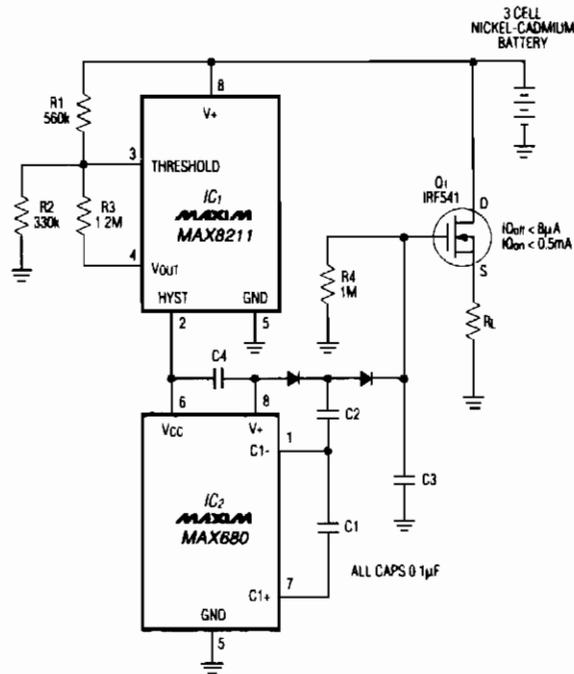


An oscillator is used here to generate a 9-V bias to switch Q1. This removes the need for a battery as a bias source.

POPULAR ELECTRONICS

FIG. 97-7

## LOAD-DISCONNECT SWITCH

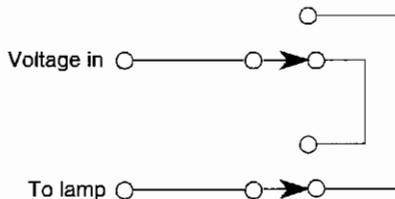


MAXIM ENGINEERING JOURNAL

FIG. 97-8

Deep discharge can damage a rechargeable battery. By disconnecting the battery from its load, this circuit halts battery discharge at a predetermined level of declining terminal voltage. Transistor Q1 acts as the switch. The overall circuit draws about 500  $\mu\text{A}$  when the switch is closed and about 8  $\mu\text{A}$  when the switch is open.

## TYPICAL TWO-WAY SWITCH WIRING

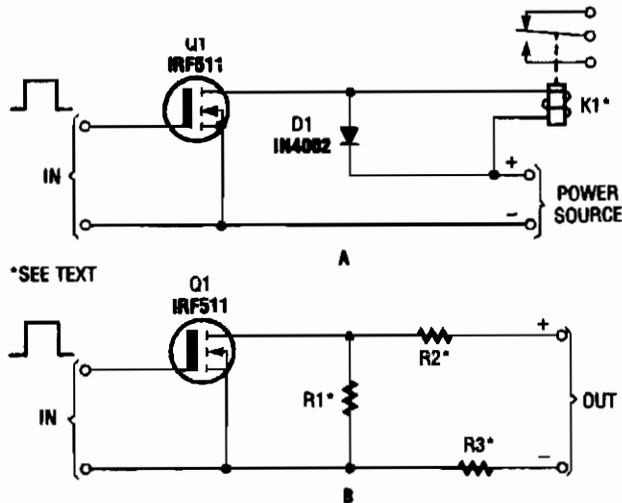


When the light is off, it can be turned on with either switch. When it's on, it can be turned off with either switch.

ELECTRONICS NOW

FIG. 97-9

## HEXFET SWITCH



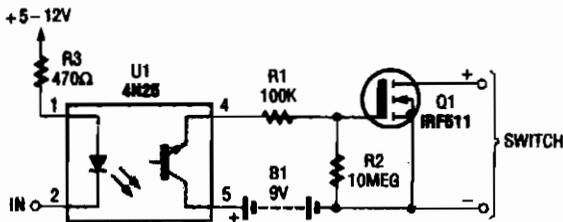
\*SEE TEXT

POPULAR ELECTRONICS

FIG. 97-10

The hexFET can switch dc power to relays (as shown in A), motors, lamps, and numerous other devices. That arrangement can even be used to switch resistors in and out of a circuit, as shown in B. R1, R2, and R3 represent resistive loads that can be switched in and out of the circuit.

## dc-CONTROLLED FET SWITCH

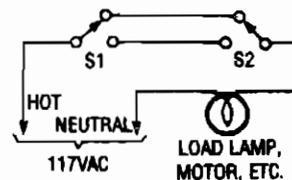


POPULAR ELECTRONICS

FIG. 97-11

This dc-controlled switch uses an optoisolator/coupler, U1, to electrically isolate the input signal from the output-control device.

## REMOTE TWO WAY ac SWITCH HOOKUP



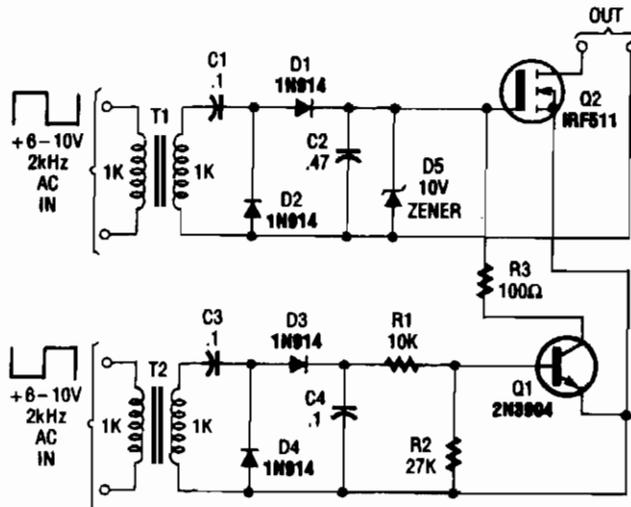
POPULAR ELECTRONICS

FIG. 97-12

This switching arrangement is the type of arrangement used in both domestic and industrial environments to allow a light or other ac-operated device to be controlled from more than one location.

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## DUAL-CONTROL HEXFET SWITCH



POPULAR ELECTRONICS

FIG. 97-13

This dual-control switch uses two 6 to 10-Vac sources to trigger the circuit on and off; one source for each function.

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# 98

## Sync Circuits

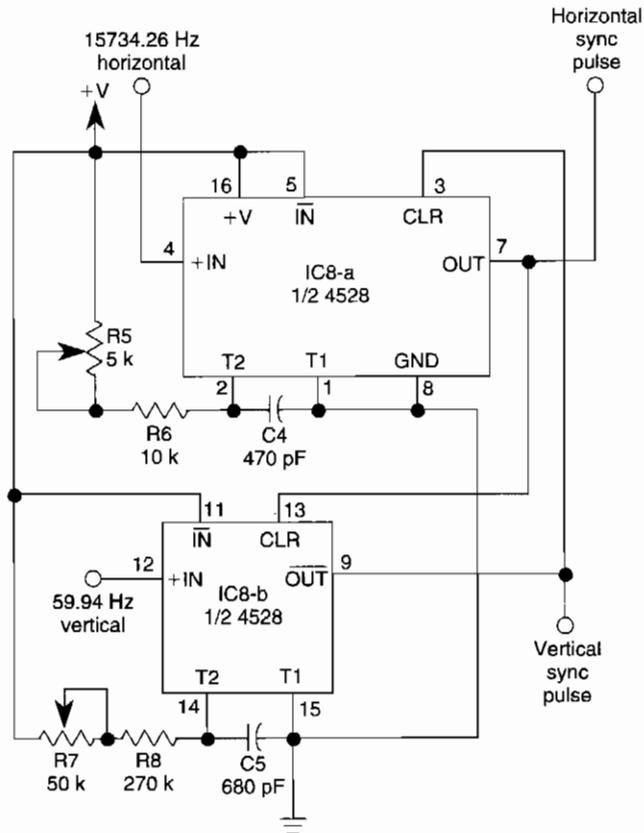
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sync Gating Circuit  
Sync Combiner

## SYNC GATING CIRCUIT

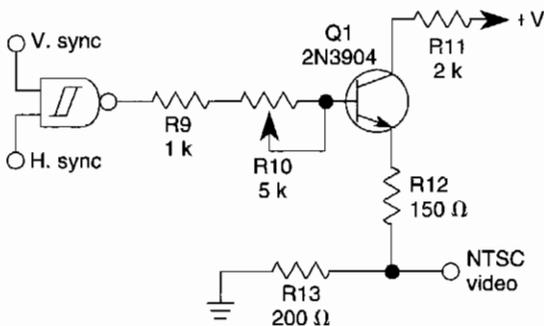


RADIO ELECTRONICS

**FIG. 98-1**

This circuit guarantees that only one type of sync pulse is generated at a time. During vertical sync periods, horizontal sync is disabled.

## SYNC COMBINER



This circuit combines H and V sync signals at TTL or CMOS levels and produces an NTSC video sync output.

RADIO ELECTRONICS

**FIG. 98-2**

99

## Tachometer Circuits

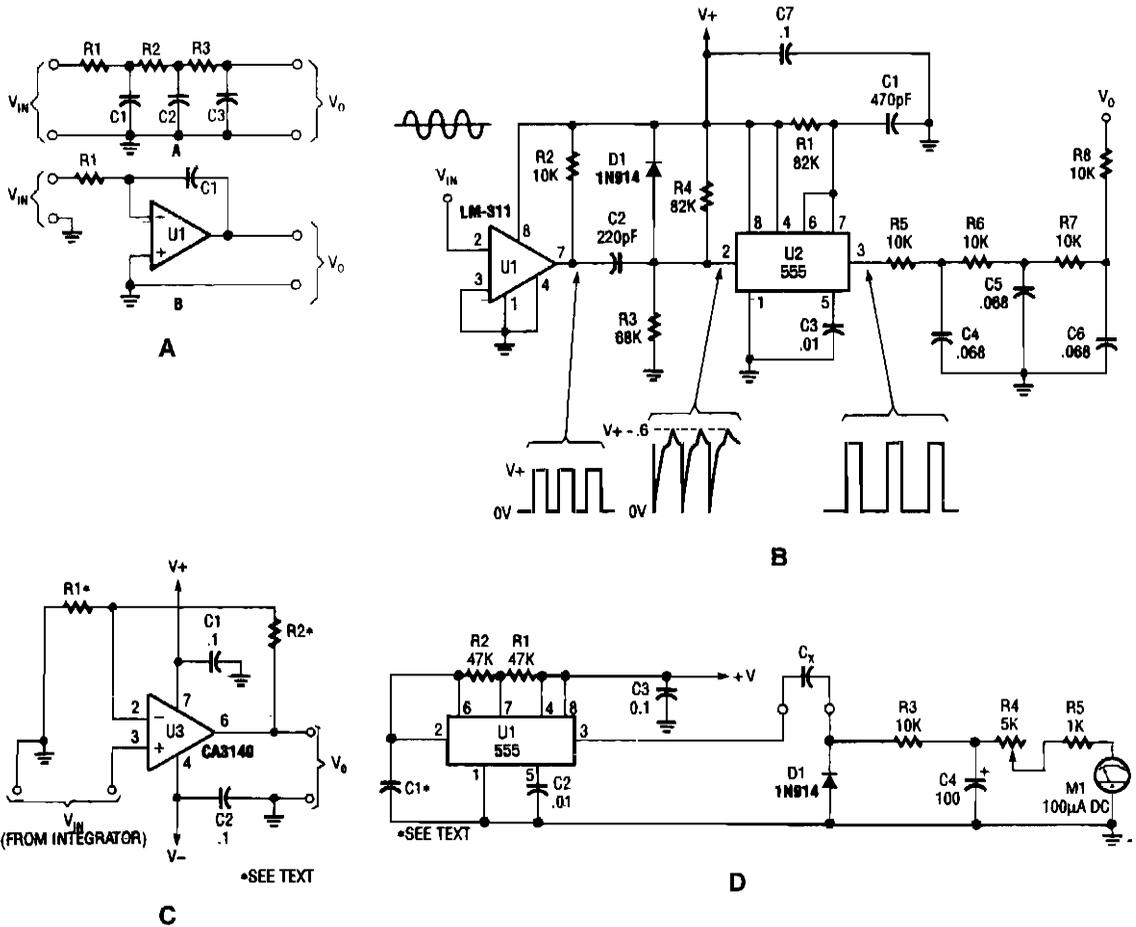
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Analog Tachometer Circuits  
Analog Tachometer Circuit

## ANALOG TACHOMETER CIRCUITS



POPULAR ELECTRONICS

FIG. 99-1

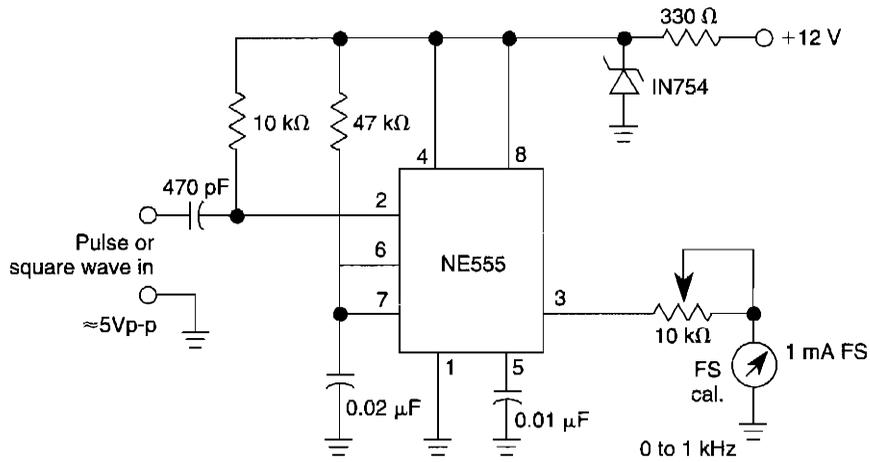
The four circuits shown are: a passive and active integrator, an analog tachometer, a scaling amplifier, and a capacitance meter.

$$\text{In B, } T = 1.1 R_1 C_1 \text{ (output pulse duration)}$$

$$\text{In C, } V_o = V_{in} \left( 1 + \frac{R_2}{R_1} \right)$$

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## ANALOG TACHOMETER CIRCUIT



WILLIAM SHEETS

FIG. 99-2

In this tachometer circuit a 555 is used as a pulse shaper. The dc value of the integrated pulse train is read by M1 which is calibrated to read frequency. With the values shown, the meter will read 0–1 kHz.

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# 100

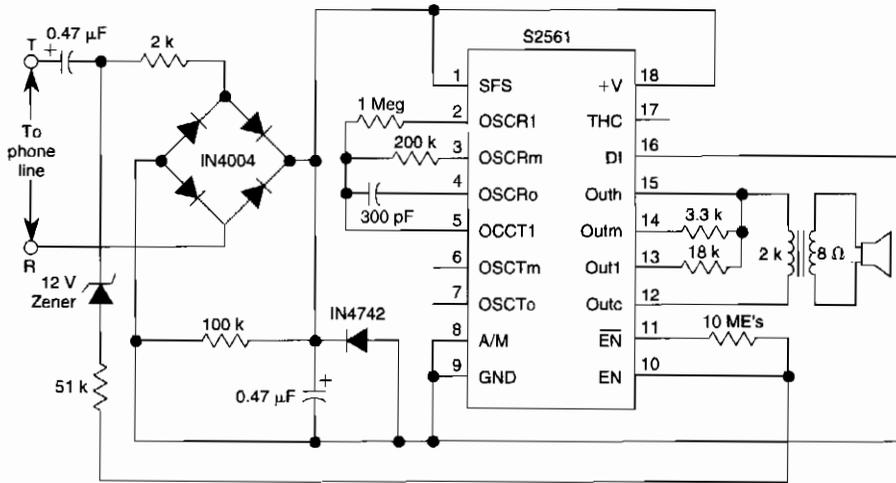
## Telephone-Related Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Telephone Ringer	Telephone Scrambler
Automatic Telephone-Call Recording Circuit	Phone Pager
Music on Hold	5-V Dial-Tone Circuit
Telephone Ring Converter	Phone Pager
Phone-In-Use Indicator	Alarm Dialer
Emergency Telephone Dialer	Telephone Audio Interface
Telephone Bell Simulator	Caller ID Circuit
Simple Telephone Ring Indicator	FCC Part 68 Phone Interface
Phone-Line Interface	Telephone Amplifier
Music-On-Hold Box	Telephone Hold Circuit
Speakerphone Adapter	Telephone Circuit
Telephonic Voice-Mail Alert	Telephone-Line Tester

## TELEPHONE RINGER

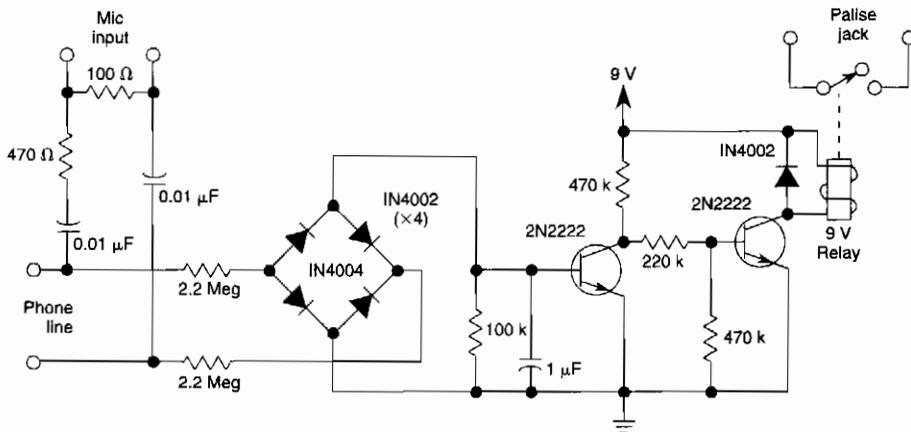


RADIO-ELECTRONICS

FIG. 100-1

Using an AMI chip P/N S2561, this telephone ringer can be powered directly off the telephone line. Audio output is about 50 mW when powered from a 10-V source.

## AUTOMATIC TELEPHONE-CALL RECORDING CIRCUIT

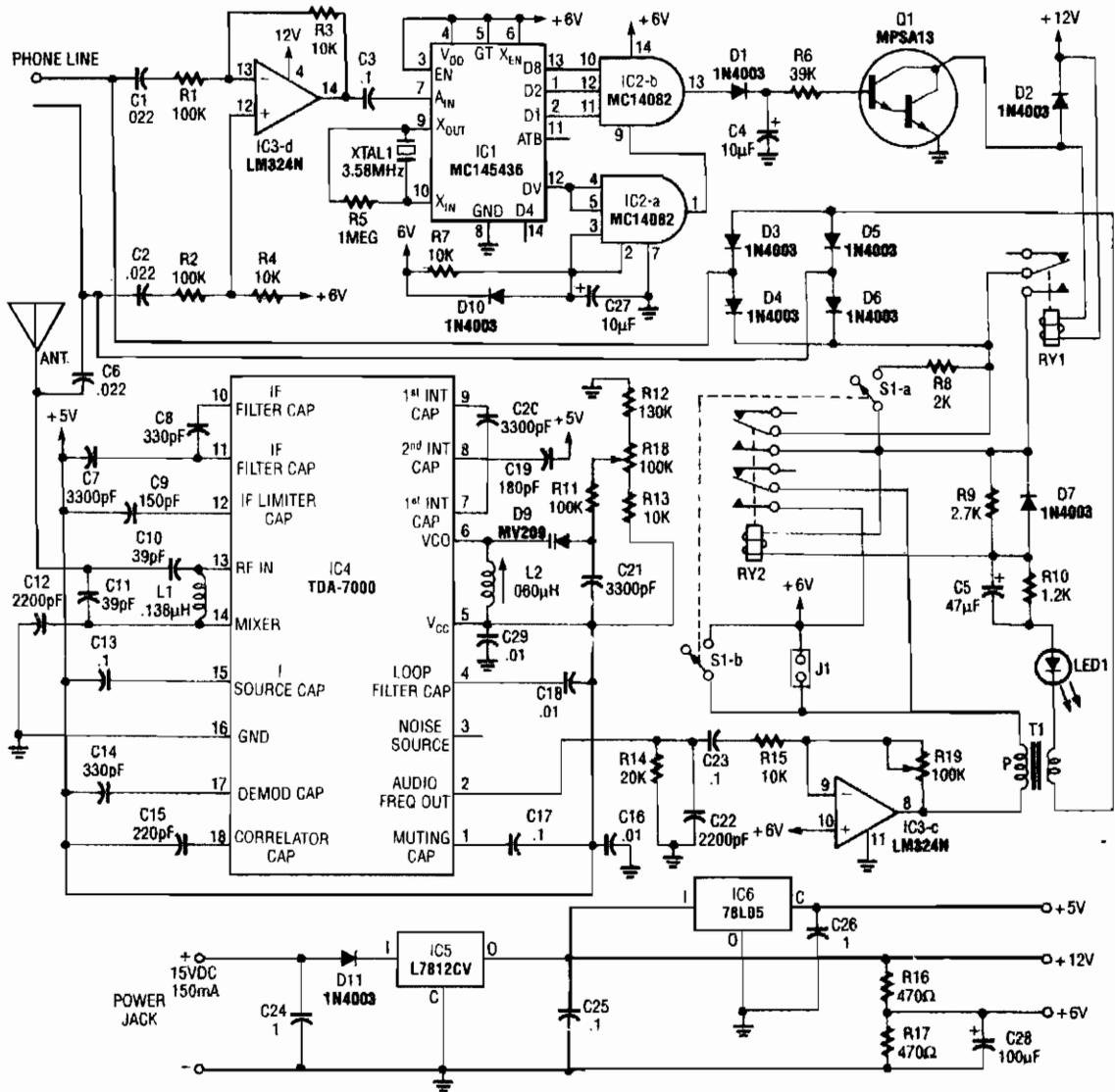


RADIO-ELECTRONICS

FIG. 100-2

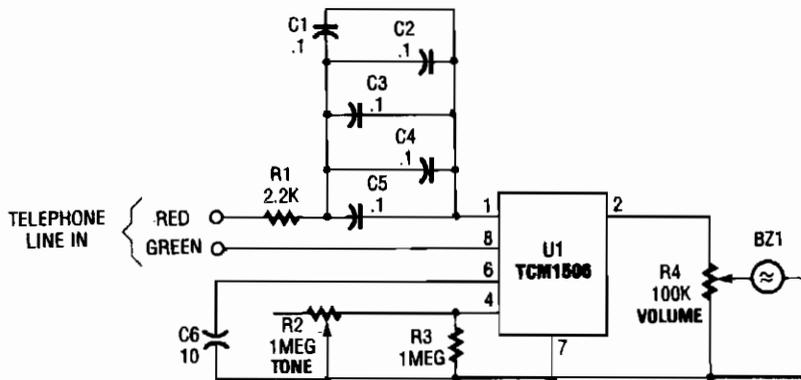
The dc voltage present on a telephone line is usually around 45 to 50 V on-hook and 6 V off-hook. This circuit uses this drop in voltage to activate a relay. The relay controls a cassette tape recorder. Audio is taken off through a network to the microphone input of the cassette.

## MUSIC ON HOLD



When an asterisk \* is pressed on the touch-tone phone, IC1 a DTMF decoder, controls on-hold logic. Audio from the FM receiver IC4 is placed on the telephone line when a hold condition is present. RV2 is a DPDT 12-V relay. To place a caller on hold, press the asterisk button on the touch-tone phone and hang up the handset.

## TELEPHONE RING CONVERTER



POPULAR ELECTRONICS

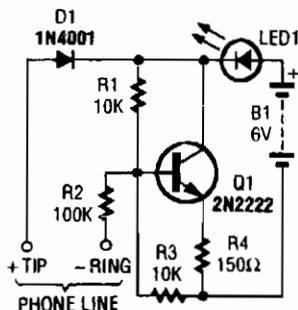
FIG. 100-4

The circuit is based on the TCM1506 ring detector/driver integrated circuit. It is a monolithic IC specifically designed to replace the telephone's mechanical bell. The chip is powered and activated by the telephone-line ring, which can vary from 40 to 150 V rms at a frequency of from 15 to 68 Hz. No other source of power is required. Again, referring to the figure shown, C1 through C5 are placed in parallel to form a 0.5- $\mu$ F capacitor that conducts the ac ring voltage to pin 1 of the TCM1506, but blocks any dc component. Of course, those capacitors can be replaced by a single 0.47- to 0.5- $\mu$ F capacitor provided that it has at least a 400-WVdc rating. Resistor R1 is in series with the capacitor network and is used to dissipate power from any high-voltage transient that might appear across the line. The diluted ac voltage that reaches pin 1 on U1 powers the chip.

Capacitor C6 is used to prevent "bell tapping." That is an annoying ringing of the bell that occurs when a phone on the same line is used to dial an outgoing call. The capacitor prevents the short dial pulses from triggering the ring detector, but still allows the much longer ring signal to activate it.

Potentiometer R2 is used to vary the tone of the ring signal from below 100 Hz to over 15 kHz. Potentiometer R4 is the volume control; adjusting that potentiometer to its lowest resistance will mute the piezo element (BZ1). When a ring signal is present on the phone-line, it powers U1. The IC then generates a tone (with a frequency that is determined by R2 and an amplitude set by R4) that is reproduced by BZ1.

## PHONE-IN-USE INDICATOR

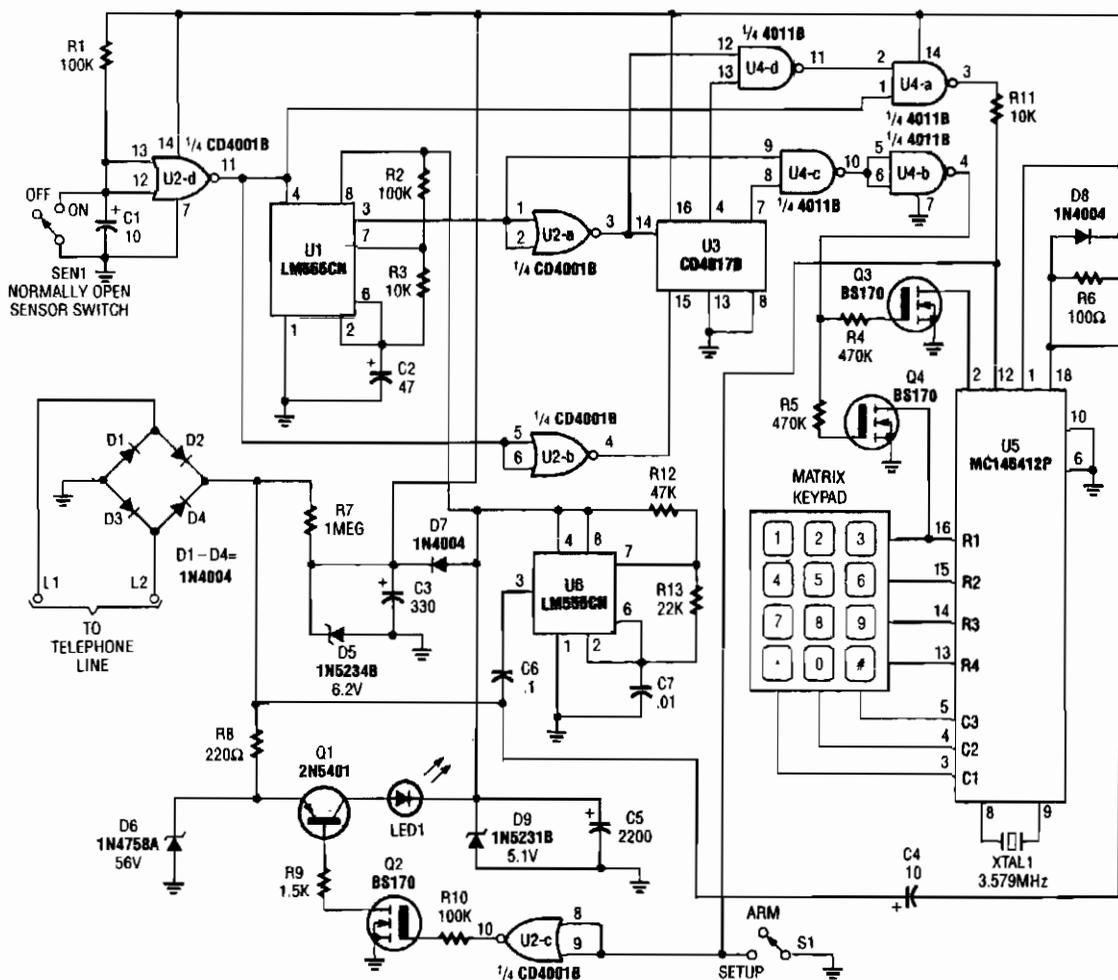


POPULAR ELECTRONICS

FIG. 100-5

This phone-in-use indicator also indicates the presence of a ring signal. Just the thing for the hearing impaired.

## EMERGENCY TELEPHONE DIALER



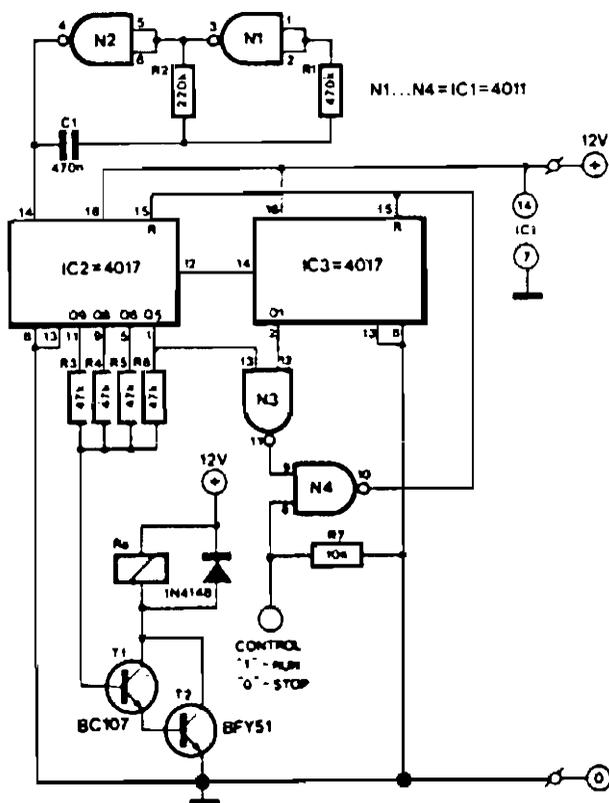
POPULAR ELECTRONICS

FIG. 100-6

This system will alert you or anyone chosen by automatically dialing a programmed phone number. This is accomplished by monitoring an open-loop or closed-loop sensor switch located in the protected area. When the sensor detects a problem (such as a break-in, fire, heating system failure, flood, etc.), Teleguard dials whatever telephone number has been programmed into its memory. When the phone is taken off the hook, Teleguard emits an unusual tone to alert the party on the receiving end that something is amiss.

The circuit is not hampered by busy signals when a call is placed; it automatically redials the number again and again (about once a minute) until it gets through. In addition, Teleguard can also automatically dial a number in the event of a medical emergency; for instance, where a mobility-impaired person is unable to dial the telephone. That can be accomplished by adding a "panic" switch to the circuit.

## TELEPHONE BELL SIMULATOR

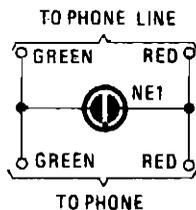


### 303 CIRCUITS

FIG. 100-7

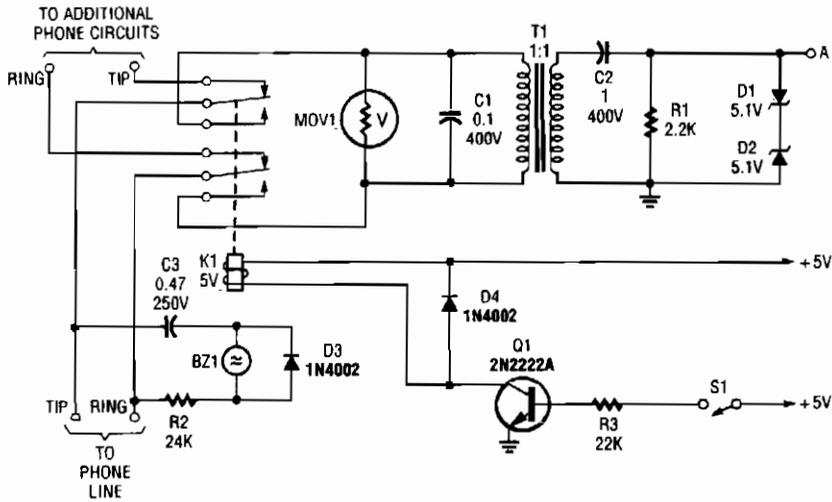
This circuit is intended for use in a small private telephone installation. The ringing tone sequence is 400 ms on, 200 ms off, 400 ms on, 2 ms off. In the accompanying diagram, N1 and N2 form an oscillator that operates at a frequency of 5 Hz, which gives a period of 200 ms. The oscillator signal is fed to two decade scalars, which are connected in such a manner (by N3 and N4) that the input signal is divided by 15. The second input of N4 can be used to switch the divider on and off by logic levels. If this facility is not used, the two inputs of N4 should be interconnected.

## SIMPLE TELEPHONE RING INDICATOR



A neon lamp can easily be added to the phone line to act as a ring indicator. It's perfect for times when you can't hear the phone.

## PHONE-LINE INTERFACE

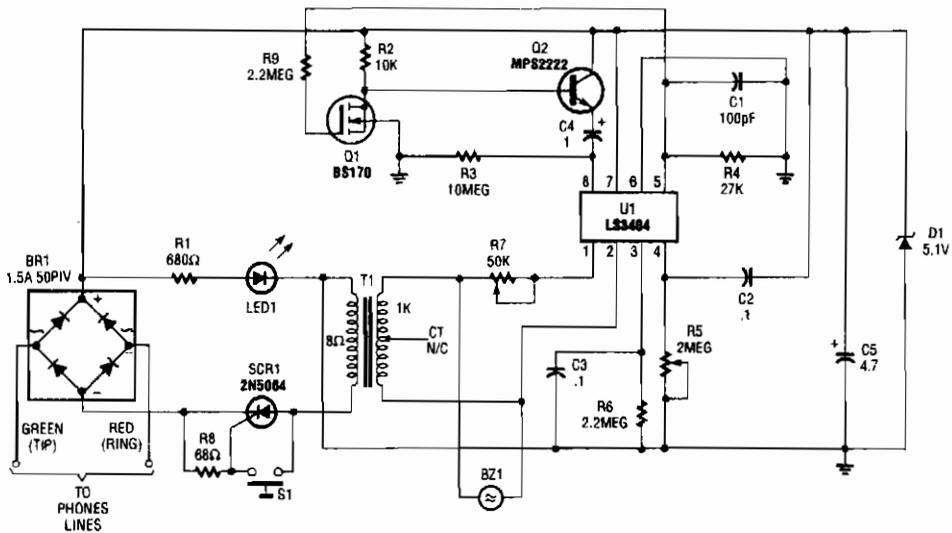


POPULAR ELECTRONICS

FIG. 100-9

This circuit should be useful for interfacing phone projects to the telephone line. It has a ringer, can interrupt the wiring, and isolates project from the phone line.

## MUSIC-ON-HOLD BOX

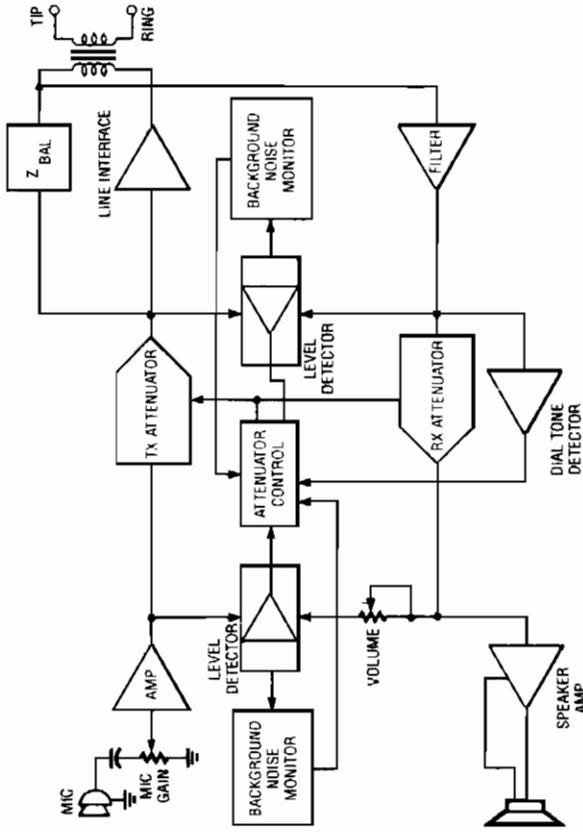


POPULAR ELECTRONICS

FIG. 100-10

U1, an LS3404 melody chip is activated when "hold" S1 is pressed, which causes SCR1 to conduct and hold the telephone line via T1, R1, and LED1. The voltage across R1 and LED1 is used to activate the melody chip. Q1 and Q2 form a restart circuit to keep the melody chip going during hold.

## SPEAKERPHONE ADAPTER



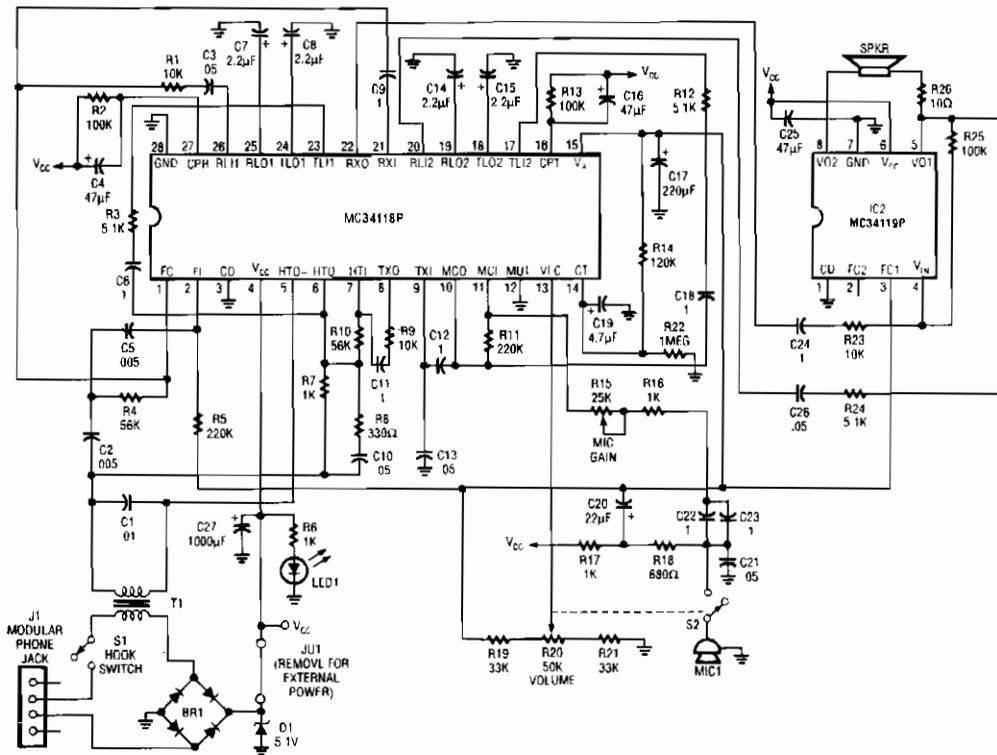
**BLOCK DIAGRAM.** The talk path goes left to right on the upper half of the drawing, and the receive path goes from right to left.

RADIO-ELECTRONICS

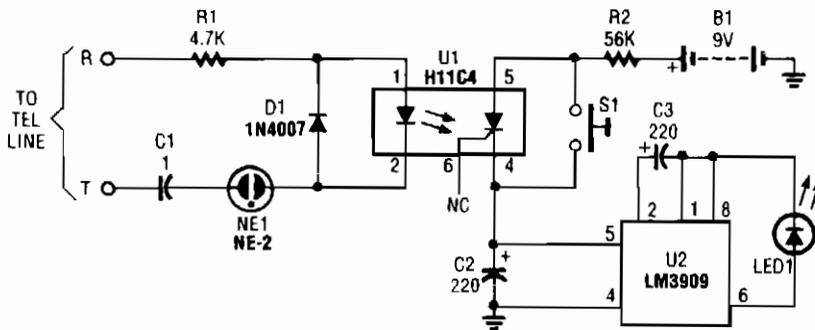
FIG. 100-11

Using a Motorola MC34118 speakerphone IC, this adapter can be used with a regular telephone to provide speaker capability. This device is powered from the phone line, but it can be powered via an external power supply if the line loop current is marginally low. An external phone is needed for ringing and dialing functions.

## SPEAKERPHONE ADAPTER (Cont.)

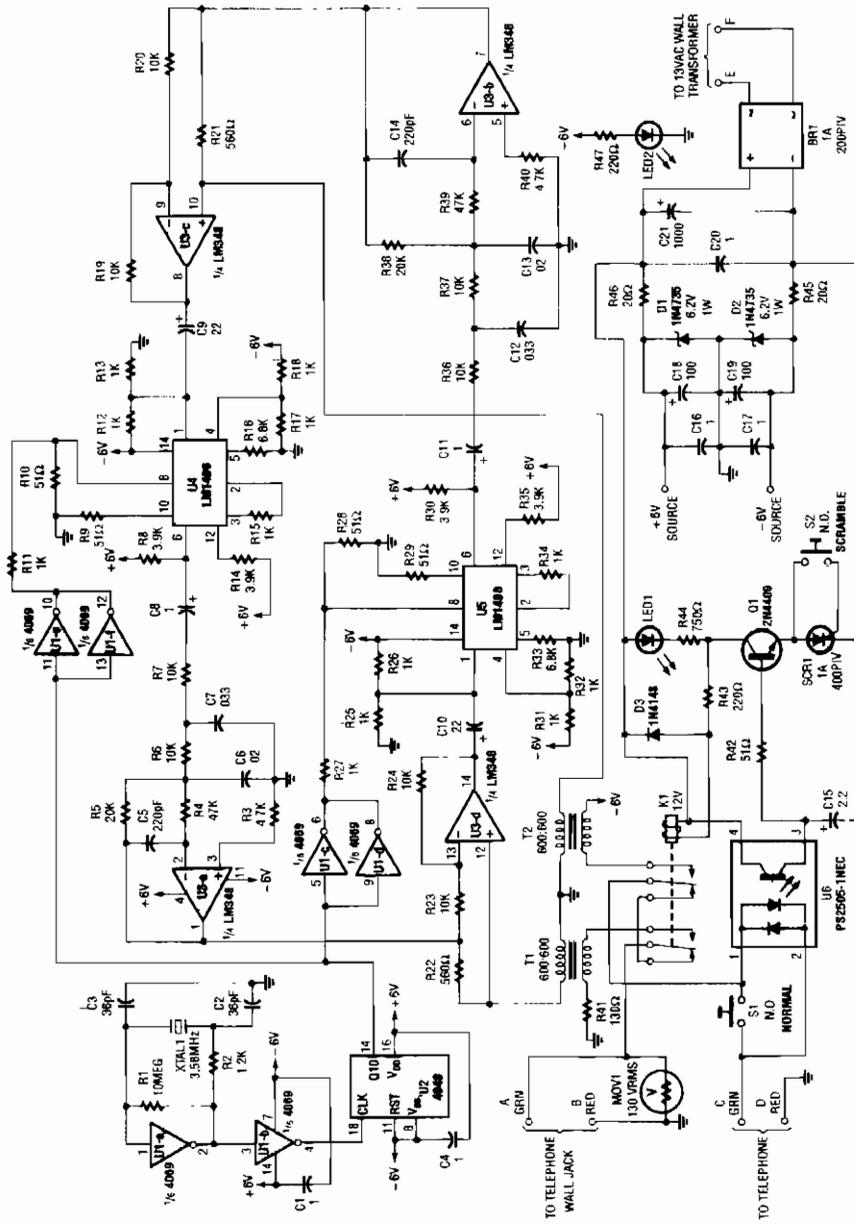


## TELEPHONE VOICE-MAIL ALERT



The circuit is built around a couple of low-cost ICs: an H11C4 optoisolator/coupler with an SCR output (U1) and an LM3909 LED flasher (U2). It is connected to the phone line in the same manner as any extension phone. A ring signal on the telephone activates the optoisolator/SCR, and causes U2 to flash LED1. This flash signifies that a ring signal has been received.

## TELEPHONE SCRAMBLER

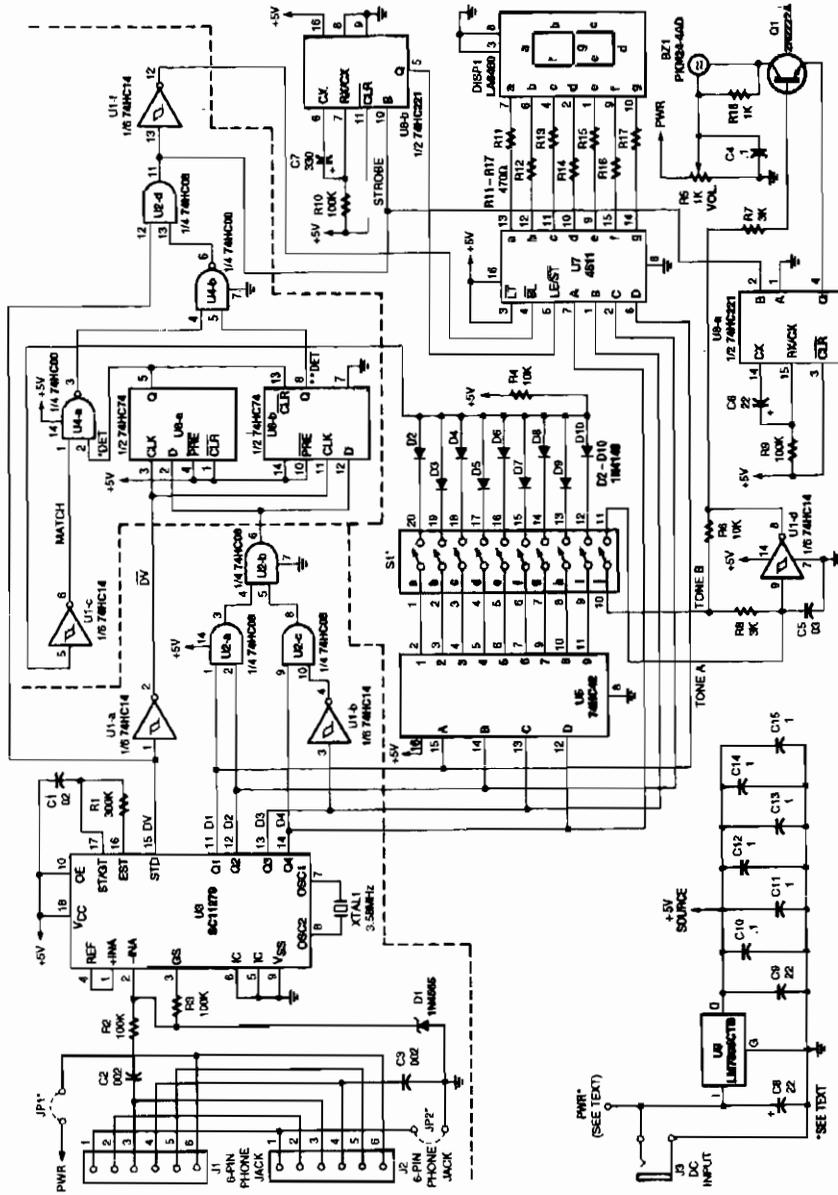


POPULAR ELECTRONICS

FIG. 100-13

Two hybrids (T1 and T2) are used to allow direct connection to a telephone line. This circuit uses the common speech-inversion algorithm where the frequency of an audio signal is inverted about a center frequency. An LM1496 balanced modulator is used to heterodyne the speech range against a 3.58-kHz signal.

# PHONE PAGER

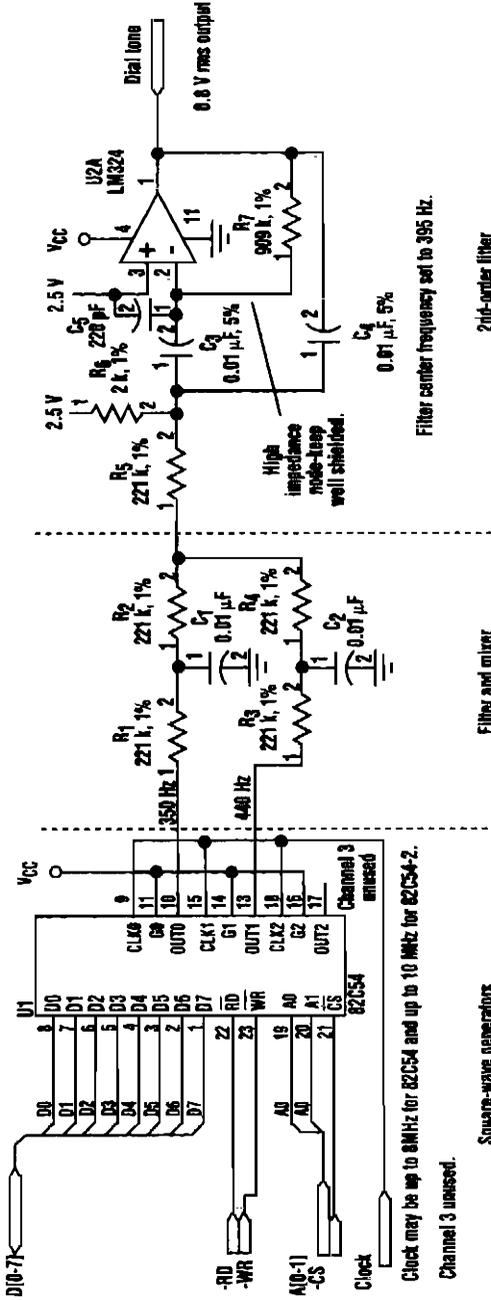


POPULAR ELECTRONICS

FIG. 100-14

This pager allows you to use your in-house phone wiring as a PA system. It uses two tone decoders to detect a particular touch-tone key. This key enables an audio amplifier.

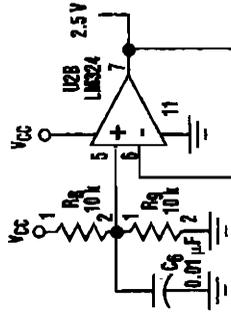
5-V DIAL-TONE CIRCUIT



Square-wave generators

Filter and mixer

2nd-order filter



82C54 PROGRAMMING INFORMATION

- OUT BASE, 76h ; Set up channel 1 as sqr wave divider
- OUT BASE+1, DIVISOR low byte ; Enter divisor for 350Hz, low byte
- OUT BASE+1, DIVISOR high byte ; Enter divisor for 350Hz, high byte
- OUT BASE, 0b6h ; Set up channel 2 as sqr wave divider
- OUT BASE+2, DIVISOR low byte ; Enter divisor for 440Hz, low byte
- OUT BASE+2, DIVISOR high byte ; Enter divisor for 440Hz, high byte

For 1.8432MHz Clock, 350 Hz divisor = 5266 or 1492 hex.  
 For 1.8432MHz Clock, 440 Hz divisor = 4189 or 105d hex.

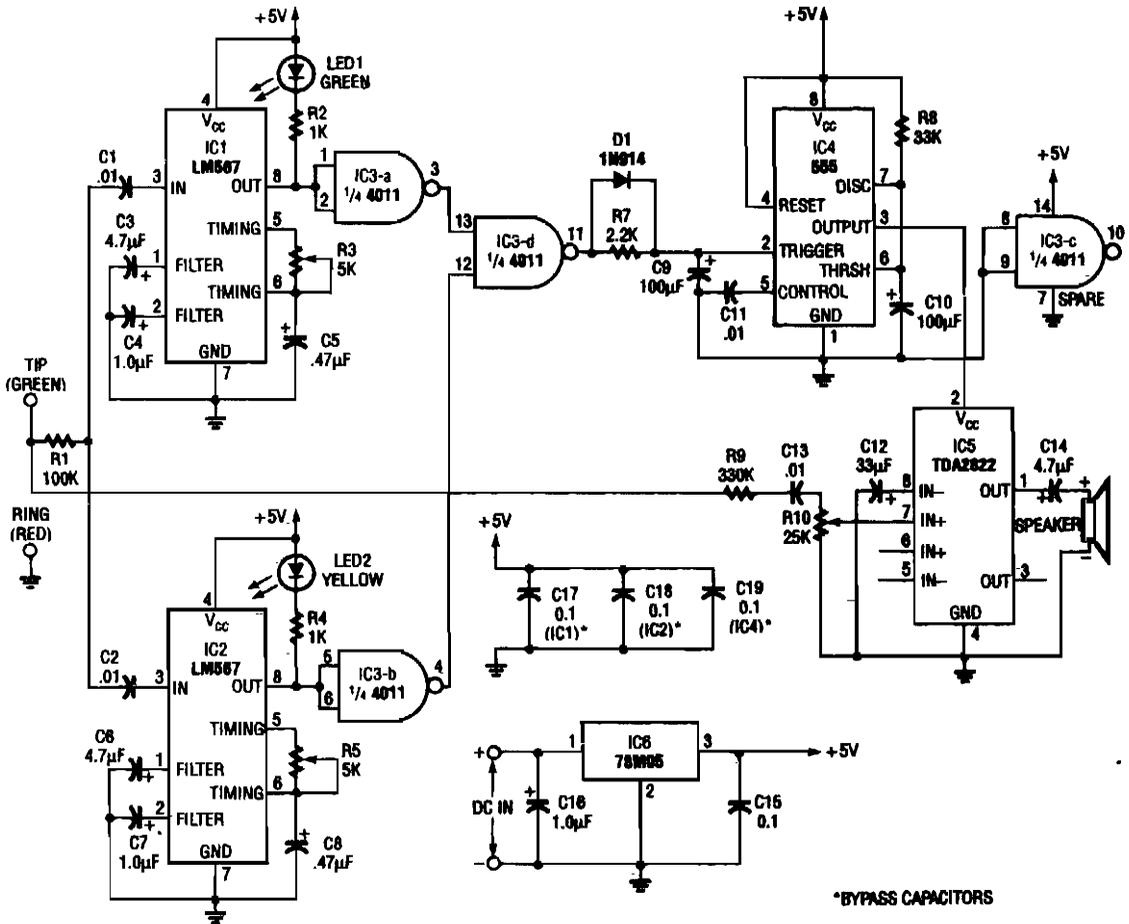
ELECTRONIC DESIGN

This circuit uses inexpensive, common components to generate a precise dial tone for phone applications (see the figure). U1 (an Intel 82C54 timer-counter) generates 350- and 440-Hz square waves that are filtered by  $R_1/C_1$  and  $R_3/C_2$ , and mixed together by resistors R2 and R4.

An operational amplifier configured as a 395-Hz, Sallen-Key, second-order bandpass filter (halfway between 350 and 440 Hz) removes unwanted signal harmonics. Almost any timer-counter can be used as the signal source, so long as it produces roughly square-wave outputs.

FIG. 100-15

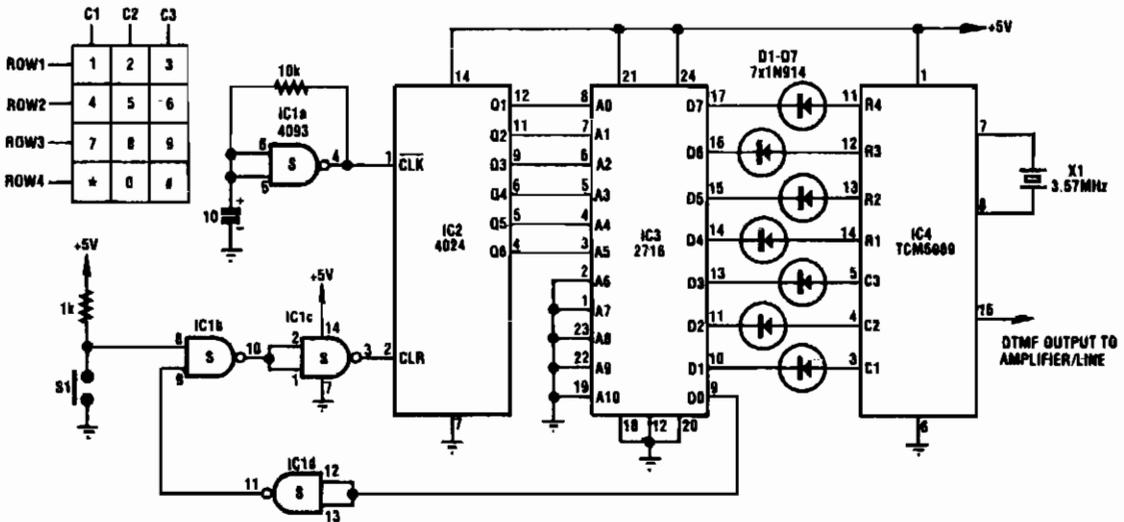
# PHONE PAGER



\*BYPASS CAPACITORS

This pager works with DTMF phones. It displays a number and sounds an alert as the number on the display corresponds to a specific message.

## ALARM DIALER



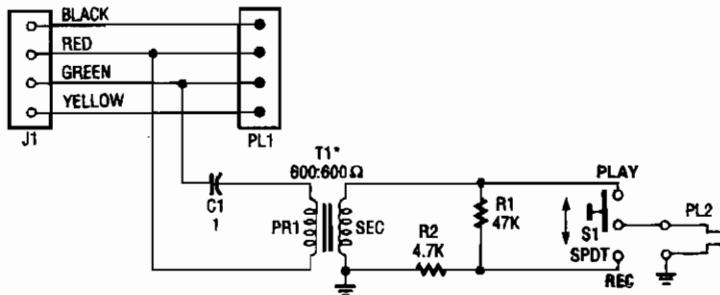
SILICON CHIP

FIG. 100-17

This circuit dials a stored DTMF tone sequence from EPROM when a control line is taken to 0 V. IC1 is a Schmitt trigger oscillator, running at around 2 Hz. It clocks a 4024 binary counter. The counter's outputs connect to the address leads of the EPROM. A 2716 was used here, but the choice of EPROM is by no means critical.

Normally, the counter is held reset by a logic 1 on its reset pin (pin 2). When the trigger input is sent low, pin 10 of IC1 goes low, pin 3 goes high, and the reset is removed from the counter. It then begins to clock, incrementing the EPROM. When moved from address 000000, the data on bit D0 of the EPROM changes to a logic 1 and holds the circuit running. The last address should have data 11111110 to reset the circuit to standby.

## TELEPHONE AUDIO INTERFACE

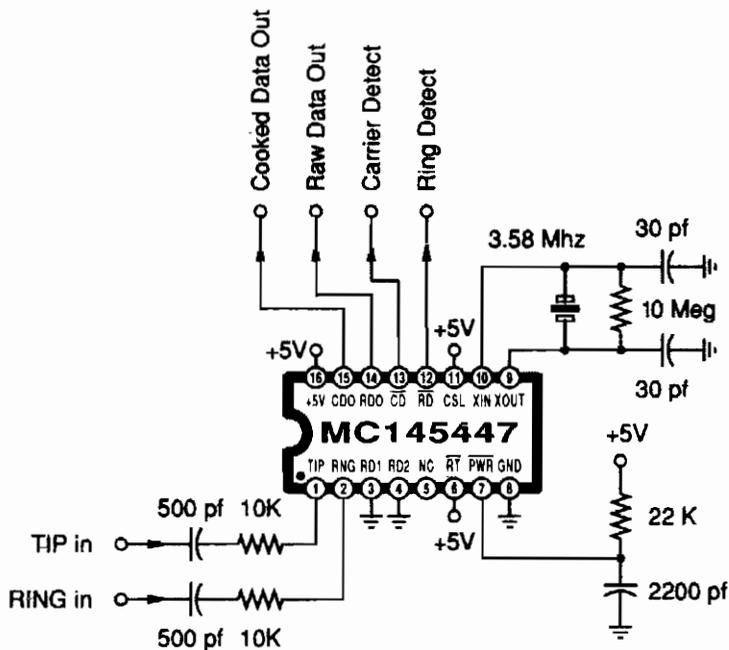


POPULAR ELECTRONICS

FIG. 100-18

Used to record and play back tapes via the phone lines, this simple circuit has an audio level switch (S1).

## CALLER ID CIRCUIT



RADIO-ELECTRONICS

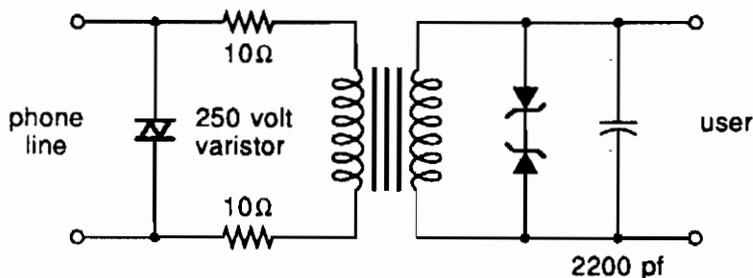
FIG. 100-19

This caller ID circuit uses the Motorola MC145447 IC chip. This service must be available from your local phone company in order for this circuit to be used.

## FCC PART 68 PHONE INTERFACE

The transformer is 1:1  
600 Ohms, with a 1500  
volt breakdown rating.

The zener diodes are  
3.9 volt devices, such  
as a type 1N5228.

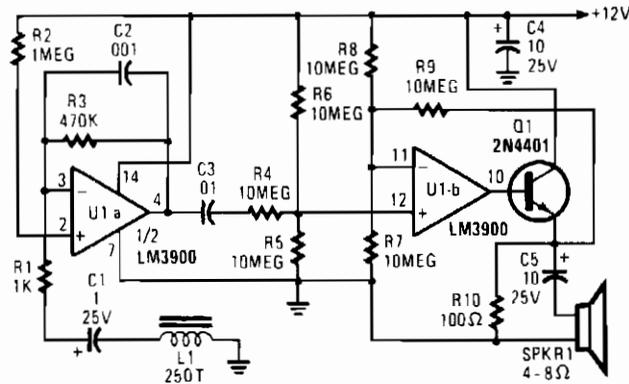


RADIO-ELECTRONICS

FIG. 100-20

An FCC Part 68 interface is required any time you connect any circuit of your own to the phone line.

## TELEPHONE AMPLIFIER



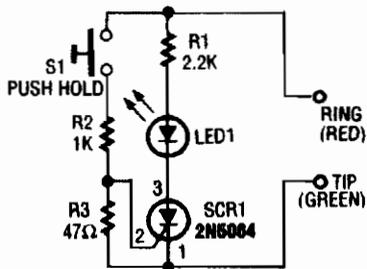
POPULAR ELECTRONICS

FIG. 100-21

Section U1-a is configured as a high-gain inverting voltage amplifier that is inductively coupled to the phone line via L1. Inductor L1 is a homemade unit that consists of 250 turns of fine, enamel-coated wire that is wound on an iron core. The op amp receives the few mV produced by L1 via C1 and R1 and amplifies the signal. Capacitor C1 acts as the negative-feedback component that limits the circuit's high-frequency gain, while R3 limits the low-frequency gain. Resistor R3 is particularly important because without it, the amplifier would saturate.

Op amp U1-b is configured as a difference amplifier. It receives a signal from U1-a via C3 and R4 and amplifies the difference between it and half of the supply voltage. Transistor Q1 is configured as a common-collector amplifier ensuring sufficient signal to drive the speaker. Capacitor C5 is used to remove any dc component provided by transistor Q1.

## TELEPHONE HOLD CIRCUIT



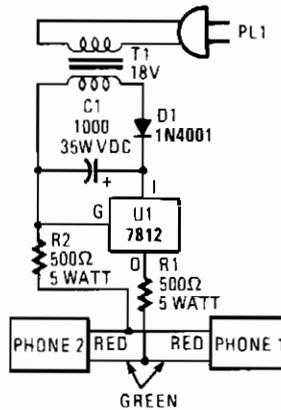
When S1 is pressed, the SCR fires, and places LED1 and R1 across the phone line. The line voltage drops to about 20 V, which holds the connection to the phone company's central office.

ELECTRONICS NOW

FIG. 100-22

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## TELEPHONE CIRCUIT



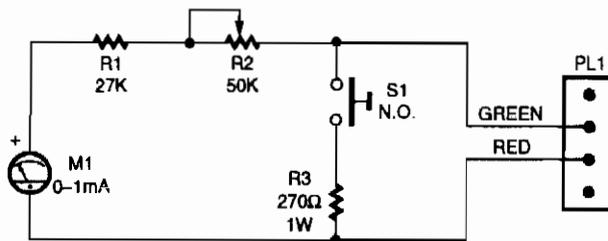
POPULAR ELECTRONICS

FIG. 100-23

This circuit is useful for checking out old telephones by providing them with the dc voltage that they require for operation.

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## TELEPHONE-LINE TESTER



POPULAR ELECTRONICS

FIG. 100-24

The telephone-line tester consists of nothing more than a meter (that's used to measure line voltage in the on- and off-hook state), three resistors (one of which is variable), a pushbutton switch, and a modular telephone connector. When the circuit is connected to the telephone line, a meter reading of 5 to 10 V (when S1 is pressed) indicates that the line is okay.

# 101

## Temperature-Related Circuits

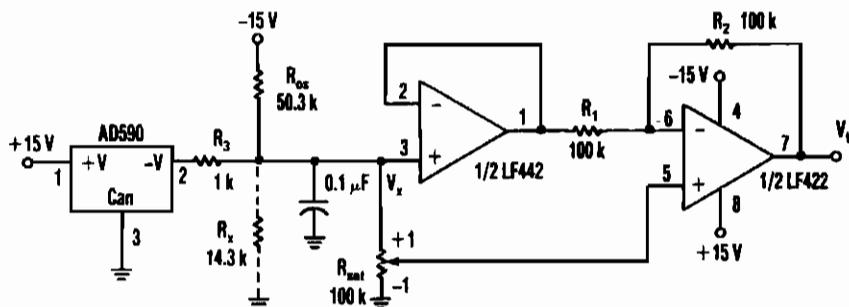
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Temperature Compensation Adjuster  
Thermometer for 5-V Operation  
Hook Sensor on 4- to 20-mA Loop  
Basic Digital Thermometer  
Remote Temperature Sensing  
Temperature Sensor  
Low Temperature Sensor  
Electronic Thermostat

## TEMPERATURE COMPENSATION ADJUSTER

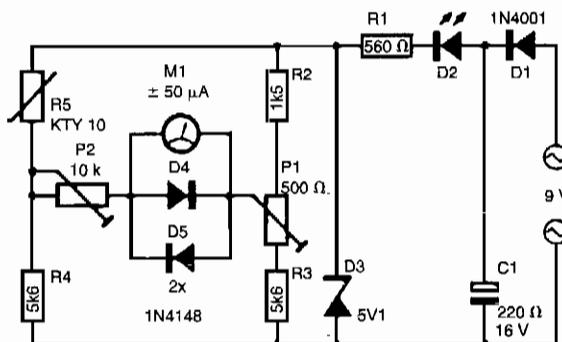


ELECTRONIC DESIGN

FIG. 101-1

The circuit shown delivers +10 to -10 mV<sup>o</sup>/C output using an Analog Devices' AD590 temperature transducer.  $R_x$  is a scaling resistor.

## THERMOMETER FOR 5-V OPERATION



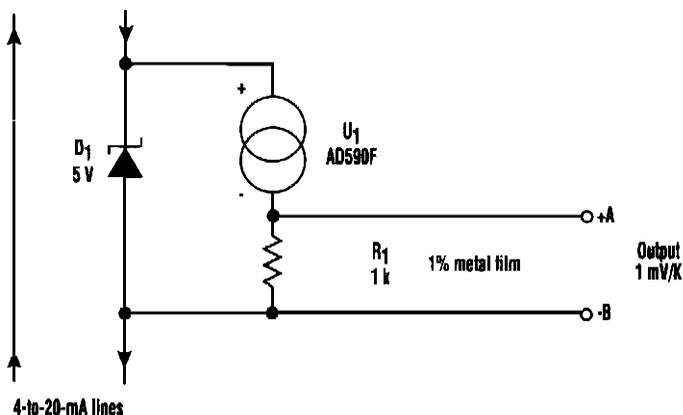
303 CIRCUITS

FIG. 101-2

At the heart of this simple circuit is the well-known type KTY10 temperature sensor from Siemens. This silicon sensor is essentially a temperature-dependent resistor that is connected as one arm in a bridge circuit here. Preset P1 functions to balance the bridge at 0°C. At that temperature, moving coil meter M1 should not deflect, i.e., the needle is in the center position. Temperature variations cause the bridge to be unbalanced, and hence produce a proportional indication on the meter. Calibration at, say, 20°C is carried out with the aid of P2.

The bridge is fed from a stabilized 5.1-V supply, based on a temperature-compensated zener diode. It is also possible to feed the thermometer from a 9-V battery, provided D1-D3, R1 and C1 are replaced with a Type 78L05 voltage regulator, because this is more economic as regards to current consumption.

## HOOK SENSOR ON 4- TO 20-mA LOOP



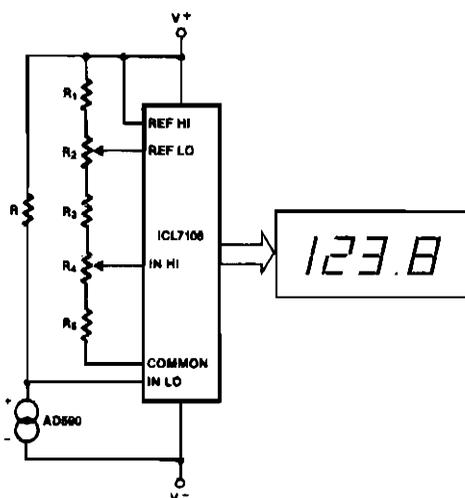
ELECTRONIC DESIGN

**FIG. 101-3**

Here's an effective for a temperature sensor to receive power from a 4-to-20 mA loop without actually affecting the loop current (see the figure). This particular temperature sensor IC (AD590F) conducts 1  $\mu\text{A}/\text{K}$  when powered by a supply in the range of 4 V to 40 Vdc.

The scheme uses a 5-V Zener diode (D1) to regulate the power source for AD590F. Most of the current flows through the Zener diode and a small current flows through AD590F. A high-impedance device can read the temperature information across R1, which is a 1 mV/K in the range of  $-55^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ . The waste of power is negligible in this arrangement.

## BASIC DIGITAL THERMOMETER



	R	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>
$^{\circ}\text{F}$	9.00	4.02	2.0	12.4	10.0	0
$^{\circ}\text{C}$	5.00	4.02	2.0	5.11	5.0	11.8

$$\sum_{n=1}^5 R_n = 28\text{k}\Omega \text{ nominal}$$

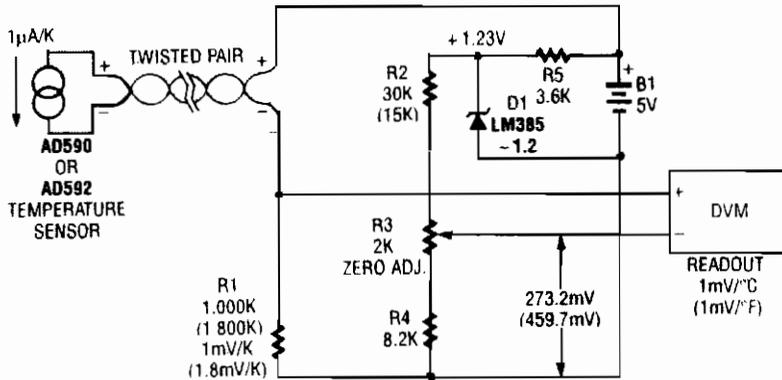
All values in  $\text{k}\Omega$

The ICL7106 has a  $V_{\text{IN}}$  span of  $\pm 2.0\text{V}$ , and a  $V_{\text{CM}}$  range of  $(V^+ - 0.5)$  Volts to  $(V^- + 1)$  Volts; R is scaled to bring each range within  $V_{\text{CM}}$  while not exceeding  $V_{\text{IN}}$ .  $V_{\text{REF}}$  for both scales is 500mV. Maximum reading on the Celsius range is 199.9 $^{\circ}\text{C}$ , limited by the (short-term) maximum allowable sensor temperature. Maximum reading on the Fahrenheit range is 199.9 $^{\circ}\text{F}$  (93.3 $^{\circ}\text{C}$ ), limited by the number of display digits. See note next page.

INTERSIL

**FIG. 101-4**

## REMOTE TEMPERATURE SENSING

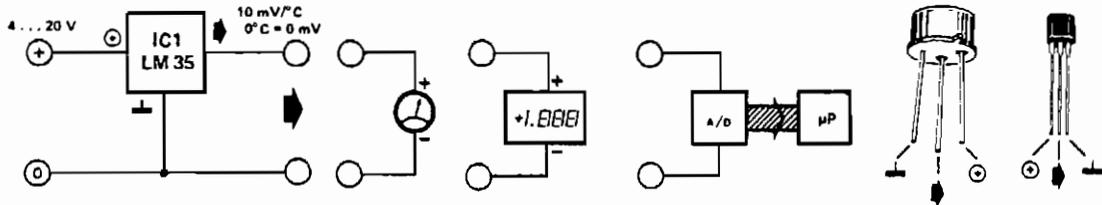


RADIO-ELECTRONICS

FIG. 101-5

An AD590 or AD592 makes it easy to transmit temperature data over a pair of wires. The circuit produces  $1\text{mV}/^\circ\text{C}$  (or  $1\text{mV}/^\circ\text{F}$  using the values in parentheses).

## TEMPERATURE SENSOR

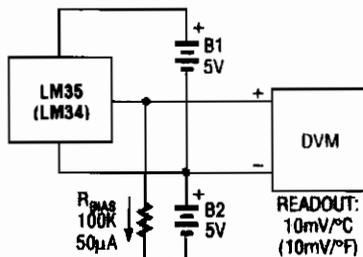


303 CIRCUITS

FIG. 101-6

The LM35 temperature sensor provides an output of  $10\text{mV}/^\circ\text{C}$  for every degree Celsius over  $0^\circ\text{C}$ . At  $20^\circ\text{C}$  the output voltage is  $20 \times 10 = 200\text{mV}$ . The circuit consumes  $60\mu\text{A}$ . The load resistance should not be less than  $5\text{k}\Omega$ . A 4- to 20-V supply can be used.

## LOW TEMPERATURE SENSOR

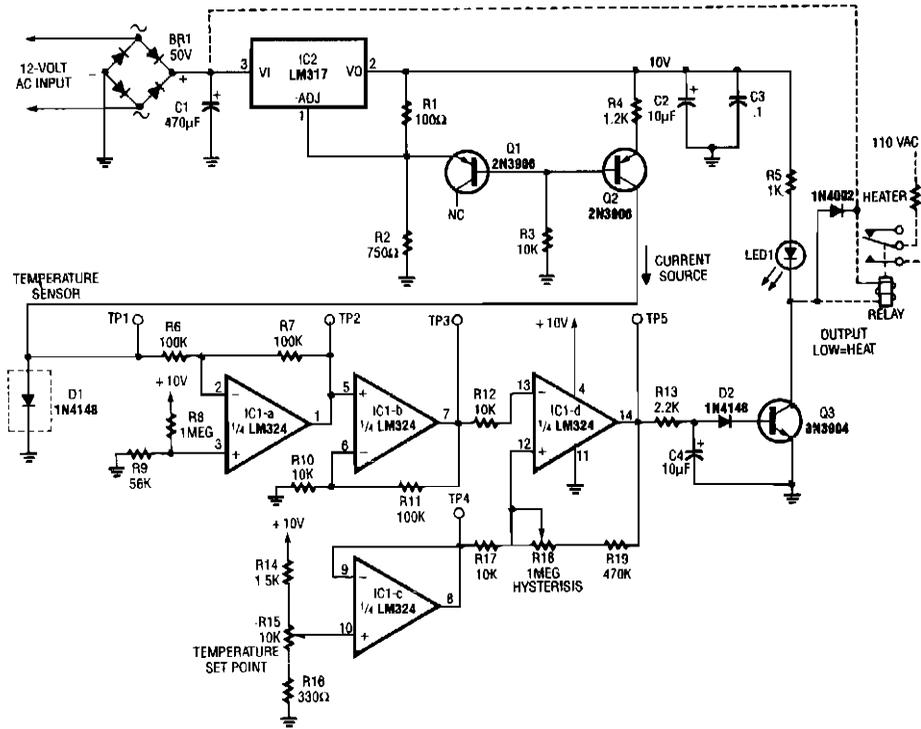


A negative bias current can produce the offset needed for below-zero readings using the LM34 or LM35 temperature sensor.

RADIO-ELECTRONICS

FIG. 101-7

## ELECTRONIC THERMOSTAT



**TABLE 1—RESISTOR VALUES**

Temperature Range (Degrees C)	R14	R15	R16
- 50 to - 30	10K	1K	330Ω
- 30 to - 10	9.1K	1K	1.2K
- 10 to 15	8.2K	1K	2.2K
15 to 35	7.5K	1K	3.3K
35 to 55	6.2K	1K	4.3K
55 to 75	5.1K	1K	5.1K
75 to 95	4.3K	1K	6.2K
95 to 115	3.3K	1K	6.8K
115 to 135	2.2K	1K	8.2K
135 to 155	1.2K	1K	9.1K

A diode, such as a 1N4148, has a typical  $-2\text{m V}/^\circ\text{C}$  temperature coefficient at a 1 mA diode current. Q1 and Q2 form a constant current source. D1 is the temperature sensor. IC1-a and -b are dc amplifiers, with IC1-c a temperature reference voltage supply. IC1-d is a comparator with variable hysteresis. R14, R15, and R16 are chosen depending on the thermostat range desired. Q3 is a relay driver (2N3904). The relay used should handle the load current or an optoisolator triac combination can be used.

# 102

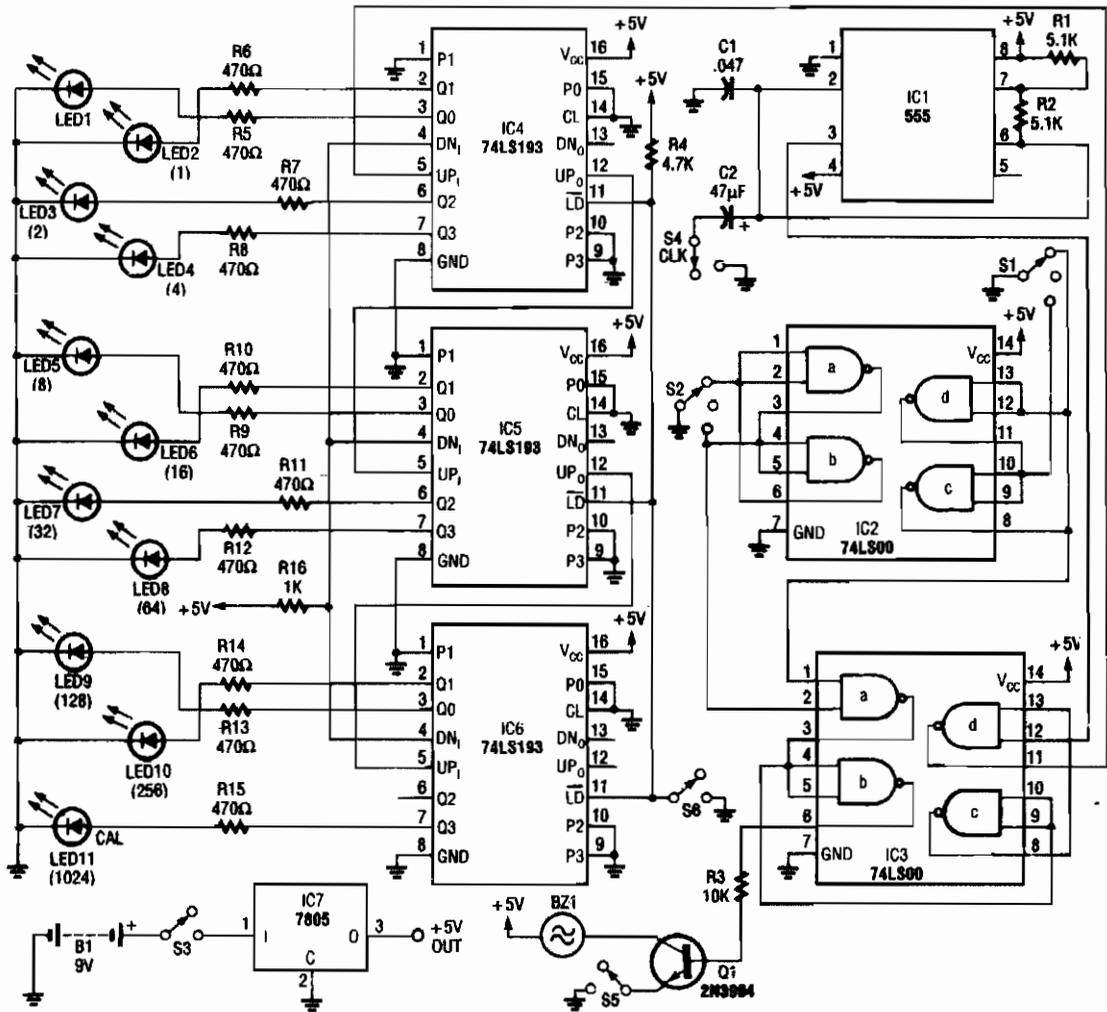
## Timer Circuits

---

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

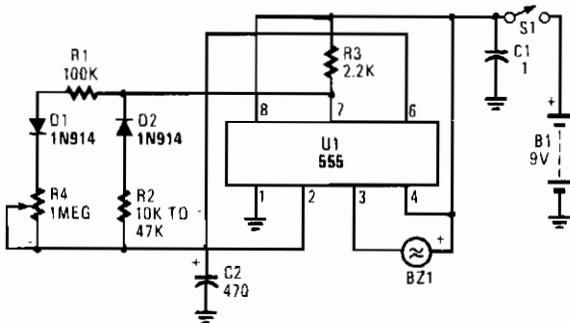
Reflex Timer  
Tele-Timer  
Three-Stage Sequential Timer  
2- to 2000-Minute Timer  
Long Period Timer  
Wide-Range Timer—1 Minute to 400 HRS  
Long Delay-Period Timer  
Count-Down Timer  
Extended On-Time Timer

## REFLEX TIMER



This timer circuit uses a 555 IC timer and three 74LS193 counters to drive an LED display. S1 is activated by one person, who turns on piezo buzzer BZ1 via Q1 and also starts the clock; S1 is activated by the other person being timed. This shuts off the timer, and the number of LEDs lit indicate, in binary form, the elapsed time.

## TELE-TIMER



Here's how the dual timer operates. When the power is switched on, C2 begins to charge through R3, R1, D1, and R4 to start the long-term timer period. When the voltage across C2 reaches the 555's internal switching point, the long-term timer times out, discharging C2 through R2, D2, and pin 7 of the 555. During that time, pin 3 of the 555 is pulled to ground, activating the piczo sounder.

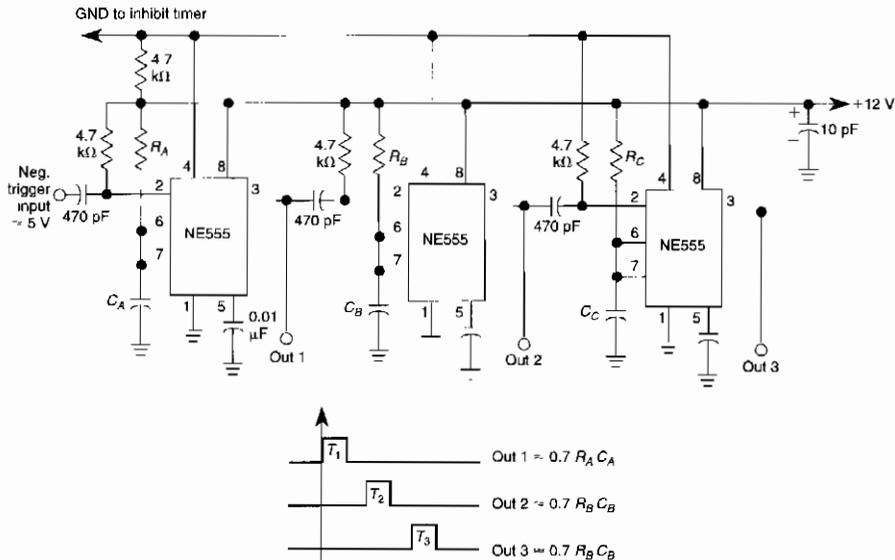
To set the short time period to about four seconds, use a 10 k resistor for R2, and for about twenty seconds use a 47 k resistor. The timing capacitor, C2, should be a good-quality, low-leakage unit.

### POPULAR ELECTRONICS

FIG. 102-2

The circuit is built around a 555 oscillator/timer. The circuit provides two time periods. The long-running time period is adjustable from about 1 to 10 minutes, and the short time period is pre-set to about three seconds.

## THREE-STAGE SEQUENTIAL TIMER

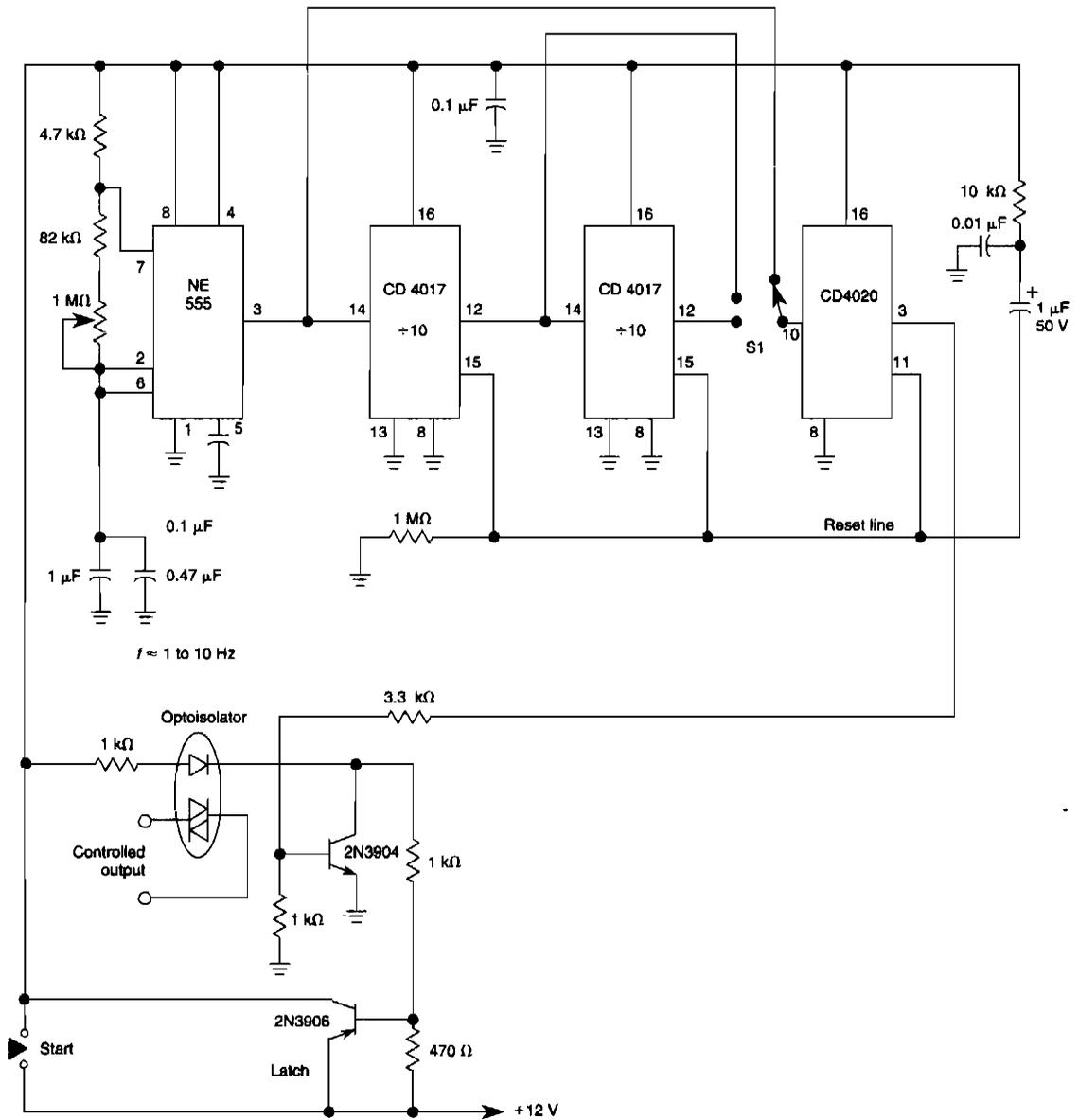


### WILLIAM SHEETS

FIG. 102-3

By using three 555 ICs, three sequential pulses can be generated. Output 3 can be connected back to trigger input to achieve astable operation.

## WIDE-RANGE TIMER—1MINUTE TO 400 HRS

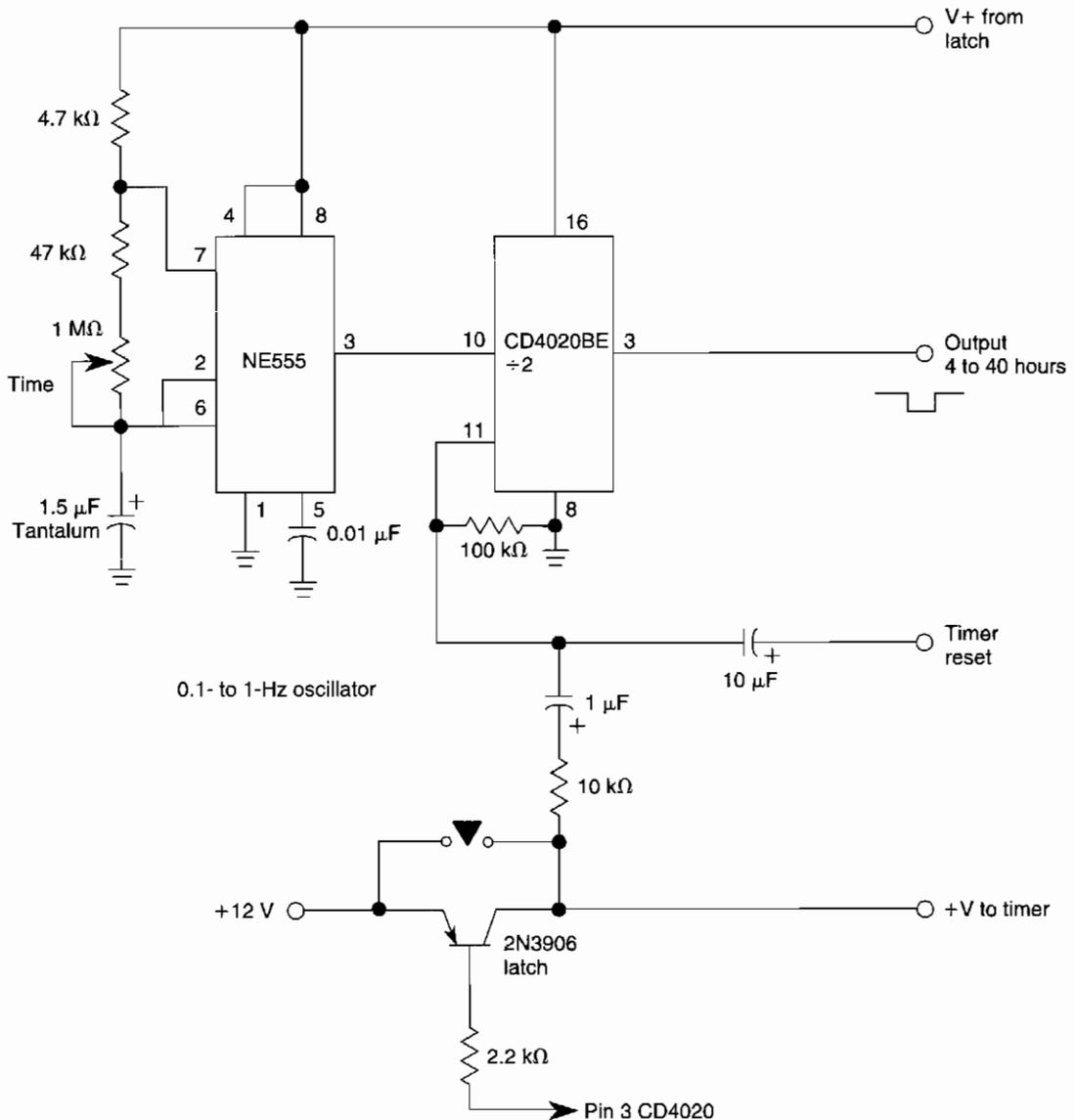


WILLIAM SHEETS

FIG. 102-6

This ultra wide range timer uses a 555 timer base, two 4017Bs and a 4020B that act as frequency dividers that can be switched in and out. S1 is a SP3T range switch.

## LONG-DELAY-PERIOD TIMER

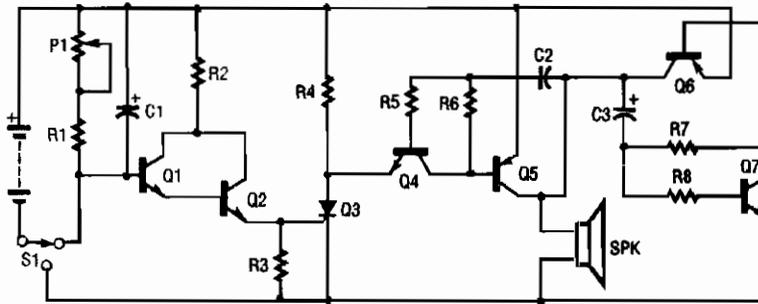


WILLIAM SHEETS

FIG. 102-7

This method of obtaining a 4 to 40 hour timing period from a 555 IC can be further expanded to produce even longer delays with equal accuracy.

## COUNT-DOWN TIMER



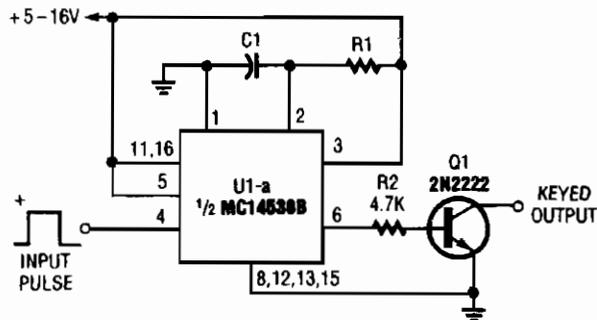
**FIG. 102-8**

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C1	100- $\mu$ F Electrolytic Capacitor	R3	33-k $\Omega$ Resistor
C2	0.0047- $\mu$ F Mylar Capacitor	R4	200 $\Omega$ Resistor
C3	1- $\mu$ F Electrolytic Capacitor	R5	2.2-k $\Omega$ Resistor
P1	2-M $\Omega$ Trimmer Resistor	R6	220-k $\Omega$ Resistor
Q1, Q2, Q4, Q7	2N3904 Transistor	R7	2.2-M $\Omega$ Resistor
Q3	106 SCR	R8	7.5-k $\Omega$ Resistor
Q5, Q6	2N3906 Transistor	S1	SPDT Slide Switch
R1	1-M $\Omega$ Resistor	SPK	Small Speaker
R2	10-k $\Omega$ Resistor	Misc	PC Board, 9-V Snap Wire

With switch S1 in the off position, as shown, battery voltage is applied across timing-capacitor C1, which stays charged while the rest of the circuitry has no power supplied to it. Transistor Q1, and thus transistors Q2 through Q4, are kept in an off condition as long as C1 has a sufficient charge.

## EXTENDED ON-TIME TIMER



**FIG. 102-9**

POPULAR ELECTRONICS

Half of a Motorola MC14538B dual, precision, retriggerable monostable multivibrator is used to form an extended on-time timer circuit. That type of circuit can be used as a switch debouncer. Such circuits are often used in digital circuitry, where each and every bounce of a switch contact is seen as a separate digital input.

The delay on time (established by C1 and R1) is easily set using the formula,  $C_1 \times R_1 = T$ , where  $C_1$  is in microfarads,  $R_1$  is in megohms, and  $T$  is in seconds.

# 103

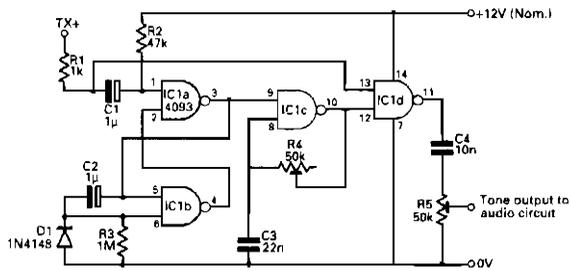
## Tone Circuits

---

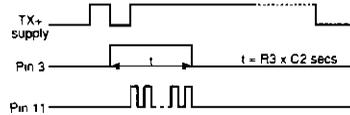
The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Repeater-Tone Burst Generator  
Two-Tone Encoder

## REPEATER-TONE BURST GENERATOR



**Fig. 1: The circuit, based on a single c.m.o.s. chip and a few other components.**



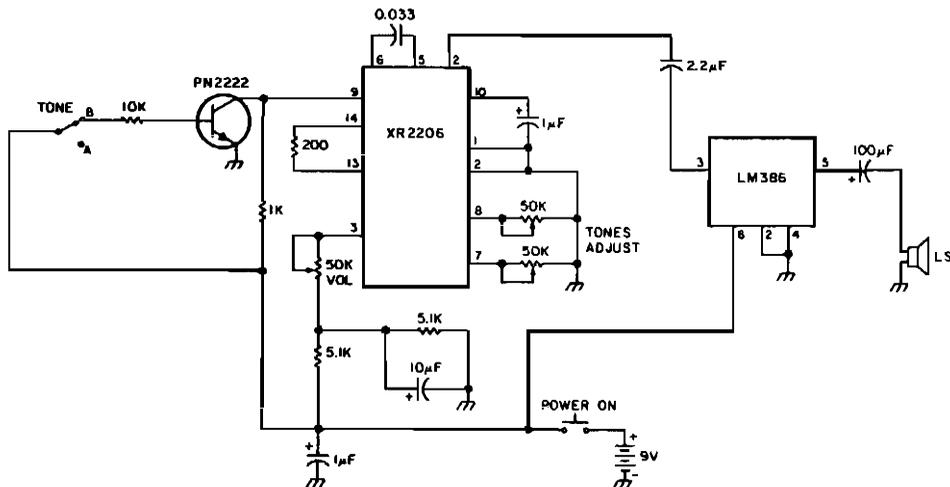
**Fig. 2: Pulse and timing diagram, see the text for more details.**

### PRACTICAL WIRELESS

**FIG. 103-1**

Integrated circuit gates IC1-a and IC1-b form a monostable, whose time constant is determined by  $C_2$  and  $R_3$ . When the transmitter is dekeyed (and then almost immediately rekeyed) point TX+ goes low and takes pin 1 low for a short time. This triggers the start of the timing period controlled by  $C_2/R_3$ . The capacitor  $C_2$ , charges via  $R_3$  until the trigger point of gate IC1-b is reached. At this point, the monostable changes state and pin 3 goes low again. On the prototype, this time was about 700 ms. The pulse occurs each time after dekeying and it is normally inaudible. If, however, point TX+ goes high again (as in immediate rekeying) the monostable is still in the enabled state and the oscillations of IC1-c are present in the transmission. During this time period, the buffer gate, IC1-d, is enabled and the tone is therefore passed to the output.

## TWO-TONE ENCODER



### 73 AMATEUR RADIO

**FIG. 103-2**

Using an XR2206 oscillator, this circuit can generate two audio tones. Switching between tones can be done with a logic level to either the base of the PN2222 or pin 9 of the XR2206.

# 104

## Tone-Control Circuits

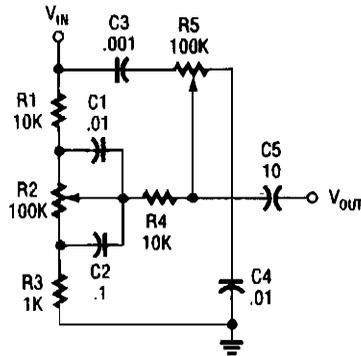
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Combined Bass and Treble Controls  
Treble Tone Control  
Bass Tone Control

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## COMBINED BASS AND TREBLE CONTROLS



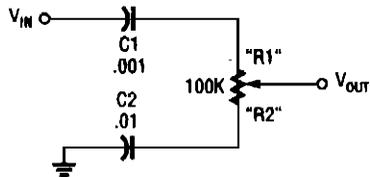
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FIG. 104-1

Bass and treble circuits can be combined to form a two-control tone-adjust circuit, as shown here.

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## TREBLE TONE CONTROL



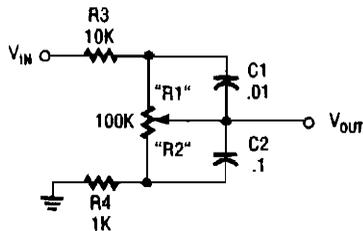
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FIG. 104-2

The treble control has capacitors placed in series with the potentiometer.

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## BASS TONE CONTROL



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FIG. 104-3

The frequency dependence of the capacitor's impedance permits this circuit to boost the bass frequencies.

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# 105

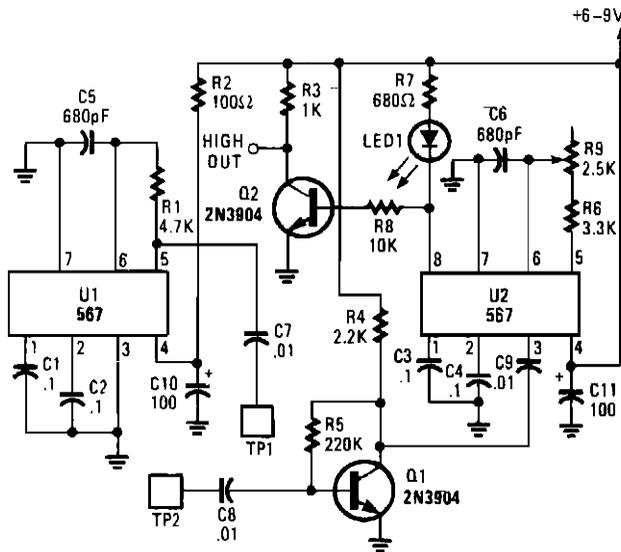
## Touch-Control Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Bridging Touch Plate Sensor  
Touch Switch I  
Touch Switch II  
Touch On-Only Switch  
Latching Touch Switch  
Single Plate Touch Sensor

## BRIDGING TOUCH PLATE SENSOR

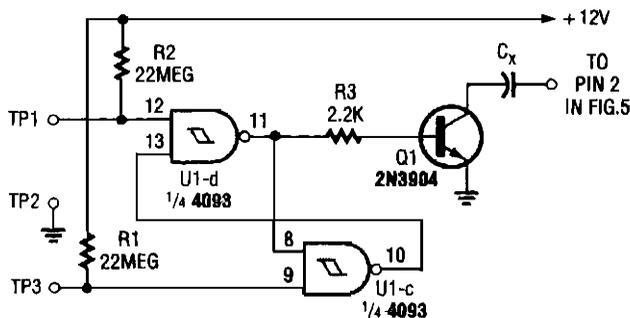


POPULAR ELECTRONICS

FIG. 105-1

In this circuit, two 567 tone decoders are used. One is an oscillator, the other is a detector. Bridging TP1 and TP2 causes U2 to receive U1's signal, which causes pin 8 of U2 to go low. This action lights LED1 and drives the output of Q2 high.

## TOUCH SWITCH I

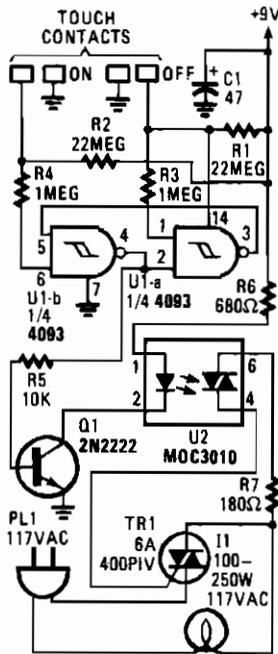


POPULAR ELECTRONICS

FIG. 105-2

Two NAND Schmitt triggers are connected in a flip-flop configuration to produce a bridged touch-activated switch.

## TOUCH SWITCH II



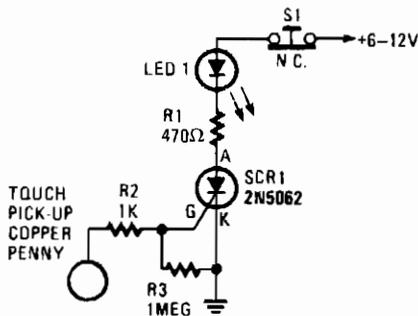
When the touch-on contacts are bridged, pin 6 of U1-b goes low, which forces its output (the set output) at pin 4 to go high. That high divides along two paths: in one path, the output is applied to pin 2 of U1-a, which causes its output at pin 3 to go low. That low is, in turn, applied to pin 5 of U1-b, which latches the gate in a high output state. In the other path, the output of U1-b is used to drive Q1. When Q1 turns on, U2's internal LED lights, which turns on its internal, light-sensitive, triac-driver (diac) output element. The triac driver feeds gate current to TR1, causing it to turn on, and light the lamp (L1).

When the off contact is bridged, U1-a's output switches and latches high, causing U1-b's output to go low, turning off the lamp.

POPULAR ELECTRONICS

FIG. 105-3

## TOUCH ON-ONLY SWITCH

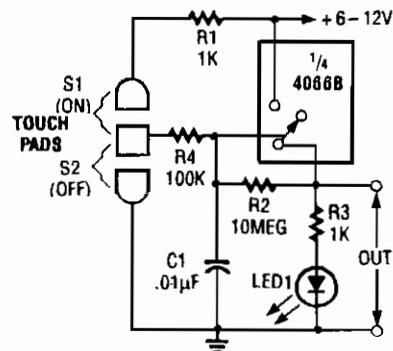


HANDS-ON ELECTRONICS

FIG. 105-4

This touch on-only switch can be triggered into conduction by electrical means, and can only be reset by way of a mechanical switch. When the touch terminal is contacted by a finger, the SCR turns on and illuminates LED1.

## LATCHING TOUCH SWITCH USING CD4066B

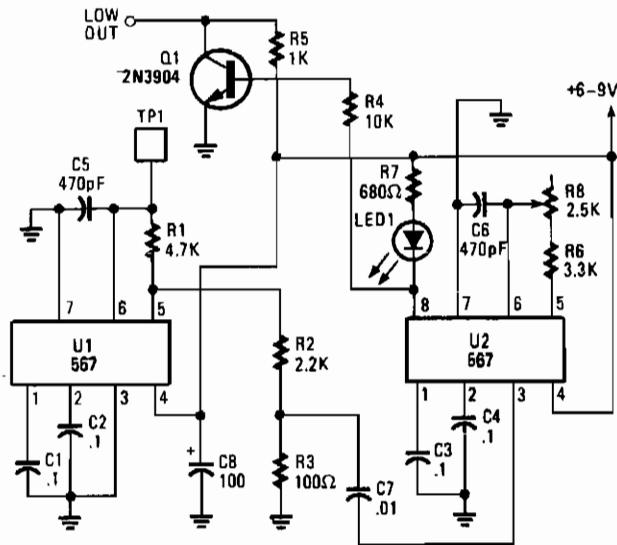


RADIO-ELECTRONICS

FIG. 105-5

When touch switch S1 is activated, R4 is driven high, and the control voltage goes high, which latches the switch. When S2 is activated, R4 goes low and the control voltage goes low, which deactivates the switch.

## SINGLE-PLATE TOUCH SENSOR



POPULAR ELECTRONICS

FIG. 105-6

This system operates on the principle that capacitance loading of an oscillator will lower its frequency. When a foreign body comes into contact with touch plate, the frequency of U1 is lowered. This removes the oscillator signal from U1 from U2's passband, which causes U2 to lose lock, turns off the LED, and causes the collector of Q1 to go low.

# 106

## Transmitter Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

27.125-MHz NBFM Transmitter

10-M DSB QRP Transmitter with VFO

ATV JR Transmitter 440 MHz

6-W Economy Morse-Code Transmitter for 7 MHz

Simple FM Transmitter

Vacuum-Tube Low-Power 80/40-Meter Transmitter

Tracking Transmitter

49-MHz FM Transmitter

QRP Transceiver for 18, 21, and 24 MHz

1750-Meter Transverter

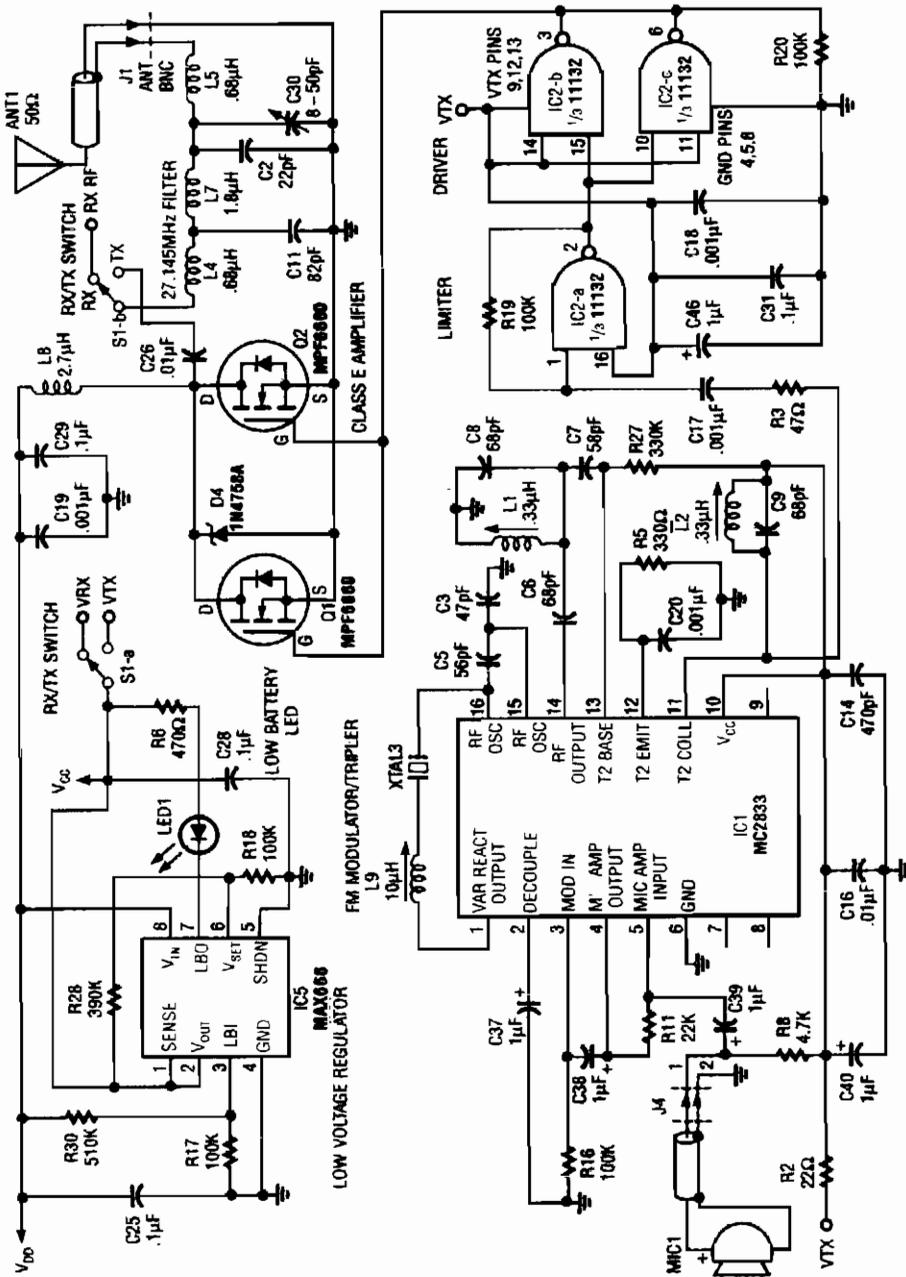
10-Meter DSB Transmitter

Low-Power 40-Meter CW Transmitter

FM Radio Transmitter

Low-Power 20-Meter CW Transmitter

## 27.125-MHz NB-FM TRANSMITTER

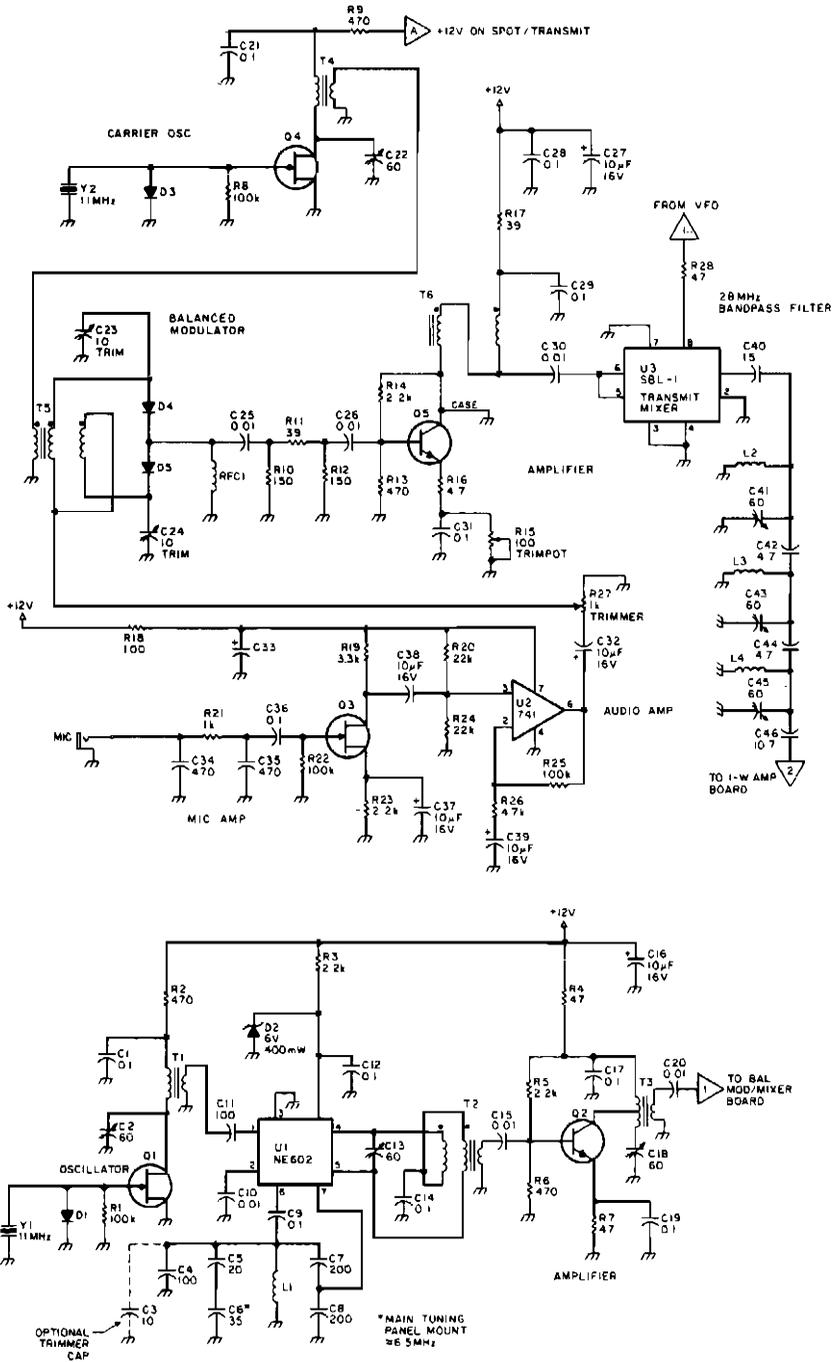


**ELECTRONICS NOW**

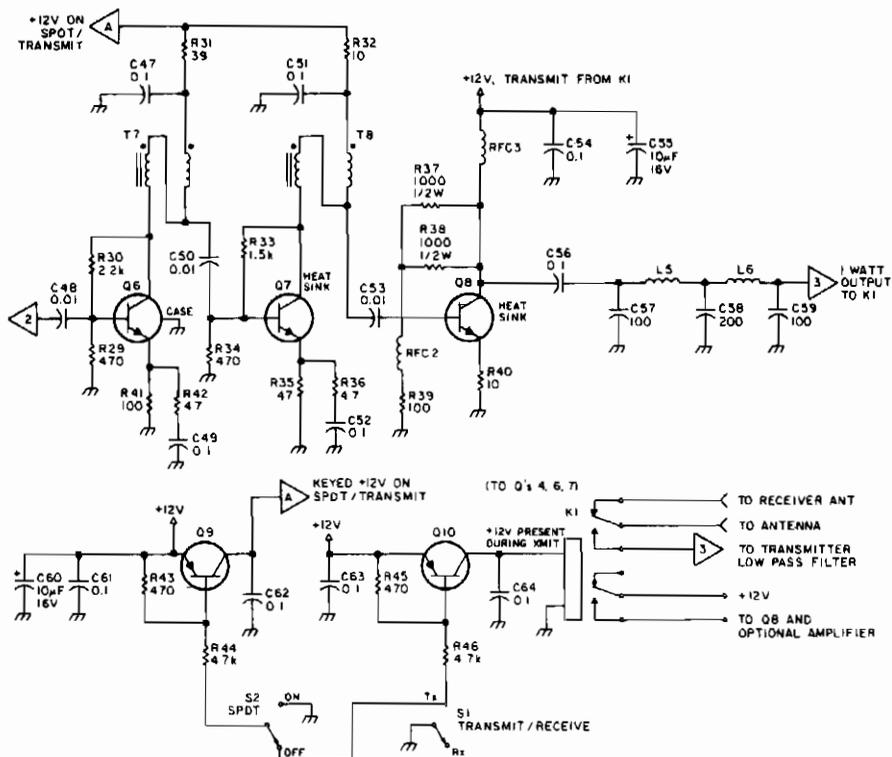
**FIG. 106-1**

Using a Motorola MC2833 one-chip FM transmitter, a few support components, and an MPF6660 FET RF amp, this transmitter delivers about 3 W into a 50- $\Omega$  load. It is capable of operation over about 29 to 32 MHz with the components shown.

# 10-M DSB QRP TRANSMITTER WITH VFO

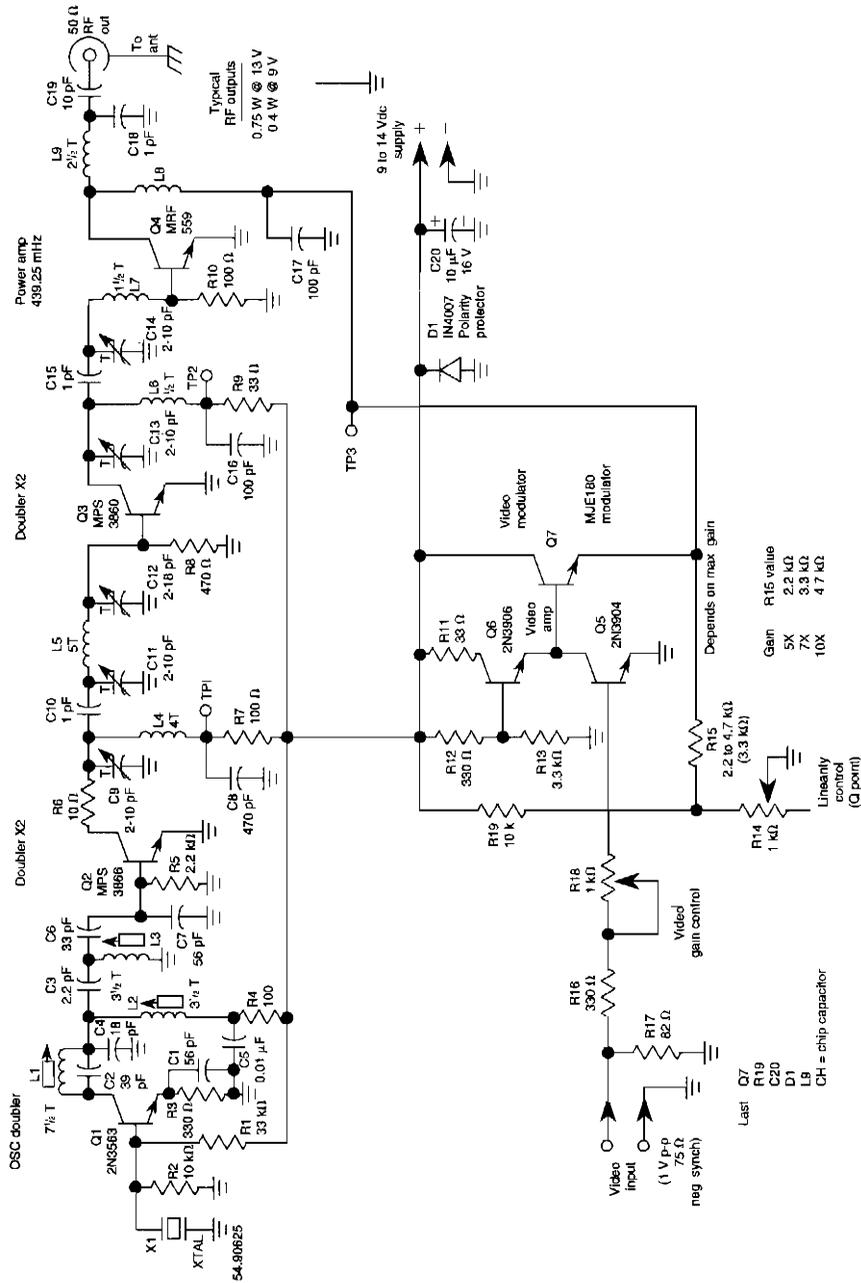


## 10-M DSB QRP TRANSMITTER WITH VFO (Cont.)



The three schematics represent three building blocks for a 10-meter SSB transmitter. Or these blocks can be used separately as circuit modules for other transmitters. The VFO board uses an FET transmittal oscillator, the VFO signal is mixed in an NE602 mixer and is amplified by Q2 to a level sufficient to drive an SBL-1 mixer in the transmit mixer stage (+7 to +10 dBm). In the balance mixer/modulator board, an 11-MHz crystal oscillator drives a diode balanced mixer. Audio for modulation purposes is also fed to this mixer. The DSB signal feeds a 28-MHz BPF. The 1-W amplifier board consists of a 3-stage amplifier and transmit/receive switching circuitry.

# ATV JR TRANSMITTER 440 MHZ

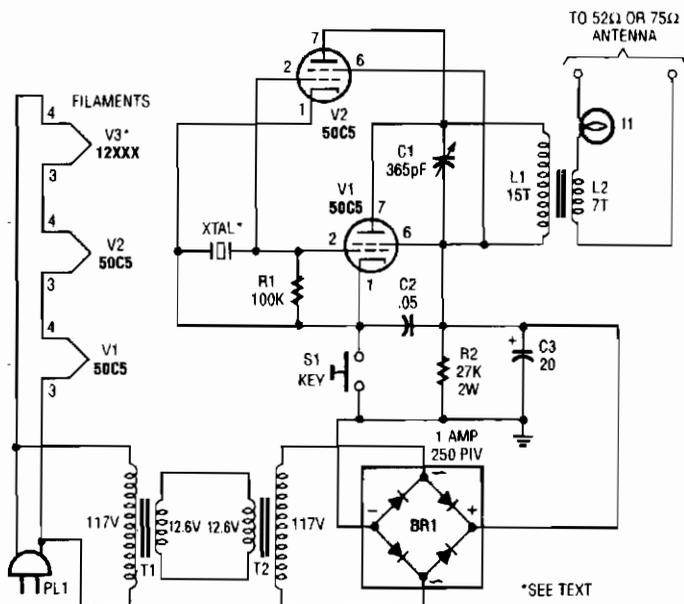


**WILLIAM SHEETS**

**FIG. 106-3**

This low-power video transmitter is useful for R/C applications, surveillance, or amateur radio applications. Seven transistors are used in a crystal oscillator-multiplier RF power amplifier chain, and a high-level video modulator. A 9- to 14-Vdc supply is required. Output is 0.4 to 1.2 W, depending on supply voltage. A complete kit of parts is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804-00530

## 6-W ECONOMY MORSE-CODE TRANSMITTER FOR 7 MHz

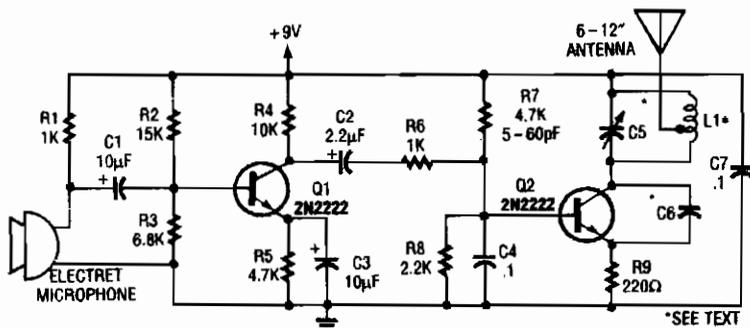


POPULAR ELECTRONICS

FIG. 106-4

The vacuum tube is still alive and useful in some applications, as in this CW transmitter. The circuit was built in old-fashioned breadboard style on a wooden base. Old table radios are a good source of parts for this circuit. V3 is used as a ballast resistor—a 75- $\Omega$  or 100- $\Omega$  5-W resistor could be substituted. L1 is 15 turns of hookup wire on a  $\frac{3}{8}$ " form 2" long. L2 is 7 turns of the same wire. L2 is wound over L1. Be careful as up to 160 V is present on V1 and V2.

## SIMPLE FM TRANSMITTER

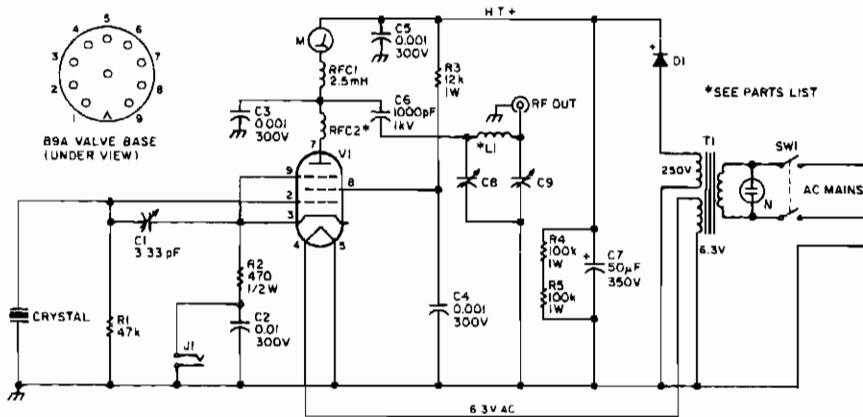


RADIO-ELECTRONICS

FIG. 106-5

Running from a 9-V battery, this transmitter can be used as a wireless microphone with an ordinary 88- to 108-MHz FM broadcast receiver. Keep the antenna length under 12 inches to comply with FCC limits. L1 is 6 turns of #24 wire wound around a pencil or a  $\frac{1}{4}$ " form, with turns spaced 1 wire diameter. C6 is a gimmick capacitor of about 1 pF.

## VACUUM-TUBE LOW-POWER 80/40-METER TRANSMITTER

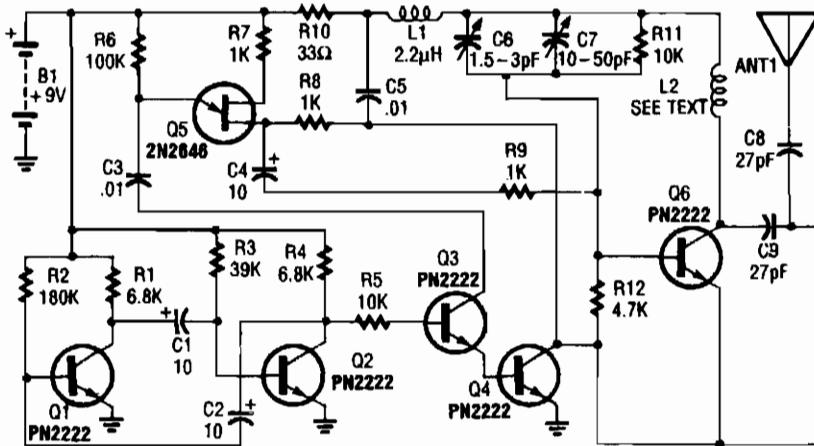


73 AMATEUR RADIO TODAY

FIG. 106-6

Using a 6BW6 vacuum tube, the above transmitter delivers about 5 W output. C1 is adjusted for cleanest CW note. C8 and C9 are 365 pF and dual-365 pF (paralleled) tuning capacitors. L1 is 35 turns of #24 enamelled wire on a 1" plastic tube. FT-243 crystals for 3.5 or 7 MHz are used. Do not use this circuit to produce a 7-MHz output from a 3.5-MHz crystal—it is not intended to “double over” crystal frequencies.

## TRACKING TRANSMITTER

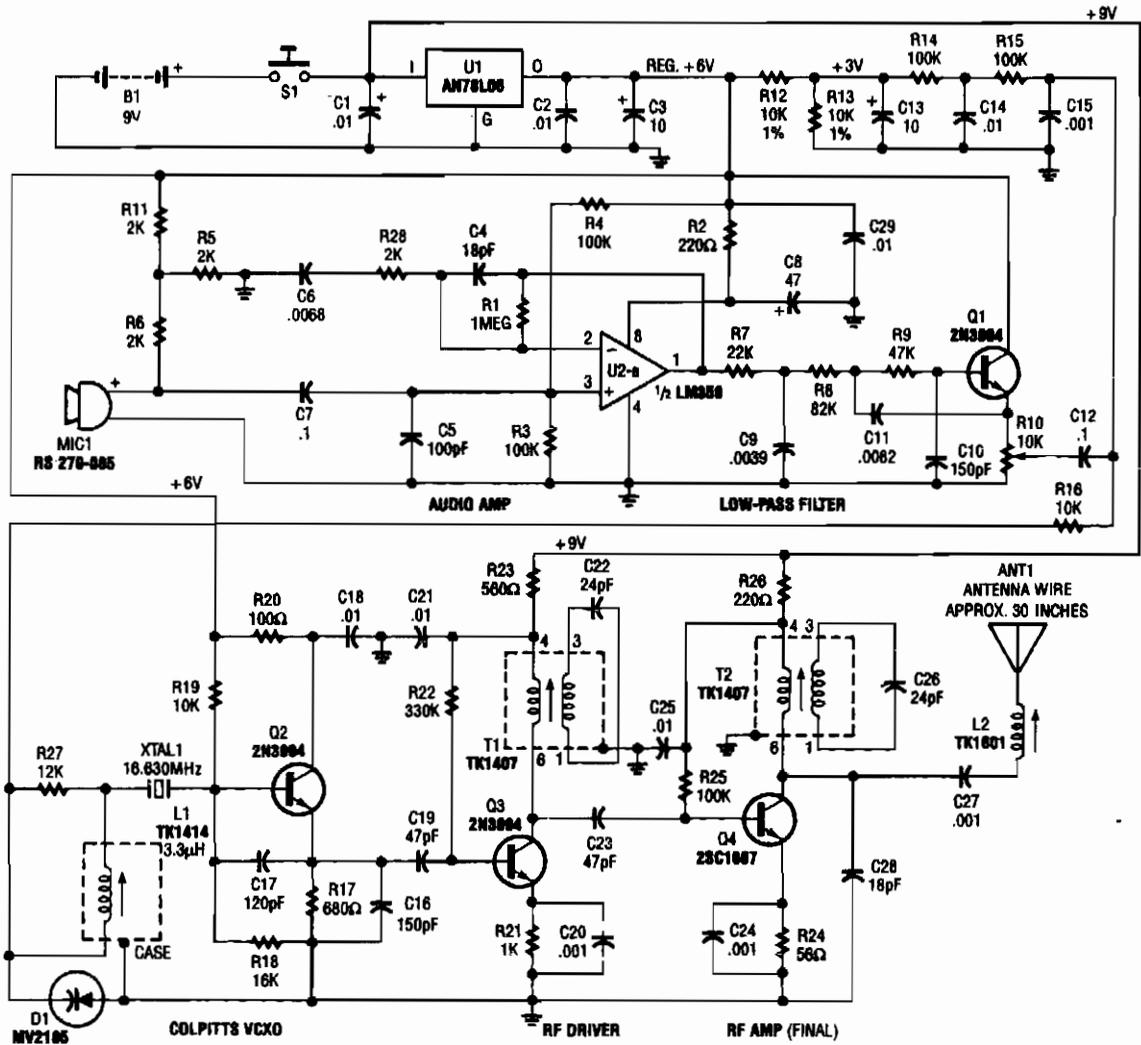


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FIG. 106-7

This tracking transmitter consists of four distinct subassemblies; a free-running multivibrator, a transmit switch, an audio-tone generator, and an FM transmitter. The multivibrator (which produces a pulse width with a pulse separation of 1500 ms) is built around Q1 and Q2. The multivibrator output is coupled through R5 to the base of Q3, whose emitter feeds Q4, which controls the circuit's transmitter section.

## 49-MHz FM TRANSMITTER

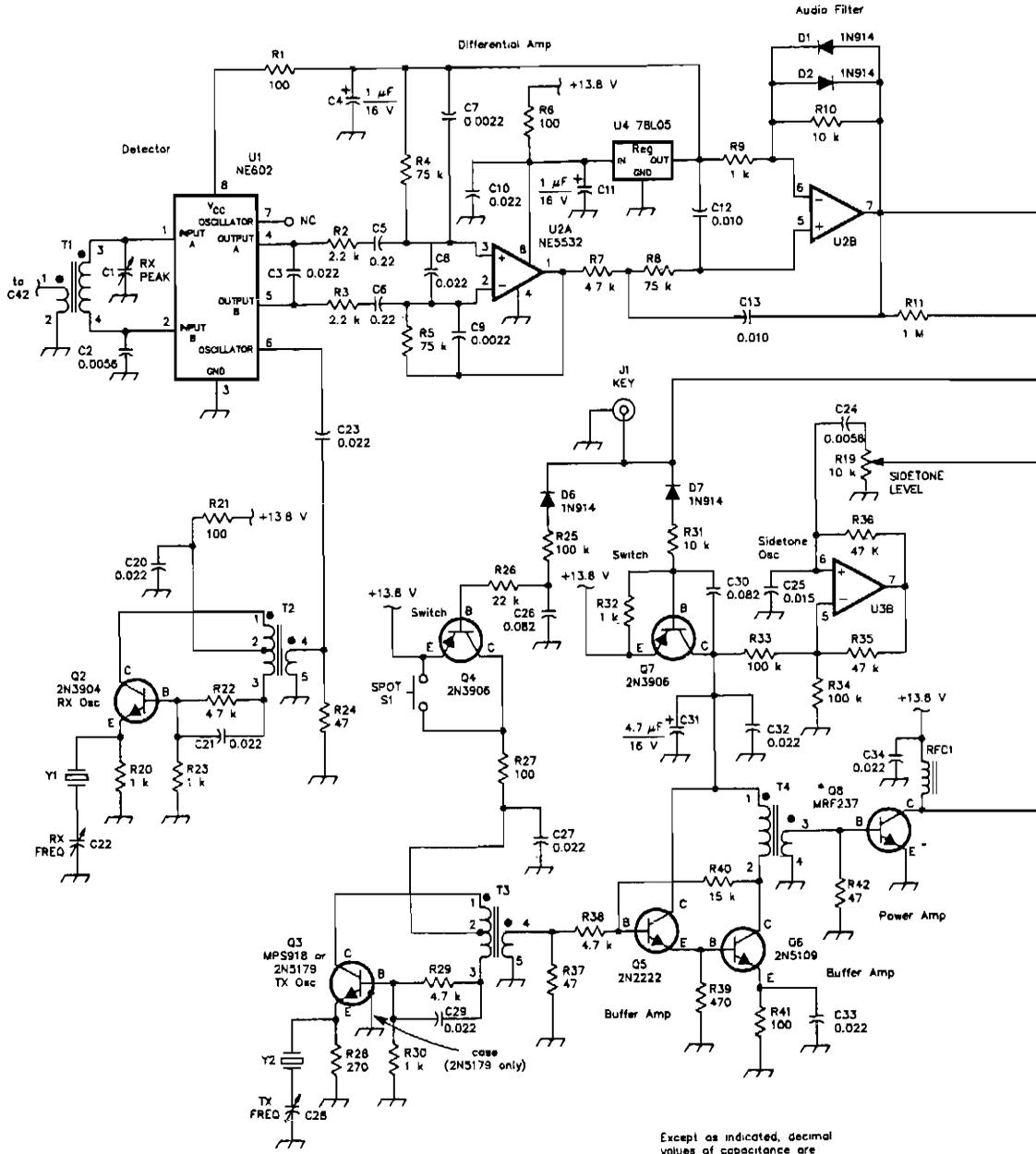


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FIG. 106-8

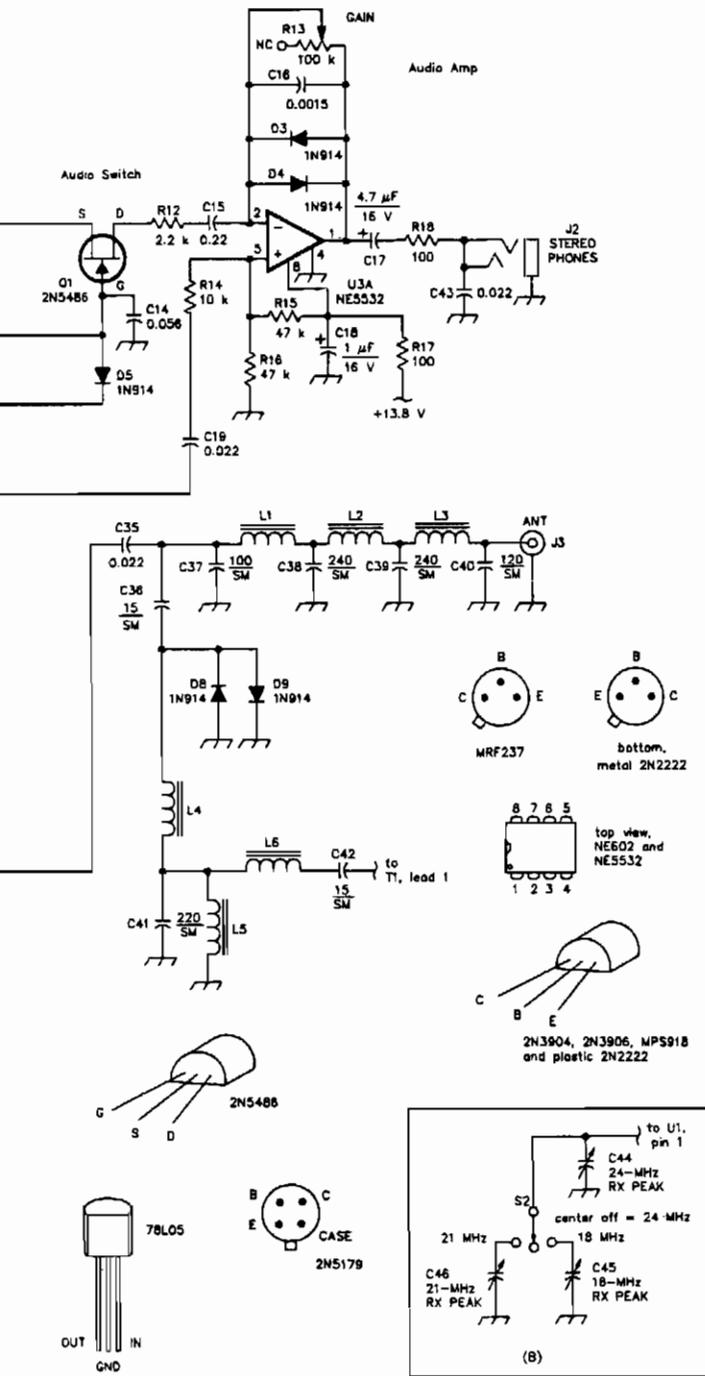
This 49-MHz FM transmitter consists of an audio amplifier, a low-pass filter, three RF stages, and a regulated-dc power supply. The output is about 16 mW into a 50-Ω load. This transmitter can be used in many 49-MHz applications, such as in a baby monitor, cordless telephone, or in conjunction with a scanner as a one-way voice link.

# QRP TRANSCEIVER FOR 18, 21, AND 24 MHz



Except as indicated, decimal values of capacitance are in microfarads ( $\mu\text{F}$ ); others are in picofarads (pF), resistances are in ohms; k=1,000, M=1,000,000

\*Heat sink required; see text  
 ● = phasing  
 SM = silver mica

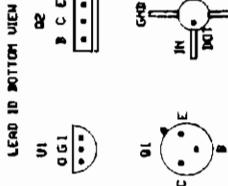
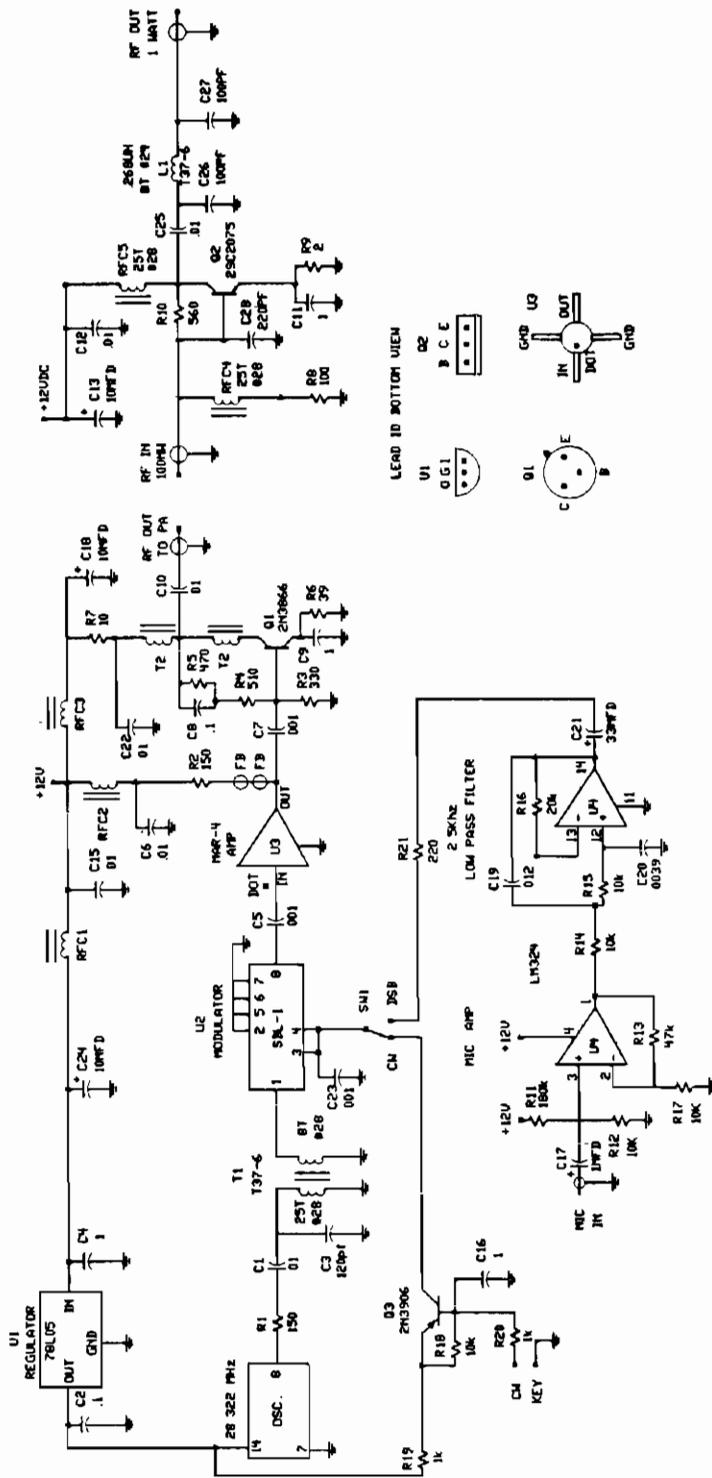


This CW transceiver has 1.25 to 4 W RF output, a direct-conversion receiver, full break-in, and SW sidetone generation. The power supply is 13.8 V, which makes this transceiver suitable for mobile or portable operation.

FIG. 106-9



# 10-METER DSB TRANSMITTER



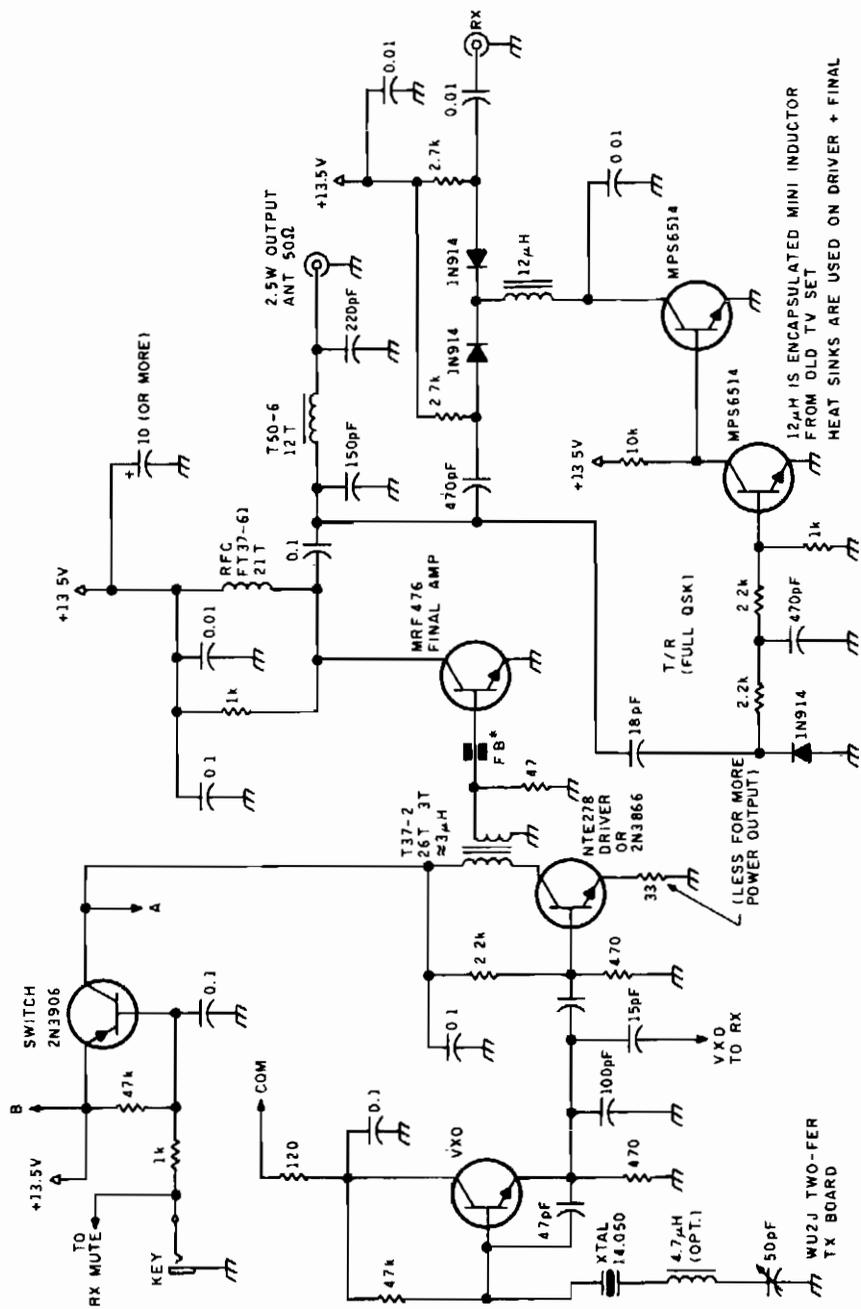
73 AMATEUR RADIO TODAY

FIG. 106-11

A DSB transmitter is much cheaper to build than an SSB transmitter because no filter or phasing networks are required. This circuit produces up to 1-W output on the 10-meter band. The frequency 28.322 MHz is used, which is a commonly available clock frequency crystal. CW operation is also provided. A doubly balanced mixer assembly is used as a modulator and CW keyer.



## LOW-POWER 20-METER CW TRANSMITTER



73 AMATEUR RADIO TODAY

FIG. 106-14

The transmitter has a VXO circuit to drive an amplifier that is keyed. The keyed amplifier drives an MRF 476 final amplifier, which delivers about 2-W output. A solid-state T-R switch is included for the receiver. The parts values shown are for the 20-meter band.

# 107

## Ultrasonic Circuits

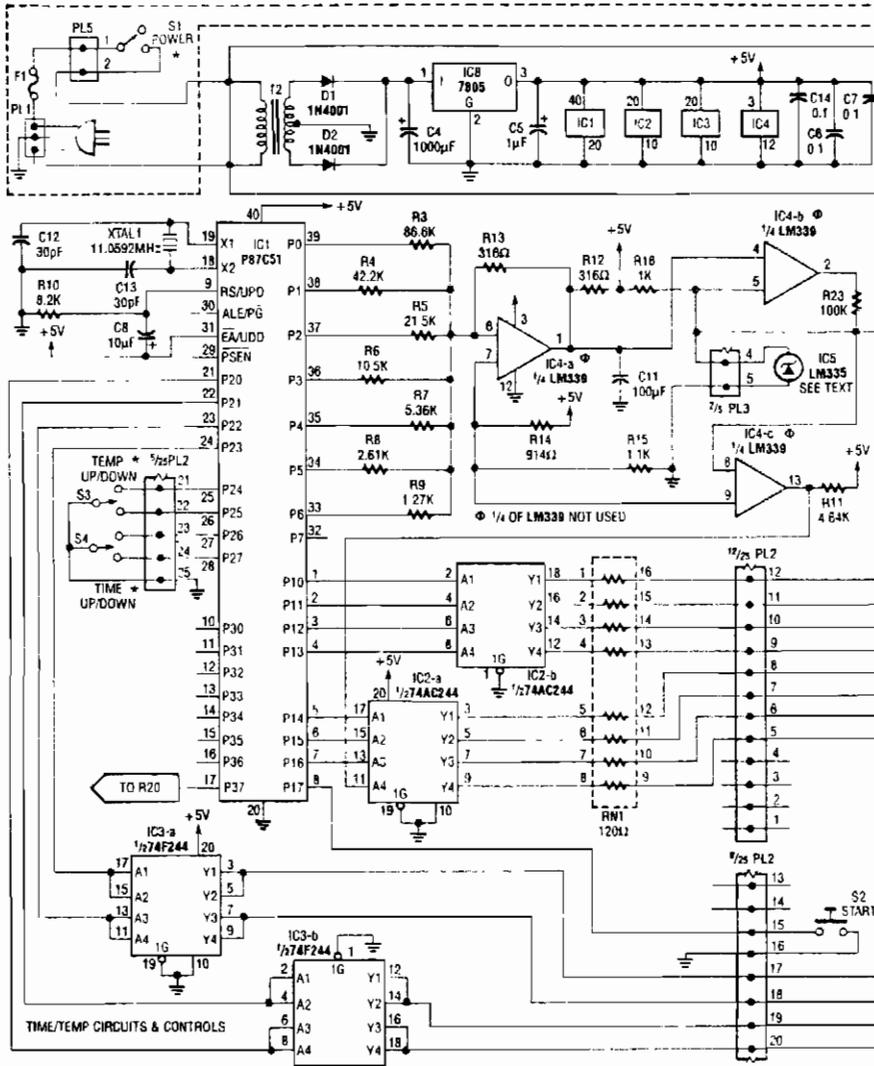
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Doppler Ultrasound Transmitter  
Doppler Ultrasound Receiver  
Ultrasonic Cleaner



## ULTRASONIC CLEANER



### ELECTRONICS NOW

An ultrasonic cleaner is useful to clean certain items. This circuit uses a microcontroller to control timing and give a digital readout, but only the basic oscillator can be used, if desired. RES1, RES2 are piezoelectric transducers driven by power oscillator Q1. Q1 is powered by a bridge rectifier-capacitor input filter that operates directly off the ac line. The frequency is 40 to 60 kHz.

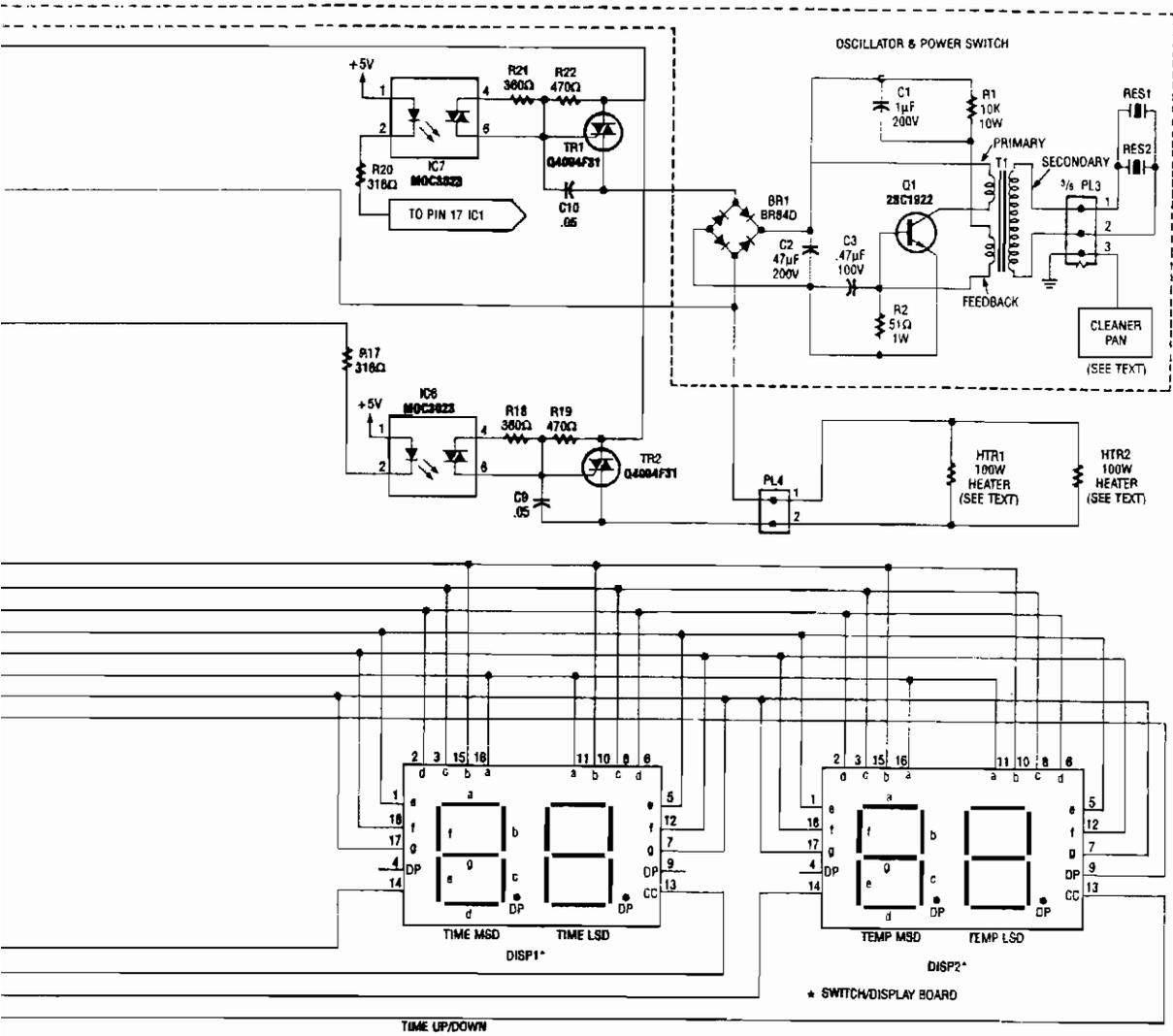


FIG. 107-3

# 108

## Video Circuits

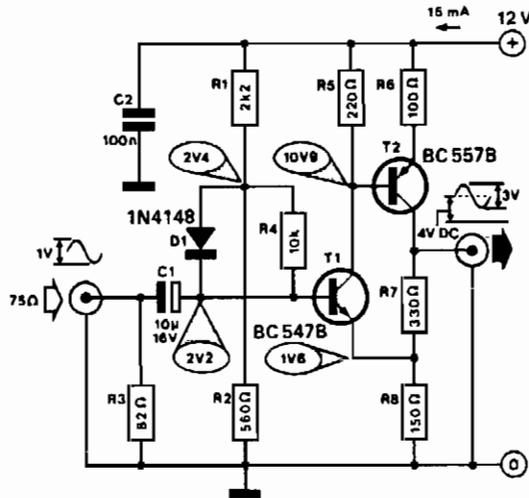
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

General-Purpose Output Amplifier	Video dc-Restore Circuit
4.5-MHz Sound IF Amplifier	Combination Sync Stripper and Universal Video Interface
Simple Video Amplifier	Video Selector
ATV Video Sampler Circuit	Video Preamp
Multiple-Input Video Multiplex Cable Driver	Video Master
Two-Input Video Multiplex Cable Driver	Simple Video Line/Bar Generator
Differential Video Loop-Through Amplifier	Video Amplifier
Video Fader	
Electronically Controlled Variable-Gain Video Loop-Through Amplifier	



### SIMPLE VIDEO AMPLIFIER

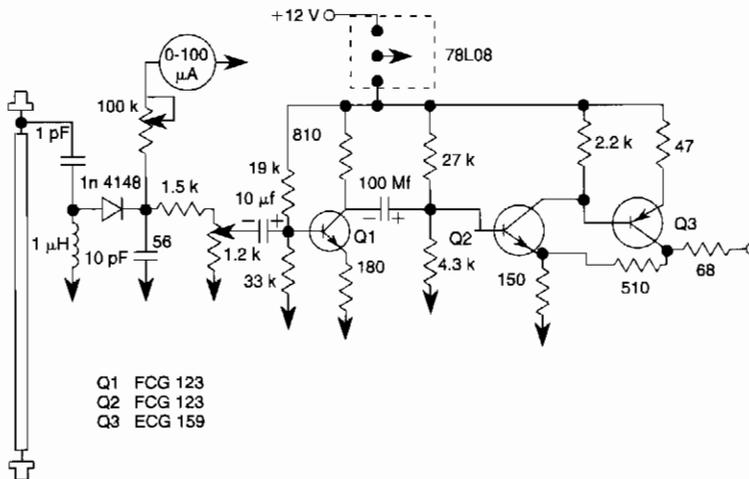


303 CIRCUITS

FIG. 108-3

Useful for interfacing B/W TV sets with a camera or computer, this amplifier has a bandwidth of  $\geq 10$  MHz and a gain of 3X.

### ATV VIDEO SAMPLER CIRCUIT

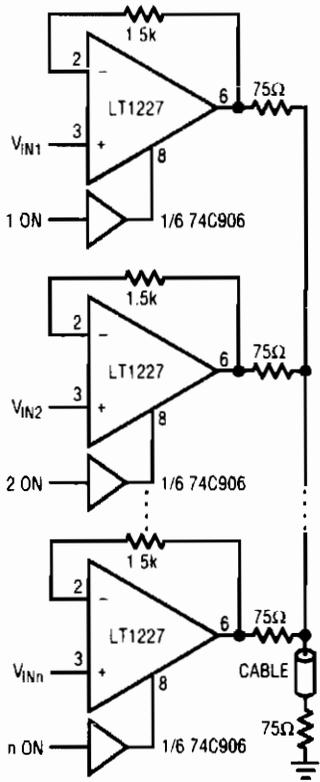


SPEC-COM

FIG. 108-4

This unit picks up your ATV signal by sampling the transmission line with negligible insertion loss. It uses 2 "N" connectors for input and output connections. A BNC connector is used on the video output. The detected output is connected to your monitor and scope so that you can accurately adjust your transmitter for proper video and synch levels. Two different models are provided. Both have relative power output meters, but one has greater accuracy. There are two PC controls, one for video level and the other for power output.

### MULTIPLE-INPUT VIDEO MULTIPLEX CABLE DRIVER

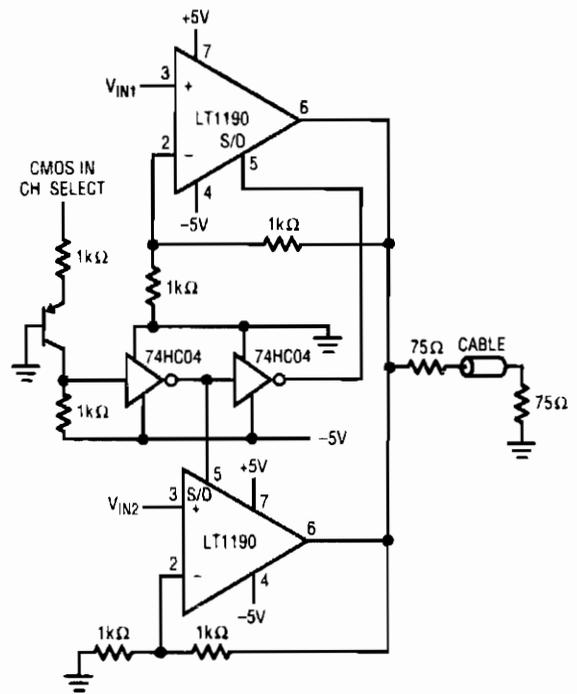


LINEAR TECHNOLOGY

FIG. 108-5

Using a Linear Technology LT1227, the multiplex video amp uses logic levels to turn on and off selected inputs.

### TWO-INPUT VIDEO MULTIPLEX CABLE DRIVER

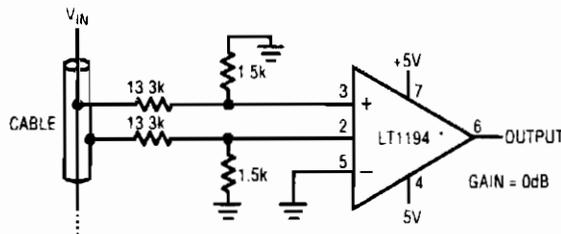


LINEAR TECHNOLOGY

FIG. 108-6

CMOS logic levels select one of two video inputs with this circuit. The op amps are Linear Technology LT1190s.

### DIFFERENTIAL VIDEO LOOP-THROUGH AMPLIFIER

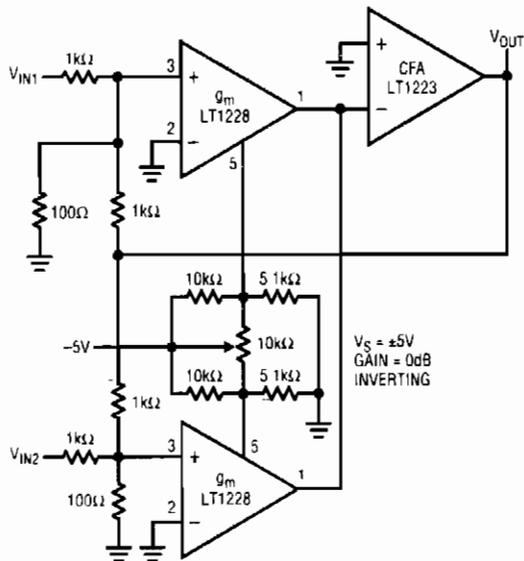


LINEAR TECHNOLOGY

FIG. 108-7

An LT1194 is used as a differential amplifier for video applications, where low cable loading is needed.

## VIDEO FADER

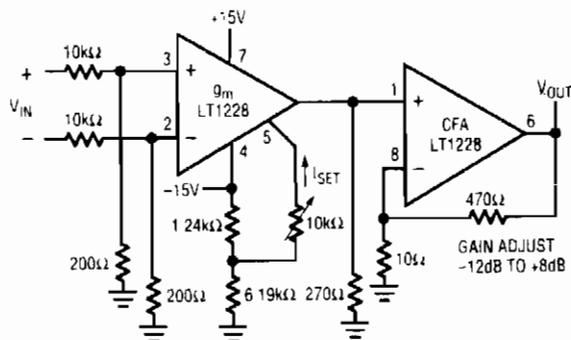


LINEAR TECHNOLOGY

FIG. 108-8

Using two LT1228 transconductance amplifiers in front of a current feedback amplifier forms a video fader. The ratio of the set currents into pin 5 determines the ratio of the inputs at the output.

## ELECTRONICALLY CONTROLLED VARIABLE-GAIN VIDEO LOOP-THROUGH AMPLIFIER

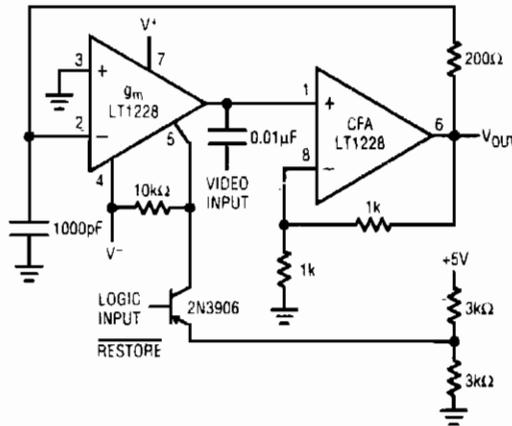


LINEAR TECHNOLOGY

FIG. 108-9

An LT1228 transconductance amplifier is used in this application. The gain is adjustable from  $-12$  to  $+8$  dB.

## VIDEO dc RESTORE CIRCUIT

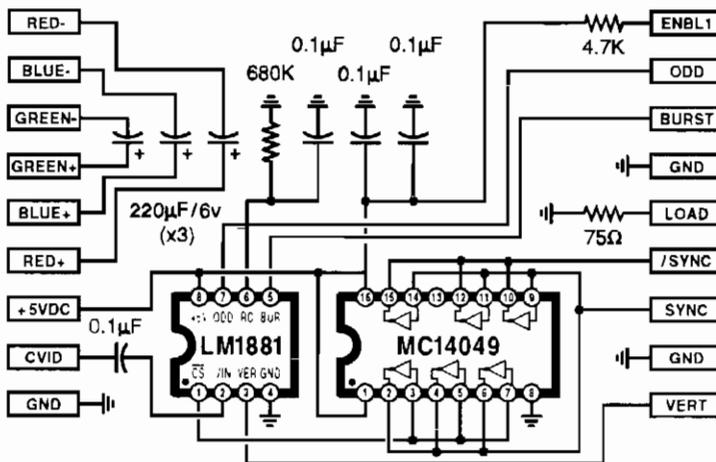


LINEAR TECHNOLOGY

FIG. 108-10

This circuit restores the black level of a monochrome composite video signal to 0 V at the beginning of every horizontal line. This circuit is also useful with CCD scanners to set the black level.

## COMBINATION SYNC STRIPPER AND UNIVERSAL VIDEO INTERFACE

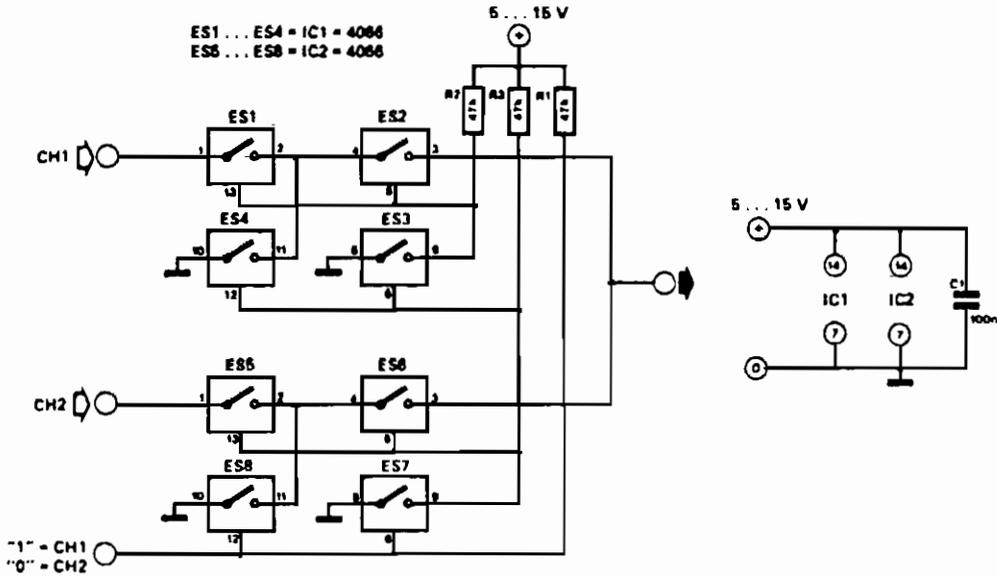


RADIO-ELECTRONICS

FIG. 108-11

This combination sync stripper and universal video interface can solve a lot of problems for you, including Super-Nintendo-to-anything interfacing, video overlay and scope TV frame locking. Kits, fully tested units, and custom cable assemblies are available through Redmond Cable. This unit uses an LM1881 (NS) synch separator IC.

## VIDEO SELECTOR

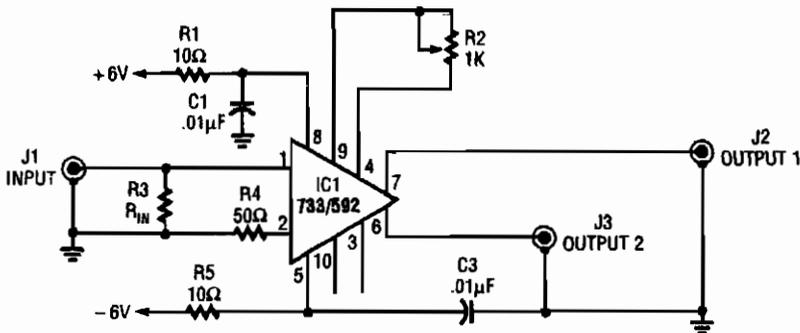


303 CIRCUITS

FIG. 108-12

This circuit selects one of two channels with a logic signal. The unused channel is shorted out, which minimizes crosstalk. The bandwidth at  $-3$  dB is about 8 MHz. It is advisable to buffer this circuit because there is some loss in the switches when feeding a  $75\text{-}\Omega$  load.

## VIDEO PREAMP

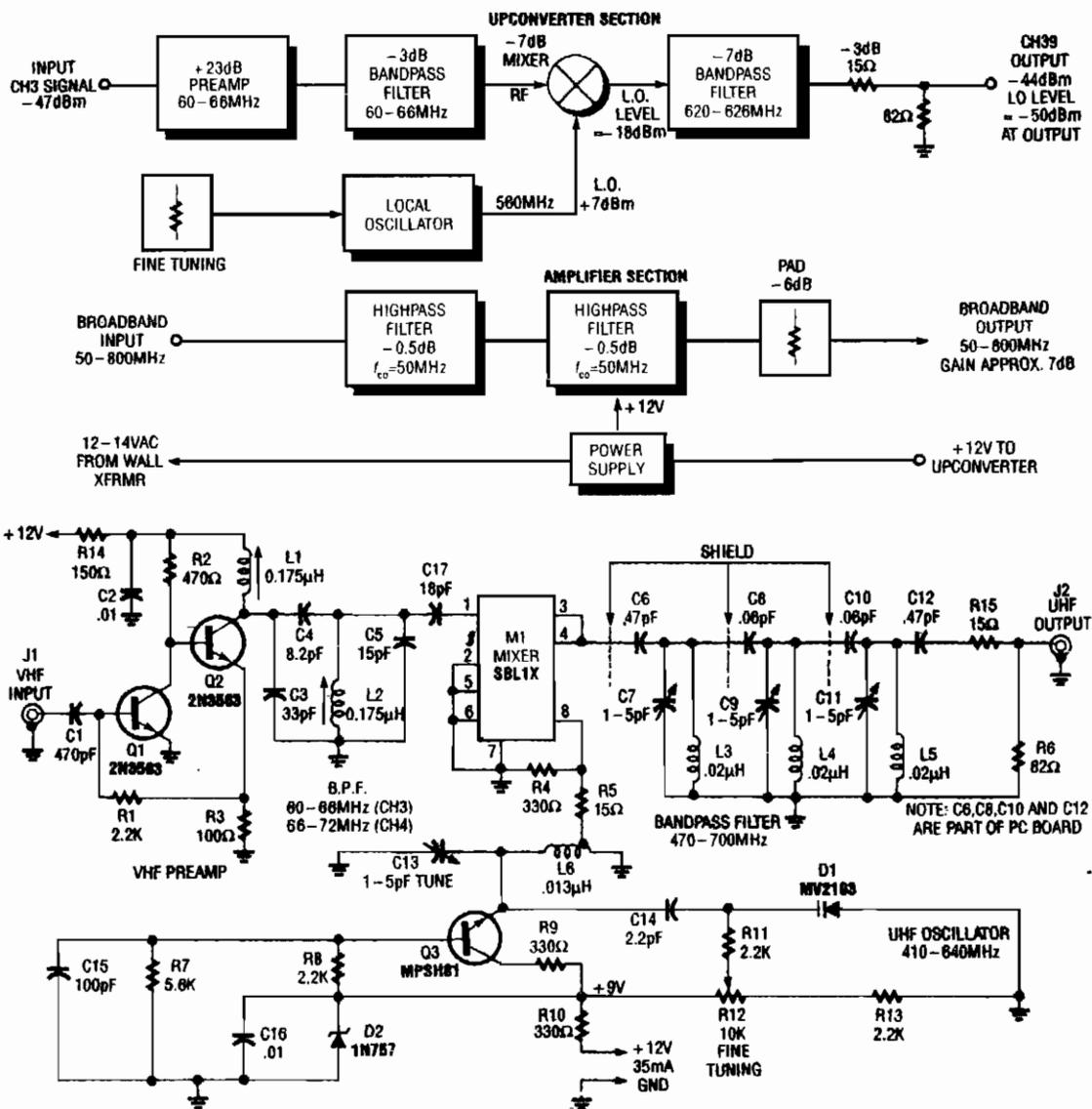


RADIO-ELECTRONICS

FIG. 108-13

An NE592 or LM733 is used as a general-purpose video amplifier in this schematic. J2 and J3 provide two anti-phase outputs. R2 is a gain control. The bandwidth is about 100 MHz.

## VIDEO MASTER



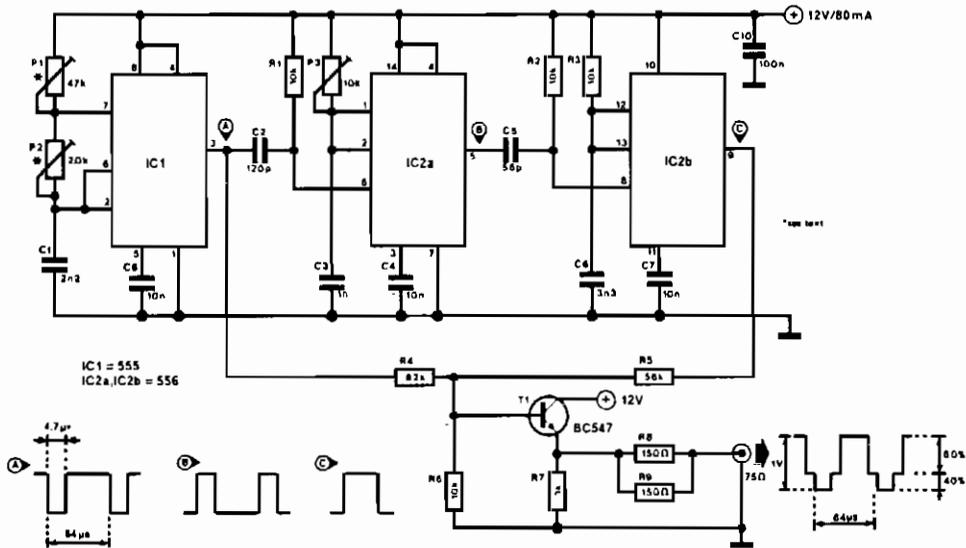
ELECTRONICS NOW

FIG. 108-14

The video master consists of a series of converters that place all your video sources on unused UHF channels, which then combines them with normal TV channels (terrestrial or cable into one cable). That one cable can then feed several TV sets for whole-house coverage. The desired video source is selected with the TV set's tuner. All of the TV's remote-control features are retained.

A complete kit of parts is available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804-0053A.

## SIMPLE VIDEO LINE/BAR GENERATOR

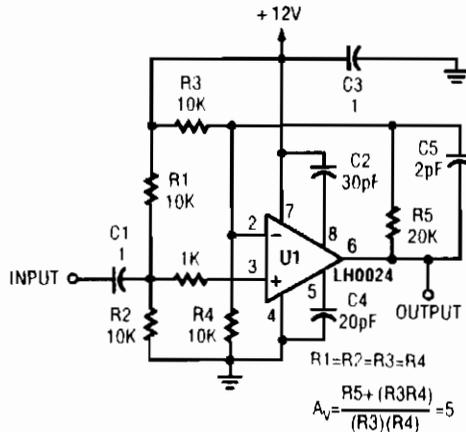


303 CIRCUITS

FIG. 108-15

A 555 and a dual 556 timer generate a rudimentary video signal, as shown in the schematic. The first timer generates 4.7-µs sync pulses operating in the astable mode with a 64-µs period. The second timer generates a delay pulse, which triggers the third timer to generate a bar. The second timer sets the bar position and the third sets the bar width.

## VIDEO AMPLIFIER



POPULAR ELECTRONICS

FIG. 108-16

# 109

## Voltage-Controlled Oscillator Circuits

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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Sinusoidal 3-Hz to 300-kHz VCO  
Simple TL082 VCO  
10-Hz to 10-kHz 3-Decade VCO  
Sine-wave VCO  
VCO I  
VCO II



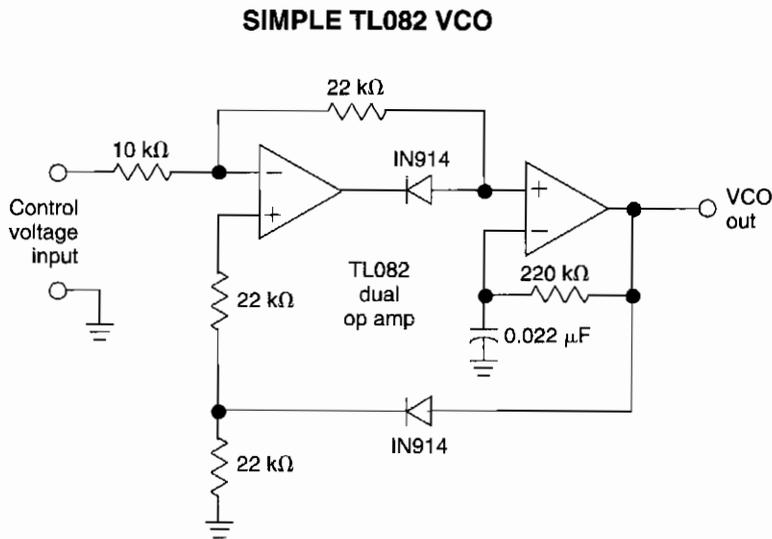
### SINUSOIDAL 3-Hz TO 300-kHz VCO (Cont.)

The 1-k $\Omega$  potentiometer variable is adjusted to give the input level to the AD639 needed to drive it over  $\pm 270^\circ$  and so produce a sinusoidal output at three times the frequency of the triangle-wave input. Offset correction for the AD639 is made at the input to the voltage follower by means of the 20-k $\Omega$  potentiometer.

Once a symmetric triangle wave has been obtained by adjusting the 2-k $\Omega$  and 50-k $\Omega$  potentiometers, and the correct frequency of 100 kHz has been set for  $V_{IN} = 10$  V, by adjusting the 5-k $\Omega$  potentiometer, the triple-frequency sine-wave output can be set up by adjustment of the 1-k $\Omega$  and 20-k $\Omega$  potentiometers.

This is best done by triggering the CRO from the triangle wave, and then viewing at least three complete cycles of output. Having adjusted for a clean-looking sine wave, the final adjustment of the 1-k $\Omega$  and 20-k $\Omega$  potentiometers should be made on a single sinusoidal cycle display, using internal trigger so that the three slightly different parts of the output cycle lie one upon the other and can be made to merge. Q1, Q2, and Q3 are 2N4391s, the two Schottky diodes are 5082–2810, and the other nine diodes are 1N914.

All device power supply pins should be decoupled with 0.33  $\mu$ F. Resistors associated with the inputs of the devices should be 1% high-stability parts.

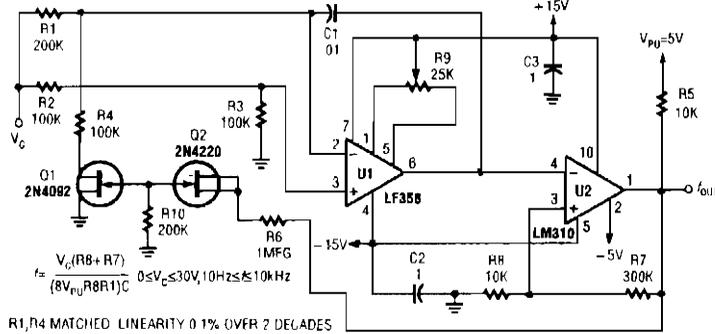


WILLIAM SHEETS

FIG. 109-2

This circuit uses a dual operational amplifier (TL082) to form a voltage-controlled oscillator (VCO). With the component values shown, the output-frequency range is 100 Hz to 10 kHz when the input control voltage is between 0.05 and 10 V.

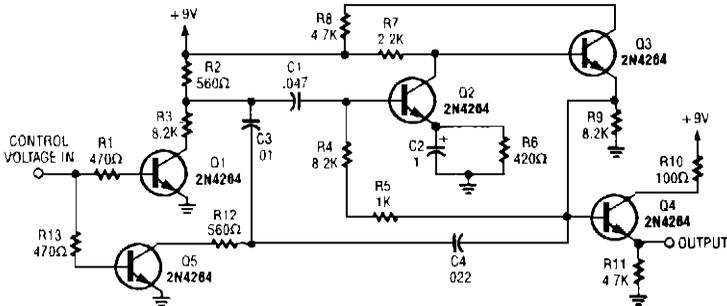
### 10-Hz TO 10-kHz 3-DECADE VCO



POPULAR ELECTRONICS

FIG. 109-3

### SINE-WAVE VCO

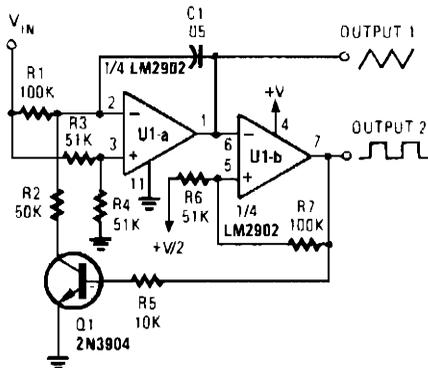


POPULAR ELECTRONICS

FIG. 109-4

A dc control voltage varies the effective resistance in feedback network C4/C3/C1 and R12/R3. Q2/Q3 are the oscillator transistors.

### VCO I



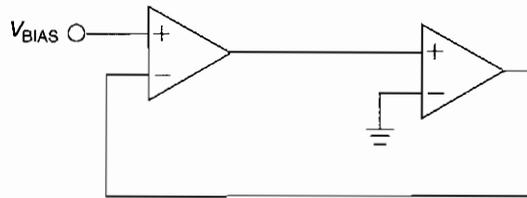
This circuit gives both triangle- and square-wave outputs. The frequency range is determined by C1.

POPULAR ELECTRONICS

FIG. 109-5

---

## VCO II



**WILLIAM SHEETS**

**FIG. 109-6**

The output frequency of this simple low-cost active voltage-controlled oscillator circuit is based upon the inherent frequency dependent characteristics of our operational amplifier.

The oscillator circuit shown uses a TL082 op amp. When power is applied, the circuit generates a sinusoidal wave. The frequency of oscillation can be changed by varying the bias supply.

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# 110

## Voltage Converter/Inverter Circuits

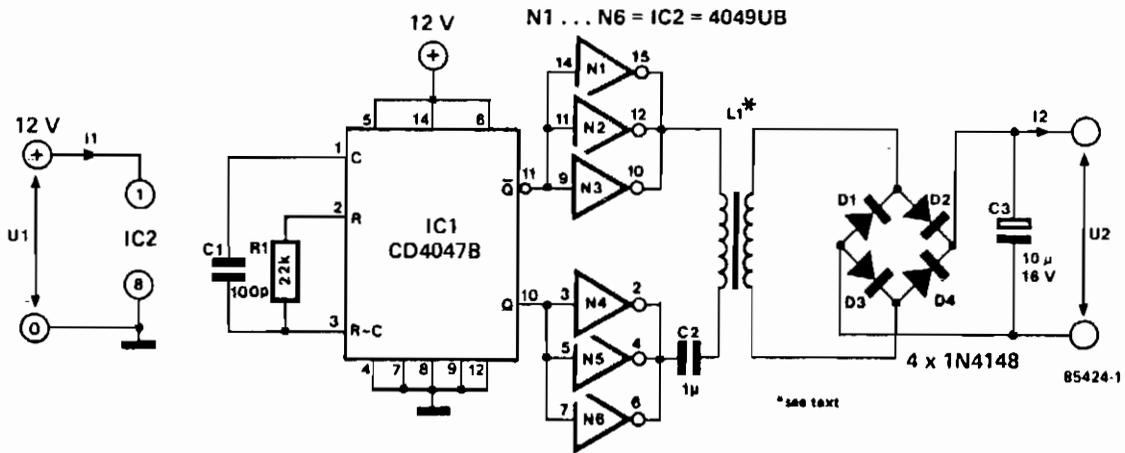
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The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

dc/dc Converter  
Simple dc/ac Inverter

### dc/dc CONVERTER

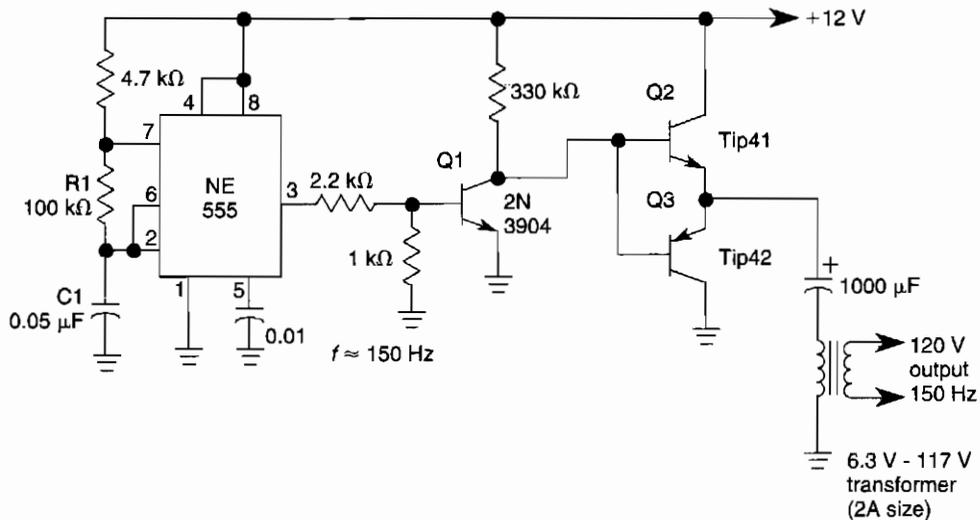


303 CIRCUITS

FIG. 110-1

This low-power converter will supply about 100 mW of dc to a load and it is useful to isolate or derive dc voltages. It operates at around 200 kHz. L1 is wound on a 22-mm diameter × 13-mm high pot core with #32 magnet wire. The primary is 80 turns and the secondary is 80 turns (for 12-V nominal output). The two windings should be insulated for the expected voltage difference between input and output in insulation applications.

### SIMPLE dc/ac INVERTER



WILLIAM SHEETS

FIG. 110-2

This dc-to-ac inverter is based on the popular 555. A 555 oscillator circuit drives a buffer amplifier consisting of Q1, Q2, and Q3. The circuit operates at 150 to 160 Hz. T1 can be a 6.3-V or 12.6-V filament transformer as applicable. The frequency can be changed by changing the values of R1 and/or C1.

# 111

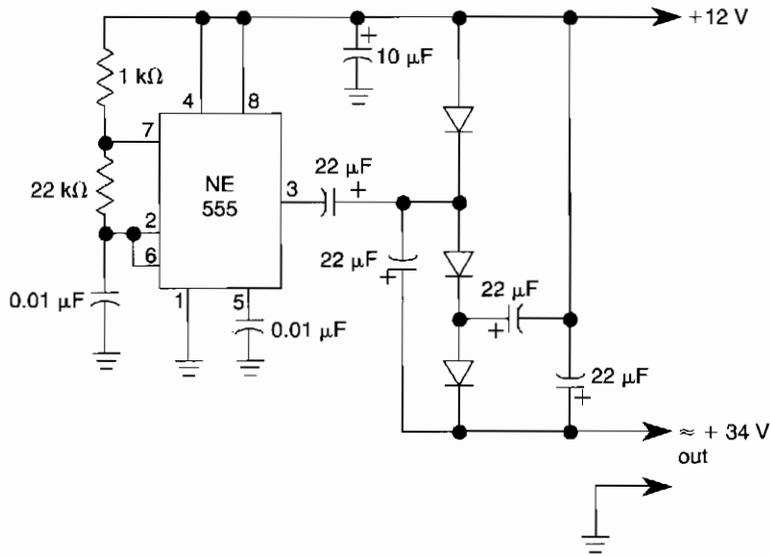
## Voltage Multiplier Circuits

---

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Low-Power dc Tripler  
Low-Power dc Quadrupler  
Low-Power dc Doubler

### LOW-POWER dc TRIPLER

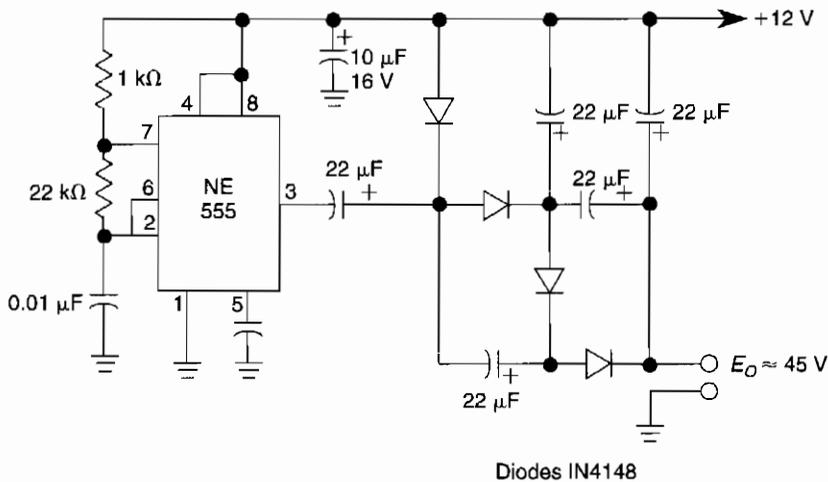


WILLIAM SHEETS

FIG. 111-1

This dc voltage-tripler circuit based on the 555 can produce a dc output voltage equal to approximately  $3\times$  the dc supply voltage.

### LOW-POWER dc QUADRUPLER

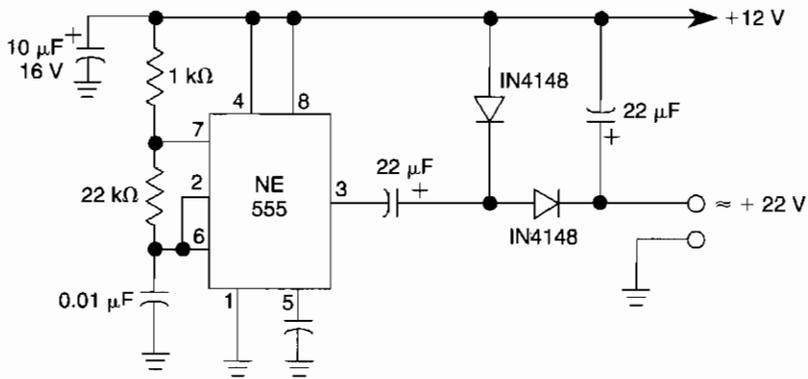


WILLIAM SHEETS

FIG. 111-2

This dc voltage-quadrupler circuit based on the 555 can produce a dc output voltage equal to approximately  $4\times$  the dc supply voltage.

## LOW-POWER dc DOUBLER



WILLIAM SHEETS

FIG. 111-3

This dc voltage-doubler circuit based on the 555 can produce a dc output voltage equal to approximately  $2\times$  the dc supply voltage.

# 112

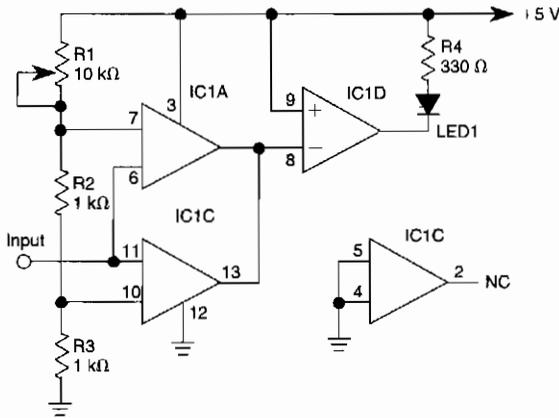
## Window Comparator and Discriminator Circuits

---

The sources of the following circuits are contained in the Sources section, which begins on page 675. The figure number in the box of each circuit correlates to the entry in the Sources section.

Window Comparator  
Multiple-Aperture Window Discriminator

## WINDOW COMPARATOR

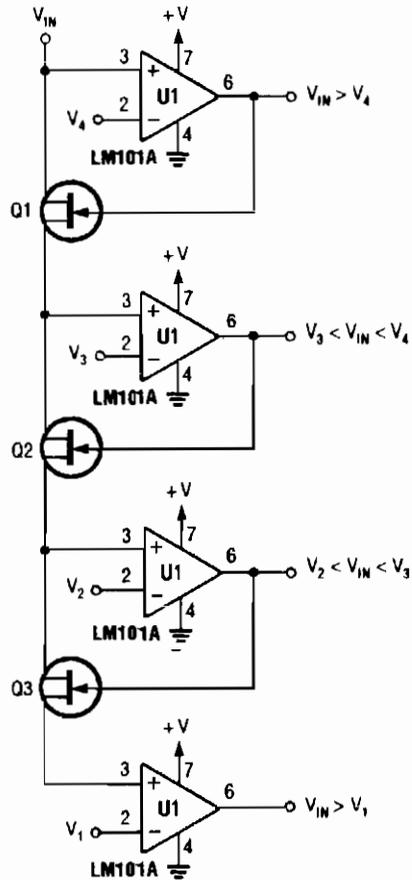


WILLIAM SHEETS

FIG. 112-1

IC1-c functions as a noninverting comparator, and IC1-a operates as an inverting comparator. Potentiometer R1 and fixed resistors R2 and R3 form a divider chain that delivers slightly different voltages to the two comparators. These voltages define the upper and lower limits of the circuit's switching "window," which can be changed easily by varying R2 and R3. The LED glows only when the input voltage falls within the window region.

## MULTIPLE-APERTURE WINDOW DISCRIMINATOR



POPULAR ELECTRONICS

FIG. 112-2

$V_1$  through  $V_4$  are reference voltages that are derived from separate sources or from a common voltage divider.

# Sources

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# Index

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## A

- absolute-value circuits, I-37, IV-274
  - amplifier, I-31
    - full wave rectifier, II-528
    - Norton amplifier, III-11
    - precision, I-37, IV-274
  - ac motors (*see also* motor control circuits)
    - control for, II-375
    - power brake, II-451
    - three-phase driver for, II-383
    - two-phase driver for, I-456, II-382
  - ac/dc indicator, IV-214
  - ac-to-dc converters, I-165
    - fixed power supplies, IV-395
    - full-wave, IV-120
    - high-impedance precision rectifier, I-164
  - acid rain monitor, II-245, III-361, V-371
  - acoustic field generator, V-338-341
  - acoustic sound receiver/transmitter, IV-311
  - active antennas (*see* antennas, active)
  - active filters (*see also* filter circuits)
    - band reject, II-401
    - bandpass, III-190, II-221, II-223
      - variable bandwidth, I-286
    - digitally tuned low-power, II-218
    - five pole, I-279
    - fourth-order low-pass, V-184
    - high-pass, V-180, V-188
      - fourth-order, V-188
      - second-order, I-297
    - low-pass, V-178, V-181, V-188
    - digitally selected break frequency, II-216
    - unity-gain, V-187
  - low-power
    - digitally selectable center frequency, III-186
    - digitally tuned, I-279
    - programmable, III-185
    - RC, up to 150 kHz, I-294
    - speech-range filter, V-185
    - state-variable, III-189
  - ten-band graphic equalizer using, II-684
  - three-amplifier, I-289
  - tunable, I-289
  - universal, II-214
- adapters (*see also* conversion and converters)
- dc transceiver, hand-held, III-461
  - line-voltage-to-multimeter adapter, V-312
    - program, second-audio, III-142
    - traveller's shaver, I-495
  - adder circuits, III-327
  - binary, fast-action, IV-260-261
- AGC (*see* automatic gain control (AGC))
- air conditioner, auto, smart clutch for, III-46
  - air motion and pressure
    - flow-detector, I-235, II-240-242, III-202-203, IV-82, V-154
    - flow-meters (anemometers)
      - hot-wire, III-342
      - thermally based, II-241
    - pressure change detector, IV-144
  - motion detector, I-222, III-364
- airplane propeller sound effect, II-592
- alarms (*see also* annunciators; sirens), I-4, III-3-9, IV-84-89, V-1-16
- 555-based alarm, V-11
  - alarm-tone generator, V-563
  - audio-sensor alarm, V-8
  - auto burglar, I-3, I-7, I-10, II-2, III-4, IV-53
  - automatic-arming, IV-50
  - automatic turn-off, 8 minute delay, IV-52
  - CMOS low-current, IV-56
  - horn as loudspeaker, IV-54
  - motion-actuated car/motorcycle, I-9
  - security system, I-5, IV-49-56
  - single-IC, III-7, IV-55
- auto-arming automotive alarm, IV-50
- automatic turn-off, IV-54
  - 8 minute delay, IV-52
- baby-alert transmitter/receiver, V-95-96
- bells, electronic, II-33, I-636
- blown fuse, I-10
- boat, I-9
- burglar alarms, III-8, III-9, IV-86
- burglar chaser, V-16
  - latching circuit, I-8, I-12
  - NC and NO switches, IV-87
  - NC switches, IV-87
  - one-chip, III-5
  - self-latching, IV-85
  - timed shutoff, IV-85
- camera triggered, III-444

alarms (*cont.*)

- capacitive sensor, III-515
  - current monitor and, III-338
  - dark-activated alarm, pulsed tone output, V-13
  - delayed alarm, V-4
  - differential voltage or current, II-3
  - digital clock circuit with, III-84
  - door-ajar, II-284, III-46
    - Hall-effect circuit, III-256
  - door rander, V-5
  - doorbells (*see* annunciators)
  - driver, high-power alarm driver, V-2
  - exit delay for burglar alarms, V-10
  - fail-safe, semiconductor, III-6
  - field disturbance, II-507
  - flasher signal, V-197
  - flex switch alarm sounder, V-15
  - flood, I-390, III-206, IV-188, V-374
  - freezer meltdown, I-13
  - headlights-on, III-52, V-77
  - heat-activated alarm, V-9
  - high/low-limit, I-151
  - home security system, I-6, IV-87
  - ice formation, II-58
  - infrared wireless system, IV-222-223
  - light-activated, V-9, V-273
    - high-output, pulsed tone, V-14
    - precision design, V-12
    - precision with hysteresis, V-14
    - self-latch, tone output, V-15
    - with latch, V-12
  - light-beam intruder-detection alarm, V-11, V-13
  - loop circuit alarms
    - closed-loop, V-3
    - multi-loop parallel alarm, V-2
    - parallel, V-3
    - series/parallel, V-3
  - low-battery disconnect and, III-65
  - low-battery warning, III-59
  - low-volts, II-493
  - multiple circuit for, II-2
  - no-doze alarm, V-8
  - one-chip, III-5
  - photoelectric, II-4, II-319
  - piezoelectric, I-12, V-10
  - power failure, I-581, I-582, III-511
  - printer error, IV-106
  - proximity, II-506, III-517, V-485-486
  - pulsed-tone, I-11, V-559
  - purse-snatcher, capacitance operated, I-134
  - rain, I-442, I-443, IV-189
  - road ice, II-57
  - security, I-4, III-3-9
  - self-arming, I-2
  - shutoff, automatic, I-4
  - signal-reception, receivers, III-270
  - silent alarm, V-16
  - siren, V-559
  - smoke alarms, II-278, III-246-253
    - gas, I-332
    - ionization chamber, I-332-333
    - line-operated, IV-140
    - operated ionization type, I-596
    - photoelectric, line-operated, I-596
    - SCR, III-251
    - solar powered, I-13
    - sonic defenders, IV-324
    - spaceship alarm, V-560
    - speed, I-95
    - Star Trek red alert, II-577
    - strobe flasher alarm, IV-180, V-6-7
    - tamperproof burglar, I-8
    - temperature (*see also* temperature-related circuits), II-4, II-643
      - adjustable threshold, II-644
      - light, radiation sensitive, II-4
    - timer, II-674
    - trouble tone alert, II-3
    - varying-frequency warning, II-579
    - wailing, II-572
    - warbling, II-573, V-7
    - watchdog timer/alarm, IV-584
    - water leakage/level (*see also* fluid and moisture), I-389, IV-190, V-374
  - allophone generator, III-733
  - alternators
    - battery-alternator monitor, car, III-63
    - regulator for automobile alternator, V-76
  - altimeter, digital readout, V-296
  - AM radio-related circuits, I-544
  - amplitude modulator, II-370
  - broadcast band signal generator, IV-302
  - car radio to shortwave converter, IV-500
  - demodulator, II-160
  - envelope detector, IV-142
  - microphone, wireless AM
    - microphone, I-679
  - modulation monitor, IV-299
  - power amplifier for, I-77
  - receivers, II-525, III-81, III-529, III-535, IV-455, V-496
    - 1.5 V broadcast, V0497
    - mixer/oscillator for AM receiver, V-412
    - transistor radio, V-502
  - carrier-current, III-81
  - integrated, III-535
  - signal generators, IV-301, IV-302
- AM/FM-related circuits
- clock radio, II-543, III-1
  - squelch circuit, II-547, III-1
- amateur radio related circuits
- linear amp, 2-30 MHz 140-W, III-260
  - receiver for, III-534
  - rf variable-frequency oscillator (VFO), V-532
  - transceiver relay interface, V-243
  - transmitter, 80-M, III-675
  - voice identifier, V-550
- ambience amplifier, rear speaker, II-458
- ambient light effects, cancellization circuit, II-328
- ambient light-ignoring optical sensor, III-413
- ammeter, I-201
- low-current, V-307
  - nano, I-202
  - pico, II-154, II-157, I-202
    - guarded input circuit, II-156
  - six-decade range, II-153, II-156
- amplifiers (*see also* audio amplifiers), II-5-22, III-10-21
- V-17-26
  - 1 watt/2.3 GHz, II-540
  - 2 to 6-W, with preamp, II-451
  - 2 to 30 MHz, 140W amateur radio linear, I-555
  - 4W bridge, I-79
  - 5W output, two-meter, I-567
  - 6W 8-ohm output-transformerless, I-75
  - 10 dB gain, III-543
  - 10 W power, I-76
  - 10 x buffer, I-128
  - 12-W low-distortion power, I-76
  - 16-W bridge, I-82
  - 25-watt, II-452
  - 30 MHz, I-567
  - 40 dB gain, IV-36
  - 60 MHz, I-567
  - 80 MHz cascade, I-567
  - 80W PEP broadband/linear, I-557
  - 100 MHz/400MHz neutralized common source, I-565
  - 100W PEP 420-450 MHz push-pull, I-554
  - 100x buffer, I-128
  - 135 to 175 MHz, I-564
  - 160W PEP broadband, I-556
  - 200 MHz neutralized common source, I-568
  - 450 MHz common-source, I-568
  - 600-W rf power, I-559
- absolute-value, I-31
- ac amplifier, noninverting, V-18, V-19
- ac servo, bridge type, III-387
- ac-coupled, dynamic, III-17
- acoustic field generator, V-338-341
- AF drive indicator, V-346
- AGC, II-17
  - squelch control, III-33
  - wide-band, III-15
- adjustable-gain noninverting, I-91
- amateur radio, linear, 2 to 30 MHz, 140W, I-555
- ambience, rear speaker, II-458
- AM radio power, I-77
- attenuator and, digitally controlled, I-53
- audio (*see* audio amplifiers)

audio converter, two- to four-wire, II-14  
 audio limiter, low-distortion, II-15  
 audio power amps (*see* audio and sound circuits, power amps)  
 audio signal amps (*see* audio and sound circuits, signal amps)  
 audio-to-UHF preamp, V-24  
 automatic fade circuit for, II-42  
 automatic level control, II-20  
 automotive audio amplifier, IV-66  
 Av/200, stereo, I-77  
 balance, II-46  
   inverting, I-33  
   loudness control, II-47, II-395  
 bootstrap circuit, V-356  
 bridge, I-74  
   4 watt, I-79  
   16 watt, I-82  
   ac servo, I-458  
   audio power, I-81  
   high-impedance, I-353  
   transducer, III-71, II-84, I-351  
 broadband  
   low-noise, I-562  
   PEP, 160-W, I-556  
   linear/PEP, 80W, I-557  
 buffers  
   10x, I-128  
   100x, I-128  
   ac, single-supply, I-126  
   battery-powered, I-351  
   rf amp with modulator, IV-490  
   sine-wave output, I-126  
   unity-gain, stable design, II-6  
 car stereo booster amp, V-72  
 cascade, III-13  
   80 MHz, I-567  
 cascade, rf amplifiers, IV-488  
 CD4049 audio signal amp, IV-40  
 chopper, +/- 15V., III-12  
   chopper channel, I-350  
   stabilized, II-7  
 clamp-limiting, active, III-15  
 color video, I-34, III-724  
 common source  
   450 MHz, I-568  
   low-power, II-84  
 complementary-symmetry audio, I-78  
 composite, II-8, III-13  
 compressor/amplifier, low-distortion, IV-24  
 constant-bandwidth, III-21  
 cool-down circuit, V-354, V-357  
 current feedback amp, V-100 mA  
   at 100 MHz, V-25  
   current-shunt, III-21  
   current collector head, II-11, II-295  
   current-to-voltage, high-speed, I-35  
 Darlington, push-pull, V-22  
 dc servo, I-457  
 dc-stabilized, fast, III-18  
 dc-to-video log, I-38  
 detector, MC1330/MC1352, TV IF, I-688  
 difference amplifier, V-18, V-21  
 differential, 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  
 discrete current-booster, V-23  
 distribution amplifiers  
   audio, I-39, II-39, V-59  
   signal, I-39  
 dual power supply, V-465  
 dynamic, ac-coupled, III-17  
 ear protector circuit, V-482  
 electret microphone preamp, V-21  
 electrometer, overload protected, II-155  
 fast-inverting, high-input impedance, V-18  
 FET input, II-7  
   offset gate bias, V-22  
   video, cascade, I-691  
 flat response, I-92, III-673  
 forward-current booster, III-17  
 four-quadrant photo-conductive detector, I-359  
 frequency counter preamp, V-24  
   gain, 10 dB, III-543  
   gain-controlled, III-34  
   gate, I-36  
   guitars, matching audio signal amps, IV-38  
   harmonic distortion analyzer, V-291  
   harmonic distortion meter, V-312  
   hi-fi compander as, II-12  
   hi-fi expander, II-13  
   high-frequency amplifiers, III-259-265  
   29-MHz, III-262  
   3-to-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, III-265  
   high-impedance/high-gain/high-frequency, I-41  
   high-impedances/low-capacitance, I-691  
   high-input-high-impedance amplifiers, II-19, II-44  
 IF amplifiers, I-690, IV-459  
   455-kHz, V-522, V-523, V-524  
   45-MHz, crystal filter, V-527  
   AGC system, IV-458  
   preamp, IV-460  
   receiver, IV-459  
   quadrature detector, TV sound IF, I-690  
   two-stage, 60 MHz, I-563  
   wideband, I-689  
 infinite sample and hold, II-558  
 input-inverting, fast, high-impedance, V-19  
 input/output buffer for analog multiplexers, III-11  
 instrumentation amplifiers, I-346, I-348, I-349, I-352, II-293-295, III-278-284, IV-229-234, V-233-235  
   +/-100 V common mode range, III-294  
   current collector head amplifier, II-295  
   differential, I-347, I-349, I-353, I-354, III-282, III-283  
   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  
   preamps, III-283, IV-230-231  
   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  
 inverting, I-42, II-41, III-14  
   ac, high-gain, I-92  
   balancing circuit in, I-33  
   gain of 2, lag-lead compensation, UHF, I-566  
   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  
 isolation  
   capacitive load, I-34  
   level-shifting, I-348  
   medical telemetry, I-352  
   rf, II-547  
   JFET, V-20  
   500-Mohm input impedance, V-23  
   bipolar cascade video, I-692  
   current source biasing, V-21  
   preamplifier, V-22  
 line amps, III-37  
   duplex, telephone, III-616

**amplifiers** (*cont.*)  
 universal design, IV-39  
**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  
 audio power amplifiers, V-51  
 CMOS inverter, II-11  
 inverter, linear amp from inverter, II-11  
 rf, IV-480-481, IV-484-485  
 load-line protected, 75W audio, I-73  
 logarithmic amplifiers, I-29, I-35, II-8  
 dc to video, I-38  
 log-ratio amplifier, I-42  
 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  
 log ratio, I-42  
 loudness control, II-46  
 low-level video detector circuit and, I-687  
 low-noise design, IV-37  
 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, I-87, III-34  
   electronically balanced input, I-86  
**microwave amplifiers**, IV-315-319  
 5.7 GHz, IV-317  
 bias supply for preamp, IV-318  
 preamplifiers, IV-316-319  
 mini-stereo amplifier, V-583  
 monostable, II-268  
**MOSFET**, high-impedance biasing method, V-19  
 neutralized common source, I-565, I-568  
 noninverting amplifiers, I-32, I-33, I-41, III-14  
 ac power, I-79  
 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  
 Norton, absolute-value, III-11  
 op amp (*see* operational amplifiers)  
 oscilloscope sensitivity, III-436  
 output, four-channel D/A, III-165  
 phono, I-80, I-81, I-89  
 photodiode, I-361, II-324, III-19, III-672  
 phototransistor amplifier, V-409  
 playback, tape, III-672  
 polarity-reversing low-power, III-16  
 power (*see* power amps)  
 power supply, V-464, V-465  
 pre-amps (*see* preamplifiers)  
 precision amplifier, I-40, II-335  
 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/programming, III-506  
 programmable-gain, I-32, II-9  
 variable-gain, wide-range digital control, III-506  
 programmable gain, I-32, II-9  
 pulse-width proportional controller circuit for, II-21  
 push-pull  
   Darlington, V-22  
   PEP 100-W, 420-450 MHz, I-554  
 PWM servo, III-379  
 recording amplifier, I-90  
 reference voltage, I-36  
 remote, I-91  
 rf (*see* rf amplifiers)  
 sample-and-hold, I-587, II-558  
 selectable input, programmable gain, I-32  
 servo amplifiers (*see also* motor controls), I-452  
 400 Hz, II-386  
 bridge type ac, I-458  
 dc, I-457  
 motor drive amplifier, II-384  
 signal amplifiers, audio, II-41-47, IV-34-42  
 signal distribution, I-39  
 sound-activated, gain-controlled, IV-528  
 silicon-controlled amplifiers (SCA), V-535-536  
 decoder, I-214, II-166, II-170  
 demodulator, II-150, III-565  
 subcarrier adapter, FM tuner, V-536  
 sinewave output buffer, I-126  
 sound mixer and, II-37  
 source follower  
   bootstrapped, V-20  
   JFET, V-20  
 speaker amplifiers, II-16, III-39  
 speech compressor, II-15  
 stereo amplifiers, I-77, II-9, III-34  
   bass tone control, V-584  
   subwoofer power supply, V-464  
   summing, I-37, III-16  
   fast-action, I-36  
   inverting, V-18, V-20  
   precision design, I-36  
   video, clamping circuit and, III-710  
 switching power, I-33  
 tape playback, I-92, IV-36  
 tape recording, I-90  
 telephonic, III-621, IV-555, IV-560, V-614  
 test bench amplifier, V-26  
 thermocouple, I-654, III-14  
   cold junction compensation in, II-649  
   high-stability, I-355  
 transducer, I-86, III-669-673  
 transformerless, 6-W, 8-ohm output, I-75  
 transistorized, I-85, II-43  
 tremolo circuit, voltage-controlled, I-598  
 tube amplifier, high-voltage isolation, IV-426  
 TV audio, III-39  
 two-meter, I-562, I-567  
 two-stage, I-563, I-689  
 UHF, I-560, I-565  
 unity gain, I-27, II-7  
   noninverting, V-21, V-22  
 variable-gain, for oscilloscopes, V-426  
 VHF, single-device, 80-W/50-ohm, I-558  
 video, I-692, III-708-712, V-655, V-656, V-657, V-658, V-662  
 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  
 voice activated switch, I-608  
 voice-operated circuits, V-553  
 voltage, differential-to-single-ended, III-670  
 voltage-controlled (*see* voltage-controlled amplifiers)  
 voltage-follower, signal-supply operation, III-20

volume, II-46  
 walkman, II-456  
 write, III-18  
 amplitude modulation (*see* AM  
     radio-related circuits; AM/FM)  
 analog circuits  
     counter circuit, II-137  
     delay line, echo and reverb, IV-21  
     multiplexers, II-431, III-396  
     multiplier, II-392  
     switch, differential analog switch,  
         I-622  
 analog-to-digital converter, II-23-31,  
     III-22-26, IV-5-6, V-27-30  
 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  
 buffer, high-speed 6-bit, I-127  
 capacitance meter, 3.5 digit, III-76  
 cyclic, II-30  
 differential input system for, II-31  
 eight-channel, for PC clones,  
     V-29-30, V-29  
 fast precision, I-49  
 four-digit (10,000 count), II-25  
 half-flash, III-26  
 IC, low-cost, I-50  
 LCD display, 3.5 digit, I-49  
 poller, V-28  
 successive approximation, II-24,  
     II-30, I-45  
 switched-capacitor, III-23  
 three-decade logarithmic, I-48  
 three-IC, low-cost, I-50  
 tracking, III-24  
 video converter, IV-610-611  
 analyzer, gas, II-281  
 AND gate, I-395, V-216  
     large fan-in, I-395  
 anemometers (*see also* air  
     motion/pressure)  
     hot-wire, III-342  
     thermally based, II-241  
 angle-of-rotation detector, II-283  
 annunciators (*see also* alarms;  
     sirens), II-32-34, III-27-28, IV-710  
 ac line-voltage, III-730  
 bell, electronic I-636, II-33, IV-9  
 buzzers, I-11, I-12, IV-8, V-170  
 chime circuit, low-cost, II-33  
 door buzzer, IV-8  
 doorbells/chimes, I-218, I-443, IV-8  
     buzzer, V-170  
     buzzer, two-door, IV-10  
     musical-tone, IV-522  
     rain alarm, I-443  
     single-chip design, IV-524  
     sliding tone, II-34  
     twin-bell, V-170  
     large fan-in, I-395  
     SCR circuit, self-interrupting load,  
         IV-9  
     twin-bell doorbell, V-170  
     two-door annunciator, IV-10  
 answering machines (*see also*  
     telephone-related circuits)  
 beeper, IV-559  
 antennas, IV-11-14, V-31-38  
     active, III-1-2, IV-1-4  
     wideband rod, IV04  
     with gain, IV-2  
 balun, V-34  
 IIIF broadband antenna preamp, V-36  
 HF/VHF switchable active antenna,  
     V-524  
     loop antenna,  
         3.5 MHz, IV-12-13  
         dual band, 80-16-M, V-32  
         preamp, V-38  
     preamps  
         HF broadband, V-36  
         VLF 60-kHz, V-33  
         wideband antenna, V-35  
     selector switch, IV-538-539  
     TR switch, automatic, V-37  
     tuner  
         1- to 30-MHz, IV-14  
         low-power, V-38  
     VLF 60-kHz antenna preamp, V-33  
     VLF/VHIF wideband, low-noise,  
         active, V-33  
     wideband antenna, preamp, V-35  
 antitheft device, I-7  
 arc lamp, 25-W, power supply for,  
     II-476  
 arc welding inverter, ultrasonic, 20  
     KHz, III-700  
 arc-jet power supply, starting circuit,  
     III-479  
 astable multivibrators, II-269, II-510,  
     III-196, III-233, III-238, V-387,  
     V-388  
     op amp, III-224  
     free-running square-wave oscillator,  
         V-386  
     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, III-30  
     programmable (1 to 0 00001), I-53  
     rf, IV-322  
     variable, I-52  
     voltage-controlled, II-18, III-31  
 audio amplifiers (*see also* amplifiers,  
     audio and sound circuits, audio  
     power amplifiers), II-41-47, III-  
     32-39, IV-34-42  
     40 dB gain design, IV-36  
     AGC, squelch control, III-33  
     audio compressor, II-44  
     automotive stereo system, high-  
         power, IV-66  
     balance, II-46, II-47, IV-215  
     Baxandall tone-control, IV-588  
     booster, 20 dB, III-35  
     CD4049 design, IV-40  
     circuit bridge load drive, III-35  
     complementary-symmetry, I-78  
     compressor, II-44  
     distribution, I-39, II-39  
     electric guitar, IV-38  
     fader, automatic, II-42  
     fixed power supplies, IV-398, IV-  
         407  
     high-slew rate power op amp, I-82  
     gain-controlled, stereo, III-34  
     line amplifier, III-37, IV-39  
     load line protection, 75W, I-73  
     loudness, II-46  
     low-noise design, IV-37  
     low-power, II-454  
     micro-sized, III-36  
     microphone, II-45, III-34  
     micropower high-input-impedance  
         20-dB amplifier, II-44  
     mm-stereo, III-38  
     power (*see* audio power amplifiers)  
     power supply, V-465  
     pre-amps  
         1000x, low-noise, IV-37  
         general-purpose, IV-42  
         impedance-matching, IV-37  
         low-noise, IV-41  
         magnetic phono cartridge, IV-35  
         microphone, IV-37, IV-41, IV-42  
         NAB tape playback, professional,  
             III-38  
         phono, III-37, IV-35, IV-36  
         RIAA, III-38  
         stereo, II-43, II-45  
     Q-multiplier, II-20  
     signal (*see* audio signal amplifiers)  
     speaker, hand-held transceivers,  
         III-39  
     tape playback amplifiers, IV-35  
     television type, III-39  
     tone control, II-686  
     transistor headphone amplifier, II-43  
     ultra-high-gain, I-87  
     volume indicator, II-46, IV-212  
 audio and sound circuits (*see also*  
     audio amplifiers; sound  
     generators; sound-operated  
     circuits)  
     acoustic field generator, V-338-341  
     acoustic sound  
         receiver/transmitter, IV-311  
     AF drive indicator, V-346  
     amplifiers (*see* audio amplifiers)  
     audio-frequency generator, V-416-  
         417

audio and sound circuits (*cont.*)

audio-frequency meter, V-305,  
V-320  
audio-rf signal tracer probe, I-527  
audio-sensor alarm, V-8  
audio-test oscillator, V-420  
audio-to-ADC interface, V-242  
audio-to-UHF preamp, V-24  
automatic gain control (AGC), II-17  
automatic level control (ALC),  
V-62  
AGC system for CA3028 IF amp,  
IV-458  
rf amplifier, wideband adjustable,  
III-545  
squelch control, III-33  
wide-band amplifier, III-15  
booster, II-455, III-35  
biquad filter, III-185  
bridge load drive, III-35  
carrier-current transmitter, III-79  
clapper, precise, II-394  
compressor, II-44  
continuity tester, I-550  
converter, two- to four-wire, II-14  
distribution amplifier, I-39, II-39  
expander, V-582  
filters (*see filters*)  
frequency doubler, IV-16-17  
frequency meter, I-311  
generators (*see sound generators*)  
LED bar peak program meter  
display, I-254  
level meters, sound levels, III-346,  
III-614, IV-305, IV-307  
limiters, II-15, V-335  
nullvoltmeter, III-767, III-769  
mixers (*see mixers*)  
notch filter, II-400  
octave equalizer, V-353  
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  
power (*see audio power amplifiers*)  
power meter, I-488  
Q multiplier, II-20  
receivers (*see receivers*)  
rf signal tracer probe, I-527  
scramblers, IV-25-27  
selector, digital, V-158  
signal amplifiers (*see audio signal  
amplifiers*)  
sine wave generator, II-564  
squelch, II-394  
switches  
eight-channel, V-588-589  
video/audio switch, V-586  
switching/mixing, silent, I-59  
transmitters (*see transmitters*)  
waveform generators, III-230  
audio generators (*see sound  
generators*)

audio-operated circuits (*see sound-  
operated circuits*)  
audio power amplifiers, II-451, III-  
454, IV-28-33  
6 W, with preamp, III-454  
18-W bridge, V-49  
20-W, III-456  
33-W bridge composite, V-46  
39-51, V-39  
40 W, V-41  
50-W, III-451  
70 W, composite, V-44-45, V 44  
audio amplifier, IV-32  
basic design, V-51  
bridge, I-81, V-49  
bridge composite, V-46  
bull horn, IV-31  
composite,  
33-W bridge, V-46  
70 W, V-44-45  
inverting 10W, V-47  
noninverting 10W, V-47  
dual, V-42-43, V-42  
general-purpose, 5-W, ac, IV-30  
half-watt, single-channel, V-41  
inverting composite, V-10W, V-47  
linear, fast, high-voltage, V-51  
MOSFET, V-47  
noninverting composite 10W, V-47  
op amp, simple design, IV-33  
personal-stereo type, V-48  
receiver audio circuit, IV-31  
stereo amp, IV-29, V-40  
subwoofer amp, V-49, V-50  
audio signal amplifiers, II-41-47,  
IV-34-42, V-52-59  
booster, V-58  
compressor, audio, V-57  
constant-volume, V-55  
distribution amplifier, V-59  
dual preamp, V-58  
headphone amplifier, V-53  
headphone amplifier, JFET, V-57  
line driver, V-54  
mm-amp, V-55  
phonograph, magnetic pickup, V-58  
tunable-filter design, V-56  
volume limiter, V-59  
audio-frequency generator,  
V-416-417  
audio-frequency meter, V-305, V-320  
audio-to-UHF preamp, V-24  
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  
automatic gain control (AGC), II-17  
AGC system for CA3028 IF amp,  
IV-458  
rf amplifier, wideband adjustable,

III-545  
squelch control, III-33  
wide-band amplifier, III-15  
automatic level control (ALC),  
V-60-62  
AGC system for audio signals, V-62  
basic design, V-62  
digital design, V-61  
automotive circuits, II-48-63, III-40-  
52, IV-43-67, V-63-77  
accessory-power controller, V-70  
alarms (*see also alarms/security  
circuits*), V-1  
automatic-arming, IV-50  
automatic turn off, IV-52  
CMOS design, low-current, IV-56  
horn as loudspeaker, IV-54  
single-IC design, IV-55  
air conditioner start clutch, III-46  
alternator/battery monitor, III-63,  
V-88  
alternator regulator, V-76  
AM radio to shortwave converter,  
IV-500  
amplifier, booster for car stereo,  
V-72  
analog expanded-scale meter, IV-46  
audio-amplifier, high-power, IV-66  
back-up beeper, III-49, IV-51, IV-56  
bar-graph voltmeter, II-54  
battery chargers/monitors (*see  
also battery-related circuits*)  
charger, ni-cad, I-115  
condition checker, I-108  
current analyzer, I-104  
electric vehicle battery saver, III-67  
monitor, I-106, I-222, III-60-67  
supply circuit, +/- 15- and 5-V,  
IV-391  
battery cranking-amps tester, V-84  
battery/alternator monitor, V-88  
brake and turn indicator, V-74  
brake lights, V-65  
delayed extra, III-44  
flashing, V-69  
flashing third, III-51  
night-safety light for parked car,  
IV-61  
third brake light, IV-60  
burglar alarms, I-3, I-7, I-10, II-2,  
III-4, III-7, IV-53  
cassette recorder power circuit,  
IV-548  
courtesy lights  
delay switch, III-42  
light extender, III-50  
dc power adapter, V-70  
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

- engine-block heater reminder, V-74
  - exhaust emissions analyzer, II-51
  - fan thermostatic switch, V-68
  - fog light controller with delay, IV-59
  - fuel gauge, digital readout, IV-46
  - fuse monitor, V-77
  - garage stop light, II-53
  - generator regulator, V-76
  - glow-plug driver, II-52
  - headlights, IV-57-62
    - alarm, III-52, V-77
    - automatic-off controller, IV-61, V-75
    - delay circuit, I-107, III-49, II-59
    - dimmer, II-57, II-63
    - flasher, V-73
    - on-lights reminder, V-74, V-77
    - switching circuit, V-75
  - headlight/spotlight control, V-67
  - high-speed warning device, I-101
  - ice formation alarm, II-58
  - ignition circuit, V-64
    - cut-off, IV-53
    - electronic ignition, IV-65
    - substitute ignition, III-41
    - timing light, II-60
  - immobilizer, II-50
  - kill-switch for battery, time-
    - delayed, V-71-72
  - light circuits, IV-57-62
  - lights-on warning, II-55, III-42, IV-58, IV-60, IV-62
  - locator, automobile locator, III-43
  - night-safety light for parked car, IV-61
  - oil pressure gauge, digital readout, IV-44, IV-47
  - PTC thermistor automotive
    - temperature indicator, II-56
  - radio receiver, II-525
  - radio WWV converter, V-119
  - read-head pre-amplifier, III-44
  - road ice alarm, II-57
  - security system, I-5, IV-49-56
  - spotlight/headlight control, V-67
  - tachometers, I-94, I-100, I-102, II-175, III-335, III-340, III-347, V-65
    - analog readout, IV-280
    - calibrated, III-598
    - closed loop feedback control, II-390
    - digital readout, II-61, III-45, IV-268-269, IV-278
    - dwell meter/tachometer, III-45
    - feedback control, II-378, II-390
    - frequency counter, I-310
    - low-frequency, III-596
    - minimum-component design, I-405
    - motor speed controllers, II-378, II-389
    - optical pick-up, III-347
    - set point, III-47
  - temperature gauge
    - digital readout, IV-48
    - PTC thermistor, II-56
  - thermostatic switch for auto fans, V-68
  - turn signals, V-65
    - audible reminder, V-74
    - monitor, III-48
    - sequential flasher for, II-109, III-1
    - smart, V-66-67, V-66
    - reminder, V-73
  - 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
  - windshield wiper circuits, I-105, II-55, II-62
    - control circuit, I-103, I-105, II-62
    - delay circuit, II-55, 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
  - WWV converter for radio, V-119
- ## B
- B-field measurer, IV-272
  - baby monitor, V-370-371
  - baby-alert transmitter/receiver, V-95-96
  - back-biased GaAs LED light sensor, II-321
  - back-EMF PM motor speed control, II-379
  - backup-light beeper, car, IV-51, IV-56
  - bagpipe sound effect, IV-521
  - balance indicator, audio amps. IV-215
  - balance meter, stereo, V-583
  - balancer, stereo, I-619
  - balance amplifiers, III-46
    - loudness control m, II-395
  - balance indicator, bridge circuit, II-82
  - balun, V-34
  - band reject filter, active, II-401
  - bandpass filter (*see also* filter circuits), II-222, V-180, V-181
    - 0.1 to 10 Hz, I-296
    - 160 Hz, I-296
    - active, II-221, II-223, III-190
    - 1 kHz, I-284
    - 20 kHz, I-297
    - 60 dB gain, I-284
    - variable bandwidth, I-286
  - biquad, I-285, III-188, V-190
  - Chebyshev fourth-order, III-191
  - high-Q, I-287, V-179
  - MFB, multichannel tone decoder, I-288
  - multiple feedback, I-285, I-297, II-224
  - notch, II-223
  - Sallen-Kcy, 500 Hz, I-291
  - second-order biquad, III-188
  - speech-range filter, V-185
  - state variable, I-290
  - tunable, IV-171
  - variable bandpass, V-184
  - variable-frequency, V-186
  - bang-bang power controllers, IV-389
  - bar-code scanner, III-363
  - bar-expanded scale meter, II-186
  - bar graphs
    - ac signal indicator, II-187
    - voltmeters, II-54, II-99
  - barricade flasher, I-299
  - barometer, IV-273
  - base tone control in stereo amplifier, V-584
  - base tuner, II-362
    - 12 V, I-111
    - 200 mA-hour, 12V Ni-Cad, I-114
    - automatic shutoff for, I-113
  - battery-operated equipment (*see also* battery-related circuits)
    - ac power control switch, IV-387
    - automatic shutoff, III-61
    - bipolar power supply, II-475
    - black light, V-281
    - buffer amplifier for standard cell, I-351
    - calculators/radios/cassette players, power pack, I-509
    - cassette deck power circuit, car, IV-548
    - 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
  - battery-related circuits (*see also* battery-operated equipment), V-82-89
    - AA cells, +5 V/+3.6 V power supply, V-452
    - battery life extenders, IV-72, V-87, 9-V, III-62
    - disconnect switch, IV-75
    - electric vehicles, III-67
    - capacity tester, III-66
    - car battery/alternator monitor, V-88
    - chargers, I-113, II-64, II-69, III-53-59, IV-68-72, V-78-81
    - 12-V charger, IV-70
    - constant voltage, current limited, I-115
    - intelligent circuit, V-81
    - mobile charger, +12 Vdc, IV-71
    - ni-cad, I-112, I-116, III-57
    - rf type, V-79
    - solar-powered, V-81
    - temperature sensing charger, IV-77

battery-related circuits (*cont.*)  
   trickle charger, lead-acid, V-79  
   checkers (*see* battery monitors, below)  
   condition checker, I-108, I-121  
   control for 12V, I-112  
   converter, dc-to-dc, IV-119  
   cranking-amp test circuit, V-84  
   current limited 6V, I-118, IV-70  
   current monitor, 0-2 A batteries, V-87  
   disconnect switch, life-extender, IV-75  
   dynamic constant current test, II-75  
   fixed power supply, 12-VDC/120-VAC, III-464  
   gel cell, II-66  
   high-voltage generator, III-482  
   indicators (*see* battery monitors, below)  
   internal resistance tester, IV-74  
   kill-switch, time-delayed, V-71-72  
   lead/acid, III-55  
   level indicator, II-124  
   lithium, II-67  
     charge indicator, II-78  
   low-battery detection/warning, I-124, II-77, III-56, III-59, III-63, III-65, IV-56, IV-80  
   low-cost trickle for 12V storage, I-117  
   monitors, I-106, I-222, II-74-79, III-60-67, IV-73-80, V-82-83  
   ni-cad batteries, I-118  
     analyzer for, III-64  
     charger, I-112, I-116, III-57  
       12 v, 200 mA per hour, I-114  
     current and voltage limiting, I-114  
     fast-acting, I-118  
     portable, IV-69  
     temperature-sensing, IV-77  
     thermally controlled, II-68  
   packs, automotive charger for, I-115  
   portable, III-47, IV-69  
   protection circuit, III-62  
   simple-cad, I-112  
   temperature-sensing charger, IV-77  
   test circuit, IV-79  
   thermally controlled, II-68  
   zappers, I-6, II-66, II-68  
   power supply and, 14V, II-73, III-42  
   protection circuit, ni-cads, III-62  
   PUT, III-54  
   regulator, I-117  
   relay fuse, V-88  
   saver circuit, V-87  
   sensor, quick deactivating, III-61  
   simple-cad, I-112  
   solar cell, II-71  
   splitter, III-66  
   status indicator, II-77  
   step-up switching regulator, 6-V, II-78  
   supply-voltage monitor, V-85  
   test circuits, IV-78, V-83, V-86  
     LED bargraph, V-89  
     ni-cad, IV-79  
     thermally controlled ni-cad, II-68  
   threshold indicator, I-124  
   UJT, III-56  
   undervoltage indicator, I-123  
   universal battery, III-56, III-58  
   versatile battery, II-72  
   voltage indicators/monitors, II-79, IV-80, V-86  
     automotive batteries, IV-47  
     detector relay, II-76  
     HTS, I-122  
     regulator, IV-77  
     solid-state design, I-120  
     watchdog circuit, V-85  
     wind powered, II-70  
     zapper, simple ni-cad, I-116  
   Baxandall tone-control audio amp, IV-588  
   BCD rotary switch, digital, V-160  
   BCD-to-analog converter, I-160  
   BCD-to-parallel converter, multiplex, I-169  
   beacon transmitter, III-683  
   beep transformer, III-555, III-566  
   beepers, I-19, III-49  
   bells, electronic (*see also* alarms; annunciators), I-636, II-33  
   bench top 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, III-185  
     second-order bandpass, III-188  
     RC active bandpass, I-285  
   bird-chirp sound effect, III-577, II-588  
   bird feeder monitor, V-371  
   bistable multivibrators, I-133, II-465  
   inverter, III-103  
   debouncer, IV-108  
   flasher, I-299, II-234  
   lamp driver, IV-160  
   pushbutton trigger, V-388  
   RS flip-flop, I-395  
   SCR, II-367  
   SR flip-flop, IV-651  
   touch-triggered, I-133  
   bit grabber, computers, IV-105  
   black light, battery-operated, V-281  
   blender-motor control circuit, V-379  
   blinkers (*see* flashers and blinkers)  
   blown-fuse alarm, I-10  
   boiler control, I-638  
   borgos, electronic, II-587  
   boosters  
     12ns, II-97  
     ac line voltage boost, V-349  
     audio, II-455, III-35, V-58  
     booster/buffer for reference current, IV-425  
     electronic, high-speed, II-96  
     forward-current, III-17  
     LED, I-307  
     power booster, op amp design, IV-358  
     rf amp, broadcast band boost, IV-487  
     shortwave FET, I-561  
   bootstrap circuit, V-356  
   source follower, V-20  
   cable, I-34  
   brake lights (*see* automotive circuits)  
   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-89  
   air-flow-sensing thermistor, IV-82  
   auto-zeroing scale, III-69  
   balance indicator, II-82  
   bridge transducer amplifier, III-71  
   crystal-controlled 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 supply, IV-398  
   remote sensor loop transmitter, III-70  
   rf bridge, V-50-MHz, V-303  
   strain gauge signal conditioner, II-85, III-71  
   transducer, amplifier for, II-84  
   Wien-bridge (*see* Wien-bridge)  
   brightness controls, III-308, III-316  
   contrast meter, I-472, II-447  
   LED, I-250  
   low-loss, I-377  
   broadband communications (*see* radio/rf circuits)

buck converter, 5V/0.5A, I-494  
buck/boost converter, III-113  
buckling regulators  
  add 12-V output to 5-V, V-472  
  high-voltage, III-481  
buffer amplifiers, V-91  
  10x, I-128  
  100x, I-128  
  ac, single supply, I-126  
  battery powered, standard cell,  
    II-351  
  MOSFET design, V-93  
  sine wave output, I-126  
  VFO design, V-92  
buffers, IV-88-90, V-90-93  
  amplifiers (*see* buffer amplifiers)  
  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, IV-425  
  capacitance buffers  
    low-input, III-498  
    stabilized low-input, III-502  
  data/clock line serial bus for PCs,  
    V-110  
  hex-buffer crystal oscillator, V-136  
  high-current, V-92  
  input/output, for analog  
    multiplexers, III-11  
  inverting, II-299, IV-90  
  oscillator buffers, IV-89  
  precision-increasing design, IV-89  
  rail-to-rail single-supply buffer, V-93  
  rf amp, buffer amp with modulator,  
    IV-490  
  stable, high-impedance, I-128  
  unity gain, stable, good speed,  
    high-input impedance, II-6  
  VFO buffer amplifier, V-92  
  video buffer, III-712, V-93  
  wideband, high-impedance/low-  
    capacitance, I-127  
buffered breakout box, II-120  
bug detector, III-365, V-150  
bug tracer, III-358  
bull horn, II-453, IV-31  
burglar alarms (*see* alarms:  
  annunciators; sirens)  
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, II-90  
  tone, II-90, III-74  
burst power control, III-362  
bus interface, eight bit uP, II-114  
Butler oscillators  
  aperiodic, I-196

  common base, I-191  
  crystal, I-182  
  emitter follower, II-190-191, II-194  
Butterworth filters  
  fourth order high-pass, I-280, V-179  
  fourth order low-pass, V-180  
  order low-pass, V-181  
buzzers (*see* annunciators)

## C

cable  
  bootstrapping, I-34  
  test circuit, III-539, V-299  
calibrated circuit, DVM auto, I-714  
calibrated tachometer, III-598  
calibrators  
  crystal, 100 kHz, I-185  
  electrolytic-capacitor reforming,  
    IV-276  
  ESR measurer, IV-279  
  oscilloscope, II-433, III-436  
  portable, I-644  
  square wave, 5-V, I-423  
  standard for calibration, I-406  
  radio calibrator, V-298  
  tester, IV-265  
  wave-shaping, high-slew rates,  
    IV-650  
cameras (*see* photography-related  
  circuits; television and video)  
canary sound simulator, V-557  
canceller, central image, III-358  
capacitance buffers  
  low-input, III-498  
  stabilized low-input, III-502  
capacitance controller, digital, V-159  
capacitance meters, I-400, II-91-94,  
  III-75-77  
  A/D, 3.5 digit, III-76  
  capacitance-to-voltage, II-92  
  digital, II-94  
capacitance multiplier, I-416, II-200,  
  V-205, V-347  
capacitance tester, one-IC design,  
  V-306  
capacitance-to-pulse width  
  converter, II-126  
capacitance-to-voltage meter, II-92  
capacitor discharge  
  high-voltage generator, III-485  
  ignition system, II-103  
capacitors, hysteresis compensation,  
  V-353  
capacity tester, battery, III-66  
car port, automatic light controller  
  for, II-308  
cars (*see* automotive circuits)  
carrier-current circuits (*see also*  
  radio/rr circuits), III-78-82, IV-  
  91-93, V-94-96  
AM receiver, III-81  
audio transmitter, III-79  
baby-alert receiver/transmitter, V-  
  95, V-96  
data receiver, IV-93  
data transmitter, IV-92  
FM receiver, III-80  
intercom, I-146  
power-line modem, III-82  
receivers, I-141, I-143  
  IC, I-146  
  single transistor, I-145  
  relay, I-575, IV-461  
remote control, I-146  
transmitters, I-144  
  IC, I-145  
  on/off 200kHz line, I-142  
cascaded amplifier, III-13  
cassette bias oscillator, II-426  
cassette interface, telephone, III-618  
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 supply,  
    IV-396  
chargers (*see* battery-related  
  circuits, chargers)  
chase circuit, III-197, I-326  
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 circuits  
  amplifier, II-7, III-12, I-350  
  dc output, V-349  
  JFET, V-352  
checkers (*see* measurement/test  
  circuits)  
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

- clippers (*cont.*)
    - zener design, fast, symmetrical, IV-329
  - clock circuits, II-100-102, III-83-85, V-97-99
    - 60Hz clock pulse generator, II-102
    - adjustable TTL, I-614
    - binary clock, V-98-99
    - buffer serial bus, V-110
    - comparator, I-156
    - crystal oscillator, micropower, IV-122
    - digital, with alarm, III-84
    - gas discharge displays, III-12-hour, I-253
    - oscillator/clock generator, III-85
    - phase lock, 20-Mhz to Nubus, III-105
    - run-down clock for games, IV-205
    - sensor touch switch/clock, IV-591
    - single op amp, III-85
    - source, clock source, I-729
    - stepper motors, V-573
    - three-phase from reference, II-101
    - TTL, wide-frequency, III-85
    - Z80 computer, II-121
  - clock generators
    - oscillator, I-615
    - precision, I-193
    - pulse generator, 60 Hz, II-102
    - clock radio, I-542, 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
    - dimmer, V-270
    - flasher, III-199
    - inverter, linear amplifier from, II-11
    - line receiver, V-497
    - mixer, I-57
    - multivibrators, V-385
    - optical coupler, III-414
    - oscillator, I-615, I-187, I-199, III-429, III-430, V-420
    - piezoelectric driver, V-440
    - programmable precision timer, III-652
    - short-pulse generator, III-523
    - touch switch, I-137
    - universal logic probe, III-499
    - variable-frequency oscillator (VFO), V-418
  - coaxial cable
    - drivers, coaxial cable, I-266, I-560
    - five-transistor pulse booster, II-191
    - test circuit, V-299
  - Cockcroft-Walton cascaded voltage doubler, IV-635
  - code-practice oscillators, I-15, I-20, I-22, II-428-431, IV-373, IV-375, IV-376, V-100-103
  - keyer, "bug" type, V-102
  - Morse code practice, V-103
  - optoisolator design, V-101
  - QRP sidetone generator, V-102
  - single-transistor design, V-103
  - VFO design, V-103
  - 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, V-104-105
  - color video amplifier, I-34
  - Colpitts crystal oscillators, I-194, I-572, II-147, V-411
  - 1-to-20 MHz, IV-123
  - frequency checker, IV-301
  - harmonic, I-189-190
  - two-frequency, IV-127
  - combination locks, electronic, II-196
  - three-dial, II-195
  - commutator, four-channel, II-364
  - companders (*see* compressor/expander circuits)
  - comparators, III-86-90, II-103-112, I-157
    - demonstration circuit, II-109
    - diode feedback, I-150
    - display and, II-105
    - double-ended limit, II-105, I-156
    - dual limit, I-151
    - four-channel, III-90
    - frequency, II-109, II-110
    - 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
    - hysteresis, I-157
    - inverting, I-154
    - noninverting, I-153
    - inverting, I-154
    - jitter suppression, V-342
    - 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
      - hysteresis, III-88
      - monostable using, II-268
    - opposite polarity-input voltage, I-155
    - oscillator, tunable signal, I-69
    - power supply overvoltage, glitches
      - detection with, II-107
    - precision
      - balanced input/variable offset, III-89
      - photodiode, I-360, I-384
      - time out, I-153
    - TTL-compatible Schmitt trigger, II-111
  - three-input and gate, op amp design, IV-363
  - variable hysteresis, I-149
  - voltage comparator, IV-659
  - voltage monitor and, II-104
  - window, I-152, I-154, II-106, III-87, III-90, III-776-781, IV-656-658
  - compass
    - digital design, IV-147
    - Hall-effect, III-258
    - talking Hall-effect compass, V-221
  - 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, V-57
  - audio compressor/audio-band splitter, IV-95
  - clock circuit, I-156
  - guitar, sound-effect circuit, IV-519
  - hi-fi, II-12, II-13
    - de-emphasis, III-95
    - pre-emphasis, III-93
  - low-voltage, III-92
  - protector circuit, IV-351
  - speech, II-2
  - universal design, IV-96-97
  - variable slope, III-94
- computational alarm, I-2
- computer circuits (*see also* interfaces), II-113-122, III-96-108, V-106-110
  - ADC, eight-channel, for PC clones, V-29-30
  - analog signal attenuator, III-101
  - alarm, I-2
  - ASCII triplex LCD, 8048/IM80C48, II-116
  - bit grabber, IV-105
  - buffered breakout box, II-120
  - buffer serial-bus for data/clock lines, V-110
  - 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, 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
  - DVM adapter for PC, V-310
  - 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  
 laptop computer power supply, V-463  
 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, II-486  
 microcomputer-to-triac interface, V-244  
 microprocessor selected pulse width control, II-116  
 modem protector circuit, V-479  
 modem/fax protector for two computers, V-482  
 multiple inputs detector, III-102  
 one-of-eight channel transmission system, III-100  
 oscilloscope digital levels, IV-108  
 password protection circuit, V-109  
 power supply watchdog, II-494  
 pulse width control, II-116  
 printer error alarm, IV-106  
 printer sentry, V-107-108  
 reset protection, childproof, 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, III-101  
 sleep-mode sound-operated circuits, V-547  
 socket debugger, coprocessor, III-104  
 speech synthesizer for, III-732  
 stalled-output detector, IV-109  
 switch debouncer, IV-105  
   auto-repeating, IV-106  
 triac array driver, II-410  
 V<sub>pp</sub> generator for EPROMs, II-114  
 XOR gates, IV-107  
   up/down counter, III-105  
 Z80 bus monitor/debugger, IV-103  
 Z80 clock, II-121  
 contact switch, I-136  
 continuity testers, I-550, I-551, II-533, II-535, III-345, III-538-540, IV-287, IV-289, IV-296  
 audible, II-536, V-317  
 buzz box, I-551  
 cable tester, III-539  
 latching design, IV-295  
 low-resistance circuits, V-319  
 ohmmeter, linear, III-540  
 PCB, II-342, II-535  
 ratiometric, I-550  
 RC decade box, V-294-295  
 resistance-ratio detector, II-342  
 single chip checker, II-534  
 visual, V-293  
 contrast meters, II-447  
   automatic, I-472  
   brightness controls, I-250, I-377, III-308  
 control circuits (*see* fluid and moisture, light-controlled circuits; motor control circuits; speed controllers; temperature-related circuits; tone controls)  
 controller circuit, IV-142  
 conversion and converters, I-503, II-123-132, III-109-122, IV-110-120, V-116-128  
   3-to-5 V regulated output, III-739  
   4-to-18 MHz, III-114  
   4-to-20 mA current loop, IV-111  
   5V-to-isolated 5V at 20mA, III-474  
   5V-to-0.5A buck, I-494  
   9-to-5-V converter, IV-119  
   12-to-9 V, 7.5, or 6 V, I-508  
   12-to-16 V, III-747  
   28-to-5 Vdc converter, V-127  
   50+ V feed forward switch mode, I-495  
   50+ V push-pull switched mode, I-494  
   100 MHz, II-130  
   100 V-to-10.25 A switch mode, I-501  
   800-to-1000 MHz scanner converter, V-122  
 ac-to-dc converters, I-165  
   fixed power supplies, IV-395  
   full-wave, IV-120  
   high-impedance precision rectifier, I-164  
 analog-to-digital (*see* analog-to-digital conversion)  
 ATV downconverter, V-125, V-126  
 ATV rf receiver/converter, IV-420  
 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  
 crystal-controlled, one-chip, V-117  
 current-to-frequency, IV-113  
   wide-range, I-164  
 current-to-voltage, I-162, I-165, V-127  
   grounded bias and sensor, II-126  
   photodiode, II-128  
 dc automobile power adapter, V-70  
 dc-to-dc, IV-118, V-119, V-128  
   1-to-5 V, IV-119  
   3-to-5 V battery, IV-119  
   3-to-25 V, III-744, IV-118  
   bipolar, no inductor, II-132  
   fixed 3- to 15-V supply, IV-400  
   isolated +15V, III-115  
   push-pull, 400 V/60 W, I-210  
   regulating, I-210, I-211, II-125, III-121  
   step-up/step-down, III-118  
 dc/ac inverter, V-669  
 dc/dc converter, V-669  
 digital-to-analog (*see* digital-to-analog conversion)  
 fixed power supply, III-470  
 flyback, I-211  
   self oscillating, I-170, II-128, III-748  
   voltage, high-efficiency, III-744  
 frequency, I-159, V-123  
 frequency-to-voltage (*see* frequency-to-voltage conversion)  
 high-to-low-impedance, I-41  
 intermittent converter, power saver, IV-112  
 IR-pulse-to-audio converter, V-224  
 light intensity-to-frequency, I-167  
 line-voltage-to-multimeter adapter, V-312  
 logarithmic  
   fast-action, I-169  
   temperature-compensated, V-127  
 low-frequency, III-111  
 ohms-to-volts, I-168  
 oscilloscope, I-471  
 period-to-voltage, IV-115  
 pico-ampere, 70 V with gain, I-170  
 PIN photodiode-to-frequency, III-120  
 polar-to-rectangular  
   converter/pattern generator, V-288  
 polarity, I-166  
 positive-to-negative, III-112, III-113  
 power supplies, inductorless, V-456  
 pulse height-to-width, III-119  
 pulse train-to-sinusoid, III-122  
 pulse width-to-voltage, III-117  
 radio beacon converter, IV-495  
 rectangle-to-triangle waveform, IV-116-117  
 regulated 15-V<sub>out</sub> 6-V driven, III-745  
 resistance-to-voltage, I-161-162  
 rf converters, IV-494-501  
   ATV receiver/converter, 420 MHz, low-noise, IV-496, IV-497  
   radio beacon converter, IV-495  
   receiver frequency-converter stage, IV-499  
   SW converter for AM car radio, IV-500

conversion and converters (cont.)  
 two-meter, IV-498  
 up-converter, TVRO subcarrier reception, IV-501  
 VLF converter, IV-497  
 WWV-to-SW converter, IV-499  
 receiving converter, 220 MHz, IV-500

RGB-composite video signals, III-714  
 RMS-to-dc, II-129, I-167  
 50-MHz thermal, III-117  
 RGB-to-NTSC, IV-611  
 sawtooth wave converter, IV 114  
 scanner converter, V-800-to-1000 MHz, V-122  
 shortwave, III-114, V-118  
 simple L.F., I-546  
 sine-to-square wave, I-170, IV-120, V-124, V-125, V-569, V-570  
 square-to-sine wave, III-118  
 square-to-triangle wave, TTL, II-123  
 temperature-to-digital, V-123  
 temperature-to-frequency, I-168, V-121  
 temperature-to-time, III-632-633  
 transverter, V-2-to-6 meter, V-124  
 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 converters  
 a/d and d/a, IV-610-611  
 RGB-to-NTSC, IV-611  
 VLF converters, I-547, V-121  
 rf converter, IV-497  
 voltage (see voltage converters)  
 voltage multipliers, V-668-669, V-668  
 WWV converter, car radios, V-119  
 WWV-to-SW rf converter, IV-193

cool-down circuit, V-354, V-357  
 coprocessor socket debugger, III-104  
 countdown timer, II-680  
 counters (see also dividers), II-133-139, III-123-130, V-129-133  
 analog circuit, II-137  
 attendance, II-138  
 binary, II-135  
 divide-by-N  
 1+ GHz, IV-155  
 1.5+ divide-by-n, IV-156  
 CMOS programmable, I-257  
 7490-divided-by-n, IV-154  
 divide-by-odd number, IV-153  
 frequency counters  
 2 MHz, V-130-131  
 10 MHz, V-132-133, V-132  
 preamp, V-24  
 frequency dividers, I-258, II-251, II-254, III-213-218, III-340, III-768  
 1.2 GHz, III-129  
 10-MHz, III-126  
 clock input, IV-151

decade, I-259  
 divide-by-1.5, III-216  
 low-cost, III-124  
 low-frequency, II-253  
 preamp, III-128  
 programmable, IV-152-153  
 staircase generator and, I-730  
 tachometer and, I-310  
 geiger, I-536-537, V-217-219  
 microfarad counter, IV-275  
 minimum/maximum selector, four-input, V-332  
 odd-number divider and, III-217  
 preamplifier, oscilloscope, III-438  
 precision frequency, I-253  
 programmable, low-power wide-range, III-126

ring counters  
 20 kHz, II-135  
 incandescent lamp, I-301  
 low-cost, I-301  
 low-power pulse circuit, IV-437  
 SCR, III-195  
 variable timing, II-134

time base, function generators, 1 Hz, IV-201  
 universal  
 10-MHz, I-255, II-139  
 40-MHz, III-127  
 up/down counters  
 8-digit, II-134  
 extreme count freezer, III-125  
 XOR gate, III 105

coupler circuits  
 linear couplers  
 ac analog, II-412  
 analog, II-413  
 dc, II 411  
 optocoupler, instrumentation, II-417  
 optical couplers/optocouplers, V-407  
 CMOS design, III-414  
 interface circuits, V-406-407  
 linear, instrumentation, II-417  
 stable, II-409  
 TTL design, III-416  
 photon, II-412  
 transmitter oscilloscope for CB signals, I-473

courtesy lights (see automotive circuits)  
 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  
 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, V-134-140  
 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  
 activity tester, V-138  
 aperiodic, parallel-mode, I-196  
 basic design, V-135  
 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 crystal oscillators, I-187, III-134  
 I-to-4 MHz, IV-125  
 Colpitts crystal oscillators, I-194, I-572, II-147  
 I-to-20 MHz, IV-123  
 frequency checker, IV-301  
 harmonic, I-189-190  
 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  
 Hartley oscillator, V-140  
 hex-buffer, V-136  
 high-frequency, I-175, II-148  
 high-frequency signal generator as, II-150  
 IC-compatible, II-145  
 impedance checker, V-136  
 LO for SSB transmitter controlled by, II-142  
 low-frequency, I-184, II-146, V-135  
 10 kHz to 150 kHz, II-146  
 low-noise, II-145  
 marker generator, III-138  
 mercury cell crystal-controlled oscillator as, II-149  
 OF-1 HI oscillator, international, I-197  
 OF-1 LO oscillator, international, I-189  
 overtone oscillators, I-176, I-177, I-180, I-183, I-186, II-146, III-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  
 Pierce oscillator, V-140  
 1-MHz, III-134  
 crystal, I-195, II-144  
 harmonic, I-199, II-192  
 JFET, I-198  
   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, II-142, III-137  
 test circuit, V-139  
 third-overtone, I-186, IV-123  
 time base, III-133, IV-128, V-137, V-138  
 TTL design, I-179, IV-127  
 TTL-compatible, I-197  
 transistorized, I-188  
 tube-type, I-192  
 VHF crystal oscillator, III-138-140  
 voltage-controlled (VCO), III-135, IV-124  
   wide-range, V-139  
 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 feedback amp, V-100 mA at 100 MHz, V-25  
 current limiter, V-146  
   rush current, V-358  
 current loops  
   4-to-20-mA converter, IV-111  
   controller, SCR design, IV-387  
 current meters and monitors, I-203, II-152-157, III-255, III-338, IV-284, V-144-146  
 alarm and current monitor, III-338  
 ac current indicator, IV-290  
 current sensing in supply rails, II-153  
 electrometer amplifier with overload protection, II-155  
 Hall-effect sensors, III-255, IV-284  
 high-gain current sensor, IV-291  
 line-current monitor, III-341  
 picoammeter, I-202, II-154, II-157, III-338  
   guarded input, II-156  
 range ammeter, six-decade, II-153, II-156  
 current readout, II-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, V-141-143  
   0-to-200-nA, IV-327  
   bilateral, III-469, I-694-695, V-143  
   bipolar sources  
     inverting, I-697  
     noninverting, I-695  
   constant, I-697, III-472  
   fixed power supplies  
     bootstrapped amp, IV-406  
     differential-input, fast-acting, IV-405  
     low-current source, IV-399  
   limiter, V-146  
   low-resistance measurements, V-142  
   negative, V-143  
   offset-adjusting, V-145  
   positive, V-142  
   precision, I-205, I-206  
   regulator, variable power supply, III-490  
   variable power supplies, voltage-programmable, IV-420  
   voltage-controlled, grounded source/load, III-468  
 current-limiting regulator, V-458  
 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, V-127  
   grounded bias and sensor in, II-126  
   photodiode, II-128  
 curve tracer, V-300  
 diodes, IV-274  
 FET, I-397  
 CW-related circuits  
   CW/SSB receiver, V-80- and 40-meter, V-499  
   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  
   transmitters  
     1-W, III-678  
     20-M low-power, V-649  
     40-M, III-684, V-648  
     902-MHz, III-686  
     HF low-power, IV-601  
     QRP, III-690  
 cyclic A/D converter, II-30

## D

Dark-activated (*see* light-controlled circuits)  
 darkroom equipment (*see* photography-related circuits)  
 Darlington amplifier, push-pull, V-22  
 Darlington regulator, variable power supplies, IV-421  
 data-manipulation circuits, IV-129-133  
   acquisition circuits, IV-131  
   CMOS system, II-117  
   four-channel, I-421  
   high-speed system, II-118  
   analog-signal transmission isolator, IV-133  
   link, IR type, I-341  
   prescaler, low-frequency, IV-132  
   read-type circuit, 5 MHz, phase-encoded, II-365  
   receiver, carrier-current circuit design, IV-93  
   receiver/message demuxer, three-wire, IV-130  
   selector, RS-232, III-97  
   separator, floppy disk, II-122  
   transmission circuits, IV-92  
 dc adapter/transceiver, hand-held, III-461  
 dc generators, high-voltage, III-481  
 dc motors (*see also* motor control circuits)  
   direction control, I-452  
   driver controls  
     fiber optic control, II-206  
     fixed speed, III-387  
     servo, bipolar, II-385  
     reversible, II-381, III-388  
   speed control, I-452, I-454, III-377, III-380, III-388  
 dc restorer, video, III-723  
 dc servo drive, bipolar control input, II-385  
 dc static switch, II-367  
 dc-to-ac inverter, V-247, V-669  
 dc-to-dc conversion, IV-118, V-669  
   1-to-5 V, IV-119  
   3-to-5 V battery, IV-119  
   3-to-25 V, III-744, IV-118  
   3.3- and 5-V outputs, V-128  
   3 A, no heatsink, V-119  
   bipolar, no inductor, II-132  
   fixed 3- to 15-V supply, IV-400  
   isolated +15V, III-115  
   push-pull, 400 V/60 W, I-210  
   regulating, I-210, I-211, II-125, III-121  
   step-up/step-down, III-118  
 dc-to-dc SMPS variable power supply, II-480  
 debouncers, III-592, IV-105, V-316  
   auto-repeat, IV-106  
   computer applications, IV-105, IV-106, IV-108

debouncers (*cont.*)  
   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-630, I-631  
   tone decoders, I-231, III-143  
     24% bandwidth, I-215  
     dual time constant, II-166  
     relay output, I-213  
     tone-dial decoder, I-630, I-631  
   video, NTSC-to-RGB, IV-613  
   weather-alert detector/decoder, IV-140  
 deglitcher circuit, IV-109, V-336-337  
 delay circuits/ delay units, III-146-148, V-147-148  
   adjustable, III-148  
   analog delay line, echo and reverb effects, IV-21  
   door chimes, I-218  
   echo and reverb effects, analog delay line, IV-21  
   exit delay for burglar alarms, V-10  
   headlights, I-107, II-59  
   leading-edge, III-147  
   long duration time, I-217, I-220  
   power-on delay, V-148  
   precision solid state, I-664  
   pulse, dual-edge trigger, III-147  
   pulse generator, II-509  
   relay, ultra-precise long time, II-211  
   timed delay, I-668, II-220  
   constant-current charging, II-668  
   windshield wiper delay, I-97, II-55  
 demodulators, II-158-160, III-149-150  
   5V FM, I-233  
   12V FM, I-233  
   565 SCA, III-150  
   AM demodulator, II-160  
   chroma, with RGB matrix, III-716  
   FM demodulator, I-544, II-161, V-151, V-155  
   narrow-band, carrier detect, II-159  
 linear variable differential transformer driver, I-403  
 LVDT demodulators, II-337, III-323-324  
 stereo, II-159  
 telemetry, I-229  
 demonstration comparator circuit, II-109  
 demultiplexers (*see also* multiplexers), III-394  
   differential, I-425  
   eight-channel, I-426, II-115  
 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  
 detectors (*see* fluid and moisture, light-controlled circuits; motion and proximity; motor control circuits; peak detectors; smoke detectors; speed controllers; temperature-related circuits; tone controls; zero-crossing)  
 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, V-18, V-21  
   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, V-347  
   negative-edge, I-419  
   positive-edge, I-420  
 digital-capacitance meter, II-94  
 digital-IC, tone probe for testing, II-504  
 digital-frequency meter, III-344  
 digital-logic probe, III-497  
 digital audio tape (DAT), ditherizing circuit, IV-23  
 digital circuits, V-156-160  
   audio selector, V-158  
   BCD rotary switch, V-160  
   capacitance control, V-159  
   entry lock, V-157  
   inverters, V-246  
   potentiometer control, V-158  
   resistance control, V-159  
 digital multimeter (DMM), IV-291, V-291  
 digital voltmeters (DVM), III-4  
   3.5-digit, I-713, III-761  
   3.75-digit, I-711  
   4.5-digit, I-717, III-760  
   auto-calibrate circuit, I-714  
   automatic nulling, I-712  
   calibrated circuit, DVM auto, I-714  
   interface and temperature sensor, II-647  
   LED readout, IV-286  
 digital-to-analog converters, I-241, II-179-181, III-163-169, V-120  
   0-to -5V output, resistor terminated, I-239  
   3-digit, BCD, I-239  
   8-bit, I-240-241  
     high-speed, I-240  
     output current to voltage, I-243  
     to 12-bit, two, II-180  
   9-bit, CMOS, III-167  
   10-bit, I-238  
     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  
     precision, I-242  
     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  
   octal converter, V-350  
   output amplifier, four-channel, III-165  
   video converter, IV-610-611  
 digitizer, tilt meter, III-644-646  
 dimmer switches, I-369, II-309, IV-247, IV-249  
   800 W, II-309  
 dc lamp, II-307  
   four-quadrant, IV-248-249  
   halogen lamps, III-300  
   headlight, II-57, II-63  
   low-cost, I-373  
   soft-start, 800-W, I-376, III-304  
   tandem, II-312  
   triac, I-375, II-310, III-303  
 diode emitter driver, pulsed infrared, II-292  
 diode tester, I-402, 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 detectors/finders, IV-146-149
  - compasses
    - digital design, IV-147
    - Hall effect, III-258
    - talking Hall effect, V-221
  - decoder, III-144
  - directional-signals monitor, auto, III-48
  - optical direction discriminator, V-408
  - thermally operated, IV-135
  - 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, V-161-167
    - 3 $\frac{1}{2}$  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
    - cascaded counter/display driver, V-163
    - common cathode, 4033-based, V-162
    - common-anode, V-167
    - comparator and, II-105
    - exclamation point, II-254
    - expanded scale meter, dot or bar, II-186
    - fluorescent tube, V-167
    - gas-discharge tube, V-167
    - LCD
      - 7-segment, V-165
      - large-size, V-164
    - LED
      - 7-segment, V-166
      - audio, peak program meter, II-254
      - common-cathode, V-167
      - driver, II-188
      - leading-zero suppressed, V-165
      - 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, V-59
    - signal, I-39
  - dividers, IV-150-156
  - binary chain, I-258
  - divide-by 2-or-3 circuit, IV-154
  - divide-by-N
    - 1+ GHz, IV-155
    - 1.5+ divide-by-n, IV-156
    - CMOS programmable, I-257
    - 7490-divided-by-n, IV-154
  - divide-by-odd number, IV-153
  - frequency dividers, I-258, II-251, II-254, III-213-218, III-340, III-768, V-343
    - 1.2 GHz, III-129
    - 10-MHz, III-126
    - clock input, IV-151
    - decade, I-259
    - divide-by-1.5, III-216
    - low-cost, III-124
    - low-frequency, II-253
    - preamp, III-128
    - programmable, IV-152-153
    - staircase generator and, I-730
    - tachometer and, I-310
  - 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
  - doorbells/chimes (*see* annunciators)
  - door-open alarm, II-284, III-46, III-256
  - door opener, III-366
  - door minder security circuit, V-5
  - dot-expanded scale meter, II-186
  - double-sideband suppressed-carrier modulator, III-377
  - 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
    - broadband, I-313
    - digital, III-216
    - GASFET design, IV-324
    - single-chip, III-218
    - low-frequency, I-314
  - voltage doublers, III-459, IV-635
    - cascaded, Cockcroft-Walton, IV-635
    - 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
  - alarm driver, high-power, V-2
  - bar-graph driver
    - LED, II-188
    - transistorized, IV-213
  - BIFET cable, I-264
  - bridge loads, audio circuits, III-35
  - capacitive load, I-263
  - Christmas lights driver, IV-254
  - coaxial cable, I-266, I-560
  - five-transistor pulse boost, II-191
  - coil, current-limiting, III-173
  - CRT deflection yoke, I-265
  - demodulator, linear variable
    - differential transformer, I-403
  - diode-emitter driver, II-292
  - FET driver, IV-241
  - fiberoptic, 50-Mb/s, III-178
  - flash slave, I-483
  - glow-plug, II-52
  - high-impedance meter, I-265
  - indicator lamp driver, III-413
  - instrumentation meter, II-296
  - lamp drivers, I-380
    - flip-flop independent design, IV-160
    - low-frequency flasher/relay, I-300
    - optical coupling, III-413
    - neon lamps, I-379
    - short-circuit-proof, II-310
  - laser diode, high-speed, I-263
  - LED drivers
    - bar graph, II-188
    - emitter/follower, IV-159
  - line drivers, I-262
    - 50-ohm transmission, II-192
    - 600-ohm balanced, II-192
    - audio, V-54
  - piezoelectric driver, V-440
  - 555 oscillator, V-441
  - CMOS, V-440
  - micropositioner, V-440
    - full rail excursions in, II-190
  - high-output 600-ohm, II-193
  - synchronized, III-174
  - video amplifier, III-710
- line-synchronized, III-174
  - load drivers
    - audio, III-35
    - timing threshold, III-648
  - I.VDT demodulator and, II-337, III-323-324
  - meter drivers, II-296
    - 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

drivers and drive circuits (*cont.*)  
 relay, I-264  
 delay and controls closure time, II-530  
 low-frequency, I-300  
 with strobe, I-266  
 rf drivers, low-distortion, II-538  
 RS-232C, low-power, III-175  
 shift register, I-418  
 solenoid, I-265, III-571-573  
 SSB, low-distortion 1.6 to 30MHz, II-538  
 stepping motor, II-376, III-390, IV-349, IV-350  
 three-phase motor driver, II-383  
 totem-pole, with bootstrapping, III-175  
 transformer driver, I-403  
 triac array driver, II-410  
 two-phase motor driver, I-456, II-382  
 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, telephonic, III-616  
 duty-cycle related circuits  
 detector, IV-144  
 meter, IV-275  
 monitor, III-329  
 multivibrator, 50-percent, III-584  
 oscillators  
 50-percent, III-426  
 variable, fixed-frequency, III-222  
 DVM adapter for PC, V-310  
 dwell meters  
 breaker point, I-102  
 digital, III-45

## E

car protector, V-482  
 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  
 electromagnetic-field sensor, V-308  
 electrometer, IV-277  
 amplifier, overload protected, II-155  
 electrostatic detector, III-337  
 emergency lights, I-308, I-378, IV-250  
 emissions analyzer, automotive exhaust, II-51  
 emitter-follower circuit,

complementary/bilateral ac, V-353  
 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 encoders, I-67, I-629  
 two-wire, II-364  
 two-tone, V-629  
 enlarger timer, II-446, III-445  
 envelope detectors, III-155  
 AM signals, IV-142  
 full-wave, V-152  
 low-level diodes, IV-141  
 envelope generator/modulator, musical, IV-22  
 EPROM, V<sub>pp</sub> generator for, II-114  
 equalizers, I-671, IV-18  
 octave equalizer, V-353  
 ten-band, graphic, active filter in, II-684  
 ten-band, octave, III-658  
 equipment-on reminder, I-121  
 exhaust emissions analyzer, II-51  
 exit delay for burglar alarms, V-10  
 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 circuits (*see also* timers)  
 alarm based on 555 timer, V-11  
 astable, low-duty cycle, II-267  
 beep transformer, III-566  
 FM modulator, V-367  
 integrator to multiply, II 669  
 missing-pulse detector, V-152  
 ramp generator, V-203  
 RC audio oscillator from, II-567  
 square wave generator using, II-595  
 fader circuits, II-42, II-312, IV-17, V-658  
 fail-safe semiconductor alarm, III-6  
 fans  
 infrared heat-controlled fan, IV-226  
 speed controller, automatic, III-382  
 thermostatic switch, V 68  
 Fahrenheit thermometer, I-658  
 fault monitor, single-supply, III-495  
 fax circuits, V-171-173  
 modem/fax protector for two computers, V-482  
 fax/telephone switch, remote-controlled, IV-552 553

feedback oscillator, I-67  
 fence chargers, II-201-203  
 battery-powered, II-202  
 electric, II-202  
 solid-state, II-203  
 FET circuits  
 amplifier, offset gate bias, V-22  
 dc controlled switch, V-592  
 hexFET switch, V-592, V-593  
 dual-trace scope switch, II-432  
 input amplifier, II-7  
 microphone mixer, V-363, V-364  
 probe, III-501  
 voltmeter, III-765, III-770  
 fiberoptics, 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  
 receivers  
 10 MHz, II-205  
 50-Mb/s, III-181  
 digital, III-178  
 high-sensitivity, I-270  
 low-cost, 100-M baud rate, III-180  
 low-sensitivity, I-271  
 very-high-sensitivity, low-speed, 3mW, 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, V-174-176  
 1.5-150 MHz, I-275  
 adjustable sensitivity indicator, I-274  
 amplified field, V-175  
 high-sensitivity, II-211  
 LF or HF, II-212  
 microwave, low-cost, I-273  
 remote, V-175  
 rf sniffer, II-210  
 sensitive, I-274, III-183  
 signal-strength meter, IV-166  
 simple design, three versions, V-176  
 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, V-177-191  
 active (*see* active filters)  
 antialiasing/sync-compensation, IV-173  
 audio filters  
 biquad, I-292-293, III-185  
 tunable, IV-169  
 audio range filter, V-190  
 bandpass (*see* bandpass filters)  
 band-reject, active, II-401  
 biquad, I-292-293  
 audio, I-292-293, III-185  
 RC active bandpass, I-285, V-190

bridge filter, twin-T,  
     programmable, II-221  
 Butterworth  
     high-pass, fourth-order, I-280,  
         V-179  
     low-pass, fourth-order, V-180,  
         V-181  
 Chebyshev (*see* Chebyshev filters)  
 CW, razor-sharp, II-219  
 dynamic filter, III-190  
 four-output filter, V-182  
 full wave rectifier and averaging,  
     I-229, V-191  
 high-pass (*see* high-pass filters)  
 IF filters, narrow-band, V-189  
 L filters, V-181  
 low-pass (*see* low-pass filters)  
 networks of, I-291  
 noise, dynamic, III-190  
 noisy signals, III-188  
 notch filters, 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, V-179  
     audio, II-400  
     bandpass and, II-223  
     high-Q, III-404, V-178  
     selectable bandwidth, I-281  
     three-amplifier design, I-281  
     tunable, II-399, II-402, V-179  
     passive-bridged differentiator,  
         II-403  
     hum-suppressing, I-280  
     op amp, II-400  
     twin-notch for 1 kHz, V-183  
     twin-T, III-403  
     shortwave receivers, V-185  
     Wien bridge, II-402  
 passive L filters, V-181  
 passive PI filters, V-181  
 passive T filters, V-190  
 Pi filters, V-181  
 programmable, twin-T bridge, II-221  
 rejection, I-283  
 ripple suppressor, IV-175, IV-396  
 rumble, III-192, III-660, IV-175  
     LM387 in, I-297  
     turntable, IV-170  
 rumble/scratch, III-660  
 Sallen-Key filters  
     10 kHz, I-279  
     500 Hz bandpass, I-291  
     current-driven, V-189  
     low-pass, active, IV-177  
     low-pass, equal component, I-292  
 scratch filters, III-189, III-660,  
     IV-175  
     LM287 in, I-297  
 simulated inductor, V-180  
 speech filters  
     bandpass, 300 Hz-3 kHz, I-295  
     second-order, 300-to-3,400 Hz,  
         IV-174  
     two-section, 300-to-3,000 Hz,  
         IV-174  
     speech-range filter, bandpass,  
         V-185  
     state-variable filters, II-215, III-189  
     multiple outputs, III-190  
     second-order, 1 kHz, Q/10, I-293  
     universal, I-290  
     T filters, V-190  
     tone filter, V-1 kHz, V-191  
     turbo, glitch free, III-186  
     twin-T bridge filter, II-221  
     Wien-bridge, III-659  
     variable Q filter, V-183  
     variable-frequency bandpass filter,  
         V-186  
     variable-state, universal, V-178  
     voltage-controlled filters, III-187,  
         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  
     +/- 35 V ac, IV-398  
     +/- 35 V, 5 A, mobile, IV-407  
     15 V isolated to 2,500 V supply,  
         IV-407  
 ac motors, IV-395  
 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  
     5V-to-isolated 5V at 20mA, III-474  
     ac-to-dc, IV-395  
     dc-to-dc, 3-to-15 V, IV-400  
     current sink, 1 mA, IV-402  
     current sources, IV-399, IV-405,  
         IV-406  
     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  
     rectifiers, III-471, IV-398  
     regulated supplies, III-462, III-463,  
         IV-401  
     ripple suppressor, IV-396  
     RTTY machine current supply,  
         IV-400  
     stabilizer, CMOS diode network,  
         IV-406  
     switching supplies, III-458, III-473,  
         IV-403, IV-404, IV-408  
     three-rail, III-466  
     uninterruptible +5V, III-477  
     voltage doubler, III-459, III-468  
     voltage regulators (*see* voltage  
         regulators)  
     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* light-  
     controlled circuits;  
     photography-related circuits), I-  
     304, II-225, III-193-210, IV-178-  
     183, V-192-197  
     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  
     brake light flasher, V-69  
     Christmas tree light flasher, V-197,  
         V-264-265  
     CMOS, III-199

flashers and blinkers (*cont.*)  
 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  
 headlight flasher, V-73  
 high-efficiency parallel circuit, I-308  
 high-voltage, safe, I-307  
 high-power battery operated, II-229  
 incandescent bulb, III-198, I-306  
 LED flashers, IV-181, V-195, V-196  
 2- to 10-LED, V-196  
 alternating, III-198, III-200  
 Christmas tree lights, V-197  
 control circuit, IV-183  
 dark-activated, V-195  
 driver, V-194  
 multivibrator design, IV-182  
 PUT used in, II-239  
 ring-around, III-194  
 sequential, reversible-direction,  
 IV-182  
 three-year, III-194  
 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 flashers, I-303  
 five-lamp, III-198  
 two-state oscillator, III-200  
 tube, I-304  
 oscillator/flashers  
 high-drive, II-235  
 low-frequency, II-234  
 photographic flashes  
 slave-flash trigger, SCR design,  
 IV-380, IV-382  
 time-delay flash trigger, IV-380  
 relay driver, low-frequency lamp,  
 I-300  
 running lights, V-269  
 SCR flashers, II-230, III-197  
 chaser, III-197  
 relaxation, II-230  
 ring counter, III-195  
 sequencer, V-263, V-264-265  
 sequential, II-233, II-238, IV-181,  
 V-193  
 pseudorandom simulated, IV-179  
 signal alarm, V-197  
 single-lamp, III-196  
 strobe alarm, IV-180  
 telephone, II-629, IV-556, IV-558,  
 IV-559, IV-561  
 transistorized, I-303, II-236, III-200  
 variable, I-308  
 xenon light, IV-180  
 flashlight finder, I-300  
 flex switch, alarm sounder circuit,  
 V-15  
 flip-flops (*see* bistable  
 multivibrators)  
 flood alarm, I-390, III-206, IV-188  
 flow-detectors, II-240-242,  
 III-202-203  
 air, II-242  
 liquids, II-248, III-202-203  
 low-rate thermal, III-203  
 thermally based anemometer, II-241  
 fluid and moisture detectors, I-388,  
 I-390, I-442, II-243-248, III-204-  
 210, IV-184-191, V-373-375  
 acid rain monitor, II-245, V-371  
 alarm, water-activated, V-374  
 checker, III-209  
 control, I-388, III-206  
 cryogenic fluid-level sensor, I-386  
 dual, III-207  
 flood alarm, III-206, IV-188, V-374  
 flow-of liquid, II-248, III-202-203  
 full-bathtub indicator, IV-187  
 full-cup detector for the blind,  
 IV-189  
 humidity, II-285-287, III-266-267  
 indicator, II-244  
 level of liquid, I-107, I-235, I-387, I-  
 388, I-389, I-390, II-174, II-244,  
 II-246, III-205, III-206, III-207,  
 III-209, III-210, IV-186, IV-190,  
 IV-191  
 moisture detector, I-442, IV-188,  
 V-375  
 monitor, III-210  
 plant water, II-245, II-248, III-208  
 pump controller, single-chip, II-247  
 rain alarm, II-244, IV-189  
 sensor and control, II-246  
 soil moisture, II-245, II-248, III-208  
 temperature monitor, II-643, III-206  
 water-leak alarm, IV-190  
 windshield-washer level, I-107  
 fluorescent lamps  
 high-voltage power supplies, cold-  
 cathode design, IV-411  
 inverter, 8-W, III-306  
 vacuum, fluorescent display, II-185  
 flyback converters, I-211  
 self oscillating, I-170, II-128, III-748  
 voltage, high-efficiency, III-744  
 flyback regulator, off-line, II-481  
 FM-related circuits (*see also*  
 radio/IF circuits)  
 5 V, I-233  
 12 V, I-233  
 clock radio, AM/FM, I-543  
 demodulators, I-544, II-159, II-161,  
 V-151  
 IF amplifier with quadrature  
 detector, TV sound IF, I-690  
 generators, low-frequency, III-228  
 modulators, V-366  
 555-based circuit, V-367  
 radio, I-545  
 receivers  
 27.145 MHz, V-495  
 carrier-current circuit, III-80  
 light-beam, V-259  
 MPX/SCA receiver, III-530  
 narrow-band, III-532  
 optical receiver/transmitter, 50  
 kHz, I-361  
 zero center indicator, I-338  
 SCA subcarrier adapter, V-536  
 snooper, III-680  
 speakers, remote, carrier-current  
 system, I-140  
 squelch circuit for AM, I-547  
 stereo demodulation system, I-544  
 transmitters, I-681, V-641  
 27.125-MHz NBFM, V-637  
 49-MHz, V-643  
 infrared, voice-modulated pulse,  
 IV-228  
 light-beam, V-259  
 multiplex, III-688  
 one-transistor, III-687  
 optical, I-367, II-417  
 optical receiver/transmitter, 50  
 kHz, I-361  
 radio, V-648  
 snooper, III-680  
 stereo, V-575, V-580  
 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, II-485  
 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, III-88  
 LED, II-110  
 frequency control, telephone, II-623  
 frequency converter, I-159  
 frequency counters, III-340, III-768,  
 IV-300, V-129-133  
 1.2 GHz, III-129  
 2 MHz, V-130-131  
 10-MHz, III-126, V-132-133  
 100 MHz, period and, II-136  
 low-cost, III-124  
 preamp, III-128, V-24

- precision, I-253
- tachometer and, I-310
- frequency detectors, II-177, III-158
- beat indicator, I-336
- boundary detector, III-156
- comparator, III-88
- digital, III-158
- limit, frequency limit, II-177
- window, frequency window, III-777
- frequency dividers, I-258, II-251,
  - II-254, III-213-218, III-340, III-768, V-343
  - 1.2 GHz, III-129
  - 10-MHz, III-126
  - clock input, IV-151
- decade, I-259
- divide-by-1.5, III-216
- low-cost, III-124
- low-frequency, II-253
- preamp, III-128
- programmable, IV-152-153
- staircase generator and, I-730
- tachometer and, I-310
- frequency-division multiplex stereo decoder, II-169
- frequency doublers, I-313, III-215
  - broadband, I-313
  - digital, III-216
  - GASFET design, IV-324
  - low-frequency, I-314
  - single-chip, III-218
  - to 1MHz, II-252
- frequency generators, fixed-frequency, III-231
- frequency indicator, beat, I-336
- frequency inverter, III-297
- frequency meters, I-310, II-249-250, IV-282, IV-301
  - analog, V-307
  - audio-frequency meter, V-305, V-320
  - audio, I-311
  - linear, I-310
  - low-cost, II-250
  - power, II-250
- frequency multipliers, II-251, III-213-218, V-198-199
  - counter, odd-number, III-217
  - doublers, I-313, III-215
  - broadband, I-313
  - digital, III-216
  - GASFET design, IV-324
  - single-chip, III-218
  - low-frequency, I-314
  - to 1MHz, II-252
  - pulse-width, III-214
  - tripler, nonselective, II-252
- frequency-boundary detector, III-156
- 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
  - averaging filter, V-191
  - op amp circuit, V-403
  - precision, I-234, III-537
  - silicon-controlled (SCR), I-375
- function generators (*see also* burst generators; sound generators; waveform generators), I-729, II-271, III-221-242, III-258-274, IV-196-202, V-200-207, V-309
  - 555 astable, low-duty cycle, II-267
  - acoustic field generator, V-338-341, V-338
  - AM broadcast-band signal generator, IV-302
  - AM/FM signal generator, 455 kHz, IV-301
  - astable multivibrators, II-269, II-510, II-597, III-196, III-224, III-233, III-237, III-238
  - audio function generator, IV-197
  - audio-frequency generator, V-416-417, V-416
  - bistable multivibrators, I-133, I-299, I-395, II-367, II-465, III-103, IV-108, IV-651
  - bistable multivibrators, I-133, II-465
  - capacitance multiplier, V-205
  - clock generator/oscillator, I-193, I-615
  - complementary signals, XOR gate, III-226
  - DAC controlled, I-722
  - debouncer, IV-108
  - emitter-coupled RC oscillator, II-266
  - fixed-frequency, III-231
  - flasher, I-299, II-234
  - F'M, 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
  - harmonic generators, I-24, III-228, IV-649
  - high-frequency, II-150
  - inverter, III-103
  - lamp driver, IV-160
  - line/bar generator, video, V-662
  - linear ramp, II-270
  - linear triangle/square wave VCO, II-263
  - logarithmic
    - dynamic-range, V-201
    - fast acting, V-202
  - monostable multivibrators, I-465, III-229, III-230, III-235, III-237
  - input lockout, I-464
  - linear-ramp, III-237
  - photo cell, monostable, II-329
  - positive-triggered, III-229
  - TTL, monostable operation, I-464
  - UJT, monostable operation, I-463
  - video amplifier and comparator, II-268
- multiplying pulse width circuit, II-264
- multivibrators
  - low-frequency, III-237
  - single-supply, III-232
- nonlinear potentiometer outputs, IV-198
- one-shots, I-465
- digitally controlled, I-720
- precision, III-222
- retriggerable, III-238
- oscillator/amplifier, wide frequency range, II-262
- pattern generator/polar-to-rect. converter, V-288
- polynomial generator, V-287
- potentiometer-position V/F converter, IV-200
- precise wave, II-274
- programmed, I-724
- pseudo-random bit sequence generator, V-351
- pulse generators, II-508-511
  - 2-ohm, III-231
  - 300-V, III-521
  - 555-circuit, IV-439
  - astable multivibrator, II-510
  - clock, 60Hz, II-102
  - CMOS short-pulse, III-523
  - delayed-pulse, II-509, IV-440
  - divider, programmable, II-511, III-226
  - EEPROM, 5V-powered, III-99
  - free running, IV-438
  - interrupting pulse-generation, I-357
  - logic, III-520
  - logic troubleshooting applications, IV-436
  - programmable, I-529
  - sawtooth-wave generator and, III-241
  - single, II-175
  - train, pulse train, IV-202

- function generators (*cont.*)
- transistorized, IV-437
  - 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
- quad op amp, four simultaneous synchronized waveform, II-259
- ramp generators, I-540, II-521-523, III-525-527, IV-443-447, 555 based, V-203
- accurate, III-526
- integrator, initial condition reset, III-527
- linear, II-270
- variable reset level, II-267
  - voltage-controlled, II-253
- rf oscillator, V-530-531
- root extractor, V-207, V-288
- RS flip-flop, I-395
- sawtooth generators, V-491
- linear, V-205
  - triggered, V-204
- sawtooth and pulse, III-241
- Schmitt trigger: transistorized, V-204
- SCR, II-367
- self-retriggering timed-on generator, V-343
- signal generators, V-204
- AM broadcast band, IV-302
  - AM/FM, 455 kHz, IV-301
  - high-frequency, II-150
  - square-wave, III-583-585
  - staircase, III-586-588
  - two-function, III-234
- sine-wave generators, IV-505, IV-506, V-542, V-543, V-544
- 60 Hz, IV-507
  - audio, II-564
  - battery power, V-541
  - I.C., IV-507
  - LF, IV-512
  - oscillator, audio, III-559
  - square-wave and, tunable oscillator, III-232
  - VLF audio tone, IV-508
  - sine/cosine (0.1-10 kHz), II-260
  - sine/square wave oscillators, I-65
  - TTL design, IV-512
  - tunable, I-65, III-232
  - single control, III-238
- single supply, II-273
- square-wave generators, II-594-600, II-225, III-239, III-242, III-583-585, IV-529-536, V-568-570
- 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
- oscillators, I-612-614, I-616, II-596, II-597, II-616, IV-532, IV-533
- phase-tracking, three-phase, II-598
- pulse extractor, III-584
- quadrature-outputs oscillator, III-585
- sine-wave and, tunable oscillator, III-232
- three-phase, II-600
- tone-burst generator, single timer IC, II-89
- triangle-wave and, III-239
- precision, III-242
  - programmable, III-225
  - wide-range, III-242
- TTL, LSTTL, CMOS designs, IV-530-532
- variable duty-cycle, IV-533
  - variable-frequency, IV-535
- SR flip-flop, IV-651
- staircase generators, I-730, II-601-602, III-586-588, IV-443-447
- sweep generators, I-472, III-438
- timebase
- 1 Hz, readout and counter applications, IV-201
  - oscilloscopes, V-425
- time-delay generator, I-217-218
- tone burst generator, repeater, V-629
- triangle-wave, III-234, V-203, V-205
- clock-driven, V-206
  - square wave, III-226, III-239, III-242
  - timer, linear, III-222
- triangle/square wave generator, V-206
- tunable, wide-range, III-241
- two-function, III-234
- 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 (*see waveform generators*)
- white noise generator, IV-201
- funct box, II-593
- furnace exhaust gas/smoke detector, temp monitor/low-supply detection, III-248
- furnace fuel miser, V-328-329
- fuses
- battery-charger relay fuse, V-88
  - electronic, V-477
  - monitor for car fuses, V-77
  - relay fuse, V-478
- fuzz box, III-575
- fuzz sound effect, II-590

## G

### GaAsFET circuits

- amplifier, power, with single supply, II-10
  - fixed power supplies, IV-405
- gam control circuits
- amplifier, stereo, gain-controlled, II-9, III-34
  - automatic audio gain control, II-17
  - automatic gain control (AGC), II-17
  - AGC system for CA3028 IF amp, IV-458
  - rf amplifier, wideband adjustable, III-545
  - squelch control, III-33
  - wide-band amplifier, III-15
  - gain block, video, III-712
- game feeder controller, II-360
- game roller, I-326
- games, II-275-277, III-243-245, IV-203-207, V-208-211
- coin flipper, III-244
  - electronic dice, III-245, IV-207
  - electronic roulette, II-276, IV-205
  - lie detector, II-277, IV-206
  - quiz master, V-210
  - reaction timer, IV-204
  - ring launcher, electromagnetic, V-209
  - roulette, II-276, IV-205
  - run-down clock/sound generator, IV-205
  - slot machine, V-211
  - Wheel-of-Fortune, IV-206
  - who's first, III-244
- garage stop light, II-53
- gas detectors (*see also smoke alarms and detectors*), I-332, II-278-279, III-246-253, III-246, V-212-214
- analyzer and, II-281
  - combustible gas detector, V-214
  - explosive gas detector, V-213
  - 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
- gated oscillator, last-cycle completing, III-427
- gated-pulse descrambler, II-165
- gates, V-215-216
- AND, I-395, V-216
  - OR, I-395
  - programmable, I-394
  - sync gating circuit, V-595
  - XOR gate, IV-107
- geiger counters, I-536-537, V-217-219

high-voltage supply, II-489  
 pocket-sized, II-514  
 gel cell charger, II-66  
 generators, electric-power  
   corona-wind generator, IV-633  
   dc generator, V-443  
   high-voltage generators, IV-413  
   ion generator, V-248-249  
   battery-powered, III-482  
   capacitor-discharge, III-485  
   dc voltage, III-481  
   negative-ions, IV-634  
   regulator for automobile generator, V-76  
   ultra-high-voltages, II-488  
 generators (see function generators:  
   sound generators; waveform  
   generators)  
 glitch-detector, comparator, II-107  
 glow-plug driver, II-52  
 gong, electronic, V-563  
 graphic equalizer, ten-band, active  
   filter in, II-684  
 grid dip meters, I-247, II-182-183  
 handswitched, IV-298  
 basic grid, I-247, IV-298  
 dual gate IGFET, I-246  
 little dipper, II-183  
 varicap tuned FET, I-246  
 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  
   mixer, low-noise, four-channel,  
     V-360-361  
   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, V-220-222  
   angle of rotation detector, II-283  
   compass, III-258  
   compass, talking, V-221  
   current monitor, III-255, IV-284  
   door open alarm, II-284  
   ground-fault detector, IV-208-209

oscillators, V-222  
 security door-ajar alarm, III-256  
 switches using, III-257, IV-539  
 halogen lamps  
   dimmer for, III-300  
   protector, V-271  
 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 distortion  
   analyzer, V-291  
   meter, V-312  
 harmonic generators, I-24, III-228,  
   IV-649  
 Hartley oscillator, I-571, V-140  
 HC-based oscillators, III-423  
 HCU/HTC-based oscillator, III-426  
 headlights (see automotive circuits,  
   headlights)  
 headphones  
   amplifier for, II-43  
   ear protector circuit, V-482  
   infrared (IR) receiver, V-227  
   infrared (IR) transmitter, V-227  
   signal amplifier, V-53, V-57  
 heart rate monitor, II-348, II-349,  
   V-342  
 heat-activated alarm, V-9  
 heat sniffer, electronic, III-627  
 heaters/heater controls (see also  
   temperature-related circuits),  
   I-639  
   element controller, II-642  
   induction heater, ultrasonic, 120-  
     KHz 500-W, III-704  
   protector circuit, servo-sensed,  
     III-624  
   temperature sensitive, I-640  
   hee-haw siren, II-578, III-565  
 hexFET switch, V-592  
   dual-control, V-593  
 hi-fi circuits (see stereo circuits)  
 high-pass filters, I-296  
   active, I-296, V-180, V-188  
   fourth-order, V-188  
   second-order, I-297  
 Butterworth, fourth-order, I-280,  
   V-179  
 Chebyshev, fourth-order, III-191  
 equal components second-order,  
   V-188  
   fourth-order, 100-Hz, IV-174  
   second-order, 100-Hz, IV-175  
   sixth-order elliptical, III-191  
   unity-gain second-order, V-187  
   variable, V-186  
 wideband two-pole, II-215  
 high-voltage power supplies (see also  
   generators, electrical power;  
   power supplies), II-487-490, III-  
   486, IV-409-413, V-442-447  
 9- to 15-Vdc input, V-456

10,000 V dc supply, IV-633  
 arc-jet power supply, starting  
   circuit, III-479  
 basic circuit, V-446  
 battery-powered generator, III-482  
 bucking regulator, III-481  
 dc generator, III-481, V-443  
 dc supply, 120-240 Vdc, single-chip  
   circuit, V-446  
 fluorescent-lamp supply, V-444  
   cold-cathode design, IV-411, V-447  
 geiger counter supply, II-489  
 generators (see generators,  
   electrical power)  
 inverter, III-484  
   40 W, 120 V ac, IV-410-411  
 laser circuits, V-253  
 negative supply, V-445  
 negative-ion generator, IV-634  
 optoisolated driver, III-482  
 photomultiplier supply, V-444, V-445  
 preregulated, III-480  
 pulse supply, IV-412  
 regulators, III-485  
   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 (see alarms,  
   annunciators)  
 horn, automobile, III-50, IV-54  
 hour/time delay sampling circuit,  
   II-668  
 Howland current pump, II-648  
 hum reducer circuit, receivers, V-347  
 humidity sensor, II-285-287,  
   III-266-267  
 hybrid power amplifier, III-455

## I

IC product detectors, IV-143  
 IC timer, crystal-stabilized,  
   subharmonic frequencies for,  
   II-151  
 ice formation alarm, I-106, II-57,  
   II-58  
 ICOM IC-2A battery charger, II-65  
 IF amplifiers, I-690, IV-459  
 AGC system, IV-458  
 preamp, IV-460  
 receiver, IV-459  
 quadrature detector, TV sound IF,  
   I-690  
 two-stage, 60 MHz, I-563  
 wideband, I-689  
 ignition circuits, automotive, V-64  
 capacitor discharger, I-103  
 cut-off circuit, automotive, IV-53

ignitions circuits, automotive (*cont.*)  
 electronic, IV-65  
 substitute ignition, III-41  
 timing light for ignition system, II-60

ignitor, III-362

illumination stabilizer, machine  
 vision, II-306

image canceller, III-358

immobilizer, II-50

impedance checker, V-136

impedance converter, high-to low,  
 I-41

impedance sensor, nanoampere, 100  
 megohm input, I-203

indicators (*see* measurement/test  
 circuits)

in-use indicator, telephone, II-629

inductance meter, linear, V-316

induction heater, ultrasonic, 120-  
 KHz 500-W, III-704

inductors  
 active, I-417  
 simulated, II-199, V-180

infrared circuits (*see* also light-  
 controlled circuits; remote  
 control devices), II-288-292,  
 III-271-277, IV-219-228, V-223-  
 229

data link, I-341

detector, II-289, III-276, IV-224,  
 V-225

emitter drive, pulsed, II-292

fan controller, IV-226

filter circuit, narrow-band, V-189

headphone receiver, V-227

headphone transmitter, V-227

IR pulse-to-audio converter, V-224

laser rifle, invisible pulsed, II-291

long-range object detector, III-273

loudspeaker link, remote, I-343

low-noise detector for, II-289

object detector, long-range, III-273

people-detector, IV-225

preamplifier for IR photodiode,  
 V-226

proximity switch, infrared-  
 activated, IV-345

receivers, I-342, II-292, III-274, IV-  
 220-221, V-226, V-229

remote A/B switch, V-225

remote controller, I-342, IV-224,  
 V-229

remote-control analyzer, V-224

remote-control tester, IV-228, V-  
 228, V-229

remote-extender, IV-227

transmitters, I-343, II-289, II-290,  
 III-274, III-276, III-277, IV-226-227

digital, III-275

pulsed for on/off control, V-228

remote-control, I-342

voice-modulated pulse FM, IV-228

wireless speaker system, III-272,  
 IV-222-223

injectors  
 three-in-one set: logic probe, signal  
 tracer, injector, IV-429

injector-tracers, I-521, I-522, II-500

input selectors, audio, low-  
 distortion, II-38

input/output buffer, analog  
 multiplexers, III-11

input/output circuits, NE602-based,  
 V-355

instrumentation amplifiers, I-346, I-  
 348, I-349, I-352, II-293-295, III-  
 278-284, IV-229-234, V-233-235  
 +/-100 V common mode range.  
 III-294

current collector head amplifier,  
 II-295

differential, I-347, I-354, III-283

biomedical, III-282

high-gain, I-353

input, I-354

variable gain, I-349

extended common-mode design,  
 IV-234

high-impedance low-drift, I-355

high-speed, I-354

LM6218-based, high-speed, V-235

LMC6062-based, V-234

low-drift/low-noise dc amplifier,  
 IV-232

low-signal level/high-impedance,  
 I-350

low-power, III-284

meter driver, II-296

preamps  
 oscilloscope, IV-230-231

thermocouple, III-283

precision FET input, I-355

saturated standard cell amplifier,  
 II-296

stram 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,  
 V-236-237

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

photoelectric, 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, V-238-240

bidirectional, III-290

carrier current, I-146

hands-off, III-291

party-line, II-303

pocket pager, III-288

telephone-intercoms, IV-557,  
 V-239, V-240

two-way, III-292

two-wire design, IV-235-237

voice-activated, one-way, V-239

intercoms (*see* also telephone-  
 related circuits), V-238

interfaces (*see* also computer  
 circuits), IV-238-242, V-241-244

680x, 650x, 8080 families, III-98

amateur radio transceiver, relay  
 interface, V-243

audio-to-ADC interface, V-242

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

fiberoptic, II-207

keyboard matrix interface, IV-240

logic-level translators, IV-242

microcomputer-to-triac interface,  
 V-244

optical sensor-to-TTL, III-314

optocouplers, V-406-407

optoisolators, V-406-407

preamp receiver interface, V-243

process control, I-30, V-242

remote-control transmitter  
 interface, V-511

tape recorder, II-614

telephone  
 audio interface, V-612

telephone-line interface, V-605

video interface with sync stripper,  
 V-659

interrupter, ground fault, I-580

interval timer, low-power,  
 microprocessor programmable,  
 II-678

intruder-detector, light-beam  
 activated, V-11

preamp, V-13

inverters, III-293-298, V-245-247

250 watt, V-246

dc-to-ac, V-247

dc-to-dc/ac, I-208

digital, V-246

fast, I-422

fixed power supplies, 12 V input,  
 IV-395

flip-flop, III-103

fluorescent lamp, 8-W, III-306

frequency inverter, III-297

high-voltage, III-484

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  
   12 VDC-to-117 VAC at 60 Hz, III-294  
   medium, III-296  
   MOSFET, III-295, V-247  
 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  
 ac, high-gain, I-92  
 balancing circuit in, I-33  
 gain of 2, lag-lead compensation, UHF, I-566  
 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  
 ion generator, V-248-249  
 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  
 isolation transformer, V-349, V-470  
 isolators  
   analog data-signal transmission, IV-133  
   digital transmission, II-414  
   stimulus, III-351

## J

JFET  
 ac coupled integrator, III-200  
 amplifiers  
   500-Mohm input impedance, V-23  
   current source biasing, V-21  
   chopper circuit, V-352  
   headphone audio signal amplifiers, V-57  
   preamplifier, V-22  
   source follower, V-20  
   voltmeter, V-318  
 jitter suppression, V-342

## K

kaleidoscope, sonic, V-548-549  
 Kelvin thermometer, I-655  
   zero adjust, III-661  
 key illuminator, V-333  
 keyer, electronic CW "bug" keyer, V-102  
 keying circuits, IV-243-245  
   automatic operation, II-15

automatic TTI, morse code, I-26  
 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, V-250-254  
 diode sensor, IV-321  
 discharge current stabilizer, II-316  
 gun, visible red, III-310  
 handheld laser, V-252  
 light detector, II-314  
 power supply, IV-636, V-251, V-254  
   high-voltage, V-253  
   with starter circuit, V-252  
 pulsers, laser diode, I-416, III-311  
 receiver, IV-368  
 rifle, invisible IR pulsed, II-291  
 simulated laser using LED, V-253  
 latches, V-356  
   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  
   7-segment, V-165  
   fixed-power supply, IV-392, IV-403  
   large-size, V-164  
 lead-acid batteries (*see also* battery-related circuits)  
   battery chargers, III-55  
   life-extender and charger, IV-72  
   low-battery detector, III-56  
 leading-edge delay circuit, III-147  
 LED circuits  
   7-segment, V-166  
   ac-power indicator, IV-214  
   alternating flasher, III-198, III-200  
   back-biased GaAs LED light sensor, II-321  
   bar graph driver, II-188  
   battery-charger test circuit, V-89  
   brightness, I-250  
   Christmas tree light flasher, V-197  
   common-cathode display, V-167  
   driver, emitter/follower, IV-159  
   flashers, V-195, V-196  
   alternating, III-198, III-200  
   Christmas tree lights, V-197  
   control circuit, IV-183  
   dark-activated, V-195  
   driver, V-194  
   multivibrator design, IV-182  
   PUT used in, II-239

ring-around, III-194  
 sequential, reversible-direction, IV-182  
 three-year, III-194  
 UJT used in, II-231  
 frequency comparator, II-110  
 light sensor, back-biased GaAsFET, II-321  
 leading-zero suppressed display, V-165  
 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  
 simulated-laser circuit, V-253  
 three-year flasher, III-194  
 voltmeter, IV-286  
 VU meter, IV-211  
 level, electronic, II-666, IV-329  
 level controllers/detectors (*see also* fluid and moisture), II-174  
 alarm, water, I-389  
 audio, automatic, II-20  
 audio (ALC), V-60-62  
 cryogenic fluid, I-386  
 hysteresis in, I-235  
 level of liquid, I-107, I-235, I-387, I-388, I-389, I-390, II-174, II-244, II-246, III-205, III-206, III-207, III-209, III-210, IV-186, IV-190, IV-191  
 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  
   high-level, I-387  
 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, V-255-256  
 light-beam communication circuits, V-257-261  
 receivers  
   audio, visible-light, V-261  
   FM light-beam, V-259  
   modulated light, V-258  
   voice-communication, V-260  
 transmitters  
   audio, visible-light, V-261  
   FM light-beam, V-259  
   modulated light, V-258  
   voice-communication, V-260  
 light-controlled circuits (*see also* laser circuits; optical circuits), II-304-312, II-318-331, III-312-319, V-262-283

light-controlled circuits (*cont.*)  
 860 W limited-range light control, I-376  
 alarms, V-9, V-273  
   dark-activated alarm, pulsed tone, V-13  
   high-output, pulse-tone, V-14  
   precision design, V-12  
   self-latch, tone output, V-15  
   with hysteresis, V-14  
   with latch, V-12  
 light-beam intruder-detection, V-11, V-13  
 ambient-light cancellization circuit, II-328  
 ambient-light ignoring optical sensor, III-413  
 audio oscillator, light-sensitive, III-315  
 back-biased GaAs LED sensor, II-321  
 black light, battery-operated, V-281  
 logarithmic light, I-366  
 optical interruption sensor, IV-366  
 battery-powered light, capacitance operated, I-131  
 brightness control, I-377, III-316  
 carport light, automatic, II-308  
 chaser lights, sequential activation, IV-251, IV-252  
 Christmas light driver, IV-254  
 Christmas tree lights sequencer, V-264-265  
 complementary, I-372  
 controller, IV-252  
 cross fader, II-312  
 detectors of light, I-362, IV-369  
 dimmers, I-369, II-309, IV-247, IV-249, V-266  
   800 W, II-309  
   CMOS touch dimmer, V-270  
   dc lamp, II-307  
   four-quadrant, IV-248-249  
   halogen lamps, III-300  
   headlight, II-57, II-63  
   low-cost, I-373  
   phase-controlled, V-267  
   soft-start, 800-W, I-376, III-304  
   tandem, II-312  
   triac, I-375, II-310, III-303  
   dissolver, solid-state, III-304  
   drivers, lamp drivers, I-380  
   flip-flop independent design, IV-160  
   low-frequency flasher/relay, I-300  
   MOS lamp driver, V-269  
   optical coupling, III-413  
   neon lamps, I-379, V-270, V-459  
   short-circuit-proof, II-310  
 emergency light, I-378, I-581, II-320, III-317, III-415, IV-250  
 exposure meter, photo enlarger, V-438  
 flame monitor, III-313  
 flasher, dark-activated, V-195  
 floodlamp power, I-373  
 fluorescent-lamp high-voltage power supplies, IV-411, V-444, V-447  
 halogen lamp protector, V-271  
 holiday lights sequencer, V-264-265, V-264  
 indicator-lamp driver, optically coupled, III-413  
 infrared circuits (*see* infrared circuits; remote control)  
 interruption detector, I-364  
 inverter, fluorescent, 8-W, III-306  
 key illuminator, V-333  
 LEDs (*see* LED circuits)  
 level of light, I-365, I-367, I-376, I-377, I-380, I-389, III-313, III-316  
 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  
 logarithmic light sensor, I-366  
 logic circuit, I-393  
 machine vision illumination stabilizer, II-306  
 marker light, III-317  
 meters, light-meters, I-382, I-383, V-305  
   photo enlargers, V-434-435  
   modulator, III-302  
 monostable photocell, self-adjust trigger, II-329  
 mooring light, automatic, II-323  
 neon light drivers, I-379, V-270, V-459  
 night lights  
   automatic, I-360, III-306  
   telephone-controlled, III-604  
 on/off relay, I-366  
 on/off reminder  
   automotive lights, I-109  
   with ice alarm, I-106  
 one-shot timer, III-317  
 optical interruption sensor, IV-366  
 oscillator, light-controlled, V-279  
 outdoor light control, V-275  
 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 sensor, V-277  
 photoelectric switches, II-321, II-326, III-319  
 phototransistor, V-279  
 porch light control, V-266, V-276  
 projector-lamp voltage regulator, II-305  
 power outage light, line-operated, III-415  
 pulse-generation interruption, I-357  
 relays, I-366, V-275, V-278, V-279  
 remote-controller, I-370  
 robot  
   eyes, II-327  
   light-seeking robot, II-325  
   running light sequencer, V-269  
 sensors, I-367  
   ambient-light ignoring, III-413  
   back-biased GaAs LED, II-321  
   logarithmic, I-366  
   multiple-input, V-273  
   optical sensor-to-TTL interface, III-314  
   photoelectric, V-277  
 sequencer, V-263,  
   holiday lights, V-264-265  
   pseudorandom, III-301  
   running light, V-269  
   shimmering light, V-268  
 short-circuit proof lamp driver, II-310  
 signal conditioner, photodiode design, II-330  
 solid-state light sources, V-282-283  
 sound-controlled lights, I-609, V-552  
 speed controller, IV-247  
 strobe  
   high-voltage power supplies, IV-413  
   photo strobe, V-435, V-437  
   trigger, V-436  
   variable, III-589-590  
   sun tracker, III-318  
 switches, II-326, III-314  
   adjustable, I-362  
   capacitance switch, I-132  
   dark-activated, V-274, V-276  
   light/dark activated, V-274  
   light-activated, self-latching, V-278  
   light-controlled, II-320, III-314  
   photoelectric, II-321, II-326, III-319  
   solar triggered, III-318  
   zero-point triac, II-311  
 tarry light, I-579  
 telephonic in-use light, II-625  
 three-way light control, IV-251  
 touch lamp, three-way, IV-247  
 triac circuit, V-268  
 triac controller, V-267, V-271  
 triac switch, inductive load, IV-253  
 turn-off circuit, SCR capacitor design, IV-254  
 twilight-triggered circuit, II-322  
 video, low-level video IF amplifier, I-687-689  
 voltage regulator for projection lamp, II-305

- wake-up call light, II-324
  - warning lights, II-320, III-317
  - light-seeking robot, II-325
  - limit comparators/detectors, I-156, III-106
  - alarm, high/low, I-151
  - double ended, I-230, I-233, I-156, II-105
  - micropower, I-155
  - frequency-hmit detector, II-177
  - limiters, III-320-322, IV-255-257
  - audio limiter, V-335
    - clipper/limiter, IV-355
    - low-distortion, II-15
  - 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 amplifiers, III-37
    - duplex, telephone, III-616
    - universal design, IV-39
  - line drivers, I-262
    - 50-ohm transmission, II-192
    - 600-ohm balanced, II-192
    - audio signal amplifiers, V-54
    - full rail excursions in, II-190
    - high-output 600-ohm, II-193
    - synchronized, III-174
    - video amplifier, III-710
  - line-dropout detector, II-98
  - line-frequency square wave generator, II-509
  - line receivers
    - digital data, III-534
    - low-cost, III-532
  - line-sync, noise immune 60 Hz, II-367
  - line-current detector/monitors, III-341
    - optically coupled, III-414
  - line-hum touch switch, III 664
  - line-synchronized driver circuit, III-174
  - line-voltage announcer, ac, III-730
  - line-voltage monitor, III-511
  - line-voltage-to-multimeter adapter, V-312
  - 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
    - audio power amplifiers, V-51
    - CMOS inverter, II-11
    - inverter, linear amp from inverter, II-11
    - rf amplifiers
      - 6-m, 100 W, IV-480-481
      - 903 MHz, IV-484-485
      - ATV, 10-to-15 W, IV-481
  - linear couplers
    - ac analog, II-412
    - analog, II-413
    - dc, II-411
  - optocoupler, instrumentation, II-417
  - linear IC siren, III-564
  - linear ramp generator, II-270
  - link, fiberoptic, III-179
  - 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
  - load-sensing circuits, V-284-285
  - locator, lo-parts treasure, I-409
  - locks, electronic, II-194-197, IV-161-163
    - combination, I-583, II-196
    - digital entry lock, IV-162, V-157
    - 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
    - amplifiers, 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
  - audible pulses, II-345
  - converter, TTL to MOS, I-170
  - four-state, single LED indicator, II-361
    - isolation and zero voltage switching, II-415
  - level shifter, negative-to-positive supply, I-394
  - light-activated, I-393
- line monitor, III-108
- overvoltage protection, I-517
- probes, logic probes, I-520, I-525, I-526, IV-430-431, IV-434
- CMOS, I-523, I-526, III-499
- digital, III-497, V-310
- four-way operation, IV-432
- memory-tester, installed, I-525
- single-IC design, IV-433
- three-in-one set: probe, signal tracer, injector, IV-429
- pulse generator for logic-troubleshooting, IV-436
- pulsar, III-520, V-489
- signals, long delay line for, III-107
- testers
  - audible, III-343, V-313
  - TTL, I-527
- translators, logic-level translators, IV-242
- long-duration timer, PUT, II-675
- long-range object detector, III-273
- loop antennas
  - 3.5 MHz, IV-12-13
  - dual band, 80-160 m, V-32
  - preamp, V-38
- loop transmitter, remote sensors, III-70
- loop-thru video amplifier, IV-616
- loudness controls, II-46, II-47
  - amplifier, loudness amp, II-46
  - balance amplifier with, II-395
- loudspeakers
  - coupling circuit, I-78
  - horn as loudspeaker, IV-54
  - protector circuit, V-483
  - remote link, I-343
- low-distortion input selector for audio use, II-38
- 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, V-178, V-181, V-188
  - digitally selected break frequency, II-216
    - fourth-order, V-184
    - Butterworth, V-180, V-181
  - Chebyshev, fifth-order, multi-feedback, II-219
  - clock-tunable, monolithic, 1mV, V-187
  - 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
    - active, IV-177
    - equal component, I-292
    - second order, I-289
    - second-order, V-188
    - second order Sallen-Key, I-289
    - unity-gain second-order, V-187
    - variable, V-186
- low-voltage alarm/indicator, I-224, II-493, III-769

low-voltage power disconnect, 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  
magnetometer, II-341  
magnets  
  current sensor, magnetic currents,  
    III-341  
  electromagnetic-field sensor, V-308  
  permanent-magnet detector, IV-281  
  preamplifiers, magnetic, I-89, I-91,  
    III-37, III-673, IV-35, IV-36  
  proximity sensor, V-308  
  transducer, magnetic transducer,  
    I-233  
mains-failure indicator, IV-216  
marker generator, III-138  
marker light, III-317  
mathematical circuits, III-325-327,  
  IV-258-263, V-286-288  
  adder circuits, III-327  
    binary, fast-action, IV-260-261  
  divider circuits, IV-150-156  
    binary chain, I-258  
    divide-by-2-or-3 circuit, IV-154  
  divide-by-N  
    1+ GHz, IV-155  
    1.5+ divide-by-n, IV-156  
    CMOS programmable, I-257  
    7490-divided-by-n, IV-154  
  divide-by-odd number, IV-153  
  frequency dividers, I-258, II-251,  
    II-254, III-213-218, III-340, III-768  
  1.2 GHz, III-129  
  10-MHz, III-126  
  clock input, IV-151  
  decade, I-259  
  divide-by-1.5, III-216  
  low-cost, III-124  
  low-frequency, II-253  
  preamp, III-128  
  programmable, IV-152-153  
  staircase generator and, I-730  
  tachometer and, I-310  
  odd-number counter and, III-217  
  one trim, III-326  
  pulse, non-integer programmable,  
    II-511, III-226  
  minimum/maximum selector, four-  
    input, V-332  
multiplier circuits, IV-325  
  low-frequency multiplier, IV-325  
  precise commutating amp,  
    IV-262-263  
  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

  cascaded, Cockcroft-Walton,  
    IV-635  
  triarc-controlled, III-468  
  laser power supply, IV-636  
  negative-ion generator, high-  
    voltage, IV-634  
  tripler, low-current, IV-637  
polar-to-rectangular  
  converter/pattern generator,  
    radio di, V-288  
  polynomial generator, V-287  
  root extractor, V-207, V-288  
  slope integrator, programmable,  
    IV-259  
  subtractor, III-327  
MC1330/MC1352 television IF  
  amplifier, I-688  
measurement/test circuits (*see also*  
  monitors; probes), II-340,  
  III-268-270, III-328-348, IV-210-  
  218, IV-264-311, V-230-232,  
  V-289-321  
  100 K megaohm dc, I-524  
  3-in-1 test set, III-330  
  absolute-value circuit, IV-274  
  ac hot wire, I-581  
  ac-current indicator, IV-290  
  ac-power indicator, LED display,  
    IV-214  
  ac/dc indicator, IV-214  
  ac outlet tester, V-318  
  ac wiring locator, V-317  
  ac-watts calculator, V-304  
  acoustic-sound receiver, IV-311  
  acoustic-sound transmitter, IV-311  
  activity tester, crystal oscillators,  
    V-138  
  alarm and, I-337  
  altimeter, digital, V-296  
  anemometer, low-current, V-307  
  anemometer, hot-wire, III-342  
  audible logic tester, III-343  
  audible TTL, I-524  
  audio frequency meter, I-311,  
    V-305, V-320  
  audio millivolt, III-767, III-769  
  audio power, I-488  
  audio-rf signal tracer, I-527  
  automatic contrast, I-479  
  automotive electrical tester, IV-45  
  automotive-temperature indicator,  
    PTC thermistor, II-56  
  B-field measurer, IV-272  
  balance indicator, IV-215  
  balance meter for stereo, V-583  
  barometer, IV-273  
  battery indicators/testers, I-108,  
    I-121, I-122, I-124, V-74, IV-78,  
    IV-79  
  beat frequency, I-336  
  breath alert alcohol tester, III-359  
  broadband ac active rectifier, IV-271  
  buzz box continuity checker, I-551  
  cable tester, III-539, V-299

  calibrator (*see* calibrators)  
  capacitance buffer  
    low-input, III-498  
    stabilized low-input, III-502  
  capacitance meters, I-400, II-91-94,  
    III-75-77  
    A/D, 3.5 digit, III-76  
  capacitance-to-voltage, II-92  
  digital, II-94  
  capacitor testers, IV-265, IV-279,  
    V-306  
  clamp-on-current compensator,  
    II-501  
  CMOS logic, I-523  
  continuity testers, I-550, I-551,  
    II-342, II-533, II-534, II-535,  
    III-345, III-538-540, IV-287,  
    IV-289, IV-295, IV-296, V-293,  
    V-317, V-319  
  crystal tester, I-178, I-186, II-151,  
    V-139  
  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 sensors, III-255, IV-284  
  high-gain current sensor, IV-291  
  picoammeter, I-202, II-154, II-157,  
    III-338  
  guarded input, II-156  
  range ammeter, six-decade,  
    II-153, II-156  
  curve tracer, I-397, IV-274, V-300  
  CW offset indicator, IV-213  
  deviation meter, IV-303  
  dial pulse, III-613  
  digital frequency meter, III-344  
  digital multimeter (DMM), IV-291,  
    V-291  
  digital voltmeters (DVM), III-4  
    3.5-digit, I-713, III-761  
    3.75-digit, I-711  
    4.5-digit, I-717, III-760  
  adapter for PC, V-310  
  auto-calibrate circuit, I-714  
  automatic nulling, I-712  
  interface and temperature sensor,  
    II-647  
  LED readout, IV-286  
  temperature sensor and DVM, 647  
  diode tester, I-401, I-402, I-406,  
    II-343, III-402  
  dip meters, I-247, II-182-183  
  bandswitched, IV-298  
  basic grid, I-247, IV-298  
  dual gate IGFET, I-246  
  little dipper, II-183  
  varicap tuned FET, I-246  
  direction-of-rotation circuit, III-335  
  diode-curve tracer, IV-274  
  diode-matching circuit, IV-280

dosage rate, I-534  
 driver, meter-driver rf amplifier,  
     1-MHz, III-545  
 duty-cycle meter, III-329, IV-265,  
     IV-275, IV-280  
 dwell meter, I-102, III-45  
 E, T, and R measurement/test  
     circuits, IV-283-296  
 electrolytic-capacitor reforming  
     circuit, IV-276  
 electromagnetic-field sensor, V-308  
 electrometer, IV-277  
 electrostatic detector, III-337  
 energy consumption monitor, V-290  
 expanded-scale analog meters, II-  
     186, III-774, IV-46  
 FET probe, III-501  
 FET voltmeter, III-765, III-770  
 field-strength meters, II-208-212,  
     III-182-183, IV-164-166,  
     V-174-176  
     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 analyzer, audio filters, IV-  
     309  
 flash exposure meter, I-484, III-  
     446  
 frequency counter, III-340, IV-300  
 frequency meters, I-310, II-249-  
     250, IV-282, IV-301  
     analog, V-307  
     audio, I-311  
     linear, I-310  
     low-cost, II-250  
     power, II-250  
     power-lme, I-311  
 frequency shift keyer tone  
     generator, I-723  
 geiger counters, I-536-537, II-489,  
     II-514, V-217-219  
 general purpose rf detector, II-500  
 go/no-go test circuits, I-401, I-157  
 grid-dip meters, I-247, IV-298  
 ground, I-580, II-345  
 ground-noise, battery-powered,  
     III-500  
 harmonic distortion  
     analyzer, V-291  
     meter, V-312  
 impedance checker, V-136  
     in-use indicator, telephone, II-629  
 inductance meter, linear, V-316  
 infrared detector, low-noise, II-289  
 injectors, IV-429  
 high-frequency and rf tester,  
     IV-297-303  
 LC checker, III-334  
 LED meters, I-251, III-347  
 level indicators (*see* fluid and  
     moisture, level)  
 line-current monitor, III-341  
 light meters, I-382, I-383, V-302  
 line-voltage-to-multimeter adapter,  
     V-312  
 logic probes, I-520, I-525, I-526,  
     IV-430-431, IV-434  
 CMOS, I-523, I-526, III-499  
 digital, III-497, V-310  
 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  
 logic tester, I-527, II-345, III-343,  
     V-313  
 low-current measurement, III-345  
 low-ohms adapter, IV-290  
 low-voltage, III-769  
 magnet/magnetic detectors, III-  
     341, IV-266, IV-281, V-308  
 magnetometer, II-341  
 mains-failure indicator, IV-216  
 measuring gauge, linear variable  
     differential transformer, I-404  
 meter tester, IV-270  
 metronomes, I-411-413, II-353-355,  
     III-353-354, IV-312-314, V-392  
 microammeter, dc, four-range,  
     IV-292  
 microfarad counter, IV-275  
 microvolt, II-499  
 millivoltmeters, III-767, III-769,  
     IV-289, IV-294, IV-295  
     ac, I-716  
     audio, III-767, III-769  
     dc, IV-295  
     four-range, IV-289  
     high-input impedance, I-715  
     LED readout, IV-294  
 modulation monitor, III-375, IV-299  
 mono audio-level meter, IV-310  
 motion sensor, unidirectional,  
     II-346  
 motor hour, III-340  
 multiconductor-cable tester,  
     IV-288  
 multimeters, IV-291, IV-293  
     noise generator, IV-308  
     ohmmeters, I-549, III-540, IV-290  
     On indicator, IV-217  
     on-the-air, III-270  
     op-amp dc offset shift tester,  
         V-319  
     optical light probe, IV-369  
     oscilloscope adapter, four-trace,  
         IV-267  
     overspeed, I-108  
 overvoltage protection, I-150, I-  
     517, II-96, II-107, II-496, II-513,  
     III-762, IV-389  
 paper sheet discriminator, copying  
     machines, III-339  
 peak detectors, II-174, II-175, II-  
     434-436, III-771, IV-138, IV-143  
     analog, with digital hold, III-153  
     decibel peak meter, III-348  
     digital, III-160  
     high-bandwidth, III-161  
     high-frequency peak, II-175  
     high-speed peak, I-232  
     LED design, peak meter, III-333  
     level detector, I-402  
     low-drift, III-156  
     negative, I-225, I-234  
     op amp, IV-145  
     positive, I-225, I-235, II-435,  
         III-169  
     true rms, I-228  
     ultra-low-drift peak, I-227  
     voltage, precision, I-226  
     wide-bandwidth, III-162  
     wide-range, III-152  
 pH tester, I-399, III-501  
 phase detection/manipulation  
     circuits  
     detectors, I-406, I-476, II-344,  
         II-439, II-441, II-442, III-440-442,  
         IV-127  
     10-bit accuracy, II-176  
     digital VOM, IV-277  
     phase-difference detector, 0- to  
         180-degree, II-344  
     phase selector/sync  
         rectifier/balanced modulator,  
         III-441  
     sequencers, phase sequence, I-  
         476, II-437-442, III-441  
     rc circuit, phase sequence  
         reversal detection, II-438  
     reversal, rc circuit to detect,  
         II-438  
     three-phase tester, II-440  
     shifters, phase shifters, IV-647  
         0-180 degree, I-477  
         0-360 degree, I-477  
     single-transistor design, I-476  
     splitter, precision, III-582  
     tracker, three-phase square wave  
         generator, II-598  
 picoammeters, I-202, II-154, III-338  
     circuit for, II-157  
     guarded input circuit, II-156  
     polarity indicator, V-231  
     power gain meter, 60 MHz, I-489  
     power line frequency tester, I-311  
     power meter, I-489  
     power supply test load, constant-  
         current, IV-424  
     prescaler, 650 MHz amplifying,  
         II-502  
     pressure gauge, digital, V-314

measurement/test circuits (*cont.*)  
 probes, 4-to-220 V, III-499  
 proximity sensor, magnetic, V-308  
 pulse-width meter, III-336  
 QRP SWR bridge, III-336  
 RC decade box, V-294-295, V-294  
 receiver-signal alarm, III-270  
 reflectometer, I-16  
 remote-control infrared device,  
     IV-228  
 resistance measurement, II-342,  
     IV-285  
 resistance/continuity meters (*see*  
     continuity tester, above)  
 rf bridge, V-303  
 rf output indicator, IV-299  
 rf power indicator, I-16  
     wide-range, III-332  
 rf probe, I-523, III-498, III-502,  
     IV-433  
 rf test oscillator, V-412  
 rf voltmeter, III-766  
 rf-actuated relay, III-270  
 S meter for communications  
     receivers, V-311  
 scale, electronic, V-297  
     SCR tester, III-344  
 short-tester, V-313, V-315  
 shutter, I-485  
 signal generators, V-309  
     AM broadcast-band, IV-302  
     AM/FM, 455 kHz, IV-301  
 signal strength meter, III-342, IV-166  
 signal tracer, IV-429, V-309  
 simulated, I-417  
 single injector-tracer, II-500  
 soil moisture, III-208  
 sound-level meters, III-346, IV-305,  
     IV-307  
     telephone, III-614  
 sound sensor, IV-218  
 sound-test circuits (*see also* sound  
     generators), IV-304  
 speedometer, bike, IV-271, IV-282  
 static detector, IV-276  
 stereo test circuits  
     audio-level meter, IV-310  
     audio-power meter, III-331, IV-306  
     balance indicator, I-618-619  
     reception indicator, III-269  
 stud finder, III-339  
 supply-voltage monitor, V-320  
 suppressed zero, I-716  
 SWR power, I-16, I-22, IV-269  
 tachometers, I-94, I-100, I-102,  
     II-175, III-335, III-340, III-347,  
     V-65, V-596-598  
 analog readout, IV-280  
 calibrated, III-598  
 closed loop feedback control, II-390  
 digital readout, II-61, III-45,  
     IV-268-269, IV-278  
 dwell meter/tachometer, III-45  
 feedback control, II-378, II-390  
 frequency counter, I-310  
 low-frequency, III-596  
 minimum-component design, I-405  
 motor speed controllers, II-378,  
     II-389  
 optical pick-up, III-347  
 set point, III-47  
 telephone  
     in-use indicator, II-629, IV-560,  
     IV-563  
     line tester, V-615  
     off-hook, I-633  
 temperature (*see* temperature-  
     related circuits)  
 temperature indicator, IV-570  
 test probe, 4-220 V, III-499  
 tester, IV-270  
 thermometers, III-637-643  
 three-in-one set, logic probe, signal  
     tracer, injector, IV-429  
 three-phase tester, II-440  
 tilt meter, III-644-646, V-302  
 tone, digital IC testing, II-504  
 transistor tester, I-401, IV-281,  
     V-306  
 transmitter-output indicator, IV-218  
 tri-color indicator, V-232  
 TTL logic tester, I-527  
 universal test probe, IV-431  
 UHF source dipper, IV-299  
 undervoltage, battery operated  
     equipment, I-123  
 universal test probe, IV-431  
 vibration meter, I-404  
 video-signal amplitude measurer,  
     V-309  
 visual modulation, I-430  
 visual level, III-269  
 voltage level indicators, I-335,  
     I-337, I-338, I-718, III-758-772,  
     V-301, V-315  
 voltage probes, V-474  
 voltmeters, III-758  
     3.5 digit, I-710, I-713, III-761  
     4.5-digit, III-760  
     5-digit, III-760  
 ac, I-716, III-765, III-772  
 add-on thermometer for, III-640  
 bar-graph, I-99, II-54  
 dc, III-762, III-763, V-301  
 digital voltmeters (DVM), III-4  
     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  
     LED readout, IV-286  
     temperature sensor and DVM, 647  
 FET, I-714, III-765, III-770  
 high-input resistance, III-768  
 JFET, V-318  
 LED expanded scale, V-311  
 millivoltmeters (*see*  
     millivoltmeters)  
 rf, I-405, III-766  
 voltohmmeters (VOM)  
     field strength, I-276  
     phase meter, digital readout,  
     IV-277  
 volume indicator, audio amplifier,  
     IV-212  
 VOR signal simulator, IV-273  
 VU meters, I-715, II-487, III-487,  
     IV-211  
 watch tick timer, V-292  
 water-level measurement circuit,  
     IV-191  
 wavemeter, tuned RF, IV-302  
 wideband test amplifier, IV-303  
 wire tracer, II-343  
 zener diode test set, V-321  
 zener diode tester, I-400, I-406  
 zero center, FM receivers, I-338  
 medical electronic circuits, II-347-  
     349, III-349-352  
     biomedical instrumentation  
         differential amp, III-282  
     breath monitor, III-350  
     EKG simulator, three-chnp, III-350  
     heart rate monitor, II-348, II-349,  
         V-342  
     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  
 memo alert, V-352  
 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,  
     V-322-324  
     low-cost design, V-323  
     micropower, I-408  
     pipe detector, V-323  
 meters (*see* measurement/test  
     circuits)  
 methane concentration detector,  
     linearized output, III-250  
 metronomes, I-413, II-353-355, III-  
     353-354, IV-312-314, V-392  
 top octave generator, V-393  
 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
- microphone circuits
  - amplifiers, I-87, III-34
  - electronic balanced input, I-86
  - electret, preamp circuit, V-21
  - external mic circuit for transceivers, V-351
  - FM wireless, III-682, III-685, III-691
  - mixer, II-37, V-363, V-364
  - preamplifiers, II-45, IV-37, IV-42
  - low-impedance, IV-41
  - tone control for, II-687
  - transformerless, unbalanced input, I-88
  - transformerless, unbalanced input, I-88
  - wireless, IV-652-654
    - AM wireless, I-679
- microprocessors (*see* computer circuits)
- microvolt comparators
  - dual limit, III-89
  - hysteresis-including, III-88
- microvolt probe, II-499
- microwave amplifiers, IV-315-319
  - 5.7 GHz, IV-317
  - bias supply for preamp, IV-318
  - preamplifiers
    - 2.3 GHz, IV-316
    - 3.4 GHz, IV-316
  - bias supply, IV-318
  - single-stage, 10 GHz, IV-317
  - two-stage, 10 GHz, IV-319
- microwave field strength meter, I-273
- MIDI (*see* musical circuits)
- Miller oscillator, I-193
- millivoltmeters, III-767, III-769, IV-289, IV-294, IV-295
  - ac, I-716
  - audio, III-767, III-769
  - dc, IV-295
  - four-range, IV-289
  - high-input impedance, I-715
  - LED readout, IV-294
- mini-stereo audio amplifiers, III-38
- minimum/maximum selector, four-input, V-332
- mixers, III-367-370, IV-330-336, V-359-364
  - 1-MHz, I-427
  - audio, I-23, I-59, II-35, IV-335, V-362, V-364
  - 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-56, I-60, II-40, III-369, IV-333
  - four-input, I-55, IV-334
  - guitar mixer, low-noise, four-channel, V-360-361
  - IIF transceiver/mixer, IV-457
  - hybrid, I-60
  - input-buffered, III-369
  - local oscillator, double-balanced mixer, V-415
  - microphone, II-37, V-363, V-364
  - mixer/oscillator for AM receivers, V-412
  - 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
  - rocket launcher, II-358
- modems
  - power-line, carrier-current circuit, III-82
  - protector, V-479, V-482
- 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, V-365-367
  - 455-kHz, V-366
  - +12V dc single supply, balanced, I-437
  - AM, I-438, II-370
  - balanced, III-376, III-441
  - double-sideband suppressed-carrier, III-377
  - FM, V-366, V-367
  - 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, II-369, III-372, III-374
  - 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; fluid and moisture; light-controlled circuits; motor control circuits; speed controllers; temperature-related circuits; tone controls), V-368-372
  - acid rain, III-361, V-371
  - baby monitor, V-370-371
  - battery monitors, I-106, I-222, II-74-79, III-60-67, IV-73-80
  - bird feeder monitor, V-371
  - blinking phone light, II-624
  - breath monitor, III-350
  - current, III-255, IV-284
    - alarm and, III-338
  - directional signals, auto, III-48
  - door-ajar, automotive circuits, III-46
  - duty cycle, III-329, IV-275
  - flames, III-313
  - home security system, I-6
  - line-current, III-341
  - line-voltage, III-511
  - logic line, III-108
  - modulation, III-375, IV-299
  - overvoltage protection, I-150, I-517, II-96, II-107, II-496, III-513, III-762, IV-389
  - power-supply monitors, II-491-497, III-493-495, IV-422-427
    - backup supply, drop-in manually-activated, IV-424
  - balance monitor, III-494
  - booster/buffer, boosts reference current, IV-425
  - circuit breaker, trip circuit, IV-423
  - connections monitor, ac lines, III-510
  - fault monitor, single-supply, III-495
  - memory protector/supply monitor, IV-425
  - polarity-protection relay, IV-427
  - SCR design, IV-385
  - test load, constant-current, IV-424
  - triac for ac-voltage control, IV-426
  - tube amplifier, high-voltage isolation, IV-426
  - voltage monitors (*see* voltage monitors)
  - room monitor, V-369
- monostable multivibrators, I-465, III-229, III-230, III-235, III-237, V-386, V-387
  - input lockout, I-464
  - linear-ramp, III-237
  - photocell, monostable, II-329
  - positive-triggered, III-229
  - TTL, monostable operation, I-464
  - UJT, monostable operation, I-463
  - video amplifier and comparator, II-268
- mooring light, automatic, II-323
- MOSFETs

MOSFETs (*cont.*)  
 amplifier, high-impedance biasing, V-19  
 audio power amplifiers, V-47  
 biasing, high-impedance method, V-19  
 buffer amplifier, V-93  
 frequency converter, V-123  
 mixer/oscillator for AM receivers, V-412  
 power control switch, IV-386  
 power inverter, III-295, V-247  
 mosquito repelling circuit, I-684  
 motion/proximity detectors, I-135-136, I-344, II-135, II-136, II-505-507, III-514-518, IV-341-346, V-376-377, V-484-486  
 acoustic Doppler motion detector, IV-343  
 alarm for, II-506  
 auto alarm, I-9  
 baby monitor, V-370-371  
 capacitive, III-515  
 field disturbance sensor/alarm, II-507  
 infrared-reflection switch, IV-345  
 light-beam intruder-detection alarm, V-11, V-13  
 low-current-drain design, IV-342-343  
 magnetic, V-308  
 microwave circuit, V-377  
 motorcycle alarm, I-9  
 object detector, long-range, III-273  
 optical detector circuit, V-405  
 optical interruption sensor, IV-366  
 people-detector, infrared-activated, IV-225  
 proximity switch, infrared-activated, IV-345  
 relay-output, IV-345  
 room monitor, V-369  
 SCR alarm, III-517  
 self-biased, changing field, I-135  
 switch, III-517  
 UHF, III-516, IV-344  
 unidirectional, II-346  
 motor control circuits, IV-347-353, V-378-381  
 400 Hz servo amplifier, II-386  
 ac motors, II-375  
 ac servo amplifier, bridge-type, III-387  
 bidirectional proportional control, II-374  
 blender control circuit, V-379  
 compressor protector, IV-351  
 dc motors  
 direction controls, I-452  
 driver controls, fixed speed, III-387 reversing, II-381 servo, bipolar control input, II-385  
 speed-controlled reversible, III-388  
 fiberoptic controls, II-206  
 direction controls  
 dc motors, I-452  
 series-wound motors, I-448  
 shunt-wound motors, I-456  
 stepper motor, IV-350  
 driver controls  
 ac motors  
 three-phase, II-383  
 two-phase, I-456, II-382  
 constant-speed, III-386  
 dc motors  
 fixed speed, III-387  
 reversing, II-381  
 servo, bipolar control input, II-385  
 speed-controlled reversible, III-388  
 N-phase motor, II-382  
 piezo drive, V-380  
 PWM, V-380  
 reversing, dc control signals, II-381  
 servo motor amplifier, I-452, II-384  
 stepper motors, III-390  
 half-step, IV-349  
 quarter-step, IV-350  
 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  
 run-drill control, IV-348  
 model train and/or car, I-453, I-455  
 phase control, hysteresis free, I-373  
 piezo motor drive, V-380  
 power brake, ac, II-451  
 power-factor controller, three-phase, II-388  
 power-tool torque, I-458  
 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  
 servo system, III-384  
 speed control (*see* speed controllers)  
 start-and-run motor circuit, III-382  
 stepper motors, V-571-573  
 half-step, IV-349  
 quarter-step, IV-350  
 speed and direction, IV-350  
 tachometers, I-94, I-100, I-102, II-175, III-335, III-340, III-347, V-65, V-596-598  
 analog readout, IV-280  
 calibrated, III-598  
 closed loop feedback control, II-390  
 digital readout, II-61, III-45, IV-268-269, IV-278  
 dwell meter/tachometer, III-45  
 feedback control, II-378, II-390  
 frequency counter, I-310  
 low-frequency, III-596  
 minimum-component design, I-405  
 motor speed controllers, II-378, II-389  
 optical pick-up, III-347  
 set point, III-47  
 three-phase controls, II-383, II-388  
 two-phase controls, I-456, II-382  
 motorcycle alarm, motion actuated, II-9  
 multiburst generator, square waveform, II-88  
 multimeters (*see also* digital multimeters (DMM)), IV-291, IV-293  
 multiple-input detector, III-102  
 multiplexers, III-391-397, V-382-383  
 1-of-8 channel transmission system, III-395  
 analog, II-392, V-383  
 0/01-percent, II-392  
 buffered input and output, III-396  
 input/output buffer for, III-11  
 single- to four-trace converter, II-431  
 capacitance, II-200, II-416  
 common-cathode LED-display ADC, III-764  
 de-, III-394  
 differential multiplexer, I-425, I-428, II-428  
 driver, high-speed line driver, I-264  
 eight-channel mux/demux, I-426, II-115  
 four-channel, low-cost, III-394  
 frequency, III-213-218  
 line driver, I-264  
 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  
 multiplier circuits, IV-325  
 capacitance multiplier, V-205, V-347  
 low-frequency multiplier, IV-325  
 photomultipliers, high-volt power supply, V-444, V-445  
 precise commutating amp, IV-262-263  
 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
    - cascaded, Cockcroft-Walton, IV-635
    - triac-controlled, III-468
  - laser power supply, IV-636
  - negative-ion generator, high-voltage, IV-634
  - tripler, low-current, IV-637
  - multivibrators, V-384-388
    - 100 kHz free running, II-485
    - astable multivibrators, II-269, II-510, II-597, III-196, III-224, III-233, III-237, III-238, V-386-388
    - bistable multivibrators, I-133, II-465
      - inverter, III-103
    - debouncer, IV-108
    - flasher, I-299, II-234
    - lamp driver, IV-160
    - pushbutton trigger, V-388
    - RS flip-flop, I-395
    - SCR, II-367
    - SR flip-flop, IV-651
    - touch-triggered, I-133
  - car battery, II-106
  - CB modulation, II-431
  - CMOS, V-385
    - current, II-203
  - duty-cycle, 50-percent, III-584
  - free-running
    - 100 kHz, I-465
    - programmable-frequency, III-235
    - with op amp, V-388
  - low-frequency, III-237
  - low-voltage, II-123
  - modulation, II-430
  - monostable multivibrators, I-465, III-229, III-230, III-235, III-237, V-386, V-387
    - input lockout, I-464
    - linear-ramp, III-237
    - photocell, monostable, II-329
    - positive-triggered, III-229
    - TTL, monostable operation, I-464
    - UJT, monostable operation, I-463
    - video amplifier and comparator, II-268
  - one-shot, I-465, I-720, II-266, II-465, III-222, III-238, III-317, III-654, V-388
  - oscilloscope, II-474
  - single-supply, III-232
  - sound level, II-403
  - square-wave generators, IV-536
  - telephone line, II-628
  - very-low-frequency, V-385
  - wideband radiation, II-535
  - music circuits (*see also* sound generators), V-389-393
    - envelope generator/modulator, IV-22
    - instrument tune-up, audio generator, V-390
    - melody circuit, V-393
    - melody generator, single-chip design, IV-520
    - metronome (*see* metronomes)
    - MIDI receiver, V-392
    - MIDI transmitter, V-393
    - multi-tone generator, V-566
    - music maker circuit, III-360, IV-521
    - musical chimes, I-640
    - musical envelope modulator, I-601, IV-22
    - octave equalizer, V-353
    - perfect pitch circuit, V-391
    - synthesizer, V-10-note, V-561
    - telephone music-on-hold circuit, V-601, V-605
  - mux/demux (*see* multiplexers)
- ## 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
  - NE602
    - dc power circuit, V-358
    - input/output circuits, V-355
  - negative-ion generator, IV-634
  - neon flashers, I-303
    - five-lamp, III-198
  - two-state oscillator, III-200
  - tube, I-304
  - networks
    - crossover networks, I-172-173, II-35
    - 5V, I-518
    - ac/dc lines, electronic, I-515
    - active, I-172
    - asymmetrical third order Butterworth, I-173
    - electronic circuit for, II-36
    - filter, I-291
    - speech, telephone, II-633
  - ru-cad batteries, I-118
  - analyzer for, III-64
  - charger, I-112, I-116, III-57
    - 12 v, 200 mA per hour, I-114
    - current and voltage limiting, I-114
    - fast-acting, I-118
    - portable, IV-69
    - temperature-sensing, IV-77
    - thermally controlled, II-68
  - packs, automotive charger for, I-115
  - portable, III-47, IV-69
  - protection circuit, III-62
  - simpl-cad, I-112
  - temperature-sensing charger, IV-77
  - test circuit, IV-79
  - thermally controlled, II-68
  - zappers, I-6, II-66, II-68
  - night lights (*see* lights/light-activated and controlled circuits)
  - no-doze alarm, V-8
  - noise generators (*see* sound generators)
  - noise reduction circuits, II-393-396, III-398-401, IV-354-356, V-396-398
    - amplified noise limiter for SW receivers, V-397
    - audio clipper/limiter, IV-355
    - audio dynamic system, V-397
    - audio shunt noise limiter, IV-355
    - audio squelch, II-394
    - balance amplifier with loudness control, II-395
    - blanker, IV-356
    - clipper, II-394
      - 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
    - filters (*see* filters)
    - limiter, II-395, III-321
    - low-level signal noise, V-398
    - receiver application, V-398
    - shortwave receiver noise limiter, V-397
  - noninverting amplifiers, I-32, I-33, I-41, III-14
    - ac power, I-79
    - 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
  - 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, V-179
    - audio, II-400
    - bandpass and, II-223
    - high-Q, III-404, V-178
    - selectable bandwidth, I-281
    - shortwave receiver filter, V-185
    - three-amplifier design, I-281
    - tunable, II-399, II-402, V-179
      - passive-bridged differentiator, II-403
      - hum-suppressing, I-280
      - op amp, II-400
    - twin-notch for 1 kHz, V-183
    - twin-T, III-403
    - Wien bridge, II-402
  - NTSC-to-RGB video decoder, IV-613

nuclear particle detector, I-537  
null circuit, variable gain, accurate,  
III-69  
null detector, I-148, III-162

## O

octal D/A converter, V-350  
ohmmeters, I-549  
  linear, III-540  
  linear scale, I-549  
  five-range, IV-290  
ohms-to-volts converter, I-168  
oil-pressure gauge, automotive,  
  IV-44, IV-47  
on/off control, I-665  
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,  
  V-388  
  digitally controlled, I-720  
  precision, III-222  
  pulse generator, V-490-491  
  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, V-399-403  
  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,  
  composite amplifier, V-401, V-403  
  compound op-amp, IV-364  
  dc offset-shift tester, V-319  
  driver, IV-158-159  
  feedback-stabilized amplifier,  
    IV-360  
  free-running multivibrator, V-388  
  full-wave rectifier design, V-403  
  gain-controlled op amp, IV-361  
  high-gain/bandwidth, V-403  
  intrinsically safe protected, III-12  
  inverter/rectifier, programmable,  
    IV-364  
  microphone mixer, V-364  
  on/off switch, transistorized, IV-546  
  polarity gain adjustment, V-400  
  power op amp, V-402  
  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

temperature-compensated  
  breakpoint, nonlinear, V-19, V-401  
tunable notch filter with, II-400  
V- and I-protected, V-25  
variable gain, II-405, V-102  
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, V-404-  
  409  
50 kHz center frequency FM  
  transmitter, II-417  
ac relay, III-418  
  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  
couplers/optocouplers, II-409, II-417  
  analog coupler, linear ac, II-412  
  analog coupler, linear, II-413  
  CMOS design, III-414  
  dc linear coupler, II-411  
  instrumentation, linear, II-417  
  optocouplers, II-409, II-417  
  stable, II-409  
  TTL design, III-416  
dc latching relay, III-417  
digital transmission isolator, II-414  
direction discriminator, V-408  
high-sensitivity, NO, two-terminal  
  zero voltage switch, II-414  
indicator lamp driver, III-413  
integrated solid state relay, II-408  
interfaces,  
  optocouplers/optoisolators,  
    V-406-407  
interruption sensor, IV-366  
isolation and zero voltage switching  
  logic, II-415  
isolators/optoisolators, IV-475  
  driver, high-voltage, III-482  
  telephone status monitor using,  
    I-626  
light-detector, IV-369  
line-current detector, III-414  
microprocessor triac array driver,  
  II-410  
optocoupler, V-407  
  interface circuits, V-406-407  
optoisolator  
  interface circuits, V-406-407  
  relay circuit, IV-475  
paper tape reader, II-414  
photoelectric light controller,  
  IV-369  
photoreceiver, optimized  
  noise/response, V-405  
phototransistors  
  amplifier, V-409  
  variable-sensitivity, V-409

power outage light, line-operated,  
  III-415  
probe, IV-369  
proximity detector, V-405  
pyrometer, I-654  
receivers, I-364, II-418  
  50 kHz FM optical transmitter,  
    II-418  
  light receiver, IV-367  
  optical or laser light, IV-367,  
    IV-368  
relays, III-412, III-417, III-418  
  dc solid-state, open/closed, III-412  
  safety-circuit switch, V-409  
Schmitt trigger, I-362  
sensor, ambient light ignoring,  
  III-413  
sensor-to-TTL interface, III-314  
source follower, photodiode,  
  III-419  
telephone ring detector, III-611  
transmitter, I-363, I-367, IV-368  
  light transmitter, IV-368  
triggering SCR series, III-411  
TTL coupler, optical, III-416  
zero-voltage switching  
  closed half-wave, III-412  
  solid-state, III-410  
  solid-state relay, III-416  
optocouplers (*see* optical circuits,  
  couplers)  
optoisolators (*see* optical circuits,  
  isolators)  
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, V-410-421  
  1 kHz, II-427  
  10 MHz, I-571  
  2 MHz, 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  
  AF power oscillator, V-412  
  astable, I-462, V-420  
  audio, I-245, III-315, III-427,  
    IV-374, IV-375  
  audio-frequency generator, V-416-  
    417  
  audio-test oscillator, V-420  
  basic designs, V-414  
  beat-frequency audio generator,  
    IV-371  
  buffer circuits, IV-89  
Butler  
  aperiodic, I-196  
  common base, I-191  
  crystal, I-182

emitter follower, II-190-191, II-194  
 cassette bias, II-426  
 clock generator, I-615, III-85  
 CMOS, I-615, III-429, III-430  
   1 MHz to 4MHz, I-199  
   crystal, I-187  
 code practice, I-15, I-20, I-22, II-428, III-431, IV-373, IV-375, IV-376, V-100-103  
 Colpitts crystal oscillators, I-194, I-572, II-147, V-411  
   1-to-20 MHz, IV-123  
   frequency checker, IV-301  
   harmonic, I-189-190  
   two-frequency, IV-127  
 crystal (*see* crystal oscillators)  
 double frequency output, I-314  
 discrete sequence, III-421  
 duty cycle  
   50-percent, III-426  
   variable, fixed-frequency, III-422  
 emitter-coupled  
   big loop, II-422  
   RC, II-266  
 exponential digitally controlled, I-728  
 feedback, I-67  
 flasher and oscillator  
   high-drive, II-235  
   low-frequency, II-234  
 free-running, I-531  
   square wave, I-615  
 frequency doubled output from, II-425, II-596  
 frequency switcher, V-418  
 gated, I-728, V-413, V-419  
   last-cycle completing, III-427  
 Hall effect circuits, V-222  
 Hartley, I-571, V-140  
 hc-based, III-423  
 HCU/HCT-based, III-426  
 high-current, square-wave generator, III-585  
 high-frequency, III-426  
   crystal, I-175, II-148  
 LC audio oscillator, V-411  
 LF oscillator, V-413  
 light-controlled, V-279  
 load-switching, 100 mA, I-730  
 local-oscillator, double-balanced mixer, V-415  
 low-distortion, I-570  
 low-duty-cycle pulse circuit, IV-439  
 low-frequency oscillators, III-428  
   crystal, I-184, II-146  
   oscillator/flasher, II-234  
   Pierce oscillator, III-133  
   TTL oscillator, II-595  
 low-noise crystal, II-145  
 Miller, I-193  
 MOSFET mixer/oscillator for AM receivers, V-412  
 NE602 local oscillator, V-411  
 neon flasher, two-state, III-200  
 one-second, 1 kHz, II-423  
 one-shot, voltage-controlled high-speed, II-266  
 overtone oscillators, I-176, I-177, I-180, I-183, I-186, II-146, III-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  
 phase-locked, 20-MHz, IV-374  
 Pierce oscillator, V-140  
   1-MHz, III-134  
   crystal, II-144  
   harmonic, I-199, II-192  
   JFET, I-198  
   low-frequency, III-133  
 quadrature, I-729, III-428  
   square-wave generator, III-585  
 quartz, III-136  
 R/C, I-612  
 reflection, crystal-controlled, III-136  
 relaxation, IV-376  
   SCR, III-430  
 resistance-controlled digital, II-426  
 rf oscillators, I-550-551, I-572, V-528-532  
   6.5 MHz VFO, V-529  
   5 MHz VFO, II-551  
   ham band VFO, V-532  
   NE602 circuit, V-531  
   rf-gcnic, II-421  
   shortwave pulsed-marker, V-532  
   sidetone, rf-powered, I-24  
   signal generator, V-530-531  
   test oscillator, V-412  
   transmitter and, 27MHz and 49MHz, I-680  
 RLC, III-423  
 sawtooth wave, modulator, III-373  
 Schmitt trigger crystal, I-181  
 sine-wave (*see* sine-wave oscillators)  
   sine-wave/square wave, tunable, I-65, III-232, IV-512  
   single op amp, I-529  
   siren oscillator, V-567  
   square-wave, I-613-614, II-597, II-616, IV-532, IV-533, V-569  
   0.5 Hz, I-616  
   1kHz, I-612  
   astable multivibrator and, V-386  
   start-stop oscillator pulse circuit, IV-438  
   switch, oscillator-triggered, V-590  
   switching, 20 ns, I-729  
   temperature-compensated, III-137  
   crystal, I-187  
   low-power 5V-driven, II-142  
   temperature-stable, II-427  
   third overtone, I-186, IV-123  
 time base, crystal, III-133, IV-128  
 timer, 500 timer, I-531  
 tone-burst, decoder and, I-726  
 transmitter and, 27 MHz and 49 MHz rf, I-680  
 triangle-wave oscillator, V-205  
 triangle/square wave, I-616, II-422  
 TTL, I-179, I-613, IV-127  
   1MHz to 10MHz, I-178  
   1MHz to 20MHz, IV-127  
   crystal, TTL-compatible, I-179  
   sine wave/square oscillator, IV-512  
   television display using, II-372  
 tube type crystal, I-192  
 tunable frequency, II-425  
 tunable single comparator, I-69  
 varactor tuned 10 MHz ceramic resonator, II-141  
 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, I-730, II-429  
 variable-duty cycle, III-422, V-419  
 variable-frequency oscillator (*see* variable-frequency oscillators (VFO))  
 VHF crystal oscillator  
   20-MHz, III-138  
   50-MHz, III-140  
   100-MHz, III-139  
 voltage-controlled (VCO) (*see* voltage-controlled oscillators)  
 wide-frequency range, II-262  
 wide-range, I-69, III-425  
 variable, I-730, II-429  
 Wien-bridge oscillators, I-62-63, I-66, I-70, II-566, III-429, III-558, IV-371, IV-377, IV-511, V-415, V-419  
 CMOS chip in, II-568  
 low-distortion, thermally stable, III-557  
 low-voltage, III-432  
 sine wave, I-66, I-70, II-566, IV-510, IV-513  
 single-supply, III-558  
 thermally stable, III-557  
 three-decade, IV-510  
 variable, III-424  
 very-low-distortion, IV-513  
 XOR-gate, III-429  
 yelp, II-577  
 oscilloscopes, II-430-433, III-433-439, V-422-426  
 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

- oscilloscopes (*cont.*)  
 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, V-423  
   counter, III-438  
   instrumentation amplifiers,  
   IV-230-231  
 sensitivity amplifier, III-436  
 spectrum analyzer adapter, V-424  
 timebase generator, V-425  
 trigger selector for timebase, V-425  
 triggered sweep, III-438  
 variable-gain amp, V-426  
 voltage-level dual readout, IV-108  
 outband descrambler, II-164  
 out-of-bounds pulse-width detector,  
 III-158  
 outlet tester, V-318  
 output limiter, III-322  
 output-gating circuit,  
   photomultiplier, II-516  
 output-stage booster, III-452  
 over/under temperature monitor,  
   dual output, II-646  
 overload indicator, V-478  
 overload protector, speaker, II-16  
 overspeed indicator, I-108  
 overtone oscillators, I-176, I-177,  
   I-180, I-183, I-186, II-146, III-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 protection, I-150, I-517,  
   II-96, II-107, II-496, III-513,  
   III-762, IV-389, V-480  
   comparator to detect, II-107  
   monitor for, III-762  
   protection circuit, II-96, II-496,  
   III-513  
   undervoltage and, indicator, I-150,  
   III-762
- 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  
 password protection circuit, PCs,  
 V-109  
 pattern generator/polar-to-  
   rectangular converter for radio  
   direction, V-288  
 PCB continuity tester, II-342, II-535  
 peak detectors, II-174, II-175, II-434-  
   436, III-771, IV-138, IV-143  
   analog, with digital hold, III-153  
   closed-loop, V-153  
   decibel peak meter, III-348  
   digital, III-160  
   high-bandwidth, III-161  
   high-frequency peak, II-175  
   high-speed peak, I-232  
   LED design, peak meter, III-333  
   level detector, I-402  
   low-drift, III-156, V-155  
   negative, I-225, I-234, V-154  
   op amp, IV-145  
   open-loop, V-153  
   positive, I-225, I-235, II-435, III-169  
   true rms, I-228  
   ultra-low-drift peak, I-227  
   voltage, precision, I-226  
   wide-bandwidth, III-162  
   wide-range, III-152  
 peak program detector, III-771  
 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,  
   V-427-428  
 pH meters/probe, I-399, III-501  
 phase detection/manipulation  
 circuits  
   detectors, I-406, I-476, II-344,  
   II-439, II-441, II-442, III-440-442,  
   IV-127  
   10-bit accuracy, II-176  
   digital VOM, IV-277  
   phase-difference detector, 0- to  
   180-degree, II-344  
 phase selector/sync  
   rectifier/balanced modulator,  
   III-441  
 sequencers, phase sequence, I-476,  
 II-437-442, III-441  
   rc circuit, phase sequence  
   reversal detection, II-438  
   reversal, rc circuit to detect, II-438  
   three-phase tester, II-440  
 shifters, phase shifters, IV-647,  
 V-429-431  
   0-180 degree, I-477  
   0-360 degree, I-477  
   eight-output, V-431  
   single-transistor design, I-476  
 splitter, III-582, V-430  
   long-tail pair, V-430  
 phase-locked loop, V-347  
 tracker, three-phase square wave  
   generator, II-698  
 phasor gun, I-606, IV-523  
 phonograph-related circuits (*see*  
   stereo/phonograph circuits)  
 photo-conductive detector amplifier,  
 four quadrant, I-359  
 photo memory switch for ac power  
 control, I-363  
 photo stop action, I-481  
 photodiode/photoelectric circuits  
   ac power switch, III-319  
   alarm system, I-13, II-4  
   amplifiers, I-361, III-19, II-324,  
   III-672  
   battery charger, solar, II-71, V-327  
   comparator, precision, I-360  
   controller, IV-369  
   current-to-voltage converter, II-278  
   flasher, photocell-controlled,  
   II-232  
   integrator, photocurrent, II-326  
   level detector, precision, I-365  
   light controller, IV-369  
   monostable photocell, self-adjust  
   trigger, II-329  
   output-gating circuit,  
   photomultiplier, II-516  
 PIN, thermally stabilized signal  
 conditioner with, II-330  
 PIN-to-frequency converters, III-120  
 preamplifier for IR photodiode,  
 V-226  
   sensor amplifier, II-324  
 smoke alarm/detectors, I-595, I-  
 596  
 source follower, III-419  
 switches, II-321, II-326, III-318,  
 III-319  
 photoelectric sensor, V-277  
 photography-related circuits, II-443-  
 449, III-443-449, IV-378-382,  
 V-432-438  
   auto-advance projector, II-444  
   camera alarm trigger, III-444  
   camera trip circuit, IV-381  
   contrast meter, II-447  
   darkroom enlarger timer, III-445  
   darkroom timer, V-436  
   electronic flash trigger, II-448,  
   III-449  
   enlarger exposure meter, V-438  
   enlarger light meter, V-434-435  
   enlarger timer, II-446  
   exposure meter, I-484, V-438  
   flash meter, III-446  
   flash slave driver, I-483  
   flash slave unit, V-433  
   flash triggers  
     electronic, II-448  
     remote, I-484  
   sound-triggered, II-449  
   time delay, V-433  
   xenon flash, III-447

- light meter, enlargers, V-434-435
- photo-event timer, IV-379
- photoflash, electronic, III-449
- picture fixer/inverter, III-722
- shutter speed tester, II-445
- slave-flash unit trigger, IV-380, IV-382, V-433, V-436
- slide projector auto advance, IV-381
- slide-show timer, III-444, III-448
- sound trigger for flash unit, II-449, IV-382
- strobe, V-435, V-436, V-437
- time-delay flash trigger, IV-380, V-433
- photomultipliers
  - high-voltage power supply, V-444, V-445
- phototransistor, V-279
  - amplifier, V-409
  - variable-sensitivity, V-409
  - timer, I-485
  - xenon flash trigger, slave, III-447
- picoammeters, I-202, II-154, III-338
  - circuit for, II-157
  - guarded input circuit, II-156
  - picture fixer/inverter, III-722
- Pierce oscillators, V-140
  - 1-MHz, III-134
  - crystal, I-195, II-144
  - harmonic, I-199, II-192
  - JFET, I-198
  - low-frequency, III-133
- piezoelectric circuits
  - 439-441
  - alarm, I-12, V-10
  - drivers, V-440
  - 555 oscillator, V-441
  - CMOS, V-440
  - micropositioner, V-440
  - temperature controller, fan-based, III-627
- PIN photodiode-to-frequency converters, III-120
- pink noise generator, I-468
- pipe detector, metal pipes, V-323
- plant-watering accessories, I-443, II-245, II-248
- playback amplifier, tape, I-77
- PLL/BC receiver, II-526
- pocket pager, III-288
- polar-to-rectangular
  - converter/pattern generator, radio direction finder, V-288
- polarity converter, I-166
- polarity gain adjustment, op amp circuit, V-400
- polarity indicator, V-231
- polarity-protection relay, IV-427
- polarity-reversing amplifiers, low-power, III-16
- poller, analog-to-digital converters, V-28
- polynomial generator, V-287
- position indicator/controller, tape recorder, II-615
- positive input/negative output charge pump, III-360
- positive regulator, NPN/PNP boost, III-475
- potentiometers, digital control, V-158
- power amplifiers, 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
  - 20-W, III-456
  - 50-W, III-451
  - 6-W, with preamp, III-454
  - booster, II-455
- bridge audio, I-81
- bull horn, II-453
- class-D, III-453
- GaAsFET with single supply, II-10
- hybrid, III-455
- inverting, I-79
- low-distortion, 12 W, I-76
- low-power audio, II-454
- noninverting, I-79
- op amp/audio amp, high-slew rate, I-82
- output-stage booster, III-452
- portable, III-452
- rear speaker ambience amplifier, II-458
- rf power amplifier
  - 1296-MHz solid state, III-542
  - 5W, II-542
  - 600 W, I-559
  - switching, I-33
  - two-meter 10 W, I-562
- walkman amplifier, II-456
- power supplies (*see also* voltage indicators/meters), II-460-486, III-464, V-448-472
  - +1.5-V supply for ZN416E circuits, V-469
  - +5 V supply, V-471
  - $\pm 5$  to  $\pm 35$  V tracking, V-469
  - 0- to 12-V, V-1 A variable, V-460
  - 13.8-Vdc, V-2 A regulated, V-459
  - 20-V adjustable, V-461
  - 5V power supply with momentary backup, II-464
  - 5V, 0.5A power supply I-491
  - 8- from 5-V regulator, V-469
  - 2,000 V low-current supply, IV-636-637
  - AA cells, +5 V/+3.6 V, V-452
  - ac outlet tester, V-318
  - ac wiring locator, V-317
  - ac-watts calculator, V-304
  - adjustable current limit and output voltage, I-505
  - adjustable 20-V, V-461
  - amplifiers, audio, dual power supply, V-465
  - subwoofer power supply, V-464
  - antique radio dc filament supply, V-470
  - arc lamp, 25W, II-476
  - arc-jet, starting circuit, III-479
  - automotive-accessory power controller, V-70
  - backup supply, drop-in main-activated, IV-424
  - balance indicator, III-494
  - battery (*see* battery-related circuits)
    - battery charger and, 14V, 4A, II-73
    - battery power pack, I-509
  - bench top, II-472
  - benchmark, dual output, I-505
  - bipolar
    - battery instruments, II-475
    - tracking double-output, V-449
  - booster, I-28, I-33, V-349
  - buck regulator, add 12-V output to 5-V, V-472
  - charge pool, III-469
  - configurable, V-455
  - connections-monitor, ac lines, III-510
  - consumption limiters, III-572
  - consumption monitor, V-290
  - controllers, IV-383-389, V-111-115
    - ac switches, IV-387, V-112, V-115
    - ac voltage control, V-114
    - automotive-accessory power, V-70
    - bang-bang controllers, IV-389
    - burst-type control, III-362
    - current-loop control, SCR design, IV-387
    - dual-control ac switch, V-115
    - high-side switches, 5 V supplies, IV-384, IV-385
    - monitor, SCR design, IV-385
    - MOSFET switch, IV-386
    - overvoltage protection, I-150, I-517, II-96, II-107, II-496, III-513, III-762, IV-389
    - power controller, universal design, IV-388
    - power-down circuit, V-114
    - pushbutton switch, IV-388
    - three-phase, power factor control, II-388
  - converter, inductorless, V-456
  - current limiter, V-146, V-358, V-458
  - current sources, I-205, I-697, V-141-143
    - 0-to-200-nA, IV-327
    - bilateral, III-469, I-694-695, V-143
    - bipolar sources, I-695, I-697

- power supplies (*cont*)
  - constant, I-697, III-472
  - fixed power supplies, IV-405, IV-406
  - low-current source, IV-399
  - low-resistance, V-142
  - negative, V-143
  - offset-adjusting, V-145
  - positive, V-142
  - precision, I-205, I-206
  - regulator, variable power supply, III-490
  - variable power supplies, voltage-programmable, IV-420
  - voltage-controlled, grounded source/load, III-468
- dc-to-dc SMPS variable 18 V to 30 V out at 0.2A, II-480
- dc power circuit, NE602-based, V-358
- delay circuit, V-148
- disconnecter, low-voltage, II-97
- dual polarity, I-497
- dual power supply, amplifiers, V-465
- failure/outage alarms/monitors, I-581-582, II-107, II-486, II-175, II-491-497, III-493-495, III-511, 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
- connections monitor, ac lines, III-510
- fault monitor, single-supply, III-495
- memory protector/supply monitor, IV-425
- polarity-protection relay, IV-427
- SCR design, IV-385
- test load, constant-current, IV-424
- triac for ac-voltage control, IV-426
- tube amplifier, high-voltage isolation, IV-426
- voltage sensor, IV-423
- fixed power supplies (*see* fixed power supplies)
- frequency, power/frequency meter, II-250
- fuses, V-477, V-478
- gain, power-gain test circuit, 60 MHz, I-489
- 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
- inductorless converter, V-456
- inverters, III-298, V-457
- 12 VDC-to-117 VAC at 60 Hz, III-294
  - medium, III-296
  - MOSFET, III-295
- isolated feedback, III-460
- isolation transformer, V-349, V-470
- laptop-computer supply, V-463
- laser power supplies, IV-636, V-251, V-252, V-253, V-254
- level sensor, voltage level, III-770
- loss detector, II-175
- low-ripple, I-500
- LTC, single supply, V-454
- meters, power meters, I-489
  - audio, I-488
  - frequency and, II-250
  - rf, I-16
  - SWR, I-16
- memory save on power-down, II-486, IV-425
- micropower bandgap reference, II-470
- microprocessor power supply watchdog, II-494
- modem, power-line, III-82
- 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
  - connections monitor, ac lines, III-510
  - fault monitor, single-supply, III-495
  - memory protector/supply monitor, IV-425
  - polarity-protection relay, IV-427
  - SCR design, IV-385
  - test load, constant-current, IV-424
  - triac for ac-voltage control, IV-426
  - tube amplifier, high-voltage isolation, IV-426
  - voltage monitors (*see* voltage indicators/meters)
- multivoltage supply, V-458
- negative supply, V-457
- neon lamp driver, V-5- to 15-V supplies, V-459
- outage light, line-operated, III-415
- overload indicator, V-478
- overvoltage protection, I-150, I-517, II-96, II-107, II-496, III-513, III-762, IV-389, V-480
- power-down circuit, V-114
- programmable, III-467
- protection circuits, I-515, I-518, II-98, II-107, II-474, II-486, II-496, II-497, III-511, IV-425, IV-427
- push-pull, 400V/60W, II-473
- rectifiers, V-464, V-466
- reference, 0-to-20 V, I-694
- regulated power supplies
  - 8-amp, for mobile equipment operation, II-461
  - 10 A, current and thermal protection, II-474
  - 12-14 V, 3A, II-480
  - 13.8-Vdc, V-2 A, V-459
  - +15V 1-A, III-462
  - 15V 1-A, III-463
  - split, I-492
- regulator loss cutter, V-467
- regulators (*see* voltage regulators)
- reset circuit, II-366
- short-tester, V-313, V-315
- split, I-512
- stand-by, non-volatile CMOS RAMs, II-477
- subwoofer amplifier power supply, V-464
- supply-voltage monitor, V-320
- switching power supplies, II-466, II-470, III-458, V-453, V-461, V-462, V-468
  - 50-W off-line, III-473
  - 500 kHz switching inverter for 12V, II-474
  - complementary ac switch, I-379
  - power-switching circuit, II-466
  - variable, 100-KHz multiple-output, III-488
- synchronous stepdown switching regulator, V-468
- telecom converter -48 to +5 V at 1 A, V-472
- three-rail, III-466
- undervoltage detector/monitor, III-762, IV-138
- uninterruptible, II-462, III-477, V-471
- universal laboratory supply, V-450-451
- variable power supplies, III-487-492, IV-414-421
  - 0- to 12-V, V-1 A, V-460
  - current source, voltage-programmable, IV-420
- dc supplies, IV-418
- dual universal supply, 0-to-50 V, 5 A, IV-416-417
- 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
- voltage regulators for variable supplies, III-490, III-492, IV-421

voltage doubler, V-460  
 voltage probes, V-474  
 voltage/current regulator, V-455  
 voltage regulators (*see* voltage regulators)  
 voltage sensor, power supplies, IV-423  
 voltage-level, III-770  
 voltage sources  
   millivolt, zenerless, I-696  
   programmable, I-694  
   voltage splitter, III-738  
 preamplifiers, I-41, V-26  
   antenna preamp  
     HF broadband, V-36  
     loop antenna, V-38  
     VLF 60-kHz, V-33  
     wideband, V-35  
   6-meter, 20 dB gain and low-NF, II-543  
   1000x, low-noise design, IV-37  
   audio preamplifiers, II-45  
     2- to 6-watt, II-451  
     6-W and, III-454  
   audio-to-UHF preamp, V-24  
   bias supply, IV-318  
   dual audio signal amplifiers, V-58  
   electret microphone preamp, V-21  
   equalized, for magnetic phono cartridges, III-671  
   frequency counter/divider, III-128, V-24  
   GaAsPET, rf amplifiers, V-516  
   general purpose, I-84, IV-42  
   handtalkies, two-meter, I-19  
   HF, rf amplifiers, V-515  
   IF, 30 MHz, IV-460  
   IR photodiode preamp, V-226  
   impedance-matching, IV-37  
   instrumentation amplifier, IV-230-231  
   JFET, V-22  
   light-beam activated alarm circuit, V-13  
   LM382 phono, I-91  
   low-noise, I-88, I-561, IV-41  
   magnetic, I-89, I-91, III-37, III-673, IV-35, IV-36  
   medical instrument, II-349  
   microphone preamplifiers, II-45, IV-37, IV-42  
   low-impedance, IV-41  
   tone control for, II-687  
   transformerless, unbalanced input, I-88  
   transformerless, unbalanced input, I-88  
   microwave preamplifiers, IV-316-319  
   mixers, I-58  
   NAB preamplifiers  
     tape playback, professional, III-38  
     record, III-673  
     two-pole, III-673  
   oscilloscope preamplifiers, III-437, III-438, IV-230-231, V-423  
   oscilloscope/counter, III-438  
   power amplifier with preamp, II-451, III-454  
   read-head, automotive circuits, III-44  
   receiver interface, V-243  
   rf amplifiers, V-526, V-527  
   RIAA, III-38  
   RIAA/NAB compensation, I-92  
   stereo/phonograph preamps, I-91, II-43, II-45, V-584  
   low-noise, IV-36  
   magnetic, I-91, III-37, III-673, IV-35, IV-36  
   tone control, V-581  
   tape, I-90  
   thermocouple instrumentation amplifier, III-283  
   tone control preamplifiers, I-675  
     high-level, II-688  
     IC, I-673, III-657  
     mixer, I-58  
   transmit/receive sequencer, V-348  
   UHF-TV, III-546  
   ultra-low-leakage, I-38, II-7  
   VHF, I-560  
   VHF/UHF, rf amplifiers, V-515  
   video, V-660  
   preregulators  
     high-voltage power supplies, III-480  
   tracking, III-492  
   prescalers  
     data circuits, low-frequency, IV-132  
     probe, amplifying, 650 MHz, II-502  
   preselectors, rf amplifiers, IV-483, IV-485, IV-488  
   pressure gauge, V-314  
   printer-error alarm, computer circuits, IV-106  
   printers  
     printer-error alarm, IV-106  
     printer sentry, computer circuits, V-107-108  
     two-sheets in printer detector, IV-136  
   probes (*see also* measurement/test circuits), II-498-504, II-496-503, IV-428-434, V-473-474  
   100 K megohm dc, I-524  
   ac hot wire, I-581  
   audible TTT, I-524  
   audio-rf signal tracer, I-527  
   capacitance buffer  
     low-input, III-498  
     stabilized low-input, III-502  
   clamp-on-current compensator, II-501  
   CMOS logic, I-523  
   FET, III-501  
   general purpose rf detector, II-500  
   ground-noise, battery-powered, III-500  
   logic 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  
   microvolt, II-499  
   optical light probe, IV-369  
   pH, I-399, III-501  
   prescaler, 650 MHz amplifying, II-502  
   rf, I-523, III-498, III-502, IV-433  
   single injector-tracer, II-500  
   test, 4-220V, III-499  
   three-in-one test set: logic probe, signal tracer, injector, IV-429  
   tone, digital IC testing, II-504  
   universal test probe, IV-431  
   process control interface, I-30, V-242  
   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/programming, III-506  
   programmable-gain, selectable input, I-32  
   variable gain, wide-range digital control, III-506  
   projectors (*see* photography-related circuits)  
   protection circuits, II-95-99, III-509-513, V-475-483  
     12ns circuit breaker, II-97  
     automatic power down, II-98  
     circuit breakers  
       ac, III-512  
       electronic, high-speed, II-96  
       compressor protector, IV-351  
       crowbars, electronic, II-99, III-510  
       ear protector, V-482  
       fuse, electronic, V-477  
       halogen lamp protector, V-271  
       heater protector, servo-sensed, III-624  
       line protectors, computer I/O, 3  $\mu$ P, IV-101  
     line dropout detector, II-98  
     line-voltage monitor, III-511  
     loudspeaker protector, V-483  
     low-voltage power disconnecter, II-97  
     modem protector, V-479  
     modem/fax protector for two computers, V-482

protection circuits (cont.)  
optical safety-circuit switch, V-409  
overload indicator, V-478  
overvoltage protection, I-150,  
I-517, II-96, II-107, II-496,  
III-513, III-762, IV-389, V-480  
password protection for PCs, V-109  
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  
relay fuse, V-478  
reset-protection for computers,  
IV-100  
safety circuit, V-477, V-483, V-589  
timed, V-481  
short-tester, V-313, V-315  
shutdown circuits, V-537-538  
speaker protector, V-476, V-479  
proximity sensors (*see*  
motion/proximity detectors)  
pseudorandom sequencer, III-301,  
V-351  
pulse circuits, IV-435-440  
amplitude discriminator, III-356  
coincidence detector, II-178  
converters  
height-to-width, III-119  
pulse train-to-sinusoid converters,  
III-122  
counter, ring counter, low-power,  
IV-437  
delay, dual-edge trigger, III-147  
detectors  
fast pulse, V-154  
russing pulse, V-152  
out-of-bounds pulse width, III-158  
sequence detector, II-172  
divider, non-integer programmable,  
II-511, III-226  
extractor, square-wave, III-584  
generators, pulse generators,  
II-508-511, V-487-492  
2-ohm, III-231  
300-V, III-521  
555-circuit, IV-439  
add-on, V-488  
astable multivibrator, II-510  
basic, V-488  
clock, 60Hz, II-102  
CMOS short-pulse, III-523  
delayed-pulse, II-509, IV-440,  
V-492  
divider, programmable, II-511,  
III-226  
EEPROM, 5V-powered, III-99  
free running, IV-438  
interrupting pulse-generation, I-357  
logic, III-520, V-489  
logic troubleshooting applications,  
IV-436

one-shot, V-490-491  
programmable, I-529  
sawtooth-wave generator and,  
III-241, V-491  
single, II-175  
train, pulse train, IV-202  
transistorized, IV-437  
two-phase pulse, I-532  
unijunction transistor design, I-530  
variable duty cycle, V-492  
very low-duty-cycle, III-521  
voltage-controller and, III-524  
wide-ranging, III-522  
missing-pulse detector, V-152  
modulators  
pulse-position, III-375  
pulse-width (PWM), III-376, IV-326  
brightness controller, III-307  
control, microprocessor  
selected, II-116  
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  
oscillators  
fast, low-duty-cycle, IV-439  
start-stop, stable design, IV-438  
pulse-position modulator, III-375  
stretchers, IV-440  
negative pulse stretcher, IV-436  
positive pulse stretcher, IV-438  
supply circuit, high-voltage power  
supplies, IV-412  
width, out-of-bounds pulse width  
detector, III-158  
pulse-dialing telephone, III-610  
pulse-width-to-voltage converters,  
III-117  
pulse-width modulators (PWM),  
III-376, IV-326  
brightness controller, III-307  
control, microprocessor selected,  
II-116  
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  
putup circuits  
controller, single chip, II-247

positive input/negative output  
charge, I-418  
push switch, on/off, electronic, II-359  
push-pull amplifier, Darlington, V-22  
push-pull power supply, 400V/60W,  
II-473  
pushbutton power control switch,  
IV-388  
PUT circuits  
battery chargers, III-54  
long-duration timer, II-675  
pyrometer, optical, I-654

## Q

Q-multipliers  
audio, II-20  
transistorized, I-566  
QRP circuits  
18-, V-21-, V-24-MHz, V-644-645,  
V-644  
CW transmitter, III-690  
sidetone generator/code practice  
oscillators, V-102  
SWR bridge, III-336  
transmitters, V-10-M DSB with  
VFO, V-638-639  
quad op amp, simultaneous  
waveform generator using,  
II-259  
quadrature oscillators, III-428  
square-wave generator, III-585  
quiz master game, V-210

## 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  
radio/rf circuits  
AM radio  
car-radio to short-wave radio  
converter, IV-500  
demodulator, II-160  
power amplifier, I-77  
receivers, II-525, III-81, III-529,  
III-535, IV-455, V-496, V-497,  
V-502  
AM/FM radio  
clock radio, I-543  
squelch circuit, II-547, III-1  
amateur radio, III-260, III-534,  
III-675  
transceiver relay interface, V-243  
VFO, V-532  
voice identifier, V-550  
amplifiers (*see* rf amplifiers)

- antique radio dc filament power supply, V-470
  - attenuator, IV-322
  - automotive receiver, II-525
  - bridge, V-50-MHz bridge circuit, V-303
  - broadband, II-546, III-264, IV-271
  - burst generators, portable, III-73
  - calibrator, V-298
  - 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
    - receivers, I-141, I-143, I-145, I-146
    - relay, I-575, IV-461
    - remote control, I-146
    - transmitters, I-144
      - IC, I-145
      - on/off 200kHz line, I-142
  - clock, I-542
  - converters, IV-494-501
    - ATV receiver/converter, 420 MHz, low-noise, IV-496, IV-497
    - radio beacon converter, IV-495
    - receiver frequency-converter stage, IV-499
  - SW converter for AM car radio, IV-500
  - two-meter, IV-498
  - up-converter, TVRO subcarrier reception, IV-501
  - VLF converter, IV-497, V-121
  - WWV for car radio, V-119
  - WWV-to-SW converter, IV-499
  - receiving converter, 220 MHz, IV-500
- current readout, I-22
  - CW-related circuits
    - filter, razor sharp, II-219
    - keying circuits, IV-244
    - offset indicator, IV-213
    - SSB/CW product detector, IV-139
    - SSB/CW receiver, V-499
    - transceiver, 5 W, 80-meter, IV-602
    - transmitters, III-678, III-684, III-686, III-690, IV-601
  - detector, II-500, IV-433
  - direction finder, radio signals, IV-148-149
    - polar-to-rectangle converter/pattern generator, V-288
  - double-sideband suppressed-carrier
    - modulator, III-377
    - rf, II-366
  - FM radio, I-545
    - 5 V, I-233
    - 12 V, I-233
  - clock radio, AM/FM, I-543
  - demodulators, I-544, II-159, II-161
  - IF amplifier with quadrature detector, TV sound IF, I-690
  - generators, low-frequency, III-228
  - receivers, I-338, I-361, III-80, III-530, III-532, V-495
  - snooper, III-680
  - speakers, remote, carrier-current system, I-140
  - squelch circuit for AM, I-547
  - stereo demodulation system, I-544, II-159
  - transmitters, I-361, I-367, I-681, II-417, III-687-688, IV-228
  - tuner, I-231, III-529
  - wireless microphone, III-682, III-685, III-691
- genie, II-421
  - input circuits, NE602, V-500
  - measurement/test circuits, IV-297-303, V-412
  - modulators, I-436, II-369, III-372, III-374
  - oscillators, I-550-551, I-572, V-528-532
    - 5 MHz VFO, II-551
    - 6.5 MHz VFO, V-529
    - ham band VFO, V-529
    - NE602 circuit, V-531
    - transmitter and, 27MHz and 49MHz, I-680
  - rf-genie, II-421
  - shortwave pulsed-marker, V-532
  - sidetone, rf-powered, I-24
  - signal generator, V-530-531
  - output indicator, IV-299
  - power meters, I-16, I-24, III-332, III-592
  - portable-radio 3 V fixed power supplies, IV-397
  - probe, I-523, III-498, III-502
  - radio beacon converter, IV-495
  - radio-commercial zapper, V-334-335
- receivers
    - AM radio, II-525, III-81, III-529, III-535, IV-455, V-496, V-497, V-502
    - automotive receiver, II-525
    - carrier-current, I-141, I-143, I-145, I-146
    - CW/SSB receiver, V-80- and 40-meter, V-499
    - data receiver, IV-93
    - FM radio, I-338, I-361, III-80, II-529, III-530, III-532, V-495
    - old-time design, IV-453
    - radio-control receiver/decoder, I-574
    - reflex radio receiver, IV-452
    - short-wave receiver, IV-454
    - superheterodyne, V-503
    - TRF radio receiver, IV-452
    - VLF whistler, V-496
  - shortwave transmissions
    - converters, III-114, IV-500
    - FET booster, I-561
    - receiver, IV-454
  - 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
    - signal tracer probe, audio, I-527
    - sniffer, II-210
    - static detector, IV-276
    - superheterodyne receivers, V-503
    - switch, low-cost, III-361
    - VHF/UHF diode switch, IV-544
    - VLF converter, V-121
    - VLF whistler receiver, V-496
    - voltmeter, I-405, III-766
    - WWV converter for car radio, V-119
  - radio beacon converter, IV-495
  - radio-control circuits (*see also* remote control devices)
    - 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
    - 555 based, V-203
    - 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
  - RC decade box, V-294-295
  - reaction timer, IV-204
  - read-head pre-amplifier, automotive circuits, III-44
  - readback system, disc/tape phase modulated, I-89
  - receivers, (*see also* transceivers; transmitters),
    - II-524-526, III-528-535, IV-448-460, V-493-503
  - 50kHz FM optical transmitter, I-361
  - acoustic-sound receiver, IV-311
  - AGC system for CA3028 IF amplifier, IV-458

- delay and controls closure time, II-530
  - with strobe, I-266
- fuse, V-478
- latching relay, solid-state, V-505
- light-beam operated on/off, I-366
- light-sensitive, V-278
- monostable relay, low-consumption design, IV-473
- optically coupled relays
  - ac, III-418
  - dc latching, III-417
- optoisolator, IV-475
- polarity-protection for power supplies, IV-427
- pulsar, sensor-activated, V-507
- rf-actuated, III-270
- ringer, telephone, III-606
- solid-state relays, I-365, I-623, II-408, III-412, III-416, III-569-570, IV-472, IV-474, V-505-506
- sound actuated, I-576, I-610
- telephone, I-631
- time delayed, I-219, I-663, V-506
- tone actuated, I-576
- TR circuit, II-532
- triac, contact protection, II-531
- remote control devices (*see also* infrared; radio-control circuits), IV-224, V-229, V-508-513
- A/B switch, IR-controlled, V-225
- ac switch hookup, two-way, V-592
- amplifier, I-99
- analyzer, V-224
- carrier, current, I-146
- drop-voltage recovery for long-line systems, IV-328
- extender, infrared, IV-227, V-512
- fax/telephone switch, IV-562-563
- infrared circuit, IV-224
- lamp or appliance, I-370
- loudspeaker via IR link, I-343
- loop transmitter for, III-70
- on/off switch, I-577
- receiver, V-510, V-513
- 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, V-228, V-229
- thermometer, II-659
- transmitter, V-509, V-513
  - interface, V-511
  - ultrasonic, V-512
- transmitter/receiver, IR, I-342
- video switch, IV-619-621
- repeaters
  - beeper, I-19
  - European-type, tone burst generator for, III-74
- fiber optic link, I-270
- telephone, III-607
- reset buttons
  - child-proof computer reset, IV-107
  - power-on, II-366
  - protection circuit for computer, IV-100
- resistance controller, digital, V-159
- resistance/continuity testers, I-550, I-551, II-342, II-533, II-534, II-535, III-345, III-538-540, IV-287, IV-289, IV-295, IV-296
- audible, V-317
- audible, adjustable, II-536
- buzz box, I-551
- cable tester, III-539
- latching design, IV-295
- low-resistance circuits, V-319
- ohmmeter, linear, III-540
- PCB, II-342, II-535
- ratiometric, I-550
- RC decade box, V-294-295
- resistance-ratio detector, II-342
- single chip checker, II-534
- visual, V-293
- resistance-to-voltage converter, I-161-162
- resistor multiplier, II-199
- resistors, voltage-controlled, I-422
- resonator oscillator, varactor tuned 10 MHz ceramic, II-141
- restorer, video dc, III-723
- reverb effect
  - analog delay line, IV-21
  - stereo system, I-602, I-606
- reversing motor drive, dc control signal, II-381
- rf amplifiers, II-537-549, III-542-547, IV-476-493, V-514-527
  - 1 W, 2.3 GHz, II-540
  - 2 meter FET power amplifier, V-521
  - 10 W, 225-400 MHz, II-548
  - 10-W, 10-M linear amplifier, V-520
  - 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
  - 20 W, V-1296-MHz module, V-522
  - 20 W, V-450 MHz amplifier, V-519
  - 30 MHz, V-519
  - 60 W 225-400 MHz, III-547
  - 125 W, 150 MHz, II-544
  - 455-kHz IF amplifier, V-522, V-523, V-524
  - 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, IV-487, V-516, V-517
  - buffer amplifier with modulator, IV-490
- cascode amplifier, IV-488
- common-gate, 450-MHz, III-544
- GaAsFET preamplifier, V-435 MHz, V-516
- HF preamplifier, V-515
- HF/VHF switchable active antenna, V-524
- IF amplifier, V-455-kHz, V-522, V-523, V-524
- IF amplifiers, V-45-MHz, crystal filter, V-527
- isolation amplifier, II-547
- LC tuned, V-525
- linear amplifiers, IV-480-485, V-520
- 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 amplifiers, I-559, II-542, III-542, V-517, V-519, V-521, V-525
- preamplifiers, V-527
  - GaAsFET, V-516
  - HF, V-515
  - receiver/scanner with MAR-1 MMIC, V-521
  - VHF/UHF, V-515
  - wideband, V-526
- preselectors, IV-483, IV-485, IV-488
- receiver/scanner preamp with MAR-1 MMIC, V-521
- TV sound system, V-519
- UHF, V-523
- UHF-TV amp/preamp, III-546, IV-482, IV-483
- VHF/UHF preamplifier, V-515
- wideband amplifiers, IV-479, IV-489, IV-490-493, V-518, V-519, V-526
- rf circuits (*see* radio/rf)
- 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 launcher game, electromagnetic, V-209
- ring-around flasher, LED, III-194
- ringers, telephone, I-628, IV-556
  - detectors, ring detectors, I-634, I-635, III-611, III-619
- extension-phone ringer, IV-561
- high-isolation, II-625
- multi-tone, remote programmable, II-634
- musical, II-619

ringers, telephone (*cont.*)  
 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  
 true rms detector, I-228  
 road ice alarm, II-57  
 robots  
   eyes for, II-327  
   light-seeking, II-325  
 rocket launcher, II-358  
 room monitor, V-369  
 root extractor, V-207, V-288  
 rotation detector, II-283  
 roulette, electronic, II-276, IV-205  
 RS-232 interface  
   CMOS-to, line receiver, III-102  
   datasector, automatic, III-97  
   drive circuit, low-power, III-175  
   LED circuit, III-103  
   line-driven CMOS circuits, IV-104  
 RS flip-flop, I-395  
 RTD signal conditioners  
   5V powered linearized platinum,  
     II-650  
   precision, linearized platinum,  
     II-639  
 RTTY machines, fixed current  
   supply, IV-400  
 rumble filters, III-192, III-660,  
   IV-175  
   LM387 in, I-297  
   turntable, IV-170

## S

S meter, III-342, V-311  
 safe area protection, power  
   amplifier with, III-459  
 safety circuits (*see* protection  
   circuits)  
 safety flare, II-608  
 Sallen-Key filters  
   10 kHz, I-279  
   500 Hz bandpass, I-291  
   current driven, V-189  
   low-pass  
     active, IV-177  
     equal component, I-292  
     second order, I-289  
 sample-and-hold circuits, I-590,  
   II-552-559, III-548-553,  
   V-502-503, V-533-534  
   x 1000, I-589  
   charge-compensated, II-559  
   de-glitch circuit, V-336-337  
   fast and precise, II-556  
   filtered, III-550

frequency-to-voltage conversion,  
   IV-194  
 high-accuracy, I-590  
 high-performance, II-557  
 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-549, III-552  
 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,  
     V-491  
     linear, V-205  
     triggered, V-204  
   oscillator modulator, III-373  
   pulse generator and, III-241  
 SCA (*see* silicon-controlled  
   amplifiers)  
 scale, I-398, V-297  
 scaler, inverse, I-422  
 scanner, bar codes, III-363  
 scanners, receiver/scanner preamp  
   with MAR-1 MMIC, V-521  
 Schmitt triggers, I-593, III-153, V-356  
 crystal oscillator, I-181  
 programmable hysteresis, I-592  
 square-wave generators, V-569,  
   V-570  
 transistorized, V-204  
 TTL-compatible, II-111  
 without hysteresis, I-592  
 SCR (*see* silicon-controlled  
   rectifiers)  
 scramblers, audio (*see also* sound  
   generators; voice-activated  
   circuits), IV-25-27  
   telephone, II-618  
   voice scrambler/descrambler,  
     IV-26, IV-27  
 scratch filters, III-189, IV-175  
   LM287 in, I-297  
 second-audio program (SAP)  
   adapter, III-142  
 security circuits (*see* alarms;  
   annunciators)  
 sense-of-slope tilt meter, II-664  
 sensors (*see* alarms; fluid and  
   moisture; light-controlled  
   circuits; motion/proximity  
   detectors; motor control  
   circuits; smoke detectors; speed  
   controllers; temperature-related  
   circuits; tone controls)  
 sequence indicator, phase, I-476

sequencer, pseudorandom, III-301  
 sequential flashers, I-109, II-233,  
   II-238  
 sequential timer, III-651  
 series connectors, telephone, III-609  
 servo amplifiers (*see also* motor  
   controls), I-452  
   400 Hz, II-386  
   bridge type ac, I-458  
   dc, I-457  
   motor drive amplifier, II-384  
 servo systems (*see also* motor  
   controls)  
   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)  
 ship siren, electronic, II-576  
 short-circuit proof lamp driver,  
   II-310  
 short-circuit tester/sensor, V-315  
   computer remote data lines, IV-102  
   for 120-V equipment, V-313  
 shortwave transmissions  
   converters, III-114, IV-500, V-118  
   FET booster, I-561  
   noise limiter, V-397  
   notch filter, V-185  
   pulsed-marker rf oscillator, V-532  
   receiver, IV-454, V-501  
 shunt, multimeter shunt, IV-293  
 shutdown circuits (*see* protection  
   circuits)  
 shutoff, automatic, battery-powered  
   projects, III-61  
 shutter speed tester, II-445  
 sidetone oscillator, rf-powered, I-24  
 signal amplifiers, audio, II-41-47,  
   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* function  
   generators; sound generators;  
   waveform generators)  
 signal injectors, III-554-555  
 signal sources, crystal-controlled,  
   II-143  
 signal tracer, V-309  
 three-in-one set: logic probe, signal  
   tracer, injector, IV-429

signal-strength meters, III-342, IV-166  
 silent alarm, V-16  
 silicon-controlled amplifiers (SCA), V-535  
   decoder, I-214, II-166, II-170  
   demodulator, II-150, III-565  
   MPX-SCA receiver, III-530  
   subcarrier adapter for FM tuners, V-536  
 silicon-controlled rectifiers (SCR)  
   circuits  
   annunciator, self-interrupting load, IV-9  
   chaser, III-197  
   crowbar, II-496  
   flashers, II-230, III-197  
     chaser, III-197  
     relaxation, II-230  
     ring counter, III-195  
   flip-flop, II-367  
   full-wave, I-375  
   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  
 simulators  
   EKG, three-chip, III-350  
   inductor, II-199  
   VOR signals, IV-273  
 sine-to-square wave converter, IV-120, V-124, V-125, V-569, V-570  
 sine-wave descrambler, II-163  
 sine-wave generators, IV-505,  
   IV-506, V-542, V-543, V-544  
   60 Hz, IV-507  
   audio, II-564  
   battery powered, V-541  
   LC, IV-507  
   LF, IV-512  
   oscillator, ancho, III-559  
   square-wave and, tunable oscillator, III-232  
   VLF audio tone, IV-508  
 sine-wave oscillators, I-65, II-560-570, III-556-559, III-560, IV-504-513, V-539-544  
   1-Hz, V-542  
   60-Hz, highly stable, V-540  
   555 used as RC audio oscillator, II-567  
   adjustable, II-568  
   audio, II-562, II-564, III-559  
   generators (*see* sine-wave generators)  
   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  
   shaper, sine-wave, V-543  
   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  
   voltage-controlled oscillator, V-666  
   Wien-bridge, I-66, I-70, II-566, IV-510, IV-513, V-541  
 sine-wave output buffer amplifier, I-126  
 sine/cosine generator, 0.1 to 10 kHz, II-260  
 sine/square wave converter, I-170  
 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  
   CW/SSB receiver, V-499  
   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, II-578, III-565  
   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, IV-515, IV-516, V-7  
   whooper, IV-517  
   yelp oscillator, II-577, III-562  
 slave-flash trigger, IV-380, IV-382  
 slide timer, III-444, III-448  
 slot machine, electronic, V-211  
 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  
   heat, electronic, III-627  
   rf, II-210  
 snooper, FM, III-680  
 socket debugger, coprocessor, III-104  
 soil heater for plants, V-333  
 soil moisture meter, III-208  
 solar circuits (*see* photodiode/photoelectric circuits)  
 soldering iron control, V-327  
 soldering station, IR-controlled, IV-225  
 solenoid drivers, I-265, 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  
   light sources, V-282-283  
   load-sensing switch, V-285  
   relays, III-569-570, V-505, V-506  
   stepping switch, II-612  
   switch, line-activated, telephone, III-617  
 sonic defender, IV-324  
 sound-activated circuits (*see* sound-operated circuits)  
 sound effects (*see* sound generators)  
 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, V-394-395, V-556-567  
   acoustic field generator, V-338-341  
   alarm-tone generator, V-563  
   amplifier, voltage-controlled, IV-20  
   amplifier/compressor, low-distortion, IV-24  
   allophone, III-733  
   audio-frequency generator, V-416-417  
   audio tone generator, VI.F, IV-508

- sound generators (cont.)  
 autodrum, II-591  
 bagpipes, electronic, III-561, IV-521  
 beat-frequency, IV-371  
 beeper, V-558  
 bird chirp, I-605, II-588, III-577  
 bongos, II-587  
 canary simulator, V-557  
 chime generator, II-604, IV-524  
 chug-chug, III-576  
 dial tone, I-629, III-609  
 dithering circuit, digital audio use, IV-23  
 doorbell, musical tones, IV-522  
 doubler, audio-frequency doubler, IV-16-17  
 dual-tone sounder, V-564  
 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, II-590, III-575  
 gong, electronic, V-563  
 guitar compressor, IV-519  
 harmonic generator, I-24, IV-649  
 high-frequency signal, III-150  
 hold for telephone, II-623  
 instrument tune-up, audio generator, V-390  
 low-level sounder, V-564  
 noise generators, I-467, I-468, I-469, IV-308, V-395  
 octave-shifter for musical effects, IV-523  
 one-IC design, II-569  
 perfect pitch circuit, V-391  
 phasor sound generator, IV-523  
 pink noise, I-468  
 portable, I-625  
 pulsed-tone alarm, V-559  
 race-car motor/crash, III-578  
 run-down clock for games, IV-205  
 sound effects, III-574-578  
 siren, V-559, V-565, V-567  
 sound-effects generator, V-565  
 space-age sound machine, V-562  
 spaceship alarm, V-560  
 speech detectors, II-617, III-615  
 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, V-561  
 telephone call-tone generator, IV-562  
 telephone ringer, II-619  
 tone burst generator, repeater, V-629  
 tone chime, V-560  
 tone generators, I-604, I-625  
 top octave generator, V 393  
 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, V-629  
 ultrasonic sound source, IV-605  
 very-low-frequency, I-64  
 vocal eliminator, IV-19  
 voice circuits, III 729-734  
 waa-waa circuit, II-590  
 warbling tone, II-573  
 white noise, IV-201  
 sound-operated circuits (*see also* ultrasonic circuits; voice-operated circuits), II-580-584, III-579-580, IV-525-528, V-545-555  
 amplifier, gain-controlled, IV-528  
 color organ, II-583, II-584  
 decoder, III 145  
 fader, V-549  
 flash triggers, I-481, II-449, IV-382  
 kaleidoscope, sonic, V-548-549  
 lights, I-609, V-552  
 memo alert, V-352  
 noise clipper, I-396  
 relay, I-608, I 610  
 sleep-mode circuit, V-547  
 switch, II-581, III-580, III-600, III-601, IV-526-527, V-553, V-555, V-590  
 ac, II-581  
 two-way, I-610  
 voice-operated, III-580, IV-527  
 speech activity detector, telephone, III-615  
 voice-operated switch, III-580  
 vox box, II 582  
 whistle-activated switch, V-551  
 sources (*see* current sources; voltage sources)  
 source followers  
 bootstrapped, V-20  
 JFET, V-20  
 photodiode, III-419  
 SPDT switch, ac-static, II-612  
 space-age sound machine, V-562  
 space war, I-606  
 spaceship alarm, V-560  
 speaker systems  
 FM carrier current remote, I 140  
 hand-held transceiver amplifiers, III-39  
 overload protector for, II-16  
 protection circuit, V-476, V-479  
 wireless RX, III-272  
 speakerphone, II-611, III-608  
 spectrum analyzer adapter, oscilloscopes, V-424  
 speech-related circuits  
 activity detector, II-617, III-619  
 compressor, II-15  
 filter  
 300 Hz-3kHz bandpass, I-295  
 second-order, 300-to-3,400 Hz, IV-174  
 speech-range bandpass filter, V 185  
 two-section, 300-to-3,000 Hz, IV-174  
 network, II-633  
 scrambler, V-554  
 speed alarm, I-95  
 speed controllers (*see also* motor control), I-450, I-453, II 378, II-379, II-455, V-380, V-381  
 back EMF PM, II-379  
 cassette-deck motor speed calibrator, IV-353  
 closed-loop, III-385  
 fans, automatic, III-382  
 feedback speed, I-447  
 dc motors, I-452, I-454, III-377, III-380, III-388  
 dc variable, fiberoptic, 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-453, I-455, IV 338 340  
 motor (*see* motor controls; tachometers)  
 power tool torque, I-458  
 PWM, II-376, III-380, V-381  
 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  
 tachometers, I-94, I-100, I-102, II-175, III 335, III-340, III-347  
 analog readout, IV 280  
 calibrated, III-598  
 closed loop feedback control, II-390  
 digital readout, II-61, III-45, IV-268-269, IV-278  
 dwell meter/tachometer, III-45  
 feedback control, II-378, II-390  
 frequency counter, I-310  
 low-frequency, III-596  
 minimum-component design, I-405  
 motor speed controllers, II-378, II-389  
 optical pick-up, III-347  
 set point, III-47

tachometerless, III-386, IV-349  
 tools and appliances, I-446  
 universal motors, I-457, 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,  
   V-568-570  
   1 kHz, IV-536  
   2 MHz using two TTL gates, II-598  
   10-Hz to 10-kHz VCO, V-570  
   60-Hz, V-569  
   555 timer, II-595  
   astable circuit, II-597, IV-534  
   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  
   oscillators, I-613-614, II-597, II-616,  
     IV-532, IV-533, V-569  
     0.5 Hz, I-616  
     1kHz, I-612  
     frequency doubled output, II-596  
     phase-tracking, three-phase, II-598  
     pulse extractor, III-584  
   quadrature-outputs oscillator,  
     III-585  
   Schmitt trigger, V-569, V-570  
   sine-wave and, tunable oscillator,  
     III-232  
   sine-to-square wave converter,  
     V-569, V-570  
   three-phase, II-600  
   tone-burst generator, single timer  
     IC, II-89  
   triangle-wave and, III-239  
     precision, III-242  
     programmable, III-225  
     wide-range, III-242  
   TTL, LSTTL, CMOS designs,  
     IV-530-532  
   variable duty-cycle, IV-533  
   variable-frequency, IV-535, V-570  
 square-wave oscillator  
   astable multivibrator and, V-386  
 square-to-sine wave converters,  
   III-118  
 squeel circuits, II-394  
   AM/FM, I-547  
   voice-activated circuits, IV-624  
 squib firing circuits, II-357  
 stabilizers, fixed power supplies, IV-  
   393, IV-406  
 staircase generators, (*see also*  
   function generators; waveform  
   generators), I-730, II-601-602,  
   III-586-588, IV-443-447  
 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  
 static deflector, IV-276  
 steam locomotive sound effects,  
   II-589, II-592, III-568  
 step-up switching regulator, 6V  
   battery, II-78  
 step-up/step-down dc-dc converters,  
   III-118  
 stepper motors (*see also* motor  
   control circuits), V-571-573  
   direction control, IV-350  
   drivers, II-376, II-390  
   bipolar, V-572  
   FET-based, V-573  
   half-step, IV-349  
   quarter-step, IV-350  
   dual clock circuit, V-573  
   speed and direction, IV-350  
 stepping switch, solid state, II-612  
 stereo/phonograph (hu-fi) circuits,  
   V-574-584  
   acoustic field generator, V-338-341  
   amplifiers, I-77, I-80-81, I-89, I-670,  
     II-9, II-43, II-45, III-34, III-37,  
     III-38, IV-29, IV-35, IV-36, IV-66  
   bass tone control, V-584  
   mini-stereo amplifier, V-583  
   audio level meter, IV-310  
   audio power amplifiers, V-40, V-  
     48  
   audio power meter, IV-306  
   audio signal amplifier, V-58  
   balance circuits, I-618-619, II-603-  
     605, V-583  
   booster amplifier for car stereo, V-72  
   companion, II-12, III-93, III-95  
   expander, II-13, III-93, III-95, V-582  
   decoders, II-18, II-167-169  
   demodulators, I-544, II-159  
   derived center channel stereo  
     system, IV-23  
   FM stereo transmitter, V-575, V-580  
   frequency decoder, II-169  
   frequency division multiplex, II-169  
   loudspeaker protector circuit, V-483  
   mixers, I-55, IV-332  
   power meter, III-331  
   preamplifiers, I-90, I-91, II-43,  
     II-45, III-37, III-671, III-673,  
     IV-35, IV-36, V-581, V-584  
   reception indicator, III-269  
   reverb systems, I-602, I-606, II-9  
   speaker protection circuit, V-476,  
     V-479  
   TDM decoder, II-168  
   test circuits, I-618-619, III-269,  
     III-331, IV-306, IV-310  
   tone control circuit, high-Z input,  
     I-676  
   TV-stereo decoder, II-167, V-576-  
     579, V-580  
 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  
   alarm system, V-6-7  
   disco-, II-610  
   high-voltage power supplies,  
     IV-413  
   safety flare, II-608  
   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  
 subwoofer amplifier, V-49, V-50  
 successive-approximation A/D  
   converter, I-45, II-24, III-30  
 summing amplifiers, I-37, III-16  
   fast action, I-36  
   inverting, V-18, V-20  
   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 (*see also* function  
   generators; waveform  
   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,  
   V-585-593

switches and switching circuits

- (cont.)
- ac switches, III-408, IV-387
  - ac power switch, V-112, V-115
  - analog switches, I-621, I-622, III-593
  - antenna selector, electronic, IV-538-539
  - audio switch, eight-channel, V-588-589
  - audio-controlled switch, V-590
  - 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
  - controller, III-383
  - dark-activated, V-274, V-276
  - dc controlled, V-586, V-592
  - dc static, II-367
  - debouncers, III-592, IV-105, IV-106, IV-108, V-316
  - delay, auto courtesy light, III-42
  - dimmer switches, I-369, II-309, IV-247, IV-249
    - 800 W, II-309
  - dc lamp, II-307
  - four-quadrant, IV-248-249
  - halogen lamps, III-300
  - headlight, II-57, II-63
  - low-cost, I-373
  - soft-start, 800-W, I-376, III-304
  - tandem, II-312
  - triac, I-375, II-310, III-303
  - DTL-TTL controlled buffered analog, I-621
  - fax/telephone switch, IV-552-553
  - FET, dc controlled, V-592
  - FET dual-trace (oscilloscope), II-432
  - flex switch, alarm sounder circuit, V-15
  - frequency switcher/oscillators, V-418
  - Hall-effect, III-257, IV-539
  - headlight switching circuit, V-75
  - hexFET switch, V-592, V-593
  - high-frequency, I-622
  - high-side power control switch, 5 V supply, IV-384, IV-385
  - infrared-activated, IV-345
  - IR-controlled A/B switch, V-225
  - kill-switch for batteries, V-71-72
  - latching, SCR-replacing, III-593
  - light-operated, II-320, III-314, V-274, V-278
    - adjustable, I-362
  - capacitance switch, I-132
  - light-controlled, II-320, III-314
  - photoelectric, II-321, II-326, III-319
  - self-latching, V-278
  - solar triggered, III-318
  - zero-point triac, II-311
  - load-disconnect switch, V-591
  - load-sensing, solid-state, V-285
  - mercury-switch tilt detector, V-302
  - MOSFET power control switch, IV-386
  - on/off inverter, III-594
  - on/off switch, I-577, II-359, IV-543, IV-546
  - optical safety-circuit switch, V-409
  - optically coupled, III-408, III-410
  - oscillator-triggered switch, V-590
  - over-temperature switch, IV-571
  - photo cell memory, ac power control, I-363
  - photoelectric, II-321, II-326
  - proximity, III-517
  - push on/off, II-359
  - pushbutton power control switch, IV-388
  - remote switches, I-630, I-577, V-592
  - rf switches, III-361, III-592
  - rotary switch, BCD digital, V-160
  - safety switch, V-589
  - satellite TV audio switcher, IV-543
  - solar-triggered, III-318
  - solid-state stepping, II-612
  - sonar transducer/, III-703
  - sound-activated, I-610, II-581, III-580, III-600, III-601, IV-526-527, V-553, V-555, V-590
  - speed, I-104
  - SPDT, ac-static, II-612
  - switching controller, III-383
  - temperature control, low-power, zero-voltage, II-640
  - thermostatic, for auto fan, V-68
  - tone switch, narrowband, IV-542
  - touch switches, I-131, I-135-136, II-690-693, III-661-665, IV-590-594, V-270
  - touchomatic, II-693
  - TR switch for antennas, automatic, V-37
  - triac switches, I-623, II-311, IV-253
  - two-channel, I-623
  - two-way switch wiring, V-591
  - ultrasonic, I-683
  - under-temperature switch, IV-570
  - VHF/UHF diode rf switch, IV-544
  - video switches, III-719, III-725, III-727, III-728, IV-618-621, V-587
  - video/audio switch, V-586
  - voice-operated, I-608, III-580, IV-527, V-553
  - whistle-activated switch, V-551
  - wiring for two-way switch, V-591
  - zero crossing, I-732
  - zero point, I-373, II-311
  - zero-voltage switching, I-623, III-410, III-412

switched-mode power supplies,

- II-470, III-458
  - 24- to 3.3-V, V-462
  - 5- to 3.3-V, V-462
  - 50 W, off-line, III-473
  - 100 kHz, multiple-output, III-488
  - converter, V-461
  - synchronous stepdown regulator, V-468
  - voltage regulators for switched supplies, V-453
    - 3 A, III-472
    - 5 V, 6 A, 25 uHz, separate ultrastable reference, I-497
    - 6 A variable output, I-513
    - 200 kHz, I-491
    - application circuit, 3W, I-492
    - fixed power supplies, 3 A, IV-408
    - high-current inductorless, III-476
    - low-power, III-490
    - multiple output MPU, I-513
    - positive, I-498
    - step-down, I-493
    - step-up, 6V battery, II-78
  - converter, +50V push pull, I-494
  - inverter, 500 kHz, 12 V, II-474
  - power amplifier, I-33
  - switched light, capacitance, I-132
  - switching/mixing, silent audio, I-69
  - sync circuits, V-594-595
    - combiner, V-595
    - gating circuit, V-595
    - separators, III-715, IV-616
  - synthesizers (*see also* musical circuits; sound generators)
    - four-channel, I-603
    - frequency, programmable voltage-controlled, II-265
    - music, I-599
- T**
- tachometers, I-94, I-100, I-102, II-175, III-335, III-340, III-347, V-65, V-596-598
  - analog readout, IV-280, V-597-598
  - calibrated, III-598
  - closed loop feedback control, II-390
  - digital readout, II-61, III-45, IV-268-269, IV-278
  - dwel meter/tachometer, III-45
  - feedback control, II-378, II-390
  - frequency counter, I-310
  - low-frequency, III-596
  - minimum-component design, I-405
  - motor speed controllers, 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
  - amplifiers, I-90, IV-36
  - audio-powered controller, IV-548

automatic tape-recording switch,  
   I-21, II-21  
 automatic-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  
 personal message recorder, V-330-  
   331  
 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  
 telecom converter -48 to +5 V at 1  
   A, V-472  
 telemetry demodulator, I-229  
 telephone-related circuits (*see also*  
   intercoms), II-616-635,  
   III-602-622, IV-549-564,  
   V-599-615  
 alarm dialer, V-612  
 amplifier, III-621, IV-560, V-614  
 answering machine beeper, IV-559  
 auto answer and ring indicator,  
   I-635  
 automatic recording device, II-622  
 basic telephone circuit, V-615  
 bell simulator, V-604  
 blinking phone light monitor,  
   II-624, II-629  
 call-tone generator, IV-562  
 caller ID, V-613  
 cassette interface, III-618  
 decoder, touch-tone, IV-555  
 dial pulse indicator, III-613  
 dial-tone circuit, 5-V, V-610  
 dialed-phone number vocalizer,  
   III-731  
 dialer  
   emergency dialer, V-603  
   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  
 emergency dialer, V-603  
 fax-machine switch, remote-  
   controlled, IV-552-553  
 flashers, II-629  
   phone-message, IV-556  
   tell-a-bell, IV-558  
   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  
 hold circuit, V-614  
 in-use indicator, II-629, IV-560,  
   IV-563, V-602  
 intercom, IV-557, V-239, V-240  
 interface  
   audio, V-612  
   FCC Part 68, V-613  
   for phone-line, V-605  
 light for, II-625  
 line interface, autopatch, I-635  
 line monitor, I-628  
 line tester, V-615  
 message-taker, IV-563  
 monitors, I-625, II-626  
 musical hold, II-623, V-601, V-605  
 musical ringer, II-619  
 night light, telephone controlled,  
   III-604  
 off-hook indicator, I-633  
 optoisolator status monitor, I-626  
 pager, V-609, V-611  
 parallel connection, III-611  
 personal message recorder,  
   V-330-331  
 piezoelectric ringer, I-636  
 power switch, ac, IV-550  
 pulse-dialing, III-610  
 recording calls, I-632, III-616,  
   IV-553, IV-558, V-600  
 redial, III-606  
 relay, I-631  
 remote monitor for, II-626  
 repeater, III-607  
 repertory dialer, line powered, I-633  
 ring converter, V-602  
 ring detectors, II-623, III-611,  
   III-619, IV-564  
 ring indicator, V-604  
 ringers, IV-556, V-600  
   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  
   tone, I-627, I-628, II-630, II-631  
 scrambler, II-618, V-608  
 series connection, III-609  
 silencer, IV-557  
 sound level meter monitor, III-614  
 speaker amplifier, IV-555  
 speakerphone, II-632, III-608  
 speakerphone adapter, V-606-607  
 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  
 telecom converter -48 to +5 V at 1  
   A, V-472  
 timer, tele-timer, V-623  
 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  
 voice-mail alert, V-607  
 television (*see video circuits*)  
 temperature-related circuits (*see*  
   *also thermometers*), I-641-643,  
   I-648, I-657, II-645, III-629-631,  
   IV-565-572, V-616-620  
 0-50 C, four-channel temperature,  
   I-648  
 alarms, II-4, II-643, II-644, V-9  
 automotive water-temperature  
   gauge, II-56, IV-44, IV-48  
 boiler temperature control, I-638  
 compensation adjuster, V-617  
 control circuits, I-641-643, II-636-  
   644, III-623-628, IV-567  
 defrost cycle, IV-566  
 heater element, II-642  
 heater protector, servo-sensed,  
   III-624  
 heat sniffer, electronic, III-627  
 liquid-level monitor, II-643  
 low-power, zero-voltage switch,  
   II-640  
 piezoelectric fan-based, III-627  
 proportional, III-626  
 signal conditioners, II-639  
 single setpoint, I-641  
 thermocoupled, IV-567  
 zero-point switching, III-624  
 converters  
   logarithmic, V-127  
   temperature-to-digital, V-123  
   temperature-to-frequency, I-646,  
     I-168, I-656, II-651-653, V-121  
   temperature-to-time, III-632-633  
 cool-down circuit for amplifiers,  
   V-354, V-357  
 defrost cycle and control, IV-566  
 differential temperature, I-654, I-  
   655  
 flame temperature, III-313  
 furnace fuel miser, V-328-329  
 heater control, I-639, I-640, II-642,  
   III-624  
 heat sniffer, III-627  
 hi/lo sensor, II-650  
 hook sensor on 4- to 20-mA loop,  
   V-618

- temperature-related circuits (*cont.*)
- IC temperature, I-649
  - indicator, II-56, IV-570
  - isolated temperature, I-651
  - logarithmic converter, V-127
  - low-temperature sensor, V-619
  - measuring circuit/sensors, II-653, IV-572
  - meters/monitors, I-647, III-206, IV-569
  - op amp, temp-compensated breakpoint, V-401
  - oscillators, temperature-controlled, I-187, II-427, III-137
  - over-temperature switch, IV-571
  - over/under sensor, dual output, II-646
  - remote sensors, I-649, I-654, V-619
  - sensors, I-648, I-657, II-645-650, III-629-631, IV-568-572, V-619
  - 0-50 degree C four channel, I-648
  - 0-63 degrees C, III-631
  - 5 V powered linearized platinum RTD signal conditioner, II-650
  - automotive-temperature indicator, PTC thermistor, II-56
  - Centigrade thermometer, II-648
  - coefficient resistor, positive, I-657
  - differential, I-654, I-655
  - over/under, dual output, II-646
  - DVM interface, II-647
  - hi/lo, II-650
  - integrated circuit, I-649
  - isolated, I-651, III-631
  - low-temperature, V-619
  - remote, I-649, I-654, V-619
  - soil heater for plants, V-333
  - soldering iron control, V-327
  - thermal monitor, IV-569
  - thermocouple amplifier, cold junction compensation, II-649
  - thermocouple multiplex system, III-630
  - zero-crossing detector, I-733
  - signal conditioners, II-639
  - single-setpoint, temperature, I-641
  - temperature-to-digital converter, V-123
  - temperature-to-frequency converter, I-646, I-168, I-656, II-651-653, V-121
  - temperature-to-time converters, III-632-633
  - thermocouples
    - amplifier, cold junction compensation, II-649
    - control, IV-567
    - multiplex system, III-630
  - thermometers (*see* thermometers)
  - thermostat (*see* thermostats)
  - thermostatic fan switch, V-68
  - transducer, I-646, 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 bench amplifier, V-26
  - 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
    - amplifiers, I-355, I-654, II-14, II-649
    - digital thermometer using, II-658
    - multiplex, temperature sensor system, III-630
    - pre-amp using, III-283
  - thermometers (*see also* temperature-related circuits), II-657-662, III-637-643, IV-573-577
    - 0-50 degree F, I-656
    - 0-100 degree C, I-656
    - 5-V operation, V-617
    - adapter, III-642
    - add-on for DMM digital voltmeter, III-640
    - centigrade, I-655, II-648, II-662
      - calibrated, I-650
      - ground-referred, I-657
    - differential, I-652, II-661, III-638
    - digital, I-651, I-658, V-618
      - temperature-reporting, III-638
    - thermocouple, II-658
    - uP controlled, I-650
    - electronic, II-660, III-639, IV-575, IV-576
    - Fahrenheit, I-658
      - ground-referred, I-656
    - high-accuracy design, IV-577
    - implantable/ingestible, III-641
    - kelvin, I-653, I-655, II-661
    - 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, I-639, I-640, V-60
  - third-overtone oscillator, I-186, IV-123
  - 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
  - mercury-switch, V-302
  - sense-of-slope, II-664
  - ultra-simple level, II-666
  - time bases
    - crystal oscillator, III-133, IV-128, V-137, V-139
    - function generators, 1 Hz, readout/counter applications, IV-201
    - oscilloscopes timebase generator, V-425
    - trigger selector for oscilloscopes timebase, V-425
  - 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-219, I-663
  - timing threshold and load driver, II-670, III-648
  - time division multiplex stereo decoder, II-168
  - timers (*see also* 555 timer circuits), I-666, I-668, II-671-681, III-650-655, IV-578-586, V-621-627
    - 0.1 to 90 second, I-663
    - 2- to 2000-minute, V-624
    - 555-based alarm, V-11
    - 741 timer, I-667
    - adjustable, II-681, IV-585
    - alarm, II-674
    - appliance-cutoff timer, IV-583
    - CMOS, programmable precision, III-652
    - countdown, V-627
    - darkroom, I-480, V-436
    - elapsed time/counter timer, II-680
    - electronic egg, I-665
    - enlarger timer, II-446, III-445
    - extended on-time, V-627
    - IC, crystal-stabilized, II-151
    - interval, programmable, I-660, II-678
    - long-delay, I-219, V-626
    - long-duration, II-675, IV-585
    - long-interval, I-667, IV-581, IV-582
    - long-period, V-624
    - long-term, II-672, III-653
    - mains-powered, IV-579
    - one-shot, II-266, III-317, III-654
    - photographic, I-485
      - darkroom enlarger, III-445
      - photo-event timer, IV-379
    - reaction timer, game circuit, IV-204
    - reflex timer, V-622
    - SCR design, IV-583

- self-retriggering timed-on generator, V-343
- sequential, I-661-662, I-663, III-651, V-623
- slide-show, III-444, III-448
- solid-state, industrial applications, I-664
- tele-timer, V-623
- ten-minute ID timer, IV-584
- three-minute, III-654
- three-stage sequential, V-623
- thumbwheel-type, programmable interval, I-660
- tune-out circuit, IV-580, IV-586
- triangle-wave generator, linear, III-222
- variable duty-cycle output, III-240
- voltage-controlled, programmable, II-676
- washer, I-668
- watch tick timer, V-292
- watchdog timer/alarm, IV-584
- wide-range, V-1-minute to 400 hours, V-625
- warning 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, III-74
- tone circuits (*see* function generators; sound generators)
- tone controls (*see also* sound generators), I-677, II-682-689, III-656-660, IV-587-589, V-334, V-630-631
- 500-Hz, III-154
- active control, IV-588
- audio amplifier, II-686
- automatic level control (ALC), V-60-62
- bass, I-670, V-584, V-631
- bass and treble, I-674, V-631
- Baxandall tone-control audio amplifier, IV-588
- decibel level detectors, III-154
- equalizers, III-658, II-684
- filter circuit, V-1 kHz, V-191
- guitar treble booster, II-683
- high-quality, I-675
- high-z input, hi fi, I-676
- level meters, sound levels, III-346, III-614, IV-305, IV-307
- loudness, II-46
- microphone preamp, I-675, II-687
- mixer preamp, I-58
- passive circuit, II-689
- preamplifiers, I-58, I-673, I-675, II-687, II-688, III-657
- rumble/scratch filter, III-660
- stereo preamp with tone control, V-581
- three-band active, I-676, III-658
- three-channel, I-672
- treble control, V-631
- tremolo circuit, IV-589
- volume limiter, audio signal amplifiers, V-59
- 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-630, I-631
- tone detectors, 500-Hz, III-154
- 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 switches, I-131, I-135-136, I-137, II-690-693, III-661-665, IV-590-594, V-632-635
- CMOS, I-137
- bistable multivibrator, touch-triggered, I-133
- bridging touch plate sensor, V-634
- dimmer, CMOS based, V-270
- 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
- latching switch, V-635
- line-hum, III-664
- momentary operation, I-133
- negative-triggered, III-662
- on-only switch, V-635
- positive-triggered, III-662
- sensor switch and clock, IV-591
- single-plate sensor, V-633
- switch, V-633, V-634, V-635
- 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
- TR switch for antennas, automatic, V-37
- tracers
  - audio reference signal, probe, I-527
  - bug, III-358
  - closed-loop, III-356
  - receiver, III-357
- track-and-hold circuits, III-667, III-668
- sample-and-hold circuit, III-549, III-552
- tracking circuits, III-666-668
- positive/negative voltage reference, III-667
- preregulator, III-492
- track-and-hold, III-667, III-668
- train chuffer sound effect, II-588
- transceivers (*see also* receivers, transmitters), IV-595-603
- transceivers
  - 1750-meter, V-646
  - CE, 20-m, IV-596-598
  - CW, 5 W, 80-meter, IV-602
  - external microphone circuit, V-351
  - hand-held, III-39, III-461
  - HF transceiver/mixer, IV-457
  - ultrasonic, III-702, III-704
- transducer amplifiers, I-86, III-669-673
- flat-response, tape, III-673
- NAB preamp, 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
- transformers, isolation transformer, V-349, V-470
- 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
  - phototransistor, V-279
  - amplifier, V-409
  - variable-sensitivity, V-409
  - pulse generator, IV-437
  - sorter, I-401
  - tester, I-401, IV-281, V-306
  - turn-on circuit, V-345
- transmission indicator, II-211
- transmitters (*see also* receivers; transceivers), III-674-691, IV-595-603, V-636-649
- 2-meter, IV-600-601
- 10-meter DSB, V-647
- 27.125-MHz NBFM, V-637
- acoustic-sound transmitter, IV-311
- amateur radio, 80-M, III-675
- amateur TV, IV-599
- ATV JR transmitter, V-440 MHz, V-640

**transmitters (cont.)**

audio, visible-light, V-261  
baby-alert, carrier-current circuit, V-95  
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 transmitters, I-681, III-684, III-686, III-678, III-690, IV-601, V-648, V-649  
DSB, 10-meter, V-647  
fiberoptic, III-177  
FM transmitters, I-681, V-641  
27 125-MHz NBFM, V-637  
49-MHz, V-643  
infrared, voice-modulated pulse, IV-228  
light-beam, V-259  
multiplex, III-688  
one-transistor design, III-687  
optical, I-361, I-367, II-417  
radio, V-648  
snooper, III-680  
stereo, V-575, V-580  
voice, III-678  
wireless microphone, III-682, III-685, III-691  
half-duplex information  
transmission link, low-cost, III-679  
IIF, low-power, IV-598  
infrared, I-342, I-343, II-289, II-290, III-275, III-277, IV-226-227, IV-228  
headphones, V-227  
pulsed for on/off control, V-228  
line-carrier, with on/off, 200 kHz, I-142  
low-frequency, III-682  
MIDI transmitter, V-393  
modulated-light transmitter, V-258  
Morse-code transmitter, V-6-W for 7-MHz, V-641  
multiplexed, 1-of-8 channel, III-395  
negative key-line keyer, IV-244  
optical, I-361, I-363, II-417, II-418, IV-368  
oscillator and, 27 and 49 MHz, I-680  
output indicator, IV-218  
QRP, V-638-639, V-644-645  
remote-control, V-509, V-513  
interface, V-511  
ultrasonic, V-512  
remote sensors, loop-type, III-70  
television, III-676  
tracking transmitter, V-642  
transceiver, V-1750-meter, V-646  
transmit/receive sequencer, preamp, V-348  
ultrasonic, 40 kHz, I-685  
ultrasound, Doppler, V-651  
vacuum-tube, low-power, V-80/40-M, V-642  
voice-communication, light-beam, V-260  
VHF, III-681, III-684  
transverter, V-2-to-6 meter, V-124  
treasure locator, lo-parts, I-409  
treble booster, guitar, II-683  
tremolo circuits, I-59, I-598, III-692-695, IV-589  
tri-color indicator, V-232  
triac circuits, V-268  
ac-voltage controller, IV-426  
contact protection, II-531  
controller circuit, V-267, V-271  
dimmer switches, I-375, II-310, III-303  
drive interface, direct dc, I-266  
microcomputer-to-triac interface, V-244  
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, V-206  
triangle-wave generators, III-234, V 203  
10-Hz to 10-kHz VCO, V-570  
clock-driven, V-206  
square/triangle-wave, III-225, III-239, III-242  
tuner, linear, III-222  
triangle-wave oscillator, V-205  
trickle charger, 12 V battery, I-117  
triggers  
50-MHz, III-364  
cancer alarm, III-444  
flash, photography, xenon flash, III-447  
load-sensing, V-285  
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-to-triangle wave converter, II-125

TTL-to-MOS logic converter, II-125  
TTL oscillators, I-179, I-613, IV-127  
1MHz to 10MHz, I-178  
1MHz to 20MHz, IV-127  
crystal, TTL-compatible, I-179  
sine wave/square oscillator, IV-512  
television display using, II-372  
tube amplifier, high-voltage isolation, IV-426  
tuners  
antenna tuner, IV-14, V-38  
FM, I-231  
guitar and bass, II-362  
turbo circuits, glitch free, III-186  
turn-on circuit, V-345  
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-related circuits (*see also* radio/rf circuits)  
amplifier, I-560-565  
audio-to-UHF preamp, V-24  
broadband rf amplifiers, V-523  
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  
VHF/UHF rf preamplifier, V-515  
wideband amplifier, I-560, III-264  
UJT circuits  
battery chargers, III-56  
metronome, II-355  
monostable circuit, bias voltage charge insensitive, II-268  
ultrasonic circuits (*see also* sound-operated circuits), III-696-707, IV-604-606, V-650-653  
arc welding inverter, 20 KHz, III-700  
cleaner, V-652-653  
induction heater, 120-KHz 500-W, III-704  
pest-control/repel, I-684, II-685, III-699, III-706, III-707, IV-605-606  
ranging system, III-697  
receiver, III-698, III-705  
Doppler ultrasound, V-651  
remote-control receiver, V-513  
remote-control transmitter, V-512  
sonar transducer/switch, III-703  
sound source, IV-605  
switch, I-683

transceiver, III-702, III-704  
 transmitter, I-685  
   Doppler ultrasound, V-651  
 undervoltage detector/monitor,  
   III-762, IV-138  
 uninterruptible power supply,  
   II-462, III-477, V-471  
 unity-gain amplifiers  
   inverting, I-35, I-80  
   noninverting, V-21, V-22  
   ultra high-Z, ac, II-7  
 unity-gain buffer  
   stable, speed and high-input  
     impedance, II-6  
 unity-gain follower, I-27  
 universal counters  
   10 MHz, I-255, II-139  
   40-MHz, III-127  
 universal mixer stage, III-370  
 universal power supply, 3-30V,  
   III-489  
 up/down counters  
   8-digit, II-134  
   extreme count freezer, III-125  
   XOR gate, III-105

**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-frequency inverter,  
   complementary output, III-297  
 variable-frequency oscillators (VFO)  
   5 MHz design, II-551  
   4093 CMOS, V-421  
   adjustable temperature  
     compensation, V-420  
   amateur radio, V-532  
   buffer amplifier, V-92  
   CMOS design, V-418  
   code practice oscillators, V-103  
   rf, V-6.5 MHz, V-529  
 variable-gain amplifier, voltage-  
   controlled, I-28-29  
 variable-gain and sign op amp, II-405  
 variable-gain circuit, accurate null,  
   III-69  
 variable-state filters  
   universal, V-178  
 variable oscillators, II-421  
   audio, 20Hz to 20kHz, II-727  
   duty-cycle, III-422  
   four-decade, single control, II-424  
   sine-wave oscillator, low-distortion,  
     III-558  
   wide range, II-429  
 variable power supplies, III-487-492,  
   IV-414-421  
   0- to 12-V, V-1 A, V-460

current source, voltage-  
   programmable, IV-420  
 dc supply  
   SCR variable, IV-418  
   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  
   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  
   voltage regulators for variable  
     supplies, III-490, III-492, IV-421  
 variable current source, 100mA to  
   2A, II-471  
   voltage regulator, III-491  
 VCR/TV on/off control, V-113  
 vehicles (*see* automotive circuits)  
 VHF-related circuits (*see also*  
   radio/rt; television; UHF)  
 amplifiers, I-558  
 crystal oscillators, III-138-140  
 IIF/VIII' switchable active antenna,  
   V-524  
 modulator, I-440, III-684  
 tone transmitter, III-681  
 transmitters, III-681, III-684  
 VHF/UHF diode rf switch, IV-544  
 VIII'/UHF rf preamplifier, V-515  
 video circuits, III-713-728, IV-607-  
   621, V-654-662  
 amateur TV (ATV) down  
   converter, V-125, V-126  
 amplifiers, video, I-688, I-690,  
   I-692, III-39, III-708-712, V-482,  
   IV-483, V-656, V-662  
   75-ohm video pulse, III-711  
   buffer, low-distortion, III-712  
   color, I-34, III-724  
   dc gain-control, III-711  
   differential video loop-through,  
     V-657  
   FET cascade, I-691  
   gam block, III-712  
   IF, I-689, II-687, V-655  
   JFET bipolar cascade, I-692  
   line driving, III-710  
   log amplifier, I-38  
   output, V-655  
   RGB, III-709  
   surrender, clamping circuit and,  
     III-710  
   TV amplifiers, I-688, I-690, III-39,  
     IV-482, IV-483  
   variable-gain video loop-through,  
     V-658  
 ATV video sampler circuit, V-656

audio/video switcher circuit,  
 IV-540-541  
 automatic TV turn-off, I-577  
 buffers, V-93  
 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  
 commercial zapper, V-334-335  
 composite-video signal text adder,  
   III-716  
 converters  
   RGB-to-NTSC, IV-611  
   video a/d and d/a, IV-610-611  
 cross-hatch generator, color TV,  
   III-724  
 data interface, TTL oscillator,  
   II-372  
 dc restorer, III-723, V-659  
 decoders  
   NTSC-to-RGB, IV-613  
   stereo TV, II-167, V-576-579,  
     V-580  
 detectors  
   IF, MC130/MC1352 design, I-688  
   low-level video, I-687 689  
 differential video loop-through  
   amplifier, V-657  
 fader, V-658  
 high-performance video switch,  
   III-728  
 IF amplifier, V-4 5-MHz sound,  
   V-655  
 IF detector, amplifier,  
   MC130/MC1352, I-688  
 line pulse extractor, IV-612  
 line/bar generator, V-662  
 loop-thru amplifier, IV-616  
 master circuit, video master,  
   V-661  
 mixer, high-performance video  
   mixer, IV-609  
 modulators, I-437, I-439, II-371,  
   II-372, II-433, II-434  
 monitors, RGB, blue box, III-99  
 monochrome-pattern generator,  
   IV-617  
 multiplexer, cascaded, I-of-15,  
   III-393  
 MUX cable driver  
   multi-input, V-657  
   two-input, V-657  
 op amp circuits, IV-615  
 output amplifier, V-655  
 PAL/NTSC decoder with RGB  
   input, III-717  
 palette, III-720  
 picture fixer/inverter, III-722  
 preamplifier, III-546, V-660  
 rf amplifiers, TV sound system,  
   V-519

video circuits (*cont.*)  
   rf up-converter for TVRO  
     subcarrier reception, IV-501  
   RGB-composite converter, III-714  
   sampler circuit, ATV video, V-656  
   satellite TV audio switcher,  
     IV-543  
   selector, V-660  
   signal-amplitude measurer, V-309  
   signal clamp, III-726  
   sound, IF/FM IF amplifier with  
     quadrature, I-690  
   stereo-sound decoder, II-167  
   stereo TV decoder, V-576-579,  
     V-580  
   switching circuits, III-719, III-725,  
     III-727, IV-618-621  
   video/audio switch, V-586  
   wideband for RGB signals, V-587  
   sync separator, III-715, IV-616  
   sync stripper/video interface,  
     V-659  
   transmitter, TV, III-676, IV-599  
   TV sound system, rf amplifiers,  
     V-519  
   variable-gain video loop-through  
     amplifier, V-658  
   VCR/TV on-off control, V-133  
   video, power, channel-select signal  
     carrier, V-344-345  
   wireless camera link, III-71  
 VLF/VHF wideband antenna  
   low-noise, active, V-33  
   vocal eliminator, IV-19  
   voice communications  
     light-beam transmitter/receiver,  
       V-260  
     personal message recorder,  
       V-330-331  
     voice-mail alert for telephone,  
       V-607  
   voice scrambler/descrambler, IV-26,  
     IV-27  
   voice substitute, electronic, III-734  
   voice-activated circuits (*see also*  
     sound-operated circuits;  
     telephone-related circuits), III-  
     729-734, IV-622-624, V-545-555  
   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  
   disguiser for voices, V-326-327  
   intercoms, V-239  
   scanner voice squealch, IV-624  
   scrambler, V-554  
   speech detector, II-617, III-615  
   stripper, vocal stripper, V-546-547  
   switches, III-580, IV-527  
   switch/amplifier, I-608, V-553  
   vocal stripper, V-546-547  
   voice identifier for amateur radio  
     use, V-550  
   voice substitute, electronic, III-734  
   VOX circuit, IV-623  
   voltage-controlled amplifier (VCA),  
     I-31, I-598, IV-20  
     attenuator for, II-18  
     differential-to-single-ended, III-670  
     reference, I-36  
     tremolo circuit, I-598  
     variable gain, I-28-29  
   voltage-controlled oscillators (VCO),  
     I-702-704, II 702, III-735,  
     IV-625-630, V-663-667  
   3-5 V regulated output converter,  
     III-739  
   10Hz to 10kHz, I-701, III-735-741  
   three-decade, V-666  
   555-VCO, IV-627  
   audio-frequency VCO, IV-626  
   basic circuit, V-666, V-667  
   crystal oscillator, III-135, IV-124  
   current sink, voltage-controlled,  
     IV-629  
   driver, op-amp design, IV-362  
   linear, I-701, IV-628  
     triangle/square wave, II-263  
   logarithmic sweep, III-738  
   one-shot, II-266  
   precision, I-702, III-431  
   restricted-range, IV-627  
   sine-wave oscillator, V-666  
   sinusoidal 3-Hz to 300-kHz, V-664-  
     665  
   stable, IV-372-373  
   square-wave generators, V-570  
   supply voltage splitter, III-738  
   three-decade, I-703  
   TL082-based, V-665  
   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-627, IV-629  
   voltage-controller, pulse generator,  
     III-524  
   voltage converters/inverters, III-742-  
     748, V-668-669  
   12-to-16 V, III-747  
   dc-to-ac inverter, V-669  
   dc-to-dc, III-744, III-746, V-669  
   flyback, high-efficiency, III-744  
   flyback-switching, self-oscillating,  
     III-748  
   negative voltage,  $\mu$ P-controlled,  
     IV-117  
   offline, I 5-W, III-746  
   regulated 15-Vout 6-V driven,  
     III-745  
   splitter, III-743  
   unipolar-to-dual supply, III-743  
   voltage-to-current converters,  
     I-163, I-166, II-124, III-110,  
     III-120, IV-118  
   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  
     10 Hz 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  
   voltage-ratio-to-frequency  
     converter, III-116  
   voltage detector relay, battery  
     charger, II-76  
   voltage doublers, III-459, IV-635,  
     V-460  
   cascaded, Cockcroft-Walton,  
     IV-635  
   triac-controlled, III-468  
   voltage followers, I-40, III-212  
   fast, I-34  
   noninverting, I-33  
   signal-supply operation, amplifier,  
     III-20  
   voltage inverters, precision, III-298  
   voltage indicators/meters (*see also*  
     voltmeters), III-758-772, IV-423  
   automotive battery voltage gauge,  
     IV-47  
   battery-voltage measuring  
     regulator, IV-77  
   comparator and, II-104  
   five-step level detector, I-337  
   frequency counter, III-768  
   HTS, precision, I-122  
   level detectors, I-338, II-172,  
     III-759, III-770  
   low-voltage indicator, III-769  
   monitor, V-315  
   multiplexed common-cathode LED  
     ADC, III-764  
   over/under monitor, III-762  
   peak program detector, III-771  
   solid-state battery, I-120  
   ten-step level detector, I-335  
   visible, I-338, III-772  
   voltage freezer, III-763  
   voltage-level circuit, V-301

**voltage multipliers**, IV-631-637,  
     V-670-672  
 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  
 cascaded, Cockcroft-Walton, IV-635  
     dc, V-672  
     triac-controlled, III-468  
 laser power supply, IV-636  
 low-frequency multiplier, IV-325  
 negative-ion generator, high-voltage, IV-634  
 quadrupler, dc, V-671  
 tripler, IV-637, V-671  
**voltage probes**, V-474  
**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, III-485  
     0- to 10-V at 3A, adjustable, I-511  
     0- to 22-V, I-510  
     0- to 30-V, I-510  
     3 A, III-472  
     5 V, low-dropout, III-461  
     5 V, 1 A, I-500  
     5 V, ultrastable reference, I-497  
     6 A, variable output switching, I-513  
     8- from 5-V regulator, V-469  
     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  
     90 V rms voltage regulator with PUT, II-479  
     100 Vrms, I-496  
     200 kHz, I-491  
     ac, III-477  
     adjustable output, I-506, I-512  
     application circuit, I-492  
     automotive circuits, III-48, IV-67  
     battery power suppliers, I-117, IV-77  
     bucking, high-voltage, III-481  
     combination voltage/current regulator, V-455  
     common hot-lead regulator, IV-467  
     constant voltage/constant current, I-508  
     current and thermal protection, 10 amp, II-474  
     Darlington, IV-421  
     dual-tracking, III-462  
     efficiency-improving switching, IV-464  
     fixed prnp, zener diode increases output, II-484  
     fixed-current regulator, IV-467  
     fixed supplies, III-461, III-468, III-471-477, IV-408, IV-462-467  
     flyback, off-line, II-481  
     foldback-current limiting, II-478  
     high- or low-input regulator, IV-466  
     high-stability, I-499, I-502, III-468  
     high-voltage power supplies, I-509, II-478, III-485, III-490  
     inductorless, III-476  
     LM317 design, IV-466  
     loss cutter, V-467  
     low-dropout, 5-V, III-461  
     low-power, I 695, III-490  
     low-voltage, I-502, I-511  
     linear, II-468, III-459  
     mobile, I-498  
     MPU, multiple output, I-513  
     negative, I-498, I-499, III-474, IV-465  
     npn/pnp boost, III-475  
     off-line flyback regulator, II-481  
     prnp, II-484  
     positive, I-498, III-471, III-475  
     pre regulators, II-482, III-480, III-492  
     programmable, IV-470  
     projection lamp, II-305  
     PUT, 90 V rms, II-479  
     radiation-hardened 125A linear regulator, II-468  
     remote shutdown, I-510  
     SCR preregulator for, II-482  
     single supply voltage regulator, II-471  
     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  
     step-down, I-493  
     step-up, II-78  
     switching supplies, I-491, I-492, I-493, I-497, I-498, I-513, II-78, III-472, III-476, III-490, IV-408, IV-463, V-453  
     3-A, III-472  
     3 W, application circuit, I-492  
     5 V, 6 A 25kHz, separate ultrastable reference, I-497  
     6 A, variable output, I-513  
     200 kHz, I-491  
     high-current inductorless, III-476  
     low-power, III-490  
     multiple output, for use with MPU, I-513  
     step down, I-493  
     variable current source with voltage regulation, IV-470  
     variable supplies, III-490, III-491, III-492, IV-421, IV-468-470  
     current source, III-490  
     zener design, programmable, IV-470  
**voltage sources**  
     millivolt, zenerless, I-696  
     programmable, I-694  
     voltage splitter, III-738  
**voltmeters**, III-758  
     3.5 digit, I-710  
     full scale, III-761  
     true rms ac, I-713  
     4.5-digit, III-760  
     5-digit, III-760  
     ac, III-765  
     wide-band, I-716  
     wide-range, III-772  
     add-on thermometer for, III-640  
     bar-graph, I-99, II-54  
     dc, III-763  
     high-input resistance, III-762  
     low-drift, V-301  
**digital voltmeters (DVM)**, III-4  
     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  
     LED readout, IV-286  
     temperature sensor and DVM, 647  
     FET, I-714, III-765, III-770  
     high-input resistance, III-768  
     JFET, V-318  
     LED expanded scale, V-311  
**mullivoltmeters**, III-767, III-769, IV-289, IV-294, IV-295  
     ac, I-716  
     audio, III-767, III-769  
     dc, IV-295  
     four-range, IV-289  
     high-input impedance, I-715  
     LED readout, IV-294  
     rf, I-405, III-766  
**voltohmmeters (VOM)**  
     field strength, I-276  
     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  
**volume limiter**, audio signal amplifiers, V-59

VOR signal simulator, IV-273  
vox box, II-582, IV-623  
Vpp generator, EPROM, II-114  
VU meters, III-487  
  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, II-320, III-317  
  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,  
  V-200-207  
  AM broadcast-band, IV-302  
  AM/FM, 455 kHz, IV-301  
  audio, precision, III-230  
  four-output, III-223  
  harmonic generators, I-24, III-228,  
  IV-649  
  high-frequency, II-150  
  high-speed generator, I-723  
  pattern generator/polar-to-rect.  
  converter, V-288  
  precise, II-274  
  ramp generators, I-540, II-521-523,  
  III-525-527, IV-443-447  
  555 based, V-203  
  accurate, III-526  
  integrator, initial condition reset,  
  III-527  
  linear, II-270  
  variable reset level, II-267  
  voltage-controlled, II-523  
  sawtooth generator, III-241, IV-444,  
  IV-446, V-204, V-205, V-491

sine-wave generators, IV-505,  
  IV-506, V-541, V-542, V-543, V-544  
  60 Hz, IV-507  
  audio, II-564  
  LC, IV-507  
  LF, IV-512  
  oscillator, audio, III-559  
  square-wave and, tunable  
  oscillator, III-232  
  VLF audio tone, IV-508  
sine/square wave generators, I-65,  
  III-232, IV-512  
square-wave generators, II-594-600,  
  III-225, III-239, III-242, III-583-  
  585, IV-529-536, V-568-570  
  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  
  oscillators, I-613-614, I-616,  
  II-596, II-597, II-616, IV-532,  
  IV-533  
  phase-tracking, three-phase,  
  II-598  
  pulse extractor, III-584  
  quadrature-outputs oscillator,  
  III-585  
  sine-wave and, tunable oscillator,  
  III-232  
  three-phase, II-600  
  tone-burst generator, single timer  
  IC, II-89  
  triangle-wave and, III-225, III-239,  
  III-242  
  TTL, LSTTL, CMOS designs,  
  IV-530-532  
  variable duty-cycle, IV-533  
  variable-frequency, IV-535  
  staircase generators, I-730,  
  II-601-602, III-586-588,  
  IV-443-447  
  stepped waveforms, IV-447  
  sweep generators, I-472, III-438  
  triangle-wave, III-234, V-203,  
  V-205, V-206  
  square wave, I-726, III-225,  
  III-239, III-242, V-206  
  timer, linear, III-222  
  two-function, III-234  
  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, I-730,  
  III-425  
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  
  HF, IV-492  
  JFET, IV-493  
  MOSFET, IV-492  
  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-66, I-70, II-566, III-429, III-558,  
  IV-371, IV-377, IV-511, V-415,  
  V-419, V-541  
  CMOS chip in, II-568  
  low-distortion, thermally stable,  
  III-557  
  low-voltage, III-432  
  sine wave, I-66, I-70, II-566, IV-510,  
  IV-513  
  single-supply, III-558  
  thermally stable, III-557  
  three-decade, IV-510  
  variable, III-424  
  very-low-distortion, IV-513  
wind-powered battery charger, II-70  
windicator, I-330  
window circuits, II-106, III-90, III-  
  776-781, IV-655-659, V-673-674  
  comparator, IV-656-657, IV-658,  
  IV-659, V-299, V-674  
  detector, I-235, III-776-781, IV-658  
  digital frequency window, III-777  
  discriminator, III-781, V-674  
  generator, IV-657  
  high-input-impedance, II-108  
windshield wiper circuits (*see*  
  automotive circuits)  
wire tracer, II-343  
wireless microphones (*see*  
  microphones)  
wireless speaker system, IR, III-272  
wiring  
  ac outlet tester, V-318  
  ac wiring locator, V-317  
  two-way switch, V-591  
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, II-66, II-68  
zener diodes  
clipper, fast and symmetrical, IV-329  
increasing power rating, I-496, II-485  
limiter using one-zener design, IV-  
257  
test set, V-321  
tester, I-400  
variable, I-507

voltage regulator, programmable,  
IV-470  
zero crossing detector, I-732, I-733,  
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, III-410, III-416

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