Encyclopedia of

ELECTRONIC CIRCUITS

Volume 5
Patent notice

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## Contents

**Introduction**  
1 Alarm and Security Circuits  
2 Amplifier Circuits  
3 Analog-to-Digital Converter Circuits  
4 Antenna Circuits  
5 Audio Power Amplifier Circuits  
6 Audio Signal Amplifier Circuits  
7 Automatic Level Control Circuits  
8 Automotive Circuits  
9 Battery Charger Circuits  
10 Battery Test and Monitor Circuits  
11 Buffer Circuits  
12 Carrier-Current Circuits  
13 Clock Circuit  
14 Code Practice Circuits  
15 Color Organ Circuit
16 Computer Circuits
17 Control Circuits
18 Converter Circuits
19 Counter Circuits
20 Crystal Oscillator and Test Circuits
21 Current Source Circuits
22 Current Limiter and Control Circuits
23 Delay Circuit
24 Detector, Demodulator, and Discriminator Circuits
25 Digital Circuits
26 Display Circuits
27 Doorbell Circuits
28 Fax Circuit
29 Field-Strength Meter Circuits
30 Filter Circuits
31 Flasher Circuits
32 Frequency Multiplier Circuit
33 Function and Signal Generator Circuits
34 Game Circuits
35 Gas Detector Circuits
36 Gate Circuit
37 Geiger Counter Circuits
38 Hall Effect Circuits
39 Infrared Circuits
40 Indicator Circuits
41 Instrumentation Amplifier Circuits
42 Integrator Circuit
43 Intercom Circuits
44 Interface Circuits
45 Inverter Circuits
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>Ion Generator Circuit</td>
<td>248</td>
</tr>
<tr>
<td>47</td>
<td>Laser Circuits</td>
<td>250</td>
</tr>
<tr>
<td>48</td>
<td>Lie Detector Circuit</td>
<td>255</td>
</tr>
<tr>
<td>49</td>
<td>Light-Beam Communication Circuits</td>
<td>257</td>
</tr>
<tr>
<td>50</td>
<td>Light-Control Circuits</td>
<td>262</td>
</tr>
<tr>
<td>51</td>
<td>Light-Controlled Circuits</td>
<td>272</td>
</tr>
<tr>
<td>52</td>
<td>Light Sources Circuits</td>
<td>280</td>
</tr>
<tr>
<td>53</td>
<td>Load-Sensing Circuits</td>
<td>284</td>
</tr>
<tr>
<td>54</td>
<td>Mathematical Circuits</td>
<td>286</td>
</tr>
<tr>
<td>55</td>
<td>Measuring and Test Circuits</td>
<td>289</td>
</tr>
<tr>
<td>56</td>
<td>Metal Detector Circuits</td>
<td>322</td>
</tr>
<tr>
<td>57</td>
<td>Miscellaneous Treasures</td>
<td>325</td>
</tr>
<tr>
<td>58</td>
<td>Mixer Circuits</td>
<td>359</td>
</tr>
<tr>
<td>59</td>
<td>Modulator Circuits</td>
<td>365</td>
</tr>
<tr>
<td>60</td>
<td>Monitor Circuits</td>
<td>368</td>
</tr>
<tr>
<td>61</td>
<td>Moisture &amp; Fluid Detector Circuits</td>
<td>373</td>
</tr>
<tr>
<td>62</td>
<td>Motion Detector Circuits</td>
<td>376</td>
</tr>
<tr>
<td>63</td>
<td>Motor Control Circuits</td>
<td>378</td>
</tr>
<tr>
<td>64</td>
<td>Multiplexer Circuit</td>
<td>382</td>
</tr>
<tr>
<td>65</td>
<td>Multivibrator Circuits</td>
<td>384</td>
</tr>
<tr>
<td>66</td>
<td>Musical Circuits</td>
<td>389</td>
</tr>
<tr>
<td>67</td>
<td>Noise-Generator Circuit</td>
<td>394</td>
</tr>
<tr>
<td>68</td>
<td>Noise-Limiting Circuits</td>
<td>396</td>
</tr>
<tr>
<td>69</td>
<td>Operational Amplifier Circuits</td>
<td>399</td>
</tr>
<tr>
<td>70</td>
<td>Optical Circuits</td>
<td>404</td>
</tr>
<tr>
<td>71</td>
<td>Oscillator Circuits</td>
<td>410</td>
</tr>
<tr>
<td>72</td>
<td>Oscilloscope Circuits</td>
<td>422</td>
</tr>
<tr>
<td>73</td>
<td>Pest Control Circuits</td>
<td>427</td>
</tr>
<tr>
<td>74</td>
<td>Phase-Shifter Circuits</td>
<td>429</td>
</tr>
<tr>
<td>75</td>
<td>Photography Related Circuits</td>
<td>432</td>
</tr>
</tbody>
</table>
76  Piezo Circuits 439
77  Power Supply Circuits—High Voltage 442
78  Power Supply Circuits—Low Voltage 448
79  Probe Circuits 473
80  Protection Circuits 475
81  Proximity Circuits 484
82  Pulse-Generator Circuits 487
83  Receiver Circuits 493
84  Relay Circuits 504
85  Remote-Control Circuits 508
86  RF Amplifier Circuits 514
87  RF Oscillator Circuits 528
88  Sample-and-Hold Circuits 533
89  SCA Circuit 535
90  Shutdown Circuits 537
91  Sine-Wave Oscillator Circuits 539
92  Sound- and Voice-Controlled Circuits 545
93  Sound-Effects Circuits 556
94  Square-Wave Generator Circuits 568
95  Stepper Motor Circuits 571
96  Stereo Circuits 574
97  Switching Circuits 585
98  Synch Circuits 594
99  Tachometer Circuits 596
100 Telephone-Related Circuits 599
101 Temperature-Related Circuits 616
102 Timer Circuits 621
103 Tone Circuits 628
104 Tone-Control Circuits 630
105 Touch-Control Circuits 632
106  Transmitter Circuits  636
107  Ultrasonic Circuits  650
108  Video Circuits  654
109  Voltage-Controlled Oscillator Circuits  663
110  Voltage-Converter/Inverter Circuits  668
111  Voltage Multiplier Circuits  670
112  Window Comparator and Discriminator Circuits  673

Sources  675
Index  699
Introduction

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

In this circuit, a low-powered SCR is used to trigger a higher powered SCR. When a switch is opening (S2, S3, S4) or closing (S5, S6, S7), either SCR1 or SCR2 triggers. This triggers SCR3 via D1, D2, and R5. BZ1 is a high-powered alarm of the noninterrupting type.

**MULTI-LOOP PARALLEL ALARM**

This alarm has status LEDs connected across each inverter output to indicate the status of its associated sensor. S8 is used to monitor the switches via the LEDs, or to trigger an alarm via Q1 and SCR1. BZ1 should be a suitable alarm of the noninterrupting type.
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.

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.

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.
The alarm/sensor circuit shown is built around two SCRs, a transistor, a 4049 hex inverter, and a few support components, all of which combine to form a closed-loop detection circuit with a delay feature. The delay feature allows you to enter a protected area and deactivate the circuit before the sounder goes off.

Assuming that the protected area has not been breached (i.e., S1 is in its normally-closed position), when power is first applied to the circuit, a positive voltage is applied to the input of U1-a through S1 and R1, causing its output to go low. That low is applied to the gate of SCR1, causing it to remain off. At the same time, C6 rapidly charges toward the +V supply rail through S2, LED2, R4, and D3. The charge on C6 pulls pin 5 of U1-b high, causing its output at pin 4 to be low. That low is applied to the base of Q1, keeping it off. Because no trigger voltage is applied to the gate of SCR2 (via Q1), the SCR remains off and BZ1 does not sound.

But should S1 open, the input of U1-a is pulled low via R9, forcing the output of U1-a high, lighting LED1. That high is also applied to the gate of SCR1 through D1 and R3, causing SCR1 to turn on. With SCR1 conducting, the charge on C6 decays, the input of U1-b at pin 5 is pulled low, forcing its output high, slowing charging C8 through R8 to a voltage slightly less than the positive supply rail.

Transistor Q1 remains off until C8 has charged to a level sufficient to bias Q1 on, allowing sufficient time to enter the protected area and disable the alarm before it sounds. Once C8 has developed a sufficient charge, Q1 turns on and supplies gate current to SCR2 through R6, causing the SCR to turn on and activate BZ1. If the circuit is reset before the delay has timed out, no alarm will sound.

The delay time can be lengthened by increasing the value of either or both C6 and R5; decreasing the value of either or both of those components will shorten the delay time.

All of the switches used in the circuit are of the normally-closed (NC) variety. Switch S1 can be any type of NC security switch. Switch S2 can be either a pushbutton or toggle switch. Because S3 is used to disable the sounder (BZ1) only, anything from a key-operated security switch to a hidden toggle switch can be used.
This circuit monitors a door to determine if it has been left open. After 24 seconds, the alarm sounds. S1 is a magnetic sensor. The alarm is an electronic chime sound that is struck once per second.
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 MΩ. 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 kΩ. 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 fuse-protected, it can still be dangerous if handled carelessly.

WARBLE ALARM

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.
In the circuit, U1 amplifies the audio picked up by the condenser microphone. Resistor R1 limits current, while R2 and R3 center the output of the amplifier to \( \frac{1}{2}B+ \) to allow a single-ended supply to be used. Diodes D1 and D2 rectify the output of U1, and C3 filters the resulting pulsing dc. Thus, a dc voltage that is proportional to the ambient sound level is produced.

That voltage is presented to the noninverting input of U2. The inverting input is provided with a reference voltage of between 0 and \( \frac{1}{2}B+ \), which is set by R11.

As long as the noise level is low enough to keep the voltage at pin 3 lower than the voltage at pin 2, the output of U2 stays low (approximately 1 V). That is enough to bias Q1 partially on. A voltage divider, formed by R8/R10 and Q1 (when it's partially on), prevents Q2 from turning on.

When the noise level is high enough to bring the voltage at pin 3 higher than the voltage at pin 2, the output of U2 goes high. That turns Q1 fully on and drives Q2 into saturation. The piezo buzzer then sounds until the power is cut off.

This circuit sends out a loud tone if the input switch (S2) is not retriggered at preset intervals. If you fall asleep and miss retriggering the circuit, it will sound until you press S2.
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.
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.

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.
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 circuit.

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).

When the light beam that falls in the CDS photocell is interrupted, transistor (EN3904) conducts thereby triggering SCR1 (G106) and activating alarm bell. S1 resets the SCR. The alarm bell should be a self-interrupting electro-mechanical type.
In this circuit, light causes R5 to conduct forward-biasing Q1. R6 sets sensitivity. SCR1 is triggered from the emitter voltage on LQ1, sounding the alarm bell. When S1 is depressed, SCR1 unlatches. Be sure that a self-interrupting alarm (electromechanical buzzer or bell) is used.

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.
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.

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.
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.

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.
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/reflecto FT. The cycle repeats itself after the strobe tube flashes.

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

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

\[ V_{\text{out}} = \frac{R_3 + R_2}{R_1 + R_4} \frac{R_4}{R_1} V_2 - \frac{R_2}{R_1} V_1 \]

FOR \( R_1 = R_3 \) AND \( R_2 = R_4 \)

\[ V_{\text{out}} = \frac{R_2}{R_1} (V_2 - V_1) \]

\[ R_1 || R_2 = R_3 || R_4 \]

FAST-INVERTING AMPLIFIER WITH HIGH INPUT IMPEDANCE

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.

NONINVERTING ac AMPLIFIER

\[ V_{\text{out}} = \frac{R_1 + R_2}{R_1} V_{\text{in}} \]

\[ R_{\text{in}} = R_3 \]

\[ R_3 = R_1 || R_2 \]

POPULAR ELECTRONICS

FIG. 2-3

A general-purpose noninverting ac amplifier for audio of 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

\[ V_{\text{out}} = -\frac{R_4}{R_1} \left( V_1 + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) \]

\[ R_5 = R_1 || R_2 || R_3 || R_4 \]

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.
High-impedance biasing method for an N-channel MOSFET to form a linear-inverting amplifier.
This bootstrapped source follower uses an N-channel MOSFET. It has a high input impedance.

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

The circuit uses positive gate bias to improve the operating point for better dynamic range.
UNITY-GAIN NONINVERTING AMPLIFIER

WILLIAM SHEETS

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

FIG. 2-13

ELECTRET MIKE PREAMP

ELECTRONICS NOW

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.

FIG. 2-15

JFET AMP WITH CURRENT SOURCE BIASING

WILLIAM SHEETS

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

FIG. 2-14

DIFFERENCE AMPLIFIER

POPULAR ELECTRONICS

FOR R1 = R3 AND R2 = R4

\[ V_{\text{out}} = \frac{R2}{R1} (V_2 - V_1) \]

\[ R1 \parallel R2 = R3 \parallel R4 \]

FIG. 2-16
GENERAL-PURPOSE JFET PREAMP

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

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

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

NONINVERTED UNITY-GAIN AMPLIFIER

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-MΩ INPUT IMPEDANCE WITH JFET AMP

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

DISCRETE CURRENT-BOOSTER AMPLIFIER

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

Based on the LM733 or NE592, the preamp shown has a bandwidth of 100 MHz. The FET inputs provide about 1-MΩ 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 Ω, 6 dB at 50 Ω. Gain is approximately +20 dB over the passband.
V- & I-PROTECTED INTRINSICALLY SAFE OP AMP

![Circuit Diagram]

**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

![Current Feedback Circuit Diagram]

**FIG. 2-26**

Using a NS LM6181, this IC is useful in cable drivers. The supply voltage is ±5 V to ±15 V.
GENERAL-PURPOSE PREAMPLIFIER

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

TEST BENCH AMPLIFIER

This amplifier might be useful in servicing or bench testing as a signal tracer or as a building block in various systems.
Analog-to-Digital Converter 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.

ADC Poller
8-Channel A/D Converter for PC Clones
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).
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 will run under the GW-BASIC interpreter if you replace the delay statements with FOR/NEXT loops, and add line numbers as shown in the second listing. These programs are available on the 73 BBS under the filenames ADC Turbo.BAS and ADCGW.BAS.

INITIALIZE:

```vbnet
' remarks follow the apostrophe screen 0 test mode 80 columns color 14.0 yellow on blue clc clear the screen clear all variables tog%<2 initialize variables
```

MINORLOOP:

```vbnet
' keep going until a key is pressed for ch%=0 to 7
out 888,8 CS high pin 5
out 888,9 CS low
out 890,0 start bit is always high DI line
out 888,0 clock high pin 1 of DB 25 printer
for slow%=0 to 1 next slow%
out 890,1 clock low
out 888,2 8 single ended measurements selected
out 890,0 clock high
out 888,odd% part of channel selection string
for slow%=0 to 1 next slow%
out 890,1 clock low
out 888,even% part of channel selection string
out 890,0 clock high
out 888,select% part of channel selection string
out 890,0 clock low
out 888,select% part of channel selection string
out 890,0 clock high
out 888,select% part of channel selection string
out 890,0 clock low
out 888,select% part of channel selection string
OUT 890,0 clock high
out 890,1 ' clock low
READBITS:

```vbnet
' for bi%=7 to 0 step -1
out 890,0 MSB is first out
for slow%=0 to 1 next slow%
out 890,1 clock high
read bits
ad%e%m8(889) read in byte
print 899 pin 10 7-low 13-high
if ad%=120 then byte%=byte%+2(2*bit%)
next bi%
```

NEXT ch%

```vbnet
next ch%= print using

```

30 SCREEN 0 test mode 80 columns 40 COLOR 14.0 yellow on blue 50 CLEAR clear the screen 60 CLEAR clear all variables 70 TOGGLE%<2 initialize variables 80 ODDSIGN%=0

IF ch%=5 THEN ' keep going until a key is pressed
100 OUT 888,1 regulator line high
110 OUT 888,0 light up the regulator
120 FOR W%=0 TO 500 NEXT W% wait 54 milliseconds to stabilize
130 FOR CH%=0 TO 7 scan 8 channels
140 OUT 888,8 CS high pin 5
150 OUT 888,9 CS low
160 OUT 890,2 start bit is always high DI line
170 OUT 890,0 clock high pin 1 of DB 25 printer
180 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
190 OUT 890,1 clock low
200 OUT 890,2 ' clock high
210 OUT 890,0 ' clock low
220 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
230 OUT 890,1 clock low
240 OUT 888,ODDSIGN% part of the channel selection string
250 SWAP ODDSIGN%,TOGGLE% toggles between high and low
260 OUT 890,0 clock high
270 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
280 OUT 890,1 clock low
290 OUT 888,SELECT1% part of the channel selection string
300 OUT 890,0 clock high
310 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
320 OUT 890,1 clock low
330 OUT 888,SELECT0% part of the channel selection string
340 OUT 890,0 clock high
350 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
360 OUT 890,1 clock low
370 REM read output bits
380 FOR BIT%=7 TO 0 STEP -1
390 OUT 890,0 MSB is last out
400 FOR SLOW%=0 TO 1 NEXT SLOW% stretches clock pulse
410 OUT 890,1 clock low
420 AD%=INP(889) read 899 pin 10 7-low 13-high
430 IF AD%=120 THEN BYTE%=BYTE%+(2*BIT%)
440 NEXT BIT%
450 IF ch%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
460 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
470 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
480 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
490 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
500 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
510 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
520 IF CH%=5 THEN SELECT1%=0: SELECT0%=0: CHVOLTS=BYTE%51
530 BYTE%=0
540 next ch%
550 PRINT USING "####.###":CHVOLTS,CHVOLTS,CHVOLTS,CHVOLTS,CHVOLTS,CHVOLTS,CHVOLTS,CHVOLTS

FIG. 3-2

8-CHANNEL A/D CONVERTER FOR PC CLONES

GW BASIC Version

A 12-channel A/D converter to perform eight sequential conversions and display the result.
An A/D converter by National Semiconductor (ADC0838), converts 0- to 5-V analog inputs to a digital data format. A 9-V battery is used. The converter connects to the pointer port connector via a 25-pin connector.
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
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.
A 30- to 50-cm whip antenna provides reception from 10 kHz to over 220 MHz. T1, a dual-gate MOSFET, provides low noise, high-input impedance, and high gain. The circuit is powered via the coaxial cable used to connect the antenna to a receiver.

Suitable for 60-kHz standard frequency reception, here is a schematic for a FET preamp and antenna.
The wires must be bound tightly together, but windings may be slightly spaced if necessary. The diagram shows a bifilar balun with two coils.

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

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.

An old ferrite rod from a junked broadcast receiver can be used to construct an antenna balun, as shown.
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 preamp via the coaxial cable feeding the unit.
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

[1], [2] and [3] consist of 75 Ω coax sections, 1/4 wave at the center of the transceiver transmitter band typically 147 MHz. [1] and [3] 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 ¼-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.

LOOP ANTENNA PREAMPLIFIER

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.
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
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**

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.
DUAL AUDIO AMPLIFIER

SOURCE > 51a > AUX 2

CD
TUNER
VCR
AUX 1
AUX 2
TAPE OUT
TAPE IN

PHILIPS 4312-020-36780

+15V

IC1 LMX353

MONITOR

VOLUME VU2a 60k LOU

STEREO

MONO MODE 62a

OTHER CHANNEL

D1 2x14140 02

R1 640k 8.7 V

D2 3T 25k 22.5 V

S51a

HEADPHONE AMPLIFIER

POWER AMPLIFIER

HEADPHONES

OTHER CHANNEL

SILICON CHIP

42
FIG. 5-4
Four LM1875 devices, suitably heatsinked, and a ±25-V supply, 70 W of output are available from this circuit. IC6 is a phase inverter.
Two LM1875 ICs provide 33 W of audio. IC4 is used as a phase inverter. IC6 and IC2 must be heatsinked.
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.

10-W NONINVERTING COMPOSITE AMPLIFIER

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

Using an LM1875, a 10-W amplifier can be build using just two IC devices. The gain = $R_4/R_3$. Note that IC12 must be heatsinked.
With the simple circuit, you can use your personal stereo to drive standard 8-Ω speakers.
Subwoofer Amplifier

Designed to feed a low-frequency subwoofer speaker system, the amplifier is capable of up to 100 W into an 8-Ω 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

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

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

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.
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.
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.

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

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

AUDIO BOOSTER

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

FIG. 6-9

FIG. 6-10
IC1-a is connected as an inverting amplifier whose gain is controlled by the LDR portion of an optocoupler.

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.
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)
This approach to automatic level control (ALC) makes use of digitally switched audio attenuators in the signal path. The output level of the system is sensed, compared to a reference, and audio pads are inserted via analog switches. This method is nearly instantaneous and eliminates the compromises necessary in conventional RC network ALC systems using fast attack, slow-decay approaches.
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 $R_3$, $R_L$, and $C_B$. The transistor Q1 and D1 are used as a voltage-controlled resistance ($Z$). The input signal is $(Z + R_1)/Z$, diminished by the voltage divider and $1 + R_2/R_1$ times, amplified by the op amp. C2 eliminates influence of dc bias voltage. R3 protects Q1 and D1 from excessive current.

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 ±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.
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
Brake and Turn-Signal Light Circuit
Vehicular Tachometer Circuit
Smart Turn Signal
Manual Headlight/Spotlight Control for Autos
Thermostat Switch for Automotive Electric Fans
Flashing Brake Light
Power Controller (for Automotive Accessories)
Automotive Power Adapter for dc-Operated Devices
Time-Delay Auto-Kill Switch
Booster Amplifier for Car Stereo Use
Auto Turn-Signal Reminder

Headlight Flasher
Automotive Audible-Turn Indicator
Engine Block Heater Minder
Headlights-On Reminder
Brake and Turn Indicator
Lamp-Switching Circuit
Automatic Turn-Off Control for Automobiles
Alternator Regulator
Auto Generator Regulator
Lights-On Reminder
Auto Fuse Monitor
Headlight Alarm
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.
This circuit enables single-filament tail lights to serve as combination brake lights and turn signals.

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.
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.

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.
SMART TURN SIGNAL (Cont.)

Flasrer 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.

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

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.
The circuit is based on a commercial temperature sensor (TS6178) and an MC3334P ignition chip. When the radiator temperature increases, the sensor pulls the base of Q2 low via Q1, which is wired as a diode. Q2’s collector thus goes high and triggers IC1, which switches its pin 7 output high and turns on the fan motor via Q3.
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 11 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)

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

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

TO AUTO BATTERY

STARTER SOLENOID

DJSTABAITEA

POPULAR ELECTRONICS

FIG. 8-10
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.

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-Ω 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 LR7, trimmer potentiometer R21, and capacitor C2. Together, R7 and R21 offer a minimum resistance of 27,000 Ω.

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**

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**

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

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.

HEADLIGHTS-ON REMINDER

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

ENGINE BLOCK HEATER MINDER

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.

BRAKE AND TURN INDICATOR

This might be a quick solution to getting the two-wire truck harness to support both turn and braking indications.
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-µF capacitor and any resistor value of from 1 to 10 MΩ can be used as the timing components.

To use the circuit on an automobile'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.

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.
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.

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

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.

POPULAR ELECTRONICS

FIG. 8-22

HEADLIGHT ALARM

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.

AUTO FUSE MONITOR

FIG. 8-23

WILLIAM SHEETS

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.

FIG. 8-24
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
The charger can be used as a stand-alone charger or for emergency lighting and burglar alarm systems using lead-acid batteries.

**RF-TYPE BATTERY CHARGER**

This type of charger couples RF from L2 to an external pickup coil. The pickup coil connects to a rectifier and battery to be charged. This idea is handy because no wire or contacts are required. L2 is 10T #24 wire and L3 is 10T #30 wire. Both coils are mounted on a 1" × ½" ferrite rod.
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**

![Solar Battery Charger Diagram]

**NATIONAL SEMICONDUCTOR**

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

**INTELLIGENT BATTERY-CHARGING CIRCUIT**

![Intelligent Battery-Charging Circuit Diagram]

**RADIO-ELECTRONICS**

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-kΩ pot. Select $R_c$ for the battery you intend to use.
Battery Test and Monitor 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.

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
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-kΩ trimmer resistor
- **R1**: 100 kΩ
- **R2, R3**: 33 kΩ
- **R4, R5**: 470 Ω
- **R6**: 12 Ω 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.
CAR BATTERY TESTER FOR CRANKING AMPS

This circuit determines the cold cranking amps of a battery by first discharging the surface charge, then checking the internal resistance. This gives a more realistic measurement than simply measuring the instantaneous drop in voltage with a load. A constant-current source draws 2.5 A. Then, after one minute, a voltage drop measurement is made under load.
SUPPLY VOLTAGE MONITOR

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

BATTERY WATCHDOG

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.
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.

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.
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 Cl/R1 discharges approximately 10 minutes, the output drops to zero. S1 resets the circuit.

IC devices by Linear Technology make up this current monitor circuit. Drain is only 70µA from a 3- to 6-V battery.
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 LED1 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.

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.
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.
Buffer 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.

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
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.

VFO BUFFER AMPLIFIER

A two-transistor feedback pair provides broadband operation. The gain is approximately $R_4/R_1$. 
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 \( Z_L = 50 \, \Omega \).

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

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

This circuit has proved to be an effective video buffer and will easily drive a 75-\( \Omega \) 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, ± 5 V or more.
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
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.
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

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
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.
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
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).
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.

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

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.

VARIABLE FREQUENCY CODE PRACTICE OSCILLATOR

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

CODE PRACTICE OSCILLATOR

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

SINGLE-TRANSISTOR CODE PRACTICE OSCILLATOR

A 2N366 is configured as an audio feedback oscillator using an audio transformer is shown. Adjust R1 for proper operation and desired audio note.
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
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-Ω impedance on the primary and 8-Ω impedance on its secondary. Connect T1 so that the 8-Ω side is connected to the speaker and the 500-Ω 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.
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-C Data and Clock Lines
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.).
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\textsuperscript{2}C DATA AND CLOCK LINES

The I\textsuperscript{2}C serial bus is a popular two-wire bus for small-area networks. I\textsuperscript{2}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 noninventory nonlatching buffer is also shown.

The circuit is symmetrical about its center so that the input and output can be swapped. Q\textsubscript{1} and Q\textsubscript{8} are the output open collector drivers. Q\textsubscript{2}, Q\textsubscript{3}, Q\textsubscript{6}, and Q\textsubscript{7} 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, Q\textsubscript{4} turns off, and the voltage across R\textsubscript{8} goes to zero. This turns off Q\textsubscript{1} and Q\textsubscript{8}. The output then goes high, which is the circuit’s normal resting place. If the input is pulled low, Q\textsubscript{4} is turned on.

Diode D\textsubscript{1} remains reverse-biased, preventing Q\textsubscript{3} from turning off Q\textsubscript{4}. With Q\textsubscript{4} on, current is supplied to both Q\textsubscript{2} and Q\textsubscript{1} to turn them on, but Q\textsubscript{2} turns on first to keep Q\textsubscript{1} off. This prevents the input from latching. Q\textsubscript{4} also turns on Q\textsubscript{8}. D\textsubscript{4} is now forward-biased, so Q\textsubscript{6} turns on, and thus turns off Q\textsubscript{5}. With Q\textsubscript{5} off, Q\textsubscript{7} 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 VOH of 5.0 V and a VOL of 0.5 V.
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
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.
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.
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.

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.
The Dual-Control Switch uses two 6-10-Vac sources to trigger the circuit on and off; one source for each function.
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
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.
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-µF, 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-Ω panel-mount potentiometer
- R2 1000-Ω, 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

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

This simple frequency converter mixes the 15-MHz WWV/WVH 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.
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.
In this circuit an LM34 or LM35 produces a frequency proportional to temperature. Reference current (138 µA) is set via R3. The output can be used to drive a display, frequency counter, or other indicating device for temperature readout.

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.
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.
The second gate (G2) of a MOSFET can be used to incorporate a crystal oscillator into the same stage as a frequency mixer. Although old hat with tubes, this scheme is seldom seen in dual-gate MOSFET circuitry. L3, C3, and X1 form the crystal oscillator, and T2 is an IF output transformer. T1 and C1 are tuned to the converter input frequency. This circuit should be useable up to 25 MHz or so, or higher with third-overtone crystals.

The devices shown from National Semiconductor are used in digital temperature circuit sensor LM35 and reference LM385 feed A-D converter ADC08031.
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.

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

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.

FIG. 18-13

FIG. 18-14
This RF converter converts amateur TV signals in the 420- to 450-MHz region to VHF channel 3 or 4, allowing reception of those signals on a standard TV receiver. RF amplifier Q1 feeds mixer M1, and Q3 acts as an IF amplifier. Q2 is an oscillator operating around 378 MHz and is tuneable over about a 30-MHz range. A complete kit is available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804.
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.

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.
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.
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
FIG. 19-1
This is a schematic and block diagram of a 2-MHz frequency counter. It uses and 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

1990 PE HOBBYIST HANDBOOK

FIG. 19-2
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.
Crystal Oscillator and Test 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-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
Q1, Q2, and the associated circuitry form a modified astable multivibrator in which the loop gain is automatically adjusted to the threshold of oscillation by means of field effect transistor Q3. Q4 linearly amplifies the signal present at the collector of Q2 and isolates the oscillator section of the circuit from the output. This stage features wideband operation and delivers a clean 2.5-V amplitude sine wave into a resistive load greater than or equal to 20 kΩ. The stage comprising Q5 has a voltage gain of 1 and its sole purpose is to isolate the nonlinear effects of rectifier D1 from the output.

The CMOS amplifier is biased into the linear region by resistor Rg. The pi-type crystal network (C1 and C2, and XTAL) provides the 180° phase shift at the resonant frequency which causes the circuit to oscillate.
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.

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.
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.).
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.

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.
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.

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

CRYSTAL-CONTROLLED HARTLEY OSCILLATOR

POPULAR ELECTRONICS  
FIG. 20-11
Current-Source 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.

Current Source for Low-Resistance Measurements
Precision Positive Current Source
Bilateral Current Source
Precision Negative Current Source
CURRENT SOURCE FOR LOW-RESISTANCE MEASUREMENTS

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.
BILATERAL CURRENT SOURCE

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 µA to 1 mA.
Current Limiter and Control 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.

Offset-Adjusting Current Source
Inrush Current Limiter
OFFSET-ADJUSTING CURRENT SOURCE

A. 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 $V_{IN}$.

B. 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.

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 $R_2$. 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 $R_7$ 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 $R_{TH}$.
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 RB. R4 can be 150 kΩ if R9 is not used. If power is removed, the circuit is ready for immediate restart.
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
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.
Detector, Demodulator, 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.

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
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.
An LM311 comparator converts a small analog signal to a digital level for the CD4046 phase-locked loop, which is configured as a first-order FM demodulator. This demodulator works with a 50-kHz FM modulated input signal. It has applications in FM light beam receivers or in remote control applications. Pin 1 of IC3 can be used to squelch the receiver if it is lifted from ground; if not desired, leave it grounded.
This missing pulse detector can use an LED or relay output.

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.
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 $R_B$ 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 kΩ to 10 kΩ) 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.

This closed-loop peak detector circuit uses a Schottky diode inside feedback loop to obtain good accuracy. The 20-Ω resistance $R_O$ isolates the 0.01-µF 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.
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 \( \frac{dv}{dt} \) limiting on the input can help this overload condition, however this will delay the response.

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.
LOW-DRIFT PEAK DETECTOR

Leakage of D2 is provided by feedback path through Rr.
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 $<<\frac{\pi}{2} R C_{D2}$, where $C_{D2}$ is shunt capacitance of D2.

FIG. 24-10

455-kHz FM DEMODULATOR

Free-running frequency of VCO: $f_0 = 1.2/4 (R_1) (C_1)$

lock range $f_1 = \pm 8f_0 \sqrt{V_{CC}}$
capture range $f_c = \pm \frac{\pi}{2} \sqrt{\frac{2\pi f_L}{r}}$

where $r = (3.6 \times 10^3) (C_2)$

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.

FIG. 24-11
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
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 µF 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.
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-dB crosstalk.

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

Digital capacitance control is possible with bilateral switches. Do not forget to consider "ON" resistance of the analog switches.
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.
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
To drive two or more common-cathode displays two or more 4033 decode counters can be cascaded.
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 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 µA. In this application, the bias network applies a voltage that sets the three quiescent currents to 100 µA.

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.
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.

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

An IC 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.

The circuit shows a frequently-used method of driving an LCD display. A square-wave drive is necessary for this application.
GAS DISCHARGE TUBE OR DISPLAY DRIVER

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 $Q_1$ and $R_I$ 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 $R_y$.

FLUORESCENT TUBE DISPLAY DRIVER

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

4543B COMMON-CATHODE LED DRIVER

This circuit shows a way of driving a common-cathode display segment or an LED with a CD4543B.
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
When the doorbell switch is pressed, the two monostable stages are activated in sequence, applying bias to a pair of voltage-controlled resistor stages. These then modulate the outputs from a pair of tone generators. The resulting signals are fed to an audio amplifier, then to the speaker.
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.

This simple electronic door buzzer draws no quiescent current. When S1 is pressed the speaker produces a tone. The NE555 (U1) generates signal.
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
FIG. 1—BLOCK DIAGRAM for the Fax-Mate. The upper path is for data, and the lower one is the decode and control path.

1992 R-E EXPERIMENTERS HANDBOOK

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

1992 R-E EXPERIMENTERS HANDBOOK
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.
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
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).

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).

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 IN34 or IN82. M is a 100-mA meter movement.

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.

FIG. 29-5
Filter 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.

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

BANDPASS FILTER

FOURTH ORDER LOW-PASS BUTTERWORTH FILTER

ACTIVE HIGH-PASS FILTER

FIG. 30-8  FIG. 30-9  FIG. 30-10  FIG. 30-11
-400-Hz LOW-PASS BUTTERWORTH FILTER

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

BANDPASS FILTER

Appropriate center frequency of this circuit is:

\[ \frac{1}{R_4C_2} \]

\[ C_1 = C_2, \quad R_1 = R_4 \]

ACTIVE LOW-PASS RC FILTER

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

PASSIVE PI FILTER CONFIGURATIONS
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 $\omega = 1/R_0 \times C_0$. 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.
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.

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

![Circuit Diagram](image)

**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. Roll-off 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

![Circuit Diagram](image)

**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.
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.

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.
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 kΩ and its output impedance is less than 1 kΩ.

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.

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.
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.

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.

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

\[
R = R_1
\]
\[
R_2 = 2R_1
\]
\[
C = C_1 = C_2
\]
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.

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.

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

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

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.
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).

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.
The LMF380 switched audio filter by National Semiconductor is used here to obtain a third-octave filter set that covers the entire audio range.
The input signal is rectified by D1 and D2 op amp U1-a, and fed to output amp U2. R8 is set for correct circuit calibration.

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.
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
A 555 timer, IC1, drives a 4017 CMOS dcdc 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 µs.

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.
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.

**Fig. 31-3**

**Dark-Activated LED Flasher**

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

**Fig. 31-4**
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.

This LED flasher has double-ended output connection. The circuit can be used with 1 to 5 LEDs on each side as indicated.
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 µF capacitor between flashes, about 2 or 3 time constants, which means about 500 kΩ to 1 MΩ for a 1-s rate. Use lower values for higher rates.

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.
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
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 $f_0$ that are much greater than that of the input signal. The impulses 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 bits 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 $f_0$, as long as the frequency of impulse generator $f_q$ is much greater than $2Mf_0$. 
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
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.

\[ E_{\text{out}} = \text{constant} \times (\log E_{\text{in}}) \]  

This circuit has 100-dB dynamic range, which is five decades of voltage change at the input.
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.

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

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.
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.

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

\[ C = \frac{R_1}{R_3} C_1 \]
\[ I_t = \frac{V_{os} + I_{os} R_1}{R_3} \]
\[ R_s = R_3 \]

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

**TRIANGLE-WAVE OSCILLATOR**

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.
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.

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

Explosive Gas Detector
Combustible 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.).
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.

FIG. 35-2

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.
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
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.
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
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-MΩ 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-kΩ 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.
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 tripper 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.
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
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.
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.
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
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

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.
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.

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

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.
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.

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.
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 (Watterson #87) is recommended.

- **BZ**: Piezo Disc
- **L1**: Jumbo Red LED
- **P1**: 2-MΩ Trimmer Resistor
- **Q1**: 2N3904 Transistor
- **Q2**: 2N3906 Transistor
- **R1**: 270-Ω Resistor
- **S1**: Solar Sensor
- **T1**: Audio Transformer

This transmitter consists of an oscillator and LEDs. It generates a pulsed tone of around 850 Hz.
Here is a complete IR remote-control system that consists of a simple transmitter (A) and an equally simple receiver (B).

**IR RECEIVER**

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**

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

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
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.
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.
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
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 ($\approx 10^{-14} \text{A}$).
This amplifier features 400-µsec settling time (to 0.01%), 140-V/µsec slow rate, and 17-MHz gain-bandwidth product. The supply voltage can be ±5 to ±20 V.
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 $V_1$ in this circuit.

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

**FIG. 42-1**
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

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

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.
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.
Interface 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.

- 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

FIG. 44-1

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

PROCESS-CONTROL INTERFACE

FIG. 44-2

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

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.
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.
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
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.

A CMOS digital inverter is formed by connecting two MOSFETS, as shown.
A multivibrator circuit drives a pair of 2N3055 power transistors. T1 is a 12.6-V CT filament transformer with a 120-V primary.

T1 is a suitable transformer for the voltage desired, with a 12.6-V CT winding.
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
This oscillator-driver induces a high voltage in the windings of T2.
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
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

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

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 \( \frac{\pi}{2} \) inch diameter.
The high-voltage power supply is a CMOS-based oscillator that pulses a high-voltage ignition transformer. The transformer output is around 20 kV.

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.
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.
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
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-µF Capacitor
Q1 2N3904 Transistor
Q2 2N3906 Transistor
R1 4.7 kΩ Resistor
R2 82 kΩ Resistor
Light Beam Communication 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.

- 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
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.

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

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

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 R2 from 1 to 10 MΩ and use a crystal microphone with a large diaphragm.

LIGHT-WAVE VOICE-COMMUNICATION RECEIVER

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.
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.

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.
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
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 LD1 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.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C4</td>
<td>0.1-µF Capacitor</td>
</tr>
<tr>
<td>C2</td>
<td>100-µF Capacitor</td>
</tr>
<tr>
<td>C3</td>
<td>47-µF, 350-V Electrolytic Capacitor</td>
</tr>
<tr>
<td>D1</td>
<td>1N4007 Diode</td>
</tr>
<tr>
<td>D2</td>
<td>6-V Zener (M747814)</td>
</tr>
<tr>
<td>IC1</td>
<td>555 Timer IC</td>
</tr>
<tr>
<td>IC2</td>
<td>4017 CMOS IC</td>
</tr>
<tr>
<td>P1</td>
<td>500-kΩ Potentiometer</td>
</tr>
<tr>
<td>Q1–Q10</td>
<td>106 SCR</td>
</tr>
<tr>
<td>R1</td>
<td>560-Ω Resistor</td>
</tr>
<tr>
<td>R2, R4, R6, R8, R10, R12, R14, R16, R18</td>
<td>100-kΩ Resistor</td>
</tr>
<tr>
<td>R20, R22</td>
<td>R3, R5, R7</td>
</tr>
<tr>
<td>R9, R11, R13</td>
<td>R15, R17, R19</td>
</tr>
<tr>
<td>R21</td>
<td>2.2-kΩ Resistor</td>
</tr>
<tr>
<td>R23</td>
<td>15-kΩ 7-W Resistor</td>
</tr>
</tbody>
</table>
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 R1. 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-µF electrolytic capacitor). Capacitor C3 is added at the supply pin of U2 to suppress transients.
AUTOMATIC PORCH-LIGHT CONTROL

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

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

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

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.

WARNING: Extreme shock hazard!
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**

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

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.
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.

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

**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 $R_2$ prevents false triggering of the triac by the trickle current through the diac.

HALOGEN LAMP PROTECTOR

**FIG. 50-14**

This circuit produces a soft turn-on for halogen lamp filaments upon powering up. MOSFET used is a BUZ10, which has $0.2 \Omega R_{DS(on)}$. $R_1$, $R_2$, and $C_1$ set the turn-on rate and $D1$ discharges $C1$ at turn-off.
Light-Controlled 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.

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
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.

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

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 ½ 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

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

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

This circuit can control the on/off cycle of a light via a CDS photocell, and turn it off after a preset 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.

WILLIAM SHEETS

DARK-ACTivated SWITCH

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

![Circuit Diagram]

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 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.
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.

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.

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

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

FIG. 51-13

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

DARK-ACTIVATED RELAY

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.
Light Sources

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
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.
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.

+5VDC

R3

2.7K

(USED FOR TTL)

V+

R2

10K*

Q1

2N2222(ETC.)

V+

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

+12VDC

V1

V2

V

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

BLACK SILICONE SEAL

BLACK HEATSHRINK TUBING

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

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 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 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.

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.
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.

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

FIG. 53-2
Mathematical 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.

Second-Order Polynomial Generator
Polar-to-Rectangular Converter and Pattern Generator for Radio Direction Finding
Root Extractor
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 R3 and R4) 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 R1, R2, and \( R_o \)) is wired to IC1’s internal summing circuit to generate the polynomial’s other two terms; the offset term \( (a) \) and the linear coefficient \( (b) \).
In order to display polar quantities (magnitude and direction of a received radio signal), a sine and cosine voltage proportional to an angle (antenna direction) is needed. In this case, a sine-cosine potentiometer coupled to a directional antenna and a sample of a voltage proportional to received signal is used to display relative magnitude and direction of a received signal.
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
- Harmonic Distortion Analyzer
- Watch Tick Timer
- Visual Continuity Tester
- RC Decade Box
- Digital Altimeter
- Electronic Scale
- Radar Calibrator
- Cable Tester
- Simple Curve Tracer
- Voltage Level Circuit
- Low-Drift dc Voltmeter
- Light Meter
- Mercury Switch Tilt Detector
- 50-MHz RF Bridge
- ac Watts Calculator
- Audio-Frequency Meter Circuit
- One-IC Capacitance Tester
- Transistor Checker
- Low-Current Ammeter
- Analog Frequency Meter
- Electromagnetic Field Sensor
- Magnetic Proximity Sensor
- High-Impedance Voltmeter
- Fast Video-Signal Amplitude Measurer
- Signal Generator
- Simple Signal Tracer
- DVM Adapter for PC
- Simple Digital Logic Probe
- S Meter for Communications Receivers
- LED Expanded Scale Voltmeter
- 1-kHz Harmonic Distortion Meter
- Line Voltage-to-Multimeter Adapter
- Audible Logic Tester
- Short Tester for 120-V Equipment
- Digital Pressure Gauge
- Simple Short Finder
- Voltage Monitor
- Linear Inductance Meter
- DeBounce Circuit
- ac Wiring Locator
- Audible Continuity Tester
- ac Outlet Tester
- JFET Voltmeter
- Check for Op-Amp dc Offset Shift
- Continuity Tester for Low-Resistance Circuits
- Supply Voltage Monitor
- Audio-Frequency Meter
- Zener Diode Test Set
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.
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).
This circuit adapts a frequency counter to measure intervals. It was originally used as a shutter speed checker for a photo application. The watch ticks are clipped and shaped and formed into a square wave. This square wave is used to gate an accurately known clock (1-MHz TTL XTAL OSC) and an external counter is used to directly count the clock pulses during the interval to be measured. A 1-MHz clock can be used to measure to a resolution of 1 µsec. Accuracy = ± time base ± 1 µs ± 1 count LSB.
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

* IF 1/4 WATT RESISTORS ARE USED, FUSE CAN BE INCREASED TO 2-25 AMP

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1989 R-E EXPERIMENTERS HANDBOOK

FIG. 55-5
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

<table>
<thead>
<tr>
<th>Configuration</th>
<th>S13 Position</th>
<th>IN/GND</th>
<th>OUT/GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>R/C</td>
<td>IN: BP1</td>
<td>OUT: BP2</td>
</tr>
<tr>
<td>Capacitance</td>
<td>R/C</td>
<td>IN: BP5</td>
<td>OUT: BP6</td>
</tr>
<tr>
<td>Series RC</td>
<td>SER</td>
<td>IN: BP1</td>
<td>OUT: BP6</td>
</tr>
<tr>
<td>Parallel RC</td>
<td>PAR</td>
<td>IN: BP1</td>
<td>OUT: BP6</td>
</tr>
<tr>
<td>Low Pass Filter (Integrator)</td>
<td>LPF</td>
<td>IN: BP1</td>
<td>OUT: BP6</td>
</tr>
<tr>
<td>High Pass Filter (Differentiator)</td>
<td>HPF</td>
<td>IN: BP6</td>
<td>OUT: BP1</td>
</tr>
</tbody>
</table>

This decade box can be set for any resistance value between 10 Ω and 11.1 MΩ in 10-Ω stops. 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.
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.
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).
This circuit is basically a system that generates a pulsed modulation signal for a Gunn diode microwave oscillator. Several speed settings are preset (S3 a and b). A 555 timer is used with a frequency divider chain to produce Doppler shift equivalents of 25, 35, and 55 mph, for both X- and D-band radars.
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.
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.
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.

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

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 phototransistor 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

If the mercury bulb in this circuit is tipped, U1-a will light LED1 by going low, indicating a “tilted” condition.
The bridge shown was used for measurements on 50-MHz amateur radio antennas. R1 is a miniature 500 Ω linear potentiometer. The unknown impedance is compared to R2, a 51-Ω resistor. An external signal source is required.
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.

**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 circuit. 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 $R_s$ 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:

$$P_L = V_L \times I_L \times \cos \theta$$
$$= V_L \times (V_s/R_s) \times \cos [2 \sin^{-1} (V_d/2V_s)]$$
$$\theta = 2 \psi = 2 \sin^{-1} (V_d/2V_s)$$
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).
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-µF order of magnitude, but they can be changed for lower or higher values.

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-µA 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.
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.

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.
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.

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

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.
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.

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

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.
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:

\[
\text{THD} = \frac{E_{res}}{E_{in}}
\]

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

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

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

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

This very simple voltmeter circuit uses a 50-μA meter in a bridge circuit. It is useful for noncritical applications.
CHECK FOR OP-AMP dc OFFSET SHIFT

![Diagram of the test circuit for checking for op-amp dc offset shift.](image)

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 NE55532N) or relatively gradual (LF358J and TL082CP).

### Table 55-45

<table>
<thead>
<tr>
<th>kHz</th>
<th>LF412CN</th>
<th>LF358J</th>
<th>NE55532N</th>
<th>TL082CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51</td>
<td>48</td>
<td>51</td>
<td>50</td>
</tr>
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<tr>
<td>170</td>
<td>14</td>
<td>12</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>

**FIG. 55-45**

### CONTINUITY TESTER FOR LOW-RESISTANCE CIRCUITS

![Diagram of the continuity tester for low-resistance circuits.](image)

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.

**FIG. 55-46**
SUPPLY VOLTAGE MONITOR

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

FIG. 55-47

AUDIO-FREQUENCY METER CIRCUIT

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

FIG. 55-48
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.
Metal-Detector 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.

Metal Pipe Detector
Low-Cost Metal Detector for Experimenters
Metal Locator
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.
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-µF Capacitor (103)
- C3, C4 0.001-µF Capacitor
- Q1 2N3906 Transistor
- R1 47-kΩ Resistor
- R2 100-Ω Resistor
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
- Soldering Iron Control
- Furnace Fuel Miser
- Personal Message Recorder
- Four-Input Minimum/Maximum Selector
- Soil Heater for Plants
- Key Illuminator
- Radio Commercial Zapper
- Audio Limiter
- Analog De-Glitch Circuit
- Acoustic Field Generator
- Suppress Jitter with Hysteresis
- Heartbeat Monitor
- Self-Retriggering Timed-On Generator
- Frequency Divider for Measurements
- Video, Power, and Channel-Select Signal Carrier
- 7805 Turn-On Circuit
- AF Drive Indicator
- Phase-Locked Loop
- Capacitance Multiplier
- Practical Differentiator
- Hum Reducer for Direct-Conversion Receivers
- Preamp Transmit-Receive Sequencer
- dc Output Chopper
- ac Isolation Transformers Use
- Inexpensive 12-V Transformers
- ac Line Voltage Booster
- Octal DA Converter
- 1-dB Pad
- Pseudo-Random Bit Sequence Generator
- Simple External Microphone Circuit for Transceivers
- JFET Chopper Circuit
- Audio Memo Alert
- Octave Equalizer
- Complementary or Bilateral ac Emitter-Follower Circuit
- Capacitor Hysteresis Compensator
- Amplifier Cool-Down Circuit I
- NE602 Input Circuits
- NE602 Output Circuits
- Basic Latch Circuits
- Bootstrap Circuit
- Simple Schmitt Trigger
- Amplifier Cool-Down Circuit II
- NE602 dc Power Circuits
- Inrush Current Limiter
A complete schematic diagram of the voice disguiser is shown. Microphone MIC1 picks up the voice signal and feeds it to an audio amplifier, consisting of Q1 and Q2, and a few support components. The amplifier has a low-pass gain response that limits the voice frequencies to 5 kHz or lower.
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-Ω 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.

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 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.

FIG. 57-3
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.

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.

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.
PERSONAL MESSAGE RECORDER

![Circuit Diagram]

FIG. 57-4
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.
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 input 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

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.

FIG. 57-6

FIG. 57-7
RADIO COMMERCIAL ZAPPER

FIG. 57-8
RADIO COMMERCIAL ZAPPER (Cont.)

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 (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-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:

\[ t_2 > t_1 \] (mono period longer than glitch)
\[ t_2/T \text{ small (to optimize output waveform)} \]

Signal bandwidth \( f_0 = \frac{1}{2\pi CR} \)

Signal phase \( \phi = \tan^{-1} \frac{2\pi f CR} \)

The signal range is approximately ±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.
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 channel signal.
ACOUSTIC FIELD GENERATOR (Cont.)

![Circuit Diagram]

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.
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 \(15\text{-kHz}\) low-pass filters. Cascading two filters produces a very sharp cut off \((-36 \text{ dB per octave})\). 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 \(\pm18\text{-V}\) 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 ±18-volts unregulated DC.
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.

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.
When power is first applied to the circuit, C2 begins to charge via LED1, R3, and R4. When the voltage across C2 reaches U1's input trigger level, the output of U1 at pin 6 goes positive for a period that is determined by the values of C1 and R1. That turns Q1 on, discharging C2 through D1 and Q1.

At the end of the set period, the output of U1 at pin 6 goes low, turning Q1 off and allowing the current to begin flowing through LED1, R3, and R4 to gain charge C2, causing the cycle to repeat. The repeat time is determined by the values of R3, R4, and C2. The previous formula won't be as accurate for this circuit, but it will at least get you close enough for the capacitor value; then R4 can be fine-tuned to obtain the desired timing period.

This circuit is meant to be driven by a 1-MHz standard signal of a few volts amplitude. U1 through U5 are 7490 decade counter/divider and produce a division ratio of 100,000:1. Successive divisions of 10 can be tapped off, if desired, between stages. One or more stages can be added for still lower frequencies.
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.

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.

RADIO ELECTRONICS

FIG. 57-17
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 ±30 to ±70 V symmetrical supply.
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.

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

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.
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.
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.

"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.

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.
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 Ω. 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.
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.

Used originally for an Icom ICZAT handle talkie, this circuit might prove useful in other applications.
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.

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**

This circuit is one section of an octave equalizer used in audio systems. The table shows the values of C1 and C2 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 R2. 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 C1 and C2 at the low-frequency end. In addition, 10 sections will only draw a combined supply current of 6 mA maximum.

<table>
<thead>
<tr>
<th>f₀ (Hz)</th>
<th>C₁</th>
<th>C₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0.18µF</td>
<td>0.018µF</td>
</tr>
<tr>
<td>64</td>
<td>0.1µF</td>
<td>0.01µF</td>
</tr>
<tr>
<td>125</td>
<td>0.047µF</td>
<td>0.0047µF</td>
</tr>
<tr>
<td>250</td>
<td>0.022µF</td>
<td>0.0022µF</td>
</tr>
<tr>
<td>500</td>
<td>0.012µF</td>
<td>0.0012µF</td>
</tr>
<tr>
<td>1k</td>
<td>0.0056µF</td>
<td>560pF</td>
</tr>
<tr>
<td>2k</td>
<td>0.0027µF</td>
<td>270pF</td>
</tr>
<tr>
<td>4k</td>
<td>0.0015µF</td>
<td>150pF</td>
</tr>
<tr>
<td>8k</td>
<td>680pF</td>
<td>68pF</td>
</tr>
<tr>
<td>16k</td>
<td>360pF</td>
<td>36pF</td>
</tr>
</tbody>
</table>

**FIG. 57-33**

**COMPLEMENTARY OR BILATERAL ac EMITTER-FOLLOWER CIRCUIT**

This noninverting circuit uses a pair of complementary npn (2N3904) and pnp (2N3906) transistors.

**FIG. 57-34**

**CAPACITOR HYSTERESIS COMPENSATOR**

*SELECT FOR TIME CONSTANT C₁ = \( \frac{R₃}{100k} \)

**FIG. 57-35**

LINEAR DATABOOK
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

FIG. 57-37

Input circuits for the NE-602.

NE602 OUTPUT CIRCUITS

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.

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 non-linearity of the JFET input capacitance. In the figure, a second feedback divider bootstraps the substrate of U1. With $R_1 = 500 \, k\Omega$ (source impedance), THD at 10 kHz was reduced an order of magnitude.

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.

FIG. 57-41
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

![Circuit Diagram]

The dc power supply circuit for the NE-602.

INRUSH CURRENT LIMITER

![Circuit Diagram]

A 7805 can be configured as a constant-current regulator, to serve as an inrush current limiter. R1 will have 5 V across it at all times so the total current through R1 will be $5 \div R_1 + 5 \text{ mA}$, the 5 mA being the regulator operating current. In this case, $R_1 = 5 \text{ V} / 95 \text{ mA} = 52.6 \Omega$ for 11 current = 100 mA.
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
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.
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).
A JFET transistor is used as a high-to-low impedance converter and signal mixer. Input impedance is approximately 500 kΩ but it can be increased by increasing R5 to R8 as high as 10 MΩ. Output Z is about 2 kΩ, but it can be increased or decreased by changing the value of R10. Use 560 or 680 Ω to feed a 600-Ω input; use 100 kΩ to 1 MΩ for high impedance.
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.

\[ E_{\text{OUT}} = -(\text{In } \#1 + \text{In } \#2 + \text{In } \#3 + \text{In } \#4) \]

IC1 = LM741, etc.

WILLIAM SHEETS

FIG. 58-4

FET OP AMP MICROPHONE MIXER

POPULAR ELECTRONICS

FIG. 58-5
Modulator 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.

FM Modulator
455-kHz Modulator
555 FM Circuit
The FM modulator is built with a Motorola MC1648P oscillator. Two varactors, Motorola MV-209, are used to frequency modulate the oscillator. The 5000-Ω 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.

This circuit shows how to frequency-modulate the oscillator using a 555. Oscillator frequency is set with the 5-kΩ potentiometer and the modulation signal is dc-coupled.
555 FM CIRCUIT

IC-1 - Motorola MC-1374P
IC-2 - National LH0002C
L1, L2 - Mouser Electronics #421IF200
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.

Circuit for applying a de-coupled FM or PPM to a 555 configured as an oscillator.
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
The circuit uses Q1 to buffer the right-channel balance output while Q2 and Q3 form a VOX circuit. When the signal level from the microphone goes high, the output of the VOX also goes high and the multiplexer inside IC1 switches the high-gain left-channel output through to a following buffer stage. This signal is then ac-coupled via C3 into an RF mixer stage and thence to an RF amplifier, which is tuned by C2 and L2.
FIG. 60-2

BABY MONITOR

A

B

POPULAR ELECTRONICS
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 30 V 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.
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 pickup facing a nearby bird feeder. The output of the amplifier is then connected to a 16-Ω speaker.

The amplifier’s voltage gain is determined by the values of the input resistor (R1) and the feedback 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.

ACID-RAIN MONITOR

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.
Moisture- and Fluid-Detector 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.

Water-Activated Alarm
Simple Flood Alarm
Moisture Detector
WATER-ACTIVATED ALARM

When sensor gets wet, it conducts, forward-biases Q1, and activates audio oscillator U1. A tone is heard from the speaker.

SIMPLE FLOOD ALARM

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.
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-µF Mylar Capacitor
- **Q1, Q2** 2N3906 Transistor
- **R1** 6.8-kΩ Resistor
- **R2** 33-kΩ Resistor
- **R3** 200-Ω Resistor
- **XDC** Piezoelectric Transducer
62

Motion Detector Circuit

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
Operating at around 1.1 GHz, the detector senses field disturbance in the neighborhood of the antenna. The Doppler signal from detector D1 is amplified and drives a power MOSFET switch. The antenna is a short (2 to 3") length of wire.
Motor-Control 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.

Blender-Control Circuit
PWM Motor-Drive Circuit
Speed-Control Switch Circuit
Piezo Motor Drive
Pulse-Width-Modulated Motor-Speed Control
Speed-Control Switch
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.
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.

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.

Using two Apex Microtechnology PA41 devices in a bridge circuit, this piezo motor driver delivers 0- to 630-V output.
Connected in this manner, an LM317 1-A adjustable-voltage regulator can be used to control the speed of a miniature dc motor or vary the brilliance of a small lamp. The circuit does so by controlling the pulse width, and therefore the current, to the load device.

To set the desired maximum output voltage, momentarily close S1 and adjust R3. Connect either a lamp or small dc motor (as is shown in the schematic to the circuit's output) and adjust R4 for the desired results. Any device that is driven by this circuit should have a current requirement of 1 A or less. And you should be sure to use good-sized heatsink for the LM317 regulator IC.

The speed-control switch offers reasonably good control and stability to both ends of its operating range. This circuit uses two SCR devices in a full-wave configuration to control the dc power to a motor. A center-tapped transformer is used to supply the SCRs.
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
Using two Siliconix DG506 multiplexer chips, this 32-channel analog multiplexer selects 1 of 32 channels, depending on the data inputs $A_0 - A_4$. 
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
IMPROVED CMOS MULTIVIBRATOR

This circuit uses a protective resistor $R_2$ in conjunction with feedback resistor $R_1$. Together, they form a voltage divider to reduce the input voltage amplitude for IC1-a so that the protective diodes never conduct. This improves temperature and voltage stability of the multivibrator.

VERY LOW FREQUENCY MULTIVIBRATOR

The use of JFETs permits high resistance and long time constants in this very low frequency multivibrator. The values shown are for 0.15 Hz operation.
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 x C1).

This free-running square-wave oscillator uses two npn transistors. Output frequency is approximately 300 Hz with the values shown.
In this multivibrator circuit frequency and pulse width can be separately controlled by using steering diodes (1N914) and two potentiometers.

The time constant of $R_A \times C$ determines the period of the monostable multivibrator. A negative pulse at pin 2 of the 555 starts the cycle.
An astable multivibrator based on the 555 is shown. Freq is approximately 975 Hz as determined by the values of $R_B$ and $C$.

A section of a quad LM139 is used here as a one-shot pulse former.
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
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.
Perfect pitch, which is based on the 8751 H microprocessor, is an inexpensive and easy-to-build instrument tuner/frequency counter with a built-in headphone amplifier and a visual metronome. Perfect pitch converts the audio signal from your instrument to a digital signal, and displays the musical note you are playing and its frequency in real time on a 16-character liquid-crystal display. It also has an auxiliary audio input for radio, tape, or CD players so that you can tune up and play along with your favorite artists.
MUSICAL INSTRUMENT DIGITAL INTERFACE (MIDI) RECEIVER

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.

ELEKTOR ELECTRONICS

FIG. 66-3

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.

FIG. 66-4
MUSICAL INSTRUMENT
DIGITAL INTERFACE (MIDI) TRANSMITTER

Used for digital control of musical instruments, this transmitter converts the digital data signals to equivalent optical signals for fiberoptic cable interface. Optocoupler IC1 provides isolation, and drives IC2-a and -b and T1, and finally provides a cable driver LED (SFH750).

MELODY CIRCUIT

A high-quality melody circuit. The slow decay waveform produced will create chime-like notes. Pitch, tempo, and duration are all adjustable.

TOP OCTAVE GENERATOR

Inputs and outputs are 12 volt square waves

Using an MK50240, this circuit produces 12 top octave tones. The input and output lines can be divided using a binary divider IC to obtain the lower notes.
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
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.
Noise-Limiting 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.

- Audio Dynamic Noise-Reduction System
- Amplified Noise Limiter for SW Receivers
- Receiver AF Noise Limiter for Low-Level Signals
- Simple Noise Limiter for Receivers
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.

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.
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.

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.
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

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.
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 $-90 \text{ dB THD}$ with a $\pm 5\text{-V, } 500\text{-kHz}$ output signal. If a 100-kHz sine-wave input is used, the circuit will drive a 600-Ω load to a level of 7 V rms with less than $-109 \text{ dB THD}$, as well as a 10-kΩ load at less than $-117 \text{ dB THD}$.

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 $R_f$.

Using resistor and transistor feedback elements, this operational amplifier circuit can be used as a nonlinear amplifier. $R_4$ and $R_6$ can be varied to change breakpoints, as required.
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.

A JFET acts as a variable attenuator for this op amp. Maximum gain is:

\[ \frac{R_2}{R_1 + R_{DS(ON)}} \]
This circuit offers the best of both worlds. It can be combined with a low input offset voltage and drift without degrading the overall system's dynamic performance. Compared to a standalone FET input operational amplifier, the composite amplifier circuit exhibits a 20-fold improvement in voltage offset and drift.

In this circuit arrangement, A1 is a high-speed FET input op amp with a closed-loop gain of 100 (the source impedance was arbitrarily chosen to be 100 kΩ). A2 is a SuperBeta bipolar input op amp. It has good dc characteristics, biFET-level input bias current, and low noise. A2 monitors the voltage at the input of A1 and injects current to A1's null pins. This forces A1 to have the input properties of a bipolar amplifier while maintaining its bandwidth and low-input-bias-current noise.

You can build a composite amplifier featuring high gain, wide bandwidth, and good dc accuracy by cascading the sections of a dual video amplifier and adding two appropriate phase-compensation components. The op amp drives a 150-Ω load and provides a closed-loop gain of 40 dB.

This circuit operates from +5 V and uses a single op amp to deliver a full-wave rectified output of the input signal.
Optical 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.

- 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
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).
Interfacing equipment, whether TTL, RS-232C, or 20mA current-loop based, with optoisolators.

FIG. 70-3
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, R2, is set to zero ohms), otherwise, the LED might burn out.

**OPTOCOUPLER CIRCUITS**

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.
The very simple circuit uses only two CD4001 packages, i.e., eight NOR gates and operates in the following way: Pulse streams are fed to an RS flip flop generating an output waveform which has a small or large duty cycle depending on the direction of rotation. The same input pulses are also fed to a NOR gate, which "adds" the two pulse trains.

The rising edges of this waveform are used to produce short positive pulses from the circuit consisting of $R_1$, $C_1$, $D_3$, and a NOR gate used as an inverter. This is used to "sample" the outputs of the flip flop to detect the direction of rotation. The output, whose duty cycle is large, forces the sampling NOR gate to generate a pulse train which sets (or resets) the second RS flip-flop continuously giving a permanent indication of the direction of rotation.
Use of two LDR devices replaces the two pushbuttons used in safety switches. The lamps provide light sources for the LDR devices.

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.

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.
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
Local oscillator circuits for the NE602.

LC AUDIO OSCILLATOR

COLPITTS OSCILLATOR
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**

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**

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)

\[ f_{\text{osc}} = \frac{1.44}{(R_A + 2R_B)C} \]

V < 0.6 V

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)

\[ f_{\text{osc}} = \frac{1.44}{(R_A + 2R_B)C} \]

> 0.6 = off
< 0.6 = on

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

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

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

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

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 ~80- to 90-MHz crystals, although values of oscillator circuit constants can be scaled for higher or lower frequencies.
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.)

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</table>

- Standard pitch, A4= 440 Hz

Values shown are stretched for the average piano.

Popular Electronics

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.
The circuit shown has a frequency range of 2 Hz to 30 kHz. R2 is a linear or log potentiometer.

This transistor can achieve frequency switching in this CMOS astable oscillator.
**PRECISION GATED OSCILLATOR**

![Circuit Diagram](image)

A 1-kHz gated oscillator with no long "turn-on" cycle is shown. R2, R3, and D1 preset the voltage on tuning capacitor C1 to $\frac{1}{2}$ of the supply voltage.

**WIEN-BRIDGE AUDIO OSCILLATOR**

![Circuit Diagram](image)

For variable-frequency operation, R1 and R2 can be replaced by a dual potentiometer.

**VARIABLE DUTY-CYCLE OSCILLATOR**

![Circuit Diagram](image)

Using a potentiometer and steering diodes, this 1.2-kHz oscillator will provide 1 to 99% duty cycle. Vary C1 to change frequency.
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.

Two gates of the Quad 4093 are used to make an oscillator. \( R_x \) can be from about 5 kΩ to around 10 MΩ. \( C_x \) can be from about 10 pF to many µF, the limit being set by the leakage of the capacitor. Frequency is approximately \( 2.8/R_x C_x \) (R MΩ, Cmfld).

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%.
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.
Oscilloscope 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.

- Oscilloscope Preamplifier
- Simple Spectrum Analyzer Adaptor for Scopes
- Simple Oscilloscope Timebase Generator
- Trigger Selection Circuit for Oscilloscope Timebase
- Variable Gain Amplifier
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.
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.
The 555 timer generates both a linear ramp and an output for Z-axis modulations of the CRT electron beam.

**FIG. 72-3**

**TRIGGER SELECTION CIRCUIT FOR OSCILLOSCOPE TIMEBASE**

Vert. defl. signal from CRT plates (ac couple) — Trigger polarity switch — Comparator

Trigger sensitivity

100 kΩ

10 kΩ

To timebay

Comparator

OP AMP: Any suitable high slew rate type or video op amp

**FIG. 72-4**
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

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
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.

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-µF Mylar Capacitor
C2  1-µF Electrolytic Capacitor
C3  0.001-µF Mylar Capacitor
IC1  555 timer IC
Q1  2N3904 Transistor
Q2  2N3906 Transistor
R1  4.7-kΩ Resistor
R2  3.3-MΩ Resistor
R3, R6  10-kΩ Resistor
R4, R5  100-Ω Resistor
R7  18-kΩ Resistor
R8  Potentiometer
XDC  Piezoelectric Transducer Disc
Misc  IC Socket, 9-V Snap, PC Board
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
The single-phase input produces out-of-phase outputs at the collectors of Q1 and Q2.

This phase splitter uses a 2N2222 (or other general purpose npn transistor) to achieve outputs that are 180° out of phase.
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 $V_{o_1}$ and $V_i$ is zero. As a result, each shifter will introduce a phase difference of exactly $\pi/\alpha$. 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.
Photography Related 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.

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
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.

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.
Meter M1, a +/-50-µA 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/stop). The opposite occurs if the light is too dim. Lamp 11, 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.
Resistors R3 and R4 should be selected for the meter used. With a dual supply of +/−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.

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.
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 (freew-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 $R_7$, turning it on.

Timing capacitors $C_1$ through $C_5$ begin to charge through timing resistors $R_1$ through $R_3$. dc voltage is applied to BZ1's driver input through $R_5$ and to its feedback terminal (through $R_4$), 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.

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.
STROBE LIGHT

C1, C2, C3 ... 10 µF 160V Electrolytic Capacitor
C4, C5, C6 ... 160 µF 200V Electrolytic Capacitor
C7 ........ 0.5 µF 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

1991 PE HOBBYIST HANDBOOK

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 µF at 160 V. Capacitors C4, C5, and C6 are connected in series and form an equivalent capacitor of about 53 µF 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 developer 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.

FIG. 75-8
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
A CMOS-gate and transistor buffer can be used as an effective driver for a piezoelectric transducer.

This circuit uses a 4049 IC to drive a 2N2222 switching transistor. The transistor drives crystal 1 a piezo transducer.

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.

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.
A 555-timer oscillator is perhaps one of the most popular circuits for driving a piezoelectric transducer.
Power Supply Circuits—High Voltage

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
In the miniature high-voltage dc generator, the input to the circuit, taken from a 12-Vdc power supply, is magnified to provide a 10,000-Vdc output causing a pulsating signal, of opposite polarity, to be induced in T1's secondary winding.

The pulsating dc output at the secondary winding of T1 (ranging from 800 to 1000 V) is applied to a 10-stage voltage-multiplier circuit, which consists of D1 through D10, and C3 through C12. The multiplier circuit increased the voltage 10 times, producing an output of up to 10,000 Vdc. The multiplier accomplishes its task by charging the capacitors (C3 through C12); the output is a series addition of the voltages on all the capacitors in the multiplier.

In order for the circuit to operate efficiently, the frequency of the square wave, and therefore the signal applied to the multiplier, must be considered. The output frequency of the oscillator (U1-a) is set by the combined values of R1, R5, and C1 (which with the values specified is approximately 15 kHz). Potentiometer R5 is used to fine tune the output frequency of the oscillator. The higher the frequency of the oscillator, the lower the capacitive reactance in the multiplier.

Light-emitting diode LED1 serves as an input-power indicator, and neon lamp NE1 indicates an output at the secondary of T1. A good way to get the maximum output at the multiplier is to connect an oscilloscope to the high-voltage output of the multiplier, via a high-voltage probe, and adjust potentiometer R5 for the maximum voltage output.
A 2N3055 oscillator (Q1) drives a homemade transformer, wound on a \( \frac{3}{8} \times 1\frac{1}{4} \)" 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.

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.
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.

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.
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.

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.
This circuit is a 92%-efficient power supply for cold-cathode fluorescent lamps (CCFLs), which are used to backlight LCD in portable equipment. The efficiency depends heavily on the component types, particularly C1, Q1, Q2, L1, and T1, whose manufacturers are noted.
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
- Universal Laboratory Power Supply
- +5 V/+3.6 V from 4 AA Cells
- Inductorless Switching Regulator
- Single LTC Power Supply
- Configurable Power Supply
- Combination Voltage and Current Regulator
- HV Power Supply with 9-to 15-Vdc Input
- Inductorless Power Supply Converter
- Simple Negative Supply for Low-Current Applications
- Inverting Power Supply
- Multivoltage Power Supply
- Current-Limiting Regulator
- Neon Lamp Driver for 5- to 15-V Supplies
- 13.8-Vdc 2-A Regulated Power Supply
- 0- to 12-V, 1-A Variable Power Supply
- Voltage Doubler Supply
- Adjustable 20-V Supply
- Switching Regulator Converter
- 5-V to 3.3-V Switching Regulator
- 24-V to 3.3-V Switching Regulator
- Laptop Computer Power Supply
- Subwoofer Amplifier Power Supply
- Dual Voltage-Rectifier Circuit
- Dual Audio Amplifier Power Supply
- Diodeless Rectifier
- Regulator Loss Cutter
- Synchronous Stepdown Switching Regulator with 90% Efficiency
- ±5- to ±35-V Tracking Power Supply
- 8-V from 5-V Regulator
- +1.5-V Supply for ZN416E Circuits
- Antique Radio dc Filament Supply
- Inexpensive Isolation Transformer (Impromptu Setup)
- 5-V UPS
- +5-V Supply
- Add 12-V Output to 5-V Buck Regulator
- Telecom Converter —48 V to +5 V @ 1 A
This circuit is useful for a bench supply in the lab. Separate or tracking operation is possible. The regulators should be properly heatsinked. T1 is a 24-Vac wall transformer of suitable current capacity.
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:

\[
(V_{\text{OUT}} - 1.25 + 1.3)/(R_{15} + R_{16}) = 1.25/R_8.
\]

Thus, the maximum value from each variable supply board is:

\[
V_{\text{OUT}} = (1.25/R_8) \times (R_{15} + R_{16}) = 50.18 \text{ Vdc}.
\]
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.
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.
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.
The adjustable supply can easily be reconfigured by altering the value of $V_a$ and beefing up some other components, as is necessary.

The output voltage is given by $V_{\text{out}} = 1.25 (1 + R_2/R_1)$. $R_2$ can be changed, as is necessary.

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:

$$R_x (\text{k}\Omega) = \frac{5 \text{ volts}}{(\text{current limit mA} - 5 \text{ mA})}$$

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

![Circuit Diagram]

**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

![Circuit Diagram]

**303 CIRCUITS**

FIG. 78-9

Using a 555 timer and voltage doubler, this circuit will supply ≥50mA 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**

![Circuit Diagram](image)

\[ f \approx 6.8 \, \text{kHz} \]

**FIG. 78-10**

WILLIAM SHEETS

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**

![Circuit Diagram](image)

**FIG. 78-11**

73 AMATEUR RADIO TODAY

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. \( V_{\text{IN}} \) is from +5 to +15 Vdc. Do not exceed 15 V or U1 might be damaged.
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.

Floating adjustable regulators can be used as current limiters. Resistor R1 programs the current flowing through R2.
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

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

![Circuit Diagram]

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

![Circuit Diagram]

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

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-µF 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-Ω resistor.

SWITCHING REGULATOR CONVERTER

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.
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:

\[
\frac{V_{OUT} + V_D - V_{IND}}{V_{IN} - V_{SAT} + V_D - 2V_{IND}}
\]

- \(V_D\) = 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.

The National Semiconductor LM2574 delivers 3.3 V out at 0.5 A from a 24-V source. The duty cycle is:

\[
\frac{V_{OUT} + V_D - V_{IND}}{V_{IN} - V_{SAT} + V_D - 2V_{IND}}
\]

- \(V_D\) = diode drop (0.39)
- \(V_{IND}\) = inductor dc drop
- \(V_{SAT}\) = saturation voltage of LM2574 (0.9 V typical)
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.

Table 1. Resistor value/voltage matchup.

<table>
<thead>
<tr>
<th>R5 Resistor Value</th>
<th>Voltage Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>750Ω</td>
<td>5V</td>
</tr>
<tr>
<td>910Ω</td>
<td>6V</td>
</tr>
<tr>
<td>1.2K</td>
<td>8V</td>
</tr>
<tr>
<td>1.5K</td>
<td>9V</td>
</tr>
<tr>
<td>1.8K</td>
<td>10V</td>
</tr>
<tr>
<td>2.0K</td>
<td>12V</td>
</tr>
<tr>
<td>2.7K</td>
<td>15V</td>
</tr>
<tr>
<td>3.3K</td>
<td>18V</td>
</tr>
<tr>
<td>3.6K</td>
<td>20V</td>
</tr>
<tr>
<td>4.3K</td>
<td>24V</td>
</tr>
</tbody>
</table>

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.
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 ±30 to 35 V.

This stepped-up dual voltage supply provides ±15 to ±18 V unregulated.
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 ±38.5 V and ±15 V regulated for the dual 50 watter.
DIODELESS RECTIFIER

ELECTRONIC DESIGN

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.
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

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. $R_{\text{SENSE}}$ is the key component used to set the output current capability according to the formula $I_{\text{OUT}} = 100 \text{ mV}/R_{\text{SENSE}}$. 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 mV/$R_{\text{SENSE}}$ or 3 A for the circuit in A.
This supply is designed to operate from a ±40-V nominal unregulated power source (bridge rectifier, etc.).

This regulator can be used with a +6-V source to supply ZN416E low-voltage TRF radio-receiver IC the necessary +1.5 V. R3 sets output voltage.
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.

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. SO1 is an ordinary, duplex ac receptacle. Use heavy-wire connections between the 12-V windings because several amperes can flow.
A 9-V wall adapter supplies $V_{\text{IN}}$. IC2 contains a low-battery detector circuit that senses $V_{\text{IN}}$ 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, $V_{\text{OUT}}$.

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 µA. 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.

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

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 $T_1$) enables an additional low-dropout linear regulator ($IC_2$) to create the 12-V output voltage that's needed to program EEPROMs. The required input voltage is 8 to 16 V.

TELECOMMUNICATION CONVERTER —48 V TO +5 V @ 1 A

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.
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
SIMPLE VOLTAGE PROBE

This simple voltage probe can be helpful in checking and troubleshooting solid-state circuitry.

ac VOLTAGE PROBE

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.
Protection 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.

- Speaker Protector
- Electronic Fuse
- Safety Circuit
- Overload Indicator
- Relay Fuse for Power Supplies
- Speaker Protector
- Modem Protector
- Overvoltage Protection Circuit
- Timed Safety Circuit
- Modem/Fax Protector for Two Computers
- Ear Protector
- Loudspeaker Protector
- Simple Safety Circuit
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.
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.

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.
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.

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.
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.

This protector uses surge voltage protectors rated at 230-V breakdown. An effective ground should be used.
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.
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

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

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.
Transistors Q1, Q2, and Q3 monitor the two outputs of the stereo amplifier. If the offsets exceed ±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.

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.
Proximity 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.

Proximity Alarm I
Proximity Alarm II
IC1 contains several oscillators and an amplifier. The low-frequency audio-signal oscillator is used to supply an input to the amplifier. That signal is the audio tone that is amplified, then supplied to the speaker by the amplifier.

The high-frequency oscillator is purposely set to be very unstable. It is dormant or “off” until the resistor-capacitor (RC) network is changed. The resistance (R) in this case is made up of R2 and P1. As the resistance of P1 is decreased, the unit becomes more sensitive (more unstable), and less capacitance (C) is needed to cause the oscillator to oscillate.

The capacitance required is provided by C2 and by any capacitance introduced via the antenna loop. When you come near that loop, your inherent body capacitance causes the high-frequency oscillator to begin to oscillate, which then causes the low-frequency oscillator to be “switched on” internally. Once the alarm is sounding, the IC is designed so that it “latches”, that is, it stays on until the power to it is switched off.

**Parts List**

- C1 1-µF Axial Capacitor
- C2 27-pF Silver Mica Capacitor
- C3 0.1-µF Mylar Capacitor
- IC1 CM1001N IC
- P1 50-kΩ Trimmer Resistor
- R1 75-kΩ Resistor
- R2 200-Ω Resistor
- R3 100-kΩ Resistor
- S1 SPDT Switch
- Spk Small Speaker
- Misc IC Socket, Battery Snap, Ground Plate, Wire, PC Board
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
WILLIAM SHEETS

This pulse generator can supplement a standalone pulse generator. Using a transistor and a 555 timer, pulse widths of <5 µs to 500 µs can be produced. The value of \( C_3 \) is approximately found from the formula:

\[
C_3 \, \mu F = 1.1 \times 10^{-5} \, T
\]

where \( T \) is the shortest pulse width (µs) desired in a 10:1 range

\( (T' \text{ should be greater than 5 µs}) \)

The capacitor values and consequent pulse width range are shown.

WILLIAM SHEETS

FIG. 82-1

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.

FIG. 82-2
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.
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.

FIG. 82-4

ELECTRONIC DESIGN
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, $t_{\text{w}}$, 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, $t_{\text{w}}$, 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

Use of an analog switch as shown allows digital control of a UJT oscillator.
DELAYED PULSE GENERATOR

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.

\[
\text{Delay: } C_1 = 1.1 \times 10^{-5} \text{ T delay } \mu \text{F} \\
\text{Pulse: } C_2 = 1.1 \times 10^{-5} \text{ T pulse } \mu \text{sec}
\]

PULSE GENERATOR WITH VARIABLE DUTY CYCLE

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-kΩ potentiometer provide a variable ±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.
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
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.
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

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

Using a single ZN416E IC and a ULN3718M, this simple TRF receiver can drive a loudspeaker. Two 1.5-V cells power the circuit.
This receiver uses the ZN416E made by GEC Plessey. The tuning is via C1.

This circuit will interface a line input to CMOS. The supply current is >1 mA at +5 V.
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.
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.
Here are a few of the many possible RF input circuits for the NE602. Just about any tuned or broadband circuit will work.
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.
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

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.
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
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 Ω. The PVR will remain in this state until a reset pulse is received by the 4043 RS latch.

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.
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.

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 $\downarrow 4$ to 16384 (about 4 hours).
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.

FIG. 84-5

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

12 V 0.5-A lamp

\( f = 2 \text{ Hz} \)
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
This transmitter sends an FM signal in the 88-to 108-MHz range, with a tone of 19 kHz. This can be used to activate the FM MPX pilot carrier indicator, which can be interfaced to external devices. L4 is for use with a 15 CM wire antenna. L1 is 9 turns of #26 enamelled wire on a ¼-W 10-kΩ resistor (carbon type), L2 is 2 turns wound over L1. L3 is 7 turns of #26 enamelled wire on a 10-kΩ ¼-W resistor.
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.
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**

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**

A GC Electronic P/N J4-815 ultrasonic transducer is used in this 40-kHz transmitter for remote-control application.
REMOTE-CONTROL TRANSMITTER

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

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.
RF Amplifier 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.

- HF Preamplifier
- VHF/UHF Preamp Using MAR-x
- Broadband RF Amplifier
- Low-Noise GASFET Preamp for 435 MHz
- Broadcast-Band RF Amplifier
- 70-MHz RF Power Amplifier
- Miniature Wideband Amplifier
- 30-MHz Amplifier
- 20-W 450-MHz Amplifier
- Wideband Power Amplifier
- TV Sound System
- 10-W 10-Meter Linear Amplifier
- 2-Meter FET Power Amplifier for IIs
- Receiver/Scanner Preamp Using MAR-1 MMIC
- 20-W 1296-MHz Amplifier Module
- Simple 455-kHz IF Amplifier
- UHF Amplifier
- 144- to 2304-MHz UHF Broadband Amplifier
- 455-kHz IF Amplifier
- Switchable HF/VHF Active Antenna
- 455-kHz IF Amp for 1.5-V Operation
- 5-W 7-MHz RF Power Amplifier
- LC Tuned Amplifiers
- Wideband Preamp
- RF Preamplifiers
- 45-MHz IF Amplifier with crystal filter
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.

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.
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.

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-Ω 5-W resistor lower voltages can be used.
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: \( R_8 = R_{OUT} - 50 \). Otherwise, connect output capacitor C4 directly to the emitter of Q3.

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 \( 20 \text{ dB} \).

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.

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R-E EXPERIMENTER'S HANDBOOK

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**

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.

**WIDEBAND POWER AMPLIFIER**

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.

**20-W 450-MHz AMPLIFIER**

Delivering 20-W output, this amplifier has a gain of 21 dB at 450 MHz. A 12-V supply powers this circuit.

**TV SOUND SYSTEM**

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.
This linear amplifier delivers 10-W PEP output with 1.25-W drive on 10 m. T1, T2, and T3 are 10 turns of bifilar windings on an FT-50-43 toroidal core. The transformers are broadband. Filters for other bands, if desired, are shown.
Using a power MOSFET, this amplifier can boast a 2-W handic-talkie power level to around 10 W on 2 meters. A transmission-line RF switch is used for T/R switching.

The low-cost Mini-Circuits MAR-X series of chips offer the RF builder a real advantage, with their inherent 50-Ω input and output impedances (needed for RF systems). An MAR-1-based receiver/scanner preamplifier is shown. C1 and C2 are chip capacitors. Use 0.01 μF for HF, 0.001 for VHF, and 100 pF for above 100 MHz, depending on the low-frequency limit that you desire. C3 can be a ceramic disc of 0.01 μF or 0.001 μF, depending on frequency range. L1 is an RF choke that is suitable for the frequency range that you desire (0.1 to 10 μH).
Using a Mitsubishi M57762 amplifier module, this amplifier delivers 20-W output on 1296 MHz. A single 12-V nominal power supply can be used.

The ZN416E can be configured as a simple 455-kHz IF amplifier. In this case, the circuit's center frequency and bandwidth are set by RES1 (a Murata CSB455E ceramic resonator).
**UHF AMPLIFIER**

![UHF Amplifier Circuit Diagram]

**NOTE:**
- Resistors: 1/4 Watt Carbon.
- L1 & L2 wound on FERRROX Cube VK200 09/38 Wideband Threaded Core.

**POPULAR ELECTRONICS**

**FIG. 86-17**

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**UHF BROADBAND AMPLIFIER**

**Table 1.**

<table>
<thead>
<tr>
<th>Device</th>
<th>Max. mA</th>
<th>Normal Current mA.</th>
<th>Approx. Gain 1-GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAR-1</td>
<td>40</td>
<td>20-30 mA</td>
<td>18 dB</td>
</tr>
<tr>
<td>MAR-2</td>
<td>60</td>
<td>30-40 mA</td>
<td>13 dB</td>
</tr>
<tr>
<td>MAR-3</td>
<td>70</td>
<td>30-50 mA</td>
<td>12 dB</td>
</tr>
<tr>
<td>MAR-4</td>
<td>85</td>
<td>50-70 mA</td>
<td>8 dB</td>
</tr>
<tr>
<td>MAR-6</td>
<td>50</td>
<td>15-25 mA</td>
<td>17 dB</td>
</tr>
<tr>
<td>MAR-7</td>
<td>60</td>
<td>25-40 mA</td>
<td>13 dB</td>
</tr>
<tr>
<td>MAR-8</td>
<td>65</td>
<td>30-50 mA</td>
<td>23 dB</td>
</tr>
</tbody>
</table>

**Table 2.**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>MMIC Amplifier Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>144 MHz</td>
<td>18.2 dB</td>
</tr>
<tr>
<td>220 MHz</td>
<td>18.3 dB</td>
</tr>
<tr>
<td>432 MHz</td>
<td>16.5 dB</td>
</tr>
<tr>
<td>902 MHz</td>
<td>15.0 dB</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>13.0 dB</td>
</tr>
<tr>
<td>2304 MHz</td>
<td>8.8 dB</td>
</tr>
</tbody>
</table>

**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.

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**455-kHz IF AMPLIFIER**

![IF Amplifier Circuit Diagram]

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.

**POPULAR ELECTRONICS**

**FIG. 86-19**

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523
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.

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

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

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.
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

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>MAX. FREQ.</th>
<th>GAIN (100/50/1000 MHz)</th>
<th>N.F.</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAR-1</td>
<td>1,000</td>
<td>18.5/17.5/15.5</td>
<td>5</td>
<td>Brown</td>
</tr>
<tr>
<td>MAR-2</td>
<td>2,000</td>
<td>13/12.8/12.5</td>
<td>6.5</td>
<td>Red</td>
</tr>
<tr>
<td>MAR-3</td>
<td>2,000</td>
<td>13/12.8/12.5</td>
<td>6</td>
<td>Orange</td>
</tr>
<tr>
<td>MAR-4</td>
<td>1,000</td>
<td>8.2/8.2/8</td>
<td>7</td>
<td>Yellow</td>
</tr>
<tr>
<td>MAR-6</td>
<td>2,000</td>
<td>20/19/16</td>
<td>2.8</td>
<td>White</td>
</tr>
<tr>
<td>MAR-7</td>
<td>2,000</td>
<td>13.5/13.1/12.5</td>
<td>5</td>
<td>Violet</td>
</tr>
<tr>
<td>MAR-8</td>
<td>1,000</td>
<td>33/28/23</td>
<td>3.5</td>
<td>Blue</td>
</tr>
</tbody>
</table>

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).

FIG. 86-25

45-MHz IF AMPLIFIER WITH CRYSTAL FILTER

WILLIAM SHEETS

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.)

FIG. 86-26
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
Figure 87-1

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 miniature air variable capacitor. Resistors are ¼-W 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.
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.
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 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.

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, \( C_1 = C_2 = 70 \, \text{pF} \) 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 \( C_3, \) determine the frequency along with \( L_1. \) \( C_6 \) can be made up of several smaller values, paralleled to get the exact required value.
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
This circuit demonstrates the principle of the sample-and-hold circuit. S1 can be replaced by electronic switches (FET, etc.) in an actual application.

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-ns aperture jitter. The direct connections shown allow the D/A converter to reconstruct signal levels within the input range of 0 to 5 V.
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
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.
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
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.

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.
Sine-Wave Oscillator 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.

- 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
- Sine-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.
Using an LC circuit, this CMOS oscillator generates sine waves.

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.

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.

$$ f = \frac{1}{2\pi RC} $$
POPULAR ELECTRONICS

1-Hz SINE-WAVE OSCILLATOR

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

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 µF 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.
In this circuit, a square wave is filtered by a high-order low-pass filter so that a $-3 \, \text{dB}$ 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.

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.
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

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 (Cont.)

Right- and left-channel signals pass through IC4-a and -b buffer amps into active crossover IC5; low frequencies are sent to the IC6-c mixer, and middle and high frequencies are sent to the analog delay lines of IC1 and IC2. That output passes through IC6-a and -d to filter high-frequency sample steps. IC6-b signals are remixed with low frequencies by IC6-c and are sent to final out via IC4-c and -d buffers.

One channel (R) is a variable-delay circuit, using an analog bucket-brigade device and a variable clock frequency. This is compared in amplitude and phase to the L channel (fixed delay). The local can therefore be nulled out via R36.

SLEEP-MODE CIRCUIT

The HA7210 oscillator IC combines with an ICL7642 quad CMOS op amp to produce a sleep-mode control circuit. The circuit is put into the sleep mode with a logic high applied to the Reset input or with an RC timer for automatic reset. The system is awakened by a signal from the microphone/sensor.

547
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 kΩ. 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

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.
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.
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 U2 amplifies the signal and feeds it to tone decoders U3 and U4. These devices trigger U5-a and U5-b and the logic circuits that drive relay K1.
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.
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.

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.
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.
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.
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
Space-Age Sound Machine

Electronic Gong
Alarm Tone Generator
Dual-Tone Sounder
Low-Level Sounder
Sound-Effects Generator
Siren
Simple Multi-Tone Generator
Siren Oscillator
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.
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.
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.

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.
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.
The space-age sound device uses a 556 dual-times IC to produce a phaser 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

FIG. 93-9

The electronic gong is comprised of an oscillator (built around half of a 74COON 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

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.
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 $R_1$ and $C_1$ for the low-frequency oscillator and $R_2$ and $C_2$ 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-Ω, 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.

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 kΩ to 8-Ω 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 $R_1$ and $C_1$. 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 kΩ for R1 because you could easily destroy Q1.
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.

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.
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.
A CD4093 chip and a few components make up a siren oscillator, which drives power MOSFET T1. A 4-Ω speaker is driven directly from this device. The siren is enabled by a logic high applied to the ENABLE input.
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

An op amp with positive feedback generates a square wave. The period of the oscillator is determined by $R_3$ and $C_1$.

$$T = T_1 + T_2 = 0.69 \times 2 (R_3 C_1), \quad T_1 = T_2$$

60-Hz SQUARE-WAVE GENERATOR

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.

SCHMITT TRIGGER OR SINE-TO-SQUARE-WAVE CONVERTER

This sine-wave triggered circuit produces two square-wave outputs that are $180^\circ$ out of phase.

SQUARE-WAVE OSCILLATOR

Positive feedback is via $R_3$ and $R_4$ and $R_1$ and $C_1$ determine period.
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.

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**

*Adjust for symmetrical square wave time when $V_{in} = 50 mV$.

Minimum capacitance 20 pF

Maximum frequency 50 kHz

**POPULAR ELECTRONICS**
Stepper Motor 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.

- Bipolar Stepper Motor Drive Circuit
- Stepper Motor Circuit with FET Drivers
- Dual Clock Circuit for Stepper Motors
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.
This motor-driver circuit replaces the eight bipolar transistors of the previous circuit with four IFR511 power hexFET's (Q1 through Q4).

This oscillator can be used to drive a stepper motor circuit at two preset speeds with override to shut the motors off.
Stereo 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.

- 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
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 ¾" drill (for a form). L3 is ¾" long. L4 is 4 turns #20 wire on ½" drill bit, spaced to %". If monophonic operation is wanted, omit C5 and the 38-kHz oscillator components.
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-µs de-emphasis network (R27 and C29) that functions just like the network that is associated with Q1. Note that Q2 feeds both Q3 and
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-kΩ series resistor at pin 6. The 18-kΩ resistor (R30) combines with the internal resistor and C32 (0.01 µF) to form a first-order filter with a 390-µs 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 \( L + R \) signal from IC3 is fed to a 12-kHz low-pass filter, IC2-b, with a –12 dB per octave slope. The output of the high-pass filter is applied to a 75 \( \mu \)s de-emphasis network (R22 and C26). The \( L + R \) audio signal is now restored properly. Q1 is wired as an emitter follower to provide a high load impedance for the de-emphasis network and a low source impedance for level control R23. Next, the \( L + R \) signal is fed to the matrix decoder.

Op amps IC7-a and IC7-b are used to recover the individual channels. First, IC7-b is configured as unity-gain difference amplifier. The \( (L + R) \) signal is applied to its inverting input, and the \( (L - R) \) signal is applied to the noninverting input. Therefore, the output of IC7-b can be expressed as \(- (L + R) + (L - R) = -L + L - R - R = -2R\). Similarly, IC7-a is configured as a mixing inverting amplifier. Here, however, both sum and difference signals are applied to the inverting input. So, the output of IC7-a is \((L + R) - (L - R) = -L - R - L + R = -2L\). Because both channels have been inverted, the stereo relationship is preserved.

The two op amps in IC8 provide an additional stage of amplification to drive a pair of stereo headphones. If you don’t plan to use your headphones, or if you are content to use only your stereo’s headphone jack, all components to the right of line-output jacks J3 and J4 can be deleted.

The noise-reduction stage de-compands the \( L - R \) signal, and emulates dbx-style processing. As described elsewhere in this article (see box), true dbx processing is not currently possible in a home-built circuit due to the inavailability of the dbx IC's.
THE MATRIX STAGE separates the L + R and L - R signals into the left- and right-channel components. Op-amp IC3 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

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 to play CD audio on an existing FM auto radio.

STEREO TV DECODER

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.
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.
This audio processor is based on the Signetics/Philips TDA3810N stereo, spatial, pseudo-stereo processor, IC. This processor uses a Philips TDA3810IC device, and it functions as an expander, pseudo stereo processor, and audio enhancer. Pseudo stereo is obtained by routing various frequencies to each channel via active filters.
Using a Thomson TEA2025, this stereo amplifier provides 1 W per channel into 4 Ω 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.

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.
A building block for audio work, the circuit can be used as a general-purpose preamp. Use two circuits for stereo applications.
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
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.
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.
This source is selected by pressing momentary-contact pushbutton switch S1. Switch S1 is connected to the trigger of a 555 oscillator/timer (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 circuit (shown here) can be used to operate inductive or resistive loads.

POPULAR ELECTRONICS

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.
This 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.

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.
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 µA when the switch is closed and about 8 µA when the switch is open.

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.
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.

This dc-controlled switch uses an optoisolator/coupler, U1, to electrically isolate the input signal from the output-control device.

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.
This dual-control switch uses two 6 to 10-Vac sources to trigger the circuit on and off, one source for each function.
Sync 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.

Sync Gating Circuit
Sync Combiner
This circuit guarantees that only one type of sync pulse is generated at a time. During vertical sync periods, horizontal sync is disabled.

This circuit combines H and V sync signals at TTL or CMOS levels and produces an NTSC video sync output.
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
The four circuits shown are: a passive and active integrator, an analog tachometer, a scaling amplifier, and a capacitance meter.

In B, \( T = 1.1 R_1 C_1 \) (output pulse duration)

In C, \( V_o = V_{in} \left( 1 + \frac{R_2}{R_1} \right) \)
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.
# Telephone-Related 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.

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone Ringer</td>
<td>Telephone Scrambler</td>
</tr>
<tr>
<td>Automatic Telephone-Call Recording Circuit</td>
<td>Phone Pager</td>
</tr>
<tr>
<td>Music on Hold</td>
<td>5-V Dial-Tone Circuit</td>
</tr>
<tr>
<td>Telephone Ring Converter</td>
<td>Phone Pager</td>
</tr>
<tr>
<td>Phone-In-Use Indicator</td>
<td>Alarm Dialer</td>
</tr>
<tr>
<td>Emergency Telephone Dialer</td>
<td>Telephone Audio Interface</td>
</tr>
<tr>
<td>Telephone Bell Simulator</td>
<td>Caller ID Circuit</td>
</tr>
<tr>
<td>Simple Telephone Ring Indicator</td>
<td>FCC Part 88 Phone Interface</td>
</tr>
<tr>
<td>Phone-Line Interface</td>
<td>Telephone Amplifier</td>
</tr>
<tr>
<td>Music-On-Hold Box</td>
<td>Telephone Hold Circuit</td>
</tr>
<tr>
<td>Speakerphone Adapter</td>
<td>Telephone Circuit</td>
</tr>
<tr>
<td>Telephone Voice-Mail Alert</td>
<td>Telephone-Line Tester</td>
</tr>
</tbody>
</table>
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.

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.
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. RY2 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.
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-µF 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-µF 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.

This phone-in-use indicator also indicates the presence of a ring signal. Just the thing for the hearing impaired.
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.
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 scalers, 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.

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**

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**

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.
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.
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.
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.
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

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 \( R_2 \) and \( R_4 \).

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.

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, 0b66h; 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.
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

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

Used to record and play back tapes via the phone lines, this simple circuit has an audio level switch (S1).
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.

An FCC Part 68 interface is required any time you connect any circuit of your own to the phone line.
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.

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.
This circuit is useful for checking out old telephones by providing them with the dc voltage that they require for operation.

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.
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
The circuit shown delivers +10 to -10 mV/°C output using an Analog Devices' AD590 temperature transducer. \( R_y \) is a scaling resistor.

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.
Here's an effective way 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 µA/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°C to 150°C. The waste of power is negligible in this arrangement.

**BASIC DIGITAL THERMOMETER**

The ICL7106 has a $V_{IN}$ span of ±2.0 V, and a $V_{CM}$ range of $(V^+ - 0.5)$ Volts to $(V^- + 1)$ Volts; $R_i$ is scaled to bring each range within $V_{CM}$ while not exceeding $V_{IN}$. $V_{REF}$ for both scales is 500 mV. Maximum reading on the Celsius range is 199.9°C, limited by the (short-term) maximum allowable sensor temperature. Maximum reading on the Fahrenheit range is 199.9°F (93.3°C), limited by the number of display digits. See note next page.
REMOTE TEMPERATURE SENSING

An AD590 or AD592 makes it easy to transmit temperature data over a pair of wires. The circuit produces 1 mV/°C (or 1 mV/°F using the values in parentheses).

303 CIRCUITS

The LM35 temperature sensor provides an output of 10 mV/°C for every degree Celsius over 0°C. At 20°C the output voltage is $20 \times 10 = 200$ mV. The circuit consumes 60 µA. The load resistance should not be less than 5 kΩ. 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.
A diode, such as a IN4148, has a typical \(-2\text{ m V/°C}\) 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.
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
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 piezo 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

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 preset to about three seconds.

THREE-STAGE SEQUENTIAL TIMER

By using three 555 ICs, three sequential pulses can be generated. Output 3 can be connected back to trigger input to achieve astable operation.

WILLIAM SHEETS
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.
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.
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.

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.
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
Integrated circuit gates IC1-a and IC1-b form a monostable, whose time constant is determined by C2 and R3. 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 C2, charges via R3 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.

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.
Tone-Control 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.

Combined Bass and Treble Controls
Treble Tone Control
Bass Tone Control
Bass and treble circuits can be combined to form a two-control tone-adjust circuit, as shown here.

The treble control has capacitors placed in series with the potentiometer.

The frequency dependence of the capacitor's impedance permits this circuit to boost the bass frequencies.
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
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.

Two NAND Schmitt triggers are connected in a flip-flop configuration to produce a bridged touch-activated switch.
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 (11).

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.

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.

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.
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.
Transmitter 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.

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
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-Ω load. It is capable of operation over about 29 to 32 MHz with the components shown.
10-M DSB QRP TRANSMITTER WITH VFO

FIG. 106-2
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 a 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.
WILLIAM SHEETS

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

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-Ω or 100-Ω 5-W resistor could be substituted. L1 is 15 turns of hookup wire on a ½" 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

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 ¼" form, with turns spaced 1 wire diameter. C6 is a gimmick capacitor of about 1 pF.
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 enameled 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.

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.
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.
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.
This circuit was described in a recent edition of an amateur radio magazine. It allows operation in the 160- to 190-kHz band with up to 1 W (license free) in any mode (CW/SSB/FM, etc.). It consists of a receiving converter for 5 kHz to 450 kHz and a transmitting converter to convert the 3.66- to 3.69-MHz (80 meter) range to 160 to 190 kHz. A 12- to 24-V power supply can be used.
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.
This CW transmitter has an output of up to 3 W. By using 24 V on Q2, up to 10 W output can be obtained. If a 24-V supply is used, Q1 must not see more than 12 V. Connect 12 V between junctions C3, R2 and L2, and remove L5. L1 should be a low-Q 18- to 20-µH inductor. R6 can be used (up to 47 Ω) to reduce the Q further.

An FM radio generates an interference signal that can be picked up on another FM radio tuned 10.7 MHz above the first one. The 50-kΩ potentiometer adjusts the modulation level to maximum without distortion. The RC network improves the fidelity of the transmitted signal and provides dc isolation. The component values shown are provided as a starting point. They can vary somewhat for different radios. Note that if you can't get the signal at 10.7 MHz above the frequency setting of the first radio, try tuning at 10.7 MHz below. Also, note that both tuned frequencies must be unused. Otherwise, you will hear your audio on top of the audio that is already there. You might have to play with both frequencies until you find two blank spots that are 10.7 MHz apart.
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

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
The 2.25-MHz oscillator Q1 drives amplifier Q2 and XTAL1, an ultrasonic transducer. The transducer is a lead zirconate-titanate type. Taps on T1 and T2 provide low-impedance drive points.

XTAL1 drives amplifier Q3/Q4, which is tuned to 2.25 MHz. The detected signal is fed to audio amplifier IC1. A 9-V supply is used. The circuit operates at 2.25 MHz and is designed to be used with an ultrasonic sound transmitter at this frequency.
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.
Oscillator & Power Switch

+5V

R21 300k
R22 470k

TR1 2N3904/3906

C10 0.05µF

R2 C2 47µF 200V

C1 1µF 200V

P1 10k 10W

RIS1

RIS2

Primary

Secondary

1/8 PL3

1 2

C3 47µF 100V

Feedback

Cleaner Pan

(See Text)

HTR1 100W Heater

(See Text)

HTR2 100W Heater

(See Text)

TIME UP/DOWN

SWITCH/DISPLAY BOARD

FIG. 107-3
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
- 4.5-MHz Sound IF Amplifier
- Simple Video Amplifier
- ATV Video Sampler Circuit
- Multiple-Input Video Multiplex Cable Driver
- Two-Input Video Multiplex Cable Driver
- Differential Video Loop-Through Amplifier
- Video Fader
- Electronically Controlled Variable-Gain
- Video Loop-Through Amplifier
- Video dc-Restore Circuit
- Combination Sync Stripper and Universal Video Interface
- Video Selector
- Video Preamp
- Video Master
- Simple Video Line/Bar Generator
- Video Amplifier
This general-purpose amplifier has a bandwidth of approximately 20 MHz and it uses an LM733/NE592 video amp IC. This circuit can be used as a line driver or as a LAN line driver.

An NE592 is used as a 4.5-MHz amplifier sound subcarrier in video applications. XTAL1 is a 4.5-MHz crystal or ceramic resonator.
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.

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.
Using a Linear Technology LT1227, the multiplex video amp uses logic levels to turn on and off selected inputs.

CMOS logic levels select one of two video inputs with this circuit. The op amps are Linear Technology LT1190s.

An LT1194 is used as a differential amplifier for video applications, where low cable loading is needed.
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.

An LT1228 transconductance amplifier is used in this application. The gain is adjustable from -12 to +8 dB.
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.

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.
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-Ω load.

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.
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.
A 555 and a dual 556 timer generate a rudimentary video signal, as shown in the schematic. The first timer generates 4.7-µs synch 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.
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
This circuit uses Analog Devices' AD639 universal trigonometric function generator to convert a triangle waveform, the basic waveform of the VCO itself, into a very low-distortion sine wave.

By using the AD639 in its frequency tripler mode [2], the frequency range 3 Hz to 300 kHz is now covered. The circuit has been drawn here so that the oscillator loop, consisting of Q1, the integrator and the LT1011 comparator, is clearly shown.

When Q1 is off, the input amplifier, which is adjusted to have a gain of exactly -1, pulls a current $V_{IN}/R$, where $R$ is 5.1 kΩ in series with two JFETs, and Q2 and Q3, out of the virtual earth of the integrator. The output of the integrator thus rises at a rate of $V_{IN}/CR$, where $C =$ 470 pF. At a level that can be adjusted by the 5-kΩ potentiometer, the comparator flips and turns on Q1.

A current of exactly $2V_{IN}/R$, is now supplied to the virtual earth of the integrator because there are now two 5.1-kΩ resistors in parallel and only a single JFET in between the virtual earth and $V_{IN}$. The integrator output now falls at a rate of $V_{IN}/CR$ and the cycle repeats. Any offset in the current to the virtual earth of the integrator, due to circuit board leakage, etc., can be corrected by adjusting the 50-kΩ potentiometer. It follows that the symmetry of the triangle wave at the integrator output can be corrected by adjusting the 2-kΩ potentiometer, and the 50-kΩ potentiometer at VLF, and the frequency can be trimmed with the 5-kΩ potentiometer.
The 1-kΩ potentiometer variable is adjusted to give the input level to the AD639 needed to drive it over ±270° 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-kΩ potentiometer.

Once a symmetric triangle wave has been obtained by adjusting the 2-kΩ and 50-kΩ potentiometers, and the correct frequency of 100 kHz has been set for $V_{in} = 10$ V, by adjusting the 5-kΩ potentiometer, the triple-frequency sine-wave output can be set up by adjustment of the 1-kΩ and 20-kΩ 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-kΩ and 20-kΩ 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 µF. Resistors associated with the inputs of the devices should be 1% high-stability parts.

**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

SINE-WAVE VCO

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.
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.
110

Voltage Converter/Inverter 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.

- dc/dc Converter
- Simple dc/ac Inverter
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 x 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.

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.
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
This dc voltage-tripler circuit based on the 555 can produce a dc output voltage equal to approximately $3 \times$ the dc supply voltage.

This dc voltage-quadrupler circuit based on the 555 can produce a dc output voltage equal to approximately $4 \times$ the dc supply voltage.
This dc voltage-doubler circuit based on the 555 can produce a dc output voltage equal to approximately $2 \times$ the dc supply voltage.
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
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.

V1 through V4 are reference voltages that are derived from separate sources or from a common voltage divider.
Sources

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Fig. 111-2. William Sheets.
Fig. 111-3. William Sheets.

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Index

Numbers preceded by a "I," "II," "III," "IV," or "V" are from Encyclopedia of Electronic Circuits Vol. I, II, III, IV, or V respectively.

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-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-386
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-204
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)
de transceiver, hand-held, III-463
dc-to-dc converters
line-voltage-to-multimeter adapter, V-312
program, second-audio, III-142
traveller's shaver, I-496
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-335, II-240-242, III-208-209, IV-82, V-154
flowmeters (anemometers)
hot wire, II-342
thermally biased, 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, II-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-16
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 shut-off, IV-85
camera triggered, III-444
alarms (cont.)
capacitive sensor, III-515
current monitor and, III-333
dark-activated alarm, pulsed tone
output, V-13
delayed alarm, V-4
differential voltage or current, II-3
digital clock circuit with, III-84
doorajar, II-284, III-46
Hall-effect circuit, III-256
door ringer, 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-187
flex switch alarm sounder, V-15
float, I-380, III-396, 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-69
low-volts, I-493
multiple circuit for, II-2
no-dose alarm, V-8
one-chip, III-5
photocell, 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-486-486
pulsed-tone, I-11, V-669
purse-snatcher, capacitance
operated, I-134
rain, I-442, I-443, IV-189
road ice, II-57
security, I-4, III-2-9
self-armed, I-2
shut-off, automatic, I-4
signal-reception, receivers, III-270
silent alarm, V-18
siren, V-589
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
spacecraft alarm, V-580
speed, I-96
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
toue tone alert, II-3
vsking-frequency warning, II-579
wailing, I-572
wailing, II-573, V-7
watchdog timer/alarm, IV-584
water leakage/level (see also fluid and moisture), I-389, IV-160, V-374
alkaline generator, III-733
alternators
battery-alternator monitor, car, III-63
regulator for automobile alternator, V-76
alligator, digital readout, V-206
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
denvelope 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-536, IV-455, V-496
1.5 V broadcast, V1497
mixer/oscillator for AM receiver, V-12
oist transistor radio, V-502
carrier-current, III-81
integrated, III-505
signal generators, IV-301, IV-302
AM/FM-related circuits
clock radio, II-543, II-1
squelch circuit, II-547, II-1
amateur radio related circuits
linear tape, II-140-W, III-590
receiver for, III-534
rf variable-frequency oscillator (VFO), V-532
transceiver relay interface, V-343
transmitter, 80-M, III-675
voice identifier, V-550
ambience amplifier, rear speaker, II-458
ambient light effects, cancellation circuit, II-328
ambient light-ignoring optical sensor, III-413
ammeter, I-201
low-current, V-307
nano, I-302
pico, II-154, II-157, I-202
guarded input circuit, II-166
six-decade range, II-153, II-156
amplifiers (see also audio amplifiers), II-522, III-10-21
V-17-26
1 watt/2.3 GHz, I-540
2 to 6-W, with preamp, II-451
2 to 30 MHz, 140W amateur radio linear, I-565
4W bridge, I-79
5W output, two-meter, I-567
6W 8-ohm output-transformerless, I-75
16 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-453
30 MHz, I-567
40 dB gain, IV-36
60 MHz, I-567
90 MHz cascode, I-567
80W PEP broadband/linear, I-567
100 MHz/400MHz neutralized common source, I-565
100W PEP 420-450 MHz push-pull, I-564
100x buffer, I-128
135 to 175 MHz, I-564
160W PEP broadband, I-566
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-7
acoustic field generator, V-338-341
AP drive indicator, V-346
AGC, II-17
squash control, III-33
wide-band, III-15
adjustable-gain noninverting, I-81
amateur radio, linear, 2 to 90 MHz, 140W, I-565
ambience, rear speaker, II-458
AM radio power, I-77
attenuator and, digitally controlled, I-53
audio (see audio amplifiers)
audio and sound circuits (cont.)
audio-frequency meter, V-305,
V-326
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-34
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-39
wide-band amplifier, III-15
booster, II-455, III-35
bi-polar filter, III-185
bridge load driver, III-35
carrier-current transmitter, III-79
clipper, precise, II-394
compressor, II-44
continuity tester, I-650
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-306, IV-307
limiters, II-15, V-335
multimeter, III-767, III-769
mixers (see mixers)
notch filter, II-460
octave equalizer, V-383
oscillators, I-64, II-34, III-427. V-374,
IV-375
20Hz to 50kHz, variable, I-727
light-sensitive III-315
sine wave, III-502
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
8 W, with preamp, III-454
18-W bridge, V-49
20-W, III-456
33-W bridge composite, V-16
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-10
bridge composite, V-46
half-tone, IV-31
composite,
33-W bridge, V-46
70 W, V-44-45
inverting 10W, V-47
non-inverting 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
non-inverting composite 10W, V-47
op amp, simple design, IV-33
personal-stereo type, V-48
receiver audio circuit, IV-31
stereo amp, IV-20, V-40
subwoofer amp, V-49, V-50
audio signal amplifiers, II-41-47,
III-34-42, V-52-59
booster, V-58
compressor, audio, V-57
constant-volume, V-55
distribution amplifier, V-69
dual preamp, V-58
headphone amplifier, V-63
headphone amplifier, JFET, V-37
line driver, V-54
MOSFET, V-58
photograph, magnet pickup, V-58
rampable-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
autotune sound effect, V-591
auto-fade circuit, II-42
auto-flasher, I-290
auto-zeroing scale bridge circuits,
III-60
automatic gain control (AGC), II-17
AGC system for CA3028 IF amp,
IV-458
RF amplifier, wideband adjustable,
engine-block heater reminder, V-74
exhaust emissions analyzer, II-51
fan thermostatic switch, V-68
log light controller with delay, IV-50
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, II-52, V-77
automatic-off controller, IV-61, V-75
delay circuit, I-107, III-40, V-59
dimmer, II-57, II-63
flashing, 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-63
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, I-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
road-head pre-amplifier, III-44
read 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-596
closed loop feedback control, II-390
digital readout, II-61, III-45, IV-298-299, IV-273
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
sequential flasher for, II-100, 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-159
water temperature gauge, IV-44
windshield washer circuits, I-105, II-55, II-62
cut-off, I-105, I-106, II-62
delay circuit, II-65, IV-64
heater control unit, I-105
intermittent, dynamic braking, II-49
interval controller, IV-47
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-EMP PM motor speed control, II-379
backup-light beeper, car, IV-51, IV-56
bagpipe sound effect, IV-621
balance indicator, audio amps, IV-215
balance meter, stereo, V-883
balancer, stereo, I-619
balance amplifiers, III-46
balance control in, II-385
balance indicator, bridge circuit, II-82
barom., 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-298
160 Hz, I-268
active, II-221, II-223, III-190
kHz, I-284
20 kHz, I-287
60 dB gain, I-284
variable bandwidth, I-286
inquad, 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-Key, 500 Hz, I-291
second-order bandpass, III-188
speech-range filter, V-185
state variable, I-290
tunable, IV-171
variable bandpass, V-184
variable-frequency, V-186
bang power controllers, IV-389
bar-code scanner, III-383
bar-expander scale meter, II-186
bar graphs
ac signal indicator, II-187
volmeters, II-54, II-99
barvade flasher, I-299
barometer, IV-273
bass tone control in stereo amplifier, V-584
bass 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)
car power control switch, IV-387
automatic shutoff, III-61
bipolar power supply, IL-475
black light, V-281
buffer amplifier for standard cell, I-351
calculators/radios/cassette players, power pack, I-199
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-853
bATTERY life extenders, IV-72, V-87
9-V, III-62
disconnect switch, IV-75
electric vehicles, 111-67
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, 0-8 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-65
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
nickel batteries, I-118
analyzer for, III-64
charger, I-112, I-116, III-67
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-70
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, IV-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, 0-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
LITT, 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-129
watchdog circuit, V-86
wind powered, II-70
zapper, simple ni-cad, I-116
Baxandall tone-control audio amp, IV-688
BCD rotary switch, digital, V-160
BCD-to-analog converter, I-160
BCD-to-parallel converter, I-160
beacon transmitter, III-683
beep transformer, III-555, III-566
beepers, I-9, 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-460
binary counter, II-136
biomedical instrumentation
differential amplifier, III-282
bipolar dc-dc converter with no inductor, II-132
bipolar power supply, II-475
bi-polar voltage reference source, III-774
biquad audio filter, III-185
second-order bandpass, III-188
RC active bandpass, I-385
bro-clip sound effect, III-577, V-588
land feeder monitor, V-371
bistable multivibrators, I-133, III-465
inverter, III-102
demodulator, IV-108
flasher, I-299, II-234
lamp driver, IV-160
pushbutton trigger, V-388
RS flip-flop, I-395
SR flip-flop, I-395
SCH, II-367
SF flip-flop, IV-651
touch-triggered, I-133
rat grabber, computers, IV-105
black light, battery-operated, V-281
blender-motor control circuit, V-379
blinks (see flashers and blinkers)
blown-fuse alarm, I-10
boiler control, I-438
bogost, electronic, II-587
boosters
12ns, II-97
ac line voltage boost, V-349
audio, II-466, III-35, V-58
booster/buffer for reference current, IV-428
electronic, high-speed, II-96
forward current, III-17
LED, I-307
power booster, op amp design, IV-358
rl amp, broadcast band boost, IV-457
shortwave PET, I-561
bootstrap circuit, V-355
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
brush 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-357
accurate null/variable gain circuit, III-69
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 control, III-308, III-316
contrast meter, I-472, II-447
LED, I-350
low-loss, I-377
broadband communications (see radio/rtf circuits)
buck converter, 5V/0.5A, I-404
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, III-351
MOSFET design, V-93
sine wave output, I-126
VFO design, V-92
buffers, IV-84-90, V-90-93
amplifiers (see buffer amplifiers)
ac, single-supply, high-speed, I-127-128
ADC input, high-resolution, I-127
A/D, 8-bit, high-speed, I-127
booster/buffer for reference current, IV-425
capacitance buffers
low-input, III-498
stabilized low-input, III-502
data/buffer line serial bus for PCs, V-110
hex-buffer crystal oscillator, V-136
high-current, V-92
input/output, for analog multiplexors, III-11
inverting, II-299, IV-90
oscillator buffers, IV-89
precision increasing design, IV-89
trail-to-train single-supply buffer, V-98
rf amp, buffer amp with modulator, I-406
stable, high-impedance, I-128
unity gain, stable, high-speed, high-input impedance, II-6
VFO buffer amplifier, V-82
video buffer, III-712, V-93
wideband, high-impedance/low-capacitance, I-127
buffered breakout box, II-120
bug detector, III-395, V-150
bug tracer, III-399
bull horn, IV-453, IV-31
burglar alarms (see alarms: burglar alarms; circuits)
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
square 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-128-170
fourth order low-pass, V-190
order low-pass, V-181
buzzers (see annunciators)

C

cable
bootstrapping, I-34
test circuit, III-530, 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, IV-433, IV-436
portable, I-644
square wave, 5-V, I-423
standard for calibration, I-406
radio calibrator, V-288
tester, IV-285
wave-shaping, high slew rates, I-450
waveform, (see photography-related circuits; television and video)
canary sound simulator, V-567
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, 8 digit, III-76
capacitance-to-voltage, II-92
digital, III-94
capacitance multiplier, I-416, II-200, V-205, I-547
capacitance tester, one IC design, V-306
capacitance-to-pulse width converter, I-126
capacitance-to-voltage meter, II-92
capacitor discharge
high-voltage generator, III-485
ignition system, III-103
capacitors, hysteresis compensation, V-353
capacitor test, battery, III-66
car port, automatic light controller for, III-308
cars (see automotive circuits)
carrier-current circuits (see also radio/RF circuits), III-78-82, IV-93-93, 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-60
intercom, I-146
power-line modem, III-82
receivers, I-141, I-143
IC, I-145
single transistor, I-145
delay, 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 base oscillator, II-426
cassette interface, telephone, III-618
centigrade thermometer, I-665, II-684, II-685
central image canceller, III-358
circuit protcted power supply, III-469
circuit protection
positive input/negative output, I-418, III-360
regulated for fixed power supply, IV-396
circuit protection (see protection circuits)
chasers (see battery-related circuits, chargers)
chasers 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, III-33
chopper circuit
amplifier, II-7, III-12, I-350
dc output, V-349
JFET, V-362
checkers (see measurement/test circuits)
chunung demodulator with RGB matrix, III-716
chung-chung sound generator, III-576
circuit breakers (see also protection circuits)
12ins, II-97
ac, III-512
high-speed electronic, II-98
trip circuit, IV-423
circuit protection (see protection circuits)
clamp-on-current probe
compressor, I-501
clamp-limiting amplifiers, active, III-15
clamping circuits
video signal, III-726
video surumung amplifier and, III-710
class-D power amplifier, III-453
clippers, III-394, IV-648
audio-powered noise, II-396
audio-clipping/limiter, IV-355
Morse code practice, V-103
optocoupler 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-104-106
color video amplifier, I-34
Colpitts crystal oscillators, I-194, I-572, II-147, V-411
1-to-20 MHz, IV-123
demonstration clock, II-157
frequency checker, IV-301
diode feedback, III-77
frequency detector, III-414
four-channel, III-90
frequency-detecting, III-88
high-impedance, I-157
high-input impedance window
compressor, III-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-106
low-power, less than 10μV
hysteresis, II-104
microvolt
dual limit, III-89
hysteresis, III-88
monostable using, II-268
oppose polarity-input voltage, I-155
oscillator, turnable 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
device, 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
class
digital design, IV-147
Hall-effect, III-258
talking Hall-effect compass, II-221
compressor, 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-96
clock circuit, I-156
guitar, sound-effect circuit, IV-519
hi-fi, II-12, II-13
dc-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
computalarm, 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 clock
lines, V-110
bus interface, 8 bit, II-114
clock phase lock, 30-MHz to Nubus,
III-105
CMSOS data acquisition system,
II-117
CPU interface, one-shot, IV-239
data separator for floppy disks,
II-122
deglitcher, IV-109
display, eight-digit, III-106
dual 8061S 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

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-166
crystal oscillator, micropower,
IV-122
digital, with alarm, III-84
gas discharge displays, III-12-hour,
I-263
clock
oscillator/distortion, III-85
phase lock, 30-MHz to Nubus, III-106
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-616
precision, I-193
pulse generator, 60 Hz, II-102
clock radio, I-542, I-643
CMOS circuits
555 astable true-rail-to-rail square
wave generator, II-506
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
capacitive cable
drivers, coaxial cable, I-266, I-566
five-transistor pulse booster, II-101
test circuit, V-299
Cockcroft-Walton cascadcd voltage
doubler, IV-685
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
eight-digit microprocessor display, III-106
flip-flop inverter, spare, III-103
high-speed data acquisition system, II-118
interface, 880x, 650x, 8080 families, III-98
interval timer, programmable, II-678
keyboard matrix, IV-240
laptop computer power supply, V-463
line protectors, 3 uP 1/0, IV-101
logic-level translators, IV-242
logic line monitor, III-108
long delay line, logic signals, III-109
memory/protector power supply, IV-425
memory saving power supply, II-486
microcomputer-to-triac interface, V-244
microprocessor selected pulse width control, II-116
mode protect circuit, V-479
modem/fax protector for two computers, IV-482
multiple inputs detector, III-102
one-of-eight channel transmission system, III-100
oscilloscope digital levels, IV-106
password protection circuit, V-109
power supply watchdog, II-494
polarity 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 data selector, automatic, III-97
RS-232C line-driven CMOS circuits, IV-164
RS-232C-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
Vpp generator for EPROMs, II-114
XOR gates, IV-107
up/down counter, III-105
280 bms monitor/debugger, IV-103
280 clock, II-121
contact switch, I-136
continuity testers, I-550, I-561, II-539, II-535, III 345, IV 38 540, IV 287, IV 289, IV 296
audible, II-586, V-317
buzz box, I-551
cable tester, III-539
latching design, IV-285
low-resistance circuits, V-319
ohmmeter, linear, III-540
PCB, II-342, II-535
ratiometric, I-560
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-6.5A buck, I-404
9-to-5V 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-406
50+ V push-pull switched mode, I-404
100 MHz, II-130
100 V-to-10.25 A switch mode, I-501
900-to-1600 MHz scanner converter, V-123
ac-to-dc converters, I-165
fixed power supplies, IV-396
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-163
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 bus and sensor, II-126
photodiode, I-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 Vdc, 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-170
flyback, I-211
self oscillating, I-170, II-128, III-748
triac, high-efficiency, III-744
triac, III-120
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, I-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-298
polarity, I-166
positive-to-negative, III-112, III-113
power supplies, inductless, 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 16-Volt 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-601
VLF converter, IV-407
WWV-to-SW converter, IV-499
receiver, 200 MHz, IV-150
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 LF, I-546
tone-to-square wave, I-170, IV-120.
V-124, V-125, V-569, V-570
square-to-square 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-square 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
cf 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
crst processor socket debugger, III-104
countdown timer, II-686
counters (see also dividers), II-133-
139, III-123-130, V-120-133
analog circuit, V-197
attendance, II-138
binary, II-138
divide by N
1 GHz, IV-155
1.5 GHz divide-by-N, IV-156
CMOS programmable, I-257
74090-divided-by-N, IV-154
divide-by-odd number, IV-153
counters
2 MHz, V-190-191
10 MHz, V-120-139, V-132
preamp, V-24
frequency dividers, II-258, II-251.
II-254, III-218-218, III-340, III-788
1.2 GHz, III-129
10 MHz, III-126
clock input, IV-151
decade, I-256
divide-by-1.5, III-216
clock, III-124
low-frequency, II-253
preamp, II-128
programmable, IV-152-153
tachometer generator, III-730
tachometer, III-310
generator, I-366-367, V-217-219
microfarad counter, IV-125
minimum/maximum selector, four-
input, V-132
odd-number divider and, III-217
preamplifier, oscilloscope, III-123
precision frequency, I-153
programmable, low-power wide-
rage, II-126
range counters
20 kHz, II-135
incandescent lamp, I-301
low-cost, I-301
low-power pulse circuit, IV-437
SCR, III-106
variable timing, II-134
timer base, function generators, 1
Hz, IV-201
universal
10-MHz, I-256, 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
integral, II-401
TTL design, III-416
photons, 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-59
SCR, II-496
crystal oscillators (see also
oscillators), I-190, I-185-185, I-
193, I-198, II-140-151, III-131-
149, IV-121-128, V-124-126
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-30.0 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-186, IV-124
ceramic, 10 MHz, varactor tuned,
I-141
clock, micropower design, IV-122
CMOS crystal oscillators, I-187,
III-134
1-to-4 MHz, IV-129
Colpitts crystal oscillators, I-194,
1-572, II-147
1-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-180, II-151
doubler and, I-184
easy start-up, I-132
FET, 1 MHz, II-144
fundamental-frequency, III-132
Harley oscillator, V-149
hex-buffer, V-136
high-frequency, I-175, II-148
high-frequency signal generator as,
II-152
IC-compatible, II-145
impedance checker, V-136
LO for SSB transmitter controlled
by, II-142
low-frequency, I-184, II-146, V-136
10 kHz to 150 kHz, II-146
low-noise, II-146
marker generator, III-138
mercury cell crystal-controlled
oscillator, 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-135
quartz, two-gate, III-136
reflection oscillator, crystal-controlled, III-136
Schmitt trigger, I-181
signal source controlled by, II-143
shock wave oscillator, I-198
stable low-frequency, I-188
standard, 1 MHz, I-107
temperature-compensated, I-187, II-142, III-137
test circuit, V-136
third-overtone, I-186, IV-123
time-base, III-133, IV-128, V-137, V-139
time, 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-296
current feedback amp, V-100 mA at 100 MHz, V-25
current limiter, V-146
input current, V-358
current limit, IV-111
controller, SCR design, IV-387
current meters and monitors, I-203, II-152-157, III-255, III-338, IV-284, V-144-149
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-342
piezometer, I-202, II-154, II-157, III-338
guarded input, I-186
range gages, six-decade, II-163, II-156
current readout, rd, I-22
current sensing, supply rails, II-153
current sink, I-206
1 mA for fixed power supplies, IV-402
voltage-controlled, IV-629
current sources, I-205, I-697, V-141-143
0-to-200 mA, IV-327
bilateral, III-469, I-694-696, V-143
bipolar sources
inverting, I-207, I-695
noninverting, I-695
constant, I-697, III-172
fixed power supplies
bootstrapped amp, IV-406
differential-input, fast-acting, IV-406
low-current source, IV-399
limiter, V-146
low-resistance measurements, V-142
negative, V-143
offset-adjusting, V-145
positive, V-143
precision, I-208, V-106
regulator, variable power supply, III-490
variable power supplies, voltage-programmable, IV-430
voltage-controlled, grounded source/found, III-488
current-limiting regulator, V-458
current-stabilized 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, II-165, V-127
grounded bias and sensor in, II-126
photodiode, II-125
curve tracer, V-360
diodes, IV-274
FET, I-397
CW-related circuits
CWSSB receiver, V-80, and 40-meter, V-409
filter, resistor, sharp, II-219
keying circuits, IV-244
offset indicator, IV-213
SSR/CW product detector, IV-109
transmitter, 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-590
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-121
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
preselector, low-frequency, I-132
receiver, V-125
receiver, carrier-current circuit design, IV-93
receiver, message demuxer, three-wire, IV-130
selector, RS-232, II-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-285
reversible, III-381, III-388
dc motor, video, III-723
dc servo drive, bipolar control input, II-385
dc static switch, III-367
dc-to-ac inverter, V-247, V-669
dc-to-de conversion, IV-118, V-669
1-to-5 V, IV-119
3-to-5 V battery, IV-119
3-to-26 V, III-744, IV-118
3-5 and 5-V outputs, V-128
3 A, no heatsink, V-119
bipolar, no inductor, I-132
fixed 3- to 15-V supply, IV-400
isolated +18 V, III-115
push-pull, 400 V/80 W, I-210
regulating, I-210, I-211, II-125, III-121
step-up/step-down, III-118
dc-to-dc SEPS variable power supply, II-480
dehumidifier, 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 PSK, I-214
42-percent bandwidth tone, I-215
direction detector, III-144
dual-tone, I-215
decoder 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, I-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
time constant, I-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
doorknobs, I-218
doors, I-218
delay 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, I-509
relax, ultra-precise long time, II-211
relax delay, I-668, II-220
constant-current charging, I-668
windshield wiper delay, I-97, II-55
demodulators, I-158-160, III-149-150
5V FM, I-233
12V FM, I-233
565 SCA, III-150
AM demodulator, I-160
chroama, 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-284
differential, I-426
eight-channel, I-426, II-115
descramblers, II-162
gate 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, III-365
differential multiplexers, I-425
wide band, I-428
differential thermometer, II-681, III-638
differential voltage or current alarm, II-3
differentializers, 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
diode lock, V-157
inverters, V-246
potentiometer control, V-158
resistance control, V-158
digital multimeter (DMM), IV-291, V-293
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-637
LED readout, IV-296
0-to-5V output, resistor terminated, I-230
3-digit, BCD, I-239
8-bit, I-340-241
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-quadrant, binary coded decimal
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-360
output amplifier, four-channel, III-166
video converter, IV-610-611
digitizer, tilt meter, III-644-646
dimmer switches, I-369, II-309, IV-247, IV-249
800W, II-309
dc lamp, II-307
four-quadrant, IV-248-249
halogen lamps, III-300
headlight, III-57, II-63
low-cost, I-373
soft-start, 800-W, I-376
800-W, II-309
diode emitter driver, pulsed infrared, II-292
diode tester, I-402, II-343, III-402
goo-go-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 ripper, II-183
varicap tuned FET, I-246
diplexer/mixer, IV-335
direction detectors/finders, II-146-149
compasses
digital design, IV-147
Hall effect, III-258
talking Hall effect, V-231
decoder, III-144
directional-signals monitor, auto, III-48
optical direction discriminator, V-408
thermally operated, IV-136
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-386
pulse width, II-227
window, III-776-781
display circuits, I-184-188, III-170-171, V-161-167
31/2 digit DVM common anode, II-713
60 dB dot mode, II-252
audio, LED bar peak program meter, II-254
bar-graph indicator, ac signals, II-187
brightness control, III-316
cascaded counter/display driver, V-163
common cathode, 4033-based, V-162
common-anode, V-167
comparator and, II-106
examination point, II-254
expanded scale meter, dot or bar, II-186
fluorescent tube, V-167
gas-discharge tube, V-167
LED
7-segment, V-165
large-size, V-164
LED
7-segment, V-166
audio, peak program meter, II-254
common-cathode, V-187
driver, II-188
leading-zero suppressed, V-185
two-variable, III-171
oscilloscope, eight-channel voltage, III-495
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 GHz, IV-156
CMOS programmable, I-257
7400-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-433
1.2 GHz, III-129
10-MHz, III-126
clock input, IV-151
decade, I-259
divide-by-1, III-216
low-cost, I-124
low-frequency, II-253
presamp, III-128
programmable, IV-152-153
staircase generator and, I-730
tachometer and, I-310
mathematical, one trim, III-336
odd-number counter and, III-217
pulse, non-integer programmable, II-511, III-226
Dolby noise reduction circuits, III-390
decode mode, III-401
encode mode, III-400
donotbells/chimes (see annunciators)
door-open alarm, II-284, III-46, III-256
door opener, III-366
door minder security circuit, V-5
det-expanded scale meter, II-186
double-sideband suppressed-carrier
demodulator, III-377
rf, II-366
doublers
0 to 1 MHz, II-252
150 to 300 MHz, I-314
audio-frequency doubler, IV-16-17
broadband frequency, I-313
CMOS, oscilloscope, III-439
crystal oscillator, I-184
frequency, I-313, III-215
broadband, I-313
digital, III-216
QASIFET design, IV-324
single-chip, III-218
low-frequency, I-314
voltage doublers, III-469, IV-635
cascaded, Cockcroft-Walton, IV-635
transistorized, III-468
downbeat-emphasized metronome, III-353-354
50 ohm, I-262
alarm driver, high-power, V-2
bar-graph driver
LED, II-188
transistorized, IV-213
BIFET, I-264
bridge loads, audio circuits, III-35
capacitive load, I-263
Christmas lights driver, IV-204
coupling cable, I-266, I-580
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
fiber optic, 50-Mb/s, III-178
flash slave, I-489
glow-plug, II-52
high-impedance meter, I-265
inductor 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
microprocessor, V-440
full rail excursions in, II-190
high-capacity output, I-319
synchronized, III-174
video amplifier, III-710
line-synchronized, III-174
load drivers
audio, III-35
timing threshold, III-648
TVDT demodulator and, II-337, III-323-324
meter drivers, II-286
rf amplifier, I-1 MHz, III-645
microprocessor timer array, II-410
motor drivers (see motor control, drivers)
multiplexer, high-speed line, I-264
incandescent lamp, I-257
op amp power driver, IV-158-159
optoisolated, high-voltage, III-482
power driver, op amp, IV-158-159
pulsed infrared diode emitter, II-262
drivers and drive circuits (cont.)
relay, I-264
delay and controls closure time, II-530
low-frequency, I-300
with strobe, I-266
cf 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-396, IV-349, IV-350
three-phase motor driver, II-383
tetm-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, III-145
amplifier, overload protected, II-155
amplifier, clamp, I-507
amplifier, clamp to paralleling, II-507
amplifier, differential, III-155
amplifier, differential, III-212
amplifier, multi-stage, III-179
domain to amplitude, II-410
three-phase inverter, I-519
transformer, IV-174-176
variable, fixed-frequency, III-426
variable, fixed-frequency, III-422
DVM adapter for PC, V-310
dwell meters
breaker point, I-162
digital, III-46

car protector, V-489
eavesdropper, telephone, wireless, III-630
echo effect, analog delay line, IV-21
delayed echo detector, I-266, III-317
EEPROM pulse generator, 5V-powered, III-99
digital multi-meter, III-396
e2K simulator, three-chip, III-350
eclipsed-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-377
amplifier, overload protected, II-155
electronically limited, III-337
emergency lights, I-308, I-378, I-265
emissions analyzer, automotive exhaust, II-51
emitter-follower circuit, complementary/biased ac, V-353
emitter-follower circuit, V-353
emitters, II-198-200
capacitance multiplier, II-200
JFET ac coupled integrator, II-200
resistor multiplier, II-199
simulated inductor, II-199
codes
encoder, decoder, and, III-14
telephone handset tone dial, I-634, III-613
tone encoders, I-67, I-629
two-tone, II-364
two-tone, V-629
enlarger timer, II-446, III-445
capacitor, envelope detector, III-155
AM signals, IV-142
full-wave, V-152
low-level diodes, IV-141
capacitor, envelope detector, III-155
tone encoders, I-67, I-629
two-tone, II-364
two-tone, V-629
enlarger timer, II-446, III-445
envelope detector, III-155
AM signals, IV-142
full-wave, V-152
low-level diodes, IV-141
envelope generator/modulator, musical, IV-22
EEPROM, Vpp generator for, II-114
equalizers, I-671, IV-18
octave equalizer, V-358
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-16
expanded-scale meters analog, III-774
dot or bar, II-186
expander circuits (see compressor/expander circuits)
extended play circuit, tape-recorders, III-693
extractor, square-wave pulse, III-884

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-357
integrator to multiply, II-669
mixed pulse detector, V-152
voltage generator, V-203
RC audio oscillator from, II-567
square wave generator using, II-565
fader circuits, II-42, II-312, IV-17
V-658
fail safe semiconductor alarm, III-46
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-483
fax telephone switch, remote-controlled, IV-562, 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-32
dc controlled switch, V-582
FET switch, V-582, V-563
dual-trace scope switch, III-422
input amplifier, I-7
microphone mixer, V-363, V-364
probe, III-501
voltmeter, III-765, III-770
fiberoptic, II-204-207, III-176-181
driver, I-707, 50-MHz, III-178
interface for, II-207
link, I-268, I-269, I-270, III-179
motor control, dc, II-206
receiver, 10 MHz, II-205
50-MHz, III-181
digital, III-178
high-sensitivity, II-279
low-cost, 100-M bandwidth, III-180
low-sensitivity, II-271
very-high-sensitivity, low-speed, 3nW, I-269
repeater, I-370
speed control, I-206
transmitter, III-177
field disturbance sensor/alarms, 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, I-212
microwave, low-cost, I-273
remote, V-175
rf sniffer, I-210
sensimw, I-274, III-183
signal-strength meter, IV-166
simple design, three versions, V-175
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-170
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-228, V-191
high-pass (see high-pass filters)
low-pass, narrow-band, L filters, V-181
low-pass (see low-pass filters)
networks of, I-291
noise, dynamic, III-190
noisy signals, III-188
noise filters, I-283, II-397-403, III-402-403
4.5 MHz, I-282
550 Hz, I-289
1800 Hz, I-398
active band reject, II-401
adjustable Q, II-398, V-179
audio, II-100
bandpass and, II-223
high-Q, III-404, V-178
selectable bandwidth, I-281
three-amplifier design, I-281
turntable, II-399, III-402, V-179
passive-bridged differentiator, II-403
tone-suppressing, I-280
op amp, II-400
twin-notch for 1 kHz, V-183
twin-T, III-403
shortwave receivers, I-285
Wien bridge, I-402
passive L filters, V-181
passive PI filters, V-181
passive TI 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 3kHz, I-295
second-order, 300-3,400 Hz, IV-174
two-section, 300-3,000 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-669
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 front +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,
IV-404
bilateral current source, III-469
bridge rectifier, IV-398
charge pool, III-469
charge pump, regulated, IV-396
current-source, safe, III-472
converter, III-470
5V-to-isolated 5V at 20mA, III-474
ac-to-dc, IV-395
dc-to-dc, 9 to 15V, 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
GASPET power supply, IV-405
general-purpose, III-465
inverter, 12 V input, IV-395
isolated feedback, III-466
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 voltage from +12 V source,
IV-401
negative voltage from positive
supply, IV-397
output stabilizer, IV-390
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, II-462, III-463,
IV-491
ripple suppressor, IV-396
RTTY machine current supply,
IV-450
stabilizer, CMOS diode network,
IV-496
switching supplies, III-468, III-473,
IV-403, IV-404, IV-405
three-way, III-466
uninterruptible +5V, III-477
voltage doubler, IC-459, III-466
voltage regulators (see voltage
regulators)
voltage-controlled current
source/grounded source/load,
III-468
fixed-frequency generator, III-231
flash igniter, III-302
flash monitor, III-313
flash/flashbulb circuits (see
photography-related circuits)
flashes and blinks (see also light-
controlled circuits)
photography-related circuits, I-
304, II-225, III-192-210, IV-178-
189, V-192-197
1.5 V, minimum power, I-308
1 kW flip-flop, II-234
1A lamp, I-306
2 kW, photodetector control in,
II-232
3V, I-306
ac, III-196
alternating, I-307, II-237
astable multivibrator, III-196
auto, I-299
automatic safety, I-302
automotive turn signal, sequential,
I-109
bar display with alarm, I-252
barbecue, I-299
boat, II-299
brake, light flasher, V-69
Christmas tree light flasher, V-197,
V-364-365
CMOS, III-199
frequency-shift frequency oscillator, tunable, 11-425
definitions, frequency-division multiplex, frequency dividers,
boundary detector, III-156
comparator, III-48
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-136
clock input, IV-151
decade, I-259
divider-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 dividers, multiplex stereo decoder, II-169
frequency doublers, I-313, III-216
broadband, I-313
digital, III-216
GASFET design, IV-324
low-frequency, I-314
single-chip, III-218
to 1 MHz, II-252
frequency generators, fixed-frequency, III-271
frequency indicator, heat, I-336
frequency inverter, III-207
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-260
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 1 MHz, II-252
pulse-width, III-214
tripler, nonselative, II-252
frequency-boundary detector, III-156
frequency oscillator, tunable, II-425
frequency-ratio monitoring circuit, IV-262
frequency-shift key (FSK) communications
data receiver, III-523
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, II-318, II-265-270, III-318-320
dc, 10 kHz, I-316
digital meter, I-317
optocoupler input, IV-193
sample-and-hold circuit, IV-194
single-supply design, IV-195
zerer regulated, I-317
fuel gauge, automotive, IV-46
full-wave rectifiers, IV-328, IV-560
absolute value, II-258
averaging filter, V-101
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-339
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-239, 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-365, III-103, IV-108, IV-651
 bistable multivibrators, I-133, II-465
 capacitance multiplier, V-265
clock generator/oscillator, I-193, I-616
complementary signals, XOR gate, III-228
DAC controlled, I-722
debounce, I-108
emitter-coupled RC oscillator, II-266
fixed-frequency, III-231
flasher, I-200, II-234
FM, low-frequency, III-298
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-238, IV-519
high-frequency, III-150
inverter, III-103
latch driver, IV-160
line/frequency generator, video, V-662
linear ramp, II-270
linear triangle/square wave generator, II-263
logarithmic
dynamic range, V-201
fast acting, V-202
input lockout, I-464
linear ramp, III-237
photocell, monostable, II-329
positive-triggered, III-229
TTL, monostable, operation, I-464
UTC, monostable operation, I-463
video amplifier and comparator, II-468
multiplying pulse width circuit, II-264
multivibrators
low-frequency, III-237
single supply, III-232
nonlinear potentiometer outputs, IV-198
one-shots, I-405
digitally controlled, I-729
precision, III-222
retriggerable, III-238
oscillator/amplifier, wide frequency range, II-252
pattern generator/polar-to-retract converter, V-288
polynomial generator, V-247
potentiometer, position V/F converter, IV-266
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, 60 Hz, II-102
CMOS short-pulse, III-523
delayed pulse, IV-609, IV-440
driver, programmable, II-511, III-226
EEPROM, 5V-powered, III-99
free-running, IV-438
interrupting pulse generator, I-357
logic, III-520
logic troubleshooting applications, IV-496
programmable, I-529
sawtooth wave generator and, III-241
single, I-175
train, pulse train, IV-202
function generators (cont.)
  transistorized, IV-437
  two-phase pulse, I-533
  unijunction transistor design, I-530
  very low-duty-cycle, III-521
  voltage-controller and, II-524
  wide-ranging, III-522

quad op amp, four simultaneous
  synchronized waveforms, II-529
  ramp generators, I-640, II-521-523,
  III-625-627, 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
  RF oscillator, V-580-581
  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, III-367
  self-retriggering timer-on
  generator, V-437

signal generators, V-204

AM broadcast band, IV-502
  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
  IF, 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, III-273

square-wave generators, II-504-600,
  II-225, III-239, III-242, III-583-
  585, IV-529-536, V-588-587
  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-696

duty-cycle multivibrator, III-50-
  percent, III-584
  four-decade design, IV-335
  high-current oscillator, III-586
  line frequency, II-599
  low-frequency TTL oscillator,
  II-598
  multiburst generator, II-88
  multivibrator, IV-536
  oscillators, I-612-614, I-616, II-596,
  II-597, II-616, IV-532, IV-533
  phased-lock, 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-226
  wide-range, II-242
  TTL, LS/TTL, CMOS designs,
  IV-530-532
  variable duty-cycle, IV-533
  variable-frequency, IV-535
  SR flip-flop, IV-651
  staircase generators, I-730, I-601-
  602, III-586-588, IV-443-447
  sweep generators, I-472, II-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-239, III-242
  timer, linear, III-232
  triangle/square wave generator,
  V-206
  tunable, wide-range, III-241
  two-function, III-234
  UJT monostable circuit insensitive
to charging bus 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
  funk box, II-593
  furnace exhaust gas/smoke detector,
temp monitor/low-supply
  detection, III-248
  voltage control circuits
  high-speed one-shot, II-266
  waveform (see waveform
  generators)
  white noise generator, IV-201
  funk box, II-593
  furnace exhaust gas/smoke detector,
temp monitor/low-supply
  detection, III-248
  voltage control circuits
  high-speed one-shot, II-266
  waveform (see waveform
  generators)
  white noise generator, IV-201
  funk box, II-593
  furnace exhaust gas/smoke detector,
temp monitor/low-supply
  detection, III-248

monitor for car fuses, V-77
  relay fuse, V-478

fuzz box, III-675

fuzz sound effect, II-590

G

GaAsFET circuits
  amplifier, power, with single supply,
  II-10
  fixed power supplies, IV-405
  gain 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-300
  game roller, I-326
  games, II-275-277, III-243-245, IV-
  203-207, V-208-211
  coin flipper, III-344
  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
  ratchet, II-376, IV-206
  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-346, V-
  212-214
  analyzer and, II-281
  combustible gas detector, V-214
  explosive gas detector, V-213
  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
  gages, V-216-216
  AND, I-386, V-216
  OR, I-385
  programmable, I-394
  sync gating circuit, V-595
  XOR gate, IV-107
  geiger counters, I-538-537, V-217-219
half-duplex information, IV-489
pocket-sized, II-514
gel cell charger, II-66
generators, electric-power
connection, V-481
dc generator, V-483
high-voltage generators, IV-513
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-568
graphic equalizer, ten-band, active filter in, II-684
grid dip meters, I-247, II-182, 183
handwaver, IV-298
basic grid, I-247, IV-298
dual gate IGFET, I-246
little dipper, II-189
variable tuned FET, I-346
ground tester, III-346
ground-fault Hall detector, IV-208-209
ground-noise probe, battery-powered, III-500
guitars
compressor, sound-effect circuit, I-519
mixing 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, III-479
-half-flash analog-to-digital converters, III-26
-half-wave ac phase controlled circuit, I-377
-half-wave rectifiers, I-230, III-526, IV-325
-fast, II-282
-half-effect circuits, II-282-284, III-254-258, V-220-222
-angle of rotation detector, II-283
-compass, III-265
-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-apar alarm, III-256
-switches using, III-257, IV-639
-bulb lamp
-eliminator for, III-300
-protection, V-271
-handtalkies, I-10
-two-meter preamplifier, I-19
-hands-free telephone, III-685
-hand-off intercom, III-291
-handset encoder, telephone, III-613
-harmonic distortion analyzer, V-281
-meter, V-212
-harmonic generators, I-24, III-228, IV-649
-Hartley oscillator, I-571, V-140
-HC-based oscillators, III-423
-HC/HTC-based oscillator, III-426
-headlights (see automotive circuits, headlights)
-headphones
-amplifier for, II-43
-far away circuit, V-482
-infrared (IR) receiver, II-227
-infrared (IR) transmitter, V-227
-signal amplifier, V-63, V-57
-heart rate monitor, III-248, III-249, V-342
-heat-activated alarm, V-9
-heat weather, electronic, III-627
-heaters/heater controls (see also temperature-related circuits), I-639
-element controller, III-642
-induction heater, ultrasonic, 120-KHz 500-W, III-704
-plate circuit, servo-sensed, III-624
-temperature sensitive, I-649
-see also area, III-655
-heet-detector switch, V-592
-dual-control, V-593
-hf circuits (see radio circuits)
-high-pass filters, I-296
-active, I-286, V-181, V-185
-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-487-489, III-486, IV-309-413, V-442-447
-9- to 15-Vdc input, V-456
-10,000 V dc supply, IV-632
-arc-jet power supply, starting circuit, III-479
-batteries, external, III-482
-buckling regulator, III-481
-direct current, III-481, V-444
dc supply, II-240-246
-Vdc, single-chip circuit, V-446
-fluorescent-lamp supply, IV-644
-cold-cathode design, IV-411, IV-447
crystal oscillator, III-489
generator (see generators, electrical power)
crystal oscillator, III-489
ulator, III-489
-watt, 120 V ac, IV-410-411
-laser circuits, V-263
-negative supply, IV-445
-negative-ion generator, IV-634
-optoisolated driver, III-482
-photomultiplier supply, IV-444, IV-445
-preamplifier, III-489
-pulse supply, IV-412
-regulator, III-488
-feedback current limiter, III-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)
-battery, 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 reducing circuit, receivers, V-437
-humidity sensor, II-285-287, III-266-367
-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
-laser amplifiers, I-680, IV-459
-AGC systems, IV-456
-preamp, IV-460
-receiver, IV-459
-quadrature detector, TV sound IF, I-660
-two-stage, 60 MHz, I-563
-wideband, I-689
-ignition circuits, automotive, V-64
-capacitor discharger, I-105
-cutoff circuit, automotive, IV-53

719
ignitions circuits, automotive (cont.)
- electronic, IV-45
- substitute ignition, III-41
- timing light for ignition system, II-60
- ignitor, III-362
- illumination stabilizer, machine vision, II-306
- image canceller, III-368
- immobilizer, II-50
- impedance checker, V-136
- impedance converter, high-to-low, I-41
- impedance sensor, nanocoupler, 100 mV/m input, I-205
- indicators (see measurement/test circuits)
in-use indicator, telephone, II-629
- inductance meter, linear, V-316
- induction heater, ultrasonic, 120-6000 W, III-704
- indicators
- active, I-417
- simulated, II-199, V-180
- infrared circuits (see also light-controlled circuits; remote control devices), II-386-292
- III-271-277, IV-219-228, V-223-229
- data link, I-941
- 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-analog converter, V-224
- laser rife, invisible pulsed, II-291
- long-range object detector, III-273
- loudspeaker link, remote, I-343
- low-noise detector for, II-286
- object detector, long-range, III-273
- people-detector, IV-226
- preamplifier for IR photodiode, V-226
- proximity switch, infrared-activated, IV-346
- 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-225
- remote-control analyzer, V-224
- remote-control tester, IV-228, V-228, V-229
- remote-extender, IV-227
- digital, III-276
- pulsed for on/off control, V-228
- remote-control, I-342
- voice-modulated pulse FM, IV-228
- wireless speaker system, III-373, 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, I-38
- input/output buffer, analog multiplexers, III-11
- input/output circuits, NE562-based, V-355
- +/-100 V common mode range, III-294
- current collector high amplifier, II-295
- differential, I-347, I-354, III-283
- biomedical, II-285
- high-gain, II-353
- input, II-354
- variable gain, I-349
- extended common-mode design, IV-234
- high-impedance low-drift, I-355
- high-speed, I-354
- LM6121-based, high-speed, V-235
- LM6062-based, V-234
- low-drift/low-noise op amplifier, IV-233
- 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
- strain gauge, III-280
- triple op amp, I-347
- ultra-precision, III-270
- 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-300
- gamma ray pulse, I-386
- long time, II-300
- low-drift, I-423
- noninverting, improved, II-288
- photocurrent, II-286
- programmable reset level, III-286
- ramp generator, thermal condition reset, III-327
- resistor, III-286
- intercoms, I-415, II-301-300, III-287-292, IV-228-240
- bidirectional, III-290
- carrier current, I-146
- hands-off, III-291
- party-line, II-303
- pocket pager, III-288
- telephone-intercoms, IV-587, 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, IV-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
- fiber optic, II-297
- keyboard matrix interface, IV-240
- logic-level translators, IV-242
- microcomputer-to-triarc interface, V-244
- optical sensor-to-TTL, III-314
- optocouplers, V-406-407
- optoisolators, V-408-407
- preamp receiver interface, V-243
- process control, I-30, IV-242
- remote-control transmitter interface, V-511
- tape recorder, II-614
- telepHone audio interface, V-612
- telepHone-line interface, V-606
- video interface with sync stripper, V-659
- interrupter, ground fault, I-380
- interval timer, low-power, II-678
- microprocessor programmable, II-678
- intruder-detector, light-beam activated, V-11
- preamp, V-13
- inverters, III-230-238, V-245-247
- 350 watt, V-246
- de-to-ac, V-247
- dc-to-dc, I-308
- digital, V-246
- fast, I-423
- fixed power supplies, 12 V input, IV-385
- flip-flop, III-103
- fluorescent lamp, S-W, III-306
- frequency inverter, III-307
- high-voltage, III-484
- 40 W, 120 V ac, IV-410-411
- low-power, fixed power supplies, III-466
- on/off switch, III-594

720
picture, video circuits, III-722
power, III-298
12 VDC to 117 VAC at 60 Hz, III-294
medium, III-396
MOSFET, III-298, 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 3, 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-36
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-340, 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-362
headphone audio signal amplifiers,
V-57
preamplifier, I-22
source follower, V-20
voltmeter, V-318
jitter suppression, V-342

K

kaleidoscope, sonic, V-548-549
Kelvin thermometer, I-665
-zero adjust, III-661
key illuminator, V-335
keyer, electronic CW "bug" keyer,
V-102
-keying circuits, IV-243-245
automatic operation, II-15
automatic TTL, morse code, I-26
Circuit keyer, IV-244
electronic, I-20
frequency-shift keyer, IV-245
-negative key line keyer, IV-244

L

lump-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
gain, 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-253
-pulsers, laser diode, I-416, II-311
receiver, IV-368
-riple, invisible IR pulsed, II-291
-simulated laser using LED, V-253
latches, V-366
12-V, solenoid driver, III-572
-comparator and, III-58
-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, I-188
-battery-charger test circuit, V-89
-brightness, I-360
Christmas tree light flasher, V-197
-common-cathode display, V-107
-driver, emitter/follower, IV-159
-flashes, 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-337
-frequency comparator, II-110
-light sensor, back-biased GaAsFET,
II-321
-leading zero suppressed display,
V-185
-matrix display, two-variable, III-171
-multimeter reader, IV-294
-multiplexed common-cathode
display, ADC, III-764
-panel meter, III-347
-peakmeter, III-333
-ring-around flasher, III-194
-RS-232, computer circuit, III-103
-simulated laser circuit, V-253
-three-year flasher, III-194
-voltmeter, IV-386
-VU meter, IV-311
-level, electronic, II-666, IV-329
-level controllers/detectors (see also
fluid and moisture), II-174
-alarm, water, I-389
-audio, automatic, II-50
-audio (ALC), I-60-62
-cryogenic fluid, I-385
-hysteresis in, I-235
-level of liquid, I-107, I-235, I-387,
I-388, I-389, I-390, II-174, II-244,
III-346, III-345, III-206, III-207,
III-208, III-210, IV-186, IV-190,
IV-191
-meter, LED bar/dot, I-261
-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
-be 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-282-283
wake-up call light, II-324
warning lights, II-320, III-317
light-sucking robot, II-325
limit comparators/detectors, I-156, III-106
alarm, high/low, I-151
double ended, I-230, I-233, I-156, II-115
micropower, I-155
frequency-hum detector, II-177
limiters, III-320-322, IV-235-237
audio limiter, V-335
clipper/limiter, IV-355
low-distortion, II-15
dynamic noise reduction circuit, III-321
hold-current, solenoid driver, III-673
noise, III-321, II-395
one-zero design, IV-257
output, III-322
power-consumption, III-572
transmit-time limiter/tuner, IV-580
voltage limiter, adjustable, IV-256
line amplifiers, III-37
duplex, telephone, III-616
universal design, IV-39
line drivers, I-282
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-500
line receivers
digital data, III-534
low-cost, III-532
line-sync, noise immune 60 Hz, II-367
line-current detector/meters, III-341
optically coupled, III-414
line-hum touch switch, III-664
line-synchronized driver circuit, III-174
line-voltage annunciator, 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-360
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
908 MHz, IV-484-486
ATV, 10-to-15 W, IV-481
linear couplers
ac analog, II-412
analog, III-413
dc, III-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-57
state of charge indicator for, II-78
little clipper dip meter, II-183
load-sensing circuits, V-284-286
loculator, in-parts treasure, I-409
locator, electronic, II-194-197,
II-161-163
combination, I-583, II-196
digital entry lock, IV-162, V-157
keyless design, IV-163
two-way combination, II-196
locowhistle, II-589
logarithmic amplifiers, I-29, I-33, II-8
de to video, I-38
log-ratio amplifier, I-42
logarithmic converter, fast, I-169
logarithmic light sensor, II-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 non-inverting, digitally selectable input and gain, II-334
precision, digitally programmable input and gain, II-336
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-436-431, 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, inductor, 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-327
translators, logic-level translators, IV-442
long-duration timer, PUT, II-676
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-40, IV-47
amplifier, loudness amp, II-46
balance amplifier with, II-395
loadspeaker 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
16 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-483, III-769
low-voltage power disconnector, II-97
LVDT circuits, II-336-339, III-333-334
driver demodulator, II-337
signal conditioner, II-338

M
machine vision, illumination
stabilizer for, II-308
magnetometer, II-341
magnets
current sensor, magnetic currents, III-341
electromagnetic-field sensor, V-308
permanent-magnet detector, IV-291
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-256-263, V-260-268
adder circuits, III-327
binary, fast-action, IV-260-261
divider circuits, IV-150-166
binary chain, I-268
divide-by-2-or-3 circuit, IV-154
divide-by-N
1 MHz, IV-155
1.5 divide-by-n, IV-156
CMOS programmable, I-257
7490-divided-by-n, IV-154
divide-by-odd number, IV-163
frequency dividers, I-258, II-251, II-264, III-212-218, III-340, III-768
1 MHz, III-129
10-MHz, III-136
clock input, IV-161
decade, I-259
divide-by-15, III-216
low-cost, III-124
low-frequency, III-253
proamp, III-128
programmable, IV-152-153
step-function generator and, I-730
tachometer and, I-310
odd-number counter and, III-217
one trim, III-326
pulse, non-integrator programmable, II-511, II-226
minimum/maximum selector, four-input, V-332
multiplier circuits, IV-335
low-frequency multiplier, IV-336
precise commutating amp, IV-263-266
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
polar-to-rectangular
converter/pattern generator, radio di, V-228
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-346
100 K megohm de, I-524
3-in-1 test set, III-390
absolute-value circuit, IV-274
ac hot wire, I-581
ac-current indicator, IV-290
ac-power indicator, LED display, IV-214
ac idicator, IV-214
ac outlet tester, V-318
ac wiring locator, V-317
ac-watts calculator, V-304
acoustic-sound receiver, IV-311
acoustical 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-tf 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 indicator/testers, I-108, I-121, I-122, I-124, V-74, IV-78, IV-79
beat frequency, I-336
breath alcohol alert tester, III-359
breadboard ac active rectifier, IV-271
buzz box continuity checker, I-551
cable tester, III-539, V-290
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, IV-92
digital, II-94
capacitor testers, IV-265, IV-279, V-306
clamp-on-current compensator, II-501
CMOS logic, I-523
coincidence testers, I-550, I-551
II-342, II-503, II-534, II-535, III-345, III-555-556, IV-287
IV-289, IV-290, IV-295, V-203, V-317, V-319
crystal tester, I-178, I-186, II-151, V-199
current meters and monitors, I-203, II-152-157, III-338
ac current indicator, IV-290
current sensing in supply rails, II-153
electric motor amplifier with overload protection, II-155
Hall-effect sensors, III-335, IV-284
current sensor, IV-291
picocoummeter, I-202, II-164, II-167, III-338
guarded input, II-156
gerage ammeter, six-decade, II-153, II-156
curve tracer, I-397, IV-274, V-300
CW offset indicator, IV-213
development meter, IV-303
dial pulse, III-613
digital frequency meter, III-344
digital multimeter (DMM), IV-291, V-201
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-403, I-408, II-343, III-403
dip meters, I-247, II-182-183
bandswitched, IV-298
digital grid, I-247, IV-298
dual gate IGFET, I-246
little dipper, I-193
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, I-517, III-545
duty-cycle meter, III-329, IV-266, IV-275, IV-280
dwell meter. I-102, III-45
E, T, and R measurement/test circuits, IV-239-266
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, 111-
186, III-774, IV-46
FET probe, III-501
FET voltmeter, III-765, III-770
field-strength meters, IV-208-212, III-182-185, IV-164-168, V-174-177,
1.5-180 MfA, I-278
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-374, III-183
signal-strength meter, IV-166
transmission indicator, II-211
tuned, I-276
ULF 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-283, IV-301
analog, V-307
audio, I-311
linear, I-310
low-cost, II-250
power, II-250
power-line, I-311
frequency shift KEYER tone
generator, I-723
gelcher counters, I-536-537, I-489,
II-514, V-217-219
general purpose rf detector, II-500
goto-go test circuits, I-401, I-167
grid-dip meters, I-247, IV-286
ground, I-980, I-345
ground-noise, battery-powered,
III-550
harmonic distortion analyzer, V-361
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-281, 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-530, I-525, I-526,
IV-430-431, IV-494
OMOS, 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-430
two-in-one test set, probe, signal
tracer, injector, IV-426
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, III-341
maintenance failure indicator, IV-216
measuring gauge, linear variable
differential transformer, I-404
tester, IV-270
metronomes, I-411-413, II-383-385,
III-353-355, IV-312-314, V-392
microamperimeter, dc, four-range,
IV-292
microfarad counter, IV-275
microwave, II-499
millivoltmeters, III-767, III-769,
IV-289, IV-294, IV-295
ac, I-716
audio, III-767, III-769
dc, IV-289
four-range, IV-289
high-input impedance, I-715
LED readout, IV-294
modulation monitor, III-375, IV-289
mono audio-level meter, IV-310
motion sensor, unidirectional,
III-346
motor hour, III-340
multiconductor-cable tester,
IV-288
multimeters, IV-291, IV-293
multi-range, III-509
nurse generator, IV-308
oscillators, 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-207
overspeed, I-168
overvoltage protection, I-150, I-
517, II-98, II-107, II-496, II-513,
III-762, IV-389
paper sheet discriminator, copying
machine, III-338
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-226, I-234
cp amp, IV-145
positive, I-225, I-235, II-435,
III-159
ture rms, I-298
ultra-low-drift peak, I-237
voltage, precision, I-226
wide-bandwidth, III-162
wide-range, III-153
pH tester, I-399, III-501
phase detection/manipulation
circuits
detectors, I-406, I-476, III-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
tic/circuit, balanced modulator,
III-441
sequencers, phase sequence, I-
476, II-437-442, III-441
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
picoameters, I-392, II-154, III-338
circuit for, II-157
guaranteed input circuit, II-166
polarity indicator, V-321
power gain meter, 60 MHz, I-489
power line frequency tester, I-311
power meter, I-499
power supply test load, constant-
current, IV-424
precursor, 650 MHz amplifying,
II-502
pressure gauge, digital, V-314
<table>
<thead>
<tr>
<th>Circuit Description</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound test circuits</td>
<td>760</td>
</tr>
<tr>
<td>Stereo test circuits</td>
<td>37</td>
</tr>
<tr>
<td>Shutter, signal generators</td>
<td>342</td>
</tr>
<tr>
<td>Scale, remote-control infrared device</td>
<td>344</td>
</tr>
<tr>
<td>Reflectometer</td>
<td>516</td>
</tr>
<tr>
<td>Analog reception indicator</td>
<td>346</td>
</tr>
<tr>
<td>Telephone, III-614</td>
<td>258</td>
</tr>
<tr>
<td>Bridge, IV-268, IV-304</td>
<td>271, 263</td>
</tr>
<tr>
<td>Generators, IV-301</td>
<td>276</td>
</tr>
<tr>
<td>Receivers, II-175</td>
<td>249</td>
</tr>
<tr>
<td>Moisture strength meter</td>
<td>209</td>
</tr>
<tr>
<td>Electronic loop feedback control, I-345</td>
<td>200</td>
</tr>
<tr>
<td>Readout, V-16</td>
<td>305</td>
</tr>
<tr>
<td>455 kHz indicator, I-16</td>
<td>307</td>
</tr>
<tr>
<td>Indicator, IV-13</td>
<td>308</td>
</tr>
<tr>
<td>Sound test circuits</td>
<td>346</td>
</tr>
<tr>
<td>Signal generators, III-342</td>
<td>350</td>
</tr>
<tr>
<td>Visual test probe, IV-41</td>
<td>306</td>
</tr>
<tr>
<td>Instrumentation, II-70</td>
<td>208</td>
</tr>
<tr>
<td>Feedback control, III-47</td>
<td>209</td>
</tr>
<tr>
<td>Sensor, II-390</td>
<td>209</td>
</tr>
<tr>
<td>Temperature sensor, IV-145</td>
<td>206</td>
</tr>
<tr>
<td>Field strength meters</td>
<td>207</td>
</tr>
<tr>
<td>455 kHz monitor, III-360</td>
<td>208</td>
</tr>
<tr>
<td>Universal test probe, IV-14</td>
<td>204</td>
</tr>
<tr>
<td>Universal test probe, IV-24</td>
<td>204</td>
</tr>
<tr>
<td>Vibration meter, III-11</td>
<td>204</td>
</tr>
<tr>
<td>Indicators, III-349</td>
<td>204</td>
</tr>
<tr>
<td>Power supply, AV-94</td>
<td>204</td>
</tr>
<tr>
<td>Power supply, AV-92</td>
<td>204</td>
</tr>
<tr>
<td>Power supply, AV-48</td>
<td>204</td>
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<tr>
<td>Power supply, AV-32</td>
<td>204</td>
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<tr>
<td>Power supply, AV-18</td>
<td>204</td>
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<tr>
<td>Power supply, AV-14</td>
<td>204</td>
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<tr>
<td>Power supply, AV-12</td>
<td>204</td>
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<tr>
<td>Power supply, AV-10</td>
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<tr>
<td>Power supply, AV-08</td>
<td>204</td>
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<td>Power supply, AV-00</td>
<td>204</td>
</tr>
</tbody>
</table>
novel design, IV-314
sight and sound, I-412
simple, II-354
version II. II-365
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
transistorized, unbalanced
input, I-88
transistorized, 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-389, IV-394, IV-396
ac, I-716
audio, III-767, III-769
dc, IV-285
four-range, IV-289
high-input impedance, I-716
1.5 OD readout, IV-394
mini-stereo audio amplifiers, III-38
minimum/maximum selector, four-input, V-332
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
duplexer, IV-335
doubly balanced, I-427
dynamic audio mixer, IV-331
four-channel, I-56, I-60, II-40, III-369, IV-383
four-input, I-55, IV-394
guitar mixer, low-noise, four-channel, V-360-361
HF transmitter/mixer, IV-457
hybrid, I-69
input-buffered, III-369
local oscillator, double-balanced mixer, V-415
microphone, II-37, V-363, V-364
mixer/oscillator for AM receivers, I-412
multiplexer, I-427
gate tunnel 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, I-461
model and hobby circuits, IV-377-340
controller, modulator and/or slot-car, IV-338-340
rocket launcher, I-388
modules
power-line, carrier-current circuit, III-82
protector, V-479, V-483
modulated readback systems, disc/tape phase, I-89
modulation indicator/meter, I-430
CB, I-431
455 kHz, V-366
+12 V 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
pulser, III-375
pulse, I-436, II-438-440, IV-336, IV-340
rf, I-436, II-369, III-372, III-374
saw oscillator, III-373
TTL oscillator for television display, III-372
TV, I-439, II-483, II-484
VHF, I-440, III-684
video, I-437, II-371, III-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-365-372
and rem, III-361, V-371
baby monitor, V-376-371
bird feeder monitor, I-371
blinking phone light, II-624
breath monitor, III-360
current, II-230, IV-284
alarm and, III-338
directional signals, auto, III-48
doorajar, 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, V-399
overvoltage protection, I-150, 1-517, 1-96, II-107, II-496, III-513,
III-762, IV-380
power-supply monitors, II-491-497
III-493-495, IV-422-427
backup supply, drop-in manufactured, 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-297
SCR design, IV-385
test load, constant-current, IV-424
triac for ac-voltage control, IV-425
tube amplifier, high-voltage
radiation, IV-426
voltage monitors (see voltage monitors)
room monitor, V-369
monostable multivibrators, I-465,
input lockout, I-464
linear ramp, III-237
photocell, monostable, II-299
positive-triggered, III-229
TTL, monostable operation, I-464
UIT, monostable operation, I-463
video amplifier and comparator, II-368
mooring light, automatic, II-323
CMOSs.
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, 1-684
- acoustic Doppler motion detector, IV-342
- 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-389
- SCR alarm, III-517
- self-biased, changing field, I-135
- switch, III-517
- UHF, III-516, IV-344
- unidirectional, III-346
- motor control circuits, IV-347-350, V-378-381
- 400 Hz servo amplifier, II-386
- ac motors, II-375
- ac servo amplifier, bridge-type, III-387
- bidirectional proportional control, II-394
- blender control circuit, V-379
- compressor protector, IV-351
- dc motors
- direction controls, I-462
- driver controls
- fixed speed, III-387
- reversing, II-381
- servo, bipolar control input, II-385
- speed-controlled reversible, III-388
- fiber optic controls, II-206
- direction controls
- dc motors, I-462
- series-wound motors, I-418
- shunt-wound motors, I-406
- 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, I-456
- fiber optic, dc, variable, II-200
- hours-in-use meter, III-340
- induction motor, I-454
- load-dependent, universal motor, I-451
- nurb 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-340
- quarter-step, IV-350
- speed and direction, IV-350
- 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-910
- low-frequency, III-396
- minimum-component design, I-406
- motor speed controllers, II-378, II-390
- optical pickup, 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-396
- 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-426, 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-109
- sample-and-hold, three-channel, Ill-396
- two-level, III-392
- video, 1-of-5 cascaded, III-383
- wideband differential, II-428
- multiplexer circuits, IV-335
- capacitance multiplier, V-205, V-347
- low-frequency multiplier, IV-325
- photomultipliers, high-volt power supply, V-444, V-445
- precise commutating amp, IV-282-283
- 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
multivibrators, V-384-388
bistable multivibrators, V-392
oscilloscope, III-229
trace-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, I-133, II-465
inverter, III-103
debouncer, IV-108
flasher, I-290, II-294
lamp driver, IV-160
pushbutton trigger, V-388
RS flip-flop, I-385
SCR, III-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
input lockout, I-464
linear-ramp, III-237
photocell, monostable, I-329
positive-triggered, III-229
TTL, monostable operation, I-464
UJT, monostable operation, I-463
video amplifier and comparator, II-268
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-369-393
envelope generator/modulator, IV-22
instrument tune-up, audio generator, V-390
melody circuit, V-399
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-366, 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-861
telephone musical-on-hold circuit, V-601, V-605
mix/mux (see multiplexers)
N
N-phase motor drive, III-382
NAB preamps
record, III-573
two-pole, III-573
NAB tape playback pre-amp, III-38
nano summer, I-329
NE602
dc power circuit, V-328
input/output circuits, V-355
negative-ion generator, IV-634
neon flashers, I-103
five-lamp, I-198
two-state oscillator, III-200
tone, I-304
networks
crossover networks, I-172-173, II-35
-5V, I-518
ac/dc links, electronic, I-515
active, I-172
asymmetrical third order
Butterworth, I-173
electronic circuit for, II-46
filter, I-291
speech, telephone, II-633
uc-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, III-68
packs, automotive charger for, I-115
portable, III-47, IV-69
protection circuit, III-62
simpi-cad, I-112
temperature-sensing charger, IV-77
test circuit, IV-79
thermally controlled, II-68
zappers, I-6, II-68, II-68
night lights (see lights/light-activated and controlled circuits)
nore-dose alarm, V-8
noise generators (see sound generators)
networks
circuit, IV-22
instrument tune-up, audio generator, V-390
emitter follower, IV-108
flasher, I-290, II-294
lamp driver, IV-160
pushbutton trigger, V-388
OSR flip-flop, I-385
SCR, III-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
input lockout, I-464
linear-ramp, III-237
photocell, monostable, I-329
positive-triggered, III-229
TTL, monostable operation, I-464
UJT, monostable operation, I-463
video amplifier and comparator, II-268
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-369-393
envelope generator/modulator, IV-22
instrument tune-up, audio generator, V-390
melody circuit, V-399
melody generator, single-chip design, IV-520
null circuit. variable gain, accurate, III-69
null detector, I-148, III-182

octal DA converter, V-350
dynamometers, I-649
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-694
on/off switch, switches, II-691, III-663
one-of-eight channel transmission system, III-100
one-shot function generators, I-466, 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-390-403
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, III-361
high-gain/bandwidth, V-403
intrinsic safe protected, III-12
inverter/rectifier, programmable, IV-364
microphone mixer, V-384
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-279
single potentiometer to adjust gain over bipolar range, II-406
swing rail-lay, LM324, IV-363
temperature-compensated breakpoint, nonlinear, V-19, V-401
 tunable notch filter, 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-415
de latching relay, II-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, III-406
isolation and zero voltage switching logic, II-415
isolators/optoisolators, IV-407
driver, high-voltage, III-482
television status monitor using, I-626
light detector, IV-369
line-current detector, III-414
microprocessor tristate 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
photocell, light, III-406
photocoupler, optimized noise/impedance, V-405
phototransistors
amplifier, V-409
variable-sensitivity, V-409
power outage light, line-operated, III-416
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, II-314
source follower, photodiode, III-419
telephone ring detector, III-611
transmitter, I-363, I-367, IV-368
light transmitter, IV-365
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-500
stylus, I-420
1 kHz, I-427
1 0 MHz, I-571
2 MHz, I-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
amplifier, I-462, I-420
audio, I-246, 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, I-371
buffer circuits, IV-89
Butler
aperiodic, I-196
crystal, I-182
emitter follower, II-180-191, II-194
cassette bias, II-426
clock generator, I-615, III-86
CMOS, I-615, III-429, III-830
1 MHz to 4 MHz, 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.
1-572, 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-265
exponential digitally controlled, I-728
feedback, I-87
flasher and oscillator
high-drive, II-235
low-frequency, II-334
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
Hardy, I-571, V-140
hc-based, III-423
HCU/HCT-based, III-436
high-current, square-wave
generator, III-685
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-585
low-noise crystal, II-145
Miller, I-190
MOSFET mixer/oscillator for AM
receivers, V-412
NE602 local oscillator, V-411
neon flasher, two-state, III-290
one-second, 1 kHz, II-423
one-shot, voltage-controlled high-
speed, I-366
overtone oscillators, I-176, I-177,
I-180, I-183, II-146, III-146
50 MHz to 100 MHz, I-181
100 MHz, IV-124
crystal, I-176, 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-378
SCR, III-430
resistance-controlled digital, II-
426
rf oscillators, I-550-551, I-572,
V-528-532
5 MHz VFO, V-529
5 MHz VFO, II-551
band VFO, V-532
NE602 circuit, V-631
rf genetic, II-421
shortwave pulse-marker, V-532
sidetone, rf-powered, I-24
signal generator, V-530-531
test oscillator, V-413
transmitter and, 27 MHz and 49
MHz, I-680
RC, III-423
sawtooth wave, modulator, II-373
Schnitt trigger crystal, I-181
sine-wave (see sine-wave
oscillators)
sine-wave/square wave, tunable,
I-65, III-234, IV-612
single op amp, I-529
siren oscillator, V-567
square wave, I-613-614, II-587,
II-616, IV-632, IV-533, V-569
0.5 Hz, I-616
1 kHz, I-612
notable multivibrator and, V-386
start-stop oscillator pulse circuit,
IV-438
switch, oscillator triggered, V-580
switching, 20 ns, I-729
temperature-compensated, III-137
crystal, I-187
low power 5 V-driven, I-142
temperature-stable, II-427
third overtone, I-196, 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
1 MHz to 10 MHz, I-178
1 MHz to 20 MHz, IV-127
crystal, TTL-compatible, I-179
sine wave/square oscillator, IV-513
television display using, II-372
tube type crystal, I-192
tunable frequency, II-425
tunable single comparator, I-68
varactor tuned 10 MHz ceramic
resonator, II-141
variable oscillators, II-421
audio, 20 Hz to 20 kHz, II-272
four-decade, single control for,
II-424
sine-wave oscillator, super low-
distortion, III-438
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-49
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-568,
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-568
thermally stable, III-557
three-decade, IV-510
variable, II-424
very-low-distortion, IV-513
XOR gate, III-429
yelp, II-577
oscilloscopes, II-430-433,
III-433-458, 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
CHO doubler, III-439
osilloscopes (cont.)
eight-channel voltage display, III-435
exander, III-434
ECL 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
outboard descrambler, II-164
out-of-bounds pulse-width detector,
III-158
outlet tester, V-518
output limiter, III-322
output-gating circuit,
photomultiplier, II-516
output-stage booster, III-452
overlaid temperature monitor,
dual output, II-646
overlay protector, speaker, II-16
overspeed indicator, I-II8
overtone oscillators, I-176, I-177,
I-180, I-181, I-186, II-146, III-146
50 MHz to 100 MHz, I-181
100 MHz, IV-124
5 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-389, IV-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
PALNTSC decoder, RGB input,
III-217
palette, video, III-720
panning circuit, two-channel, I-67
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-536
peak detectors, II-174, II-175, II-434-
36, 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-156
negative, I-225, I-294, V-154
cap amp, IV-145
open-loop, V-153
positive, I-225, I-295, IV-356, III-169
track, III-510
true rms, I-228
ultra-low-drift peak, I-227
true rms, I-228
ultra-low-drift peak, I-227
time, precision, I-226
wide-bandwidth, III-162
wide-range, III-162
peak program detector, III-771
peak converter, precision ac/dc,
I-137
people-detector, infrared-activated,
IV-225
period counter, 100 MHz, frequency
and, II-136
period-to-voltage converter, IV-115
pest-repeller, ultrasonic, II-699,
III-501
photodiode/photoelectric circuits
detectors, I-496, IV-475, II-344,
IV-439, II-441, IV-440-442,
IV-127
10-bit accuracy, I-176
digital VOM, IV-277
phase/difference detector, 0- to
180-degree, II-344
phase selector/sync
rectifier/balanced modulator,
II-141
acquencers, phase sequence, I-476,
II-437-442, III-441
rc circuit, phase sequence
reversal detection, II-648
reversal, rc circuit to detect, II-438
three-phase tester, II-440
shunters, phase shunters, IV-647,
V-439-431
0-180 degree, I-477
0-360 degree, I-477
eight-output, V-491
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-598
photograph, I-606, IV-523
photograph-related circuits (see
stereophotograph circuits)
photo-conductive detector amplifier,
four quadrant, I-359
photo memory switch for ac power
control, I-563
photo stop action, I-491
photodiode/photovoltaic circuits
ac power switch, III-319
alarm system, I-13, II-4
amplifiers, I-361, II-19, II-324,
III-672
battery charger, solar, II-71, V-227
comparator, precision, I-590
controller, IV-369
current-to-voltage converter, II-128
flasher, photocell-controlled,
II-232
integrator, photocurrent, II-326
level detector, precision, I-365
tlight 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
photovoltaic sensor, V-277
photograph-related circuits, III-443-
449, III-443-449, IV-378-382,
V-432-438
auto-advance projector, II-444
camera alarm/trigger, II-444
camera trip circuit, IV-381
contrast meter, II-447
darkroom enlarger timer, III-445
darkroom timer, V-438
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, II-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-438, V-436
slide projector auto-advance, IV-381
slide-show timer, III-444, II-448
sound trigger for flash unit, II-449, IV-382
strobe, V-435, V-436, V-437
time-delay flash trigger, IV-380, V-439
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
picocentimeters, I-202, II-154, III-328
circuit for, II-157
guarded input circuit, II-156
picture fixer/inverter, III-722
2CEO oscillators, V-140
l-MHz, I-134
crystal, I-186, II-144
harmonic, I-186, II-192
JFET, I-148
low-frequency, III-133
piezoelectric circuits
439-441
alarm, I-12, V-10
drivers, V-440
555 oscillator, V-441
CMOS, V-440
circupositioner, 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-433
plant-watering accessories, I-143, II-245, II-248
playback amplifier, tape, I-77
PLL/BC receiver, II-526
packet pager, III-288
polar-to-rectangular converter/pattern generator, radio direction finder, V-288
polarity converter, I-145
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, IV-450-459, III-450-455
2 to 6-watt audio amplifier with preamp, I-451
10 W, I-78
12 W low-distortion, I-78
25 W, II-452
90 W, safe area protection, II-459
AM radio, I-77
audio, III-451, IV-454
30 W, III-456
50 W, III-451
6 W, with preamp, III-454 booster, II-455
bridge audio, I-61
bull horn, II-453
class-D, I-454
GaAsFET with supply, III-10
hybrid, III-455
inverting, I-79
low-distortion, I-13 W, I-78
low-power audio, I-454
noninverting, I-79
op amp/audio amp, high-slew rate, I-82
output-stage booster, III-452
portable, III-453
rear speaker assistance 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
± 5 to ± 35 V tracking, V-469
0 to 12-V, V-1 A variable, III-37
13.8-Vdc, V-2 A regulated, V-459
20-25 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
2000 V low-current supply, IV-636-637
AA cells, +5 V, I-491
6V, I-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
audio/voice power supply, V-464
antique radio dc filament supply, V-470
cardioid, 25W, II-470
cardioid, starting circuit, III-479
car audio-accessory power, IV-424
backup supply, drop-in main-activated, IV-424
balance indicator, III-494
batteries (see battery-related circuits)
battery charger and, 14V, 4A, II-73
battery power pack, I-509
bench top, II-472
benchtop, dual output, I-605
dc source, V-471
bridge, audio, I-61
bull horn, II-453
class-D, I-454
cDiode, III-451, IV-454
455
connections-monitor, ac lines, III-510
cancellation limits, III-572
cell monitor, V-290
couplers, IV-383-389, V-111-116
ac switches, IV-387, V-112, V-115
ac voltage control, V-114
car audio-accessory power, V-70
bang-bang controllers, IV-389
burst-type control, III-362
current limit circuit, SCR design, III-367
dual control, ac switch, V-115
dual-control, 5V supplies, IV-384, IV-385
monitor, SCR design, IV-385
MOSFET switch, IV-386
overvoltage protection, I-150, I-151, 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, inductiveless, V-456
current limit, V-148, V-358, V-458
current sources, I-205, I-697, V-141-143
6 to 200 mA, IV-327
bilateral, III-469, I-649-695, V-143
bipolar sources, I-595, I-697

733
pseudorandom sequencer, III-301, proximity protection circuits
pulse circuits, generators, pulse generators, detectors counter, amplitude delay, divider, non-integer programmable, relay fuse, V-478
power supply, II-497, I-518
power-failure alarm, III-511
polarity-protection relay for power password protection for speaker protector, shutdown circuits, short-tester, V-313, V-315
safety circuit, V-477, converters
overvoltage protection, I-150, overload indicator, V-478
programmable logic, V-520, V-489
logic troubleshooting applications, IV-486
logic troubleshootin applications, IV-486
one-shot, V-480-491
programmable, I-529
sawtooth-wave generator and, III-241, V-491
single, II-175
train, pulse train, IV-302
transistorized, IV-437
two-phase pulse, I-522
unijunction transistor design, I-630
variable duty cycle, V-402
very low-duty-cycle, III-521
voltage-controller and, III-324
wide-ranging, III-522
missing-pulse detector, V-152
modulators
pulse-position, III-375
pulse-width (PWM), III-376, IV-326
brightness controller, III-397
control, microprocessor selected, I-116
motor speed control, II-376, III-389
multiplier circuit, II-355-365, III-366
out-of-bounds detector, III-168
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-115
motor speed control, II-376, III-380
multiplier circuit, II-364, 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
pulses, laser diode, III-311
pump circuits
telephone, single-chip, III-603
tone dialer, single-chip, III-603
positive input/negative output charge, I-418
push switch, on/off, electronic, III-359
push-pull amplifier, Darlington, V-480
push-pull power supply, 400V/60W, II-473
pushbutton power control switch, IV-388
PIT circuits
battery chargers, III-54
long-duration timer, II-675
pyrometer, optical, I-504
Q
Q multipliers
audio, II-30
transistorized, I-566
QRP circuits
18, 21-44, 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-636-639
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-379
radiation detectors, III-518-520, IV-441-442
one-chip, II-519
radio detectors, II-512-517
alarms, II-4
micropower, II-513
monitor, wideband, I-358
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-400
demodulator, I-160
power amplifier, I-77
receivers, II-525, II-81, III-529
II-536, IV-455, V-496, V-497, V-502
AM/FM radio
clock radio, I-543
squish circuit, II-547, III-1
amateur radio, III-260, III-534, III-675
transceiver relay interface, V-243
VFO, V-383
voice identifier, V-550
amplifiers (see RF amplifiers)
antique radio de 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-91-98
AM receiver, III-81
audio transmitter, III-79
data receiver, IV-90
data transmitter, IV-92
FM receiver, III-80
intercom, 1-146
power-line modem, III-82
receivers, I-141, I-143, I-145, I-146
relay, I-576, 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
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-330, III-323, V-495
snooper, III-680
speakers, remote, carrier-current system, I-140
squash 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-686, III-691
gener, IV-421
output circuits, NE802, 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-511
6.5 MHz VFO, V-529
ham-band VFO, V-529
NE602 circuit, V-631
transmitter and, 27MHz and 49MHz, I-680
rf-gener, IV-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
to radio-commercial zapper, V-334-335
receivers
AM radio, II-525, III-81, III-829, III-335, IV-465, V-496, V-497, V-502
automotive receiver, II-525
carrier-current, I-141, I-143, I-145, I-146
cW/SBB receiver, V-80-40-micron, V-498
data receiver, IV-93
FM radio, I-538, III-361, III-80, II-220, III-330, III-332, V-405
old-time design, IV-493
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 whistle, V-496
shortwave transmissions converters, III-114, IV-500
FET booster, I-561
receiver, IV-454
single-sideband (SSB) communications
CW/SBB product detector, IV-139
driver, low-distortion 1.6 to 30MHz, II-538
generators, IV-323
transmitter, crystal-controlled LO for, I-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 whistle receiver, V-496
volmeter, I-405, III-768
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-573
phase sequence reversal by, II-438
oscillator, emitter-coupled, II-266
receiver/decoder, I-574
single-SCR design, III-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-537
linear, II-270
variable reset level, II-267
circuit-controlled, II-523
ranging system, ultrasonic, III-697
RC decade box, V-284-295
reaction timer, IV-204
read-head pre-amplifier, automotive
circuits, III-44
readback system, disc/track phase
modulated, I-89
receivers, (see also transceivers,
transmitters), II-54-526, III-528-535, IV-448-460,
V-499-503
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-366
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, TV-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-985, I-623,
II-408, III-412, III-416, III-560-
570, IV-472, IV-474, V-508-508
sound actuated, I-976, I-610
telephone, I-691
tone delayed, I-191, I-663, V-506
tone actuated, I-576
TR circuit, II-532
trans, contact protection, II-531
remote control devices (see also
infrared; radio-control circuits),
IV-234, V-229, V-508-513
A/B switch, IR-controlled, V-225
ac switch hookup, two-way, V-592
amplifier, I-999
analyzer, V-224
carrier current, I-146
drop-voltage recovery for long-line
systems, IV-398
extender, infrared, IV-227, V-512
fax/data-switch, IV-563-563
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-514
sensor, temperature transmitter, I-649
servo system, I-576
telephone monitor, II-626
temperature sensor, II-654
tester, infrared, IV-228, V-228, V-229
thermometer, II-659
transmitter, V-608, V-513
interface, V-611
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
fiberoptic 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-169
resistance-continuity testers, I-550,
I-561, I-342, II-533, III-534,
II-356, III-543, III-580-540,
IV-287, IV-289, IV-295, IV-296
audible, V-317
audible, adjustable, II-586
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 (see, I-560)
RC decade box, V-394-395
resistance-ratio detector, II-342
single-shot checker, II-534
visual, II-249
resistance-to-voltage converter,
I-181-182
resistor multiplier, II-199
resistors, voltage-controlled, I-422
resonator oscillator, varactor tuned,
10 MHz ceramic, II-141
resistor, video dc, III-723
reversing circuit,
adjustable, IV-21
analog delay line, IV-21
audio system, I-602, II-699
reversing motor drive, dc control
signal, II-381
RF amplifiers, II-577-549, III-542-547,
IV-476-483, V-514-527
1 W, 2.3 GHz, II-540
2 meter FET power amplifier, V-621
10 W, 225-400 MHz, II-548
10 W, 10 MHz linear amplifier, V-530
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-582, V-523,
V-334
500 MHz, IV-491
1,296 MHz, IV-486
1,500 W, IV-478-479
AGC, wideband adjustable, III-545
broadcast-band, III-564, II-546,
IV-487, V-616, V-517
buffer amplifier with modulator,
IV-490
cascading amplifier, IV-488
common-gate, 450-MHz, III-544
GaAsFET power amplifier, V-435 MHz,
V-516
HF preamplifier, V-515
HF/VHF switchable active antenna,
V-524
IF amplifier, V-455-555, V-522,
V-523, V-524
IF amplifiers, V-5-MHz, crystal
filter, V-527
isolation amplifier, II-547
LC tuned, V-526
linear amplifiers, IV-480-485, V-520
low-distortion 16 to 30 MHz SSB
driver, II-538
meter-driver, I MHz, III-545
MOSFET RF amp stage, dual-gate,
IV-489
power amplifiers, I-589, II-542,
III-542, V-517, V-518, V-521,
V-525
preamplifiers, V-527
GaAsFET, V-518
HF, V-515
receiver/scanner with MAR-1
MMIC, V-521
VHF/HF, 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-536
RF circuits (see radiotransistor)
RGB video amplifier, III-709
RGB composite video signal
converter, III-714
RGB to NTSC converter, IV-611
ring counters
20 kHz, II-136
incandescent lamps, I-301
low-cost, I-301
pulse circuit, low-power, IV-437
SGR, III-195
variable timing, II-134
ring launcher game,
electromagnetic, V-299
ring-around flasher, LED, III-194
ringers, telephone, I-628, IV-566
detectors, ring detectors, I-694,
I-685, III-611, III-619
extension-phone ringer, IV-561
high-isolation, II-625
multi-tone, remotely programmable,
II-634
musical, II-619
Sallen-Key filters, I-392, III-393
x 1000, I-589
charge-compensated, II-559
dc-gat circuit, V-396-397
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-688
saturated standard cell amplifier, II-396
sawtooth waves
converter, IV-114
generator, digital design, IV-444, IV-446, V-491
linear, V-265
triggered, V-264
oscillator modulator, III-373
pulse generator and, III-241
SCA (see silicon-controlled amplifiers)
scale, I-388, 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-183, III-366

Sallen-Key filters, I-392, III-393
x 1000, I-589
charge-compensated, II-559
dc-gat circuit, V-396-397
fast and precise, II-556
filtered, III-550

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

6V powered linearized platinum, II-550
precision, linearized platinum, II-599

RTTY machines, fixed current supply, IV-490
rumble filters, III-192, III-660, IV-175
LM387 in, I-297
turntable, IV-170

S
S meter, III-342, V-311
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-299
x 1000, I-589
charge-compensated, II-559
dc-gat circuit, V-396-397
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-688
saturated standard cell amplifier, II-396
sawtooth waves
converter, IV-114
generator, digital design, IV-444, IV-446, V-491
linear, V-265
triggered, V-264
oscillator modulator, III-373
pulse generator and, III-241
SCA (see silicon-controlled amplifiers)
scale, I-388, 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-183, III-366

Sallen-Key filters, I-392, III-393
x 1000, I-589
charge-compensated, II-559
dc-gat circuit, V-396-397
fast and precise, II-556
filtered, III-550
signal-strength meters, III-348, IV-166
silent alarm, V-16
silicon-controlled amplifiers (SCA), V-535
decoder, I-214, II-166, II-170
demodulator, II-150, III-565
MX-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
time delay circuit with, II-670
triggering series, optically coupled, III-411
simulators
ERG, three-chip, III-350
inductor, II-186
VOR signals, IV-273
sine-to-square wave converter, IV-120, V-124, V-125, V-569, V-570
sine-wave desensitizer, II-168
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, audio, III-559
square-wave and, tunable oscillator, III-292
VLF audio tone, IV-508
sine-wave oscillators, I-65, II-560-570, III-560-569, III-560, IV-504-513, V-339-544
1-Hz, V-542
60-Hz, highly stable, V-540
555 used as RC audio oscillator, II-567
adjustable, II-508
audio, II-562, II-564, III-559
generators (see sine-wave generators)
L1 oscillator, low-frequency, IV-509
low-distortion, II-561
one-IC audio generator, II-560
phase-shift, audio ranging, IV-510
programmable-frequency, III-424
relaxation, modified IF7 for clean audio signals, II-506
shaper, sine-wave, V-543
sine-wave shaper, II-561
sine/square wave converter, IV-512
two-tone generator, II-570
two-transistor design, IV-509
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-85
easily tuned, I-85
TT1 design, IV-513
tunable, III-232
single-pulse generator, II-175
single-sideband (SSB) communications
CW/SSB product detector, IV-139
CWSSB receiver, V-499
driver, low-distortion 16 to 30 MHz, II-558
generators, IV-323
transmitter, crystal-controlled LO for, II-142
sirens (see also alarms; sound generators), I-606, II-571, III-560-566
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
beep, II-578, III-566
high-pitch, II-578
linear IC, III-564
low-cost design, IV-516
multifunction system for, II-574
ship, electronic, II-576
sound defender, IV-324
Star Trek red alert, II-577
tone generator, II-573
toy, II-575
TT1 gates in, II-576
two-state, III-567
two-tone, III-562
varying frequency warning alarm, II-570
wailing, II-563
warble-tone siren, IV-515, IV-516, V-7
whooper, IV-517
yelp oscillator, II-577, III-662
slate-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
ignition chamber, I-332-333
line-operated, IV-140
operated ignition 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-268
solar circuits (see photoelectric/photoconductive circuits)
soldering iron control, V-327
soldering station, IR-controlled, IV-225
soleno id 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-466
light sources, V-282-283
hard-segment switch, V-285
relays, III-80, III-570, V-549, V-546
stepping switch, II-612
switch, line-activated, telephone, * III-617
sonic defender, IV-324
audio circuits (see sound-operated circuits)
sound effects (see sound generators)
sound generators (see also burst generators; function generators; sirens; waveform generators), I-605, II-582-583, III-559-568, III-575, IV-15-24, IV-518-524, V-394-395, V-656-667
acoustic field generator, V-338-341
alarm-tone generator, V-563
amplifier, voltage-controlled, IV-20
amplifier/compressor, low-distortion, IV-24
allophone, III-783
audio-frequency generator, V-416-417
audio tone generator, VLF, IV-568

741
sound generators (cont.)
autodrum, II-591
bagpipes, electronic, III-561, IV-521
beepers, II-565
bird chirp, I-605, II-588, III-577
bongos, II-687
canary, II-575
drum generator, II-604, IV-524
drum machine, III-576
distortion circuit, digital audio use, IV-33
doorbell, musical tones, IV-522
doubler, audio-frequency doubler, IV-18-17
duck-tone sounder, V-564
echo and reverb, analog delay line, IV-21
electronic, III-360
elevator generator/modulator, III-601
equalizer, IV-18
fader, IV-17
frequency-shift keyer, tone-generator test circuit, I-723
fun box, II-593
fuzz box, II-500, III-575
group, electronic, V-568
 guitar compressor, IV-519
harmonic generator, I-24, IV-649
high-frequency signal, III-160
holophone, II-623
instrument tuner, III-601, audio generator, V-390
low-level sounder, V-564
noise generators, I-467, I-468, I-469, IV-308, V-396
octave-shifter for musical effects, IV-523
one-IC design, II-569
perfect pitch circuit, V-391
phaser sound generator, IV-823
pink noise, I-465
portable, I-625
pulsed-tone alarm, V-559
racecar motor/crash, III-578
run-down clock for games, IV-205
sound effects, III-574-578
siren, V-559, V-566, V-567
sound-effect generator, V-565
 space-age sound machine, V-562
spacecraft alarm, V-560
speech detectors, II-617, III-615
steam locomotive whistle, III-580, III-568
steam train/propane, II-593
stereo system, derived center-channel, IV-23
super, III-564
 synthesizer, II-598, V-563
telephone call-tone generator, IV-562
telephone ringer, II-618
tone burst generator, V-620
 tone chiming, 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-562-565, IV-569
 twang-twang, II-592
 two-tone, II-570, V-569
 ultrasonic sound source, IV-565
 very-low-frequency, 1-64
 vocal eliminator, IV-19
 voice circuits, III-729-734
 wasp circuit, II-590
 warbling tone, IV-573
 white noise, IV-201
 sound-operated circuits (see also ultrasonic circuits; voice-operated circuits), II-580-584, III-579-580, IV-525-526, V-545-555
 amplifier, gain-controlled, IV-528
 color organ, II-583, III-584
 decoder, III-145
 fader, IV-519
 flash triggers, I-181, II-149, IV-382
 kaleidoscopes, sonic, V-648-649
 lights, I-600, V-552
 memory aid, 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-525-527, V-553, V-555, V-590
 ar, II-511
 two-way, I-610
 voice-operated, III-580, IV-527
 speech activity detector, telephone, III-515
 voice-operated switch, III-580
 voice-operated switch, III-582
 whistle-activated switch, V-551
 sources (see current sources: voltage sources)
source followers
 bestrapped, V-20
 DPEP, V-20
 photoode, III-419
 SPDT switch, ar-strain, II-612
 space-age sound machine, V-562
 space war, I-606
 space-plane alarm, V-560
 speaker systems
 FM carrier current remote, I-140
 hand-held transceiver amplifiers, III-89
 overload protector for, II-16
 protection circuit, V-476, V-479
 wireless, 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 band-pass, I-285
 second-order, 300-to-3.600 Hz.
 speech-range band-pass filter, V-185
 two-section, 300-to-3,000 Hz.
 network, II-633
 scrambler, V-554
 speed alarm, I-495
 speed controllers (see also motor control), I-450, I-453, II-378, II-379, II-455, V-380, V-381
 back EMP PM, II-379
cassette-deck motor speed
 calibrator, IV-385
 closed-loop, III-386
 fans, automatic, III-382
 feedback speed, I-447
 dc motors, I-452, I-454, III-377, III-380, III-388
 dc variable, servomechanics, II-208
 feedback, I-447
fixed, III-387
 high-efficiency, III-390
 high-torque motor, I-449
 light-activated controlled, I-247
 load-dependent, I-451
 model trains and/or cars, I-453, I-485, 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, I-456
 shunt-wound motors, I-456
 stepper motors, direction and speed control, IV-360
 switched-mode, III-384
 tachometers, I-94, I-100, I-102, II-175, III-335, III-340, III-347
 analog repeat, IV-280
 calibrated, III-308
 closed-loop feedback control, II-393
digital readout, II-91, II-45, IV-208-209, IV-278
drill-meter/tachometer, III-45
 feedback control, II-378, III-390
 frequency counter, II-310
 low-frequency, III-596
 minimum component design, I-405
 motor speed controllers, II-378, II-380
 optical pick-up, III-347
 set point, III-47
tachometerless, III-388, IV-349

tools and appliances, IV-446

universal motors, I-457, II-451

speed warning device, I-86, I-101

speedometers, bicycle, IV-271, IV-282

splitters, III-581-582

battery, III-66

phase, precision, III-582

precision phase, I-177

voltage, III-738, III-743

wideband, III-582

squarer, precision, I-615

square-wave, I-583-585, IV-529-536

V-568-570

1 kHz, IV-536

2 MHz using two TTL gates, I-598

10 Hz to 1 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, I-596

duty-cycle multivibrator, III-50-501

four-decade design, IV-535

high-current oscillator, III-585

line frequency, II-559

low-frequency TTL oscillator, II-595

multiburst generator, II-59

multivibrator, IV-586

oscillators, I-613-614, II-597, II-616, II-552-553, V-569

0.5 Hz, I-616

1 kHz, I-612

frequency-doubled output, II-596

phase-tracking, three-phase, II-598

pulse extractor, III-584

quadrature-output oscillator, III-585

Schmitt trigger, V-569, V-570

sine-wave and, tunable oscillator, I-582

sine-to-square wave converter, V-568, V-570

three-phase, I-606

tone-burst generator, single timer IC, I-89

triangle-wave and, III-229

precision, III-242

programmable, III-225

wide-range, III-242

TTL, LS TTL, 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

squish circuits, I-394

AM/FM, I-547

voice-activated circuits, IV-624

squelch circuits, I-357

stabilizers, fixed power supplies, IV-393, IV-406

star-based generators, (see also

function generators, waveform
generators), I-730, II-601-602,

III-586-589, IV-443-447

stand-by power supply, non-volatile

cMOS RAMs, II-477

standard, precision calibration, I-405

standard-cell amplifier, saturated,

IV-296

standing wave ratio (SWR)

meter, IV-269

power meter, I-18

QRP bridge, II-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, II-216

second-order, 1 kHz, Q=10, I-293

universal, I-290

static detector, IV-276

steam locomotive sound effects,

II-589, II-592, III-568

step-up switching regulator, 8 V

battery, II-78

step-up/step-down dc-dc converters

II-118

stepper motor (see also motor

circuit designs), V-571-573

direction control, IV-350

drivers, II-376, II-390

bipolar, V-572

PET-based, V-573

half-step, IV-349

quadrature step, IV-350

dual clock circuit, V-573

speed and direction, IV-350

stepping switch, solid state, II-612

steering phone (or-4) 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-59, IV-66

base tone control, V-584

mini-stereo amplifier, V-583

audio level meter, IV-910

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

comparison, II-12, II-98, III-95

expander, II-13, II-93, III-95, V-582

decoders, II-18, II-167-169

demodulators, I-544, II-159

drived center channel stereo

system, IV-23

IM stereo transmitter, V-575, V-580

frequency decoder, II-169

frequency division multiplex, II-169

headphone speaker circuit, V-493

mixers, I-56, IV-173-174

power meter, III-331

power amplifiers, I-80, I-91, II-43,

II-46, III-37, III-671, IV-673,

IV-35, IV-36, V-581, V-584

reception indicator, III-393

reverb systems, I-602, I-605, II-9

speaker protection circuit, V-476,

V-479

TDM decoder, II-168

test circuits, I-618-619, II-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

stabilizer, constant-current, III-353

stabilizer, III-351

stop light, garage, II-53

strain gauges

bridge excitation, III-71

bridge signal conditioner, II-35

instrumentation amplifier, III-289

strobo circuits, II-606-610

alarm system, V-6-7

charger, II-597

high-voltage power supplies,

IV-413

safety flare, I-608

tone burst generator, II-90

trip switch, sound activated, I-483

variable strobe, III-389-390

clarifier, III-339

subharmonic frequencies, crystal-

stabilized IC timer, II-151

succeed circuit, III-327

subwoofer amplifier, V-49, V-50

successive-approximation A/D

converter, I-48, II-24, II-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-

sidband, modulator, III-377

sweep generators, (see also

function generators, waveform

generators)

10.7 MHz, I-472

add-on triggered, I-472

octave-stereo triggered, III-438

switches and switching circuits,

II-611-612, III-591-594, IV-537,

V-585-586
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-314
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, V-454
contact, I-136
controller, III-383
dark-activated, V-274, V-276
de-controlled, V-586, V-592
de-static, II-387
debouncers, III-302, IV-105, IV-106, IV-108, V-316
delay, auto courtesy light, III-42
dimmer switches, I-369, II-308, IV-247, IV-249
800 W, II-309
de-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, II-304
tandem, II-312
triac, I-375, I-310, II-303
dTL-TTL controlled, buffered
analog, I-621
fax/telephone switch, IV-552-553
FET, de-controlled, V-592
FET dual-trace (oscilloscope), II-432
flex switch, alarm sounder circuit, V-15
frequency switcher/oscillators,
V-418
Hall-effect, III-225, III-539
headlight switching circuit, V-75
hexFET switch, V-592, V-593
high-frequency, I-622
high-side power control switch, "V" supply, IV-584, IV-585
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, IV-574, V-278
adjustable, I-662
capacitance switch, I-132
light-controlled, II-320, III-314
photoelectric, II-321, II-326, III-319
self-latching, V-278
self-switching, 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-394
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-580
over-temperature switch, IV-571
photocell memory, ac power
controller, I-363
photocell switch, III-321, II-326
proximity, III-517
push on/off, II-399
pushbutton power control switch, IV-388
remote switches, I-630, I-577, V-592
rf switches, III-361, III-602
rotary switch, BCD digital, V-160
safety switch, V-589
satellite TV audio switcher, IV-543
self-latching, 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
swtiching 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-600-603, III-661-665,
IV-599-594, V-370
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/HP 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, II-360, 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, IV-488
converter, V-461
synchronous stepdown regulator, V-488
voltage regulators for switched
supply, V-453
3 A, III-472
5 V, 6 A, 25 kHz, separate
ultrastable reference, I-497
6 A variable output, I-513
200 kHz, I-491
application circuit, 3 W, I-402
fixed power supplies, 3 A, IV-408
high-current inductors, III-476
low-power, III-490
multiple output MPU, I-513
positive, I-498
step-down, I-499
step-up, 6 V battery, II-78
transformer, +50 V 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
two-channel, 1-623, II-311, IV-253, IV-255
ultrasonic, I-683
video/TV switcher, IV-551
wiring for two-way switch, V-591
zero crossing, I-732
zero point, I-373, II-311
zero-voltage switching, I-623
music, I-599
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-587-598
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
dimensional feedback control, II-376, II-390
frequency counter, I-510
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
solar 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
telecom converter -48 to +5 V at 1 A, V-472

tele communications (see video circuits)
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
defrost cycle, IV-566
heater element, II-642
heater protector, servo-sensed, III-624
heat sniffer, electronic, II-627
liquid-level monitor, II-643
low-power, zero-voltage switch, I-640
piezoelectric fan-based, III-627
proportional, III-626
signal conditioners, II-639
single coil point, I-641
thermocouple, IV-567
zero-point switching, III-624

cameras, II-479

dialer
emergency dialer, V-603
pulse tone, single-chip, III-603
dual tone decoding, II-620
duplex audio link, I-654
duplex line amplifier, III-616

eavesdropper, wireless, III-620
emergency dialer, V-603
fax machine switch, remote-controlled, IV-552-553
flashing, II-629
phone message, IV-356
tell-a-bell, IV-558
visual ring indicator, IV-550, IV-581
frequency and volume controller, II-623
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 circuits/sensors, II-653.

IV-572

meters/monitors, I-647, III-206.

IV-569

operating, temp-compensated

breakpoint, V-401

oscillators, temperature-controlled

I-187, II-427, III-137

remote temperature switch, IV-571

over-under sensor, dual output

II-646

remote sensors, I-649, I-654, V-619


III-652-653, IV-568-672, V-619

0-50 degree C four channel, I-648

0-63 degree C, III-631

5 V powered linearized platinum

RTD signal conditioner, II-450

automotive-temperature

indicator, FTC thermometer, II-56

Centigrade thermometer, I-648

coefficient resistor, positive, I-657

differential, I-654, I-655

over-under, dual output, II-646

DVM interface, II-647

hilto, II-650

integrated circuits, 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-658, II-650,

II-651-653, V-123

temperature-to-time converters,

III-632-633

thermocouples

amplifier, cold-junction

compensation, II-649

calibration, 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-658, 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

theremin, II-654-656

digital, I-655

electronic, I-655

thermal flowmeter, low-rate flow,

III-603

thermocouple circuits

amplifiers, I-355, II-654, II-649

digital thermometer using, II-659

temperature sensor

multiplex, temperature sensor

system, III-630

pre-amp using, III-283

thermocouple (see also temperature-related

circuits), II-657-662, III-657-663,

IV-573-577

0-50 degree F, I-656

0-100 degree C, I-655

5-V operation, V-617

adapter, III-612

add-on for DMM digital voltmeter,

III-640

contiguide, I-655, I-648, I-683

calibrated, I-650

ground-referenced, I-657

differential, I-652, II-661, III-638

digital, I-651, I-668, V-618

temperature-reporting, III-638

thermocouple, II-658

up controlled, I-650

electronic, I-660, III-639, IV-576,

V-576

Palotronik, I-658

ground-referenced, 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, I-659

single-de supply, IV-575

variable offset, I-652

thermostats, I-639, I-643, V-60

third-overtone oscillator, I-136.

II-653

three-in-one test set, III-330

three-minute timer, II-654

three-rail power supply, III-660

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-sample level, II-666

time bases

crystal oscillator, III-139, IV-128,

V-137, V-139

function generators, I-1 Hz,

readout/counter applications,

IV-201

oscilloscopes timebase generator,

V-425

trigger selector for oscilloscopes

timebase, V-426

time delays, I-668, II-520, II-667-670,

III-647-649

circuit, precision solid state, I-664

current, constant current changing, II-668

electronic, III-648

generator, I-218

hour sampling circuit, II-668

integrator to multiply 658 timers,

low-cost, II-669

long-duration, I-220

relay, I-219, I-668

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-578-580, 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, I-681, IV-585

abram, II-674

appliance-cutout timer, IV-583

CMOS, programmable precision,

III-653

countdown, V-627

darkroom, I-480, V-436

elapsed time/currency timer, II-680

electronic egg, I-665

enlarger timer, II-446, III-446

extended on-time, V-627

IC, crystal-stabilized, I-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-578

one-shot, II-696, III-317, III-654

photographic, I-485

darkroom enlarger, III-445

photo-event timer, IV-379

reaction timer, game circuit, IV-204

delay 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-144, III-148
solid-state, industrial applications, I-864
tele-timer, V-623
ten-minute (D) timer, IV-584
three-minute, III-654
three-stage sequential, V-623
triumbwheelt-type, programmable interval, I-660
tone-out circuit, IV-580, IV-586
triangle-wave generator, linear, III-222
variable duty-cycle output, III-240
tone alert, I-667
washer, I-668
watch dog timer, V-592
watchdog timer/alarm, IV-584
wide-range, V-1-minute to 400 hours, V-625
tuning, light, ignition, I-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-577, 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), IV-60-62
bass, I-670, V-684, V-631
bass and treble, I-674, V-631
Baxandall tone-control audio amplifier, II-688
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, I-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
tuning, light, ignition, I-60
Wien-bridge filter, III-659
tone decoders, I-231, III-143
dual tone output, III-165
dual-percentage bandwidth, I-215
tone on/off, I-213
tone-modulated decoder, I-630, I-631
tone detectors, 500-Hz, III-154
tone-generating circuit, I-629
tone-dialing telephone, III-697
tone encoder, I-67
subaudible, I-23
subaudible, I-629
tone-generating circuit, I-629
tone generators (see sound generators)
tone probe, digital IC testing with, II-504
tone ringer, telephone, II-630, II-631
totem-pole driver, III-175
CMOS, I-137
hysteresis multivibrator, touch-triggered, I-133
brlugic touch plate sensor, V-634
dimmer, CMOS, IV-270
double-button latch, I-128
hum-detecting touch sensor, IV-591
lamp control, three-way, IV-247
low-current, I-128
On/Off, II-691, II-693, IV-593
latching switch, V-636
line-hum, III-664
momentary operation, I-133
negative-triggered, III-662
on-only switch, V-635
positive-triggered, III-662
touch sensitivity, III-662
touch switch, III-663
touch sensitivity, III-662
sensor output, III-661
single-plate sensor, V-633
switch, V-633, V-634, V-635
touch sensitivity, III-662
touch-sensitive switch, IV-594
touch detector, II-683
touch-select switch, III-663
Touchtone generator, telephone, III-609
touch-sensitive sensors, III-609
track-and-hold circuits, III-667, III-688
sample-and-hold circuit, III-549, III-552
tracking circuits, III-666-668
positive/negative voltage reference, III-667
proregulator, III-492
track-and-hold, III-667, III-688
tone-clutter sound effect, II-508
transceivers (see also receivers, transmitters), IV-505-503
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-50, III-661
S transceiver/maker, IV-457
ultrasonic, II-701, IV-703
transceiver amplifier, I-86, III-660-663
flat-response, tape, III-673
NAB preamp, III-673
photodiode amplifier, III-672
preamp, magnetic phone, 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-640
transformation, isolation transformer, V-349, V-470
transistors and transistorized circuits
flashers, II-236, III-200
frequency tripler, transceivers, saturated, II-252
headphone amplifier, II-43
on/off switch for op amp, IV-456
phototransistor, V-279
amplifier, V-409
variable-sensitivity, V-409
pulse generator, IV-437
sorter, I-401
tester, I-401, IV-251, V-406
turn-on circuit, V-345
transmission indicator, II-211
transmitters (see also receivers: transceivers), III-874-871, IV-595-603, V-636-649
2-meter, IV-600-601
10-meter DSB, V-647
3.125-MHz NBFM, V-667
audio-sound transmitter, IV-311
amateur radio, 80-M, II-675
amateur TV, IV-659
ATV IR transmitter, V-440 MHz, V-640
transmitters (cont.)
audio, visible-light, V-261
baby-alert, carrier-current circuit.
V-95
beacon, III-683, IV-693
broadcast, 1-to-2 MHz, I-689
carrier circuit, I-144, I-145, III-79
computer circuit, 1-of-8 channel, III-100
DSB, 16-meter, V-647
fiber optic, III-177
FM transmitters, I-681, V-641
27.125-MHz, NBFM, V-637
49-MHz, V-648
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-80
stereo, V-575, V-580
voice, III-678
wireless microphone, III-682, III-683, III-691
half-duplex information
transmission link, low-cost, III-679
HF, low-power, IV-598
infrared, I-342, I-343, II-390, II-290, III-275, III-277, IV-226, IV-227, IV-228
headphones, V-227
pulsed for one-off control, V-228
line-carrier, with on/off, 200 kHz, I-112
low-frequency, III-682
MIDI transmitter, V-303
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
III-308
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
ultrasound, V-512
remote sensors, loop-type, III-70
television, III-675
tracking transmitter, V-642
transceiver, V-1750-meter, V-646
transmit/receive sequencer,
preamplifier, V-348
ultrasonic, 40 kHz, I-685
ultrasound. Doppler, V-651
vacuum-tube, low-power, V-8040-
M, V-642
voice-communication, light-beam, V-260
VHF, III-681, III-684
transverter, V-2-to-6 meter, V-124
treble booster, guitar, II-683
tremolo circuits, I-59, I-598,
III-692-695, IV-689
tri-color indicator, V-232
twin circuits, V-268
ac-voltage controller, IV-426
treble circuit, II-531
controller circuit, V-267, V-371
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-293
trigger, I-421
voltage detector, II-468
zero point switch, II-311
zero voltage, I-623
triangle-to-sine converter, II-127
triangle/square wave oscillator,
I-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-235,
III-239, III-242
triac, linear, III-232
triangle-wave oscillator, V-205
triode charger, 12 V battery, I-117
triggers
50-MHz, III-364
camera alarm, III-444
flash, photography, xenon flash,
III-447
load-sensing, V-285
optical Schmidt, I-362
oscilloscope-trigged sweep, III-438
remote flash, I-484
SCR series, optically coupled,
III-411
sound/light flash, I-482
triac, I-421
trigged sweep, add-on, I-472
triplexer, nonselective, transistor
saturation, I-352
trouble tone alert, II-3
TTL circuits
clock, wide-frequency, III-86
coupler, optical, III-416
gates, siren using, I-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-618, IV-127
1 MHz to 10 MHz, I-178
1 MHz to 20 MHz, 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-348
swan (notch filters, III-403
twilight-triggered circuit, II-322
twin-T notch filters, III-403
two-state siren, III-677
two-tone generator, II-687
two-tone siren, III-672
two-way intercom, II-392
two's complement, D/A conversion
system, binary, 12-bit, III-196

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-533
field-strength meters, IV-166
rf amplifiers, UHF TV-line
amplifier, IV-483, IV-483
source dipper, IV-290
TV preamplifier, III-546
VHF/UHF rf diode switch, IV-544
VHF/UHF rf preamplifier, V-616
wideband amplifier, I-560, III-264
UHF circuits
battery chargers, III-66
metronome, I-255
monostable circuit, bias-voltage
change insensitive, I-268
ultrasonic circuits (see also sound
operated circuits), III-696-707,
IV-604-609, V-650-653
arc welding inverter, 20 KHz,
III-700
cleaner, V-632-633
induction heater, 120-KHz 500-W,
III-704
post-control/repel, I-684, II-685,
III-690, III-706, IV-606-606
ranging system, III-697
receiver, III-688, III-706
Doppler ultrasound, V-661
remote-control receiver, V-513
remote-control transmitter, V-512
sonar transducer/switch, III-709
sound source, IV-606
switch, I-689
transmitter, 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, 1-265, II-139
10 MHz, III-127
universal mixer stage, III-370
universal power supply, 3-30 V, III-489
up/down counters
8-digit, II-134
extreme count freezr, III-125
XOR gate, III-105

V
vacuum fluorescent display circuit, II-185
vacuum gauge, automotive, IV-45
vapor detector, II-379
varactor-tuned 10 MHz ceramic resonator oscillator, II-141
variable current source, 100 mA to 2 A, II-471
variable-frequency inverter, complementary output, III-297
variable-frequency oscillators (VFO)
5 MHz design, II-551
4083 CMOS, V-421
adjustable temperature compensation, V-420
amateur radio, V-532
buffer amplifier, V-82
CMOS, V-418
code practice oscillators, V-103
rf, V-6.5 MHz, V-629
variable-gain amplifier, voltage-controlled, I-28-29
variable-gain and sign amp. II-405
variable-gain circuit, accurate null, III-69
variable-state filters
universal, V-178
variable oscillators, II-421
audio, 20 Hz to 20 kHz, II-727
duty-cycle, III-422
4-digit, 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
de 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, 100 mA to 2 A, II-471
voltage regulator, III-481
VCO/TV off/off control, V-113
vehicles (see automotive circuits)
VHF-related circuits (see also radio/rf, television; UHF)
amplifiers, I-558
crystal oscillators, III-138-140
IF/VHF switchable active antenna, V-524
modulator, I-440, III-684
tone transmitter, III-681
transmitters, III-681, III-684
VHF/RF diode rf switch, IV-544
VHF/UHF rf preamplifier, V-515
video circuits, II-713-728, IV-607-631, V-654-662
amateur TV (ATV) down converter, V-125, V-126
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
gain block, III-712
IF, I-689, II-687, V-655
FET bipolar cascade, I-692
line driving, III-710
log amplifier, I-38
output, V-656
RGB, III-709
summering, changing circuit and, III-710
TV amplifiers, I-688, I-699, III-30, 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-677
buffers, V-93
camera-image tracker, analog voltage, IV-608-609
camera link, wireless, III-718
color 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-bar generator, color TV, III-724
data interface, TTL oscillator, II-372
dc restorer, III-723, V-689
decoders, III-716
NTSC-to-RGB, IV-613
stereo TV, IV-167, V-576-579, V-689
detectors
IF, III-725-728, I-688, I-690
detectors, I-687-713
IF, I-690
low-level video, I-687-689
differential video loop-through amplifier, V-657
fader, I-688
high-performance video switch, III-728
IF amplifier, V-4-5 MHz, sound, V-655
IF detector, amplifier, III-725-728, I-688
lune 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-699
monitors, II-51
monochrome-pattern generator, IV-417
multiplexcr cascaded, I-51-15, III-393
MITX cable driver
multi-input, V-657
two-input, V-657
up 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-619
video circuits (cont.)

- rfi up-converter for TVRO
- subcarrier reception, IV-601
- RGR-composite converter, III-714
- sampler circuit, TVI audio 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 RGR signals, V-587
- sync separator, III-719, IV-616
- sync stripper/video interface, V-659
- transmitter, TV, III-676, IV-509
- TV sound system, rf amplifiers, V-519
- variable-gain video loop-through amplifier, V-688
- VCR/TV on-off control, V-133
- video, power, channel-select signal carrier, V-344-345
- wireless camera link, II-71
- VLF/VHF wideband antenna
- low-noise, active, V-33
- vocal eliminator, IV-19
- voice communications
- light-beam transmitter/receiver, V-200
- 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
- alligator generator, III-733
- amplifier/switch, I-608
- computer speech synthesizer, III-732
- dialed phone number vocalizer, III-731
- digitalizer for voices, V-328-327
- intercoms, V-289
- scanner voice squelch, IV-624
- scrambler, V-554
- speech detector, II-617, III-615
- stripper, vocal stripper, V-546-547
- switches, III-580, IV-537
- switch/ampifier, 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-686, 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-V regulated output converter, III-739
- 10Hz to 1kHz, I-701, III-735-741
- three-decade, V-666
- 555 VCO, IV-627
- ancho-frequency VCO, IV-636
- binc circuit, V-666, V-667
- crystal oscillator, III-165, IV-124
- current sink, voltage-controlled, IV-659
- driver, op amp design, IV-362
- linear, I-701, IV-628
- triangle/square wave, II-303
- logarithmic sweep, III-738
- one-shot, II-236
- precision, I-702, III-431
- restricted range, IV-627
- sine-wave oscillator, V-665
- 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
- Ti-402 based, V-665
- TMOS, balanced, III-735
- two-decade, high-frequency, I-704
- varicapless, IV-630
- variable-capacitance diode-spaced, III-737
- VHF oscillator, voltage-tuned, IV-628
- waveform generator, III-737
- wide-range, IV-627, IV-629
- voltage-controller, pulse generator, III-534
- voltage converters/inverters, III-742
- 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, uP-controlled, IV-117
- offline, I-5-W, III-746
- regulated 15-Volt 6-V driven, III-746
- isolator, 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-749-751, IV-638-642
- 1 Hz to 10MHz, III-754
- 1 Hz to 30 MHz, III-750
- 1 Hz to 2.5 MHz, III-755
- 5 kHz to 2MHz, III-752
- 10 Hz to 1 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, I-121
- preserved input, III-753
- ultraprecision, I-708
- wide range, III-751, III-752
- voltage-to-pulse-duration converter, II-124
- voltage-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-469
- voltage followers, I-40, III-212
- fast, I-34
- noninverting, I-33
- signal-supply operation, amplifier, III-20
- voltage inverters, precision, III-288
- voltage indicators/meters (see also voltmeters), III-758-772, IV-433
- automotive battery voltage gauge, IV-47
- battery-voltage measuring regulator, IV-77
- comparator and, I-104
- five-step level detector, I-337
- frequency counter, III-768
- HTS, precision, I-122
- level detectors, I-338, II-172, III-769, III-770
- low-voltage indicator, III-767
- 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 follower, 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
doubles, III-499, IV-635
cascaded, Cockcroft-Walton, IV-635
dc, V-672
trac-controlled, III-488
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-387
voltage regulators, I-501, I-511,
II-484, III-486
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-481
5 V, I A, I-500
5 V, ultrastable reference, I-497
6 A, variable output switching, I-513
8 from 5-V regulator, V-489
10 A, I-510
10 A, adjustable, III-492
10 V, high-stability, III-488
15 V, 1 A, remote sense, I-499
15 V, slow-turn-on, III-477
-15 V negative, I-499
45 V, I A switching, I-499
50 V rms voltage regulator with
PUT, II-479
100 Vrms, I-498
200 kHz, I-491
ac, III-477
adjustable output, I-508, I-512
application circuit, I-492
automatic circuits, III-48, IV-67
battery power supplies, I-117, IV-77
bucking, high-voltage, III-481
combination voltage/current regulator, V-455
common hot-lead regulator, IV-467
constant voltage/current, I-608
constant current and thermal protection, 10 amp, II-474
Darlington, IV-421
dual tracking, III-462
efficiency-improving switching, IV-461
fixed ppm, zener divide increases output, II-484
fixed-current regulator, IV-467
fixed supplies, III-461, III-488,
III-471-177, IV-408, IV-462-467
track-off-line, II-481
foldback-current limiting, II-478
high- or low-input regulator, IV-466
high-stability, I-499, I-602, III-488
high-voltage power supplies, I-609,
II-478, III-488, III-490
inductorless, III-476
LM317 design, IV-496
loss cutout, V-467
low-dropout, 5-V, III-461
low-power, I-639, III-480
low voltage, I-502, I-511
linear, II-468, III-490
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
pp, II-484
positive, I-488, 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-483
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
20 kHz, I-499
high-current inductorless, III-476
low-power, II-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
circuit, II-738
voltage supplies, III-758
3.5 digit, I-710
full scale, III-761
ture 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
barograph, I-98, H-54
dc, II-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,
I-761
3.75-digit, I-711
4.5-digit, III-760
4.5-digit, LCD display, I-717
auto-calibrate circuit, I-714
automatic mulling, I-712
interface and temperature sensor,
II-647
LED readout, IV-286
temperature sensor and LVM, IV-647
FTET, I-714, III-765, III-770
high-input resistance, III-768
JTFT, V-318
LED expanded scale, V-311
circuit, III-767, III-769,
IV-289, IV-294, IV-295
ac, I-716
audio, III-767, III-769
DC, IV-295
circuit, IV-289
high-input impedance, I-715
LED readout, IV-204
rf, I-405, III-766
voltage sensors (VOM)
field strength, I-767
phase meter, digital readout,
IV-277
volume amplifier, I-46
volume control circuits, IV-643-645
telephone, II-649
volume indicator, audio amplifier,
IV-222
volume limited, audio signal
amplifiers, V-59
VOR signal simulator, IV-273
VU meters, III-487, I-715
LED display, IV-311

W
wa-wa circuit, II-590
walk-up call, electronic, II-324
walkman amplifier, II-466
warblers (see alarms; sirens)
warmed devices
auto lights-on warning, II-55
high-level, I-387
high-speed, I-101
light, II-220, III-317
low-level, audio output, I-391
speed, I-96
variety-frequency alarm, II-579
water-level sensors (see fluid and moisture detectors)
water-temperature gauge, automotive, IV-44
watmeter, I-17
wave-shaping circuits (see also waveform generators), IV-646-651
capacitor for high-slew rates, IV-650
clipper, glitch-free, IV-648
clip-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-523-527, 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-206, V-491
sine-wave generators, IV-505, IV-506, V-541, V-542, V-543, V-544
60 Hz, IV-507
audio, II-568
IC, IV-507
LP, IV-512
oscillator, audio, III-559
triangular-wave and, tunable oscillator, III-232
VLP 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-584-585, IV-528-530, V-558-570
1 kHz, IV-536
2 MHz using two TTL gates, II-598
555 timer, II-505
stable circuit, IV-534
stable multivibrator, II-597
CMOS 555 astable, true rail-to-rail, II-566
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-505
multivibrator 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-508
pulse extractor, III-584
quadrature-outputs oscillator, III-585
sine-wave and, tunable oscillator, III-232
triangle-wave, II-500
tone-burst generator, single-timer IC, I-89
triangle-wave and, III-225, III-230, 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-205, V-206
square wave, I-728, III-226, III-236, III-243, V-306
timer, linear, III-222
two-function, III-234
VCO and, III-737
wavemeter, tuned RF, IV-302
weather-alarm decoder, IV-140
weight scale, digital, I-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-552
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-538
two-stage, I-689
rf, IV-488, IV-490, IV-491
HF, IV-492
JFET, IV-493
MOSFET, IV-492
two-CA3110 op amp design, IV-491
unity gain inverting, I-95
wideband signal splitter, III-582
wideband two-pole high-pass filter, II-315
Wien-bridge filter, III-569
notch filter, I-402
CMOS chip in, II-558
low-distortion, thermally stable, III-557
low-voltage, III-452
sine wave, I-66, I-70, II-566, IV-510, IV-513
single-supply, III-558
thermally stable, III-557
three-decade, IV-519
variable, III-424
very-low-distortion, IV-513
wind-powered battery charger, II-70
wind indicator, I-330
window circuits, II-106, III-90, III-776-781, IV-655-659, V-673-674
comparator, IV-656-657, V-638, IV-659, V-299, V-674
detector, I-531, 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-225
- 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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