SEATTLE PUBLIC LIBRARY
R621.38153 G348 010117
031
The Giant handbook of ele 1902856
0000102756640

SCIENCE

RED DOT

Seattle Public Library

Please note the date this item is to be returned and keep the date due card in the pocket.

Report CHANGE OF ADDRESS when checking out materials.

The GIANT Handbook Of Electronic Circuits

Edited by Raymond A. Collins

R621.38153
G348

c.2

TAB BOOKS Inc.
BLUE RIDGE SUMMIT, PA. 17214

SCIENCE

SEP 27 1982

FIRST EDITION

FIRST PRINTING

DECEMBER 1980

Copyright © 1980 by TAB BOOKS Inc.

Printed in the United States of America

Reproduction or publication of the content in any manner, without express permission of the publisher, is prohibited. No liability is assumed with respect to the use of the information herein.

Main entry under title:

The Giant handbook of electronic circuits.

Includes Index.
1. Electronics circuits—Handbooks, manual, etc.
I. Collins, Raymond A.
TK7867.G52 621.3815'3 80-21319
ISBN 0-8306-9673-3
ISBN 0-8306-9662-8 (pbk.)

Preface

Just a few months ago, I came across a novel circuit for my telephone while just glancing at a small electronics periodical. In a hurry, I put down the magazine and left the circuit for someone else's amazement. I haven't seen the circuit since that day, although the Lord knows I've tried to find a copy of that magazine and the precious circuit it contains. In this day of the ever present photocopier, I can only blame myself for temporarily—I hope—losing that circuit.

Years ago, as a teen-ager, I must have been luckier or somewhat wiser than I am now, at least in preserving electronic circuits; I bumped into one at a newsstand, bought the magazine, and soldered together all the parts I had found in New York's Radio Row. Until I outgrew it in about a year, that circuit performed well as my first ham transmitter. Electronic circuits have been one of my loves ever since.

And you might have the same vice I have. If so, like many of us who have electronics as our avocation or occupation (or both), you've misplaced a few useful circuit schematics in your time. That's where *The GIANT Handbook of Electronic Circuits* comes in. This collection of circuits from many sources is sort of a "lost and found" of circuits, those you just cannot place your finger on any longer. On the other hand, it's just as likely that you'll spot an entirely new circuit when turning to any of the following 60 chapters. And just as important, this handbook serves as a valuable reference for large-circuit design and verification.

Raymond A. Collins
Senior Electronics Editor
TAB BOOKS Inc.

Acknowledgments

Many thanks to the following manufacturers of semiconductors for furnishing a large percentage of the circuits you'll find in this handbook.

Analog Devices Inc.
Route 1—Industrial Park
Box 280
Norwood, MA 02062

Burr-Brown Research Corp.
6730 S. Tucson Boulevard
Tucson, AZ 85734

Datel Systems Inc.
1020 Turnpike Street
Canton, MA 02021

General Electric
W. Genessee Street
Auburn, NY 13021

GTE Sylvania Inc.
Emporium, PA 15834

Intersil Inc.
10900 N. Tantau Ave.
Cupertino, CA 95014

Motorola Semiconductor Products Inc.
Box 20912
Phoenix, AZ 85008

National Semiconductor
2900 Semiconductor Drive
Santa Clara, CA 95051

Precision Monolithics Inc.
1500 Space Park Drive
Santa Clara, CA 95050

RCA Corp.
Route 202
Somerville, NJ 08876

Signetics Corp.
811 E. Arques Avenue
Sunnyvale, Ca 94086

Workman Electronic Products
P.O. Box 3828
Sarasota, FL 33578

Credit within the captions uses the following key:

AD—Analog Devices Inc.
BB—Burr-Brown Research Corp.
DS—Datel Systems Inc.
GE—General Electric
GTE—GTE Sylvania Inc.
I—Intersil Inc.
M—Motorola Semiconductor Products Inc.
NS—National Semiconductor
PM—Precision Monolithics Inc.
RCA—RCA Corp.
S—Signetics Corp.
W—Workman Electronic Products

Contents

1	A/D-D/A	9
2	Alarms, Sensors and Triggering Circuits	14
3	AM and FM 8roadcast Receivers	22
4	Amateur Radio Accessories	26
5	Amateur Radio Receivers and Converters	33
6	Amplifiers and Preamplifiers	78
7	Audio Amplifiers and Preamplifiers	104
8	Audio Conditioning Circuits	125
9	Automotive Circuits	147
10	8attery Chargers	157
11	8iomedical Circuits	161
12	Bridge Circuits	168
13	Chopper Circuits	173
14	Computer-Related Circuits	178
15	Control and Tone Circuits, CORs and Repeater Circuits	199
16	Converters	224
17	CW Circuits	235
18	Data Transfer Circuits	238

19	Demodulators	251
20	Detectors	253
21	Diode Circuits	263
22	Filters	316
23	Frequency Multipliers	325
24	Gadgets	331
25	Games and Toys	349
26	Indicator Circuits	357
27	Integrators	361
28	Interface Circuits	363
29	Inverters	367
30	Logarithmic Amplifiers	370
31	Logic Circuits, Counters and Clocks	373
32	Math Function Circuits	418
33	Miscellaneous Circuits	437
34	Multiplexers	468
35	Multivibrators	472
36	Music-Related Circuits	476
37	Op Amp Circuits	482
38	Oscillators	507
39	Photo-Activated Circuits	521
40	Power Amplifiers	531

41 Power-Controlling Circuits 535

42 Power Supplies, Regulators and Voltage Multipliers 576

43 Radar and Sonar 610

44 Radioteletype, Slow-Scan Television and Specialized Communications 613

45 Readouts 618

46 Receivers and RF Preamplifiers 627

47 RF Power Amplifiers 632

48 Sample & Hold Circuits 645

49 Servo Motor Circuits 650

50 Smoke and Flame Detectors 658

51 Solid-State Switches 662

52 Telephone Circuits 666

53 Test Equipment and Metering Circuits 669

54 Thermometers and Thermostats 749

55 Timers 757

56 Transmitters, Transceivers, Exciters and VFOs 761

57 TV Circuits 797

58 Video Amplifiers 836

59 Voice Communications 839

60 Waveform Generators 846

Index 874

Chapter 1
A/D-D/A

Note. For 1 μs conversion time with 8-bit resolution and 7-bit accuracy, an LM361 comparator replaces the LM319 and the reference current is doubled by reducing R1, R2 and R3 to 2.5 kΩ and R4 to 2 MΩ.

Fig. 1-1. A complete 2-μs conversion time, 8-bit A/D converter (NS).

Fig. 1-2. High-speed 12-bit A/D converter (NS).

Fig. 1-3. Successive approximation A/D converter (M).

Fig. 1-4. A/D converter with a microprocessor (NS).

Fig. 1-5. Basic A/D converter using a voltage-to-frequency converter (NS).

Chapter 2
Alarms, Sensors and Triggering Circuits

$1\ mA \leq I_{OUT} \leq 5\ mA$
$‡50\ \mu A \leq I_D \leq 500\ \mu A$

††Center scale trim
†Scale factor trim
*Copper wire wound

Fig. 2-1. Logarithmic light sensor (NS).

* provides hysteresis

Fig. 2-2. Light level sensor (NS).

Parts list
SCR1—HEP R1220
D1—HEP R0050
C1—0.01μF nonpolarized
R1—4.7MΩ, 1/2W
R2, R3—1kΩ, 1/2W
R4—470Ω, 1/2W
S1, S2, S3—SPST switches, Lafayette 34P02302
S4, S5, S6, S7—Push-button switches Lafayette 34P0
AL1—Siren alarm, Lafayette 14P37508
T1, T2—HEP S0019

Fig. 2-3. Highly efficient tamper-proof burglar alarm.

Fig. 2-4. Make-to-operate burgular alarm.

Fig. 2-5. Remote alarm circuit.

Fig. 2-6. Tamper-proof burglar alarm.

Fig. 2-7. Electronic temperature sensor (NS).

Fig. 2-8. Isolated voltage sensor (NS).

Fig. 2-9. Remote temperature sensing (NS).

Fig. 2-10. Temperature sensor (PM).

Chapter 3
AM and FM Broadcast Receivers

Fig. 3-1. Automatic frequency control for an FM receiver.

Fig. 3-2. Stereo volume control (NS).

FIGURE 8. AM Radio Power Amplifier

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

Note 2: Twist speaker lead and ground very tightly.

Note 3: Ferrite bead is Ferroxcube K5-001-001/38 with 3 turns of wire.

Note 4: R1C1 band limits input signals.

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

Fig. 3-3. AM radio power amplifier (NS).

Fig. 3-4. A 3-band active tone control (NS).

Chapter 4
Amateur Radio Accessories

Fig. 4-1. Voice-activated switch and amplifier (NS).

Fig. 4-2. Squelch circuit for FM scanners and handie talkies (NS).

Fig. 4-3. JFET speech amplifiers.

Component Values (Typical)

R_1	6.8 to 16K ohm
R_2	4.7K ohm
R_3	20K ohm
C_1	0.10 mfd
C_2	1.0 mfd 6V
C_3	2.2mfd 6V
C_4	250 6V

Fig. 4-4. Touch-Tone® decoder (S).

Fig. 4-5. A simple, 4-channel scanner circuit which can be added to a crystal-controlled FM transceiver. The unit sequentially turns on transistors, which then complete the crystal-to-ground connections of the FM rig.

Fig. 4-6. Op amp speech amplifier.

Fig. 4-7. Op-amp speech amplifier.

Fig. 4-8. Active-low-pass filter for 3-kHz bandwidth.

Chapter 5
Amateur Radio
Receivers and Converters

Fig. 5-1. Simple radio receiver uses an audio amplifier at the output of crystal set.

Fig. 5-2. Circuit for a simple crystal set receiver.

Fig. 5-3. More advanced crystal set receiver.

Fig. 5-4. This 30 MHz i-f stage uses two FETs connected in the cascode arrangement to provide 20 dB gain without neutralization; the bandwidth is 4 MHz. Both FETs in this circuit are 2N3819, MPF105 or TIS34. With a negative supply voltage, the 2N4360 would be suitable.

Fig. 5-5. Overall converter schematic. L1, 17 turns, 15 mm OD, 25 mm long; L2, 3 turns on cold end of L1;L3, 1 turn on cold end of L1;L4, 11 turns, 8 mm OD, 35 mm long; L5, 2 turns on cold end of L4; L6, 21 turns No. 30 inside cup core from Millen 10C; L7, 4 turns No. 30 wound over L6; L8, 5 turns, 15 mm OD, 8 mm long mixer tap at 1 turn, and emitter tap at 2 turns from ground.

Fig. 5-6. This rf preamplifier is easily adapted to any range under 30 MHz simply by choosing appropriate input and output tuned circuits.

Fig. 5-7. This simple one-transistor superregenerative receiver for two meters may be used for copying many local signals. With the components shown this receiver will tune from about 90 to 150 MHz. It may be used on other frequencies by changing the inductor and capacitor Q1 is a GE-9 or HEP 2.

SPEAKER 3.2Ω
C25 320 µF 6.4 V
R14 3.9K
R15 4.7K
Q12 2N4105
Q13 2N4106
C22 32 µF/4V
R10 27
A
R11 68
C24 200 µF 6.4 V
R12 390
R13 47
R8 18K
R9 10K
C21 .002
C23 .002
R6 5K
R7 1K
C19 .22
C18 .1
C20 .01
C26 .47
FL1
C17 .1
R5 390
C13 .047
U1 TAD-100
R4 560
C6 .005
L3
L4
B
C12 200 µF 6.4V
R2 8.2K
R1 8.2K
C5 .047
C7 47
C3 .1
L2
L1
C4 10 µF 2.5V
C2 7
C1A 50

Fig. 5-8. Circuit diagram of the SWL receiver incorporating the TAD-100 IC chip.

Fig. 5-9. This high-impedance preamplifier provides up to 20 megohms input impedance and has a frequency response from 10 Hz to 220 kHz. Circuit B was developed from circuit A by replacing the emitter resistor in A with Q3 and adding an emitter follower to reduce loading. The input impedance is further increased by the components shown by the dashed line. All transistors are 2N2188, SK3005, GE-9, or HEP 2.

Fig. 5-10. Regenerative receiver for 3.5 MHz optimizes LC ratio for better tuning and controllability. Q1 = 2N370, Q2 = OC70 or 71.

Fig. 5-11. This unit offers 12-15 dB gain on 10m, and about 20 dB or more from 15m and down. All leads should be as short as possible. Building it on a PC board should give good results. Q1 can be any type of transistor. The beta should be around 15o+.ft should be 60 MHz or better.

Fig. 5-12. Rf preamplifier for 40 meters (7 MHz) employs FET and yields more than 10 dB gain.

Fig. 5-13. Preamp. C, C9—275—970 pF Elmenco padder 306; C2, C3—0.0033 μF Mylar (2200 pF for 6 ft loop); C4, C5, C8—1000 pF dippiled silver/mica; C6, C10—0.1 μF Centralab CK-104; C7—820 pF dipped silver/mica; L1—3 mH CT. Wound with No. 26 magnet wire approximately 85 turns on an Indiana General Corp. cup core TC7-04-400. Link is 3 turns of insulated wire; RFC1—10 mH Ferrite core rf choke; TR1, TR2—Motorola HEP 802 transistors or RCA 3N128.

Fig. 5-14. Dual-gate FET preamplifier for 150 MHz range ups received signal strength by 20 dB.

Fig. 5-15. Phase-locked loop allows this AM broadcast-band receiver to be tuned with a 5K pot. Can be adapted to any frequency from 1 to 15 MHz by changing values of C_Y and C1; $C_Y = (f_{hi} - f_{10})/(f_{hi} \times f_{10})$; C1 = 300 pF/f(MHz).

Fig. 5-16. FM detector, with 10.7 MHz output, uses phase-locked loop. Part values are shown.

Fig. 5-17. Here is a circuit of a simple 2m converter that works in a pocket AM radio. Since it is crystal controlled, the receiver must tune to a frequency that equals the desired frequency minus 3 × 48.5. Substitute a different frequency crystal if a strong BC station happens to heterodyne with the desired 2m signal.

L1 – Ferrite Loopstick – Philmore FF15 (packaged as set of 3 sizes)
C9 – Sub miniature variable capacitor – Philmore 1949G – 365 pF max.
T1 – Midget Audio Transformer, 1000Ω:8Ω – Archer 273-1380 (Radio Shack, Inc.)
SPKR – 2" PM Speaker, 8Ω, 0.1 watt – Philmore TS20

Fig. 5-18. Trf receiver for standard broadcast band uses LM372 integrated circuit.

Fig. 5-19. Simple rf preamplifier for 6 meters, TV channel 2 or 3, or any frequency between 50 and 60 MHz. No tuning is required because of broad bandwidth (10 MHz); output impedance is about 50 ohms.

Fig. 5-20. Tunnel-diode converter changes AM braodcast radio to receiver capable of detecting 50 MHz signals.

Fig. 5-21. Two-meter preamplifier, MOSFET. C4-5 are button micas and support transistor leads forming resonant circuit. L1 is JFD LC374 tank circuit which contains C1. L2 is 6T 22-gage enamel on 5 mm slug-tuned form, tap at 1 turn. 3N159 will also work in circuit (RTTY Journal, P.O. Box 837, Royal Oak, MI 48068).

Fig. 5-22. You say you got a real bargain on an old motorcycle FM rig, only to find out it is 6 volt? Fret no more.

Fig. 5-23. This simple 2-transistor converter tuned in 150 MHz (ham, police, commercial) and requires no direct connection to broadcast-band receiver. Position next to radio receiver.

Fig. 5-24. Tunable shortwave converter, designed for receiving WWV on ordinary table radio, allows table radio to receive any signal between 10 and 15 MHz. 15 MHz position must be calibrated with C6 to tune oscillator and C3 to peak rf amplifier; then switch S1 to 10 MHz and tune C4 and C2.

L1 – 5-1/4 TURNS, TAPPED AT 1-1/4 TURNS, NO. 26 AWG WIRE.
L2 – 9-1/2 TURNS, NO. 34 AWG WIRE.
L3 – 9 TURNS, NO. 26 AWG WIRE.
L4 – 1-1/4 TURNS, NO. 26 AWG WIRE, AT LOW END OF L3.

ALL RESISTORS-1/2W.
ALL CAPACITORS-10V.

NOTE: ALL LEADS SHOULD BE KEPT AS SHORT AS POSSIBLE (PC BOARD IS RECOMMENDED)

Fig. 5-25. Two-meter preamplifier. Very few receivers will not be improved with a preamplifier such as this. The coils are wound on Miller 60A022-4 forms, or any other small brass slug ceramic forms APC board is recommended.

Fig. 5-26. Low-frequency preamp 1 Hz to 50 kHz, voltage gain 400, extremely low noise, all capacitances in µF, all resistors ½W, transistors 2N5486.

Coil Table, Fig. 2. (All taps counted from ground (cold) end.)

L1 7 turns, airwound, 8/per in. 5/8 O.D., antenna tap at 3 turns, 590 tap at 4 turns.
L2 6 turns, airwound, 4 per in., mixer tap at 2 turns.
L3 5 turns, airwound 8 per in., tap at 1 turn.
L4 35 turns (No. 30), in Miller cup core (from No. 10c I.F.T.).

L5 5 turns, No. 32, wound over L7.
L7 35 turns, No. 34, in Miller cup core.
L6 3 turns No. 30, wound on L7.
L8 35 turns No. 34, wound in Miller cup core.
L9 3 turns wound over L8.
L10 4 turns wound on L11.
L11, 64 turns, air wound, 32 per in., 5/8 O.D.

A

Fig. 5-27. Single-conversion superhet receiver for 50 MHz uses three HEP 590 Motorola integrated circuits. Unit trades selectivity for extreme sensitivity.

Fig. 5-28. VHF TV tuner using the FT0601 dual-gate MOSFET in RF amplifier and mixer stages.

Fig. 5-29. Cascade preamp circuit, using two grounded-gate FETS, provides plenty of rf gain on 6 or 2 meters. Frequency-sensitive values are listed at the upper left portion of the diagram.

Fig. 5-30. Six-meter preamp with 30 dB of signal gain and 600 kHz bandwidth. The input and output impedances are matched. AGC may be added to pin 5. For FM use, dip the coils to 52.5 MHz.

Fig. 5-31. Simple converter allows 170 MHz receiver to be used for reception of 220 MHz signals.

Fig. 5-32. Receiver converter for 50 MHz uses integrated circuit. Output frequency is approximately 1 MHz (center of AM broadcast band).

Fig. 5-33. Complete schematic of a good working regenerative detector. Transistor T1 is the actual detector, which operates at very low power levels. T2 is an emitter follower, which copies out the signal with minimum loss.

Fig. 5-34. This simple one-transistor superregenerative receiver for 2 meters may be used for copying many local signals. With the components shown, this receiver will tune from about 90 to 150 MHz. It may be used on other frequencies by changing the inductor and capacitor. Q1 is 2N1742, 2N2398, 2N3399, GE-9, or HEP 2.

Fig. 5-36. 50 MHz converter using field effect transistor rf amplifier and mixer. The FETs cost about $1 each. This converter has excellent noise figure and great resistance to cross modulation.

A

B

Fig. 5-36. This high-impedance preamplifier provides up to 20 megohms input impedance and has a frequency response from 10 Hz to 200 kHz. Circuit B was developed from circuit A by replacing the emitter resistor in A with Q3 and adding an emitter follower to reduce loading. The input impedance is further increased by the components shown by the dashed line. All transistors are 2N2188, SK3005, GE-9, or HEP 2.

Fig. 5-37. Low-noise 2-meter preamplifier uses a beer can cavity to provide excellent discrimination against nearby kilowatts. Q1 is a 2N3478, 2N3563, 2N3564, 40235, or SK3019.

L1 3-1/2 TURNS NO. 16, 1/4" DIAM, 1/2" LONG. TAPPED AT CENTER.
L2 8-1/4 TURNS NO. 24 ON 1/4" SLUG-TUNED FORM.
L3 8 TURNS NO. 16, 1/8" DIAM, 7/8" LONG. TAPPED ONE TURN FROM COLD END.
Q1 2N3478, 2N3564, 40235
RFC 0.84 μH (OHMITE Z-220)

Fig. 5-38. Low-noise 220 MHz preamplifier. This circuit will provide extremely high gain with low noise on the 1¼ meter band. Neutralization is controlled by inductor L2.

Fig. 5-39. Schematic of low-cost, low-noise, low-cross-modulation 2-meter converter. Note that only the mixer uses an FET; the mixer is responsible for most cross modulation.

Fig. 5-40. This preamplifier provides 11 dB gain from 0.5 Hz to 2 MHz and has an input impedance of 32 megohms. Transistors Q1, Q2 and Q4 are 2N338, SK3020, or HEP 53; Q3 is a 2N328, GE-2, or HEP 52.

FREQ	FSK 455 KHz	AFSK 2550 Hz
C1	770 pF	0.13 µF

Fig. 5-41. RTTY converter circuit is taken from computer data set applications note; data set is same as AFSK converter, but gets input signal from telephone line and so is not subject to such high levels of interference as is RTTY. Input may be either at i-f or audio frequencies; table shows values of C1 for both cases. Output consists of pulses which may drive a keying circuit for selector magnets.

Fig. 5-42. A 28-MHz rf preamplifier uses HEP 590 integrated circuit (Motorola); interconnection to receiver is via coaxial cable.

D1-IN295, TAPPED ON AT 4 TURNS
L1-8 TURNS, AIRWOUND, 10 PER INCH
L2-2 TURNS AROUND L1, VARIABLE COUPLING

Fig. 5-43. A diode detector makes a convenient and useful receiver for checking the performance of your postage-stamp transmitter while it's on the bench.

Fig. 5-44. A 2m FM preamp. L1 & L4, 2T No. 22 hookup on cold end of L3; L2 & L3, 3½T No. 16 spaced the dia. L2 & L3 must be wound opposite directions: C1, 10 pF, C2, 470 pF; C3, 10 pF; C4 R1, 220Ω ½W; R2, 370Ω ½W; R3, 22Ω ½W; Q1, Motorola MPF-107 or HEP 802.

Fig. 5-45. The tiny oscillator circuit operates from a standard 9V battery. A small hunk of wire provides an antenna sufficient to insure healthy output for several feet. Placed close to a conventional all-wave receiver, the unit provides sufficient carrier injection for copying single sideband and CW.

Fig. 5-46. A 10-meter tuner circuit diagram. The Miller 9050 and 9054 should be used if at all possible. They are ideally suited to this project because they are easy to modify and fully magnetically and electrostatically shielded. They are available through most large catalogs or directly from J.W. Miller Co., P.O. Box 5825, Compton, CA 90224. For those who cannot get these coils, the 9050 varies from 1.5 to 3.9 μH and the 9054 ranges from 28.0 to 60 μH. Also, the triple ganged capacitor used is noncritical. Do some experimenting until you get something with a maximum capacity of about 11 pf per section.

Fig. 5-47. Rf preamplifier for 450 MHz. Insert shows transistor basing.

Fig. 5-48. Alternate RTTY circuit uses NE565 IC. Maximum frequency of 565 is 500 kHz. This circuit is designed to drive digital IC devices, and type 5710 voltage comparator is included to adjust output level to values suitable for digital ICs. Pot is for frequency adjustment.

Fig. 5-49. Regenerative receiver for WWV (and other signals in 3.5 MHz region).

Fig. 5-50. Low noise JFET preamplifier for 2 meters.

Fig. 5-51. This 150 MHz rf preamplifier uses Motorola FET for true 14 dB gain (after factoring out noise). Coils should be wound on ¼ in. ceramic forms with brass slugs. L1 is 5.5 turns 26-gage tapped 1.25 turns from cold end; L2 is 9.5 turns 34-gage; L3 is 5 turns 26-gage, L4 is 1.5 turns 26-gage wrapped around lower end of L3. Shield well.

Fig. 5-52. Usually the crystal filter circuit in a receiver (A) must be physically located so that phasing capacitor (C_P) is accessible to the front panel. By using the varactor phased filter in B, the crystal may be located in any convenient location. Q1 and Q2 are 2N3478, 2N3564, 2N3707, 40236 or HEP 50; D1 is a 20 pF varactor such as the IN954.

Fig. 5-53. Circuit of the Q-multiplier as constructed for a 455 kHz i-f.

Fig. 5-54. Simple Novice receiver for 80 meters.

Fig. 5-55. Schematic diagram of superregenerative receiver for the ¾ meter band.

Fig. 5-56. Simple coaxial cavity and transistor preamp for 150 MHz. Emitter should be bypassed with 1000 pF disc.

Fig. 5-57. Schematic of diode receiver for 432 MHz.

Coil data

C_4—two 2-inch lengths of insulated hookup wire twisted together.

L_1—23 turns no. 24 enamel wire, tapped at 4 turns, on 1/2-inch O.D., 5/16-inch I.D., 3/16-inch long powdered-iron toroid core. (Ami-Tron Associates T-50-2 Red).

L_2—21 turns no. 24 enamel wire, tapped at 4 turns, on same type form as L_1

L_3—25 turns no. 30 enamel wire, close-wound on 1/4-inch diam. iron slug tuned form (Miller 20A000RBI usable).

Fig. 5-58. Receiver converter accepts 21-MHz signals and amplified them before converting them to about 3.75 MHz.

Fig. 5-59. 220 MHz converter built on a 2" × 5" copper-plated board. L1, L2, L3 and L5 are each 4 turns No. 18 wire ¼" in diameter. L1 is ½" long and the other three are ⅜" long. L4 is 11 turns No. 24 enameled on a ¼" form with a brass slug. The winding is ¼" long.

Fig. 5-60. Schematic of simple 440 MHz converter. L1—L4 are quarter-wave trough lines, 5 mm (¼″) diameter and 68 mm (2 11/16″) long. L5 is 3 turns 18-gage 7 mm (5/16″) in diameter. L6 is 7 turns 18-gage on a 5/16″ form and L7 is 3 turns on it.

L_1 6T ¼" dia closewound
L_2 2T ¼" dia "
L_3 2T ¼" dia "
L_4 6T ¼" dia. "
L_5 6T ¼" dia. "
Tap 2T
L_6 6T ¼" dia " "
Tap 2T "
L_7 30T ¼" dia.
L_8 3T ¼" dia.

C_1 50 pf
C_2 50 pf
C_3 50 pf
C_4 50 pf
C_5 100 pf

Y_1 = Xtal 43.5 mhz for 6.5 ic.5 mhz *if*

R = ¼ watts
C = 50 vdc
C1-4 = 7-45 pf trimmers

Fig. 5-61. Receiver converter for 50 MHz has overall gain of 55 dB; output is difference frequency between crystal and generating frequency.

Parts Data

SM—Dipped silver mica
L1—8¼ turns No 24 enam wire closewound on ¼ in diam slug tuned form Tap 1⅝ turns from gnd end (Miller 4500-3)
L2—10 uh molded r f choke (Miller 9230-44)
L3—Slug tuuned 9 9 to 15 0 uh (Miller 4506)
L4 L5 L6 L 8—Slug tuned 44 to 76 uh (Miller 4501)
L9—2½ turns No 22 insulated wire wound around 4 Winding direction same as 1
RFC1 RFC2—22 uh molded rf choke (Miller 9230 52)
CR1—Silicon diode (optional) 50 PIV minimum 200 ma min
J2 J4—Banana jack
C1—15 to 130 pf mica padder (Area-Elmenco 3024
J1 J2—BNC receptacles
XTAL—43 000 MHz third overtone series resonant crystal

Fig. 5-62. Schematic diagram of 50 MHz converter. All resistors are ½-watt carbon. All bypass capacitors are disc ceramic. Dipped silver/mica capacitors are preferred for capacitance values below 100 pF, but disc ceramics are acceptable unless otherwise specified. The 1 pF dipped silver/mica capacitors are made by Cornell-Dubilier. For best sensitivity, connect the TIS88 source directly to a ground lug as at A. For better overload control, connect the 1N191 (or 1N191) diodes across J1 as at CX, and then connect the TIS88 source to the 330Ω(0.005 µF) bias network as at B.

L1, L2: PRI 10 turns No. 26 on Micrometals; sec 4 turns No. 26 on cold end.
L3, L4: 12 turns No. 34 Tri-filar on Indiana Ganeral CF-120-Q1.
L5: 7 turns No. 26 on Micrometals
L6, L7: 24 turns No. 28 on Micrometals; L7 has a secondary winding of 3 turns.
L8: 24 turns No. 28 on Micrometals; primary 7 turns No. 28 on cold end.
D1, D2, D3, D4: Hewlett Packard HPA-5082-2805 diodes.
Q1: RCA 40602
Q2: RCA 2N5187

PARTS LIST
C1, C3, C4, C8, C10, C11: 1.7-14.1 pF; EF JOHNSON 189-505-S; 60¢ each.
C2, C9: 1.5 pF NPO Ceramic
C5: 2.2 pF NPO Ceramic
C6: 3 pF Silver Mica
C7: 15 pF Silver Mica
C12, C13, C14, C15: 1000 pF Disc Ceramic
R1: 2.2K ¼W
R2: 50K Potentiometer
R3: 47K ¼W
R4: 100K ¼W
R5: 2.7K ¼W
R6: 10K ¼W
R7: 1K ¼W

Fig. 5-63. A 2-meter hot-carrier-diode converter.

Fig. 5-64. Schematic of the 2m converter. L1, L2, and L3—L5 turns No. 18, 0.7 cm diameter airwound, about 2 cm long, tap at one turn, adjust to resonate at 144 MHz. L4—3 turns hookup wires on L5. L5—L3 turns No. 20, 0.7 cm diameter slug tuned, 1.3 cm long, resonate at 144 MHz. L7—6 turns hookup wire on L6. L8—10 turns No. 24, 0.7 cm diameter slug tuned, resonate at 43 MHz. L9—4 turns No. 24, 0.7 cm diameter slug tuned, resonate at 130 MHz.

Fig. 5-65. Schematic diagram of 2m converter. Any one of the MOSFET types 3N140, 3N159, or MFE3007 may be substituted for any of the MOSFETs in the schematic. However, a 3N159 will give the lowest noise figure in the first stage. A 40673 should give the best protection against any rf spikes in the second stage. And a MFE3006/MFE3007 should give the best protection against steady, high-voltage rf signals in the mixer stage. All resistors are ½-watt carbon, 5%. All fixed capacitors other than SM, BM, or feedthrough types are disc ceramic.

Chapter 6
Amplifiers and Preamplifiers

Fig. 6-1. Voltage-controlled variable gain amplifier (NS).

Fig. 6-2. Precision low-drift operational amplifier (NS).

$V_S = 6V$ $R_L = 4\Omega$ $P_O = 1.0W$
$V_S = 12V$ $R_L = 8\Omega$ $P_O = 4W$

Fig. 6-3. Bridge amplifier (NS).

Fig. 6-4. Power amplifier with Av of approximately 100 (NS).

Fig. 6-5. Amplifier with bass boost (NS).

Fig. 6-6. Amplifier with a gain of 200 and minimum C_B (NS).

Fig. 6-7. Remote amplifier (NS).

Fig. 6-8. Remote thermocouple amplifier (NS).

Fig. 6-9. Ultra-low distortion amplifier with Av of 10, THD less than 0.05 percent and VOUT of 3 volts rms (NS).

Fig. 6-10. High-speed inverting amplifier with low drift (NS).

Fig. 6-11. Medium-speed, general-purpose amplifier (NS).

Fig. 6-12. Thermocouple amplifier with cold junction compensation.

Fig. 6-13. Unity gain amplifier (NS).

Fig. 6-14. A 10X buffer amplifier (NS).

Fig. 6-15. A 100X buffer amplifier (NS).

Fig. 6-16. Fast summing amplifier (NS).

Fig. 6-17. Differential amplifier (NS).

Fig. 6-18. Video DC restoring amplifier (NS).

Fig. 6-19. An AC-coupled noninverting amplifier (NS).

For $\frac{R1}{R2} = \frac{R4}{R3}$ (CMRR depends on this resistor ratio match)

$$V_O = 1 + \frac{R4}{R3} (V_2 - V_1)$$

As shown $V_O = 2(V_2 - V_1)$

Fig. 6-20. High input impedance, DC differential amplifier (NS).

Fig. 6-21. Photovoltaic cell amplifier (NS).

Fig. 6-22. Voltage-controlled amplifier (NS).

Fig. 6-23. Amplifier with gain of 50 (NS).

Fig. 6-24. Amplifier with bass boost (NS).

Fig. 6-25. Amplifier with a gain of 20 and minimum parts (NS).

Note 1: Twist supply lead and supply ground very tightly.
Note 2: Twist speaker lead and ground very tightly.
Note 3: Ferrite bead is Ferroxcube K5-001-001/3B with 3 turns of wire.
Note 4: R1C1 band limits input signals.
Note 5: All components must be spaced very close to IC.

Fig. 6-26. Power amplifier for an AM radio (NS).

Fig. 6-27. Amplifier with gain of 200 (NS).

Fig. 6-28. Typical 5-watt amplifier (NS).

Fig. 6-29. Bridge amplifier (NS).

Fig. 6-30. Automatic gain control amplifier (NS).

Fig. 6-31. Transducer amplifier (NS).

D1, D2—HEP R0052
D3—HEP R0053
T1, T3—HEP S3001
T2—HEP S5014
T4—HEP S7003
T5—HEP S7002
C1, C3—10μF, 15V, electrolytic
C2—200μF, 6V, electrolytic
C4—50μF, 25V, electrolytic
C5—4000μF, 50V, electrolytic
All resistors 1/2W unless otherwise stated
R1—10kΩ
R2, R3, R4, R9—4.7kΩ
R5—68kΩ
R6—220Ω
R7—50kΩ, trimmer pot
R8—47Ω
R10—2.2kΩ
R11, R12—470Ω
R13, R14—0.27Ω, 5W
SP1—4Ω, 50W speaker capability
Hardware, HEP TO-3 Heat Sink— Mica Insulators, Lafayette 32P05390V

Fig. 6-32. Hi-fi power amplifier.

Fig. 6-33. Gain of 1000 instrumentation amplifier (NS).

Fig. 6-34. Inverting amplifier with balancing circuit (NS).

D1~RCA N-Type Silicon P-I-N Photodiode

- Frequency response of greater than 10 MHz
- If slow rise and fall times can be tolerated the gate on the output can be removed. In this case the rise and the fall time of the LM359 is 40 ns.
- $T_{PDL} = 45$ ns, $T_{PDH} = 50$ ns—T^2L output

Fig. 6-35. Photodiode amplifier (NS).

Fig. 6-36. Meter amplifier (NS).

Fig. 6-37. Microphone amplifier (NS).

Fig. 6-38. Amplifier with digitally programmable gains. (PM).

Fig. 6-39. Stereo phonograph amplifier with bass tone control (NS).

Fig. 6-40. A 2-channel tape-playback amplifier with signal switching (NS).

Fig. 6-41. MOS memory sense amplifier (S).

Fig. 6-42. Single-stage, wideband amplifier (M).

Chapter 7

Audio Amplifiers and Preamplifiers

Fig. 7-1. Stereo phonograph amplifier with bass tone control (NS).

Fig. 7-2. A 40-watt-8-ohm, 60-watt-4-ohm amplifier (NS).

Fig. 7-3. Amplifier with gain of 200 and minimum C_B (NS).

Fig. 7-4. Load returned to ground. This amplifier has a gain of 20 (NS).

Fig. 7-5. A 2.5 -watt bridge amplifier (NS).

Fig. 7-6. Load returned to Vs. This amplifier has a gain of 20 (NS).

Fig. 7-7. Tape preamp with NAB equalization (NS).

Fig. 7-8. Phono preamp with NAB equalization (NS).

Fig. 7-9. Phono amplifier (NS).

Fig. 7-10. A 15-watt per channel audio amplifier (NS).

Fig. 7-11. A 4-watt bridge amplifier (NS).

Fig. 7-12. Rear speaker ambience (4-channel) amplifier — using two LM 378 op amps (NS).

Fig. 7-13. A 10-watt per channel audio amplifier (NS).

Fig. 7-14. Simple stereo amplifier with bass boost (NS).

Fig. 7-15. Stereo amplifier with Av of 200 (NS).

Fig. 7-15. Stereo amplifier with A_V of 200 (NS).

Fig. 7-16. A noninverting amplifier using a split supply. The split supply is also shown (NS).

Voltage gain	34 dB at 1 KHz
Input overload point	100 mVrms at 1 KHz
Output voltage swing	5 0 Vrms at 1 KHz and 0.1% THD
Output noise level	Better than 70 dB below 10 mV phono input (input shorted)

Fig. 7-17. Magnetic phono playback preamplifier/RIAA equalized (NS).

Fig. 7-18. A 20-watt-8-ohm, 30-watt-4-ohm amplifier with a 1-second turn-on delay (NS).

Fig. 7-19. Amplfiier with bass boost (NS).

Fig. 7-20. A 2-pole fast turn-on NAB tape preamplifier (NS).

Fig. 7-21. A typical tape playback amplifier (NS).

Fig. 7-22. Low-cost phono amplifier (NS).

Fig. 7-23. A 1-watt (rms) audio amplifier (NS).

Fig. 7-24. Broadband audio amplifier (M).

Fig. 7-25. Typical 4.5-MHz i-f amplifier (M).

Fig. 7-26. Typical 1-watt phonograph amplifier with ceramic cartridge input (M).

Fig. 7-27. Ceramic cartridge amplifier (NS).

Chapter 8
Audio Conditioning Circuits

1 ALL CONTROLS FLAT
2 BASS & TREBLE BOOST MID FLAT
3 BASS & TREBLE CUT MID FLAT
4 MID BOOST BASS & TREBLE FLAT
5 MID CUT BASS & TREBLE FLAT

Fig. 8-1. A 3-band active tone control for bass, midrange and treble (NS).

BASS

$$f_L = \frac{1}{2\pi R_2 C_1}$$

$$f_{LB} = \frac{1}{2\pi R_1 C_1}$$

$$A_{VB} = 1 + \frac{R_2}{R_1}$$

TREBLE

$$f_H = \frac{1}{2\pi R_3 C_3}$$

$$f_{HB} = \frac{1}{2\pi (R_1 + R_3 + 2R_5) C_3}$$

$$A_{VT} = 1 + \frac{R_1 + 2R_5}{R_3}$$

ASSUMES $R_4 \gg R_1 + R_3 + 2R_5$

Fig. 8-2. Alternate bass design active tone control (NS).

Fig. 8-3. A 2-channel panning circuit (NS).

Fig. 8-4. Preamplifier current booster (NS).

Fig. 8-5. LM387 feedback tone controls (NS).

Fig. 8-6. VOX/mike preamp with antitrip.

Fig. 8-7. VOX/mike preamp.

Fig. 8-8. Circuit of preamplifier clipper circuit. Potentiometer adjusts clipping level and may be replaced by fixed resistors once desired level is found.

Fig. 8-9. Squelched preamplifier with hysteresis.

Fig. 8-10. Speech compressor.

Fig. 8-11. Speech compressor using subsequent gain for better control.

Fig. 8-12. Audio compressor uses inexpensive Motorola FETs.

Fig. 8-13. Microphone preamplifier. Mike output low? Fix it with this one. This is for use with a ceramic or crystal microphone or even a phono cartridge. (M).

Fig. 8-14. This schematic from the U.S. Navy's handbook of "preferred circuits" shows an emitter follower that provides 12 dB gain.

Fig. 8-15. Photocell compressor/agc circuit schematic. Voltage rating of capacitor to terminal 10 must be chosen to protect unit from voltage found at sampling point. Dc operating voltage need not be supplied from an extremely well filtered source since audio quality of amplifier is not significant.

Fig. 8-16. Compressor Schematic.

Fig. 8-17. Shaping circuitry to be added ahead of existing compressor.

Fig. 8-18. Clipper and filter for use at output of existing audio compressor.

OUTPUT
OUT
INPUT
IN
L1
+12 v
VCC
R15
R16
R18
R20
R21
R23
Q3
Q4
Q5
C9
R17
R19
R22
R24
R25
C22
C4
C5
R8
C11
C12
C10
R38
R37
R36
L3
C19
R34
R35
R26
R28
R30
R32
D1
L2
C18
Q1
C2
C3
Q2
C6
C7
U1
R1
R4
R6
R9
R11
Q6
C14
Q7
C15
C16
C17
D2
R29
R27
C13
R31
R33
C1
R2
R3
R5
R7
R10
R12
R13
C20
R43
Q9
C8
R14
Q8
D3
T1
C21
R41
R42
R40
R39
D4

PARTS LIST

Components

Q1,Q8,Q9 FET-1, HEP 802, 2N3819, etc.
Q2-Q7 2N697, HEP 54
U1 CA3028A D1-D4 1N270
L1-L3 2.5 mH rf choke
L2 3.5 H miniature audio choke, UTC DOT-8
T1 GC Co. D1-728 transformer. For primary, use half of 500Ω CT secondary. For secondary, use 1000Ω CT primary.

Capacitors

C1, C19 0.001 μF
C2 0.005 μF
C3 0.05 μF
C4, C5, C8, C22, 100μF 15V
C6, C7, C9, C10, C15, C18 0.1μF
C11, C12, 10 μF 15V
C13 30 μF 15V
C14, 0.02μF
C16, C17 0.0015μF
C20, C21 6 μF 1.5V

Resistors (all except potentiometers 1/2 watt)

R1 2.2M
R2 91-R3 10K audio-taper pot
R4, R16, R23, R26 180K
R5, R17, R24 56K
R6, R7, R18, R19, R21, R22, R25, R34 4.7K
R8, R14, R15, R29, R33, R41 1.0K
R9, R11 10K
R10, R12, R37 47K
R13 2K
R28, R32, 3.9K
R30 120K
R35 5K pot
R36 24K
R38 50K audio taper pot
R39 100K
R40 2K trimmer pot
R42 30K
R27, R31 33K

Fig. 8-19. Speech processor increases effectiveness of SSB signal by compression, clipping, and filtering before modulation.

Fig. 8-20. Combination preamp and tone generator.

Fig. 8-21. Speech simulator schematic.

Fig. 8-22. Two-stage clipper/preamp will increase the talk of any rig. Transistors Q1 and Q2 are HEP 54. The diodes are 1N456 or HEP 158.

Fig. 8-23. Two-stage clipper/preamp. Transistors Q1 and Q2 are 2N1304, 2N2926, 2N3391, SK3011, or HEP 54. The diodes are 1N456 or HEP 158.

Fig. 8-24. Audio preamp compressor.

Fig. 8-25. Microphone amplifier using a field-effect transistor has an input impedance of 5 megohms. Q1 is a 2N4360, TIM12, U-112 or U-110. By reversing the polarity of the supply voltage, a 2N3820, MPF 104 or HEP 801 may be used.

Fig. 8-26. This simple dynamic range compressor provides 50 dB range; it exhibits gain with a 20 millivolt signal but will saturate with input voltages up to 6 to 7 volts. All the diodes are 1N914; transistor Q1 should be a 2N2926, 2N3391, SK3010, GE-8 or HEP 54.

1-Q1 & Q2 ARE Si NPN TYPES, hfe 30-120, VCBo 45V OR EQUIV.
2-SELECT R2 FOR DESIRED GAIN.
3-IF NECESSARY, CHANGE R4 TO YIELD 10-12 VDC AT COLLECTOR OF Q2.
4-IF LOWER OUTPUT IS DESIRED, CHANGE R10-R11 RATIO.

Fig. 8-27. Audio conditioning unit (preamplifier/compressor).

Fig. 8-28. Versatile premodulation speech processor.

Fig. 8-29. Clipper/preamp. Transistors Q1 and Q2 are 2N1304, 2N2926, 2N3391, SK3011, or HEP 54. The diodes are IN456 or HEP 158.

Chapter 9
Automotive Circuits

Parts list
T1, T2—HEP G0008
T3—HEP G0005
T4—HEP G6004
C1—25μF, 12V electrolytic
C2—100μF, 12V electrolytic
R1, R4—2kΩ, 1/2W
R2, R3—100kΩ 1/2W
R5—120Ω 1/2W
L1—bulb 12V, 1A GE 1416
S1—Switch, SPST

Fig. 9-1. Emergency road flasher.

Parts list 2
IC1—SW781, Stewart Warner Corp.
D1—9.1V, 1W, Zener HEP Z0412
C1—0.005μF
C2—0.22μF
C3—470pF
R1—6.8kΩ, 1W
R2—R3; 1.2kΩ, 1W
R4—4.7kΩ, 1/2W
R5—50kΩ, 1W pot
R6—3.6kΩ, 1/2W
R7—500Ω, 1W pot
R8—220Ω, 1/2W
X1—transformer (120V to 6.3V) Lafayette 33P80508
M1—1 mA meter, dc, Lafayette 99P51070V
S1—4PDT swtich, 3 sections, Radio Shack 275-405

Fig. 9-2. Solid-state dwell/tachometer.

Parts list

IC1—MC1555
T1, T2—HEP S3001
T3, T4—HEP S7004
SCR1—HEP R1223
D1 to D4—HEP R0078
D5—HEP R0080
D6, D7, D8—HEP R0076
R1—15Ω, 1/2W
R2, R5—4kΩ, 1W
R3—150Ω, 1W
R4—200Ω, 1W
R6—2kΩ, 1W
R7—1MΩ, 5W
R8—100kΩ, 5W
R9—20kΩ, 5W
R10—750Ω, 5W
R11, R12—30Ω, 2W
C1—.02μF, 50V
C2—1.0μF, 600V
C3—0.1μF, 50V
C4—.02μF, 600V
C5—.01μF, 600V
X1—110V to 6.3Vac CT, 4 A transformer

Fig. 9-3. Capacitive discharge ignition system.

Parts list
IC1—CA3085
Q1—2N6385 or
2N2219/2N3055 combination

D1—R0861
D2—18V Zener, IN5639A
C1—0.0015μF
All resistors 1/4W

R1—820Ω
R2—100Ω
R3—2.7kΩ
R4—470Ω

R5—5.6
R6—100Ω pot

Fig. 9-4. Electronic regulator for car alternator.

Parts list 4	D2—HEP R0600	T3—HEP S0015	otherwise stated	R —560kΩ	R6—100kΩ
IC1—MC1555	T1—HEP S7004	C1, C2—22μF, 25V electrolytic	R1—1kΩ	R4—10Ω	R7—10kΩ
D1—HEP R0050	T2—HEP S0019	All resistors 1/2W unless	R2—470Ω	R5—180Ω	R8—2.2kΩ

Fig. 9-5. Car door light delay.

Parts list 10
IC1—HEP C4000P
T1—HEP S0015
D1, D2—HEP R0050
D3, D4, D5—HEP R0052
C1—470μF, 25V, electrolytic
C2—1μF, nonpolarized
All resistors 1/2W
R1—330kΩ
R2, R5—10kΩ
R3—3.9MΩ
R4—1.5MΩ
RY1, RY2—12V relay, Lafayette 30P20047

Fig. 9-6. Microswitch vehicle immobilizer for positive voltage grounds.

Fig. 9-7. Automobile immobilizer for minus ground systems.

Fig. 9-8. Frequency-to-voltage converter (tachometer) output.

Fig. 9-9. 12 V flasher.

Fig. 9-10. Auto headlight reminder.

Fig. 9-11. Auto wiper control.

Chapter 10
Battery Chargers

*R_S—sets output impedance of charger $Z_{OUT} = R_S \left(1 + \frac{R2}{R1}\right)$
Use of R_S allows low charging rates with fully charged battery.

Fig. 10-1. A 12-volt battery charger.

Fig. 10-2. A 50-mA constant current battery charger.

*Sets peak current (0.6A for 1Ω)

**1000 μF is recommended to filter out any input transients.

Fig. 10-3. Current limited 6-volt battery charger.

*R_S—sets output impedance of charger $Z_{OUT} = R_S\left(1 + \frac{R2}{R1}\right)$ Use of R_S allows low charging rates with fully charged battery.

**1000 μF is recommended to filter out any input transients.

Fig. 10-4. Simple 12-volt battery charger. AN LM 350 chip can be substituted for the LM338.

* Sets peak current (2A for 0.3Ω)

** 1000 µF is recommended to filter out any input transients

Fig. 10-5. Current limited 6-volt charger.

Fig. 10-6. A 12-volt battery charger. An LM338 chip can be substituted for the LM350.

Chapter 11
Biomedical Circuits

Fig. 11-1. Isolation amplifier for medical telemetry (NS).

Fig. 11-2. Fetal heartbeat monitoring input circuitry using an Analog Devices 284-J isolation amplifier (AD).

Fig. 11-3. Multilead EKG recorder input circuitry using a 284J isolation amplifier (AD).

Fig. 11-4. Heart rate monitor (M).

Rate Calculation and Display
Overflow
Reset
R1
R2
(Period)
Q1 Q2 Q3 Q4
D1 11 D3 D4 CF
C MC14522
PE
MR "0"
Reset
R1 R2
(Frequency)
Q1 Q2 Q3 Q4
1/4 MC14001
A B C D
LE
LT
MC14511
BI
a b c d e f g
1/2 MC14013
S
D
Q
C
R
$\bar{Q}$
V_{DD}
1/4 MC14001
MPS 6513
Blanking
Latch
270
4.05 V Mallory
V_{SS}
Tens
Hundreds

Fig. 11-5. EKG input amplifier using an optically coupled 3652 HG isolation amplifier to protect the patient from possible lethal potentials (BB).

NOTE 1. GAIN RESISTOR, R_1, 1%, 50ppm/°C METAL FILM TYPE IS RECOMMENDED.
FOR GAIN = 1V/V, LEAVE TERMINAL 2 OPEN
FOR GAIN = 10V/V, SHORT TERMINAL 2 TO TERMINAL 1

$$\text{GAIN} = 1 + \frac{100k\Omega}{10.7k\Omega + R_1(k\Omega)}$$

NOTE 2 GUARD RESISTOR R_G, REQUIRED ONLY FOR CMV > ±2500V_{PK} (±5kV_{PK} MAX).
R_G MAY BE MOUNTED ON AC1049 MOUNTING SOCKET USING STANDOFF PROVIDED.
(USE ¼ WATT, 5%, CARBON COMPOSITION TYPE ALLEN BRADLEY RECOMMENDED).

NOTE 3 OUTPUT FILTER CAPACITOR, C SELECT TO ROLLOFF NOISE
AND OUTPUT RIPPLE (e.g. SELECT C = 1.5μF FOR dc TO 100Hz BANDWIDTH)

Fig. 11-6. Isolation amplifier for biomedical and industrial applications (AD).

Chapter 12
Bridge Circuits

Fig. 12-1. A 16-watt bridge amplifier.

Fig. 12-2. An 8-watt bridge amplifier.

Fig. 12-3. Bridge amplifier.

Fig. 12-4. A 16-watt bridge amplifier.

Fig. 12-5. A 12-watt bridge amplifier.

Chapter 13
Chopper Circuits

Fig. 13-1. MOSFET analog switching circuit (chopper) for large input voltages (M).

MAXIMUM CHOPPING FREQUENCY $f_{max} \simeq 5$ MHz
MAXIMUM INPUT VOLTAGE $E_{s\ (max)} \simeq +0.5$ V, -4.0 V

Fig. 13-2. Series-shunt chopper for high-frequency applications using complementary enhancement mode MOSFETs (M).

Fig. 13-3. Series chopper for large input voltages using an N-channel JFET (M).

Fig. 13-4. JFET chopper with extended range of ±10 volts (M).

MAXIMUM CHOPPING FREQUENCY $f_{(max)} \simeq 5$ MHz

MINIMUM INPUT VOLTAGE $E_{s\,(min)} \simeq \pm 10\mu V$

Fig. 13-5. Series-shunt chopper for low input voltages (M).

MAXIMUM CHOPPING FREQUENCY $f_{(max)} \simeq 200$ kHz

MAXIMUM INPUT VOLTAGE $E_{s\,(max)} \simeq +2$ V, -0.4 V

Fig. 13-6. Series chopper using an N-channel JFET (M).

Fig. 13-7. MOSFET chopper with extended range of ±3 volts (M).

Chapter 14
Computer-Related Circuits

Fig. 14-1. Large fan-in AND gate (NS).

One-Shot Multivibrator

Fig. 14-2. AND gate (NS).

Fig. 14-3. OR gate (NS).

Fig. 14-4. Quad MOS clock driver with 7001 type 1K RAM (M).

Fig. 14-5. Multiple output switching regulator for use with microprocessing units (M).

NOTES

1. NOR Gates – MC14001 or equiv
   Inverters – MC14049 or equiv
   NAND Gates – MC14011 or equiv.
2. The clock period should be greater then twice the worst case ripple delay through the counters to achieve full accurecy

Fig. 14-6. A 3-½ digit BCD A/D converter (M).

1/2
MC14013
D
C
Q̄
R
VDD
14518
MC14518
E
Q1
Q2
Q3
Q4
MC14042
D0
D1
D2
D3
P
Y
MC14519
Z
X
B
A
To B
BCD 1
BCD 2
BCD 4
BCD 8
D1 D2 D3
MSD
LSD
Multiplexed 8CD
Outputs
Data
Update
1/2
Digit

Fig. 14-7. Quad MOS clock driver with 1103 type 1K RAM (M).

Fig. 14-8. Basic 8-bit fully buffered accumulator (S).

Fig. 14-9. An 8-bit A/D add/subtractor (S).

Fig. 14-10. Complete 8-bit A/D converter (PM).

Fig. 14-11. An 8-bit tracking A/D converter (PM).

Fig. 14-12. A 10-bit A/D converter (PM).

Fig. 14-13. A 4-channel BCD DAC (PM).

INPUTS
OUTPUTS
REF 01
TRIM
GND
-10V
R9
R2
R1
R5
R6
DAC-08CQ
MSB
LSB
0.1μF
LSB B6
B7
B6
B5
B4
B3
B2
MSB B1

Fig. 14-14. A 4-channel binary DAC (PM).

Fig. 14-15. Programmable peak detector (PM).

Fig. 14-16. Clickless attenuator/amplifier (PM).

Fig. 14-17. Sign and magnitude clickless attenautor/amplifier (PM).

$\overline{C}_C$
$\overline{S}$
C_P
7432
7430
7404
74164
Q_{SB}
Q_1
Q_2
Q_3
Q_4
Q_5
Q_6
Q_7
$\overline{C}_P$
$\overline{E}_{SB}$ BUFFERS
$\overline{E}_{SB}$
$\overline{E}$
$\overline{E}_2$
$\overline{E}_3$
$\overline{E}_4$
$\overline{E}_5$
$\overline{E}_6$
$\overline{E}_7$
$\overline{T}_{SB}$
$\overline{T}_2$
$\overline{T}_3$
$\overline{T}_4$
$\overline{T}_5$
$\overline{T}_6$
$\overline{T}_7$
$\overline{E}_1$
TO SECOND CHANNEL REGISTER
TO THIRD CHANNEL REGISTER

Fig. 14-18. An 8-channel encoder (PM).

Fig. 14-19. External reference connection (PM).

Fig. 14-20. Digitally programmed level detector (PM).

*(CAN BE EXPANDED TO 3 DIGITS BY ADDITION OF A THIRD DAC-100 AND 99 TO CURRENT DIVIDER)

Fig. 14-21. Binary-coded-decimal D/A converter (PM).

Fig. 14-22. Analog sum of two digital numbers (PM).

Fig. 14-23. An 8-bit ADC (PM).

NOTE For a complete treatment of SA ADC's constructed with the DAC-100, refer to AN-11, "A Low Cost, Easy-to-Build Successive Approximation A/D Converter"

Chapter 15
Control and Tone Circuits, CORs and Repeater Circuits

Fig. 15-1. Temperature controller (NS).

Fig. 15-2. Light controller (NS).

Fig. 15-3. Motor speed control (NS).

Fig. 15-4. Basic temperature controller (NS).

Note 1: C1 determines proportioning frequence $f \approx \frac{1}{2R4\ C1}$

Note 2: $R10 = \frac{|V^+|+|V^-|-7}{0.0015}$

Note 3: Either V^- or V^+ can be ground.

Fig. 15-5. Proportioning temperature controller (NS).

* Output goes positive on temperature increase
†Set temperature

Figl 15-6. Temperature controller with hysteresis (NS).

Under balanced conditions, $V_{SENSE} - V_{REF}$ appears across R_S, $V_a - V_b$ appears across R_G and $I_{RG} = I_{RS}$.

$$\frac{V_a - V_b}{R_G} = \frac{V_{SENSE}}{R_S} \text{ or } V_a - V_b = V_{SENSE}\ \frac{R_G}{R_S}$$

V_{SENSE} is fixed by the temperature control resistor and R_G/R_S is constant. The LF152 is used as a comparator with a feedback loop closed through the heater and the temperature dependent resistor. If $V_a - V_b > V_{SENSE}\ R_G/R_S$. The output goes high turning "ON" the heater. If $V_a - V_b < V_{SENSE}\ R_G/R_S$. The output goes low turning "OFF" the heater.

Fig. 15-7. Temperature control circuit (NS).

Fig. 15-8. Motor speed control (NS).

Fig. 15-9. Light-level controller (NS).

Fig. 15-10. Temperature controller (RCA).

Fig. 15-11. A 3-phase heater control that uses zero-voltage synchronous switching in the steady-state operating conditions (RCA).

Fig. 15-12. A 3-phase power control that employs zero-voltage synchronous switching for both steady-state operation and for starting (RCA).

Fig. 15-13. A 3-phase control circuit for an inductive load, such as a 3-phase motor (RCA).

Fig. 15-14. Tone decoder for repeaters does not false-trip. Transistors are 2N3859A types unless otherwise noted.

Fig. 15-15. There are many methods for keying continuous-tone-carrier-squelch (PL) systems, but those employing delayed dropout relays are the most successful. Here, the tone and the signal must be present to hold the repeater on the air. Momentary tone variations because of weak signal will not cause "cycling" because of the delay, but the repeater will drop out instantly if the carrier itself drops out.

Fig. 15-16. A COR circuit using the 741 op-amp.

Fig. 15-17. Electronic control of a dc relay (M).

Fig. 15-18. Solid-state telephone ring relay. Ring signal from telephone company lights neon lamp, which causes drop in resistance in CdS cell, turning on transistor, which closes the relay. Circuit has two nice advantages—since there is no direct connection from telephone line to power supply circuit, you don't have to worry about inducing hum into the line. Also, neon lamp acts like an open circuit when not lit (below about 65V), and above that voltage has a resistance quite high (in series with 220K)—all this means is that the phone company has to stand on its head before they can detect this on your line. Instead of Clairex lamp/photocell module, you can use NE-2 neon bulb taped against a cheap CdS cell.

Fig. 15-19. Solid-state carrier-operated relay uses dual-gate FET.

Simple hook-up for a Touch-Tone pad

Fig. 15-20. A 1½V hearing aid battery mounted inside handset. C1 is approximately a 0.5—3 μF, with 1½V.

Fig. 15-21. Dual-tone sequential selective calling decoder. Upper-right drawing shows switch connections (can be used to sound auto horn).

Fig. 15-22. Carrier-operated relay and 3-minute limit timer for repeater control applications.

Fig. 15-23. Tone generator features CTCSS (low-frequency) or burst (high frequency) outputs. All gates are part of Motorola MC 14001 integrated circuit.

Fig. 15-24. Fixed-frequency oscillator. Components marked with asterisk: C1 & C2 are 0.001 μF, and R1 & R2 are 15.8K for audio frequency of 10 kHz.

Fig. 15-25. Continuous-tone encoder produces about 100 Hz for superimposition on rf carrier, for CTCSS applications.

Fig. 15-26. K6ASK single tone encoder.

Fig. 15-27. 1800-Hz decoder.

Fig. 15-28. Decoder for frequency-shift keying system uses phase-locked loop and uA710 operational amplifier. Frequency of operation: 1070 & 1270 Hz.

Fig. 15-29. Schematic of a COR circuit for the IC20/21. R4 must be adjusted to keep the collector current of the transistor less than 750 mA. The value is dependent on the relay resistance. The R2/C1 combination control tail time.

Fig. 15-30. Complete electromechanical control system for remotely operated (radio) telephone (land line).

Fig. 15-31. Touch-tone decoder.

Component values (typical)—
R1: 6.8 to 15K; R2: 4.7K; R3: 20K; C1: 0.10 μF; C2:1.0 μF, 6V; C3:2 μF, 6V; C4:250 μF, 6V.

Fig. 15-32. Paging decoder provides relay contact closure when 2805 Hz audio signal is applied at input.

Tone (Hz)	R3 (k-Ohms)	Tone (Hz)	R3 (k-Ohms)
1,800	288	2,200	231
1,850	279	2,250	226
1,900	271	2,300	220
1,950	264	2,350	215
2,000	257	2,400	210
2,050	250	2,450	206
2,100	243	2,500	201
2,150	237	2,805	178.5

A

B

R1 – 1 k	C1 – 5 μf or greater, tantalum
R2 – 910 k - 1.1 M	C2 – 820 pf, mylar or silver mica (see text)
R3 – (see Table 1)	C3 – 0.047 μf
R4 – 51 k	C4 – 0.082 μf
R5 – 51 k	Z1 – 6-10 volt Zener diode
R6 – 510 ohms	
R7 – 11 M	

C

Fig. 15-33. Tone generator uses MOS circuitry; gates are all part of RCA CD4001/D or CD4001/E. Unit designed for tone-burst keying when connected to transmitter. Chart shows R3 values when C2 = 820 pF.

Fig. 15-34. The complete whistle-on repeater control system contains two timers and an ordinary relay. If a carrier stays on for more than 1.5 minutes, the push-to-talk circuit is disconnected. If the carrier stays on 6.5 minutes, the repeater shuts down and must be whistled on again. Also, if nobody uses the repeater for 5 minutes, shutdown will occur.

Fig. 15-35. Tone decoder for CTCSS (continuous-tone carrier squelch system) applications operates from frequencies in 100 Hz range.

Fig. 15-36. A heavy-duty relay slaved to the carrier-operated relay, along with ground an voltage outputs from the tone decoder, can be used to provide a variety of very useful logic signals for all repeater control functions.

Fig. 15-37. Tone-burst entry is becoming increasingly common as a requirement—repeaters in many parts of the country now require anything from 1800 Hz to 2400 Hz for entry. The circuit above is for a tone-burst generator to meet these requirements. Circuits courtesy of the Central Ohio Radio Club FM News, September 1971.

Fig. 15-38. Electromechanical latching relay pair. Relay type is not critical. **On** pulse pulls in primary power switching contacts, which lock because coil voltage is delivered through its own contacts. A short **off** pulse is all that's required to break the circuit.

Fig. 15-39. A 1000 Hz decoder provides relay closure when audio signal of proper frequency appears at input.

Fig. 15-40. A 24 % bandwidth tone decoder.

Fig. 15-41. Light-triggered tone oscillator that can find numerous applications as a burglar alarm, or even to let you know that the sun has come up and it's time to go to work (M).

Fig. 15-42. Single-transistor tone oscillator for tone-burst or whistle-on repeater-access use produces 1750 Hz at sufficient amplitude for most transmitters.

Fig. 15-43. This single-tone decoder has a high degree of selectivity, stability, and reliability.

Fig. 15-44. Resistor and capacitor values chosen for desired frequencies and bandwidth. If C_3 is made large so as to delay turn-on of the top 567, decoding of sequential (f_1, f_2) tones is possible.

Fig. 15-45. Tone-burst repeaters can be set up with nothing more than a relay and a timer if the decoder and COR logic signals are available. Here, a short tone burst will energize the control relay, which latches as long as a carrier stays on the input. If the carrier stays on more than 1.5 minutes, the repeater will go off the air and a new tone will be required. Each transmission must be accompanied by the proper tone burst.

Component	87—112 Hz range	1750 Hz
R1	10 pot (multiturn)	50K pot (multiturn)
R2, 3, 5	10K	47K
R4	10K	22K
R5	10K	47K
R6	5.1K	5.1K
R7	5K pot (multiturn)	4.7K 5K pot (multiturn)
R8	300Ω	300Ω
R9	0.1μF	0.001 μF
C1, 2, 3	47 μF, 20V tantalum	47 μF, 20V tantalum
C4		1 μF
C5	0.01 μF	tantalum
Q1	2N930	2N930
Q2	2N2369	2N2369

Fig. 15-46. Tone encoder. Part values shown in diagram are for low-frequency continuous-tone carrier squelch system (CTCSS) applications; for single-tone refer to accompanying table.

Fig. 15-47. Single-tone decoder.

Fig. 15-48. Simple tone encoder for radio remote control applications. C2 is 10 times the value of C1. For 1000 Hz, C1 = 0.22 μF, and C2 is 2 μF. Both capacitors should be nothing less than mica for stability.

Fig. 15-49. Schematic of a COR circuit for the TR22. R4 must be adjusted to keep the collector current of the transistor less than 750 mA. The value is dependent on the relay resistance. The R2/C1 combination controls tail time.

Fig. 15-50. Simple tone oscillator connects to wiper arm of any portable radio's volume control to convert radio into audible tone generator—for keying repeaters and commanding other remotely controllable functions by holding portable radio up to microphone.

Fig. 15-51. Schematic of a subaudible tone generator. Q1, 2—MPS6513; Q3—2N1613.

Fig. 15-52. This audio decoder responds to signals in the frequency range of 2200-2900 Hz. Although Motorola part numbers are shown, equivalent values may be substituted.

Fig. 15-53. A simple and stable subaudible tone generator for CTCSS use with FM repeaters. With miniature components it can be made postage-stamp size and tucked away into any rig. For stability, Mylar capacitors and film resistors are best, but carbon resistors can be substituted successfully. It was originally designed for 100 Hz output and the 20K potentiometer is used for adjusting this to optimum.

Chapter 16
Converters

Fig. 16-1. Frequency-to-voltage converter with 2-pole Butterworth filter to reduce ripple (NS).

Fig. 16-2. Fast AC/DC converter (NS).

Fig. 16-3. True rms converter (NS).

$$V_O = \frac{1V}{R_{LADDER}} \times R_X$$

Where R_{LADDER} is the resistance from switch S1 pole to pin 10 of the LF354.

Fig. 16-4. Ohms-to-volts converter (NS).

Fig 16-5. Various voltage-to-frequency converters with isolators (NS).

Fig. 16-6. Remote voltage-to-frequency converter with 2-wire transmitter and receiver (NS).

Fig. 16-7. Voltage-to-frequency converter with square wave output using ÷ 2 flip-flop (NS).

Fig. 16-8. Voltage-to-frequency converter with isolators (NS).

Fig. 16-9. CMOS/TTL to MOS logic converter (NS).

Notes:
1. All resistor values in ohms, ± 1%, 1/4 W
2. All capacitor values in μF, = 20%, except * ± 5%.
3. All inductors ± 4%.

Fig. 16-10. A 3V to 25V DC-DC converter that uses an MC3380P chip (M).

Fig. 16-11. Two 12V-to-15V level conversion circuits.

Fig. 16-12. Light intensity-to-frequency converter (NS).

Fig. 16-13. Temperature-to-frequency converter (NS).

Fig. 16-14. DC-DC converter (+15V to −15V).

Parts list
IC1—MC1555
T1—HEP S0015
D1, D2—HEP R0052

D3, D4—Zener, 15V, 1W, HEP Z0418
C1, C2—10μF, 50V, tantalum
C3—0.001μF
All resistors 1/2W

R1—330Ω
R2—1.2kΩ
R3—3.3kΩ
R4—4.7kΩ

R5—1kΩ
XP1—Pulse transformer, pulse engineering transformer PE-3843

Fig. 16-15. DC-DC converter (+5V to +15V and −15V).

Chapter 17
CW Circuits

Fig. 17-1. A 1-watt CW final amplifier (NS).

Fig. 17-2. Key click filters.

Fig. 17-3. Simple grid block keying.

Chapter 18
Data Transfer Circuits

Fig. 18-1. Digital data transmission (NS).

Chapter 19
Demodulators

Fig. 19-1. A 2400-Hz synchronous AMdemodulator (NS).

Chapter 20
Detectors

Fig. 20-1. Peak detector and hold circuit (NS).

Fig. 20-2. Negative peak detector (NS).

Fig. 20-3. Positive peak detector (NS).

Fig. 20-4. Zero crossing detector driving MOS logic (NS).

Fig. 20-5. Zero crossing detector driving a MOS switch (NS).

Fig. 20-6. Detector for a magnetic transducer (NS).

Fig. 20-7. Zero crossing detector with a single power supply (NS).

Fig. 20-8. Window detector (NS).

Fig. 20-9. Photodiode detector (S).

Fig. 20-10. Envelope detector (M).

Fig. 20-11. Level detector with lamp driver (NS).

Fig. 20-12. Missing pulse detector using an ECG955M timer/oscillator chip. The timing cycle is continuously reset by the input pulse train. A change in frequency or missing pulse allows completion of the timing cycle, which causes a change in the output level. The time delay should be set a little longer than normal between pulse for this reason (GTE).

Fig. 20-13. Digitally programmable limit detector (AD).

Fig. 20-14. Phase-sensitive detector with square-wave reference. If the input and reference are in phase the output is positive. If they are 180° out of phase the output is negative (AD).

Fig. 20-15. Signal-level envelope detector. The MC1535G is a dual op amp and the MC844P a dual power gate. This circuit indicates by way of the lamp when the input signal is out of range (M).

$$E_o = \frac{V\,V_R}{10} \sin \omega t\,(\sin \omega t \cos \phi + \cos \omega t \sin \phi)$$

$$E_o = \frac{V\,V_R}{10} (\sin^2 \omega t \cos \phi + \sin \omega t \cos \omega t \sin \phi)$$

$$E_o = \frac{V\,V_R}{20} ([1 - \cos 2\omega t]\cos \phi + \sin 2\omega t \sin \phi)$$

$$\overline{E_o} = \frac{V\,V_R}{20} \cos \phi = \frac{V\,V_R}{20} \text{ (IN PHASE)}$$

$$-\frac{V\,V_R}{20} \text{ (180° OUT OF PHASE)}$$

Fig. 20-16. Phase-sensitive detector for sinusoidal signals This circuit measures the magnitude of in-phase or 180°-out-of-phase inputs with the proper polarity, depending on the relationship to the reference with less than 1 percent. The op amp shown is a AD741J (AD).

Chapter 21
Diode Circuits

Fig. 21-1. The most popular rectifier circuits with their output voltages and minimum safe diode PIV rating.

Fig. 21-2. Resistors are used across series diodes to equalize reverse voltage drop.

Fig. 21-3. Simple shunt rectifiers can provide low bias voltages.

Fig. 21-4. This circuit gives two outputs, 600V and 250V.

Fig. 21-5. A basic zener regulator. The values depend on input and output voltage, current, etc.

Fig. 21-6. Forward-biased silicon diodes can be used as low-voltage zeners. Their temperature drift is opposite that of regulators with breakdown voltages over 6V, which is convenient for temperature stabilization.

Fig. 21-7. A zener can be used as a ripple filter and to "increase" the voltage rating of a capacitor.

Fig. 21-8. Two zeners can furnish a regulated low voltage.

Fig. 21-9. Zener regulators can be used on AC, too.

Fig. 21-10. A bridge average-reading AC meter.

Fig. 21-11. A bridge peak-reading AC meter.

Fig. 21-12. A peak-to-peak AC meter is simply a voltage doubler.

Fig. 21-13. A half-wave peak-reading AC meter.

Fig. 21-14. A half-wave peak-reading AC meter that requires no DC path.

Fig. 21-15. A semi-rms AC meter.

Fig. 21-16. A meter for AC, or either polarity DC.

Fig. 21-17 Using clamp diodes to improve response.

Fig. 21-18. This circuit partially suppresses the low end of a range.

Fig. 21-19. This is a meter-protective circuit. The zener should be tapped on the resistor chain at a point that provides conduction when the meter pointer is pinned.

Fig. 21-20. Conventional silicon diodes can protect a meter movement, too. The 0.005 μF capacitor bypasses rectified rf.

Fig. 21-21. A basic diode mixer as used at UHF and microwave.

Fig. 21-22. A half-wave detector. This can be used as a crystal set, too.

Fig. 21-23. This detector provides better results.

Fig. 21-24. A product detector for 9 MHz SSB. The values in parentheses are for 455 kHz.

Fig. 21-25. A popular product detector for SSB.

Fig. 21-26. Forward transistor agc.

Fig. 21-27. An auxiliary agc diode improves agc action.

Fig. 21-28. An auxiliary agc detector can be used with a product detector for SSB/CW.

Fig. 21-29. Simple diode squelch.

Fig. 21-30. Adapter to provide SSB/CW reception and Q-multiplication in a receiver.

Fig. 21-31. This circuit uses a diode to limit the output of an oscillator.

Fig. 21-32. Diodes can be used to protect a transistor rf amplifier from burnout.

Fig. 21-33. One of the best noise limiters is the rate-of-change limiter designed for TV audio in England.

Fig. 21-34. This simple noise limiter is installed in an i-f stage for SSB and CW.

Fig. 21-35. This is an improved version of the SSB i-f noise limiter.

Fig. 21-36. A diode ring balanced modulator.

Fig. 21-37. Foster-Seeley FM discriminator.

Fig. 21-38. A 10.7 MHz FM ratio detector.

Fig. 21-39. Shunt diode noise limiter for use across a loudspeaker.

Fig. 21-40. Shunt diode noise limiter that can be easily added to the input of an audio amplifier.

Fig. 21-41. Half-wave series noise limiter with adjustable clipping level.

Fig. 21-42. Full-wave series noise limiter.

Fig. 21-43. This trough limiter will eliminate the background noise that is ignored by conventional limiters.

Fig. 21-44. A varactor is often used to provide automatic frequency control. The control voltage is provided by a discriminator.

Fig. 21-45. An rf stage or oscillator can be tuned with a varactor.

Fig. 21-46. Simple clippers can be made from zener diodes or silicon diodes.

Fig. 21-47. The compressor can provide 25 dB of compression, but the expense of up to 60 dB loss.

Fig. 21-48. A good clipper for AM or FM use includes adjustable clipping level and a harmonic filter.

Fig. 21-49. The need for high-level negative-peak clipping is often debated, but its value is championed by many.

Fig. 21-50 A diode can be used for direct frequency modulation.

Fig. 21-51. This is a basic varactor doubler.

Fig. 21-52. This is a popular balanced modulator for generating DSB (and eventually SSB).

Fig. 21-53. Bridge balanced modulator for SSB.

Fig. 21-54. A pair of diode switches can be used to select upper- or lower-sideband-generating crystals.

Fig. 21-55. These diode switches can be used in a transceiver or other type of equipment to select either of two inputs.

Fig. 21-56. A diode switch is used to connect a small capacitor to a VFO to shift its frequency slightly for radioteletype.

Fig. 21-57. A practical high-pe varactor tripler.

Fig. 21-58. A diode can be used for very simple spotting in a CW transmitter.

Fig. 21-59. A simple field-strength meter.

Fig. 21-60. This voltage-doubling field-strength meter is not frequency-selective.

Fig. 21-61. A special type of field-strength meter for use in a car.

Fig. 21-62. The rf sniffer is a wide-range sensitive rf detector.

Fig. 21-63. A wavemeter is simply a field-strength meter tunable to frequency. It is especially useful for checking transmitter harmonics.

Fig. 21-64. This tunable VHF wavemeter/FSM/monitor covers 6 and 2 meters.

Fig. 21-65. A dummy load should be used for all possible transmitter testing. An rf voltmeter connected to the dummy load makes it a wattmeter. A single diode is limited in voltage rating, so a voltage divider must be used for high power.

Fig. 21-66. An SWR bridge is valuable for adjusting an antenna. The critical part of the bridge is a piece of coax cable with an extra wire inserted between the cable dielectric and the shield.

Fig. 21-67. This antennascope is a simple antenna impedance bridge. It should be constructed compactly for best high frequency use.

Fig. 21-68. The James Dandy mixer is a general-purpose untuned mixer useful as an impromptu frequency meter, receiver, detector, etc.

Fig. 21-69. This amplitude modulator can be used to modulate the output of any low-level CW source.

Fig. 21-70. This audio frequency meter must be calibrated before use. It requires an input of 10V.

Fig. 21-71. This audio frequency meter/tachometer is self-limiting and linear reading. Either two zeners or two conventional diodes and batteries can be used to set the proper input voltage.

Fig. 21-72. A diode noise generator is very useful in aligning a receiver for lowest noise figure.

Fig. 21-73. A general-purpose rf detector probe for use with an oscilloscope or voltmeter.

Fig. 21-74. This simple sawtooth generator could be added to a monitor oscilloscope.

Fig. 21-75. Two zeners can be used to produce a highly clipped sine wave very similar to a square wave.

Fig. 21-76.-A transmitter can be keyed by a tape recorder for automatic code practice with this circuit.

Fig. 21-77. A field-strength meter can key a code oscillator to form a CW monitor.

Fig. 21-78. A pulse generator is needed to adjust noise limiters for best results.

Fig. 21-79. Here's how to use two batteries in your car, one for communications gear and one for the rest of the car needs. The diodes act as oneway switches, keeping the batteries charged, yet preventing any power from flowing from one to the other.

Fig. 21-80. These two circuits protect equipment from incorrectly polarized voltage. The single diode keeps the equipment from working when the polarity is wrong, while the bridge automatically selects the proper polarity.

Fig. 21-81. A battery can be floated across a power supply, keeping it charged and providing automatic switching from ac to battery power.

Fig. 21-82. Zeners can be used in dc-coupled amplifiers to replace coupling capacitors.

Fig. 21-83. Diodes can provide an artificial centertap for push-pull amplifiers.

Fig. 21-84. A zener can protect any critical load from overvoltage.

Fig. 21-85. A diode is often used to provide temperature-compensated bias for class B amplifiers.

Fig. 21-86. A zener can furnish stable screen or grid bias for a vacuum tube.

Fig. 21-87. Zeners can protect a delicate filament from overvoltage.

Fig. 21-88. A diode can damp the field generated by a coil when current through it is disconnected.

Fig. 21-89. The conventional agc system used in tube-type receivers.

Fig. 21-90. Delayed agc acts only on strong signals.

Fig. 21-91. Reverse agc for a transistor/receiver.

Fig. 21-92. "A" is a varactor tripler or doubler.

Fig. 21-93. This circuit will disconnect a load when voltage drops below a minimum.

Fig. 21-94. This transmit-receive switch can be used at VHF if it is constructed carefully.

Fig. 21-95. This is a lamp dimmer providing two brillance positions: half on and full on.

Fig. 21-96. An input voltage over the zener voltage energizes the relay.

Fig. 21-97. A diode can control the bypassing of an emitter bypass capacitor to change an amplifier's gain.

Fig. 21-98. In position 0 neither relay is energized. In position 3 both are energized. In 2, relay 2 is on and in 1, relay 1 is on.

Fig. 21-99. In this scheme, a varying input voltage selects relay contacts in turn.

Fig. 21-100. A high-frequency antenna switch using diodes.

Fig. 21-101. Diodes can be used for mysterious switching of two lamps with one pair of wires.

Fig. 21-102. "Hand" agc for SSB/CW reception.

Fig. 21-103. A zener and a low-voltage meter can be used to suppress the low end of a range.

Chapter 22
Filters

Fig. 22-1. Voltage controlled low-pass filter (NS).

Fig. 22-2. High pass filter (NS).

Fig. 22-3. 4.5-MHz notch filter (NS).

Fig. 22-4. High-pass active filter (NS).

Fig. 22-5. Bi-quad active filter (second degree state-variable network) (NS).

Fig. 22-6. Multiple feedback bandpass 1-kHz filter (M).

DC BIASING EQUATIONS FOR $V_{O1(DC)} \cong V_{O2(DC)} \cong V^+/2$

Type I	$\frac{2V_{IN(DC)}}{V^+(R_{i2})} + \frac{1}{R} + \frac{1}{R_Q} = \frac{2}{R_b}$; $R1 = 2R$
Type II	$\frac{1}{R} + \frac{1}{R_Q} = \frac{2}{R_b}$; $R1 = 2R$
Type III	$\frac{1}{R} + \frac{1}{R_Q} = \frac{2}{R_b}$; $\frac{1}{R1} = \frac{V_{IN(DC)}}{V^+(R_{i1})} + \frac{1}{2R}$

- The high speed of the LM359 allows the center frequency Q_o product of the filter to be : $f_o \times Q_o < 5$ MHz
- The above filter(s) maintains performance over wide temperature range
- One half of LM359 acts as a true non-inverting integrator so only 2 amplifiers (instead of 3 or 4) are needed for the biquad filter structure

ANALYSIS AND DESIGN EQUATIONS

Type	V_{O1}	V_{O2}	C_i	R_{i2}	R_{i1}	f_o	Q_o	f_Z (notch)	$H_{o(LP)}$	$H_{o(BP)}$	$H_{o(HP)}$	$H_{o(BR)}$
I	BP	LP	0	R_{i2}	∞	$\frac{1}{2}\pi RC$	R_Q/R	—	R/R_{i2}	R_Q/R_{i2}	—	—
II	HP	BP	C_i	∞	∞	$\frac{1}{2}\pi RC$	R_Q/R	—	—	R_QCi/RC	C_i/C	—
III	Notch/ BR	—	C_i	∞	R_{i1}	$\frac{1}{2}\pi RC$	R_Q/R	$\frac{1}{2}\pi\sqrt{RR_iCC_i}$	—	—	—	$H_o\big\|_{f\to\infty} = C_i/C$ $H_o\big\|_{f\to 0} = R/R_i$

Fig. 22-7. High-performance 2-amplifier bi-quad filter(s) (NS).

$$Q = \sqrt{\frac{R8}{R7}} \times \frac{R1C1}{\sqrt{R3C2R2C1}}, \quad f_o = \frac{1}{2\pi}\sqrt{\frac{R8}{R7}} \times \frac{1}{\sqrt{R2R3C1C2}}, \quad f_{NOTCH} = \frac{1}{2\pi}\sqrt{\frac{R6}{R3R5R7C1C2}}$$

Necessary condition for notch: $\frac{1}{R6} = \frac{R1}{R4R7}$

Ex: f_{NOTCH} = 3 kHz, Q = 5, R1 = 270k, R2 = R3 = 20k, R4 = 27k, R5 = 20k, R6 = R8 = 10k, R7 = 100k, C1 = C2 = 0.001μF
Better noise performance than the state-space approach

Fig. 22-8. Three-amplifier bi-quad notch filter (NS).

80 Hz TO 130 Hz TUNABLE BANDPASS FILTER
BANDWIDTH = 2.5 Hz, SINGLE SUPPLY

125 Hz TO 270 Hz TUNABLE BANDPASS FILTER
BANDWIDTH = 5 Hz, DUAL SUPPLIES

Fig. 22-9. Bandpass filters (NS).

Fig. 22-10. LM387 bandpass active filter (NS).

$A_0 = -1$
$f_0 = 20\,kHz$
$Q = 10$
$THD \leqslant 0.1\%$

Fig. 22-11. 20 kHz bandpass active filter (NS).

Use general equations, and tune each section separately

$Q_{1st\,SECTION} = 0.541$, $Q_{2nd\,SECTION} = 1.306$

The response should have 0 dB peaking

Fig. 22-12. A 1 kHz 4 pole butterworth (NS).

for a given

f_0 = center frequency

$A(f_0)$ = Gain at center frequency

Q = quality factor

Choose a value for C, then $R2 = \dfrac{R1 \cdot R5}{4Q^2\, R1\, R5}$

$$R5 = \frac{Q}{\pi f_0 C}$$

$$R1 = \frac{R5}{2A(f_0)}$$

To obtain less than 10% error from the operational amplifier

$$\frac{Q_0 f_0}{GBW} \leq 0.1$$

where f_0 and GBW are expressed in Hz. GBW is available from Figure 6 as a function of Set Current, I_{set}

Fig. 22-13. Multiple feedback bandpass filter (M).

Chapter 23
Frequency Multipliers

Fig. 23-1. Frequency multiplier (x10) (NS).

Fig. 23-2. Four-quadrant multiplier (NS).

$$E_O = \frac{E_1^2 - E_1^2 \cos 2\omega t}{2\,\overline{E_O}}$$

$$E_O \doteq KE_1 - KE_1 \cos 2\omega t$$

Fig. 23-3. Frequency doubler with linear amplitude response (AD).

Fig. 23-4. Broadband frequency doubler (NS).

The frequency doubler circuit shown will double low-level signals with low distortion. The value of C should be chosen for low reactance at the operating frequency.

Signal level at the carrier input must be less than 25 mV peak to maintain operation in the linear region of the switching differential amplifier. Levels to 50 mV peak may be used with some distortion of the output waveform. If a larger input signal is available a resistive divider may be used at the carrier input, with full signal applied to the signal input.

Fig. 23-5. Frequency doubler. This circuit accepts a sinusoidal signal with a 10-volt amplitude and produces a double-frequency signal also having a 10-volt amplitude with no DC offset (AD).

Fig. 23-6. Low-frequency doubler using an MC1596G. This circuit works well in the low-frequency and audio range below 1 MHz (M).

Fig. 23-7. A 150-MHz to 300-MHz frequency doubler using an MC1596G. Spurious outputs are 20 dB below the desired output (M).

Chapter 24
Gadgets

Fig. 24-1. Carrier-current remote control or intercom (S).

Fig. 24-2. Intercom (NS).

Fig. 24-3. Two-phase motor drive (NS).

Fig. 24-4. On/off touch switch (RCA).

PARTS LIST

B—9-volt transistor radio battery
C1 C8—365 pF variable capacitor
C2—80 pF mica capacitor
C3—.005 μF paper tubular capacitor
C4—1600 pF mica capacitor
C5—100 pF mica capacitor
C6—275 pF disc ceramic capacitor
C7—.25 μF mica capacitor
D1—1N34A diode (Radio Shack 276-1102 or equal)
H—high impedance magnetic head phones
L1—20 turns No. 22 AWG enameled magnet wire scramble wound on a 4-inch form
L2—ferrite rod antenna coil (Radio Shack 270-1400 or equal)
Q1—SK3004 transistor (Radio Shack 276-2005 or equal)
Q2—2N384 transistor (Radio Shack 276-2003 or equal)
Q3—SK3010 transistor (Radio Shack 276-2001 or equal)
RFC—1.5 millihenry RF choke
R1—300K 1/2 watt carbon resistor
R2—200K 1/2 watt carbon resistor
R3—1K 1/2 watt carbon resistor
R4—100K 1/2 watt carbon resistor
S1—single-pole, single-throw switch
X1—1 megahertz oscillator crystal

Fig. 24-5. Sophisticated beat frequency oscillator type metal locator utilizing headphones to amplify the "beat" tone.

Fig. 24-6. Fickering flame effect.

Fig. 24-7. Hearing aid.

Parts list
T1—2N3964
D1, D2—1N456A
D3—Zener diode, 3.9V, 1W, HEP Z0403
D4, D5, D6, D7, D8—VSK 140
All resistors 1/2W unless otherwise noted
R1—200Ω
R2—10kΩ
LP1—No. 27 bulb (4.9V, 0.3A)
B1—Four half-C-sized nickel-cadmium cells
G1—6V rms generator, Sturmey-Archer Dynohub-Generator

Fig. 24-8. Bicycle lighting system.

SCR1—HEP R1221
C1—1μF
All resistors 1/2W unless noted
R1—100kΩ
R2—500kΩ pot
RL—4 to 8Ω speaker, Radio Shack 40-1201 (4Ω)
B1—DC Source (22.5V battery)

Fig. 24-9. Clicker circuit.

Parts list
T1—HEP S0011
C1, C2—0.001μF, 100Vdc disc
C3—50pF trimmer
L1—10 turns No. 16 enameled wire wound on 3/8 inch form, spaced 1 inch end to end
R1—47kΩ, 1/2W
R2—10kΩ, 1/2W
R3—330Ω, 1/2W
MIC—Carbon microphone element
S01—Crystal socket

Fig. 24-10. Radio pager.

Parts list

T1—HEP G6C03
T2—HEP G0011
C1—0.022μF
C2—50μF, 15 Vdc electrolytic
R1—62 kΩ, 1/2W
R2—75kΩ, 1/2W
B1—9Vdc battery

S1—Push-button SPST switch, Lafayette 34P02062V
S2—SPST switch, Lafayette 34P02302V
SP1—Any 8Ω permanent-magnet speaker

Fig. 24-11. Electronic siren.

Parts list
SCR1—HEP R1245
D1, D2, D3, D4—HEP R0056
D5, D6—15V, 1/22W Zener, HEP Z0418
C1—0 1μF
R1—250kΩ, 1/2W, pot
R2—1kΩ, 1/2W
F1—3A, Lafayette 12P29129
Fuse holder—Lafayette 12P23510
LP1—Incandescent up to 150W

Fig. 24-12. Full-wave incandescent light dimmer.

PARTS LIST
D1 GE A15F or equivalent 3A, 50V
D2 1N4000, 1A, 50V
SCR GE C106F1, IR 106F1 or equivalent
R1 2 ohm, 2 watt
R2 1K, ½watt
R3. 100Ω, ½W
C1. 100μF, 25V electrolytic
Battery 10 to 30 ampere-hour, lead acid (motorcycle or garden tractor battery)
Lamp 1 to 2A, 12V automotive bulb or high intensity lamp bulb
T1: 120V to 12 6V, 2A filament or rectifier transofmer
SW1. SPST pushbutton, normally closed
Misc Oversized battery case, line cord, lamp socket to fit

Fig. 24-13. Basic emergency lighting system schematic and parts lit.

Parts list
SCR1, SCR2—HEP R1220
UJT1—ECG 6400 (Sylvania)
T1—HEP S0019
D1—HEP R0050
C1—0.1μF, nonpolarized
C2—2.2μF, nonpolarized
C3—10μF, 25V electrolytic
All resistors 1/2W
R1—33kΩ
R2—120Ω
R3—100Ω
R4—12kΩ
R5—47Ω
R6—1kΩ
R7—10kΩ pot
R8—100kΩ
S1—SPST, Lafayette 34P02302V
PC1—Photoconductive Cell, VT-30L, Newark Electronics 61F1092
LP1—12V lamp, Lafayette 32P09814V
Lamp holder, Lafayette 32P28004

Fig. 24-14. Automatic light turn-on dusk, off at dawn.

Fig. 24-15. DC lamp chaser.

Parts list
SCR1, SCR2—HEP R1220
UJT1, UJT2—ECG 6400 (Sylvania)
C1, C2—10μF, 25V electrolytic
All resistors 1/2W

R1—18kΩ
R2—120Ω
R3—100Ω
R4—1kΩ
R5—18kΩ

R6—120Ω
R7—100Ω
R8—1kΩ
S1—SPST, Lafayette 34P02302V
LP1, LP2, LP3—12V lamps, Lafayette 32P09814V
Lamp holders (3)—Lafayette 32P28004

Parts List

C1 — 1-mfd, 50-V paper capacitor
C2 — 0.1-mfd, 50-V paper capacitor
C3, C4, C5 — 0.005-mfd, 1000-V disc-ceramic capacitors (delete C5 for single lamp)
*Q1 — ETRS-4945 transistor**
R1 — GE No. 47 bulb
R2 — 470-ohm, 1/2-watt resistor
L1, L2 — GE F8T5-CW fluorescent lamps
S1 — SPST toggle switch
S2 — DPST momentary push button switch (if only one lamp is needed, a SPST push button is used)

T1 — Autotransformer — core available from GE, ETRS-4891. See text for winding details.*
Minibox — 12" x 2-1/2" x 2-1/4" (Bud CU-2114-A), or equivalent
Pin Sockets — GE ALF141-33, or equivalent

**Available from General Electric Co., Dept. B, 3800 N. Milwaukee Ave., Chicago, Ill. 60641*

Fig. 24-16. Parts list and schematic diagram for the battery-operated fluorescent lamp. (GE).

PARTS LIST
PROJECT 8

D1, D2	1N4001
Q1	2N2646
Q2	2N5778
SCR1, SCR2	2N5060 or C106B1
TR1	GE SC142B or RCA 40901
T1	115V to 24 VET, 100 ma or greater
C1	100 μF, 25V Electrolytic
C2	2 μF, 25V Electrolytic
C3	1.0 μF Film or Foil, 50V non-polar
C4, C5	0.01 μF, 50V
C6	0.1 μF 200V
R1	470Ω, ½w
R2	4.7K ¼w
R3	10Ω, ¼w
R4-R7	1K, ¼w
R8	310Ω, ½w
R9	1500Ω, ¼w
R10	390Ω, ¼w
R11	(Optional) 2 – 5 megohm, ¼w
P1	250K, ½ watt potentiometer
SW1	SPST toggel switch, 120V 5 amp AC
SW2	SW3 SPST, normally open momentary pushbutton
MISC	Line cord, load socket (Amphenol 61F), minibox

Fig. 24-17. Lazy man's switch schematic diagram.

PARTS LIST
PARTS FOR FIG. 5-13, PLUS:
R4-R7: 470Ω, ½W
R5: 220Ω, ½W
R6: 10K, ½W
SW2: SPST, NC Pushbutton (same as SW1)
C2: 0.01 μF, 25V
D3: LED
PC1: GE H11C2 or equivalent

Fig. 24-18. Emergency lighting system with latching indicator. The latching indicator can be used to drive a relay coil which could be connected to sensitive equipment.

PPS	MPH
100	107
93.5	100
50	53.5
25	27
10	11
9.3	10

Fig. 24-19. The simple windspeed indicator spins a disc between an LED and a phototransistor. Four holes in the disc pulse the transistor on and off to fire the one-shot. It maintains a constant pulse duration from the $\overline{Q}$ output, charging capacitor C2 in proportion to the windspeed. This charge drives the meter upscale.

Fig. 24-20. Proportional Speed Controller (NS).

Parts list
UJT1—HEP S9002
C1—0.1μF
All resistors 1/4W
R1—10kΩ
R2—6.8kΩ
R3—3.9kΩ
R4—680Ω
R5—68kΩ
PB1, PB2, PB3—N.O. momentary contact, Lafayette 24P02021V
SP1—8Ω speaker, Radio Shack 40-247

Fig. 24-21. Three tone doorbell.

Parts list
T1—HEP S0011
T2—HEP G6003
D1, D2—HEP R0050
C1—500μF
All resistors 1/4W unless otherwise stated
R1—1kΩ
R2—2.7kΩ
R3—330Ω
R4—2.7Ω
R5—100kΩ pot
X1—110V to 6.3V, Lafayette 33P80508
LP1—GE 47
PC1—Photocell, VT-300, Newark 61F1092

Fig. 24-22. Bedside light.

Parts list
T1, T2—HEP G0005
T3—HEP G0008
T4—HEP G6003
C1, C2—0.047μF
C3—0.0033μF
C4—0.0022μF

All resistors 1/2W
R1—11MΩ, 1/2W
R2—620kΩ
R3—3.6kΩ
R4—20kΩ
R5—200kΩ
R6—20kΩ

R7—100Ω
R8—51Ω
R9—3kΩ
S1A, S1B—DPST switch, Lafayette 34P39130V
X1—Transistor interstage transformer: 100-ohm primary, 10-ohm secondary. Stancor TA-2
B1—90Vdc battery
B2—6Vdc battery
LT1—NE-2 bulb
SP1—16Ω speaker

Fig. 24-23. Audio "fence" for animals.

Fig. 24-24. AC flasher circuit.

Chapter 25
Games and Toys

Fig. 25-1. Electronic roulette wheel counter decoder logic.

LED DISPLAY	IC1 PIN 8	IC1 PIN 9	IC1 PIN 12	IC2 PIN LOW
1	0	0	0	1
2	1	0	0	2
3	0	1	0	3
4	1	1	0	4
5	0	0	1	5
6	1	0	1	6

PARTS LIST

IC1	7490 decade counter IC
IC2	7445 or 74175 BCD to Decimal IC
IC3	555 timer IC
D1-D7	(7) LEDs Motorola MLED 650, Hewlett Packard 5082-4882 or similar
Unmarked Diodes	(10) 1N914s or 1N4148s or similar
R1-R3	(3) 330Ω, ½W
R4	390Ω, ½W
R5	1 5K ½W
R6	510Ω, ½W
C1	0 002 μF 5V or greater
C2	1 μF, 6V
Battery	(4) Penlite cells in series
SW1	Double Pole Double Throw, make before break (see text)
Misc	Wire, circuit board material or perforated board, IC socket, battery holder, plastic box

Fig. 25-2. Schematic of the digital electronic die.

C1	1	20 μF, 25 V dc	R1	1	100,000 OHMS, VARIABLE
D1–D4	4	GENERAL PURPOSE	R2–R6	5	1000 OHMS, 1/8 WATT
D5	1	LED, YELLOW	S1, S2, S3	3	SPST, NORMALLY OPEN
D6, D7	2	LED, GREEN	U1	1	74121 MONOSTABLE MULTIVIBRATOR
D8, D9,	2	LED, RED	U2, U3, U4	3	7400 QUAD 2-INPUT NAND GATE

Fig. 25-3. Two players can test their reaction time with this reflex game. These cross coupled NAND gates make up a common form of latch circuit.

REF DESIG	5V	GND
U1	14	3,7
U2–U4	14	7

UNLESS OTHERWISE INDICATED:
A. ALL RESISTANCE IN OHMS
B. ALL CAPACITANCE IN mF

+5V
R1
5 6K
C1 1
U1
74123
C2 1
U2 (MODIFIED DISPLAY MODULE)
U2U1
74192
CK
RESET
CLEAR
INPUT
U2U2
7447
R3
R9
470 TYPICAL
7 PLACES
U2U3
MAN-7

REF DESIG	+5	GND
U1	16	8
U2U1	16	8
U2U2	16	8
U2U3	3, 14	–
U2U4	14	7

UNLESS OTHERWISE INDICATED:
A ALL RESISTANCE IN OHMS
B ALL CAPACITANCE IN μF

C1, C2	4	1 μF, 12 V
C3	2	20 μ, 12 V
R1, R2	4	5600 OHMS, 1/8 WATT
R3 – R9	14	470 OHMS, 1/8 WATT
U1	2	DUAL RETRIGGERABLE MULTIVIBRATOR
U2	2	BCD1 DECADE COUNTER
U2U2	2	BCD TO 7-SEGMENT DECODER/DRIVER
U2U3	2	MAN-7, 7-SEGMENT LED DISPLAY
U2U4	1	TRIPLE 3-INPUT NAND
–	1	POWER SOURCE AS DESIRED
–	–	PACKAGING AS DESIRED

Fig. 25-4. Electronic dice update this ageless game for home entertainment. Multivibrator U1 increments a display module modified to count from 1 to 6, corresponding to the spots on a die. The NAND gate senses a 7 to reset the counter to 1. The final count is determined by the multivibrator discharging capacitor C3.

DS1	1	12 VOLT BULB
K1	1	12VAC TIME DELAY RELAY, N O
S1	1	SPST POWER SWITCH
S2	1	SPST PUSHBUTTON N O
T1	1	110V/12V TRANSFORMER
U1	1	5 VOLT POWER SUPPLY
–	–	WOOD AND PLASTIC FOR TARGET, GUN AND BAR
–	–	VECTORBOARD AND TERMINALS

THE FOLLOWING PARTS ARE REQUIRED FOR EACH TARGET·

D1	1	LED MEDIUM RED
Q1	1	FTP-100 PHOTOTRANSISTOR
Q2, Q3	2	2N3568
R1	1	20 MEGOHM, 1/8 WATT
R2	1	2 MEGOHM VARIABLE
R3	1	1000 OHMS, 1/8 WATT
S3	1	SPST PUSHBUTTON, N O
U2	*	7404 HEX INVERTER
U3	*	7400 QUAD 2-INPUT NAND

* EACH TARGET REQUIRES 2 INVERTERS AND 2 NAND GATES

Fig. 25-5. Each target for the shooting gallery requires a duplicate of circuits related to phototransistor Q1 and LED D1.Only one gun is required.

Chapter 26
Indicator Circuits

Fig. 26-1. Battery-threshold indicator (NS).

Fig. 26-2. Visible voltage indicator (NS).

Fig. 26-3. Battery-level indicator (NS).

Chapter 27
Integrators

Fig. 27-1. High-speed integrator (M).

Chapter 28
Interface Circuits

Fig. 28-1. Process control interface (NS).

Fig. 28-2. Synchronous handshake (MM74C922) (NS).

Outputs are enabled when valid entry is made and go into TRI-STATE when key is released.

Fig. 28-3. Synchronous data entry onto bus (MM74C922) (NS).

Fig. 28-4. Asynchronous data entry onto bus (MM74C922) (NS).

Fig. 28-5. ECL to TTL interface (S).

Fig. 28-6. TTL to ECL interface (S).

Chapter 29
Inverters

Fig. 29-1. DC-to-AC inverter.

Fig. 29-2. Boosted current polarity inverter (NS).

Chapter 30
Logarithmic Amplifiers

Fig. 30-1. Logarithmic amplifier using an MC1539G op amp (M).

Fig. 30-2. Logarithmic amplifier using an MC1556 op amp. The 10K pot is an offset adjustment (M).

Fig. 30-3. Logarithmic amplifier using an MC1556 op amp (M).

Chapter 31
Logic Circuits, Counters and Clocks

Fig. 31-1. MOS clock driver (NS).

C	f
200 pF	5 MHz
1600 pF	1 MHz
0.018 μF	100 KHz
.018 μF	10 KHz

Fig. 31-2. The simple TTL clock generator circuit shown provides a clock satisfactory for most simple TTL systems and it always starts oscillating without coaxing. This circuit requires only ½ of a hex inverter package and three passive components—two resistors and a capacitor.

$$\text{For } V_{O}1 = V_{O}2 = \frac{V^{+}}{2}, \quad \frac{R3}{R2} = \frac{V^{+} - 2\phi}{2(V^{+} - \phi)}, \quad \frac{R6}{R5} = \frac{V^{+} - 2\phi}{\phi} \quad \text{where } \phi \approx 0.6\text{V}$$

$$A_V = \frac{R3}{R1}\left(\frac{R6}{R4} + 1\right)$$

- 1 MHz—3 dB bandwidth with gain of 10 and 0 dbm into 600Ω
- 0.3% distortion at full bandwidth;
  reduced to 0.05% with bandwidth of 10 kHz
- Will drive C_L = 1500 pF with no additional compensation,
  ±0.01 μF with C_{comp} = 180 pF
- 70 dB signal to noise ratio at 0 dbm into 600Ω, 10 kHz bandwidth

Fig. 31-3. Balanced line driver (NS).

Fig. 31-4. Decimal counting unit. The input stage (left) converts negative-going pulses into uniform signals. Counting decades are shown at right. The value of R1 is adjusted to produce staircase whose voltage value at the source of the output FET represents the count.

Fig. 31-5. A resynchronizer using a 9310 (or 9316) as four D-input flip flops is shown. In this circuit the PE input is grounded, and the resynchronizing input is applied to the CP input. In most cases, the 9300 universal shift register is preferable for this function.

Fig. 31-6. Buffering circuit isolates frequency counter from signal source, offers high-impedance input, relatively low-impedance output. The value of the series input resistor is 100K; R3 is 1800 ohms.

STATE	Q_A
1	0
2	1

(1/2)C3073P

Fig. 31-7. Synchronous divide-by-2 up counter.

Fig. 31-8. Frequency-standard oscillator and counter circuitry with timing diagrams.

STATE	Q_A	Q_B	Q_C
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	0	1

Fig. 31-9. Synchronous divide-by-5 up counter.

STATE	Q_A	Q_B	Q_C
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	0	1
6	1	0	1

(1)C3050P
(1-1/2)C3073P

Fig. 31-10. Synchronous divide-by-6 up counter.

STATE	Q_A	Q_B	Q_C
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	0	1
6	1	0	1
7	0	1	1

(1/4)C3000P
(1)C3050P
(1-1/2)C3073

Fig. 31-11. Synchronous divide-by-7 up counter.

STATE	Q_A	Q_B	Q_C
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	0	1
6	1	0	1
7	0	1	1
8	1	1	1

(1/2)C3050P
(1-1/2)C3073P

Fig. 31-12. Synchronous divide-by-8 up counter.

STATE	Q_A	Q_B	Q_C	Q_D
1	0	0	0	0
2	1	0	0	0
3	0	1	0	0
4	1	1	0	0
5	0	0	1	0
6	1	0	1	0
7	0	1	1	0
8	1	1	1	0
9	0	0	0	1

(1)C3020P
(1/2)C3050F
(2)C3073P

Fig. 31-13. Synchronous divide-by-9 up counter.

STATE	Q_A	Q_B	Q_C	Q_D
1	0	0	0	0
2	1	0	0	0
3	0	1	0	0
4	1	1	0	0
5	0	0	1	0
6	1	0	1	0
7	0	1	1	0
8	1	1	1	0
9	0	0	0	1
10	1	0	0	1

(1)C3020P
(1)C3050P
(2)C3073P

Fig. 31-14. Synchronous divide-by-10 up counter.

Fig. 31-15. Three-stage oscillating ring counter with indicating shift register plus into household outlet; flash sequence: 2-12-12-32-12-12-3. (The 1M resistors should be matched fairly closely.)

Fig. 31-16. Frequency standard wiring diagram.

Fig. 31-17. Schematic of the digital interlaced sync generator R2 is 5.6K, ½W, 5% ; potentiometers are miniature and capacitors are Mylar.

Fig. 31-18. DVM adapter for a frequency counter. This circuit consists of 200K Ω/V input low-pass active filter stage, a polarity detector, and automatic switcher/indicator, and a voltage-to-frequency converter. The output frequency is adjusted so that 50V will give a frequency of 5000 out. The three 25K pots are used for offset balancing. Any counter capable of readout to Hz is fine.

Fig. 31-19. One-shot circuit is easily built from 914 IC by adding single capacitor and external resistor. If 3V supply is used for IC, and 22V supply to drive external timing resistor, duration of output pulse will be almost exactly ⅛ the RC time constant, with R in ohms and C in farads. Maximum resistance usable for R is 33K to permit turn-on current to flow. Capacitance C, however, may be any value desired to achieve required output pulsewidth.

Fig. 31-20. This rather complex arrangement of ICs is a frequency comparator and phase detector. The unknown frequency is fed into the TACH input and the standard to which it is to be compared goes to the STD. OUT 1 and OUT 2 are of opposite polarity. Type 915 (Q2) is same as 914 but has 3-input gates rather than 2-input elements.

Fig. 31-21. Divide-by-N circuit.

Fig. 31-22. Minor modifications to one-shot circuit, including substitution of a crystal for the timing capacitor and insertion of a capacitor in the dc feedback loop, turn it into a crystal-controlled oscillator which may be used for a frequency standard. Output is rich in harmonics, and this circuit is not recommended for transmitter use for that reason.

Fig. 31-23. Voltage-controlled oscillator can be varied over nearly 10-to-1 frequency range simply by varying control voltage. This circuit may be used as part of phase-locked detector.

Fig. 31-24. Programmable divider (÷N).

STATE	Q_A	Q_B
1	0	0
2	1	0
3	0	1
4	1	1

(1)C3073P

Fig. 31-25. Synchronous divide-by-4 up counter.

Fig. 31-26. Frequency counter input: gating, strobing, and resetting. The sensitivity is set by the ratio of the 220 to 2K resistors.

Fig. 3-27. Time base schematic diagram.

Fig 31-28. PLL makes fine frequency multiplier or divider. For this application, audio output connections are ignored and the VCO output is used instead. If input is single-ended, one of the two push-pull input leads should be bypassed to ground as shown by dotted lines. Circuit will multiply up to 10 times, and divide input frequency by 3, 5, 7 or 9. C1 and fine-tuning adjustment must be set for operation near desired output frequency. When input is applied, VCO will look to exact multiple or odd submultiple of input if it is within locking range and of adequate strength.

Fig. 31-29. A nonlocking scanner can be made easily by using an Archer dual flasher in conjunction with an external switching circuit.

Fig. 31-30. Clock schematic diagram.

Fig. 31-31. Controller for resistive loads. The RCA 2N5444 triac can be used for load currents up to 40A. The RCA 40668 triac will switch intermediate loads the 40526 will handle lighter loads and those which are somewhat inductive.

Fig. 31-32. Differential comparator circuit. The load is switched on when the voltage difference between Vs and V_R becomes less than 50 μV. Note the jumper between terminals 7 and 12, which deactivates the anti-RFI feature.

Fig. 31-33. Two-channel search-lock for FM receivers. The switch is mounted on the control head; everything else may be mounted inside the radio cabinet.

Fig. 31-34. Remote or digital control amplifier.

Fig. 31-35. A 200 kHz crystal standard for counter time base.

Fig. 31-36. Multiplier, mixer, squaring amplifier schematic diagram.

Fig. 31-37. SSTV frequency standard. This simple circuit provides the need pulses for slow-scan TV cameras, flying-spot scanners, and pattern generators.

Fig. 31-38. Low-speed counter, scope or audio dc input level and polarity switcher. This circuit will change the level of the input signal by means of the pot. The polarity (rise and fall) may be inverted by means of the switch.

Fig. 31-39. Clock generates an accurate timing signal of 1, 0.1, 0.01, or 0.001 second.

Fig. 31-40. Counter operates up to 10 MHz with 0.001% tolerance of error. Output is binary, for bank panel lamps.

Fig. 31-41. Sample logic board flip-flop with pilot light display.

Fig. 31-42. Using flip-flops to divide by various amounts.

C:	PRI		PL	
.0022 μF	70 μS	1 6 mS	15 μS	580 μS
.0047 μF	130 μS	3,7 mS	34 μS	1,3 mS
.01 μF	280 μS	8,1 mS	71 μS	2,8 mS
.022 μF	600 μS	17 mS	165 μS	6,6 mS
.047 μF	1,4 mS	40 mS	350 μS	14 mS
.1 μF	2,8 mS	78 mS	770 μS	30 mS
.22 μF	6,1 mS –	172 mS	1,7 mS	67 mS
.47 μF	12 mS –	360 mS	3,1 mS –	122 mS
1 μF	30 mS –	810 mS	8 mS	330 mS
2,2 μF	62 mS –	1,76 S	17 mS –	700 mS

Fig. 31-43. This pulse generator is a variable clock testing digital IC systems, especially at low clocking rates. Due to the wide range supply voltage allowed for the SE/NE555 it can be used with RTL, DTL, TTL, and HiNil. It uses anything between +4 and +15V. This circuit comprises three 555 timers. The first 555 is connected as an astable clock. The leading edge of the negative output pulse is used to trigger the second 555. This delivers a positive-going pulse used as the positive out. The third 555 is connected as an inverter to generate the negative-going output pulse. This pulse appears about 4 μsec after the positive pulse has started. The rise and fall times are about 100 nsec. With a load of 1K between output and $+V_{cc}$ the current drawn by the complete circuit is 17 mA at 5V, and 52 mA at 15V. Table shows the capacitor values and the corresponding PRI and PL ranges acheived. Sketches above show 3 applications.

Fig. 31-44. Programmable counter counts in modulo 2^n, where n is the programmable input. Input n drives the selected output so low that when a parallel load occurs, all highs are written into the register except at the stage represented by the address n. At condition 000011111111, the terminal count of the last stage goes high. After 14 additional pulses bring the total to $2^n - 1$, the three remaining inputs to the 9004 gate are high, and the next clock pulse reloads the counter to its original conditions.

Fig. 31-45. Counter flip-flop, lamp driver, and feedback network.

Fig. 31-46. This edge detector circuit generates a negative-going pulse on output A for each low-to-high transition of the input. The pulse width is adjustable by varying the Miller capacitance. A nonadjustable short pulse (≈ 20 ns) on the low-to-high transition of the input can be generated by replacing the transistor inverter stage with the unused fourth NAND gate.

Fig. 31-47. Pulse shaper.

Fig. 31-48. Cheaper differential amplifier.

*All 9300, 9310, 9312 and 9328 devices
in this circuit are Low Power version
9300
SHIFT REGISTER
9320
7 SEGMENT DECODER
9312
8 INPUT MULTIPLEXER
9346
EIGHT DIGIT ARRAY
OF
7 SEGMENT LEDs
(COMMON CATHODE)
hours
minutes
seconds
VCC

Fig. 31-49. This circuit stores 9 digits bit-serially in a 36-bit shift register comprised of two 9328 dual 8-bit shift registers and 9300 4-bit universal shift register incrementing or decrementing with an exclusive-OR. This counter offers very economical display multiplexing and is shown driving 7-segment LED displays. This circuit operates as a crystal-controlled stopwatch, displaying milliseconds to hours. The time counter is a 36-bit (9-digit) bit/serial incrementer controlled by a 3.6 MH crystal oscillator and time base so that the 10-second and 10-minute digits are counted modulo 6. A second set of shift registers store display data independently when the **stop** contact is activated. The contents of the storage register are strobed every four clock pulses into a 93L00 feeding 9307 7-segment decoder. This decoder, through current-limited buffers, drives the anodes of the 8-digit LED display matrix. Since this counter requires 36 clock pulses to increment the least significant digit the shift frequency is 360 kHz, drived from a 3.6 MHz oscillator through a 9305 decade counter. In this case, the low count rate inherent to serial increments is advantageous, resulting in a shorter divide chain for the time base.

Fig. 31-50. One-pulse-per-second generator.

Fig. 31-51. Counter power supply. Connections are made via the points numbered 1-5.

Fig. 31-52. Schematic of frequency counter. Note: C3—C26 are not shown. These are 0.01 disc ceramics connected directly from V_{CC} to ground at each IN.

THOUSANDS READOUT
COM
TEN-THDU READDUT
COM
HUND-THOU READOUT
COM
OVER-RANGE "1"
LAMP TEST
Q57
R9 1K
U22 7448
U23 7448
U24 7448
U16 7475
U17 7475
U18 7475
Hz
Hz
KHz
MHz
U10 7490
U11 7490
U12 7490
C38
.001
U4 7492
U5 7404
U6 7474
LINE
EXT
Q4 2N3563
R7 1K
R8 100
EXT 10 Hz 90Ω LINE

Fig. 31-53. Detailed block diagram of frequency counter. The 7490 identified by * should be selected for > 20 MHz switching speed.

HUNDREDS
THOUSANDS
TEN-THOU
HUND-THOU
MILLION
DP3
DP5
7-BAR DISPLAY
7-BAR DISPLAY
7-BAR DISPLAY
7-BAR DISPLAY
"1" DISPLAY
DRIVER
80 7447 DECODE
BI
LT
7474
S
C
D
LAMP TEST
7475 LATCH
CLOCK
R
7490 -10
7404 -4
7404 -3
XFER

DP5
DP3
DP2
MHz
KHz
Hz
Hz

Fig. 31-54. Counter "front end" contains preamplifier as well as prescaler.

Fig. 31-55. 741 used as high-speed comparator. The output of this circuit varies from +12 to +2 volts and back with extremely fast rise and fall times.

Fig. 31-56. TTL one-shot used to develop wider pulses. Chart shows values for C and R for various output pulse widths.

Fig. 31-57. Digital clock uses 19 inexpensive ICs.

NOTE
SAME RESISTOR NETWORK USED
WITH ALL 7 SEGMENT DISPLAYS
VCC
2.2K
2.2K
UNUSED Q14 NAND GATES
D4
7 SEGMENT LED DISPLAY
TENS OF MINUTES
SN7400
Q19
SN7446
NOTE
D6
7 SEGMENT LED DISPLAY
TENS OF HOURS
Q13
SN7446
SN7400
SN7400
SN7400
Q12
SN7492
SW2 #4
SW2 #5
.001
220pF
SN7410
SN7404(3)
'Q15
SN
74193
Q16
SN
74193
Q18
SN7446
Q5
7 SEGMENT LED DISPLAY
HOURS
FUSE
3A
68Ω
5000μF
10V
2N3715
1N4734A
5.6V
470
FUSE
1A
110VAC
STANCOR
P8130
1N4004
12.3V CT
1N4004

Chapter 32
Math Function Circuits

Low Cost Accurate Square Root Circuit

$$I_{OUT} = 10^{-5} \cdot \sqrt{10\,V_{IN}}$$

Fig. 32-1. MOS clock driver (NS).

Low Cost Accurate Squaring Circuit
$I_{OUT} = 10^{-6} (V_{IN})^2$

Fig. 32-2. Balanced line driver (NS).

CIRCUIT EQUATIONS

$V_1 = (V_{REF})\ (\overline{D})$

$V_2 = +(V_{REF}\ (D^2)$

$V_n = -(V_{REF})\ (D^n)$, n an odd integer

$V_n = +(V_{REF})\ (D^n)$, n an even integer

Fig. 32-3. Power generation circuit using n AD7523 8-bit multiplying D/A converters (AD).

EQUATIONS

$$V_{OUT} = -\frac{V_{IN}}{D}$$

$$A_V = \frac{V_{OUT}}{V_{IN}} = -\frac{1}{D}$$ where: A_V = Voltage Gain

and where

$$D = \frac{DB7}{2^1} + \frac{DB6}{2^2} + \ldots \frac{DB0}{2^8}$$

DB_N = 1 or 0

EXAMPLES

D = 00000000, $A_V = -A_{OL}$ (OP AMP)

D = 00000001, $A_V = -256$

D = 10000000, $A_V = -2$

D = 11111111, $A_V = -\frac{256}{255}$

Fig. 32-4. Divider circuit with digitally controlled gain (AD).

Fig. 32-5. Square rooter circuit using the 435 multiplier/divider chip (AD).

Fig. 32-6. Sine function from the 4301 multifunction chip (BB).

Fig. 32-7. Arc tangent function from the 4301 multifunction chip (BB).

Fig. 32-8. Multiplier with op amp level shift (M).

Fig. 32-9. Multiplier circuit using an MC1595 (M).

Fig. 32-10. Multiplier with discrete level shift (M).

Fig. 32-11. Analog multiplier using an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Fig. 32-12. Difference-of-squares circuit. This circuit computes the difference of the squares of two input signals. It is useful in vector computations and in weighing the difference of two magnitudes to emphasize the greater nonlinearity. If can also be used to determine absolute value if A is the input, B is connected to Eo through a diode and both Z terminals are grounded (AD).

Fig. 32-13. Percent of deviation ratio computer (AD).

INPUT CODE MSB LSB	UNIPOLAR OPERATION—STRAIGHT BINARY			
	0 TO +5V	0 TO +10V	0 TO −2MA	0 TO −4MA
1 1 1 1 1 1 1 1 1 1	+4.995V	+9.990	1.998 MA	3.996
1 1 1 0 0 0 0 0 0 0	+4.375	+8.750	1.750	3.500
1 1 0 0 0 0 0 0 0 0	+3.750	+7.500	1.500	3.000
1 0 0 0 0 0 0 0 0 0	+2.500	+5.000	1.000	2.000
0 1 0 0 0 0 0 0 0 0	+1.250	+2.500	0.500	0.100
0 0 0 0 0 0 0 0 0 1	+0.005	+0.010	0.002	0.004
0 0 0 0 0 0 0 0 0 0	0.000	0.000	0.000	0.000

Fig. 32-14. One-quadrant multiplication using a DAC-IC10BC D/A converter and AM-452 op amp. See coding table. With V_{IN} connected to pin 16 the input impedance is low; with it connected to pin 15 the input impedance is high. The range is then 0 to −10 volts (DS).

$$V_{OUT} = \frac{-V_{IN}}{D}$$

where:

$$D = \frac{BIT\ 1}{2^1} + \frac{BIT\ 2}{2^2} + \ldots \frac{BIT\ 10}{2^{10}}$$

$$0 < D \leq \frac{1023}{1024}$$

Fig. 32-15. Divider with digitally controlled gain (AD).

Fig. 32-16. Vector computer using one AD531 multiplier/divider and two AD741 op amps. The circuit derives the square root of the sum of the squares (AD).

$$E_o = \cos x \approx 1 + 0.2325\,x - \frac{x\ 1.504}{1.445}$$

Fig. 32-17. Cosine function from the 4301 multifunction chip (BB).

Fig. 32-18. True RMS circuit using one AD531 multiplier/divider and two AD741 op amps. The AD531 is combined with a simple filter to obtain the true RMS value of an AC input signal. by scaling V_{OUT} = 10 volts DC for a ± 10-volt DC input this circuit can give direct RMS readings for 100 hertz to 100 kilohertz sine waves from 0.2 volt to 7.0 volts peak (AD).

Fig. 32-19. Vector magnitude function from the 4301 multifunction chip (BB).

Fig. 32-20. Divider circuit using an AD532 multiplier/divider chip. The AD532 is available as a 10-pin TO-100 or as a 14-pin DIP (AD).

OTHER SCALES, FROM 10% PER VOLT TO 0.1% PER VOLT CAN BE OBTAINED BY ALTERING THE FEEDBACK RATIO.

Fig. 32-21. Percentage computer using an AD534 multiplier/divider chip (AD).

Fig. 32-22. Divider circuit using the 433 multiplier/divider chip (AD).

Fig. 32-23. Divider circuit using the 435 multiplier/divider chip (AD).

Fig. 32-24. Two-quadrant multiplication with AD7520 in unipolar binary operation. The Intersil AD7520 is an 18-pin multiplying D/A converter. To adjust the zero offset connect all digital input to ground, and adjust the zero trimmer on the op amp for OV ± 1 mV at V_{OUT}. To adjust for the gain connect all digital inputs of the AD7520 to V_{DD}. Monitor V_{OUT} for a $-V_{REF}(1 - 2^{-n})$ reading, where n is equal to 10. To decrease V_{OUT} connect a series resistor, 0 to 500 ohms, between the reference voltage and pin 15. To increase V_{OUT} connect a series resistor, 0 to 500 ohms, in the I_{OUT1} amplifier feedback loop (I) (AD).

Fig. 32-25. Square rooter circuit using the 434 multiplier/divider chip (AD).

Fig. 32-26. Square rooter using the 433 multiplier/divider chip (AD).

Fig. 32-27. Multiplier circuit using the 435 multiplier/divider chip (AD).

Fig. 32-28. Square root of the sum of the squares circuit. This circuit performs vector computations (AD).

$$V_C = \sqrt{V_A^2 + V_B^2}$$

$$V_C^2 = V_A^2 + V_B^2$$

$$V_A^2 = V_C^2 - V_B^2$$

$$V_A^2 = (V_C - V_B)(V_C + V_B)$$

$$\frac{V_A^2}{V_C + V_B} = (V_C - V_B)$$

$$V_C = \frac{V_A^2}{V_C + V_B} + V_B$$

Fig. 32-29. Vector computation circuit for $V_C^2 = V_A^2 + V_B^2$ using the 433 multiplier/divider and two AD741 op amps (AD).

Fig. 32-30. Vector computation circuit for *n* variables using 434 multiplier/dividers and two AD741 op amps (AD).

Chapter 33
Miscellaneous Circuits

1.5V Flasher

Typical Operating Conditions

V^+	NOMINAL FLASH Hz	C_T	R_S	R_{FB}	V^+_{RANGE}
6V	2	400μF	1k	1.5k	5–25V
15V	2	180μF	3.9k	1k	13–50V
100V	1.7	180μF	43k 1W	1k	85–200V

Fig. 33-1. Warning flasher High-Voltage powered using NSL 5027 (NS).

Note: LM3909, capacitor, and LED are installed in a white translucent cap on the flashlight's back end. Only one contact strip (in addition to the case connection) is needed for flasher power. Drawing current through the bulb simplifies wiring and causes negligible loss since bulb resistance cold is typically less than 2Ω.

Note: Winking LED inside, locates light in total darkness.

Fig. 33-2. Flashlight finder (NS).

Note Flash rate 1.5 Hz

Fig. 33-3. Incandescent bulb flasher (NS).

Fig. 33-6. 20-Segment meter with mode Switch.

Fig. 33-5. Zero-center meter, 20-segment (NS).

HIGHEST NO LED ON	COLOR	VOUT(MIN)
10	R	5.54
9	R	5.4
8	Y	5.30
7	[illegible]	[illegible]
6	G	5.06
5V		
5	G	4.94
4	G	4.87
3	Y	4.7
2	Red	4.58
1	Red	4.46

Fig. 33-6. Expanded scale meter, dot or bar (NS).

Fig. 33-7. Intercom (NS).

Fig. 3-18. Audio mixer (NS).

Fig. 33-9. Siren (NS).

Fig. 33-10. Tape recorder (NS).

Fig. 33-11. Intercom (NS).

Fig. 33-12. Two-phase motor drive (NS).

Fig. 33-13. Tachometer (NS).

Fig. 33-14. Ramp and hold (NS).

Fig. 33-15. Relay driver with strobe.

Fig.33-16. Floating voltage-controlled resistor(NS).

Fig. 33-17. Two-way intercom (NS).

Fig. 33-18. Phase-locked loop (NS).

Fig. 33-19. A 2-state siren (NS).

Fig. 33-20. Low-drift ramp and hold circuit (NS).

Fig. 33-21. Phase-locked loop.

Fig. 33-22. Single-cell voltage monitor (NS).

Fig. 33-23. A 1.0 Amp lamp flasher (NS).

Fig. 33-24. Transmitter for bridge sensor (NS).

Fig. 33-25. Tone decoder with relay output (NS).

Fig. 33-26. Differential light detector (RCA).

Fig. 33-27. Remote-control transmitter.

Parts list	C2—0.01μF	R1, R6—47kΩ	R5—2.2kΩ
IC1—LM565	C3—0.002μF	R2—390Ω	R7—390kΩ
IC2—LM107	C4—0.001μF	R3—5kΩ pot	R8—470kΩ
C1, C5, C6—1μF	All resistors 1/4W	R4—250kΩ pot	R9. R10—1kΩ

Fig. 33-28. IRIG channel 13 demodulator.

Fig. 33-29. DC overload circuit breaker.

Fig. 33-30. AC overload circuit breaker.

Fig. 33-31. Frequency differencing tachometer (NS).

Fig. 33-32. Frequency averaging tachometer (NS).

Note: Nominal flash rate: 1 Hz.

SIZE CELL	TYPE	
	STANDARD	ALKALINE
AA	3 months	6 months
C	7 months	15 months
D	1.3 years	2.6 years

Note: Estimates are made from our tests and manufacturers data. Conditions are fresh batteries and room temperature. Clad or "leak-proof" batteries are recommended for any application of five months or more. Nickel Cadmium cells are not recommended.

APPLICATIONS NOTES

Note 1: All capacitors shown are electrolytic unless marked otherwise.

Note 2: Flash rates and frequencies assume a ±5% capacitor tolerance. Electrolytics may vary −20% to +100% of their stated value.

Note 3: Unless noted, measurements above are made with a 1.4V supply, a 25°C ambient temperature, and a LED with a forward drop of 1.5V to 1.7V at 1 mA forward current.

Note 4: Occasionally a flasher circuit will fail to oscillate due to a LED defect that may be missed because it only reduces light output 10% or so. Such LEDs can be identified by a large increase in conduction between 0.9V and 1.2V.

Fig. 33-33. 1.5V flasher (NS).

Note: Nominal flash rate: 1.5 Hz.

Fig. 33-34. Emergency lantern/flasher (NS).

Note: Flash rate: 0–20 Hz.

Fig. 33-35. Variable flasher (NS).

$$f_{SWITCH} = \frac{1}{1.4\ R1C1} = 1.9\ Hz$$

Fig. 33-36. 2-tone siren (NS).

Fig. 33-37. Thermocouple transmitter (NS).

Fig. 33-38. Power comparator (NS).

Note: High efficiency, 4 mA drain.

Note: Continuous appearing light obtained by supplying short, high current, pulses (2 kHz) to LEDs with higher than battery voltage available.

Fig. 33-39. LED booster (NS).

Fig. 33-40. Double-ended voltage monitor (NS).

Chapter 34
Multiplexers

Fig. 34-1. Multiplexer (NS).

Fig. 34-2. Two-channel multiplexer and decoder using OTAs (RCA).

Fig. 34-3. Current mode multiplexer (NS).

Fig. 34-4. Multiplexer/Mixer (PM).

Chapter 35
Multivibrators

Fig. 35-1. 100 kHz free running multivibrator.

Fig. 35-2. One-shot multivibrator (NS).

Fig. 35-3. Bi-Stable Multivibrator.

Fig. 35-4. One-shot multivibrator (NS).

Fig. 35-5. Bi-stable multivibrator (NS).

Chapter 36
Music-Related Circuits

Fig. 36-1. Digital musical notes.

Parts list
T1—HEP S0014
T2—HEP S0019
IC1, IC2—HEP C2004P
IC3—MC789P
C1, C2—10μF, 6V electrolytic
C3—0.02μF
R1—10kΩ, linear pot, 1W
R2—6 8kΩ, 1/2W
R3—3.9kΩ, 1/2W
R4, R5, R6, R7—100kΩ 1/2W
R8, R9, R10, R11—250kΩ, linear pot, 1W
R12—390Ω, 1/2W
R13—22kΩ, 1/2W
R14—500Ω, linear taper pot, 1W
R15—4 7Ω, 1/2W
B1—Two 1-1/2V C-cells in series
S1, S2, S3, S4—SPST switch (optional for R8, R9, R10, R11), Lafayette 34P02302V
S5, S6—SPDT switch Lafayette 99P64164V
J1—RCA type phono jack

Digital musical notes.

Fig. 36-2. The basic visual metronome is enclosed by the dashed-in area at the upper left. If another indication is desired for every second through sixth beat, the remaining circuits must be added, except for the audio operation. It can be added with either configuration.

AUDIO OPTION

REF DESIG	+5V	GND
U1	4 8	1
U2	14	7
U3	16	8
U4 5	14	8

UNLESS OTHERWISE SPECIFIED
A ALL RESISTANCE IN OHMS
B ALL CAPACITANCE IN μF

C1	1	1 μF, 12V
C2	1	0 01 μF
*C3	1	2 μF, 12V
D1	1	LED, LARGE GREEN DIFFUSED LENS
D2	1	LED LARGE RED DIFFUSED LENS
*LS1	1	32 OHMS MINIATURE
R1, R3	2	100 000 OHMS, 1/8 WATT
R2	1	2 MEGOHM POTENTIOMETER
R4 R5	2	1000 OHMS, 1/8 WATT
*R6	1	470 OHMS, 1/8 WATT
S1	1	6 POSITION, 2 POLE, WITH KNOB
U1	1	555 TIMER
U2	1	7404 HEX INVERTERS
U3	1	74192 BCD/DECADE COUNTER
U4, U5	2	7400 QUAD, 2-INPUT NAND

* FOR AUDIO OPTION ONLY

TO SWITCHED
OUTPUT
ON STEREO
K1
120V
L1
L2
L3
R1
R2
47
R3
47
T2
T3
T4
MT1
MT1
K
G
9
0.1
200V
C1
0.1
200V
C2
0 1
200V
C3
MT2
MT2
A
LOWS GREEN
MID BLUE
HIGHS RED
600W
MAX
600W
MAX
600W
MAX
C5
0 1
200V
R4
22
C4
0 1
200V
T1 120 240V C
TRIAD N68X
R8 100K
P1
5M
R22
2 2M
R20
3300
R21
33K
C13
.001
C9
0.2
C10
.022
C11
50
25V
R17
33K
C12
.47
R14
2200
C6
0 1
R11
470
T2
R5
6800
2W

*ON HEAT SINKS, THESE UNITS HAVE INTERNAL ISOLATION FOR TABS

Fig. 36-3. Schematic of the high performance color organ.

Chapter 37
Op Amp Circuits

Fig. 37-1. Improved op amp (NS).

Fig. 37-2. Low-frequency op amp (NS).

Fig. 37-3. Low-frequency op amp with offset adjustment (NS).

Fig. 37-4. Low-drift op amp using the LM121A as a preamplifier (NS).

Fig. 37-5. Power op amp (NS).

Fig. 37-6. Gated amplifier (M).

Fig. 37-7. High-impedance input, high-current output voltage follower (M).

Fig. 37-8. High-slew-rate power amplifier using an ECG941/941D/941M operational amplifier (GTE).

Fig. 37-9. Frequency compensation circuit using an ECG915 operational amplifier. See table for component values. Supply voltage is ±15 volts (GTE).

Fig. 37-10. High-impedance high-gain inverting amplifier. Typical supply voltages are +15 volts and −15 volts (GTE).

Fig. 37-11. Voltage comparator using an MC1539G op amp (M).

Fig. 37-12. Unity-gain op amp with fast response time (M).

Fig. 37-13. Differential with low-noise output using an MC1539 op amp (M).

Fig. 37-14. Weighted averaging amplifier using half of an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Fig. 37-15. Differential amplifier using an MC1539 op amp (M).

GAIN	R_1	R_2	B W	R_{IN}
1	10 kΩ	10 kΩ	1 MHz	10 kΩ
10	1 kΩ	10 kΩ	100 kHz	1 kΩ
100	1 kΩ	100 kΩ	10 kHz	1 kΩ
1000	100 Ω	100 kΩ	1 kHz	100 Ω

Fig. 37-16. Inverting amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-17. Feedforward frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ±15 volts (AD).

Fig. 37-18. Simple differentiator using an ECG941/941D/941M operational amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-19. Op amp with FET AGC circuit (M).

GAIN	R_1	R_2	B.W.	R_{IN}
10	1 kΩ	9 kΩ	100 kHz	400 MΩ
100	100 Ω	9 9 kΩ	10 kHz	280 MΩ
1000	100 Ω	99.9 kΩ	1 kHz	80 MΩ

Fig. 37-20. Noninverting amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-21. Unity-gain op amp using an AD5098-pin TO99 (AD).

Voltage Gain = 10^3
Input Offset Voltage Drift = 0.6 μV/°C
Input Offset Current Drift = 2.0 pA/°C

ECG941M

ECG941

ECG941D

NOTE: PIN 4 CONNECTED TO CASE

Fig. 37-22. Low-drift low-noise amplifier using an ECG941/941D/941M operational amplifier and a μA727B temperature controlled differential amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-23. Op amp with minimum settling time using an AD518 8-pin TO99 (AD).

Fig. 37-24. Unity-gain voltage follower using an ECG941/941D/941M operational amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-25. Voltage follower using an MC1539 op amp with unity-gain compensation (M).

Fig. 37-26. Unity-gain voltage follower using half of an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Fig. 37-27. Instrumentation amplifier using two AD510 8-pin TO99 op amps. As shown the gain is 10. By adding R5 the gain will increase. For a gain of 10 the frequency response is down 3 dB at 500 kHz. Full output of ±10 volts can be attained up to 1800 hertz (AD).

Fig. 37-28. Op amp with high bandwidth using an AD518 8-pin TO99. Bandwidth is nearly 25 MHz with the feedforward technique shown (AD).

GAIN	VALUE OF R_G
0.1	1MΩ
1	100kΩ
10	10kΩ
100	1kΩ
1000	100Ω

Fig. 37-29. Instrument amplifier using an AD521 op amp. Typical supply is ±15 volts (AD).

Fig. 37-30. General-purpose operational amplifier with closed-loop gain greater than 10. Typical supply voltage is ±15 volts (AD).

GAIN	R_1	R_2	B W	R_{IN}
10	1 kΩ	9 kΩ	100 kHz	400 MΩ
100	100 Ω	9 9 kΩ	10 kHz	280 MΩ
1000	100 Ω	99 9 kΩ	1 kHz	80 MΩ

Fig. 37-31. Noninverting amplifier using half of an ECG947 dual operator amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Fig. 37-32. Voltage follower using an MC1556 op amp (M).

Fig. 37-33. Differential-input composite op amp (BB).

Fig. 37-34. Clipping amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ±15 volts (GTE).

Fig. 37-35. Two pole frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ±15 volts (AD).

Fig. 37-36. Fast-settling op amp with gain of – 1. For gains larger than – 1 use an input resistor valued at 500 ohms or less and pick a feedback resistor for the required gain, i.e., 1K for – 1, 1.5K for – 3, etc. (DS).

$$R_1C_1 = \frac{A_{O2}}{2\pi f_{c2}}, \quad R_2 = R_1 \qquad A'_O = A_{O2}(1 + A_{O1})$$

$$V'_{os} = V_{osA1} + R_1 I_{osA1} \qquad \underline{\underline{T}}\ 200dB$$

$$\underline{\underline{T}}\ 200\mu V,\ 1.0\mu V/^{o}C \qquad f'_c = f_{c2}\ \underline{\underline{T}}\ 100MHz$$

Fig. 37-37. Inverting-only composite op amp (BB).

Fig. 37-38. Unity-gain operational amplifier. With the compensation shown a unity-gain frequency of approximately 10MHz to 12MHz results (AD).

Fig. 37-39. Summing amplifier using an MC1539 op amp (M).

Fig. 37-40. Unity-gain feed forward amplifier using an MC1539 op amp (M).

TO-99 **Mini-DIP**

Fig. 37-41. Single pole frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ±15 volts. Voltage gain is 88 dB (AD).

Fig. 37-42. Compressor/expander amplifiers using an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Gain	Input Lag Compensation	
$\left(\frac{R2}{R1}\right)$	R4 (Ω)	C1 (pF)
1000	0	10
1000	30 k	1000
100	10 k	2200
10	1 k	2200
1	390	2200

Fig. 37-43. Op amp in closed-loop frequency-compensated configuration (M).

GAIN	R_1	R_2	B W	R_{IN}
1	10 kΩ	10 kΩ	1 MHz	10 kΩ
10	1 kΩ	10 kΩ	100 kHz	1 kΩ
100	1 kΩ	100 kΩ	10 kHz	1 kΩ
1000	100 Ω	100 kΩ	1 kHz	100 Ω

Fig. 37-44. Inverting amplifier using half of an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

Fig. 37-45. Noninverting op amp using an AD510 8-pin TO99 (AD).

Fig. 37-46. Inverting unity-gain high-slew-rate circuit using an ECG915 operational amplifier (GTE).

Fig. 37-47. Voltage follower using an ECG915 operational amplifier. Output is taken on pin 6 (GTE).

Chapter 38
Oscillators

Fig. 38-1. Free-running square wave oscillator (M).

Fig. 38-2. Phase shift oscillator (NS).

Fig. 38-3. Low-distortion power Wien-bridge oscillator (NS).

Fig. 38-4. A 1-kHz and 10-kHz TTL compatible voltage controlled oscillator (NS).

Connect pin 3 to 2.8V to invert output.

Fig. 38-5. Oscillator with quadrature output (NS).

Fig. 38-6. Single amplifier oscillator (NS).

Fig. 38-7. Triangular/square wave voltage-controlled oscillator (NS).

Fig. 38-8. A 10-Hz to 10-kHz voltage-controlled oscillator (NS).

Fig. 38-9. A two-decade high-frequency voltage-controlled oscillator (NS).

Fig. 38-10. Crystal oscillator (NS).

Fig. 38-11. Crystal-controlled sine wave oscillator (NS).

$$f_O = \frac{V_{IN} - \phi}{4C\Delta V\ R1}$$

where: R2 = 2R1

ϕ = amplifier input voltage = 0.6V

ΔV = DM7414 hysteresis, typ 1V

- 5 MHz operation
- T^2L ouput

Fig. 38-12. Voltage-controlled oscillator (NS).

Fig. 38-13. Sine wave oscillator (NS).

Fig. 38-14. Linear voltage-controlled oscillator (NS).

Fig. 38-15. Square wave oscillator (NS).

Fig. 38-16. Retriggerable one-shot (NS).

Fig. 38-17. Precision oscillator drive 100 mA loads (NS).

Fig. 38-18. Oscillator with double frequency output (NS).

Fig. 38-19. Ramp/pulse voltage-controlled oscillator (NS).

Fig. 38-20. Sinusoidal voltage-controlled oscillator (NS).

Fig. 38-21. A 1.0-MHz oscillator (NS).

Fig. 38-22. Basic Crystal Oscillator.

Chapter 39
Photo-Activated Circuits

Q1	PNP Transistor (IR-TR05 or TR14)
C1	365pf variable Capacitor (J W Miller No 2111 or equivalent)
L1	Transistor Loopstick Antenna (J W Miller No 2001, or equivalent)
D1	Germanium Diode (IR-1N34A)
PC1	Selenium or Silicon Solar Cell (IR-B2M B3M or S1M)
HEADPHONES	2 000 or 4 000 Ohms
OPTIONAL	Transistor Socket (IR-SH130 or SH131)
	Printed Circuit Board (IR-PCB21 or PCB 3)
	PC Connector Path (IR-CS60)
	PC Patterns (IR-CZ30 CZ50 CZ71)

Fig. 39-1. Single-stage, solar-powered radio (W).

Q_1, Q_2	PNP Transistors (IR-TR05 or TR14)
PC_1	Selenium or Silicon Solar Cell (IR-B2M, B3M, or S1M)
T_1	10,000 Ohm to 2,000 Ohm Interstage Transformer (Stancor TA-35, or equivalent)
L_1	Transistor Loopstick Antenna (J.W. Miller No. 2001, or equivalent)
C_1	365pf Variable Capacitor (J.W. Miller No. 2111, or equivalent)
R_1	3,900 Ohm Resistor
R_2	47K Ohm Resistor
RD_1	Germanium Diode (IR-1N34A)
Headphones	
	Transistor Socket (IR-SH130 or SH131)
	Printed Circuit Board (IR-PCB21 or PCB23)
	PC Connector Path (IR-CZ60)
	PC Patterns (IR-CZ50, CZ30, CZ70)

Fig. 39-2. Two-stage, solar-powered radio (W).

PARTS LIST

M - Single button carbon microphone, available through surplus outlets

T_1 - T_2 = Transformer (Triad F-13X sec. 6.3V @ 0.6A, pri. 115V)

Q = PNP transistor (IR-TR-05)

L - Flashlight lamp 112

S 4 pole single throw switch (Mallory type 3242 or 744)

B_1 7.5V battery (Eveready 717, Burgess 5540, or equivalent)

B_2 22.5V battery (Burgess V15 or equivalent)

B_3 Size D flashlight cell

Fig. 39-3. Light-beam transmitter (W).

PARTS LIST

PC Photocell (IR-B2M)

Q1 = Q2 PNP Transistor (IR-TR-05)

P Headphones (see text)

SW1 SPST switch

R 330 000 ohm ½ watt resistor

B 2.5V battery (Burgess U15)

T - Stancor A-3250 Triad-T 23 or Thordarson T22590

Fig. 39-4. Light-beam receiver (W).

*Lamp brightness increases until i_1 = 5V/R1 (i_1 can be set as low as 1μA).
†Necessary only if raw supply filter capacitor is more than 2" from LM320MP.

*Lamp brightness increases until $i_1 = i_Q$ (≈ 1 mA) + 5V/R1
†Necessary only if raw supply filter capacitor is more than 2" from LM320.

Fig. 39-5. Light controllers using silicon photo cells (NS).

Fig. 39-6. Photo-driven pulse stretcher (M).

Fig. 39-7. Light-relay-operated SCR alarm circuit (M).

Fig. 39-8. Light-operated SCR alarm using a sensitive gate SCR (M).

TRUTH TABLE	
$\bar{Q}1$, Q2	OUTPUT = 1
Q1, Q2	OUTPUT = 0
$\bar{Q}1$, $\bar{Q}2$	OUTPUT = 0
Q1, $\bar{Q}2$	OUTPUT = 0

Fig. 39-9. Photo-activated logic driver (M).

TRUTH TABLE	
Q1, Q2	OUTPUT = 0
Q1, $\overline{Q}$2	OUTPUT = 1
$\overline{Q}$1, $\overline{Q}$2	OUTPUT = 1
$\overline{Q}$1, Q2	OUTPUT = 1

Fig. 39-10. Photo-activated logic driver (M).

TRUTH TABLE	
Q1, Q2	OUTPUT = 1
Q1, $\overline{Q}$2	OUTPUT = 0
$\overline{Q}$1, $\overline{Q}$2	OUTPUT = 0
$\overline{Q}$1, Q2	OUTPUT = 0

Fig. 39-11. Photo-activated logic driver (M).

Fig. 39-12. Light-operated 6 kV series switch for high-voltage crowbar circuits or high-voltage pulse-forming networks (M).

TRUTH TABLE	
Q1, Q2	OUTPUT = 0
Q1, $\overline{Q}$2	OUTPUT = 1
$\overline{Q}$1, Q2	OUTPUT = 1
$\overline{Q}$1, $\overline{Q}$2	OUTPUT = 1

Fig. 39-13. Photo-activated logic driver (M).

Fig. 39-14. Light-operated relay. The phototransistor can be activated by a flashlight (M).

Fig. 39-15. Frequency-sensitive photo-activated alarm (M).

Chapter 40
Power Amplifiers

$A_V = 1$, $R_F = 10k$, $C_F = 100$ pF
$A_V = 10$, $R_F = 100k$, $C_F = 10$ pF
Bandwidth $\geq$ 100 kHz
Distortion $\leq$ 0.1%

Fig. 40-1. Power amplifier (NS).

Fig. 40-2. Switching power amplifier (NS).

Fig. 40-3. Switching power amplifier (NS).

Fig. 40-4. A 12.5-watt wideband power amplifier (NS).

Fig. 40-5. A 2-channel power amplifier with control circuits (NS).

Chapter 41
Power-Controlling Circuits

MAXIMUM LOAD IS 800 WATTS WHEN HEP R1331 SCR IS USED

Parts list
SCR1, SCR2—HEP R1221
T1—HEP G0005
T2, T3—HEP S0014
D1, D3, D5—HEP R0052
D2—HEP R0130
D4, D6—HEP R0053
C1, C2—15μF, 50V electrolytic
C3—500μF, 15V, electrolytic
R1—3kΩ, 5W
R2, R8—1kΩ, 1/2W
R3—180Ω, 1/2W
R4, R7—6.8kΩ, 1/2W
R5—2kΩ, 5W
R6—0.1MΩ linear taper pot

Fig. X1—transformer (primary not used) tapped secondary used as autotransformer to provide 1 to 5 step-up in voltage, Stancor P-6465
X2—Transformer (secondary not used), Stancor P-6465
S1—Switch, SPST

Fig. 41-1. Electric appliance power control (NS).

Fig. 41-2. Triac control circuit employing an ECG776 zero voltage switch with current boost utilizing an AC supply. The circuit is for applications requiring gate currents greater than 50 mA. Select the triac from the ECG5600 series for the particular application (GTE).

Parts List

Triac — GE-X12
F1 — 5-amp fuse
L1 — 1000 turns of No. 36 enameled copper wire on 1/4" diam. x 2" coil form (this form supplied with reed switch)
R1 — 100-ohm, 1/2-watt resistor
S1 — GE-X7 reed switch (includes coil form and bias magnet)
Receptacle — Amphenol type 61F socket, or equivalent
Misc. — Line cord, fuse holder, 9-volt transistor battery and clip, grommet, and heat sink.
S2 — DPDT switch with center OFF position (spring loaded or telephone type optional)

Fig. 41-3. Remote control for lamp or appliance using a reed switch and coil. The circuit will handle up to 500 watts (GTE).

Fig. 41-4. RMS closed-loop voltage compensator (regulator). This circuit provides an output of 90 ±2 volts RMS at 600 watts for an input of 105 to 260 volts (M).

Parts List

F1—5-amp, 3AG fuse
R1—50-ohm, 2-watt potentiometer
S1—SPST switch
TR1—GE-X12 Triac
T1—Transformer: primary, 120 volts a-c; secondary, 6.3 volts; 1-amp (min) "Filament" type

Fig. 41-5. Remote control for lamp or appliance using a filament transformer. The circuit can handle up to 500 watts. R1 is adjusted for the highest resistance that will not trigger the triac with S1 open (GTE).

Fig. 41-6. Motor control circuitry using 3650 optical isolation amplifiers (BB).

Fig. 41-7. RMS regulator for a DC power supply using a triac, phototransistor and UJT (M).

Parts List

C1 — 0.5-mfd, 200-volt capacitor
CR1 thru CR5 — GE-504A rectifier diode
F1 — 1/2-amp fuse and holder
J1 — Output jack
P1 — Output plug to track connections
Q1 — G-E Type 2N2160 unijunction transistor
R1 — 50000-ohm, 2-watt potentiometer with SPST switch
R2 — 10000-ohm, 2-watt potentiometer
R3 — 1500-ohm, 1/2-watt resistor
R4 — 470-ohm, 1/2-watt resistor
R5 — 100-ohm, 1/2-watt resistor
R6 — 10000-ohm, 1/2-watt resistor
R7 — 5-ohm, 20-watt resistor or two 10-ohm, 10-watt resistors in parallel
S1 — DPDT switch
S2 — SPST switch (on R1)
SCR1 — GE-X1 silicon controlled rectifier
T1 — Transformer: primary, 120 volts a-c; secondary, 25 volts a-c (Stancor P-6469, or equivalent)
Minibox — Aluminum, 6" x 5" x 4"

Fig. 41-8. SCR model railroading control, Bridge circuit CR1 through CR4 supplies pulsating DC to firing circuit Q1, R1 through R5 and C1, which phase controls, SCR1. The SCR is in series with the train power and thereby controls the amount of current it receives (GE).

Fig. 41-9. Line-voltage compensation circuit using UJT trigger for a thrister gate (M).

Parts List

C1 — 100-mfd, 15-volt electrolytic capacitor
C2 — 0.1 mfd, 15-volt capacitor
CR1 thru CR4 — GE-504A rectifier diode
CR5, CR6 — GE-X11 zener diode
CR7 — GE-504A rectifier diode
F1 — 3-ampere fuse
Q1, Q2 — GE-10 transistor
Q3 — GE-X10 unijunction transistor
R1 — 3500-ohm, 5-watt resistor
R2, R4 — 4700-ohm, 1/2-watt resistor
R3 — 5-megohm, 1/2-watt resistor
R5, R7 — 1-megohm, 1/2-watt resistor
R6 — 2200-ohm, 1/2-watt resistor
R8 — 470-ohm, 1/2-watt resistor
S1 — SPDT toggle switch
S2, S3 — SPST toggle switch
Triac — GE-X12
T1 — Pulse transformer — available from GE distributors as ETRS-4898, or from General Electric Co., Dept B, 3800 N. Milwaukee Ave., Chicago, Ill. 60641.
Minibox — 4" x 2-1/2" x 2 1/2"

Fig. 41-10. Time-dependent light dimmer. The circuit allows bright lights to slowly fade over a period of 15 to 20 minutes and permits loads up to 500 watts (GE).

Fig. 41-11. Triac temperature-sensitive heater control. This circuit can be modified as shown to control a motor with a constant load. As shown the circuit is for heating applications but can be used for cooling by interchanging R_T and R2. (M).

Fig. 41-12. RMS open-loop voltage compensator (regulator) for application requiring large conduction angles. It provides an output 141 ±2 volts RMS at 500 watts for an input of 150 to 182 volts RMS (M).

NOTE: Circuit supplies 25 mA drive to gate of triac at V_{in} = 25 V and $T_A \leqslant 70^{\circ}C$.

TRIAC		
I_{GT}	R2	C
15 mA	2400	0.1
30 mA	1200	0.2
50 mA	800	0.3

Fig. 41-13. Logic to inductive load interface using an MOC3011 optically coupled triac driver (M).

Fig. 41-14. Triac static motor- starting switch for 0.5 HP 115- volt AC single-phase induction (M).

Q1 — GE-X19 phototransistor
Q2 — GE-10 or 2N5172 transistor
R1 — 5-ohm, 5-watt resistor
R2 — 47,000-ohm, 1/2-watt resistor
R3 — 22,000-ohm, 1/2-watt resistor
R4 — 1000-ohm, 1/2-watt resistor
R5 — 10,000-ohm, 1/2-watt resistor
R6 — 220,000-ohm, 1/2-watt resistor
R7 — 100,000-ohm, 1/2-watt resistor
R8 — 47,000-ohm, 1/2-watt resistor
SCR-GEMR-5
Line Cord
Touch Switch — see text
Minibox — 5" x 2-1/2" x 2-1/2", Bud CR-2104A, or equivalent

Parts List *C1 — 5.0-mfd, 10-volt miniature electrolytic capacitor*
CR1 — GE-504A rectifier diode, or 1N5059, or equivalent
J1 — Socket, Amphenol Type 61F, or equivalent
L1 — 120-volt, 6-watt lamp (night lite type)

Fig. 41-15. Touch switch for loads up to 180 watts. This circuit is good for turning on and off lights, TVs, stereos,etc. Q1 is a phototransistor (GE).

Triac Power Circuit Parts List

Voltage		120 Vrms				240 Vrms			
RMS Current Amperes		8.0	12	25	40	8.0	12	25	40
BR11		MDA102	MDA102	MDA102	MDA102	MDA104	MDA104	MDA104	MDA104
C11 µF (10% line voltage ac rated)		0.047	0.047	0.1	0.1	0.047	0.047	0.1	0.1
R11 (10% 1 W)		39	39	39	39	39	39	39	39
R12 (10% 1/2 W)		19	18	16	18	18	18	18	18
R13 (10% 1/2 W)		620	620	330	330	620	620	330	330
TR11	Plastic	2N6342	2N6342A	–	–	2N6343	2N6343A	–	–
	Metal		MAC40799	2N6163	MAC4688	–	MAC40800	2N6164	MAC4689

Fig. 41-16. Triac solid-state relay circuit for AC power control. The input circuit will function over the range of 3 to 33 volts (M).

Control Circuit Parts List

Part	LINE VOLTAGE 120 Vrms	240 Vrms
C1	220 pF, 20%, 200 Vdc	100 pF, 20%, 400 Vdc
C2	0.022 μF, 20%, 50 Vdc	0.022 μF, 20%, 50 Vdc
D1	1N4001	1N4001
D2	1N4001	1N4001
OC1	MOC1006	MOC1006
Q1	MPS5172	MPS5172
Q2	MPS5172	MPS5172
R1	1 kΩ, 10%, 1 W	1 kΩ, 10%, 1 W
R2	47 kΩ, 5%, 1/2 W	100 kΩ, 5%, 1 W
R3	1 MΩ, 10%, 1/4 W	1 MΩ, 10%, 1/4 W
R4	110 kΩ, 5%, 1/2 W	220 kΩ, 5%, 1/2 W
R5	15 kΩ, 5%, 1/4 W	15 kΩ, 5%, 1/4 W
R6	33 kΩ, 10%, 1/2 W	68 kΩ, 10%, 1 W
R7	10 kΩ, 10%, 1/4 W	10 kΩ, 10%, 1/4 W
SCR1	2N5064	2N6240

Fig. 41-17. Direction and speed control for series-wound motors (M).

Fig. 41-18. Triac relay-contact protection circuit (M).

Fig. 41-19. Pulse-width-modulated DC motor speed control incorporating voltage-sensing feedback.

Fig. 41-20. Triac zero-point switch for resistive loads (M).

Parts List

C1 — 1-mfd, 400-volt capacitor
C2 — 2-mfd, 10-volt capacitor
CR1 — GE-X14 thyrector diode (optional transient voltage suppressor)
CR2 thru CR4 — GE-504A rectifier diode
F1 — 5-amp fuse and holder
R1 — 3900-ohm, 2-watt resistor
R2 — 330-ohm, 1-watt resistor
R3 — 1000-ohm, 1-watt resistor
R4 — 10K-ohms, 2-watt potentiometer
R5 — 500-ohm, 2-watt potentiometer
R6 — 200-ohm, 2-watt potentiometer
S1 — SPDT toggle switch
S2 — SPST switch (on speed and lamp adjust potentiometers)
SCR1 — GE-X1 silicon controlled rectifier mounted on 3" x 3" x 1/16" copper cooling fin
Minibox — 6" x 5" x 4"

Fig. 41-21. Half-wave variable AC control for small motors and lamps. In the lamp position the SCR is controlled by P1. In the motor position and with S2 open the circuit incorporates a feedback feature that maintains a constant motor speed as the load changes. Do not use this circuit for controlling fluorescent lamps, transformers, AC motors with capacitor start, induction motors, shaded pole motors and the like. The motor controlled must have a commutator as found in DC or AC-DC universal motors (GE).

COMPONENT	MOTOR NAMEPLATE RATING	
	LIGHT DUTY 3 AMP MAX	HEAVIER DUTY 5 AMP MAX
SCR1	GE - X1	GE-C30B
F1	3 AMP	5 AMP

Parts List

C1 — 2-mfd, 50-volt electrolytic capacitor
CR1, CR2 — GE-504A rectifier diode
CR3 — GE-X14 thyrector diode
R1 — 2500-ohm, 5-watt resistor
R2 — 500-ohm, 2-watt potentiometer
R3 — 200-ohm, 1-watt potentiometer
R4 — 1000-ohm, 1/2-watt resistor
F1 — See schematic diagram
S1 — SPDT toggle switch
SCR1 — See schematic diagram
Minibox — 4" x 2-1/4" x 2-1/4"
Line cord and grommet
Socket, AC output

Fig. 41-22. Plug-in speed control for tools and appliances. Do not use this control on motors without commutators (GE).

Fig. 41-23. Thyrister half-wave control circuit with UJT trigger designed for a 600-ohm load (M).

Fig. 41-24. Triac full-wave control circuit with UJT trigger designed for a 900-watt load (M).

Parts List

CR1 — GE-504A rectifier diode for 130 watts output
— GE-X4 rectifier diode for higher output

CR2 — GE-X14 thyrector diode (optional transient voltage suppressor)

S1 — SPDT, 3-amp, 125-volt a-c switch with center "off" position

Fig. 41-25. High-low AC switch for light dimming or small motor two-speed control (GE).

TRANSISTORS

Q1 – MRD300
Q2 – 2N4123
Q3 – 2N4123
Q4 – 2N4221
Q5 – 2N3903
Q6 – 2N3903
Q7 – 2N4125
Q8 – 2N3905
Q9 – 2N3905
Q10 – MPS6561
Q11 – 2N4901
Q12 – 2N4398

CAPACITORS

C1 – 10 nF
C2 – 1.0 μF
C3 – 8.0 μF, 15 V
C4 – 50 μF, 15 V
C5 – 1.0 μF

DIODES

D1 – 1N4001
D2 – 1N4001
D3 – 1N4001
D4 – 1N4738
D5 – 1N4001

RESISTORS

R1 – 27 kΩ
R2 – 10 kΩ
R3 – 10 kΩ
R4 – 10 kΩ
R5 – 10 kΩ
R6 – 10 kΩ
R7 – 10 kΩ
R8 – 2.0 kΩ
R9 – 10 kΩ
R10 – 47 kΩ
R11 – 10 kΩ
R12 – 1.0 kΩ
R13 – 1.0 kΩ
R14 – 470 kΩ
R15 – 47 kΩ
R16 – 47 kΩ
R17 – 10 kΩ
R18 – 22 kΩ
R19 – 2.0 kΩ
R20 – 1.0 kΩ
R21 – 11 kΩ
R22 – 10 kΩ
R23 – 160 kΩ
R24 – 3.3 kΩ
R25 – 200 Ω
R26 – 75 Ω
R27 – 100 kΩ

Fig. 41-26. Regulated DC motor control with feedback from optical sensor (M).

Fig. 41-27. Variable speed control for induction motors (M).

+160 V
XB
AB
XB + AB
2
1
hf
1 k
1.5 k
10
MR4004
50 k
4
5
4N26
MPSA92
MJ423
1 5 k
10 k
360
MC673
+15 V
ϕA
10 k
MPSA42
10
MR4004
XB
1 5 k
4N26
5
4
MJ423
1
hf
50 k
1.5 k
RS
2
1 k
360
AB
XB + AB
-160 V
Torque
13 Oz In
M
+160 V
XC
AC
XC + AC
2
1
hf
1 k
1 5 k
10
MR4004
RS
50 k
4
5
4N26
MPSA92
MJ423
1.5 k
10 k
360 Ω
MC673
+15 V
ϕB
10 k
MPSA42
10
XC
1 5 k
4N26
4
5
MJ423
MR4004
1
hf
50 k
1 5 k
2
1 k
360
AC
XC + AC
-160 V

Fig. 41-28. Variable speed control for induction motors (M).

MHTL Logic: Pin 14 V_{CC}
Pin 7 Gnd

*R_S SHOULD BE SELECTED TO BE ABOUT 3 k TO 5 k OHMS AT THE DESIRED OUTPUT LEVEL

Fig. 41-29. Feedback control circuit to trigger a thyrister (M).

Fig. 41-30. SCR full-range power controller incorporating an SUS (M).

Fig. 41-31. Electronic crowbar circuit using an SBS and a triac. This circuit protects equipment by placing a short-circuit across the line, thereby blowing the fuse. It works on DC circuits as well as AC types since the SBS and triac are both bilateral (M).

Parts List

C1 — 0.2-mfd, 200-volt capacitor
C2 — 0.05-mfd, 200-volt capacitor
C3 — 0.022-mfd, 100-volt capacitor
CR1 thru CR5 — GE-504A rectifier diode
DS1 — GE-5AH neon glow lamp
L1 — RFI choke; 65 turns of No. 18 varnished wire on 1/4" ferrite rod such as antenna loopstick rod (see Theory section)
J1 — Power socket; Amphenol type 61F, or equivalent
R1 — 100K two-watt potentiometer for fan-motor load or 250K for high-intensity lamp load
R2 — 82-ohm, 1/2-watt resistor
R3 — R4 — 470-ohm, 1/2-watt resistors
SCR — GEMR-5 silicon controlled rectifier
Minibox — 3-1/4" x 2-1/8" x 1-5/8"
Misc. — Line cord, vectorboard, push-in terminals

Fig. 41-32. High-intensity lamp dimmer or fan control. This circuit is for use with high-intensity lamps with a built-in transformer only; do not use with 120-volt standard household incandescent or fluorescent lamps. Fan motors should not draw more than 1.5 amperes (GE).

Vcc	R	HEX BUFFER
5.0 V	220 Ω	MC75492
10 V	600 Ω	MC75492
16 V	910 Ω	MC140498

Fig. 41-33. MOS to AC load interface using an MOC3011 optically coupled triac driver (M).

Fig. 41-34. Hysteresis-free power controller using an SBS and a triac (M).

Fig. 41-35. Triac overvoltage protection circuit with automatic reset. If the voltage at point A exceeds 11 volts during any half-cycle D6 fires and turns on SCR Q1, removing power from the load (M).

Fig. 41-36. Low-cost light dimmer an SBS and triac. Shunting the SBS with two 20K resistors minimizes the flash-on effect (M).

Fig. 41-37. Triac heater temperature control circuit (M).

Fig. 41-38. An 800-watt triac light dimmer (M).

Fig. 41-39. An 800-watt soft-start triac light dimmer (M).

R1 OR R2 IS AN EXTERNAL SENSOR

Fig. 41-40. Triac control circuit with current boost using an ECG776 zero voltage switch. Resistor R2 must be the external sensor for the internal short and open protection to be operative. Notice that the circuit utilizes a DC supply. Select the triac for the particular application form the ECG5600 series (GTE).

Fig. 41-41. Triac AC sttic contactor (M).

Fig. 41-42. Three-position static switch. In position 1 the switch is off; in position 2 the switch supplies full-wave power to the load; in position 3 the diode conducts only on half-cycles and the load is supplied with half-wave power (M).

Fig. 41-43. AC-controlled, triac switch. R1 is 100 ohms (M).

Fig. 41-44. Constant-current motor drive. All capacitors should be at least 50 working volts and resistors the half-watt type, except those values at 0.4 ohm and R_a. Use heat sinks for the power transistors with thermal compound. This circuit can be used where there is some likelihood or stalling or lockup. If the motor locks the current drive remains constant and the system does not destroy itself (I).

NOMINAL R5 VALUES			
Motor Rating (Amperes)	R5		$R5 = \frac{2}{I_M}$
	OHMS	Watts	I_M = Max Rated Motor Current (RMS)
2	1	5	
3	0.67	10	
6.5	0.32	15	

Fig. 41-45. Triac motor speed control with feedback (M).

Fig. 41-46. 800-watt triac light dimmer with silicon bilateral switch, SBS (M).

Fig. 41-47. Remote control of AC load using an MOC3011 optically coupled triac driver (M).

Fig. 41-48. Projection lamp voltage regulator using a phototransistor, SCR and UJT (M).

Fig. 41-49. Solid-state relay circuit with input protection of the MOC3011 triac driver. The input voltage to the protection circuit can be 3 to 30 volts DC (M).

Fig. 41-50. Simple DC power control circuit using an SCR (M).

Fig. 41-51. Full-wave average voltage feedback control circuit for a 600-watt load (M).

Fig. 41-52. Simple full-wave power control circuit using a triac (M).

Fig. 41-53. Low-voltage-controlled triac switch (M).

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

Parts List

C1 — 0.1-mfd, 200-volt capacitor
C2 — 0.1-mfd, 50-volt capacitor
CR1 — GE-X14 thyrector diode (optional transient voltage suppressor)
PC — GE-X6 cadmium sulfide photoconductor
R1 — 68K-ohms, 1/2-watt resistor
R2 — 47K-ohms, 1/2-watt resistor
R3 — 4700-ohm, 1/2-watt resistor
R4 — 250K-ohm, 2-watt potentiometer
Triac — GE-X12
Diac — GE-X13

Fig. 41-54. Full-wave variable AC control for motors and lamps using a diac and triac. This circuit gives full symmetrical control from 0 to 100% over the AC load. For fan or blower operation it may be desirable to place a 100-ohm 1-watt resistor in series with a 0.1μF capacitor directly across the triac to improve performance. Best operation is achieved when the circuit is adjusted during the brightest part of the day. R4 is adjusted so that the lamp plugged into the outlet is just off. In this manner as it gets darker the light will come on (GE).

Fig. 41-55. Proportional controller for heater using two op amps. The integrating error amplifier holds the heater current pulse width at a sustaining value at equilibrium (BB).

Fig. 41-56. RMS open-loop voltage compensator (regulator) for small conduction angles. This circuit provides an output of 110/115 ± 2.5 volts at 600 watts for an input of 200 to 260 volts. This circuit is suitable for applications requiring a conduction angle of less than 90° (M).

Fig. 41-57. 240-volt triac control circuit driven by two MOC3011 optically coupled triac drivers (M).

Fig. 41-58. Direction and speed control for shunt-wound motors (M).

Fig. 41-59. Full range AC power control circuit using a triac (M).

Fig. 41-60. M6800 microprocessor to 115-volt AC load interface using optically coupled MOC3011 triac drivers (M).

Fig. 41-61. Full-wave trigger circuit for a 900-watt load using a triac and UJT (M).

Fig. 41-62. Half-wave average voltage control circuit for a 600-watt load (M).

Chapter 42
Power Supplies, Regulators and Voltage Multipliers

Load and line regulation < 0.01% temperature stability < 0.2%

†Determines Zener current

††Solid tantalum

An LM120 12 or LM120 15 may be used to permit higher input voltages, but the regulated output voltage must be at least −15V when using the LM120 12 and −16V for the LM120 15.

**Select resistors to set output voltage. 2 ppm/°C tracking suggested.

Fig. 42-1 High-stability 1A regulator (NS).

*Required if the regulator is located far from the power supply filter. A 1 μF aluminum electrolytic may be substituted.

**Required for stability. A 1 μF aluminum electrolytic may be substituted

Fig. 42-2. Fixed output regulator (NS).

$$-V_O = -5V - (5V/R1 + I_Q) \cdot R2,$$
$$5V/R1 \gg 3\ I_Q$$

Fig. 42-3. Adjustable output regulator (NS).

Fig. 42-4. A ± 15V 250 mA dual power supply (NS).

Performance (Typical)

	(−15)	(+15)
Load Regulation at 0.5A	40 mV	2 mV
Output Ripple, C_{IN} = 3000μF, I_L = 0.5A	100μVrms	100μVrms
Temperature Stability	50 mV	50 mV
Output Noise 10 Hz ≤ f ≤ 10 kHz	150μVrms	150μVrms

*Resistor tolerance of R4 and R5 determine matching of (+) and (−) outputs

**Necessary only if raw supply filter capacitors are more than 3" from regulators

Fig. 42-5. A ± 15V, 1A tracking regulator (NS).

*Solid tantalum

Fig. 42-6. Low-voltage adjustable reference supply (NS).

Fig. 42-7. A 6V shunt regulator with crowbar (NS).

Fig. 42-8. Programmable 1A power supply (NS).

Fig. 42-9. Protected high-voltage regulator (NS).

Fig. 42-10. Laboratory power supply (NS).

Fig. 42-11. A 1A negative regulator (NS).

Fig. 42-12. A 1A positive voltage regulator (NS).

Fig. 42-13. A 3-watt switching regulator that converts 5V to 200V for gas discharge displays such as Burroughs Panaplex and Beckman. The IC is a MC338OP (M).

Fig. 42-14. A 5V, 3A regulator with plastic boost transistor (M).

Fig. 42-15. A 6A variable output switching regulator (NS).

REGULATION (NO LOAD TO FULL LOAD) < 0.005 %
INPUT REGULATION < 0.01 % / V
HUM AND NOISE OUTPUT: < 250 μV RMS UP TO 100 kHz

Fig. 42-16. Voltage regulator circuit rated at 0.1V to 50V at 1A (NS).

Fig. 42-17. A 10A regulator with foldback current limiting (NS).

Fig. 42-18. Switching regulator (NS).

Fig. 42-19. A 1A regulator with protective diodes (NS).

*Required if regulator is located more than 4" from power supply filter capacitor.

†Although no output capacitor is needed for stability, it does improve transient response. C2 should be used whenever long wires are used to connect to the load, or when transient response is critical.

NOTE: Pin 3 electrically connected to case.

Fig. 42-20. Fixed 5V regulator (NS).

*Regulation better then 0.01%, load, line end tempereture, can be obtained.
†Determines zener current. May be adjusted to minimize thermal drift.
‡Solid tantalum.

Fig. 42-21. High-stability regulator (NS).

†Optional—improves transient response

*Needed if device is far from filter capacitors

$$^{\dagger\dagger}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right)$$

Fig. 42-22. A 1.2V to 25V adjustable regulator (NS).

Fig. 42-23. A 5A constant voltage—constant current regulator (NS).

Fig. 42-24. A 4A switching regulator with overload protection (NS).

Fig. 42-25. Adjustable 4A regulator (NS).

†Solid tantalum

*Discharges C1 if output is shorted to ground

Fig. 42-26. Adjustable regulator with improved ripple rejection (NS).

†Solid Tantalum

*Core—Arnold A-254168-2 60 turns

Fig. 42-27. Low-cost 3A switching regulator (NS).

Fig. 42-28. Dual trimmed supply (NS).

Fig. 42-29. A 5V to 10V power supply with 0.1 percent regulation (NS).

Fig. 42-30. A 10A regulator with complete overload protection (NS).

†C1 = 1 μF solid tantalum or 10 μF aluminum electrolytic required for stability
*C2 = 1 μF solid tantalum is required only if regulator is more than 4" from power-supply filter capacitor

Fig. 42-31. Adjustable Negative Voltage Regulator (NS.)

*Minimum output ≅ −1.3V when control input is low

Fig. 42-32. −5V Regulator with Electronic Shutdown * (NS).

*The 10 μF capacitors are optional to improve ripple rejection

Fig. 42-33. Adjustable High Voltage Regulator (NS).

Fig. 42-34. 10 Regulator (NS).

*R1 = 240Ω for LM138 and LM238

Fig. 42-35. Slow turn-on 15V regulator (NS).

Fig. 42-36. Tracking Preregulator (NS).

**C1 is not needed if power supply filter capacitor is within 3" of regulator

†Keep C4 within 2" of LM345. There is no upper limit on C4 and unlimited capacitance can be added at extended distances from the regulator

**D2 sets initial output voltage accuracy. The LM113 is available in ±.5, ±.2, and ±1% tolerance

Fig. 42-37. −2V ECL Termination Regulator (NS).

*Minimum load current ≈ 4 mA

Fig. 42-38. 1.2V-20V Regulator with Minimum Program Current (NS).

Fig. 42-39. AC voltage regulator.

TYPICAL PERFORMANCE

Regulated Output Voltage	+50V
Line Regulation (ΔV_{IN} = 20V)	15 mV
Load Regulation (ΔI_L = 50 mA)	20 mV

Fig. 42-40. Positive Floating Regulator (NS).

TYPICAL PERFORMANCE

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 10V)	0.5 mV
Load Regulation (ΔI_L = 100 mA)	1.5 mV

Fig. 42-41. Shunt Regulator (NS).

DESIGN EQUATIONS

$$R_F = 5\ k\Omega\left(\frac{V_o}{2.5} - 1\right)$$

$$R_{CL} = \frac{\text{CURRENT LIMIT SENSE VOLT}}{I_{o(MAX)}}$$

$$f_{OSC} \simeq \frac{1}{R_T C_T}$$

$$L1 = \frac{2.5V_o (V_{IN} - V_o)}{I_o V_{IN} f_{OSC}}$$

$$C_o = \frac{(V_{IN} - V_o) V_o T^2}{8 \Delta V_o V_{IN} L1}$$

$$I_{o(MAX)} = I_{IN} \frac{V_{IN}}{V_o}$$

Fig. 42-42. Positive Regulator, Step-Down Basic Configuration ($I_{IN(MAX)}$ = 80 mA) (NS).

Fig. 42-53. 1 Amp Step-Down Switching Regulator (NS).

* Mounted to Staver Heatsink No V5 1
Q1 = BD344, MJE171
Q2 = 2N5023
L1 = >40 turns No 22 wire on Ferroxcube No K300502 Torroid core

L1 = > 25 turns No 24 wire on Ferroxcube No K300502 Torroid core

Fig. 42-44. 15V, 0.5A Step-Up Switching Regulator (NS).

*Solid tantlaum.

**Heat sink Q1

***Optional. Improves ripple rejection end transient response.

Load Regulation 0.6% $0 \leq I_L \leq 250$ mA pulsed with t_{ON} = 50 ms.

Fig. 42-45. 5V, 500 mA Regulator with Short Circuit Protection (NS).

*Resistor tolerance of R1 end R2 determine matching of (+) and (−) inputs.

**Necessary only if raw supply capacitors are more than 3" from regulators

An LM3086N array may substitute for Q1, D1 end D2 for better stability and tracking. In the array diode, transistors Q5 and Q4 (in parallel) make up D2, similarly, Q1 and Q2 become Q1 and Q3 replaces the 2N2222.

Fig. 42-46. Wide Range Tracking Regulator (NS).

*Solid tantalum.

$V_{OUT} = V_G + 5V$, $R1 = (-V_{IN}/I_{Q\ LM78L05})$

$V_{OUT} = 5V\ (R2/R4)$ for $(R2 + R3) = (R4 + R5)$

A 0.5V output will correspond to $(R2/R4) = 0.1$, $(R3/R4) = 0.9$

Fig. 42-47. Variable Output Regulator 0.5V – 18V (NS).

Fig. 42-48. HV regulator (NS).

Fig. 42-49. Precision regulator (NS).

Fig. 42-50. – + 15 volt regulator (M).

Fig. 42-51. −5.0 Volt, 10-ampere regulator with short-circuit current limiting for safe-area protection of pass transistors (M).

$$^{*}I_{OUT} = 1\ mA + \frac{5V}{R1}$$

Fig. 42-52. Current source (NS).

Fig. 42-53. Positive regulator, step-up boosted current configuration (NS).

Chapter 43
Radar and Sonar

*Note A permanent magnet attached to a rotating wheel provides modulation pulses to pin 8 The time duration for the X_{MT} mode is controlled by the voltage which is induced in a stationary pick up coil The neon display is also mounted on this wheel

**Note One possible source for transducers is Linden Labs, Inc., P.O Box 920, State College, PA 16801

Fig. 43-1. A typical sonar application (NS).

Fig. 43-2. Electronics for adding an echo annunciator (NS).

Chapter 44
Radioteletype, Slow-Scan Television and Specialized Communications

Fig. 44-1. FSK demodulator at 2025-2225 cps (NS).

Fig. 44-2. FSK demodulator with DC resoration (NS).

Fig. 44-3. FSK with slope and voltage detection M).

Fig. 44-4. Frequency shift keyer using the MC1545G wide-band amplifier (M).

Fig. 44-5. Self-generating FSK (M).

Chapter 45
Readouts

$$V_{REF} = 1.25V\left(1 + \frac{R2}{R1}\right) + R2 \times 80\ \mu A$$

$$I_{LED} = \frac{1.25}{R1} + \frac{V_{REF}}{2.2}$$

Note 1: Capacitor C1 is required if leads to the LED supply are 6" or longer.

Note 2: Circuit as shown is wired for dot mode. For bar mode, connect pin 9 to pin 3. V_{LED} must be kept below 7V or dropping resistor should be used to limit IC power dissipation.

Fig. 45-1. 0V to 10V log display (NS).

* Optional. Shunts 100 μA auxiliary sink current away from LED #11.

Fig. 45-2. 60 dB dot mode display.

Fig. 45-3. Low current bar mode display.

1 kHz pulse rate at 10% duty cycle

LEDs light up as illustrated with the upper lit LED indicating the actual input voltage. The display appears to increase resolution and provides an analog indication of overrange.

Fig. 45-4. "Exclamation point" display (NS).

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

Fig. 45-5. Bar display with alarm flasher (NS).

*The input to the Dot-Bar Switch may be taken from cathodes of other LEDs. Display will change to bar as soon as the LED so selected begins to light.

Fig. 45-6. Indicator and alarm, full-scale changes display from dot to bar (NS).

Fig. 45-7. Driving liquid crystal display (NS).

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

Fig. 45-8. Bar display with alarm flasher (NS).

Chapter 46
Receivers and RF Preamplifiers

T1	*10.7 mc. FM input IF transformer, J. W. Miller 2070*	*T6*
T2	*10.7 mc. FM interstage transformer, J. W. Miller 2071*	*T7*
T3	*455khz input transformer, J. W. Miller 2031*	*CH1*
T4	*455khz transformer, supplied with IF module*	*L1*
		L2
T5	*driver transformer, 10K to 2K c.t. Midland 250633, Calrad CR75*	*L3*

output transformer, 500 ohms c.t. to 3.2 ohms, Midland 25-631
6.3V, .6 amp or smaller filament transformer, Triad F-13X
2 hy, 15 ma. low resistance choke, Stancor C2707

Fig. 46-1. High-performance receiver for 150 MHz.

4t. #20 bare copper 5/16" ID 1/2" long
5t. #20 bare copper 5/16" ID 7/8" long
3t #BJ bare copper 5/16" ID 1/2" long tap
1t. from ground end

L4	13/4t. #14 bare copper 5/16" ID tap 3/4 turn from ground end link 1t. #20 bare copper 1/4" away from ground end
L5	200 microhenry RF choke, J. W. Miller 9210-90
Ln	8t. #26 enamel closewound at one end of 1/4" dia slug form
RFC-1	Ohmite Z-144 or 18 turns #24 wound on 1 meg 1 watt resistor
X1	crystal, 11.155 mc.

Fig. 46-2. Three transistor radio (AM). Adjust R4 so voltage across speaker is ½ supply voltage. Works surprisingly well.

Fig. 46-3. High-impedance preamplifier provides up to 1.2 megohms input impedance; the exact value depends upon resistor R. Both Q1 and Q2 should be a 2N2613, 2N2614, 2N2953, SK3004, GE-2, or HEP 254. A balanced output for reduced hum and noise may be obtained by using the padded output in B.

Chapter 47
RF Power Amplifiers

C1	=	33 pF Dipped Mica
C2	=	18 pF Dipped Mica
C3	=	10 µF 35 Vdc for AM operation,
		100 µF 35 Vdc for SSB operation.
C4	=	.1 µF Erie
C5	=	10 µF 35 Vdc Electrolytic
C6	=	1 µF Tantalum
C7	=	.001 µF Erie Disc
C8, 9	=	330 pF Dipped Mica
R1	=	100 kΩ 1/4 W Resistor
R2, 3	=	10 kΩ 1/4 W Resistor
R4	=	33 Ω 5 W Wire Wound Resistor
R5, 6	=	10 Ω 1/2 W Resistor
R7	=	100 Ω 1/4 W Resistor
RFC1	=	9 Ferroxcube Beads on #18 AWG Wire
D1	=	1N4001
D2	=	1N4997
D3	=	1N914
Q1, Q2	=	2N4401
Q3, 4	=	MRF454
T1, T2	=	16:1 Transformers
C20	=	910 pF Dipped Mica
C21	=	1100 pF Dipped Mica
C10	=	24 pF Dipped Mica
C22	=	500 µF 3 Vdc Electrolytic
K1	=	Potter & Brumfield
		KT11A 12 Vdc Relay or Equivalent

Fig. 47-1. HF power amplifier (M).

Fig. 47-2. Typical cathode-driven (grounded grid) amplifier for 80 through 10 meters (Eimac).

C4
.001
5 KV
L1'
L2
1100
RFC 2
250
4.5 KV
C1
TUNE
15
20
40
100
80
C2
LOAD
OUTPUT
S2
C3
500
M
C5
500
10 KV
RFC 3
C6
500
10 KV
B+ 2500 V.D.C.

10 K
10 W
50
10 W
M2
PLATE
C14
.01
C
RY1
50
10 W
VOX CONTROL
B−
GND. TO
POWER SUPPLY
CABINET

Fig. 47-3. A 150 MHz linear amplifier. Capacitors should have 1kV rating.

Fig. 47-4. Typical transistor rf power amplifier; L and C values depend on frequency of interest.

Fig. 47-5. 4CX250 amplifier for six and two meters, using single-pole switching. Simple modifications by K4ETZ [forget the 6 meter coil and use smaller HA tuning capacitors, class C bias and a grid tank] allow 10W drive, 200—250W out. Amplifier should have a screen clamp tube with G2 supply bled down from B+ for best results.

Fig. 47-6. Kilowatt linear amplifier (rf) for 50 MHz. Requires 2500 to 3000V dc for 5—500A plate.

PARTS LIST

Q_1	2N5591 or S3007
C_1, C_2	7-60 pF (ARCO 462)
C_3, C_4	4-40 pF (ARCO 403) 20-250 pF
C_5	(ARCO 424)
C_6	.02 µF ceramic
RFC_1	10 T #18, ¼" I.D., tightly wound, 2 ferrite beads
L_1, L_2	4 T #14, ¼" I.D. x 5/8" long
$*R_1$	20-100Ω – use if unit is instable → start with 100Ω and reduce when stability is achieved; goes from base to ground.
RFC_2	2 turns in ferroxcube bead

Fig. 47-7. Rf amplifier produces 18W output when driven with 5W at 150 MHz. Suggested layout employing shielding is shown.

Fig. 47-8. A 40m. 200W amplifier. T1:2 Amodon 15/16 in. diameter toroids. Primary; 25T No. 22 Formvar. Four secondaries; 5T No. 22 Formvar each. T2. 2 Airwound windings, 18T each, No. 14 Formvar, 13/16 diam. These windings are paralleled and shaped into a donut 3½ in. diam. C1—450 pF broadcast variable C2 through 6—0.1 μF, 100V.C7—450 pF wide spaced variable. C8—similar. R1, R3, R5—7 to 10Ω,2 to 5W wirebound. R2, R4, R6, R8—450Ω, 1W. RFC ⅜ dia. ferrite rod, 50T No. 22 Formvar.

Fig. 47-9. 40m. 75W amplifier. T1:Amidon 15/16 in. toroid. Primary; 50T No. 24. 2 secondaries; 10T, No. 24, solid insulated wire each. T2: Same type core except 2 used: 2 windings No. 16 Formvar 5T each connected in parallel. RFC: ⅜ dia. ferrite rod, 60T No. 22 Formvar. C1, C5: mica adjustable 200-800 pF. C2, C3: 1 μF disc, 100V max. 25V min. C6: mica adjustable 400-1200 pF. R2, R3: 10, 2-5W.R1, R4:450Ω.Q1, Q2: TRW PT4526 or similar.

Fig. 47-10. This 10-meter linear amplifier for SSB service uses transistors which were designed specifically for single-sideband linear operation. Many junction transistors cannot be used satisfactorily for this application, because linear amplification at low power levels is a serious problem.

Fig. 47-11. A 50 MHz transmitter power amplifier. Rf choke is 7—10 μH C6 is 1000 pF disc. Q1,Q) are HEP 75s.

Fig. 47-12. A 2-meter amplifier that has 20 dB gain. 100 or 200 mW input will be amplified to 10 and 20 watts, respectively. Be sure to keep leads short and make all grounds directly to the circuit board. The positive bus is separated so the final can be used for AM. For FM, just connect the two terminals together. Don't forget to use heatsinks!

PARTS LIST
Q1 - TRW PT5757
C1 – 51 pF 5%, DIPMICA
C2, C4 – 8–60 pF
C3 – 100 pF DISC
C5 – .001 μF DISC
C6 – .01 μF DISC
C7 – .1 μF DISC
C8 – 10 μF 20V dc
L1 – 4 No. 20 0.3 cm I.D.
L2 – 12T no. 28 0.3 cm I.D.
L3 – 10 no. 20 0.3 cm I.D.
T1 – 4:1 transmission line transformer, made up of a 3" length of twisted pair, no. 20 enameled wire.
R1 – 1.0Ω 5% ½W

Fig. 47-13. A 150-MHz 10-watt rf power amplifier schematic, parts list, and board layout.

Fig. 47-14. This 10-meter single side band linear power amplifier will provide up to 8 watts PEP. The power gain of the 2N(947 is 13 dB at this frequency, and the odd order distortion products are at least 30 dB below the desired output.

Chapter 48
Sample & Hold Circuits

Fig. 48-1. Sample & hold circuit (NS).

Fig. 48-2. Sample & hold and compare with new +VIN (NS).

Fig. 48-3. High-speed sample & hold circuit (NS).

Fig. 48-4. Negative peak detecting sample & hold (M).

Fig. 48-5. Low-drift sample & hold (NS).

Chapter 49
Servo Motor Circuits

Fig. 49-1. Line-operated servo motor amplifier (M).

Fig. 49-2. Servo motor preamplifier (M).

Fig. 49-3. Servo motor preamplifier (M).

Fig. 49-4. Servo motor preamplifier (M).

Fig. 49-5. Servo motor preamplifier (M).

MOTOR MFG	SIZE	P_{IN}/Φ WATTS	R7, R8
WESTON 11 MA2 U 211663	11	4	6.8 Ω 1/2W
DAYSTROM U 207263	18	10	3.3 Ω 1W

Fig. 49-6. Servo motor power amplifier (M).

Fig. 49-7. DC servo amplifier (NS).

Chapter 50
Smoke and Flame Detectors

Fig. 50-1. Flame detector (NS).

D1	1	HEWLETT-PACKARD 4204 PHOTODIODE
D2	1	LED MEDIUM. RED
Q1 Q2	2	2N3568
R1 R2	2	1000 OHMS 1 8 WATT
R3	1	2 MEGOHMS. VARIABLE

Fig. 50-2. This flame detector circuit uses an infrared sensitive detector diode. A transistor-type detector can be substituted for the diode.

Parts list

B1—6V buzzer, Radio Shack 273-049
PC1—Radio Shack 276-035 Detector Kit
T1—HEP F0010
T2, T3, T4, T5, T6—HEP S0015
T7—HEP S5000
C1—20μF, 10V

D1, D2, D3, D4—HEP R0602
All resistors 1/2W unless otherwise stated
R1—1kΩ
R2—100kΩ pot
R3—10kΩ pot
R4—2.2kΩ

R5—4.7kΩ
R6—3.3kΩ
R7, R9—1.5kΩ
R8—330Ω
R10—680Ω
R11—330Ω

Fig. 50-3. Fire alarm.

Parts list
SCR1—HEP R1220
D—HEP R0050
T1, T2—HEP S0019
R1—200kΩ, 1/2W. The value of this potentiometer is dependent on the resistance of photocell PC1 when it is illuminated. The potentiometer should have a resistance of roughly double that of photocell PC1 when it is illuminated.
R1, R3—5.6kΩ, 1/2W
R4, R5—1kΩ, 1/2W
R6—470Ω, 1/2W
S1—Push-button, Lafayette 34P02047V
AL1—Siren alarm, Lafayette 14P37508
PC1—Photoconductive cell VT-30L, Newark Electronics 61F1092
Lamp—Any light source that will allow photocell PC1 to be activated when no smoke is present.

Fig. 50-4. Smoke alarm.

Chapter 51
Solid-State Switches

Fig. 51-1. Two-wire remote speed switch (NS).

Fig. 51-2. Finger touch or contact switch (NS).

V3 steps up in voltage by the amount $\frac{V_{CC} \times C1}{C2}$

for each complete input cycle (2 zero crossings)

Example:

If C2 = 200 C1 after 100 consecutive input cycles.

$V3 = 1/2\ V_{CC}$

Fig. 51-3. 100-cycle delay switch (NS).

Chapter 52
Telephone Circuits

Fig. 52-1. Touch-tone decoder (NS).

Parts list

T1, T2—HEP S9100

D1, D2, D3, D4, D5—HEP R0052

C1, C2—0.01μF, 100V

C3—1μF

All resistors 1/2W

R1, R2—2 2MΩ

R3, R4—470kΩ

R5—470Ω

R6—100Ω

R7—100kΩ

R8—220kΩ

RY1—Reed relay, Triridge 101-100-6

Fig. 52-2. Full time phone monitor.

Chapter 53
Test Equipment and Metering Circuits

Fig. 53-1. Extended range VU meter (NS).

Logarithmic response allows coarse and fine adjustments without changing scale

Resolution ranges from 10 mV at $V_{IN} = 0$ to 500 mV at $V_{IN} = \pm 1.25V$

Fig. 53-2. Precision null meter (NS).

* Resistor value selects exposure
1/2 f/stop resolution
Ten f/stop range (1000:1)
Typical supply current is 8 mA

Fig. 53-3. Light meter (NS).

Fig. 53-4. Wide range AC voltmeter (NS).

Fig. 53-5. Sensitive low-cost "VTVM" (NS).

Fig. 53-6. Light meter (NS).

+15V
LH0070
1
2
3
15 4k 1%
10T
500
4 02k 1%
2 2V
0 047μF
FLOATED ANALOG GND
V_IN
+15V -15V
11 8k 1%
4 0V
VR
10 T
500
7 87k 1%
0 047 μF
0 047μF
0 047μF
A
B
C
D
E
F
100 pF
10k
+5V
AG
RU
RR
OC
LF11300*
100k
22μF POLYPROPYLENE
PO
DIGITAL GND
PW SUP GND
COMP OUT
C_OC1
C_OC2
C_OC3
3 3M
200 pF
10k
0 1μF
6k
300 pF
RESET
CLOCK IN
MM5330
TRANS
100 pF

Fig. 53-7. LF11300, MM5330 DPM (NS).

1N1804
32 V CT
200 mA
115V
T1 (NOTE 4)
1N1804
LM340-15
15V
1000 μF
51
0.1 μF
15V
LM340-5V
5V
2.4k
2k
LM555
2000 pF
R4
15k
Q1
2N2222
CLOCK
R2
20k
R3
5.1k
100 μF
-12V
100 μF
100
10 μF
0.1 μF
15V
0.1 μF
10 μF
TANTALUM
2.2 μF
0.1 μF*
0.1 μF*
15V
7.5k
LM329
100k
10T
100k
4.096V
VREF
0.1 μF
5.1M
LF13300
AD81200
(MM5063)

Note 1: All diodes, 1N914
Note 2. All resistors 1/4W, 5% tolerance
Note 3: Circuit drawn for 8V full scale operation input scaling not shown
Note 4: Inductive components U4X003 or Microtran PC6714

Fig. 53-8. 3¾ plus (±8191 Counts) and 3½-digit DPM schematic diagram (NS).

Fig. 53-9. 3½-digit voltmeter (NS).

1N914
18k
S3
B CLOCK
0.001μF
2M
0.01μF (POLYSTYRENE)
B1 = B2 = 12.5V NICAD
BUF OUT
OA IN
OA OUT
V+
COM
V−
RU
PO
OC
COMP OUT
OC1
OC2
OC3
LF11300
A GND
VIN
RR
0.047 μF
3.3k
47.5 k
LM329BH
2.000V
10k 5k
17.8k
0.1 μF
0.01μF
A1
A2
D1
D2
D3
A POLARITY
10k
VCC
200μF
S4
D4
D5
D6
R
D
Q
CK
S
300μF
POWER ON RESET
100k
ANALOG GROUND
1M 1%
VIN
11k 1%
111k 1%
20V
200V
2V
LATCH ENABLE
CLOCK IN CARRY OUT
74C928
DIGIT OUT
D1
D2
D3
D4
OD1
DS75492
VCC = 6V
(4) 1.5V NICADS

Fig. 53-10. Wide-band AC voltmeter (NS).

Fig. 53-11. Sensitive low-cost "VTVM" (NS)

Fig. 53-12. 1,000,000/1 single-control function generator—1 MHz to 1 Hz (RCA).

Fig. 53-13. 3½-Digit DVM, four decade, ±0.2V, ±2V, ±20V and ±200 V full scale (NS).

NOTES

1 ALL RESISTORS ¼ WATT 5% UNLESS OTHERWISE SPECIFIED

2 ALL CAPACITORS 10%

3 LOW LEAKAGE CAPACITOR REQUIRED

4 $\frac{R_1 R_2}{R_1 + R_2}$ $R_3 = 25\Omega$

5 OFFSET ADJUST REQUIRED FOR MM74C935 1 ONLY

Fig. 53-14. 3½-Digit, ±1.999 volts full scale (NS).

NOTES

1. ALL RESISTORS ¼ WATT ± 5% UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITORS 10%
3. LOW LEAKAGE CAPACITOR REQUIRED
4. $\frac{R_1 R_2}{R_1 + R_2} = R_3 \pm 2\%$
5. OFFSET ADJUST REQUIRED FOR MM74C935-1 ONLY

Fig. 53-15. Peak-reading VU indicator (PM).

+15V
CMP 01
IC2
15V
CL
IC3
7474
CP
PS
+5V
IC4
7486
IC4
7486
500kHz
IC5
2502
START
SERIAL PCM OUT
500kHz
IC3
7474
+5V
IC7 3205
A2 A1 A0
IC10
74279
R11
180
CR5
GREEN
R12
180
CR6
GREEN
R13
180
CR7
GREEN
R14
180
CR8
RED
+5V
-6dB
3dB
0dB
+3dB

Fig. 53-16. Wide-range LC checker.

Fig. 53-17. Dip meter.

Parts list
T1—HEP S9002 unijunction
C1— 005μF, 1000V ceramic disc
C2—0 1μF, 200V tubular
L1—1mH subminiature iron-core rf choke, J W. Miller 70F103A1
R1—47Ω, 1 2W 10%
R2—18kΩ, 1 2W 10%
B1—8 4V mercury battery, Burgess H126
S1—SPST Lafayette 34P02302V
Misc—plastic toothbrush case, perforated board, flea clips

Fig. 53-18. Pocket size signal generator.

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

Fig. 53-19. "Buzz Box" continuity and coil checker (NS).

LED	Threshold
1	60 mV
2	80 mV
3	110 mV
4	160 mV
5	220 mV
6	320 mV
7	440 mV
8	630 mV
9	890 mV
10	1.25 V

Fig. 53-20. Vibration meter (NS).

Fig. 53-21. Using a digital frequency counter without a direct connection.

Fig. 53-22. Carrier shift meter.

Fig. 53-23. Vertical and horizontal bars can be generated with this circuit for checking TV sweep linearity.

Fig. 53-24. Audio generator capable of operation from 20 to 20,000 Hz. Optional connections shown for dual or single 9V dc supplies. The 25K dual potentiometer should have a linear (not audio) taper.

Fig. 53-25. Sensitive rf voltmeter has full-scale ranges from 30 mV to 10V with a flat frequency response to 200 MHz. All FETs, transistors, and diodes used in pairs should be carefully matched.

Fig. 53-26. SWR bridge. Parts list: T1—60 turns No. 30 enameled wire over Amidon T-68-2 toroid core. Close wind the turns. Primary is two turns No. 22 or 24 hookup wire wound over center of secondary. C1 C2—1.5—7 pF ceramic trimmer (Lafayette No. 68386 mica usable) R1, R2—120 ohm ½W CR1, CR2—1N34A or equivalent (Radio Shack No. 821 for pack of 10; select two that match the closest). C3, C4—0.005 μF disc type C5—330 pF ceramic or silver mica RFC—1mH choke S1—SPDT (Use DPDT Radio Shack rocker; No. 030 for kit of two) R3—25,000 ohm linear taper control (Radio Shack No. 094) Meter—50 μA to 1 mA movement (Lafayette 500 μA No. 50361 a good size).

Fig. 53-27. A general-purpose rf detector probe for use with an oscilloscope or voltmeter.

Fig. 53-28. This high-impedance probe provides about 1200 megohms input impedance with unity gain. Upper frequency equalization is provided by the 5K pot. Q1 is a U112, 2N2607, 2N4360; Q2 is a 2N706, 2N708, 2N2926, 2N3394, or HEP 50.

Fig. 53-29. One of the easiest types of diode checks for a person with a scope is this, but it tells nothing about a diode's high voltage performance.

Fig. 53-30. Although this capacitance meter will not measure electrolytic capacitors, it will measure any other type from zero to 0.1 μF with reasonable accuracy. On the lower end 4 pF can be read accurately and 2pF easily estimated. Transistors Q1 and Q2 are 2N168, 2N1605, 2N2926, SK3011, or HEP 54; the meter is a 0-50 microampere unit and the range switch a Centralab PA1021.

Fig. 53-31. Z-match antenna tuner and SWR bridge couples any antenna to any transmitter or receiver, low frequencies to VHF. Allows smooth transition from series to parallel tuning without bandswitching. Construction details shown in accompanying figure.

Fig. 53-32. Overall schematic of the tuner.

Fig. 53-33. This logarithmic amplifier makes use of the fact that when two back-to-back diodes are driven by a current generator, they exhibit a logarithmic output of the input signals. With the circuit constants shown, this amplifier follows a nearly perfect logarithmic curve over a 60 dB range; selected diodes will increase this to 80 dB. Q1, Q2 and Q3 are 2N2924, SK3019, GE-10, or HEP 54; D1 and D2 are IN914.

Fig. 53-34. Full circuit diagram for ohmmeter capable of measuring resistance down to less than 0.001Ω. The two circuit points marked 'A' are wired directly together.

Fig. 53-35. LED voltage and continuity tester.

Fig. 53-36. Signal injector.

Fig. 53-37. Super-simple diode checker.

Fig. 53-38. Field-strength meter.

Fig. 53-39. Wattmeter uses two 50 μA meters and indicates forward and reflected power simultaneously from 100kHz to 70MHz.

Fig. 53-40. Astable multivibrator produces audio signal rich in harmonics for signal-tracing applications; may be fitted into plastic cigar container. Transistors are 2N3841; any general-purpose types will suffice.

Fig. 53-41. Portable impedance bridge, field-strength meter, and crystal calibrator.

Fig. 53-42. Performance monitor for Motorola FM communications equipment plugs in; selector switch is used to choose function to be monitored. Adapts to other units by changing connector type.

Fig. 53-43. Basic "lumped-line" oscillator. Tank circuit has appearance of conventional coil but functions as full-wave transmission line with no exposed high-impedance or "hot" points.

Fig. 53-44. A 60 Hz square waver.

Fig. 53-45. Crystal checker. When the button is pushed, a good crystal should cause the bulb to light.

RANGE (VOLTS)	Z (μA)	Rm (ohms)	Rf (ohms)
± 0 25	±0.75	333K	667K
0 75	"	1.00M	"
2.50	"	3.33M	"
7.50	"	10.0M	"
25.0	"	33 3M	"
75.0	2.25	"	222K
250	7.50	"	66.7K
750	22.5	"	22.2K

RANGE RESISTOR CALCULATION

Fig. 53-46. This simple device gives a quick check of diodes. If lamp A lights, the diode is good. If B lights, the diode is good, but connected backwards. If neither lamp lights, the diode is open; and if both light, it is shorted.

+18V
100Ω SPKR
Q5 2N656
Q4 2N706
R22 4.7K
D2 1N4001
R21 150K
C5 100μF 20V
Q6 2N656
+18V
R20 39K
D1 1N675
C4 100μF 20V
R27 1K
D7 1N4001
R17 15K
R19 500K
Q3 2N706
R18 10K
D6 1N963
+12V
R15 3.9K
R16 2.4K
C3 100μF 20V
R26 390
D5 1N4001
R14 4.9K
R11 3.3K
R13 27K
Q2 2N706
D4 1N963
-12V
R12 10K
C2 100μF 20V
R25 560
D3 1N4001
Q1 2N6027
C .01μF ±5%
+12V
1/2μA741
A2
R10 10
R9 2K
R8 20K
12VRMS 200mA
T1
R7 500 FREQ CAL
117V
ON
VOLUME CONTROL
SW1
R4 215K ±1%
+12V
1/2μA747
A1
R6 10K
-12V
NULL
R5 33K
R1 900K ±1%
R2 90K ±1%
R3 10K ±1%
R23 1K
R24 11K
+12V
10V
1V
.01V
COMM
TEST

Fig. 53-47. Audible voltmeter produces tone that rises with applied voltage. Chart shows linear relationship of tone to voltage.

R3
10K
+3.6V
2200
2200
Q3
MC714G
TO C20
10
SIG
0
100
SW1
0
C21
220
CR4
2200
+3.6V
Q8
MC726G
S
Q
T
C
Q̄
2200
12V
2200
R4
5K
6800
TR4
2N1613
C23
1000μF
6V
C24
0.1
TO RUSTRAK
RECORDER
C22
220
2200
CR5
1 ALL RESISTORS ARE 1/4 WATT
2 ALL ELECTROLYTIC (OR TANTALUM)
CAPACITORS ARE SUBMINIATURE
TYPE RATED AT 25VDC
+3.6V
Q4
MC700G
TO Q2
+3.6V
Q5
MC723G
+3.6V
Q6
MC723G
+3.6V
Q7
MC723G

Fig. 53-48. WWVB frequency comparator receiver uses a heterodyne process to display error between WWVB at 60 kHz and local rf producing device. ICs are Motorola.

Fig. 53-49. Lumped-line oscillator with tuning provisions and buffer amplifier. Circuit values shown for 21 MHz oscillator.

Fig. 53-50. Postinjection marker circuit with dc gain control of marker size.

Fig. 53-51. A 50Ω attenuator circuit for a receiver front end. Use for measuring effectiveness of different antennas by listening to a constant-amplitude signal.

Trim L1 for best waveshape. An overtone crystal (odd order) can be substituted for C1. For 51 ohm output change R1 and R4, reduce supply to 8 volts. Heat sinks suggested on Q1 and Q2. When cutting and tying, reduce input to about 6 volts.

All resistors are ½W carbon. Capacitors in decimal are disc type (short leads). 2N708's for best performance are Fairchild (other brands work, but do not give clean waveshape).

Harmonics observed into microwave region. Symmetrical square wave at output; dc reference to ground. Output at 4 MPS ≈ .5 watt. Short circuit protected.

	Typical Values	
MPS	C2 pF	L1
4.0	100	82 μH
10.0	47	15
15.0	47	10
20.0	47	4.7
30.0	47	2.2
50.0	47	2.2
72.0	39	.22

Fig. 53-52. Square-wave source.

Fig. 53-53. Various ways of using simple voltmeters as frequency readout devices in conjunction with voltage-tuned diodes (varactors).

Fig. 53-54. A 0.025 to 10W RF wattmeter.

Fig. 53-55. Direct-reading inductance meter. Must be calibrated by user.

Fig. 53-56. Dual-tone test generator uses pair of Wien bridge oscillators. Requires power source of ± 12V.

Fig. 53-57. Unijunction-transistor sweep generator offers simplicity and excellent reliability/repeatability.

Fig. 53-58. Regenerative detector generates broadband signal on 27 MHz citizen band, for use in tweaking any companion receiver unit.

Fig. 53-59. A simple "grid dip" meter that uses a bulb as a resonance indicator. Using the GE-9 transistor will enable the unit to oscillate up to 12 MHz. The indicator lamp should be a No. 48 or 49 bulb. L1 should be wound to cover desired frequency ranges.

Fig. 53-60. The square-wave output of many inexpensive signal generators deteriorates quite badly at high frequencies, but this circuit will square them off again. The diodes may be any inexpensive computer type such as the 1N914.

Fig. 53-61. A circuit for testing characteristics of "bargain pack" diodes. The transformer is 600—1000V CT and the two diodes in the half-wave circuit are 1000 PIV. The filter capacitor should be approximately 40 μF apiece with suitable voltage rating. To test an unknown diode, connect as shown and read the voltage on the VTVM Two-thirds of this reading can be interpreted as a safe PIV rating. Reversing the diode reads forward characteristics—a reading of less than 3V indicates a good diode. No voltage indicates a shorted diode.

Desired Voltage Scale	Current Rating of Meter in Amps	Necessary Resistance	Internal Resistance of Metar	Series Resistor
1	.0005	2000Ω	150Ω	1850
5	.0005	10K	150Ω	9850
10	,0005	20K	150Ω	19850
50	.0005	100K	150Ω	99850
100	.0005	200K	150Ω	199850
500	.0005	1 meg.	150Ω	999850

Fig. 53-62. Ac/dc voltmeter. Table shows resistance value for desired full-scale indication of 500 μA meter.

Fig 53-63. Beta tester.

Fig. 53-64. Field-strength meter can be used to tune coils, antennas, and other resonant devices. To cover 13—24 MHz, L1 is to be resonant when used with C1, and should consist of a couple of turns of No. 16 wire wound over L2. L2 is 11 turns No. 16 solid spaced so coil is 1 in. dia by 1 in. long.

Fig. 53-65. Schematic of milliwattmeter for measuring rf power levels of 1—1000 mW.

Fig. 53-66. Line quadrature-generator type transistor and SCR tester.

Fig. 53-67. Although this capacitance meter will not measure electrolytic capacitors, it will measure any other type from zero to 0.1 μF with reasonable accuracy. On the lower end 4 pF can be read accurately and 2 pF easily estimated. Transistors Q1 and Q2 are 2N168, 2N1605, 2N2926, SK3011, or HEP 54; the meter is a 0—50 microampere unit and the range switch a Centralab PA1021.

Fig. 53-68. LM frequency meter updated by FETs that can be made to plug directly into pentode sockets.

Fig. 53-69. Compact VOM circuit. Keep resistor values as accurate as possible. Meter movement is 500 μA with an internal resistance of 150 ohms.

Fig. 53-70. Two oscillator circuits for aligning receivers, anonymously presented originally in FM Bulletin.

Fig. 53-71. Transistor beta tester.

FIg. 53-72. A 5 to 300W rf wattmeter metering circuit. External 300 or 400W during antenna load.

Fig. 53-73. A 0.05—500 mW wattmeter.

Fig. 53-74. Capacity meter. L1-C2 and L2-C4 should tune to the same frequency, around 1450 kHz. Calibrate by setting C4 near max and mark that "zero." Peak meter with C2, which is zero adjustment. Calibrate with known capacities and mark C4 dial.

Fig. 53-75. This schematic gives the basics for a simple, inexpensive audio frequency meter. For the cheapie special version, omit all switches and components associated with them. Connect a capacitor of proper value in place of SIA. Ranges are: OFF, 30 kHz, 10 kHz, 3kHz, 1kHz, and 300 Hz. Meter is 0-1 mA.

Fig. 53-76 Dummy load and rf wattmeter for 50 ohms. R1 and R2 are each made from 8 paralleled 2-watt resistors of precisely 220 Ω each.

Fig. 53-77.Crystal tester schematic.

COIL TABLE		
FREQUENCY	DIAMETER	WINDING
7 MHz	7/8"	26 TURNS – 1 1/8" LONG
14 MHz	7/8"	7 TURNS – 1/2" LONG

GENERAL NOTES ON SCHEMATIC

ALL FIXED RESISTORS ARE 1/4 WATT
.001 AND .01 CAPACITORS ARE DISC CERAMIC
CAPACITORS MARKED "SM" ARE SILVER MICA R1
AND R2 STANDARD CARBON ELEMENT POTENTIOMETERS
C2, C3, AND C4 ARE ELECTROLYTICS - 25WVDC OR MORE

Fig. 53-78. Sweep oscillator circuit.

Fig. 53-79. Simple devices can be built to indicate when defined modulation percentages are achieved. This arrangement uses neon bulbs and switching diodes to fire the bulbs when the negative-peak modulation reaches 50%, 80%, and 100%, respectively. Bottom ends of neon bulbs return to voltages which are uniformly 65V more negative than the voltage marking the corresponding modulation percentage. These voltages, and the resistance values in the divider which establishes them, depend upon the voltage supplied to the transmitter (here assumed to be 600V). The 65V offset is the firing voltage of the neon bulb. When the upper end goes 65V more negative than the lower end, the corresponding bulb can fire. In use, the object is to keep the 50% bulb on all the time, the 80% bulb on as much of the time as possible, but never permit the 100% bulb to flash.

CRYSTAL FREQ	C2 pF
100 KHz	1000
500 KHz	430
1 MHz	39

IC1 - HEP 570

Fig. 53-80. Crystal oscillator calibrator, high in square-wave output (you will be able to hear it up into the VHF bands), which may be made into two calibrators since the circuit uses only half of the Motorola IC.

Fig. 53-81. Reflected power meter and CW monitor. L1 is 12 in. RG-11/U coax with plastic coat removed. 5 -inch pieces of No. 20 hookup wire inserted under shield for pickup loops.

Fig. 53-82. Direct-reading capacitance meter.

Fig. 53-83. VHF amplifier used to measure gain, noise figure, and agc performance of the Fairchild FT0601 MOSFETs. For agc operation, dual-gate MOSFETS have a built-in advantage owing to their separate gates, especially in the VHF region. Amplifiers such as this one eliminate cross modulation distortion, decrease receiver noise, and avoid shifting of the receiver's center frequency. Schematic from Fairchild Semiconductor Application Note APP-189.

Fig. 53-84. VHF prescaler for extending counter range to 300 MHz.

Fig. 53-85. Rf wattmeter is simple and accurate, but logarithmic. A 22K resistor gives 10W full-scale indication.

R1, R3	1.8K	
R2, R4, R5	1K	
U1	SN 7400	QUAD 2-INPUT NAND GATE
U2, U3	SN 7490	DECADE COUNTERS
Vcc	5 VDC	

Fig. 53-86. This crystal calibrator has a fundamental 1 MHz crystal and its frequency is divided to give outputs of 1 MHz, 100 kHz, and 10 kHz. Circuit courtesy of Zero Beat (Victoria BC).

Fig. 53-87. Crystal oscillator for aligning receivers.

Fig. 53-88. Simple resistance decade uses no switching but requires access to resistor junctions.

Fig. 53-89. VHF prescaler for frequencies up to 200 MHz.

Fig. 53-90. General-purpose digital IC tester.

Fig. 53-91. Linear IC tester.

R	FROM	TO
1	A	B
2	B	C
3	A	C
4	B	D
5	A	D
6	C	D
7	B	E
8	A	E
9	C	E

Fig. 53-92. Resistance decade in H configuration. Select values after examining table to see a sequence of value increases.

Fig. 53-93. When testing a capacitor, the light will blink once or twice while the plates are loading and then will remain off. If the capacitor is not good, the light will continue to blink. When checking capacitors wired into circuits, one end must be disconnected. R1-47K 2W resistor, R2—330K 2W resistor, LM-1—neon lamp NE 51, C1—8 or 10 μF capacitor 450V dc, CR1—1M3611 diode (not critical), SWL—ST toggle switch, F—¼A fuse.

Fig. 53-94. Resistance decade using rotary switch for resistance selection. Circled letters show switch connections.

Fig. 53-95. Dip meter uses junction FETs gate rather than vacuum-tube grid for dip function.

Fig. 53-96. Signal generator for aligning FM receivers in 150 MHz region. Resistor marked with * may have to be changed to lower value if recommended transistor is not used.

Fig. 53-97. Schematic of 100 KHz calibrator. Parts values are not critical and the transistors do not have to be the ones listed. It is suggested that a late version of the GE transistor manual be consulted for a slightly revised oscillator circuit.

Fig. 53-98. Transistor sorter identifies polarity of bipolars; audible signal gives good indication of device gain. T1 is a miniature 400Ω (. .8pCT) to 4 or 8Ω transistor output transformer.

Fig. 53-99. Sweep generator for 430–470 kHz.

Fig. 53-100. This circuit will provide direct reading of transistor beta right on your VOM ohm scale. Polarities are shown for PNP.

NOTES.
1. UNLESS OTHERWISE INDICATED RESISTANCE IS IN OHMS.
2. S1 = 4-POLE, 3-POSITION SWITCH.

Fig. 53-101. Transistor parameter tracer.

Fig. 53-102. Basic circuit of a popular and simple adapter for testing common "milliwatt" transistors.

Fig. 53-103. This simple bridge circuit will measure antenna input resistance at resonance. Remember tolerances on capacitors are commonly very loose. A capacitor checker can do an adequate job of matching.

Chapter 54
Thermometers and Thermostats

$$R_S = (V^- - 6.8V) \times 10^3 \Omega$$

Fig. 54-1. Basic thermometer for negative supply.

$$R_S = (V^- - 6.8V) \times 10^3 \Omega$$

Fig. 54-2. Basic thermometer for positive supply (NS.)

$$R1^* = \frac{(V_Z)\,0.01\Delta T}{I_M\,(V_Z - 0.01\,T_O)} \quad **$$

$$\text{Select } I_O \leq \frac{2V}{R1}$$

$$R2 = \frac{0.01\,T_O - I_O\,R1}{I_O}$$

$$R3 = \frac{V_Z}{I_O} - R1 - R2$$

$$\left(I_O \leq \frac{2V}{R1}\right)$$

V_Z = Shunt regulator voltage (use 6.85)
ΔT = Meter temperature span (°K)
I_M = Meter full scale current (A)
T_O = Meter zero temperature (°K)
I_O = Current through R1, R2, R3 at zero meter current (10μA to 1.0 mA) (A)

$$R_S = \frac{(V^+ - 6.8V)}{0.001A + I_M + I_O}$$

* Values shown for:
T_O = 300 K, ΔT = 100 K,
I_M = 1.0 mA, I_O = 100 μA

** The 0.01 in the above and following equations is in units of V/ K or V/ C, and is a result of the basic 0.01V/ K sensitivity of the transducer

Fig. 54-3. Thermometer with meter output (NS).

*Selected as for meter thermometer except T_O should be 5° K more than desired and I_O = 100μA

†Calibrates T_O

Fig. 54-4. Meter thermometer with trimmed output (NS).

Fig. 54-5. Remote sensing digital thermometer (NS).

Fig. 54-6. Thermometer (NS).

Fig. 54-7. Resistance thermometer transmitter (NS).

*Solenoid or 8–15W heater

†Pot will provide about a 50°F to 90°F setting range. The trim resistor (100k) is selected to bring 70°F near the middle of the pot rotation

SCR heating, by proper positioning can preheat the sensor giving control anticipation as is presently used in many home thermostats

Fig. 54-8. Two-wire remote AC electronic thermostat (gas or oil furnace control) (NS).

Fig. 54-9 Three-wire electronic thermostat (NS).

Fig. 54-10. Ground referred thermometer (NS).

Fig. 54-11. Ground referred centigrade thermometer (NS).

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

Fig. 54-12. Differential thermometer (NS).

Chapter 55
Timers

Fig. 55-1. Zero stand-by power timer (NS).

R5—150Ω 1 2W R7—10kΩ 1/2W I1—neon lamp NE-83
R6—47kΩ 1/2W F1—fuse 3 ampere 3 AG S1—toggle switch DPDT

Parts list
SCR1—HEP R1221
T1—HEP G0005
T2—HEP S0014
D1 D2 D3 D4 D5—HEP R0052
C1—50μF 15V electrolytic
C2—50μF 150V electrolytic
R1—3kΩ 5W
R2—33Ω 1/2W
R3 —potiometer 1MΩ 2W linear
R4—470Ω 1 2W

Fig. 55-2. Electronic timer (5 to 180 seconds).

Fig. 55-3. Interval timer.

Fig. 55-4. Solid-state timer.

Chapter 56
Transmitters, Transceivers, Exciters and VFOs

Fig. 56-1. VSWR protect circuit.

Fig. 56-2. This two frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed and this circuit provides a novel and simple way of obtaining two frequencies from a single stage with a minimum of switching.

L_1—¼" dia. 7T #24
L_2—2T at cold end of L_1
L_3—6T Airdux 608 (B&W 3010) CT

Fig. 56-3. A 100 mW 6 meter transmitter. Modulate AM with a TA300 IC or FM with a couple of diodes.

Fig. 56-4. This beat-frequency oscillator may be added to existing receivers with a minimum of difficulty. The BFO frequency is determined by the i-f transformer which provides feedback from collector to emitter. Transistor Q1 should be a 2N384, 2N1749, 2N2362, T1M10, SK3008, GE-9, or HEP 2.

Fig 56-5. This is the old familiar vacuum tube Pierce oscillator circuit with a field-effect transistor in place of the thermionic triode. Circuit constants shown here are for the 1 MHz region, but the tuned circuit may be adjusted to any frequency desired Q1 is a 2N4360.

Fig. 56-6. This two-frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed. This circuit provides a novel and simple way of obtaining two frequencies from a single stage with a minimum of switching. Almost any PNP rf transistor will work as Q1. D1 & 2 are general-purpose silicon diodes.

L1 8 TURNS B&W 3003 (16 TURNS PER INCH, 1/2" DIAM.) TAPPED AT 4 TURNS FROM COLD END
L2 8 TURNS NO 16, 5/16" DIAM, 1" LONG
L3 3 TURNS NO 16 BIFILAR WOUND ON COLD END OF L2.
Q1 2N384, SK3008, TIXM03
RFC 18 μH (OHMITE Z-144)

Fig. 56-7. This simple 2-meter transmitter may be used as a driver for a larger 144 MHz transmitter or a signal source for testing receivers, converters, and antennas.

Fig. 56-8. A 5-10 MHz VFO or 40-meter QRP transmitter; an idea for those backwoods hikes. Courtesy Motorola HMA36, IC Projects for Amateurs.

XTAL	7 MHz fundamental
Q1	40080
Q2	40081
L1	20 turns No. 28 on ¼" dia. slug tuned form
L2, L4	5 turns No. 24 on L3
L3	28 turns No. 28 on ¼" dia. slug tuned form
K1	sensitive spst relay for 12V (see text)

Fig. 56-9. Simple low-power transmitter (1 watt) is ideal for CW operation (no modulator).

Fig. 56-10. AM wireless transmitter. Useful for baby-sitting, sick watch, intercom, etc. L1 is a variable antenna coil, (Calectro D1 841). L2 is four turns of hookup wire wound on top of L1. Q2—3 are NPN silicon transistors (Calectro K4-507).

Fig. 56-11. Variable crystal-controlled oscillator circuit.

Fig. 56-12. FM wireless transmitter (88—108 MHz). Circuit courtesy Calectro Handbook. C7 is a short length of twisted hookup wire about ½ inch long. L1 is four turns length about ½ inch and ¼ inch dia.

Fig. 56-13. Double-sideband transmitter for operation in 27–28 MHz range.

L1	8 TURNS B&W 3003 (16 TURNS PER INCH, 1/2" DIAM.) TAPPED AT 4 TURNS FROM COLD END.
L2	8 TURNS NO. 16, 5/16" DIAM, 1" LONG
L3	3 TURNS NO 16 BIFILAR WOUND ON COLD END OF L2.
Q1	2N384, SK3008, TIXM03
RFC	1.8 µH (OHMITE Z-144)

Fig. 56-14. This simple 2-meter transmitter may be used as a driver for a larger 144 MHz transmitter or a signal source for testing receivers, converters, and antennas.

TO COLLECTOR-MODULATE FINAL:
OMIT R8
APPLY MODULATED VOLTAGE AT B
APPLY 9 TO 10V AT A

*C4 NOT USED IN 6M VERSION

COIL DATA		
COIL	80M	6M
L1	35T NO. 22 ON T68-2 CORE	9T NO. 22 ON T50-10 CORE
L2	SAME AS L1	SAME AS L1
L3	3 TO 4T NO. 22 ON COLD END OF L2	SAME AS 80M

Fig. 56-15. Here is a stable VFO that can be assembled in a short time on a piece of Vectorboard. Coil data is supplied for an 80m and 6m version but other bands may be covered with a bit of experimentation. Transistors are all MPS706 but higher output is possible by replacing Q3 with a 2N2270 or 2N3053.

Q1 – VHF PNP (GE-9, ES19, etc)
* – MAY BE NEEDED IF TRIMMER WILL NOT ZERO-BEAT. ADD IN 50 pF STEPS.

Fig. 56-16. A 2-meter crystal oscillator. The transmitter crystal is used, the netting capacitor is adjusted so that the crystal is zero-beat with someone who is considered as being on frequency. Then the oscillator may be used to align a receiver. Since the output is so high (measured 18V peak-to-peak across the choke), it must be loose-coupled to the receiver. This is done by winding two turns around the choke. One end of the winding is connected to the connector; the other end is connected to a 15Ω resistor which is then connected ground. This circuit is very active and will handle crystals from 2 MHz to 30 MHz.

FREQUENCY	C1	C2	C3	L1	MILLER NO	L2
10 - 13.5 MHz	30 pf	300 pf	.01	5.0 - 9.0 µH	4505	4-1/2T
13.5 - 18 MHz	30 pf	300 pf	.01	2.8 - 5.0 µH	4504	3T
18 - 24 MHz	30 pf	300 pf	.01	1.6 - 2.8 µH	4503	2-1/2T
23.5 - 32 MHz	10 pf	100 pf	.01	2.8 - 5.0 µH	4504	3T
32 - 42 MHz	10 pf	100 pf	.001	1.6 - 2.8 µH	4503	2-1/2T
42 - 53 MHz	10 pf	100 pf	.001	1.0 - 1.6 µH	4502	2T
58 - 84 MHz	10 pf	100 pf	.001	0.4 - 0.8 µH	4501	1-1/4T

Fig. 56-17. This Colpitts crystal oscillator may be used with either fundamental or overtone crystals from 10 to 84 MHz with the tuned-circuit components listed. It oscillates quite readily when adjusted and provides a stable output.

Fig. 56-18. Field-effect-transistor variable frequency oscillator has zero temperature coefficient. Operating frequency in 3.5 MHz range.

Fig. 56-19. This untuned crystal oscillator will oscillate with any crystal from 300 kHz to 10 MHz. Frequency stability is very good because the emitter-follower buffer amplifier effectively isolates the oscillator from the load. Q1 and Q2 are GE-9, SK30006, or HEP 2.

Fig. 56-20. FET replaces vacuum tube in the H23 oscillator to complete the transistorization operation. Components not labeled in the sketch are those components that are already part of the existing oscillator circuit.

Fig. 56-21. 10 MHz crystal oscillator.

Fig. 56-22. Schematic for beeper. All resistors are ½ watt.

Fig. 56-23. Ultrahigh-stability crystal oscillator circuit that is useful for microwave transmitter frequency control. Use crystals from 1.6 to 160 MHz, fundamental or overtone. For best results get the values of the coils and capacitors for any specific frequency from your friendly neighborhood reactance chart.

L1 = TUNED TO RESONATE WITH C2 - COLLECTOR TAP 1/3 UP FROM COLD END

C1 = CAPACITIVE REACTANCE OF APPROX. 90 Ω AT OPERATING FREQUENCY

FREQ (MHz)	50	144	220	432
C1 (pF)	36	12	8.2	3.3

Fig. 56-24. This crystal oscillator was designed specifically for overtone crystals and will oscillate up to the 11th overtone in the VHF range. Suitable values for C1 are shown for the VHF bands; for other frequencies, C1 should exhibit approximately 90Ω capacitive reactance for best results. Q1 is a TM10, T1400 or HEP 3.

Fig. 56-25. This simple UHF oscillator will provide about 2 mW up to 1000 MHz; some selected transistors will provide usable power up to 1500 MHz or so. Q1 is a 2N918, 2N3478, 2N3564, or HEP 65.

L1	13 TURNS NO 26 ON 1/4" SLUG TUNED FORM. TAPPED AT 6-1/2 TURNS.
L2	10 TURNS NO. 26 ON 1/4" SLUG TUNED FORM. TAPPED AT 5 TURNS.
L3	9 TURNS NO. 24 ON 3/8" SLUG TUNED FORM.
L4	SAME AS L3.
Q1	2N708, 2N3009, 2N3646, 2N3856
Q2	2N3641, 2N2217
Q3,Q4,Q5	2N3642, 2N2218

Fig. 56-26. This 3 watt 10 meter transmitter maintains high efficiency and low cost by paralleling three inexpensive silicon transistors in the final stage.

Fig. 56-27. This 6-meter transmitter provides up to 50 watts of power with very good efficiency and very low harmonics. The 2N3950 in the final provides a minimum power gain of 8 dB at 50 MHz and is rated at 50 watts continuous service.

TO COLLECTOR-MODULATE FINAL:
OMIT R8
APPLY MODULATED VOLTAGE AT B
APPLY 9 TO 10V AT A

*C4 NOT USED IN 6M VERSION

COIL DATA		
COIL	80M	6M
L1	35T NO. 22 ON T68-2 CORE	9T NO. 22 ON T50-10 CORE
L2	SAME AS L1	SAME AS L1
L3	3 TO 4T NO. 22 ON COLD END OF L2	SAME AS 80M

Fig. 56-28. Superstable variable-frequency oscillator uses three Motorola MPS706. Unit also serves as a low-power transmitter. Oscillator is little-known Vackar circuit, said to outperform the Clapp.

Fig. 56-29. Schematic of the VFO and power supply. Regulation is provided for both the oscillator and buffer. If more rf output is required, a tuned circuit (toroid, of course) can be installed in the emitter of Q2 in lieu of the 1000Ω resistor.

Fig. 56-30. Transistor VFO for 5-6 MHz for SSB mixing service.

Fig. 56-31. A 1800 Hz command oscillator for FM. Q1—any PNP signal transistor have a V_{CE} rating of 1½ or more times the supply voltage. Some suggestions: 2N404, 2N1303 series, 2N2904 series, 2N3638 series, or 2N6533 series. Q2—any NPN small-signal transistor having a minimum beta of 100 and a V_{CC} of at least the supply voltage. Some suggestions: 2N1308, 2N2712, 14, 16, 2N2916, 18, 10, 2N3565, 2N3569, 2N6513, 14, 15, 20, or 21. C_{TRIM}—0.0062 μF was used in the first unit. If Mylar capacitors and the toroid are ± values, f_1 = 1817 Hz. If C1 is 10% low, f_1 = 1897 Hz. If C1 is 10% high, f_1 1741 Hz. To find a value for C_{TRIM}, measure the frequency (f_1) without C_{TRIM}. If it is higher than 1800 Hz. (f_o) calculate C_{TRIM}. $C_{TRIM} = 0.1\ (f_1/f_o^2 - 1) = F$.

Fig. 56-32. A 50 MHz 40W transmitter for 12.5V operation.

Fig. 56-33. This crystal oscillator will oscillate with any crystal between 3 and 20 MHz with no tuning whatsoever; overtone crystals will oscillate on their fundamental in this circuit. Q1 is a 2N1177, 2N1180, 2N1742, GE-9, SK3006, or HEP 2.

Fig. 56-34. A 50-MHz transmitter with speaker as AM microphone.

Fig. 56-35. Schematic of 2½W 6m transmitter. L1 and L2 = 6 turns No. 20 on iron-core ⅜" ceramic form. Links are 2 turns No. 20 insulated at bottom of L1 and L2. L3 is center tapped. These coils are surplus, used, as-is. Both windings are ½" long. L4 = 6 turns Airdux 516 or B&W 3007.01 =Fairchild 2N364; Q2 = RCA 40081; Q3 = Bendix B3466 or RCA 2N3553 or 40341 (all heatsinked).

Fig. 56-36. Transistor transmitter puts out 30 watts at 3.5 MHz, and uses Texas Instruments' TIP 14s.

Q1 - 2N384, 2N525, SK3004, TI-XM03
D1, D2 - GENERAL PURPOSE SILICON DIODES

Fig. 56-37. This two frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed and this circuit provides a novel and simple way of obtaining two frequencies from a single stage with a minimum of switching.

Fig. 56-38. Single oscillator and diode provide two injection frequencies for dual-conversion receivers. Transistor Q1 is a 2N1745, 2N2188, T1M10, GE-9, or HEP 2; the diode should be a 1N82A or similar.

ANT
45
1/2A
3AG
2N1540
(HEATSINK)
5.1K
5W
WW
200
5W
WW
1N4001
1N4001
*SEE TEXT
10k
330k
100k
100k
10k
.01
.01
2N404
SK3004
GE2
HEP 250
2N404
SK3004
GE2
HEP 250
1N270
200µF 6V
PHONES
NOT USED
5µF
6V
2k:10Ω
500
2N270, SK3004
GE2, HEP 250
270
5µF
6V
4.7k
5µF
6VDC
18k
2.5k
"TOUNT"
"REC"
"SPOT"
L5
L4
9-180
120µH
KEY
.01
365
365
2N615 *
(HEATSINK)
1mH
500
2N615 *
(HEATSINK)
1mH
68
MICA
500
68
MICA
500
100k
4.7k
100k
*47
5W
WW
mA
4.7k
7 MHz
.022
2.2k
100 kHz
47k
2N640
SK6007
.003
640
33
18k
100

L1, L2 30 *turns #32 enameled wire close wound on ¼" slug tuned form. J. W. Miller 46A000CPC or CTC 2206-2-3*

L3 32¾ *turns #32 enameled wire close wound on ¼" slug tuned form. (same form as above)*

L4 11 *turns 1" diameter 16 TPI. AirDux or B & W.*

L5 4 *turns hookup wire wound around the center of L4.*

Fig. 56-39. Continuous-wave transceiver for 7 MHz produces 100 mW of rf in transmit; delivers clean notes to earphone in receive mode. Coil data at lower right.

Fig. 56-40. Minimod schematic.

L1-L2 10 turns 22 enamel 5/16" long, ¼" diameter. Fr. slug coil form.
L3 20 T 24C, ½" long by ¼" diameter poly rod form.
L4 10 T #18, 3/4" long ¼" diameter tap 3 turns up.

L5 10 T #24C, ¼" long by ¼" diameter poly rod form.
L6 6 T #18, 3/4" long, ¼" diameter tap 2½ turns up.
L7 6T #18, 1" long, ¼" diameter tap 2 turns up.
L8 5T #14, 5/8" long, 5/16" diameter tap 1 turn up.

Fig. 56-41. Unique 150 MHz exciter circuit uses 2N5188's exclusively. Output is about 1 watt unmodulated.

Fig. 56-42. Schematic of "Little Bill" transmitter. L1 = 13 turns No. 28 P.E. VW, L2 = 2 turns link on cold end, L3 = 13 turns No. 28 P.E. CW All coils close-wound on 6 mm diameter slug-tuned ceramic forms.

Fig. 56-43. This untuned crystal oscillator will oscillate with any crystal from 300 kHz. Frequency stability is very good because the emitter-follower buffer amplifier effectively isolates the oscillator from the load. Q1 and Q2 are 2N993, 2N1749, 2N2084, 2N2362, T1M10, GE-9, SK3006, or HEP 2.

Q1- 2N384, 2N525, SK3004, TIXM03
D1,D2- GENERAL PURPOSE SILICON DIODES

Fig. 56-44. This two frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed and this circuit provides a novel and simple way of obtaining two frequencies from a single stage with a minimum of switching.

Fig. 56-45. This variable crystal oscillator (VXO) may be used to vary the frequency of an 8 MHz crystal 4 or 5 kHz when the 365 pF dual variable is tuned through its range. When multiplied to 2 meters of 432 MHz, this provides a very stable variable frequency. For 8 MHz crystals, L1 is a 20—25 μH slug-tuned coil; L2 is chosen to resonate at 8 MHz with the 30 pF capacitor.

Fig. 56-46. Microminiature CW transmitter may be world's smallest! L and C are selected for resonance at crystal frequency.

Fig. 56-47. A 12 MHz VFO for TR22.

Fig. 56-48. A 6 or 2 meter transistor VFO with output on 24-25 MHz. The oscillator operates on 8-8.3 MHz.

Fig. 56-49. Schematic diagram of solid-state 7 MHz transceiver.

T1
10K
1 µF
33K
6 2K
2N
3391A
LOW PASS FILTER
5 6K
330
3 3K
390
1 µF
RFC1
500 µH
2N706
82K
4 7K
.01
.01
D1
5 6V
1200
pf
68K
L4
10
pf
620
1200
pf
C2
9-35
C3
50
100
pf
LOCAL OSC
BRIDGE
150
8 2K
.01
8 2K
1 MEG
220K
100K
22
4 7K
2N708
10K
.01
2N2646
.01
1N295
.01
1 5V
2N233A
390
CW MONITOR

Fig. 56-50. Novice transmitter for 80 meters.

Fig. 56-51. Solar-powered CW transmitter using tunnel diode.

Chapter 57
TV Circuits

Fig. 57-1. TV horizontal processor (NS).

Fig. 57-2. Channel selection by DC control or audio mixer (NS).

Fig. 57-3. TV channel and time display interfacing MM53100 (NS).

Fig. 57-4. TV channel and time display interfacing MM5318 (NS).

14
15
6.8k
100
INTENSITY
ADJ.
TO TV VIDEO
OUTPUT CIRCUIT
VIDEO
OUTPUT
0V
18
HORIZ.
6.8k
+12V
FROM TV
HORIZONTAL
RETRACE
0V
6.8k
18
VERT.
MM5840
VERTICAL
RETRACE
16
0.001
17
50k
HORIZONTAL
POSITION
ADJ.
21
0.1
20
100k
VERTICAL
POSITION
ADJ.
+12V
11

+24V
COLOR LEVEL CONTROL
5kΩ
33Ω
KILLER THRESHOLD ADJUST
10kΩ
1 kΩ
18 kΩ
01μF
05 μF
05 μF
ECG715
CHROMA I F AMPLIFIER
1μF
100 Ω
100 Ω
220pF
NORMAL
SET-UP
NORMAL
1kΩ
220pF
390 kΩ
2 2kΩ
SET-UP
COMPOSITE VIDEO INPUT
47pF
20 kΩ
ACC SET-UP
200pF
27kΩ
S
F
F
S
01μF
220 pF
470 pF
470 pF
B-Y OUTPUT
R-Y OUTPUT
G-Y OUTPUT
+24V
47pF
47pF
47pF
2 7 kΩ
3 3 kΩ
2 7 kΩ
3 3 kΩ
2 7 kΩ
3 3 kΩ
01 μF
ECG713
CHROMA DEMODULATOR

Fig. 57-5. Color TV chroma processing system with a PLL featuring APC and ACC (GTE).

Fig. 57-6. Color TV chroma signal processor. The ECG728 provides subcarrier regeneration and total chroma signal processing prior to demodulation. The coils of the chroma amplifier and bandpass amplifier are stagger-tuned to provide a combined typical bandpass of 3.08 to 4.08 MHz. A burst separator amplifier injects the burst signal into the 3.58 MHz oscillator. The ACC detector and killer detector sense the burst level or absence of burst, respectively, by monitoring the oscillator's response to the burst injection level. The thresholds for the ACC and killer are independently adjusted by resistors R2 and R1 at terminals 9 and 4. The chroma input is at pin 14 and the oscillator output is at pin 8. Pin 6 is a zener diode for use as a regulated voltage reference at 11.9 volts (GTE).

T1 (PRIM) = 24 μH
(SEC) = 8μH
+11.2 V REG.
0.1
1200
82
T1
CHROMA OUTPUT
1500
11
10
9
10
Cx
2-12
12
6
7
8
Z
4.7 K
OSCILLATOR OUTPUT
R1
47 K
120
39 K
R2
10
25 K
25 K
(TERM NO 6 ON
ECG728 AND/OR
TERM NO 4 ON
ECG729)
ECG128
Z
KILLER ADJUST
ACC ADJUST
0.1
10 K
220/2W
+30 V

Fig. 57-7. TV horizontal processor with phase detector, oscillator, and predriver, Suited for all types of TV receivers, this circuit features internal shunt regulator, preset hold control capability, ±300-hertz pull-in, linear balanced phase detector, variable output duty cycle for driving tube or transistor, low thermal frequency drift, adjustable DC loop gain and positive flyback inputs (GTE).

†R_Z = 6.8 k per 100 V of flyback amplitude.

ALL WINDINGS #22 AWG TINNED NYLON ACETATE WIRE TUNED WITH COILCRAFT #61 SLUGS SIZE 10-32 OR EQUIVALENT

L1 WOUND WITH 26 AWG TINNED NYLON ACETATE WIRE TUNED BY DISTORTING WINDING

Fig. 57-8. TV video IF amplifier and detector using two 8-pin DIPs. Power gain is as follows: 60 dB at 45 MHz (pin 3 open), 56 dB at 58 MHz (pin 3 open), 61 dB at 45 MHx (pin 3 bypassed), and 59 dB at 58 MHz (pin 3 bypassed). AGC range is 80 dB from DC to 45 MHz. C4 should be 0.002 µF at 45 MHz (GTE).

Fig. 57-9. Complete TV vertical circuit with AFC for 90-degree 20-inch receivers (GTE).

Fig. 57-10. TV video IF amplifier, video detector, and signal processor circuits. Used in color and B&W TVs (GTE).

All windings #30 AWG tinned nylon acetate wire tuned with high permeability cores. Complete transformer is available from Coilcraft, Type R4786

L1 wound with #26 AWG tinned nylon acetate wire tuned by distorting winding

	39 MHz	45 MHz	58 MHz
C1	24 pF	15 pF	10 pF
C2	18 pF	12 pF	10 pF
C3	33 pF	33 pF	18 pF
L1	12 Turns	10 Turns	
R1	See Operating Characteristics, "Noise Inverter" section		

Fig. 57-11. TV horizontal AFC and oscillator with sync separator for positive sync, using an ECG1086 16-pin DIP. The single transistor shown is an ECG199, a horizontal driver stage (GTE).

H.HOLD
R7
5kΩ 8 2kΩ
R8
6 8kΩ
R9
C8
100μF
R11
1.5kΩ
C10
470pF
TR
R12
1kΩ
680Ω R13
18kΩ
R16
15kΩ
R14
R15 3.9kΩ
R18
3.3kΩ
C7
0.01μF

Fig. 57-12. Color TV subcarrier generator using an ECG 1105 16-pin DIP. The ECG1105 consists of a keyed APC, an ACC, a killer detector amplifier, a burst amplifier and a subcarrier amplifier (GTE).

Fig. 57-13. TV video signal processor. The ECG1070 is a 16-pin DIP (GTE).

Fig. 57-14. TV horizontal AFC and oscillator with sync separator for negative sync, using an ECG1086 16-pin DIP. The single transistor stage is the horizontal driver and can be an ECG199 bipolar transistor (GTE).

H HOLD

R7
5kΩ 8 2kΩ
R8
6 8kΩ
R9
C8
100μF
R11
1.5kΩ
C10
470pF
TR
R12
1kΩ
680Ω
R13
1 8kΩ
R16
15kΩ
R14
R15
3.9kΩ
R10
3 3kΩ
C7
0.01μF

Fig. 57-15. Color TV chroma processor using an ECG797 16-pin QIP with AFPC, ACC, and killer (GTE).

.001μF
CRYSTAL FILTER
680Ω
20pF
10pF
33pF
3
6
7
DC CONTR BALANCED Ø SHIFTER
VCO
AMPL LIMIT
AMPL
CARRIER OUTPUT
SUPPLE VOLTAGE
V+=24V
8
0.01μF
1KΩ
270Ω
10KΩ
13
SW
ECG128
OVERLOAD DETECTOR
COUPLING NETWORK
+11.2V
12
.005 μF
.001 μF
COUPLING CAPACITOR
CHROMA OUTPUT
SECOND CHROMA AMPL
15
3.9KΩ
SW OPEN
V0=2.7V
SW CLOSED
V0=0.5V
KILLER AMPL
DELAY BIAS
BALANCE-UNBALANCE TRANSLATOR
KEYER
9
2KΩ
1V
0V
5μs WIDTH
HORIZONTAL KEY INPUT
ZENER REF
14
DELAY BIAS
11
.002μF

Fig. 57-16. TV video signal processor circuit. The ECG 1064 chip contains a first video amplifier, two sync pulse amplifiers, lock-out protector, noise detector, two noise gates, AGC detector, IF AGC amplifier, RF AGC delay clamp, RF AGC amplifier, beam current limiter and sync pulse separator (GTE).

Fig. 57-17. TV video IF output and detector with AFT and sound take-off output. All coils and transformers are standard and can be purchased at a local electronic parts jobber (Merit or Miller components). Sound output at 4.5 MHz is typically 300 mV RMS. AFT output is typically 210 mV RMS at a test frequency of 57 MHz. Typical voltage gain for the video IF is 36 dB (GTE).

Fig. 57-18. Color TV chroma processor using an ECG 1089 20-pin DIP. The ECG 1048 noted on the schematic is a chroma demodulator. The ECG703A is a 3.58 MHz amplifier (GTE).

Fig. 57-19. Color TV demodulator with color amplifiers. The ECG1131s shown are chroma signal amplifiers. The ECG1130 is a 16-pin DIP (GTE).

Fig. 57-20. Complete FM/TV 4.5 MHz sound channel using an ECG1045 14-pin DIP. Audio power output is 1.5 watts. The ECG1045 contains a three-state high-gain directional IF amplifier and a ratio detector. IF transformers and the AF output transformer are standard items and can be purchased at Radio Shack. This circuit can be modified for 10.7 MHz operation by selecting the proper IF transformers (GTE).

Fig. 57-21. Color TV chroma signal amplifier. The EGC1131 is a 16-pin DIP and consists of a chroma amplifier, an ACC amplifier, a burst gate amplifier, an ACC peak detector, a color killer, a DC chroma gain control, a DC uni-color control and a balanced sampling circuit for the burst signal. By connecting the control terminal of the uni-color and contrast terminal of the ECG1131 it is possible to control chroma gain and contrast simultaneously (GTE).

Fig. 57-22. Color TV subcarrier generator. The crystal shown is for 3.58 MHz. The ECG1131 noted on the schematic is a chroma signal amplifier. The ECG1132 is a 16-pin DIP (GTE).

Fig. 57-23. Color TV chroma processor. The ECG1158 includes the functions for chroma amplifier, oscillator, ACC, color killer and color control (GTE).

T_1:	1 (PRIMARY)	0.18 mmø	3T-3T	(BIFILAR WOUND)	0.37 μH
	2 (SECONDARY)	0.18 mmø	4T	(CENTER OVERLAPPING WOUND)	0.25 μH
T_2:		0.18 mmø	3T	(BIFILAR WOUND)	0.4 μH
T_3:		0.6 mmø	2-3/4T	(CENTER TAPPED)	0.11 μH
T_4:		0.1 mmø	27-7/8T	(BIFILAR WOUND)	22 μH
L :		0.1 mmø	21T		1.2 μH

Fig. 57-24. TV video processor. The ECG1134 contains a picture IF amplifier, a video detector, a video amplifier, keyed AGC with noise immunity, delayed AGC for the tuner, an AFT amplifier, a sound IF amplifier, a sound carrier detector, a 4.5 MHz sound carrier amplifier and a reverse AGC voltage for MOS FET tuner. Coil data is shown below schematic (GTE).

Fig. 57-25. TV vertical sync delay circuit.

Fig. 57-26. Full-wave SCR bridge power supply for color TV rated at 80 volts, 1.5 amperes. This circuit is designed for 19-inch color receivers (M).

Fig. 57-27. Low-noise TV IF system with two FET amplifiers (M).

4.5 MHz
130 pF
8K2
45.75
33 pF
10 k
1
2
3
4
5
6
7
MC1331
3k9
1.5 pF
14
13
12
11
10
9
8
22 pF
AFT
47 pF
0.001
4k7
6k8
5 pF
10 k
100
220
10 k
180 pF
33 pF
10 k
160 pF
150 pF
0.002 μF
390
41.25 MHz Trap
0.002
4.5 MHz
4.5 MHz
360
24 V
V_{CC}

Fig. 57-28. A 4.5MHz color TV sound IF amplifier using ECG703A. In a color TV the 4.5 MHz IF is not generated in the video detector as in B&W sets. A separate transistor sound detector, driven from the final video IF amplifier, is used to develop the 4.5 MHzIF. The driver transformer at the input of the chip is tuned to 4.5 MHz. The output drives a conventional ratio detector, which provides good AM rejection well below full limiting (GTE).

*L_1 = 16μH NOMINAL, $Q_{(UNLOADED)}$ = 50

Fig. 57-29. TV FM sound system using the ECG712. The supply terminal can be connected to any supply voltage with a suitable dropping resistor provided that the dissipation rating, 400 mW, is not exceeded since the ECG712 has internal zener regulation. Besides TV, the circuit can be used for FM mobile communications. It also enjoys DC volume so no shielding is necessary (GTE).

Fig. 57-30. Typical ECG746 video IF amplifier and ECG747 low-level video detector circuit (GTE).

Fig. 57-31. Color TV chroma demodulator. The ECG1048 is a 14-pin DIP with an end metal tab. The ECG1089 partially shown is a color processor chip (GTE).

Chapter 58
Video Amplifiers

Fig. 58-1. Video amplifier with AGC using an MC1552/1553 wide-band amplifier (M).

Fig. 58-2. Video amplifier with AGC using an MC1553 wide-band amplifier (M).

Fig. 58-3. Video switch. With a logic one at pin 1 the amplifier is turned on (M).

Fig. 58-4. 30 MHz video amplifier using an MC1552G. Set R to 1K for a voltage gain of 55 (M).

Chapter 59
Voice Communications

This figure shows the LM1596 used as a single sideband (SSB) suppressed carrier demodulator (product detector). The carrier signal is applied to the carrier input port with sufficient amplitude for switching operation. A carrier input level of 300 mVrms is optimum. The composite SSB signal is applied to the signal input port with an amplitude of 5.0 to 500 mVrms. All output signal components except the desired demodulated audio are filtered out, so that an offset adjustment is not required. This circuit may also be used as an AM detector by applying composite and carrier signals in the same manner as described for product detector operation.

Fig. 59-1. SSB product detector (NS).

Fig. 59-2. Suppressed carrier modulator (NS).

Fig. 59-3. FM scanner noise squelch circuit (NS).

Fig. 59-4. Amplitude modulator (NS).

Fig. 59-5. Typical amplitude modulator circuit.

Fig. 59-6. Frequency modulator (self-excited oscillator).

Fig. 59-7. Flea-powered CW transmitter.

Chapter 60
Waveform Generators

* PIN CONNECTIONS SHOWN ARE FOR METAL CAN.

Fig. 60-1. Pulse width modulator (NS).

Fig. 60-2. Square wave oscillator (NS).

Fig. 60-3. Sawtooth generator (NS).

Fig. 60-4. Free-running staircase generator pulse counter (NS).

(V^+ = 15 VDC)

Fig. 60-5. Triangle/square generator (NS).

Fig. 60-6. Pulse generator (NS).

Fig. 60-7. Triangle waveform generator (NS).

Fig. 60-8. Time delay generator (M).

$$f = \frac{K \times V_{IN}}{8V^{+}C1\,R1}, \quad K = R2/R'2, \quad \frac{2V_I}{K} \leq 25V, \; V^{+} = V^{-}, \; V_S = \pm 15V$$

Use LM125 for ±15V supply

The circuit can be used as a low frequency V/F for process control.

Q1, Q3: KE4393, Q2, Q4: P1087E, D1–D4 = 1N914

Fig. 60-9. Triangular, squarewave generator (NS).

Fig. 60-10. Programmable Pulse generator (M).

Fig. 60-11. Pulse generator (astable multivibrator) with provisions for independent control of "ON" and "OFF" periods (RCA).

Fig. 60-12. Function generator—(frequency can be varied 1,000,000/1 with a single control) (RCA).

Fig. 60-13. Squarewave generator (NS).

Fig. 60-14. Pulse generator uses unijunction. Pulse width is determined by base 2 inductance. Rise and fall times will be 2-5% of pulse width.

Fig. 60-15. Universal frequency generator divides input signal (1 MHz master oscillator, crystal oscillator, or any external sine-wave source) by factor of 10 or 2. Note gates driving LEDs, which light to indicate crystal is oscillating. (Output frequencies shown are for 1 MHz oscillator.)

Schematic Diagram Notes

L1 – toroid coil 1/2" od "E" material core. Amidon associated core T-50-2. Winding 45 turns number 28 enamel wire spaced over entire core.

C1 – 100 pF maximum variable capacitor. Johnson type S 148-6 or equivalent. Remove plates as required to provide desired bandspread.

C2 – Silver mica – approximately 300 pF. Adjust exact value to set lower tuning range to 3.5 MHz.

C3, C4 – Silver mica 2000 pF.

C5 – Miniature electrolytic 1 μF at 10 VDDW.

L2 – 40 turns number 28 enamel wire on 3/8 diameter slug tuned form.

CR2 Zener diode, 1N708 – 5.6 volts. (Motorola HEP-103 usable)

BA1 9 volt transistor battery

J1 Miniature jack

P1 Two prong plug with standard .486 pin spacing for crystal sockets or other to match companion transmitter.

Q1, Q2, Q3, Q4 2N706

Q5 2N697

Fig. 60-16. Variable-frequency oscillator operates over 75-80 meter range (about 3.5 MHz).

Fig. 60-17. Sync generator circuit with waveforms at representative test points.

Fig. 60-18. Crystal oscillator for 45 MHz.

Fig. 60-19. This simple sawtooth generator could be added to a monitor oscilloscope.

Fig. 60-20. Pulse generator with 25% duty cycle.

Fig. 60-21. This simple sawtooth generator is linear within 2% and may be adjusted from 1 kHz to 3 kHz with the center frequency control. Q1, Q3, Q4 and Q6 are FETs such as the 2N3819, 2N3820, T1S34, MPF105 or HEP 801; Q2 is a 2N388, 2N2926, 2N3391, SK3011 or HEP 54; Q5 is a 2N1671, 2N2160, 2N2646, 2N3480, or HEP 310.

Fig. 60-22. A 455 kHz modulated, regulated output signal generator.

Fig. 60-23. Crystal calibrator. This circuit gives symmetrical square waves out on 100, 50 25, and 10 kHz. The frequency switch may be any distance from the totally shielded calibrator, as the lines have only dc levels.

COILS

Frequency	Miller No.
65 kHz—140 kHz	9007
95 kHz—190 kHz	9006
150 kHz—300 kHz	9005
190 kHz—550 kHz	9004
380 kHz—1000 kHz	9003
700 kHz—1.8 MHz	9002
1.4 MHz—3.7 MHz	9001
3.7 MHz—4.7 MHz	4508
4.7 MHz—5.9 MHz	4507
5.9 MHz—7.5 MHz	4506
7.5 MHz—10 MHz	4505
10 MHz—14 MHz	4504
14 MHz—18 MHz	4503
18 MHz—23 MHz	4502
23 MHz—29 MHz	4304
29 MHz—36 MHz	4303
36 MHz—45 MHz	4302
45 MHz—60 MHz	4301

Fig. 60-24. A sweep frequency generator is a very handy gadget, but many times the commercial units are more complicated than required. This simple sweeper may be used at any spot frequency between 100 kHz and 60 MHz. By using a three-position range switch, the three most popular frequencies may be used, such as 455 kHz, 1600 kHz, and 10.7 MHz. Q1 is a 2N1671, 2N2160, 2N2646, 2N3480, or HEP 310; Q2 is a 2N741, 2N1747, 2N2188, GE-9 or HEP 2. The varactor is a 56 pF capicitance diode such as the 1N955 or TRW V56.

Fig. 60-25. A simple sine-wave generator.

Fig. 60-26. Complete square-wave generator. Bandswitching capacitors are 10% or tolerances. Resistors are ¼ watt.

Fig. 60-27. 567 IC makes simple dual square-wave source. Note 80° phase shift between waves.

Fig. 60-28. A 2000 Hz test oscillator. L1 is commercial 180 mH coil with about 80 added turns.

Fig. 60-29. Simple sweep generator for monitor scopes provides 30 Hz sawtooth from NE2 neons.

Fig. 60-30. This signal injector/tracer switches from the injection mode to a signal tracer by simply plugging in a pair of high-impedance magnetic earphones. As a tracer, it works from audio up to 432 MHz. Transistor Q1 is a 2N170, 2N388A, 2N1605, SK3011, or GE-7; Q2 is a 2N188A, 2N404, 2N2953, SK3004 or HEP 253.

Fig. 60-31. Extremely stable signal generator provides output in range from 1.8 to 450 MHz at impedance of 50 ohms; output is adjustable from 80 nV to more than 50 mV rf.

Fig. 60-32. Square-wave generator will operate over a wide frequency range from audio to rf. Capacitor and pot control frequency.

D1,D2 = 1N34 or other germanium.
Q1,Q2 = μL914 or equivalent.

Fig. 60-33. Circuit shown above provides a square-wave output from Q2 whose audio frequency is changed alternately by action of multivibrator Q1. The resulting warbling note provides an excellent burglar alarm.

Fig. 60-34. Oscillator with double frequency output.

Fig. 60-35. Precision oscillator with 20 nsec switching.

Fig. 60-36. Pulse generator (S).

Fig. 60-37. A 45 MHz oscillator and tripler section.

Fig. 60-38. SSTV ramp generators. This circuit will give an extremely linear ramp for SSTV monitors, cameras, and flying spot scanners. The voltage varies from ≈ −10 to +10V. A positive going pulse of +2 to +5V amplitude resets the ramp for the next sweep.

Fig. 60-39. Schematic of the ramp generator circuit.

Fig. 60-40. Schematic of the triple-wave output signal generator.

Fig. 60-41. Signal generator/amplifier.

L1 = 5T #16, 3/8 in DIA
CENTERTAPPED
OUTPUT TAP, 1 TURN UP
FROM COLD END

COIL TABLE		
FREQUENCY	DIAMETER	WINDING
7 MHz	7/8"	26 TURNS-1 1/8" LONG
14 MHz	7/8"	7 TURNS-1/2" LONG

GENERAL NOTES ON SCHEMATIC-FIG 3

ALL FIXED RESISTORS ARE 1/4 WATT COMPOSITION
.001 AND .01 CAPACITORS ARE DISC CERAMIC
CAPACITORS MARKED "SM" ARE SILVER MICA R1
AND R2 STANDARD CARBON ELEMENT POTENTIOMETERS
C2, C3, AND C4 ARE ELECTROLYTICS-25WVDC OR MORE

Fig. 60-42. Sweep oscillator circuit.

Index

A

AC control, half-wave 550
flasher circuit 348
meter 269, 270, 271
overload circuit breaker 460
power control circuit 573
switch, high-low 552
voltage regulator 599
AC-coupled noninverting amplifier 88
AC/DC converter 236
voltmeter 722
Active filter 318, 319
Active tone control 126, 127
3-band 25
Active-low-pass filter 32
A/D add/subtractor 185
A/D converter 12, 13, 186, 187, 188
8-bit 10
12-bit 11
ADC 198
Adjustable high voltage regulator 596
Adjustable Negative
Voltage Regulator 595
Adjustable output regulator 578
Adjustable reference supply 580
Adjustable regulator 590
4V 592
with ripple rejection 593
Alarm, frequency-
sensitive photo-activated 530
AM broadcast-band receiver 43
radio power amplifier 24, 442
wireless transmitter 766
Amplifier 91, 93, 100, 102,
107, 109, 306
cathode-driven 635
50MHz transmitter power 643
5-watt 93
40m, 75W 641
40m, 200W 640
40-watt—8-ohm,
60-watt—4-ohm 106
high-slew-rate power 487
low-drift low-noise 494
single sideband
linear power 644
20-watt—8-ohm,
30-watt—4-ohm 117
2-meter 643
voltage-controlled 90, 478
with bass boost 81, 91, 118
with gain of 50 90
with gain of 200 82
Amplifiers 305
Amplitude modulator 298, 843
Amplitude modulator circuit 843
Analog Devices 284-J
isolation amplifier 162
AND gate 179
Antenna impedance bridge 297
Antenna input resistance 748
Antenna switch 314
Antenna tuner, Z-match 700
Antennascope 297
Arc tangent function 423
Astable multivibrator 706
Asynchronous data entry 365
Attenuator circuit 716
Audible voltmeter 711
Audio amplifier 11, 113, 120
Audio compressor 133
Audio conditioning unit 144
Audio decoder 233
Audio fence for animals 347
Audio frequency meter 299, 730
Audio frequency
meter/tachometer 299
Audio generator 695
Audio mixer 442
Audio preamplifier compressor 142
Auto headlight reminder 155
Auto wiper control 156
Automatic gain control amplifier 95
Automatic light turn-on 340
Automobile immobilizer 153
Auxiliary agc detector 278
Auxiliary agc diode 277
Average voltage control circuit 575

B

Balanced line driver 420
Bandpass active filter 323
Bandpass filters 322
Bar display
with alarm flasher 623, 626
Battery charger 158, 159, 160
Battery-level indicator 360
Battery-threshold indicator 358
BCD A/D converter 182-183
BCD DAC 189
Bedside light 346

Beeper, schematic 773
Beta tester 723
Bicycle lighting system 336
Binary DAC 190-191
Boosted current polarity inverter 369
Bridge amplifier 80, 94, 108, 111, 169, 170, 171, 172
Bridge balanced modulator 290
Bridge sensor, transmitter for 455
Broadband audio amplifier 121
Broadband frequency doubler 328
Buffer amplifier, 10X 86
Buffered accumulator 184
Buffering circuit 377
Burgular alarm 16, 17, 18
Buzz Box continuity & coil checker 692

C

Calibrator, 100 KHz 745
Capacitance meter 699, 725
Capacitive discharge ignition system 149
Capacitor, testing 742
Capacitor values 228
Capacity meter 729
Car door light delay 151
Carrier shift meter 694
Carrier-current remote control 332
Carrier-operated relay 223
Cascade preamplifier circuit 53
Ceramic cartridge amplifier 124
Channel selection 798
Cheaper differential amplifier 405
Circuit 406-407
difference-of-squares 427
divide-by-N 386
one-shot 385, 387
Circuits 273, 279, 304, 310
Clamp diodes 272
Clicker circuit 336
Clickless attenuator/amplifier 193
Clipper/preamplifier 146
two-stage 141, 142
Clippers 287
Clipping 288
Clipping amplifier 500
Clock schematic diagram 392
Color TV chroma demodulator 835
Color TV chroma processing system 803
Color TV chroma processor 818 822, 827
Color TV chroma signal amplifier 825
Color TV chroma signal processor 804
Color TV demodulator 823
Color TV sound IF amplifier 832
Color TV subcarrier generator 814, 826
Colpitts crystal oscillator 770
Command oscillator, 1800 Hz 780
Compact VOM circuit 727
Comparator, high-speed 415
Compatible voltage controlled oscillator 509
Compensation circuit, line-voltage 541
Composite op amp, differential-input 499
inverting-only 501
Compressor 135, 136, 287
Compressor/expander amplifiers 504
Constant current regulator 591
Continuity tester 703
Continuous-tone encoder 215
Control amplifier 395
Controller 393
Conventional agc system 308
Conventional silicon diodes 274
Converter 154, 236, 238, 240, 241, 243
50 MHz 57, 74
440 MHz 72
simple 55
2-meter 44, 60, 76, 77
220 MHz 71
two-transistor 48
Converters 239
Converter schematics 36
COR circuit 209, 217, 231
Cosine function 430
Counter 389, 399
circuitry 378
flip-flop 403
front end" 414
power supply 409
time base 395
Counters 380
Crystal calibrator 737, 860
Crystal checker 709
Crystal oscillator 513, 520, 738, 775, 782 857
10 MHz 772
two freqeuncy 762, 764
785, 791
2-meter 770
untuned 771, 791
variable 792
Crystal oscillator calibrator 733
Crystal oscillator circuit, ultrahigh-stability 774
Crystal set receiver, advanced 35
simple 34
Crystal standard 395
Crystal tester schematic 731
CTCSS, tone decoder 222
Current mode multiplexer 470
Current source 608
CW final amplifier 247
CW monitor 734
CW transmitter 293
flea-powered 845
solar-powered 796

D

D/A converter 197
DC/DC converter 242, 244, 245
DC differential amplifier 89
lamp chaser 341
motor speed control 549
overload circuit breaker 459
power control circuit 568
relay 210
servo amplifier 657
Decimal counting unit 376
Decoder 216, 225, 227, 230
touch-tone 667
Delay switch, 100-cycle 665
Delayed agc 309
Delayed dropout relays 209
Detector 260, 262, 275
Differential amplifier 87, 490
Differential comparator circuit 393
Differential light detector 457
Differential thermometer 756
Differential, with low-noise output 489
Differentiator 492
Digital clock 416
Digital data transmission 250
Digital electronic die 351
Digital frequency counter 694
Digital IC tester 740
Digital interlaced sync generator 383

Digital musical notes 481
Digital numbers, analog sum 197
Digitally programmable
limit detector 260
Digitally programmed
level detector 196
Diode checker, super-simple 704
Diode checks 698
detector 62
mixer 274
noise generator 300
receiver 69
ring balanced modulator 282
squelch 278
switches 291, 292
Diodes 280, 289, 293, 302, 305, 308, 312, 314
bargain pack 722
Dip meter 691, 743
Direct frequency modulation 289
Distortion amplifier 83
Divider circuit 422, 431, 432, 433
Divider, with
digitally controlled gain 429
Dot mode display 620
DPM schematic diagram 679
DPM 3½-digit 686
Driving liquid crystal display 625
Dual power supply 578
Dual square-wave source 863
Dual trimmed supply 594
Dummy load 296, 731
DVM adapter 384
DVM, 3½-digit 684
Dwell/tachometer 148
Dynamic range compressor 143

E

ECG955M timer/oscillator chip 259
ECG746 video IF amplifier 834
Echo annunciator 612
ECL Termination regulator 598
ECL to TTL interface 366
Edge detector circuit 404
EKG input amplifier 166
Electric appliance power control 536
Electromechanical
control system 217
Electromechanical latching relay 225
Electronic crowbar circuit 559
Electronic disc 354-355
Electronic regulator 150
Electronic roulette wheel
counter decoder logic 350
Electronic siren 338
Electronic temperature sensor 19
Electronic thermostat, three-wire 754
Electronic, timer 758
Emergency lantern/flasher 463
Emergency lighting system 339, 344
Emergency road flasher 148
Emitter bypass capacitor 312
Emitter follower 134
Encoder 194-195, 216, 230
Envelope detector 258, 261
Exclamation point display 622
Exciter circuit 789
Existing audio compressor 137
Expanded scale meter 441
Extended range VU meter 670
External reference connection 196

F

Fast summing amplifier 87
Feedback control circuit 558
Feedback network 403
Feed forward amplifier,
unity-gain 503
Feedforward frequency
compensation circuit 491
FET 772
FET AGC circuit 492
FET preamplifier, dual-gate 43
Field-strength meter 293
Filters 320
Finger touch switch 664
Fire alarm 660
Fixed 5V regulator 589
Fixed output regulator 577
Flame detector 659
Flasher, 1 5 V 462
12V 154
Flashlight finder 439
Flickering flame effect 335
Flip-flops 400
Floating voltage
controlled resistor 449
Fluorescent lamp 342
FM detector 44
FM discriminator 282
FM preamplifier 2-meter 63
FM receiver 23
FM scanner noise
squelch circuit 842
FM wireless transmitter 767
FM/TV 4 5 MHz sound channel 824
Forward transistor agc 277
4CX250 amplifier 638
Four-quadrant multiplier 327
Free running multivibrator 473
Frequency
averaging tachometer 461
Frequency comparator 385
Frequency compensation circuit 487
single pole 503
two pole 500
Frequency counter 384
block diagram 412-413
schematic 410-411
Frequency counter input 389
Frequency dif-
ferencing tachometer 461
Frequency doubler 327, 329, 330
Frequency modulator 844
Frequency multiplier 326, 391
Frequency shift keyer 616
Frequency standard
wiring diagram 382
FSK, self-generating 617
FSK demodulator 614
with DC resoration 615
Function generator 853

G

Gated amplifier 486
General-purpose amplifier 84
Generator, one-pulse-
per-second 408
sine-wave 862
single-control function 683
square-wave 862, 865
Grid block keying 248
Grid dip meter 721
Ground referred
centigrade thermometer 755
Ground referred thermometer 755

H

Hand agc 315
Hearing aid 335
Hearing aid battery 211
Heart rate monitor 164-165
Heater control 206
HF power amplifier 633
Hi-fi power amplifier 96
High pass filter 317
Hold circuit 254
Hot-carrier-diode converter 75

H23 oscillator 772
HV regulator 606

I

I-f amplifier 122
I-f stage, 30 MHz 35
Impedance bridge, portable 706
Incandescent bulb flasher 440
Incandescent light dimmer 339
Indicator and alarm 624
Inductance meter, direct-reading 718
Induction motors 554-557
Infrared sensitive detector diode 659
Input voltage 312, 313
Instrument amplifier 497
Instrumentation amplifier 97, 496
Integrator 362
Intercom 332, 442, 445
Interface 366
Interval timer 759
Inverter, DC-to-AC 368
Inverting amplifier 84, 97, 488 505
Inverting unity-gain
high-slew-rate circuit 506
IRIG channel 13 demodulator 458
Isolated voltage sensor 20
Isolation amplifier 162, 167

J

James Dandy mixer 298
JFET chopper 175
preamplifier 66
speech amplifier 28

K

Key click filters 247
Kilowatt linear amplifier 638

L

Laboratory power supply 583
Lamp dimmer 311
high-intensity 559
Lamp driver 403
Lamp flasher 454
Lazy man s
switch schematic diagram 343
LC checker, wide-range 690
LED booster 466
voltage 703
Level conversion circuits 243
Level detector 259
LF11300, MM5330 DPM 677
Light controller 200, 524
Light dimmer low-cost 561
time-dependent 542
Light level sensor 15
Light meter 672, 675
Light-level controller 204
Light-operated 6kV series 528
Limiter 280
Linear amplifier 636
10-meter 642
Linear IC tester 741
Linear voltage-
controlled oscillator 515
Little Bill transmitter 790
LM frequency meter 726
LM387 bandpass active filter 323
LM387 feedback tone controls 129
Load interface 544, 560
Log display 619
Logarithmic amplifier 371, 372, 702
Logarithmic light sensor 15
Logic converter 241
Logic driver,
photo-activated 526, 527, 529
Loop, phase-locked 450, 453
Low current bar mode display 621
Low-frequency doubler 329
Low-speed counter 397

M

Magnetic transducer 256
MC1556 op amp 372
MC1539G op amp 371
Metal locator 334
Meter 293, 303
field-strength 705, 723
20-segment 440
zero-center 441
Meter amplifier 99
Meter thermometer 751
Microminiature CW transmitter 792
Microphone amplifier 100, 143
Microphone preamplifier 133
Microswitch vehicle immobilizer 152
Milliwatt transistors 748
Milliwattmeter 724
Minimod schematic 788
Minimum load current 599
MOC3011 triac drivers 574
Modulation percentages 733
Modulator 290
MOS clock driver 419
MOS memory sense amplifier 103
MOSFET analog switching circuit 174
MOSFET chopper 177
Motor control circuitry 539
Motor drive 333
constant-current 565
two-phase 446
Motor speed control 201, 204
Motors series-wound 548
shunt-wound 573
Multilead EKG recorder 163
Multiple feedback
bandpass filter 319, 324
Multiple output
switching regulator 181
Multiplexer 469
two-channel 469
Multiplication, one-quadrant 428
two-quadrant 433
Multiplier, mixer squaring,
amplifier schematic diagram 396
with discrete level shift 426
with op amp level shift 424
Multiplier circuit 425, 435
Multivibrator, bi-stable 475
one-shot 473, 474

N

NAB tape preamplifier 118
Negative peak detector 254
Negative regulator 584
Noise limiter 281, 284, 285
Noninverting amplifier 116, 493, 498
Noninverting op amp 505
Nonlocking scanner 391
Notch filter 318, 321
Novice receiver 68
Novice transmitter 796

O

Ohmmeter, full circuit diagram 703
On/off touch switch 333
Oneway switches 302
Op amp 494, 504
fast-settling 501
improved 483
low-drift 484
low-frequency 483, 484
unity-gain 489, 493
with FET AGC circuit 492
with high bandwidth 497
Op amp speech amplifiers 31

Operational amplifier 79
general-purpose 498
unity-gain 502
OR gate 180
Oscillating ring counter 382
Oscillator 215, 231
and tripler section 868
beat-frequency 763
frequency-standard 378
low-distortion power Wien-bridge 509
lumped-line 708, 714
1 0-MHz 520
superstable variable-frequency 778
two-decade high-frequency voltage-controlled 512
variable-frequency 856
voltage-controlled 387 512, 514
with double frequency output 517, 866
with quadrature output 510
Oscillator circuit 63
Oscillator circuits 727
Output, square-wave 721, 866

P

Paging decoder 219
Panning circuit 128
Peak detector 254
Percent of deviation ratio computer 428
Percentage computer 432
Performance monitor 707
Phase detector 385
Phase shift oscillator 508
Phone monitor, full time 668
Phono amplifier 110 119
Phono preamplifier 110
Phonograph amplifier 123
Photocell compressor/agc circuit schematic 134
Photodiode amplifier 98
Photodiode detector 258
Photovoltaic cell amplifier 89
PLL 391
Polarity switcher 397
Pole butterworth 324
Positive floating regulator 600
Positive peak detector 255
Positive regulator 601, 609
Positive voltage regulator 584
Postinjection marker circuit 715
Power amplifier 81 92, 532
with control circuits 534
Power comparator 466
Power control 207
Power control circuit, full-wave 569
Power controller, hysteresis-free 560
Power generation circuit 421
Power op amp 485
Power supply 304, 594
Power timer zero stand-by 758
Preamplifier 42, 61, 69
high-impedance 40, 58, 631
low-frequency 49
low-noise 2-meter 59
low-noise 220 MHz 59
six-meter 54
two-meter 47, 49
Preamplifier and tone generator, combination 140
Preamplifier clipper circuit 131
Preamplifier current booster 128
Preamplifier/RIAA 117
Precision null meter 671
Precision oscillator 867
Precision oscillator drive 517
Precision regulator 606
Probe, high-impedance 698
Process control interface 364
Product detector 276
Programmable counter 402
Programmable divider 388
Programmable 1A power supply 581
Programmable peak detector 192
Projection lamp voltage regulator 567
Proportional controller 571
Protected high-voltage regulator 582
Pulse generator 302, 401, 849, 852, 854 858, 867
Pulse shaper 405
Pulse stretcher photo-driven 525
Pulse width modulator 847

Q

Q-multiplier 68
QRP transmitter 765
Quad MOS clock driver 180 184

R

Radio single-stage solar-powered 522
two-stage, solar-powered 522
Radio pager 337
Radio receiver 34
Ramp and hold 448
low-drift 452
Ramp generator circuit 870
Ramp/pulse voltage-controlled oscillator 518
Range 315
Ratio detector 283
Rear speaker ambience amplifier 112
Receiver 67
high-performance 628-629
light-beam 523
Receiver converter 55 70 73
Receivers, dual-conversion 785
Rectifier circuits 264
Reflected power meter 734
Reflex game 352-353
Regenerative detector 720
complete schematic 56
Regenerative receiver 41, 65
Regulated DC motor control 553
Regulator, high-stability 590
high-stability 1A 577
– 5V 596
– 5 0 Volt, 10-ampere 608
– +15 Volt 607
slow turn-on 15V 597
10 587
10A 595
with foldback current limiting 588
with plastic boost transistor 586
with protective diodes 589
with short circuit protection 604
Relay 211, 213, 223, 313
light-operated 529
Relay circuit, solid-state 568
Relay driver with strobe 448
Remote AC electronic thermostat 753
Remote alarm circuit 17
Remote amplifier 82
Remote control 537, 539, 567
Remote sensing digital thermometer 752
Remote speed switch, two-wire 663
Remote temperature sensing 20
Remote thermocouple amplifier 83
Repeater control system 221
Resistance decade 738, 742 743
Resistance thermometer transmitter 753
Resistive loads 393
Resistor values 228

Resistors 265
Resynchronizer 377
Retriggerable one-shot 516
Reverse agc 309
Rf amplifier 639
Rf detector 300, 697
Rf power amplifier schematic 644
Rf preamplifier 37, 42, 46, 65
150 MHz 67
28-MHz 62
Rt sniffer 295
Rf wattmeter 731
0 025 to 10W 718
Rf wattmeter metering circuit 728
RMS circuit 430
RMS closed-loop
voltage compensator 538
RMS open-loop
voltage compensator 543, 571
RMs regulator 540
RTTY circuit 65
RTTY converter circuit 61

S

Sample & hold circuit 646
high-speed 647
low-drift 649
negative peak detecting 648
Sample log c board tlip-flop 399
Sawtooth generator 301 848, 858 859
Scanner circuit, 4-channel 30
SCR alarm,
light-operating 526
SCR alarm circuit,
light-relay-operated 525
SCR bridge power
supply, full-wave 829
SCR full-range power controller 558
Selective calling decoder 212
Sensitive rf voltmeter 696
Series chopper 175, 176
Series-shunt chopper 174 176
Servo motor amplifier
line-operated 651
Servo motor power amplifier 656
Servo motor preamplifier 652
Shooting gallery 356
Shortwave converter tunable 48
Shunt diode noise limiter 283, 284
Shunt rectifiers 265
Shunt regulator 600
with crowbar 580
Sideband-generating crystals 291
Signal generator 744, 860
pocket size 692
triple-wave output 871
Signal generator/amplifier 872
Signal injector 704
Signal injector/tracer switches 864
Silicon diodes 267
Sine function 423
Sine wave oscillator 514
crystal-controlled 513
Single amplifier VCO 510
Sinusoidel voltage-
controlled oscilaltor 519
Siren 443
2-tone 66 464
Smoke alarm 661
Solid-state timer 780
Sonar applicetion 611
Speech compressor 132
Speech processor 138-139
Speech simuletor schematic 141
Speed control, plug-in 551
Square root of the
sum of the squares circuit 435
Square rooter 434
Square rooter circuit 422, 434
Square wave oscillator 508, 515, 847
Squarewave generator 854
Square-wave source 716
Square waver, 60Hz 708
Squelch circuit 28
Squelched preamplifier 131
SSB/CW reception 279, 315
SSB i-f noise limiter 281
SSB product detector 840
SSTV frequency standard 397
SSTV ramp generators 869
Stable signal generator 865
Staircase generator
pulse counter 848
State Siren 451
Static switch, three-position 564
Stereo amplifier 114, 115
Stereo phonograph
emplifier 101, 105
Stereo volume control 23
Subaudible tone generator 232, 234
Summing amplifier 504
Superhet receiver,
single-conversion 50-51
Superregenerative receiver 69
one-transistor 37, 56
Suppressed carrier modulator 841
Sweep frequency generator 861
Sweep generator 746, 864
unijunction-transistor 720
Sweep oscillator circuit 732, 873
Switch, transmit-receive 311
Switch & amplifier
voice-activated 27
Switching power amplifier 532, 533
Switching regulator 585 588 591, 593 602 603
Switching transistors,
high-speed 852
SWL receiver 38-39
SWR bridge 297 697
Sync generator circuit 857
Synchronous AM demodulator 252
Synchronous data entry 365
Synchronous divide-by-5
up counter 379
Synchronous divide-by-6
up counter 379
Synchronous divide-by-2 counter 378
Synchronous handshake 364

T

Tachometer 447
Tepe palyback amplifier 119
Tape preamplifier 109
Tape recorder 444
Telephone ring relay 210
Temperature control circuit 203
Temperature controller 200 202 203, 205
Temperature sensor 21
Test generator, dual-tone 719
Test oscilletor 863
Thermocouple amplifier 85
Thermocouple transmitter 465
Thermometer 752
for negetive supply 750
for positive supply 750
with meter output 751
Three tone doorbell 346
Three transistor radio 630
Thyrister half-wave
control circuit 551
Time base schematic diagram 390
Time delay generator 850
Timing signel 398
Tone decoder 208, 226
with relay output 456

Tone encoder 229
Tone generator 214, 220
Tone oscillator 226 227
Tone-burst entry 224
Tone-burst repeaters 228
Touch switch 545
Touch-tone decoder 29, 218
Tracking preregulator 598
Tracking regulator 579
Transceiver, continuous-wave 787
solid-state 7 MHz 794
Trensducer amplifier 95
Transistor beta 746
Trensistor beta tester 728
Transistor, line
quadrature-generator 724
Transistor perameter trecer 747
Transistor rf power amplifier 637
Transistor sorter 745
Transistor transmitter 784
Transistor VFO 780, 793
Transistorization operation 772
Transmitter 303
double-sideband 768
50-MHz 782
50 MHz 40W 781
light-beam 523
100 mW 6 meter 763
remote-control 457
6-meter 777
3-watt 10 meter 776
2-meter 765 768
2½W 6m 783
Transmitter testing 296
Tremelo circuit 478
Trf receiver 45
Triac AC stetic contactor 564
Triac control circuit 537, 563
240-volt 572
Triac full-wave control circuit 552
Triac heater temper-
ature control circuit 562
Triac light dimmer 562, 566
Triac motor speed control 566
Triac overvoltage
protection circuit 561
Triac relay-contact
protection circuit 548
Traic solid-state relay circuit 547
Triac static motor-starting switch 544
Triac switch, AC-controlled 565
low-voltage-controlled 570
Triac temperature-
sensitive heater control 542
Triac zero-point switch 550
Triangle waveform generator 850
Triengle/square generator 849
Triangular
squarewave generator 851
Triengular/square wave
voltage-controlled oscillator 511
Trigger circuit, full-wave 575
Trough limiter 285
True instrumentetion amplifier 674
True rms converter 237
TTL clock generator 374
TTL one-shot 415
TTL to ECL interface 366
Tuner, overall schematic 701
Tuner circuit diagram, 10-meter 64
Tunnel-diode converter 46
TV channel and time display799-802
TV FM sound system 833
TV horizontal AFC 812, 816
TV horizontal processor 798, 806
TV IF system, low-noise 830
TV sweep linearity 695
TV vertical circuit 809
TV viedo IF amplifier 808, 810
TV video IF output & detector 821
TV video processor 828
TV video signal processor 815
TV video signal processor circuit 820
Two-channel search-lock 394

U

UHF oscillator 775
Unity gain amplifier 85
Universal frequency generator 855
Up counter 389
Up counters 380

V

Vacuum tube 307
Vacuum tube Pierce oscillator 764
Varactor 286
Varector doubler 289
Varactor tripler 292, 310
Variable AC, full-wave 570
Variable crystal-controlled
oscillator circuit 767
Variable flasher 463
Variable frequency oscillator 771
Varieble gain amplifier 79
Variable output regulator 605
Variable output
switching regulator 586
Variable speed control 554
Vector computation circuit 436
Vector computer 429
Vector magnitude function 431
Versatile premodulation
speech processor 145
VFO, stable 769
12 MHz 793
VFO & power supply, schematic 779
VHF amplifier 735
VHF prescaler 739
VHF prescaler 736
VHF TV tuner 52
VHF wavemeter FSM/monitor 296
Vibration meter 693
Video amplifier 837
30 MHz 838
Video DC restoring amplifier 88
Video switch 838
Visible voltage indicator 359
Visual metronome 477
Voltage comparator 488
Voltage controlled low-pass filter 317
Voltage feedback control circuit 569
Voltage follower 486, 495, 499 506
unity-gain 495 496
Voltage monitor, double-ended 467
single-cell 454
Voltage regulator circuit 587
Voltmeter, 3½-digit 681
Voltmeters 717
VOX/mike preamplifier 130
VTVM, sensitive low-cost 682
VU indicator, peak-reading 689

W

Warning flesher 438
Wattmeter 296, 705 729
Wavemeter 295
Weighted averaging amplifier 490
Wide range AC voltmeter 673
Wide range trecking regulator 604
Wideband amplifier 103
Wideband power amplifier 533
Window detector 257
Windspeed indicator 345
WWVB frequency comparator 713

Z

Zener 267
Zener regulator 266
Zener regulators 268
Zener voltage 312

PLEASE RETURN TO
The Seattle Public Library
PLEASE RETURN TO
PLEASE RETURN TO
PLEASE RETURN TO

p 237 - Converter for rms

±15V ‖ section 235 - 245

p 244 - DC to DC converter ±15V

555

INVerters p 367 - 370

p. 368 - ±12V DC To 115V, 60 Hz

100W output

see Fig 11-13