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The GIANT Handbook Of
**Electronic
Circuits**

Edited by Raymond A. Collins

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TAB **TAB BOOKS Inc.**
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SCIENCE

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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.

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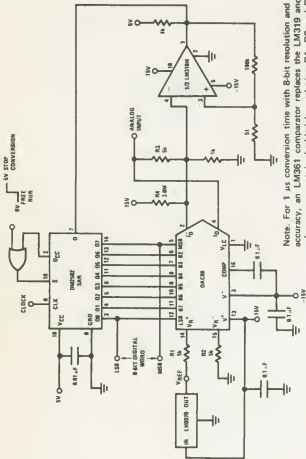
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Chapter 1
A/D-D/A



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).

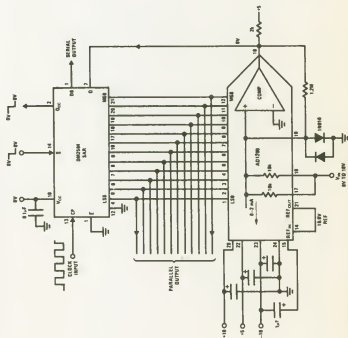


Fig. 1-2. High-speed 12-bit A/D converter (NS).

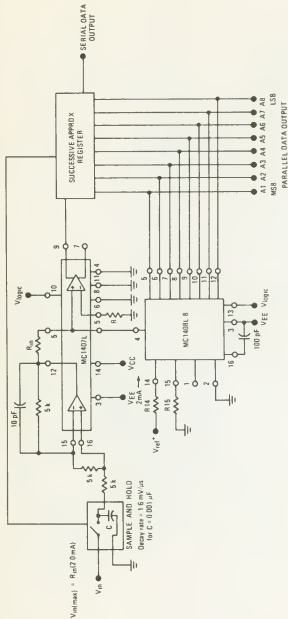


Fig. 1-3. Successive approximation A/D converter (M).

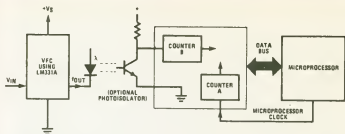


Fig. 1-4. A/D converter with a microprocessor (NS).

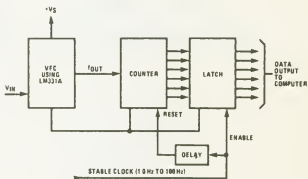
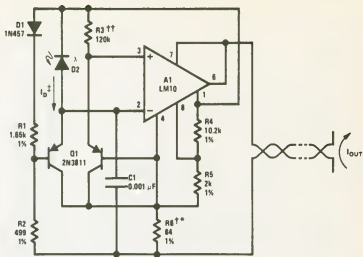


Fig. 1-5. Basic A/D converter using a voltage-to-frequency converter (NS).

Chapter 2
Alarms, Sensors
and Triggering Circuits



$$1 \text{ mA} \leq I_{out} \leq 5 \text{ mA}$$

$$150 \mu\text{A} \leq I_D \leq 500 \mu\text{A}$$

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

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

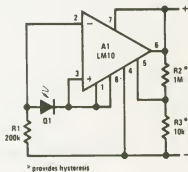
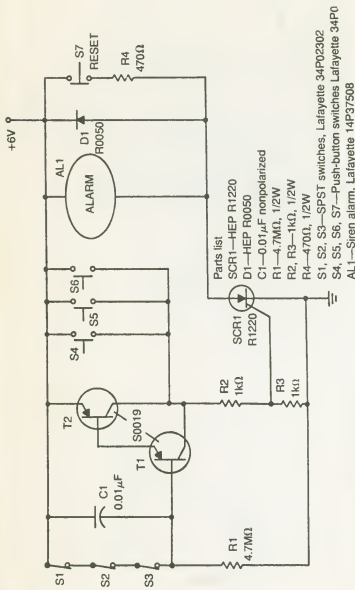


Fig. 2-2. Light level sensor (NS).



Parts list

- SCR1—HEP R1220
- D1—HEP R0050
- C1—0.01 μ F nonpolarized
- R1—4.7M Ω , 1/2W
- R2, R3—1k Ω , 1/2W
- R4—470 Ω , 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.

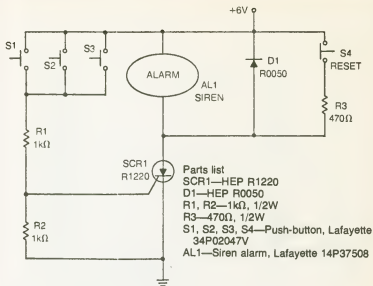


Fig. 2-4. Make-to-operate burglar alarm.

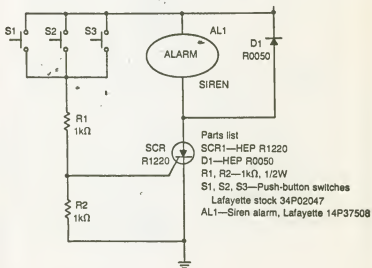


Fig. 2-5. Remote alarm circuit.

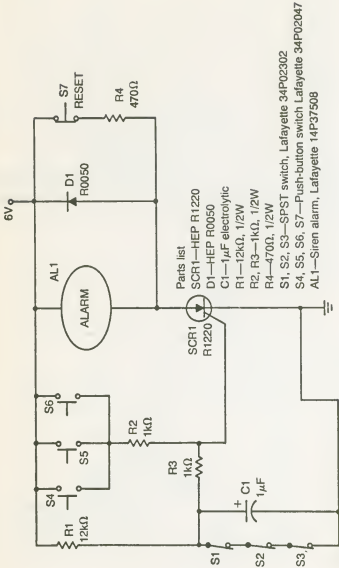
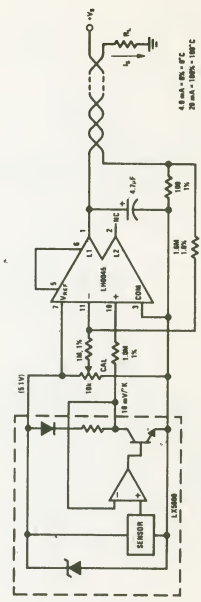


Fig. 2-6. Tamper-proof burglar alarm.



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

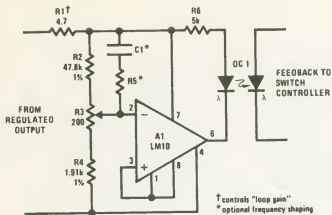


Fig. 2-8. Isolated voltage sensor (NS).

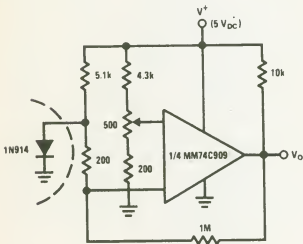


Fig. 2-9. Remote temperature sensing (NS).

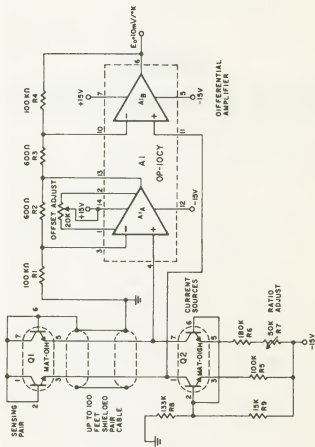


Fig. 2-10. Temperature sensor (PM).

Chapter 3
AM and FM Broadcast Receivers

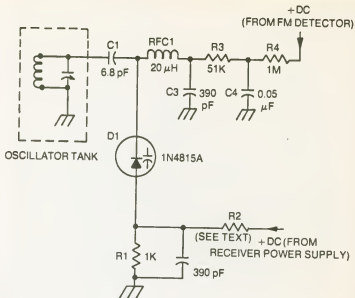


Fig. 3-1. Automatic frequency control for an FM receiver.

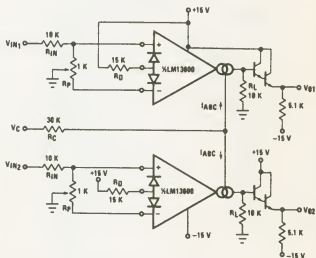


Fig. 3-2. Stereo volume control (NS).

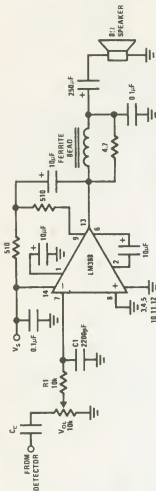


FIGURE 8. AM Radio Power Amplifier

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

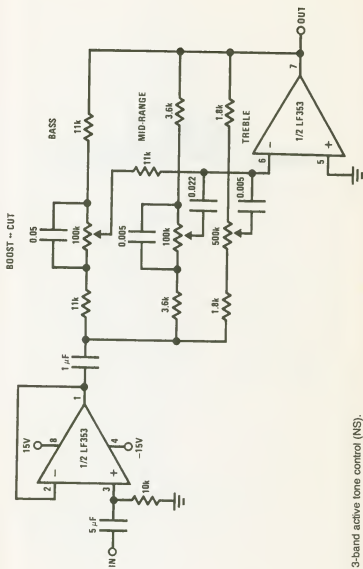
Note 2: Twist speaker lead and ground very tightly.

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

Note 4: R1C1 band limits input signals.

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

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



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

Chapter 4

Amateur Radio Accessories

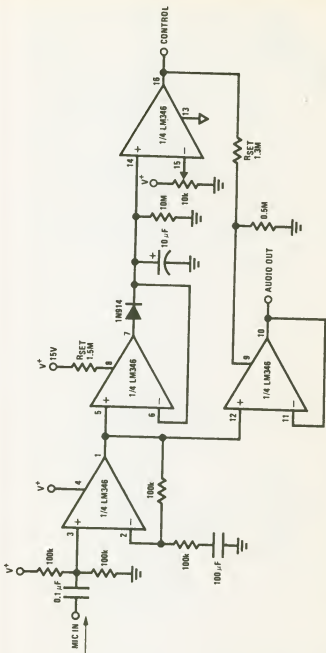


Fig. 4-1. Voice-activated switch and amplifier (NS).

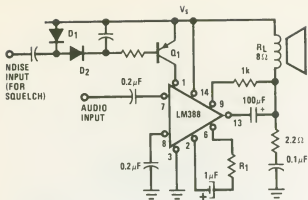


Fig. 4-2. Squelch circuit for FM scanners and handie talkies (NS).

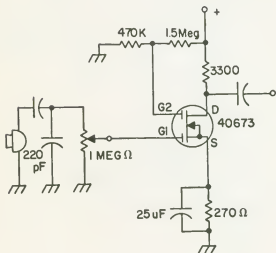
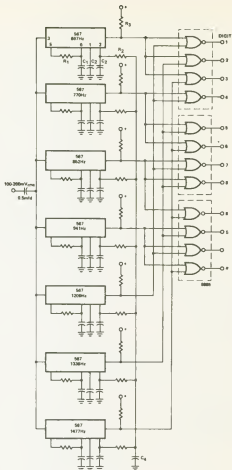


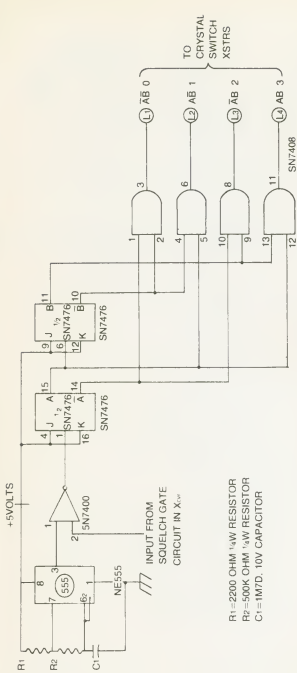
Fig. 4-3. JFET speech amplifiers.



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 5V
C_3	2.2mfd 5V
C_4	250 5V

Fig. 4-4. Touch-Tone® decoder (S).



- R1 = 2200 OHM 1/4W RESISTOR
- R2 = 500K OHM 1/4W RESISTOR
- C1 = 1M7D, 10V CAPACITOR

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.

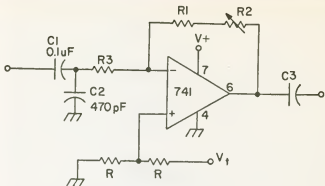


Fig. 4-6. Op amp speech amplifier.

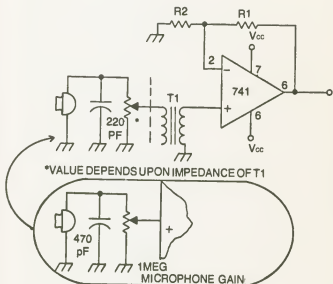


Fig. 4-7. Op-amp speech amplifier.

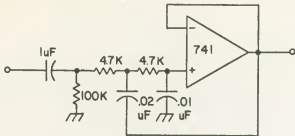


Fig. 4-8. Active-low-pass filter for 3-kHz bandwidth.

Chapter 5
Amateur Radio
Receivers and Converters

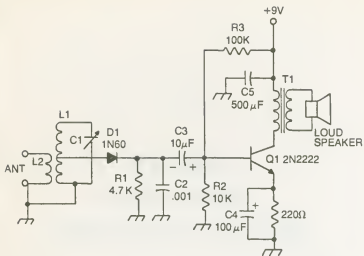


Fig. 5-1. Simple radio receiver uses an audio amplifier at the output of crystal set.

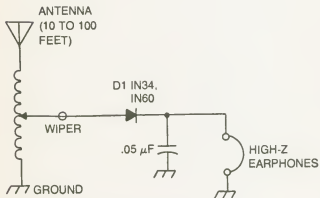


Fig. 5-2. Circuit for a simple crystal set receiver.

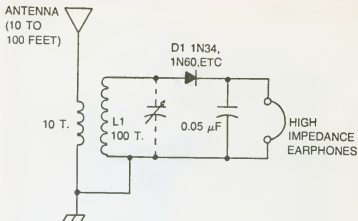


Fig. 5-3. More advanced crystal set receiver.

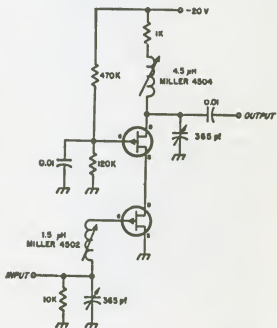


Fig. 5-4. This 30 MHz i-f stage uses two FETs connected in the cascode arrangement to provide 20 dB gain without neutralization; the bandwidth is 4 MHz. Both FETs in this circuit are 2N3819, MPF 105 or TIS34. With a negative supply voltage, the 2N4360 would be suitable.

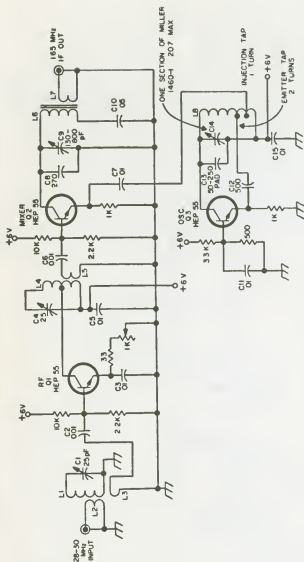


Fig. 5-5. Overall converter schematic. L1, 17 turns, 15 mm OD, 25 mm long; L2, 3 turns on cold end of L1; L4, 11 turns, 8 mm OD, 35 mm long; L5, 2 turns on cold end of L4; L6, 21 turns No. 30 inside cup core from Millen 10C; L7, 4 turns No. 30 wound over L6; L8, 5 turns, 15 mm OD, 8 mm long mixer tap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

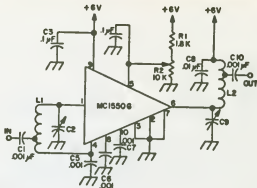


Fig. 5-6. This rf preamplifier is easily adapted to any range under 30 MHz simply by choosing appropriate input and output tuned circuits.

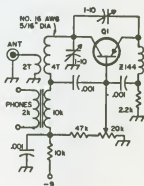
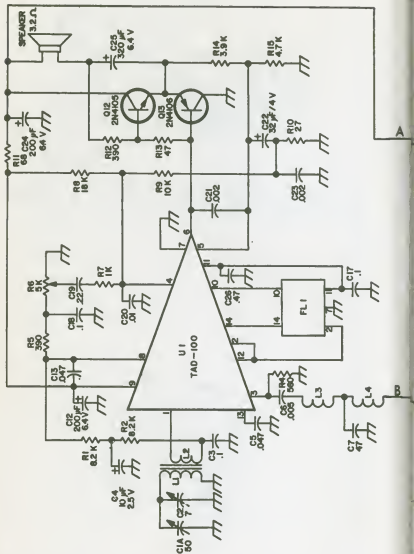


Fig. 5-7. This simple one-transistor superregenerative receiver for two meters may be used for copying many local signals. With the components shown this receiver will tune from about 90 to 150 MHz. It may be used on other frequencies by changing the inductor and capacitor Q1 is a GE-9 or HEP 2.



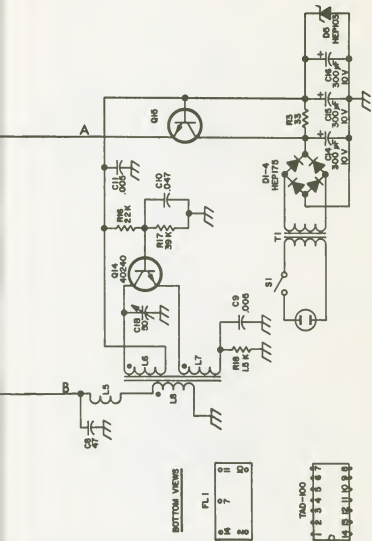


Fig. 5-8. Circuit diagram of the SWL receiver incorporating the TAD-100 IC chip.

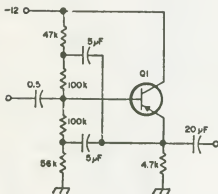
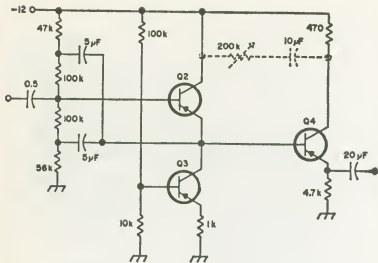
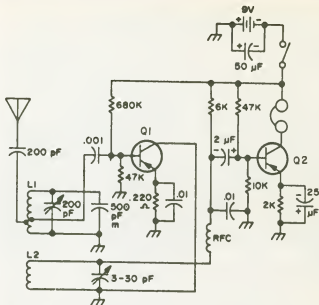


Fig. 5-9. This high-impedance preamplifier provides up to 20 megohms input impedance and has a frequency response from 10 Hz to 220 kHz. Circuit B was developed from circuit A by replacing the emitter resistor in A with Q3 and adding an emitter follower to reduce loading. The input impedance is further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



L1-8 TURNS, 3/4 in. DIA
TAPPED 1 TURN @ 3
TURNS FROM GROUND. L2-3 1J RNS

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

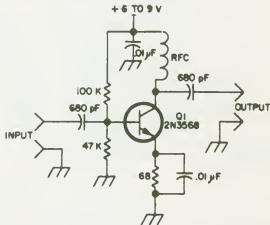


Fig. 5-11. This unit offers 12-15 dB gain on 10m, and about 20 dB or more from 15m and down. All leads should be as short as possible. Building it on a PC board should give good results. Q1 can be any type of transistor. The beta should be around 150+.f should be 60 MHz or better.

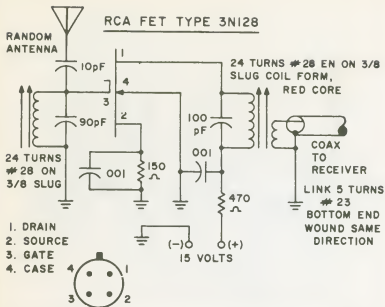


Fig. 5-12. Rf preamplifier for 40 meters (7 MHz) employs FET and yields more than 10 dB gain.

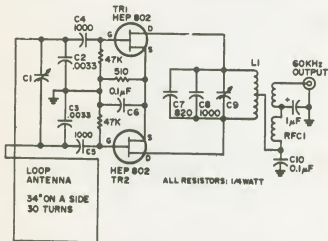


Fig. 5-13. Preamp. C, C9—275—970 pF Elmenco padder 306; C2, C3—0.0033 μ F Mylar (2200 pF for 6 ft loop); C4, C5, C8—1000 pF dipped silver/mica; C6, C10—0.1 μ F Centralab CK-104; C7—820 pF dipped silver/mica; L1—3 mH CT. Wound with No. 26 magnet wire approximately 85 turns on an Indiana General Corp. 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.

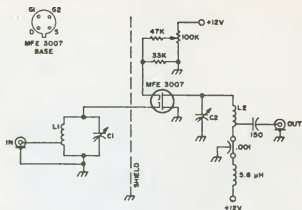


Fig. 5-14. Dual-gate FET preamplifier for 150 MHz range ups received signal strength by 20 dB.

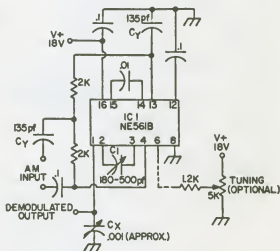
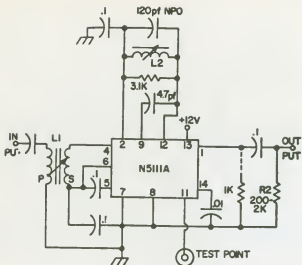


Fig. 5-15. Phase-locked loop allows this AM broadcast-band receiver to be tuned with a 5K pot. Can be adapted to any frequency from 1 to 15 MHz by changing values of C_Y and C_1 ; $C_Y = (f_{hi} - f_{f1}) / (f_{hi} \times f_{f1})$; $C_1 = 300 \text{ pF} / f(\text{MHz})$.



L2 = 1.5-3 μ H MILLER 9050

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

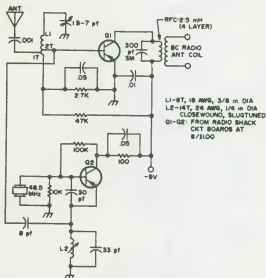
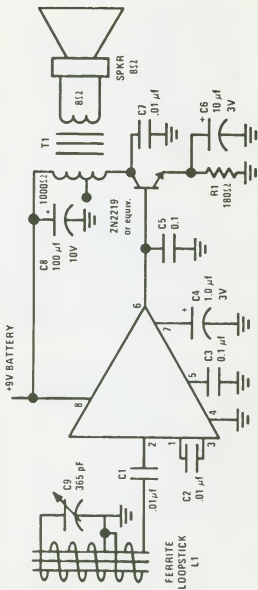


Fig. 5-17. Here is a circuit of a simple 2m converter that works in a pocket AM radio. Since it is crystal controlled, the receiver must tune to a frequency that equals the desired frequency minus 3×48.5 . Substitute a different frequency crystal if a strong BC station happens to heterodyne with the 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, 1000 Ω :8 Ω - Archer 273-1380 (Radio Shack, Inc.)
- SPKR - 2" PM Speaker, 8 Ω , 0.1 watt - Philmore TS20

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

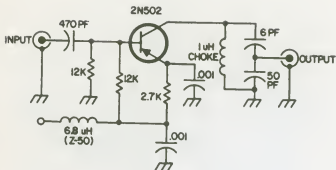


Fig. 5-19. Simple rf preamplifier for 6 meters, TV channel 2 or 3, or any frequency between 50 and 60 MHz. No tuning is required because of broad bandwidth (10 MHz); output impedance is about 50 ohms.

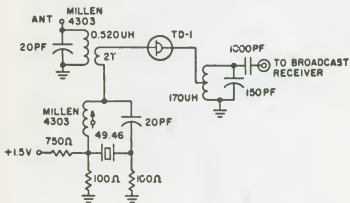


Fig. 5-20. Tunnel-diode converter changes AM broadcast radio to receiver capable of detecting 50 MHz signals.

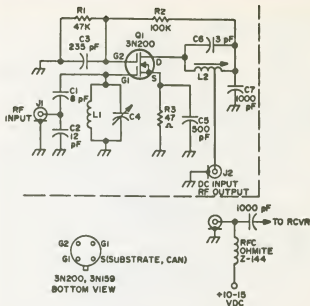


Fig. 5-21. Two-meter preamplifier, MOSFET. C4-5 are button micas and support transistor leads forming resonant circuit. L1 is JFD LC374 tank circuit which contains C1. L2 is 6T 22-gage enamel on 5 mm slug-tuned form, tap at 1 turn. 3N159 will also work in circuit (RTTY Journal, P.O. Box 837, Royal Oak,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

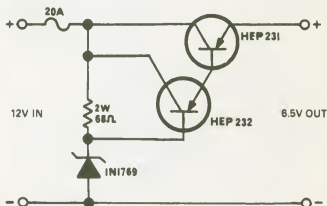


Fig. 5-22. You say you got a real bargain on an old motorcycle FM rig, only to find out it is 6 volt? Fret no more.

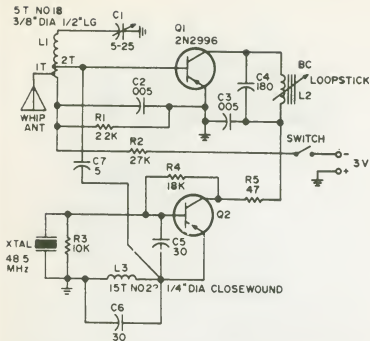


Fig. 5-23. This simple 2-transistor converter tuned in 150 MHz (ham, police, commercial) and requires no direct connection to broadcast-band receiver. Position next to radio receiver.

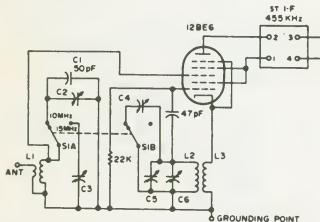
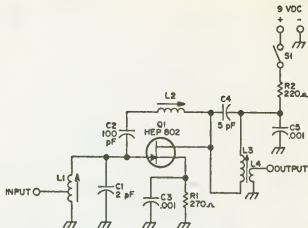


Fig. 5-24. Tunable shortwave converter, designed for receiving WWV on ordinary table radio, allows table radio to receive any signal between 10 and 15 MHz. 15 MHz position must be calibrated with C6 to tune oscillator and C3 to peak rf amplifier; then switch S1 to 10 MHz and tune C4 and C2.



L1 - 5-1/4 TURNS, TAPPED AT 1-1/4 TURNS,
NO. 26 AWG WIRE.
L2 - 9-1/2 TURNS, NO. 24 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.

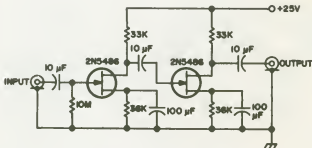
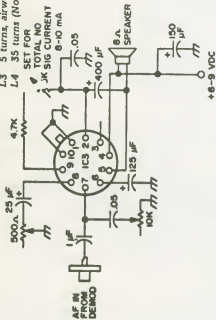


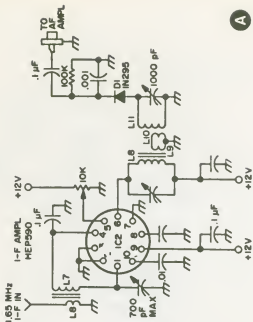
Fig. 5-26. Low-frequency preamp 1 Hz to 50 kHz, voltage gain 400, extremely low noise, all capacitances in μF , all resistors $\frac{1}{2}\text{W}$, transistors 2N5486.

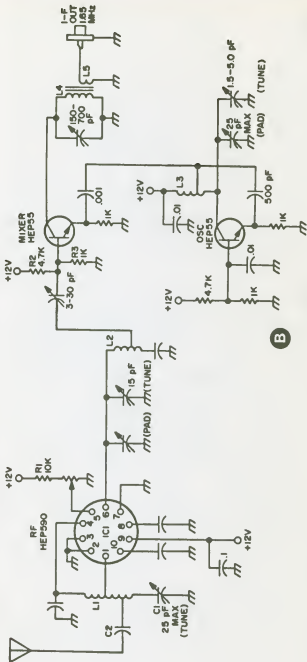
**AF AMPLIFIER
AMPEREX
TAA-300**


- 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.

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 1.F.T.).





B

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

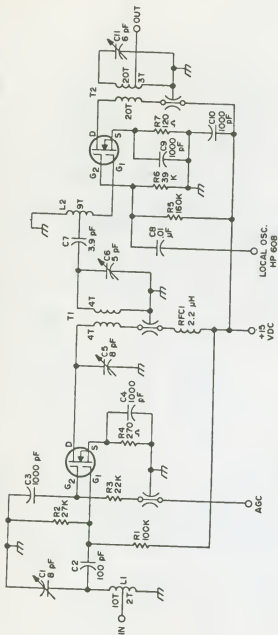


Fig. 5-28. VHF TV tuner using the FT0601 dual-gate MOSFET in RF amplifier and mixer stages.

L1, L2-2M 8 TURNS 16 AWG 6" 13 TURNS 28 AWG
 C1, C2-2M .5 pF 6M 20 pF E F JOHNSON VARIABLES
 *6m = OHMITE Z-50
 2m = OHMITE Z-144

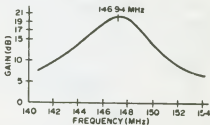
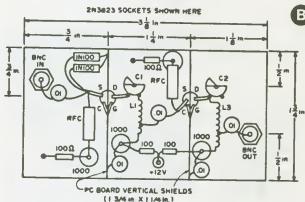
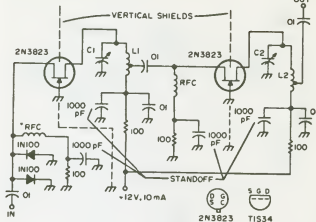
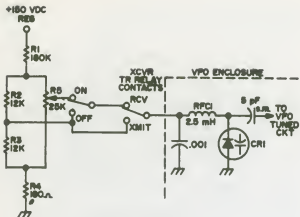
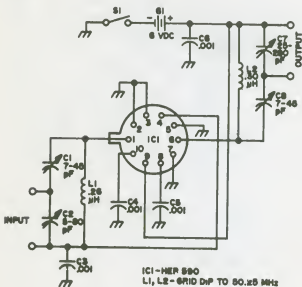


Fig. 5-29. Cascade preamp circuit, using two grounded-gate FETs, provides plenty of rf gain on 6 or 2 meters. Frequency-sensitive values are listed at the upper left portion of the diagram.



(A)



(B)

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.

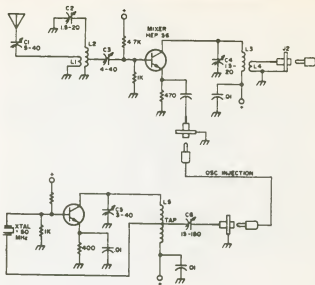


Fig. 5-31. Simple converter allows 170 MHz receiver to be used for reception of 220 MHz signals.

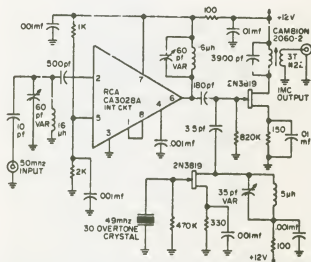


Fig. 5-32. Receiver converter for 50 MHz uses integrated circuit. Output frequency is approximately 1 MHz (center of AM broadcast band).

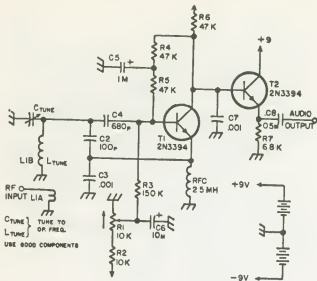


Fig. 5-33. Complete schematic of a good working regenerative detector. Transistor T1 is the actual detector, which operates at very low power levels. T2 is an emitter follower, which copies out the signal with minimum loss.

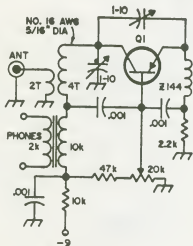


Fig. 5-34. This simple one-transistor superregenerative receiver for 2 meters may be used for copying many local signals. With the components shown, this receiver will tune from about 90 to 150 MHz. It may be used on other frequencies by changing the inductor and capacitor. Q1 is 2N1742, 2N2398, 2N3399,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

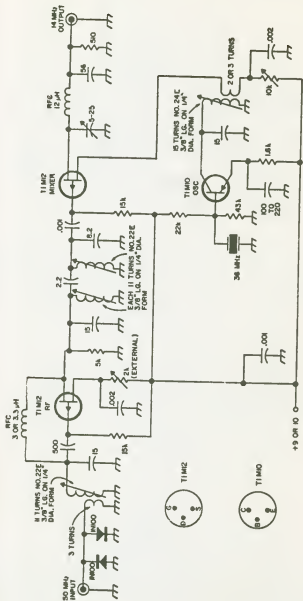
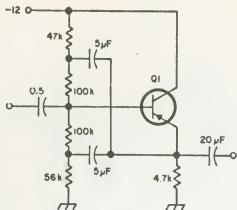
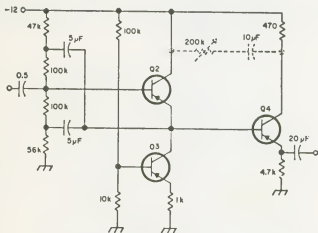


Fig. 5-36. 50 MHz converter using field effect transistor rf amplifier and mixer. The FETs cost about \$1 each. This converter has excellent noise figure and great resistance to cross modulation.



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.

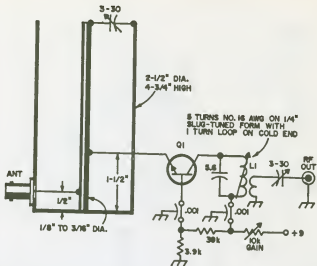
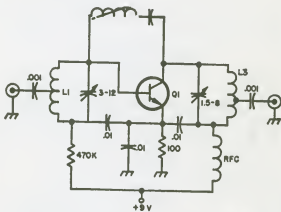


Fig. 5-37. Low-noise 2-meter preamplifier uses a beer can cavity to provide excellent discrimination against nearby kilowatts. Q1 is a 2N3478, 2N3563, 2N3564, 40235, or SK3019.



- 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 μ H (OHMMITE Z-220)

Fig. 5-38. Low-noise 220 MHz preamplifier. This circuit will provide extremely high gain with low noise on the 1 1/4 meter band. Neutralization is controlled by inductor L2.

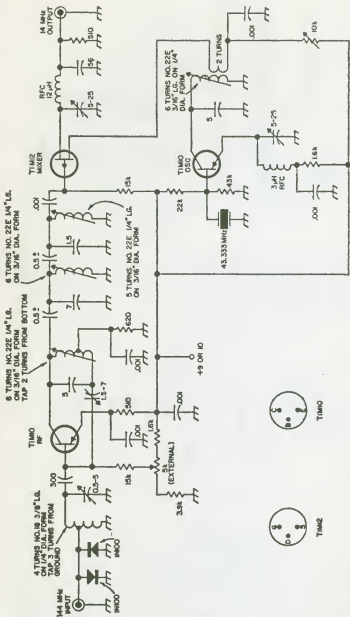


Fig. 5-39. Schematic of low-cost, low-noise, low-cross-modulation 2-meter converter. Note that only the mixer uses an FET; the mixer is responsible for most cross modulation.

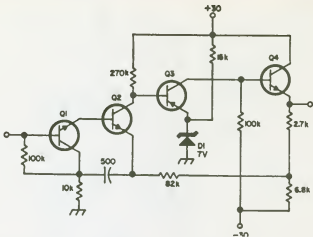


Fig. 5-40. This preamplifier provides 11 dB gain from 0.5 Hz to 2 MHz and has an input impedance of 32 megohms. Transistors Q1, Q2 and Q4 are 2N338, SK3020, or HEP 53; Q3 is a 2N328, GE-2, or HEP 52.

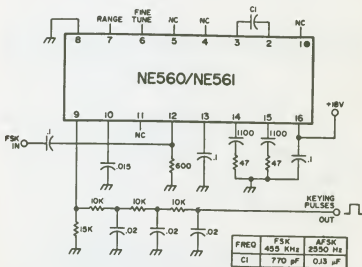


Fig. 5-41. RTTY converter circuit is taken from computer data set applications note; data set is same as AFSK converter, but gets input signal from telephone line and so is not subject to such high levels of interference as is RTTY. Input may be either at i-f or audio frequencies; table shows values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

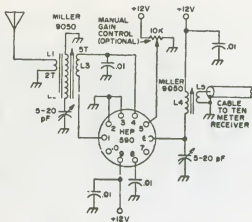
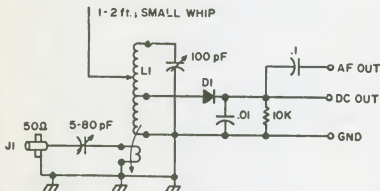


Fig. 5-42. A 28-MHz rf preamplifier uses HEP 590 integrated circuit (Motorola); interconnection to receiver is via coaxial cable.



DI - 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.

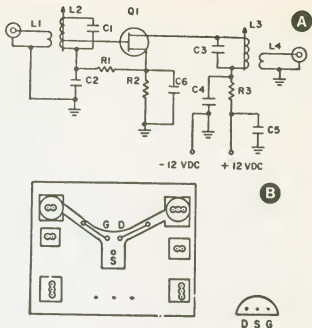
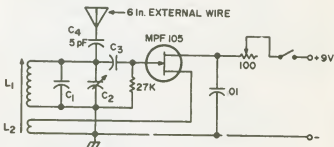


Fig. 5-44. A 2m FM preamp. L1 & L4, 2T No. 22 hookup on cold end of L3; L2 & L3, 3½T No. 16 spaced the dia. L2 & L3 must be wound opposite directions: C1, 10 pF, C2, 470 pF; C3, 10 pF; C4 R1, 220Ω ½W; R2, 370Ω ½W; R3, 22Ω ½W; Q1, Motorola MPF-107 or HEP 802.



- C₁ - SILVER MICA, 51 pF
- C₂ - 3-PLATE MIDGET VAR.
- C₃ - SILVER MICA, 27 pF
- L₁ - 20 TURNS } ON 1/4 in. SLUG-TUNED FORM
- L₂ - 8 TURNS }

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.

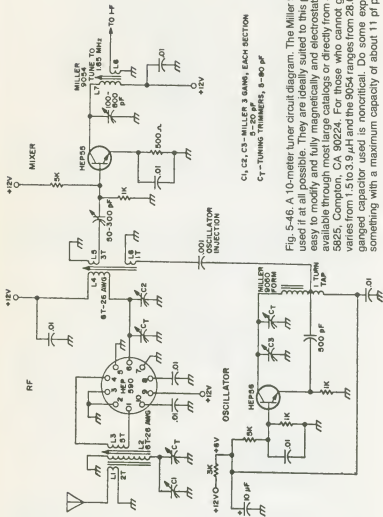


Fig. 5-46. A 10-meter tuner circuit diagram. The Miller 9050 and 9054 should be used if at all possible. They are ideally suited to this project because they are easy to modify and fully magnetically and electrostatically shielded. They are available through most large catalogs or directly from J.W. 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 μ H and the 9054 ranges from 28.0 to 60 μ H. 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.

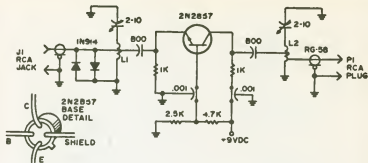


Fig. 5-47. Rf preamplifier for 450 MHz. Insert shows transistor basing.

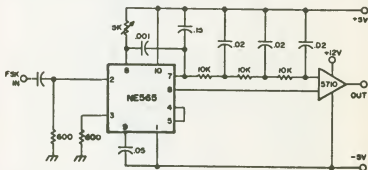


Fig. 5-48. Alternate RTTY circuit uses NE565 IC. Maximum frequency of 565 is 500 kHz. This circuit is designed to drive digital IC devices, and type 5710 voltage comparator is included to adjust output level to values suitable for digital ICs. Pot is for frequency adjustment.

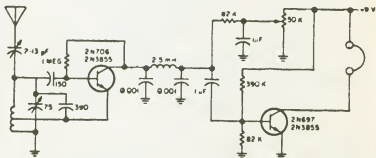


Fig. 5-49. Regenerative receiver for WWV (and other signals in 3.5 MHz region).

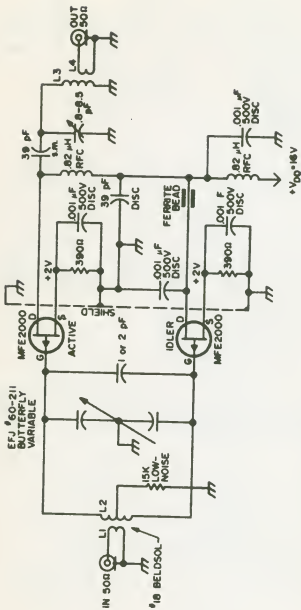


Fig. 5-50. Low noise JFET preamplifier for 2 meters.

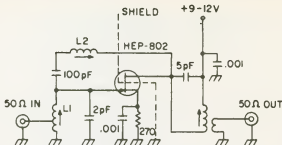


Fig. 5-51. This 150 MHz rf preamplifier uses Motorola FET for true 14 dB gain (after factoring out noise). Coils should be wound on $\frac{1}{4}$ in. ceramic forms with brass slugs. L1 is 5.5 turns 26-gage tapped 1.25 turns from cold end; L2 is 9.5 turns 34-gage; L3 is 5 turns 26-gage, L4 is 1.5 turns 26-gage wrapped around lower end of L3. Shield well.

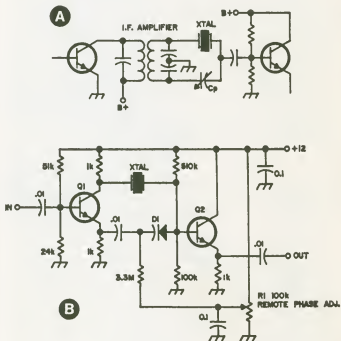


Fig. 5-52. Usually the crystal filter circuit in a receiver (A) must be physically located so that phasing capacitor (C_p) is accessible to the front panel. By using the varactor phased filter in B, the crystal may be located in any convenient location. Q1 and Q2 are 2N3478, 2N3564, 2N3707, 40236 or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

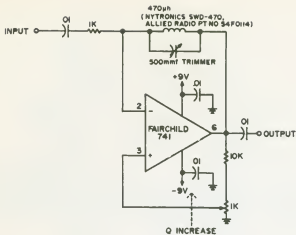


Fig. 5-53. Circuit of the Q-multiplier as constructed for a 455 kHz i-f.

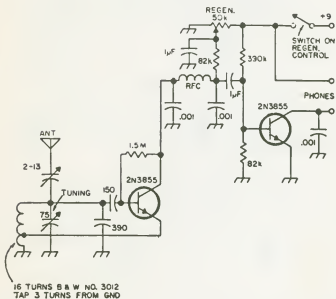


Fig. 5-54. Simple Novice receiver for 80 meters.

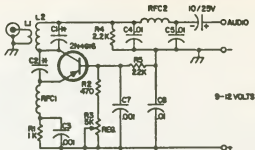


Fig. 5-55. Schematic diagram of superregenerative receiver for the $\frac{3}{4}$ meter band.

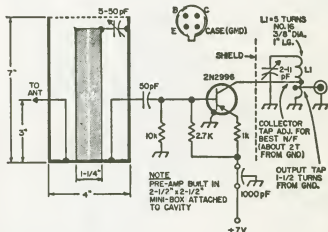


Fig. 5-56. Simple coaxial cavity and transistor preamp for 150 MHz. Emitter should be bypassed with 1000 pF disc.

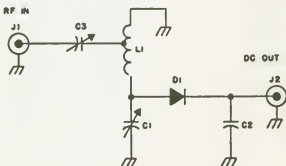
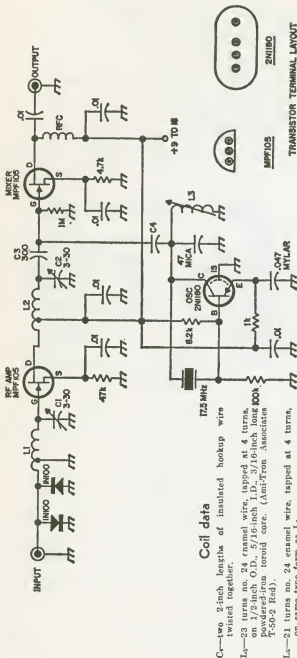


Fig. 5-57. Schematic of diode receiver for 432 MHz.

**NOTE**

ALL RESISTORS 1/4W
 ALL CAPACITORS DISC CERAMIC EXCEPT
 UNLESS OTHERWISE SPECIFIED

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

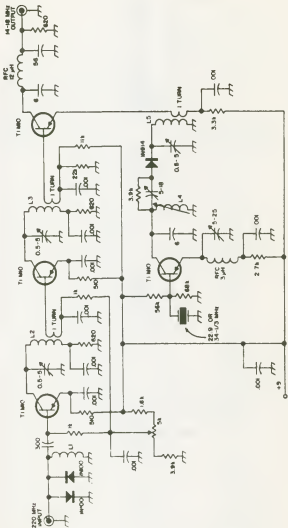


Fig. 5-59. 220 MHz converter built on a 2" x 5" copper-plated board. L1, L2, L3 and L5 are each 4 turns No. 18 wire 1/4" in diameter. L1 is 1/2" long and the other three are 3/8" long. L4 is 11 turns No. 24 enameled on a 1/4" form with a brass slug. The winding is 1/4" long.

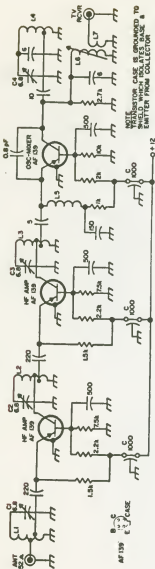
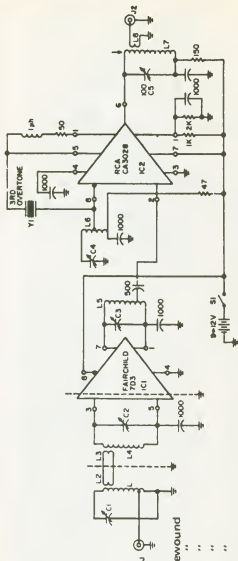


Fig. 5-60. Schematic of simple 440 MHz converter. L1—L4 are quarter-wave trough lines, 5 mm ($\frac{1}{4}$ " diameter and 68 mm ($2\frac{11}{16}$ " long. L5 is 3 turns 18-gage 7 mm ($\frac{5}{16}$ " in diameter. L6 is 7 turns 18-gage on a $\frac{5}{16}$ " form and L7 is 3 turns on it.



L1 6T 1/4" dia closewound

L2 2T 1/4" dia

L3 2T 1/4" dia

L4 6T 1/4" dia.

L5 6T 1/4" dia.

Tap 2T

L6 6T 1/4" dia

Tap 2T

L7 30T 1/4" dia.

L8 3T 1/4" dia.

C1 50 pf

C2 50 pf

C3 50 pf

C4 50 pf

C5 100 pf

Y1 = Xtal 43.5 mhz for 6.5 ic.5 mhz if

R = 1/4 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.

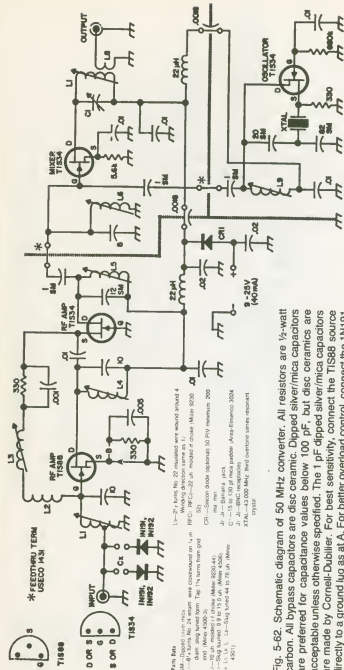
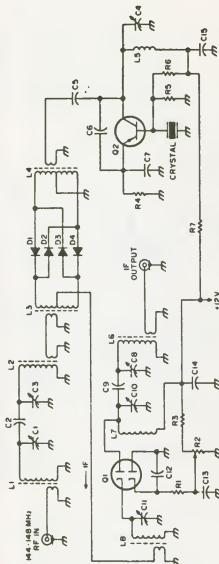


Fig. 5-62. Schematic diagram of 50 MHz converter. All resistors are ½-watt carbon. All bypass capacitors are disc ceramic. Dipped silver/mica capacitors are preferred for capacitance values below 100 pF, but disc ceramics are acceptable unless otherwise specified. The 1 pF dipped silver/mica capacitors 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.



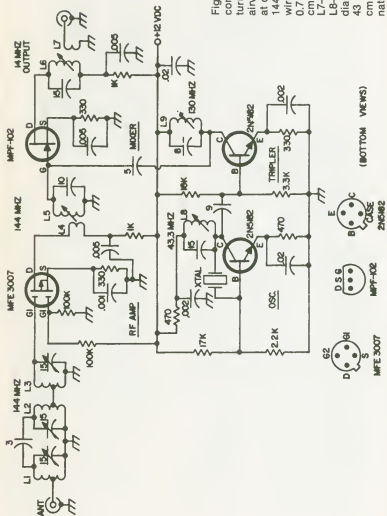
PARTS LIST

- C1, C3, C4, C8, C10, C11: 1.7-14.1 pF; EF
 JOHNSON 189-505-S; 60 μ 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 $\%W$
 R2: 50K Potentiometer
 R3: 47K $\%W$
 R4: 100K $\%W$
 R5: 2.7K $\%W$
 R6: 10K $\%W$
 R7: 1K $\%W$

- 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
 General 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

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—L3 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.



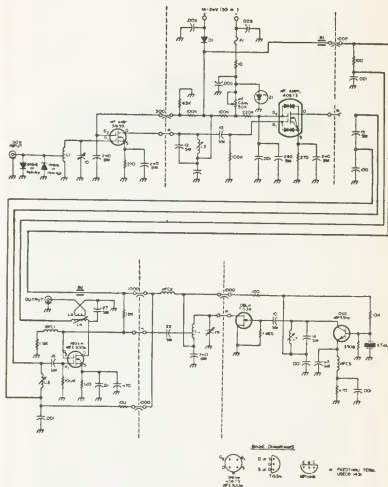


Fig. 5-65. Schematic diagram of 2m converter. Any one of the MOSFET types 3N140, 3N159, or MFE3007 may be substituted for any of the MOSFETs in the schematic. However, a 3N159 will give the lowest noise figure in the first stage. A 40673 should give the best protection against any rf spikes in the second stage. And a MFE3006/MFE3007 should give the best protection against steady, high-voltage rf signals in the mixer stage. All resistors are $\frac{1}{2}$ -watt carbon, 5%. All fixed capacitors other than SM, BM, or feedthrough types are disc ceramic.

Chapter 6

Amplifiers and Preamplifiers

*R8 - R10 and D2 provide a temperature independent gain control
 $G = -336 V_1$ (dB)

Distortion < 0.1%
 Bandwidth > 1 MHz
 100 dB gain range

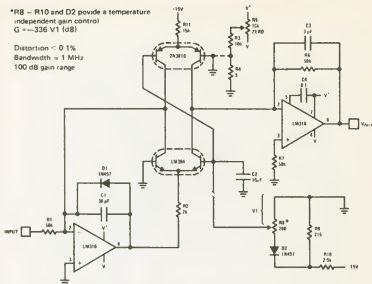


Fig. 6-1. Voltage-controlled variable gain amplifier (NS).

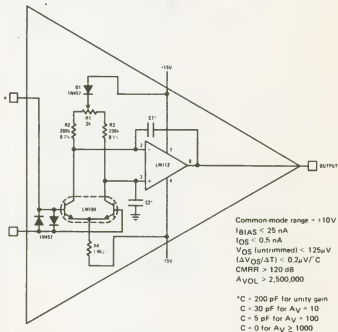
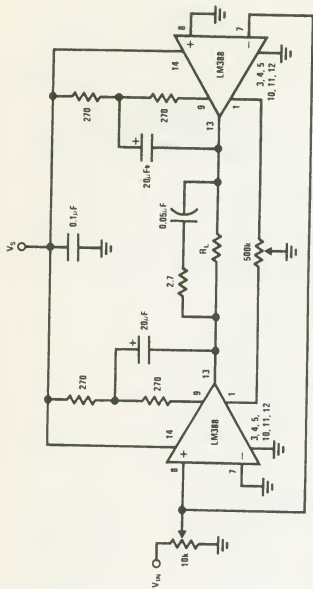


Fig. 6-2. Precision low-drift operational amplifier (NS).



$V_S = 5V$ $R_L = 4\Omega$ $P_O = 1.0W$
 $V_S = 12V$ $R_L = 8\Omega$ $P_O = 4W$

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

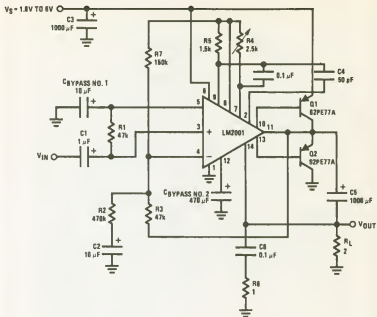


Fig. 6-4. Power amplifier with A_v of approximately 100 (NS).

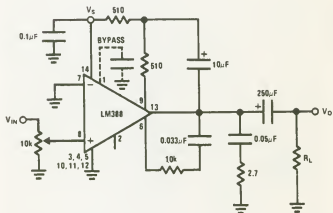


Fig. 6-5. Amplifier with bass boost (NS).

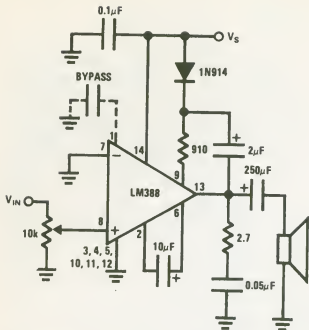


Fig. 6-6. Amplifier with a gain of 200 and minimum C_b (NS).

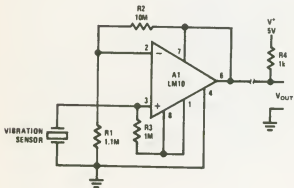


Fig. 6-7. Remote amplifier (NS).

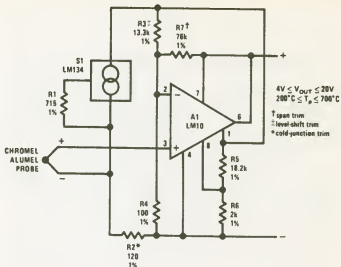


Fig. 6-8. Remote thermocouple amplifier (NS).

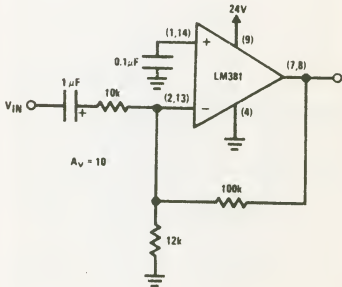


Fig. 6-9. Ultra-low distortion amplifier with A_v of 10, THD less than 0.05 percent and V_{OUT} of 3 volts rms (NS).

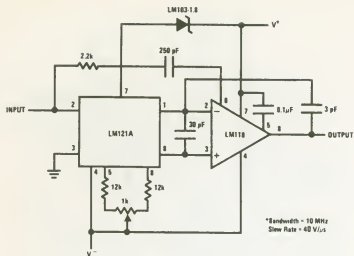


Fig. 6-10. High-speed inverting amplifier with low drift (NS).

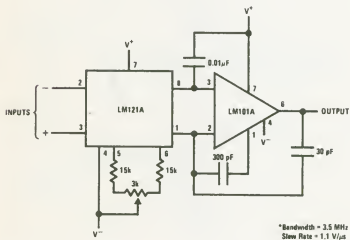


Fig. 6-11. Medium-speed, general-purpose amplifier (NS).

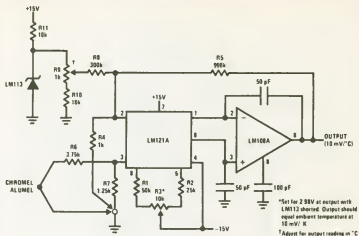


Fig. 6-12. Thermocouple amplifier with cold junction compensation.

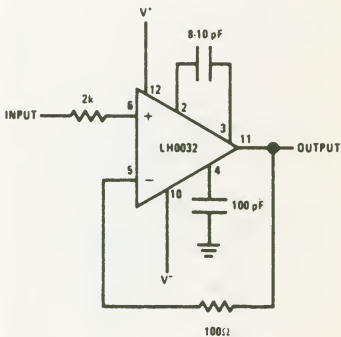


Fig. 6-13. Unity gain amplifier (NS).

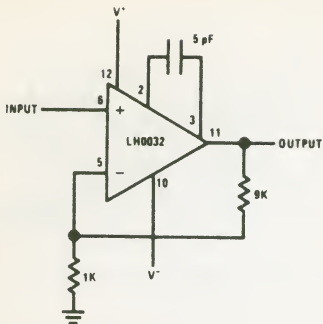


Fig. 6-14. A 10X buffer amplifier (NS).

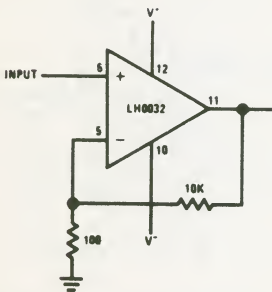


Fig. 6-15. A 100X buffer amplifier (NS).

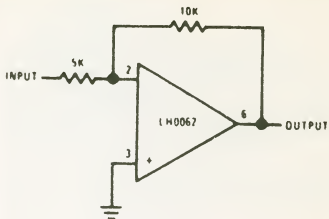


Fig. 6-16. Fast summing amplifier (NS).

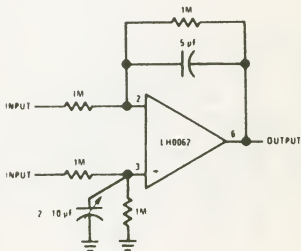


Fig. 6-17. Differential amplifier (NS).

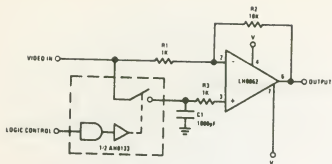


Fig. 6-18. Video DC restoring amplifier (NS).

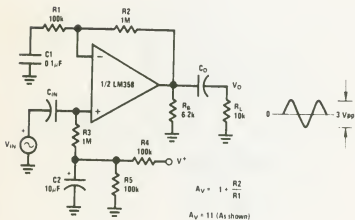
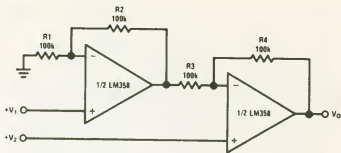


Fig. 6-19. An AC-coupled noninverting amplifier (NS).



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).

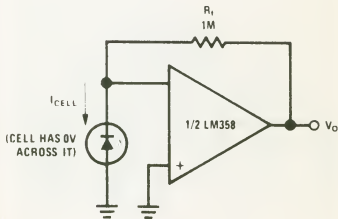


Fig. 6-21. Photovoltaic cell amplifier (NS).

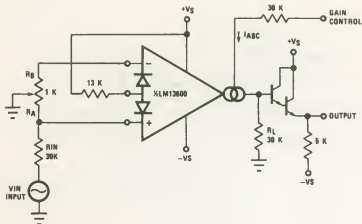


Fig. 6-22. Voltage-controlled amplifier (NS).

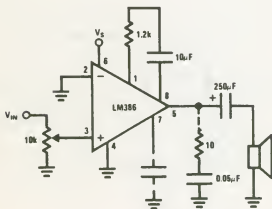


Fig. 6-23. Amplifier with gain of 50 (NS).

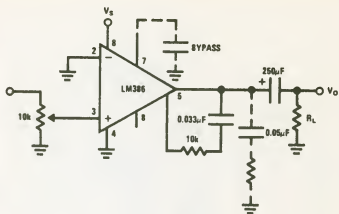


Fig. 6-24. Amplifier with bass boost (NS).

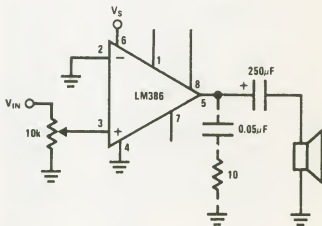
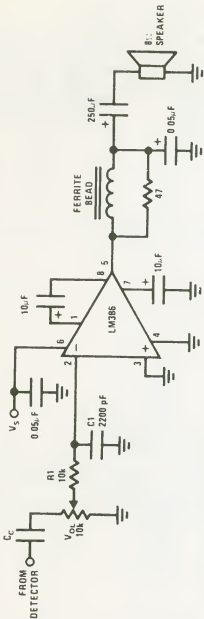


Fig. 6-25. Amplifier with a gain of 20 and minimum parts (NS).



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).

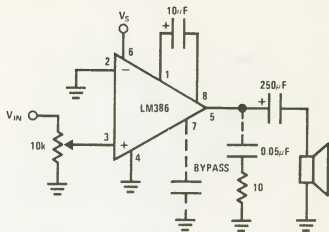


Fig. 6-27. Amplifier with gain of 200 (NS).

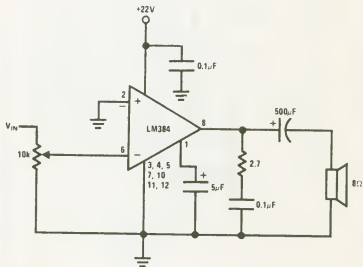


Fig. 6-28. Typical 5-watt amplifier (NS).

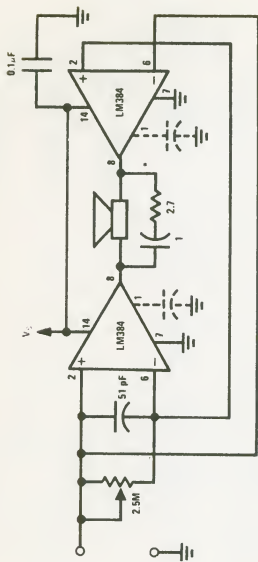


Fig. 6-29. Bridge amplifier (NS).

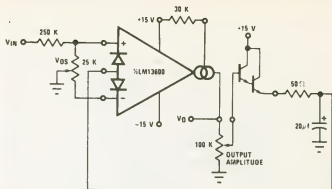


Fig. 6-30. Automatic gain control amplifier (NS).

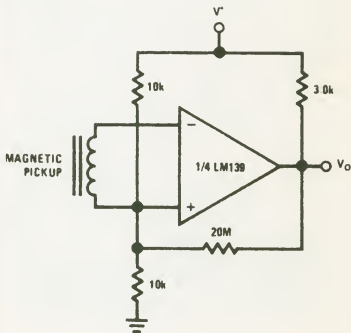


Fig. 6-31. Transducer amplifier (NS).

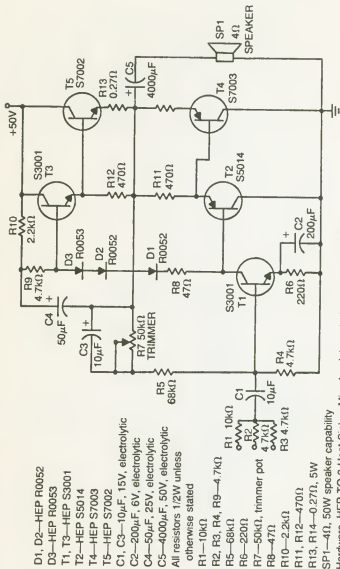


Fig. 6-32. Hi-fi power amplifier.

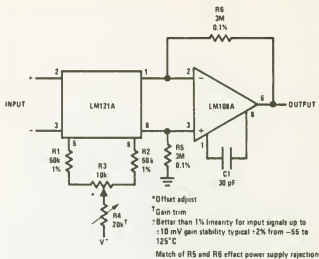


Fig. 6-33. Gain of 1000 instrumentation amplifier (NS).

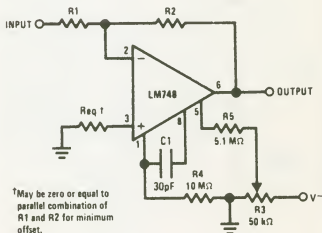
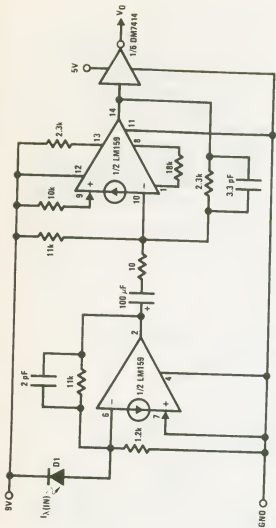


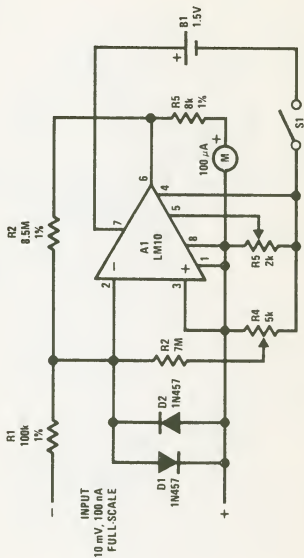
Fig. 6-34. Inverting amplifier with balancing circuit (NS).



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.
- $T_{PDL} = 45 \text{ ns}$, $T_{PDH} = 50 \text{ ns}$ — T^2L output

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



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

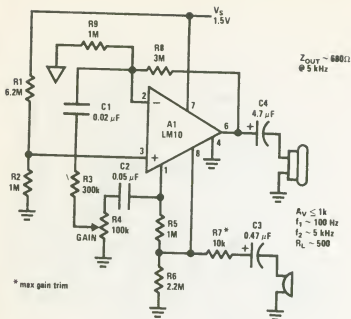


Fig. 6-37. Microphone amplifier (NS).

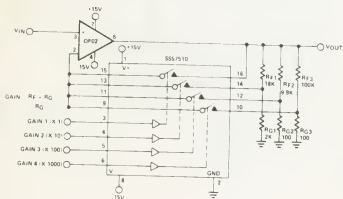


Fig. 6-38. Amplifier with digitally programmable gains. (PM).

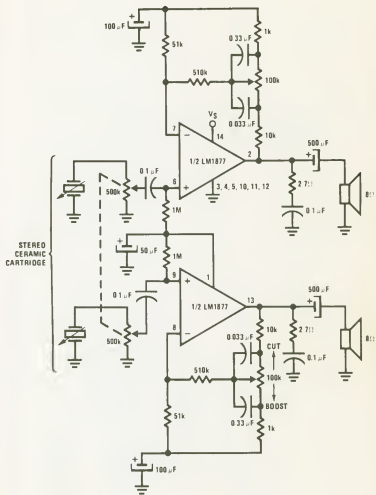


Fig. 6-39. Stereo phonograph amplifier with bass tone control (NS).

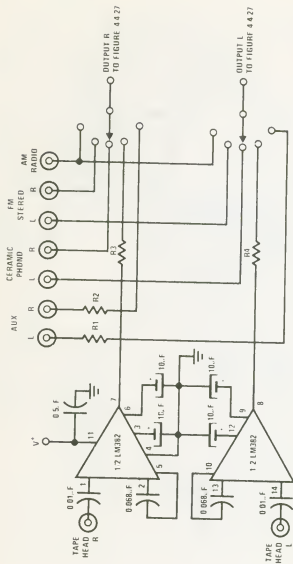


Fig. 6-40. A 2-channel tape-playback amplifier with signal switching (NS).

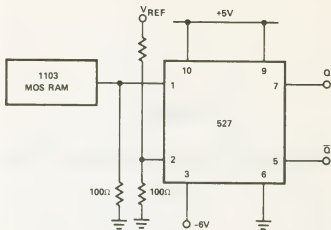


Fig. 6-41. MOS memory sense amplifier (S).

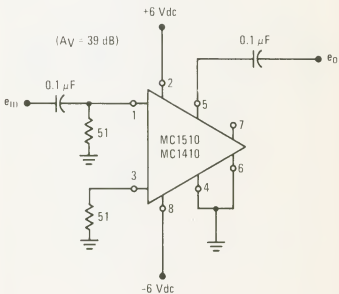


Fig. 6-42. Single-stage, wideband amplifier (M).

Chapter 7

Audio Amplifiers and Preamplifiers

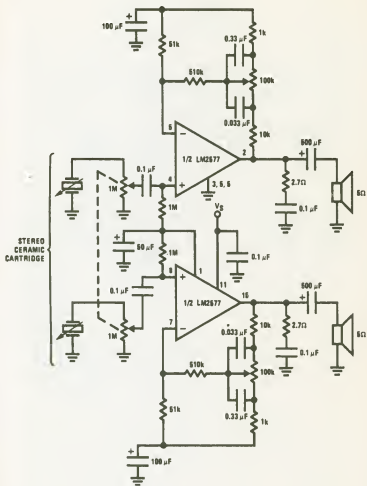


Fig. 7-1. Stereo phonograph amplifier with bass tone control (NS).

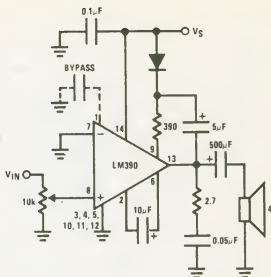


Fig. 7-3. Amplifier with gain of 200 and minimum C_b (NS).

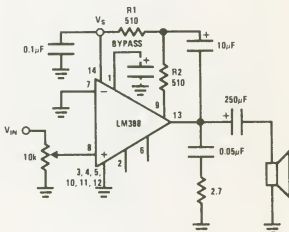


Fig. 7-4. Load returned to ground. This amplifier has a gain of 20 (NS).

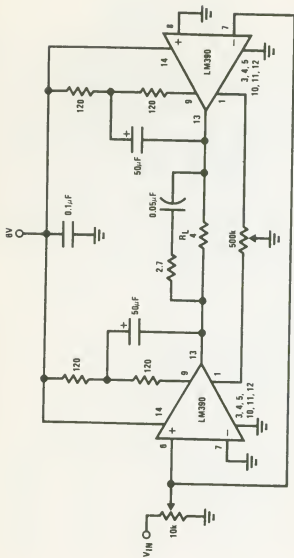


Fig. 7-5. A 2.5-watt bridge amplifier (NS).

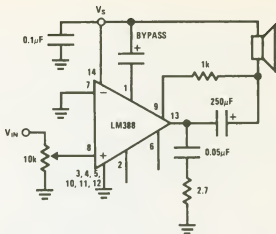


Fig. 7-6. Load returned to V_s . This amplifier has a gain of 20 (NS).

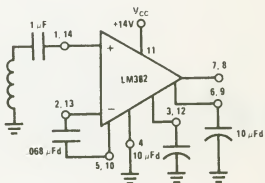


Fig. 7-7. Tape preamp with NAB equalization (NS).

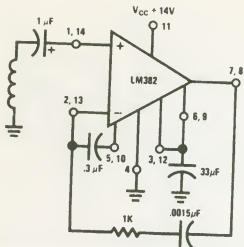


Fig. 7-8. Phono preamp with NAB equalization (NS).

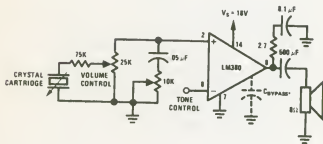


Fig. 7-9. Phono amplifier (NS).

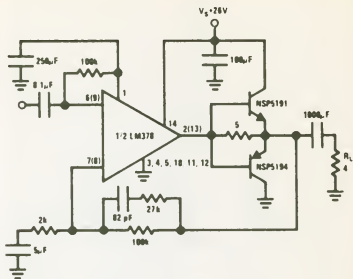


Fig. 7-10. A 15-watt per channel audio amplifier (NS).

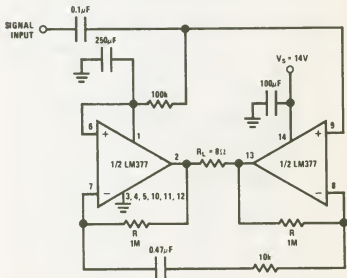
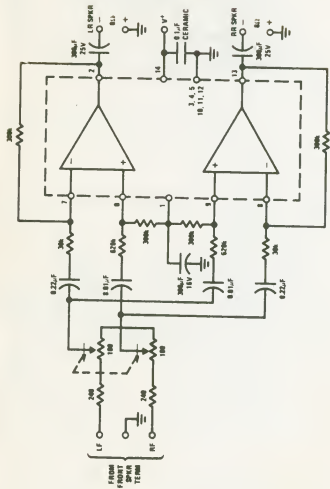


Fig. 7-11. A 4-watt bridge amplifier (NS).

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



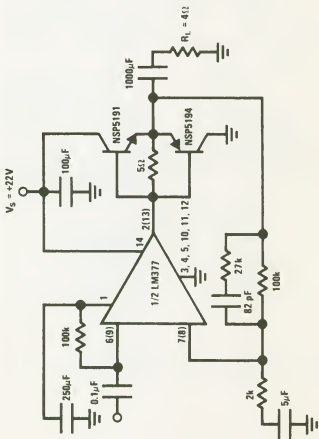


Fig. 7-13. A 10-watt per channel audio amplifier (NS).

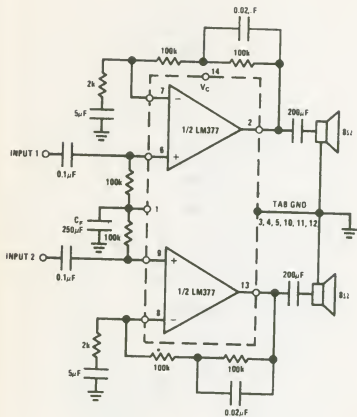


Fig. 7-14. Simple stereo amplifier with bass boost (NS).

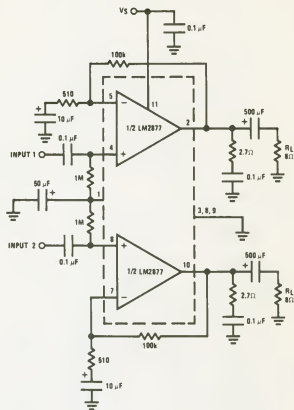


Fig. 7-15. Stereo amplifier with A_v of 200 (NS).

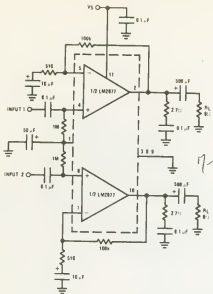


Fig. 7-15. Stereo amplifier with A_v of 200 (NS).

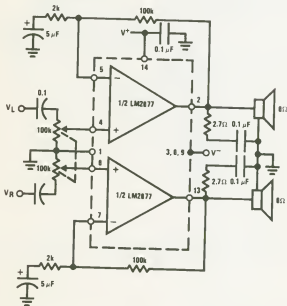
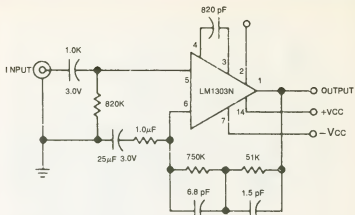


Fig. 7-16. A noninverting amplifier using a split supply. The split supply is also shown (NS).



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).

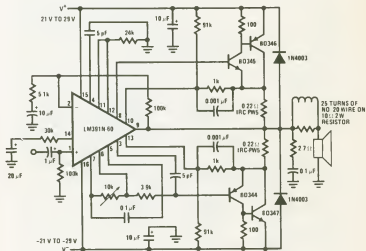


Fig. 7-18. A 20-watt-8-ohm, 30-watt-4-ohm amplifier with a 1-second turn-on delay (NS).

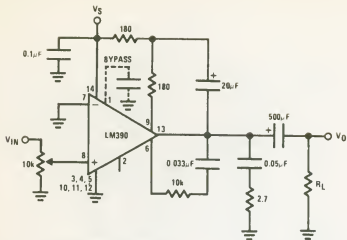


Fig. 7-19. Amplifier with bass boost (NS).

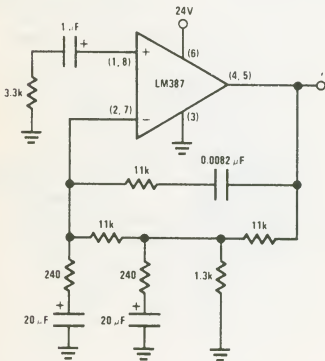


Fig. 7-20. A 2-pole fast turn-on NAB tape preamplifier (NS).

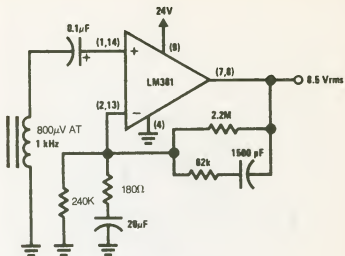


Fig. 7-21. A typical tape playback amplifier (NS).

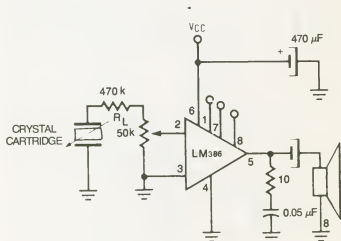


Fig. 7-22. Low-cost phono amplifier (NS).

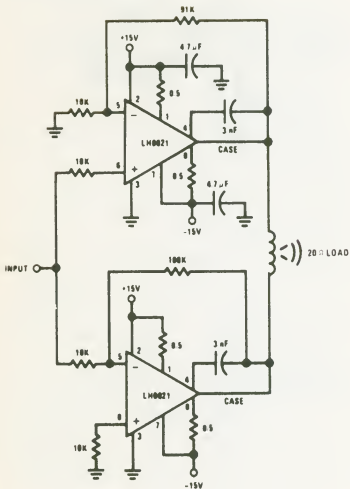
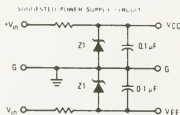
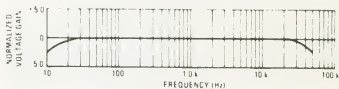
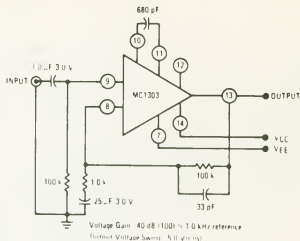


Fig. 7-23. A 1-watt (rms) audio amplifier (NS).



Z1 - MZ 500 19
 (13 V min.)
 Select wires A by
 allowing 11 mA for
 zener, and each dual
 I.C. Pre-amplifier

Pins not shown are not connected

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

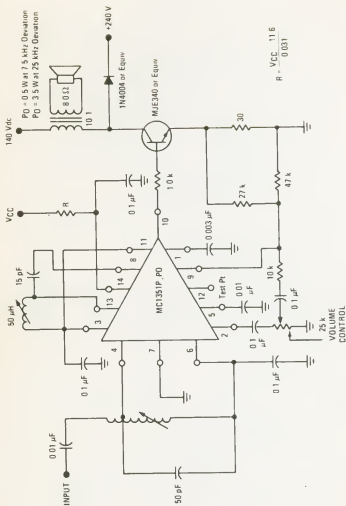


Fig. 7-25. Typical 4.5-MHz i-f amplifier (M).

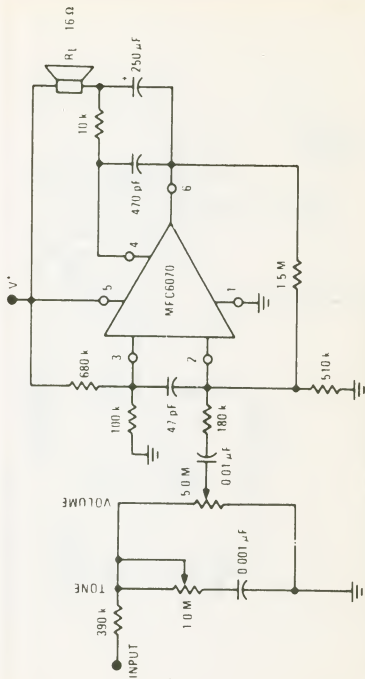


Fig. 7-26. Typical 1-watt phono amplifier with ceramic cartridge input (M).

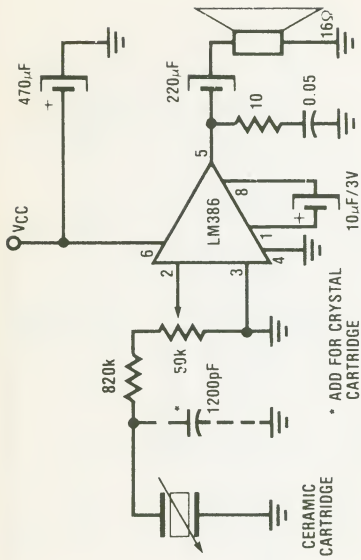
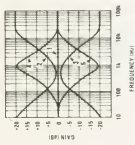


Fig. 7-27. Ceramic cartridge amplifier (NS).

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

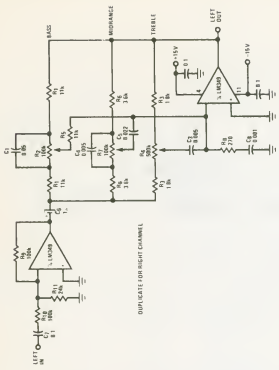


Fig. 8-1. A 3-band active tone control for bass, midrange and treble (NS).

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 $R_4 \gg R_1 + R_3 + 2R_5$

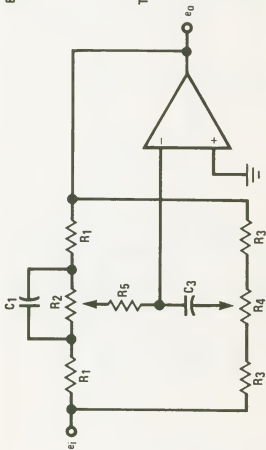


Fig. 8-2. Alternate bass design active tone control (NS).

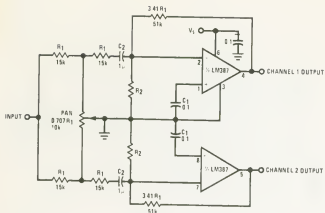


Fig. 8-3. A 2-channel panning circuit (NS).

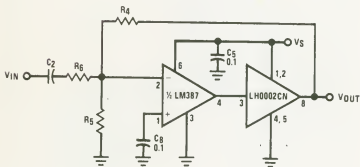


Fig. 8-4. Preamplifier current booster (NS).

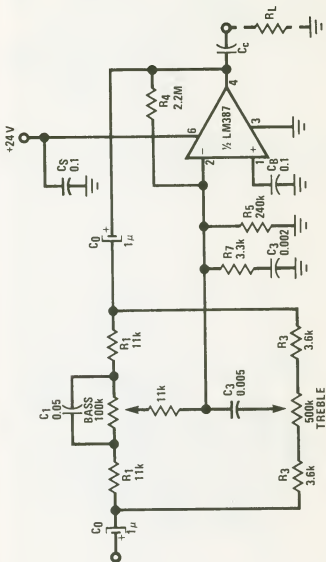


Fig. 8-5. LM387 feedback tone controls (NS).

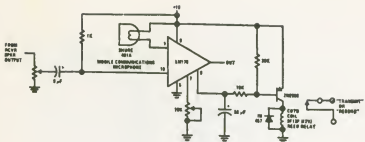


Fig. 8-6. VOX/mike preamp with antitrip.

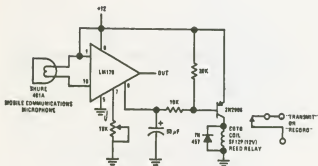


Fig. 8-7. VOX/mike preamp.

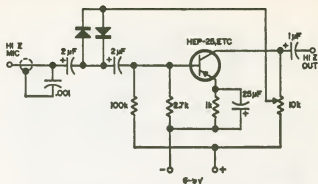


Fig. 8-8. Circuit of preamplifier clipper circuit. Potentiometer adjusts clipping level and may be replaced by fixed resistors once desired level is found.

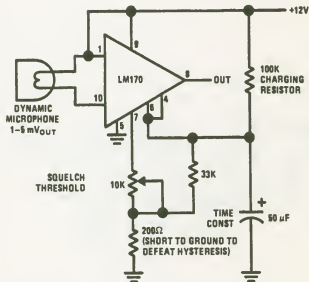


Fig. 8-9. Squelched preamplifier with hysteresis.

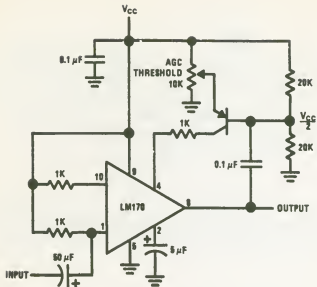


Fig. 8-10. Speech compressor.

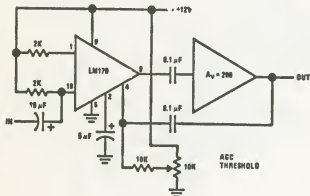


Fig. 8-11. Speech compressor using subsequent gain for better control.

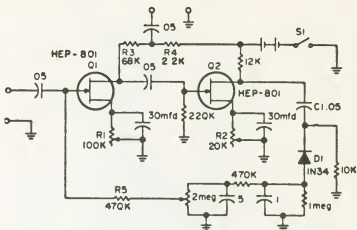


Fig. 8-12. Audio compressor uses inexpensive Motorola FETs.

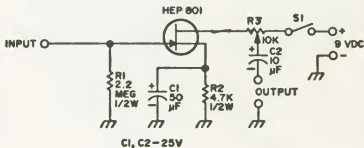


Fig. 8-13. Microphone preamplifier. Mike output low? Fix it with this one. This is for use with a ceramic or crystal microphone or even a phono cartridge. (M).

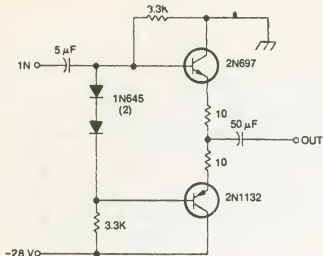


Fig. 8-14. This schematic from the U.S. Navy's handbook of "preferred circuits" shows an emitter follower that provides 12 dB gain.

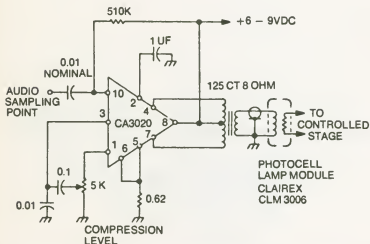


Fig. 8-15. Photocell compressor/AGC circuit schematic. Voltage rating of capacitor to terminal 10 must be chosen to protect unit from voltage found at sampling point. Dc operating voltage need not be supplied from an extremely well filtered source since audio quality of amplifier is not significant.

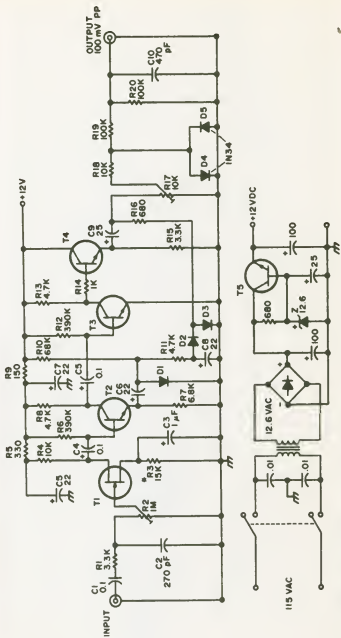


Fig. 8-16. Compressor Schematic.

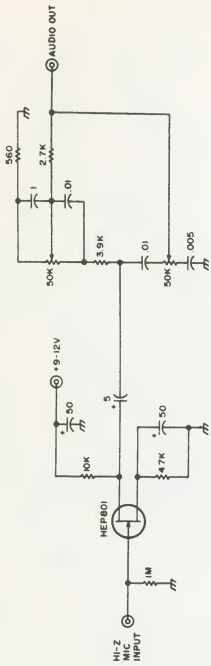


Fig. 8-17. Shaping circuitry to be added ahead of existing compressor.

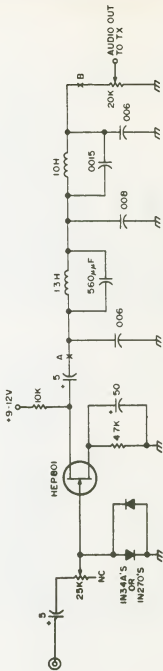
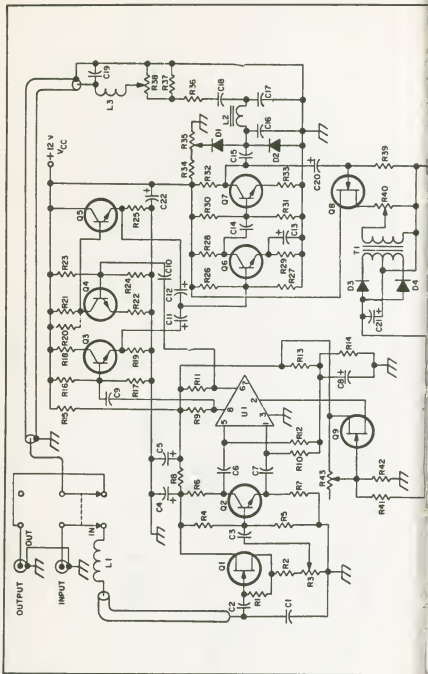


Fig. 8-18. Clipper and filter for use at output of existing audio compressor.



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 500 Ω CT secondary. For secondary, use 1000 Ω CT primary.

Capacitors

C1, C19 0.001 μ F

C2 0.005 μ F

C3 0.05 μ F

C4, C5, C8, C22, 100 μ F 15V

C6, C7, C9, C10, C15, C18 0.1 μ F

C11, C12, 10 μ F 15V

C13 30 μ F 15V

C14, 0.02 μ F

C16, C17 0.0015 μ F

C20, C21 6 μ F 1.5V

Resistors (all except potentiometers 1/2 watt)

R1 2.2M

R2 9T-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

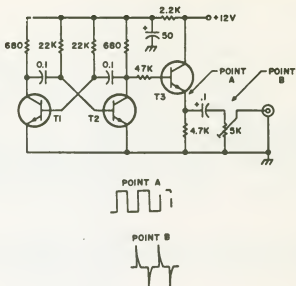


Fig. 8-21. Speech simulator schematic.

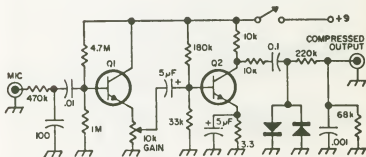


Fig. 8-22. Two-stage clipper/preamp will increase the talk of any rig. Transistors Q1 and Q2 are HEP 54. The diodes are 1N456 or HEP 158.

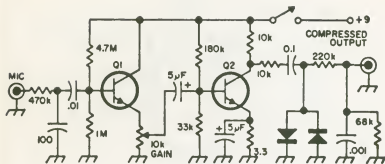


Fig. 8-23. Two-stage clipper/preamp. Transistors Q1 and Q2 are 2N1304, 2N2926, 2N3391, SK3011, or HEP 54. The diodes are 1N456 or HEP 158.

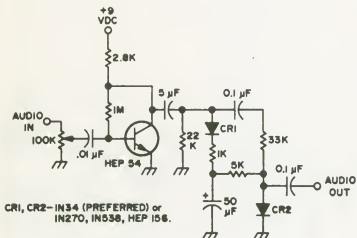


Fig. 8-24. Audio preamp compressor.

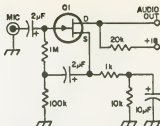


Fig. 8-25. Microphone amplifier using a field-effect transistor has an input impedance of 5 megohms. Q1 is a 2N4360, TIM12, U-112 or U-110. By reversing the polarity of the supply voltage, a 2N3820, MPF 104 or HEP 801 may be used.

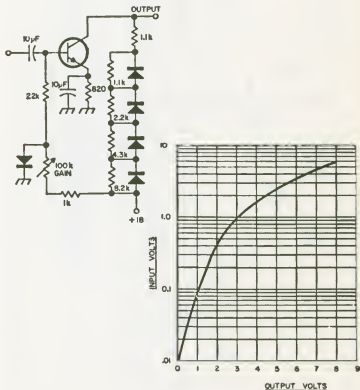
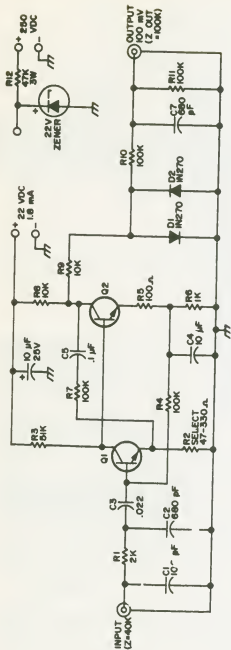


Fig. 8-26. This simple dynamic range compressor provides 50 dB range; it exhibits gain with a 20 millivolt signal but will saturate with input voltages up to 6 to 7 volts. All the diodes are 1N914; transistor Q1 should be a 2N2926, 2N3391, SK3010, GE-8 or HEP 54.



- 1-Q1 & Q2 ARE Si MPN TYPES, #s 30-120, VCBs 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).

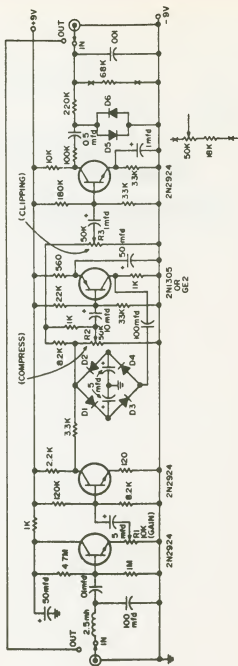


Fig. 8-28. Versatile premodulation speech processor.

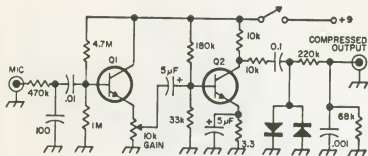


Fig. 8-29. Clipper/preamp. Transistors Q1 and Q2 are 2N1304, 2N2926, 2N3391, SK3011, or HEP 54. The diodes are IN456 or HEP 158.

Chapter 9

Automotive Circuits

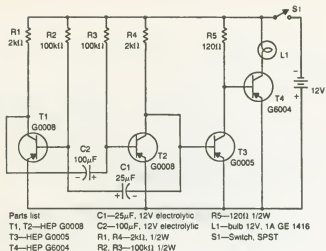


Fig. 9-1. Emergency road flasher.

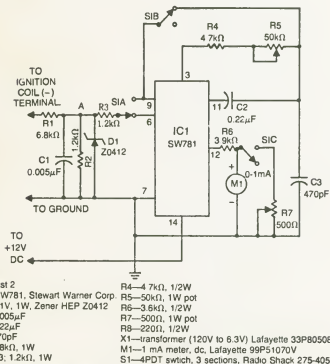


Fig. 9-2. Solid-state dwell/tachometer.

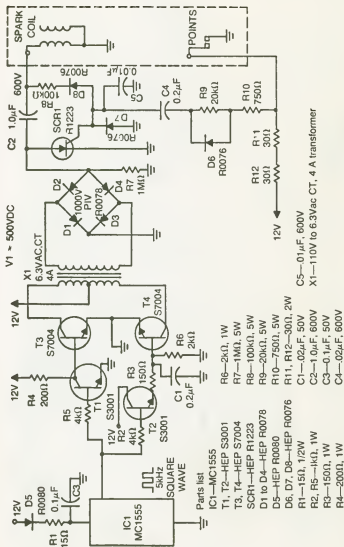


Fig. 9-3. Capacitive discharge ignition system.

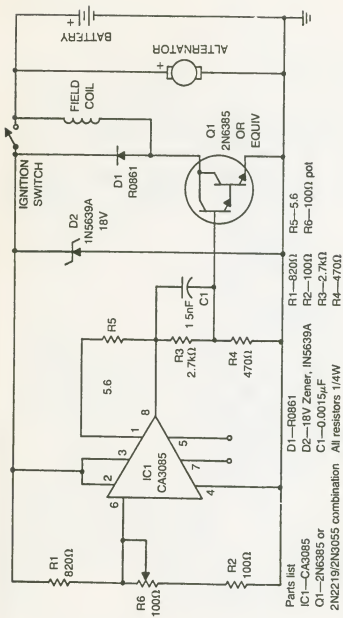
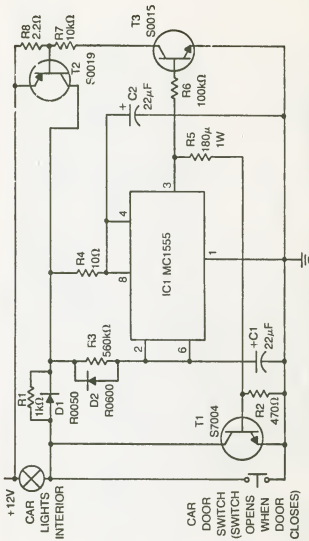


Fig. 9-4. Electronic regulator for car alternator.



- Parts list 4
 IC1—MC1555
 D1—HEP R0050
 D2—HEP R0600
 T1—HEP S7004
 T2—HEP S0019
 T3—HEP S0015
 C1, C2—22μF, 25V electrolytic
 R—560kΩ
 R1—1kΩ
 R2—470Ω
 R3—560kΩ
 R4—10Ω
 R5—180Ω
 R6—100kΩ
 R7—10kΩ
 R8—2.2kΩ
 otherwise stated
 R—560kΩ
 R4—10Ω
 R5—180Ω
 R6—100kΩ
 R7—10kΩ
 R8—2.2kΩ

Fig. 9-5. Car door light delay.

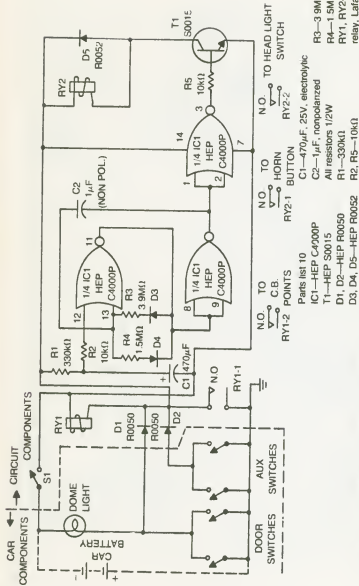


Fig. 9-6. Microswitch vehicle immobilizer for positive voltage grounds.

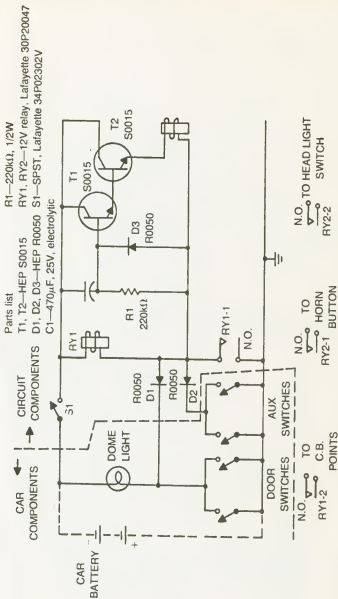


Fig. 9-7. Automobile immobilizer for minus ground systems.

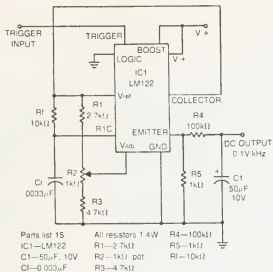


Fig. 9-8. Frequency-to-voltage converter (tachometer) output.

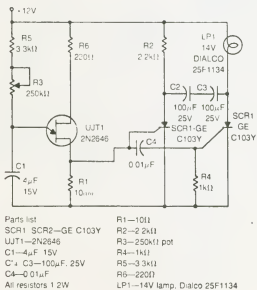


Fig. 9-9. 12 V flasher.

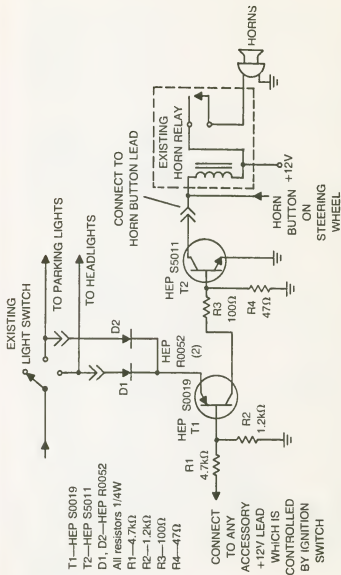


Fig. 9-10. Auto headlight reminder.

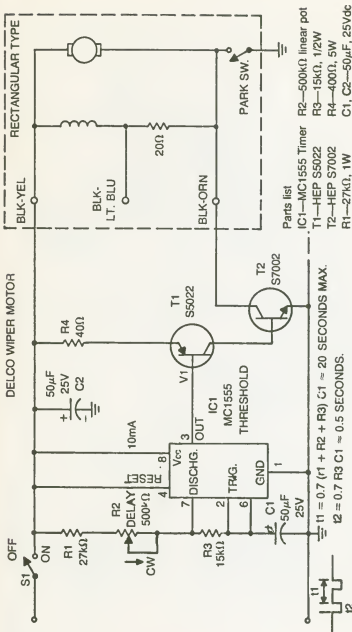
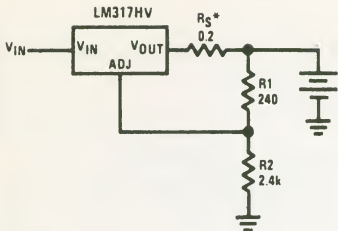


Fig. 9-11. Auto wiper control.

Chapter 10

Battery Chargers



* R_S —sets output impedance of charger $Z_{OUT} = R_S \left(1 + \frac{R_2}{R_1} \right)$
 Use of R_S allows low charging rates with fully charged battery.

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

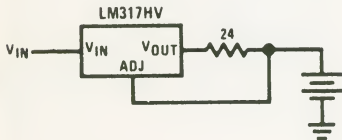
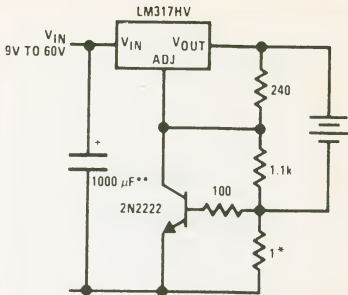


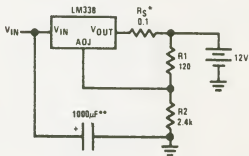
Fig. 10-2. A 50-mA constant current battery charger.



* Sets peak current (0.6A for 1Ω)

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

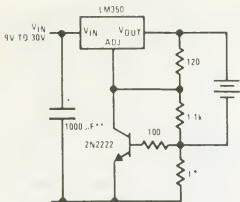
Fig. 10-3. Current limited 6-volt battery charger.



* 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.

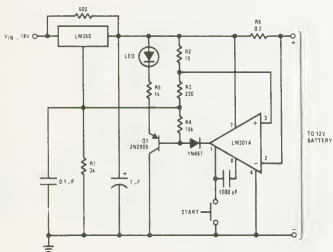


Fig. 10-6. A 12-volt battery charger. An LM338 chip can be substituted for the LM350.

Chapter 11

Biomedical Circuits

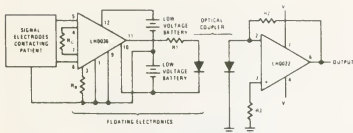


Fig. 11-1. Isolation amplifier for medical telemetry (NS).

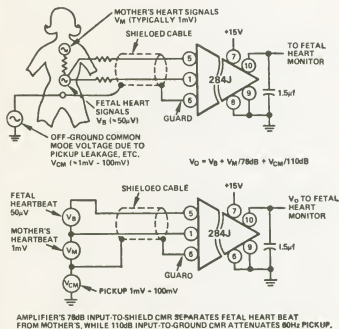


Fig. 11-2. Fetal heartbeat monitoring input circuitry using an Analog Devices 284-J isolation amplifier (AD).

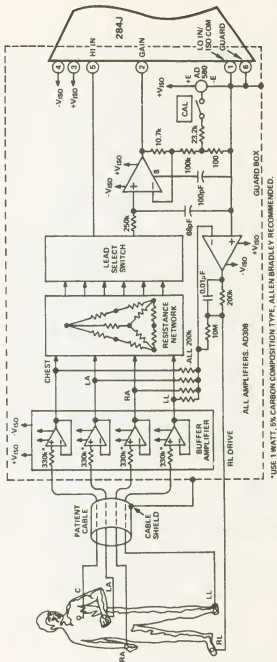
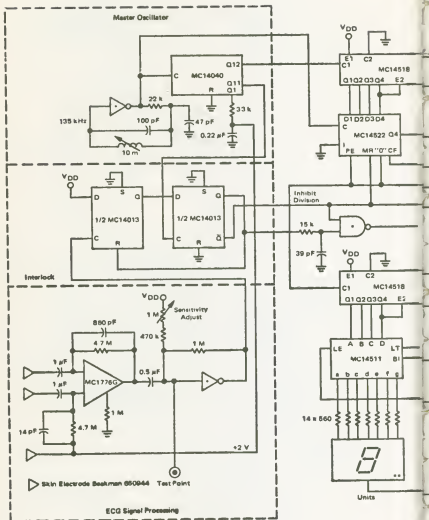
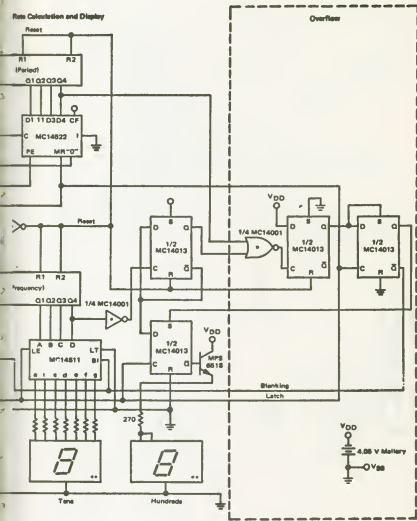


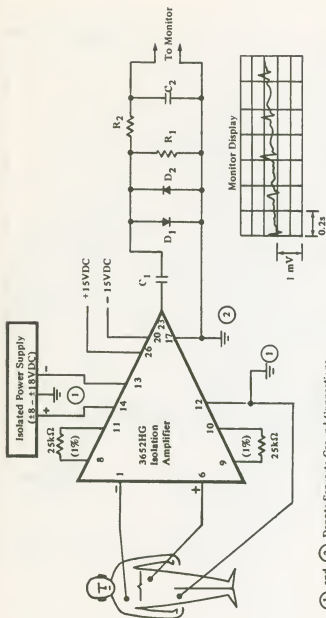
Fig. 11-3. Multilead EKG recorder input circuitry using a 284J isolation amplifier (AD).



*MC14572 Hex Functional Gate **Common Cathode Display HP5082-7740

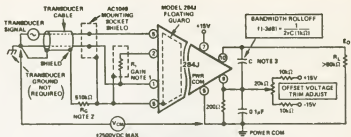
Fig. 11-4. Heart rate monitor (M).





① and ② Denote Separate Ground Connections

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



NOTE 1. GAIN RESISTOR, R_G , 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

$$\text{GAIN} = 1 + \frac{100k\Omega}{107k\Omega + R_G(k\Omega)}$$

NOTE 2. GUARD RESISTOR R_G , REQUIRED ONLY FOR $CWV > \pm 2500V_{PK}$ ($\pm 5kV_{PK}$ MAX).
 R_G MAY BE MOUNTED ON AC1049 MOUNTING SOCKET USING STANDOFF PROVIDED.
 (USE 1/2 WATT, 5% CARBON COMPOSITION TYPE, ALLEN BRADLEY RECOMMENDED).

NOTE 3. OUTPUT FILTER CAPACITOR, C, SELECT TO ROLLOFF NOISE
 AND OUTPUT RIPPLE. I.e. SELECT C = 1 μ F FOR dc TO 100Hz BANDWIDTH.

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

Chapter 12

Bridge Circuits

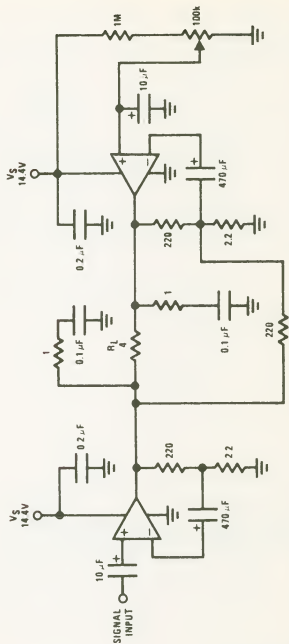


Fig. 12-1. A 16-watt bridge amplifier.

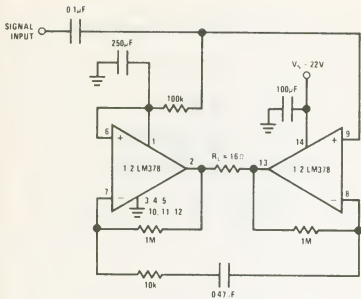


Fig. 12-2. An 8-watt bridge amplifier.

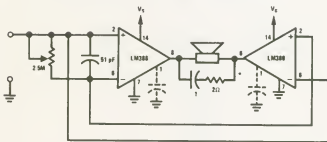


Fig. 12-3. Bridge amplifier.

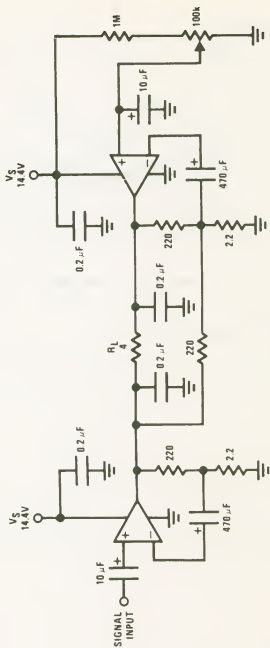


Fig. 12-4. A 16-watt bridge amplifier.

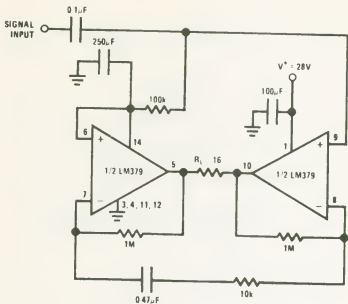


Fig. 12-5. A 12-watt bridge amplifier.

Chapter 13

Chopper Circuits

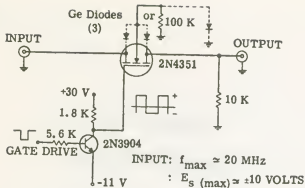
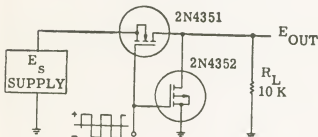


Fig. 13-1. MOSFET analog switching circuit (chopper) for large input voltages (M).



MAXIMUM CHOPPING FREQUENCY $f_{\max} \approx 5 \text{ MHz}$
 MAXIMUM INPUT VOLTAGE $E_s (\max) \approx +0.5 \text{ V}, -4.0 \text{ V}$

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

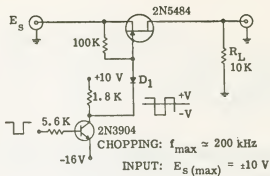


Fig. 13-3. Series chopper for large input voltages using an N-channel JFET (M).

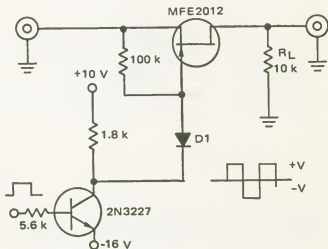
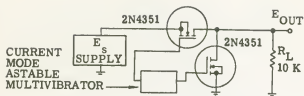


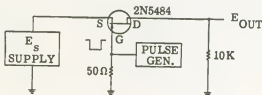
Fig. 13-4. JFET chopper with extended range of ± 10 volts (M).



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

MINIMUM INPUT VOLTAGE $E_s (min) \approx \pm 10 \mu\text{V}$

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



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

MAXIMUM INPUT VOLTAGE $E_s (max) \approx +2 \text{ V}, -0.4 \text{ V}$

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

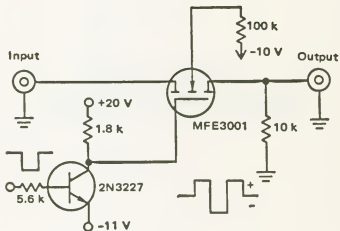


Fig. 13-7. MOSFET chopper with extended range of ± 3 volts (M).

Chapter 14

Computer-Related Circuits

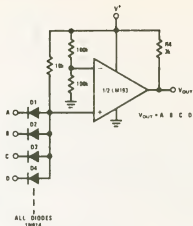


Fig. 14-1. Large fan-in AND gate (NS).

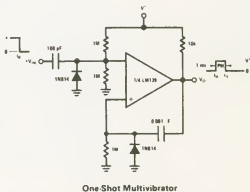
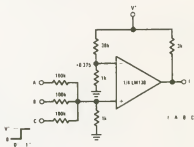


Fig. 14-2. AND gate (NS).

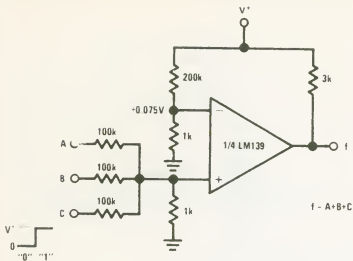


Fig. 14-3. OR gate (NS).

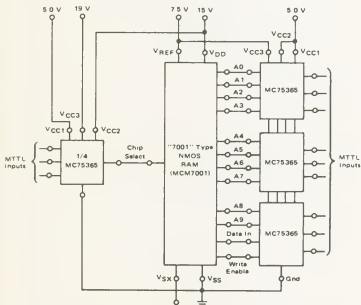


Fig. 14-4. Quad MOS clock driver with 7001 type 1K RAM (M).

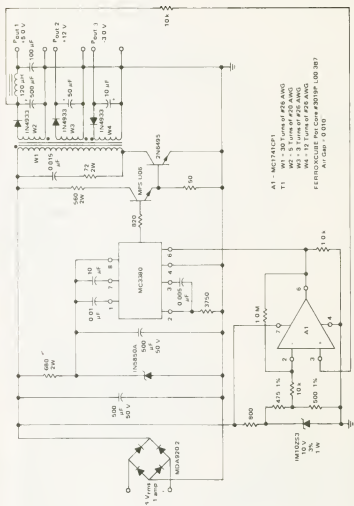
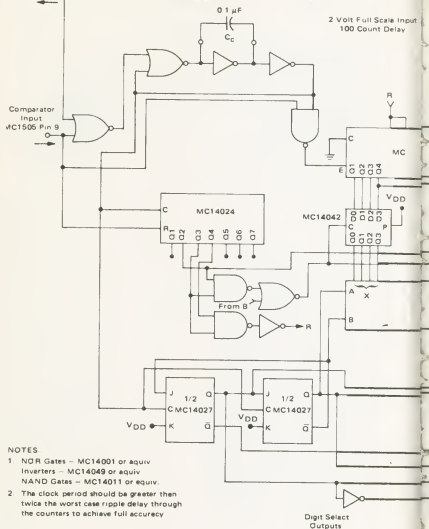


Fig. 14-5. Multiple output switching regulator for use with microprocessing units (M).

Ramp Control
MC1505 Pin 10

Comparator
Input
MC1505 Pin 9

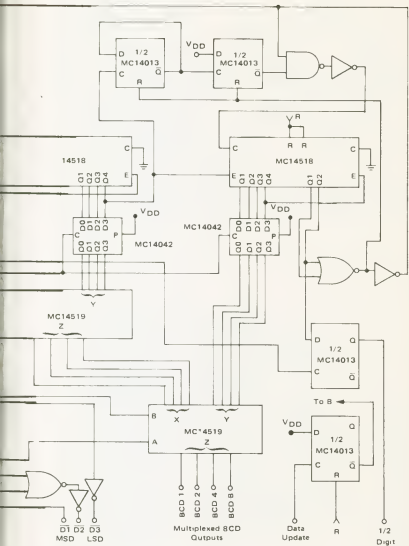
2 Volt Full Scale Input
100 Count Delay



NOTES

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

Fig. 14-6. A 3-1/2 digit BCD A/D converter (M).



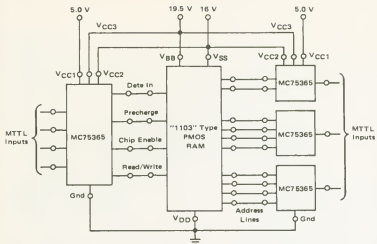


Fig. 14-7. Quad MOS clock driver with 1103 type 1K RAM (M).

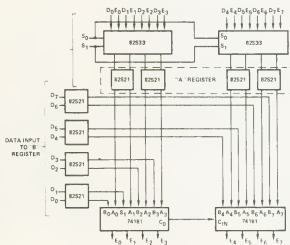


Fig. 14-8. Basic 8-bit fully buffered accumulator (S).

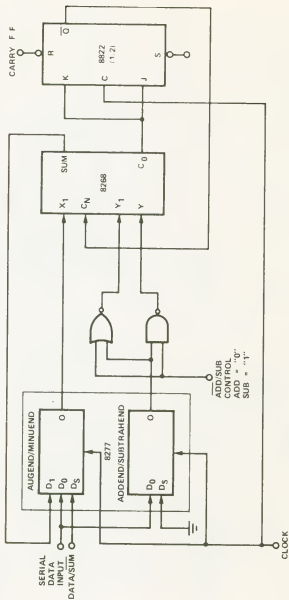


Fig. 14-9. An 8-bit A/D add/subtractor (S).

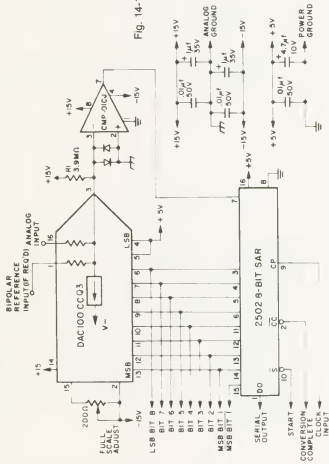


Fig. 14-10. Complete 8-bit A/D converter (PM).

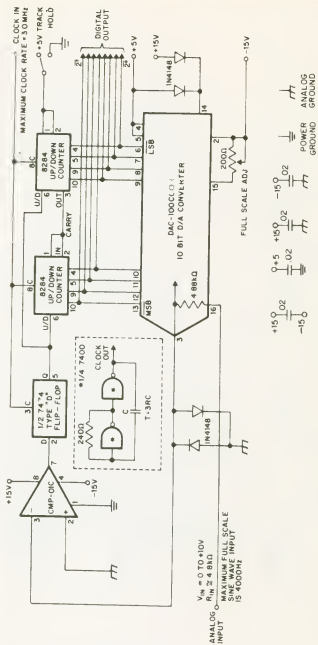


Fig. 14-11. An 8-bit tracking A/D converter (PM).

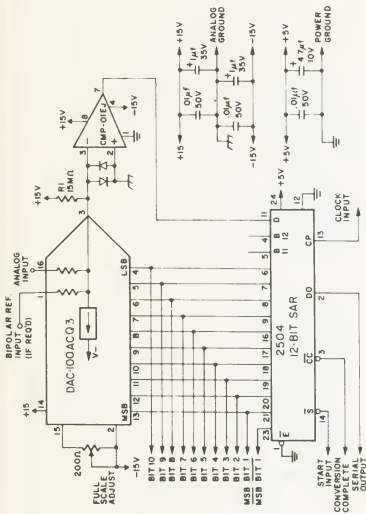


Fig. 14-12. A 10-bit A/D converter (PM).

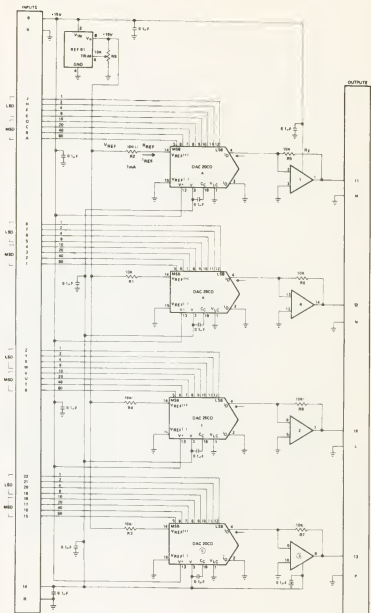
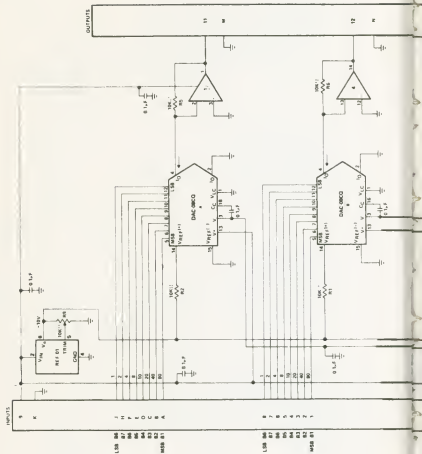


Fig. 14-13. A 4-channel BCD DAC (PM).



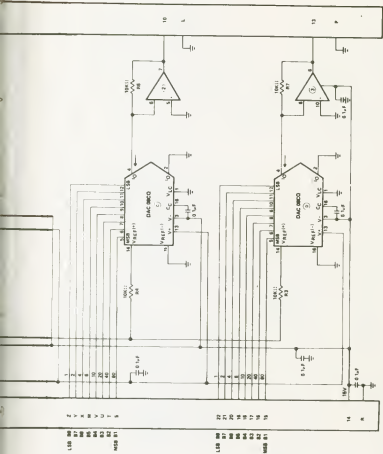


Fig. 14-14. A 4-channel binary DAC (PM).

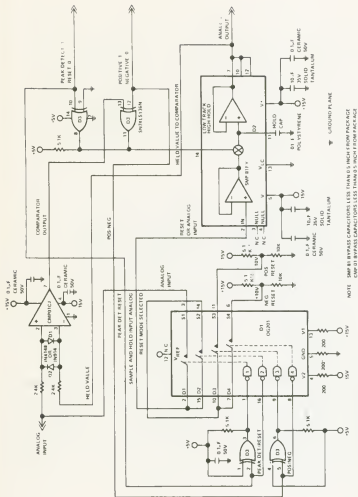


Fig. 14-15. Programmable peak detector (PM).

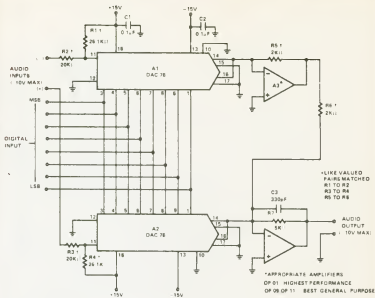


Fig. 14-16. Clickless attenuator/amplifier (PM).

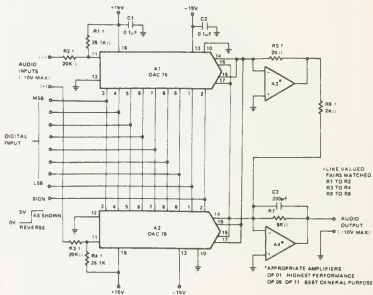
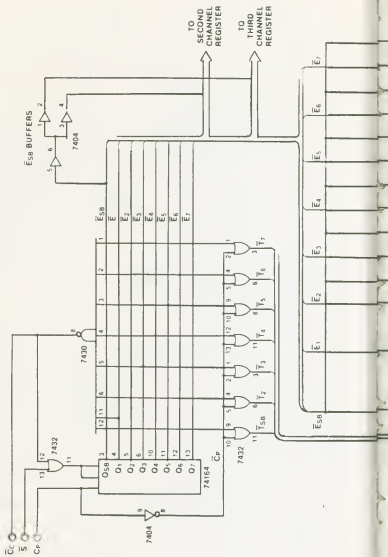


Fig. 14-17. Sign and magnitude clickless attenuator/amplifier (PM).



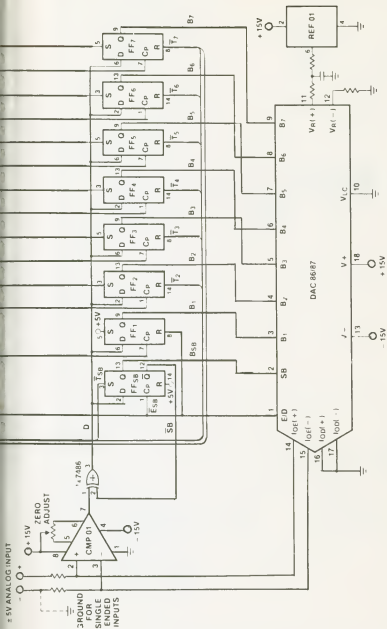


Fig. 14-18. An 8-channel encoder (PM).

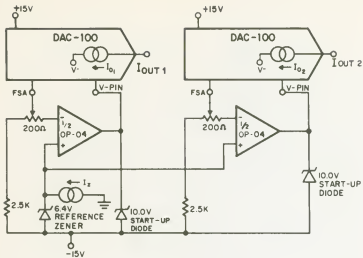


Fig. 14-19. External reference connection (PM).

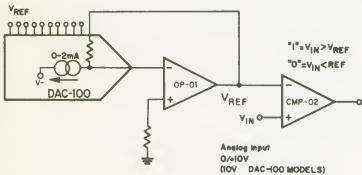
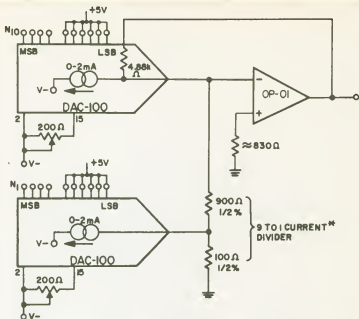
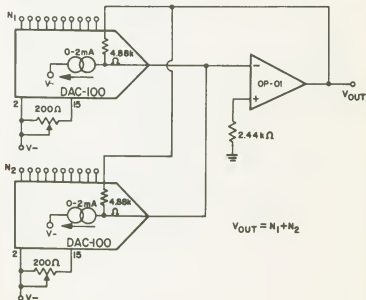


Fig. 14-20. Digitally programmed level detector (PM).



* (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).



$$V_{OUT} = N_1 + N_2$$

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

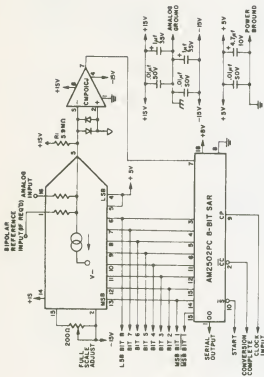


Fig. 14-23. An 8-bit ADC (PM).

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

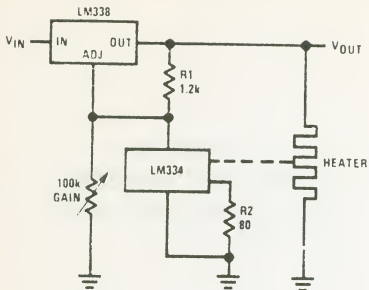


Fig. 15-1. Temperature controller (NS).

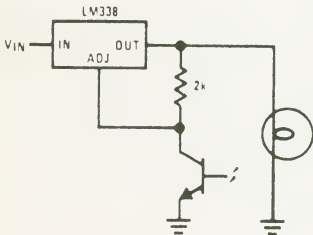


Fig. 15-2. Light controller (NS).

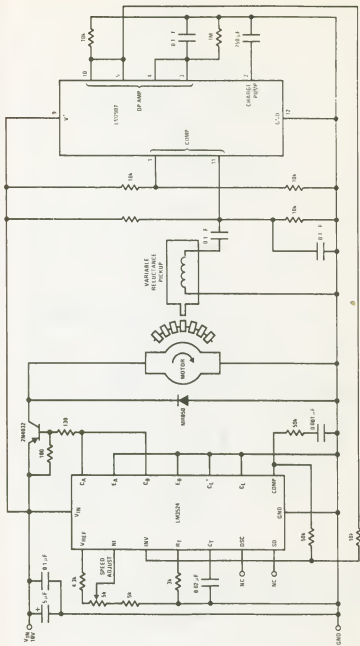


Fig. 15-3. Motor speed control (NS).

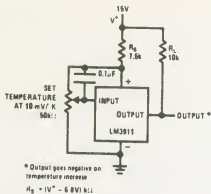
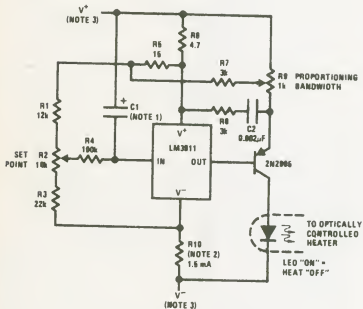


Fig. 15-4. Basic temperature controller (NS).



Note 1: C1 determines proportioning frequency $f \approx \frac{1}{2R_4 C_1}$

Note 2: $R_{10} = \frac{(V^+ + |V^-|) - 7}{0.0015}$

Note 3: Either V⁻ or V⁺ can be ground.

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

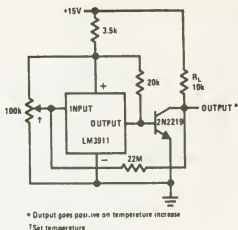
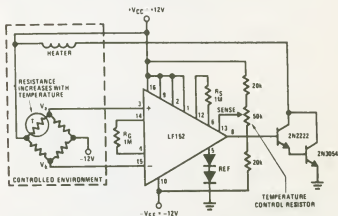


Fig 15-6. Temperature controller with hysteresis (NS).



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).

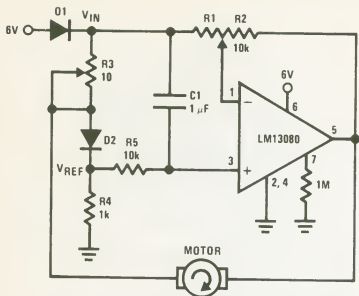


Fig. 15-8. Motor speed control (NS).

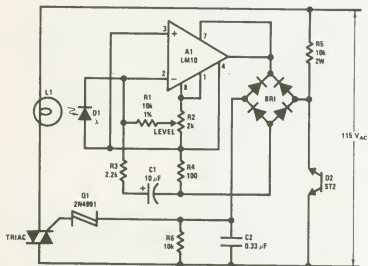
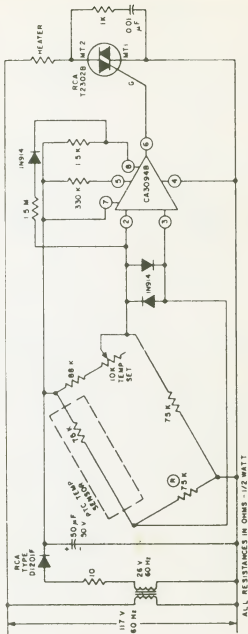
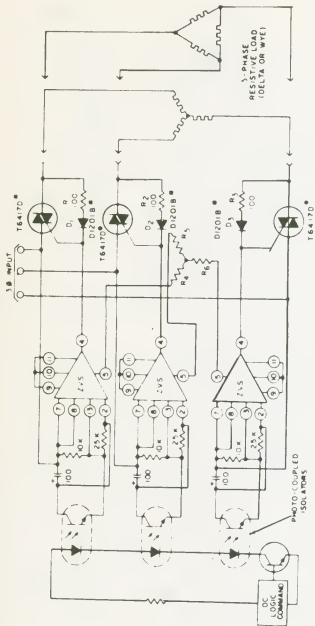


Fig. 15-9. Light-level controller (NS).



92CM 20270R2

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



- FORMERLY RCA 44003
- FORMERLY RCA 40708

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

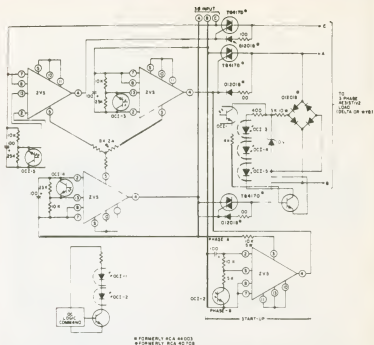


Fig. 15-12. A 3-phase power control that employs zero-voltage synchronous switching for both steady-state operation and for starting (RCA).

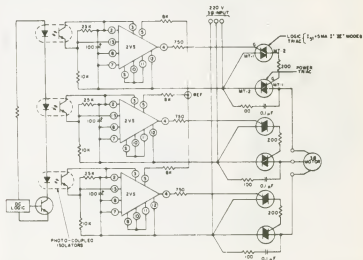


Fig. 15-13. A 3-phase control circuit for an inductive load, such as a 3-phase motor (RCA).

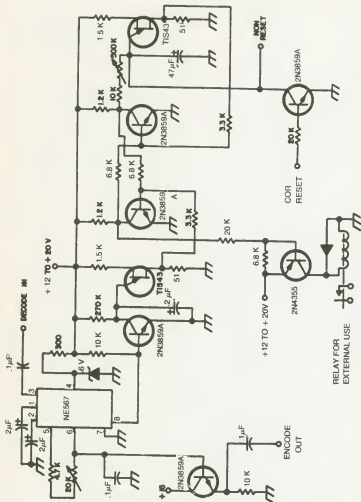


Fig. 15-14. Tone decoder for repeaters does not false-trip. Transistors are 2N3859A types unless otherwise noted.

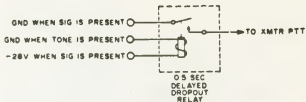
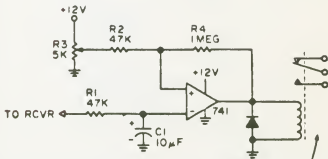


Fig. 15-15. There are many methods for keying continuous-tone-carrier-squelch (PL) systems, but those employing delayed dropout relays are the most successful. Here, the tone and the signal must be present to hold the repeater on the air. Momentary tone variations because of weak signal will not cause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



12V dc low power
relay (Sigma 65F1A-12DC
or Calectro D1-967)

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

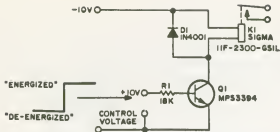


Fig. 15-17. Electronic control of a dc relay (M).

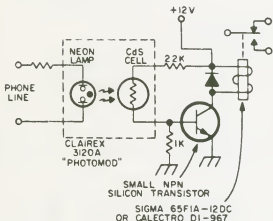


Fig. 15-18. Solid-state telephone ring relay. Ring signal from telephone company lights neon lamp, which causes drop in resistance in CdS cell, turning on transistor, which closes the relay. Circuit has two nice advantages—since there is no direct connection from telephone line to power supply circuit, 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.

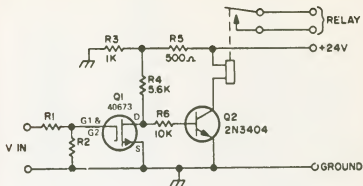


Fig. 15-19. Solid-state carrier-operated relay uses dual-gate FET.

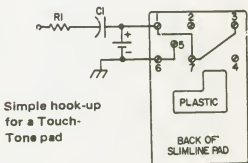


Fig. 15-20. A 1½V hearing aid battery mounted inside handset. C1 is approximately a 0.5—3 μF, with 1½V.

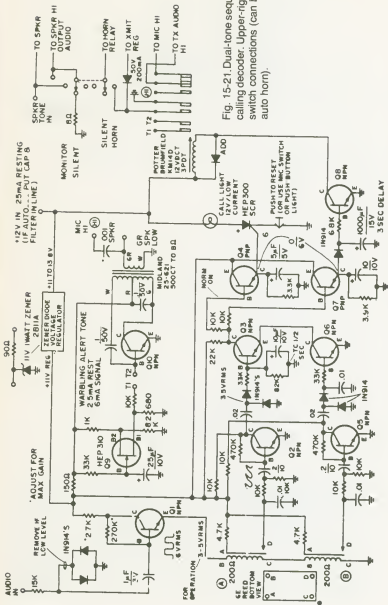
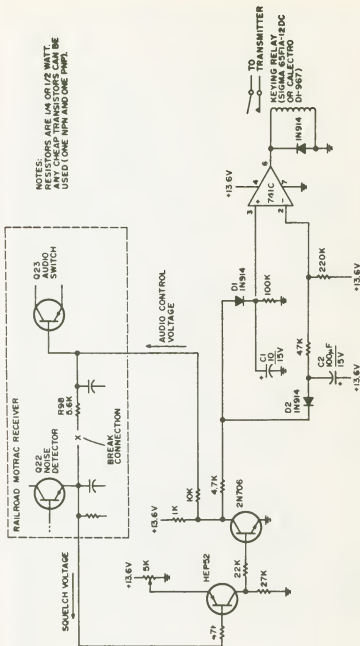


Fig. 15-21. Dual-tone sequential selective calling decoder. Upper-right drawing shows switch connections (can be used to sound auto horn).



NOTES:
RESISTORS ARE 1/4 OR 1/2 WATT
ANY CHEAP TRANSISTORS CAN BE
USED (ONE NPN AND ONE PNP).

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

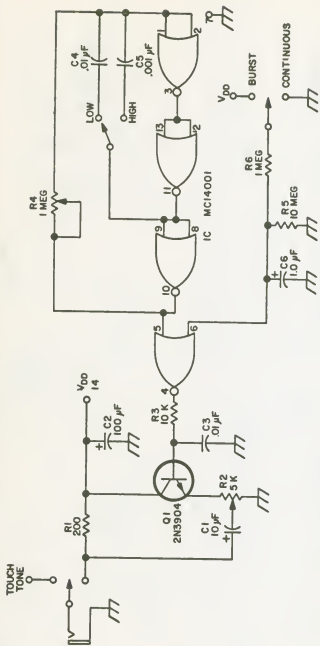


Fig. 15-23. Tone generator features CTCSS (low-frequency) or burst (high frequency) outputs. All gates are part of Motorola MC 14001 integrated circuit.

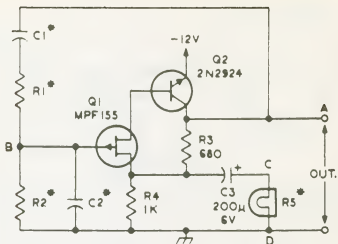


Fig. 15-24. Fixed-frequency oscillator. Components marked with asterisk: C1 & C2 are 0.001 μ F, and R1 & R2 are 15.8K for audio frequency of 10 kHz.

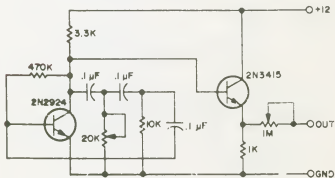


Fig. 15-25. Continuous-tone encoder produces about 100 Hz for superimposition on rf carrier, for CTCSS applications.

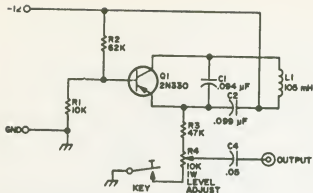


Fig. 15-26. K6ASK single tone encoder.

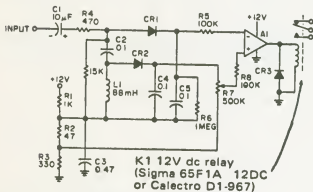


Fig. 15-27. 1800-Hz decoder.

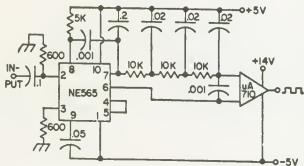


Fig. 15-28. Decoder for frequency-shift keying system uses phase-locked loop and uA710 operational amplifier. Frequency of operation: 1070 & 1270 Hz.

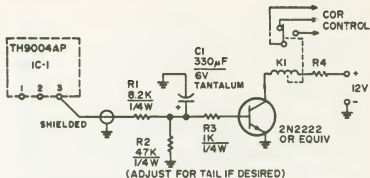


Fig. 15-29. Schematic of a COR circuit for the IC20/21. R4 must be adjusted to keep the collector current of the transistor less than 750 mA. The value is dependent on the relay resistance. The R2/C1 combination control tail time.

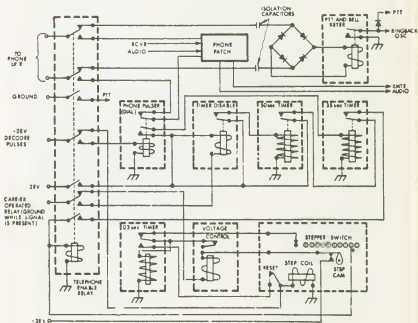


Fig. 15-30. Complete electromechanical control system for remotely operated (radio) telephone (land line).

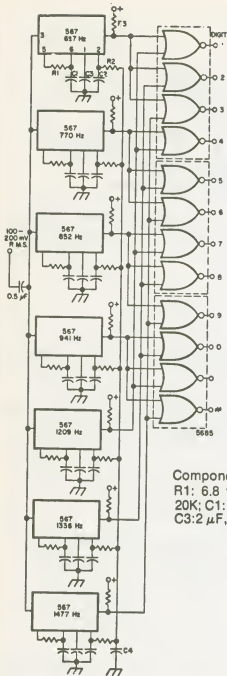
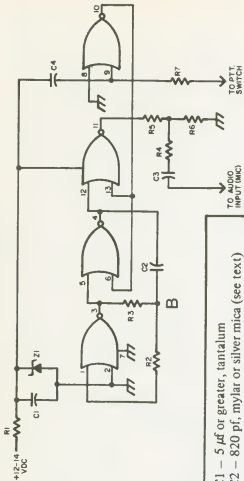


Fig. 15-31. Touch-tone decoder.

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.

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



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

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.

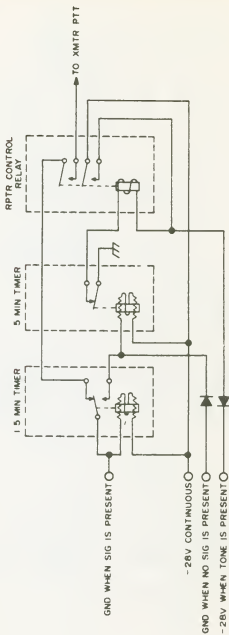


Fig. 15-34. The complete whistle-on repeater control system contains two timers and an ordinary relay. If a carrier stays on for more than 1.5 minutes, the push-to-talk circuit is disconnected. If the carrier stays on 6.5 minutes, the repeater shuts down and must be whistled on again. Also, if nobody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

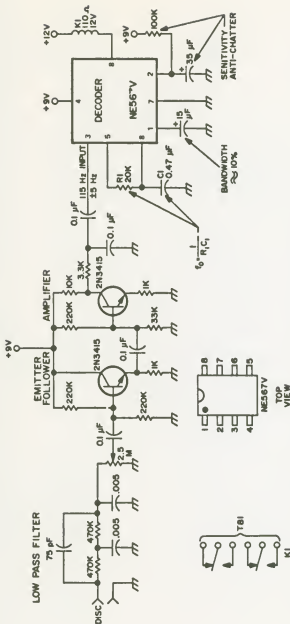


Fig. 15-35. Tone decoder for CTCSS (continuous-tone carrier squelch system) applications operates from frequencies in 100 Hz range.

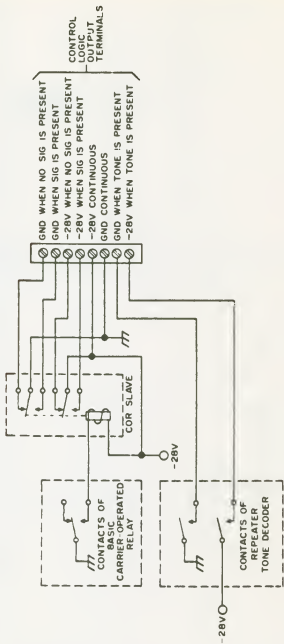


Fig. 15-36. A heavy-duty relay slaved to the carrier-operated relay, along with ground an voltage outputs from the tone decoder, can be used to provide a variety of very useful logic signals for all repeater control functions.

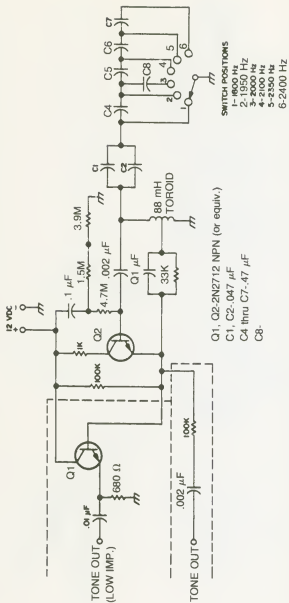


Fig. 15-37. Tone-burst entry is becoming increasingly common as a requirement—repeaters in many parts of the country now require anything from 1800 Hz to 2400 Hz for entry. The circuit above is for a tone-burst generator to meet these requirements. Circuits courtesy of the Central Ohio Radio Club FM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

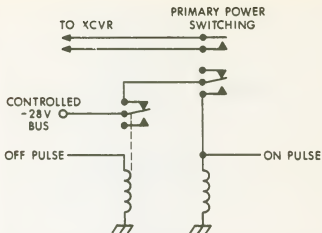


Fig. 15-38. Electromechanical latching relay pair. Relay type is not critical. On pulse pulls in primary power switching contacts, which lock because coil voltage is delivered through its own contacts. A short off pulse is all that's required to break the circuit.

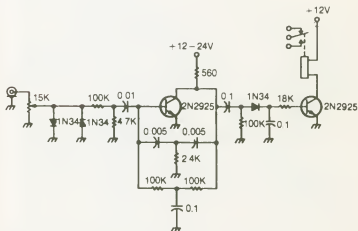


Fig. 15-39. A 1000 Hz decoder provides relay closure when audio signal of proper frequency appears at input.

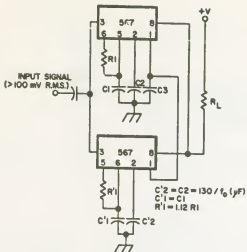


Fig. 15-40. A 24 % bandwidth tone decoder.

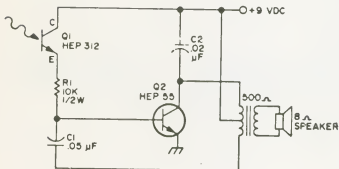


Fig. 15-41. Light-triggered tone oscillator that can find numerous applications as a burglar alarm, or even to let you know that the sun has come up and it's time to go to work (M).

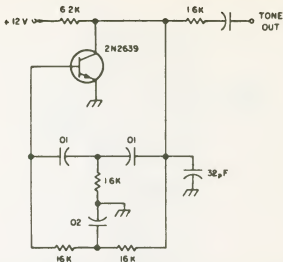


Fig. 15-42. Single-transistor tone oscillator for tone-burst or whistle-on repeater-access use produces 1750 Hz at sufficient amplitude for most transmitters.

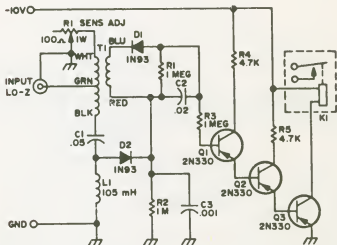


Fig. 15-43. This single-tone decoder has a high degree of selectivity, stability, and reliability.

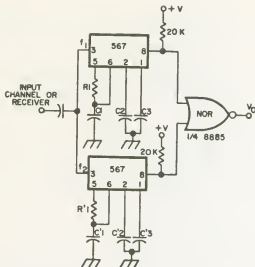


Fig. 15-44. Resistor and capacitor values chosen for desired frequencies and bandwidth. If C_3 is made large so as to delay turn-on of the top 567, decoding of sequential (f_1, f_2) tones is possible.

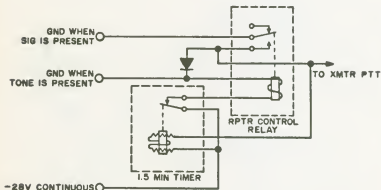


Fig. 15-45. Tone-burst repeaters can be set up with nothing more than a relay and a timer if the decoder and COR logic signals are available. Here, a short tone burst will energize the control relay, which latches as long as a carrier stays on the input. If the carrier stays on more than 1.5 minutes, 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
R8	300Ω	5K pot (multiturn)
R9	0.1μF	300Ω
C1, 2, 3	47 μF, 20V tantalum	0.001 μF
C4	0.01 μF	47 μF, 20V tantalum
C5		1 μF tantalum
Q1	2N930	tantalum
Q2	2N2369	1 μF tantalum

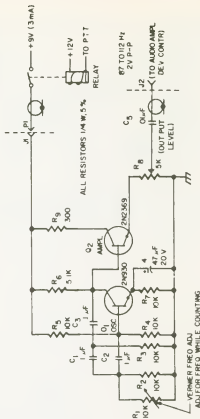


Fig. 15-46. Tone encoder. Part values shown in diagram are for low-frequency continuous-tone carrier squelch system (CTCSS) applications; for single-tone refer to accompanying table.

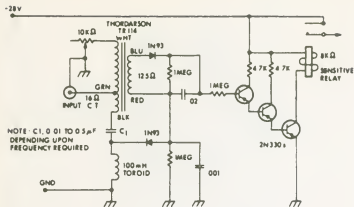


Fig. 15-47. Single-tone decoder.

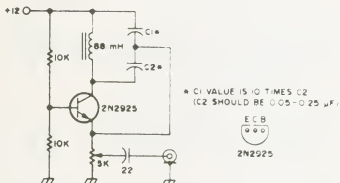


Fig. 15-48. Simple tone encoder for radio remote control applications. C2 is 10 times the value of C1. For 1000 Hz, C1 = 0.22 μ F, and C2 is 2 μ F. Both capacitors should be nothing less than mica for stability.

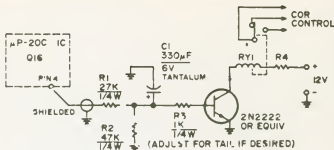


Fig. 15-49. Schematic of a COR circuit for the TR22. R4 must be adjusted to keep the collector current of the transistor less than 750 mA. The value is dependent on the relay resistance. The R2/C1 combination controls tail time.

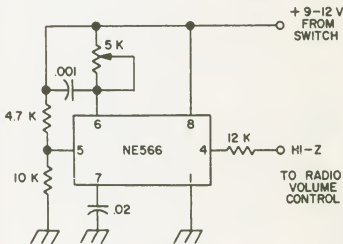


Fig. 15-50. Simple tone oscillator connects to wiper arm of any portable radio's volume control to convert radio into audible tone generator—for keying repeaters and commanding other remotely controllable functions by holding portable radio up to microphone.

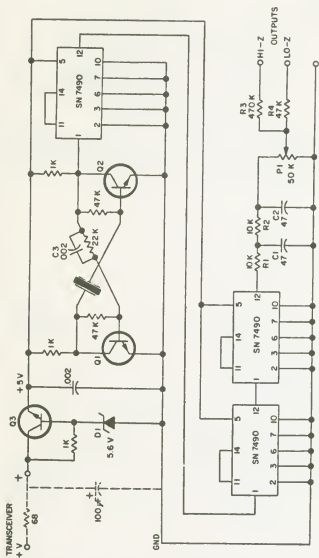


Fig. 15-51. Schematic of a subaudible tone generator. Q1, 2—MPS6513; Q3—2N1613.

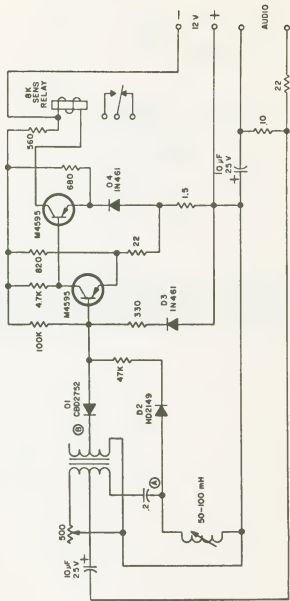


Fig. 15-52. This audio decoder responds to signals in the frequency range of 2200-2900 Hz. Although Motorola part numbers are shown, equivalent values may be substituted.

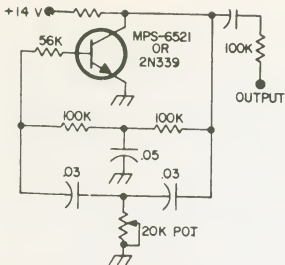


Fig. 15-53. A simple and stable subaudible tone generator for CTCSS use with FM repeaters. With miniature components it can be made postage-stamp size and tucked away into any rig. For stability, Mylar capacitors and film resistors are best, but carbon resistors can be substituted successfully. It was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

Chapter 16

Converters

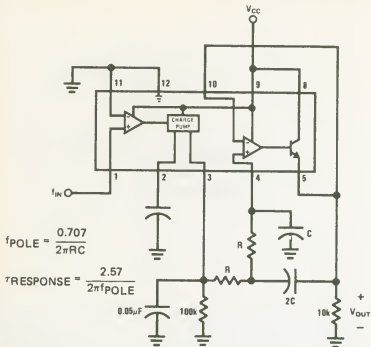


Fig. 16-1. Frequency-to-voltage converter with 2-pole Butterworth filter to reduce ripple (NS).

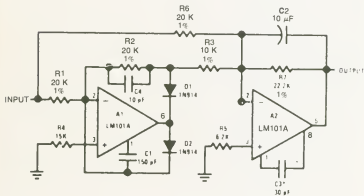


Fig. 16-2. Fast AC/DC converter (NS).

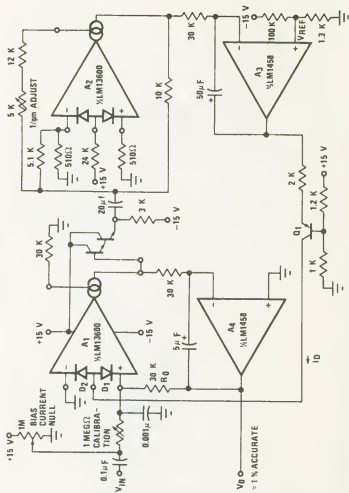
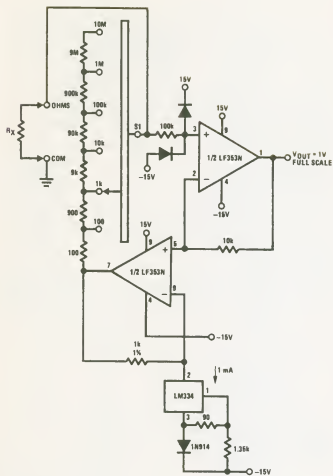


Fig. 16-3. True rms converter (NS).



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

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

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

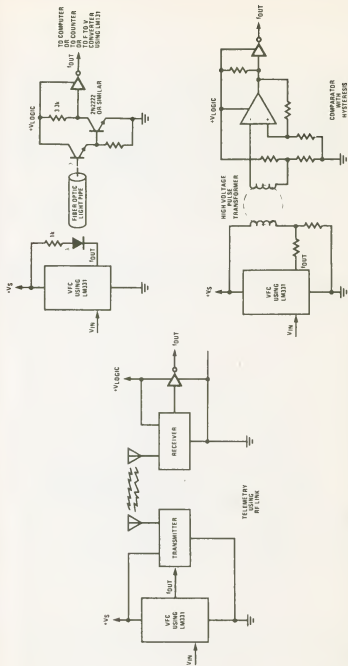


Fig 16-5. Various voltage-to-frequency converters with isolators (NS).

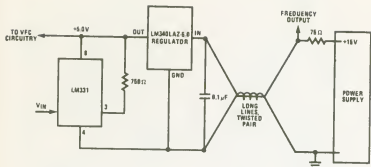


Fig. 16-6. Remote voltage-to-frequency converter with 2-wire transmitter and receiver (NS).

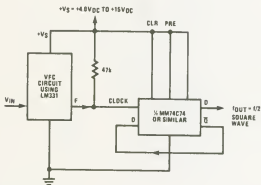


Fig. 16-7. Voltage-to-frequency converter with square wave output using + 2 flip-flop (NS).

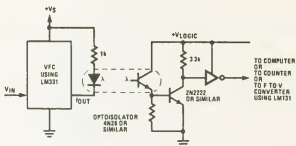


Fig. 16-8. Voltage-to-frequency converter with isolators (NS).

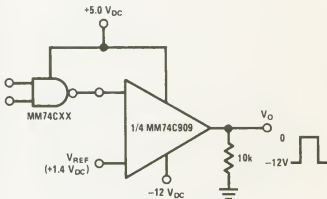
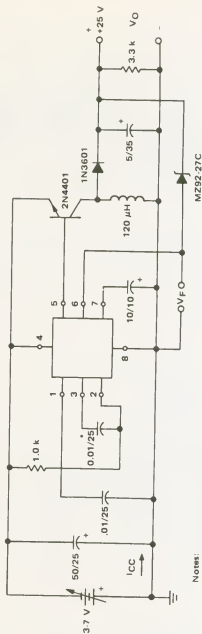


Fig. 16-9. CMOS/TTL to MOS logic converter (NS).



Notes:

1. All resistor values in ohms, $\pm 1\%$, $1/4$ W
2. All capacitor values in μF , = 20%, except * $\pm 5\%$.
3. All inductors $\pm 4\%$.

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

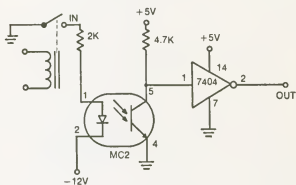
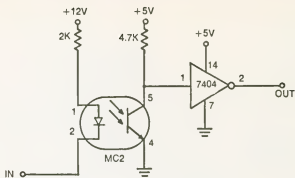


Fig. 16-11. Two 12V-to-15V level conversion circuits.

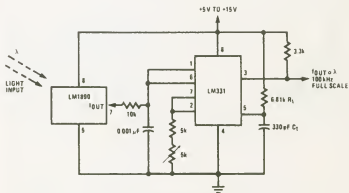


Fig. 16-12. Light intensity-to-frequency converter (NS).

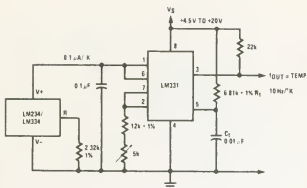


Fig. 16-13. Temperature-to-frequency converter (NS).

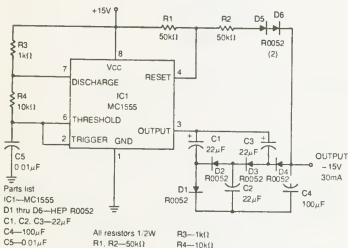


Fig. 16-14. DC-DC converter (+15V to -15V).

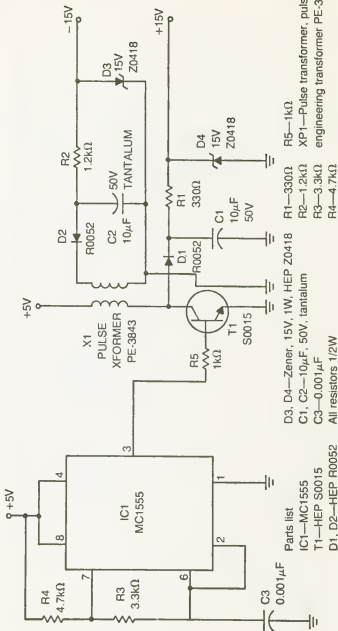


Fig. 16-15. DC-DC converter (+5V to +15V and -15V).

Chapter 17

CW Circuits

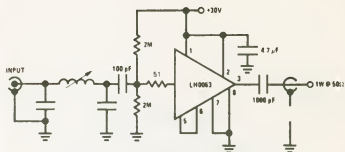


Fig. 17-1. A 1-watt CW final amplifier (NS).

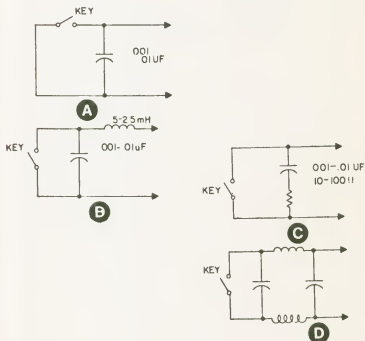


Fig. 17-2. Key click filters.

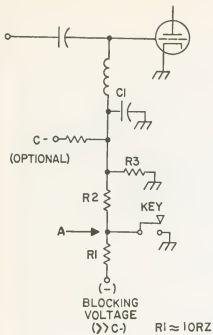


Fig. 17-3. Simple grid block keying.

Chapter 18

Data Transfer Circuits

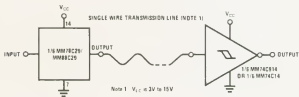
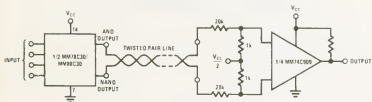
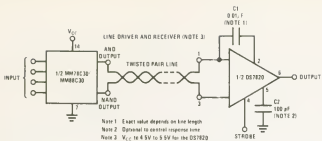


Fig. 18-1. Digital data transmission (NS).

Chapter 19

Demodulators

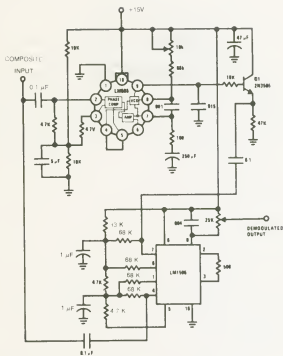


Fig. 19-1. A 2400-Hz synchronous AM demodulator (NS).

Chapter 20

Detectors

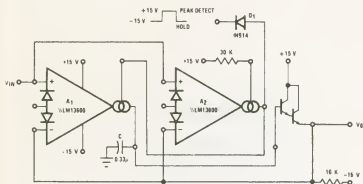


Fig. 20-1. Peak detector and hold circuit (NS).

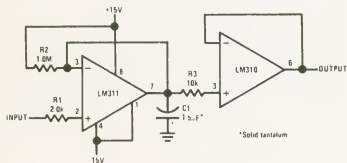


Fig. 20-2. Negative peak detector (NS).

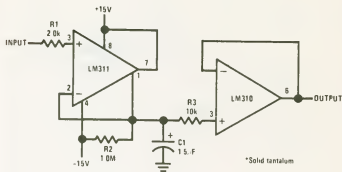


Fig. 20-3. Positive peak detector (NS).

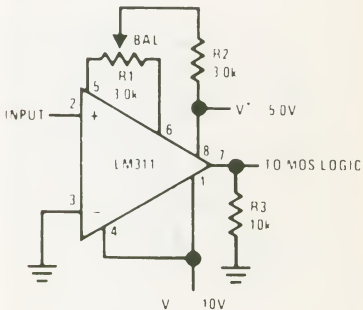


Fig. 20-4. Zero crossing detector driving MOS logic (NS).

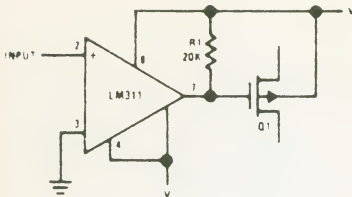


Fig. 20-5. Zero crossing detector driving a MOS switch (NS).

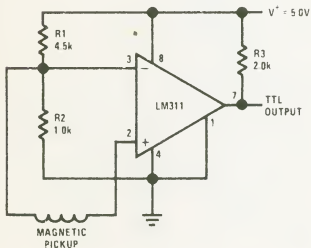


Fig. 20-6. Detector for a magnetic transducer (NS).

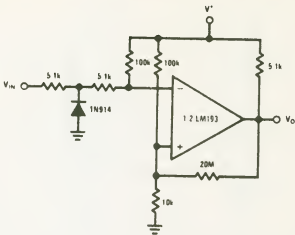


Fig. 20-7. Zero crossing detector with a single power supply (NS).

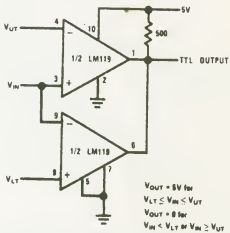


Fig. 20-8. Window detector (NS).

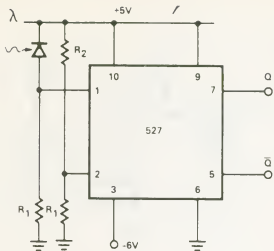


Fig. 20-9. Photodiode detector (S).

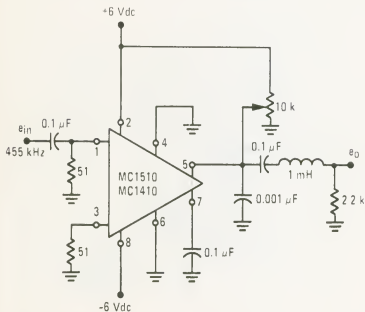


Fig. 20-10. Envelope detector (M).

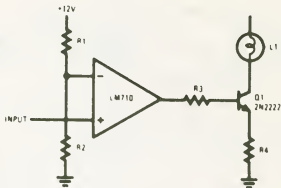


Fig. 20-11. Level detector with lamp driver (NS).

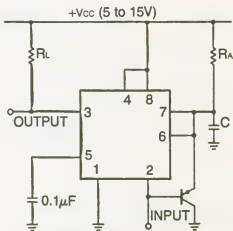


Fig. 20-12. Missing pulse detector using an ECG955M timer/oscillator chip. The timing cycle is continuously reset by the input pulse train. A change in frequency or missing pulse allows completion of the timing cycle, which causes a change in the output level. The time delay should be set a little longer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

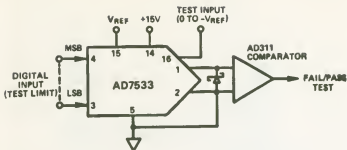


Fig. 20-13. Digitally programmable limit detector (AD).

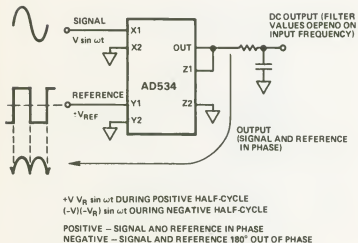


Fig. 20-14. Phase-sensitive detector with square-wave reference. If the input and reference are in phase the output is positive. If they are 180° out of phase the output is negative (AD).

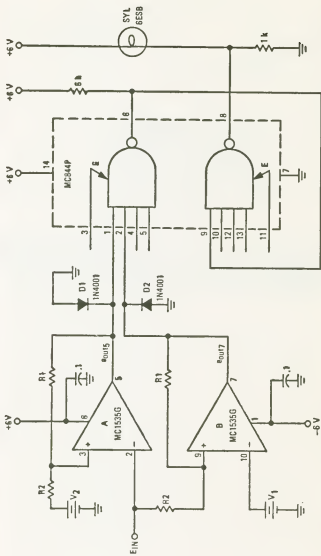
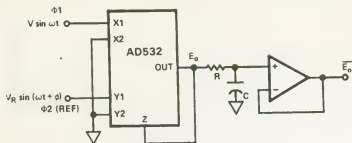


Fig. 20-15. Signal-level envelope detector. The MC1535G is a dual op amp and the MC844P a dual power gate. This circuit indicates by way of the lamp when the input signal is out of range (M).



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

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

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

$$\bar{E}_o = \frac{V V_R}{20} \cos \phi = \frac{V V_R}{20} \text{ (IN PHASE)}$$

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

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

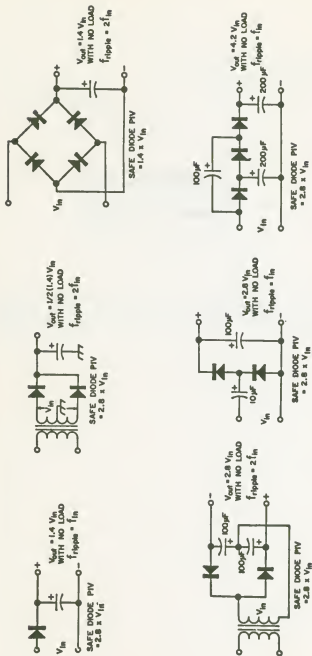


Fig. 21-1. The most popular rectifier circuits with their output voltages and minimum safe diode PIV rating.

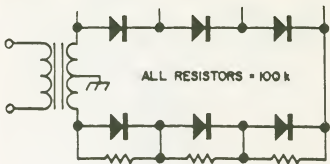


Fig. 21-2. Resistors are used across series diodes to equalize reverse voltage drop.

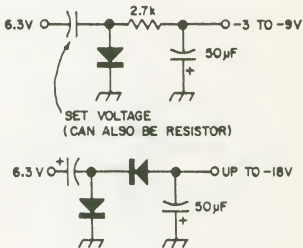


Fig. 21-3. Simple shunt rectifiers can provide low bias voltages.

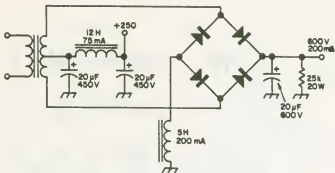


Fig. 21-4. This circuit gives two outputs, 600V and 250V.

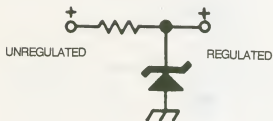


Fig. 21-5. A basic zener regulator. The values depend on input and output voltage, current, etc.

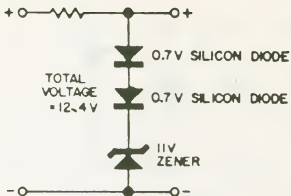


Fig. 21-6. Forward-biased silicon diodes can be used as low-voltage zeners. Their temperature drift is opposite that of regulators with breakdown voltages over 6V, which is convenient for temperature stabilization.

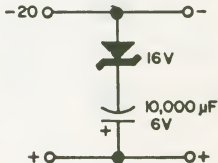


Fig. 21-7. A zener can be used as a ripple filter and to "increase" the voltage rating of a capacitor.

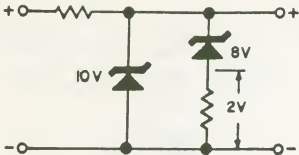


Fig. 21-8. Two zeners can furnish a regulated low voltage.

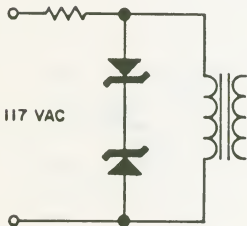
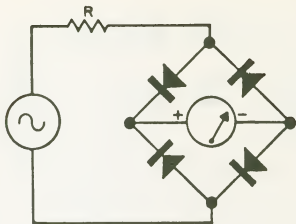


Fig. 21-9. Zener regulators can be used on AC, too.



ALL MULTIPLIER RESISTANCE AT R

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

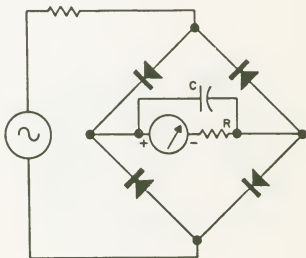


Fig. 21-11. A bridge peak-reading AC meter.

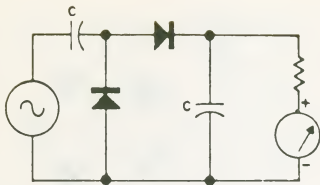


Fig. 21-12. A peak-to-peak AC meter is simply a voltage doubler.

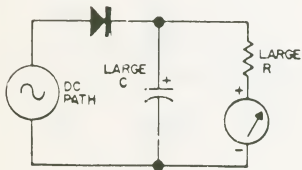


Fig. 21-13. A half-wave peak-reading AC meter.

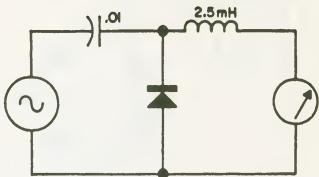


Fig. 21-14. A half-wave peak-reading AC meter that requires no DC path.

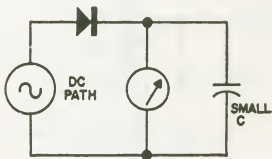


Fig. 21-15. A semi-rms AC meter.

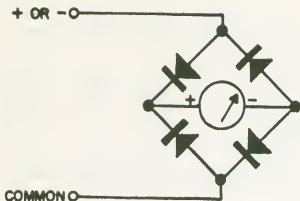


Fig. 21-16. A meter for AC, or either polarity DC.

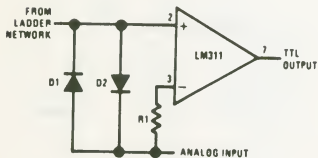


Fig. 21-17 Using clamp diodes to improve response.

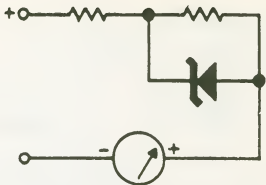


Fig. 21-18. This circuit partially suppresses the low end of a range.

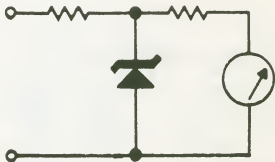


Fig. 21-19. This is a meter-protective circuit. The zener should be tapped on the resistor chain at a point that provides conduction when the meter pointer is pinned.

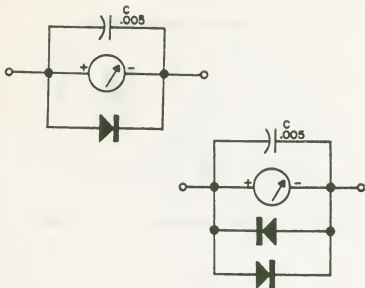


Fig. 21-20. Conventional silicon diodes can protect a meter movement, too. The $0.005 \mu\text{F}$ capacitor bypasses rectified rf.

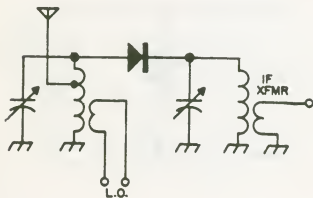


Fig. 21-21. A basic diode mixer as used at UHF and microwave.

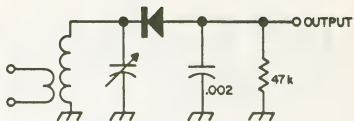


Fig. 21-22. A half-wave detector. This can be used as a crystal set, too.

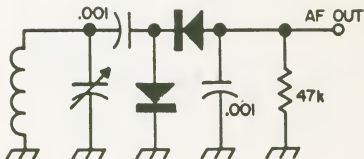


Fig. 21-23. This detector provides better results.

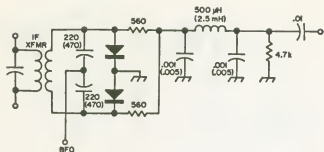


Fig. 21-24. A product detector for 9 MHz SSB. The values in parentheses are for 455 kHz.

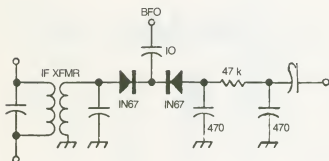


Fig. 21-25. A popular product detector for SSB.

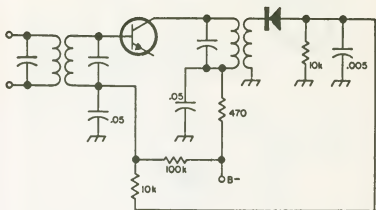


Fig. 21-26. Forward transistor agc.

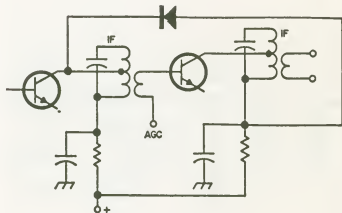


Fig. 21-27. An auxiliary agc diode improves agc action.

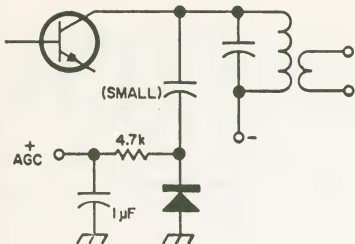


Fig. 21-28. An auxiliary agc detector can be used with a product detector for SSB/CW.

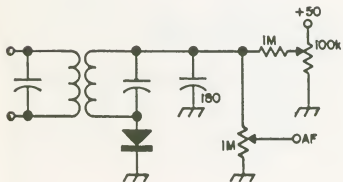


Fig. 21-29. Simple diode squelch.

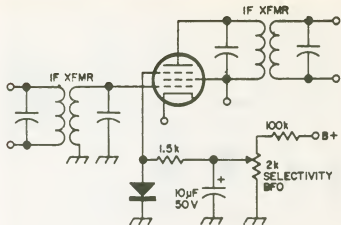


Fig. 21-30. Adapter to provide SSB/CW reception and Q-multiplication in a receiver.

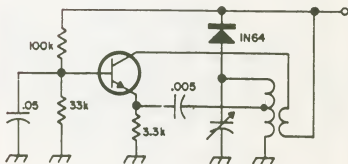


Fig. 21-31. This circuit uses a diode to limit the output of an oscillator.

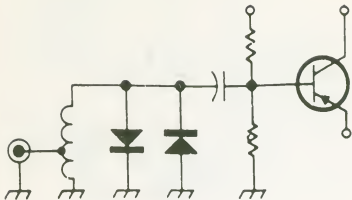


Fig. 21-32. Diodes can be used to protect a transistor amplifier from burnout.

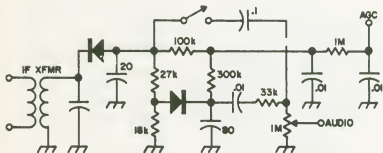


Fig. 21-33. One of the best noise limiters is the rate-of-change limiter designed for TV audio in England.

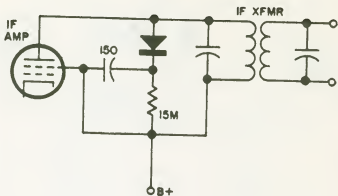


Fig. 21-34. This simple noise limiter is installed in an i-f stage for SSB and CW.

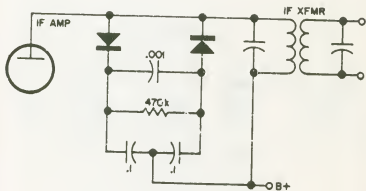


Fig. 21-35. This is an improved version of the SSB i-f noise limiter.

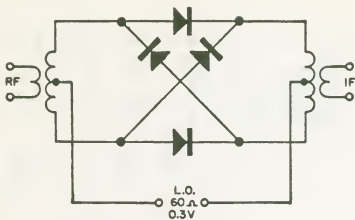


Fig. 21-36. A diode ring balanced modulator.

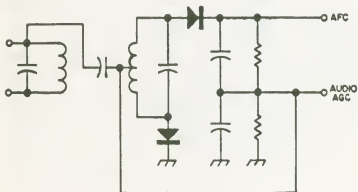


Fig. 21-37. Foster-Seeley FM discriminator.

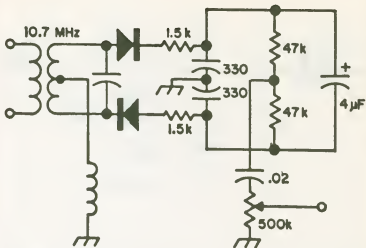


Fig. 21-38. A 10.7 MHz FM ratio detector.

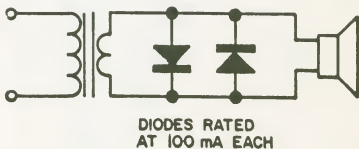


Fig. 21-39. Shunt diode noise limiter for use across a loudspeaker.

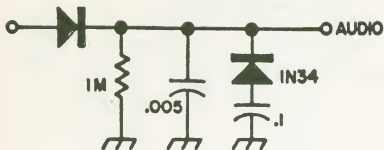


Fig. 21-40. Shunt diode noise limiter that can be easily added to the input of an audio amplifier.

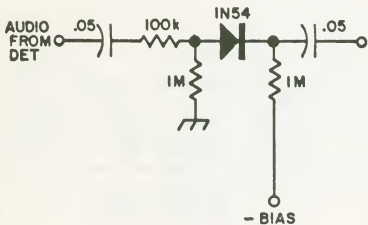


Fig. 21-41. Half-wave series noise limiter with adjustable clipping level.

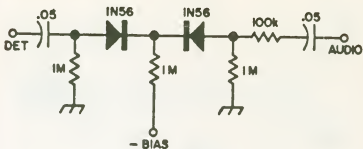


Fig. 21-42. Full-wave series noise limiter.

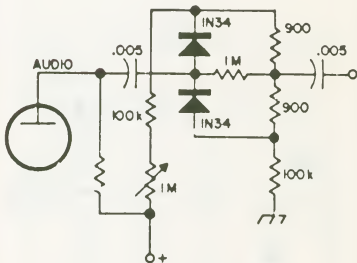


Fig. 21-43. This trough limiter will eliminate the background noise that is ignored by conventional limiters.

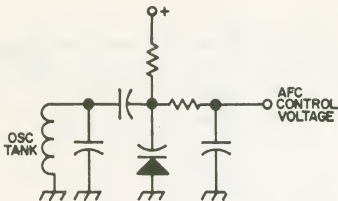


Fig. 21-44. A varactor is often used to provide automatic frequency control. The control voltage is provided by a discriminator.

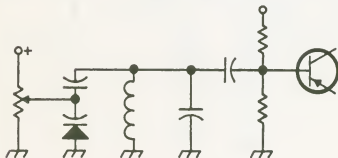


Fig. 21-45. An rf stage or oscillator can be tuned with a varactor.

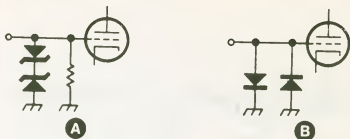


Fig. 21-46. Simple clippers can be made from zener diodes or silicon diodes.

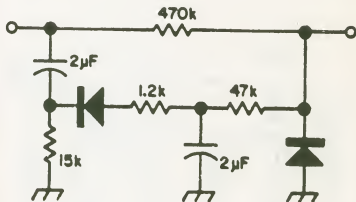


Fig. 21-47. The compressor can provide 25 dB of compression, but the expense of up to 60 dB loss.

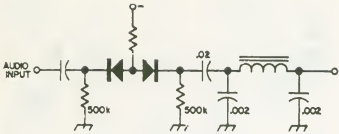


Fig. 21-48. A good clipper for AM or FM use includes adjustable clipping level and a harmonic filter.

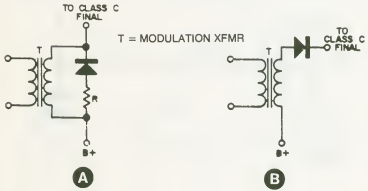


Fig. 21-49. The need for high-level negative-peak clipping is often debated, but its value is championed by many.

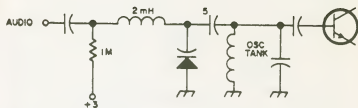


Fig. 21-50 A diode can be used for direct frequency modulation.



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

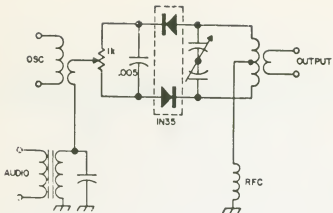


Fig. 21-52. This is a popular balanced modulator for generating DSB (and eventually SSB).

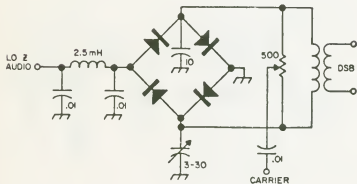


Fig. 21-53. Bridge balanced modulator for SSB.

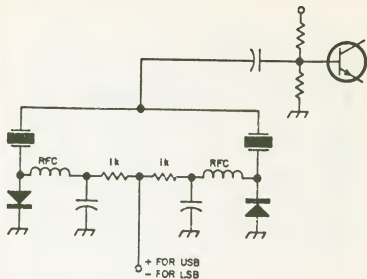


Fig. 21-54. A pair of diode switches can be used to select upper- or lower-sideband-generating crystals.

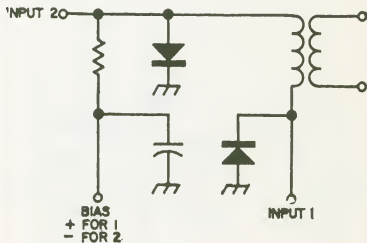


Fig. 21-55. These diode switches can be used in a transceiver or other type of equipment to select either of two inputs.

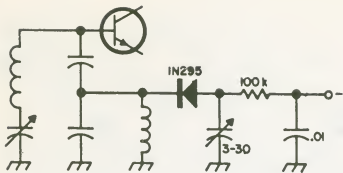


Fig. 21-56. A diode switch is used to connect a small capacitor to a VFO to shift its frequency slightly for radioteletype.

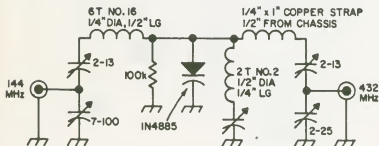


Fig. 21-57. A practical high-pe varactor tripler.

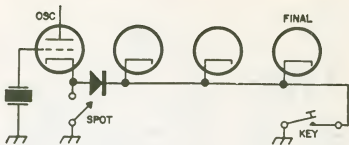


Fig. 21-58. A diode can be used for very simple spotting in a CW transmitter.

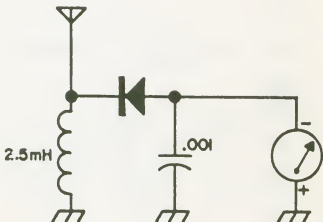


Fig. 21-59. A simple field-strength meter.

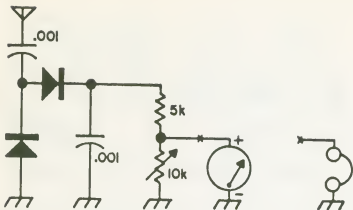


Fig. 21-60. This voltage-doubling field-strength meter is not frequency-selective.

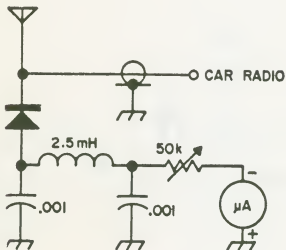


Fig. 21-61. A special type of field-strength meter for use in a car.

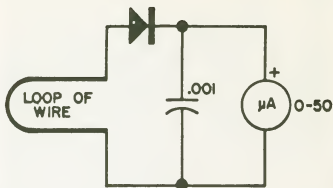


Fig. 21-62. The rf sniffer is a wide-range sensitive rf detector.

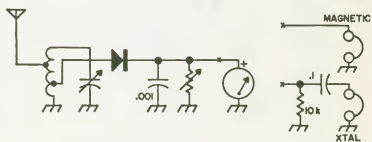


Fig. 21-63. A wavemeter is simply a field-strength meter tunable to frequency. It is especially useful for checking transmitter harmonics.

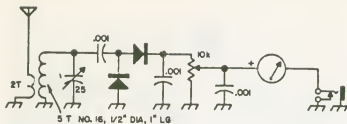
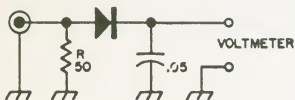
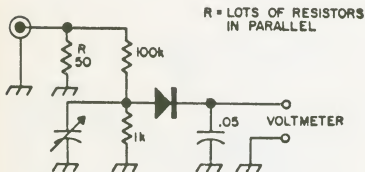


Fig. 21-64. This tunable VHF wavemeter/FSM/monitor covers 6 and 2 meters.



A



B

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.

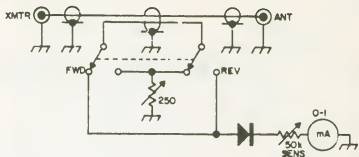


Fig. 21-66. An SWR bridge is valuable for adjusting an antenna. The critical part of the bridge is a piece of coax cable with an extra wire inserted between the cable dielectric and the shield.

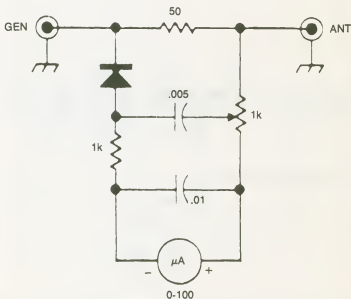


Fig. 21-67. This antenna scope is a simple antenna impedance bridge. It should be constructed compactly for best high frequency use.

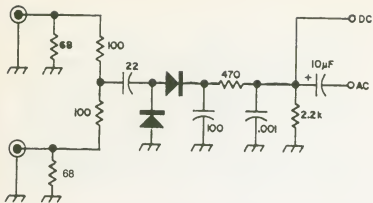


Fig. 21-68. The James Dandy mixer is a general-purpose untuned mixer useful as an impromptu frequency meter, receiver, detector, etc.

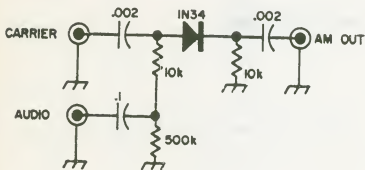


Fig. 21-69. This amplitude modulator can be used to modulate the output of any low-level CW source.

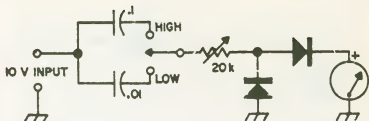


Fig. 21-70. This audio frequency meter must be calibrated before use. It requires an input of 10V.

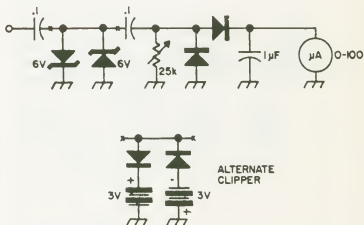


Fig. 21-71. This audio frequency meter/tachometer is self-limiting and linear reading. Either two zeners or two conventional diodes and batteries can be used to set the proper input voltage.

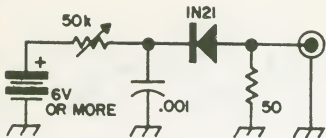


Fig. 21-72. A diode noise generator is very useful in aligning a receiver for lowest noise figure.

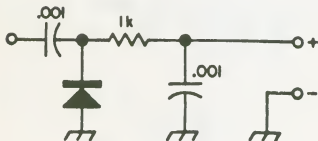


Fig. 21-73. A general-purpose rf detector probe for use with an oscilloscope or voltmeter.



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

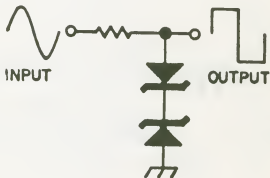


Fig. 21-75. Two zeners can be used to produce a highly clipped sine wave very similar to a square wave.

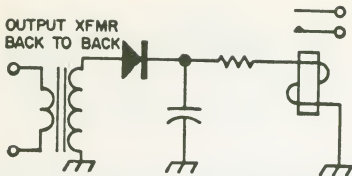


Fig. 21-76.-A transmitter can be keyed by a tape recorder for automatic code practice with this circuit.

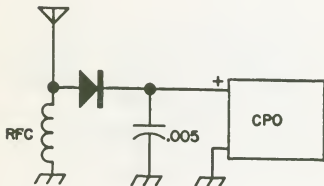
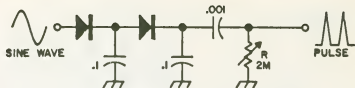


Fig. 21-77. A field-strength meter can key a code oscillator to form a CW monitor.



ADJUST R FOR BEST WAVESHAPE

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

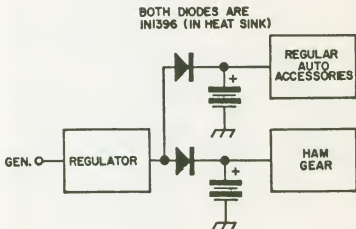


Fig. 21-79. Here's how to use two batteries in your car, one for communications gear and one for the rest of the car needs. The diodes act as oneway switches, keeping the batteries charged, yet preventing any power from flowing from one to the other.

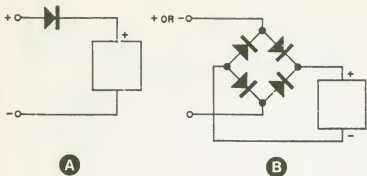


Fig. 21-80. These two circuits protect equipment from incorrectly polarized voltage. The single diode keeps the equipment from working when the polarity is wrong, while the bridge automatically selects the proper polarity.

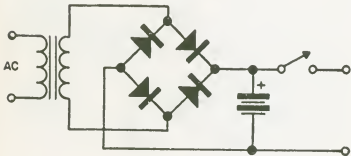


Fig. 21-81. A battery can be floated across a power supply, keeping it charged and providing automatic switching from ac to battery power.

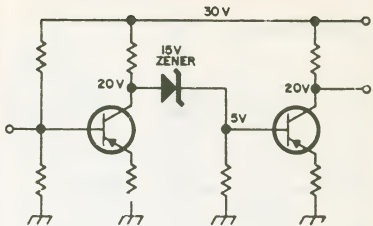


Fig. 21-82. Zeners can be used in dc-coupled amplifiers to replace coupling capacitors.

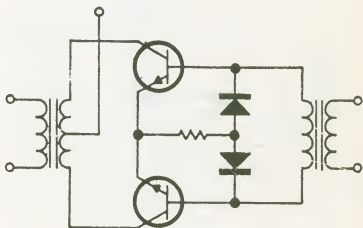


Fig. 21-83. Diodes can provide an artificial center tap for push-pull amplifiers.

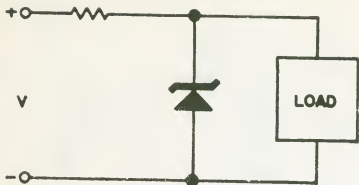


Fig. 21-84. A zener can protect any critical load from overvoltage.

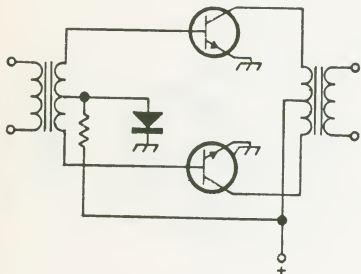


Fig. 21-85. A diode is often used to provide temperature-compensated bias for class B amplifiers.

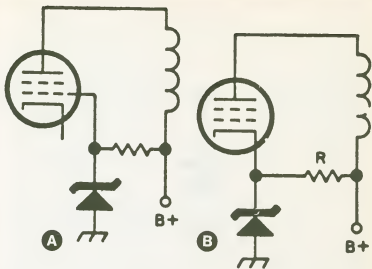


Fig. 21-86. A zener can furnish stable screen or grid bias for a vacuum tube.

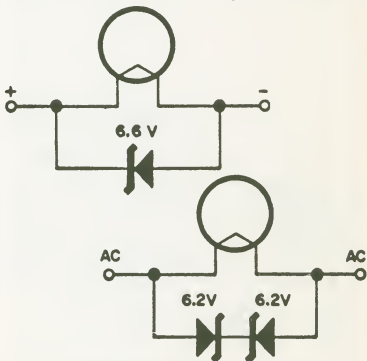


Fig. 21-87. Zeners can protect a delicate filament from overvoltage.

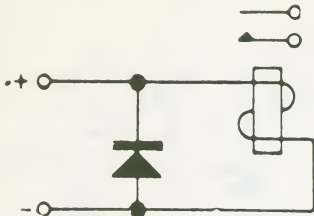


Fig. 21-88. A diode can damp the field generated by a coil when current through it is disconnected.

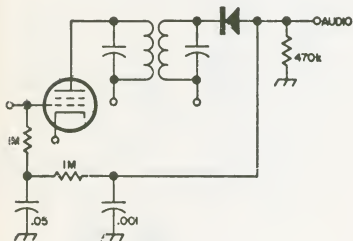


Fig. 21-89. The conventional agc system used in tube-type receivers.

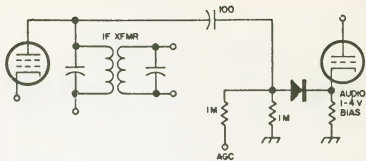


Fig. 21-90. Delayed agc acts only on strong signals.

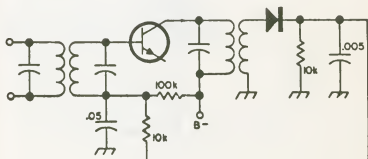


Fig. 21-91. Reverse agc for a transistor receiver.

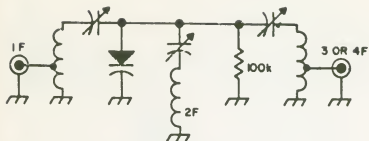


Fig. 21-92. "A" is a varactor tripler or doubler.

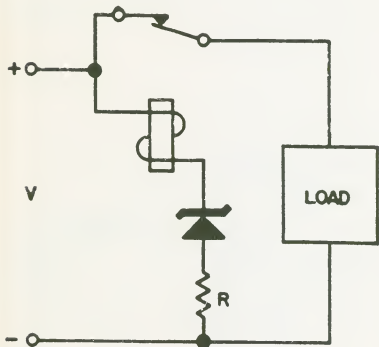


Fig. 21-93. This circuit will disconnect a load when voltage drops below a minimum.

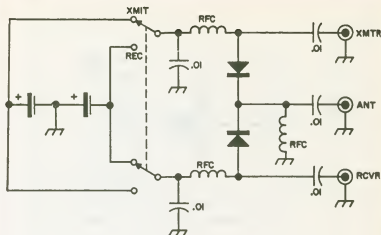


Fig. 21-94. This transmit-receive switch can be used at VHF if it is constructed carefully.

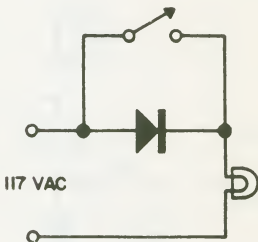


Fig. 21-95. This is a lamp dimmer providing two brilliance positions: half on and full on.

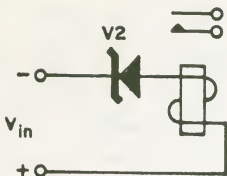


Fig. 21-96. An input voltage over the zener voltage energizes the relay.

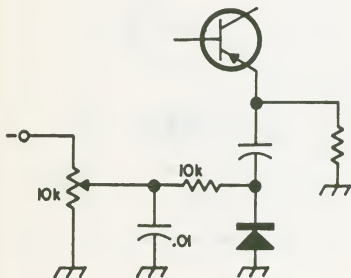


Fig. 21-97. A diode can control the bypassing of an emitter bypass capacitor to change an amplifier's gain.

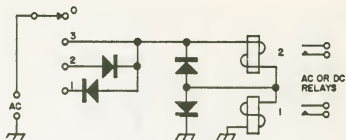


Fig. 21-98. In position 0 neither relay is energized. In position 3 both are energized. In 2, relay 2 is on and in 1, relay 1 is on.

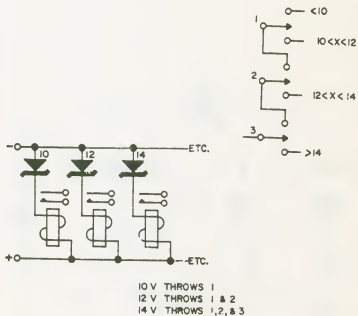


Fig. 21-99. In this scheme, a varying input voltage selects relay contacts in turn.

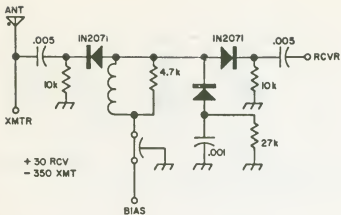


Fig. 21-100. A high-frequency antenna switch using diodes.

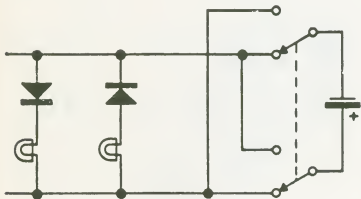


Fig. 21-101. Diodes can be used for mysterious switching of two lamps with one pair of wires.

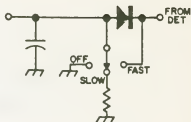


Fig. 21-102. "Hand" agc for SSB/CW reception.

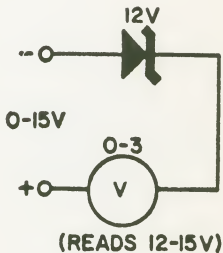


Fig. 21-103. A zener and a low-voltage meter can be used to suppress the low end of a range.

Chapter 22

Filters

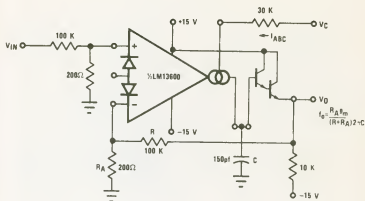


Fig. 22-1. Voltage controlled low-pass filter (NS).

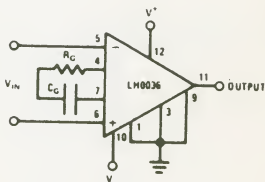


Fig. 22-2. High pass filter (NS).

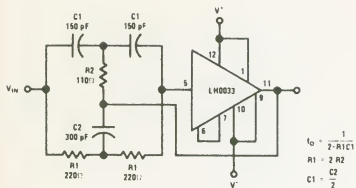


Fig. 22-3. 4.5-MHz notch filter (NS).

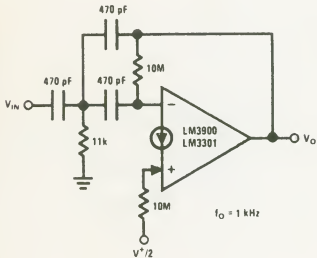


Fig. 22-4. High-pass active filter (NS).

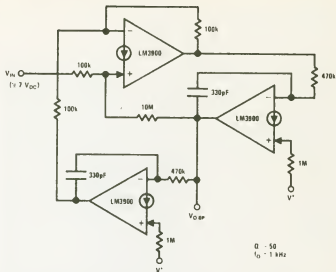


Fig. 22-5. Bi-quad active filter (second degree state-variable network) (NS).

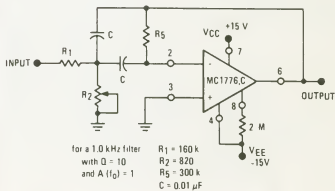


Fig. 22-6. Multiple feedback bandpass 1-kHz filter (M).

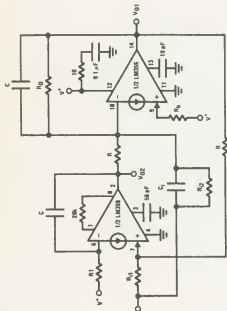
Type I	$\frac{2 V_{(INDC)}}{V^+(R_2)} + \frac{1}{R} + \frac{1}{R_0} = \frac{2}{R_0} + \frac{1}{R_b}$	$R_1 = 2R$
Type II	$\frac{1}{R} + \frac{1}{R_0} = \frac{2}{R_b}$	$R_1 = 2R$
Type III	$\frac{1}{R} + \frac{1}{R_0} = \frac{2}{R_b}$	$\frac{1}{R_1} = \frac{V_{(INDC)}}{V^+(R_1)} + \frac{1}{2R}$

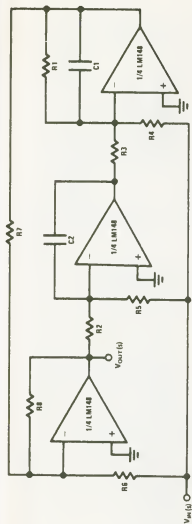
- The high speed of the LM359 allows the center frequency Q_0 product of the filter to be: $f_0 \times Q_0 < 45$ MHz
- The above filter(s) maintains performance over wide temperature range
- One half of LM359 acts as a true non-inverting integrator so only 2 amplifiers (instead of 3 or 4) are needed for the biquad filter structure

ANALYSIS AND DESIGN EQUATIONS

Type	V_{O1}	V_{O2}	C_1	R_{12}	R_{11}	f_0	Q_0	f_z (notch)	$H_{0(LF)}$	$H_{0(BP)}$	$H_{0(HP)}$	$H_{0(BR)}$
I	BP	LP	0	∞	∞	$\frac{1}{2\pi RC}$	$\frac{R_0}{R}$	—	$\frac{R}{R_2}$	$\frac{R_0}{R_2}$	—	—
II	HP	BP	C_1	∞	∞	$\frac{1}{2\pi RC}$	$\frac{R_0}{R}$	—	—	$\frac{R_0 C_1}{RC}$	$\frac{C_1}{C}$	—
III	Notch/BR	—	C_1	∞	R_{11}	$\frac{1}{2\pi RC}$	$\frac{R_0}{R}$	$\frac{1}{2\pi R R_1 C C_1}$	—	—	—	$H_0 \Big _{f \rightarrow \infty} = \frac{C_1}{C}$ $H_0 \Big _{f \rightarrow 0} = \frac{R}{R_1}$

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





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

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

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

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

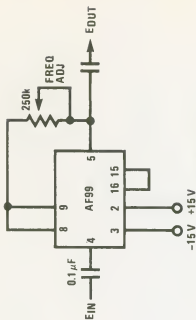
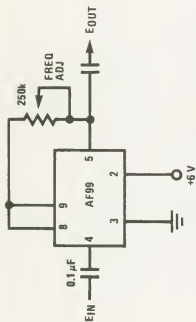


Fig. 22-9. Bandpass filters (NS).

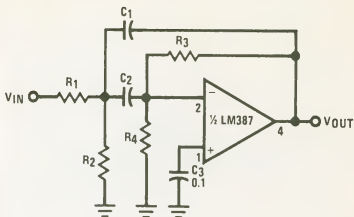
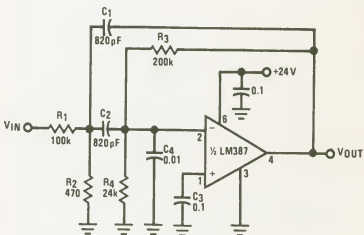
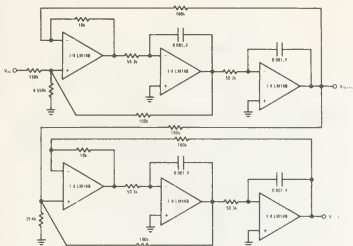


Fig. 22-10. LM387 bandpass active filter (NS).



$A_0 = -1$
 $f_0 = 20 \text{ kHz}$
 $Q = 10$
 $\text{THD} < 0.1\%$

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

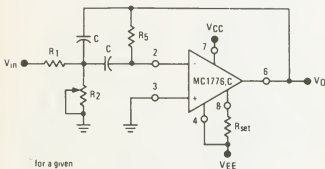


Use general equations, and tune each section separately

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

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

$$R_2 = \frac{R_1 R_5}{4Q^2 R_1 R_5}$$

$$R_5 = \frac{Q}{\pi f_0 C}$$

$$R_1 = \frac{R_5}{2A(f_0)}$$

To obtain less than 10% error from the operational amplifier

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

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

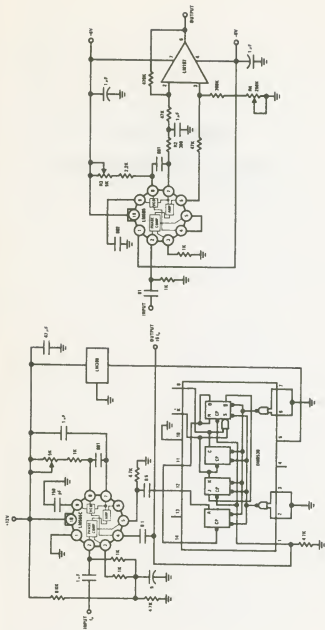


Fig. 23-1. Frequency multiplier (x10) (NS).

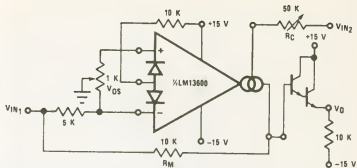
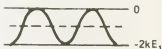
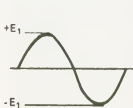
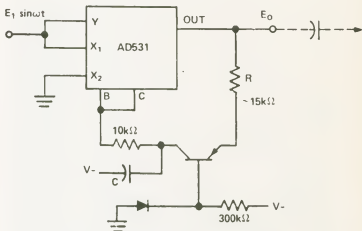


Fig. 23-2. Four-quadrant multiplier (NS).



$$E_o = \frac{E_1^2 - E_1^2 \cos 2\omega t}{2 \bar{E}_o}$$

$$E_o = KE_1 - KE_1 \cos 2\omega t$$

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

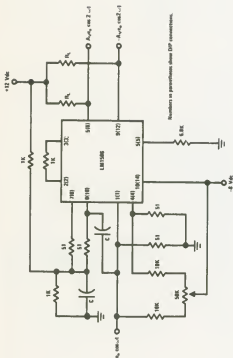


Fig. 23-4. Broadband frequency doubler (NS).

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.

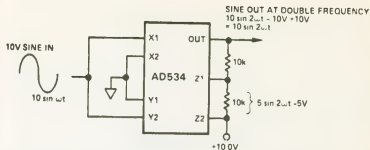


Fig. 23-5. Frequency doubler. This circuit accepts a sinusoidal signal with a 10-volt amplitude and produces a double-frequency signal also having a 10-volt amplitude with no DC offset (AD).

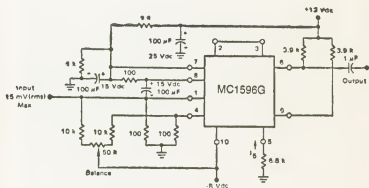


Fig. 23-6. Low-frequency doubler using an MC1596G. This circuit works well in the low-frequency and audio range below 1 MHz (M).

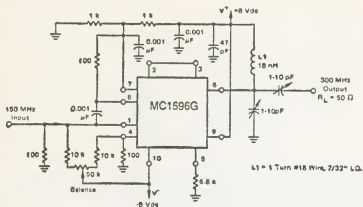


Fig. 23-7. A 150-MHz to 300-MHz frequency doubler using an MC1596G. Spurious outputs are 20 dB below the desired output (M).

Chapter 24

Gadgets

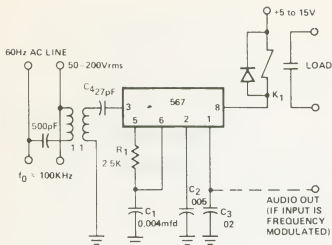


Fig. 24-1. Carrier-current remote control or intercom (S).

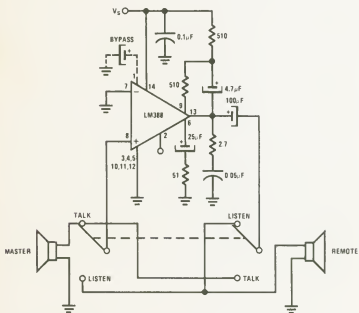


Fig. 24-2. Intercom (NS).

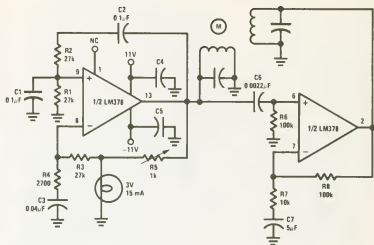
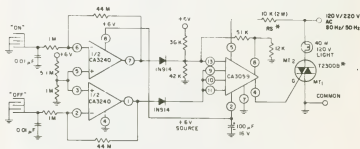


Fig. 24-3. Two-phase motor drive (NS).



*AT 220 V OPERATION, TRIAC SHOULD BE T2300D,
RS=10 K, 3 W

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

PARTS LIST

- B—9-volt transistor radio battery
 C1—365 pF variable capacitor
 C2—80 pF mica capacitor
 C3—005 μ F paper tubular capacitor
 C4—1600 pF mica capacitor
 C5—100 pF mica capacitor
 C6—275 pF disc ceramic capacitor
 C7—25 μ F mica capacitor
 D1—1N34A diode (Radio Shack 276-1102 or equal)
 H—high impedance magnetic headphones
 L1—20 turns No. 22 AWG enameled magnet wire scramble wound on a 4-inch form
 L2—ferrite rod antenna coil (Radio Shack 270-1420 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

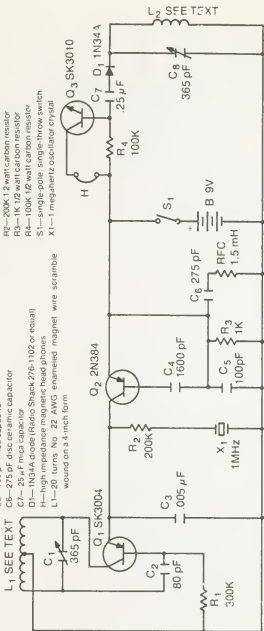


Fig. 24-5. Sophisticated beat frequency oscillator type metal locator utilizing headphones to amplify the "beat" tone.

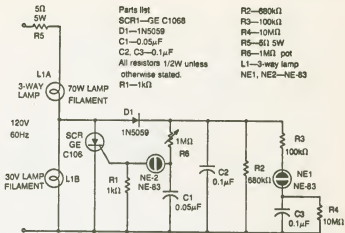


Fig. 24-6. Flickering flame effect.

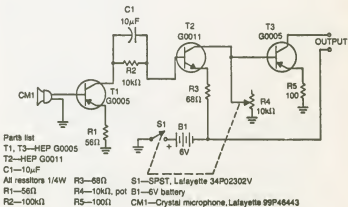


Fig. 24-7. Hearing aid.

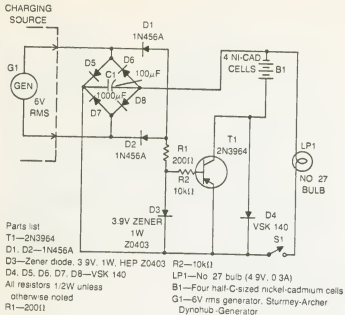
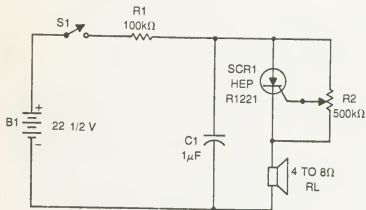
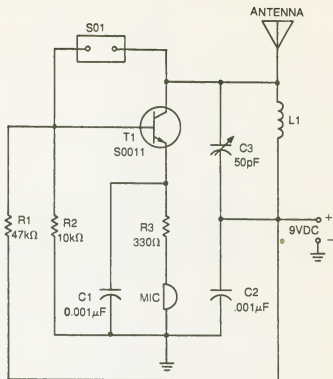


Fig. 24-8. Bicycle lighting system.



- 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—0.001 μ F, 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—47k Ω , 1/2W

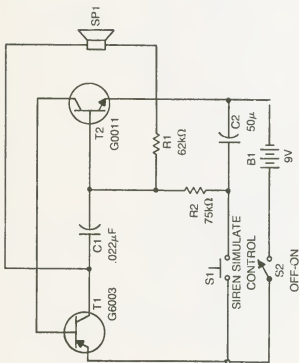
R2—10k Ω , 1/2W

R3—330 Ω , 1/2W

MIC—Carbon microphone element

S01—Crystal socket

Fig. 24-10. Radio pager.



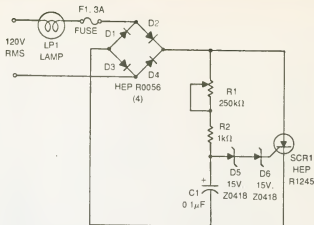
Parts list

T1—HEP G6003
 T2—HEP G0011
 C1—0.022 μ F

C2—50 μ F, 15 Vdc electrolytic
 R1—62 k Ω , 1/2W
 R2—75k Ω , 1/2W
 B1—9Vdc battery

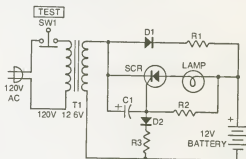
S1—Push-button SPST switch, Lafayette 34P02062V
 S2—SPST switch, Lafayette 34P02302V
 SP1—Any 8 Ω permanent-magnet speaker

Fig. 24-11. Electronic siren.



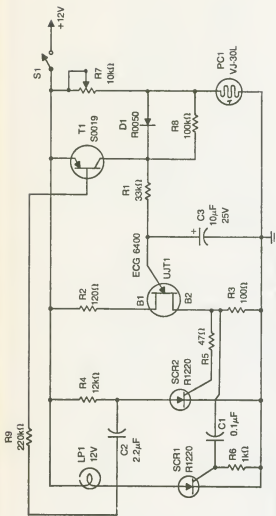
- Parts list
- | | |
|-----------------------------------|--------------------------------|
| SCR1—HEP R1245 | R1—250kΩ, 1/2W, pot |
| D1, D2, D3, D4—HEP R0056 | R2—1kΩ, 1/2W |
| D5, D6—15V, 1/2W Zener, HEP Z0418 | F1—3A, Lafayette 12P29129 |
| C1—0.1μF | Fuse holder—Lafayette 12P23510 |
| | LP1—Incandescent up to 150W |

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



- PARTS LIST
- | | |
|--|-----|
| D1 GE A15F or equivalent 3A, 50V | SCR |
| D2 1N4000, 1A, 50V | |
| SCR GE C106F1, IR 106F1 or equivalent | |
| R1 2 ohm, 2 watt | |
| R2 1K, 1/2 watt | |
| R3 100Ω, 1/2W | |
| 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 transformer | |
| 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 list.



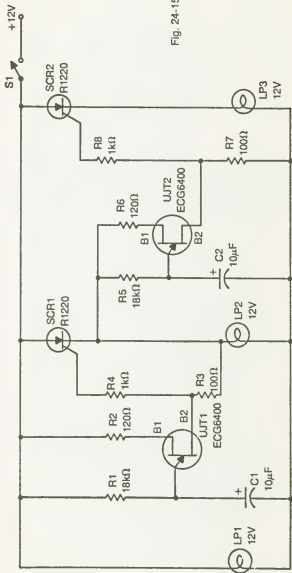
Parts list

SCR1, SCR2—HEP R1220
 UJT1—ECG 6400 (Sylvania)
 T1—HEP S0019
 D1—HEP R0050
 C1—0.1 μ F, nonpolarized
 C2—2.2 μ F, nonpolarized

C3—10 μ F, 25V electrolytic

R6—1k Ω
 R7—10k Ω pot
 R8—100k Ω
 S1—SPST, Lafayette 34P02302V
 PC1—Photoconductive Cell, VT-30L, Newark Electronics 61F1092
 LP1—12V lamp, Lafayette 32P09814V
 Lamp holder, Lafayette 32P29004

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



Parts list

SCR1, SCR2—HEP R1220

UJT1, UJT2—ECG 6400 (Sylvania)

C1, C2—10 μ F, 25V electrolytic

All resistors 1/2W

R1—18k Ω

R2—120 Ω

R3—100 Ω

R4—1k Ω

R5—18k Ω

R6—120 Ω

R7—100 Ω

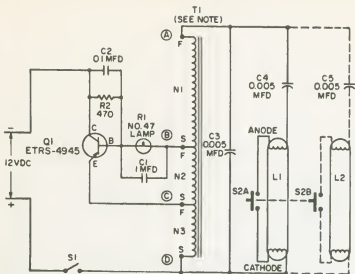
R8—1k Ω

S1—SPST, Lafayette 34P02302V

LP1, LP2, LP3—12V lamps, Lafayette 32P09814V

Lamp holders (3)—Lafayette 32P28004

Fig. 24-15. DC lamp chaser.



NOTE: AUTOTRANSFORMER WINDINGS -
 N1 - 200 TURNS NO. 32 AWG
 N2 - 6 TURNS NO. 32 AWG
 N3 - 8 TURNS NO. 20 AWG
 (WOUND ON ARNOLD A930157-2 CORE)

S - START OF WINDING
 F - FINISH OF WINDING

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.

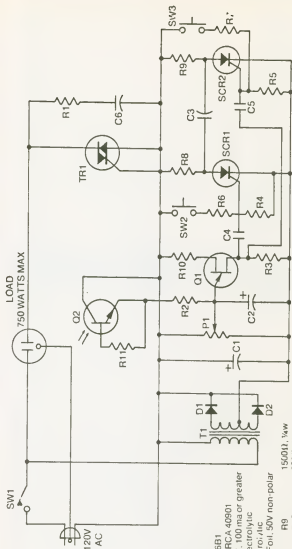
See text for winding details.

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 2N264C
 Q2 2N3778
 SCR1, SCR2 2N5060 or C106B1
 TR1 GE SC142B or RCA 40901
 T1 115V to 24VET, 100 ma or greater
 C1 100 μ F, 25V Electrolytic
 C2 2 μ F, 25V Electrolytic
 C3 10 μ F Film or Foil, 50V non-polar
 C4 C5 0C, μ F, .0V R9 1500 Ω , $\frac{1}{2}$ w
 C6 0.1 μ F 200V R10 390 Ω , $\frac{1}{4}$ w
 R1 47 Ω , $\frac{1}{2}$ w R11 (Optional) 2 - 5 megohm, $\frac{1}{4}$ w
 R2 4.7K $\frac{1}{4}$ w P1 250K, $\frac{1}{2}$ watt potentiometer
 R3 10 Ω , $\frac{1}{4}$ w SW1 SPST toggle switch, 120V 5 amp AC
 R4-R7 1K, $\frac{1}{4}$ w SW2 SW3 SPST, normally open momentary pushbutton
 R8 310 Ω , $\frac{1}{2}$ w 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

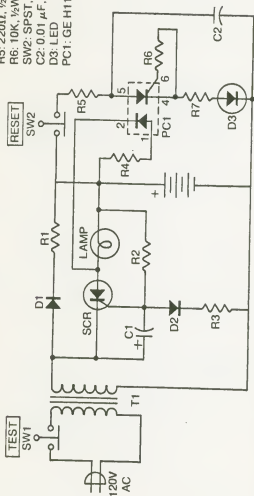
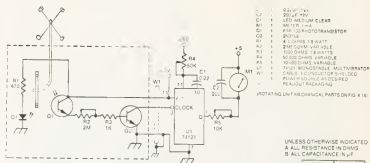


Fig. 24-18. Emergency lighting system with latching indicator. The latching indicator can be used to drive a relay coil which could be connected to sensitive equipment.



UNLESS OTHERWISE INDICATED
 A ALL RESISTANCE IN OHMS
 B ALL CAPACITANCE IN μ F

RES	MPN
100	127
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 Q output, charging capacitor C2 in proportion to the windspeed. This charge drives the meter upscale.

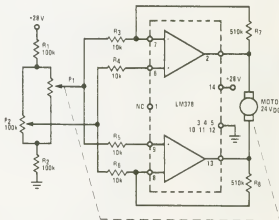


Fig. 24-20. Proportional Speed Controller (NS).

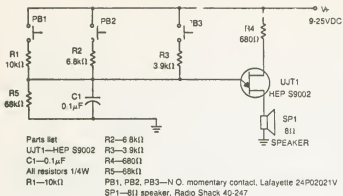


Fig. 24-21. Three tone doorbell.

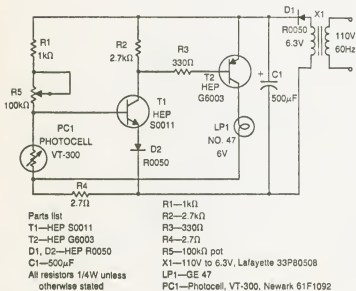


Fig. 24-22. Bedside light.

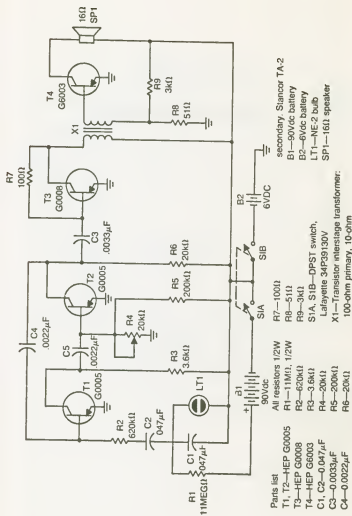
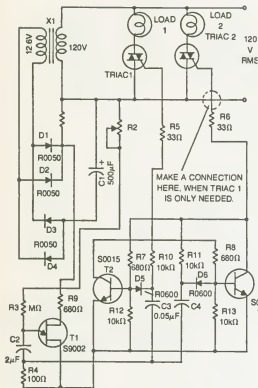


Fig. 24-23. Audio "fence" for animals.



Parts list

- X1—Step-down transformer (120V to 12.6V) Lafayette 33P81191
- TRIAC 1 and 2
- 15W load—HEP R1005
- 150W load—HEP R1221
- 2500W load—HEP R1304
- D1, D2, D3, D4—HEP R0050
- D5, D6—HEP R0600
- T1—HEP S9002
- T2, T3—HEP S0015
- C1—500 μ F, 25V electrolytic
- C2—2 μ F
- C3, C4—0.05 μ F
- All resistors 1/2W unless otherwise stated
- R1—56 Ω , 2W
- R2—2M Ω , pot
- R3—1M Ω
- R $\frac{1}{2}$ —100 Ω
- R5, R6—33 Ω
- R7, R8, R9—680 Ω
- R10, R11, R12, R13—10k Ω

Fig. 24-24. AC flasher circuit.

Chapter 25
Games and Toys

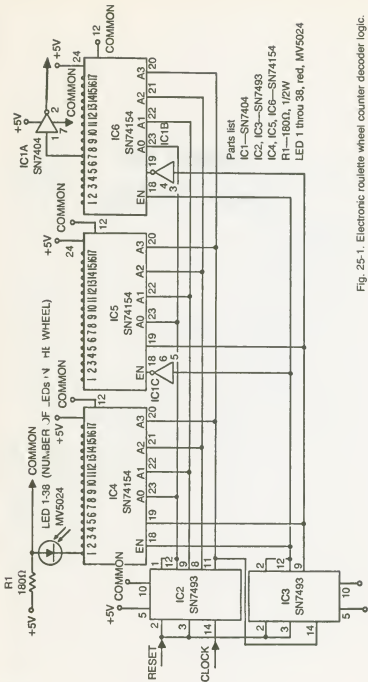
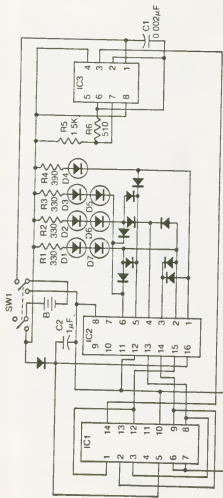


Fig. 25-1. Electronic roulette wheel counter decoder logic.



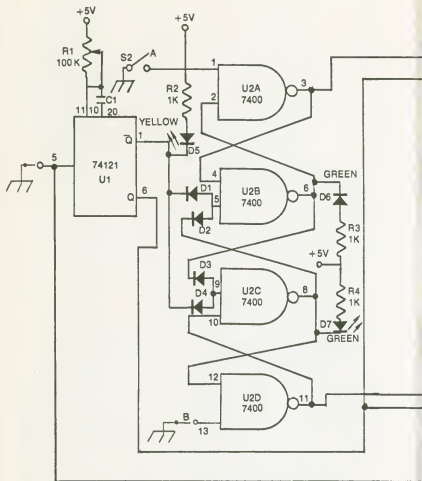
LED DISPLAY	IC1		IC2	
	PIN	PIN	PIN	LOW
1	0	0	1	
2	1	0	2	
3	0	1	0	3
4	1	1	0	4
5	0	0	1	5
6	1	0	1	6

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
 SW1
 Misc

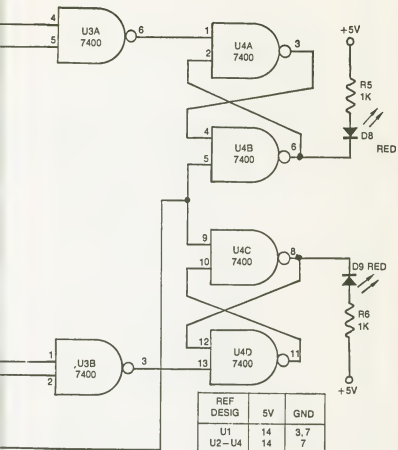
- (4) Permite cells in series
 Double Pole Double Throw, make before break (see text)
 Wire, circuit board material or perforated board.
 IC socket, battery holder, plastic box

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



C1	1	20 μ F, 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

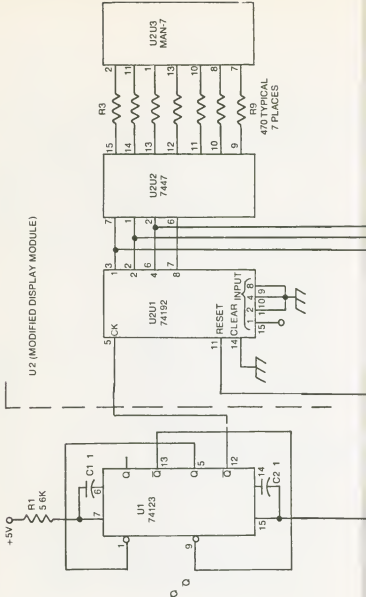
Fig. 25-3. Two players can test their reaction time with this reflex game. These cross coupled NAND gates make up a common form of latch circuit.



UNLESS OTHERWISE INDICATED:

A. ALL RESISTANCE IN OHMS

B. ALL CAPACITANCE IN mF



U2 (MODIFIED DISPLAY MODULE)

470 TYPICAL
7 PLACES



C1, C2	4	1 μ F, 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

UNLESS OTHERWISE INDICATED:

A ALL RESISTANCE IN OHMS

B ALL CAPACITANCE IN μ F

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

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.

Chapter 26

Indicator Circuits

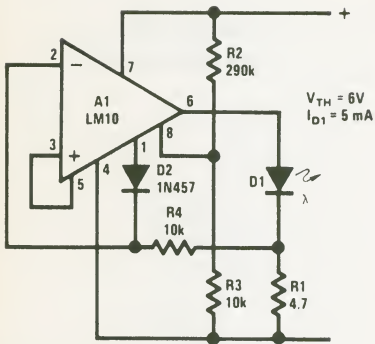


Fig. 26-1. Battery-threshold indicator (NS).

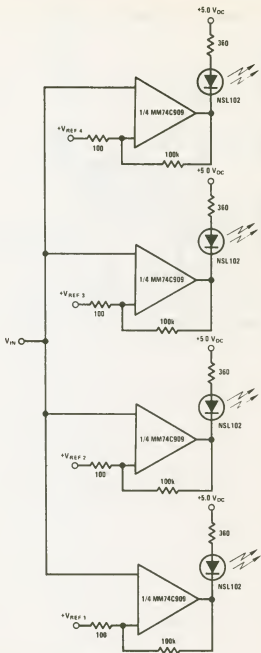


Fig. 26-2. Visible voltage indicator (NS).

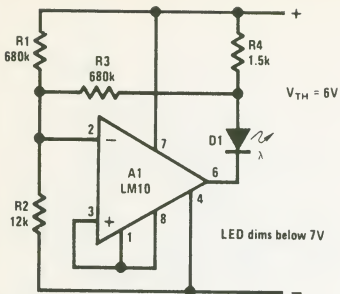


Fig. 26-3. Battery-level indicator (NS).

Chapter 27

Integrators

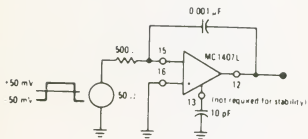


Fig. 27-1. High-speed integrator (M).

Chapter 28

Interface Circuits

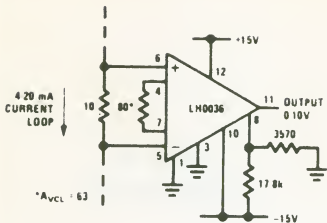


Fig. 28-1. Process control interface (NS).

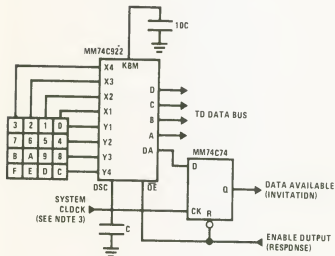
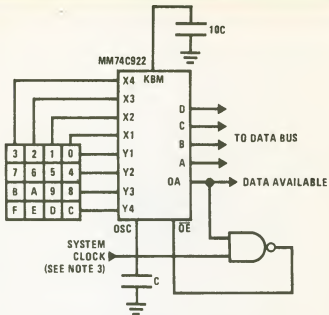


Fig. 28-2. Synchronous handshake (MM74C922) (NS).



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).

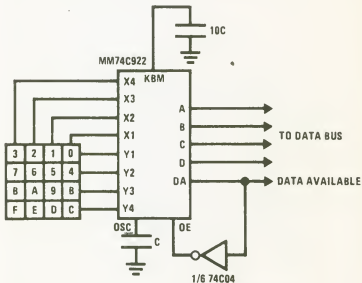


Fig. 28-4. Asynchronous data entry onto bus (MM74C922) (NS).

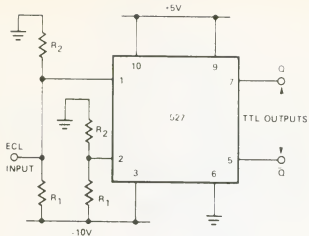


Fig. 28-5. ECL to TTL interface (S).

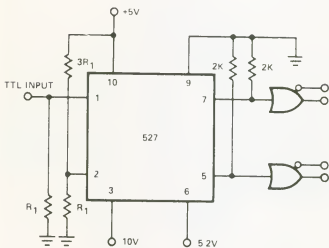


Fig. 28-6. TTL to ECL interface (S).

Chapter 29

Inverters

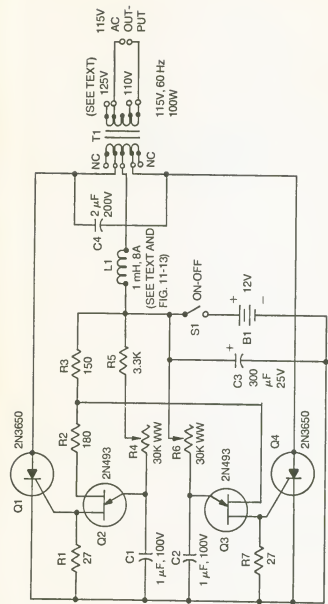


Fig. 29-1. DC-to-AC inverter.

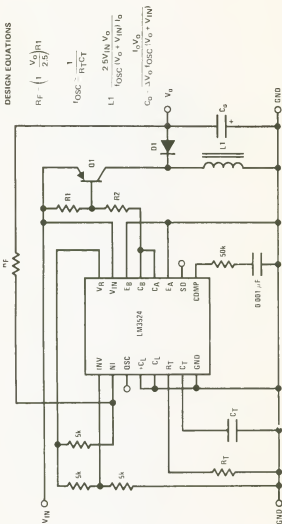


Fig. 29-2. Boosted current polarity inverter (NS).

Chapter 30

Logarithmic Amplifiers

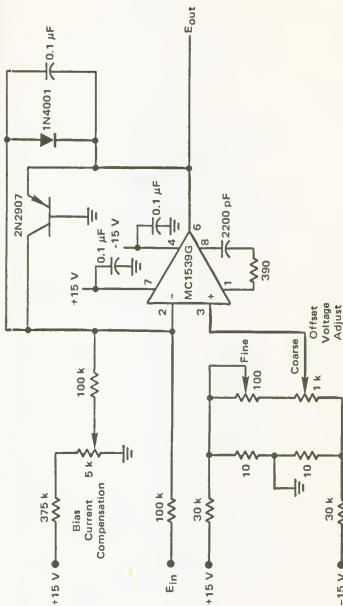


Fig. 30-1. Logarithmic amplifier using an MC1539G op amp (M).

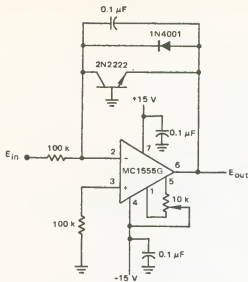


Fig. 30-2. Logarithmic amplifier using an MC1556 op amp. The 10K pot is an offset adjustment (M).

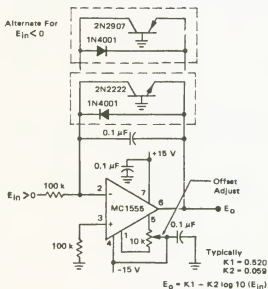


Fig. 30-3. Logarithmic amplifier using an MC1556 op amp (M).

Chapter 31
Logic Circuits,
Counters and Clocks

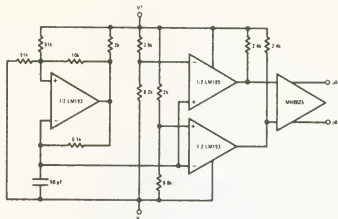


Fig. 31-1. MOS clock driver (NS).

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

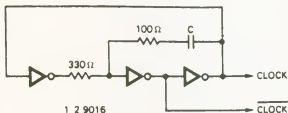
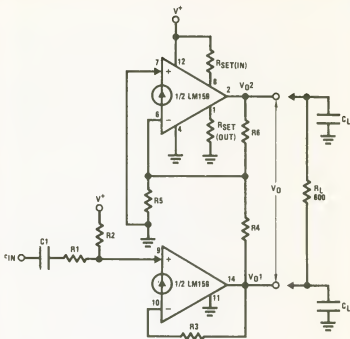


Fig. 31-2. The simple TTL clock generator circuit shown provides a clock satisfactory for most simple TTL systems and it always starts oscillating without coaxing. This circuit requires only $\frac{1}{2}$ of a hex inverter package and three passive components—two resistors and a capacitor.



$$\text{For } V_{O1} = V_{O2} = \frac{V^+}{2}, \quad \frac{R3}{R2} = \frac{V^+ - 2\phi}{2(V^+ - \phi)}, \quad \frac{R6}{R5} = \frac{V^+ - 2\phi}{\phi} \quad \text{where } \phi = 0.6V$$

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

- 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,
 $\pm 0.01 \mu\text{F}$ with $C_{\text{comp}} = 180$ pF
- 70 dB signal to noise ratio at 0 dbm into 600Ω, 10 kHz bandwidth

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

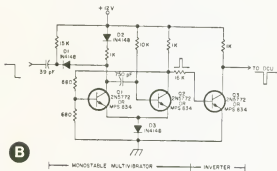
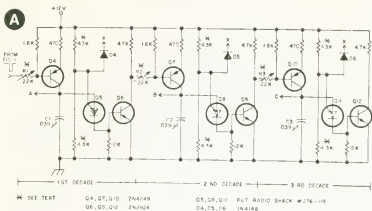


Fig. 31-4. Decimal counting unit. The input stage (left) converts negative-going pulses into uniform signals. Counting decades are shown at right. The value of R1 is adjusted to produce staircase whose voltage value at the source of the output FET represents the count.

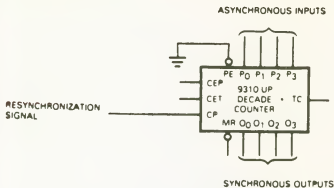


Fig. 31-5. A resynchronizer using a 9310 (or 9316) as four D-input flip flops is shown. In this circuit the PE input is grounded, and the resynchronizing input is applied to the CP input. In most cases, the 9300 universal shift register is preferable for this function.

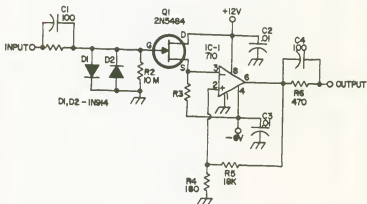
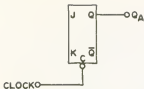


Fig. 31-6. Buffering circuit isolates frequency counter from signal source, offers high-impedance input, relatively low-impedance output. The value of the series input resistor is 100K; R3 is 1800 ohms.



STATE	Q _A
1	0
2	1

(1/2)C3073P

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

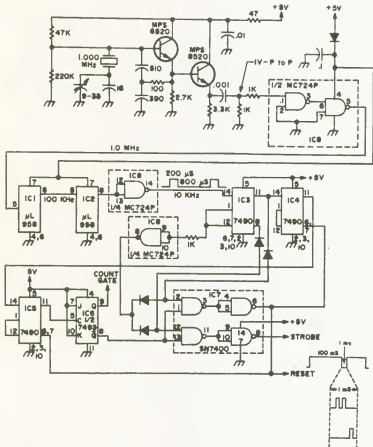
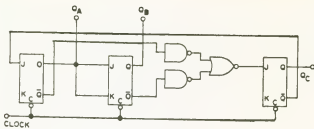
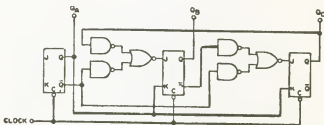


Fig. 31-8. Frequency-standard oscillator and counter circuitry with timing diagrams.



STATE	QA	QB	QC
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	0	1

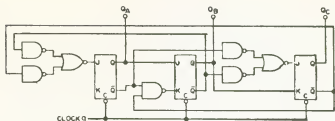
Fig. 31-9. Synchronous divide-by-5 up counter.



STATE	QA	QB	QC
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)C373P

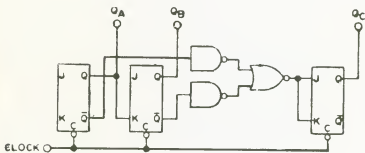
Fig. 31-10. Synchronous divide-by-6 up counter.



STATE	QA	QB	QC
1	0	0	0
2	1	0	0
3	0	1	0
4	1	1	0
5	0	1	1
6	1	0	1
7	0	0	1

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

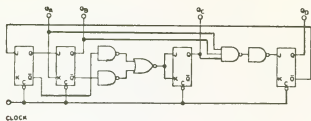
Fig. 31-11. Synchronous divide-by-7 up counter.



STATE	QA	QB	QC
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

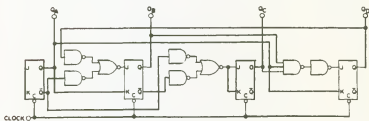
Fig. 31-12. Synchronous divide-by-8 up counter.



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	0	1
6	1	0	0	1
7	0	1	0	1
8	1	1	0	1
9	0	0	0	1

(1) IC3020P
 (1) IC3050P
 (2) IC3073P

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	0	1
6	1	0	0	1
7	0	1	0	1
8	1	1	0	1
9	0	0	0	1
10	1	0	0	1

(1) IC3020P
 (1) IC3050P
 (2) IC3073P

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

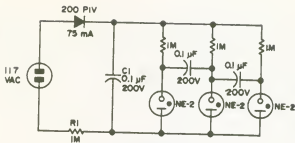


Fig. 31-15. Three-stage oscillating ring counter with indicating shift register plus into household outlet; flash sequence: 2-12-12-32-12-12-3. (The 1M resistors should be matched fairly closely.)

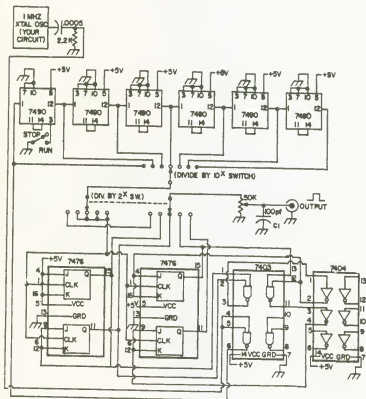


Fig. 31-16. Frequency standard wiring diagram.

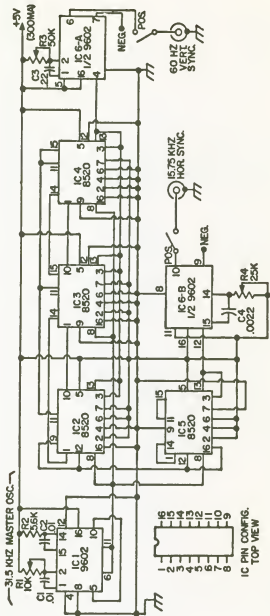


Fig. 31-17. Schematic of the digital interlaced sync generator R2 is 5.6K, 1/2W, 5%; potentiometers are miniature and capacitors are Mylar.

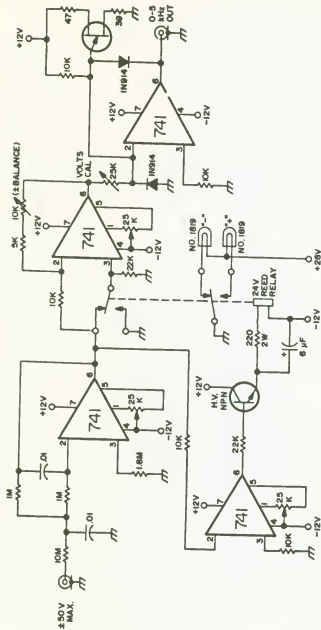


Fig. 31-18. DVM adapter for a frequency counter. This circuit consists of 200K Ω/V input low-pass active filter stage, a polarity detector, and automatic switcher/indicator, and a voltage-to-frequency converter. The output frequency is adjusted so that 50V will give a frequency of 5000 out. The three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

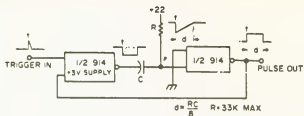


Fig. 31-19. One-shot circuit is easily built from 914 IC by adding single capacitor and external resistor. If 3V supply is used for IC, and 22V supply to drive external timing resistor, duration of output pulse will be almost exactly $\frac{1}{8}$ the RC time constant, with R in ohms and C in farads. 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.

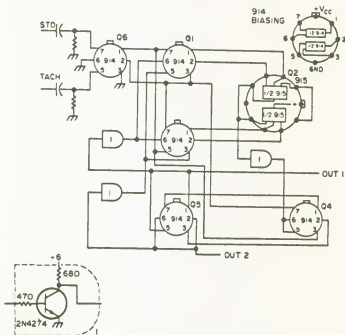


Fig. 31-20. This rather complex arrangement of ICs is a frequency comparator and phase detector. The unknown frequency is fed into the TACH input and the standard to which it is to be compared goes to the STD. OUT 1 and OUT 2 are of opposite polarity. Type 915 (Q2) is same as 914 but has 3-input gates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

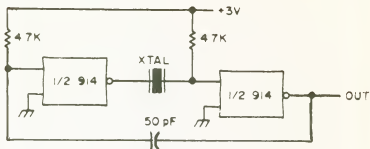


Fig. 31-22. Minor modifications to one-shot circuit, including substitution of a crystal for the timing capacitor and insertion of a capacitor in the dc feedback loop, turn it into a crystal-controlled oscillator which may be used for a frequency standard. Output is rich in harmonics, and this circuit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

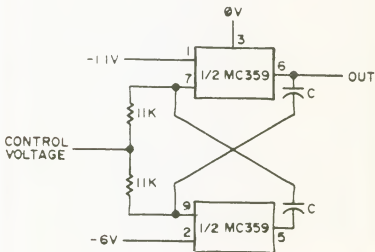
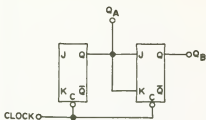


Fig. 31-23. Voltage-controlled oscillator can be varied over nearly 10-to-1 frequency range simply by varying control voltage. This circuit may be used as part of phase-locked detector.



STATE	QA	QB
1	0	0
2	1	0
3	0	1
4	1	1

(1)C3073P

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

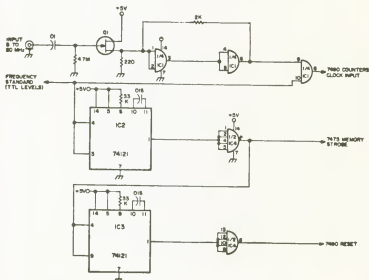


Fig. 31-26. Frequency counter input: gating, strobing, and resetting. The sensitivity is set by the ratio of the 220 to 2K resistors.

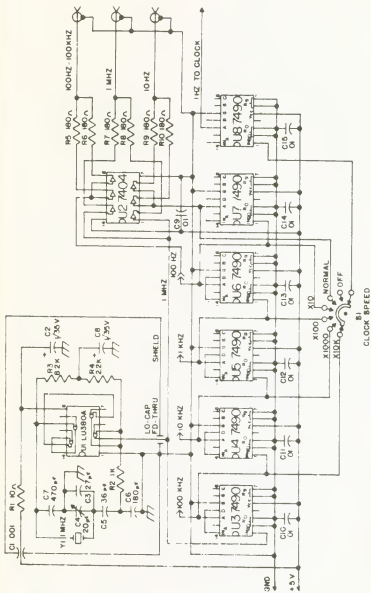


Fig. 3-27. Time base schematic diagram.

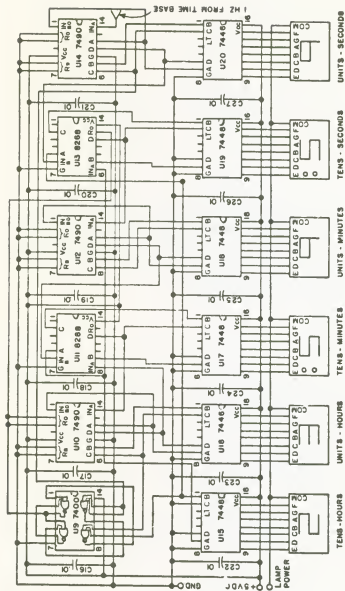


Fig. 31-30. Clock schematic diagram.

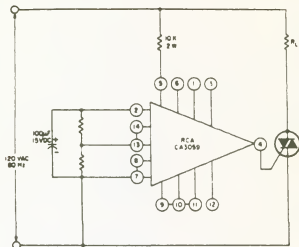


Fig. 31-31. Controller for resistive loads. The RCA 2N5444 triac can be used for load currents up to 40A. The RCA 40668 triac will switch intermediate loads the 40526 will handle lighter loads and those which are somewhat inductive.

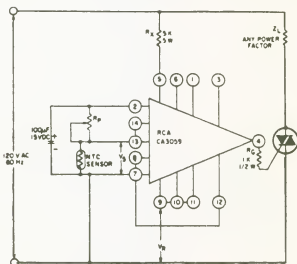


Fig. 31-32. Differential comparator circuit. The load is switched on when the voltage difference between V_S and V_R becomes less than $50 \mu\text{V}$. Note the jumper between terminals 7 and 12, which deactivates the anti-RFI feature.

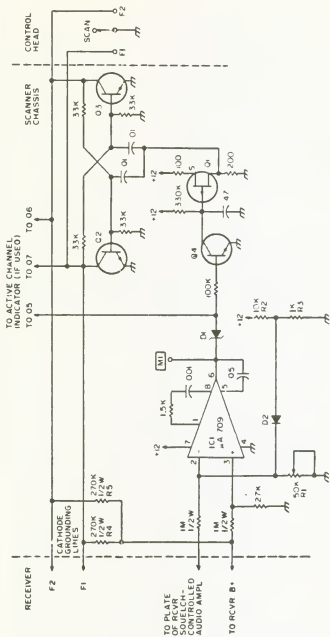


Fig. 31-33. Two-channel search-lock for FM receivers. The switch is mounted on the control head; everything else may be mounted inside the radio cabinet.

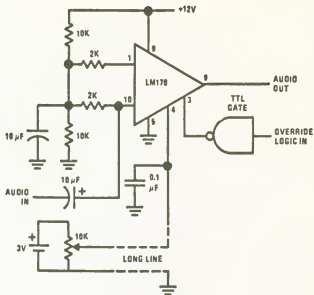


Fig. 31-34. Remote or digital control amplifier.

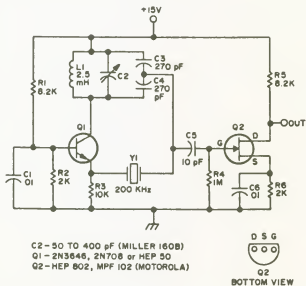
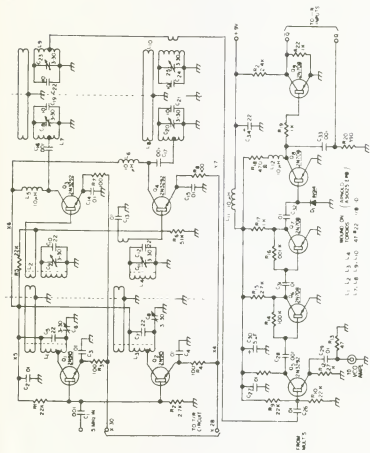


Fig. 31-35. A 200 kHz crystal standard for counter time base.

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



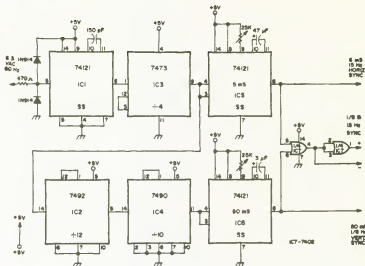


Fig. 31-37. SSTV frequency standard. This simple circuit provides the need pulses for slow-scan TV cameras, flying-spot scanners, and pattern generators.

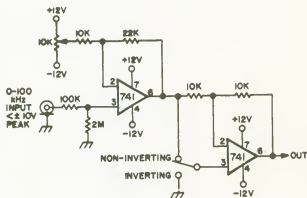


Fig. 31-38. Low-speed counter, scope or audio dc input level and polarity switch. This circuit will change the level of the input signal by means of the pot. The polarity (rise and fall) may be inverted by means of the switch.

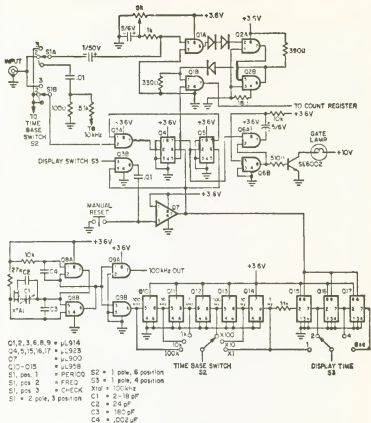


Fig. 31-40. Counter operates up to 10 MHz with 0.001% tolerance of error. Output is binary, for bank panel lamps.

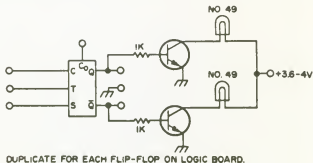


Fig. 31-41. Sample logic board flip-flop with pilot light display.

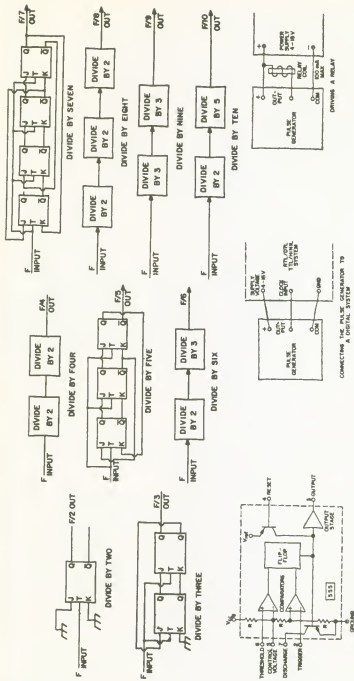


Fig. 31-42. Using flip-flops to divide by various amounts.

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

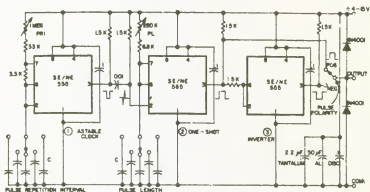
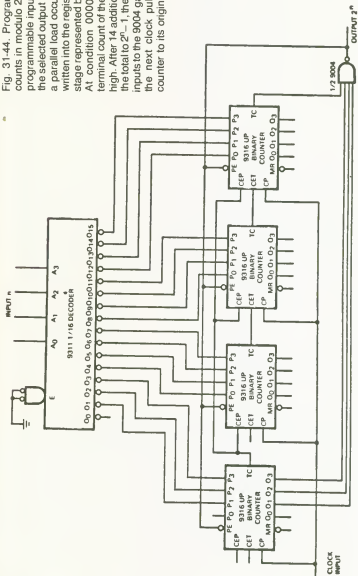
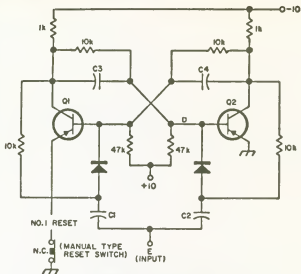


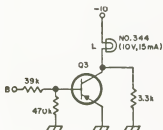
Fig. 31-43. This pulse generator is a variable clock testing digital IC systems, especially at low clocking rates. Due to the wide range supply voltage allowed for the SE/NE555 it can be used with RTL, DTL, TTL, and HiNil. It uses anything between +4 and +15V. This circuit comprises three 555 timers. 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_{cc}. Table shows the capacitor values and the corresponding PRI and PL ranges achieved. 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.

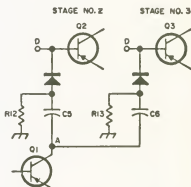




COUNTER FLIP-FLOP
(4 REQUIRED PER DECADE)



LAMP DRIVER



FEED-BACK NETWORK

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

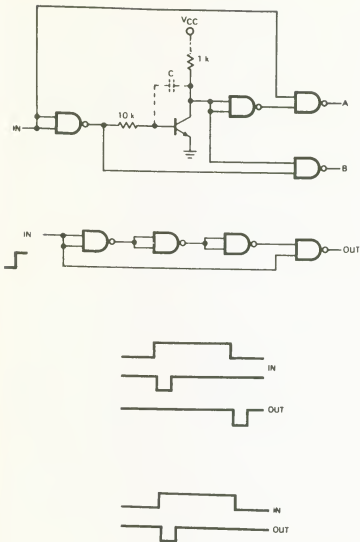


Fig. 31-46. This edge detector circuit generates a negative-going pulse on output A for each low-to-high transition of the input. The pulse width is adjustable by varying the Miller capacitance. A nonadjustable short pulse (≈ 20 ns) on the low-to-high transition of the input can be generated by replacing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

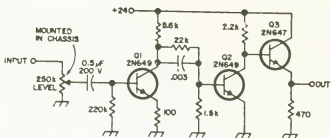


Fig. 31-47. Pulse shaper.

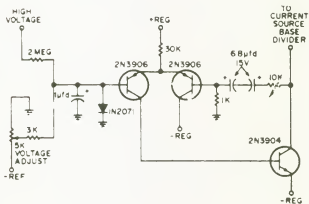
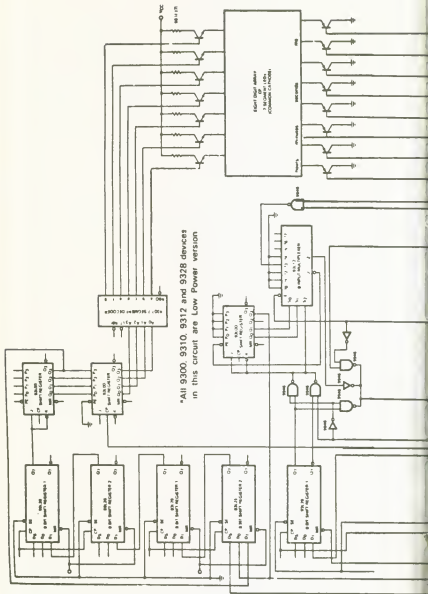


Fig. 31-48. Cheaper differential amplifier.



*All 9300, 9310, 9312 and 9328 devices
in this circuit are Low Power version

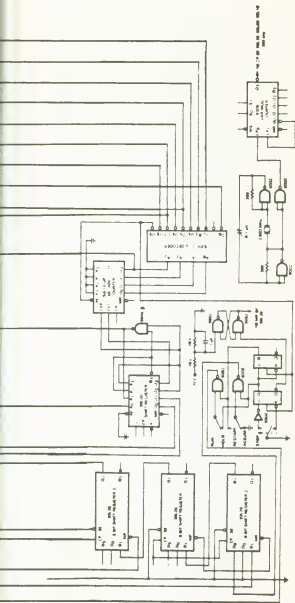
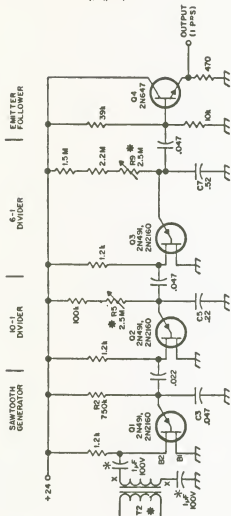


Fig. 31-49. This circuit stores 9 digits bit-serially in a 36-bit shift register comprised of two 9328 dual 8-bit shift registers and 9300 4-bit universal shift register incrementing or decrementing with an exclusive-OR. This counter offers very economical display multiplexing and is shown driving 7-segment 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 MHz 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, driven 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.



* MOUNTED IN CHASSIS
 * IN POWER SUPPLY
 * MINIATURE TYPE

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

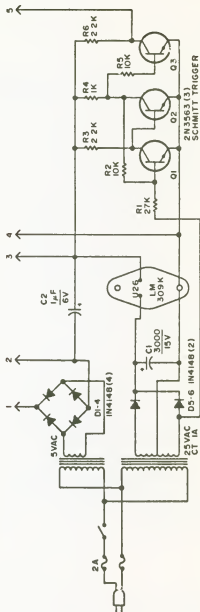


Fig. 31-51. Counter power supply. Connections are made via the points numbered 1-5.

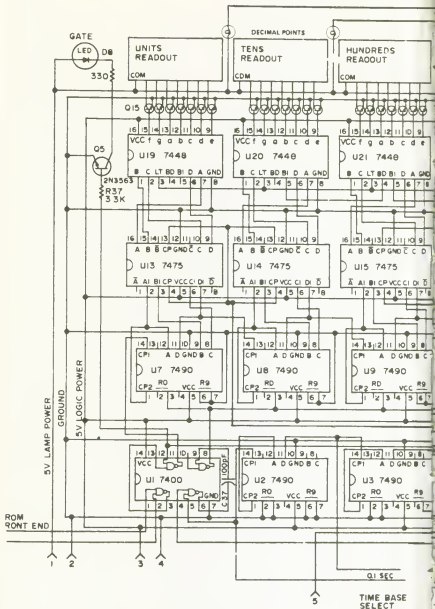
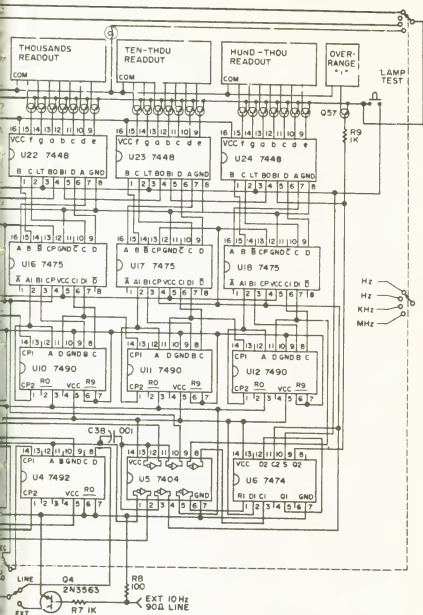


Fig. 31-52. Schematic of frequency counter. Note: C3—C26 are not shown. These are 0.01 disc ceramics connected directly from V_{CC} to ground at each IN.



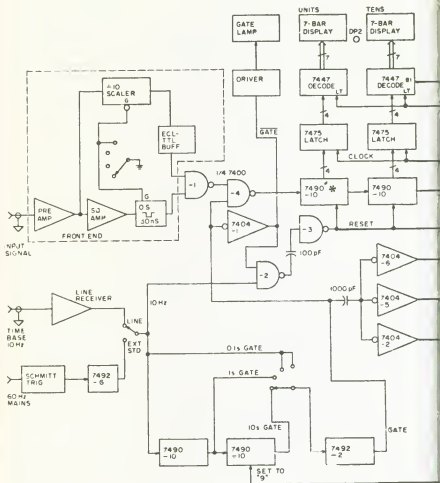
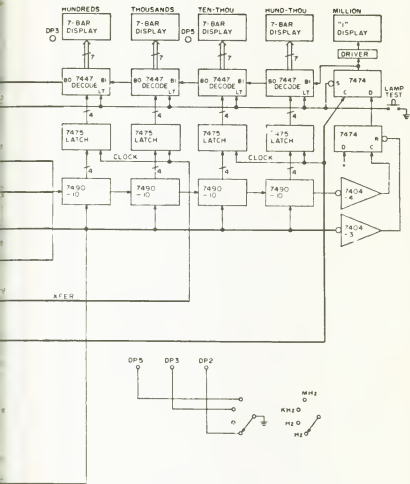


Fig. 31-53. Detailed block diagram of frequency counter. The 7490 identified by * should be selected for > 20 MHz switching speed.



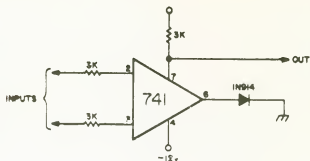


Fig. 31-55. 741 used as high-speed comparator. The output of this circuit varies from +12 to +2 volts and back with extremely fast rise and fall times.

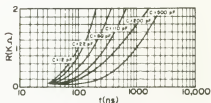
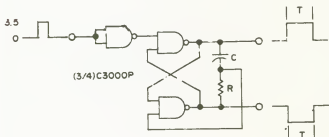


Fig. 31-56. TTL one-shot used to develop wider pulses. Chart shows values for C and R for various output pulse widths.

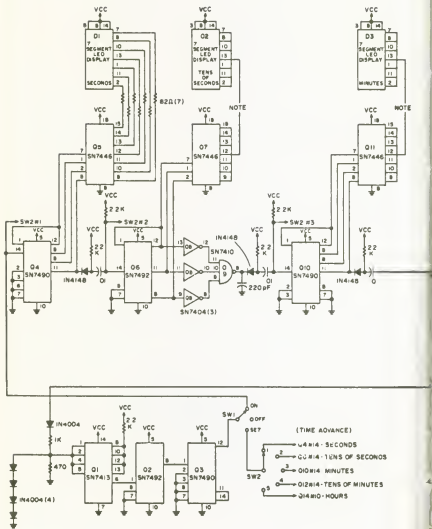


Fig. 31-57. Digital clock uses 19 inexpensive ICs.

Chapter 32

Math Function Circuits

Low-Cost Accurate Square Root Circuit
 $I_{OUT} = 10^{-5} \cdot \sqrt{10 V_{IN}}$

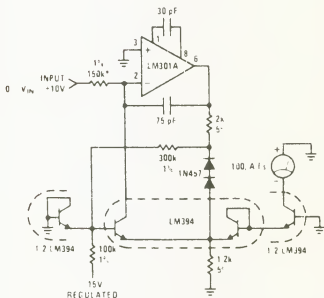


Fig. 32-1. MOS clock driver (NS).

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

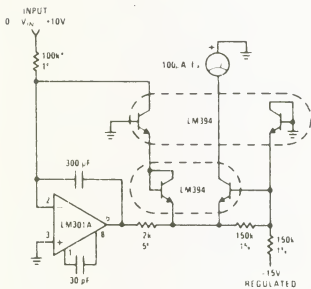
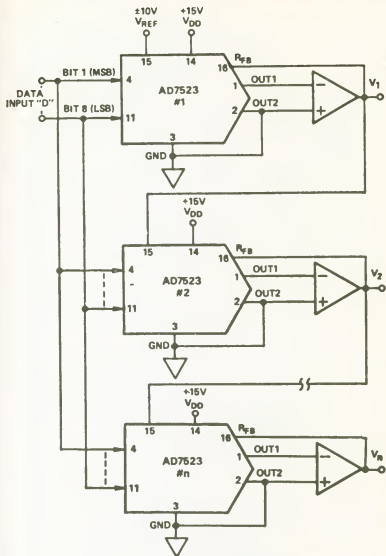


Fig. 32-2. Balanced line driver (NS).



CIRCUIT EQUATIONS

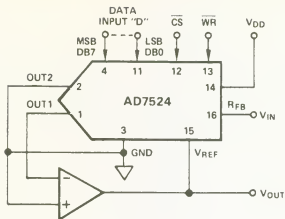
$$V_1 = (V_{REF}) (D)$$

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

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

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

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



EQUATIONS

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

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

and where:

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

$$DB_N = 1 \text{ or } 0$$

EXAMPLES

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

$$D = 00000001, A_V = -256$$

$$D = 10000000, A_V = -2$$

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

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

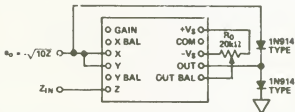
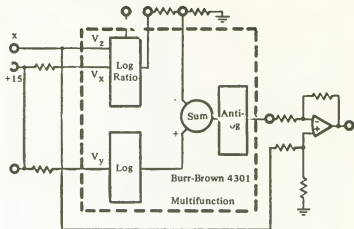


Fig. 32-5. Square root circuit using the 435 multiplier/divider chip (AD).



$$E_o = \sin x \approx x - \frac{x^2 \cdot 827}{6.28}$$

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

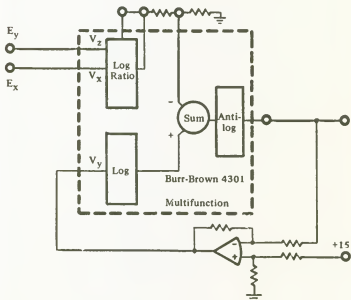


Fig. 32-7. Arc tangent function from the 4301 multifunction chip (BB).

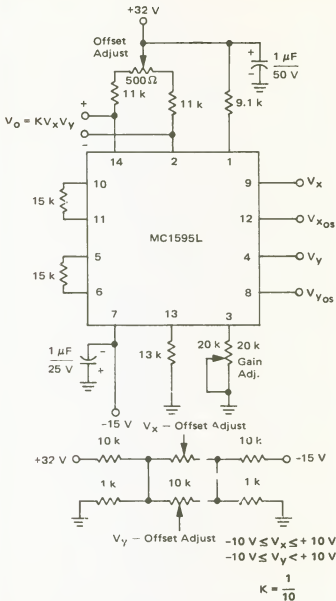


Fig. 32-9. Multiplier circuit using an MC1595 (M).

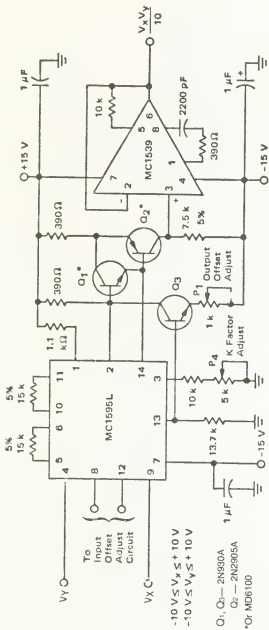


Fig. 32-10. Multiplier with discrete level shift (M).

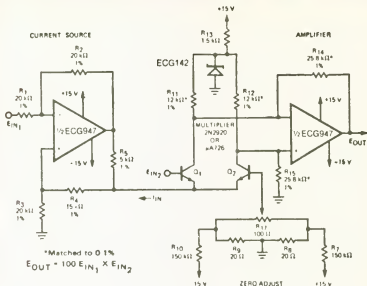


Fig. 32-11. Analog multiplier using an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

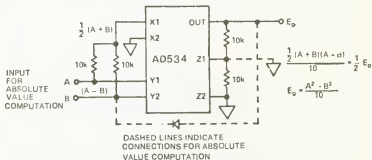


Fig. 32-12. Difference-of-squares circuit. This circuit computes the difference of the squares of two input signals. It is useful in vector computations and in weighing the difference of two magnitudes to emphasize the greater nonlinearity. It can also be used to determine absolute value if A is the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

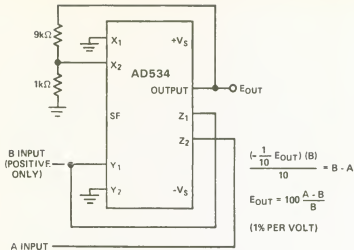
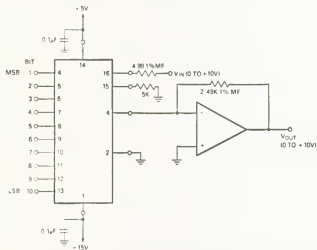
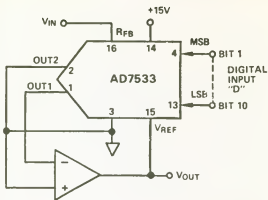


Fig. 32-13. Percent of deviation ratio computer (AD).



INPUT CODE		UNIPOLAR OPERATION - STRAIGHT BINARY			
MSB	LSB	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:

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

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

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

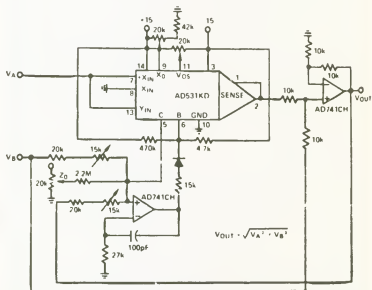
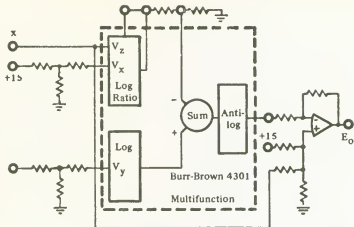


Fig. 32-16. Vector computer using one AD531 multiplier/divider and two AD741 op amps. The circuit derives the square root of the sum of the squares (AD).



$$E_o = \cos x = 1 + 0.2325 x - \frac{x^2 1.504}{1.445}$$

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

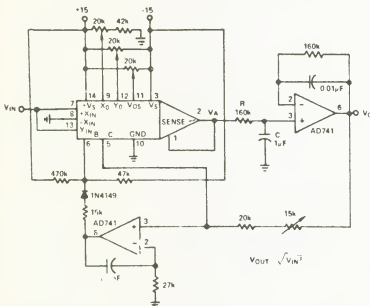


Fig. 32-18. True RMS circuit using one AD531 multiplier/divider and two AD741 op amps. The AD531 is combined with a simple filter to obtain the true RMS value of an AC input signal. by scaling $V_{OUT} = 10$ volts DC for a ± 10 -volt DC input this circuit can give direct RMS readings for 100 hertz to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

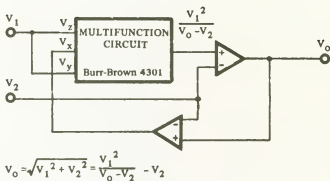


Fig. 32-19. Vector magnitude function from the 4301 multifunction chip (BB).

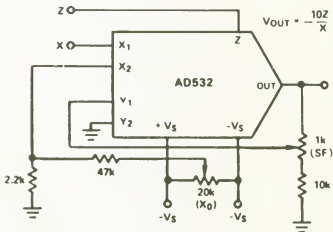
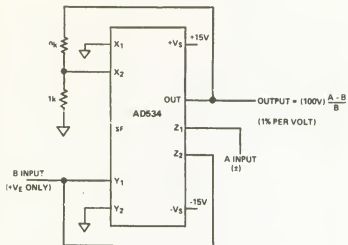


Fig. 32-20. Divider circuit using an AD532 multiplier/divider chip. The AD532 is available as a 10-pin TO-100 or as a 14-pin DIP (AD).



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).

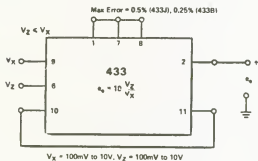


Fig. 32-22. Divider circuit using the 433 multiplier/divider chip (AD).

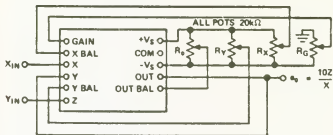


Fig. 32-23. Divider circuit using the 435 multiplier/divider chip (AD).

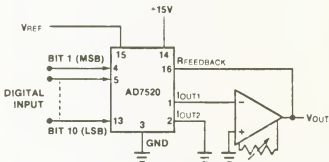


Fig. 32-24. Two-quadrant multiplication with AD7520 in unipolar binary operation. The Intersil AD7520 is an 18-pin multiplying D/A converter. To adjust the zero offset connect all digital input to ground, and adjust the zero trimmer on the op amp for $0V \pm 1 \text{ mV}$ at V_{OUT} . To adjust for the 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 (1) (AD).

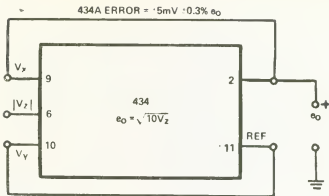


Fig. 32-25. Square rooter circuit using the 434 multiplier/divider chip (AD).

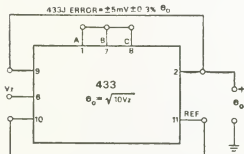


Fig. 32-26. Square rooter using the 433 multiplier/divider chip (AD).

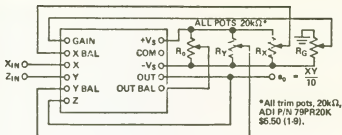


Fig. 32-27. Multiplier circuit using the 435 multiplier/divider chip (AD).

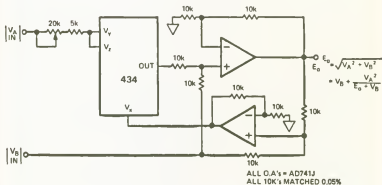
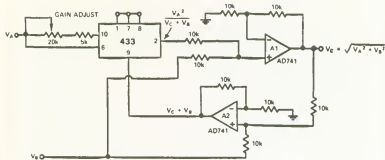


Fig. 32-28. Square root of the sum of the squares circuit. This circuit performs vector computations (AD).



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

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

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

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

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

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

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).

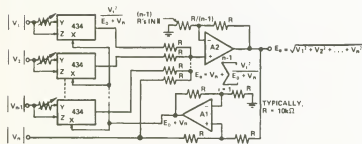
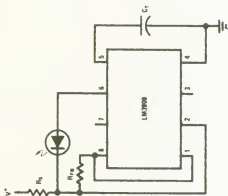


Fig. 32-30. Vector computation circuit for n variables using 434 multiplier/dividers and two AD741 op amps (AD).

Chapter 33

Miscellaneous Circuits

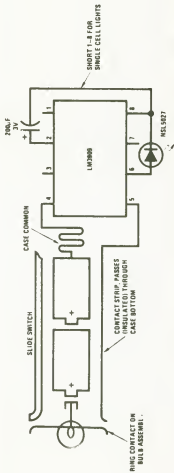


1.5V Flasher

Typical Operating Conditions

V^+	NOMINAL FLASH Hz	C_T	R_S	R_{FB}	V^+ RANGE
6V	2	400 μ F	1k	1.5k	5-25V
15V	2	180 μ F	3.9k	1k	13-50V
100V	1.7	180 μ F	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 2 Ω .

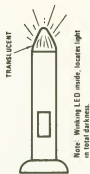
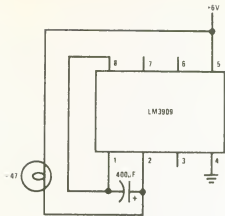


Fig. 33-2. Flashlight finder (NS).



Note Flash rate 1.5 Hz

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

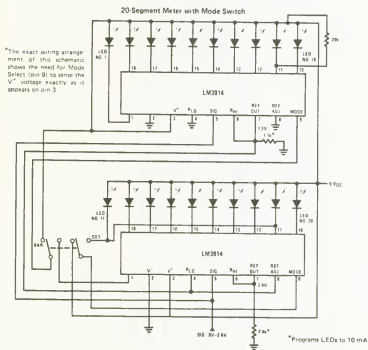


Fig. 33-6. 20-Segment meter with mode Switch.

Zero Center Meter, 20 Segment

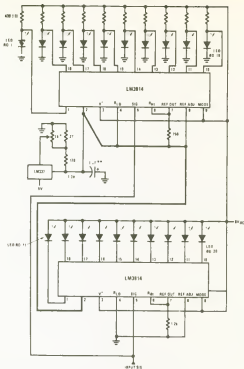


Fig. 33-5. Zero-center meter, 20-segment (NS).

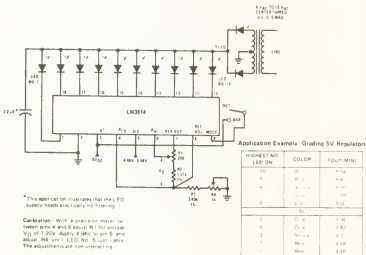


Fig. 33-6. Expanded scale meter, dot or bar (NS).

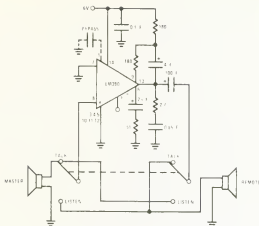


Fig. 33-7. Intercom (NS).

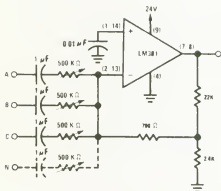


Fig. 3-18. Audio mixer (NS).

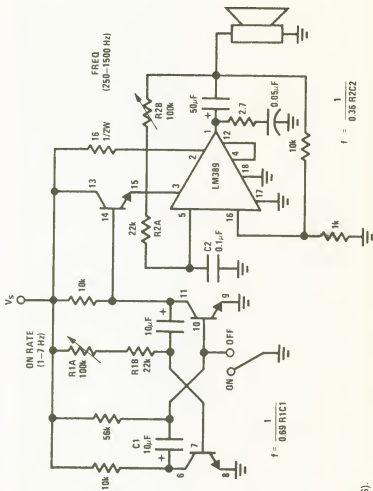


Fig. 33-9. Siren (NS).

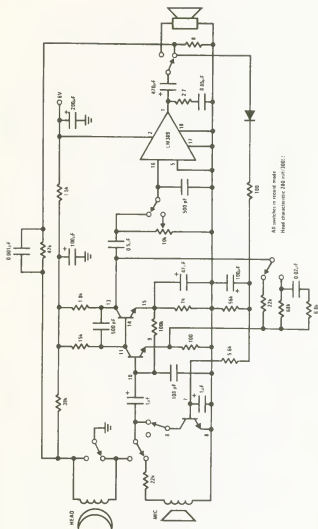
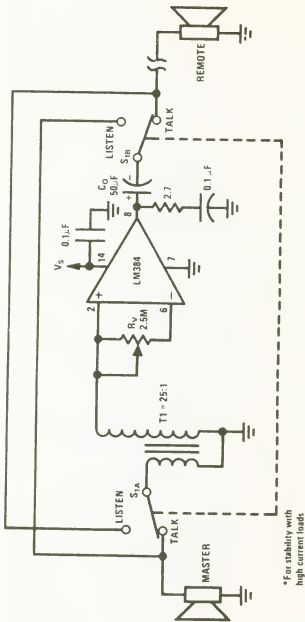


Fig. 33-10. Tape recorder (NS).



*For stability with high current loads

Fig. 33-11. Intercom (NS).

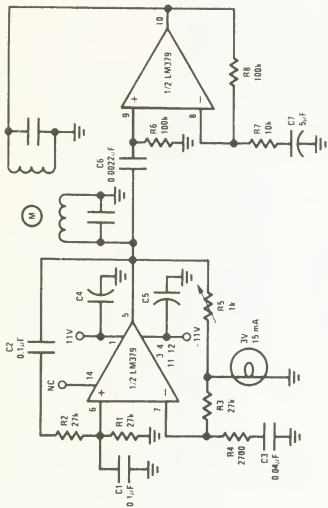


Fig. 33-12. Two-phase motor drive (NS).

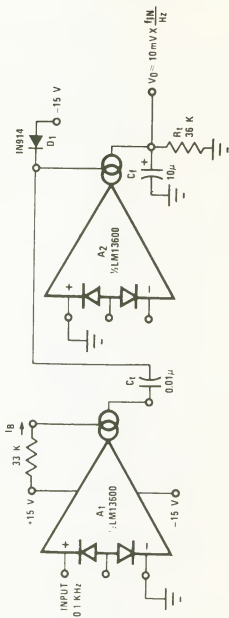


Fig. 33-13. Tachometer (NS).

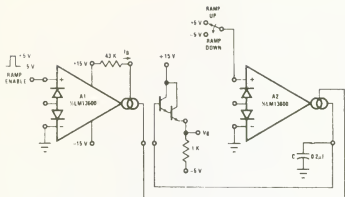


Fig. 33-14. Ramp and hold (NS).

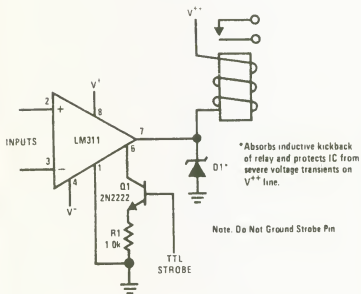


Fig. 33-15. Relay driver with strobe.

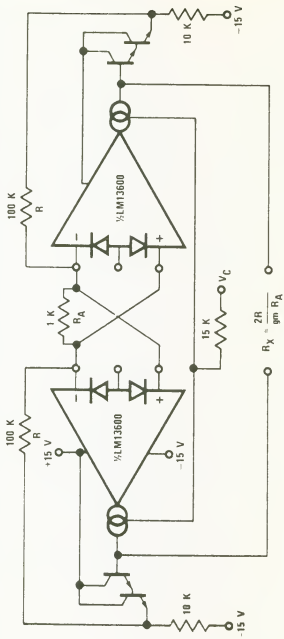


Fig.33-16. Floating voltage-controlled resistor(NS).

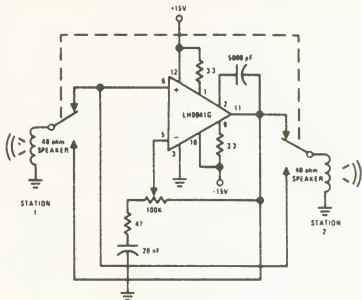


Fig. 33-17. Two-way intercom (NS).

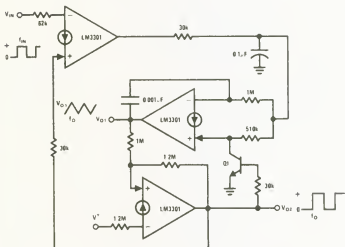
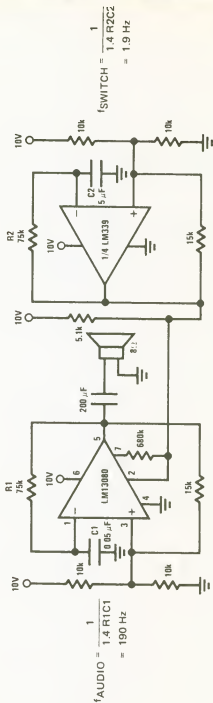


Fig. 33-18. Phase-locked loop (NS).



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

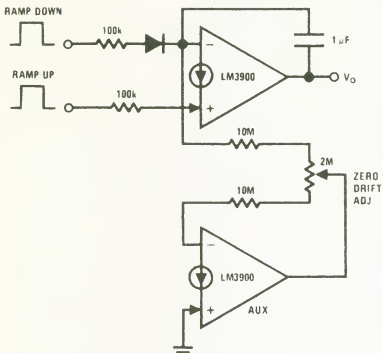


Fig. 33-20. Low-drift ramp and hold circuit (NS).

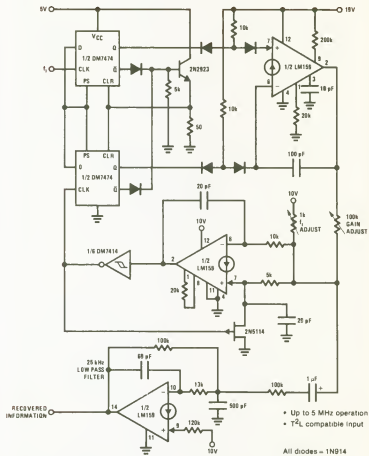


Fig. 33-21. Phase-locked loop.

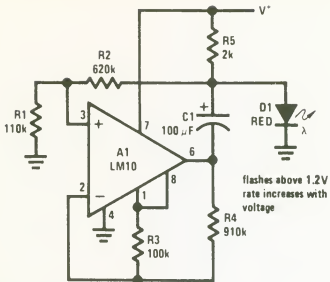


Fig. 33-22. Single-cell voltage monitor (NS).

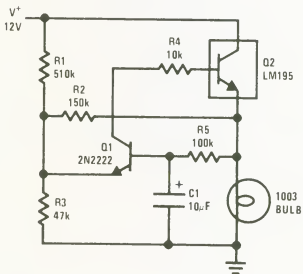


Fig. 33-23. A 1.0 Amp lamp flasher (NS).

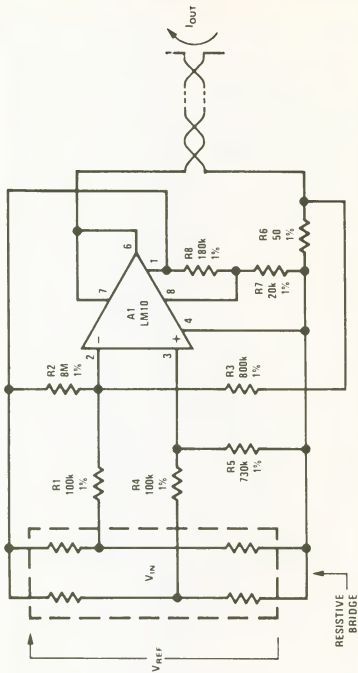


Fig. 33-24. Transmitter for bridge sensor (NS).

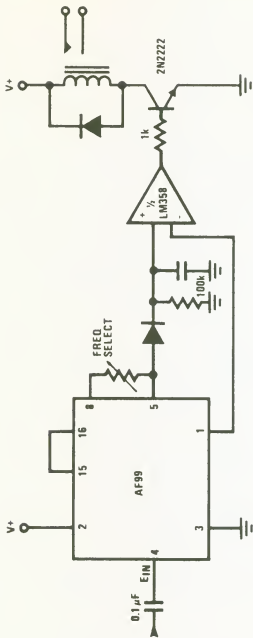


Fig. 33-25. Tone decoder with relay output (NS).

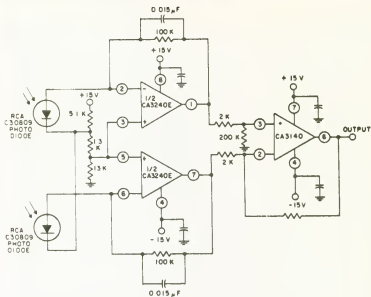


Fig. 33-26. Differential light detector (RCA).

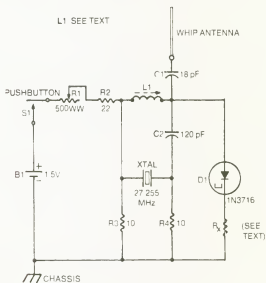
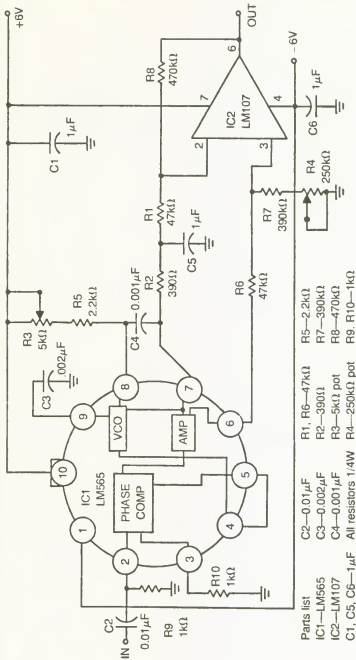


Fig. 33-27. Remote-control transmitter.



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

Fig. 33-28. IIRIG channel 13 demodulator.

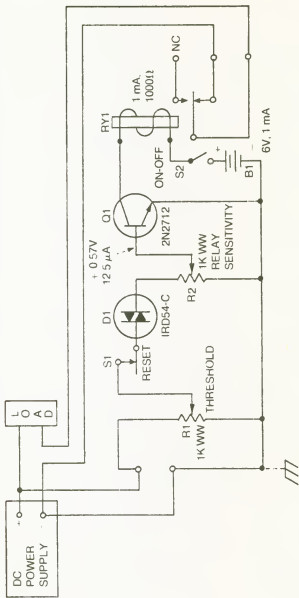


Fig. 33-29. DC overload circuit breaker.

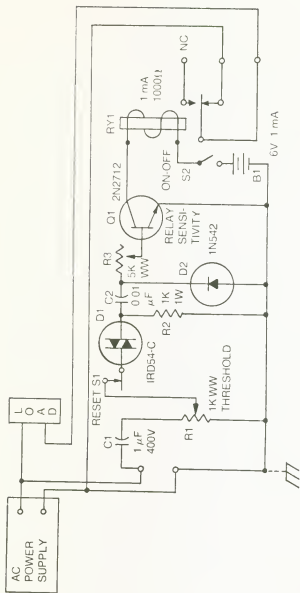


Fig. 33-30. AC overload circuit breaker.

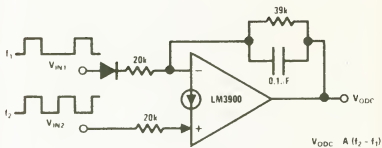


Fig. 33-31. Frequency differencing tachometer (NS).

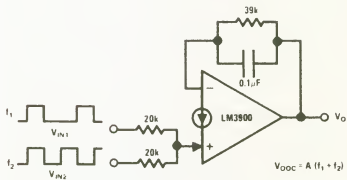
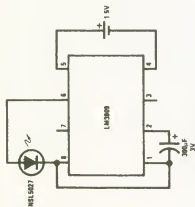


Fig. 33-32. Frequency averaging tachometer (NS).



Note: Nominal flash rate: 1 Hz.

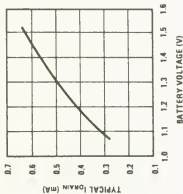
APPLICATIONS NOTES

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

Note 2: Flash rates and frequencies assume a $\pm 5\%$ 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.



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.

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

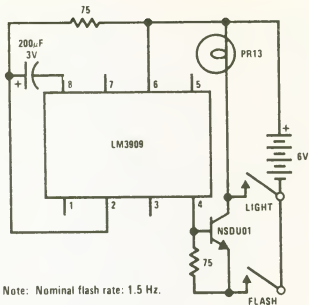


Fig. 33-34. Emergency lantern/flasher (NS).

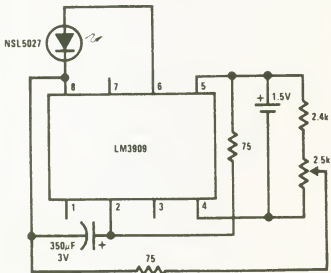


Fig. 33-35. Variable flasher (NS).

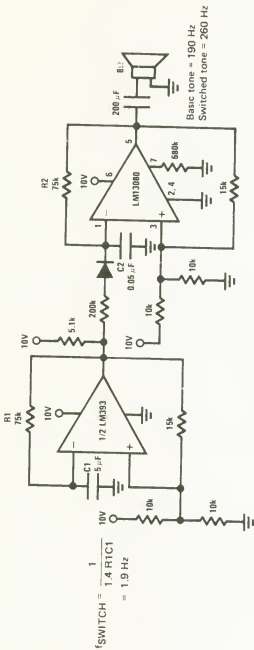


Fig. 33-36. 2-tone siren (NS).

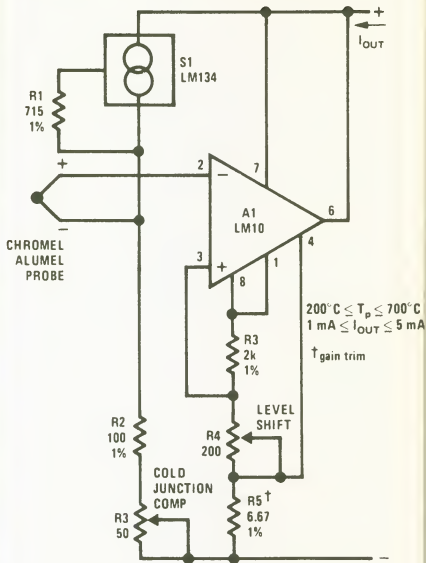


Fig. 33-37. Thermocouple transmitter (NS).

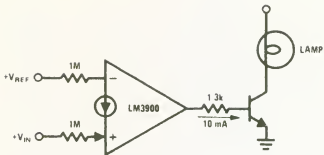
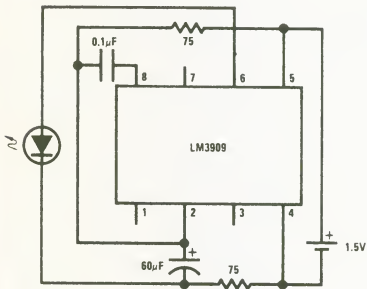


Fig. 33-38. Power comparator (NS).



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).

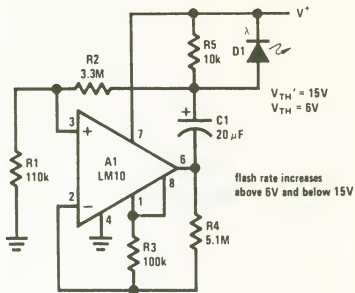


Fig. 33-40. Double-ended voltage monitor (NS).

Chapter 34

Multiplexers

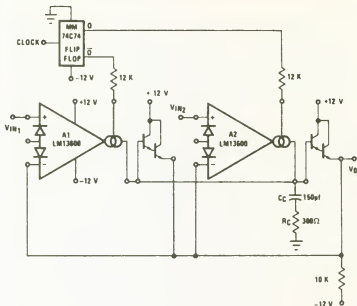


Fig. 34-1. Multiplexer (NS).

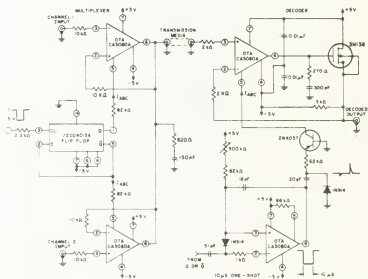


Fig. 34-2. Two-channel multiplexer and decoder using OTAs (RCA).

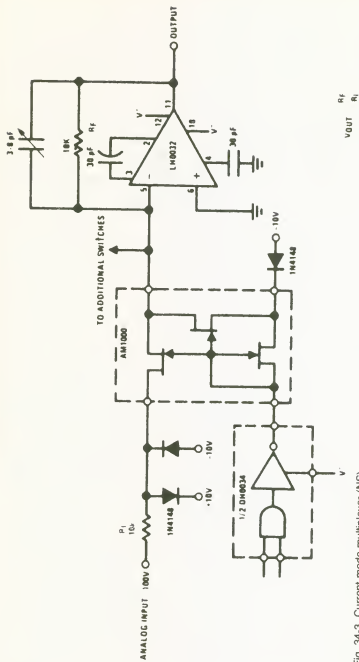


Fig. 34-3. Current mode multiplexer (NS).

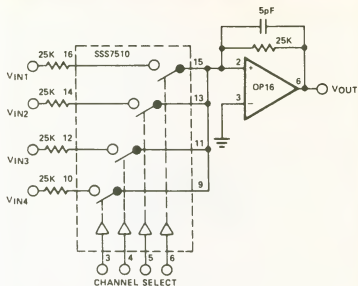
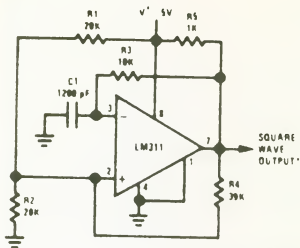


Fig. 34-4. Multiplexer/Mixer (PM).

Chapter 35

Multivibrators



*TTL or DTL fanout of two.

Fig. 35-1. 100 kHz free running multivibrator.

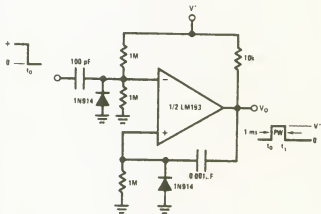


Fig. 35-2. One-shot multivibrator (NS).

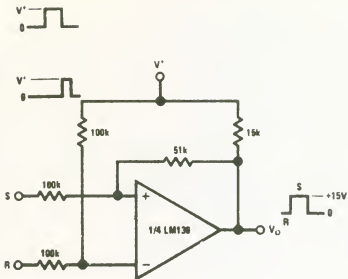


Fig. 35-3. Bi-Stable Multivibrator.

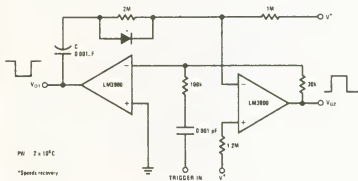


Fig. 35-4. One-shot multivibrator (NS).

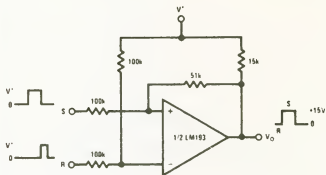


Fig. 35-5. Bi-stable multivibrator (NS).

Chapter 36
Music-Related Circuits

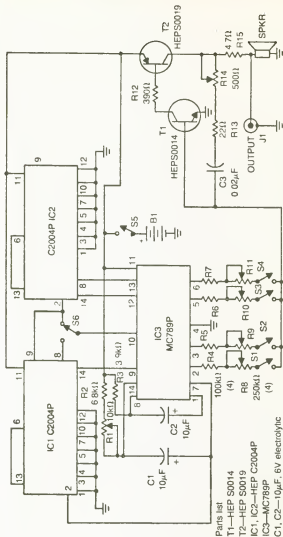


Fig. 36-1. Digital musical notes.

Parts list

T1—HEP S0014

T2—HEP S0019

IC1, IC2—HEP C2004P

IC3—MC789P

C1, C2— $10\mu\text{F}$, 6V electrolytic

C3— $0.02\mu\text{F}$

R1— $10\text{k}\Omega$, linear pot, 1W

R2— $6.8\text{k}\Omega$, 1/2W

R3— $3.9\text{k}\Omega$, 1/2W

R4, R5, R6, R7— $100\text{k}\Omega$ 1/2W

R8, R9, R10, R11— $250\text{k}\Omega$,

linear pot, 1W

R12— 390Ω , 1/2W

R13— $22\text{k}\Omega$, 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.

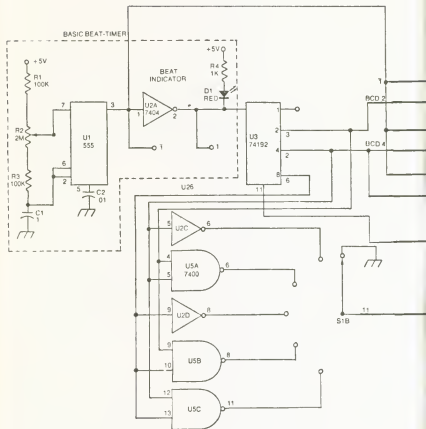
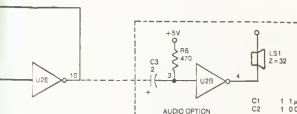
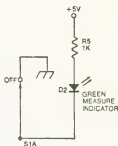
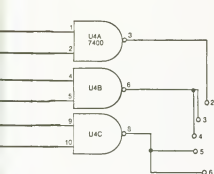


Fig. 36-2. The basic visual metronome is enclosed by the dashed-in area at the upper left. If another indication is desired for every second through sixth beat, the remaining circuits must be added, except for the audio operation. It can be added with either configuration.



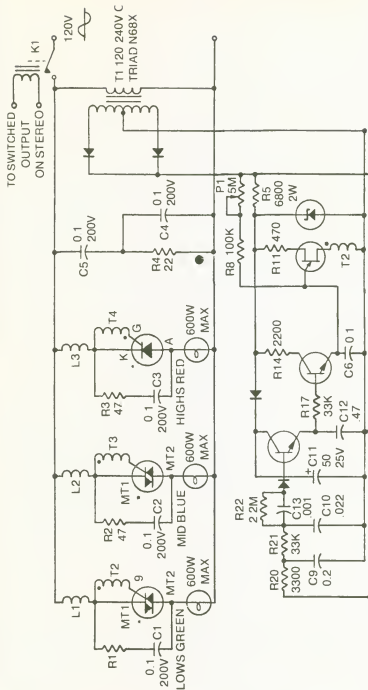
AUDIO OPTION

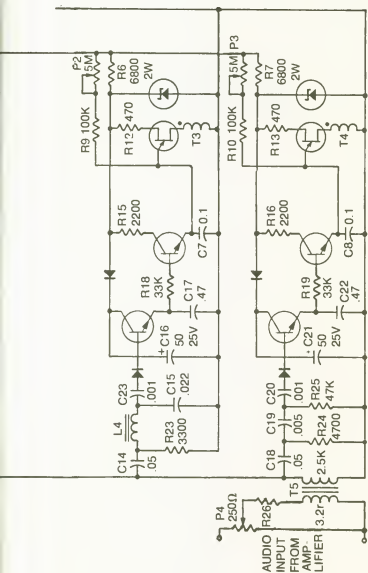
- C1 1 1 μ F, 12V
- C2 1 0.01 μ F
- *C3 1 2 μ F, 12V
- D1 1 LED, LARGE GREEN DIFFUSED LENS
- D2 1 LED, LARGE RED DIFFUSED LENS
- *LS1 1 32 OHMS MINIATURE
- R1, R3 2 100 000 OHMS, 1/8 WATT
- R2 1 2 MEGOHM POTENTIOMETER
- R4, R5 2 1000 OHMS, 1/8 WATT
- *R6 1 470 OHMS, 1/8 WATT
- S1 1 6 POSITION, 2 POLE, 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

UNLESS OTHERWISE SPECIFIED
 A ALL RESISTANCE IN OHMS
 B ALL CAPACITANCE IN μ F

REF DESIG	+5V	GND
U1	4, 8	1
U2	14	7
U3	16	8
U4, 5	14	8

* FOR AUDIO OPTION ONLY





*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

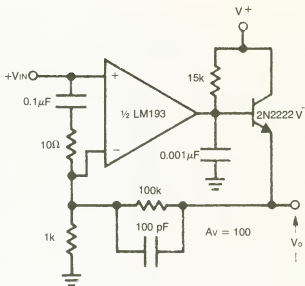


Fig. 37-1. Improved op amp (NS).

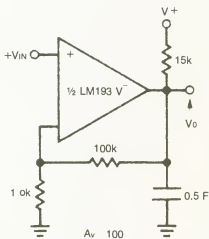


Fig. 37-2. Low-frequency op amp (NS).

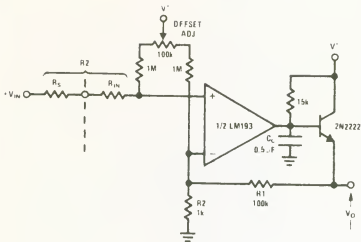


Fig. 37-3. Low-frequency op amp with offset adjustment (NS).

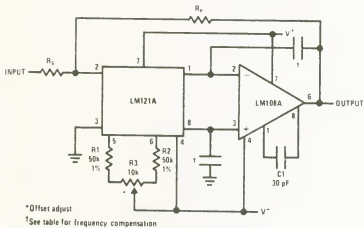


Fig. 37-4. Low-drift op amp using the LM121A as a preamplifier (NS).

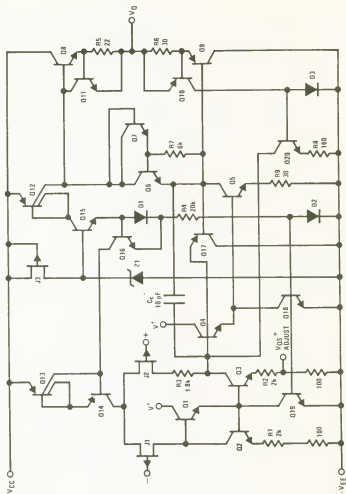


Fig. 37-5. Power op amp (NS).

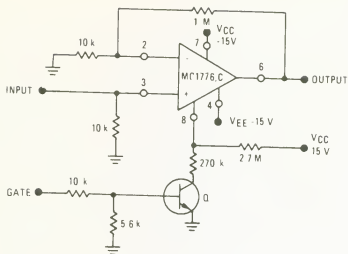


Fig. 37-6. Gated amplifier (M).

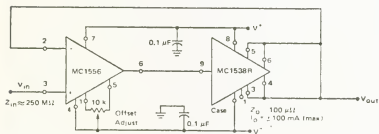
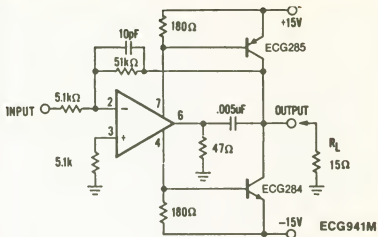


Fig. 37-7. High-impedance input, high-current output voltage follower (M).



ECG941D

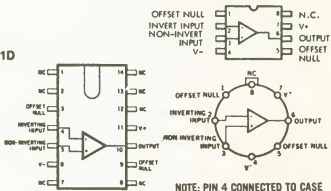


Fig. 37-8. High-slew-rate power amplifier using an ECG941/941D/941M operational amplifier (GTE).

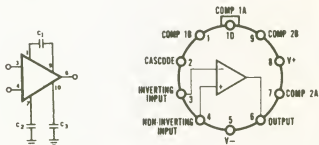


Fig. 37-9. Frequency compensation circuit using an ECG915 operational amplifier. See table for component values. Supply voltage is ± 15 volts (GTE).

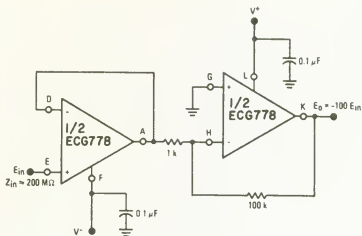


Fig. 37-10. High-impedance high-gain inverting amplifier. Typical supply voltages are +15 volts and -15 volts (GTE).

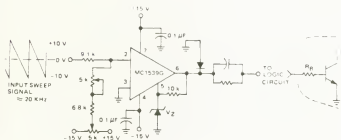


Fig. 37-11. Voltage comparator using an MC1539G op amp (M).

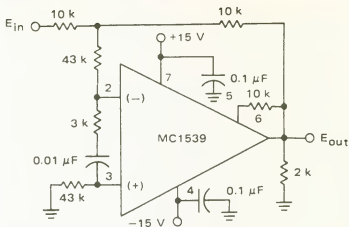


Fig. 37-12. Unity-gain op amp with fast response time (M).

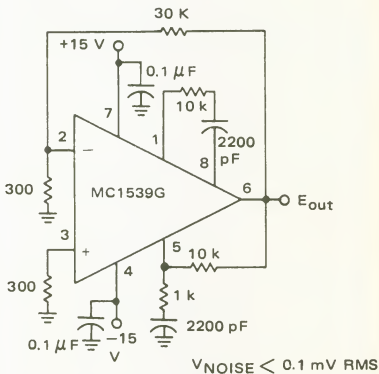


Fig. 37-13. Differential with low-noise output using an MC1539 op amp (M).

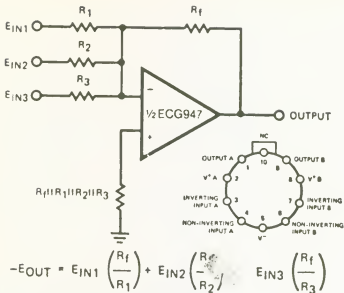


Fig. 37-14. Weighted averaging amplifier using half of an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

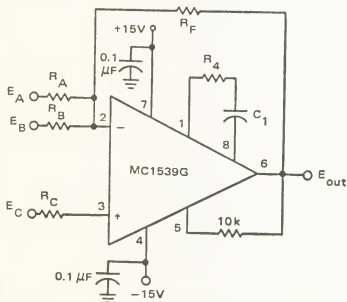


Fig. 37-15. Differential amplifier using an MC1539 op amp (M).

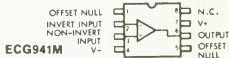
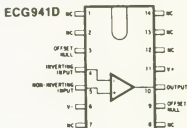
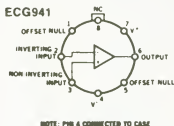
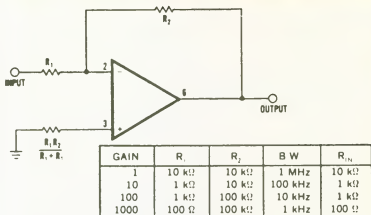


Fig. 37-16. Inverting amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ± 15 volts (GTE).

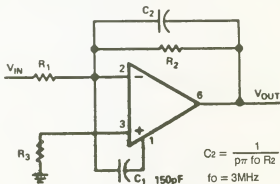
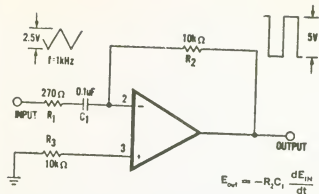
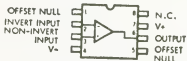
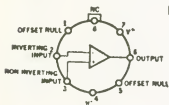


Fig. 37-17. Feedforward frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ± 15 volts (AD).

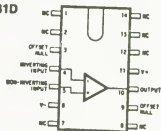


ECG941M

ECG941



ECG941D



NOTE: PIN 4 CONNECTED TO CASE

Fig. 37-18. Simple differentiator using an ECG941/941D/941M operational amplifier. Typical supply voltage is ± 15 volts (GTE).

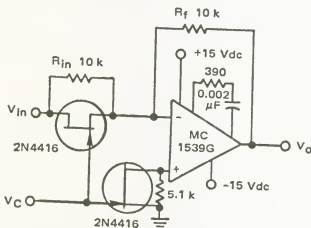
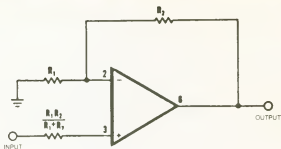


Fig. 37-19. Op amp with FET AGC circuit (M).



GAIN	R_1	R_2	B.W.	R_{IN}
10	1 k Ω	9 k Ω	100 kHz	400 M Ω
100	100 Ω	99 k Ω	10 kHz	280 M Ω
1000	100 Ω	999 k Ω	1 kHz	80 M Ω

ECG941M

OFFSET NULL
INVERT INPUT
NON-INVERT INPUT
V-



ECG941



NOTE: PIN 4 CONNECTED TO CASE

ECG941D

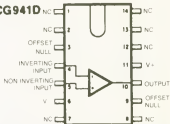


Fig. 37-20. Noninverting amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ± 15 volts (GTE).

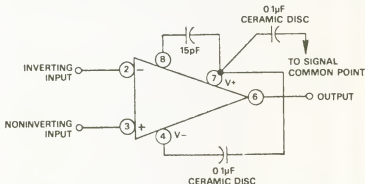
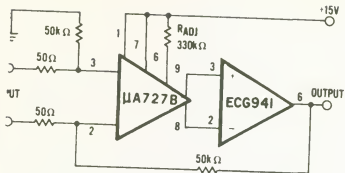
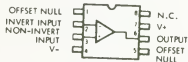


Fig. 37-21. Unity-gain op amp using an AD5098-pin TO99 (AD).

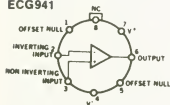


Voltage Gain = 10^3
 Input Offset Voltage Drift = $0.6 \mu\text{V}/^\circ\text{C}$
 Input Offset Current Drift = $2.0 \text{ pA}/^\circ\text{C}$

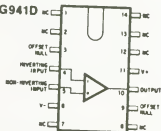
ECG941M



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 $\mu\text{A}727\text{B}$ temperature controlled differential amplifier. Typical supply voltage is ± 15 volts (GTE).

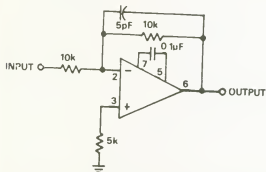
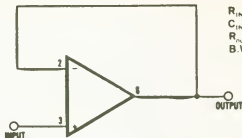


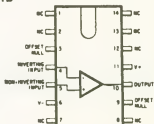
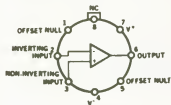
Fig. 37-23. Op amp with minimum settling time using an AD518 8-pin TO99 (AD).



$R_{IN} = 400 \text{ M}\Omega$
 $C_{IN} = 1 \text{ pF}$
 $R_{OUT} < 1 \Omega$
 $\text{B.W.} = 1 \text{ MHz}$

ECG941

ECG941D



NOTE: PIN 4 CONNECTED TO CASE

Fig. 37-24. Unity-gain voltage follower using an ECG941/941D/941M operational amplifier. Typical supply voltage is ± 15 volts (GTE).

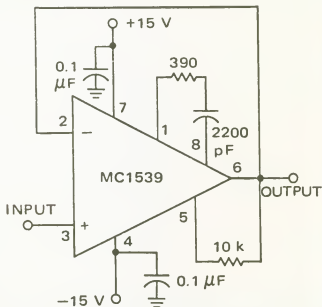


Fig. 37-25. Voltage follower using an MC1539 op amp with unity-gain compensation (M).

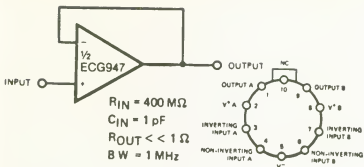


Fig. 37-26. Unity-gain voltage follower using half of an ECG947 dual operational amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

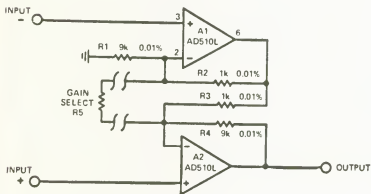


Fig. 37-27. Instrumentation amplifier using two AD510L 8-pin TO99 op amps. As shown the gain is 10. By adding R5 the gain will increase. For a gain of 10 the frequency response is down 3 dB at 500 kHz. Full output of ± 10 volts can be attained up to 1800 hertz (AD).

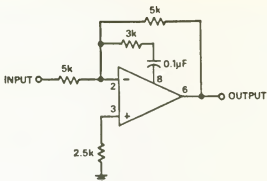


Fig. 37-28. Op amp with high bandwidth using an AD518 8-pin TO99. Bandwidth is nearly 25 MHz with the feedforward technique shown (AD).

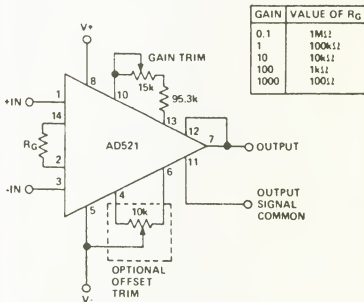


Fig. 37-29. Instrument amplifier using an AD521 op amp. Typical supply is ± 15 volts (AD).

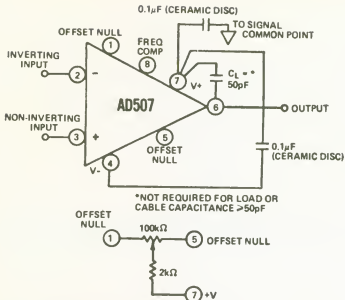


Fig. 37-30. General-purpose operational amplifier with closed-loop gain greater than 10. Typical supply voltage is ± 15 volts (AD).

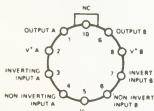
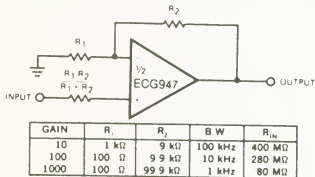


Fig. 37-31. Noninverting amplifier using half of an ECG947 dual operator amplifier. The ECG947 is short-circuit protected and requires no external components for frequency compensation (GTE).

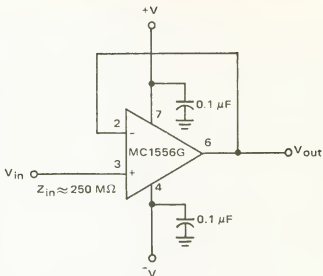


Fig. 37-32. Voltage follower using an MC1556 op amp (M).

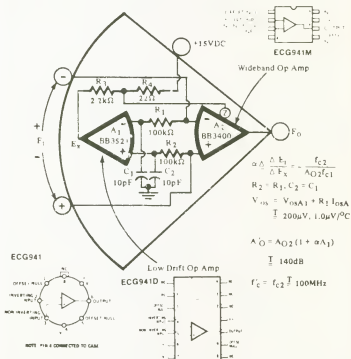


Fig. 37-33. Differential-input composite op amp (BB).

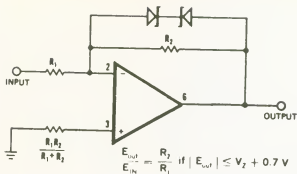


Fig. 37-34. Clipping amplifier using an ECG941/941D/941M operational amplifier. Typical supply voltage is ± 15 volts (GTE).

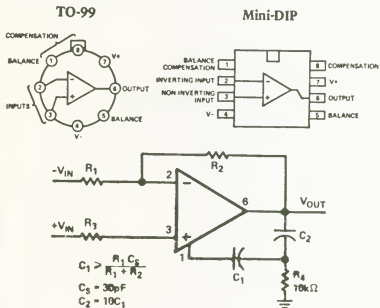


Fig. 37-35. Two pole frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ± 15 volts (AD).

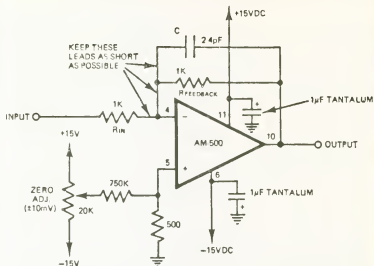


Fig. 37-36. Fast-settling op amp with gain of -1 . For gains larger than -1 use an input resistor valued at 500 ohms or less and pick a feedback resistor for the required gain, i.e., 1K for -1 , 1.5K for -3 , etc. (DS).

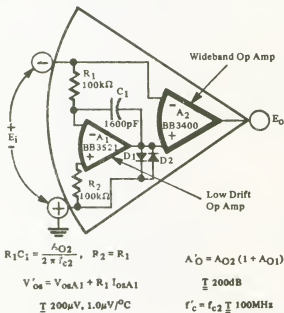


Fig. 37-37. Inverting-only composite op amp (BB).

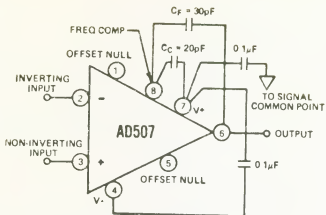


Fig. 37-38. Unity-gain operational amplifier. With the compensation shown a unity-gain frequency of approximately 10MHz to 12MHz results (AD).

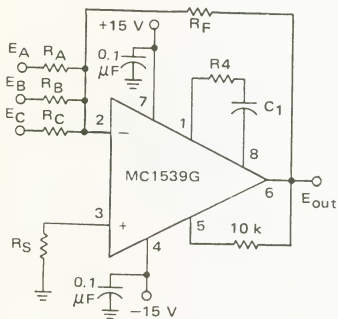


Fig. 37-39. Summing amplifier using an MC1539 op amp (M).

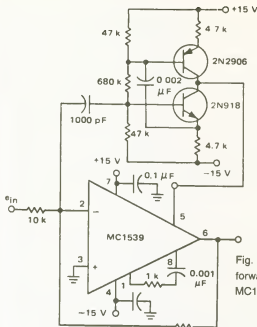


Fig. 37-40. Unity-gain feed forward amplifier using an MC1539 op amp (M).

TO-99

Mini-DIP

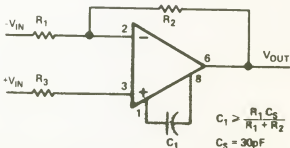
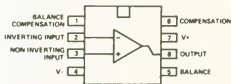
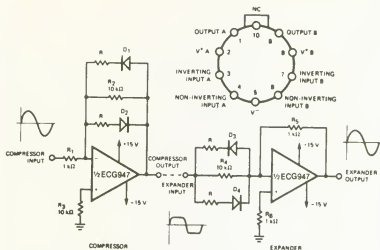


Fig. 37-41. Single pole frequency compensation circuit using an AD101A/201A/301A op amp. Typical supply voltage is ± 15 volts. Voltage gain is 88 dB (AD).



MAXIMUM COMPRESSION EXPANSION RATIO = R_1/R ($10\text{ k}\Omega > R > 0$)
 NOTE DIODES D_1 THROUGH D_4 ARE MATCHED ECG178'S

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).

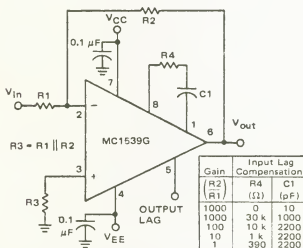
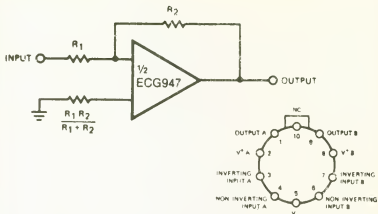


Fig. 37-43. Op amp in closed-loop frequency-compensated configuration (M).



GAIN	R_1	R_2	BW	R_{IN}
1	10 k Ω	10 k Ω	1 MHz	10 k Ω
10	1 k Ω	10 k Ω	100 kHz	1 k Ω
100	1 k Ω	100 k Ω	10 kHz	1 k Ω
1000	100 Ω	100 k Ω	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).

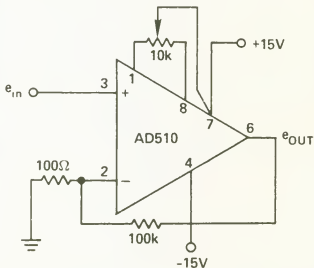


Fig. 37-45. Noninverting op amp using an AD510 8-pin TO99 (AD).

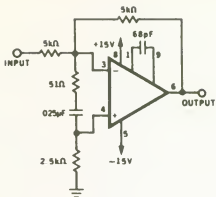


Fig. 37-46. Inverting unity-gain high-slew-rate circuit using an ECG915 operational amplifier (GTE).

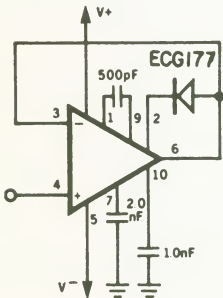


Fig. 37-47. Voltage follower using an ECG915 operational amplifier. Output is taken on pin 6 (GTE).

Chapter 38

Oscillators

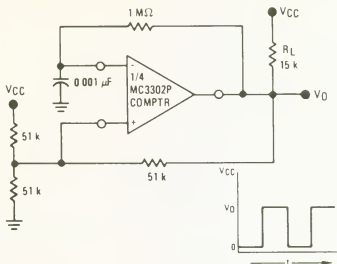


Fig. 38-1. Free-running square wave oscillator (M).

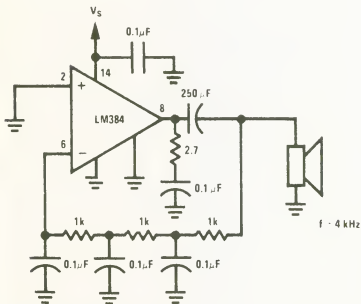


Fig. 38-2. Phase shift oscillator (NS).

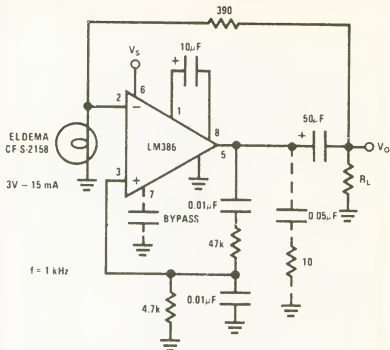


Fig. 38-3. Low-distortion power Wien-bridge oscillator (NS).

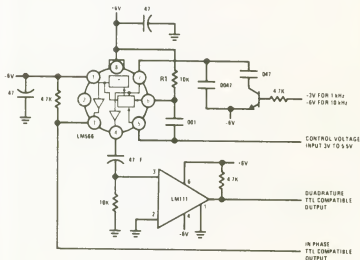
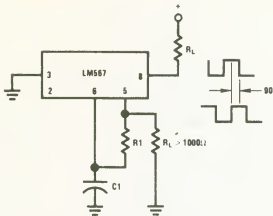


Fig. 38-4. A 1-kHz and 10-kHz TTL compatible voltage controlled oscillator (NS).



Connect pin 3 to 2.8V to invert output.

Fig. 38-5. Oscillator with quadrature output (NS).

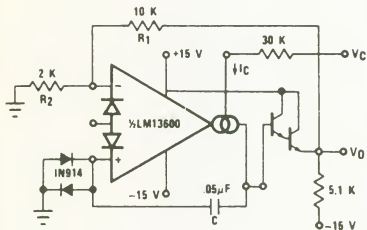


Fig. 38-6. Single amplifier oscillator (NS).

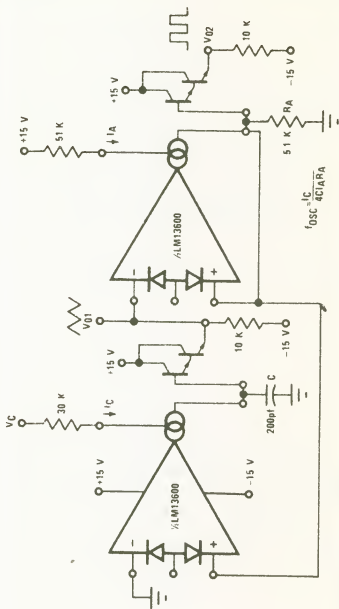


Fig. 38-7. Triangular/square wave voltage-controlled oscillator (NS).

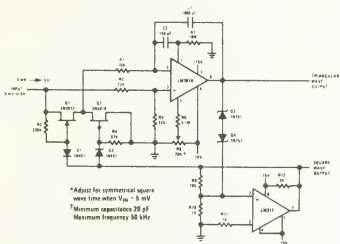


Fig. 38-8. A 10-Hz to 10-kHz voltage-controlled oscillator (NS).

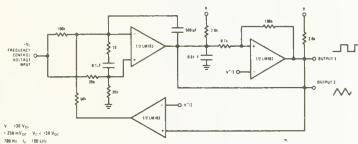


Fig. 38-9. A two-decade high-frequency voltage-controlled oscillator (NS).

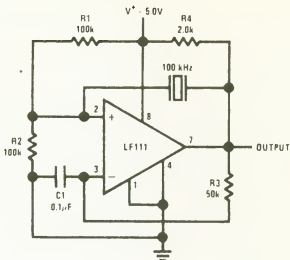


Fig. 38-10. Crystal oscillator (NS).

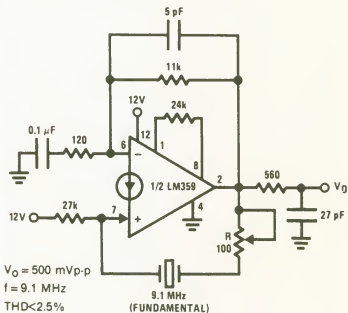


Fig. 38-11. Crystal-controlled sine wave oscillator (NS).

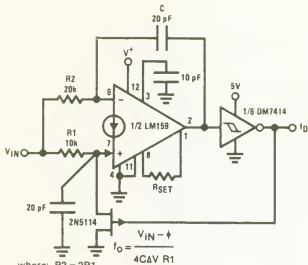


Fig. 38-12. Voltage-controlled oscillator (NS).

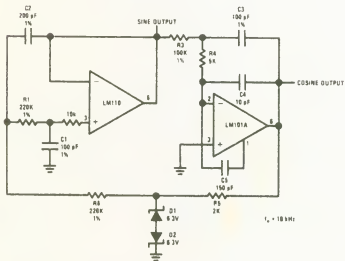


Fig. 38-13. Sine wave oscillator (NS).

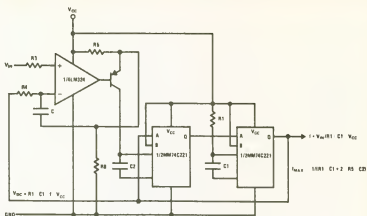


Fig. 38-14. Linear voltage-controlled oscillator (NS).

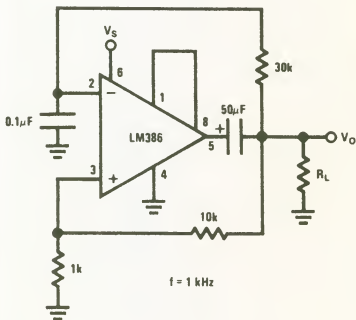


Fig. 38-15. Square wave oscillator (NS).

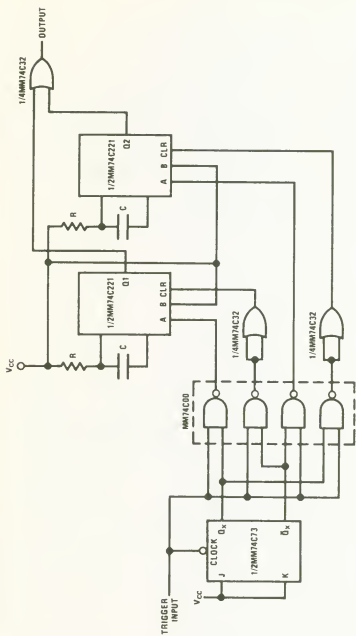


Fig. 38-16. Retriggerable one-shot (NS).

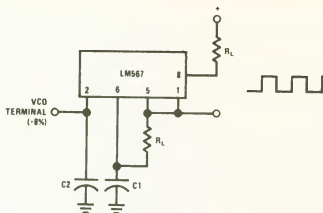


Fig. 38-17. Precision oscillator drive 100 mA loads (NS).

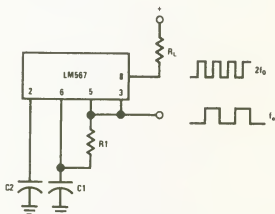


Fig. 38-18. Oscillator with double frequency output (NS).

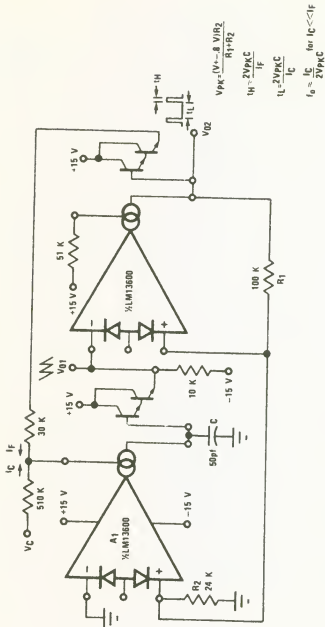
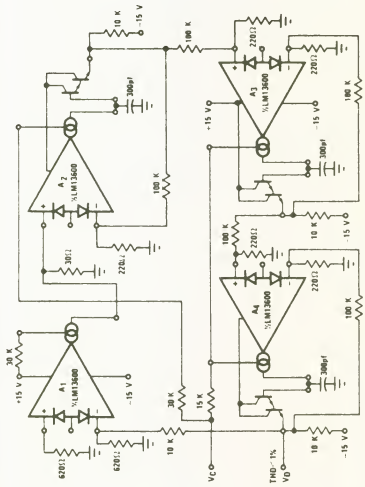


Fig. 38-19. Ramp/pulse voltage-controlled oscillator (NS).

Fig. 38-20. Sinusoidal voltage-controlled oscillator (NS).



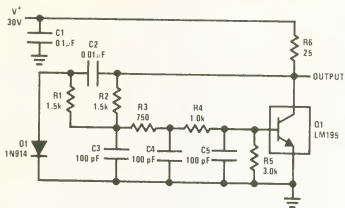


Fig. 38-21. A 1.0-MHz oscillator (NS).

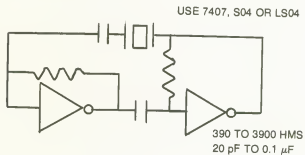
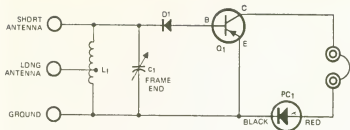


Fig. 38-22. Basic Crystal Oscillator.

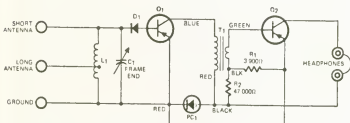
Chapter 39

Photo-Activated Circuits



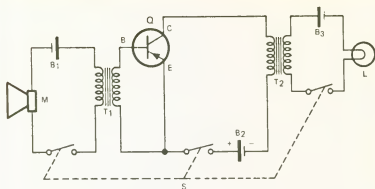
- Q1** PNP Transistor (IR-TR05 or TR14)
C1 365pf variable Capacitor (J.W. Miller No. 2111 or equivalent)
L1 Transistor Loopstick Antenna (J.W. Miller No. 2001, or equivalent)
D1 Germanium Diode (IR-1N34A)
PC1 Selenium or Silicon Solar Cell (IR-B2M, B3M, or S1M)
HEADPHONES 2,000 or 4,000 Ohms
OPTIONAL 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).



- Q1, Q2** PNP Transistors (IR-TR05 or TR14)
PC1 Selenium or Silicon Solar Cell (IR-B2M, B3M, or S1M)
T1 10,000 Ohm to 2,000 Ohm Interstage Transformer (Stancor TA-35, or equivalent)
L1 Transistor Loopstick Antenna (J.W. Miller No. 2001, or equivalent)
C1 365pf Variable Capacitor (J.W. Miller No. 2111, or equivalent)
R1 3,900 Ohm Resistor
R2 47K Ohm Resistor
RD1 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)

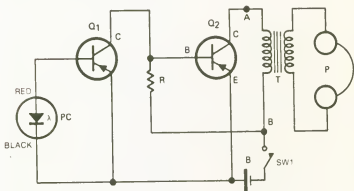
Fig. 39-2. Two-stage, solar-powered radio (W).



PARTS LIST

- M - Single button carbon microphone, available through surplus outlets
- T₁ - T₂ - Transformer (Triad T-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)
- B₁ - 7.5V battery (Eveready 717, Burgess 5540, or equivalent)
- B₂ - 22.5V battery (Burgess V15 or equivalent)
- B₃ - Size D flashlight cell

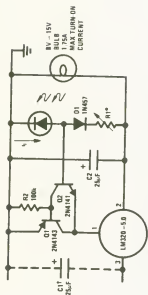
Fig. 39-3. Light-beam transmitter (W).



PARTS LIST

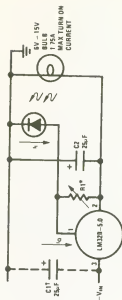
- PC - Photodiode (IR-B2M)
- Q1 - Q2 - PNP Transistor (IR-TR-05)
- P - Headphones (see text)
- SW1 - SPST switch
- R - 330,000 ohm 1/2 watt resistor
- B - 2.5V battery (Burgess U15)
- T - Stancor A-3250 Triad-T 23 or Thordarson T22590

Fig. 39-4. Light-beam receiver (W).



*Lamp brightness increases until $I_0 = 5V/R1$ (i.e. can be set as low as $I_{L(A)}$).

†Necessary only if raw supply filter capacitor is more than 2" from LM320MP.



*Lamp brightness increases until $I_0 = I_L$ ($\approx 1 \text{ mA}$) = $5V/R1$

†Necessary only if raw supply filter capacitor is more than 2" from LM320.

Fig. 39-5. Light controllers using silicon photo cells (NS).

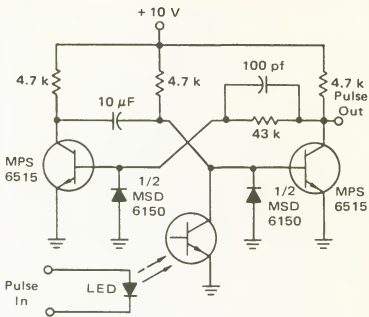


Fig. 39-6. Photo-driven pulse stretcher (M).

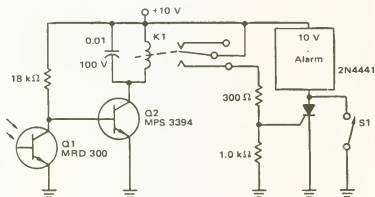


Fig. 39-7. Light-relay-operated SCR alarm circuit (M).

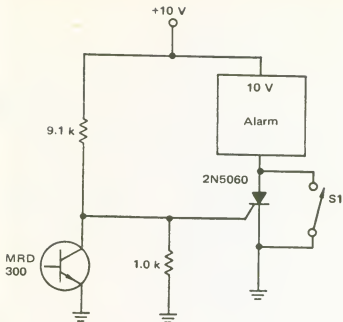


Fig. 39-8. Light-operated SCR alarm using a sensitive gate SCR (M).

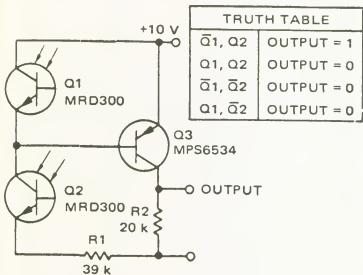


Fig. 39-9. Photo-activated logic driver (M).

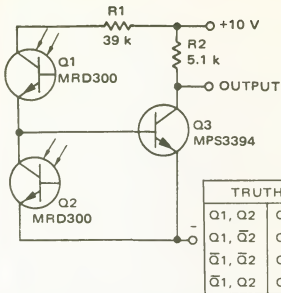


Fig. 39-10. Photo-activated logic driver (M).

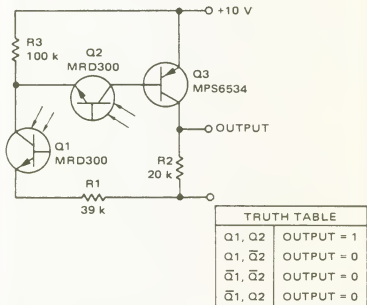


Fig. 39-11. Photo-activated logic driver (M).

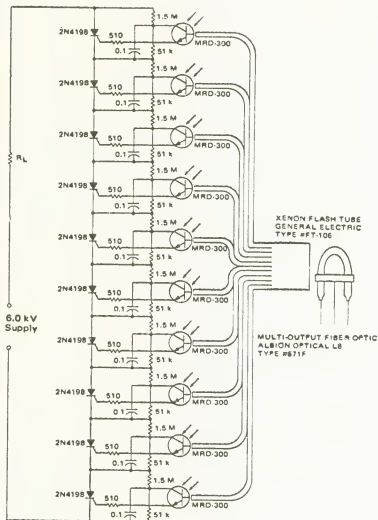
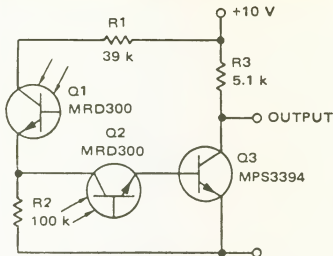


Fig. 39-12. Light-operated 6 kV series switch for high-voltage crowbar circuits or high-voltage pulse-forming networks (M).



TRUTH TABLE	
Q1, Q2	OUTPUT = 0
Q1, $\bar{Q}2$	OUTPUT = 1
$\bar{Q}1$, Q2	OUTPUT = 1
$\bar{Q}1$, $\bar{Q}2$	OUTPUT = 1

Fig. 39-13. Photo-activated logic driver (M).

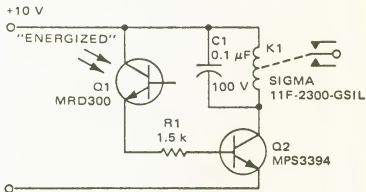


Fig. 39-14. Light-operated relay. The phototransistor can be activated by a flashlight (M).

Chapter 40

Power Amplifiers

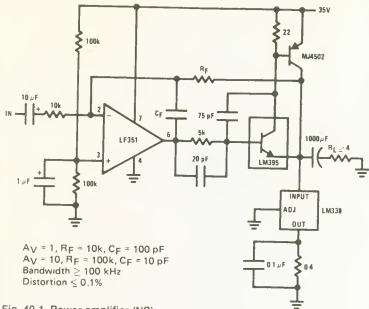


Fig. 40-1. Power amplifier (NS).

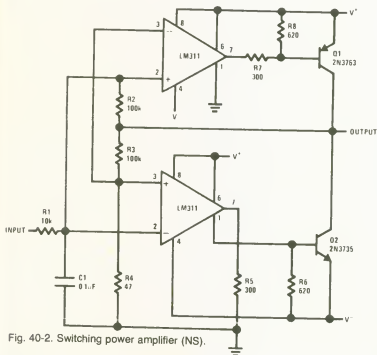


Fig. 40-2. Switching power amplifier (NS).

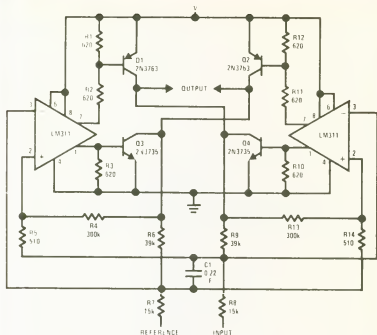
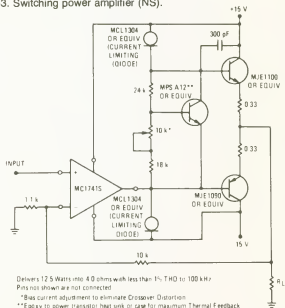


Fig. 40-3. Switching power amplifier (NS).



Delivers 12.5 Watts into 4 Ohms with less than 1% THD to 100 kHz
 Pins not shown are not connected

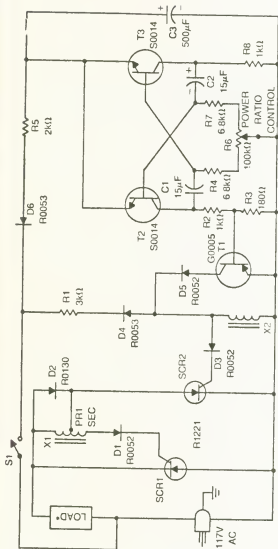
*Bias current adjustment to eliminate Crossover Distortion

**Epoxy to power transistor heat sink or case for maximum Thermal Feedback

Fig. 40-4. A 12.5-watt wideband power amplifier (NS).

Chapter 41

Power-Controlling Circuits



MAXIMUM LOAD IS 800 WATTS WHEN HEP R1331 SCR IS USED

Parts list

SCR1, SCR2—HEP R1221 D2—HEP R0130

T1—HEP G0005 C1, C2—15 μ F, 50V electrolytic

T2, T3—HEP S0014 C3—500 μ F, 15V, electrolytic

D1, D3, D5—HEP R0052 R1—3k Ω , 5W

D2, D4, D6—HEP R0053 R2, R8—1k Ω , 1/2W

R3—180 Ω , 1/2W R4, R7—6.8k Ω , 1/2W

R5—2k Ω , 5W R6—0.1M Ω linear taper pot

X1—transformer (primary not used) X2—Transformer (secondary not used), Stancor P-6465

Fig. 41-1—transformer (primary not used)

tapped secondary used as autotransformer

to provide 1 to 5 step-up in voltage.

Stancor P-6465

S1—Switch, SPST

Fig. 41-1. Electric appliance power control (NS).

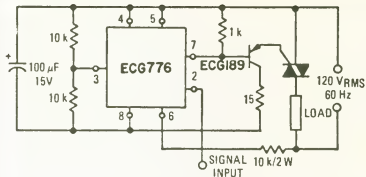
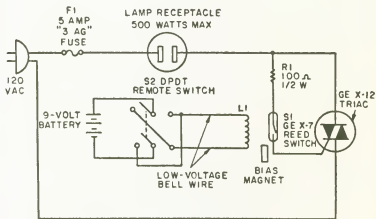


Fig. 41-2. Triac control circuit employing an ECG776 zero voltage switch with current boost utilizing an AC supply. The circuit is for applications requiring gate currents greater than 50 mA. Select the triac from the ECG5600 series for the particular application (GTE).



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).

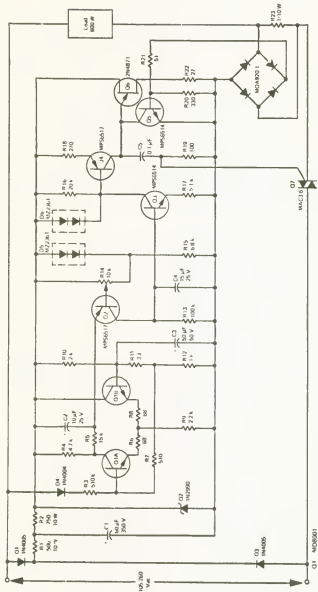


Fig. 41-4. RMS closed-loop voltage compensator (regulator). This circuit provides an output of 90 ± 2 volts RMS at 600 watts for an input of 105 to 260 volts (M).

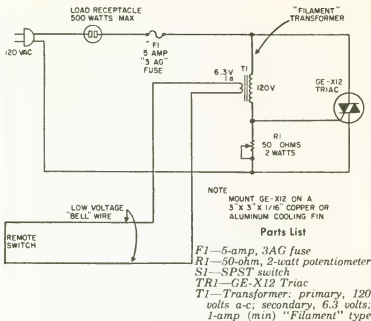


Fig. 41-5. Remote control for lamp or appliance using a filament transformer. The circuit can handle up to 500 watts. R1 is adjusted for the highest resistance that will not trigger the triac with S1 open (GTE).

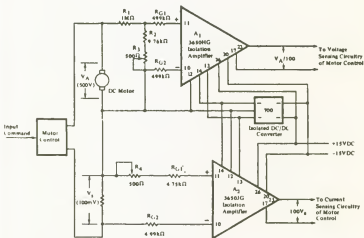


Fig. 41-6. Motor control circuitry using 3650 optical isolation amplifiers (BB).

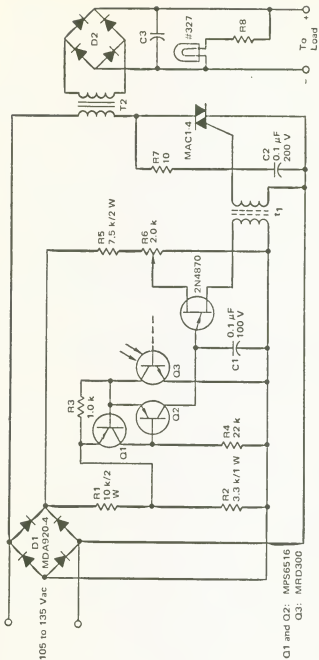
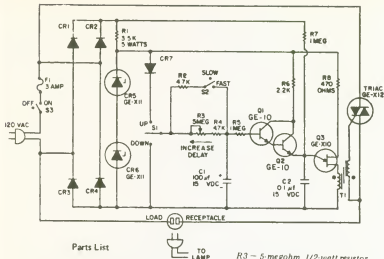


Fig. 41-7. RMS regulator for a DC power supply using a triac, phototransistor and UJT (M).



Parts List

C1 - 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
*T1*ac - 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).

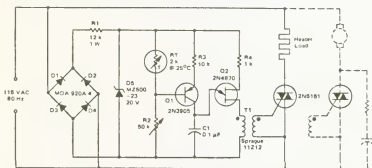


Fig. 41-11. Triac temperature-sensitive heater control. This circuit can be modified as shown to control a motor with a constant load. As shown the circuit is for heating applications but can be used for cooling by interchanging *R1* and *R2*. (M).

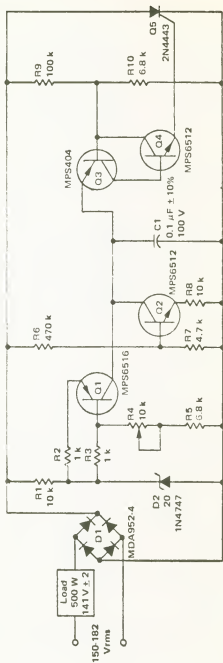
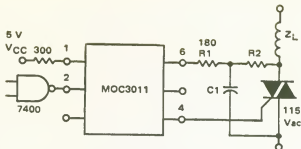


Fig. 41-12. RMS open-loop voltage compensator (regulator) for application requiring large conduction angles. It provides an output 141 ± 2 volts RMS at 500 watts for an input of 150 to 182 volts RMS (M).



NOTE: Circuit supplies 25 mA drive to gate of triac at $V_{in} = 25 \text{ V}$ and $T_A \leq 70^\circ\text{C}$.

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).

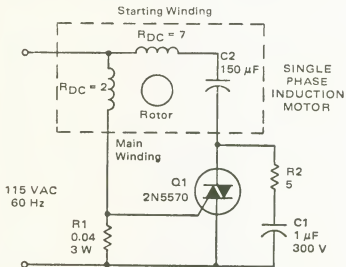
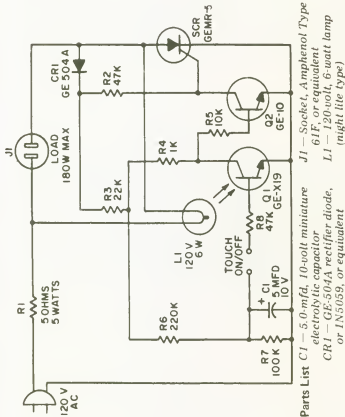


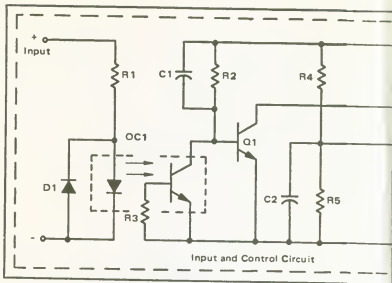
Fig. 41-14. Triac static motor-starting switch for 0.5 HP 115-volt AC single-phase induction (M).



Parts List C1 — 5.0-mfd, 10-volt miniature electrolytic capacitor
 CR1 — GE-504A rectifier diode, or IN5059, or equivalent
 J1 — Socket, Amphenol Type 61F, or equivalent
 L1 — 120-volt, 6-watt lamp (night lite type)

Q1 — GE-X19 photo transistor
 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

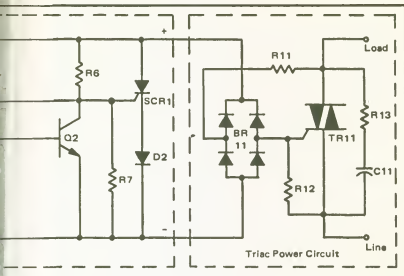
Fig. 41-15. Touch switch for loads up to 180 watts. This circuit is good for turning on and off lights, TVs, stereos, etc. Q1 is a phototransistor (GE).



Triac Power Circuit Parts List

Voltage	120 Vrms				240 Vrms			
	8.0	12	25	40	8.0	12	25	40
RMS Current: Amperes	0.0	12	25	40	0.0	12	25	40
BR11	MDA102	MDA102	MDA102	MDA102	MDA104	MDA104	MDA104	MDA104
C11 μ F (10% rms voltage ac rated)	0.047	0.047	0.1	0.1	0.047	0.047	0.1	0.1
R11 110% 1 W	39	39	39	39	39	39	39	39
R12 110% 1/2 W	18	18	18	18	18	18	18	18
R13 110% 1/2 W	620	620	330	330	620	620	330	330
TR11	Plastic	2N6342	2N6342A	-	2N6343	2N6343A	-	-
	Metal	MAC40789	2N6363	MAC4688	-	MAC4980	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

LINE VOLTAGE

Part	120 Vrms	240 Vrms
C1	220 pF, 20%, 200 Vdc	100 pF, 20%, 400 Vdc
C2	0.022 μ F, 20%, 50 Vdc	0.022 μ F, 20%, 50 Vdc
D1	1N4001	1N4001
D2	1N4001	1N4001
OC1	MOC1005	MOC1005
O1	MPS5172	MPS5172
O2	MPS5172	MPS5172
R1	1 k Ω , 10%, 1 W	1 k Ω , 10%, 1 W
R2	47 k Ω , 5%, 1/2 W	100 k Ω , 5%, 1 W
R3	1 M Ω , 10%, 1/4 W	1 M Ω , 10%, 1/4 W
R4	110 k Ω , 5%, 1/2 W	220 k Ω , 5%, 1/2 W
R5	15 k Ω , 5%, 1/4 W	15 k Ω , 5%, 1/4 W
R6	33 k Ω , 10%, 1/2 W	68 k Ω , 10%, 1 W
R7	10 k Ω , 10%, 1/4 W	10 k Ω , 10%, 1/4 W
SCR1	2N5064	2N6240

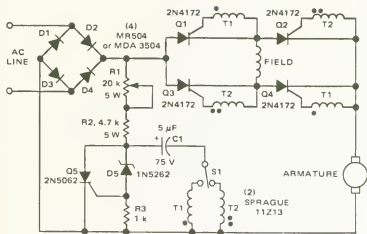


Fig. 41-17. Direction and speed control for series-wound motors (M).

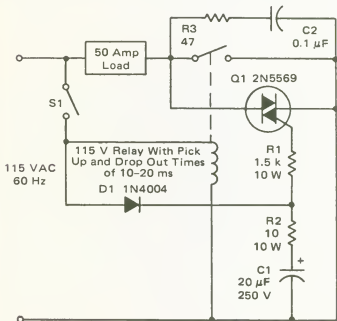


Fig. 41-18. Triac relay-contact protection circuit (M).

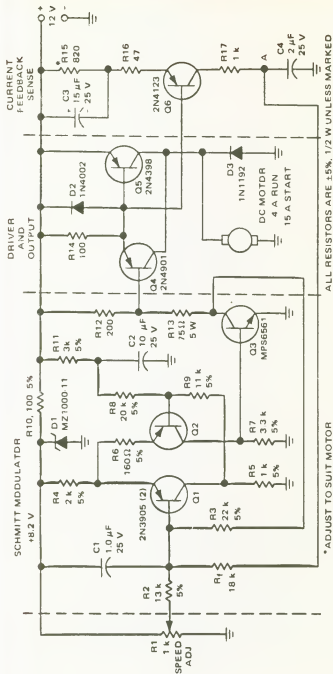


Fig. 41-19. Pulse-width-modulated DC motor speed control incorporating voltage-sensing feedback .

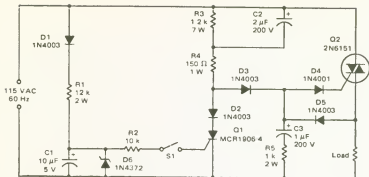
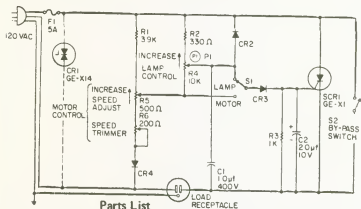


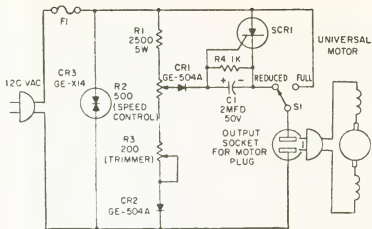
Fig. 41-20. Triac zero-point switch for resistive loads (M).



Parts List

- | | |
|---|--|
| <i>C1</i> — 1-mfd, 400-volt capacitor | <i>R5</i> — 500-ohm, 2-watt potentiometer |
| <i>C2</i> — 2-mfd, 10-volt capacitor | <i>R6</i> — 200-ohm, 2-watt potentiometer |
| <i>CR1</i> — GE-X14 thyrector diode (optional transient voltage suppressor) | <i>S1</i> — SPDT toggle switch |
| <i>CR2</i> thru <i>CR4</i> — GE-504A rectifier diode | <i>S2</i> — SPST switch (on speed and lamp adjust potentiometers) |
| <i>F1</i> — 5-amp fuse and holder | <i>SCR1</i> — GE-X1 silicon controlled rectifier mounted on 3" x 3" x 1/16" copper cooling fin |
| <i>R1</i> — 3900-ohm, 2-watt resistor | <i>Minibox</i> — 6" x 5" x 4" |
| <i>R2</i> — 330-ohm, 1-watt resistor | |
| <i>R3</i> — 1000-ohm, 1-watt resistor | |
| <i>R4</i> — 10K-ohms, 2-watt potentiometer | |

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).

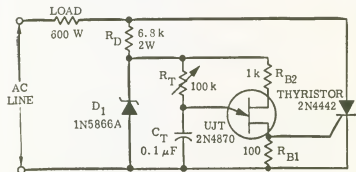


Fig. 41-23. Thyristor half-wave control circuit with UJT trigger designed for a 600-ohm load (M).

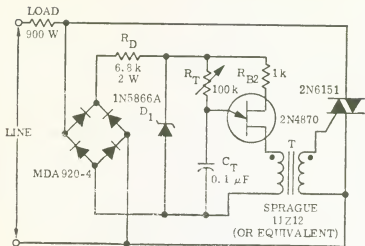
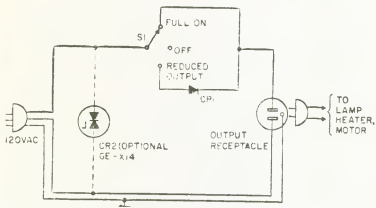


Fig. 41-24. Triac full-wave control circuit with UJT trigger designed for a 900-watt load (M).



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

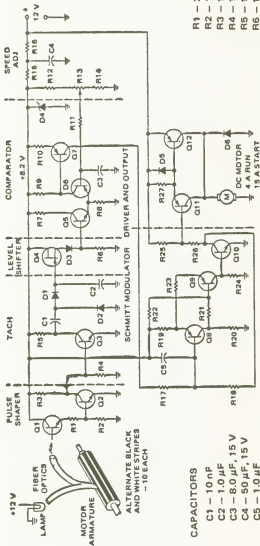
Fig. 41-25. High-low AC switch for light dimming or small motor two-speed control (GE).

TRANSISTORS

Q1 - MFD300
 Q2 - 2N4123
 Q3 - 2N4123
 Q4 - 2N4221
 Q5 - 2N3903
 Q6 - 2N3903
 Q7 - 2N4125
 Q8 - 2N3905
 Q9 - 2N3905
 Q10 - MPS6561
 Q11 - 2N4901
 Q12 - 2N4398

RESISTORS

R1 - 27 k Ω
 R2 - 10 k Ω
 R3 - 10 k Ω
 R4 - 10 k Ω
 R5 - 10 k Ω
 R6 - 10 k Ω
 R7 - 10 k Ω
 R8 - 2.0 k Ω
 R9 - 10 k Ω
 R10 - 47 k Ω
 R11 - 10 k Ω
 R12 - 1.0 k Ω
 R13 - 1.0 k Ω
 R14 - 470 k Ω
 R15 - 47 k Ω
 R16 - 47 k Ω
 R17 - 10 k Ω
 R18 - 22 k Ω
 R19 - 2.0 k Ω
 R20 - 1.0 k Ω
 R21 - 11 k Ω
 R22 - 10 k Ω
 R23 - 160 k Ω
 R24 - 3.3 k Ω
 R25 - 200 Ω
 R26 - 75 Ω
 R27 - 100 k Ω



CAPACITORS

C1 - 10 nF
 C2 - 1.0 μ F
 C3 - 8.0 μ F, 15 V
 C4 - 50 μ F, 15 V
 C5 - 1.0 μ F

DIODES

D1 - 1N4001
 D2 - 1N4001
 D3 - 1N4001
 D4 - 1N4738
 D5 - 1N4001

Fig. 41-26. Regulated DC motor control with feedback from optical sensor (M).

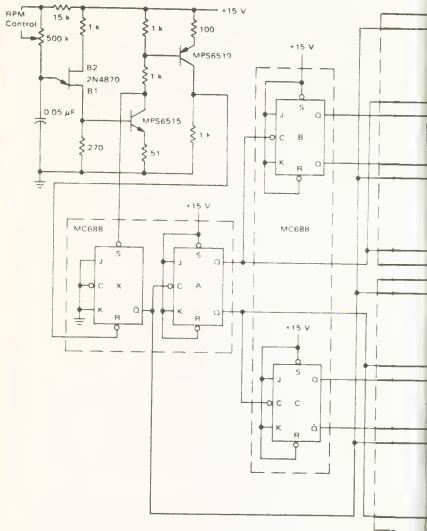
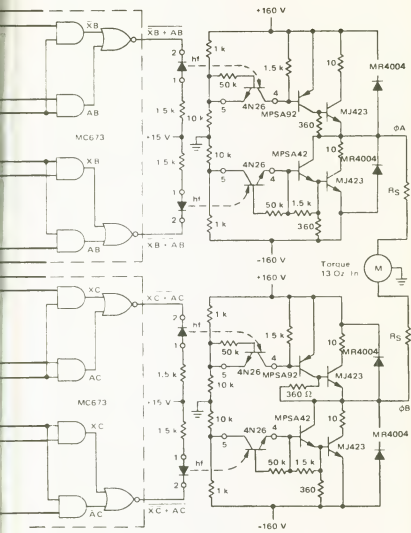


Fig. 41-27. Variable speed control for induction motors (M).



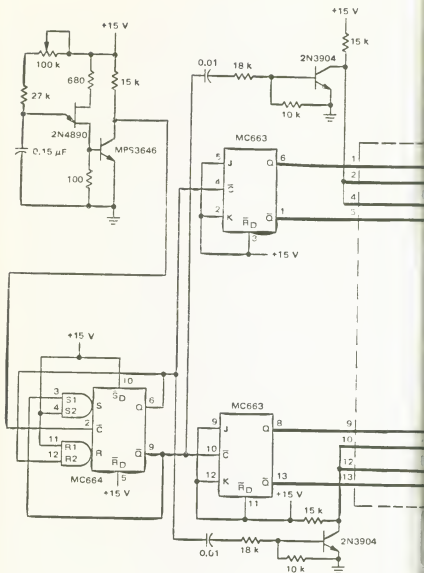
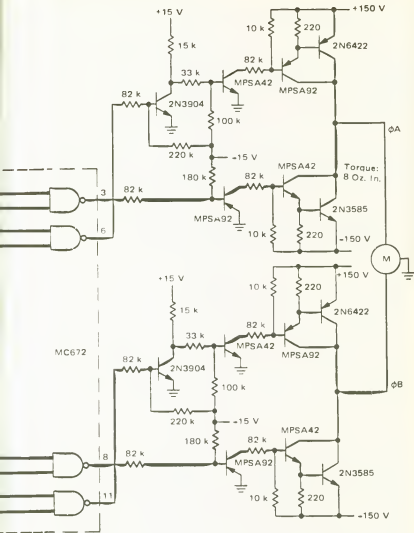
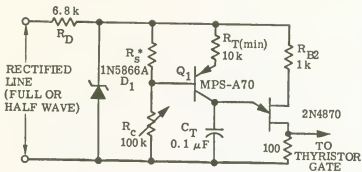


Fig. 41-28. Variable speed control for induction motors (M).



MHTL Logic: Pin 14 VCC
Pin 7 Gnd



* R_S SHOULD BE SELECTED TO BE ABOUT 3k TO 5k OHMS AT THE DESIRED OUTPUT LEVEL

Fig. 41-29. Feedback control circuit to trigger a thyristor (M).

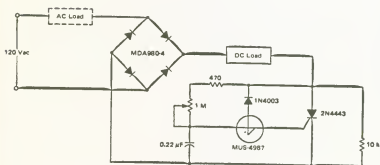


Fig. 41-30. SCR full-range power controller incorporating an SUS (M).

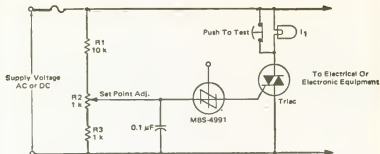
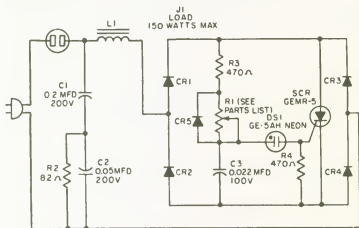


Fig. 41-31. Electronic crowbar circuit using an SBS and a triac. This circuit protects equipment by placing a short-circuit across the line, thereby blowing the fuse. It works on DC circuits as well as AC types since the SBS and triac are both bilateral (M).



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,³ 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).

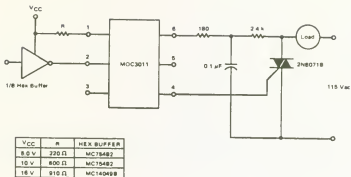


Fig. 41-33. MOS to AC load interface using an MOC3011 optically coupled triac driver (M).

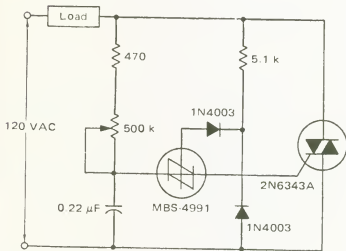


Fig. 41-34. Hysteresis-free power controller using an SBS and a triac (M).

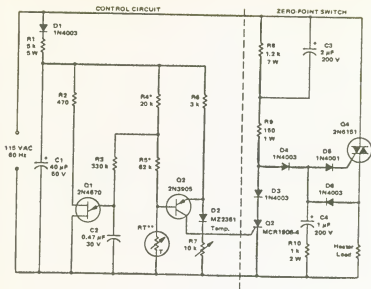


Fig. 41-37. Triac heater temperature control circuit (M).

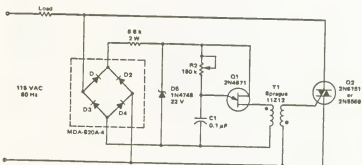


Fig. 41-38. An 800-watt triac light dimmer (M).

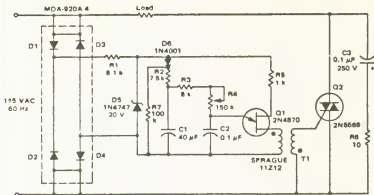


Fig. 41-39. An 800-watt soft-start triac light dimmer (M).

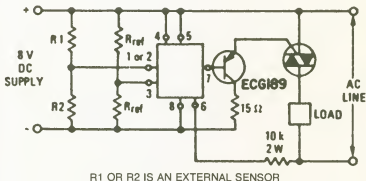


Fig. 41-40. Triac control circuit with current boost using an ECG776 zero voltage switch. Resistor R2 must be the external sensor for the internal short and open protection to be operative. Notice that the circuit utilizes a DC supply. Select the triac for the particular application from the ECG5600 series (GTE).

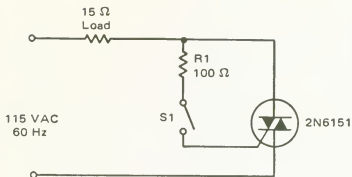


Fig. 41-41. Triac AC static contactor (M).

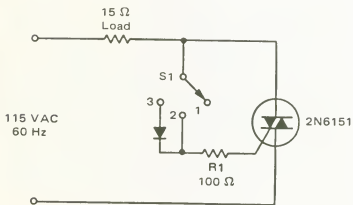


Fig. 41-42. Three-position static switch. In position 1 the switch is off; in position 2 the switch supplies full-wave power to the load; in position 3 the diode conducts only on half-cycles and the load is supplied with half-wave power (M).

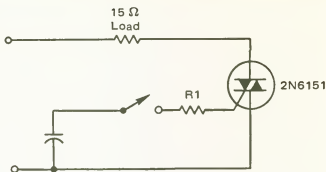


Fig. 41-43. AC-controlled, triac switch. R1 is 100 ohms (M).

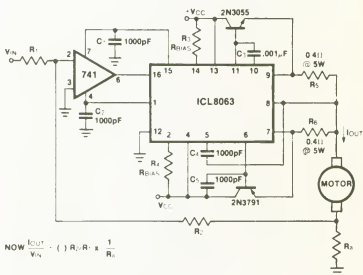
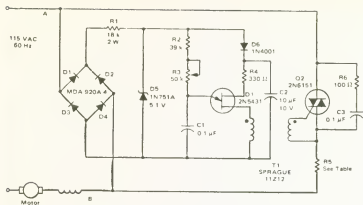


Fig. 41-44. Constant-current motor drive. All capacitors should be at least 50 working volts and resistors the half-watt type, except those values at 0.4 ohm and R_a . Use heat sinks for the power transistors with thermal compound. This circuit can be used where there is some likelihood of stalling or 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		$R5 = \frac{2}{I_M}$ $I_M = \text{Max. Rated Motor Current (RMS)}$
	DHMS	Watts	
2	1	5	
3	0.67	10	
6.5	0.32	15	

Fig. 41-45. Triac motor speed control with feedback (M).

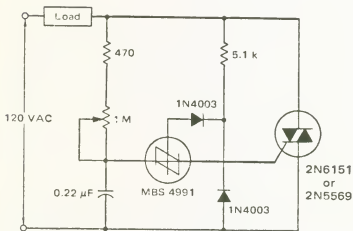


Fig. 41-46. 800-watt triac light dimmer with silicon bilateral switch, SBS (M).

Non-Conduct #22 Wire

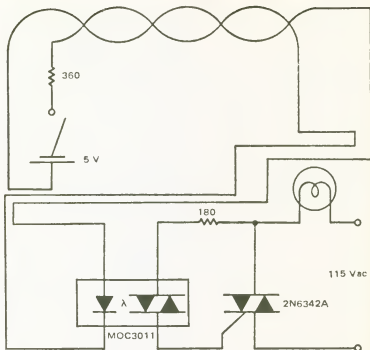


Fig. 41-47. Remote control of AC load using an MOC3011 optically coupled triac driver (M).

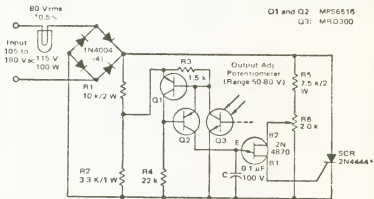


Fig. 41-48. Projection lamp voltage regulator using a phototransistor, SCR and UJT (M).

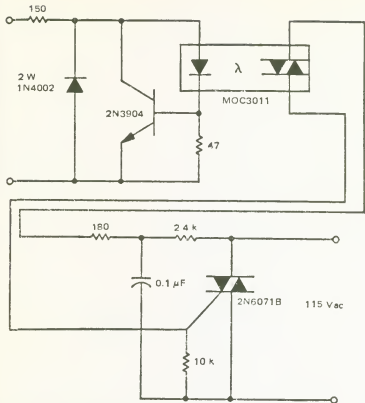


Fig. 41-49. Solid-state relay circuit with input protection of the MOC3011 triac driver. The input voltage to the protection circuit can be 3 to 30 volts DC (M).

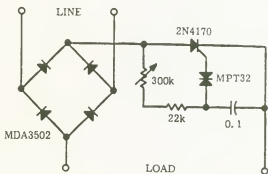


Fig. 41-50. Simple DC power control circuit using an SCR (M).

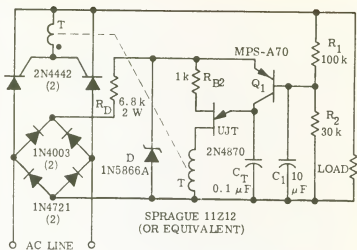


Fig. 41-51. Full-wave average voltage feedback control circuit for a 600-watt load (M).

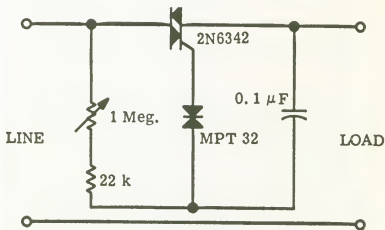


Fig. 41-52. Simple full-wave power control circuit using a triac (M).

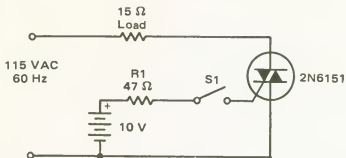
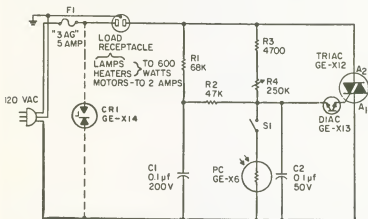


Fig. 41-53. Low-voltage-controlled triac switch (M).



NOTE:
MOUNT GE-X12 ON 3" X 3" X 1/16" COPPER OR ALUMINUM COOLING FIN

Parts List

- | | |
|--|--|
| <i>C1</i> — 0.1-mfd, 200-volt capacitor | <i>R1</i> — 68K-ohms, 1/2-watt resistor |
| <i>C2</i> — 0.1-mfd, 50-volt capacitor | <i>R2</i> — 47K-ohms, 1/2-watt resistor |
| <i>CR1</i> — GE-X14 thyrector diode
(optional transient voltage suppressor) | <i>R3</i> — 4700-ohm, 1/2-watt resistor |
| <i>PC</i> — GE-X6 cadmium sulfide photoconductor | <i>R4</i> — 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 0.1 μ F 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).

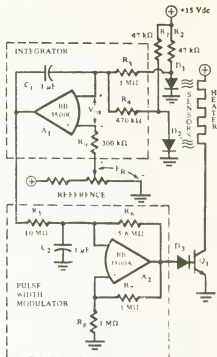


Fig. 41-55. Proportional controller for heater using two op amps. The integrating error amplifier holds the heater current pulse width at a sustaining value at equilibrium (BB).

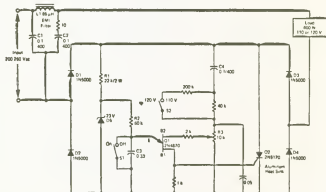


Fig. 41-56. RMS open-loop voltage compensator (regulator) for small conduction angles. This circuit provides an output of $110/115 \pm 2.5$ volts at 600 watts for an input of 200 to 260 volts. This circuit is suitable for applications requiring a conduction angle of less than 90° (M).

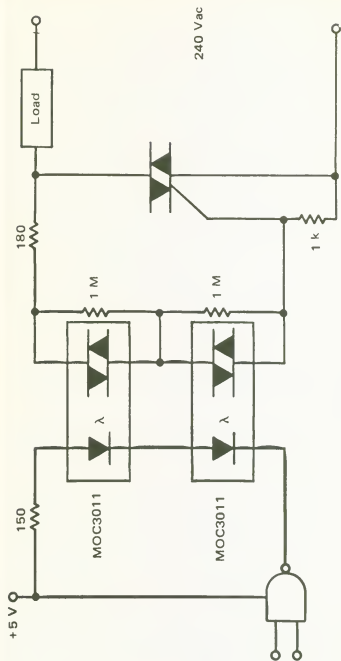


Fig. 41-57. 240-volt triac control circuit driven by two MOC3011 optically coupled triac drivers (M).

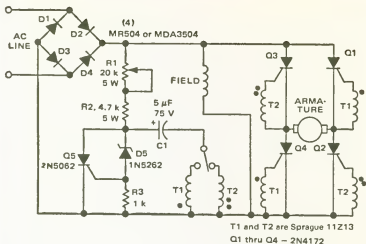


Fig. 41-58. Direction and speed control for shunt-wound motors (M).

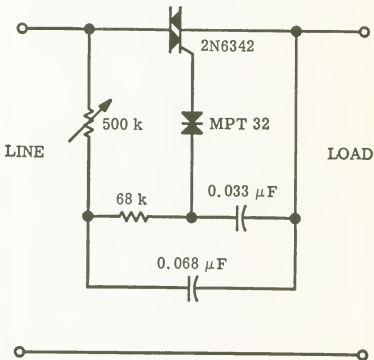


Fig. 41-59. Full range AC power control circuit using a triac (M).

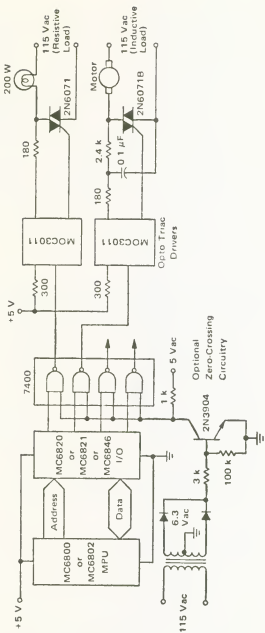


Fig. 41-60. M6800 microprocessor to 115-volt AC load interface using optically coupled MOC3011 triac drivers (M).

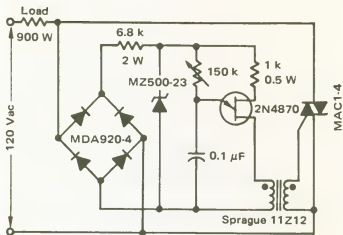


Fig. 41-61. Full-wave trigger circuit for a 900-watt load using a triac and UJT (M).

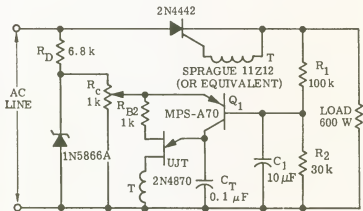
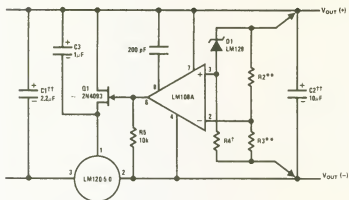


Fig. 41-62. Half-wave average voltage control circuit for a 600-watt load (M).

Chapter 42
Power Supplies,
Regulators and Voltage Multipliers



Load and line regulation - 0.01% temperature stability < 0.2%

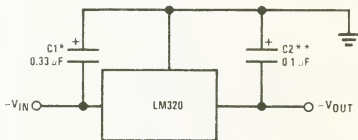
† Determines Zener current

†† 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 1_z and -16V for the LM120 15.

** Select resistors to set output voltage. 2 ppm/°C tracking suggested.

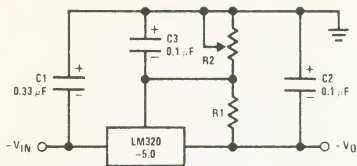
Fig. 42-1 High-stability 1A regulator (NS).



* Required if the regulator is located far from the power supply filter. A 1 μ F aluminum electrolytic may be substituted.

** Required for stability. A 1 μ F aluminum electrolytic may be substituted.

Fig. 42-2. Fixed output regulator (NS).



$$-V_O = -5V - (5V/R1 + I_Q) \cdot R2,$$

$$5V/R1 > 3 I_Q$$

Fig. 42-3. Adjustable output regulator (NS).

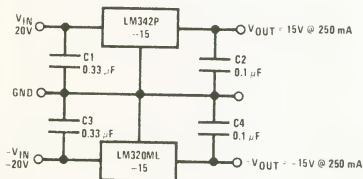
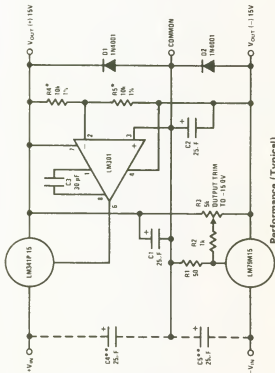


Fig. 42-4. A $\pm 15V$ 250 mA dual power supply (NS).



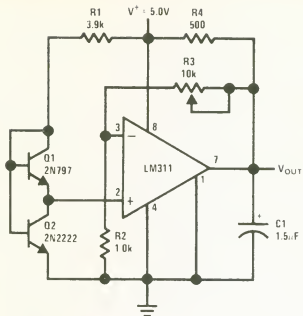
Performance (Typical)

	(-15)	(+15)
Load Regulation at 0.5A	40 mV	2 mV
Output Ripple, $C_{IN} = 3000\mu F$, $I_L = 0.5A$	100 μ Vrms	100 μ Vrms
Temperature Stability	50 mV	50 mV
Output Noise $10\text{ Hz} \leq f \leq 10\text{ kHz}$	150 μ Vrms	150 μ Vrms

Load Regulation at 0.5A
 Output Ripple, $C_{IN} = 3000\mu F$, $I_L = 0.5A$
 Temperature Stability
 Output Noise $10\text{ Hz} \leq f \leq 10\text{ kHz}$

Fig. 42-5. A $\pm 15V$, 1A tracking regulator (NS).

*Resistor tolerance of R4 and R5 determine matching of (+) and (-) outputs
 **Necessary only if raw supply filter capacitors are more than 3" from regulators



*Solid tantalum

Fig. 42-6. Low-voltage adjustable reference supply (NS).

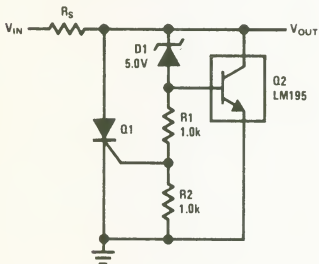


Fig. 42-7. A 6V shunt regulator with crowbar (NS).

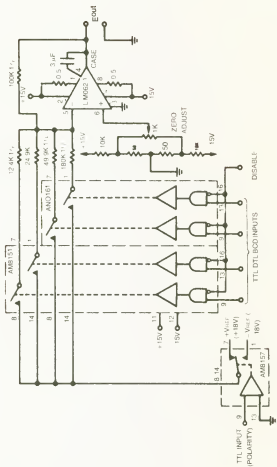


Fig. 42-8. Programmable 1A power supply (NS).

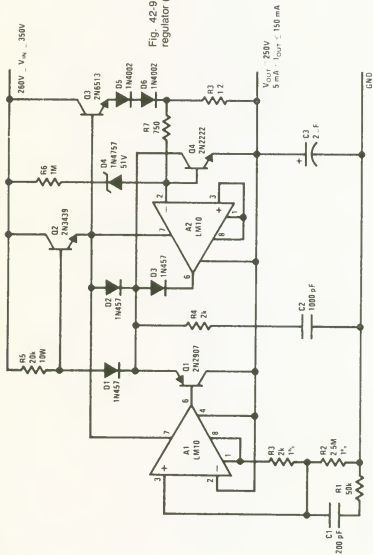
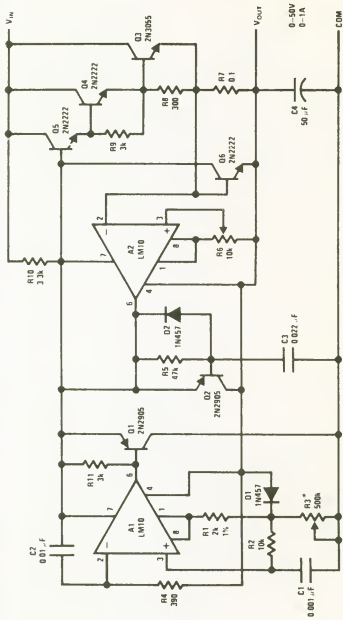


Fig. 42-9. Protected high-voltage regulator (NS).



* $V_{out} = 10^{-4} R_3$

Fig. 42-10. Laboratory power supply (NS).

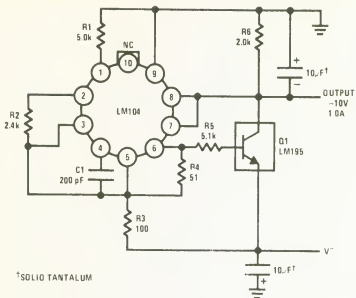


Fig. 42-11. A 1A negative regulator (NS).

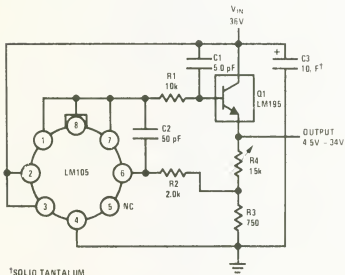
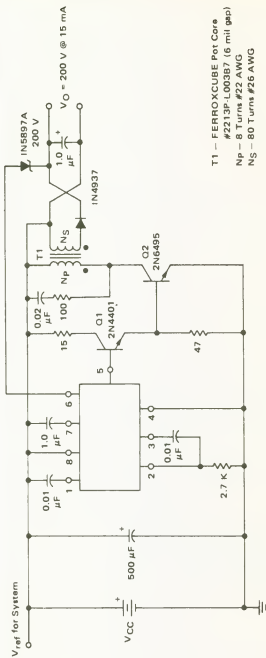
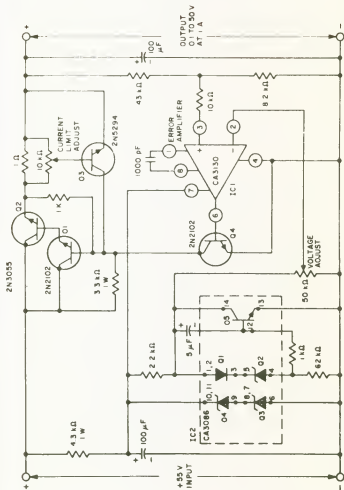


Fig. 42-12. A 1A positive voltage regulator (NS).



T1 — FERROXCUBE Pot Core
 #2213P-L003B7 (6 mil gap)
 Np — 8 Turns #22 AWG
 Ns — 80 Turns #26 AWG

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 MC3380P (M).



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).

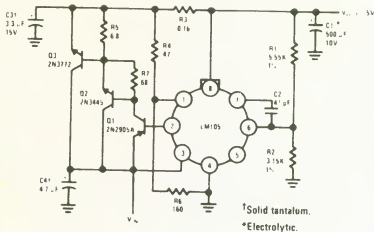


Fig. 42-17. A 10A regulator with foldback current limiting (NS).

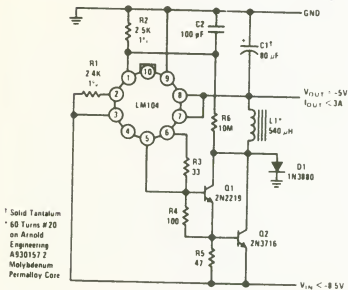


Fig. 42-18. Switching regulator (NS).

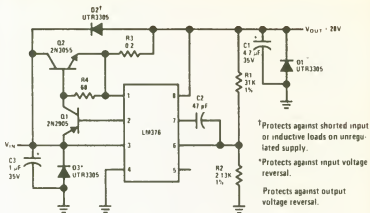
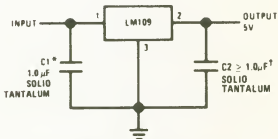


Fig. 42-19. A 1A regulator with protective diodes (NS).



* 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).

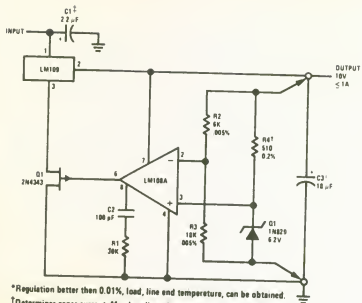
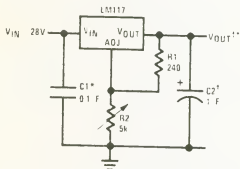


Fig. 42-21. High-stability regulator (NS).



†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).

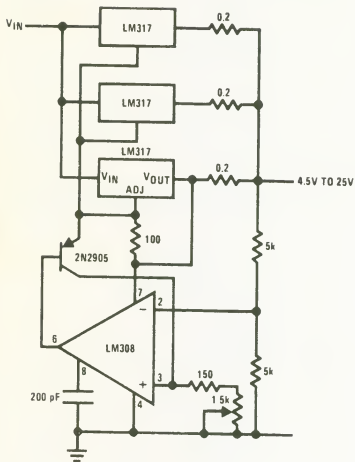
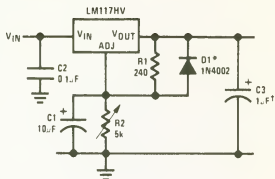


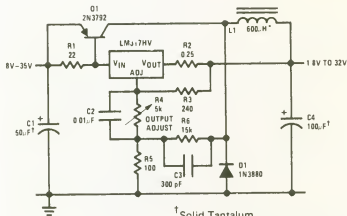
Fig. 42-25. Adjustable 4A regulator (NS).



†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).

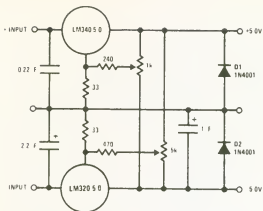


Fig. 42-28. Dual trimmed supply (NS).

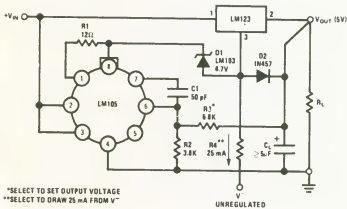


Fig. 42-29. A 5V to 10V power supply with 0.1 percent regulation (NS).

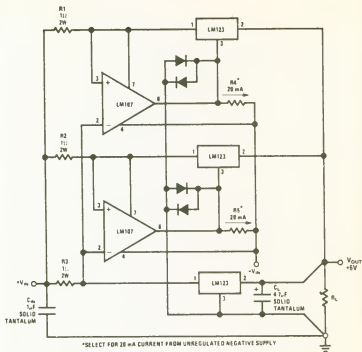
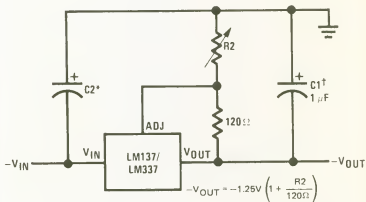


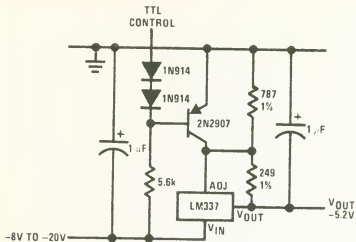
Fig. 42-30. A 10A regulator with complete overload protection (NS).



†C1 = 1 µF solid tantalum or 10 µF aluminum electrolytic required for stability

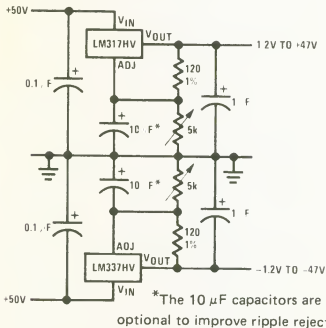
*C2 = 1 µF solid tantalum is required only if regulator is more than 4" from power-supply filter capacitor

Fig. 42-31. Adjustable Negative Voltage Regulator (NS.)



* Minimum output $\cong -1.3\text{V}$ when control input is low

Fig. 42-32. -5V Regulator with Electronic Shutdown * (NS).



* The $10\ \mu\text{F}$ capacitors are optional to improve ripple rejection

Fig. 42-33. Adjustable High Voltage Regulator (NS).

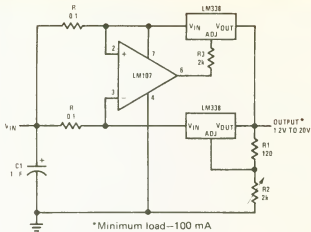
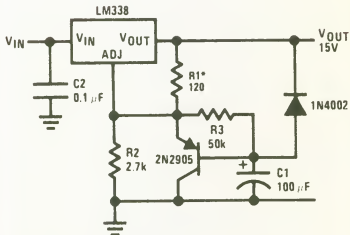


Fig. 42-34. 10 Regulator (NS).



* $R_1 = 240\Omega$ for LM138 and LM238

Fig. 42-35. Slow turn-on 15V regulator (NS).

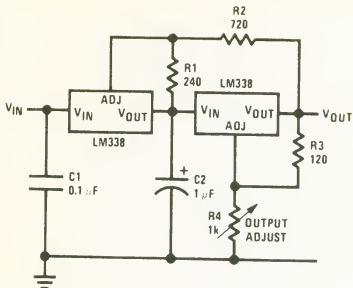
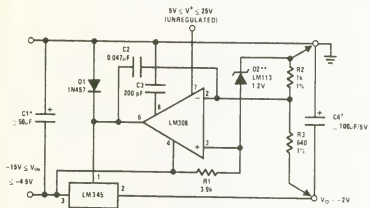


Fig. 42-36. Tracking Preregulator (NS).

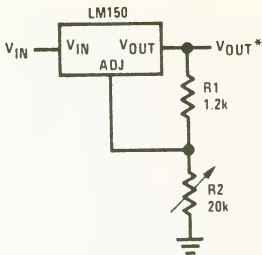


**C1 is not needed if power supply filter capacitor is within 3" of regulator

† 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).

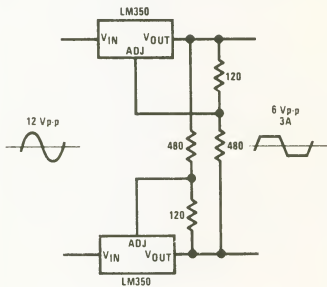


Fig. 42-39. AC voltage regulator.

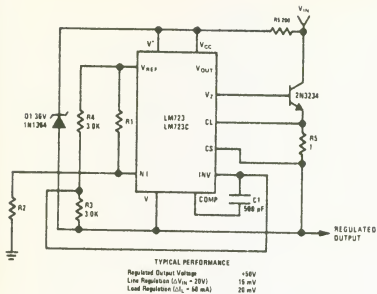


Fig. 42-40. Positive Floating Regulator (NS).

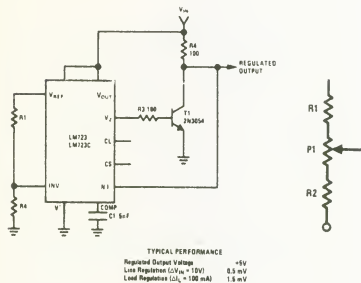


Fig. 42-41. Shunt Regulator (NS).

DESIGN EQUATIONS

$$R_F = 5 \text{ k}\Omega \left(\frac{V_O}{2.5} + 1 \right)$$

CURRENT LIMIT
SENSE VOLT

$$R_{CL} = \frac{I_O(\text{MAX})}{I_O(\text{MAX})}$$

$$f_{OSC} = \frac{1}{RT CT}$$

$$L1 = \frac{2.5V_O (VIN - V_O)}{I_O VIN f_{OSC}}$$

$$C_O = \frac{(VIN - V_O) V_O T^2}{8 \Delta V_O VIN L1}$$

$$I_O(\text{MAX}) = I_{IN} \frac{VIN}{V_O}$$

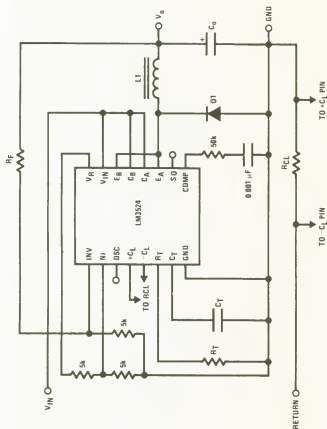


Fig. 42-42. Positive Regulator, Step-Down Basic Configuration ($I_{IN(\text{MAX})} = 80 \text{ mA}$) (NS).

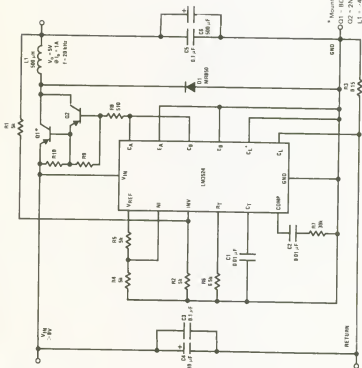
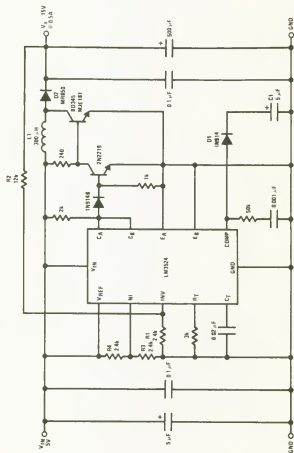


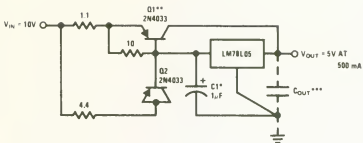
Fig. 42-53. 1 Amp Step-Down Switching Regulator (NS).

* Mounted to Silver HeatSink No. VS 1
 Q1 - 80C34, MJE171
 Q2 - 2N5023
 L1 - 40 turns No. 22 wire on Ferrocube No. K300502 Ferrrod core

Fig. 42-44. 15V, 0.5A Step-Up Switching Regulator (NS).



$L_1 \rightarrow > 25$ turns No. 24 wire on Ferracube No. K300502 Torroid core



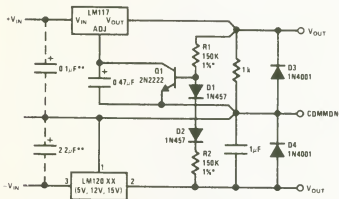
*Solid tantalum.

**Heat sink Q1.

***Optional. Improves ripple rejection and transient response.

Load Regulation: $0.6\% \leq I_L \leq 250 \text{ mA}$ pulsed with $t_{ON} = 50 \text{ ms}$.

Fig. 42-45. 5V, 500 mA Regulator with Short Circuit Protection (NS).

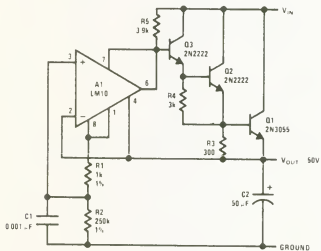
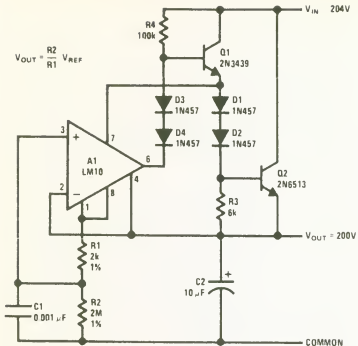


*Resistor tolerance of R1 and R2 determines matching of (+) and (-) inputs.

**Necessary only if raw supply capacitors are more than 3" from regulators

An LM3086N array may substitute for Q1. D1 and D2 for better stability and tracking. In the array diodes, transistors D5 and D4 (in parallel) make up D2, similarly, Q1 and Q2 become Q1 and Q3 replaces the 2N2222.

Fig. 42-46. Wide Range Tracking Regulator (NS).



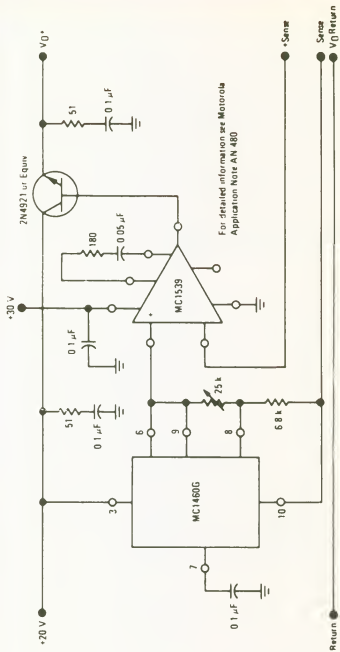


Fig. 42-50. — + 15 volt regulator (M).

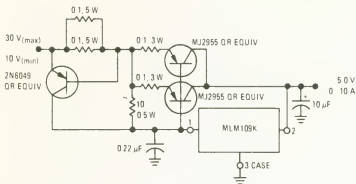
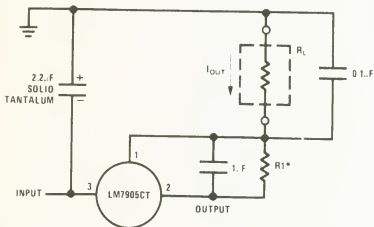


Fig. 42-51. -5.0 Volt, 10-ampere regulator with short-circuit current limiting for safe-area protection of pass transistors (M).



$$*I_{OUT} = 1 \text{ mA} + \frac{5V}{R1}$$

Fig. 42-52. Current source (NS).

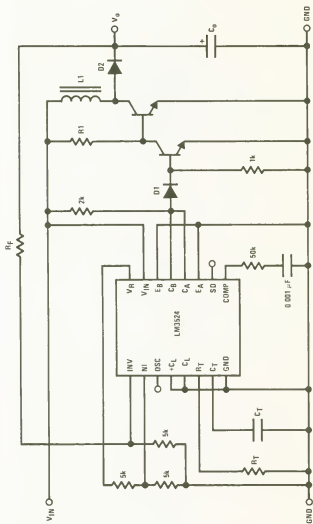
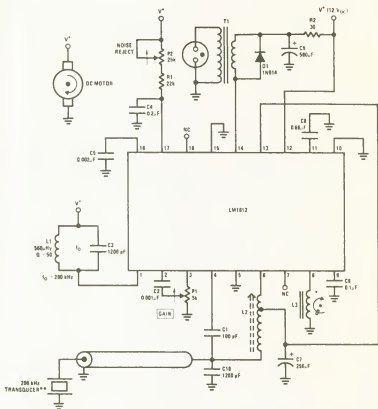


Fig. 42-53. Positive regulator, step-up boosted current configuration (NS).

Chapter 43

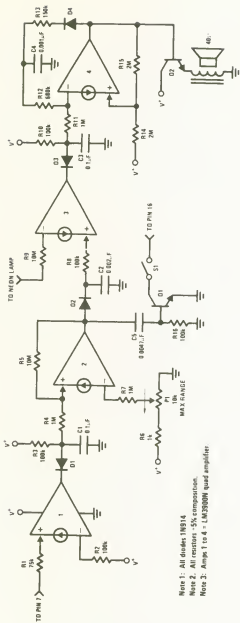
Radar and Sonar



*Note: A permanent magnet attached to a rotating wheel provides modulation pulses to pin 8. The time duration for the X-ray 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).



- Note 1: All diodes 1N514
- Note 2: All resistors ±5% composition.
- Note 3: Amps 1 to 4 = LM3900N quad amplifier

Fig. 43-2. Electronics for adding an echo annunciator (NS).

Chapter 44
Radioteletype, Slow-Scan Television
and Specialized Communications

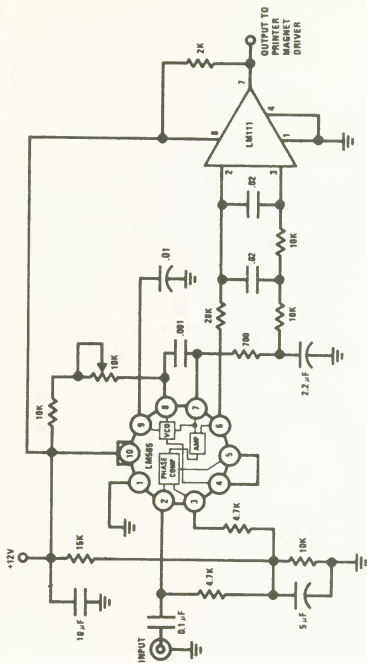


Fig. 44-1. FSK demodulator at 2025-2225 cps (NS).

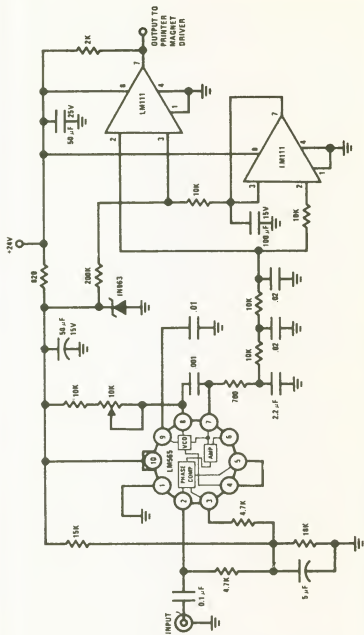


Fig. 44-2. FSK demodulator with DC restoration (NS).

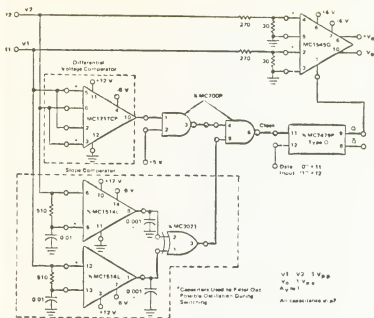


Fig. 44-3. FSK with slope and voltage detection (M).

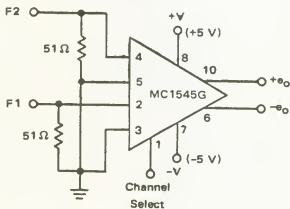


Fig. 44-4. Frequency shift keyer using the MC1545G wide-band amplifier (M).

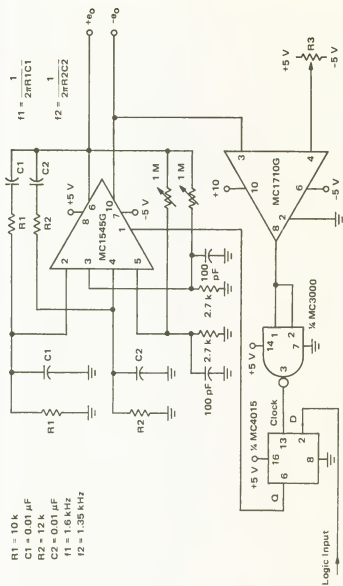
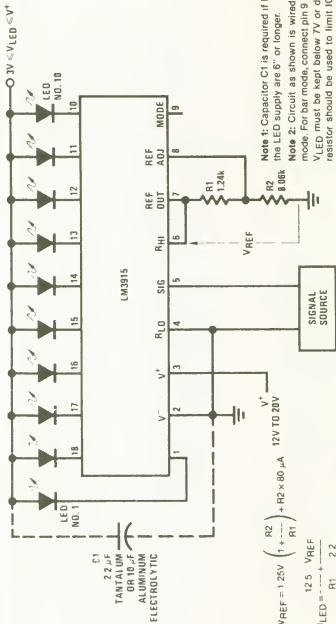


Fig. 44-5. Self-generating FSK (M).

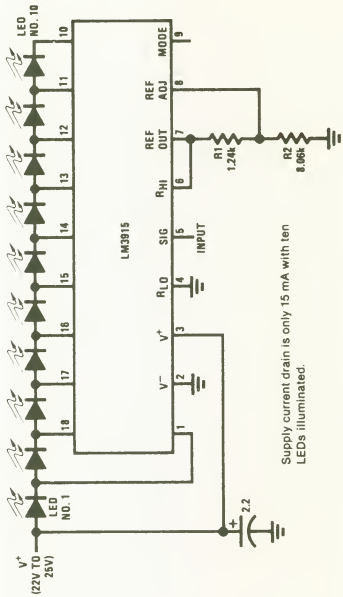
Chapter 45

Readouts



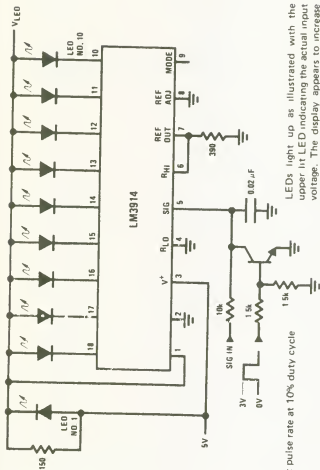
Note 1: Capacitor C1 is required if leads to the LED supply are 6" or longer.
 Note 2: Circuit as shown is wired for dot mode. For bar mode, connect pin 9 to pin 3. VLED must be kept below 7V or dropping resistor should be used to limit IC power dissipation.

Fig. 45-1. 0V to 10V log display (NS).



Supply current drain is only 15 mA with ten LEDs illuminated.

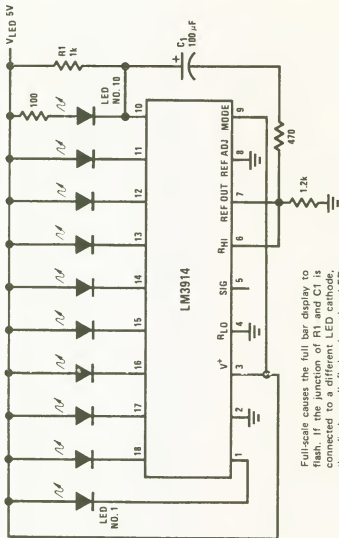
Fig. 45-3. Low current bar mode display.



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.

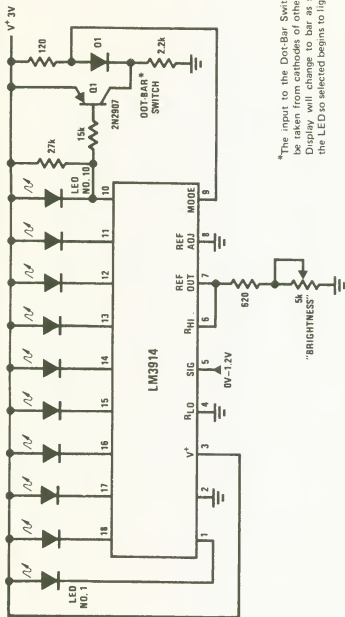
1 kHz pulse rate at 10% duty cycle

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).

LIQUID CRYSTAL BAR GRAPH

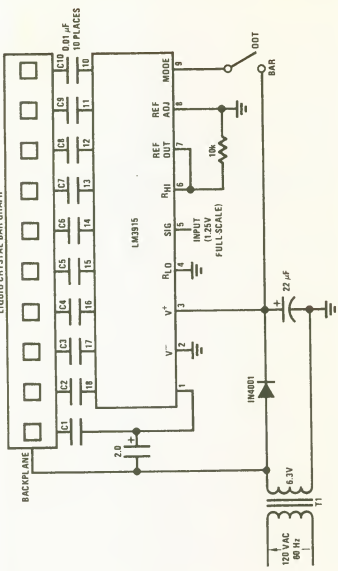


Fig. 45-7. Driving liquid crystal display (NS).

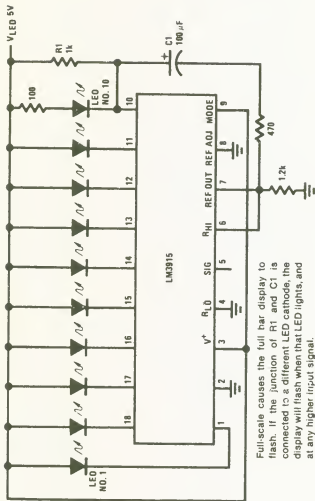
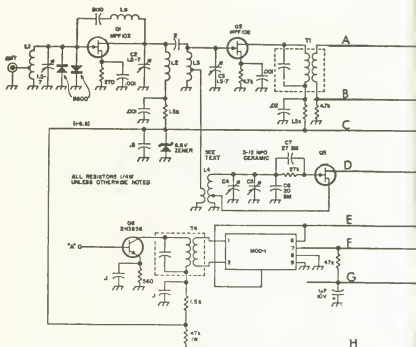


Fig. 45-8. Bar display with alarm flasher (NS).

Chapter 46

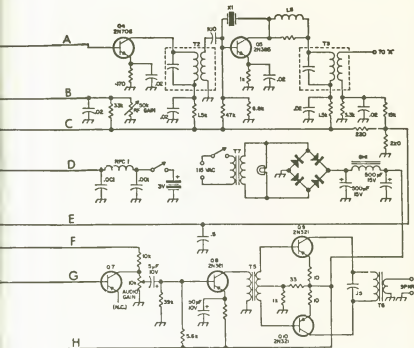
Receivers and RF Preamplifiers



- T1 10.7 mc. FM input IF transformer, J. W. Miller 2070
 T2 10.7 mc. FM interstage transformer, J. W. Miller 2071
 T3 455kHz input transformer, J. W. Miller CH1 2031
 T4 455kHz transformer, supplied with IF module
 T5 driver transformer, 10K to 2K c.t. Midland 250633, Calrad CR75

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 $\frac{7}{16}$ " ID $\frac{1}{2}$ " long
 5t. #20 bare copper $\frac{7}{16}$ " ID $\frac{3}{8}$ " long
 3t #BJ bare copper $\frac{7}{16}$ " ID $\frac{1}{2}$ " long tap
 1t. from ground end

L4 13/4t. #14 bare copper $\frac{7}{16}$ " ID tap $\frac{3}{4}$
 turn from ground end link 1t. #20 bare
 copper $\frac{1}{4}$ " away from ground end

L5 200 microhenry RF choke, J. W. Miller
 9210-90

Ln 8t. #26 enamel closewound at one end of
 $\frac{1}{4}$ " dia slug form

RFC-1 Ohmite Z-144 or 18 turns #24 wound on
 1 meg 1 watt resistor

X1 crystal, 11.155 mc.

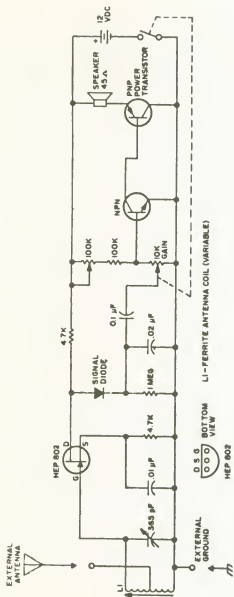


Fig. 46-2. Three transistor radio (AM). Adjust R4 so voltage across speaker is 1/2 supply voltage. Works surprisingly well.

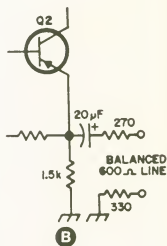
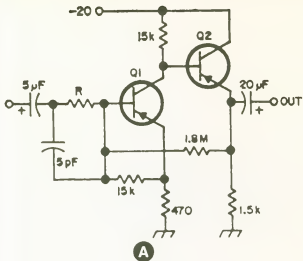


Fig. 46-3. High-impedance preamplifier provides up to 1.2 megohms input impedance; the exact value depends upon resistor R. Both Q1 and Q2 should be a 2N2613, 2N2614, 2N2953, SK3004, GE-2, or HEP 254. A balanced output for reduced hum and noise may be obtained by using the padded output in B.

Chapter 47

RF Power Amplifiers

- C1 = 33 pF Dipped Mica
- C2 = 15 pF Dipped Mica
- C3 = 10 μ F 35 Vdc for AM operation.
- C4 = 100 μ F 35 Vdc for SSB operation.
- C5 = 1 μ F Ene
- C6 = 10 μ F 35 Vdc Electrolytic
- C7 = 1 μ F Tantalum
- C8 = 001 μ F Ene Dnc
- C9 = 330 pF Dipped Mica
- R1 = 100 k Ω 1/4 W Resistor
- R2, 3 = 10 k Ω 1/4 W Resistor
- R4 = 33 Ω 5 W Wire Wound Resistor
- R5, 6 = 10 Ω 1/2 W Resistor
- R7 = 100 Ω 1/4 W Resistor
- RFC1 = 9 Ferrascube Beads on #18 AWG Wire
- D1 = 1N4001
- D2 = 1N4957
- D3 = 1N914
- Q1, Q2 = 2N4401
- Q3, 4 = MRF454
- T1, T2 = 16:1 Transformers
- C20 = 910 pF Dipped Mica
- C21 = 1100 pF Dipped Mica
- C22 = 24 pF Dipped Mica
- C23 = 500 μ F 3 Vdc Electrolytic
- K1 = Potter & Brumfield
KT11A 12 Vdc Relay or Equivalent

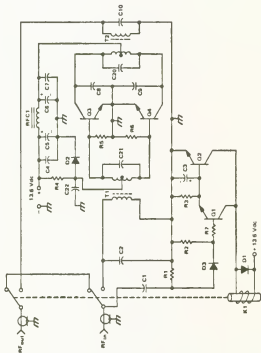


Fig. 47-1. HF power amplifier (M).

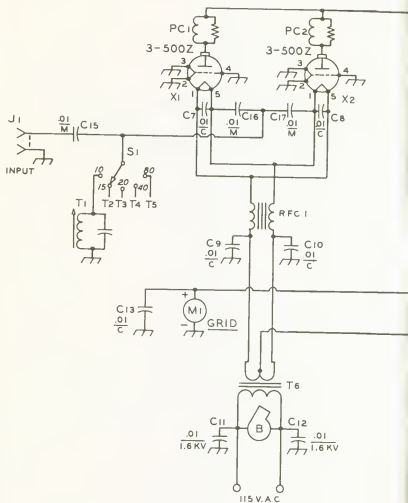
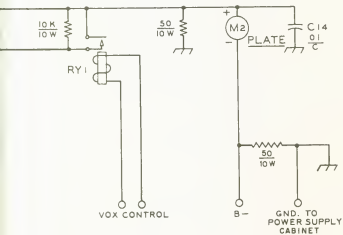
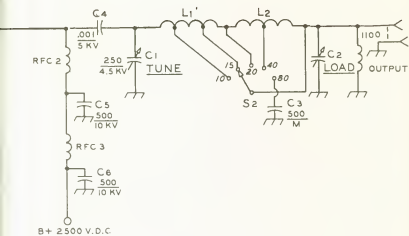


Fig. 47-2. Typical cathode-driven (grounded grid) amplifier for 80 through 10 meters (Eimac).



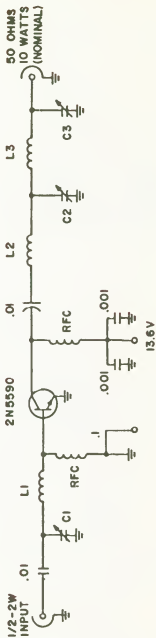


Fig. 47-4. Typical transistor rf power amplifier; L and C values depend on frequency of interest.

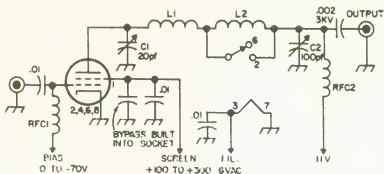


Fig. 47-5. 4CX250 amplifier for six and two meters, using single-pole switching. Simple modifications by K4ETZ [forget the 6 meter coil and use smaller HA tuning capacitors, class C bias and a grid tank] allow 10W drive, 200—250W out. Amplifier should have a screen clamp tube with G2 supply bled down from B+ for best results.

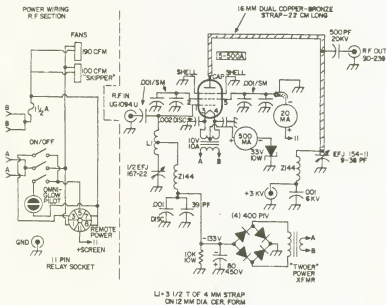
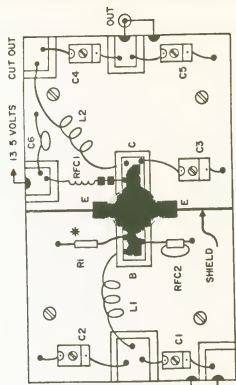
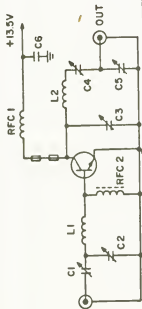


Fig. 47-6. Kilowatt linear amplifier (rf) for 50 MHz. Requires 2500 to 3000V dc for 5—500A plate.



PARTS LIST

- Q1 2N5591 or S3007
- C1, C2 7-60 pF (ARCO 462)
- C3, C4 4-40 pF (ARCO 403) 20-250 pF
- C5 (ARCO 424)
- C6 .02 μ F ceramic
- RFC1 10 T #18, $\frac{1}{2}$ " I.D., tightly wound, 2 ferrite beads
- L1, L2 4 T #14, $\frac{1}{4}$ " I.D. x 5/8" long
- *R1 20-100 Ω - use if unit is instable - start with 100 Ω and reduce when stability is achieved; goes from base to ground.
- RFC2 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.

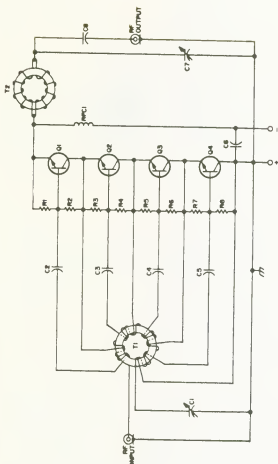


Fig. 47-8. A 40m. 200W amplifier. T1:2 Amodon 15/16 in. diameter toroids. Primary; 25T No. 22 Formvar. Four secondaries; 5T No. 22 Formvar each. T2: 2 Airwound windings, 18T each, No. 14 Formvar, 13/16 diam. These windings are paralleled and shaped into a donut 3½ in. diam. C1—450 pF broadcast variable C2 through 6—0.1 μ F, 100V. C7—450 pF wide spaced variable. C8—similar. R1, R3, R5—7 to 10 Ω , 2 to 5W wirewound. R2, R4, R6, R8—450 Ω , 1W. RFC—ferrite rod, 50T No. 22 Formvar.

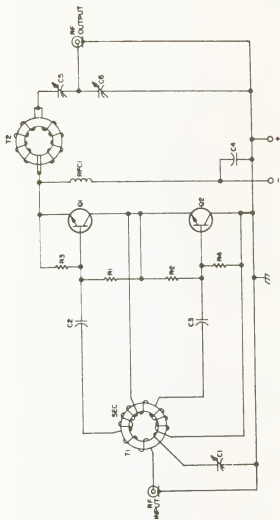


Fig. 47-9. 40m. 75W amplifier. T1-Amidon 15/16 in. toroid. Primary: 50T No. 24, 2 secondaries; 10T, No. 24, solid insulated wire each. T2: Same type core except 2 used; 2 windings No. 16 Formvar 5T each connected in parallel. RFC: $\frac{3}{8}$ dia. ferrite rod, 60T No. 22 Formvar. C1, C5: mica adjustable 200-800 pF. C2, C3: 1 μ F disc, 100V max. 25V min. C6: mica adjustable 400-1200 pF. R2, R3: 10, 2-5W. R1, R4: 450 Ω . Q1, Q2: TRW PT4526 or similar.

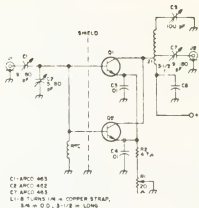


Fig. 47-11. A 50 MHz transmitter power amplifier. Rf choke is 7—10 μ H C6 is 1000 pF disc. Q1,Q2 are HEP 75s.

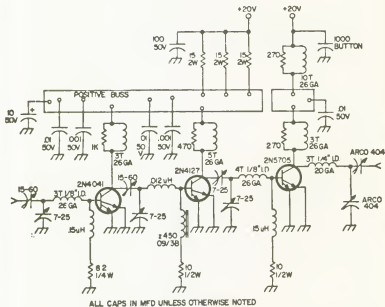
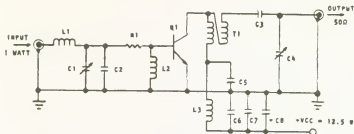


Fig. 47-12. A 2-meter amplifier that has 20 dB gain. 100 or 200 mW input will be amplified to 10 and 20 watts, respectively. Be sure to keep leads short and make all grounds directly to the circuit board. The positive bus is separated so the final can be used for AM. For FM, just connect the two terminals 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 μ F DISC
 C6 - .01 μ F DISC
 C7 - .1 μ F DISC

C8 - 10 μ F 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 - 1.0 Ω 5% 1/2W

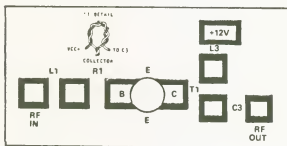


Fig. 47-13. A 150-MHz 10-watt rf power amplifier schematic, parts list, and board layout.

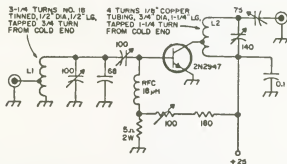


Fig. 47-14. This 10-meter single side band linear power amplifier will provide up to 8 watts PEP. The power gain of the 2N(947 is 13 dB at this frequency, and the odd order distortion products are at least 30 dB below the desired output.

Chapter 48

Sample & Hold Circuits

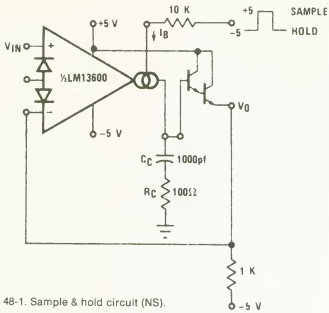


Fig. 48-1. Sample & hold circuit (NS).

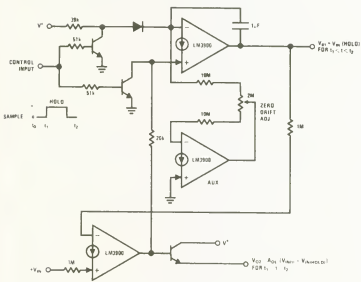


Fig. 48-2. Sample & hold and compare with new $+V_{IN}$ (NS).

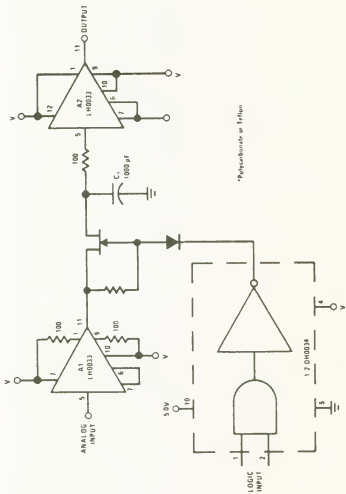


Fig. 48-3. High-speed sample & hold circuit (NS).

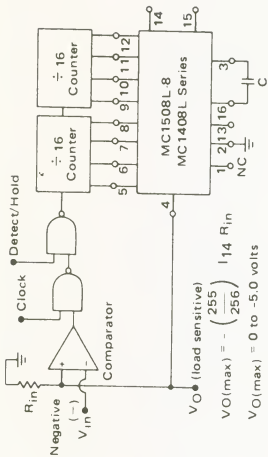


Fig. 48-4. Negative peak detecting sample & hold (M).

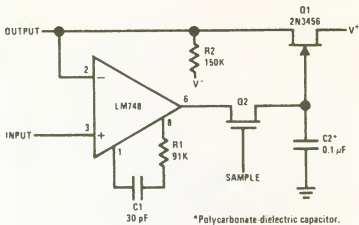


Fig. 48-5. Low-drift sample & hold (NS).

Chapter 49

Servo Motor Circuits

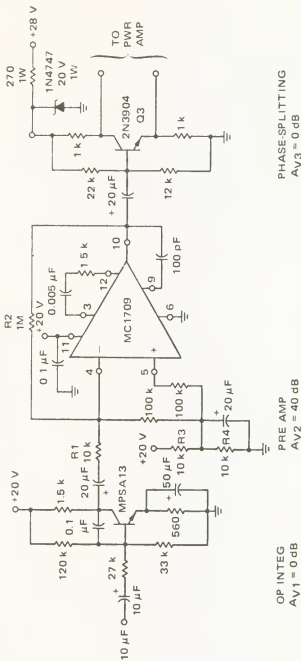


Fig. 49-2. Servo motor preamplifier (M).

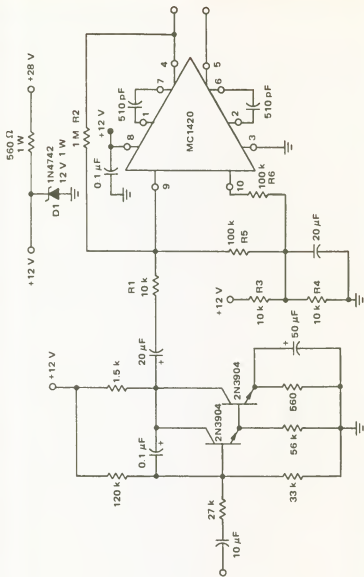


Fig. 49-3. Servo motor preamplifier (M).

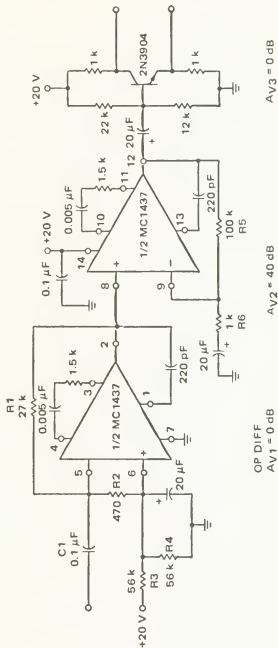


Fig. 49-4. Servo motor preamplifier (M).

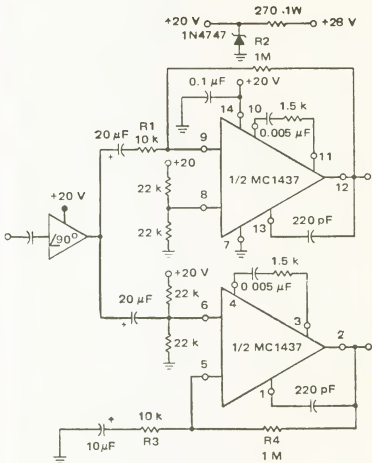


Fig. 49-5. Servo motor preamplifier (M).

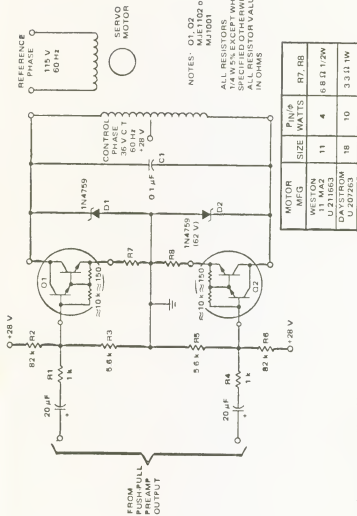


Fig. 49-6. Servo motor power amplifier (M).

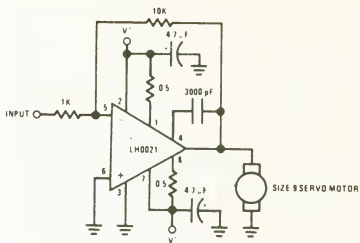


Fig. 49-7. DC servo amplifier (NS).

Chapter 50
Smoke and Flame Detectors

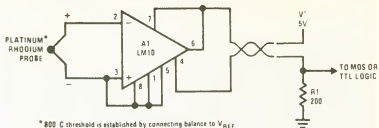
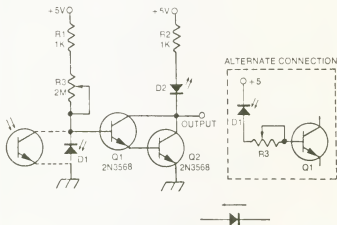
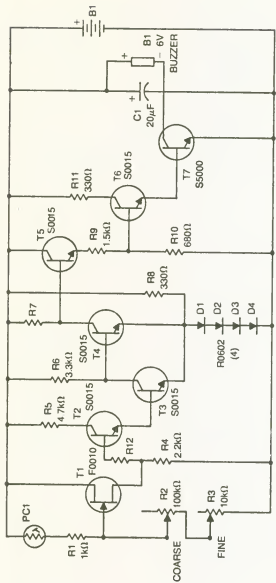


Fig. 50-1. Flame detector (NS).



- | | | |
|-------|---|---------------------------------|
| 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 |

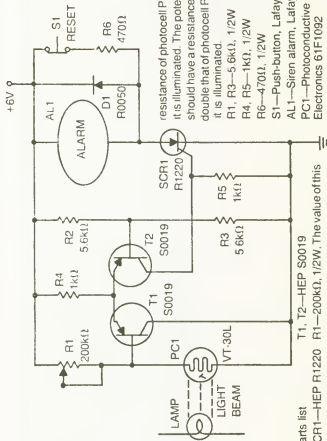
Fig. 50-2. This flame detector circuit uses an infrared sensitive detector diode. A transistor-type detector can be substituted for the diode.



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—20 μ F, 10V
- D1, D2, D3, D4—HEP R0602
- All resistors 1/2W unless otherwise stated
- R1—1k Ω
- R2—100k Ω pot
- R3—10k Ω pot
- R4—2.2k Ω
- R5—4.7k Ω
- R6—3.3k Ω
- R7, R9—1.5k Ω
- R8—330 Ω
- R10—680 Ω
- R11—330 Ω

Fig. 50-3. Fire alarm.



resistance of photo cell PC1 when it is illuminated. The potentiometer should have a resistance of roughly double that of photo cell PC1 when it is illuminated.

R1, R3—5.6k Ω , 1/2W

R4, R5—1k Ω , 1/2W

R6—470 Ω , 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 photo cell PC1 to be activated when no smoke is present.

Parts list

SCR1—HEP R1220 R1—200k Ω , 1/2W, The value of this

D—HEP R0050 potentiometer is dependent on the

T1, T2—HEP S0019

PC1—VT-30L

R2—5.6k Ω

R3—1k Ω

R4—1k Ω

R5—5.6k Ω

R6—470 Ω

S1—RESET

AL1—ALARM

Fig. 50-4. Smoke alarm.

Chapter 51

Solid-State Switches

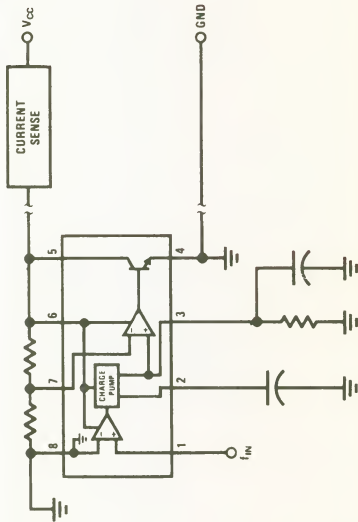


Fig. 51-1. Two-wire remote speed switch (NS).

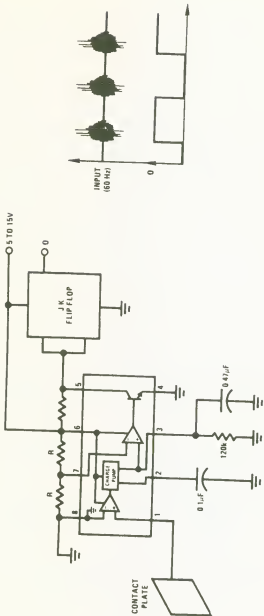
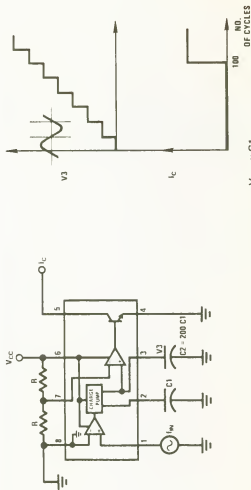


Fig. 51-2. Finger touch or contact switch (NS).



V_3 steps up in voltage by the amount $\frac{V_{CC} \times C_1}{C_2}$

for each complete input cycle (2 zero crossings)

Example:

If $C_2 = 200 C_1$ after 100 consecutive input cycles.

$V_3 = 1/2 V_{CC}$

Fig. 51-3. 100-cycle delay switch (NS).

Chapter 52

Telephone Circuits

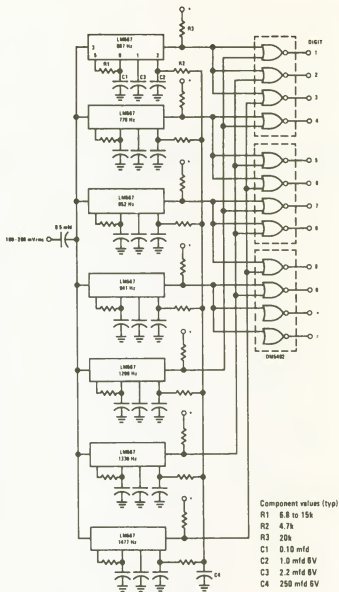


Fig. 52-1. Touch-tone decoder (NS).

Chapter 53

Test Equipment and Metering Circuits

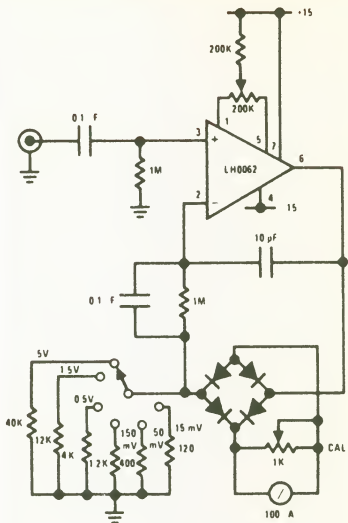


Fig. 53-4. Wide range AC voltmeter (NS).

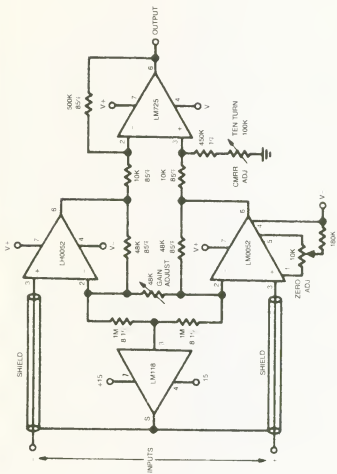


Fig. 53-5. Sensitive low-cost "VTVM" (NS).

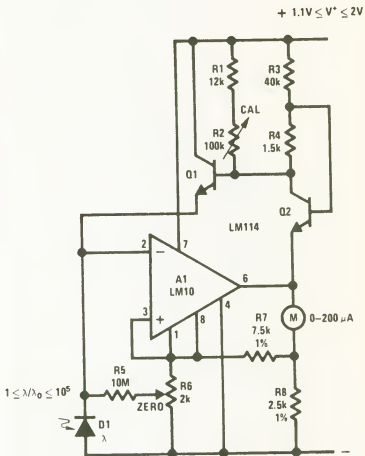
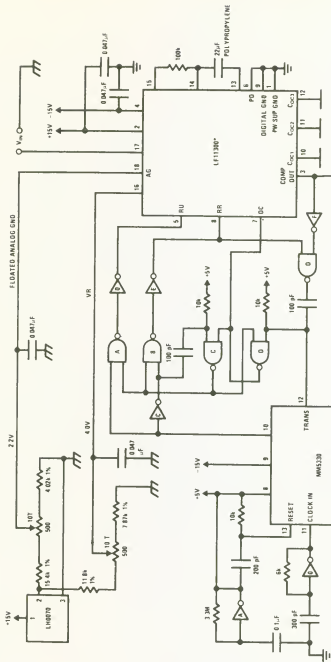


Fig. 53-6. Light meter (NS).



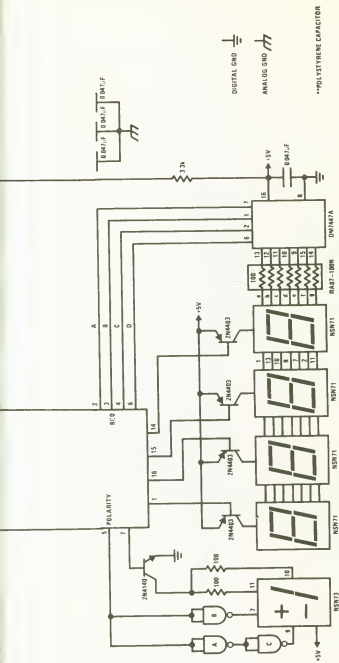


Fig. 53-7. LF11300, MM5330 DPM (NS).

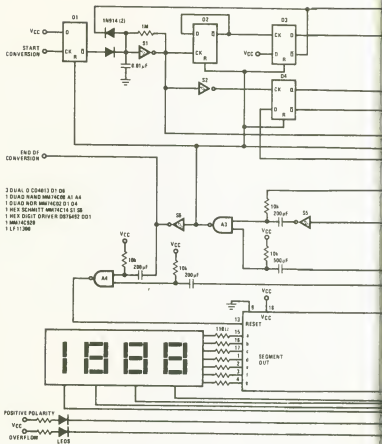


Fig. 53-9. 3½-digit voltmeter (NS).

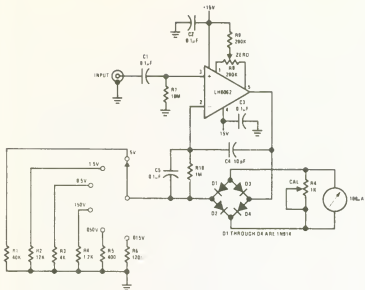


Fig. 53-10. Wide-band AC voltmeter (NS).

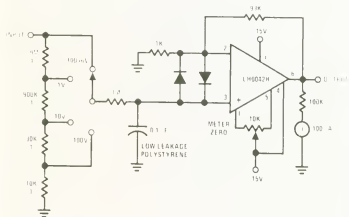
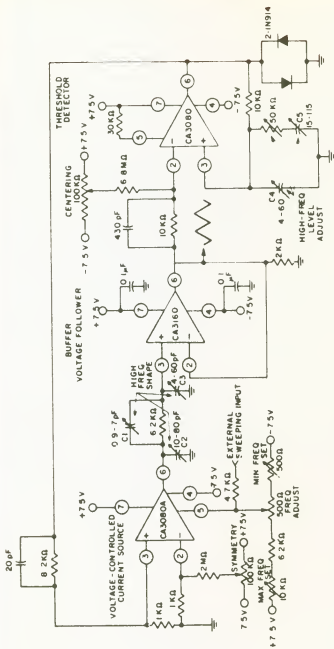


Fig. 53-11. Sensitive low-cost "VTVM" (NS)



92CM 2-8586R1

Fig. 53-12. 1,000,000:1 single-control function generator—1 MHz to 1 Hz (RCA).

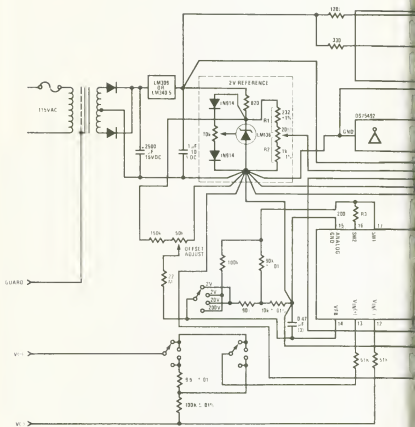
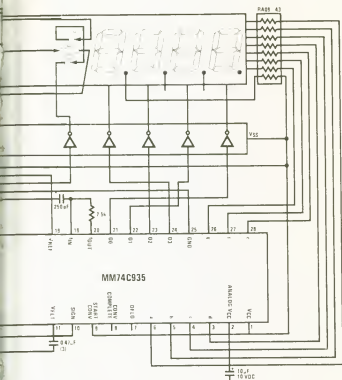


Fig. 53-13. 3 1/2-Digit DVM, four decade, $\pm 0.2V$, $\pm 2V$, $\pm 20V$ and $\pm 200V$ full scale (NS).



NOTES

- | | |
|--|--|
| <p>1 ALL RESISTORS 1/4WATT · 5% UNLESS OTHERWISE SPECIFIED</p> <p>2 ALL CAPACITORS 10%</p> <p>3 LOW LEAKAGE CAPACITOR REQUIRED</p> | <p>4 $\frac{R_1 R_2}{R_1 + R_2} = R_2 \cdot 25 \dots$</p> <p>5 OFFSET ADJUST REQUIRED FOR MM74C935-1 ONLY</p> |
|--|--|

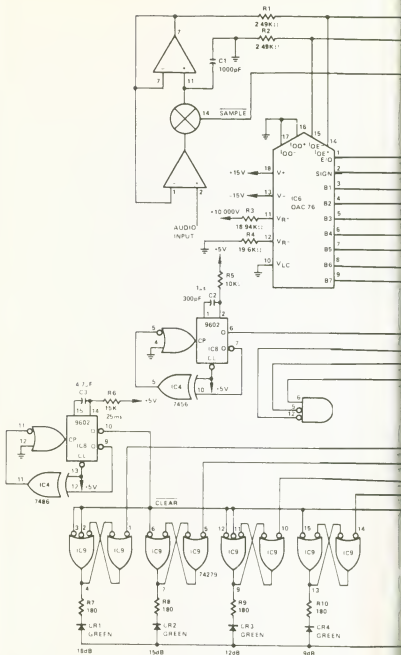
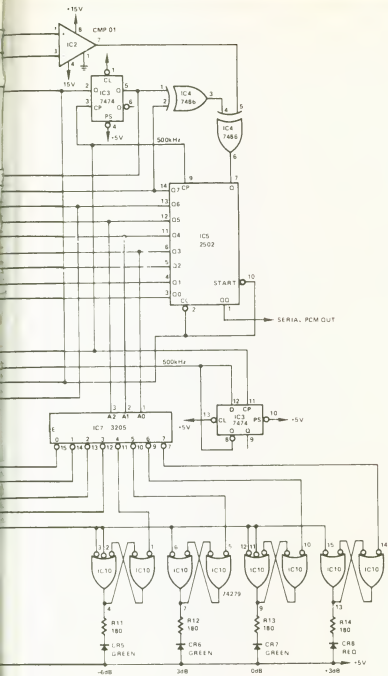


Fig. 53-15. Peak-reading VU indicator (PM).



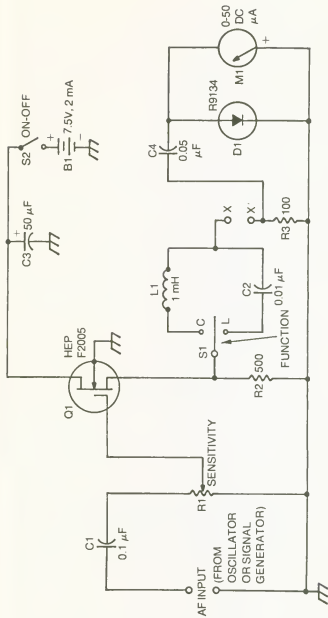


Fig. 53-16. Wide-range LC checker.

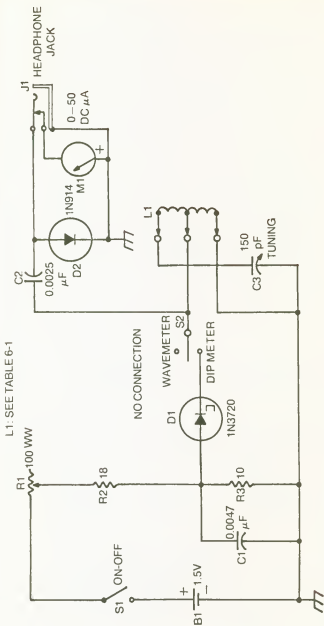
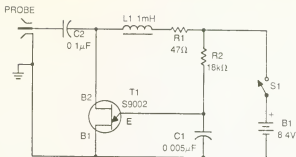


Fig. 53-17. Dip meter.



Parts list

T1—HEP S9002 unijunction

C1—0.005 μ F, 1000V ceramic disc

C2—0.1 μ F, 200V tubular

L1—1mH subminiature iron-core rf choke, J. W. Miller 70F103A1

R1—47 Ω , 1/2W 10 $\%$

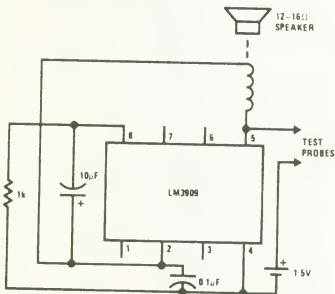
R2—18k Ω , 1/2W 10 $\%$

B1—8.4V mercury battery, Burgess H126

S1—SPST Lafayette 34P02302V

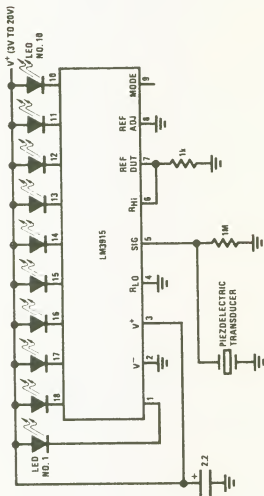
Misc—plastic toothbrush case, perforated board, flea clips

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).

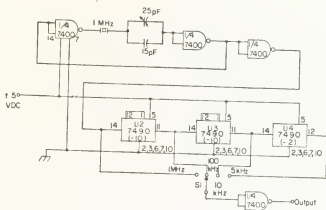


Fig. 53-21. Using a digital frequency counter without a direct connection.

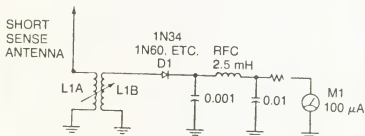


Fig. 53-22. Carrier shift meter.

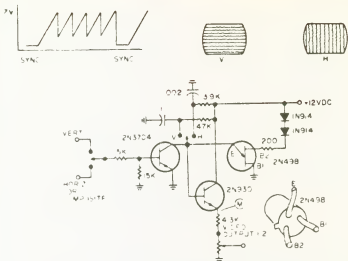


Fig. 53-23. Vertical and horizontal bars can be generated with this circuit for checking TV sweep linearity.

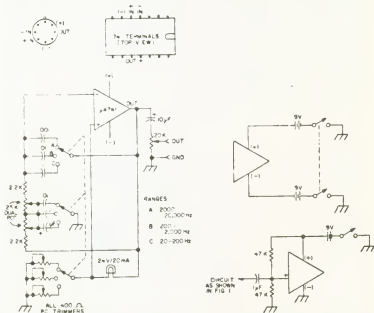


Fig. 53-24. Audio generator capable of operation from 20 to 20,000 Hz. Optional connections shown for dual or single 9V dc supplies. The 25K dual potentiometer should have a linear (not audio) taper.

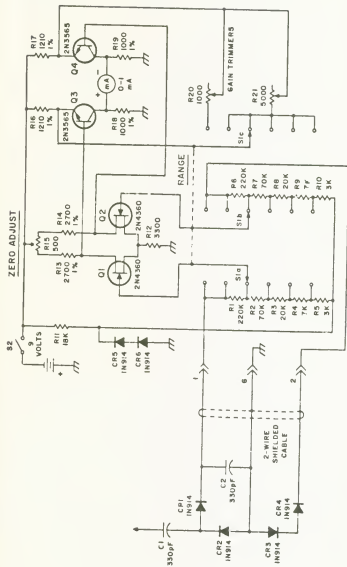


Fig. 53-25. Sensitive rf voltmeter has full-scale ranges from 30 mV to 10V with a flat frequency response to 200 MHz. All FETs, transistors, and diodes used in pairs should be carefully matched.

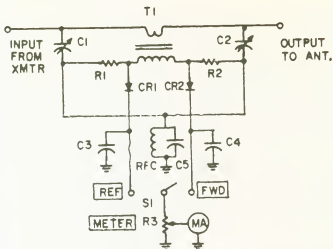


Fig. 53-26. SWR bridge. Parts list: T1—60 turns No. 30 enameled wire over Amidon T-68-2 toroid core. Close wind the turns. Primary is two turns No. 22 or 24 hookup wire wound over center of secondary. C1 C2—1.5—7 pF ceramic trimmer (Lafayette No. 68386 mica usable) R1, R2—120 ohm $\frac{1}{2}$ W CR1, CR2—1N34A or equivalent (Radio Shack No. 821 for pack of 10; select two that match the closest). C3, C4—0.005 μ F 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 μ A to 1 mA movement (Lafayette 500 μ A No. 50361 a good size).

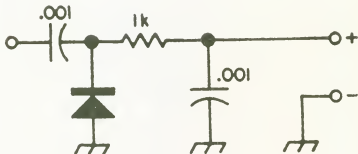


Fig. 53-27. A general-purpose rf detector probe for use with an oscilloscope or voltmeter.

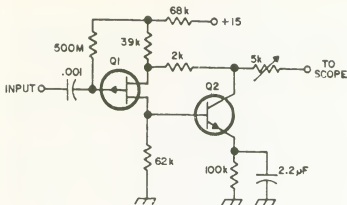


Fig. 53-28. This high-impedance probe provides about 1200 megohms input impedance with unity gain. Upper frequency equalization is provided by the 5K pot. Q1 is a U112, 2N2607, 2N4360; Q2 is a 2N706, 2N708, 2N2926, 2N3394, or HEP 50.

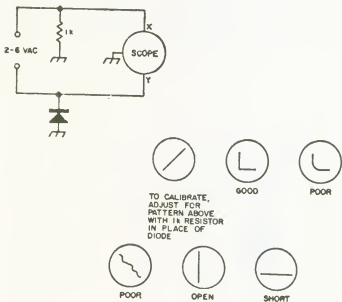


Fig. 53-29. One of the easiest types of diode checks for a person with a scope is this, but it tells nothing about a diode's high voltage performance.

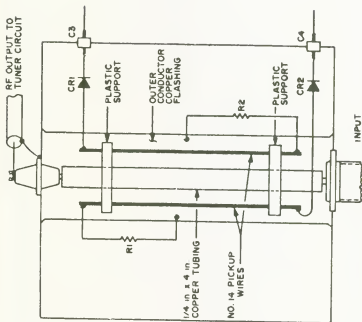


Fig. 53-31. Z-match antenna tuner and SWR bridge couples any antenna to any transmitter or receiver, low frequencies to VHF. Allows smooth transition from series to parallel tuning without bandswitching. Construction details shown in accompanying figure.

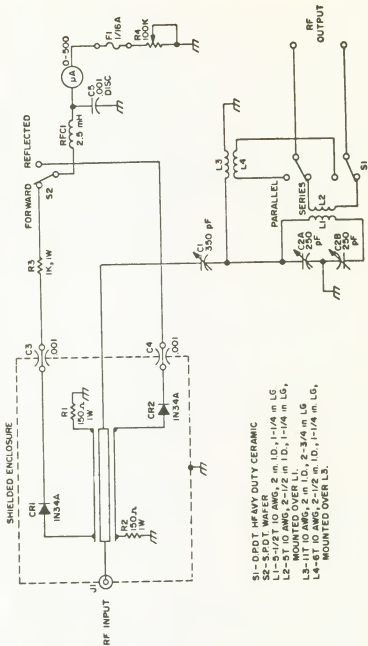


Fig. 53-32. Overall schematic of the tuner.

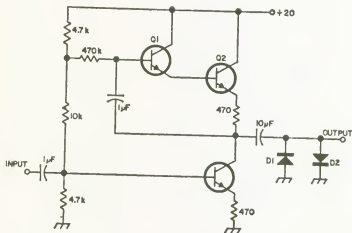
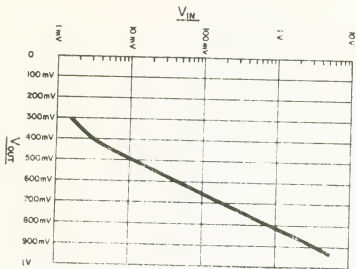


Fig. 53-33. This logarithmic amplifier makes use of the fact that when two back-to-back diodes are driven by a current generator, they exhibit a logarithmic output of the input signals. With the circuit constants shown, this amplifier follows a nearly perfect logarithmic curve over a 60 dB range; selected diodes will increase this to 80 dB. $Q1$, $Q2$ and $Q3$ are 2N2924, SK3019, GE-10, or HEP 54; $D1$ and $D2$ are IN914.

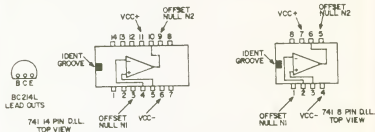
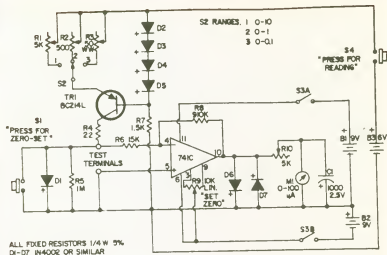


Fig. 53-34. Full circuit diagram for ohmmeter capable of measuring resistance down to less than 0.001Ω . The two circuit points marked 'A' are wired directly together.

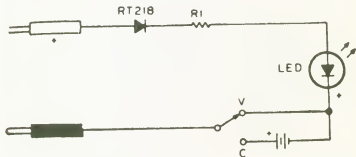


Fig. 53-35. LED voltage and continuity tester.

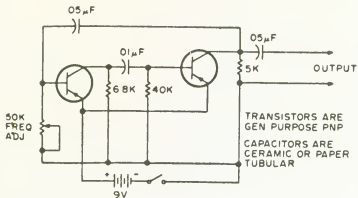


Fig. 53-36. Signal injector.

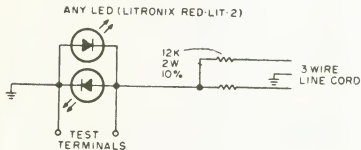


Fig. 53-37. Super-simple diode checker.

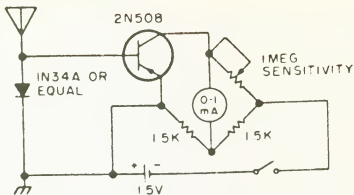


Fig. 53-38. Field-strength meter.

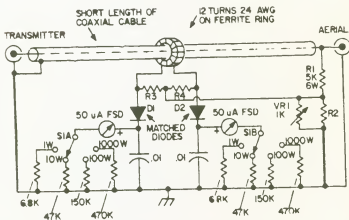


Fig. 53-39. Wattmeter uses two 50 μ A meters and indicates forward and reflected power simultaneously from 100kHz to 70MHz.

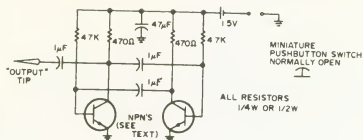


Fig. 53-40. Astable multivibrator produces audio signal rich in harmonics for signal-tracing applications; may be fitted into plastic cigar container. Transistors are 2N3841; any general-purpose types will suffice.

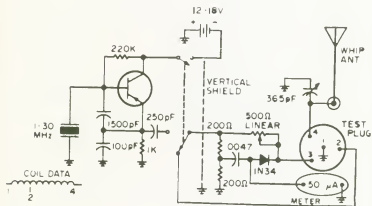


Fig. 53-41. Portable impedance bridge, field-strength meter, and crystal calibrator.

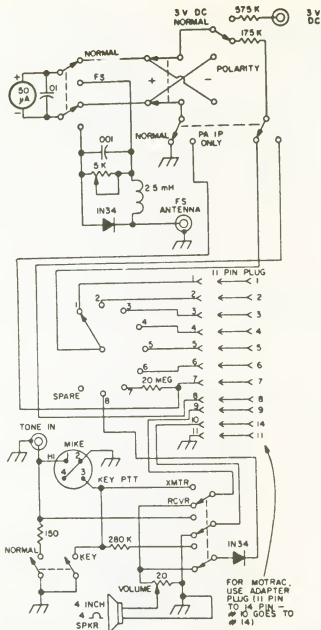


Fig. 53-42. Performance monitor for Motorola FM communications equipment plugs in; selector switch is used to choose function to be monitored. Adapts to other units by changing connector type.

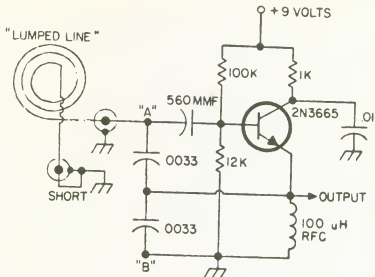


Fig. 53-43. Basic "lumped-line" oscillator. Tank circuit has appearance of conventional coil but functions as full-wave transmission line with no exposed high-impedance or "hot" points.

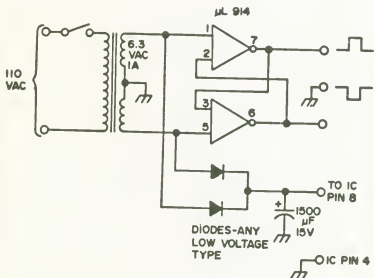


Fig. 53-44. A 60 Hz square waver.

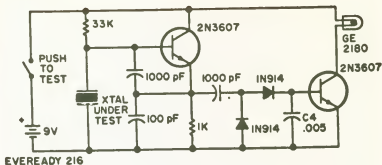
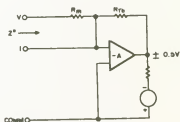


Fig. 53-45. Crystal checker. When the button is pushed, a good crystal should cause the bulb to light.



RANGE (VOLTS)	Z (μ A)	Rm (ohms)	Rf (ohms)
± 0.25	± 0.75	335K	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.

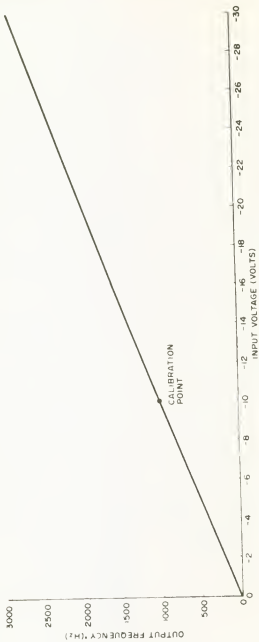


Fig. 53-47. Audible voltmeter produces tone that rises with applied voltage. Chart shows linear relationship of tone to voltage.

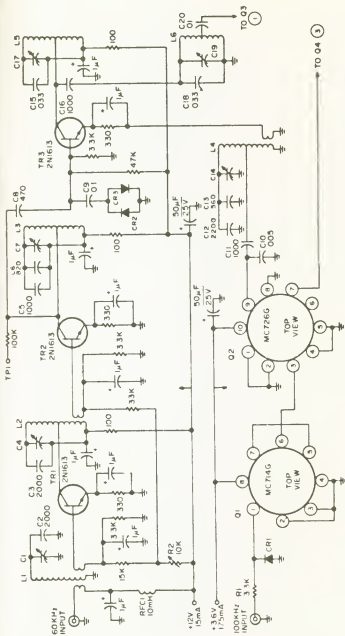


Fig. 53-48. WWVB frequency comparator receiver uses a heterodyne process to display error between WWVB at 60 kHz and local rf producing device. ICs are Motorola.

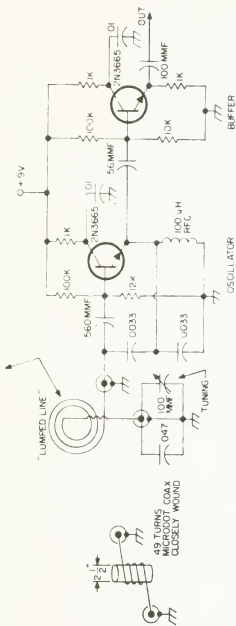


Fig. 53-49. Lumped-line oscillator with tuning provisions and buffer amplifier. Circuit values shown for 21 MHz oscillator.

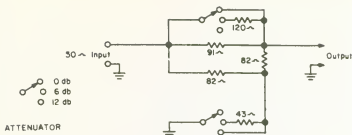
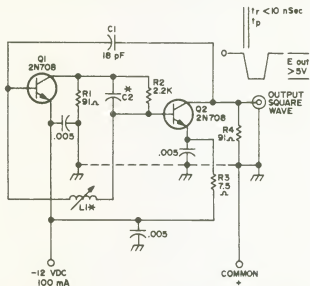


Fig. 53-51. A 50 Ω attenuator circuit for a receiver front end. Use for measuring effectiveness of different antennas by listening to a constant-amplitude signal.



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.

MPS	Typical Values $C2$ pF	$L1$
4.0	100	82 μ H
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

All resistors are $\frac{1}{2}$ W 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 \approx .5 watt. Short circuit protected.

Fig. 53-52. Square-wave source.

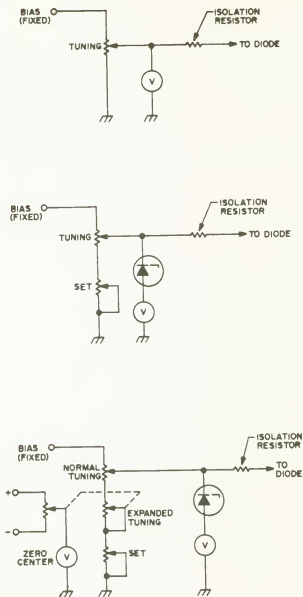


Fig. 53-53. Various ways of using simple voltmeters as frequency readout devices in conjunction with voltage-tuned diodes (varactors).

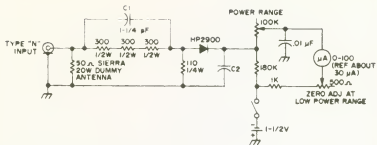


Fig. 53-54. A 0.025 to 10W RF wattmeter.

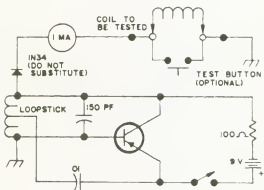


Fig. 53-55. Direct-reading inductance meter. Must be calibrated by user.

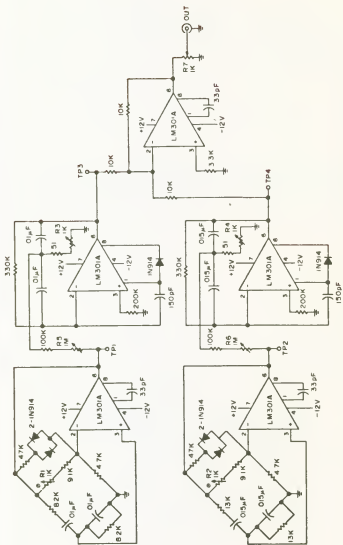


Fig. 53-56. Dual-tone test generator uses pair of Wien bridge oscillators. Requires power source of $\pm 12V$.

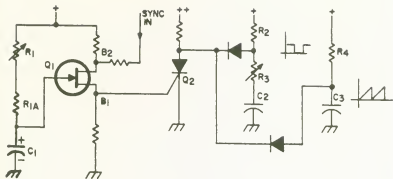


Fig. 53-57. Unijunction-transistor sweep generator offers simplicity and excellent reliability/repeatability.

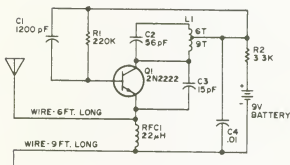


Fig. 53-58. Regenerative detector generates broadband signal on 27 MHz citizen band, for use in tweaking any companion receiver unit.

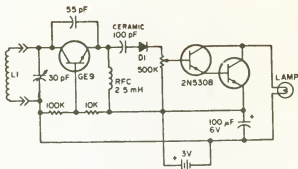


Fig. 53-59. A simple "grid dip" meter that uses a bulb as a resonance indicator. Using the GE-9 transistor will enable the unit to oscillate up to 12 MHz. The indicator lamp should be a No. 48 or 49 bulb. L1 should be wound to cover desired frequency ranges.

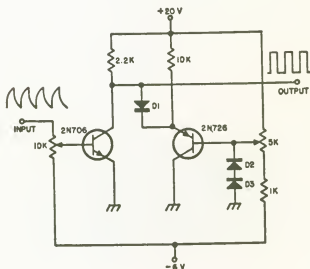


Fig. 53-60. The square-wave output of many inexpensive signal generators deteriorates quite badly at high frequencies, but this circuit will square them off again. The diodes may be any inexpensive computer type such as the 1N914.

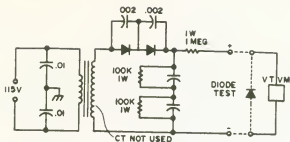
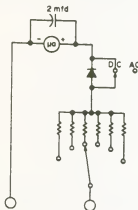


Fig. 53-61. A circuit for testing characteristics of "bargain pack" diodes. The transformer is 600—1000V CT and the two diodes in the half-wave circuit are 1000 PIV. The filter capacitor should be approximately 40 μ F apiece with suitable voltage rating. To test an unknown diode, connect as shown and 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 Meter	Series Resistor
1	.0005	2000 Ω	150 Ω	1850
5	.0005	10K	150 Ω	9850
10	.0005	20K	150 Ω	19850
50	.0005	100K	150 Ω	99850
100	.0005	200K	150 Ω	199850
500	.0005	1 meg.	150 Ω	999850

Fig. 53-62. Ac/dc voltmeter. Table shows resistance value for desired full-scale indication of 500 μ A meter.

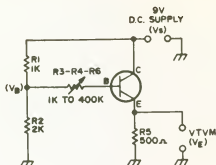


Fig 53-63. Beta tester.

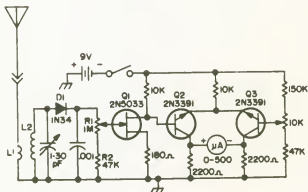


Fig. 53-64. Field-strength meter can be used to tune coils, antennas, and other resonant devices. To cover 13—24 MHz, L1 is to be resonant when used with C1, and should consist of a couple of turns of No. 16 wire wound over L2. L2 is 11 turns No. 16 solid spaced so coil is 1 in. dia by 1 in. long.

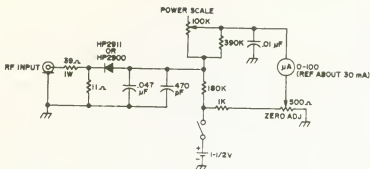


Fig. 53-65. Schematic of milliwattmeter for measuring rf power levels of 1—1000 mW.

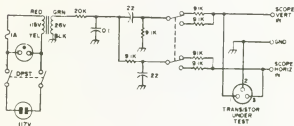


Fig. 53-66. Line quadrature-generator type transistor and SCR tester.

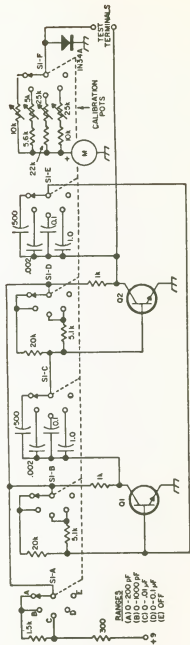


Fig. 53-67. Although this capacitance meter will not measure electrolytic capacitors, it will measure any other type from zero to 0.1 μF with reasonable accuracy. On the lower end 4 pF can be read accurately and 2 pF easily estimated. Transistors Q1 and Q2 are 2N168, 2N1605, 2N2926, SK3011, or HEP 54; the meter is a 0-50 microampere unit and the range switch a Centralab PA1021.

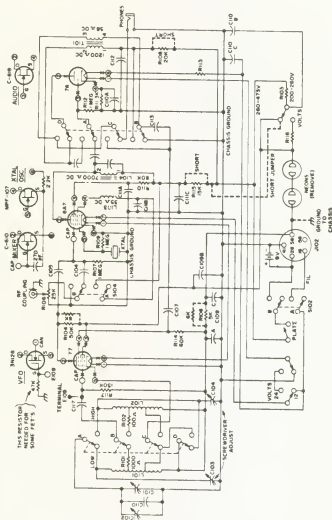


Fig. 53-68. LM frequency meter updated by FETs that can be made to plug directly into pentode sockets.

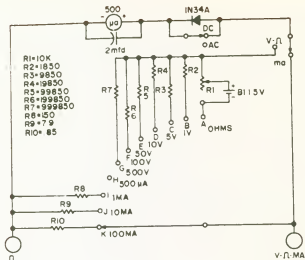


Fig. 53-69. Compact VOM circuit. Keep resistor values as accurate as possible. Meter movement is 500 μ A with an internal resistance of 150 ohms.

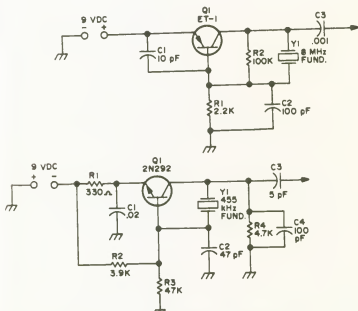


Fig. 53-70. Two oscillator circuits for aligning receivers, anonymously presented originally in FM Bulletin.

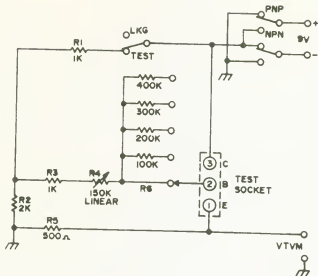


Fig. 53-71. Transistor beta tester.

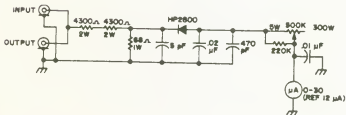


Fig. 53-72. A 5 to 300W rf wattmeter metering circuit. External 300 or 400W during antenna load.

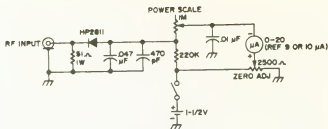


Fig. 53-73. A 0.05—500 mW wattmeter.

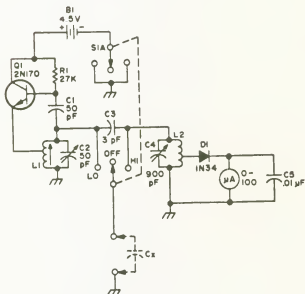


Fig. 53-74. Capacity meter. L1-C2 and L2-C4 should tune to the same frequency, around 1450 kHz. Calibrate by setting C4 near max and mark that "zero." Peak meter with C2, which is zero adjustment. Calibrate with known capacities and mark C4 dial.

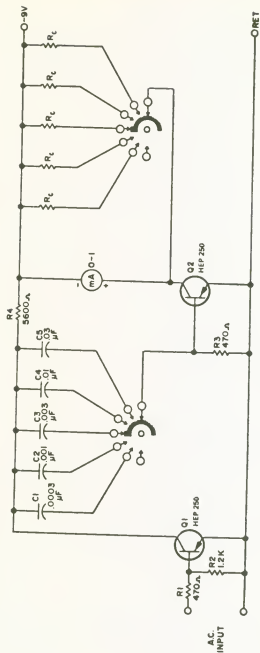


Fig. 53-75. This schematic gives the basics for a simple, inexpensive audio frequency meter. For the cheapie special version, omit all switches and components associated with them. Connect a capacitor of proper value in place of S1A. Ranges are: OFF, 30 kHz, 10 kHz, 3kHz, 1 kHz, and 300 Hz. Meter is 0-1 mA.

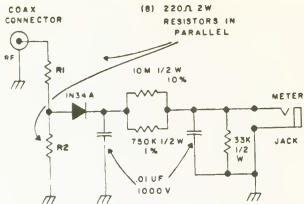


Fig. 53-76 Dummy load and rf wattmeter for 50 ohms. R1 and R2 are each made from 8 paralleled 2-watt resistors of precisely 220 Ω each.

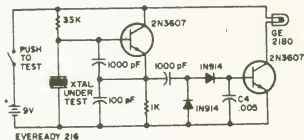
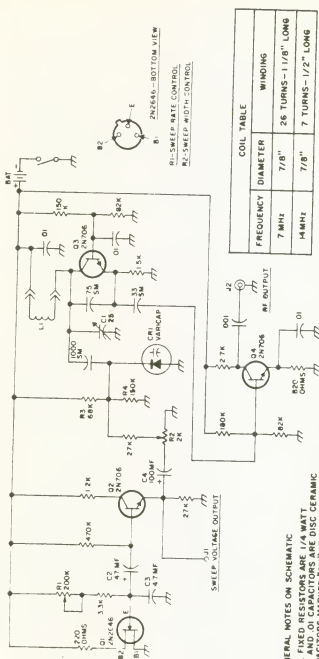


Fig. 53-77, Crystal tester schematic.



GENERAL NOTES ON SCHEMATIC
 ALL FIXED RESISTORS ARE 1/4 WATT
 .001 AND .01 CAPACITORS ARE DISC CERAMIC
 AND R2 STANDARD CARBON ELEMENT POTENTIOMETERS
 C2, C3, AND C4 ARE ELECTROLYTICS - 25WVDC OR MORE

Fig. 53-78. Sweep oscillator circuit.

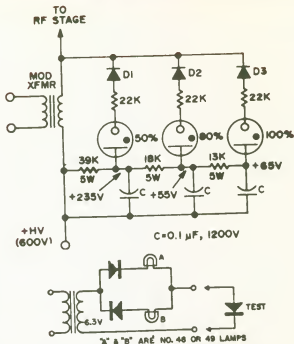


Fig. 53-79. Simple devices can be built to indicate when defined modulation percentages are achieved. This arrangement uses neon bulbs and switching diodes to fire the bulbs when the negative-peak modulation reaches 50%, 80%, and 100%, respectively. Bottom ends of neon bulbs return to voltages which 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.

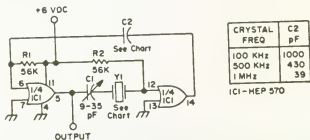


Fig. 53-80. Crystal oscillator calibrator, high in square-wave output (you will be able to hear it up into the VHF bands), which may be made into two calibrators since the circuit uses only half of the Motorola IC.

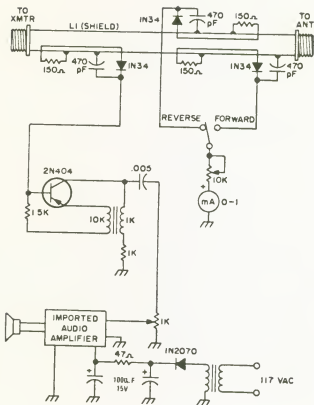


Fig. 53-81. Reflected power meter and CW monitor. L1 is 12 in. RG-11/U coax with plastic coat removed. 5-inch pieces of No. 20 hookup wire inserted under shield for pickup loops.

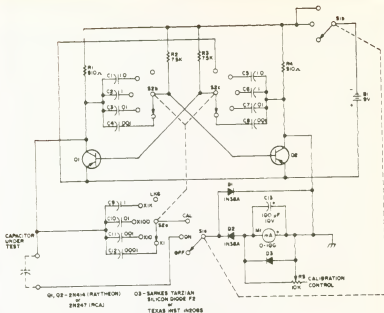


Fig. 53-82. Direct-reading capacitance meter.

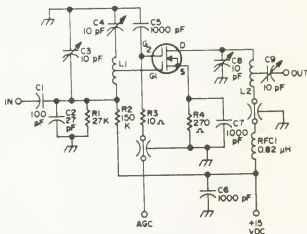


Fig. 53-83. VHF amplifier used to measure gain, noise figure, and agc performance of the Fairchild FT0601 MOSFETs. For agc operation, dual-gate MOSFETs have a built-in advantage owing to their separate gates, especially in the VHF region. Amplifiers such as this one eliminate cross modulation distortion, decrease receiver noise, and avoid shifting of the receiver's center frequency. Schematic from Fairchild Semiconductor Application Note APP-189.

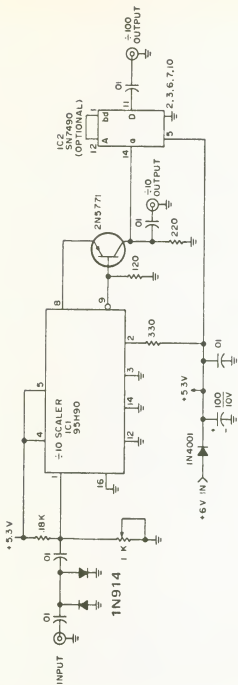


Fig. 53-84. VHF prescaler for extending counter range to 300 MHz.

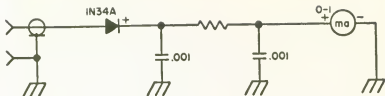


Fig. 53-85. Rf wattmeter is simple and accurate, but logarithmic. A 22K resistor gives 10W full-scale indication.

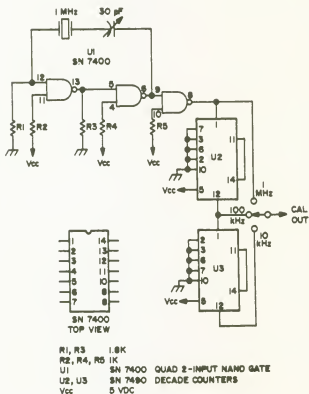


Fig. 53-86. This crystal calibrator has a fundamental 1 MHz crystal and its frequency is divided to give outputs of 1 MHz, 100 kHz, and 10 kHz. Circuit courtesy of Zero Beat (Victoria BC).

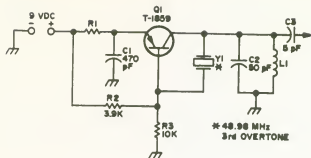


Fig. 53-87. Crystal oscillator for aligning receivers.

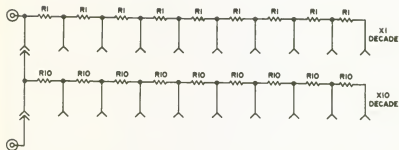


Fig. 53-88. Simple resistance decade uses no switching but requires access to resistor junctions.

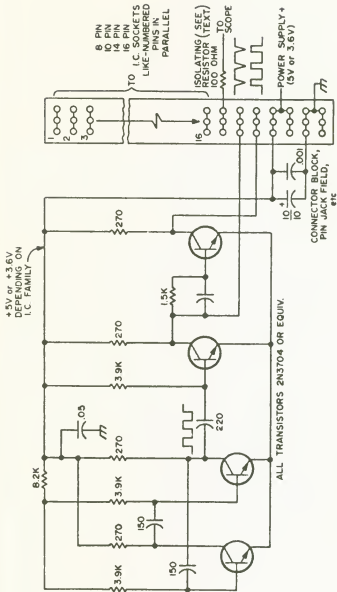


Fig. 53-90. General-purpose digital IC tester.

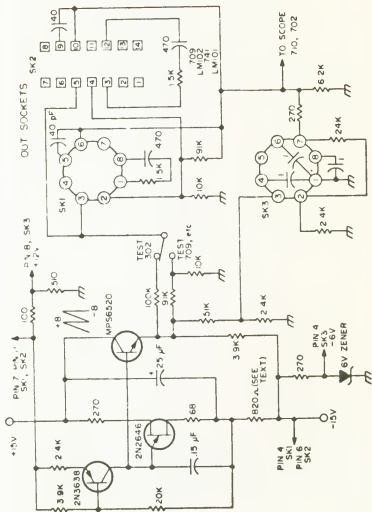


Fig. 53-91. Linear IC tester.



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.

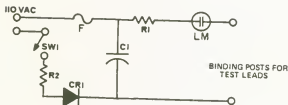


Fig. 53-93. When testing a capacitor, the light will blink once or twice while the plates are loading and then will remain off. If the capacitor is not good, the light will continue to blink. When checking capacitors wired into circuits, one end must be disconnected. R1—47K 2W resistor, R2—330K 2W resistor, LM—neon lamp NE 51, C1—8 or 10 μ F capacitor 450V dc, CR1—1M3611 diode (not critical), SWL—ST toggle switch, F— $\frac{1}{4}$ A fuse.

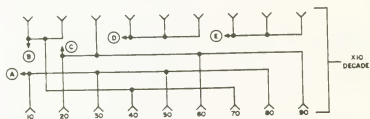
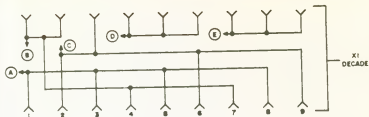


Fig. 53-94. Resistance decade using rotary switch for resistance selection. Circled letters show switch connections.

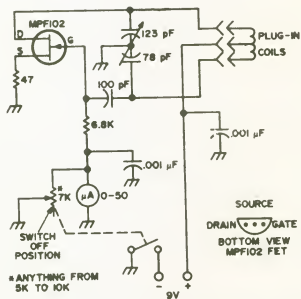


Fig. 53-95. Dip meter uses junction FET's gate rather than vacuum-tube grid for dip function.

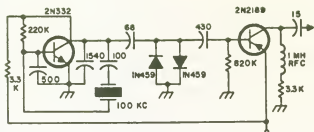


Fig. 53-97. Schematic of 100 KHz calibrator. Parts values are not critical and the transistors do not have to be the ones listed. It is suggested that a late version of the GE transistor manual be consulted for a slightly revised oscillator circuit.

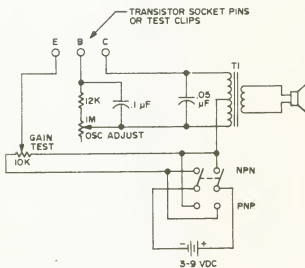


Fig. 53-98. Transistor sorter identifies polarity of bipolars; audible signal gives good indication of device gain. T1 is a miniature 400 Ω (. .8pCT) to 4 or 8 Ω transistor output transformer.

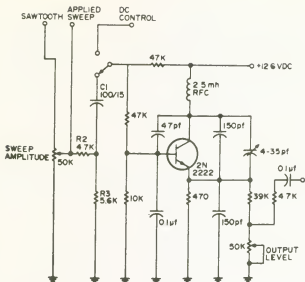


Fig. 53-99. Sweep generator for 430-470 kHz.

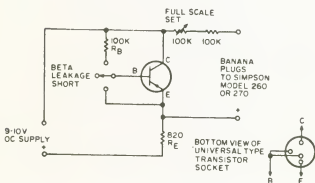
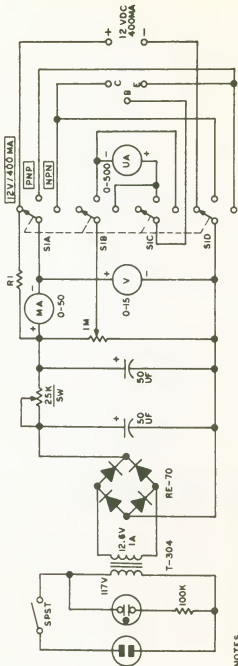


Fig. 53-100. This circuit will provide direct reading of transistor beta right on your VOM ohm scale. Polarities are shown for PNP.



NOTES.

1. UNLESS OTHERWISE INDICATED RESISTANCE IS IN OHMS.
2. S1 = 4 - POLE, 3 - POSITION SWITCH.

Fig. 53-101. Transistor parameter tracer.

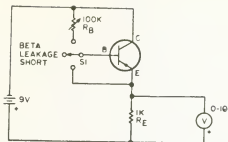


Fig. 53-102. Basic circuit of a popular and simple adapter for testing common "milliwatt" transistors.

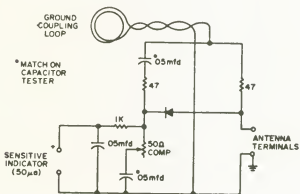
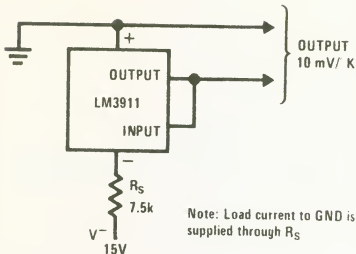


Fig. 53-103. This simple bridge circuit will measure antenna input resistance at resonance. Remember tolerances on capacitors are commonly very loose. A capacitor checker can do an adequate job of matching.

Chapter 54
Thermometers and Thermostats



$$R_S = (V^- - 6.8V) \times 10^3 \Omega$$

Fig. 54-1. Basic thermometer for negative supply.

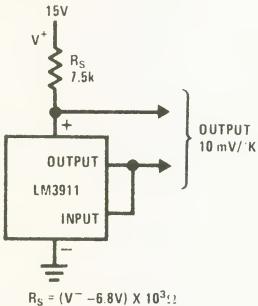
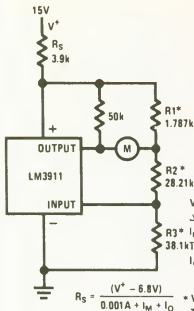


Fig. 54-2. Basic thermometer for positive supply (NS.)



$$R1^* = \frac{(V_Z) 0.01 \Delta T}{I_M (V_Z - 0.01 T_0)} \quad **$$

$$\text{Select } I_0 \leq \frac{2V}{R1}$$

$$R2 = \frac{0.01 T_0 - I_0 R1}{I_0}$$

$$R3 = \frac{V_Z}{I_0} - R1 - R2$$

$$\left(I_0 \leq \frac{2V}{R1} \right)$$

V_Z = Shunt regulator voltage (use 6.85)

ΔT = Meter temperature span ($^{\circ}K$)

I_M = Meter full scale current (A)

T_0 = Meter zero temperature ($^{\circ}K$)

I_0 = Current through $R1, R2, R3$ at zero meter current ($10\mu A$ to 1.0 mA) (A)

$$R_S = \frac{(V^+ - 6.8V)}{0.001A + I_M + I_0}$$

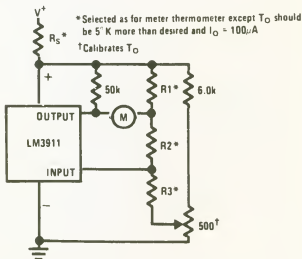
* Values shown for:

$T_0 = 300$ K, $\Delta T = 100$ K,

$I_M = 1.0$ mA, $I_0 = 100\mu A$

** 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_0 should be $5^{\circ}K$ more than desired and $I_0 = 100\mu A$

† Calibrates T_0

Fig. 54-4. Meter thermometer with trimmed output (NS).

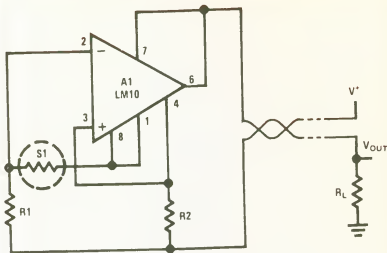
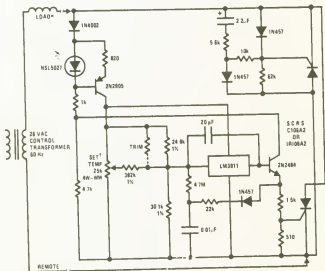


Fig. 54-7. Resistance thermometer transmitter (NS).



* Soldered on 8-1540 heater

† Pot will provide about a 50 F to 60 F setting range. This trim resistor (100k) is selected to bring 70 F near the middle of the pot rotation.

SCR heating, by proper positioning, can protect the sensor giving control as top position as is presently used in many home thermostats.

Fig. 54-8. Two-wire remote AC electronic thermostat (gas or oil furnace control) (NS).

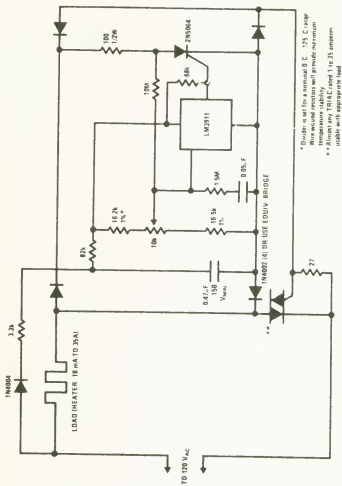


Fig. 54-9 Three-wire electronic thermostat (NS).

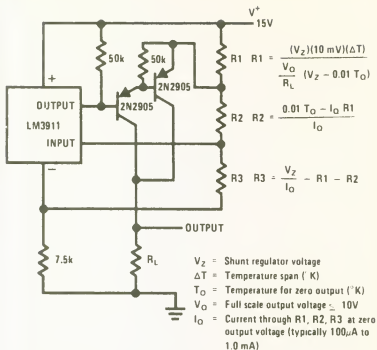


Fig. 54-10. Ground referred thermometer (NS).

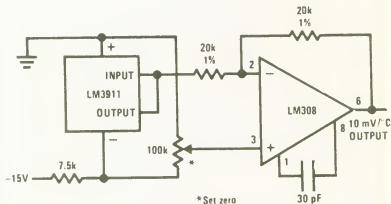


Fig. 54-11. Ground referred centigrade thermometer (NS).

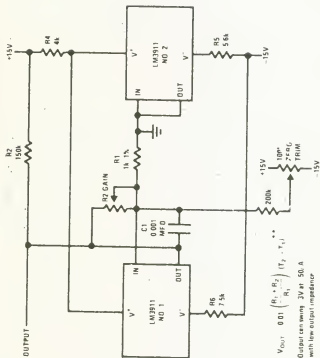


Fig. 54-12. Differential thermometer (NS).

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

Chapter 55

Timers

340

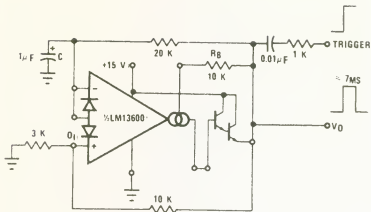
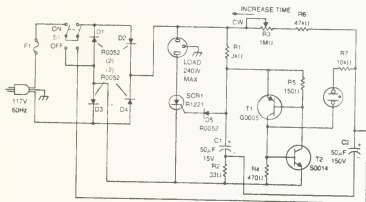


Fig. 55-1. Zero stand-by power timer (NS).



R5—150Ω 1/2W R7—10kΩ 1/2W T1—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 1/2W
 R2—33Ω 1/2W
 R3—potentiometer 1MΩ 2W linear
 R4—470Ω 1/2W

Fig. 55-2. Electronic timer (5 to 180 seconds).

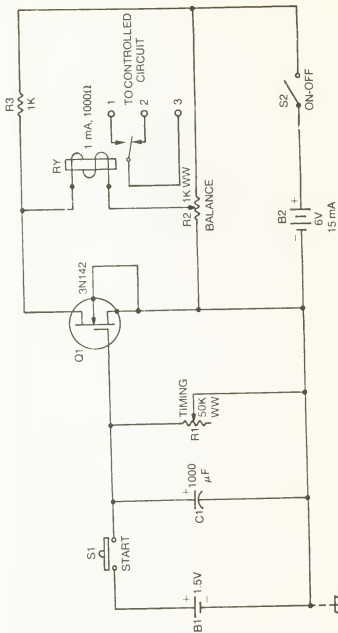


Fig. 55-3. Interval timer.

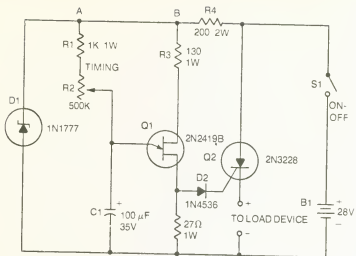


Fig. 55-4. Solid-state timer.

Chapter 56
Transmitters,
Transceivers, Exciters and VFOs

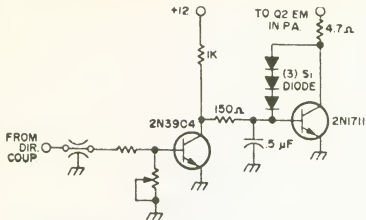


Fig. 56-1. VSWR protect circuit.

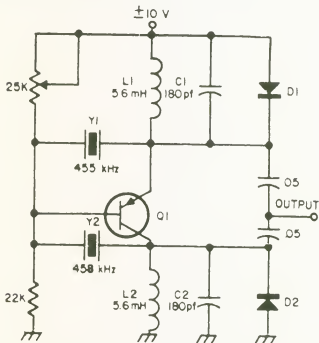
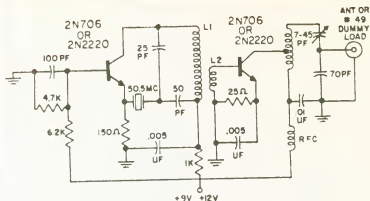


Fig. 56-2. This two frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed and this circuit provides a novel and simple way of obtaining two frequencies from a single stage with a minimum of switching.



L_1 — $\frac{1}{4}$ " 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.

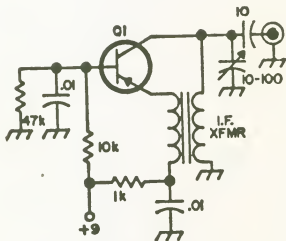


Fig. 56-4. This beat-frequency oscillator may be added to existing receivers with a minimum of difficulty. The BFO frequency is determined by the i-f transformer which provides feedback from collector to emitter. Transistor Q1 should be a 2N384, 2N1749, 2N2362, T1M10, SK3008, GE-9, or HEP 2.

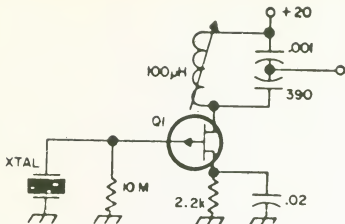


Fig 56-5. This is the old familiar vacuum tube Pierce oscillator circuit with a field-effect transistor in place of the thermionic triode. Circuit constants shown here are for the 1 MHz region, but the tuned circuit may be adjusted to any frequency desired Q1 is a 2N4360.

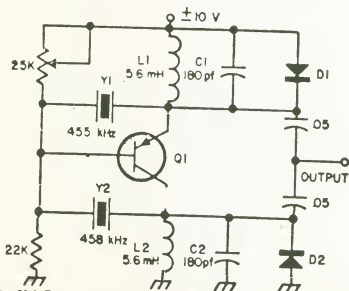
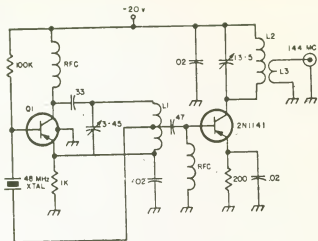
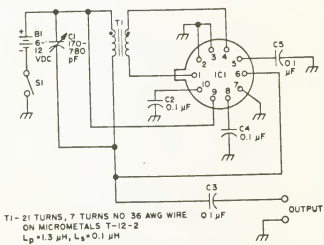


Fig. 56-6. This two-frequency crystal oscillator changes frequency by simply reversing the supply voltage. When the supply voltage is changed, the transistor inverts itself; usually transistors may not be used in the inverted mode, but in an oscillator a gain of only 1 or 2 is needed. This circuit provides 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.



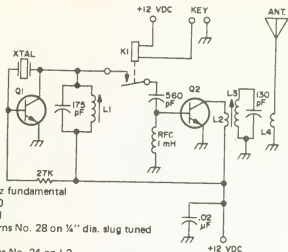
- L1 8 TURNS BW 3003 (16 TURNS PER INCH, 1/2" DIAM) TAPPED AT 4 TURNS FROM COLD END
- L2 8 TURNS NO 16, 5/16" DIAM, 1" LONG
- L3 3 TURNS NO 16 BIFILAR WOUND ON COLD END OF L2.
- Q1 2N584, 5K300B, TIXM03
- Q2 2N1141
- RFC 18µH (OHMITE Z-144)

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.



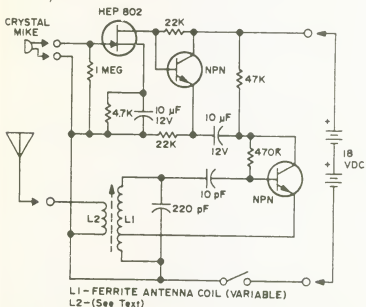
- T1- 21 TURNS, 7 TURNS NO 36 AWG WIRE ON MICROMETALS T-12-2
- $L_p = 1.3 \mu H$, $L_s = 0.1 \mu H$

Fig. 56-8. A 5-10 MHz VFO or 40-meter QRP transmitter; an idea for those backwoods hikers. Courtesy Motorola HMA36, IC Projects for Amateurs.



- XTAL 7 MHz fundamental
 Q1 40080
 Q2 40081
 L1 20 turns No. 28 on 1/4" dia. slug tuned form
 L2, L4 5 turns No. 24 on L3
 L3 28 turns No. 28 on 1/4" 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).



- L1 - FERRITE ANTENNA COIL (VARIABLE)
 L2 - (See Text)

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).

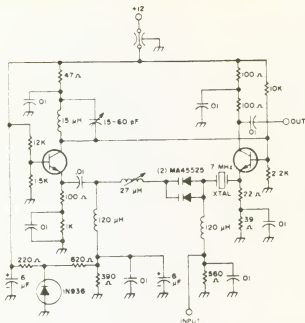


Fig. 56-11. Variable crystal-controlled oscillator circuit.

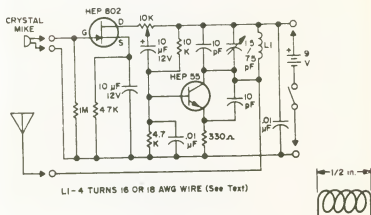


Fig. 56-12. FM wireless transmitter (88—108 MHz). Circuit courtesy Calectro Handbook. C7 is a short length of twisted hookup wire about $\frac{1}{2}$ inch long. L1 is four turns length about $\frac{1}{2}$ inch and $\frac{1}{4}$ inch dia.

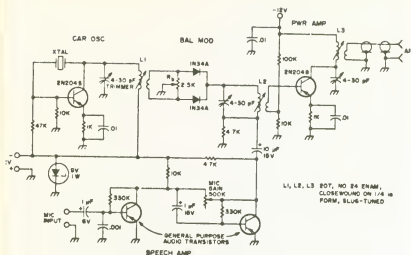


Fig. 56-13. Double-sideband transmitter for operation in 27-28 MHz range.

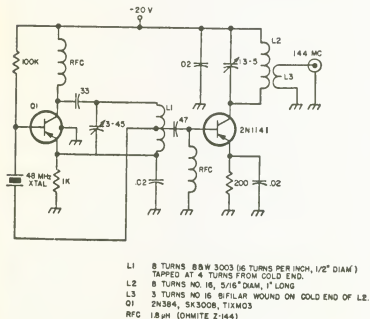


Fig. 56-14. This simple 2-meter transmitter may be used as a driver for a larger 144 MHz transmitter or a signal source for testing receivers, converters, and antennas.

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	BOM
L1	35T NO. 22 ON 168-2 CORE
L2	SAME AS L1
L3	3 TO 4T NO. 22 ON COLD END OF L2
	6M
	9T NO. 22 ON 150-10 CORE
	SAME AS L1
	SAME AS BOM

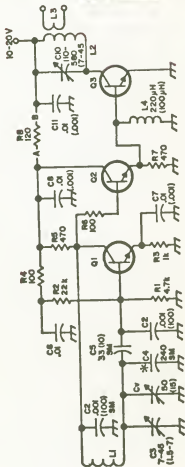
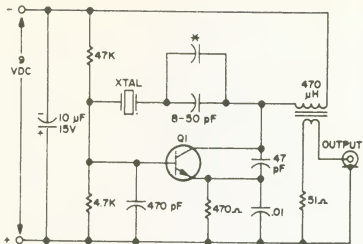
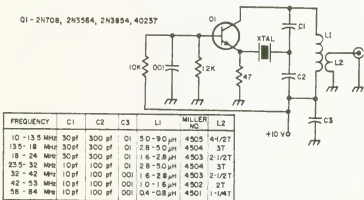


Fig. 56-15. Here is a stable VFO that can be assembled in a short time on a piece of Vectorboard. Coil data is supplied for an 80m and 6m version but other bands may be covered with a bit of experimentation. Transistors are all MPS706 but higher output is possible by replacing Q3 with a 2N2270 or 2N3053.



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.



Q1 - 2N708, 2N3584, 2N3854, 40237

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.

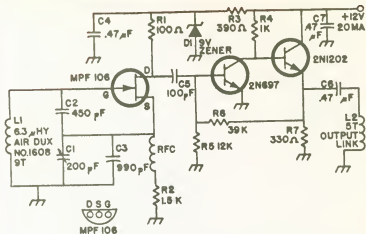


Fig. 56-18. Field-effect-transistor variable frequency oscillator has zero temperature coefficient. Operating frequency in 3.5 MHz range.

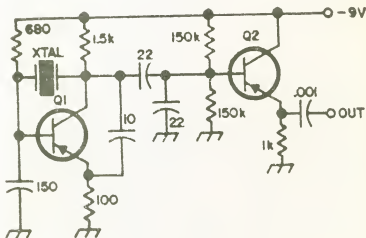


Fig. 56-19. This untuned crystal oscillator will oscillate with any crystal from 300 kHz to 10 MHz. Frequency stability is very good because the emitter-follower buffer amplifier effectively isolates the oscillator from the load. Q1 and Q2 are GE-9, SK30006, or HEP 2.

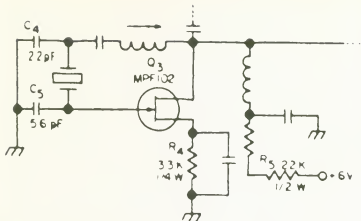


Fig. 56-20. FET replaces vacuum tube in the H23 oscillator to complete the transistorization operation. Components not labeled in the sketch are those components that are already part of the existing oscillator circuit.

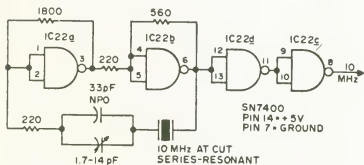


Fig. 56-21. 10 MHz crystal oscillator.

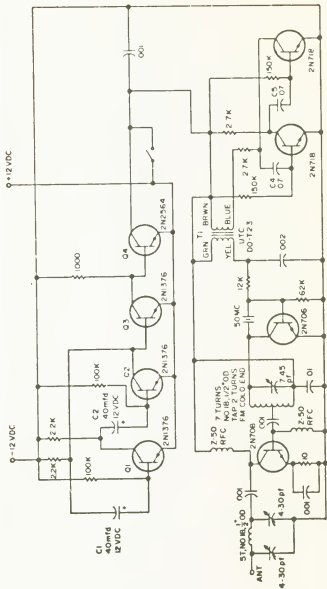


Fig. 56-22. Schematic for beeper. All resistors are $\frac{1}{2}$ watt.

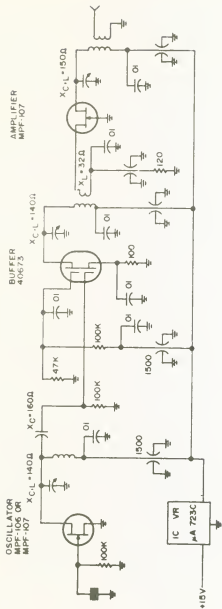
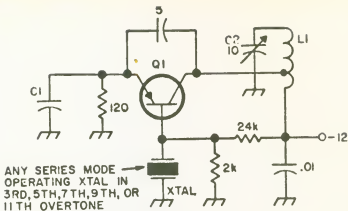


Fig. 56-23. Ultrahigh-stability crystal oscillator circuit that is useful for microwave transmitter frequency control. Use crystals from 1.6 to 160 MHz, fundamental or overtone. For best results get the values of the coils and capacitors for any specific frequency from your friendly neighborhood reactance chart.



L1 = TUNED TO RESONATE WITH C2 - COLLECTOR TAP 1/3 UP FROM COLD END

C1 = CAPACITIVE REACTANCE OF APPROX. 90Ω AT OPERATING FREQUENCY

FREQ (MHz)	50	144	220	432
C1 (μ F)	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.

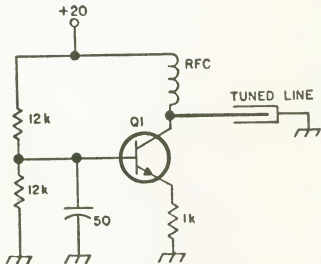


Fig. 56-25. This simple UHF oscillator will provide about 2 mW up to 1000 MHz; some selected transistors will provide usable power up to 1500 MHz or so. Q1 is a 2N918, 2N3478, 2N3564, or HEP 65.

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

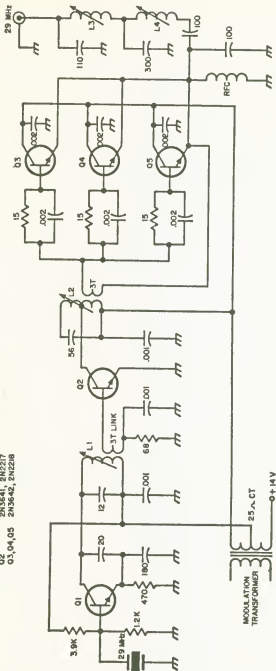


Fig. 56-26. This 3 watt 10 meter transmitter maintains high efficiency and low cost by paralleling three inexpensive silicon transistors in the final stage.

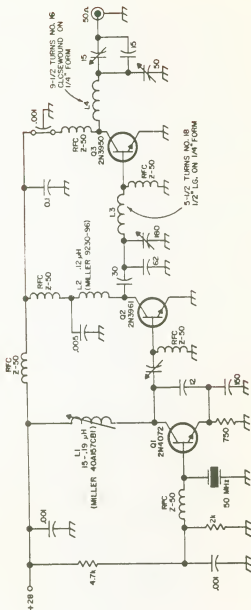
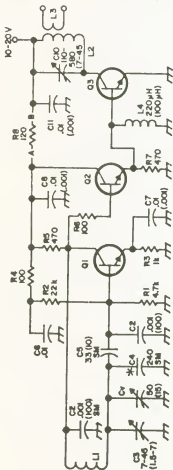


Fig. 56-27. This 6-meter transmitter provides up to 50 watts of power with very good efficiency and very low harmonics. The 2N3950 in the final provides a minimum power gain of 8 dB at 50 MHz and is rated at 50 watts continuous service.



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 T08-2 CORE 9T NO. 22 ON 150-10 CORE
L2	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.

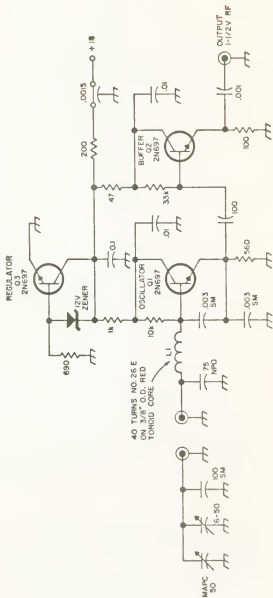


Fig. 56-29. Schematic of the VFO and power supply. Regulation is provided for both the oscillator and buffer. If more rf output is required, a tuned circuit (toroid, of course) can be installed in the emitter of Q2 in lieu of the 1000 Ω resistor.

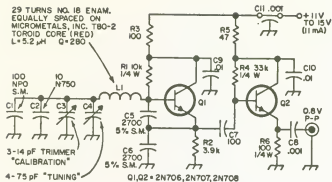


Fig. 56-30. Transistor VFO for 5-6 MHz for SSB mixing service.

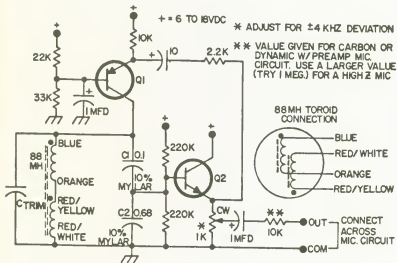


Fig. 56-31. A 1800 Hz command oscillator for FM. Q1—any PNP signal transistor have a VCE rating of $1\frac{1}{2}$ or more times the supply voltage. Some suggestions: 2N404, 2N1303 series, 2N2904 series, 2N3638 series, or 2N6533 series. Q2—any NPN small-signal transistor having a minimum beta of 100 and a Vcc of at least the supply voltage. Some suggestions: 2N1308, 2N2712, 14, 16, 2N2916, 18, 10, 2N3565, 2N3569, 2N6513, 14, 15, 20, or 21. CTRIM—0.0062 μF was used in the first unit. If Mylar capacitors and the toroid are \pm 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 CTRIM, measure the frequency (f_1) without CTRIM. If it is higher than 1800 Hz. (f_0) calculate CTRIM. $\text{CTRIM} = 0.1 (f_1/f_0^2 - 1) = F$.

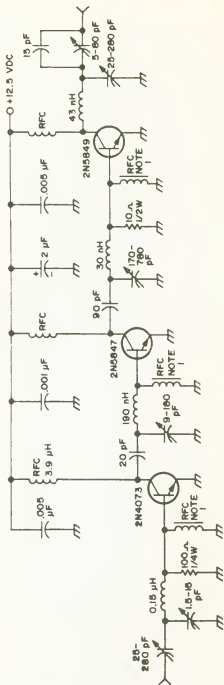


Fig. 56-32. A 50 MHz 40W transmitter for 12.5V operation.

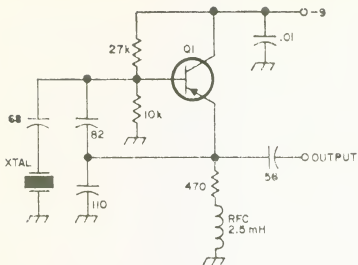


Fig. 56-33. This crystal oscillator will oscillate with any crystal between 3 and 20 MHz with no tuning whatsoever; overtone crystals will oscillate on their fundamental in this circuit. Q1 is a 2N1177, 2N1180, 2N1742, GE-9, SK3006, or HEP 2.

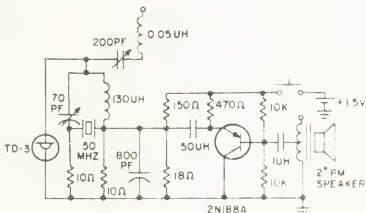


Fig. 56-34. A 50-MHz transmitter with speaker as AM microphone.

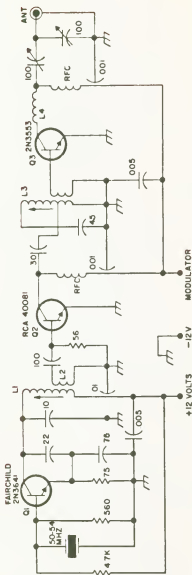


Fig. 56-35. Schematic of 2½W 6m transmitter. L1 and L2 = 6 turns No. 20 on iron-core ⅜" ceramic form. Links are 2 turns No. 20 insulated at bottom of L1 and L2. L3 is center tapped. These coils are surplus, used, as-is. Both windings are ½" long. L4 = 6 turns Airdux 516 or B&W 3007.01 = Fairchild 2N364; Q2 = RCA 40081; Q3 = Bendix B3466 or RCA 2N3553 or 40341 (all heatsinked).

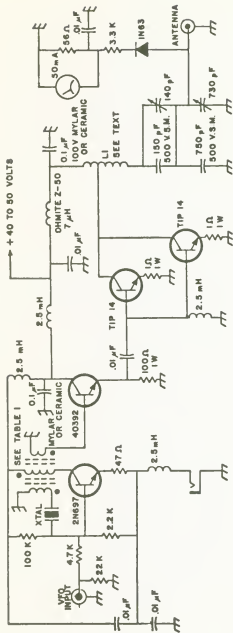
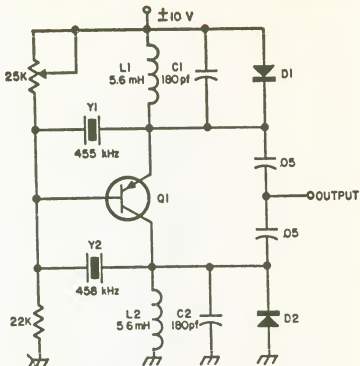


Fig. 56-36. Transistor transmitter puts out 30 watts at 3.5 MHz, and uses Texas Instruments' TIP 14s.



Q1- 2N384, 2N525, SK3004, T1-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.

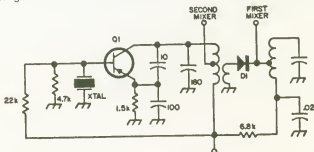
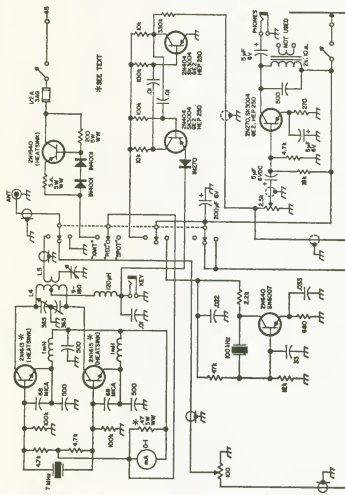
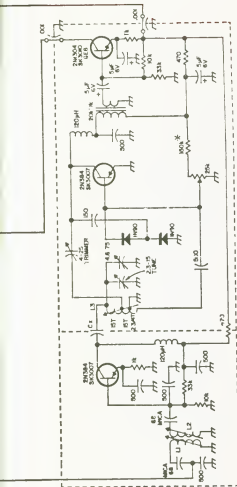


Fig. 56-38. Single oscillator and diode provide two injection frequencies for dual-conversion receivers. Transistor Q1 is a 2N1745, 2N2188, T1M10, GE-9, or HEP 2; the diode should be a 1N82A or similar.



*SEE TEXT



- I.1, L2 30 turns #32 enameled wire close wound on 1/4" slug tuned form. J. W. Miller 46A0006PC or CTC 2206-2-3
- I.3 32 3/4 turns #32 enameled wire close wound on 1/4" slug tuned form. (same form as above)
- I.4 11 turns 1" diameter 16 TPI. AirDux or B & W.
- I.5 4 turns hookup wire wound around the center of L4.

Fig. 56-39. Continuous-wave transceiver for 7 MHz produces 100 mW of r.f. in transmit; delivers clean notes to earphone in receive mode. Coil data at lower right.

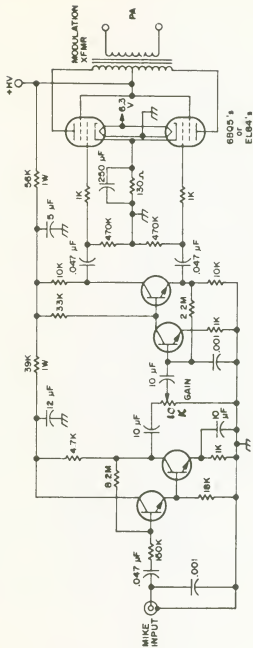
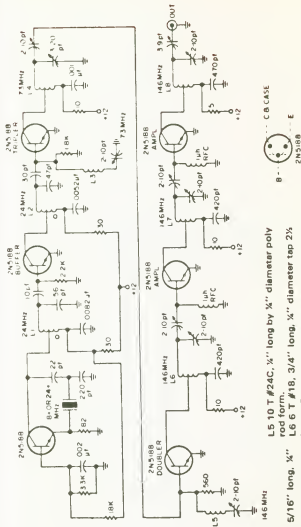


Fig. 56-40. Minimod schematic.



- L1-L2 10 turns 22 enamel 5/16" long, 1/4" diameter. Fr. slug coil form.
- L3 20 T 24C, 1/2" long by 1/4" diameter poly rod form.
- L4 10 T #18, 3/4" long 1/4" diameter tap 3 turns up.
- L5 10 T #24C, 1/2" long by 1/4" diameter poly rod form.
- L6 6 T #18, 3/4" long, 1/4" diameter tap 2 1/2 turns up.
- L7 6 T #18, 1" long, 1/4" diameter tap 2 turns up.
- L8 5 T #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.

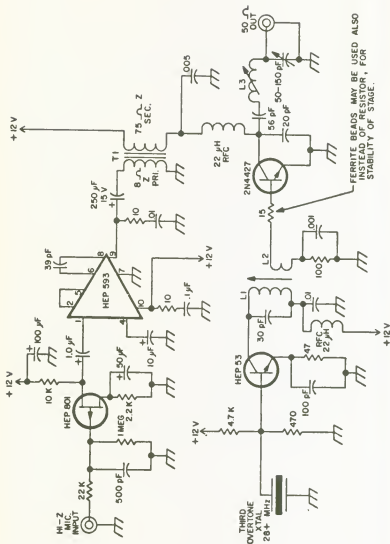


Fig. 56-42. Schematic of "Little Bill" transmitter. L1 = 13 turns No. 28 P.E. VW, L2 = 2 turns link on cold end, L3 = 13 turns No. 28 P.E. CW. All coils close-wound on 8 mm diameter aluminum form.

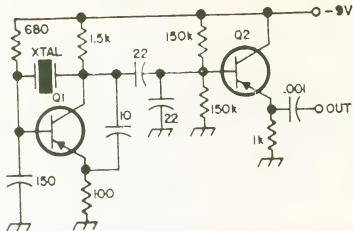
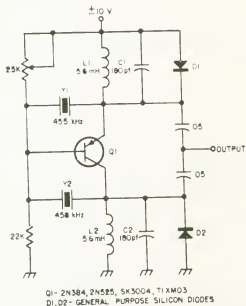


Fig. 56-43. This untuned crystal oscillator will oscillate with any crystal from 300 kHz. Frequency stability is very good because the emitter-follower buffer amplifier effectively isolates the oscillator from the load. Q1 and Q2 are 2N993, 2N1749, 2N2084, 2N2362, T1M10, GE-9, SK3006, or HEP 2.



Q1- 2N384, 2N525, SK3004, T1XM03
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.

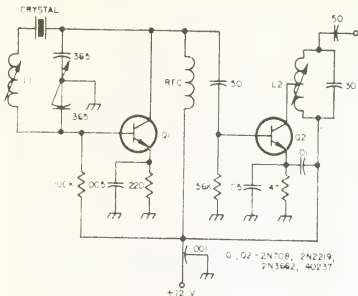


Fig. 56-45. This variable crystal oscillator (VXO) may be used to vary the frequency of an 8 MHz crystal 4 or 5 kHz when the 365 pF dual variable is tuned through its range. When multiplied to 2 meters of 432 MHz, this provides a very stable variable frequency. For 8 MHz crystals, L1 is a 20—25 μ H slug-tuned coil; L2 is chosen to resonate at 8 MHz with the 30 pF capacitor.

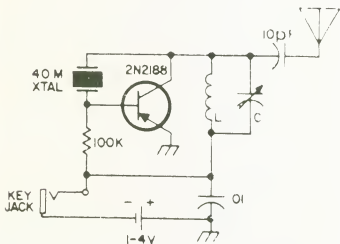


Fig. 56-46. Microminiature CW transmitter may be world's smallest! L and C are selected for resonance at crystal frequency.

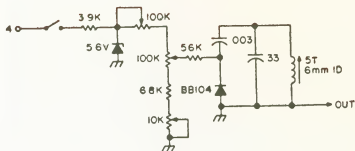


Fig. 56-47. A 12 MHz VFO for TR22.

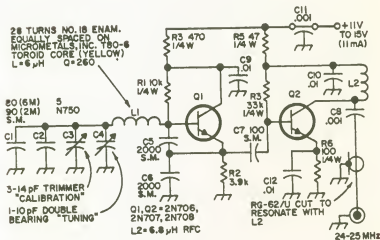


Fig. 56-48. A 6 or 2 meter transistor VFO with output on 24-25 MHz. The oscillator operates on 8-8.3 MHz.

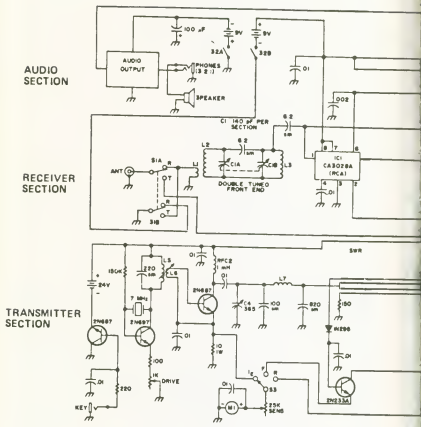


Fig. 56-49. Schematic diagram of solid-state 7 MHz transceiver.

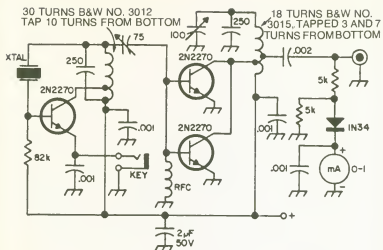


Fig. 56-50. Novice transmitter for 80 meters.

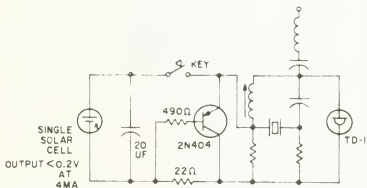


Fig. 56-51. Solar-powered CW transmitter using tunnel diode.

Chapter 57

TV Circuits

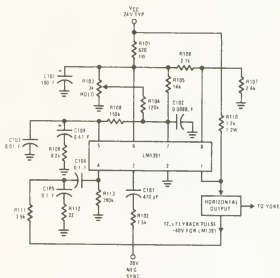


Fig. 57-1. TV horizontal processor (NS).

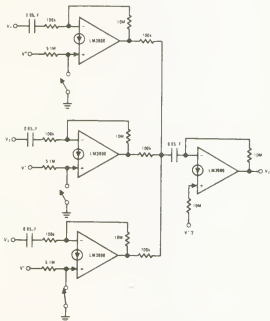


Fig. 57-2. Channel selection by DC control or audio mixer (NS).

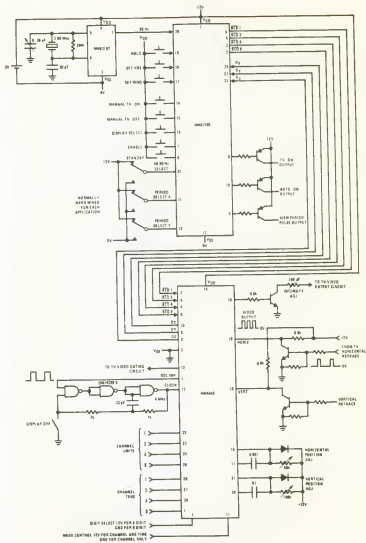


Fig. 57-3. TV channel and time display interfacing MM53100 (NS).

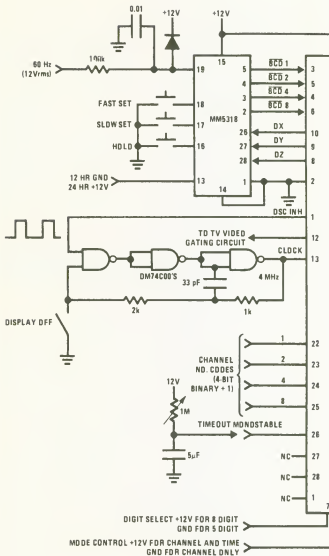
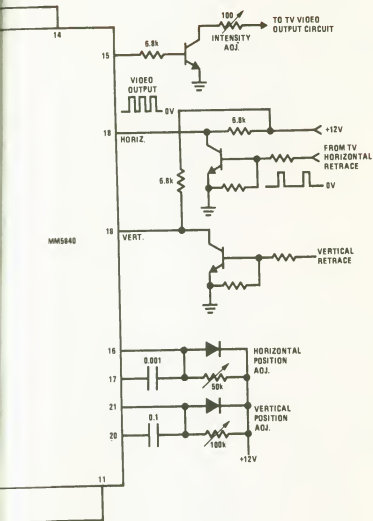
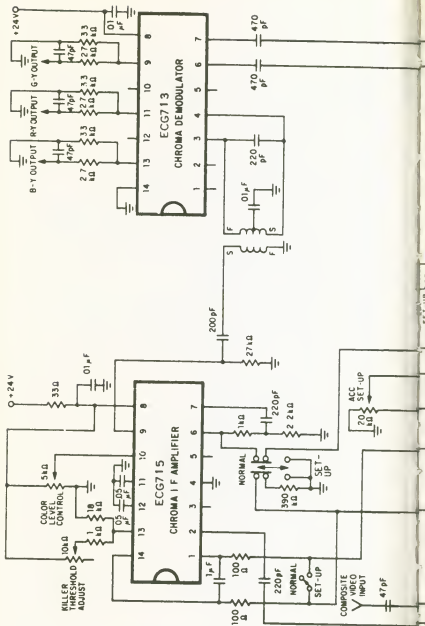


Fig. 57-4. TV channel and time display interfacing MM5318 (NS).





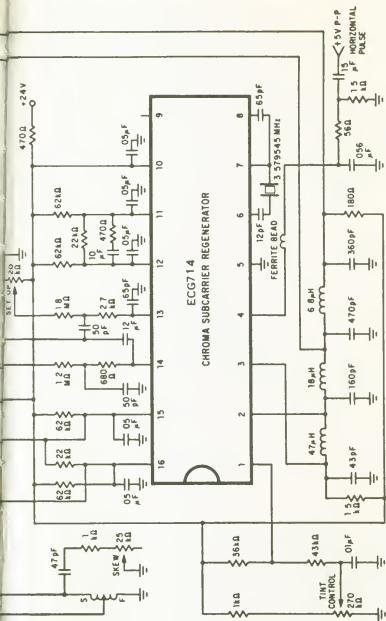


Fig. 57-5. Color TV chroma processing system with a PLL featuring APC and ACC (GTE).

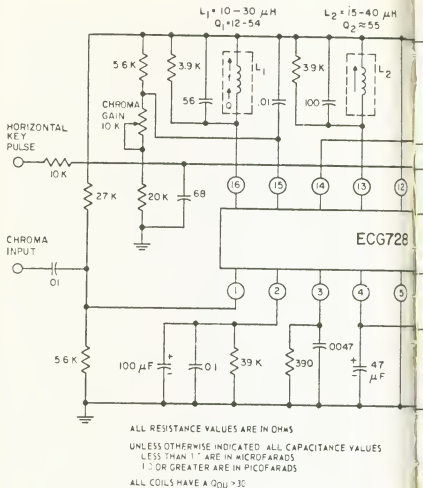
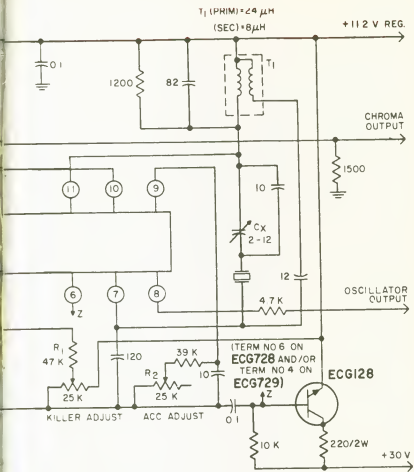
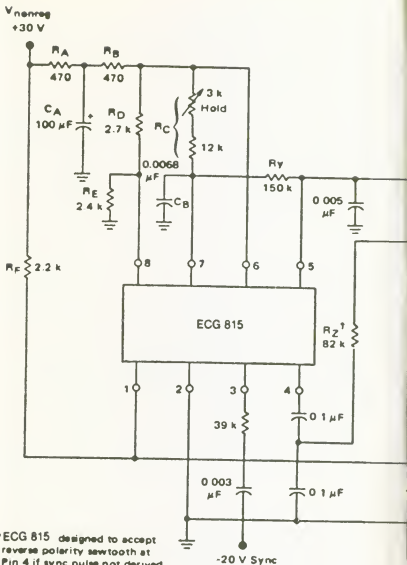


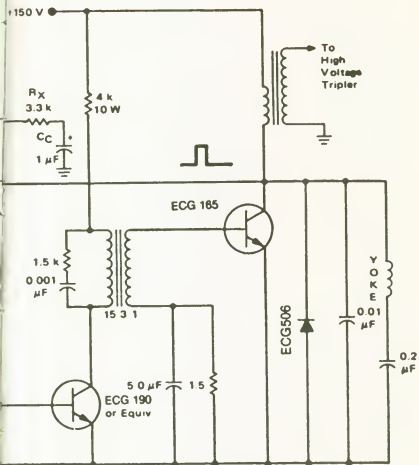
Fig. 57-6. Color TV chroma signal processor. The ECG728 provides subcarrier regeneration and total chroma signal processing prior to demodulation. The coils of the chroma amplifier and bandpass amplifier are stagger-tuned to provide a combined typical bandpass of 3.08 to 4.08 MHz. A burst separator amplifier 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).





* ECG 815 designed to accept reverse polarity sawtooth at Pin 4 if sync pulse not derived from ECG 165 collector.

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).



[†] $R_Z = 6.8 \text{ k per } 100 \text{ V of flyback amplitude.}$

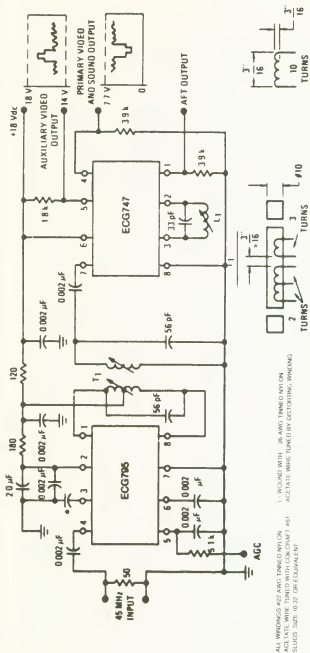


Fig. 57-8. TV video IF amplifier and detector using two 8-pin DIPs. Power gain is as follows: 60 dB at 45 MHz (pin 3 open), 56 dB at 58 MHz (pin 3 open), 61 dB at 45 MHz (pin 3 bypassed), and 59 dB at 58 MHz (pin 3 bypassed). AGC range is 80 dB from DC to 45 MHz. C4 should be 0.002 μF at 45 MHz (GTE).

90°20' Color TV

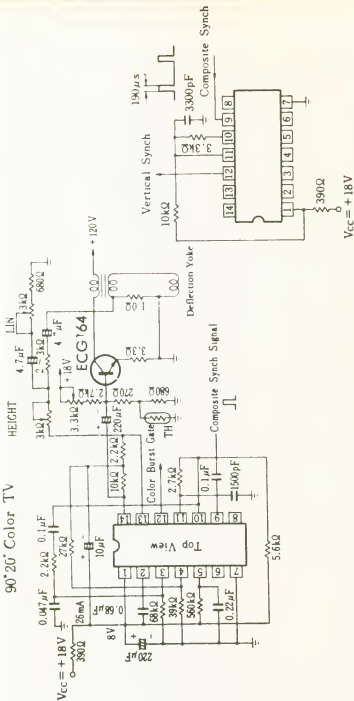


Fig. 57-9. Complete TV vertical circuit with AFC for 90-degree 20-inch receivers (GTE).

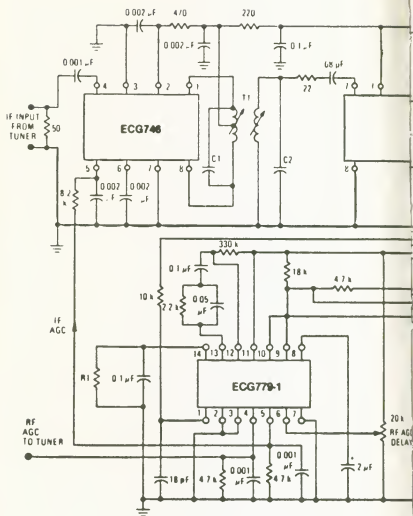
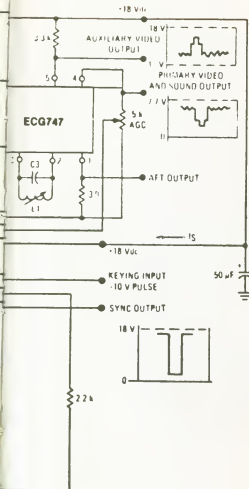


Fig. 57-10. TV video IF amplifier, video detector, and signal processor circuits. Used in color and B&W TVs (GTE).



All windings #30 AWG tinned nylon acetate wire tuned with high permeability cores. Complete transformer is available from Colcraft, 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		

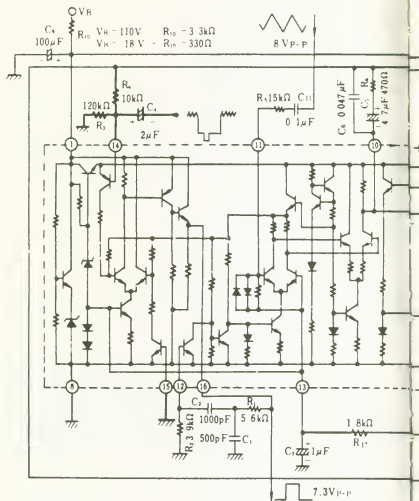
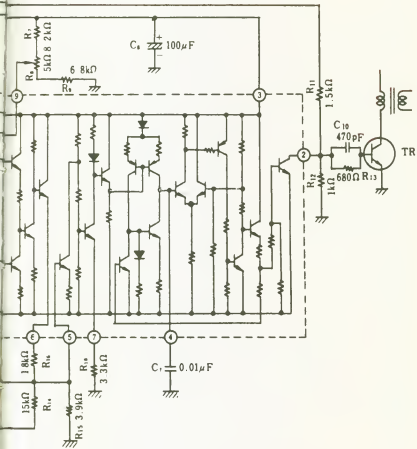


Fig. 57-11. TV horizontal AFC and oscillator with sync separator for positive sync, using an ECG1086 16-pin DIP. The single transistor shown is an ECG199, a horizontal driver stage (GTE).

H.HOLD



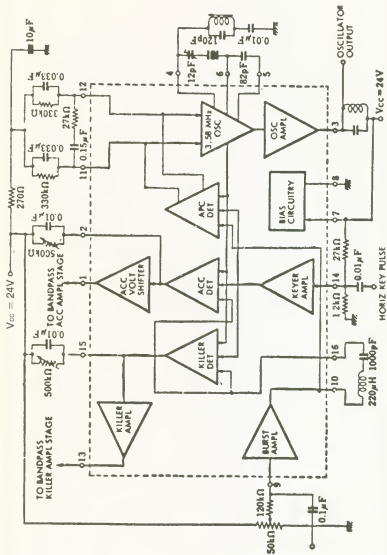


Fig. 57-12. Color TV subcarrier generator using an ECG 1105 16-pin DIP. The ECG1105 consists of a keyed APC, an ACC, a killer detector amplifier, a burst amplifier and a subcarrier amplifier (GTE).

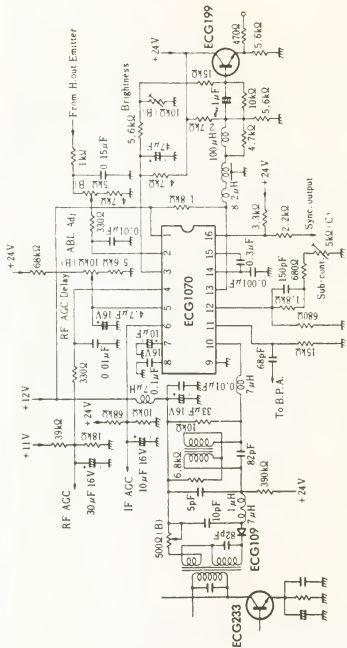


Fig. 57-13. TV video signal processor. The EGG1070 is a 16-pin DIP (GTE).

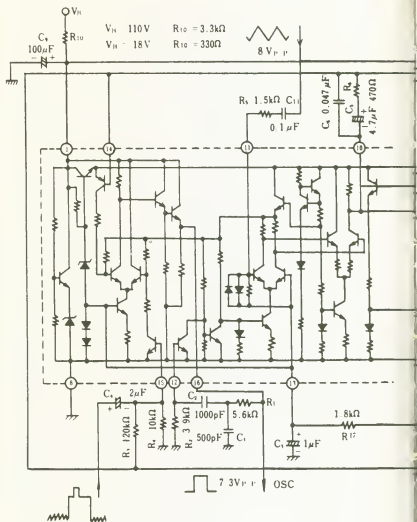
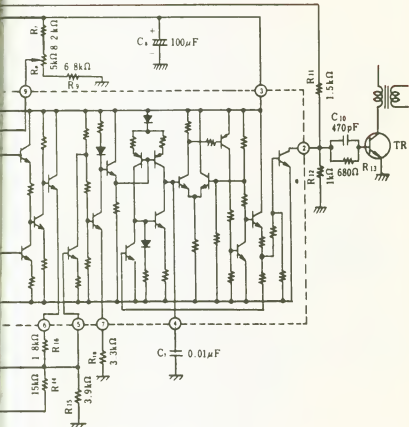


Fig. 57-14. TV horizontal AFC and oscillator with sync separator for negative sync, using an ECG1086 16-pin DIP. The single transistor stage is the horizontal driver and can be an ECG199 bipolar transistor (GTE).

H HOLD



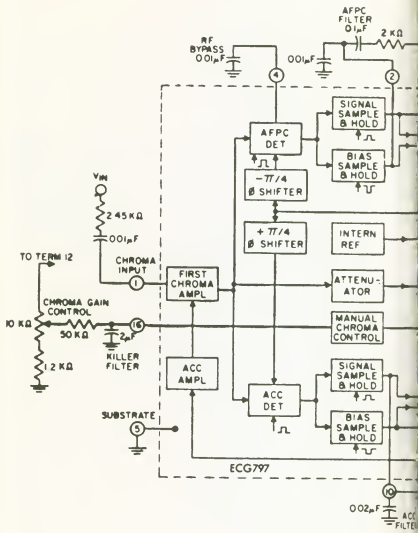
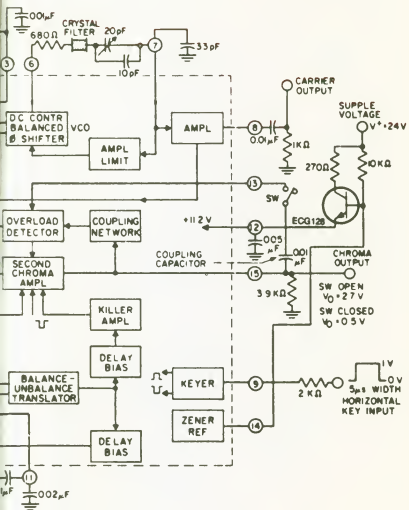


Fig. 57-15. Color TV chroma processor using an ECG797 16-pin QIP with AFPC, ACC, and killer (GTE).



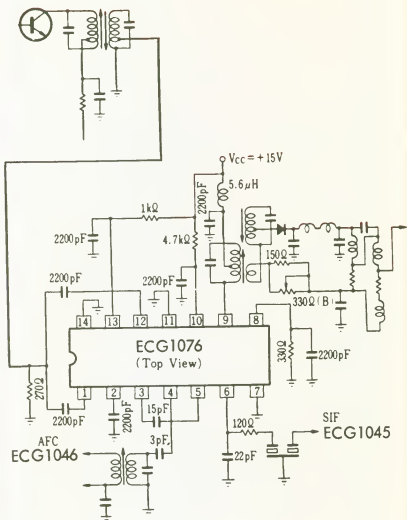


Fig. 57-17. TV video IF output and detector with AFT and sound take-off output. All coils and transformers are standard and can be purchased at a local electronic parts jobber (Merit or Miller components). Sound output at 4.5 MHz is typically 300 mV RMS. AFT output is typically 210 mV RMS at a test frequency of 57 MHz. Typical voltage gain for the video IF is 36 dB (GTE).

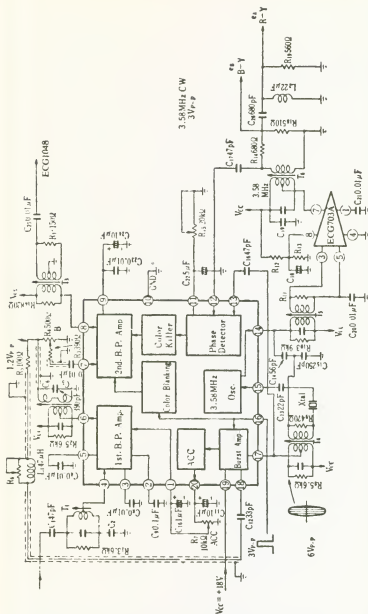


Fig. 57-18. Color TV chroma processor using an ECG 1069 20-pin DIP. The ECG 1048 noted on the schematic is a chroma demodulator. The ECG703A is a 3.58 MHz amplifier (GTE).

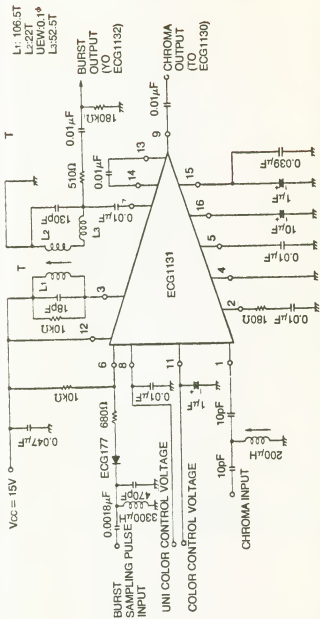


Fig. 57-21. Color TV chroma signal amplifier. The ECG1131 is a 16-pin DIP and consists of a chroma amplifier, an ACC amplifier, an ACC amplifier, a burst gate amplifier, an ACC peak detector, a color killer, a DC chroma gain control, a DC uni-color control and a balanced sampling circuit for the burst 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).

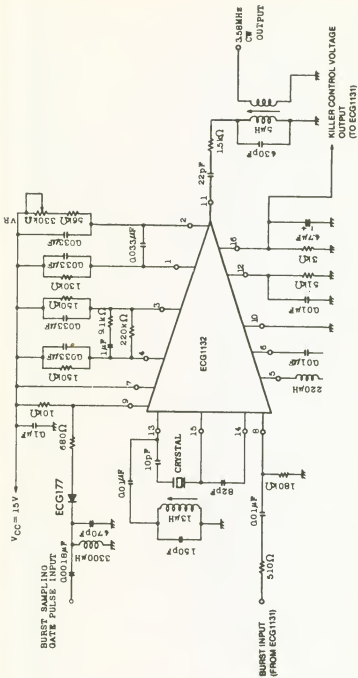


Fig. 57-22. Color TV subcarrier generator. The crystal shown is for 3.58 MHz. The ECG1131 noted on the schematic is a chroma signal amplifier. The ECG1132 is a 16-pin DIP (GTE).

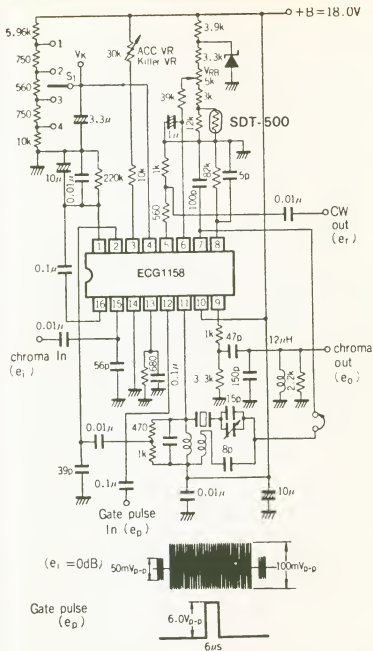
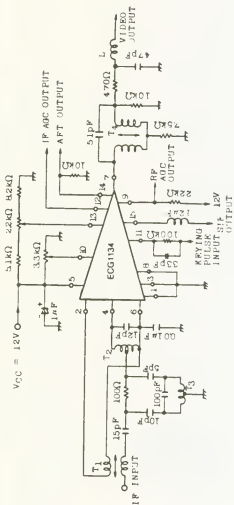


Fig. 57-23. Color TV chroma processor. The ECG1158 includes the functions for chroma amplifier, oscillator, ACC, color killer and color control (GTE).



T_1 : 1 (PRIMARY)	0.18 mm ϕ 3T-3T (BIFILAR WOUND)	0.37 μ H
2 (SECONDARY)	0.18 mm ϕ 4T (CENTER OVERLAPPING WOUND)	0.25 μ H
T_2 :	0.18 mm ϕ 3T (BIFILAR WOUND)	0.4 μ H
T_3 :	0.6 mm ϕ 2-3/4T (CENTER TAPPED)	0.11 μ H
T_4 :	0.1 mm ϕ 27-7/8T (BIFILAR WOUND)	22 μ H
L :	0.1 mm ϕ 21T	1.2 μ H

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).

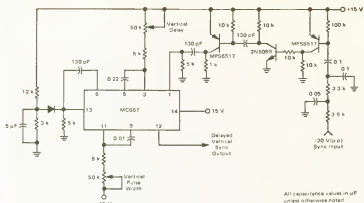


Fig. 57-25. TV vertical sync delay circuit.

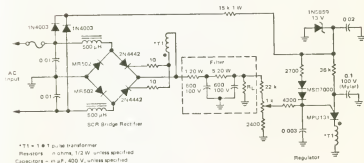


Fig. 57-26. Full-wave SCR bridge power supply for color TV rated at 80 volts, 1.5 amperes. This circuit is designed for 19-inch color receivers (M).

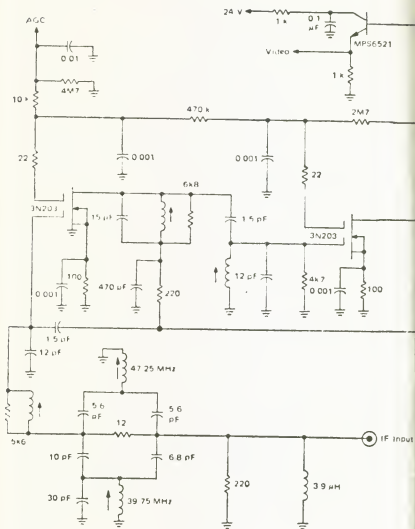
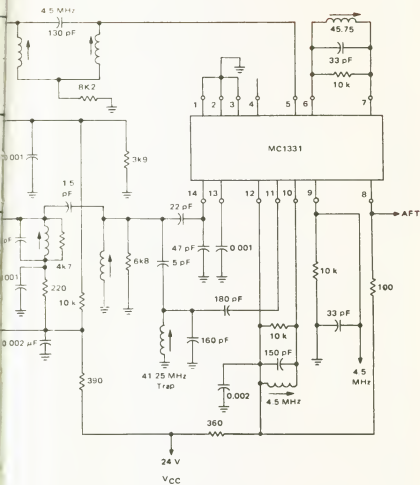


Fig. 57-27. Low-noise TV IF system with two FET amplifiers (M).



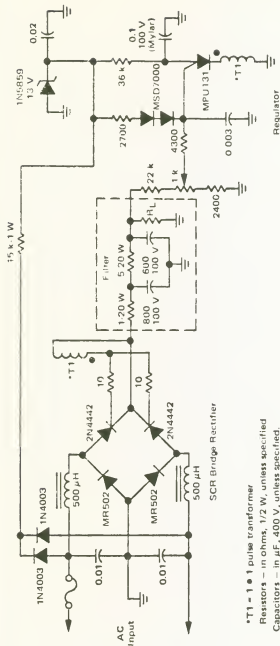
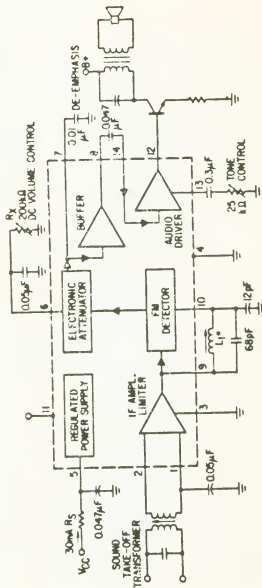


Fig. 57-28. A 4.5 MHz color TV sound IF amplifier using ECG703A. In a color TV the 4.5 MHz IF is not generated in the video detector as in B&W sets. A separate transistor sound detector, driven from the final video IF amplifier, is used to develop the 4.5 MHz IF. The driver transformer at the input of 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).



* $L_1 = 16\mu\text{H}$ NOMINAL, $Q(\text{UNLOADED}) = 50$

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).

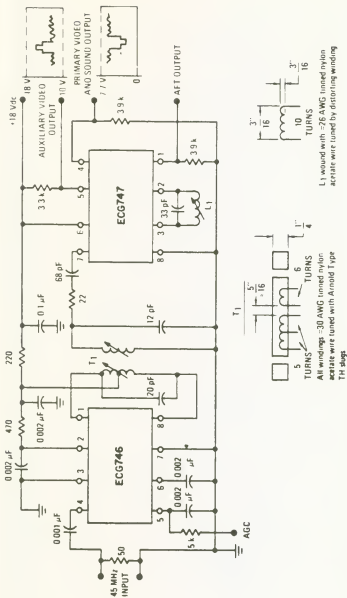


Fig. 57-30. Typical ECG746 video IF amplifier and ECG747 low-level video detector circuit (GTE).

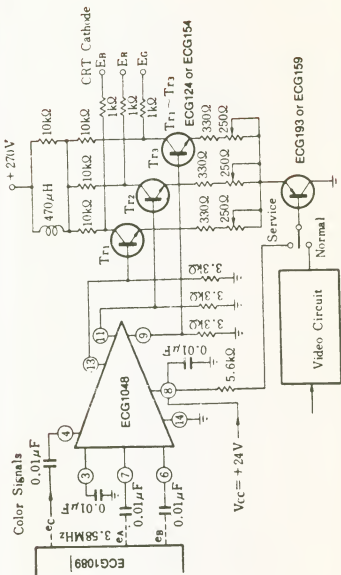


Fig. 57-31. Color TV chroma demodulator. The ECG1048 is a 14-pin DIP with an end metal tab. The ECG1089 partially shown is a color processor chip (GTE).

Chapter 58

Video Amplifiers

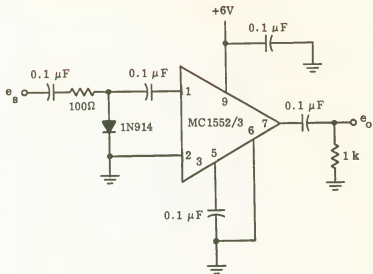


Fig. 58-1. Video amplifier with AGC using an MC1552/1553 wide-band amplifier (M).

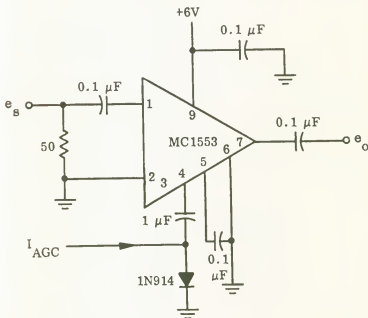


Fig. 58-2. Video amplifier with AGC using an MC1553 wide-band amplifier (M).

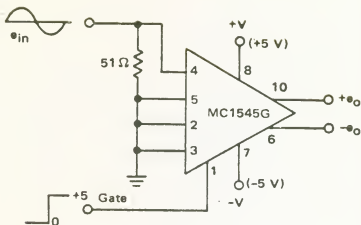
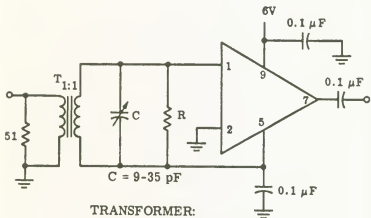


Fig. 58-3. Video switch. With a logic one at pin 1 the amplifier is turned on (M).



TRANSFORMER:
12 TURNS

#30 AWG SE WIRE ON 1/4" FORM

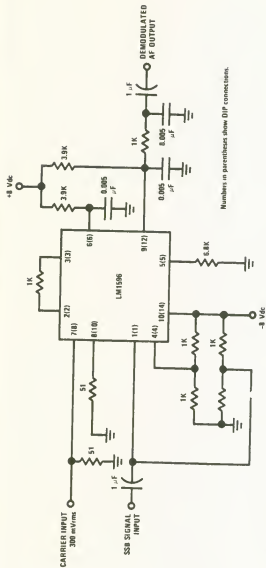
$L_p = 1\mu h$

$L_s = 1\mu h$

$L_m = 0.35\mu h$

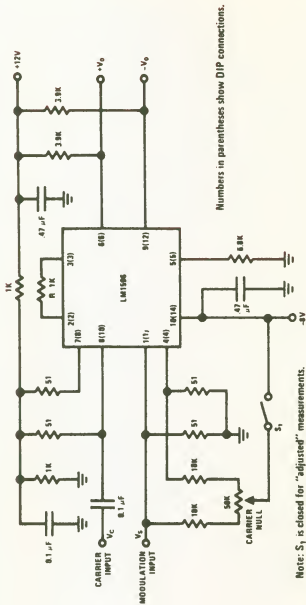
Fig. 58-4. 30 MHz video amplifier using an MC1552G. Set R to 1K for a voltage gain of 55 (M).

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).



Note: S_1 is closed for "adjusted" measurements.

Fig. 59-2. Suppressed carrier modulator (NS).

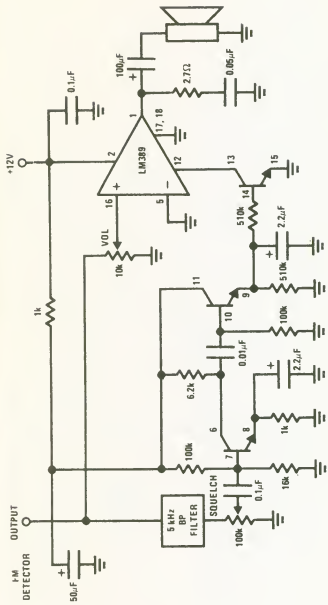


Fig. 59-3. FM scanner noise squelch circuit (NS).

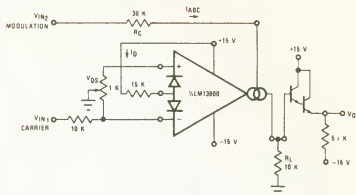


Fig. 59-4. Amplitude modulator (NS).

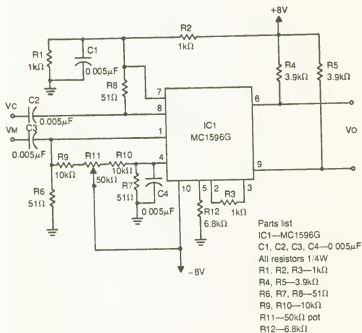


Fig. 59-5. Typical amplitude modulator circuit.

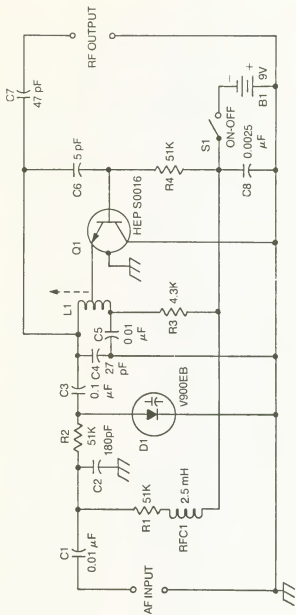


Fig. 59-6. Frequency modulator (self-excited oscillator).

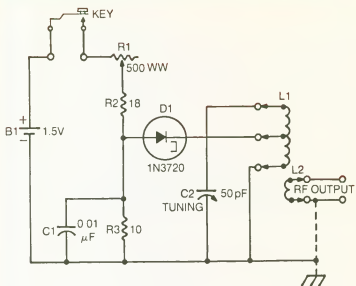
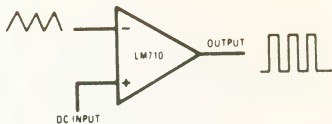


Fig. 59-7. Flea-powered CW transmitter.

Chapter 60

Waveform Generators



* PIN CONNECTIONS SHOWN ARE FOR METAL CAN.

Fig. 60-1. Pulse width modulator (NS).

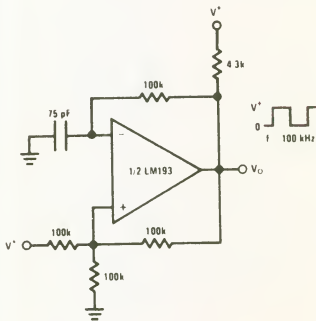


Fig. 60-2. Square wave oscillator (NS).

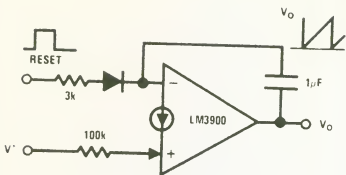


Fig. 60-3. Sawtooth generator (NS).

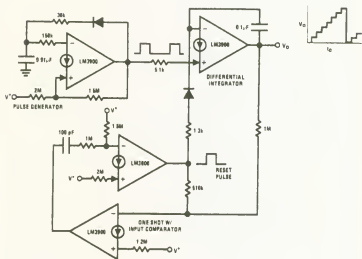


Fig. 60-4. Free-running staircase generator pulse counter (NS).

($V^+ = 15 \text{ Voc}$)

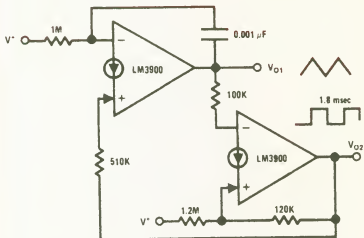


Fig. 60-5. Triangle/square generator (NS).

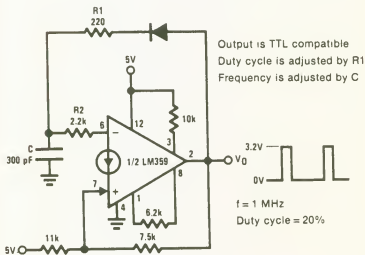


Fig. 60-6. Pulse generator (NS).

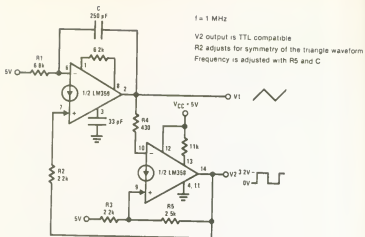


Fig. 60-7. Triangle waveform generator (NS).

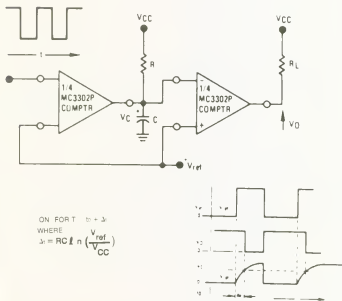
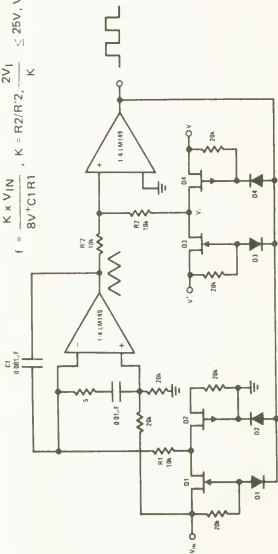


Fig. 60-8. Time delay generator (M).

$$f = \frac{K \times V_{IN}}{8V^+C1R1}, \quad K = \frac{R2/R'2}{K} \leq 25V, \quad V^+ = V^-, \quad V_S = \cdot 15V$$



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).

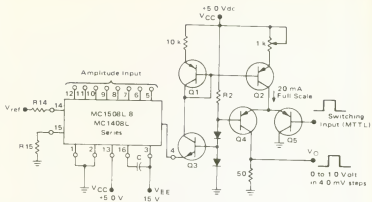


Fig. 60-10. Programmable Pulse generator (M).

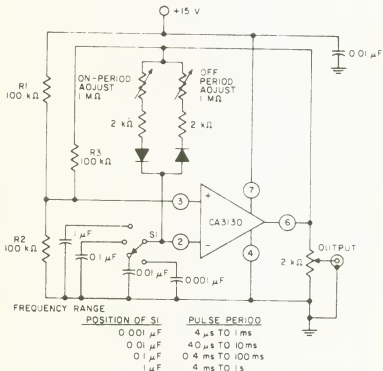
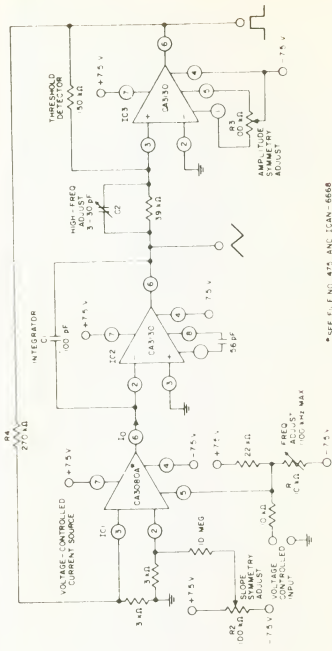


Fig. 60-11. Pulse generator (astable multivibrator) with provisions for independent control of "ON" and "OFF" periods (RCA).



* SEE FILE NO. 475 AND ICAN-6668 FOR TECHNICAL INFORMATION

Fig. 60-12. Function generator—(frequency can be varied 1,000,000/1 with a single control) (RCA).

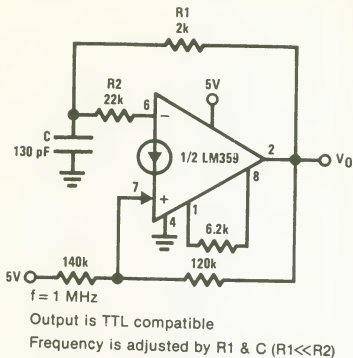


Fig. 60-13. Squarewave generator (NS).

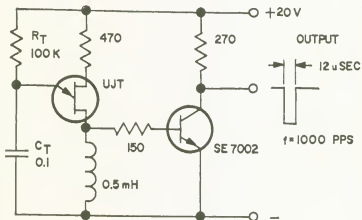


Fig. 60-14. Pulse generator uses unijunction. Pulse width is determined by base 2 inductance. Rise and fall times will be 2-5% of pulse width.

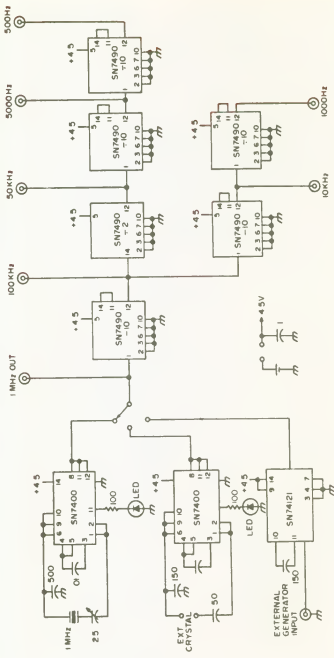
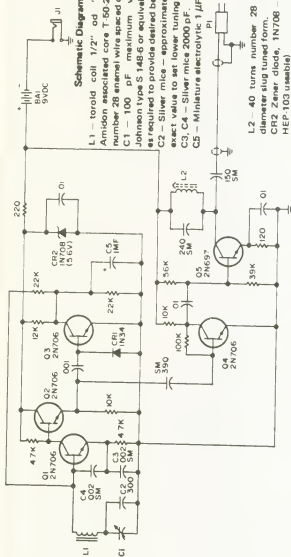


Fig. 60-15. Universal frequency generator divides input signal (1 MHz master oscillator, crystal oscillator, or any external sine-wave source) by factor of 10 or 2. Note gates driving LEDs, which light to indicate crystal is oscillating. (Output frequencies shown are for 1 MHz oscillator.)



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 bandwidth.
- 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 μ F 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 useable)
- 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. 60-19. This simple sawtooth generator could be added to a monitor oscilloscope.

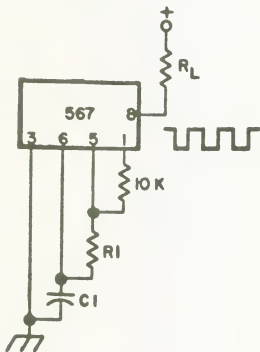


Fig. 60-20. Pulse generator with 25% duty cycle.

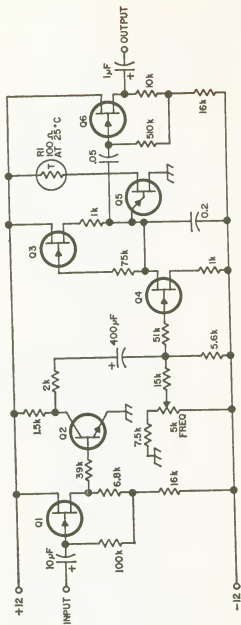


Fig. 60-21. This simple sawtooth generator is linear within 2% and may be adjusted from 1 kHz to 3 kHz with the center frequency control. Q1, Q3, Q4 and Q6 are FETs such as the 2N3819, 2N3820, T1S34, MPF105 or HEP 801; Q2 is a 2N388, 2N2926, 2N3391, SK3011 or HEP 54; Q5 is a 2N1671, 2N2160, 2N2646, 2N3480, or HEP 310.

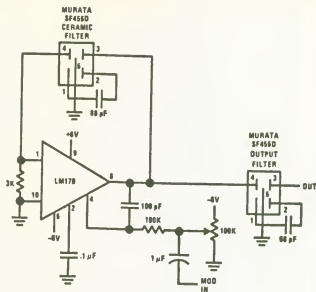


Fig. 60-22. A 455 kHz modulated, regulated output signal generator.

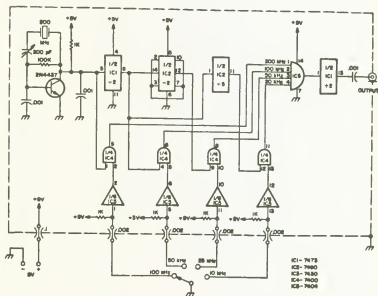
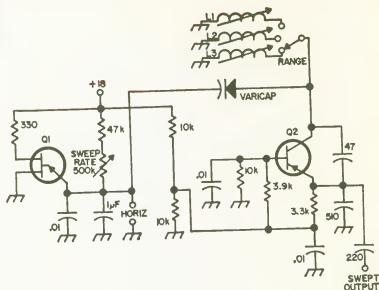


Fig. 60-23. Crystal calibrator. This circuit gives symmetrical square waves out on 100, 50 25, and 10 kHz. The frequency switch may be any distance from the totally shielded calibrator, as the lines have only dc levels.



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 capacitance diode such as the 1N955 or TRW V56.

TM - THERMISTOR, VECO 35CI or equiv. (8K COLD)

$$f_{OUT} = \frac{1}{2\pi RC} = \frac{.159}{RC}$$

ICI - MCH48BP

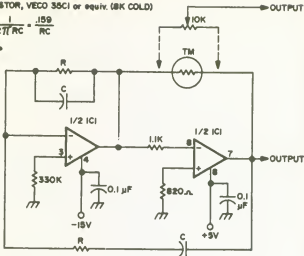


Fig. 60-25. A simple sine-wave generator.

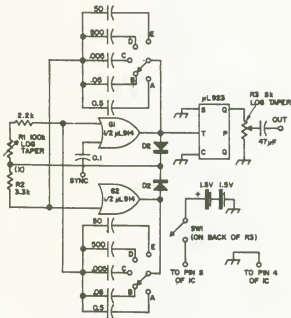


Fig. 60-26. Complete square-wave generator. Bandswitching capacitors are 10% or tolerances. Resistors are 1/4 watt.

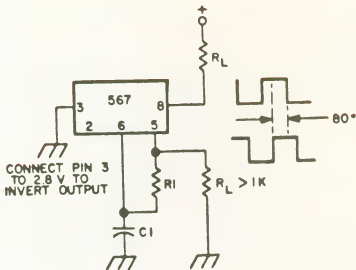
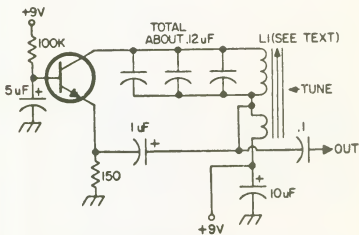


Fig. 60-27. 567 IC makes simple dual square-wave source. Note 80° phase shift between waves.



L1 = MILLER 9009, 180 TO 750 mH,
WITH ADDED TURNS

Fig. 60-28. A 2000 Hz test oscillator. L1 is commercial 180 mH coil with about 80 added turns.

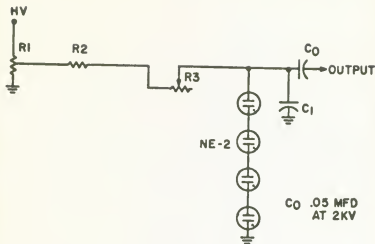


Fig. 60-29. Simple sweep generator for monitor scopes provides 30 Hz sawtooth from NE2 neons.

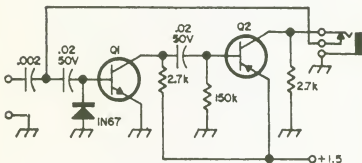


Fig. 60-30. This signal injector/tracer switches from the injection mode to a signal tracer by simply plugging in a pair of high-impedance magnetic earphones. As a tracer, it works from audio up to 432 MHz. Transistor Q1 is a 2N170, 2N388A, 2N1605, SK3011, or GE-7; Q2 is a 2N188A, 2N404, 2N2953, SK3004 or HEP 253.

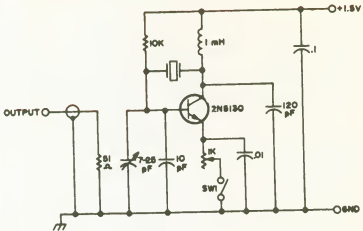


Fig. 60-31. Extremely stable signal generator provides output in range from 1.8 to 450 MHz at impedance of 50 ohms; output is adjustable from 80 nV to more than 50 mV rf.

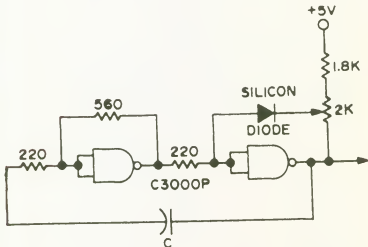
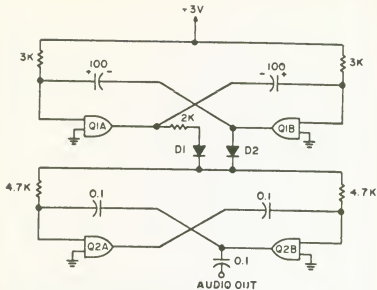


Fig. 60-32. Square-wave generator will operate over a wide frequency range from audio to rf. Capacitor and pot control frequency.



D1,D2 = 1N34 or other germanium.
 Q1,Q2 = μ L914 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.

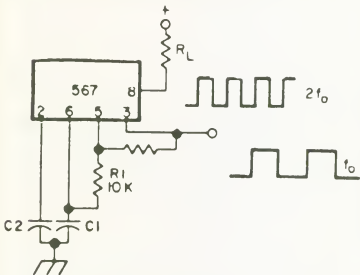


Fig. 60-34. Oscillator with double frequency output.

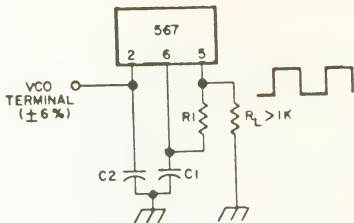


Fig. 60-35. Precision oscillator with 20 nsec switching.

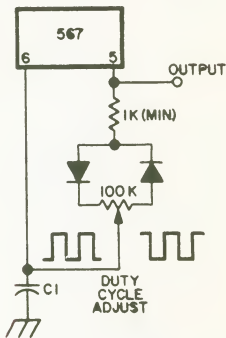


Fig. 60-36. Pulse generator (S).

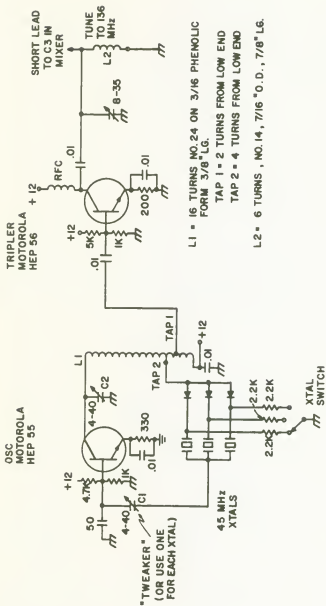


Fig. 60-37. A 45 MHz oscillator and tripler section.

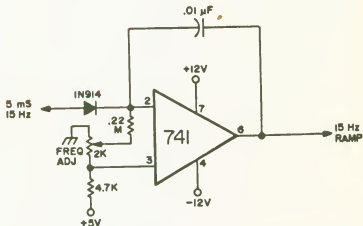
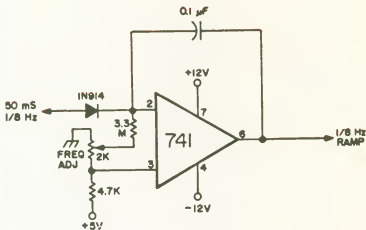
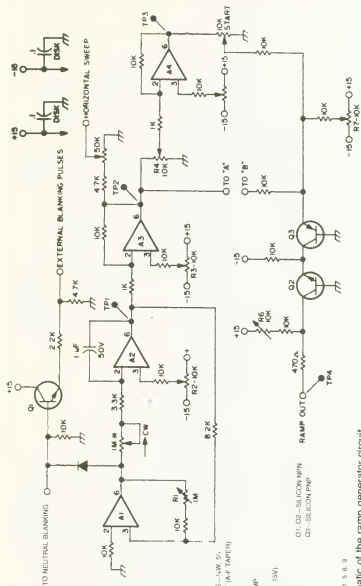


Fig. 60-38. SSTV ramp generators. This circuit will give an extremely linear ramp for SSTV monitors, cameras, and flying spot scanners. The voltage varies from ≈ -10 to $+10\text{V}$. A positive going pulse of $+2$ to $+5\text{V}$ amplitude resets the ramp for the next sweep.



ALL FIXED RESISTORS— $\frac{1}{2}$ W, 5%
 *SWEEP TIME ADJUST (A-F TAPE(R))
 R1-R7 BECKMAN 89 P
 15-TURN TRIMMERS
 A1 A4 TYPE 741 OP-AMP
 TO-5 CASE
 (PIN 7 = +15V PIN 4 = 15V)



741 BOTTOM
 NOTE OFF PINS 1 5 8 9

Fig. 60-39. Schematic of the ramp generator circuit.

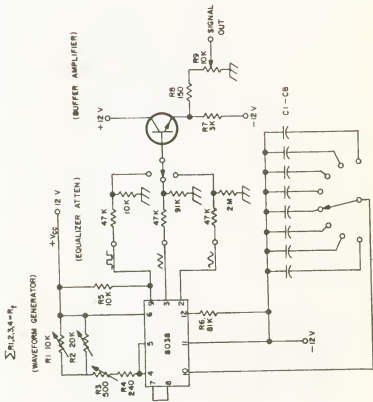
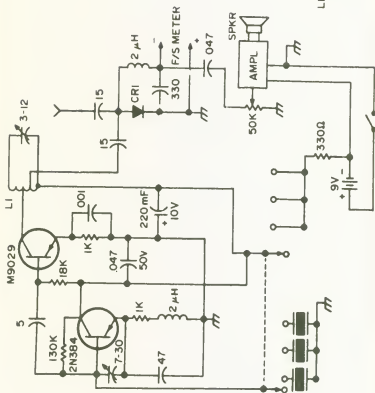


Fig. 60-40. Schematic of the triple-wave output signal generator.



L1=5T #16, 3/8 in DIA
CENTERTAPPED
OUTPUT TAP, 1 TURN UP
FROM COLD END

Fig. 60-41. Signal generator/amplifier.

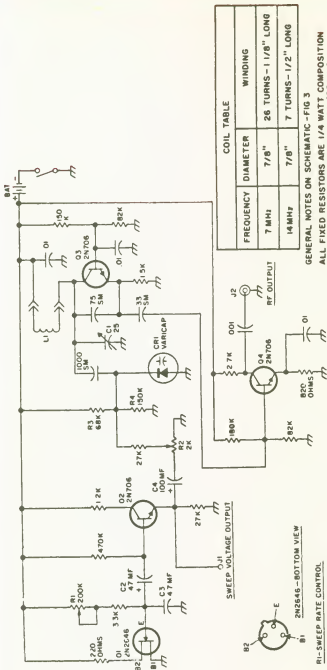


Fig. 60-42. Sweep oscillator circuit.

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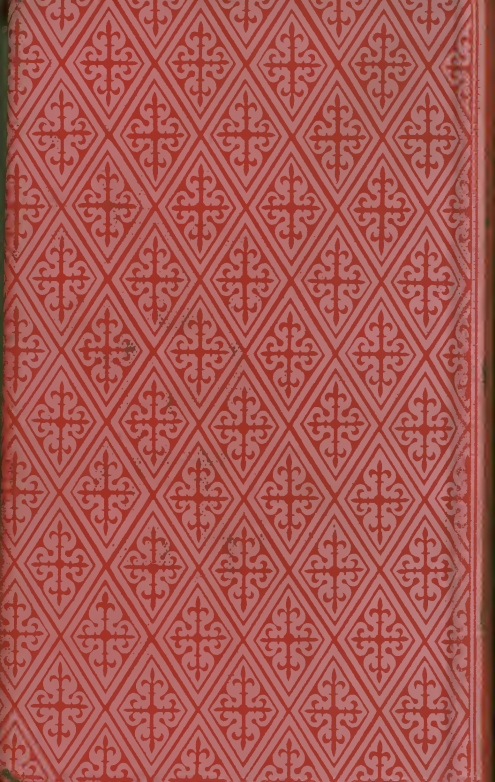












p237 - Converter for RMS

$\pm 15V$ 11 action 235 - 245

p244 - DC to AC converter $\pm 15V$
555

INverters p367 - 370

p.368 = $\pm 12V$ DC To 115V, 60 Hz

see Fig 11-13

100W output