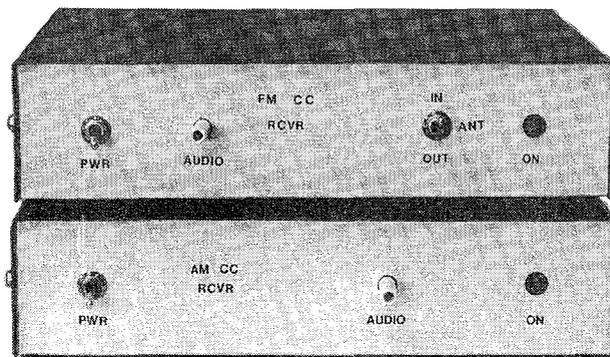


CARRIER CURRENT RECEIVER

LAST MONTH WE WENT OVER the operating theory of a carrier-current transmitter, and then showed you how to build one. Now we will describe two receivers that can be used with that transmitter. One receiver is a simple AM unit, best suited for applications where some noise can be tolerated (such as speech), and the other one is for wide-band FM use. Both receivers have an output that can be connected directly to a speaker.



**WILLIAM SHEETS and
RUDOLF F. GRAF**

AM receiver

Figure 1 shows the AM-receiver schematic. It is a TRF- (Tuned Radio Frequency) type receiver, meaning that there is no signal mixing or heterodyning; the unit is tuned only once upon calibration, and then left alone. It has a sensitivity of about 1 millivolt at the input for an audio output of ½-watt.

Capacitor C22 couples audio signals from the power line to the PC board—it *must* be rated at 600-volts DC. R8 will cause F1 to blow if C22 shorts. As another safety precaution, the chassis of the unit must be grounded. If an older two-wire electrical system is used, the receiver must be grounded to a cold-water pipe.

The signal from C22 goes to a tuned network (C1–C5 and L1 and L2) that has a 20-kHz bandwidth, which allows only the desired signal to pass through. A jumper (J) between the line (antenna) and the input network can be removed for reception of very strong signals if distortion (overload) becomes a problem.

IC1 is a “gain block” IF chip, normally used for TV IF applications, but it is useful at low frequencies as well. It has AGC (Automatic Gain Control) capability and approximate-

ly 60 dB of gain. Components C8, C9, and L3, which are placed across the output of IC1, are broadly resonant around 280 kHz. C10 couples RF to detector-diode D1, which is used as an envelope detector.

AGC, which keeps the receiver output relatively constant, is obtained in the following manner: The cathode of D1 is connected to the variable resistor R5. A voltage from 4 to 6 volts appears on the cathode of D1 even with no received signal. When a signal is received, the DC voltage at the anode of D1 increases. That DC voltage appears across C14 (the detector output), and is then fed through R3 and C13, which remove audio components, to the base of Q1. The voltage at the emitter of Q1 is fed to pin 5 of IC1. A more positive voltage tends to reduce the gain of IC1, which in turn reduces the signal fed to D1 and subsequently the DC voltage at pin 5.

Complete your

carrier-current

audio system with an

AM or FM receiver.

The detector output is taken from C14, which sets the upper frequency limit at about 10 kHz or so. By reducing the value of C14, a higher frequency response can be obtained; but using the FM receiver, which will be described later, is a better approach. The detector output is connected to an external jack. Audio components are fed to audio-gain control

R6, through C16 to IC2, an audio amplifier. C18 couples up to ½-watt of audio to an external speaker.

Power for the AM receiver is supplied via T1, D2, and IC3. The power supply formed by those components provides a regulated 12-volts DC across C19.

FM receiver

The schematic of the FM receiver is shown in Fig. 2, and it operates as follows: Input signals from the power line are coupled through C23 and R19 to the input filter network. As with the AM transmitter, C23 *must* be rated at 600 volts. Switch S2 is used as an attenuator. It is provided to prevent receiver overload in case it is located too close to the transmitter. Signals above about 500 kHz are rejected by C1, which reduces the tendency for the filter network to “leak” signals at frequencies far above the passband. Components C2–C7, L1–L3, and R1 and R20 form a triple-tuned bandpass filter having a passband from 220–340 kHz. Signals from the filter are fed to pin 4 of IC1, an MC1350P “gain block” IC, which is used as a tuned RF amplifier. C8 and C9 provide internal bypassing for the chip. R2 biases IC1 so that it operates at maximum gain. An amplified signal appears at pin 8 of IC1. L4 provides DC bias and high RF impedance to pin 8, and D1 and D2 provide amplitude

PARTS LIST

AM RECEIVER

All resistors are 1/4-watt, 10%, unless otherwise noted.

R1—4700 ohms
R2—1000 ohms
R3—47,000 ohms
R4, R8—47 ohms
R5—10,000 ohms, potentiometer
R6—50,000 ohms, potentiometer
R7—10 ohms
R9—680 ohms

Capacitors

C1, C5—33 pF, NPO
C2, C4—3-40 pF trimmer
C3—3 pF, NPO
C6, C7, C17—0.1 μ F, 50 volts, Mylar
C8, C9—330 pF, NPO
C10, C14, C21—0.01 μ F, disc
C11, C15—10 μ F, 16 volts, electrolytic
C12, C13, C16—1 μ F, 50 volts, electrolytic
C18—470 μ F, 16 volts, electrolytic
C19, C20—2200 μ F, 16 volts, electrolytic
C22—0.1 μ F, 600 volts

Semiconductors

IC1—MC1350P gain block IF
IC2—LM386 audio amplifier
IC3—LM7812 12-volt regulator
D1—1N914B silicon diode
D2—1N4002 or 1N4007 rectifier diode

LED1—red light-emitting diode
Q1—2N3565 NPN transistor

Other components

L1, L2, L4—4.7 mH inductor
L3—470 μ H inductor

F1—1-amp fuse
S1—SPST switch
T1—12-volt, 450-mA transformer
J1—J4—RCA jack

Miscellaneous: PC board, cabinet, hardware, grounded AC line cord, etc.

PARTS LIST FM RECEIVER

All resistors are 1/4-watt, 10%, unless otherwise noted.

R1, R10—15,000 ohms
R2, R4—R7, R17—4700 ohms
R3, R19—47 ohms
R8, R15—10,000 ohms
R9—10,000 ohms, potentiometer
R11—2200 ohms
R12—22 ohms
R13—10 ohms
R14, R20—22,000 ohms
R16—100,000 ohms
R18—50,000 ohms, potentiometer
R21—680 ohms

Capacitors

C1—0.0015 μ F, 50 volts, Mylar
C2, C4, C6—56 pF, NPO
C3, C5—24 pF, NPO
C7—150 pF, NPO
C8, C9, C22—0.1 μ F, 50 volts, Mylar
C10, C17, C18—1 μ F, 50 volts, electrolytic
C11, C24, C26, C27—0.01 μ F, disc
C12, C13—10 μ F, 16 volts, electrolytic
C14, C29—0.001 μ F, 50 volts, Mylar
C15—47 pF, NPO
C16—0.01 μ F, Mylar
C19, C20—470 μ F, 16 volts, electrolytic

C21—0.0033 μ F, 50 volts, Mylar
C23—0.1 μ F, 600 volts
C25, C28—2200 μ F, 16 volts, electrolytic

Semiconductors

IC1—MC1350P gain block IF
IC2—LM565 PLL detector
IC3—LM386 audio amplifier
IC4—LM7812 12-volt regulator
D1, D2—1N914B silicon diode
D3—D6—1N4002 rectifier diode
LED1—red light-emitting diode
Q1, Q2—2N3565 NPN transistor

Other components

L1—L4, L6—4.7 mH inductor
L5—470 μ H inductor
F1—1-amp fuse
S1, S2—SPST switch
T1—12-volt, 450-mA transformer
J1, J2—RCA jack

Miscellaneous: PC board, cabinet, hardware, grounded AC line cord, etc.

Note: The following items are available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804. A kit of parts containing a PC board and everything that is installed on it; For the AM receiver: \$28.50. For the FM receiver: \$38.50. A PC board for either receiver is available for \$10.00 each. Add \$2.50 to any order for postage and handling. NY residents must include sales tax.

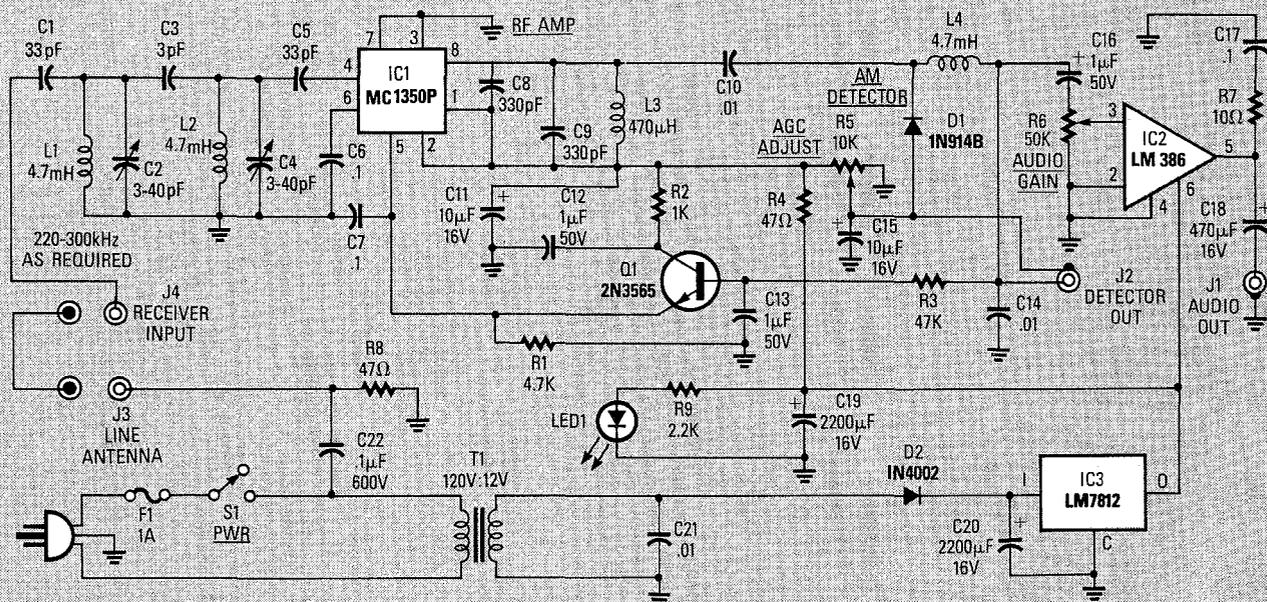


FIG. 1—THE AM RECEIVER. Shown here is the complete, and rather simple circuit, which is best suited for receiving speech.

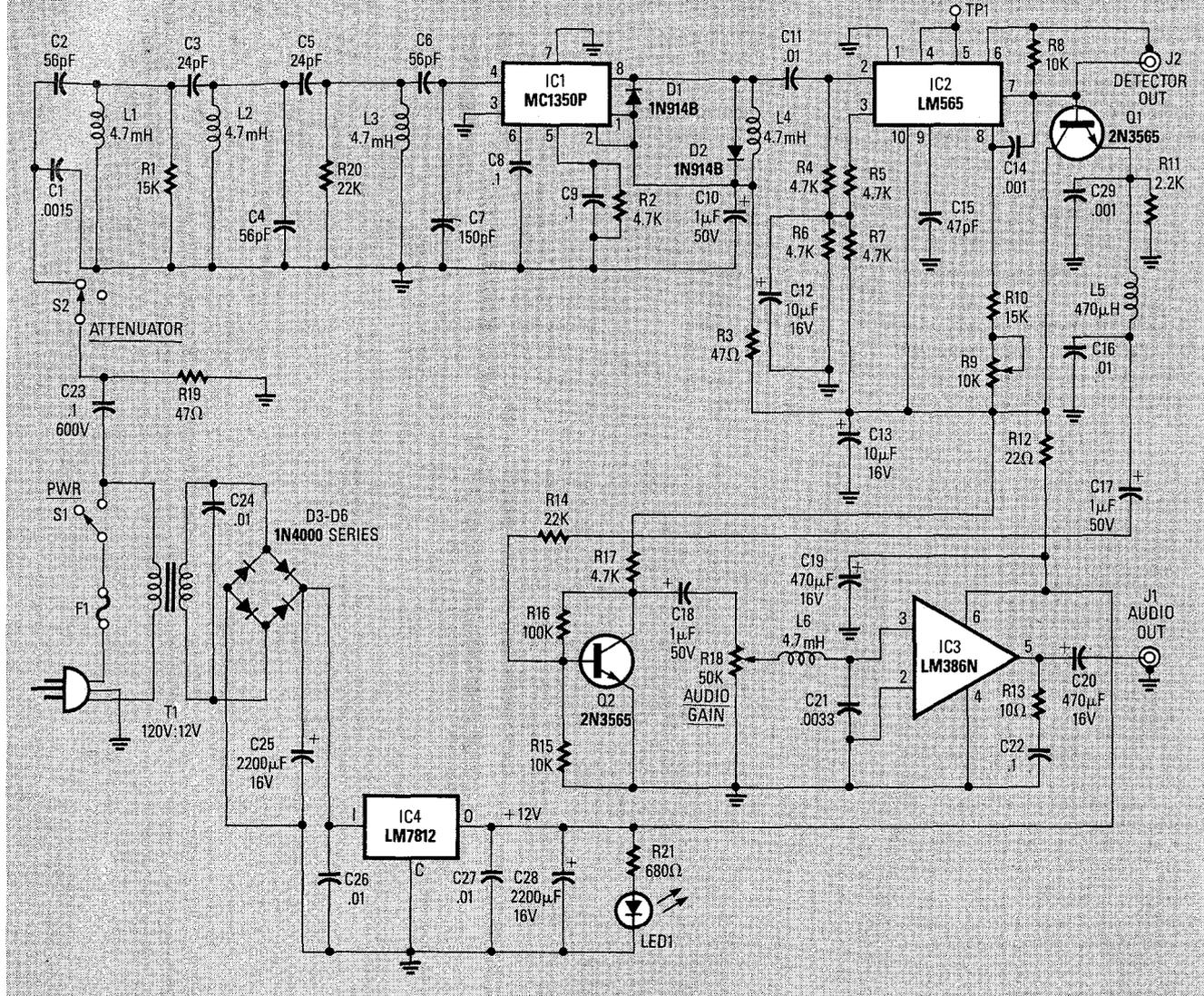


FIG. 2—THE FM RECEIVER. This receiver is slightly more complex than the AM receiver.

limiting of the FM signal. C10 and R3 form a decoupling network, and C11 couples the signal from IC1 to IC2, and also blocks DC.

IC2, an LM565 PLL, is used as an FM demodulator. Pins 8 and 9 are connected to an internal VCO (Voltage Controlled Oscillator), and components R9, R10, and C15 set the VCO's free running frequency. The output of the VCO appears at pin 4, and is fed right back in to pin 5, which is the input to the internal phase detector (the test point between those two pins is used for setting the PLL's VCO frequency—280 kHz in this application). The VCO signal and the input signal (from pin 2) are compared in the phase detector. The output from the phase detector is internally amplified, and then appears at pin 7. The output at pin 7 is a replica of the original modulation on the FM input

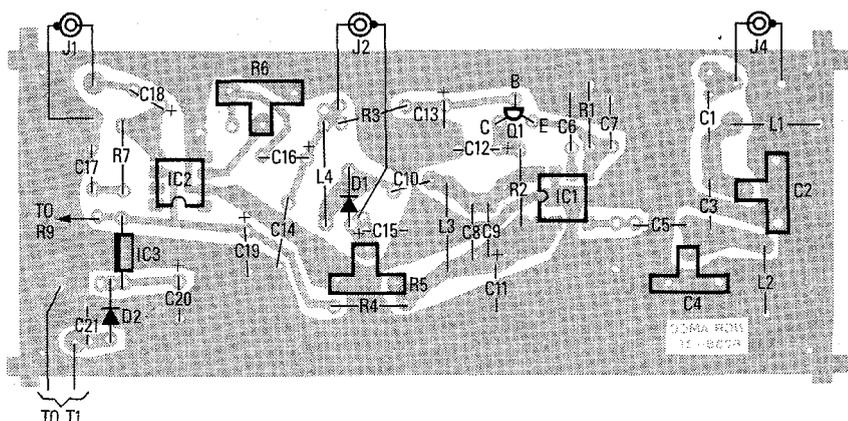


FIG. 3—AM PARTS PLACEMENT. Follow this diagram when building the PC board for the AM receiver.

signal to the receiver; the output (pin 7) is therefore the recovered audio. (The outputs from pins 6 and 7 are externally available for future interface purposes.)

The detector output at pin 7 is cou-

pled to Q1 and R11. Components C16, C29, and L5 form a low-pass filter that eliminates 280-kHz components from IC2's output. C17 and R14 couple audio to the base of Q2, which, in conjunction with R15, R16, R17, and

C18, form an audio amplifier that brings the recovered audio up to around 1-volt peak-to-peak. R18 is a volume control, and L6 and C27 suppress any remaining 280-kHz components. The signal is then fed into IC3, an LM386N audio amplifier, which can deliver up to ½-watt of audio, coupled via C20, to any standard 8-ohm external speaker.

A power supply for the FM receiver is made up of T1, a bridge rectifier made up of D3–D6, and the 12-volt regulator, IC4. The power-supply requirements concerning ripple and noise are more stringent for the FM receiver than the AM receiver.

Construction

The Parts-Placement diagrams for the AM and FM receivers are shown in Figs. 3 and 4 respectively. You can build the receivers using PC boards made from the foil patterns given in PC Service, or else by using the ready-made PC boards that are available from the source mentioned in the Parts List. Complete parts kits containing all components that mount on the PC boards are also available from that same source for either receiver. Otherwise, all of the components, with the exception of the chokes and coils, are readily available from many suppliers. Of course you only need

the parts for one of the receivers—either AM or FM, unless you want to build both.

Following Figs. 3 and 4 as a guide, start by first installing the fixed resistors, and then the capacitors. Next, install the coils and potentiometers, and the IC's last. It's always a good idea to leave the IC's for last, as they are susceptible to static damage. Use only rosin-core solder, and be sure to carefully inspect the PC board for shorts, solder bridges, and poor solder joints before applying power. All components that are not mounted on the PC board should be mounted to the chassis or soldered onto a terminal strip, as shown in Figs. 5 and 6. In the FM receiver, as you can see from Fig. 6, voltage-regulator IC4 is actually heat-sinked by mounting it to the bottom surface of the metal cabinet; IC4 is electrically grounded to the cabinet as well.

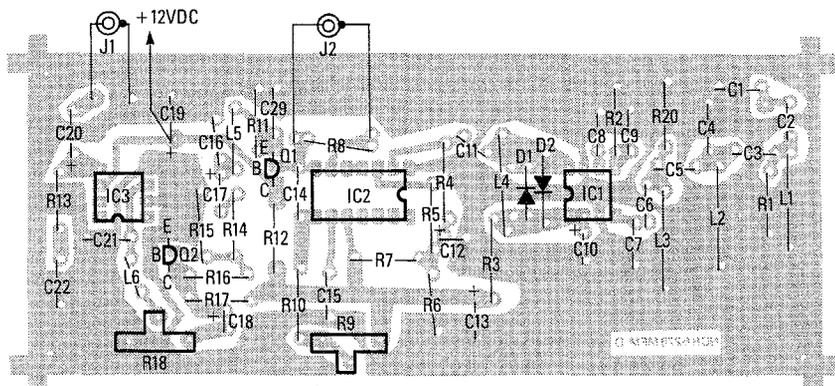


FIG. 4—FM PARTS PLACEMENT. Follow this diagram when building the PC board for the FM receiver.

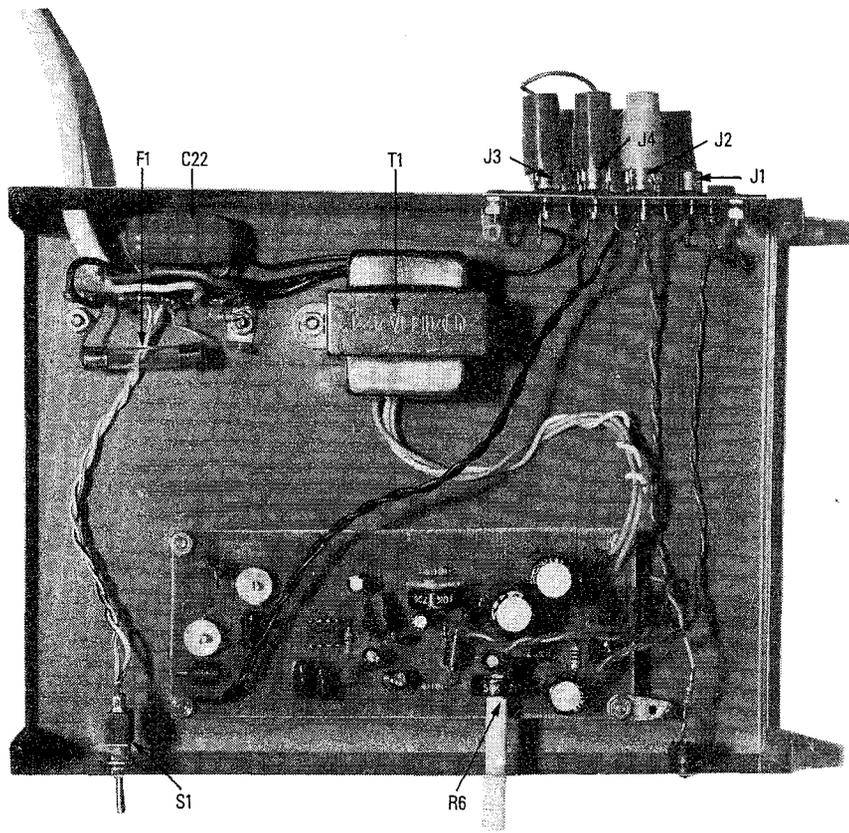


FIG. 5—THE PC BOARD for the AM receiver is installed inside the cabinet as shown. Notice the components that are *not* on the PC board.

Checkout

The following checks should be made before power is applied to either board:

AM receiver

- Check all coils for DC resistance: L1, L2, and L4 should be 48 ohms, and L3 should be 22 ohms.
- IC2, pin 6 to ground: 500 ohms or more (after 10 seconds).
- IC2, pin 5 to ground: 10K or more.
- IC1, pins 1, 2, 4–6, and 8 to ground: no shorts (should read more than 500 ohms).
- Make sure that D1 and D2 are correctly polarized.

Set all potentiometers at halfway, apply DC power, and check for the following positive voltages (all measurements are made with respect to ground):

- Across C20: 16 volts.
- Across C19: 12 volts.
- IC2 pin 5: 6 volts.
- IC1 pins 1, 2, and 8: 11.8 volts.
- Q1 collector: 11 volts.
- Q1 emitter: 6 volts (varies with R5).
- IC1 pin 5: 5 volts (varies with R5).

FM receiver

- Check all coils for DC resistance: L1–L4 and L6 should be 48 ohms, and L5 should be 22 ohms.
- IC3 pin 6 to ground: more than 500 ohms (after 10 seconds).
- IC3 pin 5 to ground: more than 10K.

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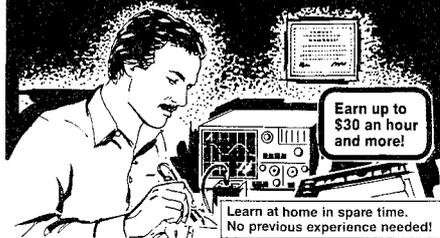


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CARRIER CURRENT

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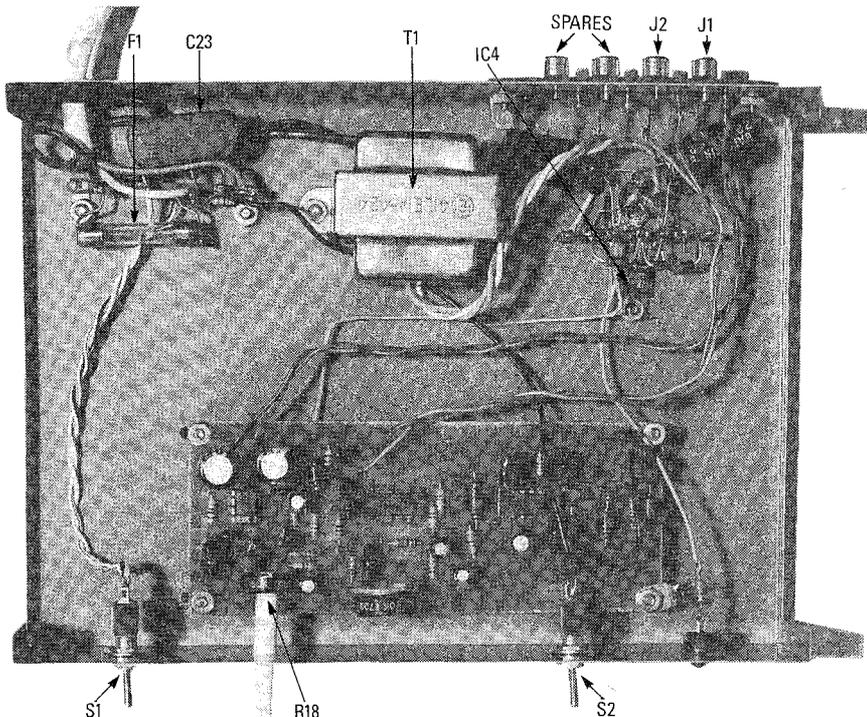


FIG. 6—THE PC BOARD for the FM receiver is installed as shown. Notice how the voltage regulator is mounted to the bottom of the cabinet; the cabinet serves as a heat sink.

- IC1 pins 1, 2, 4–6, and 8 to ground, and IC2 pins 2–10 to ground: no shorts (more than 500 ohms).

Set all potentiometers at halfway, apply DC power, and check for:

- Across C25: 16 volts (exact voltage depends on T1).
- IC3 pin 6: 12 volts.
- IC3 pin 5: 6 volts.
- Q2 collector: 7 volts.
- Q1 emitter: 9–10 volts.
- IC2 pin 7: 10–11 volts.
- IC2 pin 8: 10.5 volts.
- IC2 pins 2 and 3: 4 volts.
- IC1 pins 1 and 2: 11 volts.
- IC1 pin 5: 4 volts.

If everything's OK, connect a speaker to the output of either receiver. Apply power and continue:

AM receiver—Set R10 at about $\frac{2}{3}$ open (to get between 6 and 7 volts across C15). Apply a 1-millivolt, 30% amplitude-modulated signal at 280 kHz between C1 and ground. If no signal generator is available, connect a long (25 feet or so) piece of wire to that point and try to pick up some noise from an appliance, etc. peak C2 and C4 for maximum audio output. Adjust R5 so that the audio output stays relatively constant over a range of inputs between 1 millivolt and 1 volt. R5 will affect the receiver's gain,

so don't set it too high. Terminate the detector output terminals with a 1K resistor for that test.

FM receiver—Set R9 at midpoint and apply a 1-millivolt modulated signal with 40-kHz deviation, and then adjust R9 for minimum distortion. If no generator is available, set R9 at midpoint; you should hear a hiss in the speaker with no input signal. If possible, verify the frequency response of the input network by connecting a scope to pin 8 of IC1 and applying a CW signal (unmodulated) to the junction of C1 and C2. The signal should be low enough so that no more than 0.5 volts peak-to-peak appears at that pin, and also so that D1 and D2 do not conduct. Vary the signal frequency between 200 and 350 kHz, and plot the response (keep the input level constant). You should get ± 1 dB flatness or better between 240 and 330 kHz. If not, try adjusting the value of C3, C4, and C5 as required.

The boards are mounted as shown in Figs. 5 and 6. Another alternative is to install the receiver board and power supply inside an old speaker cabinet and use the existing speaker. Sometimes a speaker can be purchased for less than it might cost for just a project case alone.