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 wideband FM use. Both receivers have an output that can be connected directly to a speaker.

**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 1/2-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 approximately 60 dB of gain. Components C8, C9, and L3, which are placed across the output of IC1, are broadband 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.

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 1/2-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 CI, 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.
**AM RECEIVER**

All resistors are 1/8-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—9 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 µF, 50 volts, Mylar
- C8, C9—330 pF, NPO
- C10, C14, C21—0.01 µF, disc
- C11, C15—10 µF, 16 volts, electrolytic
- C12, C13, C16—1 µF, 50 volts, electrolytic
- C18—470 µF, 16 volts, electrolytic
- C19, C20—2200 µF, 16 volts, electrolytic
- C22—0.1 µF, 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 µH inductor

**PARTS LIST**

**FM RECEIVER**

All resistors are 1/8-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 µF, 50 volts, Mylar
- C2, C4, C6—56 µF, NPO
- C3, C5—24 pF, NPO
- C7—150 pF, NPO
- C8, C9, C22—0.1 µF, 50 volts, Mylar
- C10, C17, C18—1 µF, 50 volts, electrolytic
- C11, C24, C26, C27—0.01 µF, disc
- C12, C13—10 µF, 16 volts, electrolytic
- C14, C29—0.001 µF, 50 volts, Mylar
- C15—470 µF, NPO
- C16—0.01 µF, Mylar
- C19, C20—470 µF, 16 volts, electrolytic

**Semiconductors**

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

**Other components**

- L1—L4, L6—4.7 mH inductor
- L5—470 µH inductor
- F1—1-amp fuse
- S1, S2—SPST switch
- T1—12-volt, 450-mA transformer
- J1—J4—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.

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**FIG. 1—THE AM RECEIVER.** Shown here is the complete, and rather simple circuit, which is best suited for receiving speech.
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 detector output at 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 coupled 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 \( \frac{1}{2} \)-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. 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.

**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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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 TI).
  - 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 ½ 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, 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.