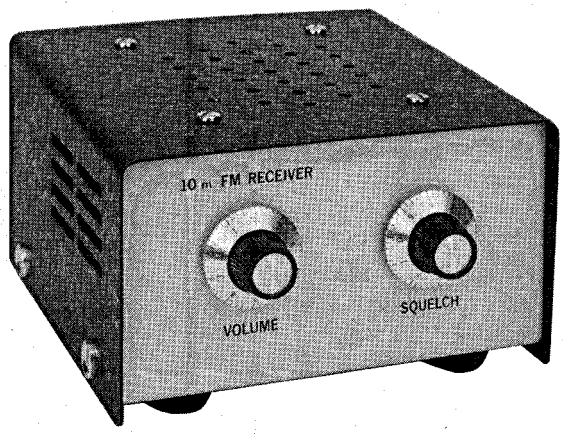
Simple QRP, Notch Filter, Switched C filter

A Simple 10-Meter FM Receiver



Need a 10-meter FM receiver for the SSTV signals WØORE will be sending back from the Shuttle? Build this simple, inexpensive receiver and you'll be ready for "Live, from space, it's ham radio!"

By Jonathan F. Towle,* WB1DNL

When Astronaut Tony England, WØORE, lifts off the launch pad later this spring and heads for space, he'll be using SSTV equipment and a 10-meter FM transmitter along with the regular 2-meter FM gear. If your station equipment is not capable of receiving FM signals on the 10-meter band, here's a simple FM receiver that can be built at home.

The only active circuit components are three ICs. Most parts are available from your local electronics supply house or your local Radio Shack. The second-LO crystal, the crystal filter, the RF coil in the front-end and the coil in the first LO are available from Semiconductors Surplus, Mouser Electronics or Amidon Associates (see Table 1).

A single 9-V supply was chosen to keep the project simple. Lower voltages limit the range of the audio amplifier, and higher voltages required more extensive regulation to operate the RF front-end IC.

Table 1
Parts Suppliers

Radio Shack (RS).
Semiconductors Surplus (SS), 2822 No. 32nd St. Unit 1, Phoenix, AZ 85008, tel. 602-956-9423.
Mouser Electronics (M), P.O. Box C, Lakeside, CA 92040, tel. 619-449-2222.
Amidon Associates, 12033 Otsego Street, North Hollywood, CA 91607, tel. 213-760-4429.

General Description

The block diagram in Fig. 1 may appear incomplete because many of the discrete parts you might expect to find in a typical FM receiver are contained within the ICs. The local oscillators are shown as separate blocks to indicate the frequency mixing that occurs in the circuit. The active components, however, are contained in the ICs.

The signal from the antenna is amplified and then mixed with a 39.7- to 40.4-MHz signal produced in the first LO. This creates a 10.7-MHz intermediate frequency (IF). This signal passes through a 10.7-MHz crystal band-pass filter into the narrow-band FM IC.

A second mixing process converts the 10.7-MHz IF to 455 kHz. The second IF is routed through a band-pass filter and then to a limiting amplifier to remove any AM signal components. Audio is recovered by a quadrature FM detector and sent to the squelch circuit and the audio amplifier. The squelch circuit is activated by noise when no audio signal is present. When the squelch circuit is triggered, the audio mute output grounds the audio amplifier input.

The audio amplifier is a high-gain device that provides more than enough output to drive an 8-ohm speaker. Frequency response is determined by the values of the components coupling the audio amplifier to the narrow-band FM IF IC.

Circuit Details

Refer to Fig. 2. Because all the active components in this receiver are contained in the three ICs, only four parts of the circuit must be tuned. Two are in the first LO, one in the front end, and the fourth is the coil in the quadrature discriminator.

The first LO uses a parallel LC circuit. L1 is a Zenith Radio coil of 6½ turns on a molded plastic form with an adjustable slug. A fixed-value silver mica and a trimmer capacitor, C1, complete the circuit. Tuning is accomplished by adjusting the trimmer capacitor after the circuit is brought into the correct range by adjusting the inductor.

The RF front-end coil, L2, consists of 18 turns of no. 28 enameled wire, center tapped, wound on an Amidon T-37-10 black (μ = 6) toroid core. Again, a fixed capacitor and a trimmer capacitor, C2, are used to resonate the circuit to the input frequency.

The SK7669 front-end chip is a low-power device that provides about 20 dB of conversion gain. The series diodes in the 9-V supply lead drop the voltage to the correct value for the device.

RF from the antenna is coupled into the device through a 0.01-μF capacitor coupled to pin 1. The output from pin 6 is connected to the crystal filter; filter bandwidth is approximately 15 kHz. The insertion loss

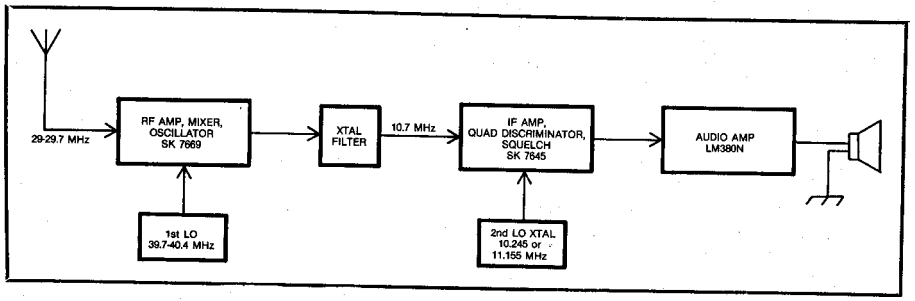


Fig. 1 — Block diagram showing frequency-mixing scheme of 10-meter FM receiver.

*ARRL Laboratory Engineer

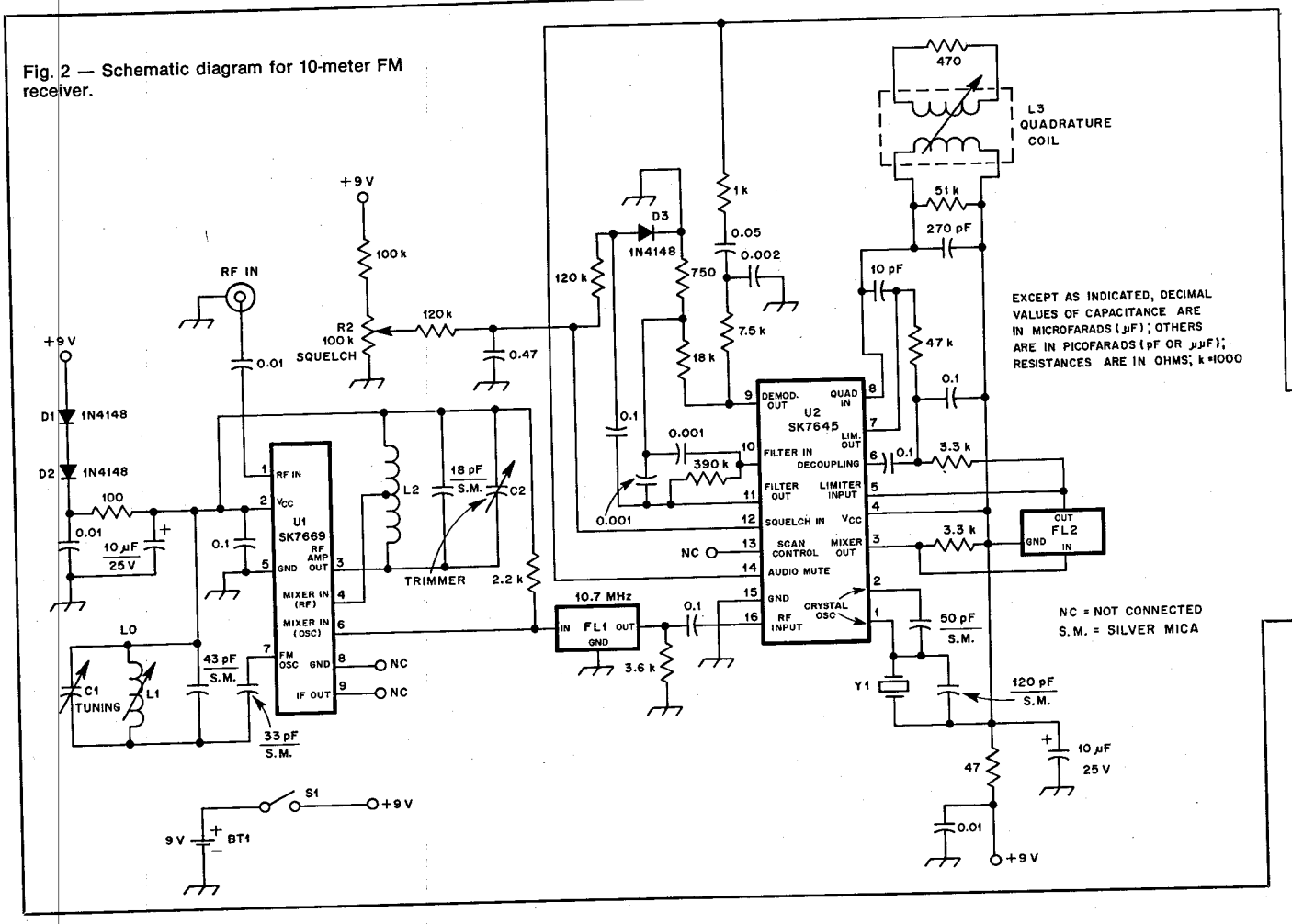


Fig. 2 — Schematic diagram for 10-meter FM receiver.

is less than 1 dB. A 2.2-kilohm resistor from pin 6 to the supply voltage provides a load and impedance matching for the crystal filter. A 0.01-µF capacitor between pins 2 and 5 prevents the front end from oscillating.

RF signals that pass through the crystal filter are coupled into the SK7645 FM IC through a 0.01-µF capacitor. The 3.6-kilohm resistor is used for impedance matching.

A crystal oscillator and doubly balanced mixer in the SK7645 convert the 10.7-MHz IF to 455 kHz. A ceramic filter provides band-pass filtering. Following the filter, the signals are amplified in the limiting amplifier and the audio is recovered in the quadrature detector. The quadrature coil, L3, is a 455-kHz IF transformer. The 470-ohm resistor on the secondary side of the transformer acts to lower the Q and broaden the circuit frequency response.

Audio output from pin 9 goes to the 10-kHz active band-pass filter to derive the squelch information. After some additional filtering, the audio is routed to the VOLUME control, a 10-kilohm potentiometer at the input of the LM-380N.

When an FM signal is not present, the noise output from the active band-pass filter is enough to forward bias the 1N4148 diode. This diode acts as a noise detector and, when forward biased, pulls pin 12 low. With pin 12 low, pin 14 is internally shorted to ground. Pin 14 is connected to the input of the LM-380N. This prevents any audio from reaching the amplifier.

The LM-380N is a common IC audio amplifier with very high gain, and has a tendency to oscillate at its output and back through the power supply. The 200-µF capacitor mounted next to pin 14 is necessary to keep the power supply quiet, while the 0.47-µF capacitor on pin 1 and the RC series filter on pin 8 keep the output from oscillating. A 10-kilohm resistor from pin 6 to ground keeps the audio signal centered between ground and the supply voltage.

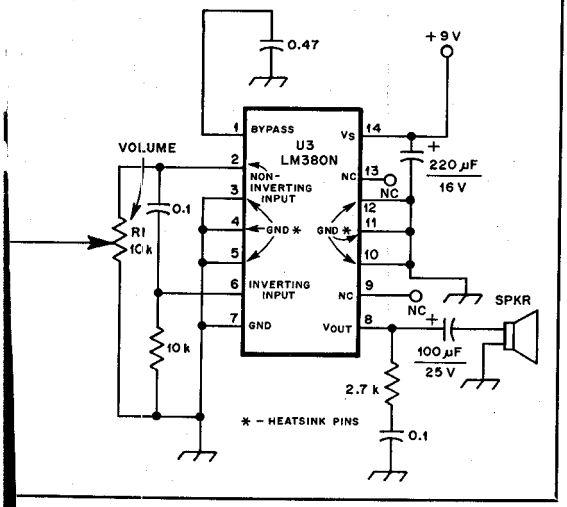
Construction

The receiver is constructed on a double-sided circuit board. Only one side of the board, however, is etched. This provides a ground plane under all circuit components. The etching pattern for the circuit is shown in the Hints and Kinks column, this issue. After the board is etched, the holes can be drilled to mount the components. Before mounting any components, it is necessary to drill away the copper around the holes on the top side of the board. (A 90° countersink works well for this.) Be careful not to drill all the way through the board with the counter-

Table 2
Parts List†

R1 — 10-kilohm audio potentiometer with SPDT switch (RS 271-215).
R2 — 100-kilohm linear-taper potentiometer (RS 271-092).
C1, C2 — 3-10 pF trimmer capacitor (RS 272-1338).
FL1 — 10.7-MHz narrow-band crystal filter (SS Type 2194 F).
FL2 — 455-kHz ceramic filter SFU 455A (RS 272-1302).
Y1 — 11.155-MHz crystal (SS).
U1 — SK7669 RF Amp/Mixer/Oscillator/AFC (RCA SK Series).
U2 — SK7645 Narrow Band FM IF IC.
U3 — LM-380N 2.5-W amp for 8-ohm load, 14-pin DIP (RS 276-706).
L1 — Zenith Radio Corp. 20-3935-05 blue 6½ turns 0.27-0.45 µH.
L2 — 18 turns, center tapped no. 28 enameled wire on Amidon T-37-10 (black) core.
L3 — 455-kHz 3rd IF; 20 kΩ: 5 kΩ black (M 421F103).
D1-D3, incl. — 1N4148 or equiv.
Cabinet — 5-1/4 × 3 × 5-7/8 in (RS 270-253).††

†Supplier and part no. are in parentheses.
††mm = in × 25.4.



sink — just far enough to insulate the component lead from the top side conductor. This technique is shown in Fig. 3.

Do not drill away the center six holes, where the LM-380N is placed, or the holes for the shield of L3. The pins that pass through the board here form the heat sink for U3, and should be soldered on both sides of the board. Fig. 4 shows the parts placement on the circuit board.

The receiver can be mounted in any small enclosure. You'll need room for a speaker, a battery, VOLUME, SQUELCH and ON/OFF controls, and the circuit board. The enclosure shown in Fig. 5 is available from Radio Shack.

Tune-up

A four-step tune-up procedure is all that is required to make the receiver operational. First, adjust the quadrature coil for lowest noise, as viewed on your oscilloscope or as heard in the speaker. Second, set the frequency (f_{rec} + 10.7 MHz) of the first LO by connecting a frequency counter to pin 6 of the SK7669 and adjusting L1 and C1. Third, peak C2 for best signal or highest noise. Fourth, check the adjustment of the quadrature coil, L3 — adjust for best-sounding audio.

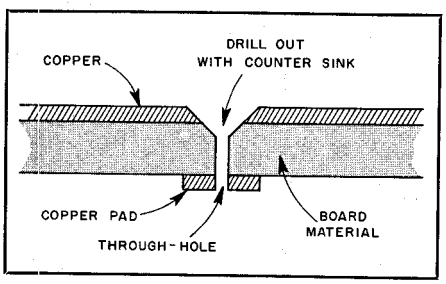


Fig. 3 — Cross section showing use of drill or countersink to remove copper from top side of circuit board.

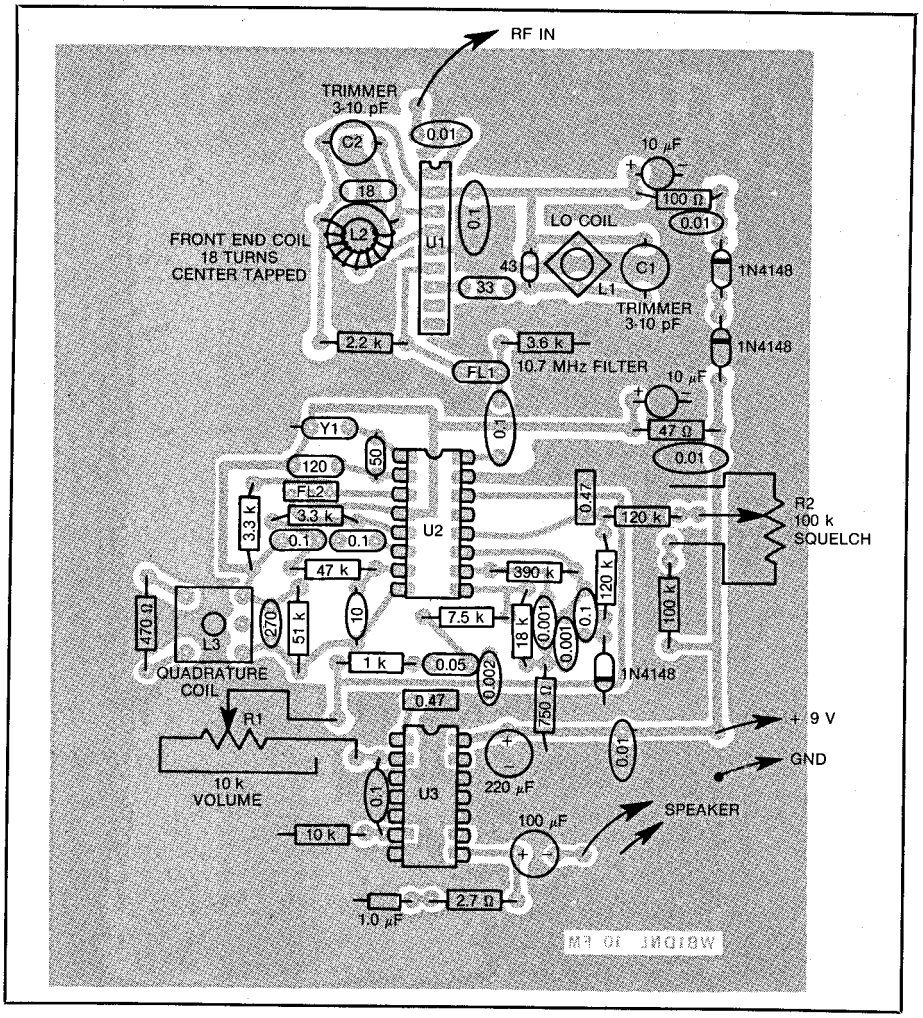


Fig. 4 — Parts-placement guide for 10-meter FM receiver, shown from the component side of the PC board. Gray areas represent an X-ray view of the circuit pattern. The etching pattern is given in the Hints and Kinks column of this issue. A PC board is available from A & A Engineering, 7970 Orchid Dr., Buena Park, CA 90620; tel. 714-521-4160. Price: $13.75.

Operation

After the receiver is tuned and placed in its enclosure, you're ready to start listening. Open the squelch, and set the volume to a comfortable level. Next, bring up the squelch until the receiver mutes. Not all the speaker hiss will disappear because the high-gain characteristic of the LM-380N generates some internal noise.

Any dipole or vertical antenna cut for 10 meters will work well with the receiver. The input sensitivity of the rig is about 1 µV, which is adequate for most uses. A GaAsFET preamp, however, may be desirable for weak-signal operation.

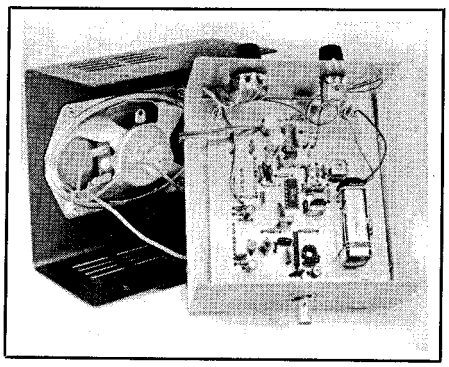


Fig. 5 — An inside view of the 10-meter receiver. The top surface of the circuit board forms a continuous ground plane under all circuit components. Note U1, the single-in-line-package IC, next to the toroidal inductor, L2.

Summary

Here is a receiver that is simple to build and requires little or no previous experience with electronics. It makes a fine classroom project for an amateur or electronics course. It's also a nice little monitor receiver for your local repeater. Tony England, WØORE, plans to transmit on 10 meters during his Space Shuttle mission, scheduled for April 1985, so get ready!

I would like to thank ARRL Lab Supervisor Phil Accardi for his help and suggestions during the construction of this project. Also, I would like to thank Jeanne Hickam at RCA for information on the SK7669.