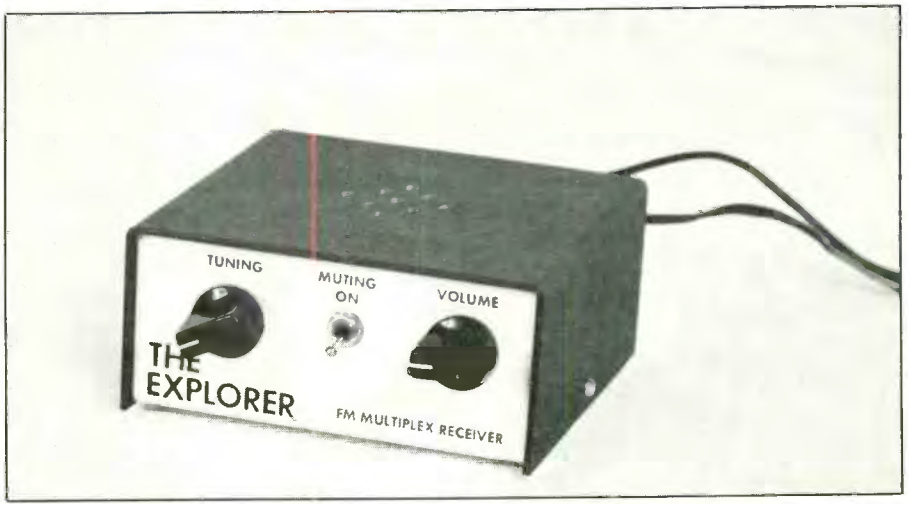
Discover the "Hidden World" of FM Broadcasting

Project lets you tune in on SCA subchannels with almost any FM-stereo tuner or receiver

By Gary McClellan



If you are like most people, your FM listening is probably restricted to the usual music and news. You may not even be aware that there are buried within the signals of many FM stations hidden programming meant for special audiences. Even if you are aware they exist, you may not know how widespread and diverse this programming has become. Without a special decoder, available to commercial subscribers for a rental fee, you cannot receive these programs with an ordinary FM receiver or tuner. However, if you build and use the "Explorer" SCA adapter described here, you can save the cost of the monthly rental fee of a decoder and still be able to listen to SCA broadcasts, though you will not get the benefit of program guides and other helpful materials.

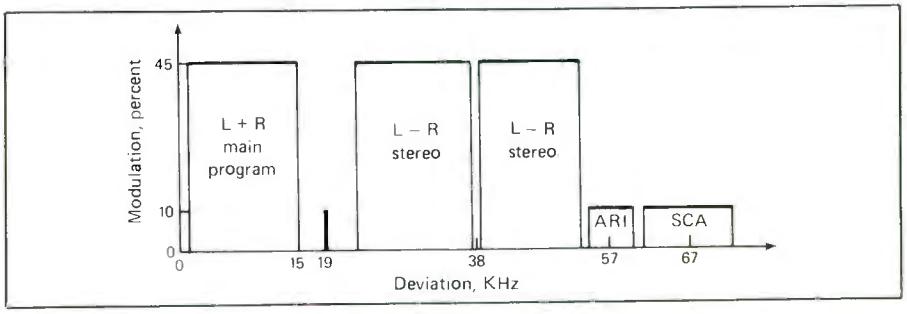
If you live in or near a major city and can clearly receive FM stations, you are a candidate for the Explorer. To obtain the greatest benefit from this project, you need a high-quality FM-stereo tuner or receiver, which should be solid-state in design and have an ac power transformer. You must also know something about electronic circuitry so that you can "install" the Explorer in your receiver.

The Explorer will not decode stock quotation services or receive ARI broadcasts. Both services require leased decoders for proper reception. Also, you should know that these broadcasts are copyrighted. While it is okay to listen to them in the privacy of your own home, you cannot under law use them to promote a business or use them for profit, nor can you record them or divulge their contents to other people.

SCA Theory

Before we discuss how the Explorer works, let us look at a cross-section of a typical SCA-carrying FM broadcast signal, shown in graph form in Fig. 1. Note that the zero point is the

Fig. 1. Anatomy of FM Spectrum.



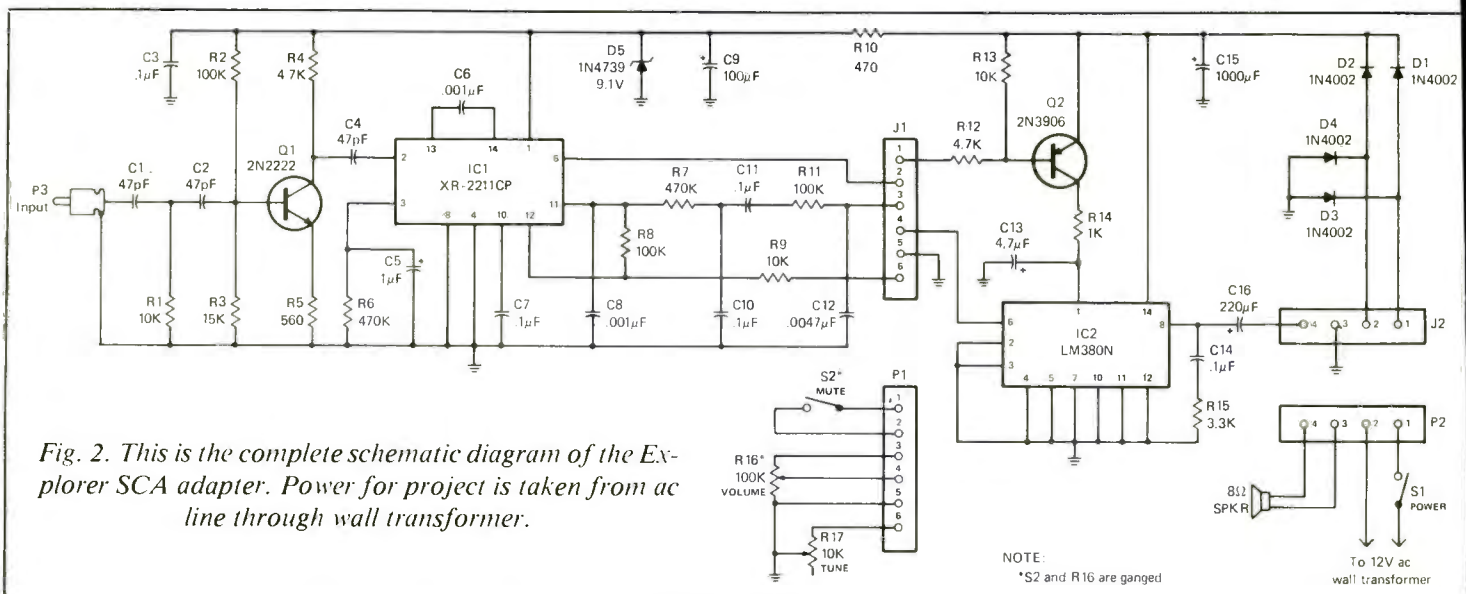


Fig. 2. This is the complete schematic diagram of the Explorer SCA adapter. Power for project is taken from ac line through wall transformer.

PARTS LIST

Semiconductors

D1 thru D4—1N4001 rectifier diode
D5—1N4739 (9.1-volt) zener diode
IC1—XR-2211CP linear FSK decoder (EXAR)
IC2—LM380N linear audio amplifier (National)
Q1—2N2222 npn transistor
Q2—2N3906 pnp transistor

Capacitors

C1,C2,C4—47-pF disc
C3,C7,C14—0.1-μF, 16-volt disc
C5—1-μF, 16-volt radial-lead tantalum
C6,C8—0.001-μF polyester
C9—100-μF, 16-volt radial-lead electrolytic
C10,C12—0.0047-μF polyester
C11—0.1-μF polyester
C13—4.7-μF, 25-volt radial-lead electrolytic
C15—1000-μF, 25-volt radial-lead electrolytic
C16—220-μF, 16-volt radial-lead electrolytic

Resistors (¼-watt, 5% tolerance)

R1,R9,R13—10,000 ohms
R2,R7,R8,R11—100,000 ohms
R3—15,000 ohms
R4,R12—4700 ohms
R5—560 ohms
R6—470,000 ohms
R10—470 ohms
R14—1000 ohms
R15—3300 ohms
R16—100,000-ohm linear-taper potentiometer with pull-on/push-off switch (Radio Shack No. 271-1722)
R17—10,000-ohm linear-taper potentiometer

Miscellaneous

J1—6-pin socket header (Calectro No. 41-046)—optional; see text
J2—4-pin socket header (Calectro No. 41-044)—optional; see text
P1—6-pin plug (Calectro No. 41-126)—optional; see text
P2—4-ping plug (Calectro No. 41-124)—optional; see text
P3—Phono plug
S1—Spst switch (part of R16)
S2—Miniature spst toggle switch
SPKR—2½" 8-ohm speaker
12-volt ac, 250-mA plug-in wall transformer; printed circuit board; 14-pin IC socket; 4" × 4" × 2" metal box (see text); 2 control knobs; RG-174 or microphone cable; phono jack; ¼" spacers (threaded for 4-40 hardware); rubber grommet; No. 6 solder lug; heat-shrinkable tubing (optional); dry-transfer lettering kit; clear acrylic spray; 4-40 machine hardware; solid and stranded hookup wire; solder; etc.

Note: Etched and drilled No. EXP1 printed-circuit board is available for $10.00 (+ 60¢ tax for California residents) from: Mendakota Products, P.O. Box 2296; 1001 W. Imperial Hwy., La Habra, CA 90631.

frequency of the FM station tuned. Figure 1 is an idealized representation of the signals and shows only the basics. The lower sideband from −75 kHz to 0, for example, is left out because it is a mirror image of the drawing. In practice, the bandwidths of the various programs will vary with the program material. Also, the amplitudes of the L − R stereo and ARI subcarriers will vary with program peaks. The L + R main program is the audio you would hear if you were using a mono FM receiver. It covers a 50-Hz to 15-kHz range.

The 19-kHz "pilot" carrier is the key to receiving stereo and Automobile Radio Information (ARI) programs. It does not carry any audio signals. Centered on 38 kHz, the L − R stereo signal covers the 23-to-53-kHz range. It is a double-sideband signal. The stereo decoder inside your FM receiver doubles the 19-kHz pilot carrier to 38 kHz, which is used to detect the L − R signal. Ultimately, the L + R and L − R signals are combined (matrixed) to form left- and right-channel stereo sound.

ARI signals are also in double-sideband format and are centered on 57 kHz. The decoder inside the receiver multiplies the 19-kHz pilot

carrier to 57 kHz that is then used to detect ARI announcements.

The ARI system is a lot more than a 57-kHz signal. Also broadcast is a 20-to-120-Hz tone, related to different traffic zones and selected by the listener who wants to hear traffic announcements that apply to a particular area. The decoder rejects unselected tones, preventing the listener from hearing unwanted ARI reports. (Note that you cannot receive ARI signals with the Explorer because it does not contain the circuitry for detecting double-sideband signals.)

Topping the FM spectrum is the SCA signal. It is a narrow, low-level FM signal that is centered at 67 kHz. SCA covers 59.5 to 74.5 kHz, giving only a 7.5-kHz bandwidth. This explains why background music heard in stores and other places tends to lack treble sounds.

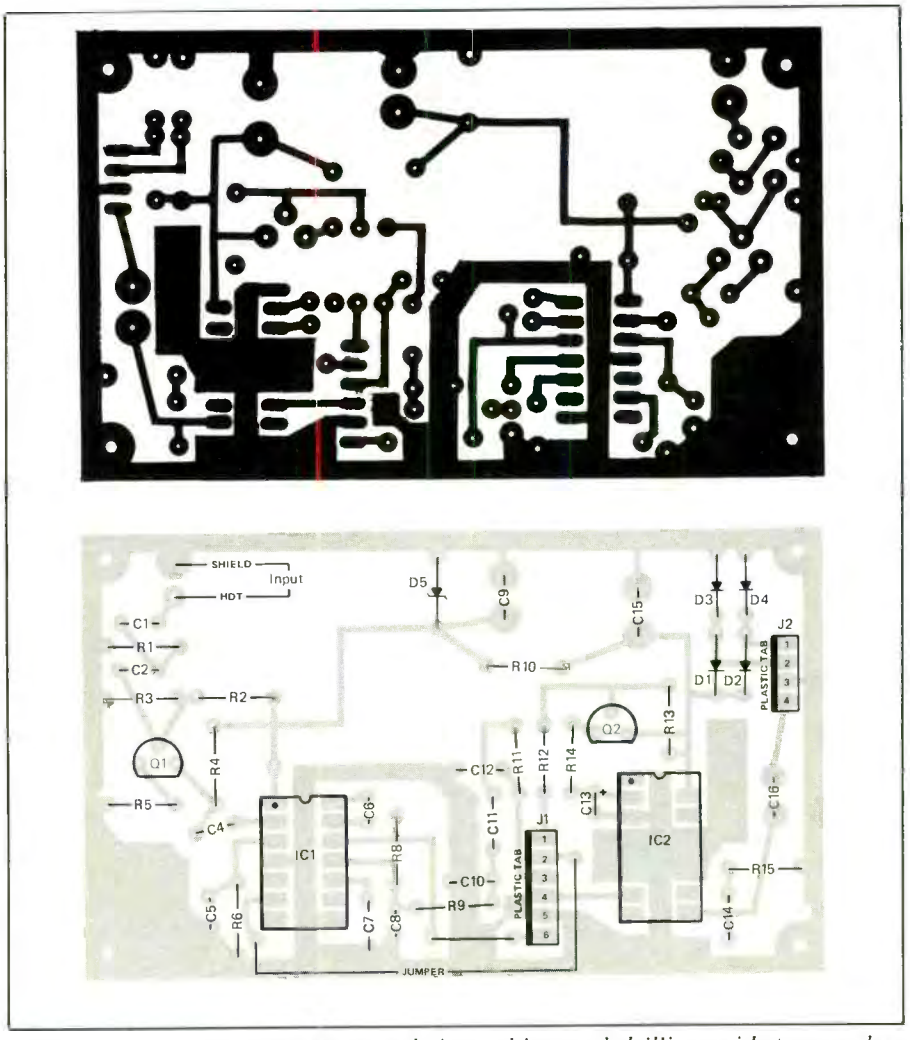


Fig. 3. Shown at the top is the actual-size etching-and-drilling guide to use when fabricating your own printed-circuit board. Install components on this board as shown in placement/orientation diagram at the bottom.

About the Circuit

Our Explorer SCA adapter, shown schematically in Fig. 2, contains a tunable phase-locked loop (PLL) with squelch and an amplifier that drives a small speaker. Tuning range is 53 to 97 kHz, permitting reception of any signal within that range, including SCA signals.

Incoming SCA signals are tapped from the FM detector inside your receiver or tuner and are coupled into the Explorer via *P3*. (Proper connection of the Explorer to your receiver/tuner will not affect stereo reception nor degrade overall performance in any way.)

A high-pass filter consisting of *C1*, *C2* and *R1* strips regular FM audio from SCA signals to reduce annoying interference. Then the SCA signals are amplified by *Q1*, which compensates for filter losses. The output from *Q1* drives the *IC1* PLL circuit through *C4*, which serves as another high-pass filter.

The Exar XR-2211 PLL used for *IC1* was originally designed for computer modems, but it gives excellent results as a tunable decoder and contains a detector for a squelch circuit. Squelch is desired in this application because it prevents you from hearing background noise when the SCA subcarrier goes off-the-air.

Capacitor *C5* and resistor *R6* affect the response time of the squelch circuit. They keep noise and interference from falsely triggering the squelch. Capacitor *C6*, resistor *R9* and TUNING control *R17* set the tuning frequency of the Explorer. They vary the frequency of a voltage-controlled oscillator (vco) inside *IC1*. Capacitors *C8* and *C10* and resistors *R7* and *R8* make up a loop filter that stabilizes the *IC1* PLL circuit. At the same time, the filter reduces high-frequency content of the audio signal, which is intentionally boosted (preemphasized) by FM broadcasters.

Audio at the output of the PLL circuit is filtered by a low-pass filter comprised of *C12* and *R11* and is passed through *J1* and *P1* to VOLUME control *R16*.

Next comes the squelch circuit. The output of the squelch circuit is at pin 6 of *IC1*. When the Explorer detects that the SCA channel has gone off-the-air, the signal at pin 6 of *IC1* goes low. Then through MUTE switch *S2*, transistor *Q2* turns on and shuts

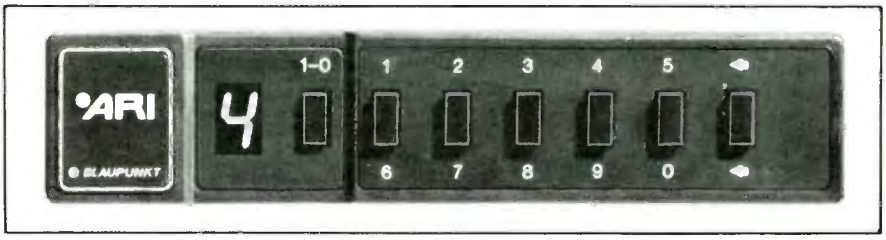
Timesaving Service for Motorists

The Automobile Road Information service (ARI for short) is a relatively new—in the U.S.—broadcast service designed to help motorists from being caught in traffic tieups. ARI is transmitted as a subchannel program on FM stations in a manner similar to that used for standard SCA broadcasts. A special decoder, available only by rental, is required to receive these broadcasts. Therefore, the Explorer SCA adapter described in the body of this article cannot be used to receive this service. We mention the ARI service here because it is similar in operating principle to standard SCA services and because of its importance to the motorist.

ARI can provide you with advance warning of accidents, road closings and other conditions that can snarl traffic. By advising you of hazardous driving conditions on roads, caused by bad weather, it can save lives during an emergency where seconds count.

ARI made its first appearance in the U.S. in 1981 (it has been in use in Europe since the early 1970s) when it quietly underwent tests to determine if interference problems existed. Passing the tests handily, the system was inaugurated in New York in April 1983 with four FM stations covering the metropolitan New York City area. By the end of 1985, a projected 20 more metropolitan U.S. areas were to have ARI service, plus a few areas in Canada. Considering the importance of this service, you can expect its popularity—and coverage—to grow in the near future.

Stereo receivers used for ARI reception look and install like other autosound units, except that they have ARI controls. The equipment ranges from two manually operated decoders that mount under the dashboard to complete receivers with built-in ARI decoders. At present, all ARI receivers and accessories are manufactured by Blaupunkt (distributed in the U.S. by Robert Bosch Sales), but other manufacturers are expected to introduce ARI-equipped models this year.



A low-cost ARI decoder accessory made by Blaupunkt.

A Blaupunkt electronically tuned AM/FM stereo cassette car radio equipped with night illumination and a built-in ARI decoder.

Manually operated decoders are low-cost accessories intended to upgrade older Blaupunkt radios for ARI reception. One Model is for analog-tuned, the other is for digital-tuned radios. Either decoder plugs into a jack on the radio, with no other modifications required. Reception of an ARI broadcast is simply a matter of turning on the decoder and tuning in the station assigned to the area. An indicator light shows the "traffic zone," verifying that the proper station is being received. If the ARI signal is lost, a warning tone sounds 30 seconds later.

There is an important distinction between analog and digital accessories. With the analog model, tuning is done by FM station at the receiver, while with the digital model, tuning is done by traffic zone at the decoder. More effort is required with the analog model, with tuning proceeding until the proper traffic zone is displayed. With the digital model, the desired traffic zone is selected by pushing a button. The receiver then scans the FM band until the station broadcasting the corresponding code is found and then stops scanning. Thus, the digital model is easier to use. However, the ultimate choice is determined by receiver choice—not convenience.

Deluxe model car radios have the ARI decoder built in. They have only an on/off switch and zone display for the ARI function. In operation, the user simply selects the desired traffic zone by pushing a button. The radio scans for the proper station and announces reports from that zone. As with manual decoders, a warning tone sounds if the ARI signal is lost.

off *IC2*, silencing the speaker when an SCA program goes off the air. Capacitor *C13* minimizes turn-on thump that occurs every time the squelch circuit deactivates and reduces hum from the speaker.

The speaker is directly driven by *IC2*. Power is provided by an ac adapter, with 15 volts dc going to *IC2* and 9 volts dc (via zener diode *D5*) going to the PLL circuit.

This concludes Part 1. Next month's conclusion will cover construction details and explain how to set up and use the Explorer. **ME**