

The Crystal Radio

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What's old is new again!

Even a casual auditor of the amateur bands will conclude that the hobby is largely populated by wizened old geezers—and I'm one of them. This is a sad situation because most of us entered Amateur Radio as kids. If ham radio is to continue for generations to come, we must get youngsters interested in radio communication while they're still in grammar school and still capable of wonder. We need to reach them while they are still asking questions about everyday matters (that all too often go unanswered) such as, "Why does it get light in here when I push this thing?"

Reaching today's kids won't be easy. With the Internet, cellular telephones and other forms of global communication commonplace in their lives, the true magic of radio lies buried beneath the technology. We must strip away layers upon layers of complicated hardware and reveal radio in its purest form. The perfect tool to achieve this goal is the "lowly" crystal receiver.

Imagine the curiosity you'll inspire when you demonstrate a radio that has no obvious power source whatsoever! The simple crystal receiver described in this article works surprisingly well. It's selective and produces robust headphone volume. I've been able to tune several local AM broadcast stations with ease. Best of all, it's inexpensive, uses readily available parts, and can be built by a youngster (with a little guidance). Of course, adults will love this little receiver, too.

There is a fascinating resurgence of interest in crystal radios. Even hams normally accustomed to owning rigs with four-digit price tags are rediscovering the joys of simple, "powerless" reception. To get a taste of what is going on, pick up a copy of *Crystal Set Projects* from the Xtal Set Society, Box 3026, St Louis, MO 63130; tel 314-725-1172, or visit their Web site at <http://www.midnightscience.com>. (The book was reviewed in the August, 1997 *QST*, page 102.)

About the Circuit

The circuit shown in Figure 1 was developed in the early '30s by Elmer G. Osterhoudt. Selectivity problems plagued most crystal sets of the day due to the proliferation of broadcast stations. Elmer devised a solution. He determined that poor crystal receiver selectivity was caused by the headphones swamping the tuned circuit and lowering its Q. The net result was an inability to separate individual signals. Elmer improved selectivity considerably by connecting the detector near the cold (ground) end of the tuned circuit to minimize the swamping.

Capacitor C2 is used to match the antenna system, and C3 is the main tuning capacitor. Absent from this circuit is the finicky galena-and-catwhisker detector. It has been supplanted by a 1N34 germanium diode that is connected near the grounded end of the tuned circuit that includes coil L1. C1 is an RF bypass capacitor.

Headphones

You must use high-impedance headphones (2000 Ω or greater) with crystal receivers. If you attempt to use common 8- Ω headphones, you'll have very disappointing results. You'll find high-impedance headphones at hamfest flea markets, but if you're not

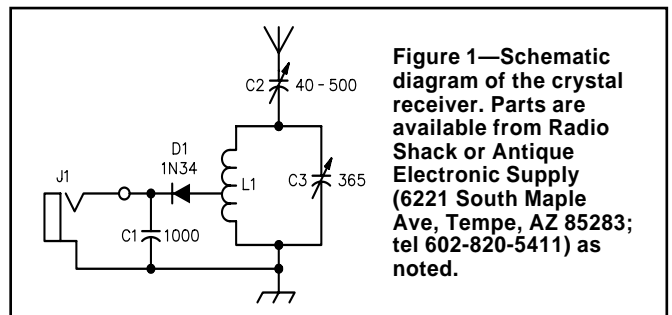


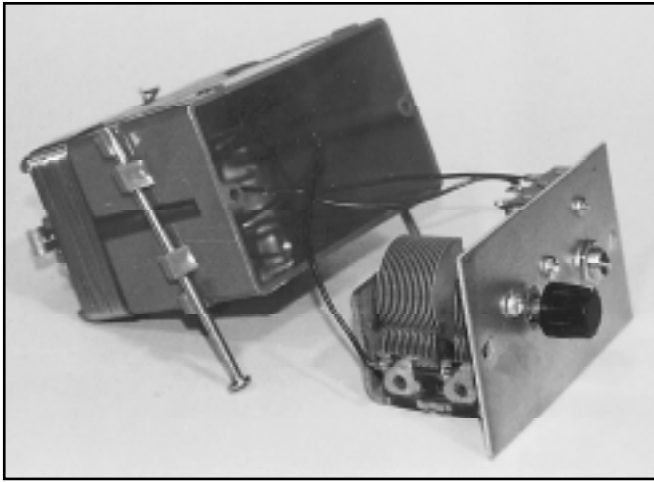
Figure 1—Schematic diagram of the crystal receiver. Parts are available from Radio Shack or Antique Electronic Supply (6221 South Maple Ave, Tempe, AZ 85283; tel 602-820-5411) as noted.

- C1—1000 pF mica or disc ceramic trimmer (Radio Shack 272-123)**
- C2—40 to 500 pF trimmer capacitor (Antique Electronic Supply CV-263)**
- C3—365 pF variable capacitor (Antique Electronic Supply CV-231)**
- D1—1N34 germanium diode (Radio Shack 276-1123)**
- J1— $\frac{1}{4}$ -inch, 2-conductor headphone jack (Radio Shack 274-252)**
- L1—35 feet of 22-gauge enamel wire. See text. (Radio Shack 278-1345)**
- Fahnestock clips (Antique Electronic Supply SH-11-4034)**
- 2000- Ω headphones (Antique Electronic Supply PA-466)**

up to the hunt, you can buy them from Antique Electronic Supply (see Figure 1).

The Importance of a Good Antenna System

Since the crystal receiver depends completely on the energy from the transmitted signal, you need to gather as much signal out of the air as possible! Remember that this receiver is designed to tune the AM broadcast band. A half-wavelength dipole cut for about 1 MHz would be ideal, but few of us own enough real estate to accommodate a 500-foot long antenna. The practical solution is



Plastic electrical outlet boxes make terrific enclosures. Note that I've mounted the main tuning capacitor, C3, and the headphone jack on the front using copper-clad PC board.

to simply use an end-fed wire about 100 feet in length. You'll also need to provide a connection to an Earth ground (a cold-water pipe may suffice). With the proper antenna system, you should be able to receive most of the AM stations in your area. If you live in a rural location without an AM broadcaster nearby (within about 50 miles), try using even more antenna wire. Just string it over trees, bushes, or any other supports.

Construction

You can build a crystal receiver into almost anything. I used plastic electrical outlet boxes. They're available at home centers and hardware stores. They are attractive, rugged and inexpensive. They even serve as forms for winding the coil. I made the front panel of my box from a piece of copper-clad PC board. You can cut this material into the proper shape using a hacksaw, and it is easily drilled for mounting parts.

For C3, a miniature variable capacitor salvaged from an old AM-only radio will work, but a single-section air variable is better. If you don't have these capacitors in your junk box, don't despair. You can order one from Antique Electronic Supply.

L1 is wound on the outside rear portion of the enclosure and consists of 32 turns of 22-gauge enamel-covered wire. The coil is tapped nine turns from the grounded end. The tap is made by tightly twisting about 1 inch of the magnet wire and scraping off the enamel insulation. You can secure the windings to the enclosure with transparent plastic tape.

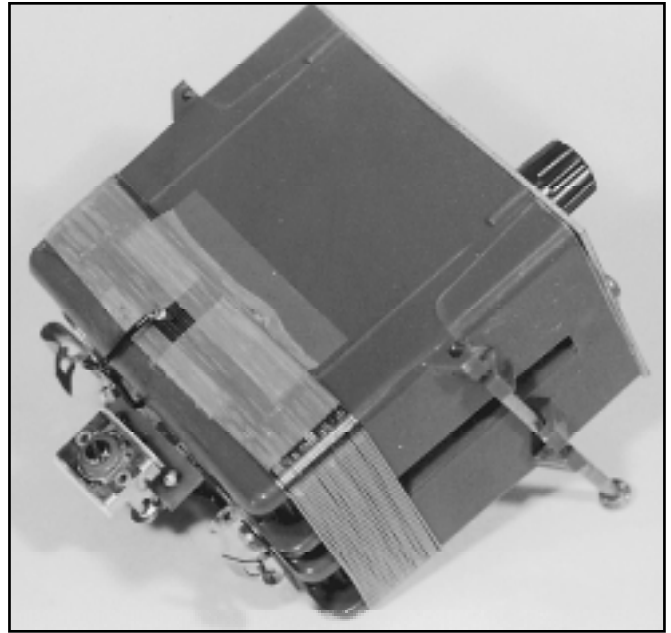
The antenna trimmer capacitor (C1) and the Fahnestock clips for the antenna and ground connections are mounted on the rear of the enclosure. The tuning capacitor, phone jack and detector are mounted on the front panel. Interconnecting wires are fed through holes in the enclosure and soldered to the trimmer capacitor, ground and cold connections.

Operating Adjustments

Connect the antenna, ground and headphones. Tighten the antenna trimmer capacitor C2. Slowly adjust C3 to tune in the stations. Note the number of stations and log their call letters and frequencies. Readjust C1 to provide the best trade-off between volume and selectivity. If you're using your crystal radio near a particularly strong broadcast station, removing the ground connections will often improve selectivity (with some reduction in volume).

Use Your Radio as a Teaching Tool!

You can use your crystal radio to teach a number of important concepts. For example:



The rear view of the crystal radio enclosure. You can easily see the windings of coil L1 held in place with transparent tape.

Inductance: Applying the "right hand rule," the coil for the tuned circuit can be used to explain how a magnetic field is developed by electron flow through a conductor, and how the magnetic field is increased by forming the conductor into a coil.

Capacitance: Varying capacitance may be illustrated by simply observing how the total area increases as the rotor plates mesh with the stator plates. The compression trimmer capacitor (C1) illustrates the function of a dielectric other than air. It also shows how the capacitance can be varied by changing the separation between the plates.

Resonance, modulation and detection: You can teach these concepts by inviting your student to tune in a station while you display the modulated RF on an oscilloscope! Move the 'scope probe from one side of diode D1 to the other to illustrate "before" and "after."

Magnetism and transduction: High-impedance headphones are ideal instructional aids to demonstrate these ideas. Disassemble a pair of headphones and show your students what's inside. Touch the permanent magnet with a screwdriver so they can see that it is indeed magnetic. Explain how the detected signal flows through the tiny headphone coil, creating a magnetic field that adds or subtracts from the field produced by the permanent magnet. This causes the metal diaphragm to vibrate, creating sound! What began as electrical energy has become mechanical energy—*transduction*.

Summary

Throughout the years, the simple crystal radio has spawned tens of thousands of radio amateurs, engineers and electronic hobbyists. And despite the antiquity of its design, it is still an effective tool for recruitment and instruction. A crystal radio is a delightful device, and the perfect way to introduce the wonder of radio to a young mind—or rekindle it in your own!

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