HOW TO BUILD "FREE-POWER" RADIOS

Successors to crystal radios use single high-gain transistor amplifier

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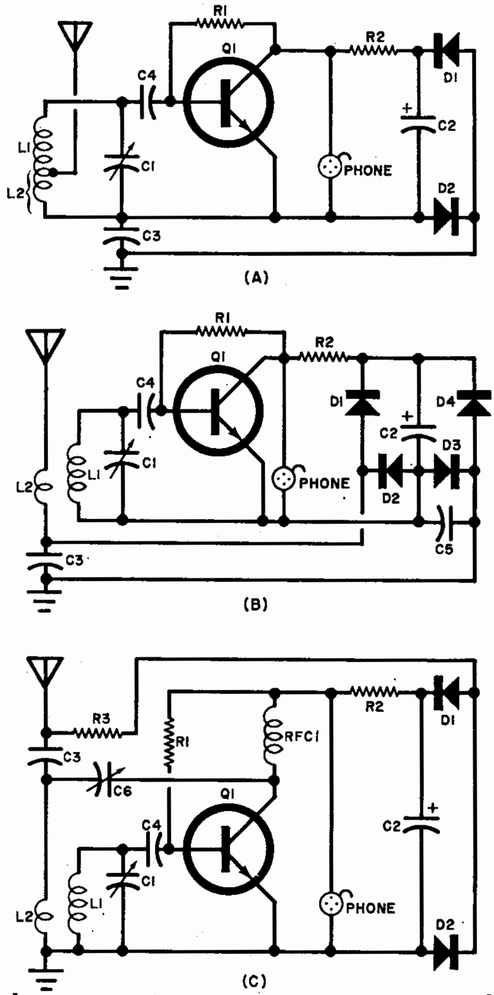
EXPERIMENTERS and hams have liked to fool around with battery-less radios since wireless communication was first thought about. Although notable improvements have increased the sensitivity and selectivity of the devices, their performance is limited unless the newest design techniques are used. Described here are three battery-less receivers which have improved gain as a result of the use of a simple transistor amplifier powered by random electrical fields which are everywhere. These circuits, which are relatively inexpensive to build, have higher volume and better reception than a crystal radio.

The first circuit (Fig. 1A) is a broadcast-band receiver and requires the fewest number of components. The circuit in Fig. 1B also tunes the broadcast band but it has increased gain due to a more efficient design. Figure 1C's circuit has improved selectivity and sensitivity due to regeneration, and it is designed to receive shortwave as well as conventional broadcast transmissions.

In the construction, although circuit layout is not critical, it is wise to keep component leads short and neat. The antenna and ground leads from the receiver could have various lengths of stranded insulated wire with alligator clips attached for connecting the receiver to large metallic objects.

If some components cannot be located, substitute others with similar characteristics. For example, the tantalum capacitor (*C2*) can be replaced by an electrolytic with the same specifications. The 1N459 diode can be replaced by another low-power silicon unit with small reverse current characteristics. Likewise, another small-signal, high-gain silicon unit can be used for the 2N3391 npn transistor. A 4700-ohm resistor can be used for *RFC1*. Finally, the crystal earphones can be interchanged with high-impedance magnetic phones with a suitable series capacitor.

Operation. Once the receiver is completed, a tuner dial can be added. Calibration of the dial is accomplished by listening to stations which have a known transmitting frequency or by coupling a variable r-f signal generator to the receiver through



PARTS LIST

C1,C6—365-pF variable capacitor
C2—5-μF, 50-volt tantalum capcitor
C3—0.002-μF ceramic disc capacitor
C4,C5—0.005-μF ceramic disc capacitor
D1-D4—1N459 silicon diode
L1—Fig. 1A: tapped transistor antenna coil
Fig. 1B: transistor antenna coil
Fig. 1C: see Fig. 2
L2—Fig. 1B: 15 to 20 turns of #24 enameled wire wound directly over antenna coil. Adjust turns or reverse leads for optimum performance
Fig. 1C: see Fig. 2
Q1—2N3391 transistor
R1—10-megohm resistor
R2—470,000-ohm resistor
R3—10,000-ohm resistor
RFC1—2.5-mH r-f choke

Fig. 1. Three versions of simple single-transistor radios that derive their operating power from the random electrical noise that is usually found in atmosphere.

HOW IT WORKS

The noise and signal are separated by coupling the series *L2C3* resonant circuit to the parallel *L1C1* resonant circuit. This arrangement functions as a bandpass filter, allowing broadcast information to appear across *L1C1* while leaving the noise across *L2C3*. When *L1C1* is adjusted to a standard broadcast frequency, an amplitude-modulated carrier is produced across the tuned circuit. This r-f signal is sent through dc blocking capacitor *C4* to the base-emitter junction of transistor *Q1*, a common-emitter amplifier.

The transistor is biased by a large value of shunt feedback *(R1)* and its load resistance *(R2)* also has a large value. This arrangement performs several functions. First, the voltage drop across the base-emitter junction is quite small. This allows the junction to detect the incoming signal by changing it to modulated dc. Although the shunt feedback biasing arrangement lowers *Q1's* input impedance, its emitter current is so small that the input impedance is still very large and does not appreciably load the tuned circuit.

Secondly, the transistor is biased in a region of extremely high gain and some nonlinearity. The latter acts to a small degree as an agc. When signals get larger, the amplifier's gain is reduced whereas, on weak signals, the gain is large.

The power supply for the transistor derives its energy from the noise obtained across *L2C3*. This noise derives primarily from a 60-Hz field radiated from household wiring, lights, and appliances. The noise is rectified by *D1* through *D4* and the resulting dc is filtered by *C2*. Limiting resistor *R2* connects the supply to the transistor circuit.

Although the three receivers operate in basically the same manner, there are several differences between them. The first two rectify voltage fluctuations (low-frequency noise) appearing across *C3*. The first circuit has a voltage doubling diode arrangement to reduce the number of components. On the other hand, the second circuit utilizes a full-wave bridge rectifier with improved efficiency; but it requires the addition of *C5*, *L2*, and two diodes. Capacitor *C5* is used to reference the *L1C1* circuit to ground, which increases the signal and minimizes hum.

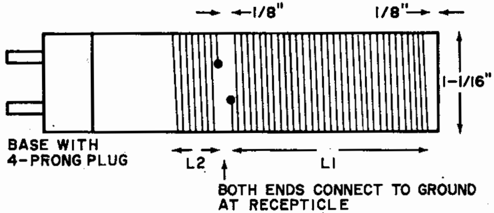
The third receiver uses a voltage doubler, however it is connected across the *L2C3* circuit through *R3*. This arrangement allows high-frequency noise as well as low-frequency noise to be rectified with high efficiency and minimum receiver hum. If a full-wave bridge rectifier were added to this circuit, low-frequency noise would be allowed to pass through *C5* to produce hum in the earphone. A possible solution is to add another feedback coil, but this might load the tuned circuit and reduce sensitivity and selectivity of the receiver. This receiver also has exchangeable coils so that several bands can be received. Some of the amplified signal in this circuit is returned to the input of *Q1* by *C6*, *L2*, and *RFC1*. This adds positive feedback and further increases the receiver's gain.

a suitable antenna. If the receiver is not operating in the specified range, adjust the core of *L1* in the first two circuits or add or remove a few turns from *L1* in the third circuit.

To operate the third circuit (Fig. 1C), advance (counterclockwise) the regeneration control (*C6*) until a slight hiss is heard. The proper position of *C6* depends on the length of the antenna, the receiver coil, and the position of the tuner capacitor (*C1*). However, the receiver may not operate with regeneration at high frequencies, but *C6* will serve to boost the receiver's performance. Shortwave reception is obtained by changing coils in accordance with Fig. 2.

For optimum performance, these receivers require a good earth ground and a large metallic antenna. Water pipes and other low-lying metallic objects make good grounds. The antenna lead can be clipped to a window screen, roof gutter, refrigerator, or similar items. Sometimes just touching the antenna lead with the hand is sufficient to power the receiver. To increase reception, attach a 9-volt battery across *C2*, observing the correct polarity.

For listening to weak signals, connect two earphones in parallel to form a head set. Local stations in the broadcast band may interfere with distant transmissions.



Range	Turns	Wire
540-1500 kHz	L1: 149.6 closewound	#28
	L2: 41.3 closewound	#28
1.5-4.0 MHz	L1: 49.2 even for 2"	#24
	L2: 11.2 even for 7/16"	#24
4.0-11.0 MHz	L1: 18.4 even for 2"	#22
	L2: 4.2 even for 7/16"	#22

All wire is enamel coated, wound on low-loss 1 1/16" diameter forms at least 3½ in. Use plastic pill containers or thin-wall cardboard tubing. Coat with clear lacquer, if desired, to keep wire in place.

Fig. 2. Windings for coils in Fig. IC.

If so, a series *LC* circuit may be constructed to remove the unwanted station, This circuit connects between the receiver's antenna and ground and is built using a standard antenna coil connected in series with a 365-pF variable capacitor. When this circuit is tuned to the interfering frequency, the latter will be effectively removed. However, the antenna coil must be kept away from *L1*, and the chassis of the capacitor should be connected to ground. ◈