A Simple Receiver for the Beginner

All Electronics Corp. has listed a curious device in its catalogs for several years. The item is advertised as a complete receiver in one low cost TO-92 package. This "pill" has but three leads. It has 10 transistors on its substrate. After regarding this $2.25 item with idle curiosity for three years I decided to buy two pieces and conduct some experiments. This IC-like device is manufactured by Plessey Semiconductors Ltd in the United Kingdom. It is identified as part no: ZN414Z.

The ZN414Z is made for use as a broadcast (BC), band tuned-radio frequency (TRF) receiver in hi-fi systems. It is not designed for service as a superheterodyne receiver, although it can be used as the intermediate frequency (IF) section of a superhet radio. I discovered also that a direct-conversion (DC) receiver can be made with this unit if a local oscillator (LO) signal is applied to the output of the device, as shown in Figure 2.

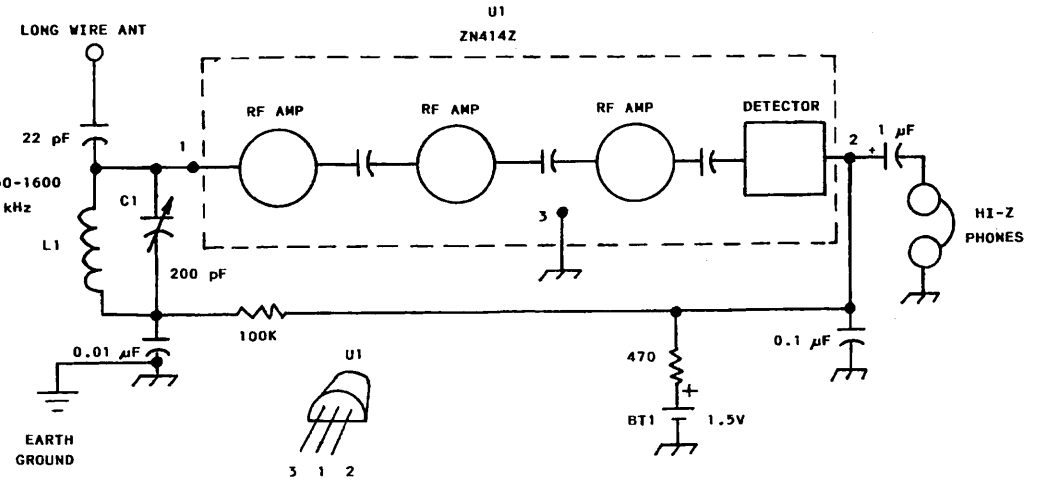

FIGURE 1: *Circuit for a simple TRF radio using the Plessey ZN414Z 10-transistor IC. L1 consists of 131 close-wound turns of no. 20 enamel wire on a 5-1/2 inch length of 2-3/8 inch OD PVC tubing. L1 has 420 microhenries of inductance for tuning from 550 to 1600 kHz with a 200-pF variable capacitor (see text for toroidal coil data). The audio amplifier in Figure 2 can be added for greater headphone volume, and to permit using 8-ohm phones. Omit RFC1 if this is done.*

■ ZN414Z Characteristics

Maximum operating voltage is +1.6-volts. Therefore, a single 1.5-volt AA, C, or D cell will suffice as the power source. Maximum current drain is a mere 0.5 mA. This ensures that the battery will last almost through its normal shelf life.

The upper frequency limit for the ZN414Z is listed as 3 MHz, but I was able to obtain good performance, at slightly reduced overall gain, up to 4 MHz with my test circuits. The power gain from the antenna to a pair of earphones is 72 dB. The device has a built-in automatic gain control (AGC) circuit that has 20 dB of amplitude control.

The sensitivity of the overall circuit is a tad low for weak-signal work. Full specified audio output occurs with a 50 microvolt RF signal applied to the input tuned circuit. A simple transistor radio frequency (RF) amplifier stage ahead of the ZN414Z would provide good weak-signal response.

High-impedance earphones provide the greatest audio volume. Headphones with an impedance of 64 or greater ohms are suitable if an external audio amplifier is not used with the device. A transistor audio amplifier, such as that seen in Figure 2, is recommended for use with standard 8-ohm hi-fi phones.

■ A Basic TRF Circuit

Figure 1 shows how to use the ZN414Z as a TRF radio for the standard AM broadcast band. C1 and L1 are tuned to the frequency of interest. A high-Q (quality factor) coil is essential for L1 in order to ensure sufficient selectivity for separating the stations. A large coil with fairly heavy wire is needed to obtain a high-Q. In effect, the big coil and the tiny ZN414Z are not unlike the "tail that wagged the dog." The bulk of the physical size of the tuned circuit can be reduced if you are willing to wind L1 on an Amidon Assoc. FT-140-61 ferrite toroid core.[1] An inductance of 420 microhenries is required. Therefore, you will need to wind 54 turns of no. 20 enamel wire on the toroid core.

The input section of the ZN414Z is designed for very high impedance. Consequently, the device does not load the tuned circuit and spoil the Q. Please note that there are three RF amplifier stages ahead of the detector. Only five external components, other than the battery and phones, are required for the Figure 1 circuit. You should be able to tack the circuit together on a piece of perforated board, or similar, and have it operational in an hour or less.

■ Receiving SSB and CW on 160 Meters

Figure 2 shows how to add a variable frequency oscillator (VFO) and an audio amplifier to make the ZN414Z function as a direct-conversion receiver. The coil dimensions have been changed for operation from 1.8 to 2.0 MHz. RFC1 prevents the VFO energy applied to the U1 output from reaching the Q1 audio amplifier. This unwanted RF energy would otherwise prevent Q1 from functioning correctly as an audio amplifier. C4 helps to isolate the RF energy from Q1, because it is a bypass capacitor.

A VFO designed for the broadcast band can be used with the Figure 2 circuit if the Figure 1 coil inductance is used. The net result is enhanced reception, caused by increased detector gain. This is called "conversion gain." The tradeoff is that the BC stations will need to be tuned for zero beat to prevent a heterodyne (beat note) from being heard. Performance with the VFO is similar to that of a regenerative receiver, which should also be tuned for zero beat when copying AM signals.

■ The ZN414Z as an IF Amplifier

The data sheet that comes with the ZN414Z from All Electronics shows how to use this device as an IF amplifier section in a superhet receiver. An IF filter is used immediately after the mixer in the superhet receiver. The ZN414Z

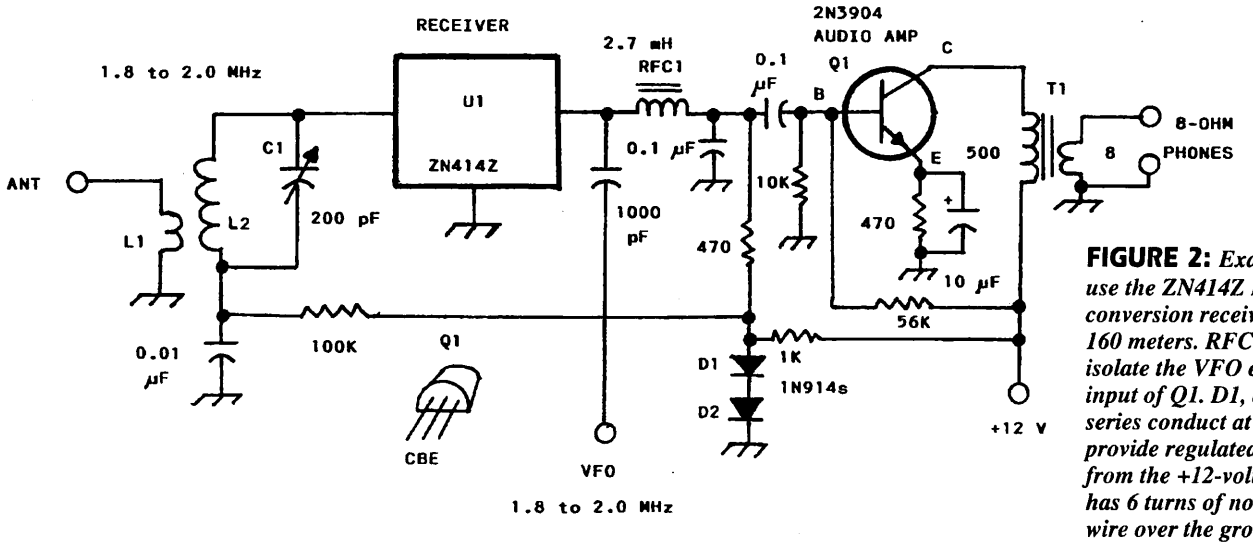

FIGURE 2: *Example of how to use the ZN414Z IC in a direct-conversion receiver circuit for 160 meters. RFC1 is used to isolate the VFO energy from the input of Q1. D1, and D2 in series conduct at 1.4 volts to provide regulated voltage for U1 from the +12-volt supply line. L1 has 6 turns of no. 20 enamel wire over the ground end of L2. Winding L2 consists of 48 close-wound turns of no. 20 enamel on a 1.5-inch OD by 2 inch coil form. T1 is a miniature 500- to 8-ohm audio output transformer (Mouser). See text for references to VFO design.*

is utilized after the filter to provide an IF amplifier and detector with 20 dB of AGC. A crystal-controlled beat frequency oscillator (BFO) can be added to allow reception of CW and SSB signals, as is done with the VFO in Figure 2. The BFO frequency must be 1.3 kHz above or below the IF, depending upon whether upper or lower sideband reception is desired. A tunable BFO that uses a coil and capacitor may be used to replace a crystal-controlled BFO.

■ Construction Notes

The 3-MHz upper frequency limit of the ZN414Z minimizes the need to maintain short, direct leads. This feature makes things easier for the novice builder. However, it is always wise to keep all RF-circuit leads short.

You may build the circuits described here on perforated board, or use point-to-point wiring with multilug terminal strips.

Tuning capacitor C1 can be burgled from a discarded AM-band transistor radio. Most of these receivers have two-gang variable capacitors with 75- and 125-pF sections. All you need do is wire the two sections in parallel to obtain a 200-pF capacitor. Alternatively, you can use a single-gang 365-pF variable capacitor. If you use a capacitor from a transistor radio you may want to add a 1/4-inch shaft to allow using a standard knob at the front panel. Adapters can be made from dowel rod that has been drilled and cemented to the original smaller shaft with epoxy glue.

If you opt for the circuit in Figure 2, be sure the VFO parts are mounted firmly to the chassis or PC board to prevent frequency shifts if the receiver is bumped. The VFO leads should be kept short and rigid. A vernier drive for the VFO tuning capacitor will make tuning slower and smoother. Details for building simple VFOs are given in *W1FB's QRP Notebook* and *W1FB's Design Notebook*. Both are available from The ARRL, Inc.[2]

Most of the parts needed for the simple receivers in Figures 1 and 2 can be purchased by mail from Mouser Electronics.[3] The ZN414Z is available from All Electronics Corp.[4] or from Plessey distributors in the United States. However, you may wish to "shop around" in the many surplus electronics catalogs that are available. Don't overlook Radio Shack for the basic components you will need.

■ Closing Remarks

This article is aimed at those of you who have avoided experimentation because you feel that building simple equipment is beyond your ability. There is considerable satisfaction associated with building a receiver and hearing the signals it can bring to your ears. Certainly the cost of the projects described here are affordable for even those who live in "Poverty Gulch!"

Notes

1. Amidon Assoc., Inc., 3122 Alpine Ave., Santa Ana, CA 92704. Phone: (714) 850-4660. Catalog available.
2. AARL, Inc., 225 Main St., Newington, CT 06111. Phone: (203) 666-1541.
3. Mouser Electronics, 2401 Hwy. 287 N., Mansfield, TX 76063-4827. Phone: 1-800-346-6873 for catalog or ordering.
4. All Electronics Corp., 14928 Oxnard St., Van Nuys, CA 91411. Phone: 1-800-826-5432 for parts or catalog.