Tune in on the New Frontiers of VLF

Simple converter brings the low low bands in on 80-meter receivers.

by David Curry WD4PLI

Ever wanted to try Very Low Frequency (VLF) operation, but didn't know how to get into it? If so, and if you have 80m capability, you may want to try this project—the 80AU.

The 80AU provides active whip preamplification of an incoming signal, then upconverts it to the 80 meter amateur band. The unit's 5-element Chebyshev filtering eliminates broadcast and above frequencies. A balanced mixer rejects spurious signals, and it has phantom power capability for remote operation. Used in conjunction with a quality shortwave or 80 meter amateur receiver, this converter accurately converts all frequencies from 5 to 450 kHz, up to frequencies from 3.5 to 4 MHz.

There are many fascinating and unusual signals on the LF and VLF frequencies, as well as the activity within the 1750 meter band (160 to 190 kHz).

You can use any 5- to 10-foot wire for an antenna, but I highly recommend using a Citizen's Band 102″ steel whip, available at most electronics stores. With this whip, you can use the converter in remote and mobile operation, or on the top of a roof for clear, unobstructed reception. The wire antenna will also work, and you can use it if you are limited to "invisible antennas," such as in apartment complexes. Longer antennas will work, but they need a small series capacitor at the input port (J1). See the "Operation Requirements" section for more information on this.

The 80AU is very sensitive, so use a separate ground, located directly at the antenna site. A ground rod placed in the earth directly under the active whip and connected to the coax braid or the 80AU box, will provide the best ground reference, clean and free of noise. The coupling method shown in section B of the schematic is an excellent way to separate the two grounds and provide good broadband coverage. If you use this particular circuit, be sure to use battery power to eliminate any coupling to the AC power line.

Whip Placement

The active whip site is CRITICAL. Always locate it away from power lines and above or away from the house and other structures. At my house, the active whip is located right in the front yard near the sidewalk, against a chain link fence. The "higher the better" rule also applies, helping the signal-to-noise ratio by lessening capacitive coupling to structures where noise may be present.

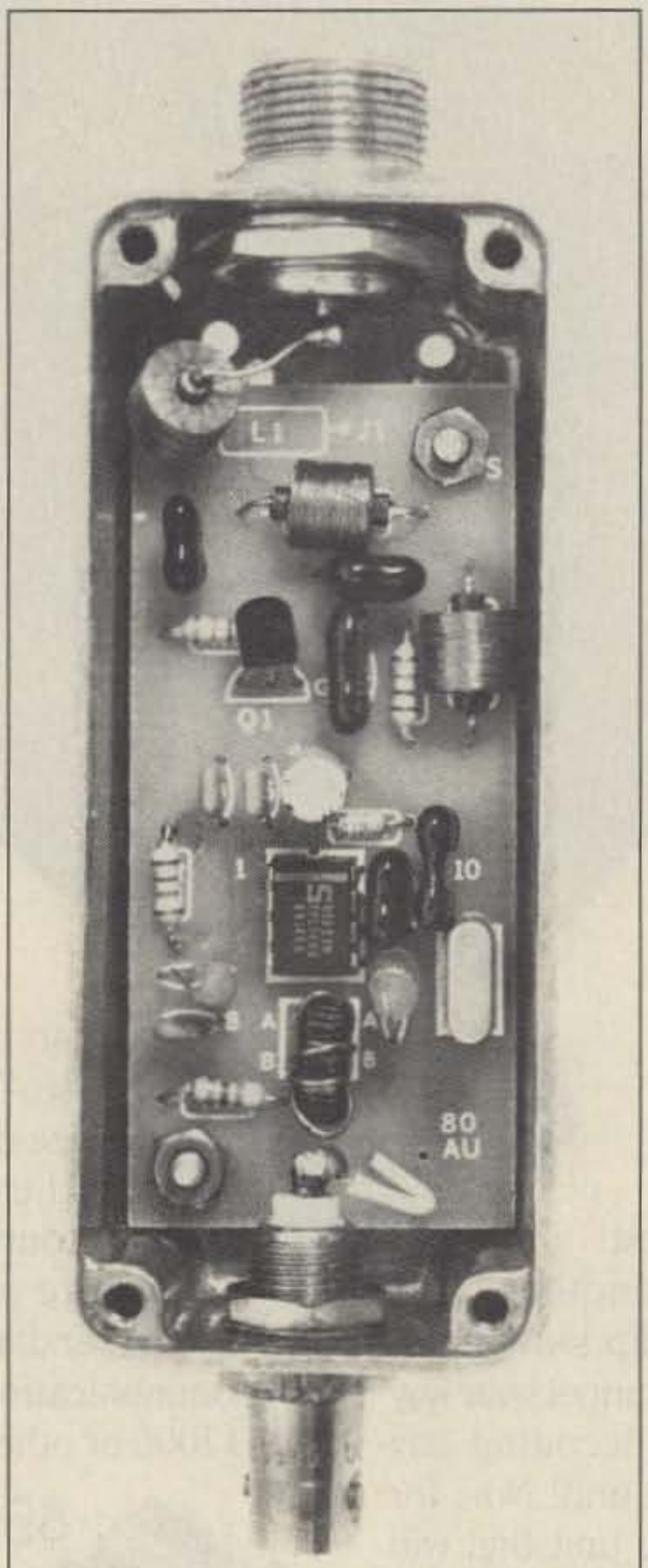

Photo A. Inside the 80AU converter.

Sometimes just moving the antenna 3 or 4 feet can make all the difference. Experiment after finding what you think might be the best area. A tree can be an excellent place, when the 80AU is placed on a wood pole at the very top, away from limbs. Use a wooden pole for mounting to avoid rust.

Tune In!

Once you've decided which coupling circuit method to use and you've "planted" your antenna, simply apply power and tune the receiver within the 3.5–4 MHz range. You can use the direct readout in kHz to accurately indicate the frequency if you are using an amateur receiver or any other type of receiver with a calibrated kHz display, either analog or digital. As an example, if you were listening to a signal and the frequency indicated on the dial was 3.680 MHz, then you would actually be receiving a signal at 180 kHz. The "3.5" is dropped or subtracted. This adjustment quickly becomes second nature.

Operation Requirements

The 80AU antenna input uses an SO-238 style plug, which interfaces with PL-259 plugs and banana-style jacks. You can use a longwire antenna by simply inserting a 39 pF capacitor between the 80AU input port and the longwire antenna. This works exceptionally well for untuned, broadband coverage. Tuned antennas can also be used in the manner described above, by coupling the tuned antenna lightly to the 80AU input through a 39 pF capacitor. However, a simple stainless steel 102″ CB whip provides the best consistent overall performance for portable and land-based installations.

Coupling Methods

The operation of the 80AU is simple. The unit typically is mounted remotely because it needs to be mounted near the active antenna; and the active antenna typically needs to be mounted away from the house to keep the received noise level as low as possible. For convenience, I power the unit using the coax that conducts the RF from the upconverter to the 80m transceiver.

You must use a coupling device end to apply power to the coax for "phantom" pow-

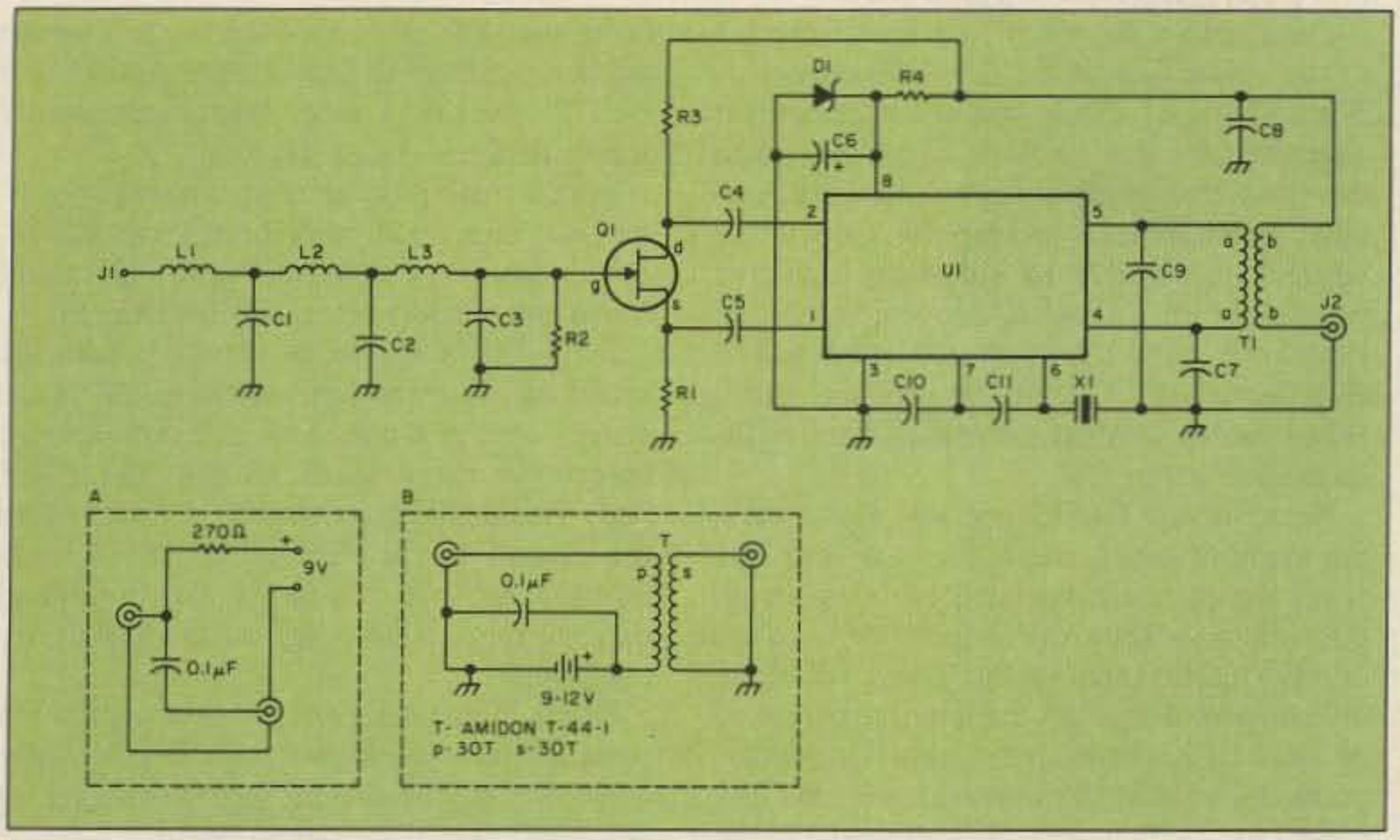

Figure 1. Schematic for the 80AU converter.

er, and to effectively couple the RF to the receiver. Notice the two methods drawn in sections "A" and "B" of the schematic.

Section A shows a simple resistor-capacitor combination that works well for mobile, remote or "clean" ground systems at home. Most ground systems in homes are "dirty" because the ground, or common, return for the AC power line carries the leftover remains from all the neighbors' light dimmers and power line hash. Also, it's securely coupled to the power lines over the course it takes from the power pole to the house. I suggest that you try to ground your system at the house, but even with this precaution there is no guarantee that the ground will "sink" all the noise, especially when the ground rod is placed in sandy or poorly conductive soil. The active whip will capacitively couple to the coax going to the 80AU and pick up all the noise, even if the 80AU is located far away from the house, where it can also couple to the power lines.

Parts List

Resistors: All ¼ watt, carbon composition.

	R1–R3	22kΩR4470Ω
Capacitors	C1, 2	47pF NPO 50V DC/10%
	C3	30 pF NPO 50V DC/10%
	C4, 5, 8	0.1 µF/50V DC
	C6	4.7µF electrolytic, 16V DC
	C7, 9	470 pF NPO 50V DC/10%
	C10	150 pF NPO 50V DC/10%
	C11	47 pF NPO 50V DC/10%
Inductors	L1,3	8.2 mH Miller #70F823AI
	L2	9.1 mH Miller #70F913AI
Transistor, IC, Miscellaneous		
	Q1	J310 JFET
	U1	NE602
	X1	3.499 or 3.5 MHz Crystal
	T1	Output toroid transformer: Amidon T-37-3 Primary: 26 turns, #26 Ga. (black) Secondary: 5 turns, #22 Ga. (red)
	D1	1N753A
	2	Pairs of 4/40 nut and bolt, ½" length
	2	¼" spacers
	1	Aluminum housing, Hammond Mfg. 1590A
	1	SO-238 connector
	1	BNC connector

tor leads, and clip when through. Make sure that the bodies of the parts are against the board, and not lifted away after you've finished soldering.

Now insert and solder the capacitors. An oval shape drawn on the board identifies the locations for the capacitors. The polarity of these parts isn't important, but C6 is an electrolytic. It is identified by a small circle with a "+" on the upper left side, indicating where the positive lead should be inserted. Be sure that the negative and positive leads are identified and inserted into the board so that the polarity will match correctly.

Crystal X1 is identified by the frequency on the side of the part, which should be read either 3.499 MHz or 3.500. This should be inserted and soldered. Apply as little heat as possible to solder X1, as the crystal is temperature sensitive.

Final Assembly

Insert the large RF connector through the appropriate hole, from the inside of the box.

Technical Details

Input impedance	22kΩ
Input frequency response	5–450 kHz (450 kHz–3 dB point)
Converter output	3.5–4 MHz broadband
Filter passband ripple	0.4 dB
Mixer noise figure	0.5 dB
Mixer third order intercept point	−17 dBm
Mixer type	Doubly balanced, active bipolar
Power requirements	5 to 18V DC, 12 volts nominal approx. 30 mA

Construction

Spread out all the parts so that you can identify them using the the parts list. Be careful when you install the inductors (L1–L3) and the JFET (Q1). The JFET is VERY static-sensitive, so be sure that you and your soldering iron are well grounded. Insert Q1 last to avoid overheating and to reduce the chances of zapping the poor thing.

Use a small soldering pencil (NOT a soldering gun) between 25 and 60 watts, and a good quality rosin core solder. Find the NE602 IC and insert it into the board so that the key at the end of the IC will line up with the key drawn on the component-side silkscreen. Push it through and solder all the leads. Clip excess leads after you're done. Insert all parts from the component side, where the silk-screen is printed. Then insert diode D1 so that the band around the diode is aligned with the band drawn on the part silk-screen.

Now insert the resistors, using the parts list for correct insertion. The resistors are marked by an "R" showing where the body of the part should be placed. Solder diode D1 and all resis-

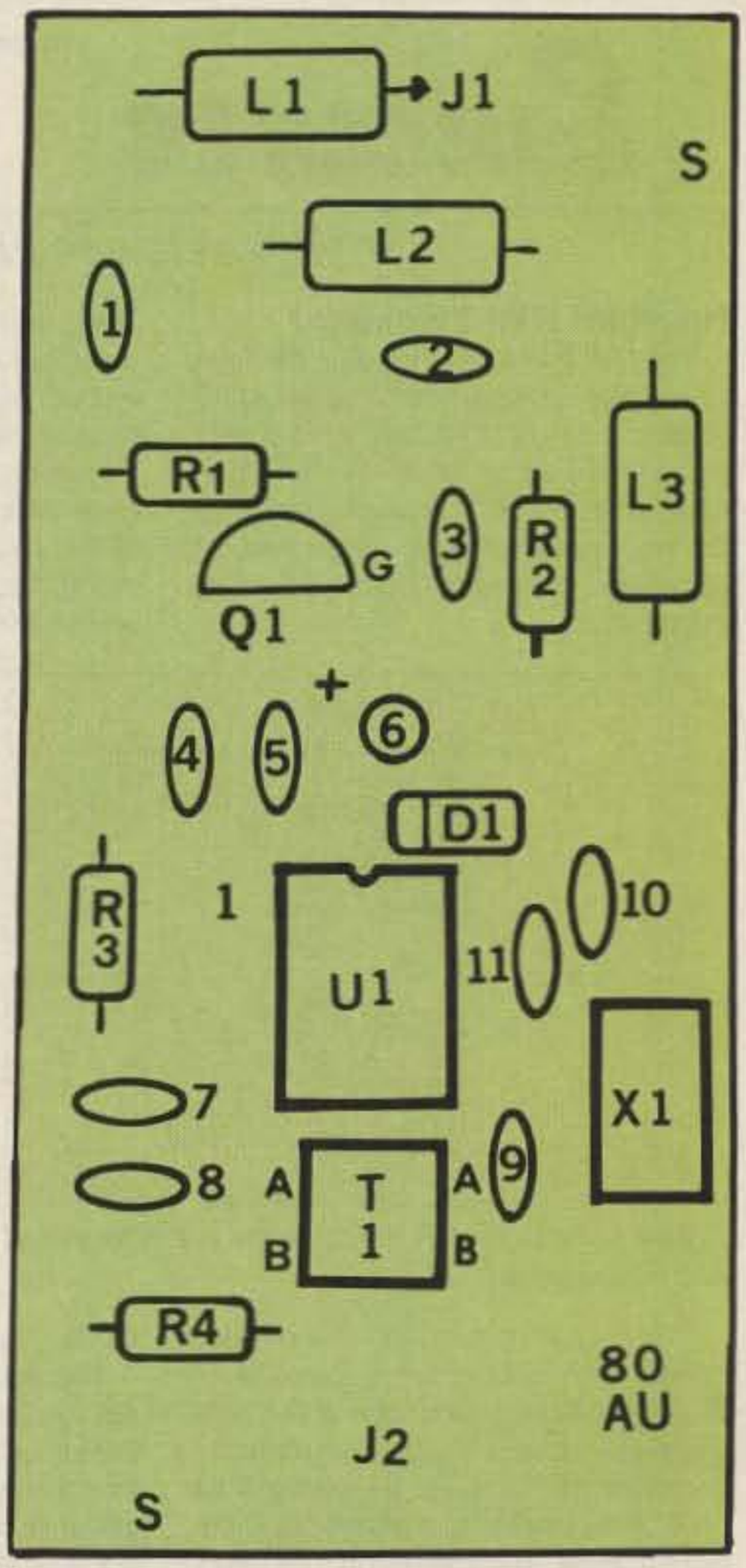

Figure 2. Components layout diagram.

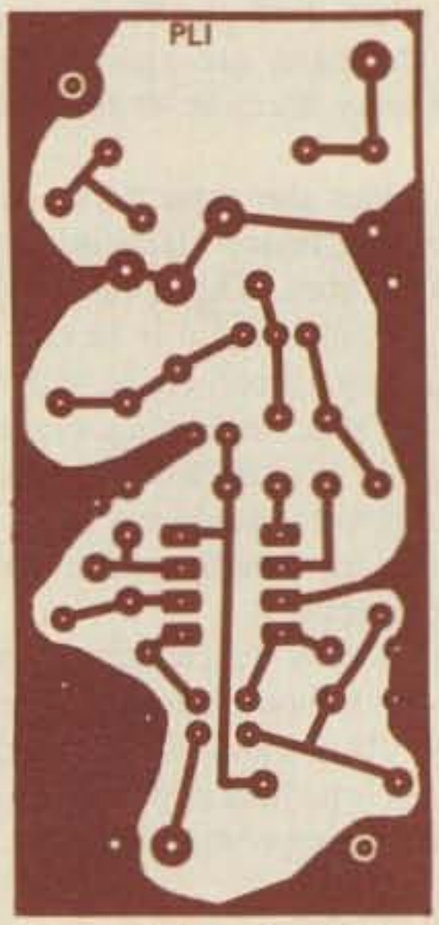

Figure 3. Interface foil pattern.

Once it is in place tighten it with the included bolt. Do the same with the remaining smaller BNC RF connector placed opposite the SO-238. Both connectors should have the solder lugs on the inside of the box.

Next, insert the two screws through the holes in the box from the outside and, holding the screws against the box with your fingers, put the ¼" spacers over the length of the screws inside the box. Take the circuit board and feed the screws through the holes marked "S." Then, push the board toward the bottom of the box, with all circuit board components facing toward you. Tighten the two 4/40 bolts against the circuit board to finish mounting the board securely. The spacers will lift the circuit board away from the box enough to prevent accidental shorting.

Cut the wire from J2 and solder it to the solder lug of the BNC connector. Also, cut and solder the remaining lead from L1 to the solder lug of the SO-238 connector. The body of L1 should rest at a near vertical angle to the circuit board, with the lead to the connector going across almost horizontally. It is important to keep this inductor as vertical as possible to minimize inductive coupling with L2. Also, keep in mind that you don't want L1 to sit too close to the aluminum box. Visually inspect the parts. When you're satisfied, close the lid and tighten the four screws.

Next, look at L1, L2 and L3. These parts are made of many, many turns of very fine wire, and have a manufacturer's number on the side to indicate which inductor to insert into the marked area on the board. All of the inductors indicated on the board are marked by an L. L1 is a little bit different: One lead is pointed toward J1, the terminal of the SO-238 connector, which will be mounted on the housing later. The other lead of L1 is soldered into the hole on the circuit board, just like L2 and L3.

Transformer T1 is a toroid or round transformer with four wire leads, two red and two black. All four leads need to be stripped of their enamel insulation. Use any fine sandpaper to remove the enamel, leaving the four wires bare and ready for soldering. Place the body of the toroid between the holes marked "A,A" and "B,B." The two small black wires, one on each side of the toroid, go into the holes marked "A." The remaining two red wires on each side of the toroid go into the holes marked "B." Pull the wires through the holes gently but firmly, then solder them well to the solder side. Inspect the solder joints, then clip the excess leads.

Take a small piece of copper wire about 1" long and insert it through the hole marked J2. Solder the wire on the foil side of the circuit board and clip any remaining lead length.

JFET Q1 is last to be inserted, with the shape of the transistor matching the shape drawn on the component side silk-screen. Insert the three leads so that the JFET body remains approximately ¼" inch from the circuit board. Solder all three leads quickly so that you don't overheat and damage the device. Clip excess leads after soldering.

Check all the parts one last time against the parts list for correct part insertion. Visually check for any accidental solder bridging on the solder side of the circuit board.

A kit for this project, including the circuit board, housing, and all the parts, is available for $59, postpaid. I will also make just the etched board available for $7.50, postpaid. Contact *Curry Communications, 852 N. Lima, Burbank CA 91505.* 73

David Curry WD4PLI has been a ham for over 15 years. He specializes in RF electronics. Dave is also a professional musician, and owns a small communications business, Curry Communications, which specializes in small electronics kits. Contact him at 852 N. Lima Street, Burbank CA 91505.

Number 14 on your Feedback card

CIRCUITS

Great Ideas From Our Readers

Heathkit HW-8 Speaker

The HW-8 is a fine rig, but you have to use high impedance headphones for listening. Sometimes, two or more people would like to listen at the same time; other times, you might like to listen via a speaker as you work around the shack. Also, some of us hate wearing cans!

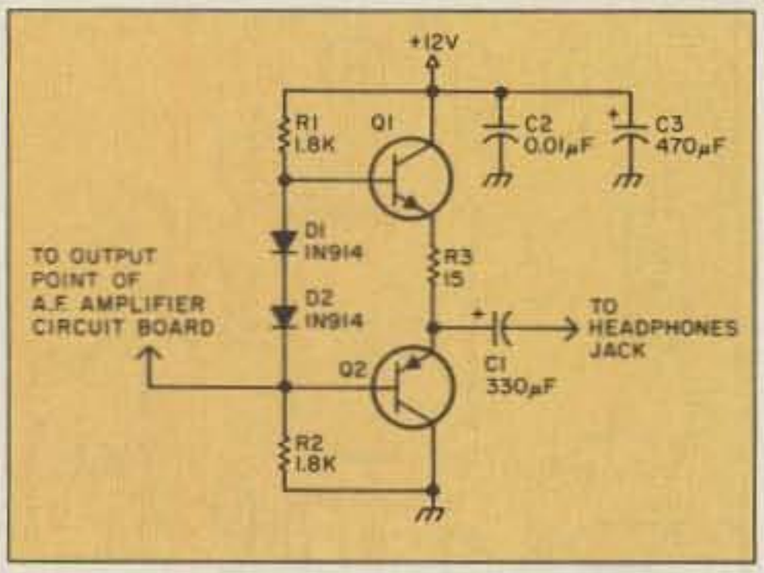

Figure 1. Parts for this modification are easy to find and inexpensive.

The only thing keeping the original circuit from directly driving a speaker is the high output impedance of the rig's transistor audio output amplifier. I came up with a mod to let the rig drive an 8 ohm speaker to a comfortable listening level. It mounts on the back chassis, adds little to the rig's current draw, and is not a major re-design. Finally, parts are not critical, and they're easy to salvage. If you must buy them, they're inexpensive.

I simply cascaded an extra amp between the receiver's audio output amplifier and the headphone jack. This method also ensures that you can easily restore the rig to its original condition if you want to sell it or try a different experiment.

My solution was a simple complementary push-pull amplifier. This circuit's idling current is only a few milliamperes, and since the voltage gain is around one, oscillation problems are minimized.

Figure 1 shows the circuit. I used a pair of salvaged silicon transistors close to the 2N2222/2N2907 combination. Two silicon diodes (D1 and D2) are used for biasing; any switching or rectifier diodes should be fine.

The values used at R1, R2, and R3 set the current draw. The trade here is between low current and low distortion. For this circuit, an idling current of about 3 milliamperes seems to be a good compromise. R1 and R2 should be the same value to set the idling output voltage at about one-half supply voltage. This is necessary to allow a full swing in output. R3 thermally stabilizes Q1 and Q2, and lowers the gain a little. This is the resistor to change to set the idling current of Q1 and Q2.

C1 is used as a coupling capacitor. Its x_c should be low compared to the speaker at the lowest operating frequency. Using an 8 ohm speaker and 500 Hz, this comes to an ideal minimum value of around 330 μF. C2 and C3 are for decoupling and RF bypassing. I recommend a value of several hundred pF to around 0.01 μF for C2, and several hundred μF for C3. Be sure that all capacitors have a voltage rating of at least 20 volts.

I built this circuit on a small piece of perforated board, tested it for current draw and any excess heat, and verified that it worked, all even before I took the cover off of the rig. This could also make a good output amplifier for many of the direct conversion sets popular in QRP work. In this case, it wound up putting my HW-8 on the air more often than before.

Larry Gotts WA3UKC
Box 490, Susquehanna University
Selinsgrove PA 17870

Improve Drake TR-6 Front End

The Drake TR-6 six meter transceivers originally used TI-588 transistors in the RF amplifier stages. Since the original design, transistors with more gain and lower noise figures have been developed. At present, the best device for the job is the U-310 FET. These are available from RF Parts, 1320-16 Grand Ave., San Marcos CA 92069 ($15 minimum order).

If you're at all handy with a soldering pencil, and you have *two* pairs of hemostats or locking scissor-type tweezers to use as heatsinks, you can easily perform the modification. Remove the bottom cover of the set. Locate the double compartment just to the rear of the REC GAIN control. The second half of the compartment contains a slug-tuned coil (L10) and the two RF amp transistors (Q11 and Q12). Observe the layout in Figure 2 to make the change.

[FETs are easily destroyed by static discharge or excessive heat. Follow all normal anti-static precautions, and use TWO locking-type heatsinks, as the author suggests, when soldering connections common to both devices!—Eds.]

L.J. Hemmis K3VLQ
919 West Gore Rd.
Erie PA 73

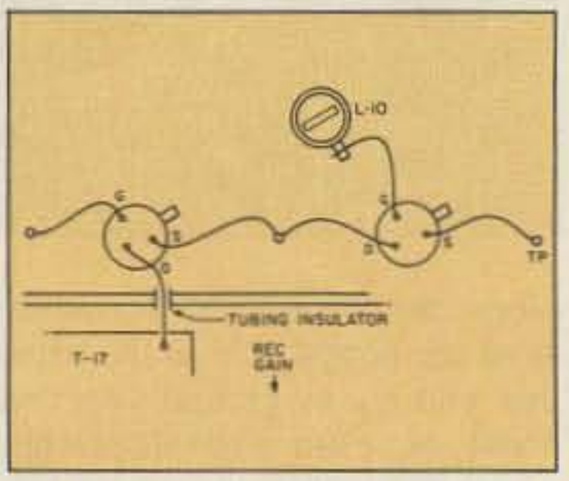

Figure 2. The U-310 FET is best for the job.