Try Building Your Own Equipment

Getting the Parts

The first step is to carefully read the schematic diagram and compile a complete parts list. Parts lists in most articles typically describe only the less-than-ordinary parts being used. So read the parts list carefully, to be sure you understand *exactly* what each part must be.

Once you know *what* you need, you have to figure out *where* to get the parts. It took me about a month of thumbing through ham radio and electronics magazines to find sources for all the parts I needed. Finally, between a couple of very well-stocked QRP kit companies[3] and a local electronics surplus store, I acquired all the parts.

Wes (W7ZOI) and Roger (KA7EXM) Hayward encourage the use of "ugly" construction techniques.[4] But, because I was new to building, I opted for PC boards that were offered by FAR Circuits.[5] My rationale was twofold: First, I felt that I could more easily diagnose a problem in a circuit that was neatly laid out. Second, I estimated there would be fewer component-insertion mistakes with a clearly marked PC board (FAR's component overlays make part placement easier). Those are two primary considerations for the beginning builder. Finally, I wanted the finished product to look good and operate well.

Populating the Boards and Initial Testing

Once I had the PC boards, the building started. Being a complete novice to such a venture, I built all three boards in a weekend, without thought of testing each subsection. (My education continued: I later learned to build a small section of a board and test it before going on to the next one, so problems can be localized as they occur). Besides, what would I test for anyway? How was I supposed to know what the output of a correctly operating oscillator should look or sound like?

I went back to the article to find out what to do next. The next logical step, it said, was to test each section as it was being built. Oops! It was a little late for that. This makes a very good point: Before you start work, read the article (or instruction sheet) thoroughly and repeatedly, to be sure you understand *everything* you should do, such as when to stop building and perform intermediate testing!

"Testing should begin with the oscillator board." Okay, I can hook up a 12-V supply and listen for an 800-Hz tone at 7.000 MHz on my Kenwood rig. This is one of many little tricks I learned along the way: using another radio to test the radio under construction. I powered up the board, tuned my rig to 7.000 MHz and began turning the air-dielectric variable capacitors hooked to the oscillator board. But alas! No signal! What happened? How could this be? I did everything according to the instructions!

I went back and immediately began looking for obvious mistakes. Okay, I did solder the main inductor into the oscillator incorrectly, grounding the wrong end. I found another mistake, a transformer wound with the incorrect number of turns. I hooked the power back up, and began tuning the oscillator, while listening on the Kenwood rig for a 7-MHz signal. Still nothing!

At this point, I enlisted the help of other hams I knew. As you would expect, each one had a different piece of advice. One thought that the oscillator was just being finicky, and maybe if I replaced the transistor in it, it would work. Another suggested that the original circuit might be incorrect. I followed through with these suggestions, testing the circuit yet again and determined that the VFO still would not oscillate!

To put it mildly, I was very frustrated. Reading the construction articles made everything sound so easy, and here I was with about $50 worth of parts that did *nothing!* I decided to start at square one and rebuild the oscillator. I purchased another oscillator board (by now, the original had several lifted traces caused by the several times I had placed, removed and replaced parts).

From reading the various QRP books, I was able to figure out which part of the board was the oscillator circuit (my education was paying off!). I put the 10 or so components on the board, powered it up and listened with my Kenwood for a signal. Still nothing! I was really discouraged at this point; 10 little components were defeating me! I decided to yet again replace those components, one by one. I did this, checking for oscillation after each new part was installed.

I had replaced all but two disc-ceramic capacitors, yet the board still didn't function. The capacitors were clearly marked with the correct value and coefficient, so I didn't question their integrity. As a last resort, I decided to change them anyway, using components from another parts source. I powered up the oscillator board and it immediately started oscillating—success at last! And another lesson learned: Never assume that a component—even a new component—must surely be okay.

The next step was to connect the oscillator board with the transmit buffer/amplifier board. This went well. With the buffer/amplifier, I heard a much louder signal in my receiver. Then I connected the receive board to the oscillator and buffer/amplifier boards. Using the calibration feature, I was able to tune the lower end of the oscillator to exactly 7.025 MHz. The calibration feature allows you to tune in a known frequency with your radio, and use that as a reference as you tune the VFO. I set the band edge to 7.025 MHz with the VFO tuning capacitor in the fully meshed position; then as I turned the VFO capacitor clockwise, the operating frequency increased. The rig operates from 7.025 to just above 7.100 MHz—a nice frequency spread for CW operating. The frequency reference used is strictly according to which part of the band you are licensed for. I could have easily set the lower band edge to 7.100 MHz, for the Novice/Technician part of 40 meters, or to 7.000 MHz for the Amateur Extra Class portion of the band.

First QSO

Before putting the Ugly Weekender into an enclosure, I hooked up my multiband vertical, and eight NiCd D cells, trying eagerly to make my first contact with the newly finished rig. Propagation was poor, though, and I was unable to make a contact that evening.

I woke early the next day and began calling CQ about 6 AM. Rick, AC4WB, answered my call. We chatted for a few minutes and then signed off. I was ecstatic! I'd made a good contact with only about 1.5 W from Rochester, New York, to North Carolina! The thrill of contacting another ham with a low-power signal—*on a rig you've built yourself*—is a great feeling!

About the time Rick's QSL card for that contact arrived, I also received a card from an ARRL official observer (OO). I had heard of OOs, but never had any direct experience with them. The OO, an amateur not far from Rick, had heard my signal and sent me a card notifying me that my signal sounded chirpy. I thought about the report and realized that the eight NiCd batteries weren't sufficient to power my new rig. I added another two cells, to bring the voltage up from 10 V to 12.5 V, and the chirp problem was solved.

Putting the Rig in a Box

After the excitement of the initial QSO, I started work on how to integrate the three circuit boards in an enclosure. My search for an enclosure started at the local electronics surplus store. They had an aluminum chassis without a bottom plate (or, in the manner I used it, no top plate), but I could resolve that matter at a later date.

I wanted to build a home-station-size rig, so there wasn't a need to squeeze the project into a miniature enclosure. I may have opted for the latter *ii* I had planned on taking the rig backpacking. My next step was to build a sub-enclosure for the oscillator board, which would also contain the two air-dielectric variable capacitors. The enclosure isolates the VFO from the other circuits and minimizes any changes in capacitance caused by nearby objects (the operator's hand, for example).

I built this inner enclosure from some single-sided printed circuit (PC) board (see Figure 1). I cut the pieces of PC board by scoring them with an X-acto knife, then snapping the board along the scored line. Very carefully, I soldered each of four sides onto the bottom of the sub-enclosure, which would be bolted to the main enclosure later in the assembly. I used hot-melt glue to secure a threaded standoff in each of the four corners. This permits the oscillator enclosure to be bolted, not soldered, to the top of this inner enclosure. I could have soldered the entire unit, but that would have made access to the circuitry difficult if a problem arose in the future.

Planning the Control Layout

After building an enclosure for the oscillator and bolting the board and variable capacitors into it, I considered how to arrange the controls on the enclosure's front and rear panels. There are no right or wrong ways to lay out the panels. However, I didn't want the controls so close together that I would accidentally nudge one while adjusting another. I wanted the controls arranged in the most user-friendly fashion, from my point of view. Wow! I had progressed from being an equipment builder to being an ergonomics engineer!

The photos show how I chose to place the tuning knobs, calibration, on/off, spotting, and audio output functions on the front of the rig. The power, key, and antenna jacks are on the rear panel. Based on the location of these controls, I placed the two boards and oscillator enclosure into the aluminum enclosure, trying to minimize lead lengths between the boards. From the photo you'll see that I placed the receiver board on the left, the oscillator enclosure in the center, and the transmit buffer/amplifier board on the right. Before installing any boards, I first made a template of the holes I needed to drill in order to accommodate the controls on the rig, as well as what would go inside it.

I used a pencil to carefully mark the aluminum enclosure so as to ensure that the holes were aligned with each other, and that they were a comfortable distance from one another. I didn't want the volume switch too close, for example, to the tuning knobs. Again, I wasn't trying to build the world's tiniest radio, so ease of use was a higher priority than minimizing the package size. Next, I drilled the holes. Using a drill press, I started with a 1/8-inch-diameter hole everywhere a hole was called for. When larger holes were needed, I drilled several times, increasing the drill-bit size each time. This procedure produces a neater hole than trying to blast a 1/2-inch-diameter hole from the start.

Finishing the Enclosure

I sanded the enclosure to remove any burrs resulting from the drilling. Next, I washed the enclosure in soapy water and rinsed it well to remove any oil or grease. I painted the enclosure, first with a primer coat, followed by several coats of gloss black enamel. Be sure to follow the paint manufacturer's instructions! In my haste to paint, I applied a coat of paint before the previous coat was cured—the result was an enclosure with an unwanted wrinkle finish! That mistake sent me back to the enclosure-sanding phase! Now, I let the paint dry for 48 hours (drying times differ with paint brands—read the label!) before applying another coat

Lettering

After the paint was dry, it was time to letter the controls. I purchased dry transfer letters from the local college bookstore. These transfers come in a variety of sizes and type faces, both in black and white. White letters were fine for my black enclosure. The method for putting these letters on an object is simple: Just put the page of letters on the surface of the project and using a pencil, apply gentle and uniform pressure over the surface of the letter to be transferred, by drawing lines across it. The pressure of the pencil point makes the letter stick to the object. Aligning the letters is crucial; I used pieces of Post-It paper as a guide line for alignment of the letters. Another trick I learned was to begin lettering a label with the middle letter of the label. This character goes directly above the control. Next you add letters working from the middle character toward both ends. The result is neat and aligned labels on the rig's controls! Once the lettering was complete, I coated the enclosure with several applications of clear gloss enamel, to protect the labels from being chipped or rubbed off. Be careful when applying the clear coat (apply it sparingly), as any damage to the black undercoat or lettering will send you back to the enclosure-sanding phase.

Mounting the Boards and the Controls

Once the enclosure was ready, I bolted the two boards and oscillator enclosure into the main enclosure, reconnecting the boards with wires that were just the right length. Next, I mounted all the controls and jacks on the enclosure, being careful not to scratch or damage the finish. All that was left to do was to figure out what to use as a top for the enclosure. I thought it would be neat to put a transparent cover on the rig, so the viewer could see how the rig was put together. So I put a piece of 1/8-inch acrylic plastic on the top of the enclosure. In order to secure the panel to the enclosure, I again used the hot-melt glue gun to affix threaded standoffs into the upper corners of the enclosure. Using countersunk bolts, the top is attached to the enclosure. A strip of rubber, about 1/16×3/8 inch, acts as a gasket between the enclosure and the acrylic. Four rubber feet on the base keep my desk from getting scratched.

The End Product

I took great pains to plan and align the controls and jacks, was careful to ensure a smooth paint finish, and used the label aligning and centering technique described to ensure a neat job. The result is a rig for which I have received many compliments on both its appearance and its on-the-air signal.

Summary

In the process of building and debugging this project, I learned a lot. Since this rig was built, I have met other hams who, as I am, are excited about home brewing their own station equipment. We have exchanged information on rig building, and this has also increased my knowledge. I have even made several circuit boards after Brad Mitchell, WB8YGG, showed me how easy it was.

My bench now sports a 30-meter QRP (milliwatt) transmitter project, a Neophyte receiver, and a version of the Ugly Weekender for 30 meters.

There is an upsurge in the number of hams who are becoming interested in learning how radios work, using the hands-on technique of learning by doing. I can remember how I would read *The ARRL Handbook*, *QST* and other ham radio books and magazines—I would think I was understanding things, but then I couldn't assimilate it. I couldn't put it in practice. When you build something, troubleshoot its problems, and make all the necessary adjustments to get it to work, you finally start to understand all those words you read!

With patience and careful attention to detail, you can home brew a rig that looks as good as the available kits—and may look as good as some of the commercially built radios. As a bonus, you'll take pride in operating a radio that you made yourself!

Acknowledgments

Many thanks to Wes and Roger Hayward for their effort in designing, building, and writing the articles for the Ugly Weekender. I also thank N2HZK, KB3W, WD4RDZ, WK2A, and WA2N for their help and encouragement during the debugging phase of my Ugly Weekender (which turned out so well they call it the Professional Weekender).

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Notes

(1) Some examples of recommended background reading are as follows: *QRP Classics*, 1990; *W1FB's QRP Notebook,* 1991; *W1FB's Design Notebook: Practical Circuits for Experimenters,* 1990 (all ARRL: Newington). *G-QRP Circuit Handbook*, 1983 (G-QRP Club: Rochdale, Lancaster, UK, 1983). Wes Hayward, W7ZOI, and Doug DeMaw, W1FB, *Solid State Design for the Radio Amateur,* (ARRL: Newington, 1986).

(2) Roger Hayward, KA7EXM, and Wes Hayward, W7ZOI, "The Ugly Weekender," *QST,* Aug 1981, pp 18-21. (The Ugly Weekender also appears on pages 30-33 to 30-36 of the 1994 and several earlier editions of *The ARRL Handbook* . Also Roger Hayward, KA7EXM, "The Ugly Weekender II: Adding a Junk-Box Receiver," *QST,* Jun 1992, pp 27-30. (This second article describes a receiver and a method of interfacing it with the Ugly Weekender transmitter article.)

(3) Oak Hills Research, 20879 Madison St, Big Rapids, MI 49307; tel 800-842-3748. 624 Kits, 171 Springlake Dr, Spartanburg, SC 29302; tel 803-583-1304. Dan's Small Parts and Kits, 1935 S 3rd W, No. 1, Missoula, MT 59801; tel 406-543-2872. It is just happenstance that these are the suppliers I used; there are many other suppliers of equal quality. Check the ads in *QST* for the many possible parts sources, and ask local hams for their suggestions along these lines.

(4) "Ugly" construction is a method in which the builder solders components directly to a single or double-clad PC board of selected size, without etching the board and usually without drilling any component-mounting holes. "Dead bug" construction is frequently used synonomously with ugly construction because the components (such as ICs) are often secured to the PC board with a dab of glue, their leg-like leads erect, resembling a dead bug with its legs in the air.

(5) FAR Circuits, 18N640 Field Court, Dundee, IL 60118.

Why Would I Want To Home Brew My Own Equipment?

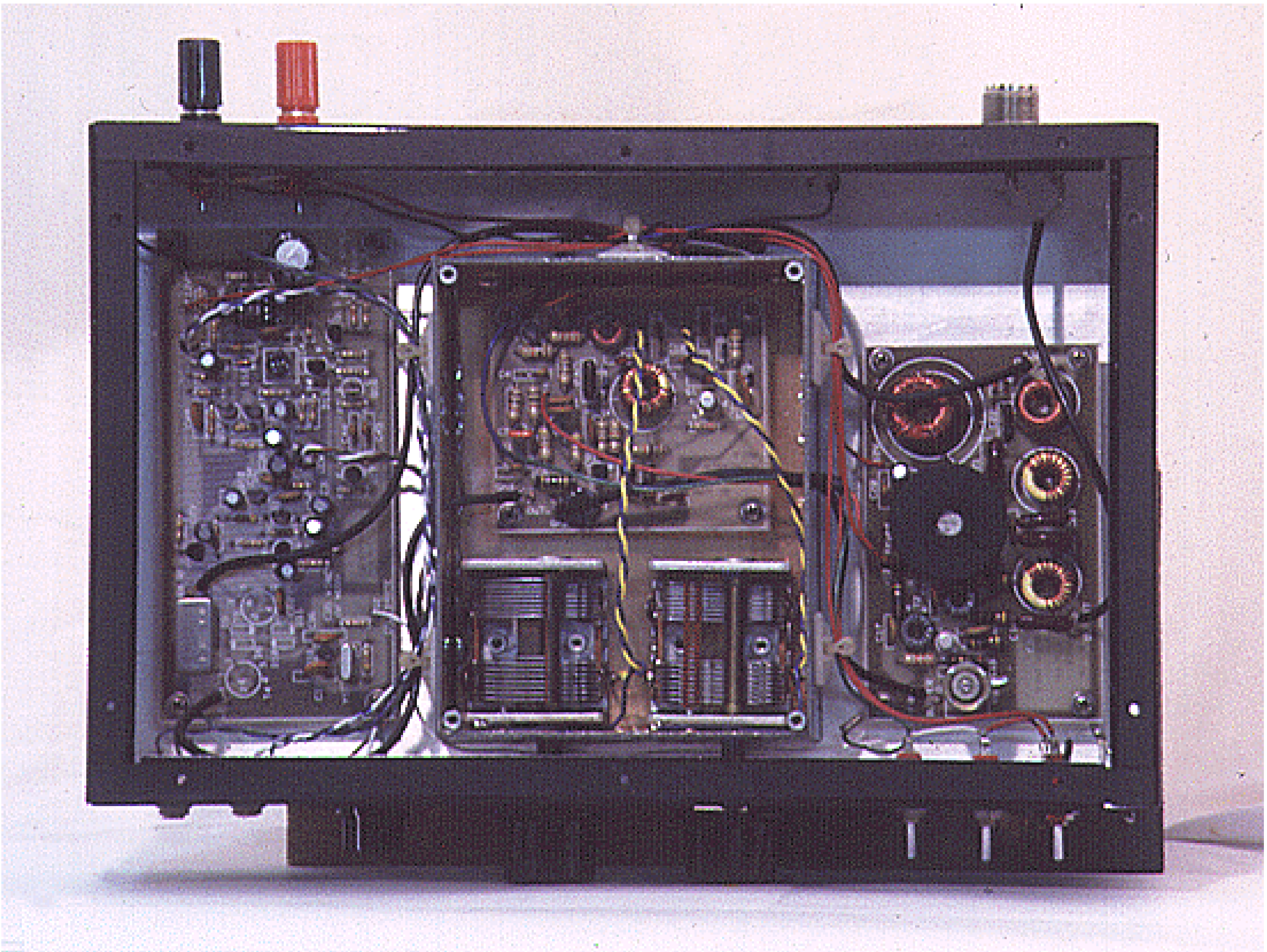
The main reason for wanting to home brew your own equipment is that it is *fun*; what's more, you can learn a great deal. If you thought your first contact using ham radio was fun, you won't believe the feeling of accomplishment you get by doing the same with a radio you built yourself!

Don't let your current class of license discourage you from a home brew project, even those for the HF bands. You can build an HF transceiver and use it in the receive mode to build your code speed to upgrade your license class. W1AW transmits code practice on many ham bands every day (see the W1AW Schedule in this issue for details of time and frequency)!

There are resources out there to help you with your project. If you have Internet access, you can read the newsgroups that relate to home brewing (ie, rec.radio.amateur.homebrew), or you can subscribe to the QRP listserver (mail listserv@netcom.com, subscribe qrp-l).

There are several excellent QRP newsletters that offer information on home brewing: the Northern QRP Club, QRP ARCI, MI QRP Club, G-QRP Club, etc. There may even be some hams in your town that have experience building their own equipment. Join or start your own club for home brewers.

The front panel of N2JGU's Ugly Weekender.



Looking through the clear plastic top cover into the N2JGU "pretty" version of the Ugly Weekender.

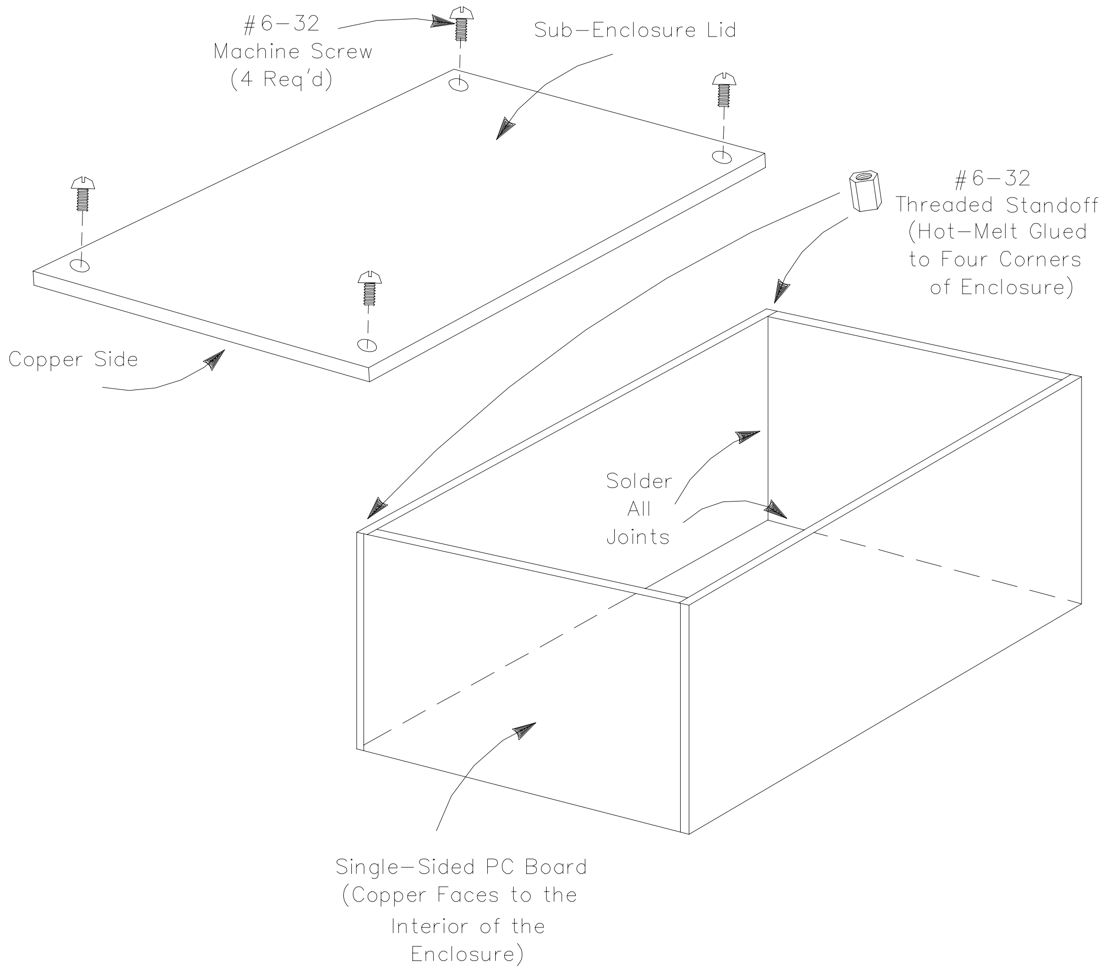


Figure 1—The oscillator sub-enclosure, fabricated from pieces of single-sided PC-board material.

A collection of N2JGU's home brew QRP gear, showing that home brew doesn't have to be homely!