

Smoother Tuning for the HW-8 Transceiver

Simple modification improves a great QRP rig!

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The QRP bug bit me again, so I picked up a clean little Heathkit HW-8 QRP CW transceiver at a recent hamfest. My first QSO on the little rig was with G3UFY on 15 meters, which was quite a surprise. Although the HW-8 uses a direct conversion receiver, the sensitivity is excellent, and adequate selectivity is provided by the built-in audio filter. The heterodyne VFO provides excellent frequency stability, but the tuning is a bit touchy, and there is just a hint of backlash. Although I had told myself that this was one rig I was not going to modify, I could not help myself. How about one simple, easily reversible modification that slows down the tuning rate by decreasing the tuning range from 250 kHz to 125 kHz, which is where I always operate anyway? And besides, with the renewed interest in QRP these days, there must be plenty of other HW-8 owners out there who would be interested in this simple modification.

Theory of operation

The frequency of the VFO is determined by the inductor (L9); numerous fixed capacitors; the main tuning variable capacitor (C302); and stray inductance and capacitance of the circuit. L9 is center-tapped, with one half forming the inductive portion of the resonant circuit, and the other half providing feedback for the oscillator. C302 is divided into two sections: C302a is the main tuning section, and C302b is the trimmer which is adjusted during alignment of the VFO. The ratio of the highest to the lowest frequency in any VFO which is tuned by a variable capacitor is equal to the square root of the ratio of the minimum to the maximum net capacitance in the resonant circuit, including fixed capacitors, the tuning capacitor, and all stray capacitance. The tuning range of a VFO can be altered by knowing the capacitance range of the variable capacitor alone; the inductor value is a constant which cancels out, so long as the net capacitance is held constant for one end of the tuning range. However, once the equations are solved to reveal the net stray capacitance in the circuit, the inductance value can be calculated.

Table 1 shows the effective component values for the original and modified VFO tuning ranges.

| | | Original | | Modified |
|--|--------------|-----------------|--|---------------|
| (L9, tapped) | L = | 1731nH | | 1731 nH |
| (C47, 48, 49, 51) | Cfixed = | 145.8 pF | | 145.8 pF |
| (C44, 45, 46) | Cseries = | 1530 pF | | 1530 pF |
| (C53, C54, D9, Q2) | Cstray = | 33.1 pF | | 33.1 pF |
| (C302a, b) | Cvar (min) = | 6.2 pF | | 6.2 pF |
| (C302a, b) | Cvar (max) = | 17.2 pF | | 11.6 pF |
| | | | | |
| Bottom of band (0 kHz) | Fmax = | 8.895 MHz | | 8.895 MHz |
| Top of band (250 kHz or 125 kHz) | Fmin = | 8.645 MHz | | 8.770 MHz |
| | | | | |
| Capacitance required to reduce effective range of C302: | | | | |
| | | Series = | | 28 pF |
| | | Shunt = | | 1.6 pF |

Table 1 - VFO Tuning Range

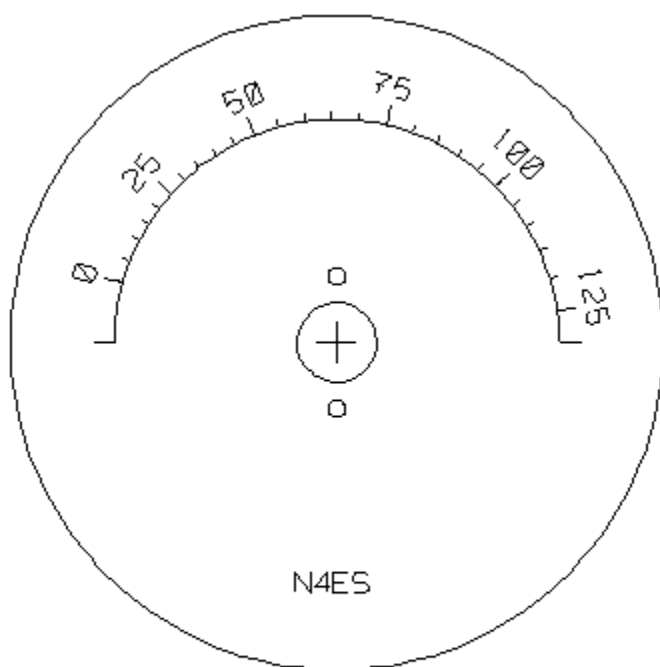


FIGURE 1 - FULL-SIZED DIAL SCALE

As shown in Table 1, the tuning range of the main VFO tuning variable capacitor C302 can be reduced appropriately by connecting a 28 pF capacitor in series and a 1.6 pF capacitor in parallel. In the HW-8, the "hot" side of C302 is connected to the main circuit board by a single wire, which is an ideal place to insert the series 28 pF capacitor. The trimmer portion of C302 has more than enough range to add the required 1.6 pF parallel capacitance. Inductor L9 may need a slight tweak as well. The only remaining requirement is a new scale for the tuning dial.

You will notice that in the mixing scheme employed in the HW-8, the VFO tunes backwards, as shown in Table 1. Measurement of the original tuning dial of the HW-8 reveals that the dial scale starts 15.5 degrees from the mechanical stop (minimum capacitance), and rotates approximately 31 degrees per 50 kHz. The overall dial is 3.13 inches in diameter, and has a scale arc that is 2.13 inches in diameter. The new dial scale starts at the same point, and rotates approximately 31 degrees per 25 kHz. The dial calibration tick marks, originally spaced at approximately 3.1 degrees per 5 kHz, are now spaced at approximately 6.2 degrees per 5 kHz. A dial based upon purely linear tuning was tried, but the calibration error was unacceptable. The deviation from linear tuning was measured, and a corrected dial was designed. Looking back, the most direct way to design an accurate dial scale would have been to fabricate a degree wheel calibrated from 0 to 180 degrees, and note the reading for each desired frequency mark in a table. The rotate function of a CADD program could then be used to place the calibration marks at the appropriate locations on the dial. Instead, I started with a linear dial, determined the error of each mark in degrees, and rotated each mark by the amount of the error. The new dial was designed using the Generic CADD program for the IBM PC, and "printed" to a disk file in the "Epson 8-pin very high resolution" mode. The file HW8-DIAL.PRF may be downloaded from www.expandedspectrumsystems.com. Make your own paper dial on an Epson compatible printer by copying the file to the printer. For example, type: COPY HW8-DIAL.PRF LPT1:. You can also just make a photocopy of the full-size dial scale shown in Figure 1.

Modification

The modification of the HW-8 is simple and easily reversible. Just rotate the original dial scale so that the blank half is showing, lay the new paper dial scale over it, and reinstall the two screws. Insert a 28 pF capacitor between C302 and the circuit board, and realign the VFO. The entire process takes about an hour, using the following step-by-step procedure. Ceramic disc capacitors are available from Radio Shack or from various mail order outlets. Most low capacitance ceramic capacitors use thermally stable materials, and no frequency drift has been noticed with the modified VFO. I bought the "Picofarad 50-pack" assortment from Radio Shack (272-806) for \$2.99, and used a 22 pF and a 6 pF capacitor in parallel. Just twist the capacitors' leads together to make your own 28 pF value. You can use any two or more capacitor values which add up to 28 pF, such as 10 pF and 18 pF. Unfortunately, 28 pF is not a standard value in most capacitor series. The 28 pF capacitor is the optimum value for 125 kHz total coverage. A larger value would increase the frequency coverage, while a smaller value would decrease the frequency coverage.

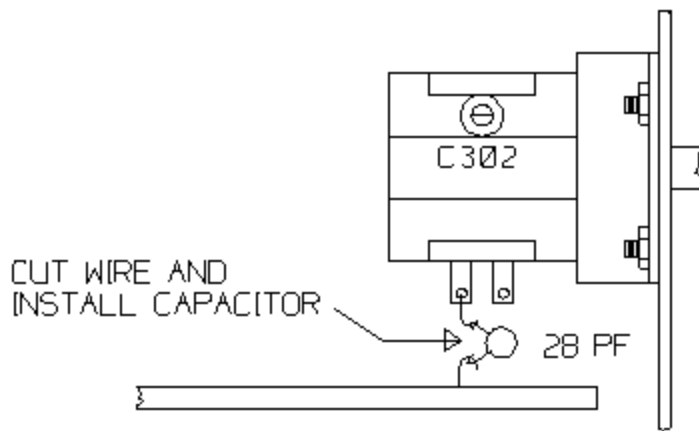


FIGURE 2 - CAPACITOR INSTALLATION

Start preparing the new paper dial scale by cutting it out with scissors. Next, carefully cut out the large center shaft hole and the two smaller screw holes using a sharp hobby knife. Once you are satisfied with the dial scale, set it aside and begin working on the HW-8. Remove the top cover by removing the two rear screws and the two side screws. Set the main tuning dial to the 250 kHz end of its travel to fully mesh the plates of C302. This gets the plates out the way and protects them from damage. It also keeps you from installing your new dial backwards.

Set the LOADING and RECEIVER PRESELECTOR controls for full engagement of the capacitor plates. Note the positions of the control knobs. Remove the front panel by first removing all of the knobs, and then removing the bushing nuts from the SELECTIVITY switch and the AF GAIN control. Set the front panel aside. Remove the two screws securing the original dial scale. The original dial scale is used to provide support for the new paper dial scale. Leave the original dial scale on the shaft, but rotate it 180 degrees so that the plain white half is showing. (Note: DO NOT flip the original dial face inward, toward C302. I tried it, and damaged the original dial by scratching the numbers where the dial rubs against the heads of the screws which secure the mounting bracket for C302.) Set the new paper dial scale over the original dial scale with the 125 kHz end pointing upward, and reinstall the two screws, being careful not to overtighten them and tear the paper. A few tiny dots of "glue-stick" applied with a toothpick may be required to get the paper dial scale to lie flat against the original dial scale.

Reinstall the front panel, being careful to properly align the RELATIVE POWER meter with the opening in the panel. Reinstall the bushing nuts to secure the panel, and reinstall the knobs. Do not reinstall the top cover until completing the VFO alignment procedure.

Cut the wire from C302 to circuit board point "F" near the center of the wire, as shown in Figure 2. Using long-nosed pliers or sturdy tweezers, form hooks in the two remaining wire ends for attachment of the capacitor. Form similar hooks in the leads of the 28 pF capacitor, and attach the capacitor leads to the hooked ends of the two wires. Crimp the hooks to secure the capacitor in place, and solder the connections, being careful not to overheat any adjacent components. Allow the capacitor to cool before beginning the alignment procedure.

Alignment

The alignment can be performed using a frequency counter, as described below, or it can be performed in accordance with the VFO ALIGNMENT steps from the HW-8 manual, substituting 7.125 MHz for 7.250 MHz as appropriate.

To perform the VFO alignment using a frequency counter, connect the HW-8 to a dummy load prepared as shown in PICTORIAL 5-2 of the HW-8 manual. If you do not have access to the manual, fabricate a 50-ohm dummy load by connecting two 100-ohm 2-watt resistors in parallel to an RCA connector, using short leads. Connect a manual key to the HW-8's key jack. Turn on the HW-8 and the frequency counter, and allow them both to warm up for at least 30 minutes. Connect a shielded lead to the frequency counter that has a two-inch insulated but unshielded section at the end. Select the 7 MHz band on the HW-8, and set the dial to 7.000 MHz. Press the key, and hold the unshielded end of the frequency counter's pick-up cable near the dummy load until a stable frequency is displayed. If necessary, tape the pick-up lead in place near the dummy load. Adjust the trimmer portion of C302 (C302b) until a frequency of 7.000 MHz is displayed on the frequency counter. Release the key. Set the dial to 7.125 MHz. Press the key, and adjust the slug in L9 until a frequency of 7.125 MHz is displayed on the frequency counter. Repeat the 7.000 MHz and 7.125 MHz steps until correct tracking is achieved. The process can be shortened by slightly "over correcting" during the first few steps. Remember to adjust only C302b at 7.000 MHz and only L9 at 7.125 MHz.

Now it is time to reinstall the top cover and enjoy operating the modified HW-8. The frequency accuracy with the new dial installed should be better than 1 kHz across the 125 kHz tuning range.

Conclusion

Operating the modified HW-8 is a pleasure. Digging other QRP signals out of the QRM with the narrow audio filter is easier now, because the dial backlash is no longer noticeable. The tuning now has more of a big-rig feel, yet it is not so slow as to be annoying. Perhaps the best feature of this modification is that it can be undone by simply reversing the two dial scales, connecting a jumper wire across the 28 pF capacitor, and realigning the VFO.