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Heath HW-5400 HF Transceiver

Product Review

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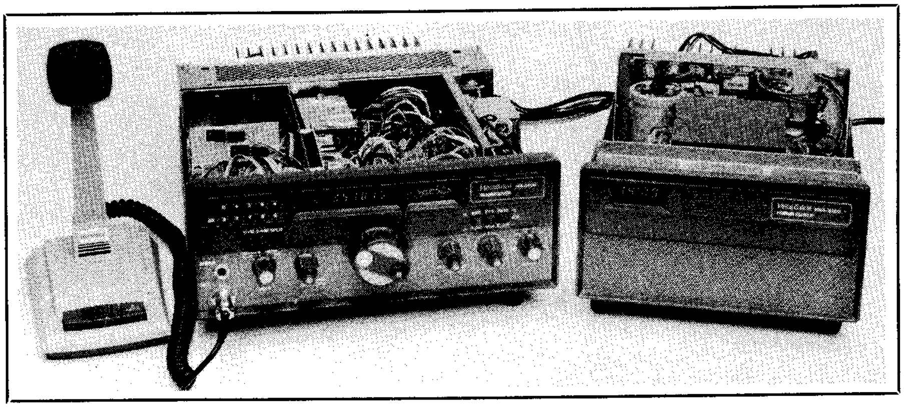

My excitement ran high that Christmas of 1967. I had recently passed my Novice exam, and my parents had bought me a Knight-Kit T-60 crystal-controlled AM and CW transmitter. I spent most of my Christmas vacation assembling the kit. I got a lot of soldering experience, I learned how the pieces of my transmitter fit together (so that later, when repairs were necessary, I was willing to dive right in and locate the faulty components), and my parents saved about 40% of the cost of an assembled, comparable rig.

There was a lot of excitement around my house for the Christmas of 1983, too. This time most of the excitement was generated by my three harmonics, but I also had a new radio kit to build. I had been asked to complete the construction and review the Heath HW-5400 transceiver. This rig has many features I wish I could add to my Tempo 2020, so I quickly accepted the challenge.

A former ARRL Hq. staffer had started the project in April 1983. Three boxes were returned to Headquarters by mid-December: one for the radio, one for the power supply, and the heaviest and smallest one of all for the power transformer. The review unit also included the optional SSB filter unit, the push-button frequency-entry keypad and the HDP-242 desk microphone.

Luckily, the original reviewer had followed the most important instruction of all when he began the project: *Do not remove any bag or parts from the shipping carton until it is called for in the instructions.* There are 14 circuit boards in this kit, and the components for each one are found in one or two small paper bags. Heath has even included a map to show you where each bag of components is located in the carton.

My first step was to transfer all of the corrections on the enclosed addendum into the construction manual (a large, three-ring notebook). One point of confusion here was that I had two sets of addendum sheets, and at one or two points they made different changes to the same assembly step! Which change is correct? A call to Heath helped me determine which sheet to follow in those cases.

Most of the small hook-up wires are supplied in a 30-inch length of 25-conductor ribbon cable.[1] One of the first steps is to cut this cable into various length strands and multi-conductor cables. I found that it is very easy to ruin this wire. If you try to cut the full length of the cable with a knife, you are sure to nick the insulation in many places. When you perform this operation, do not attempt to cut all the way along the length of cable. Use a very sharp knife to start the cut, then zip the wires apart by hand. I called Heath and explained why I needed a new length of ribbon cable and a few other parts that had not survived the change in hands for the project. In the meantime, I had all of this work to do, and a deadline for the review that was only about a month away.

That was when I decided to start on a fresh project — the power supply. Actually, I recommend that anyone building this kit start with the power supply. It is a small project that goes together quickly. My total assembly time, including circuit checkout and a minor modification (more on this later), was just over 13 hours. Besides, when you have completed the '5400 assembly, you will want to power it up right away, so it helps to have a power supply ready and waiting.

The HWA-5400-1 complements the transceiver nicely. It supplies 13.8 V at up to 20 A to power the rig. It also supplies a 13.8-V memory keep-alive voltage so the transceiver will remember the frequencies stored in memory and the last operating frequency even when the power is switched off. The main supply transformer is activated with the HW-5400 power ON/OFF switch. It features a remote voltage-sensing circuit for the regulator transistors. This circuit monitors the voltage being supplied at the rig, and feeds control information back to the transistors. The power supply includes a remote speaker, and it even has a digital-display clock! What more could you ask for?

A small transformer is used to power the clock and memory keep-alive circuit. This transformer is on as long as the supply is plugged in. The main power-transformer primary circuit is closed by means of a relay that is activated when the power switch is turned on.

At construction time, you must decide if you will use the supply on 117- or 234-V mains. There are separate steps in the procedure to guide you through the installation of the proper fuses and jumpers. I decided to wire my supply for use on 117-V circuits. Even though a 234-V supply is more efficient, it is easier to find a 117-V outlet to plug into! Heath provides a standard 117-V, 15-A plug on the line cord. If you decide to go with 234-V operation, you are instructed to cut the plug off the cord and install the proper one.

When you wire the clock circuit board, you must select 50- or 60-Hz operation, depending on the line frequency you have, and you also select 12- or 24-hour display format. I chose the 24-hour format.

The only problem I had while constructing the power supply occurred when I tinned a couple of the larger-diameter wires, as instructed. They would not fit through the circuit-board holes provided. Then I had to clip off the tinned end and use a clean end to solder the wire to the PC board. The wire lengths provided seem adequate in most cases, so making the wire ½-inch shorter did not present any problems. As expected, the instruction manual is detailed and well written.

After completing the power supply and checking the operation, I was shocked to realize that this beautiful station clock provided no way to synchronize the seconds with a WWV time signal! The only way to come close is to plug the power cord in right on the BEEP. I found I could get the clock within 5 or 6 seconds of the correct time this way. But wait! If the only radio I will have in my station to receive WWV signals is the '5400, and it needs the power supply to operate, how can I listen for the tone to plug my supply in? It just won't work! What a disappointment.

Inspection of the clock chip revealed it to be an MM53113N IC. Checking the specifications on this chip in the back of the instruction book proved that it is indeed a full-featured clock chip, capable of alarm functions and much more. Grounding pin 32 (by means of a switch) displays a single minute digit, along with seconds. Now the fast-set switch holds the seconds and the slow-set switch resets them to zero. It didn't take me more than a few minutes to drill a small hole on the bottom of the cabinet, near the front, and to epoxy a small toggle switch to the main chassis

[1]mm = in × 25.4; m = ft × 0.3048.

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so the handle just fits through the hole. One word of caution here. Since Heath's warranty does not cover modified kits, I would recommend you build the radio and power supply without modification. After you are sure everything is operating as it should be, then go back and start making your modifications. You might even want to wait for the warranty to expire.

To set the clock, you must use some device to reach through a small hole in the front panel. A plastic tube about 1 inch long, which is a molded part of the front panel, guides the tool to the contact switch. Heath suggests use of a toothpick, but it did not work for me. A flat toothpick flares too much to fit all the way through the tube, and when I shaved one down so it would fit, it lacked the necessary strength. The perfect instrument proved to be a paper clip, with one end straightened. The remaining bends in the clip form a nice handle, the metal is thin enough to fit through the tube, and it has the required strength.

On with the Construction

The replacement parts arrived before I had completed assembling the power supply, so I was ready to get on with the radio by now! After I got into "virgin territory," things went smoothly with the kit assembly. The 259-page assembly manual is complete and detailed (so what else is new?). The instructions for each circuit board direct you the parts-box map to locate the correct bag and circuit board. Then you do a quick parts inventory for that section, and begin stuffing the board. Some of the boards are rather densely packed, but not so much that you can't work on them. The parts are installed in an orderly fashion, usually starting with the small resistors, diodes and capacitors, and then on to the larger components, such as electrolytic capacitors. You are instructed to move around the board, adding components section by section. A pair of small needle-nose pliers and a close-cut dikes are handy tools for this project.

Chuck Hutchinson, K8CH, showed me a nifty trick for installing the components. Even though the instructions are to mount the small components flush against the PC board, Chuck likes to mount them a little above it. His reasoning is that when a component burns or explodes, it is not as likely to char the PC-board markings. This can be important when you try to identify the part number and value to replace the damaged part. A piece of scrap PC-board material can be cut to a width about equal to the length of a ¼-W resistor body, and several inches long. This "spacer" can be held under the component being installed and the leads flared slightly to hold it in place while you solder them to the board. This provides a uniform spacing for the components above the board, and makes a very professional-looking job when the circuit board is done.

After each circuit board is completed, you are directed to make a series of visual checks on your work. It is much easier to double-check each component location and orientation at this time than after the boards are installed in the chassis! Also be sure to check every solder connection for cold-soldered joints or excess lead lengths that could short against another circuit trace or the chassis.

Most of the check-out procedures include a few resistance measurements. Heath recommends use of a high-input-impedance VOM. My meter has an input impedance of 20 kΩ/V. Heath also cautions that the negative ohmmeter lead must be connected to the ground foil unless you are told to do otherwise. Most hams will be aware that the red (+) lead on most VOMs is negative in the ohmmeter positions. Be sure to check your meter with a second voltmeter. You will get erroneous results on many of the measurements if the leads are reverse connected. My VOM gave results that did not agree with the expected measurements in a number of instances. I tried a VTVM from the ARRL lab to double-check those results. In most cases, the results were in the range of acceptable values when I used the VTVM. I would recommend the use of an FETVM or VTVM if at all possible.

Even with the VTVM, some measurements indicated problems with certain components. On the audio board, I found one troublesome measurement that indicated a faulty capacitor. When I tried to locate that part on the board, I discovered that it had been replaced with a jumper wire in the installation step! This illustrates the fact that a kit as complex as an HF transceiver is a dynamic project. The engineers at Heath are constantly working to improve the radio, but the documentation may not always keep up with the changes. (Of course, the same is also true for fully assembled rigs, but you would not be as aware of the changes. Many of the schematic diagrams supplied with those rigs do not match the actual circuitry inside the box.) There are markings and mounting holes on several boards for components no longer used. I used a felt-tip pen to mark off those areas, just so I wouldn't wonder if I had left out an important component later on.

There were a few other minor snags in doing these resistance checks. On the HI and LOW VCO boards you are instructed to check for shorts on the feedthrough capacitors, using your ohmmeter set to the × 1-kΩ range. The + 12 V leads on both these boards have a 600-Ω resistor to ground on this capacitor, which looks like a dead short on the recommended range. It can be rather confusing until you start tracing the circuit wiring and schematic diagram.

On the controller circuit board, I installed a set of wires in holes I, G and O. A few steps later, I was again instructed to solder wires to holes I, G and O. That was when I discovered two sets of holes on the board with the same labels! Of course, I had seen the wrong set first. So I had to unsolder the wires and move them. Why label two sets of holes with the same letters on one board? Beats me!

Well, I finally had all of the boards built after spending about 70 hours working on the radio. Approximately another 10 hours of putting the circuit boards on the chassis, and I was ready to begin the alignment procedure. It has been very time-consuming, but fun. I am intimately familiar with every piece of my radio, and how it all fits together.

Then came the snag! While adjusting the USB oscillator on the BFO board, I found that I could not set the frequency to 8.83145 MHz. In fact, I could not adjust it higher than 8.827 MHz. Heath suggests a couple of diodes, an inductor or a transistor as possible culprits, so I lifted them off the board to check. All seemed normal. After many hours searching the circuit board for a bad solder joint and studying the schematic diagram for other possibilities, I came to realize that there was plenty of tuning adjustment, and everything was working. The trimmer capacitor was set to minimum value when the oscillator was tuned to the highest frequency possible. I just couldn't tune high enough — too much capacitance in the circuit! Then I noticed that the manual originally called for a 7.7-pF NP0 capacitor in the circuit, but that value had been changed to a 27-pF NP0 unit. I tried replacing the capacitor with the original one supplied with the kit. Now the frequency was too high, and would not adjust low enough! Well, try some values in between. After several hours of changing capacitors and checking the resonant frequency, I managed to hit on a combination that worked. Now I was able to adjust the frequency properly.

I spent some time on the phone with the Heath technicians on this one! They suggested a faulty capacitor or an incorrect inductor in the circuit. I received prompt, courteous service every time I called (even without identifying myself as an ARRL employee!), and within a few days I had some replacement parts to install. These did not seem to cure my problem, so I put my previous capacitor combination back into the circuit.

Toward the end of the alignment procedure, I hit another snag. To adjust the HI VCO circuit on 12 meters, you are instructed how to set the controls, and then directed to adjust a trimmer capacitor for a reading of + 4 V at a test point. I found that by changing the trimmer setting, I could set the voltage to + 1.6 or + 11, but nothing in between! More calls to Heath. This is a complicated piece of equipment, and troubleshooting over the telephone is next to impossible, but the hams on the technical assistance line really know their stuff. The two or three gentlemen I talked to always had some suggestions or ideas about what could be causing my problems. We finally decided that I had a defective band-switch wafer, causing improper voltages to be switched to the HI VCO board. The band-switch wafers mount on the RF circuit board. A plastic shaft goes through three wafers on this PC board, and connects the front-panel knob and a wafer mounted to it with the sections mounted on the filter circuit board. There seems to be quite a bit of play in this system, and if one of the plastic-capsule wafers is a bit loose (as one of mine was), I don't see any way the whole thing can track properly. I replaced the band-switch wafers on the RF board and a few other components suggested by the Heath technicians. The problem just would not go away!

Heath Solves the Problem

I concluded that I was spending an unreasonable amount of time trying to solve this problem, while Heath could probably swap one or two circuit boards to locate the faulty one, and then it would be much easier to pinpoint the problem component. So I completed the final assembly without doing the rest of the alignment. Then I packed the radio up and shipped it back to Heath, along with a detailed letter explaining the problem I was having. The unit was sent out in early April, but by early June I still had not even received an acknowledgment that it had arrived at the service center! After several phone calls to the Advertising Manager, we did locate the radio. It appears to have had been repaired since early May, but it had been misplaced. I was promised that it would be returned that day, and a week later I had my '5400. I believe this is a case in which a regular customer would have received faster service. Apparently, there was some confusion about how to handle a repair for the ARRL!

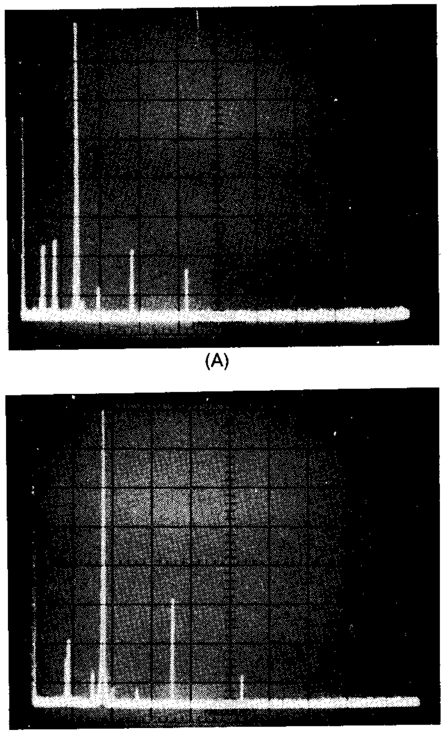
Heath returned a copy of the service technician's report and all of the components they replaced. One small coil on the HI VCO board was open. That apparently caused all of

Table 1
Heath HW-5400 HF Transceiver, Serial No. 01-47504

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency Coverage: 3.450-4.050 MHz, 6.950-7.350 MHz, 10.000-10.200 MHz, 13.950-14.400 MHz, 18.018-18.218 MHz, 20.950-21.500 MHz, 24.840-25.040 MHz, 28.000-29.750 MHz.	As specified.
Modes of operation: CW-W, CW-N, LSB, USB.	As specified.
Tuning rate: 50 Hz/step, 1.25 kHz/turn 1 kHz/step, 25 kHz/turn with touch sensor.	As specified. Backlash nil.
Frequency display: 7 digit, vacuum-fluorescent green.	5/16-inch-high digits.
S-meter sensitivity (μV for S9): Not specified.	80 m: 46; 40 m: 43; 30 m: 85; 20 m: 65; 17 m: 82; 15 m: 160; 12 m: 180; 10 m: 94
Transmitter power input: 100 W minimum, except 80 W minimum on 10 m.	117 W maximum on 12 m, 94 W minimum on 10 m.
Harmonic suppression: −50 dB min., referenced to 100-W output.	−58 dB worst case, except −48 dB on 17 m.
Spurious suppression: −60 dB min., referenced to 100-W output.	See Fig. 1.
Third-order IMD: −30 dB min., referenced to 100-W output.	As specified.
Receiver sensitivity: less than 0.35 μV for 10 dB S+N/N.	Receiver dynamics measured with narrow (250-Hz) CW filter:

	80 m	*20 m*
Noise floor (MDS) dBm:	−135	−133
Blocking DR (dB):	110	112
Two-tone, 3rd-order IMD DR (dB):	82	90
Third-order intercept (dBm):	−12	+2

Receiver audio output at 10% THD: 2 W min. into 4 Ω.	2.2 W.
IF shift tuning: ±600 Hz (receive only).	Not measured.
RIT tuning: ±350 Hz.	+400, −700 Hz.
Operating temperature range: 0 to 40° C.	Not measured.
Size (HWD): 5 × 11½ × 14 in (12.7 × 29.2 × 35.6 cm).	5½ × 11½ × 15 in (14 × 29.2 × 38.1 cm), with raised front feet and clearance for heat sink and knobs.
Weight: 24 lb (10.9 kg).	



(A)

(B)

Fig. 1 — Worst-case spectral output of the HW-5400. At A, the rig was operated at 100 W on the 20-meter band. At B, the power output was 109 W on the 17-meter band. For both photos, the vertical scale is 10 dB/division and the horizontal scale is 10 MHz/division. The spectrum analyzer bandwidth was 100 kHz. The transceiver meets the manufacturer's specifications and current FCC spectral-purity requirements.

the difficulty I had with the alignment. I believe I did also have a defective band-switch wafer, but it is hard to be sure. Several other components had to be replaced as a result of improper voltages being applied, either as I had tried to set the band switch to track properly or because of the defective wafer. The technician had even replaced my two 7.7-pF parallel capacitors on the BFO board with the original 27-pf value, and the USB BFO circuit adjusts to the proper frequency now. All of the remaining alignment steps had been completed.

After testing the rig in the ARRL lab (see Figs. 1, 2 and 3 and Table 1), I was ready to take it home for some on-the-air operating. Field Day weekend was fast approaching, and I planned to to use that contest to really see how good the receiver is.

Circuit Description

The main signal flow follows the pattern of most modern transceivers. I will describe only those features that are unique or specific to the HW-5400. Two voltage-controlled oscillators (VCOs) provide the LO signals for the transceiver. One operates on 80, 40 and 30 meters, while the other functions on the higher-frequency bands. Incoming signals are converted to the 8.83-MHz IF before being routed to the audio circuit board. With the HWA-5400-2 2.1-kHz, four-pole SSB crystal filter installed, the signal is filtered before being amplified. After the first IF amplifier, the signal goes through a six-pole filter and three more stages of amplification before being passed to the audio board. The wide and narrow CW filters are active audio stages. The narrow CW filter has a 250-Hz bandwidth, centered on 700 Hz.

At the heart of this radio is a microprocessor. Some of the functions it performs are: refresh the frequency display line; receive input from the shaft encoder or the frequency-entry keypad; program the frequency synthesizer for the desired frequency; poll the front-panel switches for the desired band and modes of operation; ensure that the PLL circuits are locked and the frequency is within certain limits before allowing the transmitter to operate; store the display and memory frequencies for each band, even when the transceiver is turned off (provided the memory-keep-alive voltage is present); and perform diagnostics on the transceiver when it is first powered up.

This last feature can be helpful if some problems develop with your radio. The controller displays certain information to help you track down the problem. If you see PLL on the display when you turn the transceiver on, for example, you will know that one or more of the PLL circuits has not locked. The information is rather limited, but it could prove helpful.

BCD information from the CONTROLLER board is routed to the display circuit board to provide a frequency readout. The vacuum-fluorescent display includes seven digits, a comma, a decimal point and several special display symbols. A small U, L or C to the left of the digits indicates USB, LSB or CW operation. A one-segment bar above this letter indicates that the unit is in the transmit mode. If you tune above or below either amateur-segment band edge, a left-pointing arrow near the left edge of the display will warn you that you are out of band. When you select split-frequency

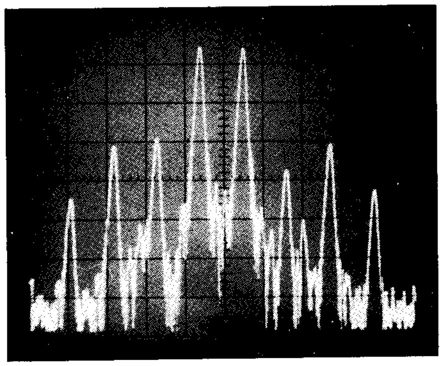


Fig. 2 — Results of the two-tone transmitter test. Third-order products are down approximately 30 dB. The transmitter was being operated at 100-W PEP output on the 20-meter band. The horizontal scale is 1 kHz/division, and the vertical scale is 10 dB/division. The spectrum analyzer bandwidth was 100 kHz.

operation, a bar will light under the arrow position; and if you choose to display the memory frequency (which is the transmit frequency during split-mode operation), a bright M will light.

The main-tuning method is quite interesting. The knob contains a metal insert connected to a capacitive-touch circuit. If you place a finger into this indentation, the microprocessor changes from a 50-Hz tuning rate to a 1-kHz rate! Behind the front panel is a plastic disc that has alternate clear and black radial stripes. When you rotate the tuning knob, these stripes pass between two pair of optical encoders. Signals from these encoders enable the microprocessor to determine which way you are turning the knob, and then decide to increase or decrease the operating frequency. During alignment, I discovered that if a bright light shines on the encoder, the frequency will not change! This could lead to a simple "dial lock" modification for the radio!

Most modern transceivers use PLL frequency-synthesis circuits. One problem with these circuits is that the time required to make a frequency step is inversely proportional to the loop filter bandwidth. This filter must have a bandwidth that is narrow enough to attenuate the reference-frequency signal to an acceptable level, and yet wide enough to allow a fast response to frequency changes. For a single-loop synthesizer, the minimum step size is equal to the reference frequency. If the filter bandwidth is left wide enough to provide small frequency steps, then more reference-frequency-oscillator noise will get through to the audio stage, or appear in the transmitted output.

A dual PLL synthesizer is employed in the Heath HW-5400. Loop one has a 10.05-kHz reference frequency, while loop two has a 10-kHz reference. Thus, the loop filters can have a fairly wide bandwidth and still provide good attenuation of the reference frequency. Each loop uses a VCO, whose output varies depending on the band and operating frequency. The VCO signals are combined with the PLL reference oscillators through a divide-by-N counter on the synthesizer board to provide 50-Hz frequency steps. The output from this synthesizer does not suffer from severe phase-noise problems, as has been common with many synthesized rigs. Evidence of this is shown in Table 1. We were able to measure the blocking dynamic range. Many rigs have a "noise limited" entry in that position!

The power amplifier uses three push-pull amplifier stages to produce 100 W of RF output. The final-amplifier transistors are a matched pair of Motorola SRF3351P power transistors. These devices are thermally protected by a pair of diodes mounted in contact with them. As the diodes heat up, they turn off a bias transistor, reducing the bias on the finals. While the transmitter should only be operated into a 50-ohm load, this type of protection does prevent the transistors from being damaged by a mismatched condition. When rigs with transistor final amplifiers first came out, they were prone to destruction of the output transistors if the SWR on the feed line was allowed to go too high. Many hams still seem to believe that this is a problem, but protection schemes such as are employed in the Heath HW-5400, have virtually eliminated this effect.

An Uncluttered Front Panel Means Easy Operating

One of the first things I noticed about the '5400 was that the pictures show a minimum of control knobs on the front panel. Does that mean the radio lacks some of the features of the other manufacturers' newest offerings? You may have noticed that some manufacturers seem to be competing to see how many controls they can squeeze onto the front panel of their radios. Well the HW-5400 may not have *all* of the features, but it does seem to have the important ones!

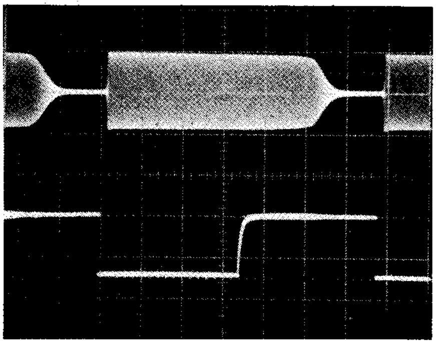


Fig. 3 — Display of the original keyed CW output waveform. The top trace is the RF output envelope, and the bottom trace is actual key closure and opening. Each horizontal scope division is 10 ms. Notice that it takes approximately 20 ms after the key contacts open before the output wave begins to decay. This delay appears to be independent of keying speed, and tends to eliminate the interelement spacing at speeds much above 20 WPM. This should be considered unacceptable for high-speed CW operation.

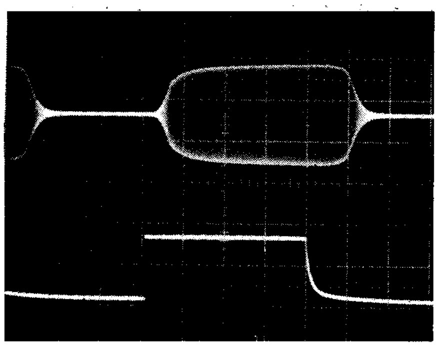


Fig. 4 — CW output waveform of the HW-5400 after I performed Heath's suggested modification. Each horizontal division is only 5 ms on this photo. The rise and fall times are much better, but most important, it only takes about 5 ms for the radio to begin to turn off the carrier after the key contacts are opened.

There is a grand total of six knobs on the front panel. Three of them are concentric, dual controls, however. Single knobs control the main tuning, and select the band and operating mode. The dual controls are for MIC/CW GAIN on transmit, AF/RF GAIN on receive and RIT/IF SHIFT. There are also six, small push-button switches to select other operating features, such as FAST or SLOW AGC action, PTT or VOX operation, TUNE, SPLIT transmit/receive operation, swapping memory and display frequencies or writing the display frequency to memory. With the optional frequency-entry keypad (for the price, I don't understand why anyone would choose to be without this), add 11 more buttons in the top-left corner. Hidden under the name label at the top right are the VOX controls and the sidetone-level adjustment. While you will need a small-bladed screwdriver to turn these controls, it sure beats hiding them under the top cover, where they end up being virtually inaccessible in many cases. Rounding out the front panel are the S meter, a PHONE jack and a MIC connector.

The rear panel is equally simple. A large heat sink for the power amplifier circuit board takes up most of the space. On one side of the heat sink is an SO-239 coaxial connector, a ground lug and phono jacks for a power amplifier ALC voltage and a set of relay contacts that close when the transmitter is activated. On the other side is a six-pin accessory connector, which provides a speaker output, memory-keep-alive voltage input and an output for the voltage-sensing circuitry of the HWA-5400-1 power supply. There is a phono jack for a positive CW keying line and a switch to turn the relay on or off. The largest connector on this side is for the four-conductor power-cord.

Operating Impressions

Lab testing of the receiver section showed it to be a fine performer. The characteristics listed in Table 1 will compare favorably with most receivers on the market today. The two-tone output spectrum and the CW keyed waveform gave me reason for concern about the transmitter portion of the radio, however. The two-tone output does meet Heath's specifications for the radio in terms of the third-order products, but normally we expect the fifth-order products to be reduced below that level. Fig. 2 indicates that the transmitted audio may be distorted somewhat. This is not a major problem, but something that could be improved. Actual operating experience brought no complaints of distorted audio.

My main concern was for the CW waveform. When you look at Fig. 3, you will notice a rather sharp turn-on characteristic, but the real problem is what happens when you let the key up. It takes 20 ms for the radio to realize it is supposed to turn off the carrier, and then about 6 ms more to accomplish this task. For the dot shown here, the transmitted dot length is almost twice the keyed dot length.

Notice what happens to the interelement spacing. For speeds much above 20 WPM, the space almost goes away completely. At Novice speeds, the rig will probably work fine, but for a high-speed CW operator, this waveform would be totally unacceptable. I called Heath for help with this problem. Their engineers looked at the waveform from a '5400 they had, and discovered that it was not what they had intended. I received a phone call a few days later, with a suggested modification to the keying circuit. I was assured that this simple change is being incorporated immediately. If you own an early version of the kit, contact Heath for the information. Any new kits purchased should include the changes on the RF board. Fig. 4 shows the keyed waveform after I made the changes. Quite an improvement!

I made a few contacts prior to the start of Field Day to become familiar with the operation of the rig. This radio is easy to operate, and the controls are placed so that large fingers can use them. The concentric controls have a full-sized knob next to the front panel, with a thin extension through the center. I do not feel like I must carefully reach around the center control to reach the rear one, as I do with many rigs that use this type of control.

I was anxious to try the IF SHIFT feature. I found several CW and SSB signals that had rather severe interference on them during Field Day. By turning this knob to the + or − side, I could usually find a setting that would allow copy of the original station. I find this feature to be very effective!

Since it was such a nice day, I decided to take the rig out to my picnic table for some Field Day fun. After about a half hour of sitting in the direct sunlight, I was getting warm, but not ready to quit yet. The '5400 felt differently about it, though. The brown cabinet and black heat sink were soaking up more heat than I was, and the radio decided to "go north" for a while! After I took it back inside and let it cool off a bit, everything was back to normal.

Switching between the memory and display frequency is an effective way to make a few more contest exchanges while listening to a particular station, waiting for a chance to work it. A single front-panel button makes this change quick and easy.

Fast break-in CW operation is achieved by setting the VOX DELAY to a minimum. It takes a little practice to get used to hearing the active receiver between code letters. But there is no better way to keep track of what is happening on your transmit frequency. More than once I completed a transmission with a non-QSK rig, only to find that the contact was broken because of a strong interfering signal. It is much easier to pick up the pieces when you are aware of the interference right away.

The HW-5400 selects the "normal" sideband on each amateur band. You have the option of choosing the reverse sideband if you have some reason to do so. There are two active audio filters that are selectable for CW operation. The narrow filter has a 250-Hz bandwidth. If you wish to operate other modes, you will have to adapt the radio to suit your needs. To get on RTTY, for example, you will have to wire an extra microphone connector to your modem for AFSK operation.

The S meter has the normal 0-to-9 signal-strength markings, plus marks for 20, 40 and 60 dB over S9. During transmit, the meter doubles as a relative power output meter. There is a block marked ALC on the meter face. It is important that you keep the needle within this block on voice peaks while transmitting SSB. Otherwise, you will overdrive the final amplifier, causing a distorted signal. Adjust the MIC GAIN control while talking into the microphone. For CW operation, you press the TUNE push button and adjust the CW GAIN control for the desired output.

I obtained an extra power cable from Heath so I could connect the transceiver in my car during the review period. The '5400 is small and lightweight, making it be a nice mobile rig. It may present some problems if you want to find space under the dash of a compact car, however. You will have to find some means for connecting a speaker for mobile operation. This could be through the front-panel PHONE jack or by means of a mating connector for the accessory jack. If you want the radio to remember your favorite frequencies between operating periods, you will also have to provide a battery connection to the memory-keep-alive pins.

What has been left out of the HW-5400? It has no noise-blanker circuit, no RF attenuator and no crystal-calibrator or marker-generator circuit. Neither is there any means to disable the AGC operation. There is no provision for auxiliary microphone input or audio output. These features would make it easier to connect an RTTY modem to the radio.

Tuning the receiver without an antenna connected revealed numerous weak "birdies" and other "growlies." The receiver has some odd-sounding noises on the 80-meter band. These seem to be coming from the controller circuit, because when I entered numbers on the keypad while tuned to some of these frequencies, the noise would change. The loudest birdies occur at 4.02112 MHz, 7.0362 MHz, 28.13850 MHz and 28.96365 MHz. These signals just barely move the S meter. I found one stronger signal by tuning to 10.000 MHz and then turning the RIT control as low in frequency as possible. When I also move the IF SHIFT control to the low-frequency side, the S meter moves nearly half an S unit. I did not find any of these spurious signals to be a problem during normal operation, even after I knew where to look for them.

Conclusions

At the beginning of this review I mentioned my first transmitter, a Knight-Kit T-60. There were many reasons for buying a kit then, the greatest of which was the fact that it was possible to save as much as 40% of the cost of a comparable rig. Other reasons were the claims that the builder would learn a lot about electronics in the process, gain knowledge of the radio itself and the sheer pleasure associated with being able to say, "I built it myself!" Were these claims valid then, and are they still valid today? Well, there are probably many different opinions about this.

I never did believe a person could learn electronics by building a kit. You certainly gain a lot of soldering experience, but there is more to electronics than being able to solder properly. There is a potential to learn some electronics, however, if you want to take the time to learn the function of each component as you install it. By tracing the schematic diagram as you go, you can certainly begin to understand the general flow of signals through the radio. While my T-60 was an excellent first-time kit for a high-school-aged Novice, I don't think I could recommend the HW-5400 as a first project under the same circumstances!

Dollar for dollar, can you get a better-performing rig today by building it from a kit than if you bought one already built? Probably not. The price of a fully equipped HW-5400 may be a little less than the price of a comparable transceiver already assembled, but you must be willing to spend on the order of 100 hours to complete this transceiver. Certainly not a weekend project!

So why buy a kit radio? Well, it is certainly true that you will be intimately familiar with the component layout. And I am sure that I will be better able to dig into my '5400 to correct any problems. Heath includes a detailed troubleshooting section with the manual. Complete realignment instructions are also included. To get similar information about another brand of transceiver, you would have to purchase a service manual. Even that may not contain as much material as Heath supplies.

All of this familiarity with the radio also leads to ease of modification. While I was building my kit I thought of several features I might add at some point. I like having a stereo phone jack for my headphones. I have purchased a pair of the lightweight headphones that go with the popular portable FM stereo radios. These 'phones are ideal for long hours of operating, because they are light and comfortable. Also, with a stereo jack, it is possible to insert the plug half way, and have audio in the speaker and the headphones. I've found this to be handy under a variety of circumstances. It might also be nice to have an auxiliary audio output and mic input for use with a radioteletype modem or phonepatch. These and many other modifications will be easy to add.

Finally, there is definitely a great satisfaction to be gained by operating a radio that you have built yourself. This sense of pride is all the greater when the result of your work is a nice-looking, functional transceiver like the HW-5400.

Yes, there are many valid reasons for building a project like this. I hope you'll enjoy it as much as I did. The HW-5400 and accessories are available from Heath Company, Benton Harbor, MI 49022, tel. 616-982-3411. Price classes: HW-5400, $500; HWA-5400-1 (power supply), $200; HWA-5400-2 (SSB crystal filter), $60; HWA-5400-3 (frequency-entry keypad), $60. — *Larry Wolfgang, WA3VIL, ARRL Hq.*

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