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Heath HW-9 Deluxe QRP CW Transceiver

Tono EXL-5000E

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Heath HW-9 Deluxe QRP CW Transceiver

A compact HF transceiver for low-power CW operation, the Heathkit HW-9 covers the lower 250 kHz of the 80, 40, 20 and 15-meter amateur bands. With the optional HWA-9 accessory band pack installed, the transceiver also covers the 30, 17 and 12-meter WARC bands, and the lower 250 kHz of the 10-meter band.

Circuit Description

Receive Signal Path

During receive, the incoming signals pass from the antenna connector through a low-pass filter on the TR (transmit/receive) circuit board. The BAND switch selects the proper filter. A diode switch routes this filtered signal through a band-pass filter. The resulting signal is combined with a premixed injection signal in a Mini-Circuits Labs doubly balanced mixer to produce an 8.83-MHz IF signal. There is no RF amplifier stage in the receiver section. An amplifier is not needed; in fact, one would only limit the receiver dynamic range.

The 8.83-MHz IF signal is routed through another diode switch, then amplified and passed through a four-pole IF filter. The signal is amplified again before it is routed to the product detector. An AGC (automatic gain control) voltage is produced at this point to keep the second IF amplifier operating linearly.

The product detector converts the 8.83-MHz IF signal to audio, which then passes through either a wide or a narrow active audio filter. An audio-frequency amplifier then amplifies the filtered signal to drive an 8-ohm speaker or a set of headphones.

Transmit Signal Flow

During CW transmissions, an 8.8307-MHz signal is coupled to the second mixer (the same MCL model mentioned earlier), where it is combined with the premixed injection frequency from the oscillator circuit board to produce the desired transmitter signal. This signal is then filtered (by the same band-pass filters that are used in the receiver section) before it is preamplified and applied to the power amplifier.

The power amplifier is made up of two transistors in parallel. To reduce harmonic radiation, the output is filtered by the proper low-pass filter for the selected band.

Oscillator Circuit Board

All frequency-determining circuits are located on the oscillator circuit board. The VFO uses an FET in a Hartley oscillator that operates between 5.9993 and 5.7493 MHz. The higher frequency corresponds to the low-frequency end of the band. VFO output is buffered, filtered and fed to the first mixer, a dual-gate MOSFET.

The RIT circuit is in parallel with the main tuning capacitor in the VFO. A diode is used as a voltage-variable capacitor. Switching transistors apply voltage to the diode through

Heath HW-9 QRP CW Transceiver, Serial No. 01-52413

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 3.5-3.75, 7.0-7.25, 10.0-10.25,* 14.0-14.25, 18.0-18.25,* 21.0-21.25, 24.750-25.0,* 28.0-28.25 MHz.* (* indicates band coverage provided by HWA-9 accessory).	As specified.
Mode of operation: CW.	As specified.
kHz per turn of knob: 40.	As specified.
Frequency display: Analog dial.	As specified.
Frequency resolution: 5 kHz per division.	As specified.
Frequency stability: Less than 150 Hz/h drift after 30-min warmup.	2-kHz drift in first hour, less than 200 Hz/h thereafter.
S-meter sensitivity (μV for S9 reading): Not specified.	80 m, 32; 40 m, 30; 30 m, 34; 20 m, 34; 17 m, 40; 15 m, 42; 12 m, 50; 10 m, 175.
Transmitter power (output): 4 W; except 10 m, 3 W.	80 m, 7; 40 m, 6; 30 m, 7; 20 m, 6; 17 m, 6; 15 m, 5; 12 m, 5; 10 m, 4W.
Harmonic suppression: 35 dB minimum at rated output.	42 dB (see Fig. 1).
Spurious suppression: 40 dB minimum at rated output.	42 dB (see Fig. 1).
Receiver sensitivity: Less than 0.5 μV for 10-dB S/N.	
Receiver audio output at 10% THD: 1 W into 8-ohm load.	1 W.
Color: Two-tone brown and gray.	
Size (HWD): 4.25 × 9.25 × 8.5 in.	
Weight: 4.7 lb.	

	80 m	*20 m*
Noise Floor (MDS) dBm:	–130	–128
Blocking DR (dB):	124	122
Two-tone 3rd-order IMD DR (dB):	99	88
Third-order intercept (dBm):	18.5	4

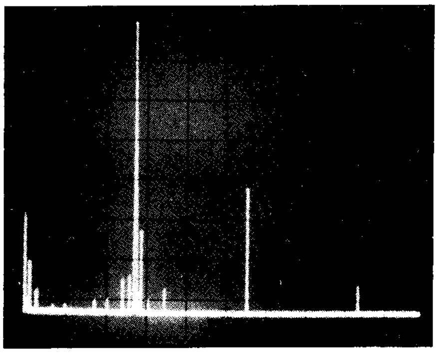


Fig. 1—Worst-case spectral display of the Heath HW-9. Vertical divisions are each 10 dB; horizontal divisions are each 5 MHz. Output power is approximately 4 W at 14.05 MHz. All spurious emissions and harmonics are at least 42 dB below peak fundamental output. The HW-9 complies with current FCC specifications for spectral purity.

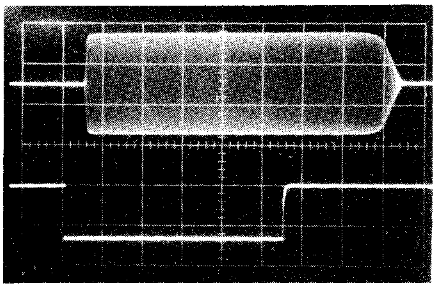


Fig. 2—CW keying waveform of the HW-9. Upper trace is the RF envelope; lower trace is the actual key closure. Each horizontal division is 5 ms.

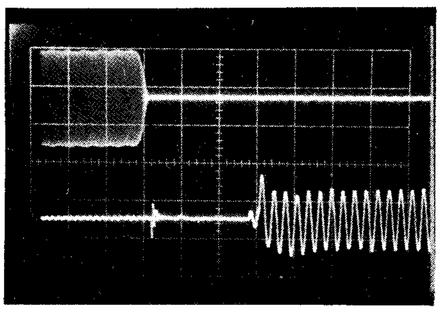


Fig. 3—Receiver turnaround time for the HW-9. Upper trace is the transmitter RF envelope; lower trace is receiver audio. Each horizontal division is 10 ms. The slight ripple on the waveforms is caused by the testing procedure.

an internal adjustment on transmit or a front-panel adjustment on receive.

In addition to the VFO, an HFO (heterodyne-frequency oscillator) feeds the first mixer. The HFO is a crystal-controlled oscillator that uses eight crystals and two transistors. One transistor is used for the bands 80 through 20 meters; the other is used on the remaining bands. The appropriate crystal and transistor are selected by switching diodes. The HFO output is buffered before it is applied to the first mixer.

Output from the first mixer supplies the premixed injection signal mentioned earlier. The first-mixer output is band-pass filtered. Diode switches steer the signal through the appropriate filter.

An interesting BFO circuit is also found on the oscillator circuit board. This circuit produces an 8.8314-MHz output in the receive mode, and an 8.8307-MHz output in the transmit mode. To do this, an FET is used as a VXO (variable crystal oscillator). BFO output feeds the product detector during receive. On transmit, two additional buffer stages are used; these are switched off during receive. Output level for transmit is controlled from the front panel and feeds the second mixer.

Other Circuitry

Circuits for keying, receiver muting and sidetone generation are located on the TR circuit board. The metering circuit is also on this board. The meter, mounted on the front panel, serves as an S meter on receive and indicates relative output power on transmit.

Construction

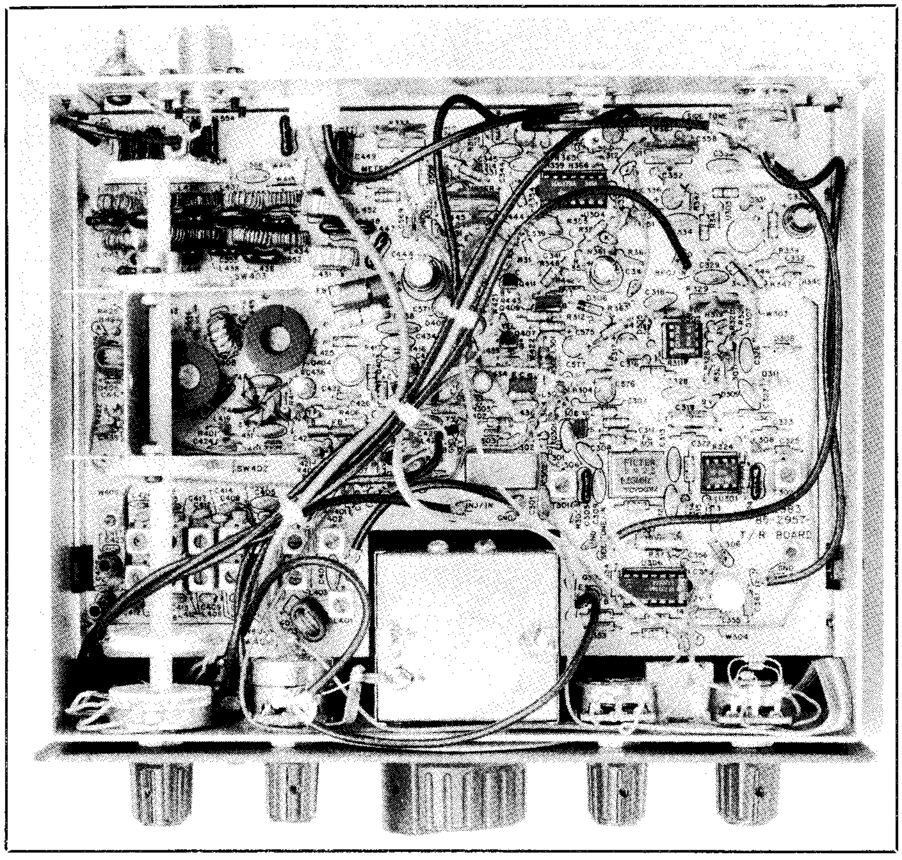
My son Scott, KA1MDH, did most of the work on the oscillator board. He had no difficulty following the instructions in the manual. I finished the project. The only tricky part was winding transformers T401 and T404; but even that was no great problem. The larger-than-life drawings in the illustration booklet combined with the text in the manual make it very clear how to proceed.

A word of caution is in order. Do not use the cable diagrams in the illustration booklet as a template to prepare cables. Use the measurements given—the drawings are not full-size. You will find a ruler line printed at the bottom of the appropriate pages of the assembly manual.

Parts are crowded in places on the TR board. That proved to be no inconvenience, however. The finished board makes you feel proud that you put it all together.

I did have two problems during the mechanical assembly, both in the VFO chassis area. My first difficulty appeared when I turned the tuning knob and noticed dial slippage. The main tuning-capacitor drive worked fine with the VFO shield off, but there was a bind when the shield was put in place. I decided that the vernier drive was defective and called the Heath technical assistance number given in the front of the manual. The friendly technician told me the cure. It was easy: Loosen the setscrews on the vernier drive and seat the main-tuning capacitor shaft a bit farther in. That pulled the sides of the VFO chassis a bit closer together. (The VFO chassis is a U-shaped piece.) The VFO shield then slid easily over the chassis and—voilà!—no bind!

That cured my ailments with the VFO chassis. But when it came time for VFO alignment, the second problem appeared. The VFO operated intermittently. It took a while to discover that the intermittent operation could be cured by placing a ground jumper from ground to the VFO chassis. Curious—that chassis contains only the vernier drive and main tuning capacitor. The VFO chassis is fastened to the main chassis by four no. 4-40 flat-head screws. The main chassis has countersunk holes so that the screw heads are flush. On the back of the main chassis, each screw is secured by a star washer and nut. (The VFO chassis then slips over the



A bottom view of the HW-9.

screws and is secured by another star washer and nut combination.) The problem was that the no. 4 star washer was contacting the beveled screw head, preventing a solid mechanical contact between the screw and the main chassis. The solution was quite simple—replace the no. 4 star washers with no. 6 star washers! Then, the flat-head screws could be brought tightly against the chassis. Had I noticed this situation during assembly, it would have saved a lot of time and effort.

One further word of caution. Make sure the mounting hardware for the oscillator board is tightened. I had problems with frequency "jumps" before tightening the mounting nuts. Don't overdo it—just fully snug will do.

Operation

On-the-air operation with the HW-9 couldn't be easier. Set the band switch for the desired band, dial up the frequency and you are ready to transmit. Amenities like sidetone, break-in, RIT and a selectable-bandwidth audio filter make the HW-9 a joy to use.

My first two QSOs with the HW-9 were with FM7WD on 40 meters and 3D6AK on 20 meters. Scott put it through its paces on the 80-meter Novice band—even worked another Novice who was running an HW-9!

Keying tends to be heavy. That is no problem at speeds below 35 WPM. Between 35 and 40 WPM, the code elements begin to run together. If you operate at those higher speeds, you should use a keyer with a weight control. QSK in the HW-9 works fine. As shown in Fig. 3, the receiver requires 30 ms to become active after the transmitter turns off. At 20 WPM, a dot (or the space between elements) is 60 ms. There is some thumping with the audio gain at higher settings during QSK operation. Scott finds it easier to time his CW sending by setting the delay so the receiver activates at the end of a word space. For that reason, I did not use the QSK very much, even though I enjoy that style of operation.

As mentioned earlier, there is no RF amplifier stage in the receiver. That does not seem to limit reception, however. One evening I heard an East Coast DXer call CQ on 40 meters; a UA3 answered. The East Coaster called CQ again. Again, I clearly heard the UA3 calling. Nothing more heard from the CQer.

Scott said he'd like to have the front-panel bands indicated in megahertz rather than in meters (he logs frequency of operation); I agree. But that is a minor matter.

The main transceiver remains in our shack, as does my half-legal-limit amplifier (in case an operation from Bouvet Island should come on the air). For now, we use the HW-9 for fun and sharpening our operating skills. The HW-9 will be our vacation and portable radio.

The HW-9 is available from the Heath Company, Benton Harbor, MI 49022, tel. 616-982-3411. Price class: HW-9 transceiver, $250; HWA-9 accessory band pack, $40; PSA-9 accessory ac power supply, $40. *—Chuck Hutchinson, K8CH*

TONO EXL-5000E

Price class: $650.
Power supply: 110-120/220-240 V ac 50/60 Hz or +13.8 V dc at 2 A.
Dimensions: 14¼ × 13¾ × 4¾ in.
Speed: Morse—5-100 WPM; RTTY—12-600 bauds (300 bauds max. with internal modem).

TONO EXL-5000E

☐ The Amateur Radio manufacturer's challenge today is to produce equipment that packs the most capability into the smallest, least-expensive package. Tono has met that challenge admirably with their EXL-5000E RTTY/CW/AMTOR terminal.

The EXL-5000E contains all that one needs to operate RTTY (either Baudot or ASCII code), CW and AMTOR in one unit. A detached keyboard is provided for text entry and control of some of the operating modes and options. Display of the unit's status and the received text is produced on a built-in, 5-inch (diagonal) CRT. The display is sharp, and the characters are well formed. Characters on a screen this size are necessarily small, but a composite-video output is provided for attaching an external video monitor if a larger display is desired. A printer with a Centronics parallel interface may be connected to the EXL-5000E for hard-copy output.

Features

The flexibility provided by the front-panel controls is something you will quickly learn to appreciate! When first seen, the array of front-panel switches is rather daunting, but once the switches have been set to select the operating mode, most of them need not be adjusted further. With these controls, you can select the mode (RTTY, CW or AMTOR), frequency shift, mark frequency, signal polarity and several special-purpose options. A front-panel keypad is used to enter the time and operating speed, manually shift the Baudot case, select the AMTOR mode (A, B or "L") and select other options.

RTTY high- and low-tone modems are included. The high-tone mark frequency is 2125 Hz, and the low-tone is 1275 Hz. The received-signal space frequency is selected for 170-, 425- or 850-Hz shift, with a FINE tuning control provided for nonstandard shifts. The AFSK output is on the same frequencies, except that the FINE tuning control has no effect on the output audio frequency. The CCIR Rec. 476-3 frequencies of 1615 and 1785 Hz are available in AMTOR mode.

Received text is displayed in 40-character lines on the top 10 screen lines, with optional end-of-line word wrap-around. Just below the received-text area is a status line displaying the mode, speed, case, date/time and several characters showing the options in effect. Below that is a four-line area for the transmit type-ahead buffer, which is 160 characters long.

A bar-graph LED display is used for tuning in received signals. This display consists of two five-segment bars, one for the mark tone and one for the space. The number of segments that are lit indicates the received-signal frequency error. First adjust your receiver for maximum illumination of the mark display, then adjust the FINE tuning control for maximum on the space display. This control adjusts the frequency of the space filter for signals that are not shifted exactly by the selected amount. Outputs for an X-Y oscilloscope tuning indicator are also provided.

Speeds of up to 300 bauds are possible using the Tono's demodulator. RTTY demodulators capable of such speeds usually are a compromise between high-speed capability and sufficient selectivity at the lower speeds. Tono, however, provides a front-panel switch that changes the demodulator filter Q to a more optimal value for the desired reception speed. Since 300-baud operation is a rarity on the HF bands, it's nice to see that Tono didn't degrade the low-speed performance to achieve 300-baud capability.

Outputs provided include AFSK audio, with a rear-panel level control, and FSK, CW and PTT keying lines. All of the output keying transistors are isolated from the internal circuitry via optoisolators, providing a measure of protection against abusive voltages that might be connected to those lines. An internal speaker may be used to monitor the received signal after the internal AGC action has processed it, or to listen to the output of the mark or space filter.

Operation

After you've selected the proper demodulator frequencies, signal polarity and, for RTTY, speed and code, reception is simple. I was skeptical of the LED tuning-indicator usefulness, but the one on the Tono is *almost* as good as a tuning 'scope. Tuning in a signal with less than 20-Hz error is easy after a little practice. As a test, an X-Y oscilloscope was connected, and the 'scope display was checked after tuning in a signal via the LEDs. In only a few cases did the 'scope display show that any improvement in tuning could be achieved.

The RTTY demodulator is as good as any I have seen. Watching the Tono produce perfect print as it tracks a signal through a deep fade on HF is a joy! In general, if a signal can be heard, it can be demodulated. The performance on CW is less outstanding, but this is largely because of the inherently poor machine-readability of on-off keyed transmissions.

One benchmark of a CW receiving machine is its ability to "lock on" to the incoming signal. The machine must determine the speed of the Morse signal before it can decode it. Again, the Tono does this well. As you tune across different signals, the time it takes for the EXL-5000E to determine the signal speed and to begin producing readable copy is hardly noticeable. There is no need to specify the received-signal speed range—the Tono determines it automatically. For very high speeds, reception is improved by selecting a high-speed mode via a front-panel switch, but the overlap between the high- and low-speed ranges is large enough to make this a non-critical control.

Transmission of text can be on a character, word or line basis. In the character mode, each character is transmitted as it is entered. The word mode buffers the text until a space or carriage return is entered, giving you a chance to correct any misspellings or typing mistakes. In the line mode, the text is held until a carriage return is entered.

Transmitted text may be automatically formatted into line lengths of 64, 72 or 80 characters. The Tono will insert a carriage-return/line-feed sequence when the end of a line has been reached.

Control of the PTT keying line can be automatic or manual. In the automatic mode, the line is keyed whenever the Tono has text to send. This can occur when you begin entering text or when, having specified that text should be buffered, you release the buffer for transmission. In the manual mode, you execute a keyboard control sequence to key the PTT line on and off. Other outputs are independent of the PTT line. That is, you can select manual PTT control and generate normal outputs without ever keying the transmitter PTT line, if you so wish. This has several uses, not least of which is allowing QSK transceivers to control the TR switching from the CW keying output without being overridden by the PTT line.

As an apartment dweller, I was concerned about RFI from the Tono. It's hard to imagine any setup more susceptible to RFI problems than mine, in which the antennas were located less than 6 feet away from the Tono. Fortunately, the RFI protection is very good. The only effects I noticed were some S2 "birdies" on 15 meters and a slight tearing of the Tono's display when transmitting a 100-W signal on 40 meters. A decent antenna system would have eliminated such problems.

"Bells and Whistles"

The presence of a dedicated microprocessor within the EXL-5000E makes possible a number of complex functions. Examples of these are RTTY SELCAL operation and timed transmissions. SELCAL operation consists of entering a text string which, when received, will enable printing of received text until a terminating text string is received. During the time that SELCAL reception is enabled, the REMOTE output on the rear panel is keyed. This output may be used to turn on a device of your choice, such as a printer, tape recorder or, perhaps, a bell to signal an incoming message. A timed transmission may be programmed to occur at any time within the next 30 days, a feature that is interesting, if not particularly useful.

Complaints

By now, you know that I am impressed with the EXL-5000E. Still, there are a few things that could stand improvement. Foremost among these is the size of the transmit type-ahead buffer. When 160 characters (four lines) of text have been entered into the buffer, no more text is accepted. The 160-character limitation is bad enough, but no indication is given that the buffer is full! This might not be a problem for a touch typist, but we "hunt and peck" types aren't looking at the screen to see the lines filling up! A larger type-ahead buffer and some indication that it is full would be an improvement.

Although the controls on the EXL-5000E provide a great deal of flexibility, they can become annoying at times. During the period of this review, most of the operating was done with a Kenwood TS-930S running in the FSK mode. The polarity of the TS-930S FSK input requires that the Tono's output polarity be inverted via the front-panel switch during RTTY operation. When you are switching to AMTOR mode, the output mode must be normal and the *input* must be inverted because the Tono expects the rig to be in USB mode for AMTOR operation. While USB is normal for AMTOR, the TS-930S receives in a LSB mode while in FSK. Couple this with the number of other switches that must be actuated to select the proper mode and you have a complex procedure.

To illustrate, switching from Baudot RTTY to AMTOR mode L with the above setup, you must (1) set the IN switch to reverse, (2) set the OUT switch to normal, (3) set the MODE switch to select TOR C and (4) use the two-key sequence on the front- panel keypad to select mode L if it hasn't been selected previously. It tends to inhibit rapid mode switching! It would be nice (but probably expensive) if the microprocessor could store the standard settings for each mode and electronically switch the circuits upon receipt of a one- or two-key command.

Although CW reception works well, there is one annoying problem. The internal audio filter used in the CW mode drifts in frequency. This drift makes it necessary to tweak the receive frequency often. There is no adjustment on the Tono to set the center frequency of the filter, so all tuning must be done with the receiver. The filter is so sharp that even a 20-Hz error degrades reception.

You might expect to receive a fat manual with a piece of equipment this complex, but, in fact, the manual is pretty skimpy. All of the controls and operating modes are mentioned in the manual, but there are few details and fewer examples. You will have to experiment a little to determine how to use some of the controls and options. No schematic diagram is supplied.

The EXL-5000E was apparently designed by active amateurs. Aside from being a high-tech marvel, it is a clean, fun and valuable operating tool. In short—it's a winner. The EXL-5000E is available from Amateur-Wholesale Electronics, 8817 SW 129th Terr., Miami, FL 33176, tel. 305-233-3631.—*Jon Bloom, KE3Z*

New Products

CMOS CHOPPER OPERATIONAL AMPLIFIER

☐ Teledyne Semiconductor recently announced a proprietary CMOS IC—the TSC900 low-power, chopper-stabilized operational amplifier. The TSC900 is designed for battery-operated systems or systems for which minimum supply power is available. The low, 200-μA maximum supply current, 5-V maximum offset voltage and 0.05-μV/°C drift specifications make the '900 attractive. This device is pin compatible with the 7650/7652 op amp, and is available in 8- and 14-pin DIPs.

Other specifications of the '900 include 120-dB minimum open-loop voltage gain, 110-dB common-mode rejection and 120-dB power-supply-rejection ratio. Slew rate is typically 0.2 V/μs, and the unity gain bandwidth is 0.7 MHz. Noise over the range of 0.1 to 1.0 Hz is 0.3-μV Pk-Pk. The TSC900 is internally compensated for unity gain operation. An output voltage clamp reduces circuit gain to prevent output stage saturation. This eliminates overload-recovery time delay. When the 14-pin DIP device is used, the internal chopping oscillator may be overridden.

Pricing and additional information are available from David Gillooly, Marketing Manager, Teledyne Semiconductor, 1300 Terra Bella Ave., P.O. Box 7267, Mountain View, CA 94039-7267, tel. 415-968-9241. —*Paul K. Pagel, N1FB*