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Product Review

WA3RNC TR-25 40/20-Meter CW Transceiver Kit

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The TR-25 CW transceiver kit from John Dillon, WA3RNC, covers two popular bands — 40 and 20 meters — and operates from 9.5 to 14 V dc, which is helpful for portable operation where battery voltage may decline over time. There's an adjustable low-battery indicator that you can set according to your power source. The TR-25's RF output power is adjustable, and the radio delivers up to about 10 W output on 40 meters and 7 W on 20 meters.

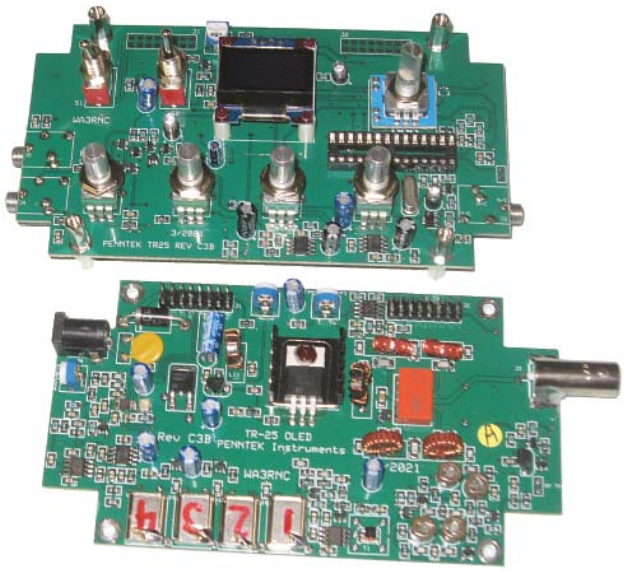
One of the more interesting features of the TR-25 is its operating controls. Small kit transceivers often use multifunction controls and cascading menus, and unless you use the kit regularly, you may forget how to use the menus and settings. With the TR-25, there is a knob or a switch for every function — no multi-level menus!

Circuit Highlights

The TR-25 circuitry is divided into two PC boards (see Figure 1). The upper board contains a preprogrammed ATmega328P microcontroller for control functions. The **TUNE** encoder sets the frequency and incorporates a pushbutton switch to select tuning increments (10 Hz, 100 Hz, or 1 kHz). Other functions, such as receiver incremental tuning (RIT, ± 5 kHz), band selection, and the internal CW keyer speed are controlled by the microcontroller as well.

The bulk of the analog/RF circuits are on the lower board. From the BNC antenna connector, a received signal is routed to a band-select relay and then to a band-pass filter for the selected band. The filter output passes through a solid-state TR switch and a gain control, then through a second set of filters and finally to an SA612 double balanced mixer.

An SI5351 phase-locked loop with a 25 MHz crystal as its time base provides a switched local oscillator (LO)



Bottom Line

The WA3RNC TR-25 40/20 meter CW transceiver kit goes together quickly. The finished product is attractive, has a quality feel, and is very easy to use.

Figure 1 — The kit is assembled as two PC boards. The upper board contains the display and controls. On the center right is the microcontroller. This IC is plugged in after the two boards are assembled as a sandwich. The lower board has the final amplifier FET and heat sink in the center. The numbered and matched filter crystals are along the bottom edge.

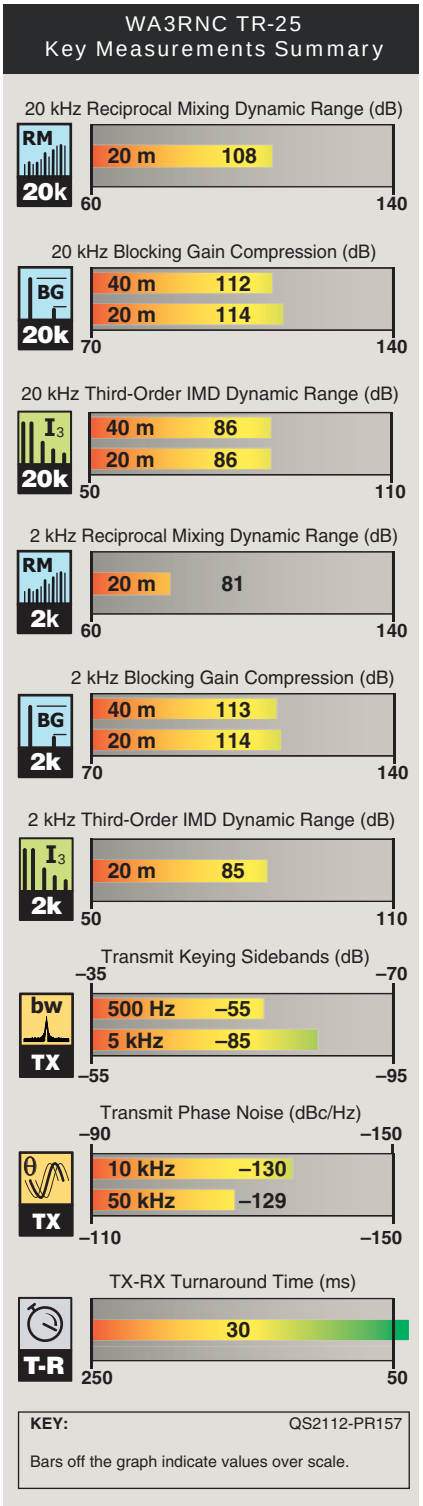


Table 1
WA3RNC TR-25 CW Transceiver

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: 7.0 – 7.3 MHz and 14.0 – 14.35 MHz	As specified.
Power requirement: 9.5 – 14 V dc at >110 mA receive; 1.1 A transmit at 10 V.	Receive: 102 mA from 9.5 – 14 V dc. Transmit, 7 MHz/14 MHz: 10 V dc, 1.1/1.07 A; 14 V dc, 1.4/1.3 A.
Mode of operation: CW.	As specified.
Receiver	**Receiver Dynamic Testing***
Sensitivity: –125 dBm.	Noise floor (MDS): 7 MHz, –137 dBm; 14 MHz, –135 dBm.
Noise figure: Not specified.	7 MHz, 11.6 dB; 14 MHz, 13.6 dB.
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range: *20/5/2 kHz offset* 7 MHz 112/112/113 dB 14 MHz 114/114/114 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 108/104/81 dB

ARRL Lab Two-Tone IMD Testing

Band	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
7 MHz	20 kHz	–137 dBm	–51 dBm	86 dB
		–97 dBm	–37 dBm	
		–26 dBm	0 dBm	
14 MHz	20 kHz	–135 dBm	–49 dBm	86 dB
		–97 dBm	–36 dBm	
		–36 dBm	0 dBm	
14 MHz	5 kHz	–135 dBm	–49 dBm	86 dB
		–97 dBm	–36 dBm	
14 MHz	2 kHz	–135 dBm	–50 dBm	85 dB
		–97 dBm	–37 dBm	

Second-order intercept point: Not specified.	+43 dBm at 7 and 14 MHz.
IF/audio response: Better than 350 Hz.	Range at –6 dB points: 600 – 825 Hz (225 Hz).
Transmitter	**Transmitter Dynamic Testing**
Power output: At 14 V dc, 7 MHz, 0 – 9 W; 14 MHz, 0 – 7 W.	7 MHz: 0 – 9.6 W at 13.8 V dc; 0 – 4.5 W at 9.5 V dc. 14 MHz: 0 – 7.2 W at 13.8 V dc; 0 – 3.5 W at 9.5 V dc.
Spurious-signal and harmonic suppression: 52 dB.	>60 dB (see Figure A). Complies with FCC emission standards.
CW keying characteristics: Not specified.	See Figures B and C.
Transmitted phase noise: Not specified.	See Figure D
Transmit-receive turnaround time: Not specified.	S-9 signal, 30 ms.

Size (height, width, depth): 2 × 6 × 3.25 inches including protrusions. Weight, 11 ounces.

Second-order intercept point was determined using S-5 reference.

*Receiver bandwidth is fixed and measured in the ARRL Lab at 225 Hz at –6 dB.

signal to the mixer. Following the mixer is a crystal filter made from four matched and numbered crystals in series. These feed another SA612, which has the beat frequency oscillator (BFO) feeding one of its inputs. The audio output is from an LM386 op-amp on the upper board. One interesting auxiliary circuit uses an LM358 dual op-amp to make an operator settable alarm that blinks the **LOW BATT** LED when the input voltage falls below the set value.

On the transmit end, the TR-25 uses a BS170 driver and an IRF510 final amplifier operating in Class B. The amplifier output is routed through a bifilar impedance matching transformer and the appropriate bandpass filter at the BNC output.

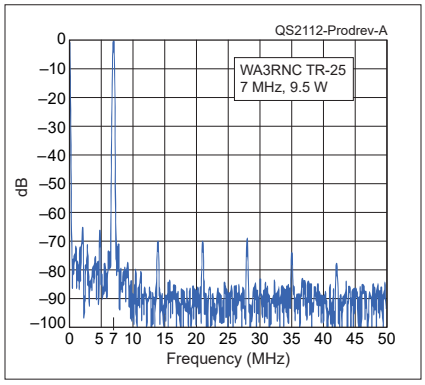


Figure A — Spectral display of the WA3RNC TR-25 transmitter output. Power output is 9.5 W on the 7 MHz band. This plot shows the output spectrum from 0 to 50 MHz. The second harmonic is down 70 dB from the carrier, and the third harmonic is down 69 dB. The vertical scale is 10 dB per division.

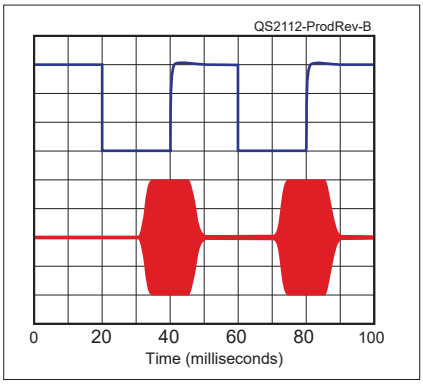


Figure B — CW keying waveform for the WA3RNC TR-25 showing the first two dits using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 7 W output on the 14 MHz band. Rise time is 2.1 ms and fall time is 2.9 ms. First dit: on delay, 12.8 ms; off delay, 7.2 ms. Second dit: on delay, 12.8 ms; off delay, 7.2 ms.

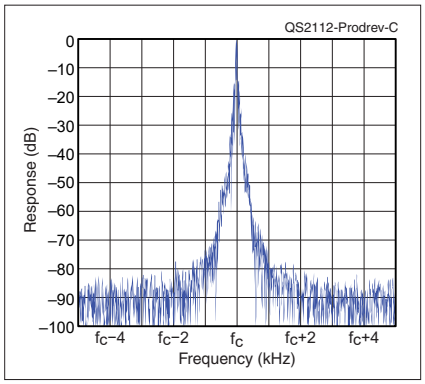


Figure C — Spectral display of the WA3RNC TR-25 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 7 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

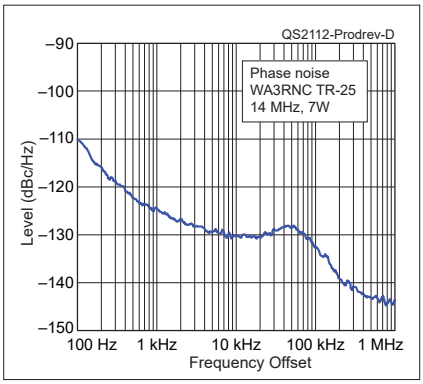


Figure D — Spectral display of the WA3RNC TR-25 transmitter output during phase-noise testing. Power output is 7 W on the 14 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows phase noise 100 Hz to 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 10 dB per division.

Figure 2 — The parts are packed in individual bubbles arranged in the order they are assembled. One set is for the lower board, another set for the upper board, and a third set for hardware and connectors.

Building the Kit

In the supplied kit, the two PC boards are populated with about 200 surface-mounted components, leaving 55 through-hole parts for the builder to install. Critical circuits are pre-aligned.

The WA3RNC website offers downloadable instructions as several PDF documents. It's a good idea to read the *TR-25 Pre-Assembly Information* document first, as it gives an overview of how the assembly will proceed, as well as some general notes about things to be aware of as you build. There are separate *Assembly Procedure* documents for the upper and lower PC boards. *TR-25 Final Assembly* and *TR-25 Checks and Tests* explain how to adjust internal controls that are not usually changed very often after initial set-up, and also show how to make sure the radio is operating properly. The last document is *TR-25 Operating Instructions*.

The parts are supplied in small bubble-like connected envelopes (see Figure 2) arranged in the same order as the steps in the assembly manuals. I put a 16 ×18- inch aluminum oven liner from the supermarket cooking section on my workbench to catch any parts that I may drop. A few small paper cups are useful for temporary storage of small hardware that will be used in a later step.

Not supplied is clear nail polish, needed to keep a few screws and nuts from loosening, and two clothespin-like plastic clips for holding the PC board and case in place during assembly (you can also use rubber bands). A very small amount of thermal heatsink compound is suggested for the final amplifier transistor heat sink.

The assembly instructions are clear, although in some sections the text is printed as one long extended paragraph, which can make it easy to lose your place. I used a red pencil to put a check mark next to the part number in the text as I mounted each component.

Lab Notes

WA3RNC TR-25 CW Transceiver

The ARRL Lab tested an assembled version of the TR-25, with the results shown in Table 1. The transceiver is rated for operation from 9.5 to 14 V dc and draws just over 100 mA on receive, a plus for conserving battery power during portable operation. Even with minimum supply voltage, our radio put out 4.5 W on 40 meters and 3.5 W on 20 meters.

Receive sensitivity is excellent, and dynamic range is good. If too many strong signals are a problem, turn down the RF gain with the front-panel control. The CW waveform is clean, with good keying sidebands. The transmitter easily meets FCC spectral purity requirements.

During testing, we noticed that output power dropped off after 7.5 to 15 seconds of transmitting a steady carrier at full power. John Dillon explained that the radio does this by design, using a polyfuse whose resistance is dependent on current and temperature. This is a safety measure to protect the final amplifier and does not affect normal operation, except perhaps if you're transmitting for a long time to adjust an external antenna tuner. I set the Lab's keying generator to 35 WPM and transmitted for 10 minutes with no drop in output power.

I thought the radio was well constructed, wonderful to operate (no endless menus to back out of), and all of the controls and switches have a quality feel about them and operate smoothly. — *Paul Cianciolo, W1VLF, ARRL Lab Test Engineer*

Mounting the final amplifier and heat sink requires some care. The FET leads have to be bent over to fit the solder holes. I found that everything fit fine when I bent the leads at the transition of the wide and the narrow sections. As noted in the instructions, be careful with the placement of the plastic washer and mica insulator.

The kit uses six toroids (five inductors and a transformer). The instructions describe how to wind them, but pre-wound and prepared toroids are also available as an option. Winding the toroids is not difficult but does require finger agility and attention to detail. When you use enameled wire for windings, be aware that solder will not adhere to the enamel coating. Therefore, you must prep the wire ends down to clean, bare copper to ensure good solder joints. For this project, though,we chose to use the pre-wound toroids, which came ready to install with pre-tinned leads.

Finishing Touches

The PC boards fit neatly into a two-piece plastic case, but first there are internal trimmer potentiometers that must be adjusted. The process is described in the *TR-25 Final Assembly* manual. The first trimmer controls a blue LED, which is set to just barely light when no signal is present and glow brighter with received signals. The second trimmer sets the operating point for the final amplifier FET in a multi-step procedure detailed in the manual. Once this trmmer is set you should not have to re-adjust it, but it is accessible with the case removed.

Another trimmer accessible with the case removed sets the sidetone volume. The sidetone is the actual transmitted signal heard in the receiver. When the tone of the incoming signal is matched to the transmit sidetone pitch, it will be perfectly on frequency. The final trimmer sets the threshold of the red low-voltage warning LED from 9 to 11.5 V.

The case is held together with four long self-tapping screws. The knobs are held in place with set screws, so they can be placed to clear the front panel. The large **TUNE** knob requires more clearance because it also has a pushbutton function. Two toggle switches, POWER and BAND/RIT, are secured to the panel with nuts. A red cover dresses up the POWER switch and a white one does the same for BAND/RIT. A clear plastic cover protects the display. Disassembling the enclosure can be tedious, so it's a good idea to complete all adjustments and fully test the radio before placing the PC board assemblies in the enclosure.

On the Air

The TR-25's connections and controls are refreshingly simple. On the left side are a 2.1 millimeter coaxial dc power jack and two 3.5 millimeter phone jacks. One is for an external key or keyer, and the other for paddles controlling the internal keyer. The right side has the BNC antenna jack and a 3.5 millimeter jack for headphones or a loudspeaker. I found the audio output a bit low, but this is somewhat dependent on the sensitivity of the loudspeaker.

The TR-25 seems to have been designed with human factors in mind; an operator can use it without a long learning process. For example, the pushbutton switch of the large **TUNE** knob selects the tuning steps. A short push of the knob switches between 10 Hz and 100 Hz, but a longer push changes to 1 kHz steps. This prevents you from accidently tuning far away from the station you were trying to hear.

Similarly, all the controls are on the front panel. Keyer speed is adjustable from 5 to 35 WPM. Transmit power is adjustable from 0 to 5 W or more, depending on battery voltage. RF gain and volume are easily adjustable as well.

The **BAND/RIT** toggle switch with the white cap uses momentary contacts. One short click up alternates the band between 40 and 20 meters. One long click up stores the current frequency (one memory per band), and the radio returns to this frequency each time it's turned on. Two short upward clicks recalls the stored frequency. Clicking down toggles the receiver incremental tuning (RIT) on and off. The orange LED reminds you that RIT is on, and the RIT offset is shown in the display.

I found plenty of signals on 40 meters in the evening and 20 meters during the day. Even though the power output is less than 10 W, it wasn't very hard to have many enjoyable contacts. With the slow tuning rate, it was easy to match the sidetone pitch to the received signal and arrive right on frequency. TR switching is silent. The TR-25 is so easy to use that I felt right at home after using it only once or twice.

Manufacturer: John Dillon, WA3RNC, **www.wa3rnc.com.** Price: $250 (kit); pre-wound toroids, $18; precision optical encoder, $30; factory wired and tested, $310.