Product Reviews

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K1EL K45 CW Modem

Product Review

K1EL K45 CW Modem

Reviewed by Paul Danzer, N1II
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This lightweight (12 ounces), compact (4.25 × 3.25 × 2.1 inches) unit is known as "the Swiss Army knife of CW keyers." Its predecessor, the K1EL K16 (reviewed in the February 2017 issue of *QST*), had a set of 39 commands, in addition to message storage and processing, numbering, and any function you might want in a keyer. However, in addition to four pushbuttons, it was Morse in, Morse out. The K45 adds a USB port for a keyboard, a four-line-by-20-character display with status indicators, an audio input jack for a CW reader, beacon capability, and several other features.

For manual CW it retains the K16 CW command language, but when a keyboard (not included in the package) is plugged in, there are several pages of allowable commands. Some of the functions may come as a surprise; for example, there is the capability to lock the transmit speed to the receive speed. There is a 44-page online manual that includes detailed interface instructions. A summary of interface cable connections is also available, and it is best to read the "Quick Start" (Appendix B) information in the instruction manual and then the one-page supplement. One capability I found useful — which is often missing from other keying units — is pressing **CTRL T** to toggle transmit on and off. This is helpful for checking power out, SWR, and the like when using paddles rather than a straight key. Additionally, built in is a Morse tutor, with functions like the K1EL Morse Tutor (reviewed in the May 2020 issue of *QST*). Please note that the K45 has a WinKeyer mode that allows it to work the same as the K1EL WinKeyer USB product, so both products are included in one box.

The CTRL and ESC Keys Are Important

The commands for setting up and controlling the K45 are selected by using two keys: **CTRL** (control) and **ESC** (escape). Control commands are immediate. As soon as you press the **CTRL** key and a selected letter, the resulting command takes effect. For example, **CTRL T** toggles the key down (tunes) on and off; **CTRL B** sends 73 de (your call stored in F11); and **CTRL R** sends 5NN.

There are approximately 15 such commands. **CTRL H** brings up a list of these commands (see Figure 1). You can scroll through the list vertically by using the keyboard up and down arrows.

The **ESC** key controls various options and settings through a set of menus. To call up the menus, press **ESC** followed by **C**. The top-level menu contains five parts, one of which is shown in Figure 2. Each part has eight selections. See the sidebar, "Using the **ESC** Key," at **www.arrl.org/qst-in-depth** for more details.

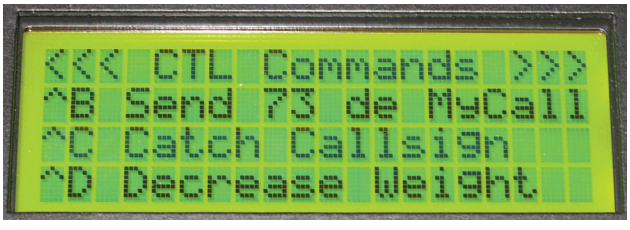

Figure 1 — Partial list of **CTRL** commands. The up/down arrows on the keyboard or the front panel rotary control will move to the rest of the list.

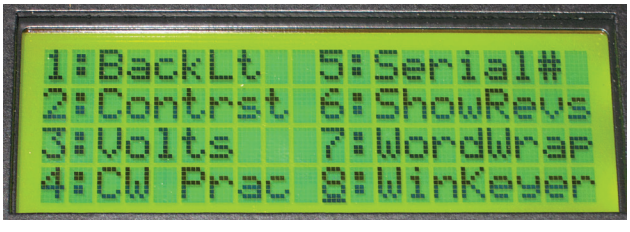

Figure 2 — One of the five menu screens brought up by **ESC+C**.

Bottom Line

The K1EL K45 CW modem has a large set of capabilities and is adaptable to just about every sort of CW operation.

Figure 3 — Back panel connections. The three leftmost jacks accept ⅛-inch stereo plugs. A cable matching the USB host connector to a USB jack is supplied with the unit. A standard USB keyboard plugs into the right-hand socket.

There is only one external control — a rotary encoder with an integral push switch on the front panel that is used in configurations and modes where the keyboard is not used or where it replaces the up/down arrows. All connections are on the back panel (see Figure 3), with setup instructions in the manual. For the most part, each of the connections shown requires only a few words of explanation. A speaker with adjustable tone and volume is included in the package.

Iambic Paddle

This can be set as a paddle with or without reverse dot/dash configuration or a straight key.

Audio Input

This is the only input that requires some thought. You can connect it to any audio output, such as a speaker, from your rig. However, you will be controlling both what you hear and what the CW reader is operating on. The recommendation is that you connect this input to the audio line output found on most newer rigs. The manual for my Icom IC-7300 contains a drawing of the connections to the accessory socket on the rear. This is a constant level audio output. The K45 has controls to adjust this level to vary the input for best operation.

Keying Output

This can be configured to provide two independent key outputs (to use with two rigs, perhaps) without making any changes. It can also be set for one key output and the other contact for a push-to-talk (PTT) line, if needed. The key output is isolated from the K45 metal case. The output connection is given as a solid-state relay, capable of handling +/– 350 V at 120 mA.

Host

A Mini Type-A USB connector on the rear is used, for most modes, as the power source for the unit. For some modes (not CW) you may need to install a driver in your PC. Detailed instructions in the manual describe how to go about it. I have a 2014 HP desktop computer; I just plugged in the USB cable (supplied with the K45) and all was well. I also tried an inexpensive 120 V ac-to-USB plug converter, and again the unit ran well.

Keyboard

Most USB keyboards will work. I tried a wired USB unit and a wireless unit; both worked with no problem — just as the K45 manual said they would. A USB Type-A connector for a keyboard is located on the rear of the enclosure.

Messages and Macros

A set of 12 messages, each 120 characters long, can be stored (see the sidebar, "Storing and Editing a Message," at **www.arrl.org/qst-in-depth** for more details). Having a keyboard makes it easy to write a message, store it, and edit it. Two sets of messages can be stored. The unit allows setting up two users, and you can toggle between the two every time you press **CTRL U**. When the user is changed, a brief message flashes on the status line while the current configuration is changed. Each user has customized settings and a message list.

I set up a group of messages for everyday operating, including brief exchange messages for working "hit and run" DX contacts.

I stored (and changed) messages as user 2 with the requirements of a contest. Serial number insertion, chaining message, and repeating are also set with keyboard commands.

Beacon operation is supported with the ability to set spacing, delays, speeds, and repetition rates.

Key mapping is also available. A set of 20 preset remapped characters is included; each can be remapped to another key.

CW Speeds

Transmit keying range is specified as 5 – 99 words per minute, and rounding it off for five-letter groups (five letters plus one space per word) translates to approximately 600 letters per minute maximum. But before you think using a keyboard will turn you into a very high-speed transmit operator, consider that most average skilled people type 190 – 200 letters per minute or 38 – 40 words per minute. Hunt-and-peck typists, remember — you will not be able to transmit any faster than you can type!

The instruction book specifies the CW reader as DSP-based and operating over the range of 7 – 60 WPM. My

experience with the K45 was positive; my QTH is about 50 miles from W1AW. Therefore, on 80 meters and sometimes 10 meters, W1AW was solid and error-free, as though I was in the W1AW shack in Newington, Connecticut.

However, as expected, under poor conditions and high noise, the reader put out some random letters. Often the first letter of a string of letters is incorrect, as any CW reader will not be synchronized to the incoming dots and dashes.

One operator I copied had what used to be called a "Missouri Swing," and to my surprise the CW reader did very well — better than I could, certainly. What is different from some other CW readers is the instantaneous control you have. The **CTRL** and **ALT** keys are used to make changes as you listen and copy:

CTRL left and right arrows — audio gain adjustment. I set my rig's audio output to 80% and trimmed the audio level using these K45 controls.

ALT left and right arrows — CW noise filter levels. These controls cycle through 10 levels of noise filtering.

CTRL up and down arrows — CW threshold adjustment. Raise in a noisy environment, and lower when things are quiet. It is used to reduce false letter triggering when noisy.

ALT up and down arrows — CW spacing adjustment. This is used to change, through 10 selectable values, the spacing between letters to compensate for incorrect spacing of incoming letters.

If the incoming letters are machine-sent with the standard dot-to-dash-to-spacing ratios, this adjustment shouldn't be necessary. According to Wikipedia, a dash is three times the length of a dit; each letter is followed by a dit length of space, the letters are separated by the length of three dits, and words are separated by seven dits. If the ratios are not standard, this is one you must try for yourself!

LCD Display

The front panel display is four lines by 20 characters. Backlight level and contrast are adjustable by key press. You can select what kind of information you see. The top line is a status readout, with the leftmost number the decoded CW speed and the rightmost number your transmit speed. In the center of this line is an S-meter bar with the selected user number to its right. There are three more status indicator letters to the right of the user number. Below the status line, the received letters — or when transmitting, your transmit letters — are displayed.

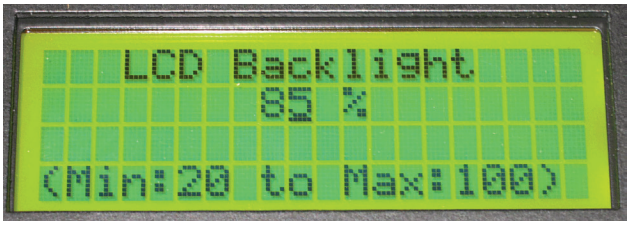

Figure 4 — Selecting the backlight control screen allows adjusting this value with the up/down arrow keys or the front panel rotary control.

Switching between these two can be automatically or manually controlled.

Both the contrast and the backlight brightness can be changed. Selecting the fifth menu group, followed by 1 for the backlight or 2 for the contrast, allows these settings to be changed (Figure 4). Number selections are changed with the arrow keys or the knob on the front panel. The change is confirmed by pressing the **ENTER** key, and a message appears confirming the change.

Additional Modes

HSCW

This mode is used mostly for working stations via meteor scatter propagation. Short bursts of characters are sent repetitively at high speeds for a predetermined period. The receiving station listens and records the intermittently received bursts and plays them back at a slow speed to decipher the Morse message.

The K45 instruction manual provides the needed explanation for setting the speed to match the commonly used rates in the US and Europe.

For more information about HSCW, see **https://www.nitehawk.com/rasmit/ws1_15.html**.

QRSS

QRSS uses tiny amounts of power to send messages long distances. Detailed descriptions on the web point out that this technique averages seconds of audio, which correlates in the processing (as compared to the same time and amount of noise, which does not correlate). For example, 200 mW QRSS transmitters are often spotted on QRSS grabbers thousands of miles away.

The applicable K45 commands for QRSS include setting the speed:

1 = QRSS3: 3-second dits

2 = QRSS6: 6-second dits

3 = QRSS30: 30-second dits

4 = QRSS60: 60-second dits

For example, \Q1 selects QRSS3 or 3-second dits, and \Q4 selects 60-second dits.

Although it's possible to send QRSS directly from the keyboard by entering a command before a string, the most efficient use of QRSS is to format a specific QRSS message.

RTTY

The K45 can be configured to operate in RTTY transmit mode. Receive RTTY is not included. The format is fixed to Baudot FSK with many options. Two menus of choices are provided by a keyboard command (**ESC-R**). Message storage and editing are also used, as with straight CW. Most common RTTY functions — reverse, diddling, and CR/LF handling — can be selected.

The K45 provides FSK output, which directly drives a transceiver's FSK input — assuming the transceiver has this capability. When RTTY is first enabled, transmitter FSK output is assigned to the ring of the output jack, while transmitter key output is assigned to the tip. These can be changed by command.

In Summary

There is a large set of capabilities in the K45 that you can select, modify, use, or not use. It is adaptable to just about every sort of CW operation because it does not need a PC. Generally, any sort of USB supply will power it to full ability.

During this test, the unit added quite a bit of interest and fun to my CW operating. It was interesting to see the letters and words appear on the LCD screen as I compared them with the ones I copied in my head. I am not a very good typist; when I got tired of using the keyboard, I moved my right hand over to my Bencher paddles and I was back in familiar territory. Brief stored messages were nothing new here, but the mapped letter capability was a nice feature.

Manufacturer: K1EL Systems LLC, made in the USA. **https://hamcrafters2.com**. Price: $239.

Buddipole BuddiHEX Portable Hexagonal Beam Antenna

Reviewed by John Leonardelli, VE3IPS
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When I was a teenager, I made my first DX contact from a local schoolyard using a Citizens Band (CB) walkie-talkie. It was then that my fascination with ham radio started. Once I obtained my amateur radio license, I got much satisfaction from operating from parks or out in the field using battery power and portable antennas to recreate the thrill of my first DX contact. Over the years, my Buddipole and Buddistick antennas served me well, but it became time to add a Yagi antenna to my deployment kit.

My first thought was to use a three-element Yagi, but the weight and the inability to transport it in an easy manner had me looking at alternate antennas. Also, the Yagi would cover only three bands, and I wanted a solution

Bottom Line

The BuddiHEX bundle is a complete and easily transportable antenna system that provided me the opportunity to make better contacts, farther, and with less noise.

Figure 5 — Vertical feed point (VFP) hub.

Figure 6 — BuddiHEX unboxed.

Figure 7 — Mastwerks mast unboxed.

for 17 and 6 meters. It was around this time that Chris Drummond, W6HFP, started talking about the BuddiHEX antenna and had several prototypes being field-tested. I knew instantly that I needed to get one to use in my portable operations.

Description

The BuddiHEX antenna offers a **W**-shaped driven element with a **U**-shaped parasitic reflector in a two-element format. This is like some other hexagonal (HEX) beam antenna designs. Research shows that these antennas offer approximately 8 dB forward gain at 30-feet elevation and approximately 15 – 20 dB front-to-back ratio. These figures provide meaningful improvements on reception and transmission over basic dipoles. The HEX-style beams use a center vertical feed-point (VFP) hub (see Figure 5) for element termination, six spreader arms, and tension cables. My portable operation needs a fast deployment, lightweight and easy transport, and rugged construction.

My requirements for a portable beam antenna are met with the BuddiHEX beam. The assembled weight of 10 pounds (4.54 kg) and an 11-foot turning radius make it easy for a single person to deploy. I also needed a mast to get the antenna up high (for better results) and a way to carry everything easily and not lose parts along the way. The BuddiHEX makes for a complete and easily transportable antenna system.

This antenna is also perfect for ARRL Field Day operations, as it can handle the full-power legal limit of 1.5 kW.

BuddiHEX Bundle

This year, I attended Hamvention® with the sole purpose of picking up this antenna. At the show, Buddipole was offering only a bundle that included the BuddiHEX,

Table 1 — Buddipole BuddiHEX (HX6) Portable Hexagonal Beam Antenna
Manufacturer advertised specifications (not tested by the ARRL lab)
Frequency coverage: 6 to 20 meters
(V)SWR: <1.5:1 at band center
Maximum power rating: 1500 W
Connector: BNC (optional PL-259)
Antenna weight: 10 pounds (4.54 kilograms)
Turning radius: 11 feet (3.35 meters)
Gain: 8 dB (30-feet elevation above ground)
Antenna type: Hexagonal beam antenna
Dimension: Not specified
Wind load area: 4 square feet

the 7m Mastwerks Tripod and Mast System, and a Sportube transport case (see Figures 6, 7, and 8). The BuddiHEX is a lightweight and portable six-band HEX beam antenna that is perfect for POTA activations, camping trips, Field Day, or operating from other automobile-accessible locations. The antenna package comes complete with a padded carry bag with high-quality YKK zippers, pre-tuned wire elements, line winders, a VFP hub, six spreader arms, a BNC terminated feed point, and a manual with visual diagrams for each step. The antenna offers six bands, including 20, 17, 15, 12, 10, and 6 meters. The 6-meter band addition is important to me, because I do a lot of operations in the magic band. Unfortunately, it doesn't provide coverage for 40 meters. However, this was a brilliant bundle, as I was able to deploy the antenna in the parking lot of the local motel in which we were staying.

7m Mastwerks Tripod and Mast System

I already have the 8- and 18-foot Buddipole masts, but I wanted something that would allow me to rotate the antenna. The bundle included the Mastwerks tripod and mast system. This is a lightweight and portable tripod and rotational quick-deployment mast. The tripod has rubber feet and adjustable leg lengths. It is rugged and uses customized injection-molded parts with the same kind of nylon plastic used in the Buddipole antenna, but it also has customized aluminum tubing. This plastic is fiberglass-reinforced (filled) nylon providing strength to the components. The mast is oval shaped, which prevents it from twisting. The advantage of this system is that it weighs only 14.8 pounds for the 23-foot model, which collapses down to 4 feet. It fits into the Sportube or in its carry bag. It also has a hand crank, which is unique, because it allows rotation of the mast. A built-in bubble level ensures a proper setup. Included in the high-quality carry bag is an upper and lower guyline kit with its own line winders. The VFP hub mounts on the mast without any adapter, but the Buddipole mounts on the mast with an adapter that uses the standard 0.5-inch national pipe thread (NPT). If you want to mount any other type of antenna on it, like an Arrow Yagi, you need to make an adapter. I look forward to using the mast with an Arrow Yagi for VHF/UHF contesting.

Sportube Series 2 Transport Case

The BuddiHEX bundle also comes with the Sportube (see Figure 8), which is perfect for holding the antenna bag and the tripod bag. The antenna comes in a hard-shell case that protects the equipment when traveling. This case weighs 12 pounds, and the roller wheels make transport easy.

The whole antenna system weighs 37 pounds. This is within the 50-pound limit most airlines have for checked luggage.

Field Report

My first deployment of the antenna — using the instruction manual in one hand, and putting the antenna together with the other hand (no tools required) — was straightforward and took an hour. The Buddipole team provides pre-tuned wires, and no measurement or cutting is required. I've done this several times, and I can put up the antenna by myself within 20 to 30 minutes.

The first step is to deploy the tripod. After making it level, I add the upper and lower guy rings and ropes to the mast. I then push up each telescopic mast element with the upper and lower guy wires loosely in place. Then, I tighten the guys for the appropriate height. That way, when I build the BuddiHEX, I can push it up and everything is in place. Buddipole recommends two people to do this, but it can be done alone with some patience. Each of the six spreader arms is unfolded, placed on the ground, and inserted into the lower section of the VFP hub, which is facing upwards. The next step is deploying the perimeter tension cords by inserting the toggle into the next arm insertion point. Then, insert the remaining tension cords into the peripheral ends of the hub. After adding the tension cords, you have what looks like an upside-down umbrella laying on the ground.

Figure 8 — Sportube case.

The wire elements are color coded and pre-tuned, and they are stored on the included line winders. The color-coded marks on the arms help to simplify the wire element installation. The 20-meter band connects the end wire to the top of the VFP hub. Clip it onto the spreader using the same color-coded clips (facing upward), and walk around until the other connection is made. The antenna element-binding points are hand-tightened. Do this for the other five bands. Attach the BNC feed point to the top banana jacks on the VFP, and add your coax assembly. I use the Buddipole coax, as it comes with end covers, uses military-grade coax, and is easy to coil and uncoil. The final step is to install a special tensioning cord to the driven element area at the front of the director section to maintain the hexagonal shape and to keep it tight.

I lift the antenna assembly off the ground, holding the VFP hub in one hand and an element in the other, and place it onto the Mastwerks mast. The two components fit together perfectly. Now I can push the mast up to its operating height, and the preloaded guy wires are in place. I connect the coax to my radio and check my SWR, and I'm now on the air. I did an SWR sweep for all of the bands and found the SWR for all of them to be under 1.5 (see Figures A – F). There is enough bandwidth that an antenna tuner is not required. Everything works as designed out of the box. On my first deployment, I used no tools or measuring tape and was transmitting an hour later.

During a POTA activation at Mary Lake, VE-5549, I was working a pileup into the southern US on 20 meters with the antenna pointed south. I used the Yaesu FT-891 transceiver and Bioenno LiFePO4 12 V 12 Ah battery. Mike, CU3HY, in Azores, Portugal, called me and was coming in 5 by 5. I rotated the beam toward Europe using the hand crank. I then had a 5 by 8 signal report that allowed a 20-minute QSO to discuss a future trip to the islands for a SOTA activation. The BuddiHEX proved itself with improved signal reports both ways. I found that the antenna provided several S-units of improvement over my vertical dipole antenna on transmit and receive. The front-to-back ratio was also useful, with as much as five S-units. This allowed me to work Europeans while reducing the US signals behind me, causing less interference. On-air tests also provided similar results, with the BuddiHEX performing admirably.

This antenna has also allowed me to null out noise sources on 6 meters and work a weak KP4 station that was not possible with my Buddistick antenna as I did an A/B antenna check.

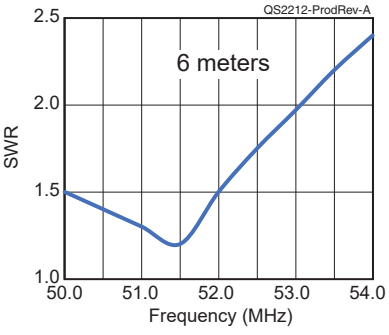

Figure A — 6-meter SWR sweep.

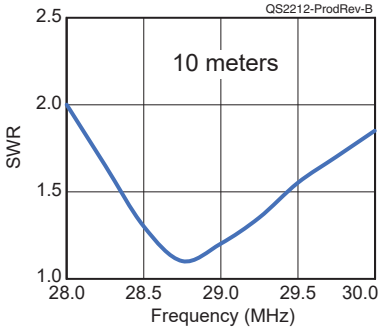

Figure B — 10-meter SWR sweep.

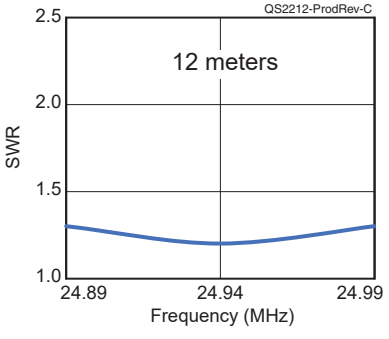

Figure C — 12-meter SWR sweep.

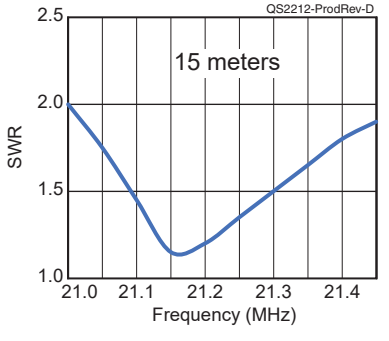

Figure D — 15-meter SWR sweep.

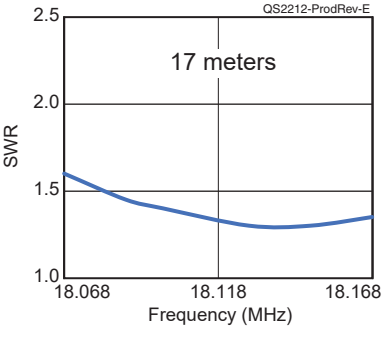

Figure E — 17-meter SWR sweep.

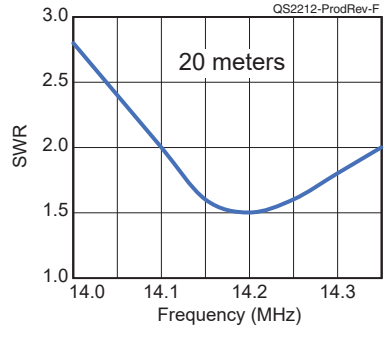

Figure F — 20-meter SWR sweep.

BuddiHEX Hacks

One modification I made immediately was to use some plumbing bits to make a mast adapter, which allowed me to use an Arrow antenna on top of the Mastwerks mast. This plumbing fitting has the same NPTs as the Buddipole (see Figure 9).

Figure 9 — Mast adapter.

The 40/20-meter antenna is an inverted **V**-linked dipole using a PackTenna Mini balun with switches to add or remove the 40-meter legs as needed. I use a small Nite Ize carabiner clip to attach the balun to the upper guy ring. So now I can cover 40 – 6 meters with two antennas on one mast, deployed in less than 30 minutes, with no tools and no tuning required.

I am also looking at adding a dual-band VHF/UHF antenna on the top of the VFP hub, which could allow me coverage of those bands as well.

The BuddiHEX bundle does everything I expected. It performs well on all bands, doesn't require an antenna tuner, and can quickly and easily be deployed by a single person. If you are looking to add a directional antenna to your portable go-box, the BuddiHEX may be the right choice for you.

Conclusion

The BuddiHEX provided me the opportunity to make better contacts, farther, with less noise. The system is an investment, and the build quality is excellent. I see many years of usage. This antenna can be left outdoors in a permanent type of installation, but this may not be designed for harsh winters and rain-soaked environments.

Manufacturer: Buddipole, Inc. 3028 SE 59th Ct. #600, Hillsboro, OR 97123. **www.buddipole.com**. Price: $599; 7m Mastwerks Tripod and Mast System, $659; Sportube Series 2 transport case, $249.

WA3RNC TR-35 40/30/20/17-Meter CW Transceiver Kit

Reviewed by Mark Wilson, K1RO
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Building on the TR-25 40/20-meter CW transceiver kit reviewed in the December 2021 issue of *QST*, the TR-35 from John Dillon, WA3RNC, adds coverage of 30 and 17 meters, along with narrow/wide CW filter choices and SSB reception. The transceiver is available as a kit or assembled and tested. We ordered the kit version for this review.

Like the TR-25, the TR-35 was designed with portable operation in mind. It's compact and lightweight, and all functions are controlled by front-panel switches and knobs (no menus). The radio requires 9.5 – 14 V dc and still produces 4 – 5 W RF output at the low end of that range. Maximum power output is 8 – 10 W with a 14 V dc power source. The transceiver draws about 100 mA on receive and 1 A on transmit, so a modest 12 V battery will power your operation for several hours.

Although you can use any suitable battery or power supply, the WA3RNC website (**www.wa3rnc.com**) indicates that the TR-35 is optimized for operation from

Bottom Line

The WA3RNC TR-35 40/30/20/17-meter CW transceiver kit is well thought out and packaged, making it an attractive project for anyone who has learned the basics of soldering and PC board construction. The radio works well and is easy to use, and it is especially suited to portable operation where size, weight, and power requirements matter.

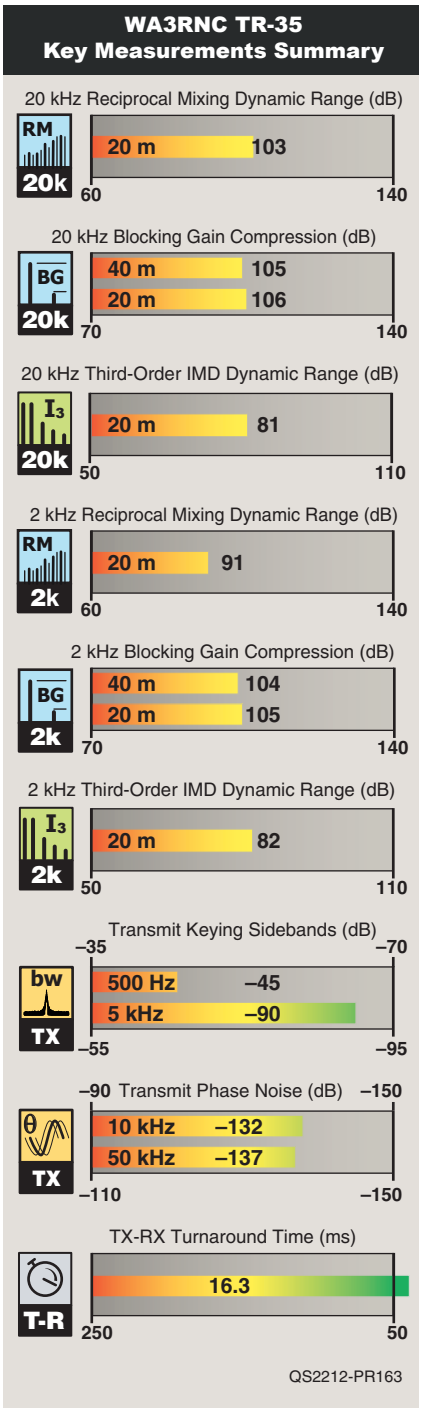

Table 2
WA3RNC TR-35 CW Transceiver

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Full coverage of the 40-, 30-, 20-, and 17-meter amateur band, with extended receive above and below.	As specified.
Power requirement: 9.5 – 14 V dc at <100 mA receive; 1 A transmit at 10 V.	Receive: Typically 116 mA at 9.5 – 14 V dc. Transmit: Typically 1.1 A at 13.8 V dc and 5 W output power.
Mode of operation: CW transmit and receive; SSB receive only.	As specified.
Receiver	**Receiver Dynamic Testing**
Sensitivity: –125 dBm.	Noise floor (MDS): 7 MHz, –132 dBm 10.1 MHz, –132 dBm 14 MHz, –133 dBm 18 MHz, –134 dBm
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range: *20/5/2 kHz offset* 7 MHz 105/105/104 dB 14 MHz 106/106/105 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 103/95/91 dB

ARRL Lab Two-Tone IMD Testing

Band	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
14 MHz	20 kHz	–133 dBm –97 dBm	– 52 dB – 40 dB	81 dB
14 MHz	5 kHz	–133 dBm –97 dBm	– 51 dB – 39 dB	82 dB
14 MHz	2 kHz	–133 dBm –97 dBm	– 51 dB – 38 dB	82 dB

Second-order intercept point: Not specified.*	+43 dBm at 14 MHz.
IF/audio response: Better than 350 Hz at –6 dB (CW narrow setting).	Range at –6 dB points: CW narrow: 630 – 920 Hz (290 Hz); SSB: 350 – 3045 Hz (2695 Hz).
Transmitter	**Transmitter Dynamic Testing**
Power output, 7/10.1/14/18 MHz: At 14 V dc, 8.5/10/9.5/8.5 W At 9.5 V dc, 4.0/4.9/4.5/4.4 W	7/10.1/14/18 MHz: As specified. As specified.
Spurious-signal and harmonic suppression: 52 dB.	>62 dB (see Figure G). Complies with FCC emission standards.
CW keying characteristics: Not specified.	See Figures H and I.
Transmitted phase noise: Not specified.	See Figure J.
Transmit-receive turnaround time: Not specified.	S-9 signal, 16.3 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.

three series-connected external 18650 cells. These inexpensive 3.7 V rechargeable Li-ion cells, typically rated at 2500 – 3000 mAh, are widely available.

Building the Kit

The kit includes two PC boards, the case, and three strips of components packaged in bubbles. The package includes printed assembly and operating instructions and full schematic diagrams. These documents are also available as PDFs on the WA3RNC website. As delivered, the PC boards are populated with several hundred surface-mounted components, and the builder adds about 55 through-hole parts.

The PC boards are called the upper and lower boards, referring to how they will be positioned in the final assembly. There is one strip of components for the upper board, one for the lower board, and another with knobs and connectors for the final assembly. Within each strip, the components are arranged in the order

they will be used during assembly. Everything is extremely well organized — no hunting through a pile of parts or guessing at component values. The parts packaging and illustrated step-by-step instructions make assembly quick and easy. I spent an afternoon stuffing the boards, and I did the final assembly and checkout the next day, perhaps 4 to 5 hours total.

No special tools are needed for assembly — just a good soldering iron with a fine tip and thin-gauge solder, flush cutters for trimming component leads, and some clear nail polish for securing several nuts. I also needed a magnifier and good lighting for soldering to tiny component pads. A digital multimeter is required for a few final checks and adjustments.

I built the upper board first (see Figure 10). This board has all of the switches and controls, the organic LED (OLED) display and indicator LEDs, and an ATmega328P microcontroller. Jacks for a keyer paddle, an external key, and headphones are mounted under the board, along with a couple of potentiometers. The final assembly steps for this board involve placing three toggle switches, the tuning encoder, and four potentiometers, and then using the top half of the case to align everything before soldering. The board and components must be firmly secured before soldering, and the instructions recommend some plastic clips from Harbor Freight or rubber bands. I used two small adjustable clamps from my toolbox. The upper and lower boards are closely spaced, and the instructions clearly indicate which components require special attention during installation to ensure that the final assembly goes smoothly. For example, some parts must be mounted

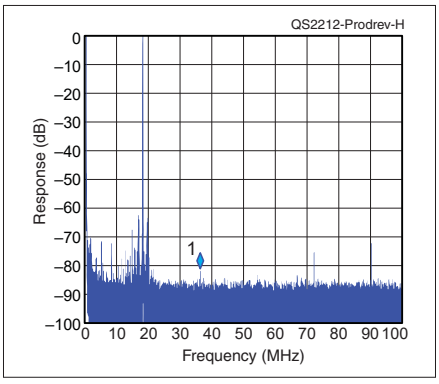

Figure G — Spectral display of the WA3RNC TR-35 transmitter output. Power output is 5 W on the 18.068 MHz band. This plot shows the output spectrum from 0 to 100 MHz. The second harmonic is down 82 dB from the carrier, and the third harmonic is down more than 85 dB. Close-in spurious emissions are down 63 dB. The vertical scale is 10 dB per division.

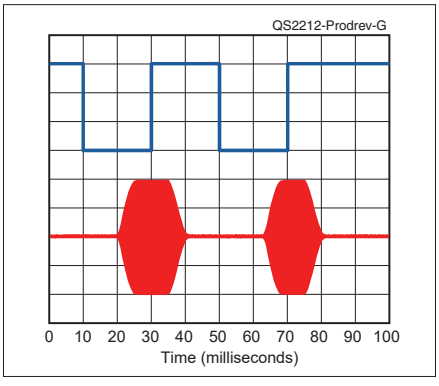

Figure H — CW keying waveform for the WA3RNC TR-35 showing the first two dits using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 5 W output on the 14 MHz band. Rise time is 3.6 ms, and fall time is 4 ms. First dit: on delay, 12 ms; off delay, 7.8 ms. Second dit: on delay, 14.9 ms; off delay, 7.9 ms.

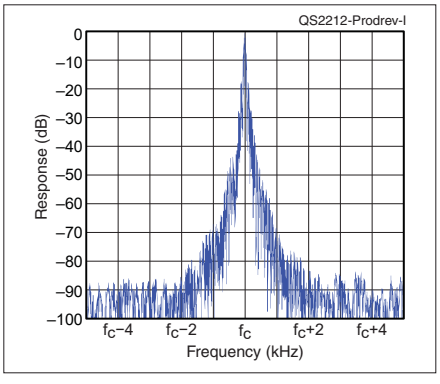

Figure I — Spectral display of the WA3RNC TR-35 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 5 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is 10 dB per division.

Lab Notes: WA3RNC TR-35 Four-Band HF Transceiver

The TR-35 tested to be a decently performing radio for its price class. For a small and portable rig that will often be used by amateurs without the big antennas often used with big rigs, this rig delivers reasonable performance.

Its noise floor (MDS) is more than adequate for HF. This means that when it is hooked up to almost any HF antenna, the limiting factor is external noise, not the sensitivity of the radio.

Dynamic range is also reasonable for a radio of this price class. It may not be the radio to use with a Yagi antenna during a major contest, but it performs well enough that overload should not be an issue with the modest antennas or when the band is not chock-full of big-gun signals.

As can be seen in Figure H, when keyed at 60 WPM, the keying showed a slight shortening of the dits, but even at this speed, this will sound okay on the air. (At lower speeds, this shortening would hardly be noticed.) The shape of the keyed waveform is smooth, and although the rise and fall times are a bit faster than the 5 – 6 ms that ARRL recommends for minimal keying sidebands (clicks), the rig won't generate significant key clicks up and down the band.

The rig achieved full power on all bands and operates well over a wide voltage range, making it well suited to operating in the field for camping or some of the QRP operating activities. Harmonics are better than the rules require, and transmit phase noise is good. — *Ed Hare, W1RFI, ARRL Laboratory Manager*

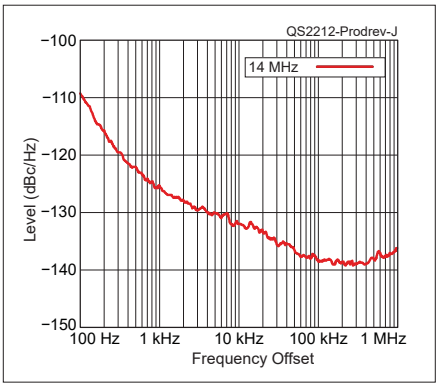

Figure J — Spectral display of the WA3RNC TR-35 transmitter output during phase-noise testing. Power output is 5 W on the 14 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows phase noise at 100 Hz – 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 10 dB per division.

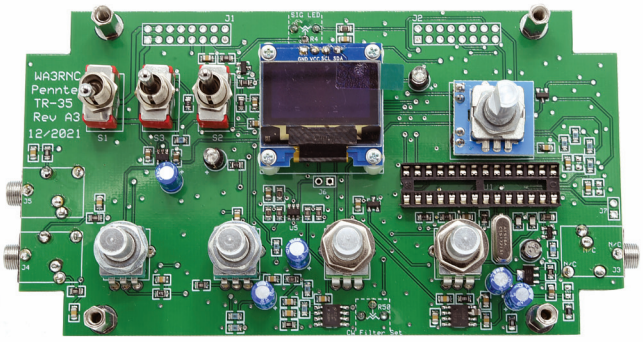

Figure 10 — The upper board contains the display and controls. When this photo was taken, the 16-pin connectors to join the two PC boards had not been installed, and the protective film was still in place on the OLED display. The microcontroller will be plugged into the empty socket in one of the final steps.

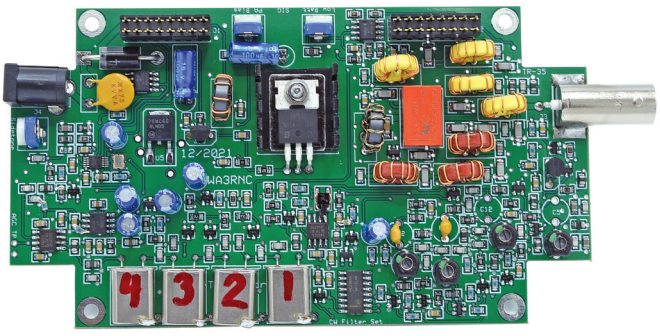

Figure 11 — The lower board has the RF and audio components. The final amplifier FET is on its heatsink in the center of the board. All of the toroids are pre-wound with tinned leads. The instructions clearly indicate the core color and number of turns, so you can double-check that you have the right part. The numbered and matched crystals for the narrow CW filter are along the bottom edge.

flush with the board, some are bent over, and others require closely trimmed leads.

The lower board carries most of the receiver and transmitter RF circuitry (see Figure 11). The IRF510 final amplifier is mounted with a small heatsink, mica insulator, and plastic washer. Mounting the final amplifier and heatsink requires some care. The IRF510 leads have to be bent correctly before soldering so that the insulating material lines up. There are seven toroid inductors and a bifilar wound transformer, and these are all supplied pre-wound with tinned leads. They install just like any other part. A crystal filter following the mixer uses four matched crystals in series. The crystals are labeled 1 – 4 and are installed in the corresponding spot on the PC board.

One of the things I really like about this kit is that all of the connections between the upper and lower boards are made using two 16-pin connectors. All of the switches and controls mount to the boards, so there are no interconnecting wires at all. The upper and lower boards simply plug together using the two connectors and are secured with machine screws and spacers.

Adjustments and Final Assembly

At this point, the radio is fully assembled but not placed in the case until you perform some checks and adjustments. Before applying power to the boards, the instructions show a few simple ohmmeter checks for power bus shorts. Then connect an antenna and speaker or headphones, apply power, and listen for signals on the four bands while checking operation of the display and controls. At this point, the receiver sounded deaf, so I stopped there to recheck my work. Because of the way the board interconnections are done with the two 16-pin connectors, it was easy to pop the boards apart and inspect everything with a magnifier, revealing a bad solder joint on the filter switch. With that fixed, the receiver sounded fine on all bands, so I moved on to the final adjustments with the radio connected to a wattmeter and dummy load.

Several trimmer potentiometers need to be adjusted. The first trimmer is set to just barely light the blue **SIG** LED with no signal present. It glows brightly with strong received signals. The next step requires a multimeter in series with the power supply that can measure current of around 100 mA with a resolution of a few milliamps (most digital multimeters will work here). In this multistep process, watch the current draw while adjusting the **BIAS** trimmer to set the operating point for the final amplifier FET. This should be a set-and-forget adjustment. Next, adjust the sidetone level trimmer for comfortable listening.

Now adjust the low-voltage alarm trimmer to light the red **LOW BATT** LED when the power supply voltage drops too low, helping to keep your battery from excessive discharge. The alarm range is about 9 – 11 V. I set mine with an adjustable power supply. This isn't a critical adjustment — it's just an alarm to warn you that your battery is getting low, and it doesn't affect operation of the radio.

The final trimmer centers the audio band-pass filter frequency at 700 Hz. The instructions suggest using an oscilloscope or audio meter to adjust for maximum signal, but it's easy enough to do it by ear.

With the trimmers adjusted, it's time to put the radio in the case and get on the air.

Connections and Controls

The left side of the radio has three jacks: a coaxial dc power jack, a 3.5-millimeter **KEY** jack for an external key or keyer, and another 3.5-millimeter jack for paddles for the internal keyer. You can have both an external key

and paddles for the internal keyer connected at the same time and switch back and forth. The right side has a 3.5-millimeter jack for headphones or a speaker, along with the BNC antenna jack.

Be sure to read the instructions for the headphone jack. In the review kit, which uses a 12/2021 Rev. A3 upper board, the jack will work with headphones with a standard mono or stereo plug. For a speaker, use a stereo plug with the ground connection made to the ring terminal. Connecting the tip and ring together on a stereo plug will cause a short to ground and damage the audio amplifier.

The 02/2022 Rev. B upper board currently shipping is wired for a 3.5-millimeter mono plug, so you will need an adapter if you have stereo headphones and want sound in both ears. The instructions show a modification to the board that will allow both earpieces to play without an adapter, but once the modification is made, connecting a mono plug will damage the audio amplifier.

Although an ATmega328P microcontroller runs the TR-35 control functions, the radio was designed to be simple to operate. Instead of menus, it uses hardware switches and knobs for all functions.

Pressing up on the **BAND/RIT** switch cycles through 40, 30, 20, and 17 meters. The **TUNE** encoder at the upper right adjusts the operating frequency, with selectable 10 Hz, 100 Hz, and 1 kHz tuning steps. Engage receiver incremental tuning (RIT) by pressing the **BAND/RIT** toggle and turning the **TUNE** knob to adjust the offset. The RIT range is ±5 kHz, and the orange **RIT** LED lights when active. Although the receiver tuning range extends beyond the ham bands, the TR-35 will not transmit past the band edges.

Pressing up on the **RCVR MODE/AUX** switch toggles between narrow and wide CW filters, and a longer click selects SSB reception. In SSB mode, the receiver automatically selects lower sideband for 40 meters and upper sideband for 20 and 17 meters. You can store one operating frequency/mode combination as the initial setting for each band.

Pressing down on this switch (**AUX** position) activates the internal memory keyer record and playback functions. The two memories can store up to 125 characters each, with the memory to use selected by tapping the dit or dah paddle. The iambic keyer range is about 5 – 45 WPM, adjusted with the **KEYER** knob.

According to the manual, the TR-35 is designed for CW duty cycle use and cautions against transmitting continuously for more than 10 seconds or so at full power. To protect the transmitter from damage, the TR-35 uses a polyfuse, a device that increases resistance as temperature increases over time, to fold back power if it gets too hot. I never experienced power foldback during normal CW operation, even when CQing and making contacts for extended periods.

On the Air

I finished the TR-35 kit on the weekend of the IARU HF World Championship, so the bands were packed with stations. Tuning through 20 meters in the narrow CW mode, I was impressed with how well the receiver was able to separate closely spaced strong signals. In three short operating sessions that totaled about an hour, I worked 45 stations in 19 different DXCC countries. (My antenna is a two-element beam at 25 feet.)

With its small size, simple controls, and modest power requirements, the TR-35 is a joy to use for portable operation. I set up the TR-35, a small battery, and modest antennas for activations at six nearby state forests and parks for the Parks on the Air® (POTA) and World Wide Flora and Fauna (WWFF) programs. I made about 160 contacts using all four bands, including stations in Alaska, Europe, and the Caribbean.

The OLED display characters are crisp and easy to read despite the small size. It can, however, be difficult to read outdoors in bright sunlight if you're operating in an exposed area. There's a "reverse optic display" mode that changes the display to black numbers on a blue background. While that helped somewhat, at times I ended up using my hat to throw a bit of shadow on the radio when I needed to read the frequency display.

The solid-state full break-in (QSK) is terrific. Switching is practically instantaneous, with no clicking or popping, so it's easy to monitor the frequency between sent characters.

The transmit offset is fixed at about 700 Hz, and the sidetone is a sample of the transmitted signal, not generated by a separate oscillator. During final assembly, I had adjusted the internal sidetone level potentiometer on the lower PC board for comfortable listening on a quiet band. With a lot of activity on the air, I sometimes wanted to increase the sidetone level to make it easier to hear when competing with strong received signals. While I could accomplish that by reducing the RF gain to quiet the received signals, a small hole in the case to adjust the level trimmer for changing band conditions might be helpful.

Manufacturer: John Dillon, WA3RNC, **www.wa3rnc.com.** Price: $279 (kit); precision optical encoder, add $38; factory wired and tested, add $100.