Mark J. Wilson, K1RO, k1ro@arrl.org

Product Review

Lab599 Discovery TX-500 160 – 6 Meter Portable Transceiver

Reviewed by Phil Salas, AD5X
ad5x@arrl.net

Several low-power, portable transceivers have taken advantage of the continual development of DSP hardware, including Elecraft's KX2 and KX3, and the Xiegu G90 and X5105. A recent entry is the Discovery TX-500 transceiver from Lab599, a relatively new Russian company. The radio is distributed in the US by Ham Radio Outlet and is supported by a US service center in Nevada.

Overview

The Lab599 Discovery TX-500 is an attractive and very rugged transceiver that covers the ham bands from 160 to 6 meters, along with a general-coverage receiver that tunes continuously from 500 kHz to 56 MHz. It's hard to find any online comments about the TX-500 that don't describe it as being built like a tank. The housing is a heavy machined aluminum chassis. Left- and right-side front-panel extensions protect the display and all controls from being damaged if dropped. The transceiver is also water resistant because of its liquid-protected housing, encoders with sealing rings, and water-resistant connectors.

This radio has a flat profile compared to typical transceivers. Two feet on the back fold out to orient the radio at about 30 degrees for operating and ease of viewing the display and controls. A 3.6-inch, high-contrast monochrome LCD shows everything necessary during operation (see Figure 1).

Transmit power is adjustable from 1 to 10 W, and operating modes include SSB, CW, FM, AM, and digital modes using an external computer. The TX-500 includes many useful features, such as two VFOs, split-frequency operation, transmit and receive offset tuning (RIT/XIT), an SWR bridge, a receiver preamp and attenuator, a noise blanker, digital noise reduction, a notch filter, a speech processor, and variable bandwidth DSP filters. There is also a built-in 48 kHz high-speed panadapter for easy signal search and evaluation of band conditions. Finally, the TX-500 has two 20-second voice memories, four CW memories, and 100 general-purpose memories that store VFO frequency, mode, and other settings.

There is no internal automatic antenna tuner, and no built-in speaker. However, the speaker in the provided speaker/microphone offers plenty of audio for any environment and it sounds fine.

Interfaces and Controls

The water-resistant I/O connectors, located on the left and right sides of the TX-500, seem to be what determines the 1.1-inch thickness of the radio

Bottom Line

The Lab599 Discovery TX-500 is a rugged, compact, feature-loaded 10 W portable transceiver that should satisfy any QRP portable operator.

Figure 1 — The Lab599 TX-500 display conveys quite a bit of operating information at a glance, and even includes a spectrum scope. The wide vertical bar near the center of the scope shows the received bandwidth. Labels for the rows of soft keys above and below the display change depending on settings.

(see Figure 2). Other than the BNC RF connector, the interface connectors are different from those typically found on QRP transceivers. They are GX12 series multipin connectors that are readily available online from **www.w2eny.com** and other sources. You probably won't need to worry about that because adapter cables for the CW key, the USB computer interface, the dc power, and the external mic/headphone/speaker (with PTT switch) are included. All of the connectors use a different number of pins, so you won't mix them up.

The one cable that's shown in the manual but not included is an audio interface cable for digital-mode operation. A connector is included, so you can make your own, and wiring diagrams for all interfaces are available for download from the Lab599 website.

Three variable controls on the front panel provide AF gain, RIT/XIT offset, and frequency tuning. Buttons to the left of the large tuning knob provide for band, mode, filter, and menu selection. To the right of the tuning knob are buttons for RIT/XIT, VFO/memory, VFO lock/unlock, and VFO step size. There are four soft keys above the LCD screen, and four more soft keys below the LCD. These buttons change functions for different operations, and they are also used for menu selections. All of the buttons have excellent tactile feel, and the three controls feel solid and are wobble free.

More Testing

Table 1 lists the TX-500 specifications and the ARRL Lab measurement results. Because the TX-500 doesn't have an internal autotuner, I wanted to see how the radio would do with some reasonable mismatches, like you might encounter with a temporary portable antenna. Table 2 shows the output power when transmitting into high-impedance and low-impedance 2:1 and 3:1 SWR loads.

The TX-500 manual states that the radio's SWR protection reduces transmitter output power as the SWR increases. This does appear to be the case if the higher SWR is due to a high-impedance load. However, it is interesting to note that the TX-500 output increases with high SWR with a low-impedance load. (Of course, it's best to observe the rated RF power output at all times.)

General Operation

The TX-500 is powered from an external 9 – 15 V dc battery or power supply capable of sourcing up to 2.5 A. The TX-500 does have overvoltage and reverse-polarity protection, but the manual cautions that

Figure 2 — The connectors on either side of the radio case are for antenna, CAT (computer-aided transceiver), and CW key on one side, and dc power, data/remote, and speaker/mic on the other. The GX12 series I/O connectors offer weather protection.

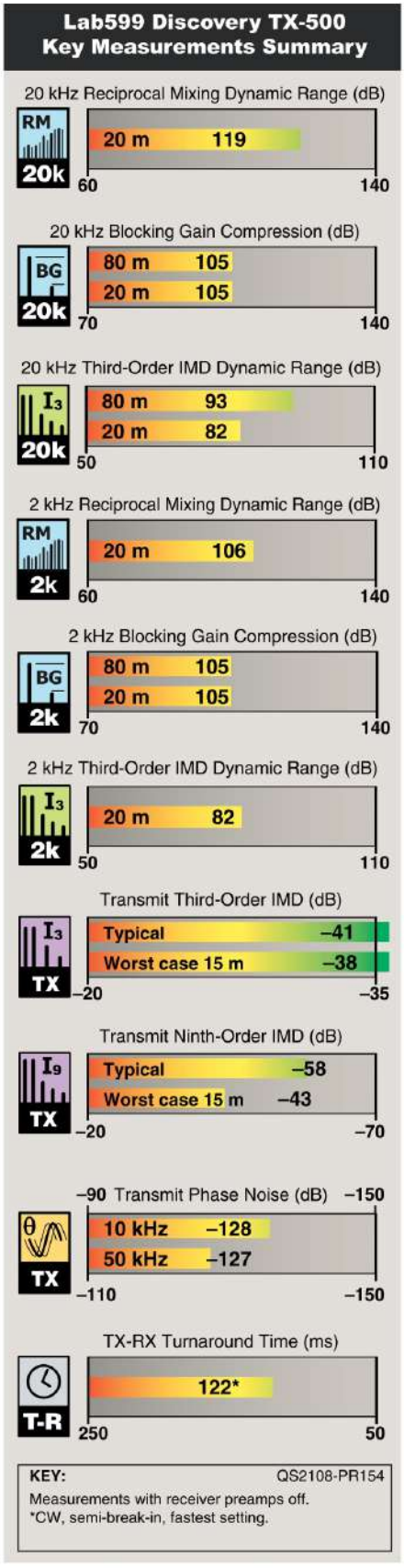

Table 1
Lab599 Discovery TX-500, S/N N/A

Manufacturer's Specifications

Frequency coverage: Receive, 0.5 – 56 MHz; transmit, 1.8 – 54 MHz (amateur bands only).

Power requirements: 9 – 15 V dc. Receive, 100 mA (backlight on, preamp off, no signal). Transmit, 1 – 3 A typical.

Modes of operation: SSB, CW, Digital AM, FM.

Measured in the ARRL Lab

Receive and transmit, as specified. 60-meter segment transmit, 5.3515 – 5.3665 MHz.

At 13.8 V dc: Receive, 104 mA (max brightness, max volume, no signal). Transmit, 2.0 A at max RF output; 930 mA at minimum RF output.

As specified.

Receiver

Sensitivity: –136 dBm typical with preamp on.

Noise figure: Not specified.

AM sensitivity: Not specified.

FM sensitivity: Not specified.

Blocking gain compression dynamic range: Not specified.

Reciprocal mixing dynamic range: Not specified.

Receiver Dynamic Testing

Noise floor (MDS), 500 Hz bandwidth:

Preamp	*Off*	*On*
1.0 MHz	–123 dBm	–138 dBm
3.5 MHz	–125 dBm	–141 dBm
14 MHz	–125 dBm	–141 dBm
50 MHz	–109 dBm	–129 dBm

Preamp off/on: 14 MHz, 22/6 dB; 50 MHz; 38/18 dB.

10 dB (S+N)/N, 1 kHz tone, 30% modulation, 10 kHz bandwidth:

Preamp	*Off*	*On*
1.02 MHz	8.31 µV	1.80 µV
3.88 MHz	5.37 µV	1.16 µV
29.0 MHz	8.12 µV	1.43 µV
50.4 MHz	17.6 µV	2.24 µV

For 12 dB SINAD, 3 kHz deviation, 12 kHz bandwidth:

Preamp	*Off*	*On*
29 MHz	2.54 µV	0.40 µV
52 MHz	5.68 µV	0.68 µV

Blocking gain compression dynamic range, 500 Hz bandwidth:†

	20/5/2 kHz offset *Preamp off*
3.5 MHz	105/105/105 dB
14 MHz	105/105/105 dB
50 MHz	140/140/140 dB

14 MHz, 20/5/2 kHz offset: 119/108/106 dB

ARRL Lab Two-Tone IMD Testing (500 Hz bandwidth)

Band/Preamp	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
3.5 MHz/Off	20 kHz	–125 dBm –97 dBm	–32 dBm –23 dBm	93 dB
14 MHz/Off	20 kHz	–125 dBm –97 dBm	–43 dBm –28 dBm	82 dB
14 MHz/On	20 kHz	–141 dBm –97 dBm	–50 dBm –27 dBm	91 dB
14 MHz/Off	5 kHz	–125 dBm –97 dBm	–43 dBm –27 dBm	82 dB
14 MHz/Off	2 kHz	–125 dBm –97 dBm	–43 dBm –27 dBm	82 dB
50 MHz/Off	20 kHz	–109 dBm –97 dBm	–18 dBm –31 dBm	91 dB
50 MHz/On	20 kHz	–129 dBm –97 dBm	–40 dBm –29 dBm	89 dB

Manufacturer's Specifications	Measured in the ARRL Lab
Second-order intercept point: Not specified.	Preamp off/on, 14 MHz, +47/+43 dBm; 21 MHz, +47/+39 dBm; 50 MHz, +45/+35 dBm.
FM adjacent channel rejection: Not specified.	Preamp on: 29 MHz, 63 dB; 52 MHz, 78 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	Preamp on, 20 kHz offset: 29 MHz, 63 dB;* 52 MHz, 78 dB.* 10 MHz offset: 29 MHz, 91 dB; 52 MHz, 78 dB.
S-meter sensitivity: Not specified.	For S-9 signal, preamp off/on: 14 MHz, 58.8 µV; 50 MHz, 64.5 µV. Scaling: 6 dB/S-unit.
Squelch sensitivity: Not specified.	14 MHz SSB, minimum to maximum squelch: 1.78 µV to 158 mV.
Receive signal processing delay time: Not specified.	29 ms.
IF/audio response: Not specified.	Range at –6 dB points:‡ CW (500 Hz BW): 507 – 925 Hz; Equivalent Rectangular BW: 457 Hz; SSB (2.7 kHz BW): 400 – 2937 Hz; AM (10 kHz BW): 400 – 2937.
Transmitter	**Transmitter Dynamic Testing**
Power output: HF, 1 to 10 W PEP; 50 MHz, 1 to 7 W.	As specified.
Spurious signal and harmonic suppression: >50 dB.	Harmonic suppression: HF, typically >70 dB (62 dB worst case, 15 m). 50 MHz: 68 dB. Spurious suppression: 48 dB (see Lab Notes). Meets FCC requirements.
Third-order intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th-order IMD products 10 W PEP RF output: –41/–52/–54/–58 dB (HF typical) –38/–57/–42/–43 dB (worst case, 15 m) –32/–44/–52/–54 dB (50 MHz)
CW keyer speed range: Not specified.	1.8 to 51 WPM, iambic mode B.
CW keying characteristics: Not specified.	See Figures A and B.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	S-9 signal, AGC fast, 28 ms. CW semi-break-in, 122 ms.
Receive-transmit turnaround time (tx delay): Not specified.	SSB, 41 ms; FM, 30 ms (29 MHz), 33 ms (52 MHz).
Transmitted phase noise: Not specified.	See Figure C.

Size (height, width, depth, incl. protrusions): 1.1 × 9.1 × 3.5 inches; weight, 1.2 pounds.

Second-order intercept points were determined using S-5 reference.

†The AGC cannot be turned off (AGC is normally disabled during dynamic range testing). The TX-500 blocked adjacent signals with no effects on the desired signal, up to the point of ADC overload at +4 dBm with the preamp off and –15 dBm with preamp on.
*Measurement was noise limited at the value indicated.
‡Bandwidth is adjustable via DSP.

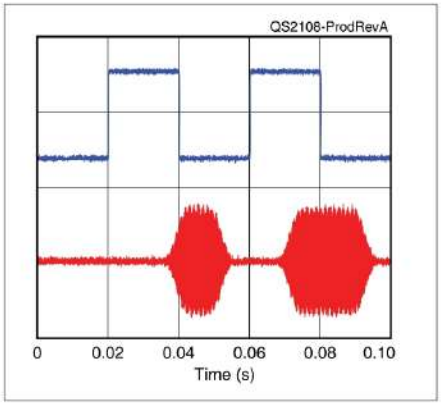

Figure A — CW keying waveform for the LAB599 Discovery TX-500 showing the first two dits using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 10 W output on the 14 MHz band.

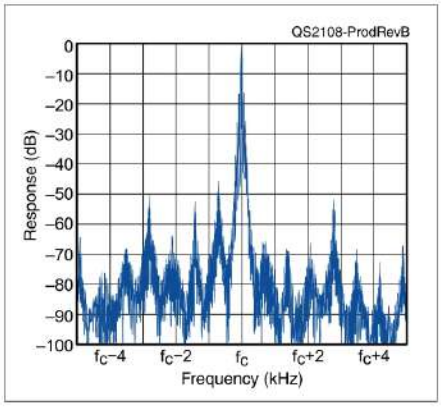

Figure B — Spectral display of the LAB599 Discovery TX-500 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 10 W PEP output on the 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.

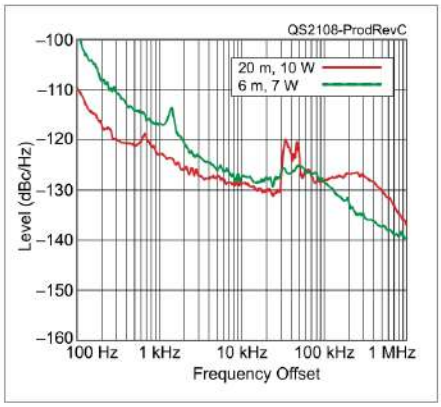

Figure C — Spectral display of the LAB599 Discovery TX-500 transmitter output during phase-noise testing. Power output is 10 W on the 14 MHz band (red trace) and 7 W on the 50 MHz band (green trace). The carrier, off the left edge of the plot, is not shown. This plot shows phase noise 100 Hz to 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 5 dB per division.

Table 2
SWR Impact on TX-500 Transmit Power

SWR	Forward Power (W)
1:1	10.8
2:1 (high impedance)	7.7
3:1 (high impedance)	6.3
2:1 (low impedance)	13.1
3:1 (low impedance)	13.8

Lab Notes: Lab599 Discovery TX-500

Bob Allison, WB1GCM

The TX-500 receiver is well suited for field use. Its lowest dynamic range is third-order IMD dynamic range, which is 82 dB at 2 kHz spacing at 14 MHz. Though the AGC cannot be turned off, the TX-500 blocked adjacent signals with no effects on the desired signal, up to the point of ADC overload. On some frequencies, internally generated spurious signals are heard in the receiver. These tones were quite noticeable around 14.044 MHz in the review radio, even with an antenna connected and typical band noise. According to the manual, this results from the way the internal signal conversion is performed. Enabling the DIF (virtual intermediate frequency) feature moves the tones to a different frequency.

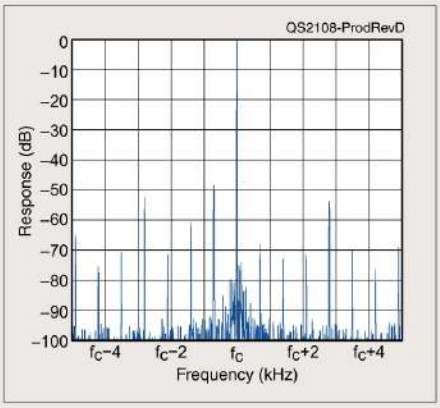

Figure D — A spectral sweep ±5 kHz from the carrier while a constant CW tone is transmitted reveals several additional low-level signals at least 48 dB below the carrier level.

On the transmit side, the TX-500 exceeds the FCC's requirement for harmonic and spurious suppression, which is 43 dB for HF and 60 dB above 50 MHz. However, I observed multiple low-level signals transmitted along with the intended signal. For example, in CW mode, a spectrum analyzer typically displays a single carrier, which turns on and off as CW characters are transmitted. As shown in Figure D, a spectral sweep ± 5 kHz from the carrier, there are numerous low-level signals also transmitted. These signals are at least 48 dB below the carrier (a fraction of a milliwatt). The added spurious signals explain the unusual plot of the CW sidebands in this review, despite the TX-500's nice CW waveshaping (see Figures A and B with Table 1).

In SSB mode, two tones into the microphone jack produce the expected transmit IMD odd-order products, but also present were other low-level distortion products.

All of the low-level spurious emissions observed during this test are suppressed more than the FCC-required 43 dB below the carrier and are unlikely to be heard on the air because they will be below the receiver's noise floor. However, I do not recommend using an RF amplifier with this transceiver because that could raise the level of these signals enough to be heard by other stations operating nearby.

Finally, I observed the carrier suppression on 6 meters of only 42 dB. This is okay for QRP, but more carrier suppression is desirable for higher transmitted power. Also, sensitivity could be improved on 6 meters.

Additional spectral plots from the TX-500 transmitter are available from **www.arrl.org/qst-in-depth**.

exceeding 16 V dc can damage the transceiver. The receive current drain is just over 100 mA, which is important to help conserve battery power because typically a high percentage of operating time is spent listening.

The TX-500 comes with a fold-out *Quick Start Guide*. A detailed user manual can be downloaded from **lab599.com**, but I found that the accompanying guide was really all I needed to operate the radio because the TX-500's controls and buttons are mostly self-explanatory, and the menu system is well thought out. The more commonly used functions are available through the soft keys above and below the display. Tap the **MENU** button, and you can change many less-often-needed settings, such as microphone gain, compression level, type of CW key, break-in delay, and other set-and-forget items.

I particularly liked the **INTEL** tuning setting. This feature increases the tuning rate based on how fast you turn the tuning knob, which makes moving around in the bands very easy. There are also four default receive bandwidths per mode, all of which can be easily changed by the user. An internal CR2032 battery powers internal memory to save user settings and keep the real-time clock operating.

As mentioned earlier, there is no internal antenna tuner, but the **TONE** soft key transmits a 4 W constant carrier to enable you to adjust an external antenna tuner if needed. It is interesting that the **TONE** control can be changed to output two tones instead of the single tone. I'm not sure what the purpose of this is though, as the tones are 1 kHz and 2 kHz. Because the two tones are harmonically related, they are not suitable for two-tone intermodulation distortion (IMD) testing. Perhaps a future firmware update will change these to the more traditional 700 Hz/1900 Hz tones used for IMD testing.

Finally, the TX-500 can drive an external speaker or external headphones via a 3.5-millimeter monaural jack on the speaker/mic with up to 3 W of audio power. The supplied mic/headphone cable does produce dual outputs for stereo headphones.

CW Operation

The TX-500 internal keyer speed range is 2 – 51 WPM as measured in the ARRL Lab. Sending speed is dis-

Computer Interface and Digital Modes

Mark Wilson, K1RO

The included USB cable can be used for interfacing the TX-500 with a computer for computer-aided transceiver (CAT) operation and for firmware upgrades. As with other radios, the first step is to install a driver to create a virtual COM port when the radio is plugged in. According to the manual, Lab599 ships the radio with either FTDI (blue) or Prolific (black) USB adapters. Ours came with a Prolific adapter.

Windows 10 automatically installed a driver when I connected the TX-500 to my computer, but I got an error message, and it didn't work. I downloaded the recommended driver from the Lab599 website. With that driver, the radio showed up as COM7 in Windows Device Manager, but the Lab599 firmware update utility software wouldn't recognize it. After uninstalling the driver, restarting the computer, and reinstalling the Lab599 driver, everything worked as expected. Other TX-500 users have reported similar behavior with the Prolific USB adapter and driver. A few days after my initial installation, I had to uninstall/reinstall the driver again to get the software to recognize the radio. Based on my experience with other devices, if you are lucky enough to get the FTDI version, installation should be automatic and seamless.

Firmware upgrades are easily performed as new features and bug fixes become available. A TX-500 firmware update utility for Windows or Linux is available from the Lab599 "Downloads" page, along with the latest firmware files. With the USB driver issue sorted, it was just a matter of pressing two buttons on the TX-500 at power-on to put it into the update mode, starting the firmware update utility, and selecting the appropriate COM port and firmware version. The update took only a minute or two, with progress and successful completion clearly indicated.

Digital Modes

As noted in the text, the TX-500 can be operated with a computer and sound card for any of the popular audio-based digital modes. Following the well-illustrated diagram available for download from the Lab599 website, I made an interface cable using the provided seven-pin GX12 connector for the **REM/DATA** jack. The connector is small and tightly packed, so it took a steady hand, and in my case magnifying glasses, to solder the pins. The cable uses just three of the pins for connection to your computer's sound device — input and output signal lines and a ground. You'll also need a 10 µF capacitor for the **AUDIO IN** line. Given the popularity of FT8 and other digital modes, it is surprising that this cable is not part of the package.

Transmit-receive switching for digital modes can be implemented using either the VOX function or the CAT cable. For CAT operation, the TX-500 emulates the Kenwood command set available in most ham radio applications.

With the audio and CAT cables in place, I quickly configured *WSJT-X* using the Kenwood TS-2000 settings and appropriate computer sound devices. Everything worked, and soon I was making contacts using FT4 and FT8 on 15, 17, 20, and 40 meters with the TX-500. I'm always impressed by how effective these modes can be while running just 5 to 10 W.

Audio level settings for the data modes are independent of settings for the voice modes. I found that I had to increase the default audio level setting in the TX-500 quite a bit using the **GAIN>DIG** menu to fully drive the transmitter. I also tried the CAT interface with N3FJP's *Amateur Contact Log*, and it correctly followed the TX-500's frequency and mode changes using the **KENWOOD2** settings.

played as characters per minute (CPM), and the TX-500 user manual states that you can divide CPM by five to get the more common speed in WPM. CW speed is one of the top soft key options. Tap **CW SPEED**, adjust it using the tuning control, and then tap **RETURN** on the bottom left soft key.

The four CW memories are also accessible through top soft keys. Memories are programmed by pressing and holding the appropriate soft key, then sending the desired message.

CW pitch is adjustable from 400 to 1200 Hz (700 Hz default), and the center of the receive bandwidth filter adjusts itself to track the pitch frequency. The default CW filter bandwidths are 300 Hz, 200 Hz, 100 Hz, and 50 Hz. As I like to tune around with wider bandwidths, I reprogrammed these to 1 kHz, 500 Hz, 300 Hz, and 100 Hz. You can select either CW or CW-R (reverse), depending on interference conditions.

The TX-500 is not capable of full-break-in operation because the minimum break-in delay time is 100 milliseconds (primarily due to the digital processing time). The TX-500 uses a relay for transmit-receive switching, and you can definitely hear the relay click. I found that the default 100-millisecond break-in delay resulted in too much clicking for me. Changing the break-in delay to 500 milliseconds kept the clicking to a minimum.

Voice Operation

Speech compression is turned on and off via a soft key on the top row. Compression level and microphone gain are set up in the menu, and should be a one-time

adjustment unless you change microphones. The four default SSB filter bandwidths are 3 kHz, 2.7 kHz, 2.4 kHz, and 2.05 kHz.

The TX-500 has receive and transmit audio equalization filters (three bands), but I found that the default responses were fine. The radio offers two voice memories of up to 20 seconds each. Voice-operated transmit (VOX) and push-to-talk (PTT) operation may be selected.

Digital Modes

The TX-500 can be operated with a computer and sound card for FT8, FT4, RTTY, PSK, or any of the other popular audio-based digital modes. See the sidebar, "Computer Interface and Digital Modes," for more information.

On the Air

I am primarily a CW and SSB QRP portable operator. During the review period, band conditions limited my portable operations to 40, 30, and 20 meters. The 10 W output from the TX-500 is only 10 dB down from the typical 100 W desktop transceiver output — about 1½ S-units — so I had no problems making CW contacts as long as I kept this in mind. There is no internal speaker, so to hear anything when operating CW, you must have the speaker/mic connected, or else use the included audio breakout cable with mono or stereo headphones.

Take a look at the "Lab Notes" sidebar if you think you might use an amplifier with the TX-500. As you can see from the spectrum plot, spurious tones range from 48 to 70 dB below the carrier. To put this into real world terms, if a station is receiving you at an S-9 level, the strongest spurious signal will be about S-1. I can hear these signals on my lab receiver with no external band noise present. However, in the real world, the spurious signals will normally be below the noise floor. I asked a few contacts to listen off to the side while I sent a string of dits, and they could not hear any spurious signals. However, they could easily become apparent if an amplifier is used. Add 10 dB or more to the CW signal with a 100 W amp, and some of these tones can exceed the noise floor, especially on quiet bands.

SSB operation was a bit more of a challenge than CW at the 10 W level. However, by focusing on calling strong stations, I could normally make contacts with minimal problems. The audio reports were all quite good. Again, review the "Lab Notes" comments should you think about using the TX-500 with an amplifier.

Conclusion

The Lab599 Discovery TX-500 is a rugged, easy-to-use transceiver that you will feel comfortable using even in the least hospitable portable operating environments. An integrated battery pack would be a big plus for simplifying operation in the field. Lab599 has announced an attachable battery pack that will be fully compatible with the form factor of the TX-500, but pricing and availability were not available when this was written. An autotuner for compromise portable antennas would be useful as well.

For more information, you can download the TX-500 user manual and other documentation from the Lab599 website or from **pileupdx.com/downloads/**. There is also an active TX-500 user group at **groups.io/g/Lab599** and another group on Facebook.

Manufacturer: Lab599, Rubtsovsk, Altari region, Russia; **lab599.com**. Distributed in the US by Ham Radio Outlet. US service center: Box 165, 3983 S. McCarran Blvd., Reno, NV 89502; **usa.service@lab599.com**. Price: $899.95.

BridgeCom Systems SkyBridge Plus Dual-Band Digital Hotspot

Reviewed by Pascal Villeneuve, VA2PV
va2pv@arrl.net

The open-source *Pi-Star* software package running on the Raspberry Pi with a multimode digital voice modem (MMDVM) add-on board is probably the most popular type of multimode digital hotspot these days. A hotspot is a digital radio internet gateway that uses an integrated low-power VHF or UHF transceiver to com-

Bottom Line

The BridgeCom SkyBridge Plus hotspot is a plug-and-play solution for adding a VHF/UHF digital voice internet gateway to your home or portable station. It can be used with a variety of popular modes, including DMR, D-STAR, and System Fusion.