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

# Icom IC-R8600 Communications Receiver

## A high-performance broadband receiver, with SDR versatility.

*Reviewed by Martin Ewing, AA6E*
**aa6e@arrl.net**


Amateurs of a certain age will remember operating with separate receivers and transmitters. At one time, this was the only option. Since the 1970s, however, we generally purchase integrated transceivers. These combine the receiver and transmitter in a single box, simplifying station setup and saving cost.

Why would you consider a standalone communications receiver today? Advanced amateur-friendly models, such as the IC-R8600, cover a very wide frequency range and support a variety of signal modulations and operating modes. They allow you to scan wide swaths of spectrum, looking for interesting signals and diagnosing interference. In one compact box, you get a very good receiver for ham communications, a fine scanning monitor and shortwave listening (SWL) radio, and an excellent piece of test equipment. A receiver in this category will probably not be your first radio, but it can round out the capabilities of any ham shack.

I used the earlier IC-R8500 for many years. Produced between 1996 and 2004, that radio covered 100 kHz to 2 GHz.[1] When it departed my shack, it left quite a gap — and seller's remorse! Now, after 13 years, Icom's R8000 series resumes with the IC-R8600. The latest advances in software-defined radio (SDR) have brought many high-end features into the R8600's price range. This radio compares favorably with Icom's IC-R9500, now 11 years on the market and aimed at professional users at a higher price point.[2]

In addition to the classic communications receiver and spectrum analyzer that monitors specific channels or bands, the R8600 is also a "scanner" radio, where the emphasis is on rapid scanning across wide bandwidths, searching for signals of interest that may have unknown frequencies.

### Bottom Line

Covering 10 kHz through 3 GHz and demodulating many popular analog and digital modes, the IC-R8600 can be used as a high-quality ham band receiver, or for listening to many other radio services. Its dynamic performance rivals top-tier amateur transceivers.

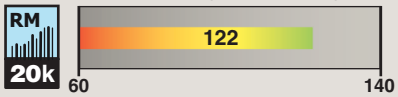
### Technical Overview

The IC-R8600 receiver covers the RF spectrum from 10 kHz to 3000 MHz, with the usual US cell phone exclusions. Figure 1 shows a simplified block diagram. Frequencies between 10 kHz and 30 MHz are direct sampled for SDR processing. Above 30 MHz, the radio converts the signal frequency two or three times in a double or triple superheterodyne scheme. To reduce spurious responses, some 11 RF band-pass filters (BPFs) are provided for HF bands, and 13 filters for the VHF/UHF bands. The analog/digital converter (A/D) samples at 122.88 MHz. A field programmable gate array (FPGA) converts the time samples to the frequency domain, for display on the spectrum scope (aka panadapter/waterfall display) or for further digital signal processing (DSP) and digital/analog conversion to produce a demodulated audio signal.

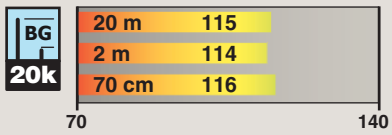
As shown, there are three available antenna inputs. A type-N connector supports the radio's full frequency range. When you are operating below 30 MHz, you can instead select a UHF or a phono connector. The N and UHF

## Icom IC-R8600 Key Measurements Summary

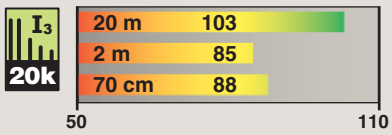
20 kHz Reciprocal Mixing Dynamic Range (dB)



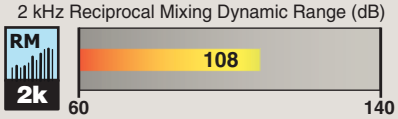

20 kHz Blocking Gain Compression (dB)



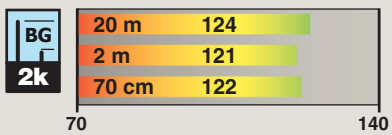

20 kHz Third-Order IMD Dynamic Range (dB)



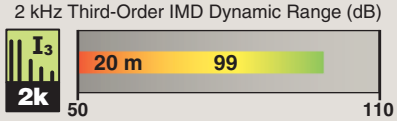

2 kHz Reciprocal Mixing Dynamic Range (dB)



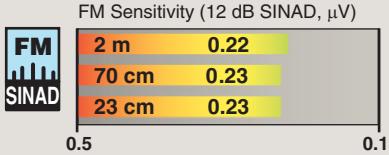

2 kHz Blocking Gain Compression (dB)



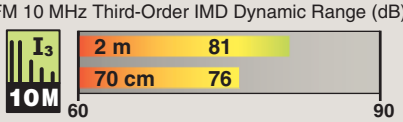

2 kHz Third-Order IMD Dynamic Range (dB)



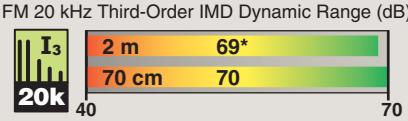

FM Sensitivity (12 dB SINAD, µV)



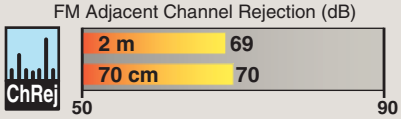

FM 10 MHz Third-Order IMD Dynamic Range (dB)




FM 20 kHz Third-Order IMD Dynamic Range (dB)




FM Adjacent Channel Rejection (dB)




**KEY:** QS1711-PR121
Dynamic range measurements with receiver preamp off.
Third-order IMD measurements with IP+ on.
FM sensitivity measurements with preamp on.
*Noise limited at value shown.

## Table 1
## Icom IC-R8600, serial number 02001068

| Manufacturer's Specifications | Measured in the ARRL Lab |
|---|---|
| Frequency coverage: 0.01 – 821.999.999, 851 – 866.999999 MHz, 0.896 – 3.0 GHz. | As specified. |
| Power requirement: 13.8 V dc, ±15%. | At 13.8 V dc: 1.49 A (maximum volume, no signal). Off, 8 mA. |
| Modes of operation: SSB, CW, AM, FM, WFM FSK, D-STAR, P25, NXDN, dPMR, and DCR. | As specified. |

| Receiver | Receiver Dynamic Testing |
|---|---|
| Sensitivity (MDS): Preamp on, 500 Hz BW, 0.1 – 1.8 MHz, –113 dBm; 1.8 – 30 MHz, –121 dBm; 30 – 2,000 MHz, –117 dBm; 2 – 3 GHz, –115 dBm. | Noise floor (MDS), 500 Hz bandwidth:<br>*Preamp off* / *Preamp on*<br>0.137 MHz –126 dBm / –136 dBm<br>0.475 MHz –128 dBm / –138 dBm<br>3.5 MHz –131 dBm / –141 dBm<br>14 MHz –132 dBm / –142 dBm<br>28 MHz –132 dBm / –142 dBm<br>50 MHz –133 dBm / –141 dBm<br>70 MHz –133 dBm / –142 dBm<br>144 MHz –133 dBm / –141 dBm<br>222 MHz –133 dBm / –141 dBm<br>432 MHz –133 dBm / –141 dBm<br>902 MHz –131 dBm / –138 dBm<br>1,296 MHz –134 dBm / –140 dBm<br>2,300 MHz –133 dBm / –137 dBm |
| Noise figure: Not specified. | 14 MHz, 5 dB; 144 MHz, 6 dB; 432 MHz, 6 dB; 1.3 GHz, 7 dB; 2.3 GHz, 10 dB. |
| AM sensitivity: For 10 dB (S+N), 6 kHz BW, 0.1 – 30 MHz, 7.96 µV; 1.8 MHz – 3 GHz, 6.32 µV. | For 10 dB (S+N/N), 6 kHz bandwidth:<br>*Preamp off* / *Preamp on*<br>1.020 MHz 1.74 µV / 0.65 µV<br>3.885 MHz 1.82 µV / 0.60 µV<br>29.0 MHz 1.78 µV / 0.50 µV<br>50.4 MHz 1.64 µV / 0.68 µV<br>120 MHz 1.64 µV / 0.68 µV<br>144 MHz 1.64 µV / 0.68 µV<br>430 MHz 1.74 µV / 0.68 µV |
| FM sensitivity: For 12 dB SINAD, 15 kHz BW, 28 MHz – 2 GHz, 0.5 µV; 2 – 3 GHz, 0.8 µV. | For 12 dB SINAD, 12 kHz bandwidth:<br>*Preamp off* / *Preamp on*<br>29 MHz 0.50 µV / 0.21 µV<br>52 MHz 0.51 µV / 0.22 µV<br>70 MHz 0.76 µV / 0.20 µV<br>100 MHz 0.94 µV / 0.41 µV (WFM)<br>146 MHz 0.53 µV / 0.22 µV<br>162 MHz 0.54 µV / 0.24 µV<br>223 MHz 0.57 µV / 0.23 µV<br>440 MHz 0.56 µV / 0.23 µV<br>902 MHz 0.71 µV / 0.29 µV<br>1,296 MHz 0.41 µV / 0.23 µV |
| Blocking gain compression dynamic range: Not specified. | Blocking gain compression dynamic range, 500 Hz bandwidth:<br>*20 kHz offset* / *5/2 kHz offset*<br>*Preamp off/on* / *Preamp off*<br>3.5 MHz 123/113 dB / 123/124 dB<br>14 MHz 124/115 dB / 124/124 dB<br>50 MHz 122/114 dB / 122/122 dB<br>144 MHz 121/114 dB / 121/121 dB<br>440 MHz 122/116 dB / 122/122 dB |
| Reciprocal mixing dynamic range (500 Hz BW): Not specified. | 14 MHz, 20/5/2 kHz offset: 122/114/108 dB. |

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

| *Band/preamp* | *Spacing* | *Measured IMD Level* | *Measured Input Level* | *IMD DR* |
|---|---|---|---|---|
| 3.5 MHz/Off | 20 kHz | –131 dBm<br>–97 dBm | –32 dBm<br>–7 dBm†† | 99 dB |
| 14 MHz/Off | 20 kHz | –132 dBm<br>–97 dBm | –29 dBm<br>–14 dBm†† | 103 dB |
| 14 MHz/On | 20 kHz | –142 dBm<br>–97 dBm | –39 dBm<br>–33 dBm†† | 103 dB |
| 14 MHz/Off | 5 kHz | –132 dBm<br>–97 dBm | –33 dBm<br>–19 dBm†† | 99 dB |

| Manufacturer's Specifications | | Measured in the ARRL Lab | | |
|---|---|---|---|---|
| *Band/preamp* | *Spacing* | *Measured IMD Level* | *Measured Input Level* | *IMD DR* |
| 14 MHz/Off | 2 kHz | –132 dBm<br>–97 dBm | –33 dBm<br>–19 dBm†† | 99 dB |
| 50 MHz/Off | 20 kHz | –133 dBm<br>–97 dBm | –50 dBm<br>–24 dBm | 83 dB |
| 50 MHz/On | 20 kHz | –141 dBm<br>–97 dBm | –55 dBm<br>–35 dBm | 86 dB |
| 144 MHz/Off | 20 kHz | –133 dBm<br>–97 dBm | –48 dBm<br>–28 dBm | 85 dB |
| 144 MHz/On | 20 kHz | –141 dBm<br>–97 dBm | –56 dBm<br>–35 dBm | 85 dB |
| 432 MHz | 20 kHz | –131 dBm<br>–97 dBm | –43 dBm<br>–33 dBm | 88 dB |

| | |
|---|---|
| Spectral sensitivity: Not specified. | Waterfall and panoramic display, preamp off/on, –107/–121 dBm. |
| Tuning dial accuracy: Not specified. | Standalone, without 10 MHz reference signal input, with tuning dial set to 10 MHz, 0 Hz; 50 MHz, +12 Hz; 500 MHz, +122 Hz; 1 GHz, +245 Hz; 2 GHz, +488 Hz; 3 GHz, +730 Hz. (Tuning dial reads high by listed amount.) |
| Second-order intercept point: Not specified. | Preamp off/on: 14 MHz, +71/+67 dBm; 21 MHz, +77/+59 dBm; 50 MHz, +85/+85 dBm; 144 MHz, +65/+65 dBm; 432 MHz, +91/+79 dBm. |
| FM adjacent channel selectivity: Not specified. | 29 MHz, 85 dB; 52 and 70 MHz, 68 dB; 144 and 223 MHz, 69 dB; 440 MHz, 70 dB. |
| FM two-tone third-order dynamic range: Not specified. | 20 kHz spacing: 29 MHz, 85 dB*; 52 and 70 MHz, 68 dB*; 144 MHz, 69 dB*; 223 MHz, 69 dB*; 440 MHz, 70 dB.<br>10 MHz spacing: 29 MHz, 91 dB, 52 MHz, 79 dB; 70 MHz, 91 dB; 144 MHz, 81 dB; 223 MHz, 84 dB; 440 MHz, 76 dB. |
| Squelch sensitivity: Not specified. | Preamp on: 29 MHz, 0.09 µV; 52 MHz, 0.13 µV; 70 MHz, 0.11 µV; 144 and 223 MHz, 0.12 µV; 440, 902, 1,296 MHz, 0.13 µV; maximum squelch ≥13 mV.<br>SSB squelch, preamp off: 14 MHz, 2.06 µV. |
| Signal strength meter accuracy: Not specified. | For S-9 level input, preamp off/on: 14 MHz, 82.1/31.6 µV; 50 MHz, 82.1/33.1 µV; 144 MHz, 78.4/43.6 µV; 432 MHz, 88.0/40.2 µV; 1 GHz, 132/55.5 µV; 2 GHz, 184/146 µV; 3 GHz, 103/65.2 µV. |
| DSP noise reduction: Not specified. | 5 dB.** |
| Notch filter depth: Not specified. | Manual notch, 57 dB; auto notch, >65 dB. |
| IF/audio response: Not specified. | Range (bandwidth) at –6 dB points:‡<br>CW (500 Hz): 344 – 851 Hz (507 Hz)<br>USB: (2.4 kHz): 242 – 2,750 Hz (2,408 Hz)<br>LSB: (2.4 kHz): 242 – 2,750 Hz (2,408 Hz)<br>AM: (6 kHz): 150 – 3,150 Hz (6,000 Hz). |
| Audio output: 2 W at 10% THD, 8 Ω load. | 2.3 W at 10% THD into 8 Ω.<br>THD at 1 $V_{RMS}$, 0.4%. |
| Signal processing delay time: Not specified. | 15 ms. |

Size (height, width, depth): 4.0 × 8.6 × 10.5 inches (including protrusions). Weight: 9.5 lbs.
Price: IC-R8600, $2,499; AD-55NS power supply, $59; CS-R8600 programming software, $80.

†Third-order IMD dynamic range data taken with IP+ on. See Lab Notes sidebar.
††–97 dBm (S-5) level measurements taken at threshold of ADC overload.
*Measurements are noise limited at the value indicated.
**See Lab Notes sidebar.
‡Default values; bandwidth and cutoff frequencies are adjustable.

connectors support a 50 Ω coax connection, while the phono jack is nominally 500 Ω, intended for long-wire (probably non-resonant) antennas.

You can direct audio output to a built-in or external speaker, a headphone jack, a constant-level "line" output, or as digital audio to your computer or other device over USB or ethernet. You can view digital mode decoded text output on screen, or you can direct output to an external device COM port over USB. You may also store up to 32 GB of video screenshots, audio, or decoded data on an SD memory card.

The R8600 will internally decode FSK (RTTY) signals, along with a number of data modes. For ham use, the radio's main data mode of interest is probably D-STAR. Other modes (P25, NXDN, dPMR, and DCR) are generally used by other radio services. Unfortunately, there is no support for the digital voice modes DMR or C4FM (Yaesu System Fusion) or other common data modes, such as PSK31.

The radio offers a number of extra signal output options. An analog 10.7 MHz IF output with 10 MHz fixed bandwidth, allows you to connect alternative back-end equipment. There is a dedicated USB jack for output of complex I/Q IF data, and a 12 kHz digital IF output can be taken from a ⅛-inch phone jack or either a front or rear USB connection.

## User Interface

A key feature of any modern radio gear is the user interface. With SDR techniques, you can control and monitor operation through a full complement of buttons, knobs, touchscreens, or even from remote computers. The R8600 controls closely resemble other recent Icom products, such as the IC-7300, so many users will find the scope, memory, and scan system very familiar.

The R8600 sports an attractive 4.3-inch color touchscreen display that can be configured to show operating condi-

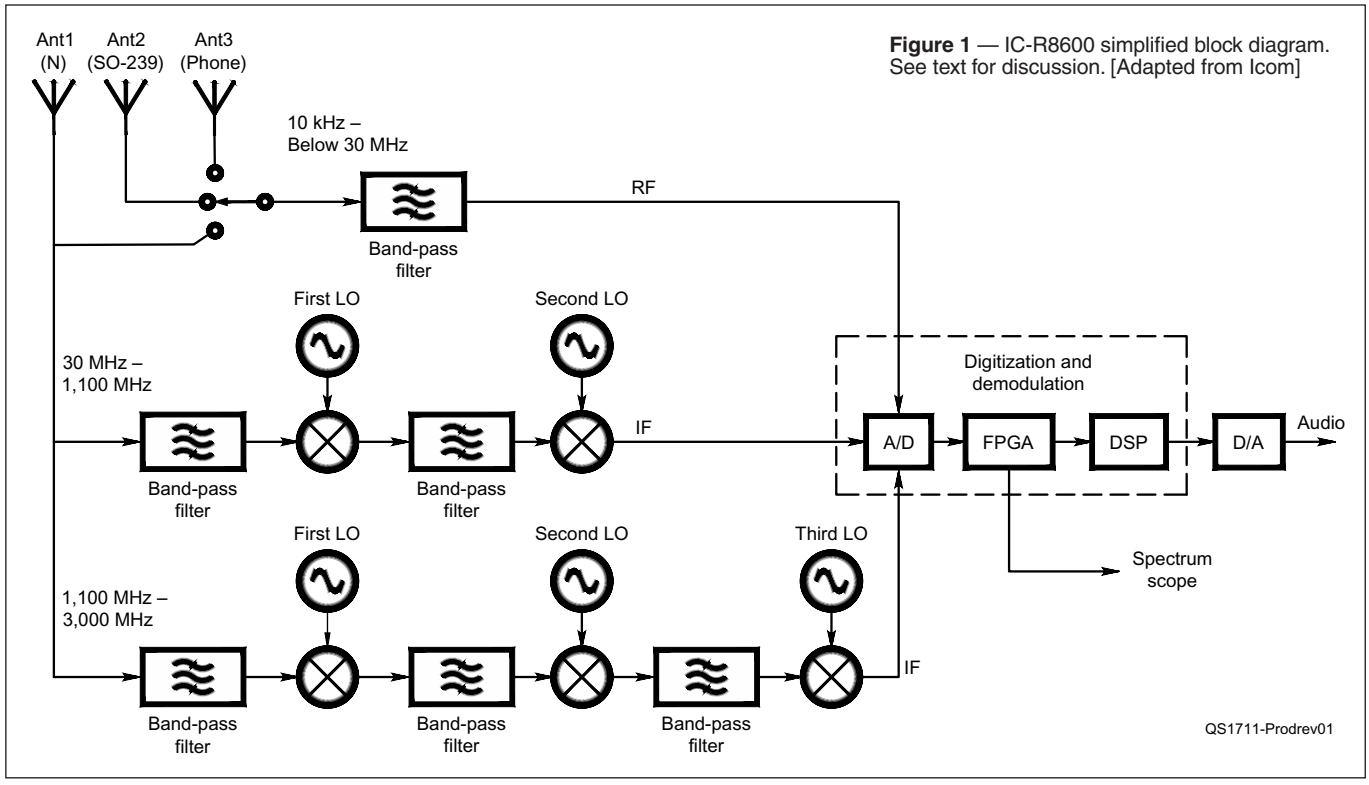



**Figure 1** — IC-R8600 simplified block diagram. See text for discussion. [Adapted from Icom]

tions. There is also a spectrum scope/waterfall that will show up to 5 MHz of spectrum typically centered on the current operating frequency. You can narrow the spectrum display range down to 5 kHz, giving a useful frequency resolution of about 10 Hz, which is the minimum VFO step size. (VFO resolution is actually 1 Hz, but 10 Hz is the step accessible from the normal controls. You can get 1 Hz settings via the touchscreen "zoom" function.)

If you want to preserve a screen display, there is a convenient screenshot option to store .png or .bmp files with 480 × 272 resolution on an SD card. Alas, there is no support for an external video display. There is, however, an output to drive an external signal strength meter.

Three multifunction (turn/push) controls are assigned to scanning control (Dial A), audio/RF gain and squelch (Dial B), and memory selection (Dial C). Other functions are selected either by screen touches or by physical buttons. The main tuning knob has a good feel with three rather different settings — low friction, high friction, and (my favorite) a step detent action.

The signal-strength meter displays as a bar graph that is notable because it supports four different scales. One is the classic "S-meter," which displays S-1 to S-9 and up to S-9 + 60 dB. This is meant to observe the normal convention that S-9 is 50 μV, with a change of 1 S-unit corresponding to 6 dB, although the R8600 did not conform to this convention (see the "Lab Notes" sidebar). You can alternatively select a dBm scale that shows 0 dBm for a 1 mW input level. Unlike the S-meter, the dBm reading does not vary as you switch in the preamp or attenuators. It is meant to represent the actual power level at the input connector. You can also view absolute voltage (dBμ) in either 50 Ω terminated or open-circuit modes.

## Other Features

The 10 MHz internal frequency reference is specified to be better than ±0.5 ppm. A back panel connector will supply this reference to external equipment. Optionally, this connector can accept a reference from an external 10 MHz source. Note that a 1 ppm offset at 3 GHz is 3 kHz, so a high-quality external reference may be needed if you want full accuracy and stability at the highest frequencies.

The R8600's internal clock can be synchronized to an external internet NTP (Network Time Protocol) server through an ethernet connection. The same ethernet connection should support remote control operation, which Icom says is coming in a future software product.

If you set up the receiver's antenna port and preamp, attenuator, and IP+ settings at a particular frequency, how far can you tune away from that frequency before the settings might change? This is not discussed in the *Instruction Manual* (but should have been), so I experimented and found that the radio

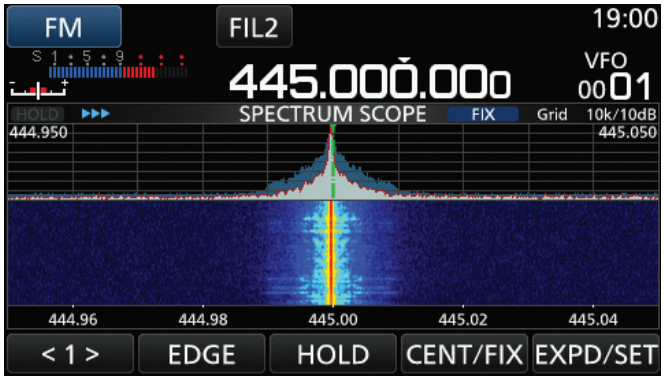



**Figure 2** — A UHF FM voice transmission.

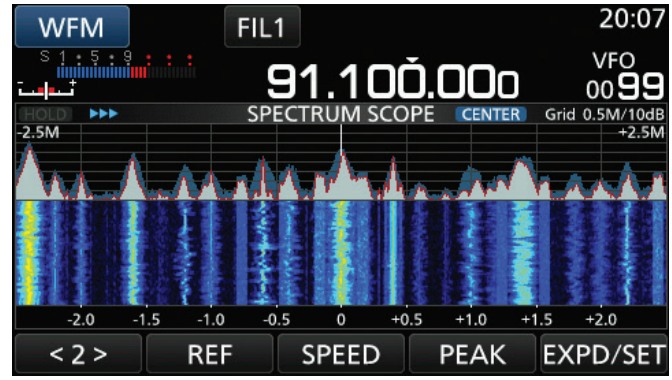



**Figure 3** — Spectrum of FM broadcast signals.

divides up the spectrum into "bands." If you change any of those settings anywhere within a particular band, they seem to apply all throughout the band. I found band edges at 1.6, 2, 6, 8, 11, 15, 20, 22, 26, 30, and 1100 MHz. (The low band goes down to 10 kHz, and the high band goes up to 3 GHz.) Presumably, the radio is switching its filters and signal paths at these frequencies also.

You may run into unexpected changes in settings as you tune across a band boundary, but the panel display always shows the active values.

## Operating Modes

The R8600 provides full support of the classical modulation modes along with some digital modes. Indirectly, you can supply your own DSP hardware or demodulation software (for example, *Fldigi*) to use the 10.7 MHz IF output, the 12 kHz IF output, or the SSB audio output.

AM operation is supported in four modes. There is AM and synchronous AM (SAM). SAM is provided for upper, lower, and double sideband operation. You can select an IF bandwidth from 200 Hz to 10 kHz. SAM is especially useful when selective fading of the AM carrier would cause audio distortion. The single sideband SAM options allow you to avoid interference that may appear on top of an AM signal in one sideband or the other.

CW operation is supported by IF band-pass adjustable from 50 Hz to 3.6 kHz, with sidetone frequencies (pitch at band-pass center) between 300 and 900 Hz.

SSB (LSB or USB) is supported with IF bandpass from 50 Hz to 3.6 kHz.

FM IF bandpass is fixed at 50 kHz, 15 kHz, or 7 kHz. You get a deviation indicator and an optional automatic frequency control (AFC) that can help you get on frequency (see Figure 2).

WFM (wide FM) is typically used for FM broadcasting. Its bandwidth is fixed at 200 kHz (see Figure 3).

With FSK, you get a tuning indicator and also a useful optional decode display that shows four to nine lines of decoded text alongside an audio spectrum scope that helps you tune in a RTTY station (see Figure 4). Default band-pass settings range from 2.4 kHz down to 250 Hz. Manually, you can set 50 Hz to 2.7 kHz. The decoder supports either 45 or 50 baud RTTY, with a range of standard mark/space tones and shifts. You can record decoded text as a text or HTML file on the SD device, or you can pass the data to your computer over USB.

There are default filter settings (FIL1, FIL2, FIL3) from wider to narrower, as appropriate for each mode. When you adjust filter settings manually, your new setting temporarily replaces one of the defaults.

The IF band-pass filter in these modes can be set to sharp or soft. Sharp filtering is best for eliminating nearby interference, while soft is preferred as a more traditional sound by some users.

The digital modes decode a number of signaling schemes, but only D-STAR is widespread among amateurs. It was simple enough to monitor a local D-STAR repeater, receiving both voice and text messages.

In addition to IF filtering, you can set different audio tone controls for each mode. That's a lot of customization!

## Signal Processing

For most signal modes, you have the usual receiver controls, resembling other Icom radios. There is an "IP+" mode that greatly increases IMD performance in certain situations — multiple signals in a low noise environment, such as in our Lab tests (see the "Lab Notes" sidebar). Controls for notch filtering, noise blanking, and noise reduction will be familiar. Icom's digital twin passband tuning (TPBT) allows you to shift and narrow the passband as desired.

## Memory and Scanning

The R8600 provides many memory channels that record frequency, mode, antenna setting, and other data associated with a particular receiving setup (a


**Figure 4** — Spectrum and waterfall of 40-meter RTTY signals, showing decoded text and fine audio spectrum for precise tuning.

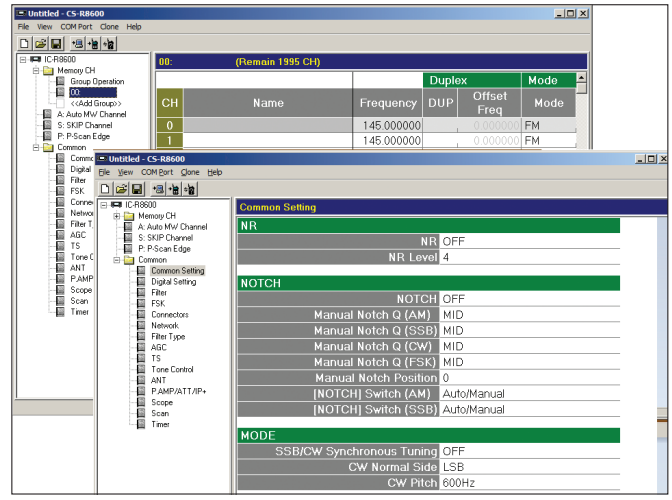



**Figure 5** — Screenshots of *CS-R8600* software: memory programming (below) and hardware settings (above).

station, in other words). You can set up 100 groups that can each contain 100 channels, up to the overall limit of 2,000 channels.

The R8600 scanning operation is similar to many other radios. You can scan predefined memory channels or defined frequency ranges. You can search for activity over a frequency range and store the active frequencies in memory channels.

It is interesting to note that the search function listens to one channel at a time, so it can take a long time to cover a wide band, stepping at a rate of 50 channels per second or less. If we made full use of the SDR's FFT capability, we should be able to search hundreds of channels in parallel, cutting search time dramatically. Maybe in the future!

## Cloning Software

You can manage the R8600 for routine tasks from the front panel. However, that gets tedious for such a complex radio with its 2,000 memory channels. To configure the radio and especially to "clone" the settings from one radio to another, you need computer assistance. Icom provides the *CS-R8600 Cloning Software* ($79.95) just for this purpose (see Figure 5). Any computer running *Windows Vista* or above with USB or SD card capability should support the software. I checked for alternative free cloning programs, but could find none that support the R8600 at this time.

## Updates

There are several upgradable software components in the R8600. The manual gives clear update instructions that allowed us to update the main CPU using an external computer and SD card. (It would have been handier if the R8600 could update itself over its ethernet connection, but this is not supported.) For this review, we used the following firmware versions: Main CPU 1.10; Front CPU 1.00; DSP Program 1.02; FPGA 1.00, and DV DSP 1.00. If you have the *CS-R8600* software, you will need to update it to the same level.

Note that you should check Icom's Japan site (**www.icom.co.jp/world/support/**) for manuals and firmware updates. Icom's American website (**www.icomamerica.com**) may not have the latest files.

The R8600 is ruggedly built, allowing Icom to claim MIL-STD-810 compliance.[3] Dissipating up to 25 W, the radio can run warm to the touch, but requires no special ventilation.

## Wrap-Up

As an ultra-versatile receiver, the Icom IC-R8600 may not be optimized for any particular service. For convenience and price, a fully integrated SDR transceiver will still be most amateurs' choice for operating. If you want to use it on the higher UHF and microwave bands, you will need a more sensitive preamplifier.

Some of the more interesting features (ethernet, I/Q outputs) do not have support from Icom software as this is written. You will have to wait for remote control, for example, or start coding your own software.

Still, the R8600 is a remarkable radio that serves many applications beyond ham radio. In an amateur's shack, the R8600 will provide access to a big swath of spectrum that includes all the ham frequencies from dc through the 13-centimeter band. It can be used as a high-quality ham band receiver, but it is much more than that. You can check out all the radio services up to 3 GHz. It is also excellent test equipment that will let you check spurious emissions and locate interference sources.

The receiver has a significant learning curve if you want to master all its features, but its similarity to other Icom

# IC-R8600

## 10kHz - 3GHz SDR Communications Receiver

- Ultra-wide frequency coverage with RSSI
- Real-time spectrum scope
- Decodes multiple digital protocols
- Touch screen display
- Clear audio quality using FPGA/DSP base architecture
- I/Q signal output for use with third-party SDR software
- The SD card slot and voice recording
- Optional SP-39AD external speaker with integrated power supply
- Optional RS-R8600 remote control software


# Listen to the World

**Information & Downloads**

AMATEUR TOOL KIT | COMIC BOOKS | VIDEOS | WWW.ICOMAMERICA.COM

**Electronic advertisements feature active links.**

ICOM®

## Lab Notes: Icom IC-R8600 Communications Receiver

*Bob Allison, WB1GCM, ARRL Assistant Laboratory Manager*

The IC-R8600 receiver is small in size, but a giant in performance. It uses direct sampling below 30 MHz, dual conversion from 30 to 1100 MHz, and triple conversion from 1.1 to 3 GHz. Overall, sensitivity is very good to excellent above 15 kHz, all the way to 3 GHz. Sensitivity drops off to more than 1 µV below 15 kHz.

The lowest of the three dynamic ranges, as typically measured in our laboratory, is 99 dB (third-order IMD dynamic range at 14 MHz with 2 kHz spacing), rivaling some of the top-tier amateur band transceivers on the market. This high dynamic range is possible only when the IP+ function is on, which turns on an internally generated dither signal. With it off, expect this measurement to be around 60 dB.

On the FM side, adjacent-channel rejection is very good with a receive bandwidth of 15 kHz. Switching to Filter 3 in this mode narrows the bandwidth to 7 kHz and provides an extra 4 dB of rejection.

Second-order IMD dynamic range is very good to excellent. Direct sampling receivers can be deficient in this department, with strong signals adding up to create false signals on another frequency. For example, a strong 6 MHz signal and a 15 MHz signal at the antenna jack can create a false signal at 21 MHz — not so with the R8600, unless you live close to an active shortwave broadcast facility. With the antenna disconnected, I hunted for birdies until my finger fell off, and found only a few in the HF and VHF spectrum; one birdie, understandably, was found at 10.7 MHz. I will leave it up to the user to hunt for the few other birdies hiding among the GHz.

No IF bleed-through or images were detected for input levels up to +10 dBm. Below 30 MHz, there are occasions when ADC overload occurs. For example, a signal above –13 dBm, or two signals at –19 dBm, resulted with an overload indication during testing. If the user experiences such signals (–13 dBm is 60 dB over S-9), the attenuator can be used to clear the overload.

The noise reduction feature reduced the background noise in relation to the desired signal by 5 dB. Though this may seem deficient by measurement, the user will find the level of noise reduction, by ear, to be good — more than indicated by our lab measurement.

Tuning dial accuracy was good, considering the wide tuning range of the R8600. It was off by less than 1 kHz at 3 GHz. With the use of an outboard GPS-locked 10 MHz reference signal, the tuning dial should be spot on.

Signal strength meters give an indication of the level of signal reaching the antenna jack at the tuned frequency. We are all familiar with the S-meter; its desired accuracy requires a –73 dBm (50 µV) signal for an S-9 indication, with 6 dB per S-unit below that level. The S-meter *should not* read higher with the preamp on. With the R8600, the S-meter does not meet this standard. The S-9 level varies from band to band. The meter is calibrated to about 4 dB per S-unit, and it reads higher when the preamp is switched on.

For those who get tied in a knot about such things, don't worry. Signal strengths can also be measured in dBm and microvolts. Lab measurements found both scales to read close to the output of our Lab's signal generators. Best yet, the signal strength readings with the preamp on and off were the same or nearly the same. I like that.

Finally, the squelch threshold control of the R8600 has a wide range — nearly 95 dB! Icom certainly understands the need for a usable squelch range.

products will help many users get in the swing pretty quickly.

*Manufacturer:* Icom America, 12421 Willows Rd. N.E., Kirkland, WA 98034; tel. 800-872-4266; **www.icomamerica.com**.

**Notes**

[1]B. Moore, NC1L, "Icom IC-R8500 Communications Receiver," Product Review, *QST*, Apr. 1997, pp. 61 – 64.

[2]D. Newkirk, AB2WH, "Icom IC-R9500 Communications Receiver," Product Review, *QST*, Jan. 2008, pp. 69 – 73.

[3]See **en.wikipedia.org/wiki/MIL-STD-810**. The ARRL Lab does many tests, but we do not check shock and vibration resistance.


**Visit https://youtu.be/hTproxYcpyM to see our review of the Icom IC-R8600 Communications Receiver on YouTube.**

# Tytera MD-380 Analog and DMR Handheld Transceiver

*Reviewed by Jim MacKenzie, VE5EIS*
**jim@photojim.ca**

Perhaps you have an itch to try out digital mobile radio (DMR), and don't know where to start. A good choice might be this excellent handheld from Chinese manufacturer Tytera (TYT). This is probably the least expensive introduction to handheld digital UHF radio that's available, short of finding a great deal at your local flea market.

If you are unfamiliar with DMR, see the sidebar, "DMR — An Introduction," for more information.

## Introduction

Tytera may not be a household name in ham radio yet, but the company has been around for 15 years, according to its website. The MD-380 has been available on the market for a couple of years and has been a popular choice among hams who want to give the DMR mode a try. Available in two versions, one for the 2-meter band (136 – 174 MHz), and another for the 70-centimeter band (400 – 480 MHz), this radio isn't trying to be anything fancy. It does DMR, it does analog FM, and that's about it. (A later model, the MD-390, adds GPS capability.) Both radio models support transmit power of 5 W, with a low-power mode of 1 W. This article reviews the 70-centimeter version.

In the box, the radio comes with a charging dock and power adapter, two antennas (a short flexible antenna and a longer, higher-gain one), a 2,000 mAh lithium-ion battery, a belt clip, and a user manual. A USB programming cable came with my radio, but I understand that not all vendors supply this cable. (You will want one, if your radio doesn't come with one.)

### Bottom Line

This DMR handheld is well made, easy to use, and provides great value for the price. It's a very satisfying gateway radio into the world of DMR, and highly usable on traditional FM, too.

## Physical Description

At the price point of this radio, most handhelds have monochrome displays, so I was surprised to see that the MD-380 has a full-color dot matrix liquid-crystal display (LCD). I am not normally a fan of color displays, because they often wash out in bright sunlight, but this display is bright enough that it holds its own. Once configured, it powers up with your call sign and DMR radio ID, which is a nice feature if your radio gets mixed in with others of the same model. Unfortunately, the font Tytera chose is a rather ugly serif-based font that doesn't have proper descenders, but it's legible enough and suffices for the purpose.

The radio is about 5.2 × 2.3 × 1.3 inches and weighs about 10 ounces. That puts it on the hefty side of handheld radios, but I find myself not minding this. The radio fits very well into my hands (which are admittedly on the long side), and the heft of the radio gives a perception of quality that seems lacking in a lot of Chinese-made radios. The radio feels truly professional in the palm. The antenna connector is a standard SMA female jack, same as the mainstream handheld radio manufacturers are using, which gives you more flexibility when you need to use other antennas or adapters.

The controls are fairly straightforward. The left side of the radio (see Figure 6) has a large push-to-talk (PTT) button flanked by two smaller auxiliary buttons, one blank, the other labeled M. These auxiliary buttons are programmable in Tytera's programming software and can each perform two actions, differentiated by either pressing for a short time or for a full second. Hidden under a plastic cover, the right side has a jack for standard Kenwood-type speaker-microphones and programming cables. The top features the antenna jack, a taller channel selection knob, and the slightly shorter on/off/volume knob. Ergonomically, the layout is quite satisfying.

On the front of the handheld is a four-by-four grid of buttons, the standard 0 – 9 plus * and # buttons (with the *, 0, and # buttons offset to the right — the 0 next to the 6 instead of below the 8), plus a green "okay" button, up and down arrows, and a red "back" button. The buttons have adequate feedback and a noticeable click when depressed. Of note, the channel selection knob makes a loud solid tone when you reach an unprogrammed channel, and it stops when you reach the extreme ends of the chan-

**Table 2**
**Tytera MD-380, serial number 1611A03818**

| Manufacturer's Specifications | Measured in ARRL Lab |
|---|---|
| Frequency coverage: 400 – 480 MHz. | Tested in the 440 – 450 MHz amateur band. |
| Modes: DMR, analog FM. | As specified. |
| Power requirements: 7.4 V, 2,000 mAh Li-ion battery (included). | At 8.3 V dc (full charge): Receive, 400 mA (max volume, backlight on); 384 mA (max volume, backlight off); standby, 137 mA; battery save, 93 mA. Transmit, 1.51 A (high), 0.78 A (low). Off, <1 mA. |
| **Receiver** | **Receiver Dynamic Testing** |
| Sensitivity: 0.22 µV typical. | FM, for 12 dB SINAD, 0.14. µV. |
| FM two-tone, third-order IMD dynamic range: Not specified. | 20 kHz offset, 70 dB; 10 MHz offset, 78 dB. |
| FM two-tone, second-order IMD dynamic range: Not specified. | 75 dB. |
| Adjacent-channel rejection: Not specified. | 20 kHz offset, 70 dB. |
| Squelch sensitivity: Not specified. | At threshold, 0.25 µV (min), 0.47 µV (max). |
| Audio output: Not specified. | 250 mW at 10% THD. THD at 1 $V_{RMS}$, 4% |
| **Transmitter** | **Transmitter Dynamic Testing** |
| Power output: <5.0 W (high), <1 W (low). | 5.4 W (high), 1.5 (low) at 8.3 V dc (full charge). 4.5 W (high), 1.2 W (low) at 7.4 V dc. |
| Spurious signal and harmonic suppression: Not specified. | >70 dB; meets FCC requirements. |
| Transmit-receive turnaround time (PTT release to 50% of full audio output): Not specified. | Squelch on, S-9 signal, 31 ms. |
| Receive-transmit turnaround time ("TX delay"): Not specified. | 8 ms. |

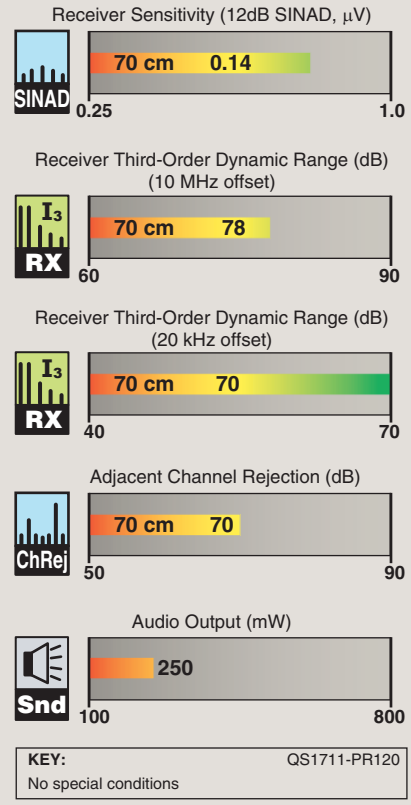
Size (height, width, depth): 5.2 × 2.3 × 1.3 inches (including protrusions). Belt clips, add 0.5 inches to depth. Antenna length: 3.8 inches. Weight: 10.3 oz (incl. battery and antenna).
Price: $100. Replacement 7.4 V dc, Li-ion 2,000 mAh battery, $24. Mobile battery eliminator, $14.

**Figure 6** — The rear of the radio, showing the battery release button (right), plus the push-to-talk button (bottom, outlined in orange) and, on either side of it, the two dual-action programmable buttons. I have mine programmed for power-level toggling, squelch opening, and quick scanning.

nel range. While some may lament that the channels don't wrap around to the beginning from the end, visually impaired hams or those using the radio without looking at it will appreciate the physical and audio feedback so they know precisely where they are in the program range.

The battery release button requires a firm but not ridiculous amount of pressure to free the battery. Again, this design points to thoughtfulness on the part of the development engineers. Even the belt clip feels somewhat substantial. Nothing about the radio feels delicate.

**Tytera MD-380**
**Key Measurements Summary**




Tytera supplies programming software via its website (**www.tyt888.com/?mod=download**), which only runs under *Windows*. (Mac and *Linux* users are unfortunately out of luck for now.) Firmware updates are also available at this address.

## Radio Programming

Unlike radios designed exclusively for the Amateur Radio market, the MD-380 requires programming to be used. There is no VFO setting where you can set the frequency manually (although you can manually program a free memory location on the fly, if you need to do so). You'll want to start by installing and running the programming software. It's readily available for download from the TYT website and other sources. Figures 7 and 8 show a couple of the programming screens.

If you haven't done so already, make sure you apply for a DMR ID (most

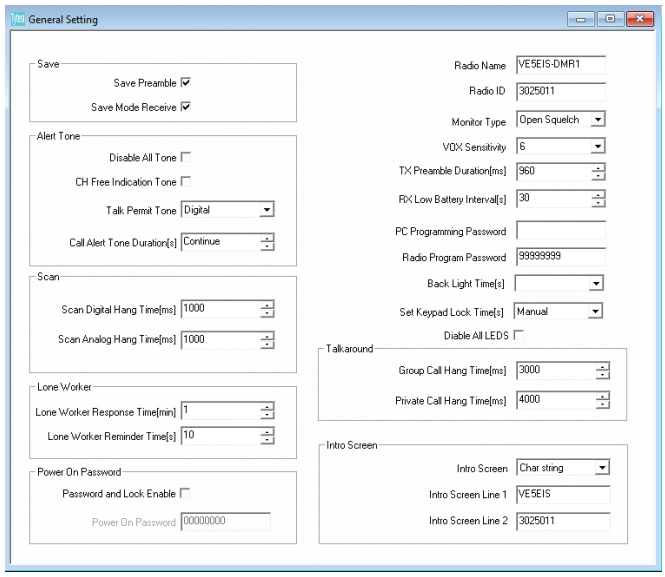



**Figure 7** — The general settings. I've programmed my call sign, VE5EIS, and DMR ID, 3025011, although the call sign isn't actually transmitted. (The DMR ID is unique for each ham.)


**Figure 8** — A sample programming for a DMR simplex channel — in this case, my DV4Mini hotspot.

can apply at **www.dmr-marc.net**, and Canadian hams can apply at **www.va3xpr.net/dmr-marc-canada**). This can take 24 hours, so you may want to register for one before you have a compatible radio in your hands. Once ready, configure your DMR ID into the software.

You can program repeaters manually, which is simple if you have relatively few frequencies to program. Many radio clubs provide "codeplugs," which are preprogrammed blocks of DMR repeaters that you can insert into the programming software. (For example, Canadian hams can insert a codeplug for all DMR repeaters in the entire country by visiting **www.va3xpr.net/dmr-codeplug-files** and downloading the appropriate file.) If your club operates DMR repeaters, it may well provide its own codeplug for you to use.

Using the software, it's reasonably straightforward to add in analog repeaters and simplex frequencies as well. The Canadian codeplug divides the country into geographic programming pages called "zones," so I simply added one more for my area and added entries for all our local 70-centimeter analog repeaters plus some simplex analog frequencies that I often use (CTCSS and DCS tones are fully supported). Each program zone can have 16 different programmed channels, so you can organize these as you need. Unprogrammed channels make a loud constant tone, so you'll be well aware if you've chosen an inappropriate program setting.

Once you wrap your head around how to work your way through the programmed pages of memories, operation is pretty straightforward. Select the zone that you want using the menu buttons, then select the channel within that zone using the left knob on the top.

## Operation

Now that you've selected a frequency, you're ready to operate. Whether you're selecting a DMR repeater (or simplex frequency) or an analog one, operation is the same.

DMR audio sounds surprisingly rich for a digital mode. Audio is clear, with some digital artifacts, but I find the audio to be quite a bit clearer than my

## Customizing Your MD-380

Some creative amateurs have discovered that the firmware on the MD-380 is replaceable, and have figured out the means to rewrite it. This has some interesting long-term implications, including the possibility (as yet unrealized) that the MD-380 might be usable on C4FM, D-STAR, and P25 in the future. (Memory limitations will probably prevent it from doing more than one mode at a time, but this is promising.)

Current modifications include some interesting hacks, such as one that lets the radio send screen text content as Morse code (which could be extremely exciting for visually impaired hams), changing the screen font (which solves one of my complaints about the radio), displaying recently heard stations on the screen (a form of screen logging), and translating DMR IDs into call signs.

For more information about these customizations, here are a couple of websites, but be sure to do some searching, as other hams are also working on similar projects.

- TYT MD380 Tools — **md380.tools** (one of the more active customization websites)
- **www.qsl.net/dl4yhf/RT3** (includes modifications for both the MD-380 and the Retevis RT3, which seems to be a very similar radio)

experience with D-STAR audio and about on par with C4FM from System Fusion. When signal strength is insufficient for error-free receptions, some shrill noises can occasionally be heard. I got nothing but good reports of my outbound audio.

The real surprise for me with this radio was analog operation. Surely, to the engineers, analog capability must have been an afterthought. Nonetheless, audio is extremely clear and surprisingly rich sounding. I run an Internet Radio Linking Project (IRLP) net every week and have gotten in the habit of using this radio because the audio quality is so solid. When I mentioned that I was using the Tytera, hams checking into the net gave me extremely favorable comments about my outbound audio quality. This radio might be the richest-sounding analog handheld in my excessively large collection.

Not all is perfect with this radio, however. The programming software is on the clunky side and has a bit of a learning curve. I also find the charging cradle to be a bit peculiar. It's not a rapid charger by any means, and it has a bright dual-color LED on it that glows red when charging and green when not charging. However, it glows green even when a radio isn't in the cradle. You may want to keep it in a discreet place where the light won't be intrusive.

## DMR — An Introduction

Digital mobile radio, or DMR, has been extremely popular in commercial radio circles for some time, and is becoming more and more popular among hams. Motorola is the market leader with its professional product line called MOTOTRBO. No effort is made to sell these radios to the Amateur Radio marketplace, but many hams use them because some of the models support segments of our VHF and UHF bands. John S. Burningham, W2XAB, has a comprehensive article discussing DMR, entitled "Introduction to Digital Mobile Radio (DMR)," in the October 2015 issue of *QST*.

DMR does have a steeper learning curve than the Japan Amateur Radio League's D-STAR digital platform (originally only supported by Icom but now also by Kenwood), which is steeper still than Yaesu's System Fusion (C4FM) effort. However, a larger expenditure is required to purchase a handheld for one of these systems.

Compared to C4FM and D-STAR, there are relatively few DMR repeaters around, but they are becoming more and more common (a small city near me even has one). However, if you lack a repeater within radio range, digital hotspots, such as the DV4 Mini, Nano-DV, and openSPOT, will let you run a short-range simplex system that you can run in your station. (These solutions also support C4FM, D-STAR, and P25, so they give you future options for experimentation, too.)

DMR, like the other digital modes, has *talkrooms* that allow many hams to speak to each other from different repeaters or simplex nodes. Even if you have no local users to talk to, you'll be able to find other DMR users who can share your enthusiasm.

### Final Thoughts

DMR is a fun mode and has a lot going for it, and the Tytera MD-380 is an excellent handheld to help you explore these possibilities. It also makes an excellent radio for analog use if being limited to a single band doesn't bother you. (Tytera now also makes the MD-2017 dual-band DMR radio, if this is a deal-breaker for you.)

I was expecting to like this radio for DMR, but I didn't expect to like it so much for analog use. I now use it for most of my IRLP and AllStar use (which I do with compact 70-centimeter hotspots). While the peculiar font on the display is somewhat unsatisfying, everything else about this radio's build quality pleases me. At street prices as low as $99 at the time of writing, this radio is well worth a look.

*Manufacturer*: TYT Electronic Co. Ltd., Block 39-1, Opto-electronics Industry Base, Nanan, Quanzhou, Fujian, China; **www.tyt888.com**. Available from many US Amateur Radio dealers.

# LNR Precision Mountain Topper MTR-5B Multiband QRP Transceiver

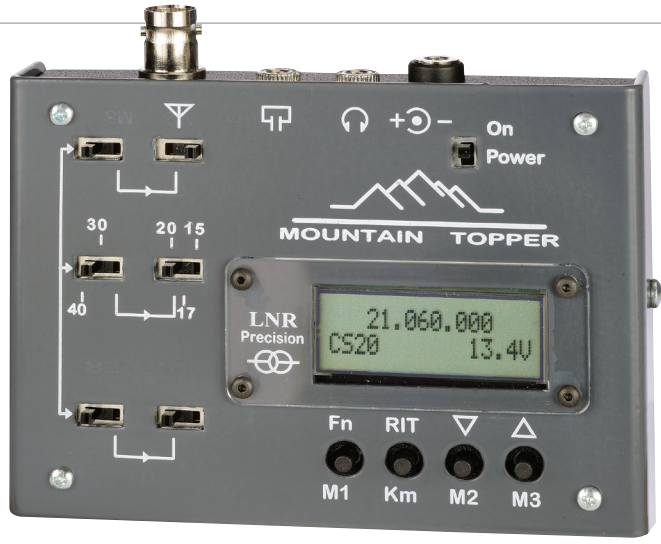
*Reviewed by Zach Manganello, K1ZK*
**k1zk@arrl.net**

This review of LNR Precision's Mountain Topper MTR-5B is a natural follow-up to my MTR-3B review in the May 2017 issue of *QST*.[4] Designed by Steve Weber, KD1JV, both radios are small and efficient QRP CW transceivers that are well-suited for operations requiring extreme portability. The MTR-5B is slightly bigger and heavier than the MTR-3B, but offers better performance and a total of five bands (40, 30, 20, 17, and 15 meters). LNR Precision also sells an MTR-4B, which covers 80, 40, 30, and 20 meters,

## Bottom Line

The LNR Precision MTR-5B combines excellent portability, performance, efficiency, and features, making it easy to bring your QRP CW operations into the field.

[4]Z. Manganello, K1ZK, "LNR Precision MTR-3B QRP CW Transceiver," Product Review, *QST*, May 2017, pp. 51 – 54.




and operation of which is advertised as identical to the MTR-5B. I elected to review the MTR-5B primarily because I find it more difficult to deploy an efficient 80-meter antenna in the field. The MTR-5B also gives the operator access to 17 meters, which could potentially offer refuge if your activation happens to fall on a contest weekend.

Those familiar with the MTR-3B will be right at home operating the MTR-5B. Operators who are new to this line of radios may find the MTR-5B to be the easier radio to master, especially because it has a backlit two-line LCD that displays a wealth of information about the operating state of the radio at a glance. Indeed, the addition of the display makes the MTR-5B seem a bit more like a traditional transceiver. But the MTR-5B remains true to its name — it is a very small and very efficient QRP CW transceiver that is particularly well designed for netting contacts from remote locations, including mountaintops.

## Excellent Portability and Efficiency

The MTR-5B is just a bit heavier and bigger than its three-band sibling. It weighs 6.4 ounces and its dimensions are 1.3 × 4.5 × 3.6 inches. I found it was slightly too big to fit in the Pelican 1020 Micro Case that I have been using for the MTR-3B. (It appears that a Pelican 1040 Micro Case would be about the right size for the MTR-5B.) Overall, the MTR-5B remains a very lightweight and very small transceiver.

Designed for battery-powered portable operations, the MTR-5B will operate very efficiently at a wide range of voltages. Like the MTR-3B, there is no RF power knob or menu selection, and transmit power depends on supply voltage. A 12 V supply gives you about 5 W and a 6 V supply gives you about 2 W. As measured by the ARRL Lab, current drawn during transmit with a 12 V supply is about 650 mA (slightly more than the MTR-3B's 590 mA), and during receive, it is about 19 mA (amazingly, this is with the backlit display running and is less than the MTR-3B's 39 mA on receive). In short, like the MTR-3B, the MTR-5B is an extremely efficient QRP CW rig.

## Accessories, Controls, and User Interface

The MTR-5B has only four ports: antenna, key, headphones, and power. The antenna port on the MTR-5B is a BNC female connector, so I was able to dispense with the adapter I was using for the MTR-3B's RCA jack and simply plug my AlexLoop's BNC connector directly into the rig. (The AlexLoop is a small magnetic loop antenna that I often use for portable work.) The power receptacle on the MTR-5B is the same as on the MTR-3B, so I was able to use the fused power cables with the 1.7 × 4.0 millimeter plug that I built for the MTR-3B. For power, I primarily used a Tenergy 11.1 V, 2,200 mAh lithium-ion battery.

The MTRs do not have internal speakers, so I used a simple pair of earbuds with a ⅛-inch stereo plug for listening. There is no volume control on the transceiver; instead, automatic level control is built into the rig. I found I was able to hear a wide variety of signals quite easily, but an in-line volume control could be added in series if desired. Audio output is at headphone level, which made everything quite a bit louder in the earbuds compared to the MTR-3B. I found the MTR-5B's sidetone was loud enough that I frequently used only one earbud when calling CQ.

My trusty Palm Pico paddle rounded out the array of outboard accessories, and worked flawlessly with the MTR-5B's built-in keyer, which can handle speeds of about 10 to 33 WPM. The MTR-5B also has a straight-key mode that is available via a menu selection or is automatically enabled if a mono plug is inserted in the key port. Some features are not available in straight-key mode, including direct frequency entry, message memory entry, and tune (described later).

Like the MTR-3B, the MTR-5B has a minimalist user interface. Most of the transceiver's features are controlled by four buttons, each of which has more than one function. Some additional functions require the use of the CW paddle. The buttons protrude only slightly from the face of the radio, keeping the radio streamlined and reducing the chance of damage during transport.

In addition to a single on/off slide switch, a bank of six three-position slide switches (arranged in two columns of three switches) provides band

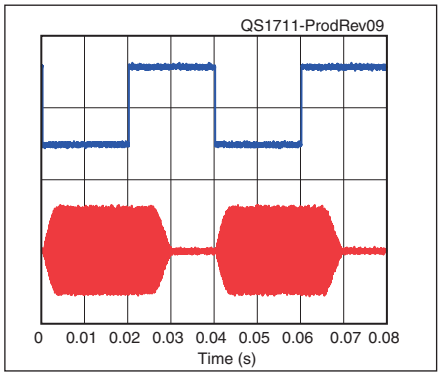



**Figure 9** — CW keying waveform for the MTR-5B transmitter showing the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 5 W output on the 14 MHz band.

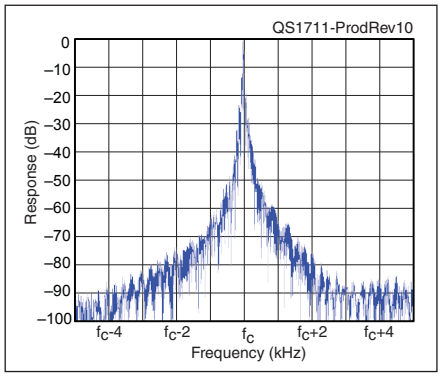



**Figure 10** — Spectral display of the MTR-5B transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 5 W output on the 14 MHz band, and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

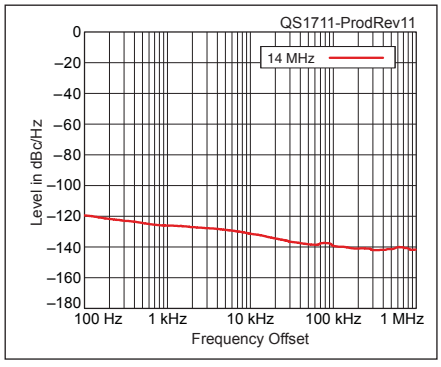



**Figure 11** — Spectral display of the MTR-5B transmitter output during phase-noise testing. Power output is 5 W on the 14 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 10 dB per division.

**Table 3**
**LNR Precision MTR-5B, serial number n/a**

| Manufacturer's Specifications | Measured in the ARRL Lab |
|---|---|
| Frequency coverage: 40-, 30-, 20-, 17-, and 15-meter amateur bands. | Receive and transmit, 7 – 7.15, 10.1 – 10.15, 14 – 14.15, 18.068 – 18.110, 21 – 21.15 MHz. |
| Power requirements: 6 to 12 V dc. | At 12 V dc: Receive, 19 mA; transmit 650 mA. |
| Modes of operation: CW. | As specified. |
| **Receiver** | **Receiver Dynamic Testing** |
| Sensitivity: Not specified. | Noise floor (MDS), 300 Hz bandwidth:<br>7.0 MHz –130 dBm<br>10.1 MHz –130 dBm<br>14 MHz –130 dBm<br>18.1 MHz –127 dBm<br>21 MHz –127 dBm |
| Noise figure: Not specified. | 14 MHz, 18 dB. |
| Blocking gain compression dynamic range: Not specified. | Blocking gain compression dynamic range (300 Hz bandwidth):<br>*20 kHz offset* *5/2 kHz offset*<br>14 MHz 106 dB 106/106 dB |
| Reciprocal mixing dynamic range: Not specified. | Not measured.* |
| ARRL Lab Two-Tone IMD Dynamic Range Testing (300 Hz bandwidth) | |

| *Band* | *Spacing* | *Measured IMD Level* | *Measured Input Level* | *IMD DR* |
|---|---|---|---|---|
| 14 MHz | 20 kHz | –130 dBm<br>–97 dBm | –44 dBm<br>–37 dBm | 86 dB |
| 14 MHz | 5 kHz | –130 dBm<br>–97 dBm | –44 dBm<br>–37 dBm | 86 dB |
| 14 MHz | 2 kHz | –130 dBm<br>–97 dBm | –44 dBm<br>–37 dBm | 86 dB |

| | |
|---|---|
| Second-order intercept point: Not specified. | 14 MHz, +31 dBm.** |
| IF/audio response: Not specified. | Range at –6 dB points (bandwidth)<br>CW (300 Hz): 549 – 816 Hz (267 Hz)<br>Equivalent Rectangular BW, 272 Hz. |
| Receive processing delay time: Not specified. | 1 ms. |
| **Transmitter** | **Transmitter Dynamic Testing** |
| Power output: Up to 4.5 W. | At 12 V dc: 7 MHz, 5.2 W; 10.1 MHz, 5.3 W; 14 MHz, 5.0 W, 18.1 MHz, 4.7 W; 21 MHz, 4.7 W. At minimum operating voltage (6 V dc): 2 W typical. |
| Spurious-signal and harmonic suppression: Not specified. | 7 MHz, 64 dB; 10.1 MHz, 58 dB; 14 MHz, 47 dB; 18.1 MHz, 58 dB; 21 MHz, 49 dB. Complies with FCC emission standards. |
| CW keyer speed range: 9 to 31 WPM. | 10 to 33 WPM. |
| CW keying characteristics: Not specified. | See Figures 9 and 10. |
| Iambic keyer mode: Not specified. | Mode A. |
| Transmit-receive turnaround time: Not specified. | S-9 signal, 122 ms. |
| Composite transmitted noise: Not specified. | See Figure 11. |

Size (height, width, depth): 1.3 × 4.5 × 3.6 inches (including protrusions). Weight, 6.4 oz.

Price: $380.

*AGC could not be disabled. No reciprocal mixing was present up to the blocking level.
**Second-order intercept points were determined using S-5 reference.

## Lab Notes: LNR Precision Mountain Topper MTR-5B

*Bob Allison, WB1GCM*

Overall, the MTR-5B performs better and has a friendlier user interface than the MTR-3B reviewed previously. The lowest dynamic range at 2 kHz spacing is a respectable 86 dB, more than enough for a portable QRP station using simple antennas. Importantly, the current drain while in receive mode is a mere 19 mA, even though the display backlights cannot be turned off. On the transmit side, key-down current drain is typically 650 mA.

Sensitivity is good, –127 to –130 dBm, though signals at that level are barely audible. I found that a test signal at the –120 dBm level is quite usable. The audio output is at headphone level and is noticeably louder than the MTR-3B. Note that there is no volume control on this radio. An amplifier speaker system is always an option, but this can detract from the portability of the Mountain Topper.

Harmonics and spurious emissions easily meet FCC requirements on all bands. The first MTR-5B we tested exhibited very hard keying, resulting in wide keying sidebands and key clicks. The developer, Steve Weber, KD1JV, promptly addressed the issue, and the radio now has the good keying characteristics shown in Figures 9 and 10. Transmit phase noise is low as well.

**Figure 12** — The MTR-5B and accessories set up on Champlain Mountain in Bar Harbor, Maine (Summits on the Air designator W1/DI-004).

selection. The manual explains why six switches are used: the first row controls the processer and connects the receive filter, the second row connects the transmit filter, and the third row connects the output of the power amplifier. The first column of switches selects 40 meters, 30 meters, or the sub-bank, and the sub-bank (second column) selects 20, 17, or 15 meters. It does not take long to get used to moving three rows of switches for band changes.

The biggest difference between the MTR-5B's user interface compared to the MTR-3B is the MTR-5B's backlit two-line LCD display. Although color (white), contrast, and brightness are not adjustable, I found the display to be easy to read from most angles and in most lighting conditions.

The top line ordinarily displays all digits of the operating frequency down to increments of 50 Hz. The bottom line ordinarily displays the keyer code speed and battery voltage (typically accurate to within ±0.1 V). The second line will also optionally display the time on a 24-hour clock, which can be set via a menu. The transceiver has a provision for an internal backup battery to keep the clock running, but the manufacturer is now recommending against using the backup battery because it causes erratic operation of the processor. The clock is still usable without the backup battery, but it must be set each time the radio is powered on. The display shows other information in an intuitively sensible manner as different features are used.

### Field Operations

After a very successful 2016 season operating the MTR-3B, I was looking forward to trying out the MTR-5B, and I am pleased to report that it didn't disappoint, notwithstanding the generally lackluster HF propagation conditions. I used the MTR-5B in my shack and in the field in Maine and Vermont to make numerous contacts and to activate multiple Summits on the Air (SOTA) peaks and state parks. Figure 12 shows a typical operating site. Setup was easy, and the MTR-5B supplied all the features I needed to get contacts into the log. Many of the features are similar to those offered by the MTR-3B, but are easier to use thanks to the MTR-5B's display.

An RIT feature is useful, particularly for working split; it's tunable in steps of 50 Hz and can be toggled on and off, so you can quickly check for signals on your transmit frequency. (The manual states that the RIT range is ±9.950 kHz, but I found that it was only ±1.5 kHz.) A direct frequency entry feature allows you to quickly change frequencies instead of tuning with the UP and DOWN buttons. A tune feature automatically reduces transmit power when dc supply is greater than 10 V, and it allows you to toggle the transmitter on and off with the CW paddle while you adjust your antenna.

The feature I used most was the MTR-5B's programmable CW messages; they free you up to take in a view, check the Reverse Beacon Network (RBN) while calling CQ to see how well you are getting out, or to scribble in your log while sending exchange information. The MTR-5B has three memory slots for messages, each up to 63 characters long. I typically programmed one CQ message and used the two additional memories for my SOTA summit identifier or other information. Preprogramming the messages before hitting the trail is helpful, but much less critical than with the MTR-3B, which requires keying the complete message correctly in full

before saving. Programming the MTR-5B's messages is much easier, both because the display allows you to see your message as you program it, and because the MTR-5B includes a "backspace" feature that allows you to correct mistakes on the fly.

A "beacon" mode allows the user to set any one of the three memories to repeat continuously, with the delay between repeats adjustable between 2 and 9 seconds. One harmless quirk I noticed: after the 9-second option, the next option does not cycle back to 2 seconds, but instead goes on to a full character set with no apparent function. While in beacon mode, the message can be terminated in between words by using the CW paddle. On a few occasions, I found myself wishing I could terminate the beacon immediately or in between letters, but for the most part, this feature worked very well.

A few other options are available in the MTR-5B's configuration menu. You can customize the default frequencies for each band and the keyer speed upon power-up. You can also select a feature that will display the Morse characters you are sending. Finally, there is an optional feature to audibly annunciate your operating frequency — this works just like the feature in the MTR-3B, but is not a vital feature on the MTR-5B because the display shows the operating frequency at a glance.

## Documentation

A straightforward six-page *User Manual* (rev. 2.0) provides an overview of the radio and explanations on using all of the features. An earlier revision of the manual is available on the LNR Precision website and includes detailed assembly and alignment instructions, as well as schematics.

## Conclusion

These days, there are multiple innovative ways to get on the air while away from your shack, including remote control and internet-connected VHF/UHF digital voice modes. But bringing an effective HF station with you might seem a bit more challenging, especially if you need a station that is small and lightweight. The MTR-5B rises to that challenge. Combining excellent portability, performance, efficiency, and features, the MTR-5B makes it easy to bring your QRP CW HF operations into the field.

*Manufacturer:* LNR Precision, 1954 N. Fayetteville St., Asheboro, NC 27203; **www.lnrprecision.com**.

# RigExpert AA-55 ZOOM 0.06 – 55 MHz Antenna Analyzer

*Reviewed by Phil Salas, AD5X*
**ad5x@arrl.net**

Because most current "HF" transceivers cover 160 through 6 meters, antenna experimentation and analysis probably dominates over this frequency range. Therefore, the most-often-needed antenna analyzer frequency coverage is undoubtedly also 1.8 – 54 MHz. While RigExpert offers a number of antenna analyzers spanning up to 1 GHz, the AA-54 has been a popular version because of its cost and frequency coverage.[5]

The AA-55 ZOOM is the next generation of the AA-54, adding many features from the AA-230 ZOOM, such as a large color display, higher resolution, and graphical zoom capability.[6] Because the AA-55 ZOOM bridges some of the features between the AA-54 and the AA-230 ZOOM, a comparison of these analyzers is appropriate and is given in Table 4.

## Basic Description

The AA-55 ZOOM is a single-port vector network analyzer (VNA) that provides signed, complex impedance measurements from 60 kHz through 55 MHz with a frequency resolution of 1 kHz. The measurement port is a standard UHF female connector. Included


### Bottom Line

The AA-55 ZOOM is a flexible and accurate antenna analyzer that will satisfy 160- through 6-meter antenna and component measurement requirements.

**Table 4**
**RigExpert Antenna Analyzer Comparison**

| Function | AA-54 | AA-55 Zoom | AA-230 ZOOM |
|---|---|---|---|
| Frequency range | 0.1 – 54 MHz | 0.06 – 55 MHz | 0.1 – 230 MHz |
| Frequency entry step size | 1 kHz | 1 kHz | 1 kHz |
| Minimum sweep range | 10 kHz | 10 kHz | 10 kHz |
| SWR2Air mode | No | Yes | Yes |
| MultiSWR mode | Yes | Yes | Yes |
| Reactance sign measurement | Yes | Yes | Yes |
| Antenna connector type | UHF | UHF | N |
| Output power | +13 dBm | +13 dBm | –10 dBm |
| Output amplifier | CMOS IC | CMOS IC | CMOS IC |
| Output signal shape | Square wave | Square wave | Square wave |
| SWR reference impedances | 50/75 Ω | 25/50/75/100 Ω | 25/50/75/100 Ω |
| A/D converter | 10-bit | 12-bit | 16-bit |
| Batteries (alkaline or NiMH) | 2 × AA | 2 × AA | 4 × AAA |
| Battery voltage sensor | Yes | Yes | Yes |
| External power (no battery) | USB | USB | USB |
| LCD display resolution | B&W 128 × 64 | Color 320 × 240 | Color 290 × 220 |
| TDR mode | No | Yes* | Yes |
| Flash memory for graphs | 100 slots | 10 slots** | 100 slots |
| Multilingual support | Yes | Yes | Yes |
| Amateur band presets | Yes | Yes | Yes |
| USB cable supplied | No | Yes | Yes |
| Carrying case included | No | Yes | No |
| Zoom X and Y parameters | No | Yes | Yes |
| OSL calibration capability | No | Yes | Yes |
| Price | $290 | $380 | $480 |

*Only available through the *AntScope* software
**This is not a misprint.

**Table 5**
**RigExpert AA-55 ZOOM, serial number n/a**

| Manufacturer's Specifications | Measured Performance |
|---|---|
| Frequency range: 0.06 – 55 MHz. | As specified. |
| Frequency resolution: 1 kHz. | As specified. |
| Open circuit output impedance: Not specified. | See Table 6. |
| Output power: +13 dBm typical into 50 Ω. | See Table 7. |
| Output signal shape: Square wave. | Harmonics: Even, >–25 dBc; 3rd, –10 dBc; 5th, –15 dBc. |
| Measurement systems: 25, 50, 75, and 100 Ω. | As specified. |
| SWR range: 100:1 numerical, 10:1 graphical. | SWR of ∞ is indicated into open circuit. |
| R, X range (numerical): 0 – 10 kΩ, ±10 kΩ. | Less than ±10 kΩ above 14 MHz. |
| R, X range (graph): 0 – 1 kΩ, ±1 kΩ. | As specified. |
| Display modes: Swept-frequency SWR, return loss, R and X; single-frequency SWR, return loss, phase, R, X, L, C; multiband SWR. | As specified. |
| SWR chart, R, X chart, Smith chart, and return loss chart: 100 points. | As specified. |
| Power: USB interface or two AA 1.5 V alkaline or 1.2 V NiMH batteries. | |
| Battery operating time: 4 hours continuous, 2 days standby. | |
| Dimensions (height, width, depth): 4.1 × 8.1 × 1.4 inches; weight, 10.9 oz. | |
| Operating temperature: 32 – 104° F (0 – 40° C). | |
| Price: $380. | |

with the AA-55 ZOOM is a nice carrying case with a shoulder strap, a USB cable for computer interfacing, a user manual for standalone operation, a software manual for computer interfacing, and two AA-size alkaline batteries. The carrying case protects the AA-55 ZOOM and permits full access to the controls, so the analyzer may be operated from within the carrying case.

The batteries are accessed through a rear battery compartment cover. Rechargeable AA-size NiMH batteries may be used, but they must be taken out of the AA-55 ZOOM for charging with a user-provided charger. Three levels of battery saver modes (intensive, optimal, saver) may be selected in the SETUP menu, and a battery indicator on the Main Menu shows the status. When a computer is connected, power is provided through the USB connection.

All information is displayed on a large, easy-to-read 2.6 × 1.9 inch TFT color screen. You can select a single-frequency display, a multiband SWR display, a swept-frequency display, or a Smith Chart display. The single-frequency mode lets you select displays of SWR, impedance (Z, R, and X), or the equivalent series and parallel representation of an impedance. The MultiSWR display shows single-frequency SWR information on up to five bands simultaneously. The swept-frequency mode displays SWR, return loss, or impedance (R/X). The graphical displays can be expanded with the ZOOM feature for display convenience.

Finally, the AA-55 ZOOM may be connected to your computer to provide additional data recording and analysis, along with analyzer control, using the supplied RigExpert *AntScope* program. Internal memory provides for the storage and recall of measured parameters (up to 10 screens), as well as firmware updates.

**Table 6**
**Open Circuit Output Impedance**

| Frequency (MHz) | Impedance (Ω) |
|---|---|
| 1.8 | >40,000 |
| 3.5 | >25,000 |
| 7 | >11,000 |
| 14 | >5,000 |
| 28 | 2,500 |
| 50 | 1,400 |

## AA-55 ZOOM Testing

Table 5 summarizes the performance and features of the AA-55 ZOOM. Table 6 displays its open-circuit output impedance. This gives an indication of the impedance magnitude you can accurately measure as a function of frequency.

When checked against 10 MHz WWV, there was no noticeable frequency drift over a 5-minute test period, and the displayed frequency was within 20 Hz of WWV. A menu selection permits you to correct the frequency by up to ±999 ppm (parts per million). The output level is quite constant over the full frequency range, making the AA-55 ZOOM stable and accurate enough for receiver sensitivity testing when used with a good step attenuator. Table 7 shows the output power level versus frequency measured with my Mini-Circuits PWR-6GHS+ power sensor.[7]

Next, I measured SWR accuracy using shorted microwave attenuators (5 dB/2:1 SWR and 3 dB/3:1 SWR), and homebuilt 7.5 Ω (theoretically 6.67:1 SWR) and 400 Ω (theoretically 8:1 SWR) loads using Caddock thick-film resistors. The AA-55 ZOOM SWR measurements are tabulated in Table 8 as compared to an Array Solutions VNA2180 vector network analyzer.[8] As you can see, the AA-55 ZOOM is quite accurate.

Finally, I built complex loads of approximate 50 –*j*36 Ω for 12 and 6 meters. Table 9 displays the AA-55 ZOOM complex load measurements compared to the Array Solutions VNA2180. As you can see, the AA-55 ZOOM provides excellent measuring capability.

## Using the AA-55 ZOOM

Before using the AA-55 ZOOM for the first time, check that you have the latest firmware. Simply go to the **rigexpert.com** software downloads page, which has the necessary installer programs for *Windows* or *Mac OS*. The *Windows* installer program loads the necessary drivers, downloads the *AntScope* software, *User* and *Software* manuals, and finds the AA-55 ZOOM connected to your computer. Then run the appropriate Firmware Update Tool from the RigExpert site. That tool determines the current version of your firmware and updates and installs the latest firmware if your unit is not up to date.

The AA-55 ZOOM menus and keypad markings are quite self-explanatory. Tap FQ. RANGE to set the frequency or frequency range. Use the ∧/∨ keys to change the span range, the </> keys to change the center frequency, and the F-∧/∨ keys to change the vertical scale of the graphs. The MultiSWR feature simultaneously displays the SWR on up to five bands at the same time. This is probably of particular interest when adjusting popular multiband vertical antennas, as adjusting one band often changes the SWR on other bands. My main antenna, a Hy-Gain TH-1 rotatable dipole, consists of a 20/15/10 meter trap dipole with a 6-meter fan dipole element. I took advantage of the multiband feature of the AA-55 ZOOM to look at these four bands, as shown in Figure 13.

Next, I took a 10 – 60 MHz scan of the antenna, as shown in Figure 14. You can clearly see the four highlighted ham bands covered by this scan. You can use the < and > buttons to center the band of interest for more detail. Then use the zoom feature to narrow the frequency range, and the ∧ and ∨ buttons to zoom in or out to get more or less detail from the scan. Because of the 100-point scan resolution, however, you may lose some resolution when you zoom in on a small section of a large sweep when compared with an individual band sweep.

Figures 15 and 16 show separate unzoomed sweeps of 20 meters and 6 meters with the TH-1 dipole.

As discussed earlier, single-frequency parameters may also be displayed in order to provide detailed impedance information. Other features include the ability to measure cable length, cable loss, velocity factor, and characteristic impedance.

One very useful feature is the ability to calibrate the AA-55 ZOOM. The unit is calibrated accurately when it leaves the factory. However, this calibration capability permits you to recalibrate the AA-55 ZOOM should you question its accuracy. And you can use this feature to calibrate out a transmission line between the analyzer and the antenna. For example, if the calibration is done at the far end of a transmission line, the transmission line parameters will be subtracted from measurement results, so the analyzer will display the true parameters of the antenna. Further, while not mentioned in the manual, you can calibrate out a pigtail/clip lead

**Table 7**
**Output Power vs. Frequency**

Power measured with a NIST-traceable MiniCircuits PWR-6GHS+ power sensor.

| Specified Power (dBm) | ---- Measured Power (dBm) at Frequency (MHz) ---- 1.8 | 3.5 | 7 | 14 | 28 | 50 |
|---|---|---|---|---|---|---|
| +13 typ | +12.8 | +12.8 | +12.8 | +12.8 | +12.8 | +12.7 |

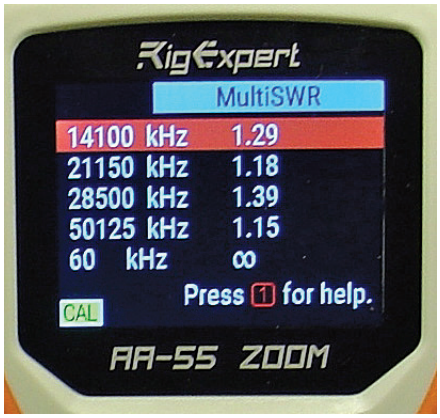



**Figure 13** — A multiband SWR display.


**Figure 14** — A 10 – 60 MHz scan of the reviewer's TH-1 20/15/10/6 meter multiband dipole.

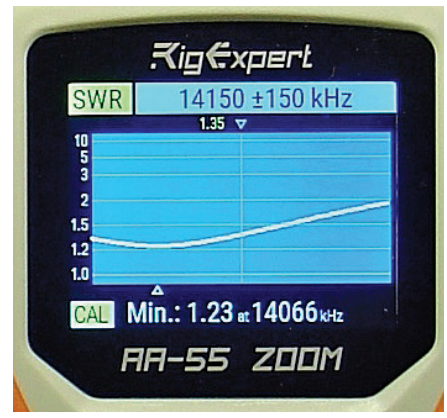



**Figure 15** — A scan of the reviewer's TH-1 multiband dipole, showing the response over the 20-meter band.

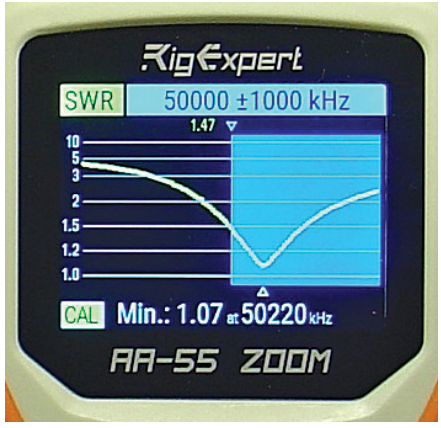



**Figure 16** — A scan of the TH-1 multiband dipole, showing the response over the 6-meter band.

**Table 8**
**Resistive Load Measurements**

Loads measured with the AA-55 ZOOM compared to the AIMuhf.

| Frequency (MHz) | 2:1 SWR AA-55/AIM | 3:1 SWR AA-55/AIM | 7.5 Ω Load SWR AA-30/AIM | 400 Ω Load SWR AA-30/AIM |
|---|---|---|---|---|
| 1.8 | 1.98/2.00 | 3.1/3.2 | 6.7/6.9 | 7.9/8.0 |
| 3.5 | 1.98/2.00 | 3.1/3.2 | 6.7/6.9 | 7.9/8.0 |
| 7 | 1.97/2.00 | 3.1/3.21 | 6.7/6.9 | 7.9/8.0 |
| 14 | 1.97/1.99 | 3.1/3.2 | 6.6/6.9 | 7.9/8.0 |
| 28 | 1.99/1.99 | 3.1/3.2 | 6.6/6.9 | 8.0/7.9 |
| 50 | 1.96/1.99 | 3.1/3.2 | 6.6/6.9 | 8.0/7.9 |

**Table 9**
**Complex Load Measurements**

Loads measured with the AA-55 ZOOM compared to the AIMuhf.

| Frequency (MHz) | SWR AA-55 | SWR AIMuhf | Impedance AA-55 | Impedance AIMuhf |
|---|---|---|---|---|
| 24.9 | 1.99 | 1.99 | 49.5 –*j* 34.8 | 48.7 –*j* 34.5 |
| 50 | 1.92 | 1.95 | 49 –*j* 33 | 47 –*j* 33 |

interface for measuring components accurately.

The calibration process is enabled by selecting CALIBRATE in the Main Menu and then following the instructions on the display. This process requires open, shorted, and 50 Ω loads. For clip lead calibration, use a leaded 50 Ω metal film resistor (these are quite good through 6 meters), short the clip leads, and leave the clip leads open when prompted. For a coax interface, you can build accurate calibration loads utilizing an SMA/UHF adapter, an SMA short, and an SMA load. When prompted, screw on the SMA short and 50 Ω load to the SMA/UHF adapter, and leave the adapter unterminated for the open circuit. Table 10 lists the necessary parts. The UHF female/female adapter can be used at the far end of a transmission line for calibrating out the transmission line. Keep in mind that you must turn off the calibration adjustment with the F2 key combination for normal use if you have recalibrated it for clip leads or a transmission line.

## Computer Interface

RigExpert provides a powerful, easy-to-use *AntScope* program that permits importing data from the AA-55 ZOOM memory, as well as providing real-time control of the AA-55 ZOOM. Upon installation, *AntScope* does not create a desktop icon, so you must go to the appropriate folder to execute the program. Alternatively, create a desktop icon by right-clicking on the ANTSCOPE.EXE program and following the instructions. Figure 17 is the *AntScope* output of the 10 to 60 MHz scan display of Figure 14.

A time domain reflectometer (TDR) is convenient for finding the distance to discontinuities in your antenna system. While the AA-55 ZOOM does not have a direct TDR capability built in, the TDR capability is available

**Table 10**
**Components for the Calibration Loads**

| Qty | Description | Part Number* |
|---|---|---|
| 1 | SMA-female/UHF-male adapter | 523-242109 |
| 1 | SMA 50 Ω termination† | 523-132360 |
| 1 | SMA shorting cap | 523-132360 |
| 1 | UHF female/female adapter | 523-182109 |

†The SMA 50 Ω termination return loss exceeded 40 dB up to 1 GHz as measured on an HP/Agilent 8722D VNA.
*Part numbers are from **www.mouser.com**.

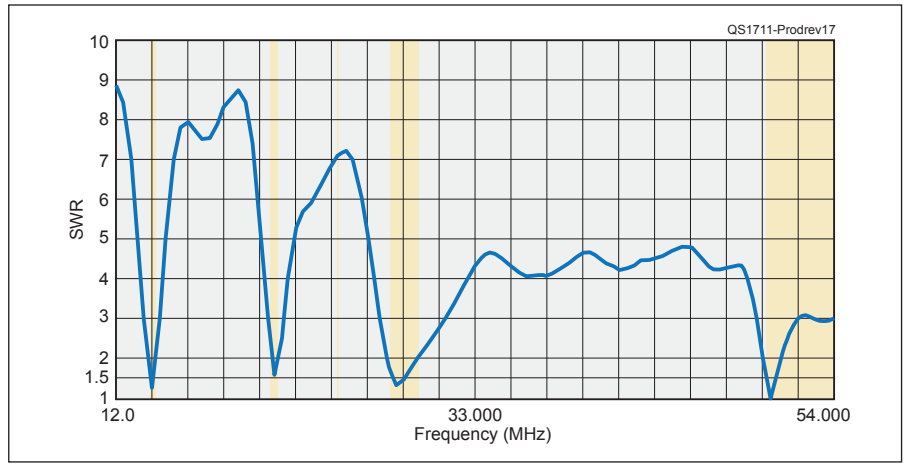



**Figure 17** — The same measurement as in Figure 15, but displayed with the *AntScope* software.

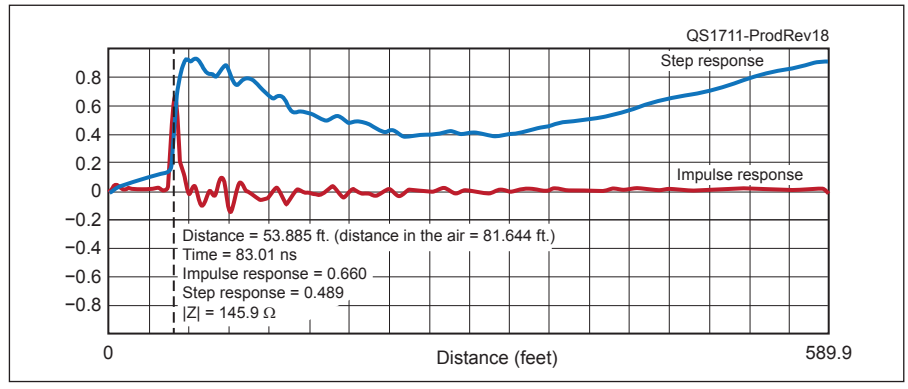



**Figure 18** — *AntScope* display of the AA-55 ZOOM in TDR mode, used to determine the length of the coax feeding the author's 43-foot vertical antenna.

through the *AntScope* program. I used the TDR feature to determine the physical length of coax from my operating position to my 43-foot vertical, which I'd estimated to be about 60 feet. Figure 6 shows the *AntScope* TDR response. Placing the cursor on the vertical dotted line shows a distance of 53.89 feet.

## Just a Few Glitches

I did find a couple of minor issues. First, I could not store the MultiSWR display. After storing the MultiSWR screen, it always showed infinite SWR for the five bands displayed when it was recalled. Also, data is displayed under the cursor in *AntScope* displays. As an example, in Figure 18, the *AntScope* display shows a box with the detailed data under the cursor. But when I tried to copy the screen using the *AntScope* software, this data box did not show up. I was only able to copy this screen with the data box by using the Print Screen function in *Windows*.

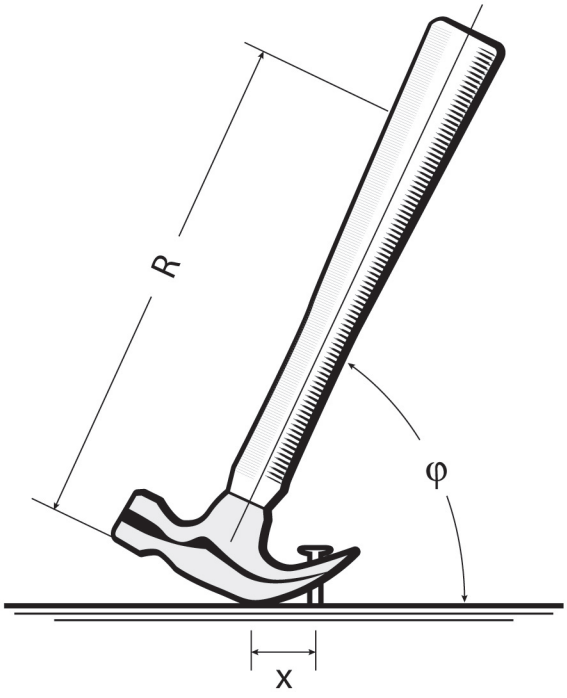
## Conclusion

The AA-55 ZOOM is an accurate, easy-to-read, and easy-to-use antenna and component analyzer. The zoom and open-short-load calibration features and the *AntScope* program make this a particularly useful device for typical antenna measurements and adjustments, and even as a lab-grade analyzer for some of your bench work. You can investigate the AA-55 ZOOM further by viewing the manual on the RigExpert website.

*Manufacturer*: Rig Expert Ukraine Ltd., Yakira St., 17A 04119 Kyiv, Ukraine; **www.rigexpert.com**. Available from many US dealers.

**Notes**

[5]J. Hallas, W1ZR, "A Look at Four Antenna Analyzers," Product Review, *QST*, Mar. 2012, pp. 46 – 51.
[6]P. Salas, AD5X, "RigExpert AA-230 ZOOM 0.1 – 230 MHz Antenna and Cable Analyzer," Product Review, *QST*, Mar. 2016, pp. 54 – 56.
[7]P. Salas, AD5X, "MiniCircuits PWR-6GHS+ USB Power Sensor," Product Review, *QST*, Feb. 2011, pp. 56 – 59.
[8]P. Salas, AD5X, "Array Solutions VNA2180 Vector Network Analyzer," Product Review, *QST*, Mar. 2011, pp. 57 – 59.




# Every job needs the right tool

## ZOOM Family of RigExpert® Antenna Analyzers

to assemble and test your antennas and cables

AA-35 ZOOM (up to 35 MHz)
AA-55 ZOOM (up to 55 MHz)
AA-230 ZOOM (up to 230 MHz)


Buy now:

http://I.LOVE.RIG.EXPERT

See the AA-55 ZOOM review at page 62

# QRPworks K-Board and SideKar Accessories for Elecraft Transceivers

*Reviewed by Stuart Thomas, KB1HQS*
**KB1HQS@fastmail.com**

As an avid user of the Elecraft KX3 radio and a portable operating enthusiast, I am always looking for new gear to help maximize my efficiency in making radio contacts while in the field.

Two products I tried this past summer were the K-Board and SideKar, both made by QRPworks. Both accessories are designed to work with the Elecraft KX2/KX3 and K3/K3S radios, providing a keyboard interface and, in the case of the SideKar, logging features.

## K-Board

The manual describes the K-Board (see Figure 19) as a "smart keyboard interface," and that's an apt description. It allows the operator to add a wireless or wired USB keyboard to make it easier to use the features of their Elecraft radio without adding a computer. Using the K-Board, the operator can store, play, and manage PSK, RTTY, and CW messages at a touch of a keyboard button. You can also program macros for rig control functions, such as changing frequencies, bands and modes, setting the transmit power, enabling RIT, or entering split frequency operation, all from the keyboard without having to touch the radio.

The K-Board measures 3.625 × 1 × 1.9 inches and weighs 3.2 ounces with a professional-looking metal case. It requires an 8 – 15 V dc power source and has a 2.1-millimeter coaxial power connector. QRPworks offers an optional power splitter cable (to power the radio and K-Board from a single source) and a 9 V battery holder with power cable that fits the K-Board. We also ordered the companion wireless keyboard from QRPworks. The compact keyboard isn't much bigger than the K-Board and uses an internal rechargeable lithium-ion battery. (QRPworks also offers a larger size wireless keyboard.)

Three LEDs (red, yellow, and green) on the front of the K-Board case indicate the firmware and input/connections status, a useful feature considering the K-Board has no LCD display. A reference guide is printed on the case above the LEDs, a feature appreciated when you don't have the manual with you.

On the top of the unit (see Figure 20) are the connections for external power input and radio data cable, along with a power switch. For operating outdoors, I would prefer to see a sealed rocker switch in its place.

### Bottom Line

The QRPworks K-Board and SideKar offer a compact way to add a keyboard and other features to Elecraft transceivers. They are especially attractive for portable operations.

### *Setting up the K-Board*

Setting up the K-Board requires connecting the radio and the K-Board with the included 3.5-millimeter stereo cable. I then verified that my KX3 was set to the correct baud rate of 38,400. If you supply your own keyboard, it can be either wired or wireless. If wireless, you will need a 2.4 GHz version (not Bluetooth) for it to work properly. A PC port is located on the side of the K-Board for programming the unit using a computer. It's interfaced to the computer using the same Elecraft KXUSB or KXSER cable used to connect the radio to a computer.


**Figure 19** — The QRPworks K-Board, shown here with its optional compact wireless keyboard, uses the LEDs to indicate status and communicate with the user.


**Figure 20** — Connections for the radio, computer, and power, plus an on/off switch, are located along the bottom of the K-Board. The SideKar is similar.

I started by interfacing the K-Board to my MacBook and downloaded the *Message Management Utility* program from the QRPworks website. (A *Windows* version of the software is available as well.) Using *Message Management Utility*, I programmed my predetermined messages for the K-Board. The unit is capable of storing up to 200 messages or macros, a very handy feature when participating in various contests and operating activities. Messages/macros are arranged in 10 groups of 20 messages/macros each. They are accessed using the F1 to F10 and ALT F1 to F10 keys. Use ALT-G and one of the function keys to access the different message/macro groups.

The *Elecraft K3s/K3/KX3/KX2 Programmer's Reference* offers an in-depth look at the wide variety of rig control commands that can be sent to the radio from an external computer. The K-Board can store rig control macros in memory and send them to the radio in the same way messages are handled. Rig control macros begin with a period to differentiate them from messages. They can have a short name, followed by a colon, followed by the programming code(s) separated by semicolons. For example, .CW15:MD3;KS015; is a macro named CW15 that commands the radio to switch to CW mode (MD3) and set the keyer speed to 15 WPM (KS015). Macros can be much more complicated than that, stringing together any number of commands.

It should be noted that you can program the messages directly into the K-Board using the keyboard and/or CW paddle (without a computer), which is useful in the field when you want to change messages on the go or as your operating situations change. The contents of messages or macros can be previewed using the radio's scrolling display.

One issue I encountered initially was that the K-Board would not recognize the wireless keyboard. After a full charge of the keyboard battery, everything synced up correctly. Considering that this was an issue with the keyboard and not the K-Board, you might prefer a wired keyboard if you have limited charging capability in the field. The user should select a wired or wireless keyboard based on their operating location and preference.


**Figure 21** — The SideKar and compact wireless keyboard with the author's KX3 transceiver.

### On the Air with the K-Board

During a recent Parks on the Air (POTA) activation in Maryland, the message feature proved to be very useful as the band conditions were not cooperating that day. (POTA is part of the World Wide Flora and Fauna in Amateur Radio program — see **wwff-kff.com**.) I used the F1 button on my wireless keyboard to send CQ POTA on CW repeatedly, hoping to start up some activity. Using this setup was very convenient because I didn't have to be located right next to the radio while calling CQ.

Once contact was established with another operator, I sent another message including signal report, park designator, and state. Along with the message memories, I used the keyboard to send typed text as needed. Using a keyboard and hearing CW as I typed was a little strange at first, but I quickly adapted. To my ears, the spacing sounded good and would be easily decodable by the other operator (or by a computer program).

The K-Board programming uses a series of ALT key combinations to initiate different commands. For example, the Quick QSY feature allows you to change frequencies and modes from the keyboard — press ALT-Q then type 14070P to switch to PSK31 on 14.070 MHz. Or press ALT-Q then 7235L for 7.235 MHz LSB. This is a handy feature compared to the multiple button presses and tuning knob dialing required for band and mode changes from the KX3's front panel.

Another example of the ALT key command that I found useful was ALT-V, allowing me to check the battery or power supply voltage of the K-Board.

QRPworks provides a helpful ALT command table as a reference sheet in the manual.

The 37-page manual does a great job of covering all the features in depth as well as offering tips to operate the device. It's extensive in size, but is well organized and includes a number of color photos.

### SideKar

The SideKar (see Figure 21) offers all the K-Board features plus an LCD screen and logging capabilities. The QRPworks website offers a comparison chart of their products if you would like to see all the features side by side. As with the K-Board, the SideKar is supported with an 82-page, well-illustrated manual available for download from the QRPworks website.

The SideKar measures 3.6 × 1.7 × 1.9 inches and weighs 5.6 ounces — like the K-Board, a very compact and portable-friendly package that requires an 8 to 15 V dc supply. The LCD screen located on the face of the SideKar has five levels of amber brightness and is readable in sunlight, a must-have when operating outside on sunny summer days. Also found on the face are two pushbuttons that can be programmed with user-defined commands, such as sending a message or freezing the display (handy if decoded data is flying by too fast). The pushbuttons also allow for entering contacts in the log without a keyboard.


**Figure 22** — Transmitted text rolling across the SideKar screen.

Unlike the K-Board, the SideKar can be mounted to the side of the KX3 or the top of the KX2 using supplied mounting brackets (specify the radio at time of order). If you don't want to mount it on your radio, you can also place it near the radio on your working surface.

Setting up the SideKar is very similar to the K-Board, and it also uses the *Message Management Utility* software. In addition to displaying sent messages/macros (see Figure 22), the two-line LCD displays the most recent 40 characters of decoded PSK, RTTY, or CW from the radio. That's quite a bit more text than is available on the radio's eight-character scrolling display. (A SideKar Plus version, with a four-line display, is also available.)

In addition, once powered on and connected, the SideKar can store a log with up to 1,000 contacts, including call sign, date, time, frequency, mode, and exchange information up to 10 characters. A special DXpedition logging mode offers a quick way to respond and log calls. This abbreviated logging mode was designed for Summits on the Air, county hunting, and other portable/mobile operations. When you have completed your on-the-air operations, the SideKar offers the option for ADIF file export to a PC or MacBook.

During my summer radio outings using the SideKar, I found having the keyboard gave me easy access to control all my messages, modes, frequencies, and logging. With this external keyboard, I was no longer required to be hunched over the radio while operating, giving me the freedom to kick back, drink some cold lemonade, and relax at the park.

For those portable Elecraft radio operators looking to expand their radio's functionality, keyboard messaging, and logging options, these QRPworks products are a great addition to their radio gear.

*Manufacturer:* QRPworks, **www.qrpworks.com**. Price: K-Board, $169; SideKar, $259; SideKar Plus (four-line display), $279; compact wireless keyboard, $27.95; power splitter cable, $19.95.

# MFJ-914 AutoTuner Extender

*Reviewed by Steve Ford, WB8IMY*
QST *Editor*
**wb8imy@arrl.org**

The antenna tuners inside most HF transceivers are only designed to handle SWRs of 3:1 or less. And even some external tuners, including some automatic antenna tuners, have restricted tuning ranges. These limitations are understandable when you consider that the designs must juggle a number of variables, including physical size and cost.

The MFJ-914 AutoTuner Extender aims to solve, or at least mitigate, this problem by adding inductance beyond what a tuner can usually offer.

### Bottom Line

The MFJ-914 offers a way to bring antenna system SWR within the range of the internal autotuner found in many transceivers. It may not work in all cases, but could allow operation on an additional band (or bands) with an existing antenna.


Within its compact 5 × 3 × 2 inch footprint, the MFJ-914 enclosure is dominated by an eight-position rotary switch that selects various sections of a stacked set of three toroidal coils. The OFF position selects a dummy load, if you have one attached to the labeled SO-239 connector. (The OFF position also grounds the center conductor of the antenna system coaxial cable.) Position D bypasses the MFJ-914 entirely for a direct connection to the antenna.

## Using the MFJ-914

I decided to try the MFJ-914 with my 40-, 20-, 15-, and 10-meter off-center-fed dipole antenna. Using an antenna analyzer, I measured SWRs on 80, 60, 30, and 17 meters that were well in excess of what my transceiver's built-in automatic tuner could handle (see Table 11).

By switching in the MFJ-914 and selecting various positions, I was able to lower the SWRs on 60, 30, and 17 meters by about half, placing them within range of the transceiver tuner. The SWR on 80 meters remained out of reach, but I knew that was a stretch to begin with!

## Some Caveats

The toroidal coil stack within the MFJ-914 is rather small (see Figure 23); it is only about the size of my ample thumb. So, despite the 300 W specification, I would be wary of running more than 100 W with a continuous-duty mode, such as PSK31 or RTTY, especially if the SWR on the antenna side is high. I made some RTTY contacts on 30 meters with about 80 W output, and the MFJ-914 became noticeably warm to the touch. That's usually a symptom of saturated toroids, which results in elevated losses.

Also, keep in mind that the MFJ-914 isn't capable of working magic. The 5.4:1 antenna system SWR that I measured on 60 meters, for example, is still present, even with the intervention of the extender. Just like your antenna tuner, all the MFJ-914 is doing is making an impedance transformation. It may allow your antenna tuner to cope with bands you cannot otherwise use, but the losses caused by the elevated SWR remain between the station and the antenna. If you are using low-loss coaxial cable, these SWR losses may not be significant, but it is something to consider.

Finally, as they say in the car commercials, "your mileage may vary." Each antenna system presents a unique impedance at various frequencies. What worked well for me may not work as well for you. But if you find an inductance that lowers your SWR sufficiently, you may suddenly add a new band to your station.

*Manufacturer:* MFJ Enterprises, P.O. Box 494, Mississippi State, MS 39762; **www.mfjenterprises.com**. Price: $79.95.

**Table 11**
**SWRs With and Without the MFJ-914**

| Band (Meters) | Without MFJ-914 | With MFJ-914 |
|---|---|---|
| 80 | 6.8:1 | 4.2:1 |
| 60 | 5.4:1 | 3.2:1 |
| 30 | 4.7:1 | 2.8:1 |
| 17 | 6:1 | 3.7:1 |

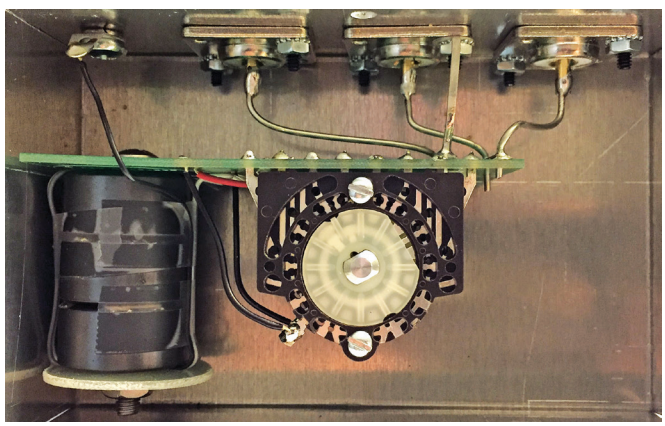


**Figure 23** — An inside view of the MFJ-914. The three-toroid stack is visible on the left-hand side.

# *Satellite Ham Radio* (*HamSat*) App for *iOS* Devices

*Reviewed by Steve Ford, WB8IMY*
QST *Editor*
**wb8imy@arrl.org**

According to AMSAT's Bruce Paige, KK5DO, satellite operating during Field Day 2017 was at its highest level since Bruce began keeping records nearly 15 years ago. Hams at Field Day sites were working the FM repeater satellites, enjoying SSB and CW contacts through linear transponder birds, such as OSCAR 29, and even making packet radio connections through the digipeater aboard the International Space Station.

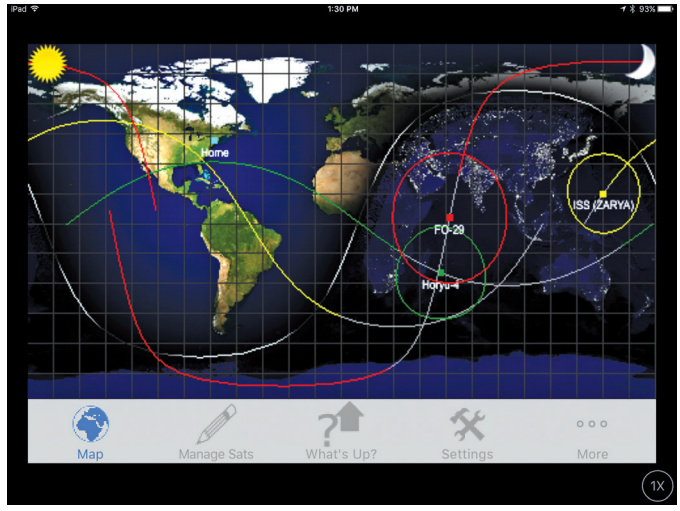



**Figure 24** — The *HamSat* map display.

In years gone by, if you wanted to enjoy satellite operating from the field, you had to drag along a laptop computer so that you could calculate the position of your chosen satellite and predict when it would arrive overhead. Thanks to the advent of smartphones and tablets, however, that aspect of satellite operating has become much more convenient.

Today, we have satellite-prediction apps for Apple and Android devices. Some of these apps are quite elaborate with a multiplicity of features, but when you're on the road, simple is often best.

## Satellite Ham Radio

The *Satellite Ham Radio* app for iPhones and iPads, better known as *HamSat*, takes a no-nonsense approach to presenting the information you need. This is not to say that *HamSat* doesn't offer a number of convenient features, but rather than presenting you with a complex program and a steep learning curve, this app is designed to make it quick and easy to find your way around.

Of course, like all satellite-prediction apps, *HamSat* includes a map with the ability to display the tracks of your selected satellites (see Figure 24). For this review, I chose the iPhone version of *HamSat*, which provides a lower-resolution display to accommodate smaller screens. If you want improved graphics, there is also an HD version for iPads.

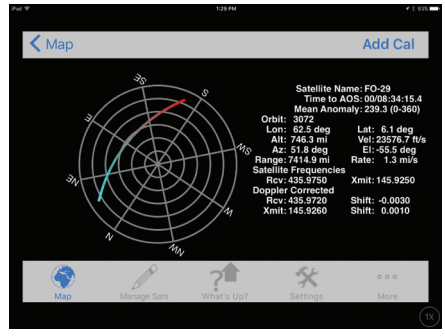



**Figure 25** — In the overhead pass display, you can see the track your chosen satellite will take (OSCAR 29, in this example). If you tap CAL in the upper left corner, *HamSat* will automatically place an entry in your calendar app and sound an alert when the bird is approaching.

The pass display (see Figure 25) is particularly well done. In addition to displaying the path the satellite will take over your location, it can display uplink and downlink frequencies with Doppler compensation included. As the satellite passes overhead, you'll notice that *HamSat* indicates a section of the track in red. That's a handy reminder that the bird is heading down toward the horizon. If you're going to wrap up the contact, you'd better do it now!

Speaking of locations, *HamSat* makes use of the mobile device's built-in GPS receiver to determine your position relative to the expected track of the satellite (see Figure 26). As you turn your device, *HamSat* will also use the compass function to automatically update the track.

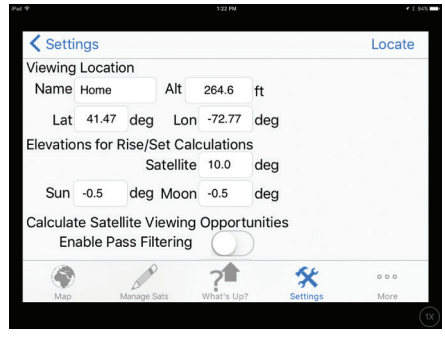



**Figure 26** — You don't have to worry about filling in latitude and longitude information. Tap LOCATE and *HamSat* will do it for you.

*Manufacturer:* Craig Vosburgh, WØVOS. Available in the Apple iTunes app store. Price: $7.99.

### Bottom Line

The *HamSat* app for *iOS* offers a convenient way to track satellites with your iPhone or iPad while you're on the go.

# Borden One-Tube AM Broadcast Band Radio Kit

*Reviewed by Paul Danzer, N1II*
**n1ii@arrl.net**

After unpacking the Armstrong One-Tube Radio Kit from Borden Radio Company, the first thing I did was sand down the wooden base a little bit. As I did so, I realized that this was something I had not done since woodworking shop in high school. In fact, the last time I built a one-tube radio was about then.


I started to wonder what I would hear when I finished the kit, which receives the AM broadcast band, approximately 550 to 1,700 kHz. With my last one-tube radio, I listened to the late Jean Shepherd, K2ORS, on WOR — a clear channel station out of New York at that time. Listening along with me were many other teenagers up and down the east coast and into the midwest as Jean regaled us with stories of his childhood.

## Reviving the Past

The concept of positive feedback (a regenerative circuit) is usually credited to Edwin Armstrong in 1912. As applied to a tube-type radio receiver, a small amount of the output signal from the plate circuit is fed back to the grid circuit (input). The same circuit could be used as a transmitter, although it would probably be somewhat unstable.

Regenerative receivers using one tube (and occasionally a second tube as an audio amplifier) were very popular as simple receivers for new hams. There were usually just two knobs — one for frequency tuning and one to control the amount of feedback or regeneration. If there was an additional audio amplifier tube, a third knob controlled volume.

Because the amount of feedback had to be controlled manually, this configuration was never popular in home radios — they required two hands to tune in each station. For amateur use, the regeneration control could be set high enough so that the single tube acted both as an amplifier and a local oscillator; the resulting beat note allowed reception of CW signals.

Although designs for these simple receivers were still being published in the 1950s, they were not terribly useful — especially in the crowded Novice segments of 40 and 80 meters at night. But they did give many new hams their initial thrill of building a receiver.

## Circuit Description

Lance Borden, WB5REX, provides an interesting description of this radio, as well as some history of the circuit, online at the Borden Radio Company website. It is a classical regenerative circuit with a few changes to make the notoriously regenerative circuit a bit more stable.

You will need high-impedance earphones/headphones or an amplified speaker to listen to the kit. A high-impedance magnetic earphone is included, and a number of options are available from the Borden Radio website. The kit includes a blocking capacitor, so the dc fed to the tube does not go through the earphones.

The largest part of the kit is a pre-drilled wood base. A classical variable capacitor does the tuning for the 3S4 tube. You have to wind your own coil on a cardboard form with the supplied wire. Some connections are made through the eight Fahnstock clips. Caution: at first glance, the coil form could be mistaken for a spacer in the packing material. Save everything until you know you have found all the pieces.

## Putting It Together

Probably the best way to start is to skim the instructions and prepare the coil form and base. Sanding the base may be a good idea, and the instructions suggest several coats of acrylic lacquer. I decided to first shellac the base for color and then use clear lacquer, but you could also use a lacquer with a built-in stain. Coating the board is just for appearance, so you can skip this step if you prefer the unfinished look.

Finishing the cardboard coil form with several coats of lacquer is highly recommended. If it is used or stored in humid conditions for an extended period, the cardboard could swell and change the coil dimensions. It's a good idea to lightly sand the inside of the coil form where small islands of cardboard remain after the holes were drilled.

### Bottom Line

The Borden One-Tube AM broadcast band radio is a fun project that lets you try out skills needed in the 1950s and earlier.

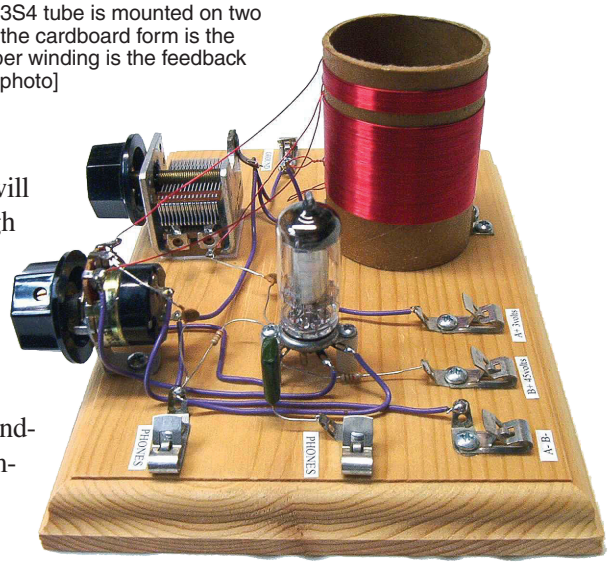



**Figure 27** — The socket for the 3S4 tube is mounted on two standoffs. The lower winding on the cardboard form is the tuned circuit inductance; the upper winding is the feedback loop. [Lance Borden, WB5REX, photo]

To assemble the coil, you will need to thread wires through the holes from both the outside and inside of the form. If you jump ahead to the last few pages of the assembly instructions, there are some excellent hand-drawn pictures of the assembled parts, so you can see where you are going. Plan ahead — you are going to need a ruler and perhaps masking tape to hold the wire down when you wind the coils.

You must make three windings on the coil form — 20, 55, and 15 turns. It's a bit tedious, but is something to point to with pride when you show off this radio to your local ham club. Pay attention to the instruction that the 15-turn coil must be wound in the same direction as the 55-turn coil, or else you will probably have to reverse the leads of the 15-turn coil to get regeneration.

Have pre-cut pieces of masking tape to hold the wires down if you have to pause winding before you have finished. The instructions give you the lead lengths when you start and finish each winding. Cut the wires to the length shown in the instructions. When you are ready to solder each coil end, completely sand or scrape off the enamel on the wire and tin the exposed wire surface.

When you unpack the kit, you will find a rolled-up piece of paper about the size of a large cigar. Inside are the few needed small components, already sorted and labeled.

The wiring is completed by following the three sketches supplied. There was only one pair of wires not very visible in the sketches. Pin 6 of the tube goes to the right-hand lug of the REGEN potentiometer (as you face the pot), and Pin 4 goes to the left-hand lug. The instructions also caution you to make sure the top (smaller) winding is connected correctly to the potentiometer. Reverse these leads, and you will not get any regeneration. If you have any questions, an e-mail to Lance, WB5REX, will usually bring a quick response.

I did run into one snag. Being ultra-cautious, and not wanting to blow out the tube, I left the tube unplugged and turned power on to measure the filament voltage — it read zero. That's when I discovered I left one wire off.

When you have completed the assembly, you will find a set of four felt bumpers. These are feet for the board, so you can display the radio on a finished table. Figure 27 shows the finished product. The manufacturer calls this a two-evening kit, but the time it takes between coats of lacquer on the base and coil form stretches that out.

## Finishing Touches

A high-impedance earphone is included with the kit, but we ordered the optional high-impedance headphones. They came with an adapter jack to convert the ¼-inch phone plug to two clip leads for the earphone Fahnstock clips on the wood chassis.

The last step is to set up batteries for power. The kit includes a holder for two standard 1.5 V D cells that provide 3 V for the filament (the "A battery" in vintage terms). Plate voltage (45 V — the "B battery") is supplied by five 9 V batteries clipped together in series with supplied connectors.

In keeping with the old-time spirit of this radio, we ordered the reproduction vintage battery cases, shown in the photo. When you pop open the A battery case, you will find a plastic holder for a standard D cell, connected to the terminals on the case top. The bottom of the B battery case comes off, revealing series-wired connectors for five standard 9 V batteries.

## When You Are Finished

With headphones connected, the first station I heard was a high-power CBS outlet whose antennas are more than 50 miles away. Then, with careful tuning, I had no problem hearing other stations. Selectivity, as expected, is not great, but control of the regeneration is a lot easier than I remember from years ago. I found that adding a small audio amplifier to the output improved reception.

Performance depends highly on the antenna used. A good outdoor antenna, at least 50 feet long, is needed for best results. There are two antenna inputs, one through a capacitor and one directly to the coil. A bit of experimentation will be in order to see which connection works best for your particular antenna.

In summary, the Borden One-Tube Radio offers an opportunity to build a simple radio like they did in the old days. It looks good enough to put on display and works well enough to listen to listen to AM broadcasts.

*Manufacturer*: Borden Radio Company, **www.xtalman.com**. Price: One-Tube Radio kit, $74.95; battery cases, $29.95 each; high-impedance headphones, $29.95.