Product Reviews

November 2014

Product Reviews:

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Hilberling PT-8000A MF, HF, and VHF Transceiver

This offering from Hilberling brings a new level of equipment to the US Amateur Radio marketplace.

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It's been a long time since we've seen Amateur Radio HF transmitting equipment manufactured in Europe offered in the US market, but that's changing. In the June issue of *QST,* we reviewed the Zeus ZS-1 software defined transceiver from SSB Electronic, and this month we explore the Hilberling PT-8000A, also from Germany. The PT-8000A is Hilberling's first offering in the Amateur Radio field, and they have entered with a very serious radio. It's important to note that Hilberling has been developing telecommunications equipment for the commercial marketplace for many years and is no stranger to high-end RF gear.

The PT-8000A is a nominal 200 W HF (160 through 10 meters), and 100 W VHF (6, 4 [European version only], and 2 meters) SSB, CW, AM, FM, and digital mode transceiver. The '8000A arrives fully equipped, with a separate dedicated power supply, all available IF filters, a very solid and good sounding push-to-talk (PTT) desk mic, interconnecting cables and matching plugs for many sockets on front and rear. In addition to its operational and technical features, the '8000A is sure to fit into your shack's décor with its choice of several designer front panel colors. We picked the medium blue, as shown in the photos. It might even make it into the family room!

This radio appears to be solidly engineered and constructed to a level not frequently seen in amateur gear. All controls and connectors appear to be a professional type, and of first quality, and there is unprecedented access to points within the signal paths via miniature coax jumpers with SMA connectors along the rear of the unit. The transceiver is not small, with plenty of space for all controls and indicators on the front panel. It also isn't a lightweight. At 62 pounds, it's a two-person lift — and once in place, it doesn't even think about moving while the headphone plug is seated or the controls adjusted.

Bottom Line

The Hilberling PT-8000A is a high-quality, full sized HF and VHF transceiver that combines a fine receiver and very good sounding transmitter in a well-made, professional package.

The separate power supply is actually lighter than I expected. It puts out both 13.8 V dc for the low level circuits and 50 V dc for the field-effect transistor (FET) based transmit power amplifier. It includes a large DC INPUT power meter on the front panel (0 – 0.8 kW scale) — an interesting and unusual touch — as well as a front firing speaker for the sub receiver.

Conversion Architecture

The transceiver is of dual-conversion architecture with the first receive IF at 40.7 MHz, including a 50 kHz wide filter. The analog noise blanker receiver and processor is tapped from the wideband 40.7 MHz IF. The main signal path next converts down to its 10.7 MHz second IF, at which point there are crystal lattice filters at 0.5, 3, and 15 kHz bandwidth. The FM demodulation occurs following the 15 kHz filter while other modes continue for additional processing, including a bank of 16-pole 10.7 MHz crystal filters with more bandwidth choices.

The 10.7 MHz IF includes the gate driven by the noise blanker, as well as the analog notch filter. The 10.7 MHz IF signal is demodulated for DSP processing, providing mode specific DSP bandwidth selection from 50 Hz to 6 kHz width. The DSP also provides a digital receive notch (in addition to the manually adjusted analog notch), and three bands of microphone equalization on transmit.

If a bandwidth is selected that matches the crystal filters, the DSP can be bypassed with the receiver using just the competent crystals filters to set the operating bandwidth. For the many more available bandwidths, the DSP is inserted in the process. It is so seamless that you have to look at the indicator to see which filters you are using — very nice!

A very flexible automatic gain control (AGC) system is provided. Hang times of 100 or 500 ms can be selected as well as 1, 2, or 3 seconds, with the system automatically going to 100 ms while tuning to avoid missing weak signals near strong ones. The AGC is driven by the RF level past the analog crystal filters; AGC threshold is adjustable.

The entire receiver described above is duplicated for the sub receiver. The sub receiver audio can be combined with the main receiver audio output or maintained as separate audio paths for use with stereo headphones, external speakers, or even the two internal speakers, one on the main unit, the other on the front of the power supply.

The sub receiver can operate from either of the two HF antenna inputs, the separate receive antenna input, or the VHF antenna port. It is designed to be always available in order to monitor another frequency, perhaps a local 2 meter repeater, even while the transceiver is in two-way operation on HF. In the version of software available during the review period, it is muted during transmit only if the radio is operating in SPLIT mode. It took a note to the factory to find out why I was getting feedback or hash in the sub receiver audio while transmitting on the same band. They noted that the next firmware version will allow sub receiver muting, even if not in SPLIT mode. This will facilitate diversity reception using a separate antenna on the RX ANT port, for example.

Each receiver has a dedicated front panel tuning knob, each with a very smooth weighted feel. The SUB-VFO knob is considerably smaller but has just as good a feel. It is easy to move frequencies between the VFOs, as well as a second frequency avail-

Table 1
Hilberling PT-8000A, serial number 13040144

Manufacturer's Specifications	**Measured in the ARRL Lab**
Frequency coverage: Receive, 0.009 – 30, 50 –54, 69.9 – 70.5, 110 – 148 MHz; transmit, 160, 80, 60, 40, 30, 20, 17, 15, 12, 10, 6, and 2 meter amateur bands.	Receive and transmit, as specified.
Power requirement: 90 – 260 V ac, 12.5 A, 50-60 Hz.	660 VA (transmit, maximum RF power output), 122 VA (receive, full volume, no signal, maximum display brightness), 119 VA (minimum display brightness).
Modes of operation: SSB, CW, AM, FM, data.	As specified.
Receiver	**Receiver Dynamic Testing, Main Receiver**
CW sensitivity, 10 dB S+N/N: 0.5 µV (9 kHz – 1.8 MHz); 0.1 µV (1.8 – 30, 50 – 54 MHz); 0.09 µV (69.9 – 70.5, 144 – 148 MHz); 0.14 µV (110 – 143.999MHz) for 500 Hz filter bandwidth.	Noise floor (MDS), 500 Hz DSP bandwidth, 500 Hz roofing filter: *Preamp off* / *Preamp on* 0.137 MHz –127 dBm n/a 0.475 MHz –127 dBm n/a 1.0 MHz –127 dBm n/a 3.5 MHz –127 dBm –140 dBm 14 MHz –128 dBm –140 dBm 50 MHz –123 dBm –143 dBm 70 MHz –120 dBm –141 dBm 144 MHz –123 dBm –144 dBm
Noise figure: Not specified.	Preamp off/on: 14 MHz, 19/7 dB; 50 MHz, 24/4 dB; 70 MHz, 27/6 dB; 144 MHz, 24/3 dB.
AM sensitivity, 10 dB S+N/N: 2.0 µV (9 kHz – 1.8 MHz); 1.2 µV (1.8 – 30 MHz); 1.0 µV (50 – 54, 69.9 – 70.5, 144 – 148 MHz); 1.5 µV (110 – 143.99 MHz) for 6 kHz filter bandwidth.	10 dB (S+N)/N, 1 kHz, 30% modulation, 6 kHz DSP bandwidth: *Preamp off* / *Preamp on* 1.0 MHz 5.30 µV n/a 3.8 MHz 3.39 µV 0.82 µV 50.4 MHz 7.15 µV 0.60 µV 70.4 MHz 8.00 µV 0.62 µV 120 MHz 3.75 µV 0.40 µV 144.4 MHz 6.30 µV 0.55 µV
FM sensitivity, 10 dB S+S/N: 0.5 µV (9 kHz – 1.8 MHz); 0.18 µV (1.8 – 30 MHz); 0.16 µV (50 – 54, 69.9 – 70.5 MHz); 0.15 µV (144 – 148 MHz); 0.18 µV (110 – 143.99 MHz) for 15 kHz filter bandwidth.	For 12 dB SINAD, 3 kHz deviation, 15 kHz bandwidth: *Preamp off* / *Preamp on* 29 MHz 1.55 µV 0.33 µV 52 MHz 3.05 µV 0.25 µV 70 MHz 2.88 µV 0.22 µV 146 MHz 2.26 µV 0.18 µV
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz DSP BW, 500 Hz roofing filter: *20 kHz offset Preamp off/on* / *5/2 kHz offset Preamp off* 3.5 MHz >137/143 dB >137/>137 dB 14 MHz >138/144 dB >138/>138 dB 50 MHz >133/138 dB >133/126 dB 70 MHz >130/137 dB >130/>130 dB 144 MHz >133/139 dB 131/123 dB*
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 118/115/111 dB.

ARRL Lab Two-Tone IMD Testing (500 Hz bandwidth, 500 Hz roofing filter)**

Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
3.5 MHz/Off	20 kHz	–34 dBm	–127 dBm	93 dB	+13 dBm
		–14 dBm	–97 dBm		+28 dBm
14 MHz/Off	20 kHz	–24 dBm	–128 dBm	104 dB	+28 dBm
		–9 dBm	–97 dBm		+35 dBm
		0 dBm	–70 dBm		+35 dBm
14 MHz/On	20 kHz	–36 dBm	–140 dBm	104 dB	+16 dBm
		–18 dBm	–97 dBm		+22 dBm
14 MHz/Off	5 kHz	–24 dBm	–128 dBm	104 dB	+28 dBm
		–12 dBm	–97 dBm		+31 dBm
		0 dBm	–60 dBm		+30 dBm

Manufacturer's Specifications			Measured in the ARRL Lab		
Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
14 MHz/Off	2 kHz	–28 dBm	–128 dBm	100 dB	+22 dBm
		–12 dBm	–97dBm		+31 dBm
		0 dBm	–58 dBm		+29 dBm
50 MHz/Off	20 kHz	–25 dBm	–123 dBm	98 dB	+24 dBm
		–16 dBm	–97 dBm		+25 dBm
50 MHz/On	20 kHz	–45 dBm	–143 dBm	98 dB	+4 dBm
		–29 dBm	–97 dBm		+5 dBm
70 MHz/Off	20 kHz	–20 dBm	–120 dBm	100 dB	+30 dBm
		–13 dBm	–97 dBm		+29 dBm
144 MHz/Off	20 kHz	–26 dBm	–123 dBm	97 dB	+23 dBm
		–18 dBm	–97 dBm		+22 dBm
144 MHz/On	20 kHz	–41 dBm	–144 dBm	103 dB	+11 dBm
		–25 dBm	–97 dBm		+11 dBm

Manufacturer's Specifications	Measured in the ARRL Lab
Second-order intercept point: Not specified.	Preamp off/on, 14 MHz, +71/+47 dBm; 50 MHz, +93/+51 dBm; 70 MHz, +89/+75 dBm; 144 MHz, +77/+57 dBm.
DSP noise reduction: Not specified.	10 dB.
Notch filter depth: Not specified.	Auto notch, 50 dB; attack time, 22 ms.
FM adjacent channel rejection: Not specified.	Preamp on: 29 MHz, 89 dB; 52 MHz, 90 dB; 70 MHz, 89 dB; 144 MHz, 87 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset, preamp on: 29 MHz, 89 dB*; 52 MHz, 87 dB; 70 MHz, 89 dB*; 144 MHz, 87 dB*. 10 MHz offset: 29 MHz, 100 dB; 52 MHz, 87 dB; 70 MHz, 98 dB; 144 MHz, 89 dB.
S-meter sensitivity: Not specified.	S-9 signal, preamp off/on: 14 MHz, 50.1/48.4 µV; 50 MHz, 41.6/58.8 µV; 144 MHz, 42.6/56.2 µV.
Squelch sensitivity: Not specified.	At threshold, preamp on: FM, 29 MHz, 0.8 µV; 50 MHz, 0.33 µV; 144 MHz, 0.32 µV; SSB, 0.6 µV (14.2 MHz).
Receiver audio output: 4.48 W into 8 Ω (main and sub receiver combined).	Main receiver, 2.25 W at 10% THD into 8 Ω. THD at 1 V RMS, 3.3%.
IF/audio response: Not specified.	Range at –6 dB points (bandwidth) †: CW (500 Hz): 340 – 850 Hz (510 Hz); Equivalent Rectangular BW: 501 Hz; USB (2.7 kHz): 122 – 1910 Hz (1788 Hz); LSB (2.7 kHz): 123 – 1913 Hz (1790 Hz); AM (6.0 kHz): 393 – 3923 Hz (7054 Hz).
Spurious and image rejection: Not specified.	First IF rejection, 14 MHz, 91 dB; 50 MHz, 88 dB; 70 MHz, 111 dB; 144 MHz, 110 dB. Image rejection, 14 MHz, 116 dB; 50 MHz, 74 dB; 70 MHz, 86 dB; 144 MHz, 105 dB.

Receiver	Receiver Dynamic Testing, Sub Receiver
CW sensitivity, 10 dB S+N/N: 0.5 µV (9 kHz – 1.8 MHz); 0.1 µV (1.8 – 30, 50 – 54 MHz); 0.09 µV (69.9 – 70.5, 144 – 148 MHz); 0.14 µV (110 – 143.999 MHz) for 500 Hz filter bandwidth.	Noise floor (MDS), 500 Hz DSP bandwidth, 500 Hz roofing filter:

	Preamp off	*Preamp on*
0.137 MHz	–122 dBm	n/a
0.475 MHz	–122 dBm	n/a
1.0 MHz	–122 dBm	n/a
3.5 MHz	–129 dBm	–142 dBm
14 MHz	–130 dBm	–142 dBm
50 MHz	–122 dBm	–142 dBm
70 MHz	–120 dBm	–140 dBm
144 MHz	–121 dBm	–143 dBm

Receiver	Receiver Dynamic Testing, Sub Receiver
Noise figure: Not specified.	Preamp off/on: 14 MHz, 17/5 dB; 50 MHz, 25/5 dB; 70 MHz, 27/7 dB; 144 MHz, 26/4 dB.

able for either VFO, all clearly shown on the multicolor screen.

A four-channel voice recorder function allows recording from the audio stream of either receiver or from the mic or transmit audio. The recordings can be listened to, or they can be transmitted by pushing the mic PTT switch or the TX/ON button. They are thus usable as a contest voice keyer.

Transmitter Architecture

Not surprisingly, the transmitter architecture follows that of the receiver, with separate processing and filtering of SSB, AM, and CW at 10.7 MHz, joining up with 10.7 MHz FM and dc driven FSK before conversion to 40.7 MHz and then to the operating frequency. All amplifier stages, including the 200 W PEP FET final amplifier, are used on all bands, with just filtering changing for the different bands and ranges. If the 50 V dc output of the external power supply is not turned on, or if just a 13.8 V supply is provided, the transmitter will still operate, but with 10 W maximum output and a corresponding change in the POWER meter display. During normal operation, the transmitter can be switched to low power with a front panel button, handy for adjusting antenna tuners or amplifiers or checking general operation. An adjustable 0 to 20 dBm output is also provided for transverter or instrumentation use. A manually activated automatic antenna tuner is provided to trim loads that are not quite matched.

Control and Display Functionality

The PT-8000A is run from the front panel. There are seven groups of controls clustered within lined boxes on the panel and labeled by function, such as BAND, MODE, VFO, ANT-TUNER. In addition there are the usual knobs for functions such as MIC GAIN, IF NOTCH, MAIN, and SUB audio level that are not within clusters. In addition to front panel controls, there are a number of recessed, screwdriver-adjusted, set-and-forget controls on each side panel for functions that are not generally needed.

The display (Figure 1) is a crisp and bright multicolored TFT screen that provides lots of information in an easy-to-grasp fashion. The main VFO frequency is shown in large text, with resolution dependent on the tuning step — to 1 kHz, 100 Hz, 10 Hz, or 1 Hz. A bar above the digital frequency readout is a simulated analog dial showing where you are within the band — a nice touch. The secondary VFO is in slightly smaller text and a contrasting color, while the sub receiver VFO frequency is shown in a small block at the top. Additionally, there is a small graphical display of bandwidth, showing the width, notch, and shift compared to the carrier frequency.

The bottom of the display includes metering with a large bar-type S meter above the similar power output meter. The calibrated S meter can read in S units, dBm, or microvolts. A nice feature is that the squelch threshold is shown as a mark on the S meter, so you can adjust it to any desired level and see the level it is set to in comparison to ambient noise. (Squelch is usable in all modes.) The power meter scale automatically shifts between 250, 100, and 10 W full-scale, depending on band and selected power level. A 100 mW range is available for the low level output. Below the S/POWER meter are bar graphs for SWR and ALC, along with indications of CPU and PA TEMPERATURE.

The right-hand edge of the display includes six indicators that correspond to six buttons just outside the display window. These are indicators for "soft keys" that control functions that shift depending on the context of your control operation. For example, if you hit the SSB/CW button in the MODE cluster, the indicators and buttons become: USB, LSB, CW, CW–, STEP-UP, STEP-DOWN, with the step buttons setting the tuning step increment. Alternately, if you hit the A/B button in the VFO cluster, the buttons become: A>SUB, SUB>B, A>B, SPLIT, STEP-UP, STEP-DOWN. While it does take a bit of getting used to, I found the context-sensitive buttons to be intuitive and easier to deal with that the typical off-line MENU mode of many current transceivers.

The receive audio can feature either combined or separate paths. In order to shift to separate audio paths, the MENU button in the DISPLAY cluster in engaged. The soft keys that appear include one that can be toggled between AUDIO NORM and AUDIO SPLIT. Note that this is independent of the choice of split frequency operation (the SPLIT soft key appears in the menu that comes up when the A/B button of the VFO group is pressed, as noted above). Note that a return to the default AUDIO NORM occurs whenever power is cycled.

Unlike many receivers, plugging in headphones does not disable the speakers.

Manufacturer's Specifications Receiver (continued)	**Measured in the ARRL Lab Receiver Dynamic Testing, Sub Receiver**
AM sensitivity, 10 dB S+N/N: 2.0 µV (9 kHz – 1.8 MHz), 1.2 µV (1.8 – 30 MHz); 1.0 µV (50 – 54, 69.9 – 70.5, 144 – 148 MHz); 1.5 µV (110 – 143.99MHz), for 6 kHz filter bandwidth.	10 dB (S+N)/N, 1 kHz, 30% modulation, 6 kHz DSP bandwidth: *Preamp off / Preamp on* 1.0 MHz: 4.36 µV / n/a 3.8 MHz: 2.69 µV / 0.65 µV 50.4 MHz: 6.23 µV / 0.60 µV 70.4 MHz: 8.60 µV / 0.69 µV 120 MHz: 5.37 µV / 0.58 µV 144.4 MHz: 6.52 µV / 0.54 µV
FM sensitivity, 10 dB S+S/N: 0.5 µV (9 kHz – 1.8 MHz), 0.18 µV (1.8 – 30 MHz), 0.16 µV (50 – 54, 69.9 – 70.5 MHz), 0.15 µV (144 – 148 MHz); 0.18 µV (110 – 143.99 MHz) for 15 kHz filter bandwidth.	For 12 dB SINAD, 3 kHz deviation, 15 kHz bandwidth: *Preamp off / Preamp on* 29 MHz: 1.27 µV / 0.22 µV 52 MHz: 2.37 µV / 0.20 µV 70 MHz: 2.88 µV / 0.23 µV 146 MHz: 2.57 µV / 0.21 µV
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz DSP BW, 500 Hz roofing filter: *20 kHz offset Preamp off/on / 5/2 kHz offset Preamp off* 3.5 MHz: 135‡/145 dB / 135‡/135‡ dB 14 MHz: >140/144 dB / >140/>140 dB 50 MHz: >132/135 dB / >132/>132 dB 70 MHz: >130/135 dB / >130/>130 dB 144 MHz: >131/139 dB / >130/129 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 112/111/103 dB.

ARRL Lab Two-Tone IMD Testing (500 Hz DSP bandwidth, 500 Hz roofing filter)**

Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
3.5 MHz/Off	20 kHz	–34 dBm	–130 dBm	96 dB	+14 dBm
		–13 dBm	–97 dBm		+29 dBm
14 MHz/Off	20 kHz	–27 dBm	–130 dBm	103 dB	+25 dBm
		–17 dBm	–97 dBm		+23 dBm
		0 dBm	–54 dBm		+27 dBm
14 MHz/On	20 kHz	–42 dBm	–142 dBm	100 dB	+8 dBm
		–28 dBm	–97 dBm		+7 dBm
14 MHz/Off	5 kHz	–32 dBm	–130 dBm	98 dB	+17 dBm
		–18 dBm	–97 dBm		+22 dBm
		0 dBm	–48 dBm		+24 dBm
14 MHz/Off	2 kHz	–33 dBm	–130 dBm	97 dB	+16 dBm
		–18 dBm	–97 dBm		+22 dBm
		0 dBm	–48 dBm		+24 dBm
50 MHz/Off	20 kHz	–26 dBm	–122 dBm	96 dB	+22 dBm
		–18 dBm	–97 dBm		+24 dBm
50 MHz/On	20 kHz	–46 dBm	–142 dBm	96 dB	+2 dBm
		–32 dBm	–97 dBm		+1 dBm
70 MHz/Off	20 kHz	–23 dBm	–120 dBm	97 dB	+26 dBm
		–16 dBm	–97 dBm		+25 dBm
144 MHz/Off	20 kHz	–21 dBm	–121 dBm	100 dB	+29 dBm
		–15 dBm	–97 dBm		+26 dBm
144 MHz/On	20 kHz	–41 dBm	–143 dBm	102 dB	+10 dBm
		–28 dBm	–97 dBm		+7 dBm

Second-order intercept point: Not specified.	Preamp off/on, 14 MHz, +71/+67 dBm; 21 MHz, +51/+33 dB; 50 MHz, +93/+51 dBm; 70 MHz, +89/+75 dBm; 144 MHz, +77/+57 dBm;
DSP noise reduction: Not specified.	10 dB.
Notch filter depth: Not specified.	Auto notch, 45 dB; attack time, 23 ms.
FM adjacent channel rejection: Not specified.	Preamp on: 29 MHz, 88 dB; 52 MHz, 89 dB; 70 MHz, 89 dB; 144 MHz, 86 dB.

Manufacturer's Specifications Receiver (continued)	Measured in the ARRL Lab Receiver Dynamic Testing, Sub Receiver
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset, preamp on: 29 MHz, 88 dB; 52 MHz, 83 dB; 70 MHz, 86 dB; 144 MHz, 86 dB*; 10 MHz offset: 29 MHz, 111 dB; 52 MHz, 88 dB; 70 MHz, 98 dB; 144 MHz, 88 dB.
S-meter sensitivity: Not specified.	S-9 signal, preamp off/on: 14 MHz, 47.3/42.6 µV; 50 MHz, 48.9/54.9 µV; 144 MHz, 45.1/54.9 µV.
Squelch sensitivity: Not specified.	At threshold, preamp on: FM, 29 MHz, 0.12 µV; 50 MHz, 0.09 µV; 144 MHz, 0.09 µV; SSB, 0.43 µV (14.2 MHz).
Receiver audio output: 4.48 W into 8 Ω (main and sub receiver combined).	Sub receiver, 2.25 W at 10% THD into 8 Ω. THD at 1 V RMS, 3.2%.
IF/audio response: Not specified.	Range at –6 dB points (bandwidth) †: CW (500 Hz): 350 – 850 Hz (500 Hz); Equivalent Rectangular BW: 503 Hz; USB (2.7 kHz), 123 – 1655 Hz (1643 Hz); LSB (2.7 kHz), 122 – 1655 Hz (1644 Hz); AM (6.0 kHz), 370-3980 Hz (7220 Hz).
Spurious and image rejection: Not specified.	First IF rejection, 14 MHz, 96 dB; 50 MHz, 81 dB; 70 MHz, 83 dB; 144 MHz, 128 dB. Image rejection, 14 MHz, 110 dB; 50 MHz, 73 dB; 70 MHz, 82 dB; 144 MHz, 108 dB.
Transmitter	**Transmitter Dynamic Testing**
Power output: HF, 200 W (50 W AM); VHF, 100 W (25 W AM).	1.8 MHz, 4 – 189 W; 3.5 MHz, 8 – 215 W; 5.3 MHz, 0 – 93 W; 7.0 MHz, 3 – 192 W; 10.1 MHz, 3 – 187 W; 14 MHz, 2 – 180 W; 18.1 MHz, 2 – 187 W; 21 MHz, 2 – 187 W; 24.9 MHz, 2 – 183 W; 28 MHz 3 – 183 W; 50 MHz, 3 – 92 W††; 144 MHz, 4 – 100 W; AM, HF typically 3 – 30 W; VHF, 3 – 13 W.
Spurious-signal and harmonic suppression: Not specified.	1.8 MHz, 55 dB; 3.5 MHz, 46 dB; 5.3 MHz, 46 dB; 7.0 MHz, 56 dB; 10.1 MHz, 63 dB; 14 MHz, 55 dB; 18.1 MHz, 59 dB; 21 MHz, 54 dB; 24.9 MHz, 57 dB; 28 MHz, 56 dB; 50 MHz, 60 dB; 144 MHz, 65 dB. Complies with FCC emission standards.
SSB carrier suppression: ≥ 70 dB.	65 dB.
Undesired sideband suppression: >70 dB.	>70 dB.
Third-order intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th order, HF, 200 W PEP, –26/–41/–50/–52 dBc (worst case, 160 m), typically –35/–48/–54/–59 dBc; 50 MHz, –40/–44/–57/<–60 dBc; 144 MHz, –29/–41/–55/<–60 dBc.
CW keyer speed range: Not specified.	5 to 54 WPM, iambic modes A and B.
CW keying characteristics: Not specified.	See Figures 3 and 4.
Transmit-receive turn-around time (PTT release to 50% audio output): Not specified.	S9 signal, AGC fast, 40 ms.
Receive-transmit turn-around time (tx delay): Not specified.	SSB, 43 ms; FM, 51 ms.
Transmitted phase noise: Not specified.	See sidebar.

Size (height, width, depth, including protrusions: transceiver, 6.8 × 16.8 × 18.3 inches; power supply, 6.8 × 9.0 × 17.0 inches (including protrusions). Weight, transceiver, 62 pounds; power supply, 22 pounds.

Price: 13,290 Euros including 19% VAT, not including shipping (about $17,500).

*Measurement was noise-limited at the value indicated.
**ARRL Product Review testing includes Two-Tone IMD results at several signal levels. Two-Tone, Third-Order Dynamic Range figures comparable to previous reviews are shown on the first line in each group. The "IP3" column is the calculated Third-Order Intercept Point. Second-order intercept points were determined using –97 dBm reference.
†Default values; bandwidth adjustable via DSP.
‡Threshold of receiver overload was +6 dBm at 3.5 MHz.
††Power output was measured at 55 W at 50.1 MHz.

Instead, each receiver VOLUME control includes a push ON/OFF function that can silence each speaker independently. These also return to the default ON position following a power cycle.

Band selection can be accomplished in a number of ways. A keypad, which also serves as a numeric frequency entry device, has indicators for each HF band; the 0 numeric key indicates VHF. Pushing one of the band keys moves the main VFO and receiver to the last frequency you used on that band, including the last mode and bandwidth (DSP or analog). Push it again and you will switch to the second to last mode and frequency.

If the band buttons don't suit you, you can enter your frequency of choice using the numeric keypad, or you can select one of the memory channels in three banks of 99 channels each. Each memory channel includes frequency, mode, and receive bandwidth.

Connections and Connectors

The front panel MIC connector is of the popular eight-pin round type. The connections for dynamic mic and PTT match the Kenwood configuration, but the rest of the connections are different. It should work fine with a commercial adapter designed to connect a Kenwood radio to a dynamic headset, for example. The other connections in the MIC jack are interesting — such as audio outputs for main and sub receiver, a separate input for electret mics that want the operating voltage in line with the audio, and a line level (0 dBm) input — perhaps designed for a remote audio connection. Thus if you make your own adapter, there can be additional flexibility.

The front-panel HEADPHONE jack is a standard ¼-inch stereo jack that can provide the same audio feed to each ear, or the main receiver output can be in one ear, while the sub receiver is in the other, as described above — just what you want for SPLIT operation while chasing DX.

Next to the HEADPHONE jack is the CW KEY jack, also a ¼-inch stereo jack. By pushing the KEYER soft key (in the TX menu), you will be able to select EXT keyer (can also be used with a straight key), NORMAL or REVERSE connected paddles, or specify ULTIMATIC, IAMBIC A or B modes. The KEYER SPEED, DELAY, and MONITOR controls are located near the CW KEY jack.

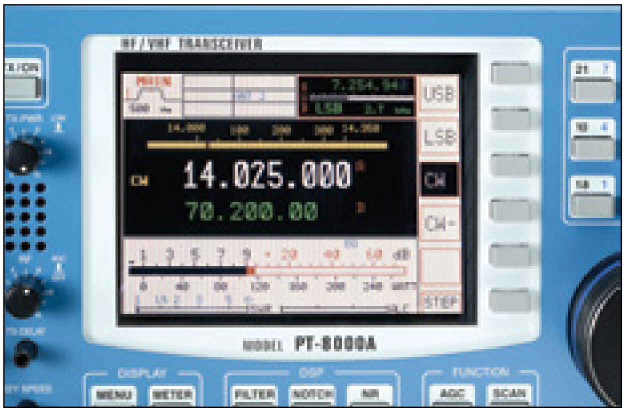


Figure 1 — The PT-8000A's colorful display prominently indicates the main receiver's VFO A and B frequencies, mode and filter bandwidth. The sub receiver frequency, mode and bandwidth are shown in the upper right corner. Metering functions (S meter, transmitter power, ALC, and SWR) are shown along the bottom. Along the right-hand side are soft buttons — button functions change to allow quick access to various settings and menu options.

Figure 2 — The Hilberling PT-8000A rear panel, showing the available connections.

A bit of an unfortunate design choice (for this operator) is that the MONITOR control serves as both voice monitor in voice modes and CW keyer monitor in CW mode. Thus if you change modes frequently, you always have to remember to change the control to match the new mode. The audio feedback with the MONITOR turned up for CW will remind you quickly if you change to a voice mode while the speaker is on and forget to readjust.

Rear Panel Connections

The rear panel (Figure 2) provides Type N sockets for two HF antennas and another for a VHF antenna. There is also a BNC socket for a receive-only antenna. There is no question that Type N coax connectors are electrically superior to the UHF type usually found on commercial amateur gear, although it's not clear that the advantages are necessary in the usual HF home station environment. I used Type N to UHF adapters for each connection to my UHF terminated antenna cables, along with right-angle UHF adapters, because space behind the radio was not sufficient for the needed bend radius of the RG-213 coax runs leaving the radio. This worked fine, although if it were my radio, I would change out the connectors on the cables to match those on the radio and select Type N right angle adapters.

Along the bottom edge of the rear panel are many of the typical connections, along with a few that are not commonly seen on an amateur transceiver. Starting from the left, there is a typical ground stud, but also a proprietary GROUND socket intended for the supplied ground cable that goes to a similar connector on the power supply. Next there are two BNC sockets. One provides an output of the internal 10 MHz reference oscillator, in case you want to synchronize your other gear. The other is for a 10 MHz reference input that could be used to lock the radio to a high-accuracy frequency standard. Next are two 3.5 mm stereo jacks. The first is a 60 kHz modulated carrier containing I and Q samples of both the main and sub receiver. This is designed to connect to a sound card for use with Hilberling's supplied spectrum scope software (more on this later). The second is a jack for external stereo speakers. An input is provided for an ALC voltage to control the transmit output level. Next is a nine-pin D-SUB socket that provides PTT in and out, dc samples of the forward and reflected power level, ALC and other functions that might be useful to control a connected linear amplifier.

Near the middle is the DC INPUT connector. This is a sturdy four-pin connector of a type I haven't seen, designed to bring in the 13.8 V and 50 V supply voltages from the companion power supply using the supplied cable. Next is a socket for a PS/2 keyboard for communicating with the main CPU. This appears to be a development connection, since no functions are defined. A 15-pin D-SUB socket that provides audio-in for data modes, as well as audio out for both receivers and PTT is next. Then there is a 25-pin D-SUB socket that is intended to support audio, PTT control, data and 1 A at 12 V for interconnection of up to two transverters. On the far right of the bottom row is a standard USB connector, which can be used with a supplied cable to connect to a USB port on a PC for computer control of the radio (Kenwood emulation) or updating of software.

What is really unusual is the set of eight SMA coaxial sockets along the rectangular box at the upper left of the rear panel. These sockets provide samples of — or in two cases, allow insertion of — processing within the RF signal path of each receiver. One pair (interconnected by a short jumper) is in the antenna circuit after the selection matrix and TR switching of the main receiver; the other in the same position of the sub receiver. Two more are at the 40.7 and 10.7 MHz IFs, right after the first and second mixer of the main and sub receiver. In each case they provide a wideband sample of what each receiver has to work with at that point in the signal chain. These could be used for an alternate parametric display, within the bandwidth limits, or many other off-line processing functions — left for the user to contemplate.

How Does it Play?

As you might expect, this radio performs very well as measured by most key parameters. Initial testing in the ARRL Lab indicated a non-uniform two-tone IMD dynamic range response in the main receiver — on HF, the IMD levels were different above and below the desired frequency — and levels were not consistent from test to test. In the sub receiver, IMD levels were consistent and uniform, but the reciprocal mixing dynamic range at 2 kHz spacing measured only 93 dB and noise created by reciprocal mixing made receiver tests difficult. After discussing these issues and some transmitter issues (see below) with Hilberling, we returned the transceiver to Germany for repair.

Table 1 shows the results of ARRL Lab testing of our PT-8000A after its return from Germany. Of particular note is the receiver dynamic performance. This is a very good receiver in terms of the important near-in (2 kHz) intermodulation and blocking dynamic range. Even better is the reciprocal mixing dynamic range, one of the best we've measured in a traditional heterodyning receiver. What was surprising to me was that I had come to believe this kind of receiver performance could only be achieved with a down-converting architecture. The folks at Hilberling have shown that with careful system design and component selection, it can be achieved in other configurations as well.

On the transmit side, the performance is good, but perhaps not quite as remarkable. Almost all of the parameters are within or close to specifications. The spurious responses are also within FCC requirements, although it took some work on its trip back to Germany to get the spurious response on 60 meters within FCC requirements. They also improved spurious suppression on 80 meters, blocked transmission on the 4 meter band (for US versions), and fixed a CW keying problem on 20 – 10 meters.

The transmit output power was not quite up to specification on most bands, a surprising result. This is not a big deal in most circumstances since the difference between 200 and 183 W, for example, is less than 0.4 dB. I did find that the AM HF carrier power of 30 versus the specified 50 W did cause me some operational problems, as noted below.

The internal automatic antenna tuner is specified to tune an SWR of up to 2:1 to within 1.5:1. I found that it could easily deal with antennas with a somewhat higher SWR, but this should be considered a *trimming* tuner, not the kind of wide-range tuner needed for many multiband antenna systems.

On the Air at W1ZR

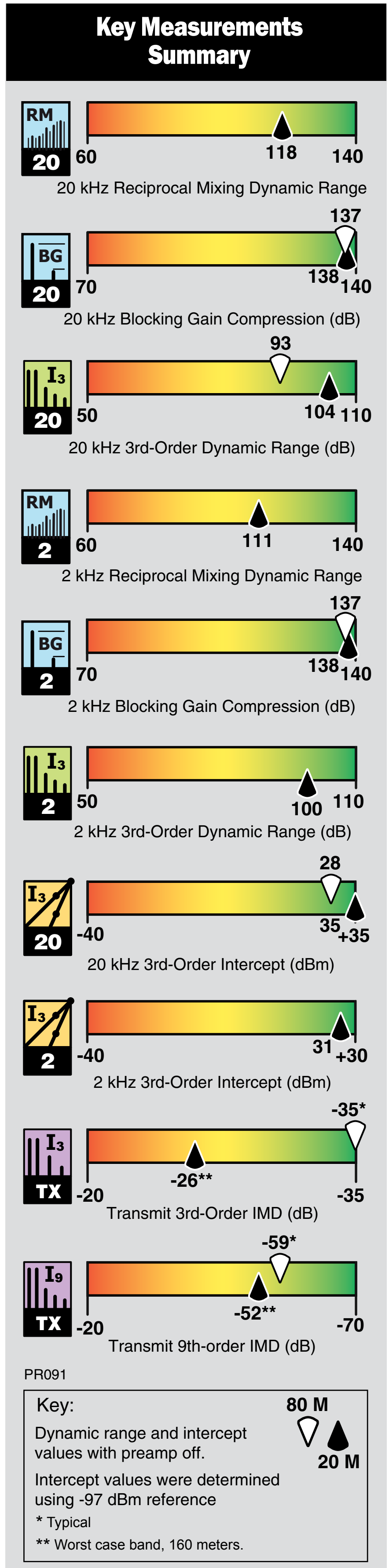
I used this transceiver as my regular HF and VHF radio over several months. My impressions were generally positive, although there were a few areas that would have suited me better if done somewhat differently.

Not surprisingly, the receiver is a joy to operate in all modes. It sounds very good and is smooth and precise to operate. One surprise that wasn't a problem, but might be for some, is that the separate receive antenna can be used only while transmitting on ANTENNA 1. This might be a matter of just arranging your antennas accordingly, but it could be an issue for some who need more flexibility. In a similar fashion, 6 meters is permanently routed toward the VHF antenna port, along with the signals for operation on the 2 and 4 meter bands. For many, this will be the perfect arrangement, but this is not the case at W1ZR where the HF tribander also serves as home to the 6 meter coupled resonator Yagi, sharing the same coax run. There are a number of commercial HF antennas that also include coverage of 6 meters and they will run into this issue, as will those using one of the many available linear amplifiers that cover HF through 6 meters. This is not the end of the world, but it either means a couple of extra coax switches, or perhaps an antenna patch panel, for those with a similar antenna configuration.

SSB Operation

As with many current transceivers, the PT-8000 is built around SSB operation. It includes speech processing and a smooth and easy to adjust ALC function. I received excellent signal reports, especially after I adjusted the internal three-band equalizer to maximum (9 dB) high end boost and low end cut. I thought it might be the microphone, but another mic I tried wanted the same settings. Perhaps my voice is not the one they were expecting — still, once adjusted, I had fine reports. VOX is initiated by a push to the MIC GAIN control knob. VOX has its own mini-cluster of VOX GAIN, DELAY, and ANTI VOX knobs located just above and to the right of the MIC connector, a sensible place. Although the knobs were small, it was easy to set them up so it worked smoothly with all but very loud speaker audio.

Available receive selectivity in SSB mode includes bandwidths of 1.8, 2.0, 2.4, 2.7, 3.1, and 6 kHz using the excellent 16-pole crystal analog filters only and 1.0 to 1.8 kHz in 200 Hz steps, 1.9 to 3.5 kHz in 100 Hz steps, as well as 4.6 and 6 kHz, with DSP following the next higher bandwidth



analog filters. They all provided extremely good sounding receive response and each filter could be easily moved up and down ±600 Hz across the passband to minimize adjacent channel spillover. Both the DSP and analog notch filters could be used independently to eliminate any pesky carriers or heterodynes. This is a very nice receiver — and you get two of them!

CW Operation

The PT-8000A puts out a fine CW signal. In fact my regular (since 1974) 80 meter CW schedule partner, W1WO, thought it sounded better than most radios he's heard. This is likely due to the nicely shaped waveform (Figure 3) and narrow CW transmit sidebands (Figure 4), one of the cleanest we've seen.

The internal keyer works well, in NORMAL or IAMBIC modes A or B through the push of the appropriate soft-key buttons. The keyer can also be disabled by poking the EXT KEYER button to use either a straight key or external keyer connected via the front panel KEY jack. There do not seem to be any other key ports, nor any provision for keying memories, so that will need to be handled from outside the transceiver.

The monitor function is also crisp, but

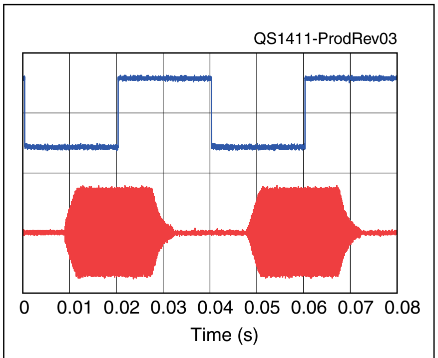


Figure 3 — CW keying waveform for the PT-8000A showing the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 180 W output on the 14 MHz band.

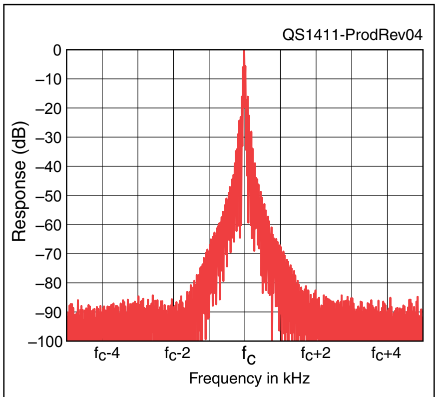


Figure 4 — Spectral display of the PT-8000A transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 180 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

Phase Noise Testing in the ARRL Lab

Bob Allison, WB1GCM
ARRL Senior Test Engineer

Most radio amateurs today will agree that receiver performance has improved dramatically over the past generation or two of transceivers. With the widespread use of better filtering and improvements in digital signal processing, the effect of intermodulation distortion (IMD) at close signal spacing has been reduced greatly. Many software defined receivers (SDRs) now experience little to no reciprocal mixing or reduction of audio level on the received frequency from strong adjacent signals. Signals generated within the receiver during reception of one or more strong nearby signals are not the problem they once were, and it's possible to operate effectively in a crowded band.

While the ARRL Laboratory staff is impressed by the new receiver technology at our fingertips, we believe transmitter performance has not kept pace. Although today's receivers can hear weak signals very close to adjacent strong signals, even the best receivers cannot eliminate the effects of a wide signal from an adjacent transmitter. Transmitted signal issues include excessive keying bandwidth on CW, poor suppression of transmitted IMD products (which causes splatter on SSB), or transmitted phase noise (which raises a receiver's noise floor) in the speaker. ARRL Lab Product Review test reports include transmitter IMD products (both typical and worst case), a plot showing keying sidebands, and a plot showing transmitted phase noise.

Phase Noise

Phase noise is essentially the noise generated above and below an oscillator's frequency, also called sideband noise. All oscillators generate some level of phase noise. This is most evident while receiving when a close adjacent signal is very strong and the receiver's background noise increases. This is due to the mixing of the first local oscillator's phase noise with the incoming signal at the first IF (reciprocal mixing). The Lab reports the effects of reciprocal mixing in the receiver as "Reciprocal mixing dynamic range" or RMDR. In most receivers we've tested, RMDR is the limiting dynamic range. In other words, third order IMD dynamic range and blocking dynamic range are better than RMDR.

A transmit oscillator, the heart of the transmitter, has phase noise too. A transmitter's phase noise is a fixed characteristic and, at times, can be a nuisance to other operators. A good example of observed phase noise can happen at Field Day or other environment where several transmitters are operating in close proximity. When two stations are operating on one band, the CW station blasts the phone operator's

Figure A — The ARRL Lab's new Rohde & Schwartz FSUP 26 Signal Analyzer, used for transmitter phase noise testing.

you have to remember to turn it back up if you've been using voice modes with the speaker, since the MONITOR knob controls both voice and CW monitor levels. The sub receiver is not normally muted during transmit, so it is also possible to use the sub receiver as a CW monitor. This is one of the few transceivers that actually allows you to monitor your own signal while you transmit — never a bad idea.

The PT-8000A supports full break-in (QSK) with a TR delay of typically 15 ms, fast enough for all but the highest speed operators to hear between dots. I didn't find it a problem while using headphones, but I found the TR relays noisy enough to be distracting if using QSK with the speaker. For my usual casual operation, I backed off on the delay so it went from transmit to receive between characters instead of code elements and was much happier.

Figure B —The FSUP 26 screen shows quite a bit of detail during testing of the Hilberling PT-8000A on the 14 MHz band.

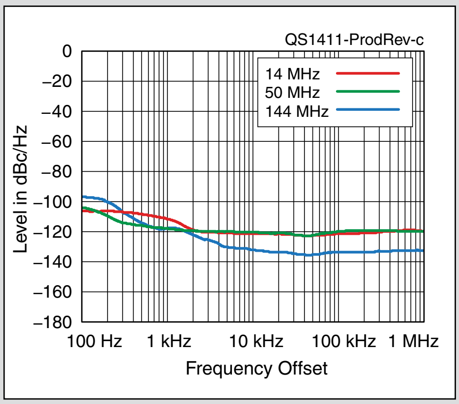


Figure C — Spectral display of the PT-8000A transmitter output during phase noise testing with the FSUP 26 and plotted on the grid used in previous Product Reviews. Power output is 180 W on the 14 MHz band (red trace), and 100 W on the 50 MHz band (green trace) and 144 MHz band (blue trace). The carrier, 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 0 dBc, and the vertical scale is in dB.

ears with bursts of noise, and vice versa. Using a transmitter exhibiting high phase noise with an RF amplifier magnifies the problem.

Another example is two radio amateurs living in the same neighborhood. The noise floor increases every time the neighbor is on the air. The effect is more noticeable on VHF, where the noise floor is considerably lower.

The solution for the reduction of both transmitted phase noise and receiver reciprocal mixing is the employment of high quality oscillators by the manufacturer. Generally, the better the oscillator (the lower the phase noise), the better the RMDR and the lower the transmitted phase noise.

ARRL Lab Testing

At the ARRL Laboratory, we have been measuring transmitted phase noise for several years with a Hewlett-Packard HP-3048A Phase Noise Test System. Product Reviews of HF transceivers include a chart showing the transmitted noise from 100 Hz to 1 MHz away from the carrier. Because our original test setup measured both phase and amplitude components, we used the term "composite noise" rather than "phase noise" in the test results.

The HP-3048A eliminated the amplitude components but we continued to refer to the results as *Composite Noise* testing. Starting with this review, we will use the term *Phase Noise* in the test results.

While the HP-3048A is older, it is accurate. However, we could only measure phase noise on one frequency in the 20 meter amateur band. This was adequate for HF transmitters but the VHF and UHF side of multiband transceivers had to be overlooked.

The Lab is pleased to announce it has acquired a new Rohde & Schwarz FSUP 26 Signal Source Analyzer (Figures A and B), which will allow us to measure phase noise on any frequency up to 26.5 GHz. Dr Ulrich Rohde, N1UL, an ARRL technical advisor, helped us to acquire this instrument, which is one of the best of its kind. First unveiled at the ARRL's open house during the Centennial Convention this past July, the FSUP 26 was pressed into service to measure the phase noise of the Hilberling PT-8000A. In addition to the usual measurement at 14 MHz, we now happily include phase noise test results for 50 and 144 MHz, as shown in Figure C.

The goal is to have each line on this chart as low as possible. I consider –100 dBc/Hz within 1 kHz, with the plot receding away from the carrier down to –130 dBc/Hz, as good performance. The effect of one transmitter is not that significant (unless you're in proximity to it!), but the effect of every transmitter on an amateur band at once is *cumulative*. I'm sure many radio amateurs with high gain antenna arrays have experienced an increased noise floor from multiple strong signals within 1 MHz or less.

Manufacturers of Amateur Radio equipment are aware of phase noise, and some transceivers we have reviewed exhibit fairly low transmitted phase noise while others do not. The use of better oscillators will allow better weak signal work and more effective operation during crowded band conditions. We hope that manufacturers will pay close attention to phase noise in the design of new transceivers in all price ranges.

On receive in CW mode, you have selectivity choices of 250 or 500 Hz using the provided 16-pole analog crystal filters or, in addition, 50, 100, 200, or 400 Hz using the DSP. Even at 50 Hz bandwidth, I found the reception quite pleasant without any noticeable ringing or distortion.

Other Voice Modes

The PT-8000A provides for AM and FM operation. Within AM, one can choose the usual dual-sideband full-carrier operation, or a carrier and just one sideband. This is the kind of AM that the classic Collins KWS-1 provided, and can be useful if the receiver at the far end can just copy one sideband at a time, thus reducing interference.

I tried the standard double-sideband AM and initially had a problem. I believe it was largely because our test sample had a carrier output of 30 W, rather than the specified 50 W. While 30 W by itself is not a problem — similar to the output level of the popular 1950s Johnson Ranger transmitter — it meant that with the audio gain set for proper operation on SSB, the transmitter was significantly overmodulated on AM. The PEP output should be no more than four times the output carrier level (in this case, 120 W rather than the expected 200 W). There is no instrumentation provided, nor any clipping or limiting, as with the ALC on SSB, so one must watch the PEP output meter. After my first unhappy experience on the AWA AM net, I thought to use the sub receiver to provide real-time monitoring (be sure to turn the sub receiver speaker off to avoid feedback) while I watched the meter and was able to get myself calibrated. Of course any of the standard AM modulation monitoring techniques, such as using a ’scope, could also be used — but not many stations are set up that way these days. My next AWA net appearance received very good reviews. I have a feeling that if the carrier output were at the 50 W design point, the SSB mic gain level would likely have been just about right.

VHF FM shared the same lack of built-in instrumentation, but seemed to have the appropriate level of deviation with the gain set for SSB. While the radio has provision for repeater offsets, and can memorize channels for repeater use, unfortunately it does not currently support CTCSS tone access. I couldn’t use any of my local repeaters, which all require CTCSS, but did have some successful simplex contacts. With 100 W output, I was also able to simulate being a repeater and check in with some folk who were looking for repeater contacts. CTCSS is not used in Europe, explaining this deficiency for the US market. Hilberling indicated that a future firmware release will include CTCSS tones, making FM operation much more useful to North American operators.

Digital Modes

Digital mode operation with the ’8000A can be supported using SSB transmission in concert with a PC sound card. Both rear and front-panel (MIC) connectors can be used to support PC-driven digital modes. In addition, direct FSK is supported for those who prefer it for RTTY, with all required connections available at the rear panel. The only feature that I might have expected to find in a top-drawer transceiver was the availability of dual filtering centered around the mark and space frequencies. This can improve both S/N and interference rejection on receive. Perhaps this will be on their upgrade list.

Spectrum Scope

The PT-8000A offers a 60 kHz carrier output with I and Q channels for both the main and sub receivers. The supplied disk provides spectrum scope software, but it is of somewhat limited utility compared to many other similar offerings. Hopefully it is a work in progress, but it does work within its limitations if you have a sound system with sufficient resolution (192 kHz sample rate) — mine was not up to the task. The limitation that I found most troubling was that it required the full PC screen and could not even be minimized to allow access to other programs. Even though the PC had access to serial data to provide frequency information for other programs, the spectrum scope software just provided relative frequency information — 0 Hz in the center and ± offset frequency indication. There was also no provision to allow the scope display to control the radio. My guess is that this will improve over time, or perhaps others will adapt their spectrum display programs to the Hilberling signal format.

Documentation

The PT-8000A comes with a professional quality 104-page, loose-leaf-bound, full color instruction manual and a packet containing CD-ROMs for the firmware upgrade and spectrum scope software. The manual includes appendices describing the firmware upgrade process and the use of the spectrum scope software, with illustrated step-by-step instructions for each.

While I believe everything is covered within the manual, I think it would be helpful to add a page that summarized the soft-key menus and indicated how to get to each. While the trial-and-error process does work, and the menus do become second nature after a while, I think it would make it much easier for new users to get started.

Final Thoughts

Hilberling’s PT-8000A is certainly an impressive new take on the Amateur Radio transceiver. It brings together many desirable features — excellent transmit and receive performance, a 200 W transmitter, operation on all bands through 2 meters, two equally capable receivers, ease of use — in one attractive, well made package. With a price tag around $17,500, it’s not for everyone, but it shows what is possible with great engineering and attention to detail. Think of it as a Porsche 918 Spyder for the ham shack.

Manufacturer: Hilberling, Kieler Strass 53, D-24768 Rendsburg, Germany; **http://hilberling.de**. US distributor: **www.hilberling-usa.com**.

See the Digital Edition of *QST* for a video overview of the Hilberling PT-8000A MF, HF, and VHF transceiver.

OM Power OM2500A HF Power Amplifier

Reviewed by Norm Fusaro, W3IZ, Assistant Manager, Membership and Volunteer Programs Department
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I have a friend who is an avid collector of vintage radio gear. During one visit to his home, he demonstrated a Collins ART-13 transmitter that was considered cutting edge technology for its time. The transmitter had five dials across its lower front section. When he put it into the TUNE mode, all the dials would spin, whirring around back and forth until each one arrived at the correct value to tune the transmitter to the desired operating frequency. He told me that this technology was introduced during the latter part of World War II and was used in the B-29 bombers that flew over Europe and the Pacific, and later during the Korean War.

The OM2500A from OM Power in Slovakia is a legal-limit RF power amplifier for 160 through 10 meters that offers manual or automatic tuning. I mention the ART-13 because that is the first thing that came to mind when I fired up the OM2500A amplifier and heard the whizzing and whirring of electric motors and witnessed the rotating control knobs on the front of the amplifier. It's an interesting blend of vintage technology and microprocessor control. (A similar model, the OM2500HF, is manual tune only.)

The OM2500A uses a GU84b (4CX2500A) tetrode tube that requires 60 W or less to drive this rock crusher to 1500 W output. The pi-L output circuit will tune into an SWR of 2:1 and the amplifier incorporates a number of protection features. Automatic operation is compatible with many popular transceivers.

Initial Impressions

The OM2500A is a heavy amplifier — just over 90 pounds — as expected for any legal limit device using ceramic tubes and requiring a high voltage power supply. The amplifier is fitted with side handles to make lifting and positioning a bit easier than other amps in this category. I was able to lift it out of the shipping carton and onto the table without assistance, but help was required with the hand truck getting the unit down the stairs to my station.

The front panel is neatly laid out and has a clean, modern look. Two bar graph indicators display RF output power and reflected power. Another bar graph displays screen current. A multifunction bar graph handles display of anode voltage, anode current, and a tuning aid. A bright and easy to read LCD screen displays mode (auto or manual), type of transceiver in use, and frequency of operation as well as all menu items when selected. Rounding out the visual display is a variety of colored LEDs to indicate status such as fault, standby or operate.

The amplifier has protection circuits for excessive anode, screen or grid current, excessive reflected power, low anode voltage, excessive output power and incorrect tuning settings. Faults can be diagnosed from flashing LEDs or from a combination of flashing LEDs. When a fault is detected, the amplifier goes into standby for two seconds and then automatically returns to operation. If the fault repeats three times, the control circuitry places the amplifier in standby. The operator must use the OPR/STBY switch to return to operation after correcting whatever condition caused the fault.

Figure 5 shows the amplifier interior. On the left are the power supply components,

Bottom Line

The OM2500A from OM Power is a rugged, legal-limit, automatic amplifier for 160 through 10 meters that will integrate seamlessly into most stations.

Figure 5 — Interior of the OM2500A.

Table 2
OM Power, OM2500A, serial number U2 12001

Manufacturer's Specifications	Measured in ARRL Lab
Frequency range: All amateur frequencies in the range of 1.8 to 29.7 MHz.	Tested on 160, 80, 40, 30, 20, 17, 15, 12, and 10 meters. (US power limit is 200 W on 30 meters.)
Power output: 1500 W, continuous, no time limit.	Tested at 1500 W continuous output for 5 minutes.
Driving power required: 40 to 60 W.	48 to 60 W (typical) for 1500 W output.
Spurious and harmonic suppression: >52 dB (2nd harmonic), >65 dB (3rd harmonic).	2nd harmonic: 43 dB worst case (18 MHz)*, typically 57 to 63 dB; 3rd harmonic, 49 dB worst case (21 MHz band), typically >70 dB. Meets FCC requirements.
Third-order intermodulation distortion (IMD): 36 dB below full power output.	14 MHz, 3rd/5th/7th/9th: 43/44/>60/56 dB below PEP.
TR switching time: Not specified.	Amplifier key to RF output: 10 ms; amplifier un-key to RF power off: 10 ms.
Primary power requirements: 240 V ac, 60 Hz.	
Size (HWD): 8.0 × 22.1 × 22 inches (including protrusions); weight, 92 lbs.	
Price: $7995; remote control console, $395.	

*Second harmonic suppression was at the FCC limit (43 dB) at 18.070 MHz. The suppression improved to 49 dB at the top end of the band.

Figure 6 — The OM2500A rear panel.

including two massive toroidal power transformers underneath PC boards with some of the control and power supply circuitry. On the right you can see the GU84b with its large blower, and the pi-L tank circuit components. An auxiliary fan on the rear panel supplies additional cooling if the air exiting the amplifier reaches 70 °C.

Station Integration

Generally speaking, connecting an amplifier is a simple procedure: connect a cable from your transceiver's RF output to the RF input of the amp, connect an antenna to the output of the amplifier, add a keying line to switch the amplifier from standby to operate when the transceiver is keyed, and plug the amplifier into a properly rated ac power source (240 V ac in this case). This is pretty much all that is needed to use the OM2500A in its manual mode — perhaps better described as semi-automatic operation because the user is not required to make any tuning adjustments after changing bands manually.

To take full advantage of the automatic tuning and band switching features of this amplifier, you must make a few more connections and configure the amp for use with your radio. In addition to standard rear panel connections, the OM2500A has a nine-pin D-SUB male TCVR jack, which is an RS-232 interface to connect to supported Yaesu, Kenwood, TEN-TEC, or Elecraft transceivers to receive band data and make changes to the amplifier as the operating frequency changes on the radio. Icom transceivers are supported with the CI-V interface jack. Another serial interface, a nine-pin D-SUB female jack labeled PC, connects to your station computer's serial port, allowing communication between the radio and software such as a logging program running on the PC. See Figure 6.

To complete setup of the transceiver-to-amplifier communications, the user enters a menu via the front panel of the OM2500A and selects from a list of supported radios. In addition to instructions and diagrams for connecting the OM2500A to several popular brands of transceivers, the manual includes information that may be helpful for connecting the amplifier to unsupported radios.

I didn't find my transceiver in the menu, but selecting another model from the same manufacturer allowed communication from radio to amplifier. At the time, I checked the OM Power website but did not find any downloads for updating the amplifier's firmware or list of supported transceivers. After selecting a compatible transceiver from the menu, I had to set the serial port speed. The RS-232 configuration worked well with a USB-to-serial converter as I set it up in my station on both a desktop PC and a laptop running *Windows 7*. I found the use of RS-232 a bit curious as these connections are rare on newer computers and laptops.

I soon discovered that unless the amplifier is powered on, the computer control to the radio was disabled. Rechecking the user manual showed that I needed to apply 12 V dc to the BYPASS COM jack on the rear of the amplifier to allow independent communication between PC and transceiver without having to power on the OM2500A. I thought that this is an important connection that should be included in the connection schematics. Nonetheless, what I first considered to be a deal breaker was resolved with a connection to an external 12 V dc supply.

I should note that the instruction manual shipped with our review amplifier did not show the BYPASS COM jack and seemed to be missing other information. Array Solutions quickly sent an updated copy of the manual, and this version contained pictures and descriptions matching the unit under review. Overall, the user manual is well laid out with diagrams, close-up photos, and simple descriptions making it very easy to use.

Other Connections

The OM2500A has two other interface jacks. The ANT & BPF SW jack permits automatic selection of antennas and band pass filters via external third party switches. Antenna ports are configured via a menu accessible on the front of the amplifier. This feature greatly reduces the chance of being on the wrong antenna when transmitting and sending the amplifier into fault.

My station is outfitted with a Top Ten Devices band decoder and antenna switches providing automatic antenna switching via the transceiver. I didn't sample this feature of the amplifier because it involves fabricating a cable from the amplifier to the antenna switches and disconnecting the existing configuration. If the OM2500A were to be a permanent fixture in any station, making the cable would not a big project and could be simplified by using a store-bought cable with a DB-25 male connector on one end. Based on the performance of everything else on the OM2500A, I doubt there would be any problem switching antennas or filters via the ANT & BPF SW connection.

The second interface provides a number of signals, including ALC output, TX inhibit (prevents the transceiver from transmitting while the amplifier is tuning), key out and key in. If your transceiver doesn't have provisions for TX inhibit, the manual recommends connecting the OM2500A's ALC output to your transceiver's ALC input and using the SET MUTE menu to ensure that there is no RF output from the transceiver while the amplifier is tuning.

As with any power amplifier, the TR switching relays must close before RF is applied, and must open after the transceiver is finished transmitting (ie, avoid "hot switching" the relays). Most modern transceivers have adjustable PTT-switching-to-RF-output times, and the amplifier's switching times as measured in the ARRL Lab are shown in the data table. If your transceiver's switching times can't be adjusted to avoid hot switching the OM2500A, you can connect a foot switch or other PTT device to the amplifier's KEY IN jack and use the KEY OUT jack to key the transceiver PTT.

On the Air

Before using the OM2500A on the air, it's a good idea to check the default automatic tune settings and, if needed, touch up the TUNE and LOAD controls for your antenna system. The amplifier memorizes tuning settings for band segments ranging from 15 kHz wide on 160 meters to 70 kHz wide on 10 meters. Following the procedure in the manual, start with the first segment on a band, make any needed adjustments, store the new settings and the amplifier steps to the next segment. Next time you return to a band segment, the amplifier will recall the TUNE and LOAD settings and adjust itself automatically.

Once this brute is configured to your station, operation is basically hands off. In the automatic mode, the amplifier quickly follows the band changes made at the transceiver. The OM2500A did a fantastic job of amplifying signals. As shown in the ARRL Lab tests, it provides full legal limit on all bands, with low IMD products. The OM2500A has plenty of headroom, loafing along at 1500 W output all day long (or all weekend long in the case of serious contest operators), even when using full duty cycle modes. I had no issues on any band using CW, SSB, or RTTY. The amplifier performed flawlessly and followed the transceiver everywhere using the CAT interface.

Each band change, whether in manual or automatic mode, requires the amplifier to perform a retuning of the TUNE and LOAD controls as described in the opening paragraphs of this review. To change bands manually, you press the UP/DWN to move up or down one frequency band and then select the desired segment within the band. The amp stops at each band as you step up or down through the spectrum. For example, to go from 40 meters to 12 meters you must tab through each band along the way (40, 30, 20, 17, 15, 12 meters) and wait as the amp stops and tunes itself at each band. I found this to be tiresome — consider the manually tuned version if you don't plan to make full use of the transceiver interface for fully automatic operation.

The OM2500A is not a silent amplifier. The first time I powered it on, I thought that the blower seemed excessively loud — loud enough to be heard when wearing high-quality headphones. After a few sessions with the amplifier, I decided to try to quantify what I was hearing. Using a sound level meter, I took measurements from my operating position of the noise level with the amplifier turned off. Then I turned on the OM2500A while leaving everything else the same, and took a reading from the same position. The OM2500A blower measured 19.4 dB above the ambient noise in the room. I then took measurements of my normal legal limit amplifier under the same conditions, and it measured 7.2 dB quieter than the OM2500A. Measurements of three other legal limit automatic amplifiers in use at ARRL indicated blower noise about 5 dB above the ambient noise in the room. Of course this is not a scientific sampling in an anechoic chamber, but these simple measurements validated my subjective observations. The OM2500A surely makes its presence known.

Remote Control

One way I could alleviate the blower noise is by placing the amp further away from the operating positing and using the optional OM2500A remote control. The remote control is a nice compact box that sits at the operating position and controls the amplifier through approximately 30 feet of supplied control cable. It permits the user to power the amp on or off and put it in operate or standby modes. An LED bar graph displays output power, and LEDs indicate a fault or an SWR issue. The remote control box requires a 12 V dc power supply.

Final Thoughts

Most operators consider an amplifier

See the Digital Edition of *QST* for a video overview of the OM Power OM2500A HF power amplifier.

a station accessory and something that should not take center stage in any station configuration. The designers of the OM2500A seem to have a different view, and they have designed this product to be an integral component of the modern ham shack, ready to be included in the station automation system. Today's radio amateur must be a systems integrator, configuring transceivers, switches, accessories, specialized computer software, and other components into a fully functioning station. Integrating the OM2500A into the modern ham shack is relatively easy, and the reward of a big clean signal from an amplifier that automatically follows the transceiver is worth the time and effort.

Manufacturer: OM Power, s.r.o. 930 30 BÁČ 126, Slovakia; **www.om-power.com**. Distributed in North America by Array Solutions, 2611 North Belt Line Rd, Suite 109, Sunnyvale, TX 75182; **www.arraysolutions.com**.

ERC-M Rotator Controller and *PSTRotatorAZ* Rotator Control Software

Reviewed by Pete Smith, N4ZR
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In this era of software defined radios and surface mount components, one of the remaining pleasures for those of us with an urge to build things is in the area of station control. I've done quite a bit of station automation, but sometimes, with two rotators, I still feel a little like a one-armed paper hanger. I went looking for a relatively simple, low cost way to automate control of my rotators, while not adding anything to my operating desk if I could help it.

Figure 7 — The completed Rotorcard installed in a Yaesu G-800SA rotator control box.

A Solution from Germany

Casting around through all the usual sources, one of the first Google hits was the Easy Rotor Controller (ERC) from the German firm Schmidt-Alba. Schmidt-Alba's proprietor, Rene Schmidt, DF9GR, is a well-known member of the Bavarian Contest Club. His ERC controller line includes one- and two-axis rotator controllers, assembled or in kit form, that can connect to virtually every rotator ever made. The controller does the heavy lifting in firmware, translating commands from your logging or station control software, as well as storing calibration, rotation stops, and so on. It connects to control-ready rotators through a six-pin mini-DIN connector.

For those rotators that aren't control-ready, Rene offers a couple of solutions. One is a "Rotorcard" that mounts inside the existing controller, providing relays that emulate pressing the left or right rotator controls. Another is the ERC Version 4 kit, just announced. It has the necessary relays included and is designed to mount inside most rotator control boxes. For one rotator, Version 4 would be the easiest, cheapest solution by far.

ERC-M is the two-axis model, which can be used either for azimuth-elevation (az-el) control in a satellite or EME system, for example, or to control either one or two azimuth-only rotators. All of Rene's controllers connect to the station computer through USB or RS-232 serial ports (choose the version you need when you order), while the ERC-M has a LAN option suitable for remote control applications. Finishing touches include either a desktop controller box with front panel displays and pushbuttons, or a minimal enclosure for behind-the-scenes control.

Bottom Line

The ERC-M rotator controller, Rotorcard interface, and *PSTRotatorAZ* software provide tools to include control of one or more antenna rotators in a station automation system. Excellent vendor support is available to help with complicated requirements.

In my station, I needed control for two Yaesu rotators — one ready for computer control (a G-1000DXA) and the other in need of a Rotorcard (G-800SA). I wanted to rotate my tribander stack and a 40 meter short Yagi above the top tribander. The lower Yagi in the stack is on a side mount with less than 360 degree rotation, and the 40 meter Yagi is offset 90 degrees from the tribander below it, so I knew my requirements might be difficult.

A quick exchange of e-mails with Rene persuaded me both that his hardware would work for me and that tech support would not be a problem. So, off went my order and PayPal payment, about $175 including shipping. I consider this quite competitive with other solutions available on the US market, particularly for two rotators. I could have added a desktop controller case, but I chose not to.

Getting the Hardware Ready

Only six days later, the package arrived. Inside were a ready-to-go ERC-M USB controller, a very small "slimline" enclosure, a Rotorcard in kit form, a couple of mini-DIN cables, and a CD with software and extensive, systematic documentation. The Rotorcard kit took me about an hour to build, soldering relays and a half-dozen through-hole components on a nice-quality glass-epoxy PC board. At first, I anticipated the hardest part might be installing the Rotorcard inside my G-800SA, but after a little thought and study of the instructions I felt confident to proceed. Six wires soldered

Figure 8 — The ERC-M rotator controller in its slimline case. A USB cable connects to the station computer, and both rotators are connected to a single 15-pin connector.

to readily accessible connections, guided by a schematic drawn from the original rotator manual, gave me all I needed, and the Rotorcard fit neatly into the controller cabinet (Figure 7).

For the other rotator, all that was required was to cable it to the ERC-M, with both cables passing through a single 15-pin D-SUB connector (Figure 8). Again, with care and a little thought, I had no trouble wiring the connector specifically to match the two rotators. You do need to be careful to label the cables, though, because the hookup is different for a Rotorcard than for the Yaesu rotator that is controller-ready, but both use a six-pin mini-DIN connector.

With this complete, I connected a USB cable to the ERC-M, and its driver self-installed on my *Windows 7* PC; the CD also included a driver for *Windows XP*, had I needed it. If you use a Rotorcard or have the RS-232 version, the ERC-M requires a 12 V dc supply (10 mA for the ERC-M, 300 mA for the Rotorcard). A wall cube power supply works fine. The USB version of the ERC-M without a Rotorcard can be USB-powered.

I then installed two pieces of software: a *Service Tool* that is used to test and calibrate the ERC-M, and a *Rotor-Control*, with two compass rose indicators, one for each axis. I should note that calibration was particularly quick and easy, which I understand is exceptional in the rotator control field.

I tried the controller, and of course it didn't work. A couple of quick e-mail exchanges with Rene corrected my mistakes, and he also provided an update of the *Service Tool* to better manage the less-than-360-degree rotation of one tribander. Turnaround time was less than a day, due in part to a 6 hour time difference. As Rene observed wryly, "this rotator business can't be my only job," but in any case, both rotators were quickly dancing to my tune.

Integration with Logging Software

I then turned to the problem of interfacing the ERC-M to *N1MM Logger*, the logging and station control software I use during contests. This revealed an unexpected problem, because *N1MM Logger* requires one serial port per rotator, while ERC-M looks to handle all communications for both rotators through a single port. Rene had the answer, which brings me to the second part of the story. It would be necessary, he said, to use *PSTRotatorAZ* (*PSTRA*) by Codrut Buda, YO3DMU, between *N1MM Logger* and the ERC-M controller.

PSTRA costs 15 Euros by download, and I very quickly had a licensed copy of the software. There is a lot to *PSTRA* — one friend called it the "Swiss Army Knife" of rotator control software. It can act as a smart controller for virtually any rotator ever built, with lots of ways to tell the rotator(s) where to turn. It also functions as an intermediary between any of those rotators and a large number of logging programs. For my purposes, the essential thing it does is to read the UDP (User Datagram Protocol) messages that *N1MM Logger* sends to its own *N1MMrotor* program, which is not used in this case, and translate them into messages on a single COM port in the appropriate format to control two rotators through the ERC-M (Figure 9).

With some more long-distance help from Rene and Codrut, I soon had *PSTRA* controlling my rotators, and *N1MM Logger* talking to *PSTRA*. The one thing that was still lacking was proper handling of *N1MM Logger*'s way of indicating the offset of my 40 meter Yagi. Until that was resolved, I could point my upper rotator to a station using the built-in N1MM command keystrokes, but on 40 meters it was not taking the offset into account. I mentioned this in passing in an e-mail to Codrut, saying

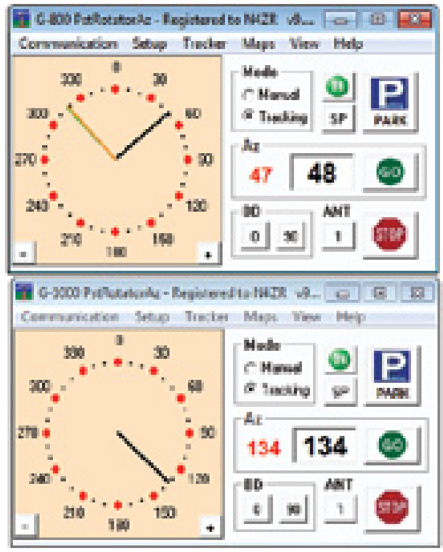

Figure 9 — The *PSTRotatorAZ* display showing the direction of both of the author's rotators.

I thought it was probably a matter for the N1MM team. The very next day, Codrut released an update of *PSTRA* that delivered a perfect solution.

A Happy Ending

Where do things stand now? With a stream of DX Cluster or Reverse Beacon Network spots displayed in *N1MM Logger*, I can click on a needed station and depending on the band, either the whole stack turns (for 20 – 10 meters), or the top rotator turns and points the offset 40 meter Yagi in the correct direction. It's all automatic. The ERC-M protects the lower tribander against over-rotation, and the calibration of both rotators is as good as I can resolve by eye.

Even more to the point, these two vendors have demonstrated that in the Internet era, distance is no longer a significant barrier to superb service and support. (I should add that neither Rene or Codrut knew that I was thinking of doing this review, so I believe the level of support is indicative of what any customer can expect.)

Manufacturer: ERC-M controller — Eida Alba de Schmidt, Kreuzangerstr. 58, 86399 Bobingen, Germany; **http://easy-rotor-control.com**. Price: ERC-M (USB version, assembled and tested), $120. Rotorcard kit, $23. Slimline case, $22. (Prices are approximate, not including VAT or shipping. Pricing is in Euros, exchange rate will vary.) *PSTRotatorAZ* software — PstRotator. **www.qsl.net/yo3dmu/index_Page346.htm**. Price: about $20 (pricing is in Euros, exchange rate will vary).

Smart Tweezers ST5 LCR Meter

Reviewed by Phil Salas, AD5X
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Surface mount device (SMD) components are inexpensive and small, and they lend themselves well to modern automatic manufacturing processes. As SMD components grow in popularity, leaded (through-hole) components are becoming more expensive and even obsolete. As much as I dislike working with SMD components because of their small size, more and more projects seem to require them — even some kits that are currently available.

When I work with SMD components, I have to be extremely careful to keep the parts properly sorted. If I accidentally mix the parts, I have to measure multiple components in order to make sure I don't install the wrong one. Unfortunately, measuring these tiny parts is extremely difficult with typical test equipment in the ham workshop. Enter the Siborg Systems ST5 Smart Tweezers — a compact, highly accurate LCR (inductance, capacitance, resistance) meter that is especially made for measuring SMD components. (While I was preparing this review, Siborg Systems introduced the ST5S, a newer model that is smaller and lighter than the ST5 but has the same specifications and capabilities.)

The ST5 is a precision instrument with a basic accuracy of ±0.2% and supplied with a NIST-traceable calibration certificate. Its gold plated tweezers tips can easily hold SMD components down to 0201-size. In addition to measuring inductance, capacitance and resistance, the ST5 also displays Q, ESR, and impedance. It also performs diode and continuity tests, and provides a selectable component tolerance offset test. The ST5 specifications are given in Table 3.

Table 3
Smart Tweezers ST5 Specifications

Measurement rate: 1 sample/second.
Tolerance offset: 1%, 5%, 10%, and 20%, selectable for automatic component sorting.
Measurement frequencies: 100 Hz, 120 Hz, 1 kHz, 10 kHz.
Test signal levels: 0.2, 0.5, and 1 V RMS sine wave.
Resistance: 0.05 Ω – 9.9 M Ω, ±0.2% from 100 Ω – 10 k Ω, ±0.5% from 1 Ω – 1 M Ω.
Capacitance: 0.5 pF – 4999 μF, ±0.2% from 10 nF – 10 μF, ±0.5% from 100 pF – 1 mF.
Inductance: 0.5 μH – 999 mH, ±0.2% from 10 mH – 100 mH, ±0.5% from 100 μH – 999 mH.
Dissipation factor: 0.001 – 1000 (Q = 1/D: 1000 – 0.001).
Component sorting: Settable to 1%, 5%, 10%, or 20% tolerance.
Weight: 52 grams (less than 2 oz).
Price: ST5 with carrying case and charger: $400. ST5S with carrying case and charger: $400.

Using the ST5

When you open the ST5 package, you might think there is a computer interface as you'll find a USB cable. However, this cable is only used for charging the internal Li-ion battery from your computer's USB port or with the supplied USB charger. Charging time is approximately 2.5 hours for a fully discharged battery.

The ST5 is turned on by momentarily pressing the navigation button, after which the last selected measuring function is displayed. The navigation button may be rocked to select different measuring parameters and test functions. Rock the button up cycles through test signals levels of 0.25, 0.5, or 1.0 V RMS (default). Rock the button left to select the device type to be measured: R, L, C, |Z| (absolute value of impedance), ESR, diode test, Rdc (dc resistance), and AUTO. Rocking the button down selects one of three test ranges or AUTO. Finally, rocking the button right selects one of four test frequencies, or AUTO. The ST5 automatically powers off after 30 seconds (default) of inactivity. The power-off time is settable from 10 to 200 seconds.

Bottom Line

If you have the need for a highly accurate LCR surface-mounted component measuring and evaluation instrument, the Smart Tweezers ST5 is worth considering.

When in AUTO mode, AM shows in the bottom left of the display. For most uses the AUTO mode works well as the ST5 will determine the component type and best measuring range and frequency at the default signal level of 1 V RMS. The 1.0 V RMS signal level provides the best accuracy for most resistors, capacitors, and inductors. Lower signal levels may be better for very low value, high-Q induc-

Figure 10 — The ST5 measuring a precision 0201 50 Ω SMD resistor.

Table 4
Auto vs Manual Frequency Measurement

Component Marking	Measured Value with Auto Mode & Freq	Measured Value with Manual Entry
2 pF +5%	2.1 pF/10 kHz	N/A
1000 µF +20%	916 µF/100 Hz	N/A
1 µH +5%	675 mΩ/1 kHz	1.03 µH @ 10 kHz, Selected L

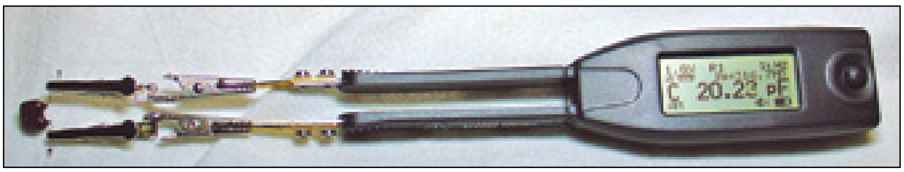

Figure 11 — The author's leaded component adapter.

tors. Some ceramic capacitor data sheets specify lower test voltages depending on the capacitor voltage rating.

According to the manual, the AUTO mode is accurate when measuring capacitance from 3 pF to 199 µF and inductance from 5 µH to 500 mH. Outside of these ranges the frequency can be changed manually for better accuracy (lower frequency for higher inductance and higher frequency for lower capacitance). I checked a few parts outside of the AUTO range to see how the ST5 would do in the AUTO mode. The results are shown in Table 4.

As you can see, the AUTO mode worked well, even for capacitors out of the AUTO range. The ST5 correctly selected the highest test frequency for the 2 pF capacitor, and the lowest test frequency for the 1000 µf capacitor. However, the 1 µH inductor measured as a low value resistor in the AUTO mode. But when I manually selected L as the component type, the ST5 automatically selected a 10 kHz measuring frequency and displayed the inductance accurately.

The ST5 fit my hand well and is very easy to use. In addition to easily picking up almost any size SMD component for measuring (see Figure 10), the ST5 tweezers tips are perfect for measuring an SMD component mounted on a PC board, probing nearby pads on a PC board, and even measuring leaded components on a PC board. Once you touch the ST5 tweezers tips to a component's leads, the component type and value are determined instantly, along with loss shown as a series or shunt resistor on the display. For highest accuracy, you can set the ST5 to automatically subtract out the tweezers' residual resistance (typically 30 milliohms), stray capacitance (typically 0.5 – 1.2 pF), or stray inductance (typically 0.1 µH). And incidentally, the ST5 "knows" when a component is being measured and will not power off until after the component is no longer being measured.

Finally, the tolerance sorting feature may be of interest to hams designing active filters. Often the actual component-to-component variation is just as important as the calculated component value, especially in multisection filters. Or perhaps you need to sort 5% or 10% resistors to find some within 1% for a critical project. Using the tolerance sorting capability, you can quickly sort parts to be within the desired tolerance from a reference component. The ST5 beeps once when a component is within the tolerance specified, and three times if it is out of tolerance.

Most of my components are still leaded, through-hole components and the ST5 is a little clumsy to use when measuring these components. Therefore, I soldered two pairs of alligator clips (Mouser 534-5033) together so as to make a leaded-component adapter as shown in Figure 11.

As you can see in Figure 11, a 20 pF silver-mica capacitor is being measured in the AUTO mode. The capacitor value and parallel shunt resistance are displayed along with the measuring frequency and signal level.

Conclusion

The ST5 is a very nice multifunction handheld device that is perfect for surface mount component measurement and evaluation. While pricey, you do get a precision instrument that is applicable for both tight manufacturing process control and home lab measurements. The new ST5S model is the same price as the one I reviewed. Another new model, the LCR-Reader, is a lower cost (about $200) instrument for those who can tolerate a bit less accuracy. The LCR-Reader has a basic accuracy of 1%, a fixed 0.5 V RMS test signal, and does not come with a NIST-traceable calibration certificate.

Manufacturer: Siborg Systems, 24 Combermere Crescent, Waterloo, Ontario N2L 5B1 Canada. US Distributor: SIBBIS International LLC, 1998 Lancashire Drive, Potomac, MD 20854; tel 301-762-1021; **www.smarttweezers.us**.

MFJ-4603 Antenna Window Feedthrough Panel

Reviewed by Mark Wilson, K1RO
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When we moved to a new house a couple of years ago, I located the ham shack in a corner of our walkout basement. My operating position has two windows with a nice view of the lake and distant hills. The first order of business was to hang my trusty 130-foot inverted V fed with window line through an antenna tuner. That antenna has served me well over the years with contacts on all bands from 80 through 10 meters.

To get the window line in the house, I just opened the top half of one of the double-hung windows, sandwiched the feed line between two pieces of foam, closed the window, secured it with a piece of wood and called it good. That worked fine for the flat window line, but within a few months the cables had multiplied. I needed to bring in several runs of RG-8, a run of RG-58, and a rotator cable too — clearly a better solution was needed.

MFJ Window Feedthrough Panels

MFJ offers several different panels designed to provide a clean and weatherproof way to route cables through a double-hung or glider window. These window antenna feedthrough panels (MFJ-46xx series) are all similar in appearance but accommodate different types of connectors. Five of the six available models are made from a 48 inch length 1 × 4 piece of wood (actual dimensions ¾ × 3½ inches) with metal plates on each side. The last version, the MFJ-4605, is 7 inches tall and has two plates.

I chose the MFJ-4603, which would accommodate the cables I currently have and leave some room for expansion later. This model has four UHF type bulkhead connectors, one Type N bulkhead connector, one 75 Ω F bulkhead connector, a pair of high-voltage ceramic feedthrough insulators for balanced line and another for a random wire, two five-way binding posts for low voltage dc, a ground post and one "Adaptive Cable Feedthru" to bring in rotator cable.

Installing the Panel

The first order of business is to carefully measure the window opening and cut the wood panel to size. All four edges of the panel will be wrapped with adhesive-backed foam insulation, so the panel needs to be just slightly shorter than the opening. If you make the panel too short, it won't seal well. Note that supplied pressure treated wood doesn't have the nice smooth finish you'd expect from material intended for interior trim. However, it is intended for outdoor use and should resist damage from insects and moisture. The metal plate is not quite square in the wood, but that doesn't affect use of the panel, and I didn't notice it once the panel was installed and the cables connected.

After wrapping the panel with insulation, place it at the bottom of the windowsill and close the window. It makes a weather-tight fit. Next, seal the gap where the lower sash overlaps the top sash (same routine as installing a window air conditioner). The instructions show how to use two pieces of the supplied foam insulation to seal the gap, but unfortunately the remaining piece of supplied foam was way too short. I ended up plugging the gap with a piece of foam I normally use with a window air conditioner.

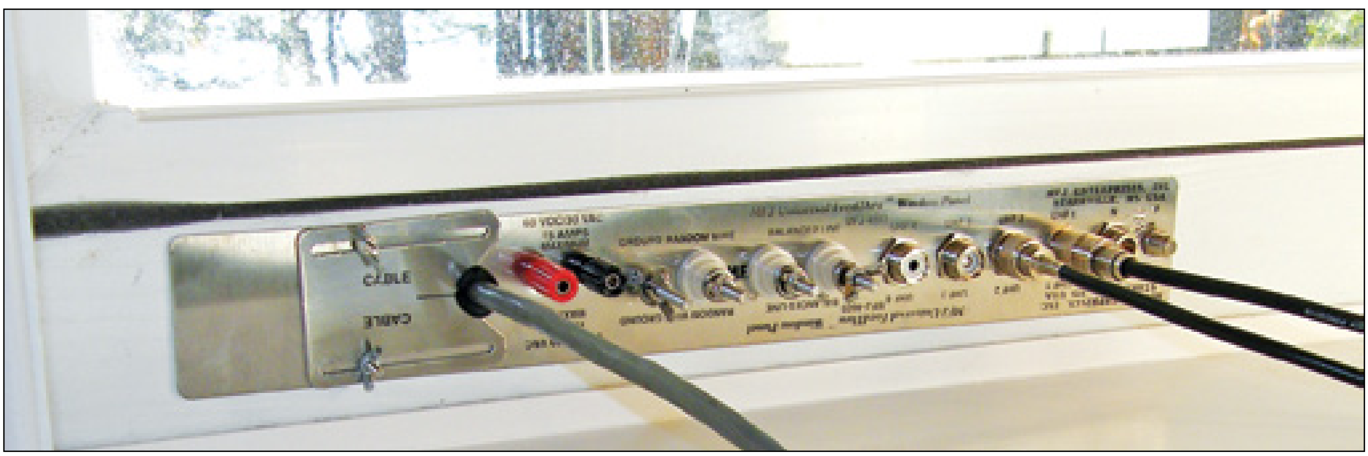
The final step is to cut a supplied piece of 1 × 2 pine to the correct length to secure the lower sash and prevent someone from opening the window. I ended up using a piece of wood on each side of the window.

Using the Feedthrough Panel

First order of business was running the rotator cable through the Adaptive Cable Feedthru. A plate on each side of the panel slides open to reveal a diamond-shaped opening large enough to pass a cable, perhaps with connector installed (depending on connector size). Run the cable through the opening, slide the plates closed, and tighten the wing nuts on the machine screws that secure the plates. Grommets are supplied to protect the cable and make a weather-tight seal. (You may need to cut the grommets to fit the cable.) To make a good weather-tight seal, you need one person inside the house and one outside to hold both plates snug and hold the screws while you tighten the nuts.

Bottom Line

The MFJ-4603 offers a convenient way to get a variety of feed lines and control cables into your station if a window is available. Some care is required to make the installation weatherproof, and the UHF bulkhead connectors could be better quality.



This system worked very well.

Next I connected my window line to two of the ceramic feedthrough insulators. No issues there. The Type N bulkhead connector worked fine. I didn't use the F connector, five-way binding posts, or the single ceramic insulator for a random wire.

I wasn't as impressed with the four UHF bulkhead connectors. The center conductors are hollow all the way through the connector, allowing a noticeable amount of outside air (and perhaps insects) to pass through. Unused connectors will need to be capped, and MFJ indicates that they now include end caps for unused connectors.

Also, the supplied UHF bulkhead connectors are not very sturdy. They rattle a little bit, and one actually pulled apart when I disconnected a PL-259 plug. I ended up replacing that one with a good quality Amphenol bulkhead connector left over from another project (and this one is not hollow all the way through).

An interesting quirk showed up the first night the temperature dipped to around zero degrees. With metal plates on both sides of the panel, the cold is conducted from the outside to the inside plate and moisture from the inside air condensed and formed a noticeable amount of frost on the inside plate and connectors — it looked like the inside of a vintage freezer! Then the frost melted when the sun came out, and dripped water onto the windowsill. This was only an issue on the coldest nights, but we had quite a few of those last winter. According to MFJ, the design has been changed to include insulation between the metal plates to keep out cold and help with condensation.

Overall I'm happy with MFJ-4603 window feedthrough panel. It solved my feed line entry problem without damaging the window or house and allows a weatherproof installation if you cut everything carefully. I do plan to replace the UHF bulkhead connectors with better quality ones the next time I order some coax connectors and will follow MFJ's lead by adding insulation to reduce the condensation.

Manufacturer: MFJ Enterprises, PO Box 494, Mississippi State, MS 39762, tel 800-647-1800; **www.mfjenterprises.com**. Price: $89.95.

Telewave 44AP RF Wattmeter

Reviewed by Phil Salas, AD5X
QST *Contributing Editor*
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The Telewave 44 series is a bidirectional RF wattmeter that directly measures forward and reflected power from 1 W to 500 W in a coaxial line. The model 44A covers 20 MHz to 1000 MHz. The 44AP, reviewed here, also includes an RF sampling port that is coupled nominally 40 dB below the transmission line level. This coupled port may be used to inject a signal into a unit under test, or for frequency measurement and/or spectrum analysis. Normal operation of the 44AP is unaffected when using the sampling port. There are also two lower frequency versions. The model 44L1 covers 2 MHz to 200 MHz, and the 44L1P is similar but with a –40 dB sampling port.

The Telewave 44AP is similar in construction, size, and functionality to the popular Bird 43 wattmeter. However, the Telewave 44AP includes both a wide-band coupler and a high dynamic range power sensor, so it does not require the use of additional elements to cover its full power and frequency range. The meter movement can be turned off for rough handling when not in use. It has rubber feet on the back and bottom, along with a leather carrying strap. The 44AP uses quick change connectors, and Type N female is standard. Options include UHF, DIN, TNC, and BNC. The sampling port connector is a BNC female.

Bottom Line

The rugged Telewave 44AP accurately measures power levels from 5 to 500 W from 20 to 1000 MHz. It is particularly useful for measuring VHF and UHF transmitters and antenna systems, and for use in the field or harsh environments.

Operational Details

The Telewave 44AP is not a peak-reading instrument. Its precision directional coupler and detectors sample forward and reverse continuous current which is then scaled to drive an analog, multiscaled meter. Forward and reflected power are displayed by selecting FWD or REV on the front-panel switch. SWR is determined by using a chart on the back of the instrument (Figure 12) or with an equation provided in the manual. The five power levels — 5, 15, 50, 150, and 500 W full scale — provide for testing most transmitters. Table 5 lists the Telewave 44AP specifications.

Detailed Testing Results

Table 6 details power measuring tests that compare the 44AP to my NIST-traceable MiniCircuits PWR-6GHS+ power sensor and calibrated attenuators. I used the scales that gave the maximum reading achievable with the equipment I had available. For measurements below 150 MHz, the Telewave manual shows a chart of correction values that must be applied to the value displayed on the meter. Table 6 shows my measurements with correction values applied (+39% at 21 MHz, +9.5% at 50 MHz, and 0% from 144 MHz and up). The greatest difference between the 44AP and my PWR-6GHS+ occurs on the lowest frequency, where the correction factor is changing rapidly.

Next I measured SWR accuracy. For this

Table 5
Telewave 44AP, s/n 34780

Manufacturer's Specifications	Test Results
Frequency range: 20 – 1000 MHz	As specified.
Full-scale power ranges: 5, 15, 50, 150, 500 W.	As specified.
Accuracy: 20 – 150 MHz, ± 6% of full scale after correction; 150 – 1000 MHz, ± 6% of full scale.*	See Table 7
Impedance, primary line: 50 Ω.	As specified
SWR (max): 1.1:1.	As specified to 800 MHz; increases to 1.27:1 at 1000 MHz
Insertion loss: 0.1 dB maximum	See Figure 16.
RF sample port attenuation: 40 dB ±2 dB below total power.	As specified 100 to 1000 MHz; increases to 55 dB at 21 MHz.

Size (height, width, depth): 6.625 × 4 × 3.25 inches. Weight: 3 lbs.

Price: Model 44AP, $1035. Model 44A (20 MHz – 1000 MHz, no sampling port), $953. Model 44L1 (2 – 200 MHz), $953. Model 44L1P (2 – 200 MHz with sampling port), $1035.

*With N connectors. Accuracy not specified with UHF connectors.

Figure 12 — The rear panel includes an SWR chart and table of correction factors for various frequencies so you don't need to carry the manual.

test I used 4.8 dB (2:1 SWR) and 3 dB (3:1 SWR) microwave attenuators with open-circuit and short-circuit outputs so as to provide both low impedance and high impedance SWR loads. The loads were measured on an Array Solutions VNAuhf and the results are compared with the 44AP in Table 7. As with the power measurements, 44AP meter scales were used that gave the largest meter deflection. The SWR determined from the 44AP's forward and reflected power readings compared reasonably well with the measurements from my VNAuhf.

Next the 44AP was terminated in a precision 50 Ω load (load return loss >30 dB). The input SWR was measured with an Array Solutions VNAuhf. The 44AP meets its 1.1:1 SWR spec to about 800 MHz. It degrades slightly to about 1.27:1 at 1000 MHz.

I also used the VNAuhf to scan insertion loss. As shown in Figure 13, the 0.1 dB insertion loss spec is met to about 370 MHz, and insertion loss rises gradually to about 0.6 dB at 1000 MHz.

The final test was a check of the attenuation at the RF sampling port. The 40 dB ±2 dB spec is met from 100 to 1000 MHz. Below 100 MHz the attenuation increases rapidly, to about 55 dB at 21 MHz.

A Few Comments on Measurement Accuracy and Precision

The Telewave 44AP uses an analog meter, so there may be some parallax error when reading it. The readings must also be interpreted when they don't fall exactly on

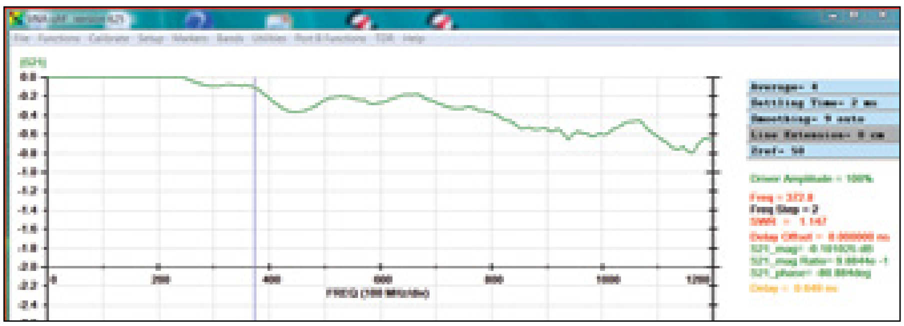

Figure 13 — Insertion loss of the Telewave 44AP as measured with the author's Array Solutions VNAuhf. Insertion loss is 0.1 dB or less to about 370 MHz, rising to about 0.6 dB at 1000 MHz.

Table 6
Telewave 44AP Power Measurements

	5 W Range			15 W Range			50 W Range			150 W Range		
Frequency	Pact	44AP	Difference	Pact	44AP	Difference	Pact	44AP	Difference	Pact	44AP	Difference
21 MHz	5.0	5.4	+8%	15	16.7	+11%	50	55.6	+11%	100	111	+11%
50 MHz	5.0	4.9	–2%	15.0	14.8	–1%	50	49	–2%	97	95	–2%
146 MHz	4.7	4.5	–4%	—	—	—	49	47	–4%	—	—	—
222 MHz	—	—	—	11	11	0%	27	27	0%	53	53	0%
450 MHz	4.0	4.0	0%	8.2	8.2	0%	43.5	43.5	0%	—	—	—

Measurements by the author of power measured with a MiniCircuits PWR-6GHS+ power sensor and calibrated attenuators (Pact) compared with the 44AP. The 44AP power measurements include correction factors shown in the manual.
— = not measured

Table 7
Telewave 44AP SWR Measurements with High and Low Impedance (Z) Loads

Frequency (MHz)	2:1 SWR Low Z		2:1 SWR High Z		3:1 SWR Low Z		3:1 SWR High Z	
	VNAuhf	44AP	VNAuhf	44AP	VNAuhf	44AP	VNAuhf	44AP
21	2.0	1.73	2.02	2.38	3.14	2.51	3.0	3.52
50	2.0	1.84	2.03	2.25	3.13	2.54	2.99	3.50
146	1.99	2.41	2.01	1.99	3.13	3.19	2.99	3.42
220	1.97	1.79	2.01	2.46	3.14	3.49	2.96	3.00
450	2.04	2.13	2.03	2.38	3.09	3.17	2.87	2.78

Measurements by the author of various loads with the Telewave 44AP compared to Array Solutions VNAuhf.

a meter mark, keeping in mind that power markings are divided into five segments on some power ranges, and four segments on other power ranges. Below 150 MHz, you must apply a correction factor that is read from a relatively coarse graph that changes rapidly below 100 MHz. However, the bottom line is that the Telewave 44AP is accurate enough for most transmit power and transmission line or antenna measurements.

Final Thoughts

The Telewave 44AP is a compact, self-powered through-line wattmeter that provides a wide power measurement range along with wide frequency coverage. While it is easiest to read when measuring transmitters and antenna systems from 140 to 1000 MHz, it can be used down to 20 MHz by adding in a correction factor. Its rugged, self-contained package makes it a good choice for measurements in the field as well.

Manufacturer: Telewave, 660 Giguere Ct, San Jose, CA 95133; **www.telewave.com**.

Radio Works Carolina Windom 80 Antenna

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The traditional ½-wavelength dipole offers an impedance around 70 Ω when fed at the center, which is close enough for a simple connection to 50 Ω coaxial cable. On the other hand, a center-fed dipole is often only resonant on a single band. Yes, you can use an antenna tuner and load a center-fed dipole on almost any frequency you desire, but that raises the specter of RF loss due to high SWR on the feed line, not to mention the complication of adding an antenna tuner to the system.

But rather than feeding a dipole at its 50 Ω point, why not try feeding it somewhere else? In an off-center-fed (OCF) dipole, the feed point slides to the 200 Ω point, which is about ⅓ of the way from one end of the antenna. If you place a 4:1 current balun there, you'll have a 50 Ω impedance for your coaxial cable (200 / 4 = 50).

Bottom Line

The Carolina Windom 80 from Radio Works allows operation from 80 through 10 meters with a single feed line. This 133 foot long OCF antenna can be installed horizontally or as an inverted V, but it must be at least 25 feet off the ground.

Best of all, the impedance will be at or near 50 Ω on more than one band.

Some amateurs refer to OCF dipole antennas as "Windoms," but true Windom antennas are rather different. The original design was the creation of Loren Windom, W8GZ, and his idea was to feed a horizontal antenna with a single wire at the 600 Ω point. The single wire acted as a feed line, after a fashion, but it also radiated RF.

The Radio Works Carolina Windom 80 takes an interesting approach. According

Figure 14 — The complete Radio Works Carolina Windom 80 arrives in a large plastic bag. The kit includes stranded copper wire, insulators, a matching unit and line isolator.

to the Radio Works website, the Carolina Windom was the result of experiments by Jim Wilkie, WY4R, Edgar Lambert, WA4LVB, and Joe Wright, W4UEB, to create an antenna that would provide decent coverage on 75 meters between Norfolk, Virginia and northern North Carolina, while still being resonant on several additional bands. The antenna is fed at the 200 Ω point using a matching unit, which is also connected to a 22 foot vertical length of coaxial cable that is deliberately designed to radiate, providing both horizontally and vertically polarized radiation patterns. The RF is kept off the feed line to your station through the use of a sizeable line isolator.

This 80 through 10 meter antenna is 133 feet long. One leg is 50 feet in length and the other leg is 83 feet in length. If you have enough room to mount the Carolina Windom 80 in a straight horizontal line, more power to you, but the antenna can be installed in several different configurations — even an inverted V. The antenna is rated at 1500 W for SSB and CW (it's not rated for continuous duty cycle modes such as AM and RTTY).

Installation and Testing

The Radio Works Carolina Windom 80 arrives in a large plastic bag that contains everything you need, including a detailed manual and connector-sealing putty. Figure 14 shows the kit. Construction quality is excellent; the antenna is almost entirely pre-assembled with large gray insulators at the ends of both legs.

The instructions state that center of the antenna should be at least 35 feet off the ground. Since the line isolator hangs at the end of a 22-foot cable, you certainly have to get the center at least 25 feet high. In the case of the Carolina Windom 80, higher is better, but the best I could do was about 28 feet which brought the bottom end of the line isolator to eye level. Considering the postage-stamp-sized lot I live on, my remaining options were few. Figure 15 shows the apex of the installed antenna.

Figure 15 — The matching unit at 28 feet above ground.

To keep the legs of the antenna from dangling over the property lines, I had to use an inverted V configuration with one end 8 feet high and the other end about 20 feet high. When I attached my antenna analyzer to the feed line, I wasn't optimistic. This was far from an ideal installation, so I was prepared to see high SWR on most bands.

To my astonishment, the Carolina Windom 80 provided SWRs of less than 2.5:1 on 80, 40, 30, 20, 15, 12, and 10 meters. The manual indicates that the antenna will work on 6 meters with a 200 W rating, but I didn't try it there. I'm confident that with a better installation the low-SWR points would be less than 1.5:1 on the bands shown.

Taking it On the Air

One of the pernicious myths in Amateur Radio is that a low SWR guarantees good antenna performance. In truth, a low SWR only means that you can deliver the maximum amount of RF power to the antenna system. "Performance" depends on what happens to the RF once it reaches the antenna.

Yet another myth is that one can measure performance by how many stations one can contact. This is true to a point, but so often you'll hear an amateur proclaim that his new sky wire is a super performer because "I worked a Serbian station [or fill in the DX entity of your choice] on my first attempt with the antenna!" This conveniently ignores the fact that there many variables in play. What if the DX station was aiming a high gain directional antenna at you? And running full legal power? And using a high-performance transceiver that could make your mediocre signal intelligible?

If you can switch between antennas, you might be able to get a sense of how one compares to another. You can also use certain digital modes such as JT65 and WSPR to obtain objective signal reports as you swap antennas.

With that in mind, allow me to make a few *subjective* statements about how the Radio Works Carolina Windom 80 performed at my station. I switched back and forth between the Windom and my 40 meter delta loop and I have to say that the Carolina Windom 80 seemed to outperform the loop by a noticeable margin, especially on the higher bands. On 20 through 10 meters, it was consistently one to two S units above the loop. Because of the Windom's low height, my range on 80 and 40 was somewhat limited, but the performance was still impressive, perhaps because of its combination of horizontal and vertical radiation.

Radio Works has a well-made product in its Carolina Windom 80. If I can realize such impressive results from my compromised low-height installation, imagine what it could do when installed in its optimum configuration.

Manufacturer: Radio Works, Box 6159, Portsmouth, VA 23703; tel 757-484-0140, 800-280-8327; **www.radioworks.com**. Price: $170.