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Kenwood TS-990S HF and 6 Meter Transceiver

Kenwood's top-tier transceiver is loaded with features.

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The long-awaited, top-tier Kenwood TS-990S is a magnificent behemoth — not surprising when you consider it swallowed an entire TS-590S for its subreceiver. Among its interior features are separate DSP chips for the main receiver, the subreceiver, and the bandscope to spread the workload, and hefty FETs operating at 50 V that help to moderate transmit IMD, keying sidebands and operating temperature while it's cranking out 200 W. Words such as "bulletproof" and "brick wall" barely begin to describe this receiver's ability *not* to hear something you don't want to hear.

This handsome radio sports an ambitious front panel, with no fewer than 110 buttons — including the one that actually turns on the radio — and 28 knobs, including concentric controls and the main and sub tuning knobs. A lot are dual-purpose — press, or press and hold. Given their tight proximity and the less-than-prominent off-white labeling, it's very easy to, for example, mix up the CW T. and FIL/SEL buttons or turn the MULTI/CH knob when you *really* meant to grab the RIT/XIT knob.

User Friendly

Much of the transceiver's personality resides in upgradable firmware, and the radio incorporates functions you've been relying on your PC to perform in the shack. Many critical functions exist only in code, so features can be added or improved (we updated our unit twice). Will the paradigm among manufacturers shift from introducing new hardware to developing better software for *existing* platforms?

The true beauty of the TS-990S is that it although it's a "hardware" radio, it essentially lets you configure the radio that *you* want. The other side of that coin, however, is that you can invest *considerable* time getting it "just so." For operators who desire one array of transceiver settings for casual operating and another for contesting or DXing, the TS-990S lets you save two *complete* transceiver configuration sets on a USB thumb drive — menu settings, audio equalization and routing, and other parameters. This fine tuning may be an enjoyable exercise — sort of like sitting in the driveway with your head under the hood, tinkering, with the engine of your high-performance sports car — but it doesn't beat getting on the air. *Zoom zoom!*

Bottom Line

Kenwood's top-tier TS-990S offers high performance and an extensive list of features. Its settings are highly customizable, and it looks and sounds terrific.

Figure 1 — The larger of the two colorful LCD panels can be configured to show many different operating parameters.

On the Face of It

The '990 has *two* colorful LCD front-panel display windows, the larger measuring about 3.5 × 5.8 inches (Figure 1), the smaller "subdisplay" — directly above the sizeable main tuning knob — about 2.3 × 2.8 inches (Figure 6). Between them they can tell you everything you need to know. The displays are clear and sharp.

Connecting an external display may be a wise decision, because the main display contains an encyclopedia's worth of status information and can include a bandscope and/or waterfall to boot — your call. It's easy for info such as time and date to get "lost" in the display.

The smaller display duplicates the main radio's frequency readout, contains a *mini*-bandscope, and, depending on mode, can graphically represent such things as filter and IF shift settings and provide a tuning aid for RTTY or PSK. The most unusual thing about this tuning display, however, is the virtual analog apron, or "skirt," that recalls the Kenwood TS-520 era.

Scoping the Waterfall!

Repeatedly pressing the SCP button will cycle you through a screen where the bottom half is blank, a screen where the bandscope takes up the bottom half, and a screen where the bottom half is roughly divided between a reduced-height bandscope and a waterfall that uses a color-coding scheme to indicate relative signal strength. The pattern rendered on the bandscope in the main display is smooth and sharp. Shadowing is a choice on the bandscope. Averaging lets you "settle down" the spectrum scope, making it a bit easier to spot signal peaks under certain conditions.

A lot of new TS-990S owners are enthusiastic about the waterfall. It's available in all modes, although most hams are probably familiar with this feature from their digital mode software. It's terrific but has its limitations. If you tune the receiver with the waterfall display in CENTER mode, the waterfall *stops*! This means you cannot tune *over* to a signal on the waterfall that may not be making much of an impression on the bandscope but is showing clearly on the waterfall. This leaves FIXED mode, in which the waterfall spans the limits of the current band. This also applies to CENTER and FIXED mode with the bandscope.

A *mini* waterfall shows up in FSK or PSK,

Table 1
Kenwood TS–990S, serial number B3200197

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 0.03–60 MHz; transmit, 1.8–2.0, 3.5–4, 5.25–5.45, 7–7.3, 10.1–10.15, 14–14.35, 18.068–18.168, 21–21.45, 24.89–24.99, 50–54 MHz.	Receive and transmit, as specified.
Power requirement: 90–132, 180–264 V ac; transmit, ≤720 VA; receive, ≤120 VA.	560 VA (transmit, maximum RF power output), 66 VA (receive, full volume, no signal, maximum display brightness).
Modes: SSB, CW, AM, FM, FSK, PSK.	As specified.
Receiver	**Receiver Dynamic Testing, Main Receiver**
SSB/CW/FSK/PSK sensitivity, 10 dB S/N: 0.5 µV (0.13–0.522 MHz), 4 µV (0.522–1.705 MHz), 0.2 µV (1.705–24.5 MHz), 1.3 µV (24.5–30 MHz), 1.3 µV (50–54 MHz).	Noise floor (MDS), 500 Hz bandwidth, 500 Hz roofing filter: *Preamp off* / *Preamp on* 0.137 MHz: –123 dBm / –127 dBm 0.475 MHz: –133 dBm / –138 dBm 1.0 MHz: –109 dBm / –119 dBm 3.5 MHz: –129 dBm / –139 dBm 14 MHz: –128 dBm / –138 dBm 50 MHz: –127 dBm / –140 dBm
Noise figure: Not specified.	14 MHz, preamp off/on: 19/9 dB.
AM sensitivity, 10 dB S/N: 0.5 µV (0.13–0.522 MHz), 32 µV (0.522–1.705 MHz), 2 µV (1.705–24.5 MHz), 1.3 µV (24.5–30 MHz), 1.3 µV (50–54 MHz).	10 dB (S+N)/N, 1–kHz, 30% modulation, 6 kHz bandwidth, preamp off/on: 1.0 MHz: 27.8 µV / 6.5 µV 3.8 MHz: 2.48 µV / 0.75 µV 50 MHz: 2.72 µV / 0.63 µV
FM sensitivity, 12 dB SINAD: 0.22 µV (28–30 MHz); 0.22 µV (50–54 MHz).	For 12 dB SINAD, 3 kHz deviation, 15 kHz bandwidth, preamp off/on: 29 MHz: 1.55 µV / 0.21 µV 52 MHz: 1.00 µV / 0.22 µV
Spectral display sensitivity: Not specified.	With 100 kHz display width, preamp off/on: 14 MHz: –102 dBm / –113 dBm 50 MHz: –106 dBm / –121 dBm
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz bandwidth, 500 Hz roofing filter: *20 kHz offset Preamp off/on* / *5/2 kHz offset Preamp off* 3.5 MHz: >139/>149 dB / >139/134 dB 14 MHz: >138/>148 dB / >138/133 dB 50 MHz: >137/141 dB / >137/132 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 117/101/87 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	–25 dBm	–129 dBm	104 dB	+27 dBm
		–6 dBm	–97 dBm		+40 dBm
14 MHz/Off	20 kHz	–16 dBm	–128 dBm	112 dB	+40 dBm
		–3 dBm	–97 dBm		+44 dBm
		0 dBm	–88 dBm		+44 dBm
14 MHz/On	20 kHz	–25 dBm	–138 dBm	113 dB	+32 dBm
		–11 dBm	–97 dBm		+32 dBm
14 MHz/Off	5 kHz	–17 dBm	–128 dBm	111 dB	+39 dBm
		–3 dBm	–97 dBm		+44 dBm
		–0 dBm	–90 dBm		+45 dBm
14 MHz/Off	2 kHz	–27 dBm	–128 dBm	101 dB	+24 dBm
		–9 dBm	–97 dBm		+35 dBm
		0 dBm	–88 dBm		+44 dBm**
50 MHz/Off	20 kHz	–19 dBm	–127 dBm	108 dB	+35 dBm
		–9 dBm	–97 dBm		+35 dBm

Second-order intercept point: Not specified.	Preamp off/on: 14 MHz, +69/+69 dBm; 50 MHz, +57/+57 dBm.
DSP noise reduction: Not specified.	Variable, 20 dB maximum.
Notch filter depth: ≥70 dB (manual), ≥70 dB (auto).	Manual notch: >60 dB; Auto notch: >60 dB, attack time: 164 ms.

FM adjacent channel rejection: Not specified.	Preamp on: 29 MHz, 89 dB; 52 MHz, 87 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset, preamp on: 29 MHz, 86 dB; 52 MHz, 85 dB; 10 MHz offset: 29 MHz, 113 dB; 52 MHz, 115 dB.
S meter sensitivity: Not specified.	S-9 signal, preamp off/on: 14.2 MHz, 75.8/19.3 µV; 50 MHz, 69.1/8.2 µV.
Squelch sensitivity: Not specified.	At threshold, preamp on: FM, 0.09 µV (29 MHz); SSB, 0.6 µV (14.2 MHz).
Receiver audio output: ≥1.5 W into 8 Ω.	2.8 W at 10% THD into 8 Ω. THD at 1 V RMS: 0.3%.
IF/audio response: Not specified.	Range at –6 dB points, (bandwidth) ‡: CW (500 Hz BW): 449–949 Hz (500 Hz); Equivalent rectangular BW: 496 Hz; USB: (2.6 kHz):100–2530 Hz (2430 Hz); LSB: (2.6 kHz): 101–2530 Hz (2429 Hz); AM: (2.9 kHz): 140–2590 Hz (4900 Hz); AM: (5 kHz): 120–2940 Hz (5640 Hz).
Spurious and image rejection: Not specified.	First IF, 14 MHz, 68 dB; 50 MHz, 70 dB; image, 14 MHz, >72 dB; 50 MHz, >137 dB.

Receiver	Receiver Dynamic Testing, Sub Receiver‡‡
SSB/CW/FSK/PSK sensitivity, 10 dB S/N: 0.5 µV (0.13–0.522 MHz), 4 µV (0.522–1.705 MHz), 0.2 µV (1.705–24.5 MHz), 1.3 µV (24.5–30 MHz), 1.3 µV (50–54 MHz).	Noise floor (MDS), 500 Hz bandwidth, default roofing filter:

	Preamp off	*Preamp on*
0.137 MHz	–126 dBm	–133 dBm
0.475 MHz	–128 dBm	–138 dBm
1.0 MHz	–109 dBm	–118 dBm
3.5 MHz	–128 dBm	–138 dBm
10.1 MHz	–126 dBm	–134 dBm
14 MHz	–128 dBm	–137 dBm
50 MHz	–125 dBm	–137 dBm

Noise figure: Not specified.	14 MHz, preamp off/on: 19/10 dB.
AM sensitivity, 10 dB S/N: 0.5 µV (0.13–0.522 MHz), 32 µV (0.522–1.705 MHz), 2 µV (1.705–24.5 MHz), 1.3 µV (24.5–30 MHz), 1.3 µV (50–54 MHz).	10 dB (S+N)/N, 1-kHz, 30% modulation, 5 kHz bandwidth, preamp off/on:

1.0 MHz	26.0 µV	8.60 µV
3.8 MHz	3.59 µV	1.40 µV
50 MHz	4.41 µV	0.91 µV

FM sensitivity, 12 dB SINAD: 0.22 µV (28–30 MHz); 0.22 µV (50–54 MHz).	For 12 dB SINAD, 3 kHz deviation, 15 kHz bandwidth, preamp off/on:

29 MHz	1.11 µV	0.23 µV
52 MHz	1.51 µV	0.29µV

Blocking gain compression dynamic range: Not specified.

Blocking gain compression dynamic range, 500 Hz bandwidth, default roofing filter:

	20 kHz offset Preamp off/on	*5/2 kHz offset Preamp off*
3.5 MHz	>138/145 dB	>138/138 dB
10.1 MHz	136/135 dB	127/124 dB
14 MHz	>138/143 dB	>138/130 dB
50 MHz	135/130 dB	108/98 dB

Reciprocal mixing dynamic range: Not specified. 14 MHz, 20/5/2 kHz offset: 117/105/94 dB

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

Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
10.1 MHz/Off	20 kHz	–24 dBm	–126 dBm	102 dB	+27 dBm
		–15 dBm	–97 dBm		+26 dBm
		0 dBm	–48 dBm		+24 dBm
10.1 MHz/On	20 kHz	–35 dBm	–134 dBm	99 dB	+15 dBm
		–23 dBm	–97 dBm		+14 dBm
10.1 MHz/Off	5 kHz	–34 dBm	–126 dBm	92 dB	+12 dBm
		–25 dBm	–97 dBm		+11 dBm
10.1 MHz/Off	2 kHz	–37 dBm	–126 dBm	87 dB	+5 dBm
		–26 dBm	–97 dBm		+10 dBm

[continued on page 56]

though, and it does continue to flow as you tune, although its width is determined by the filter you have set. The bandscope works in all modes, and if you add the waterfall along the bottom half of the main display, the height of the bandscope reduces by two-thirds. Using the digital mode decode screen takes the waterfall down to about one-third its usual width, and the bandwidth is reduced to a maximum of 1500 Hz.

Span choices in CENTER mode are 5, 10, 20, 50, 100, 200, and 500 kHz. Narrower is better on the bandscope, but you can easily distinguish signals by using the waterfall.

Touchy Feely

The TS-990S offers limited touch-screen capability. Touch a signal on the bandscope or waterfall, and the radio tunes to it. (The mini-waterfall is *not* a touch display.) This sounds better in theory. You must apply fairly firm pressure (compared, say, to an iPad), and tuning precision is only approximate at best, especially for narrow bandwidth modes (unless you have *very* pointy fingertips). It is far more precise with the waterfall. It's a nice touch, however (pun intended), and I did find myself using it more as I got familiar with the radio. It's also an excellent way to speed frequency changes. It's possible to exact far greater precision using a touch stylus.

On the Menu

The TS-990S menu befits such a substantial radio, and navigation is straightforward. Press the orange-labeled MENU button (it's the *only* orange label), and it brings up the top-level menu, which is divided into groups 0 through 9. Each group covers a certain group of controls. For example, 0 is "Basic Configurations." Highlight a group, and its abbreviated contents appear in (or stream across) the highlighted field. Kenwood has employed streaming-text menus in previous models but not in such a sophisticated presentation. Select the menu and you can navigate among the various parameters in that group. For example group 0, item 02 lets you adjust the font style for the frequency display (there are three choices). Many parameters are settable using the buttons below the menu screen or along the right side, although some are (also) adjustable by using the MULTI/CH knob.

All Things Being Equal

The TS-990S does not leave transmit or receive audio to chance. In addition to some

[continued from page 55]

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

Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
14 MHz/Off	20 kHz	–21 dBm	–128 dBm	107 dB	+33 dBm
		–11 dBm	–97 dBm		+32 dBm
		0 dBm	–58 dBm		+29 dBm
14 MHz/On	20 kHz	–34 dBm	–137 dBm	103 dB	+18 dBm
		–21 dBm	–97 dBm		+17 dBm
14 MHz/Off	5 kHz	–21 dBm	–128 dBm	107 dB	+33 dBm
		–11 dBm	–97 dBm		+32 dBm
		–0 dBm	–58 dBm		+29 dBm
14 MHz/Off	2 kHz	–30 dBm	–128 dBm	98 dB	+19 dBm
		–16 dBm	–97 dBm		+25 dBm
		0 dBm	–57 dBm		+29 dBm

Second-order intercept point: Not specified.	Preamp off/on, 14 MHz, +73/+73 dBm; 50 MHz, +65/+27 dBm.
FM adjacent channel rejection: Not specified.	Preamp on: 29 MHz, 85 dB; 52 MHz, 83 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset, preamp on: 29 MHz, 85 dB†; 52 MHz, 83 dB†; 10 MHz offset: 29 MHz, 106 dB; 52 MHz, 106 dB.
S meter sensitivity: Not specified.	S-9 signal, preamp off/on: 14.2 MHz, 86.0/20.9 µV; 50 MHz, 107.0/10.7 µV.
Squelch sensitivity: Not specified.	At threshold, preamp on: FM, 0.1 µV (29 MHz), SSB, 0.7 µV (14.2 MHz).
Receiver audio output: ≥1.5 W into 8 Ω.	2.8 W at 10% THD into 8 Ω. THD at 1 V RMS: 0.3%.
IF/audio response: Not specified.	Range at –6 dB points, (bandwidth): CW (500 Hz): 460–950 Hz (490 Hz); Equivalent rectangular BW: 476 Hz; USB: (2.6 kHz): 226–2481 Hz (2255 Hz); LSB: (2.6 kHz): 227–2537 Hz (2310 Hz); AM: (4.9 kHz): 137–2299 Hz (5324 Hz).
Spurious and image rejection: Not specified.	First IF, 10 MHz, 107 dB; 14 MHz, 99 dB; 50 MHz, 117 dB; image, 10 MHz, 100 dB; 14 MHz, 88 dB; 50 MHz, 92 dB.

Transmitter	**Transmitter Dynamic Testing**
Power output: 200 W (50 W AM).	HF: typically 4.5–200 W (4.5–50 W AM); 50 MHz, 4.3–190 W (4.2–50 W AM).
Spurious-signal and harmonic suppression: HF: ≥60 dB (harmonics), ≥50 dB (others), 50 MHz, ≥66 dB.	HF, 69 dB (worst case, 10 meters), typically > 70 dB; 50 MHz, 68 dB. Meets FCC requirements.
SSB carrier suppression: ≥60 dB.	HF and 50 MHz, >70 dB.
Undesired sideband suppression: >55 dB.	HF and 50 MHz, >70 dB.
Third-order intermodulation distortion (IMD) products: Not specified.	HF, 200 W PEP, 3rd/5th/7th/9th order: –31/–46/–52/–57 dB (worst case, 10 m), typically –39/–46/–54/–56; 50 MHz, –36/–47/>–60/–58 dB.
CW keyer speed range: Not specified.	4 to 60 WPM.
CW keying characteristics: Not specified.	See Figures 2 and 3.
Iambic keyer mode: Not specified.	Mode B
Transmit-receive turn-around time (PTT release to 50% audio output): Not specified.	S9 signal, 35 ms.
Receive-transmit turn-around time (tx delay): Not specified.	SSB, 18 ms; FM, 8 ms.
Composite transmitted noise: Not specified.	See Figure 4.

Size (height, width, depth): 7.2 × 18.1 × 17.7 inches (incl protrusions); weight, 54 lbs.
Price: $7999

*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.
**This measurement was made with the 270 Hz roofing filter.
†Measurement was noise–limited at the value indicated.
‡Default values; bandwidth and cutoff frequencies are adjustable via DSP. For SSB, DSP was set to 2800 Hz for "high" and 200 Hz for "low" for a width of 2600 Hz. For AM, it was set to 100 Hz/3000 Hz and 0 Hz/5000 Hz for the main receiver and 100 Hz/5000 Hz for the sub RX.
‡‡The TS-990S subreceiver operates as either a double downconversion receiver (RX1) or triple upconversion receiver (RX2) depending on the band of operation and filter bandwidth selected. To give an example of the performance of each configuration, RX1 with 500 Hz roofing filter was used for receiver tests at 14 MHz; RX2 with 15 kHz 1st IF filter and 2.7 kHz 2nd IF filter was used for testing on 10.1 MHz.

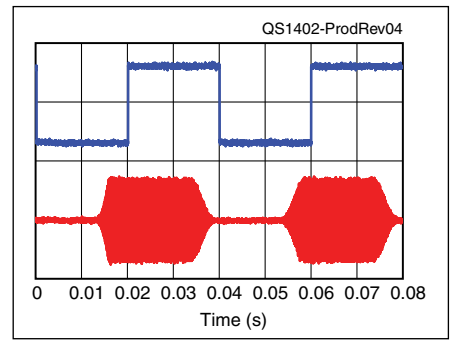


Figure 2 — CW keying waveform for the TS-990S showing the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 200 W output on the 14 MHz band.

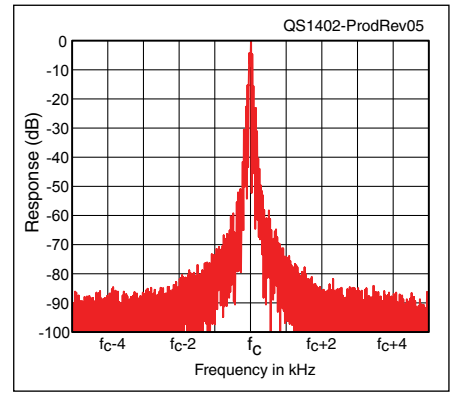


Figure 3 — Spectral display of the TS-990S transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 200 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

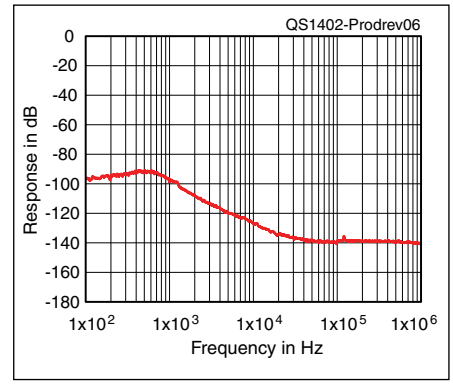


Figure 4 — Spectral display of the TS-990S transmitter output during composite-noise testing. Power output is 200 W on the 14 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

"presets" for transmit and receive audio response (such as "High Boost 1 and 2" or "Formant Pass"), there are three configurable user settings.

Press the ADJUST key for one of those and an *18 octave* parametric equalizer pops up, allowing nearly limitless tweaking within the confines of the overarching receiver and transmitter DSP filter settings.

The Roofing Crew

The TS-990S offers a wide selection of stock roofing filters. A selection of comparatively narrow filters ahead of the receiver's first mixer is a more recent wrinkle in ham receiver technology. Narrow roofing filters are another hedge against the effects of nearby strong signals. The TS-990S can automatically select an appropriate roofing filter based on mode, but you can set it up to insert a 270 Hz, 500 Hz, 2.7 kHz, 6 kHz, or 15 kHz roofing filter.

The TS-990S subreceiver uses the same design as the TS-590S, reviewed in the May 2012 issue of *QST*, and its performance is very similar. The subreceiver operates as a double downconversion receiver 160, 80, 40, 20, and 15 meters with a mode-appropriate roofing filter selected automatically (500 Hz is the narrowest). For the other bands it's a triple upconversion design with wider filters — 15 kHz at the 1st IF filter and 2.7 kHz at the 2nd IF.

Configuring Filters

A seemingly infinite variety of filter settings are available — roofing, IF DSP and AF DSP. The TS-990S also lets you perform some rudimentary filter shaping — sharp, medium, or soft. You can have either two or three filter settings (pressing the FIL/SEL button for either receiver steps through the choices for the current mode; pressing and holding the FIL/SEL button brings up the configuration table).

One screen configures all filter settings, greatly simplifying matters. Within the matrix for the selected mode are three (or two, if selected) choices for roofing, IF and AF filters, FIL-A, FIL-B, and FIL-C. The concentric HI/SHIFT and LO/WIDTH controls adjust the upper and lower filter passbands inside and outside the configuration window. A graphical representation in the configuration window lets you view the effects of your individual choices.

Noise Reduction

As Kenwood has done with its other recent HF transceiver offerings, the TS-990S provides two noise reduction modes, each based on a different adaptive (ie, "self-learning") algorithm, but it's really three types. Here's the thing about adaptive noise reduction. Enabling noise reduction in the absence of a signal is not going to tell you very much about how well it works. You may hear some difference in the tone or background "sound," but adaptive noise reduction systems need a signal to distinguish from the noise, and once they "figure out" which is which, the signal will emerge as if by magic. This was especially the case with the NR systems in the TS-990S. They work very, very well.

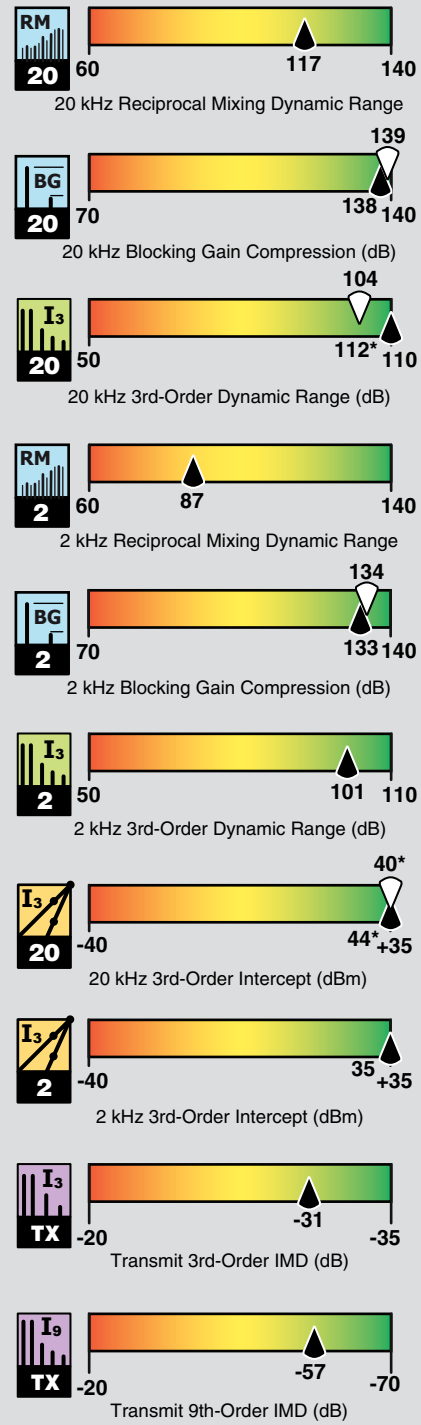
NR1 activates a spectrum subtraction-type noise reduction filter when the transceiver is in SSB, FM or AM mode. When receiving CW, FSK or PSK, however, the noise reduction system emphasizes the intermittent nature of CW. The second flavor of noise reduction — NR2 — which I long ago dubbed "crazed weasels" on my TS-480HX because of its squealy backdrop — is a SPAC (speech processing by auto correlation) system that, ironically, is terrific for CW reception, although some may find the digital artifacts bothersome.

Adjusting the NR1 control varies the degree of desired noise reduction, while adjusting the NR2 control varies the time constant for that noise-reduction system. You may experience popping and distortion on CW if you don't have it set up just right and/or are not tuned dead-on. NR2 *can* sound worse in elevated noise situations (in some instances NR2 can overlay a crackling noise, but it really clears things up). You most likely would not want to use NR2 on SSB, but the TS-990S offers so many *other* means of fighting noise and interference you're sure to find *something* that does the trick.

Using the noise reduction made a big difference when trying to hear relatively weak signals on 160 meters, which can be annoyingly noisy at my location. The preselector can also help to reduce noise by limiting the amount of broad-spectrum noise (2 or 3 MHz away) entering the IF passband. I was able to drop noise from about S-7 to S-1. You cannot use the preselector in combination with the preamp.

Speaking of noise, the adjustable APF (audio peak filter) is excellent to enhance readability in noisy conditions on CW — and the narrower the better in that mode,

Key Measurements Summary



pr082

Key: *Off Scale

Measurements shown are for main receiver only.

Dynamic range and intercept values with preamp off.

Intercept values were determined using -97 dBm reference

80 M

20 M

although you can set three filter passband choices. It doubles as a twin-peak audio filter for RTTY.

I used the TS-990S during the August North American QSO parties — CW and SSB. I found the receiver quiet, yet I was easily copying signals that were S-0 on the meter. The noise reduction was very effective in both modes, with NR1 superior for SSB. Although it rolls off the high end somewhat, you can overcome that by changing the audio output equalization.

The '990 offers two noise blankers to, as the manual explains, suppress "crunching pulse noise." NB1 is an analog noise blanker, while NB2 is a DSP noise blanker that works in the IF stage. Neither works in FM. The knobs to set the degree of blanking for both NB1 and NB2 are on a concentric set of front panel controls. You can enable one or both blankers. In some cases, too high a level will result in some signal degradation. I found this especially true of NB2, although for *severe* noise (I ran a vacuum cleaner that generated S7 static), neither will get you that much closer to pulling out an underlying signal. As ARRL Lab Test Engineer Bob Allison, WB1GCM, points out, "Noise comes in many shapes and amplitudes and is difficult to quantify." There is no standard test for noise blankers. The noise reduction systems are a better bet, I found.

Taking Things in a Notch or Two

The BEF (band elimination filter) doesn't make bands disappear. It applies a stop-band filter that can shape the filter bandpass to reduce noise or (especially) close-in interference. It's one of the transceiver's most useful features. It operates like a manual notch, applying an adjustable stop-band filter from 300 to 1200 Hz at a selectable attenuation level (20 dB to 80 dB in 20 dB steps) that you can sweep through the passband. The subdisplay shows you where the notch is in relationship to the signal you're trying to copy.

I made use of it while trying to copy a weak signal in atmospheric noise. I moved a 400 Hz notch downstream of the signal, and it helped keep down the static, easing copy.

The BEF and the manual notch are mutually exclusive. The manual notch is less flexible, allowing only a wide or narrow setting. Using the audio peak filter, which centers on the CW pitch frequency, in combination with one of these notch filters doubles down on CW selectivity, lopping off noise and interference from nearby stations.

Figure 5 — The TS-990S rear panel showing the available connections.

The exquisite filter graphic in the subdisplay shows your WIDTH/SHIFT settings and reads out the values numerically. I really appreciated being able to graphically see the notch with respect to the signal I was trying to read.

Tuning Around

The default tuning rate is 1000 steps per turn of the main dial. You can reduce this to 500 or to 250, which I found about right for reasonable precision and to avoid over or undershooting. The tuning step does *not* increase the faster you spin the knob.

One quick way to move from place to place without cranking the tuning knob is to use the MULTI/CH knob. It defaults to 5 kHz steps for all modes except FM, where the step is 10 kHz (the step frequency is adjustable via the menu and can be set as low as 500 Hz for SSB, CW, FSK or PSK modes). Using the MULTI/CH knob to change frequency will cause successive frequencies to round off to the nearest integer, although you can turn this off. Just be sure that in the heat of battle you don't mistake it for the XIT/RIT knob directly above it.

Other navigation methods the TS-990S offers include using the UP or DOWN buttons to move in increments of 1 MHz or entering a frequency directly using the keypad (but not an external keyboard). When you press the ENT key, the numerals on the keypad illuminate to avoid confusion with the band designation labels. You can recall the last 10 frequencies you have entered this way.

The '990s has just one RF preamplifier setting. For SSB, CW, FSK and PSK, we measured an additional 10 dB of gain on the HF bands, slightly more on 50 MHz and about half that on the LF and VLF bands that the receiver covers. The manual says the radio swaps a "low-gain type preamp" and a "sensitivity-prioritized high-gain type preamp" above 21.5 MHz, and this may account for the 13 dB of gain we measured on 6 meters. The '990S offers 6, 12 and 18 dB of attenuation.

Data Modes

The bottom button in the column of mode buttons to the left of the main tuning knob is labeled DATA. This does not enable data modes *per se* but lets you configure external modulation inputs, including such things as canned audio tracks from your PC's soundcard or digital mode (eg, AFSK RTTY or PSK31) tones to the mic input, ACC2, USB audio or optical (see Figure 5). This functions in LSB/USB, FM or AM modes. Successively pressing the DATA button cycles through audio input settings D1, D2, and D3, annunciated in abbreviated CW, if you have enabled that feature. Pressing and *holding* DATA takes you to the screen where you can configure the routing for one or more audio sources. This transceiver is the first I've encountered that incorporates an optical input, although Kenwood's home audio offerings have included this for years.

You can customize the audio input settings and routings in each of the three DATA registers, as well as determine which input handles PTT and which handles VOX. Of course, you then can tailor the audio passband in seemingly myriad ways for each individual setup. Want the contest voice tracks from your contest logging software to sound identical in timbre to your mic audio? Easy peasy!

Observations from *NCJ* Editor K4RO

After I test drove the TS-990S for a bit, I shipped it off to a real contest operator, Kirk Pickering, K4RO. Kirk likes big radios with large front panels, and the TS-990S delivered in this area. He also liked the rear panel, which he deemed "very clean and spacious, with easy access to connectors."

The waterfall display, Kirk observed, "is terrific in FIXED mode, and next to useless in CENTER mode." His primary issue with CENTER mode was that it does not update while tuning, making it harder to zero in on a specific blip. He found the waterfall to be "very helpful for contesting, both for S&P (search and pounce) and for finding a clear CQ frequency."

Kirk wired up his own connector for the serial (RS-232) interface. "Once I got my band decoder configured properly, it interfaced perfectly with my station," he said. "No issues with serial communication or the command set." The Kenwood instruction set is robust, and communication never showed any glitching.

In terms of intuitive operation, Kirk was able to figure out 90 percent of the transceiver's functions without cracking the manual. "The menu system is well pretty thought out, and the menus are clear," he said.

He felt the metering was good, but he missed the multifunction meter that his own transceiver offers, which displays a half-dozen operating parameters simultaneously.

He liked the independent MONITOR knob and the fact that it works on all modes. He also liked the lighted MUTE button for each receiver. "Very handy when running split," he said. "Sometimes you just want to quickly mute and unmute the second receiver during a DX pileup. Nice feature."

Kirk also observed, "The startup time from a 'cold' start was a bit long — long enough to lose your run frequency at the bottom of 20 meters, should you experience a power glitch." He noted that it restarts more quickly once the power supply has already been "booted" and the receiver is simply switched on from the front panel.

He didn't like it that he could not set CW-R (LSB CW) as the "normal" CW mode. "I don't like USB CW tuning. While it's selectable from the front panel, logging programs default to the 'normal' CW, which is always USB in the Kenwood implementation. I would have preferred the ability to set the radios default CW tuning to LSB." Overall, thought the TS-990S offered "a good receiver."

Most of Kirk's operating was done on the CW mode, but he received good audio reports using a dynamic microphone popular with contesters. Receiver SSB audio was pleasing to Kirk's ear, with good fidelity and overall tone characteristics. Kirk also liked the visual passband tuning indicator in the sub display, as it provided useful feedback on the filter's width and position relative to the center frequency. — *Rick Lindquist, WW1ME*

In the Box

Included in the box along with the transceiver is a thick *Instruction Manual* in 19 sections — one in English and one in French. In addition, Kenwood has enclosed the TS-990S schematic in four foldout sheets.

This transceiver has so many features and is so flexible that it's well worth downloading the 290 page PDF file on Kenwood's website in order to search for and read in detail about features that interest you. The manual is well illustrated with screen captures from the two LCD panels.

What does *not* come in the box? For starters, no "stock" microphone. Kenwood also does not include an external "selector" (programmable function keypad); you either have to build your own or buy one from a third party manufacturer. An external keypad, among other things, lets you control memory and other functions while keeping something else up on the main display.

The Inside Track

More to the point is what's inside *the radio*. Users typically enjoy pitting transceivers against each other. We can't generalize, but in terms of where the rubber meets the road, dynamic range is a suitable metric for such comparisons. Simply put, dynamic range is the receiver's ability to hear very weak signals in the presence of nearby very strong signals, and the Lab tests for that in three different ways.

A little history: In mid-2007, the ARRL Lab improved its two-tone (ie, *two* signals), third-order intermodulation distortion dynamic range (IMD DR) and blocking gain compression dynamic range (BGC DR) test methods and added reciprocal mixing dynamic range (RMDR) at the same time. RMDR represents the receiver's ability to distinguish one signal in the presence of a *single* nearby signal. "This new test gave us a better picture of the overall performance of a receiver when it is subjected to a strong adjacent signal," explains Test Engineer Bob Allison. As Allison points out, "In most cases, reciprocal mixing dynamic range is the most limiting dynamic range of the three [IMD DR, BGC DR and RMDR] at close spacing."

Which brings us to the Kenwood TS-990S. BGC DR and IMD DR at narrow (2 kHz) spacing are both similar to other high-end transceivers we've tested. At 87 dB the RMDR at 14 MHz, 2 kHz spacing, is about average. "As you can see, the TS-990S has average 2 kHz RMDR," Note that the subreceiver measured 94 dB RMDR at 2 kHz spacing.

RTTY and PSK31/63

Remember doing RTTY the old fashioned way? No, not *that* way, but by loading some freeware on your PC and running audio to and from your sound card? While the TS-990S may not be the first radio to incorporate plug-and-play RTTY, it has splendidly enhanced and simplified the experience. It is literally plug and play.

Plug any USB keyboard into one of the front-panel jacks, hit ESC to clear the bottom half of the main display, press the DECODE button (F3), and you're good to go. There are two tuning displays: An FFT scope in the main display above the waterfall, and a vector scope in the subscreen. Press F12 (I had to look that up), and you're transmitting with direct keyboard input. There are eight transmit memories if you prefer that route. As the TV pitchman says, "It's *that* easy!"

Operating RTTY is a bit like typical CW operation. You can't see the whole swath of signals you might be able to view on a PC waterfall and must tune each in the small waterfall. PSK31 is the same.

The audio peak filter (APF) cum twin-peak audio filter supports both high tone and low tone signals but does not function when you're decoding the signal using the transceiver.

You can have a great deal of fun with RTTY on this radio by itself. Ditto for PSK31/63, for which the TS-990S offers largely the

same feature set. Kenwood did not include a means to use the external keyboard for CW or include a CW decoding screen. Perhaps this could be included in a firmware update.

Only the LO/WIDTH control functions in RTTY or PSK, and you use it to set the overall bandwidth, so you may need to tune a bit to find stations beyond the reaches of whatever size waterfall you have set. With tight filters applied for PSK operation, you have to be right on the button. This is where the tuning aids come in handy.

The TS-990S does "true" FSK, but you can feed AFSK input into the ACC2 connector, as mentioned. Most contesters, I would venture to say, prefer to control the radio via a computer program such as *N1MM Logger* with the *MMTTY* engine for RTTY. For FSK, you'd connect to ACC2's FSK pins. For AFSK, you have the choice of routing via the ACC2 connector or a USB connection.

You can record and save the contents of your RTTY and PSK communications (html or text) that you have transmitted on the radio itself. In short you can do pretty much anything that you're used to doing with your PC sound card/interface setup, just more efficiently.

Making Tracks

Recording voice tracks on the fly with the TS-990S is easier than using *N1MM Logger* or similar. The TS-990S offers a generous six voice memories that retain up to 100 seconds, about 15 seconds per channel. It's possible to save audio files you've recorded on a thumb drive or other external drive.

You cannot monitor your audio when recording voice tracks, although the receiver mutes when you're recording. This said, the audio quality is *excellent*! But be warned: When you play back a message, *it goes over the air*, whether or not VOX is enabled!

I set up the TS-990S to play audio files on my computer from *N1MM Logger* via the USB cable. This requires setting several levels. You have to have your VOX delay set to practically 0 to have it drop out, so it will play a voice track via USB. The VOX is not locked out when you're playing the track, and if you hit the F key to play your track too *soon* after coming back to a station (ie, before VOX completely drops out), it will not play the track.

Figure 6 — This view of the smaller LCD panel shows operating frequency and mode, along with a graphic illustrating the filter bandwidth characteristics. The virtual analog dial skirt gives this thoroughly modern transceiver a retro touch from the classic TS-520S era of the 1970s. This image is a screen capture via the transceiver's USB port.

Way Back Cool

If you find yourself yearning for your SWL days, the TS-990S includes a feature that no other transceiver in *any* price class offers: SWL mode. At the push of a button, the top half of the main display instantly transforms into a virtual vintage shortwave receiver's slide-rule dial (Figure 7). It represents the face of the Trio/Kenwood 9R-59 receiver of 1960s vintage, complete with a vertically oriented S meter dedicated to the main receiver. The dial shows separate pointers for the main and sub receivers. It's possible to switch among the various broadcast "meter bands," such as 31 meters or 25 meters, and the selected band will appear above the slide-rule dial. For the best of both worlds, you can enable the bandscope, which fills the lower half of the main display, but don't expect that old vacuum tube ambiance.

Random Observations

As I was packing up the TS-990S with some regret, I had to conclude that if you can't pull out an intelligible signal on this radio, you most likely will not be able to do so with any other. Strong signals will sound stupendous; so will your transmitted signal. (Can you say "Kenwood audio," boys and girls?)

The antenna tuner is *lightning* fast, and it easily handled all of my oddball antennas. You *cannot* tune the antenna with a voice message screen up, though. Even the quick memory recall does not work, making an external keypad more a necessity than a nicety, if you plan to use the TS-990S in this manner.

Switching modes can be somewhat less than straightforward. After decoding digital signals, you must press ESC to clear the bandscope and its associated F keys. The bandscope may not be the default when changing modes, say, from digital to CW; it's not fully intuitive.

The TS-990S offers a handy audio scope and oscilloscope to view audio envelopes — your own or someone else's. You can look at both received and transmitted audio, making it simple to gauge the effectiveness of your noise limiter or noise reduction settings.

Some TS-990S users employ virtual COM ports to control multiple devices or to interface with multiple programs. Most operators will want to interface the transceiver with their shack computer, and you can do this using a USB A/B cable from the rear panel or female-to-female RS-232C serial port cable, also from the rear panel. You also can connect the TS-990S to a compatible Kenwood transceiver this way. There's an Ethernet port on the rear apron as well, although you can't use it to download firmware upgrades. Its primary use is for operating the radio from a remote location. Kenwood offers free software.

The TS-990S supports Kenwood's Sky Command System II, which lets you remotely control the transceiver from another location using Sky Command System II-compatible Kenwood VHF/UHF transceivers. One transceiver, which Kenwood designates as the "commander," is the remote control unit. The other, which Kenwood calls the "transporter" serves as an interface between the commander and the TS-990S. Using Sky Command System II, you can only control the main receiver

There are 3, 5, or 10 quick-recall or "scratch pad" memory channels. In quick memory scan, the receiver will scan through all of them. As with several other terrific features, though, you cannot have the spectrum scope or the waterfall on display while scanning.

For 60 meters you need to set up the five tuning frequency channels in individual memories and use the MULTI/CH knob to access each. Since no band registers are assigned to 60 meters, you may want to set up CW and SSB memories, as appropriate.

The PF (program function) buttons are

Figure 7 — Here's something I've not seen before. In the SWL mode, the top half of the TS-990S main display replicates a 1960s vintage Trio/Kenwood shortwave receiver.

handy, and two hardware PF buttons, PFA and PFB, are available on the front panel. (You can program the others via the menu and actuate them via an external keypad or keyboard).

Most of the subreceiver controls are distinguished on the front panel by light hatching behind the controls.

You can place limits on the output power by band — for example in DATA mode, where you may want lower output for 100 percent duty cycle.

Some may want a larger subreceiver tuning knob. The MUTE button is a nice touch.

AUTO mode lets you configure band plans, so that when you tune, say, from a CW subband into the phone subband, the radio will automatically switch to the correct mode. Setting these up involves entering beginning and end point frequencies for each mode, and it can be a bit tedious.

All Told...

According to an informal reflector poll among TS-990S owners, about 55% indicated they mostly used their radio for DXing, while nearly 30% said their primary application was ragchewing.

Another nearly 16% said they used their TS-990s for contesting. This seemed appropriate. The TS-990S struck me as more of a DXer's radio. It's a level or two more complex from an operating standpoint than many other contest-worthy radios, and, like some of today's software, it offers dozens of features (with more possible through firmware updates) that many contest or casual operators will never want or need to take advantage of. (See the sidebar "Observations from *NCJ* Editor K4RO" for additional thoughts from a contester's viewpoint.)

This said, it's a very good high-performance transceiver that will satisfy many needs for those whose budgets can accommodate the cost.

Manufacturer: Kenwood USA Corp, 3975 Johns Creek Ct, Suite 300, Suwanee, GA 30024; tel 310-639-4200, fax 310-537-8235; **www.kenwoodusa.com**.

See the Digital Edition of *QST* for a video overview of the Kenwood TS-990S HF and 6 Meter Transceiver.

New Products

Journal of the Cave Radio and Electronics Group

The *Journal of the Cave Radio and Electronics Group* (*The CREG Journal*), published by the British Cave Research Association (BCRA), is now available online. Communicating between a cave and the surface is a formidable challenge yet it's a common requirement for underground explorers and it plays a vital role in coordinating cave rescues. With the growth of interest in low frequency radio in recent years, radio amateurs and electronic enthusiasts can make a contribution in this area. Many of the cave radios currently used by the world's volunteer cave rescue teams were developed by radio amateurs. Price: £4.00 per year (four issues) online. For more information, or to subscribe, visit **http://bcra.org.uk/pub/cregj/**.

Solderless BNC Connectors for LMR-400 Cable from Times Microwave Systems

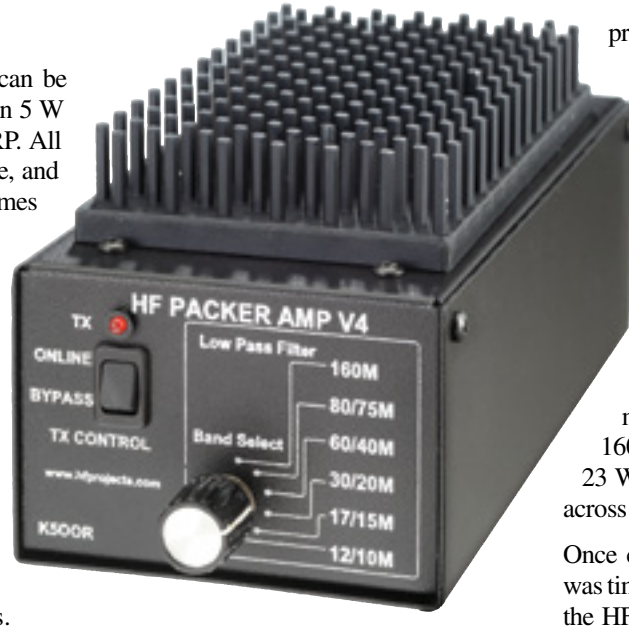
The EZ-400-BM-X BNC male straight connector and EZ-400-BM-RA-X BNC male right angle connector for LMR-400 coaxial cable are crimp-style connectors that do not require soldering of the center conductor or braid trimming. They are compatible with the Times Microwave CST-400 cable prep tool and either the CT-400/300 or HX-4 (with Y1719 dies) crimp tools. Price: EZ-400-BM-X, $13.50; EZ-400-BM-RA-X, $15. For more information, see your favorite dealer or visit **www.timesmicrowave.com**.

Steve Ford, WB8IMY, wb8imy@arrl.org

HF Projects HF Packer-Amp

Jeffrey Fritz, WB1AAL

It is amazing how many contacts can be made across the world with less than 5 W of power, a technique known as QRP. All it takes is a decent antenna, patience, and the right conditions. But there are times when conditions aren't great and a few more watts make a difference. That is the premise behind HF Projects HF Packer-Amp Version 4. It adds punch to your QRP transceiver.



The HF Packer-Amp is physically small, easily fitting into a carrying case. Running off 12 V dc, the amp is useful for portable, mobile, or fixed operation. It runs as a Class AB1 linear amplifier using two low cost IRF510 MOSFETs. The amp takes up to 5 W input and is specified to produce 20 to 35 W output from 10 to 160 meters including 60 meters. A band switchable LPF using 5% 500 V dip mica style capacitors filters the amp's output.

The HF Packer-Amp is a construction kit including all circuit boards and parts. A nice looking black and white silk-screened metal case is included. The well-written and illustrated construction and operational manual is available as a PDF download.

The amp can be used for SSB and CW. (Higher duty cycle modes such as PSK31 require an optional fan.) Unfortunately, changing between CW and SSB modes requires an internal jumper change. That means removing the six screws that secure the top case to the amp base. It's not difficult, but it is something of a chore. A CW/SSB mode switch on the front panel would have been a nice addition.

The amp can be RF-sense triggered or use PTT from the transceiver. (The CW and SSB jumper change is not needed if the amp is triggered by the transceiver. The amp will simply follow the delay-time set in the rig. Both the FLEX-1500 and the Yaesu FT-817 transceivers have the ability to directly trigger the amp.)

There are cautions to be aware of when running the HF Packer. In fact, HF Projects offers a list of "Do's and Don'ts for Successful Operation:"

- Do set the band switch to match the transceiver band.
- Do install the CW jumper for CW operation. Remove it for SSB.
- Do not exceed 5 W input drive.
- Do not touch up the antenna tuning with the amp in the online (bypass off) position.
- Do not operate with a VSWR > 2.0:1.

It is a good idea to be conservative and obey these warnings or you may wind up replacing a pair of blown MOSFET finals. Though MOSFETs are not expensive (Mouser sells them for less than a dollar each) and you can replace them yourself, simply using precaution is easier.

Building and Testing

It took me about 12 hours to build the amp. When I needed to troubleshoot, I found support readily available. My problems were quickly resolved and questions promptly answered either by e-mail by HF projects or via their Yahoo Group. If your amp project goes astray, HF Projects offers a "Safety Net" repair service for a $69 flat fee (including parts). It is fair to say that this level of support is exemplary.

The finished amplifier easily passed ARRL Laboratory spectral purity tests. In terms of output power with 5 W input, the Lab measured a maximum of 52 W on 160 and 80 meters and a minimum of 23 W on 10 meters. The average output across all bands was 35 W.

Once constructed, tested, and adjusted, it was time to put the amp on the air. I fired up the HF Packer on 40 meter SSB from my West Virginia home using a dipole antenna. I immediately made contacts with hams in Philadelphia, Baltimore, and Fort Wayne, Indiana. None were DX, but under the circumstances (rather poor conditions at the time on 40 meters) all the reports were good. Each of these stations gave me from an S-7 to a 10 over S-9 report.

As for DX, my first contact with the amp gave me a 57 report from Switzerland. Not too shabby with 20 W without using a dipole! The same afternoon I checked into a 20 meter net. The net control was located in Naples, Florida, about 950 miles from my station. When I told him what I was running, he reported, "There was a little QSB at the end of your transmission, but your signal was completely readable. I must say that your HF Packer is really getting the job done."

"Getting the job done" says it all. There is really little more that we can ask of our gear.

Manufacturer: HF Projects, 5802 Miller Valley Dr, Houston, TX 77066; tel 281-467-9424 (between 8 AM and 9 PM CST); e-mail **vstamps@comcast.net**; *website* **www.hfprojectsyahoo.com/hf-packeramp.html**. *$259.*