Kenwood TS-450S and TS-690S Transceivers

Reviewed by Rus Healy, NJ2L

After Kenwood's introduction of the TS-950S in 1989 and the TS-850S last year, their recent unveiling of the TS-450S and TS-690S rounded out their latest line of MF/HF transceivers. The TS-140S is Kenwood's current entry-level MF/HF transceiver, but the TS-690S replaces the TS-680S in Kenwood's line. The only real differences between the '450 and '690 are the silk-screened labels on their front panels and the physical changes necessary to implement 6 meters in the '690. And the rigs share so much of the user interface and general design principles used in the TS-950S and TS-850S that a look back at the *QST* reviews of those radios (in the January and July 1991 issues, respectively) will give you some useful background.

Standard features of the TS-450S and TS-690S include AM, CW, FSK, FM, LSB and USB operation, 100 W output, 500 kHz to 30 MHz receiver coverage, 100 memories, dual VFOs, scanning, RIT, XIT, IF shift, a notch filter, dual noise blankers, speech processing, a selectable 20-dB attenuator, and numerous user-definable functions (including 10- or 100-Hz display, RIT/XIT range of ±1.27 or 2.54 kHz, instantaneous or peak-hold meter operation, CW messages or beep tones to acknowledge programming operations and mode selection, and so on). A hand mike, fused power cord, manuals, and plugs to match all the radio's jacks are included. The TS-690S adds 50 watts of 6-meter RF output and continuous receiver coverage from 500 kHz to 60 MHz. Both radios require 12-16 V dc at about 20 A maximum drain.

Options include the AT-450 internal automatic antenna tuner, which works on 80-10 meters (yes, you can install this in both the '690 and the '450—or buy the installed option at purchase), a voice synthesizer (speaks the displayed frequency at the touch of a button), and narrow CW and SSB filters (more on these later). These radios are commonly available from dealers with and without the antenna tuner installed.

The TS-450S and TS-690S are quite small. Although close to the same size as their aging competitor, the ICOM IC-735, the TS-450S and TS-690S weigh about three and six pounds more, respectively, even without their optional internal antenna tuners. This is largely a result of the TS-450S platform's rugged die-cast-aluminum chassis. Still, topping out at about 18 pounds (for a TS-690S with the AT-450 installed), they're light and easily lugged about for portable operation.

In a nutshell, here's my impression of how the '450/'690 fit into the current market for 100-watt-class Amateur Radio transceivers:

What Puts Them Near the Entry Level

Here are some of the things that separate the TS-450S and TS-690S from transceivers in the next higher price class:

- Small size and simple front-panel layout.
- Lack of sophisticated interference-fighting features.
- Lack of CW full break-in operation (QSK).
- Inability to disable receiver AGC.
- Lack of an SSB monitor circuit (for listening to your transmitter output) and offset-tracking CW sidetone.
- Moderate receiver dynamic range.
- Lack of provisions for separate receive and transmit antennas.
- An audio (not IF) notch filter.

What Makes Them Shine *in Their Price Class*

- Excellent-sounding receiver audio.
- A wonderfully quiet frequency-synthesizer chain.
- Optional filters at both 8830- and 455-kHz IFs.
- Fast, quiet optional internal antenna tuner.
- Wonderfully easy to use (examples: filter selection, VFO and memory manipulation, split operation, direct frequency entry—for an overview of how these functions work, see the TS-850S review in July 1991 *QST*).
- The ability to receive CW on either sideband, variable CW offset and selectable 1-kHz-per-revolution (or 500-Hz-per-revolution) tuning rate.
- Same basic pleasant multifunction display as the TS-850S.
- Computer-control capability using the same hardware interface and the same basic commands as the TS-940S, TS-950S and TS-850S.
- Filter installation ease befitting first-time radio owners—even those who get nervous when there's a screwdriver in the same room. It's a sub-10-minute operation, start to finish.

Many of these features—especially adjustable CW offset, an optional internal automatic antenna tuner, the ability to install optional narrow filters at *two* IFs, an exceptionally quiet synthesizer and great receiver audio—really set the '450 and '690 apart from the earlier alternatives in their class.

Kenwood has reduced the front-panel size *and* increased these radios' ease of operation. Some of this has come as a result of fewer features than the TS-850S (no CW keyer, IF-bandwidth control, quick-memory feature or optional voice recorder). So, fewer buttons are needed, and some used on the '850 for these functions have other roles on the '450. For instance, keypad

Table 1

Kenwood TS-450S Transceiver, Serial Number 30200807

Manufacturer's Claimed Specifications	***Measured in the ARRL Lab***
Frequency coverage: Receive, 0.5-30 MHz; transmit, 1.8-2, 3.5-4, 7-7.3, 10.1-10.15, 14-14.35, 18.068-18.168, 21-21.45, 24.89-24.99, and 28-29.7 MHz.	Receive, 0.03-30 MHz; transmit, 1.705-2, 3-4, 6.5-7.5, 10-10.5, 13.5-14.5, 18-19, 20.5-21.5, 24-25 and 27.5-30 MHz.
Modes of operation: AM, CW, FM, FSK, LSB, USB.	As specified.
Power requirement: 12-16 V dc at 2 A (receive) and 20.5 A (transmit).	At 13.8 V, receive, 1.45 A max; transmit, 17 A max.
Receiver	*Receiver Dynamic Testing*
Receiver sensitivity (bandwidth not specified): CW, FSK and SSB (10 dB S+N/N): 0.5-1.62 MHz, 4 μV (−95 dBm); 1.62-21.5 MHz, 0.2 μV (−121 dBm); 21.5-30 MHz, 0.13 μV (−125 dBm).	Minimum discernible signal (noise floor) with 500-Hz IF filters, AIP off: 1.8 MHz, −138 dBm; 3.5 MHz, −140 dBm; 14 MHz, −141 dBm; 28 MHz, −141 dBm.
AM (10 dB S/N): 0.5-1.62 MHz, 32 μV (−77 dBm); 1.62-21.5 MHz, 2 μV (−101 dBm); 1.62-21.5 MHz, 2 μV (−101 dBm); 21.5-30 MHz, 1.3 μV (−105 dBm).	6-kHz IF filter, signal 30% modulated with a 1-kHz tone, AIP off: 1 MHz, −111 dBm; 3.8 MHz, −117 dBm; 14.2 MHz, −118 dBm.
FM (12 dB SINAD, 28-30 MHz): 0.25 μV (−119 dBm).	At 29 MHz, AIP off: −123 dBm.
Receiver dynamic range: Not specified.	Blocking dynamic range (500-Hz IF filters, AIP off):* 3.5 MHz, 109 dB; 14 MHz, 108 dB.
	Two-tone, third-order intermodulation distortion dynamic range (500-Hz IF filters, AIP off):*† 3.5 MHz, 70 dB; 14 MHz, 71 dB.
Third-order input intercept: Not specified.	AIP off:† 3.5 MHz, −35 dBm; 14 MHz, −33 dBm.
S-meter sensitivity: Not specified.	At 14 MHz: S1, 1.7 μV; S9, 31 μV.
AM, CW, FSK, SSB squelch sensitivity: 0.5-1.62 MHz, 20 μV (−81 dBm); 1.62-30 MHz, 2 μV (−101 dBm).	14 MHz, −111 dBm.
FM squelch sensitivity (20-30 MHz): 0.25 μV (−119 dBm).	29 MHz, −131 dBm.
Notch filter attenuation: More than 20 dB.	More than 30 dB.**
Receiver audio output: 1.5 W at 10% distortion into an 8-Ω load.	1.9 W at 10% total harmonic distortion (THD) into an 8-Ω load.
Receiver IF/audio response: Not specified.	At −6 dB: CW (500-Hz filters), 511 Hz; SSB (1.8-kHz filter), 1692 Hz; AM (6-kHz filters), 3976 Hz.
Transmitter	*Transmitter Dynamic Testing*
Transmitter power output: CW, FSK, FM, SSB, adjustable from less than 20 W to 100 W; AM, adjustable from less than 10 W to 40 W.	Output power: Continuously adjustable from 0 to 96-107 W (maximum output is typically more than 100 W and varies slightly from band to band); AM, as specified.
Spurious-signal and harmonic suppression: More than 50 dB.	Meets FCC regulations. See Fig 1.
Third-order intermodulation distortion products: Not specified.	See Fig 2.
CW-keying characteristics: Not specified.	See Fig 3.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	S1 signal, 24 ms; S9 signal, 24 ms. The TS-450S is suitable for AMTOR ARQ operation.
Composite transmitted noise: Not specified.	See Fig 4.
Size (height, width, depth): 3-25/32 × 10-5/8 × 12 inches (projections included); weight, 16.5 lb with AT-450, 13.9 lb without.	

*Blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

†See text and sidebar.

**Test-equipment limitations inhibit ARRL Lab measurement of notches deeper than about 30 dB.

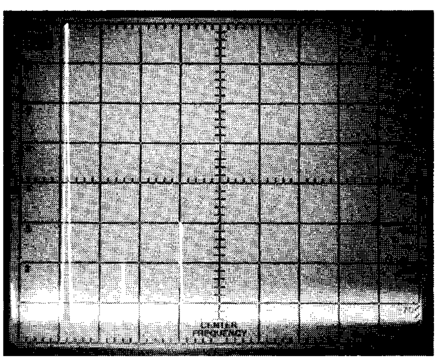


Fig 1—Kenwood TS-450S worst-case spectral display. Horizontal divisions are 10 MHz; vertical divisions are 10 dB. Output power is approximately 100 W at 14 MHz. All harmonics and spurious emissions are at least 50 dB below peak fundamental output. The TS-450S complies with current FCC specifications for spectral purity for equipment in this power-output class and frequency range.

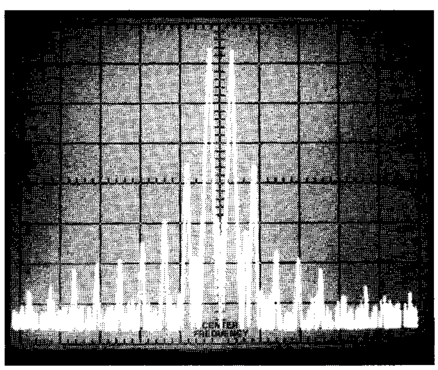


Fig 2—Worst-case spectral display of the TS-450S transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 35 dB below PEP output, and fifth-order products are approximately 49 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 100 W PEP output at 14 MHz.

buttons **1** and **2** select 8830- and 455-kHz IF bandwidths, respectively, whereas separate buttons perform these functions on the '850.

The TS-450S and TS-690S support true FSK and AFSK operation. FSK shifts of 170, 200, 425 and 850 Hz are selectable via a power-on, user-defined function selection. During FSK operation, the transceiver displays the mark frequency.

The TS-690S

As mentioned earlier, the TS-690S and TS-450S differ very little. The '690 has nearly twice the '450's receiver coverage and a small 6-meter driver/power amplifier module that mounts in the back of the rig. Two antenna connectors are included, as is a switch atop the rig for choosing whether you want to use one connector for MF/HF and the other for 6 meters, or the MF/HF connector for all bands. This is handy; if you're

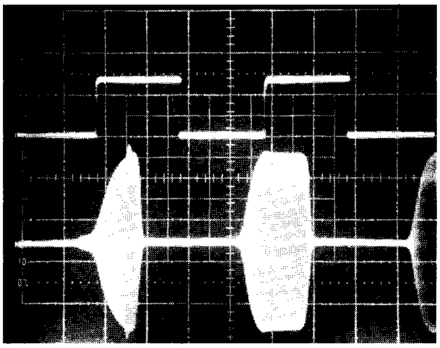


Fig 3—CW-keying waveforms for the TS-450S. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output at 14.2 MHz.

Table 2

Kenwood TS-690S, Serial Number 30400085

Manufacturer's Claimed Specifications*	***Measured in the ARRL Lab***
Frequency coverage: Receive, 0.5-30 MHz and 50-54 MHz; transmit, same as TS-450S, plus 50-54 MHz.	Receive, 0.03-60 MHz; transmit, same as TS-450S, plus 50-54 MHz.
Power requirement: Same as TS-450S.	50-MHz transmit, 10 A max.
Receiver sensitivity (bandwidth not specified): CW, FSK and SSB (10 dB S+N/N): 50-54 MHz, 0.13 μV (−125 dBm).	Minimum discernible signal (noise floor) with 500-Hz IF filters, AIP off: 50 MHz, −140 dBm.
FM (12 dB SINAD): 50-54 MHz, 0.25 μV (−119 dBm).	50 MHz, AIP off: −118 dBm.
Receiver dynamic range: Not specified.	Blocking dynamic range (500-Hz IF filters, AIP off):† 50 MHz, 109 dB. Two-tone, third-order intermodulation distortion dynamic range (500-Hz IF filters, AIP off):†** 50 MHz, 82 dB.
Third-order input intercept: Not specified.	50 MHz, AIP off: −24.5 dBm.
Transmitter power output: 50-54 MHz, CW, FM, FSK, SSB adjustable from less than 10 W to 50 W; AM, adjustable from less than 10 W to 20 W.	CW, FM, FSK and SSB, continuously adjustable from 0 W to 45 W; AM, as specified.
Spurious signal and harmonic suppression: Better than 60 dB.	Meets FCC specifications. See Fig 5.
Third-order intermodulation distortion products: Not specified.	See Fig 6.
Weight: 15.2 lb.	

*Except where noted, TS-690S specifications are the same as those for the TS-450S.

†Blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

**See text and sidebar.

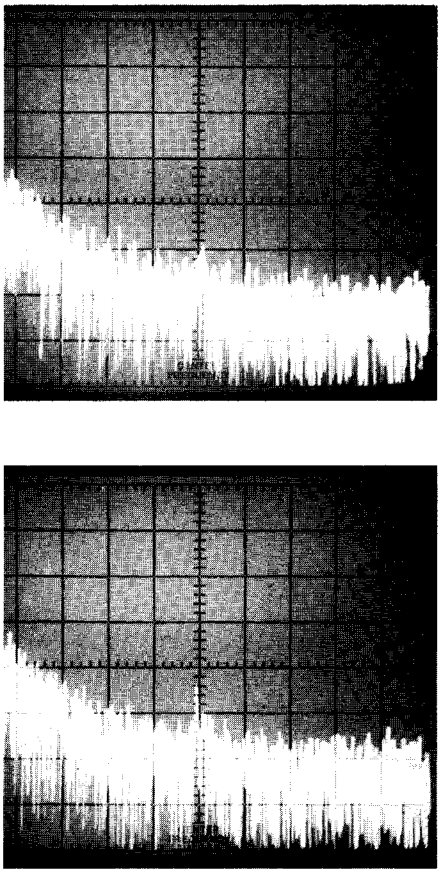


Fig 4—Spectral display of the TS-450S transmitter output during composite-noise testing. Power output is 100 W at 3.52 MHz (A) and 100 W at 14.02 MHz (B). Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The scale on the spectrum analyzer on which these photos were taken is calibrated so that the log reference level (the top horizontal line on the scale) represents −60 dBc/Hz and the baseline is −140 dBc/Hz. Composite-noise levels between −60 and −140 dBc/Hz may be read directly from the photographs. The carrier, off the left edge of the photographs, is not shown. These photographs show composite transmitted noise at frequencies 2 to 20 kHz offset from the carrier.

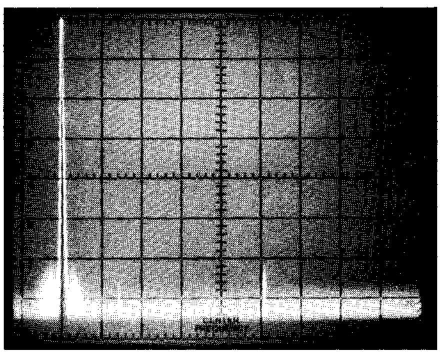


Fig 5—Kenwood TS-690S worst-case 50-MHz spectral display. Horizontal divisions are 10 MHz; vertical divisions are 10 dB. Output power is approximately 38 W at 50.1 MHz. All harmonics and spurious emissions are at least 62 dB below peak fundamental output. The TS-690S complies with current FCC specifications for spectral purity for equipment in this power-output class and frequency range.

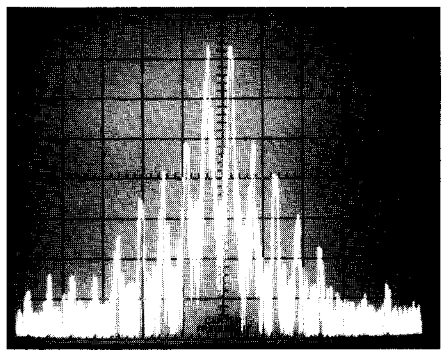


Fig 6—Worst-case spectral display of the TS-690S transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 32 dB below PEP output, and fifth-order products are approximately 38 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 44.5 W PEP output at 50.1 MHz.

using MF/HF antennas and a 6-meter antenna that's fed with a separate cable, you'd opt to separate the antennas. But if you have a remote coax switch, fed with a single cable, that selects your MF/HF and 6-meter antennas, the '690's combined output eliminates the need for more external switching.

The TS-690S shares most of the TS-450S's specifications (Table 1), and not surprisingly, performs very much like the '450. The significant differences in specifications and performance are shown in Table 2.

On the Air

My operating experience has shown me that there's just no getting along without narrow IF filters in crowded band conditions. I was thrilled to learn that Kenwood kept one of the higher-end radios' nicest features in these rigs: the ability to install IF filters in two of its IFs. Optional filters for the 8830-kHz IF include a 1.8-kHz SSB unit, and for CW, 500- and 270-Hz units.

TS-450S/TS-690S IMD Dynamic Range

Because the TS-450S and TS-690S receivers have such good sensitivity and audio, when we first tested their dynamic ranges, we were disappointed. It turns out, however, that our standard test results don't tell the whole story.

Understanding this requires some knowledge of our test procedures. Our basic third-order intermodulation distortion (IMD) dynamic-range test is to insert two signals at the same level, 20 kHz apart, into the receiver. Then we increase their levels until an IMD product 20 kHz above the higher-frequency signal (or 20 kHz below the lower-frequency signal) is detectable at the receiver's minimum discernible signal (MDS) level. The difference between the test signals and the MDS is the IMD dynamic range. Once an IMD product reaches the MDS, the product usually begins to increase dramatically compared to the test signals—typically 3 dB for every 1 dB increase in the test signals.

The TS-450S and TS-690S behave very differently from this, however. Fig A shows the TS-690S's response on the 14-MHz band. This curve is representative of how the TS-450S and TS-690S behave on other bands. Fig A shows how the TS-690S responds when the two equal-level test signals are applied at 14.02 and 14.04 MHz. The solid line shows the amplitude of the IMD response at 14.06 MHz as a function of test-signal amplitude; the broken line shows a normal receiver response. These curves show that, although IMD products first reach the MDS level at lower test-signal levels than we expected, implying vastly inferior IMD dynamic range, the TS-450S and TS-690S actually behave like receivers with much higher dynamic ranges because the IMD products increase slowly in amplitude until well after they first appear.

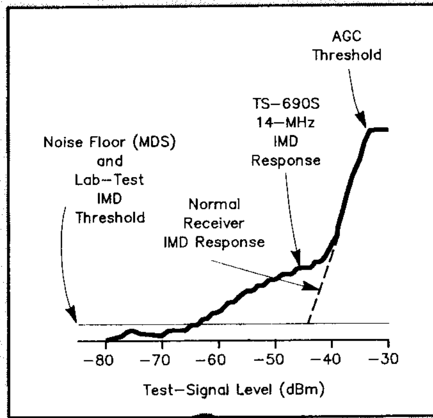


Fig A—TS-690S receiver third-order IMD response.

For instance, Fig A shows that the TS-690S first produces a 14.06-MHz third-order IMD product at the MDS with a test-signal level of −65 dBm. When subtracted from the receiver's −141 dBm MDS, this gives an IMD dynamic range of 71 dB. That's where we'd normally see the receiver IMD response take off into a nearly vertical line—but the '690 doesn't behave like this: It takes another 23 dB of test signal to make it do so. Thus, the receiver doesn't begin to exhibit normal IMD response until the test signals are more than 95 dB above the MDS. In effect, the '450/'690 acts more like a radio with a 20+-dB higher dynamic range than the numbers show.

Even though the receiver's AGC can't be turned off, we know it doesn't affect this unusual IMD response because the AGC takes hold well below the IMD threshold—about 20 dB below the level at which IMD products are first detectable. We're not sure what *does* cause this response, but we've never seen it before in the ARRL Lab. If we gave only our usual test results, these receivers would appear to be much less usable than they really are. Senior Laboratory Engineer Ed Hare, KA1CV, characterized these receiver responses.—*NJ2L*

The 455-kHz IF can hold only one optional filter of 500 or 250 Hz. The 1.8-kHz SSB filter makes a big difference in operating on crowded bands with these radios. It's really a necessity for HF SSB contest and DX types. For most CW operation, the 500-Hz filters are very good (I'd opt for the 8830-kHz-IF unit if I could only have one of the optional filters). Because these rigs lack other bandwidth controls, such as the **SLOPE TUNE** control found on the TS-850S, most users will do well to spring for at least one filter.

The TS-450S and TS-690S got lots of good audio reports. The adjustment-free speech processor works well with the stock hand mike, a Kenwood desk mike and my Heil boom mike headset. CW operation is smooth, and the rig's keyed CW waveshaping is generally good, except that the first element at key closure is softer and shorter than the subsequent ones. Although Kenwood has included adjustable CW offset (variable from 400 to 800 Hz, in 50-Hz steps), which is great, the CW sidetone is fixed at 800 Hz, which isn't. So, if you change the offset to, say, 500 Hz, and you zero-beat stations to the rig's sidetone, you'll be calling them 300 Hz from where they're listening.

In casual operation, I got around this by setting my keyer's sidetone to the offset I used (400 Hz) and turning down the rig's sidetone level—but this is not an acceptable alternative to offset-tracking sidetone. There *must* be a cheap and easy way to slave the CW sidetone to the offset. Can Kenwood find it?

On SSB, it would have been nice to be able to monitor my transmitted SSB audio through an internal monitor, but because the speech processor isn't adjustable, doing without it isn't a big deal. (Monitor circuits are mainly useful for aiding speech-processor adjustment.) Speaking of SSB, the TS-450S's transmitter IMD performance is substantially better than that of the TS-850S. It's a nice neighbor on the phone bands, doing quite well for a radio with 13-V finals.

The whisper-quiet cooling fans cycle occasionally during receiving and run most of the time during heavy-duty operation. The fans aren't audible with headphones on, and the rigs run cool, even at high transmitter duty cycles.

Six-meter operation with the TS-690S is lots of fun! The rig's receiver sensitivity makes an external preamplifier unnecessary for most operation. Its effective noise blanker gets rid of most of the noise problems that it seems all serious 6-meter operators experience, but doesn't substantially degrade receiver performance. Fifty watts is a good power level for most 6-meter operation. Using the '690 barefoot with a small Yagi netted several European and South American contacts during the review period. The front-panel **PWR** control gives smooth and stable output-power adjustment, so I was able to turn the power down to 10 W and use the rig to drive a higher-power, tower-mounted brick amplifier during the January VHF SS.

Basic Receiver Performance

A quiet synthesizer is the keystone of good receiver performance. Even a highly sensitive receiver RF and IF chain with great dynamic range can't be used to best advantage if it isn't driven by a clean oscillator. As mentioned earlier, the TS-450's low-noise frequency-synthesis chain opens the door for the receiver to perform at its best. Very few synthesizer artifacts are present anywhere in the tuning range. I found a handful of barely audible spurs in the ham bands.

Like the TS-950S and TS-850S, the '450 and '690 provide excellent sensitivity—typically about −140 dBm with a pair of 500-Hz IF filters in line. Smooth AGC and pleasant, hiss-free audio also mark these rigs as a cut above average. As the sidebar explains, these rigs' biggest limitation is receiver dynamic range. Blocking dynamic range is acceptable for rigs in this class—although the numbers aren't as good as you might expect after initially listening to the receivers. Third-order IMD dynamic range is the subject of the sidebar.

Like the other radios in Kenwood's newest line, the TS-450S and TS-690S have both selectable 20-dB RF attenuators and an **AIP** button that bypasses the FET front-end amplifier. The TS-450S/TS690S AIP circuit effects only a marginal improvement in receiver IMD dynamic range, but improves the third-order input intercept by about 11 dB (which is almost exactly how much sensitivity the receiver loses when you push the **AIP** button). You'd get the same effect from an 11-dB attenuator.

The AIP makes the difference between being able to use these radios in serious crowded-band conditions and having to shelve them for something with a better receiver. I used the TS-450S and TS-690S in several contests, operating from stations with high monoband beams as well as tribanders and wire antennas. Many times, the receivers created lots of phantom signals (IMD products) on crowded bands with the AIP and attenuator off, but switching in the AIP (and, in tough cases, the attenuator) brought the real signals to the surface again. In the TS-850S, which has much better IMD dynamic range than the '450/'690, poking the **AIP** button is almost never necessary to eliminate IMD products; in the '450 and '690, the AIP is on almost all the time on an open band.

Although I sometimes wished for more interference-fighting features, I didn't feel that the little rigs were holding me back from hearing real signals, once I discovered how much of an impact the AIP circuit has. And even with the AIP on, they're quite pleasant to operate, considering that their wide-open sensitivity is much better than is usually needed at MF and HF.

Documentation

The '450 and '690 are well documented (the two radios share a single manual). Separate tables cover specifications for the two rigs. Like the '850 documentation, the 95-page '450/'690 manual uses facing pages to cover each mode of operation, which is handy when you're learning to use the rig. Information on mobile and home-station installation and wiring the radio's accessory connectors is also included. It appears that Kenwood has taken pains to make this manual friendly; its numerous graphics and step-by-step operating instructions are clear and easy to understand. One of the documentation's shortcomings is in a sidebar on zero-beating stations in CW operation. This sidebar assumes that you're using an 800-Hz offset, and doesn't even mention what to do if you've changed the offset (or even that it can be changed, for that matter).

Rough Edges

A lot of transceivers have rolled through the Product Review process in the past few years. Although they share many similar features, the radios we've reviewed implement features in different ways. After extensive operating time with a variety of rigs, I've developed a list of features that I think should be included in *every* multiband MF/HF transceiver platform to roll off the line, regardless of price class:

- Selectable fast/slow/off AGC constants.
- CW sidetone that tracks offset.
- RIT/XIT offset that can be cleared without manually centering a knob.
- Low-level transmitter output and transverter/receive-antenna input connectors *on the back panel*. You shouldn't have to open a radio and break its receive line just to use a separate listening antenna or a VHF/UHF transverter. Kenwood makes absolutely no provisions for transverter or separate-antenna operation with the '450/'690—nor is it even mentioned in the documentation.
- VOX controls placed where we can reach them during normal operation! (**VOX GAIN** and **ANTI-VOX** are recessed in the left side.)

Like the TS-950S and -850S, the '450/'690 are much less sensitive (by 26-30 dB) in the AM-broadcast band than in the rest of their tuning ranges. Broadcast-band DX listeners may be disappointed.

Other Thoughts

The growing popularity of 6-meter operation by DXpeditioners makes the TS-690S attractive for both DXpeditioners and home-station operators who want everything in one light, small package. A CW keyer would have been a nice addition in a radio that's so well suited for portable and mobile operation.

So, did Kenwood trim the appropriate features and performance from its higher-end radios when designing the TS-450S and TS-690S? I think so. The '450 has all the basics that make the TS-850S such a strong contender in the next higher price range—except for correspondingly high receiver dynamic range. The '450 platform is lacking in this category, judging more by the fact that you usually operate with the AIP on than by the lab-test results. In practice, the difference is that the TS-850S's receiver holds its own *with any radio ever made* in heavy-duty operating, and the TS-450S doesn't, although with the AIP on, it's good enough for most operation. The TS-450S, however, will spoil anyone who doesn't have big antennas and/or wants to add a second rig for backup, occasional contest or DX use, or more casual operation. I think that this describes 99 percent of the market for which the TS-450S was intended, so it looks like Kenwood has hit very close to the mark with the '450 platform. I feel that these radios represent very good dollar values.

Thanks to Mark Wilson, AA2Z, Dan Street, K1TO, Chet Slabinski, N8RA, and Dave Newkirk, WJ1Z, for contributing to this review.

Suggested retail prices: TS-450S, $1350; TS-450S/AT, $1550; TS-690S, $1550; AT-450, $206; PS-33 power supply, $230; 500-Hz CW filters, $99 (8830-kHz IF) and $150 (455-kHz IF); 1.8-kHz SSB filter (8830-kHz IF), $85. Manufacturer: Kenwood USA Corp, 2201 E Dominguez St, Long Beach, CA 90801-5745.

TELEX HY-GAIN 155CA 15-METER YAGI ANTENNA

Reviewed by David Sumner, K1ZZ

Considering how much theoretical and empirical work has been devoted to Yagi antenna design over the years, it's remarkable that ways are still being found to improve the performance of this popular antenna. Recently, personal computer software has become available that, in the hands of an experienced professional engineer or a talented amateur, can trim hundreds of hours from the time required to optimize the performance of a particular Yagi design through the old cut-and-try method. The result is a new generation of Yagis, similar in appearance to older designs but (if the computer models are to be believed) tweaked to deliver the last hundredth of a decibel of performance.

The new Hy-Gain 155CA is such a design. In fact, it's *five* designs. The instructions explain how to optimize the antenna for the CW or the phone ends of the 15-meter band, or the middle of the band; for maximum front-to-back (f/b) ratio at 21.250 MHz (with a slight degradation in gain); or for the 12-meter band, 24.89-24.99 MHz. You pick the option you want when you assemble the antenna.

A five-element, 15-meter monoband Yagi isn't for everyone. With a 26-foot boom and the longest element about 25 feet from tip to tip, it's about the size of a large tribander, but lacks the tribander's versatility since it only works on one band. If you have the space or the budget for only one antenna, you'll likely not be interested. On the other hand, if the designers have done their job, a monobander will outperform a tribander of approximately the same size because fewer compromises have to be made. Note that we said *fewer*, not *no*, compromises: Every antenna design involves making choices, and the four 15-meter configurations offered for the 155CA illustrate just a few of the many options one could select for a 15-meter beam on a 26-foot boom. Although Hy-Gain rightly cautions purchasers to not deviate from the instructions in measuring element length and placement, the instructions include sample *Yagi Optimizer*[1] output screens and input files for three of the five designs and someone familiar with the *YO* software could use the program to modify the design to suit their particular needs (eg, for MARS frequencies or possibly for slightly better performance at one end of the band at the expense of reduced performance at the other end).

For most purchasers, the choices made by Hy-Gain's designers are good ones. The

[1] *Yagi Optimizer* (*YO*) is a commercial computer software package for Yagi design and optimization. For more information, contact Brian Beezley, K6STI, 507½ Taylor St, Vista, CA 92084.

front-to-back ratio of a Yagi tends to be frequency-sensitive, so the three settings (phone, CW, and midband) give you the opportunity to place the maximum f/b ratio in the 200-kHz band segment of your choice. Hy-Gain says you can increase the f/b ratio to 40 dB at 21.250 MHz if you're willing to sacrifice a half-decibel of gain. We didn't attempt to verify this claim, because once the antenna was installed it would have been difficult to make adjustments (as discussed later) and because any measurement we could make would be only approximations. Hy-Gain's specifications call for a 2:1 SWR bandwidth of 400 kHz (our test antenna looked a bit better than this at the ham-shack end of the coax, possibly because of feed-line loss) and fairly uniform gain across the entire band.

The 155CA comes packed in two cartons. Heft them, and you'll know this is a serious antenna and not a lightweight: it weighs 42 pounds (shipping weight is 46 pounds), quite a lot for its size, due to the use of double-wall tubing in the center half of the boom. (This eliminates the need for any sort of truss to support the boom.) Hy-Gain says to allow five hours for assembly; it took three. The work area must be at least 26 by 26 feet if you're going to assemble the antenna in one piece on the ground. The stainless steel hardware is a pleasure to use, and assembling the elements is a breeze.

Hy-Gain uses an element-to-boom bracket that avoids any need for holes in either the boom or the elements, and provides the electrical equivalent of a through-the-boom element. This is a fine design, but it pretty much forces you to assemble the antenna on the ground and to raise it to the top of the tower in one piece, or at most two. In some installations, this is easier said than done.

The 155CA under test was destined for the top of a mast protruding seven feet above the top plate of a 92-foot guyed tower, which already had a home-brew four-element 20-meter beam installed just above the top plate. One New England winter afternoon, Mark Wilson, AA2Z, and I decided to raise the new antenna in one piece and to snake it past the ground clutter, three sets of guy wires, and the 20-meter beam. This turned out to be barely possible to do, although the next time we have to tackle something like this we'll first take the middle two elements off the 20-meter beam. That the 155CA survived the manhandling it got is testimony to its durability, which had given us some concern because of the relatively small diameter (7/16 inch) of the element tips (all the better to reduce wind loading).

Hy-Gain's cast-aluminum boom-to-mast bracket deserves mention, because it's one of the nicest arrangements we've ever used for attaching a moderately large Yagi to a mast. The two halves of the bracket are placed around the mast like horizontal parentheses, and held in place by two bolts that don't get in the way of the antenna. Around the boom is a second bracket, with four holes that line up with holes in the one mounted to the mast. Attaching the antenna to the mast is easy; as soon as you can get one bolt through both brackets you're home free. Anyone who's juggled **U** bolts at the top of a tower will appreciate the convenience (and safety) of this feature. This arrangement also permits tilting the antenna for easy maintenance and adjustment, although that's of limited value in an installation like ours where there's a bigger beam underneath.

If you're thinking about side-mounting the 155CA on a tower, you'll want to know that the first director (the element closest to the center of the antenna) is about two feet from the boom-to-mast bracket, toward the driven element.

Before the antenna was hoisted, a length of RG-213 coaxial cable was connected to the feed point using one of several methods recommended by Hy-Gain: I made a home-brew RF choke out of a dozen turns of the cable, positioned close to the feed point, and weatherproofed the pigtails leading to the two halves of the driven element. Hy-Gain uses a beta match (their term for a hairpin match) that required no adjustment whatsoever—a good thing, since the feed point is well out of reach from the tower!

As soon as the coax was connected to the rig, it was obvious that the antenna was working just fine. A check on a line-of-sight signal 20 miles away showed the f/b ratio was just about what Hy-Gain says it should be: Using a calibrated attenuator, I measured 23 dB versus the claimed 24 dB, an insignificant difference that might easily arise from the presence of the large 20-meter beam underneath. The radiation pattern was very clean, with no discernible side lobes and a pronounced null off the ends of the elements. We have no way to verify gain claims for HF antennas, but were able to verify (with a possible measurement error of 5 degrees) Hy-Gain's specification of a 55-degree 3-dB beamwidth.

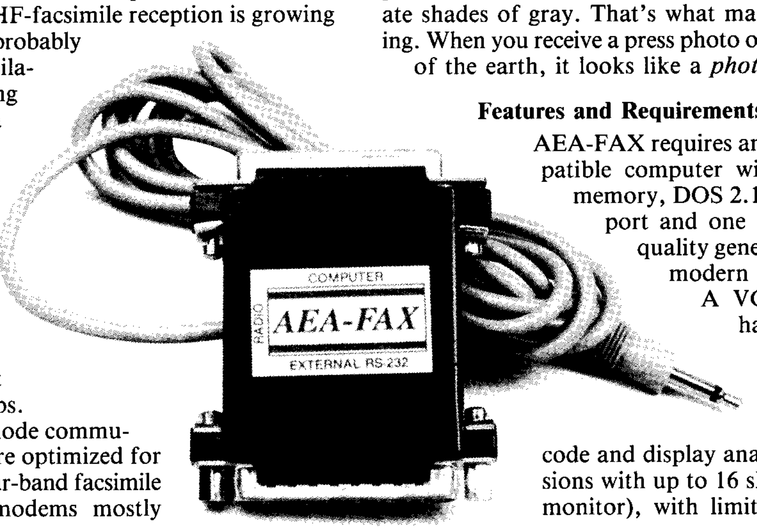
Will the 155CA make you a Big Gun on 15 meters? Big is relative. There are lots of bigger antennas around. On the other hand, it's difficult to see where Hy-Gain could have milked any more performance out of a 26-foot boom. The quality of the material used and of the mechanical design instill confidence that the antenna will survive lots of New England winters. That's a winning combination.

Manufacturer: Hy-Gain RF Consumer Department, Telex Communications, Inc, 9600 Aldrich Ave S, Minneapolis, MN 55420, tel 612-887-5528. Suggested retail price: $430.

AEA-FAX HF-FACSIMILE RECEIVING SYSTEM

Reviewed by Kirk Kleinschmidt, NT0Z

If the magazine ads and chatter on the computer bulletin boards are any indication, interest in HF-facsimile reception is growing rapidly. The sudden increase is probably due, at least in part, to the availability of low-cost fax receiving systems such as AEA-FAX, a palm-sized demodulator that plugs into your IBM PC (or compatible) computer's serial port. With its matching software (and a shortwave receiver), AEA-FAX lets you receive great-looking fax transmissions—weather maps, press photos, and more—for a fraction of the cost of traditional analog fax setups.



The modems in most multimode communications processors (MCPs) are optimized for *digital* fax reception and amateur-band facsimile transmission. These digital modems mostly produce stark, black-and-white images, with few or no intermediate shades of gray. That's what makes AEA-FAX so interesting. When you receive a press photo or a satellite-generated photo of the earth, it looks like a *photo*, not a line drawing!

Features and Requirements

AEA-FAX requires an IBM PC, XT, AT or compatible computer with at least 640 kbytes of memory, DOS 2.1 or later, at least one serial port and one floppy drive, and a good-quality general-coverage receiver (most modern ham rigs will do just fine). A VGA or EGA monitor and hard disk are recommended.

For such a simple device, AEA-FAX has several impressive features:

- The ability to decode and display analog HF facsimile transmissions with up to 16 shades of gray (with a VGA monitor), with limited false-color imaging (at

EGA resolution only).

• A plug-in demodulator with a "daisy-chain" RS-232-C connector (Fig 7) that passes serial-port data straight through. That way, you don't have to dedicate a serial port to the fax module.

• Unattended image reception and store-to-disk capability (leave room on your hard disk; an average weather map takes up about 300 kilobytes of disk space).

• Automatic detection of gray scale, line speed and index of cooperation (IOC, discussed later).

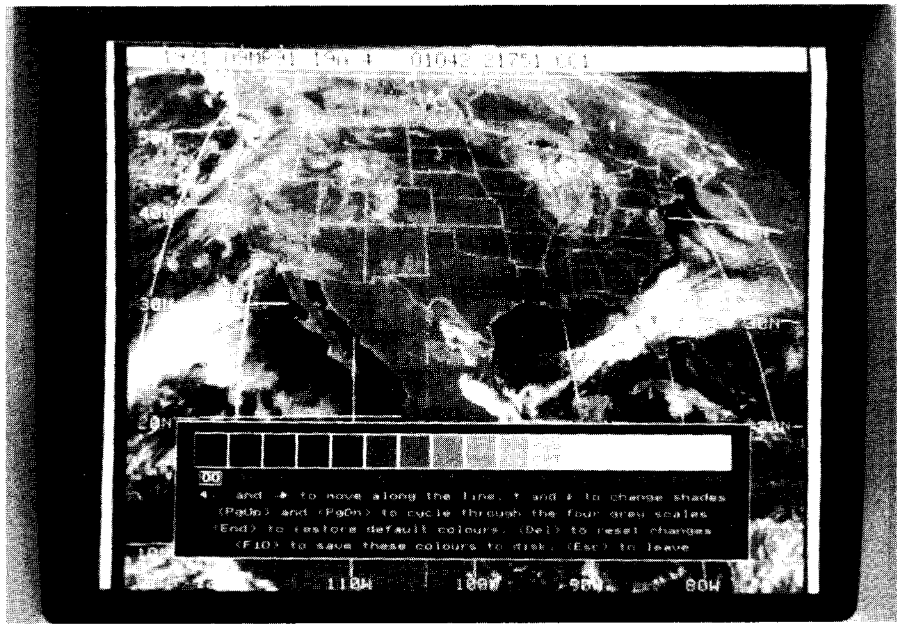
• Automatic screen blanking.

• An on-screen tuning display that's visible when receiving an image on the screen (this sets AEA-FAX apart from systems costing as much as ten times more; more on this later).

• The ability to print faxes on dot-matrix and HP-compatible laser printers (up to 300 dot-per-inch resolution on laser printers).

• The ability to export fax data as PCX-format files for manipulation with graphic-design software.

• A slide-show mode that lets you display several fax pictures, each for a selected period (1 to 99 seconds).



A typical AEA-FAX screen. *(photo courtesy of AEA, Inc)*

Using AEA-FAX

Getting AEA-FAX up and running is a piece of cake. Simply plug the demodulator unit into your computer's serial port (COM1 or COM2) and plug the shielded audio cable into your receiver's headphone or external speaker jack (use a **Y** adapter to share your rig between your headphones and the AEA-FAX).

The software installs in a minute or less, and comes up with a user-friendly menu. I found the program's several DOS command-line switches somewhat clumsy at first, but once I figured out which ones I needed to use, I had no problem.

At the opening menu, you can load and view previously received faxes, set system preferences, export fax files or receive an incoming fax, among other options. To receive a fax, simply type *I* or select **Input** with the mouse. The program jumps to a full-screen incoming fax window and the status line displays the current demodulator settings. You can manually select the settings, such as lines per minute (LPM), index of cooperation (IOC), the number of gray-scale shades and whether you want the computer to begin decoding the fax immediately or to look for synchronization tones before starting the display.

Most weatherfax transmissions are sent at 120 LPM with an IOC of 576, so unless you're receiving press photos (which usually run at 60 LPM with an IOC of 288), you can usually leave these settings locked. The automatic settings work well, too. (Index of cooperation, by the way, reflects the rate at which the fax transmitter's light sensor travels.)

At this point, I like to activate the AEA-FAX's Miniscope, a nearly real-time waveform-analysis scope. This feature really makes the AEA-FAX shine. The Miniscope overlays the lower third of the fax display area with a graphic display of the received waveform—it's like an audio spectrum analyzer. A line at the top of the zigzag waveform indicates the frequency of the white threshold, while a line at the bottom of the display indicates the black threshold. The Miniscope lets you precisely tune the somewhat tricky analog fax signals, which often sound like a phonograph with a needle stuck at the end of the record. AEA-FAX also lets you adjust the white and black thresholds to your tastes. The adjustable demodulator and Miniscope waveform analyzer are an unbeatable combination. With AEA-FAX and Miniscope, imprecise tuning (which makes an analog fax look really bad, by the way) is a thing of the past.

The Owner's Manual

The 28-page AEA-FAX *Owner's Manual* does a pretty good job of explaining the mechanics of HF facsimile to novice fax hunters (myself included). Installation of the demodulator and software are clearly described, as are most of the various software functions and options. Typical fax frequencies are included, as is a suggested reading list and a display of interesting waveforms likely to be displayed on the Miniscope. The manual, though it contains lots of information, is somewhat disorganized. Unfortunately, the documentation doesn't include a circuit description or a schematic of the interface.

Operating Impressions

The AEA-FAX system is a lot of fun to use. After trying in vain to receive decent HF fax images with several multimode communications processors and a fancy, professional-grade RTTY/FAX demodulator, I was thrilled to have a beautiful, clear weather map on my screen in less than 15 minutes with AEA-FAX. I could hardly believe it after what I'd experienced before! Soon, faxes from Europe, Africa and Australia were on my hard disk, and I started hunting for now-elusive press photos from South America and Japan.

My wish list has only two items. First, AEA-FAX doesn't do all that well with moderate or weak signals. To get a sparkling-clear fax image, the demodulator needs a powerhouse signal (listen to the fax signal from NAM, Norfolk, Virginia, at 8080 kHz, to hear a biggie). The interface does decode weak fax signals, but at much degraded image quality. Improved demodulation of weaker signals would be nice.

The other thing that bothered me, as it has with every other fax decoder I've tried, is that nowhere in the manual is there a description of exactly how to tune an HF fax signal on your receiver. Adjusting the demodulator settings with the Miniscope is explained well, tuning fax signals on a receiver is not. Luckily, the Miniscope makes the process intuitive, and even beginning fax listeners will be able to figure out how to tune their radios after a bit of fiddling with the waveform analyzer.

Conclusion

If you're looking for an inexpensive and easy way to get in on the exciting world of HF facsimile, AEA-FAX won't disappoint you. It's a friendly little box that takes the mystery out of those scratchy signals you've always wondered about.

Manufacturer: Advanced Electronic Applications, Inc, PO Box C2160, Lynnwood, WA 98036-0918, tel 206-775-7373. Suggested retail price: $120. QST