



Product Review and Short Takes from QST Magazine

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Product Reviews:

TS-480SAT and TS-480HX HF + 50 MHz Transceivers

Short Takes:

CircuitMaker Student Version

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Two from Kenwood—TS-480SAT and TS-480HX HF + 50 MHz Transceivers

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Decisions, decisions. Automatic antenna tuner or 200 W output? That's the choice facing prospective Kenwood TS-480 buyers. The SAT version offers 100 W plus a competent internal auto tuner, while the HX model trades off the tuner for 200 W output, making it the *smallest* radio on the market at that power level. In all other respects, the units are identical. Supersize me? Or auto tune me? Whichever way you go, you are likely to think you made the right choice.

In a very literal sense, Kenwood strayed outside the box in designing the TS-480. While it appears to have drawn upon a heritage that includes not only the TS-50 but the TS-570 and the more recent TS-2000, you've never seen a transceiver quite like the TS-480. It's the first to arrive in two pieces (at least intentionally). There's a "remote control panel" and what Kenwood calls the "TX/RX unit"—the radio body.

The advantages for mobile and portable installations are obvious. Nonetheless, more, uhh, traditional hams may not readily buy into this two-piece transceiver concept. Judging from scattered early-buyer comments on the Internet, a few hams still prefer their radios to come as *one* box, preferably a substantial one with a flashy display and scores of knobs, buttons, dials and meters to confer swagger rights. Interestingly, the manual describes a "portable bracket" that holds the two pieces together, but it is offered only in the European market. Perhaps Kenwood will offer it in the US for those who see a need to put the pieces together.

Maybe this is why otherwise impressive computer-controlled radios with "virtual" front panels (the short-lived but capable Kachina 505DSP comes quickly to mind) never made a big dent in the ham radio market.

Where's Your Radio, Dude?

Welcome to a piece of Amateur Radio's future, where your entire station need no longer occupy an entire room or corner of the basement. The TS-480 could finally kick off an era of mini ham shacks containing little more than a control head,



Figure 1—View of the major assemblies of the Kenwood TS-480SAT. The 'HX' appears identical in this view.

a mike and/or a keyer paddle, a few accessories and maybe a PC. Indeed, in the case of the TS-480, your "station" can be somewhere else entirely, since you can control the transceiver remotely via the Internet.

Not Just Another Mobile

Kenwood's excellent *Instruction Manual* describes mobile installation *first*, suggesting the manufacturer primarily intended the TS-480 for that application. Could the TS-480 *really* be the long-awaited follow-on to the now-venerable TS-50/TS-60—putting HF and 6 meters into a single box? Given that the TS-480

is light years ahead of the TS-50 and a very decent performer, this carries more than just a ring of logic. Perhaps it's true, but Kenwood's not saying.

This is a great little home station rig too, especially for amateurs who value a minimalist, attractive, contemporary space-saving installation or whose spouses don't want "all that dirty old junk" in plain view. While using any of the current crop of small radios with detachable front panels as fixed station transceivers often means compromising features (remember, the TS-50 included neither VOX nor CW keyer, much less an antenna tuner) and performance for size, that's not the case with the TS-480.

The more I played with these radios the better I came to appreciate them and what they can do. These are not the perfect radios for everyone, nor are they small-box superstations, but I came away much more impressed than I'd initially expected—and, in the interest of full disclosure, my wife and I already own three Kenwood transceivers between us.

Bottom Line

A competent HF + 50 MHz performer in two flavors—200 W or 100 W with automatic antenna tuner—the TS-480's flexible two-piece design and manifold features make it appropriate virtually anywhere.

No Big Ugly Radio

Liberated from ever having to be attached to a radio body, the TS-480 remote control panel is free to find its own shape, which veers away from the typical clean rectangle and the staid, linear layout we've come to expect from detachable front panels. The stylish, modernistic result—its protruding main tuning knob flanked by buttons reminiscent of Kenwood's TS-2000—may not enjoy universal appeal, but it's sensibly laid out and, by and large, easy to see and access.

It's also larger than the typical detachable front panel, which, by definition, can't be any wider or taller than the radio box itself. The TS-480's TX/RX unit alone is larger than other radios in this class—bigger than an entire IC-706 or TS-50, for example. The remote control panel is approximately $3 \times 7 \times \frac{1}{2}$ inches (counting the tuning knob).

The back-lighted amber/black text display measures about $4 \frac{3}{4} \times 7 \frac{1}{8}$ inches, and the main frequency readout numerals are a smidge over $\frac{1}{4}$ inch tall. Even the much-smaller legends are readily readable some distance away. The display offers excellent clarity from above and laterally; visibility does fade rapidly when it is viewed from below. Four levels of display brightness (plus "off") are available via the menu, as is the option to illuminate the numerous buttons.

One minor layout complaint: The PF, ATT/PRE and AT buttons on the left side are slightly raked and rounding the curve of the panel's edge. This makes them a bit less easy to read, but once you know what each does, it's no longer an issue. I also had to get used to the AF/SQL control being on the left instead of the right.

Most of the front panel controls are buttons—or keys, as Kenwood calls them. There are 34 in all (as opposed to just six rotary controls plus a little lever to tighten the tuning dial tension), and a lot of these keys access more than a single function. Press and release a button to enable its primary function; press and hold it one second for a secondary one or to change the main function's setting. In a few cases, the function of a button changes with mode.

Form Follows Function

Kenwood has grouped controls by function and done so in a way that draws your eye right to the one(s) you want. Contesters will be happy to see in the upper right hand corner a *dedicated* RIT knob and associated CL (clear), XIT and RIT buttons.

Five of the seven buttons immediately adjacent to the main tuning knob—three on the left, four on the right—access tun-

ing and memory-related functions, such as the A/B and A=B keys. The other two are MODE and MENU/F.LOCK buttons you'll likely be using a lot. Placing them next to the tuning knob makes perfect sense.

To the left just below the virtual meter on the display is a "pad" of a dozen keys. In addition to letting you punch in a particular frequency (very handy), these keys each have their own specific functions, so Kenwood's made the most of the available real estate. This means you don't always find yourself jumping to the menu to, say, set your CW sending speed (just press the KEY key) or to turn the VOX on or off or change its settings (just press, or press and hold, the VOX button). Very, very convenient! Some radios of this genre force you to scroll through multiple menus to get at the same controls—although in all fairness, most of those radios also have smaller front panels.

In that same vein, having a dedicated menu button is a real treat and greatly eases user stress. Better still, the TS-480 lets you set up not one but *two* full configurations of all 60 menu items. This can accommodate operator preferences in a multioperator station as well as for differing operating environments—casual vs contesting or mobile vs fixed, for example. You can also set up a "Quick Menu" of functions you use a lot.

Accompanying each menu item is a text crawl in *real* English to describe the function. No more jumping back and forth between the radio and the manual!

A diamond-shaped cluster of buttons between the main tuning knob and the keypad buttons facilitates functions dealing with interference: DNL (digital noise limiter), FIL (filter), BC (beat cancel—a heterodyne eliminator) and NR (noise reduction). More on how (and how well) these work later. One quibble: The noise blanker (NB) is among the keypad buttons rather than within the interference fighting cluster.

Rounding out the key complement are the FINE/STEP, SCAN/SG.SEL (SG.SEL = scan group selection) and the sizable, uniquely shaped \vee down and \wedge up buttons, primarily for changing bands or menu settings. You also can set up the down and up buttons to serve as a TF-SET (transmit frequency set) button while operating split, although swapping VFOs by pressing the A/B key does the same thing. By the way, the display can show both receive (main) and transmit frequencies in split operation.

In addition to the AF/SQL and RIT rotary controls, the TS-480 includes concentric MULTI/IF SHIFT knobs. As its name implies, the MULTI knob, a feature of many earlier Kenwood radios, has mul-

tiplied functions. Unless you're in a menu or changing a setting, it lets you zip across the band in large steps.

Getting Up and Running

Making the transition from packing box to first QSO is pretty painless. Experienced hams can be putting contacts into their log in almost no time at all. (This radio is a good choice for less-experienced hams, as well.)

Of course, a mobile installation likely will take additional planning and execution. Wiring to a vehicle's battery with the supplied 6 foot long fused twin power cables could mean mounting the radio "body" a lot closer to the front of the vehicle. An optional 23 foot long power cable is available as an accessory, but you'll need two of them for the HX model. The required 13.8 V at 41 A for the HX can come from a single battery in a mobile or, in a fixed installation, from a single heavy-duty power supply or two comparable lighter-duty units. If you have one from an earlier 100 W transceiver, it likely can be half of the power system, so you don't need to buy a new 41 A supply and relegate your earlier supply to door-stop duty.

At home the remote control panel can go just about anywhere. Ham shack in a closet, anyone? The radio body can be tucked away out of sight—although you must ensure adequate ventilation, especially for the higher-power model.

The approximately 13 foot long cable connecting the remote control head with the radio body should be ample for most any installation (an optional extension is available), but *all other electrical connections* with the exception of headphones must be made to the radio body, and this could present some challenges. These include the microphone, key/paddle and extension speaker lines. There's a jack for headphones on the remote control panel as well as a speaker. It's rear firing, but it sounds quite decent. Kenwood reasons that the sound will reflect from whatever surface is behind the remote control panel.

I've always appreciated the convenience of being able to connect the microphone directly to the removable faceplate of my IC-706, or to choose to connect it to the radio body, depending on mounting configuration.

Initially, I placed the TS-480's radio body on the floor, but it was not very handy for plugging in my Heil headset (Heil makes an adapter for these radios). The provided mobile microphone with its coiled cord kept wanting to slip off the table and join the body on the floor. Again, optional extension cables are available.

The radio body has connections on both

Table 1 Kenwood TS-480HX, serial number 50800363¹

Manufacturer's Specifications

Frequency coverage: Receive, 30 kHz-60 MHz; transmit, 1.8-2, 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, 28-29.7, 50-54 MHz.

Power requirement: Receive—1.5 A; transmit—TS-480HX, 41 A (max); TS-480SAT, 20.5 A.

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

Receiver

SSB/CW sensitivity, bandwidth not specified, 10 dB S/N: 0.5-1.7 MHz, <4 μ V; 1.7-24.5 MHz, <0.2 μ V; 24.5-30, 50-54 MHz, <0.13 μ V.

AM sensitivity, 10 dB S/N: 0.5-1.7 MHz, <32 μ V; 1.7-24.5 MHz, <2.0 μ V; 24.5-30 MHz, 50-54 MHz, <1.3 μ V.

FM sensitivity, 12 dB SINAD: 28-30 MHz, 50-54 MHz, <0.22 μ V.

Blocking dynamic range: Not specified.

Two-tone, third-order IMD dynamic range: Not specified.

Third-order intercept: Not specified.

Measured in the ARRL Lab

Receive² and transmit, as specified.

Receive—1.0 A; transmit—TS-480HX, 35 A; TS-480SAT, 17 A. Tested at 13.8 V.

As specified.

Receiver Dynamic Testing

Noise floor (MDS), 500 Hz filter:

	Preamp off	Preamp on
1.0 MHz	-115 dBm	-122 dBm
3.5 MHz	-133 dBm	-141 dBm
14 MHz	-133 dBm	-141 dBm
50 MHz	-131 dBm	-143 dBm

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

	Preamp off	Preamp on
1.0 MHz	12 μ V	5.0 μ V
3.8 MHz	1.4 μ V	0.57 μ V
50 MHz	1.8 μ V	0.47 μ V

For 12 dB SINAD:

	Preamp off	Preamp on
29 MHz	0.74 μ V	0.16 μ V
52 MHz	0.76 μ V	0.17 μ V

Blocking dynamic range, 500 Hz filter: spacing:

	Preamp off/on	Preamp off/on
20 kHz	122/117 dB	98/92 dB
3.5 MHz	123/115 dB	98/91 dB
14 MHz	123/117 dB	97/91 dB
50 MHz		

Two-tone, third-order IMD dynamic range, 500 Hz filter, spacing:

	Preamp off/on	Preamp off/on
20 kHz	97*/99* dB	76/72 dB
3.5 MHz	98*/99* dB	75/71 dB
14 MHz	96*/81 dB	75/69 dB
50 MHz		

Intercept:

	Preamp off/on	Preamp off/on
3.5 MHz	+24/+11 dBm	-18/-31 dBm
14 MHz	+26/+12 dBm	-18/-32 dBm
50 MHz	+26/-14 dBm	-18/-35 dBm

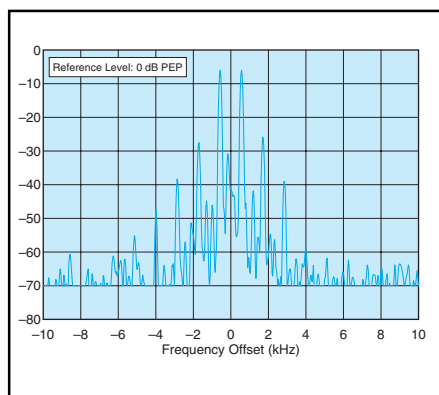


Figure 2—Worst-case spectral display of the Kenwood TS-480HX during HF two-tone intermodulation distortion (IMD) testing. The worst-case third-order product is approximately 26 dB below PEP output, and the worst-case fifth order product is down approximately 39 dB. The transmitter was being operated at 200 W PEP output at 24.950 MHz.

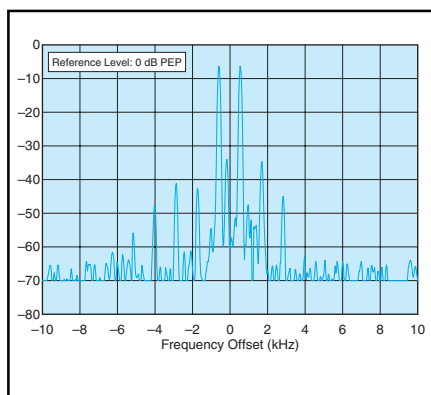


Figure 3—Worst-case spectral display of the Kenwood TS-480HX during VHF two tone intermodulation distortion (IMD) testing. The worst-case third-order product is approximately 35 dB below PEP output, and the worst-case fifth order product is down approximately 42 dB. The transmitter was being operated at 100 W PEP output at 50.200 MHz.

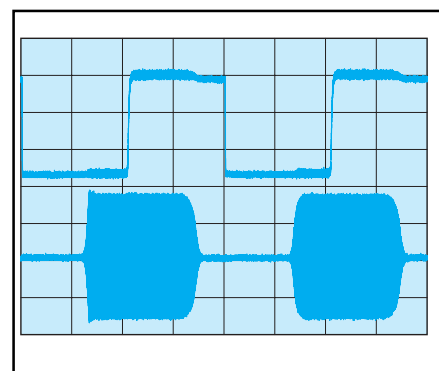


Figure 4—CW keying waveform for the Kenwood TS-480HX showing the first two dits in full break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure (indicated by the drop in key voltage at the left edge); the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 200 W output at 14.2 MHz.

Manufacturer's Specifications

Second-order intercept: Not specified.

FM adjacent channel rejection: Not specified.

FM two-tone, third-order IMD dynamic range: Not specified.

S-meter sensitivity: Not specified.

Squelch sensitivity: SSB, 0.5-1.7 MHz, <18 μV ; 1.8-30 MHz, <1.8 μV ;
50-54 MHz, <1.1 μV ; FM, 28-30, 50-54 MHz, <0.2 μV .

Receiver audio output: 2.0 W at 10% THD into 8 Ω .

IF/audio response: Not specified.

Spurious and image rejection: 70 dB.

Transmitter

Power output: HF—SSB, CW, FM, 200 W high, 5 W low; AM, 50 W high, 5 W low;
VHF—SSB, CW, FM, 100 W high, 5 W low;
AM, 25 W high, 5 W low.

Spurious-signal and harmonic suppression:
HF, ≥ 50 dB; VHF, ≥ 60 dB.

SSB carrier suppression: ≥ 40 dB.

Undesired sideband suppression: ≥ 40 dB.

Third-order intermodulation distortion (IMD) products: Not specified.

CW keyer speed range: Not specified.

CW keying characteristics: Not specified.

Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.

Receive-transmit turnaround time (tx delay): Not specified.

Composite transmitted noise: Not specified.

Size (height, width, depth): main unit, 2.8 \times 7.0 \times 10.9 inches; control head, 3.0 \times 7.2 \times 2.6 inches.

Weight: main unit, 7 pounds; control head, 1.1 pounds.

Note: Unless otherwise noted, all dynamic range measurements are taken at the ARRL Lab standard spacing of 20 kHz.

*Measurement was noise-limited at the value indicated.

Third-order intercept points were determined using S5 reference.

¹Kenwood TS-480SAT, serial number 50800556, similar except power level is 100 W on all bands and transmit current is as shown.

²Receive sensitivity degrades below 0.1 MHz.

Measured in the ARRL Lab

Preamp off, +64 dBm; preamp on, +63 dBm.

20 kHz channel spacing, preamp on: 29 MHz, 78 dB;
52 MHz, 75 dB.

20 kHz channel spacing, preamp on: 29 MHz, 78 dB*;
52 MHz, 70 dB.

S9 signal at 14.2 MHz: preamp off, 87 μV ; preamp on, 18 μV .

At threshold, preamp on: SSB, 14 MHz, 3.6 μV ;
FM, 29 MHz, 0.1 μV ; 52 MHz, 0.1 μV .

2.5 W at 10% THD into 8 Ω .

Range at -6 dB points (bandwidth):
CW (500 Hz filter): 508-1114 Hz (606 Hz);
USB: 205-2815 Hz (2610 Hz);
LSB: 175-2781 Hz (2606 Hz);
AM: 102-3132 Hz (3030 Hz).

First IF rejection, 14 MHz, 106 dB; 50 MHz, 70 dB;
image rejection, 14 MHz, 122 dB; 50 MHz, 115 dB.

Transmitter Dynamic Testing

HF—CW, SSB, FM, typically 203 W high, 4.7 W low;
AM, typically 44 W high, 4.3 W low;
VHF—CW, SSB, FM, typically 107 W high, 4.5 W low;
AM, typically 25 W high, 3.0 W low.

HF, 58 dB; 50 MHz, 66 dB. Meets FCC requirements.

>53 dB.

>62 dB.

See Figures 2 (HF) and 3 (VHF).

10 to 60 WPM.

See Figure 4.

S9 signal, 23 ms.

SSB, 12 ms; FM, 14 ms. Unit is suitable for use on digital modes.

See Figures 5 (HF) and 6 (VHF).

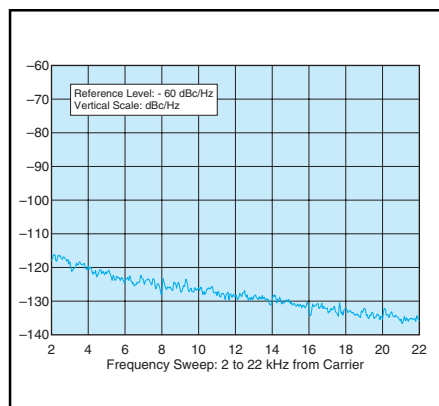


Figure 5—Worst-case spectral display of the Kenwood TS-480HX transmitter output during HF composite-noise testing. Power output is 200 W at 14.020 MHz. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 2 to 22 kHz from the carrier.

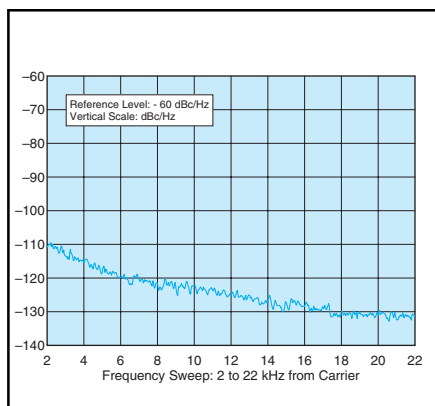


Figure 6—Worst-case spectral display of the Kenwood TS-480HX transmitter output during VHF composite-noise testing. Power output is 100 W at 50.020 MHz. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 2 to 22 kHz from the carrier.

ends. A cooling fan (or fans in the case of the HX) is on the “rear” end. Two antenna jacks are at the ends of short pigtailed.

Once everything’s hooked up, operating the radio will prove largely intuitive for most—although I did need to consult the *Instruction Manual* to figure out how to put the radio together (so to speak). Otherwise, the manual thoughtfully includes a two-page section called “Your First QSO” that will have you on the air in a flash.

The control-head-cum-radio motif does present one basic issue—how to keep the comparatively lightweight remote control panel down on the desk when you’re punching buttons and twirling knobs. The four little protective rubber pads affixed to the little oval base don’t prevent it from sliding on finished surfaces.

A station I worked who was using his new TS-480 at home said he weighted it

down. Other choices include “temporary” adhesive products, tilting the remote control panel up slightly, mounting the base to a larger platform or, if you desire, attaching it right to the operating desk with small screws.

Confronting the Good, the Bad and the Ugly

The TS-480 combines crystal IF filters and audio-level digital signal processing (DSP) to enhance selectivity, reduce extraneous noise and null heterodynes. The processor is a 16-bit fixed-point chip running at 100 MHz. The noise reduction (NR) system is adaptive and generally beneficial, but it’s not something I’d engage without a specific need.

There are two modes. NR1 is intended for SSB, CW, FSK, AM or FM. You can set NR1 at AUTO or choose settings between 1 and 9 that yield varied results. NR2 is a SPAC (speech processing by auto correlation) system that, oddly enough, Kenwood recommends solely for CW. It takes some getting used to. Adjustable from roughly 2 to 20 ms, the manufacturer says it can “suppress noise at the same frequency as the target signal, allowing it to pull a weak target signal out from the surrounding noise.” Whatever. It can and does improve readability under rough-copy CW conditions—sometimes dramatically.

NR1 and the digital noise limiter (DNL) are a big help when atmospheric static rears its ugly head. NR works on all modes; DNL works on all modes but FM. One or the other or a combination of the two won’t eliminate all the noise, but it considerably ameliorates the annoyance. The trade-off is that the NR affects audio quality on voice modes. The DNL also can distort received audio at its top setting.

Using the NR and/or DNL will roll off top end audio response on nearly every setting, muddying the audio. It can be a tricky trade-off. You can overcome this somewhat via the RX EQ menu, another excellent feature.

The RX EQ complements the DSP and crystal filters by applying predefined equalization curves to the received audio. There’s an adjacent and similar TX EQ menu to tailor transmitted audio, too. The choices on both menus are FLAT (off), HIGH BOOST 1 and 2 (think Richard Simmons), FORMANT PASS (Kenwood says this improves clarity by suppressing audio frequencies outside the normal voice range), BASS BOOST 1 and 2 (think Barry White), CONVENTIONAL (slightly trims audio above 2 kHz) and USER-



Figure 7—Rear view of the main unit of the Kenwood TS-480SAT. The 'HX is similar except that there are fans on both sides, aligned with each PA module.

DEFINED (via the PC control software). Incidentally, this radio sounds really great on AM, especially on the FORMANT PASS setting.

In addition, the DSP filter lets you customize the receive audio passband—up to a full 5 kHz (0 on the low end, 5000 Hz on the upper)—for voice modes, a very nice touch indeed. On SSB, it’s possible to crank down the SSB filter considerably and still copy the audio—helpful in contesting. The IF shift also is effective, much more than the “tone control” found on some transceivers. There are special DSP filters for PSK31 and other digital modes.

Although the TS-480 lacks a true IF notch, the beat cancel (BC) feature is marvelous. While trying to work a 6Y8 with someone tuning next to him, I pushed the BC key, and voilà, there he was in the clear. If the offending signal is strong enough, however, beat cancel can degrade the desired signal, and, in any event, the carrier will continue to activate the AGC—and, thus, show up on the S meter.

There are two BC settings. One works on continuous tones, the other on intermittent tones like CW. But they only work in voice modes. You can’t use BC while in CW to, say, notch out a nearby signal. You *can* use the crystal and digital filtering, however.

Memory Lane

The 100 memory channels will hold receive and transmit frequency, mode and step size as well as CTCSS and tone frequencies and memory name. You can lock out specific memories for scanning purposes. The TS-480 also has 10 scratchpad or “Quick Memory” channels. These are handy for storing frequencies on the fly

on a first-in/first-out basis. Say you hear a multiplier you need in a contest, but conditions aren’t there yet for you to break the pileup. The Quick Memory feature lets you mark the spot (and nine others) so you can easily keep an ear on them and pounce when the chance arrives.

The three standard CW memories hold 50 characters, and they are “recording” memories. Whatever you send, the memory will parrot it back at the press of a button. You can interrupt the memory playback to, say, insert a serial number or to add a customized response or message. A message interval time for repeat playback can be set from zero to 60 seconds.

Twirling the Knob

You can adjust the tuning step for coarse or AM and FM channel tuning for 10 and 6 meter repeaters or for tuning across the AM broadcast band. You can select a tuning rate of 250, 500 or 1000. These numbers—the default is 500—represent the number of pulses the tuning encoder generates in a complete revolution of the tuning knob. The actual frequency depends on the step size for the mode.

In SSB and CW, the step size is 10 Hz, so a tuning rate of 250 represents 2.5 kHz per full spin (in actual practice, it’s a bit more than that). Pushing the FINE button shifts the decimal point one place to the left, so you’re down to a languid 250 Hz per rev—very nice for precise tuning. There are ample choices to find a tuning rate just right for you.

Antenna Tuning on the Fly

The built-in automatic antenna tuner worked rather well on the SAT model, although you do incur some loss. In the ARRL Lab, we measured from a low of 12 percent loss on 10 meters up to a high of 21 percent on 6 meters going into a nonreactive 50 Ω load—although this only represents around 1 dB or less. It would not tune my multiband antenna on 160 meters (it’s a half-wave there), but my TS-850S/AT would. In fairness to the ‘480, it is only spec’d for up to a 3:1 SWR.

In general, I found the TS-480’s relay-type autotuner less flexible than the motorized capacitor unit in my TS-850S/AT in matching the weird sorts of loads my multiband antenna presents. You can select the tuner for receiving via the menu. By the way, the Morse implications of

WRC-03 aside, operators still need to know a bit of Morse code when using this (and other) Kenwood radios. The audio tuner sends SWR if it cannot get a match and T if it can. Hey, that's four letters right there!

Remote Control

You can remotely control the TS-480 using the free Kenwood *ARCP-480* software, which lets you control all transceiver functions via your PC. One problem, however, is that Kenwood installed a male serial jack on the radio, so you'll need a serial cable with female connectors on each end. In fact, one station we worked was using his laptop to control his brand-new TS-480SAT.

But wait! Remote control via the Internet or over a network also is possible using the Kenwood Network Command System radio host program *ARHP-10* on the computer connected to the radio. Then, you can control it using the *ARCP-480* software from a remote PC. Voice transmission is via Voice over Internet Protocol (VoIP); CW is possible using the keyboard.

A Brief Encounter of the Mobile Kind

To simplify testing (my Kenwood HF mobile rig was not plug compatible nor heartily enough wired), I connected the TS-480—the HX model in this case—to a deep-cycle marine battery (the boat was in dry dock). It easily ran the unit at full output. This exercise presented an opportunity to check out radio features of great importance to us mobileers.

For starters, the NB worked *very* well on the slight bit of ignition noise my engine generates plus full-tilt HVAC fan noise on 20 meters and 40 meters. I ran the NB all the way up to its most aggressive setting (10) with no signal impairment on CW. Since it will degrade audio on SSB, however, it's best to throttle the NB back to the lowest setting that does the job.

The DNL also drastically cut into the ignition noise, and the DNL and NB in tandem were terrific on CW. It's not a good idea to run the DNL at its most aggressive setting (3) on SSB either, since it starts to distort the received audio. I found it's best at 1 or 2.

The NR provides an added benefit in cutting the other sorts of noise one encounters while under way. I did not find it essential for mobile work, but it's there if you need it.

The radio is plenty sensitive, even on a mobile antenna. I generally find it best not to run a preamplifier while mobile. Although the TS-480's preamp boosts the

desired signal by about 8 dB, that can come at the cost of undesired noise.

The stations I worked on both CW and SSB were unable to detect much of a difference between 100 W and 200 W, but it might make the operator *feel* louder. It represents one-half S unit in terms of power. (Another mobile I worked was running a full kilowatt. Talk about loud!)

Let's Do the Numbers

Kenwood credits a quad-JFET mixer for receiver "dynamic range equivalent to that of the TS-950 class (at 50 kHz separation)." Briefly, dynamic range measures a receiver's ability to hear weaker signals in the presence of stronger ones. Kenwood's parenthetical qualifier is important, for 50 kHz is a *lot* wider than the typical roofing filter. That said, the TS-480 acquits itself quite well in terms of dynamic range at the ARRL Lab's 20 kHz spacing standard. Two-tone third-order IMD dynamic range (see Table 1) on 14 MHz was 98 dB noise-limited (preamp off). At the same spacing—equivalent to the typical roofing filter—the third-order intercept (TOI) for the TS-480 is a quite creditable +26 dBm—slightly better than the +23 dBm we calculated for the top-end Ten-Tec Orion. Many consider TOI an indicator of strong-signal handling capability, an overall measure of receiver quality. So far, so good!

Crunch time arrives at the 5 kHz spacing test—something a lot closer to real-world conditions. There, the TS-480 came in at 75 dB (preamp off), and the TOI was -18 dBm. Contrast that with the Orion's 92 dB two-tone, third-order IMD dynamic range and +22 dBm TOI for the same band and spacing.

Even so, the TS-480's numbers are superior to those of Kenwood's TS-2000. On that transceiver, we measured 94 dB of two-tone, third-order IMD dynamic range at 20 kHz spacing, and 69 dB at 5 kHz. The TOI for the TS-2000 was +19 dBm at 20 kHz and -15 dBm at 5 kHz.

All other factors being equal, dynamic range and TOI for the TS-480 also are substantially better than other transceivers in this category.

Other Really Keen (or Not) Stuff

- Borrowing from a feature Kenwood first included in the TS-570, the TS-480 has a CWTUNE button. This automatically zero beats a CW signal—provided it's reasonably strong. Don't try this on that weak and watery DX signal you're attempting to tune in.

- The PF key can be set to something you might adjust a lot. As the manual suggested, I set it to transmit a "tune" signal—about 30 W of carrier—very handy

to get the manual tuner set up.

- To get 200 W (HX model) with a 13.8 V supply, Kenwood uses a splitter feeding identical 100 W output modules followed by combiner. (The output on 6 meters is 100 W.)

- It's annoying to have step through most of the modes (you can select either FM and AM) to get (back) to the one you want. Most operators will be using CW or SSB and maybe FM. A menu setting that lets you "lock out" certain modes would be a real plus. The NR selections also work this way.

- The separate key and paddle jacks were great touch and something I wish *my* radio had.

- Some on-the-air reports indicated that keying was softer than my TS-850's, but I had the opportunity to work someone who was using a TS-480 on CW, and it sounded just fine to my ear. The transceiver supports full break-in.

- The TS-480 has probably the best VOX I've ever used. It's just superb. The anti-VOX system is automatic, so there's not nearly as much diddling to get the settings just right.

- Not expecting to find one, I nearly overlooked the first-rate transmit monitor early on.

- There's a linear-switching relay (with menu-selectable delay settings), but you can disable it.


And in Conclusion . . .

Some minor issues aside, I grew quite fond of the TS-480 and have added it to my personal wish list. The radio offers the sorts of features and flexibility you'd expect to find only in a higher-end rig.

The extra 100 W the HX model offers doesn't buy you much, but I'll give it at least partial credit for helping me to snag 3B9C (Rodriguez Island) on 40 CW and on 12 SSB. It does allow you to run at the 30 meter limit, as well as drive some linear amplifiers that need more than 100 W for full power. On the other hand, that auto tuner sure comes in handy. *Decisions, decisions.*

Thanks to Bob Heil, K9EID, of Heil Sound for his assistance with the headset adapter.

Additional information about this and other Kenwood radios as well as software downloads are available at the Kenwood Information & Communication Products Web page, www.kenwood.com/i/index.html.

Manufacturer: Kenwood Amateur Radio Products Group, 3975 Johns Creek Ct, Suwanee, GA 30024-1266; 310-639-4200; www.kenwood.net. Typical street prices: TS-480HX, \$1080; TS-480SAT, \$970; optional 500-Hz CW filter, \$120. 



CircuitMaker Student Version

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I have no formal training in electronics, but I love homebrewing. I've always wanted to try a program that allowed me to model electronic circuits on the computer, both to see if my design worked, and to see what does not work. All the programs I have tried in the past were either too complex, or didn't live up to my expectations. I recently downloaded a program called *CircuitMaker Student Version* that was mentioned in "The Doctor Is IN" (*QST*, January 2004, page 53) and I have fallen in love with it. This is a small program for the *Windows* operating system (only 3.24 MB), so even with a dial-up connection it is no problem to download.

Drawing It Out

When I installed *CircuitMaker* on my computer, I was amazed at how easy it was to learn. You can begin building and testing your own "virtual" circuits within minutes.

When you click on the PARTS icon in the toolbar, a drop-down menu appears showing the parts that are available. If you want to put a transistor in the design area, click on the PARTS icon, select MAJOR DEVICE CLASS and scroll down to transistors. The MINOR DEVICE CLASS box then displays your choices. Everything from Darlingtons to enhancement-mode MOSFETs is available. Click on BJT, for example, and you'll see a list of 50 different transistors to choose from. If you double click on a 2N3904, you will be taken back to the design area. One more click at this point will place the transistor in the design.

Other parts can be placed in similar fashion. You can then

drag the parts into position with your mouse. By right clicking the parts, other parameters can be changed such as the orientation or the component value. An option to duplicate the part is also available, which saves a few steps when putting multiple parts of the same type in a circuit.

All of the parts in the design area can be interconnected simply by clicking on the + icon and moving the cursor over the lead of the part you want to wire. When you do, a red box will appear. Click the box and, as you move the mouse, a blue line will trail behind. Think of this blue line as a "wire." As you reach another component lead, another red box will appear. Just click again and the parts will be instantly connected between those two points. If you make a mistake before clicking the second time, press the ESC (escape) key and the operation is aborted. (Another way to erase is by clicking on the DELETE TOOL. The cursor then becomes a lightning bolt. Touch the tip of the lightning bolt to the part or wire you want to remove and it will vanish with a single mouse click.)

Modeling

Now comes the fun part. Let's say that you've completed a circuit for your project, or copied a circuit from *QST*, and you want to see how it works. No need to buy test equipment because *CircuitMaker* will take the measurements for you.

With the circuit displayed on screen, click on the RUN icon and multimeter will open. With the multimeter (PROBE tool), you can check voltage, current and power at any point. You can check waveforms with the *CircuitMaker* oscilloscope by making it active and then holding down the shift key and, for example, clicking the base and the collector of an amplifier circuit. You can see amplification taking place right before your eyes.

The Verdict

CircuitMaker is a boon to experimenters. You can use it to design, test and learn about the circuits you have been seeing in books and magazines for years. Don't be afraid to try new things. You can design a circuit on a whim, then change components and see what happens. This is all part of the learning process, and the more you use *CircuitMaker* the more you learn.

The student version is free, but it has limitations. The help section in particular is truncated. The student version is also limited to a maximum of 50 devices per design (any type) and the device library is limited to 1000 models. The symbol editor and macro features are disabled as well. Despite these limitations, *CircuitMaker Student Version* has more than enough power to keep you building—and dreaming.

Manufacturer: Altium Limited, 12A Rodborough Rd, Frenchs Forest NSW 2086, Australia. Download from the Web at www.circuitmaker.com/. System requirements: Windows 98/NT/2000/XP with a Pentium-class PC with 32 MB of RAM and 40 MB of hard disk space.

