73 Review

Number 5 on your Feedback card

by Steve Katz WB2WIK/6

Kenwood Communications Corporation
Amateur Radio Products Group
2201 E. Dominguez Street
Long Beach CA 90801-5745
Telephone: (310) 639-5300
Price Class: $1,210

The Kenwood TS-60S

50 MHz all-mode transceiver.

When Kenwood introduced the TS-50S all-mode HF transceiver a year ago, there were a lot of justifiable "oohs" and "aahs" from the amateur radio world. The TS-50S is the smallest, lightest full-powered (100W output) all-band (160-10 meters) full-featured HF transceiver ever offered to the commercial market. A number of VHF enthusiasts proclaimed, "If only it covered 6 meters, I'd buy this rig in a minute!"

I don't know if Kenwood ever considered trying to add 6 meters to the TS-50S, but they did come up with another solution: the TS-60S, which is the same size and has the same features as the TS-50S, but covers the 6 meter amateur band only. The TS-60S is priced at $1,209.95 (suggested list price), so not every 6 meter user will run out to buy one, but the rig is special in a variety of ways that may make it a good deal for VHFers. And its only serious competition, the Icom IC275H (similarly rated and featured, but covering both 6 and 10 meters), costs even more at $2,021 (suggested list price).

Having been active on 50 MHz since 1966 (Egad! 28 years now!) and having "grown up" with 6 meters from the AM days to SSB and FM repeaters, I feel particularly qualified to review equipment for this band. Already owning lots of 6 meter gear and not wishing to shell out over a kilobuck on an experiment, I was among those who didn't rush right out to buy a TS-60S, but a friend of mine, Chuck Armstrong KD6EQW, did. In fact, when he went to buy one, there was exactly one TS-60S in the entire country that he could find for sale from a distributor, so he bought it immediately, before it disappeared. In speaking with Jon KA6ZBI, the manager of the local HRO store (who is also a 6 meter enthusiast), I found that the rig is so popular he literally can't keep any in stock. This review is based on Chuck's radio, having serial number tag #60100237 (maybe the 237th one ever built?), purchased new in June 1994.

The Rig

The TS-60S is a rugged-looking piece of gear. With few front-panel controls, it appears deceivingly simple, but this is a very sophisticated radio that holds its own with the best equipment ever used on 6 meters. Despite its miniscule (7" x 2-3/8" x 9-5/32", WxHxD) dimensions and tiny exterior heat sink, it is also a powerful radio, rated at 90 watts output power (SSB, CW, FM; 20W on AM). Most of the transmitter's power amplifier heat sink is inside the radio, and is fan-cooled with a thermostatic control that maintains a safe PA temperature at maximum output power. For FM users, the TS-60S features 100 memories—more than anyone could ever need—and standard "PL" CTCSS tones. Programming repeater channels uses the two VFOs and any frequency split is accommodated, from zero offset (simplex) to 4 MHz input/output spacing.

Operation

When you first power up the TS-60S, its display greets you with a friendly "HELLO." The ON/OFF switch has about a one-second delay, preventing accidental punches of the "OFF" button from turning the radio off. The receiver is sensitive, selective and reasonably immune to overload (see Note 1). Because of its diminutive size, input/output jacks are all either RCA "phono" type (ALC and RELAY) or 3.5mm "mini" phone type (PHONES, KEY, EXT SPEAKER), although the microphone jack is the standard-sized Kenwood eight-pin, which will accommodate a variety of Kenwood microphones. The normally-supplied hand-held PTT mike is the MC47, which features both "UP/DOWN" buttons and four programmable priority functions. The supplied microphone sounds excellent on the air and received rave reviews on both SSB and FM from the stations contacted.

Three things initially bothered me about the TS-60S: One, the "fuzzy logic" VFO tuning speed control system, which makes the rig tune faster as you turn the VFO knob faster; two, the lack of a panel-mounted transmitter power output level control; and three, the lack of a panel-mounted mike gain control. I'm not used to radios having variable-rate tuning, and it does take some getting used to. When the dial-drag lever on the TS-60S (located immediately below the VFO main tuning knob) is switched to the "minimum drag" position, it is possible to "spin" the dial across the band. Doing so makes the VFO change frequency very rapidly, much faster than you would think after turning the knob slowly. However, I'll admit it only took me a few minutes to become accustomed to the variable-rate tuning system and, after this initiation period, I liked it.

Photo A. The Kenwood TS-60S all-mode transceiver.

Although I like continuously-variable power output controls on my rigs, it isn't much of a selling point for 6 meter equipment. Most 6 meter users will run the radio "wide open" at full output 99% of the time anyway, as there's no special place in heaven for 6 meter QRPers. (The rig does have three power output levels, controlled by the operating menu, which is easy to get used to.) The "continuous" output control is more useful on HF, and this is a VHF radio. The only time I might want more output level control is when operating at a Field Day station, where there's a special multiplier for stations running 5 watts output power—the TS-60S can only "QRP" down to 10 watts. Oh, well. The Japanese engineers who designed this radio probably aren't aware of U.S. Field Day rules.

The lack of a panel-mounted mike

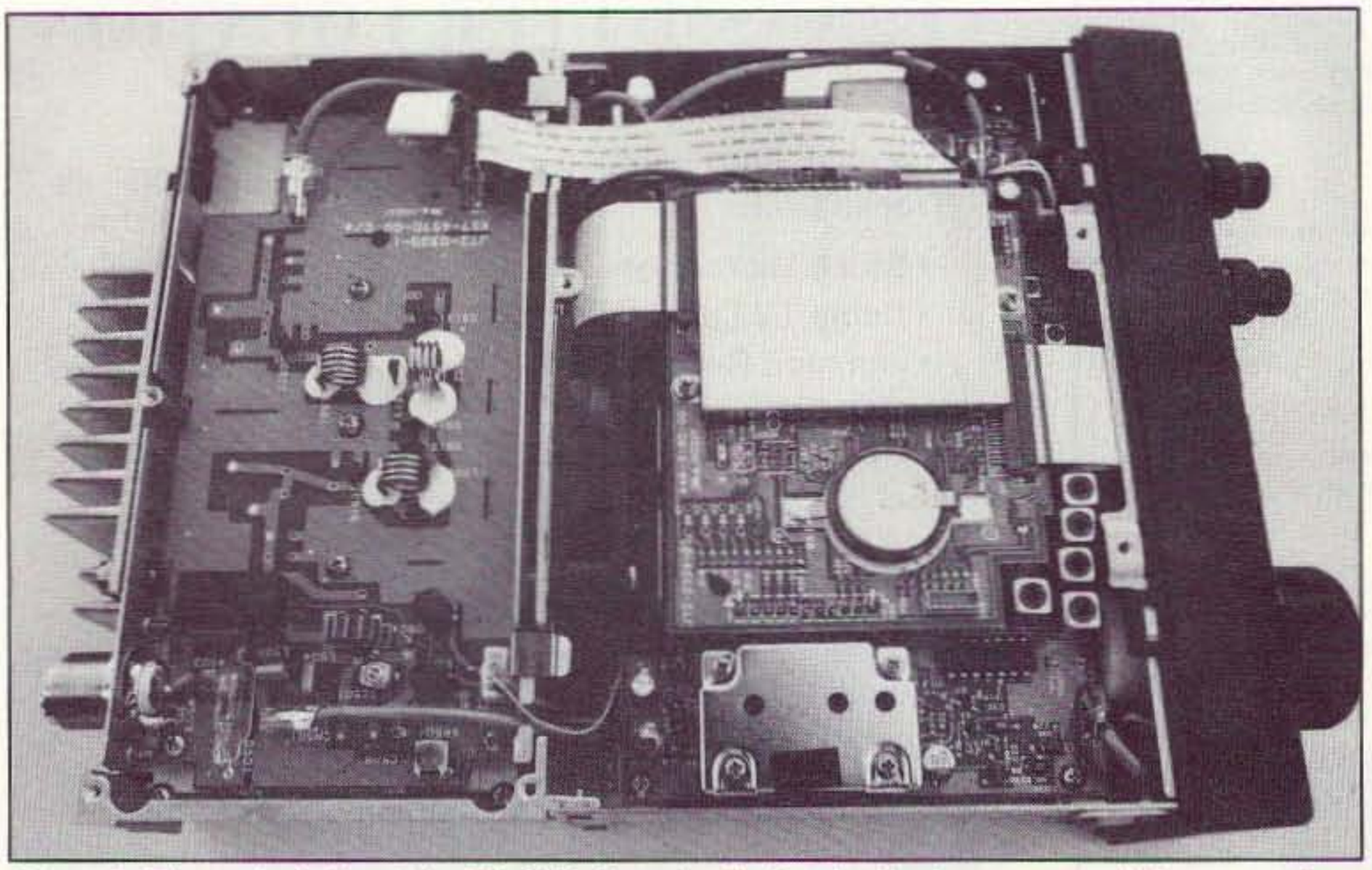

Photo B. The underbelly of the TS-60S. Note the fan's edge in the center, and the output low-pass filter and antenna T/R relay on the output board. The shiny round thing is a 3V battery used for memory backup.

gain control still bothers me a bit. There is a mike gain control, as well as an FM deviation level control, located inside the TS-60S, but you have to remove the top or bottom cover (depending on which one you want to adjust) to make any changes. Considering the variations in operators' voices, this wasn't a great idea; however, one of the 40 menu-addressable functions is "microphone gain High or Low," selected as #66 on "Menu B." Making adjustments using the menus sounds far more difficult than it is. It's so easy, in fact, that once I read the simple description of how to do it, I never had to refer back to the 59-page instruction manual again. That is, except to refer to the "Menu Number" and "Description" of each function, which would be almost impossible to memorize.

Since the TS-60S front panel contains only 24 knobs, controls and switches (a small number compared to most base-station radios nowadays!), only those which must be frequently adjusted are placed there. Obviously, the on/off (POWER) switch, volume (AF) control, squelch (SQL), tuning dial and mode switches (SSB/CW on one button and FM/AM on another) will be most often used. In addition, the TS-60S has panel-mounted receiver incremental tuning (RIT) and IF SHIFT controls, plus switches for its noise blanker (NB), advanced intercept point system and receiver attenuator (AIP/ATT), changing between the two VFOs (A/B), splitting the VFOs (SPLIT), setting the two VFOs to the same frequency (A=B), locking the frequency (F.LOCK), stepping the frequency in MHz increments (MHz), buttons to control both frequency and scanning direction, and menu items (DOWN and UP) activate the scanner (SCAN), entering data to memory (M.IN), entering memory data to the VFO (M>V), switching between memory and VFO modes (M/V), and clearing an operation such as a menu address (CLR). Some of these switches will be infrequently used, except in initial setup, but need to be on the panel to avoid confusion from having to address multiple menu items simultaneously.

The panel switches with more than one label "toggle" between two functions. An example is the AIP/ATT switch which, when first depressed, activates the AIP feature (to prevent receiver overload in strong-signal environments). When depressed again, the same switch activates the attenuator. When depressed a third time, it activates both AIP and ATT. When depressed a fourth time, it turns AIP and ATT off, clearing the system and returning back to normal full-sensitivity receiver operation. Maybe Japan has a lot of 6 meter operators in a small area; I cannot envision ever needing the AIP or ATT here, since the strongest signals I could find did not overload this receiver, anyway.

Menu Functions

Depressing the MENU button clears the frequency display and addresses either MENU A or MENU B, selectable with the front-panel A/B switch (also used to switch between the VFOs). You then spin the main tuning knob to the menu item you want, which is indicated on the left-hand side of the main display panel, then use the UP and DOWN buttons to toggle the features of that menu item. As stated earlier, this sounds more complicated than it is.

For example: Say you want to switch from full power (the default setting) to the QRP 10-watt output level. Press the MENU button, then the A/B button, until the letter "A" appears in the main display, then spin the tuning knob until menu number "00" appears on the left-hand side under the word "MENU." Menu item "00" is the power setting. Push the DOWN button twice, and you'll see the display go from 100 to 50 to 10, indicating you're now set at 10 watts output power. Then push either the MENU button again, or the CLR button, and the radio reverts to normal operation, but now at the 10W power level. This all takes about two seconds—not difficult at all. If you want to program a "PL" tone for repeater operation, you'd depress MENU, then "B," then turn the tuning control to bring up menu item #53, then depress either UP or DOWN to arrive at the right tone frequency (the PL tone frequencies are displayed directly in Hz), then either MENU or CLR, and you're done. I wouldn't do this "on the fly," while driving down the freeway at 55 mph, but it's easy to do while parked, or on the bench at home. Besides these two MENU functions there are 38 others, some of which are almost silly.

Silly menu functions: Five levels of adjustable display brightness (!); CW keying delay adjustable from full QSK (no delay) to 1.8 seconds delay (a real long time) in 10 increments; RIT range (two increments); automatic power off function (turns radio off after a period of non-use); three separate menu items to adjust the beep tones the rig emits when functioning controls; etc. Who cares? But the TS-60S has all these, and many more useful functions as well.

One neat thing about the rig and its MC47 microphone is the ability to program the mike's four "priority" buttons to perform any of 26 functions, all menu-addressable. You could, for example, program the rig so that one of the priority keys controls the rig's output power, and another one controls its mike gain (from High to Low, anyway), thus almost overcoming my initial objections to these items not being on the front panel.

The Manual

The TS-60S instruction manual is typically-Kenwood excellent, with clear, concise explanations of all controls and functions. However, it completely lacks any circuit description and leaves the owner wondering what the heck's inside the rig. There is a two-page "Troubleshooting" guide, but it only points out what should be obvious operator errors and gives no clues about what to do if something in the radio actually fails. I'd really like to see detailed circuit descriptions (e.g., "The received signal passes though a nine-section bandpass filter and is fed to the first RF amplifier, a 40673 MOSFET, before reaching the first RF mixer, a doubly-balanced set of 5082-2800 hot-carrier diodes having an LO injection level of +13 dBm at 70 MHz," or whatever). In the old days, most equipment manuals contained such descriptions, and they helped explain how the rig really worked and helped the user read through the schematic diagram and make sense of the circuitry.

Circuitry

The rig comes complete with schematic diagrams, a set of four-page fan-folded dual-sided sheets that appear complete enough for me to offer this abbreviated description:

The antenna feeds a low-pass filter always in series with the receiver, as well as a 40-60 MHz bandpass filter, and is relay-switched to either a pair of 2SK520 JFETs in parallel (presumably for a high intercept point) as an

RF preamp, or directly to the balanced JFET RF mixer (four 2SK520s), depending on whether the "AIP" circuit is in use or not. (The "AIP" circuit, when switched "ON," bypasses the RF preamplifier, using switching diodes.) The "ATT" (attenuator), if activated, is relay-switched. There is an intricate array of front-end protective components called a "lightning surge arrestor" circuit, which appears to be metal-oxide varistors in series with small-signal switching diodes to reduce the capacitance of the MOVs. This is a common approach and might help protect the JFETs against lightning transients. The local oscillator injection to the first RF mixer is provided by the PLL UNIT's output which tunes 113.045-133.045 MHz and produces a first IF at 73.045 MHz (this is called "upconverting"; that is, the first IF is at a higher frequency than the received signal input). The tuning range of the PLL is so broad because the TS-60S does feature a 40-60 MHz continuous-coverage receiver, although it can only transmit in the 50-53.999 MHz range.

The first IF is filtered by XF1, a crystal filter at 73.045 MHz, before the signal passes to the second mixer, another pair of 2SK520 JFETs; between the crystal filter and the second mixer is the first IF amplifier, a 3SK131 dual-gate MOSFET, which is AGC-controlled by bias applied to its second gate. This same stage also drives the receiver's NOISE BLANKER circuit, a common pulse-clipper type. The second mixer injection is at 62.35 MHz and also provided by the PLL UNIT, to produce a second IF at 10.695 MHz. This is the last conversion stage used for SSB/AM/CW. The second IF signal passes through either a 5 kHz bandpass filter for AM, or a 2.2 kHz bandpass filter for SSB/CW (or an optional, sharper CW filter), before being amplified by a 2SC2712 bipolar IF amplifier, whose output drives a hybrid integrated circuit product detector system using additional postamplification provided by a pair of 3SK131 MOSFETs and a balanced detector using a pair of HSM88AS diodes. The carrier injection to the product detector is a signal at 10.695 MHz provided by the PLL UNIT.

On FM, the receiver employs an additional conversion stage producing an IF of 455 kHz, standard in the FM industry. This last conversion stage uses an MC3372 integrated FM IF subsystem having its own local oscillator and a 12 kHz monolithic bandpass filter. Thus, on SSB/CW/AM the TS-60S is dual-conversion, while on FM it is triple-conversion. This makes a good deal of sense, considering the FM IF subsystem integration available today, which helps make FM receivers as simple as they are.

The transmitted SSB/CW/AM signal is generated by an integrated circuit balanced modulator, type uPC1037HA, which is audio-driven by the microphone preamplifiers, shaping circuits and a 2SC2712 bipolar buffer amplifier, and has carrier injection at 10.695 MHz provided by the PLL UNIT, the same source as used for product detection in the receiver. The output of the balanced modulator is diode-switched to the same set of bandpass (crystal) filters used in the receiver's second IF, then buffered by another 3SK131 MOSFET which has ALC control by bias to its second gate, before passing to the first transmitter mixer, a pair of 3SK131s having an L.O. injection at 62.35 MHz provided by the PLL UNIT. The mixer's output is bandpass filtered and mixed again by another balanced mixer using a pair of 3SK184 dual-gate MOSFETs having an injection at 123.045-127.045 MHz, again provided by the PLL UNIT. The second transmitter mixer's output at 50-54 MHz is bandpass filtered, buffered by a 2SC2954 bipolar transistor and then fed to the FINAL UNIT for additional amplification.

The FINAL UNIT consists of a "predriver," type 2SC1971, a "drive amp," a pair of push-pull 2SC1972s, and then the "final amp," a pair of push-pull MRF492s or 2SC2879s. (Depending on where you look in the schematics, both part types are called out.) The final's output signal passes through a 54 MHz low-pass filter before reaching the SWR protection circuit and antenna relay. The FINAL UNIT also contains a sophisticated temperature control system which drives the internal heat sink cooling fan. In fact, the comparator circuit which supplies signals to the fan motor drive transistors (three type DTD114EK bipolars) has three separate outputs to drive the fan at progressively higher speeds as the heat sink reaches higher temperatures! Speaking of fans, the one in the TS-60S kicks into operation after only 15 to 20 seconds keydown time at full power. If you transmit longer, the fan speeds up. When operating at full power for any length of time, the fan reaches maximum velocity and creates an audible noise level that might be distracting if the operator doesn't use headphones.

Obviously, this circuit description is an abbreviated overview and doesn't go into much detail, but it offers the technical readers some feel for the rig's circuitry. I enjoy perusing schematic diagrams, taking tips from the "pros" on circuit design. I was gratified that the TS-60S uses discrete, rather than integrated, final output transistors (cheap, easy to replace), and a push-pull output circuit which should practically eliminate any second-harmonic output, leaving only the third harmonic to filter (a much easier task, since it's so far away from the desired frequency).

Table 1.
TS-60S Measurements Taken

Transmitter output power into a 50-ohm load, 13.8 VDC supply:

SSB (peak)/CW/FM		HI 95W	MED 44W	LO 10W
AM		HI 20W	MED 15W	LO 5W

Receiver sensitivity, closed 50-ohm system:

SSB/CW	MDS	<-130	dBm	(<.07 µV)
	10 dB S+N/N	-117.5	dBm	(0.3 µV)
	"S1"	-107	dBm	(1.0 µV)
	"S3"	-104	dBm	(1.4 µV)
	"S5"	-98.5	dBm	(2.6 µV)
	"S7"	-89.5	dBm	(7.5 µV)
	"S9"	-77.5	dBm	(30 µV)
	"+20 dB"	-57	dBm	(300 µV)
	"+40 dB"	-37	dBm	(3.2 mV)
	"+60 dB"	-20	dBm	(23 mV)
	IF BW	2.19	kHz	@ -6 dB
FM	Sqlch threshold	-125	dBm	(.13 µV)
	20 dB NQ	-112	dBm	(0.6 µV)
	"DFQ"	-92	dBm	(6 µV)
	"S1"	-113	dBm	(.5 µV)
	"S3"	-110	dBm	(.7 µV)
	"S5"	-108	dBm	(.9 µV)
	"S7"	-105	dBm	(1.2 µV)
	"S9"	-102	dBm	(1.8 µV)
	"+20 dB"	-97	dBm	(3.1 µV)
	"+40 dB"	-94	dBm	(4.5 µV)
	"+60 dB"	-92	dBm	(6 µV)
	IF BW	5.05	kHz	@ - 6 dB

Blocking dynamic range: Approx 105 dB

Features and Options

The TS-60S comes with a 6-1/2-foot-long DC power cable fused in both leads, using automotive-style cartridge fuses which are inexpensive and readily available (hooray!). It also comes with a mounting bracket, although a better one, model MB-13 (list price $47.95), is available. Other options include a matching heavy-duty AC power supply, model PS53 ($249.95); a high-stability temperature-compensated crystal oscillator reference for the frequency synthesizer, model SO-2 ($179.95); a narrow CW filter, YK-107C ($109.95); a variety of desk-stand microphones (MC60A dynamic $149.95; MC80 electret $104.95; MC85 multiple-output electret with compression control and meter $159.95), and other lesser-used items. I wouldn't buy an accessory speaker for the rig, as its internal top-mounted speaker is loud and sounds great. Unfortunately, the optional CW filter and TCXO are both solder-in, not plug-in, accessories. Oh, well.

The TS-60S "S" meter and power output level meter are of the "bar graph" variety and are quite useful. The bar graph power output level display reads "0 to 10," and provides only relative output power indications. For example, on the unit tested, a display reading of "1" corresponded to 5 watts output; "2" was 10W; about "2.5" was 15W; about "4.5" was 20W; a bit over "7" was 42W; and "10" was full power, which in this case was 95W or so. I was able to achieve all these different output levels by using the menu-driven power output level control and by switching modes between CW and AM (AM always runs less power than CW/FM, regardless of the control setting).

The bar graph S-meter is quite good on SSB/CW and pretty useless on FM, as is the case with most multimode transceivers I've seen. While the receiver's MDS (minimum discernible signal) on SSB/CW was less than -130 dBm (under 0.1 µV), the S-meter doesn't indicate anything until about -107 dBm (1 µV) signal is applied to the antenna jack. Above this signal strength, the meter is surprisingly good. An "S9" signal was 30 µV; "+20 dB/S9" was 300 µV (exactly a 20 dB

change); "+40 dB" was 3.2 mV (again, a 20 dB change); and "+60 dB" was 23 mV (a 17 dB change). As S-meters go, this one is pretty accurate. On FM, all bets are off. "S1" required -113 dBm (0.5 μV), but "S9" was only -102 dBm (1.8 μV), a change of only 11 dB for an indicated 8 "S" points difference (which should be 48 dB or so). On FM, the meter indicating "+20 dB" only required -97 dBm (5 dB more than "S9"), and "+40 dB" required -94 dBm (only 3 dB more than "+20"). S-meter accuracy can be useful (even on FM) for beam steering.

The receiver in the TS-60S is top-notch. Not only did I make bench measurements using a lab-standard signal generator, but I compared the rig with my much more expensive Yaesu FT-736R and its 6 meter module. Results? The little TS-60S held its own very well against the full-sized, base-station FT-736R. There was almost no measurable difference in sensitivity between the two, and extremely weak signals tuned in on both sounded about the same. (I used the XE2UZL beacon in Mexico, which operates around the clock on 50.027 MHz, as a QSB-free standard. When I turn my beam to null this beacon, it becomes a very steady, unwavering weak signal, just above the noise. It's a great reference signal!) The IF filtering in the TS-60S is certainly adequate (rated 2.2 kHz/-6 dB for the SSB filter; measured at 2.189 kHz/-6 dB), but more amazing is the receiver's ability to resist desensitization from strong off-channel signals.

The Author's Experience

I ran this test: I nulled the XE2UZL beacon until it was almost in the noise, registering "S0" on the meter, and barely detectable. Then I introduced a signal offset by 10 kHz, at 50.037 MHz, from my signal generator, essentially in parallel with the antenna connection. I had to adjust the generator's level to -24 dBm, or about 12 millivolts, before I could detect any change in level on the weak beacon. This is a difference in signal strength of more than 105 dB, and the 12 millivolt signal is far stronger than any I've ever come across on the air, including from stations operating only a few miles away. Older-generation 6 meter receivers were never this good.)

The receiver is also almost free of internally-generated spurious signals. The "other side" of the IF filter "shadow" signals are greatly attenuated, and any very strong signals occurring outside the IF passband can likely be rejected further with the IF SHIFT tuning control, which works well.

OK, already: How does it play on the air? Like a champ! As I mentioned, I borrowed the radio for this review. After playing with it for one day, I really didn't want to give it back. But I had to—this was written right in the middle of the peak sporadic-E season (June) and the rig's owner, KD6EQW, was chomping at the bit to get back on the air. Chuck uses a Diamond DP-GH62 collinear vertical base station antenna (vertically polarized, 21' tall, 6 dB rated gain) at about 25' above ground with the TS-60S and has already had a ball with it, working E-skip all over the country with this nominal antenna. He intends to also use it mobile, with either a Larson 5/8-wave 2 meter whip (surprise—these work just fine as a 1/4-wave on six) or an M-Squared "Sqloop" horizontal, omnidirectional antenna on his truck, and should have some great fun doing so.

Two caveats are worth mentioning: First, if you are measuring your vehicle for determining where and how to mount the TS-60S before actually buying one, be aware that Kenwood's published dimensions need clarification. Its "depth" specification is 233mm, which corresponds to about 9-5/32"; however, the rig is really 10-5/8" deep, if measured from the main tuning knob to the rear heat-sink fins. Only the case measures 233mm, but you'll need more space than this for the rig. Second, on the remote chance you'll be using the rig for AM work (as opposed to SSB), be advised this is not a great-sounding AM rig. Like most SSB radios using "low-level" modulation for full-carrier AM, power output for AM work must be substantially reduced from the SSB peak value, and even then, modulation is anything but "broadcast quality." The TS-60S, like many SSB rigs used on AM, produces "downwards modulation," meaning its output power actually drops down on modulation voice peaks. This is remedied to some degree by using the rig in the "medium" or "low" power settings, where it runs 15W or 5W output, rather than the full 20W produced in the "high" setting. Frankly, there's not much AM activity on 6, and if that's all you want a rig to do, a less expensive choice would be an old Gonset G50, Clegg Thor-VI, or some similar—if ancient—high-level modulated AM rig.

Six meters is a great band. It offers a combination of VHF tropospheric and HF ionospheric propagation and might be the only amateur band capable of producing strong-signal contacts from local, direct-wave to 10,000-mile F2-layer DX contacts, with lots of useful propagation in between. WAS, WAC, DXCC are all possible on 6 meters, and maybe WAZ will be someday, too, with increased activity and the return of a solar cycle peak. Best sporadic-E "skip" conditions occur at the beginning of the summer and winter seasons, but the band is known for producing lots of "E-skip" all through the months of June and July (in the northern hemisphere). There's bound to be local FM simplex and repeater activity, too, in most parts of the country. The TS-60S combines a good receiver with a powerful enough transmitter to work most anything right out of the box, and it provides an amplifier keying circuit to interface with an outboard high-powered amp for serious QRO (high powered) work. There are a variety of power amplifiers now on the market, both solid-state and tube type, as well as some excellent 6 meter antennas, to compliment the TS-60S as a serious base station for 50 MHz enthusiasts. 73