Product Review and Short Takes from *QST* Magazine

April 2005

Product Reviews:

Short Takes:

PRODUCT REVIEW

SDR-1000 Software-Defined HF/VHF Transceiver

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QST Editor

The debut of the FlexRadio SDR-1000 opens a new chapter in the history of Amateur Radio. I'm not indulging in hyperbole by making such a statement—it is a fact. For the first time in ham history, you can purchase "off the shelf" an HF and 6 meter transceiver that uses software to define its functionality—a *software-defined* radio.

What does this mean? Is the SDR-1000 just a software product?

Not necessarily. The SDR-1000 most definitely has hardware. If you purchase what I like to call the "full Monty" version of the SDR-1000 with the 100 W PEP RF amplifier and RF expansion board, you are presented with nondescript $10\times8\frac{1}{2}\times4$ inch black box. On the front of the box there is an ON/OFF rocker switch, a four-pin microphone connector and a cooling fan. On the back, you'll find ports for computer connections, dc power and, of course, an antenna.

Inside the box there are a few circuit boards, as shown in Figure 1, but they are not populated in the manner you may be accustomed to seeing in a "traditional" transceiver. The receiver is an advanced direct-conversion design using direct digital synthesis. It converts RF directly to audio. Separate in-phase and quadrature signals are then fed to the computer sound card for digital signal processing using an innovative in-phase and quadrature (*I and Q*) image-reject approach. The connectors are provided on the rear panel as shown in Figure 2.

For transmitting, the SDR-1000 hardware is designed to take processed audio from the sound card and convert it to RF. In the case of the SDR-1000, used in this review, the transmit conversion includes boosting the RF to 100 W on 160 through 10 meters.

It's quickly apparent that the true heart of the SDR-1000 transceiver is *not* within the black box. *Data* is the lifeblood of this radio; the hardware is just a portal between the analog and digital worlds. To invoke a different metaphor, the SDR-1000 hardware is like unformed clay on the potter's wheel, waiting for the hands of the artist to shape it into something meaningful.

The artist—and the artistry—is in the software that runs on your computer. The SDR-1000 software—known as *PowerSDR*—determines how a received signal will be demodulated. It also creates the transmitted signal according to the mode you wish to operate. Therefore, the SDR-1000 is a software-defined radio in the most literal sense of the term.

Don't confuse the SDR-1000 with microprocessor controlled radios that offer updateable firmware. The changes imple-

Bottom Line

The SDR-1000 may mark the beginning of a new generation of Amateur Radio equipment, but the pioneers who take it up may need a bit of frontier spirit!

Figure 1—A look inside the SDR-1000 transceiver.

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mented by a firmware update are limited in scope because the inflexible hardware defines (and constrains) what can be done with the radio. In the SDR-1000, the software *is* the radio to the greatest extent possible. When you modify the software in a software-defined radio, you can make very large changes indeed.

How Large?

How about adding a new operating mode? Or totally revamping the digital signal processing (DSP) functions? Or designing a completely new "front panel" monitor display? Depending on the nature of the change, you could install new software and suddenly have a very different transceiver.

And unlike firmware-based transceivers, the SDR-1000 software architecture is completely open. This means that anyone with enough computer savvy can modify the software (and, hence, the radio) to suit their individual needs. It also means that hams throughout the world can pool their collective genius and create new software for the SDR-1000. So rather than a static box full of hardware, the SDR-1000 will evolve through the years as clever hams take up the "clay" and create new works of engineering art.

With the evolving nature of software in mind, I should point out that this is a review of the SDR-1000 as it existed in late January 2005. By the time you read this, it is certain that the software will have changed with the addition of even more features and improvements.

Also, it is important to note that our review was conducted with *Windows*-based PCs because, at the time of the review, the SDR-1000 software was only available for *Windows 2000* and *XP* systems. However, a *Linux* version is in the works for later this year.

The Critical Sound Card and PC

The sound card is the engine that enables the SDR-1000. In particular, the dynamic range and distortion performance of the SDR-1000 is *directly* related to the quality of the sound card. At the time of this writing, FlexRadio Systems officially supported only the SoundBlaster Audigy2 ZS, Audigy2, Extigy, MP3+ and the Turtle Beach Santa Cruz sound cards. This is not to say that other sound cards cannot be used, but the radio may not perform as specified. And if you run into trouble with a non-supported card, FlexRadio may not be able to help you.

In addition, not all sound cards have the separate line input, line output and microphone jacks necessary to work with the SDR-1000. They may also lack mixer controls with independent level adjustments for the line input and microphone input.

Table 1
FlexRadio SDR-1000, amplifier serial number 0445-058

Manufacturer's Specifications	***Measured in ARRL Lab***
Frequency coverage: Receive, 0.01-65 MHz; transmit, 1.8-2, 3.5-4, 5.33-5.4, 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.[1]	Receive and transmit, as specified.
Power requirement: Receive, 1.0 A max; transmit, 25 A (max).	Receive, 0.9 A; transmit, 15 A.[2] Tested at 13.8 V.
Modes of operation: SSB, CW, AM, FM.	As specified.
Receiver	***Receiver Dynamic Testing***
CW sensitivity, 500 Hz bandwidth, 26 dB INA setting: –141 dBm.[3]	Noise floor (MDS), 500 Hz filter: *Preamp off* / *Preamp on* 3.5 MHz: –127 dBm / –134 dBm 14 MHz: –127 dBm / –134 dBm
AM sensitivity, 10 dB S/N, 30% modulation: Not specified.	10 dB (S+N)/N, 1 kHz tone: *Preamp off* / *Preamp on* 3.8 MHz: 6.8 µV / 0.68 µV
FM sensitivity, 12 dB SINAD: Not specified.	For 12 dB SINAD: *Preamp off* / *Preamp on* 29 MHz: 2.5 µV / 0.66 µV
Blocking dynamic range: Not specified.	Blocking dynamic range, 500 Hz filter: Spacing: 20 kHz / 5 kHz *Preamp off/on* / *Preamp off/on* 3.5 MHz: 93/90 dB / 93/90 dB 14 MHz: 93/90 dB / 93/90 dB
Two-tone, third-order IMD dynamic range, 500 Hz filter, 90 dB:	Spacing: 20 kHz / 5 kHz *Preamp off/on* / *Preamp off/on* 3.5 MHz: 87/82 dB / 86/82 dB 14 MHz: 87/85 dB / 86/84 dB
Third-order intercept: Not specified.	Spacing: 20 kHz / 5 kHz *Preamp off/on* / *Preamp off/on* 3.5 MHz: –4/–5 dBm / –4/–5 dBm 14 MHz: 0/–3 dBm / –1/–5 dBm
Second-order intercept: Not specified.	Preamp off/on, +69/+62 dBm.
FM adjacent channel rejection: Not specified.	20 kHz channel spacing, preamp on: 29 MHz, 37 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz channel spacing, preamp on: 29 MHz, 37 dB.*
S-meter sensitivity: Not specified.	S9 signal at 14.2 MHz: See Note 3.

These sound-card feature requirements spell trouble for laptop users. Most laptops offer only a microphone input and a headphone output. The good news is that it is possible to use an external USB sound device such as the SoundBlaster Extigy or MP3+.

In addition to a quality sound card, you'll need a quality (read: "fast") PC. The minimum requirement for the SDR-1000 is an 800 MHz Pentium computer. In our tests, an 800 MHz system was *just* adequate. Stepping up to a machine with a clock speed greater than 1 GHz makes a

Figure 2—The rear panel of the SDR-1000.

Manufacturer's Specifications	Measured in ARRL Lab
Squelch sensitivity: Not specified.	At threshold, preamp on: SSB, 14 MHz, 5.0 μV; FM, 29 MHz, N/A.
Receiver audio output: Not specified.	See Note 4.
IF/audio response: Not specified.	Range at –6 dB points, (bandwidth): CW (500 Hz filter): 460-935 Hz (475 Hz); USB: 211-2816 Hz (2605 Hz); LSB: 213-2778 Hz (2565 Hz); AM: 2-5980 Hz (5978 Hz).
IF and image rejection: Not specified.	First IF rejection, 14 MHz, 116 dB; image rejection, 14 MHz, 56 dB.
Transmitter	***Transmitter Dynamic Testing***
Power output: SSB, CW, FM, 100 W high, low, not specified; AM, not specified.	CW, SSB, FM, typ 100 W high, <1 W low; AM (carrier), typ 25 W high, <1 W low.
Spurious and harmonic suppression: Not specified.	47 dB; meets FCC requirements.
SSB carrier suppression: Not specified.	70 dB.
Undesired sideband suppression: Not specified.	70 dB.
Third-order intermodulation distortion (IMD) products: Not specified.	See Figure 5.
CW keyer speed range: Not specified.	0 to 54 WPM.[5]
CW keying characteristics: Not specified.	See Figure 6.[5]
Transmit-receive turn-around time (PTT release to 50% audio output): <20 ms.	S9 signal, 25 ms.
Receive-transmit turnaround time (tx delay): Not specified.	SSB, 150 ms; FM, 150 ms. Unit is not suitable for digital modes.[5]
Composite transmitted noise: Not specified.	See Figure 7.

Size (height, width, depth): 4"×10"×8.5"; weight, 6 pounds.

*Measurement was noise-limited at the value indicated.
[1]100 W operation on HF bands only. Pre-selector required below 1.8 MHz.
[2]Current consumption higher on 160 meters (see text).
[3]Dependent on software calibration. Once calibrated (see XG-1 review for possible calibrator), the S-meter is relatively accurate.
[4]Dependent on PC sound card (SDR speaker output requires amplified speakers).
[5]Dependent on PC (see text).

substantial difference (it also allows you to tweak the SDR-1000's software CW keyer to function above 15 WPM). For my on-air tests, I used a 2.4 GHz system.

The SDR-1000 requires a connection to the computer's parallel (printer) port for all the control lines going to and from the transceiver hardware. For most desktop PCs this isn't an issue, but you'll need a 25 pin straight-through male-to-male computer cable, which isn't a common animal these days. Fortunately, FlexRadio sells the cable if you can't find it at your favorite dealer.

If your computer has two parallel ports, you're in luck. You can connect your printer to one port and the SDR-1000 to the other. My computer is limited to a single parallel port, so I found that I had to unplug my printer and plug in the SDR-1000 whenever I wanted to get on the air. For a permanent installation, I'd need to install an A/B switch.

The SDR-1000 provides a port on the rear panel for receive audio, but it isn't intended to drive a speaker directly. Instead, you must feed the audio to an amplifier, or a so-called "amplified speaker" (a speaker with an amplifier built in). For this review, I used an amplifier to drive two large station speakers.

Installation

The SDR-1000 manual isn't printed; you must download it as a PDF file from the FlexRadio Web site and print it yourself. At well over 100 pages, this can consume a considerable amount of paper and printer ink (or toner). My solution was to view the manual on my monitor and print only the pages that I knew I'd need to refer to repeatedly during the setup.

Fortunately, the hardware installation is straightforward. You connect the parallel cable between the radio and the computer. Three audio cables connect between the rear of the SDR-1000 and the LINE IN, LINE OUT and MIC IN ports on your sound card. The leads from the 13.8 V dc power supply (not included) connect to terminals on the SDR-1000 rear panel. Finally, your antenna system coaxial cable attaches to the SDR-1000's BNC output connector.

The True Challenge Begins when you Install the Software

My first step was to download the latest version of *PowerSDR* from the FlexRadio Web site. The file is less than 1 MB in size, so that step went quickly. When I ran the setup program to install the software, however, it came to an immediate halt and informed me that I didn't have the Microsoft *.Net Framework* installed on my PC. Oops!

I jumped to the Microsoft Web site and downloaded *.Net*. That's a 23 MB file. With my broadband connection I had the file within a few minutes. A dial-up user may need an hour or longer.

Okay, so *.Net* is installed and we're ready for action. The *PowerSDR* setup runs and uses a "wizard" to lead you through each step. My sound card is a Turtle Beach Santa Cruz and it appeared on a drop-down menu during the setup process.

Unfortunately, the setup wizard discovered that I didn't have an ASIO (Audio Stream Input Output) driver installed. An ASIO driver offers lower latency and higher bit depths. That's critical to getting maximum performance from the SDR-1000. However, many sound cards—including my Santa Cruz—do not come with native ASIO drivers. That revelation entailed another trip to the Web to grab *ASIO4ALL*, a piece of free software that allows your sound card to achieve "near-ASIO performance" (according to the SDR-1000 manual). With the ASIO driver installed, I assumed I was good to go.

I fired up the *PowerSDR* console software and clicked my mouse on the POWER button. Relays clicked and the SDR-1000 came to life…sort of. I saw quivering lines on the spectrum display, but heard nothing coherent in the speaker. Now what?

I rechecked all the cables and the *PowerSDR* console settings. Thirty minutes later I was about to unfurl the surrender flag when I spied the *ASIO4ALL* driver icon on my *Windows* desktop. I double clicked on the *ASIO4ALL* icon and found a menu that asked me to choose between my Turtle Beach sound card and my ATI video capture card. Ah-hah! The ATI capture card had been automatically selected by *ASIO4ALL*, *not* my Santa Cruz. I changed the selection to the Santa Cruz and instantly heard 40 meter SSB audio in my speaker.

Now I had signals. Boy, did I have signals! The S-meter was pegged and the quivering lines were bouncing off the top of the spectrum window. Clearly, some-

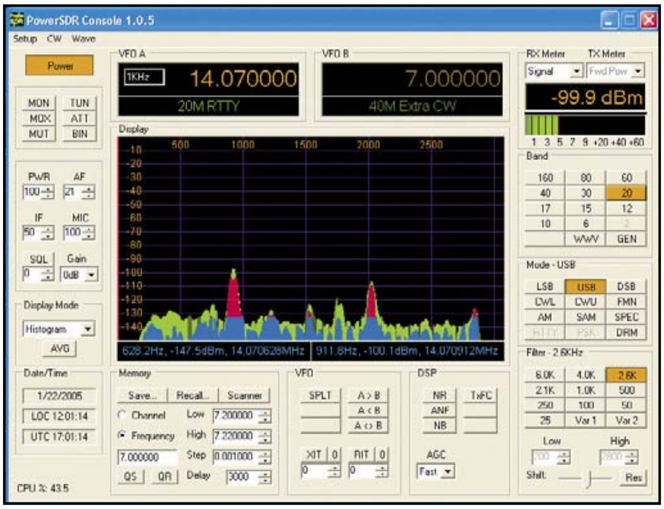


Figure 3—A histogram view of PSK31 activity on 20 meters.

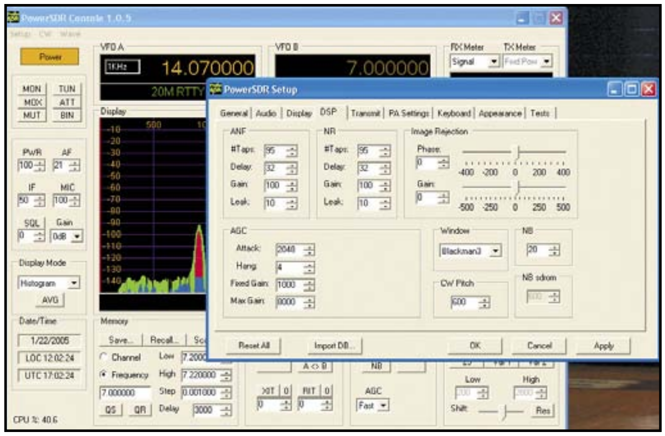


Figure 4—One of nine *PowerSDR* setup screens. This one can be used to tweak the performance of several DSP options, as well as the AGC.

thing was still not right. It was time to calibrate the receiver.

There are three receiver calibration steps: frequency, signal level and image null. Frequency calibration was relatively easy. I tuned in a strong WWV signal on 15 MHz and clicked the START button. Seconds later the SDR-1000 was frequency calibrated.

According to the manual, the signal-level calibration procedure requires an external signal source such as the Elecraft XG1 for best results. Not having an Elecraft XG1 at hand, I had to use the alternative procedure: Remove the antenna and set the calibration level at –110 dB. I clicked START and within 20 seconds the *PowerSDR* software measured the no-antenna noise level and calibrated itself accordingly.

The final step would be the image null calibration to compensate for phase and amplitude imbalances on the I and Q signal lines, but that requires a high quality signal generator or a separate transmitter with a dummy load. Having neither, I was forced to skip that step.

When I reconnected the antenna, I was rewarded with signals at realistic levels. The spectrum display looked great (see Figure 3) and the S meter was responding appropriately.

Listening

The SDR-1000 offers several modes, with more to come as the software evolves. The software version used for this review (1.0.5) included SSB, CW, AM, FM and DRM (Digital Radio Mondiale). The receive frequency range extends well below 160 meters, but FlexRadio recommends an outboard preselector if you choose to plumb those depths. There are also optional filter slots on the RF Expansion board that will likely help in this regard. Our SDR-1000 included the RF Expansion board, but not the optional filters.

The AUDIO FREQUENCY GAIN, INTERMEDIATE FREQUENCY GAIN, MICROPHONE GAIN, TRANSMISSION POWER and SQUELCH controls are all mouse selectable. You can enter specific values or click on the up/down arrows. The same is true for the receiver and transmitter incremental tuning (RIT and XIT).

Tuning the SDR-1000 is accomplished in one of several ways. I quickly discovered that my favorite method was to click my mouse on the frequency display and use the mouse wheel to move up or down the bands. The more direct method is to simply type the frequency into the display and press the ENTER key. You can also tune within the spectrum analyzer display. When you right click the mouse, a crosshair appears. Move the crosshair cursor to the signal of interest and left click to instantly tune the SDR-1000 to the signal.

If the idea of tuning with a keyboard or mouse makes you uncomfortable, FlexRadio offers a Griffin Powermate USB tuning knob. The USB knob works quite well, giving more of a "traditional radio" feel to the SDR-1000.

As you cruise the airwaves, you have your choice of various DSP-enhancing tools such as noise reduction, automatic notch filtering (to remove those annoying "tune up" signals) and a noise blanker. The characteristics of all three can be varied in the setup screen. For example, I found the default setting of the noise blanker to be a bit "weak," especially when my neighbor was using his power tools. It took just a few mouse clicks to increase the blanker performance to the point where the staccato pops ceased to be a problem. A typical setup screen in shown in Figure 4.

AGC is variable within several steps and you have the luxury of choosing a number of DSP filters, depending on the application. For instance, I found that the 2.6 kHz filter offered the best fidelity when listening to SSB, but when the going became rough, I'd switch to 2.1 kHz. When it *really* got rough, I clicked on one of the VAR (variable) filter buttons and "designed" my own filter on the fly. You simply drag the high and low frequency cutoff sliders until you achieve the filtering you desire. Under difficult SSB conditions I set up a 1.3 kHz filter—drastic and a bit odd sounding, but at least the QRM was kept at bay.

With the selectable and adjustable filters, you can narrow the window to a mere 25 Hz for extremely selective CW reception. This was a remarkable thing to behold—and even more remarkable to hear.

Speaking of CW, don't forget that two receive audio channels (I and Q) are available at the sound card. This means that you have the ability to select either one (referred to as U or L on the mode buttons), or listen to both in the binaural mode. Binaural CW reception is a strange experience, especially with headphones. The signals seem to float in space, shifting to right, center or left as you tune the radio. This odd effect comes in handy when you're trying to pick a signal out of a crowd (such as a DX pileup or a contest).

AM reception was pleasant with excellent fidelity. The *PowerSDR* software also provides a synchronous AM (SAM) detector, a feature that is only found on high-end receivers. In the SAM mode, the SDR-1000 replaces the varying carrier from the transmitting station with its own internally generated carrier. The result is astonishing if you've never heard it before. SAM is such a rare treat for me, I spent most of an evening just tuning through the shortwave broadcast bands. SAM even makes music listenable.

Listening to DRM requires additional software, which I did not have available. Proprietary DRM software must be downloaded from the DRM Software

Project following purchase of a license at **www.drmrx.org**.

And what software radio would be complete without a signal database? *PowerSDR* offers a *big* database capable of holding all your favorite frequencies and modes, along with call signs and other information. This is ideal for shortwave listening, but it can be used for other applications as well. You can even choose to scan through the database memories.

Operating

As enjoyable as it is to explore the bands with the SDR-1000, there comes a time when you feel the need to transmit.

The SDR-1000 manual states that you must do an RF output calibration procedure using a dummy load. I didn't have a dummy load available at the time, so I used the alternative approach—to accept the *PowerSDR* default settings.

My first on-air experience with the SDR-1000 was on 40 meter SSB. I used a microphone/headset combo and a footswitch to activate the push to talk (PTT). The power metering doesn't respond quickly to voice peaks and at first I had the impression that I was only generating about 10 W output. My response was to fiddle with the power amplifier settings (adjustable for each band) in an effort to extract more "juice."

Suddenly, I noticed the telltale odor of overheated components. If Scotty from *Star Trek* were standing in the room, he would have been screaming, "She can't take the strain, Captain. She's gonna blow!" For a moment, I experienced the sinking feeling that comes with the realization that you may have just fried a set of transceiver finals. Fortunately, the SDR-1000 opted to forgive my blunder—at least this time.

Connecting an external peak-reading wattmeter, I discovered that the SDR-1000 was indeed peaking at 100 W even when the meter seemed to indicate that I was barely generating power at all.

With the output at a safe level, I proceeded to enjoy a number of contacts. Everyone reported good audio, although some commented that it seemed to lack "low end." I adjusted the *PowerSDR* equalizer and that helped considerably. I also tested the speech compression feature, but didn't want to push my luck and overstress the finals.

During the review period, I was lucky enough to run into a DX operator who was using split, which gave me the ideal opportunity to exercise the SDR-1000's dual VFO feature. Setting one VFO to the receive frequency and the other to the transmit frequency was as easy you'd expect on a traditional transceiver—and it worked just as well.

My CW experience with the SDR-1000 was disappointing. The problem appeared when I tried to use my CW paddles. There were timing issues that resulted in maddening delays in the sidetone audio. In addition, when attempting to work semi break-in, the first character seemed to be clipped. In fact, the "dit" lengths seemed to vary. These two issues combined to make it nearly impossible to carry on a CW conversation. The good news is that FlexRadio is presently working on an external keyer module that will solve the problem. Until it is available, CW is best sent using an external keyer or the keyboard and memories (an anathema to purists, but a solution for contests).

One more surprise on the transmit side: The SDR-1000 requires more current from the 12 V supply on 160 meters than on the other bands. It will put out the specified 100 W, but at a load that exceeds the 25 A specification (and fuse size). The maximum power output of our unit with a 25 A power supply current was 82 W. The manufacturer is investigating this condition.

FlexRadio is anticipating *PowerSDR* updates in the near future that will add digital modes such as PSK31 and RTTY to the console. Not content to wait, I crafted my own solution using a laptop computer connected to the SDR-1000 microphone jack through a West Mountain RIGblaster interface. Using this approach, I was able to make a number of PSK31 contacts and briefly participated in the January BARTG RTTY contest. (It was a joy to set up a 250 Hz RTTY filter to corral the QRM on 20 meters. I had never experienced that luxury before!) It was fascinating to switch between the spectrum, waterfall and histogram displays and observe the signal characteristics of different digital modes.

If you have the capability to use two sound cards simultaneously in your PC, that would be another solution for digital operating with the SDR-1000. Either way, take care to limit the RF output to 25 W as the manual recommends. After my experience on SSB, I was *very* careful in that regard.

VHF on 6 and 2 Meters

Although reception seemed good on 6 meters, I didn't gather much experience on the transmit side. The output on 6 meters is limited to only 500 mW. I did manage to make a local contact, but for serious work you must invest in a power amplifier. You'll also need a method to switch the SDR-1000 output cabling between your 6 meter amplifier/antenna system and your HF antenna(s).

For 2 meter operating, the SDR-1000 has a provision to add a Down East Microwave DEMI144-28FRS transverter within the enclosure. This transverter covers 144 to 146 MHz, converting down to 28 to 30 MHz. With a transverter RF output of about 100 mW, you will also need an amplifier to achieve the power necessary for long-distance work. We did not test the DEMI144-28FRS for this review.

Impressions

The SDR-1000 is a work in progress, and it always will be. This review is a snapshot of the transceiver captured at a particular point in time.

As I've mentioned before, the performance of the SDR-1000 is dependent on the quality of the computer sound card, particularly as it concerns dynamic range. If you use a mediocre sound card, you'll get mediocre results. If you spring for an expensive, high-end card such as those made by M-Audio (**www.m-audio.com**), you will see impressive results. The commercial cliché "your mileage may vary" applies here.

In our measurements, as shown in Table 1 and associated figures, the receive performance of the SDR-1000 was at least comparable to a traditional transceiver in its $1300 price class. Of course, the crucial difference is that the SDR-1000 will undergo continuous updating and improvement for years after the initial purchase. A hardware rig remains essentially the same forever.

As it stands today, the SDR-1000 is a decent SSB, FM, AM and digital transceiver. As a CW rig, it needs work, but that is reported to be in system test now. My wish list for other SDR-1000 improvements includes:

- PSK31, RTTY and other digital modes completely integrated into the *PowerSDR* console.
- A peak-reading power output meter that responds in real time to rapidly fluctuating signals (such as SSB). FlexRadio reports that their latest release includes this feature.
- A better manual. The current manual describes the controls and functions, but it lacks descriptions of how to actually use them to operate the radio in various modes. It should follow the example of traditional transceiver manuals in this regard. For instance, there should be separate sections that describe how to set up the SDR-1000 to operate SSB, CW or any other mode the radio supports.
- Calibration routines that don't require external test equipment.
- A built-in speaker, or an external speaker port that doesn't require an amplifier.

Is the SDR-1000 a radio for all hams? At this point, probably not. The current incarnation of the SDR-1000 is best suited to the amateur who knows his or her way around a computer. It takes a ham with

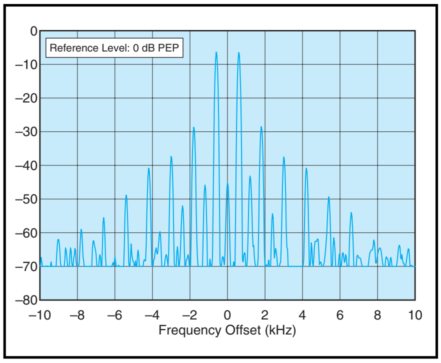


Figure 5—Worst-case spectral display of the SDR-1000 transmitter during two-tone intermodulation distortion (IMD) testing on HF. The worst-case HF third-order product is approximately 29 dB below PEP output, and the worst-case fifth-order is approximately 38 dB down. The transmitter was being operated at 100 W output at 28.35 MHz.

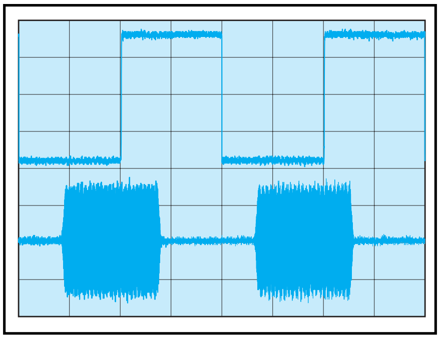


Figure 6—CW keying waveform for the SDR-1000 showing the first two dits in full break-in (QSK) mode using external keying. Equivalent keying speed is 15 WPM (limited by PC buffer size). The upper trace is the actual key closure (first closure starting at left edge of figure); the lower trace is the RF envelope. Horizontal divisions are 40 ms. The transceiver was being operated at 100 W output on 14.02 MHz. A PC faster than our 866 MHz unit will support faster keying.

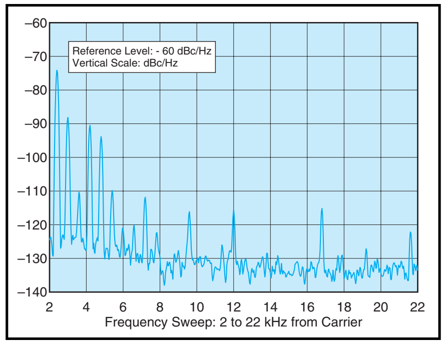


Figure 7—Worst-case tested HF spectral display of the SDR-1000 transmitter output during composite-noise testing at 14.02 MHz. Power output is 100 W. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 2 to 22 kHz from the carrier. Note the spurs that are above the level of the noise output—but within regulations. Their position is frequency dependent.

intermediate or advanced computer skills to get the most out of an SDR-1000 with the least amount of frustration.

But this is just the first step into a new era. As the SDR-1000 evolves, new versions are likely to emerge that will be "friendlier" and well within the understanding of any amateur. The manufacturer reports that they plan to offer a turnkey sound-card and radio solution including a CD with drivers and calibration routines by the time you read this. If so, that will be a real plus. With the collective intelligence of the global Amateur Radio community at work, the potential of the SDR-1000 is almost limitless.

Manufacturer: FlexRadio Systems, 8900 Marybank Dr, Austin, TX 78750; tel 512-250-8595; e-mail **sales@flex-radio.com**; **www.flex-radio.com**. Model SDR-ASM/TRA (fully assembled transceiver with 100 W amplifier and RF expansion board): $1325; SDR-ASM/TR (fully assembled transceiver with 1 W output and RF expansion board): $875; SDR-PKG/TRA (partially assembled transceiver with 100 W amplifier and RF expansion board [enclosure is a kit]): $799; SDR-1000/TR (1 W board set only—no enclosure): $648.

Elecraft XG1 Receiver Test Oscillator

Michael Tracy, KC1SX
ARRL Test Engineer

S-meters—the majority of radios have them, but like snowflakes, no two are exactly alike. Most amateurs realize this on some level, but there isn't much awareness of exactly how much variation there is between the meters of two different radios, or even on the same radio when used on different bands. Worse, there seems to be a lot of complacency in the practice of using these meters to provide the strength indication of RST reports (and that is aside from the infamous, "You are 59 here OM, could you please repeat your name and QTH?").

So What Should They Read?

While there has never been an official standard for S-meters, Collins adopted an internal standard that has become widely accepted among the amateur community (it was also adopted as an IARU Region 1 recommendation for HF use in 1990). According to this standard, a level of 50 µV (–73 dBm for 50 Ω inputs) is equal to S9, with every lower S unit decreasing the level by 6 dB.

Virtually none of the S-meters found on commercial amateur equipment follow this "quasi-standard." In fact, a lot of knowledgeable folk call these devices "guess-meters" instead. As explained in great detail by the late Doug DeMaw, W1FB, in 1977,[1] S-meters are typically controlled by a receiver's AGC voltage, which can vary from band to band and with changes in preamp or attenuator settings. For a sampling of S9 levels from *QST* Product Reviews, see Table 2. In addition to the variation at S9, there is quite a bit of variation in the level change per S-unit. Some rigs are around 4 dB per increment, some are less (as low as 2 dB per) and still others are more. Two samples are shown in Table 3. What's more, the level change is typically not consistent on the very same radio; the increase required to go from S1 to S2 can be very different from S4 to S5 and different again at S8 to S9, as shown. Quite a mess!

Bottom Line

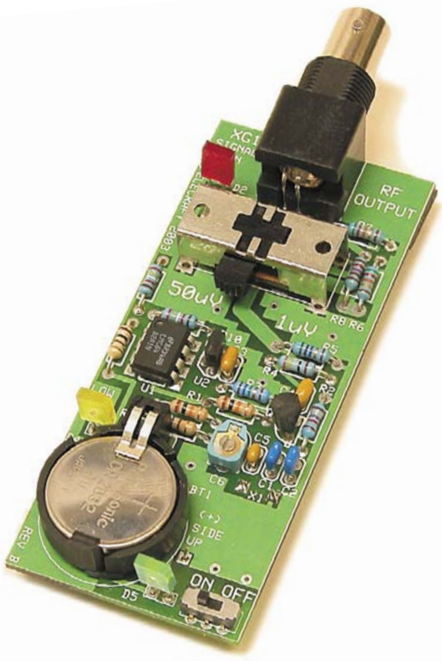
Priced considerably less than a typical wattmeter, this is one station accessory that really adds value to your shack.

What's a Ham To Do—Elecraft to the Rescue

So what's an operator to do to make the S-meter useful? Part of the problem has been a lack of accurate level signal sources at reasonable cost. Certainly a lab-grade signal generator would do nicely, but its cost can easily exceed that of the transceiver being measured! Enter the Elecraft XG1. The XG1 is a crystal oscillator with accurate output levels at 50 µV and 1 µV at 7.040 MHz. The output on the oscillator's harmonics is not as precise, nor as high, as would be expected, but nonetheless provides some useful functionality there as well, as we'll discuss.

When coupled with a step attenuator with a 1 dB step size, the XG1 can provide a full characterization of the S-meter levels below S9. For those who don't have an attenuator, several companies offer commercial units, at least one company offers a kit, and they are fairly easy to design[2] and build.[3,4,5]

The XG1 is meant to be simple and inexpensive. Everything is mounted on a 1.5×3.5 inch double-sided circuit board and no enclosure is provided nor needed. Stick-on mounting feet are included to keep it up off the workbench, but if you have a cluttered bench, you may want to consider keeping it in a plastic container when you aren't using it to prevent accidentally shorting out the battery. Speaking of the battery, it is a fairly large, but very common, button cell type. The XG1 has a low current drain, so it will last quite a long time—80 operating hours according to the manual. I once accidentally left it on for a whole day, and the output remained unchanged when I finally discovered my faux pas and tested it. The RF connector is a BNC type, so an adapter is required to connect it to the SO-239 UHF connector found on most transceivers. As



small and light as it is, you can dispense with coax jumpers and attach it directly to the rig if there's room.

The unit I tested was built by Joel Hallas, W1ZR, *QST*'s Product Review Editor. Joel reported that the assembly instructions were clear, all parts were there, the assembly was straightforward and it was completed in about an hour. It even worked the first time!

A green LED lets you know the XG1 is on, a yellow LED warns of a low battery and a red LED warns of accidental application of transmit power of 100 mW or more. As explained in the manual, damage will occur at significantly higher levels, but don't leave it connected to your transceiver when you're done testing, and wonder why your SWR is so high the next day!

In addition to providing a "sanity check" for your S-meter on 40 meters, the XG1's 1 µV output level can be used to evaluate receiver sensitivity, so you can make sure your rig is still up to snuff as it gets older. The 1 µV level can also help determine the rest of the S-meter scale, since it should read 2 dB above S3, call it S3.3, by the Collins standard. You can also use it to check for problems after the inevitable visit by infamous Murphy or for those times when you wonder whether the bands are really that dead or you had a lightning strike while you were sleeping. It also makes an ideal carry-along for checking out rigs at hamfests (provided the rig has power, of course), or for helping check out rigs for friends. The unit is remarkably accurate considering its price and the person who assembled it! See Table 4 for the details.

The output on the harmonic frequencies of 14.08, 21.12 and 28.16 MHz ranges from 7 to 24 dB down from the fundamental, and these levels will vary somewhat—the manual says ±3 dB, but when the 50 µV setting is used, the level of the harmonics is still useful for checking approximate S-meter response on these other bands. Additionally, the fundamental crystal can be changed to another HF frequency if desired (note that using a crystal socket is not recommended). Some folks may find it helpful to have several XG1s around the shack with crystals for their preferred bands of operation. Output level accuracy is only guaranteed on the original 40 meter frequency, however.

Manufacturer: Elecraft, PO Box 69, Aptos, CA 95001-0069; tel 831-662-8345; fax 831-662-0830; **www.elecraft.com**. Price: $39.

Table 2
S-meter Signal Levels for S9 Reading, 20 Meters

Radio Model	*Preamp Off*	*Preamp On*
ICOM IC-7800	58 µV	7.2 µV
Kenwood TS-480SAT	87 µV	18 µV
Ten-Tec Orion	135 µV	33 µV
Yaesu FT-857	17 µV	6.6 µV

Table 3
Difference Between S-meter Readings on Two Amateur Transceivers

	Radio 1		*Radio 2*	
S Value	*Level*	*Difference*	*Level*	*Difference*
S1	–89 dBm	2 dB	not taken	
S2	–87 dBm	2 dB	–114 dBm	11 dB
S3	–85 dBm	3 dB	–103 dBm	9 dB
S4	–82 dBm	2 dB	–94 dBm	5 dB
S5	–80 dBm	2 dB	–89 dBm	5 dB
S6	–78 dBm	3 dB	–84 dBm	5 dB
S7	–75 dBm	3 dB	–79 dBm	4 dB
S8	–72 dBm	3 dB	–75 dBm	4 dB
S9	–69 dBm		–71 dBm	

Table 4
Elecraft XG1

Manufacturer's Specifications	*Measured in the ARRL Lab*
RF output level: 1 µV and 50 µV	As specified (±1 dB).
Frequency: 7.040 MHz, ±100 Hz	As specified.
Current consumption:	2.5 mA typical.
Size (W×D): 1.5" × 3.5."	

Notes

[1]D. DeMaw, W1FB, "What Does My S-Meter Tell Me?" *QST*, Jun 1977, pp 33-36.
[2]H. Silver, NØAX, "Hands-On Radio, Experiment #13—Attenuators," *QST*, Feb 2004, pp 69-70.
[3]P. Pagel, N1FB, B. Shriner, WAØUZO, "A Step Attenuator You Can Build," *QST*, Sep 1982, pp 11-13,
[4]D. Bramwell, K7OWJ, "An RF Step Attenuator," *QST*, Jun 1995, pp 33-35.
[5]P. Ostapchuk, N9SFX, "A Rugged, Compact Attenuator," *QST*, May 1998, pp 41-44.

KU4AB 2-Meter and 70-cm Antennas

The square loop has been a popular VHF/UHF omnidirectional antenna for decades and it is easy to understand why. The simple design packs solid horizontally polarized performance in a very small package. While it can't compare to a directional antenna, an omni loop is useful for antenna-restricted environments, weak-signal mobile operating and even amateur satellites.

Phil Brazzell, KU4AB, designs and builds a line of "SQ loops" for 6 meters through 70 cm. Phil's increasingly popular loops are fashioned from solid aluminum rods for lightweight durability. Because the antennas are often installed outdoors, the rest of the hardware is crafted from stainless steel to resist corrosion.

Installation

For this review, I purchased 2-meter and 70-cm loops for my cramped attic antenna farm. The 2-meter SQ loop is only about 12 inches across and the 70-cm loop is just under $4\frac{1}{2}$ inches wide (Figure 1).

SQ loops arrive completely preassembled. You simply lift them from their shipping containers and they're ready to install. The antennas also arrive pre-tuned for the "weak signal" portions of the bands, which is where most hams will use them. However, you can adjust the tuning by increasing or decreasing the distance between the ends of the loop elements.

Figure 1—The 70-cm SQ loop antenna is less than $4\frac{1}{2}$ inches across.

Using a piece of PVC tubing as a mast, I placed the 2-meter loop about a foot above the attic floor and the 70-cm loop near the attic roof (see Figure 2). With a diplexer in the attic, I "split" a single feed line to feed both antennas. The loops sport standard SO-239 coaxial connectors.

Figure 2—My attic SQ loop installation.

The results of my SWR measurements on 2 meters and 70 cm are shown in Figures 3 and 4, respectively. As you can see, the low-SWR points fall right where KU4AB intended. You'll also note that the SWR curve for the 2-meter loop is a bit sharper than the 70-cm antenna.

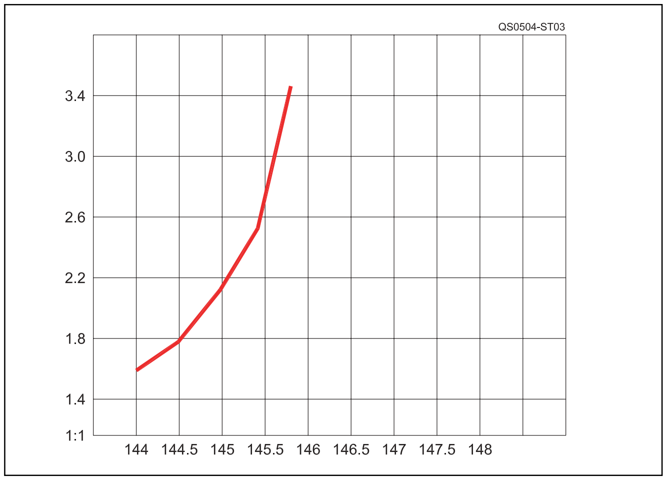


Figure 3—The SWR curve with the 2-meter SQ loop.

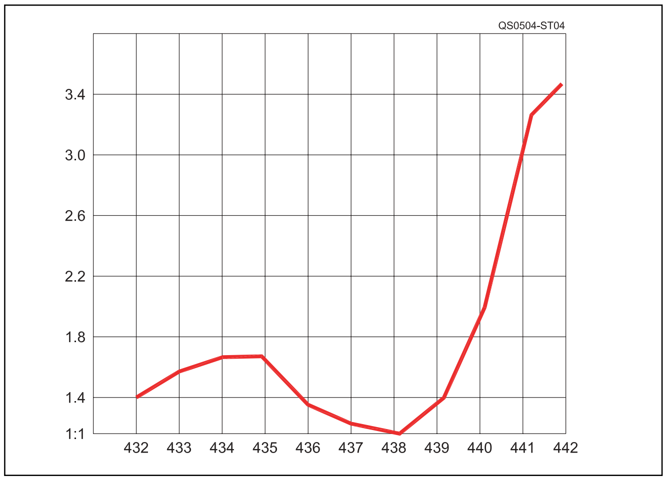


Figure 4—The SWR curve with the 70-cm SQ loop.

So How Well Do They Work?

My first test was with the AMSAT-OSCAR 51 satellite. I was pleasantly surprised at the strength and consistency of the 70-cm downlink signal. At the highest point of a high-elevation pass, I enjoyed S7 signals, which resulted in full-quieting FM audio from the bird.

Another interesting test occurred during the January ARRL VHF Sweepstakes. I couldn't hear most of what the guys with the big beams were working, but with my 50 W of RF, I was making contacts out to about 90 miles (and I am *not* on a hilltop).

And even with the polarity mismatch (and despite the high SWR when operating in the repeater subbands), the SQ loops were also usable for local FM work.

Conclusion

KU4AB's SQ loop antennas perform as advertised, if not better. They are a snap to install and extremely rugged. The SQ loops are also very reasonably priced. With those considerations in mind, I suspect SQ loops will find homes at many stations.

Manufacturer: KU4AB Antennas, 339 Venice Cove, Collierville, TN 38017; **www.ku4ab.com/index.html**. *Model SQ-144m1: $34.95; SQ-432: $28.95.*

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